Progress of HERD calorimeter

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On behalf of HERD group
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Outline

1, HERD calorimeter configuration

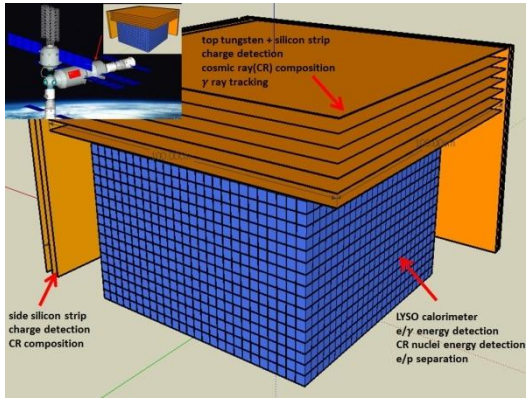
2, Readout and trigger system of the calorimeter

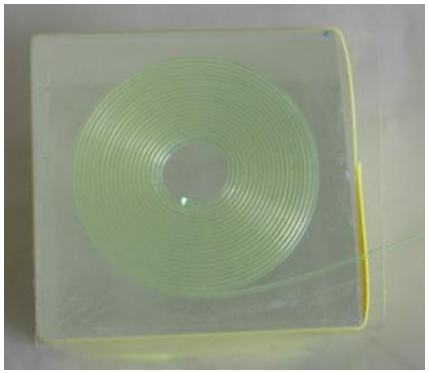
3, Cosmic ray test of calorimeter prototype

4, Linearity study of image intensifier and ICCD

5, Summary

The HERD calorimeter configuration





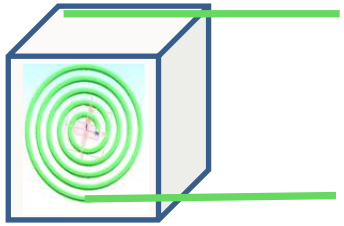
LYSO Cell length(cm^3)	3.0×3.0×3.0
Number of LYSO	21×21×21=9261
Calorimeter Size(cm^3)	63.0×63.0×63.0
Mass of Calorimeter(Kg)	1800
Depth of Calorimeter(R.L.) (I.L.)	55 3.0

The HERD calorimeter is a cubic homogeneous detector, made of LYSO scintillator. It is a 3D imaging calorimeter, used to measure the development of particle shower .

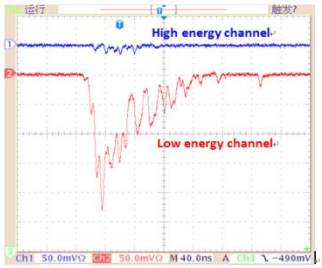
The scintillation light of LYSO is absorbed and transmitted by 0.3 mm diameter wavelength shifiting(WLS)fibe glued to the surface of the scintillator.

Readout system of the calorimeter(1)

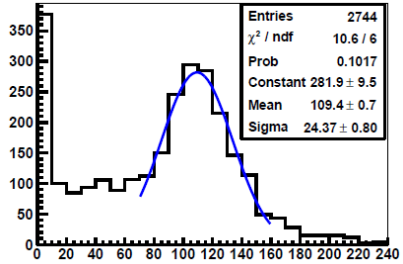
Oscilloscope trace from one cosmic ray event



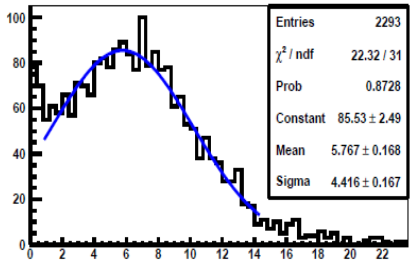
LYSO/Fiber configuration: Low and high channel



Raw Signal From two fibers



Low channel: ~110 P.E.

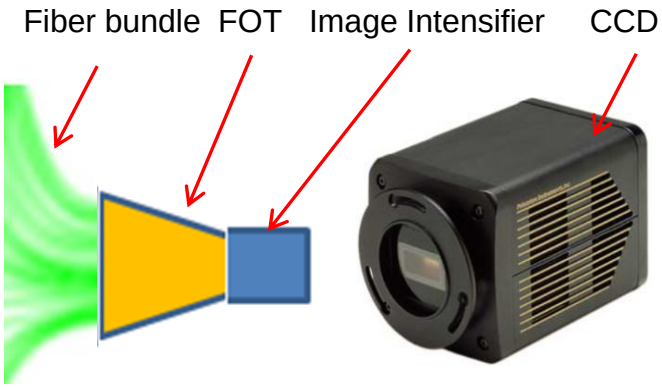


High channel: ~ 6 P.E.

One crystal readout by two fibers is designed to cover the whole dynamic range : 2e6.
One fiber with several loop spiral defined as low channel, another fiber with no spiral defined as high channel.
Cosmic rays were used to test the two channels response to MIPs.
Light output of low and high channel (readout by PMT(XP2020)) is about 110 P.E. and 6 P.E. respectively.
High energy channel light output need to be decreased to obtain 1000 times difference between the two channels.
The linearity requirement of ICCD: 5e3.

Readout system of the calorimeter(2)

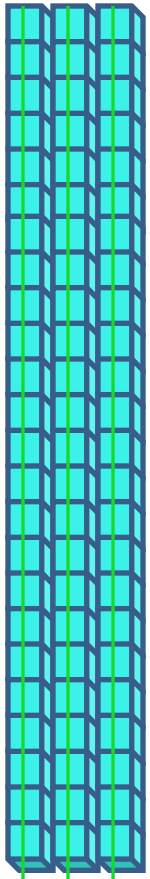
Fiber bundle



There are nearly 20 thousand readout channels, all the fiber ends are bundled in two compact bunch correspond to low and high channel, which has a size of only a couple of centimeters. The fibers at the end of the bundle can be glued together and polished making a ”fiber optic plate”-like structure.

The shower development profile of the event in the detector is translated into the surface of the fiber optic plate (FOP). This image on the FOP can be photographed by using an externally triggered ICCD.

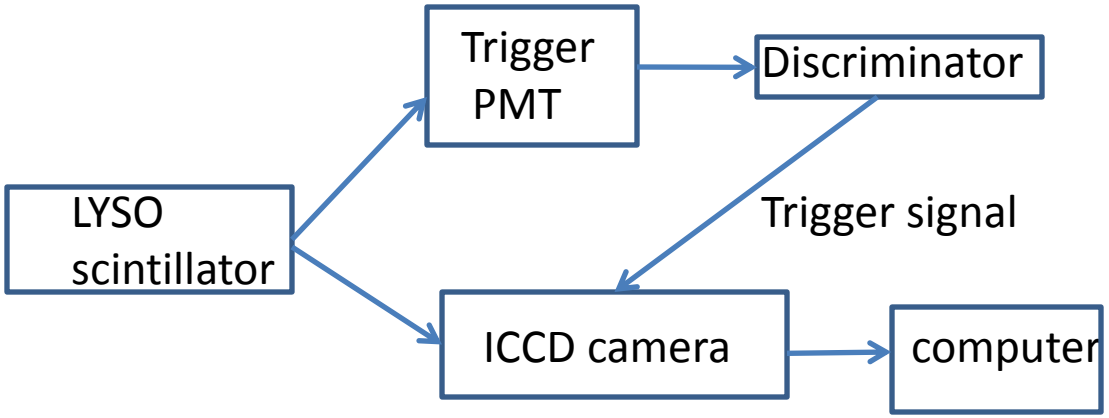
The trigger system of HERD



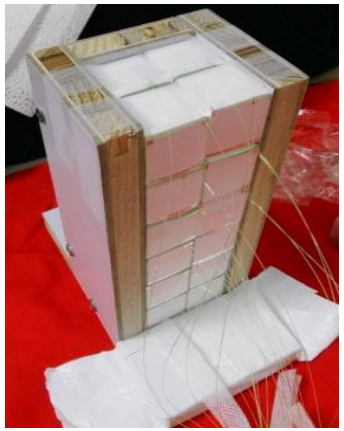
WLSF

PMT

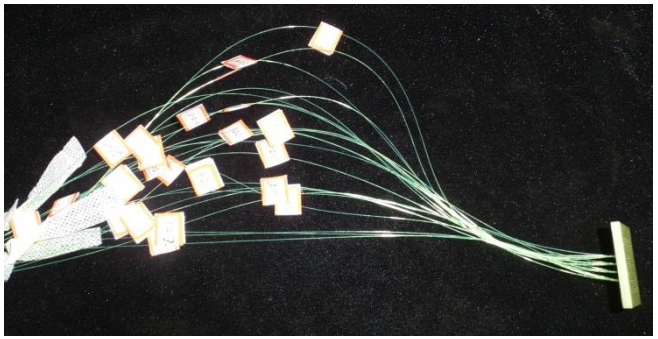
One WLS fiber attached to the surfaces of a row of crystals
In total there are 21X21=441 fibers couple to one PMT.
PMT： multi- dynode readout similar to DAMPE, to cover the huge dynamic range.
The trigger signal record energy and time information.
when a high energy particle incident, we can get a fast signal(<100 ns) from the PMT that proportional to the particle energy.
So a threshold can be set for trigger.



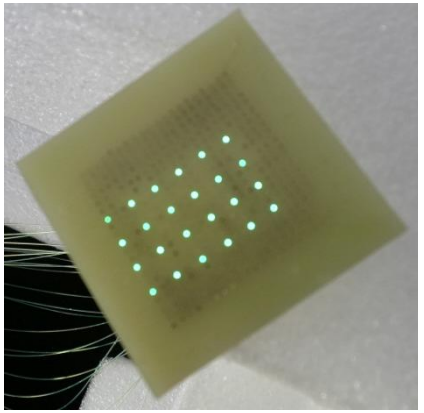
Cosmic ray test of calorimeter prototype(1)



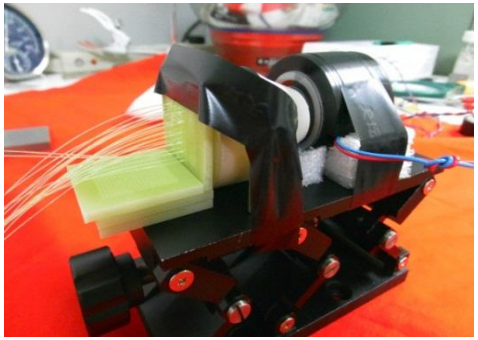
2×2×4 CsI(Na) module
2.5cm× 2.5cm × 2.5cm



24 fibers with number

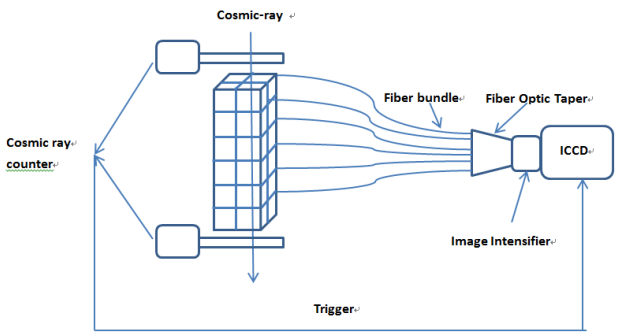


24 fibers fixed on a micropore plate



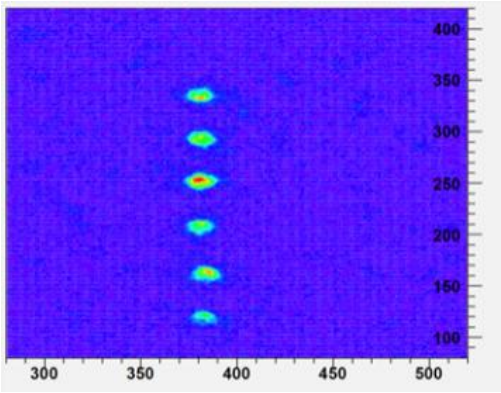
Fibers coupled to II through fiber Optical taper

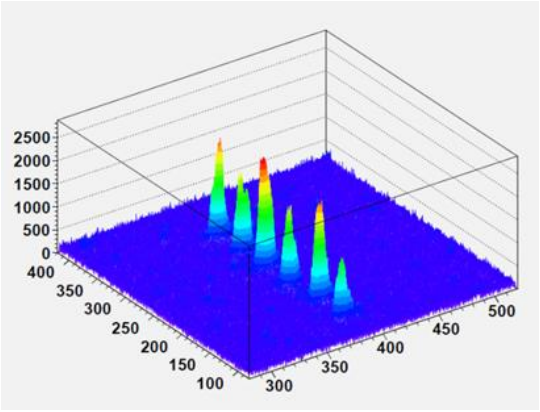
ICCD system and cosmic ray counter



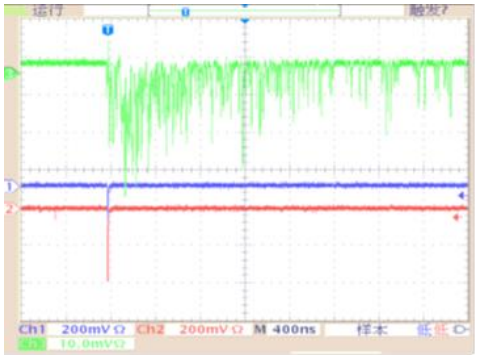
Schematic presentation of cosmic ray test

Cosmic ray test of calorimeter prototype(2)

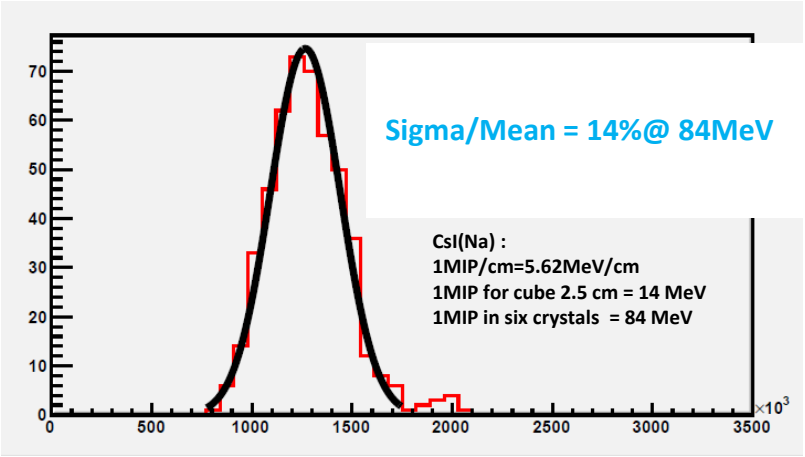




Display of a typical cosmic muon event passing through six crystals read out by ICCD



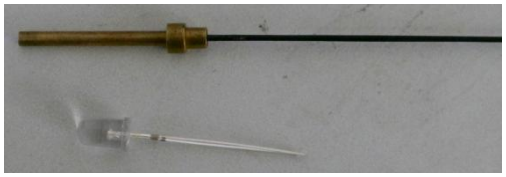
Raw signal from CsI(Na) and WLS cell detected by PMT



Energy resolution of MIPs in six crystals

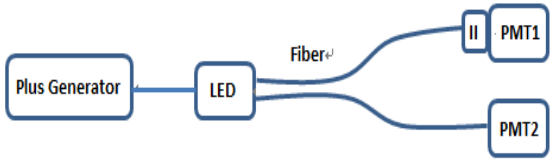
Linearity study of image intensifier

18mm diameter Image intensifier



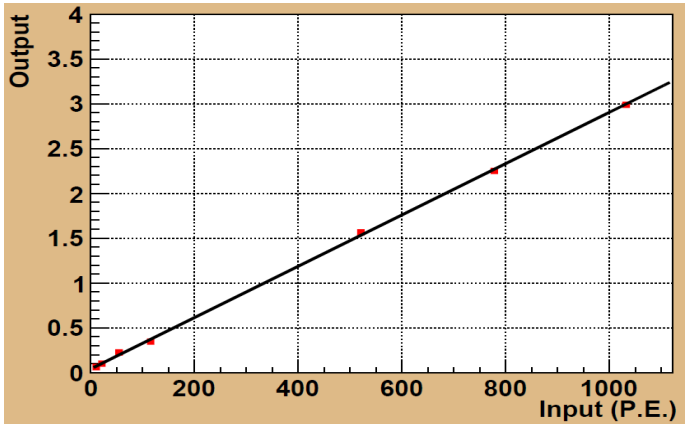
LED and quartz fiber

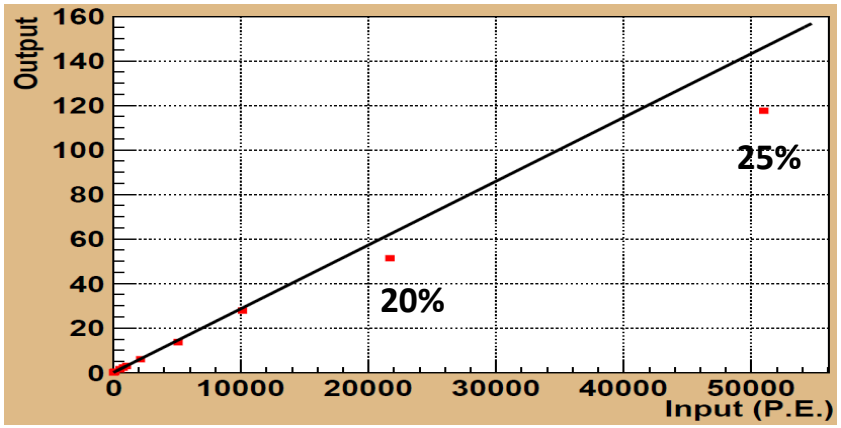
The gain of II is 30



Schematic presentation of the test

LED : wave length 505-510nm，close to WLS output light
Fiber: 0.4mm diameter quartz fiber
PMT1：test detector
PMT2：monitor the stability of the LED

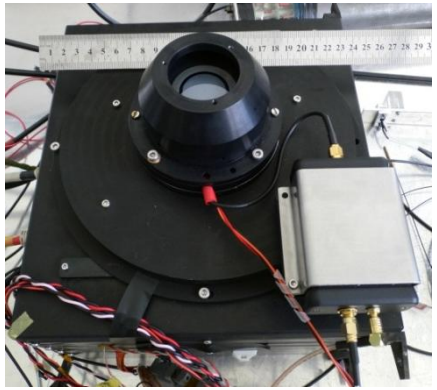




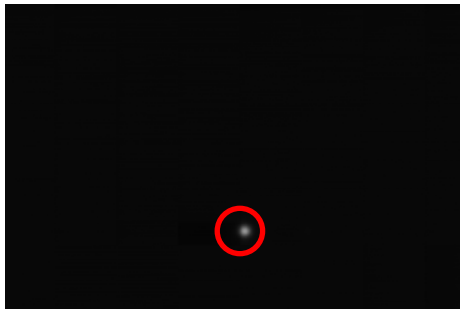
Fitting data from 10 P.E. to 1000P.E. , and then extrapolated the fitted cure to 50000 P.E.

The divergence at 20000 P.E. and 50000 P.E. is 20% and 25% respectively.

Linearity study of ICCD prototype



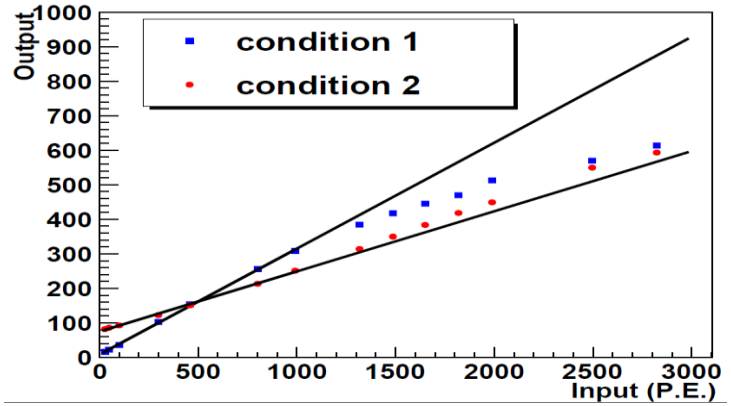
The ICCD prototype



The fiber image in the ICCD

The test setup is identical to the linearity study of image intensifier, one fiber used to test the ICCD, another used to monitor the stability of the LED

See Bingliang-Hu's talk for details



Linearity of the ICCD prototype with different II gain

In condition 1, the gain of II is 1.5e5, the linearity range of ICCD is 100.
In condition 2, the gain of II is 1.0e4,the linearity range of ICCD is 300.
II with lower gain can obtained larger linearity.

In linearity study of Image Intensifier and ICCD, the PMT's non-linear response is not exclude, this issue will be studied in future.

Summary

1, The property of scintilator and WLS have been studied.

2, The performance of calorimeter prototype have been tested by cosmic ray.

3, Huge dynamic range is vital to ICCD, this is a real challenge .


Thanks for your attention