Nuclear Science and Applications with Neutrons: Utilization of Research Reactors and Accelerators

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IAEA
International Atomic Energy Agency

21 October 2005, Trieste

Outline

- IAEA Organizational Structure
- Research Reactors
- Accelerators
- Detection of Explosives
- Summary

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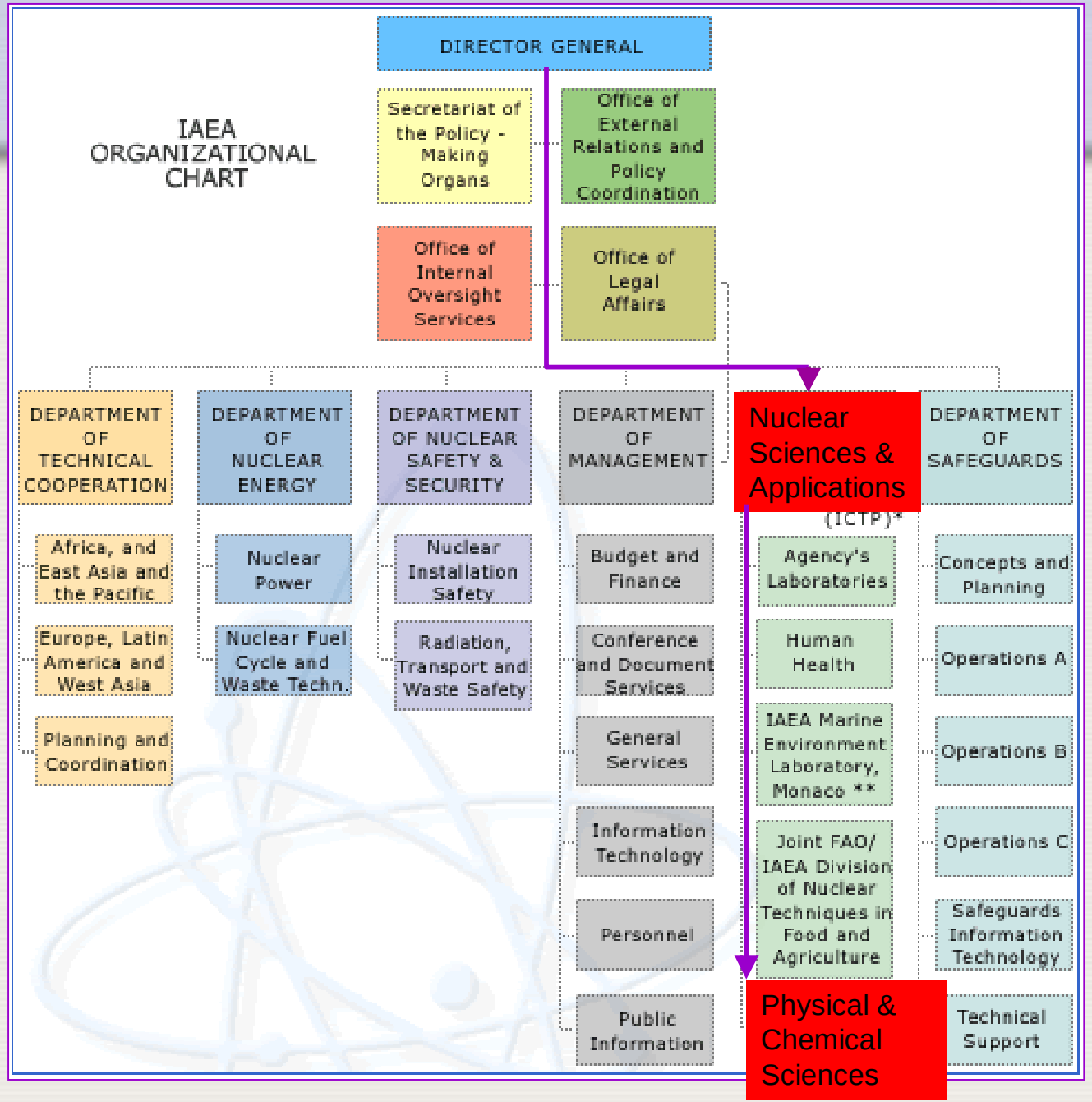
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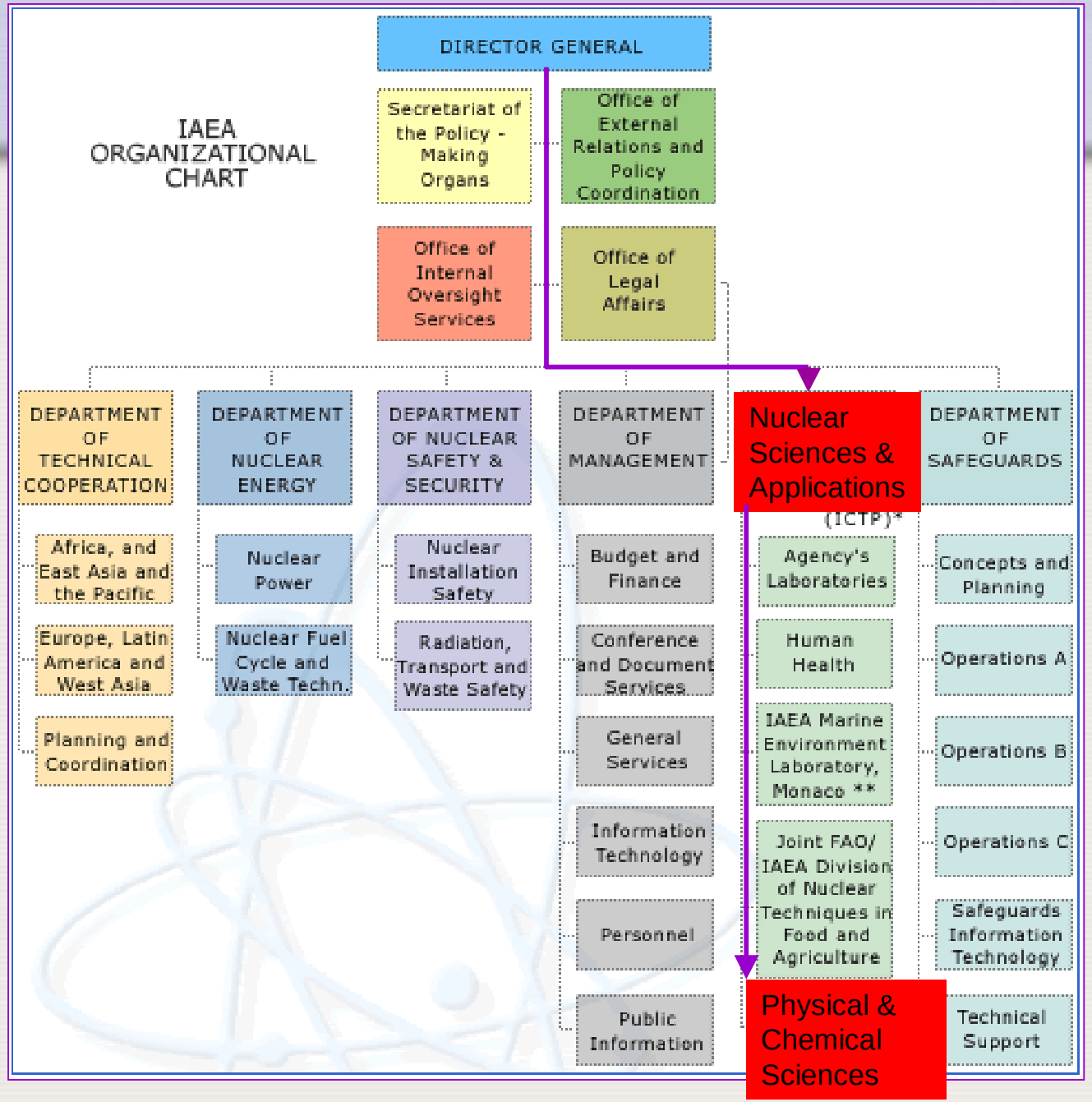
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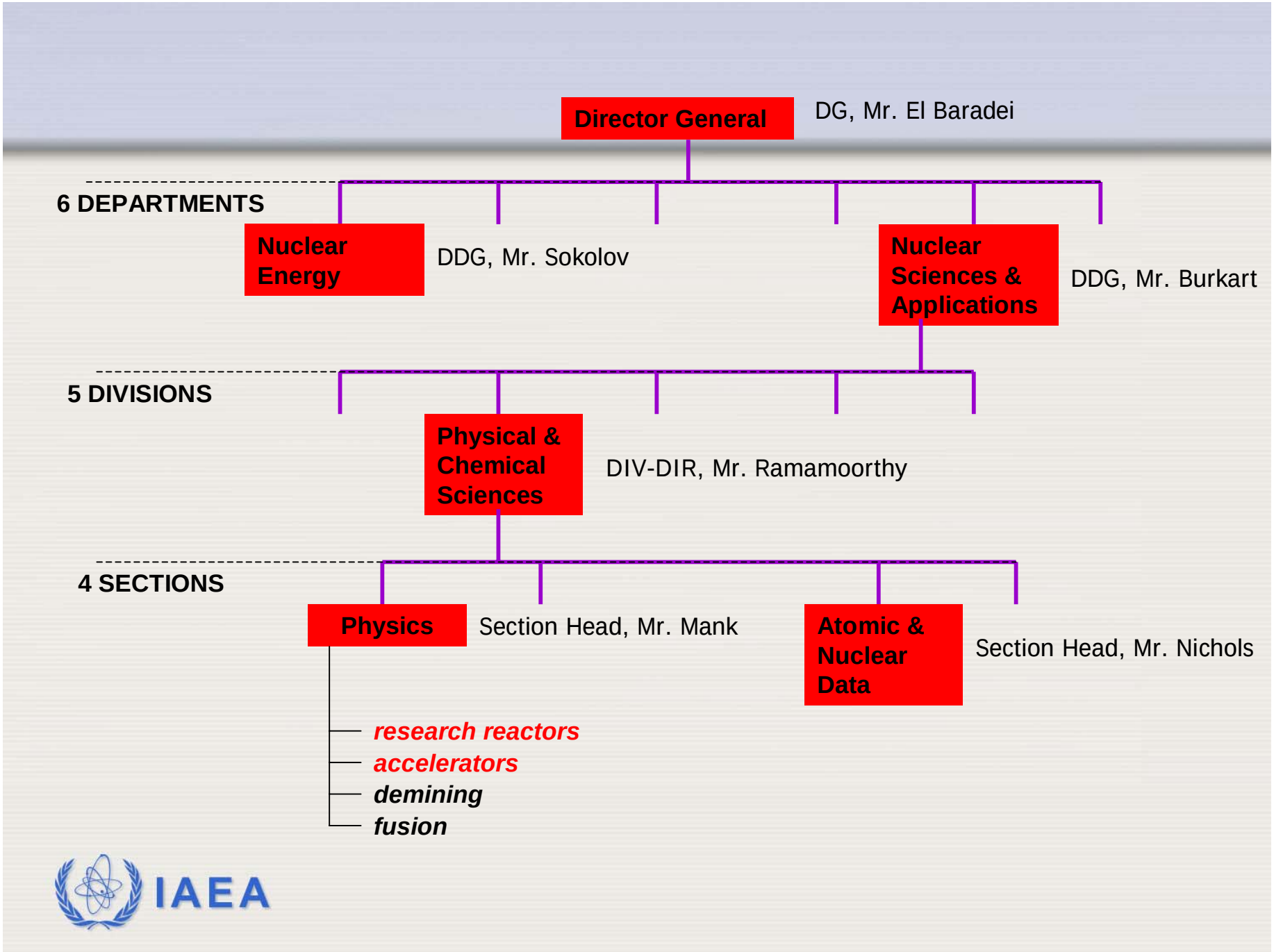
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DDG, Mr. Burkart
5 DIVISIONS
Physical & Chemical Sciences
DIV-DIR, Mr. Ramamoorthy
4 SECTIONS
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Section Head, Mr. Mank
Atomic & Nuclear Data
Section Head, Mr. Nichols
research reactors
accelerators
demining
fusion
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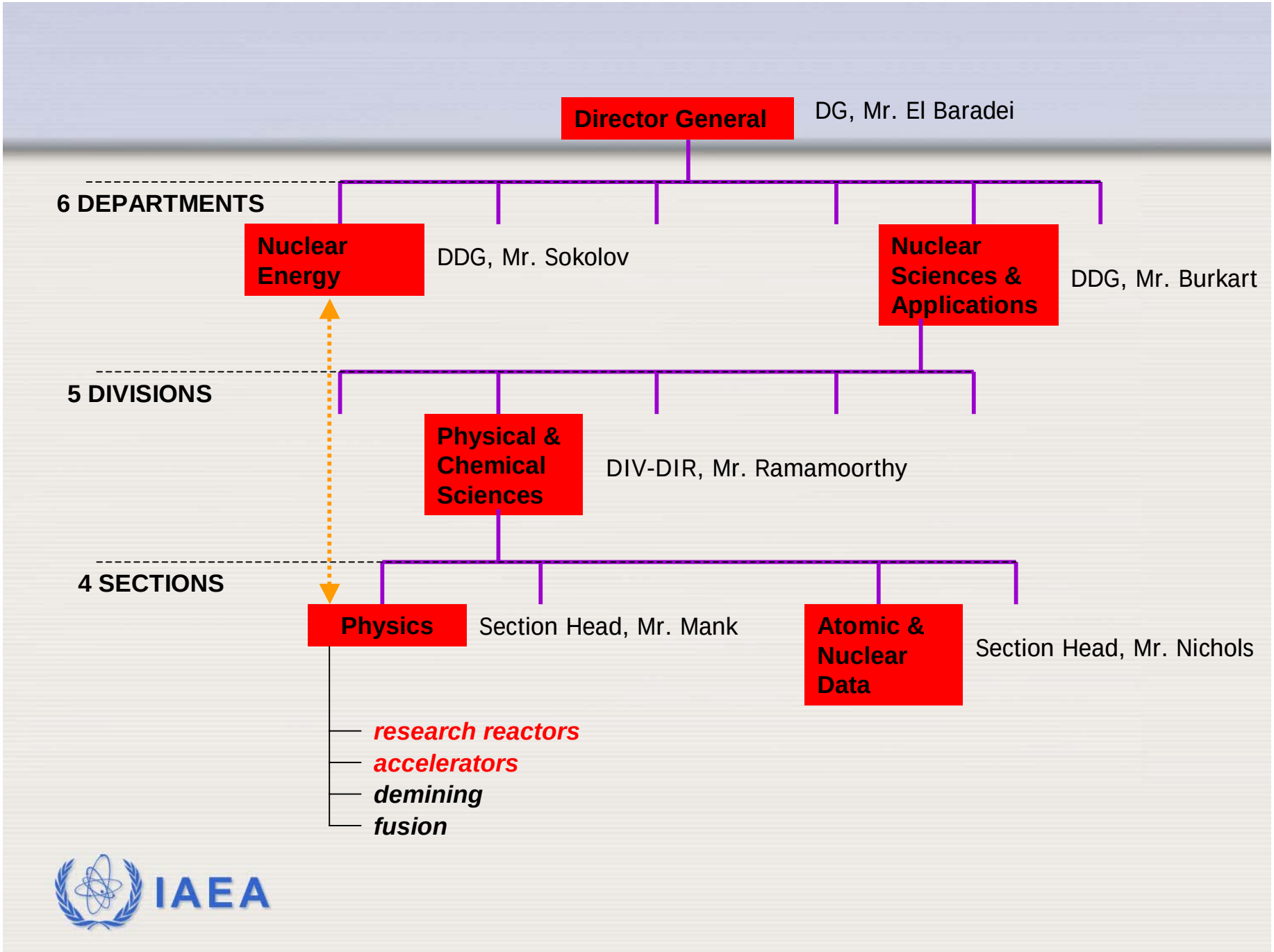
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The three IAEA pillars

Promoting Safeguards & Verification

Promoting Safety & Security

Promoting Science & Technology

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The three IAEA pillars

Promoting Safeguards & Verification

Promoting Safety & Security

Promoting Science & Technology

Mobilizing peaceful applications of nuclear science and technology for critical needs in Member States

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Promoting Science & Technology

- **Supporting research among Member States**
- **To foster and exchange scientific knowledge**
- **Transfer expertise among MS**

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Research Reactors

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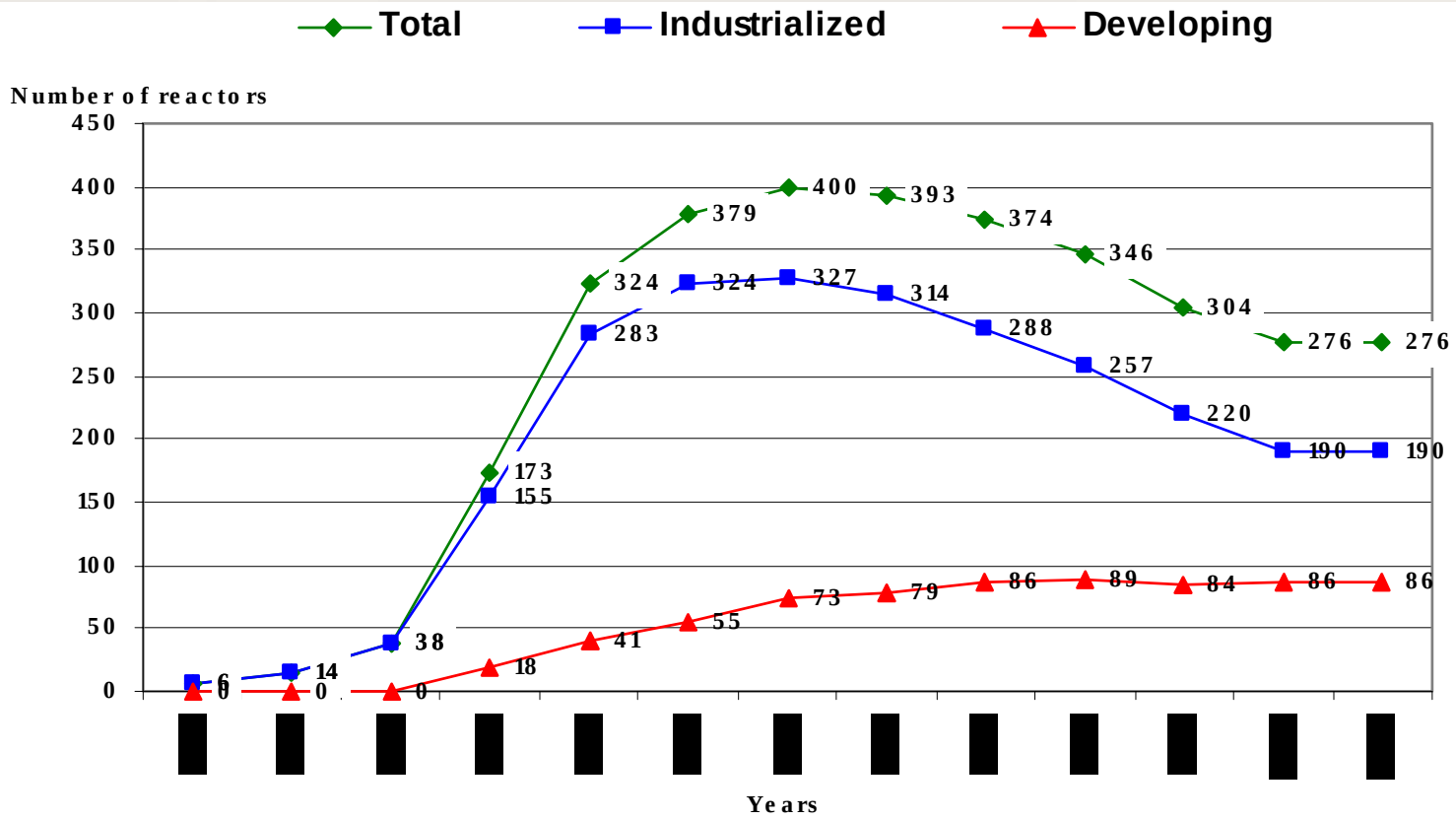
Status Research Reactors I

DEVELOPED COUNTRIES	DEVELOPING COUNTRIES
188 IN OPERATION	84 IN OPERATION
187 SHUT DOWN	27 SHUT DOWN
154 DECOMMISSIONED	14 DECOMMISSIONED
3 PLANNED	5 PLANNED
4 UNDER CONSTRUCTION	5 UNDER CONSTRUCTION

Status Research Reactors II



Number of research reactors in industrialized and developing countries

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NTR 2004

Status Research Reactors III

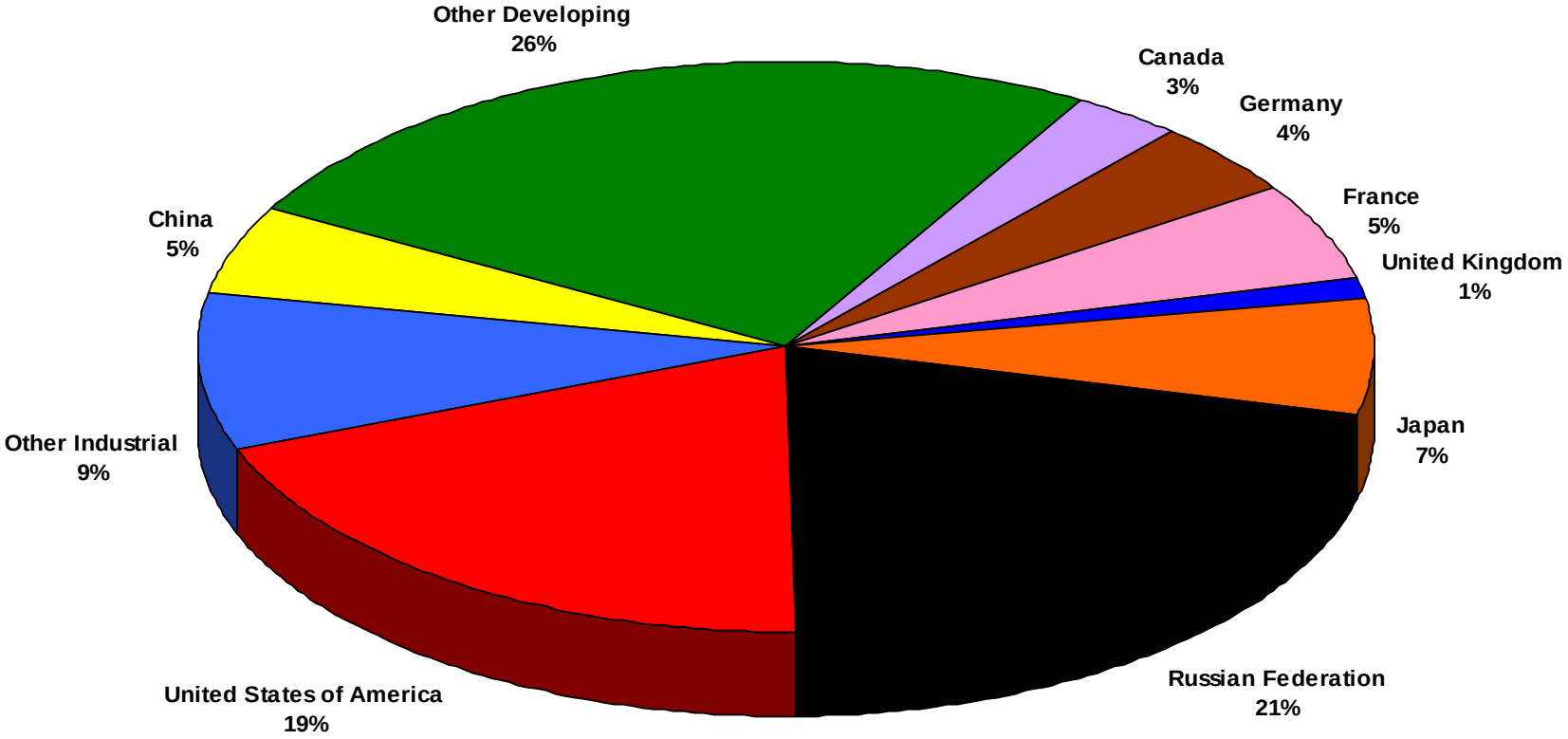
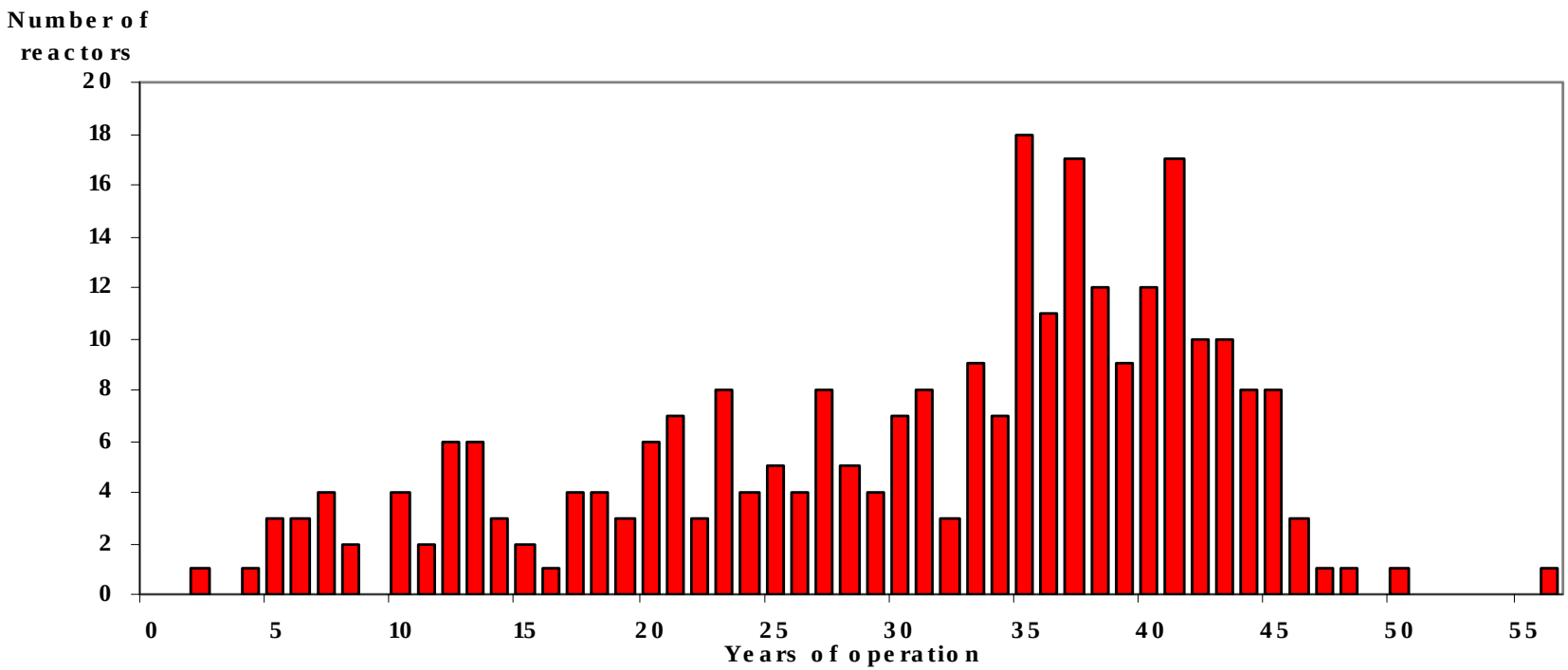


Figure 2. Operational research reactors in IAEA member states - 273 Reactors

Ageing of Research Reactors



Age distribution of research reactors in the RRDB: Number of reactors and years in operation

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Frequency of applications of research reactors

Application	Number of reactors declaring involvement
Neutron activation analysis	71
Teaching	68
Training	63
Materials or fuel tests	53
Isotope production	48
Neutron scattering research	34
Neutron radiography	32
Transmutation (Si or gems)	21
Geochronology	14
Neutron capture therapy	9
Other uses	47

IAEA Priorities

- Enhance the utilization of facilities consistent with their capabilities and objectives, provided there is financial commitment by the national government and/or industry.
- Assist countries within regions to collaborate and address common issues and problems with their government's support.
- Help to share reactor resources and assist in the development of state-of-the-art facilities; encourage scientists and engineers to remain in their region, thus helping in socio-economic development through emergence of spin off technologies.
- Solve safety and security problems in existing, viable research reactors and associated fuel cycle facilities. Also, assist in the decommissioning of shutdown reactors with appropriate political and financial commitment by the national government and/or industry.
- Assist in setting up new research reactor facilities.

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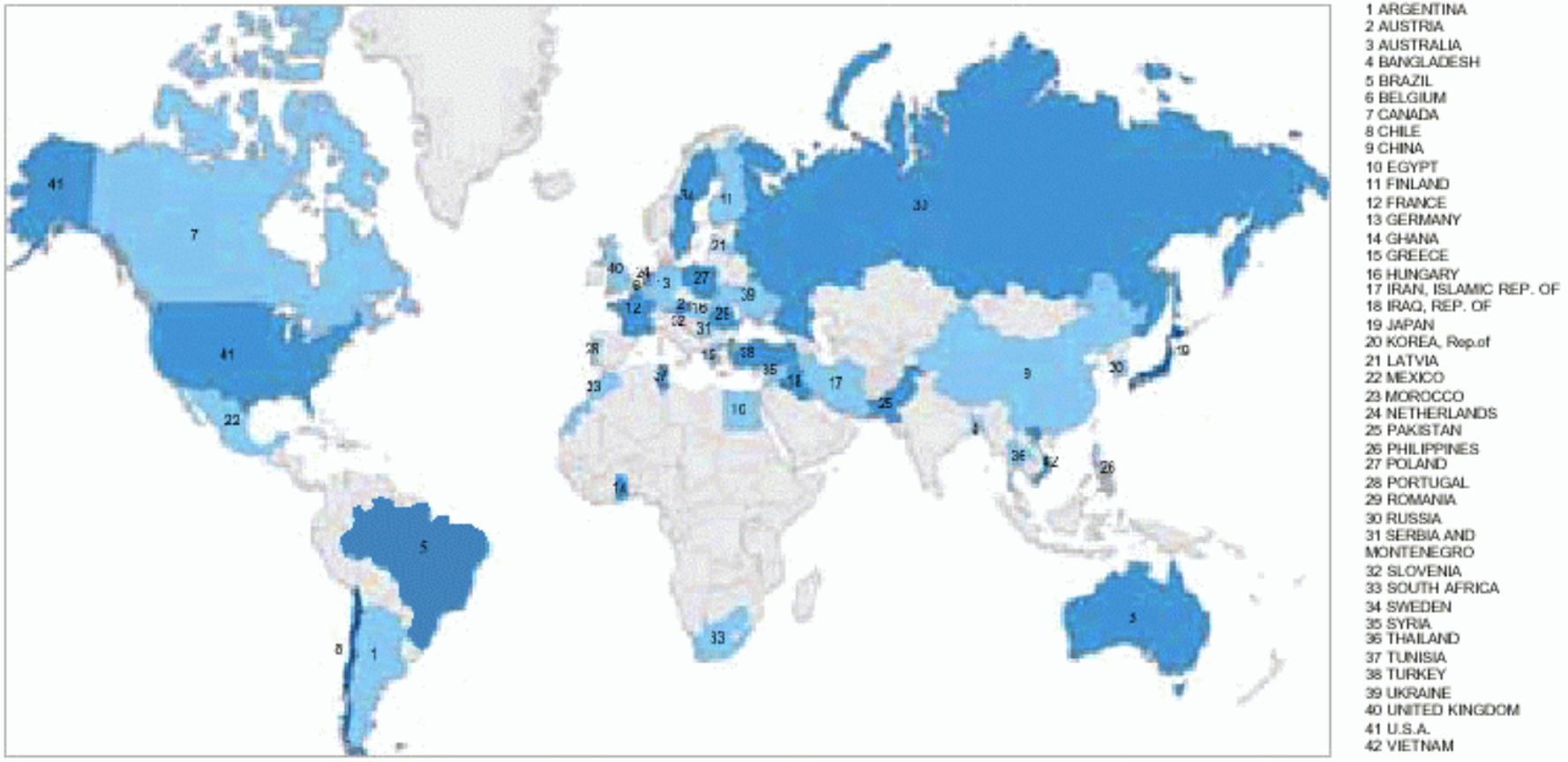
Research Reactors Worldwide



Member States who have joined the Incident Reporting System for Research Reactors (IRSRR)

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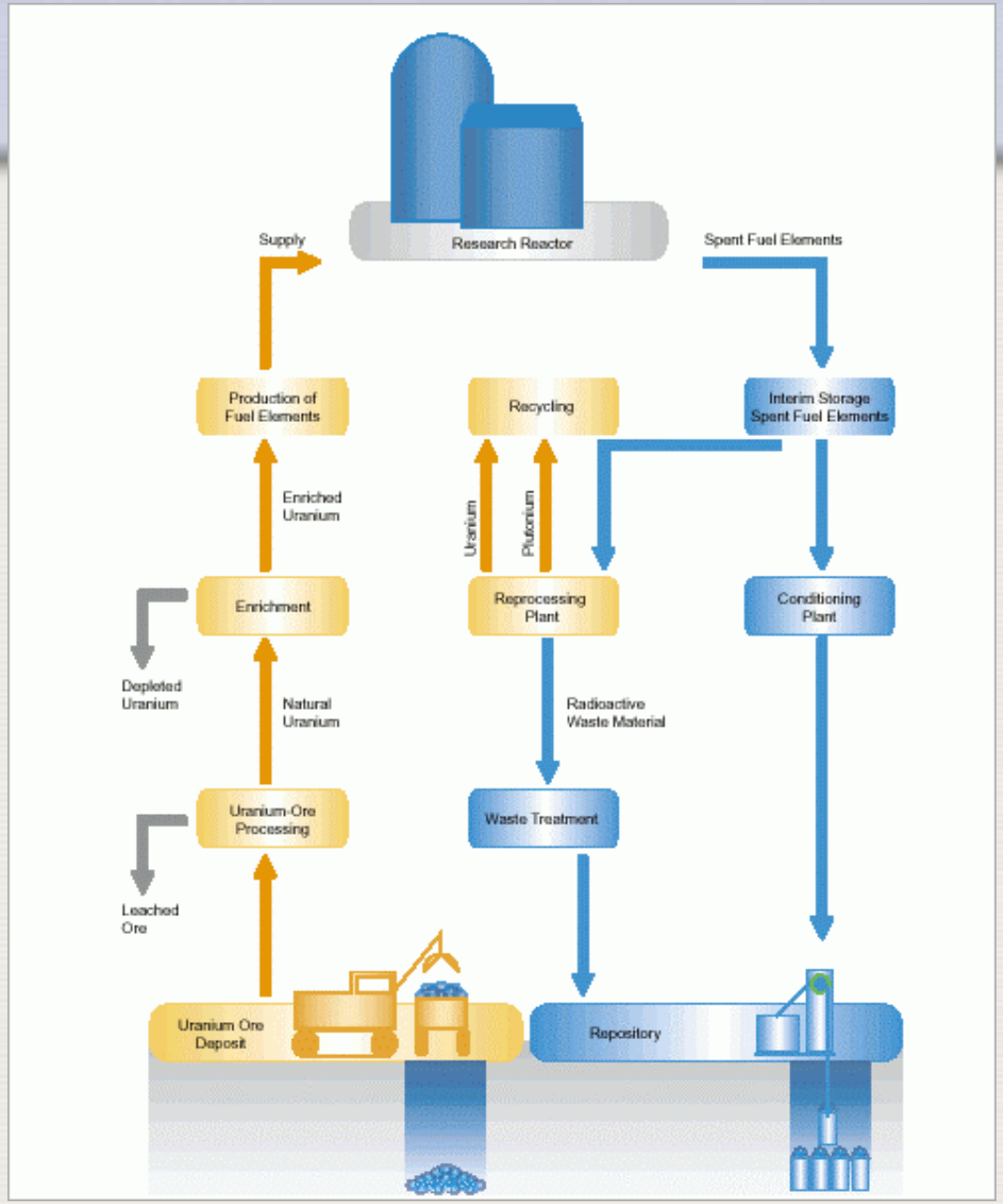
Fuel Cycle



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The Challenge

If the benefits from research reactors are to be maintained, then the premises upon which they are built and operated must be reconsidered and brought into the today's technical, economic, and social realities.

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Research Reactor Projects

IAEA-TECDOC-1457

Measurement of residual stress in materials using neutrons

Proceedings of a technical meeting held in Vienna 13-17 October, 2003

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Research Reactor Projects

IAEA-TECDOC-1457

IAEA-TECDOC-1212

Strategic planning for research reactors

Guidance for reactor managers

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Research Reactor Projects

IAEA-TECDOC-1457

IAEA-TECDOC-1212

IAEA-TECDOC-1234

The applications of research reactors

Report of an Advisory Group meeting held in Vienna, 4–7 October 1999

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Research Reactor Projects

CRPs:
Development of improved sources and imaging systems for neutron radiography (2003 – 2005)
Development of Distance Learning (DL) modules on troubleshooting of nuclear instruments (2001 – 2005)
Development of harmonized QA/QC procedures for maintenance and repair of nuclear instruments (2005 – 2008)

Networking:
Regional Networking for Research Reactor Utilization in Mediterranean Region (May 2005), in South-East Asia Region (June 2005) and in Latin-America (Sept. 2005)

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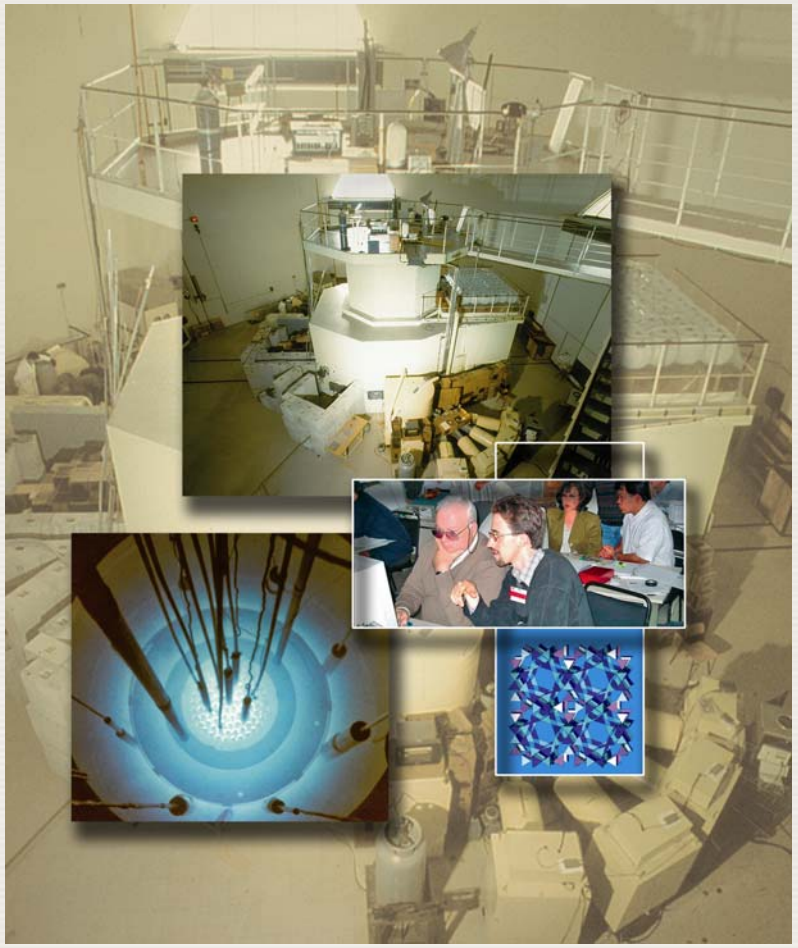
Physics Section Research Reactor Activities

Means of implementation:

- Conferences
- Technical meetings
- Workshops/ training courses
- Coordinated research projects
- Technical cooperation projects



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Accelerators

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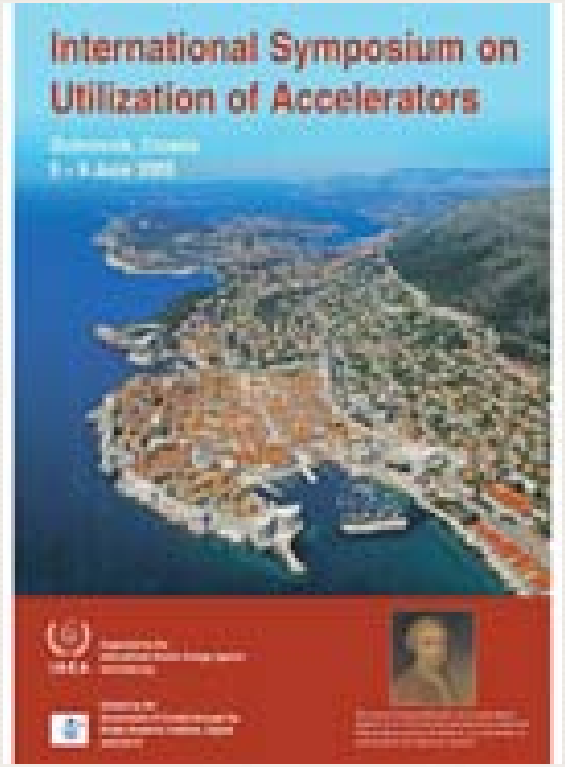
Physics Section Accelerator Activities

- Stimulate research in specific fields of interest to the Agency
- Increase international cooperation in nuclear science
- Assist developing countries to increase their participation in nuclear research
- Provide technical input to National/ Regional technical cooperation projects



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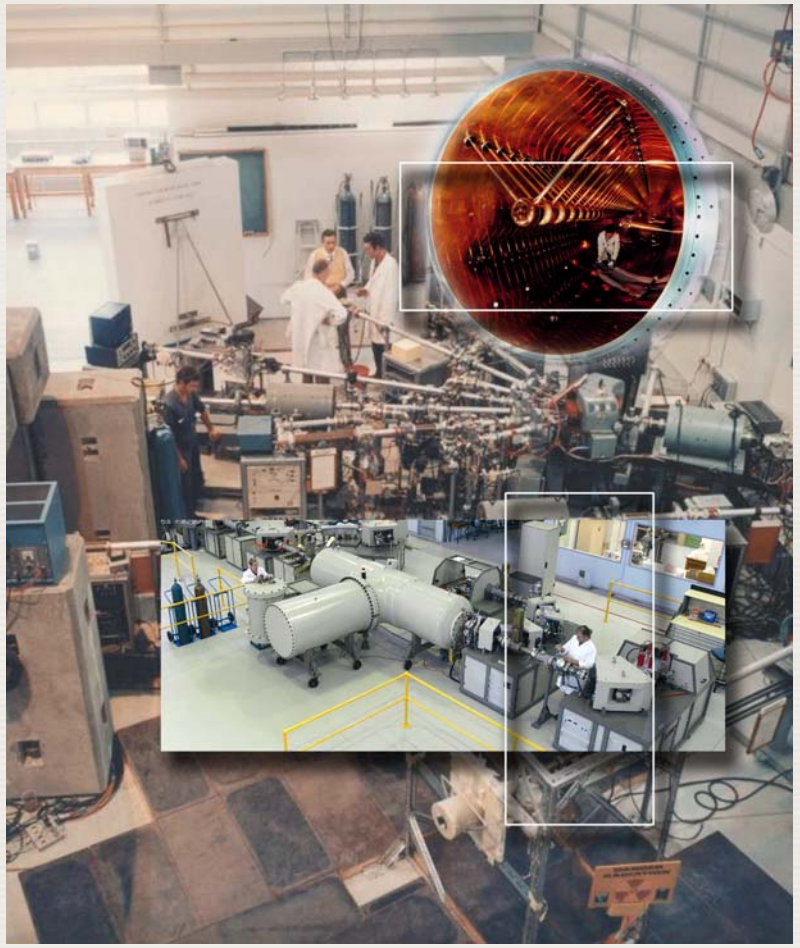
Accelerators

- **Promoting innovative nuclear science and technology**

  Enhancing the effective utilization of accelerators and accelerator based techniques

- **Capacity building**

  Activities to build and sustain nuclear knowledge and expertise



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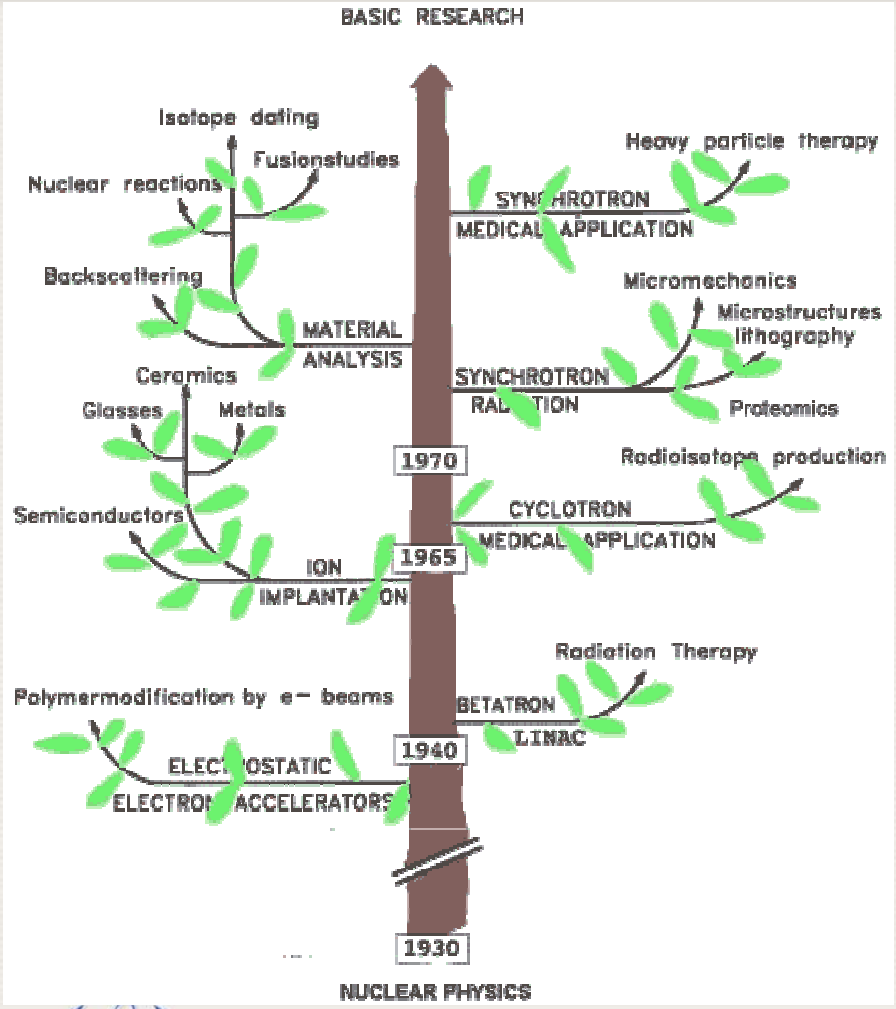
Accelerators: a tool for nuclear research



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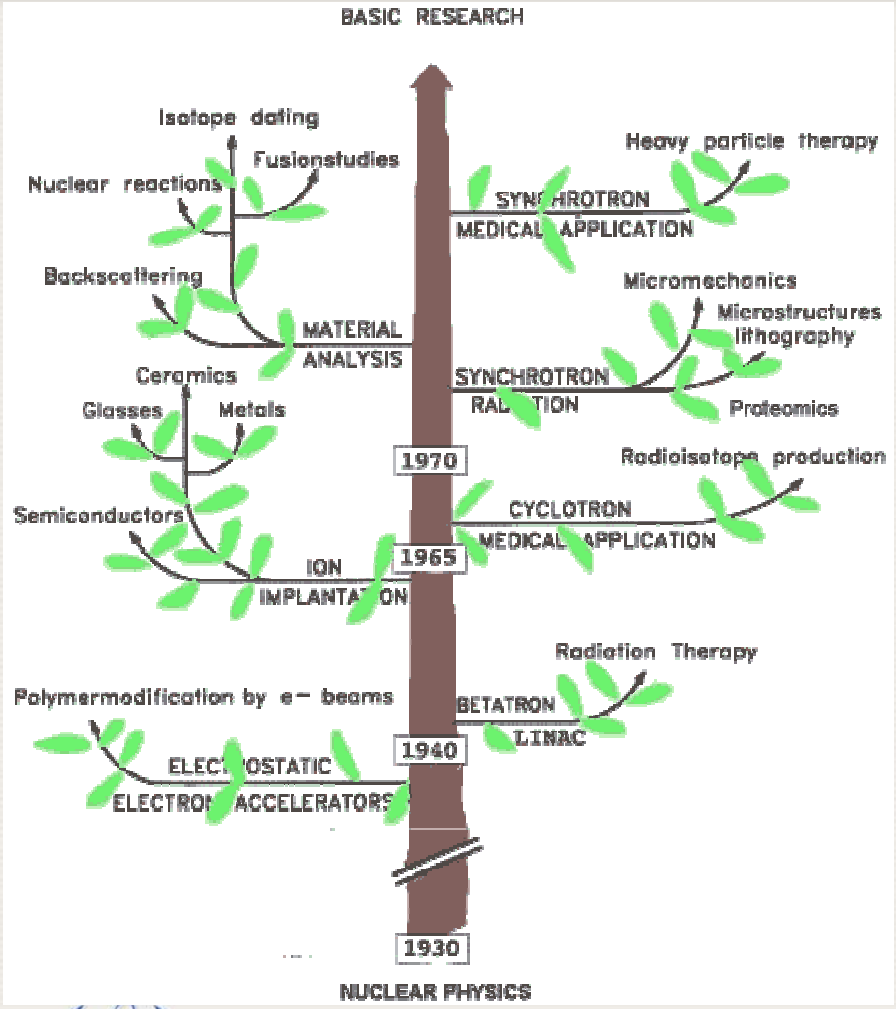
Accelerators: a tool for nuclear research



CATEGORY	NUMBER
Ion implanters and surface modification	~ 7,000
Radiotherapy	~ 5,000
Accelerators in industry	~ 1,500
Accelerators in non-nuclear research	~ 1,000
Medical isotopes production	~ 200
Research in nuclear and particle physics	~ 150
Synchrotron light sources	~ 70
Hadrontherapy	~ 20
TOTAL	**~ 15,000**

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Accelerator Systems for Neutrons

SYSTEM	Reaction	Beam Energy (MeV)	Beam Power (kW)	Neutron Production Rate (n/s)	Cost (approximate)
D-T	$T(d,n)^4He$	~0.3	0.05	10^9	$100K
AccSys DL1	Be(d,n)	1	0.12	10^{10}	$0.5M
AccSys PL11	Be(p,n)	11	11	10^{13}	$3.5M
LENS	Be(p,n)	13	30	10^{14}	$20M
Model A	Li(d,n)	20-30	100	10^{15}	>$50M
Model B	Spallation	400-1000	100	10^{16}	>$500M

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ADNS: Networking

Opportunities offered by networking in the field of ADNS

Apart from the transfer of knowledge from existing facilities to potentially new/planned, there are several other arguments that make networking attractive:

- Designing, construction, operation, and utilization of accelerator driven neutron sources will require skills and resources, not all of which may be available in any particular country;
- The opportunities offered by such facilities may be sufficiently broad to serve the needs of more than one country;
- Conversely, special opportunities may be available at some facilities, and not on others;
- Limited resources, that are insufficient to build independent, state-of-the-art facilities within a given nation can be pooled;
- Distributed **medium size** ADNS can offer possibilities otherwise only available at large facilities.

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CRP on ADNS

An IAEA Coordinated Research Project (CRP) on "Development Of Small And Medium Scale Accelerator Driven Neutron Sources".

Contrary to existing user program schemes, which are generally supported by individual funding agencies, a network would aim at pooling resources among independent entities, and be based on contractual agreements between these entities. There would be a joint planning and scheduling scheme, and regular reporting and co-ordination meetings to monitor progress and decide on new activities.

Introducing ADNS facilities in developing nations will be greatly facilitated through the formation of networks (among developing nations, as well as among more developed ones).

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CRP on ADNS, Topics

SANS (Small Angle Neutron Scattering)

Reflectometry

Powder /polycrystalline diffraction and strain measurements
Neutron Radiography

Activation analysis

Special Stations (Neutronics engineering/Instrumentation)

Education

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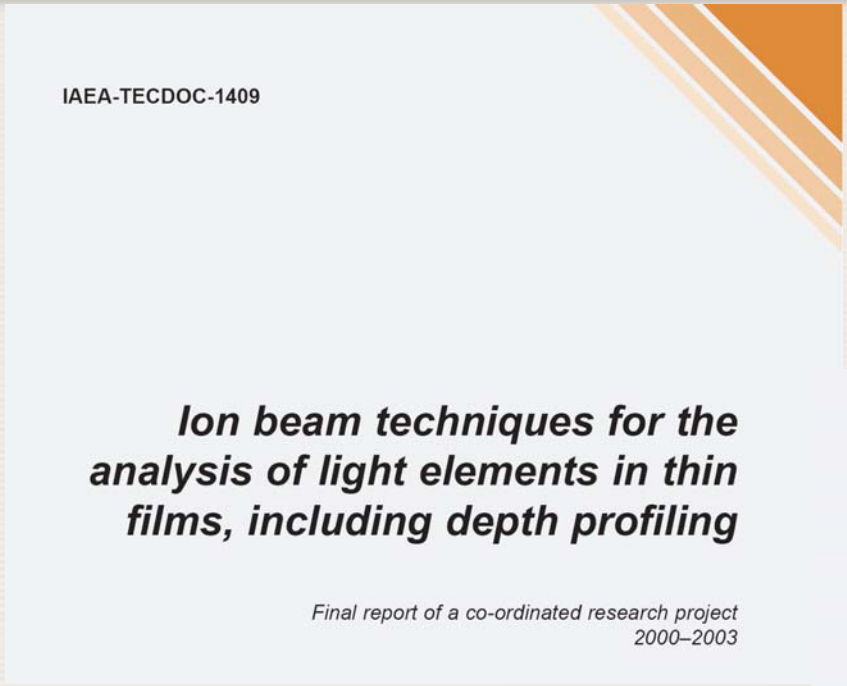
Accelerator Projects



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Accelerator Projects

CRPs:

Ion beam modification of insulators (2004 – 2008)
Development of new techniques and applications of accelerator mass spectrometry (2004 – 2008)
Development of nuclear microprobe techniques for the quantitative analysis of individual microparticles (2005 – 2008)

Analytical and experimental benchmark analyses of Accelerator Driven Systems (ADS) (2005 – 2010, NE)

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Detection of Explosives and Demining

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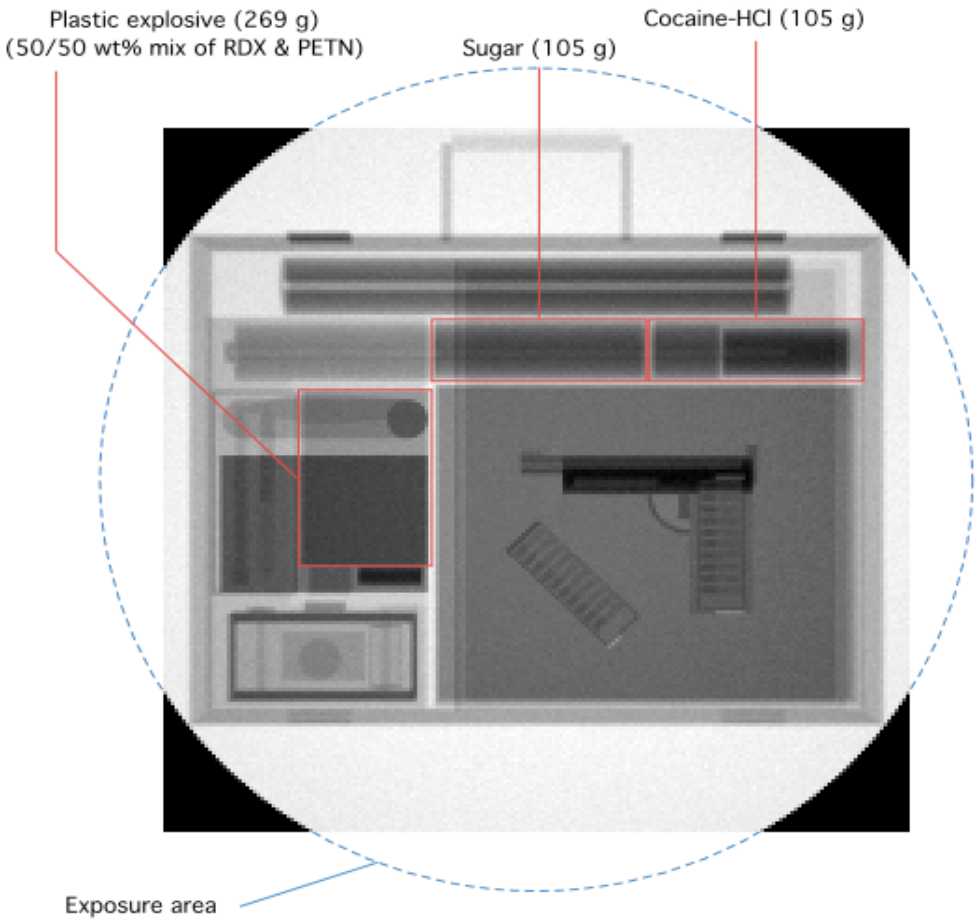
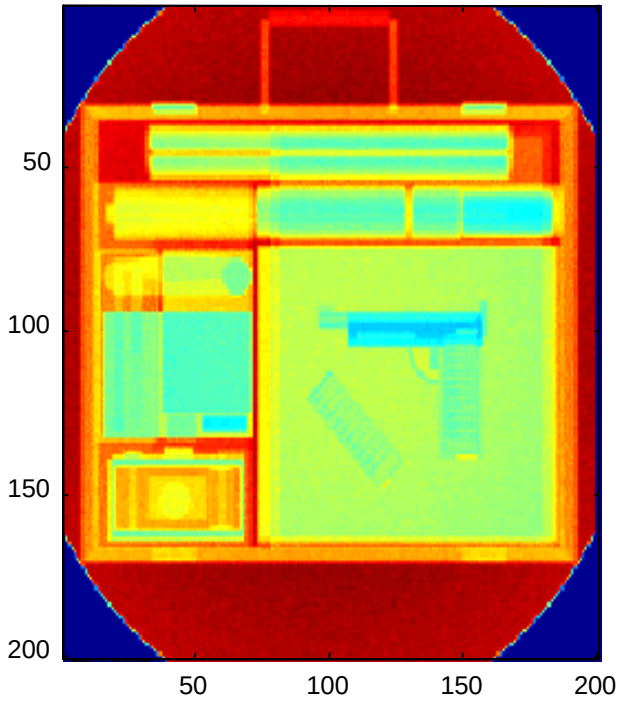
APPLICATIONS OF ACCELERATORS FOR THE SAFETY AND SECURITY OF PEOPLE

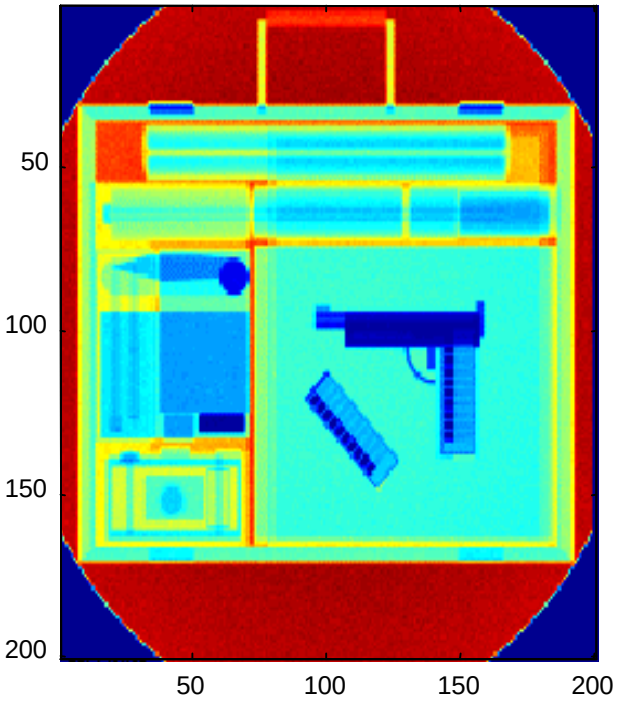


APPLICATIONS OF ACCELERATORS FOR THE SAFETY AND SECURITY OF PEOPLE

Neutron Image(0 degree)



X-Ray Image(140kev)



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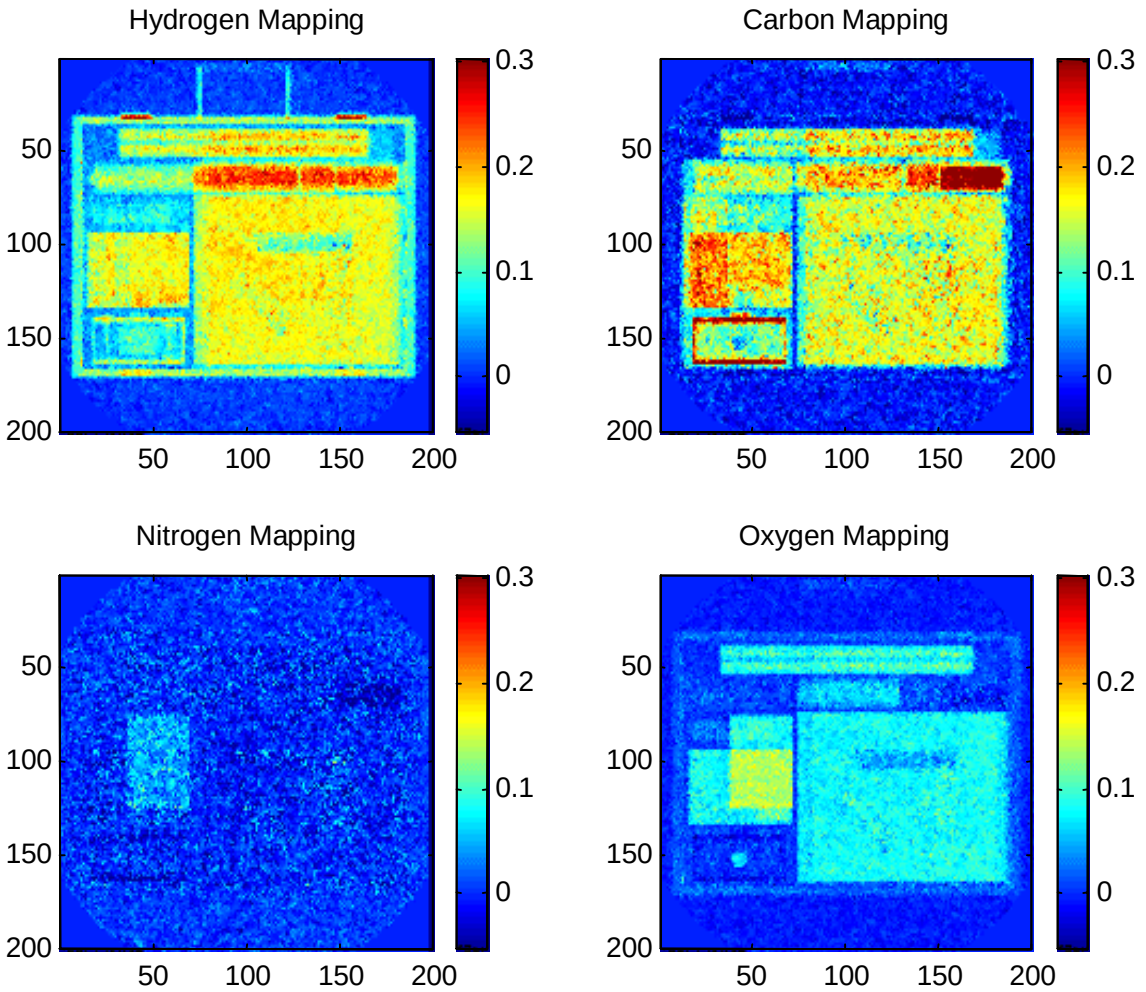

Detection of Explosives and Radioactive Material

CRPs:

Neutron techniques for the detection of illicit materials and explosives (2005 – 2009)

Improvement of technical measures to detect and respond to illicit trafficking of nuclear material and other radioactive materials (2003 – 2006, SG)

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Summary

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Summary

The IAEA has an integrated approach towards the utilization of research reactors and accelerators in the Member States:

Education:	School on Neutrons, School on Accelerators
Training:	Technical Cooperation Projects
Hardware:	Technical Cooperation Projects
Research:	Coordinated Research Projects
Information Exchange:	Conferences, Meetings, Workshops

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