



Contribution ID: 31

Type: **Talk**

Prototyping of Large-Size SiPM Based Detector Modules in IACTs

Tuesday, 12 June 2018 12:15 (20 minutes)

MAGIC is a system of two imaging atmospheric Cherenkov telescopes (IACTs) operated by an international collaboration at the Canary island of La Palma. Like all large-size IACTs (>12 m diameter), MAGIC uses imaging cameras consisting of more than a thousand photomultiplier tubes (PMTs). The modular assembly of the camera and the design of its structure offer the possibility to install a maximum of six additional prototype detector modules next to the PMTs, at the vertexes of the hexagonal structure and to operate them in parallel with the camera. We developed three silicon photomultiplier (SiPM) based detector modules using SiPMs from Hamamatsu, SensL and Excelitas. Their purpose is to investigate the potential use of SiPMs in large-size IACTs.

The capacitance of SiPMs limits the size (speed and gain) of the active area of a single sensor. Therefore we use a matrix of up to nine 6×6 mm² SiPMs to achieve an active area comparable to a 1-inch PMT and actively sum the individual signals to a composite output.

The first SiPM prototype was installed in 2015 in one of the open corners in the MAGIC-1 camera. In 2017 two second-generation modules, with improved photon detection efficiency and fill factor, were installed. All three SiPM modules are integrated into the standard data taking procedure, providing data for a performance comparison during real telescope operations.

SiPM detector modules were calibrated using single-photoelectron spectra and the F-factor (excess-noise) calibration method. Artificial light pulses as well as real Cherenkov light from air showers, are used for our performance comparison. Details of the methods will be presented.

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Session Classification: Miscellaneous and Others

Track Classification: Large Scale Characterization and Reliability