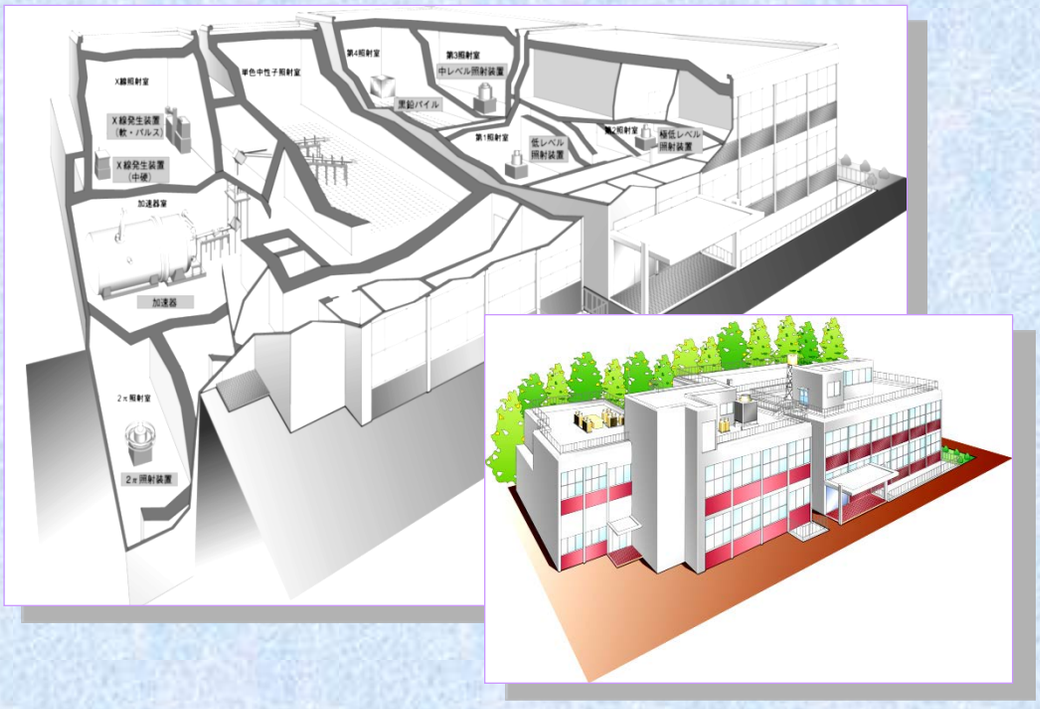
Facility of Radiation Standards

FRS

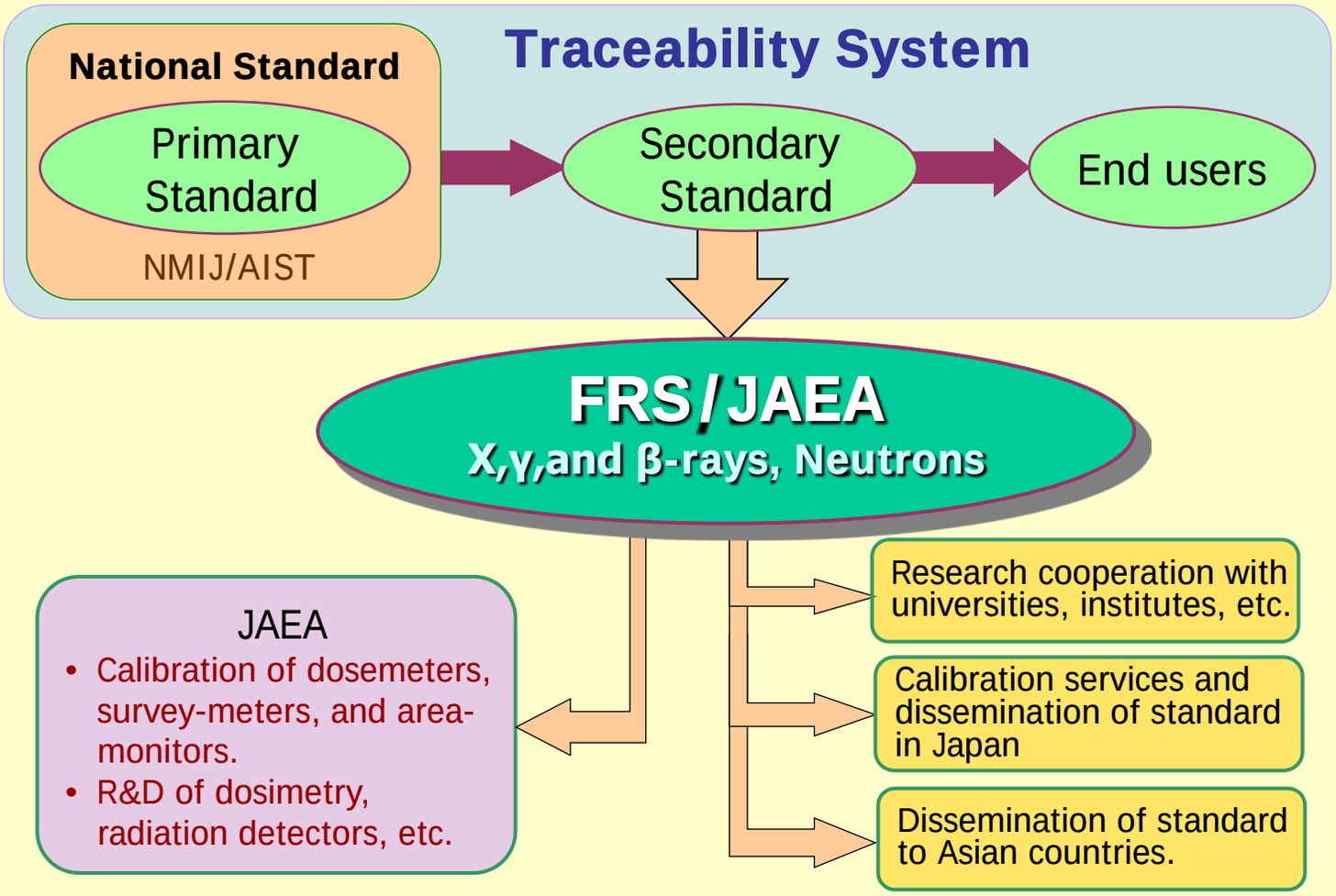


Department of Radiation Protection,
Nuclear Science Research Institute,
Japan Atomic Energy Agency

Facility of Radiation Standards

It is important that radiation measuring instruments are calibrated by the standardized procedures and radiation standard for calibration are related to the national standards (traceability).

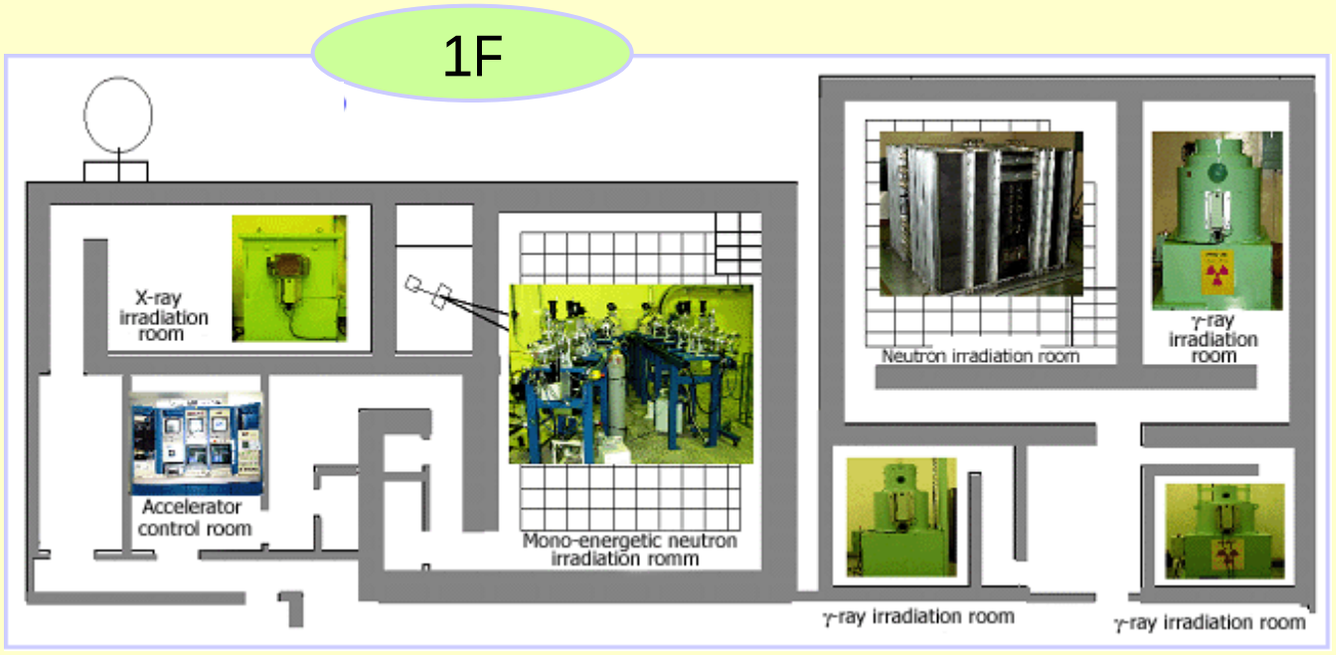
The Facility of Radiation Standards(FRS) is equipped with calibration fields using X-ray generators, gamma-ray irradiators, beta and neutron sources, which are traceable to the national standard. The fields are used not only for the calibration and type-test of radiation measuring instruments but also for R&D on dosimetry and research coordination.

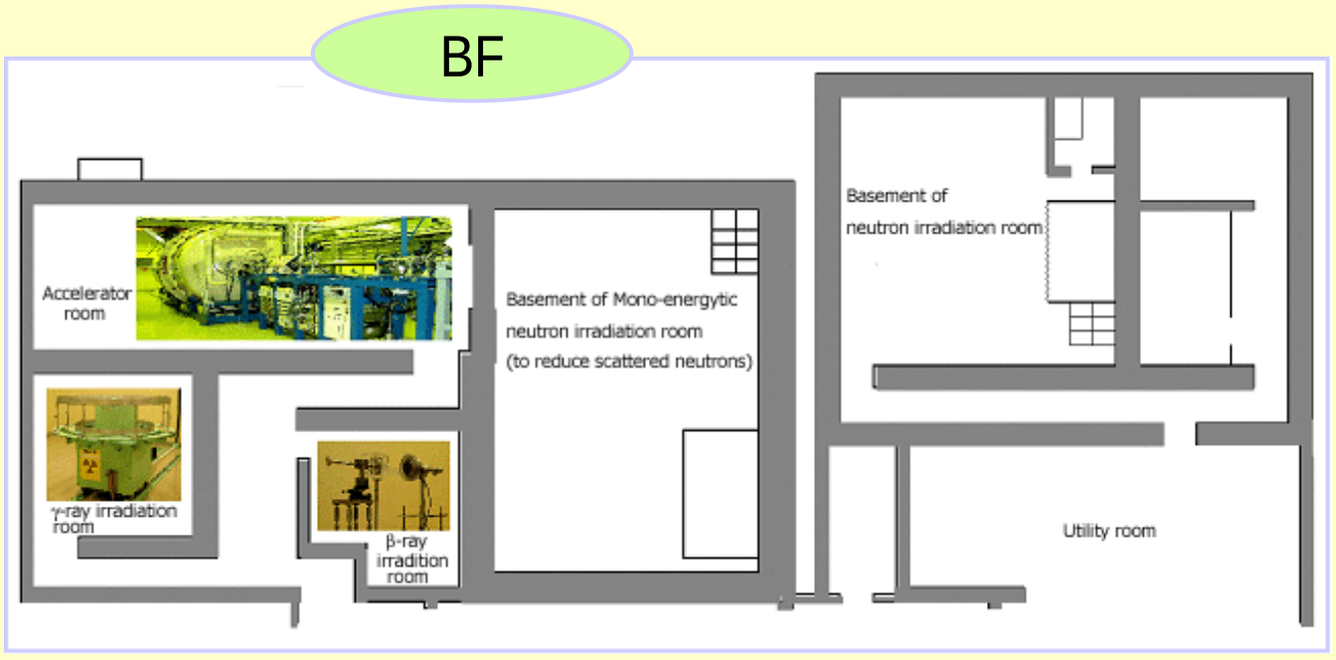


Layout of FRS

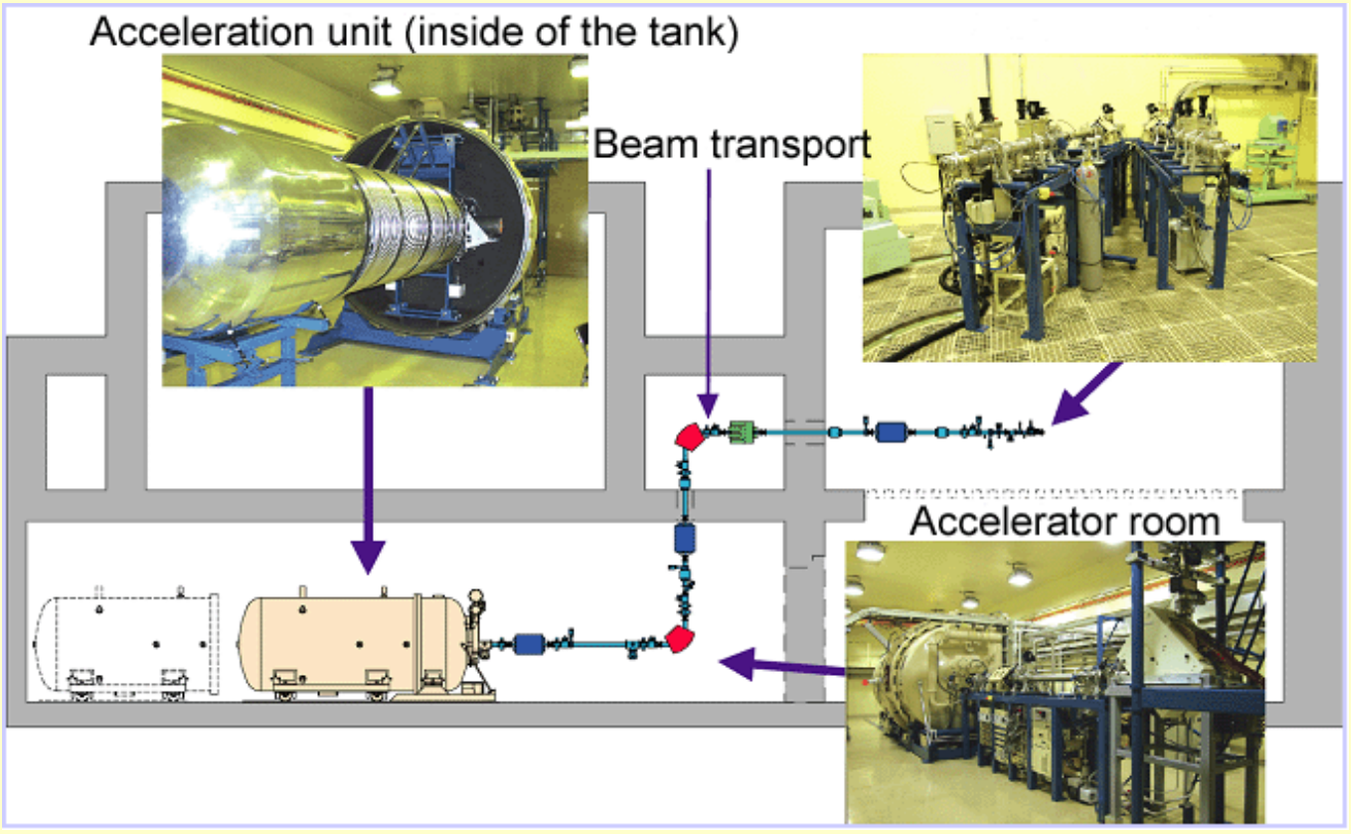
The Facility of Radiation Standards, FRS, was established in 1980. This facility has been equipped with calibration fields of X-ray, γ-ray, β-ray and neutrons from radionuclide sources. In 2000, an additional facility with an accelerator for generating neutrons and some irradiation rooms was constructed, and the FRS has completed as the most comprehensive calibration facility for radiation protection in Japan.

Building structure :	Reinforced concrete
Floor surface :	4,153 m^2 ; 2 floors (partially 3 floors) and a basement
Rooms :	8 irradiation rooms, Radioisotope laboratory, Accelerator room, Operation room, etc.





4MV Van-de-Grraff Accelerator

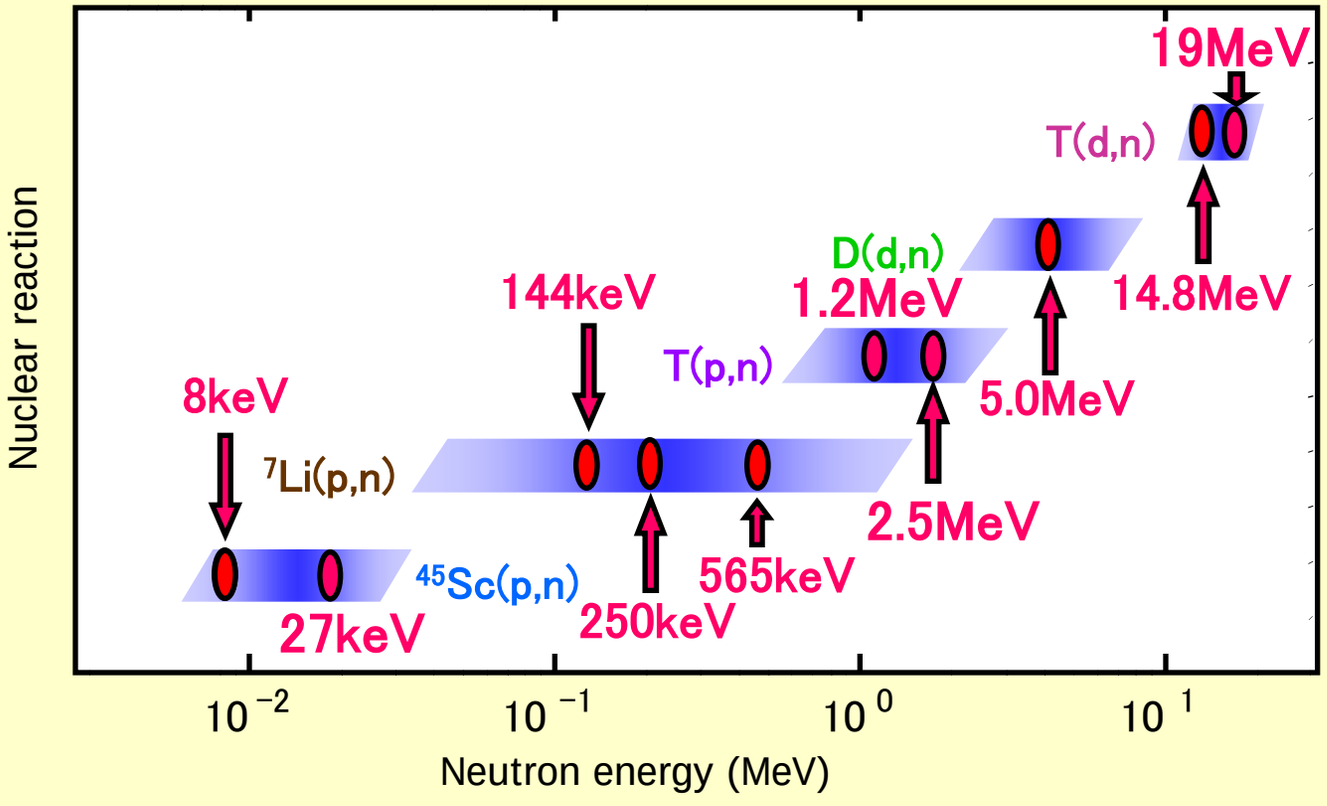


Specifications of 4MV VdG Accelerator

Model	Pelletron 4UH-HC (US NEC)
Acceleration voltage	0.4 ～ 4.0 MV
Ion current	0 ～ 50 μA
Particle	Proton and deuteron
Stability	Voltage: ±100 V, Ion current: ±0.1 %
Ion source	Positive ion duoplasmatron
Pulsed beam	Pulse width: 1.5ns (FWHM), Peak current: 10 mA, Frequency: 0.5, 1, 2, and 4MHz
Ultimate vacuum	Acceleration system: 2×10^{-8} mbar Beam line: 2×10^{-9} mbar
Beam efficiency	≥95 % after 90° magnet
Faraday cup	Max. beam power: 1 kW, Transit time of shutter: 0.2 s
Beam profile monitor	Min. sensitivity: 1.0 nA
Ion vacuum pump	≥120 L/min.
Fast acting valve	Transit time of shutter after detecting low vacuum: 35ms
Target thermal detector	0 ～ 800 ℃, Accuracy: ±1 %
Irradiation time with timer	1 ～ 1×10^{5} s

Monoenergetic Neutron Calibration Fields

Neutron energies and nuclear reactions



Specifications of monoenergetic neutron fields

Target and nuclear reaction	Neutron energy range (Energy range of incident particle)	Neutron energies for calibration*	Max. dose equivalent rate	Major specification of target
Tritium $^{3}H(d,n)^{4}He$	15～20MeV (d:0.4~4.0MeV)	**14.8MeV, 19MeV**	30μSv/h 3mSv/h	**^{3}H/Ti** Thickness: ~2mg/cm^2
Deuterium $^{2}H(d,n)^{3}He$	3～7MeV (d:0.4~4.0MeV)	**5.0MeV**	20μSv/h 7mSv/h	**^{2}H-gas** Size of gas cell: 1cmΦ x 2.4cm
Tritium $^{3}H(p,n)^{3}He$	0.4～3MeV (p:1.2~4.0MeV)	**1.2MeV, 2.5MeV**	30μSv/h 15mSv/h	**^{3}H/Ti** Thickness: ~0.5mg/cm^2
Lithium $^{7}Li(p,n)^{7}Be$	120keV～2.3MeV (p:1.92~4.0MeV)	**144keV, 250keV, 565keV**	20μSv/h 7mSv/h	**LiF** Thickness: ~0.1mg/cm^2
Scandium $^{45}Sc(p,n)^{45}Ti$	8keV～30keV (p:2.91~2.93MeV)	**8keV, 27keV**	～2μSv/h	**Sc (metal)** Thickness: ~0.1mg/cm^2

* Neutron energies specified in the international standard of 'Reference neutrons' (ISO 8529-1, 2001).

Neutron Calibration Fields

Neutron calibration fields produced with RI-sources

Graphite pile (for thermal neutrons)

Neuton sources
^{252}Cf : 2.0 GBq
^{241}Am-Be : 37 GBq
^{239}Pu-Be : 37 GBq

Concrete-moderated neutron field

Neutron source
^{241}Am-Be : 37 GBq

Characteristics of neutron calibration fields

Type of calibration field		Neutron source	dose equivalent rate, H*(10) (μSv/h)		dose equivalent average energy (MeV)	Calibration position
Thermal neutrons	Inside pile	^{241}Am-Be ^{239}Pu-Be	1 2 3 4	164 137 102 66.8	2.5×10^{-8}	Cavity in the center of the pile
	Outside pile	^{252}Cf	21.1		2.5×10^{-8}	40cm from the surface
Fast neutrons	~1m above the grating floor	^{252}Cf ^{241}Am-Be	700 ~ 11000 7 ~ 110		2.3 4.4	Distance 50~200 cm
Moderated neutrons	Concrete moderated fields	^{241}Am-Be	1 2 3	148 50.2 11.3	3.5 2.8 1.8	50 cm 110 cm 160 cm
	D_2O-sphere (30cmϕ)	^{252}Cf	16 ~ 250		2.1	Distance 50~200 cm

γ-ray Calibration Fields

γ-ray irradiators

Low-level irradiator (I)

^{60}Co : 7.4 GBq
^{137}Cs : 1.85 GBq
37 GBq
740 GBq

Low-level irradiator (II)

^{137}Cs : 1.11 GBq
11.1 GBq
111 GBq

Medium-level irradiator

^{60}Co : 7.4 GBq
185 GBq
3.7 TBq
7.4 TBq

Characteristics of γ-ray calibration fields

Irradiation type	Sources and energies	Range of dose equivalent rate, $H^*(10)$
		10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 (μSv/h)
Low-level Irradiator (I)	^{137}Cs (662keV) ^{60}Co (1250keV)	10 μSv/h — 80 mSv/h 30 μSv/h — 800 μSv/h
Low-level Irradiator (II)	^{137}Cs (662keV)	4 μSv/h — 20 mSv/h
Medium-level Irradiator	^{60}Co (1250keV)	30 μSv/h — 5 Sv/h
Panoramic Irradiator (r=50 or 70 cm)	^{137}Cs (662keV) ^{226}Ra (830keV) ^{60}Co (1250keV)	0.13mSv/h, 0.25 mSv/h, 3.4 mSv/h, 6.8 mSv/h 330 μSv/h — 640 μSv/h 5.4 mSv/h — 10.5 mSv/h
Uncollimated (4π irradiation)	^{241}Am (60keV) ^{57}Co (122keV) ^{51}Cr (320keV) ^{133}Ba (340keV) ^{137}Cs (662keV) ^{226}Ra (830keV) ^{60}Co (1250keV)	8 μSv/h — 400 μSv/h 7 μSv/h — 300 μSv/h 6 μSv/h — 200 μSv/h 6 μSv/h — 35 μSv/h 1 μSv/h — 70 μSv/h 1 μSv/h — 800 μSv/h 1 μSv/h — 500 μSv/h
High-energy γ-rays	^{16}N (6.1MeV) (JRR-4) p-F (6.1MeV) (Accelerator)	30 μSv/h — 700 μSv/h 1 μSv/h — 10 mSv/h (Under construction)

X-ray Calibration Fields

X-ray generators

Medium and hard X-ray generator

Max. tube voltage: 380 kV
Max. tube current: 30 mA

Soft X-ray generator (right)
Max. tube voltage: 100 kV
Max. tube current: 70 mA
Pulsed X-ray generator (left)
Max. tube voltage: 125 kV
Max. tube current: 800 mA(peak)

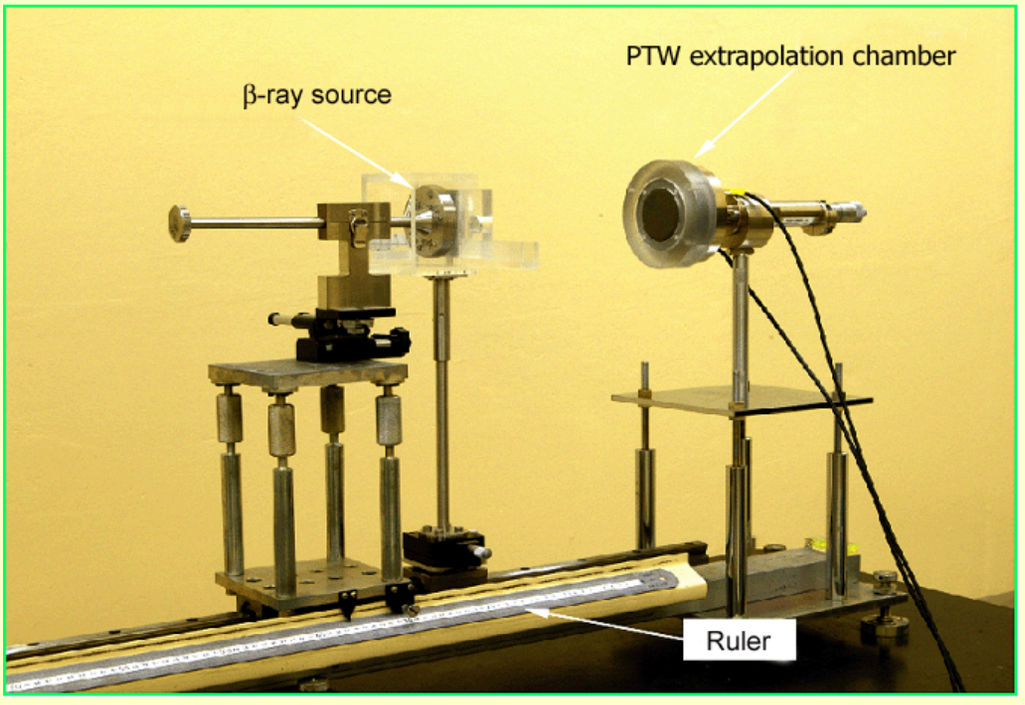
Characteristics of X-ray calibration fields

X-rays	Range of effective energies	Dose equivalent rate, $H^*(10)$ (μSv/h)
		10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7
Soft X-rays (Under construction)	5 keV ~ 90 keV	2μSv/h; QI 0.9; QI 0.8; QI 0.7; QI 0.6; 90 mSv/h
Medium and hard X-rays	20 keV ~320 keV	2μSv/h; 900 mSv/h
Pulsed X-rays Width: 1ms ~ 10s	30 keV ~100 keV	2μSv/h; 200 mSv/h
Fluorescent X-rays Radiator: Cu, Mo, Sn, Er, W, Au, and Pb	8 keV ~ 75 keV	10μSv/h; 700μSv/h

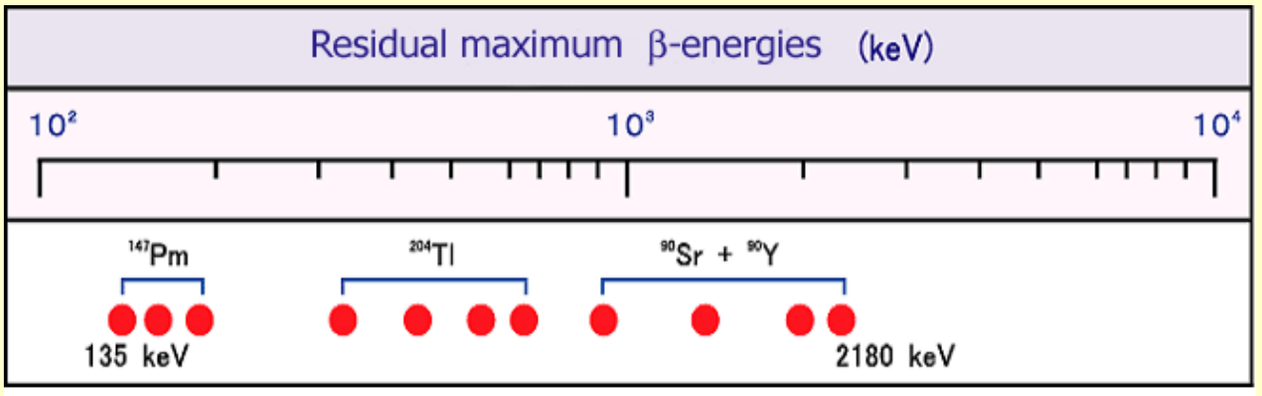
QI: Quality Index = Effective energy/Maximum energy

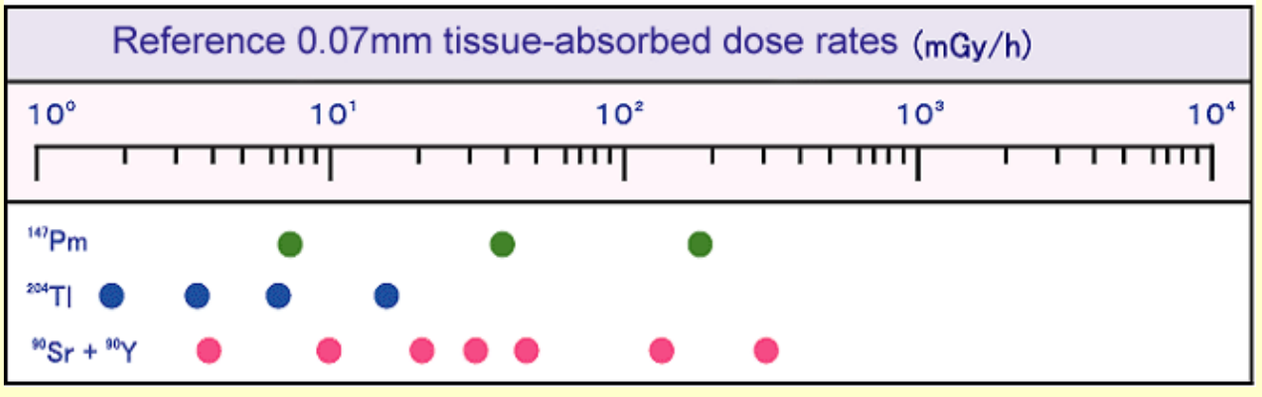
β-ray Calibration Fields

Setup of β-ray Calibration Field (Example)



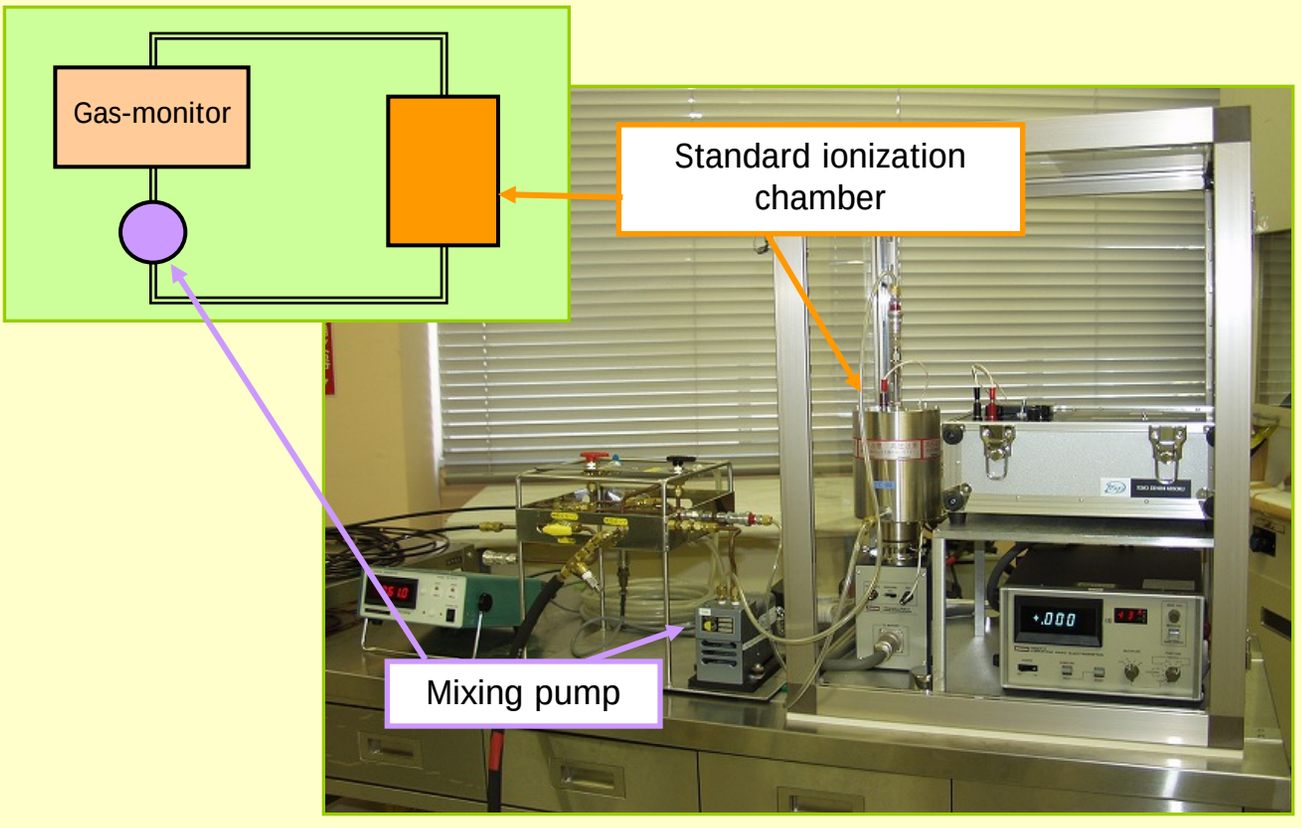
Characteristics of β-ray calibration fields





Calibration of Gas- and Water- Monitor

Closed gas-loop with a standard ionization chamber for gas-monitor calibration

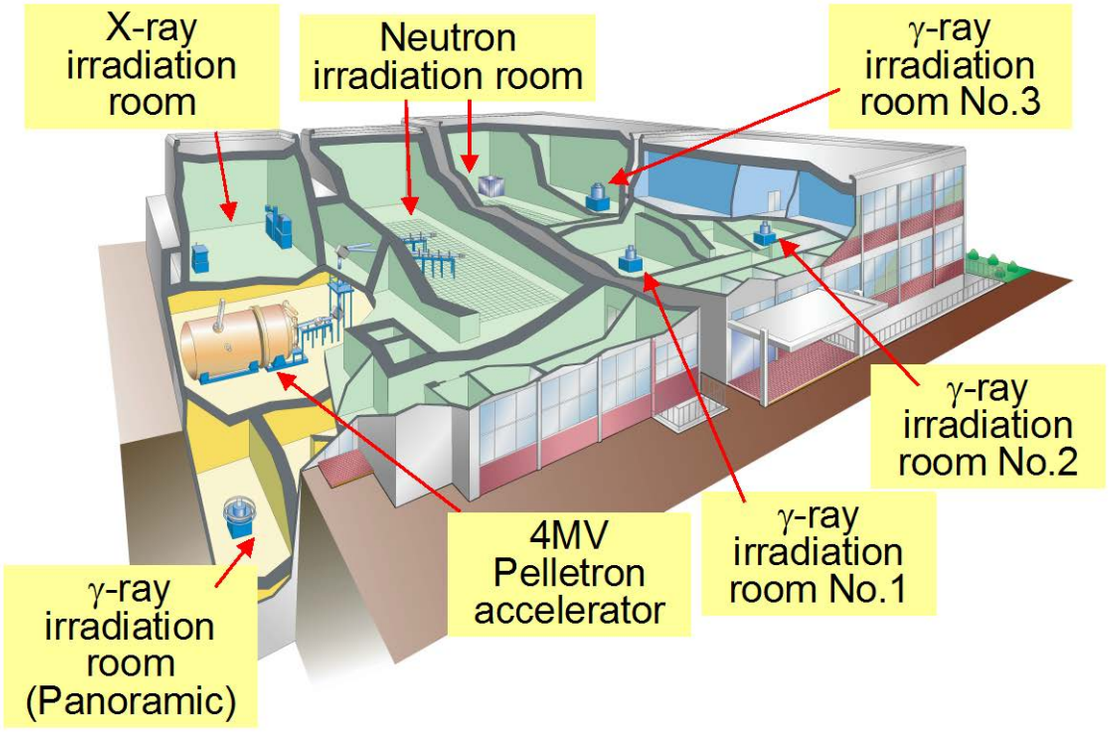


Radionuclide and activity concentration available for gas-monitor calibration

Radionuclide	β-ray energies	Calibration range
^{3}H ^{14}C ^{41}Ar ^{85}Kr ^{133}Xe ^{135}Xe	19 keV～1.2 MeV	0.3 Bq/cm^3 ～ 30 Bq/cm^3

Radionuclide and activity concentration available for water-monitor calibration

Radionuclide	β-ray energies	Calibration range
^{51}Cr ^{137}Cs ^{60}Co	320 keV～1.25 MeV	1 Bq/cm^3～1000 Bq/cm^3



Cutaway view of FRS

Memo

Japan Atomic Energy Agency

Nuclear Science Research Institute

Tokai, Naka-gun, Ibaraki, 319-1195, Japan

Information: Department of Radiation Protection

Telephone: +81-29-282-5205, Facsimile: +81-29-282-6063

Web-site

JAERI: http://www.jaea.go.jp/

Calibration Standards and Measurement Section :http://www3.tokai-sc.jaea.go.jp/rphpwww/senryo