DOME: Discrete oriented muon emission in GEANT4 simulations

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Abstract

Amongst various applications that experience a multi-directional particle source is the muon scattering tomography where a number of horizontal detectors of a limited angular acceptance conventionally track the cosmic-ray muons. In this study, we exhibit an elementary strategy that might be at disposal in diverse computational applications in the GEANT4 simulations with the purpose of hemispherical particle sources. To further detail, we initially generate random points on a spherical surface for a sphere of a practical radius by employing Gaussian distributions for the three components of the Cartesian coordinates, thereby obtaining a generating surface for the initial positions of the corresponding particles. Since we do not require the half bottom part of the produced spherical surface for our tomographic applications, we take the absolute value of the vertical component in the Cartesian coordinates by leading to a half-spherical shell, which is traditionally called a hemisphere. Last but not least, we direct the generated particles into the target material to be irradiated by favoring a selective momentum direction that is based on the vector construction between the random point on the hemispherical surface and the origin of the target material, hereby optimizing the particle loss through the source biasing. We also show a second scheme where the coordinate transformation is performed between the spherical coordinates and the Cartesian coordinates, and the above-mentioned procedure is applied to orient the generated muons towards the target material. In the end, a recipe hinged on the restrictive planes from our previous study is furthermore provided, and we incorporate our strategies by using G4ParticleGun in the GEANT4 code. While we plan to exert our strategy in the computational practices for muon scattering tomography, these source schemes might find its straightforward applications in different neighboring fields including but not limited to atmospheric sciences, space engineering, and astrophysics where a 3D particle source is a necessity for the modeling goals.