Radiation protection related x-ray spectrometry at PHELIX

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Introduction

In the context of a bachelor thesis [1], a thermoluminescence dosimetry (TLD) based method has been developed for the measurement of photon spectra in ultrashort-pulsed radiation fields as generated e.g. during operation of the PHELIX-laser at GSI [2]. The method is a further development of a work from Behrens et al. [3] and has been validated at a clinical electron-linac (Elekta Synergy: 6 and 18 MeV) by comparing spectra measured by the developed method with spectra obtained by detailed Monte Carlo simulations of the linac. It has been first applied at PHELIX during a beamtime in December 2013. The following article presents the principle of the method of measurement and first results from the measurements at PHELIX.

Method of measurement

As a result of the sub-picosecond time scale of the laser pulses at PHELIX, an active measurement is quite difficult to implement. For that reason, TLD's are used. 10 TLD-cards (*Harshaw TLD-700H*) are placed into a stack of absorbers, made of various materials and thicknesses, surrounded by a shielding stepped from lower to higher Z materials. The prototype is shown on Figure 1.

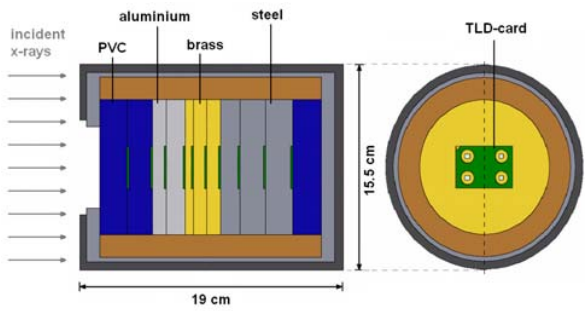

Figure 1: Schematic view of the TLD-spectrometer

The response functions of the 10 TLD's to monoenergetic photon- and electron-radiation were simulated by the use of the Monte Carlo code FLUKA [4]. The different gradients and thresholds of these response-functions (Figure 2) allow the reconstruction (unfolding) of photon spectra from the readings of the 10 TLD's. An algorithm for the purpose of unfolding bremsstrahlung spectra in the range of 30 keV to 100 MeV, resolved in 10 different energy bins, was developed (written in SCILAB [5]).

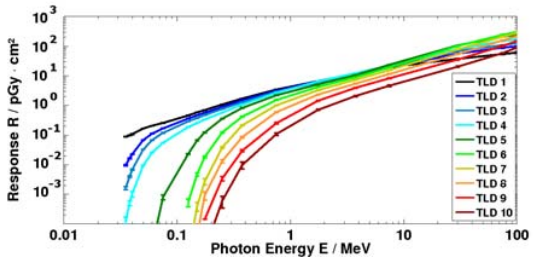

Figure 2: Simulated response-functions of the 10 TLD's to monochromatic photon radiation

First results

Figure 3 shows an x-ray spectrum, measured by this prototype at the PHELIX petawatt target area from the outside of the target chamber behind a 2 cm steel window during experiments in December 2013. The laser intensity deposited on the Ti-foil target was about 10^{19} W/cm^2. The distance between the target and the spectrometer was 80 cm. The presented x-ray spectrum is equivalent to an ambient dose of 80 ± 20 μSv/shot.

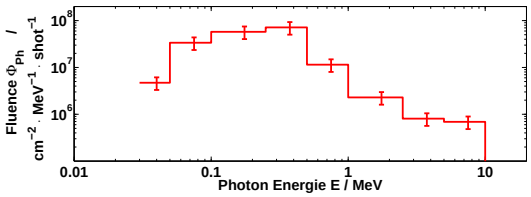

Figure 3: X-ray spectrum: measured at PHELIX

Repeated measurements with a variation of the window materials and thicknesses provided evidence, that the wall of the target chamber is the main x-ray source.

References

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[3] R. Behrens et al., "A thermoluminescence detector-based few-channel spectrometer for simultaneous detection of electrons and photons from relativistic laser-produced plasmas", Review of Scientific Instruments Vol. 74, 961, Feb 2003

[4] http://www.fluka.org/

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