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High-energy photonuclear reactions contribution to the ground-level muon content of extensive air showers

In the extensive air showers (EASs), photonuclear reactions transfer energy from the electromagnetic to the hadronic cascade and thus contribute to the muon production rate. However, the high-energy (center-of-momentum frame energy > 100 GeV) photonuclear cross-section is poorly constrained by laboratory experiments. This implies a systematic uncertainty in the Monte-Carlo (MC) simulations of EASs. In this work, we develop a simple analytic approach to estimate this uncertainty over a vast range of high-energy photonuclear cross-section models. We derive a parametric formula that estimates the expected number of muons at the ground level as a functional of the assumed photonuclear cross-section. We fit the parameters using MC simulations and discuss the physical implications in the context of the so-called 'muon puzzle'.

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