ECAL Status Report

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Outline

1 Scintillator strip optimization

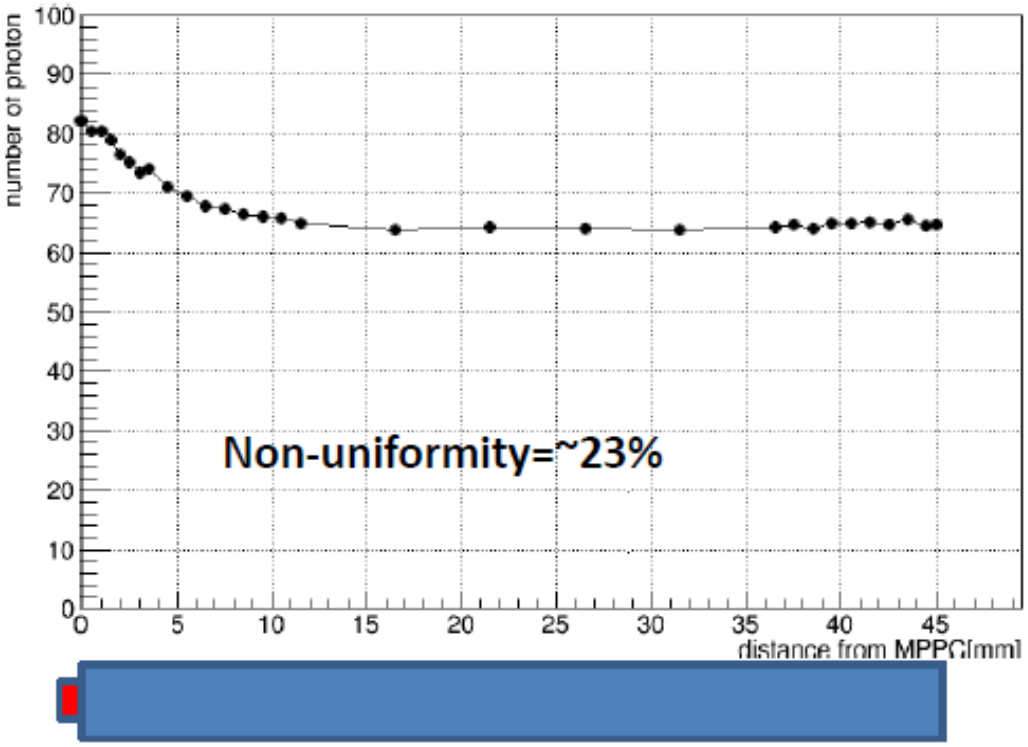
2 SiPM response curve study

3 Test of readout electronics for ECAL prototype

4 Design of cooling system

5 MC optimization

1 Baseline design of ECAL readout unit



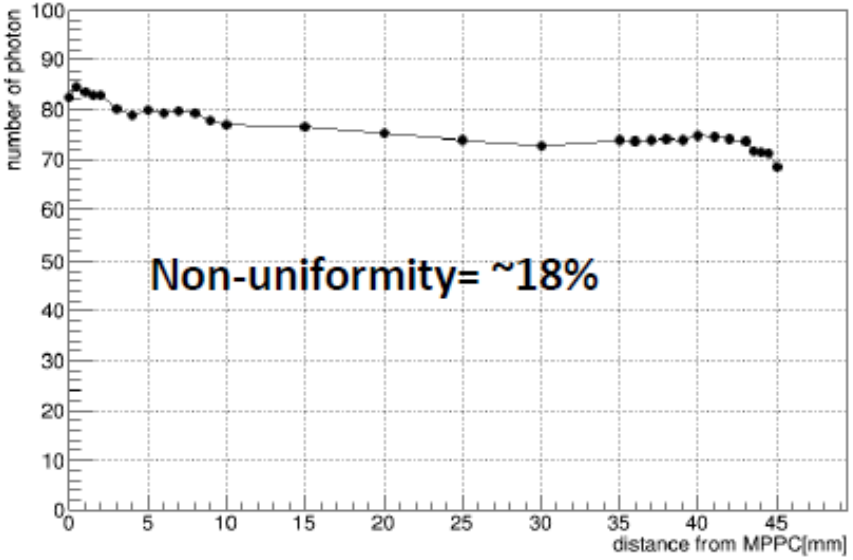
Scintillator strip： 5mm*45mm*2mm

Baseline design of the CEPC ScW ECAL readout structure:

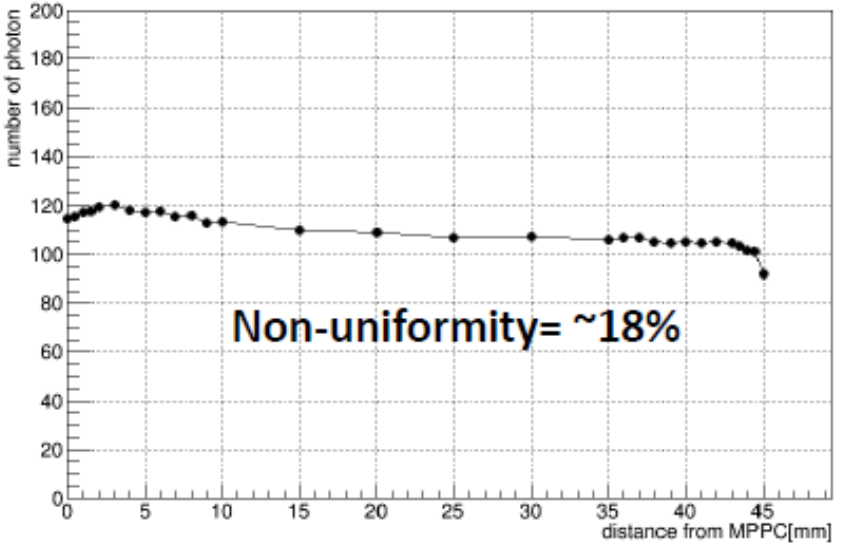
1 Peaky structure close to SiPM

2 Dead gap caused by SiPM

Scintillator structure optimization



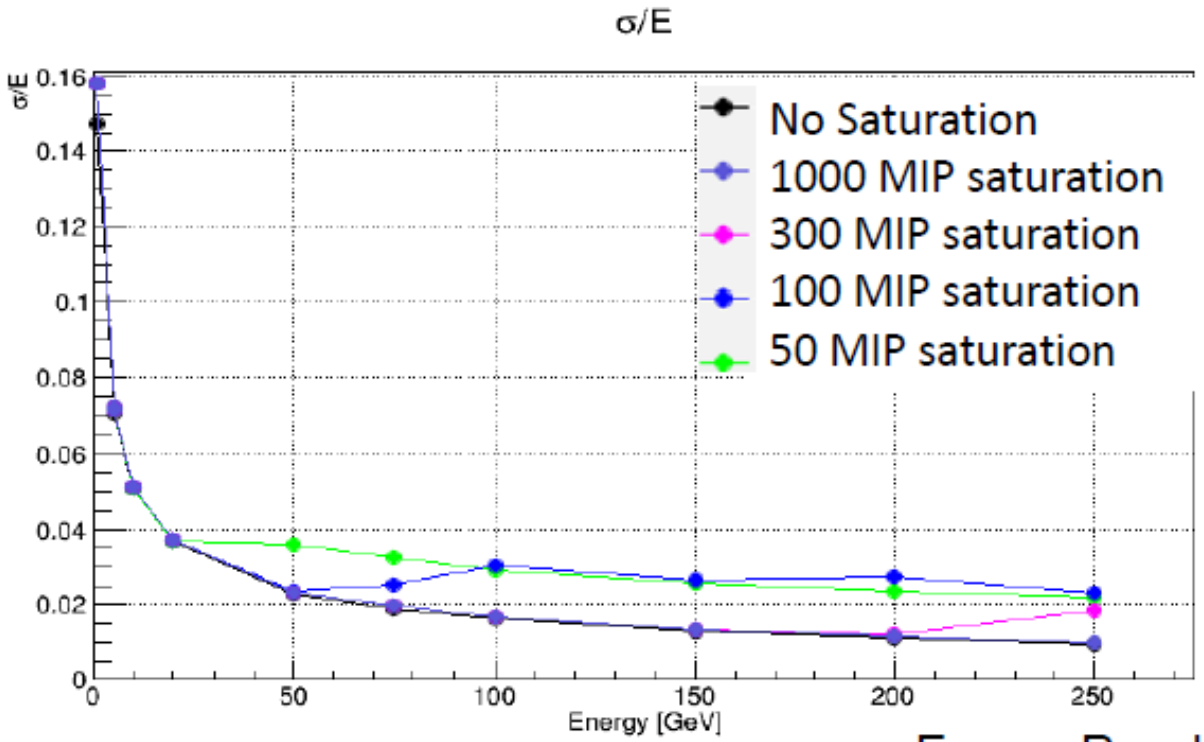
Strip with five rough surfaces



Strip with a hole to mount sipm

Next: **Combine two methods to improve peak structure and dead gap of the baseline design.**

2 Saturation effect on energy resolution

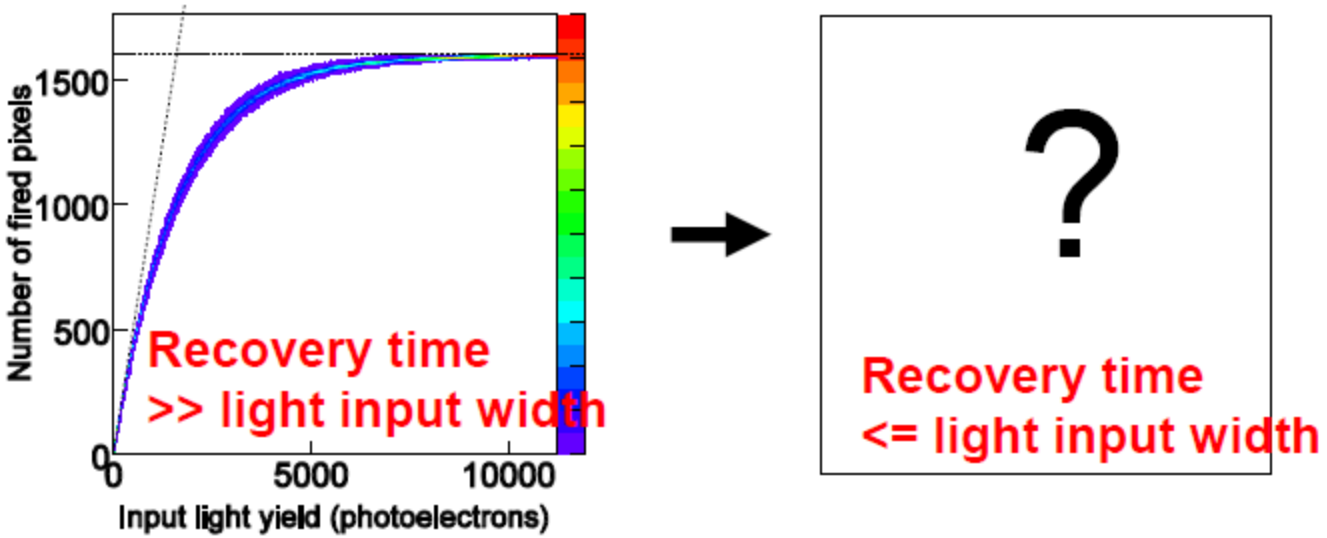


Energy Resolution

Photon， Cell Size 5x5mm
(W:3,Air:0.5,Scintillator:2,Air:0.5,PCB:2,Air:0.5)*50

SiPM Dynamic range

- The SiPM is a non-linear device, because one pixel can detect one photon at once.
- For a short light pulse input, response to input light can be theoretically calculated as
  $N_{\text{fired}} = N_{\text{pix}}(1 - e^{-N_{\text{pe}}/N_{\text{pix}}})$.
- However for the ScW ECAL, it is not the case !
  Since recovery time is order of a few ns, one pixel can detect a photon several times.



Expression of SiPM behavior

$$N_{fire} = N_{pix}\,(1 - e^{-\epsilon N_{in}/N_{pix}}) \qquad (1)$$

N_{fire}: the number of fired pixels,
N_{pix}: the number of pixels this SiPM has,
ε : photon detection efficiency(PED),
N_{in} : the number of incident photons.

This equation explains the saturation phenomenon of SiPM: the charge of each pixel is released only once in an event by photons so that some multiple hits on a pixel are counted as one hit.

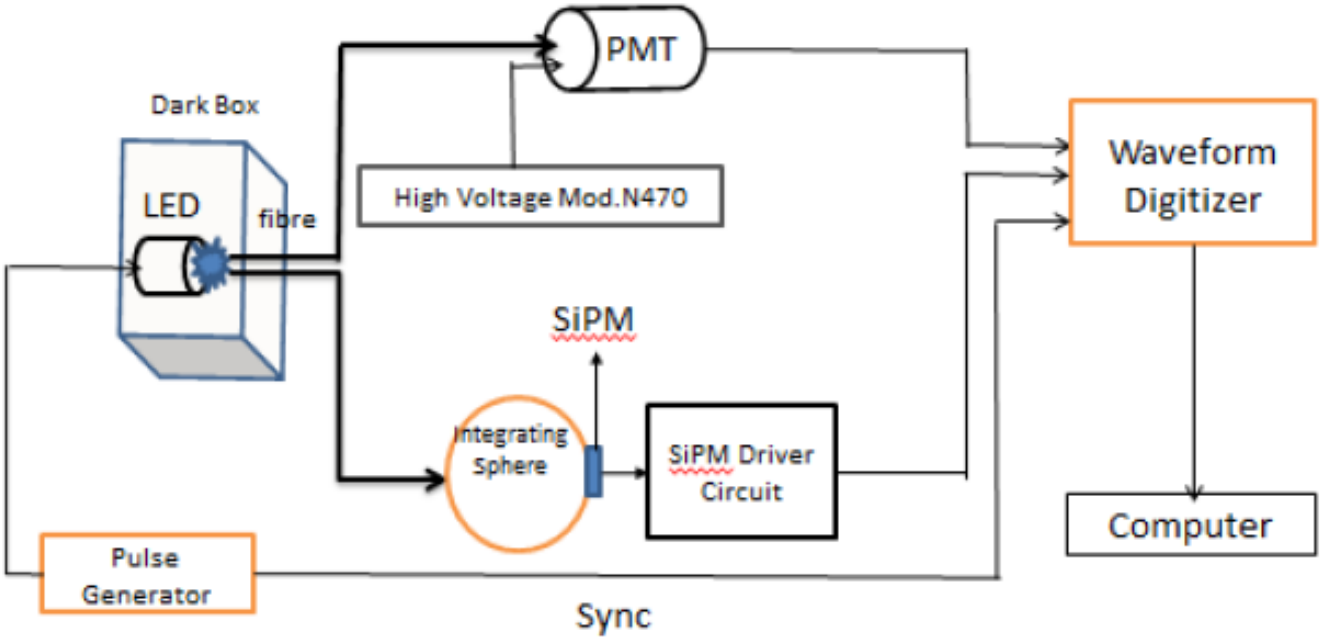
$$N_{fire} = N_{eff}(\,1 - e^{-\epsilon N_{in}/N_{eff}}\,) \qquad (2)$$

N_{eff}: the effective pixel number of pixels this SiPM has.

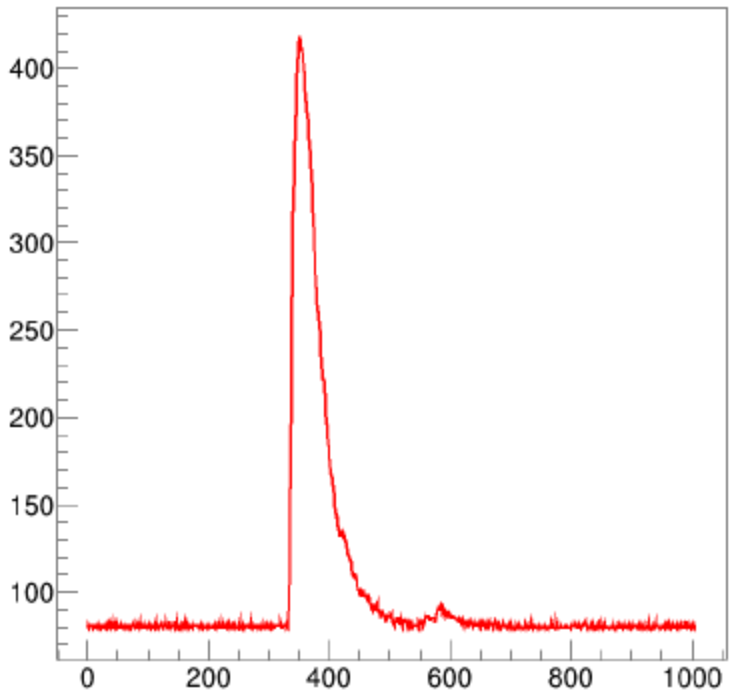
When the recovery time of each cell of SiPM is faster than the duration of one event, some of cell will contributing to an signal more than once. It makes the N_{pix} greater than the real number of pixels effectively.

N_{eff} functions as a fitting parameter when this equation is fitted to real data.

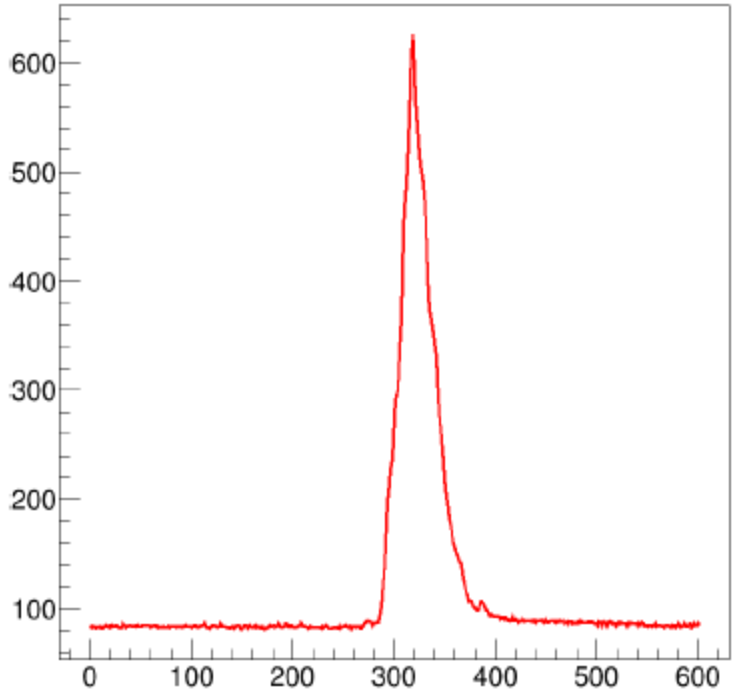
Schematic diagram of measurement



Waveform of SiPM

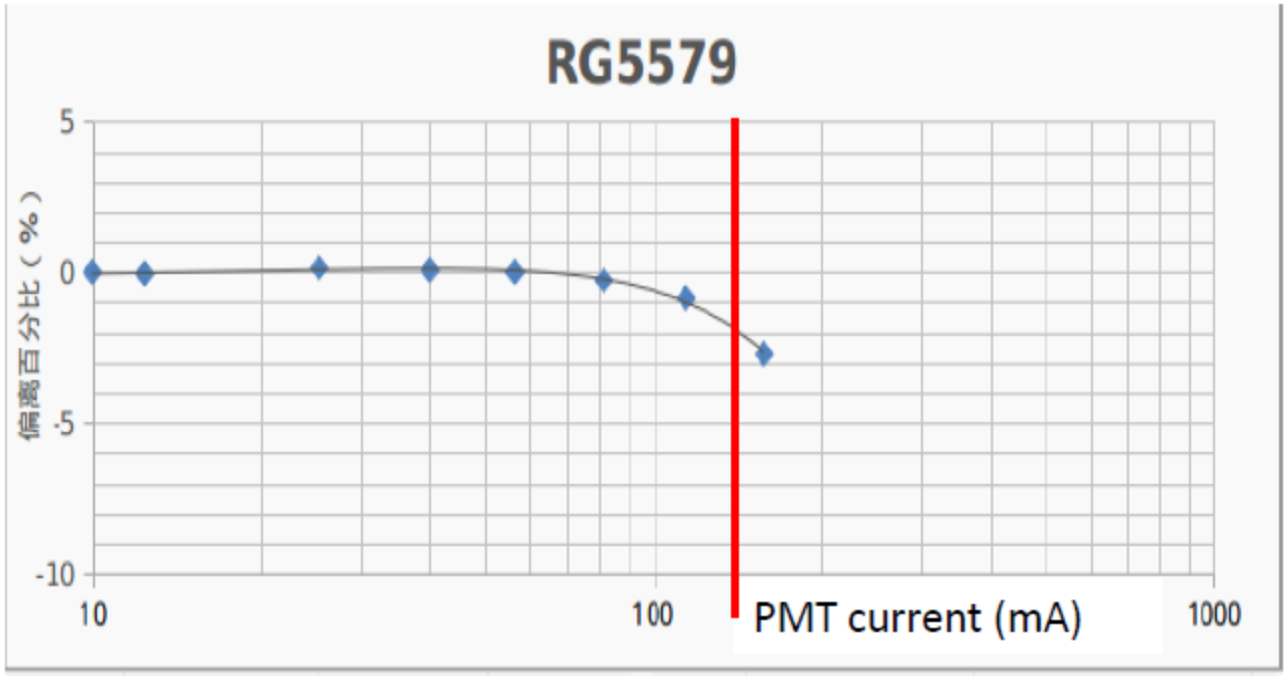


Scintillator coupled with SiPM + Cosmic ray



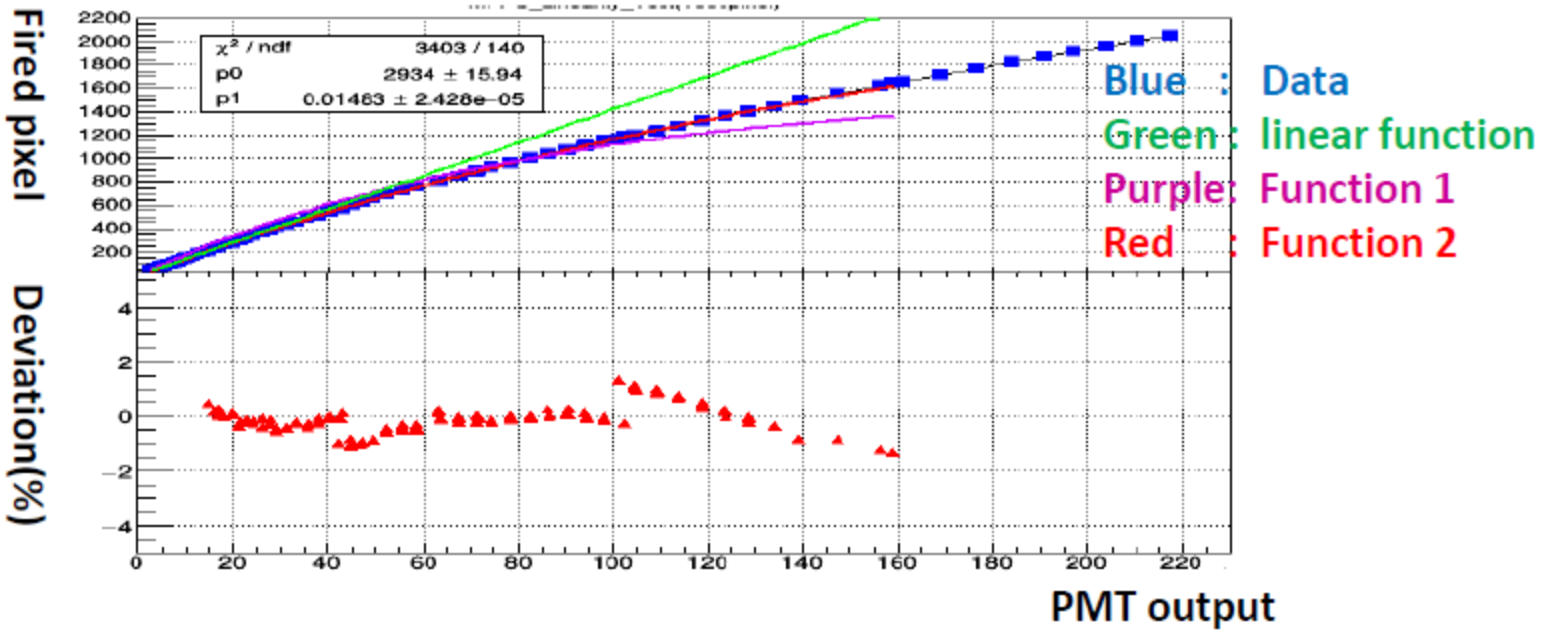
LED+Integrating Sphere + SiPM

PMT linearity Calibration



The linearity of calibration PMT used in measurement < 2%.

Response curve of 1600 pixel sipm

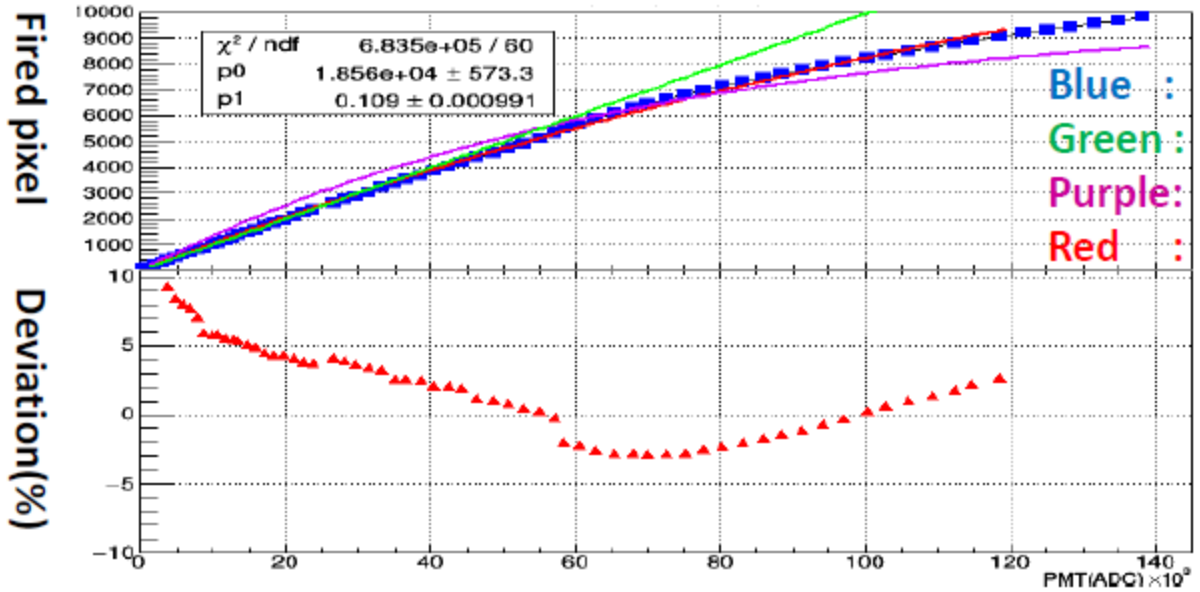


SiPM: S12571-025C

N_{eff} = 2934 >> 1600

The behavior of 1600 pixel SiPM can be described by function 2 very well, the deviation of experimental data and fitting function is less than 2%.

Response curve of 10000 pixel sipm



Blue : Data
Green : linear function
Purple: Function 1
Red : Function 2

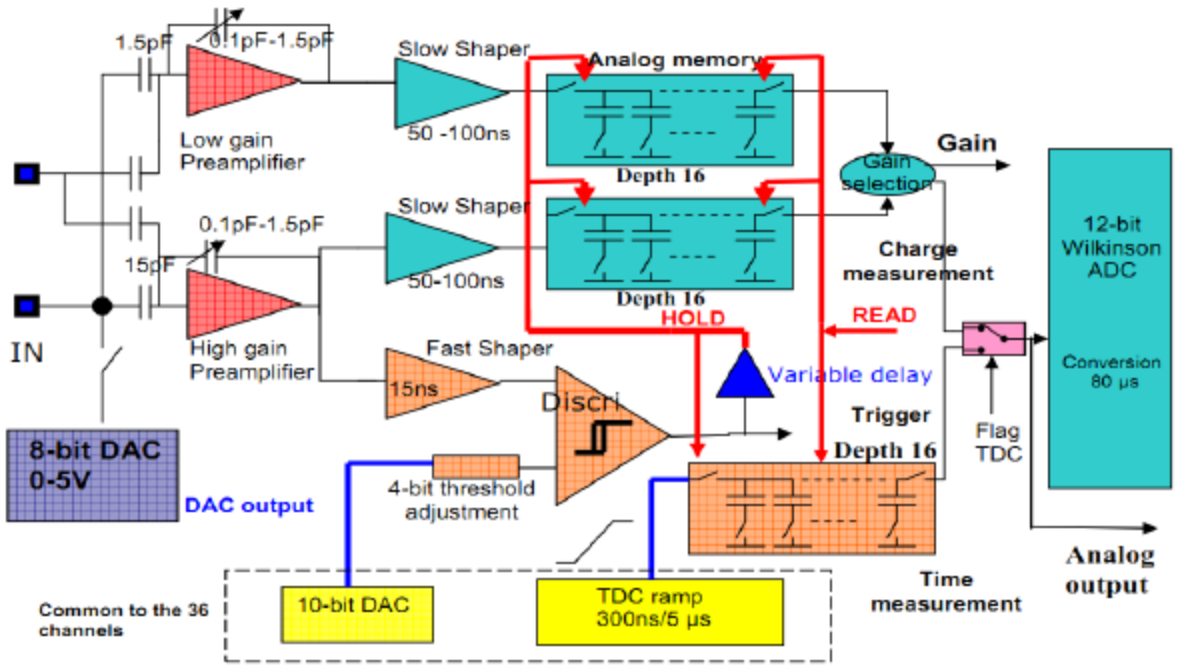
SiPM: S12571-010C

N_{eff} = 18560 >> 10000

The deviation of experimental data and fitting function is larger than 1600 pixel sipm.

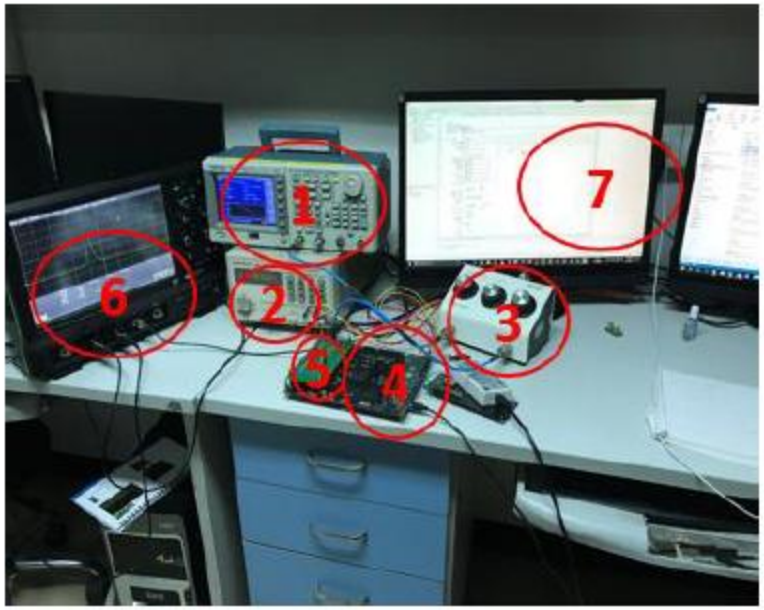
Next: The response curve of 10000 SiPM will input to calorimeter digitization progress to study the influence on energy resolution.

3 Readout electronics of ECAL



Design of SiPM readout system based on SPIROC chip

Physical map of test platform



Test board: SPIROC2b chip was selected

Setup：

1. AFG3252 signal generator
2. LPS-305 linear DC regulated power
3. WAVETEK attenuator
4. SPIROC2b test plate
5. Signal exchange coupling plate
6. HDO6104 1Ghz oscilloscope
7. PC

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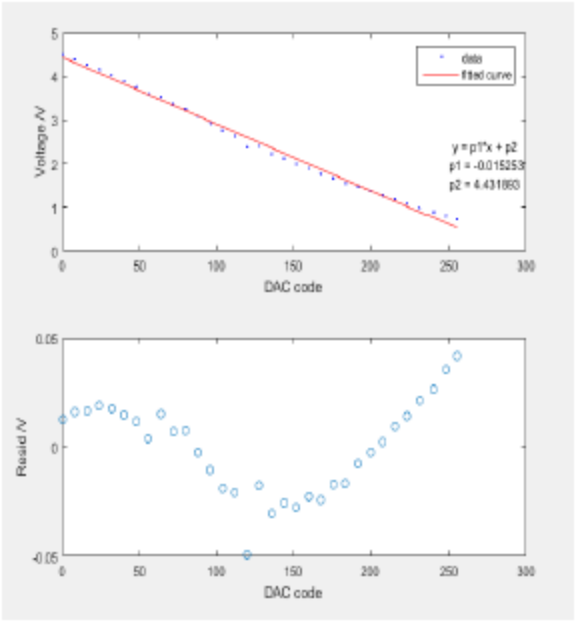
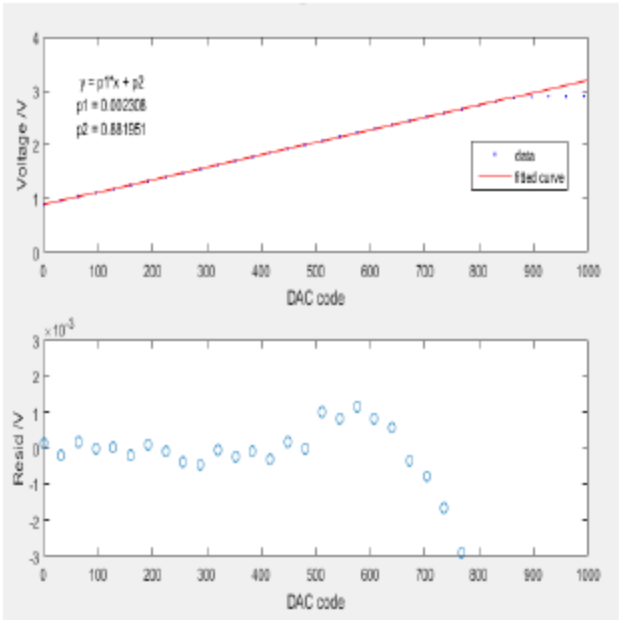
DAC linear testing

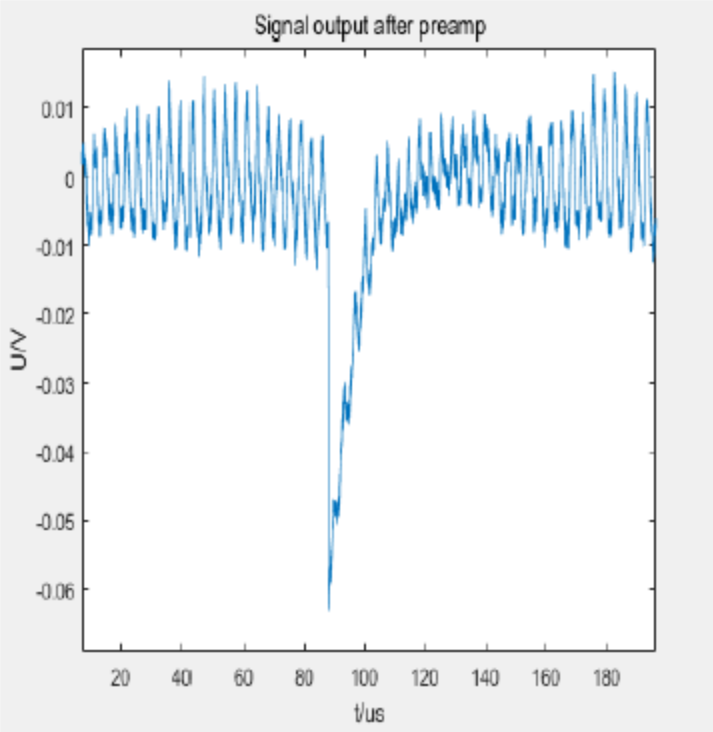
- 8 bit DAC linear test for high voltage：
  - range： 0.5-4.5 V
  - precision: ±5%



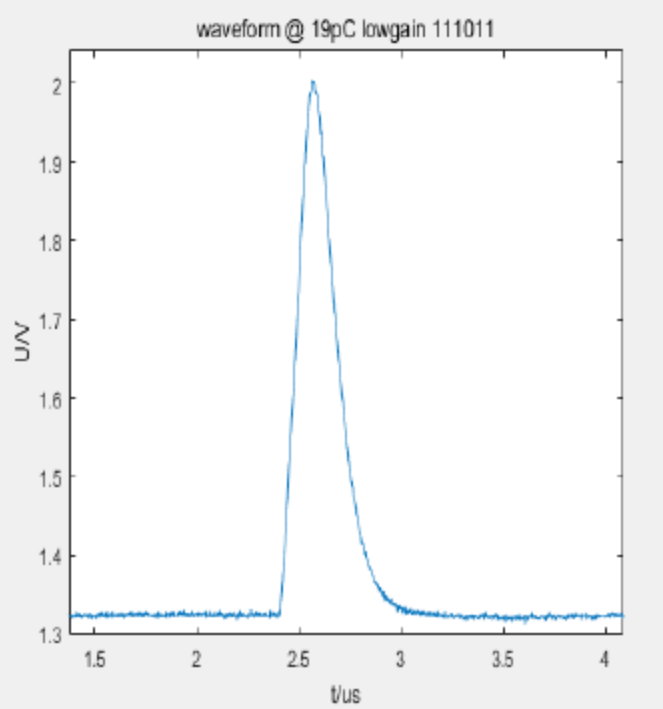
- 10 bit DAC linear test for threshold :
  - range： 1.0- 2.9V
  - precision: ±0.2%



Output from amplifier

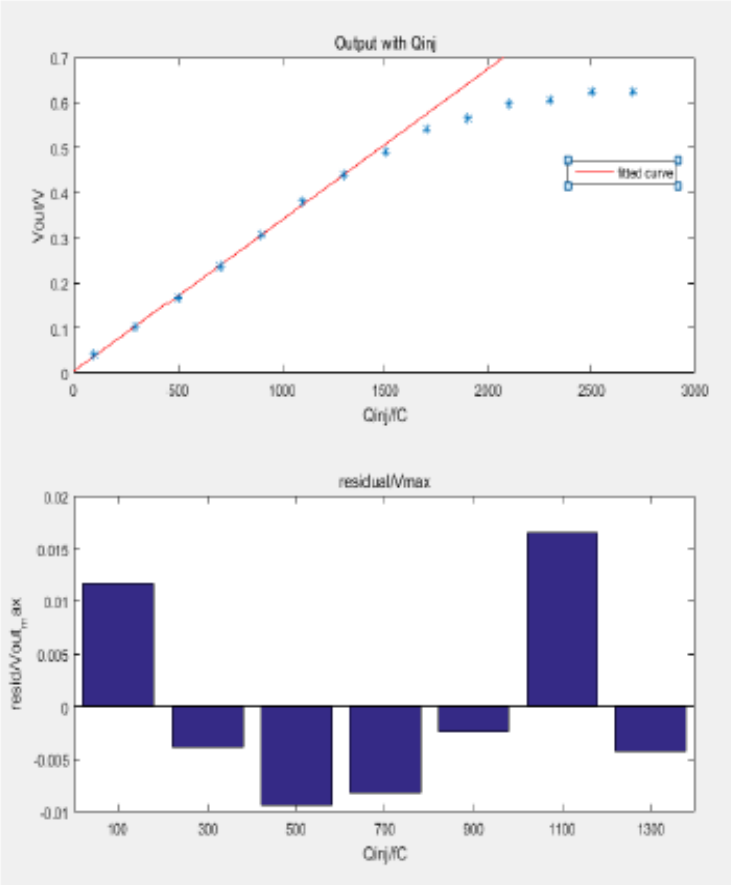


Signal after front-end-amplifier

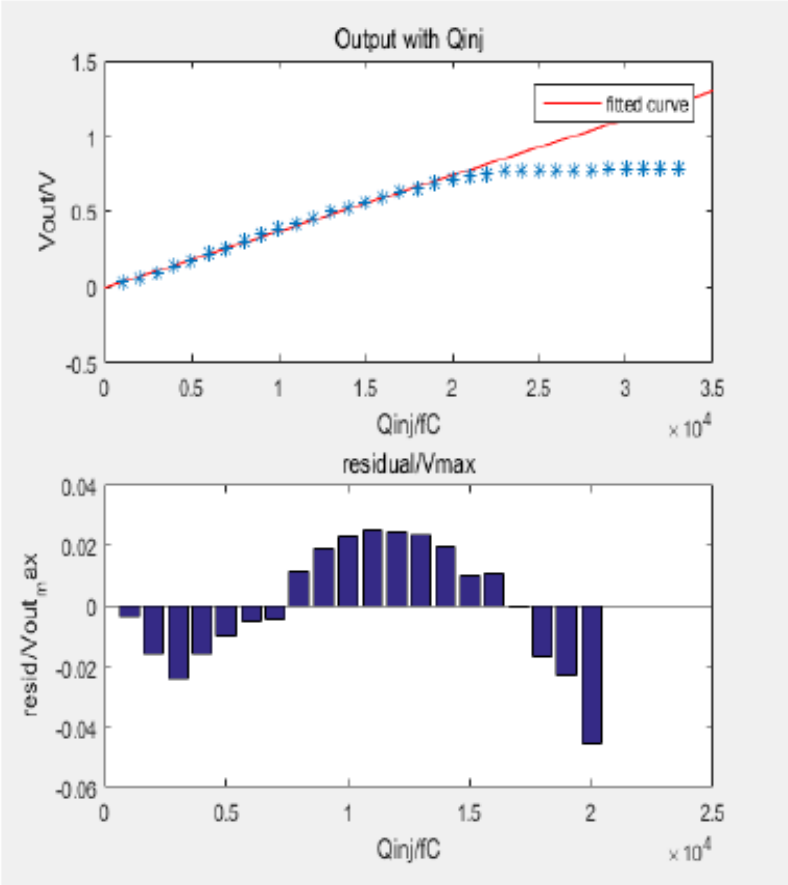


Signal after shaping

Linearity test



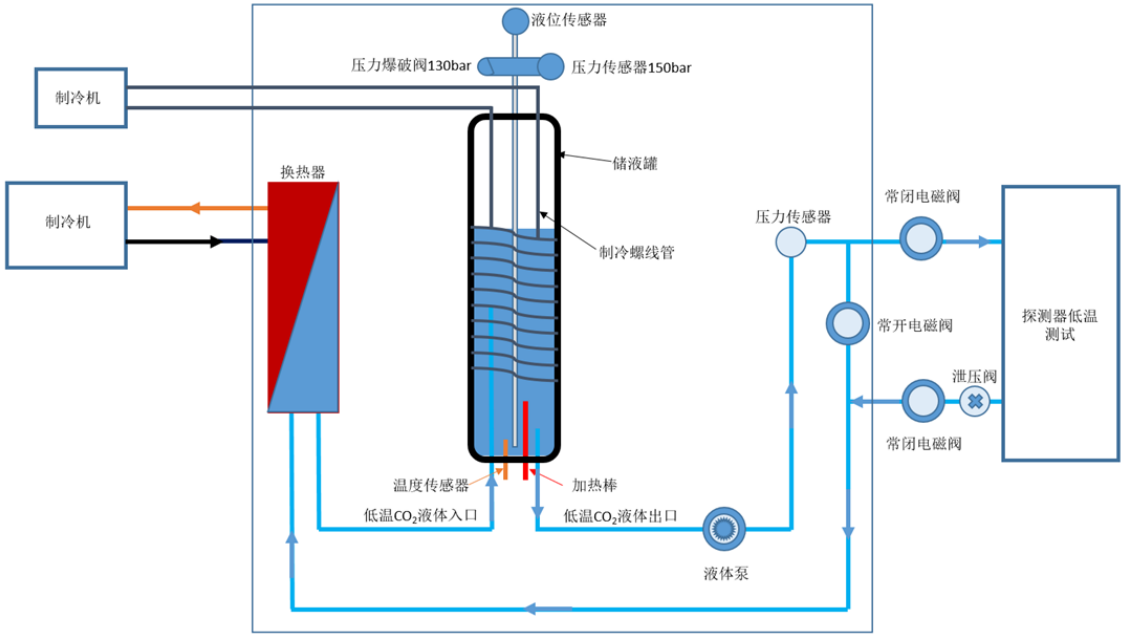
High gain



Low gain

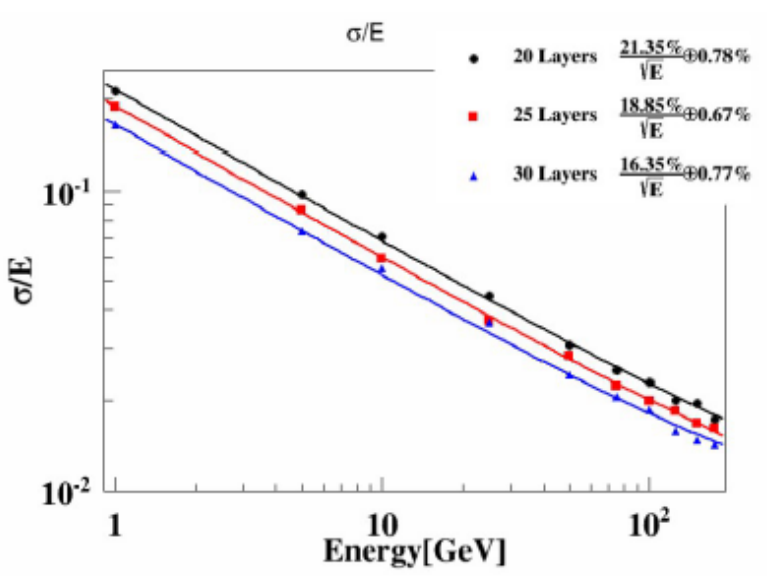
4 Design of cooling system

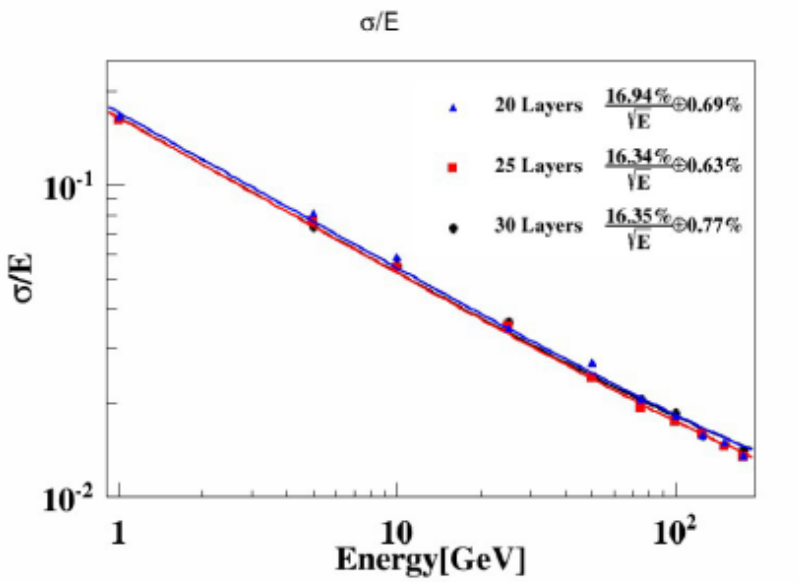
- The structure of CEPC ECAL cooling system has been designed.
- The construction of cooling system ready to start.



5 MC optimization

Longitudinal: #Layer & Si Thickness



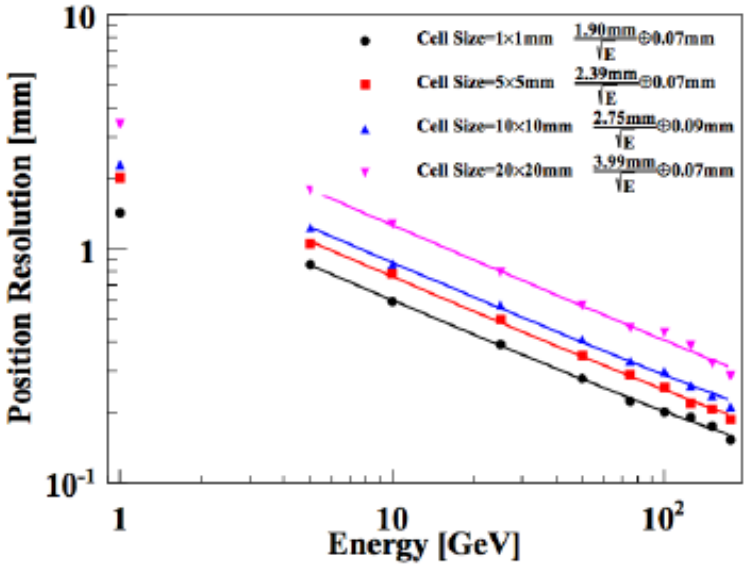


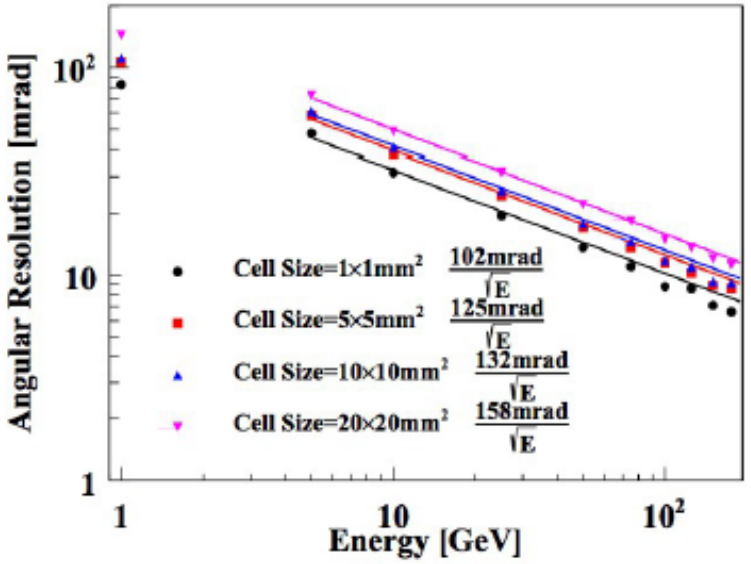
Performance @ Photon with E > 1 GeV:

Energy Resolution is comparable at:

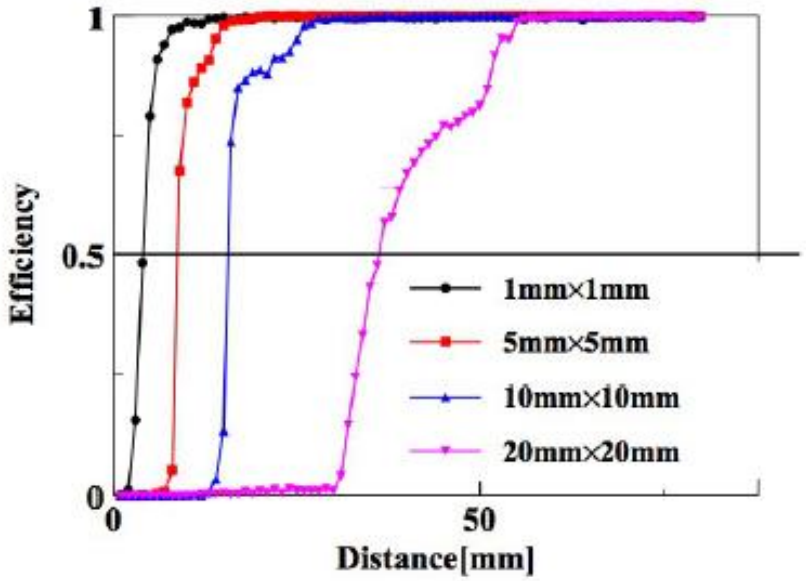
20 * 1.5 mm Si + 4.5 mm W
25 * 1 mm Si + 3.6 mm W
30 * 0.5 mm Si + 3 mm W

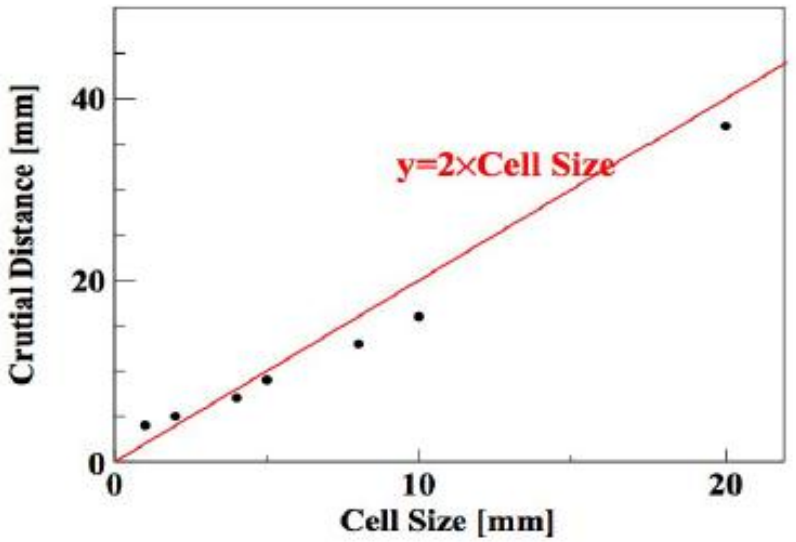
Cell Size: Position/Angular





Separation Power

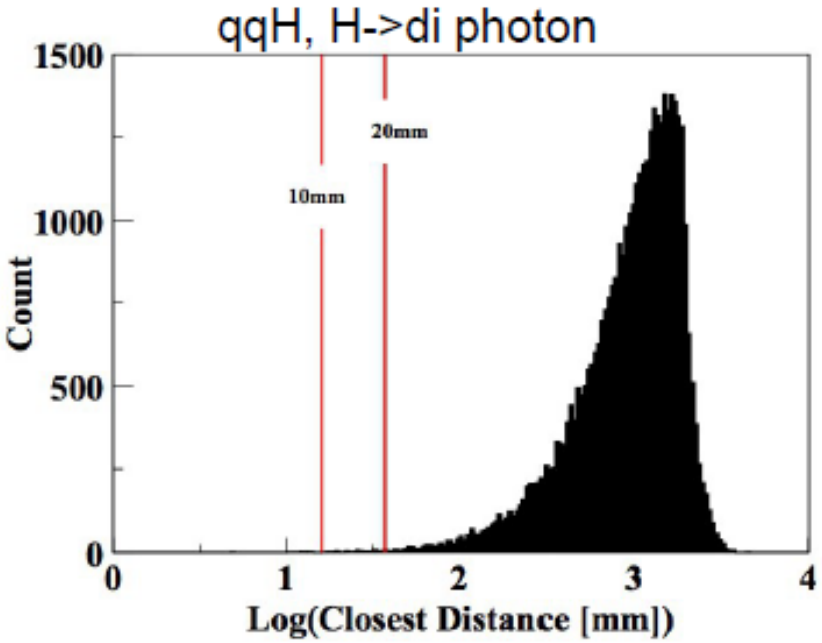




Separation ~ 2 times Cell Size

Phase transition ~ Moliere radius

Impact of Separation



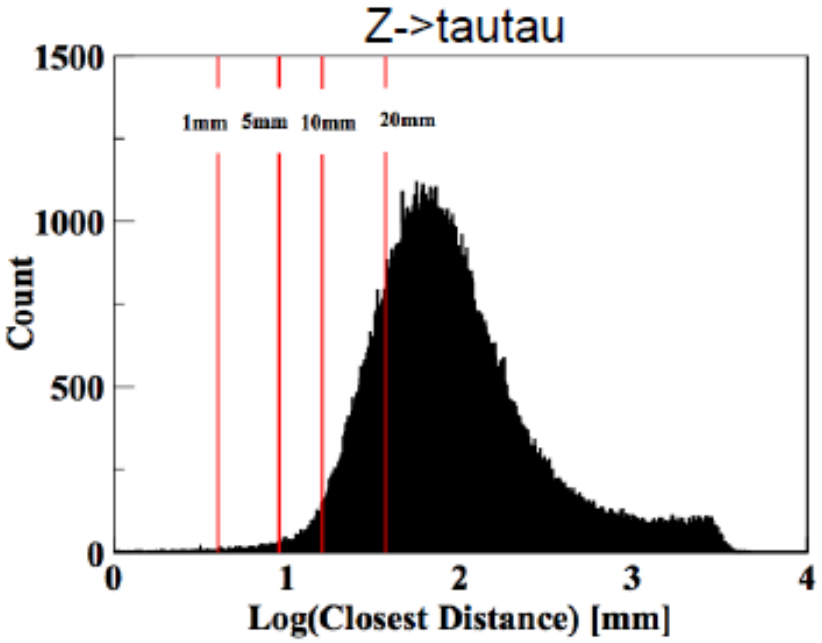


Table 2. Percentage of photons that would be polluted by neighbor particle

Cell Size	Crucial Separation Distance with Arbor	Percentage of H->di photon	Percentage of Z->tautau
1mm	4mm	0	0.827%
5mm	9mm	0	0.486%
10mm	16mm	0.03%	1.96%
20mm	37mm	0.17%	18.4%

Summary

- R&D on ScEcal is on the way
- Thickness & Cell size can be optimized based on the full simulation

Thank you !