# ZDC ECal
# Test Beam Analysis

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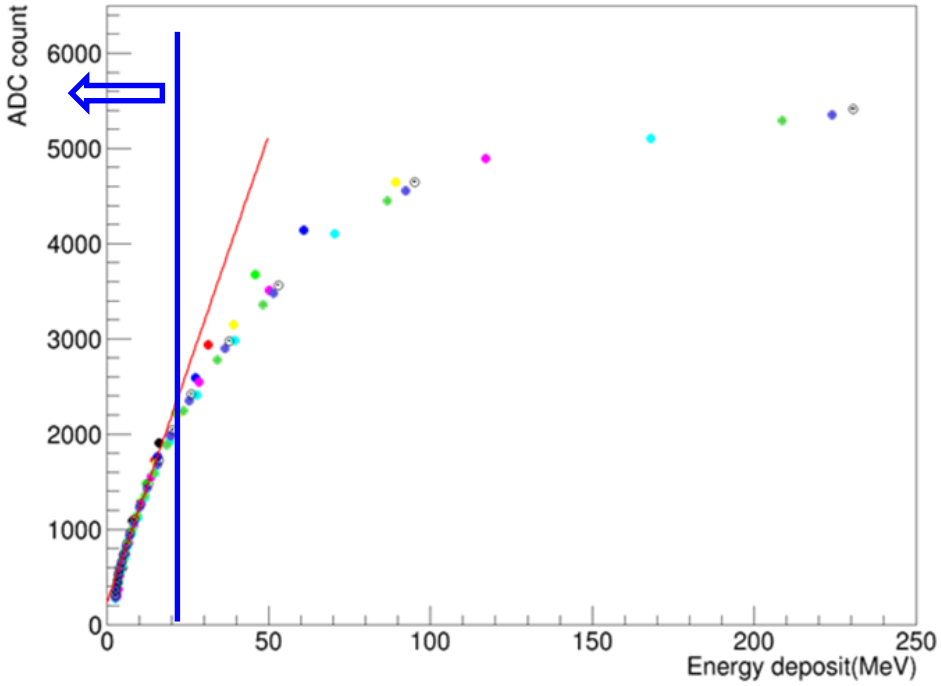
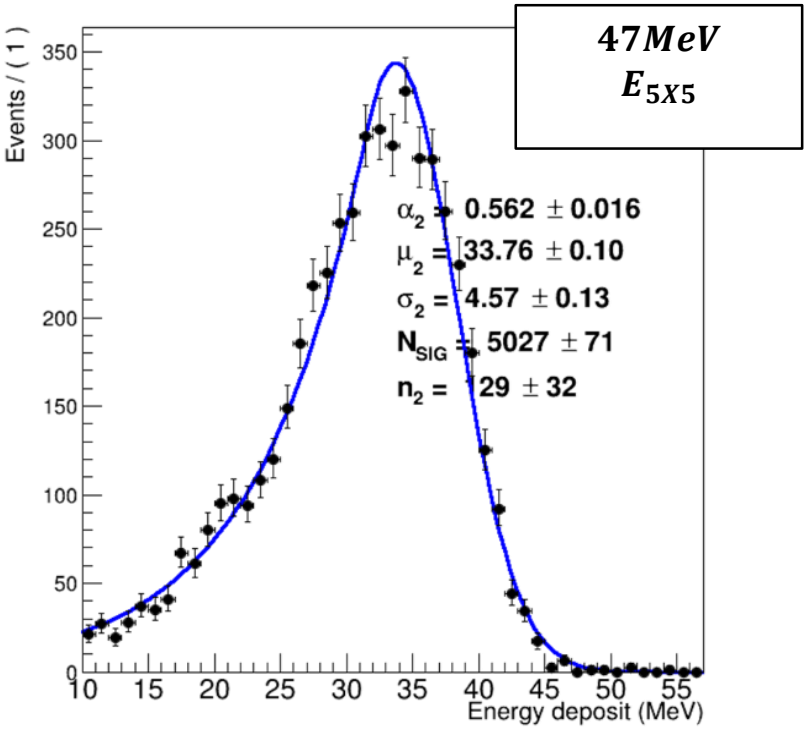
# Reminder : Energy Resolution of 47MeV

linear

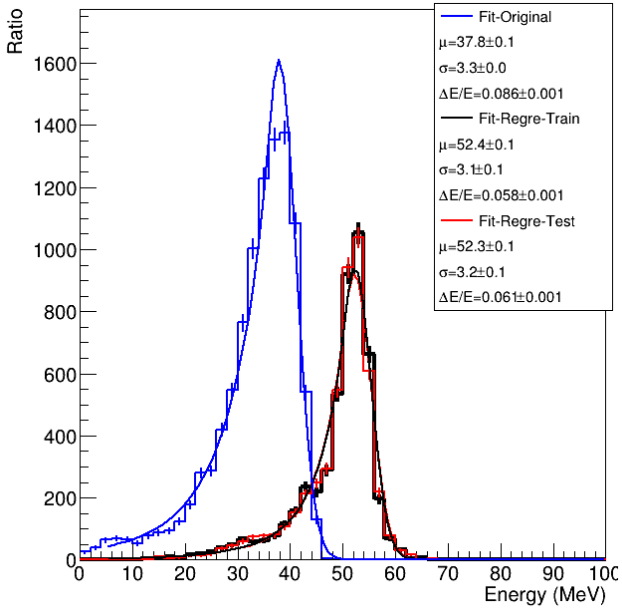


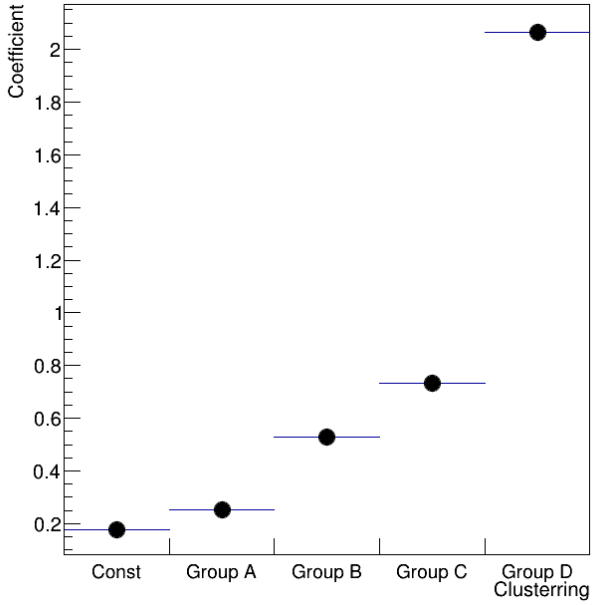



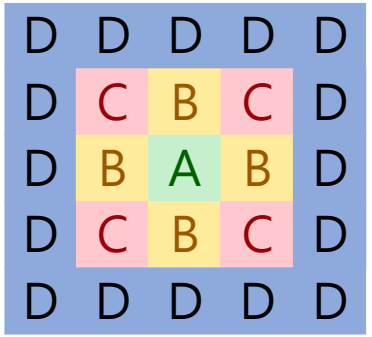

- We analyzed the 47 MeV data in this linear range(crystal Edep<20 MeV), estimating an energy resolution of approximately 13%, factoring in an 11% beam momentum resolution. It means the energy resolution is around 7%.
- Next step : perform **energy regression** on 47MeV data to improve energy resolution.

# Energy Regression w/ Linear Fit

## 50MeV MC sample



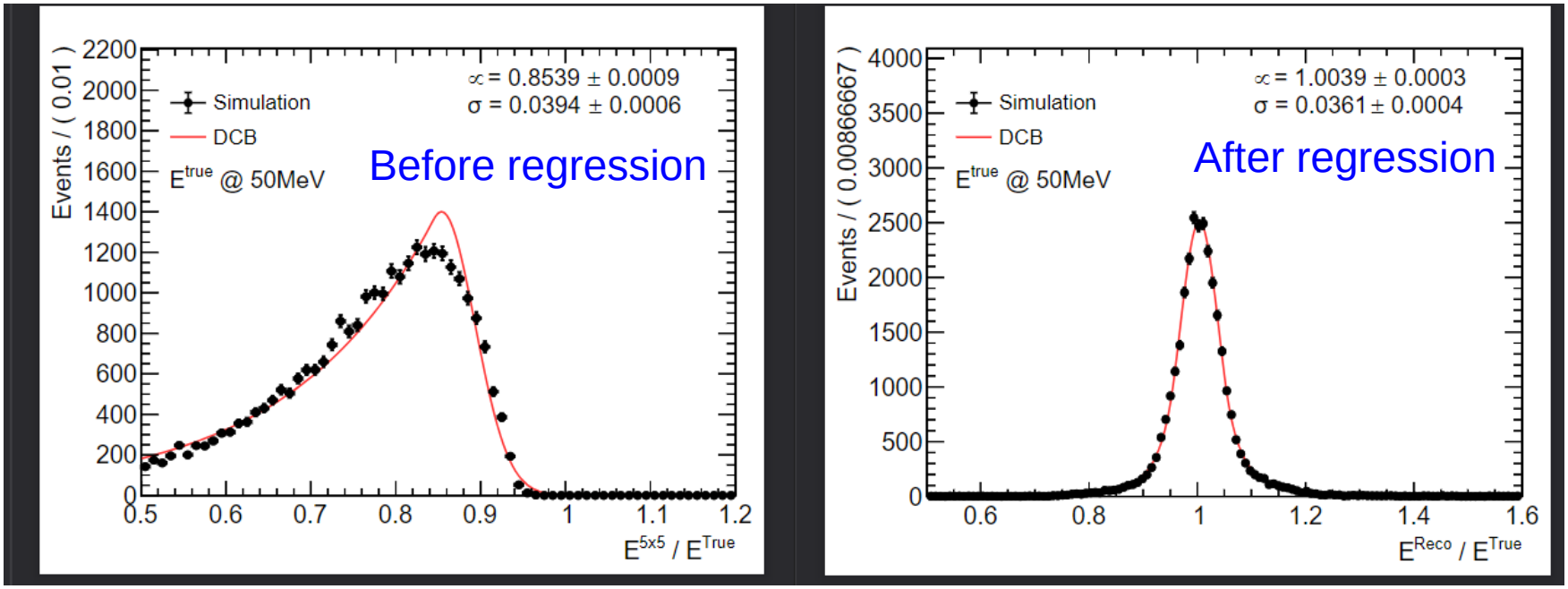

$$E'_{55} = \Sigma_{ig=0}^{3} C_{ig} E_{ig} + Constant$$

$$\chi^2 = \Sigma_{k=0}^{Nev} \frac{\left(E_{beam} - E'_{55}\right)^2}{E_{beam}}$$

- **50MeV MC sample** is used to test the method of energy regression.
- **Linear fit** is test to perform regression.
- **Before** regression : $\boldsymbol{E_{5x5} = 37.8\,MeV}, \Delta E_{5x5} = 3.3\ MeV, \boldsymbol{\Delta E/E \sim 8.6\%}$
- **After** regression : $\boldsymbol{E_{5x5} = 52.4\,MeV}, \Delta E_{5x5} = 3.2\ MeV, \boldsymbol{\Delta E/E \sim 6.1\%}$
- Resolution is improved but the energy is not reagreed to 50MeV.
- This method will be applied to data to test.

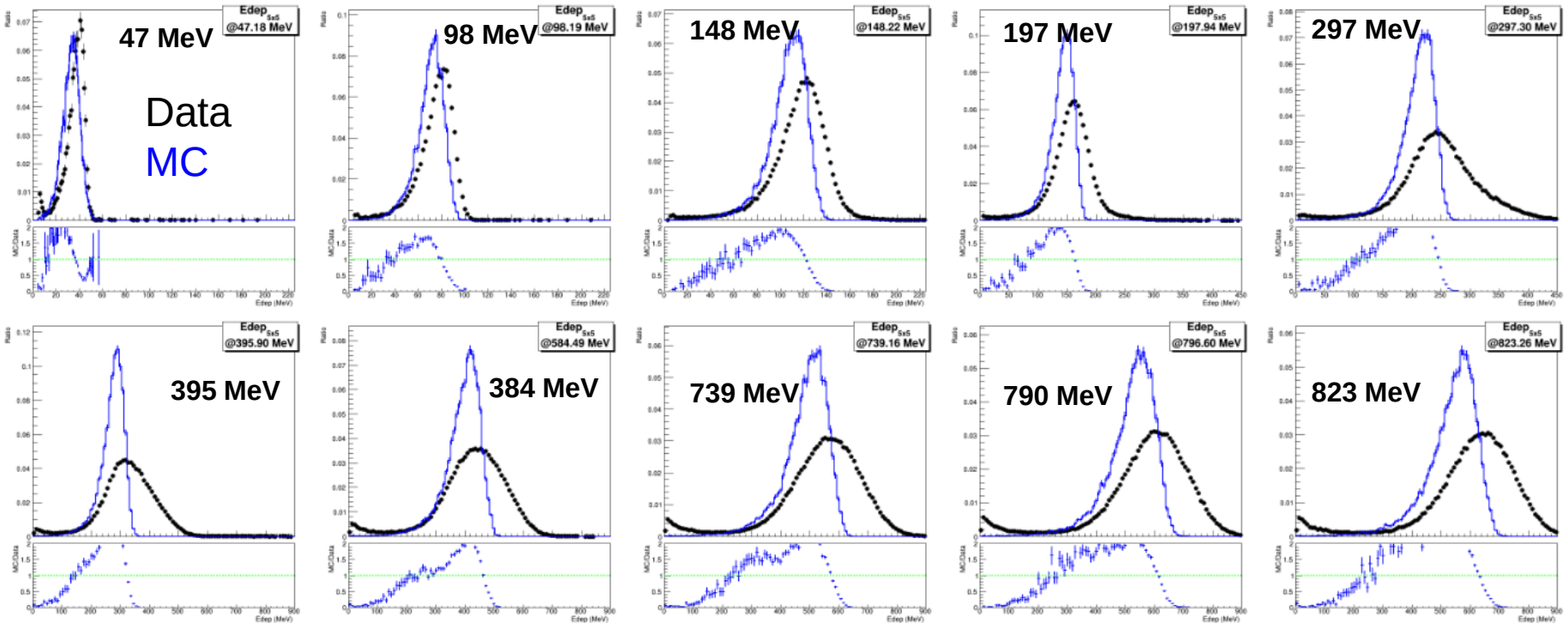
# Energy Regression w/ ML Method (XGboost)

**50MeV$\pm$10$MeV$ MC sample**



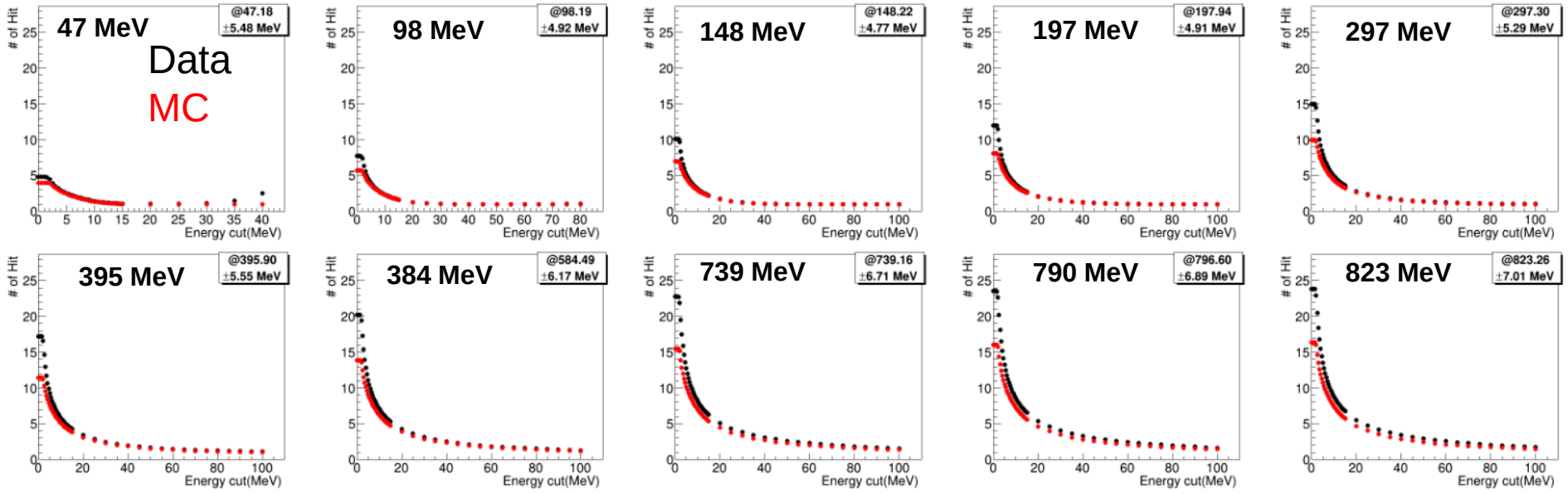

- 50MeV $\pm$ 10MeV MC sample (flat distribution) is used to test the method of energy regression.
- Linear fit is test to perform regression.
- **Before** regression : $E_{5x5}/E_{beam} = 0.85$, $\Delta E_{5x5}/E_{beam} = 3.94\,\%$
- **After** regression : $E_{5x5}/E_{beam} = 1.00$, $\Delta E_{5x5}/E_{beam} = 3.61\%$
- After regression, the energy is well estimated and resolution is also improved.
- This method will be applied to data to test.

# Data in Nonlinear Range of SiPM (1)



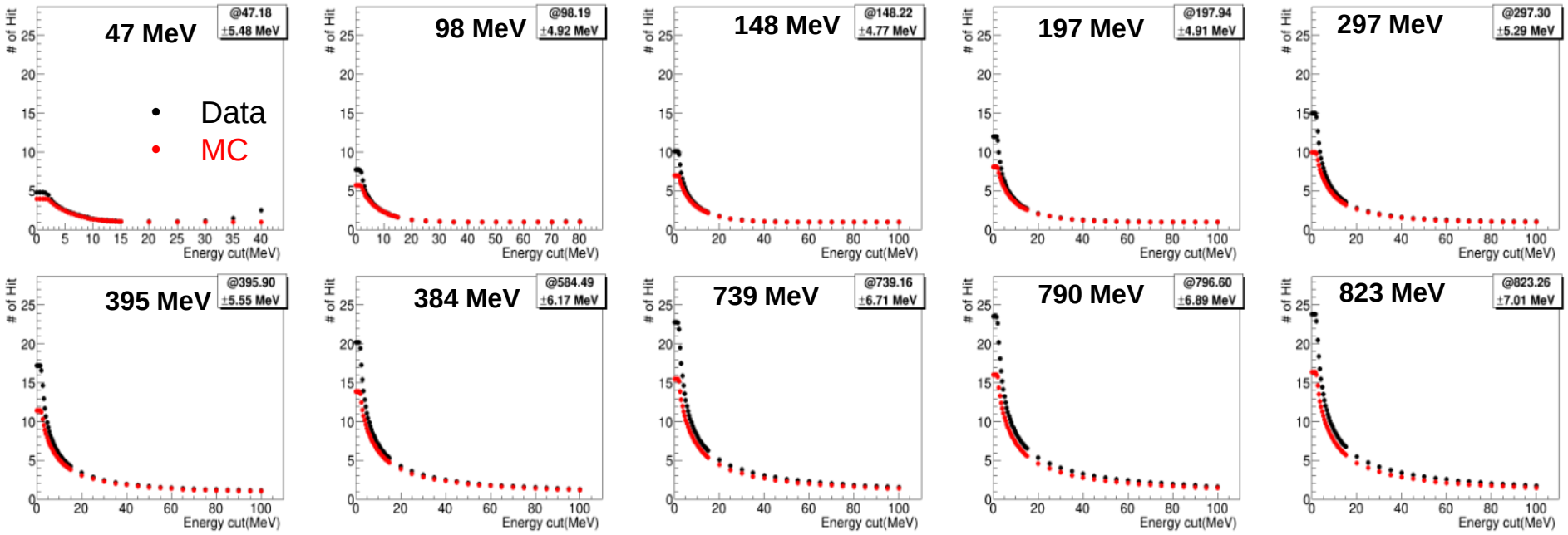

- Energy cut of crystals : Edep>2.5MeV
- Worse data and MC consistency towards to higher beam energy.

# Data in Nonlinear Range of SiPM (2)



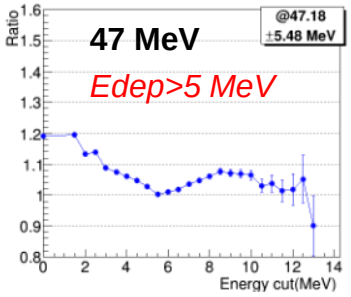

- Number of hits (number of fired crystal) is studied to optimize the energy cut.
- Data has more fired crystal than MC.

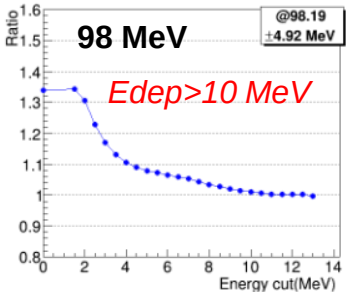
# Data in Nonlinear Range of SiPM (3)

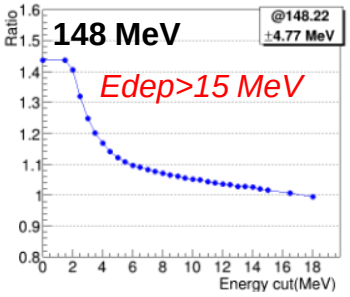


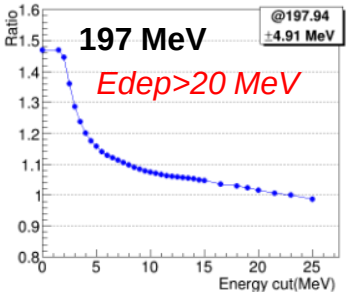

- Number of hits (number of fired crystal) is studied to optimize the energy cut.
- Data has more fired crystal than MC.

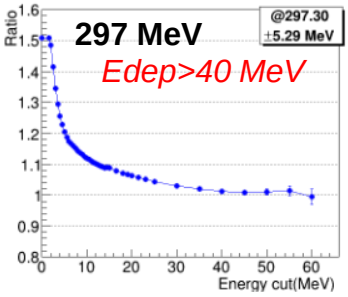
# Data in Nonlinear Range of SiPM (4)

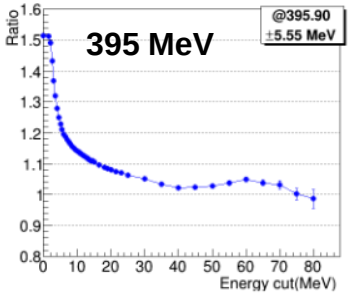


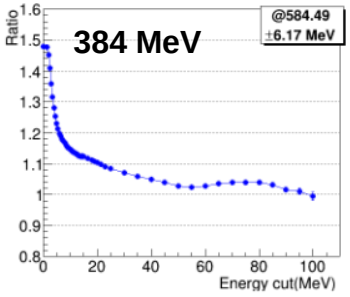



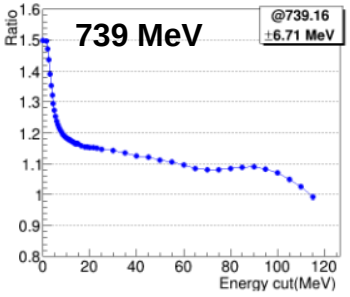



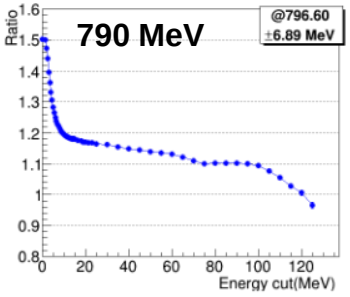



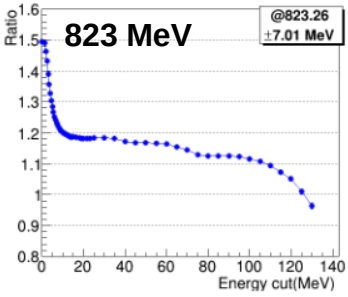



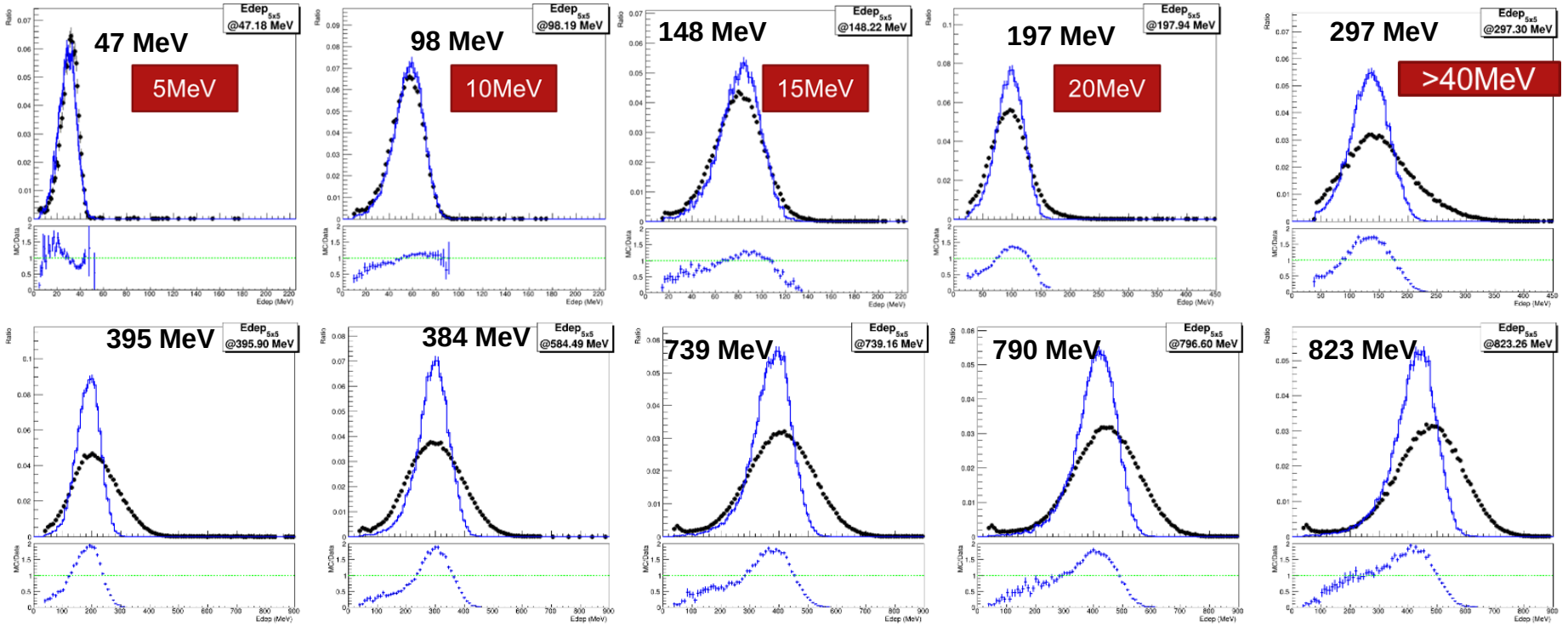



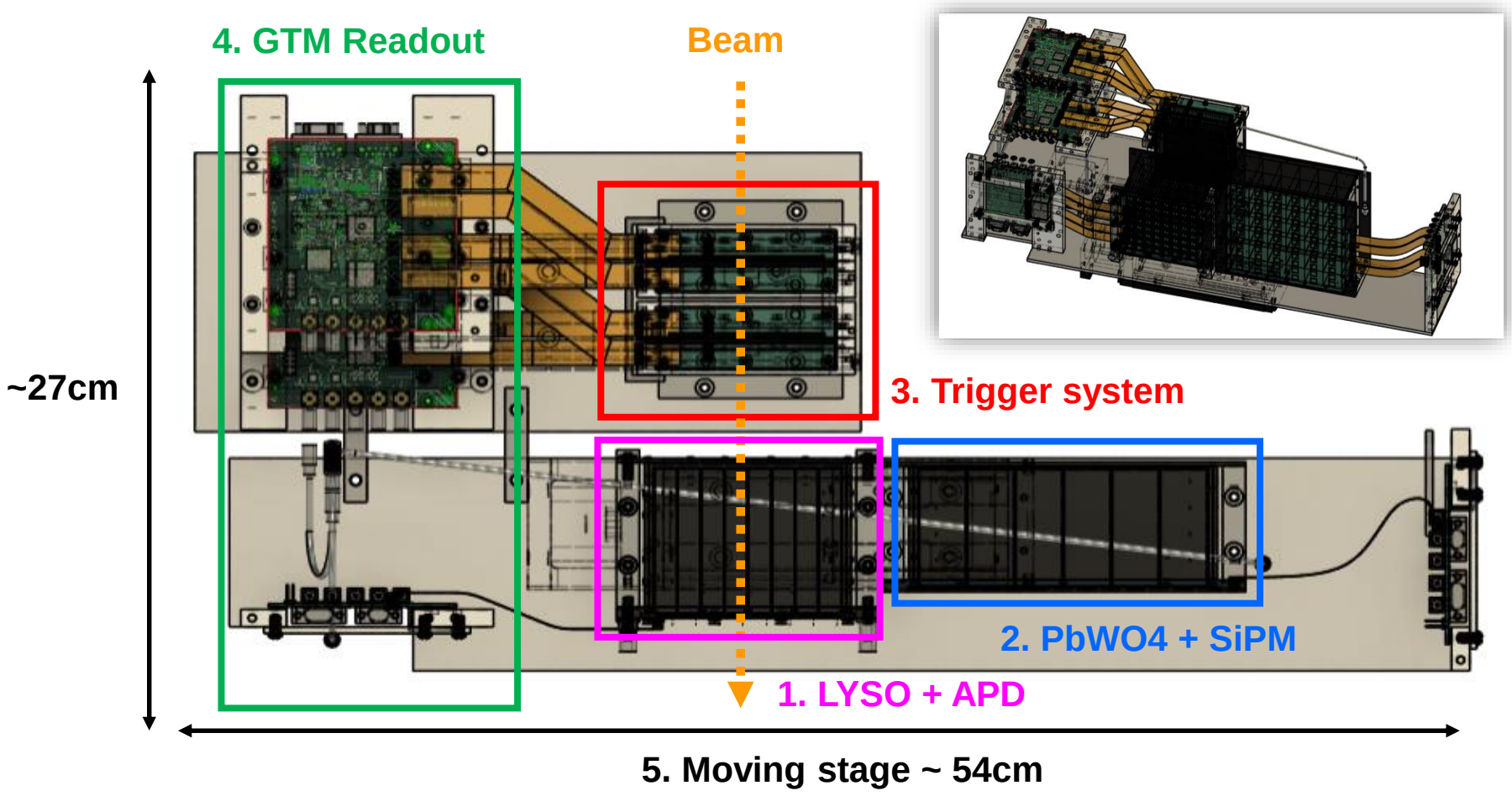

- Larger energy cut towards to higher beam energy.

# Data in Nonlinear Range of SiPM (4)




- When beam energy is less than 200MeV, the strategy of increase cut limit works well.
- For the higher beam energy, tuning MC is necessary. The optical photon option will be turned on in MC and check.

# Status of 2nd Prototype(1)



# Status of 2nd Prototype(2)

| | Parts | Progress@2024/11/18 |
|---|---|---|
| **1. LYSO**<br>1cm*1cm*6.6cm<br>8x8 array | LYSO Cryatal | ready |
| | APD (C30739ECERH) | ready |
| | APD Readout PCB | under production, 12/16 |
| | LYSO Housing | ready |
| | LYSO Base support | ready |
| **2. PbWO4**<br>2cm*2cm*5.3cm<br>6x6 array | PbWO4 | designing |
| | SiPM (MICROFC-60035) | ready |
| | APD (C30739ECERH) | under production, 12/16 |
| | SiPM Readout PCB | designing |
| | APD Readout PCB | designing |
| | PbWO4 Housing | designing |
| **3. Trigger**<br>2mm*2mm*8cm<br>32ch in X<br>32ch in Y<br>XY layers/set<br>Two sets | scintillator | ready |
| | SiPM | ready |
| | SiPM Readout PCB | under production, 12/16 |
| | scintillator Housing | under production |
| | trigger Base support | under production |
| **4. GTM** | GTM firmware | designing |
| | GTM base support | under production |
| | cable | under production |
| **5. Moving stage** | base plate | designing |
| | slide rail | ready |
| | remote control | ready |

**Color code**

| Designing | Production | Ready | Testing |
|---|---|---|---|

**New LYSO crystals**

# Summary and To Do

- **Data in linear range** : We are now practicing the methods of energy regression for 47MeV data.
- **Data in non-linear range** : We are facing the problem of inconsistency between data and MC. Increase the cut limit of energy on crystal can improve consistency for the data with energy below 200MeV. For higher beam energy, MC will have to be turned.
- **2$^{nd}$ Prototype ZDC ECal** : The construction is undergoing. More than 70% components are either ready or under production.