TC for ionising radiation; Dosimetry, Radionuclides and Neutrons

TC-IR

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Statens strålevern
Norwegian Radiation Protection Authority

Outline

A. Overview of the TC-IR

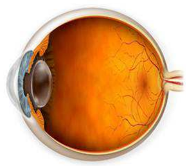
B. Research in ionising radiation

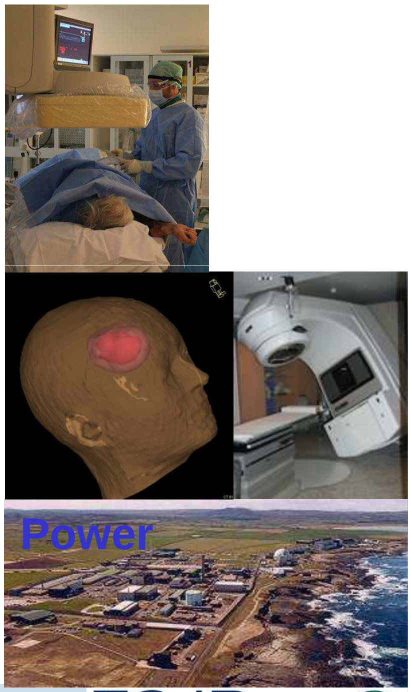
C. Roadmaps

1. Dosimetry and Radionuclides in Health Care

2. Anthropogenic and Natural Radionuclides
in Environment and Industry

3. Novel dosimetry concept for ionising radiation interaction with matter

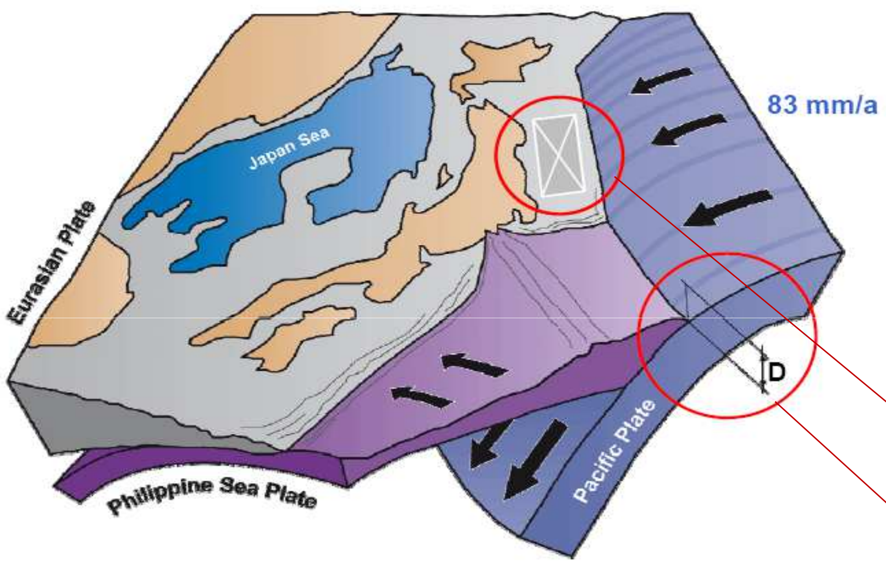




A. Overview of the TC-IR

- The Fukushima accident
- New standards, EUAMET projects and EMRPs
- Overview of CMCs
- CCRI meetings and International Conference on Radionuclide Metrology and its applications (ICRM)
- Strategic planning

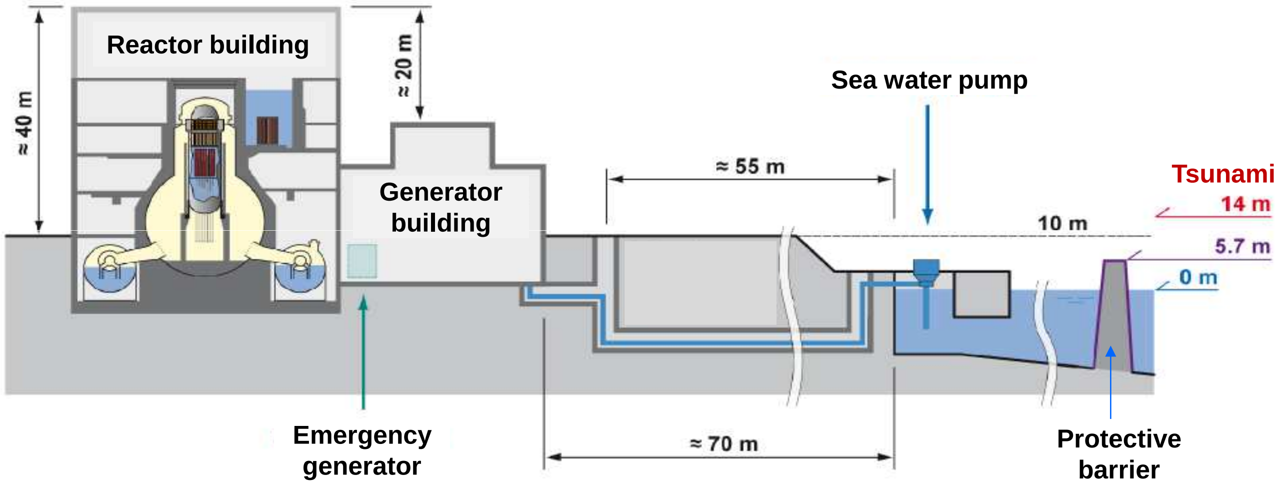
The Tohoku sea earthquake, 11 March 2011, 14:46:23, 9.0 MW



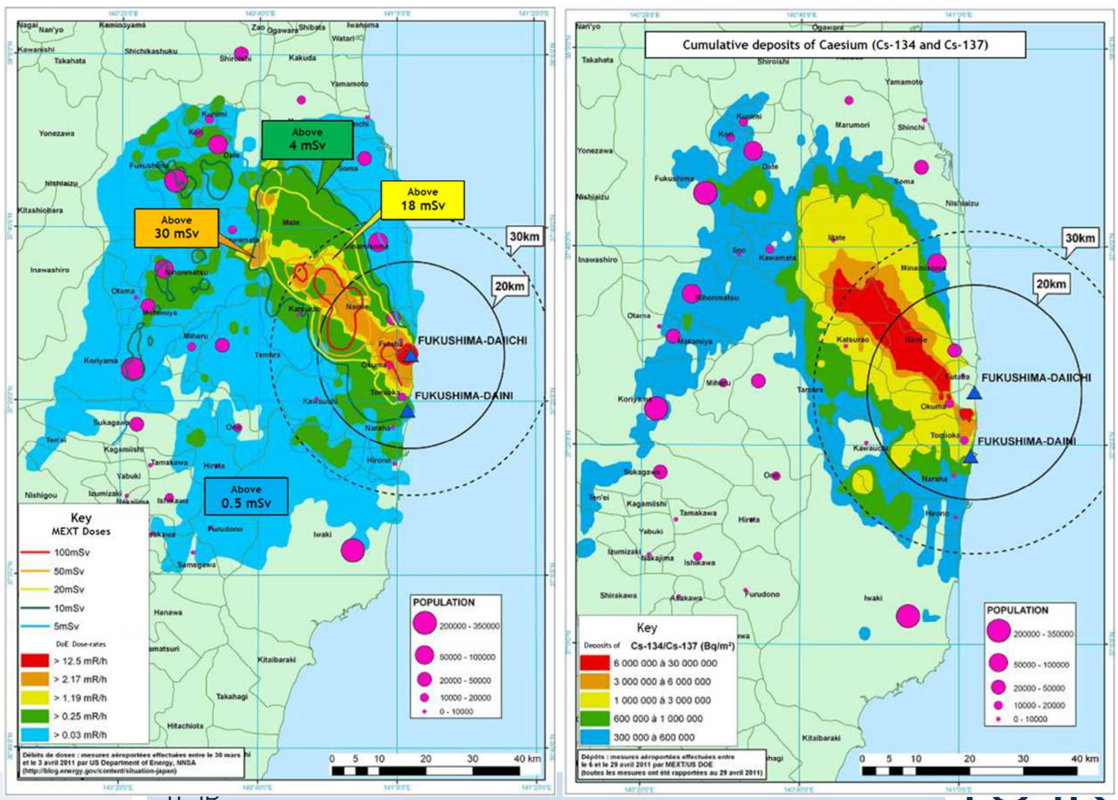
- **Water depth**
  $Z \approx 7$ bis 8 km
- **Hypo center**
  $Z_H \approx 20$ bis 25 km
- **Maximum vertical shift**
  $D_{max} \approx 17$ bis 25 m 1)
- **Break velocity**
  $v \approx 2$ km/s
- **Break area**
  $A \approx 500\ \text{km} \cdot 100\ \text{km}$
- **Vertical shift**
  $D \approx 7$ bis 10 m

- **Estimated total water volume in motion**
  $V \approx A \cdot \frac{1}{4} D \approx 500\ \text{km} \cdot 100\ \text{km} \cdot 2{,}5\ \text{m} = 125\ \text{km}^3$

Fukushima Daiichi – cross section



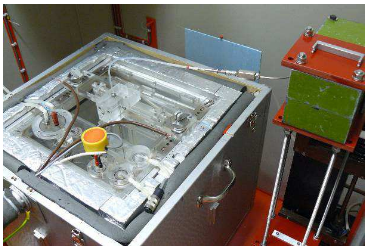
Fukushima accident

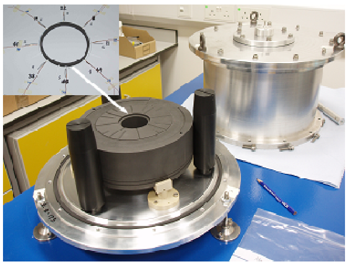


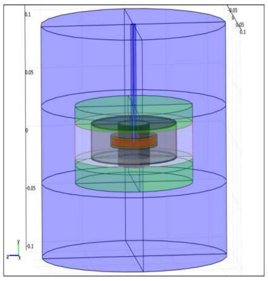
Dose rates and deposits of caesium-134 and -137 from Institut de radioprotection et de sûreté nucléaire (IRSN)

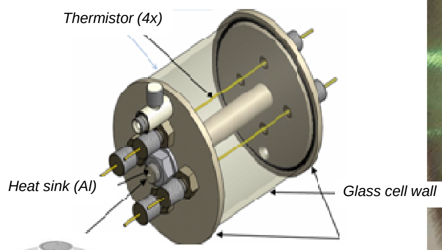
New standards and EMRP projects

Standards for HDR sources, iridium-192









Overview of the ionising radiation CMCs

	Country/lab	dosimetry	date of publ.	reviewed	activity	date of publ.	reviewed	neutron	date of publ.	reviewed	total
1	Austria/BEV	50	11.03.2005	52	100	15.09.2003					150
2	Bulgaria BIM NCM	7	14.02.2007				11 (new)				7
3	Czech Republic CMI	7	11.03.2005	X	104	15.09.2003		12	19.05.2005	X	123
4	Finland/STUK	31	11.03.2005	30							31
5	France LNE-LNHB	63	11.03.2005	X	166	15.09.2003		15	19.05.2005	X	244
6	Germany PTB	88	19.11.2010		158	20.01.2010		20	19.05.2005	X	266
7	Greece GAEC	35	12.10.2009								35
8	Hungary/MKEH	20	11.03.2005	26	84	15.09.2003	71				104
9	IAEA	13	23.02.2007								13
10	IRMM				110	15.09.2003					110
11	Italy ENEA	76	11.03.2005	X	13	15.09.2003		9	19.05.2005	X	98
12	Netherlands /VSL	28	11.03.2005	25	57	15.09.2003					85
13	Norway/NRPA	22	14.02.2007	22							22
14	Poland/GUM	5	11.03.2005	4	68	15.09.2003					73
15	Portugal ITN	43	11.03.2005	X							43
16	Romania IFIN				34	15.05.2008					34
17	Slovakia SMU	30	15.05.2008		37	15.05.2008		9	15.05.2008		76
18	Spain CIEMAT	52	15.05.2008		97	15.05.2008					149
19	Sweden/SSM	29	11.03.2005	26							29
20	Switzerland/METAS	8	11.03.2005	3	21	15.09.2003					29
21	United Kingdom NPL	36	11.03.2005	X	116	15.09.2003		42	19.05.2005	X	194
	total	643		188	1165		82	107		0	1915

X selected for second round

TC-IR
Ionising Radiation
EURAMET Technical Committee

European IR laboratories have dominated the international IR forums

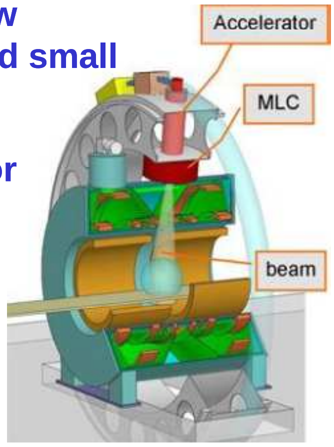
- Where will it goes?
  - **New engine**: the EMRPs
  - **Forum**: CCRI, ICRM
  - **A brake**: the economy
  - **Involvement**: Stakeholders (users, industry and authorities)

B. IR research 1: Strategic planning

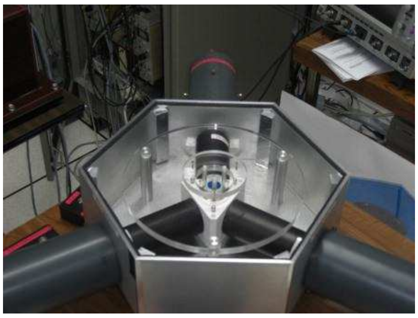
- Separate session at our annual meeting
- Workshop on new Roadmaps
- Three pilot roadmapper appointed
- Active in CCRI meetings
- Formalisation of the relation between EURAMET and the Atomic Energy Agency (IAEA) laboratory
  - situated at Seibersdorf, Austria
  - performing IR- comparisons, important CCRI-stakeholder, publishing calibration standard methods

B. IR research 2: evolution of RT

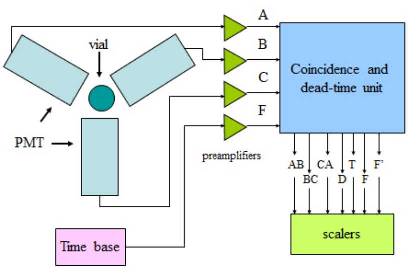
- **Radiotherapy is developing**
  - **4 mill. new cancer patients per year**
  - **implementation of guidelines sets requirements to new calibration service (Absorbed dose in Brachytherapy and small field in external photon beams)**
- **New approach: the MRI and the electron linear accelerator**
- **New understanding of biological effects from radiation**



B. IR research 3: nuclear power



Triple to Double Coincidence Ratio



- **New generation fission nuclear power plants**
- **The radioactive waste**
- **Handling of fallout from accidents**
- **Nuclear fuel account and the Non Proliferation Treaty (NPT)**
- **Political priorities**

B. IR research 4: EMRP

- The IR community look to EUARAMET's research program
- Results published on large scale
- Implementation of EMRPs results on-going
- Transparency to CCRI and users
- Taking account on CCRI strategy and user needs

RM 1: Drivers

Dosimetry and Radionuclides in Health Care

Health care: **Radiotherapy** and **Radiation Protection** for both **patients** and **workers**

About 75% of **4 million new European patients** with cancer are treated using radiotherapy. This rate is expected to increase due to:

- Improvement of diagnostic methods
- Global ageing
- New treatment modalities and irradiation techniques

About one diagnostic exam per person and per year. A need to control radiation protection of patients in:

- New improved diagnostic modalities
- New diagnostic equipment
- Global ageing

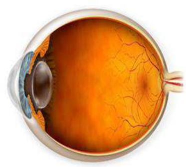
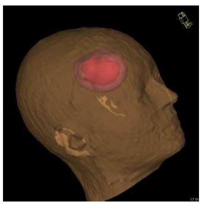
About 23 mill. workers exposed to radiation world wide mainly in developed countries. 7,5 millions in medical uses.

- lower limit of exposure (e.g. cataract)
- Increased number of workers due to production and decommissioning issues
- Needs for better definition of quantities and measurement protocol

Dosimetry and Radionuclides in Health Care

- Traceability of the patient dose in complex forms of radiotherapy
  - Rotational therapy and robotic techniques using small fields
  - Online imaging (Conebeam CT, MRI linacs)
  - New electron brachytherapy sources
  - Protontherapy, Hadrontherapy
  - Targeted radionuclide therapy
- Novel diagnostic equipment
  - new CT scanners (two tube scanners, 256 line scanners)
  - new or adapted quantities well suited for new diagnostic modalities
- Challenges for radiation protection dosimetry
  - Stricter limits on eye lens
  - Definition of operational quantities

Dosimetry and Radionuclides in Health Care


Improved metrology for dosimetry will:

- improve sustained patients' Quality of Life (higher cure rate and reduction of side effects)
- facilitate faster clinical dissemination of new radiotherapy, and diagnostic techniques
- enhance safety of European working environment
- lower the radiation burden to the European citizen by improved optimisation of dose and image quality.

Anthropogenic and Natural Radionuclides in Environment and Industry

Radioactivity in Industrial Processes

- Enhanced natural radioactivity in industrial processes presents high exposure to workers and users
- About 23 millions of workers exposed to radiation world wide mainly in developed countries with the majority working in the non-medical industry.
- Release of radioactivity from Industry interferes with monitoring networks

Nuclear Industry

- Safe and efficient use of nuclear power
- Decommissioning of old nuclear sites will be required as well as improved waste management and minimised radioactive waste
- Metrology for New Build to meet CO_2 emission targets

Anthropogenic and Natural Radionuclides in Environment and Industry

Homeland Security

- Prevention and reduction of significant security threats
- Preparedness in case of “event”, e.g. terrorism or Fukushima

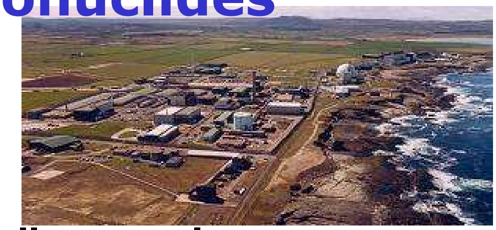
Climate Change

- Climate change is one of the major concerns of today’s politics, economy, technology and research.

Science

- Applications of radionuclide metrology to new or other fields of science
- Relation between the Bq and the SI base units for mole and mass

Anthropogenic and Natural Radionuclides in Environment and Industry



Radioactivity in Industrial Processes

Development of metrology for:

- Consistent and reliable control of naturally occurring radioactive material
- Conformity with recommendations and EU council directives
- Improved accuracy in monitoring networks for radioactive releases

Nuclear Industry

- Improved safety, sustainability and reduced environmental burden in the use of nuclear power
- Better and safer control in Decommissioning operations
- Improved accuracy in waste sentencing
- Reduced environmental impact and socio-economic benefits from better radioactive waste management

Anthropogenic and Natural Radionuclides in Environment and Industry

Homeland Security

Prevention of significant security threats by

- improved detection networks and monitoring of food stuff
- Development of Nuclear Forensics
- Development of quick, specific, high yield chemical analyses
- Improved de-contamination methods

Climate Change

- Development and support for radionuclide tracer methods including low-level techniques and mass spectrometry
- Provide accurate and traceable measurements of radionuclides and isotope ratios for accurate conclusion regarding climate change

Science

- Detector developments applied to other fields e.g. X-ray detection in space applications
- Relation between activity and mass investigated as a unit by implementing new technology such as single atom counting

Novel dosimetry concept for ionising radiation interaction with matter

Medical applications – radiotherapy

- different biological effectiveness of radiation qualities on cancerous and healthy tissue
- different irradiation conditions for external photon beam therapy and radionuclide therapy using alpha emitters
- different patient radio-sensitivity

The ESTRO 2020 vision of individualised radio-therapeutic treatment using a multi-disciplinary approach

- A dosimetric concept that facilitates the combination of different treatment modalities
- Providing metrology support based on the virtual human approach
- Development of a unified dosimetric concept for radiation quality
- Developing a measurement protocol for biological effects
- Measuring individual radio-sensitivity, enabling treatment plans based on patient-specific rather than population-averaged dose-effect curves

Novel dosimetry concept for ionising radiation interaction with matter

System of physical operational quantities in dosimetry (Unit: sievert) is based on phenomenological weighting factors that are almost exclusively based on epidemiological evidence

Metrological challenges:

- Prevention and reduction of significant security threats
- Extension of the range of applicability of biological dosimetry toward lower doses by enhancing the through-put and reliability of biological assays through better control of experimental conditions by application of metrology
- Establishing a traceability chain of biological dosimetry to physical standards of ionising radiation or, alternatively, develop biological standard systems

New materials of geometrical dimensions of particle track diameters.

A measurand quantifying damage due to radiation interaction:

- in nano-tech components
- electronics and bio-systems
- in space application
- at fusion reactor experiments
- in accelerator-based treatment units in clinics

Novel dosimetry concept for ionising radiation interaction with matter

Medical applications of ionising radiation
- combination of different treatment modalities
- optimisation of image-guided techniques in radiotherapy
- development of radio-sensitizers and patient-specific treatment planning based on quantitative measures of individual radiation sensitivity

New or redefined operational quantities in dosimetry
- Improved standards for occupational radiation protection
- Better data base for decision maker and regulatory bodies
- Reduction of radiation risk to occupationally exposed personnel and the general public

Facilitation the development of radiation-resistant
- nano-electronics and other nano-structured devices
- reliable biological-cell based production techniques

Realisation of the components of the virtual human that are related to ionising radiation

First radium i Norway 100 years old