



Contribution ID: 922

Type: **Talk**

Probing the Cosmic-Ray Proton Fraction with Cosmogenic Multi-PeV Neutrinos and Gamma-rays Constraints

Monday 21 July 2025 17:20 (15 minutes)

The recent detection of a multi-PeV neutrino event by KM3NeT/ARCA opens a new window into the origins of ultra-high-energy cosmic rays (UHECRs). We revise the possibility of a cosmogenic origin for this event while considering constraints from the diffuse extragalactic gamma-ray background (EGRB) observed by Fermi-LAT and the non-detection of ultra-high-energy (UHE) photons ($\sim 10^{19}$ EeV) by Auger.

We find that cosmogenic cascade photons may impose even stronger constraints on the allowed proton fraction of UHECRs than neutrinos, depending on the redshift evolution of cosmic accelerators. Additionally, we examine limits on the proton fraction at energies E

$\sim 10^{19}$ eV, informed by the inferred cosmogenic neutrino flux from the new KM3NeT detection and the absence of neutrinos above a few PeV in Auger and IceCube data. These results take on particular importance in light of upcoming observations by AugerPrime, which will directly probe UHECR composition and provide key insights into the luminosity and evolution of cosmic-ray sources across cosmic time.

Collaboration(s)

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Session Classification: CRI

Track Classification: Cosmic-Ray Indirect