

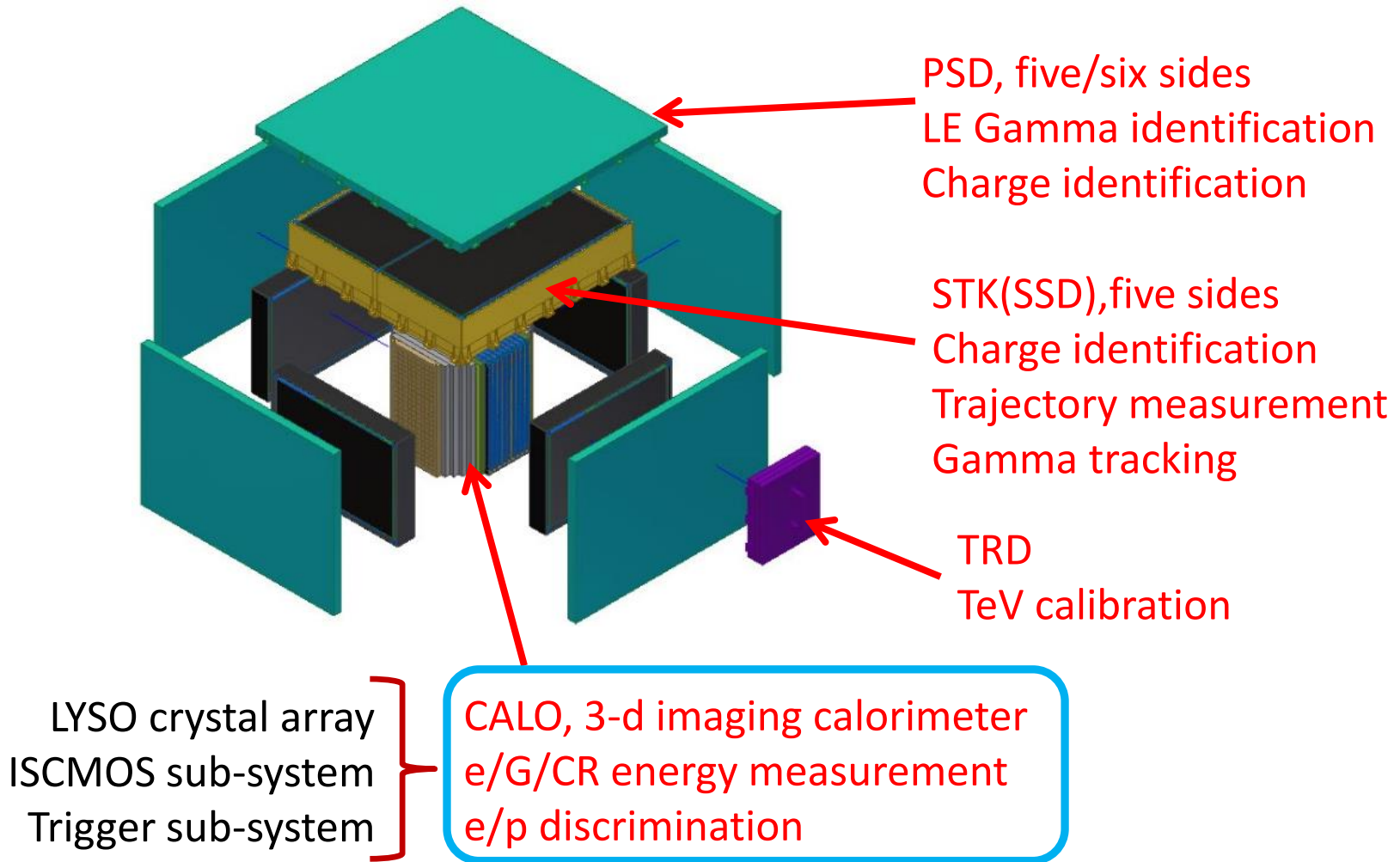
Crystal array of CALO

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2018-03-27

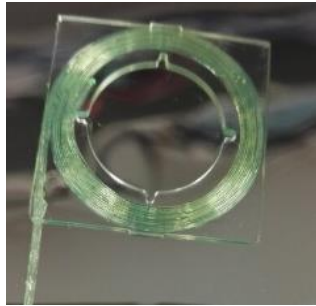
The 6th HERD workshop, Beijing, IHEP

HERD payload

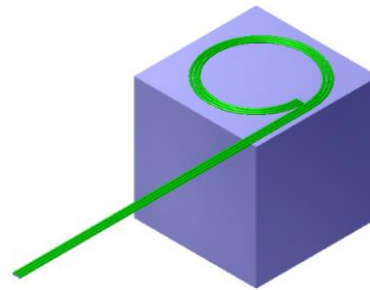


CALO – LYSO array

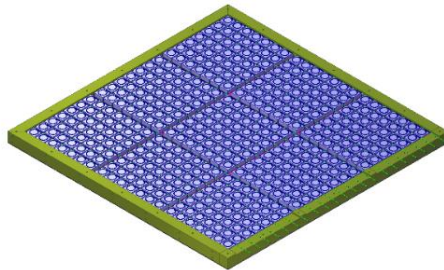
- ~7500 LYSO/WLSF units
- LYSO: Convert energy deposition of incident high energy particles
- WLSF: Read out crystal signals



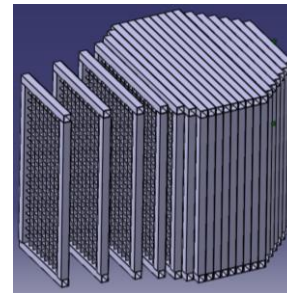
Encapsulation of WLSF with optical cement



WLSF coupled to LYSO and covered by reflector

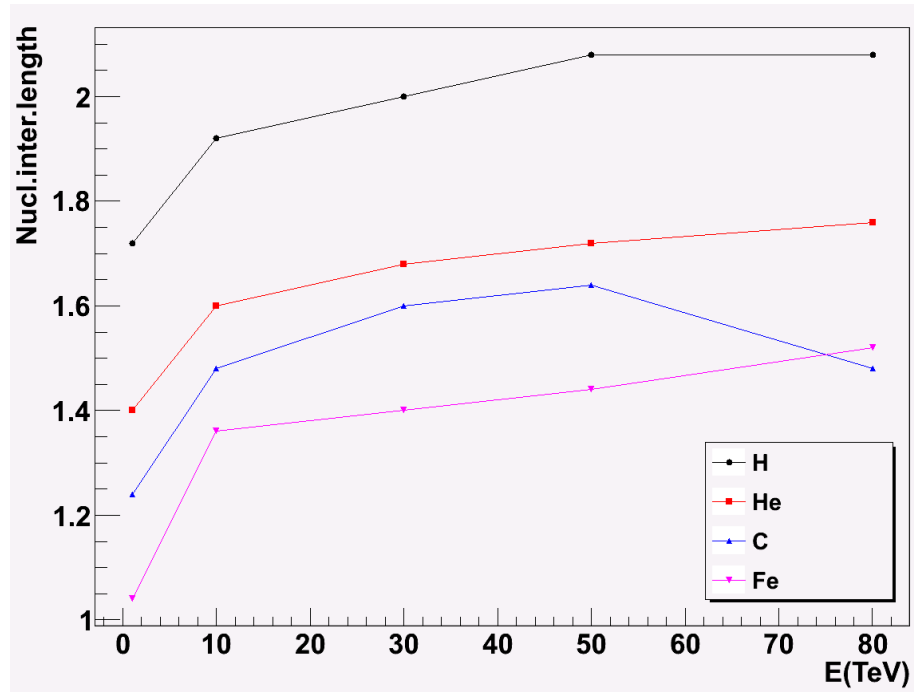


LYSO/WLSF assigned in carbon fiber supporter-module



Construction of CALO by 21 modules

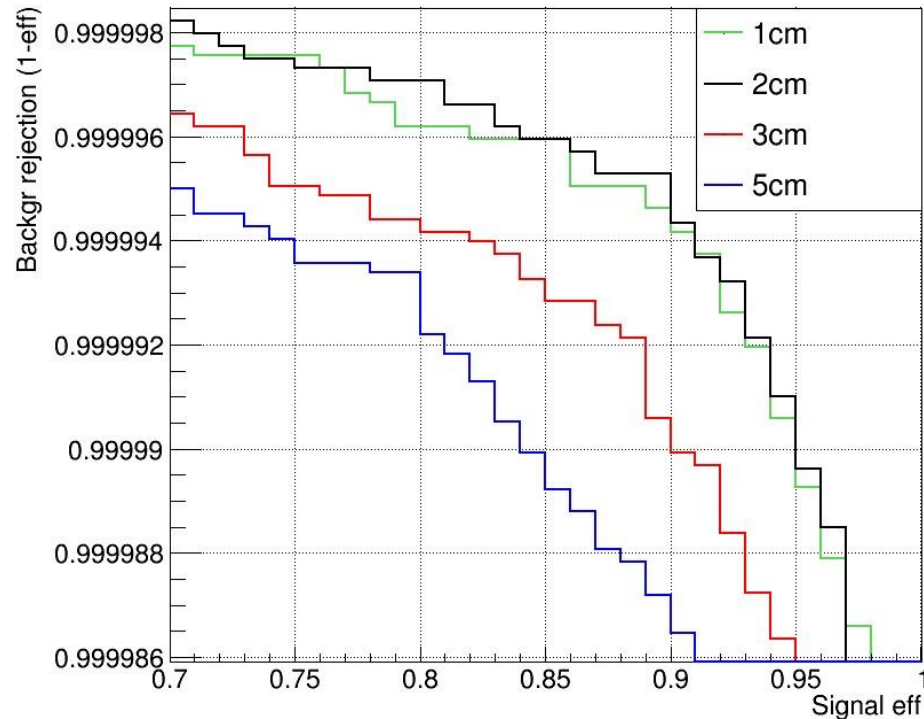
Depth of CALO



Depth requirements of CALO to guarantee 20% energy resolution for high energy cosmic rays.

CALO with 2 nuclear interaction length is required to measure 100 TeV cosmic rays. Estimated from this figure, 3 nuclear interaction length is required to get 20% resolution for cosmic rays with PeV energy.

LYSO size optimization



e/p discrimination power dependence on LYSO size

In order to obtain e/p discrimination power higher than 10^{-5} while keeping electron detection efficiency at about 90%, **the size of LYSO cube should not be larger than 3 cm.**

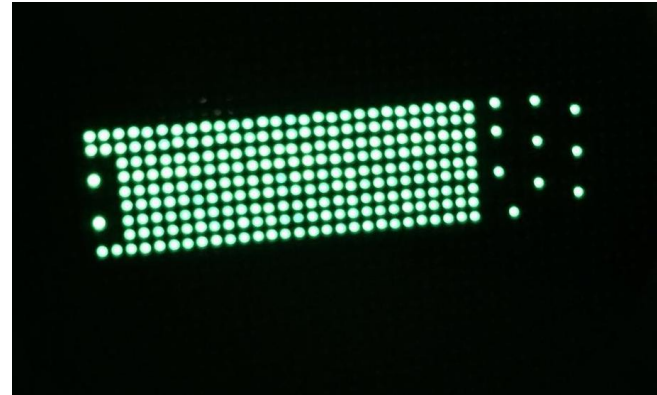
Calorimeter specifications

Item	Value	Note
Type of crystal	LYSO	
Crystal dimension	3cm*3cm*3cm	
Number of crystals	~7500	
Radiation Length	55	~ 21 LYSO crystals
Nuclear Interaction Length	3	
Fiber readout	3 WLSF/crystal	Low range, high range & trigger
Energy resolution(e)	1%@200 GeV	
Energy resolution(p)	20%@100GeV-PeV	
e/p discrimination	~10 ⁻⁶	3-d crystal array

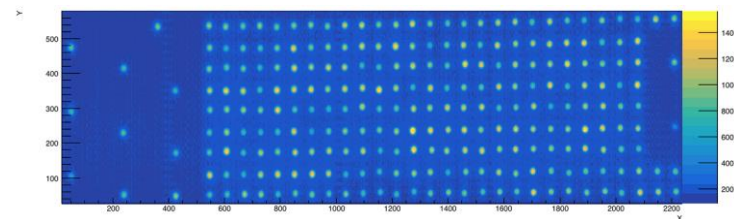
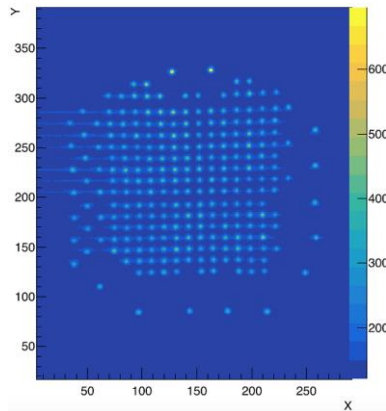
Construction of 5*5*10 prototype



5*5*10 LYSO calorimeter

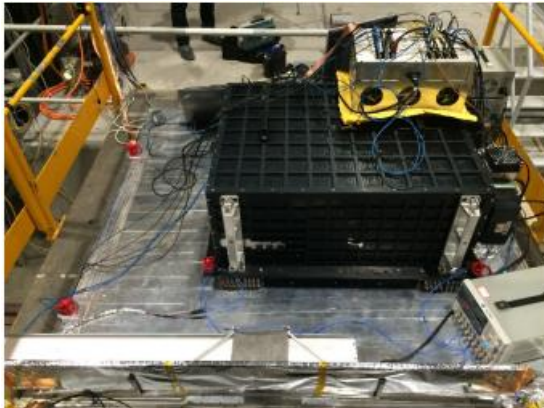


Fibers fixed to micro plate and polished

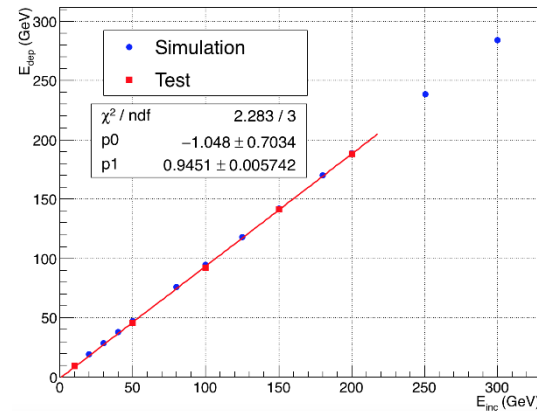


Fiber images in ICCD and IsCMOS

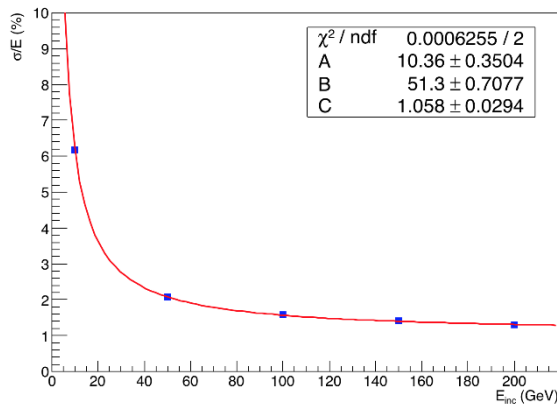
2017 CERN SPS beam test



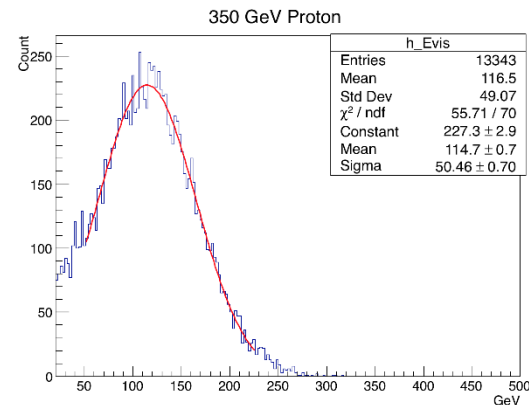
Beam test setup



Energy linearity of electron



Energy resolution of electron,
1.3% @ 200 GeV



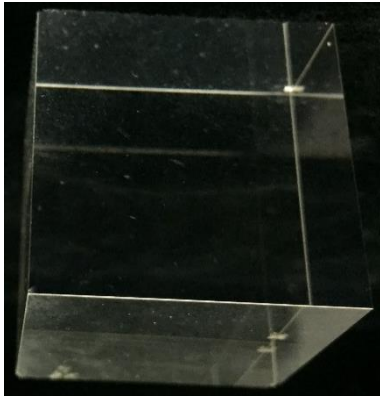
Energy resolution of proton,
44% @ 350 GeV

Improvement of next CALO prototype

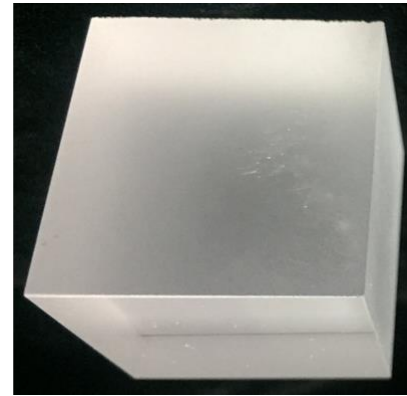
1, Surface treatment of LYSO cube -> Increase light output

2, Crystal number of prototype increased to 500
-> Improve energy resolution of proton from 40% to 20%; Verify 5 sides sensitive ability of CALO.

Surface treatment of LYSO cube



Six sides polished LYSO cube



5 roughened and 1 polished sides LYSO cube

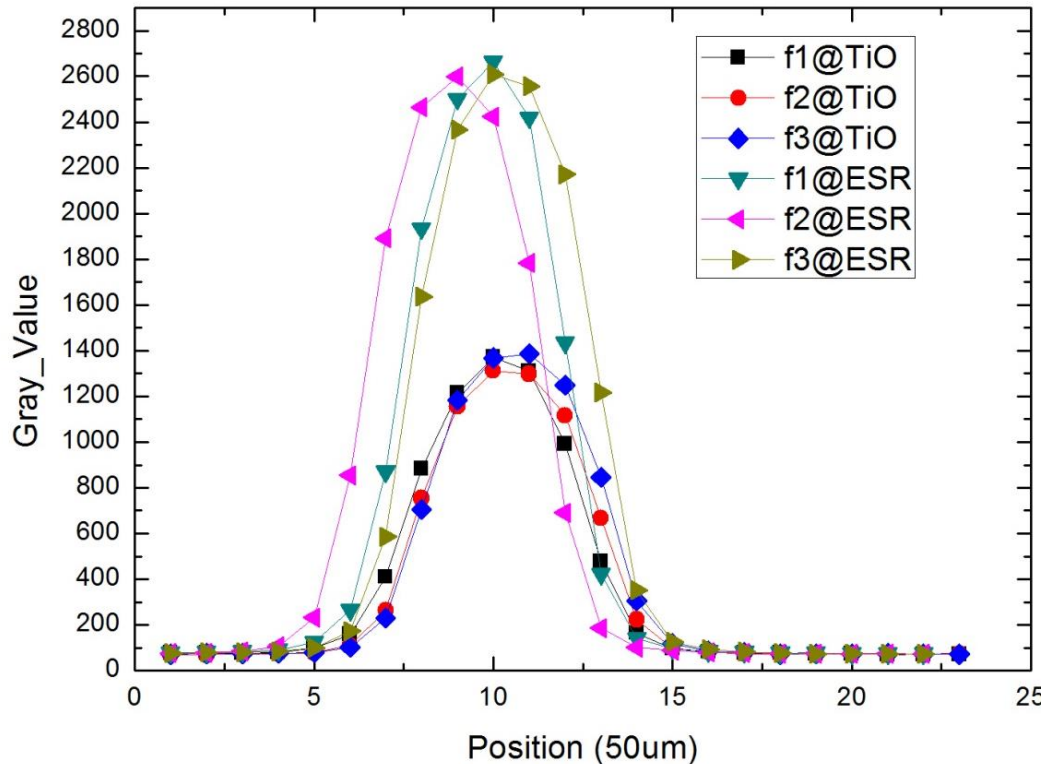


Titanium dioxide (TiO_2) coating



ESR film reflector

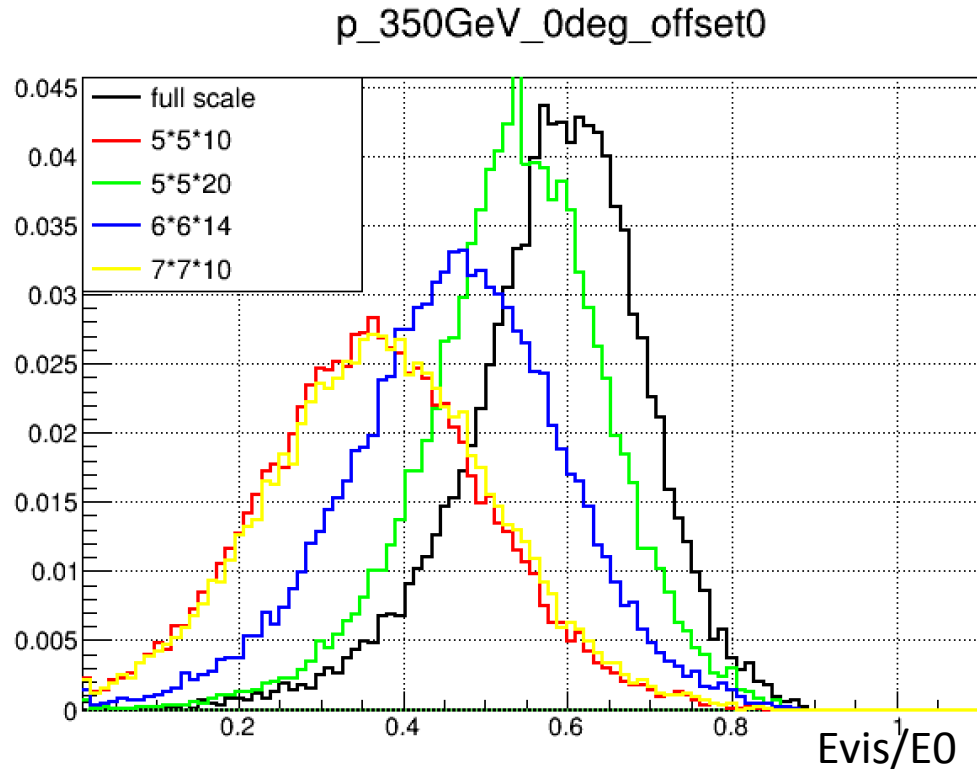
Light output improvement



LYSO/WLSF output profile with x-ray excited and PD array imaged

**Intensity of LYSO/WLSF unit output is increased by ~100%.
Improve MIP detection ability**

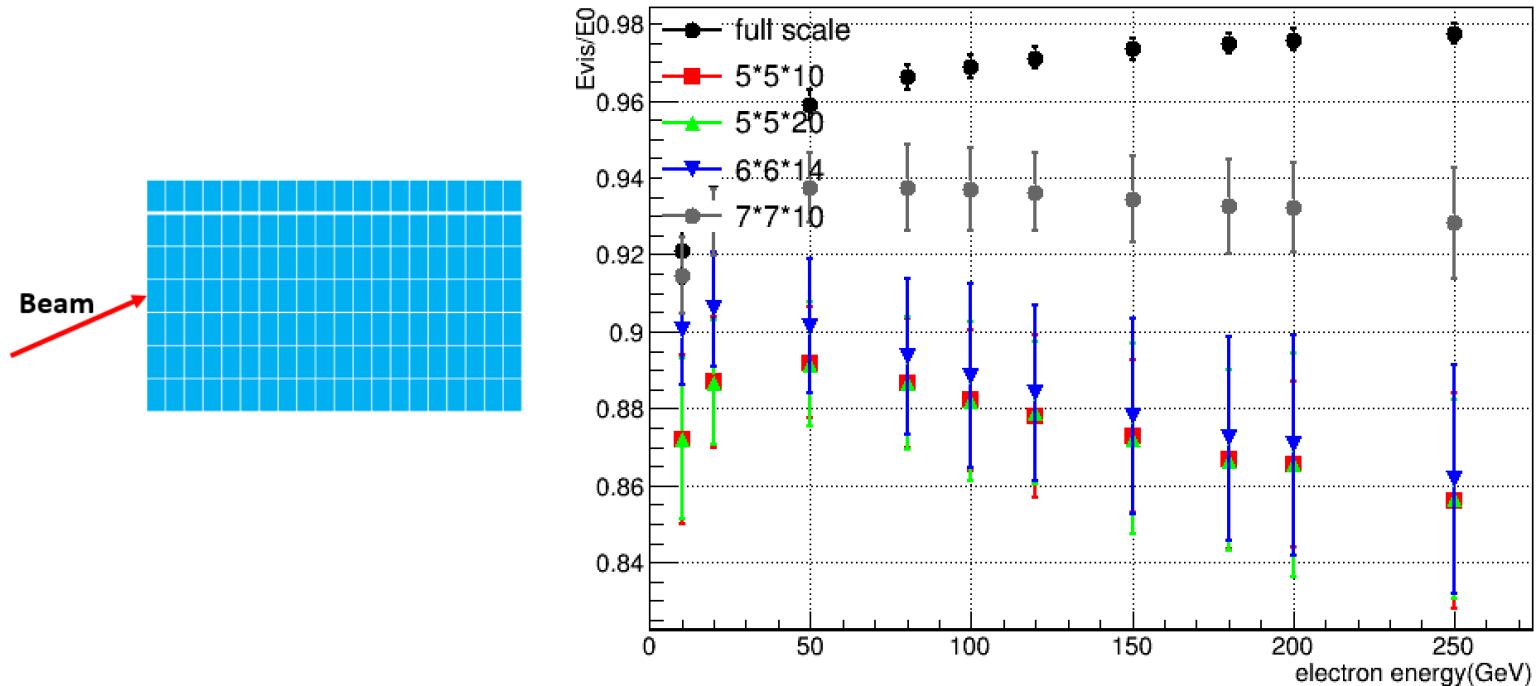
Energy deposition of proton



For 350 GeV proton, a deeper detector is needed to get better energy resolution.

5*5*20 LYSO array is optimum choice for proton beam test.

Energy deposition of electron(45 deg)



Electron beam incident at 45 degrees to LYSO array

7*7*10 LYSO array is optimum choice to get a reasonable resolution

2018 Beam test plan

The updated prototype consists of 10 modules, every module contains 5*10 LYSO cube.

	1	2	3	4	5	6	7
1							
2							
3							
4							
5							
6							
7							

Calibration, Proton beam test

5*5*20

	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
3												
4												
5												
6												

Electron beam test

5*10*10

The CALO prototype arranged in 5*5*20 array to do calibration and proton beam test at first to study proton energy resolution(20%). Rearranged to 5*10*10 array to do electron beam test to verify 5 sides detection ability.

Summary

1, CALO prototype with 250 LYSO built and tested by test beam, the energy resolution of electron and proton is 1.3%@200GeV and 44%@350GeV.

2, An updated prototype with 500 LYSO is under construction.