E_LIBANS 2017 Activity

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In collaboration with Trieste, Torino and Milano INFN sections

1 Introduction

The e_LiBANS project started in 2016 to develop homogenous and portable neutron fields for interdisciplinary applications. The first phase was devoted to thermal neutron fields.
The idea was to produce neutrons via photo-reaction and then to moderate them to the wanted energy in a dedicated assembly [1].
For the purpose, a reconditioned ELEKTA SL18 MV was installed and commissioned in an existing bunker at the Physics Department of University of Torino.
The LINAC is coupled to a novel photo-converter, optimized through extensive Monte Carlo simulations, to achieve in the experimental cavity a pure thermal spectrum with a highly homogenous transverse profile.
In order to monitor on-line and to achieve highly accurate metrology of the generated neutron field, new devices have been developed within this project. The field is complex, pulsed and mixed, and this makes e_LiBANS also very interesting and challenging for radiation detection.

The work assignment was as follows:
- Frascati: Neutron diagnostics development
- Torino: photoconverter-moderating assembly, design and development
- Milano: electronics readout
- Trieste: measurements with passive sensors (bubble detectors)

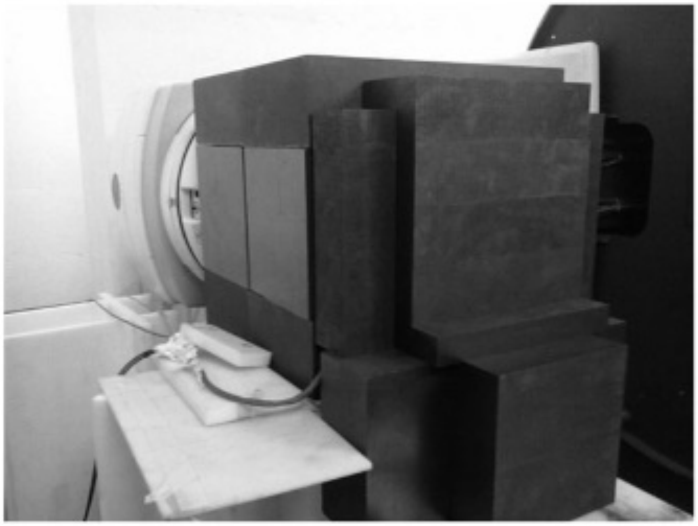

Figure 1. The Linac coupled with the photoconverter and moderating assembly. Simulations were performed with MCNP [2]. Lead was used as photoconverter. Graphite and heavy water were used as moderating and reflectin materials. The experimental cavity has 30x30x20 cm3 volume and is accessible by removing a graphite wall mounted on a movable carriage.

2 The Neutron Diagnostics (LNF task)

Three thermal neutron detectors have been employed, all sensitized to thermal neutron through a ^{6}LiF deposition. An evaporation-based deposition process allows to precisely deposit multiple detectors at the same time. All detectors can operate in current mode. This relies on a dedicated ultralow current analog board that drives the radiation-induced current (tens of fA or higher) to a resistor, making it measurable as a voltage drop. Below a short description of the detectors:

TNRD (thermal neutron rate detector), Silicon-based and prone to radiation damage when exposed to fluence higher than 10^{11} cm^{-2}. This was also used in a Bonner Sphere System to determine the in-cavity neutron spectrum. The TNRD [3] was developed within INFN project NESCOFI@BTF. It is an easy-to-use, small device. Its gamma sensitivity is minimal and works over a wide range of thermal neutron fluence rate values. Due to its degree of validation and long operating history, the TNRD was used as reference in this work. Nevertheless, it is made of silicon, so it may suffer radiation damage when exposed to a thermal fluence higher than 10^{11} cm^{-2}. Large exposures affect the reticular structure of the Silicon, thus compromising the detector's response.

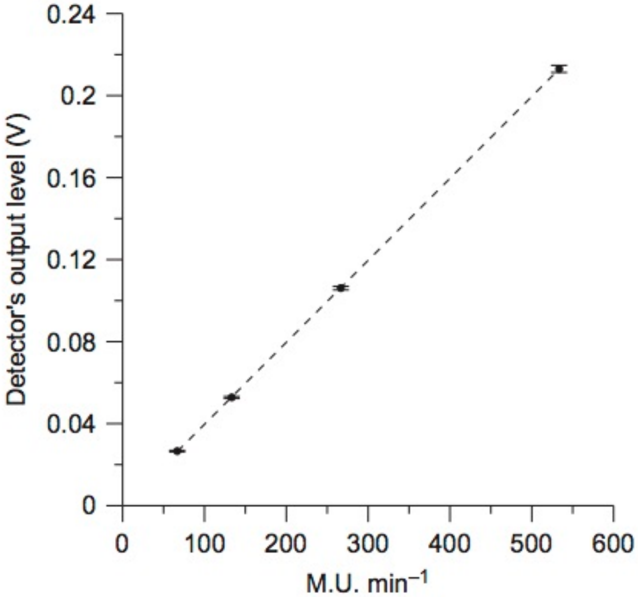

Fig. 2. Linearity test of TNRD using different LINAC dose rate (thermal neutron fluence rate at 500 MU/min is about 1.5 10^6 cm^{-2}s^{-1})

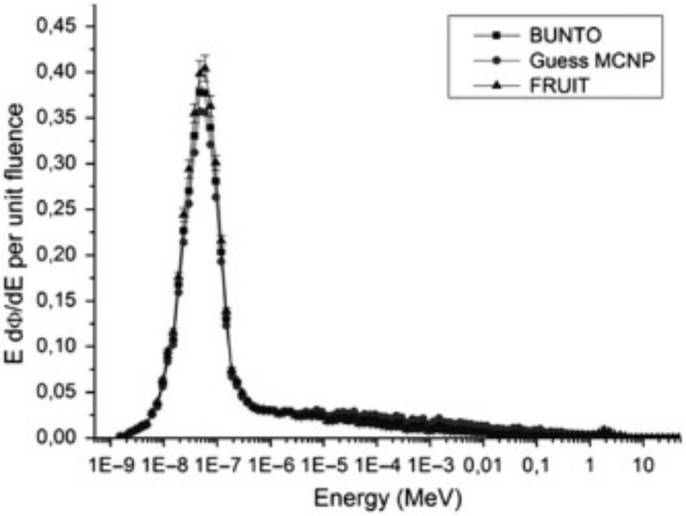

Fig. 3. Neutron spectrum in the experimental cavity by Bonner Spheres with TNRD as central sensor.

Silicon carbide

SiC-based diodes with active area 7.6 mm^2 were sensitized to thermal neutron through evaporation-based ^{6}LiF deposition (30 micron thick). Fig. 4 shows the depleted layer Vs. bias dependence.
Fig. 5 reports the linearity tests performed in the E_LIBANS experimental cavity.

SiC detectors arranged in a 2D array were used to spatially map the E_Libans experimental cavity, see Fig. 6.

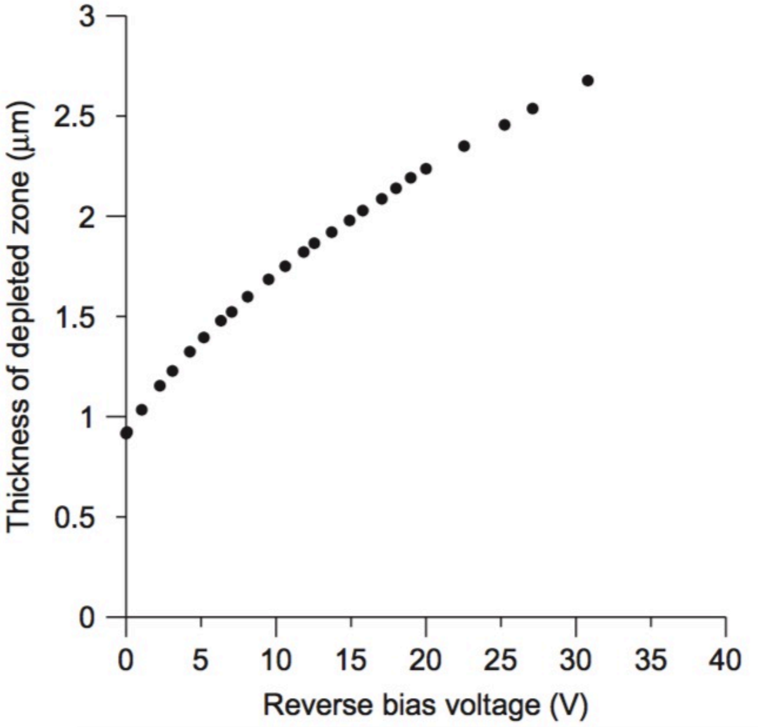

Fig. 4. Measurement of depletion layer thickness (about 3 µm) of SiC detector (sensitive area 7.6 mm^2) thanks to the elaboration of capacitance-voltage measurements.

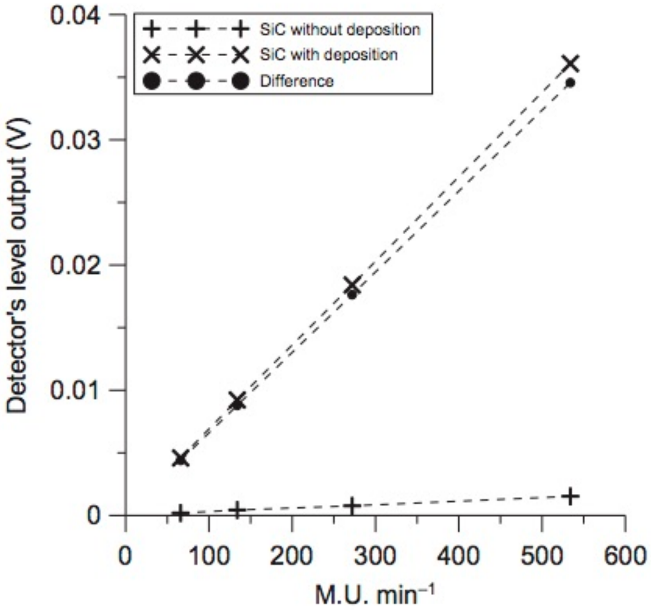

Fig. 5. Linearity test performed in the E_LIBANS cavity, by varying the LINAC Monitor Unit rate. By subtracting the bare SiC signal from the SiC + ^{6}LiF one, the contribution due to the ^{6}LiF layer can be achieved ("difference" line in Fig. 7). This is about 97% of the SiC + ^{6}LiF signal. The "undeposited" signal accounts for Boron impurities in the substrate, plus parasitic signal due to photon-induced secondary electrons.

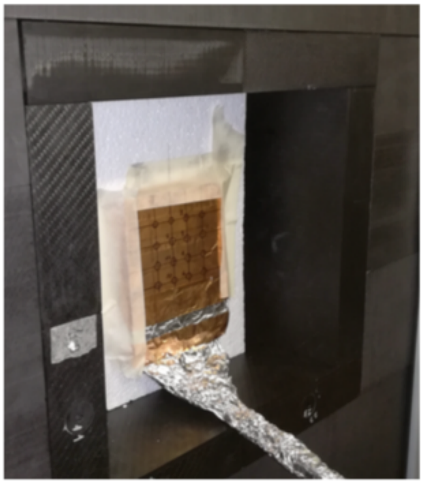

Fig. 6. SiC-based 2D array for spatial mapping of the cavity.

3 Publications

[1] M. Costa, M., Durisi, E., Giannini, G., Monti, V., Visca, L. and Zanini, A. Neutron sources based on medical Linac, Il Nuovo Cimento 38 C, 180 (2015).

[2] Goorley, J. T. et al. Initial MCNP6 Release Overview - MCNP6 version 1.0. LA-UR-13-22934 (2013).

[3] Bedogni R., Bortot D., Pola A., Introini M.V., Gentile A., Esposito A., Gómez-Ros J.M., Palomba M., Grossi A. A new active thermal neutron detector. Radiation Protection Dosimetry, pp. 1–4 (2013).