Simulation and tests of HEPD-02 scintillator prototypes

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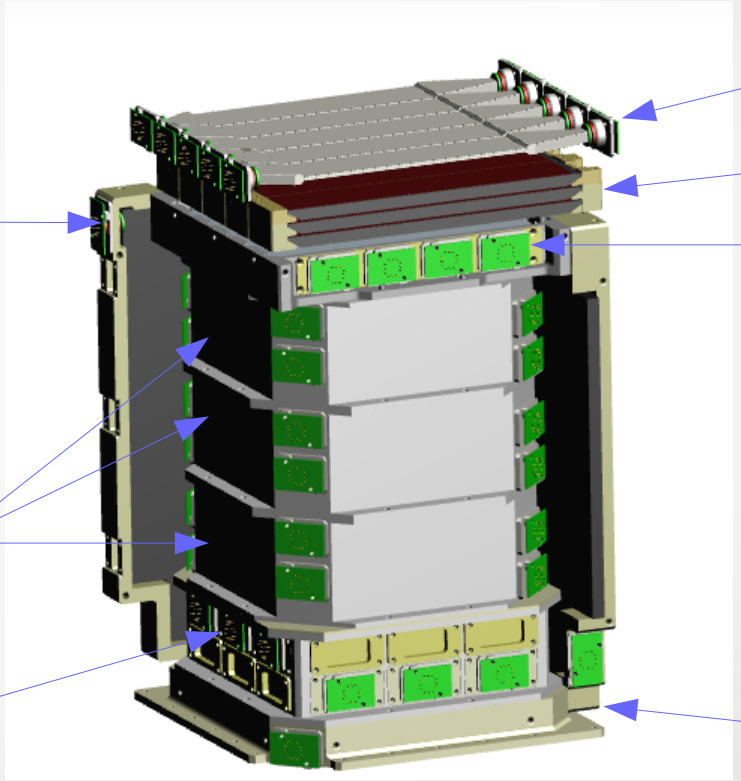
on behalf of the CSES-Limadou collaboration

The High Energy Particle Detector (HEPD-02)

HEPD-02, on board of the China Seismo-Electromagnetic Satellite (CSES-02) is aimed to measure particle precipitation due to short-time perturbations in the radiation belts caused by solar and terrestrial phenomena.

The energy range explored is:
3 - 100 MeV for electrons and
30 - 200 MeV for protons.

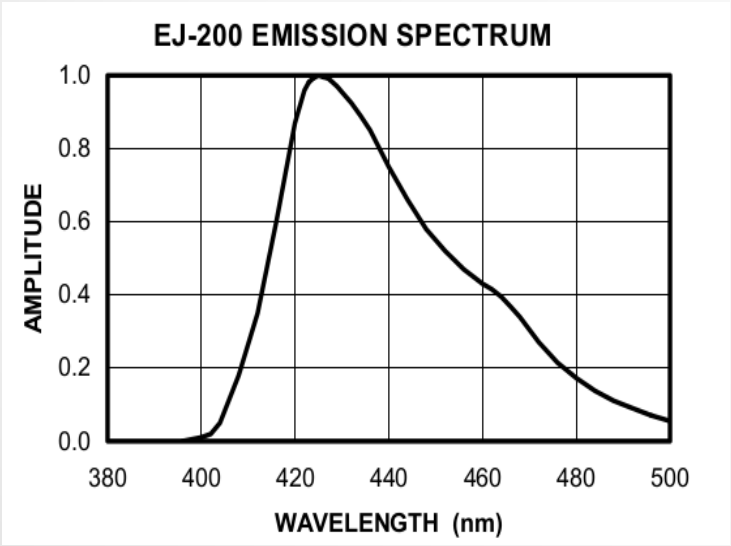
The detection of Particle Bursts for Earthquake study needs a low Energy threshold
→ Thin trigger counters



Prototypes

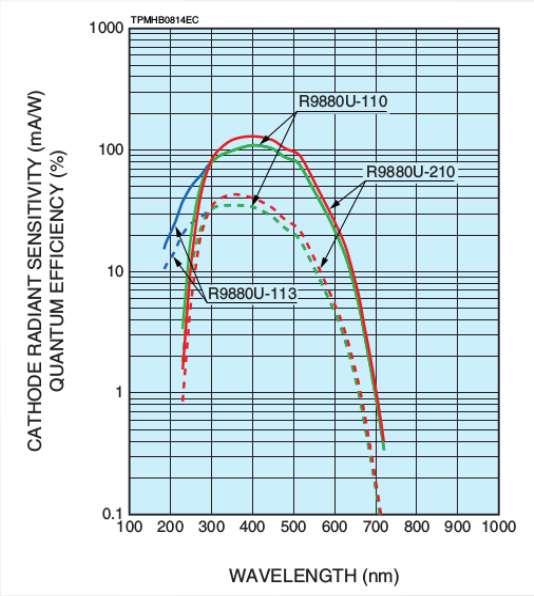
Scintillator bar 16 cm × 3 cm ; 2 mm (3 mm) thick with 2 cm long trapezoid light guides

EJ-200 Plastic Scintillator emission spectrum.



EJ-200 plastic scintillators combines a long attenuation length, a fast timing and high light output

Radiant sensitivity and Quantum efficiency of R9880U- Series Hamamtsu Photomultipliers.



High Gain, fast time response and high quantum efficiency

Geant4 Simulation

Scintillator bar 16 cm × 3 cm ; 2 mm (3 mm) thick with 2 cm long trapezoid light guides

Implemented in Geant 4.10:

- Geometry and optical properties of materials : refractive index, absorption length.
- Optical photons and processes.
- Scintillation properties of the plastic (EJ-200)
- Reflectivity of the wrapper (Mylar).
- Quantum efficiency of Photocathodes

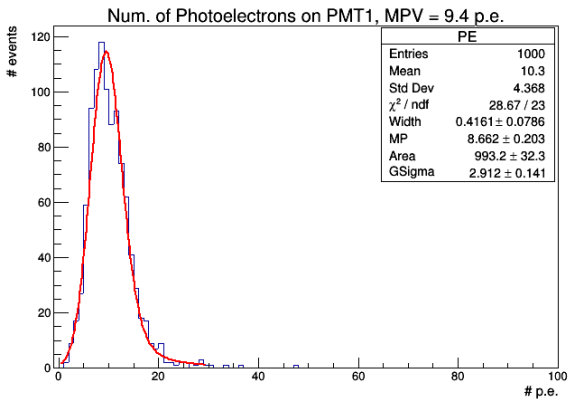
output
Number of photoelectrons on each PMT, with their arrival times and wavelengths

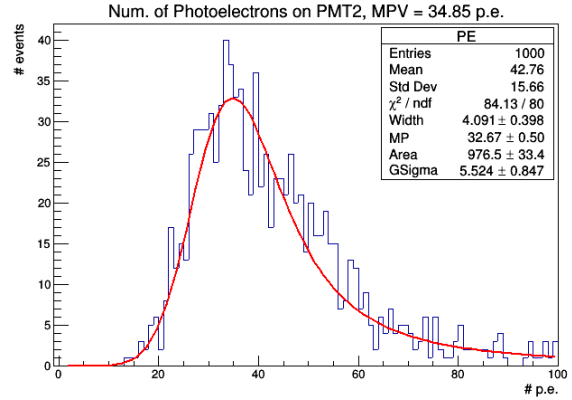
Run:
Muon beam at minimum ionization with normal incidence uniformly distributed on the scintillator surface.

Most Probable number of Photoelectrons

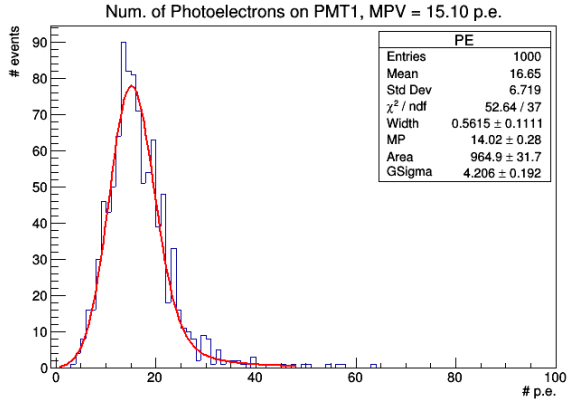
Square 3×3 cm²

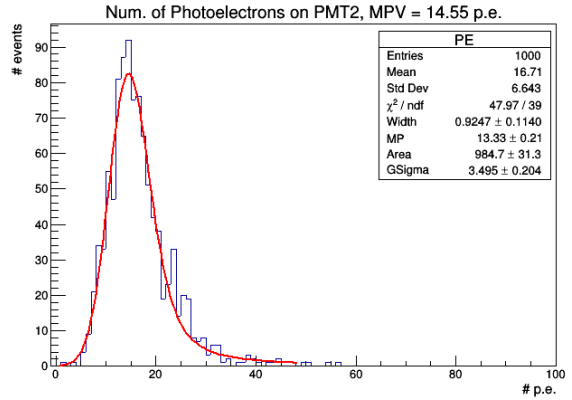
2 mm



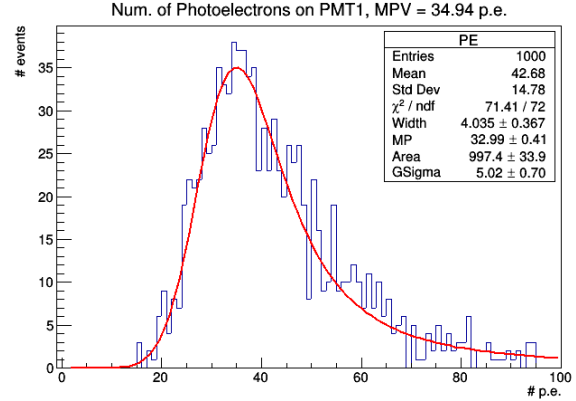


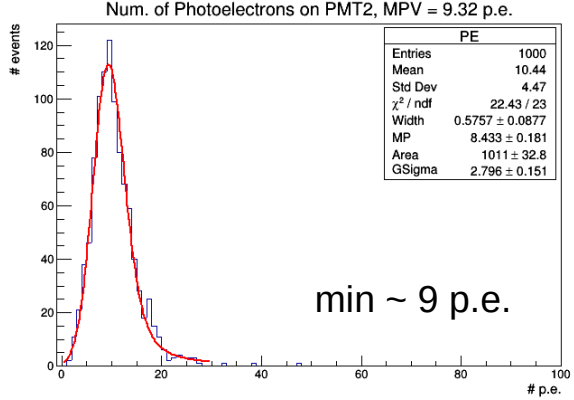
near PMT2





Center



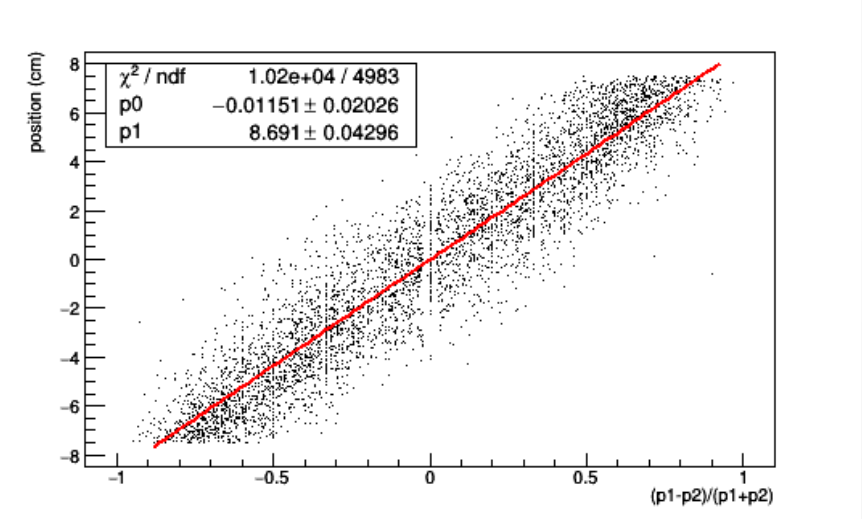


near PMT1

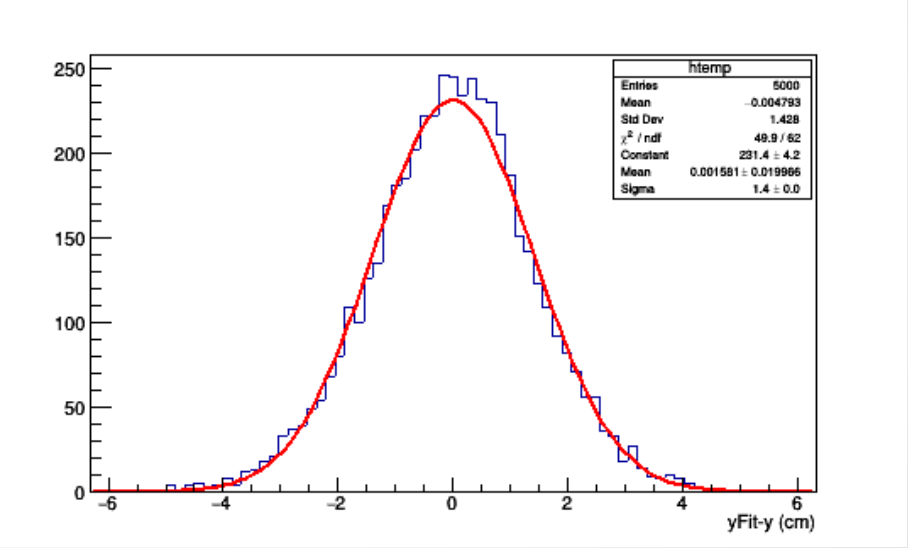
Spatial Resolution

2 mm

Position along the bar versus the ratio (p1-p2)/(p1+p2)



Distribution of the difference between reconstructed and real position.



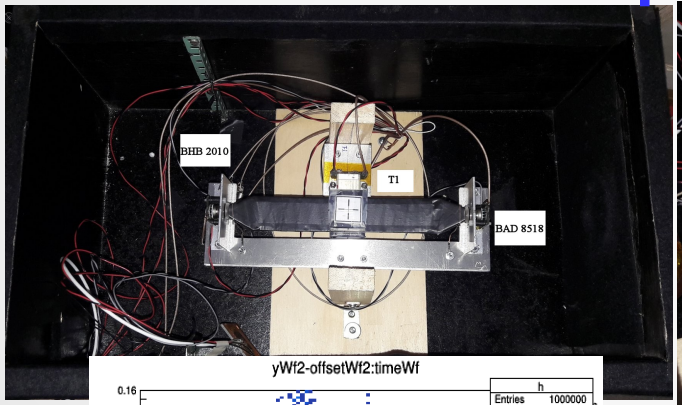
p1: number of photoelectrons seen by PMT1
p2: number of photoelectrons seen by PMT2

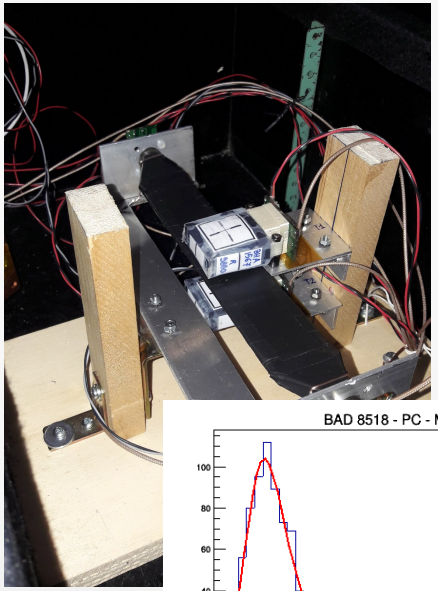
The fit is a Gaussian distribution with :
Sigma = 1.4 cm

Experimental Test

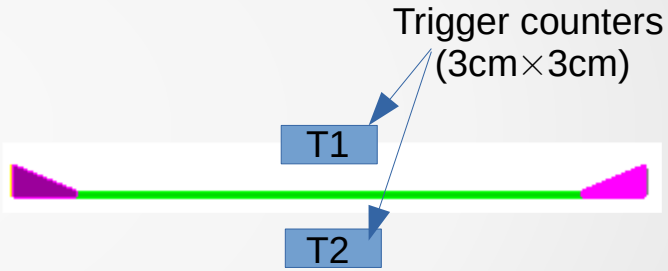
Prototypes of plastic scintillator 2 mm and 3 mm thick coupled at each end to Hamamatsu R9880-210 photomultipliers trough 2 cm long trapezoidal light-guides.

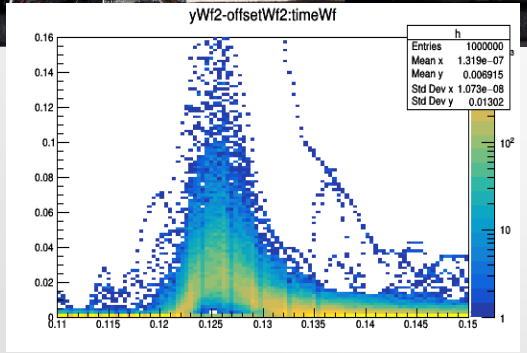
Setup

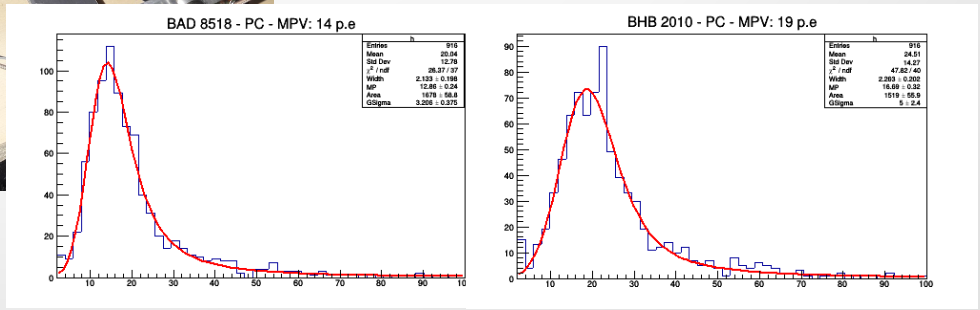




Tested under cosmic muons



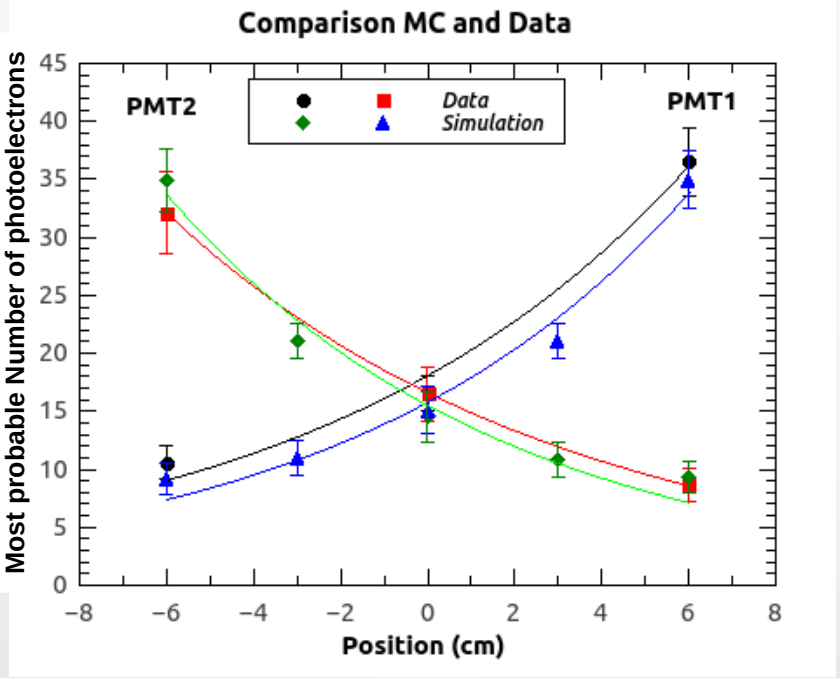




Comparing Simulation to Data from experimental test

Scintillator bar 2 mm

PMT2 → ← PMT1



Data:
Slope : -0,11 ± 0,01
+0,11 ± 0,01

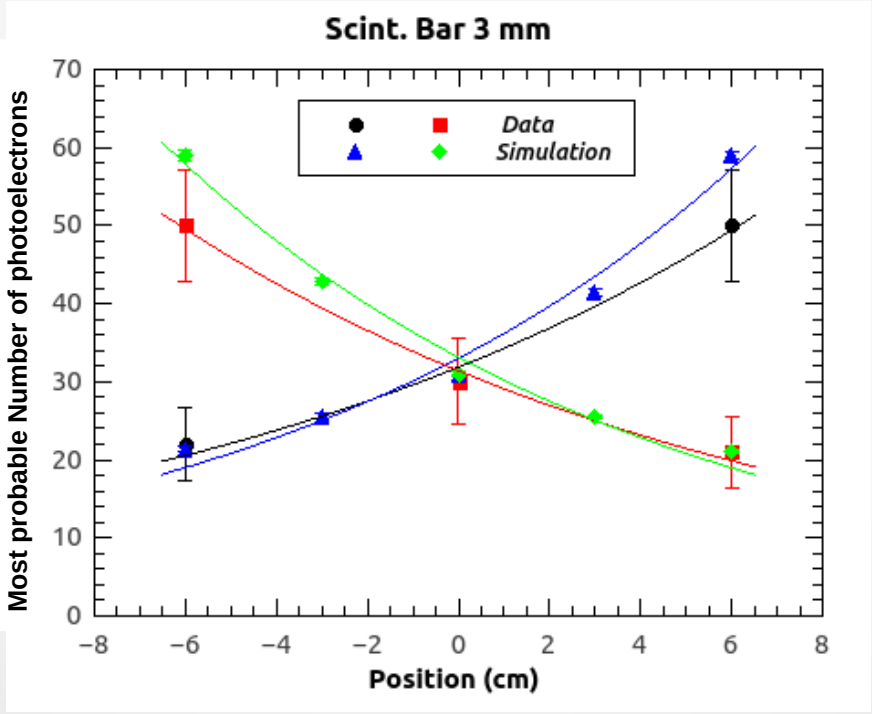
Simulation :
Slope : -0,12 ± 0,01
+0,12 ± 0,01

Ratio : #PE near/far
- Simulation :→ ratio ~ 3,7
- Data: → ratio ~ 3,4 - 3,7

Comparing Simulation to Data from experimental test

Scintillator bar 3 mm

Data:
Slope : -0,076 ± 0,007
+0,073 ± 0,009



Simulation :
Slope : - 0,092 ± 0,01
+ 0,092 ± 0,01

Ratio : #PE near/far
- Simulation : → ratio ~ 2,7 – 2,8
- Data: → ratio ~ 2,2 – 2,4

Reasonable agreement with Data

Conclusion

- Two prototypes of trigger counters 2mm and 3mm thick were tested
- The number of photoelectrons collected was found to be sufficient to ensure a good detection efficiency for low energy electrons and protons
- Thin counters minimize scattering and allow for a low threshold which is also valuable for cosmic nuclei studies.
- A Geant4 MonteCarlo simulation was implemented and tuned to reproduce experimental data

  → it shows a reasonable agreement with data collected and is being used to study the total trigger plane/system efficiency and resolution.

  → it also serves as a basis for the plastic calorimeter simulation studies.