

Simulating scintillation light transport in a ton-scale LXe detector

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Accurate modelling of scintillation light transport is critical for the design, calibration, and reconstruction performance of ton-scale liquid xenon detectors. Current optical simulations tools based on CPU-driven Geant4 workflows are often slow to iterate on, with substantial start-up overhead, and quickly become computationally intractable with high statistics requirements.

We present a GPU-accelerated optical photon simulation toolkit developed for large LXe detectors, built on the open-source Chroma ray-tracing framework. Detector geometries are imported directly from CAD via STL files, with photosensor definitions and optical material properties configured through YAML inputs. The framework supports a range of relevant photon sources, including lasers, diodes, Cherenkov emitters, and scintillation photon generation using NEST, and can optionally ingest track information from Geant4 for detailed reconstruction studies. We further include a Monte Carlo-based SiPM response model incorporating correlated noise effects and a two-dimensional SiPM photon detection efficiency model benchmarked against measurements in liquid xenon and vacuum. We show current performance and applications, and discuss plans to release the toolkit as an open-source resource for the community, enabling rapid startup simulations and the generation of high-statistics light maps for fast simulation response models.

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