JEM-EUSO on ISS explores the origin of the highest energy particles in the Universe

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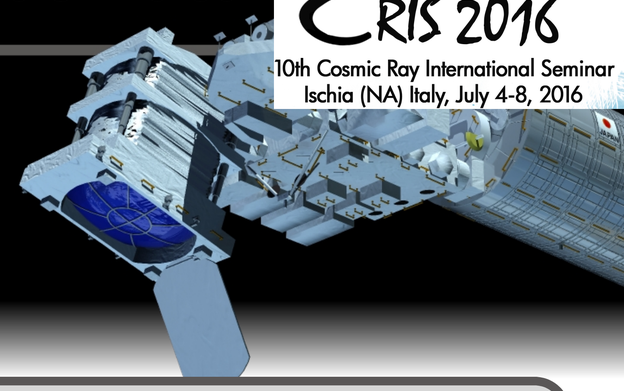


Using two-photon statistical contribution in the detection with telescopes EUSO

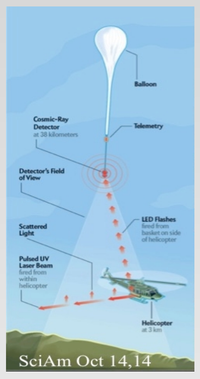
Julio Arturo Rabanal Reina, Sylvie Dagoret-Campagne ,Pierre Barrillon (Laboratoire de l'accélérateur linéaire, IN2P3,CNRS and University Paris-Sud)
E-mail: rabanal@lal.in2p3.fr
Aera Jung, Simon Bacholle, Philippe Gorodetzky, Guillaume Prévôt (APC-Université Diderot, Paris 7)
Sylvie Blin-Bondil OMEGA (Ecole Polytechnique, IN2P3,CNRS)

Abstract

The JEM-EUSO (Extreme Universe Space Observatory on Japanese Experiment Module) experiment is about a space telescope that will be installed on the ISS in 2020. The UHECR study aims to improve by a factor of 10-100 the current measures of Pierre-Auger observatory. The telescope EUSO-Balloon, which was technologically validated in 2014 was the first prototype with the whole chain of detection of telescope JEM-EUSO. This work is about a final study of the performance of the telescope EUSO-Ballon. More specifically, a method for information retrieval pixels with low sensitivity was developed. To achieve this, we use 2-photon contribution on the pulse of an event, as the short-time detection obeys the Poisson distribution. Homogenization of the sensitivity of pixels is critical to trigger algorithms. Also the deterioration of the sensitivity of detection in each channel is inevitable. Thus, this method is useful for recalibration cases, where the sensitivity of one photon's detection decreases dramatically. As the method uses a curve generated by changing the threshold of discrimination of the measure, it is valid for all EUSO telescopes and it will be most useful in the space, where the manipulation of the instrument is limited.

The EUSO - Balloon Mission (Timmins-Ontario, Canada August 2014): This is a telescope formed by two Fresnel's lenses and a PDM (Photo Detector Module).

Its aim was the detection of the background noise UV and the capture of the signal from lighting shots witch was simulating the EAS (Extreme Air Showers) during a flight of 5h. The mission achieved its goals.



Overall description of the UV camera:
The PDM consists of an focal surface (15cm×15cm), made up of an array of 6x6 Multi-Anode-Photomultipliers (MAPMT), each of 64 pixels. The focal surface is covered by UV filter (290-430 NM).

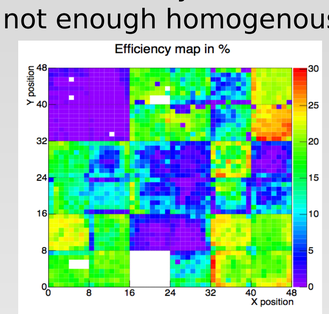
Nine Cockroft-Walton High Voltage (HV) generators.

The 64 anodes of a MAPMT are handled by a single ASIC chip, placed 6 ASIC per boards (called EC-ASICs).

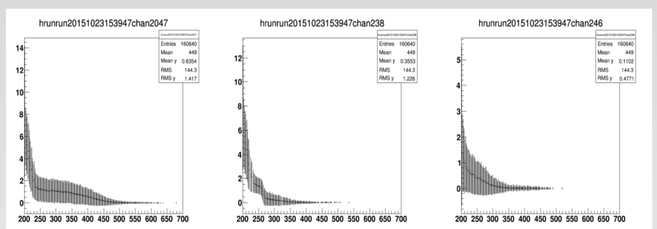
A master FPGA control board named the PDM-board collects the 64x8-bits numbers produced by each of the 36ASICs in a period called a Gate Time Unit (1GTU = 2.5μs).

Efficiency

The efficiency of detection is not enough homogenous



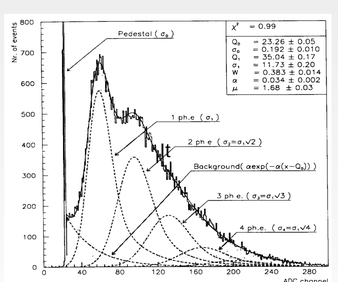
The shape of Scurve gives information about performance of pixels



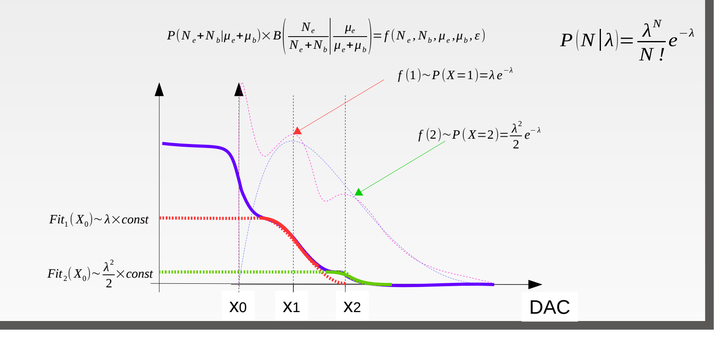
Good pixel (red-green) bad pixel(bleu) bad pixel (magenta)

The signal of two Photons

According to the distribution of Poisson is likely to peak signal is also 2 or 3 pe and this is evident in the load spectrum.

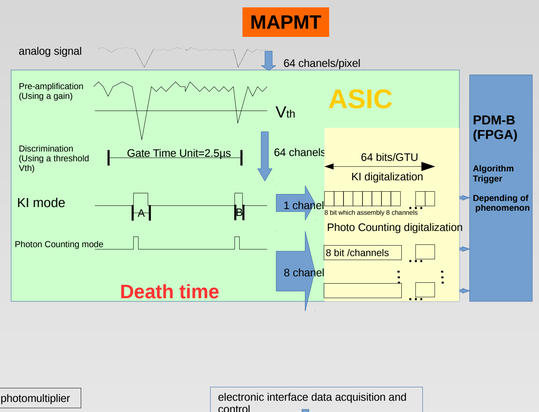


Then it must be possible to observe the contribution of two PE on the S-Curve and rely on an integral of the charge distribution.



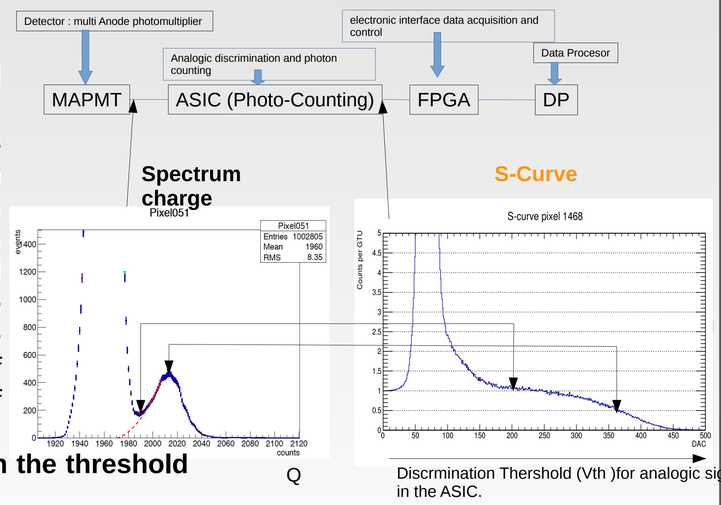
Photodetection

A photon releases an electron on the photocathode for the photoelectric effect. This electron (photoelectron PE) generates an electronic cascade through the dynodos the MAPMT to amplify their electric charge a million times.
This charge is the pulse (2-5ns) signal to be discriminated and counted by the electronic front-end (single photon counting) in periods of 2.5μs and for each pixel.



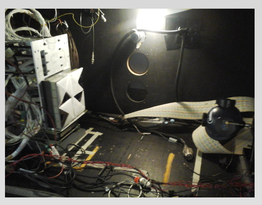
S-Curve

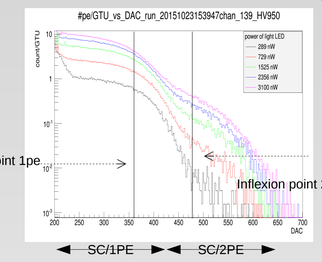
The measure is taken for a fixed discrimination threshold.
However the front-end electronics allows discrimination variation threshold (Vth) for building a curve of probability of detecting a signal peak at different threshold values. This curve is the S-curve and can be interpreted as the integration of the distribution of electric charge of the detection of a photon.
A good measurement is made when the threshold is in the flat Scurve.



Test of the existence of the signal of 2PE

Indeed, the presence of a second hill corresponding to the contribution of 2PE appears in the Scurve.



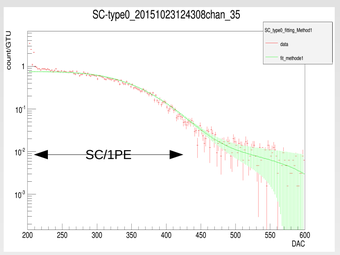


Fitting the Scurve

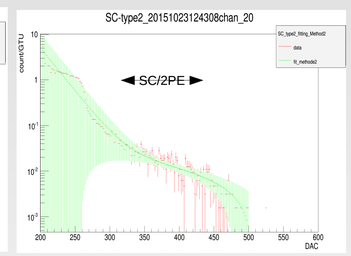
A fit equation is formulated to treat SC precisely determine the 1PE and 2PE flats. After the ratio between accounts corresponding to flats of 1PE and 2PE is evaluated.

The result shows a linear dependence between accounts 1PE and 2PE, for pixels that share the same components chain detection.

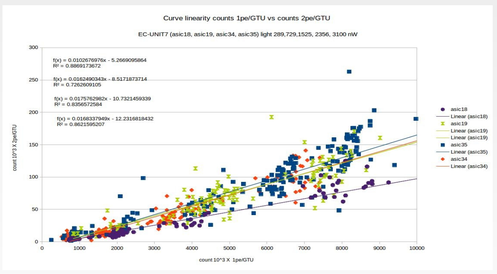
This means that this linearity depends on the instrument and can be used in bad pixels which have 2PE plate and estimate the accounts should have their virtual flat 1PE.



The statistical error derived from the S-Curve fit (green bar) is short in the SC/1pe

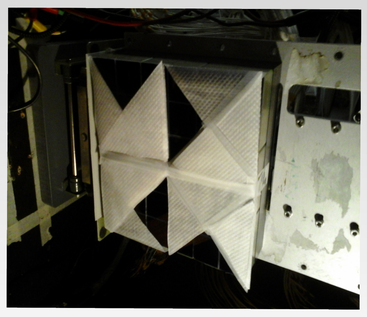


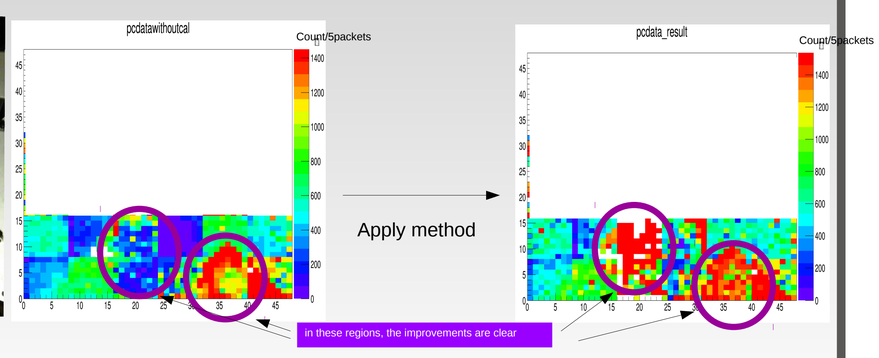
The statistical error derived from the S-Curve fit is small in the flat part of SC/2pe. So the fit is enough for the analysis.



Conclusions and perspectives

This idea of recovering accounts 1PE using those 2PE, it was used in a test in which a mask is added to the detection surface so that the light intensity dims according to the number of layers of mask.
As it is shown in the graph on the left, the recovery method the homogeneity in two regions of low sensitivity. The trigger system is very important in these instruments and depends on a sufficient homogeneity of the effectiveness of detection between pixels.
This method would allow calibrating underperforming pixels and meet the requirement of trigger system especially when the imminent deterioration pixels increase. Especially when the instrument is not accessible in space.





JEM-EUSO collaboration 16 Countries, 93 Institutes, 351 people