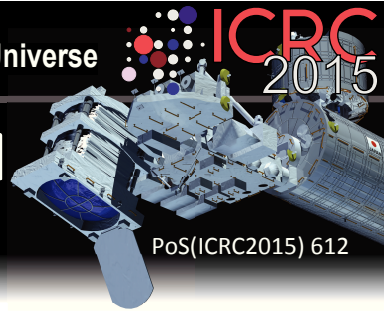
JEM-EUSO on ISS explores the origin of the highest energy particles in the Universe

ICRC 2015

Ground calibration of MAPMT and SiPM

Michael Karus, Francesca Bisconti, Thomas Huber - Karlsruhe Institute of Technology (KIT)
for the JEM-EUSO Collaboration



PoS(ICRC2015) 612

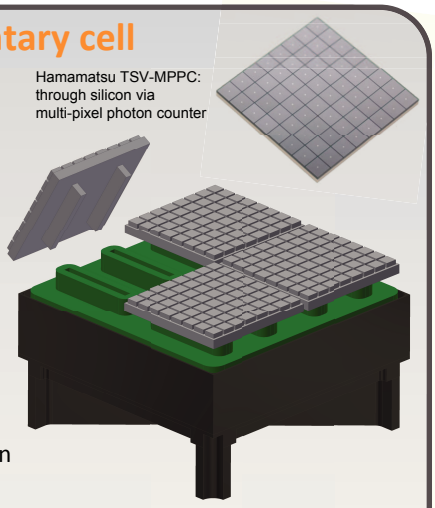
SiPM-based elementary cell

Advantages of using SiPMs

- similar PDE as MAPMTs
- high time resolution
- compact and light structure
- low operation voltage

New 64-pixel TSV-MPPC

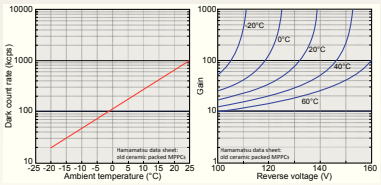
- candidate for a SiPM-based focal surface (FS)
- anode & cathode wired through the substrate
- reduced dead space between two pixels to 0.2 mm
- no Winston cones to increase the active area

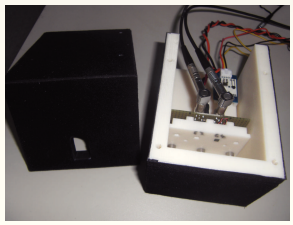


CAD design of a SiPM-based elementary cell prototype with the 64-pixel TSV-MPPC array series from Hamamatsu.

Temperature dependence

- dark count rate & gain strongly depend on temperature
- behavior of TSV-MPPC below 0°C is not well known
- read-out of single pixel TSV-MPPCs with different temperatures
- temperature profiles in a freezer & a cold chamber (down to -60°C)
- prototype read-out board with adjustable bias voltage, amplifiers, fast & integrated read-out in production

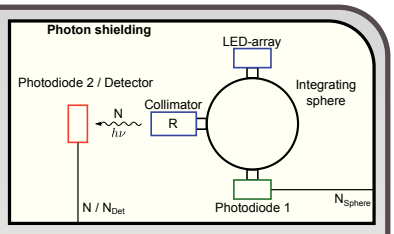


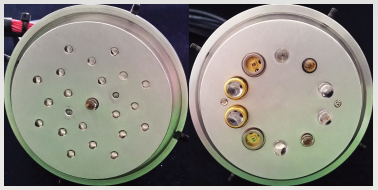


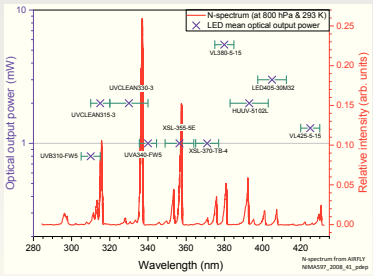
Calibration stand

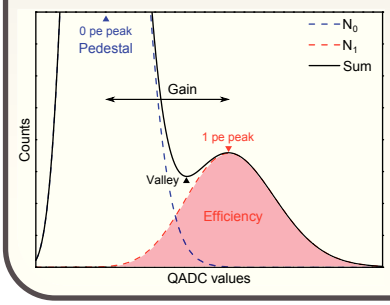
Reference light source

- photon shielding
- integrating sphere
- NIST-calibrated photodiode
- collimator to reduce the light flux to single photons
- LED-arrays for several light levels & wavelengths
- spectral light source for nitrogen fluorescence bands









SiPMs

- single photon mode & dynamic range measurements
- efficiency via pedestals of light & dark spectra
- single channel read-out via Hamamatsu evaluation board & DRS4 evaluation board
- temperature controlled bias voltage

MAPMTs

- single photoelectron spectra for efficiency & gain
- 64 channel multiplexer & 16 channel QADC (25 fC LSB)
- automated scan of single pixels

MAPMTs versus SiPMs for EUSO-TA

Wavelength range issue

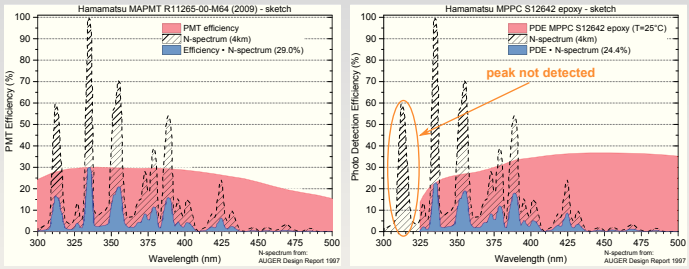
Nitrogen fluorescence spectrum:

- 310-430 nm

Different sensors sensitivity range:

- MAPMT: 280-650 nm
- SiPM: 320-900 nm

First peak of fluorescence spectrum is not detected by SiPMs (absorption of deep UV photons in epoxy surface).



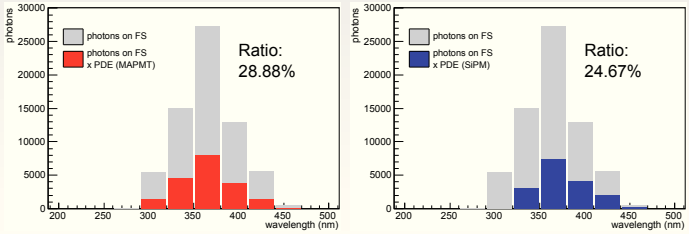
Overlay of the MAPMT (left) and SiPM (right) efficiencies with the nitrogen fluorescence spectrum. The blue area denotes the convolution of the N-spectrum with the sensors efficiencies.

Simulation response of EUSO-TA

Preliminary response of EUSO-TA to a 10^{20} eV EAS in 20 km distance.

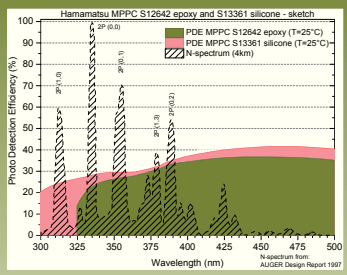
- photons@FS x $PDE_{MAPMT}(\lambda)$ = 28.88%
- photons@FS x $PDE_{SiPM}(\lambda)$ = 24.67%

More photons detected with MAPMTs than with SiPMs (contribution of the first peak is not detected).



Photons arriving at the FS (grey) and fraction of remaining photons after the application of the PDE of MAPMT (red) and SiPM (blue).

New SiPM - wider sensitivity range



Overlay of the current SiPM (green) and new wider sensitivity range SiPM (pink) efficiencies with the nitrogen fluorescence spectrum.

New SiPMs by Hamamatsu coated with silicone instead of epoxy resin.

Wide sensitivity range - first peak of fluorescence spectrum detected.

Probably the SiPMs detection capability will reach or exceed that of MAPMTs.

michael.karus@kit.edu