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

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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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