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Interference of extraterrestrial particle accelerators and accelerators operated in the terrestrial atmosphere

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Different kinds of particle accelerators are operating in the intergalactic plasmas filling the space with high-energy hadrons and gamma rays, which reach the earth's atmosphere and unleash extensive air showers (EASs) consisting of millions and billions of elementary particles covering several km2 on the ground. During thunderstorms, emerging strong electric fields modulate the EAS particles significantly altering their energy spectra. When researching the operation of the electron accelerators in the thunderclouds the ambient population of the cosmic rays from the small and large EASs constitutes a background during measurements of the particle enhancements (so-called thunderstorm ground enhancements –TGEs) from the electromagnetic avalanches reaching the earth's surface. Thus, both processes are interconnecting and measured energy spectra of EAS and TGE particles should be disentangled carefully.
A major challenge of EAS experiments is the energy scale calibration. The shower size (Ne) is rather well correlated with the energy of the primary particle. However, the particle type identification and large fluctuations of first interaction depth (shower size) smear the E-Ne relation. Additional difficulty poses possible biases due to emerging atmospheric electric fields. In the presented report, we will discuss how the emerging electric fields can introduce a bias in the energy estimation made by one square kilometer array of scintillator detectors and muon detectors of the Large High-Altitude Air Shower Observatory (LHAASO). Due to the large surface of detectors and high location, LHASSO has a very low energy threshold (1 TeV) and excellent rejection of hadron-induced extensive air showers (reaching 10-5 at PeV energies). We select the LHASSO array not only because recently they identified 12 PeVatron candidates, which have been previously observed by imaging atmospheric Cherenkov telescopes. LHAASO site locates at Haizi Mountain, Daocheng County, Sichuan Province, which is the edge of Tibetan Plateau with an altitude up to 4410 m.
The Tibetan plateau is also known as a place of frequent thunderstorms and a very large intracloud electric field, that vertical profile can extend to 1-2 km. We perform simulations of gamma ray transport in the thunderous atmosphere above the LHASSO array and obtain possible biases in the energy estimation (we use a very simple estimator based on shower size Ne only). For the low primary energies (1 TeV) the bias was tenfold and more, for the higher primary energies (1 PeV) 2-3 times. We demonstrate as well the threshold effect of intracloud electric field for starting a runaway process, that exponentially multiplied the free electrons entering a strong atmospheric electric field.

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