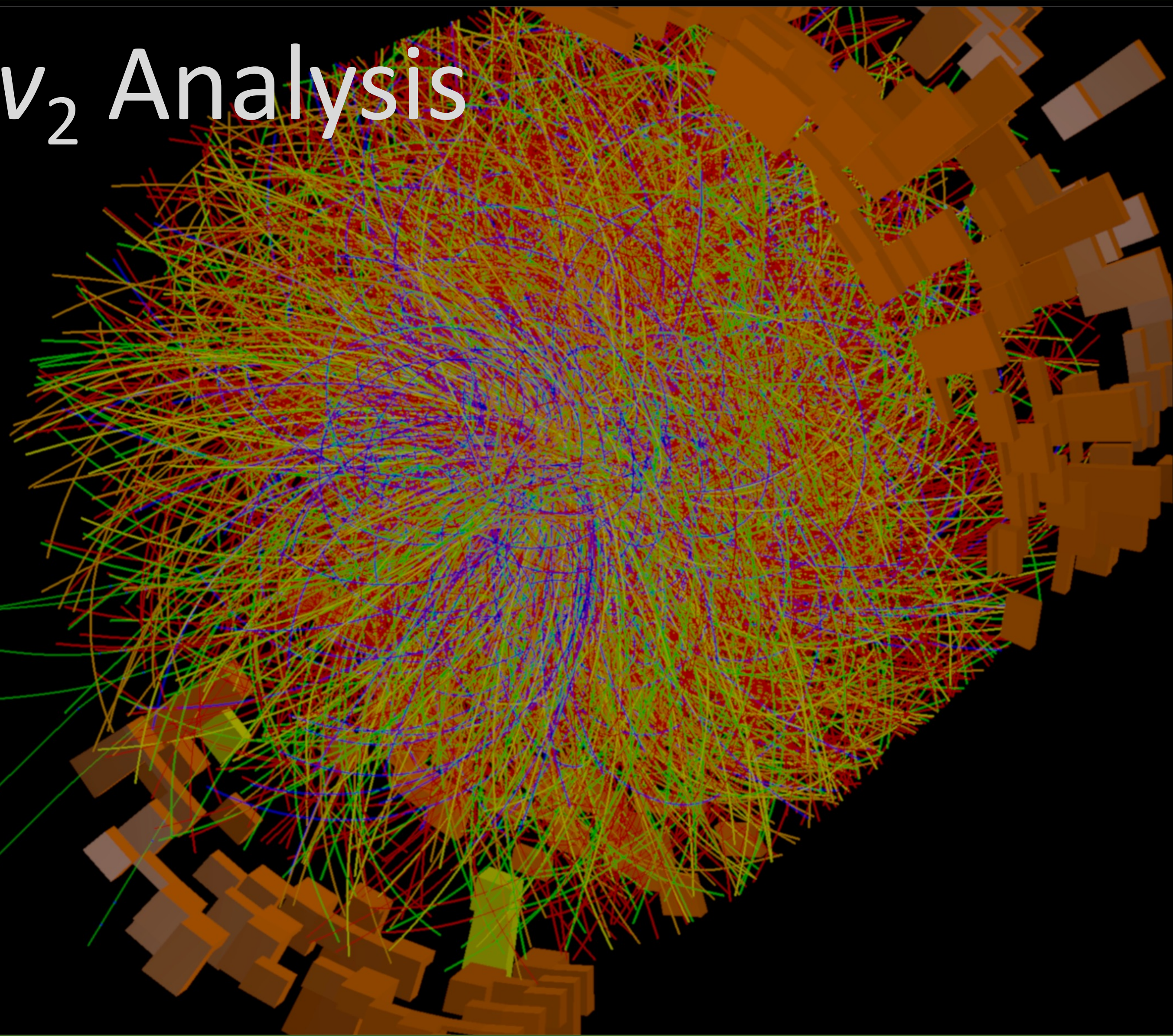
# Inclucive Jet $R_{AA}$ and $v_2$ Analysis

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# Recent Progress

- Ph.D 2nd Seminar

-> done

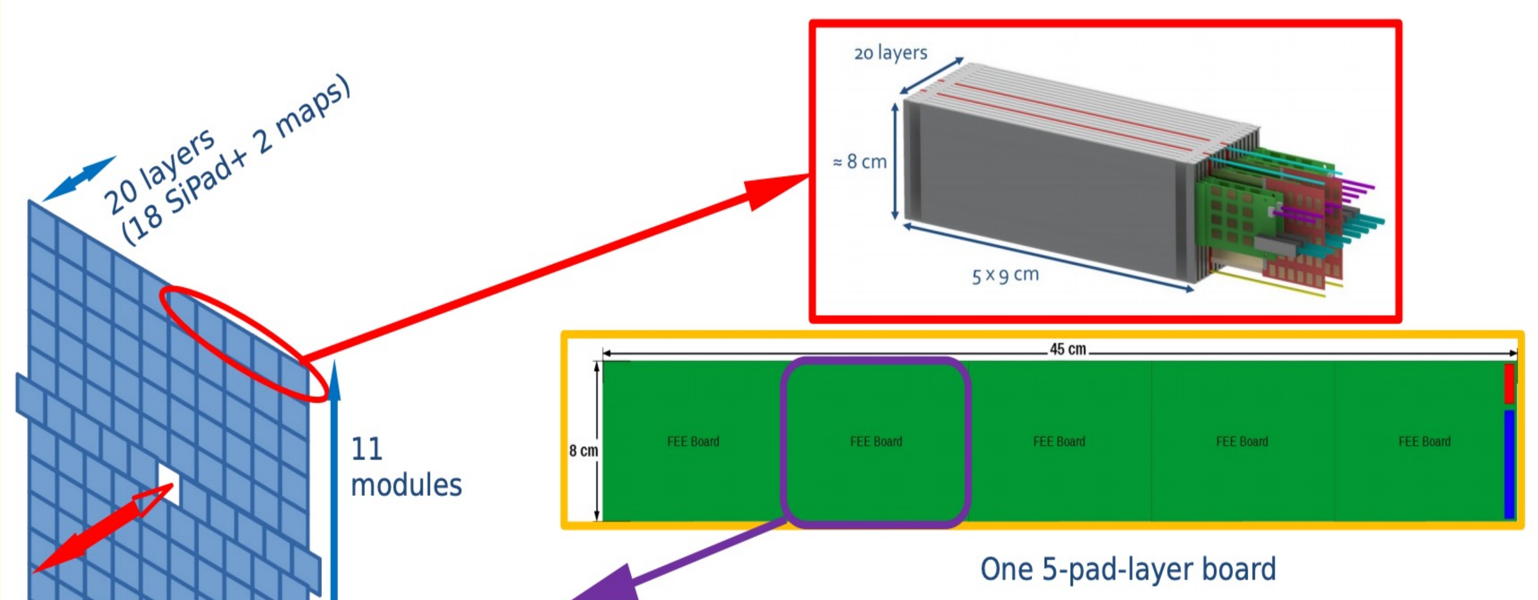
- FoCal trigger simulation

-> Next slides

- Modify EP calibration/Raw pT distribution

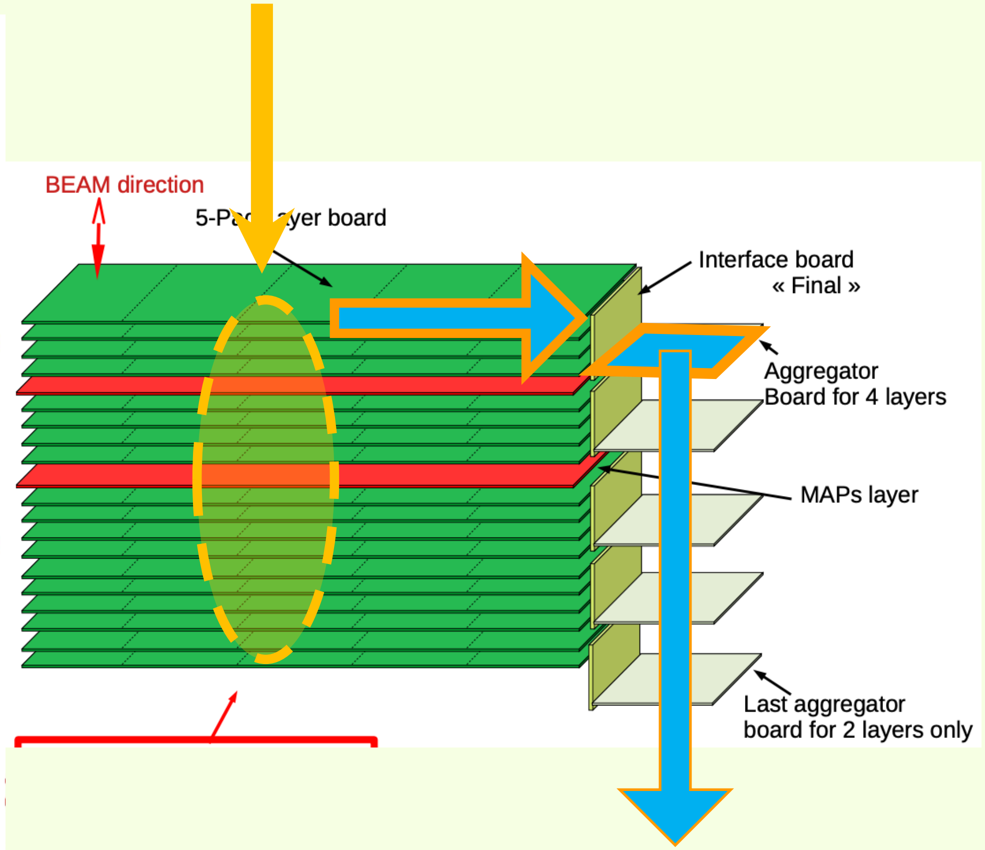
-> Merge request (local aliPhysics environment crushing…)

# FoCal simulation





- Each cell will be equipped with a SiPad of 72 pixels
- Each SiPad will be read-out with an HGCROC ASIC
- 18 of the 20 layers will use SiPad, that is :
  - 18*11*2=396 five-pad-layer boards
  - 1980 HGCROC V2 ASICs
  - 142,560 channels



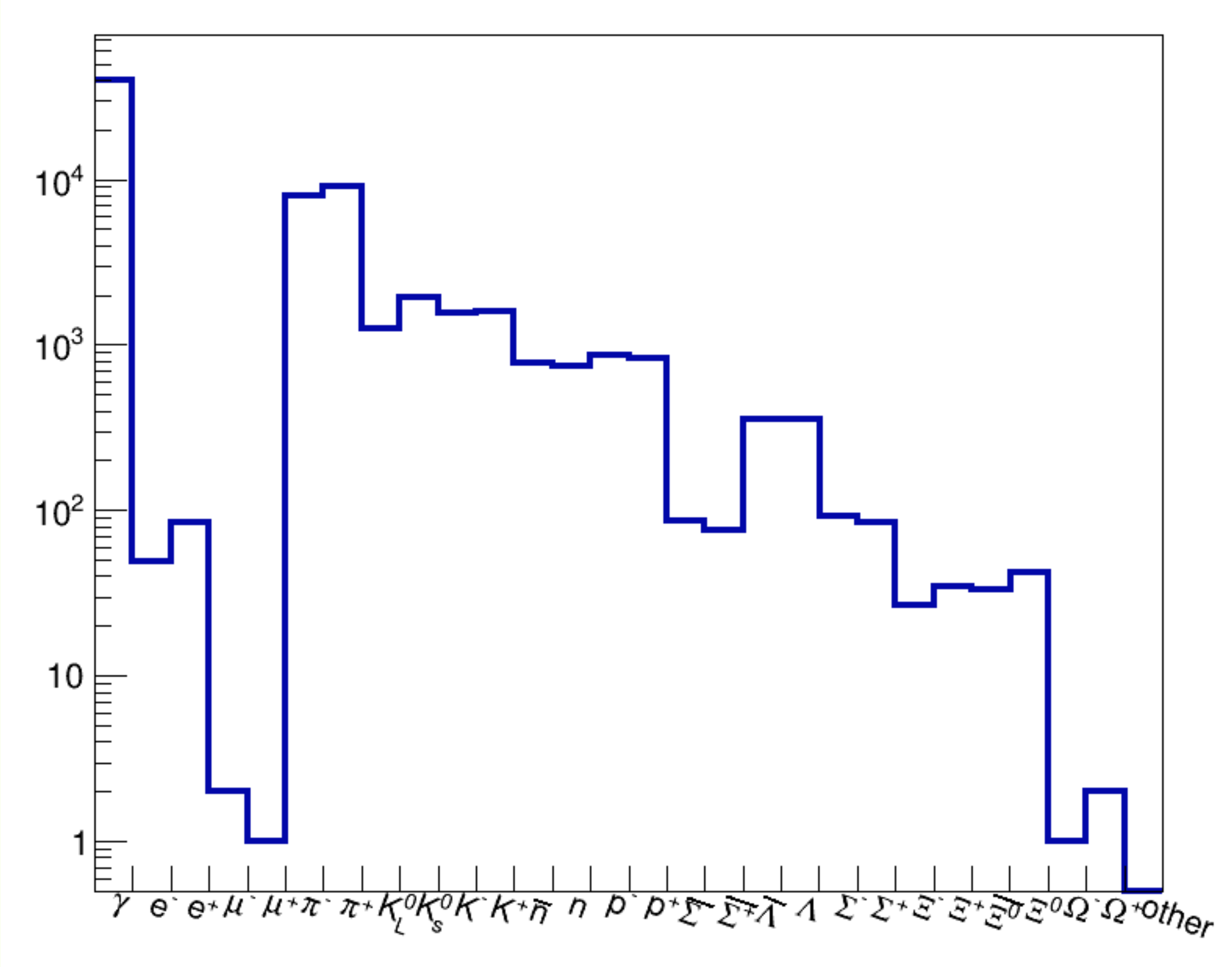

Make trigger by using 4 layer information (5 X 4 pads)

→ As Next step I will understand the pad ID layout and its location.

# Tree contents

| Row | iEvent | row | col | layer | seg | x | y | z | depEn | particleN | pdgCode | px | py | pz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 75 | 30 | 0 | 0 | -16.14249 | 26.237499 | 696.375 | 68654.726 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 1 | 0 | 75 | 30 | 0 | 0 | -16.15250 | 26.237499 | 696.375 | 79663.421 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 2 | 0 | 75 | 30 | 0 | 0 | -16.16250 | 26.242498 | 696.375 | 38548.171 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 3 | 0 | 75 | 30 | 0 | 0 | -16.17250 | 26.242498 | 696.375 | 50277.410 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 4 | 0 | 76 | 29 | 3 | 0 | -17.08250 | 27.167499 | 699.40496 | 141713.07 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 5 | 0 | 93 | 51 | 1 | 0 | 4.0325012 | 44.482498 | 697.38494 | 167321.64 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 6 | 0 | 63 | 39 | 3 | 0 | -7.367500 | 14.612497 | 699.40496 | 17078.906 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 7 | 0 | 63 | 39 | 3 | 0 | -7.382500 | 14.607497 | 699.40496 | 147404.79 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 8 | 0 | 63 | 39 | 3 | 0 | -7.367500 | 14.617497 | 699.40496 | 60068.613 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 9 | 0 | 88 | 11 | 3 | 0 | -35.38249 | 39.522499 | 699.40496 | 85305.320 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 10 | 0 | 88 | 11 | 3 | 0 | -35.37749 | 39.527500 | 699.40496 | 19152.939 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 11 | 0 | 30 | 25 | 1 | 0 | -21.85750 | -18.75249 | 697.38494 | 213130.20 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 12 | 0 | 30 | 25 | 1 | 0 | -21.85750 | -18.75749 | 697.38494 | 22632.757 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 13 | 0 | 30 | 25 | 1 | 0 | -21.85250 | -18.67749 | 697.38494 | 142588.64 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 14 | 0 | 30 | 25 | 1 | 0 | -21.89750 | -18.65749 | 697.38494 | 139224.04 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 15 | 0 | 86 | 27 | 0 | 0 | -19.28250 | 37.947498 | 696.375 | 91474.921 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 16 | 0 | 86 | 27 | 0 | 0 | -19.28750 | 37.947498 | 696.375 | 6882.8061 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 17 | 0 | 86 | 27 | 0 | 0 | -19.29249 | 37.962497 | 696.375 | 124760.23 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 18 | 0 | 86 | 27 | 0 | 0 | -19.29249 | 37.967498 | 696.375 | 31849.115 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 19 | 0 | 87 | 27 | 3 | 0 | -19.63249 | 38.107498 | 699.40496 | 157424.28 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 20 | 0 | 87 | 27 | 6 | 2 | -19.84250 | 38.1875 | 701.98498 | 149456.85 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 21 | 0 | 87 | 26 | 12 | 4 | -20.30750 | 38.282497 | 707.59497 | 114856.89 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 22 | 0 | 87 | 26 | 12 | 4 | -20.30750 | 38.277500 | 707.59497 | 80702.523 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 23 | 0 | 87 | 26 | 12 | 4 | -20.30249 | 38.282497 | 707.59497 | 91006.578 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |
| 24 | 0 | 87 | 26 | 3 | 0 | -20.25749 | 38.282497 | 699.40496 | 75277.960 | 85 | 22 | -0.077486 | 0.3450198 | 3.8775069 |

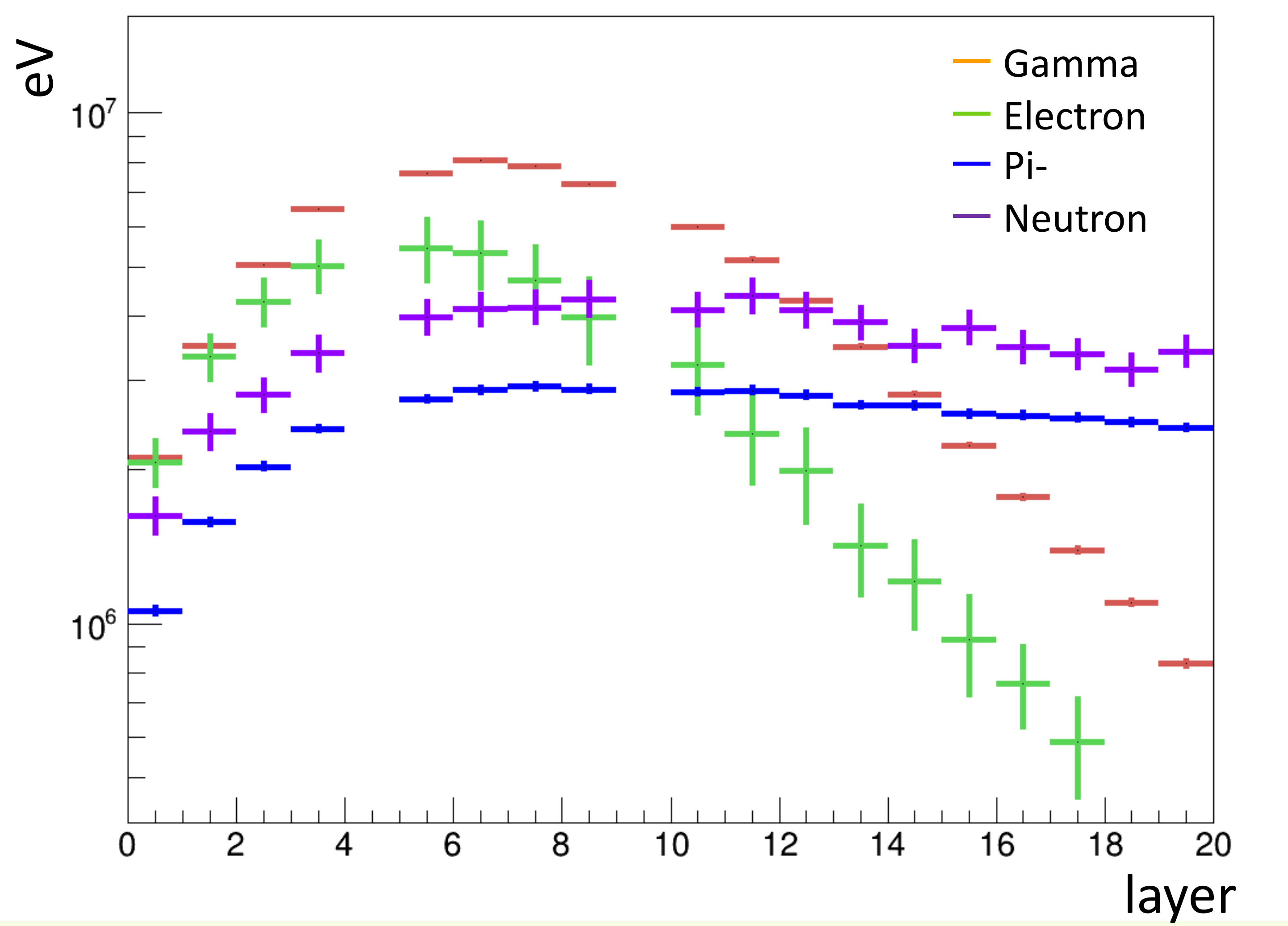
# Particle kinds




Pi0 is recorded as decayed gammas

# Deposit energy for each particle

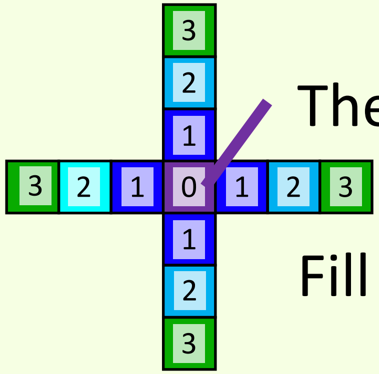
Fill all cell’s deposit energy for each layer




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.

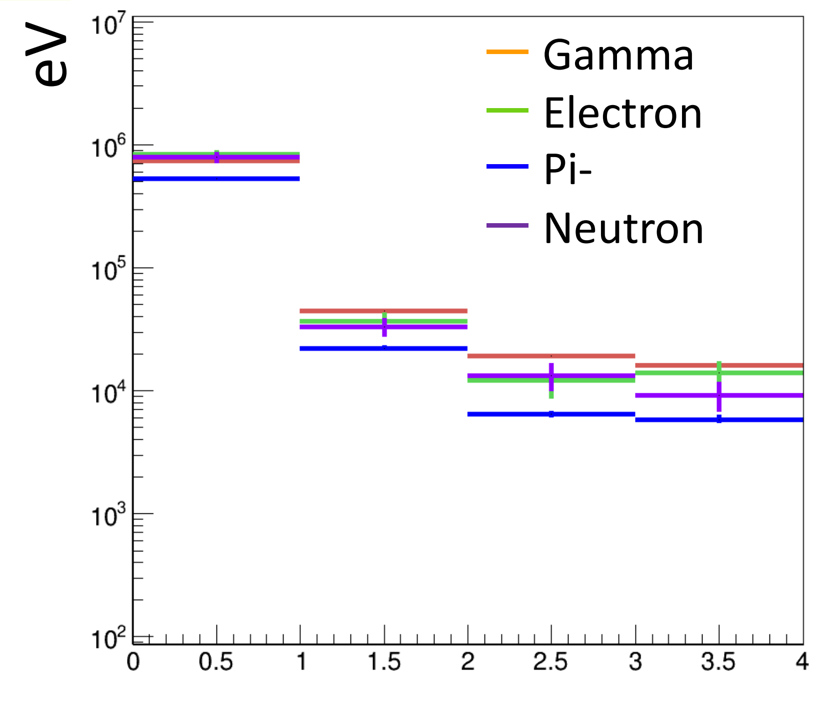
# Geometrical expansion confirmation



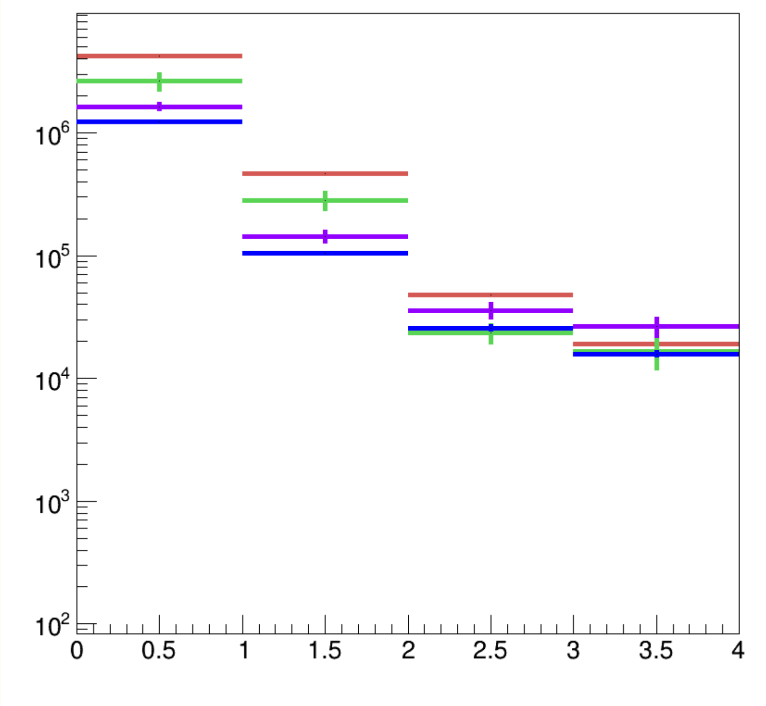

The cell having the highest deposit energy

Fill the average energy on the deposit energy of each numbering cell

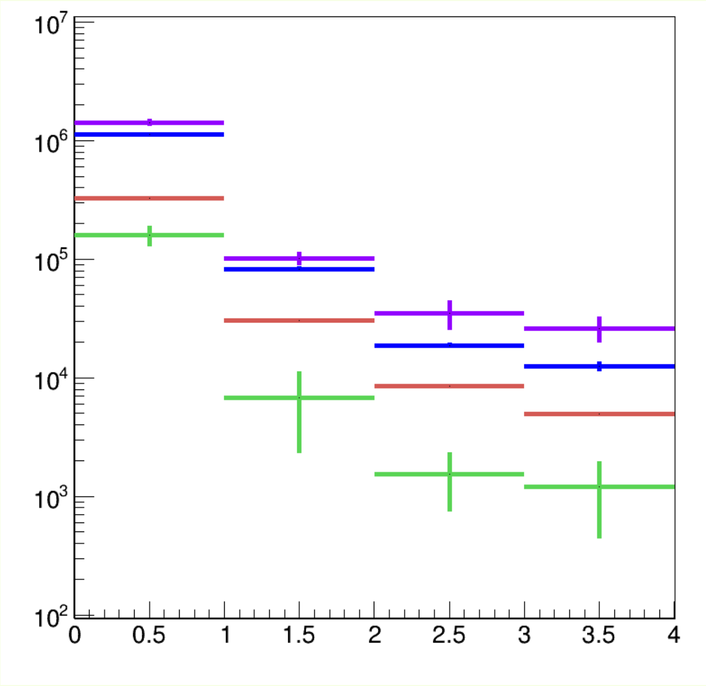
Layer = 0




Layer = 6

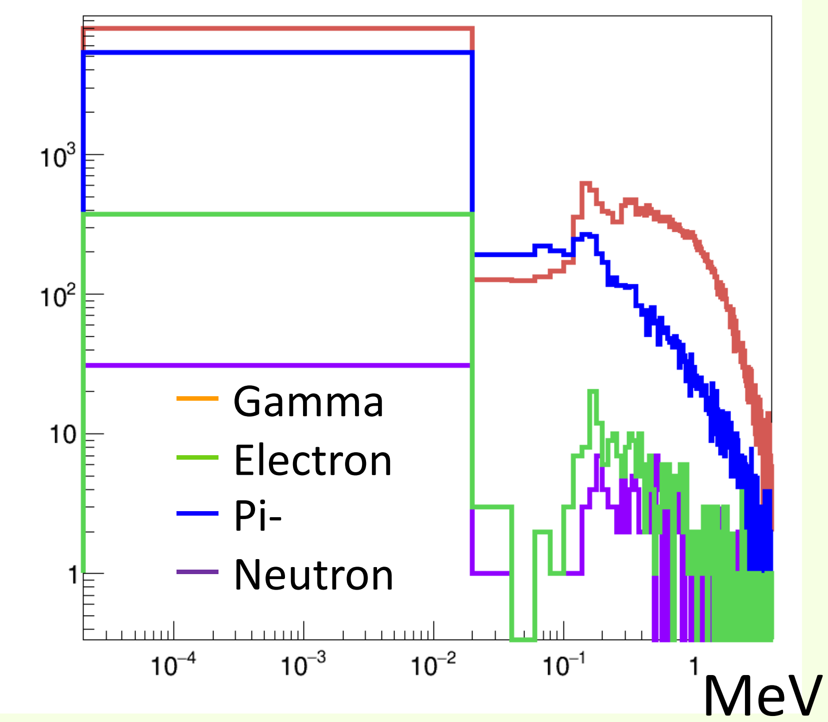


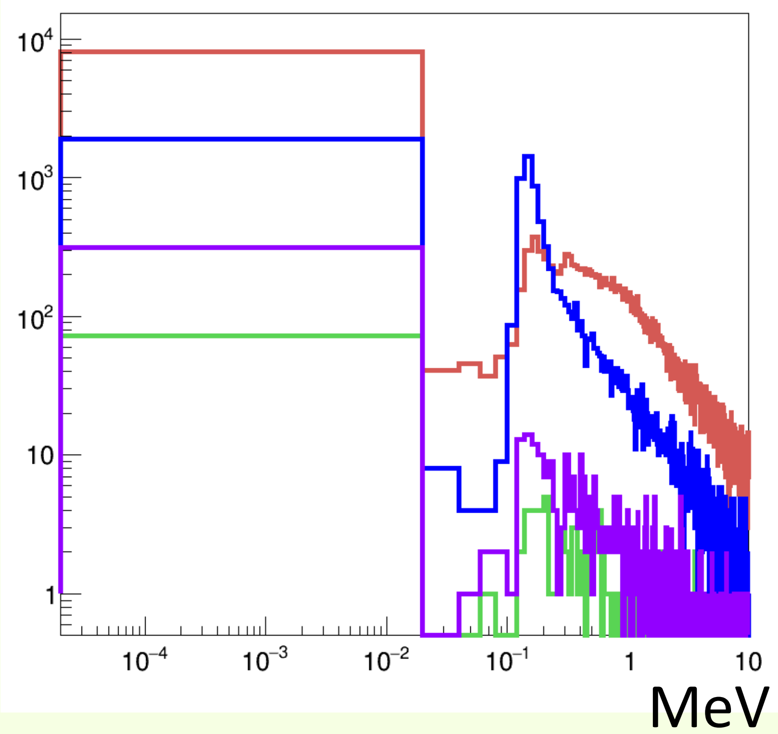

Layer = 19

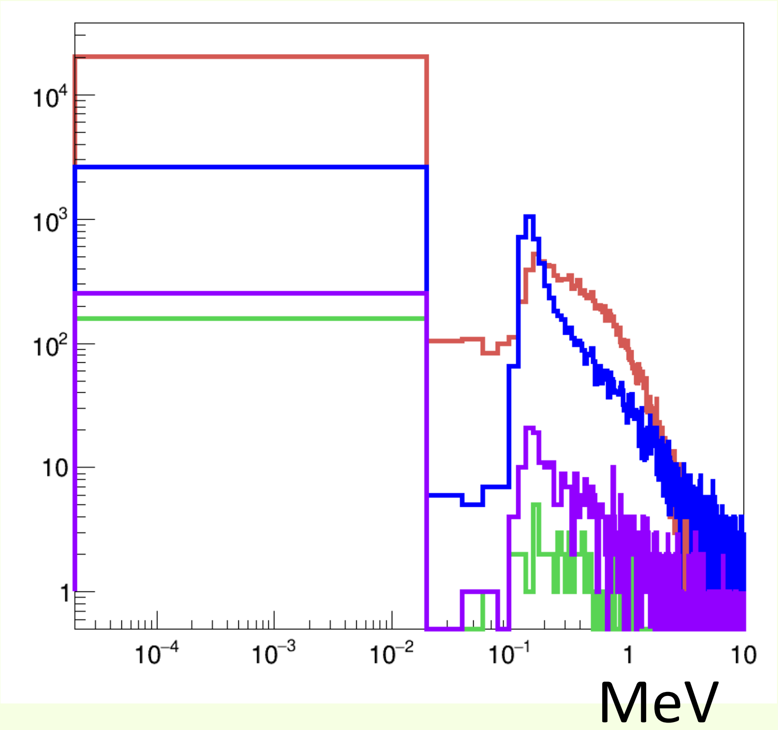


# Each Particle energy fluctuation

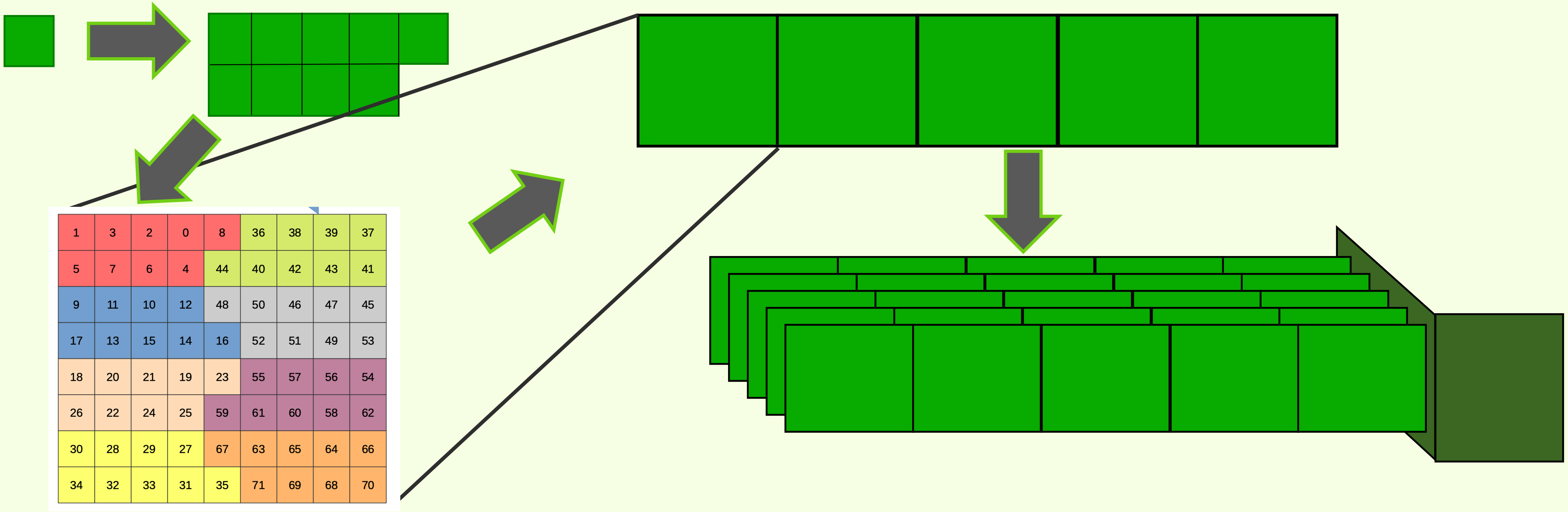
Fill only the highest deposit energy of one cell.



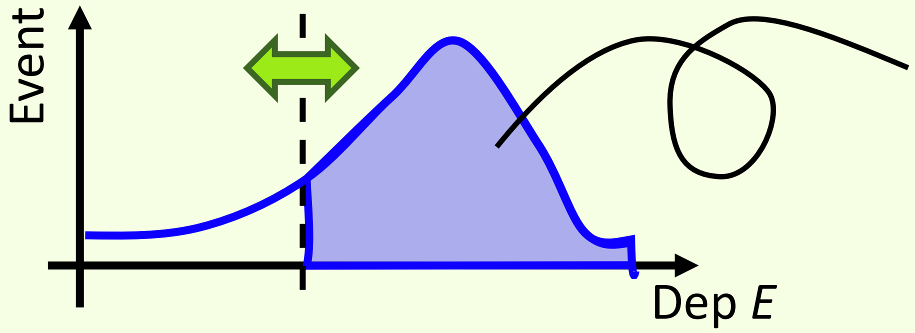




It seems difficult to distingush the particles by deposit energy because these peaks are mostly same.



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 2 | 0 | 8 | 36 | 38 | 39 | 37 |
| 5 | 7 | 6 | 4 | 44 | 40 | 42 | 43 | 41 |
| 9 | 11 | 10 | 12 | 48 | 50 | 46 | 47 | 45 |
| 17 | 13 | 15 | 14 | 16 | 52 | 51 | 49 | 53 |
| 18 | 20 | 21 | 19 | 23 | 55 | 57 | 56 | 54 |
| 26 | 22 | 24 | 25 | 59 | 61 | 60 | 58 | 62 |
| 30 | 28 | 29 | 27 | 67 | 63 | 65 | 64 | 66 |
| 34 | 32 | 33 | 31 | 35 | 71 | 69 | 68 | 70 |

Determine the appropriate threshold for each trigger logic, respectively.
→ Estimate the rate of the pi0 /direct photons .

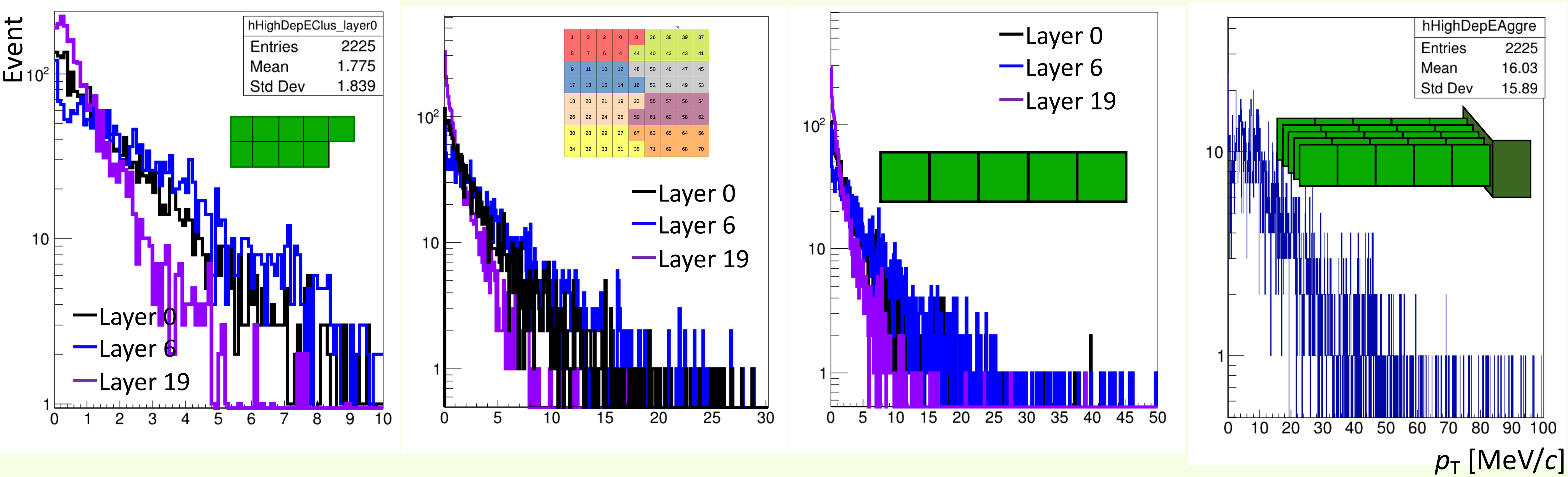



direct/pi0 photon rate

$$\frac{\pi_0}{\gamma} \ll 1$$

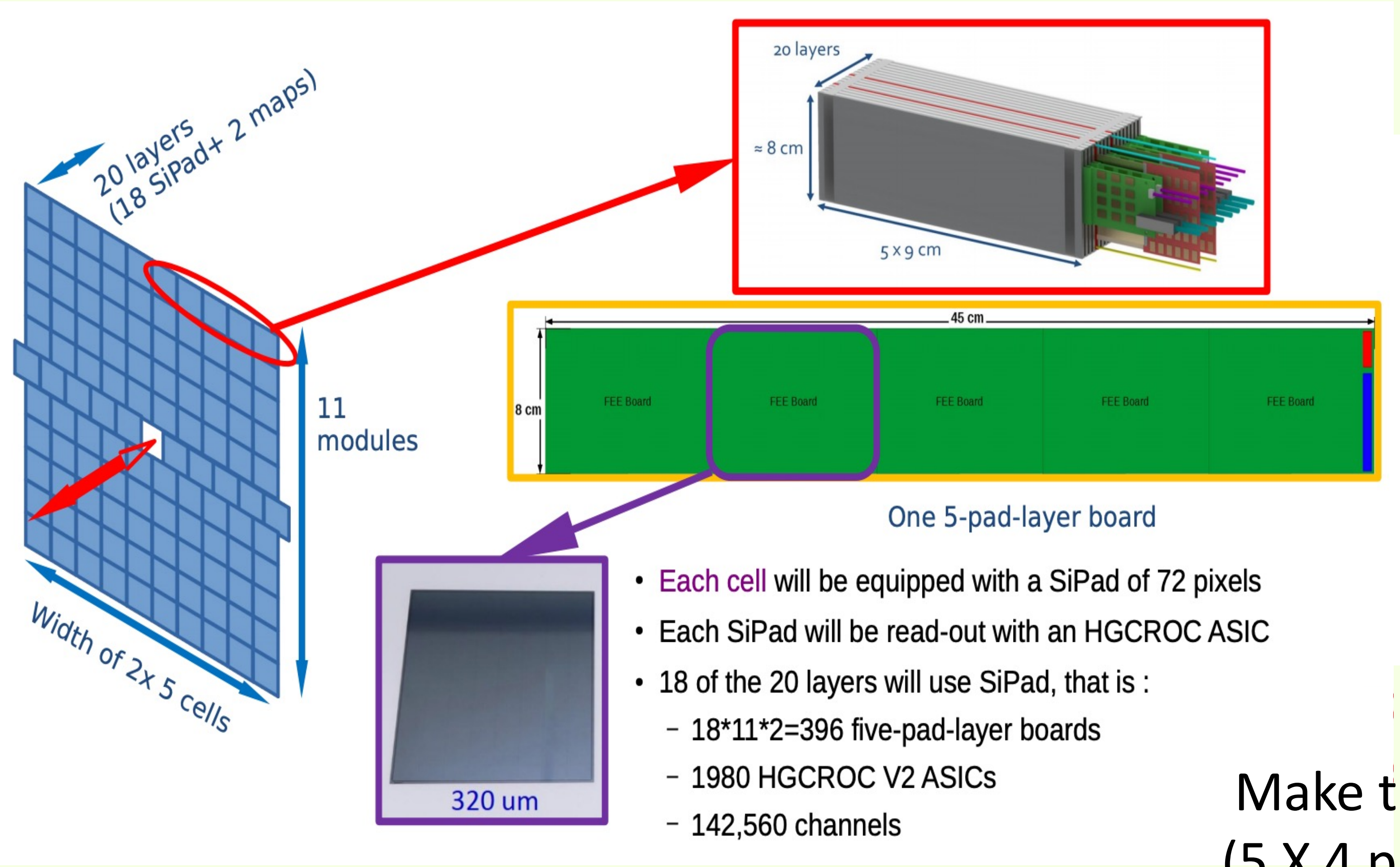
# High deposit energy distribution

High deposit energy per event



# *Backup Slides*

# Next My work

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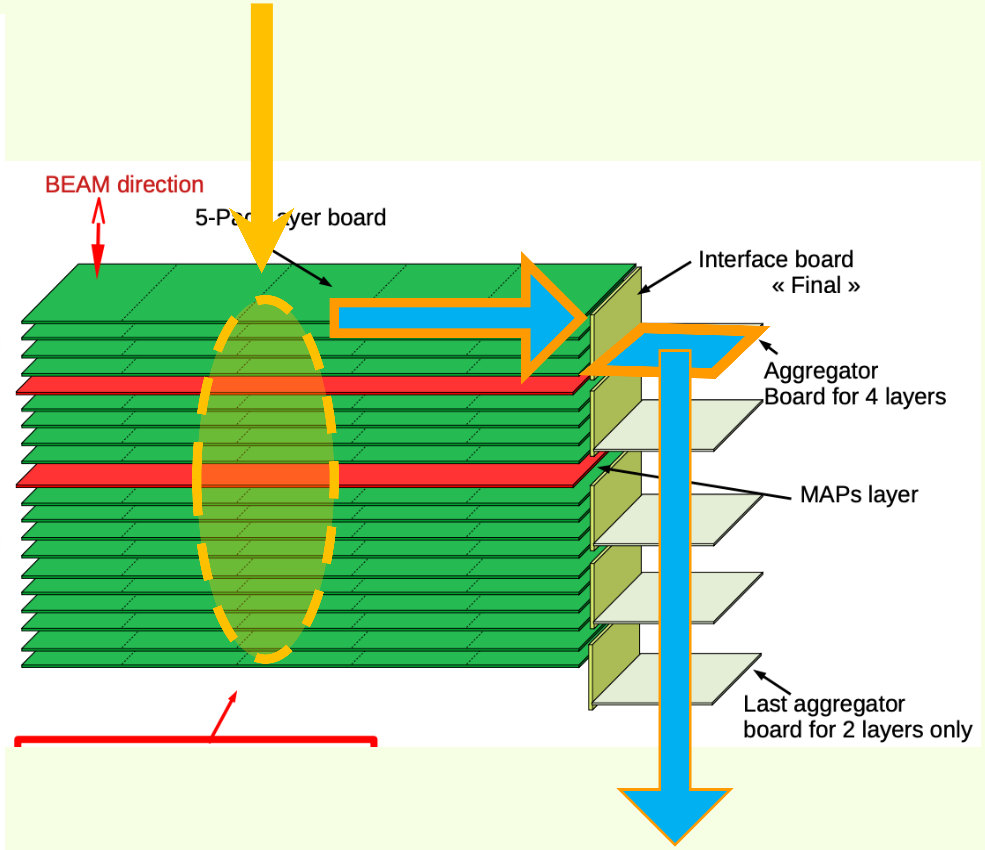
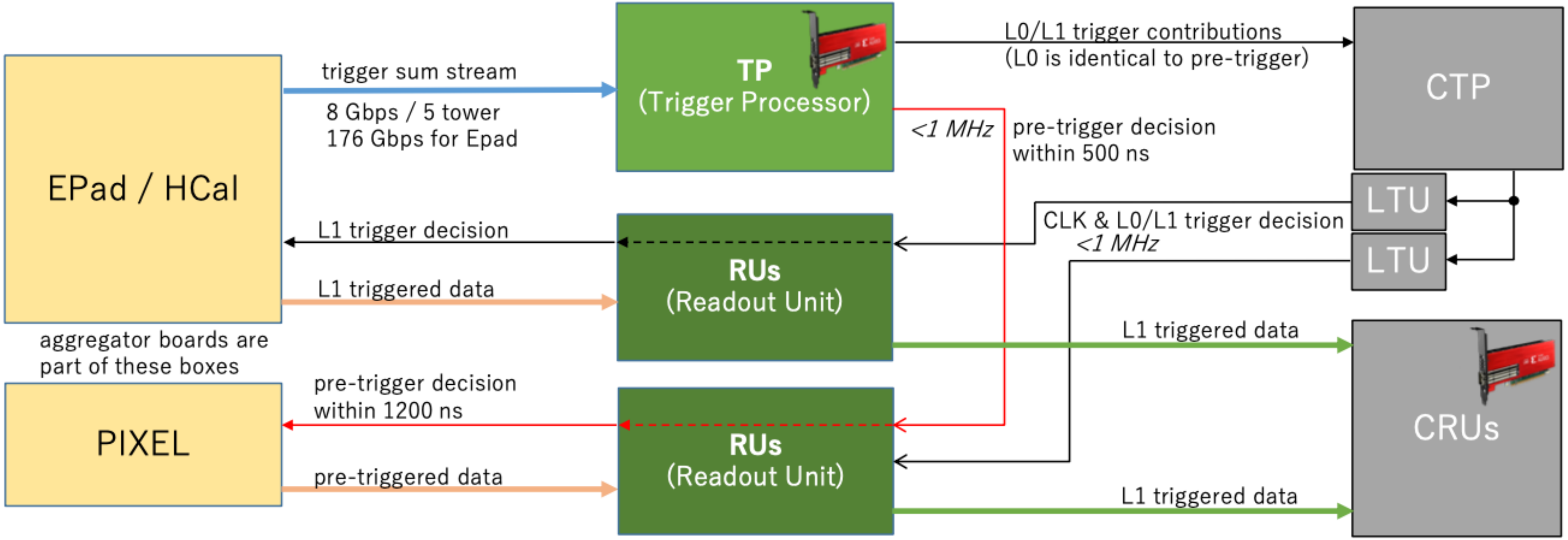



Make trigger by using 4 layer information (5 X 4 pads)
→ As Next step I will understand the pad ID layout and its location.




- **RUs** for EPad/HCal ··· forward L1 trigger decisions to detector, receive data, and forward it to CRUs
  - so simple thus it acts as just media converter
- **RUs** for PIXEL ··· forward pre-trigger to detector, buffer pre-triggered data, ship it to CRU if it is confirmed by L1 trigger of CTP
  - quite some complication similar to ITS (pre-trigger merging, tagging, etc)
- **RUs** functions and present aggregator functions can be merged (location is question)
- **TP** ··· large scale FPGA together with trigger stream aggregation custom hardware
  - collect 2x1.28 Gbps streams from each or selected HGCROCs)

Ken's slide Feb.8, 2022

# Run4 with ALICE 2.1



■ numbers based on page 10 of "ALICE Upgrade LoI" (2014)

| collision system | Luminosity avg. – peak ($cm^{-2}$ $s^{-1}$) | hadronic rate avg. – peak (kHz) | HGCROC min. bias data rate at detector (non ZS) (Mbps) | E-Pad total min. bias data rate without selection (non ZS) (Gbps) |
|---|---|---|---|---|
| p-p | $6.0 \times 10^{30}$ | 360 | 830 | 1752 |
| p-Pb | $1.0 \times 10^{29}$ | 200 | 460 | 971 |
| Pb-Pb | $2.8 \times 10^{27} – 7.2 \times 10^{27}$ | 28 – 72 | 65 – 166 | 137 – 350 |

- Each HGCROC has 2 x 1280 Mbps E-Links readout → possible to readout full min. bias events even for p-p if one neglect cost
- However, we can't of course write these data onto tape
- Strong reduction before (hardware) and at online system (O2) is essential

**memo for calculations:**

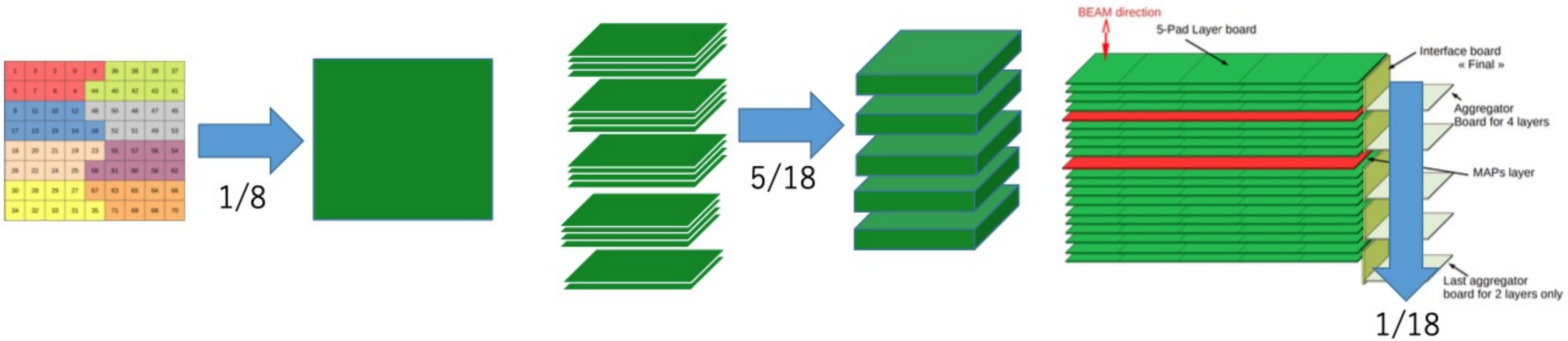
- 1 barn = $10^{-24}$ $cm^2$=100 $fm^2$
- assumed 10 barn for Pb-Pb c.s., 2 barn for p-Pb, and 60 mbarn for p-p
- single HGCROC event size: 72 ch x 32 bit = 2304 bit
- E-Pad has total 90 x 11 x 2 = 1980 HGCROCs

# 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



# My work plan

Last meeting Ken's suggestion

1. sort interesting physics phenomena and implement them in event generator if missing, then run it with min. bias events
    - min.bias → obtain rates, occupancies
    - characterize events (shower pattern, energy, etc) → gives rough idea how to trigger, and necessary trigger rejection

Development FoCal pi0 trigger

By using $\pi_0$ simulation data, making the algorithm of pi0 trigger.
Determine appropriate threshold for the limit late of FoCla
and Estimate the purity and efficiency of the trigger

# Trigger Simulation Study

Defining threshould values (ex. Energy[finally charge(ADC, TOT)], the number of cells, layers, etc
-> Check rates of triggers, purity, and efficiency by each threshold for each physics
-> Define an acculate threshold to limitaion of hardware

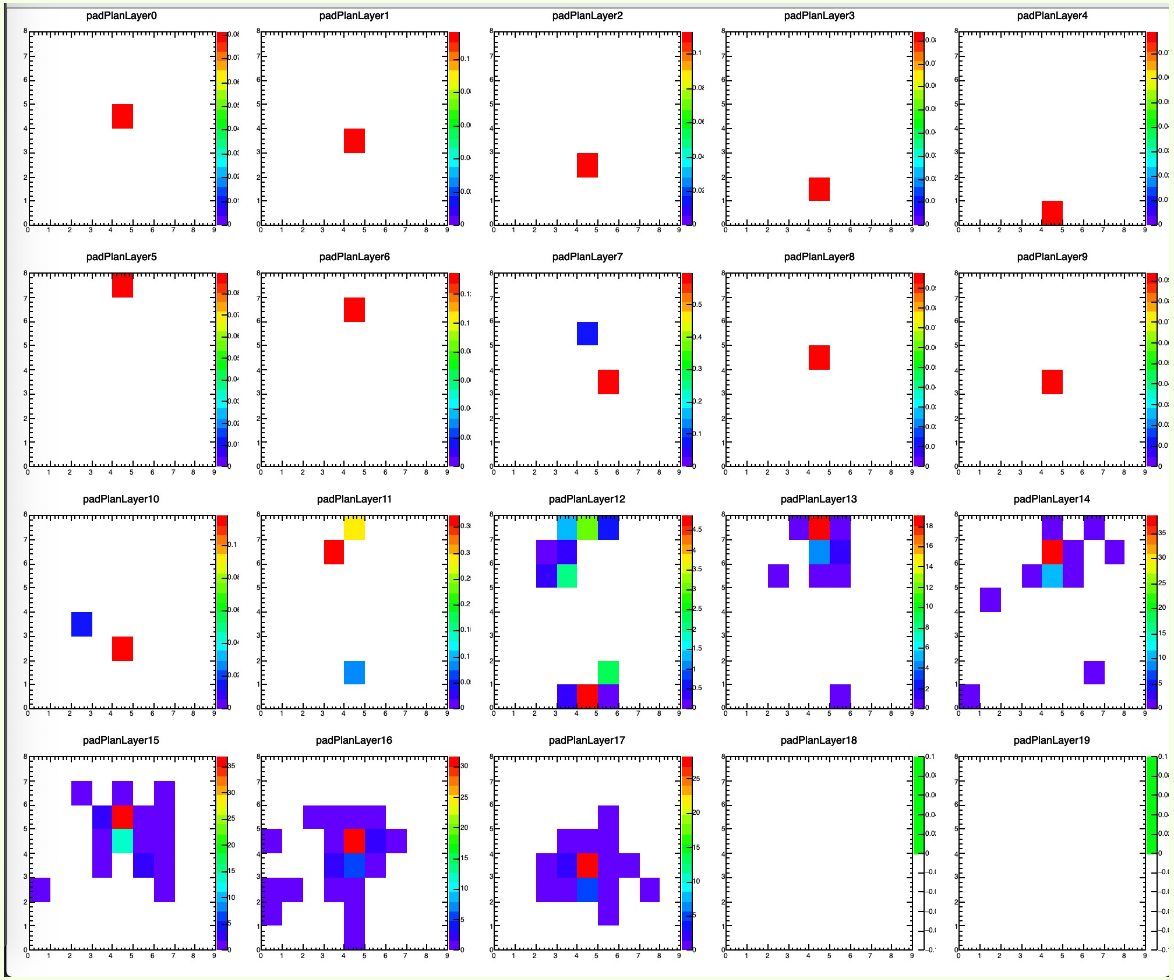
1. Create simulation data of Physics and BKG
2. Get each deposit energy on FoCal layers
3. Create algorithm for each physics

(ex. Over 5 pad has 15 MeV, three layers reacted)

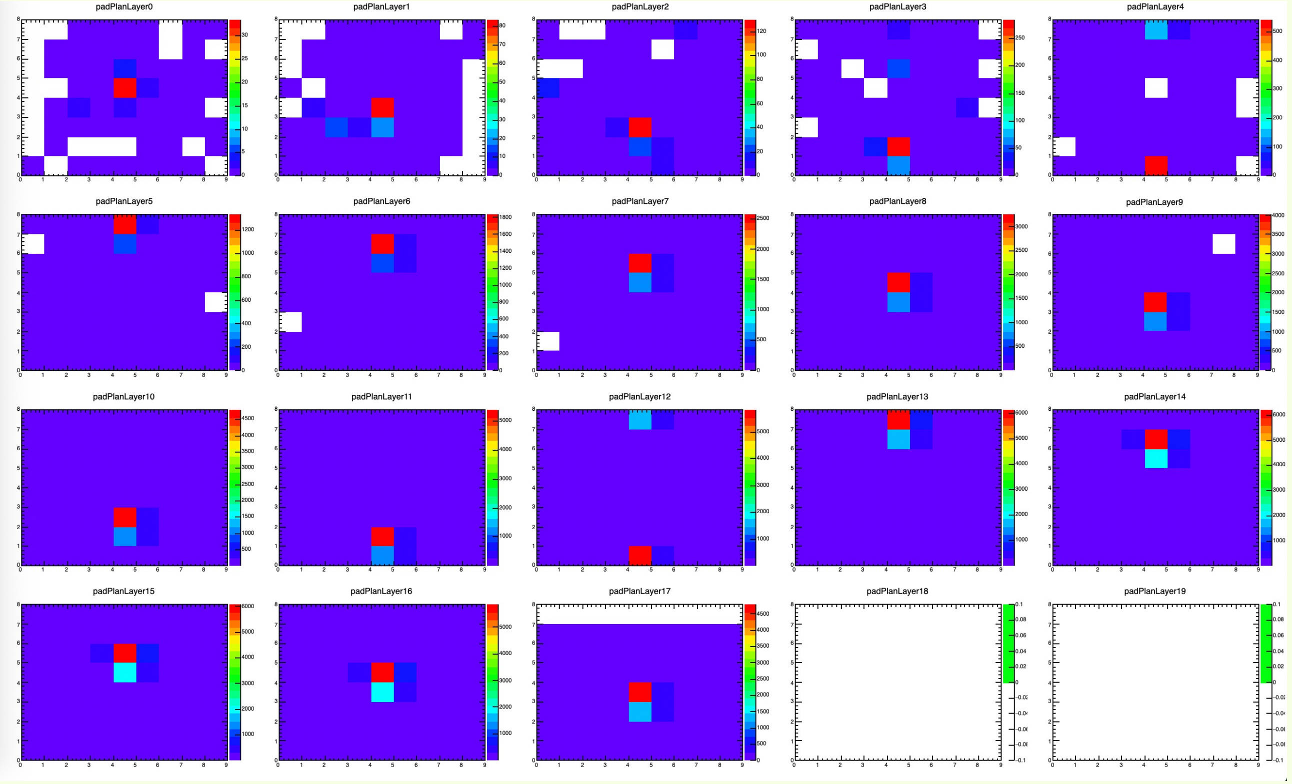
4. Esitmate rate, purity, efficiency

I studied Geant4 simulation of FoCal-E.
This simulation was ran by using single physics particle ($\gamma$, $\pi_0$, η)

Pi- 1000 GeV, 1 event

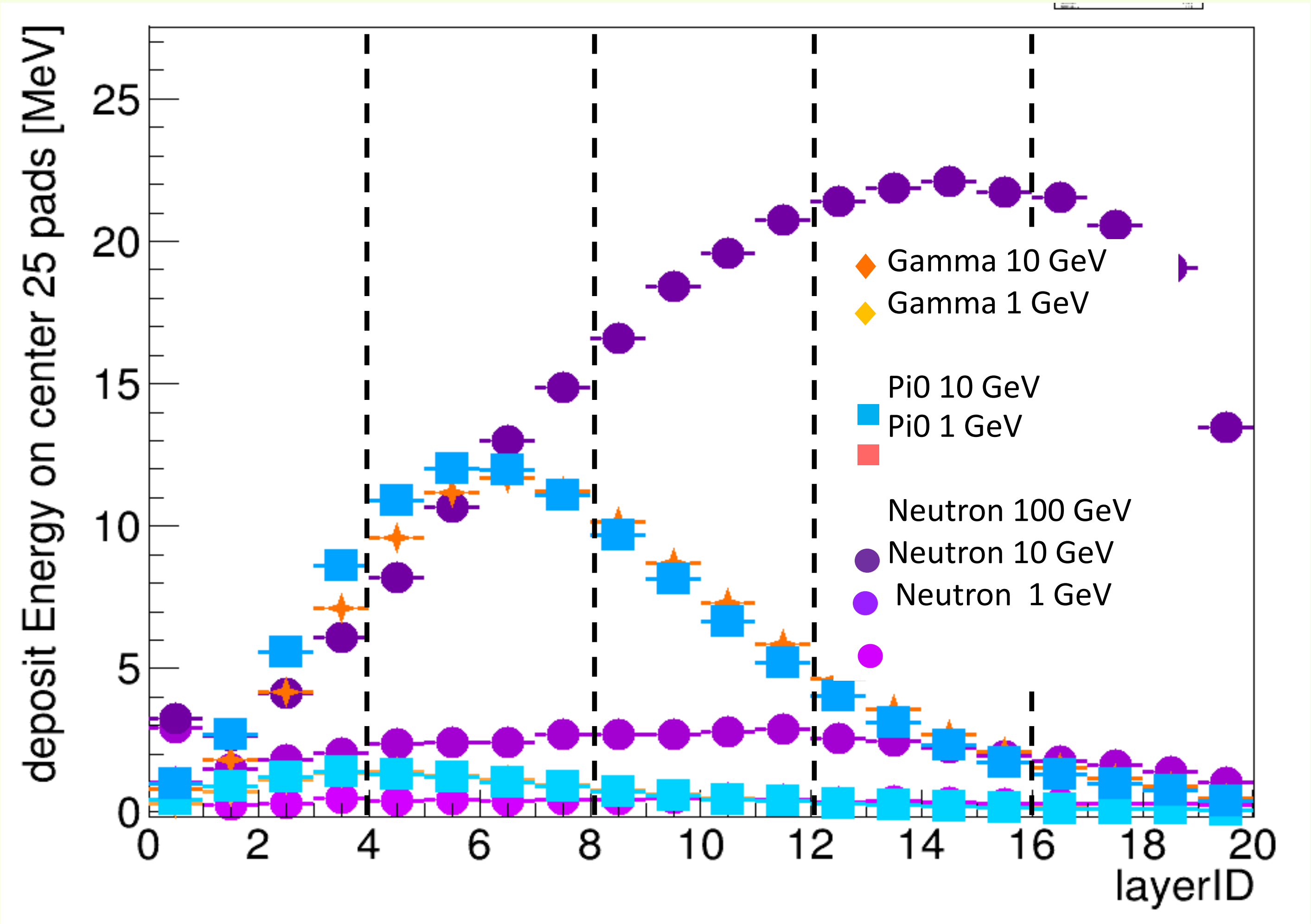


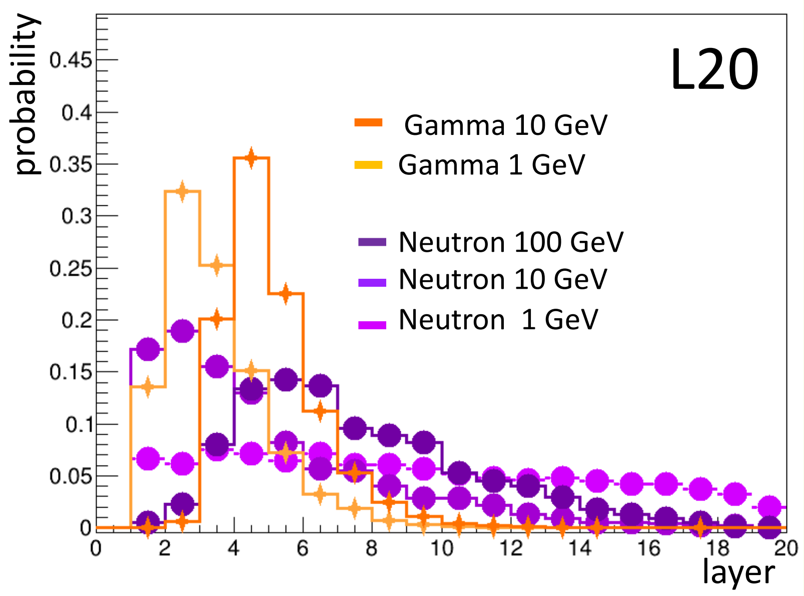

Pi- 1000 GeV, 100 event

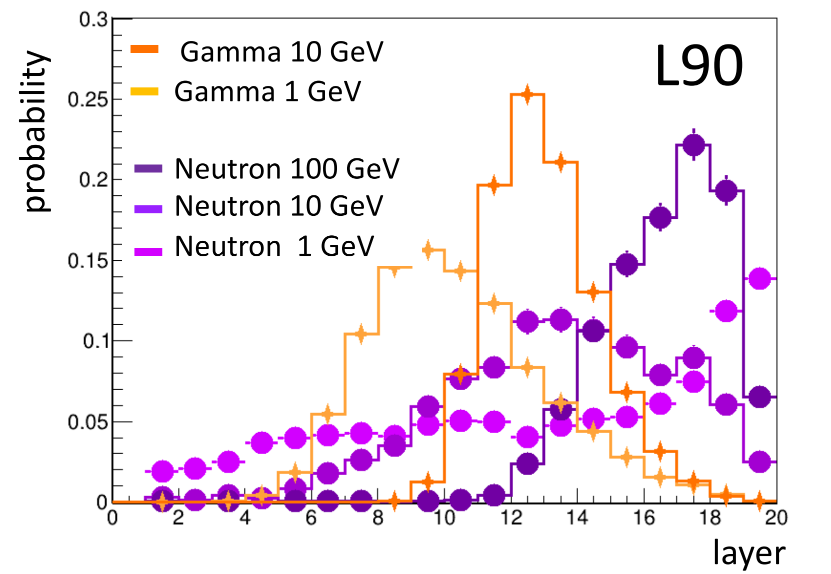



If I made mistake the location of pads, I will face segmentation vioration

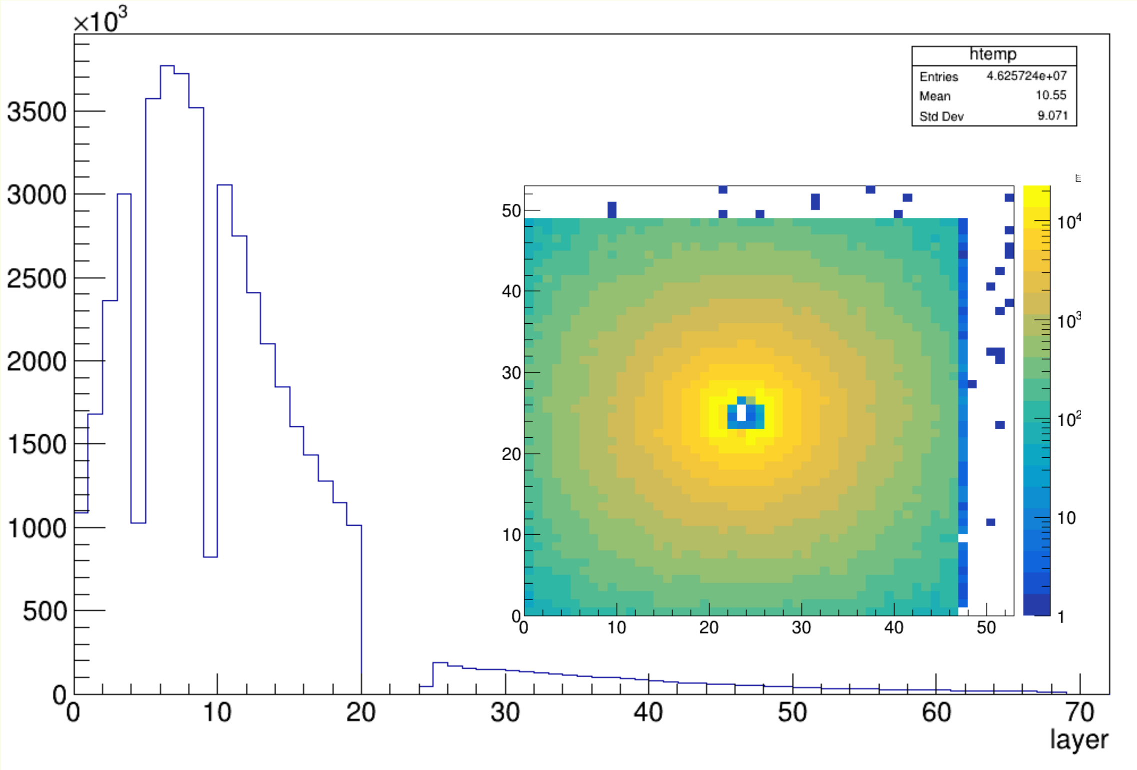
# L20, L90 estimation for each injection particle

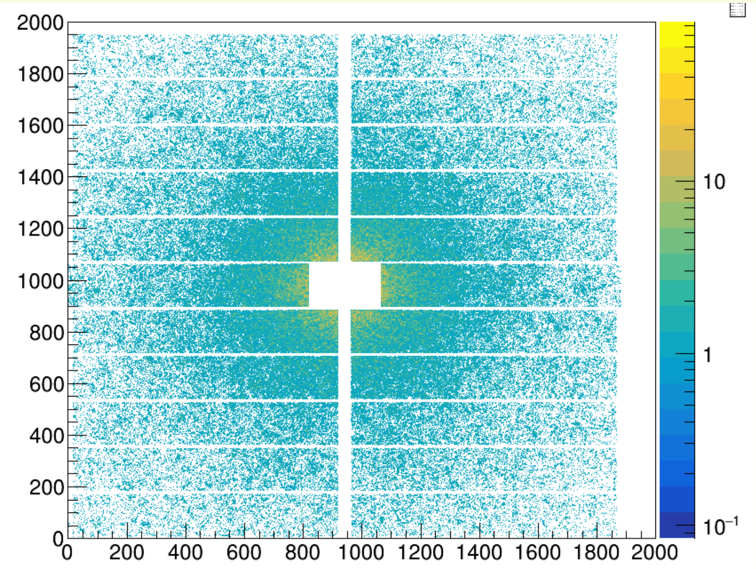


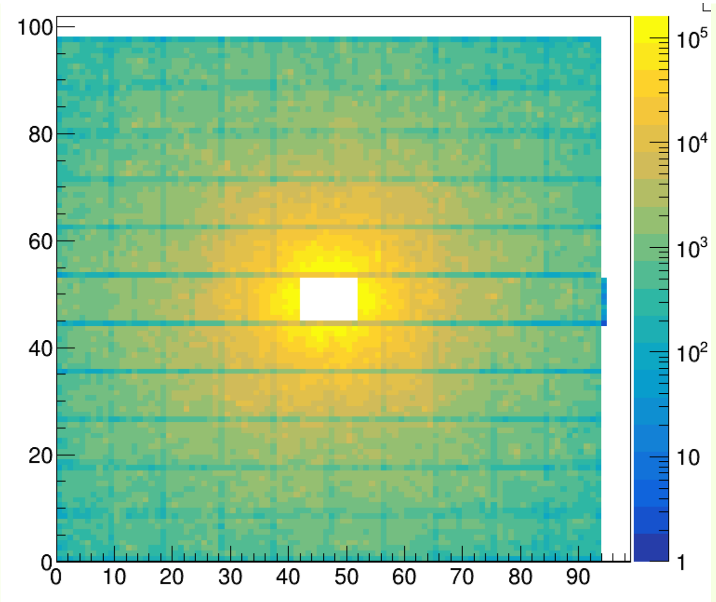



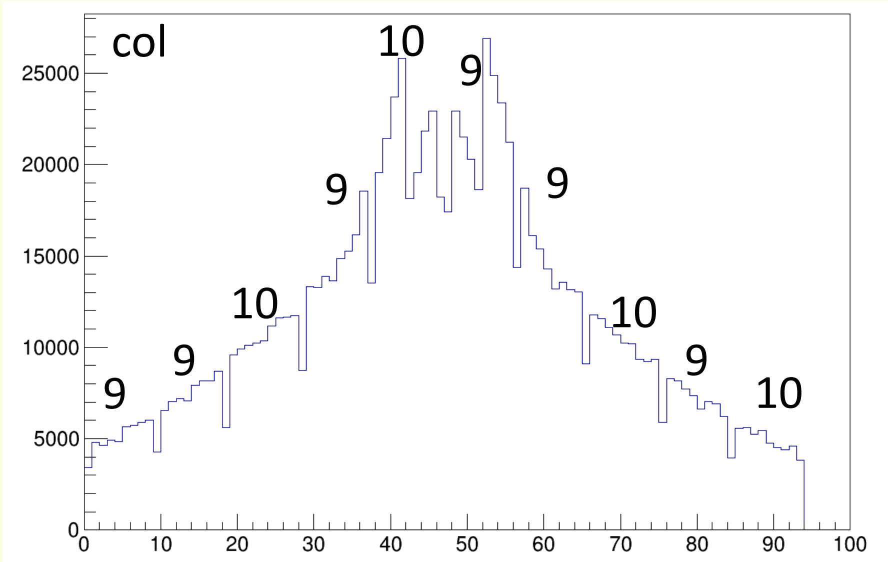



# Hit array



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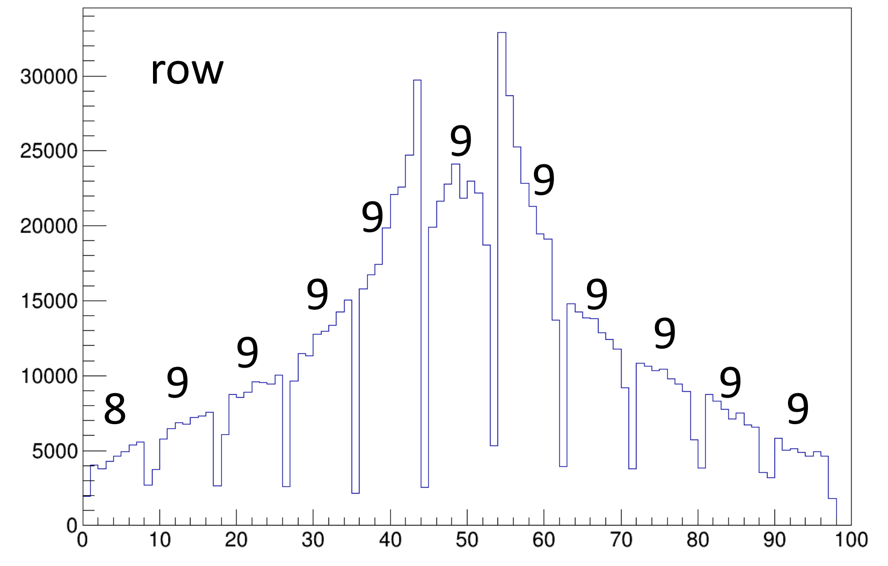
25000
20000
15000
10000
5000
0
0 10 20 30 40 50 60 70 80 90 100
9 9 10 9 10 9 9 10 9 10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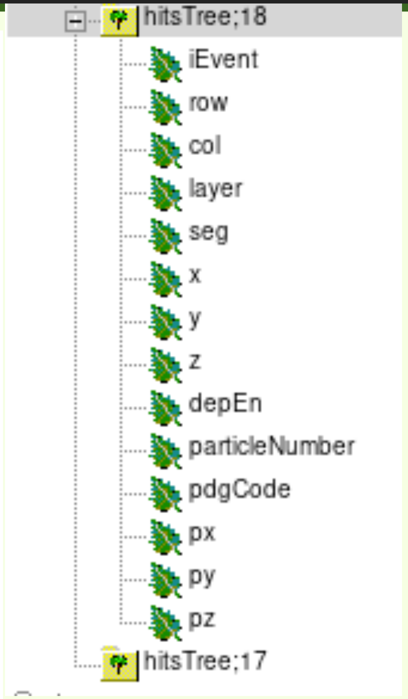
25000
20000
15000
10000
5000
0
0 10 20 30 40 50 60 70 80 90 100
8 9 9 9 9 9 9 9 9 9 9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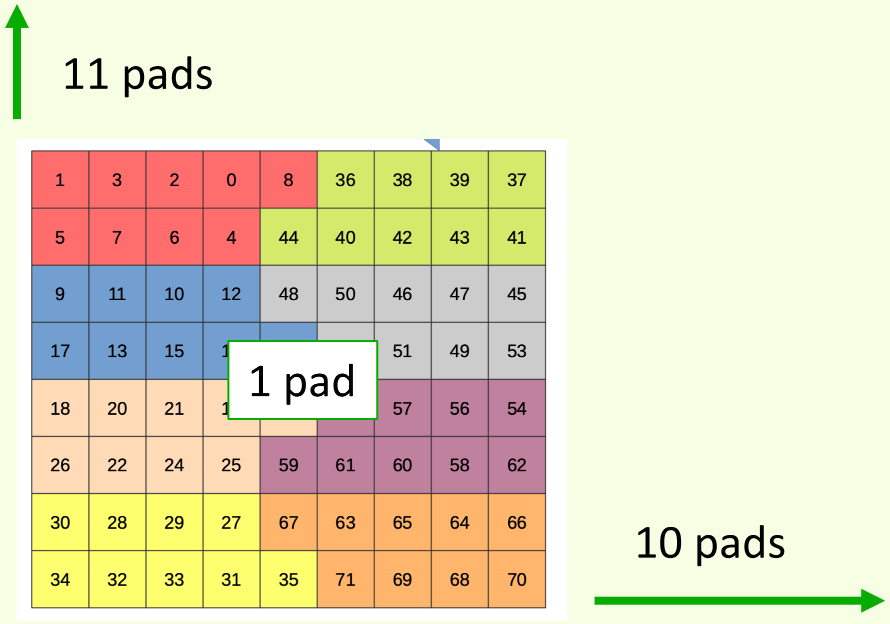
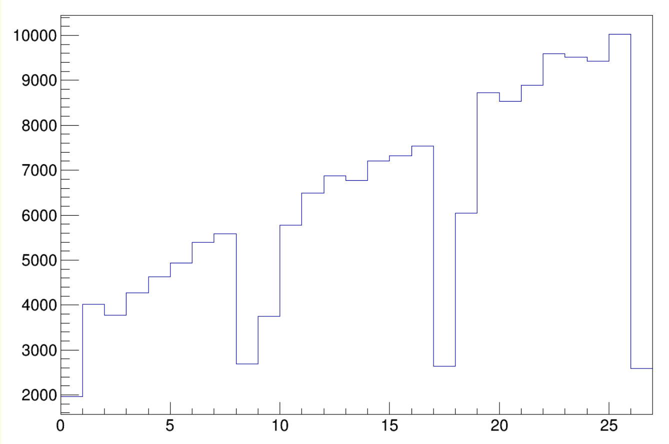
col
layer
seg
x
y
z
depEn
particleNumber
pdgCode
px
py
pz
hitsTree;17


11 pads
1 3 2 0 8 36 38 39 37
5 7 6 4 44 40 42 43 41
9 11 10 12 48 50 46 47 45
17 13 15 51 49 53
18 20 21 57 56 54
26 22 24 25 59 61 60 58 62
30 28 29 27 67 63 65 64 66
34 32 33 31 35 71 69 68 70
1 pad
10 pads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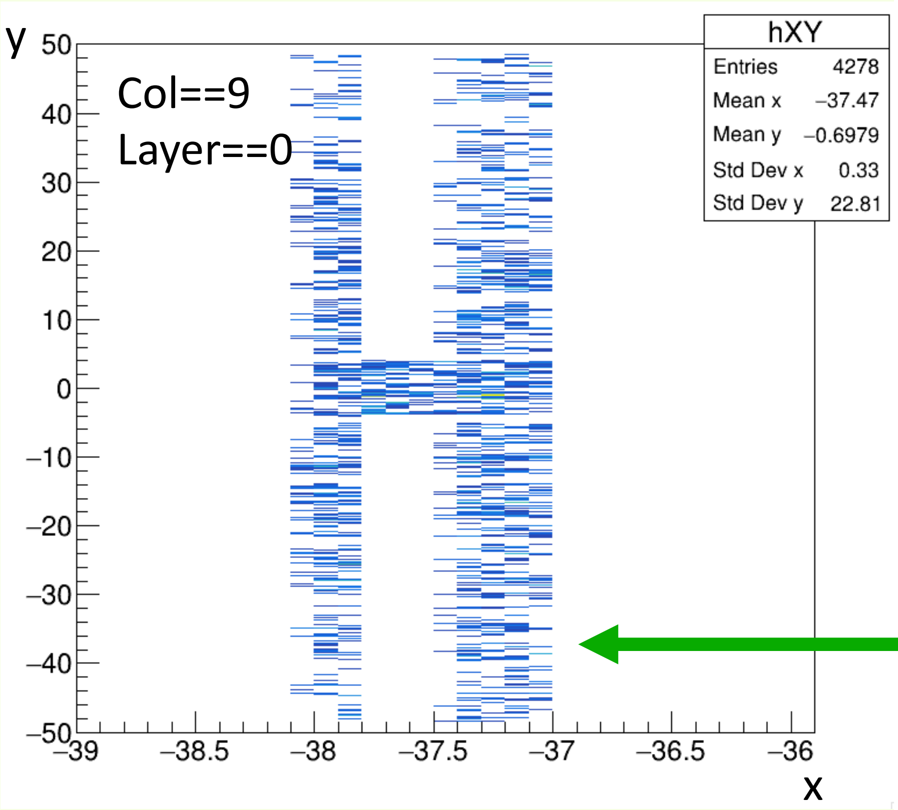
8000
7000
6000
5000
4000
3000
2000
0 5 10 15 20 25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Entries 4278
Mean x −37.47
Mean y −0.6979
Std Dev x 0.33
Std Dev y 22.81
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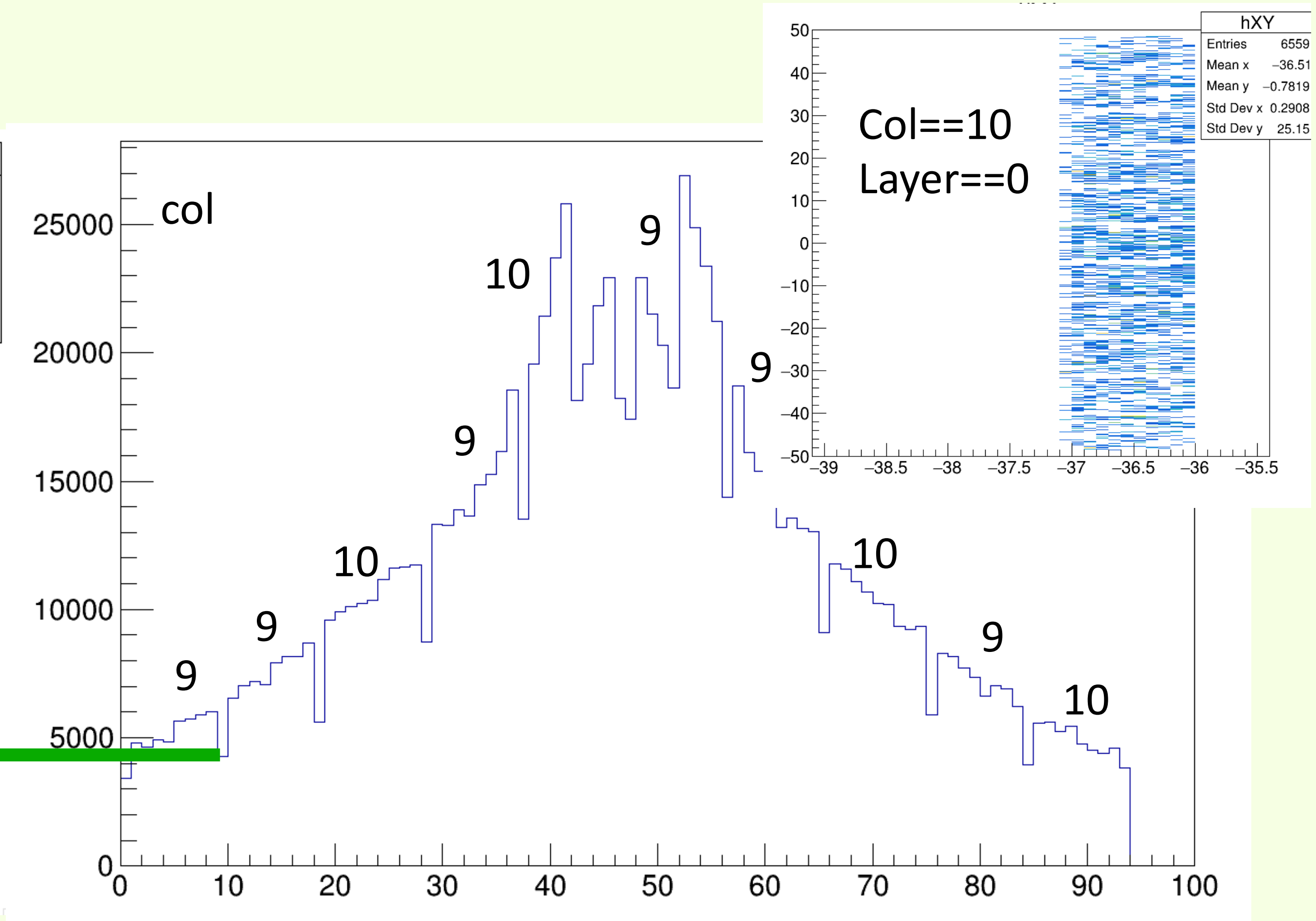
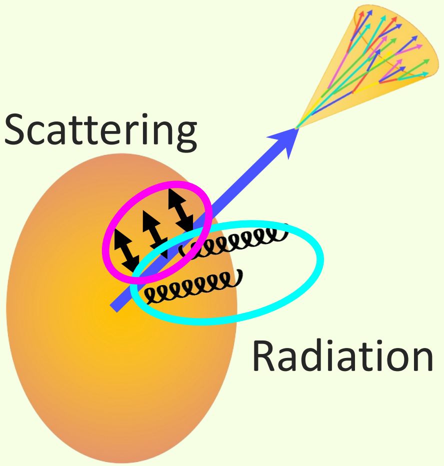
Layer==0
y
x


col
9
9
10
9
10
9
9
10
9
10
hXY
Entries 6559
Mean x −36.51
Mean y −0.7819
Std Dev x 0.2908
Std Dev y 25.15
Col==10
Layer==0

# *Backup Slides*

## Clarify the jet suppression mechanism

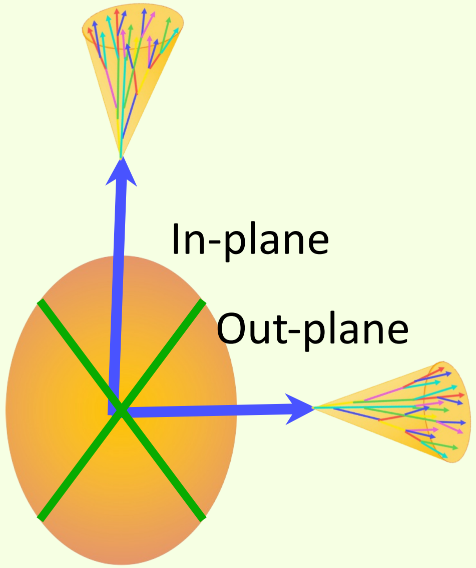


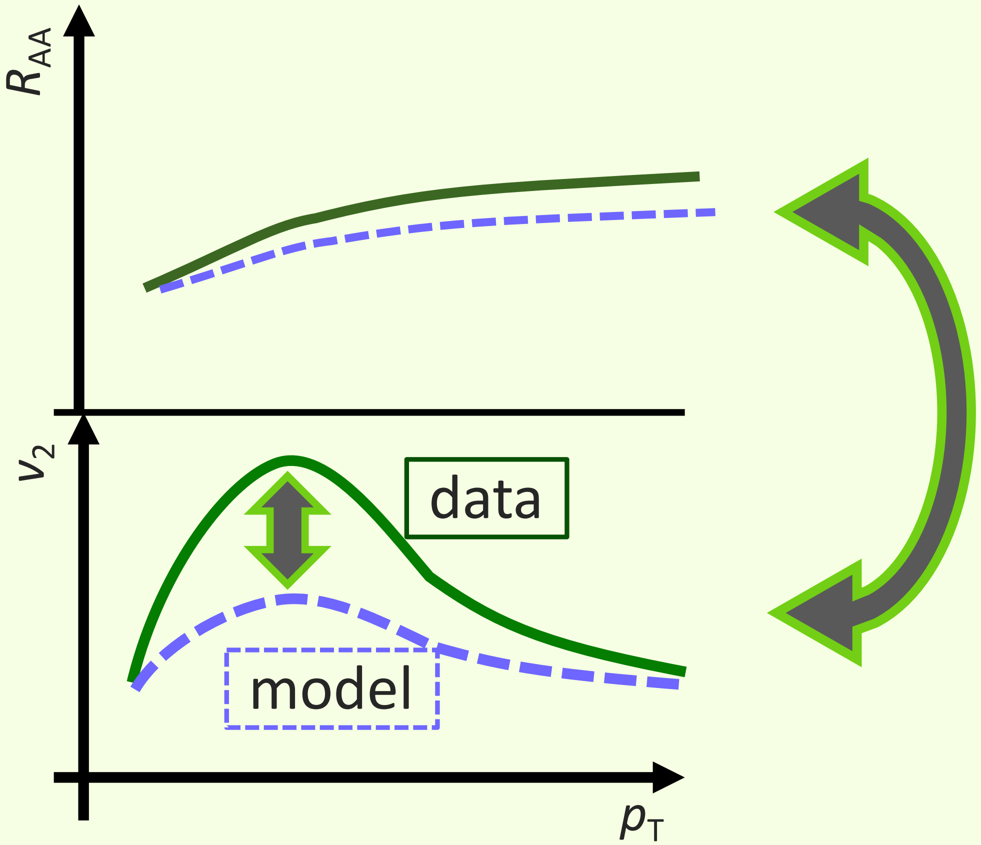

$$v_2^{\text{jet}} = \frac{1}{\text{Res}\left\{\psi_2^{meas}\right\}} \frac{\pi}{4} \frac{N_{in} - N_{out}}{N_{in} + N_{out}}$$

$N_{in},\ N_{out}$ : Jet yield at in-plane and at out-of-plane

$\text{Res}\left\{\psi_2^{meas}\right\}$ : Event plane resolution

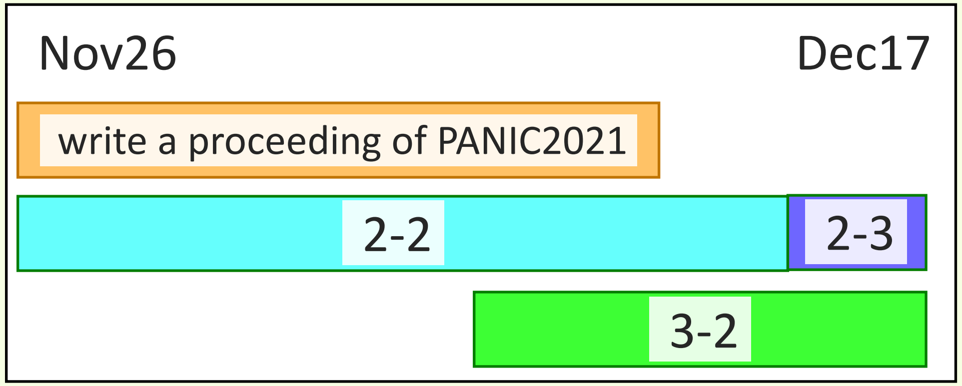
Radiation / Scattering dominant?
→ $L^2$ or L




Radiation / Scattering dominant?
→ $L^2$ or L

# Current Progress




1. Create a new own task code.
   1-1. Git Merge (done)
   1-2. Train run (done)
   1-3. Run the code to read result file (done)

2. Event plane calibration code
   2-1. Test run of the code (done)
   2-2. Apply to PWGJE framework from PWGPP. (<-new)
   2-3. Apply this code for train (on-going)
   2-4. Run train

3. Mearsure the Raw jet for each event plane
   3-1. Test run a simple code that gets event plane[w/o calibration] (done)
   3-2. Impliment more detail V2 calculation code (AliAnalysisTaskV2) (on-going)
   3-3. Run train code (after 2)

4. Embedding, Unfolding, Systematic Error

# New Event Plane Calibration Task Code for PWGJE

2-2. Apply the event plane calibration task to PWGJE

- Add  lines to apply AliAnalysisEvent cut(accepted)

(https://github.com/alisw/AliPhysics/tree/master/PWGJE/EMCALJetTasks/FlowVectorCorrections/macros)

- Estimate a event plane by the combined V0C and V0A.

→ It is essential to measure three kinds of $\Psi_n$ for esitimate $v_n$ resolution.

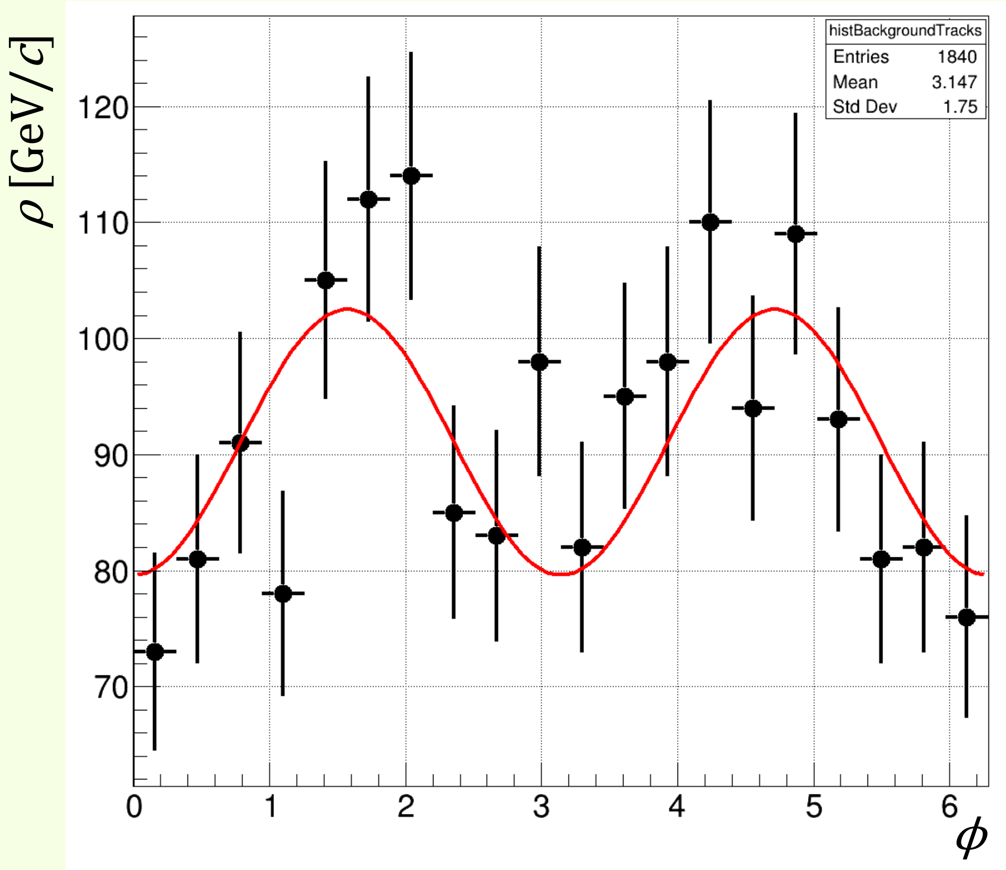
$(\Psi_n^{\mathrm{V0}}, \Psi_n^{\mathrm{TPC\_}\eta_{\mathrm{posi}}}, \Psi_n^{\mathrm{TPC\_}\eta_{\mathrm{nega}}})$

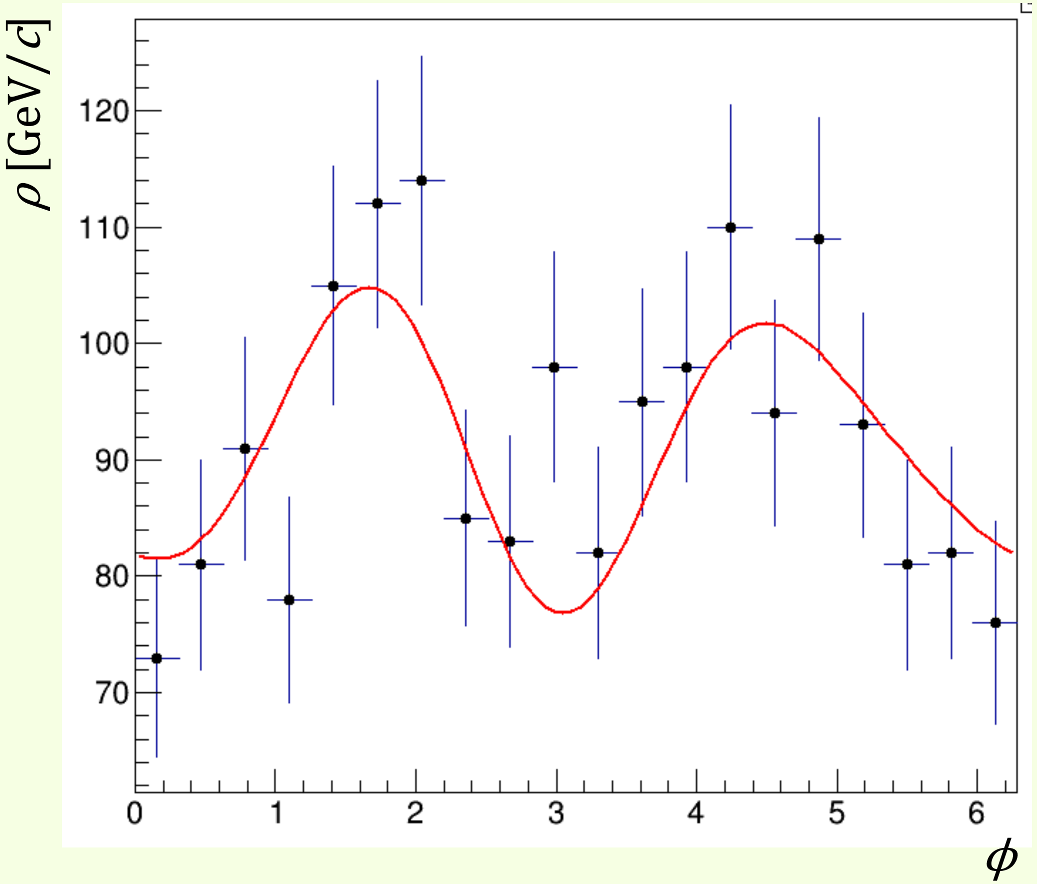
- Git Merge request (accepted)

2-3. Apply this task code for train

- Include macro directory into $ALICE_PHYSICS (done)
- Modify some line to use it on a train. (requesting git merge)

1 event




$$\rho(\phi) = \rho_0\,(1 + 2v_2\cos 2\phi)$$

$$\rho(\varphi) = \rho_0 \times \left(1 + 2\left\{v_2^{\mathrm{obs}}\cos(2[\varphi - \Psi_{\mathrm{EP},2}]) + v_3^{\mathrm{obs}}\cos(3[\varphi - \Psi_{\mathrm{EP},3}])\right\}\right)$$

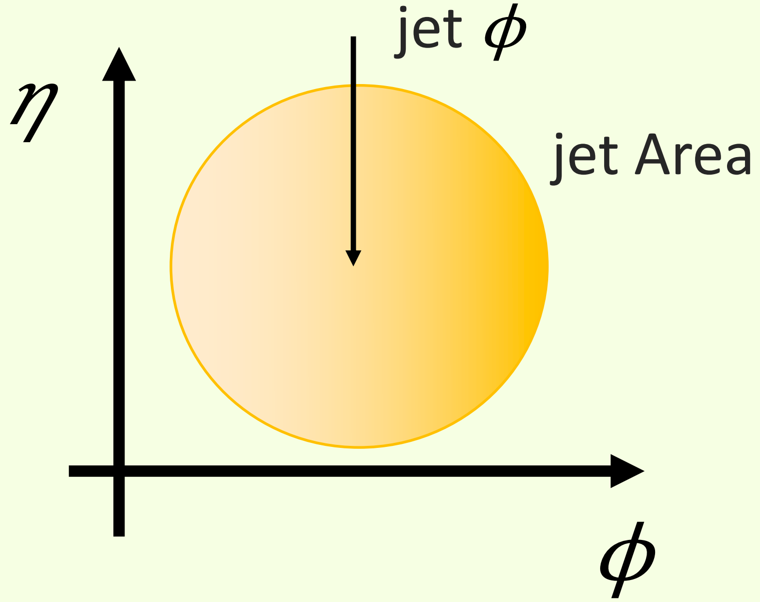
# Two inplimentation

1. resolution

$$v_n = \frac{v_n^{obs}}{\mathscr{R}}$$

$$\mathscr{R}_n^a = \langle \cos(n[\Psi_{\mathrm{EP},n}^{\mathrm{a}} - \Psi_n]) \rangle = \sqrt{\frac{\left\langle \cos(n[\Psi_{\mathrm{EP},n}^{\mathrm{a}} - \Psi_{\mathrm{EP},n}^{\mathrm{b}}]) \right\rangle \left\langle \cos(n[\Psi_{\mathrm{EP},n}^{\mathrm{a}} - \Psi_{\mathrm{EP},n}^{\mathrm{c}}]) \right\rangle}{\left\langle \cos(n[\Psi_{\mathrm{EP},n}^{\mathrm{b}} - \Psi_{\mathrm{EP},n}^{\mathrm{c}}]) \right\rangle}}$$

2. local rho calculation




Calculate detail local rho value
(the rho is gradually different on each phi)

# Next plan

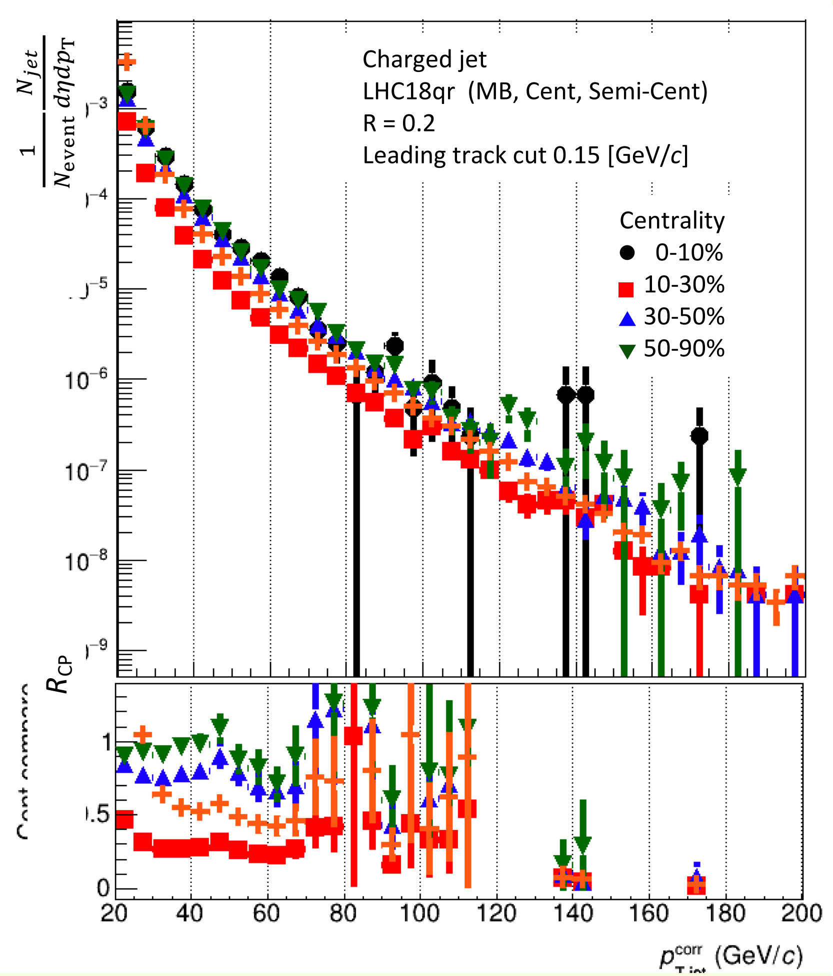
1. Create a new own base task code. (done)

2. Event plane calibration code
 2-1. Test run of the code (done)
 2-2. Apply this code for train (on-going -> mid-Dec)
 2-3. Run train (the end of Dec)

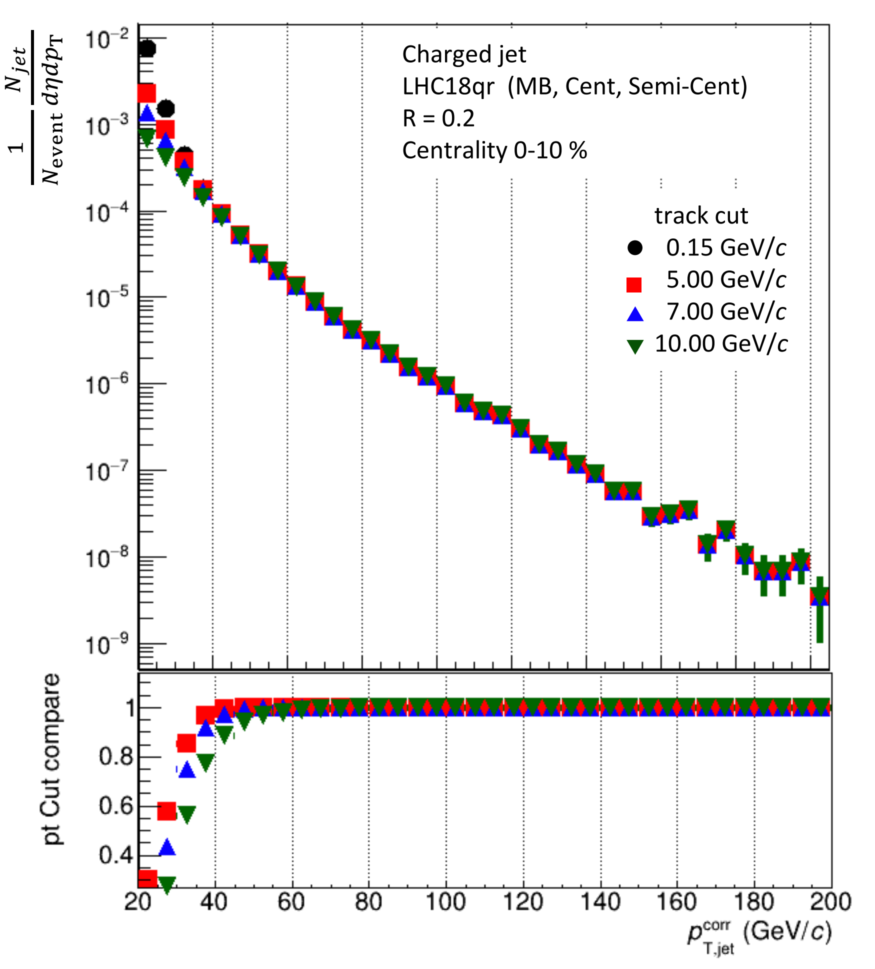
3. Mearsure the Raw jet for each event plane
 3-1. Test run a simple code that gets event plane[w/o calibration] (done)
 3-2. Impliment more detail V2 calculation code (AliAnalysisTaskV2) (on-going -> end-Dec)
 3-3. Run train code (Jan)

4. Embedding (Feb/Mar)
5. Unfolding (Ape)
6. Systematic Error (May)

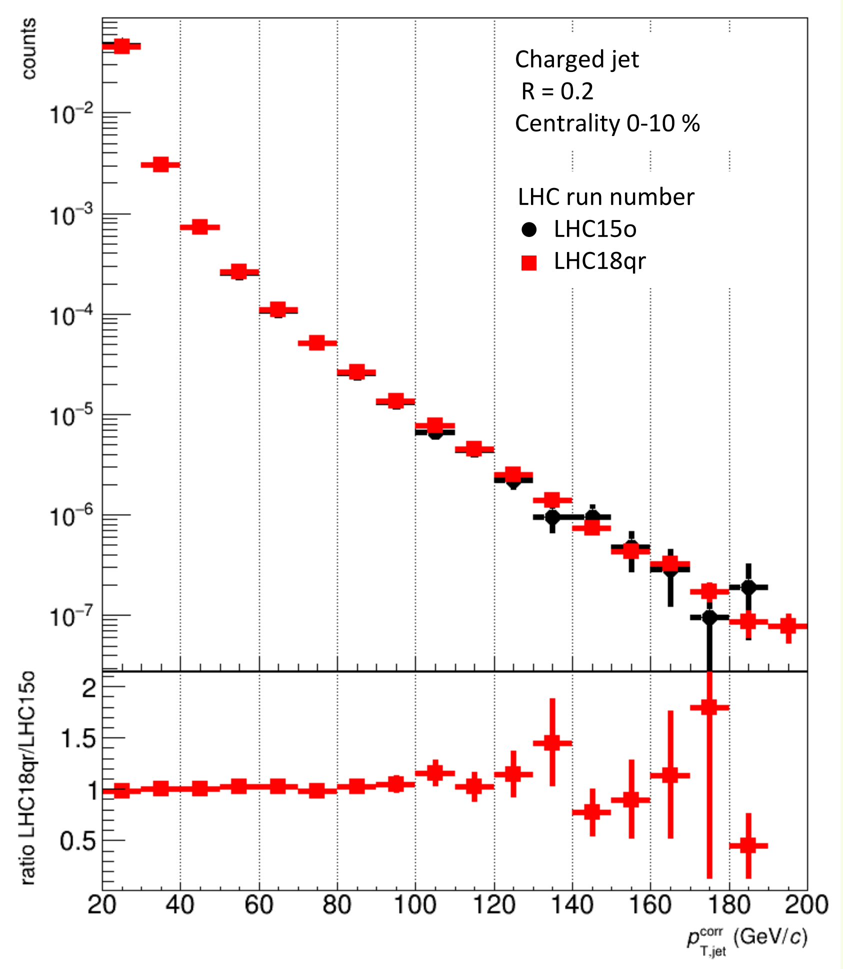
# Raw Jet distribution



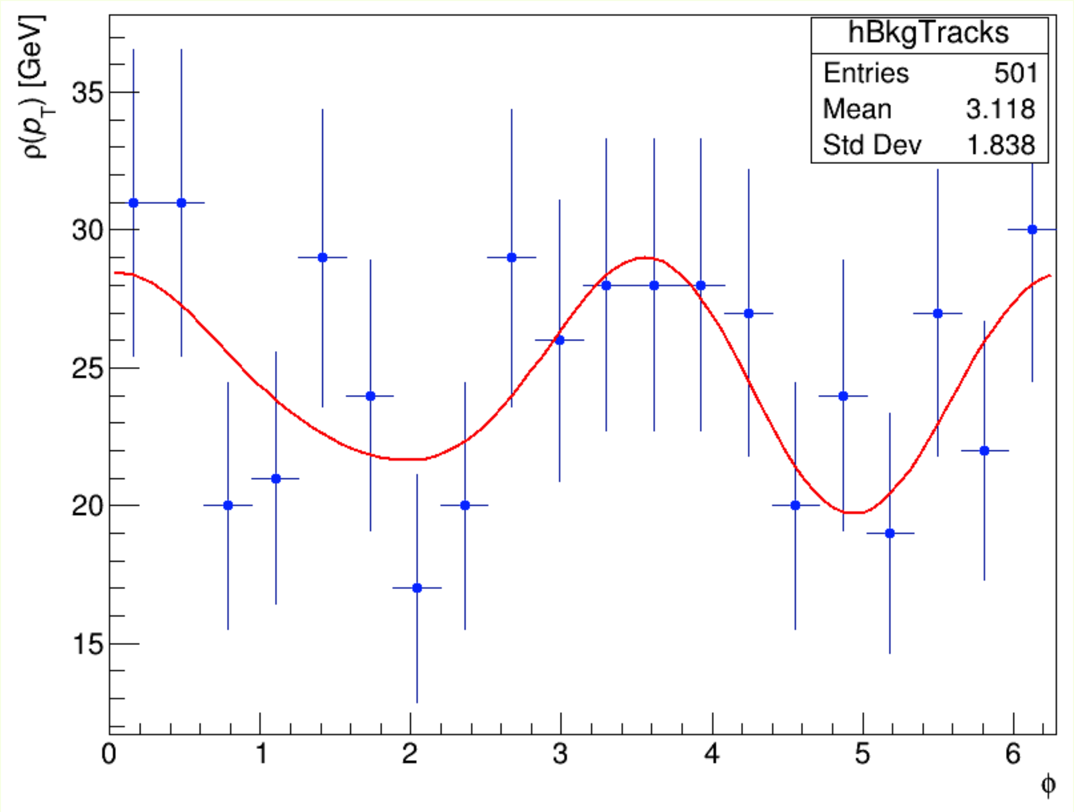

Cetrarity dependence




Leading track pt cut dependence



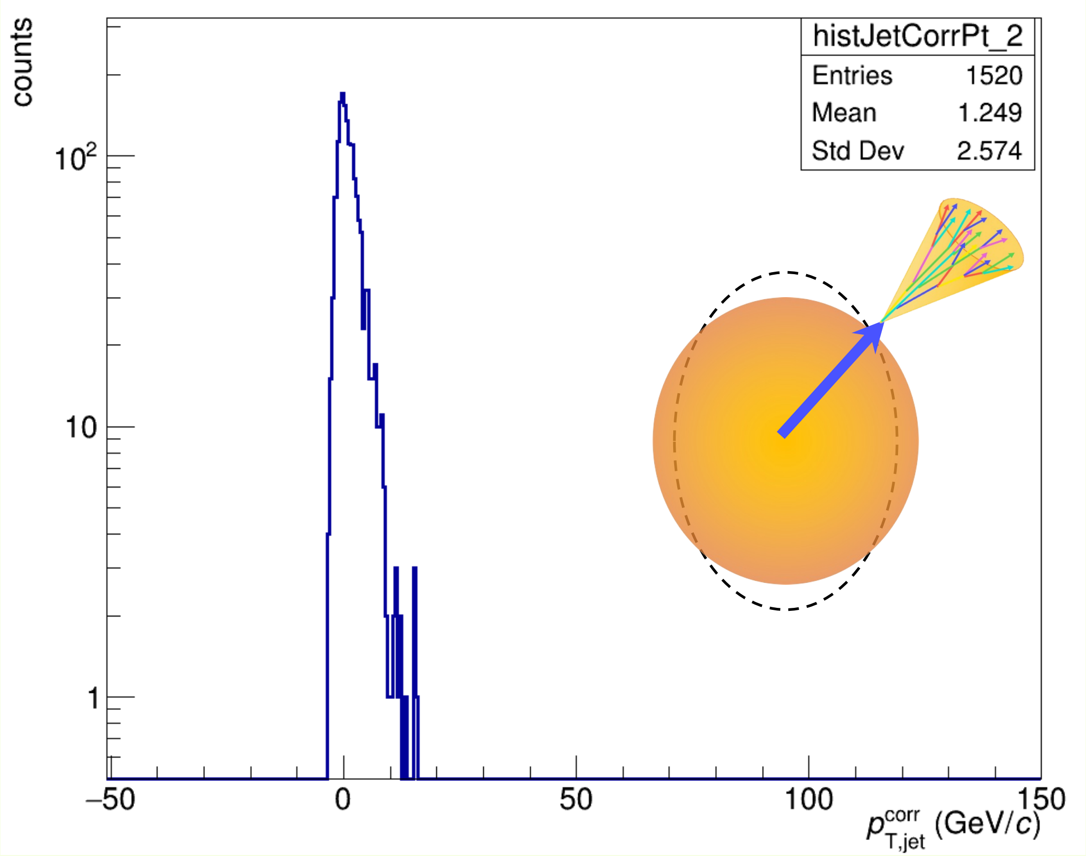

Difference between the run periods


hBkgTracks
Entries 501
Mean 3.118
Std Dev 1.838
ρ(p_T) [GeV]
ϕ

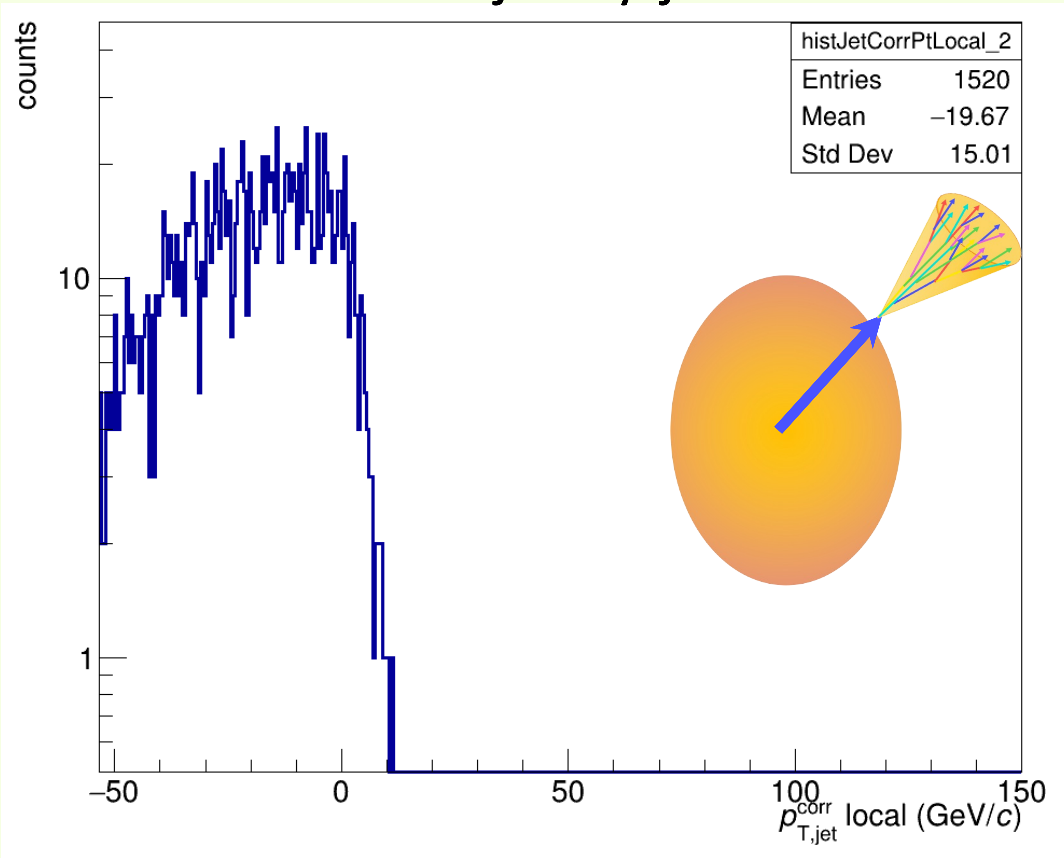
# Compare backgroudn subtraction (average vs local)

300 Events

Average rho event-by-event

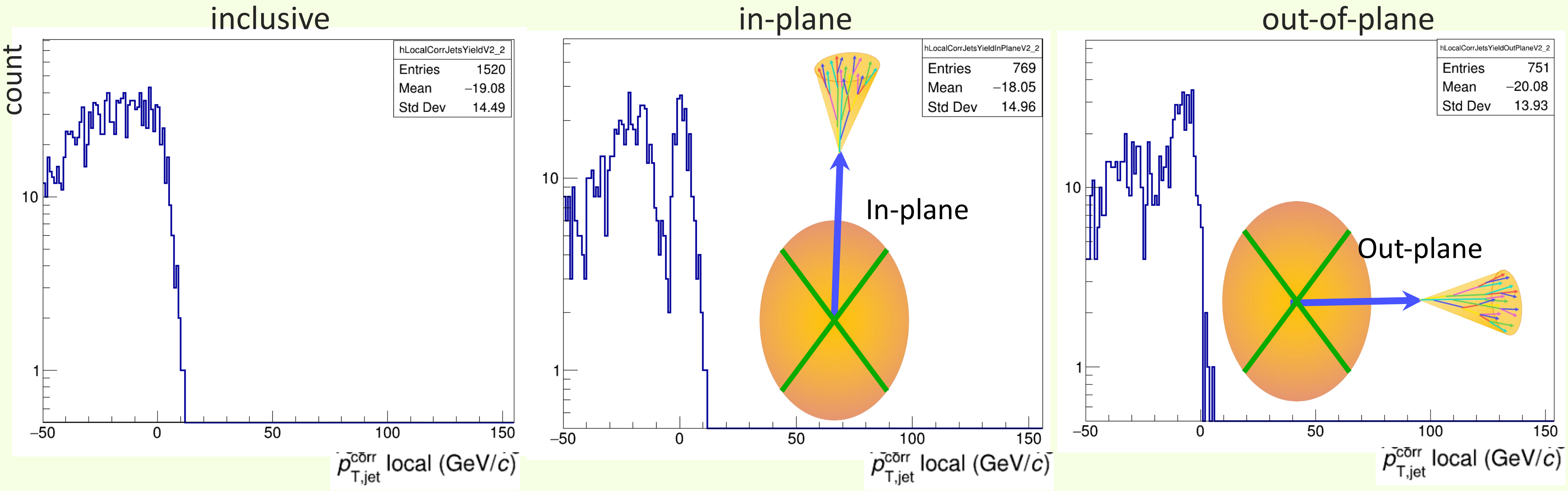



Local rho jet-by-jet




the local background measurement lower than average. But I still do not search the reason.

# Compare differencies of the jet yields for d$\phi$




- Need more accurate event plane measurement and calibration
- Need more statistic