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Cosmic muon flux measurements from mid-latitude to Antarctica with a novel nested plastic scintillator detector

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We present cosmic muon flux measurements performed across two geomagnetically distinct environments with a novel concentric double-layer plastic scintillator telescope, developed and produced entirely in-house. The detector employs a nested geometry in which a cylindrical active core is coaxially enclosed by a cup-shaped outer scintillator, so that coincidence between the two optically isolated volumes provides active background rejection and wide-angle acceptance within a portable, two-channel package. Both volumes were cast from a custom epoxy-resin matrix doped with PPO and POPOP, a liquid-phase route that removes the need for geometry-specific glass moulds and permits complex shapes such as the outer cup, which would be difficult and costly to machine from commercial scintillator blocks. GEANT4 simulations give a geometric factor of $60.6 \text{ cm}^2\text{sr}$, in agreement with the Sullivan analytical prediction to within 2% and approximately three times that of a conventional flat two-panel telescope built from the same detector diameters. The nested geometry exhibits no hard angular cut-off, and its coincidence efficiency is flat from 50 MeV to 50 GeV, so that soft muons below 1 GeV/c are registered without loss.

The system was deployed during the 10th Turkish Antarctic Expedition, with measurements taken at a mid-latitude baseline in Istanbul and at Horseshoe Island, Antarctica. After barometric correction the Antarctic flux exceeds the Istanbul baseline by approximately 41%, consistent with the reduced geomagnetic cut-off rigidity at polar latitudes and with an appreciable soft-component response, the latter independently supported by a barometric coefficient ratio of about 3.3 between the two sites. A Forbush decrease was also recorded in Istanbul, coinciding with a $K_p \approx 8$ geomagnetic storm driven by a coronal mass ejection and corroborated by simultaneous neutron monitor data. Pre- and post-expedition fluxes agree within statistical uncertainty, indicating that intercontinental transport did not affect the detector response.

The talk additionally reports on the wider scintillator development programme from which this instrument emerged: the optical and scintillation characterisation of the epoxy-resin material against commercial scintillators, laboratory results on formulations engineered for pulse-shape discrimination including lithium-tetraborate nanoparticle loading for thermal-neutron sensitivity, and a Monte Carlo feasibility study of opaque plastic scintillators for muon tomography.

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