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A Universal Mapping Between Proton-Air Interaction Variables and Air Shower Observables: Depth of Shower Maximum and Muon Content

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We introduce a set of new multiparticle production variables derived from the energy spectrum of secondary hadrons in ultra-high-energy proton-air interactions. The distributions of these variables can be measured within the phase space accessible to particle detectors in accelerator experiments and are highly dependent on the hadronic interaction model. Furthermore, we demonstrate a precise, hadronic-model-independent mapping between these variables and the joint distribution of the depth of shower maxima and the number of muons in extensive air showers. This enables the use of air shower measurements to constrain hadron production in kinematic regimes beyond the reach of human-made colliders.

Collaboration(s)

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