E_LIBANS project

R. Bedogni (Resp. loc.)

M. Romano (Laur.), O. Sans Planell (Ass.), A. Sperduti (Laur.), M. Treccani (Ass.)

In collaboration with LNF *Servizio Progettazione e Costruzioni Meccaniche*

INFN- LNF

The E_LIBANS project (CSN 5, 2016-2018) aims, in its first stage, at producing intense thermal neutron fields for diverse interdisciplinary irradiation purposes. The primary source will be a reconditioned medical LINAC Elekta SL18, recently commissioned in a dedicated bunker at Physics Department and INFN in Torino.

The LINAC head has been configured to deliver gamma or electron beams with or without flattening filters. Different primary electron beam energies can be chosen up to 18 MeV. The Linac head was coupled with a photo converter / moderator apparatus, developed within the collaboration, equipped with a 30x30xL cm^3 irradiation cavity. The depth L can be modulated between 10 cm and 40 cm. Taking advantage of extensive Monte Carlo simulations, the photo converter / moderator design was optimized to achieve a pure thermal spectrum, very few gammas and nearly constant homogeneity profile in the irradiation cavity.

As a feasibility study for this installation, the moderator was experimentally benchmarked using the Linac available at S. Luigi Orbassano hospital (Fig. 1).

Figure 1: Linac and photo converter / moderator installed at S. Luigi Orbassano Hospital

Specially designed thermal neutron detectors (or diagnostics) were designed by the LNF and Milano Groups to resist the intense field and to provide very high neutron-to-photon discrimination capability, namely:

- Silicon Carbide (SiC) detectors (Fig. 2) with sensitive area 1 mm^2, sensitized to thermal neutrons through in-house deposition of a 30 micron layer of 6LiF
- Air filled vented ion chambers with sensitive volume 2 cm x 2 cm x 0.8 cm, sensitized to thermal neutrons through in-house deposition of a 30 micron layer of 6LiF.

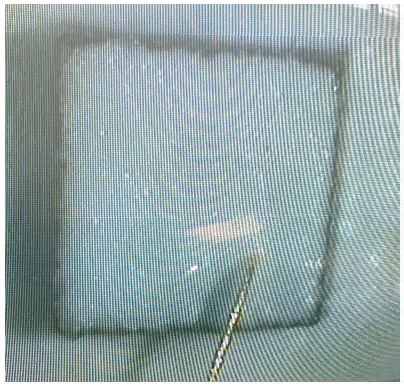

Figure 2: One-mm^2 Silicon Carbide detector sensitized to thermal neutrons through deposition of 6LiF

The mentioned thermal neutron detectors were tested in two experimental campaigns:

- The thermal neutron field emerging from the radial thermal column of a TRIGA reactor (ENEA Casaccia), see Fig. 3. These measurements were intended to calibrate the neutron detectors and verifying their linearity. By varying the reactor power, thermal neutron fluence rate values from 1E+2 to 1E+6 cm^{-2} s^{-1} are available.
  Both diagnostics proved their linearity within 1-2% in the studied range of thermal fluence rate.

- The realistic photo-neutron field produced by installing the E_LIBANS photo-converter / moderator on the medical LINAC of the S. Luigi Hospital (Orbassano). This campaign aimed at estimating the typical thermal neutron fluence rates achievable with the photo-converter / moderator and to estimating the neutron-to-photon rejection capability of the diagnostics.
  Whilst for the SiC detector the ratio between a 6LiF-deposited (neutron-sensitive) detector and a bare one was in the order or 20, for the ion chambers this ratio was higher than 100.
  Ion chambers show better neutron-to-photon rejection capability than SiC detectors in the realistic photo-neutron field from a LINAC.
  Both detectors allowed appreciating the pulsed structure of the LINAC beam and its variation with the LINAC current, controlled through the so-called “Monitor Unit rate”, see Figs. 4 and 5.

Figure 3: The collimated output of the TRIGA thermal column.

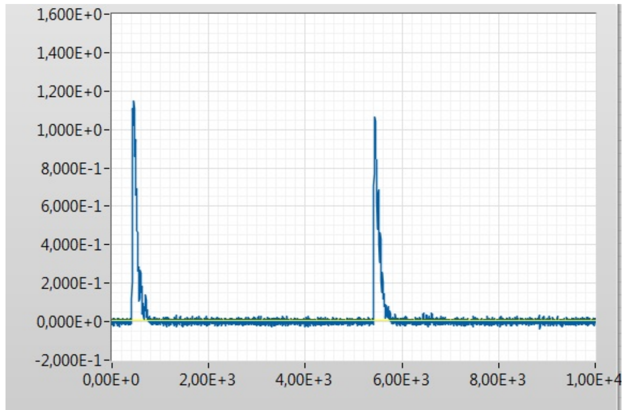

Figure 4: Typical detector output at 66 MU/min (1E+4 samples = 80 ms).

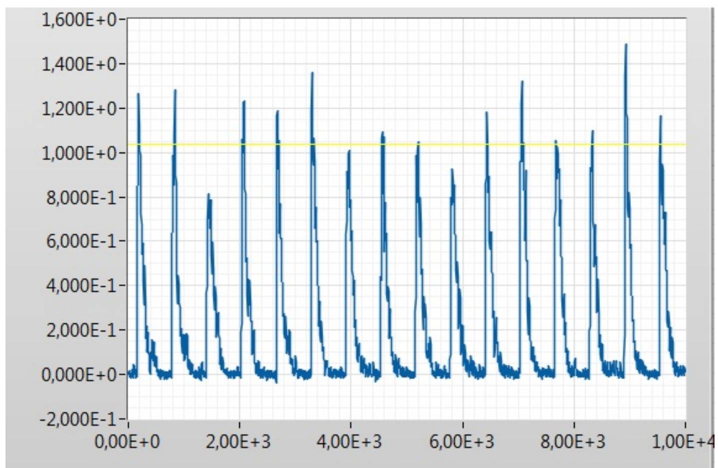

Figure 5: Typical detector output at 535 MU/min (1E+4 samples = 80 ms).