Muography background sources: simulation, characterization, and machine-learning rejection.

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Muography scans large-size objects, natural or anthropic, by detecting atmospheric muon flux after crossing these buildings. Muography suffers an overwhelming background noise because of the weakness of the emerging muon flux from scanned objects. The background noise sources are scattered muons, electromagnetic particles of Extensive Air Showers (EAS), inverse trajectory particles, and particles arriving simultaneously.

We carried out a muography background analysis using Monte Carlo simulations (CORSIKA-GEANT4) and data recorded by MuTe (a hybrid Muon Telescope composed of a scintillator hodoscope and a water Cherenkov detector). We estimated the scattered muon energy-angular spectra and the EAS components impinging the MuTe. We quantified the muography background using measurements of the Time-of-Flight and deposited energy of particles.

We found that the spectrum of particles impinging on MuTe is mainly composed of muons (~3 GeV/c average) and electromagnetic particles (~20 MeV/c average). The scattering probability of muons increases inversely with the energy and relative incidence angle concerning the object surface. For muons with momentum smaller 1 GeV/c, the scattering angle is above 1 degree. Backward impinging particles represent up to 22% of the flux and depend on their elevation angle. Additionally, two processes cause multiple particle background. Independent particles from the atmospheric radiation background and correlated particles (mainly a muon pair) originated in the same EAS, with relative arriving times larger 300 ns and smaller 100 ns, respectively. This study offers a better understanding of background sources in muography and proposes machine learning methods to filter them.