Weekly meeting

YU-SIANG XIAO (蕭宇翔)

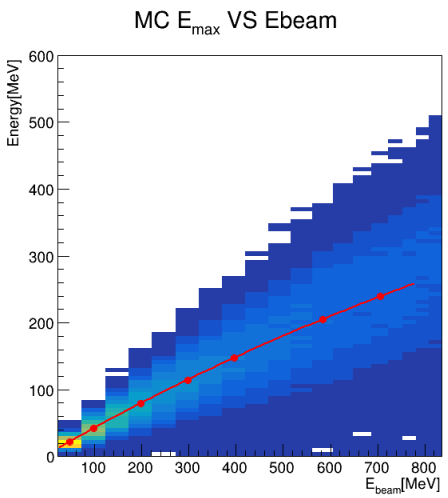
The E_{max} comparison with data and MC-LYSO

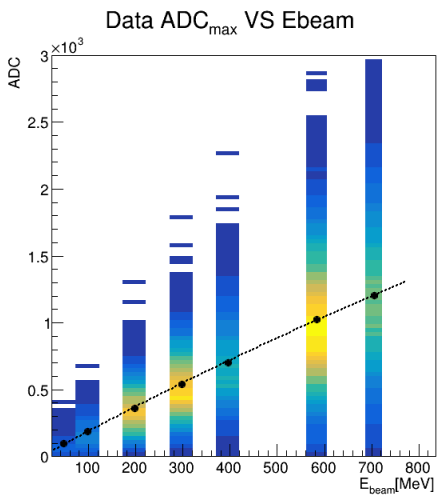
- Check the MC is correct enough on E_{max} compare to the data.
- Draw the E_{max} and ADC_{max} VS Ebeam between MC and Data. PS: data minus 2175ADC for pass through (0,0).
- Use profile to get the average on Y and the error.
- The ratio between MC Edep and data ADC is almost a constant ~ 4.811.

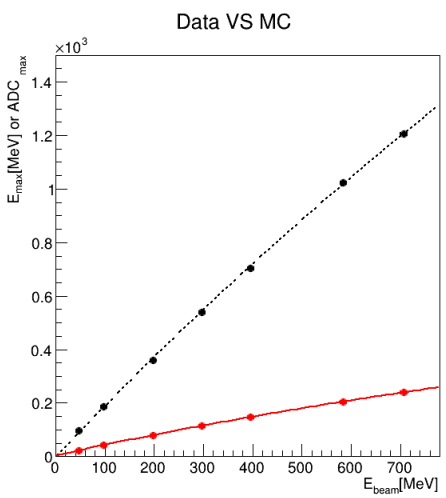
Data ADC – 2175 VS MC Edep

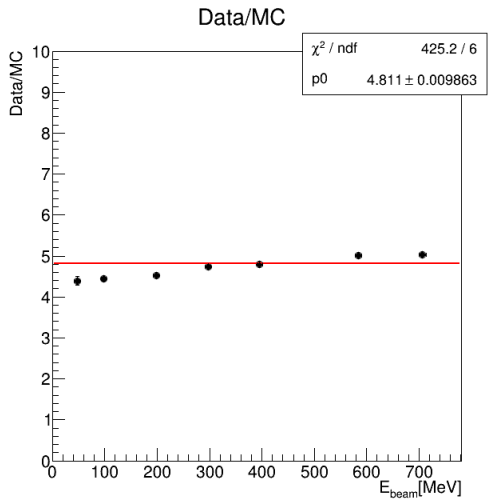
Data/MC

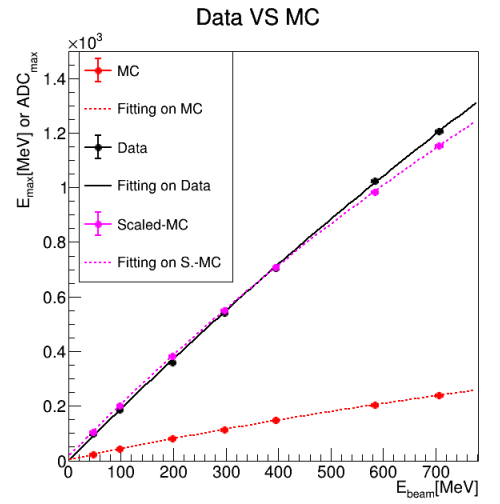
Data/Scaled-MC











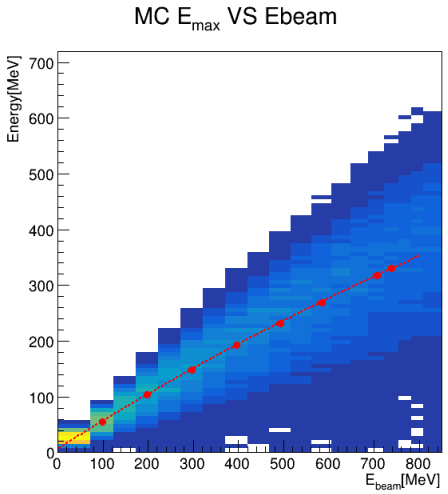
The E_{max} comparison with data and MC-PWO

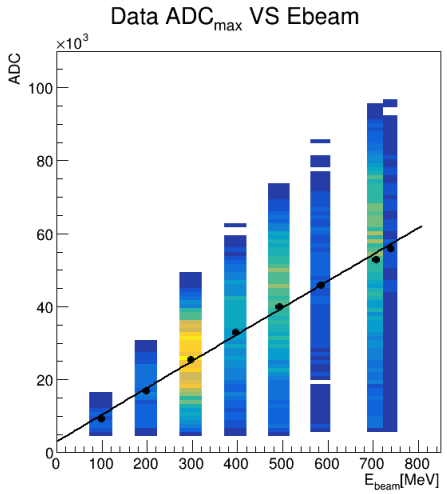
- Check the MC is correct enough on E_{max} compare to the data.
- Draw the E_{max} and ADC_{max} VS Ebeam between MC and Data. PS: data minus 4825ADC for pass through (0,0).
- Use profile to get the average on Y and the error.
- The ratio between MC Edep and data ADC is almost a constant ~ 169.7.

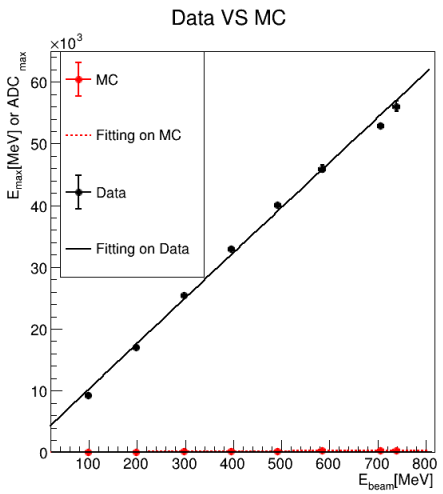
Data ADC – 4825 VS MC Edep

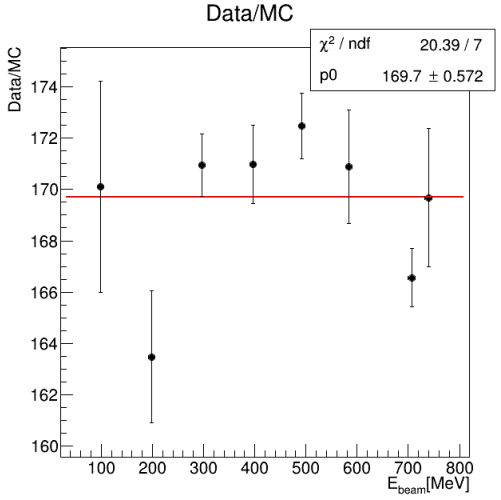
Data/MC

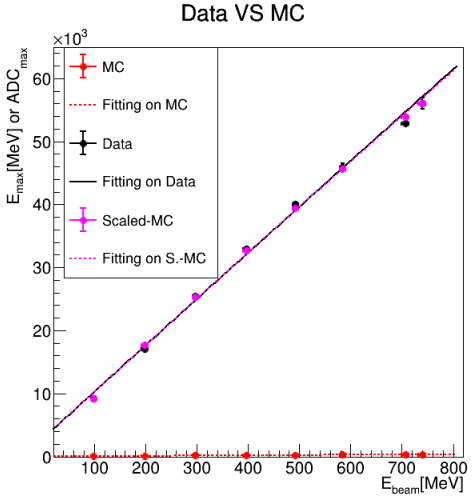
Data/Scaled-MC







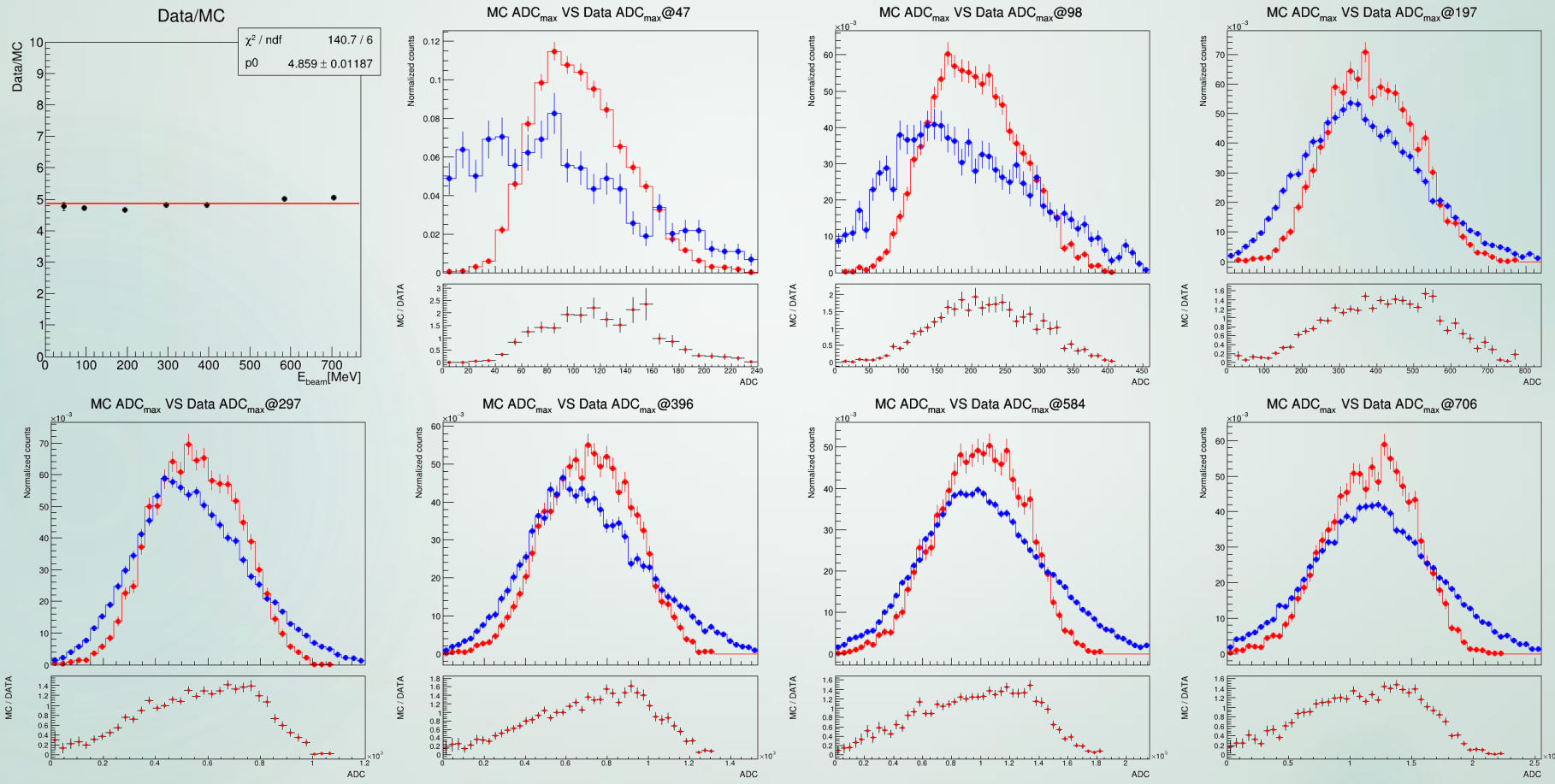




LYSO: Data/MC in different energy

- (Data-2175)/(MCx4.859)

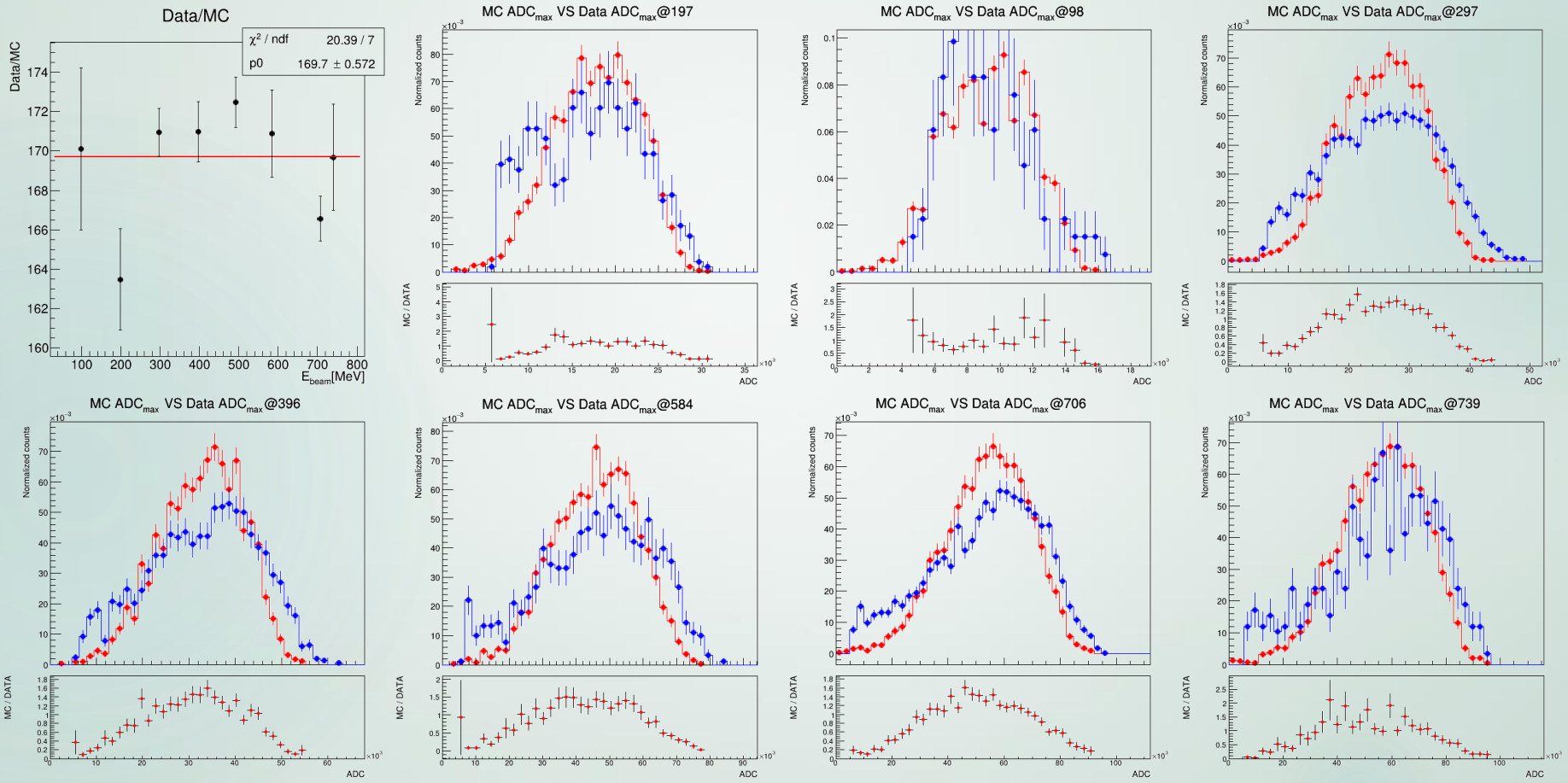
Data-2175
MCx4.859



$PbWO_4$: Data/MC in different energy

- (Data-4825)/(MCx169.7)

Data-4825
MCx169.7

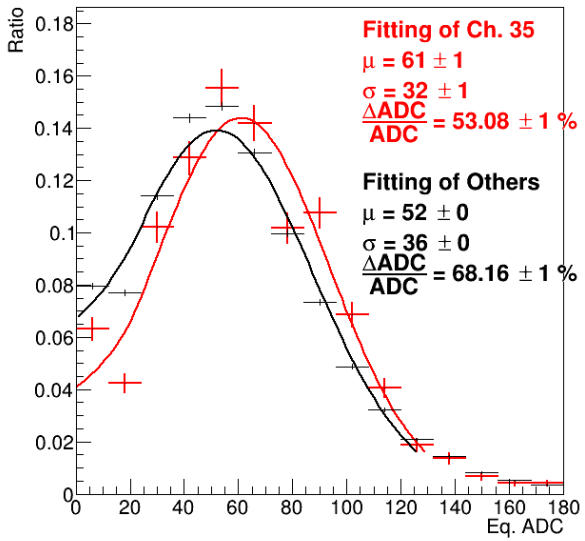


LYSO: Apply the THR cut on MC

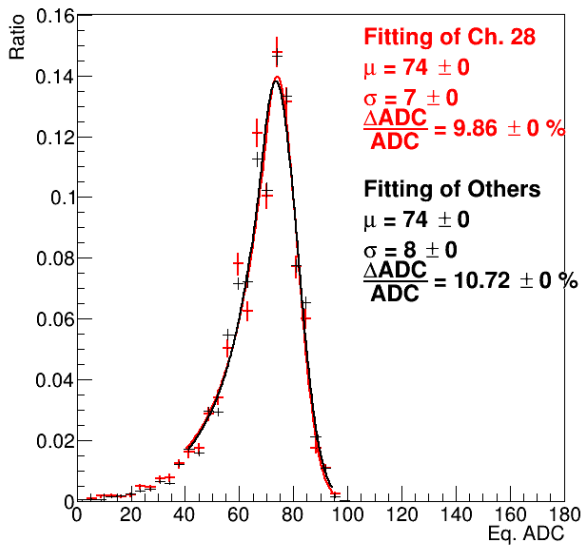
- Use the study result of threshold(threshold VS DAC per channel and the threshold fluctuation).
- Apply the cut on MC by convert the Edep of MC to be ADC and cut by threshold.

98MeV

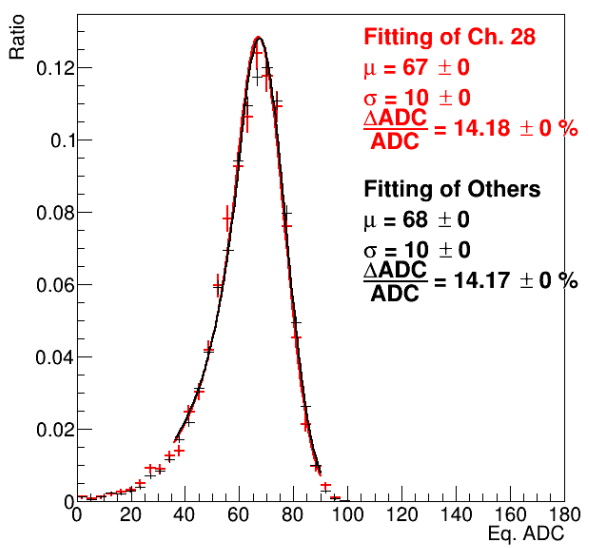
E5x5 of Data
HV = 395V



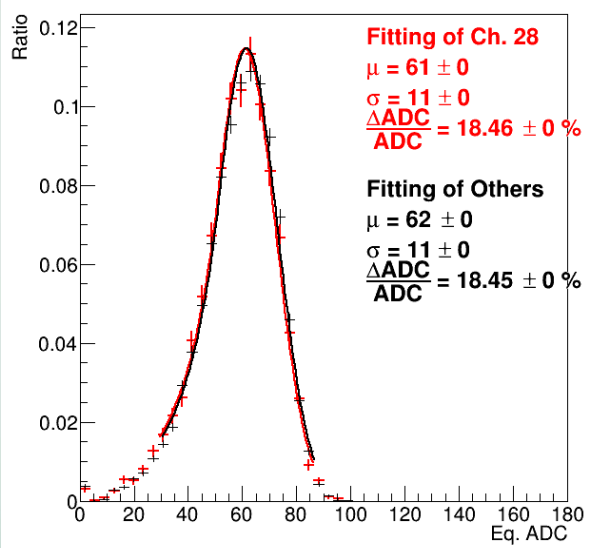
E5x5 of MC
THR.: 0 (MeV)



E5x5 of MC
THR.A:1.7 (MeV)
THR.B:1.4 (MeV)

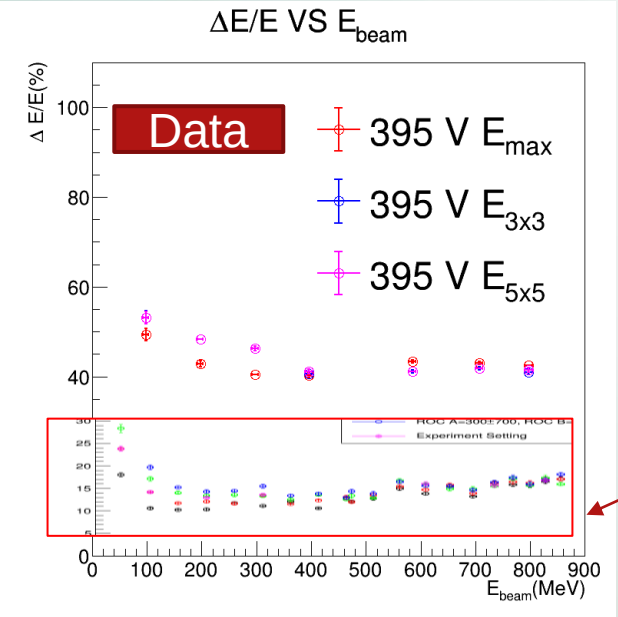


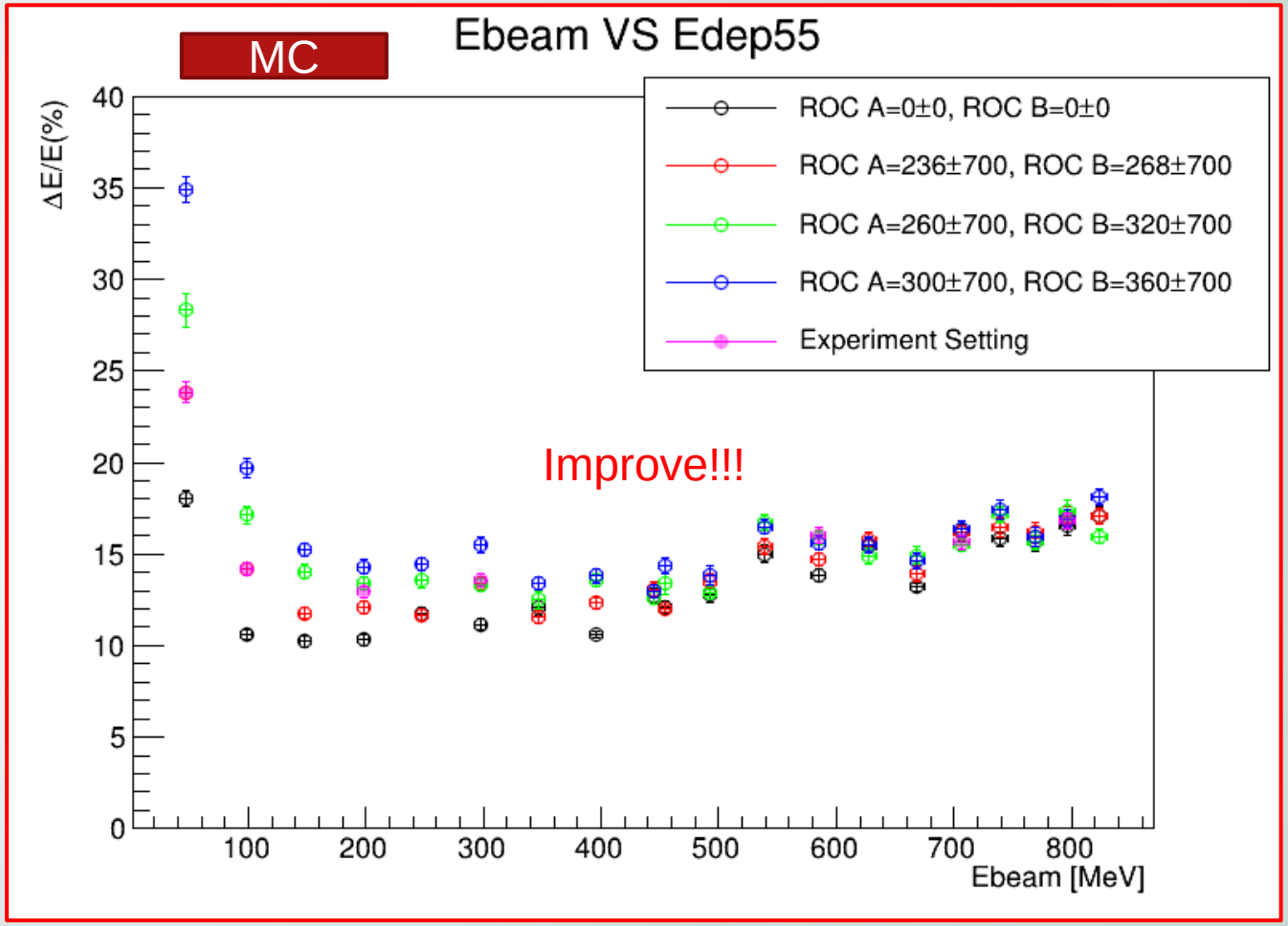
E5x5 of MC
THR.A:2.8 (MeV)
THR.B:1.8 (MeV)



LYSO: MC after applying the THR. and σTHR

- LYSO part was trying to apply the cut by the all setting which are used in Feb. 2025 beam test.
- The magenta color is the threshold for the analysis data
- The resolution is approach to the data, but still different.
- The resolution of LYSO is too wired, we want to observe $PbWO_4$ first...





$PbWO_4$: Apply the THR cut on MC

- Use the study result of threshold(threshold VS DAC per channel and the threshold fluctuation).
- Apply the cut on MC by convert the Edep of MC to be ADC and cut by threshold.
- Scaling # of photon receive at SiPM by 3.26 in MC to fit the data ADC_{max}.

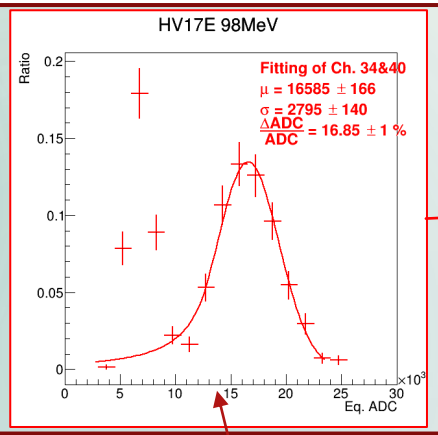
$\mu THR(DAC) = -3375 + 15.255\ X + 0.017\ X^2$

400DAC = 5447ADC , 650DAC = 13723ADC

MeV = (ADC+1367)/334

5447ADC= 20.4 MeV, 13723ADC = 45.2MeV

E5x5 of Data, HV = 30V



Why? The 98 MeV use 650 to be THR. But, it's more like the 450 case.

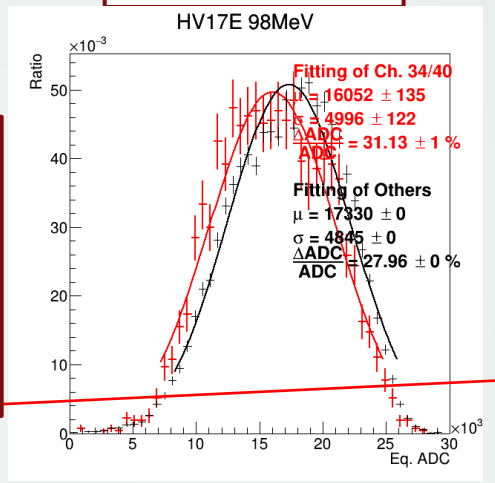
Why the ADC_{max} contains 2 peak but $Edep_{max}$ without?

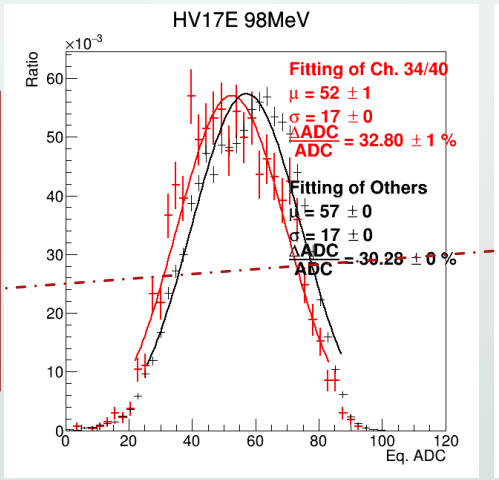
In the high THR cases, the resolution is wired!

ADC_{max}

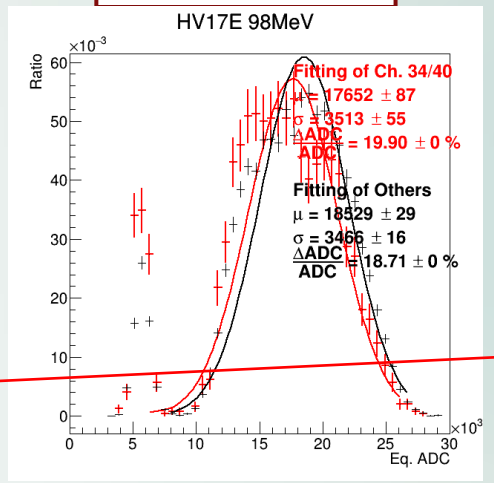
$Edep_{max}$

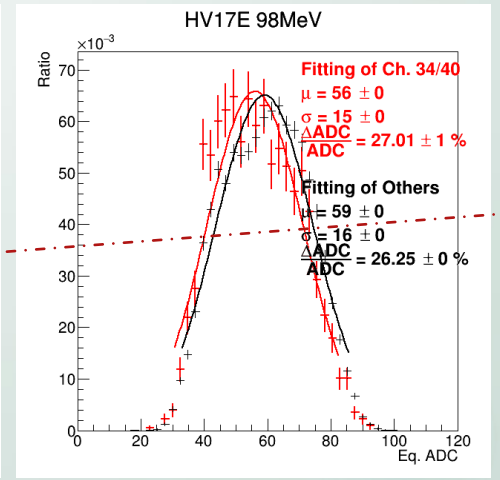
THR.: 0 MeV



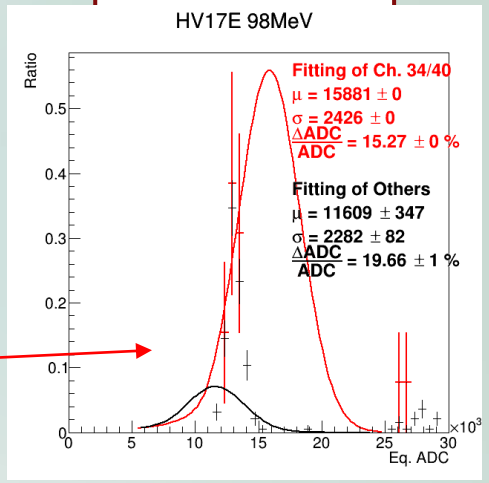


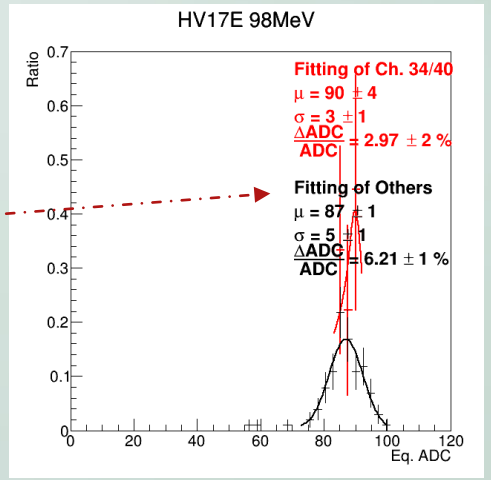
THR.: 20.4 MeV





THR.: 45.2 MeV

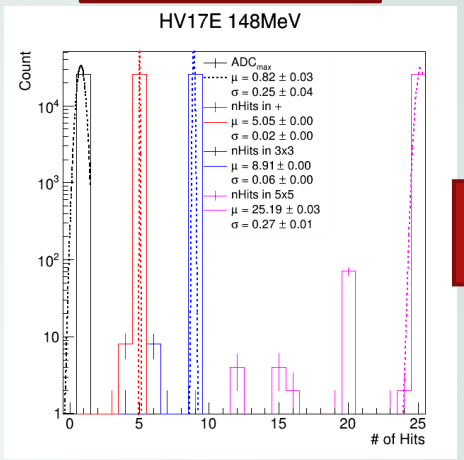




MC after applying the THR.: multiplicity

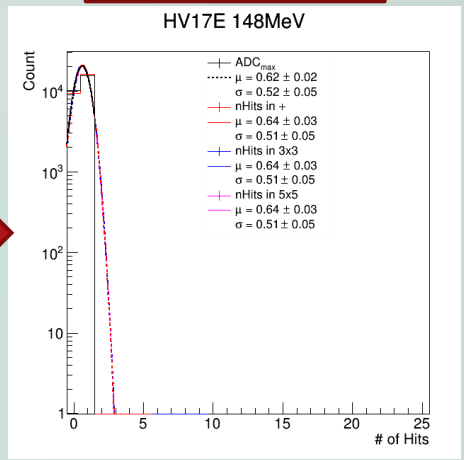
- PbWO part was trying to apply the cut by the all setting which are used in Feb. 2025 beam test.
- The magenta color is the threshold for the analysis data
- By the result of multiplicity, the setting in experiment is too large.
- When it cut the E_{max} too much, THR. make the resolution unreasonable.
- Thus, we should remove the <250 MeV data under the 45 MeV threshold.

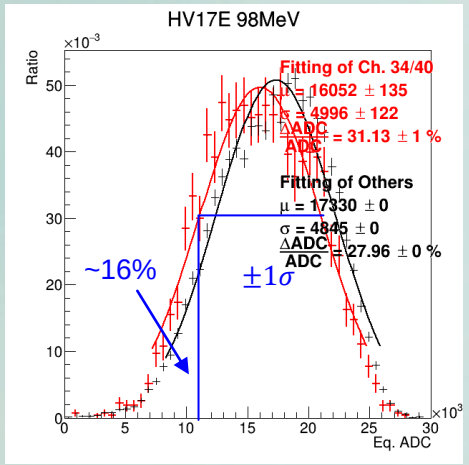
MC THR.: 0 MeV



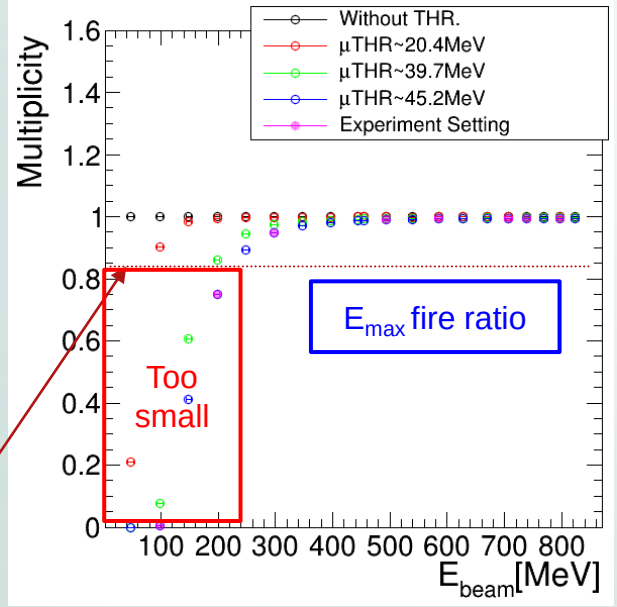
Exp. THR. setting

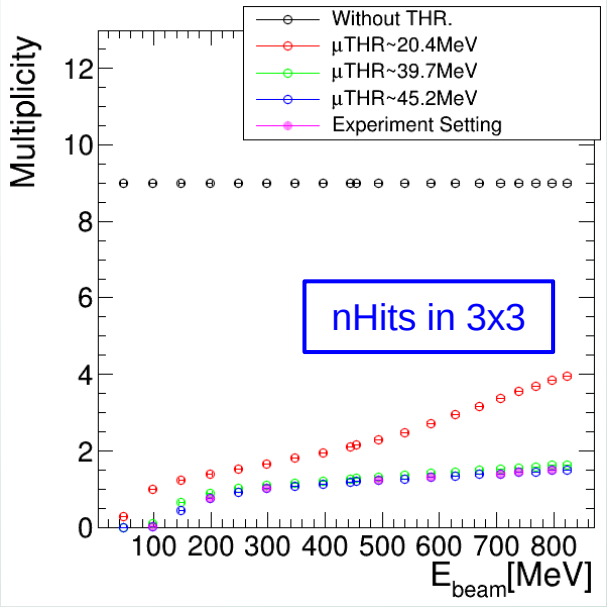
MC THR.: 45.2 MeV

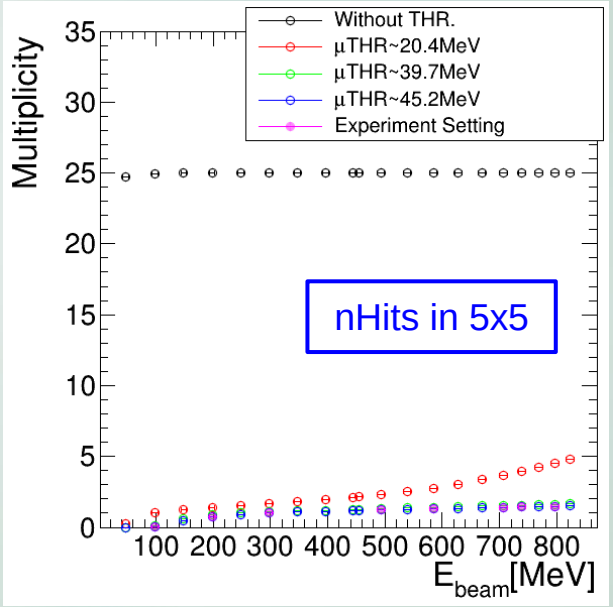




For a gaussian distribution, if THR cut at 1 σ, the ratio become ~84%

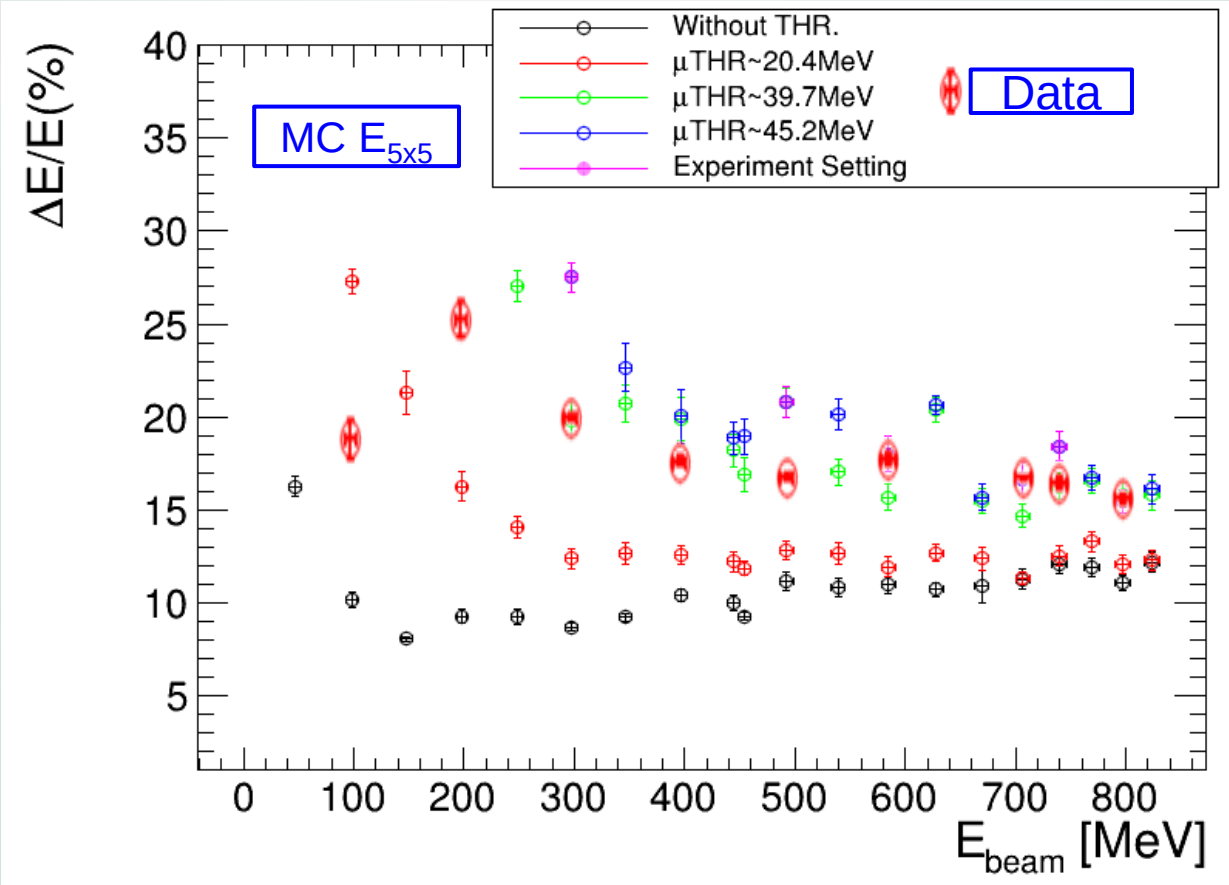






MC after applying the THR. and σTHR

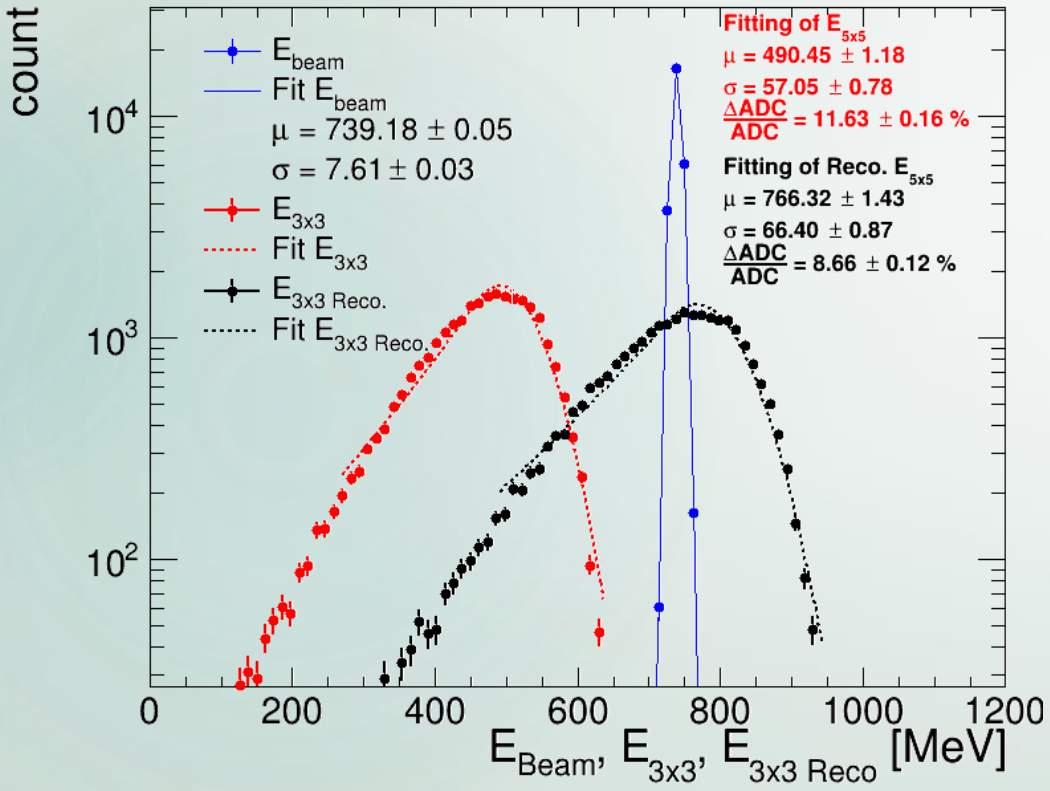
- PbWO part was trying to apply the cut by the all setting which are used in Feb. 2025 beam test.
- The magenta color is the threshold for the analysis data
- Do the comparison with data, the data is better then MC in THR = 45.2MeV case…



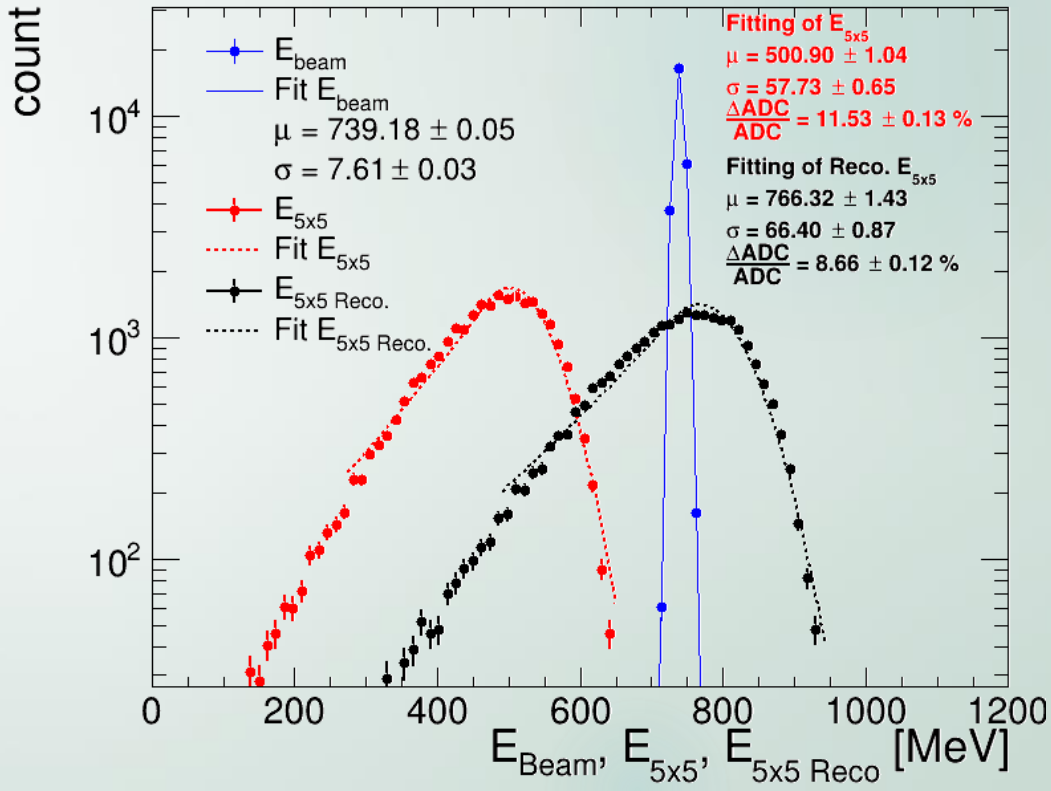
MC Regression

- Finish the test code for MC regression, in both case E_{3x3} and E_{5x5}.
- The test MC: E_{beam} = 739MeV , THR. = 30MeV
- The resolution is better than the case without regression, but the peak appears to exceed 3.6%...☹

E_{3x3}



E_{5x5}



Summary

- The ratio between MC Edep and data ADC is almost a constant ~ 4.811 in LYSO, and 169.7 in PWO.
- The spectrum shape in MC is similar to the data.
- The adding of THR make the MC more approach to the data in both detector, and the E_{max} fire ratio could be the principle to remove the high THR. Cases.
- The resolution of MC is approach to data after cut.
- The resolution is better in MC after regression, but the peak is not correct enough(+3%).

To do

- Data:
  - Update the calibration part with the harder selection on Emax(Esec /Emax<0.4~0.6) to get the narrow peak.
  - ~~Energy regression by MC.~~ => Scan all MC case and apply the parameters on data to improve resolution.
  - Analysis the full setup data(BMx2+LYSO+PbWO).
- MC:
  - Use the MC by the B-field to generate the beam (wait for new version!).

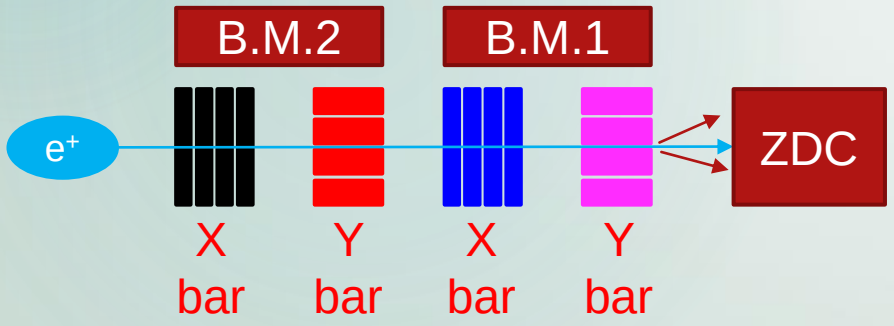
END

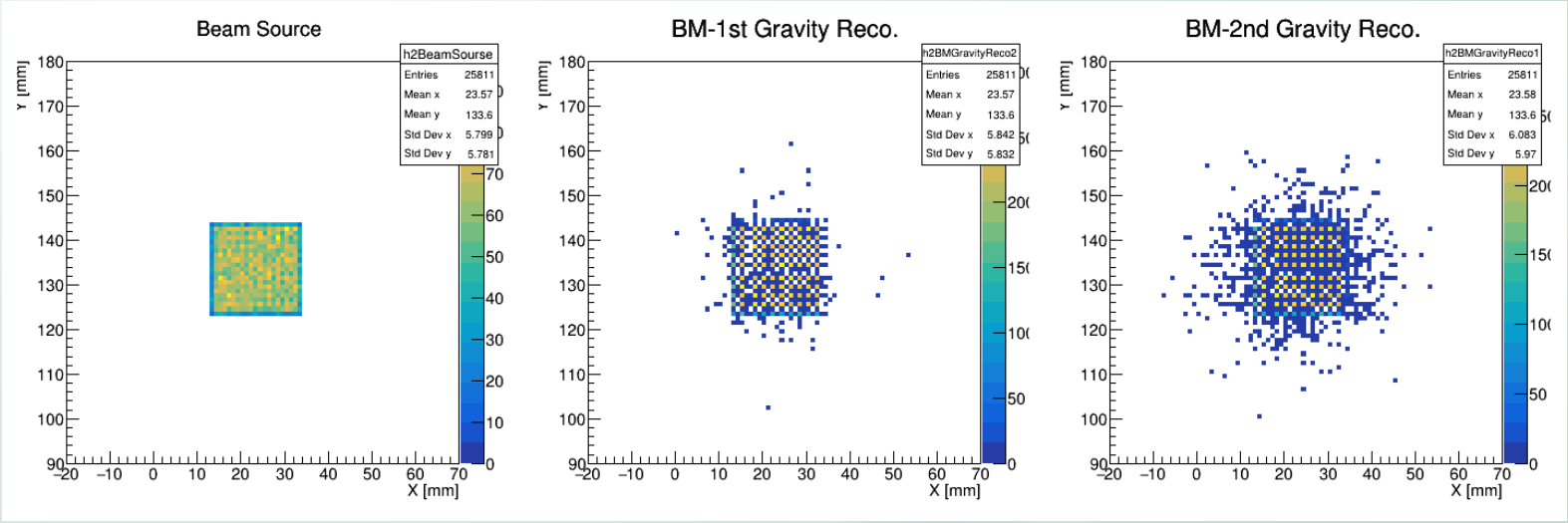
The MC condition

- Simulation content: energy deposit in the crystal array.

- Particle type: -21(positron)
- Beam energy: W-200μm-30deg in lns-tn-440e-2.pdf →
- Beam position: a square at Ch. 28 and surrounding channels.
- Beam direction: Fix the direction straight to the ZDC.
- Option: (O) optical photon, (O) circuit simulation.
- Setup: almost experimental model.

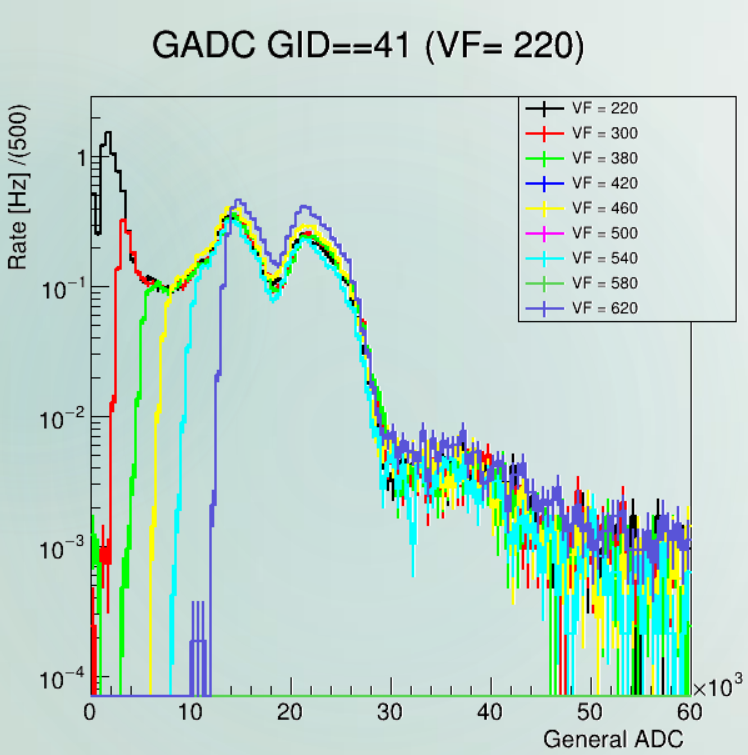
I (A)	No constraint on $x_{Positiom}$		
	μ_P (MeV/c)	σ_P (MeV/c)	σ_P/μ_P (%)
025	47.18(2)	5.48(1)	11.63(3)
050	98.19(4)	4.92(3)	5.01(3)
075	148.22(4)	4.77(2)	3.22(2)
100	197.94(3)	4.91(2)	2.48(1)
125	247.79(3)	5.00(2)	2.02(0)
150	297.30(2)	5.29(2)	1.78(0)
175	346.81(2)	5.31(1)	1.53(0)
200	395.90(2)	5.55(1)	1.40(0)
225	444.56(2)	5.73(1)	1.29(0)
230	454.25(2)	5.74(1)	1.26(0)
250	492.50(2)	5.83(1)	1.18(0)
275	539.29(2)	6.00(1)	1.11(0)
300	584.59(2)	6.17(1)	1.06(0)
325	628.06(2)	6.32(1)	1.01(0)
350	669.20(2)	6.45(1)	0.96(0)
375	706.61(2)	6.58(1)	0.93(0)
400	739.16(2)	6.71(1)	0.91(0)
425	768.86(2)	6.87(1)	0.89(0)
450	796.60(2)	6.89(1)	0.87(0)
475	823.26(2)	7.01(1)	0.85(0)
500	849.10(2)	7.08(1)	0.83(0)

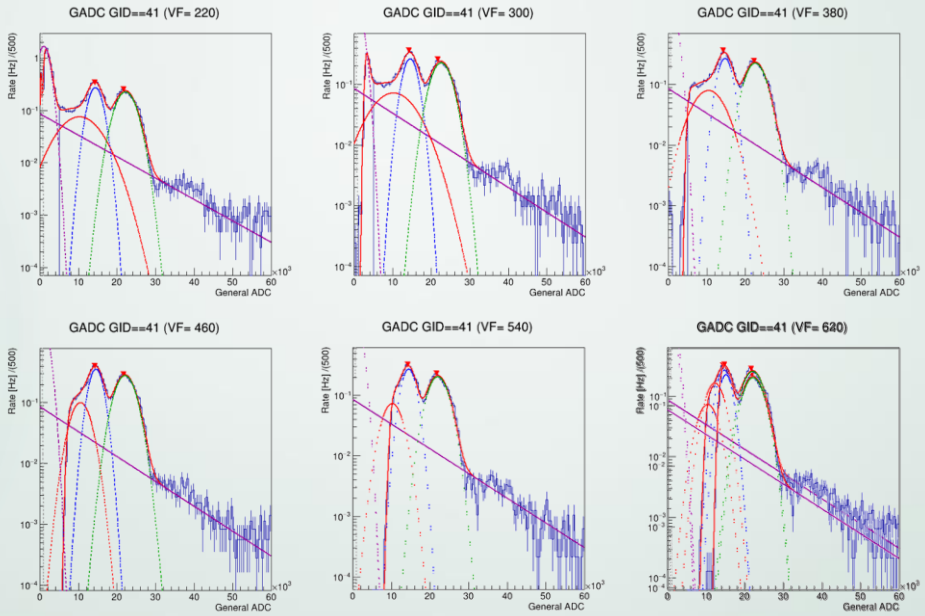


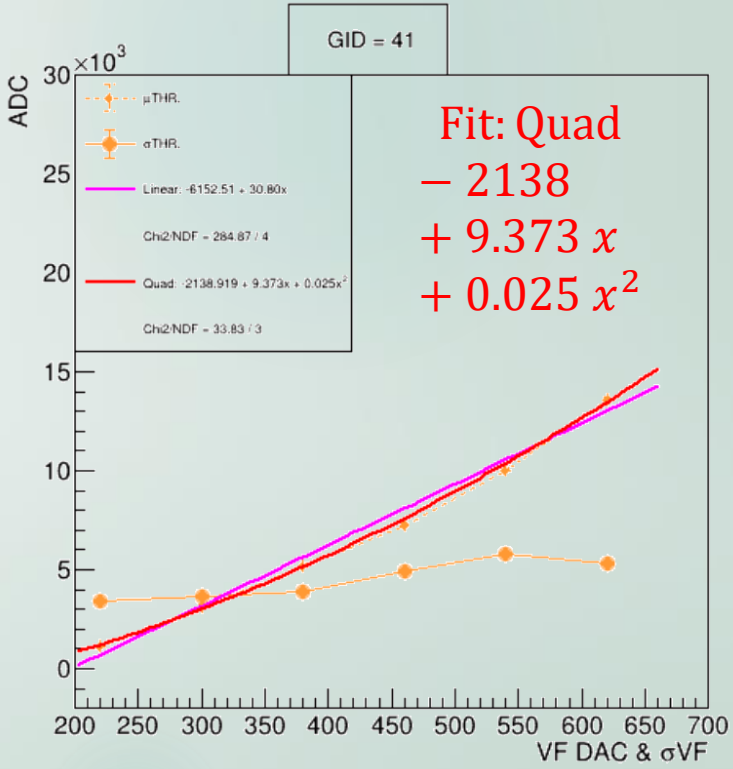


THR. fit of readout board: $PbWO_4$

- Kai-Yu did the experiment of PWO readout board + (GAGG-SiPM) scintillator module + LYSO source.
- Fitting function of spectrum: 1. Gaussian(pedestal, 297,395keV, 297 escape peak) 2. Expo. decay(circuit noise). 3. Gasuuian-CDF Aka. error function(threshold decay fitting).
- Fit the relationship of VF-DAC VS THR. and σTHR. The VF-DAC VS THR is fited well by Quad..

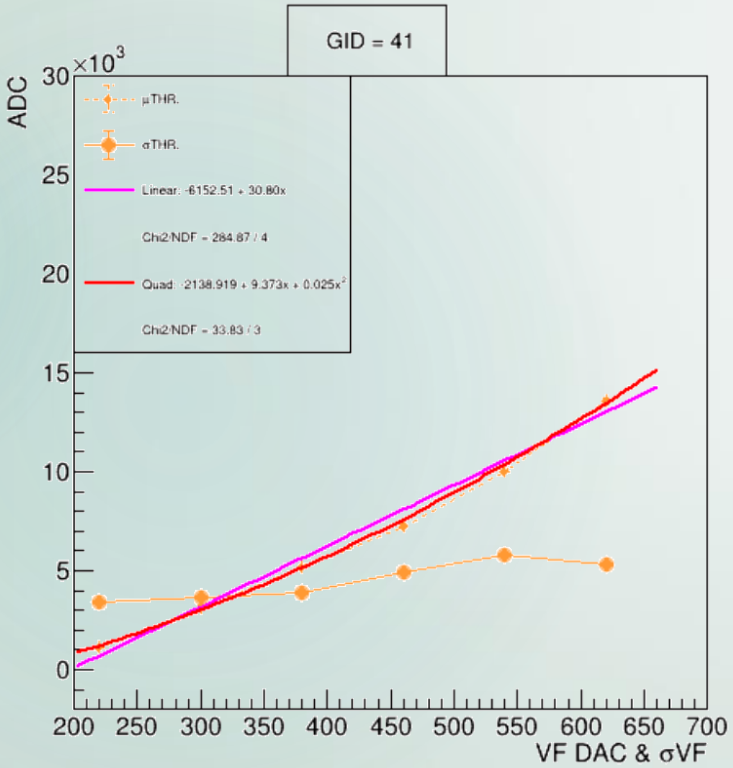






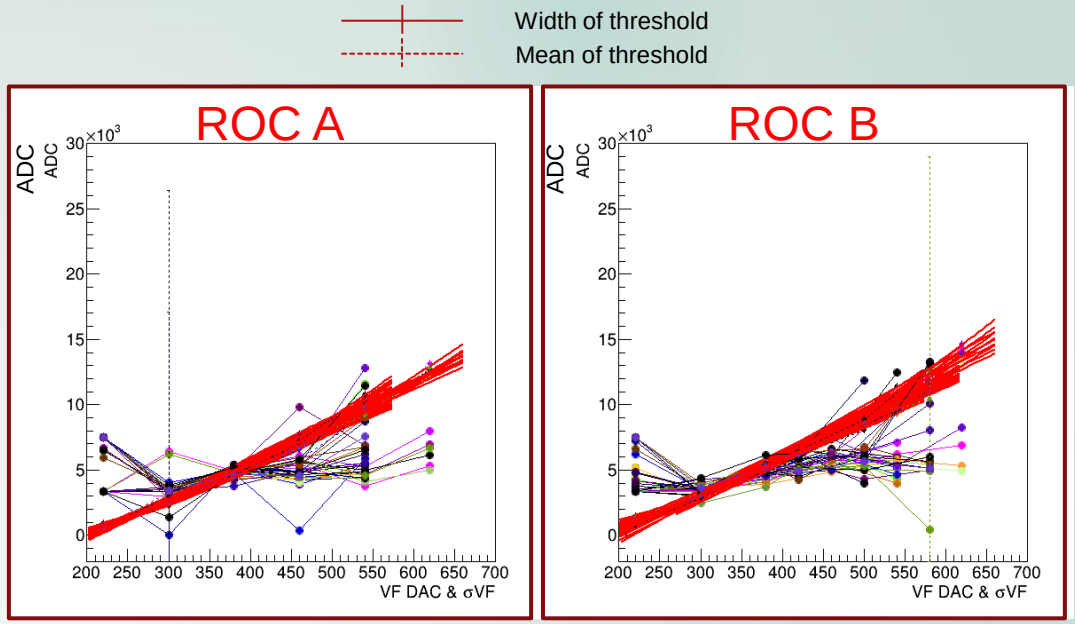
Mean THR

- Extract the mean THR and compare to ADC.
- Fit the mean THR by linear and quadratic.
  - Quadratic is better in much cases.
- Almost case could fit will by quadratic.

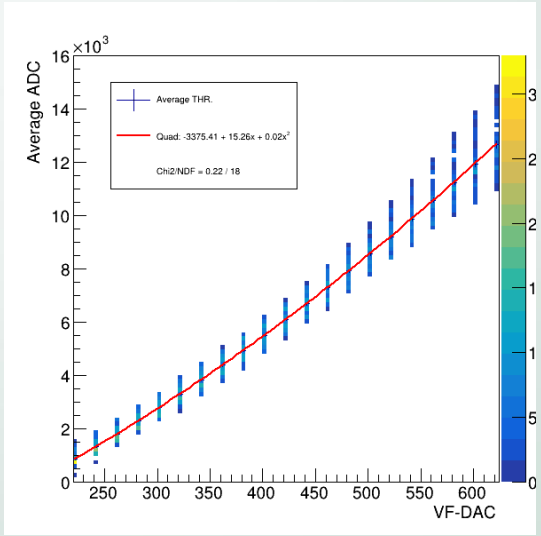


Mean THR

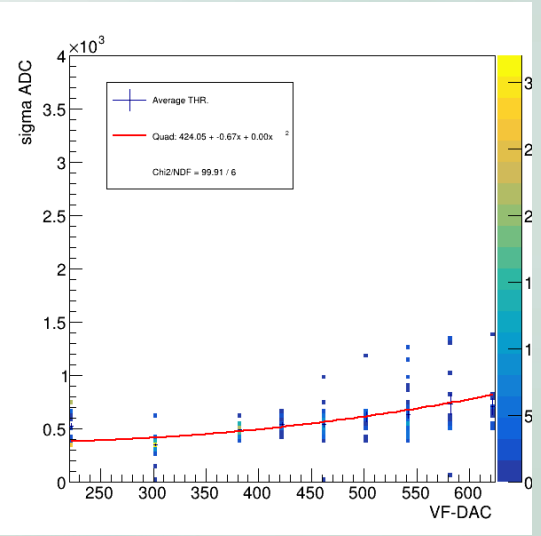
- Extract the mean THR and compare to ADC.
- Fit the mean THR by linear and quadratic.
  - Quadratic is better in much cases.
- The mean could fit will by quadratic.
  - Use quadratic to construct the all channel case and fill them into TH2 to fit by quadratic for total channel.
  - Average THR of all channel:
    - -3375.410 + 15.255 ADC + 0.017 ADC^2.
- The width of THR is no relationship.



Fit the σTHR



Fit the σTHR



Back up: X-ray escape peak

- X-ray escape peak is kind of process that the gamma ray loss some energy by X-ray in crystal.
- In some crystal scintillator detector paper, they describe the X-ray escape peak in the gamma radiation case.

Text book: G. F. Knoll, *Radiation Detection and Measurement*, 4th ed. (Wiley, 2010)

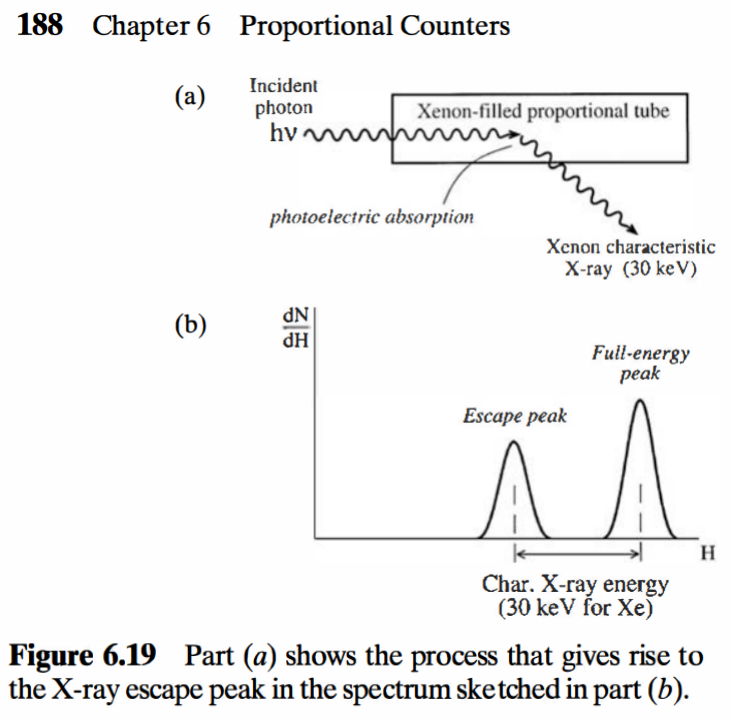


Figure 6.19 Part (*a*) shows the process that gives rise to the X-ray escape peak in the spectrum sketched in part (*b*).

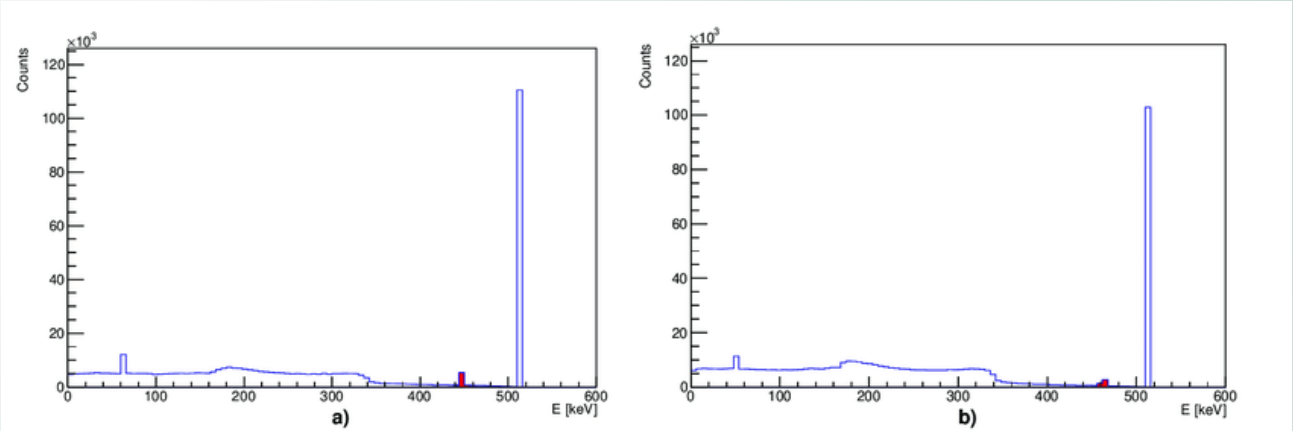
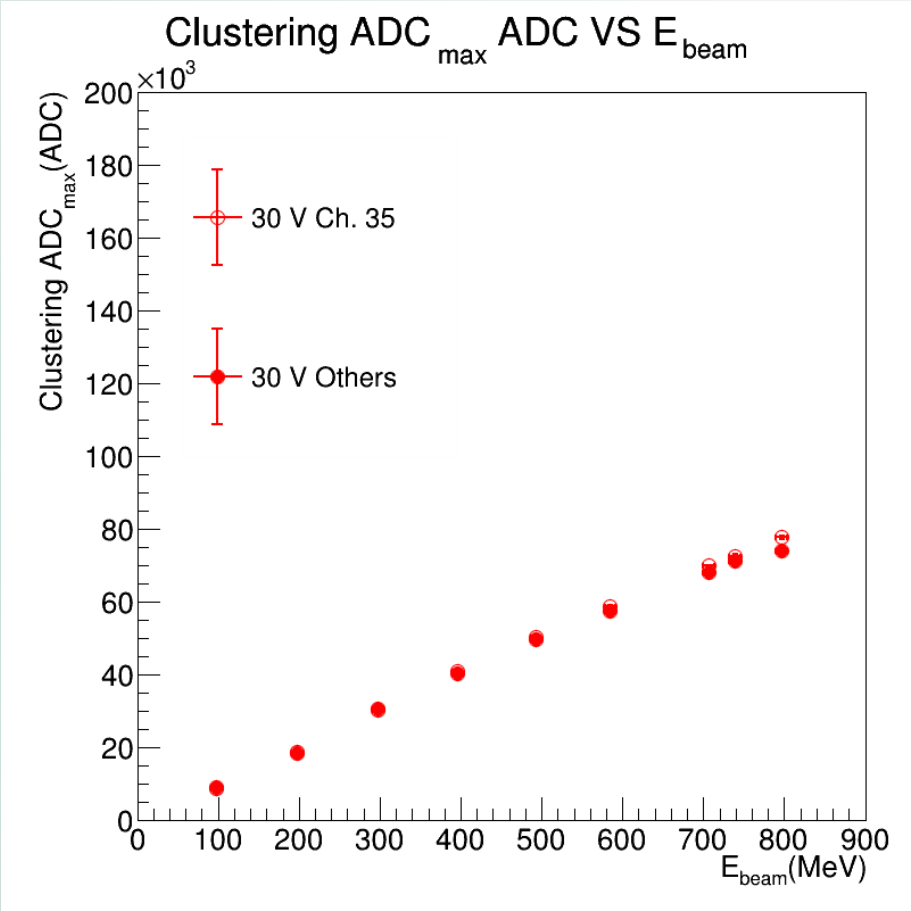


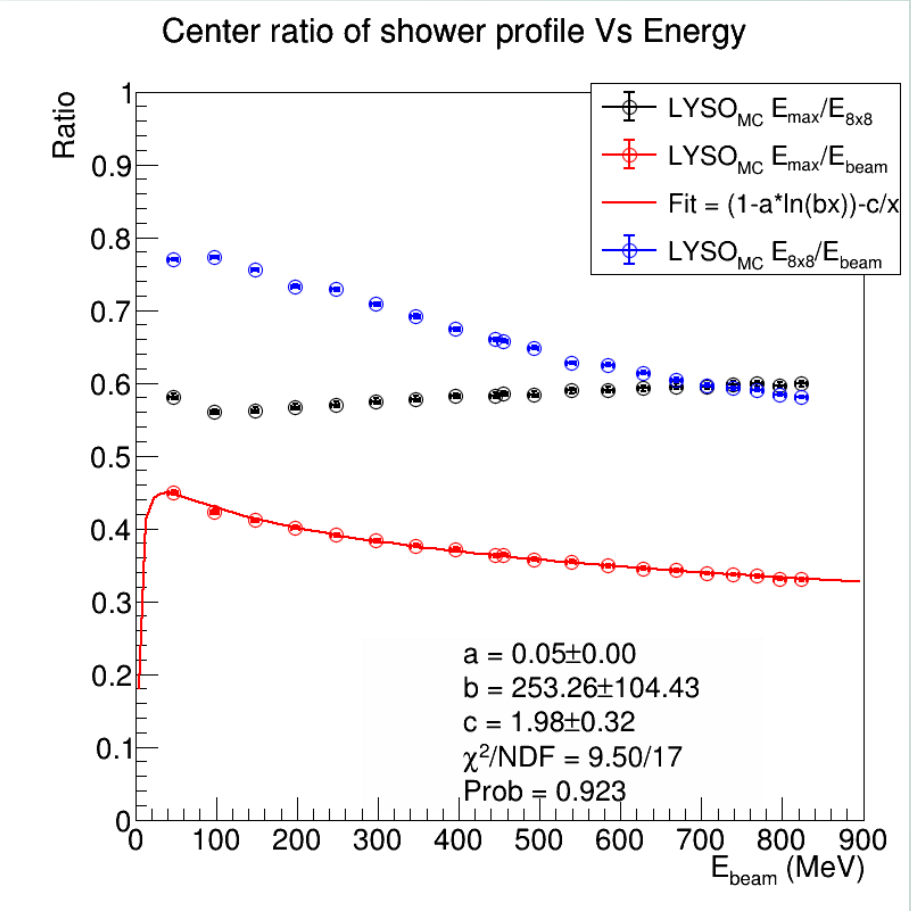
Figure 11. Simulated spectra of GAGG and LYSO crystals. The X-ray escape peaks are visible in red at around (**a**) 450 keV for LYSO and (**b**) 460 keV for GAGG crystals.

Reference: Matter **2021**, *6*(4), 43; **https://doi.org/10.3390/condmat6040043**

ADC to MeV: PWO

- Use the relationship of ADCmax VS Emax and Ebeam VS ADCmax, we can convert the ADC to MeV, and know the MeV of THR and σTHR –ADC.

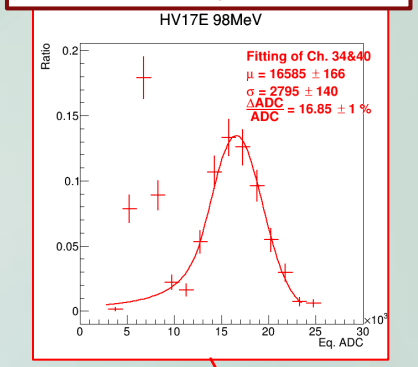


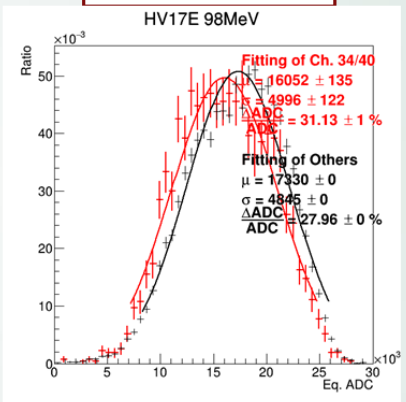
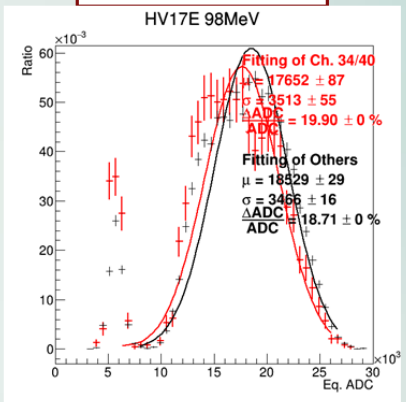
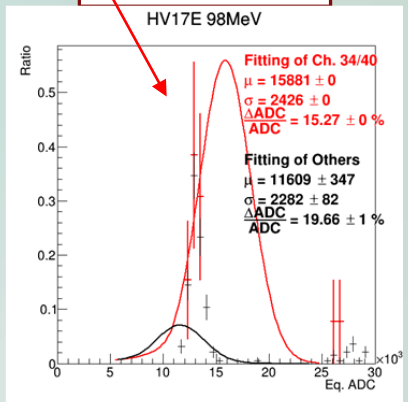


Problem: Apply the THR cut on $PbWO_4$ MC

- **Why does ADCmax show 2 peaks in both MC and data, but $Edep_{max}$ not?**
  - In simulation, energy is from crystal, but collected photons are from SiPM.
  - Applying THR cuts makes SiPM channels act separately → sometimes 2 peaks appear in data/MC
- **For 98 MeV, THR=650, but it behaves like the 450 case in data?**
  - THR(DAC) must be set channel by channel.
  - Try 450 files of data to check.
- **In the high THR cases, the resolution is wired!**
  - The THR make the data point in a small range.
  - When the THR approach the peak, the resolution of Emax is better…
  - When the THR filter the channels without max tower channel
    - => $\Delta E_{\max} = \Delta E_{5x5}$, and also have a smaller resolution.

E5x5 of Data, HV = 30V



	THR.: 0 MeV	THR.: 20.4 MeV	THR.: 45.2 MeV
ADC_{max}			
$Edep_{max}$