12.3 The Neutron Source Generated with Electron Linear Accelerator; Theoretical Calculations

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Monte-Carlo simulations were performed using the Fluka code [1]. Monoenergetic electron beam with intensity of 10^{14}e/s and an energy of 10MeV and 15MeV irradiated the conversion targets system. In the first case the system consist of one target (tungsten or lead) with high electron to photon conversion efficiency. In the second case the system consist of two conversion targets, the first tungsten and the second beryllium converter, because of low (~1.7MeV) neutron separation energy. The neutron flux was measured by a detector of size 40×40cm placed 1m behind the conversion targets system. The result of research to find an optimal thickness of single conversion target for photoneutron generation is shown in Fig. 1. Similar results for beryllium layer with four various thicknesses of tungsten layer are shown in Fig. 2. Energy spectra of produced photons and neutrons are shown in Fig. 3.

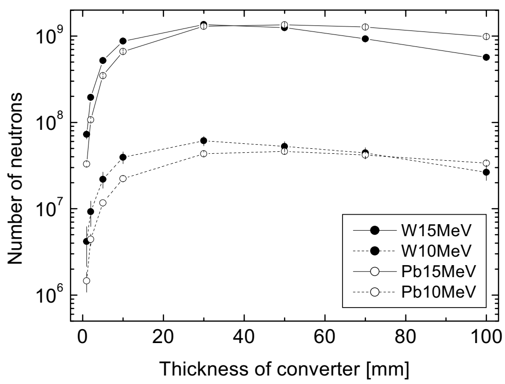

Fig. 1 Number of neutron detected behind the tungsten and lead converters bombarded by 10^{14} monoenergetic 10 MeV and 15 MeV electrons.

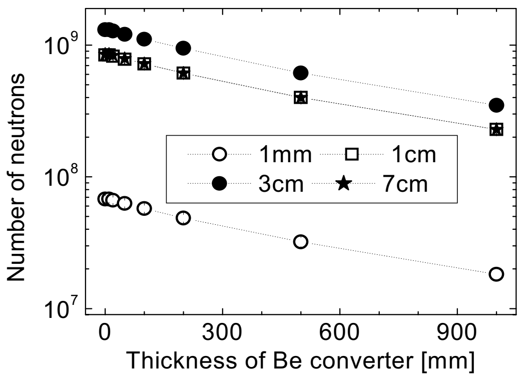

Fig. 2 Neutron production by the 10^{14} electron beam with energy 15 MeV in beryllium converter after 1 mm, 1 cm, 3 cm and 7 cm of tungsten converter. Neutron production for 1 cm and 7 cm tungsten layer is almost the same.

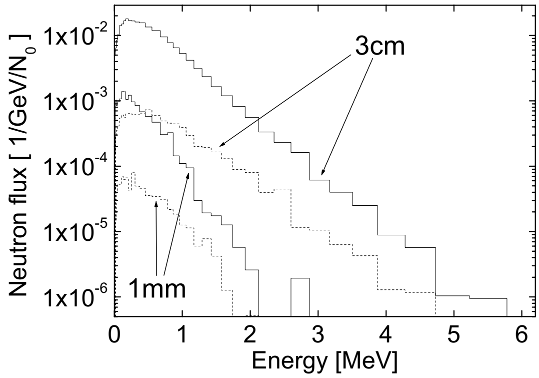

Fig. 3 Energy spectra of produced neutrons for 10 MeV and 15 MeV electron beam for two arbitrarily chosen tungsten converter thickness (1 mm and optimal for neutron yield 3 cm).

The obtained results of performed Monte Carlo simulations indicate that the largest number of neutrons can be generated in a single, high-Z converter (tungsten, lead), when the conversion target thickness is in the 3 to 5 cm range. Using monoenergetic electron beam with energy of 15 MeV and intensity ~10^{14} e/s the flux of ~10^{9} n/s is generated in the 40×40 cm detection field in a distance of 1 m from the conversion target.

Using 10 MeV electron beam the flux ~$5 \cdot 10^{7}$ n/s is generated within this field.

Photon spectra generated by Monte Carlo simulations have typical energy distribution characteristic for the bremsstrahlung process.

No considerable increase of the neutron flux has been observed when two conversion targets have been used, the first made of tungsten to generate photons and the second made of beryllium to generate photoneutrons. The increase of the beryllium converter thickness causes the increase of neutron scattering and results in the decrease of the neutron flux in the detection field. The increase of thickness of the first converter does not change the characteristic decrease of neutron flux with an increase of the second beryllium converter.

[1] A.Fasso, A.Ferrari, J.Ranft, P.R.Sala, computer code Fluka2003 version 1.0b, mar-04, http://www.fluka.org