ZDC design

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Reminder: Information on the Yellow Report

- ZDC size: 60 cm x 60 cm x 2m

Detector	(x,z) Position [m]	Dimensions	θ [mrad]	Notes
ZDC	(0.96, 37.5)	(60cm, 60cm, 2m)	$\theta < 5.5$	~4.0 mrad at $\phi = \pi$

Table 11.44

- Physics requirements:
  - Detect soft photons
  - Neutron energy resolution: acceptable **50%/√E + 5%**, ideally **35%/√E + 2%**
  - Neutron angular resolution: **3mrad/√E** (but < 300 µrad is not useful)

    300 µrad <-> 1 cm <-> p_T~ 30 MeV for 100 GeV neutron
  - Large acceptance of 60cm x 60 cm.

Contents today

- Information from Bill, the convener of the diffractive & tagging group (ECCE).
- Information from Yulia, on space around ZDC.
- Reduction of the EMC thickness

Information from Diff. & Tagging group (Bill W.)

- No soft photon requirement for IP6

"*there is no soft photon requirement for IP6 since there is no secondary focus to support the e+Pb or e+Au diffractive study.*"

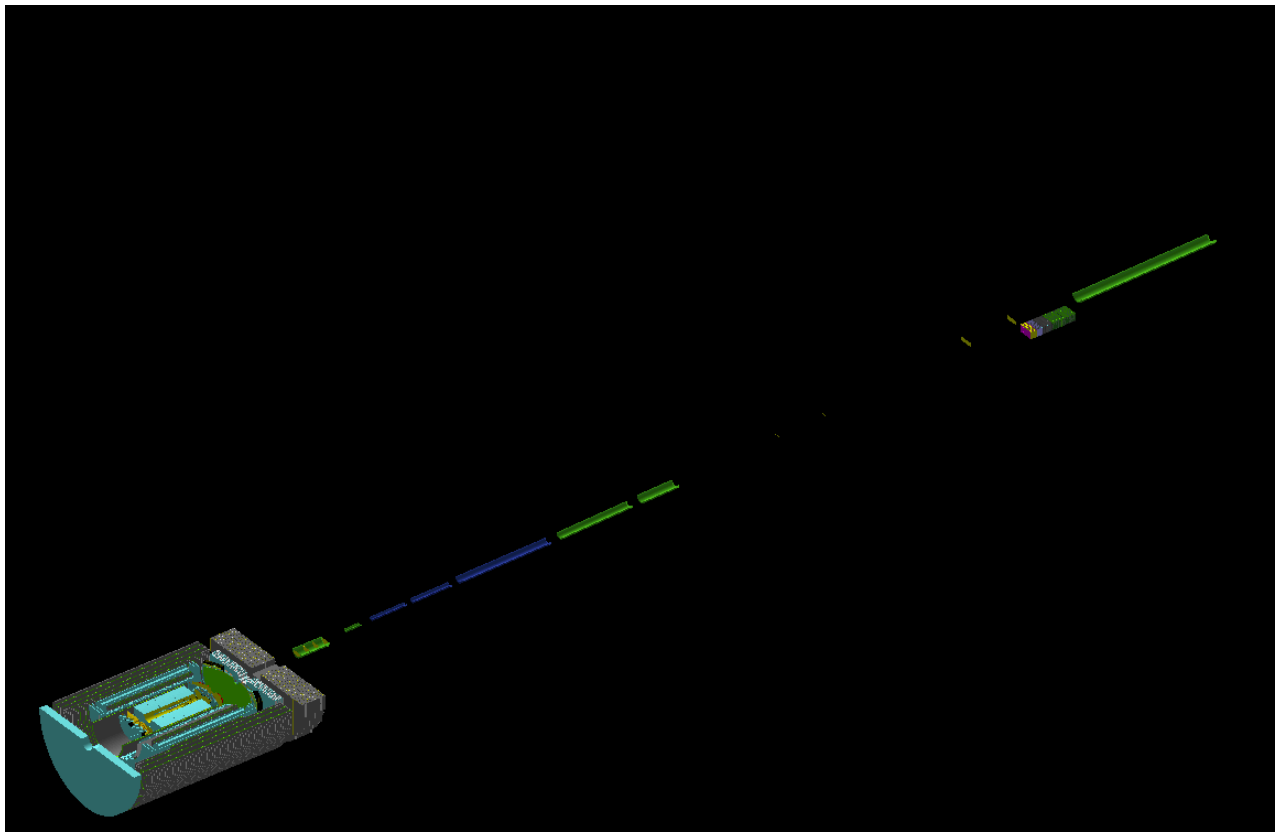
  - IP8: Detection of soft photons is needed, but actual resolution is not important.

- Photons
  - Interested energy region: ~ 20-40 GeV
  - Energy resolution: YR requirement = 45%/√E + 7.5% (?)
  - Position resolution: 0.5-1mm (tentative) from the meson structure group

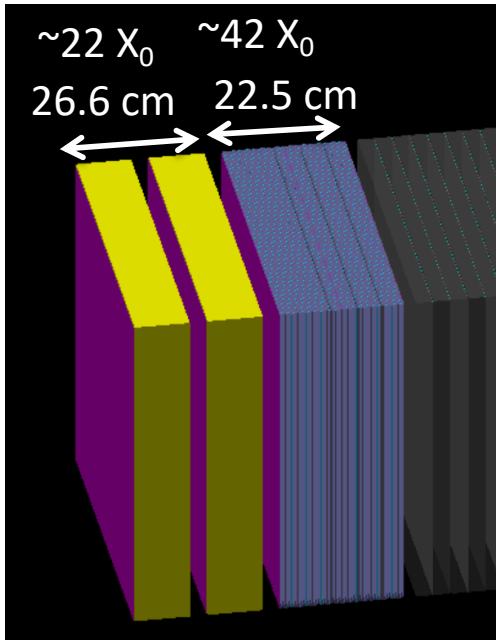
➔ Perhaps we can already start to consider two types of ZDC design, i.e. for IP6 and IP8

Information on the space around the ZDC (Yulia F.)

- IP6
  - Positive x side: Space restriction. It is direction of proton bending.
  - Negative x side: More space, but some limitations due to electron ling
  - Z : More space. Could consider extension of ZDC to 2.5-3m.



Reduction of EMC thickness



Current design in Fun4All has too thick EM calorimeter:

- 64 radiation lengths.

Can consider reduction of its size:

- Reduction of the thickness of Crystal?
- Reduction of number of Si/W layers?
  - Does it affect photon energy reconstruction?
  - How many layers we need, to distinguish neutrons and photons?

Start looking at Si/W layers first, with reduced Crystal size of 7 cm.

- Particle gun: neutron and photon
- Energy: 300 MeV, 1 GeV, 10 GeV, 100 GeV, 300 GeV
- 20 events for each sample.

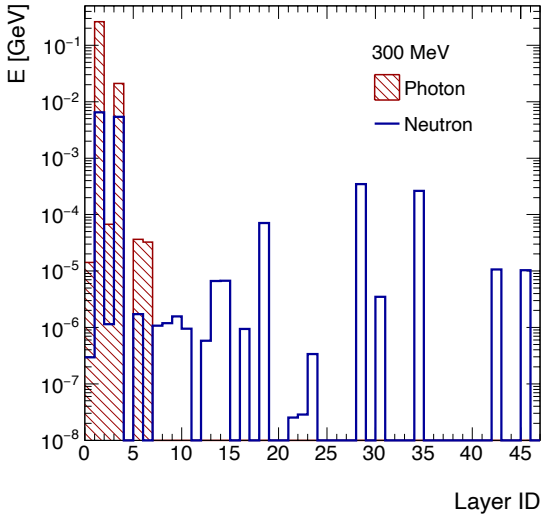
Energy per layer

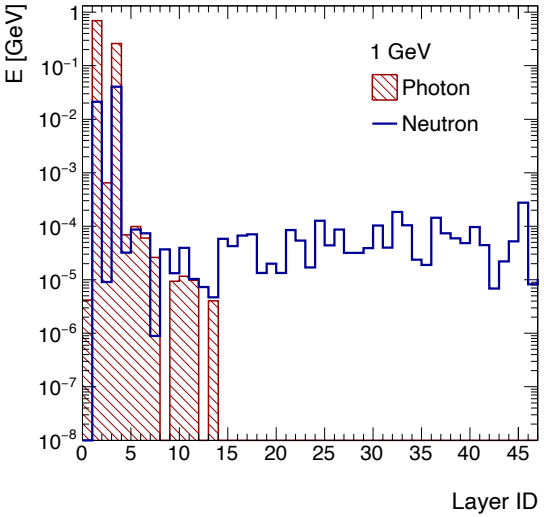
W/Si 42 layers
= Layer ID up to 46

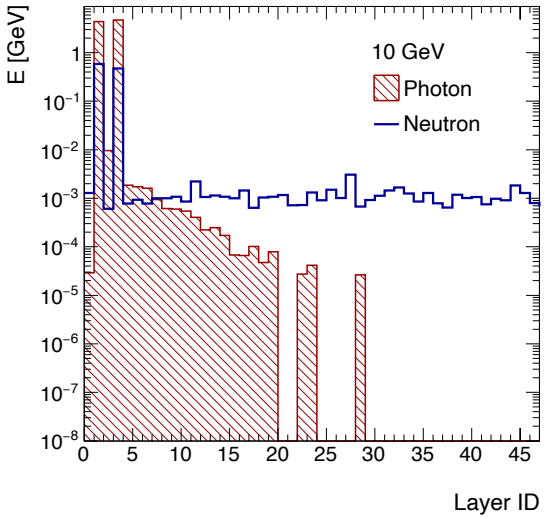
→ If we take out 16 layers:

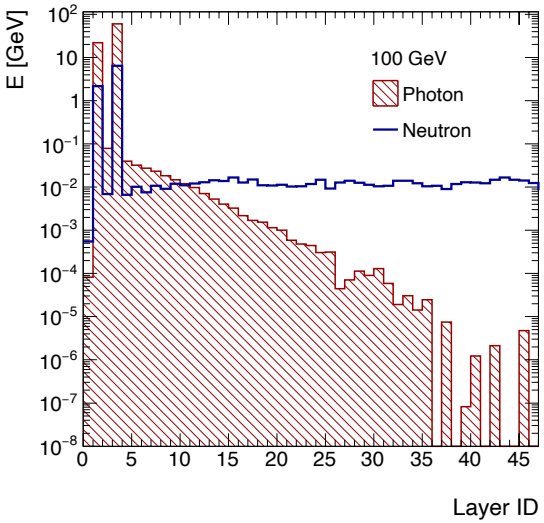
W/Si 26 layers

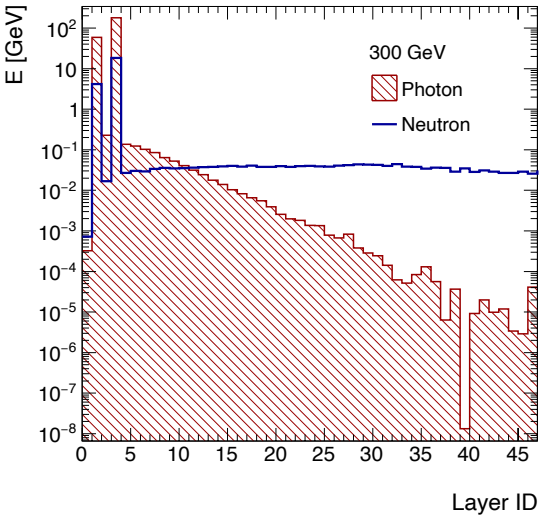
i.e. up to layer ID=30





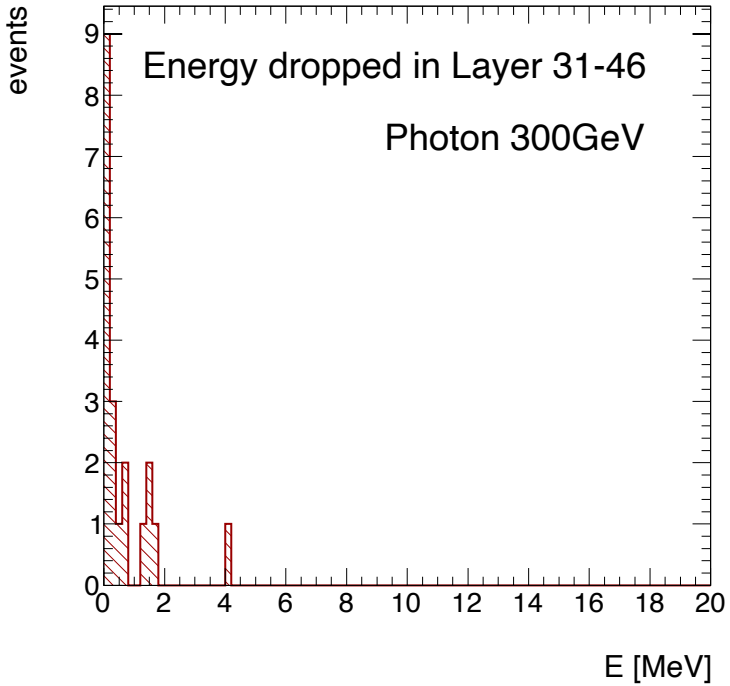






Sum of energy deposits in Layer ID > 30

- A master thesis on FoCal-E says the sampling fraction ~89.
- If sampling fraction=100, 10 MeV in W/Si layers → 1 GeV = 1% of O(100) GeV



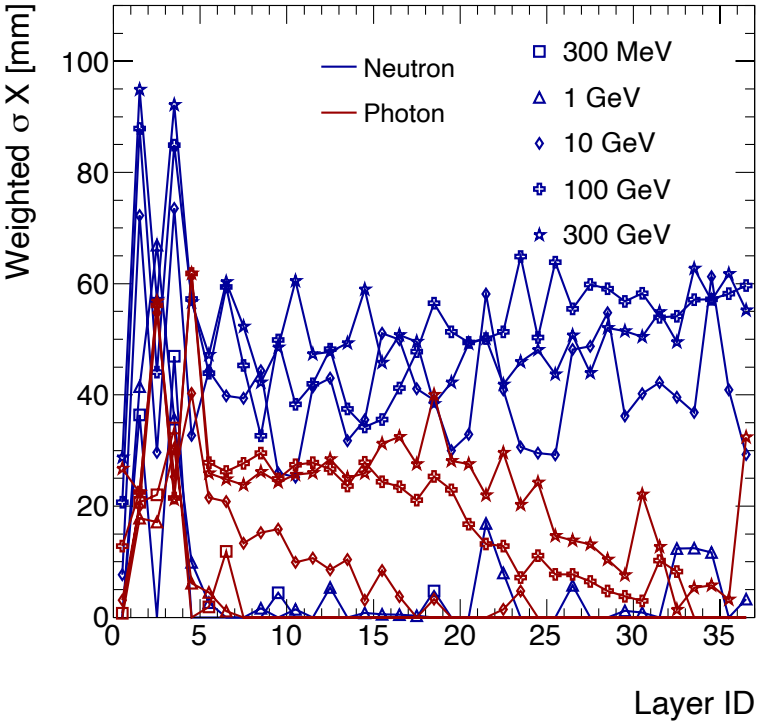
Dropped energy < 5 MeV
→ O(0.1) % of the photon energy will be affected. i.e. measured in Pb/Si.

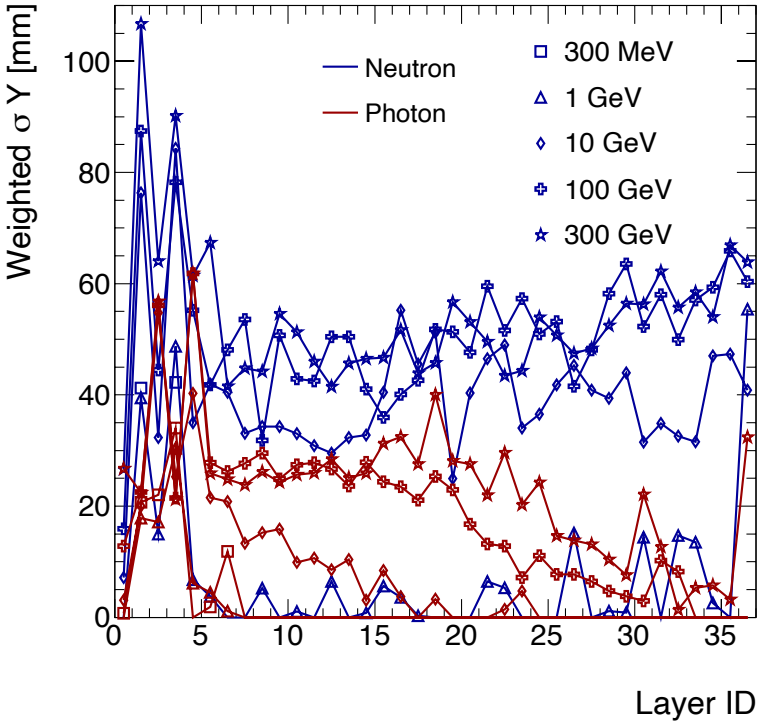
➔ Deletion of 16 layers should be quite safe.

Transverse spread of energy deposits

- Energy weighted sigma are checked.

$$\sigma = \sqrt{\frac{\sum E_i (x_i - \bar{x})^2}{\sum E_i}} = \sqrt{\left| \frac{\sum E_i x_i^2}{\sum E_i} - \bar{x}^2 \right|}, \text{ where } \bar{x} = \frac{\sum E_i x_i}{\sum E_i}$$





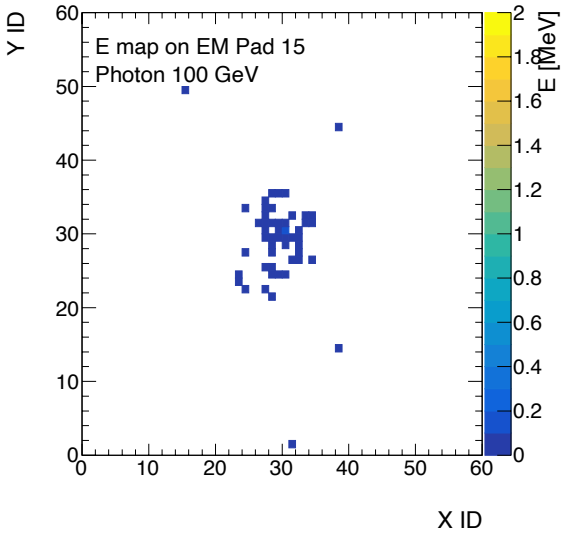
- First 5 layers will be looked in details later.
- Difference of shower width is visible in Si/W layers (Layer ID > 5).
- Photon shower is fading around Layer ID 20-30.

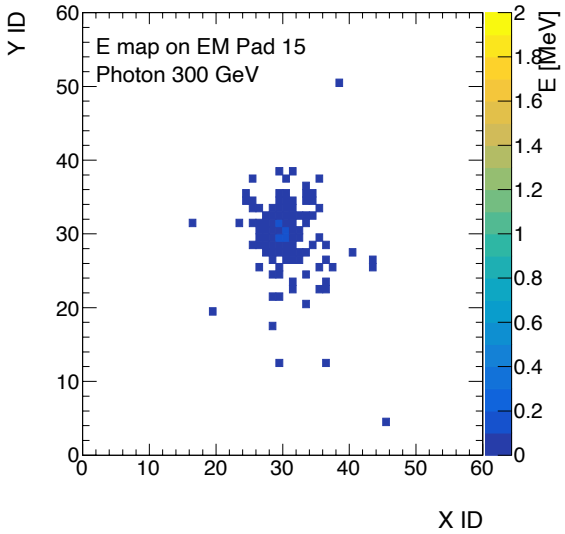
Energy deposits on Layer ID 20

Photon

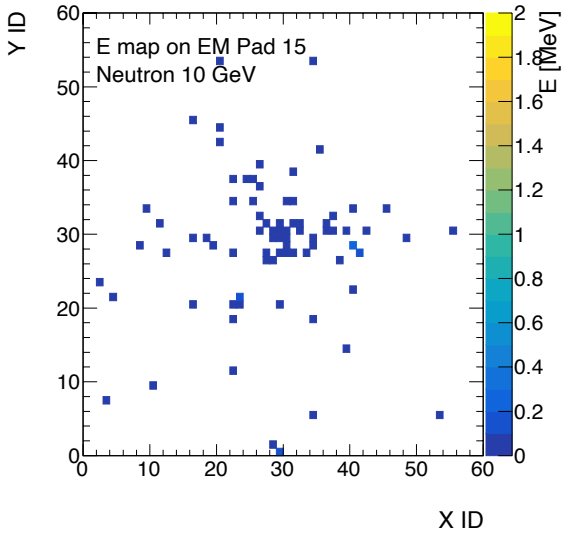
Difference of shower shape is seen at Layer 20.

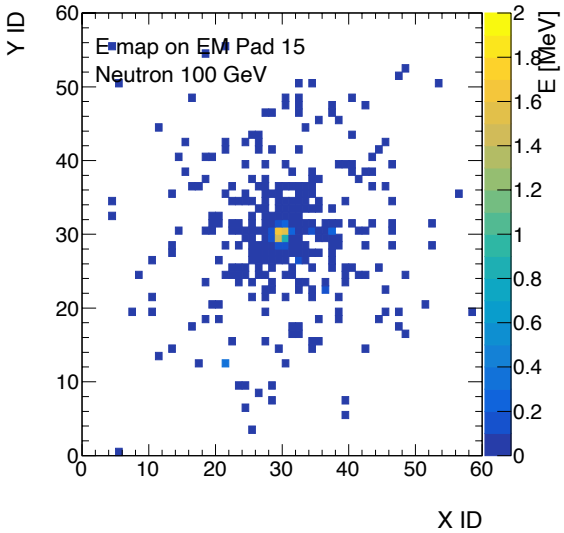
Again, deletion of 16 layers should be safe.

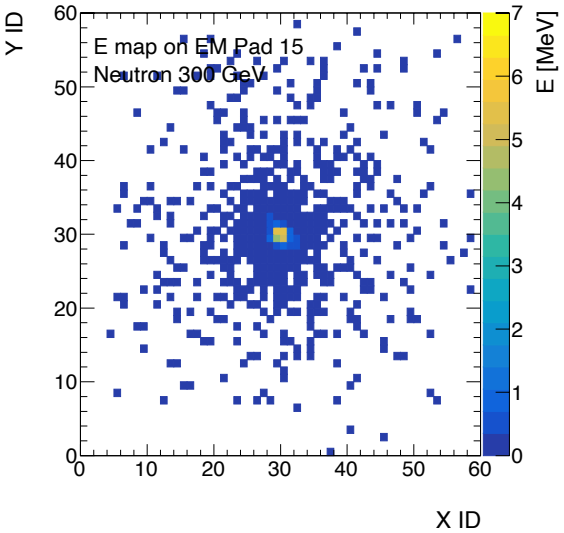




Neutron







Summary

- Current design in Fun4All has:
  - 64 X_0 EMC + 7 λ_I Hadron Calorimeter.

- Information from the Diff. & tagging group
  - We could take out crystal for IP6 ZDC?

  → Shall we prepare two version of ZDC design?

- Information from Yulia
  - We can extend Hadron Calorimeter

- A study shows:
  - With 16 X_0 of crystal (tentative), reduction of W/Si layers to 26 layers seems to be quite safe.

    [12 Pad layers + 1 Pix layer] x 2 → 26 X_0 W/Si layers

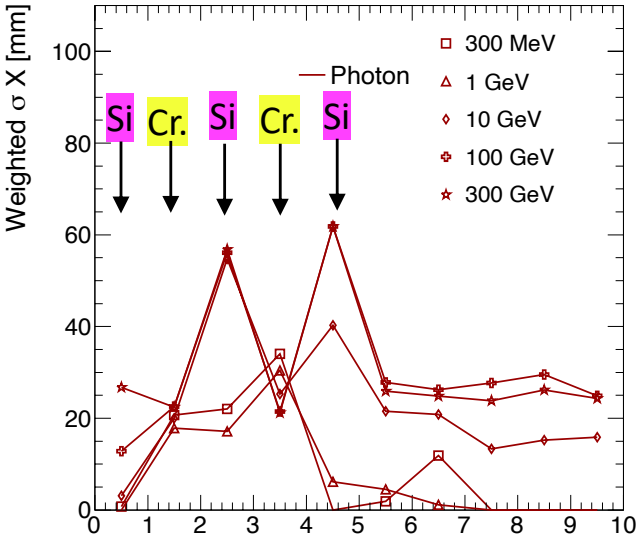
    ➔ 42 X_0 EMC

Backup

Reduced crystal 10cm -> 7cm

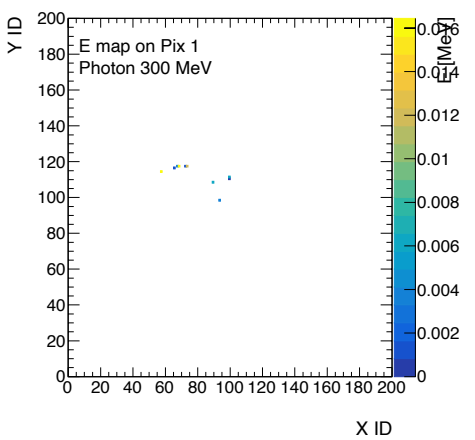
Crystal part

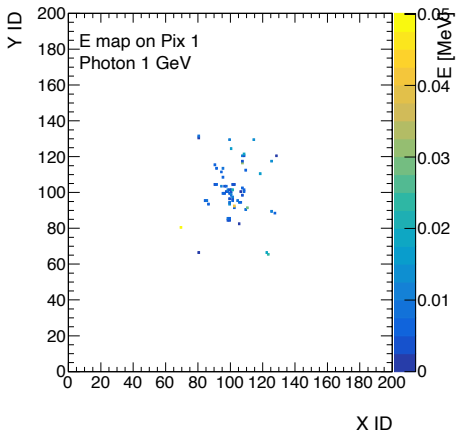
- Looking at sigma again, for photons only.

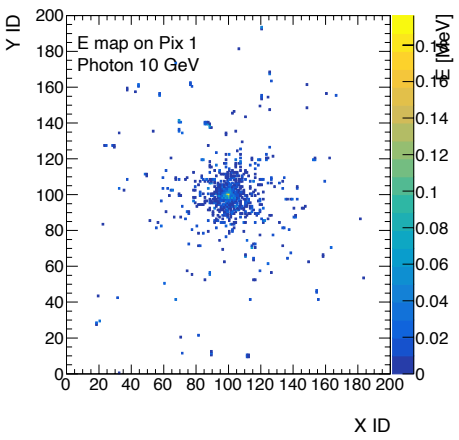


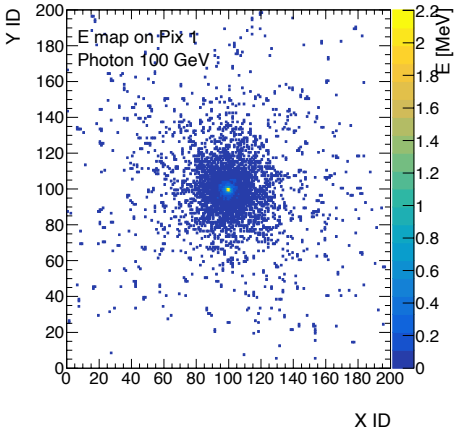
Silicon
3 mm x 3mm x 300 µm
PET (Glue, FPC) 0.39 mm
Gap 1.2mm
Crystal (PbWO4)
3cm x 3cm x 7 cm
Gap 3 cm

- On crystal 3cmx3cm, shower width is not really seen.
- On Silicon, shower width can be seen for E > 10 GeV.



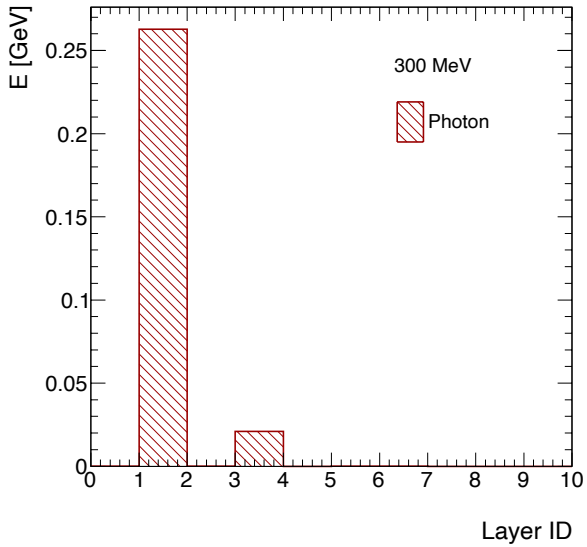


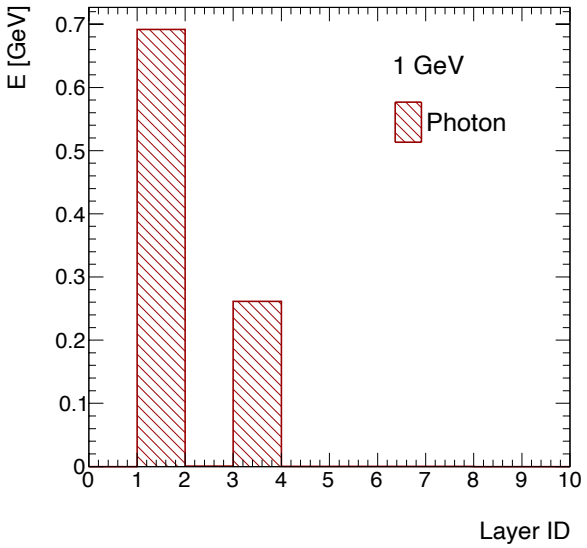


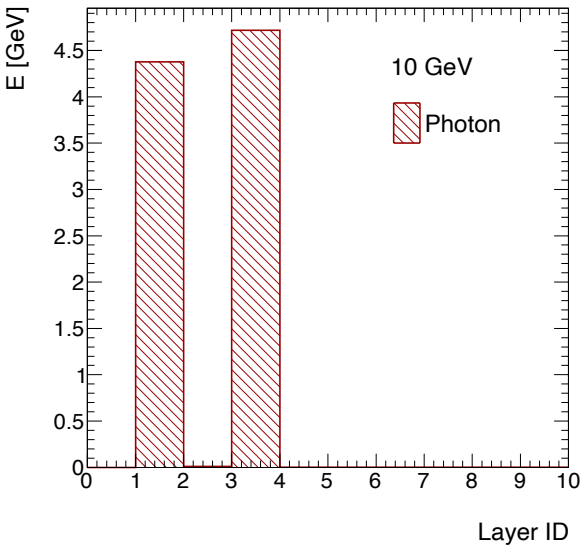


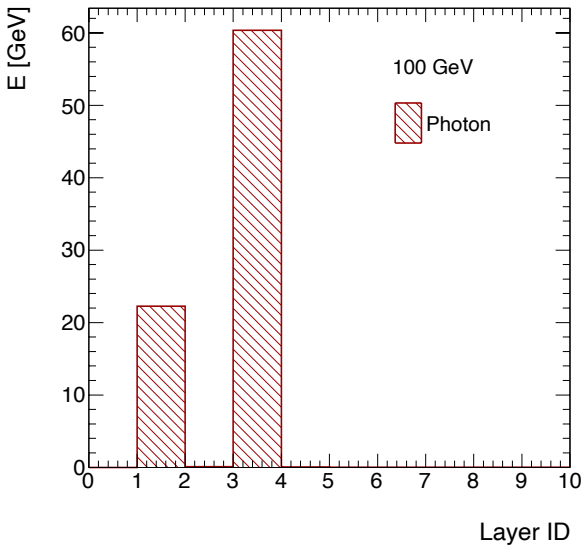
Reduced crystal 10cm -> 7cm

Energy deposit in Crystal part





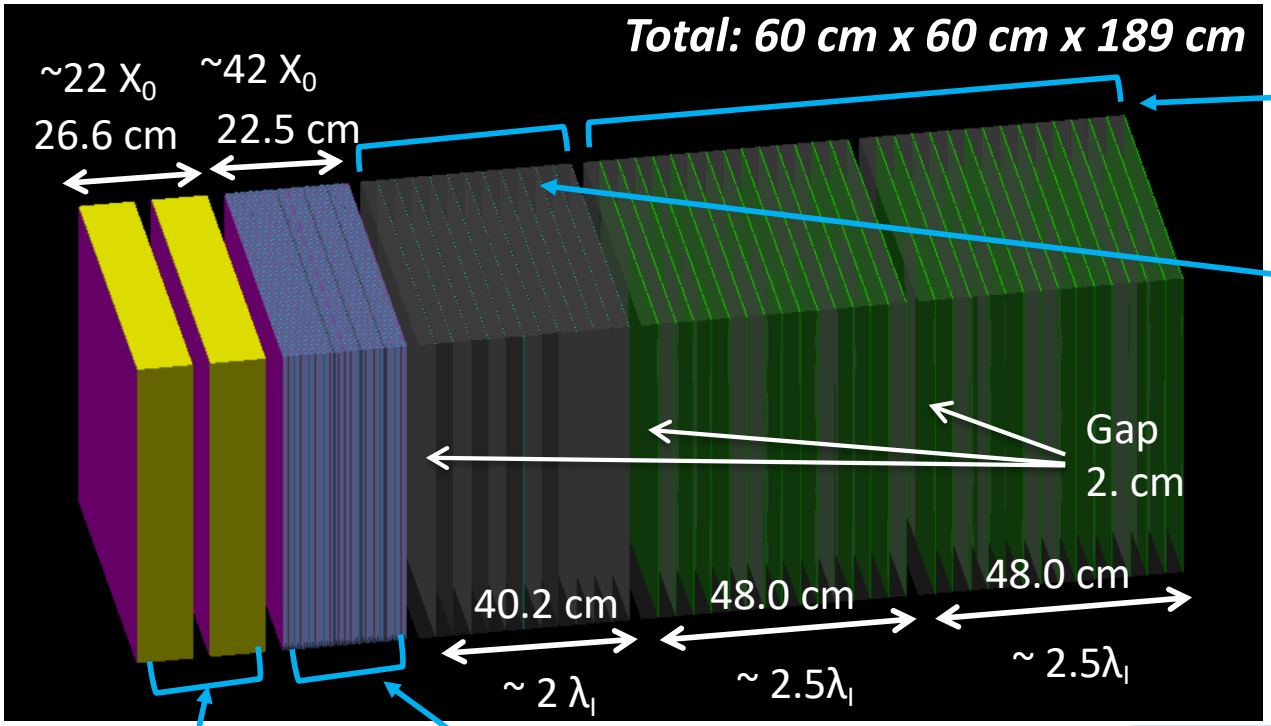




- Should learn how much resolution are needed for low energy photons

First ZDC design

Plots of energy deposition are in backup slides.



30 layers (15 layers x 2)

Pb 3cm Thickness
Scintilator
10 cm x 10 cm x 2 mm
Gap 0.0013 mm

12 layers

Pb 3cm Thickness
PET (Glue) 0.11 mm
Silicon
1 cm x 1 cm x 320 µm
PET (Glue, FPC) 0.41 mm
Gap 1. mm

2 layers

Silicon
3 mm x 3mm x 300 µm
PET (Glue, FPC) 0.39 mm
Gap 1.2mm
Crystal (PbWO4)
3cm x 3cm x 10 cm
Gap 3 cm

Si: 3 layers,
Si: 40 layers,
W: 42 layers

= Si + 2 x

20 layers

Tungsten 3.5 mm Thickness
PET (Glue) 0.11 mm
Silicon 1 cm x 1 cm x 320 µm
PET (Glue, FPC) 0.41 mm, Gap 1.mm

+

1 layer

Tungsten 3.5 mm Thickness
PET (Glue) 0.11 mm
Silicon 3 mm x 3mm x 300 µm
PET (Glue, FPC) 0.39 mm, Gap 1.2mm