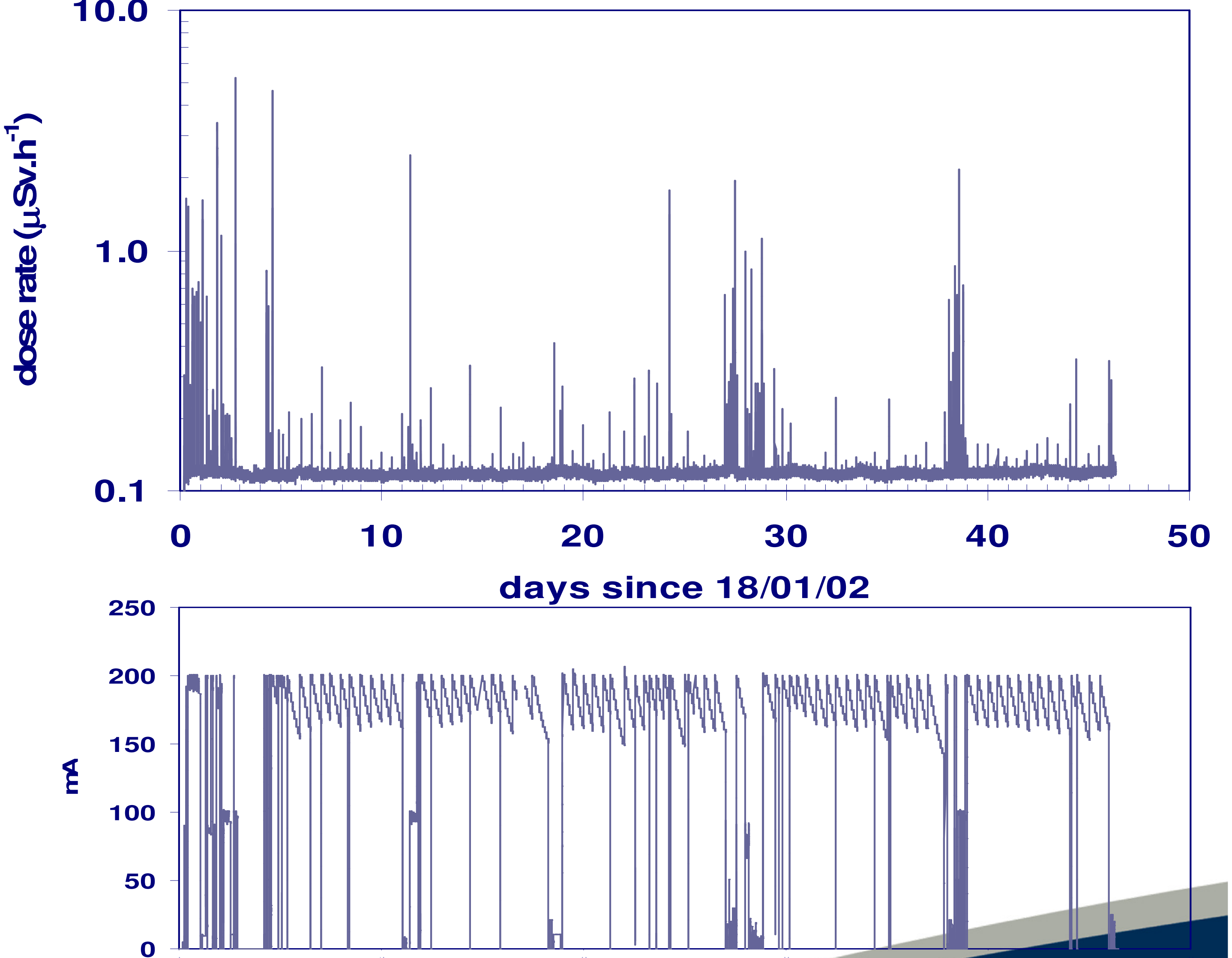
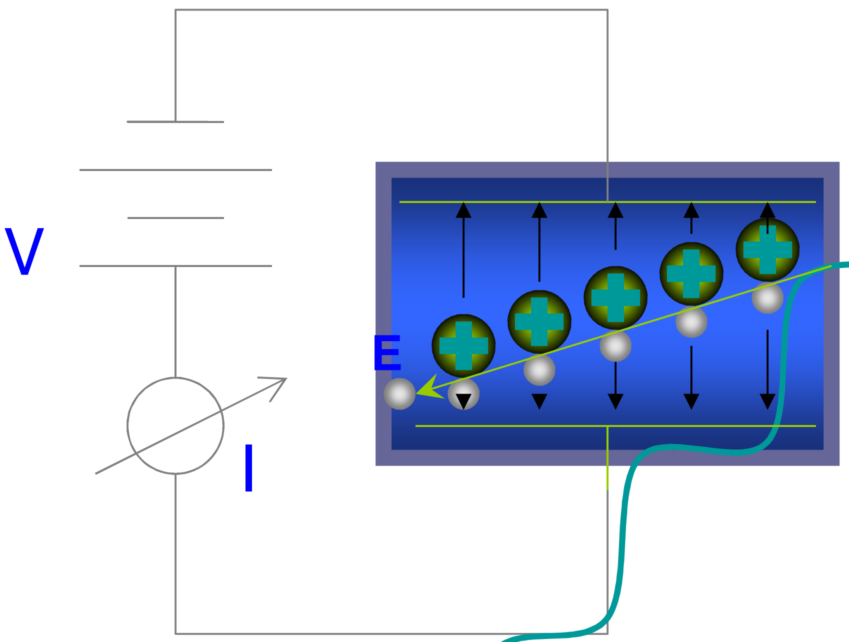
Part E. Radiation monitors

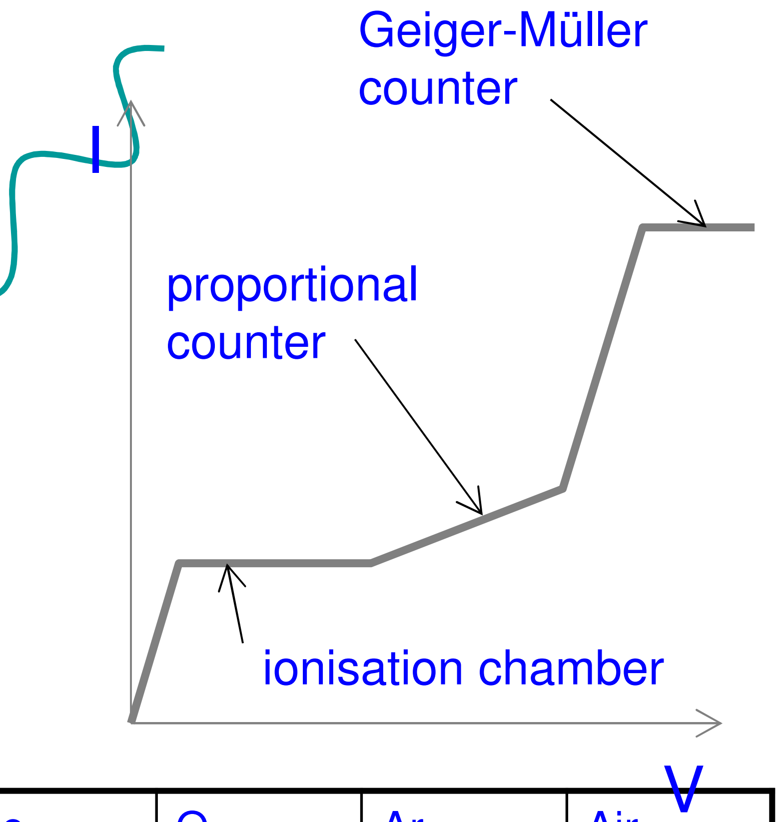
Radiation monitors



Example: photon dose rate measurement around ESRF storage ring

Radiation monitors Gas-filled detectors





$$N_{pairs} = \frac{E}{w}$$

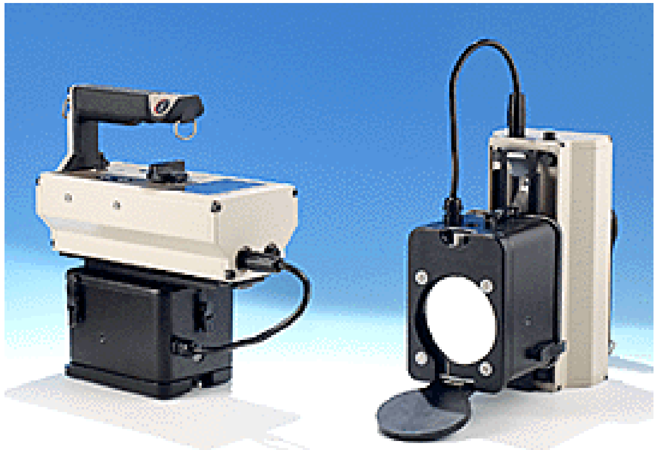
$$\frac{dD}{dt} \propto \frac{w}{\rho_{gas} V_{gas}} \frac{dN_{pairs}}{dt}$$

$$\frac{dD}{dt} \propto \frac{w}{e \rho_{gas} V_{gas}} I$$

W	H_2	He	O_2	Ar	Air
electrons	36.3 eV	41 eV	31 eV	26.4 eV	34 eV
alphas	36.5 eV	44 eV	32.4 eV	26.4 eV	35.3 eV

Radiation monitors

Ionization chambers



Radiation monitors

Proportional counter

Radiation monitors

Geiger - Müller counter

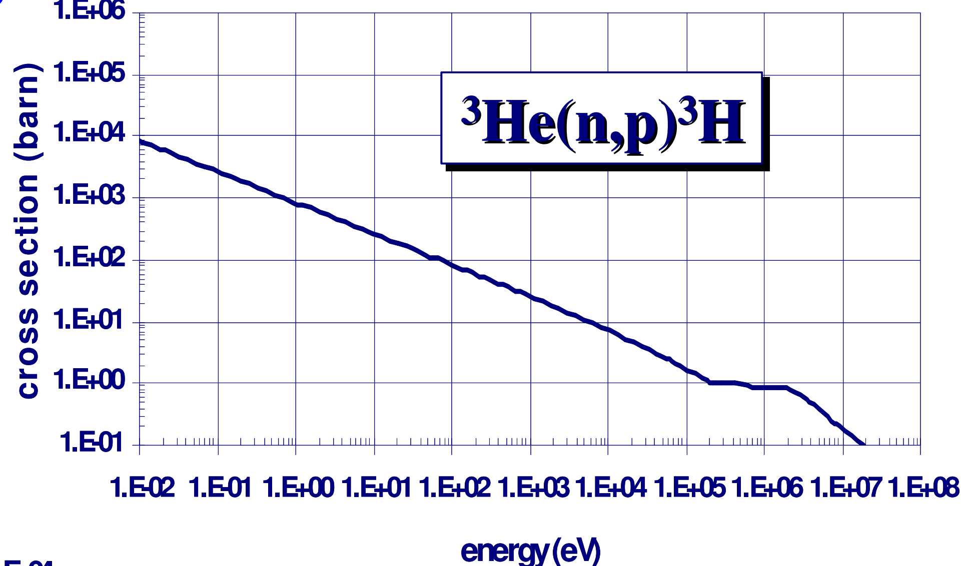
juas Joint Universities Accelerator School
Radiation Safety

Radiation monitors

Moderated neutron monitors

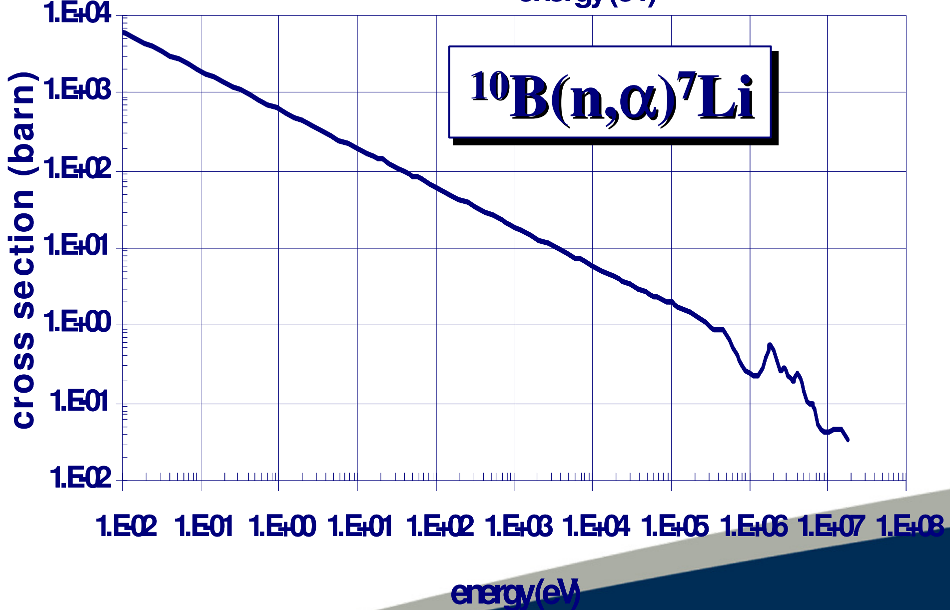
^{3}He-filled proportional counter:

$$n + {}^{3}He \rightarrow p + {}^{3}H + 765\,keV$$



BF_3 counter:

$$n + {}^{10}_{5}B \rightarrow \begin{cases} \alpha + {}^{7}_{3}Li + 2.310\,MeV\,(94\%) \\ \alpha + {}^{7}_{3}Li + 2.792\,MeV\,(6\%) \end{cases}$$

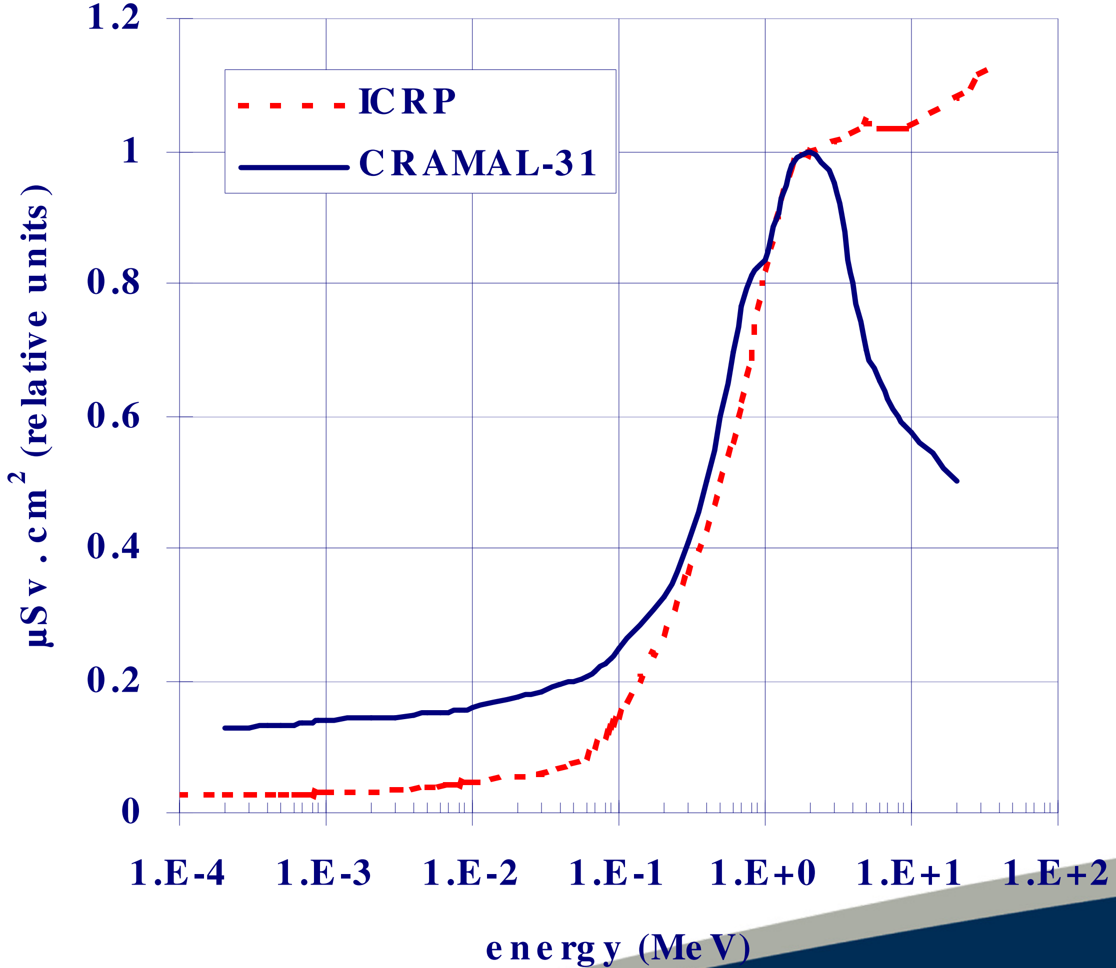


→ Polyethylene moderator

Science & Technology Facilities Council ISIS

Radiation monitors

Moderated neutron monitors



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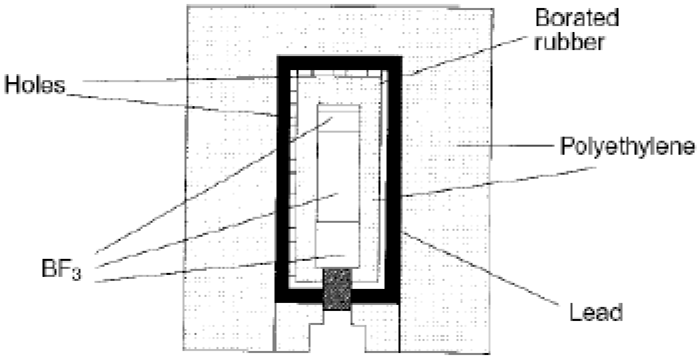
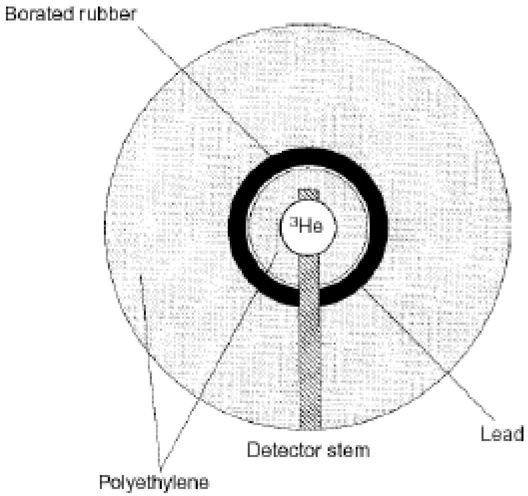
Radiation Safety

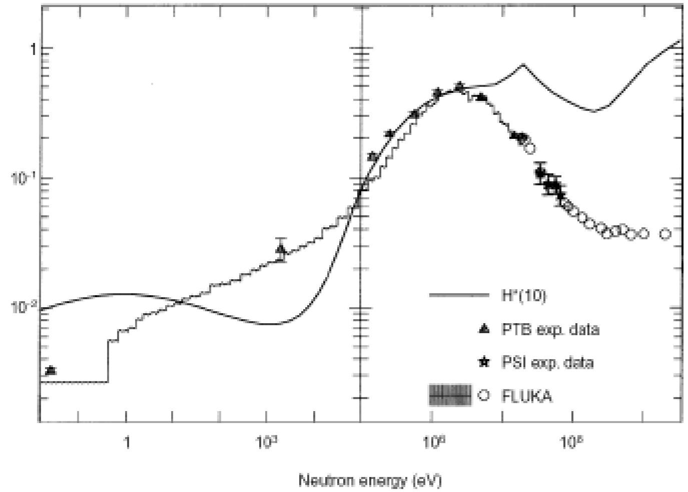
Radiation monitors

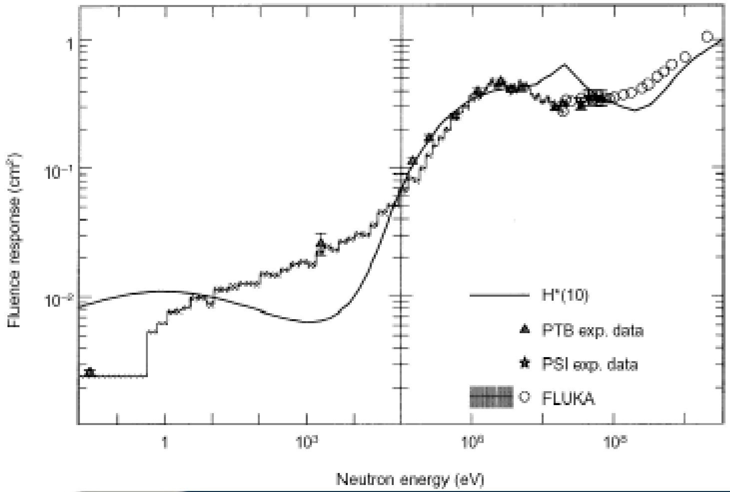
Moderated neutron monitors

Berthold
LB-6411





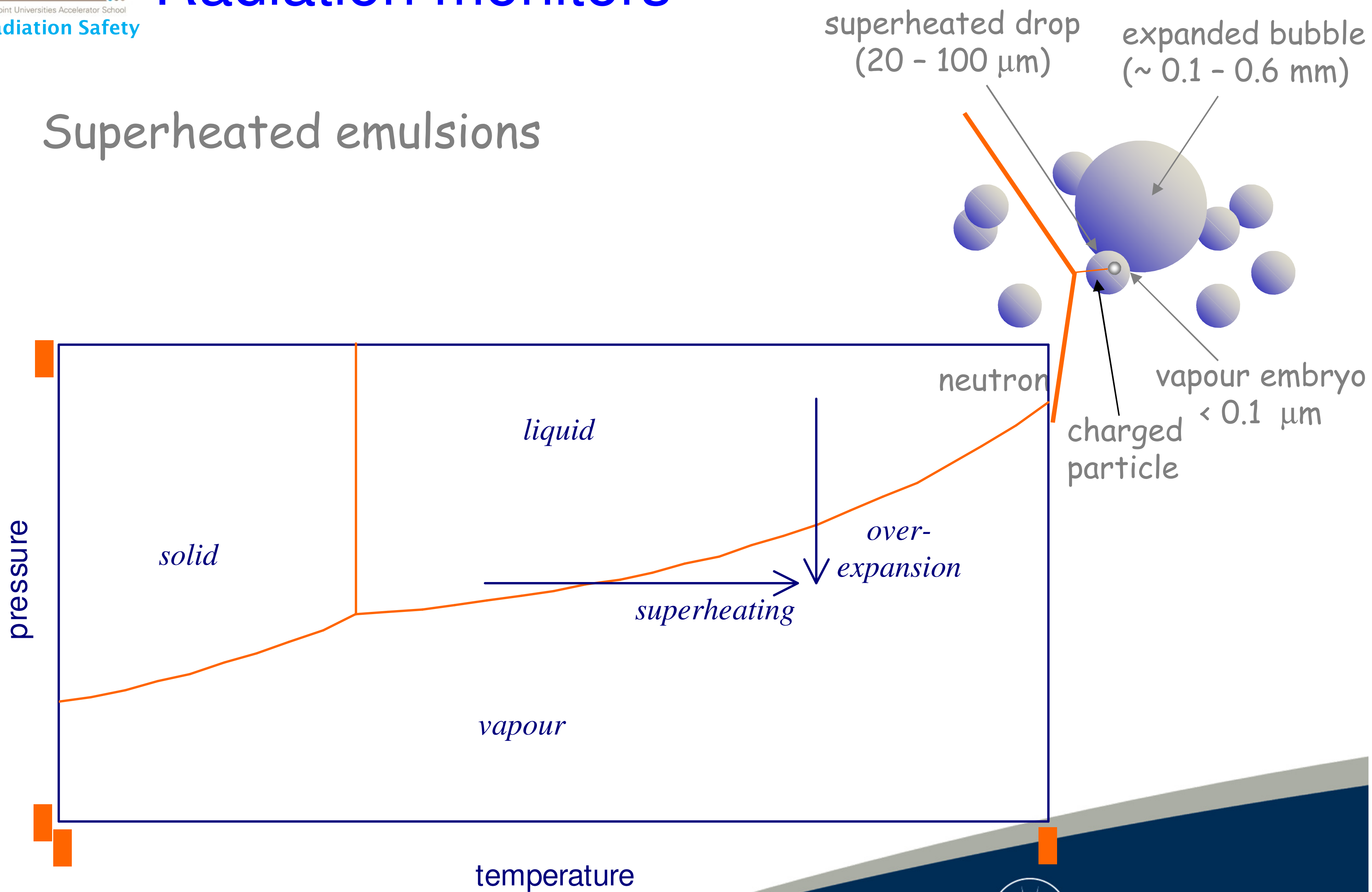




Neutron response enhancement using lead-shell in moderator type counters

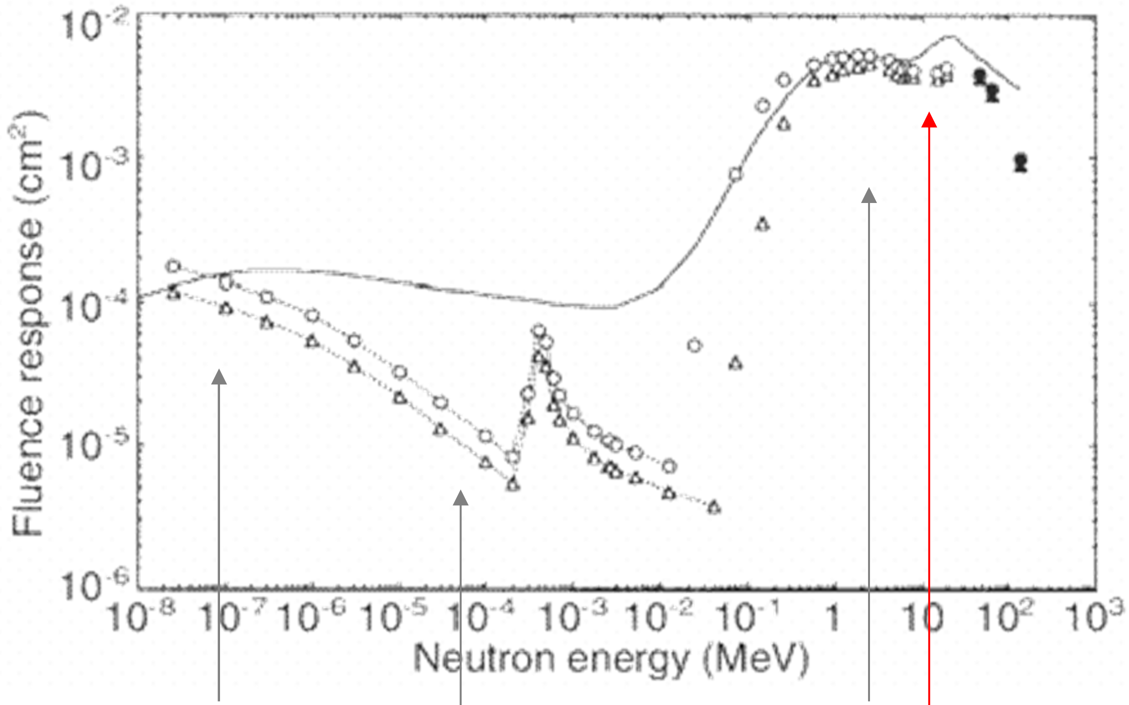
Radiation monitors

Superheated emulsions



Radiation monitors

Superheated emulsions



Thermal neutrons: OK

0.1 – 10 MeV: OK

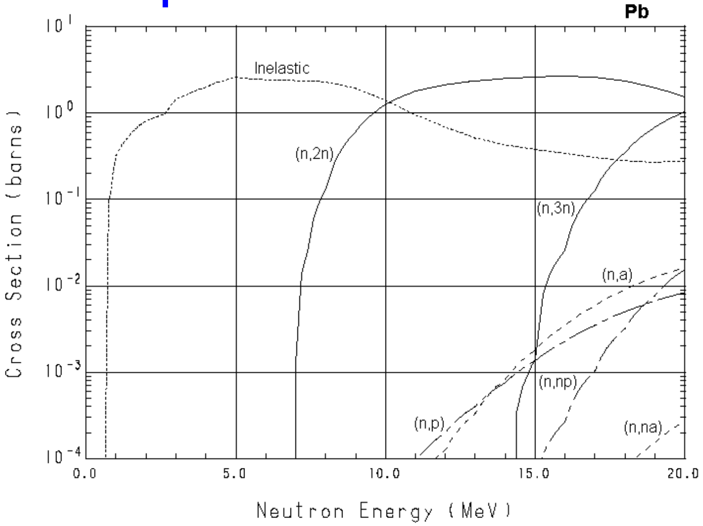
Epithermal neutrons: not important

Under-read > 10 MeV

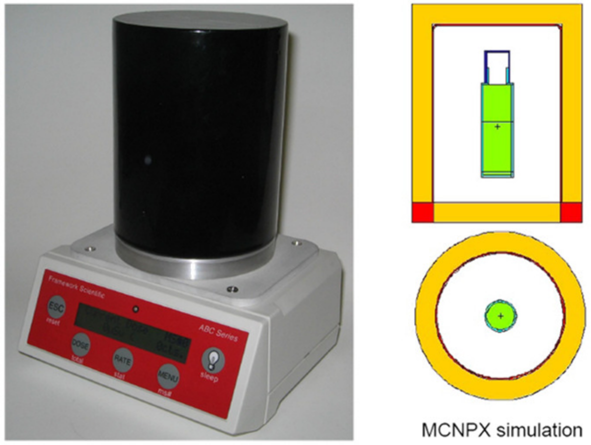
Energy response of SDD100 vials (dichlorodifluoromethane)

Radiation monitors

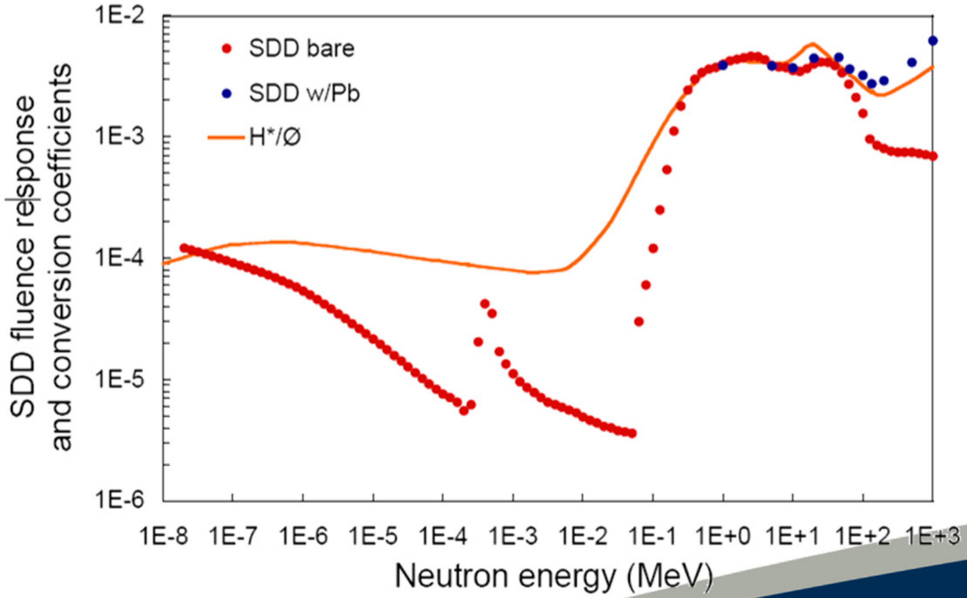
Superheated emulsions



ABC-HE with lead-shell



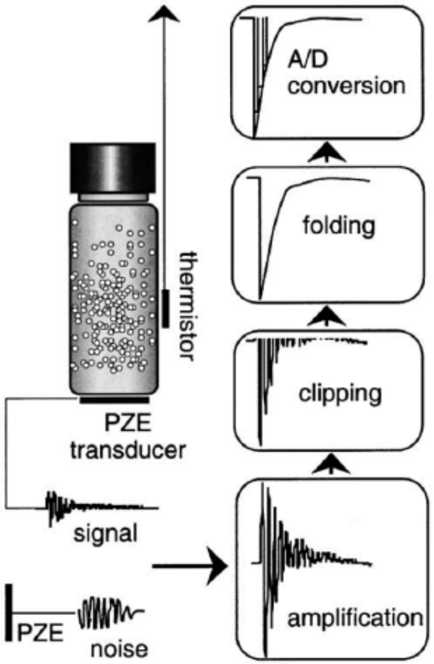
MCNPX simulation geometry

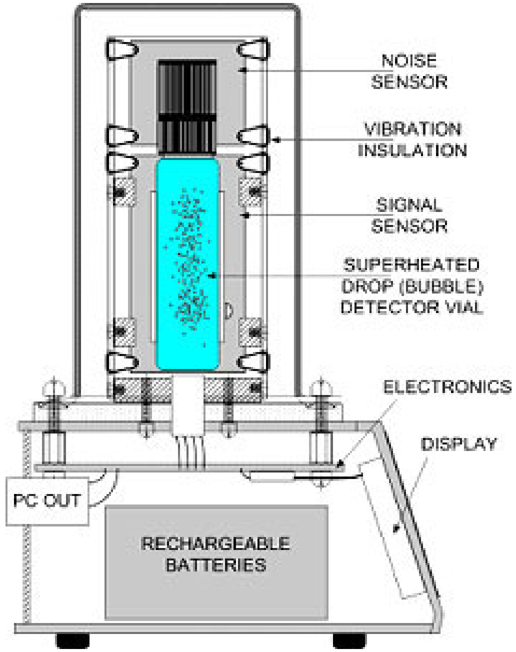


effect of lead moderator

Radiation monitors

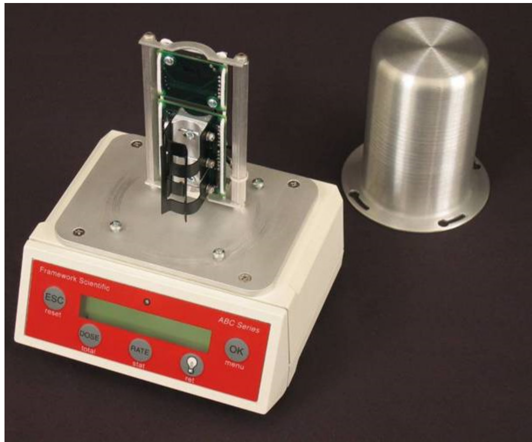
Superheated emulsions





Acoustic bubble counting

Model ABC1260
Framework Scientific
www.framesci.com



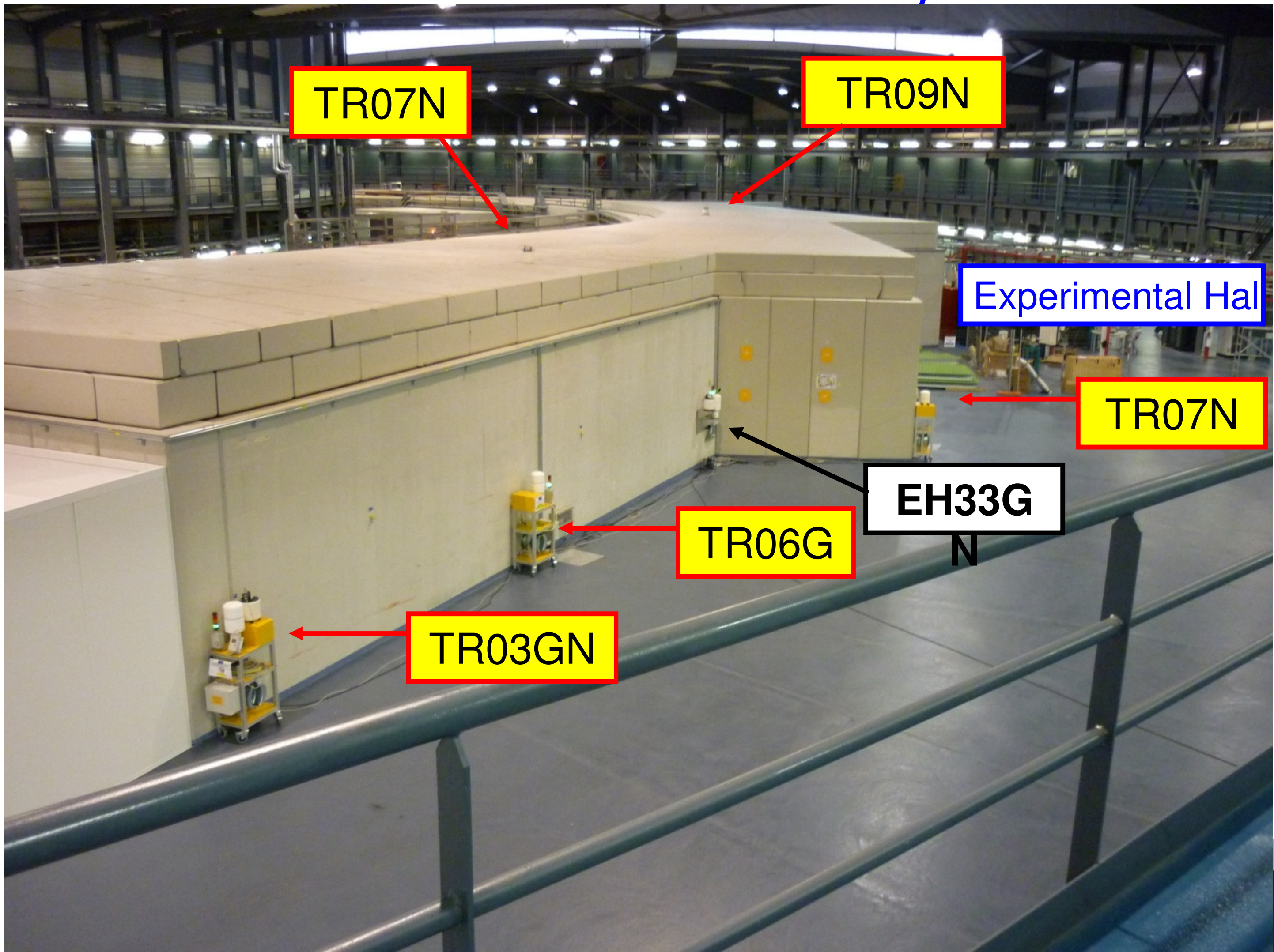
Radiation monitors

- Active radiation detectors:

		FHT192	FHT 762 Wendi-2	EPD
0	**Manufacturer**	Thermo Electron GmbH	Thermo Electron GmbH	Thermo Electron GmbH
1	**Particle**	Photons	Neutrons	Photons
2	**Energy range**	30 keV– 7 MeV	25 meV–5 GeV	15 keV–10 MeV
3	**Measuring range**	100 nSv/h–1 Sv/h	1 nSv/h – 100 mSv/h	Resol. 1 mSv/h: <0.5 Sv/h – 4 Sv/h Resol. 1 Sv/h: 4–50 Sv/h
4	**Energy response**	Calibration factor resp. Cs-137: For low dose rate: 0.01-0.02 (μSv/h)/cps For high dose rate: 1.9 - 2.2 (μSv/h)/cps	Calibration Factor: 1.14 (μSv/h)/cps	Ref. Cs-137 ±30% from 17keV to 6MeV ±50% from 6MeV to 15Mev
5	**Quantity**	Hp(10)	Hp(10)	Hp(10)
8	**Type**	Active Ionization chamber	Active Proportional counter	Active semiconductor dosimeter
9	**Sensitive material**	Inert gas (7 bar)	He-3 (2 bar) + polyethylene moderator	Silicon diode detectors
10	**Dead Time**	Dead Time for high dose rate: 6-7 μs	Dead Time: 1.8 μs	--

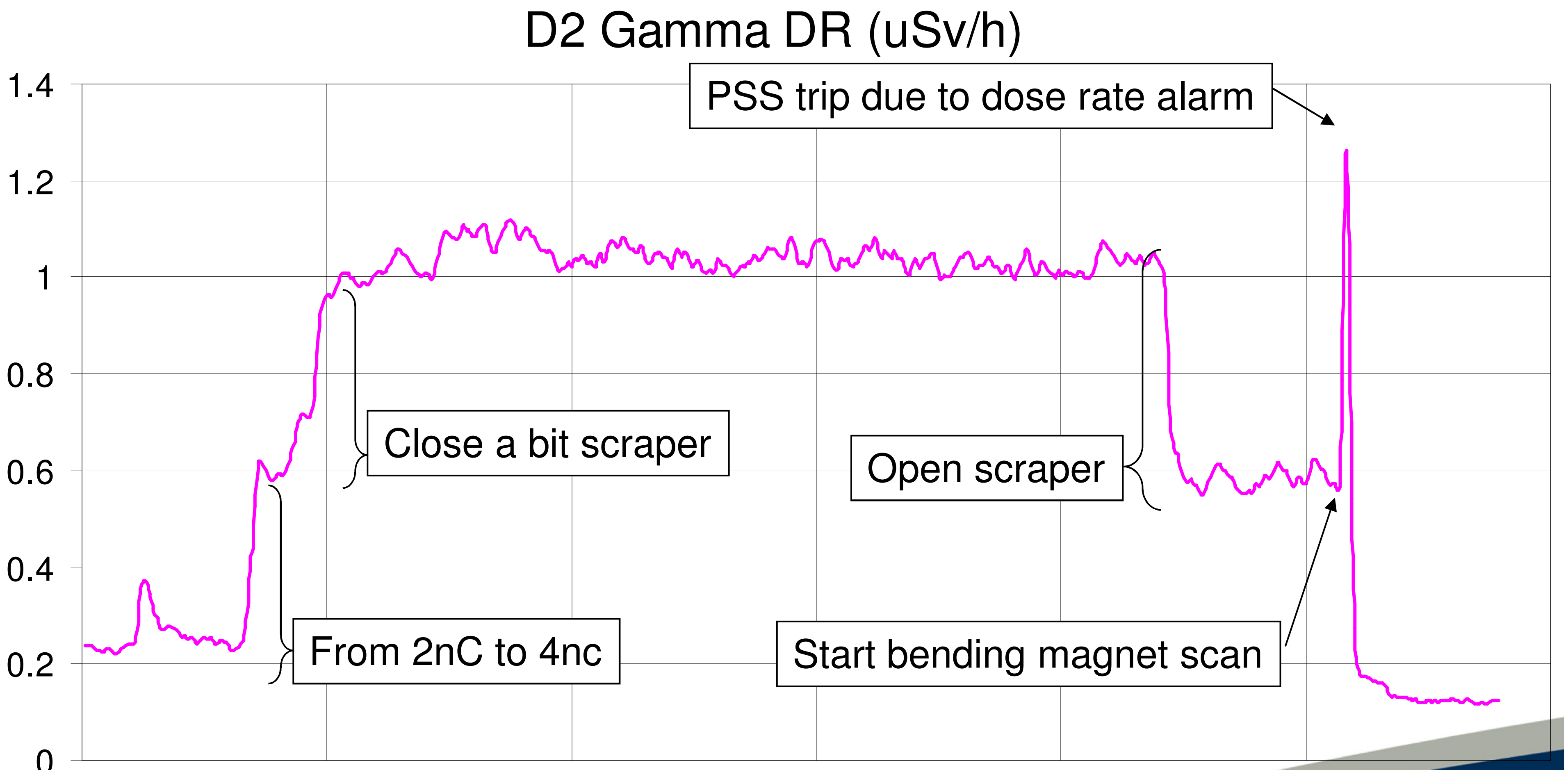
1. Engineering solution

- Radiation Monitors Network reinforced by movables monitors



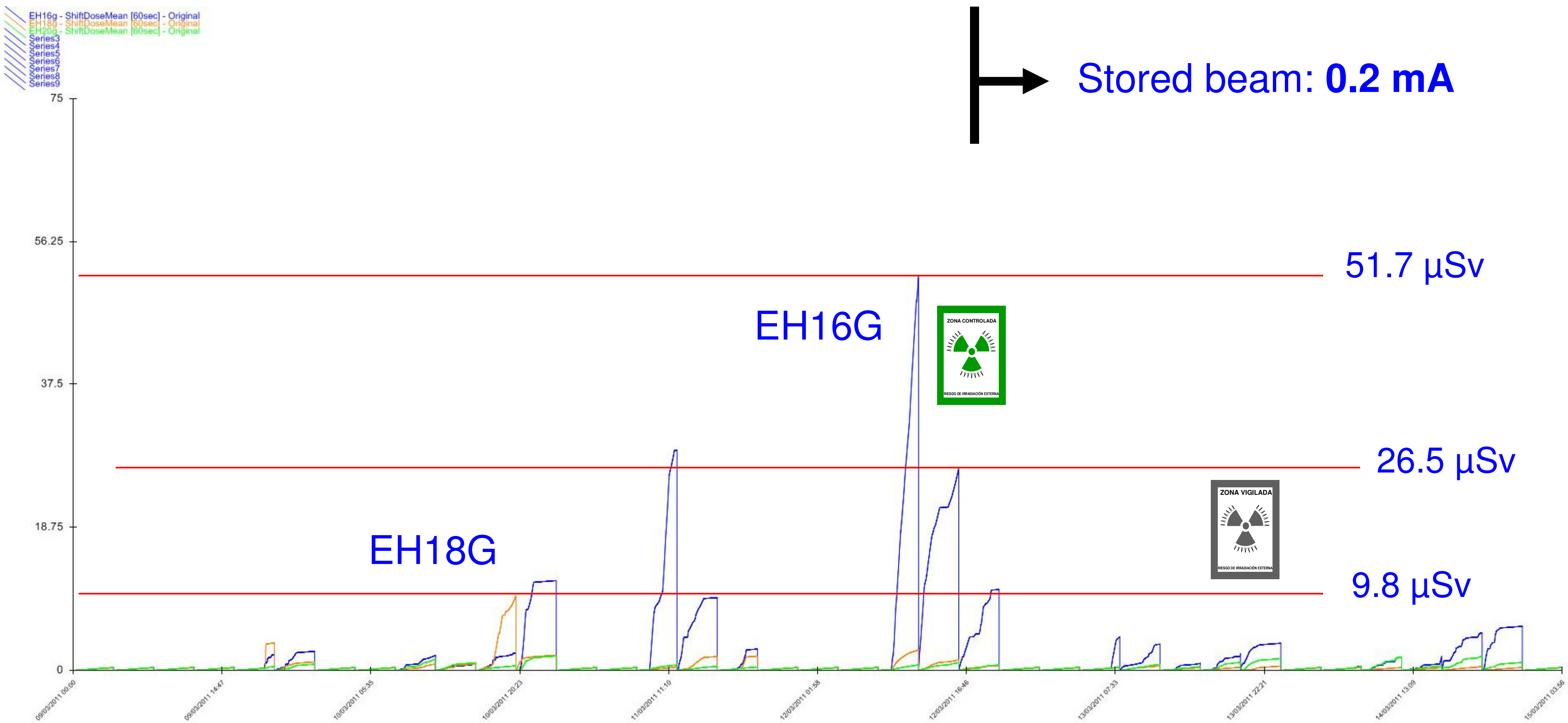
1. Engineering solution

September 16th ’09



1. Engineering solution

❖ Integrated dose measured at the shield wall next to: BL16 & BL18 & BL20



12th March '11

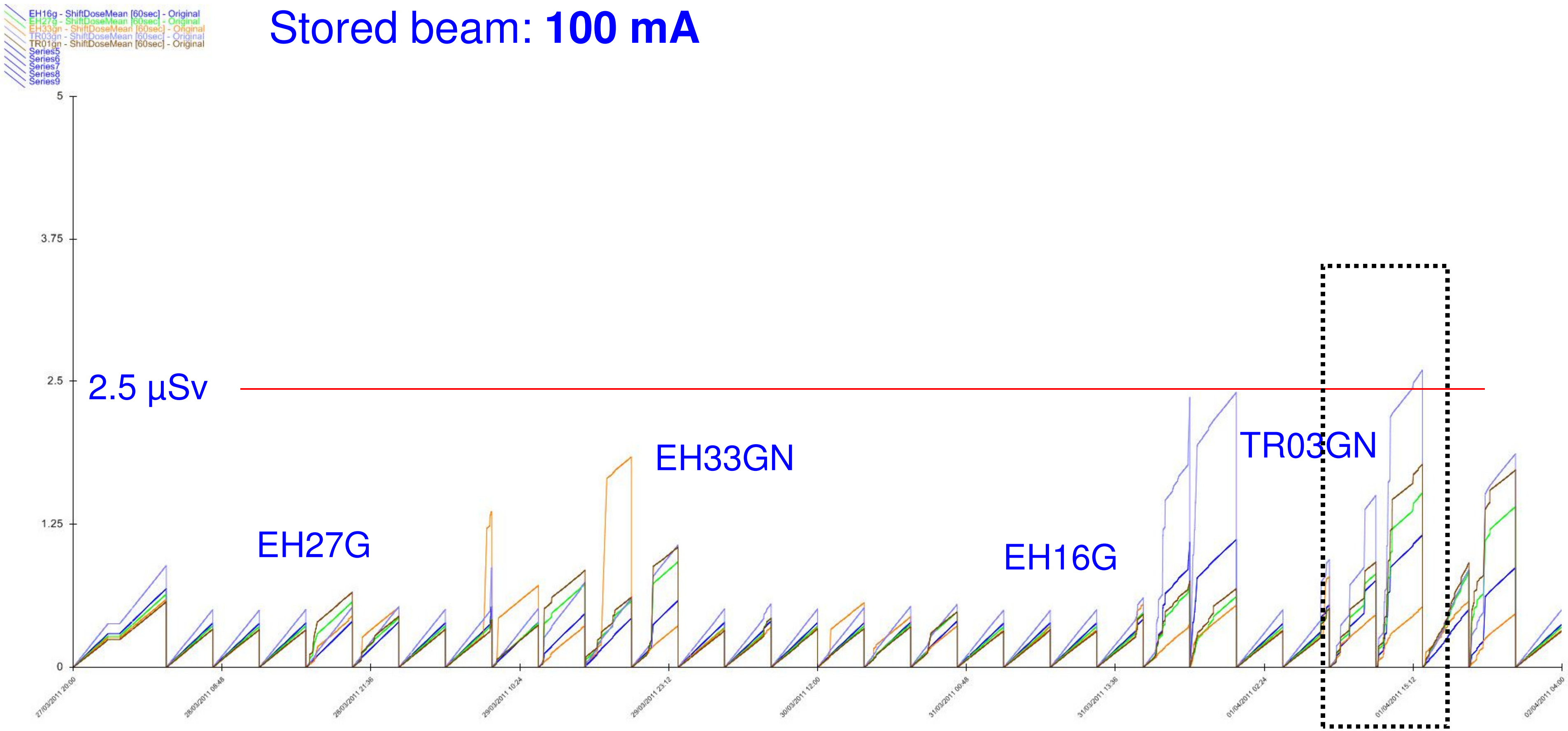
Integrated over 4 hours period

1. Engineering solution

❖RADMON next to (integrated dose):

BL16 & TR03 (next to BL16) & BL27 & TR01 (next to BL27)

Stored beam: **100 mA**



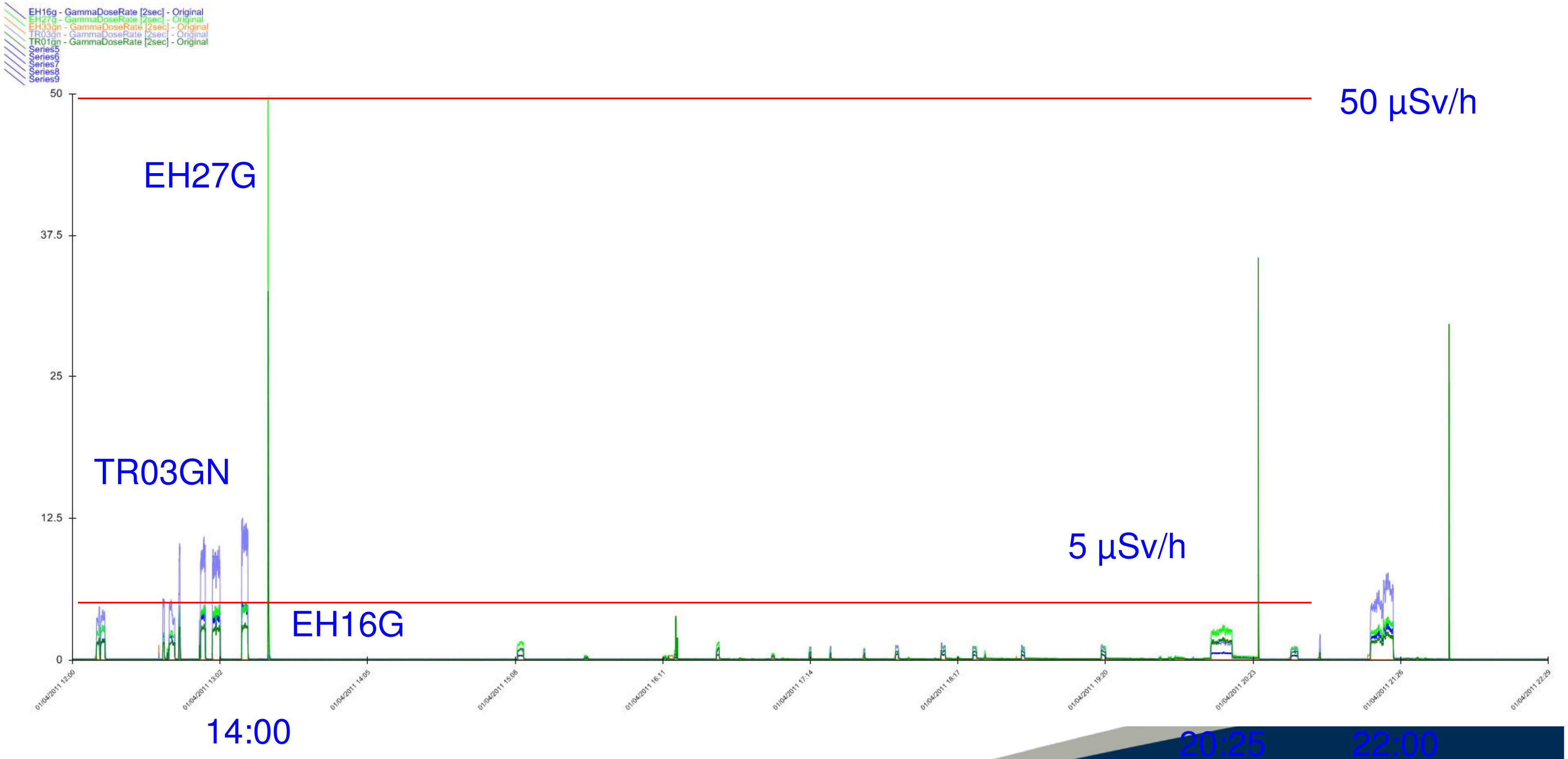
30th: 50 mA

1st: 100 mA

1. Engineering solution

❖ RADMON next to (gamma dose rate):

BL16 & TR03 (next to BL16) & BL27 TR01 (next to BL27)



References

Radiation Safety – JUAS 2007, P. Berkvens

NCRP Report No 51: Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities. NCRP, 1979 - Although dated, still very useful. Scope limited to mostly radiation source terms and shielding. Concise, only technical information.

NCRP Report No 144: Radiation Protection for Particle Accelerator Facilities. NCRP, 2003.

It is a substantial revision and expansion of NCRP Report No. 51, the Report revises and expands on the earlier report and includes new information on source intensities, shielding, dosimetry, and the environmental aspects of particle accelerator operation. It is primarily concerned with radiological safety aspects that are special to the operation of particle accelerators having energies above about 5 MeV up to the highest energies available, while not neglecting low-energy neutron generators.

IAEA Report No. 188: Radiological Safety Aspects of the Operation of Electron Accelerators, IAEA, Vienna,1979. - Scope limited to electron machines. Very detailed and comprehensive: all facets covered, except safety systems. Strongest points: source terms, shielding, yields (activation, ozone, noxious gases). Although dated, still a “must” for electron machines.

IAEA Report No. 283: Radiological Safety Aspects of the Operation of Proton Accelerators, IAEA, Vienna,1988. - Equivalent to No. 188 for proton machines. More detailed, good reading on general issues, with some high-energy bias.

References

SLAC Report 327: Health Physics Manual of Good Practices for Accelerator Facilities. Stanford Linear Accelerator Center, - Written by a committee from DOE accelerator labs - bias towards large, high-energy facilities. Little technical detail, but strong on operational issues, including safety systems. Certain aspects not found elsewhere; useful general reading.

Landolt-Borstein Compendium: Shielding Against High Energy Radiation, 1990, Springer- Verlag - Written by former members of the CERN Radiation Protection group (Fasso et al). Very expensive, availability limited. Encyclopedic approach - compilation of large amounts of available data. Not good for general reading and learning, but a valuable reference for specialists.

A. H. Sullivan: A Guide to Radiation and Radioactivity Levels near High Energy Particle Accelerators, 1992, Nucl. Technology Publishing - Small "cookbook" with limited scope, but very practical. Essence distilled to rules-of-thumb and simple formulae.

ICRP Publication No 60: 1990 Recommendations of the International Commission on Radiological Protection, Oxford, 1991, Pergamon Press – Contains the latest recommendations on quantities and units for radiation protections, in particular the concepts of equivalent dose and effective dose.

ICRP Publication No 103: 2007 The 2007 Recommendations of the International Commission on Radiological Protection – It is an update of the No 60 and also include an approach for developing a framework to demonstrate radiological protection of the environment.

✓*Many Thanks for Your Attention!*