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Improved muon decay simulation with Geant4 and McMule

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The search for signals beyond the Standard Model can be pursued through precision measurements of flavour-changing processes, such as muon decays. In this regard, the MEG II experiment at PSI searches for the $\mu \to e\gamma$ decay with a sensitivity of $6 \cdot 10^{-14}$ at 90% of confidence level. Furthermore, the MEG II apparatus appears to be competitive in searching for more exotic processes, in which the lepton flavour violation is mediated by an invisible axion-like particle X. The experimental search for such an elusive signal requires an exhaustive Monte Carlo simulation, including extremely accurate theoretical predictions for the event generation.

We present an improved simulation of muon decays, both in the Standard Model and beyond, implemented in the Geant4 framework of MEG II.

The event generation is based on McMule, acronym of Monte Carlo for MUons and other LEptons. McMule is a novel numerical tool for the fully-differential computation of higher-order radiative corrections for low-energy processes involving leptons. The code features the most accurate theoretical predictions ever made for polarised muon decays and notably achieves a precision of 10^{-6} on the $\mu \to e\nu\bar{\nu}$ energy spectrum.

Such predictions, specifically developed for this project, are used as theoretical input to the Geant4 simulation of the MEG II detectors. The new implementation is tested by studying the reconstruction of $\mu \to e\nu\bar{\nu}$, $\mu \to e\gamma$ and $\mu \to eX$ events in the MEG II positron spectrometer.

The analysis shows that the new simulation has a noticeable impact on experimental observables and is therefore required for an experiment such as MEG II, featuring state-of-art detectors for precision studies of low-energy leptons.

Collaboration

MEG II

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