



Development of the photon detector for a space based observatory of very high energy cosmic rays

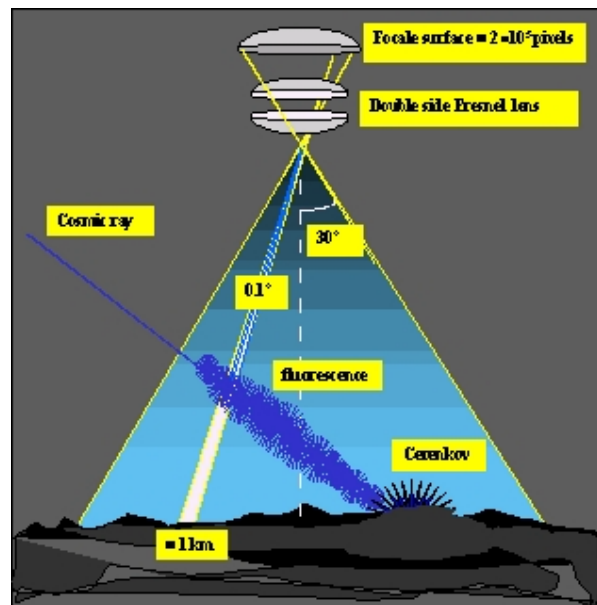
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- ✓ Introduction
- ✓ The focal surface structure
- ✓ The sensors with the optical coupling system
- ✓ The interface electronics (the front end)
- ✓ Conclusions

INTRODUCTION



EUSO optical scheme

- The work is carried on within the INFN R&D activities of the EUSO project
- EUSO (Extreme Universe Space Observatory) is devoted to study EECR and very high energy neutrinos ($E \geq 10^{19}$ Ev)
- It will be installed on the ISS
- The installation is scheduled in late 2008
- It is foreseen a 3 year operational period
- It will look nadir direction from the ISS observing nitrogen fluorescence and Cerenkov diffused light

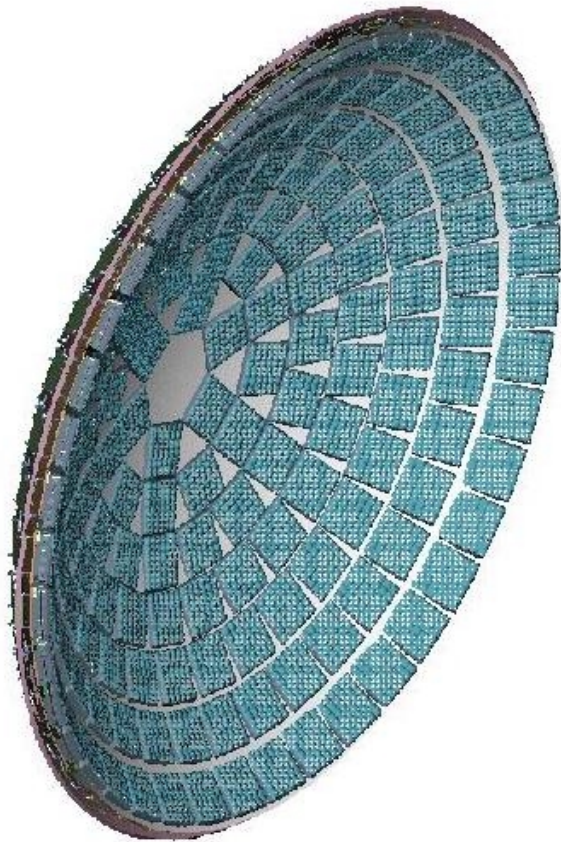


DETECTOR RELATED MAIN PARAMETERS

ISS average orbit height	$H \approx 380 \text{ Km}$
Orbital period	$T \approx 90 \text{ min}$
Observation duty cycle	$\eta \approx 0.1 \div 0.2$
Optics diameter	$D \approx 2.5 \text{ m}$
Optics field of view	$\text{FOV} = \pm 30^\circ$
Pixel size at Ground level	$\Delta \approx 0.8 \text{ Km}$
Number of pixels	$N \approx 200000$
Light wavelength	$330 \text{ nm} \leq \lambda \leq 400 \text{ nm}$
Background	$B \approx 3 \times 10^{11} \text{ ph m}^{-2} \text{ s}^{-1} \text{ str}^{-1}$



FOCAL SURFACE STRUCTURE

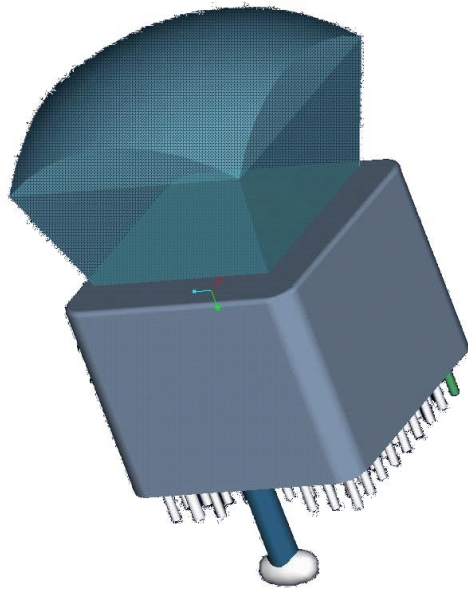


Incoming photons are focalized onto a parabolic surface by means of a double lens system. The structure is realized with a composite material: a sandwich made with carbon fibers glued on an aluminum honeycomb gives high rigidity and light weight.

All the surface is symmetrically covered with elementary independent units: the **macrocells**. All the macrocells have same size: the coverage of the surface is about 85 %.



THE SENSORS



The active element of the detector is the Multi Anode Photomultiplier (MAPMT).

The chosen MAPMT is the Hamamatsu R7600-M64 which has 8×8 anode matrix with 2.3 mm pitch.

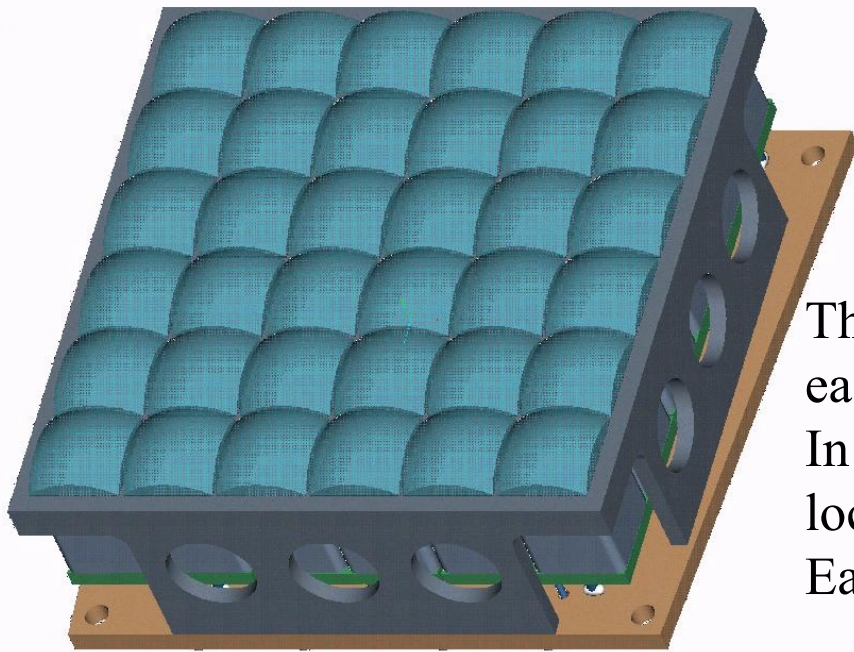
Each pixel is 2×2 mm square, the MAPMT area coverage is about 39 %.

Lens are added to recover dead area in the periphery of the MAPMT.

The HV power supply is kept to the minimum allowed (~ 800 V) to extend the lifetime of the device. The related Gain is about 3×10^5 .

The MAPMT is used in single photon counting mode.

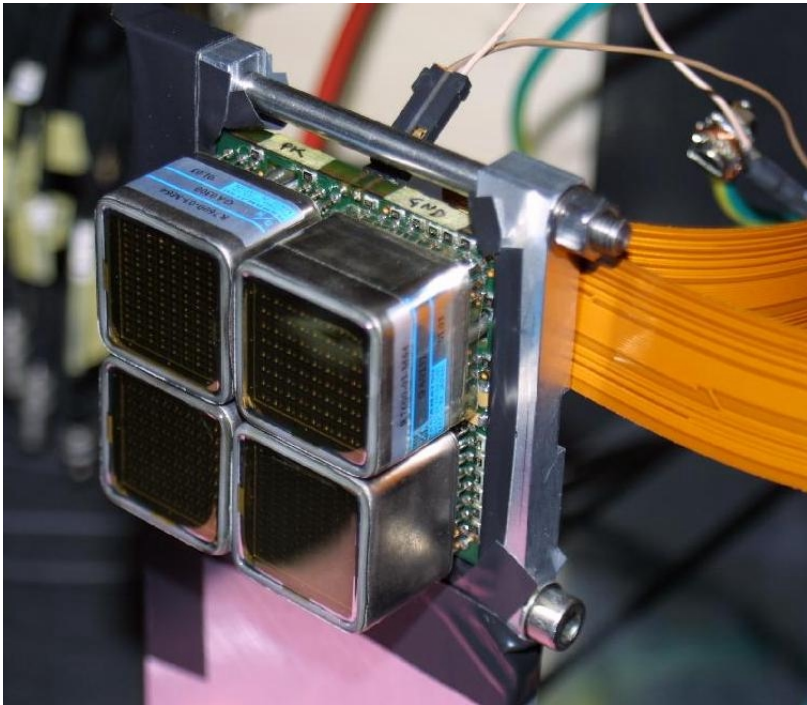
FOCAL SURFACE BASE ELEMENT: THE MACROCELL



The macrocell houses 9 **microcells**, each one has 4 MAPMTs on it. In the back side (not seen) there is the local read-out logic and power supply system. Each macrocell is independent from the others.

The macrocell mechanical structure also support all the lenses used to focalize the image onto the photocathode sensitive area.

FOCAL SURFACE BASE ELEMENT: THE MICROCELL



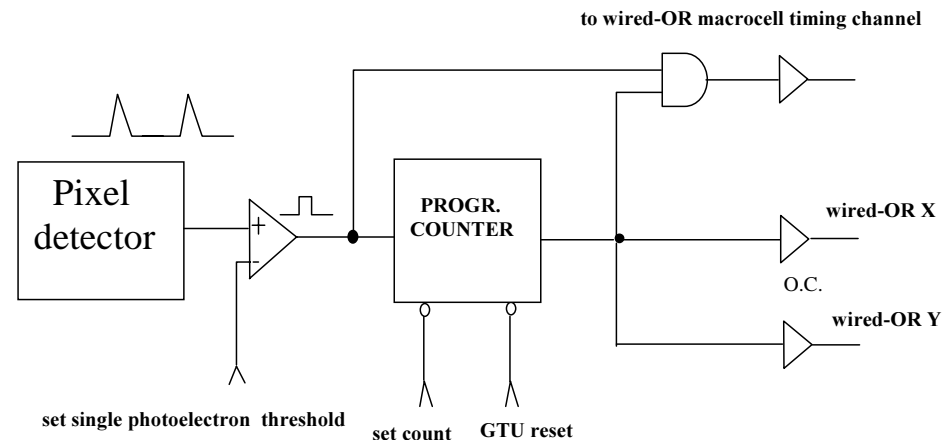
Microcell lab prototype

The microcell houses 4 MAPMT closely packed together, the voltage divider to supply the dynodes and the front end electronics.

On the back side there will be the front-end custom chips and the interconnections with the macrocell logic.

THE FRONT END ELECTRONICS

For each pixel we need to count the incoming photoelectrons in a given time slot (the GTU, Gate Time Unit) and activate a signal if a threshold has been reached. Every GTU the activated pixel cells will be saved in a circular memory buffer and read-out only if a trigger is issued. We plan to develop a 64 channels VLSI chip to handle all signals coming from a MAPMT.



FRONT END DESIGN IDEA

Current amplifier, low input impedance, direct anode connection (with cathode connected to $-HV$).

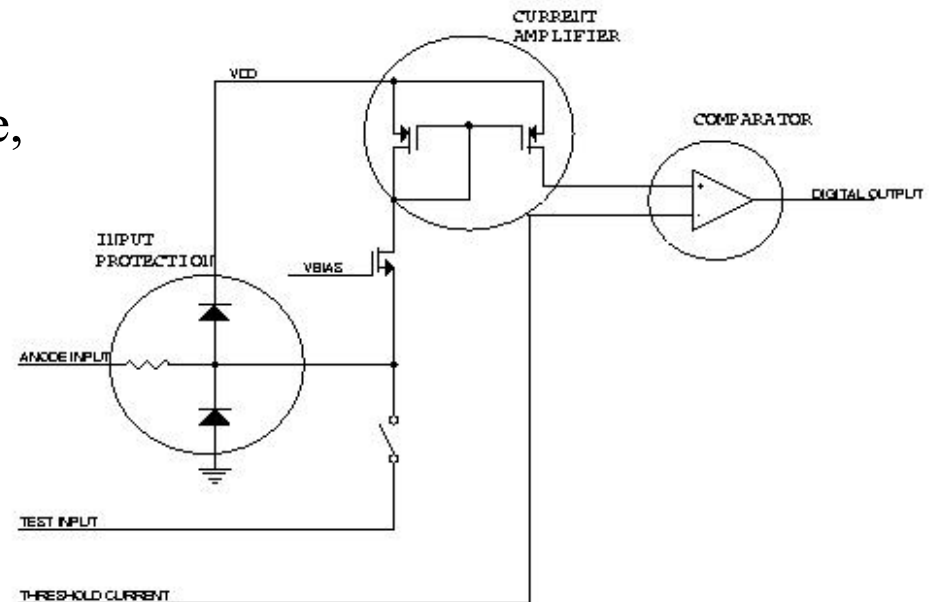
Low gain ($\sim 5 \div 20$)

High bandwidth (> 100 MHz)

Low power (< 1 mW)

Test input for diagnostic purpose

High speed current comparator with global threshold set using a DAC and standard CMOS output level (double pulse resolution $\sim 10 \div 20$ nsec).

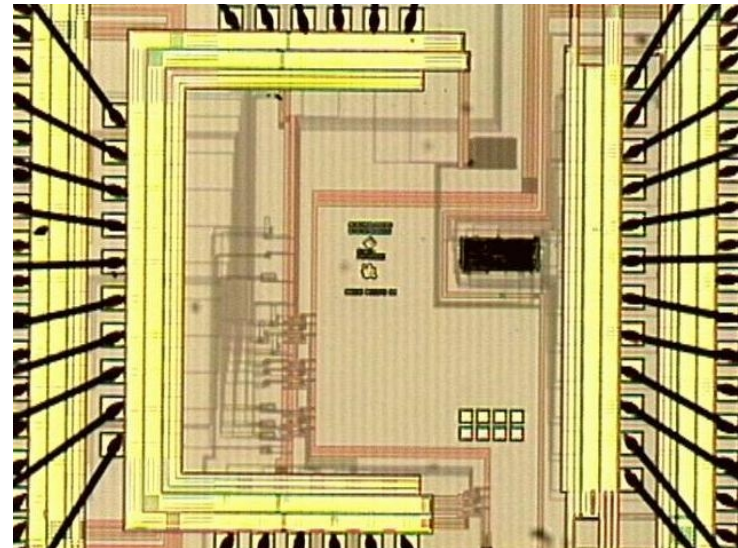


ELECTRONICS PROTOTYPING

A chip was developed to test various front end configurations (preamp-discriminator pairs).

Also included:

- An 8 bit current DAC with $1\mu\text{A}$ LSB
- A digital section with an 8 bit counter (triggered by the discriminator output) and a digital comparator
- Digital serial interface to load DAC and comparator register
- Voltage and current reference generator



Technology: AMS $0.35\ \mu\text{m}$



CONCLUSIONS

The study of the photon detector is in advanced phase.

The actual design fulfills all the experimental goals.

The first prototype of the microcell is under evaluation in our lab.

We start the debugging of the front end prototype chip in the next days.

We plan to design a new test chip in 2002 including all the functions needed by the microcell architecture: 64 channels, local data buffers, serial interface for configuration and read-out, analog setting DACs.

The goal is to prove the feasibility of the detector in term of performances, power and mass by the end of 2002 in order to satisfy ESA Phase A requirements.