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Use of small photomultiplier tube to extend dynamic range of Pierre Auger Observatory surface detector

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The surface detector of the Pierre Auger Observatory consists of 1660 water-Cherenkov detectors (WCD). When detecting extensive air showers with energy larger than 3 x 10ˆ19 eV is present a saturation for at least the detector closer to the shower core. In this work we present an analysis of the performance of the engineering array which consists of ten WCD with a fourth photomultiplier tube with a small photocathode area. We verified that during the analisis period the photomultiplier tubes presented a very robust and stable behaviour. The calibration of the small photomultiplier tubes was performed so that their signals can be converted from hardware units to a physical unit which reflects the particle density that crossed the station, such unit is the VEM (vertical equivalent muon) defined as the average charge registered in the standard photomultiplier tubes when a vertical central-going muon cross a station. A dependency of the calibration with long-term variations of temperature was discovered. Finally, we showed that the implementation of a small photomultiplier tube in a station extends its dynamic range by a factor of 25 times.

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