Contribution ID: **34** Type: **Poster**

Validation of the Geant4-based Calorimeter Acceptance Model in Fermilab Muon g-2 Experiment

Saturday 20 April 2024 16:40 (5 minutes)

In the Fermilab Muon g-2 experiment, the anomalous precession frequency of the muon was extracted from calorimeter data that recorded the energy and time spectrum of the positrons. The probability of a calorimeter detecting a positron from muon decay exhibits spatial and energy dependence, as well as variations due to the materials in the vicinity of the calorimeter. Coupled with muon beam dynamics, this acceptance effect introduces systematic shifts in the calorimeter time spectrum. These related systematic effects have been studied with a Geant4-based model of calorimeter acceptance, which has raised concerns regarding its validity. We generate a muon beam distribution from a Geant4-based simulation of muon beam motion, augmented with a synthetic data approach. Combining with the acceptance model of the calorimeters, the simulated time spectra of the detected positrons $N(t)_{sim}$ at the calorimeters were calculated and compared with the $N(t)$ of the positrons obtained from experiment data. The behavior of $N(t)_{sim}$ was found to agree with the experiment at an average level. Ongoing investigations are underway to delve deeper into these results and elucidate any underlying implications.

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Session Classification: Poster (For two days)