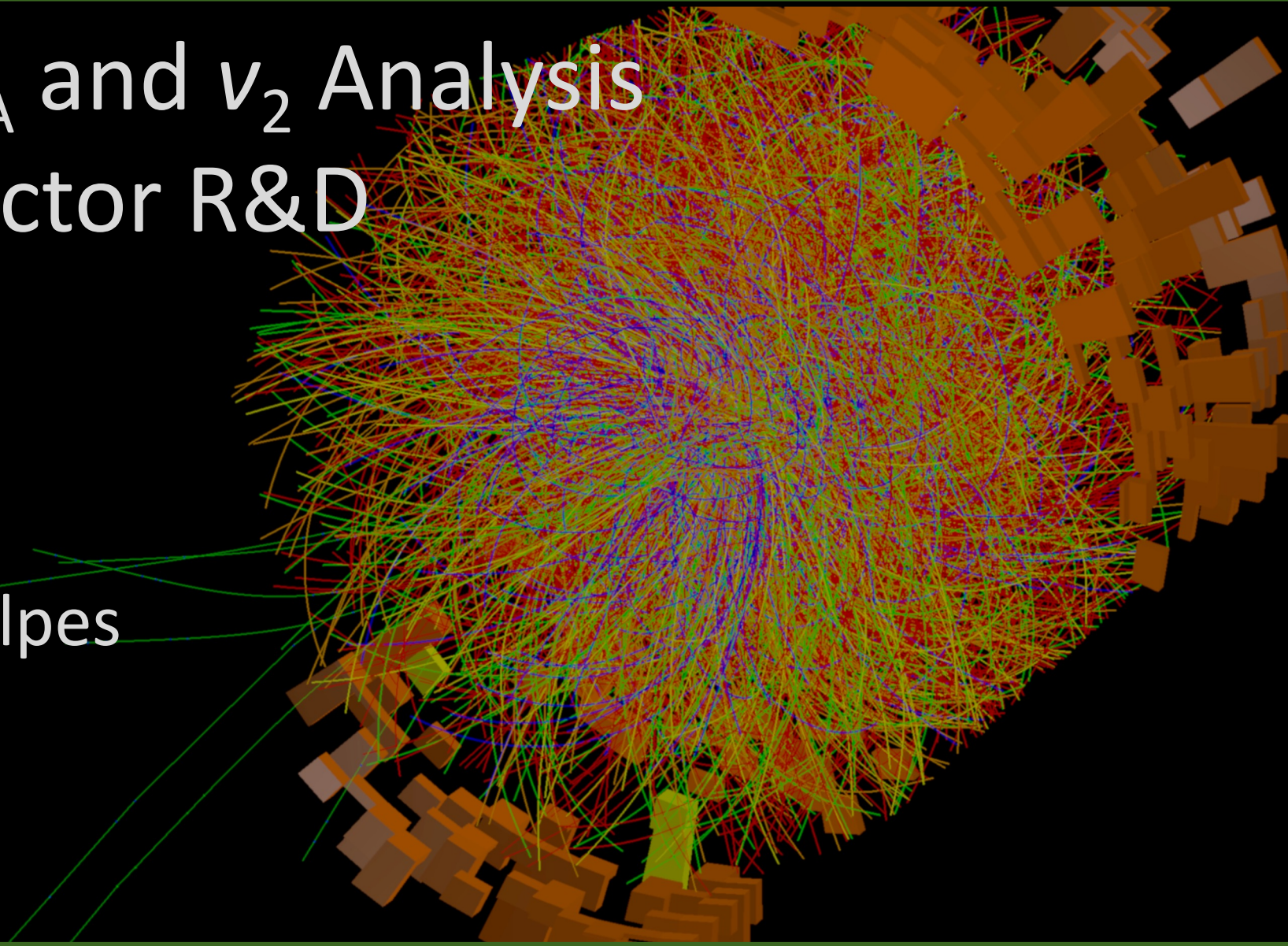
Inclusive Jet R_{AA} and v_2 Analysis and FoCal detector R&D



University Grenoble Alpes
University of Tsukuba
RIKEN (JRA)

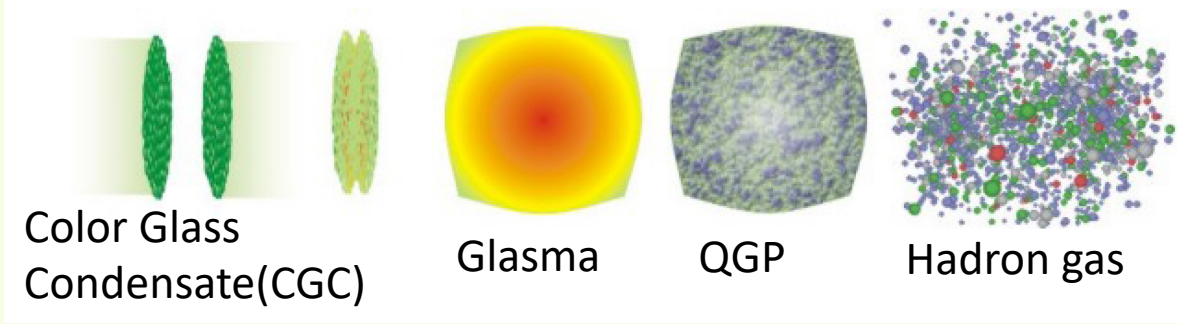
Takuya Kumaoka

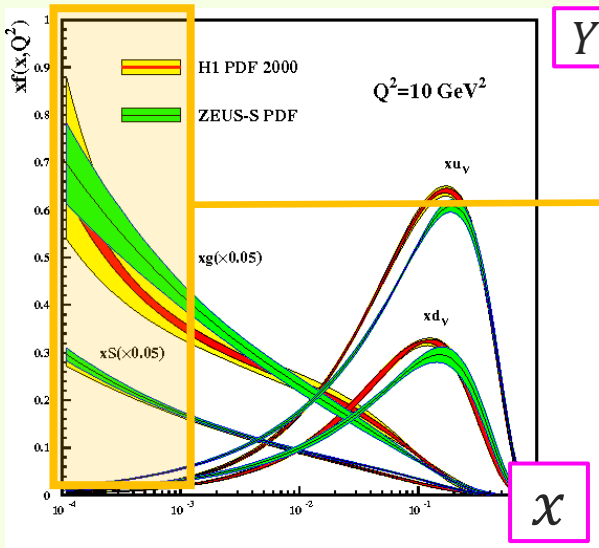
Current Progress

Forcused on my service task (FoCal-E pad trigger performance estimation)
-> Mostly finished

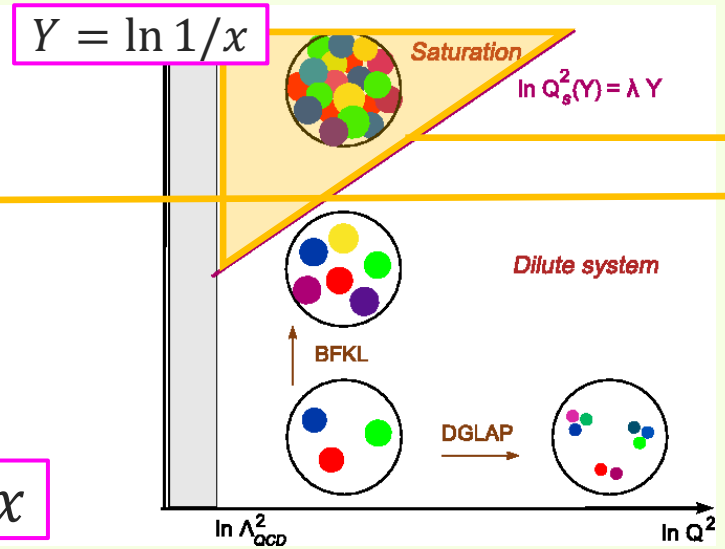
ALICE FoCal

FoCal-E (ALICE)
Forward Calorimeter (FoCal) of ALICE detector for LHC Run 4 (2026-2028) to measure parton distribution function (PDFs) and clarify the existence of color grass condensate (CGC).





Parton distribution funciton

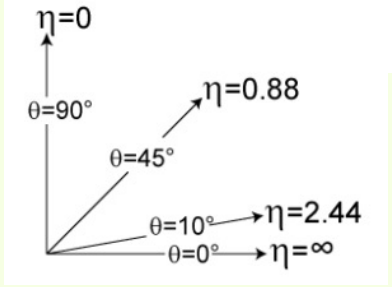


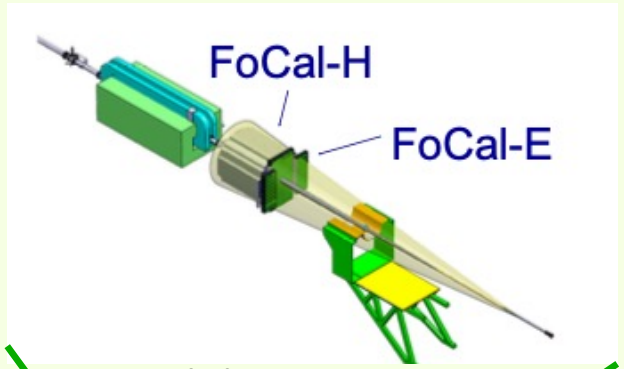
Parton distribution funciton

small x region

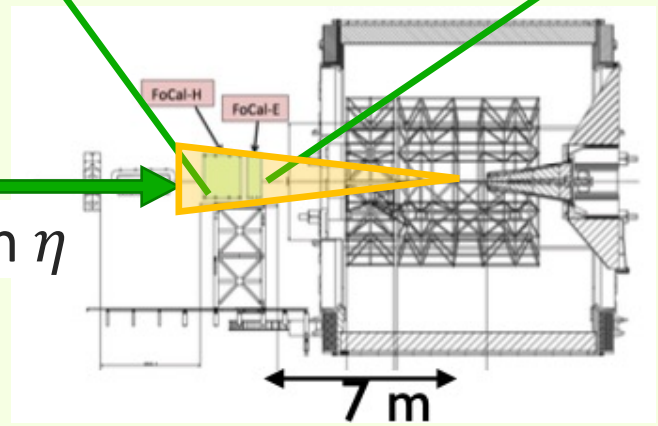
$$x \approx \frac{2p_T}{\sqrt{s}} e^{-\eta}$$

high η





FoCal detector overview

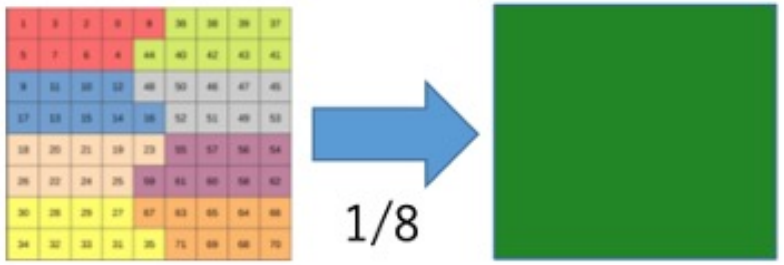


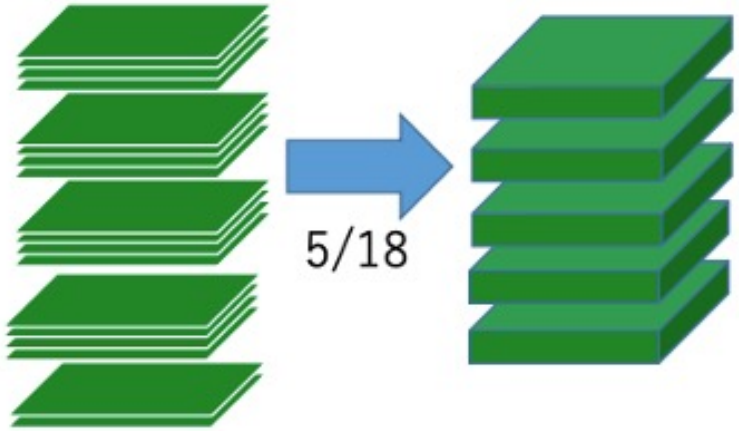
FoCal detector location of ALICE

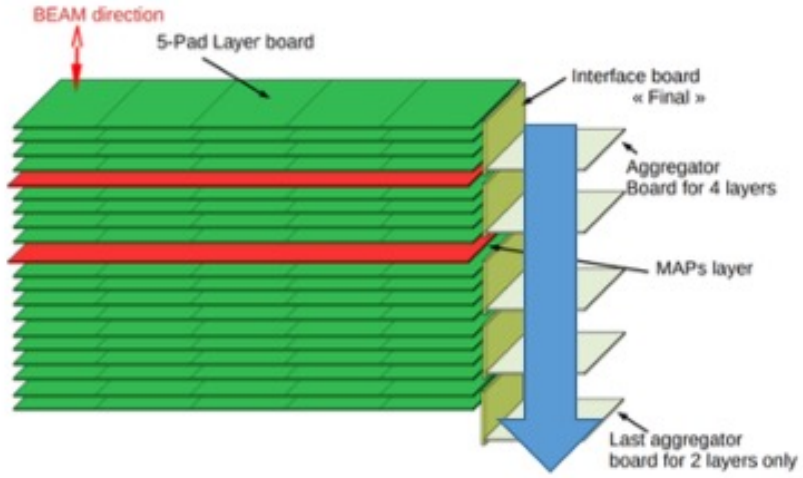
Trigger stream data reduction (EPad)

Steps	reduction factor	data rate per 5 tower module
sum up single HGCROC data into one (8 sums → 1 sum) in RU or aggregator	1/8	29 Gbps
sum up 4 or 2 HGCROCs (possible within aggregator)	1/8 × 5/18	8 Gbps (fits in single LpGBT)
sum up all 18 layers (needs communication between two aggregators)	1/8 × 1/18	1.6 Gbps (fits in single GBT)

there could be also other option such as not sum up fully at HGCROC but sum up among aggregators





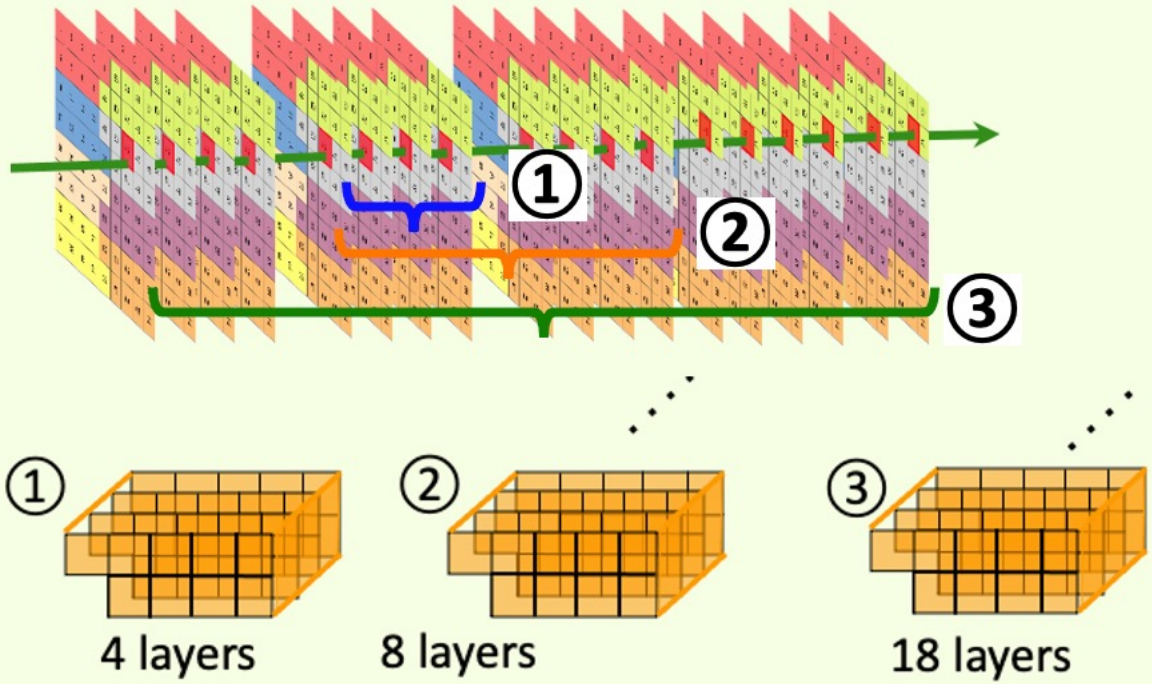


Ken's slide Feb.8, 2022

Trigger tower1-3

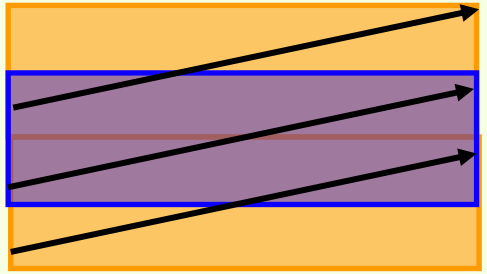
Simple Trigger tower
→ Used the unit of 9 cells and sum up layers

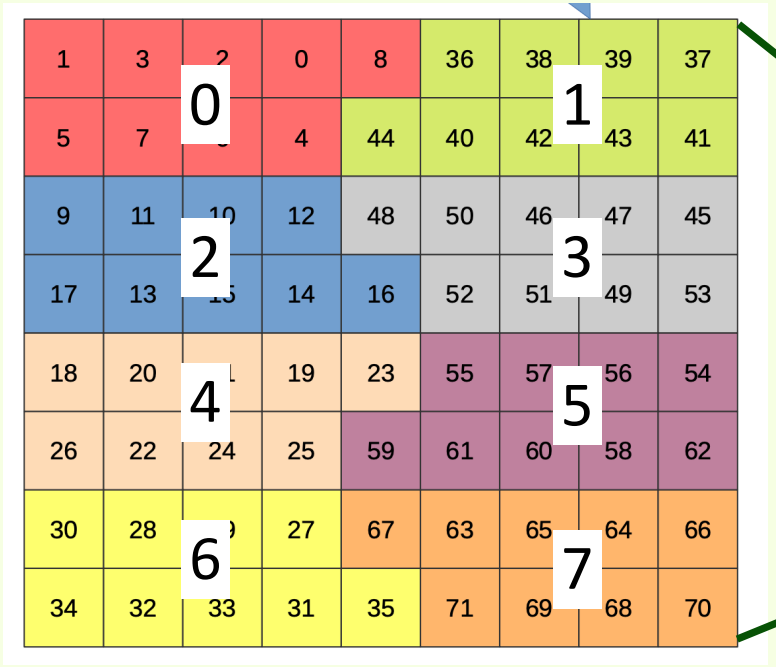
I estimated three kinds of length thower.

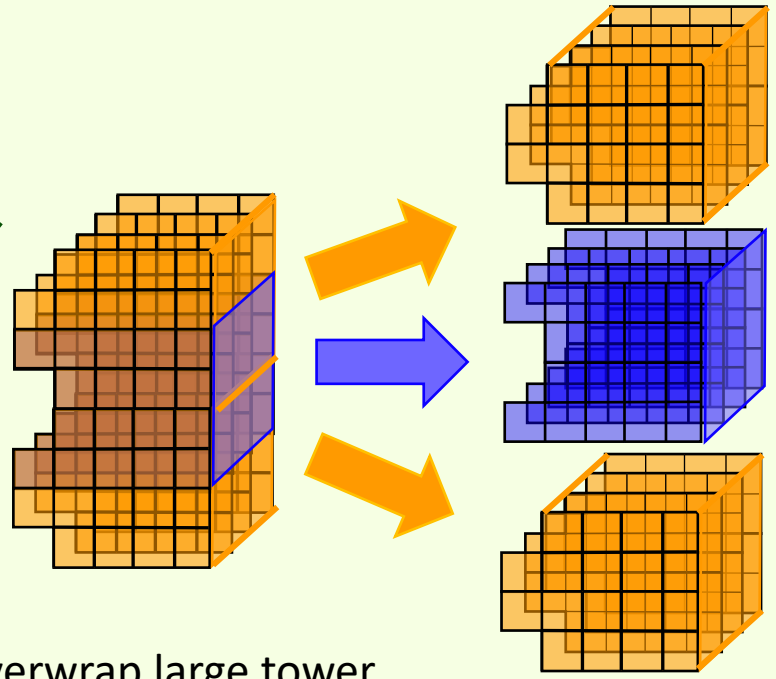


Trigger 4 (Large size tower and overwrap)

Unit: 18 cells (twice of Trigger1-3)
Length: all layer (18)
Overwrap Unit Tower
-> We expect to recover the particle that go through out the tower

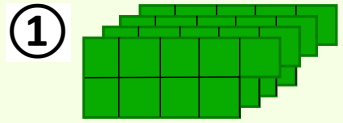




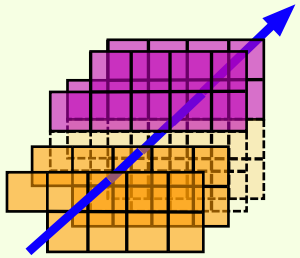


Overwrap large tower

Unit: Sum of cells on a layer
Tower: Sum of units for z direction

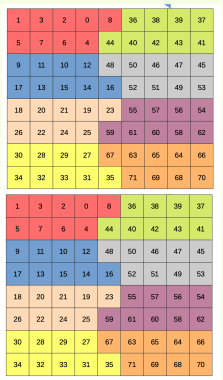


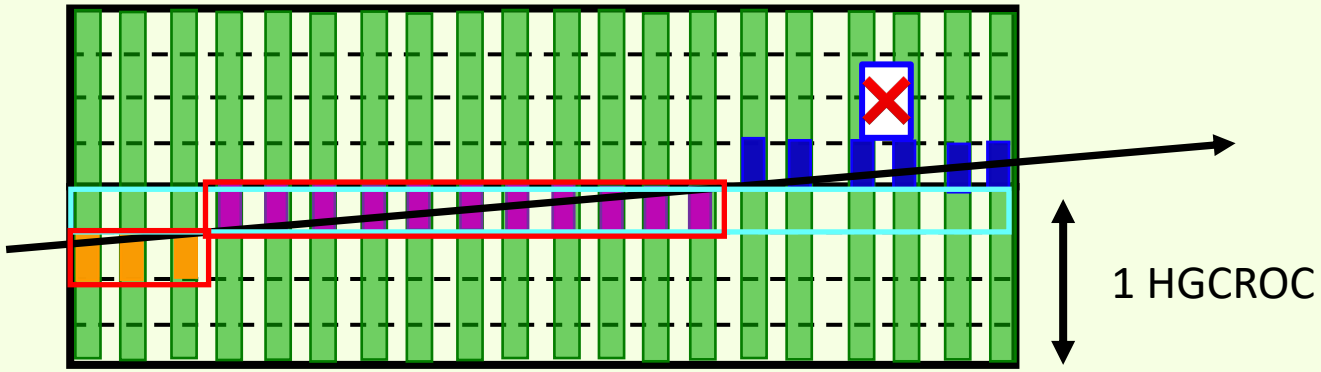
Trigger6 (Tower combining 9 cells unit having highest energy)



Felxible:

- Merge highest unit not fix x-y direction
- ✕ : not over 1 HGCROC





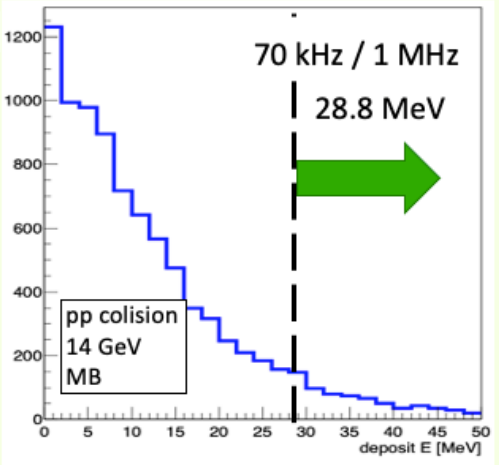
It will help for the readout of pixcel layer

only pixel strip with signal on HGCROC
are readout

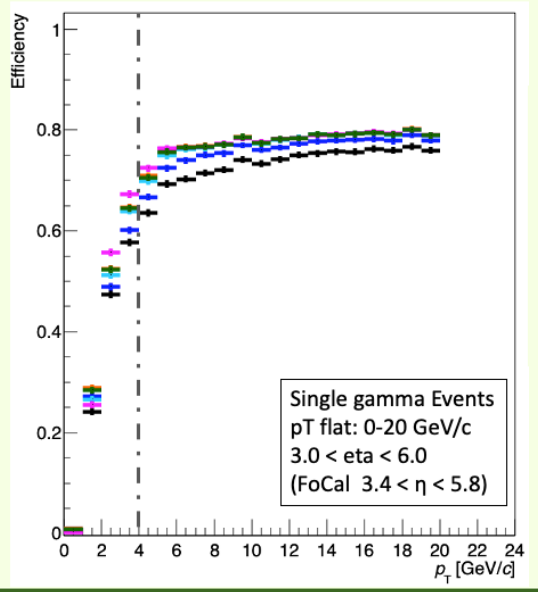
Simulation sample

Generator	FOCAL tag	Geant version	ROOT version	Name	Number of events	Location
Box (single photon, 0<pT<20 GeV/c)	v1.1	3	6	boxPhoton	100000	v1.1_root6/boxPhoton
Box (single photon, 15<pT<40 GeV/c)	v1.1	3	6	boxPhoton	100000	v1.1_root6/boxPhoton_ptGT15
Box (single pi0, 0<pT<20 GeV/c)	v1.1	3	6	boxPi0	100000	v1.1_root6/boxPi0
Box (single pi plus, 0<pT<20 GeV/c)	v1.1	3	6	boxPiPlus	100000	v1.1_root6/boxPiPlus
Pythia (min bias pp 14 TeV)	v1.1	3	6	pythiaMinBias	100000	v1.1_root6/pythiaMinBias

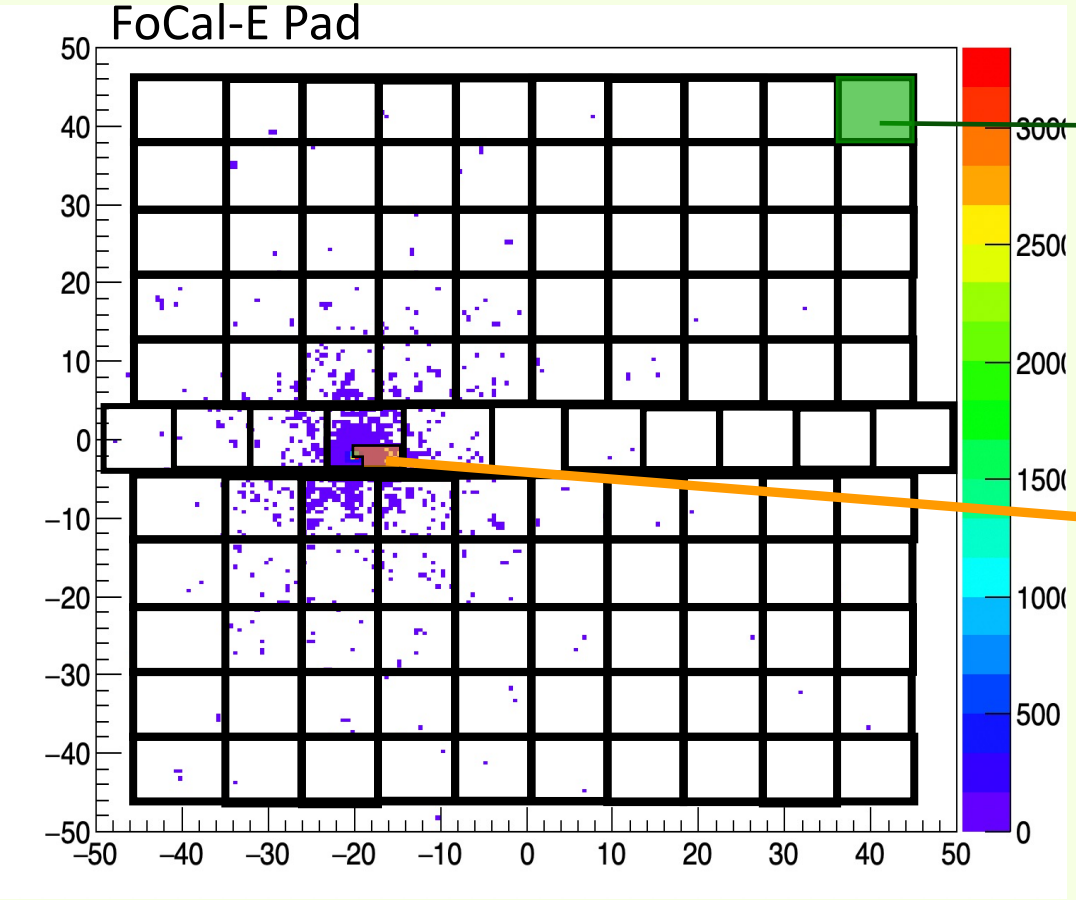
1. To determine the appropriate thresholds, I used pp 14 TeV MB sample →



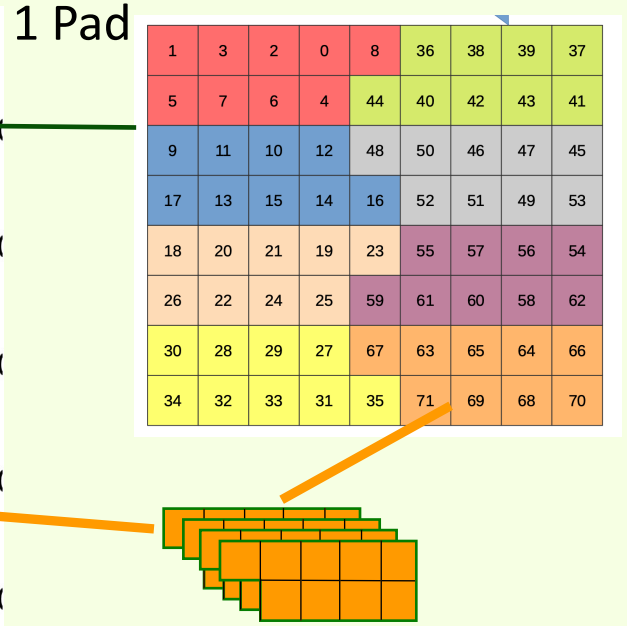
2. To esitmate the efficiency of phton and pi0,
I used sigle particle samples



Trigger Decision



Deposit energy map in one event



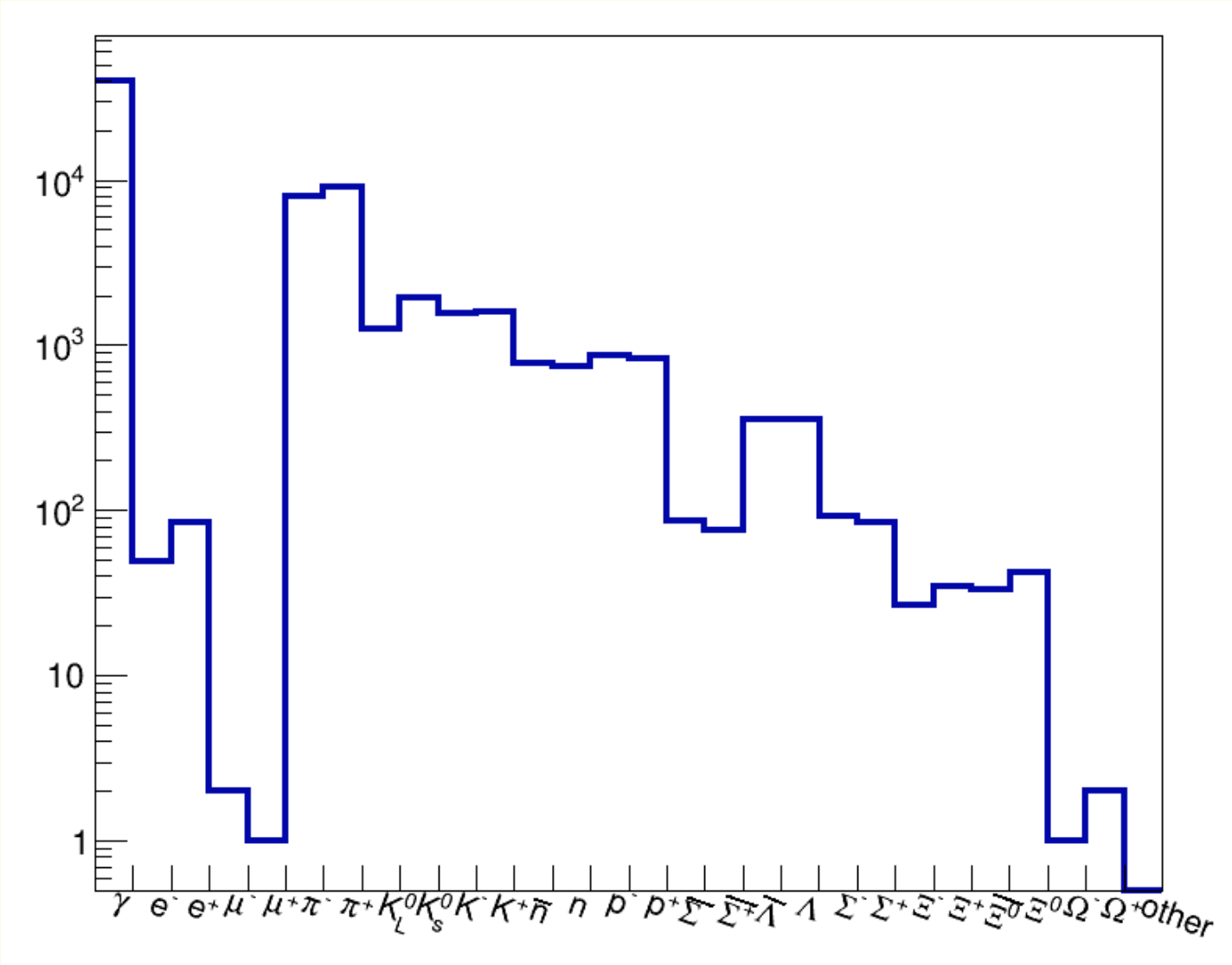
- Find a tower that has the highest deposit energy or pT. (pT = deposit energy × sinθ)
- Trigger events that there is a tower having deposit E/pT over **threshold.**

Current lough assumption

- 1 HGCROC:32bit x 72 ch = 2304 bit
- Read 1 HGCROC by GBT (3.2 Gbps)
- 1 aggregator board has 20 HGCROC
  -> 3.2x10^9 / 20 / 2304 = 70 kHz

→ Determine the threshold value of deposit E or pT based on the data reading rate

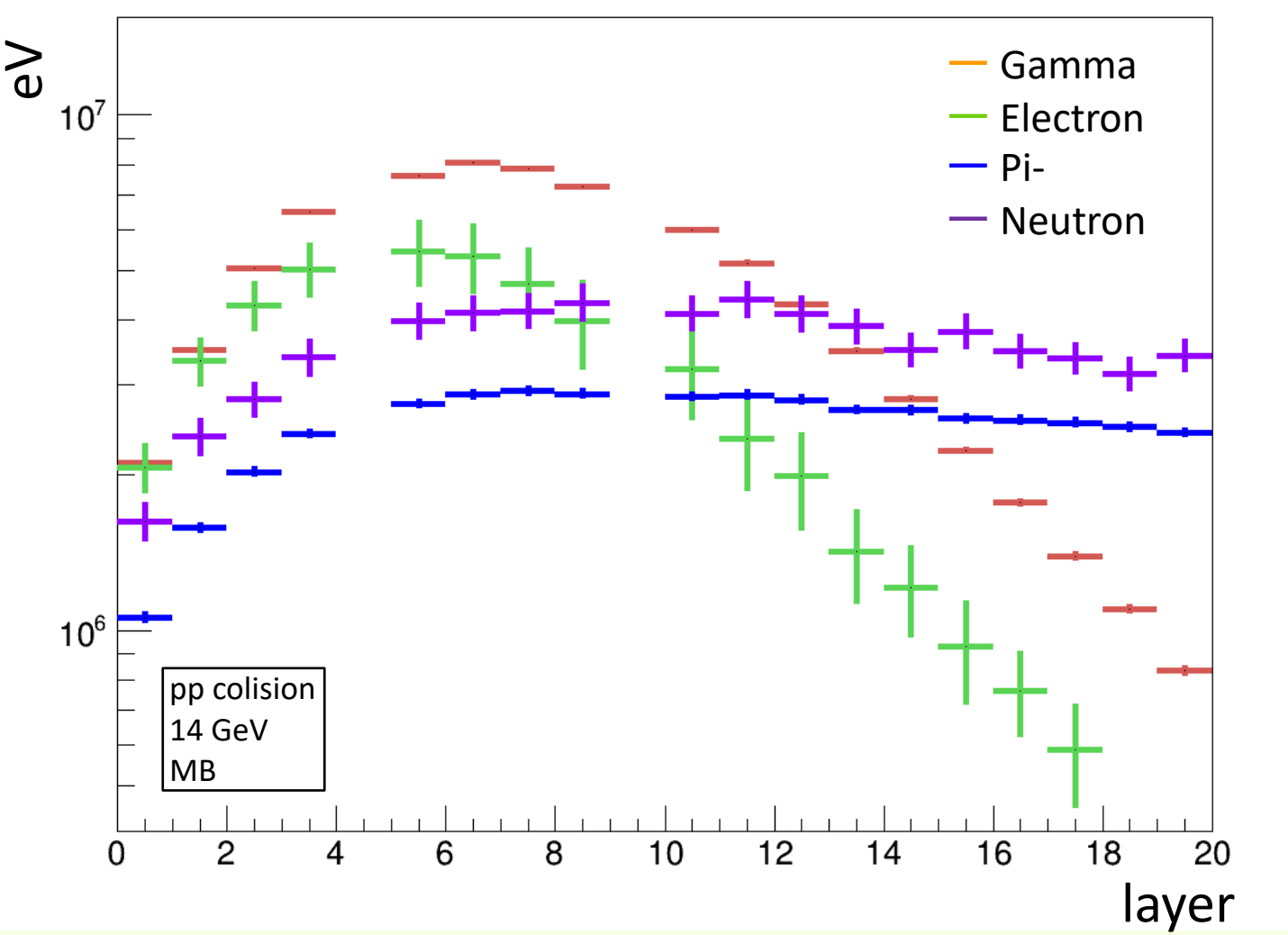
Particle kinds in MB sample



* Pi0 is recorded as decayed gammas

Deposit energy for each particle

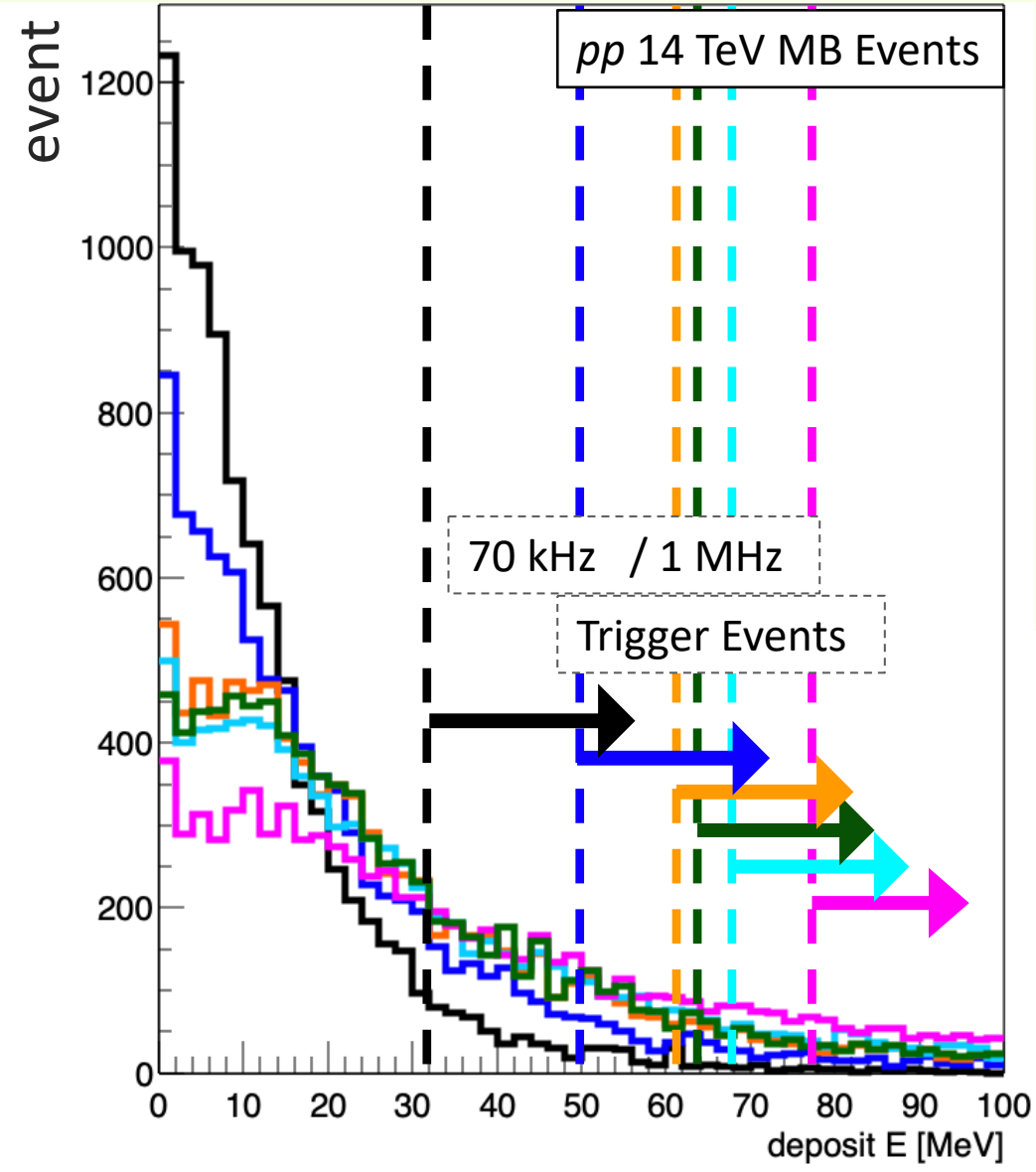
Fill all cell's deposit energy for each layer

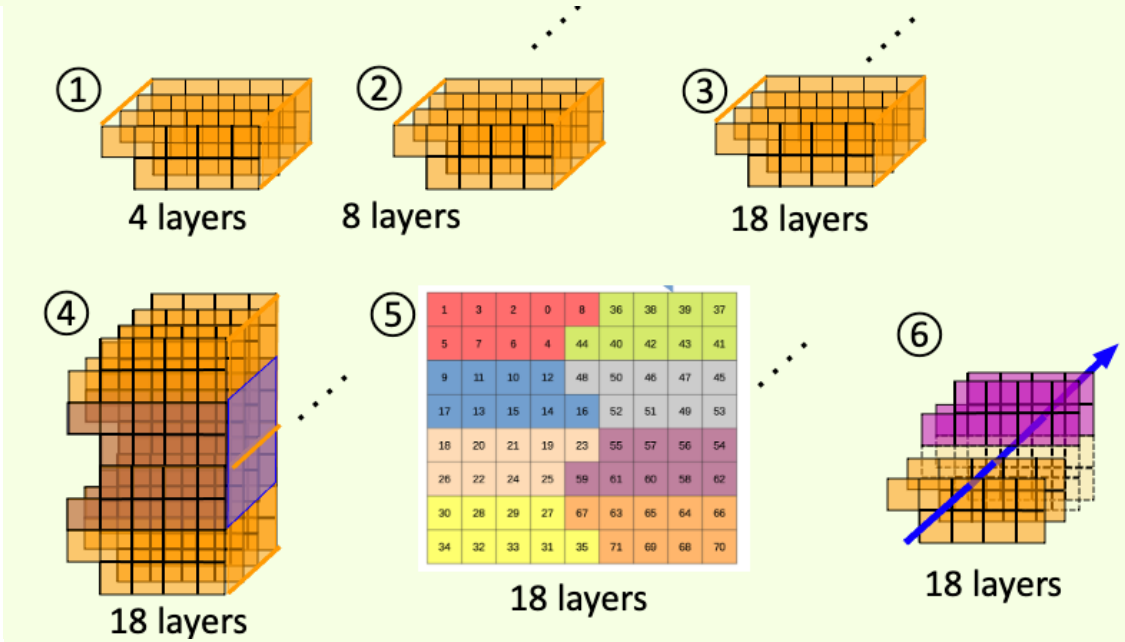


The plot show the peeks of each distribution are around 5-7 layer.

Gamma and Electron declease the deposit energy after 7-8 layer.
While hadrons are keep deposit value.

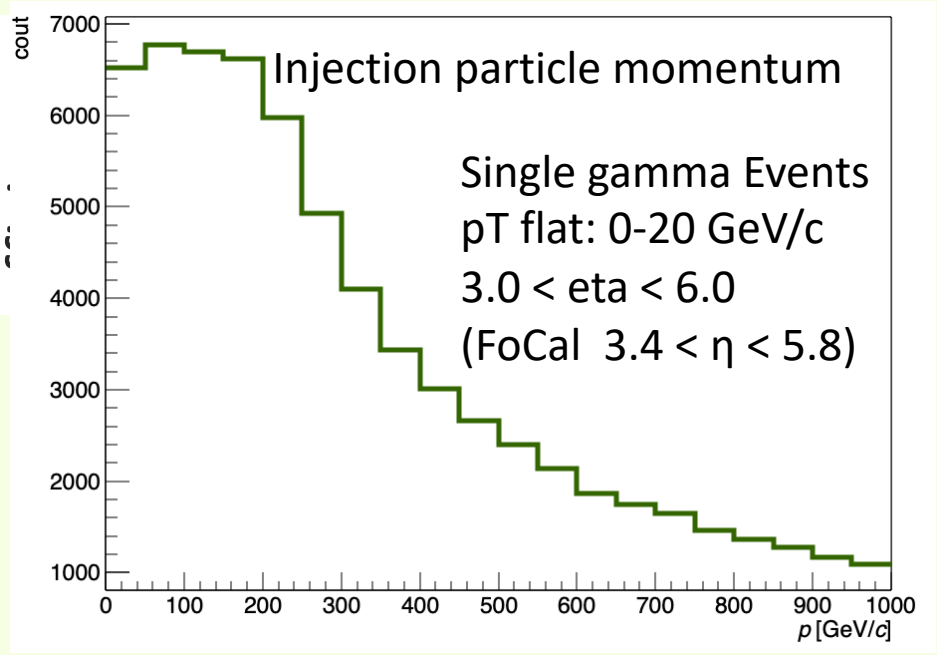
Kinds Deposit Energy Distribution

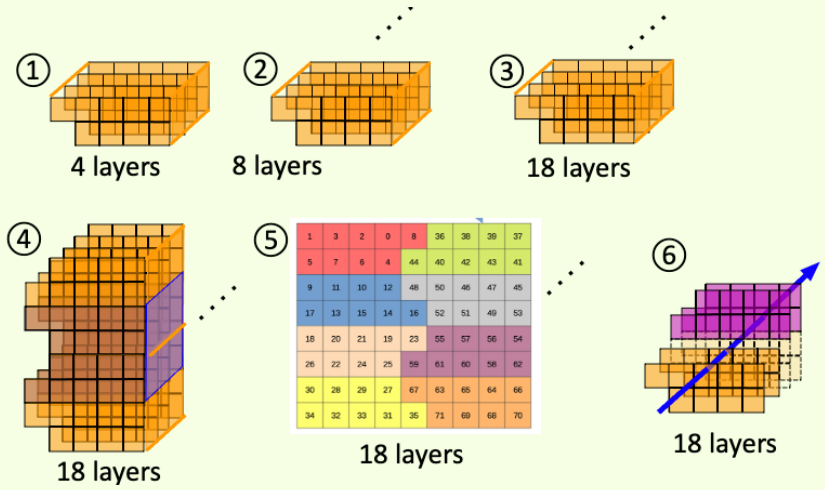


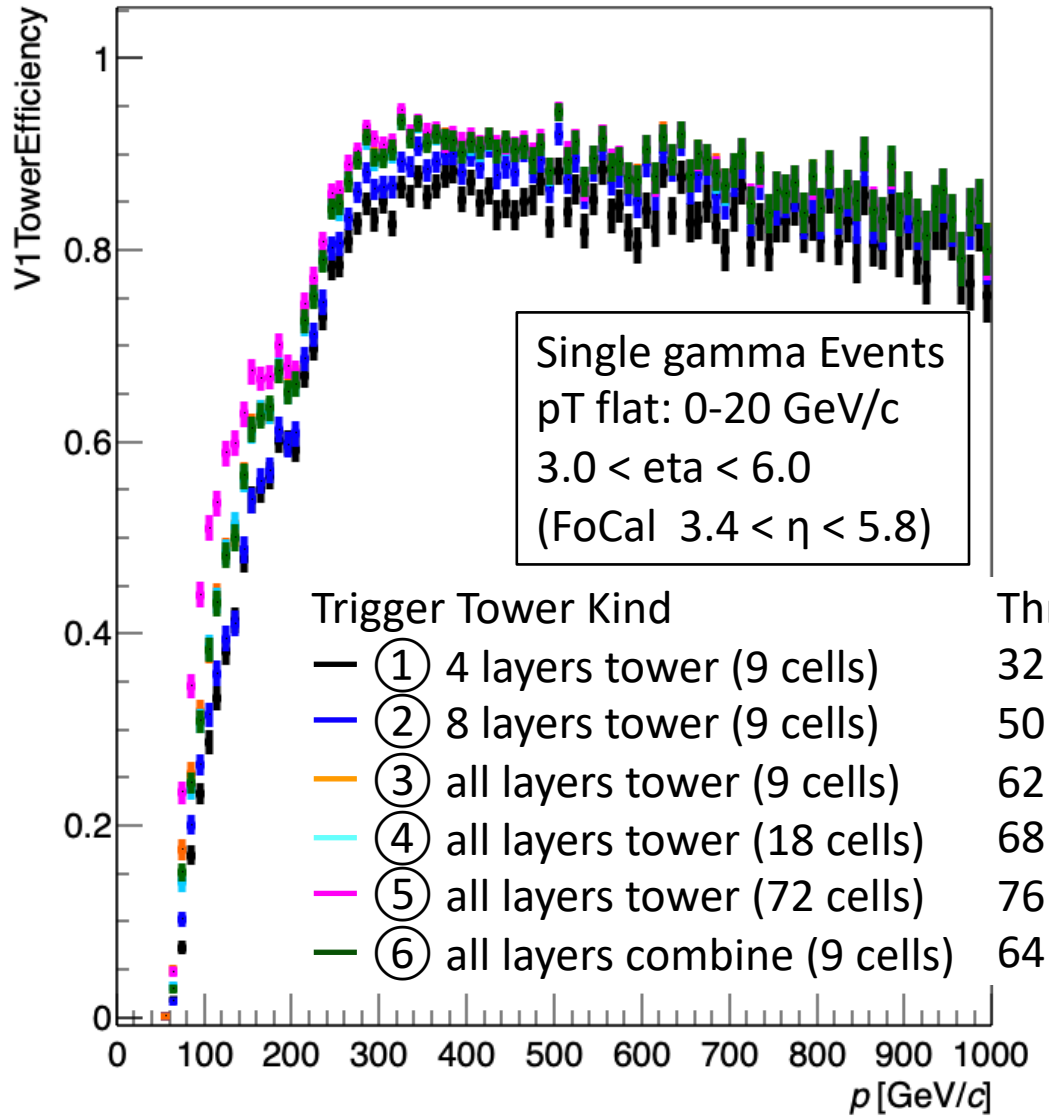


Trigger Tower Kind	Threshold (MeV)
① 4 layers tower (9 cells)	32
② 8 layers tower (9 cells)	50
③ all layers tower (9 cells)	62
④ all layers tower (18 cells)	68
⑤ all layers tower (72 cells)	76
⑥ all layers combine (9 cells)	64

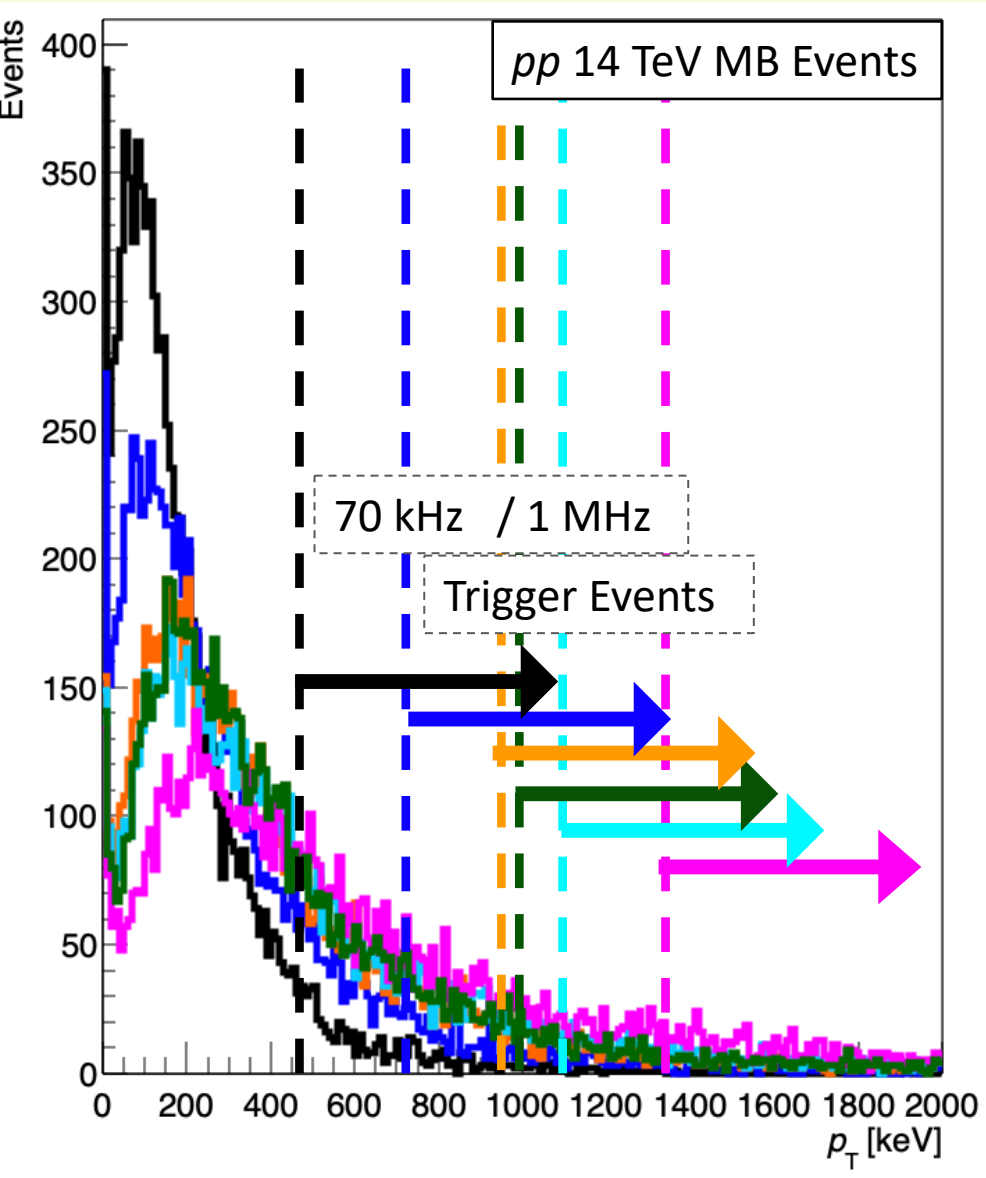
Deposit Energy Trigger Efficiency (Tower kind)



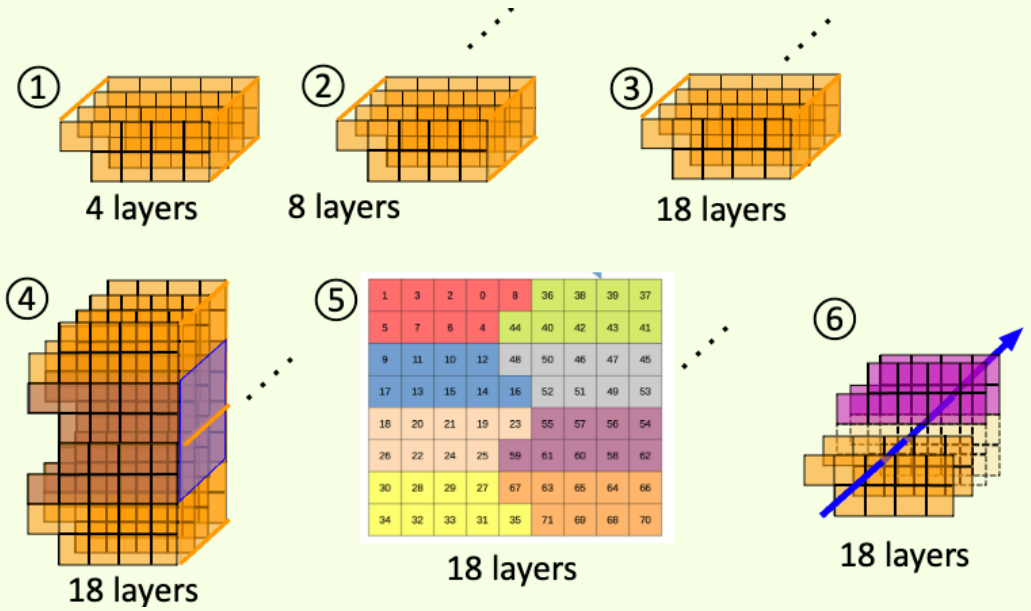




Tower Kinds pT DistributionTower

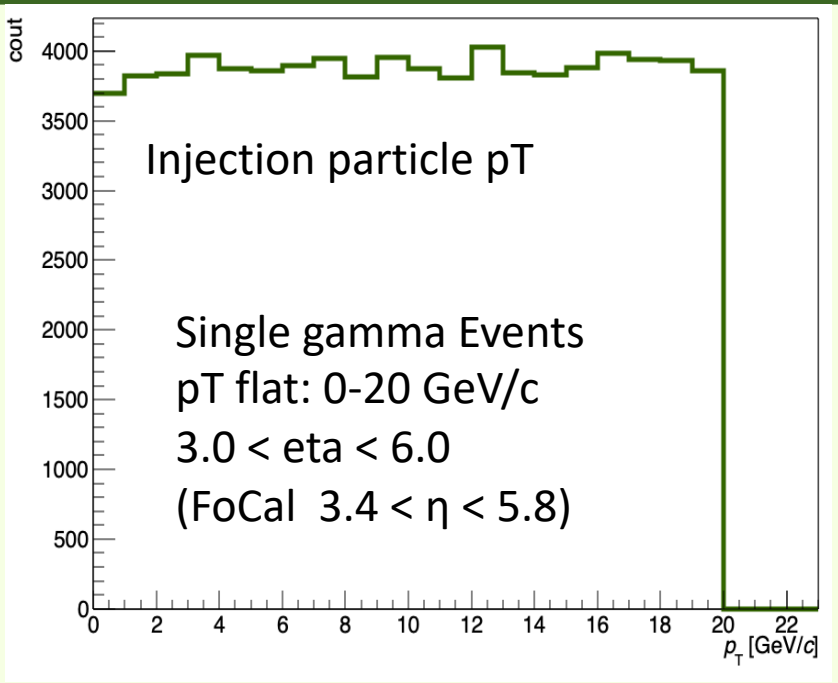


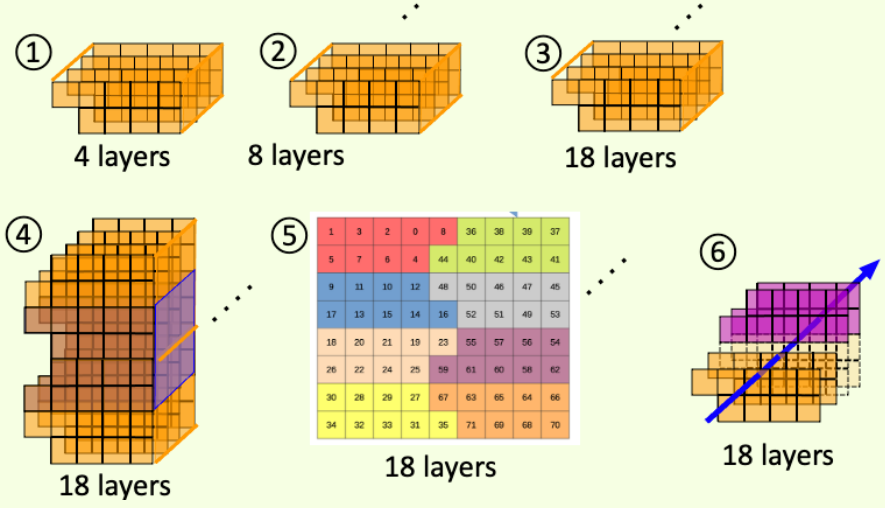
Fill the most highest pT from the pT the tower units have in an event.
(pT = towerDepE × sinθ)

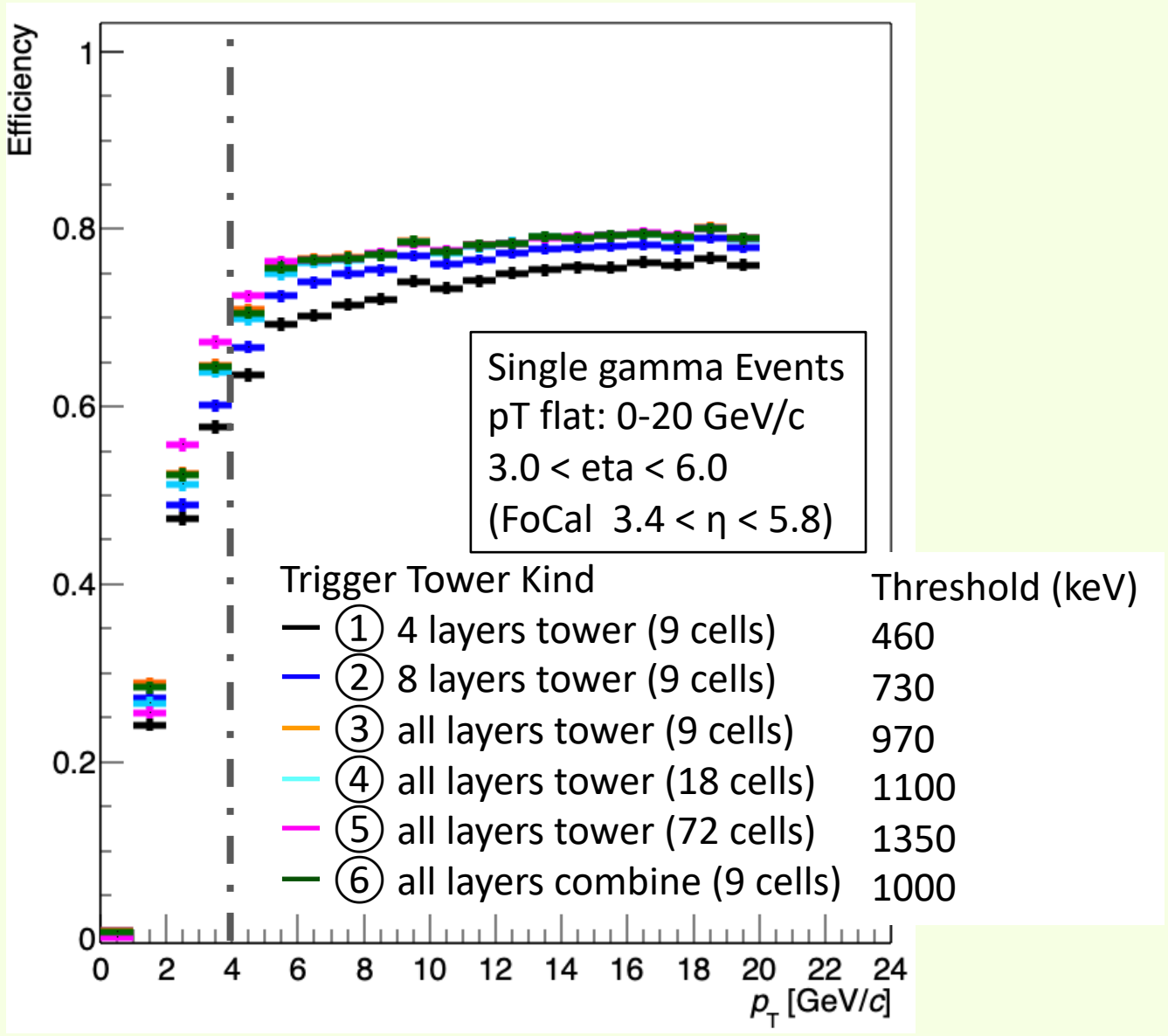


Trigger Tower Kind	Threshold (keV)
— ① 4 layers tower (9 cells)	460
— ② 8 layers tower (9 cells)	730
— ③ all layers tower (9 cells)	970
— ④ all layers tower (18 cells)	1100
— ⑤ all layers tower (72 cells)	1350
— ⑥ all layers combine (9 cells)	1000

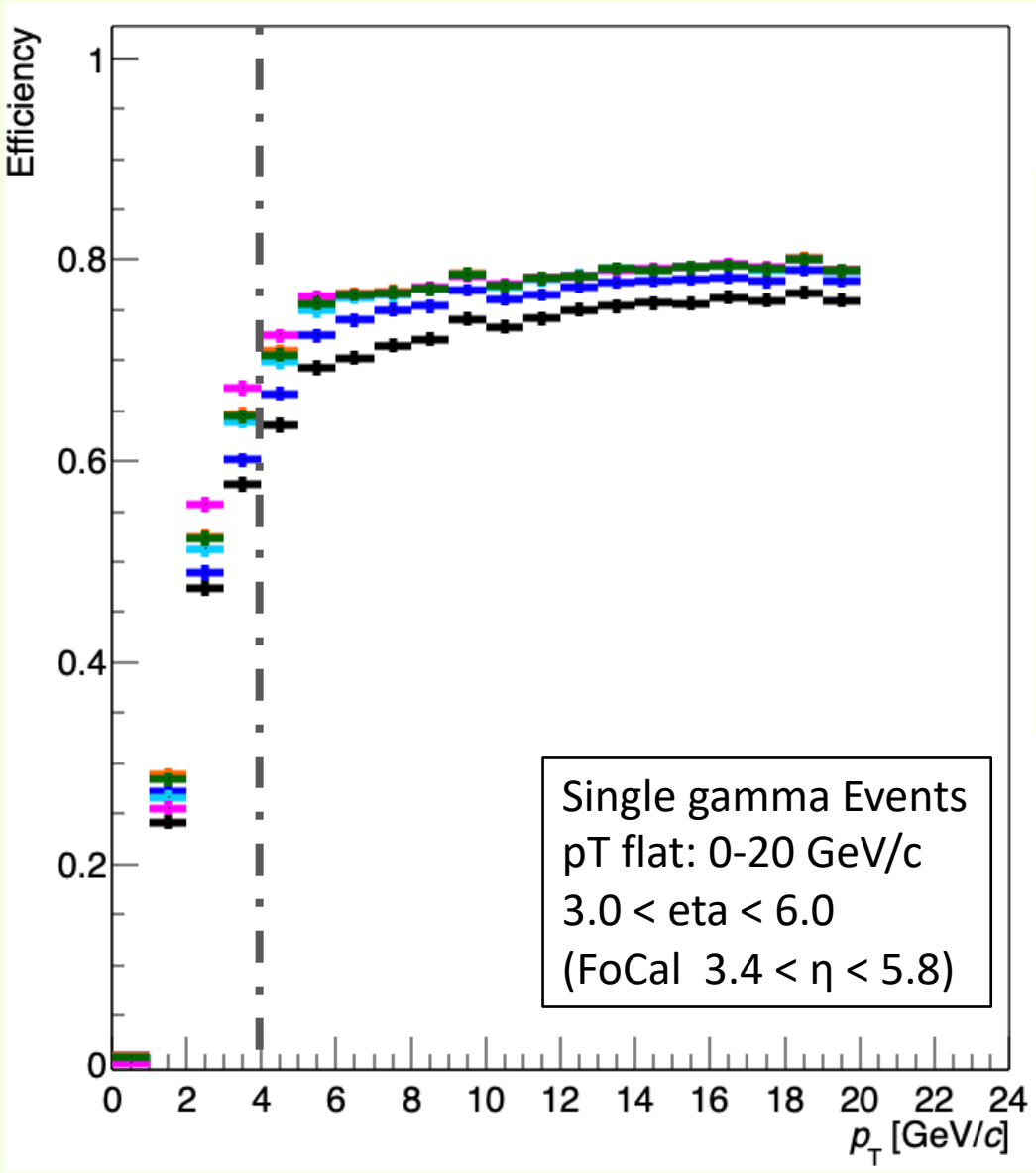
pT Trigger Efficiency (Tower kind)

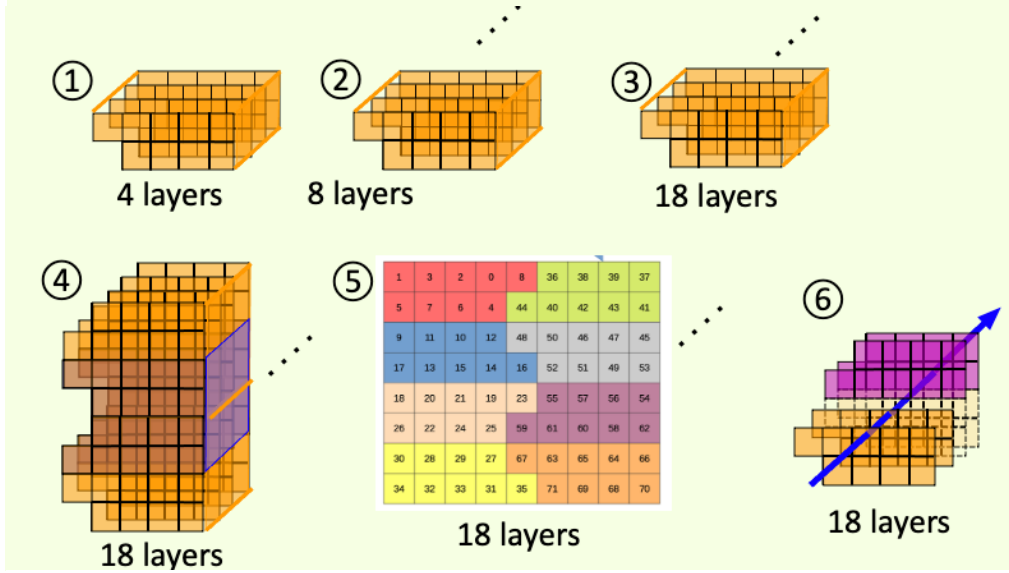






pT Trigger Efficiency (Tower kind)





Trigger Tower Kind	Threshold (keV)
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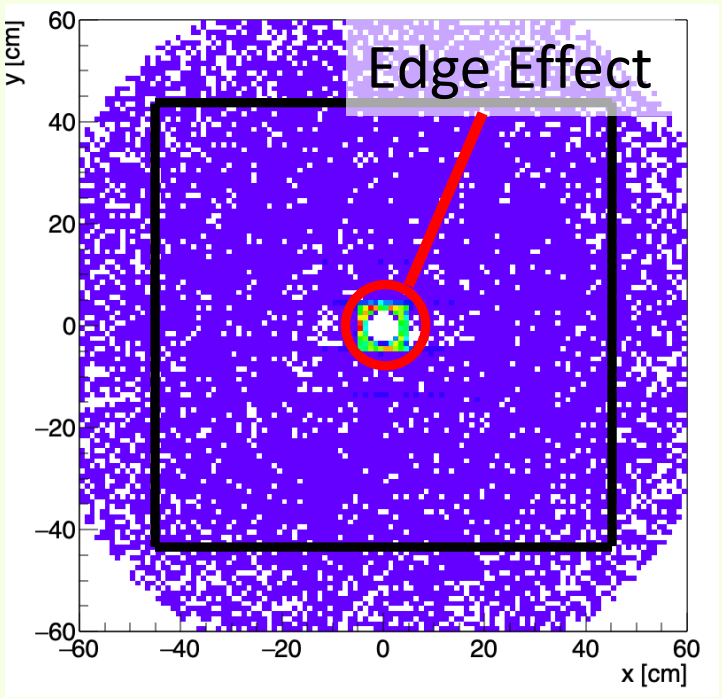
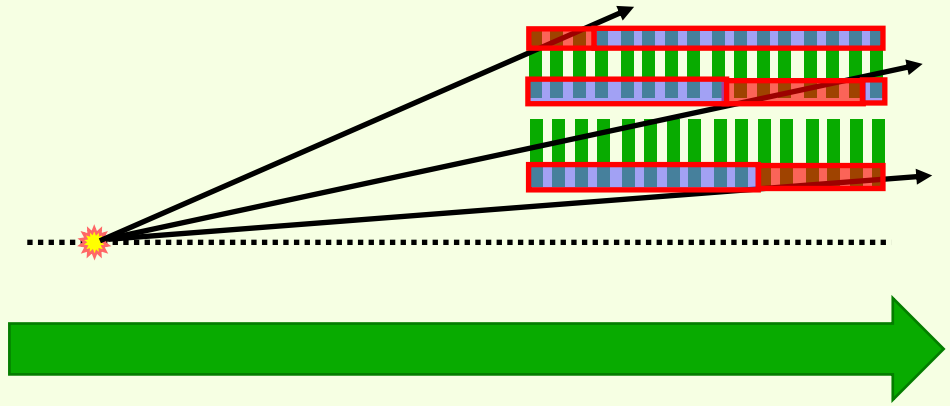
③ all layers tower (9 cells)	970
④ all layers tower (18 cells)	1100
⑤ all layers tower (72 cells)	1350
⑥ all layers combine (9 cells)	1000

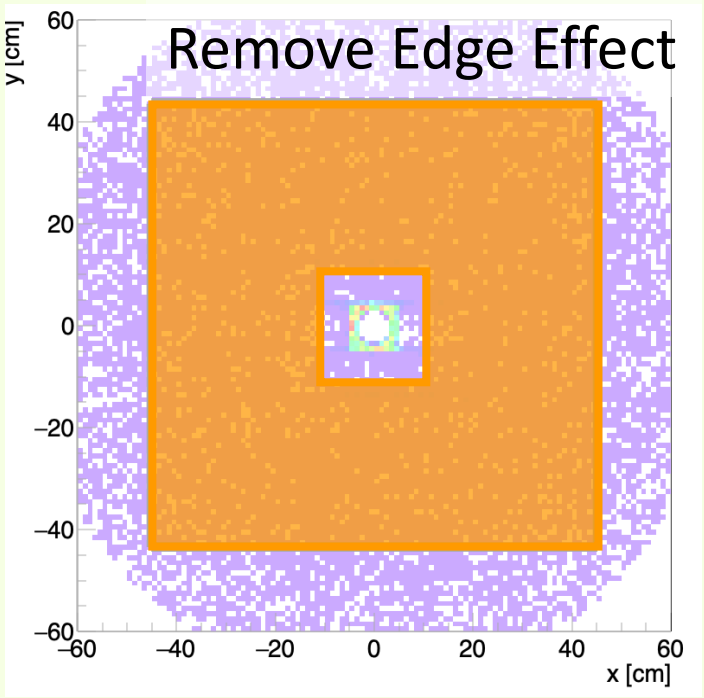
Check Miss Event Hit position

Fill a position gammas in miss event at 7000 mm
(x = 7000. * (px/pz), y = 7000. * (py/pz))

(Every event has a hit point on FoCal.
So even if the point is on the out of FoCal region at 7000 mm, the particle has hit inner or outer layer.)



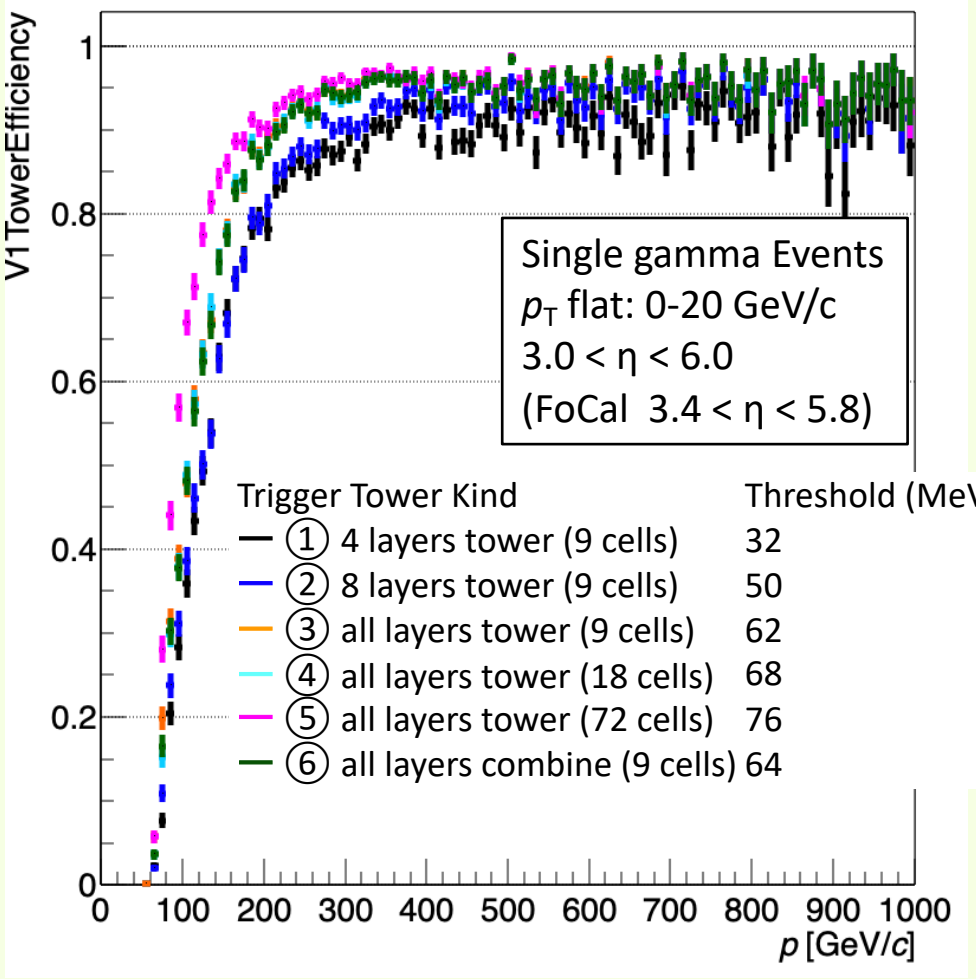




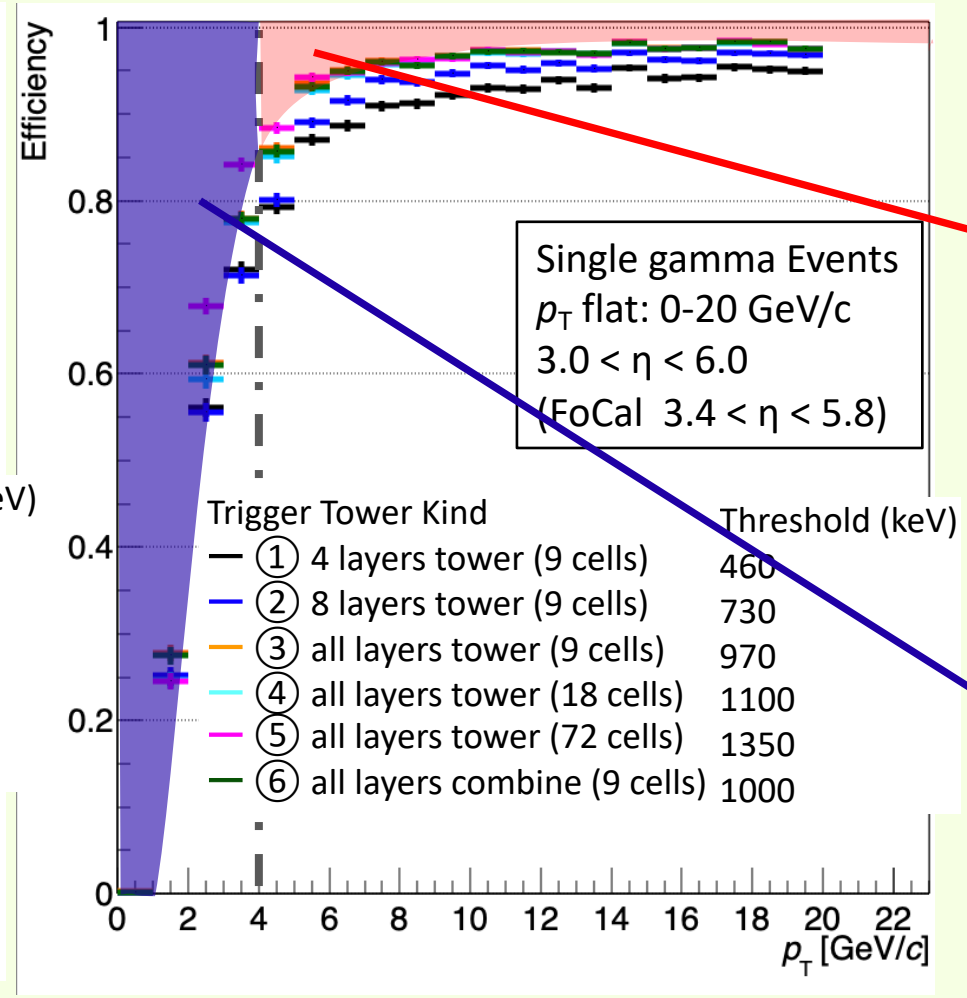
Remove edge Effect

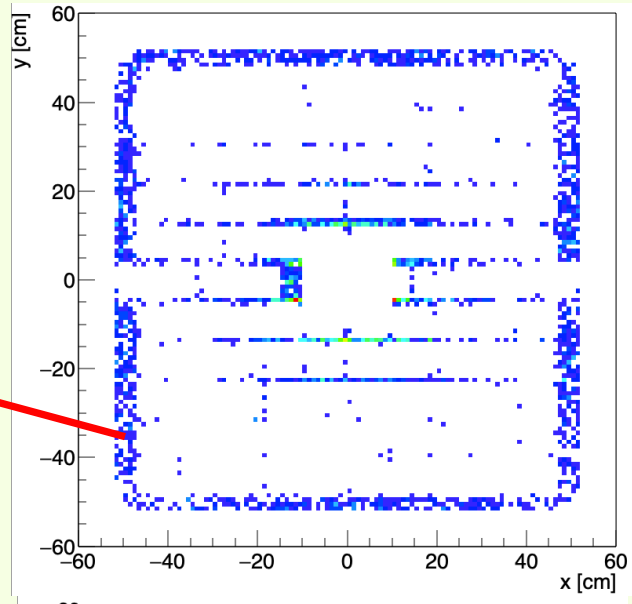
Remove the small θ region

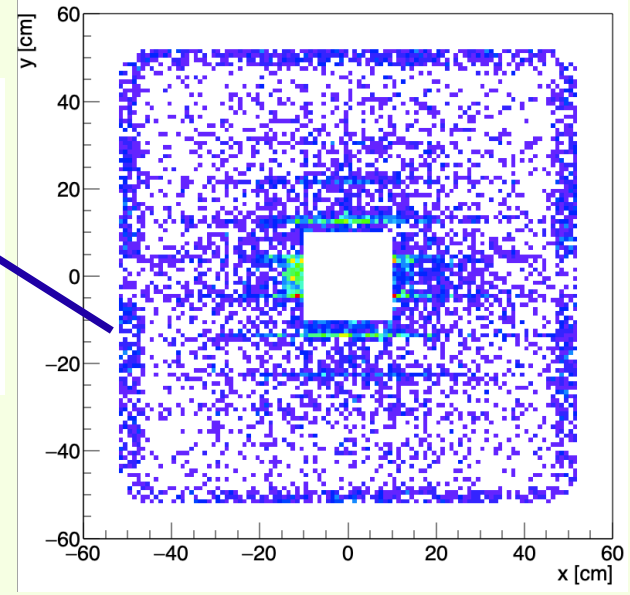
Momentum efficiency



pT efficiency

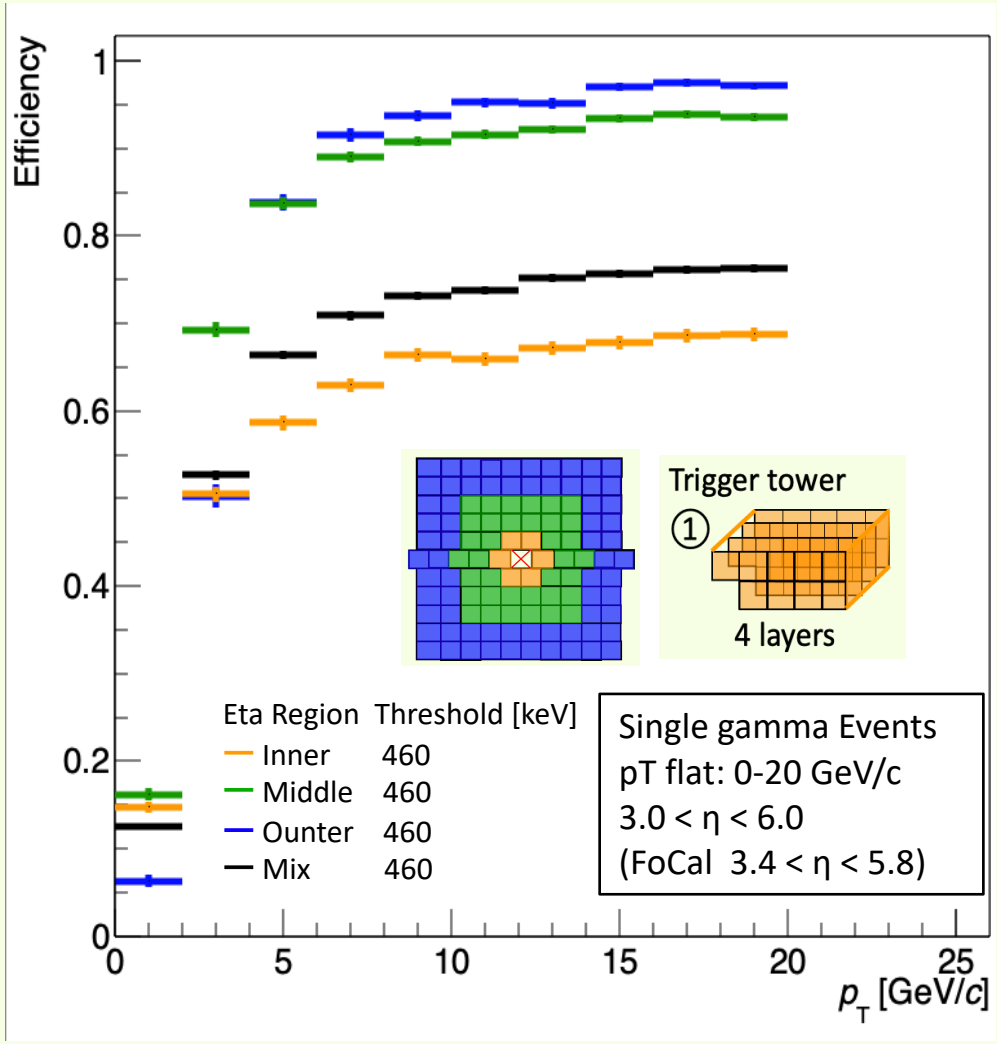




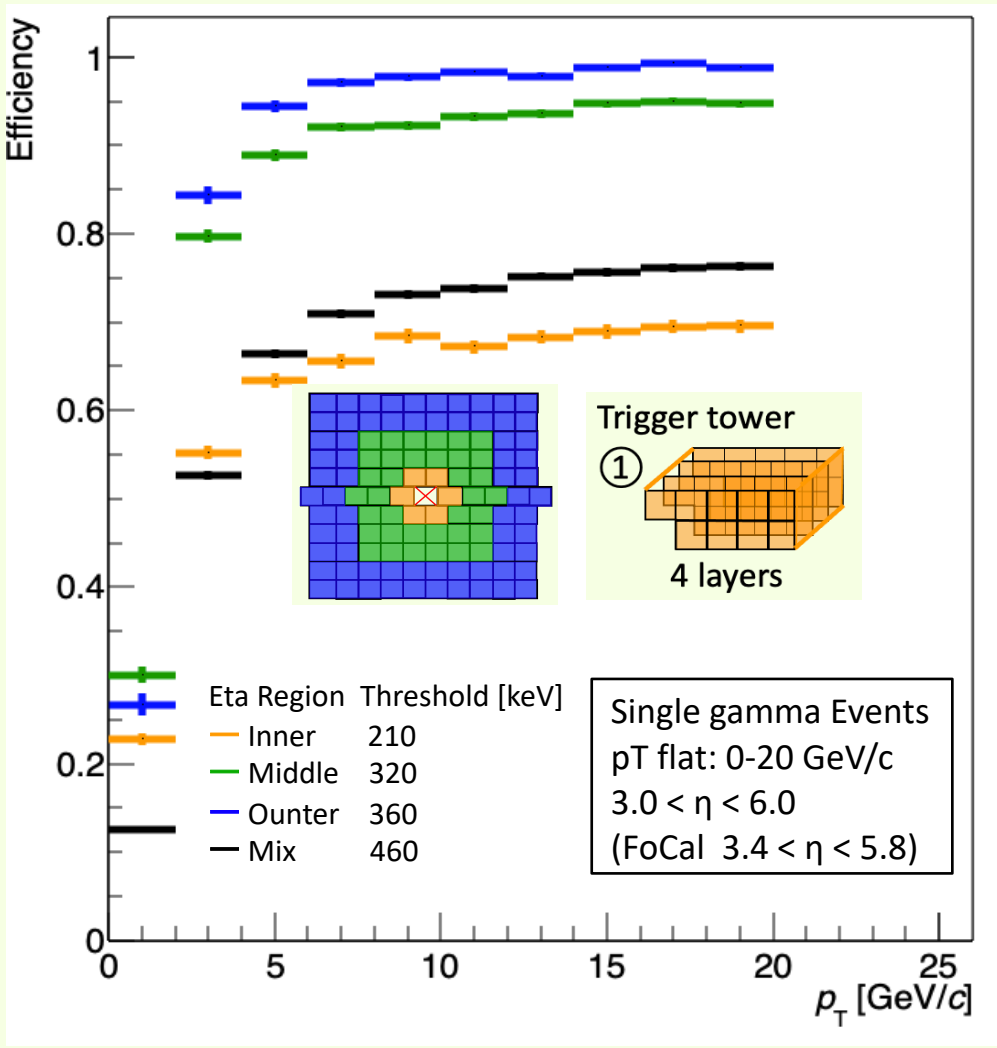


Divide for each eta region

Same threshold

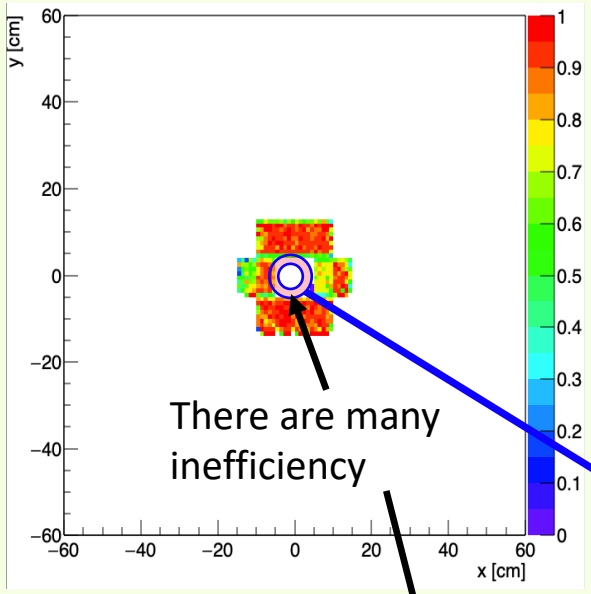


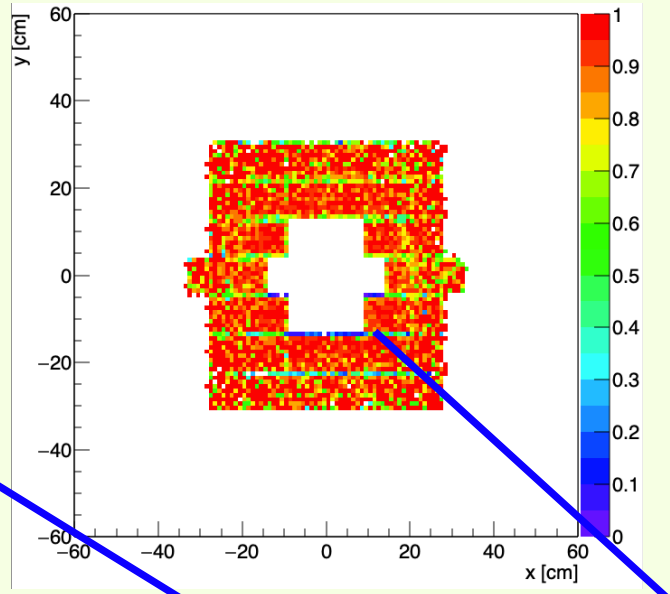
Determine thresholds for each part

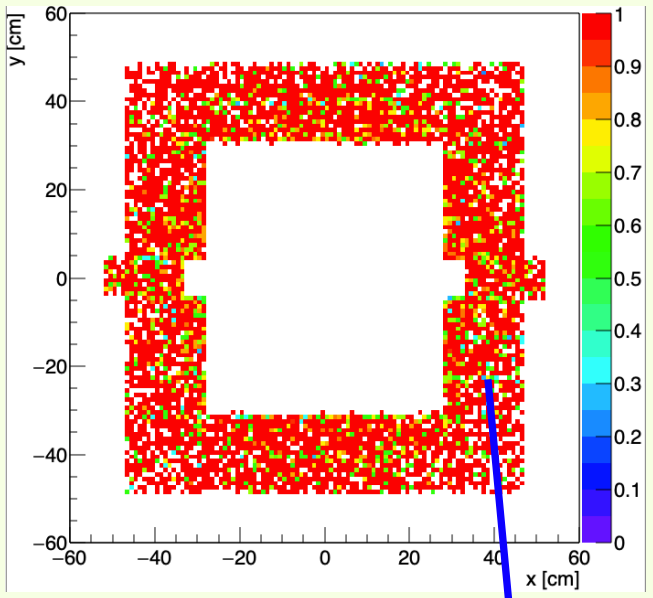


To determine the threshlds for each parts makes the efficiency better

Efficiency x,y map







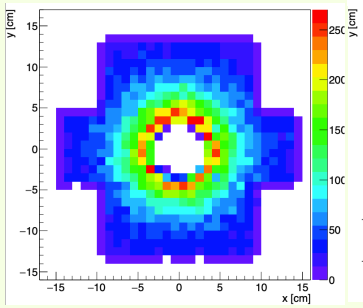
There are many inefficiency

θ

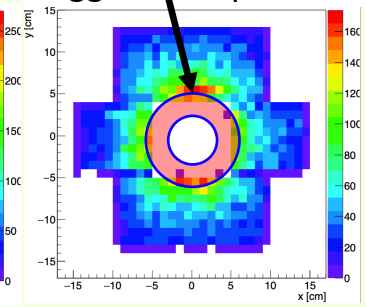
FoCal-E

θ

Injection point map



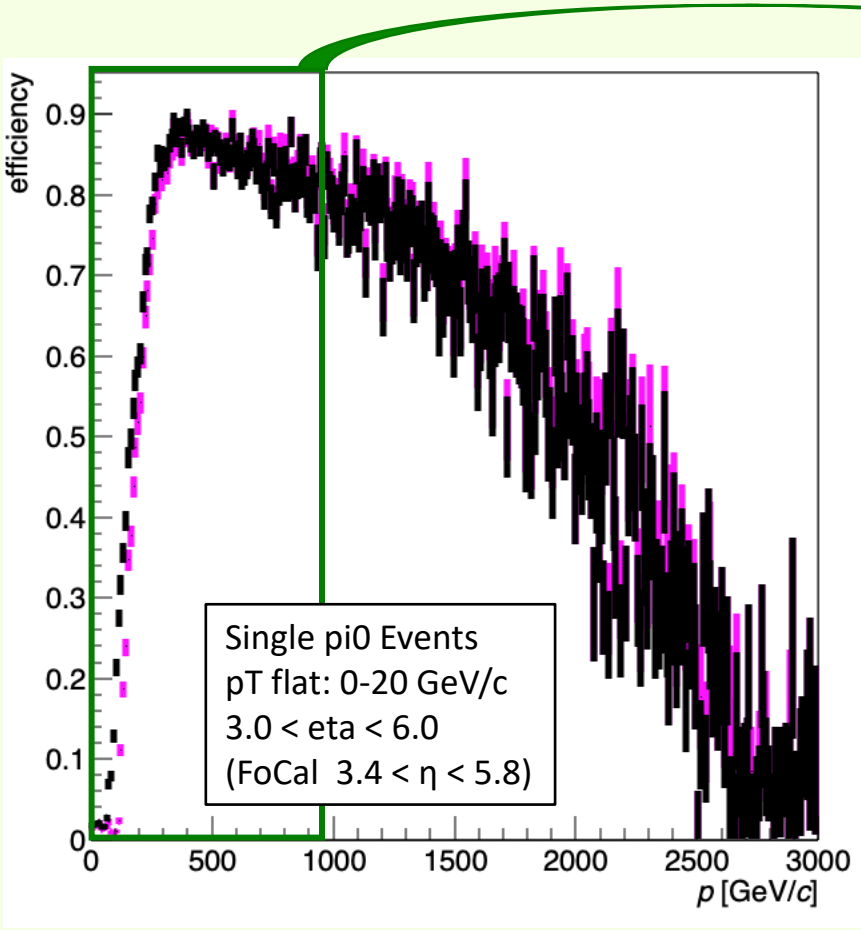
Triggered hit point map

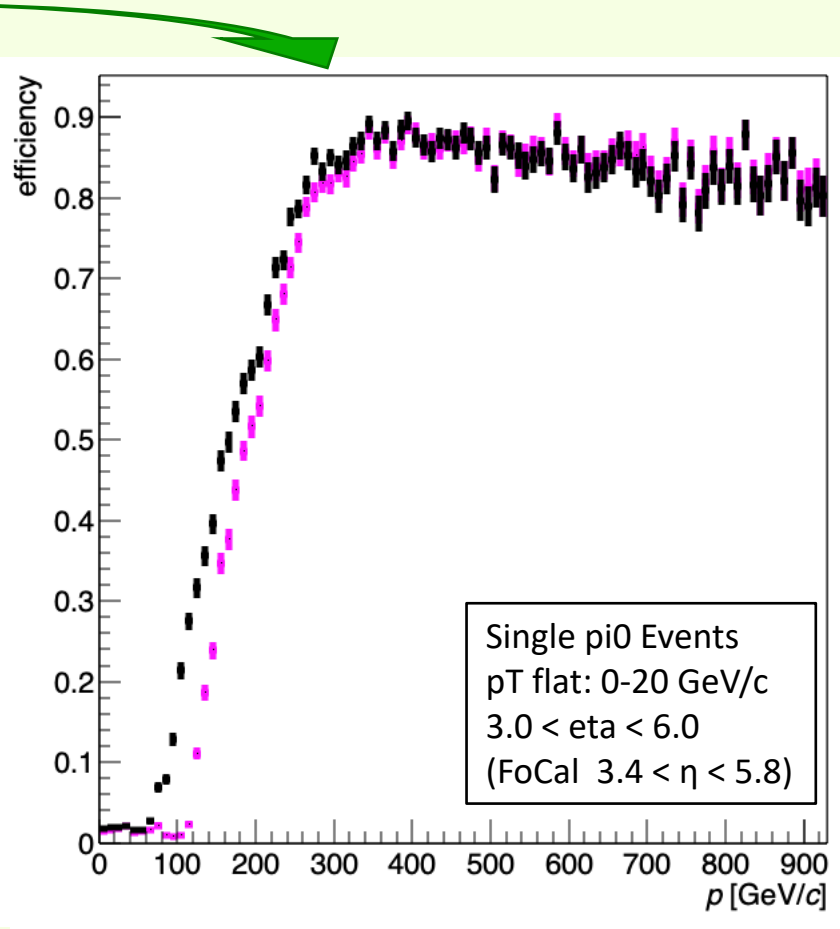


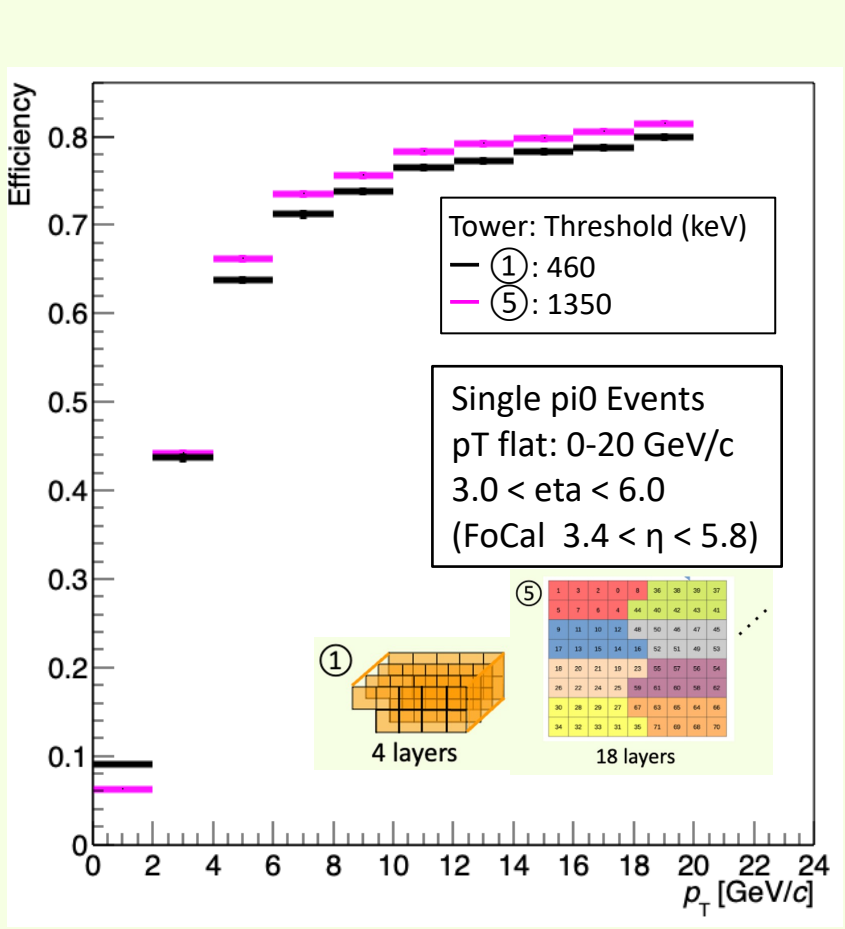
Collision point

In lower θ region, the effect of ineffective area is lager

Pi0 Efficiency





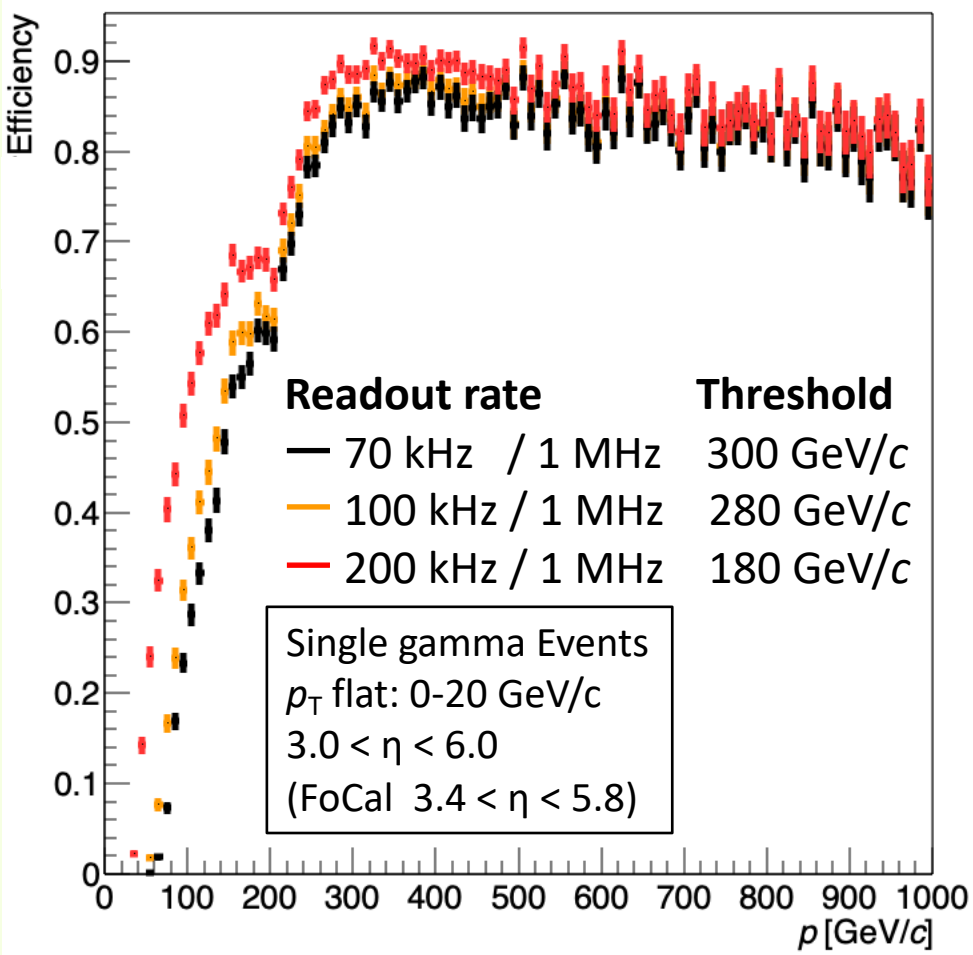


The efficiency of pi0 is mostly same of the single gamma resutls.

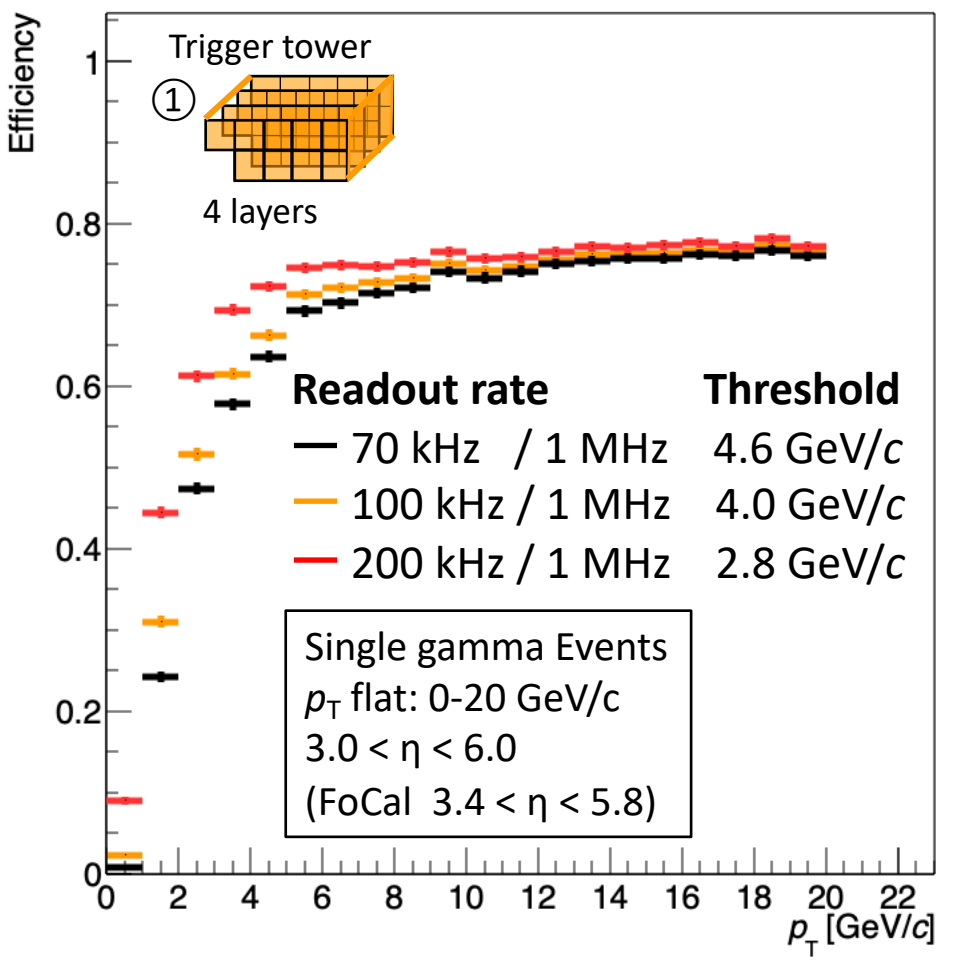
The reason the momentum efficiency decrease in high pT region is the fidutial area
(The most high momentum paticles injected in small θ region on pT flat sample).

Change the limet of the read-out rate

Deposit Energy Trigger



p_T Trigger



Event If we inclease the readout rate limit, the efficiency is not so inproved.

Next plan

FoCal

1. Estimate direct photon efficiency
2. Write the thesis