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Deferred Optical Photon simulation for the JUNO experiment

The Jiangmen Underground Neutrino Observatory (JUNO) is designed to determine the neutrino mass ordering and precisely measure oscillation parameters. It is under construction at a depth of 700˜m underground and comprises a central detector, water Cherenkov detector and top tracker. The central detector is designed to detect anti-neutrinos with an energy resolution of 3\% at 1˜MeV, using a 20 kt liquid scintillator target with 17,612 20-inch PMTs and 25,600 3-inch PMTs. The scintillator provides a light yield of approximately 10,000 photons per MeV. Monte Carlo simulation is a crucial tool for developing an understanding of detector performance, requiring the production of large samples of background processes with optical photons. Simulation of large numbers of optical photons with Geant4 is computationally challenging for both processing time and memory resources. In order to optimize resource usage a deferred optical photon simulation workflow is proposed and implemented using Geant4 classes. The key idea is to simulate events initially without optical photons, only performing the optical photon simulation when user specified criteria are met.

In this contribution, the design and the implementation of the deferred optical photon simulation will be presented. Optical simulation comprises generation of photons and propagation through the detector implementing optical physics processes including reflection, refraction, scattering and absorption. Instead of generating the optical photons at each step by Geant4 immediately, the necessary data to generate optical photons at each step are collected, which is termed {\tt GenStep}. At the end of each event user specified criteria determines if the optical photon simulation is performed using a class called {\tt G4OPSimulator}. The class {\tt G4OPSimulator} implements a customized simulation workflow, based on Geant4 internal classes including {\tt G4TrackingManager} and {\tt G4StackManager}. The simulator passes references to the collected {\tt GenStep} objects to customized Scintillation and Cherenkov processes which generate the optical photons in {\tt G4Track} objects. As a track could be absorbed and re-emitted, the secondaries will be retrieved from the {\tt G4TrackingManager} and pushed to the {\tt G4StackManager}. The performance of the simulator will be presented. The technique of deferred optical photon simulation can be applied to all event types and it is expected to be particularly beneficial with rare processes. Especially the events must be selected during the detector simulation at runtime, instead of the event generation. An application of the technique to the simulation of such events will be shown.

Significance

References

Speaker time zone

Compatible with Asia

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