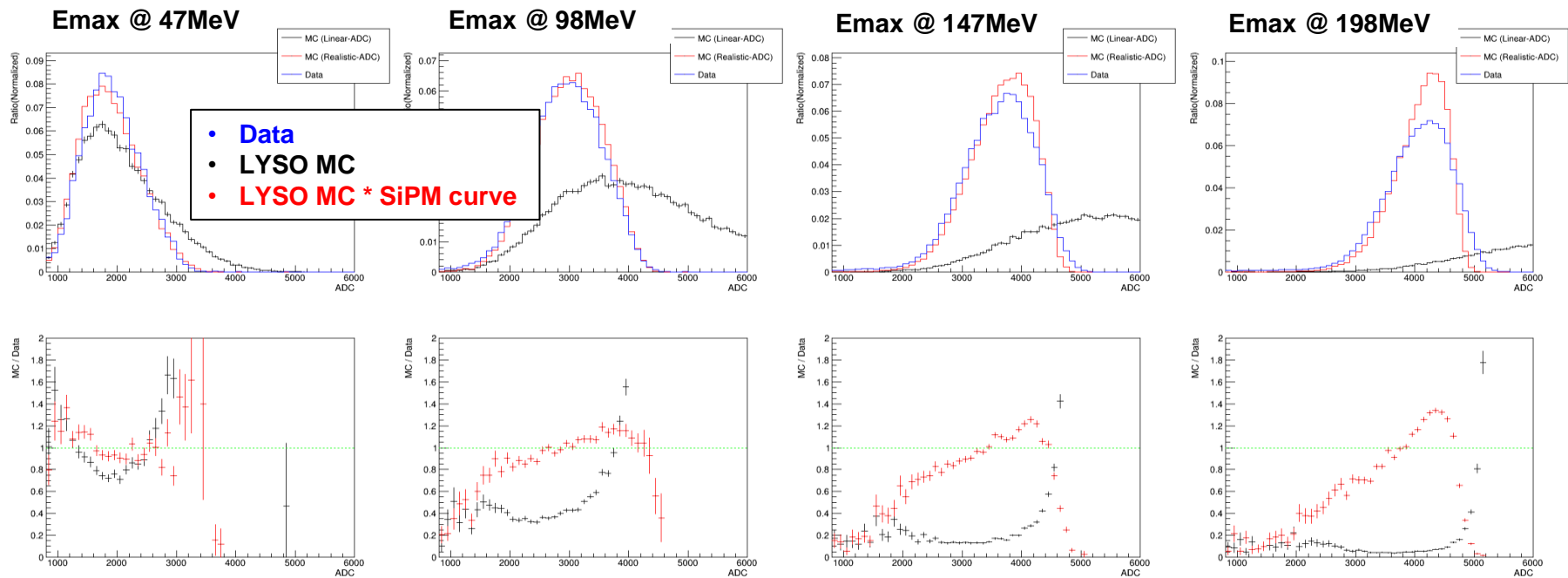
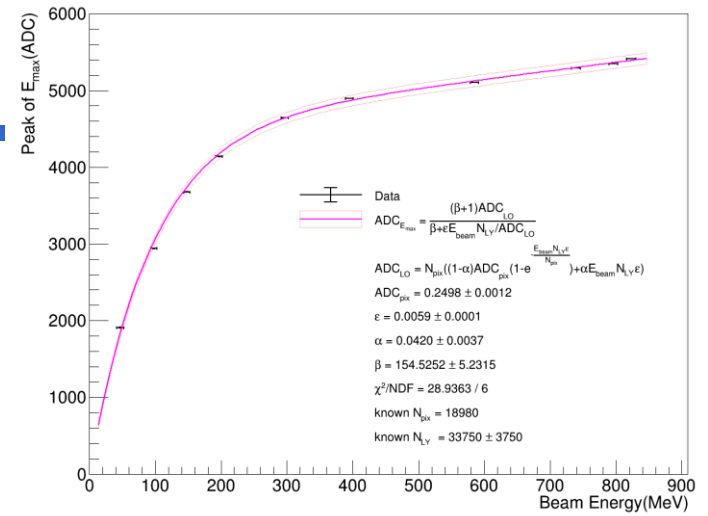
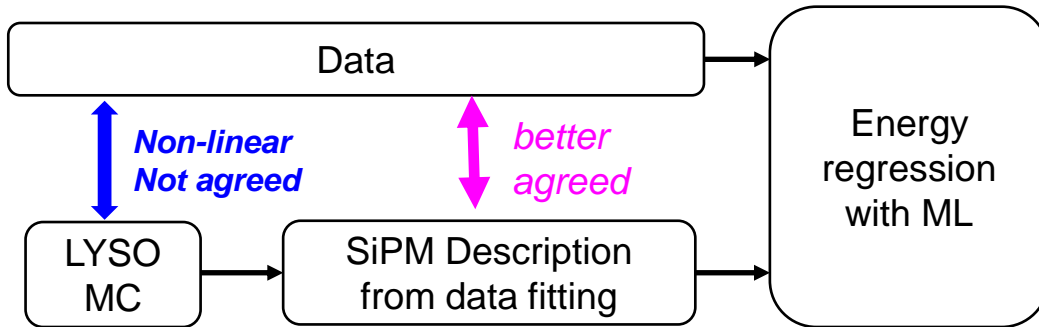


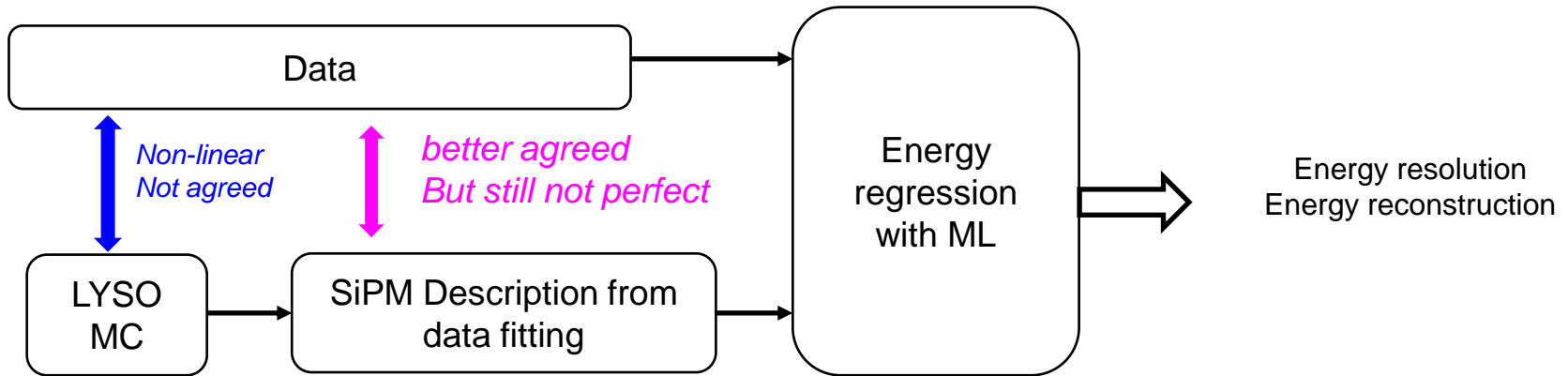
# Beam Test Analysis of 1<sup>st</sup> Prototype of ZDC ECal ePIC-ZDC@20240709

Jen-Chieh Peng, Wen-Chen Chang, Chih-hsun Lin,  
Chia Ming Kuo, Rong-Shyang Lu, Po-Ju Lin,  
Kai-Yu Cheng, Chia-Yu Hsieh (presenter),  
**Yu-Siang Xiao, Shao-Yang Lu,**  
Yuji Goto, Tatsuya Chujo, Motoi Inaba, Subaru Ito,  
Kentaro Kawade, Yongsun Kim

# Review

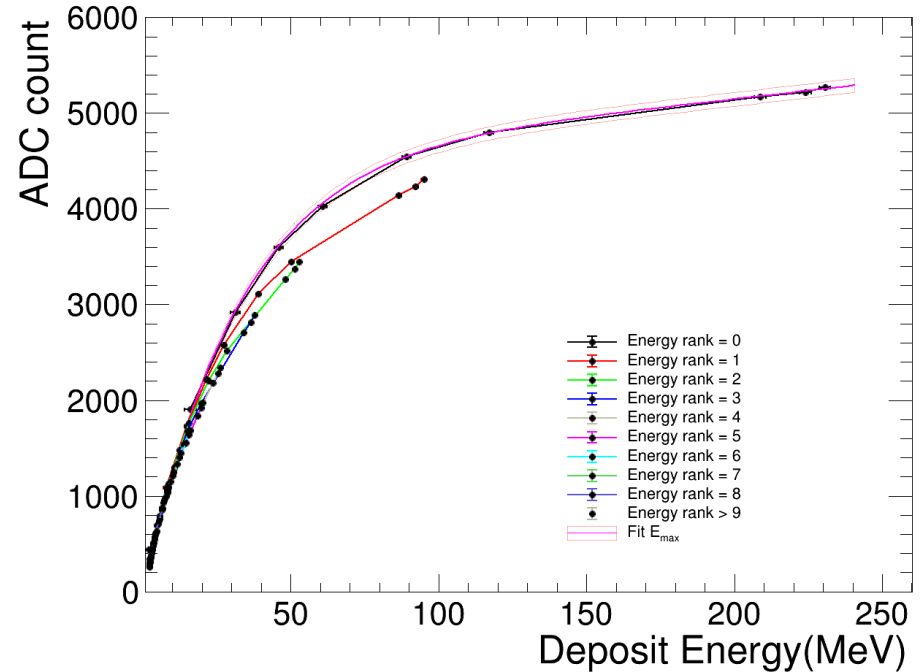
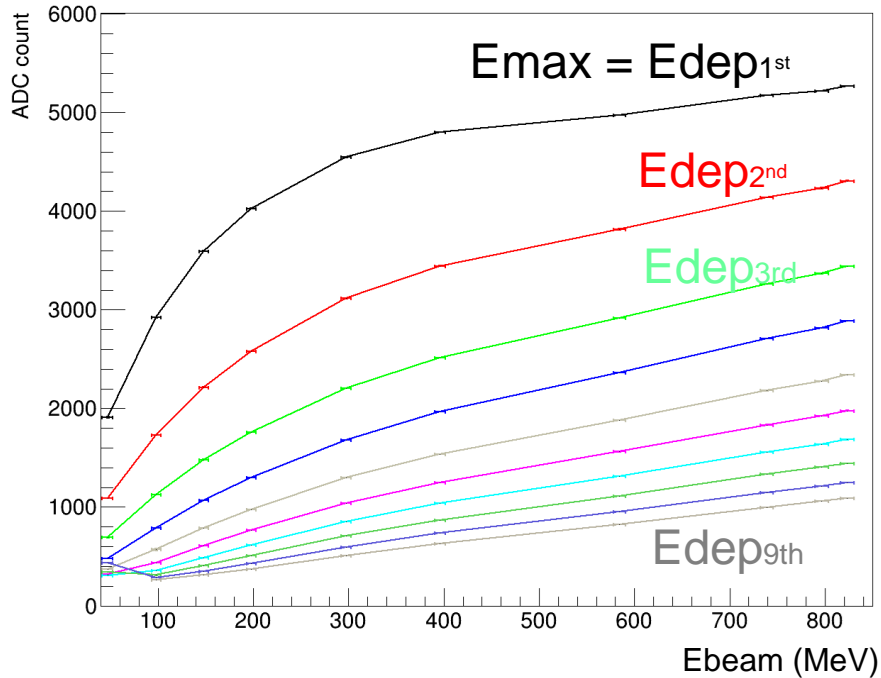


# Review



- To do
  - ① SiPM description :
    - Fit more data with higher beam energy
    - Fit data with not only  $E_{max}$ , but also  $E_{3 \times 3}$  and  $E_{5 \times 5}$
  - ② LYSO MC : move from  $E_{dep}$  to optical photon
  - ③ Energy regression : Train model with wide beam energy
- Today we have some updates concerning LYSO MC and SiPM description.

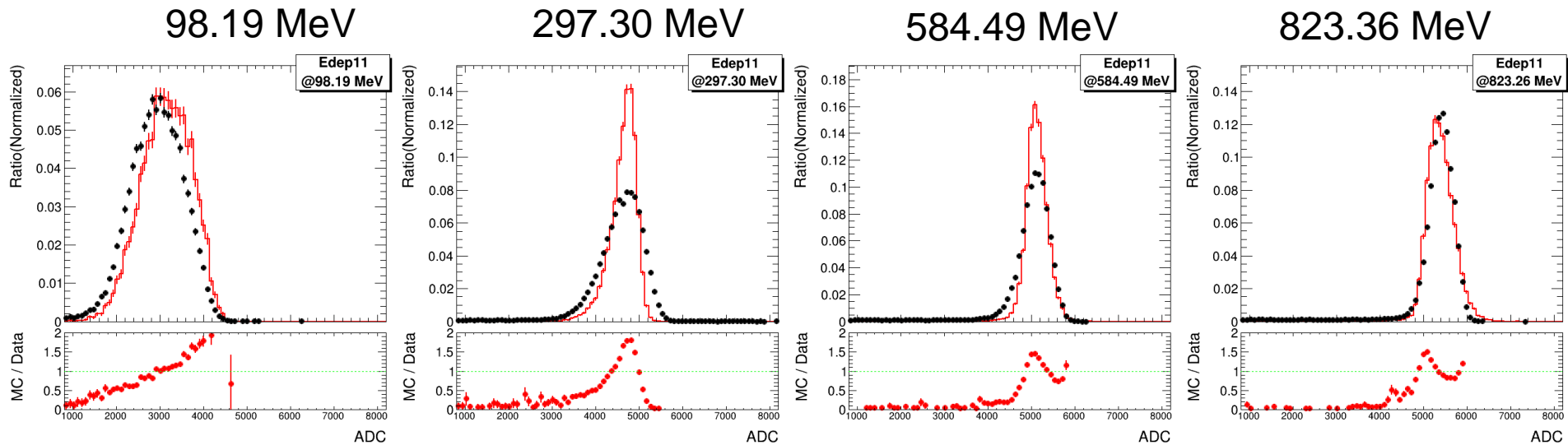
# SiPM Behavior with More Data



$$Edep(ith) = Ebeam * [Edep(ith)/Ebeam] \text{ from MC}$$

- SiPM behavior of Edep(2nd) and Edep(3rd) is slightly deviated from Edep(1<sup>st</sup>).
- For now, we applied SiPM behavior to Edep(ith) still with the fitting of Edep(1<sup>st</sup>) to check E3x3 and E5x5.

# Data vs MC : Emax



- Data
- LYSO MC \* SiPM curve

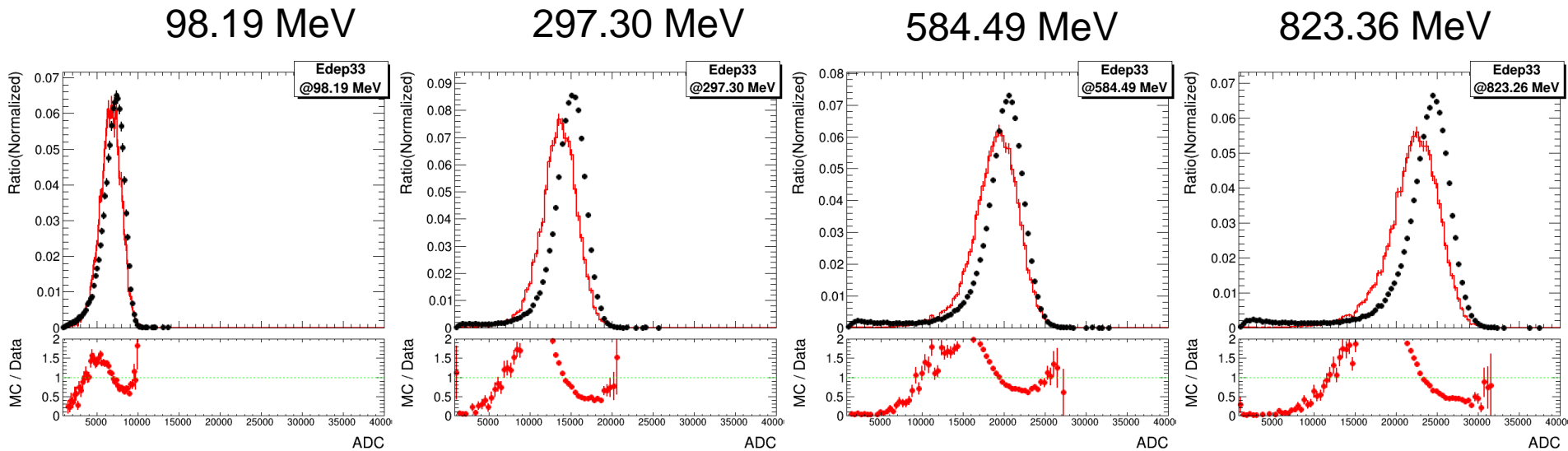
- **LYSO MC conditions**

- Still use Edep from particle, no optical photons involved (no MPT, no Birk's law).
- Beam position and beam spread are simulated as same as in the beam test.

- **Data and MC comparison of Emax**

- Normalization → ok
- Shape → not ok. Need to check with optical photons.

# Data vs MC : E3x3



- Data
- LYSO MC \* SiPM curve

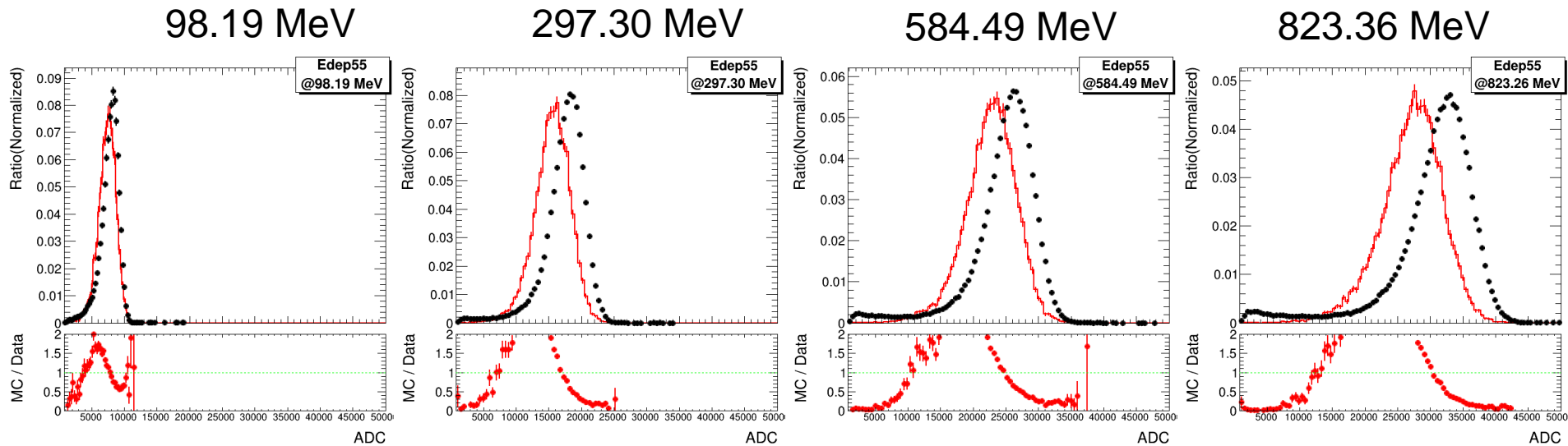
## • LYSO MC conditions

- Still use Edep from particle, no optical photons involved (no MPT, no Birk's law).
- Beam position and beam spread are simulated as same as in the beam test.

## • Data and MC comparison of Emax

- Normalization → Data is higher than MC. Worse goes to higher energy.
- Shape → not ok.

# Data vs MC : E5x5

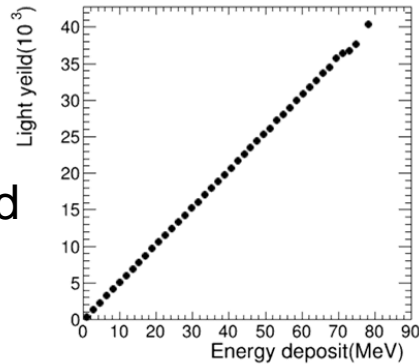


- **LYSO MC conditions**
  - Still use Edep from particle, no optical photons involved (no MPT, no Birk's law).
  - Beam position and beam spread are simulated as same as in the beam test.
- **Data and MC comparison of Emax**
  - Same conclusion as E3x3.

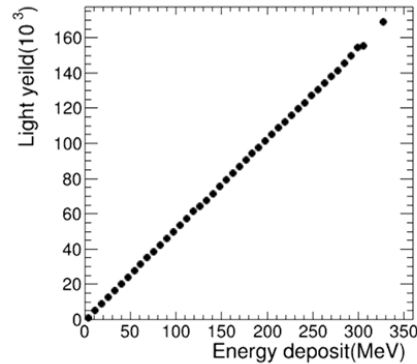
# MC with Optical Photons (w/o Birk's Law) Produced Light Yield

LY  
produced

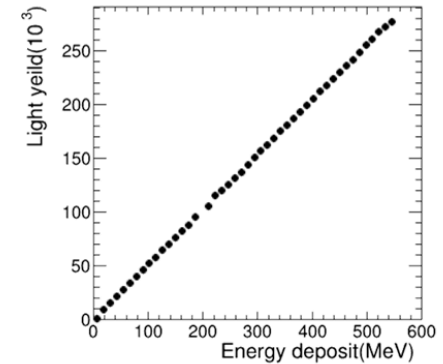
100 MeV



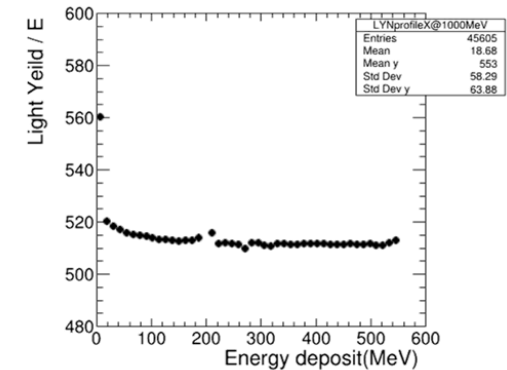
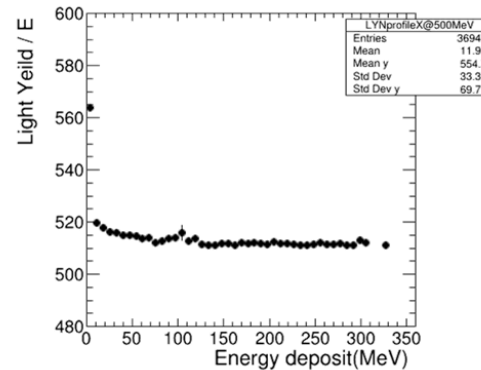
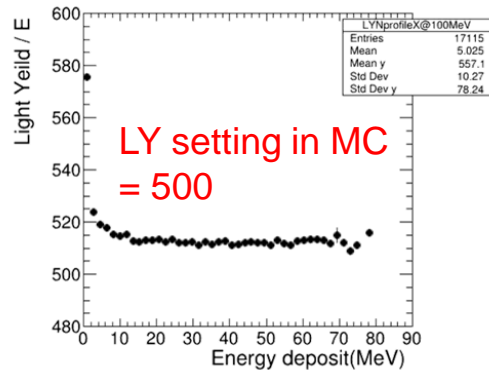
500 MeV



1000 MeV



LY/Edep



- MC condition : with MPT turn on but no Birk's law applied.
- Energy deposition inside each crystal is proportional to the light yield produced inside.

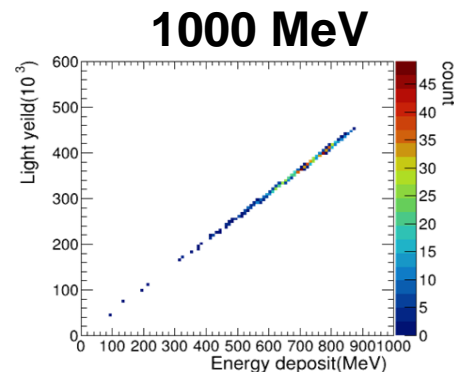
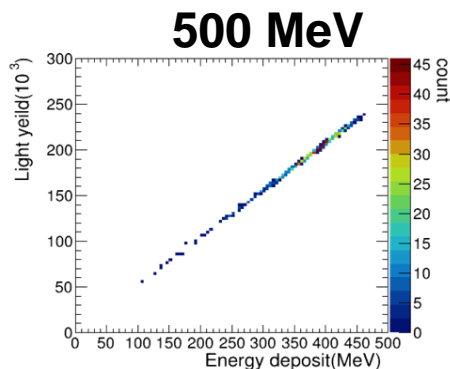
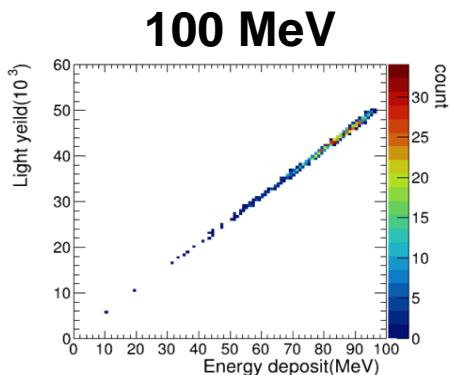


# MC with Optical Photons (w/o Birk's Law)

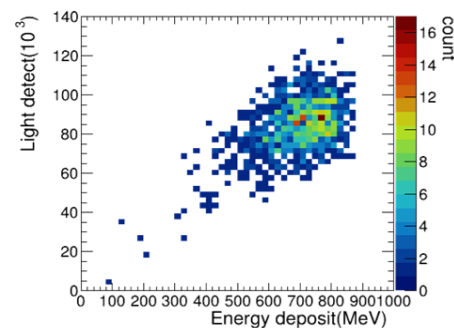
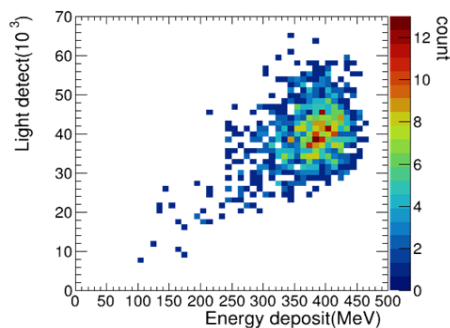
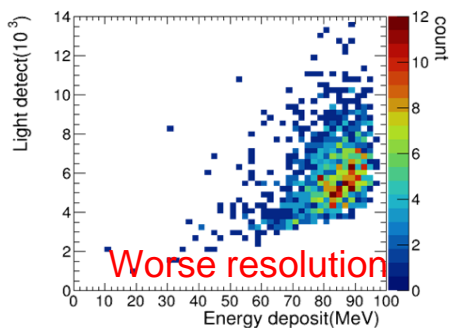


## Detected Light Yield

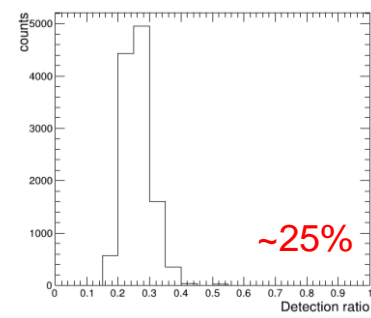
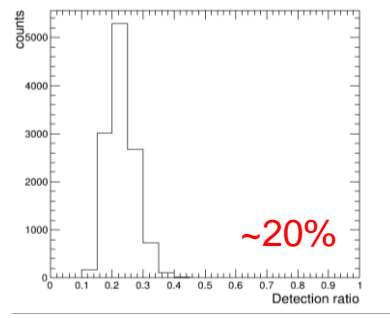
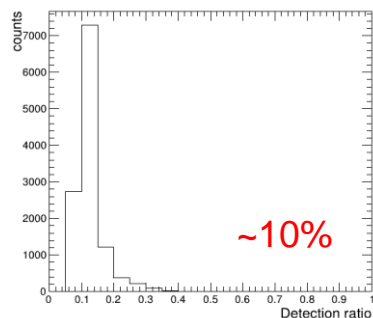
LY  
produced



LY  
arrive  
SiPM



arrive  
divided by  
produced

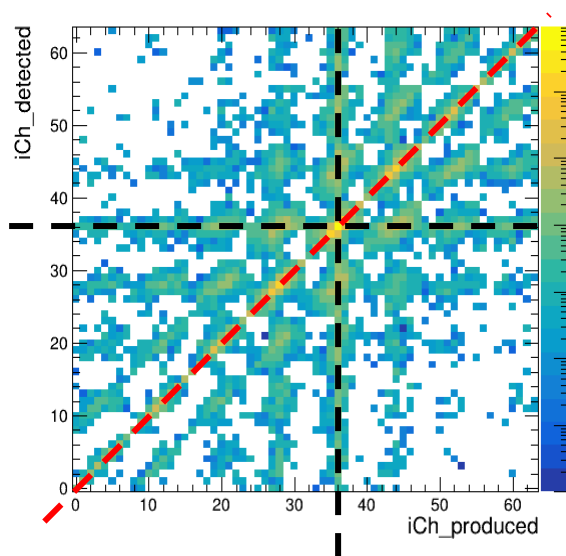


- We expect worse energy resolution for MC with optical photons.
- Around 10% to 25% photons arrive SiPM.

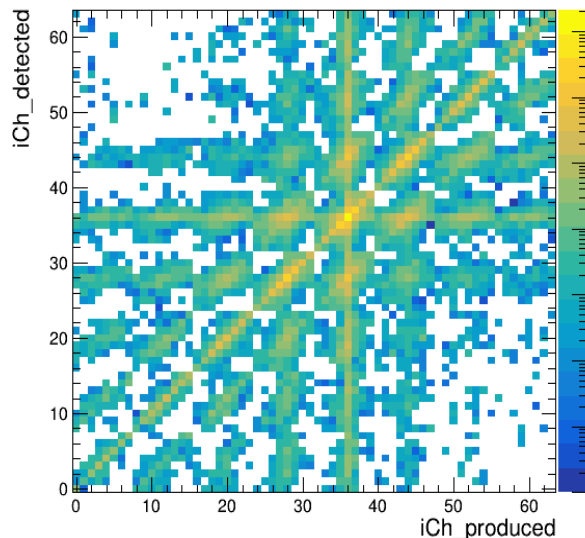
# MC with Optical Photon (w/o Birk's Law)

## Leakage of Photons

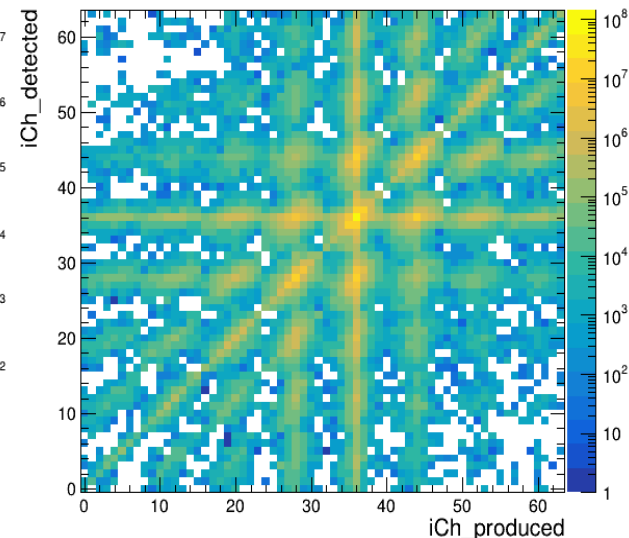
100 MeV



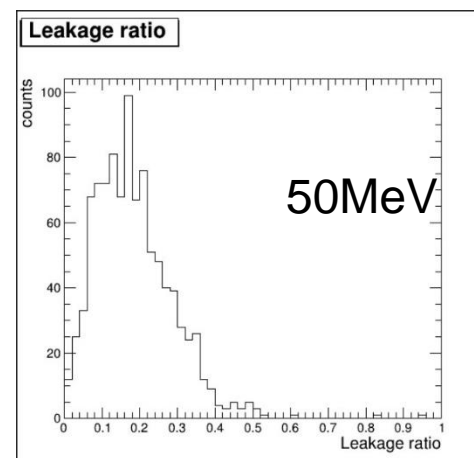
500 MeV



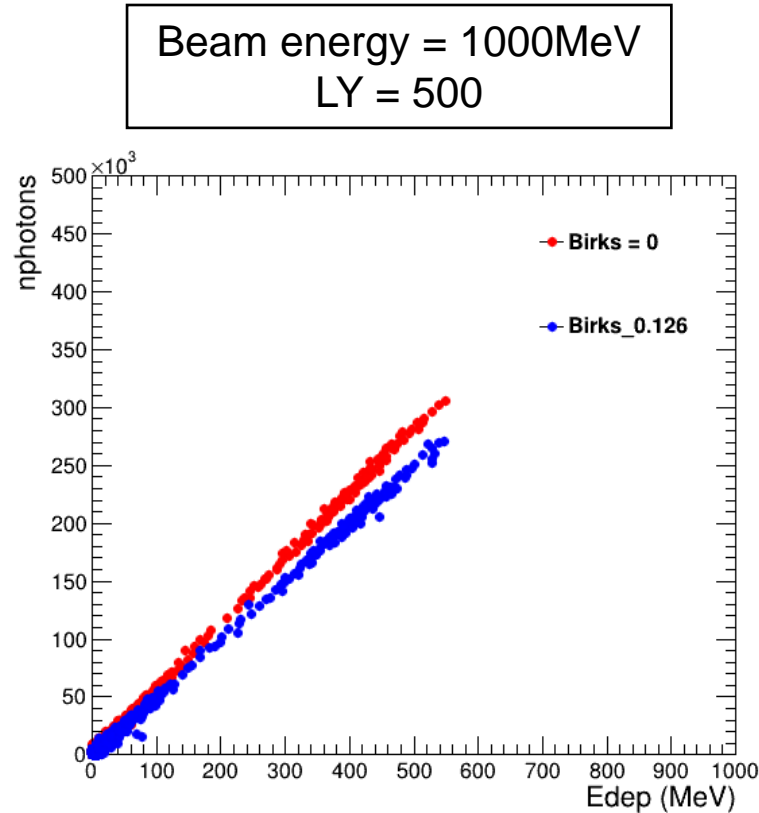
1000 MeV



There is photon leakage ~ 10%

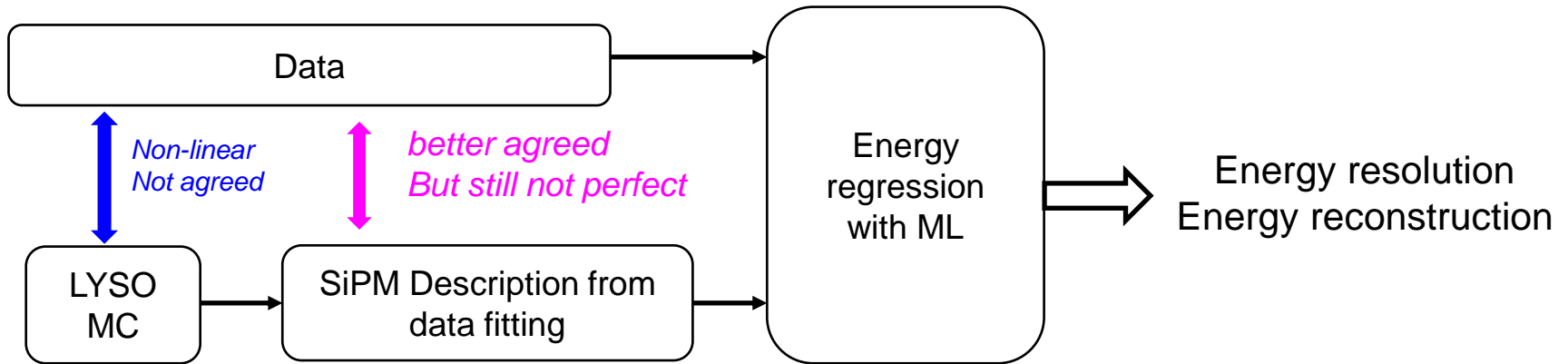


# MC with Optical Photon w/ Birk's Law



- Produced LY is non-linear with Edep if Birk's law turn on.

# Summary and To Do



- To do
  - ① SiPM description :
    - ~~Fit more data with higher beam energy~~
    - ~~Fit data with not only  $E_{max}$ , but also  $E_{3x3}$  and  $E_{5x5}$~~
    - **New Fit**
  - ② LYSO MC : move from  $E_{dep}$  to optical photon
    - ~~Basic check of MC with optical photon~~
    - **Fit data with LYSO MC with optical photons**
  - ③ **Energy regression : Train model with wide beam energy**

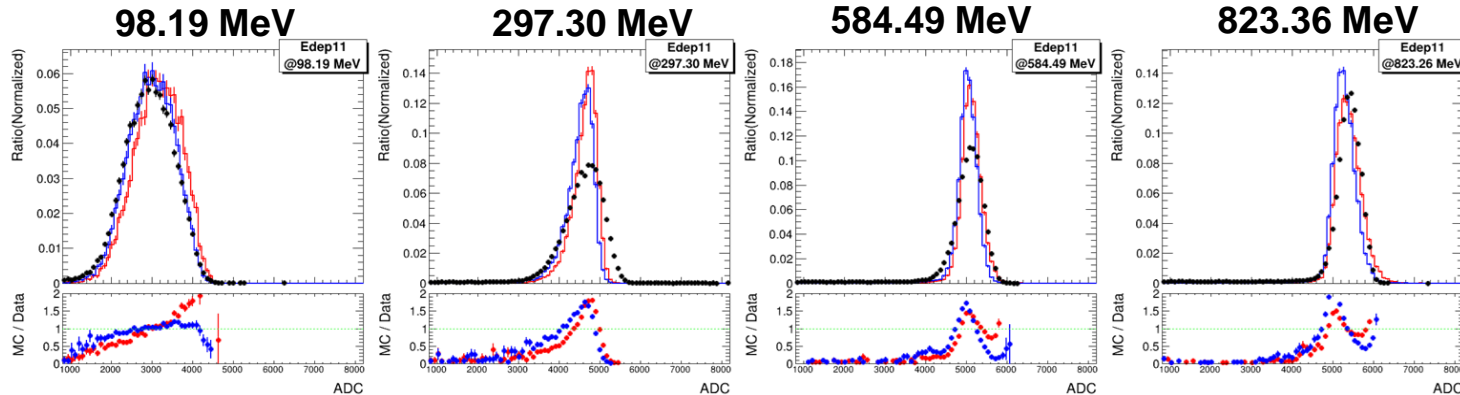


# Back up

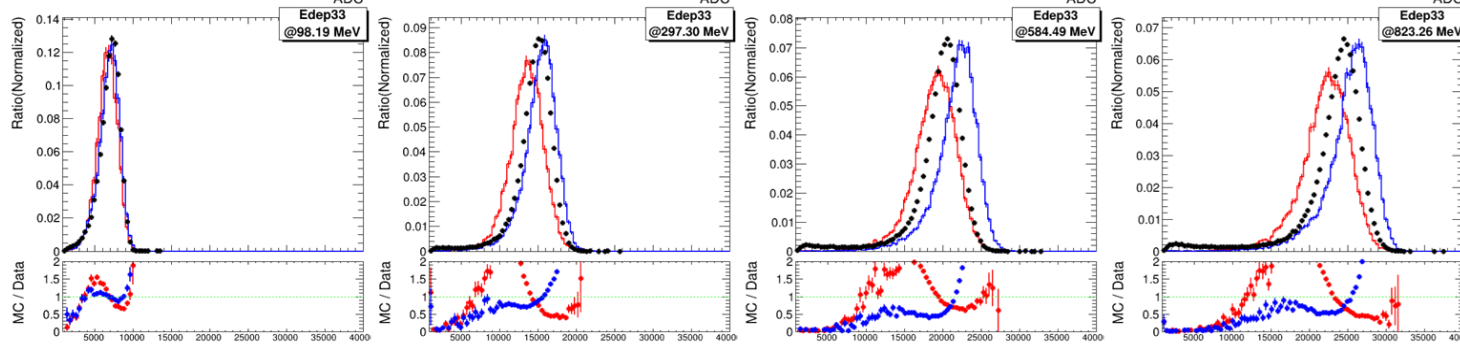
# Leakage Test

- Data
- LYSO MC \* SiPM curve
- LYSO MC Edep\* leakage \* SiPM curve

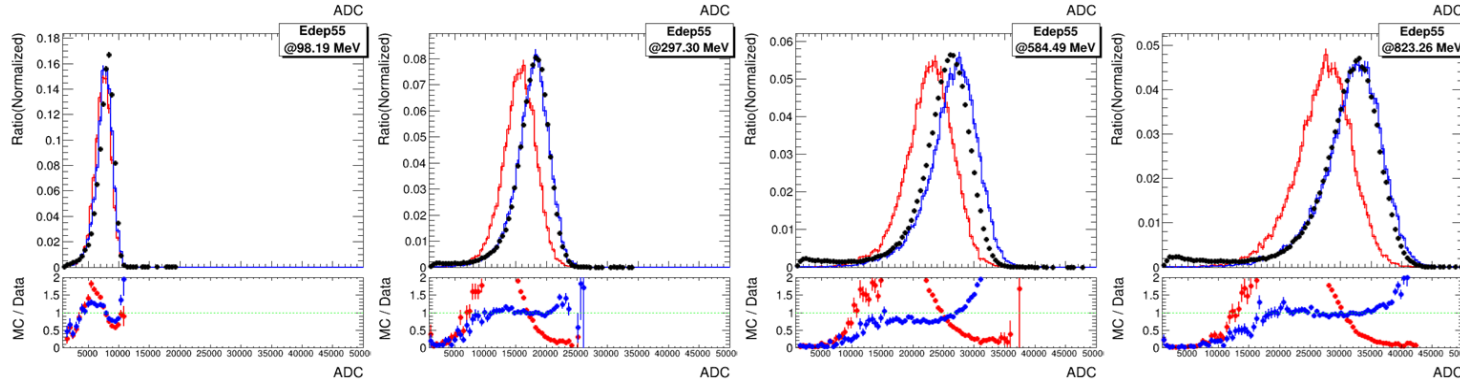
E<sub>max</sub>



E<sub>3x3</sub>

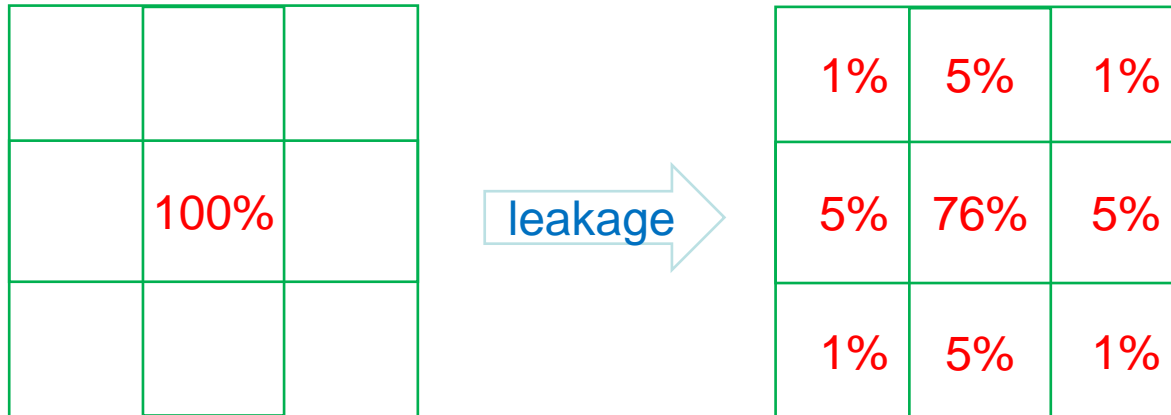


E<sub>5x5</sub>



MC and data are better agreed with leakage exercise applied.

# Leakage Test



- Assuming leakage pattern as above.
- Apply this rule to each crystal.
- Renormalize MC
- ➔ LYSO MC with  $E_{dep} * \text{leakage behavior} * \text{SiPM behavior}$