Measurement of neutron production spectra at the forward direction from thick graphite, aluminum, iron and lead targets bombarded by 250 MeV protons

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Various Monte Carlo transport calculation codes have been widely employed for the shielding designs of proton accelerator facilities. In such designs by use of simulation codes, it is important to estimate the production spectra of secondary particles, especially neutrons, produced by beam losses in thick materials of beam line modules and the beam dump as source terms. The accuracy of calculated results has been verified by the benchmark experimental data. The double differential neutron production spectra at 0-degree by bombarding 210 MeV protons on a thick iron target were measured at RIKEN [1]. No other experimental data are available to confirm the accuracy of neutron production spectra at 0-degree from thick target. We have measured neutron production spectra from thick graphite, aluminum, iron and lead targets at the forward direction bombarded by 250 and 350 MeV protons at the TOF course of the RCNP (Research Center of Nuclear Physics) ring cyclotron of Osaka University. The 350 MeV measurement results were already presented [2]. In this work, the 250 MeV measurements are reported.

The experimental results were compared with the calculated ones by the Monte Carlo particle transport code, the PHITS and MCNPX codes. In these calculations, the JENDL/HE2004 and the LA150 evaluated neutron data libraries for energies up to 150 MeV and the Bertini model based on intranuclear cascade model were employed.

Figure 1 shows the measured and the calculated neutron production energy spectra from the graphite target. The difference of calculation results between using the JENDL/HE2004 and the LA150 is very small. A discrepancy of the results between PHITS and MCNPX is observed above 200 MeV. This is come from the difference of the type of Bertini model. All calculation results underestimate the experimental ones in the neutron energy range between 30 MeV and 200 MeV. The underestimations of the calculations are also found in 210 MeV proton incident experiment at RIKEN [1] and 350 MeV experiment at RCNP [2]. Those may result from the underestimation of neutron-production cross sections at small angles and the strong self-shielding in target nucleus.

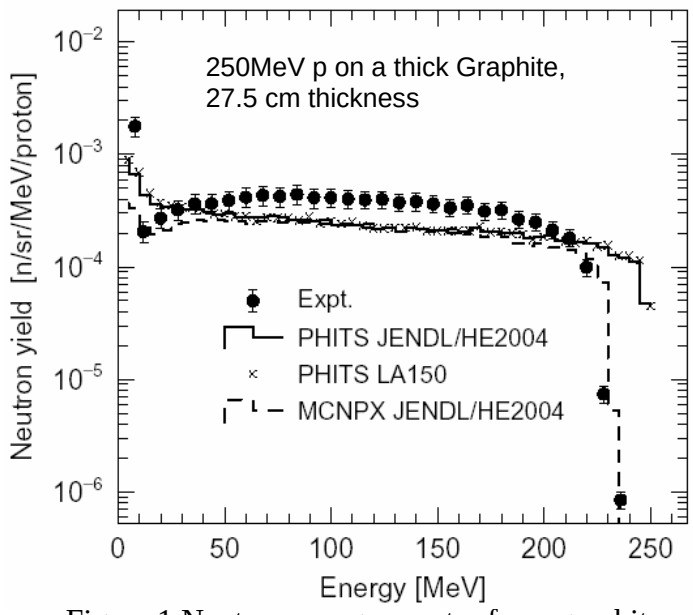

Figure 1 Neutron energy spectra from graphite.

[1] S. Yonai, T. Kurosawa, H. Iwase, H. Yashima, Y. Uwamino, T. Nakamura, Nucl. Instr. and Meth. A 515 (2003) 733.

[2] Y. Iwamoto, S. Taniguchi, N. Nakao, T. Itoga, T. Nakamura et al., the AccApp05 Proceedings