PM2018 – 14-th Pisa Meeting on advanced detectors

Intense thermal neutron source based on a medical Linac the e_LiBANS Project

M. Costa
Istituto Nazionale di Fisica Nucleare (INFN) & University of Torino

On behalf of e_LiBANS Collaboration

OBJECTIVES

The e_LiBANS project, funded by INFN, aims at developing a flexible facility dedicated to thermal and epithermal neutron irradiations.

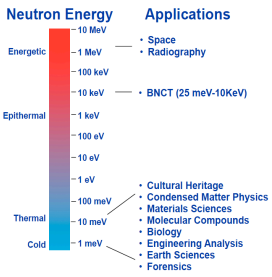
In particular:

- developing a high intensity (10^6-10^7 cm^{-2} s^{-1}) thermal neutron source based on a medical Linac;
- characterising the source in terms of metrological parameters: neutrons fluence, field uniformity, fast neutrons and photons contamination;
- developing new solid state neutron detectors, insensitive to photon background and able to work in high intensity neutron fluxes and pulsed beam

An Elekta Precise SL24MV has been installed and commissioned with the support of INFN and University of Turin

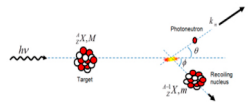
APPLICATIONS

e_LiBANS will offer the possibility to exploit a well described thermal neutron field with high uniformity and high purity, inside an expandable cavity, for different applications in biomedical field, material science, spatial research and cultural heritage

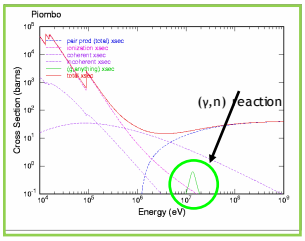


MATERIALS and METHODS

PHOTO-NEUTRONS

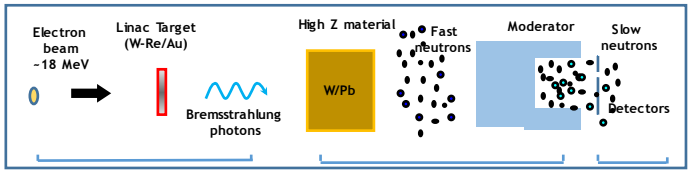


Neutrons are generated by Giant Dipole Resonance (GDR) reactions from photons on lead and tungsten, above 7 MeV energy threshold. The (γ,n) cross section peak reaches about 600 mbarn.

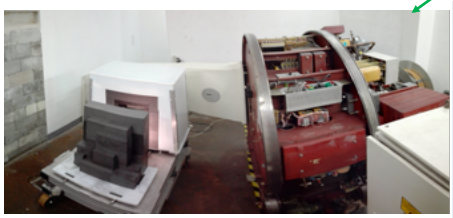


Photons cross section in Lead

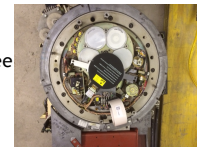
A photo-converter is coupled to the LINAC. Neutrons are produced inside the W/Pb target which also stops the unconverted photons and are then moderated to thermal energies. Samples can be irradiated inside a dedicated cavity where the field is monitored in real time with novel semiconductor devices

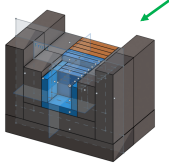


1) LINAC 2) PHOTO-CONVERTER 3) DIAGNOSTICS



Five output modes:
18 MeV electron
18 MeV electron Filter Free
18 MV gamma
18 MV gamma Filter Free
15 MV gamma

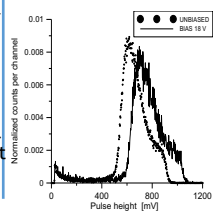




The target of the photoconverter is surrounded by moderator materials like deuterated water, graphite and polyethylene.
MCNP6 simulations have been done to find the best geometry in order to maximise the thermal neutron flux and to minimise fast neutron and gamma background.

TNRD/SiC:
Rad-hard, low cost, minimum size, active neutron detectors with DC output signal proportional to the fluence rate.

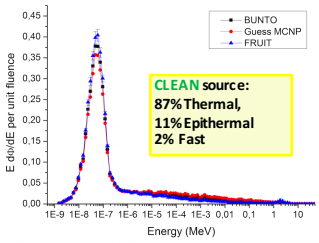
Response calibration 2%



SiC with ^{6}LiF deposit and ^{241}Am alpha spectrum measured with SiC

RESULTS

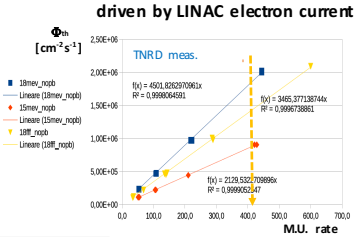
Neutron Energy Spectrum measured with BSS+TNRDs



CLEAN source:
87% Thermal,
11% Epithermal
2% Fast

Linear and Flexibile

Neutron Fluence rate linearly driven by LINAC electron current



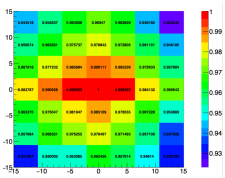
Gamma dose measured in the mid cavity for different configurations and corresponding in air figure of merit

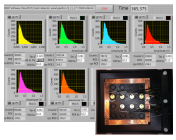
γ beam	D_g μGy MU^{-1}	st.dev %	D_g @400MU/min mGy/h	Φ_{th} @400MU/min cm^{-2}s^{-1}	ratio D_g/Φ_{th} Gy cm^2
18 MV	0.277	2.05	6.65	1.80 10^6	1.53 10^{-12}
15 MV	0.204	0.38	4.88	3.42 10^6	1.59 10^{-12}
18 MV FFF	0.211	0.65	5.06	1.39 10^6	1.01 10^{-12}

Au foils measurement and active diagnostics results have been found to agree at the 2% level.

Thermal field xy,z profiles

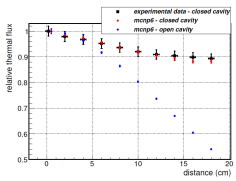
TRANSVERSE plane uniformity:
max difference 8%, σ_{rms} = 1.3%





Matrix of SiCs read in parallel to monitor transverse plane uniformity

LONGITUDINAL profile in the closed (open) cavity configuration. Optimum agreement with MCNP predictions



CONCLUSIONS

A new thermal neutron source has been developed in Turin, based on a medical e-Linac. Results show a quite pure and uniform thermal neutron field with fast component <2% and acceptable γ background. Neutron Fluence rate linearly depends on beam current. New active solid state detectors calibrated at 2% have been built to monitor the neutron field

Aknowledgments

The Linac facility has been supported by
Compagnia di San Paolo
Fondazione CRT