

Weekly report

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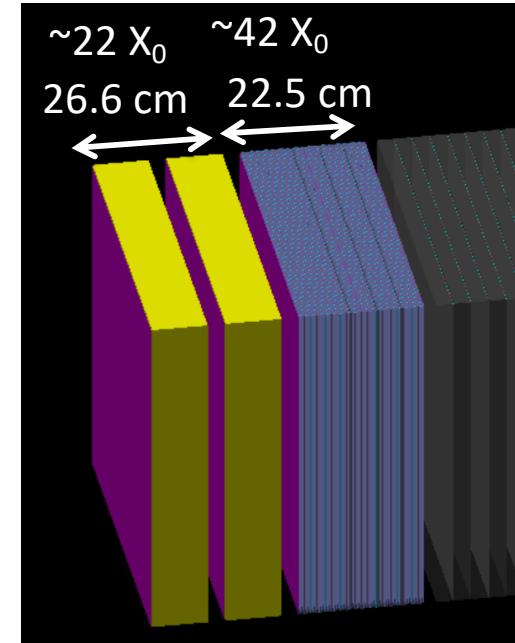
17/June/2021 RBRC weekly meeting

Weekly report

- ◆ ZDC
 - Looking at EM part of the ZDC, for reduction of size.
 - **ECCE:** ZDC will not be in the standard simulation campaign, but will have a dedicated neutron and gamma samples for study.
- ◆ Inclusive analysis
 - Start looking at DJANGOH events.
 - This is to understand reconstruction of hadrons, but so far I only played with truth particles.

Reduction of EMC thickness

- ◆ Crystal 10 cm x2 → 7 cm ($7.9 X_0$) x2
 - Can we keep the position and energy resolution?
- ◆ W/Si 42 layers → ~ 30 layers
 - Does it affect photon energy reconstruction?
 - How many layers we need, to distinguish neutrons and photons?

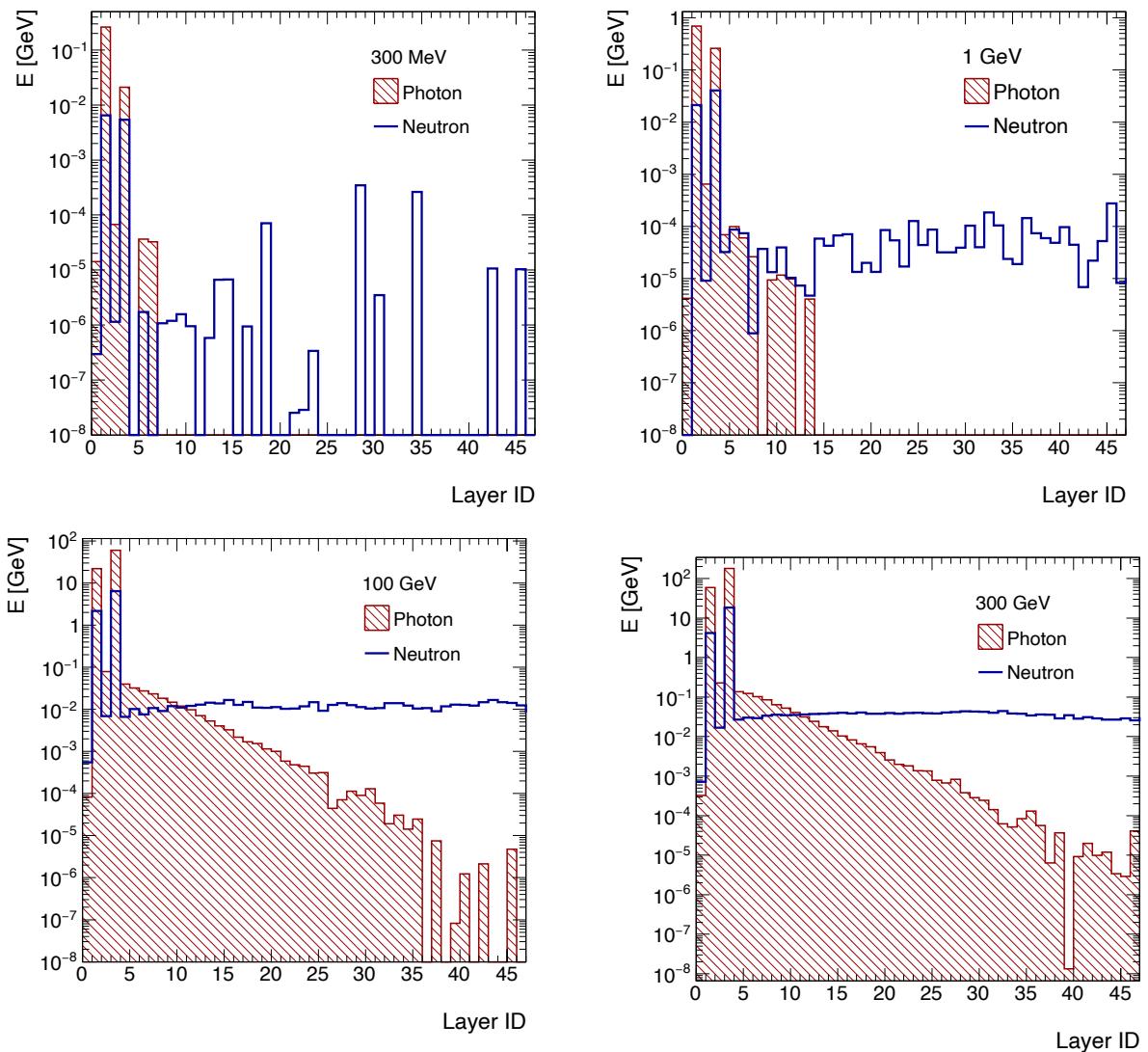


Looking at Si/W layers first, with reduced Crystal size of 7 cm.

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

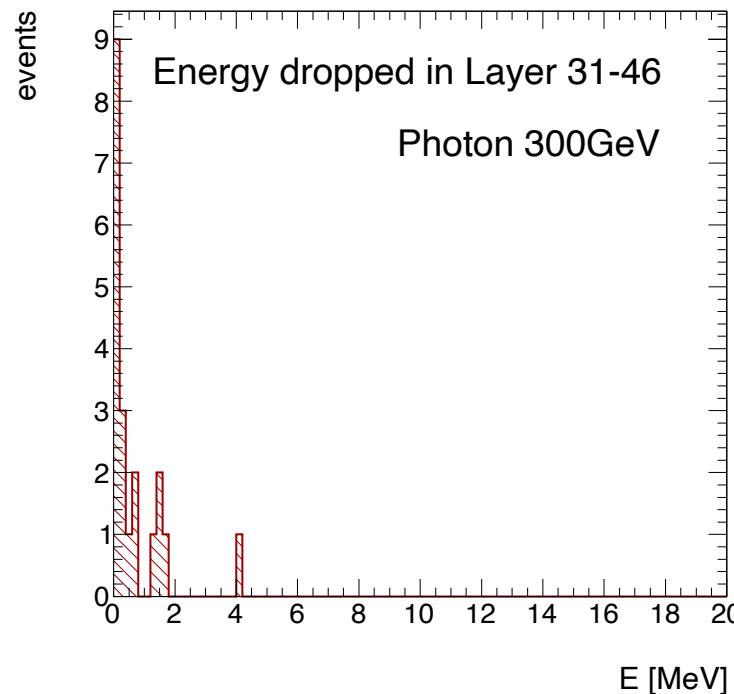
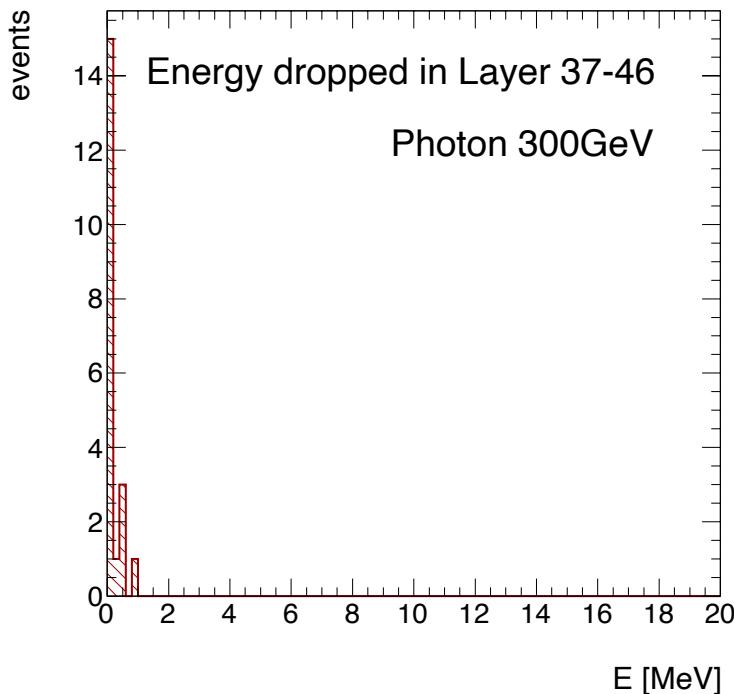
Energy per layer

- ◆ W/Si 42 layers
= Layer ID up to 46 →
 - 32 layers = up to layer ID = 36
 - 26 layers = 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 $\rightarrow 1 \text{ GeV} = 1\% \text{ of } O(100) \text{ GeV}$

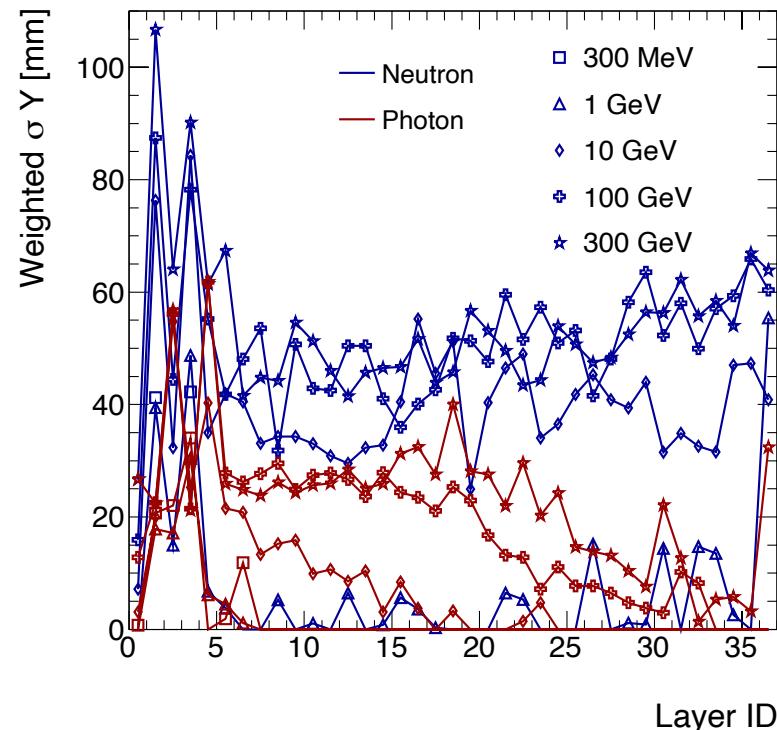
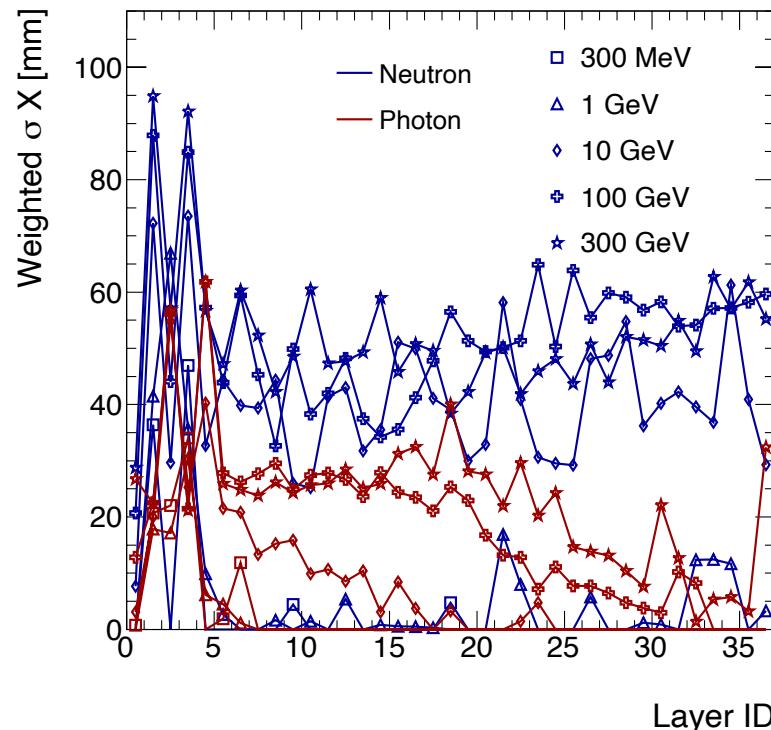


Dropped energy $< 5 \text{ MeV} \rightarrow O(0.1) \% \text{ of the photon energy will be affected. i.e. measured in Pb/Si.}$

Transverse spread of energy deposits

- ◆ Energy weighted sigma are checked.

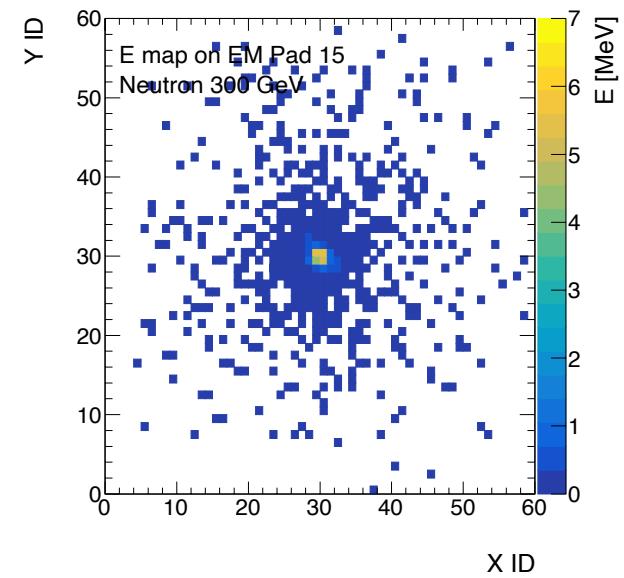
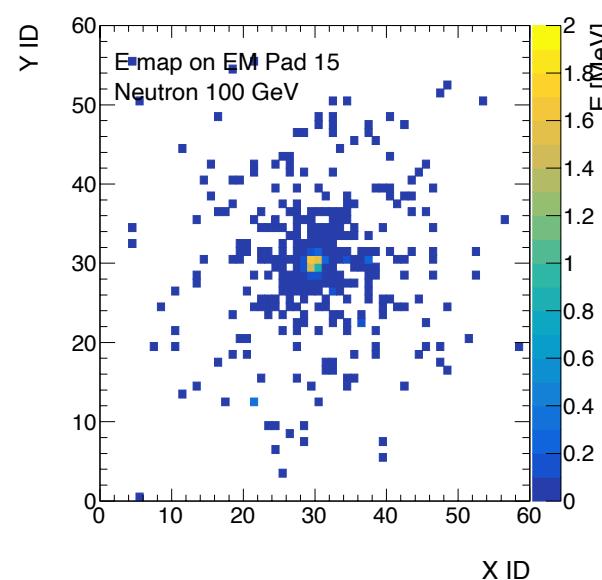
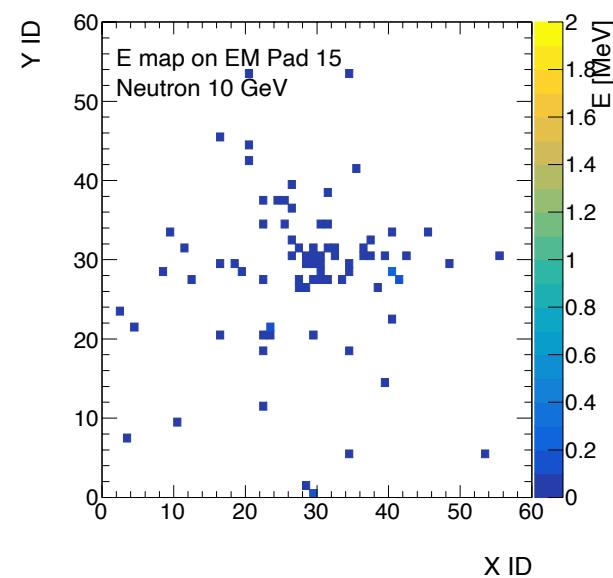
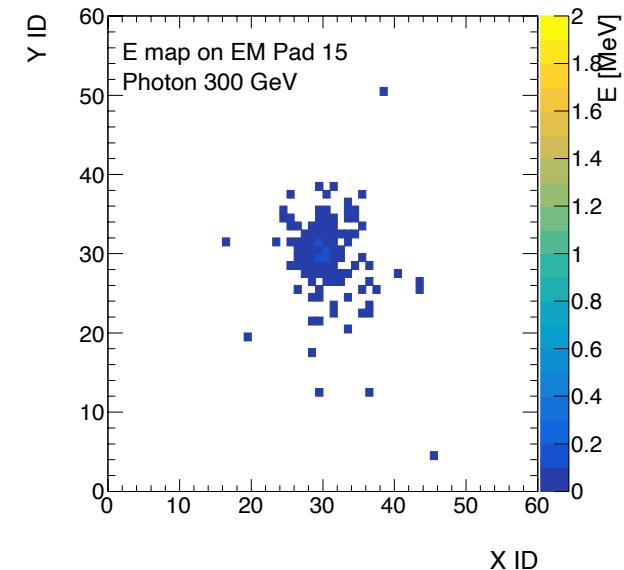
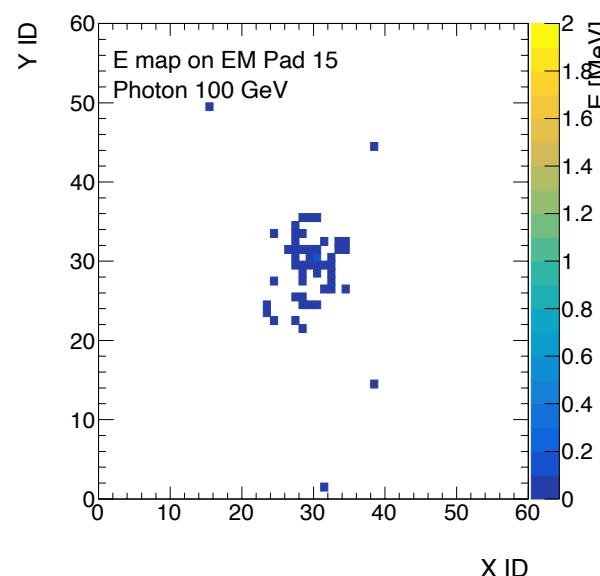
$$\sigma = \sqrt{\frac{\sum E_i(x_i - \bar{x})^2}{\sum E_i}} = \sqrt{\left| \frac{\sum E_i x_i^2}{\sum E_i} - \bar{x}^2 \right|}, \text{ where } \bar{x} = \frac{\sum E_i x_i}{\sum E_i}$$



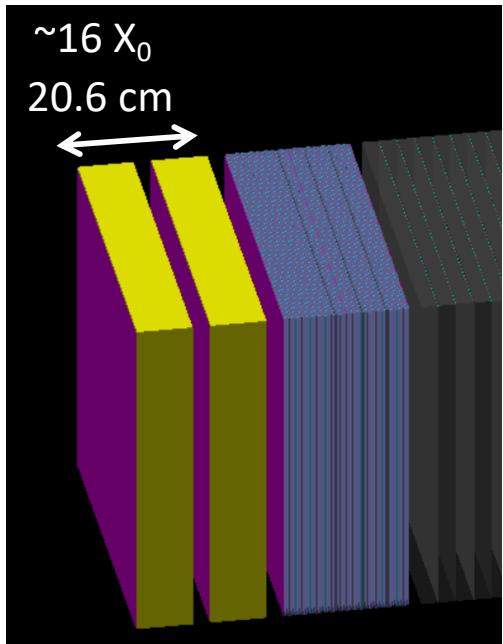
- First 5 layers (i.e. Crystal part) will be looked in details later.
- Difference of shower width is visible in Si/W layers (Layer ID > 5).
- Photon shower is fading around Layer ID 20-30.

Energy deposits on Layer ID 20

Difference of shower shape is seen at Layer 20.



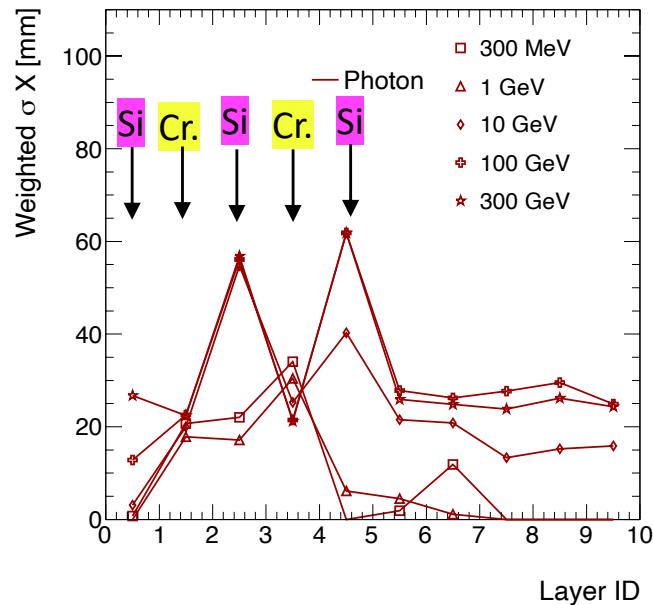
Conclusion of Si/W (FoCal-E) layers



- ◆ With 16 X_0 of crystal, reduction of FoCal-E to 26 layers seems to be quite safe.
 - (12 Pad layers + 1 Pix layer) $\times 2$
- Total EMC: 16 X_0 Crystal + 26 X_0 Si/W layers
- ◆ Probably we can reduce more, but keep 26 layers for future discussion.

Crystal part

- ◆ Looking at sigma again, for photons only.

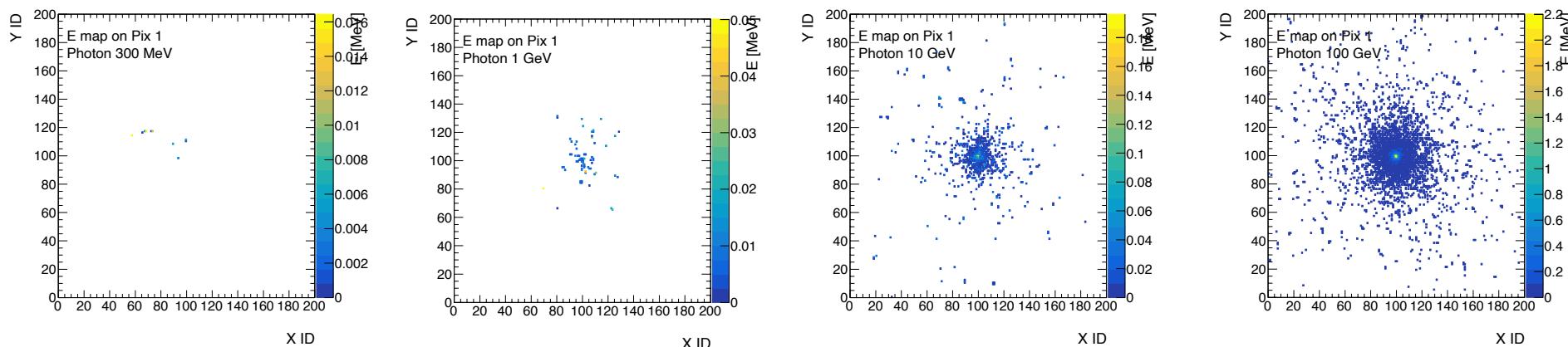


Silicon
3 mm x 3mm x 300 μm
PET (Glue, FPC) 0.39 mm
Gap 1.2mm

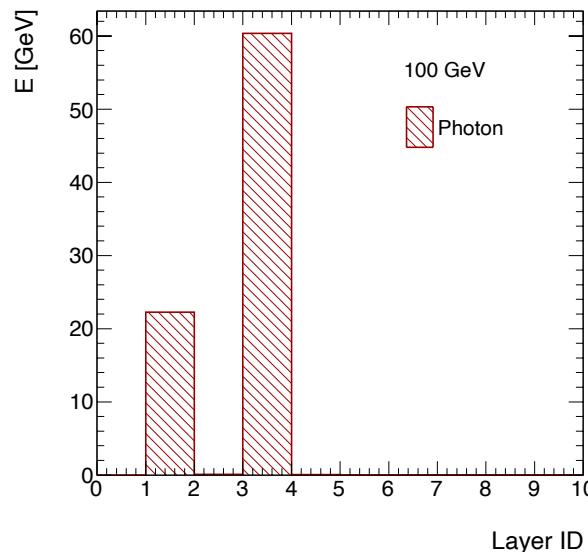
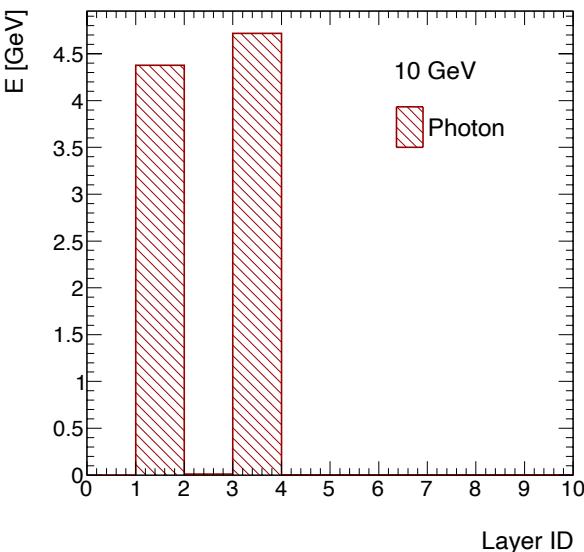
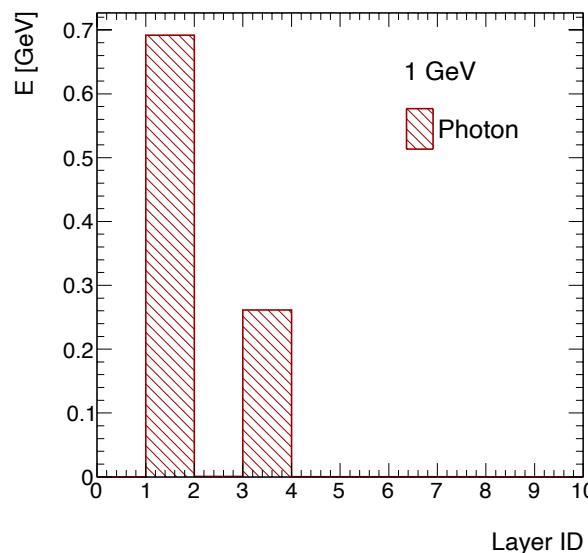
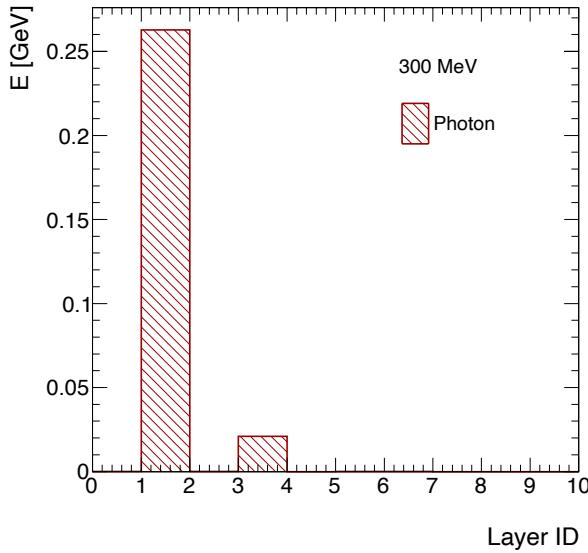
Crystal (PbWO₄)
3cm x 3cm x 7 cm
Gap 3 cm

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

Energy map on Layer ID = 2



Energy deposit in Crystal part



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

Inclusive analysis

- ◆ Workflow for DJANGOH
 - 1. Generate DJANGOH events → .dat files
 - 2. ECCE BuildTree → .root files
 - 3. Detector Simulation → G4EIC_eventtree.root, *_eval.root
(.x Fun4All_G4_EICDetector.C in root*)
- * Is there a way to do this in a compiled job?
- ◆ Generated DJANGOH NC sample, $18 \text{ GeV} \times 275 \text{ GeV}$, $Q^2 > 2 \text{ GeV}^2$, $W_{\min} > 1.4 \text{ GeV}$, 1M events.
 - Detector Simulation is running for 10K events.
- ◆ Looking at small sample of 10 events passed detector simulation.

Kinematic variables

- ◆ In DJANGOH, two types of kinematic variables are available, due to radiative correction.
 - x_{rad} , y_{rad} , Q^2_{rad} : calculated from the scattered lepton.
i.e. including effect from radiative correction.
 - x_{true} , y_{true} , Q^2_{true} : kinematic variables at the hard scattering vertex.
No radiative effect.

Note: Born level cross section should be measured.

1. Count the number of events.
→ Radiative cross section.
2. Correct for radiative effect based on calculation.
→ Born level cross section.

Need time to recall/think
which definition should
be used for the bin
definition.

Reminder: Kinematic reconstruction

Electron method

Using Energy and angle of the scattered electron

$$y_{el} = 1 - \frac{E'_e}{2E_e}(1 - \cos \theta_e)$$

$$Q_{el}^2 = 2E_e E'_e (1 + \cos \theta_e)$$

Double Angle method

Using angle of the scattered electron and hadrons

$$Q_{DA}^2 = 4E_e^2 \frac{\sin \gamma_h (1 + \cos \theta_e)}{\sin \gamma_h + \sin \theta_e - \sin(\gamma_h + \theta_e)}$$

$$x_{DA} = \frac{E_e \sin \gamma_h + \sin \theta_e + \sin(\gamma_h + \theta_e)}{E_p \sin \gamma_h + \sin \theta_e - \sin(\gamma_h + \theta_e)}$$

$$y_{DA} = \frac{\sin \theta_e (1 - \cos \gamma_h)}{\sin \gamma_h + \sin \theta_e - \sin(\gamma_h + \theta_e)}$$

Jacquet Blondel method

Using hadron information only

$$y_{JB} = \frac{\delta_h}{2E_e}$$

$$Q_{JB}^2 = \frac{p_{T,h}^2}{1 - y_{JB}}$$

$$\delta_h = \sum_h (E - p_z)_i \text{ and } p_{T,h} = \sqrt{(\sum_h (p_{x,i}))^2 + (\sum_h (p_{y,i}))^2},$$

Remark!

I should go back to a textbook in the case that $s=4E_p E_e$ is broken.

Other methods: p_T method, Σ method...

Event #7

- ◆ Photoproduction event? (Diffractive photoproduction??)

i	status	PDG	mother	E	px	py	pz	theta
0	4 (beam)	11 (e-)	0	18	0	0	-18	180.0
1	3	23 (Z0)	10001 (i=0)	-0.028	0.487	-0.063	-0.038	
2	1 (final state particle)	11 (e-)	10001 (i=0)	2.587	-0.562	0.131	-2.522	167.1
3	1 (final state particle)	22 (gamma)	10001 (i=0)	15.441	0.075	-0.068	-15.441	179.6
4	1 (final state particle)	2212 (p)	0	232.070	-0.005	0.006	232.069	0.2
5	1 (final state particle)	14 (nu_mu)	0	3.486	0.077	-0.050	3.484	1.5
6	1 (final state particle)	-14	0	5.151	-0.039	0.062	5.151	0.8
7	1 (final state particle)	12 (nu_e)	0	15.623	0.340	-0.084	15.619	1.3
8	1 (final state particle)	-11	0	1.393	0.021	-0.028	1.393	1.5
9	1 (final state particle)	-14	0	8.008	0.193	-0.026	8.005	1.4
10	1 (final state particle)	-12	0	6.108	-0.038	0.059	6.107	0.7
11	1 (final state particle)	11 (e-)	0	0.874	-0.030	0.014	0.874	2.2
12	1 (final state particle)	14	0	2.260	-0.031	-0.016	2.259	0.9
13	4 (beam)	2212 (p)	0	275	0	0	274.998	0.2

- ◆ DJANGOH says: $Q^2_{\text{rad}} = 2.35 \text{ GeV}^2$ $Q^2_{\text{true}} = 0.242 \text{ GeV}^2$

How to treat this event? Should I raise the Q^2 cut for simplicity?

Check of 10 events -- ongoing

- ◆ Using HEPMC particles.

Event #	DJANGOH x_rad	DJANGOH x_true	EL method (true e')	EL method (true e' + rad γ)	N of radiativ e photon	E-pz	JB method (particles from proton side)	DA method (e' not including γ)	DA method (e' incl rad γ)
0	3.048E-03	4.184.E-03	3.048.E-03	4.184.E-03	1	36.00	4.184.E-03	4.184.E-03	4.183.E-03
1	1.732E-02	1.732.E-02	1.732.E-02	1.732.E-02	0	36.00	1.734.E-02	1.722.E-02	1.722.E-02
2	6.943E-03	6.943.E-03	6.943.E-03	6.943.E-03	0	36.00	6.936.E-03	6.936.E-03	6.936.E-03
3	7.768E-03	7.768.E-03	7.768.E-03	7.768.E-03	0	36.00	7.743.E-03	7.743.E-03	7.743.E-03
4	1.317E-04	1.317.E-04	1.317.E-04	1.317.E-04	0	36.03	1.332.E-04	1.316.E-04	1.316.E-04
5	3.430E-03	3.706.E-02	3.430.E-03	3.828.E-02	1	36.00	3.706.E-02	3.881.E-02	3.674.E-02
6	1.337E-03	1.922.E-03	1.337.E-03	1.922.E-03	1	36.00	1.922.E-03	1.922.E-03	1.922.E-03
7	1.383E-04	4.372.E-02	1.383.E-04	-9.038.E-03	1	35.99	nan	nan	nan
8	2.335E-03	2.335.E-03	2.335.E-03	2.335.E-03	0	36.00	2.334.E-03	2.334.E-03	2.334.E-03
9	9.900E-04	5.530.E-03	9.899.E-04	5.531.E-03	1	36.00	5.524.E-03	5.496.E-03	5.524.E-03