Medical Radiation Physics

a European Perspective

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Organiser of the Conference is the Department of Medical Engineering and Physics, King's College School of Medicine and Dentistry, London, represented by Professor V. Colin Roberts and Dr Slavik D. Tabakov (Project Co-ordinator).

The contributions to the book were collected with the active involvement of the European Federation of Organisations for Medical Physics (EFOMP).

MEDICAL RADIATION PHYSICS
A European Perspective

Based on the contributions to the European Conference on
Post-Graduate Education in Medical Radiation Physics,
Budapest 12-14 November 1994

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Participants to the European Conference on Post-Graduate Education in Medical Radiation Physics, Budapest 12-14 November 1994

FOREWORD
TO THE INTERNET E-EDITION OF THE BOOK

The First European Conference on Post-graduate Education in Medical Radiation Physics, held in Budapest on 12-14 November 1994 was a milestone for the development of the profession in Central and Eastern Europe and also triggered various international activities in the field.

Hundreds of copies of the *"blue book"*, which second Internet-edition is presented here, were distributed all over Europe and other countries in the world. Based on this book more than 10 new post-graduate courses in Medical Physics were initiated in various East European countries. Additionally, members of the Network formed after the Conference developed and introduced a number of international projects in education and training. The first meeting of the Network was in Krakow, Poland (satellite to the 10^{th} Polish Congress on Medical Physics).

The international (European) projects on Education and Training in Medical Physics and Medical Engineering, developed after 1994 will be briefly described below (in chronological order).

1995 - members of the Network introduced the European Tempus Project ERM, whose objective was the development, in Bulgaria, of a one-year post-graduate MSc course in Medical Radiation Physics and Engineering. The project partners were: three Bulgarian Universities – the Medical University VMI - Plovdiv, the Technical University – br. Plovdiv and the University of Plovdiv, King's College London (Project Contractor and Co-ordinator), the University of Florence and the University of Dublin. In 3 years the project established an Inter-University Medical Physics Centre (IUC) in Plovdiv, Bulgaria and developed a successful MSc course (launched in 1997), which was later accredited by the UK's IPEM. The whole education in the IUC is in English and modularised in order to facilitate the attendance of eminent lecturers from various Universities throughout Europe. The books with Lecture Notes produced for the MSc course in Plovdiv were printed, by a specially established Foundation, for distribution to other countries. More information about this MSc course can be found at www.kcl.ac.uk/erm and www.erm.dir.bg

1996 - The needs for harmonised European training in Medical Radiation Physics were addressed through an EC Leonardo da Vinci pilot project, prepared by a Consortium of Universities and Hospitals from UK, Sweden, Italy and Portugal: King's College London (Contrcator and Co-ordinator), the University of Lund, the University of Florence, King's College Hospital, Lund University Hospital, Florence University Hospital, the Portuguese Oncological Institute and the International Centre for Theoretical Physics in Trieste. The objective of this project (EMERALD - **E**uropean **Me**dical **Ra**diation **L**earning **D**evelopment) was to develop a Framework of three training modules in Medical Radiation Physics (Physics of : X-ray Diagnostic Radiology; Nuclear Medicine; Radiotherapy). These modules are for the training of young graduates and post-graduate students in medical physics. The project produced structured training timetables and syllabi, Course Guide, 3 Student Workbooks and 3 CD-ROMs with Image Databases. During 1998 EMERALD Consortium organised the First European Conference on Medical Physics Training in ICTP, Triest, Italy (24-25 September 1998). More information about the EMERALD training materials and scheme can be found at www.emerald2.net

1997 – the project TEMPERE (Training and Education in Medical Physics and Engineering Reformation in Europe) was initiated. The project involved a network of professionals and professional bodies in the fields of Medical Physics and Biomedical Engineering from 16 EU countries (with University of Patras as Contractor and Co-ordinator). The project aimed to provide a forum for productive interaction among professionals on the relevant professional issues, which would lead to a proposal for a European framework for mutual co-operation and recognition in the above fields. The project developed guidelines for education and training courses and for their accreditation. A book with project results is in print at the moment. More information about the TEMPERE project can be found at http://etros1.vub.ac.be/tempere

1998 - based on the experience from the project ERM another European Tempus Project was developed aiming to establish Joint Baltic MSc courses in Medical Physics and Biomedical Engineering. The partners in this project were the University of Linkoping (Contractor), King's College London, Riga Technical University (Co-ordinator), the University of Latvia, Tallinn Technical University, the University of Tartu and Kaunas University of Technology. The launch of the MSc course, organised between the 3 Baltic states (Estonia, Latvia, Lithuania) was in 2000. The project published all syllabi of this joint modular course in the book *Baltic Biomedical Engineering and Physics MSc Courses*

(ISBN 9984 681 52 1). More information about this project and course can be found at www.rtu.lv/fakult_lapas/mzf/eemti/BaltTemp.html

1999 - A second EU Leonardo project - *EMERALD Internet Issue* (EMERALD II) - was initiated by the EMERALD Consortium with additional partners from France, Ireland, North Ireland, Czech Republic and Bulgaria. The project aimed at the development of EMERALD training materials for Internet distribution. The project developed 3 sets of Web-based materials (available also on CD-ROMs). A demo is presented at the EMERALD web site. A number of International Seminars on Medical Physics training were organised in the wramework of this project: Dublin, Ireland (25-26 February 2000); Lille, France (17-18 June 2000); Prague, Czech Republic (3-5 September 2000); Lisbon, Portugal (20-22 November 2000); Lund, Sweden (19-20 January 2001) and London, UK (16-17 March 2001). At the moment the EMERALD training materials are used in more than 40 countries around the world.

Most of these activities were supported by the respective national societies, the European Federation of Organisations for Medical Physics (EFOMP) and the International Organisation for Medical Physics (IOMP). During (and after) the above seminars (2000-2001) new materials were gathered to be e-published in a new "blue book" with working title - *Medical Radiation Physics – A European Perspective UPDATE 2001*. This new electronic book will soon be available from the web site of EMERALD: www.emerald2.net

Additional materials to this new e-book from other countries are welcome Please send these as attached MS Word files to slavik.tabakov@kcl.ac.uk

August 2001, London

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INTRODUCTION

The idea for an East/West European discussion on Education in Medical Physics and Engineering has a long history. Many of the Western European countries have discussed within the European Federation of Organisations for Medical Physics (EFOMP) activities for harmonising the professional training and education, these being reflected in the Policy Statements of EFOMP. At the same time the countries from Central/Eastern Europe have had mutual agreements in the field of education, but due to the small number of professionals working in Medical Physics & Engineering, these specialities have not been addressed. Contacts between East and Western Europe in the area of education were rare before 1989. The collaborative activities which occurred after the catastrophe in Chernobil in 1986 showed that effective results can be achieved with joint endeavours.

In the field of Medical Physics & Engineering the first and most important step towards a true joint effort is the harmonisation of education and training. The necessity for a pan-European forum on these questions has been discussed on various occasions including the 5th Conference of the Bulgarian Society for Biomedical Physics and Engineering held in Sofia in 1988; the 5th Mediterranean Conference on Medical and Biological Engineering held in Patras Greece in 1989; and the Weimar Clinical Engineering Workshop in the former GDR which was held in 1990. During the International Federation for Medical & Biological Engineering (IFMBE) Intra-European Biomedical Engineering Workshop held in Szentendre, Hungary in 1991, it was agreed that there is considerable interest in and need for future collaboration between Central/Eastern and Western European countries in the area of the professional training, and activities for a joint venture were initiated. As a result of this a submission was made successfully to the CEC for support towards the First European Conference on Education in Medical Radiation Physics.

THE EUROPEAN CONFERENCE ON POST-GRADUATE EDUCATION IN MEDICAL RADIATION PHYSICS, BUDAPEST'94

The objectives of the Conference were:

- To increase the East/West European co-operation in the field of Medical Physics;
- To establish the status and needs of education and training in Medical Radiation Physics in Central/Eastern European countries;
- To formulate proposals for the advancement of post-graduate education in Medical Radiation Physics and identify resource sharing initiatives;

- To consider the need for a Training Authority and a professional network in the field of Medical Physics & Engineering in Central/Eastern Europe.

The Organising Committee was set up in London with members:
Prof. V. Colin Roberts, Chairman,
Dr Slavik D. Tabakov, Secretary,
Dr Cornelius A. Lewis, Treasurer.
The Local Organising Committee was set up in Budapest with members:
Prof. Pal Zarand, Chairman,
Dr Nandor Richter,
Dr Istvan Polgar.

EFOMP was closely involved in the organisation of the conference the concept of which was received enthusiastically in almost all countries invited to participate. This showed once again the enthusiasm of all colleagues for collaboration. The delegates to the conference were senior professionals in Diagnostic Radiology (Roentgenology), Radiotherapy, Nuclear Medicine, Radiation Safety and Imaging, each delegate being a nominee of their European professional society and/or their University. In total 37 Institutions, Societies and Universities from 23 European countries were represented at the Conference, the majority of the delegates being active members and officials of EFOMP or the IFMBE.

The European Conference on Post-graduate Education in Medical Radiation Physics was held in Budapest from 12-14 November 1994. It was opened by Prof P. Vittay, representing the Hungarian Minister of Welfare Dr Pal Kovacs. An initial overview was presented by the Secretary General of EFOMP, Dr W. Seelentag. This was followed by presentations of the institutions and countries on the present status of medical physics education and training in their respective countries. Two general discussions (round tables) followed which focused on two major themes:

- education and accreditation of centres for education & training;
- training and continuing professional development.

The conclusions and decisions of the round tables were approved in the final plenary discussions where it was agreed that a pan-European Network should be formed and that five Working Groups should be organised to examine the following subjects:

- syllabus for education schemes;

- minimum requirements for education centres (accreditation and assessment);
- syllabus for training schemes;
- minimum requirements for training centres (accreditation and audit);
- terminology and interpretation of EU Legislation.

Details of these are printed at the end of the book together with the ***Declaration of Intent*** signed by all the delegates to the Conference.

The potential contribution of the conference to the further development of the education in Medical Physics & Engineering, its harmonisation, and the potential for intra-European collaboration in Medical Radiation Physics was highly appreciated by the delegates. It was decided at the Conference that a post-conference book should be produced to include papers from as many European countries as possible. This has been achieved with the help of EFOMP and the prompt answers of colleagues from additional European countries to our request for contributions.

Several previously published documents provide interesting background information to the subject of this book and are commended to the reader. These include the materials from the 1st IAEA/WHO seminar on the education and training of medical physicists which was held in Kiel, Germany in 1972, the policy statements of EFOMP and the IPSM Training Scheme Prospectus.

This present book *Medical Radiation Physics - A European Perspective,* contains data covering the Medical Radiation Physics support to more than 90% of the population of the European continent. We believe that it is an appropriate contribution to the world celebration of the 100th anniversary of the discovery of X-rays by W.K. Roentgen. We hope that it will facilitate an increase in the professional contacts and collaboration within a wider Europe. We also hope that the strong wish of all Professional Societies involved in the Project to hold subsequent conferences on these topics will be realised.

ACKNOWLEDGEMENTS

The editors of this book and the organisers of the conference would wish to express our sincere gratitude to all colleagues who gave their time and enthusiasm to ensure the success of the European Conference and the contributions from which this book has been prepared. In particular, we would acknowledge the help received from Dr K.A .Jessen, President of EFOMP; Dr P.P. Dendy, immediate Past President of the UK's IPSM and former chairman of the ETP Committee of EFOMP; Dr A. Benini, Division of Nuclear Safety of IAEA; Dr W. Seelentag, Secretary General of EFOMP; Dr I.-L. Lamm, Chairman of ETP Committee of EFOMP; Dr G.Hanson, WHO; Dr O. Chomicki, Secretary General of Foundation Maria Sklodowska-Curie and Councillor of the International Organisation for Medical Physics (IOMP).

Special gratitude has to be expressed to Dr V. Tabakova and Mrs E. Langford for their most valuable contribution in all phases of the Project. We would also like to thank our colleagues from King's College London: Mrs J. Walker, Mrs N. Pierson, Miss T. Sullivan and especially Miss D. Smith for their secretarial support in the preparation of the Proceedings of the Conference, as well as to Mrs G. Barry for her advice. We are also grateful to SIEMENS and VARIAN for supporting some activities during the Conference. Last but not least we are grateful to the officers of CEC DGXII/B/Contracts in Brussels for their helpful advice throughout the realization of this Project and to the Commission of the European Communities for the financial support.

The Organiser
London, February 1995

Department of Medical Engineering and Physics, King's College School of Medicine and Dentistry, London SE5 9RS, U.K. , fax 0207 346 3314.

OPENING ADDRESS

P. VITTAY [(1)]

"Ladies and Gentlemen,

Doctor Pal Kovacs, Minister of Welfare had conferred upon me the honour to address and open, on his behalf, the European Conference on Postgraduate Education in Medical Radiation Physics.

It is my particular honour to welcome, on behalf of the Minister of Welfare as well as on my own behalf, Mr Seelentag and Ms Lamm, who represent EFOMP, Mr Roberts representing the IFMBE and Mrs Benini, who is with us today on behalf of the IAEA.

The fact that the Commission of the European Communities (activity for Co-operation in Science and Technology with Central and Eastern Europe) is holding this meeting in Hungary is an important event for us and is seen as the acknowledgement of this country's efforts.

During her history, Hungary drove back many attacks that came from the East and endangered Western Europe. Thus, the role that Hungary had in history was that of a stronghold for Western Europe. On the other hand, it is also our historical role to be a bridge that unites, a link between the cultures of the West and the East.

Medicine and health care have been increasingly dependent on technology for decades. This technology-dependency can be seen to the greatest extent in the field of Radiology, in terms of both diagnostic procedures and radiation therapy. This implies also that the efficient and safe operation of the extremely sophisticated and complicated equipment and machines requires the contribution of specially qualified personnel, namely of physicists and engineers. Although this requirement was recognised, in theory, quite some time ago, in practical life physicists, technicians and engineers do not enjoy the same level of appreciation as do doctors.

Therefore, if I have just referred to Hungary's role as a bridge, in addition to her being a bulwark, then continuing along these lines, I can now safely say that this Conference has a bridging role between doctors and physicists-engineers on the one hand, and between the medical and technical ways of thinking, on the other. One of the major expectations from this European Conference is to formulate, in line with the European ideal, a common platform for clinical physicists and engineers working in hospitals who, through their training and post graduate education, would create a pool of qualified experts with interchangeable skills.

Another important aspect of the bridging role that the present Conference has to play is to promote the idea that clinical physicists and engineers may enjoy moral and financial esteem, as well as opportunities for professional careers that derive from the responsibility they have to shoulder that are equal to, and are at the same level as those of medical doctors.

We know that we are far from this situation all over the world and that today, it is a sense of vocation rather than financial interests that drive physicists and engineers towards the health services. In spite of this, we must do our best and make efforts to the end that, while maintaining the sense of vocation, moral and financial remuneration should also fall to the lot of these enthusiastic people.

Ladies and Gentlemen,

May I conclude by wishing every success to all the participants of this Conference on behalf of Minister Pal Kovacs and on my own behalf. Herewith, I declare the European Conference on Post-graduate Education in Medical Radiation Physics open".

[(1)] **Professor Pal Vittay, Director General, National Institute for Radiology and Radiation Physics, H-1135 Budapest, HUNGARY.**

RADIATION PROTECTION ACTIONS OF THE CEC IN THE FIELD OF RADIATION PROTECTION AND QUALITY ASSURANCE IN DIAGNOSTIC RADIOLOGY

H. SCHIBILLA [(1)]

These actions follow the requirements of the EURATOM Treaty concerning the establishment and up-dating of safety standards for the health protection of the general public and workers against the dangers arising from ionising radiation. It also covers the study of adequate preventive and protective measures.

The main purpose is the reduction of population exposure from man-made sources, of which the medical use of ionising radiation and radionuclides constitutes about 80% of that exposure.

A special EURATOM Directive has been issued, laying down basic measures for the radiation protection of persons undergoing medical examination or treatment. It requires justification of the use of ionising radiation, to keep doses as low as reasonably achievable, to give adequate training to the medical and auxiliary staff involved and to assure periodic surveillance of all equipment.

The CEC Radiation Protection Actions, therefore, concentrate special efforts on:

I. Study and implementation of measures for the optimisation of radiation protection in medicine.
II. Education and training of radiation protection principles and their practical implementation

Specific topics on which the CEC Actions are providing scientific advice and guidance with a view to harmonising and standardisation are:

I OPTIMISATION OF RADIATION PROTECTION MEASURES

I.1. Establishment of quality criteria for radiographic images and equipment functioning, with reference to good imaging performance: image detail detectability and patient reference dose levels.

I.2 Optimisation of equipment functioning by quality control measures.

I.3 Development of knowledge based systems for the selection of the optimum intervention during quality control measures.

I.4 Establishment of European protocols for quality assurance and quality control, eg Mammography.

I.5 Dose measurement protocols.

II EDUCATION AND TRAINING

II.1 Organisation of training courses on the most recent state of knowledge in specific areas, addressed mainly to teachers and those in control of radiation protection, taking into account the varied background levels of persons to be trained.

II.2 Preparation of training programmes and training packages (including audio-visual material).

II.3 Promotion of participation of young professionals in training courses, workshops and seminars

A list of the documents prepared by the CEC Radiation Protection Actions on Quality Assurance and Radiation Protection in Diagnostic Radiology is given in Appendix 1.

RESEARCH PERSPECTIVES IN THE FIELD OF RADIATION PROTECTION AND QUALITY ASSURANCE IN DIAGNOSIC RADIOLOGY

Since the medical use of ionising radiation is generally increasing in the European Union, due to newly introduced techniques and procedures, the implementation of the EC Directive on Radiation Protection of the Patient requires more specific research work in order to establish scientifically-based guidance and training. The revision of this Directive might become another consequence of the changing situation in diagnostic radiology and of the new level of the quality and safety culture in the medical field.

Optimisation of radiation protection in medicine should now be approached by quantitative methods defining the link between the required diagnostic information and the exposure of the patient. The appropriate parameters have to be studied and the correlation between patient dose, radiological and technical procedures and the image quality must be established.

The quality criteria concept has been shown to be a valuable tool for describing image quality and the corresponding technical parameters. The implementation of the quality criteria will make the involved medical and technical staff aware of the possibilities for optimising the use of the diagnostic procedures and techniques, which will simultaneously contribute to avoid unnecessary patient exposure. The quality criteria concept has to be refined on close co-operation with the medical and technical staff so that the framework will be established for objectively evaluating the diagnostic image quality for a given dose.

The impact of the use of optimisation measures has to be assessed on the day to day practise for specific types of examination associated with relatively large individual doses or height frequency. Special attention should be given to paediatric radiology, with regard to paediatric radiology, with regard to the risk from exposure to ionising radiation which is about 2 times higher than for adults under comparable circumstances.

More thought should be given to the elaboration of quantities for risk assessment related to patient protection and referral criteria for the selection of adequate techniques and procedures.

The new research tasks will contribute to also establish a scientific basis for computer aided developments in quality assurance to the diagnostic radiological procedure. This could, at the same time, promote a closer link between the user and the manufacturer of the medical equipment involving ionising radiation, since the quality control of the installations, including certain measures for radiation protection can become an integral part of of the imaging process. Further research work should also be encouraged with a view to look for technical developments with a potential of optimising the detection and interpretation of X-rays for diagnostic purposes..

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APPENDIX 1

Documents prepared by the CEC Radiation Protection Actions on Quality Assurance and Radiation Protection in Diagnostic Radiology:

1 Drexler G, Eriskat H and Schibilla H (eds) (1981). Patient exposure to radiation in medical X-rays - possibilities for dose reduction. Proceedings of the seminar organised jointly by the CEC and the Gesellschaft fur Strahlen und Umweltforchung , Munich - Neuherberg (FRG) 27-30 April 1981. **Report EUR 7438 EN 1981**, 470pp.

2 Drexler G, Eriskat H and Schibilla H (eds) (1985). Criteria and methods for Quality Assurance in Medical Xray Diagnosis. Proceeding of a Scientific Seminar organised jointly by the CEC and the Centre di Ricerca Applicate e Documentazione, Udine, (1) 17-19 April 1984. **Report EUR 9255 EN 1985,BJR Supplement No. 18**, 179pp.

3 Moores BM, Stieve FE, Eriskat H and Schibilla H. (eds) (1989). Technical and Physical Parameters for Quality Assurance in Medical Diagnostic Radiology: Tolerance, Limiting Values and Appropriate Measuring Methods. Proceedings of a Workshop. **Report EUR 11620, EN 1989, BIR Report 18**, 165pp.

4 Moores BM, Wall B, Eriskat H and Schibilla H. (eds) (1988). Optimization of Image Quality and Patient Exposure in Diagnostic Radiology. Proceedings of a Workshop organised jointly by the CEC and the National Radiological Protection Board - Chilton held in Oxford. (UK), 27-29 September 1988. **Report EUR 11842 EN BIR Report 20**, 288pp.

5 Fitzgerald M, and Courades JM. (eds) (1990) Medical Radiation Protection Practice within the CEC. Proceedings of a meeting organised jointly by the CEC and the British Institute of Radiology, held in London (UK). **BIR, London: ISBN 0905749 26 X**. 53pp.

6 Kramer HM, and Schnuer K. (eds) (1992). Dosimetry in Diagnostic Radiology. Proceedings of the Seminar jointly organised by the CEC, the Physikalisch - Technische Bundesanstalt, Braunschweig (FRG) the World Health Organisation and the International Commission on Radiation Units and Measurements held in Luxembourg (L) 19-21 March 1991. **Report EUR 14180 EN 1991, Radiation Protection Dosimetry.** ***43***, 1-4.

7 Busch HP, and Georgi M (eds). (1992). Digital Radiography: Quality Assurance and Radiation Protection Proceedings of the Workshop jointly organised by the CEC, the Klinikum Mannheim and the European Association of Radiology, held in Mannheim (FRG) May 1992. **Schnetztor-Verlag GmbH, Konstanz, EN 1992**. 103pp.

8 Moores BM, Petoussi N, Schibilla H, Teunen D (eds). (1992). Test Phantoms and Optimisation in Diagnostic Radiology and Nuclear Medicine. Proceedings of the Workshop jointly organised by the CEC, the Forschungszentrum fur Umwelt and Gesundheit, Neuherberg (FRG), the International Commission of Radiation Units and Measurements and the

European Federation of Organisations for Medical Physics, held in Wurzburg (FRG) June 1992. **Report EUR 14767 EN 1992, Radiation Protection Dosimetry,** *49,* 1-3.

9 Maccia C, Moores BM, Nahrstedt U, Radovani R, Wall B. (1988). CEC Quality Criteria for Diagnostic Radiographic Images and Patient Exposure Trial. **Report EUR 12957 EN 1990,** 131pp.

10 Quality Criteria for Diagnostic Images. Working Document, 2nd Edition June 1990 . **CEC XII/173/90,** EN, DA, DE, ES, FR, GR, IT, NL, PO.

11 Quality Criteria for Diagnostic Radiographic Images in Paediatrics. Working Document, June 1992. **CEC XII/307/91,** EN, DA, DE, ES, FR, GR, IT, NL, PO.

12 European Guidelines for Quality Assurance in Mammography Screening + Appendix. European Protocol for the Quality Control of the Technical Aspects of Mammography Screening. Working documents of "Europe Against Cancer" and the "Radiation Protection Actions" October 1992 **CEC V/775/92, Report EUR 14821,** EN DA, DE, ES, FR, GR, IT, NL, PO.

13 Contento G, Wall B, Schibilla H, and Teunen D. (eds) (1995). Data Analysis and Optimisation in Quality Control and Radiation Protection of the Patient in Diagnostic Radiology and Nuclear Medicine. Proceedings of the Workshop jointly organised by the CEC, the Unita Sanitaria Locale No.7, Udine (I) and the World Health Organisation, held in Grado (I) 29 September - 1 October, 1993. **Report EUR 15257 EN Radiation Protection Dosimetry**. *57* Nos 1-4 .

EUROPEAN FEDERATION OF ORGANISATIONS FOR MEDICAL PHYSICS (EFOMP)

K.A. JESSEN[(1)], President of EFOMP

Medical physicists are primarily and professionally engaged in the application of physics to medicine and biology in clinical, research, and educational institutions. The practice of medical physics varies under this general description from country to country throughout Europe and even between institutions within the countries variations can be observed. Different education requirements and legal status are the main cause of these variations. Within individual countries national organisations work on improvements and provide information and guidance on the training, responsibilities, organizational relationships and roles of persons in the field of medical physics.

The suggestion that the medical physics profession in Europe would benefit from bringing national societies together was first discussed in 1978 and the European Federation of Organisations for Medical Physics was founded in London in May 1980 with 14 founder members. In 1995 EFOMP has 25 member societies, representing some 5100 individual scientists.

It was a general feeling in the late seventies, that there was an urgent need to raise the professional status and increase the political awareness of medical physics in Europe and that the new body should aim to establish itself as "The voice of Medical Physics in Europe". Since that time there has ever been a pressing need to harmonise the differences between countries in Europe, especially within the European Union, where freedom of movement and employment has been in effect since 1992. It is not appropriate that each national organisation has to develope its own chain of experiences, but it is obvious, that we in the European region should take advantage of the results obtained by the most developed organisations in order to accelerate a harmonization of the differences and in this way to promote the best practice of medical physics in the whole region.

The aims of EFOMP are described in the constitution: to foster and coordinate the activities of member organisations; collaborate where appropriate with national and international organisations; to encourage exchanges between the member organisations and disseminate professional and scientific information through publications and meetings; to propose guidelines for education, training and accrediation programmes and making recommendations on the appropriate general responsibilities, organisational relationship and roles of workers in the field of medical physics.

The administration of EFOMP is held by the Council and by the Officers. The Council is formed by two delegates form each member organisation and meets once a year. The Officers are nominated for a 3-year term by the EFOMP Council.

The reason for two delegates is related to the main work of EFOMP being conducted in the two main Committees - the Scientific Committee and the Education, Training and Professional (ETP) Committee. In the Scientific Committee the main tasks are the organisation of scientific meetings and the sponsoring of scientific journals. The tasks of the Education, Training and Professional Committee are described by Dr. Inger-Lena Lamm in the present book.

The Publication and Electronic Communications Committee is mainly concerned with the publication of the newsletter "European Medical Physics News", and exploring the possibilities of electronic mail for EFOMP's purposes.

From its start the Federation has aimed at a close working relationship with the European Union and its administration in Brussels and Luxembourg. Over the past ten years the Federation has responded to those Directives issued by the EU which have influence on the practice of medical physics and EFOMP is now accepted by the EU as the body which speaks for medical physics in Europe.

EFOMP works in collaboration with the **I**nternational **O**rganisation of **M**edical **P**hysics (IOMP), which represents the medical physics associations from all over the world. There are discussions within IOMP to organise itself on a regional basis: in this event EFOMP has been asked to act as the European regional liaison group.

The Federation represents a unique information network with linkage to medical physics organisations throughout Europe and collaboration with bodies such as ESTRO, EAR, WHO and IAEA is an important way of promoting the profession of medical physics.

An increased involvement of colleagues from Central and Eastern Europe would be desirable - with the political barriers removed we can now hope for this to evolve in the not too distant future. The European Conference on Post-Graduate Education in Medical Radiation Physics is an important step in that direction to establish the required levels of education and training and to help achieve parity of professional standards of medical physics in Eastern and

Medical Radiation Physics
Western Europe.

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POST-GRADUATE EDUCATION IN MEDICAL RADIATION PHYSICS - THE EFOMP VIEW

I.-L. LAMM[(1)]

INTRODUCTION

The European Federation of Organisations for Medical Physics, EFOMP, was inaugurated in May 1980 as an umbrella organisation for National Medical Physics Organisations. National activities would be strengthened and made more effective by bringing about and maintaining a systematic exchange of professional and scientific information, by the formulation of common policies on the responsibilities and roles of the medical physicist, on training programmes etc. From 1980 to 1995 the number of national member organisations has grown form 14 to 26.

The aims and purposes of EFOMP are defined in Article 4 of the constitution, and among them are:

- proposing guidelines for education, training and accreditation programmes;
- encouraging scholarships and the exchange of Medical Physics between countries;
- making recommendations on the appropriate general responsibilities, organisational relationships and roles of workers in the field of Medical Physics.

The EFOMP activities are directed by the Council and the practical management is referred to one of the two working committees, the Scientific Committee and the Education Training and Professional (ETP) Committee, when applicable.

EFOMP SURVEYS ON EDUCATION AND TRAINING

One of the first EFOMP activities was to make a survey of the medical physics education and training in the member countries. The survey showed that in nearly half of the countries there was no recognised training programme. The result was published in 1984 in the EFOMP policy statement "Medical Physics Education and Training: The present European Level and Recommendations for its future Development". In this policy statement EFOMP recommended that properly structured education and training should be introduced with:

- well defined entry criteria - usually a first degree with physics as a major subject;

- postgraduate education in medical physics lectures, seminars, practical and tutorial work;
- on-the-job training - under the supervision of a medical physicist at a senior level;
- examination - and certification as a qualified medical physicist.

Since then there has been steady progress in the introduction of training programmes. In the 1991 survey, 17 countries reported having training programmes even if all programmes were not yet fully satisfactory.

In 1993 EFOMP made a survey on the number of trained medical radiation physicists working in radiation therapy, diagnostic radiology and nuclear medicine. Answers were received from 18 countries, giving a broad overview of the European situation.

Trained medical radiation physicists per 10^{-6} population in Europe (1993)

	Radiation therapy	**Diagnostic radiology**	**Nuclear medicine**
Maximum	6.5	4.3	4.9
Minimum	1.0	0.1	0.3
Median	3.0	0.8	1.6
Upper quartile	4.4	1.9	3.0

The survey covered both trained medical radiation physicists and trained radiation physicists with at least five years of relevant experience since completion of training. The number of physicists with five extra years of experience were markedly lower than the total number of trained physicists, probably reflecting the fact that medical radiation physics is a relatively young and growing profession. In radiotherapy, for example only around two thirds of the trained physicists had more than five extra years of relevant experience.

Allowing for fairly large uncertainties in the figures reported, certain useful conclusions can still be drawn. There is a large variation in numbers between different countries, especially in diagnostic radiology. Some countries have almost no physics support in nuclear medicine and diagnostic radiology. Half of the countries have less than three radiotherapy physicists per million of the population.

It is obviously a difficult task to specify minimum numbers of trained physicists required per million inhabitants, as the numbers also have to depend to some extent on the amount of equipment available and the complexity of examinations and treatments. If standards in health care in Europe are to be harmonised by levelling up rather than down, it is reasonable to consider the staffing levels in those countries that are relatively well equipped. A useful guide could be the upper quartile figures presented above. EFOMP, as well as other organisations, has published recommendations on minimum staffing levels (Criteria for the Number of Physicists in a Medical Physics Department: EFOMP policy statement 1991). A review of future requirements for cancer services in London, made by Professor S Dische, suggests 4.5 trained physicists per million, while the EFOMP recommendations indicate about six physicists per million for the corresponding routine workload, excluding development and teaching. Very few countries in the survey lie in this range, 4.5 - 6 physicists per million. The EFOMP recommendations would suggest about two physicists per million for a fully equipped diagnostic radiology department and about four physicists for nuclear medicine; again, very few countries have staffing levels that meet the EFOMP minimum recommendations.

COOPERATION WITH THE CEC

Directives of the commission of the European Communities, CEC, relating to basic safety standards and radiation protection of the patient have provided a big stimulus to the discussion of training requirements in medical physics especially medical radiation physics. As a legal instrument "*A Directive shall be binding, as to the result to be achieved, upon each Member State to which it is addressed but shall leave to the national authorities the choice of form and methods*". Even if the CEC directives are binding only for Member States, they do affect every European country. It is therefore necessary for all National Organisations in EFOMP to be familiar with the directives related to the medical physics profession.

The directives related to the exposure of individuals are the Directives 76/579/Euratom, amended as 80/836/Euratom, and further amended as 84/467 Euratom, laying down the basic safety standards for the health protection of the general public and workers against the dangers of ionising radiation. The 1980 directive is the most informative, and it has been further amended by Directive 90/641/Euratom, (equivalent protection for outside workers as for permanent staff) and Directive 84/466 Euratom, (specifically related to health care, medical exposures).

The Directive 84/466, The Patient Protection Directive, lays down the basic measures for the radiation protection of persons undergoing medical examination or treatment. This Directive contains the following statements:

Article 2, Paragraph 1:
Without prejudice to Directives 75/362/EEC and 75/363/EEC as amended by Directive 82/76/EEC, and Directives 78/687/EEC, Member States shall take all appropriate measures to ensure that any ionising radiation used in medical procedures is effected under the responsibility of doctors or dental practitioners or other practitioners who are entitled to perform such medical procedures in accordance with the national legislation and who during their training have acquired competence in radiation protection and received adequate training appropriate to the techniques used in medical and dental diagnostic radiology, in radiotherapy or in nuclear medicine.

Article 5:
A Qualified Expert in radiophysics shall be available to sophisticated departments of radiotherapy and nuclear medicine.

EFOMP was invited by CEC officers to assist in the interpretation as well as the implementation of Article 5. In 1988, the policy statement "Radiation Protection of the Patient in Europe: The Training of the Medical Physicist as a Qualified Expert in Radiophysics" was published. In this policy statement EFOMP identified the Qualified Expert in Radiophysics, the QE(r), described the role of the QE(r) and recommended an education and training programme for the QE(r).

EFOMP proposed the following description of the QE(r), which has also been accepted by the representatives of the national authorities of the CEC Member States:

> "The *Qualified expert* should normally be a suitably experienced physical scientist who would be responsible for the safe application of radiological techniques in respect of the protection of the patient. This person would normally work in a hospital, or in a recognised analogous institution and would have knowledge and training in radiation physics appropriate to services where the quality of the diagnostic image or the precision of the treatment is important and the doses delivered to patients undergoing these medical examinations or treatments must be strictly controlled".

The role of the QE(r) as accepted by the national representatives reads as follows:
- to carry out physical measurements related to evaluation of the dose delivered to the patient and to take responsibility for dosimetry;
- to improve any conditions that leads to a reduction in patient dose;

- to lay down tests in the field of quality assurance of the equipment;
- to ensure the surveillance of the installations with regards to radiological protection;
- to choose equipment required to perform radiation protection measurements both in diagnosis and therapy and to give advice on medical equipment;
- to take part in the training of medical practitioners and other staff in relevant aspects of radiation protection;
- to provide skills and responsibilities that complement those of medical practitioners as mentioned in Article 2 paragraph 1 EEC Directive 84/466 Euratom.

In the education and training programme recommended for the QE(r), three main elements were identified:

- a basic course covering fundamental principles
- a special course in the three main fields of application
- practical experience

Several countries and National Medical Physics Organisations do not have the means to organise these special courses themselves. In order to make the special courses available to all physicists, the CEC cooperates with EFOMP by financially supporting the Summer Schools, which EFOMP has introduced in the three specialists areas for the QE(r). The EFOMP Summer Schools are becoming more and more popular, and three Schools have already been organised.

Advanced Summer Schools organised by EFOMP for the QE(r)

Date	**July 1991**	**June 1992**	**June 1994**
Subject	**Nuclear Medicine**	**Radiotherapy**	**Diagnostic Radiology**
Location	**Dublin, Ireland**	**Sevile, Spain**	**Nancy, France**
No of Lectures	**9**	**15**	**17**
No. of participants*	**42**	**45**	**60**
Countries represented	**17**	**12**	**15**

*including lecturers

Medical Radiation Physics

EFOMP and National Organisations have emphasized strongly the importance of including diagnostic radiology in Article 5:

i) the use of X-rays in diagnosis is the source of the highest man-made radiation dose to the population:

ii) a number of complex high dose procedures are now in use:

iii) surveys have shown a wide range of doses for the same official version of Article 5, and "les installations lourdes de radiotherapie et de medicine nucleaire" in the French, are not exact translations and are not very helpful. EFOMP has suggested ways of describing the QE(r) and his roles and responsibilities, avoiding this problem. The cooperation with the CEC also continues in connection with the now ongoing revision of the Patient protection Directive.

COMPETENCY BASED TRAINING AND CAREER DEVELOPMENT

The details of education and training programmes differ a great deal from country to country, and it is not the intention of EFOMP to try to standardise them. Instead, EFOMP takes the view that it is important to focus on the tasks the trained medical physicists must be competent to do. A structure with five competency levels has been assigned to cover the full career development for a medical physicist.

Competency Level	**Education, Training, Experience**
1 Relevant first degree or equivalent	Adequate knowledge on a relevant scientific discipline to a level normally expected of a university diploma in physics or equivalent academic degree.
2 Completion of specialist education	Adequate span of theoretical knowledge to current state of the art, able to apply this knowledge with reasonable skill, under supervision; able to explain problems to other specialists and discuss response, with appropriate vocabulary.
3 Completion of practical training	Adequate span of practical knowledge plus a demonstrated capacity for interpreting the state of the art, to non-specialist clients, professionals in related disciplines, students, enforcing authorities or administrators; able to perform given or routine professional tasks without supervision; able to estimate project budget and manpower costs and delivery schedules.

4 Advanced practical experience	Demonstrated practical capability for applying theoretical knowledge and experience to give timely, economic and appropriate solutions to particular problems and hypothetical scenarios; fluent communicator, competent presenter of ideas, effective teacher and/or manager
5 Mature overview and greater responsibility	Capability for managing a range of routine services, record of significant contribution to the state of the art by initiating/developing research or development; ability to promote new thinking and adoption of novel perspectives, ability to manage change and resolve conflict.

Recognition as a qualified medical physicist, a trained medical physicists, should follow completion of level 3. Competency level 5 would be appropriate for the head of a Medical Physics Department or a large section.

The tasks and duties of the physicist in the three main specialist areas in radiation physics have been analysed, expressed in competency format and assigned a competency level. Examples of competency levels assigned to tasks in radiotherapy, for dosimetry applications and advice on choice of treatment machines, are:

Level	**Dosimetry**
2	Knowledge of calibration chain from National Physics Laboratory to field instruments;
2	Knowledge of basic principles of radiation detectors;
3	Use of ionisation chambers and dosimetry systems for measuring treatment machine output, beam symmetry, beam data for treatment planning systems;
3	Measurement of does in vivo, knowledge of available techniques and necessary calibration and quality assurance procedures for their use;
4	Writing and organising of protocols for dosimetry measurements;
4-5	Assessment of various National and International protocols and consideration of their applicability to local circumstances;

Advice on choice of treatment machines:

2-3	Carrying out commissioning measurements according to a written protocol under the direction of a more senior staff member;

3-4	Writing and organising commissioning program for radiotherapy treatment machine, to provide clinical data and to ascertain that the machine meets its specification;
4-5	Assessing likely reliability, suitability for task, compliance with current regulations, servicing arrangements;
4-5	Assessing resource requirements for commissioning new radiotherapy treatment machines.

As the requirements of a QE(r) include (i) demonstrable problem solving skills, including the ability to define a problem and formulate strategies for solving it, (ii) the ability to interpret novel or non-standard data, (iii) the ability to make value judgements in unfamiliar situations, (iv) the ability to communicate scientific advice clearly and accurately to others, (v) the ability to recognise fault situations, e.g. inappropriate images, and take suitable corrective action and (vi) appreciation of the limitations of one's knowledge, EFOMP would recommend completion of level 4 as the appropriate level for the QE(r). But, considering the result of the survey on the number of trained medical physicists, this may not be realistic at present.

NATIONAL REGISTRATION SCHEMES

As already stated, one of the aims of EFOMP is to propose guidelines for accreditation programmes. Already in the 1984 policy document, the idea of a European certificate was put forward. In the 1988 policy document the last paragraph reads "Appropriate arrangements should be made for assessment and certification of Qualified Experts either by the competent authorities or by the national professional organisation for medical physics. The certificate awarded on successful completion of the designated training should be formally recognised by the competent national authority as indicating a Qualified Expert in radiophysics".

The current EFOMP view is that EFOMP should not be over-prescriptive in this matter but should instead guide National Organisations. Therefore, EFOMP has recently adopted guidelines for National Registration Schemes for Medical Physicists. These guidelines include the following criteria that EFOMP will look at before accepting a national Registration Scheme.

- A clear statement of the aims of the scheme.
- A properly constituted Registration Council.
- A clear statement of criteria of scientific knowledge and practical competencies for inclusion on the Register.
- Evidence that there is a training programme consistent with the EFOMP

policy statements on training.

- A mechanism for identifying specialist areas of registrants.
- A regular renewal mechanism with a requirement for evidence of continuing activity in the area.
- Agreed rules of professional conduct.
- Interpretation of Professional Misconduct and procedures for disciplinary action.

Formal recognition by EFOMP of a National Registration Scheme will by extrapolation also recognise the qualifications and competence of anyone on the register. This recognition will provide a guarantee to patients that uniformly high standards of medical physics are being attained as well as facilitate free movement of medical physicists throughout Europe. For National Organisations, the register will help in discussions on training requirements and staffing levels. It will also strengthen the position of EFOMP in the discussions with the European Union on the role and responsibilities of the medical physicist, and might in the long term perspective lead to a European certificate.

CONCLUSIONS

- Training arrangements in Europe have improved steadily since the EFOMP policy statement of 1984.
- The number of trained medical radiation physicists is still unacceptably low in many countries.
- An effective working relationship on education and training has been established with the CEC.
- Statutory or indicative Registration Schemes guided and formally recognised by EFOMP will strengthen the position of EFOMP in the future discussions on the role of medical physics.

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PRACTICAL EXPERIENCES IN THE ORGANISATION OF THE IAEA TRAINING ACTIVITIES RELATED TO RADIATION PROTECTION AND QUALITY ASSURANCE IN MEDICINE

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INTRODUCTION

The International Atomic Energy Agency (IAEA) is an organisation within the United Nations family, with the objective to expand the contribution of atomic energy to peace, health and prosperity throughout the world.

The application of ionising radiation in medicine for both diagnostic and therapeutic purposes is a significant part of the IAEA programme. In fact, in a number of developing Member states, medicine is one of the principle applications of ionising radiations. A brief introduction to the IAEA's Radiation Protection-Radiation Safety programmes is necessary in order to explain the Agency's approach to radiation protection in medicine.

The increased efforts by the Agency on radiation safety systems are a direct, immediate response to requests from more than 60 developing Member States for assistance in this area. Many of the Member States still rely entirely on the Agency's support and co-operation in establishing a solid infrastructure for carrying out programmed activities in radiation safety that are required at a national level. There are rapidly growing needs for applications of ionising radiation and radioactive sources in medicine, in most developing Member States, but often these needs can neither be properly absorbed nor co-ordinated, due to inadequate radiation safety infrastructures at national and hospital levels. In practical terms, this is reflected by insufficient financial and manpower resources, deficiencies in/or lack of legislation on radiation protection, as well as poor or non-existent programmes of radiation protection and quality assurance. In this perspective very little attention, if any, is paid to the practical implementation of quality control and maintenance and it is known that much of the equipment provided by the IAEA to developing countries, does not function properly or is out of order within a short period of time.

Training activities are an essential part of the IAEA programmes and are organised within different frameworks.

RADIATION PROTECTION ADVISORY TEAM

The IAEA first offered the service of Radiation Protection Advisory Team

(RAPAT) in 1984, and to date about 60 missions have been completed. Each RAPAT consists of three or four experts on different aspects of radiation protection and associated areas, who are recruited both from the IAEA staff and externally (including WHO). The duration of a mission is normally one week. The purpose of RAPAT is to make a general assessment of the radiation protection infrastructure in the Member State visited. The RAPATs make recommendations to the ministries and to the authorities in the country and to the Agency in order to define immediate needs and long term strategies for technical assistance and co-operation. The RAPAT recommendations should be considered as an umbrella for radiation protection aspect. Inter alia, medical application of ionising radiations is given particularly careful consideration in all RAPAT missions.

A number of group training activities, both at regional and national levels, was organised within the RAPAT follow-up programme.

TECHNICAL CO-OPERATION PROJECTS

The technical assistance and co-operation programme is a major instrument of the IAEA. Under this programme the Agency has, among other things, provided developing countries with X-ray machines, gamma cameras, cobalt units, accelerators and radioactive sources for medical purposes, the benefits of which are well known, but the application presents a radiation hazard if the equipment is not properly used and maintained. Consequently, programmes on radiation protection, quality control and maintenance are introduced as an integral part of the technical co-operation programme.

The technical co-operation activities are divided into two regional projects as follows:
ARCAL for Latin America, RCA for Asia and the Pacific, RER for Europe and the Middle East and RAF for Africa. In conjunction with these projects various forms of support are feasible: training courses, expert missions, fellowships and purchasing of equipment.
Training activities at interregional, regional and national levels are organised within TC. Regional activities are planned accordingly to the above mentioned geographical distribution. In Africa the same activity is usually planned for French and English speaking countries separately. Regional trainings are therefore planned well in advance. National training activities usually more practically orientated (workshops) are often organised under the umbrella of national TC projects, using the expert time available to invite experts to give lectures and eventually stay over to advise on the situation in the country.

The general approach of this kind of training is of the kind "train the trainers", as the participants are supposed to be in the position to organise other local training.
A few persons per country will participate in a regional training. The major topics are radiation protection quality assurance and dosimetry techniques in the various medical fields.

National workshops are designed to meet the requirements of the country and are usually very flexible in the structure. Special workshops are tailored for Health Physicists, Medical Physicists and Radiographers.

CO-ORDINATED RESEARCH PROGRAMMES

Co-ordinated research programmes (CRP) can be launched by the IAEA, and one of the goals of the IAEA's CRPs is to network Institutes. Valuable opportunities are offered to researchers in developing countries to meet and exchange experiences. They are particularly effective when operating parallel with other forms of technical aid provided by the IAEA, or other international organisations. A typical contract runs for three to five years. The results of a CRP are often published by the IAEA as a TECDOC and distributed on request, free of charge.

CONCLUSIONS

Within the IAEA, the activities regarding the medical applications of ionising radiations are carried out by various departments: (1) Technical Co-operation, (2) Nuclear Energy, (3) Research & Isotopes. Each department has its own approach but actions are well integrated, co-operation and exchange of information are satisfactory.

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THE INTERNATIONAL FEDERATION FOR MEDICAL & BIOLOGICAL ENGINEERING

V.C. ROBERTS(1)

INTRODUCTION

In 1959 a group of physicists, medical engineers and physicians met in Paris to create an organisation entitled International Federation for Medical Electronics and Biological Engineering. At the time there were few national societies and workers in the discipline joined as Associates of the Federation. Later, as national societies were formed, these societies became affiliates of the Federation. In the mid 60's the name was shortened to its present form.

The Federation now has a total membership of some 40 Affiliated National Societies. It has also recently changed its constitution to allow it to admit to membership a small number of Trans-national Societies, whose activities and membership are drawn from more than one country.

The affairs of the Fereration are administered under an Administrative Council whose eight members are elected at each tri-ennial General Assembly nominations from the Affiliated National Societies. In addition to the elected Councillors there are a President, Vice-President (President elect), Treasurer and Secretary General. The Federation's Secretariat is currently based in the Netherlands[1].

PURPOSE

The purpose of the IFMBE is to foster the development of medical and biological engineering throughout the world. The IFMBE achieves this through a number of means. Most conspicuously it is responsible for organising an International World Congress, held in collaboration with the International Organisation for Medical Physics (IOMP), every three years. The IFMBE, together with the IOMP are affiliated under the umbrella of the International Union for Physical and Engineering Sciences in Medicine (IUPESM) which itself is in the process of affiliating to the International Council of Scientific Unions (ICSU), the most senior scientific body in the world. In addition to its World Congresses, the Federation sponsors a number of regional conferences, in Europe, Asia and the Americas. Scientific papers from the Federation's conferences are often published in the Federation's international journal, *Medical & Biological Engineering & Computing*, among others.

In addition to its conference and publication activities, the IFMBE has a number of Divisions and Working Groups, established from time to time to address specific tasks. The Divisions, though under the administrative umbrella of the Federation's Administrative Council, have considerable freedom of action. The IFMBE has a *Clinical Engineering Division* whose activities are concentrated on the development of clinical engineering (encompassing medical equipment management) throughout the world. An International Register of those working in this field has recently been published. A *Division on Technology Assessment in Health Care* has recently been established.

In addition to its Divisions, the IFMBE has Working Groups on Cellular Engineering, Asian-Pacific Activities and European Activities. The former has been particularly active and has recently been associated with a number of very successful conferences devoted to a rapidly expanding field. The Working Group on European Activities has recently been re-constituted and will be addressing extension of its activities to Eastern Europe. At present it is addressing the problem of bringing together a group of experts and institutions in the Western European countries who can work with the counterparts in Eastern Europe. It is planning contributions at conferences throughout Europe over the next few years.

The IFMBE has always been pleased to support ventures which will encourage and enhance and the international community of medical engineering and medical physics. A recent development has been the move towards the establishment of an Academy of Medical & Biological Engineering. This move has been supported by the General Assembly and endorsed by the Administrative Council. It seems likely that the Academy will be established before the next World Congress to be held in Nice in 1997. The principal of the Academy is to conduct programmes which will serve to encourage young people entering the field and their development in the early stages of their careers.

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EDUCATION AND TRAINING OF MEDICAL PHYSICISTS IN AUSTRIA

H. BERGMANN[1] and E. NOVOTNY[1]

INTRODUCTION

The Austrian Society of Medical Physics (OEGMP) was founded in 1980. At present, it comprises about 135 members. About 50% of them are employed by hospitals. The main scope of activities is within radiotherapy, nuclear medicine and diagnostic radiology. There are a few more who work in the field of ultrasound and medical laser applications. The other half of the members consists mainly of employees of government agencies, but there is also a substantial proportion working in industry.

Education and training has been of primary concern to the OEGMP. The basic document which served as a guideline for the efforts to introduce post-graduate training was the EFOMP Policy Statement on Education and Training of Medical Physics in Europe. Another important guideline used was the DGMP document specifying in detail the requirements for post-graduate training of medical physicists in Germany. Both documents were the main input for producing an Austrian document laying down the situation of medical physics in Austria and the requirements for a post-graduate education, which was published in 1988. Based on this document, the University of Vienna initiated a post-graduate course for medical physics of three years duration. The course was officially recognised by the ministry of Science and Research in 1989 which also awarded the official title of "Akademisch geprufte(r) Medizinphysiker(in)" to the students of the course having successfully completed all required examinations. Official recognition by the Ministry at the same time signified official recognition of the specialty of medical physics as a profession.

UNIVERSITY COURSE FOR POST-GRADUATE TRAINING OF MEDICAL PHYSICISTS

Entrance requirements

The students accepted must hold at least an M.Sc. in physics or biomedical engineering. Also graduates in the specialty of electrical engineering are accepted, but they have to provide proof of having satisfactory knowledge on atomic and nuclear physics.

Structure of the course

The duration of the course is six semesters, i.e. three years. Lectures and laboratory courses are organised to take place seven times per semester: they are held on Friday and Saturday tenable the participation of medical physicists who are already employed. About 60% of the course accounts for lecture time and 40% for laboratory courses. Each semester comprises as a minimum about 90 hours of both teaching and laboratory work, thus totalling 540 hours of lecture and guided laboratory work throughout the course.

The topics follow the usual layout for medical physics. There are two groups of compulsory lectures and laboratory courses, the first one covering basics of medicine and medical physics, and the second one dealing with topics of medical radiation physics. The third group includes other lectures in medical physics from which the participant may make a selection of his or her own according to interest and which may vary depending on availability of lectures. A tabular summary of the topics is given in the appendix.

The student has to pass an exam covering each of the lectures. Participation in the laboratory courses is also evaluated.

For a successful completion of the course, the student has to give either a written survey on a particular topic in medical physics supervised by one of the lecturers or to submit a published scientific paper in which he/she is the first author.

The student has to take a final examination before a board of examiners consisting of three members recruited amongst the lecturers.

The number of participants per course is limited to 25. The first course started in 1990 with nine participants the second and third courses started off with 25 participants. The drop-out rate is surprisingly low, with about 90% of the participants finishing the course.

The course organised by the Vienna University meets the requirements with regard to formal education as laid down by EFOMP in its recommendations on post-graduate training. However, such a university course cannot offer on-the-job training at the required extent. Although believed to be much more efficient than on-the-job training, in addition to the laboratory courses further supplementary practical experience is required.

THE "FACHANERKENNUNG"

In order to remedy this situation and to make post-graduate training of medical physicists compatible to that of other European Countries, the Austrian Society has designed a "Fachanerkennung" similar to those that have been introduced already in Germany and in Switzerland.

The "Fachanerkennung" finally has to be accepted by the members of the Society. A draft is, however, already available. In general, the structure follows the recommendations laid down by EFOMP as regards both the extent and duration of the training. Special consideration, however, is given to students who have successfully completed the post-graduate training course at the Vienna university. These clearly meet all the requirements of formal education and do meet part of the requirements for practical training. Depending on their individual curriculum, they may obtain the "Fachanerkennung" already after one and a half years' time of on-the-job training instead of the usual three years as is required from medical physicists who pass through the normal curriculum of post-graduate training.

CONCLUSION

The Austrian facilities for post-graduate training offer the physicists ample opportunity to qualify as a medical physicists according to the standards set up by EFOMP. The Austrian Society is in contact with other German-speaking societies of medical physics to negotiate mutual recognition of the "Fachanerkennung". It is hoped that mutual recognition can be achieved with other European Countries to help to establish medical physics as a recognised profession throughout Europe.

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Appendix

Curriculum of the post-graduate training course in medical physics at the University of Vienna

Hours /semester
(V - Lecture, P - Laboratory course)

a. **Basic Sciences:**

1.	Anatomy	30	V
2.	Physiology	30	V
3.	Biophysics	15	V
4.	Biomathematics and informatics	15	V + 30 P
5.	Biomedical engineering	15	V
6.	Hospital Management	15	V
7.	Methods of physical measurements in medicine	15	V + 15 P

b. **Compulsory Topics**

1.	Radiation therapy	60	V + 45 P
2.	Nuclear Medicine	30	V + 30 P
3	Diagnostic radiology	30	V + 15 P

c. **Additional Topics:**

1.	Medical optics	15	V + 30 P
2.	Medical applications of lasers	30	V + 30 P
3.	Medical acoustics	15	V
4.	Medical ultrasound	30	V + 15 P
5.	Physical medicine	15	V
6.	Digital image processing	30	V + 30 P
7.	Magnetic resonance in medicine	30	V + 15 P

MEDICAL RADIATION PHYSICS IN BELARUS

I. G. TARUTIN[(1)] and A. G. STRAKH[(1)]

STATUS

At present time, the approximate number of radiation physicists and engineers involved in radiation medicine in Belarus is 32. The population of Belarus is 10 million. This gives only 1.2 physicists per million inhabitants - one of the lowest levels in Europe.

The radiation physicists and clinical engineers involved in medical application are mainly concentrated at the Research and Development Institute of Oncology and Medical Radiology in Minsk (22): radiotherapy - 6 physicists and 11 engineers: nuclear medicine 2 engineers: radiation protection - 1 physicist and 2 engineers. We have 12 radiotherapy regional hospitals. There are about 5 physicists and 5 engineers employed mainly in radiation therapy departments.

At present in Belarus 26 Cobalt^{60} units are being used , 14 units are available for brachytherapy and there are 7 treatment planning systems.

EDUCATION

The Physics Faculty of Belorusian State University is the main source of physicist staff in Belarus. The 5 year course consists of two years of basic courses in mathematics and physics. In the following three years the radiation physics syllabus covers atomic, nuclear and quantum physics, radiation sources, interaction between radiation and substance, detectors and methods of dosimetry, radiobiology, radiation protection, diagnostic X-ray physics, imaging and non-ionizing radiation. Arriving at health service centres the graduates have no previous knowledge or experience in any medical topics.

Post-graduate training is done on an individual basis. Usually a candidate for medical physics undergoes training in clinical practise under the supervision of more experienced colleagues. There is no formal graduate training in medical physics. Some physicists have been trained in other institutes and have attended courses and meetings before 1991 (In the former USSR). Post-graduate training courses in medical physics had been organised periodically at the Medicine Institute High Specialisation in Moscow. This education has included a number of 3 months special courses: brachytherapy, clinical dosimetry, therapy planning. These courses had been made available to only 4 physicists before 1991.

The engineers' duties include installing, checking and maintaining the equipment, special repairs and supplies, technical assistance for setting up of X-ray machines usually without the necessary training. Physicists deal mainly with routine duties in hospitals. Only a few of them are involved in research and educational activities.

A few medical radiation physicists (3) from Belarus obtained their "Doctor of science" degree (Ph.D) in different specialities (not in medical physics). Up to 1991 this had been provided individually in different ways. The post-graduate education system (of the former USSR) at some Universities and Research institutes had included Ph.D theses in medical physics. It had been possible to prepare an individual research project according to the needs of the medical department where they had been employed.

FUTURE NEEDS

We would like to develop an advanced medical physics programme of education and research in our republic. However, since 1991 in Belarus there has been no organised training system due to the lack of such type of official education system and also because of financial difficulties. Our participation in international scientific events is minimal and modern literature and equipment for education in Medical Physics is not available. Two physicists attended the International Summer School "Physics in Radiotherapy" in 1993, Warsaw (supported by the Developing Countries Committee of the International Union for Physics & Engineering Science in Medicine (IUPESM) and one physicist attended the regional training course on radiobiology treatment planning which was held in Turkey in 1993 (supported by IDEA). We are grateful for this support as due to the low monthly salaries (20-30 US) we cannot otherwise attend the international medical physics programmes and meetings. A good solution to our immediate problems could be for our graduates to undergo training on a regional basis at the Ph.D level in different Western Hospitals which are well equipped for research activities in medical physics.

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MEDICAL RADIATION PHYSICS AND POST-GRADUATE EDUCATION IN BELGIUM

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INTRODUCTION

Belgium has three regions, (Wallonia, Flanders, Brussels) and two Communities (Dutch speaking and French speaking, the German speaking community is a minority) in a federal state organised country.
Facts that are important for Medical Physics, are:

- Education (including at University level) is now dependent on the different communities:
- Health Services, Social Security and Radiation Protection is controlled by the Federal Government.

This politically complicated situation makes co-ordination between the practice of medical physics and the education and recognition (status) very difficult.

THE BELGIAN HOSPITAL PHYSICISTS' ASSOCIATION

The Belgian Hospital Physicists' Association (SBPH-BVZF: Société Belge des Physiciens des Hôpitaux-Belgische Vereniging Ziekenhuis Fysici) is still a unitarian association and covers the whole of Belgium (communities and regions). The Society has about 75 members in 1994. It was founded in 1978 and represents the medical radiation physicists in all official contracts with governmental or scientific bodies.

HEALTH SYSTEM IN BELGIUM

Public and private hospital and care system co-exist but reimbursements are mainly from social security.
In radiotherapy the physicists are paid by the reimbursement procedure of the social security; treatment planning is reimbursed as well.
In nuclear medicine the physicists are paid by the hospital.
In diagnostic radiology (excluding MRI) no one is paid by the hospital. The very few physicists are paid from research funds.

LEGAL ENVIRONMENT AND DEFINITION OF MEDICAL PHYSICIST

The CEC issued the so called patient Directive of September 1984 [(1)] , this Directive was implemented in the Belgian law system in April 1987 [(2)] however no clear definition was given of the "Qualified Expert in Radiation Physics". Presently the Belgian Advisory Board on Radiation Protection, the Department of Protection against Ionising Radiation of the Ministry of Health and representatives of the professional bodies (Physicists, Radiologists, Radiotherapists and Nuclear Medicine Physicians) are working out a law defining the education and the recognition of the medical radiation physicists. Three orientations are defined: radiation therapy, nuclear medicine and radiology. This document, if completed, anticipates on a revision of the CEC patient directive, since in the field of diagnostic radiology the responsibility of the qualified expert is orientated towards radiation protection and quality assurance.

The major problem of recognition of the medical physicists is the lobbying of a minority of medical doctors against the legal requirements for a radiation physicist with responsibilities in nuclear medicine and radiology. One of the arguments is that since a law published in October 1993 [(3)], all specialist MDs using ionising radiation have to obtain a certificate proving that they have followed successfully a minimum of 120 hours of practicals in nuclear physics, methods of radiation measurement, radiochemistry, radioprotection, legislation on radioprotection, radiobiology, radiotoxicology and radiopharmacology.

For radiotherapy explicit rules are set. In April 1991, the Official Journal published requirements for a radiotherapy department: every complete radiotherapy department has to have one physicist, or a person (engineer) competent in physics. For each 750 new patients/year, a second physicist is required and so on. If very specialised techniques are applied (brachytherapy, intra-operative, whole body, etc) extra physicists are needed. Education is, however, not mentioned in the requirements.

PRESENT EDUCATION SCHEME

There are two ways in general education which lead to medical radiation physics:

-First is the education as an "Industrial Engineer". This is a baccalaureate + 4 years education in a technical high school. Two schools have a typical radiation physics orientation. Their education is more practically oriented, with background in electronics or nuclear science.

-The second path goes through university with either engineering degree in physics- (baccalaureate + 5 years), or a university degree in physics (or chemistry)- (baccalaureate +4 years).

Many radiation physicists in the past started working in four Belgian hospitals (after their general education) under the supervision of an experienced senior physicist, without further training. Professional skill and knowledge were obtained on-site, with occasional post-graduate training in summer schools of EFOMP, ESTRO and the CEC.

Presently post-graduate training is organised in four Belgian universities for industrial engineers and several other university degrees (in general, accessible after examination of the applicants curriculum). This education is mostly with duration of one year, and concludes with a small thesis. Very often students spread the courses and exams over two years.

EDUCATION SCHEME UNDER NEGOTIATION

Since 1991 the Belgium Hospital Physicist Association has been cooperating in a working group with the Ministry of Health on the status, responsibilities and education of the medical physicist in nuclear medicine, radiotherapy and radiology. The representatives of the physicists proposed a post-graduate training with a content very similar to the EFOMP recommendations. The negotiations are still going on, but we hope the outcome will be along the following lines:

- Basic education university degree in chemistry or physics, or engineering or equivalent. Industrial engineers can be accepted if the screening commission of the universities give their approval.
- For the post-graduate education itself, with duration of 2 years, three different options can be taken: radiotherapy, nuclear medicine or radiology. A total of 600 hours of courses (anatomy, physiology, dosimetry, radioprotection, radiobiology, quality assurance, techniques of radiology, radiotherapy and nuclear medicine, detection of ionising radiation, legislation,...) and 1 year on site training in one of the disciplines completed by a short thesis.
- A certificate will be obtained after completing this curriculum. this certificate should be requested in the future for recognition as a medical radiation physicist.

This education scheme is part of a proposal from the Ministry of Health. However, education is a responsibility of the universities, hence of the Communities.

This information is of course only tentative. Finalising this in a law can still take some time.

FUTURE NEED FOR HOSPITAL PHYSICISTS IN BELGIUM

There are about 4 "medical physicists" per 10^6 inhabitants in Belgium. This is far from the EFOMP or IPSM recommendations. So there is room for more physicists, but the offer from the hospitals is still rather low at the moment.

In radiotherapy saturation is almost reached, and most of the active physicists are young. If ISO9000 procedures for quality assurance are implemented (as recommended by the CEC and the ESTRO), a slight increase in staffing is possible. Once the legislation is modified, there will be a need for medical physicists in radiology. SPECT and PET applications in Nuclear Medicine will offer some extra positions.

References

1 Directive of the Council of 3 September 1984, **84/466/Euratom, Official Journal L265** of 5/Oct./1984

2 **Moniteur Belge-Belgisch Staatsblad**, *8-1V*-1987, pp 5212-5213

3 **Moniteur Belge-Belgisch Staatsblad**, *15-X*-1993, pp 22715-22719

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MEDICAL RADIATION PHYSICS AND ENGINEERING IN BULGARIA

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STATUS

Applied medical physics in Bulgaria developed since the early 1950's in line with the development of medical radiology in the country. In 1975 a National Secondary Standard Dosimetry Laboratory for ionising radiation was established. Radiation physics & engineering continues to be the most developed part of medical physics in Bulgaria to this day. About 35 physicists are working at the national and regional centres for nuclear medicine and radiotherapy. Nearly 100 specialists, mainly physicists, are working in the radiation protection laboratories associated with various institutions throughout the country, as well as in the respective departments of the Regional Environmental Inspectorates. They work under the methodological guidance of the National Centre of Radiobiology and Radiation Protection at the Ministry of Health.

A small group of physicists and physicians are working successfully in the field of climatology and climatotherapy. Their work is very promising with a view to the good and varied climatic conditions in the country.

Unfortunately medical physics has not yet found its due place in electrodiagnostics and electrotherapy, in medical and dental orthopaedics, in ultrasound diagnosis, in ophthalmology and otorhinolaryngology. For the time being the introduction of lasers for diagnostic and therapeutic purposes also takes place without the participation of physicists.

EDUCATION AND TRAINING IN MEDICAL RADIATION PHYSICS

The main reason for that state of medical physics should be sought in the training of physicists and in the teaching of medical physics to medical students. Applied physics is neglected at the Faculty of Physics at the University of Sofia. This has a negative effect on the training of the students and later complicates immensely the quality selection of teaching staff for the Departments of Physics and Biophysics. On the other hand the administration of the Faculties of Medicine tends to underestimate the fundamental role of medical physics. As a result of this attitude some faculties teach only 75 hours of medical physics (30 hours lectures and 45 hours laboratory practice).

Postgraduate training courses in medical radiation physics are organized periodically at the High Medical University in Sofia. The training lasts for three years. The training programme is comprised of two parts: a general part for all the trainees and a special part in which the specific individual field of activity is considered. These courses have been made available to several dozens of physicists working predominantly in the sphere of medical radiology, as well as in the Departments of Medical Physics and Biophysics at the Higher Medical Institutes in the country.

In general the education in medical physics in Bulgaria is in a critical situation. In our opinion there are several reasons for that:

1 The education of students in Physics Faculties does not provide reasonably good insight into applied physics and more specifically into medical physics.
2 The prominent physicians tend to underestimate the importance of medical physics. That is most likely to reflect the low level of education in physics which they have received in their medical universities.
3 The isolation of Bulgarian medical physicists from the scientific community in the world - political isolation before and financial isolation now.

A fact of deep concern is the growing average age of the medical physicists' community and the lack of adequate young substitutes. This leads to new vacancies every year and lack of applicants.

X-RAY AND RADIOLOGICAL ENGINEERING

At present about 40 X-ray and clinical engineers (CE) are employed in the Diagnostic Radiology (Roentgenology) field and about 15 CE's - in the nuclear medicine and radiotherapy field. All of them have MSc degrees mainly in electronics. About 10 of them have a PhD degree. Some of the X-ray and clinical engineers have graduated from the course of Medical and Nuclear Electronics at the Technical University of Sofia. This sub-speciality of electronics includes subjects like medical cybernetics, basics of human anatomy and physiology, biomedical engineering, methods and instruments for acquisition, processing and recording of biological signals, medical imaging, X-ray engineering, etc.
A post-graduate course in Medical Engineering (including radiological physics & engineering and medical imaging) was initiated recently in the Technical University of Plovdiv in collaboration with the Medical University of Plovdiv (the module on X-ray engineering from this course consists of 24 h lectures and 12 h practicals). CEs get extra qualifications in the field from specialised firm-

courses in connection with purchasing of new high-tech equipment. Most of the CEs have the status of research associates and participate actively in medical engineering investigations. The CEs are usually organised in laboratories within the respective medical department. Active research activities used to be carried out in the Institute of Biomedical Engineering, the National Centre for Radiobiology and Radiation Protection and some of the Laboratories in the Medical Universities.

There are about 10 books on Radiation Physics, X-ray Engineering, Radiation Protection and Medical Engineering from Bulgarian authors published in the last 20 years, as well as numerous other translated books. After 1990 the number of professional books and journals available decreased dramatically.

REPRESENTING BODY

The Scientific Society of Biomedical Physics and Engineering was founded in 1971. The Society has two divisions, which comprise of two main groups of specialists: physicists and engineers working in the field of biomedical physics and engineering.

The activities of the Society focus mainly on the Scientific Conferences on Biomedical Physics and Engineering, which are organised every four years. The six conferences held so far were attended by specialists from all over the country and abroad - USA, France, Germany and UK. The most numerous foreign participants were from the former socialists countries. A WHO Symposium was organised in parallel with the conference in 1988. Due to financial difficulties the editing and distribution of the Journal of the Society ceased some 10 years ago.

The Society has taken the initiative of organising annual colloquia on the role of physics for protection of man and his environment, jointly with the Ministry of Environment.

The activities of the Society also include preliminary approvals of theses for Ph.D; information about the participation of its members in scientific congresses and conferences abroad; reviews of new books in the field of medical physics and engineering; celebrations dedicated to important anniversaries, etc.

Since 1983, the Scientific Society of Biomedical Physics and Engineering is a member of the European Federation of Organisations for Medical Physics (EFOMP) , of the International Organisation of Medical Physics (IOMP) and of the International Federation of Medical and Biomedical Engineering (IFMBE). This could be seen as a recognition of the Society's role and prestige.

FUTURE NEEDS

What is the support that could be provided to the Bulgarian medical physics community?

1 Improved contacts with prominent institutes, clinics and laboratories abroad through exchange of information and specialists and collaboration in common scientific research projects. A good example in that regard are the scientific meetings organised in Bulgaria with the help of the Clinical Science Foundation-London. Practically all medical physicists and bioengineers involved in medical radiology participated at those meetings.
2 Regular supply with programs for education and scientific literature. The help of the International Organisation of Medical Physics IOMP and personally of Dr C. Orton in that regard is highly appreciated. A library of IOMP has been established in Sofia. Regretfully we are not able to keep it up-to-date because of financial reasons.

The economic difficulties which Bulgaria has experienced during the last few years had an adverse effect on scientific societies as well. Many of our members, especially young people, went abroad. Our financial resources for organising training courses, regional conferences and working meetings are minimal. Our participation in international scientific events has also decreased sharply. The modern literature and equipment for education in Medical Physics & Engineering is not sufficient. There is a need for collaboration with other Universities and Institutions in the field of education and training.

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MEDICAL RADIATION PHYSICS IN CROATIA

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INTRODUCTION

In today's medicine in Croatia the rather wide scope of radiation physics applications, researches and educational activities confirms that the collaboration of technical (i.e. physical and engineering) professions with other health care staff in advanced medicine here has always had a pronounced tradition. However, the number of such collaborations has never been very high. The radiation physicists and clinical engineers involved in medical radiation applications are mainly concentrated at University Clinical Hospital Centres (UHC), General Hospitals (GH), and specialised Clinics for Tumours (SCT), while the physicists engaged in the field of radiation protection and safety work in some research institutes in Zagreb. Currently, nobody is dealing exclusively with diagnostic radiology, but some are engaged periodically in supervision and control of the X-ray equipment. They are mainly the physicists from the Institute for Medical Research and Occupational Health (IMR), where the service for granting operations of the radiation facilities and the personnel dosimetry laboratories is situated. There is also a dosimetry department in the scientific research Institute "Ruder Boskovic" (IRB). At the present time the Croatian state service for standards in radiation dosimetry is in the process of being formed. Previously (in former Yugoslavia) there existed a state regulation based on IEC norms which has been applied continuously in Croatia until the new regulation has been set up. Now, the approximate number of radiation physicists involved in medical treatments in Croatia is about 30: **radiotherapy** (rt) - 11, **nuclear medicine** (nm) - 11, **radiation protection** (rp) - 8. They are working in the following institutions:

Zagreb: Clinic of oncology and radiotherapy UHC "Rebro" (rt - 2), Gynaecological cancer centre (rt - 1),
Clinic of nuclear medicine UHC "Rebro" (nm - 5),
Clinic of nuclear medicine and oncology UCH "S. Milosrdnice" (nm,rt - 3),
Clinic for tumours (rt - 3),
Department of nuclear medicine New Univ. Hospital (nm - 1),
Laboratory for dosimetry IMR (rp - 5),
Department for radiation protection IRB (rp - 3).

Rijeka: Clinic of nuclear medicine and oncology UHC (nm, rt - 2)
Medical Faculty (nm, rt - 2)

Split: Department of oncology and radiotherapy GH, (rt - 1)
Osijek: Department of oncology and radiotherapy GH, (rt -1)
Zadar: Department of oncology and radiotherapy GH, (nm - 1)

NATIONAL SOCIETY

As the number of medical radiation physicists in Croatia is relatively low, and there is often overlap between the various engineers of similar professions (such as electro and computer engineers) in clinical hospitals, medical research institutes, specialised laboratories and other skilled areas dealing with health care, we decided to join the Croatian Medical and Biological Engineering Society (CROMBES). The Society was established in January 1992 in Zagreb. In September 1993 the application of CROMBES was accepted and the Society became a member of the International Federation for Medical and Biological Engineering (IFMBE). Now CROMBES has two Divisions: Medical Physics Division (MPD) and Clinical Engineering Division (CED) and about 120 members in all. It has to be pointed out that the members can also be experts from other professions engaged in similar work, for example medical doctors. The MPD was accepted through CROMBES as a member of the European Federation of Organisations for Medical Physics (EFOMP) from October 1993 and our CED became automatically (also through CROMBES) the member of IFMBE-CED. So far our young Society and its MPD has gathered almost all the physicists in medical radiation in Croatia.

MEDICAL PHYSICS DIVISION ACTIVITIES

MPD extends the knowledge of its members and of other professions such as doctors and technicians during their specialization in some associated branches of medicine (radiotherapy, radiology, nuclear medicine), exchanges the experiences with clinical engineers dealing with radiation equipment and instrumentation, organises symposia in connection with Medical Institutions, the Croatian Society for Communications, Computers, Electronic Measurements and Automation (KOREMA) and participates in the meetings of the Society for Irradiation Protection. The principal aim is keeping the members and others with an interest in medical radiation physics in touch with new developments in the field, maintenance of the radiation standards and quality assurance (QA), as a complex process involving all medical and physical steps. Some of the medical radiation physicists have been collaborating in scientific projects, researches and conferences with international organizations (IAEA and ESTRO) or some foreign societies (e.g. Deutsche Gesellschaft fur Medizinische Physik (DGMP) - workshop on physical aspects of Total Body Irradiation - TBI). These were highly successful in including the highest medical standards of radiation applications, for example, in introducing the TBI method in connection with Bone Marrow Transplantation, in establishing the Centre for Prevention of Consequences in Nuclear Accidents, in participating courses concerning the hypothetical accidents in a nuclear power plant, and so on. We also answered the questionnaire on radiotherapy QA requested by the EFOMP Scientific Committee. The physicists working in Clinical and University Hospitals take part in some hours of clinical Oncology & Radiotherapy and Nuclear Medicine lectures at the Faculty for Natural and Mathematical Sciences (FNMS), the Faculty of Medicine and the Faculty of Electrical Engineering (FEE), introducing the students to radiation physics principles and measurements.

EDUCATION OF MEDICAL PHYSICISTS

Study of medical physics at an undergraduate level has not been organized in Croatia until now. However, there is a very famous four year study of physics at the Faculty for natural and mathematical sciences in Zagreb, where the students also have a possibility to hear some themes from medical physics which are involved in subjects of the 4th year of study. At the end of study they get the title "Diplom Engineer in Physics". In post-graduate education study at the same faculty there is a two-year scientific direction named Medical Physics which results in a "master of science" degree (MSc) (after defending the theme). The programme of this study is:

Numerical methods and mathematical modelling
Physics and techniques of ultrasound in medicine
Physical aspects of nuclear medicine
Physics in radiology
Selected aspects of functional anatomy
Selected aspects of radiographic anatomy
Physiology with pathophysiology
Biomedical electronics and instrumentation
Radiation protection

In practice, many of today's medical physicists reached their "doctor of science" degree (Ph.D) after they finished their MSc in nuclear physics and dosimetry. The reason is that Medical Physics is a relatively new direction and the main core of the present radiation physicists population has already been working for several years. Unfortunately, we observed significant difficulties in the internal status and recognition of physicists (and clinical engineers too) in the hospital institutions, clinics and institutes. Namely, although our experts may have MSc and Ph.D scientific levels, can be the members of the highest international associations and are participating in many teams of advanced medical practice enjoying the obligations and activities of the same level of responsibilities as doctors in the medical work, they are treated in today's health regulations law as "non-medical" professions. The reason arises from the non-existence of the form of **organized specialization**, during the study of postgraduate medical physics at FNMS, (which would include on-the-job training, for example in oncology and radiotherapy, radiology or nuclear medicine, as for medical doctors). The final consequence reflects in the inequality in position and (material) status (compared to medical staff).

INTENTIONS FOR IMPROVEMENT OF THE STATUS

Croatia is a country of about 4.5 million of population and a small number of university hospital institutions, so that the experts with wide knowledge of clinical applications are needed. A desire for the improvement of the status of radiation medical physicists and clinical engineers inspired a scientific group (of CROMBES members) with a wide range of expertise from the science disciplines of physics, electrotechnics and computer technic, to propose to the Faculty of Electrical Engineering to organize an expert study (specialization) in **Clinical Engineering.**

This expert study, considered as post-graduate, should cover the interdisciplinary technical branches of medical physics including radiation physics, biomedical electronics and clinical engineering in all its aspects. The participants of the two-year study should be graduates (Dipl. Engineers) in physics or electrotechnics (after 4 years of study) and seconded from the health care institutions (hospitals, clinics, institutes) or should pay from their own resources. The practical residence and in-service training would be in the clinical hospitals in Zagreb. After finishing the final theme, under the supervision of a mentor, the students could reach the title "**Specialist in clinical engineering".** We also expect this title to be recognised by the Ministry of health to facilitate the position of medical physicists in our hospitals. The main subjects of the expert study are outlined below.

POSTGRADUATE STUDY FOR SPECIALISTS IN CLINICAL ENGINEERING

SEMESTER 1

Selected aspects of functional anatomy. Selected aspects of physiology. Medical electronics. Selected aspects of medical physics.

SEMESTER 2

Digital signal processing, Digital image processing.
Sensors and transducers.

SEMESTER 3

Physics in radiology and radiotherapy. Physics in nuclear medicine. Bioelectrical signals and systems.

SEMESTER 4

Physics and techniques of ultrasound and non-ionizing irradiations. Electrotherapy and electrostimulation. Systems for extra-corporal support. Clinical engineering and legal regulations.

* practical residence and in-the-job training should be performed for each of the presented subjects in Clinical Hospitals in Zagreb.

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MEDICAL PHYSICS AND ENGINEERING - THE CYPRUS EXPERIENCE

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INTRODUCTION

Cyprus is an island located in the Eastern Mediterranean. Its population reached the 600,000 mark only recently. It gained its independence from British rule in 1960 and in 1974 was invaded by neighbouring Turkey which seized up and occupied 40% of its land. In the meantime it has been trying to catch up with the rest of the world. In this presentation the educational and health care delivery services will be examined and reference will be made to professional groups related to medical engineering and physics.

EDUCATION

The colonial interests would not allow any kind of educational system to develop and the only local education available to Cypriots until 1960 was secondary school, which was non-obligatory and was considered at the time to be a luxury.

Since that time post-secondary-school education has been developing slowly, probably too slow, with the establishment of 4 public institutions in the fields of engineering, hotel and catering, forestry and nursing. The only engineering establishment is the Higher Technical Institute which offers 3-year full time courses in engineering and computers at the Engineering Technician level. In the private sector a number of colleges offer higher education in all disciplines. The University of Cyprus has been established recently, in 1991, and offers education in the fields of art, computing and some science subjects. It is expected that the Applied Sciences and the Engineering Schools will be established soon.

For these reasons all Cypriots who hold a university degree have obtained it abroad, mainly in Greece, the UK and the USA, and have brought into the country a variety of standards.

Medical Physicists and Biomedical Engineers are no exception to this rule. It is also worth noting that when these specifications were created, professionals from related fields were converted after following short courses and seminars abroad.

At present the situation is no different from the above. Our Medical Physicists and Biomedical Engineers receive their education abroad and are forced to follow specialisations which are available to them in various countries.

THE REGIONAL TRAINING CENTRE

In August 1978 a joint project was signed between the World Health Organisation and the Government of Cyprus which set up a Regional Training Centre at the HTI. The aim of this centre is to train different levels of Hospital Technical Personnel. The student eligible to attend are selected from the Eastern Mediterranean Region of the World Health Organisation which stretches from Morocco in the West to Pakistan in the East, the Arabian peninsula and Somalia to the South. Students from other WHO Regions, the commonwealth (CFTC), National Donor Agencies and other countries are also accepted. It is preferable that candidates are employees of their National Health Care Technical Services.

Candidates should be graduates of any of the RTC Specialised Technician Courses or graduates of 6 years Technician Secondary School specialising, preferably in electrical or electronics subjects, with at least three years practical experience in the maintenance and repair of medical equipment. Candidates may be examined in two papers, English Language and Technology.

The centre in recognition of its contribution in this field, was designed as a Commonwealth Centre of Excellence and in 1987 as a WHO Collaborating Centre for Training and Research in Management, Maintenance and Repair of Health Care Equipment. Courses offered by the Centre are:

- Specialised Technician Courses in Medical Electronics (10 month duration)
- Advanced Technician Courses on Electromedical and Clinical Laboratory Equipment, Diagnostic X-Ray and Nuclear Medicine Equipment and Operating Theatre and Dental Equipment (10 month duration)
- Short courses on Logistics of the Cold Chain, Refrigerator Repair Technicians (RRT) and Solar Refrigerator Repair Technician (SRRT). These are of two weeks duration and are organised in collaboration with WHO's Expanded Programme of Immunisation (EPI). In addition the Centre is now in the planning process of providing a 3-month technician course on Diagnostic X-Ray and Nuclear Medicine Equipment. It is hoped that it will be ready for the period September to December 1995.

MEDICAL PHYSICS

There are no facilities or institutions in Cyprus where Medical Physicists can be educated or trained. All the Medical Physicists working in Cyprus have been educated and trained abroad, the majority in the United Kingdom. The Medical Physics Department (MPD) of the Nicosia General Hospital (NGH), the only one in the country, is staffed with one senior physicist, four physicists and six technicians. It is responsible for all matters concerned with ionising radiation in the whole country. Since 1974, after the Turkish invasion of Cyprus, the responsibilities of the MPD are limited to the Government controlled area of the island.

Table 1 Departments using ionising radiation in Cyprus

Departments		**Equipment**		**Number of Physicists**
Type	No	Type	No	
Radiotherapy	2	Co^{60} Superficial X-ray X-ray Brachytherapy	3 1 2 1	1
Nuclear Medicine	3	ã-camera	3	1
Diagnostic Radiology	25	Diagnostic Radiology Diagnostic Flouroscopy Angiography suites CT's Mammography	91 28 2 7 10	2
Dental	58	Dental X-ray	68	

The services provided by the MPD include: Radiation Protection Services, Secondary Standard Dosimetry Laboratory (SSDL), Radiotherapy Physics, Nuclear Medicine, Diagnostic Radiology and Radioactive Waste Management.

The MPD also provides education and training to other related groups:

- Nurses School: The physics part of the syllabus of the three year nurses course of the Nurses School is the responsibility of the MPD.
- Health Inspectors School: The school of Health Inspectors is operated by the Ministry of Health on a demand and supply basis. The school offers a three year course in Health Hygiene. The physics part of its syllabus is the

responsibility of the MPD.

- Regional Training Centre (RTC): The staff of MPD collaborate closely with the staff of the RTC offering theoretical and hands-on training.
- Other Courses and Workshops: With the collaboration of the IAEA and the World Health Organisation (WHO), a number of courses and workshops were organised and took place in Cyprus in the past. Others are expected to be organised in the near future.

BIOMEDICAL ENGINEERING

It would be superfluous to talk about Biomedical Engineering in Cyprus and to attempt to isolate it from other related disciplines such as Clinical and Hospital Engineering. Defining each one of these is difficult enough in any case and attempting to distinguish who is who in Cyprus would be out of the question.

It should be stated, however, that the number of engineers and technicians involved in matters relating directly to patients e.g. implants, not equipment, is limited. Biomedical engineering in its strict definition is confined within the Cyprus Institute of Neurology and Genetics where research is going on in fields of genetics and the processing of electromyographic signals. It is, therefore, quite true to state that the majority of the engineers are involved with health care equipment in the process of acquisition, installation, maintenance, repair and calibration.

Traditionally, the hospitals needs in engineering staff were covered by converting technical personnel from other engineering fields, mainly electrical, into the necessary specialisations. It is also true to say that until recently the "other engineering disciplines" were the main source of technical personnel in the hospital. Now however, this is not the case and engineering staff are specifically educated for the purpose.

Engineering education at university level, is not yet available locally and Cyprus has to rely on educational establishments in other countries. What is available, is training at technician level at the Regional Training Centre of the Higher Technical Institute whose activities are outlined in this paper.
Being a Medical/Biomedical Engineer in the private sector in a small society such as that of Cyprus, is a title usually associated with either a service or a sales engineer. As far as the duties are concerned, these include installing and maintaining state-of-the-art equipment, without usually, the necessary training. This engineer, would be responsible for the user training and smooth operation of the equipment. Participating in tenders, presenting products to prospective customers and organising exhibitions, are all part of the duties of the medical engineer in the private sector.

Although the duties of the engineer in the private sector are quite demanding, lately there are many young graduates who are seeking employment in this sector. The career opportunities may be a disadvantage compared with that in the private sector, but as the remuneration has changed for the better it is believed that the career prospects will change as well.

THE CYPRUS ASSOCIATION OF MEDICAL PHYSICS AND BIOMEDICAL ENGINEERING (CAMPBE)

Medical Physicists and Engineers engaged in the Health Care Delivery system felt that there wasn't a professional organisation in Cyprus which would represent them and satisfy their professional needs. Individual attempts from both groups to form a recognised association failed because the legal system in Cyprus requires a minimum membership of 21 persons. Negotiations between them, resulted in the setting up of the Cyprus Association of Medical Physics and Bio-medical Engineering in 1987, an umbrella organisation where both groups would be represented on equal terms.

Furthermore, the constitution allows other suitably qualified professionals, such as doctors engaged in research, to become full members or Associates depending on their field of interest and qualifications. Experience so far has shown that these two groups share more common interests than originally anticipated, because in a small country, like Cyprus, the overlap between the professional duties and interests of the two groups is much greater than in other larger countries.

The activities of the Association have been mainly aimed at updating and upgrading the knowledge of its members. These activities involve the following:

- Lectures- These are usually delivered at frequent intervals, on average 7-8 per year and cover the whole spectrum of the health care delivery system.
- Scientific Visits- These are organised on an ad-hoc basis and are mainly organised in conjunction with lectures. These include visits to hospitals, clinics or special purpose installations related to the interests of its members.
- Annual National Seminars- These are annual events and take the form of either a small conference on a specific topic or the form of an open discussion following introductory speeches. Overseas participants and speakers were present in some of these.
- International Conferences - the First International Conference on Medical Physics and Biomedical Engineering was held in May 1994. Participants included 85 persons from abroad. It is worth mentioning that the President of

the Republic opened the work of this conference.

- Participation in Government Committees- The Government of Cyprus has decided to assign to the Association the setting-up and running of a technical committee which will establish National Standards on Medical and Clinical Equipment and Devices.

The Association is a member and has close relations with the following international bodies:
The International Organisation of Medical Physics (IOMP), the International Federation of Medical and Biological Engineering (IFMBE), the International Federation of Hospital Engineers (IFHE), the European Organisation of Medical Physics (EFOMP) and the International Radiation Protection Association (IRPA).

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MEDICAL RADIATION PHYSICS IN THE CZECH REPUBLIC

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SITUATION

The present state of medical departments applying ionizing radiation in the Czech Republic (approx. 10.5 million inhabitants) are described in Table 1. Representative bodies are the Czech Medical Society - Radiation Oncology, Biology and Physics Society and the Nuclear Medicine Society.

TABLE 1: Medical departments applying radiation in the Czech Republic

Type of Department	Number of Departments	Unit Type	Unit No.	No. of Physicists (& other technical staff on MSc level)
Radiotherapy	22	Co/Cs LA B XRU AFL	30/19 8 7 60 11	35
Nuclear Medicine	52	GCC IVA	6055	55
Radio-diagnostics		XRU CT MR	2250 433	5

LA-linear accelerator, B-betatron, XRU-X-ray unit, AFL-afterloading system, GCC-gamma-camera with computer, IVA-in-vivo apparatus, CT-computer tomograh, MR-magnetic resonance.

Comments:

1 The number of diagnostic X-ray units does not include dental units. Because of rapid changes all the given data are approximate and represent the best available estimate.

2 There are no Medical Physics Departments in the Czech Republic. Physicists are usually staff members of the nuclear medicine or radiotherapeutic

departments. Only a few work in radiodiagnostic departments, even if sophisticated equipment is available.

3 Approx. 10 to 12 departments of each of the above type are at the regional level, and they are better and more adequately equipped than the others. Such departments usually employ more than one physicist. Some of the local departments are rather small and their and their future development is endangered by lack of funding.

4 Physicists engaged in at least two or in all three of the above activities, work in five hospitals.

5 About 30 radiation physicists are employed in radiation hygiene institutions organisationally related to medicine.

EDUCATION SYSTEM

Undergraduate studies of radiation physics are not specifically orientated to medical radiation physics at any university. Courses which are closest to the needs of medical departments are offered at the Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague. The 5-year degree course consists of two years of basic courses in mathematics and physics, which (referring to subjects important for specialization) also include optional chemistry studies and lay increasing emphasis on computer science and the application of mathematical methods.

Some of the courses related to this basic education continue for yet another year, which is devoted mostly to specialised courses. The list of subjects is given in Table 2. One of the specialisations into which the degree course is divided in the following 3 years is orientated to the dosimetry and application of ionising radiation. These specialized courses begin with a complex course on experimental nuclear physics, including radiation detection and nuclear electronics. Lectures on dosimetry cover basic radiation quantities and their measurements, integrating dosimetric methods, dosimetry in the environment and the workplace, shielding calculations and design, radiation metrology, microdosimetry, etc. Lectures on applications of radiation include applications in industry, science and medicine. Quite a lot of time is devoted to the project work of students, which begins in the 6th semester.

Table 2.

Course	**Hours per semester**					
	1	2	3	4	5	6
Mathematical analysis	96	104	72	78		
Linear algebra	48	52				
Differential equations			48			
Numerical mathematics				52		
Equations of mathematical physics					72	
Numerical mathematics and statistics					24	26
Monte Carlo methods					24	
Mechanics	72					
Electricity and magnetism		78				
Waves, optics and atomic physics			72			
Theoretical physics				78		
Experimental physics			24	26		
Thermodynamics and statistical physics				39		
Practice on physics (laboratories)			48	52		
Quantum mechanics					72	
English	48	52	48	52	48	52
Other foreign language	48	52	48	52	48	52
Social sciences	24	26				
Review of specialisations			24			
Sports training	24	26				
Further optional and recommended basic courses are included in the 1st to 4th semester (general chemistry, thermodynamics and molecular physics, programming, computer applications, operational systems, etc.						

Table 3: Review of the subjects of the specialised course

Course	Hours per semester					
	5	6	7	8	9	10
Physics of atomic nucleus	24					
Ionizing radiation physics		78				
Solid state physics	24					
Principles of nuclear electronics	24		48			
Principles of dosimetry		78				
Radiation detectors		52				
Nuclear technology devices			24			
Biological effects of radiation			24			
Dosimetry in environment				52		
Applications of radiation			24	52	36	
Physics of radiation shielding				52		
Radiation metrology					36	
Microdosimetry						16
Analytical. methods of measurement				26		
Detection and dosimetry practice			48			
Specialised seminar				26	24	16
Project work		24	48	52		
Diploma project					120	160
Further optional and recommended courses are included, e. g. mathematical methods in dosimetry, radiation effects in matter, dosimetry of internal sources, spectrometry, low level activity measurements, nuclear chemistry, etc.						

The project work continues up to the degree thesis and may be orientated to medical use of radiation, dosimetry in medicine etc., especially in co-operation with some medical departments.

Graduates from other faculties and universities also work to some extent as physicists in medicine. They are graduates from the Faculty of Mathematics and Physics of the Charles University. Faculty of Electrical Engineering of the CTU Prague, the Faculty of the Electrical Engineering of the TU Brno, and in a few single cases also from some other schools. Generally, all the graduates beginning work in the medical departments hold a degree corresponding to MSc.

The postgraduate education system at the university may also include issues of medical physics. As individual plans are prepared for the PhD student, it is possible to tailor their courses and especially individual research projects according to the needs of the medical departments where they are or will be employed. In such cases the PhD thesis must be co-ordinated with these departments and, at least partially , prepared in collaboration with them.

However, there is yet another independent and compulsory postgraduate line of training for physicists working in medicine which is the responsibility of the Ministry of Health. The course is run by the Postgraduate Medical School and this type of education is required by law (Decree No.77 of the Ministry of Health, dated 21 July 1981). The course structure is as follows:-

6 months of introductory medical courses and 2 years of "On-the-job-training", the content varying according to the specializing of the trainee, There is a possibility of optional courses and practical training at the large and well equipped departments. An important part of the course is devoted to radiation protection. Examination are organized by the Postgraduate Medical School and the graduate receives a certificate for "Technical collaboration in radiotherapy, nuclear medicine and radiodiagnosis ", which is recognized by the Ministry of Health. This certificated qualification corresponds partially to the EC demands placed on the Medical Physicist as a Qualified Expert in Radiophysics. A wider comparison with the EC standard would be desirable.

However some problems exists in this line of education, not so much in the content, but in the realisation:

1 The courses are insufficient especially for physicists who graduated at faculties other than FNSPE CTU Prague and for those who work alone in small departments.
2 Examinations are rather formal, chairpersons of the examination boards are always physicians (physicists are only members of the boards). Since 1989, we

have had the opportunity of taking part in some courses and workshops organised by IAEA, ESTRO, WHO, EFOMP, etc, and this has been beneficial to the education and training of Czech medical radiation physicists. There still exist some limitations in participating in such events, but these are due to lack of financial support, not political difficulties. Therefore these events are the most important for our professional societies which are organised in our country or supported by grants. Of course, they can be only supplementary to the regular system of education and training described above, and the improvement of this system must have a high priority.

EXPECTATIONS FOR THE NEAR FUTURE

At present both the medical care and education system in the Czech Republic have been undergoing a rapid transformation and private practitioners are entering this area of activity. Thus to assure high quality of health care and education, good legislative measures are required. New laws regarding public health and higher education are under preparation and they are expected to improve the system of licensing.

Another important bill being prepared just now is the "Atomic Law". Though inspired mostly by the needs of nuclear plants, power engineering and waste disposal, it is intended to be more general and cover all areas of ionizing radiation applications, including medicine.

These new laws - if passed - will certainly influence the system of education and certification of both physicians and physicists in the radiation applying departments. Discussion has been going on, how to design the system for comparison with the EC system, including the demands on and structure of training for the qualified Expert in Radiophysics. These discussions may result in the preparation of the structure summarized in Table 4.

TABLE 4 : Proposed education structure for physicists in medicine

Level	Practice	Demands
I. Basic	up to 1 year	MSc. degree, basic knowledge for work in medical care Qualification: licence 3
II. Medium	1 to 4 years	Licence 3, general training for the specialisation Qualification: licence 2
III. High	4 to 7 years	Licence 2, specialised courses and training Qualification: licence 1
IV. Advanced		Licence 1*, PhD. degree in medical physics or equivalent level

***** Licence 1 corresponds to the Qualified Expert (QEr)

PROBLEMS

Very low salaries of the hospital staff make the career as a medical physicist unattractive. Moreover, the social status of "non-physicians" in medicine is relatively low (see, e.g. the non-existence of specialized medical physics departments even in the largest hospitals). Combined with generally decreasing interest in "nuclear" specialization, fuelled also by unqualified but noisy arguments and activities of various organizations of environmentalists, the result is as may be expected. The interest in studying, e.g. medical physics, dosimetry, radiation protection, etc, has been decreasing and thus there is a shortage of young graduates properly educated and willing to start a career in medicine.

On the other hand, hospitals are not pushed to employ physicists, as they are evaluated (and financed) according to the number of patients and direct diagnostic and therapeutic "output". From this point of view physicists are less attractive members of the staff.

As physicists in the medical departments are usually highly qualified staff, it is not difficult for them to find some other employment, far better paid than in the hospitals, especially in private companies. This is the case, of course, and enticing away experienced specialists is thus another danger for these departments.

The personal view of the authors of how to improve the situation is as follows:

- to take legislative measures obliging the medical departments to employ physicists in numbers corresponding to the equipment and number of examinations and/or treatments, taking into consideration also demands for metrology.

- to create a good system of education and accreditation of medical physicists in collaboration between the physical and medical faculties of the universities and the postgraduate schools in the field of health care and to take legislative measures obliging physicists in medicine to pass through this system.

- to increase salaries of qualified staff in hospitals to work systematically for the better status of "non-physicians" in medicine; the importance of modern diagnostic and therapeutic methods must enter the minds of not only specialists, but of all physicians and of the general public.

Unfortunately, we are afraid that this will be a long-term process. In the mean time information on any positive experience of the international community will be appreciated.

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EDUCATION AND TRAINING IN MEDICAL PHYSICS IN DENMARK

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INTRODUCTION

The Danish Society for Medical Physics was founded in 1981 and was accepted as a member of EFOMP and IOMP in 1982. The participation in the European and international organisations of medical physicists is particularly important for such a small group as the Danish numbering about 50 hospital physicists. An important goal for the Society has been to establish a forum to take care of the education and training in medical physics in Denmark, and a report was finished in 1985. The basic qualification is a M.Sc. in physics from a University or a Technical University. Due to the small number of hospital physicists required, there has been no possibility to establish institutes for medical physics at the universities and there will not be such possibilities in a foreseen future, therefore the majority of hospital physicists start their first appointment without any previous experience in medical physics.

TRAINING SCHEMES

The Danish Society for Medical Physics recommends a period of minimum three years in-service training in a hospital to become a qualified hospital physicist. The Society has elected a Council for education and training which has the professional competence to approve the individual plans for the theoretical and practical training. The actual department/candidate has to prepare a program report annually. Finally the Council recognize the candidate as a qualified hospital physicist related to either radiotherapy, nuclear medicine or diagnostic radiology. This is in full agreement with the EFOMP recommendations and several candidates are taking part in this scheme at the present time (12). This structure has been discussed with the Danish health authorities and a preliminary agreement was reached in the end of 1991. The agreement to formally recognize the completed training has not come into effect due to problems arising with the biomedical engineers especially about quality control in Diagnostic Radiology. According to ICRP, WHO and now also IAEA the involvement of medical physicists in quality assurance is recommended for Diagnostic Radiology and therefore these problems have to be solved. The biomedical engineers have never been excluded from taking part in the technical aspects of this matter - mostly it is done by external companys anyway. The Danish health authorities has recently confirmed the importance of the educational efforts done by the Society and a revival of the discussions is expected in the near future. The Society of course continue its educational schemes but we are still waiting for a formal recognition of our educational structure and the competence belonging to it, and to our profession as a whole. The national registration scheme with the guidelines will be submitted to EFOMP for formal recognition.

TABLE 1: NUMBER OF HOSPITAL PHYSICISTS

Subject	1: Qualified Hospital Physicists	2. As 1+5years experience
Radiotherapy	25	20
Diagnostic Radiology	3	3
Nuclear Medicine	9	6
Total	37	29

MEDICAL PHYSICS DEPARTMENTS

All hospital physicists in Denmark are employed within hospitals under the National Health Care system either in Departments of Medical Physics /Radio-physics or as individuals in different clinical departments. All Physics departments are connected to a Department of Oncology and only the largest departments are functioning with some autonomy but none are fully independent. Because the education in medical physics mainly is on-the-job training this system does unbalance the profession as indicated by the numbers of qualified hospital physicists in the different subjects and also paralyse the efforts for further academic education and training to a Ph.D. level in medical physics.

LEGAL REQUIREMENTS

Denmark is a member of the EU and as such has to adjust its national laws and regulations to the EU Directives - in this respect it is the so called Patient Directive and Directive 89/48/EC on "Mutual Recognition of Higher Education Diplomas". As has been mentioned no Danish hospital physicist has an official certificate indicating his competence - therefore he cannot expect to get a position f.ex. in France and the intention of the Directive to facilitate freedom of movement of the various professional groups between countries seems not to be acting. Concerning the Patient Directive a Government Notice on electron accelerators for radiotherapy from October 1991 gives some guidelines about the necessary training for a physicist to get sufficient competence to become qualified hospital physicist. In Nuclear Medicine the term "qualified technical/physical assistance" has been used without any specification of training in a revised Notice from December 1992 - this term was also used in a Notice from before the Directive was active. This concept has been questioned by the Danish Society for Medical Physics for several years.

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EDUCATION IN MEDICAL RADIATION PHYSICS AND MEDICAL ENGINEERING IN ESTONIA

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INTRODUCTION

Estonia is the smallest of the former republics of the USSR. It restored its independence step-by step between 1989 and 1991. Its population is 1.5 million and about 1/3 of the population lives in the capital - Tallinn.

The health care facilities are arranged at 3 levels. The radiological equipment is used on the 2nd and 3rd level, beginning from town and district hospitals. The highest, the 3rd level of medical care is concentrated in Tallinn and in Tartu, the second biggest town in Estonia, where the national University is also located. The University has a Medical Faculty, which is the only university-level institution providing medical education.

X-RAY DIAGNOSTICS

There are 118 hospitals and 18 outdoor clinics in Estonia. Most of them have one or two Diagnostic X-ray Rooms. The maximum is 11. The total amount of stationary diagnostic X-ray units in Estonia is about 170. Users: 173 radiologists and 268 X-ray technicians. The equipment is technically supported by approximately 30 service engineers, who are employed:

3 - in local agencies of OEM-s;
17 - in independent service organisations (ISO-s) and
10 - have full or part time jobs as in-house servicemen.

The education of service people ranges from a local electrician (husband of an X-ray technician) to a PhD in Physics. Sixteen of them are Diploma Physicists or Diploma Engineers in a wide range of specialities, but the dominating majority of them are self-educated in Medical Engineering.

Post-graduate education:

1 person has undergone a post-graduate program in a technical university in Moscow as a Medical Engineer,

1 person is undergoing post-graduate education at OEM (Philips) as an X-ray and Imaging Engineer,

3 persons have taken 1-2 two-week courses on principles of X-ray imaging equipment in the USA.

Most of the others have taken some short (1-3 weeks) courses provided by OEMs on certain models of X-ray equipment, mainly related to the production of Russia or former socialist countries. About 35% are totally self-educated or have obtained their experience from their more skilled colleagues. Most of them are *well-educated*, but *poorly trained*, as is typical for previous Soviet republics. It is a good prerequisite for quick development of the people in post-graduate educational training if they should have suitable facilities, teachers and motivation. The best form of education for these people would be hands-on training on X-ray equipment principles, adjustments, service, QA, etc.

There are no specialised medical physicists, involved in radiological imaging, in Estonia today. Their tasks are partly performed by service engineers (20% of them are graduate physicists) and by medical doctor-radiologists.

RADIATION THERAPY

This is concentrated in two oncological hospitals, one in Tallinn, the other in Tartu. The total radiation therapy equipment of these two hospitals consists of: Co^{60} devices - 3pcs; high dose rate afterloading systems - 4 pcs; X-ray therapy devices - 2 pcs; circular electron accelerators (E<20MeV) - 1 pce. 5 radiophysicists and engineers are involved in treatment planning and utilisation of the equipment. 3 of them are Diploma Physicists and 1 of these 3 has PhD degree in physics. Their education in radiophysics consists of 2 months specialisation courses in Moscow and some sporadic participation in 1-week schools and workshops, what is evidently too little. So in general they are self-educated.

NUCLEAR MEDICINE

This is provided by two specialised departments of central hospitals, one in Tallinn and the other in Tartu. The total amount of equipment: 2 gamma cameras and 4 renographs. The equipment is supported by 2 radiophysicists (totally self -educated in Medical Physics) on part time jobs.

RADIATION SAFETY AND DOSIMETRIC CONTROL

QA of radiation equipment is provided by the Department of Radiation Hygiene (DRH)in the body of the National Board of Health Protection. It is located in Tallinn and consists of 7 employees, mostly Diploma Engineers from our technical university. There is a big need for radiophysicists in DRH.

Under the former Soviet regime the radiation control was strictly regulated by laws and regulations from Moscow and therefore accomplished quite regularly. But as all very strict rules, it could not adequately reflect rapid changes in radiation technology and therefore became a bureaucratic formality for hospitals. On the other hand: low salaries and somewhat biased attitude of medical personnel towards the DRH as towards an organisation, which belonged to bureaucratic repressive structures, had prevented qualified radiation specialists from joining this department. Also it has restrained professional development of the employees of the DRH.

Today radiation control and QA is organised on a voluntary basis and hospitals must pay to the DRH for performed measurements. Therefore, at the very beginning of independence from Moscow this work was almost to die out. But today, as the market of health care services becomes competitive, the interest which hospitals take in QA from the side of hospitals has steeply arisen. At the same time it is much more complicated today, compared to the Soviet time, because of :

1 the appearance of Hi-Tech medical equipment, such as CT scanners, MRI equipment, gamma cameras etc. , in the hospitals,
2 widespread use of radiation equipment of different manufacturers and different origin, purchased very cheaply or donated as humanitary aid, sometimes fallen into disuse in their countries of origin because of safety problems. Furthermore, the hard pressures exerted by manufacturers to buy the new equipment and their attempts to discredit the ideas of humanitary aid and the use of refurbished equipment,
3 a) rapid increase of competition in medical services market, which enables the use of QA data for "unfair play" in the competition for patient visits and
b) the introduction of licensing systems for hospitals, which enables to use the data for simplified bureaucratic decisions at licensing procedures if the QA personnel is not enough unbiased and qualified.
4 an almost total lack of equipment for QA measurements in hospitals and the difficulty of obtaining it in the conditions of hard financial restrictions.

Estonia has neither radiation law nor legislative regulations officially in effect today. The situation in radiological medicine needs the creation of these but the reasons mentioned above and the lack of specialists restrain it.

Besides DRH, some other sporadic attempts are made to measure the personnel radiation doses and equipment safety. The most successful is the joint project of the Finnish Centre for Radiation and Nuclear Safety and Universities of Helsinki (Finland) and Tartu (Estonia) - for QA of X-ray diagnostics in Estonia, which began in 1993. As a result of the research, the safety situation is found to be not too bad. The problems are concentrated rather on the quality of accessories (film and screen quality), film processing and the right methods of work by personnel rather than the quality of equipment. Nevertheless, the problems exist in monitoring patient doses during fluoroscopy, which in many cases are too high and uncontrolled. This problem can be divided to 3 "sub-problems":

- lack of trained technical maintenance personnel with adequate knowledge in fixing and adjusting of fluoroscopy parameters and Image Intensifier - TV chain,
- lack of qualified safety specialists to train the medical personnel in proper and safe methods of fluoroscopy and
- absence of suitable dose rate measuring devices.

In conclusion the need for competent radiation safety and QA specialists is evident. The best way would be the post-graduate courses and training for graduates of physics.

EDUCATION SCHEMES

As for general education of Medical Physics and Medical Engineering, there are now 4-5 graduates of Medical Engineering in Estonia. They have graduated from technical universities in Russia. Because of the lack of specialists with such education they were, after graduation, immediately seized for administrative jobs and therefore their influence to the level of medical engineering is very indirect, if at all.

In 1993 the preparations began for a programme of Medical Physics and Medical Engineering in Tartu University and for study of Medical Engineering in Tallinn Technical University.
Now 7 4th year students will supposedly graduate as Bachelors in Medical Physics in Tartu next spring. Some of them will continue their study for two more years to became Masters of Medical Physics. It is possible to get PhD degree in Medical Physics in Tartu after additional 4 years of study.

In Tallinn the undergraduate study has not begun yet, but there are about 13 participants in a programme for Master degree and 6-7 for the PhD degree. Syllabuses for under- and post-graduate study are put together in both Universities (please see the appendix), but both suffer somewhat from the same disease - they are compromises between the completeness of the programme and presence of suitable lecturers. Also it seems that the bridge between these academic syllabuses and practical Medical Physics and Medical Engineering is narrow. Nevertheless there is enough reason to think about cooperation with other countries in the preparation and the exchange of lecturers for biomedical disciplines.

As with the other forms of post-graduate study, there have been some short workshops about processing of bioelectrical and physiological information, organised and under the sponsorship of OEMs and the other vendors of medical equipment; some 2-3 day seminars on radiology, addressed mainly at medical doctors - radiologists, etc. This kind of post-graduate education has been quite random, possibly because of small amount of people, involved in certain narrow specialities. The same situation will apparently go on in future as well because of smallness of the population of Estonia. This causes our special interest in international contacts and cooperation in post-graduate study.

REPRESENTING BODY

The **Estonian Society for Medical Engineering and Medical Physics** (ESMEMP) was founded in January '94 and now has 52 personal members (about 1/3 of them being medical doctors). In the future the ESMEMP will cover the implementation of such workshops and courses, mentioned above. The first workshop (about the processing of blood flow data and ECG) will be held in Tallinn at the beginning of November. The ESMEMP will also present Estonian medical physicists and biomedical engineers in international organisations. It is already accepted by the IFMBE and joining with IOMP is now under discussion.

CERTIFICATION AND RECOGNITION OF THE PROFESSION

Today Estonia has no certification programs for biomedical disciplines, so there is no mechanism for those who have reached significant levels of competence to be formally recognised. In the conditions of insufficient QA; significant amount of vacancies in biomedical professions; wide use of renowned equipment and great variances in the background of professionals, the absence of the certification system leads to a situation, where less qualified people are significantly overpaid and more qualified are underpaid. This fact, in its turn, has the tendency to stabilise the situation of incompetence. The situation is made worse by the fact that medical managers, who are usually employers of medical engineering staff, are representatives of medical professions which are quite different from engineering. Therefore they cannot, in many cases, value adequately the professional level of their technical co-workers. They need some qualified and unbiased support in this. Because of the small amount of people involved in Estonia, we need obviously international collaboration in the certification process either in the form of some specialization between the countries or exchange of certification programs and questionnaires. Both solutions need setting up of some international standards in the quality of certification. Sufficiently unified general education schemes in post-socialist countries form a good basis for such kind of cooperation. In Estonia the process will be supposedly carried out under the control and coordination of ESMEMP and the interested members of this Society.

In summary the Medical Physics and Medical Engineering staff in Estonia is involved in:

2 universities;
2 oncological clinics;
1 Department of Radiation Hygiene;
3 ISO-s;
2 local agencies of OEM-s;
9 research and design groups, laboratories and companies (some of these groups are independent and some are included in the body of the other institutions).

Totally Estonia accounts for 19 institutions of Medical Physics and Medical Engineering, the number of employees mainly 2.3, the maximum ca 30 (dependent on criteria, we set up to separate Medical Engineers from Medical "non-Engineers"). The total number of Medical Physics and Medical Engineers in Estonia is about 100, with great variances in background, competence, their way into Medical Engineering, self-cognition as Medical Engineers, affiliation to societies, affiliation to occupation field (such as research, education or technical support) etc.

CAREER OPPORTUNITIES

Opportunities are good in Medical Engineering in Estonia due to the fact that whereas under the Soviet regime Health Care was the last branch of the economy where new technology was introduced, in western countries it seems to be the second (after military) or the third (after military and science). This has generated a gap in Medical Technology between Estonia and the advanced countries. Therefore the introduction of modern technology into health care in Estonia is very rapidly filling this gap and there are quite clear signs of "overheating" in this branch of economy. One of the results of "overheating" is the fact, that the education of the people involved, cannot meet the needs of the technology introduced. It causes a lot of potential vacancies, lot of jobs filled with people with inadequate competence, thus leading to misuse of equipment, low quality purchasing decisions etc. Today we have 8-10 clinical physicists and engineers who have obtained significant level of experience in self-education and they all have 3-5 job offers from different companies, governmental and educational institutions, but essentially their education has remarkable "holes". The most important way to overcome the difficulties is wide use of different kinds of post-graduate education, combined with undergraduate education in medical physics and medical engineering, what has recently begun in Estonia.

FUTURE NEED FOR MEDICAL PHYSICISTS AND ENGINEERS

Supposedly the number of people involved in Medical Physics and Medical Engineering will not increase remarkably in Estonia in the future, but the professional level of competence will increase rapidly after 2-3 years. Today the decision makers in hospitals are occupied in obtaining the new technology, after this relaxation time they supposedly will feel the need for proper handling and maintenance of this technology and thus the need for investment into professional development of Medical Engineers and Medical Physicists will increase. The professional and educational sectors in Estonia must be ready to satisfy the need.
Supposed changes in the nearest future in these professions will be:

a)clearing the borders between different adjacent professions (e.g. between clinical physicists and clinical engineers, between imaging and physiological equipment specialists etc.),
b)increasing the share of radiological and imaging professions among the other technical professions in health care,
c)increasing the number of teachers and safety specialists/consultants.

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Appendix

TARTU UNIVERSITY, Faculty of Physics & Chemistry
Syllabus for upper stage of undergraduate study.

Main Subject: Physics
Sub-speciality: Medical Physics and Biomedical Engineering.
Obligatory to gain in upper stage of undergraduate study: 53 CU consisting of:

1.	Obligatory courses from section A	23 CU
2.	Elective courses from section B	6-10 CU
3.	Free courses - social sciences	5 CU
4.	Free courses - professional	2 - 6 CU
5.	Thesis, written to obtain Bachelor Degree	13 CU

A.	**Obligatory courses (23 CU)**	Hours	Year / Semester	CU
1.	Introduction to metrology	16	2 - 1	1
2.	Basics of information theory	32	2 - 2	2
3.	Control and measuring systems	64	3 - 2	4
4.	Digital electronics I	32	4 - 2	4
5.	Digital electronics, training	32	4 - 1	1
6.	Introduction to visualisation of biological objects and processes	32	4 - 2	2
7.	Biomedical signals and measuring methods	64	4 - 4	4
8.	Anatomy and physiology	64	4 - 1&2	4
9.	Medical biomechanics and modelling	32	4 - 2	2
10.	Functional morphology	32	3 - 2	2

B.	**Elective courses (6-10 CU)**	Hours	Year / Semester	CU
1.	Methods of NMR in physics and chemistry	32	3 - 2	2
2.	Non linear circuits	32	4 - 1	2
3.	Planning and analysis of experiment	48	3 - 1	2
4.	Digital electronics II	24	3 - 1	1
5.	Metrology of non-electric parameters	32	4 - 4	2
6.	Human biology	32	4 - 1	2
7.	Laser physics	32	4 - 1	2
8.	Dosimetry	32	3 - 2	2
9.	Processing of analogue signals	32	4 - 1	2
10.	Radiations in medicine and their measuring	32	4 - 4	2
11.	Biomechanical diagnostics of skeletal muscles	32	4 - 1	2

Estonia

TARTU UNIVERSITY, Faculty of Physics & Chemistry
Syllabus for Master's Degree

Main Subject: Physics (80 C.U.)

Sub-speciality: Biomechanical Engineering and Medical Physics

1.	Free courses in general physics	6 CU
2.	Free courses in mathematics & computer sciences	4 CU
3.	Free courses in natural & humanitary sciences	4 CU
4.	Special courses from the list below	16 CU
5.	Master's examination in physics	4 CU
6.	Thesis, written to obtain Master's Degree	46 CU

Special courses in Biomedical Engineering and Medical Physics

1.	Theory of random functions	2 CU
2.	Basics of physical metrology	2 CU
3.	Programming language C	2 CU
4.	Methods & equipment of medical diagnostics	2 CU
5.	Methods & equipment in therapy	2 CU
6.	Biological Substances and replacement composites	2 CU
7.	Orthopaedic devices and prostheses	2 CU
8.	Biomechanics of functional systems	2 CU
9.	Radiation dosimetry	2 CU
10.	Mathematical methods in biological medicine	2 CU
	Obligatory to gain	*16 CU*

TALLINN TECHNICAL UNIVERSITY
Syllabus for Biomedical Engineering

The special courses are considered for students with different background: electrical, mechanic, computing systems etc. engineering. Courses of group A are mainly predicted for undergraduate study. B are mainly predicted for postgraduate study:

		Semester	Total hours	Lectures-laboratory exercises	CU
A.	**Obligatory**				
1.	Fundamentals of physiology and nerve activity	2	3	2-1-0	2.5
2.	Biomechanics	1	3	2-0-1	2.5
3.	Electromagnetic waves in biological tissues	2	4	3-1-0	3.0
4.	Medical signal processing	2	3	2-1-0	2.5
5.	Medical imaging	1	4	2-2-0	2.5
B.	**Electives (minimum 6.5 CU)**				
1.	Computed tomography	2	4	2-2-0	3.0
2.	Radiothermography	1	3	2-1-0	2.5
3.	Mathematical modelling of physiological signals	2	3	2-0-1	2.5
4.	Medical ultrasound	2	4	2-2-0	2.5
5.	Bioelectromagnetism	1	4	3-0-1	3.0
6.	ECG, EEG	1	3	2-1-0	2.5
7.	Thesis in Biomedical Engineering				
				Total	30.0CU
		Obligatory to gain			*6.5CU*

MEDICAL PHYSICS IN FINLAND

G.T. KUIKKA [(1)]

STATUS

The first hospital physicist started work in 1937 at Helsinki University Hospital. Nowadays there are about 60 hospital physicists in Finland who are working in different fields of medical physics i.e. in clinical physiology, in clinical neurophysiology, in nuclear medicine, in radiology (including NMR), in radiotherapy as well as in radiation safety. The majority of them are involved in radiation physics.

There is only one Medical Physics Department in Finland (at Tampere University Hospital) due to the fact that the hospital physicists are scattered into several clinical or diagnostic departments. However, the chief physicists (nine in the country) have considerable independence to lead their physicists.

EDUCATION

The educational and training background for the degree of hospital physicist has been recently renewed. The minimum university degree is Ph.L. (analogous to M.D.) which usually takes 6-7 years to complete. There is 4 years job in training (as an assistant physicists) in a teaching (university) hospital under the guidance of the chief physicist. In addition there are 2 written examinations, one for the competence of hospital physicists and one for radiation safety. The National Board of Training and Education (under the Ministry of Education + the Ministry of Social Health) in Hospital Physics supervises this training, courses, competencies etc.

Post-graduate courses (5-6 days) are organised nationwide 1-2 times per year. Shorter (1-2 days) courses together with medical doctors are much more frequent. There are also local weekly seminars as well as courses in hospital administration etc.

There are 4 ranks in hospital physics; assistant physicist, hospital physicist, assistant chief physicist and chief physicist. Their salary classes are equal to those ones of the corresponding physicians. More than 1/3 of the Finnish hospital physicists have a competence of professor or docent in Medical Physics or in equivalent fields.

The profession of the hospital physicist is recognised by the Finnish bylaw.

This means that no one else than the competent hospital physicist can be taken into full-time job in a given hospital. Career opportunities have been rather good but may come heavier in the coming future. On the other hand there are several physicists who will retire soon which will open new posts for younger hospital physicists.

Research and scientific activities of the Finnish hospital physicists are better than the average. But - more professional scientific way to do research has to be taught into our brains. Of course there is lack of time to do research and some suggestions have been done. One generally used solution is a research hospital physicist (free from daily routine for 3-6 months) which allows to concentrate for scientific activities.

Future need for medical radiation physicists is not increasing heavily, the estimation being that 3-6 new positions within the next 5 years will be the maximum. However, in other fields of medical physics (in NMR, in clinical physiology, in clinical neuro-physiology etc.) there is a greater demand. There are also several engineers and other specialists (in computer science) who partly apply their skills in medical physics.

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RADIOLOGICAL AND MEDICAL PHYSICS IN FRANCE

A. NOEL[(1)] and B. AUBERT[(2)]

INTRODUCTION

In France, Medical Physics is practised by scientific specialists who must have received a specific postgraduate training both theoretical and practical. The working field of the Medical Physicist, Hospital Physicist or Radiation Physicist as called in France cover the use of ionising radiation mainly in radiotherapy and now entering nuclear medicine and radiology. All figures in this report are as at 01/01/93.

The presence of a medical physicist has been imposed in radiotherapy since 1969 and in departments of nuclear medicine since 1988. In these cases the profession is regulated and an agreement procedure has been drawn up stipulating qualifications for hospital physicists which became law in 1977.

HOSPITAL PHYSICIST

All physicists have a postgraduate degree in radiology and medical physics and about 2/3 get a higher academic qualification i.e. Ph.D. At present 220 hospital physicists work in radiological physics, 92% working exclusively or primarily in Radiotherapy, 6% in Nuclear Medicine and the remaining 2% in Radiology. Following the EFOMP policy statement 3/4 of French physicists can be considered as qualified experts in radiophysics. Many hospital physicists are also designated as qualified experts in radiation protection.

It has to be stated that few medical physicists have research activities and/or training responsibilities but no hospital physicists has an academic position in France unlike in some other countries.

RADIOTHERAPY

In France there are 204 Radiotherapy departments, 116 having brachytherapy facilities. Radiotherapy is performed either in a public service (Hospital) or in private practice or in Cancer Centres which have a particular status. There are 76 departments in Hospitals, 107 in private practices and 20 Cancer centres. These radiotherapy departments use 163 cobalt units and 195 high energy linear accelerators as shown in table 1.

TABLE 1: Distribution of the treatment machines as a function of the departments' status

	Cobalt Units	Accelerators	Totals
Private Practice	82	87	169
Hosital	47	60	107
Cancer Centre	34	48	82
	163	195	358

It is interesting to indicate the constitution of the medium sized radiotherapy department:

* Private practice: 50% use 1 treatment unit (cobalt or accelerator), 40% have 2 treatment units (1 cobalt unit and 1 linear accelerator) with 1 Medical Physicist in most cases.
* Hospital: 25% have 1 treatment unit (cobalt or accelerator), 55% use 2 treatment units (1 cobalt unit and 1 linear accelerator), 10% have 3 treatment units (1 cobalt unit and 2 linear accelerators) with 1 Medical Physicist in most services
* Cancer Centre: 75% have 4 treatment units (2 cobalt units and 2 linear accelerators) with 2 Medical Physicists.

TABLE 2: Number of medical physicists per radiotherapy department

	1 Phys	2 Phys	3 Phys	4 Phys	5 Phys
Hospital	41	11	3	2	1
Private Practice	68	12	1		
Cancer Centre	2	12	5	2	1

TABLE 3: Number of medical physicists per treatment unit

	Machine	Physicists	Ratio
Hospital	107	85	0.8
Cancer Centre	82	56	0.7
Private pactice	169	95	<0.6

Actually very few Medical Physics Departments have been set up in France. At present there are about 13 Medical Physics Departments of which there are 10 in Cancer Centres and 3 in Hospitals.

NUCLEAR MEDICINE

In 1993 there were 159 nuclear medicine departments with the following distribution: 11(63.5%) for public or university hospital, 19(12%) for cancer centres and 39(24.5%) for private institutions. The number of installed gamma cameras was 321 corresponding to 1 camera per 170,000 inhabitants. The number of cameras per department is indicated in table 4. There were 196(61%) cameras in public or university hospitals 72(22%) in cancer centres and 55(17%) in private institutions.

TABLE 4: Distribution of nuclear medicine departments versus number of gamma cameras in France

Number of Cameras per department	1	2	3	4	5
Number of departments	49	51	30	15	4

In 1994 the number of medical physicists working mainly, or exclusively in nuclear medicine is 6 in public or university hospitals, 7 in cancer centres and 1 in private institutions.

DIAGNOSTIC RADIOLOGY

In diagnostic radiology there now does not exist legal requirements for the services of a physicist. However, there is currently a proposal under consideration that radiology departments should be included in article 5 of the European directive 84/466/EURATOM as radiodiagnostic is the largest contribution to radiation exposure in medicine.

Without considering the way practices are structured there are approximately 22,000 x-ray tubes (includes radiographic, fluoroscopic, tomographic, mammographic, portables and CT units), 35,500 dental units and very few physicists. Only 1 or 2 Medical Physicists are working exclusively in diagnostic radiology. Although the number of sophisticated machines (table 5) and the necessity of quality assurance for screening in mammography justify the needs of these experts in diagnostic radiology departments.

TABLE 5: Number of sophisticated machines in diagnostic radiology departments in France

CT Scanner	M.R.I.	Digital Radiology
430	80	457

SOCIETE FRANCAISE DES PHYSICIENS D'HOPITAL (SFPH)

Founded in 1972, the French Society of Hospital Physicists (SFPH) is a scientific association for all those who have an interest in Medical Physics. The SFPH aims to promote the professional, academic and social communication between its members.

Each year the French Society of Hospital Physicists organise an annual meeting which takes place at the beginning of June and 2 teaching courses on various subjects of interest in Radiotherapy, Nuclear Medicine or Diagnostic Radiology.

The scientific work of the Society is dealt with within the committees such as Linear Accelerators, Diagnostic Radiology, Computer in Radiotherapy, Quality Assurance of the Radiotherapy Treatment, Quality Assurance in Digital Imaging, Quality Assurance in Nuclear Medicine and Ethical and Professional matters. The work of these Committees is published by the Society.

THE FRENCH MEDICAL PHYSICIST TRAINING

The education of Medical Physicists in France can be divided into 3 stages:

* First stage: Entrants to medical physics should have, as a minimum requirement, the Master of Science, or its equivalent.

* Second stage: One year is required. The purpose is to introduce Medical Physics in the form of an academic program for postgraduate degree in Radiological and Medical Physics. At the beginning of this period 200 hours of formal courses are given followed by 6-months research work. Some students are supposed to reach a higher academic level in defending a thesis

to obtain a doctorate in radiological physics.

* Third stage: This step is in-service training in hospitals. The in-training program is aimed at providing both education and practical experience simultaneously. This stage includes mandatory formal courses, practicals and an hospital-based medical physics training. In-Service training is done in an accredited physics department under the supervision of a senior medical physicist i.e. with a Ph.D. degree. All aspects of radiological physics (Radiation Therapy, Nuclear Medicine and Diagnostic Radiology) should be taught. The length of this is 1 year.

After finishing this the student is recognised as a medical physicist and can apply for the agreement delivered by the Ministry of Health, a compulsory procedure to be able to get a place as a hospital physicist in France.

FUTURE NEED FOR HOSPITAL PHYSICISTS IN FRANCE

There are 3 hospital physicists per million inhabiltants in France, ranking just ahead of Portugal which has only 2 physicists per million, lagging far behind the other countries of the European Community.

Ultimately a majority of medical physicists practice their activity in radiotherapy and each year 170,000 radiotherapy treatments are performed. Taking only this field into account and if we look at the different recommendations there is already a dramatic lack of physicists in France (without mentioning the shortage in nuclear medicine and diagnostic radiology).

Considering the figures of the ESTRO, laying down that 1 qualified medical physicist is needed per 600 patients, 280 physicists are required. Following the EFOMP recommendations about 550 hospital physicists will be needed. At the present time there are only about 165 qualified experts in radiophysics in France.
In nuclear medicine according to a report of the SFHP based on the recommendation of the EFOMP and the AAPM we can estimate the needs for medical physicists working mainly in nuclear medicine between 50 (all departments with at least 3 cameras) and 120 (all departments in public or university hospitals and in cancer centres).

Finally, if we apply the criteria given by EFOMP (1 physicist per 500,000 inhabitants) for the number of physicists in a diagnostic radiology departments utilizing a full range of techniques about 120 radiological medical physicists will be required. According to the IPSM criteria the needs in medical physicists would be about 2000.

To summarise, this means that between 115 and 385 physicists have to be trained just to satisfy the demand in radiotherapy and more if we are considering the need in nuclear medicine (50 to 120) and diagnostic radiology departments (120 to 200).

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EUROPEAN SCIENTIFIC INSTITUTE

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INTRODUCTION

The European Scientific Institute (ESI), established on the border between France and Switzerland, is devoted to high level post-graduate teaching needed for the transfer of the latest technologies between Research and potential users like Medicine for instance.

The first idea of something like ESI came from the fact that it is very difficult for a small university to have a number of students large enough to organise high level teaching in very specialised fields like Accelerator Technologies, for instance. A typical example was Norway, in the University of Bergen, it would be possible to find each year one or two students wishing to follow specialised Accelerator courses. There are three Universities in Norway. At national lever, the total number of students would not exceed half a dozen. Such specialised courses would need much more lecturers then students!

The only solution would be to organise such courses at a European level. As most of the experts in this field are often present in Geneva, an appropriate locations would be the Geneva area, but inside European Union territory, so as to take part in the ERASMUS or TEMPUS university European programmes (including financial help from European Union to exchange of students or lecturers).

PRINCIPLES

The European university academics who have been working on the project have emphasised the need to respect four principles:

- ESI will only offer subjects that are not already being taught elsewhere at the envisaged level and in the same form. In effect, its purpose is to provide tuition on highly specialised or rapidly evolving subjects, which are proposed by the universities.
- It will use the skills available in the Geneva area or connected with it (CERN, Hospital Cantonal de Geneve...)
- It can operate only with the fullest European involvement. The aim is to strengthen European universities and laboratories by enhancing the level of skills.

- ♦ The administrative link with the home institution will be maintained as the institution itself is a member of ESI.

♦ A fifth principle can also be underlined, namely a "flexibility" principle allowing students to choose any number of 3-month (or less) units from a normal 9 months year, and possibly shared over different years.

The Institute offers a unique opportunity of bringing the students of many nations together. This creates a more stimulating environment than the binary exchange which is the current practice through the European Union programmes.

STUDY LINES

Many study lines have been suggested by the universities involved in the setting up of the Institute. In the first priorities are an Accelerator Technologies teaching program and a Biomedical Physics Development study line covering the domains of detectors, imaging and accelerators. There are some obvious connections between these two study lines. Teaching staff will be under contract with the Institute for a limited period.

Accelerator Physics + Associated Technologies

In this domain, the Geneva area benefits from the expertise of the many physicists and engineers of CERN and of the close-by centres of ESRF in Grenoble, and PSI in Zurich, in a number largely exceeding what universities can offer. This study line was operational early in 1994. The next session will take place from 9th January - 24th March 1995. Coordinator of this study line is Dr M. Rey-Campagnolle.

Biomedical Radiation Physics Teaching

With specialised courses in Biomedical Physics, one aim of ESI is to give access to top level knowledge which will allow the physicists to apply and further improve, inside their home institution, the latest developments of detectors, imaging and accelerators for use in fields like Diagnostic, Nuclear Medicine and Radiotherapy. This will clearly be complimentary to already existing teaching in some European countries at graduate or postgraduate level. The courses will help to satisfy the requirement for high level radiation physicists which is continuing to increase mainly for development of new detectors allowing less irradiation, Medicine Imaging techniques and new uses of accelerators. Coordinator of this study line is Dr Y. Lemoigne.

WORKSHOP

To prepare the definition and the practical organisation of the study line, a workshop has been held at mid-October with the participation of some experts (14 nationalities were represented). In parallel, a detailed investigation about present teaching of Biomedical Physics in Europe and future needs has been done using the channels of the national representatives inside the European Federation of Organisations for Medical Physics (EFOMP). We obtained answers from 18 countries.

The workshop was organised in three parts: First there was a review on emerging technologies in accelerators, detectors and imaging, which could be useful in Medical Physics in the coming years.
There was then a review of training, teaching and needs for Medical Physics in some European countries. The third part was devoted to discuss how ESI could fulfill these needs, at least partially.

The workshop has retained an organisation of three levels:

Level 1:
The highest would be one week devoted to only one topic which will be intensely studied (symposium type). The public addressed will be senior medical physicists and the heads of Medical Physics. It is foreseen to start as soon as Easter 95 with "Medical Imaging and new types of detectors". Other topics could be (for example):

- Conformal Radio-Therapy
- Functional Imaging
- Algorithms and Mathematics for Imaging
- Dosimetry and Mathematics for Imaging
- Quality Insurance in Radiology and Radiotherapy
- Radiopharmaceutics
- Non-Ionising Biomedical Diagnostics

Level 2:
These will be high level courses aimed at advanced post-graduate students or physicists wiling to specialise in Medica Physics. True multidisciplinarity will be necessary i.e. well balanced basic and clinical research programmes. A typical topic could be: "Accelerators for Nuclear Medicine, Diagnosis and Therapy". About 150 lectures (4-5 weeks?) are foreseen.

3.3 Level 3:
These will be basic courses in Medical Physics. The demand was expressed

urgently by some countries that need some help to start a post-graduate training programme.
The present scheme foresees a teaching programme organised in three terms mixed with practical sessions. A part of the practical training will be programmed in expert centres under ESI co ordination.

The workshop has retained the principle of three levels gradually put in place: two one-week-symposia in 1995 (Level 1), a module of High Level Courses (Level 2) in 1996 and Basic Courses (Level 3) later.

4. CONSTITUTION OF ESI

ESI has been created as an association based on the French Law of 1901 which is commonly used. It is an highly flexible structure which applies to association with a non-profit aim. As such, it perfectly suits ESI's purpose. As soon as regulations will allow, ESI will become an European Association (the European Union is preparing such regulations).

The members of the Association can be Universities of Research Institutions, companies, private societies, local public authorities and bodies in Europe that are automatically entitles to membership by virtue of their contributions to the operation of the Association. The Association was set up early 1994.

Members

- Centre Universitaire et de Recherche d'Archamps:\archamps (France)
- II Faculty, of Sciences, Uni. of Milano at Como: Como (Italy)
- Universite de Geneve: Geneve (Switzerland)
- Institute of Theoritical and Exp. Physics: Moscow (Russia)
- Moscow Physical and Technilogical University: Moscow (Russia)
- IN2P3-LAPP : Annecy-le-Vieux (France)
- Universite Charles : Praque (Czech Republic)
- Uppsala University : Uppsala (Sweden)
- University of Mines and Metallurgy: Krakow (Poland)
- A Commercial Company: Compact Detector System (C.D.S): Thoiry (France)

The present Association is open to Universities willing to join.

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MEDICAL PHYSICS IN GERMANY

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INTRODUCTION

The Deutsche Gesellschaft fur Medizinsche Physik DGMP (German Association of Medical Physicists) was founded in 1969. The former GDR hospital physicists working in the field of ionising radiation had formed a section "Clinical Radiation Physics" within the former Society for Medical Radiology of GDR. Physicists engaged in non-ionizing medical physics were associated in a section "Medical Physics" which in fact aimed to cover the total spectrum of physics applied in medicine, and in so far has been comparable to the DGMP which for the time being represents about 1200 members. Our society publishes the monthly journal "Medizinische Physik" (Medical Physics).

GENERAL REMARKS ON MEDICAL PHYSICS AS A PROFESSION

In Germany Medical Physics is considered in a more general sense as a branch of Applied Physics which according to the definition of MAYNORD at the first International conference of Medical Physics 1965, deals with any application of Physics in Medicine. The interdisciplinary character of Medical Physics is not only obvious in its bridge function between Physics and Medicine, moreover Medical Physics is integrated in a network of natural and biosciences such as mathematics, chemistry, biology, computer informatics, biophysics, bioengineering. Slightly different to some other countries we consider Medical Physics to cover a number of other branches or sub-specialities like radiation physics, laser physics in medicine, physiological measurements, etc. This interpretation of Medical Physics is the essential base of the DGMP-qualification concept outlined in the last part of this paper. Each year the German Association of Medical Physics arranges a scientific congress. The last conference was in Erfurt in September this year.

WORKING CONDITIONS OF MEDICAL PHYSICISTS IN GERMANY

Based on the results of a general inquiry performed within the DGMP in 1990 the present situation of the medical physicists can be described in detail. However, limitations of this inquiry have to be taken into account in so far as the DGMP members are predominantly (ca 70%) working in radiation physics, whereas especially physicists engaged in other specialities (laser, physiology, ophthalmology etc) are more often affiliated to the corresponding medical associations. Concerning the qualifications of German medical physicists we found 85% with university degree in physics or a technical college (diploma), 59% with a doctor-degree and 17% with an appointment as university lecturer. At very few institutions (Berlin, Heidelberg, Hamburg) postgraduate studies in Medical Physics have just been initiated, demonstrating that training in Medical Physics typically does not get started prior to a complete physics study at a university. Medical physicists. 38% are most often appointed to radiotherapy, nuclear medicine, more rarely to radiation diagnostic departments in universities; other 30% are working at community hospitals, 14% in industrial companies, the rest in other institutions (research, administration etc). Interesting to note is that there is a continuous relative increase of positions for medical physicists in hospitals compared to universities reflecting mainly the increasing number of radiotherapy units and the significant spread of sophisticated equipment such as accelerators, treatment planning etc, in the domain of routine cancer treatment. It has to be emphasised that 50-70 medical physicists will be needed per year in the future.

The **Table** below shows in more details, for the different fields of Medical Physics, the first and the second priority of our medical physicists.

Field	**1st priority (%)**	**Next priority**
radiotherapy	48.8	7.0
nuclear medicine	10.0	13.5
X-ray diagnostic	10.8	17.6
radiation protection	9.2	30.5
computer informatics	1.2	8.8
other fields	20.0	22.6

The fields corresponding in the general inquiry within the DGMP in 1990 are:
aerosol research - audiology - biophysics - biomechanics - biosignal analysis - research organisation - MRT, MRS - medical laboratory - lithotripsy - medical optics - medical physics (common) - medical technique - neurosurgery - physiological measurements - radiation biology - immersion medicine - ultrasound - administration.
About 70% of members are working in the 3 most important radiological fields. In the **Table** below (including only the old federal countries) the institutions are listed where medical physicists are working:

Designation	% of all 677 members of DGMP (inquiry 1990)
university clinic	38
Community hospital	30
research institution (without university)	5
administration	8
industrial firm	14
others	5

Still today it is the most frequent structure of Medical Physics to be an integrated part of the respective medical section. In so far all efforts of DGMP are aiming at a more independent and separate structure Medical Physics should be organised in the medical environment. According to the recent DGMP-inquiry only every 7th medical physicist is working in a separate medical physics department, whereas nearly 40% are indicating to be organised in a medical physics unit being independent to a certain degree only; finally, every second medical physicist is working as a member of a small group not at all separated from the medical section.

Considering the growing importance of physics in all medical fields the organisational structure of medical physics should comply with this trend; otherwise a lack of high level physicists is preprogrammed for the future which in fact will have serious consequences for the standard of medical physics itself, for the education and training level and not least for the whole health system. Therefore, DGMP feels the structure of medical physics at the universities and larger hospitals has to be a key issue for the future, not only in Germany. Departments and sections for Medical Physics are essentially the pillars of a qualification system in our profession which in fact is another main DGMPgoal.

THE DGMP PROFESSIONAL QUALIFICATION SCHEME IN MEDICAL PHYSICS

Stimulated by WHO demanding in 1972 a training program in Medical Physics, and supported by the German federal health advisory board, DGMP set up its first professional qualification scheme in Medical Physics in 1974. Since then DGMP is undertaking all efforts to get an official state approval for this qualification scheme which due to formal legislative problems is still on the way with the exception of the federal country Berlin. However, the federal and state governments are aware of the need to come up with a solution of the problems, at least in medical radiation physics where the EEC-directive 84/466/Euratom is claiming the availability of a "qualified expert" in radiophysics in sophisticated departments of radiotherapy and nuclear medicine.

GENERAL RULES OF THE DGMP-QUALIFICATION SCHEME:

a) The entrance qualifications are a first degree in the area of physics from an institute of higher education or a technical college (diploma), which entitles the person concerned to commence a doctorate. The further training comprises a professional activity in Medical Physics.

b) Qualification as a medical physicist needs to prove professional activity in medical physics under supervision of a qualified medical physicist for at least 3 years.

c) Totally 360 hours training courses in Medical Physics have to be completed. This acquisition of theoretical knowledge is split into three phases nearly equivalent in time:
Basic Courses - fundamental knowledge in anatomy, physiology, biochemistry, biomathematics, biophysics, informatics, biomedical engineering, public health care.
Courses in special branches -thorough knowledge and practical experience in one area of Medical Physics contained in the DGMP-prospectus.
Courses for various fields - basic knowledge in two or three additional areas of Medical Physics according to the subject matter catalogue prospectus.

The DGMP has produced a prospectus for further training, in Medical Physics which is regularly updated by the committee at the DGMP responsible for further training. All important decisions in the procedure for the granting of professional recognition are taken after consulting the applicant's tutor, and are explained to the applicant.

A tutor is usually the medical physicist employed at the applicant's place of work, who is authorised by the DGMP to provide further training. If a person's professional activity is undertaken at a place of work where no medical physicist authorised to provide the training is employed, the approval committee must, on request, appoint a tutor. Tutors support further training by :

- means of frequent contact with the applicant;
- examining the physical, technical equipment of the place of work;

- talking to superiors and colleagues of the applicant;
- giving advice in the planning of training and the selection of courses and lectures.

Successful completion of the whole qualification scheme is attested by the granting of a recognized professional qualification in Medical Physics which authorises a person to add to his professional title the words "with a recognised professional qualification in Medical Physics (DGMP)" and an addendum "field medical radiation physics or "field audiology".

When DGMP initiated activities in setting up the qualification scheme its adjustment to the EFOMP policy statements was a major concern. We are sure we could attain this goal fairly well, supporting the idea of a uniform, high level education and training in medical Physics in Europe.

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MEDICAL PHYSICS EDUCATION IN GREECE

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STATUS

In 1956 two physicists were appointed in the "Alexandra Hospital" of Athens, to work for the first Greek Laboratory of Nuclear Medicine and one of the first teletherapy installations equipped with a Cobalt-60 unit. Following their appointment these two first physicists were educated in Medical Physics by attending several seminars organized by international organizations, such as the IAEA and by studying books and papers.

In 1959, the writer returned to Greece from MIT (Cambridge, U.S.A), where he was awarded a M.Sc. Degree and he was trained in the Physics of Radiotherapy. He was appointed as the first medical radiation physicist in the Greek Anticancer Institute, which was then the only cancer Hospital in Greece.

From 1961 to 1982 the School of Hospital Physicists, organized by the Greek Atomic Energy Commission at the Nuclear Center "Dimokritos" educated a total of about 70 Medical Radiation physicists.

From 1960 to 1994 about 50 Medical Physicists educated abroad mainly in U.K. and France to an M.Sc degree level, have returned home and they are employed mainly in Greek Hospitals.

This way, the Greek Association of Physicists in Medicine has now about 125 members.

EDUCATION IN THE UNIVERSITY OF PATRAS

From 1989 to 1994 a Course on Medical Physics (MP) and Biomedical Engineering (BME) organized through ERASMUS at the University of Patras is implemented annually. About forty Greek medical physicists were educated through this course. Most of them are now under practical training, in order to be eligible for the State License Examination. This way, they will obtain the License to practice Medical Physics in the hospitals of Greece.

This double Course on MP and BME is now supported by one ERASMUS and two TEMPUS projects. This year (1994-95) 14 Romanian and about 10 Bulgarian students are joining the students coming from the Countries of European Union.

The policy and structure of this Course is presented in the following:

The Course is entirely given in English
No more than fifty students are admitted
A Course teacher acts as a coordinator in each of the participating Universities. He/she is responsible for evaluating and selecting the students of his/her University as candidates to be sent to Patras.
The students must speak English and they must posses adequate knowledge of Physics, Mathematics and Electronics to follow the Course.
Preference to admission is given to students who apply for the whole Course and who hold a Degree in Physics, for the Medical Physics (MP) part or a Degree in Electrical or Electronic or Computing or Mechanical or Chemical Engineering, for the Bio-medical Engineering (BME) part of the Course. If the first degree requires more than four years to undergraduate University studies, then the student of the fifth or higher year is also eligible as a candidate, provided that he/she has completed all his/her obligations of the first four years.

Prior to their departure for Patras, the students are notified of their admission and they receive the necessary travel, financial and accommodation information from their local coordinator.

Upon their arrival at the University of Patras, most of the Course students are accommodated in a Students House. Each student is offered a room and three meals per day for about 120 ECU per month. Private apartments are also available for rent, at monthly rates of 100 to 150 ECU. This way, the ERASMUS or TEMPUS student grant sufficiently covers all expenses.

The Course starts at the end of September and ends at the end of April. The first Semester consists of three monthly Modules. They are commonly addressed to engineers an physicists, because they include introductory Topics of interest to all of them. The Second Semester includes four monthly Modules. It consists of specific Topics for engineers and other Topics for physicists. They are given to these two groups in separate classrooms simultaneously.

The first weeks of each Module are devoted to teaching (four hourly lectures each and every working morning and laboratory practicals in most working afternoons).
The fourth week, is covered by written examinations on all of the Module's Topics. To reduce the number of examinations, two or three related Topics are joined in one Cluster, which is examined in one written test.

Finally, the student is given one grade for each Cluster, which is the weighed average of the grades of the Cluster Topics.

At the end of his/her teaching period the teacher prepares the examination questions and gives them to the Course coordinator. At the examination day, the questions for each cluster are photocopied and distributed to the students, who have to answer them within two hours. The answers are photocopies and mailed to the teacher to be evaluated. The teacher mails the grades back to Patras.

During Christmas and Easter Holidays the Course in interrupted for two weeks each time.
The student who failed in up to 30% of the clusters, is given the opportunity of a second written examination on these clusters, during the month of May.

Finally, each student is awarded a certificate, which presents his/her attendance and success in passing the Clusters. The University of origin is already committed to recognising the Clusters passed and to give the corresponding credit to the student.

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MEDICAL PHYSICS IN HUNGARY

P. ZARAND[(1)]

STATUS

The population of Hungary is some 10.3 million and is slowly decreasing. The approximate number of beds in hospitals is 100,000 from these 500 beds are parts of the oncology centres, but the activity is shared in some centres between radiotherapy and chemotherapy.

We have 10 radiotherapy centres (+2 under construction) which seems to be in accordance with the WHO recommendations. The location and the instrumentation of these centres are, however, far from optimal: five (from the 12) are just on or very near to the border, other 3 in East Hungary are lying on a triangle with 60km sides, only 4 of them have accelerator(s) although 9 of them have rooms planned for accelerators. These centres have a medical physics laboratories. Research institutes like the National Research Institute for Radiobiology and Radiohygiene, or the Central Research Institute for Physics (Radiation Protection Department), the Nuclear Power Plant at Paks (Radiation Protection Departments) and the National Office for Metrology (Primary Calibration Laboratory) have laboratories and groups working in related topics. A few radiation protection laboratories are working as part of the radiation protection network of the authorities.

About 30 medical physicists (a few places are vacant) are employed in hospitals mainly in radiation therapy departments usually with more than 5 years experience and different education depending mainly on local equipment and instrumentation. This results in 2.5 physicists/million inhabitants being in the lower half in Europe. The number of physicists/centres varies between 1 and 7. Radiation protection is usually a part time job (with no salary) of the medical physicist(s) and its level is highly dependent on both the local requirements and the engagement of the physicists. The number of medical physicists working in the radiation protection network of the authorities is 7-8. The number of medical physicist working in nuclear medicine is approximately 17-18. The non-doctors in this field usually have, at least in our country, education in physics, electrical engineering, chemistry, pharmacy or biology.

At present there is no legislation regulating the number and qualification of "medical physicists". In the early era of megavoltage therapy e.g. in the "grey book" 1/2 (later 1) physicist per therapy unit per shift was recommended and then 1 physicist per centre was added for computer aided treatment planing in

1978. The workload of a centre has not been considered. It is varying between 500 and 3000 new patients per year. Since approximately '86 neither a valid recommendation nor legislation exist and a manpower figure close to that suggested by EFOMP (1991) is accepted in practice.

REPRESENTING BODY

Medical physicists in Hungary working in radiotherapy or diagnostic radiology are organised in the "Medical Physics Section of the Hungarian Biophysics Society" (this section is a member of both IOMP and EFOMP) and about half of them have some kind of radiation protection responsibilities and are also members of the Radiation Protection Section of the Roland Eotvos Physical Society. The physicists working in nuclear medicine departments are usually members of the appropriate Hungarian society.

EDUCATION AND TRAINING

The present low number of medical physicists is connected with the general problems in health care. Without discussing the reasons, it should be mentioned that the total number of "deep therapy" field/year has remained a constant 600.000 in the past 25 years. The cancer mortality is about 32.000 per year. from this figure 20.000 external therapy patients per year is expected (including recurrence). Using 20 fields per course and 2.5 fields per session a rough estimate of 1 million fields are needed. The actual number is approximately only half of it. Combining the WHO report 644 (new patients per equipment) and EFOMP staffing data then 50 medical physicists are required in the whole country. Similar data may be valid for nuclear medicine and radiation protection.

This results in practically two new physicists per topic per year and a formal graduate training in medical physics seems not to be feasible. Post graduate teaching course at one university, starting every 2-3 years can be an adequate solution. The curriculum of the medical physicist should harmonise with that accepted in the UK or Germany or preferably with that to be adopted by the EC. A good solution can be a training on a regional basis in English or German.

There are no university courses in Hungary where medical physicists can be educated to post-graduate level. Until now the Technical University (Budapest) has organised some post graduate courses in biomedical engineering supported by UNIDO. From the beginning of 1995 they are offering an accredited M.Sc programme containing 1080 hours plus thesis. This is organised in co operation with the Medical and Veterinary Universities of Budapest. Some parts of this programme (anatomy, physiology, statistics, etc.) can be very useful in the education of medical physicists. Radiation protection courses are organised at various levels. Two offered by Technical University can be useful for medical physicists: 50 hours theory + 65 hours practise for all medical physicists, while a special course is dealing with the planning of new installations (64 hours theory + 24 hours practise). Regular three day Training workshops are organised by our society in co operation with the Roentgen and Radiation Physics and The Clinical Science Foundation (CSF, London). This year our first annual conference, supported by the European Comunity and the CSF was held.

The special literature is not available in Hungarian . Since there is no organised education for medical physics in the country most of the books and periodicals are available only in research institutes where the main profile of the activity is quite different. Recently the Medical Physics Section of the Hungarian Biophysics Society has received some 50 books on different topics of medical physics and some volumes of Health Physics from EFOMP. Since Hungarian is not the most commonly used language in the world the only possibility to get professional information is to have a good knowledge of English.

In Hungary a certificate of specialisation cannot be given by a medical society. This has no tradition at all in medicine, consequently a possible certification by another society is not recognised. For medical doctors a special office, the Committee on Medical Specialisation is responsible for certification in a speciality. This body is not responsible for the post graduate education of any people not having the education from a medical university.

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POST-GRADUATE EDUCATION IN MEDICAL RADIATION PHYSICS IN THE REPUBLIC OF IRELAND

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INTRODUCTION

Internationally accepted routes for post-graduate education in the field of medical radiation physics include taught Master's degree courses, Master's and Doctorate degrees by research alone, and courses managed by the various professional organisations. These formal educational options need to be supplemented by in-service training, as well as continuing education opportunities. Most of these educational options are available to medical physicists in the Republic of Ireland, with the exception that the professional body, the Association of Physical Scientists in Medicine (APSM), does not manage its own training course, but was instrumental in setting up a taught Master's degree course which is now managed by Trinity College, Dublin University (TCD).

With regard to undergraduate education, some courses include a medical physics or physiological measurement component. Diploma-level education, as well as professional education for technicians in this field have not been adequately developed as yet. The TCD post-graduate course is the only structured educational option dedicated wholly to the application of physical sciences to medicine which is presently available in Ireland, and the remainder of this paper will deal mainly with the TCD course.

GENERAL PERSPECTIVES

The Physical Science in Medicine course offered by TCD integrates medical radiation physics with the broader field of physical science applications in medicine (e.g. physiological measurement, rehabilitation engineering). This broad-curriculum approach is suited to the present health services structure in Ireland, which supports relatively small, hospital-based medical physics departments; in such departments narrow specialisation is not normally feasible and physicists must expect to contribute to a broad range of demands, such as electromedical equipment management, physiological measurement, quality assurance and rehabilitation engineering as well as the traditional radiation physics and imaging services. The integrative approach is not peculair to the Irish context. The accreditation scheme introduced by the Institute of Physical Sciences in Medicine (IPSM) encourages a broad-based curriculum, and many benefits for this can be cited such as: fostering closer cohesion among the various branches of the profession; crossover of knowledge from different fields; avoidance of the prohibitive costs of running a number of separate courses for relatively small numbers of students.

Students of the Physical Sciences in Medicine course at TCD may register for either an MSc or Diploma. The registration requirements (good honours degree in the Physical Sciences), curriculum and examination procedures for the taught section of the Masters and Diploma courses are identical. The course is timetabled so as to accommodate students who are in full-time employment in the field of physical sciences in medicine, and runs over a two-year duration.

In addition, to passing all the set examinations for the taught course, Master's degree students must submit a dissertation which demonstrates the ability to define, research and report a significant piece of scientific work in the field of physical sciences in medicine. Thus the Master's degree certifies that the student has all the knowledge and skills necessary to a new entrant to the profession of physical sciences in medicine.

The option of registering for a Diploma is useful for students from fields outside of the Physical Sciences in Medicine Profession (e.g. hospital management or medical industry); it is also attractive to those wishing to enter the profession but who do not feel the need to demonstrate research skills, e.g. to students who may have already obtained an MSc or PhD by research alone.

STATUS

The status of Trinity College, Dublin University is well recognised, so that the Master's degree and the Diploma enjoy excellent status both nationally and internationally. Inaddition the MSc course enjoys full accredation from the Institute of Physical Sciences in Medicine (IPSM), and was among the small number of courses to achieve this status in the first year of the accredation scheme.

NEEDS

At present there are less than 50 graduate posts in Medical Physics/Clinical Engineering in the Irish Republic. This figure signifies a considerable under-staffing problem. In order to provide an effective scientific support for health services in the country at least 100 new graduate posts must be created. It is difficult to forecast the rate of creation of new posts, but despite the financial problems of the Irish Health Services, it is reasonable to estimate that at least 4-

5 jobs per annum will be created over the next few years, and that there will be some additional vacancies due to natural turn-over. Thus the training services are required to educate approximately 5 graduates per year in the field of Physical Sciences in Medicine. A self-financing course can be run with this level of intake, but the fees from just 5 students per annum do not provide sufficient finance to operate more than one course. Despite the fact that a sound financial case can be made for the course, and the evident need for a formal education course in Ireland, the TCD course costs have not yet been formally underwritten by either the University or any other body such as the Department of Health; thus the financial basis of the course is at present insecure.

SYLLABUS

The Physical Sciences in Medicine taught course has four major branches:

(i) Imaging Science and Technology (including diagnostic radiology, nuclear medicine as well as non-ionising imaging modalities and image processing);
(ii) Physiological Measurement (including electronic instrumentation design and signal processing);
(iii) Safety (including ionizing radiation safety, electrical, mechanical, chemical, fire safety etc as well as safety legislation);
(iv) Therapeutic Instrumentation (including radiotherapy, rehabilitation engineering and electromedical therapeutic instrumentation).

The syllabus is taught in the form of lectures (about 230 hours total) as well as demonstrations/hospital visits (about 80 hours total). Formal examinations are held each year (six examinations over the two-year period), and these are monitored by the MSc Course Committee and an External Examiner. Students must sit examinations in all subjects i.e. students may not specialise in a particular area such as medical radiation physics, and
are expected to achieve a good understanding of the overall field.

RESEARCH COMPONENT

The ability to conduct independent research is essential to the role of the medical physicist: research projects stimulate critical review of practise, safeguard against out-dated practises, provide a mechanism for contact with assessment and development of research skills, Master's students are required to undertake a supervised research project in the field of physical sciences in medicine. The project must address a worthwhile scientific (or occasionally a professional) problem, and examples of some recent dissertations include:

The Resolving Power of Flexible Endoscopes
Blood Pressure Simulation in a Tubular Model;
Bone Mineral Measurement using Digital Fluoroscopy and Computer Radiography;

Stimulation of Gustatory Brain Potentials;
Qauntitive Analysis of Noise in Hospitals;
Uniformity Analysis in X-ray Image Intensifier/TV Systems;
Digital Image Restoration Techniques applied for Nuclear Medicine and Radioaerosol Imaging.

The dissertation must demonstrate that the student is capable of carrying out and reporting the research project to professionally acceptable standards (i.e. standards that would be considered acceptable to a good quality peer-review journal).

IN-SERVICE TRAINING

Students who are not in full-time employment in the field of physical sciences in medicine are expected to complete a twelve-week placement at a hospital or other institution in order to gain some insight to the practice of the profession in Ireland. However no formal training posts have been established as of yet, so that students do not gain practical experience of all the various specialities within the ambit of Physical Sciences in Medicine. To date, informal rotation practices have allowed many students to gain experience in fields other than radiotherapy, but the absence of a formal, co-ordinated rotation scheme has led to the current serious shortfall of experienced radiotherapy physicists in Ireland. Thus, despite the fact that practice in many fields of medical physics is recognised to be excellent (e.g. students have travelled from other European countries to obtain experience in Irish hospitals) the in-service training component is not well developed in Ireland and is not assessed formally. This problem is presently being addressed by the professional body.

CONTINUING EDUCATION

The provision of continuing education in Ireland is complicated by the small size of the Medical Physics community here at present, and the high costs of attending meetings overseas. Despite this, lectures, workshops and scientific meetings are held on a regular basis by a number of professional associations, and Irish delegates often attend and contribute to international conferences. Many Irish hospitals enjoy close association with third-level educational establishments, and thus medical physicists usually have good access to the published literature, and often contribute to this literature.

SUMMARY

While there are a number of significant gaps in the development of professional education in the field of Physical Science in Medicine in Ireland (including the absence of structured in-service graduate training and technician training) the graduate taught program at TCD provides an appreciation of the academic and practical core of knowledge in this field.

The syllabus includes subjects such as physiological measurement as well as the subjects traditionally taught in courses in medical radiation physics. The program enjoys university status as well as accreditation from IPSM, and is recognised as providing the knowledge and skills necessary for new entrants to the profession.

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CURRENT STATUS OF MEDICAL PHYSICS IN ITALY

F. MILANO[(1)]

ORGANISATION OF HEALTH PHYSICS SERVICE

Health Physics Services in hospitals in Italy, were established by law in 1969 (D.P.R. 27.3.69 N. 130 art 34) with the aim of giving a contribution "to solve problems related with the use of ionizing radiation and in electronic application in medicine". Before that time, since the early sixties, some physicists however worked in radiotherapy departments.

In order to have access to the initial position in the Health Physics Services the applicant has to pass a mandatory public exam for the planned position with the only prerequisite of having a university degree in Physics. The positions are divided into three levels. The passage from one level to another is based on a public exam after a four year experience in the previous level and an eight year experience, respectively from the first to the second and from the second to the third level.

The regulation changed last year, even though it has not yet been applied. The new organisation of staff will only be on two levels. In order to enter the first level applicants must have a degree in Physics and a post-graduate degree in Health Physics.

NUMBER OF PHYSICISTS, SERVICE DISTRIBUTION IN THE COUNTRY AND THEIR ACTIVITY

The number of physicists in the Health Physics Services inside the National Health Service (NHS) is about 5 per million inhabitants. The Italian population is about 57 millions. In 1993 300 hospital physicists operated in 95 services, 34 independent and 61 aggregated to medical specialities like radiotherapy, radiology and nuclear medicine. (1). The number of physicists in the single service depends on the activities which are performed, the area of competence of the service, the amount and the complexity of equipment. 80% of the total number of physicists are placed in services in the northern part of Italy.

In the National Health Service some physicists are also employed in environmental and prevention areas. Sometimes their activity covers elements of medical physics.

Another important area of medical physics activity is in the universities and research institutes.

In the following table an estimate is reported for the physicists involved in the area of medical physics.

ESTIMATE OF THE NUMBER OF MEDICAL PHYSICISTS IN ITALY

Number of Physicists	Number of Service Sections	Type
300	95	Hospitals
120	60	Environmental
250	30	University and Research Institute
670	185	Total

HEALTH PHYSICS SERVICE ACTIVITY IN THE NHS

Radiotherapy	21.4%
Nuclear Medicine	23%
Statistics	12.8%
Informatics	11.1%
Quality Control	19.7%
Research	12%

ENVIRONMENTAL SERVICE ACTIVITY IN THE NHS

Acoustic pollution	26.7%
Atmospheric pollution	20%
Microclimate	11.1%
Ionizing Radiation	28.9%
Non-ionizing Radiation	13.3%

No investigation has been made about the number of engineers involved in the medical specialities. A rough estimate of their number is about 10% of the physicists.

The prominent kind of activity carried out inside the National Health Service in 1988 is reported in the following tables. Radiation protection is not included in the tables even if many physicists of the NHS are involved in this activity.

REPRESENTATIVE BODY

In 1987 the "Associazione Italiana di Fisica Biomedica" (AIFB) was founded with the aim of promoting the activity of research and to provide educational and professional training in medical physics. The association joins the major part of medical physicists in every field of activity. Actually the Society has about 400 members.

The Society issues "Physica Medica" an International journal, which is the official journal of AIFB (Associazone Italiana di Fisica Medica), DGMP (Deutsche Gessellschaft fur Medizinesche Physik) and NVFK (Nederlandse Verening voor Klinische Fysika). Physica Medica is now indexed/abstracted in EMBASE (Excerpta Medica Data Base), INSPEC (for Current Papers in Physics and Physics Abstracts), QUEST (a data base dedicated to Health Physics and Medical Physics Journals) and ISI (for Biophysics and Biochemistry Citation Index).

The "Societa Italiana di Fisica" (SIF) is another representative body that joins all physicists in Italy. SIF has, in its yearly National congress, a section dedicated to Medical Physics and Biophysics. Some physicists acting in medical physics are members of SIF and very often they have inscription to both Societies.

GENERAL EDUCATION OF A MEDICAL PHYSICIST

The educational entry requirement of a medical physicist is the university degree in physics. The degree is obtained after a four year course and corresponds to a masters degree. In these studies courses that in some foreign curricula are considered graduate courses, are introduced. After the degree it is possible to attend Ph.D training. A rough estimate in 1991 indicates that there are less than 4000 Ph.D positions for 80000 applicants from all university disciplines.

Recently a three-year university diploma has been introduced which however is not active for physics.

The preparation of a physicist in Italy, is at a higher level than the B.Sc. level but it does not give any specific preparation in medical physics. Only since last year it is possible to have some specific courses, 5 in number, in the physics curriculum, the so-called Physics of Biosystems, area related to items of medical physics.

POST GRADUATE EDUCATION

The only specific training in medical physics is given by the post-graduate School of Specialization of the University.

In 1994 there are post graduate Schools at the Universities of Milan (15 positions per year) Bologna, (15 positions), Florence (5 positions), Pisa (5 positions), Rome La Sapienza and Rome Tor Vergata (15 positions). The education level for access to the school is a degree in Physics, Chemistry, Industrial Chemistry and Engineering. The duration of the school is two years, excepting one school in Rome which is three years.

The courses are programmed in lectures and practical training. The total number of hours is 400 hours per year for formal and practical training, seminars and visits to outside institutions and laboratories.
The academic programme contains a set of topics as follows:-

Selected topics in Physics
Elements of anatomy, biology, and physiology
Radiation physics and dosimetry
Biomedical instrumentation and techniques
Non-ionizing radiations
Radiation protection of staff
Environmental radiation measurements
Informatics
Statistics
Regulations

The course contents may differ from one university to another.

In future the general agreement is to request the transformation of the existing two year schools into four year schools with grants to students enrolled, following the EC model. The entry requirements will only be a degree in Physics.

FUTURE NEED OF MEDICAL PHYSICISTS

The number of physicists which operates in clinical structures is about 14 per million inhabitants in Sweden, 10 per million in the US and this evidence can induce an increase of their number in Italy. Actually there are 93 public radiotherapy centres in Italy (2) using 72 linacs, 46 with electron beams, 83 Cobalt 60 units, 6 cesium units and 112 x-ray units. There are 51 simulators. In 27 centres interstitial and in 49 endocavitary brachytherapy is active. The ratio number of Radiotherapy Centre per number of inhabitants (centre/number of inhabitants) in Italy is 1/614000 (1/594000 in the Middle Italy; 1/999000 in South Italy; 1/483000 in North Italy). Considering an optimal ratio of 1/500000, there is the need of other 15-20 Radiotherapy centres. 4 Italian Regions have no Radiotherapy centres. Their population is about 3.18 millions of inhabitants.

The number of public Nuclear Medicine Services is 154 (3). Moreover public opinion is very sensitive to pollution and, as previously exposed, in this area physicist competence is required. These facts indicate a tendency of the increasing physicists in number. On the other hand the course containment programs and some changes in the organization of the National Health Service, which are presently in course, do not permit prediction of real future trends.

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POST-GRADUATE EDUCATION IN MEDICAL RADIATION PHYSICS AND BIOPHYSICS IN LATVIA

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STATUS

Latvia has no nuclear power plants and radiation fuel processing. Thus, medicine, agriculture, industry and science are the main branches where radiation is used in the Republic of Latvia. Medicine has radioisotope sources, radio pharmaceutical preparations (eight hospitals and oncology clinics). ^{222}Rn is applied for physiotherapy by eight hospitals and sanatoriums, in addition. Besides, X-ray equipment is installed in about 250 hospitals. Up to of 50 agriculture establishments use radioisotope sources, mainly in the relay-type equipment. Gamma - radiography and various radioisotope instruments are found in 200 industrial enterprises. Science applies radiation (as radioactive substances, nuclear reactor and electron accelerator) is used in about 20 research groups. Transportation of radioactive materials for users is supplied by the special company "Radon" and the Department of Health. Specialised vehicles are being used for this purpose. The medical aspect of radiation physics consists of dosimetry for personal monitoring, treatment and investigation of process which are carried out in biological systems. For providing these directions thermoluminescent dosimetry systems and semiconductor detectors have been developed. Different scientific searches touch on the exerting of radiation influence on biological objects. The main results of these are as follows: tissue - equivalent phantoms, evaluation methods of radiation risk have been created.

The activity of the mentioned branches is being regulated by the Latvian legislation according to the requirements of such International Organisations as the Commission of Radiation Protection the International Atomic Energy Agency, the Commission of European Community, etc.

EDUCATION, RESEARCH AND FUTURE NEEDS

An adequate education is necessary to realise radiation application principles. The studying process is organised mainly at Latvian University, Medicine Academy and Riga Technical University.

Latvian University has 20 years experience in the education of specialists in radiochemistry, radiation chemistry, radioncology and applied dosimetry. Bachelors' and Masters' degrees are received by graduated students. Following special courses are attended : radiation chemistry, radioecology, radiation and environment, radiation checking of food, nuclear physics and dosimetry, dosimetry. Special equipment is being used to provide education : radiation sources dosimeters radiometers, ionization and scintillation counters. Alpha, gamma, beta, neutron irradiations are available too, in particular due to collaboration with the National Centre of nuclear Investigations. Doctorants for the above directions are trained too. The main problem of the education process development are lack of modern equipment and means for acquisition of expensive radiation sources. Medical Academy provides mainly the education of physicians as radiologists. Riga Technical University develops two main ways related to radiation physics. Courses for education of technician dosimetrists have been organised. New speciality Medical Engineering and Physics has been established. This has been made in frameworks of the scientific and training direction of Applied Physics. Development of Medical Engineering and Physics speciality is foreseen using International Co- Operation.

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MEDICAL PHYSICS IN LITHUANIA

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STATUS

Lithuania is a small country in the Southeast of the Baltic States. The population of Lithuania is approximately 3.7 million. There are 44 districts in Lithuania. Potentials of culture and science are concentrated in the 5 biggest cities. The capital of Lithuania is Vilnius.

The medical physics and engineering departments and laboratories are concentrated in Vilnius and Kaunas in the following departments:

-Laboratory of Clinical Dosimetry and Radiobiology in Lithuanian Oncology Centre, Vilnius (Radiotherapy).
-Department of Radiology of Kaunas Medical Academy Hospital, Kaunas (Radiotherapy).
-Department of Medical Engineering, Kaunas Medical Academy Hospital, Kaunas (Service Engineers).
-Laboratory of Dosimetry, Vilnius University, Centre of Radiology, Vilnius.
-Laboratory of Imaging, Kaunas University, centre of Radiology, Vilnius:
-Radiological Laboratory, National Centre of Hygiene, Vilnius:
-Five Regional Radiological Laboratories of Radiation Hygiene and Imaging.

The approximate number of medical physicists and engineers is about 40. They are involved in Radiotherapy (12), Diagnostic Radiology (3-4), Nuclear Medicine (11), Radiation Safety (11), Radiation Hygiene and Imaging (4-5). The approximate number if service engineers, working in Diagnostic Radiology is about 50-60.

REPRESENTATIVE BODY

Medical Physicists of Lithuania are represented by the Lithuanian Association of Radiologists and by the Committee of Clinical Dosimetry, Radiation Hygiene, Radiobiology and Radiation Engineering of this Association.

EDUCATION

Undergraduate studies of radiation physics are not specifically orientated to medical radiation physics either at Vilnius University or at Kaunas University of Technology. There are no facilities or institutions in Lithuania for the education of medical physicists or training in radiotherapy. All the medical physicists working in Lithuania have been trained abroad, the majority in the former USSR.

The specialists for Radiation Safety are trained in radiation hygiene at the Vilnius University - 1 year residence.

The specialists for Diagnostic Radiology and Nuclear Medicine undertake a course (3 years) on medical engineering at Vilnius Technical College (20 per year) or a course (4 years) on biomechanics at Vilnius Technical University (10 per year).

CONCLUSION

There are no unified programmes for education of medical radiation physicists in Lithuania. There is a great need for co-operation with other Universities and Institutions in the field of education and training.

International support is necessary for education of medical physicists and for training courses, research and studies for specialists working at present for shorter or longer time in the European centres.

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PROFESSIONAL TRAINING ON MEDICAL PHYSICS IN THE NETHERLANDS

P. INIA [1]

INTRODUCTION

Representing Body - NVKF

The Netherlands Society of Clinical Physics (Netherlandse Vereniging voor Klinische Fysica, NVKF) has got about 250 members. It represents nearly all clinical physicists working in the Netherlands in several areas of specialisation, such as audiology, general hospital instrumentation, medical informatics, nuclear medicine, therapeutic and diagnostic radiology. It has installed two committees for organising the post academic professional training for the clinical physicists. These committees are the Legislative Educational Committee (Council) and the Executive Educational Committee (Toetsingscommissie).

Aim of professional training

In the course f the professional trainee must acquire adequate knowledge and experience to be able to co-operate with medical and paramedical specialists and other health care workers to provide for the physical aspects of medical practice and for the safe and correct application of medical instrumentation. After completion of the training, the trainee should be able to function independently as a clinical physicist in his area of specialisation and to accept the associated responsibility towards the patient, the staff, the management of the Institute and public authorities, all of this in agreement with the professional rules for the clinical physicist.

General and special requirements

The Legislative Educational Committee frames requirements for the professional training according to clause 2a of its regulations. The requirements applicable to all areas of specialisation are described in the document "General requirements for professional training". Requirements that can differ for each area of specialisation are given in other document - "Special requirements for professional training".

Executive Educational Committee

The Executive Education Committee has to verify that in individual cases these requirements are met. It is important to note that the regulations of this committee give it the right to deviate from the general and the special requirements, for instance if a trainee possesses previous relevant knowledge or experience.

GENERAL REQUIREMENTS FOR PROFESSIONAL TRAINING

1.1 Entry qualifications for entrance

1.1.1. To be admitted to the professional training a trainee should possess a master's or a doctor's degree in physics from a university in the Netherlands, o r a degree that is considered of equal merit by the Executive Educational Committee.

1.1.2. The trainee should be employed by a qualified institute for at least 50% of a full-time job and be under the guidance of a qualified mentor.

1.2. Duration of Training

1.2.1. The duration of the training is based on a schedule equivalent to a minimum of 3 years and a maximum of 4 years full time, during which time the trainee must be employed by the training institute.

1.2.2. The duration of the training in a particular area of specialisation is stated in the "Special requirements for professional training".

1.3. Areas of Specialisation

The professional training is divided into several areas of specialisation.

1.4. Level of professional training

A large number of topics should be studied, including anatomy, physiology, pathology, mathematics, statistics, physics, electronics, computer science, business economics, management and organisation of health care. Part of the knowledge to be acquired, that is of a general nature, is needed for a good understanding of medical practice. The other more specialised part of the knowledge is meant to be applied directly and to enable the clinical physicist to bear final responsibility for certain matters.

A general indication of the level of professional training can be deducted from the required previous academic training and the aim of the training programme.

1.5. Training programme

1.5.1. Set up of a training programme:
The training programme consisting of a list of topics to be studied and tasks to be performed, is composed by the mentor in accordance with the

lists of topics in the "Special requirements for professional training" of the area of specialisation concerned (see clause 1.5.3).

1.5.2. Mandatory components of the training programme:

Every programme includes the following:

- Participation in relevant training courses
- Regular participation in relevant local or regional meetings about clinical subjects
- Regular participation in local, regional, national and possibly international scientific meetings.
- Participation in local, regional or national working groups
- Participation in applied clinical research that yields at least one scientific publication and one presentation at a scientific meeting.
- Visits to other institutes
- Teaching to members of the staff of the institute

1.5.3 Topics and tasks:

For each are of specialisation "Special requirements for professional training" are set up. They provide lists with topics to be studied, tasks and literature,. These lists serve as a guideline for composing the training programme.

GENERAL REQUIREMENTS FOR ORGANISING PROFESSIONAL TRAINING

2.1 Requirements for the mentor

2.1.1. The mentor should have a full time job with the same training institute as the trainee.

2.1.2. When the training starts the mentor should have been employed for a least two years as a registered clinical physicist with the same area of specialisation as the trainee.

2.1.3. Requirements mentioned in clause 2.1.1 and 2.1.2 can be supplemented by the "Special requirements for professional training".

2.2. Requirements for the institute of professional training

2.2.1. The number and variety of examinations, treatments or consultations should be such that all relevant aspects can be dealt with sufficiently during the training period. If there is a close co-operation with one or more other departments or institutes of health care, this requirements is valid for those departments or institutes jointly.

2.2.2. Adequate instruments for examination and treatment of patients, for technical and physical measurements, and for calculations and data management should be available in sufficient number and variety.

2.2.3. Sufficient technical support (electronics, fine mechanics, technical service) should be available at adequate levels.

2.2.4. Sufficient staff and laboratory space should be available.

2.2.5. Documentation and archiving of results of investigations, examinations and treatments or consultations should be well organised.

2.2.6. Structured meetings should be held on a regular basis with co-operating medical, paramedical and other departments or institutes. This applies both to patient care and management.

2.2.7. The library should possess recent handbooks and journals in the field of specialisation.

2.2.8. Requirements mentioned in clause 2.2.1. up to 2.2.7. can be supplemented by the "Special requirements for professional training".

3. Revision

The General and Special requirements for professional training shall be subject to revision at least once every five years.

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EDUCATION IN MEDICAL RADIATION PHYSICS IN POLAND

B. GWIAZDOWSKA[(1)] and M. MORAWSKA-KACZYNSKA[(1)]

HISTORY

The tradition of medical radiation physics in Poland dates from the early thirties when M Sklodowska-Curie establishing the Radium Institute in Warsaw (with a large Physics Department) started a co-operation with the Physics Faculty of Warsaw University. This faculty was the main source of physics staff in the Radium Institute. After the Second World War until the mid-sixties medical physicists were graduated mainly from Warsaw Technical University where the program of specialisation in Technical Physics was adjusted to the needs of radiation physics by Prof. Pawlowski (assistant to M. Curie). Later on physicists from the Physics Faculties of Universities and Academies of Education came to work in hospitals where radiation physics was applied.

ACADEMIC EDUCATION

The first impetus to start education and training of medical physicists on a regular basis came from the IAEA/WHO Seminar in 1972. The report from that Seminar prepared for the Polish Academy of Sciences by Oskar Chomicki was widely circulated. It finally found a response at Warsaw University where in the same year the program of education was established as a specialization during the fourth and fifth years of experimental physics.

The program was a result of many discussions among various specialists both in Poland and the United Kingdom. Since that time medical physics was recognised as a specialisation and also the possibility of scientific careers was opened for medical physicists. Later on, in 1979, the Medical Physics specialisation was set up also at the University in Krakow. Although the Krakow program is concentrated more around biophysical subjects, the Warsaw program around radiation physics in radiodiagnostics and radiotherapy, analyses of biosignals and imaging, the common features of both programs is that they provide training in a wide spectrum of subjects.

Table I. Medical Physics Programme at the Warsaw University

Year of Study	Subject	Hours per year
IV	- Cell biology and physiology - Physical fundamentals of radiation diagnostics - Radiation dosimetry - Radiotherapy planning - Statistical methods in biology - Bioelectricity and biocybernetics - Medical physics laboratory - *Seminars	30 50 30 30 100 80 150 50
V	- Biochemistry - Mathematical modelling of processes in biology and medicine - *Seminars - MSc Thesis	30 50 50
VI	- *Seminars - MSc Thesis	50

* The subjects of seminars are devoted to the problems connected to medical and health physics as well as biophysics and bioengineering. The invited speakers are specialists in the field, some seminars are prepared by the students.

Table II. Examples of MSc theses in radiation physics. The theses were prepared at Warsaw University in co-operation with the Medical Physics Departments of Cancer Centre in Warsaw.

- Analysis and verification of various computer programs used in radiotherapy (1988)
- Calculation of dose distributions by means of Clarkson method - investigation of parameters (1988)
- Measurements of Modulation transfer Function in diagnostic radiology (1989)
- Experimental verification of Fermi-Eyges theory for electron scanning beam (1990)
- Analysis of Compton-scattering in scintigraphic pictures (1992)
- Density measurements in CT (1993)
- Accuracy of dose rate determination in the ICRU-reference point (1993)
- Contrast and resolution measurements in CT (1993)
- Measurement and evaluation of physical parameters in mammography (1994)

The specialisation in technical physics oriented towards medicine has been build up over the last years at some technical universities all over Poland. Starting from 1990 at the Academy of Mining and Metallurgy (AGH) in Krakow there are B.Sc. and M.Sc. courses in medical physics and dosimetry. Warsaw and Kracow established multi lateral co-operation with various biomedical institutions e.g. in teaching staff exchange, organising laboratory classes, providing M.Sc and Ph.D tutoring. The education at engineering universities is mainly based on their own possibilities and has a rather technical profile.

PROFESSIONAL AND SCIENTIFIC STATUS QUO

Nowadays about 200 medical radiation physicists and engineers, not including service engineers, work in various hospitals and institutes (the population of Poland is almost 40 million).

In **Table III** the number of radiotherapy units, diagnostic radiology equipment, nuclear medicine equipment and the approximate number of hospital physicists employed. As can bee seen the radiotherapy physicists are the most numerous group. They are employed either in regional Cancer Centres (CC) in special sections at Radiotherapy Departments or in separate Medical Physics Departments (MPD), which are oriented not only uniquely towards RT. In Figure I the structure of the largest MPD in Poland with 20 physicists employed is shown. In other MPDs related to radiotherapy the number of physicists is between 2 and 6. Radiotherapy is performed only in large government hospitals and the distribution of these hospitals is quite uniform all over Poland. In Nuclear Medicine Departments and Radiology Departments usually not more than one physicist is employed. There are Biophysics Departments in Academies of Medicine, but radiation physics is a marginal subject there. Radiation physicists are also involved in development and production of Polish made accelerators, simulators, dosimeters and detectors, and in production of isotopes. The main institution for dealing with radiation safety matters is the Central Laboratory for Radiological Protection with about 50 highly qualified physicists and engineers employed. The duties of radiation protection officer in most hospitals are usually performed as additional responsibility by one of the physicists from the staff. In some big institutions with numerous isotope laboratories and sources of ionizing radiation the safety surveillance requires a full time post.

Presently the MPD or sections in Polish hospitals are seriously understaffed. The number of medical physicists per patient in radiotherapy in Poland is about two times smaller than in West European countries. Due to low salaries and not very promising career opportunities in the profession many physicists switched from medical physics to other disciplines or simply left Poland in recent years.

Hospital Physicists deal mainly with routine duties in hospitals and participate in clinical projects. Only part of them are involved in research and educational activities. Research concentrates mainly on theoretical problems or practical implementations closely connected with the clinical needs. Only physicists from larger facilities or universities are in position to get Ph.D degrees. Some of these dissertations result from co-operation with better-equipped institutes abroad.

POST GRADUATE EDUCATION AND OTHER ACTIVITIES

Poland has neither legislation on certification procedures for medical radiation physicists nor national requirement for their postgraduate education. The only exception is radiation safety, where the certification procedure for radiation officers is satisfactory regulated.

Post-graduate training is done on individual basis. The entry requirement for such training is MSc in physics, the specialised under-graduate education in radiation physics is not obligatory. Thus the physicists, who starts his training is usually on the level I or II of EFOMP competency scale. The specialised training in clinical practice is done under supervision of more experienced colleagues. Some physicists undergo an individual training in other institutes and voluntarily attend courses and meetings.

Since the sixties until mid-eighties MPD of CC in Warsaw organized each year one-month training courses on radiation physics in radiotherapy and nuclear medicine. Presently the staff of MDP is very much involved in academic teaching so the courses are discontinued, however individual training of the physicists from other hospitals are still being held. The Warsaw courses were replaced by the three days meetings on radiation physics in radiotherapy for physicians and physicists in Bydgoszcz. The main goal of the meetings is specialised education but different forms of active participation are welcome: presentations and posters on interesting developments in hospitals, discussions on "homework" which has to be prepared by participants.

In 1993 the Second International Summer School "Physics in Radiotherapy" took place in Warsaw (the first one was in 1977). Well known physicists from Western Europe and the United States presented excellent lectures on up to date topics in radiation physics. 70 participants came from Central and East

European Countries including 20 from Poland. The Schools (at advanced level) are intended to be organised every third year in framework of European School of Oncology (ESO), the Third School is planned for 1996.

Some Polish physicists attended the international courses (ESTRO, IAEA) and some of them underwent professional training abroad in a framework of international bilateral programs in medicine in Belgium, France, the Netherlands, Sweden, UK, USA.

Every fourth year the general meetings of members of Polish Society of Medical Physicists (PTFM) take place. One of them (international) was devoted to educational problems. PTFM (established in 1966) has about 300 members (about 60% of them are hospital physicists). PTFM works in following sections: 1) medical radiophysics 2) bioengineering 3) radiation safety 4) biophysics The president of the Society is Prof. G. Pawlicki (both physician and engineer). Meetings of sections are organised at least once a year.

The Medical Physics Section of the Polish Academy of Sciences brings together senior professionals interested in medical physics problems and organises their meetings once or twice a year.

For more than twenty years a national journal devoted to progress in medical physics has been issued as the PTFM journal (Postepy Fizyki Medycznej). Significant contribution to the publications has been given by radiation physicists. The physicists have also possibilities to publish in a few Polish medical journals. The Polish literature on medical radiation physics is rather limited. The basic literature is mainly in English and is seldom available in smaller centres.

Table 3. Approx. number of radiation hospital equipment and physicists

Department	**Equipment**	**No. Units**	**No. Physicists**
Radiotherapy	Cobalt Unit	28	total
(17 Depart's)	Accelerator	23	80
	Afterloading sys.	22	
Nuclear Med.	Scint.cam.&scanners	60	30
Diagnostic	X-ray equip.(ex.dent.)	4000	
Radiology	Mammographs	150	total
	CT scanner	100	10
	MRI	8	

CONCLUSIONS

Introduction of a national post-graduate education and training programme with certification procedure for Polish medical physicists is an urgent matter for the near future. However, the establishment of such programs might be a long-term process: it will require a lot of efforts from the physicists themselves and from some authorities like Ministry of Health and Ministry of Education. It would also require serious financial resources. The certification procedure should be followed by better financial prospects for clinical physicists.

The role of pan-European collaboration in the strengthening of national activities in this field should be emphasised here. The following activities can provide the starting point for such working relationship:

- Directives of the Commission of the European Communities relating to basic safety standards and radiation protection of the patient;
- EFOMP guidelines and EFOMP policy statements;
- experiences of the countries with established training programme;
- outcome of the first East\West European Conference on Medical Physics/Engineering Education.

Joint research projects on the Ph.D level between different Eastern and well equipped Western institutes would be beneficial for research activities of medical physicists. Significant financial support for such initiatives is absolutely essential.

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THE CURRICULUM OF MEDICAL PHYSICS IN KRAKÓW

M. WASILEWSKA-RADWANSKA(1) and M. P.R. WALIGORSKI(2,3)

INTRODUCTION

Brief History of Undergraduate Education (M.Sc.- level) in Medical Physics in Poland:

c.1950 - Technical Physics specialisation established:
*at the Warsaw Technical University, by Prof. Cezary PAWLOWSKI
*at the University of Mining and Metallurgy in Kraków, by Prof. Marian MI SOWICZ

1974 - Medical Physics programme initiated at Warsaw University by Prof. Ewa SKRZYPCZAK and Prof. Jerzy PNIEWSKI, as a specialisation over the fourth and fifth years of the undergraduate course in Experimental Physics

1979 - Medical Physics programme initiated at the Jagiellonian University (Krakow) by Prof. Andrzej HRYNKIEWICZ as a specialisation over the fourth and fifth years of the undergraduate course in Experimental Physics

1990 - Medical Physics and Dosimetry programme established at the University of Mining and Metallurgy by Prof. Jerzy NIEWODNICZANSKI (now led by Assoc. Prof Marta WASILEWSKA-RADWANSKA), in close cooperation with the Collegium Medicum of the Jagiellonian University (Prof. Zbigniew CHLAP, Prof. Zbigniew SZYBINSKI and Prof. Stanislaw KONTUREK). This specialisation began as an M.Sc Course (five years) in Applied Physics. Now (1994/95) two courses are offered: B.Sc level (1/2/3 years) and M.Sc-level (1 1/2 years)

Graduate Education (Ph.D-level) in Medical Physics in Poland:

PhD degrees in Medical Physics (strictly: Experimental Nuclear Physics) have been conferred by:

Warsaw University
Warsaw Technical University

Jagiellonian University, Krakow
University of Mining and Metallurgy, Krakow
Institute of Nuclear Physics, Krakow
Institute of Atomic Energy, Otwock-Swierk (Warsaw)

Professional Training:

1977 - First Summer School on Physics in Radiotherapy, organised by the Medical Physics Department of the Cancer Centre in Warsaw.

1993 - Second International Summer School on physics in Radiotherapy, organized by Prof. Andrzej HLINIAK, Assoc. Prof. Barbara GWIAZDOWSKA and Oskar A CHOMICKI.

MEDICAL PHYSICS PROGRAMMES IN KRAKOW

The curricula consist of lectures, problem classes, laboratory classes and seminars.

* Jagiellonian University - Medical Physics and Environmental Protection Programme
* University of Mining and Metallurgy - Medical Physics and Dosimetry Programme

The following professional training is included in the Medical Physics and Dosimetry programme:

- "in vitro" laboratory techniques, after the fourth semester (4 weeks)
- "in vivo" clinical techniques, after the sixth semester (4 weeks)
- Diploma (M.Sc) training after the eighth semester.

Cooperation in teaching Medical Physics and Dosimetry courses.

- Collegium Medicum (University School of Medicine), Jagiellonian University,
- Institute of Molecular Biology, Jagiellonian University,
- Cancer Centre, Krakow Division
- Institute of Nuclear Physics Krakow
- Institute of Biocybernetics and Biomedical Engineering, Polish Academy of Sciences, Warsaw.

Since 1993 a regular Regional Seminar in Medical Physics and Dosimetry has been held at the University of Mining and Metallurgy, with invited lectures every two weeks, given by eminent specialists in medicine, experimental physics, medical physics, bioengineering and related subjects. The Seminar, intended for scientists, secondary-school teachers, students, and secondary school pupils, is also part of the activities of the Krakow Division of the Polish Medical Physics Society.

CAREER OPPORTUNITIES

Students seek employment in their own places, but the University assists them by maintaining contacts with research institutions, clinics, companies, etc and by arranging job interviews. The course structure is designed to prepare students for work in hospitals, health institutions, environmental monitoring, development laboratories and for research in biomedical engineering.

Research-oriented graduates can enter post-graduate Ph.D courses at the University of Mining and Metallurgy or at other collaborating institutions.

NEEDS FOR THE FUTURE

The programme at the University of Mining and Metallurgy in Krakow is a relatively new one, however apparently a very attractive one to our students. So far, many of the course subjects are being taught outside the Department of Physics and Nuclear Techniques of the Academy of Mining and Metallurgy. On the one hand this is advantageous to our students, on the other we observe some repetition and a certain lack of co-ordination between our different lecturers. We would like to develop a strong and advanced biomedical physics programme of education and research in our Department and elsewhere, incorporating the latest developments in detectors, imaging and accelerators for medical applications. As a community, we have considerable expertise in experimental and theoretical nuclear and solid state physics in Krakow on which to base a wide range of biomedical methods and techniques, hopefully arriving at a community of physicists, engineers and clinicians forming one of the largest research and education centres in Poland.

We expect to establish close collaboration with other teaching and research organisations in Europe, such as the Department of Medical Engineering and Physics of the King's College London, UK, Institute of Physical Sciences in

Medicine, European Federation of Organisations for Medical Physics, International Atomic Energy Agency, International Federation for Medical and Biological Engineering, European Scientific Institute.

We think that the European Conference on Post-Graduate Education in Medical Radiation Physics sponsored by the Commission of the European Communities under its activities for Co-Operation in Science and Technology with Central and Eastern is an extremely important step in bringing us all together.

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(2) Centre of Oncology, Kraków Division.
(3) Institute of Nuclear Physics.

APPENDIX

UNIVERSITY OF MINING AND METALLURGY KRAKOW

MEDICAL PHYSICS AND DOSIMETRY PROGRAMME (ORIENTED SUBJECTS)

SUBJECT SEMESTER	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	NUMBER OF HOURS (TOTAL)
BIOMEDICAL SUBJECTS (ANATOMY, HISTOLOGY, PHYSIOLOGY, GENETICS, MOLECULAR BIOLOGY, CELL PATHOLOGY)											**225**
BIOCHEMISTRY											**60**
BIOPHYSICS AND BIOCYBERNETICS											**60**
RADIATION PHYSICS											**135**
DETECTORS OF NUCLEAR RADIATION											**75**
RADIOCHEMISTRY											**135**
RADIOPHARMACOLOGY											**45**
RADIOBIOLOGY											**60**
RADIOTHERAPY											**45**
NUCLEAR MEDICINE											**30**
DOSIMETRY											**180**
RADIATION PROTECTION											**45**
ELECTRONICS OF MEDICAL EQUIPMENT											**120**
BIOSTATISTICS											**45**
COMPUTER IMAGING											**150**
COMPUTER METHODS AND SYSTEMS IN MEDICINE											**45**
SEMINAR											**90**
M.Sc. THESIS											

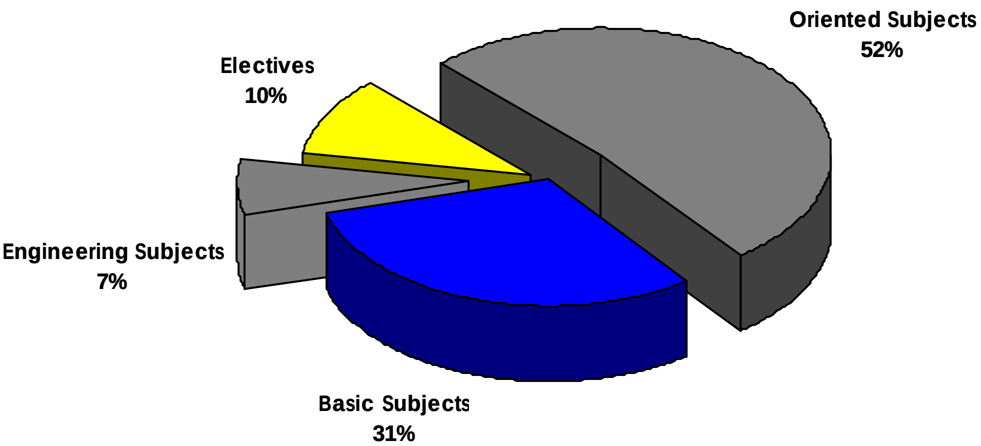
UNIVERSITY OF MINING AND METALLURGY KRAKOW

MEDICAL PHYSICS AND DOSIMETRY PROGRAMME

SUBJECT SEMESTER	1	2	3	4	5	6	7	8	9	10	NUMBER OF HOURS (TOTAL)
MATHEMATICS	■	■	■	■							**300**
INTRODUCTION TO STATISTICS	■										**45**
PHYSICS	■	■	■								**330**
COMPUTER SCIENCE		■	■								**150**
ELECTRONICS					▒	▒	▒				**195**
CHEMISTRY	■										**90**
ELECTIVES							▒	▒	▒	▒	**300**

MEDICAL PHYSICS AND DOSIMETRY PROGRAMME

CONTRIBUTION OF TYPE OF SUBJECTS IN PROGRAMME



UNIVERSITY OF MINING AND METALLURGY KRAKOW

MEDICAL PHYSICS AND DOSIMETRY
B. Sc. PROGRAMME

SUBJECT SEMESTER	1	2	3	4	5	6	7	NUMBER OF HOURS (TOTAL)
MATHEMATICS	■	■	■	■				**300**
INTRODUCTION TO STATISTICS	■							**45**
PHYSICS	■	■	■					**330**
COMPUTER SCIENCE		■	■					**150**
CHEMISTRY	■		■					**90**
ELECTRONICS				■	■	■		**195**
ELECTIVES							■	**120**

ORIENTED SUBJECTS

SUBJECT SEMESTER	**1**	**2**	**3**	**4**	**5**	**6**	**7**	NUMBER OF HOURS (TOTAL)
BIOMEDICAL SUBJECTS (ANATOMY, HISTOLOGY, PHYSIOLOGY, GENETICS, MOLECULAR BIOLOGY)		■		■	■	■		**225**
BIOCHEMISTRY			■	■				**60**
BIOPHYSIC & BIOCYBERNETICS					■	■		**60**
RADIATION PHYSICS				■	■			**135**
RADIOCHEMISTRY					■	■		**135**
RADIOPHARMACOLOGY						■		**30**
DOSIMETRY					■	■	■	**195**
RADIATION PROTECTION						■		**30**
ELECTRONICS OF MEDICAL EQUIPMENT							■	**60**
COMPUTER IMAGING				■	■			**120**
COMPUTER METHODS AND SYSTEMS IN MEDICINE							■	**60**
SEMINAR							■	**60**

UNIVERSITY OF MINING AND METALLURGY KRAKOW

MEDICAL PHYSICS AND DOSIMETRY
M.Sc. PROGRAMME

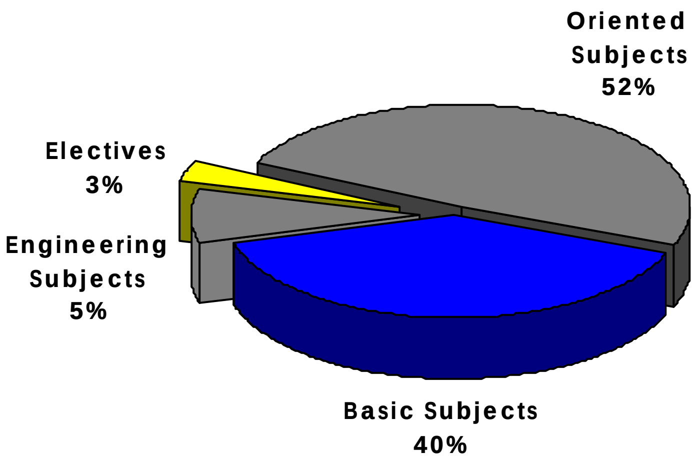
SUBJECT SEMESTER	**8**	**9**	**10**	NUMBER OF HOURS (TOTAL)
DETECTORS OF NUCLEAR RADIATION				**75**
RADIOBIOLOGY				**60**
ENVIRONMENTAL PHYSICS				**45**
BIOSTATISTICS				**45**
CELL PATHOLOGY				**45**
NUCLEAR MEDICINE				**30**
PHYSICAL FUNDAMENTALS OF DIAGNOSTICS				**60**
RADIOTHERAPY				**45**
SEMINAR				**90**
ELECTIVES				**210**
M.Sc. THESIS				

UNIVERSITY OF MINING AND METALLURGY KRAKOW

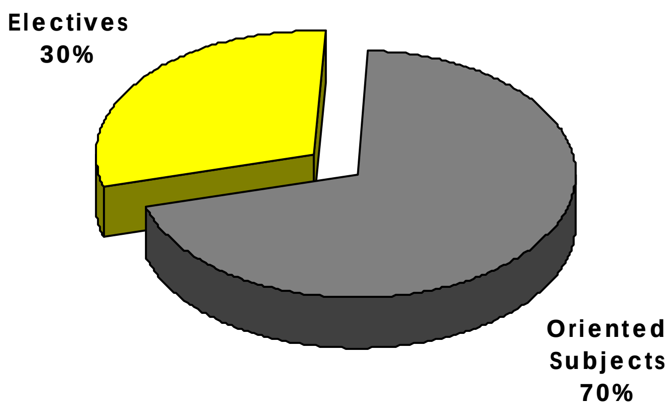
MEDICAL PHYSICS AND DOSIMETRY PROGRAMME

CONTRIBUTION OF TYPE OF SUBJECTS IN PROGRAMME :

B.Sc. :



M.Sc. :



JAGIELLONIAN UNIVERSITY KRAKOW

MEDICAL PHYSICS PROGRAMME
(ORIENTED SUBJECTS)

SUBJECT SEMESTER	7	8	9	10	NUMBER OF HOURS (TOTAL)
BIOPHYSICS	■				**30**
MATHEMATICAL MODELING OF PROCESSES IN BIOLOGY AND MEDICINE	■				**30**
THERMODYNAMICS OF BIOLOGICAL SYSTEMS	■				**30**
QUANTUM CHEMISTRY	■				**30**
MEDICAL PHYSICS LABORATORY	■	■			**90**
PHYSICS IN BIOLOGY AND MEDICINE		■			**60**
BIOCHEMISTRY		■			**60**
MEDICAL EQUIPMENT		■			**45**
PHYSIOLOGY		■	■		**45**
CELL BIOLOGY			■		**60**
CANCER BIOLOGY AND THERAPY					**60**
ELECTIVES					**30**
SEMINAR	■	■	■	■	**120**
M. Sc. THESIS			■	■	

75% core subjects
25% oriented subjects

WARSAW UNIVERSITY

MEDICAL PHYSICS PROGRAMME
(ORIENTED SUBJECTS)

SUBJECT SEMESTER	**7**	**8**	**9**	**10**	NUMBER OF HOURS (TOTAL)
CELL BIOLOGY AND PHYSIOLOGY					**30**
PHYSICAL FUNDAMENTALS OF DIAGNOSTIC					**60**
PHYSICAL FUNDAMENTALS OF RADIOTHERAPY AND RADIATION PROTECTION					**45**
BIOELECTRICITY AND FUNDAMENTALS OF BIOCYBERNETICS					**45**
STATISTICAL METHODS IN BIOLOGY					**90**
MATHEMATICAL MODELING OF PROCESS IN BIOLOGY AND MEDICINE					**60**
BIOCHEMISTRY					**30**
MEDICAL PHYSICS LABORATORY					**180**
SEMINAR					**120**
M. Sc. THESIS					

75% core subjects

25% oriented subjects

ELECTIVES :

	Number of hours (total)
Medical Image Processing	**60**
Environmental Physics	**45**
Introduction of Biomaterials Science	**30**
Artificial Internal Organs	**30**
Technique of Membrans	**30**
Quick Analytical Tests for Medical Application	**15**
Mathematical Modelling of Process in Biology	**30**
Biosensors	**30**
Microdosimetry	**60**
Clinical Application of Computed Tomography	**60**
Computerization of measurements	**45**
Introduction to Aerosol Science	**30**
Electronic Dosimetry Equipment	**30**
Radioactive Waste Disposal	**30**
Radiation Protection in Hospitals	**45**
Accelerators	**30**
Cryogenics and Superconductivity	**45**
Physics of NMR and EPR	**30**

Poland, Krakow

M.SC. THESES IN MEDICAL PHYSICS AND DOSIMETRY 1994/95

-Influence of strong MW fields on selected bioindicator (Tradiscantia Statemen Hair Assay

-Analysis of n-penthan in exhausted air for medical diagnosis

-ACTH tracing for imaging of superrenal gland

-Study of reflective power of biological surfaces

-Comparative analysis of genotoxic hasard induced by ionizing radiation and petroleum products

-Modeling of detection process in physical and biological systems

-Clinical application of TLD dosimetry

THE HOSPITAL PHYSICIST IN PORTUGAL

J.GOMES da SILVA[1,2] , NUNO TEIXEIRA[1,2], J. MARIANO[2]

STATUS

The Population of Portugal is 10 million and the history of Medical Physics in Portugal dates from 1931. At the present moment, there are a very small number of Hospital Physicists in Portugal (26): 15 working in Radiotherapy, 10 in Nuclear Medicine and 1 in Radiology, all of them working in three main cities of Portugal: Lisboa (12), Porto (9) and Coimbra (5).

There are also 8 physicists in the protection area, in the Ministry of the Environment, where there exists a radioprotection and Nuclear Safety Department. They are in charge of the radioprotection film dosimetry, covering all the country (government and private institutions) and ambient radioactivity.

The national authority in radioprotection is the National Radiation Protection Commission. The legal decrees D.L. 348/89 and D.R. 9/90 implement the Community directives about radioprotection in Portugal.

HISTORY

1931-1933:

IPOFG (Lisbon) New building for the Radiodepartment; Physics section (Radium Dosimetry and Radioprotection) with several physicists (not H.P.); Roentgentherapy Section.

Later:

Nuclear Medicine laboratory with several physicists; Radioprotection section.

1958:

First Cobalt machine in Portugal; First H.P. in Radiotherapy (IPOFG, Lisbon)

After 1960:

IPOFG (Coimbra) 2 Ro therapy machines, 1 Co unit, 1 H.P.
IPOFG (Porto) 1 Co unit, 1 H.P.

Until 1974 - 1 H.P. in Angola, 1 H.P. in Mozambique.

LEGISLATIVE BACKGROUND CONCERNING THE HOSPITAL PHYSICISTS

In Portugal a regular training scheme has not yet been implemented. The medical physicists working in governmental hospitals received their training abroad or from colleagues in the hospital where they started work. There are also private clinics, some of them employing physicists full time (3) and others having a part-time assistance or no co-operation with medical physicists at all.

The hospital physicists working at the governmental hospitals are Health Civil Servants and their career is named Tecnicos Superiores de Saude. They must have an university degree ("Licenciados") in Physics or Physical Engineering (4-5 years of study).

For the last two months our government has been modifying the career of the hospital physicists. That career was initially ruled by the legal decree D.L. 414/91. In September 1994 two decrees were issued in the Official Journal about the training course for new hospital physicists (291/94 and 796/94), and a process of admission for new physicists is starting just now. Last October, in the Official Journal another decree was published (931/94) with the final regulation of the H.P. career. The career system requires as further qualification ("Especialista", Specialist) an in-service training course of two years, with courses on different physical and medical areas, as well as legislation, administration and financial areas. In Fig. 3 an inter-comparison is shown between the levels of our career and the recommendations of EFOMP.

STATUS AND THE ACTUAL NUMBER OF HOSPITAL PHYSICISTS IN PORTUGAL

The number of hospital physicists in Portugal is given in the following tables. As we can see, the number of hospital physicists is very small (26) when we consider the EFOMP recommendations (more than 70). From those 26, only 9 (35%) are working less than 5 years (time that we think necessary to prepare a hospital physicist), 15 (58%) are working in Radiotherapy, 10 (38%) are working in Nuclear Medicine and 1 (4%) are working in Radiology.

Although we do not have the exact number of new patients and equipment, we can see clearly that there is an enormous deficit of Hospital Physicists in Portugal.

At the present moment one of the authors is establishing contacts with academic authorities (Universidade Nova de Lisboa) in order to promote M.Sc. or Ph.D degrees in the H.P. areas.

Under our point of view it is also necessary to improve our career (higher salaries and more attractive); to define responsibilities (H.P./Radiotherapists/Technicians) and to establish medical physics departments in government hospitals. It is necessary also to reorganise the actual H.P. association (actually is a section of medical radiological society) or to create a separate organisation when the number of H.P. grows up.

FUTURE NEEDS

The number of medical physicists in Portugal has to be increased in order to accomplish with the EC Directives and the role and status of the Qualified Expert in Radiophysics has to be regulated. The first steps in this direction will be opening new vacancies and organising of training courses. For this MSc/Ph.D schemes need to be developed together with the appropriate Universities (UNL). These steps would be facilitated if Medical Physics Departments with defined responsibilities were established in the Governmental Hospitals and perhaps with reorganisation of the professionals in a separate association. Last, but not least, improvement of the basic salaries will attract more young people to the profession.

The present paper is a personal point of view about the Portuguese hospital physicists (HP) position and does not express the Portuguese health authorities opinion, as the authors are participating in this meeting as a single physicist and not as a civil servant and/or governmental representatives.

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Appendix

Table 1:
COMPARISON BETWEEN EFOMP RECOMMENDATIONS AND THE PORTUGUESE H.P. CAREER

COMPETENCE LEVEL	**TRAINING/** EFOMP RECOMMENDATIONS	**EXPERIENCE** PORTUGUESE H.P.CAREER
1	Relevant first degree or equivalent (Bsc, 3 years)	University Degree in Physics "Licenciado" (4/5 years)
2	1 + 2 years directed training	1 + 2 years course/training + examination: Especialista Gov. Post: Assistente
3	2 + 2 years subsequent practical experience	2 + 3(*) years + curriculum appreciation. G.Post: Assistente Principal
4	3 + 4-5 years of subsequent experience (e.g. Head of a small section)	3 + 4 (*) years + examination G.Post: Assessor
5	4 + greater responsibility and a mature overview (e.g. Head of department or large Section)	4 + 3 years (*) + Examination and Thesis G.Post: Assessor Superior
QUALIFIED EXPERT	Level 3	??? not legally established

(*) The number of years depends on the permission of the Government.

The IPOFG (Lisboa) with academic authorities (UL, UNI,) is promoting training/research programmes (1 academic year) for students (5th year), after completion of their scholar studies programme (4 years). Financial help from Portuguese Cancer League (LPCC) and other possible organisations are in progress at the present moment.

Nuclear Medicine (Portugal)

	Physic	Gamma C	Bone D
Lisbon			
IPO	2	3	0
FML	1	2	1
HSC	0	1	0
I.Cor.	0	1	0
F.Aerea	0	1	0
Priv.1	0	2	0
Total	3	10	1
Porto			
IPO	1	1	0
HSJ	2	3	1
Priv.1	0	1	0
Priv.2	1	1	0
Priv.3	0	1	0
Total	4	7	1
Coimbra			
HUC	0	3	1
FCM	1+2(<5y)	3	0
Priv.1	0	1	0
Total	3	7	1
TOTAL	**8+2(<5y)**	**24**	**3**

Considering just Gamma cameras, we obtain the number of 12 Hospital Physicists in Nuclear Medicine, according to the EFOMP.

Radiology (Portugal)

Hospital Physicists	1
CT Systems	68
MR Systems	14
Angiographic systems	20+8(card.)
General X-ray	?

If we just consider the number of Diagnostic Radiology equipment (Digital X-rays + CT + Mammography) serving 500 000 people, we should have 20 Hospital Physicists in Radiology.

Table 2: RADIOTHERAPY (PORTUGAL - 10,000,000 PEOPLE)

	Phys.<5y	Phys.>5y	Lin.Acc.	Co-60	Xray	Simul.	Af.Load	Comp.T.P	Wat.Tank	Dos./I.C	TLD Sist.	S.S.Dos.	N.Pat/y
Lisbon													
IPO	2	4	2(+1)	5(+1)	0	1	3	2	1	6	2	2	3000+600
HSM	1	0	1	1	0	1	1	2	1	2	0	2	1000
Priv.1	0	0	0	1	0	0	0	0	0	0	0	0	400?
Priv.2	0	1	1	1	0	0	0	0	0	1	0	0	400?
Total	2	6	4(+1)	8(+1)	0	2	4	4	3	9	2	4	
Porto													
IPO	2	2	3	2	0	2	4	2	2	2	2	0	1862+993
HSJ	0	0	0	1	0	1	0	1	1	1	1	0	Star/1994
Priv.1	1	0	0	2	0	0	0	0	0	1	0	0	400
Priv.2	0	0	0	1	0	0	0	0	0	0	0	0	Star.1994
Total	3	2	3	6	0	3	4	3	3	4	3	0	
Coimbra													
IPO	1	1	1	2	1	1	2	2	1	2	1	1	1111+164
Total	1	1	1	2	1	1	2	2	1	2	1	1	
Total	6	9	8(+1)	16(+1)	1	6	10	9	6	15	6	5	8973+1600
WTE (EFOMP)			0.8	0.4		0.4	0.4	0.4					1.2/2.5
Num.Phys			7.2	6.8		2.4	4	3.6					10.7/4

If we consider the EFOMP numbers, we can see that there is just a small part of the necessary Hospital Physicists working in Portugal. Considering the existence of 400 new patients in each institution where we do not have good information, the number of Hospital Physicists should be 24+ 15 = 39, and at the moment there are just 16.

MEDICAL RADIATION PHYSICS AND ENGINEERING IN ROMANIA

C.MILU[(1)] and M.ANTONEANU[(2)]

STATUS

In Romania ionizing radiation is widely used for both diagnosis and treatment, e.g. X-ray diagnosis, radiotherapy and nuclear medicine. According to the 1993 Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (1), before 1989, in a population of more than 23 millions of inhabitants in Romania, were reported as existing; 2, 746 X-ray diagnostic units and additionally, 1,100 dental units, 202 X-ray Teletherapy units, 20 Cobalt-therapy laboratories and 2 LINACs, as well as 39 nuclear medicine clinics. The situation is given in Table 1. After 1989, the total number of units is roughly the same, but the structure of medical devices has been slightly improved, especially by the acquisition of about 25 new CTs and of some other modern X-ray diagnostic machines.

The annual number of medical radiation examinations and treatments, reported for 1990 is: 11,392 thousand X-ray diagnostic examinations (which means about 500 examinations per 1,000 population and a strong decrease from 70: more than 1,000 exams), 55.8 thousand radioisotopes examinations and 157 thousand therapeutic treatments (about 2/3 of them by X-ray). The situation is presented in Table 1.

In the medical radiation field there are approximately 165 medical radiation physicists and engineers. Their distribution by specific domains of professional activity is presented in Table 2.

The 41 medical radiation physicists and engineers from diagnostic radiology and imaging, are mainly from CTs Network (approx 20 labs), which was developed during the last 8 years. All the other X-ray diagnostic units have no medical physicists.

All the 33 physicists and engineers from radiotherapy are involved in Cobalt-60 teletherapy, and LINACs. By a regulation of the Ministry of Health, each Cobalt-therapy laboratory must have engaged at least one radiotherapy physicist.

The 26 physicists and engineers from nuclear medicine, as in X-ray diagnosis, appeared during the last 8 years, due by the introduction in this field of some new techniques of investigation.

All the 32 physicists and engineers from radiation safety belong to the Radiation Hygiene Laboratories Network (21 labs) of the Ministry of Health. This National

Network is co-ordinated by the Institute of Hygiene, Public Health, Health Service Management, in Bucharest. The staff members of this network carried out the national studies on medical exposure of the population of Romania (investigations on frequency of procedures, patient dose measurements, risk assessments, quality assurance and control). Part of their research results are included in UNSCEAR Reports.

The repair and maintaining of all installations is provided by specialized teams of the Ministry of Health, belonging to the county Medical Directions. In Bucharest, in addition to such a team, there is also a Central Service Laboratory of the Ministry of Health, which performs checking of the equipment, special repairs and supplies, technical assistance for setting-up of X-ray machines.

The majority of the 165 medical radiation physicists and engineers from Romania are active members of one of the following national societies and professional associations:

- Romanian Medical Physicists' Association (approx.60 members);
- Romanian Society for Radiobiological Protection (an Associate Society to the International Radiation Protection Association, having 370 members, 50 being physicists and engineers from medical radiation field);
- Romanian Society for Clinical Engineering and Medical Computing (about 100 total members, 30 from medical radiation).

All medical physicists, engineers and other radiation specialists (radiochemists) radiobiologists) have a university education (University or Polytechnic Institute), with an M.Sc degree.

EDUCATION

Post-graduate specific education in the medical radiation field is actually acquired in the process of work, as unfortunately, in Romania there is not existing now for this purpose an organized training system. Due to the lack of such an official education system, the certification and recognition of the profession encounters in practice great difficulties .

This situation must be improved very soon, as the number of specialists requested in radiation medicine will increase during the next years. Good career opportunities in the profession are available in the near future, the Ministry of Health already ordered some new and very complex equipments, which certainly need to be operated and maintained by appropriate persons (physicists and/or engineers). It was also realised that physicists are requested and even in conventional X-ray diagnosis, for quality assurance and control activities.

With the aim to improve the specific training of workers from medical radiation, several courses and seminars were organised by the professional societies and associations and/or by different medical research institutes. We can mention here the last Workshop organised by the Institute of Hygiene, Public Health, Health Services and Management-Bucharest from 18th to 21st of October 1994 on "Radiation protection and quality assurance in diagnostic radiology". 30 Physicists and engineers and 20 radiologists attended the meeting. The lectures were presented by 6 experts from U.K. Belgium, Italy and Switzerland, and the kind support from the Clinical Science Foundation, London and The International Atomic Energy Agency-Vienna. Similar further assistance would be very useful.

A part of medical radiation physicists and engineers from Romania succeeded to have Ph.D degree in different specialities (not in medical physics). Some of them were trained in several scientific specialities (not in medical physics). Some of them were trained in several scientific institutions abroad and/or attended international meetings. A reduced number of members of other national societies (like, American Association of Physicists in Medicine).

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Appendix

TABLE 1: Radiation medicine units and procedures in Romania (in 1990, 23 Million inhabitants)

	Diagnostic Radiology		Radiotherapy		Nuclear Medicine (number of laboratories)	
	X-ray diagnostic	Dental	Conven-tional X-ray	Co-60	LINAC	
Number of units	2746	1100	202	20	2	39
Tot. No exams. or treatments (1000)	10688	704		157**		55.8*

TABLE 2: Medical radiation physicists and engineers in Romania (Sept 1994)

Medical Physics						
	Total No	Diag. Radiol/ Imaging	Radio-therapy	Nuclear Med.	Rad. Safety/ hygiene	Equip. Maintenance
Med. Rad. Physicist	100	23	25	19	30	3
Engineer	65	18	8	7	2	30

MEDICAL PHYSICS IN ROMANIA
AND AT THE "AL.I.CUZA" UNIVERSITY OF IASI

C. COTRUTZ[(1)], P. FRANGOPOL[(1)], G. POPA[(1)], M. SANDULOVICIU[(1)],
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STATUS

Romania (23 million inhabitants) is probably of the few countries in Europe which has not yet recognised the medical physicist profession as a necessity, by law and/or by internal orders of the Ministry of Health (1).

None of the major Romanian Universities has medical physics as a distinct area of education and research. Similarly, until now, no special training has been given to the graduated physicists, based on a syllabus scheme in order that the trainee could acquire an adequate academic knowledge of the application of physical sciences and engineering in medicine.

The Romanian Medical Physicists' Association (RMPS), organised in 1990, is the professional body for the radiation physicists working directly in hospitals and related fields to medical physics (around 35 from a total membership of 61). Thus, Romania has only slightly more than 1.5 medical physicists per million inhabitants.

Despite the fact that oncological treatments with Radium started early in 1927, with sources donated by Maria Sklodowska-Curie to the hospitals of Bucuresti, Brasov and Cluj, the medical physicists appeared in the hospitals, only later in '60's, as a necessity to use the cobalt therapy apparatus, just introduced in the Oncological Institutes of Bucuresti and Cluj.

The first years were very difficult since it was necessary to surpass, firstly, the suspicions and lack of confidence of the medical doctors and secondly, the non-existence of scientific literature and techniques for a real physical and clinical dosimetry. These heroical years of very good self-education (1960-1990) received an unexpected confirmation: before and after the fall of the "iron-curtain" (1989), a lot of medical physicists emigrated and now are working as medical physicists in countries with tradition in the field, e.g. USA, Switzerland, France, Israel, Germany etc.

It is worth mentioning a very important step in the field: the Ministry of Health organised at the end of '70s some Institutes and regional laboratories of Hygiene and Public Health (Bucuresti, Iasi, Timisoara, Cluj, etc.), which are involved mainly with radiation protection, occupational health, food contamination, water and air pollution, radiation hygiene Inspection of radiation installations, etc. Here are also working medical physicists mainly for quality assurance. The regional laboratories (17) now, have special duties and new names: centres of oncology and external radiotherapy with ^{60}Co, which by decision of the Ministry of Health "should have a medical physicist." In the last decade an increased number of nuclear medicine laboratories within Romania have been organised in the regional hospitals (with M.D., chemists, biologists and a few medical physicists).

The development of the applications of radiation in other fields as well, led the State Committee for Nuclear Energy to organise with the Institute of Atomic Physics Magurele-Bucharest and the Faculty of Physics of the Bucharest University, a common postgraduate training course (M.D., chemists, engineers, biologist, etc.) in the utilization and application of radioisotopes for persons who will have responsibilities in the application of radiation (industry, hospitals, Universities). The course is effective, every year since 1956, but is not useful for medical physicists (well known syllabus from the Faculty of Physics courses) and for the M.D's is hard to understand (lack of the elementary background). Until today, the true education remains the same: within the internal seminars of the Institutes as well as during the Internal National Conferences of the RMPA.

It should be mentioned that within the National Centre of Physics, the Institute of Atomic Physics and other Institutes located at Magurele (15 Km from downtown Bucharest), a strong nucleus in radioprotection, dosimetry, etalon sources, quality assurance and control, nuclear medicine, preparation of radioisotopes, radiopharmaceuticals, labelled compounds and dosimeters, has been developed in the last 40 years. Currently, various apparatus (electronic devices or big machines - e.g. betatrons for oncological use etc.) are realised. Also, internal contamination in the whole body (thyroid and lungs) biokinetic studies for committed effective doses, are currently measured using in-house international homologated equipments with original and/or well known methods (e.g. the **BO**ttle-**M**anechin-**AB**sorbtion, **BOMAB** type of calibration, etc.) All the above activities are related also with direct applications in medical physics. There are numerous books from Romanian authors on Radiation Physics, Radiation Protection (2,3) and Medical Engineering, also original papers published in leading international journals, proving an international recognised expertise in the domain. Only the latest published materials (selected) are mentioned in the bibliography (4-14).
Disintegrated after the 1989 Revolution, the Romanian Agency for Atomic Energy was recreated, by Government Decree on October 30, 1994. It is a new and real hope for reinvigorating the Medical Physics in Romania according to

European standards. Until now, the existing national regulatory body for nuclear/radiation safety is the National Commission for Nuclear Activities Safety Norms, Law No. 61/1976; b) Norms for Radiation Protection, 1976; c) Work Rules with Nuclear Radiation Sources, 1976; amended in 1979 and 1981; d) Norms for Transport of Nuclear Materials, 1975; e) Rules for Issue of the Permits to Work in the Nuclear Field, 1990.

In the last three years advanced technology has been introduced in all medical domains. It became necessary to create a University Medical Physics Department in order to train physicists able to ensure the proper and safe use of new technology in Romania.

THE EDUCATION IN THE UNIVERSITY OF IASI

The ministry of education received the proposal made by "Al.I.Cuza" University to enlarge the scope and activities of the Department of Biophysics, which is part of the Faculty of Physics, to become "Biophysics and Medical Physics Department", including in this way graduate and postgraduate educational and research projects in both Medical Physics and Biophysics, beginning with the 1995 University year.

A radiation Medical Physics laboratory will be set up at the "Al. I. Cuza" University of Iasi, Department of Biophysics and Medical Physics, the first such laboratory in a Romanian University, to train future physicists specialising in Medical Radiation Physics. This laboratory will be realised and with the assistance of the International Atomic Energy Agency (IAEA), Vienna (1995-1996).

A scientific cooperation and practical training of the students from Iasi University with the Oncological Institute in Bucuresti, a methodological oncological Centre for Romania, also with the Oncological and Radiotherapeutical Centre in Brasov has already started.

To achieve the immediate above mentioned objectives e.g. to engage in educational and research work, directed to accomplish the requirements for MSc and PhD thesis, besides the broader international assistance requested, important support has already been received from:

1. IAEA Vienna, with a project for technical cooperation (1995-1996), a model one for Europe and the Middle East, decided to assist our Biophysics Department to set-up a Medical Physics Laboratory, for training medical physicists, in order to meet Romania's requirements for medical physicists for the next ten years.

2. JEP-TEMPUS II Program (1994-1997) with the kind help of ERASMUS Project coordinated by Patras University, Greece, for training in medical physics each year 5 students from our university, for 8 months. It should be mentioned that another 9 students from Technical Universities of Romania are attending the training in Patras, only in Bioengineering. They come from: Iasi (2), Bucuresti (2), Craiova (1), Timisorara (2), Cluj-Napoca (2).
3. Scientific Collaboration in medical physics between Iasi, Patras and Thessaloniki Universities.
4. Scientific collaboration in medical physics within the frame of Governmental accord between Greek and Romanian Ministries of Research and Technology, with the University of Patras (Prof. B Proimos).

As can be seen, the points 2-4 fall within the framework of a general effort to establish University Centres of Medical Physics and Bioengineering in Romania and particularly in Iasi.

As far as we know it is a unique example of pragmatic cooperation and collaboration now, in Europe, in this field, as a concentrated and rapid effort toward the integration of Romania within the International standards in medical physics, Greece playing a particularly very important role in our very beginning: the IAEA expert from Romania for medical physics was Professor Basil S. Proimos, from Patras University, Greece.

It is our strong hope that the European Federation of Organisations for Medical Physics (EFOMP), in collaboration with the International Organisation for Medical Physics (IOMP), the International Federation for Medical and Biological Engineering IFMBE), the World Health Organisation (WHO), and different other National West European Associations in Medical Physics, along with other international associations, will try to find a way to help in promoting our efforts recommending and/or advising the Romanian authorities to establish by law the necessity of recognising the profession of medical physicist in all the hospitals and clinics in Romania. The Medical Physicist profession is well established and without it the health care service is impossible to be done normally. Medical physics can be described as the scientific discipline which is concerned with the application of the concepts and methods of physics in medicine; also, medical physics is a health care profession and the medical physicists whose training and function are specifically directed towards health care is entitled to an official recognition as a specialists; the formal entry training into the profession of medical physics has physical sciences as an essential component of the academic education (15-17).

Establishing and organising in Romania medical physicist education, profession and career (higher salaries and more attractive positions), according to the already existing international standards, is our first priority for the near future.

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THE EDUCATION OF MEDICAL PHYSICISTS IN RUSSIA

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STATUS

Medical physics in Russia has been developing for the last twenty years. Specialists work mainly at radiation therapy and nuclear medicine departments in oncological hospitals. There are about 200 hospitals which need medico-physical services. Most of them are in the European part of Russia. The specialists' work is various including physics, engineering, teaching etc. As a rule medical teaching training is provided at the working place. There are also one-month courses organised by the Institute for Post-graduate Medical Education. They are only held once every two years which appears to be quite insufficient. That is why the Association of Medical Physics in Russia (AMPR) and the Cancer Research Centre in Moscow decided to organize appropriate education and training for physicists working in Radiation Therapy Departments.

The Association was founded in 1991. The first President was the late Professor A. Gurvich. At present the AMPR has more than 250 members. This is not a large number taking into consideration that there are more than 200 hospitals and oncological dispansers which need qualified radiation medical physicists as well as many scientific institutes for research and development of medical equipment.

One third of the Association's members are hospital physicists most of these working in radiation therapy departments. Another one-third are specialists developing various medical equipment and the rest are academic staff (professors and lecturers) working at chairs of Physics in Medical Institutes. The present President of AMPR is Dr V.A.Kostylev, Head of Medical Physics Department in the Cancer research Centre of the Russian Academy of Medical Sciences and the Secretary-General is T.G.Ratner, Ph.D. and Senior Research Fellow at the same department.

The Cancer Research Centre is the largest oncological institute in Russia. There is a clinic with 1000 hospital beds for all kinds of treatment of oncological patients and a big emergency department. The radiation therapy and medical physics departments are well equipped. There are simulators and a CT unit for topometry, seven various systems for computer dose planning and dosimetric equipment. For tele-irradiation 3 liner accelerators, 6 gamma-units and proton beam ITEP are used. For intra-cavitary and interstitial therapy are used Co-60 and Cf-252 needles, 2 Selectrons with Cs-137, low and high-dose microselectrons with Cs and Ir-192, AGAT with C0-60 and ANET-VA with Cf-252(with a gamma-neutron source).

EDUCATION

At present there is no specialized undergraduate education in medical physics in Russia. Post-graduate education is rather sporadic. One-month courses are organised for physicists working in radiation therapy only. The Association also organizes short 1-2 week refreshing courses and courses for training in particular subjects only for physicists and doctors, i.e.: calibration of dosimetric equipment; quality control of tele-irradiation; manual and computer dose-planning; intra-cavitary irradiation; new regimes in radiation therapy; equivalence of biological doses; new modes of equipment; hypertermia etc.The best qualified specialists from Moscow Institutes provide tuition for those courses. Up to now more than 100 specialists have received a certificate.

At present one of the main tasks of the Russian Association is the developing of a National Educational System which will be oficially approve. The Association accepts in general the EFOMP recommendations for a 4-year basic course in physics followed by a 2-year study of medicine, biology and special techniques and then two years of training at a clinic. Special attention is to be paid to the education or rather the preparation of physicists to work in clinics and especially in clinical research. During the two years the students will study various subjects: special techniques, biology, radiobiology, medical topics, anatomy, physiology, oncology, roentgenology etc. Their substance is very different and in two-years' time the students' psychology would be changed very much.

One of the biggest problems that physicists face at the beginning of work is the lack of understanding (at times) with the medical doctors. To our opinion physicists should be prepared to understand that the main strategic tasks in clinical work are clinical problems while technical and dosimetric problems are subsidiary. Another important problem for physicists is to acquire knowledge of relations with the patient and of patient behaviour. We are trying to include such topics in the envisaged post-graduate education for medical physicists so that they will be prepared to work in clinics as true partners to medical doctors.

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POST-GRADUATE EDUCATION IN MEDICAL RADIATION PHYSICS IN THE SLOVAK REPUBLIC

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STATUS

Slovakia has approximately 5.5 million inhabitants. The departments, equipment and number of physicists in Slovakia are shown on Table 1 below:

Table 1

Department	Number of Departments	Equipment		Number of Physicists
		Type	No.	
Radio-diagnostics		XRU CT MRI	1500 27 2+3*	5.5
Radiotherapy	14	Cs/Co LA XRU AF SIM TPS	3/14 3+5* 16 10+4* 3+1* 12	19
Radiation Physics	1	dos TPS	3	4
Nuclear Medicine	12	GCC IVA GC	20/9** 25 10	14
Radiation hygiene	6			28

Key to the Table:
XRU - X ray unit; CT - Computer tomography; MRI - magnetic resonance; Cs - 137 cesium unit; Co - 50 colbalt unit; LA - linear acceserator; AF - afterloading HDR, LDR, PDR, SIM - SIMULATOR; TPS - Treatment planning system; dos - Dosimetry. GCC - gamma camera computer; IVA - in vivo apparatus; GC - gammagraphy; + will be installed shortly, ++ - spect.

The only independent department of Radiation Physics is the one at the National Cancer Institute (hospital of St. Elizabeth), the rest of the physicists presented in the table 1 are members of the Departments of Radiotherapy, or Departments of Nuclear Medicine. The distribution of the respective equipment in Slovakia is shown below:

BANSKA BYSTRICA	3 TPS 2 GCC 2 Co 2 IVA 1 GG 1 AF 1 LA willbe installed
BRATISLAVA	5 GCC 6 IVA 1 LA 2 AF 1 SIM 2 Co 3 TPS 3 GG 2 LA will be instaled
KOMARNO	1 Co
KOSICE	2 GCC 1 GG 4 IVA 1 LA 2 Co 1 SIM A AF 2 TPS
LUCENEC	1 Co
MARTIN	2 GCC 1 IVA 1 TPS 1 Co 1 Cs 1 AF
MICHALOVCE	3 IVA 1 GCC 1 TPS 1 AF 1 Co
NITRA	2 GCC 1 IVA 1 GCC 1 TPS 1 AF 1Co
POPRAD	1 GG 2 GCC 2 IVA
PRESOV	1 GG 1 VA 1 GCC 1 LA will be installed
RIMAVSKA SOBOTA	1 Co 2 IVA 1 AF 1 TPS
ROZNAVA	1 GG 2 GCC 1 Co 1 AF
TRANCIN	1 SIM 1 Co 3 TPS 2 AF 1 LA
TRANAVA	2 IVA 1 GCC 1GG
ZILINA	1 Co 1 Cs 1 AF 1 TPS 1 LA will be installed

EDUCATION

The undergraduate education of physicists can be realised at various faculties of the University: Mathematico-physical Faculty, Facualty of Natural Sciences, or Electrotechnical Faculty. At the end of this education the candidates are granted the degree of RNDr (rerum naturalium doctor) - equal to MSc. During these studies the students are educated in dosimetry, nuclear physics and electronics. Consequently, arriving at health service institutions, the physicists have no experience in the field of any work with patients and are lacking the knowledge of anatomy, physiology or pathophysiology. Therefore, before starting the work with patients, they are obliged in 6 months to complete their education finalised by a test.

STRUCTURE OF THE POST-GRADUATE EDUCATION

There are two alternatives of post-graduate education in Slovakia:

Alternative 1: 4 - 6 semestral education in clinical dosimetry, radiobiology, the use of computers in medicine, etc. This education is closed by a the defense of thesis and examination. The education is usually organised by a faculty of the particular university.

Alternative 2: Three years of postgraduate education at the Institute of Postgraduate Medical Education [IPME], following which a candidate is granted the specialisation of a physicist with permission to work in radiotherapy, nuclear medicine and radiation hygiene. This education includes a 4-week stay in one of the specialised institutions, participation on special courses [brachytherapy, clinical dosimetry, therapy planning, etc.], organised by the IPME or by the ESTRO. The education is organised in two sections of theoretical and practical areas (general section and special section). They include the following topics:

1. General Section:
-a. basic anatomy: **(See appendix 1)** topography of organs on the basis of body orientation points and lines related to the: brain, upper respiratory tract, lung, gastrointestinal system, urinary tract, female and male reproductive organs, lymphatic system and thyroid gland.
-b. health service organisation, focused on the field of radiotherapy and oncology.
-c. psychological aspects in cancer patients.
-d. ethios of health service personnel.
-e. basic emergency services.

2. Special section:
-a. basic clinical oncology [cancer aetiology, pathology, diagnostics and treatment methods]
-b. basic radiobiology [effects of irradiation in cell, damage following irradiation, radiosensitivity, tolerance of critical organs, etc.]
-c. basic radiophysics [corpuscular and electromagnetic radiation, interaction of ionising radiation with matter, absorption coefficients, LET, etc.]
-d. dosimetry [absorbed dosis, equipment, data for planning systems, etc]
-e. therapeutic application of ionising radiation [equipment, techniques, therap planning, fractionation, reactions, etc.]
-f. standardisation of dosimetry
-g. radiohygiene [directives, safety, controls, etc.]
-h. statistical methods
-i. practical knowledge [dosimetry, planning, equip. control] - see appendix 2

A thesis and oral examination finalized the course.

The above listed syllabuses have been elaborated and our present aim is to adjust the education to the standards of the EFOMP, ESTRO and EC, to be able to provide internationality acceptable certification.

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APPENDIX 1:

a/ basic anatomy
CNS (brain, spinal cord...)
Skeleton (head, spine, pelvis, extremities)
upper respiratory tract (epipharynx, larynx, trachea)
lung (lobar, bronchial arbor)
gastrointestinal system
(oral cavity, oropharynx, hypopharynx,oesophagus, stomach..)
urinary tract (kidney, gall bladder...)
female and male reproductive organs
lymphatic system (lynph, nodes in neck, thorax and abdomen)
thyroid gland
physiology

APPENDIX 2:

a/ diagnostic methods
X-ray, CT - MRI and nuclear medicine
treatment methods
surgery, radiotherapy, chemotherapy etc.

b/ basic radiobiology
4 R, reversible, irreversible damage, genetic changes etc.

c/ basic radiophysics
ionization and non ionization radiation, interaction, scatter, radiation protection, dose quantities
quality factors
medical electronics

d/ **dosimetry**
equipment, dosimetry theory and methods in radiotherapy, beam characteristics; in vivo dosimetry

e/ **therapy application**
X-ray, accelerators, afterloadings, target volume, critical organs localization, 2 D, 3D, treatment planning systems and algorithm...

f/ **standardisation** - dosimetry
quality standards
equipment
laws and legislative

g/ **radiohygiene and protection**
staff and patients
training and test
electrical, mechanical and biological safety

h/ **statistical methods**

i/ knowledge from all previous courses

MEDICAL RADIATION PHYSICS IN SPAIN

P. FERNANDEZ LETON[(1)] and M. RIBAS MORALES[(2)]

STATUS

The population in Spain is over 38 millions of inhabitants. In general, medical physicists belong to The Spanish Society for Medical Physics (SEFM) that has 221 members distributed in the following areas:

Radiotherapy (RT) 96(43.4%)
Diagnostic radiology (RD) and Radiation protection (RP) 49 (22%)
Nuclear Medicine (NH) 10 (4.7%)
Teaching at University 48. (22.6%)
Other areas (civil servants, instrumentation, etc) 18 (8.1%)

At the end 1992, according to the data given by the Spanish Assocation for Radiotherapy Oncology (AERO), there were 78 RT centres (public and private), 43 of them also included Brachytherapy and the number of equipment in external RT was:

Conventional X ray	43
Cobalt units	84
Linacs (photons 6 MV)	6
Linacs (photons + electrons)	40
Simulators	45
Treatment planning Systems	66
Radiation field analyzer	38
Number of treated patients per year	39524

At the end of 1994, according to the data given by the Spanish Society for Nuclear Medicine (SEMN), there were 70 centres (public and private), each with two gamma cameras at least.

Concerning the physicists who are working in hospitals within ionising radiation field, they can be grouped into two different situations, about half:

- an independent Department of Medical or Radiation Physics and Radiation Protection, for covering it altogether, in which case have 3-6 people, or
- one department of Radiation Protection and other physicists working in RT, NM Departments who belong to each of them.

Table 1 below shows the number of physicists per hospital

	1 physicists	2 physicists	3 physicists	4 physicists	5 physicists
No. Hospitals	16	15	12	6	8

REGULATORY BODIES IN RP

In our country there are two regulatory bodies related to RP:
Council of Nuclear safety, responsible for RP of workers and general public, Ministry of Health, responsible for RP of patients.

GENERAL EDUCATION

Up to 1993, the majority had got a degree in Physical Science or equivalent .
Since 1994 a draft Royal Decree from the Ministry of Health concerning a "**training and attainment of Diploma in Hospital Radiation Physics",** allows people having a degree in Physical Sciences, Engineering or Chemical Science to take a post-graduate educaiton on medical radiation physics. The SEFM has complained of the access for chemists.

POST GRADUATE EDUCATION

Up to 1993 this was provided individually by different ways i. e. :

- following a formal post-graduate course abroad,
- special programme in a public notice as residents in 70's (M. Health),
- self taght,
-spending and working sometime with experienced colleagues in recognised national or foreign centres, etc.

Since 1994, according to the draft above mentioned, post-graduate education is provided like a "residence" in a hospital (similar to medical residence) during 3 years with a theoretical programme and practical period in-service (1 year and a half in RT and 6 months in each other areas DR NM and RP). Every year 14 people are accepted and a workable full-time contract is established between the resident and the hospital.

Theoretical programme (temporary)

General topics in Anatomy and Physiology, Rdiological Physics, Radiobiology and instrumentation in radiologialphsics. Specific in each radiation area.

Radiotherapy: radiation sources, physical dosimetry, clinical dosimetry in external RT, clinical dosimetry in brachytherapy, treatment planning systems and quality control.
Diagnostic Radiology: equipment and special procedures, image receptor systems, components and factors affecting the image, physical dosimetry

ACTIVITIES IN PROFESSIONAL DEVELOPMENT
The SEFM organizes every two years national meetings and this year has also organised a post-graduate course in specific topic: Electrons Dosimetry.

CERTIFICATION AND RECOGNITION OF THE PROFESSION
Until now the profession is not officially recognised, but this point is taken into account in the draft mentioned. The career opportunities in the profession are occasional

SCIENTIFIC CONFERENCES
The SEFM has participated in some scientific meetings, invited by other Scientific Societies related to ionising radiaiton field.

FUTURE NEED FOR MEDICAL PHYSICISTS

Up to year 2000, according to the draft Royal Decree a maximum of 56 physicists will have finished their training, however the SEFM has made a first overview of the necessary specialists in these fields and in their opinion a minimum number of 90 (43 in RT, 25 in NM and 22 in DR) would be necessary, depending both on equipment load, number of patients and procedures in each area.

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MEDICAL RADIATION PHYSICS IN SWEDEN

I.-L. LAMM[(1)]

INTRODUCTION

The Swedish Hospital Physicists Association is the Swedish professional body for physicists working in health care The total membership is 213 (August 1994), and around 140 of the members are working clinically as hospital physicists. The remaining membership consists of physicists or engineers (required to be at least university graduates in physics or equivalent) with interest in the field of hospital physics, as well as of students in radiation physics. The Swedish Hospital Physicists Association is the Swedish member of EFOMP.

Hospital physicists, as we are called in Sweden, have traditionally been working in the field of clinical medical radiation physics, especially in ionising radiation applications, the classical areas being radiation therapy, nuclear medicine including radionuclide therapy, diagnostic radiology and radiation protection. With the advent of readily accessible computer power, imaging in a wide sense has been steadily growing in all areas of the clinical responsibilities. Today hospital physics also covers non-ionising radiation applications such as MRI, ultrasound and laser.

NUMBER OF HOSPITAL PHYSICISTS

In 1993, EFOMP made a survey of the number of "Qualified Experts in radiophysics, QE(r)s" in the member countries. This survey asked for the number of all trained medical radiation physicists according to the rules of the country, as well as the number of trained medical radiation physicists with at least five years of relevant experience since completion of training. The outcome in Sweden in number of persons involved is shown in a table below.

The numbers presented below include for diagnostic radiology also those working in radiation protection and in MRI.

Application	All trained medical physicists	Medlical physicists with > 5y experience after completion of training
Radiotherapy	53	38
Diagnostic radiology	38	32
Nuclear medicine	44	37
Total	135	107
Total per 10^6 inhabitants	15.7	12.4

HOSPITAL PHYSICISTS DEPARTMENTS

All hospital physicists are at present employed in hospitals within the National Health Care system, and there are still virtually no private hospitals in Sweden. (Two private MRI installations do exist, in Stockholm and in Lund.) The administration of the hospitals is generally speaking based on 24 "län and landsting", administrative provinces with their county councils. Each province has at least one larger läns-hospital, central hospital, and a relevant number of smaller hospitals. On top of this are six health care regions, each with a larger regional hospital, including specialist clinical departments. The regional hospitals are generally also university hospitals, connected to basic education and training of medical doctors and hospital physicists. To be noted is, that the university hospitals are administrated by the county councils, while the universities are "connected" to the government.

There are of course big differences between different provinces, and 11 of the provinces have only one hospital physicist each. The very last province without a physicist actually created a hospital physicist's position earlier this year, 1994. Thus, there is at least one hospital physicist in each province today. Hospital physicists can be found in 30 hospitals in Sweden, and 13 hospitals are single physicist ones. The three largest hospital physics departments belong to the university hospitals in Gothenburg, Lund and Stockholm, all having 15-16 physicists each. The clinical departments at the university hospitals in Linköping, Malmö, Umeå and Uppsala are slightly smaller, with 7-9 physicists each. The remaining ten departments each have between 2-7 (average 4) physicists.

Number of qualified physicists at department	**Number of departments**	**Total number of qualified physicists**
1 (at central hospitals)	**13**	**13**
2 - 7 (at central hospitals)	**10**	**42**
7 - 9 (at univ. hospitals)	**4**	**32**
15 - 17 (at univ. hospitals)	**3**	**48**
Total	**30**	**135**

The hospital physics departments are generally organised as "clinics", on the same organisational level as clinical departments, with exceptions for some of the hospitals with single physicists. At the university hospitals, the professor in medical radiation physics is also head of the hospital physics department. It is also to be noted for the universities/university hospitals, that the physicists belonging to the university departments are not included in the numbers above; only the clinically working physicists, the hospital physicists, at the university hospital departments are counted.

As an example, eight physicists are working in the radiation therapy section of the hospital physics department at Lund university hospital. In full time equivalents they correspond to 6.5 physicists. In the external beam section there are 7 accelerators (3 with dual photon energies and a number of electron energies), 1 cobalt unit, 1 orthovoltage unit, 1 superficial unit, 2 simulators, 1 dedicated CT-scanner, 1 3D treatment planning systems with 3 workstations. In the brachytherapy section there are 2 remote afterloading units (1 LDR and 1 HDR), 1 simple simulator and 1 dedicated treatment planning system. There are also 2 computerised watertank dosimetry systems, TL, Fricke and ionisation chamber dosimetry systems. With a patient load per year of around 2000 new courses of treatment with external beam therapy and 150 with brachytherapy and a high degree of advanced treatments, the number of physicists ought to be around 9.5 whole time equivalents.

THEORETICAL EDUCATION AND TRAINING, M.Sc. and Ph.D. IN RADIATION PHYSICS

The population of Sweden is around 8.6 million; the number of hospital physicists per million inhabitants is thus rather high. One explanation might be the long tradition of physicists working in clinical radiation physics applications, another might be the strong connections between the clinical applications and the academic world. Radiation physics is a university discipline of its own with a total of seven professorships, and there are university departments of radiation physics at the universities in Lund - departments both in Lund (two chairs) and Malmö, Gothenburg, Stockholm, Umeå and Linköping. The professors of medical radiation physics belong to the medical faculty with only one exception.

Radiation physics is taught as one of several alternatives within the physics programme at the faculty of Natural Sciences at the universities in Lund, Gothenburg, Stockholm and Umeå (the latter at the institute of technology). The first two years of undergraduate education consist of mathematics and physics, computer science, mathematical statistics etc, common to a number of alternatives in the physics M.Sc programmes. The last two years of education are then dedicated to radiation physics, with half a year allotted to the M.Sc. thesis. The basic radiation physics education is harmonised in such a way, that the courses given at the different university departments largely cover the same knowledge material. The radiation physics syllabus covers atomic, nuclear and quantum physics, radiation sources, interaction between radiation and matter, detectors and methods of measurement, dosimetry, radiobiology, medical introduction, radiation protection, environmental radiology, nuclear medicine and systemic radiotherapy, diagnostic X-ray physics, radiotherapy physics including brachytherapy, applied dosimetry, imaging and non-ionising radiations including MR. The Lund syllabus is presented below:

M.Sc. in Radiation Physics: 160p = 4 years of academic education and training

<table>
<tr><td>year 1</td><td rowspan="2">Basic physical sciences, 80p.</td><td rowspan="2">Requirements for RAF001: 80p, with > 30p mathematics, > 30p physics, 5p computer science + other relevant subjects</td></tr>
<tr><td>year 2</td></tr>
<tr><td>year 3</td><td>RAF001, 0-40p</td><td>Basic radiation physics; req. for RAF002</td></tr>
<tr><td>year 4</td><td>RAF002, 41-80p</td><td>Applications in health care ...</td></tr>
</table>

1p = 1 week of study

3years: B.Sc. Basis for medical radiation physics and for industrial work requiring knowledge of radiation physics.

4 years: M.Sc.Theoretical requirements for hospital physicist.

Requirement for post-graduate radiation physics studies - Ph.D.

Year 3: RAF001 - Radiation Physics 1-40p (Lund syllabus)

Introduction, Quantum mechanics 2p	**Atomic and nuclear physics, Radiation sources 7p**	**Interaction radiation - matter 6p**	**Radiation detectors methods of measurem. 5p**
Radiation dosimetry 10p	**Medical orientation 2p**	**Radiation biology 4p**	**Rad. protection - ionising and non-i. rad 4p**

1p = 1 week of study

Year 4: RAF002 - Radiation physics 41-80p (Lund syllabus)

Environment radiology 2p	**Tomographic methods, Imaging 2p**	**X-ray physics 3p**	**Nuclear magnetic resonance 2p**
Nuclear medicine physics 4p	**Radiotherapy physics 4p**	**Dosimetry in radiotherapy 3p**	**M.Sc. thesis 20p**

1p = 1 week of study

Further academic education and training to a Ph.D. level in radiation physics is arranged at all radiation physics departments. The Ph.D. programme covers four years, including approximately one and a half whole time year of theoretical studies and around two and a half years devoted to the thesis. A Ph.D degree is generally required for the higher positions as hospital physicist.

Ph.D. in Radiation Physics: M.Sc + 160p = M.Sc. + 4 years of academic education and training

Number of points	**Equivalent time**	**Type of education**
60p = 20p + 30p + 10p	**1.5 years**	**Theoretical courses**
100p	**2.5 years**	**Thesis**

The theoretical courses are divided into three groups. All post-graduate students have to take the two courses "Interaction between radiation and matter" (12p) and "Radiation dosimetry" (8p). Then there are optional courses which should cover 30p, to be chosen among advanced courses in the common subjects, medical radiation physics (X-ray, radiotherapy, treatment planning, nuclear medicine, ultrasound, MR, etc.), modern physics (e.g. quantum mechanics, solid state physics), electronics and computers, mathematical models and Monte Carlo methods, radiation ecology, radiation biology, medical orientation, imaging, radiation pharmacology, information theory and statistics... The last 10p are devoted to specialised courses connected to the subject of the thesis.

Clinically working hospital physicists are wellcome to participate in these post-graduate courses. There is also a Nordic collaboration around the post-graduate courses in dosimetry, interaction, radioecology and systemic radiation therapy, where teachers and research students from all Nordic countries have participated

LEGAL REQUIREMENTS TODAY

Hospital physics is not a regulated profession in Sweden. However, in 1989 the National Swedish Board of Health and Welfare issued a "General advice on competency requirements for hospital physicists", which replaced an older advice issued as early as 1958. An advice is of course never as strong as a regulation, but this advice is nevertheless of great importance for the profession.

The hospital physicist is "defined" in the introduction of the advice**: "To be able to use new and existing diagnostic and therapeutic methods and techniques in the fields of ionising and non-ionising radiation in a safe, rational and optimal way for patient, personnel and general public, collaboration with persons with competency in radiation physics, *hospital physicists*, is necessary."** The roles and responsibilities of the hospital physicist are then described in some length, as well as the development of the specialty with a presentation of the existing education and training. The requirements laid down on education, training and professional experience are in accordance with EFOMP recommenda-tions, in principle:
"when employing a hospital physicist, this person should have the full qualifications of a hospital physicist, consisting of
***	a university degree with a complete basic education in radiation physics from a department of radiation physics;**
***	clinical experience; a hospital physicist should during the first years of his/her clinical work be supervised by an experienced hospital physicist.**
Hospital physicists having management responsibilities should have several years of documented experience of clinical hospital physics tasks. Generally, these physicists also have a PhD in radiation physics or equivalent."
It is pointed out in the advice, that hospital physics is generally organised in

independent departments and thus not subordinate to any other specialty. Further, it is mentioned that the responsible authority must plan carefully for the development of the field of hospital physics activities, as there is a limited access to physicists with appropriate clinical experience.

Even if the 1989 document is an advice and thus not compulsory, the advice has generally been accepted by the local authorities.

TRAINING AND EXPERIENCE

The Swedish advice on competence for a trained hospital physicist does follow the EFOMP recommendations in principle, by requiring not only theoretical university education but also clinical experience and on-the-job training. However, as there is no official training scheme for hospital physicists in Sweden, it is not possible to require clinical experience when first employing a physicist, according to the authorities; thus the formulation in the advice above concerning clinical experience.

Until some years ago, it was relatively easy for the new university graduates to find temporary positions at the larger hospital physics departments, thus getting the required clinical experience under the supervision of experienced hospital physicists. Even if the training was not provided as a formalised programme, in practice training posts were available. However, the situation is changing today with the much more restrained economic situation. In the newly introduced "buy-and-sell systems", all employees must be fully productive in the short term perspective. The long term perspective is regretfully disregarded (in spite of the advice above), and county councils tend to consider it outside their responsibility to provide organised on-the-job training for new physicists. The hospital physicists are a small group, on one hand with not too much power, but on the other it would not be too expensive to organise the clinical training for this small but necessary specialist group. All parties interested in promoting radiation physics in general and hospital physics in particular are collaborating in the organisation of relevant training schemes.

REGULATED PROFESSION?

For medical doctors there exists a training scheme, where the county councils are required to supply a certain number of paid training positions per year. This scheme is connected to the requirements a fully qualified medical doctor must fulfil in order to be allowed to practice medicine; a regulated profession. The situation might change to the better also for hospital physicists, as there are developments in the regulation area both in Sweden (see below) and on the European level in connection with the revision of the patient protection directive of the CEC.

In spring 1994, the government initiated a committee with the task to look into the qualification requirements of the professions in health care which are not yet regulated. Among the professions listed are hospital physicists. Just over ten years ago, there was another round of regulation discussions. The authorities then decided that it was unnecessary to regulate the profession of hospital physicists. One main argument was that hospital physics services were only required within hospitals, which all belonged to the national health service. As regulations were intended to protect patients and should be as few as possible, only those professions which could include private practices were regulated. The 1989 advice, described above, was a spin-off from those discussions. The situation today is different, with new privatisation trends in all areas of society; a private company selling hospital physics services could well be envisaged, for instance. EFOMP is now recommending guidelines on National Registration Schemes, and we are working along these lines in Sweden, at the same time as we are looking after our interests in the government committee.

Quoted from the EFOMP recommendations: "It is in the public interest, especially patients, that there should be an authoritative means of identifying those persons who have been recognised as competent to practice the application of physical sciences in health care."

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MEDICAL RADIATION PHYSICS EDUCATION IN SWITZERLAND

W. W. SEELENTAG [(1)]

STATUS

Medical physicists in Switzerland are organised in the "Swiss Society for Radiation Biology and Medical Physics" (SGSMP); many also have radiation protection responsibilities and will also be members of the "Fachverband", the German/Swiss Radiation Protection Association.

Some 30 medical physicists are employed in hospitals; 18 of them are certified with 16 working in radiation therapy: with a population of 7 mil. inhabitants this results in just over 2 experienced physicists in radiation therapy per mil.: a figure at the lower end of Europe with 1 ... 6.5 physicists/mil (EFOMP survey 1994). On the other hand there are 13 radiotherapy clinics, equipped with at least 1 linear accelerator (plus 2 under installation): roughly 1 clinic per 1/2 mil. inhabitants - many more centres than considered economically reasonable e.g. by WHO (recommends minimum 1 mil. inhabitants per centre). This is partly due to the fact that health care is to be organised by the counties - and there are 26 counties. So on average there are some 2 .... 2 1/2 physicists per centre: few centres employing several physicists and many clinics with just one single physicist. Other fields of medical radiation physics (nuclear medicine and diagnostic radiology) will usually be covered "part time" by the radiotherapy physicists.

There are also several research institutions employing medical physicists, e.g. the Institute of Applied Radiation Physics (Lausanne), and the Paul-Scherrer-Institute (Villingen, working e.g. on pion and proton therapy).

The combination of low numbers of medical physics positions (relative to the population), and a small country like Switzerland, hampers the establishment of formal, university based training courses. There is no formal graduate training in medical physics; prospective medical physicists will get their degree in physics in general; there are limited possibilities to do the diploma work in medical physics. This winter (1994/95) a first postgraduate teaching course will be held at the Technical University (ETH) Zurich, organised by the Institute for Biomedical Engineering in close co-operation with SGSMP.

Historical development: In 1980 the (then) new legislation regulating the use of accelerators for radiotherapy came into force; this made it mandatory to employ a "suitably qualified physicist". In order to help to identify "suitable qualification" the SGSMP set up in 1987 a voluntary certification scheme (the "Fachanerkennung") for "Medical Radiation Physics"; in 1988 15 physicists with long experience were awarded the certificate within a transitional regulation. In 1991 an agreement was reached with the "Swiss Society for Medical Radiology" to actively support this scheme; at the same time the subject was extended to "Medical Physics"in general, with the possibility to name a field of specialisation: as Swiss medical physicists are still predominantly engaged in radiotherapy, "Medical Radiation Physics" is the only specialty which has been certified so far. The importance of this certification has been considerably advanced by the new (1994) radiation protection legislation: a physicist is now required for other radiotherapy procedures as well, and the "Fachanerkennung SGSMP" is demanded explicitly - a big step towards state recognition.

THE "FACHANERKENNUNG"

Aims:

The candidate has to have sufficient theoretical knowledge and practical experience to work independently in the fields of

- clinical aspects of medical physics
- application of ionising and non-ionising radiation, considering the basic radiobiology
- dosimetry
- radiation protection
- instrumentation
- equipment evaluation and quality assurance

Prerequisites and procedure;

- a university degree (at least M.Sc) in physics or a related subject
- 3 years of practical education and training in a hospital
- lectures on medical subjects, which may be replaced by study of the literature for applicants not working at a university hospital
    - anatomy
    - physiology
    - medical radiology
    - radiobiology
    - one more medical speciality to be chosen by applicant.

- guidance by a supervisor (with Fachanerkennung), who should preferably work at the same institution as the applicant, and who has to write a yearly report on the applicant's progress

- radiation protection course (at least two weeks)
- attendance of at least 4 scientific conferences
- at least 1 publication
- written and oral exams by a commission, consisting of:
    - 4 representatives of the Society of Radiobiology and Medical Physics, usually:
    - 1 radiation biologist
    - 1 radiation protection expert (usually also representing the regulatory authority)
    - 2 radiologists, representing the Society of Medical Radiology.

Results to date:

- 4 certifications according to this procedure, i.e. outside the transitional regulation
- 22 practising medical physicists are certified (some with foreign training were considered equivalent, some retired)
- 7 candidates enrolled in his scheme (see below for additional candidates with postgraduate course at ETH)

POST-GRADUATE TEACHING AT ETH ZURICH

Since 1991 a lecture on "Medical Physics" (2 terms) has been offered at the Institute of Biomedical Engineering at the Federal Technical University (ETH) Zurich. This lecture has now been incorporated into a postgraduate training course, beginning winter 1994/95. The course is designed to contain all theoretical studies required for the "Fachanerkennung" and at the same time offers several wider options for students not aiming at the "Fachanerkennung". The lectures are complemented by practical block courses during vacations.

Syllabus first year (basic studies): all students

	Biomedical technology I
	Biostatistics
	Radiation biology
Block course	Computers in medicine
Summer (lectures):	Biomedical technology II
	Medical optics
	Physiology

Block course: Biomedical procedures

Syllabus second year (specialised): students aiming at "Fachanerkennung"

Winter (lectures):	Clinical medicine II
	Medical acoustics
	Medical physics I
Block courses	Dosimetry
	Radiation protection advisor
Summer (lectures)	Clinical medicine II
	Medical physics II
	"practical medical physics" (*)
Thesis	Possible subjects to be decided

(*) This lecture is to be given by several medical physicists from different hospitals with two main aims:-

- to give students a chance to get in contact with practising medical physicists: as most positions for medical physicists will be available in non-university clinics, this is considered especially useful.

- to cover fields of medical physics routine not fitting well into the main medical physics lecture.

Other possible specialities for the second year could be e.g. biomechanics, biophysics, or medical engineering.

All students are urged to attend also other lecture of interest (e.g. medical informatics, radiology, oncology) offered at Zurich University Hospital: this will be co-ordinated for each individual student by a tutor.
26 students have enrolled for this first course, including 20 physicists; 8 of these are aiming at the "Fachanerkennung".

FURTHER SGSMP ACTIVITIES

SGSMP organises annual scientific congresses, on several occasions in co-operation with the Austrian and/or German Medical Physics Societies, or the Swiss Society for Biomedical Engineering. These conferences will often also offer tutorials. The papers presented are published as proceedings.

Roughly once a year symposia (lasting 1 or 2 days) on areas of special interest (e.g. planning systems, magnetic resonance procedures, predictive assays) are organised.

There are working groups on specialised subjects, either to foster co-operation, or to draft recommendations (e.g. on dosimetry, or quality assurance in all aspects of radiological physics).

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MEDICAL PHYSICS TRAINING - HISTORY AND DEVELOPMENTS IN TURKEY

G. KEMIKLER(1), I. OZBAY(1), S. KUTER(1)

HISTORY

The history of Medical Physics in Turkey goes back to 1935, when the German Biophysicist Prof. Dr. Friedrich Dessaner was appointed as Director to the Radiology and Biophysics Institute, Faculty of Medicine, University of Istanbul. Medical Physics as a profession in Turkey was initiated in the same department in 1953, when the possibility of employment was created. In 1986, formal postgraduate training and education in the field of Medical Radio-physics was initiated by the Oncology Institute of Istanbul University.

THE PRESENT STATUS OF MEDICAL PHYSICS IN TURKEY

Medical Physics generally stresses on radiation oncology physics in Turkey. The medical physics profession primarily involves the application of physics in diagnostic and therapeutic radiology and includes responsibilities directly relating to patient care. Due to the large and growing demand for Medical Physicists in our country, candidates start to work without sufficient background in physics and medically related subjects. Less than half of the physicists begin their careers in Medical Physics after going through education and training in required area(s).

In our country, medical physicists work in different medical fields. Most of them are working with ionizing radiation, few of them with non-ionizing radiation. There are approximately 150 medical physicists employed in different medical fields (Table 1).

The majority of medical physicists are at present employed in Radiation Oncology departments within the university or public hospitals.

In Turkey, the medical physics units or medical radiophysics departments are sections of radiation oncology departments of public hospitals, or medical faculties. They are organised and managed by the director of the clinic, the head of the department or the chief physicist . The M.Sc. and Ph.D. in Medical Physics is a multi-disciplinary course administered by the Department of Radiophysics and taught by the Institute of Oncology and a number of departments at the University of Istanbul.

TABLE 1: Fields where medical physicists are currently working in Turkey

Number of Physicists	Percentage	Working Areas
60	41%	Radiation Oncology
36	24%	Radiation Protection and Safety
16	11%	Nuclear Medicine
7	5%	Diagnostic Radiology
Total 121	81%	WITH IONISING RADIATION
19	13%	Biophysics and Biology
10	6%	Other Disciplines
Total 29	19%	WITH NON-IONISING RADIATION
150	100%	TOTALLY

POST-GRADUATE EDUCATION AND TRAINING IN MEDICAL RADIOPHYSICS

In Turkey specialisation education on Medical Radiophysics is not available, due to the fact that Medical Radiophysics is not accepted as a specialisation. The Medical Radiophysics unit included in the Radiotherapy Department has been unique school for radiophysicists and almost all of the radiophysicists in our country have been educated here through long-term postgraduate courses. Since it has not been possible to do the required amount of clinical practise, this unit has not been able to give the desired level of practical training. Special courses and summer schools have only served the purpose of refreshing knowledge. After the institute of Oncology has been established in 1986, the academic education on Medical Radiophysics began M.Sc. education on Medical Physics also began in the Oncology Institute of Hacettepe University in Ankara in 1993. These education programmes have been prepared according to recommendations of international federations.

POSTGRADUATE EDUCATION

a) Up to 1986, there was no formal grading criteria of Medical Physics in Turkey. The first postgraduate programme was started by The Institute and Clinic of Radiology, Faculty of Medicine, University of Istanbul. Postgraduate education of young medical radiation physicists was carried out on the Radiation Physics Department. It was the largest and most acknowledged centre in Turkey. We used to organise basic and advanced postgraduate medical radiation physics courses and give training and practise to there physicists and physicians who entered the radiological fields. The training courses had been organised every now and then by our Medical Radiation Unit and continued until 1986.

b) The postgraduate Education and Training in Medical Physics initiated formally at The Oncology Institute of the University of Istanbul in 1986. The Medical Radiophysics Department of a scientific discipline in the Basic Oncology main branch The Medical Radiophysics Division of Oncology Institute of Istanbul University has been seven medical physicists, two of whom are in academical position. Our department is responsible for the treatment planning of over 3 thousand new patients per year. The institute has several treatment machines, a 18 MV linear accelerator Saturn (electron 6, 9, 13, 15, 17 and 20 MeV), 2 Co-60 units, 2 superficial Xray machines, one ortho-voltage X-ray machine, one high dose Curieton remote afterloading system with Co 60 source, manual low dose-rate brachytherapy with Ir-192 wire, two simulators and Theraplan, treatment planning system, water phantom system and dose measurement systems. The Medical Radiophysics division of the Oncology institute offers two post-graduate programmes. The aim of postgraduate education is to acquire an adequate academic knowledge of the application of physical science to medicine.

1: Master of Science Degree (MSc.) Program: This is postgraduate education and training after BSc. degree. It takes at least two years and includes a formal curriculum of lectures, seminars and practical training. Thesis study and practical training are carried out in second year. While in the first year the trainee is given a background in all the required fields. The first term lasts from October till February and second term - from March till mid-June. The curriculum topics are listed on table 2, below.

The trainee must pass all of the topics. On-the-job training for practical experience involves practical exercises and routine work in the hospital. Trainees work in their theses in the second year. The trainee, then, takes an oral exam prepared by an examiners team including medical physics and radiation oncology experts and is awarded a M. Sc. Diploma.

Table 2. Master of Science of Degree (M.Sc.) Educational programme. Name of the topics.

1st Year First Term	1st Year Second Term
General Radiation Physics	Medical Radiation Physics
Basic Radio-Biology	Medical Radio-Biology
Clinical Oncology 1.	Clinical Oncology 1.
Anatomy Histology and Pathology 1.	Anatomy, Histology and Pathology 1.
Biostatistics	Seminar
Computer Techniques and Procedures	
*Bio-physics	
*Medical Biology and Genetic	
*General Epidemiology	
*Elective topics	

2: Doctorate Degree (PhD.) Program: This is higher level postgraduate education and training after completion of MSc. Degree Program. It takes at least three years. The trainee is to take specified courses in the first two years. These two years also, include practical training that is done under the supervision of a qualified medical radiation physicist. In the third and forth years, trainees work on their theses. 2-3 years of practical experience in a hospital helps the physicists to work with confidence in the clinical atmosphere. Usually, a number of medical physicists work for and complete Ph.D. programmes while in service. These candidates are assessed by written exam and then oral exam, and if successful, work on their thesis. The curricula of doctorate degree education are given in table 3, below:

Table 3. Doctorate Degree (Ph.D.) Educational Programme
Name of Topics

Ph.D. Education I. Year	Ph.D. Education II. Year
Photon Dosimetry	Brachytherapy Dosimetry
Electron Dosimetry	Medical Imaging Systems
Clinical Oncology II	Medical Radio Biology

Anatomy, Histology and Pathology II.
Quality assurance in TR.
Radiation protection and safety
Treatment planning
Seminar

* Cancer epidemiology
* Medical biology and cancer genetics
* Elective topics

GENERAL OUTLOOK OF SYLLABUS

General Radiation Physics: Atomic and nuclear structure, radioactive decay, decay of modes, natural and artificial radioactivity, interactions of X-and gamma rays, production of X-rays, physical principles of diagnostic radiology, dose units, primer and secondary ionization chambers, methods of measurements, measurement of radiation quality and exposure.
Medical Radiation Physics: Low, medium and high treatment machines, sources and machines in brachytherapy, radiation dosimetry for X-rays and electron beams, measurements of absorbed dose, physical principles of radiotherapy, dose-volume concepts, immobilisation devices, dose distributions in external beam therapy, dosimetric variables, inhomogeneity, systems used in brachytherapy, dose time-fractionation relations in RT, radio protection and quality control in RT.
Photon Dosimetry: Absorbed dose protocols, radiation quantities and units, equipments, radiation quality specification and determination, formalism, determination of absorbed dose to water, correction factors, conversion of absorbed dose from one medium to another, quality control for absorbed dose and inter comparison.
Electron Dosimetry: Electron accelerating structures, beam bending systems, flattening of beam, electron interactions with matter, energy losses, basic parameters of electron beams, beam distribution in the patient, practical electron dosimetry, dosimetry methods and algorithms.
Brachytherapy Dosimetry: Sealed-sources therapy, radionuclides and sources application methods of brachytherapy, specification of sources, standardisation of source-dose-volume, dose calculation methods - intracavitary and interstitial -Paris system, Quimby system, Manchester system, Stockholm system, Houston system, source reconstruction methods and time dose-fractionation in brachytherapy.
Treatment Planning: Pre-treatment procedures, principles of external beam treatment planning, isodose charts. parameters of isodose curves, wedge filters, tumor-dose specifications, acquisition of patient data, irregularities inhomogenities, field shaping adjacent fields and practical treatment planning.
Medical Imaging Systems: Standard roentgen units, tomography and

computerises tomography units, ultrasonography, emission type imaging units, gamma cameras, positron emission tomography and physical principles, principles of magnetic resonant imaging, current concepts and issues in radiation protection and quality control of imaging systems.

Radiation Protection and Safety: protection quantities and units, risk-benefits-analysis, biological effects of radiation risk factors and side limits, dose calculation of in and out irradiation, shielding, legislation, administration and organisation and licensing regulations.

Basic Radiobiology: Absorption of X-rays, neutron and heavy ions, cell-survival cures, RBE, LET, oxygen effect, dose response relationships for normal tissues, lethal and sub-lethal radiation damage, radiosensitizers, radioprotectors, acute effects of whole body irradiation, genetic changes.

Clinical Radiobiology: The physics and chemistry of radiation, absorption, cell-survival curves, dose response relationships for normal tissues, radio sensitivity, radiation damage and dose-rate effect, cell-tissue and tumor kinetics, time-dose fractionation in radiotherapy, sensitivity of tissues, late effect of radiation.

Anatomy-Histology-Pathology: Anatomy and histology of skin, musculo-skeletal, respiratory, digestives, cardiovascular, urinary reproductive, endocrine, haematopoietic and nervous system, origins of disease and disability, review of the pathology of cancer, pathological classification of organs, modes and sides of metastases.

Clinical Oncology: Malignancies of organs and systems, etiology. staging of tumors, treatment modalities, surgery RT and chemotherapy and side RT schemes

Medical Biology: Cell, tissues and organs DNA, RNA, mitosis, meiosis, differentiation, genetics, effect of radiation cell degeneration.

Computer Techniques and Procedures: Basic concepts, programming, personal computers, high and low level languages, formatting floppy discs, back up electronic data and operating systems.

Biostatics: Data recording, graphical and parametric presentation, probability, tests of significance, binomial, Poisson and Gaussian probability distributions, sampling theory, and design of experiments.

Educational programmes have been organised according to the recommendations of international organisations like EFOMP, AAPM, IAEA and IOMP. Up till now, 25 physicists have received a Masters Degree diploma and 5 have received a doctorate degree diploma. Currently, over 15 physicists are either in training or are working in their theses. More than 30 physicists, who have completed their training are working in radiation oncology departments spread over the country.

The population of Turkey is around 60 million. The number of Medical Physicists per million inhabitants is very low, only one physicist. There are 21 departments in public or university hospital and 7 private centres. The distribution of the treatment machines and status of RT. departments is shown Table 4.

Table 4. The Distribution of the Treatment and Status of RT. departments.

Status	Number	Linac	Co-60	Orthov	Superfic	Brachyth.	Brachyth
Public or Univ. Hospitals	21	12	30	10	9	16	
Private Centres	7	--	8	1	2	--	
TOTAL	28	12	38	11	11	16	

In table 5 the number of medical physicists in Turkey with various educational qualification is shown.

CONCLUSION

In conclusion, the structure and organisation of Medical Radiation Physics (Radiation Oncology Physics only) are formally approved and fairly advanced in Turkey. Diagnostic Radiology, Nuclear Medicine and non-ionising radiation. postgraduate programmes have not been initiated formally. However, there is increasing demand for these programmes. Every year, about 4-6 M. Sc. and 2-4 Ph.D. students are admitted for postgraduate education and training. Foreigners are acceptable. The training scheme and status of the clinical medical physicists are broadly in agreement with the EFOMP policy statements.

Table 5. Educational qualification of Medical Physicists in Radiotherapy.

Degree	Working areas	No. of Medical Physicists
B.Sc.	Radiotherapy Dep.	32
M.Sc.	"	25
Ph.D	"	5

A medical physicist has to make some decisions about the patients and such decisions are based on a competence that only the discipline of Medical Physics covers. These facts have to be taken into account within the organisation and management of the Medical Physics Service. After the basic qualification (B.Sc.) further education and training in Medical Radiation Physics is essential before a medical physicist is allowed to take responsibility.

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THE HISTORY, ACHIEVEMENTS AND PROBLEMS OF UKRAINIAN MEDICAL RADIATION PHYSICS AND ENGINEERING

V. E. OREL(1)

HISTORY

In 1920 the specialists in medical physics Yu.P.Teslenko and E.E.Trotsky organised departments of medical physics and engineering at the Kiev Roentgen Institute. On this occasion, one of the Kiev newspapers published an articled called "A House of Mysterious Rays". From 1923 through to 1933, the department was headed by professor V.K.Roche. The major issues facing physicists and engineers at the time were to develop metrology and x-ray standards. The scientific seminars held by the department were attended by would-be Nobel Prize winners N.N. Semonov and I.E. Tamm. During 1933 through to 1939 when the Department was headed by Professor I.V. Domansky medical physicists were studying X-ray radiation on photographic film in order to enable Quality diagnosis of cancer patients. An interesting approach for using ionizing radiation in medical jurisdiction expertise was developed by B.R. Kirichinnsky who headed the department in 1940-1941 and 1946-1948. In the pre-war years, the biologic effects of ultra-high frequency were studied by Yu. A. Sikorsky, brother of a well-known helicopter designer of Ukrainian descent. During 1948-1973, headed by M.S. Ovoshnikov, the department organised an engineering office, an experimental production unit and a dosimetry laboratory. This unit dealt with developing original X-ray equipment: fluorographic equipment and instruments for filming humans full-length at a reduced scale. In 1974-1991, the department headed by B.J. Nikishin was engaged in implementing the ideas of using neutron and gamma irradiations for treating cancer patients. They developed a model of a fourth generation X-ray computer tomograph.

An outstanding achievement of the Ukrainian scientists is the development of the theoretical basis of the X-ray Computed Tomography as early as 1957. This fact has been discovered occasionally some 10 years ago and after we were informed for it by Dr S.D.Tabakov a copy of this historical paper was discovered in the Polytechnic Institute of Kiev (S.I.Tetelbaum, About a method for obtaining volume-images using X-rays, News of the Polytechnic Institute of Kiev, v.22, 1957), the mathematical base had been worked out by B.I.Korenblyum. Although these papers had been published several years before the well-known Nobel prise winning papers, they have not been seen from the scientific world and now it is not known even if a working model has been built.

STATUS AND RESEARCH

Since 1991, the physico-technical department has been headed by the author of this article. The work is carried out in the basic fields of medical physics and applied medical radiation engineering. As to the basics we study the dynamics of change in the spectral features of mechanically stimulated electromagnetic emission from blood, i.e. mechanoemmision under the influence of ionizing radiation. We have demonstrated a relation between mechanically stimulated electromagnetic blood emission in optical and radio ranges and absorbed doses of ionizing radiation. Studies were also carried out on cellular organelles, i.e. mitochondria and DNA. These experimental investigations served as the basis for mechanoemission hypothesis for chains of developing oncologic lesions as one possible mechanism of radiation induced carcinogenesis. The technical implementation of the physical principles of mechanoemissions was used for creating an instrument, a mechanoemmision analyzer, designed for the study of the spectral composition of blood mechanoemission from cancer patients for differential diagnosis and control during radiotherapy, as well as a biological indication of human radiation injury. A problem for medical physics is posed by methodologic features of radiotherapy for deeply seated human tumours. One of the promising approaches for the solution of this problem can be a synergic effect of ionizing radiation and hyperthermia. To solve this problem we developed an original installation of inductive ultra high frequency treatment for cancer patients in combination with radiotherapy. (For more information on these subjects please see the references).

A vast amount of work was done by Ukrainian medical physicists in physical dosimetry and biological indication of victims and the environment after the Chernobyl nuclear power station accident in 1986. In this connection a Ukrainian Centre of Radiation Medicine was founded in Kiev. One should mention the work of medical physicists and engineers from Kharkiv Institute of Radiology who carried out fruitful investigations in the field of clinical and individual dosimetry of ionizing radiations.

In recent years Ukraine has been producing X-ray computer tomographs at the Relay and Automatics plant in compliance with Siemens technical recommendations. Some parts of X-ray diagnostic and radiological therapeutic instruments are developed and manufactured by the Medapparatura company in Kiev. The institute of Nuclear Investigations developed a medicobiologic complex for neutron treatment of cancer patients. An X-ray emitter is being developed by the Saturn company.

REPRESENTING BODY AND EDUCATION

In 1993 the Ukrainian Association of Medical Physicists was founded which publishes a journal "Physics of the Alive". The number of physicists and engineers working in Ukrainian cancer hospitals approaches 200. The number of specialists engaged in engineering and the medical radiation physics in Ukraine as a whole is about 1000.

In May 1995 a Ukrainian Radiological Congress will be held in Kiev with international participation at which a section of medical physics and engineering will work.

The Kharkiv College of Radioelectronics is training students for servicing radiological equipment. Specialists in radiation medical physics and engineering are trained at the Department of Medical Engineering of the International Solomon University in Kiev. Post Graduate courses can be completed in Kiev and Kharkiv.

PROBLEMS

Despite the glorious history and certain advances, Ukrainian medical radiation engineering and physics have certain problems today. These are primarily:

1. Absence of a unique system of metrology and standard of ionizing radiation with Europe;
2. A limited number of modern instruments, computers and programs for clinical and individual dosimetry;
3. Lack of possibilities for training at leading European centres for specialists in radiation physics and dosimetry;
4. Lack of modern textbooks in radiation physics and engineering for students
5. Lack of funds for purchasing medical, physical, and bioengineering journals.

One might hope that under the new conditions of a new Europe these problems could be solved and we might hope for the support of European specialists in Medical Radiation Physics and Engineering. In this context we would like to express our acknowledgements to the organisers of this Conference.

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TRAINING FOR PHYSICAL SCIENTISTS IN HEALTH CARE - UK SCHEME

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The Institute of Physical Sciences in Medicine, with a total membership of 1717, is the United Kingdoms professional body for physicists and engineers with an interest in health care. The scope of the work is manifold encompassing not only the traditional areas of radiation physics and imaging but also topics such as rehabilitation engineering, instrument design and physiological measurement. 1154 of the members work directly in the UK health care sector in either National Health Service Hospitals or University Medical Schools. These 1154 are spread throughout approximately 125 departments of varying size spanning the length and breadth of the United Kingdom from Inverness to Plymouth and Norwich to Belfast. The breakdown of staff by departmental size, and by discipline are given in Tables 1 and 2 respectively.

Table 1.

No of Departments	No. of staff in Department
67	< 5
32	5 - 14
16	15 - 30
8	> 30
Total 125	1154

Table 2.

Field of Medical Physics	No. of staff
Radiotherapy	252
Radiation Protection	145
Non-Ionising Radiation	24
Diagnostic Radiology	103
Nuclear Magn. Resonance	32
Nuclear Medicine	193
Ultrasonics	58
Other	347
Total	1154

Table 1 shows the number of Medical Physics Departments in the UK grouped according to the number of graduate scientists in each department.

Table 2 shows the various fields of Medical Physics together with the number of graduate scientists who have declared that to be their main area of activity.

The diverse range of modern Medical Physics and Biomedical Engineering and the evolution of identifiable sub-disciplines within the field require that there is a formal approach to the training of new entrants to the profession so that a proper vocational foundation to their careers is ensured. The Board of directors of the Institute of Physical Sciences in Medicine appointed a Training and Education Committee to both devise and administer a suitable Training Scheme.

The first official Training Scheme was set up in 1981 in response to the need for a more formalised training programme. At that time, the majority of persons entering the scheme were employed as basic grade physicists. Many of them were required to combine their training with the exercise of routine duties and the scheme was devised to take this into account. In 1990 following a fairly fundamental change in the way physicist's posts in the NHS are funded the concept of supernumerary posts for trainee medical physicists was introduced. This gave us an opportunity to review training methods, to look again at both how training should be provided and what training should be provided. The current scheme, which has an annual intake of around 32, was devised with the purpose of producing highly competent medical physicists and biomedical engineers by providing new entrants to the profession with a structured programme of education, training and experience enabling them to progress to Corporate Membership of the Institute and entry to the appropriate Practice Register.

The requirement for Registration of both the medical physicist and the chartered engineer consists of three elements; knowledge base, training and experience. The Training Scheme attempts to provide for all three facets of registration.

KNOWLEDGE BASE:

The trainee obtains the necessary knowledge component of training from an accredited MSc. The IPSM, as the professional body setting the standards for the Training Scheme as a whole, has responsibility for accrediting MSc courses. The accreditation process includes: a review of the Syllabus and Curriculum to assess the coverage by the course of the knowledge content specified in the IPSM syllabus; a site visit; the examination and assessment process; the project and dissertation work, etc. It is not however an audit of the academic worth of a MSc. This is entirely the responsibility of the University involved. A suitable knowledge base is defined in the IPSM syllabus as one which provides a satisfactory balance between, (i) a breadth of topics giving a trainee an adequate overall view of the subject and (ii) a study in sufficient depth of a limited range of topics expected to equip the trainee with the knowledge to underpin practical training and future work in a narrower set of selected areas and eventually in a particular speciality.

The syllabus sets out Prescribed topics, Core topics and In-depth topics. The Prescribed topics, which are set out in some detail, consist of anatomy and physiology, and safety. The core topics, defined as those which contain material which may be required in more than one specialist area, include: Computing; Statistical Methods; Equipment Management; Quality Management; Introductory Signal Processing, Ionising Radiation Physics; Non-Ionising radiations; Imaging; and Medical Electronics. Each In-depth topic is intended to provide essentially complete coverage of a particular specialist area when taken in conjunction with the relevant core topic material. The In-depth topics listed are: Anaesthesia and Respiration Therapy; Audiology; Biomedical Engineering; Computing and Medical Informatics; Diagnostic X-ray Physics; Imaging; Image and Signal Processing; Magnetic Resonance; Medical Electronics and Instrumentation; Non-ionising Radiation; Nuclear Medicine; Ophthalmology; Physiological Measurement; Radiation Protection; Radiotherapy Physics; Rehabilitation Engineering; and Ultrasound.

TRAINING

Candidates are only accepted onto the Training Scheme if they are based in an accredited training centre. Just as in the case of the MSc courses the IPSM, as the professional body setting the standards for the Training Scheme, has responsibility for accrediting training centres. The accreditation process involves a site visit by two surveyors and includes a review of: subject areas available for training; staffing levels; facilities such as library, study room, computers, and meeting programmes; training organisation; research output; and continuing professional development programmes. A total of 30 centres have received accreditation and approval to take Trainees.

The *total* Training Period is based on a broad developmental progression of competencies, leading towards increased specialisation during the experience period. It is divided into two parts: two years basic training as a supernumerary trainee (Grade A) and at least two years experience/higher training in a substantive full time medical physics post (Grade B). The Prospectus has been written with reference to Competency Levels. Emphasis is placed primarily on continuous assessment by the supervisors in the recognised training centres. The trained medical physicist should be capable of undertaking a given job of work in any medical physics and biomedical engineering department, in the UK or abroad.

When assessing competencies against the markers provided, it is deemed important to test the qualities normally associated with a professional physicist or engineer. These include demonstrable problem solving skills, including the ability to define a problem and formulate strategies for solving it, the ability to interpret novel or non-standard data, the ability to make value judgements in unfamiliar situations, the ability to communicate scientific advice clearly and accurately to others, the ability to recognise fault situations, e.g. inappropriate images, and take suitable corrective action, also an appreciation of the limitation of one's knowledge.

Three levels of competence (A,B,C) have been described in the Training Scheme Prospectus, these are interpreted in a table below.

The three levels of competence described are currently available in ten major subject areas: Computer Science; Diagnostic Radiology; Electronics and Instrument Design; Non-Ionising Radiation; Nuclear Medicine; Physiological Measurement; Radiotherapy Physics; Rehabilitation Engineering and Ultrasound. We hope to provide these levels of competence in more subject areas and to extend the competency levels to higher levels, D, E, etc. in order to cover mature continued professional development.

The two year supernumerary training period in Grade A, has an emphasis on acquisition of knowledge and basic training. It includes training to competence level B in three major subject areas and in the Core competencies common to all areas (e.g. safety; interpersonal skills; scientific method), training to level A, acquaintenceship, in at least three additional subject areas, and the maintenance of a training portfolio. Throughout this training period the trainee has regular meetings with his/her supervisor and training co-ordinator.

Level	Interpretation
A	**Acquaintanceship**: Experience gained during a brief period spent within a subject area.
B	**Basic**: Adequate span of theoretical knowledge to current state of the art: ability to apply this knowledge with reasonable skill, under supervision; ability to explain problems to other specialists and discuss response, with appropriate vocabulary.
C	**Corporate**: Higher training/experience leading to an adequate span of theoretical knowledge; ability to perform given or routine professional tasks without supervision; demonstrable problem solving skills; ability to recognise fault situations; demonstrable capacity for interpreting the state of the art to non-specialist clients, professionals in related disciplines, students, enforcing authorities or administrators.

Once the trainee has satisfied the supervisors and training co-ordinator that s/he has achieved the necessary competencies in the continuous assessment they may proceed to the *viva voce* examination. This takes approximately one hour and is conducted by a panel of examiners, each one a specialist in a specific area of medical physics and, drawn from senior members of the profession. The examination comprises an in-depth examination of the core competencies and three major subject areas, a superficial examination of other areas with which the trainee is expected to have an acquaintanceship, and questions on health and safety. Following a successful *viva voce* examination the Examiners evaluate the supervisor's and training co-ordinator's reports and the trainee's portfolio before determining the overall grade of the trainee. An award of the Postgraduate Dip IPSM is made to successful candidates and the trainee becomes eligible for a substantive, Grade B, post.

EXPERIENCE/HIGHER TRAINING

During a further training period consisting of a minimum of two years whole-time equivalent in a substantive Grade B post the progressive development of competence continues, but with the greater degree of specialisation and the deeper understanding that is expected of such a post. For satisfactory completion of the higher training period it is necessary to demonstrate competence to level C in one major subject area plus proficiency in relevant topics in related subject areas. The trainee must maintain a training portfolio in order to provide evidence of the depth and to a lesser extent the breadth of experience acquired.

The end-point assessment of competence, which may be taken after a minimum of two years in higher training, is in the form of an oral examination at the trainees place of work. During a period of approximately two hours the higher trainee is invited to demonstrate and discuss his/her work with two External Assessors both of whom are senior experts in the specialist field. Satisfactory completion of the assessment entitles the candidate to be entered on the Register of Scientists in Health Care and to become a Corporate member of the IPSM.

CONTINUING PROFESSIONAL DEVELOPMENT

Individual medical physicists have always recognised that education and training does not stop on reaching registration status but that it is a continuum from entry to university to retirement from the profession. It is not sufficient to rely solely on the knowledge gained during pre-registration training if patients are to be provided with a high standard of care for the ensuing 20/30 years of a members working life. Continuing professional development, which ensures the acquisition and dissemination of knowledge and skills, takes place informally, for example, by the reading and writing of scientific articles, the preparation of teaching material for undergraduate and postgraduate students, continuing research, participation in scientific meetings and attendance on courses and conferences. In the United Kingdom this is partially facilitated by the IPSM via the publication of journals, books and reports on Medical Physics and by the provision of a full programme of scientific meetings, with topics ranging from 'Quality Assurance and Patient Dosimetry in Diagnostic Radiology' to 'Engineering and Technology in the Management of Diabetes' and from 'Computer Aided Diagnosis in Nuclear Medicine' to 'Biomechanics in Sports Rehabilitation'.

To date the only group where a semi-formalised programme of CPD operates is for those members working as Radiation Protection Advisers. The comprehensive training for such a person takes place post registration and a set of competencies, at level D/E, has been devised based on nine major units as follows: supporting risk control; updating radiation safety policies; assessing risk; establishing radiation controls; monitoring of controls; cultivating safety awareness; legislation compliance; training of staff; contributing to advances in safety. The certification of RPA's is the responsibility of the IPSM; any prospective adviser has to satisfy the Institute that they are competent in the areas specified above before being issued with a five year certificate. To renew the certificate an applicant must be able to show that they are currently active in the field and that they have attended a number of 'update' meetings during the preceding five years. A programme of update meetings is organised at regular intervals by the Institute.

The IPSM is in the preliminary stages of designing formal post registration education programmes and is looking towards requiring evidence of satisfactory participation in CPD for those members wishing to be involved in the education, assessment and examination of their various disciplines. There are many questions still to be answered. What should be the basic unit of activity? How many units should be the target? How long should the time cycle be 3 years 5 years? Is a mix of home and away training the most appropriate? How will the need for protected time and funding for CPD be obtained, etc.? Nevertheless given the rate at which medical physics is advancing, the complexity of many of the issues and the increasing public expectation in the provision of health care it is essential that CPD becomes more structured.

In the final event the success or failure of any training programme is dependent not just upon the endeavours of the Institute or Organisation, but upon all the members of the profession.

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DISCUSSIONS

The Discussion on Education, Training and Accreditation began after the presentations of the participating countries. Various questions for this discussion were prepared during the distant pre-Conference discussion, when the Policy Statements of EFOMP were distributed to the delegates.

EDUCATION

The discussion began with specifying the level of the post-graduate education. Considerable differences were found. Almost all Central/Eastern European (EE) countries and some EC countries considered post-graduate education as education after the MSc (~5 years of academic education). As in those countries the MSc equivalent degree (Diploma, etc) is regarded as entry requirements for post-graduate education, the post-graduate students receive an official certificate after completing the course. This certificate is very important for career and PhD development, but is not considered as an academic degree. In many of the EE countries there exist specialised educational institutions, which deal with the post-graduate education of medical doctors. These are normally one per country and the Medical Radiation Physics (MRP) post-graduate courses are often incorporated within their activities. Only recently some Universities have introduced post-graduate education with MSc degrees in MRP.

In many Western European (WE) countries the entry requirement for post-graduate education is B.SC (~3 years of academic education) and completion of the course leads to MSc degree. These major differences are of the competence of the Higher educational Authorities and the Universities of the countries.

Special attention was given to the fact that the post-graduate education in MRP should also cover some engineering aspects, as the complex modern medical equipment can not be studied as a "black box" only. There are many engineers in X-ray, nuclear, imaging, etc. fields which are to be considered as medical radiation physicists. In EE these specialists are members of the national professional societies and through them - to EFOMP and IFMBE. In many countries the physicists and the engineers have formed merged societies and have equal status. It was agreed that the most appropriate length for post-graduate education is one academic year.

At this point it was agreed that revealing the weaknesses and strengths of the existing education schemes will be of importance for the development of proper strategy in post-graduate education. **Table 1** shows the result of this analysis (some of the weaknesses and strengths are related with particular countries).

Table 1. Strength and weakness in MRP post-graduate education

STRENGTH	WEAKNESS
Basic physics	Basic radiation physics
Computer science	Basic biology and medicine
Dosimetry	Internal dosimetry
Environmental Physics	Environmental issues
Equipment evaluation	Equipment testing and acceptance
Design of devices for Radiotherapy	Management
Mathematics and Biostatistics	Ethics
Quality Assurance	Non-ionising radiation
Ultrasonics	Physiological measurements
	General safety
	X-ray engineering
	Adequate European view

Common strengths for all participants were basic physics and dosimetry.
Common weaknesses were non-ionising radiation, physiological measurements, X-ray engineering, general safety issues and the European view on the education.

From this analysis areas for collaboration between various countries were easily established. Several countries decided to apply in EC for funding joint education courses with Eastern Europe.

It was agreed that additionally to the basic professional education on Diagnostic Radiology, Nuclear Medicine, Radiotherapy, Non-ionising radiation, Imaging and Radiation Protection some knowledge on the following subjects will be of importance for the further development of the physicist:

- Management
- Cost benefit analysis and financial planing
- Contract negotiation and Policy writing
- Protection of intellectual property
- Quality issues in medical technology

It was agreed that an International Working Group should be formed to develop, in collaboration with EFOMP, IAEA, CEC and other Institutions and Organisations in the field, the Syllabi for education schemes to provide a basis for a future harmonisation of European education in MRP.

TRAINING AND CONTINUOUS PROFESSIONAL DEVELOPMENT

The discussion began with the defining of the contents of the activity. This was agreed as:

Prescribed practical work which takes place during or after specialist education aimed at developing appropriate skills which are necessary to perform correctly and safely the profession or specialisation.

Following directly from the definition, the question of entry requirements arose. It was agreed that most of the countries require level 2 to be acquired before the beginning of training. It was generally agreed that the EFOMP framework for the 5 levels of career development (please see the EFOMP ETP paper) is appropriate to be used in this case and completion of 3^{rd} level (basic training) is the point at which a hospital physicist can start to performing routine work unsupervised. However, there were various opinions on the breadth and depth of the basic training (from 6 months to more than 2 years).

Further the place/body of training was discussed and it was generally agreed that the Training Centres should be either large hospital departments or a well organised consortium of smaller ones. It was pointed out that every country should have at least one such Centre. There was also general agreement that the work of these Training Centres as well as their schemes should be formally accredited. However Accrediting organisation/body do not exist. Similar problem was found with the question on audit of the Training Centres.

Further it was agreed that the Qualified Expert should be specialist in MRP who has completed level 4 specialist training.

The summary of this discussion was as follows:

- The EFOMP framework is appropriate for career development;
- Completion of level 3 training is an appropriate entry point for a hospital physicist to perform routine work unsupervised, however, there is some misunderstanding over the EFOMP definition of basic training in terms of breadth and depth;

- In the majority of countries no organised training schemes exist;
- Training should be carried out in accredited Training Centres, and every country should have at least one such Centre;
- Accredited Training Centres should be either large hospital departments or a well organised consortium of smaller departments;
- There must be a full formal accreditation process for Training Centres and schemes;
- There must be a formal process for the audit of Training Centres;
- There is a confusion over the definition of the term Qualified Expert, However, this Conference agreed that the QE(r), who is a specialist in MRP, will have qualification on level 4 training.

It was agreed that a collaboration on courses for Continuing professional Development should be made with the EE countries.

It was agreed International working groups to be formed on the Syllabus for the training schemes and on Accreditation and Audit (minimum requirements) for Training Centres , who are to develop in collaboration with EFOMP, IAEA, CEC and others Institutions and Organisations in the field the base for a future harmonised European Training in MRP.

ACCREDITATION

The discussion began with describing the levels of the accreditation process of an education scheme:

1. Local Assessment
2. National Assessment
3. National Accreditation
4. European Accreditation

The contributors to the process were identified as:

- Internal Peer
- External Peer (Agency, Organisation..)
- Customer (including students)

The Strengths and Weaknesses of the Assessment were analysed as shown in table 2 below:

Table 2.

STRENGTH	WEAKNESS
Experience Economy of efforts Market awareness	External acceptance Information, Language difference Standards/Legislation difference Technological difference University structure difference

The Strengths and Weaknesses of the Accreditation were analysed as shown on Table 3 below:

Table 3.

STRENGTH	WEAKNESS
Broad perspective Connection with other bodies Independence Market knowledge	Credibility Lack of uniform European Method Information, Language difference University structure difference Lack of guidelines

The major problems in this process were identified as :

- Lack of unified procedure
- Lack of international guidelines
- Critical mass of assessors/accreditors
- Mobility

A special need of inter-evaluation of post-graduate education schemes was expressed. It was agreed International working groups to be formed on the Assessment and Accreditation who are to develop in collaboration with EFOMP, IAEA, CEC and others Institutions and Organisations in the field the minimal requirements for Accreditation of the Education and Training Centres on MRP.

CONCLUSIONS

The requirements and summaries of the discussions were revised on the final Panel Discussion of the Conference where it was agreed five working groups to be formed on:

- Syllabus for Education Schemes;

- Minimum requirements for Education Centres (Accreditation and Assessment);
- Syllabus for Training Schemes;
- Minimum requirements for Training Centres (Accreditation and Audit);
- Terminology and Interpretation of EU legislation.

The groups will develop the respective questions and will prepare their conclusions in order to be accepted at the following Professional Meeting/Conference.

The delegates assessed highly this Conference and its organisation. Strong need was expressed that the Organisers should seek further EC support for a following Conference to be prepared together with EFOMP after 2-3 years. It was also agreed that the for the post-Conference book contributions for as many as possible European countries should be collected and the book distributed throughout Europe for strengthen the professional contacts. In this context was agreed that a Network should be formed and the Organiser will initiate the necessary activities in this direction.

Special gratitude was expressed to the Commission of the European Communities for funding the Project and to the organisers from the Department of Medical Engineering and Physics at King's College London for their efforts for the success of the Conference.

The Conference on Post-graduate Education in Medical Radiation Physics concluded with a Declaration of Intent agreed and signed by all delegates.

DECLARATION OF INTENT

We have examined the education and training needs for medical radiation physics. This examination has identified areas, which require to be addressed in order to maximise the benefits of applying physical science to healthcare provision throughout Europe.

We declare our intent to work together to develop a programme of initiatives in education and training which will complement and integrate existing programmes. Our aim is to harmonise activities and opportunities available to students working in this area throughout Europe.

To this end we have agreed to form a Network to facilitate the initiation and promulgation of individual initiatives between members and other agencies including the European Federation of Organisations of Medical Physics, the International Atomic Energy Agency, the International Organisation for Medical Physics, the International Federation for Medical and Biological Engineering. We have further established a number of working groups to facilitate our aim.

Budapest
14th November 1994

Signed by:

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Photography of the Declaration