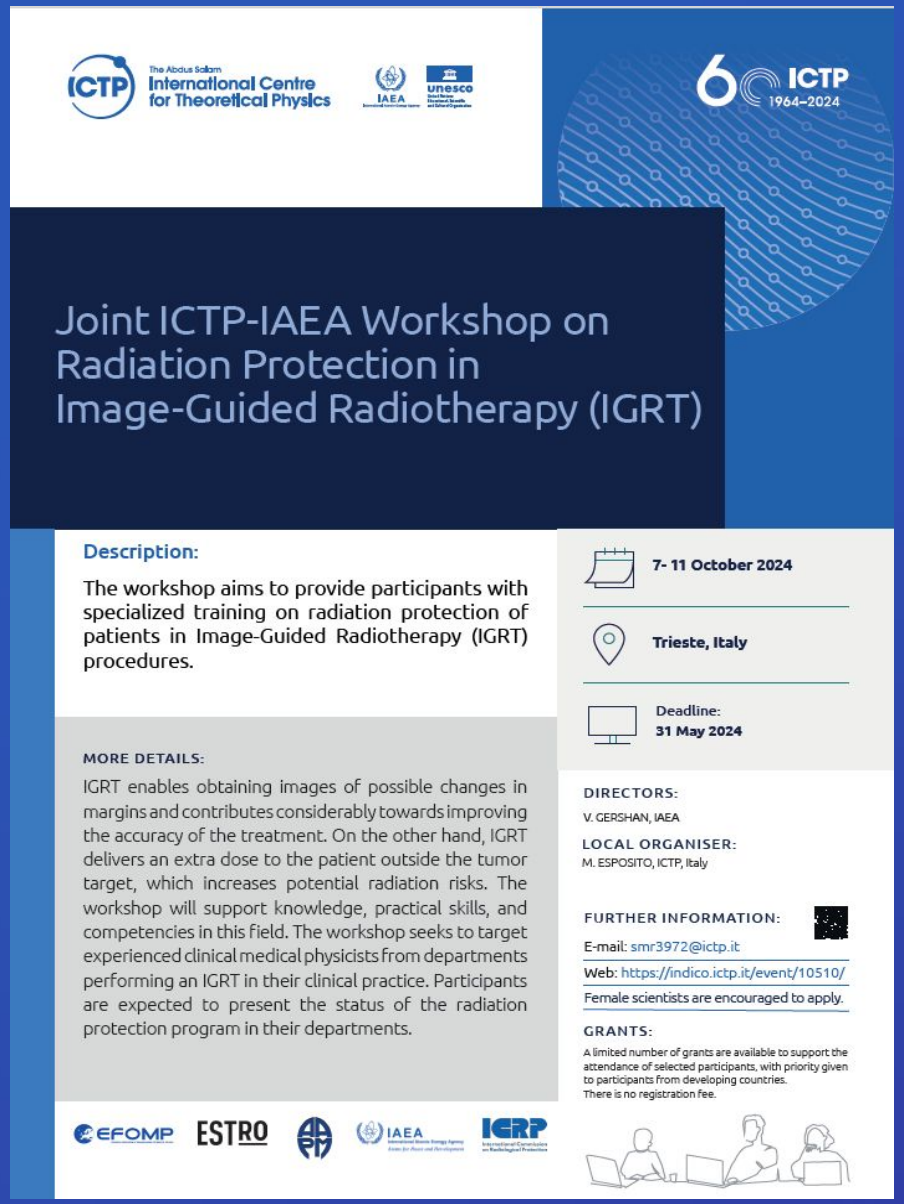
IAEA
International Atomic Energy Agency



Joint ICTP-IAEA Workshop on

Radiation Protection in Image-Guided Radiotherapy (IGRT)

7 – 11 October 2024
Trieste, ITALY

MOTIVATION, OBJECTIVES AND SCOPE

Vesna Gershan, PhD
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INERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

International Atomic Energy Agency (IAEA)

- World's centre for cooperation in the nuclear field
- Seeks to promote the safe, secure and peaceful use of nuclear technologies
- Established in 1957 as an autonomous organization under the United Nations
- 178 Member States (19 Sept 2023)
- Headquarters in Vienna, Austria
- Nobel Peace Prize 2005

International Atomic Energy Agency (IAEA)

Vienna International Center
(IAEA- Headquarters)

The **nuclear applications laboratories** in Seibersdorf, near Vienna:

- Applied research and development,
- Provide technical and analytical services and
- Deliver training and capacity-building to Member States

IAEA statutory role

- The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world
- Establish or adopt standards of safety for protection of health and minimization of danger to life and property, and provide for the application of these standards

IAEA Technical Cooperation (Europe, Asia, Africa and Latin America)

- **Many regional and national projects**
  - High number of countries participating in TC projects on radiation protection of patients
  - Tasks in all major areas of patient protection
  - Expert missions, direct advice and provision of tools and euipment
  - Fellowships
  - Scientific visits
  - Regional and national training courses

IAEA RPOP photo archive, J. Vassileva

Part of the IAEA Projects related to Radiation Protection of Patients and Quality in Radiotherapy (active 2022 – 2024)

Regional projects in TC Europe

- RER/6/04: Improving Radiotherapy Practices for Advanced Radiotherapy Technologies Including Quality Assurance and QC
- RER/9/157: Strengthening Implementation of the Justified and Optimized Use of Ionizing Radiation in Medicine

Regional projects in TC Africa

- RAF/6/055: Improving the Quality of Radiotherapy in the Treatment of Frequently Occurring Cancers (AFRA)
- RAF/6/056: Supporting Human Resources Development in Radiation Medicine (AFRA)
- RAF/9/070: Enhancing the Radiation Safety Infrastructure (AFRA)

IAEA Projects related to Radiation Protection of Patients, Capacity building, Quality Assurance, etc in Radiotherapy (active 2022 – 2024)

Regional projects in TC Asia

- RAS/6/096: Empowering Regional Collaboration among Radiotherapy Professionals through Online Clinical Networks (RCA)
- RAS/6/098: Standardizing Radiotherapy in Palliative Care (RCA)
- RAS/6/099: Developing Sustainable, High Quality, and Safe Medical Diagnostic Imaging and Radiotherapy Services (SAPI)
- RAS/6/101: Improving the Quality and Safety of Radiation Medicine through Medical Physicist Education and Training (RCA)
- RAS/9/075: Strengthening Radiation Protection Infrastructure and Technical Capabilities for the Safety of Workers, Patients and the Public

Regional projects in TC Latin America

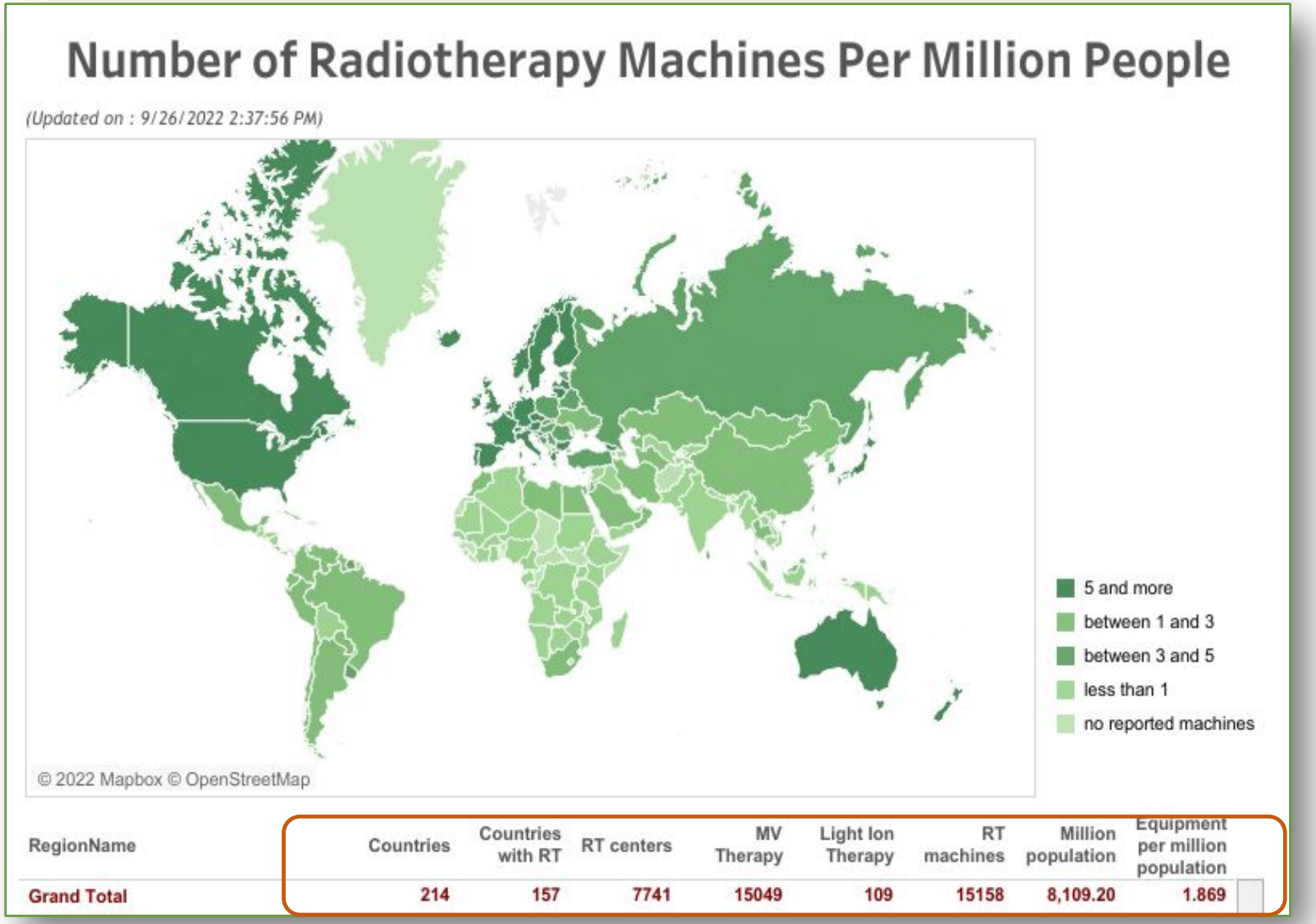
- RLA/6/090: Strengthening Radiotherapy Management for the Treatment of Cervical Cancer in Latin America and the Caribbean (ARCAL CLXXXII)
- RLA/6/092: Strengthening the Use of Advanced Techniques and Hypofractionation Schemes of Radiotherapy in the Countries of the Region (ARCAL CLXXXVIII)

Motivation for the workshop

1. Global needs and availably of Radiotherapy machines

- The annual number of new cancer cases is projected to rise from 14.1 million in 2012 to 21.6 million in 2030.
- Approximately 50% of cancer patients would benefit from radiotherapy at some stage in the course of their therapy.

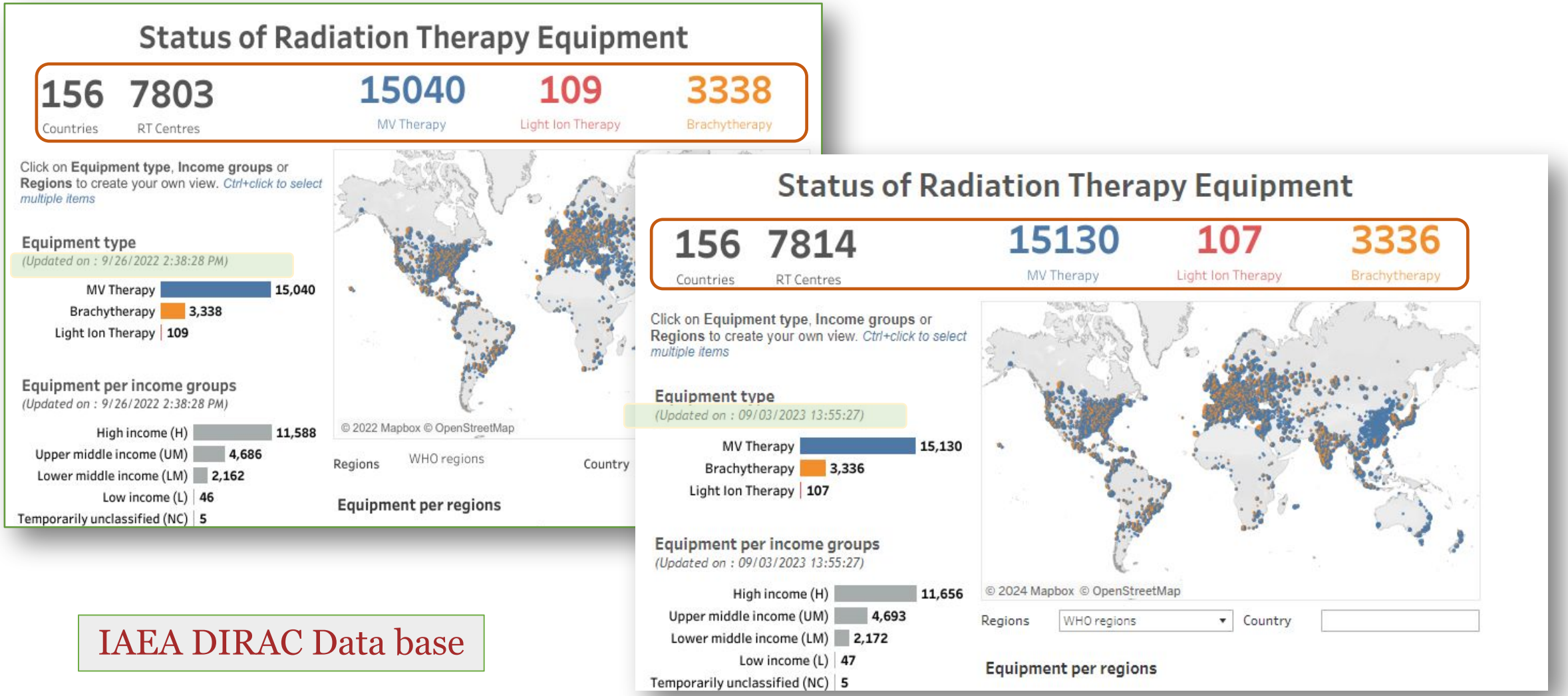
World Health Organization



RegionName	Countries	Countries with RT	RT centers	MV Therapy	Light Ion Therapy	RT machines	Million population	Equipment per million population
Grand Total	214	157	7741	15049	109	15158	8,109.20	1.869

IAEA DIRAC Data base

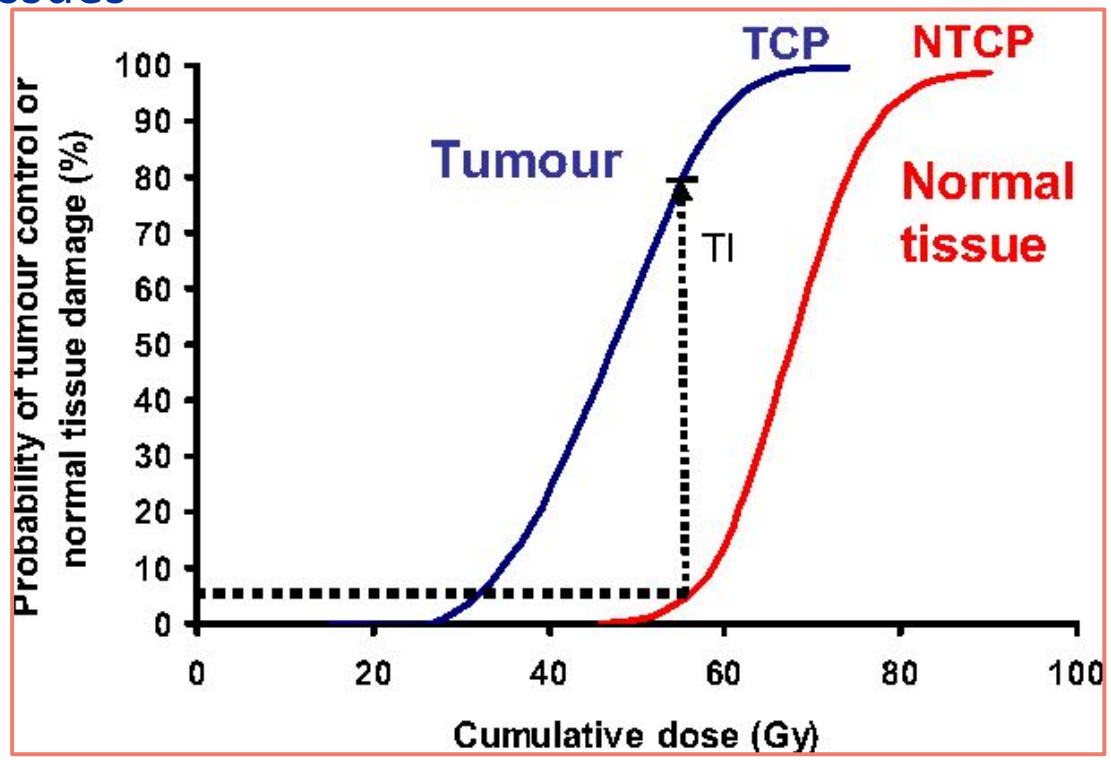
2. Global increase of available radiotherapy equipment



IAEA DIRAC Data base

3. Goal of radiotherapy

To conform the treatment to the targeted area while minimizing dose to surrounding normal tissues



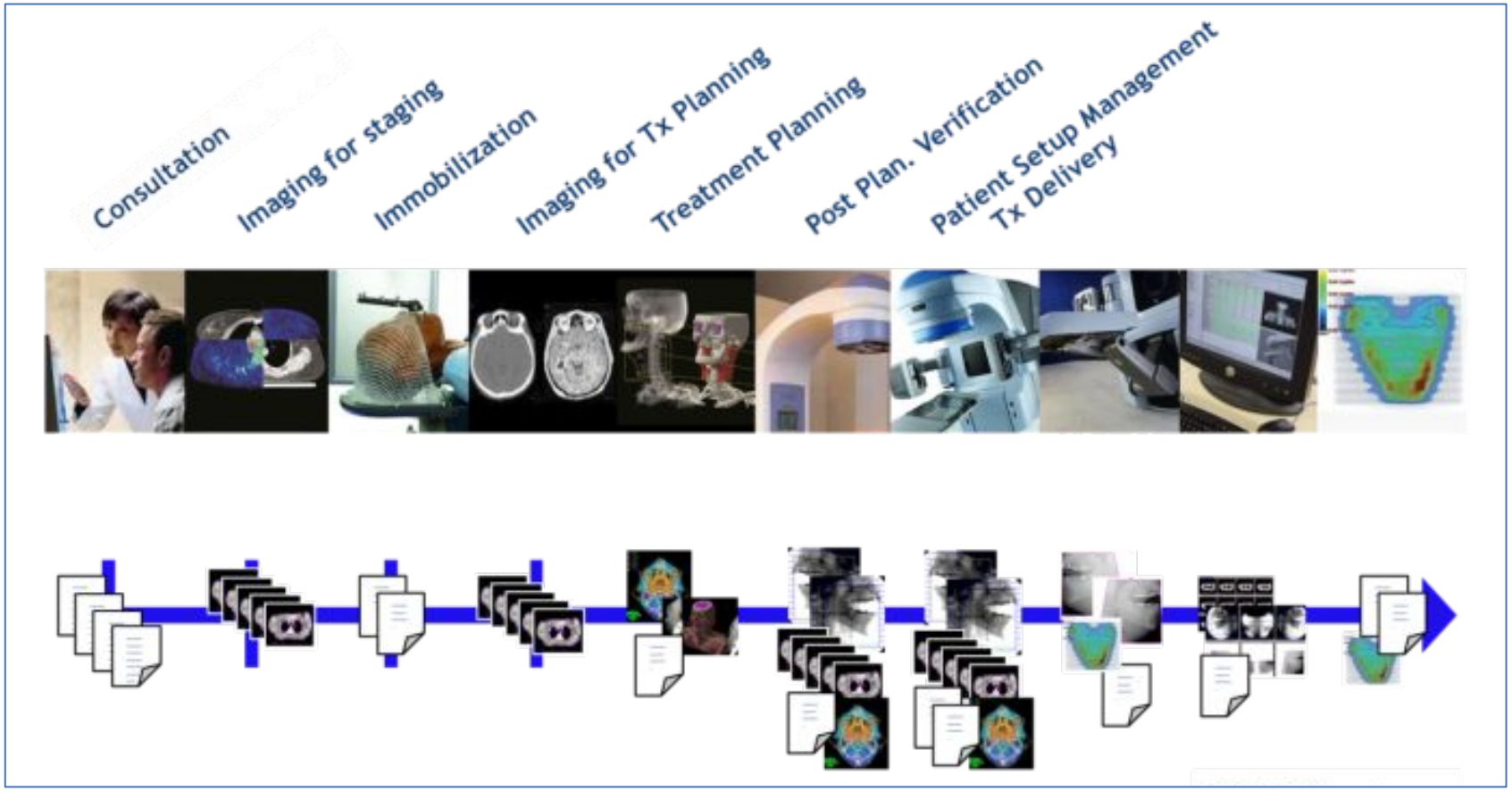
Karsten Eilertsen Imaging the Beams Eye View in External Beam Radiotherapy : Geometric and Dosimetric Precision, K. Eilertsen, T. Tung, Published 2012, Physics

https://wonderopolis.org/wonder/can-you-walk-the-tightrope

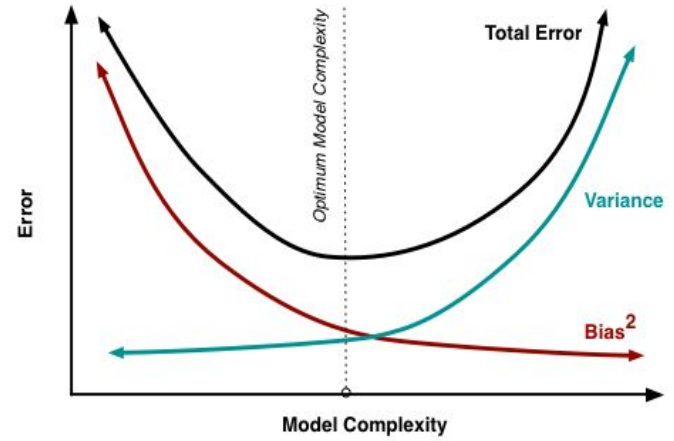
✔ For a given radiation schedule and technique, a high probability of tumour of control (TCP) can be reached **at a dose level that does not inflict severe normal tissue complications** (NTCP).

4. Importance of radiation protection in Radiotherapy

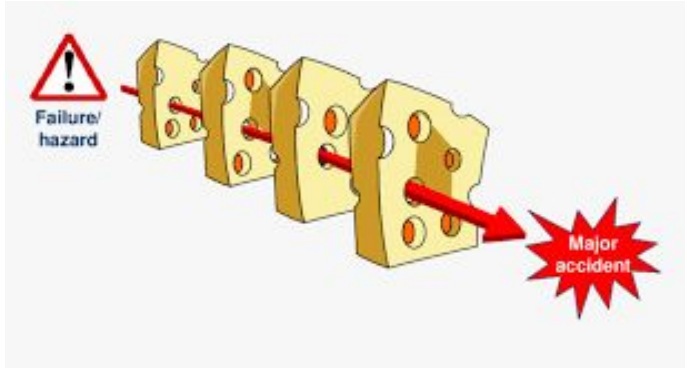
✔ Radiotherapy is a highly complex, multi – step process that requires the input of many different staff groups in the planning and delivery of the treatment.



Physical and Radiobiological Evaluation of Radiotherapy Treatment Plan | IntechOpen

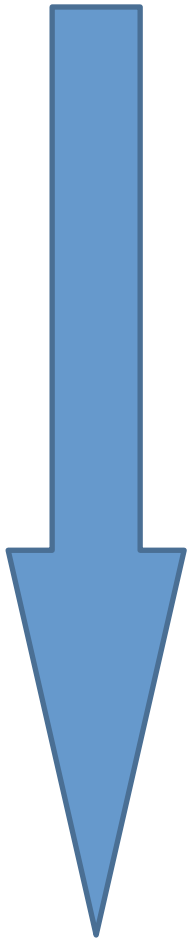


scikit-learn : Bias-variance tradeoff - 2020 (bogotobogo.com)



5. Increasing complexity in Radiotherapy

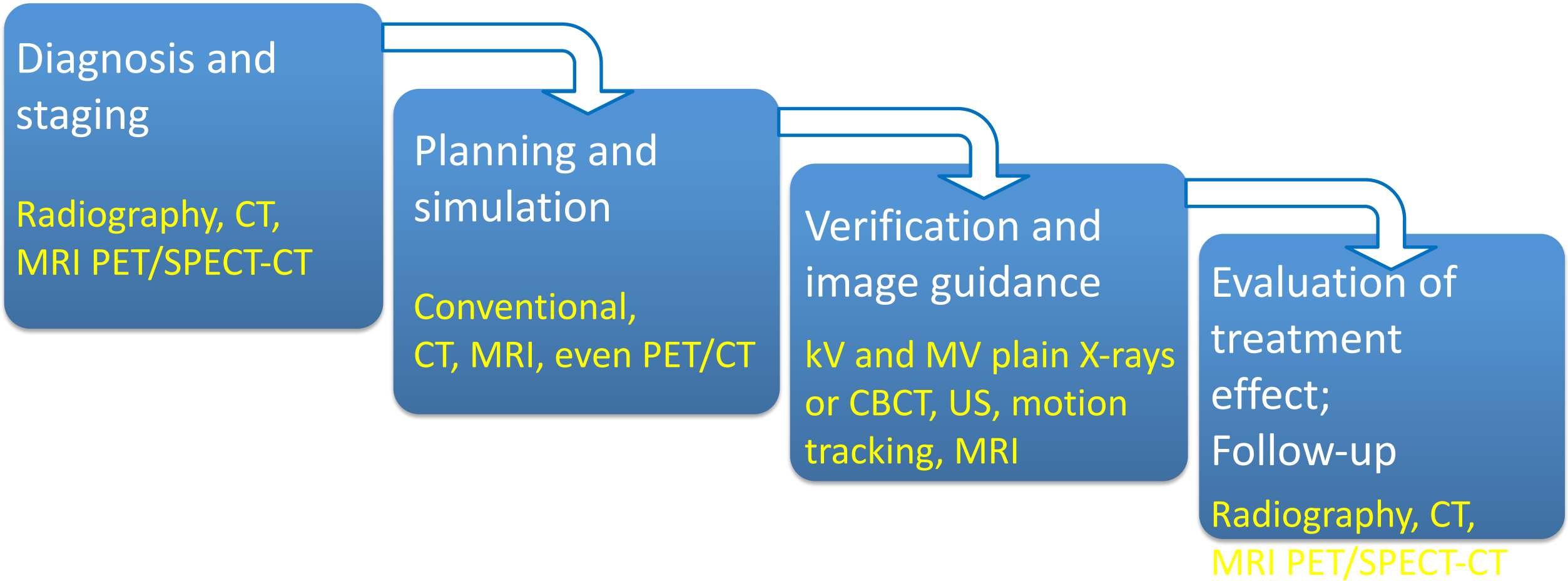
5. Increasing complexity in RT - Sample IGRT workflow with on-line correction



- Perform CT simulation
- Transfer reference CT images and planning data to treatment workstation
- Position patient in treatment room
- Perform in-room imaging
- Compare in-room image with reference CT to determine patient and target position
- Determine if corrections are needed
- Send any necessary shifts in position to the treatment unit automatically
- Treatment unit automatically moves the treatment couch
- Reimage to confirm shift was made correctly
- Compare daily shifts with previous shifts
- Note any systematic changes in target volumes or organs at risk etc.

6. Role of imaging is increasing (1/2)

- Highly conformal treatments are becoming routine
- Imaging is increasingly used at various points in the radiotherapy process
- Use of IGRT is rapidly expanding



6. Role of imaging is increasing (2/2)

- Highly accurate and precise treatment
- Better tumor control
- Decreases side effects
- Improve outcomes

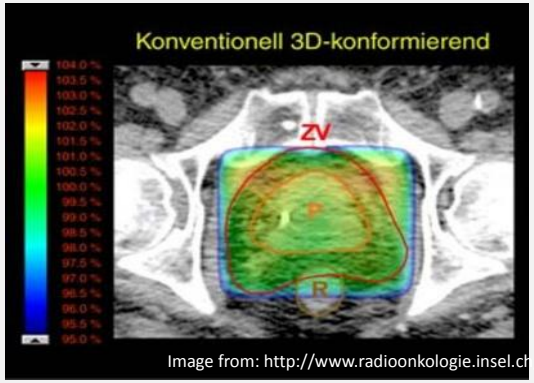
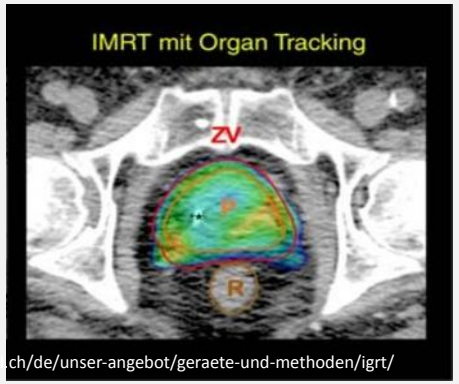
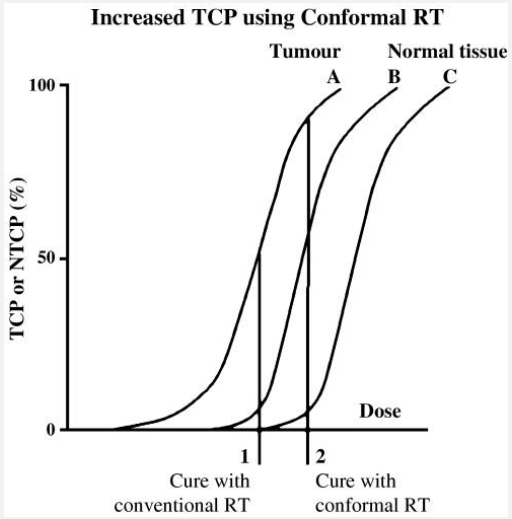


Image from: http://www.radioonkologie.insel.ch/de/unser-angebot/geraete-und-methoden/igrt/



ologie.insel.ch/de/unser-angebot/geraete-und-methoden/igrt/



- The imaging can contribute significant doses to tissues and organs
- Including dose to the tissue outside the target volume
- Increased risk of secondary cancer, especially for children

7. Radiation protection issues

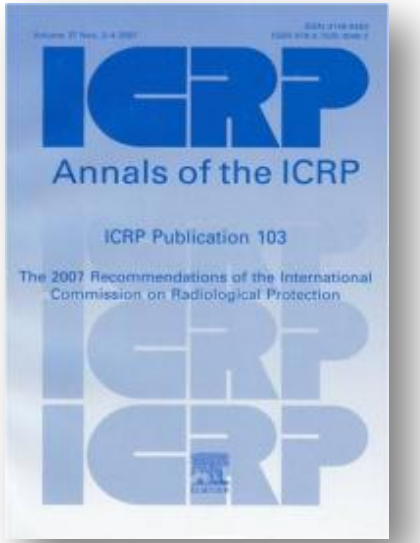
- Although imaging can increase dose to both the treatment site and surrounding normal tissues, patient dose from imaging procedures in RT has traditionally been regarded as unimportant in comparison with the therapeutic dose:

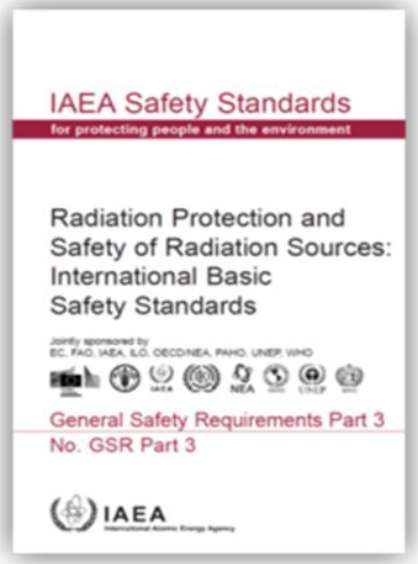
  - CBCT scans often irradiate 45-1600% more patient volumes than the therapeutic beams depending on patient size and tumor volume, adding 21-26% more integral doses to the surrounding normal tissues

  - Doses vary for different imaging modalities and protocols, but daily imaging can add up to 2 Gy or more over a 7-8 week course of curative treatment

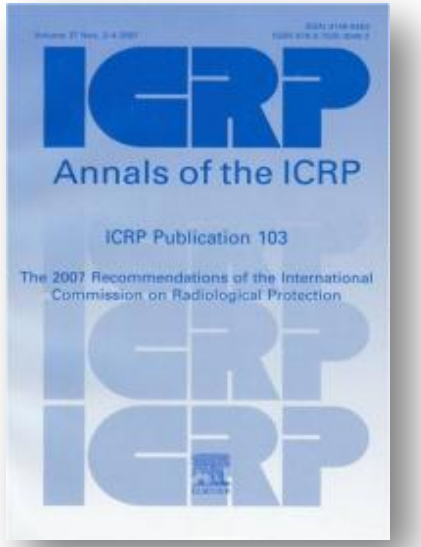
8. Aims of radiation protection

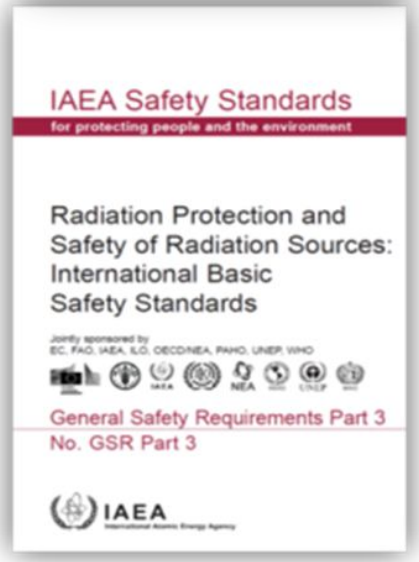
- Prevention of deterministic effects (except for those in radiotherapy that are intentionally produced and not accidental)
  - Deterministic effects are tissue reactions like cataracts and skin burns
- Reduction of the probability of stochastic effects
  - Stochastic effects are induction of cancer or genetic damage





9. Radiation protection principles





No dose limits apply to patients

① Justification:

The expected benefits to individuals and to society outweigh the harm:

Perform only needed and most appropriate procedures

② Optimization of protection:

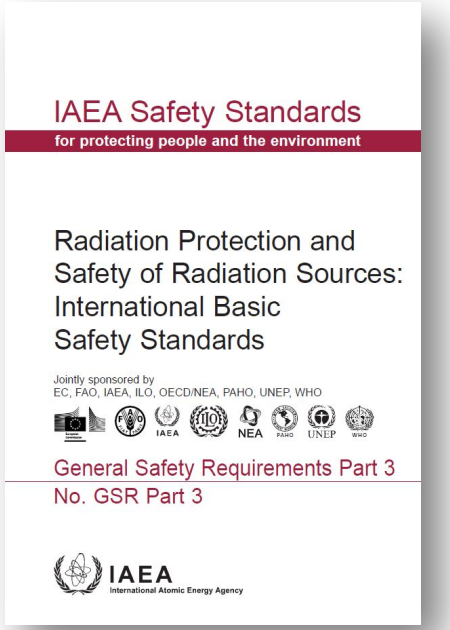
Management of the radiation dose commensurate with the medical purpose

10. Justification in medical exposure (1/3)

- Three level approach

- **Level 1: Justification of use of radiation in medicine in general**

IAEA BSS 3.155: “Medical exposures shall be justified by weighing the diagnostic or therapeutic benefits that they are expected to yield against the radiation detriment that they might cause, with account taken of the benefits and the risks of available alternative techniques that do not involve medical exposure.”

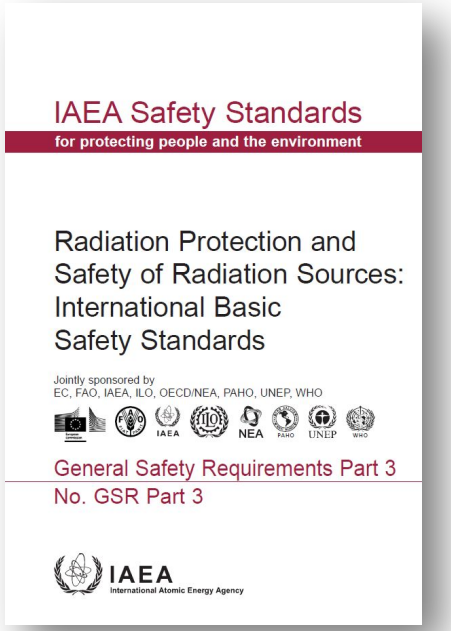


10. Justification in medical exposure (2/3)

- Three level approach

- **Level 2: Justification of a defined radiological procedure (generic)**

  IAEA BSS 3.156: “Generic justification of a radiological procedure shall be carried out by the health authority in conjunction with appropriate professional bodies, and shall be reviewed from time to time, with account taken of advances in knowledge and technological developments.”

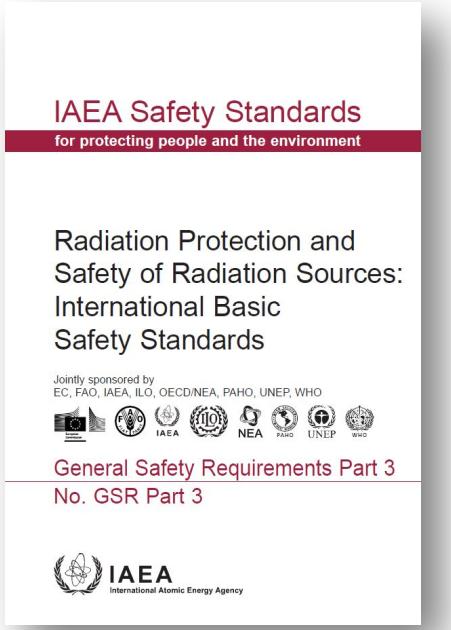


10. Justification in medical exposure (3/3)

- Three level approach

- **Level 3: Justification of a procedure for an individual patient**

IAEA BSS 3.158: “Relevant national or international referral guidelines shall be taken into account for the justification of the medical exposure of an individual patient in a radiological procedure.”

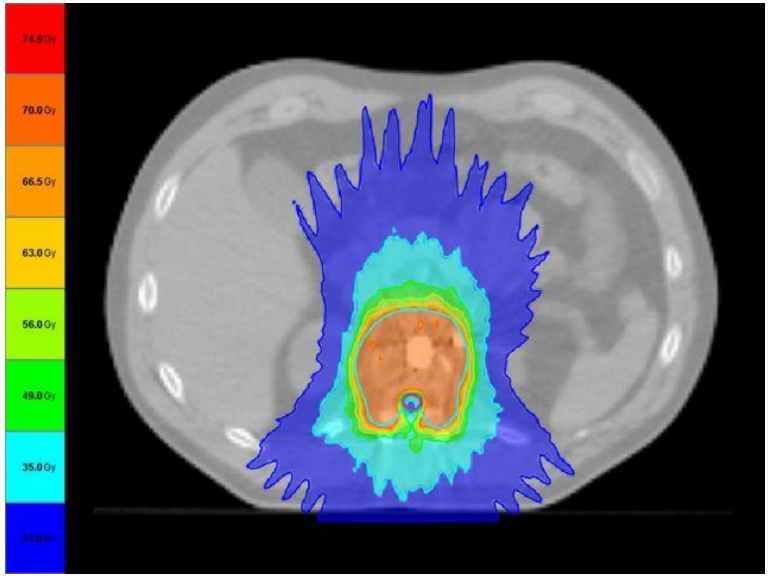


11. Justification in radiotherapy

- Risk/benefit analysis:
  - The benefits of radiotherapy treatments for cancer patients are clearly recognized
  - Assessment of the risks of radiotherapy imaging requires knowledge of all doses associated with the various imaging procedures during a course of treatment

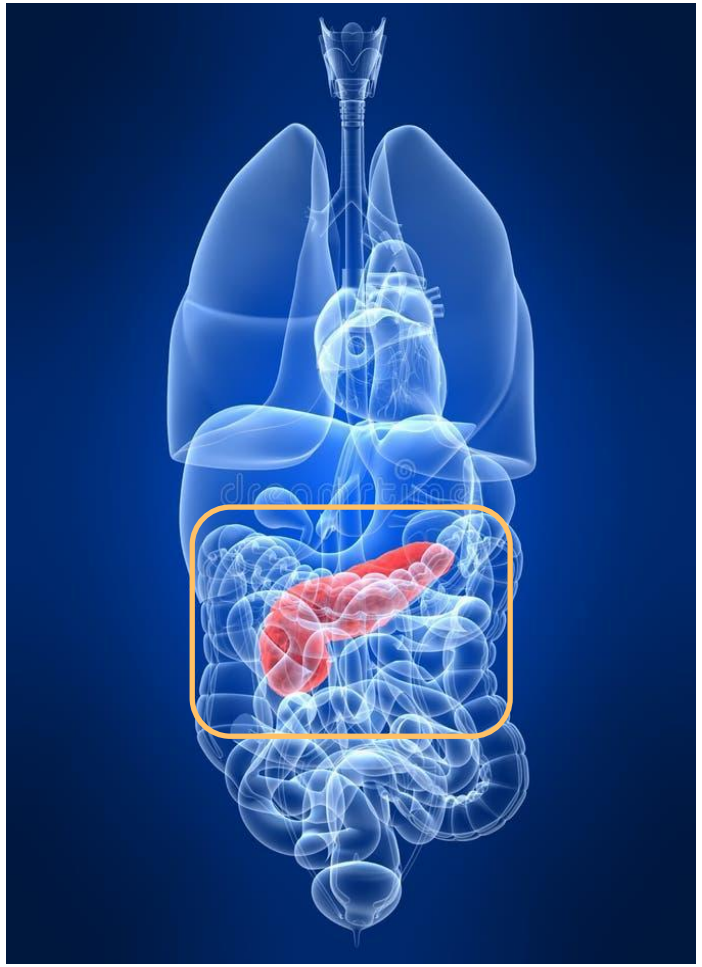
12. Optimization in radiotherapy (1/3)

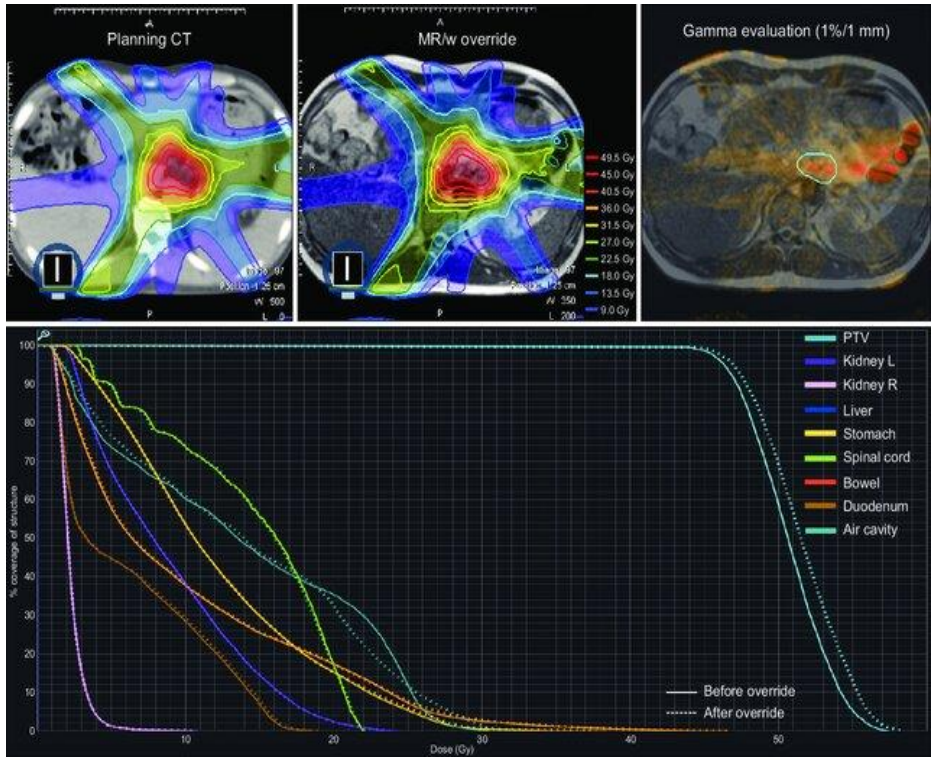
- Optimization of treatment is the primary objective of radiotherapy
  - Optimize the dose distribution to the target
    - In curative treatments using IGRT, optimization of dose to the target may be maximization of dose
  - Minimize the dose to other structures

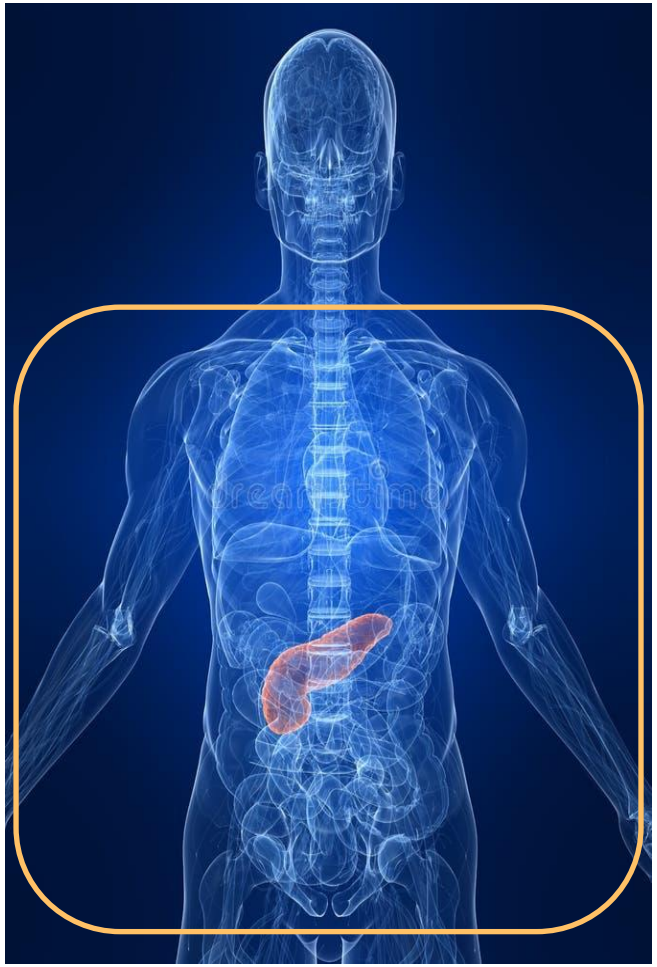


12. Optimization in radiotherapy (2/3)

Common misconception



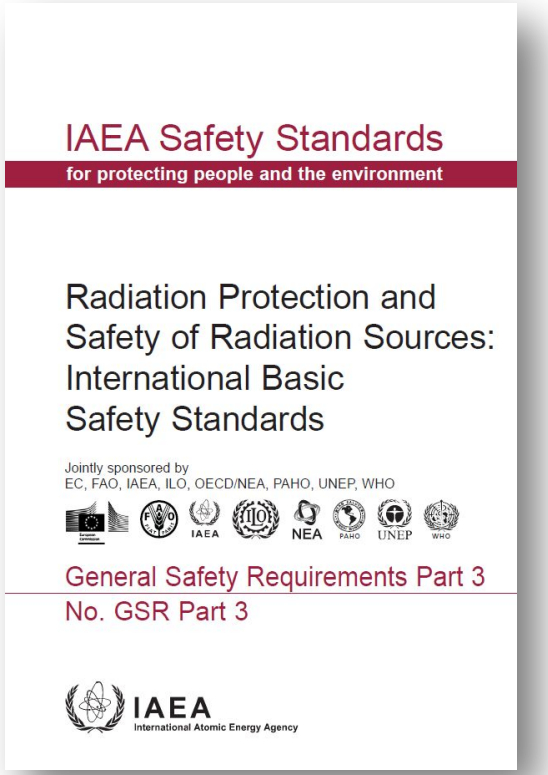




12. Optimization in radiotherapy (3/3)

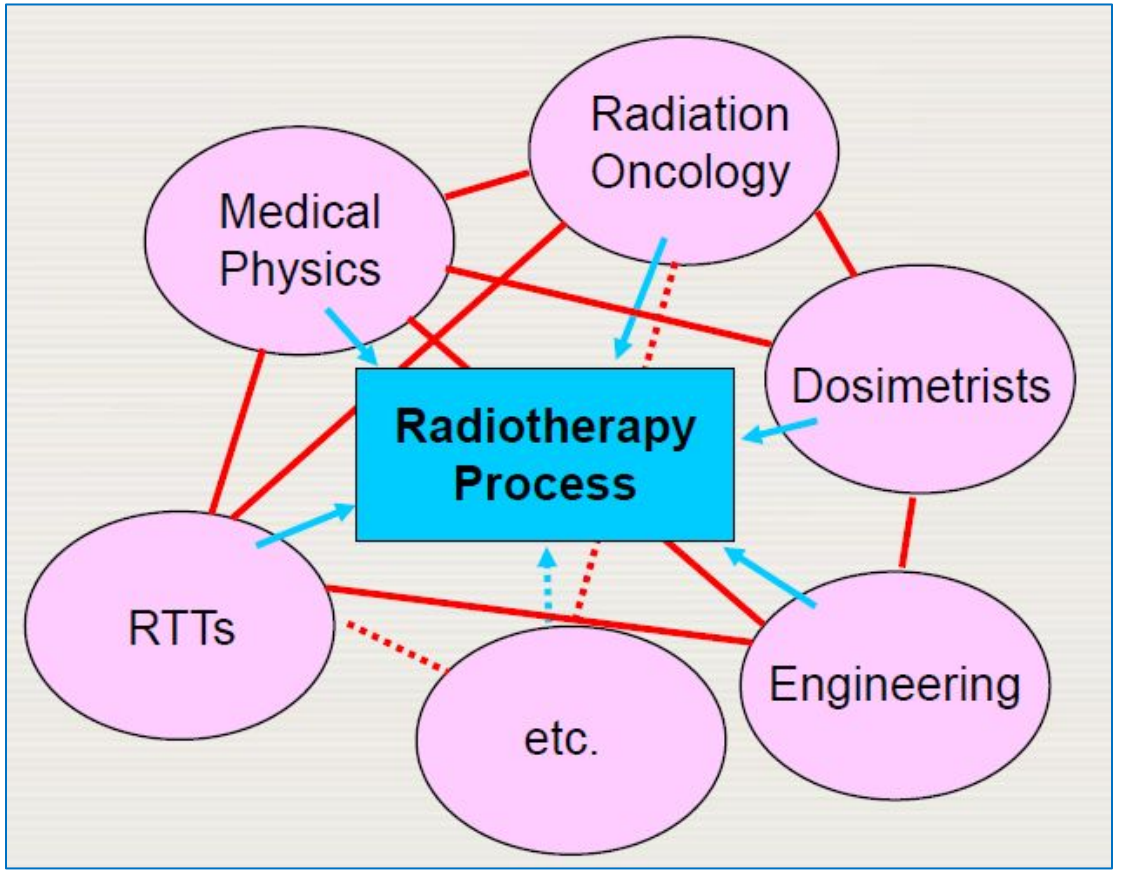
IAEA GSR Part 3, 3.164

"For therapeutic radiological procedures, the radiological medical practitioner, in cooperation with the medical physicist and the medical radiation technologist, shall ensure that for each patient the exposure of volumes other than the planning target volume is kept as low as reasonably achievable consistent with delivery of the prescribed dose to the planning target volume within the required tolerances."



13. Radiation protection challenges

- Risk assessment before implementing new techniques
- Multi-professional team with clearly defined responsibilities
- Training: IGRT requires new skill sets
- Quality Assurance program
- Development of protocols and procedures



Goals of the workshop

- ✔ The purpose of the workshop is to provide participants with specialized training on good practice guidelines for radiation protection of patients in Image-Guided Radiotherapy (IGRT).

- ✔ The workshop will consist of lectures and information exchange among participants who will gain knowledge on safety aspects related to the use of IGRT treatment

The Abdus Salam International Centre for Theoretical Physics

IAEA

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ICTP 1964–2024

[Joint ICTP-IAEA Workshop on Radiation Protection in Image-Guided Radiotherapy (IGRT) | (smr 3972) (07-11 October 2024)]

Joint ICTP-IAEA Workshop on Radiation Protection in Image-Guided Radiotherapy (IGRT) | (SMR 3972)

07 Oct 2024 - 11 Oct 2024
ICTP, Italy

2 Directors

1.	**ESPOSITO Marco**	(In Pers.)	ICTP	Italy
2.	**GERSHAN Vesna**	(In Pers.)	IAEA - Radiation Protection of Patients Unit	Austria

6 Speakers

1.	**ALAEI Parham**	(In Pers.)	University of Minnesota	United States of America
2.	**BRAMBILLA Marco**	(In Pers.)	Universitaria Maggiore della Carità Azienda Ospedaliero	Italy
3.	**GROS Sebastien Alexandre Adrien**	(In Pers.)	Loyola University Chicago Stritch School of Medicine Department of Radiation Oncology	United States of America
4.	**ISAMBERT Aurelie Monique Nicole**	(In Pers.)	Institut de Radioprotection et de Sureté Nucléaire (IRSN)	France
5.	**JORNET SALA Nuria**	(In Pers.)	Hospital de la Santa Creu i Sant Pau European Society of Radiation Oncology (ESTRO)	Spain
6.	**MARRAZZO Livia**	(In Pers.)	University of Florence	Italy

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