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Extension of the dynamic range of large photocathode PMTs for a UHECR detector

Ground arrays for UHECR shower detection based on traditional counters, water Cherenkov tanks or scintillator modules, are unavoidably limited by the saturation suffered by the counters nearest to the shower axis and exposed to the largest particle density. The incomplete response from these detectors hampers the knowledge of the shower development near the shower core, limiting the accuracy in the reconstruction of the lateral density distribution and increasing the uncertainty on the energy estimation. Reducing to a negligible level the number of events recorded with one or more saturated counters should be mandatory in a future UHECR ground array.
At the particle density of interest, the detector saturation is directly related to the finite extension of the linear range of the photomultipliers used. In principle, the use of the signals extracted from the internal dynodes, where the number of multiplication electrons is much lower than at the anode and the saturation by the space charge effect strongly reduced, can offer an elegant and inexpensive way to increase the linearity of a PMT.
The viability of this technique has been explored studying a sample of 3 Hamamatsu R5912-mod photomultipliers and their performances. The PMTs were operated and monitored in the INFN-Torino laboratory with the Auger North control station electronic unit, front-end, and LED-based control system developed in the context of the Auger North RDA (Research & Development Array). Exploiting the signal from the fifth dynode, a linear response up to an equivalent anodic peak current larger than 1A (@ <G=2 x 10^5 >)$has been measured for all the studied PMTs. The feasibility of this technique in the context of a new ground array for UHECR studies has to be verified with a much larger sample$

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