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Revealing the journey of cosmic rays with petaelectronvolt energies through the observation of sub-PeV gamma rays by the upcoming experiment ALPACA

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The ALPACA experiment is an international project between Bolivia, Mexico, and Japan, the prototype of which started data-taking in Bolivia in September 2022. One of the motivations of the experiment is to explore the southern sky in the sub-PeV (E > 10^14 eV) gamma-ray sky to locate astrophysical accelerators of Galactic cosmic rays in the PeV (E > 10^15 eV) range, so-called PeVatrons. The experiment has two types of detectors: a surface air shower array consisting of scintillation detectors which reconstruct the energies and directions of gamma rays by observing extensive air showers, and an underground water-Cherenkov-type muon detector array which effectively discriminates between gamma rays and background cosmic rays. In addition to the principal motivation of the PeVatron search, transient gamma-ray sources such as gamma-ray bursts (GRBs) should be interesting targets to be observed by the experiment taking advantage of its wide field of view and high duty cycle. Gamma rays of several hundreds of GeV to multi-TeV energies can be detected by densely arranging the scintillation detectors covering the surface over several thousand square meters above one of the muon detectors. The lower-energy extension of observation would help improve our understanding of prompt and afterglow emission from GRBs, some of which could be closely related to the merger of neutron stars synthesizing heavy elements through the r-process. The presentation gives a design of such a dense air shower array, which should be called the ALPACA high-density array, and a simulation-based study of its performance for GRBs.

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