Crystal array of CALO

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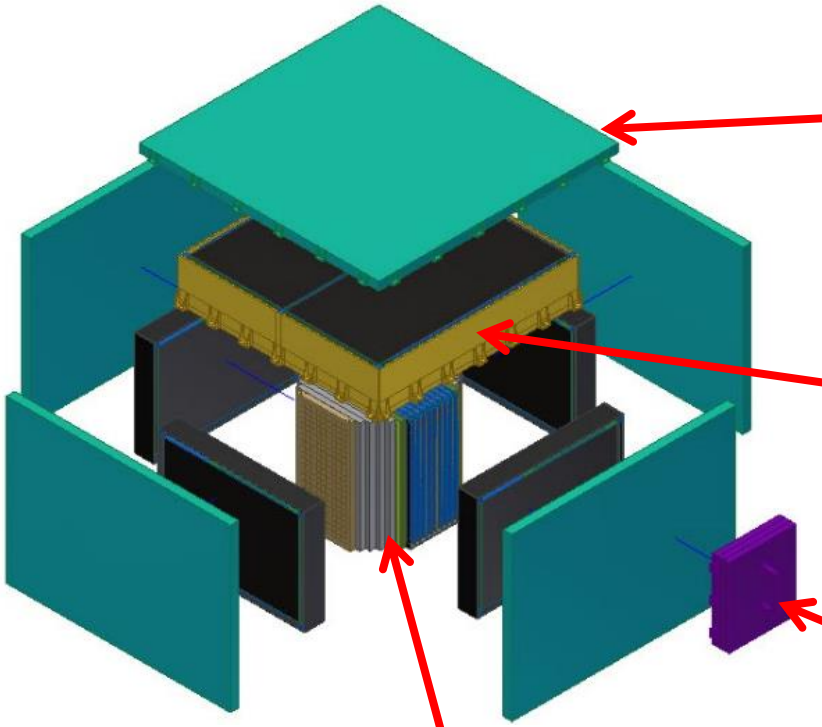
The 7th HERD workshop, CERN

HERD payload



PSD, five/six sides
LE Gamma identification
Charge identification

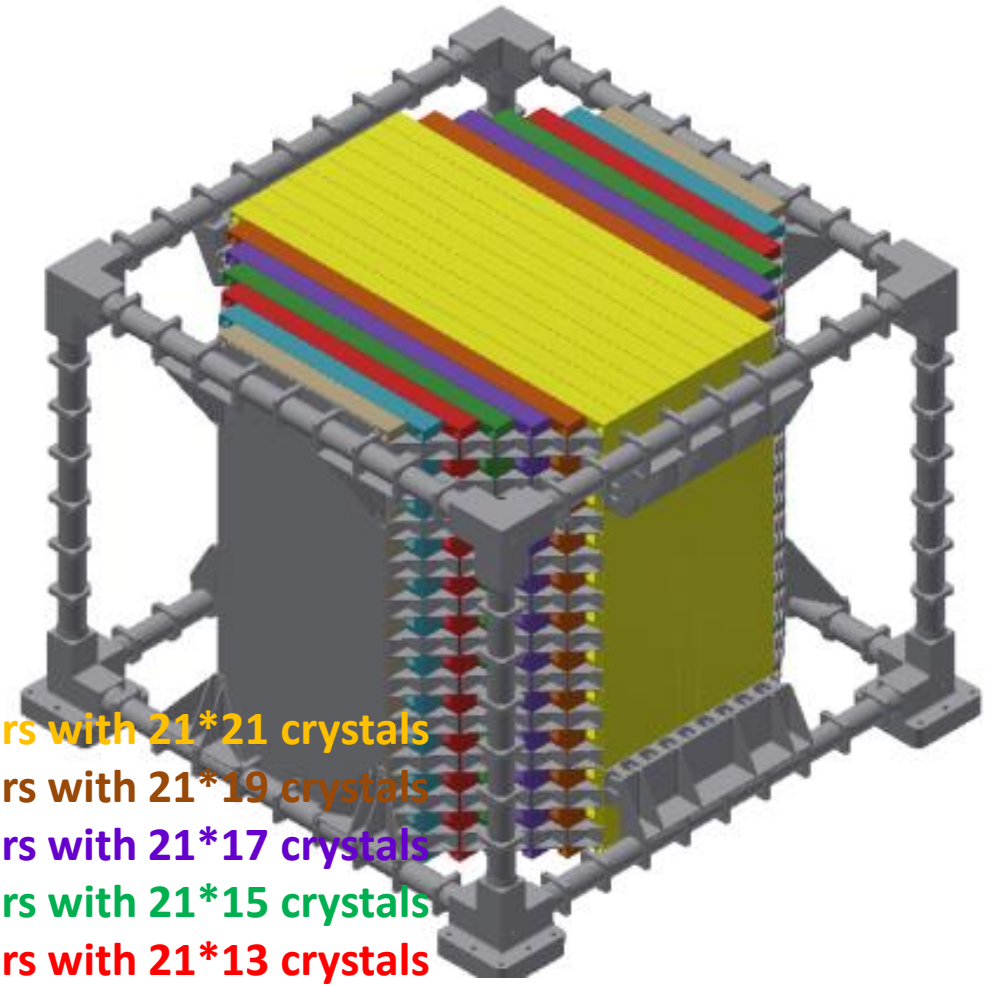
STK(SSD),five sides
Charge identification
Trajectory measurement
Gamma tracking

TRD
TeV calibration

LYSO crystal array
ISCMOS sub-system
Trigger sub-system

CALO, 3-d imaging calorimeter
e/G/CR energy measurement
e/p discrimination

Calorimeter specifications

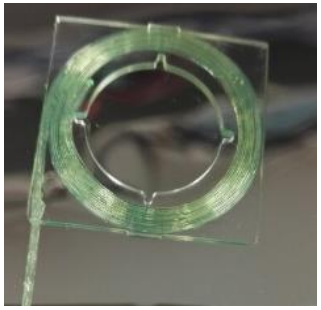


layers with 21*21 crystals
layers with 21*19 crystals
layers with 21*17 crystals
layers with 21*15 crystals
layers with 21*13 crystals
layers with 21*11 crystals
layers with 21*9 crystals

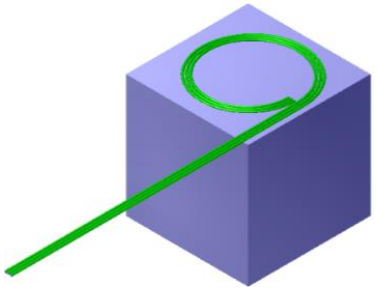
Item	Value	Note
Type of crystal	LYSO	
Crystal dimension	3cm*3cm *3cm	
Number of crystals	~7500	
Radiation Length	55	~ 21 LYSO crystals
Nuclear Interaction Length	3	
Fiber readout	3 WLSF/crystal	Low range, high range & trigger
Energy resolution(e)	1%@200 GeV	
Energy resolution(p)	20%@100 GeV-PeV	
e/p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

CALO-LYSO array

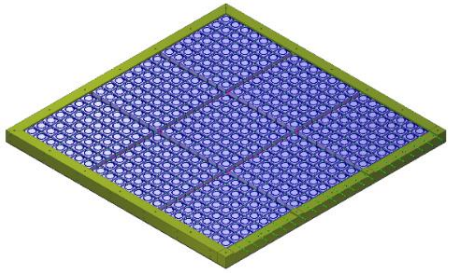
- ~7500 LYSO/WLSF units
- LYSO: Convert energy deposition of incident high energy particles
- WLSF: Read out crystal signals



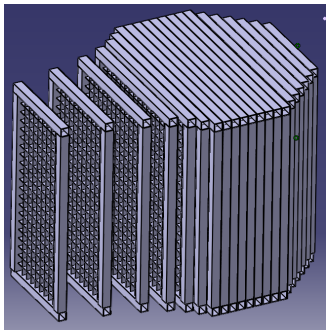
Encapsulation of WLSF with optical cement



WLSF coupled to LYSO and covered by reflector



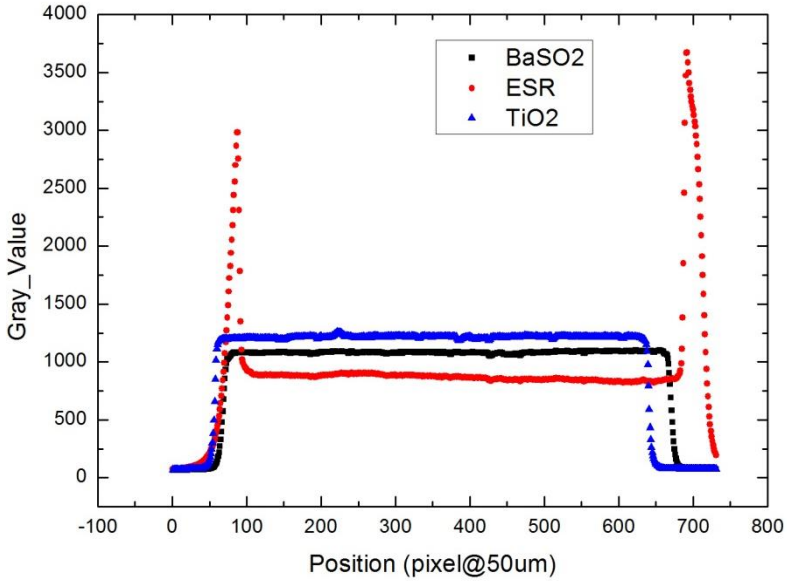
LYSO/WLSF inserted in CFRP



Construction of CALO by 21 modules

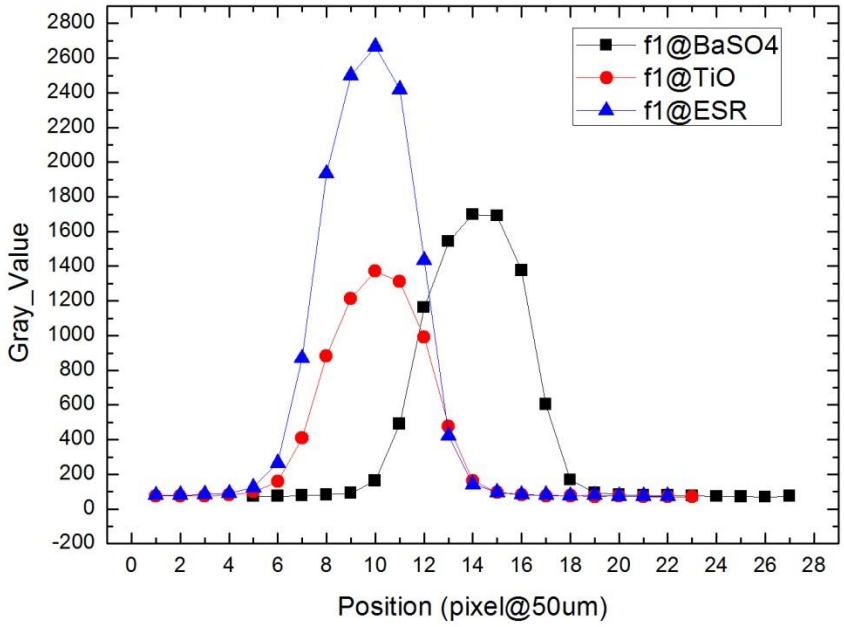
Light-collection optimization

- The intensity output of LYSO and LYSO+WLSF are irrelevant



	BaSO2	ESR	Ti02
integral	663355.8	666254.6	722456.6

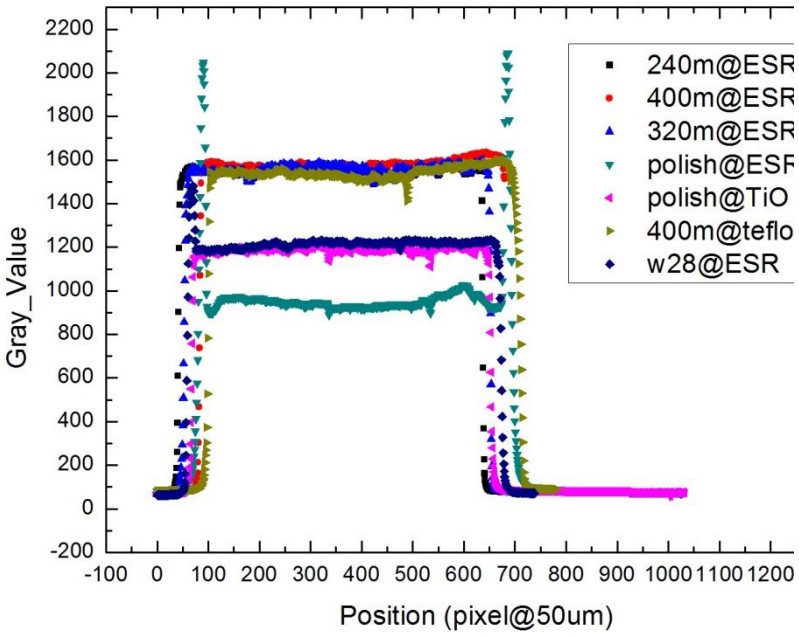
LYSO irradiated by MXS and readout by PD



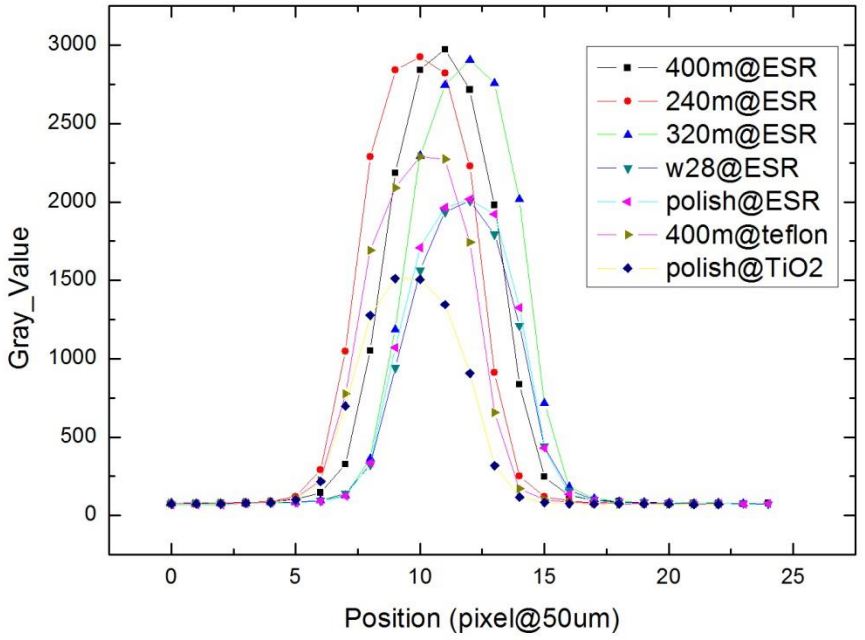
LYSO+WLSF irradiated by MXS and readout by PD

Light-collection optimization

- The output of LYSO highly relies on surface grinding method.

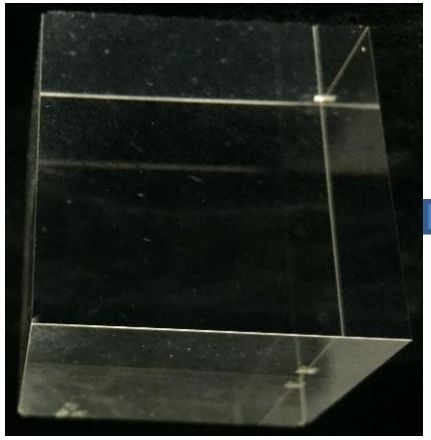


LYSO irradiated by MXS and readout by PD



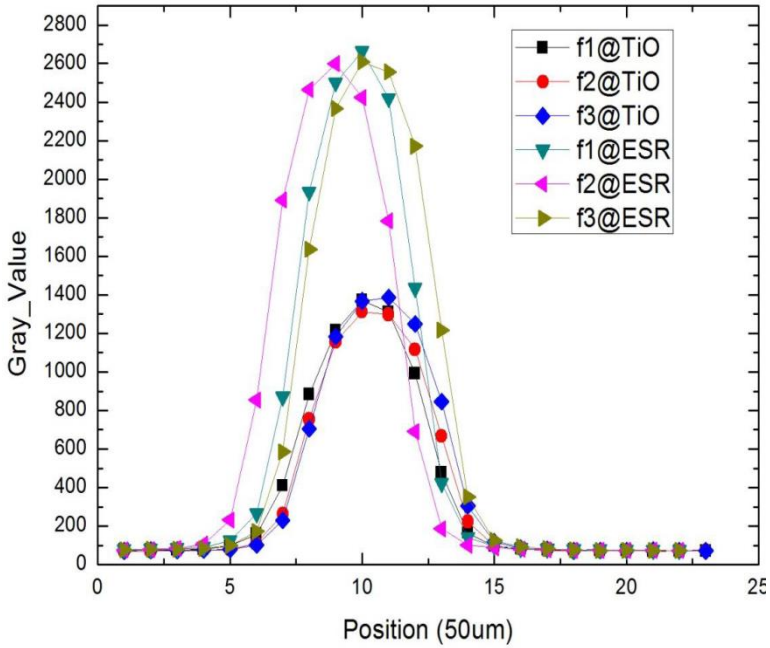
LYSO+WLSF irradiated by MXS and readout by PD

Light-collection optimization



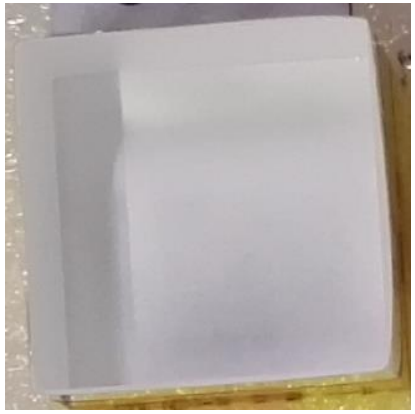
LYSO cube polished on all six sides

LYSO cube grinded on 5 sides and polished on 1 side



LYSO+WLSF irradiated by MXS and readout by PD

Titanium dioxide (TiO2) coating



ESR film reflector

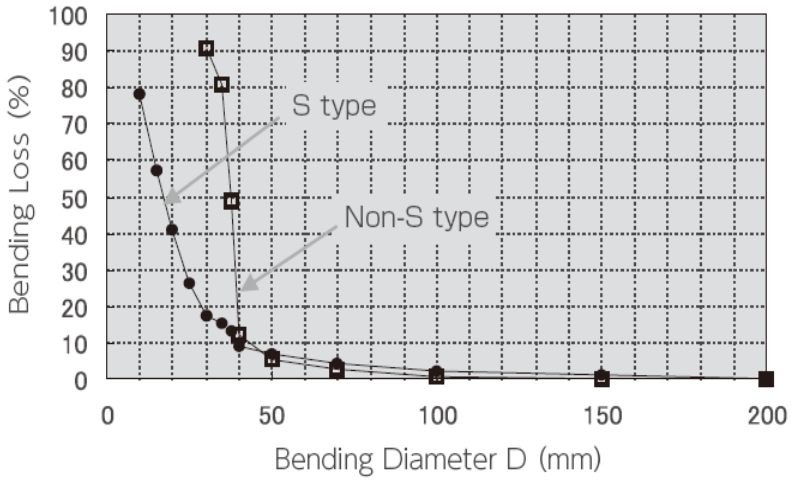
Intensity of LYSO+WLSF cell output is increased by ~100%.

Wavelength shifting fiber

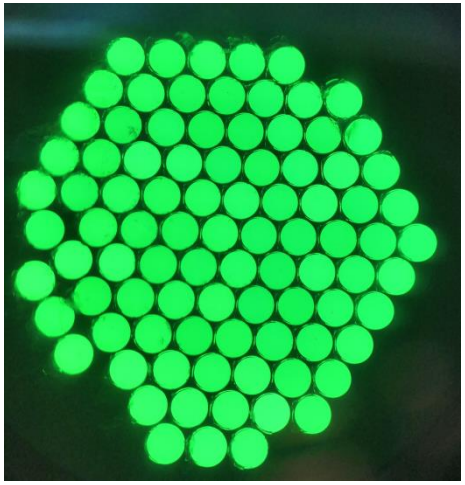
Y11(200)M,0.3mmD

↓

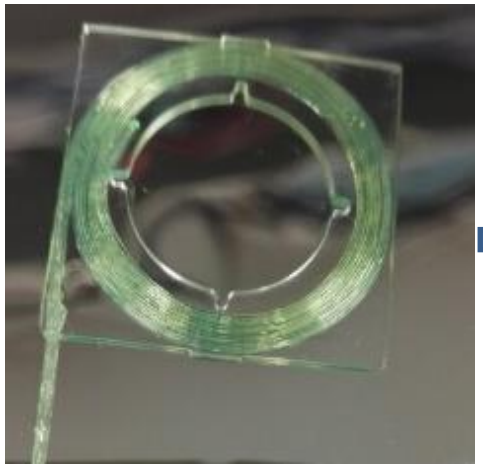
Y11(200)MS,0.3mmD



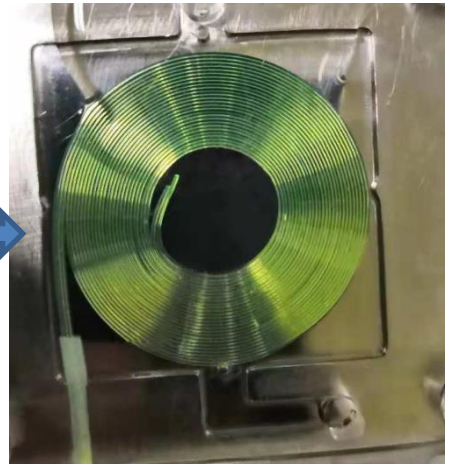
S type (S) is mechanically stronger .
The attenuation length of this type is nearly 10% shorter than standard type.



Fiber polishing before making spirals



3 circles

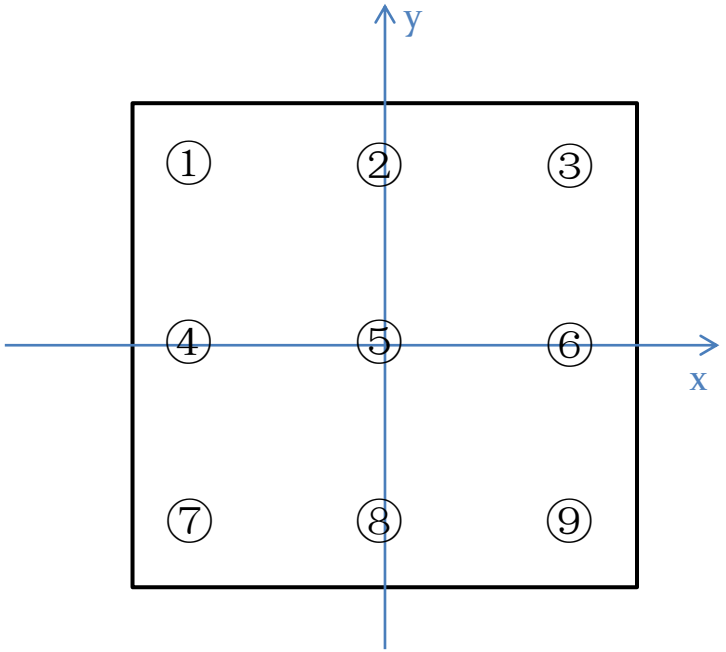


9 circles

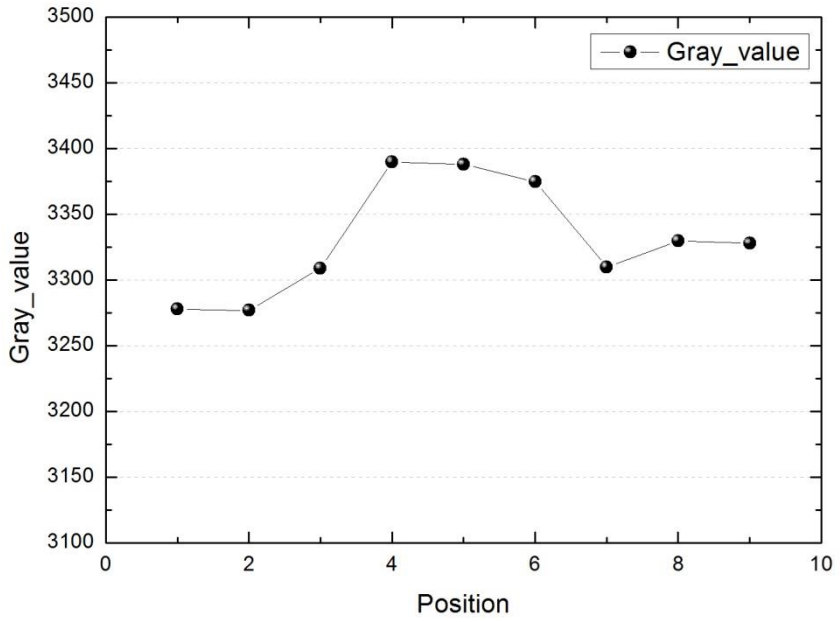
In our test, significant drop of L.O. in S type is found. So number of spiral circles is increased to 9 to guarantee high L.O. in the new prototype. Final decision will be made with further tests and comparison

The uniformity inside LYSO

- The ratio of maximum to minimum output is 1.034:1



From crystal bottom view



LYSO+WLSF irradiated by MXS and readout by PD

Irradiated from the bottom of crystal

The uniformity of LYSO+WLSF(1)

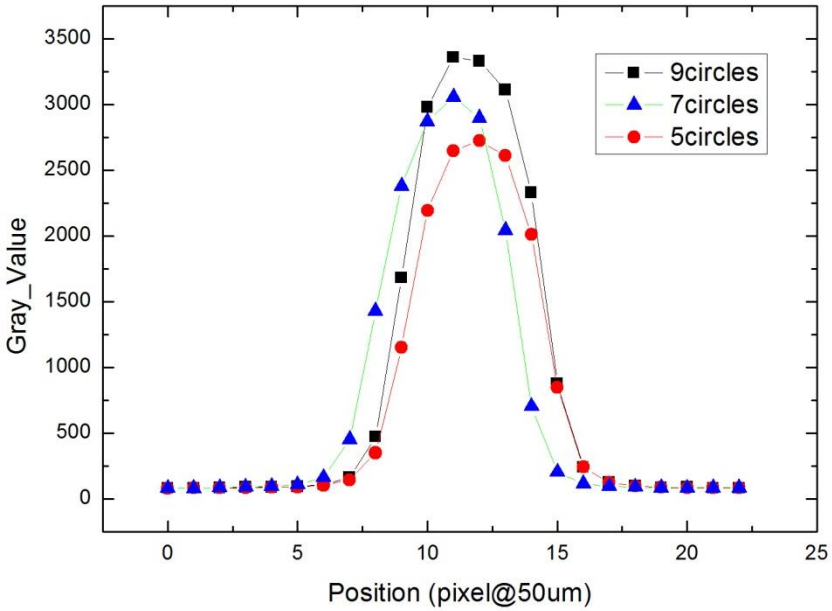
- The uniformity of the LYSO+WLSF may be controlled under ±15%

➢ Making WLSF to different circles

➢ LYSO surface treatment

➢ The crystal and WLSF can complement each other

➢ Reduce WLSF wear

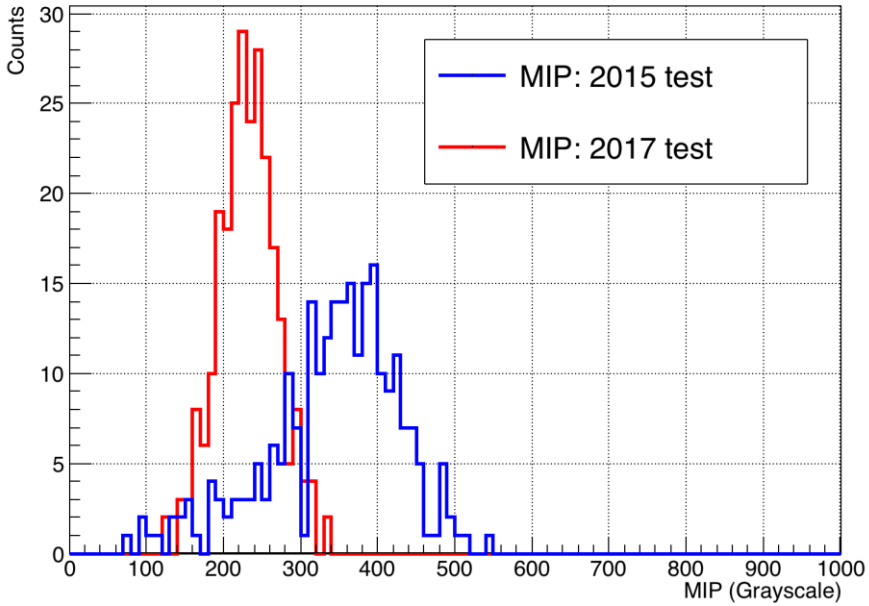


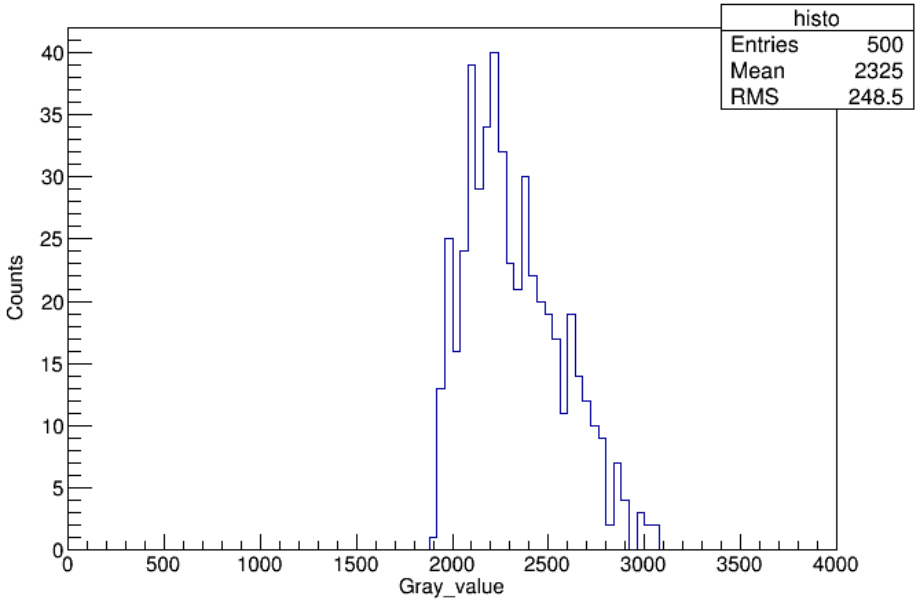
LYSO+WLSF irradiated by MXS and readout by PD

New mold for WLSF spirals

The uniformity of LYSO+WLSF(2)

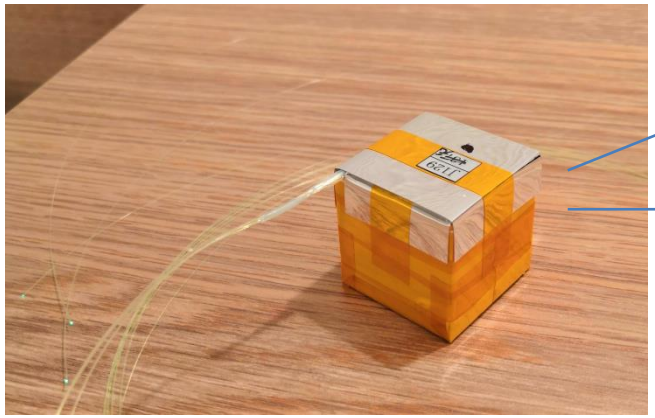
- 2017:strict selection criteria of fiber spirals(500 ps.)
- 2018:no screening, removed damaged fiber(600 ps.)
- Uniformity between crystals can be easily verified by a MXS scanning on the surface of one crystal layer during AIT.





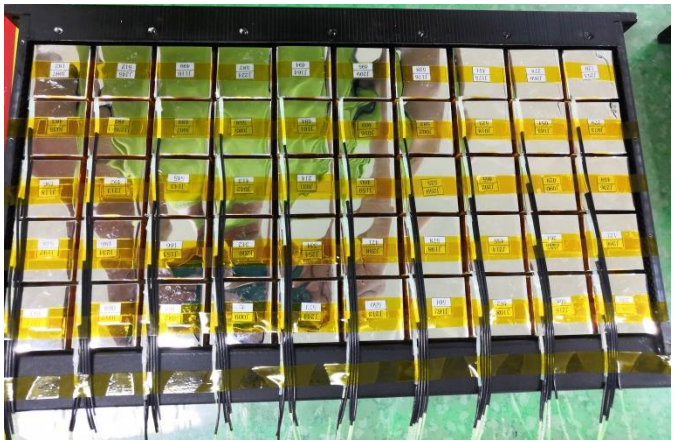
500 LYSO+WLSF cells irradiated by MXS and readout by PD

LYSO encapsulation



One cell of LYSO array

- **inner layer** : 0.065mm thickness ESR film and 0.02mm 3M tape
- **outer layer** : 0.08mm thickness, BC-642 PTFE Reflector Tape and 0.02mm 3M tape

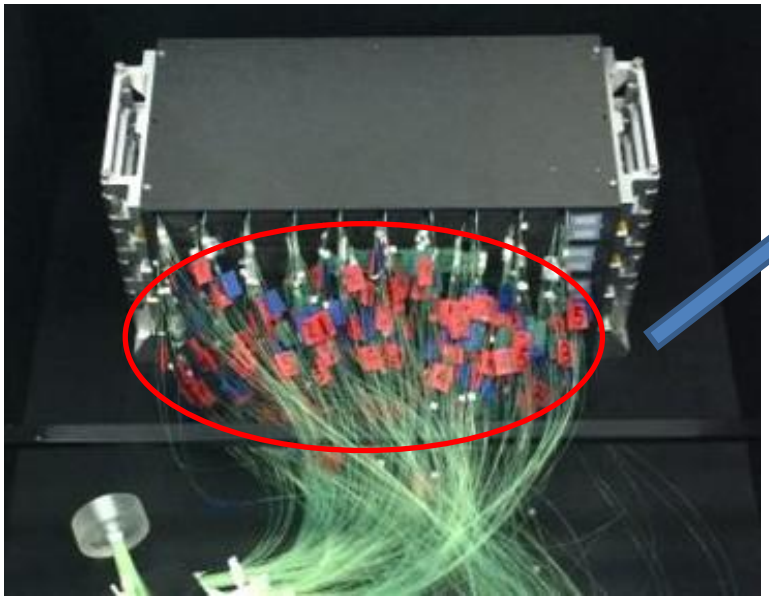


One layer of crystals in prototype

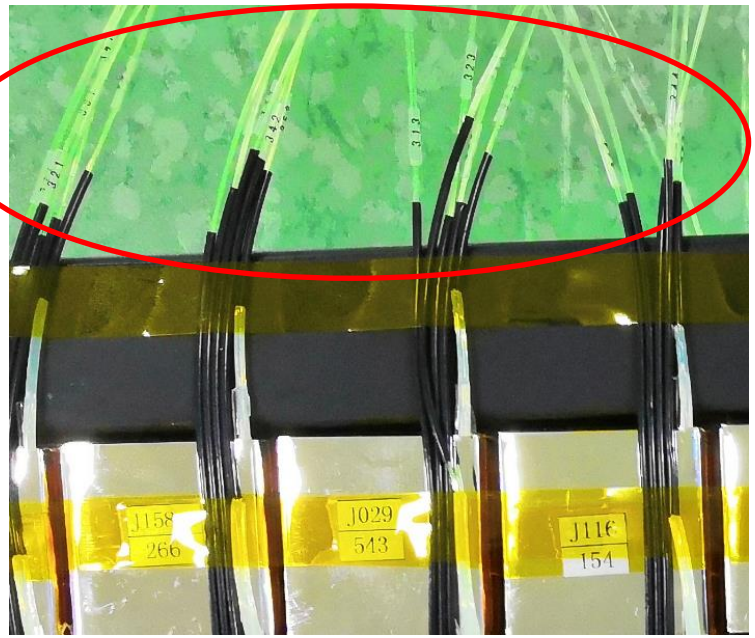
- Avoid infiltration of Silicone Elastomer which is filled in gaps
- Reduce friction between ESR and LYSO roughed surface.

Fiber tag

- The capillaries with mark are placed on three fibers of a LYSO cell.
- The three fibers are cut into different fixed lengths.
- The fiber can be identified by the mark combined with the lengths



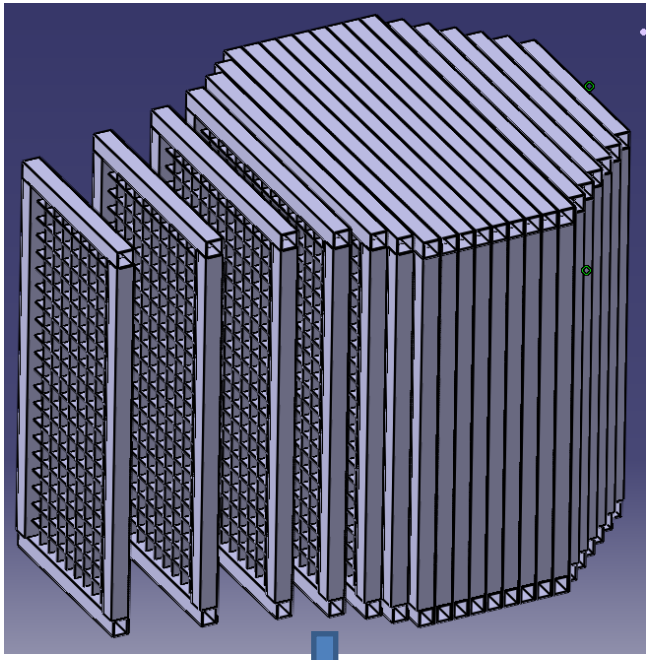
2017 beam test prototype



The capillaries with mark over the fiber

The crystal array assembly

- All fibers routed below the crystal array

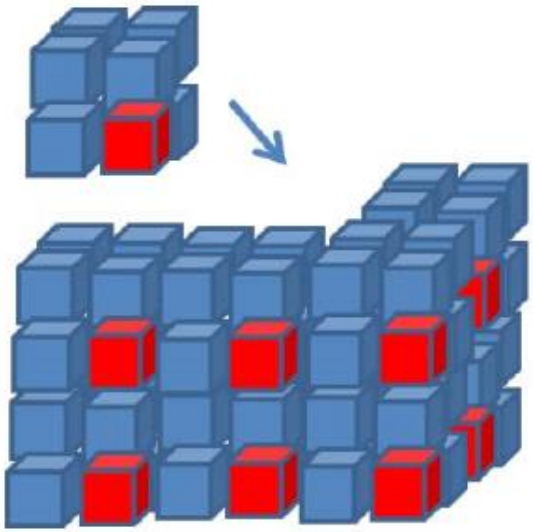


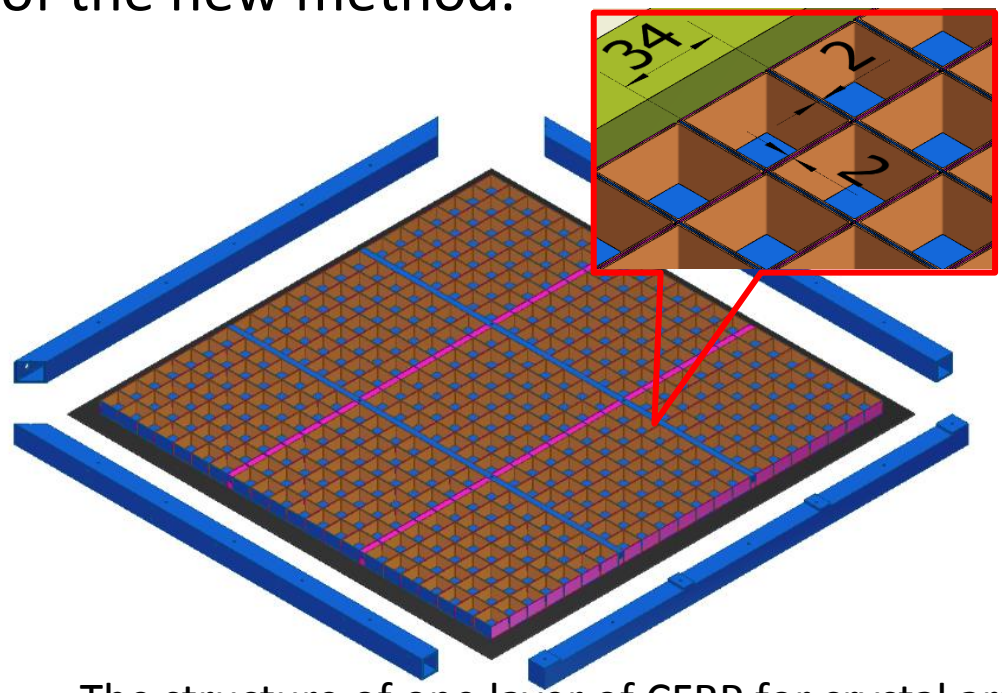
Fiber routing direction

2018 beam test prototype

Hybrid readout with photodiode and WLSFs

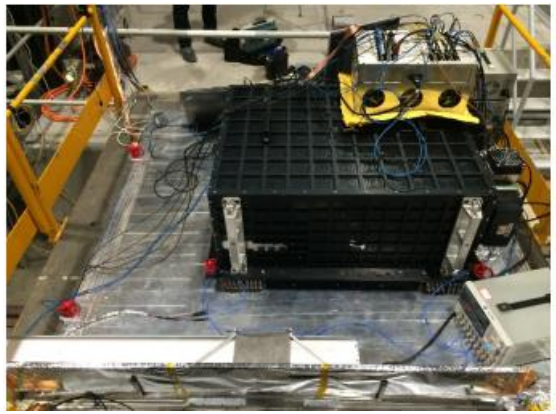
- Gap: In layers≤ 4mm;Between layers≤ 8mm;Depth of grid=20mm
- PD may be coupled on one of the lateral sides.
- Hybrid readout of LYSO crystal has been proposed by Oscar. IHEP will help providing ~30 crystals encapsulated with ESR films for the verification of the new method.



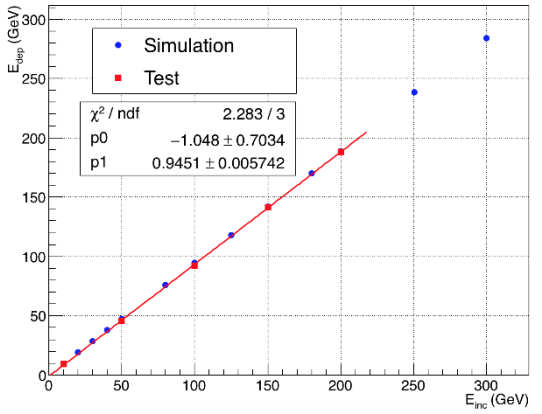


The structure of one layer of CFRP for crystal array

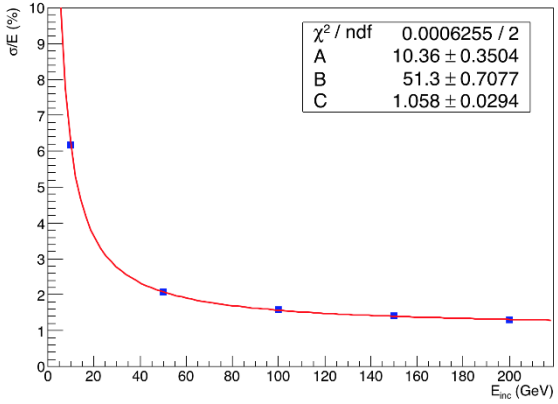
2017 CERN SPS beam test



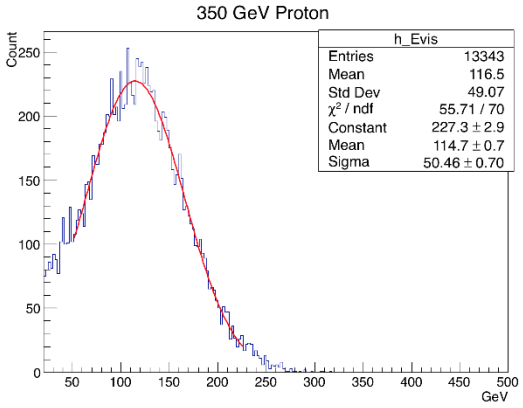
Beam test setup



Energy linearity of electron

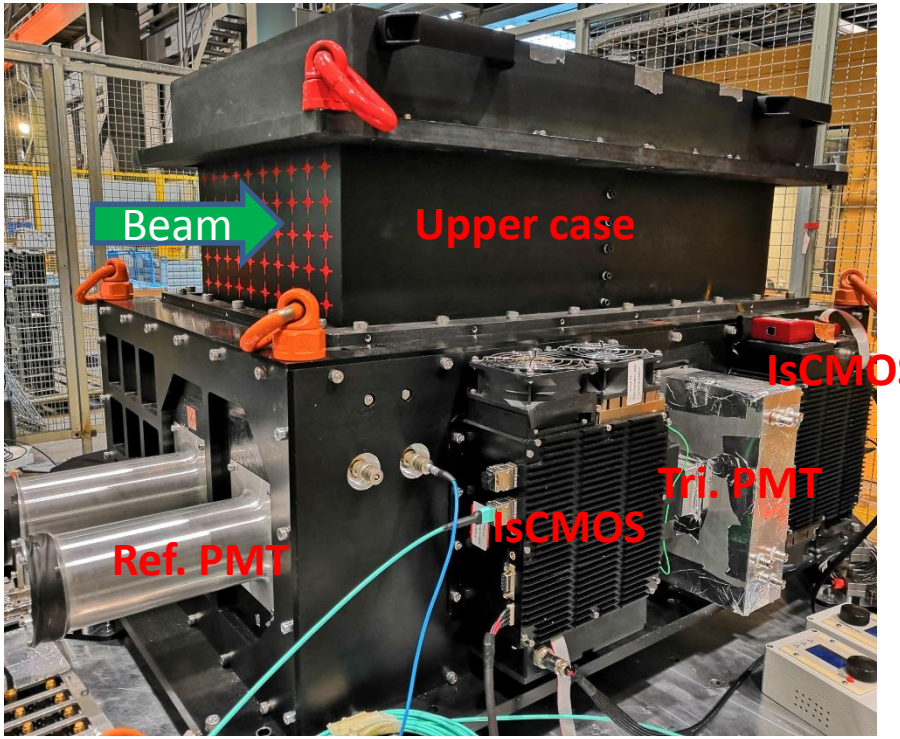


Energy resolution of electron,
1.3%@200GeV



Energy resolution of proton,
44%@350GeV

2018 CERN SPS beam test



The third CALO prototype

- ✓ Verify the energy resolution of proton
- ✓ Verify effect of light-collection optimization
- ✓ Verify some technical improvements and schemes about LYSO encapsulation, WLSF coupling, fiber tag, array assembly, etc.

Summary

- ✓ Detailed design on crystal encapsulation and fiber routing is undergoing and being verified in prototype.
- ✓ Various test method during development and AIT has been proposed.
- ✓ Verification of fiber routing and labelling will be implemented in the next months on a 1:1 scale prototype.
- ✓ New hybrid readout method is being proposed.