Monte Carlo Simulation of the Yield of Secondary Protons and Neutrons and their Emission from an Extended Lead Target under Irradiation with High Energy Ion Beams

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Abstract. Emission of secondary neutrons and protons from an extended lead target under irradiation with high energy protons at 1 GeV was studied in the report. Comparison is made between predictions of two independent transport codes: Dubna cascade model (DCM) and MCNP-X. Comparison shows relatively good agreement between the two calculations.

Generation of secondary particle fluxes attracts considerable attention over the last few years due to possibility to develop environmentally safe power generation facilities capable to transmute highly hazardous radioactive waste isotopes. Therefore, an attempt was made to calculate emission of secondary neutrons and protons from an extended cylindrical lead target (natural composition[1] , radius 9 cm, length - 70 cm, gravity 11,34 g/cm3) under irradiation with high energy ion beams (1 GeV per nucleon). This configuration can possibly be used as a primary target of the demonstration subcritical facility SAD [1]. Two computer codes developed independently were used for the comparison: the Dubna cascade model (DCM) and MCNP-X. We compared spectra of neutrons and protons emitted from the target through the side and overall surface. Integral figures for neutron and protons emitted from the target are shown in the Tables below.

Particle	Surface	DCM	MSNP-X
Neutrons	Side surface	35,7	20,9
	Total surface	37,1	21,5
Protons	Side surface	8,6 10^{-2}	6,97 10^{-2}
	Total surface	9,9 10^{-2}	1,6 10^{-1}

Table 1: Multiplicity of secondary neutrons and protons emitted from side and overall surface of the lead target under irradiation with 1 GeV protons.

Particle	Surface	DCM	MSNP-X
Neutrons	Side surface	49,2	43,9
	Total surface	51,4	45,5
Protons	Side surface	8,9 10^{-2}	1,2 10^{-1}
	Total surface	1,06 10^{-1}	2,0 10^{-1}

Table 2: Multiplicity of secondary neutrons and protons emitted from side and overall surface of the lead target under irradiation with 2 GeV deuterons

Relevant spectra are presented in the figures below:

[1]In case of DCM code pure Pb207 was considered

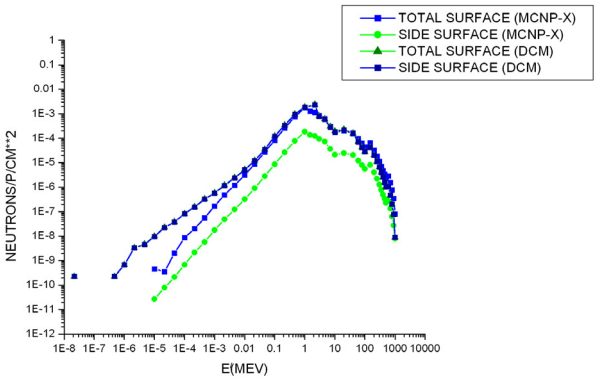

Figure 1: Spectra of neutron emitted from the lead target under irradiation with 1 GeV protons

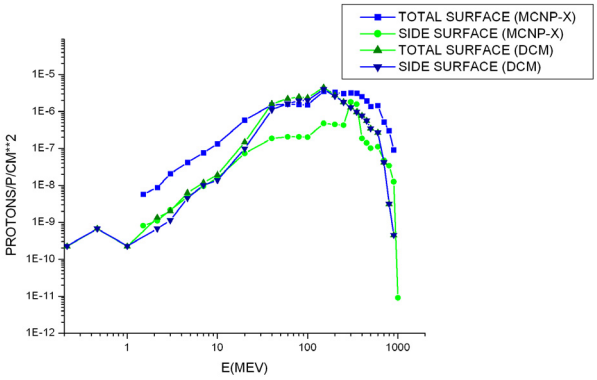

Figure 2: Spectra of protons emitted from the lead target

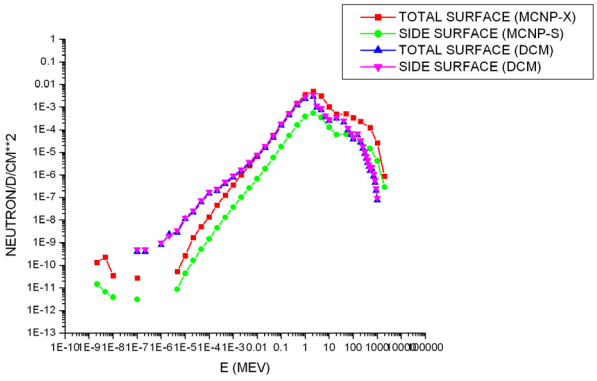

Figure 3: Neutron spectra generated in lead target under irradiation with 2 GeV deuterons

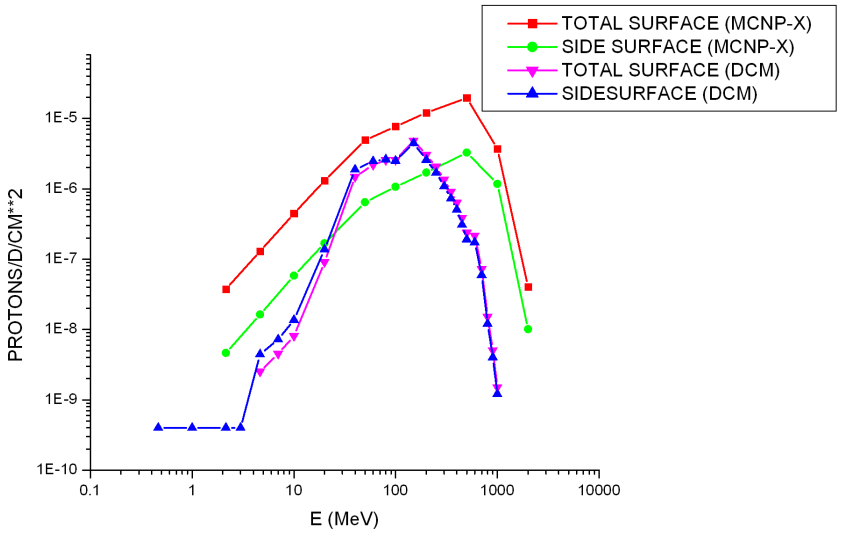

Figure 4: Proton spectra generated in lead target under irradiation with 2 GeV deuterons

Presented data demonstrate more or less satisfactory agreement for the proton data; however, discrepancy between code predictions is reaching up to 50 percent when we consider neutron fluxes. And in both cases there is a considerable difference in the ratio between emission through side surface and total overall emission of particles.

Proton emission amounts for a few percent of secondary neutron flux.

Conclusions. Prediction of two independent computer simulation codes (DCM and MCNP-X) are compared regarding spectra and multiplicities in secondary neutron and proton fluxes emitted from side and overall surface of the lead target. Comparison shows more or less reasonable agreement for protons, however, approximately 50.

References

[1] 1. A.A. Polanski, A.N. Sosnin. Monte-Carlo Modeling on Secondary Neutron and Proton Fluxes from the Surface of Subcritical Assemblies under Irradiation with High Energy Proton Beams, Transport Theory and Statistical Analysis, 2008, 37; pp. 576-588.

[2] Seltborg P., Polanski A, Petrochenkov S., Lopatkin A, Gudowski W. Radiation Shielding of High Energy Neutron in SAD, NIM A, 2005, 550, pp.313-328. Sosnin A.N. et al. Monte Carlo Modeling of Neutron Spectra in the U/Pb Assembly Irradiated with Protons. Proceedings of the 52 Workshop on Nuclear Psectroscopy and Structure of Atomic Nucleus, September 3-8, 2001, Sarov, Russia. Proceedings of the Russian Academy of Sisences, Series Physics, 2002, 66; pp. 1494-1496.