

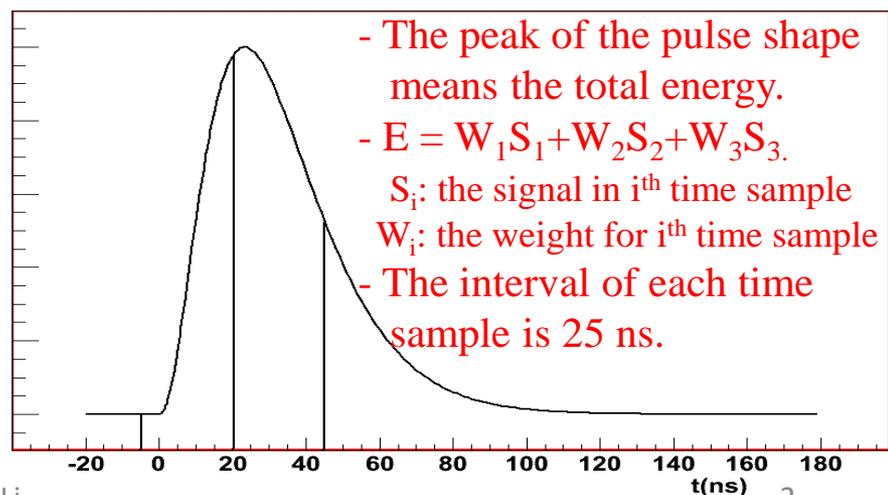
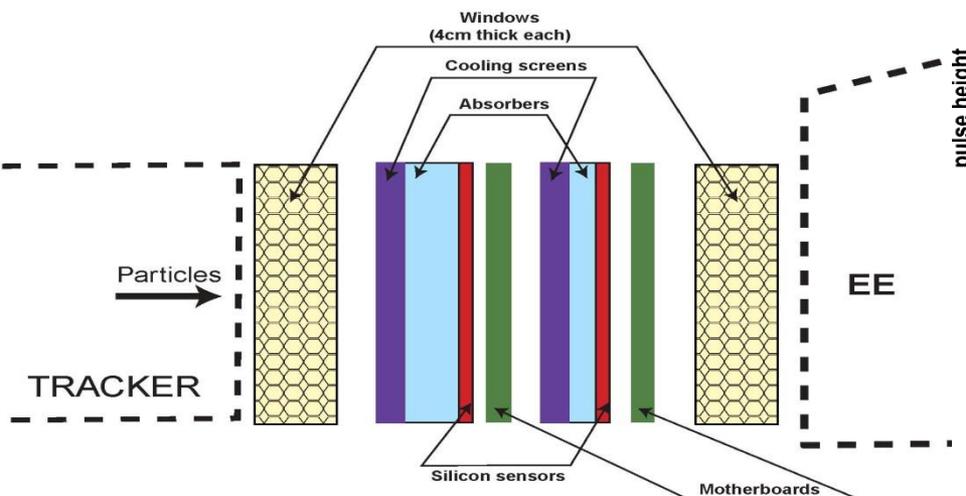
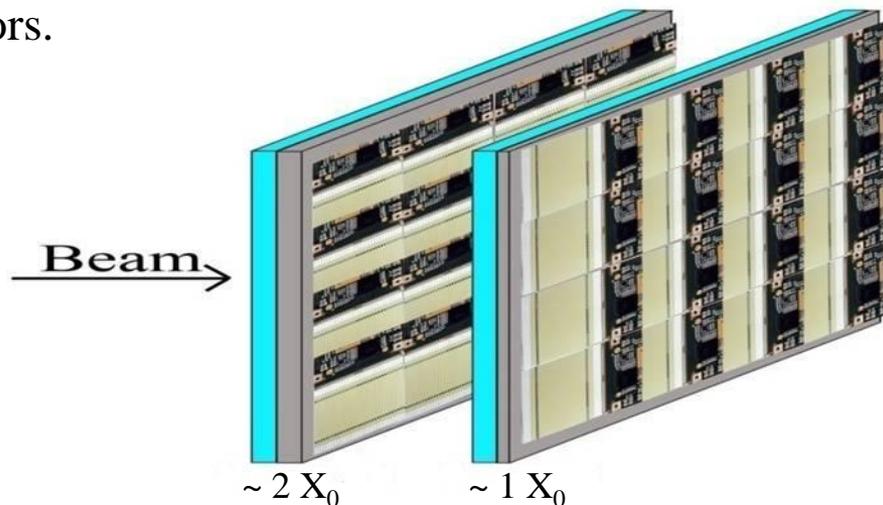
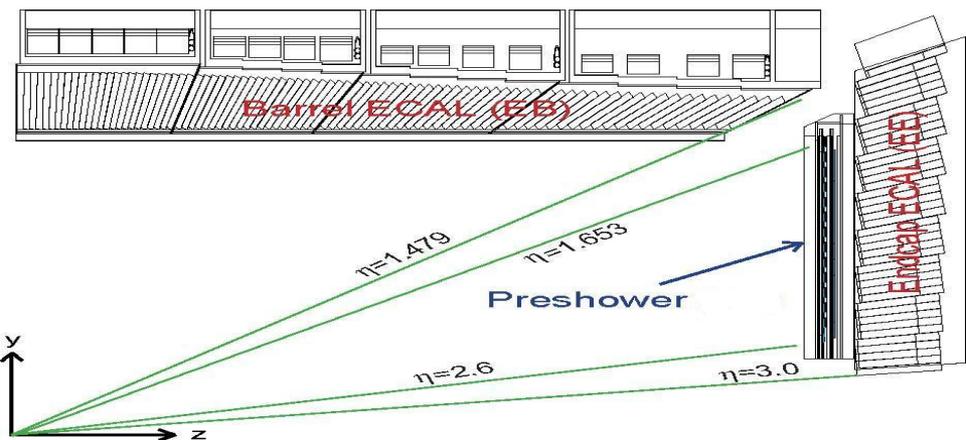


# Performance of CMS ECAL Preshower in 2007 test beam

Syue-Wei Li, Apollo Go, Chia-Ming Kuo  
National Central University, Taiwan  
On behalf of CMS Preshower Collaboration

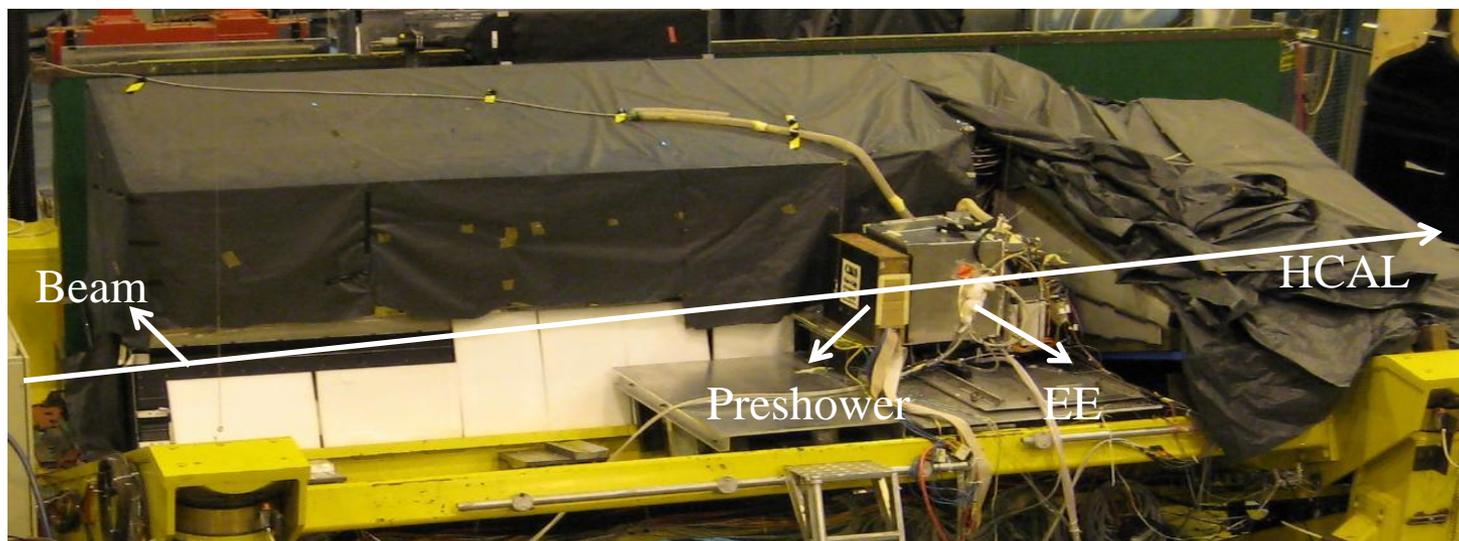
# Preshower

- The purpose of the Preshower is to identify two closely spaced photons from  $\pi^0$  decays (main background of  $H^0 \rightarrow \gamma\gamma$ ) in order to separate these photons from single photons.
- The Preshower, placed in front of the end-cap ECAL, consists of two absorbers (lead,  $3 X_0$ ) and two orthogonal planes of silicon strip sensors.



- The peak of the pulse shape means the total energy.
- $E = W_1 S_1 + W_2 S_2 + W_3 S_3$ .
- $S_i$ : the signal in  $i^{\text{th}}$  time sample
- $W_i$ : the weight for  $i^{\text{th}}$  time sample
- The interval of each time sample is 25 ns.

- A combined beam test of close-to-final prototypes of the Hadron calorimeter (HCAL), the end-cap crystal calorimeter (EE) and the Preshower (ES) detector was performed in the summer of 2007.
- It was the first time we had the full electronics chain (on-detector, off-detector ES-DCC etc.) + XDAQ (integrated into the main CMS DAQ system for the combined beam test) + DQM + DCS etc.
- **Small scale ES operated successfully in realistic conditions.**





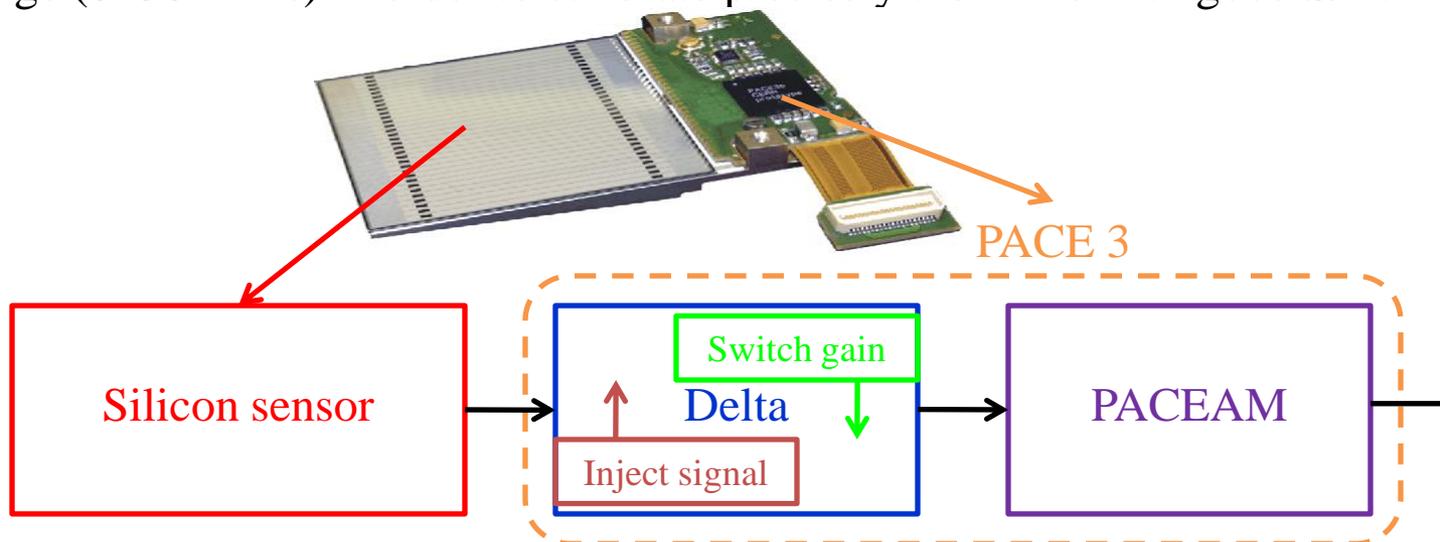
# Outline



- Preshower MIP calibration
  - MIP is the energy unit in the Preshower
  - **MIP is defined as the deposited energy when a high energy  $\mu/\pi$  goes perpendicularly through the sensor**
  - Preshower absolute calibration can only be performed with MIPs
- Preliminary result of combined EE/ES energy
  - Understand the energy resolution with and without ES

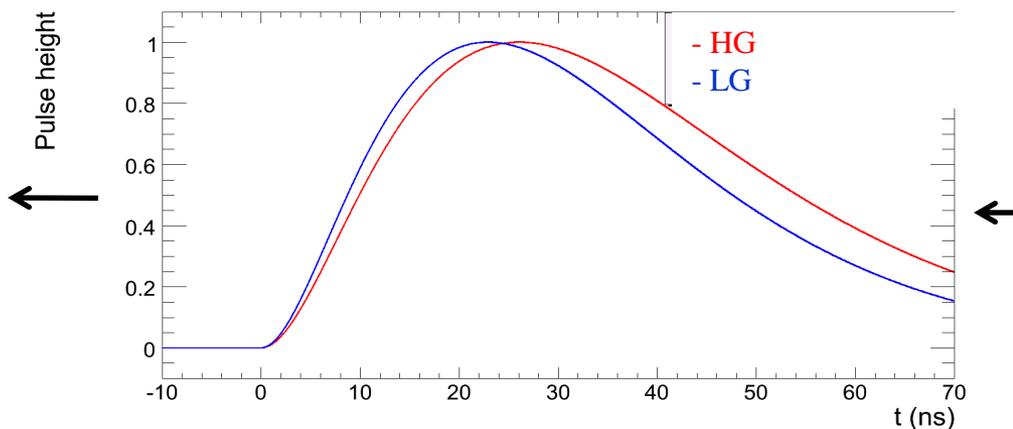
# Preshower operation

The physics operation of the Preshower is in “low gain”. It has higher dynamic range (0~400 MIPs). The Preshower is also designed to operate in “high gain” with limited dynamic range (0~50 MIPs) in order to calibrate precisely the MIPs with good S/N.



From injection result, there is an obvious difference in pulse shape between HG and LG.

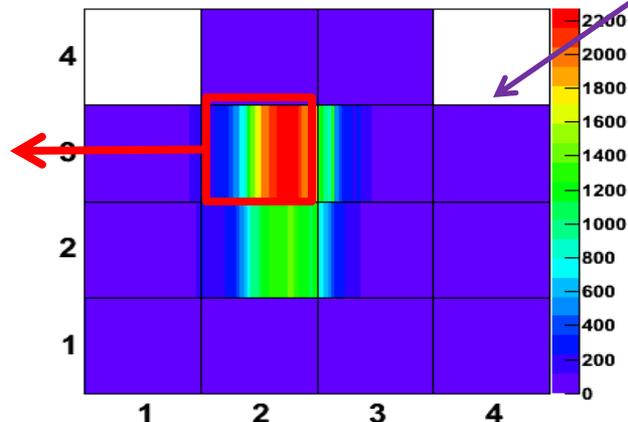
**It shows that we need to calibrate the MIPs in HG and LG respectively.**



- MIP calibration in high gain(HG)
  - Using  $\pi$  data to obtain the pulse shape, the “weight functions”(for reconstructing the energy from the three time samples), and the MIPs
- MIP calibration in low gain(LG)
  - Using the pulse shapes from HG and injection test to deduce the pulse shape in LG and calculate the weight functions
  - Using  $\pi$  data for MIP calibration
  - Using e data to obtain the “correction factor”(see later)

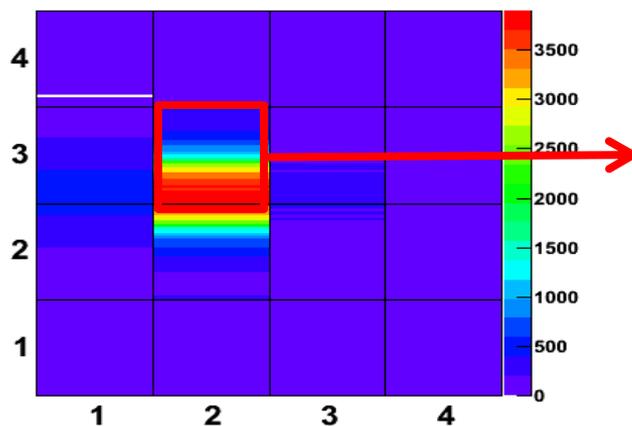
Use this sensor to obtain the pulse shape and the weight functions. Select the most energized strip.

Beam spot in ES 1<sup>st</sup> Plane



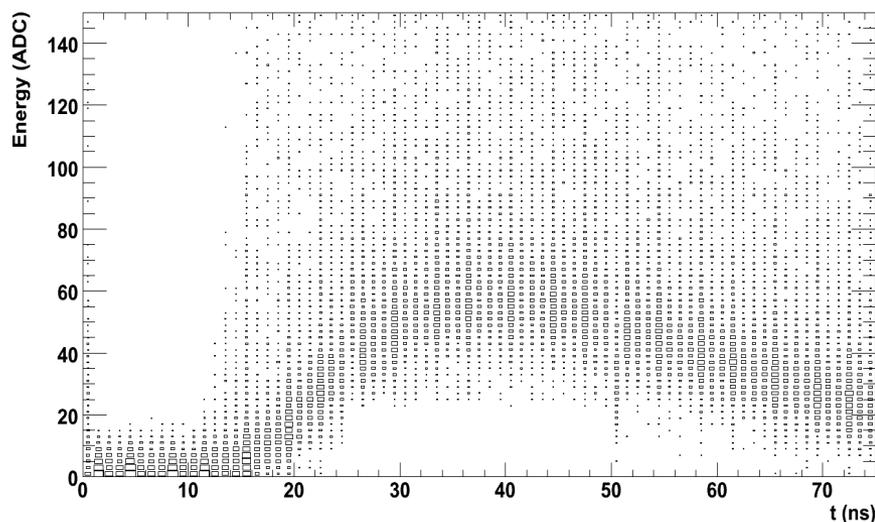
Each box presents one sensor

Beam spot in ES 2<sup>nd</sup> Plane

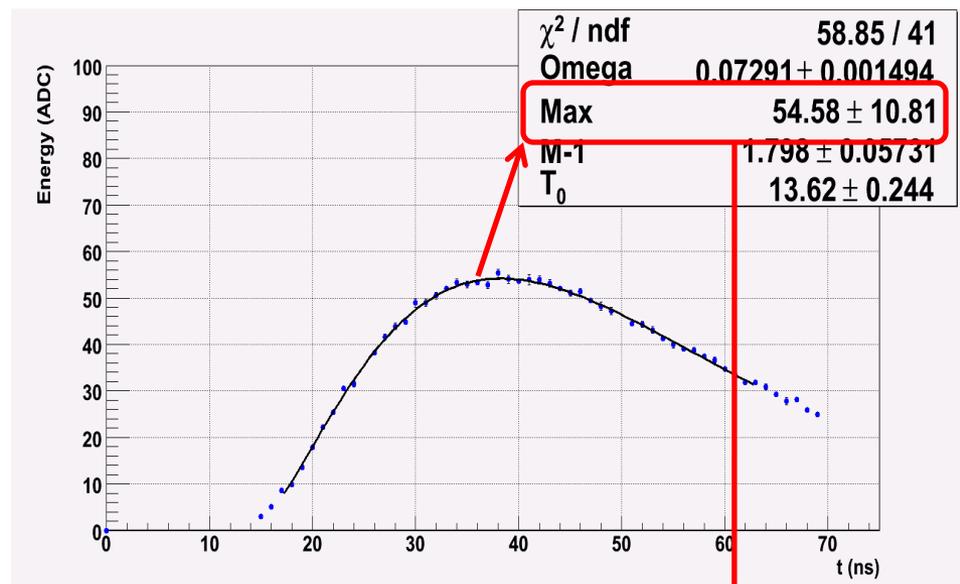


Use this sensor to cross-check the pulse shape, and the difference is negligible.  
**It proves that the pulse shape is identical.**

The beam is asynchronous and the distribution of  $t_{TDC}$  spreads within 25 ns. **This is the advantage to obtain the full pulse shape.** Combine the energy of 3 time samples in ES and  $t_{TDC}$  to obtain this 2-D histogram.

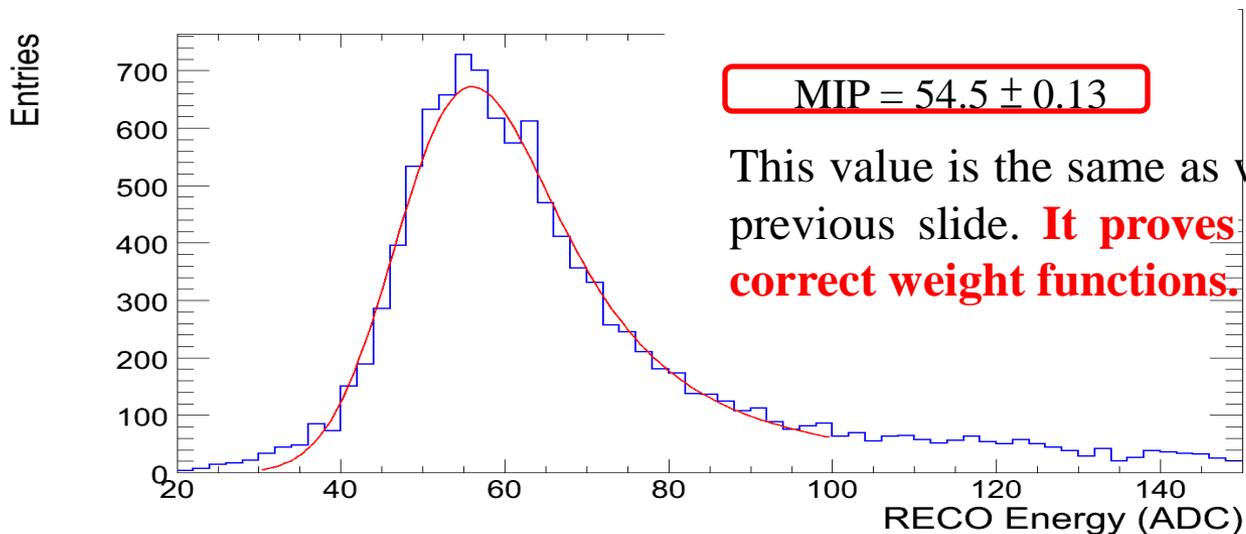


Each bin in time is fitted by Landau convoluted with Gaussian distribution

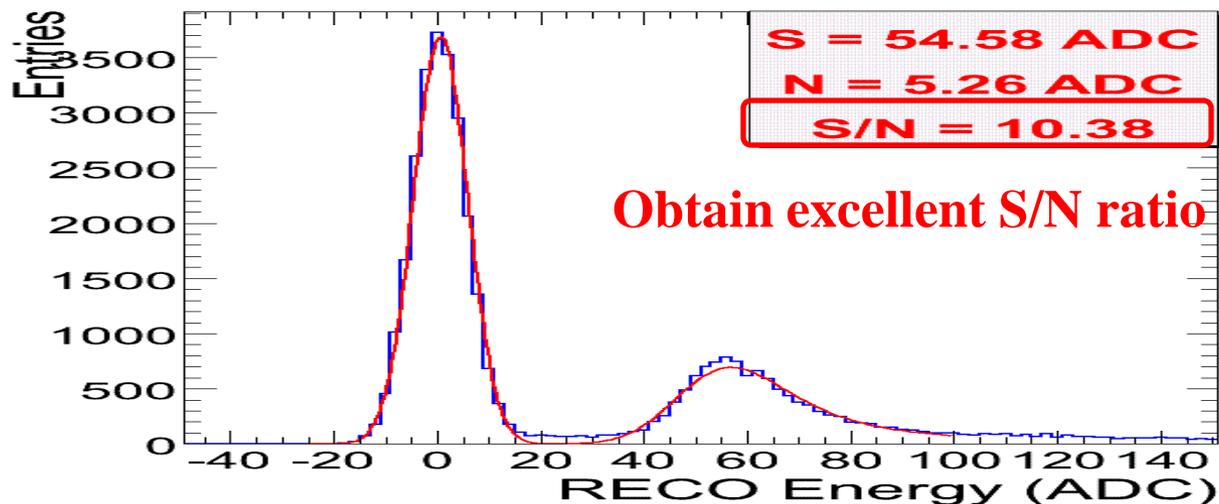


After obtain the pulse shape, we can figure out the weight functions

Use this value to check if the weight functions are correct



This value is the same as what we obtain in the previous slide. **It proves that we obtain the correct weight functions.**



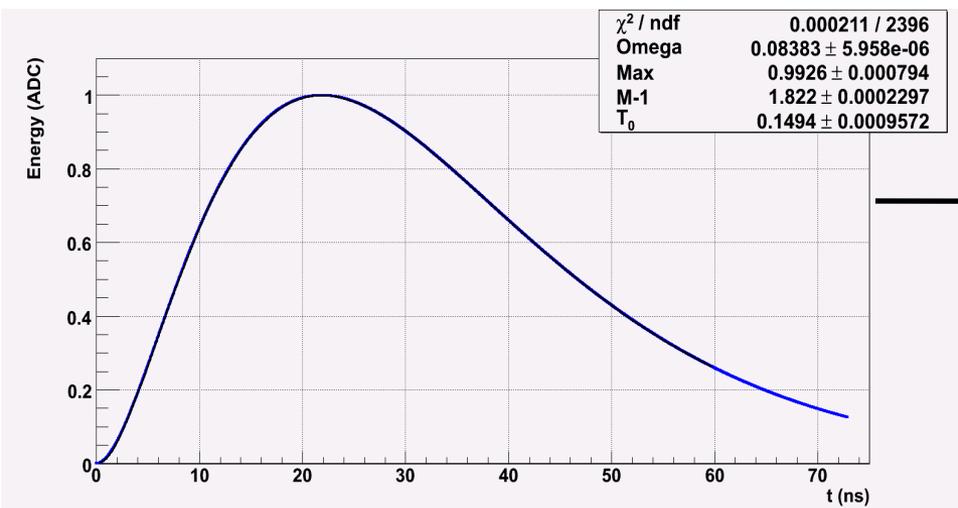


# Pulse shape and MIP in LG



The MIP resolution in LG is not enough to obtain the pulse shape directly.

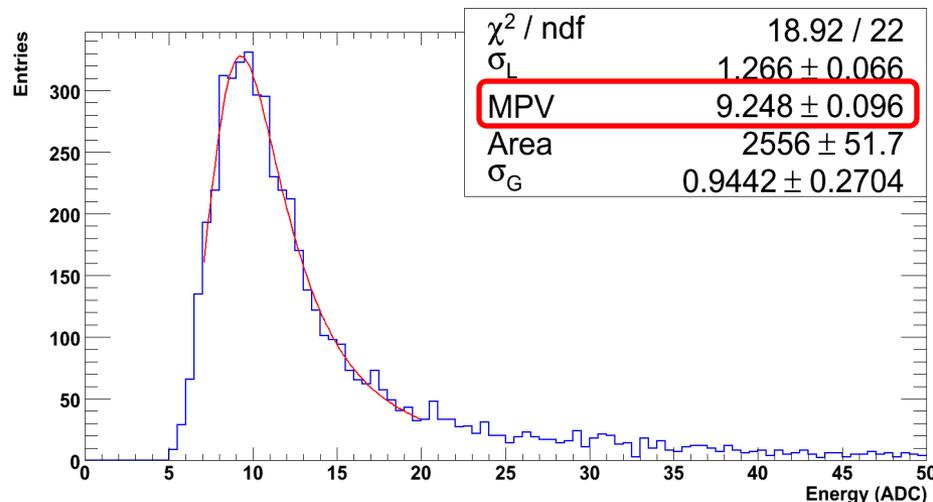
Use injection result and HG pulse shape in TB to deduce the pulse shape in LG.



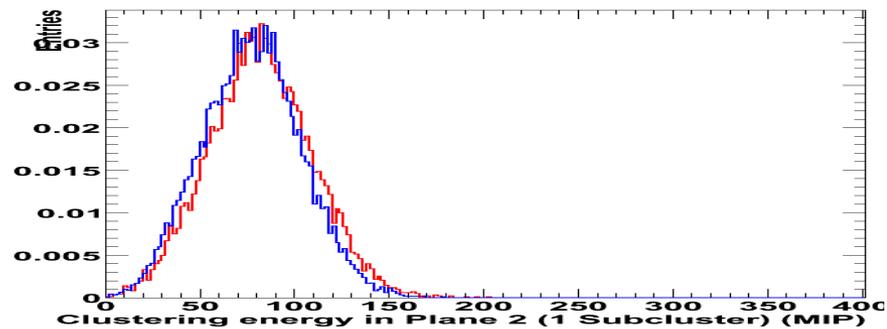
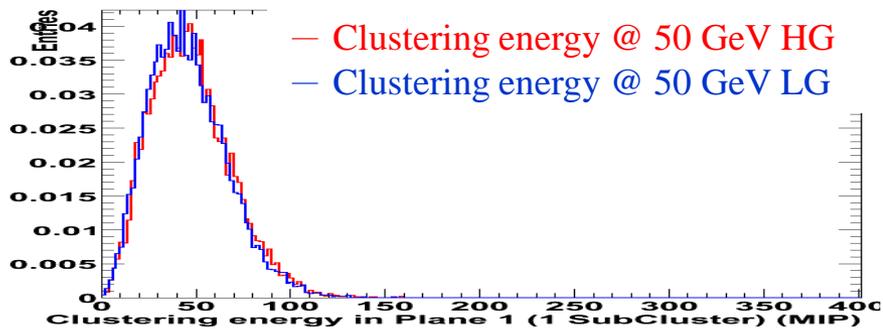
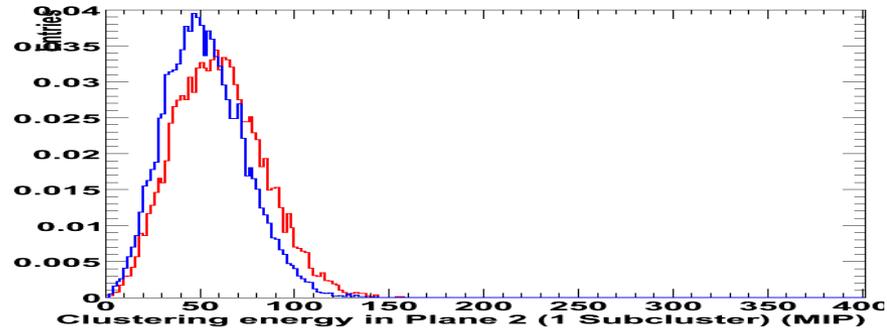
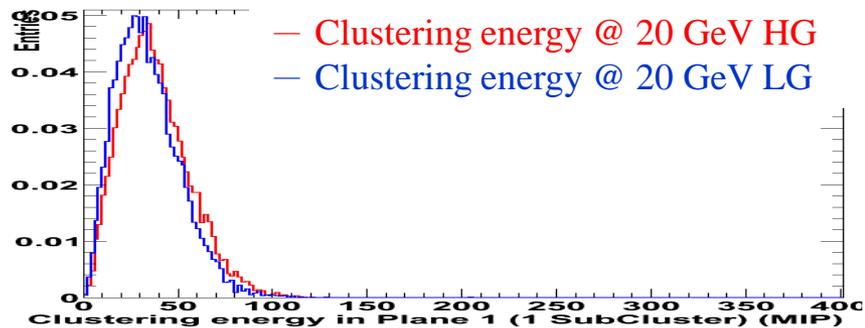
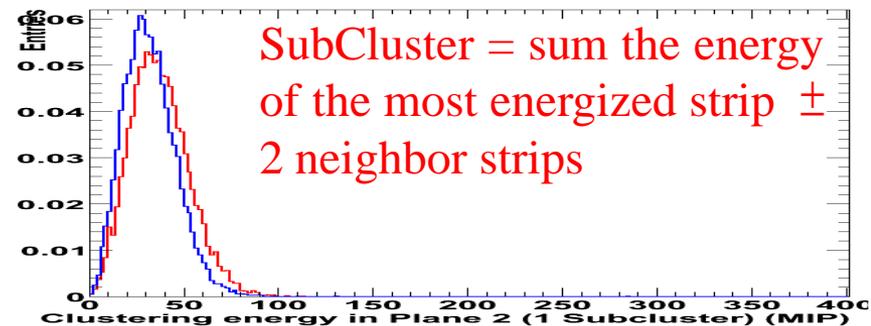
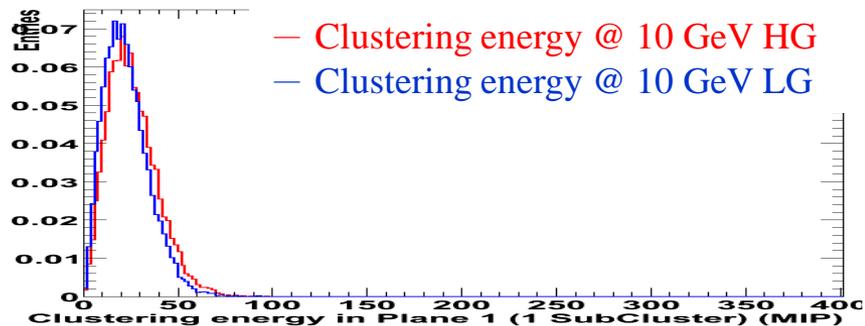
Obtain the corresponding weight functions.



Using  $\pi$  data for MIP calibration in LG



Ideally, the spectrum of the clustering energy in HG and LG should be the same



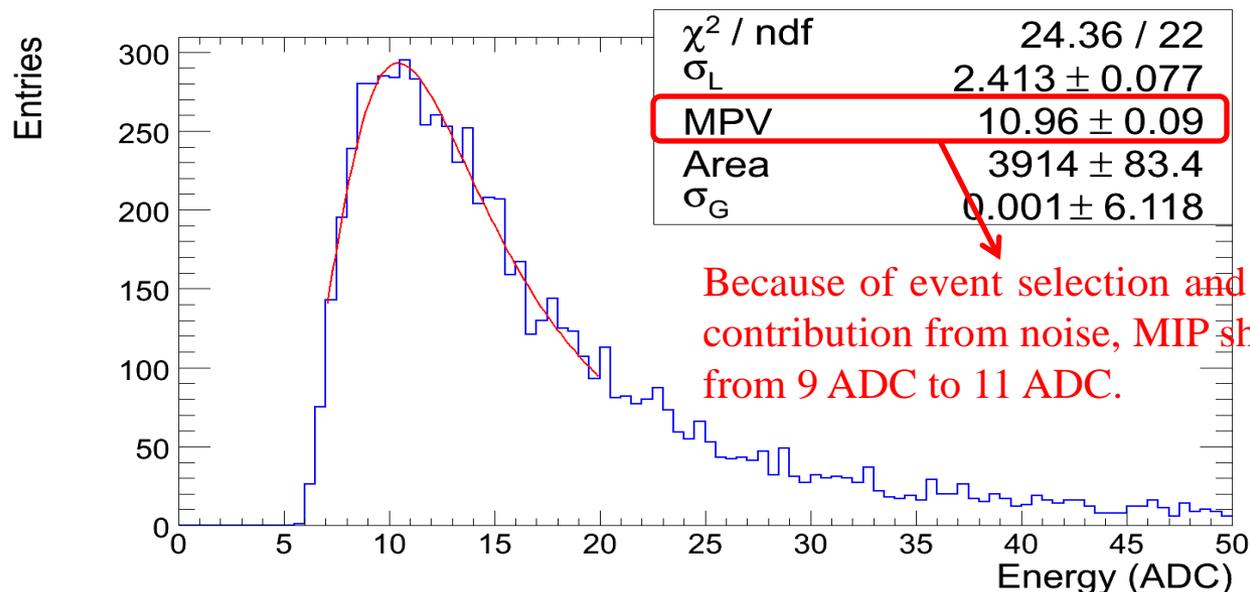
There are some effects which are not taken into account in LG

- We select the most energized strip but because  $S/N(\approx 3)$  is marginal, the MIP would shift by the effect from noise.

Use “Toy MC” to study this effect

Signal = 9 ADC

Noise = 2.5 ADC



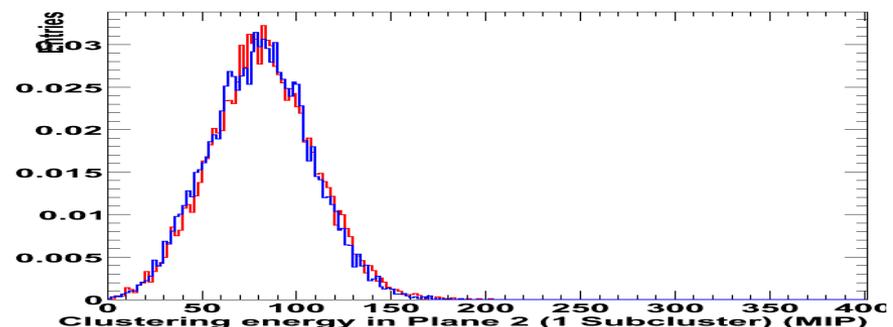
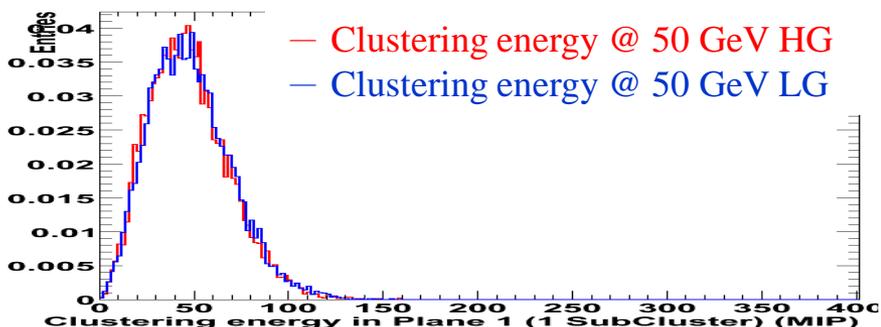
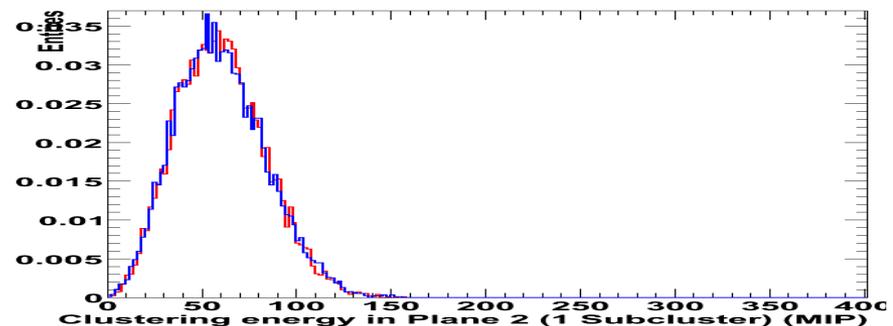
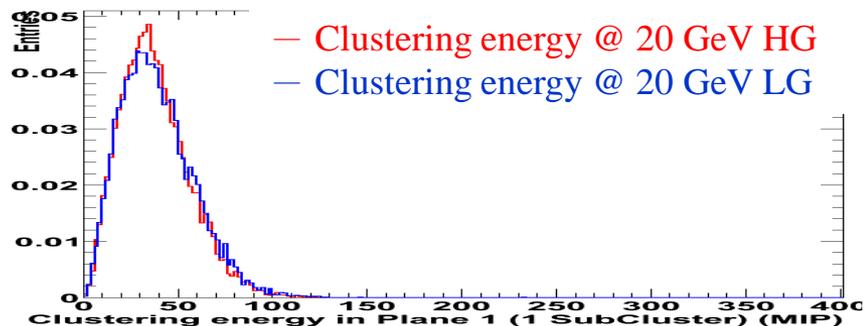
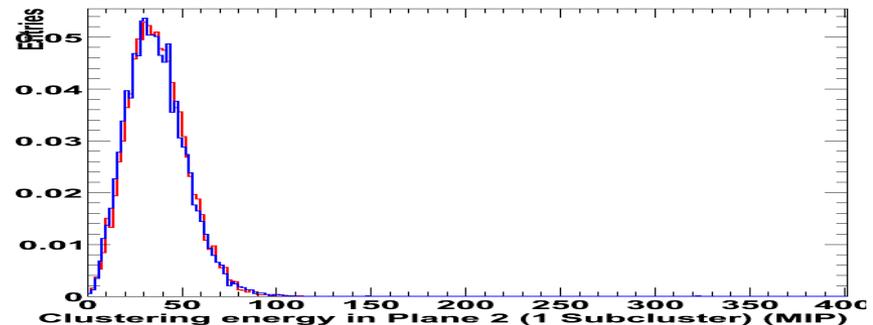
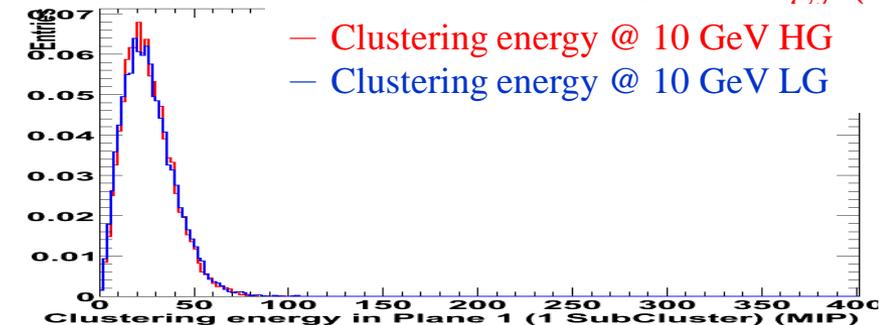
- Use indirect method to deduce the pulse shape and the weight functions in LG, this effect may make the energy spectrum shift (or wider).

→ Need to apply additional correction factor

# After correction

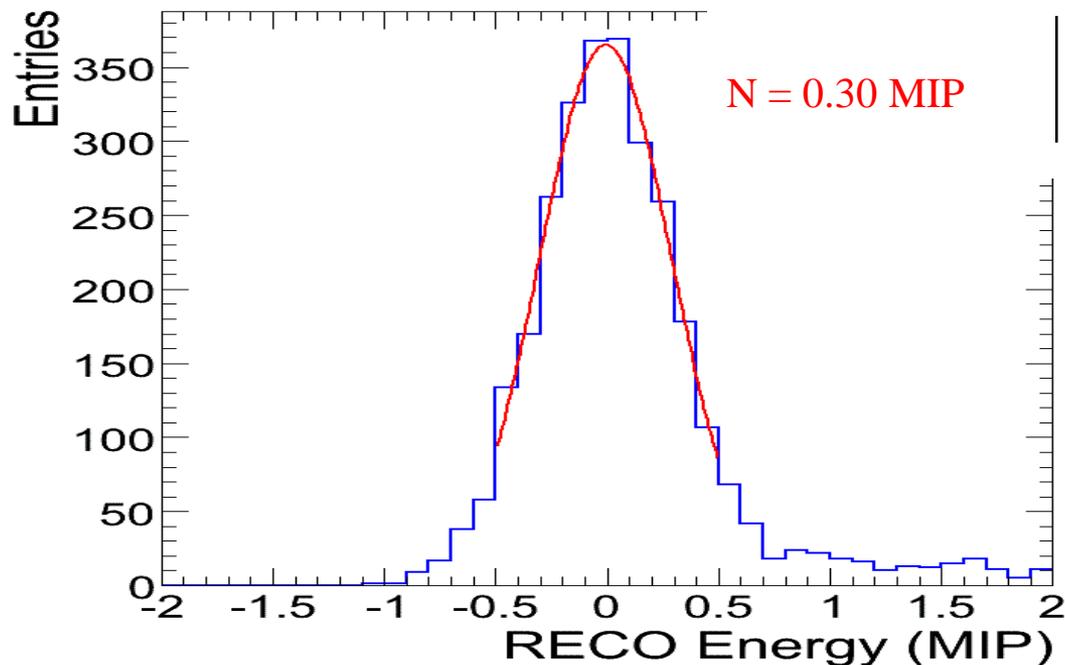
Minimize the  $\chi^2$  between the energy spectrums in LG and HG to obtain the correction factor(1.14)

RECO energy (MIP) in LG x 1.14



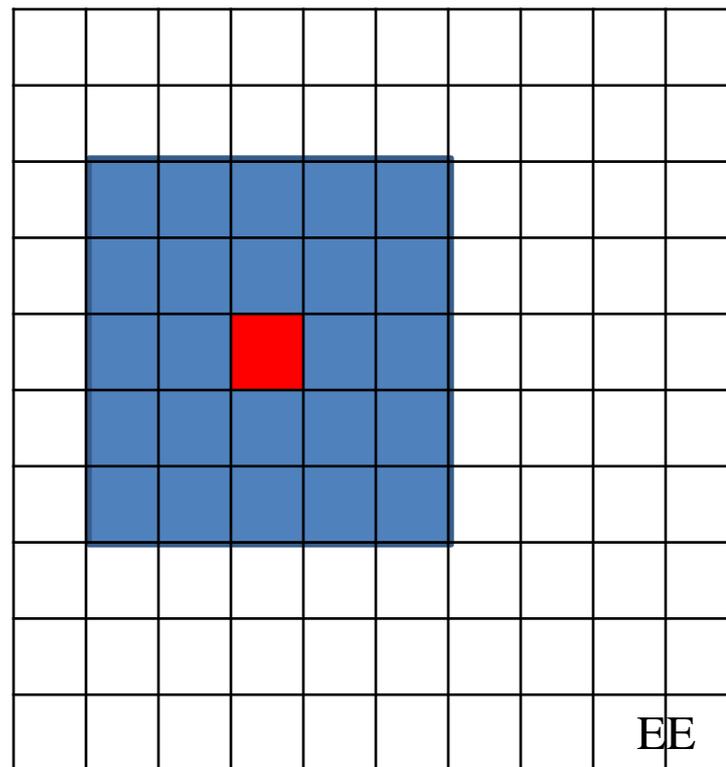
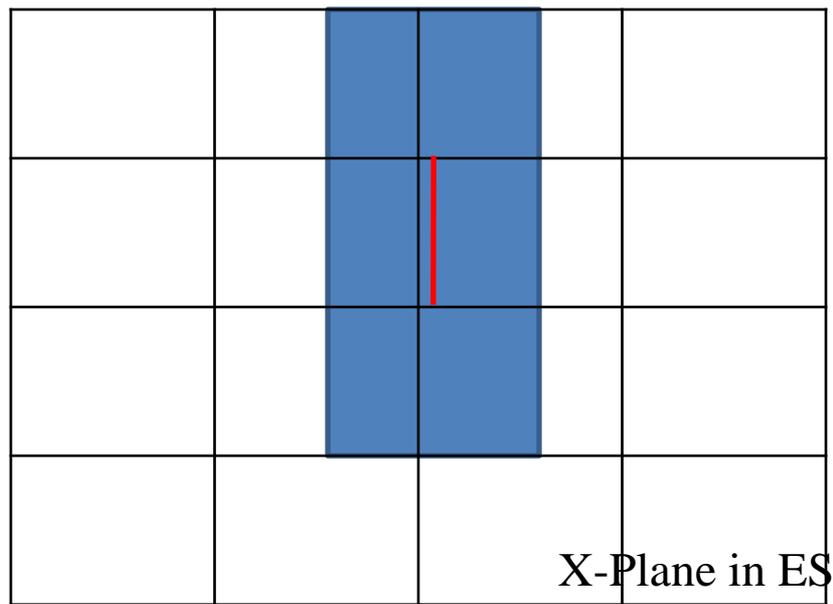
Apply “one correction factor”, the energy spectrums in HG and LG are consistent

## The noise spectrum

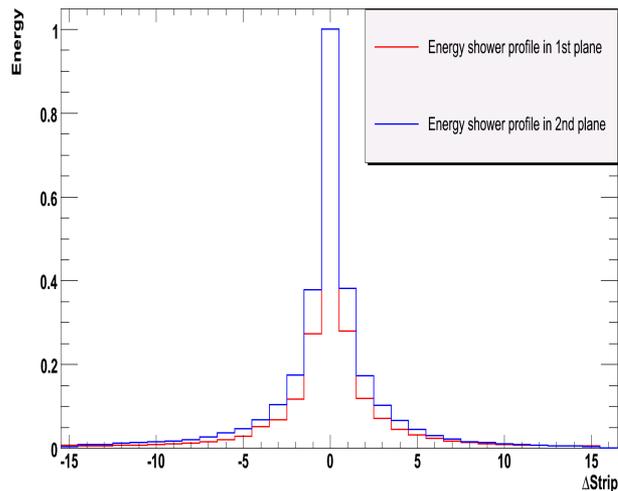


From  $N = 0.3 \text{ MIP}$ , it implies that  $S/N \approx 3$   
 **$S/N$  in LG is the same as what we design**

- Combined EE/ES energy
  - Total energy of electron  $\equiv EE + \alpha \times (ES_1 + 0.7 \times ES_2)$
  - The clustering energy in EE: the basic cluster (5x5 crystals)
  - The clustering energy in ES: 4 ESCs within the most energized strip  $\pm 15$  strips and  $\pm 1$  sensor (ESC  $\equiv$  sum the energy of the most energized strip  $\pm 2$  neighbor strips)

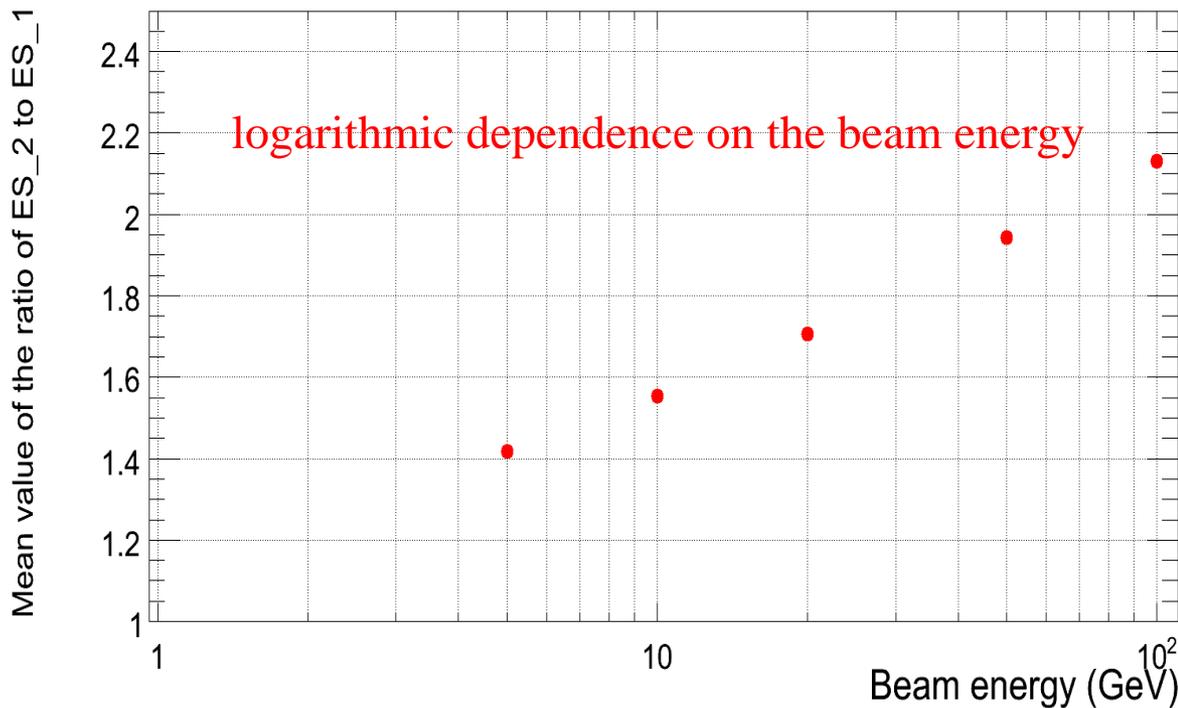
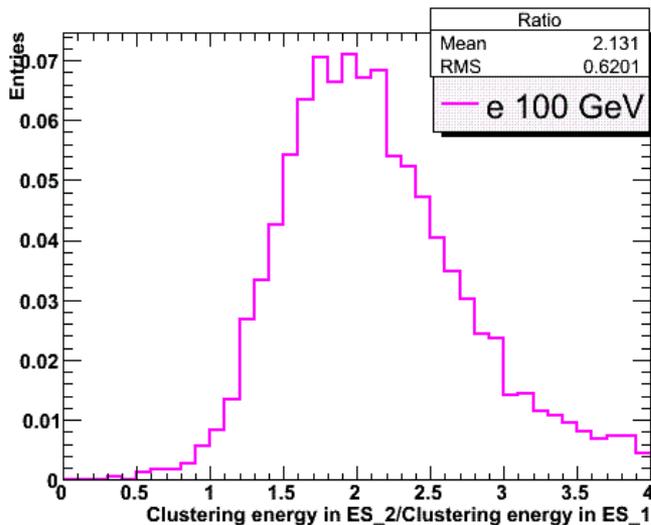


# Ratio of clustering energy in Preshower



Ratio  $\equiv$  Clustering energy in 2<sup>nd</sup> plane / Clustering energy in 1<sup>st</sup> plane

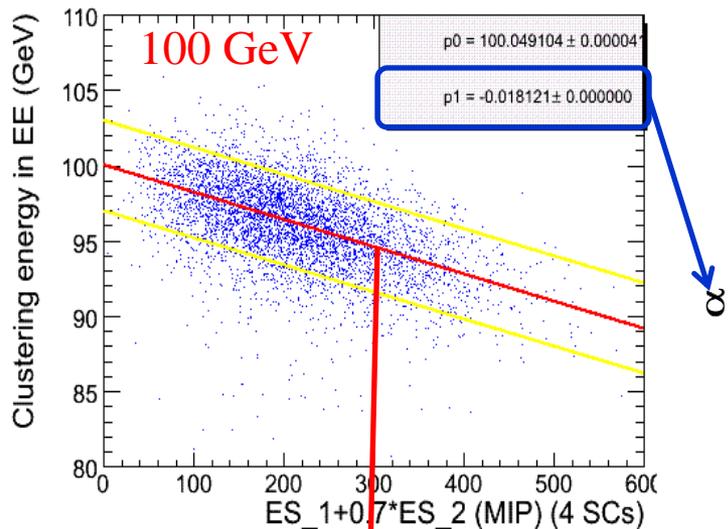
The shower profile in 2<sup>nd</sup> plane is wider than in 1<sup>st</sup> plane



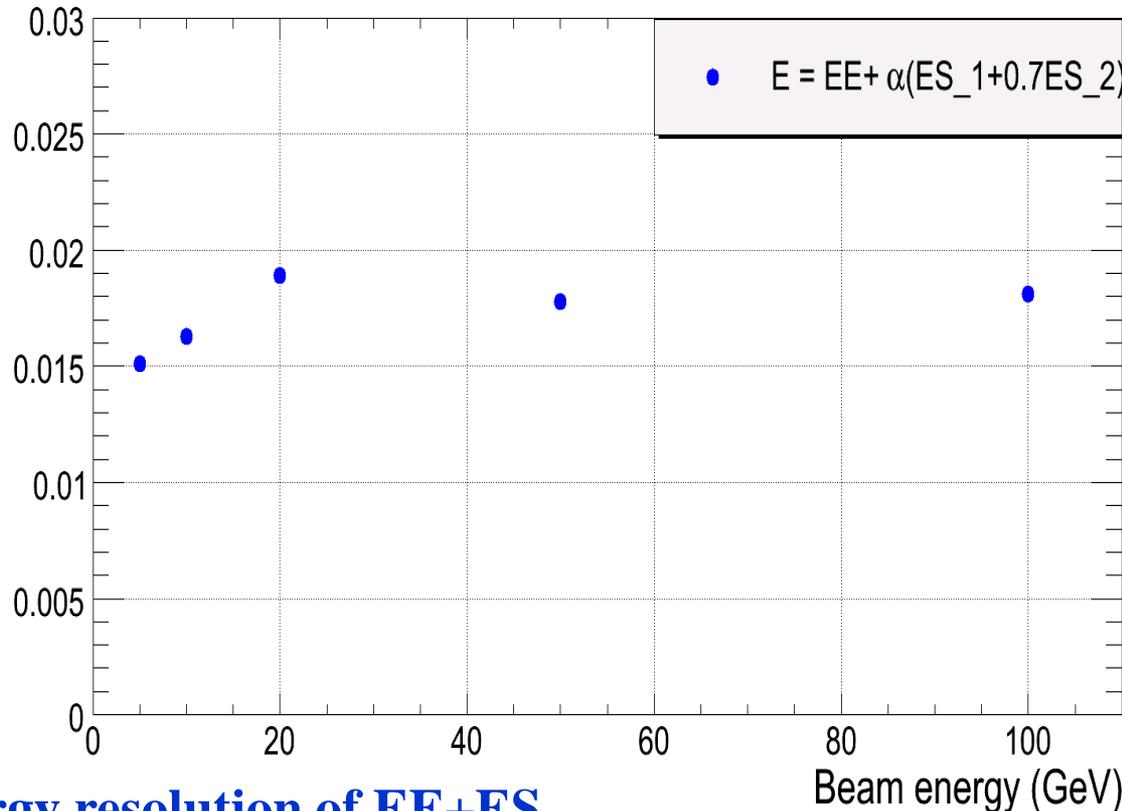
# The correlation of the clustering energy EE and ES

Total energy of electron  $\equiv EE + \alpha \times (ES\_1 + 0.7 \times ES\_2)$

$\alpha$  is constant when the beam energy is above 20 GeV



Fitted by the linear least-squares



We are still working on the energy resolution of EE+ES



# Conclusion



- Small scale ES operated successfully in realistic conditions for the first time.
- Tools are developed for extracting the MIPs.
- Obtain excellent S/N ratio in HG(10) and LG(3).
- From MIP calibration in TB, we can obtain the experience and then move confidently to the initial Preshower in-situ calibration.
- Tools for inter-calibrating (EE+ES) are developed. The analysis is on going.