ZDC Test Beam
Past and the Future

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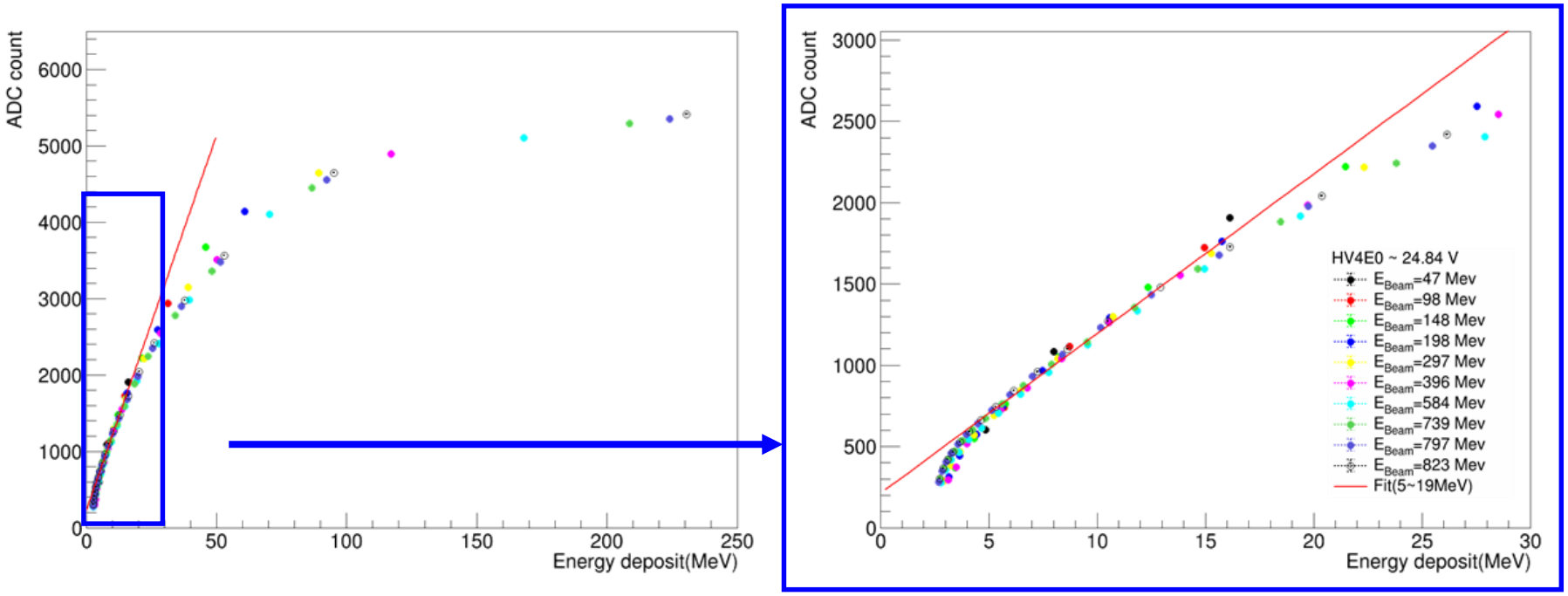
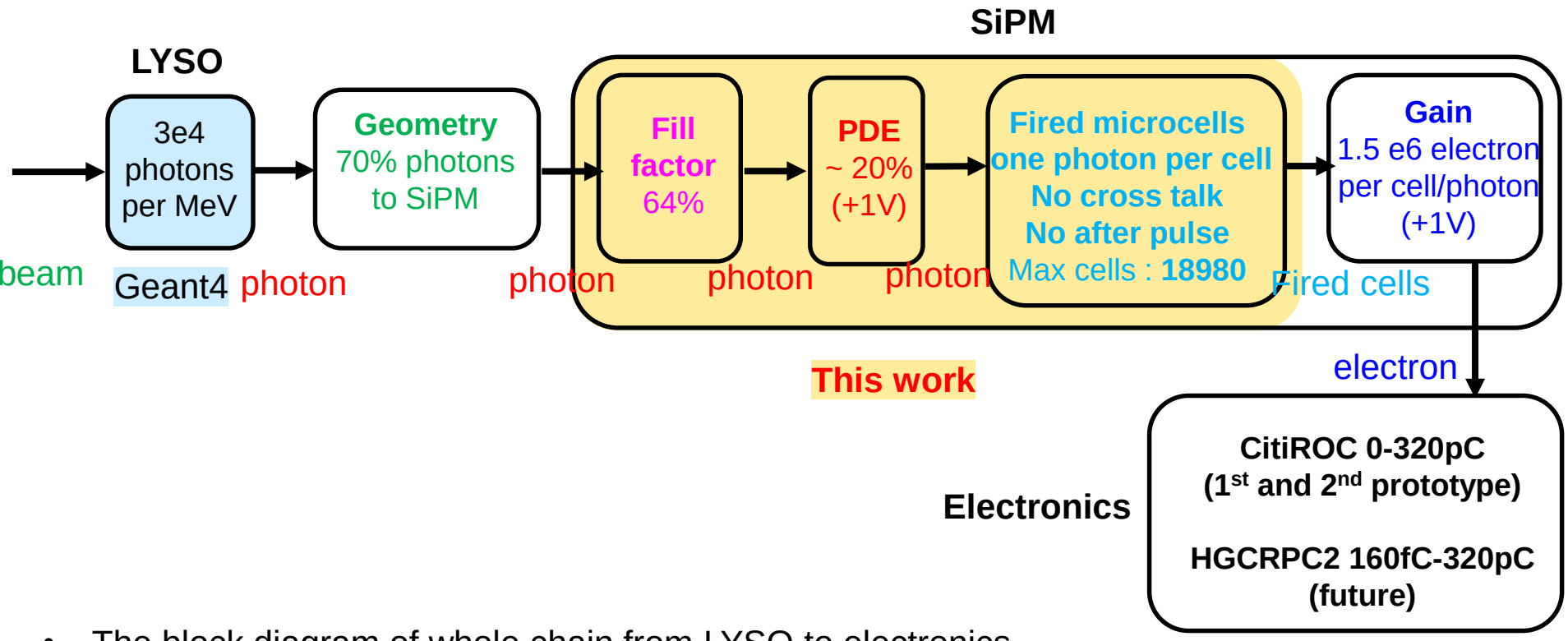
Linear Range of SiPM in Data Analysis



- Linear range in data analysis < 20MeV.
- **How about the theoretical calculation?**

SiPM Simulation : Block Diagram



- The block diagram of whole chain from LYSO to electronics.
- LYSO simulates the optical photons excited by injected beam by GEANT4.
- SiPM detects the optical photons and generated detected signals after amplification.
- CitiROC includes the ADC measurement is used in the 1st prototype and will still be used in the second prototype.
- **This work will be shown simulate the behavior of SiPM by software calculation.**

Saturation of SiPM : Results

Input

Random photon distribution on active area of SiPM 6mm*6mm surface

SiPM

Fill factor 64%

photon

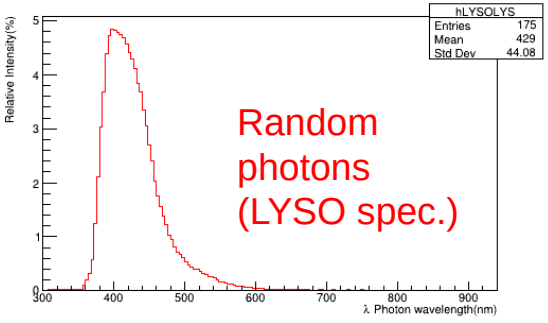
PDE ~ 20% (+1V)

photon

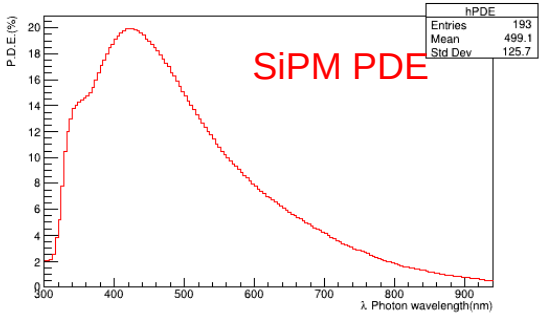
Fired microcells
one photon per cell
No cross talk
No after pulse
Max cells : **18980**

Gain
1.5 e6 electron per cell/photon (+1V)

Output : # of Fired cells

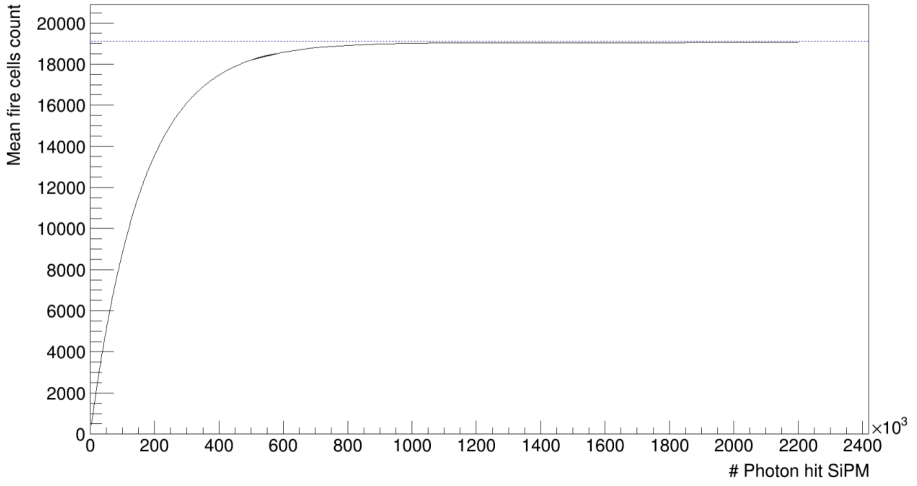


Random photons (LYSO spec.)



SiPM PDE

# of random input photons VS # of fired cells



SiPM Simulation : Spec. of SiPM

Onsemi C-Series, sensor size 6mm, microcell size 35μ
(https://www.onsemi.com/pdf/datasheet/microc-series-d.pdf)

- **Geometry occupation ~ 70%.**
  - **Active area of SiPM = 6mm*6mm**
  - **LYSO cross section = 7.12 mm x 7.12 mm**
- **Microcell fill factor ~ 64%.**
  - **Active area of SiPM = 6mm*6mm**
  - **Filled area of microcells = 35um*35um* 18980 microcells (Number of microcells = 18, 980)**
- **Bias = [24.2V-24.7V] + [1V ~ 5V] from datasheet. We use 1V bias to calculate.**
- **Photon Detection Efficiency (PDE) = 20% max@1V bias (wavelength Dep., bias Dep.)**
- **Gain = 1.5 electron/photon @ 1V bias (Bias Dep.)**

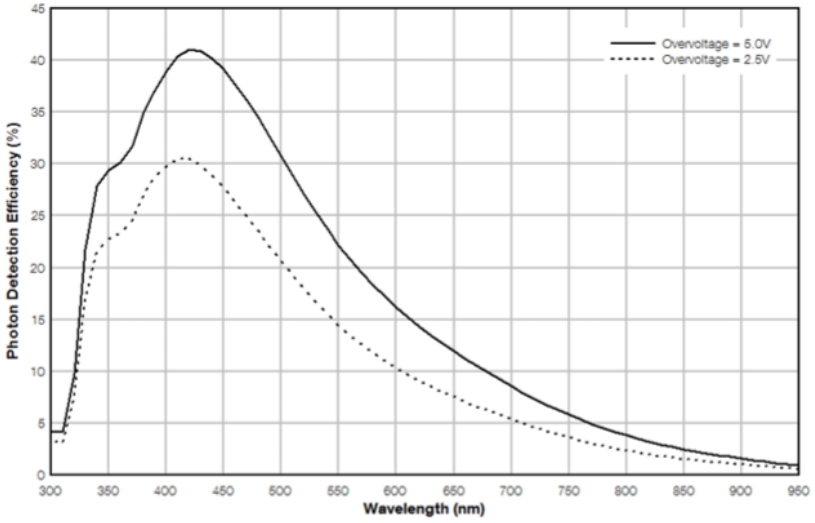


Figure 3. PDE versus Wavelength

PDE is wavelength dependent

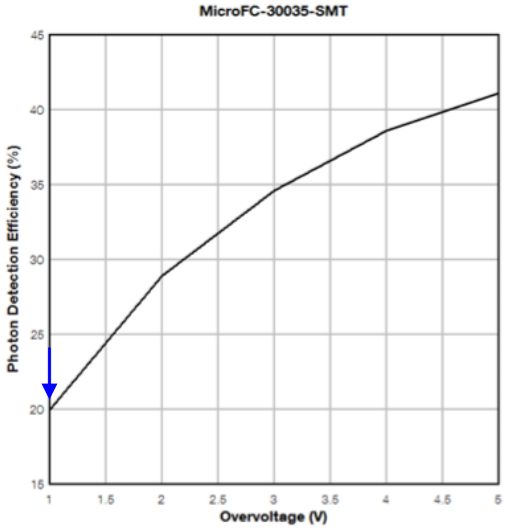


Figure 5. PDE at 420 nm versus Voltage

PDE is bias dependent

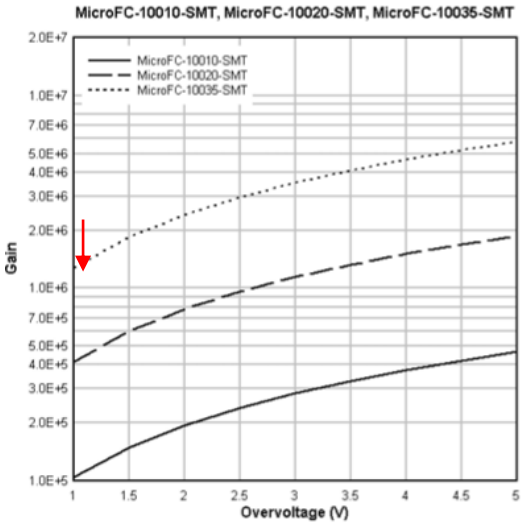
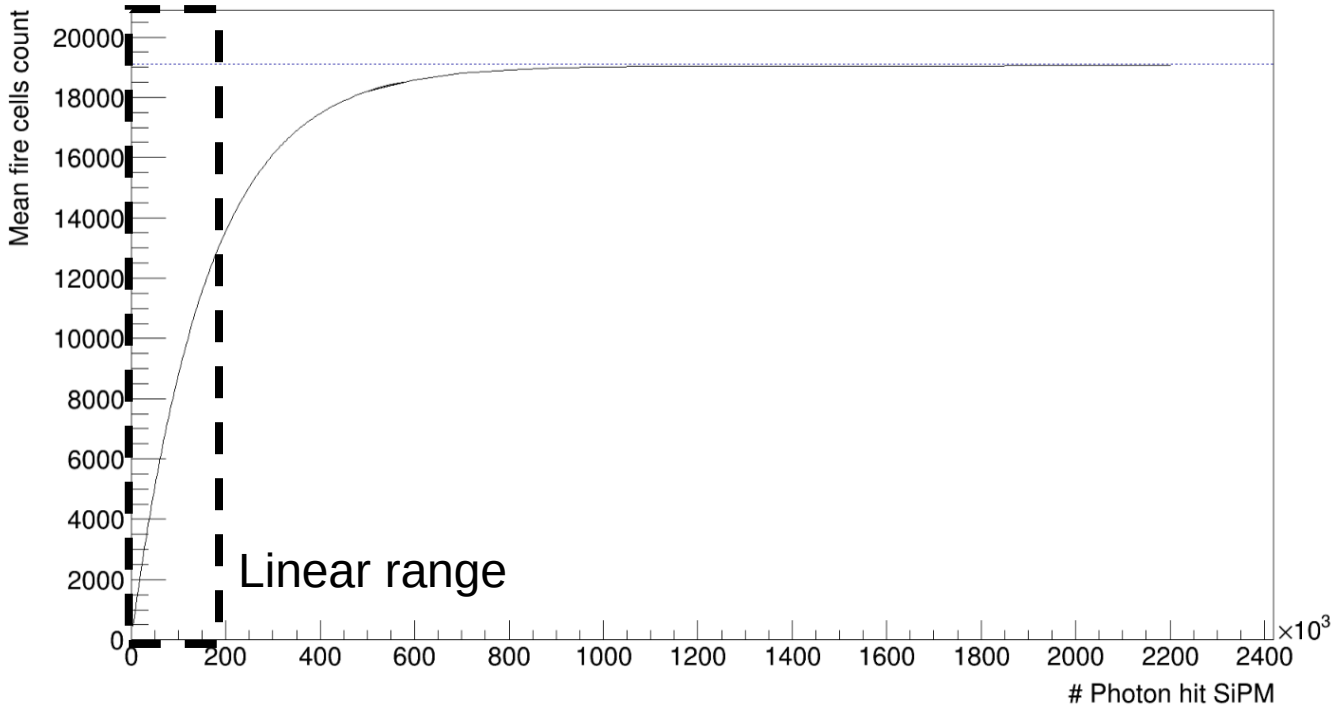


Figure 7. Gain versus Overvoltage

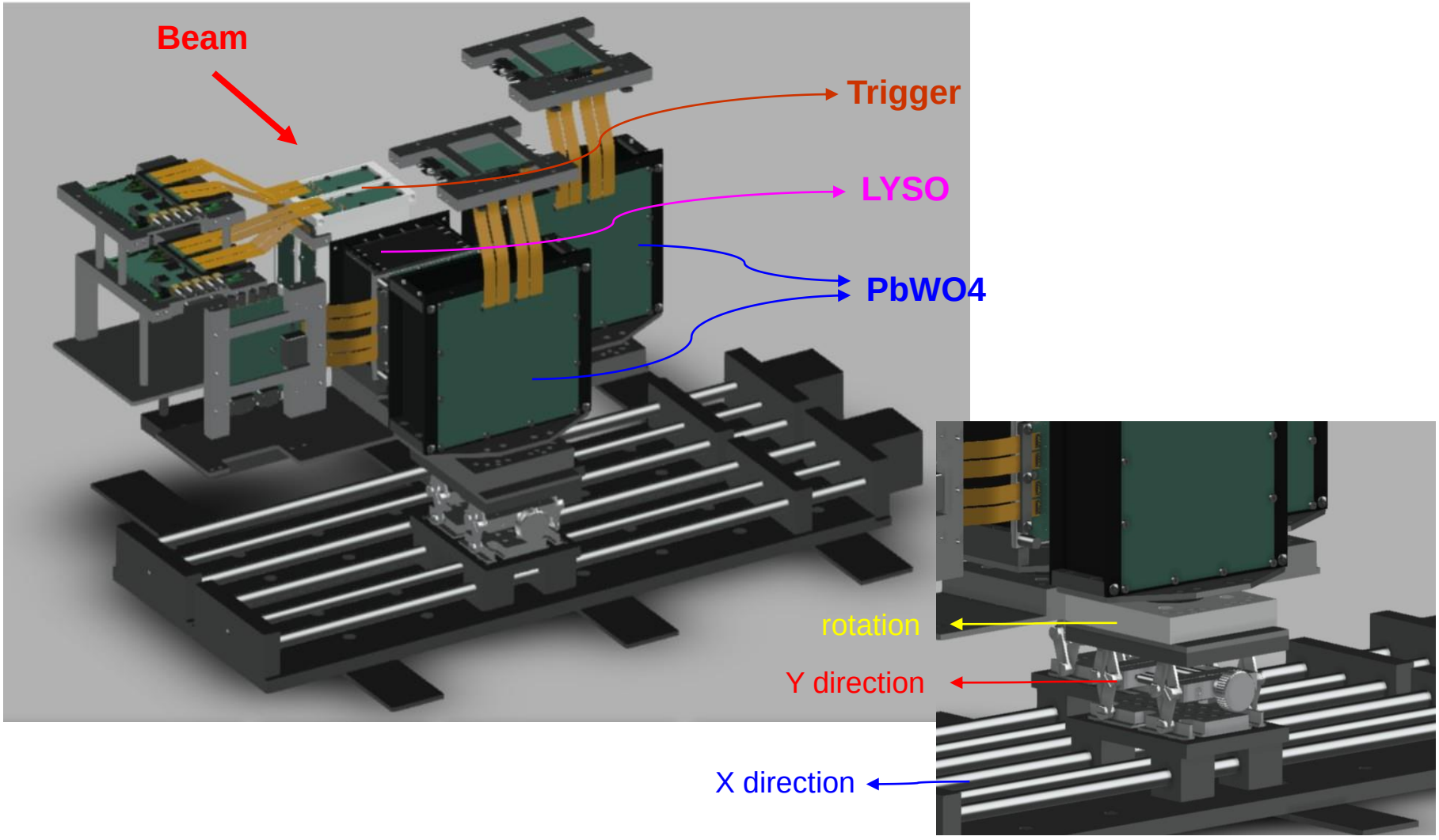
Gain is bias dependent

Saturation of SiPM : Results



- Linear below 200e3 photons ~ 7MeV (30e3 photons/MeV for LYSO)
- In data analysis, we define linear range < 20MeV.
- In the test beam, our bias voltage is not even at 1V since we would like to reduce the gain as much as possible. Our PDE should be below 20% which is the value at 1V.
- **Beam test bias : 24.8V = 24.2V + 0.6V.**
  (Suggested bias : [24.2V-24.7V] + [1V ~ 5V])

2nd ZDC EMCal Prototype



Design of 2nd Prototype

- Size of detector
  - LYSO ~ 8cm*8cm*6X0
  - PbWO4 ~ 12cm*12cm*6X0
  - Trigger ~ 6.5cm*6.5cm

- **Setup**
  - Trigger position fixed
  - Two moving stages after trigger : one for LYSO in middle and one for PbWO4 in downstream
  - Move middle stage to the left could change the from LYSO to PbWO4
  - PbWO4 could be placed after LYSO as well (but not vice versa)

- Range of detector movement :
  - Y range : 0cm - 2.5cm (remote control, not full range of detector, need adjustable platform)
  - X range : 0cm - 40cm (remote control)
  - Rotation : 5 degree and 10 degree (access required)

- Requirement of platform for the 2nd test beam :
  - Beam height = 160cm
  - Bottom of LYSO/PbWO4 from platform ~ 18cm
  - **Maximum height of platform = 160 - 18 = 142 cm**
  - **Minimum height of platform = 142 - 12 = 130 cm**
  - **Plateform size required = 50cm*50cm**

Status of 2nd Prototype

Color code

Designing	Production	Ready	Testing

	Parts	Progress@2024/11/18	**Progress@2024/12/17**	
1. LYSO 1cm*1cm*6.6cm 8x8 array	LYSO Cryatal	ready	ready	Testing
	APD (C30739ECERH)	ready	ready	
	APD Readout PCB	production	ready	
	LYSO Housing	ready	ready	
	LYSO Base support	ready	ready	
2. PbWO4 2cm*2cm*5.3cm 6x6 array	PbWO4	designing	production	
	SiPM (MICROFC-60035)	ready	ready	
	APD (C30739ECERH)	production	ready	
	SiPM Readout PCB	designing	designing	
	APD Readout PCB	designing	designing	
	PbWO4 Housing	designing	designing	
3. Trigger 2mm*2mm*8cm 32ch in X 32ch in Y XY layers/set Two sets	scintillator	ready	ready	Testing
	SiPM	ready	ready	
	SiPM Readout PCB	production	ready	
	scintillator Housing	production	ready	
	trigger Base support	production	ready	
4. GTM	GTM firmware	designing	**ready (continuing updating)**	
	GTM base support	production	ready	
	cable	production	ready	
5. Moving stage	base plate	designing	designing	
	slide rail	ready	ready	
	remote control	ready	ready	

Summary

- The SiPM behavior is simulated through software calculations to study its linearity. In calculation, it remains linear up to **200,000 photons ~7 MeV**, given the LYSO light yield of **30,000 photons/MeV**. However, in data analysis, we define the linear operating range to be **< 20 MeV**. The inconsistency could be the low bias ~ 0.6V which is below the suggested 1V during the test beam. The PDE ~ 20% used in calculation should be overestimated.

- We are working on the 2nd prototype and started the tests. We will soon report the tested results and communicate with all the participants.