

AbstractID: 10087 Title: Effect of hadronic process differences on fluence distributions of particles generated from proton interactions in tissues - A GEANT4 Monte Carlo simulation

Introduction: Clinical proton beam (up to 250 MeV) is currently being used by many institutions for cancer treatment. Monte Carlo simulations using both electromagnetic interactions (EMI) and hadronic interactions (HI) are being performed to accurately determine the target dose as well as the secondary radiation for radiation protection issues. The CERN developed Monte Carlo code GEANT4 toolkit (version 4.8.3) utilizes recent physics models based on theory and experimental data. The EMI covers proton's energy loss and straggling with atomic electrons and multiple scattering with atomic nuclei; where as the HI covers proton's elastic, inelastic scattering, and nuclear interactions with the atomic nuclei in the medium. The objective of the present study has been to simulate the interaction of 250 MeV proton beam in a cylindrical phantom using GEANT4 in order to determine the yield and the angular distributions of generated proton, neutron and photon. Different sets of HI processes were used in this study.

Materials and Methods: A cylindrical phantom (length=42 cm, diameter= 42 cm) was placed in vacuum. The material was selected as ICRU 4-element soft-tissue to mimic human body. A spherical scoring geometry surrounding the phantom with radius = 100 cm was implemented. The number of generated proton, neutron, and photon crossing this scoring geometry was counted in 18 theta bins (ten degree each). The modular of physics list consisted of four parts: (a) electromagnetic; (b) elastic scattering; (c) inelastic scattering for proton and neutron; and (d) inelastic scattering for heavy ions. The following three HI nuclear inelastic processes for proton (1) low-energy parameterized nuclear inelastic; (2) binary cascade (3) pre-compound (below 170 MeV) with a Bertini cascade (above 150 MeV) were studied. Common to all the three processes above were standard electromagnetic for gamma, electron and positron; low-energy parameterized electromagnetic for proton and ions; low-energy parameterized nuclear elastic scattering (G4LElastic) for proton and ions; and low energy parameterized inelastic for ions. The elastic and inelastic processes for neutrons with energy higher than 4 eV were computed using high precision neutron model (G4NeutronHPorLEModel). At thermal neutron energies, atomic translational motion and vibration and rotation of the chemically bound atoms affect the neutron scattering cross section and the energy and angular distribution of secondary neutrons. The thermal neutron scattering cross section data (G4NeutronHPThermalScatteringData available in library G4NDL3.1) was plugged for computation when neutron energy is lower than 4 eV.

Results: The total number of generated proton, neutron and photon per incident proton, as a function of three hadronic processes are shown in Table 1. Normalized fluence angular distributions for proton, neutron and photon are shown in figure 1, 2, 3 respectively.

Conclusions: Our results show that the careful selection of hadronic process plays a critical role for secondary particle generation. To ensure radiation safety for personal, patients and public, Monte Carlo simulations are needed for extensive shielding studies.

Table.1. The total number of generated proton (p), neutron (n) and photon (γ) per incident proton for different hadronic processes

Hadronic Processes		Yield/incident proton		
		p	n	γ
Process (1)	LE inelastic	0.0059	0.389	0.39
Process (2)	Binary cascade	0.0027	0.208	0.57
Process (3)	Pre-compound + Bertini cascade	0.0023	0.158	0.72

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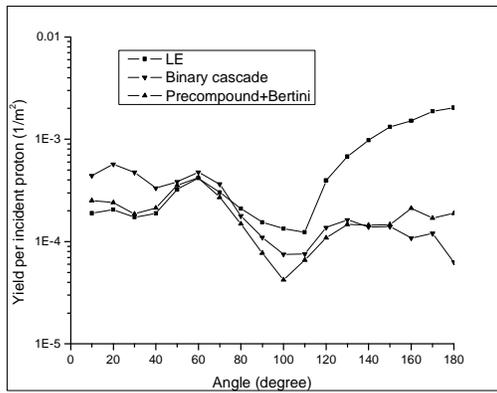


Figure.1. Angular distributions of protons for different hadronic processes

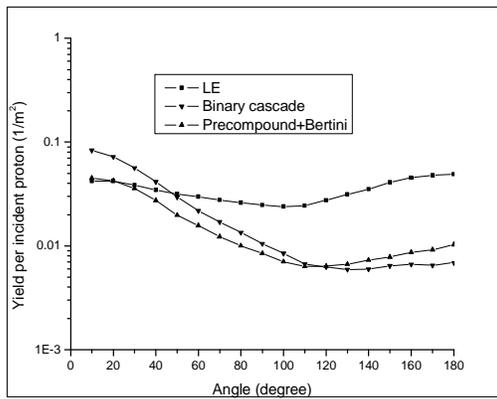


Figure.2. Angular distributions of neutrons for different hadronic processes

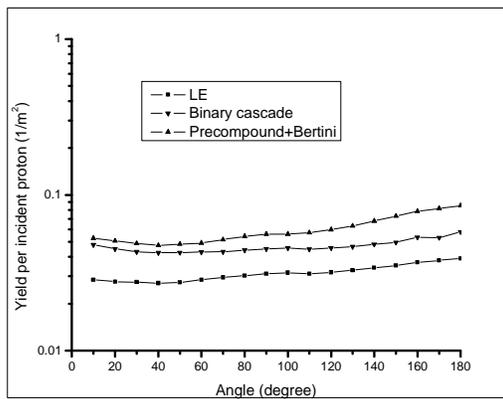


Figure.3. Angular distribution for photon for different hadronic processes