IRRADIATION FACILITIES

in Hungary

with regards to the investigation of radiation tolerance (resistance/susceptibility) of equipment and material (e.g. electronic devices and optical cables)

Gamma Irradiation Facility

Electron Accelerator

Budapest Research Reactor

Neutron, Gamma and Beta Irradiator Labs

Training Reactor

ATOMKI

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OVERVIEW

Gamma and/or neutron irradiation of equipment, components and material can be carried out at nuclear installations introduced in this report. These organizations may be contacted directly, or irradiation programs could be organized and coordinated by the Radiation Safety Department of the Institute of Isotopes, Budapest.

Institute of Isotopes (IoI or IKI), Hungarian Academy of Sciences (HAS)

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Major Irradiation Facilities

Gamma and X-rays

- Co-60 and Cs-137 sources (TBq/kCi) at the Institute of Isotopes Ltd., Budapest, the National Office of Measures, Budapest and the Atomic Energy Research Institute, Budapest (AEKI); X-ray machine at the National Office of Measures, Budapest

Electron beams; Bremsstrahlung and (X,n) secondary radiation

- LINAC 4 MeV electron accelerator at IoI, Budapest

Neutron beams

- Pu-Be sources at the IoI, Budapest and the AEKI, Budapest
- Training Reactor, Budapest Technical University, Institute of Nuclear Techniques
- Research Reactor, Atomic Energy Research Institute (KFKI-AEKI), Budapest
  - Thermal/fast horizontal channels (filtering possible), ∅ 5 and 15 cm
  - Biological channel, thermal/fast (energy ranges can be varied by filtering), ∅ 10 cm
  - Cold neutron channel, beam 10x2.5 cm, neutron energy around 5 meV

More data is given in Table below

Type of irradiation	Facility	Energy [MeV]	Flux density [$n \cdot cm^{-2} \cdot s^{-1}$]	Dose rate [$kGy \cdot h^{-1}$]	Irradiation space or beam size [mm]
X- rays	OMH IKI LINAC	0 - 0.3 0 – 4		n x 10^{-3} 70 ?	∅ = 113 ∅ = 50
γ - rays	IKI Co-60 OMH Co-60 IKI Cs-137 OMH Cs-137 AEKI Cs-137	1.25 1.25 0.66 0.66 0.66		15 2 x 10^{-2} 5 ? 5 x 10^{-4} 0.01 $3x10^{-8}$/1m	∅180 x 300 ∅ =113 ∅ =50 ∅ =220 ∅50 x 15 open ∅ =100
	KFKI-AEKI				
$n_{th,f}$ + γ	hor. channels No 2 and 3	25 meV	$2x10^{9}$	0.03	∅ =150, 50
$n_{th,f}$ + γ	hor. (Biology) channel No 5	25 meV +f	10^{8}		∅ =100
n_{cold}	cold neutron channel	5 meV	10^{9}		100 x 25 beam
n_{th} + γ	vertical channels	25 meV	$\sim 2x10^{14}$	1700-2500	∅ = 30
n_{f} + γ	vertical channels	0 - 5	$2\text{-}3x10^{13}$	330-450	∅ = 30
$n_{th,f}$ + γ	vertical channel “topaz”		?	?	∅52x160
$n_{th,f}$ + γ	BME TR hor. channel	25 meV +f	10^{7}	0.003	∅ = 80-90
$n_{th,f}$ + γ	BME TR vert. Channel	25 meV +f	$3x10^{12}$	?	∅ = 30 / 100
$n_{th,f}$ + γ	BME irrad. tunnel	25 meV +f	10^{9} -10^{10}/10^{9}	1.3-3300	400 x400
n_{f} + γ p + Be n_{f} + γ d + Be	**ATOMKI** Cyclotron horizontal beamline: No. 2	0 – 16 0 – 12	5.0 x 10^{9} 3.0 x 10^{9}	~ 0.6 (for TE) ~ 0.34 (for TE)	In air, ~ 1 steradian around the zero degree direction; the volume is determined by the accepted inhomogenity of the field in the sample.

					in vacuum or in open air
Proton	**ATOMKI** Cyclotron	5 – 18	~ 3 x 10^{14} (~ 50 µA)		∅ = max. 15 (standing target)
Deuteron	4 beamlines for all:	3 – 10	~ 3 x 10^{14} (~ 50 µA)		∅ = max. 15 (standing target)
$^3He^{++}$	horizontal: No. 2a, 6, 7 vertical: No. 7	8 – 24	~ 6 x 10^{13} (~ 20 µA)		∅ = max. 15 (standing target)
alpha		6 – 20	~ 6 x 10^{13} (~ 20 µA)		∅ = max. 15 (standing target)
γ - rays	**ATOMKI** Co-60	1.25		0.26 at 0.1m	in air ~ 4π

Legend

BME TR: Training Reactor at Technical University, Budapest
IKI (or IoI): Institute of Isotopes, Budapest
KFKI-AEKI: KFKI, Atomic Energy Research Institute, Budapest
OMH: National Office of Measures, Budapest
ATOMKI: Institute of Nuclear Research, Debrecen

TE: medium equivalent with human muscle tissue

Note: The figures in the Table are typical or maximum values, for more detailed information the facility operator should be consulted

Measurement of radiation exposure

Neutron flux density/fluence and gamma dose-rate/dose measurements are performed regularly and also during the experiment. Results are documented. Radiation beams are usually monitored continuously. More information on the methods used is available on the web-sites of the relevant institutes:

www.iki.kfki.hu www.kfki.hu www.omh.hu www.atomki.hu

Special expertise at the Institute of Isotopes, HAS

- R&D and applications of safeguards verification techniques
- R&D and applications of thermoluminescent and chemical dosimetry, with emphasis on high-dose dosimetry
- R&D in radiation chemistry and radiation damage
- R&D in Nuclear Physics; prompt gamma-activation analysis (PGAA by cold neutrons)

Selected Publications

A. Kovács et al.: Oscillometric and Conductometric Analysis of Aqueous and Organic Dosimeter Solutions; Radiat. Phys. Chem. 46/4-6, pp 1211-1215 (1995)

M. Osvay: Measurements on Shielding Experiments Using Al_2O_3:Mg.Y TL Detectors; Rad. Prot. Dosimetry, 66/1-4, pp 217-219 (1996)

J. Pálfalvi et al: Realistic Neutron Spectra for Radiation Protection and Other Applications at AERI, Budapest, Hungary; Proc. Int. Workshop on Neutron Field Spectrometry, 5-8 June 2000, Pisa, Italy, Nucl. Instr. Meth. A 476/1-2, pp 452-456 (2002)

G. Molnár et al.: A New Prompt Gamma-Activation Facility at Budapest; J. Radioanal. Nucl. Chem. 215/1, pp 111-115 (1997)

A. Fenyvesi et al: Results on photon and neutron irradiation of semitransparent amorphous-silicon sensors; Nucl. Instr. Meth. A 455, pp 361-368 (2000)

Subject index

Type of irradiation	Page	Type of irradiation	Page
X-rays	1/2, 3/1–5, 4/4	$n_{fast} + \gamma$	1/2, 3/6-17, 5/1-6, 6/3
α-rays	1/3, 6/2	$n_{thermal,fast} + \gamma$	1/2, 3/6-17, 5/1-6
β-rays	1/1, 3/1-5, 4/2	proton	1/3, 6/2
γ-rays	1/2-3, 2/1-7, 4/2, 4/4, 6/4	deuteron	1/3, 6/2
n_{cold}	1/1-2, 3/18-21	$^3He^{++}$	1/3, 6/2
$n_{thermal} + \gamma$	1/2, 3/6-17, 5/1-6, 7/2		