



Contribution ID : 110

Type : **Poster**

Study of the Spatial Distribution of Atmospheric Muons: FANSY Simulations and Results from the Underground LVD experiment

Tuesday, 27 October 2026 19:25 (5)

The decoherence curve of muon bundles in extensive air showers is investigated in this work using the FANSY 2.0 package. Using the Monte Carlo method, the development of cascades in the atmosphere is simulated for different types of primary particles (protons and iron nuclei), a wide range of initial energies and zenith angles. The dependence of the spatial distribution of muons at the detector location on the characteristics of the primary cosmic radiation and the shower arrival angle is analyzed. It is shown how variations in the composition, energy, and direction of the primary particle affect the degree of muon-group decoherence and the shape of the distributions. Accounting for muon scattering in the overburden enables comparison of the simulation results with the decoherence curve measured in the LVD experiment (Gran Sasso, Italy). The obtained results allow a refined interpretation of data from underground experiments and an assessment of the sensitivity of the decoherence curve to parameters of the primary cosmic-ray flux.

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Session Classification : Poster session

Track Classification : Astroparticle physics