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Performance Studies of Layered Water Cherenkov Detectors

Next-generation air-shower detectors, such as the Global Cosmic Ray Observatory (GCOS) and the Probing Extreme PeVatron Sources (PEPS) experiment, will face many challenges in terms of detector design and construction. A key factor in improving the sensitivity to ultra-high energy gamma rays and to the mass composition of ultra-high energy cosmic rays is the ability to measure the muonic content of air showers. To address this, a layered water Cherenkov tank design has been proposed. The water volume of the tank is divided into two optically separated layers. The electromagnetic component of the shower is mostly absorbed in the top layer, while the bottom layer records the light produced by through-going muons. Two prototype tanks were deployed at the Pierre Auger Observatory site in 2014 and have been recording data for more than 10 years. We present the performance of the prototype tanks and compare it with simulations. Furthermore, different dimensions for the optical volumes are investigated to study the reconstruction performance of muonic and electromagnetic components of air showers. The detector geometry is kept as compact as possible to account for realistic design constraints. Finally, the number and spacing of detectors needed for a full trigger efficiency above 10 EeV, as required for GCOS, are assessed.

Collaboration(s)

Authors: FLAGGS, Benjamin (Bartol Research Institute, University of Delaware); MARIS, Ioana (Université Libre de Bruxelles); PARENTI, Andrea (Université Libre de Bruxelles)

Presenter: PARENTI, Andrea (Université Libre de Bruxelles)

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