Contribution ID: **230** Type: **Poster**

Monte Carlo Simulation Studies for the BRAND Experiment

The Standard Model (SM) of electroweak interactions relies on key assumptions, such as the vector and axial-vector nature of the weak force, parity violation, and the masslessness of neutrinos, which were initially inferred from neutron beta decay. Nowadays, precision experiments with slow neutrons are involved in searches of physics beyond SM (BSM). The BRAND experiment is one of them. It aims to measure eleven neutron beta decay correlation coefficients simultaneously, with seven of them—H, L, N, R, S, U, and V—being accessible through the transverse polarization of scattered electrons which will be measured using Mott-scattering. Beta decay events of polarized cold neutrons will be identified through the reconstruction of the three-body kinematics.

The current experimental setup for BRAND-II consists of two main components: the electron detection system (EDS) and the proton detection system (PDS). The EDS includes a Mott polarimeter equipped with plastic scintillators for measuring energy and a low-mass multiwire gas chamber for accessing their tracks. The PDS consists of an accelerating electric field, a proton-electron converter, and scintillation detectors for measuring proton time-of-flight and hit position. A Geant4-based Monte Carlo model of the setup has been developed for simulation studies of critical aspects of the experiment.

Very few experimental studies have focused on polarized electrons with energies below 1 MeV. Therefore, extensive Monte Carlo simulations are necessary in order to optimize the experimental setup. This work presents preliminary Monte Carlo results for Mott scattering, focusing on optimizing the target thickness and evaluating the detector setup's figure of merit for BRAND-II. Depolarization effects from multiple and plural scattering as the dominating destructive effects are examined. Additionally, the sensitivity of selected correlation coefficients is studied using energy and geometric cuts imposed by Mott polarimeter geometry using Monte Carlo simulations.

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Session Classification: Poster session

Track Classification: Fundamental Symmetries and Interactions