Contribution ID: **128** Type: **Parallel Sessions**

Simulation of Polarized Electron Interactions with Matter in the MeV Energy Range

Thursday, 13 September 2018 15:30 (20 minutes)

The effects of multiple interactions of electrons passing through matter cannot be calculated analytically, thus simulation tools have to be used to reliably model polarimetric measurements. A new method for simulation of polarized electron interactions, based on the commonly used Geant4 Monte Carlo package, will be presented.

In case of polarized electron beams in the MeV energy range, three main processes (listed in the order of importance) have to be considered: (i) Mott scattering (electron-nucleus), (ii) Møller scattering / ionization (electron scattering off atomic electrons) and (iii) bremsstrahlung emission. The Geant4 package includes models of Møller scattering and bremsstrahlung, that take into account electron polarization. However, polarization effects are not accounted for in the description of Mott scattering.

Therefore, a new model of Mott scattering for electrons, that can be used with Geant4 instead of the default description, has been created. The implementation uses scattering amplitudes from the ELSEPA package, which is a source of data for NIST reference database.

Reliability of the simulation has been proven by comparison with experimental data regarding the azimuthal asymmetry (effective Sherman function) in Mott scattering of polarized electron beams. Promising agreement with available data was found.

Presented results encourage the use of this code to obtain predictions for polarimetry in kinematical regions and conditions (energy, scattering angle, target material and thickness) where no measurements exist. Its usefulness is of particular value at the design stage of a polarimetric measurement. A comprehensive optimization of a measurement based on experimental studies would require collecting a large amount of data (e.g., the effective Sherman function has a complicated dependence on several parameters), which is no longer necessary provided a reliable simulation code.

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Session Classification: Acceleration, Storage and Polarimetry of Polarized Beams

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