Status of the ZDC simulation studies in Korea

EIC-Asia Workshop on QCD and Hadron Structure

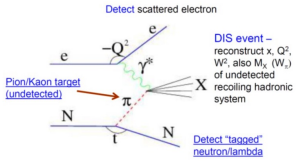
May 1, 2026, Institute of Physics, Academia Sinica

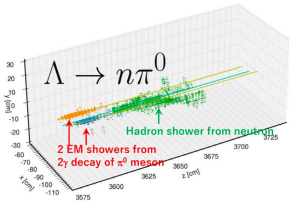
Gyeongjun Kim, Yeonwoo Park, Yongsun Kim, **Saehanseul Oh** (Sejong University)

Sullivan process and Λ baryon

Λ Identification

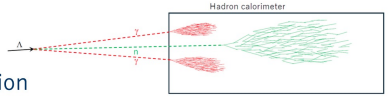
- Physics – Pion/Kaon structure
  - Sullivan process
- Λ neutral decay
  - $\Lambda \rightarrow n+\pi^0 \rightarrow n+2\gamma$
  - Λ lifetime: $c\tau = 7.89\text{cm}$ → Lorentz boost: $c\tau\beta\gamma$ > several meter
  - Need to find Λ decay point downstream of B0 magnet in front of ZDC
  - Kinematic fit to identify Λ neutral decay with ZDC
    - Vector (or direction) information of showers in ZDC, EM showers of 2γ in particular
    - Evaluation of S/N



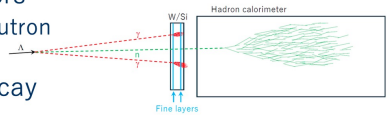


Λ Identification

- Hadron calorimeter
  - ~2.5 cm x 64 layers = ~160 cm
    - 8.0 interaction length
    - 75 radiation length
    - 10 mrad direction resolution



- W/Si imaging calorimeter
  - ~5 mm x 20 layers = ~10 cm
  - More confined EM showers
    - Clear separation from neutron
  - Much better direction resolution → to find Λ decay point
    - 1 mrad direction resolution
  - Better energy resolution



- Yuji's talk today: https://indico.phys.sinica.edu.tw/event/495/contributions/3441/attachments/1608/3288/ZDCWS_2605.pdf

Main questions

- **What is the optimal detector configuration to measure the Λ baryon?**
  - Varying the detector configurations

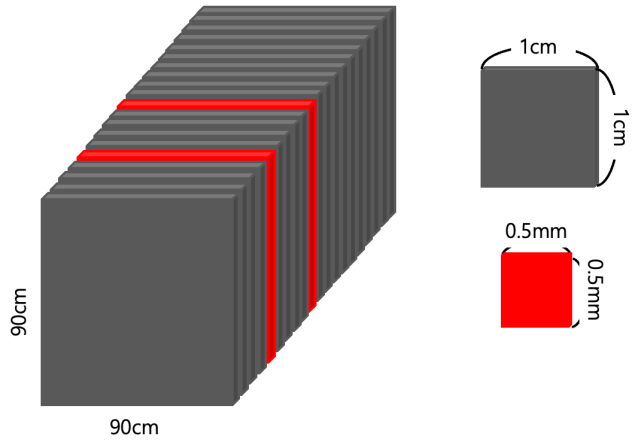
- **What is the optimal tracking algorithm to measure the Λ baryon?**
  - Developing the reconstruction procedures

- What is the optimal detector configuration to measure the Λ baryon?
  - Varying the detector configurations

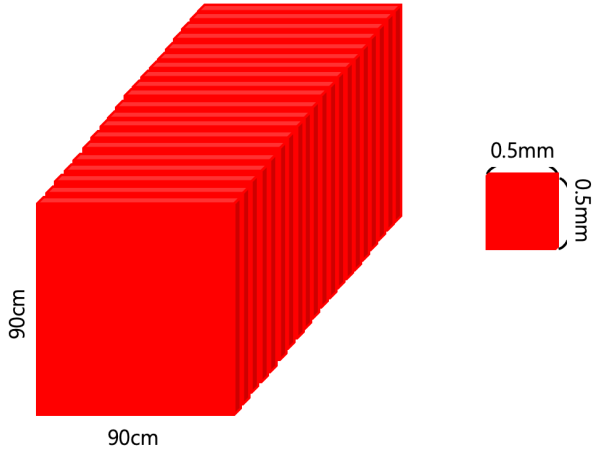
- What is the optimal tracking algorithm to measure the Λ baryon?
  - Developing the reconstruction procedures

W-Si layers

- Current ECal + HCal configuration did not show enough performance for the Λ reconstruction – W-Si layers are considered in addition



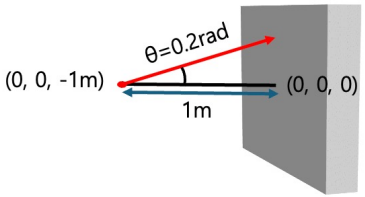
- Design based on ALICE FoCal
- 2 pixel layers (5^{th}, 10^{th}), 18 pad layers



- 20 pixel layers

W-Si layers

- Current ECal + HCal configuration did not show enough performance for the Λ reconstruction – W-Si layers are considered in addition

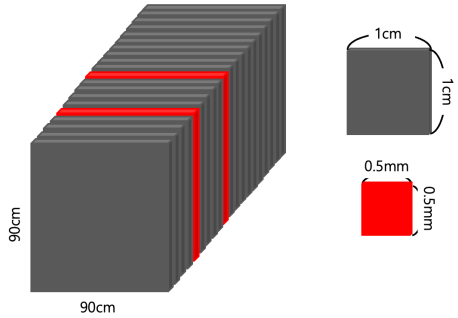


- 10 GeV photon beam with various θ is used for the detector simulation

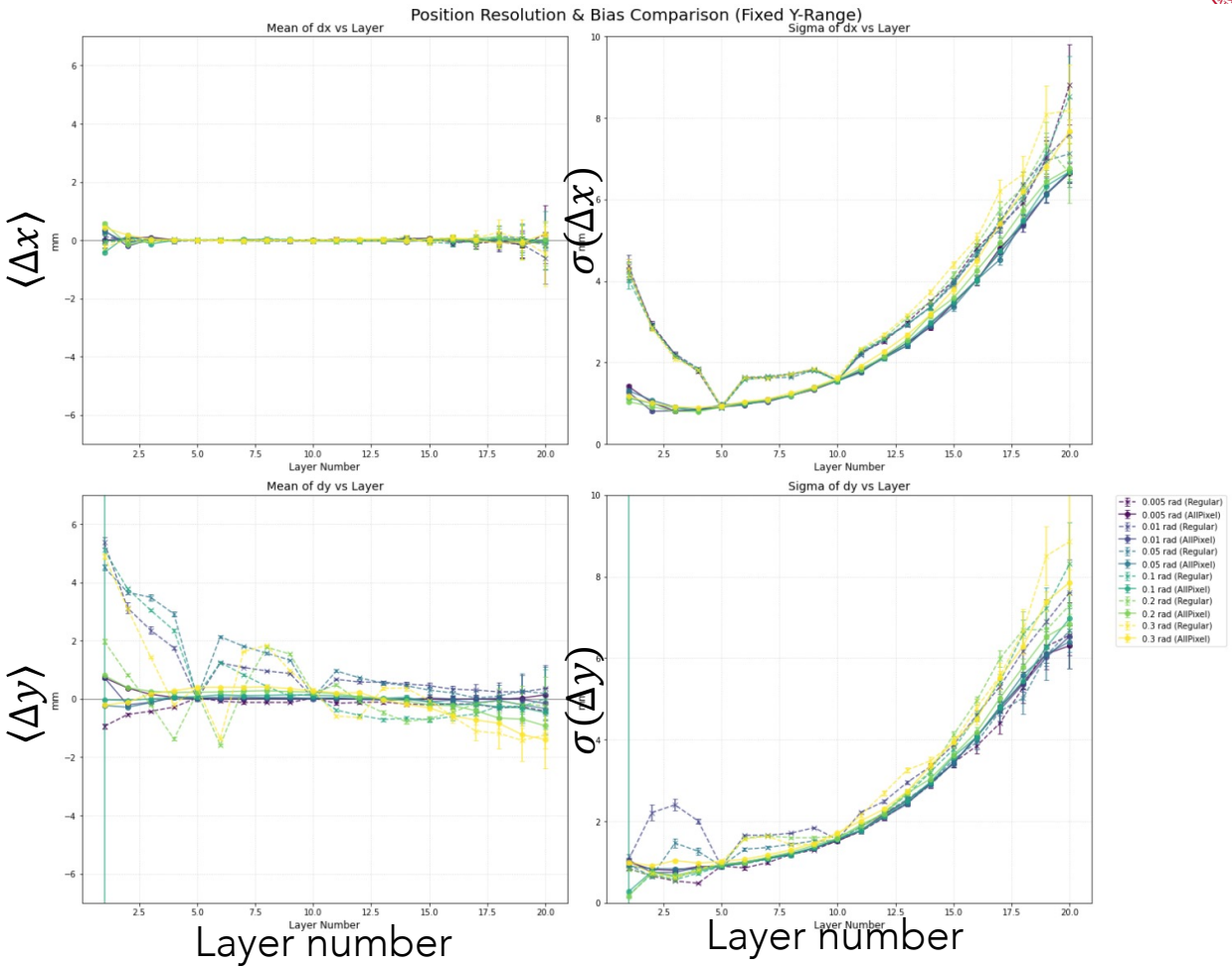
- Design based on ALICE FoCal
- 2 pixel layers (5th, 10th), 18 pad layers

- 20 pixel layers

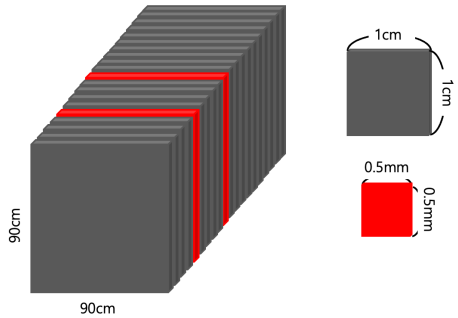
W-Si layers



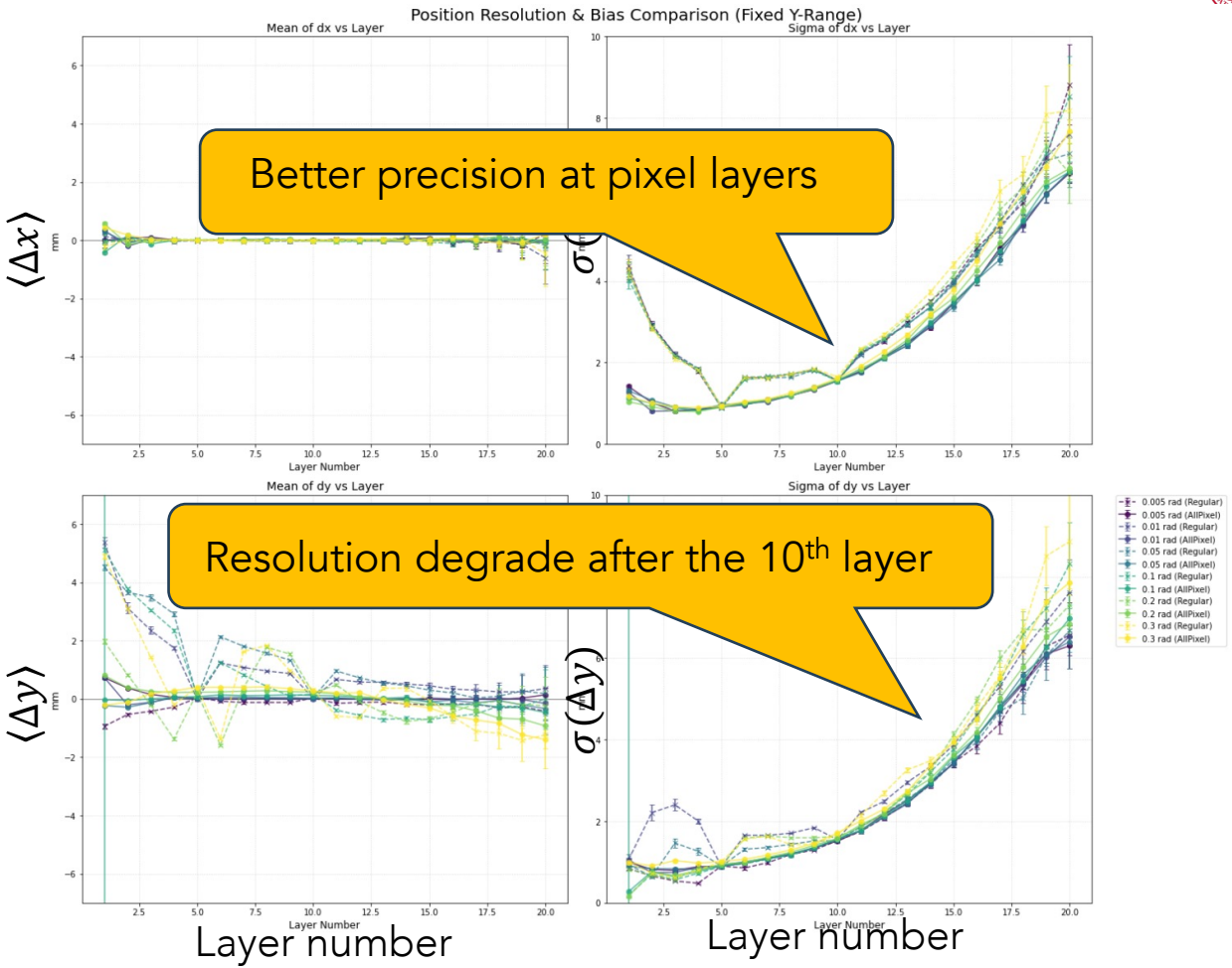
2 pixel layers, 18 pad layers



W-Si layers



2 pixel layers, 18 pad layers



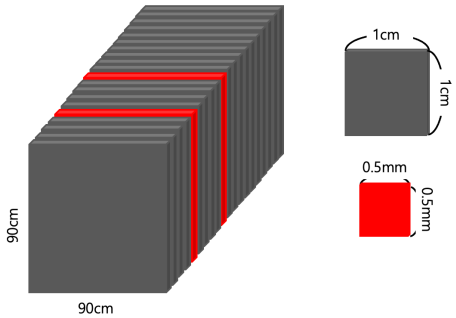
Better precision at pixel layers

Resolution degrade after the 10th layer

Layer number

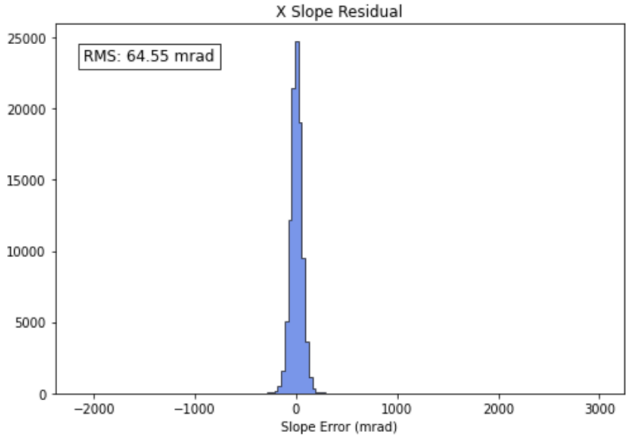
Layer number

W-Si layers

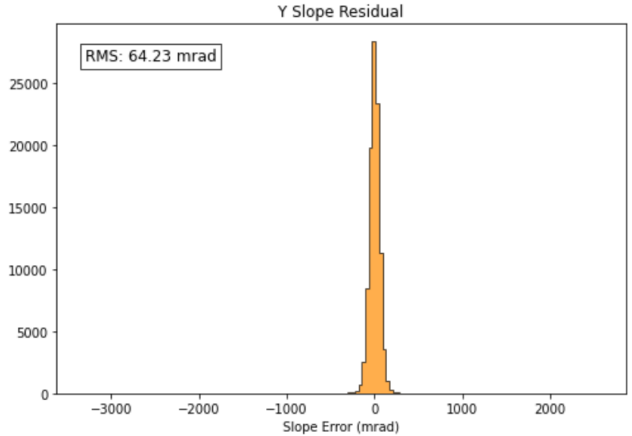


2 pixel layers, 18 pad layers

- Track reconstruction in xz and yz plane with the Least Square Method (LSM)
- Slope is extracted and compared with the input

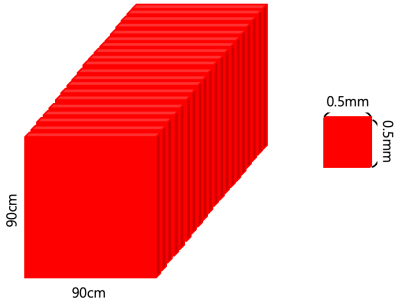


Δslope



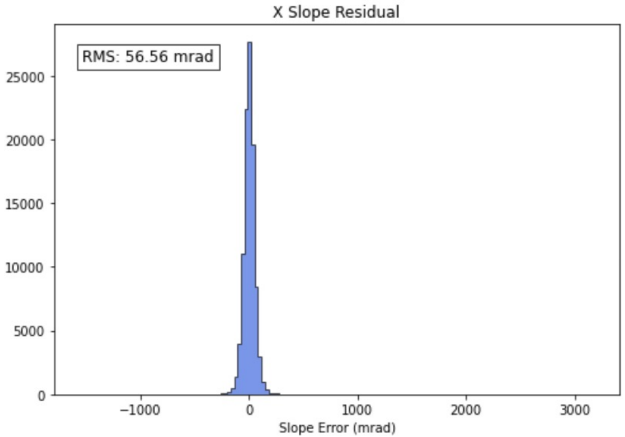
Δslope

W-Si layers

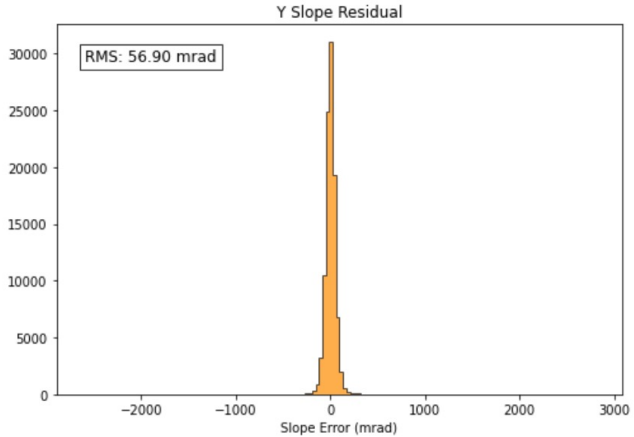


All pixel layers

- Track reconstruction in xz and yz plane with the Least Square Method (LSM)
- Slope is extracted and compared with the input

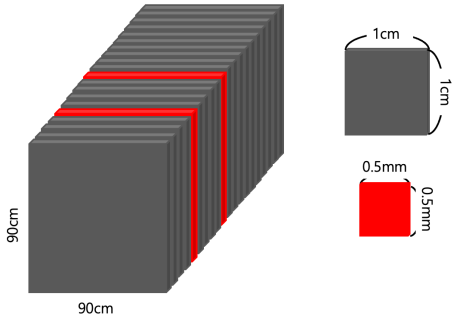


Δslope

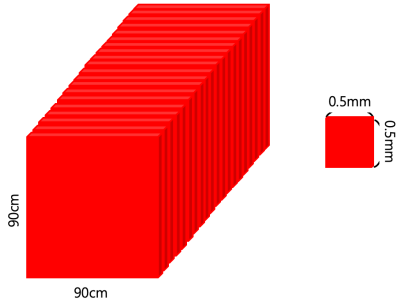


Δslope

W-Si layers



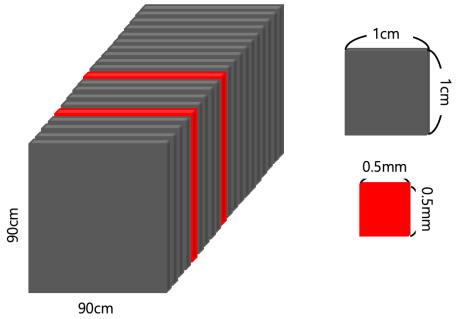
2 pixel layers, 18 pad layers



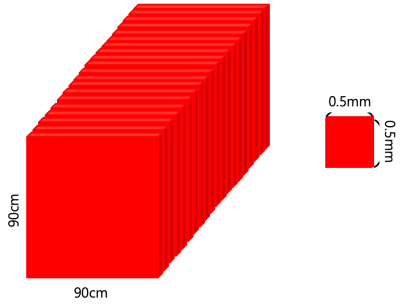
All pixel layers

	2nd, 10th Pixel	5th, 10th Pixel	All layers Pixel
XZ Plane Resolution[mrad]	65.44	64.55	56.56
YZ Plane Resolution[mrad]	64.99	64.23	56.90

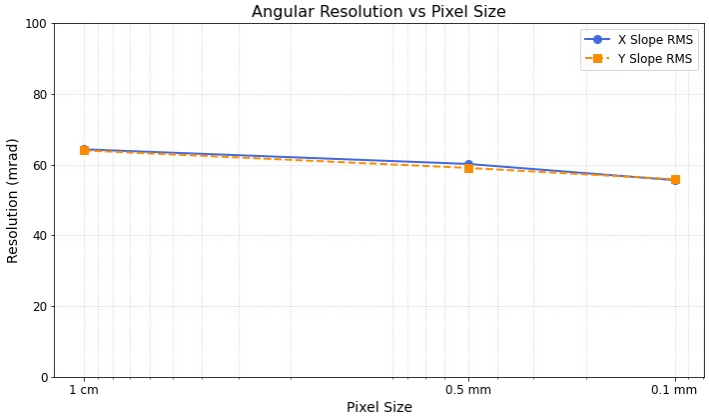
W-Si layers



2 pixel layers, 18 pad layers



All pixel layers



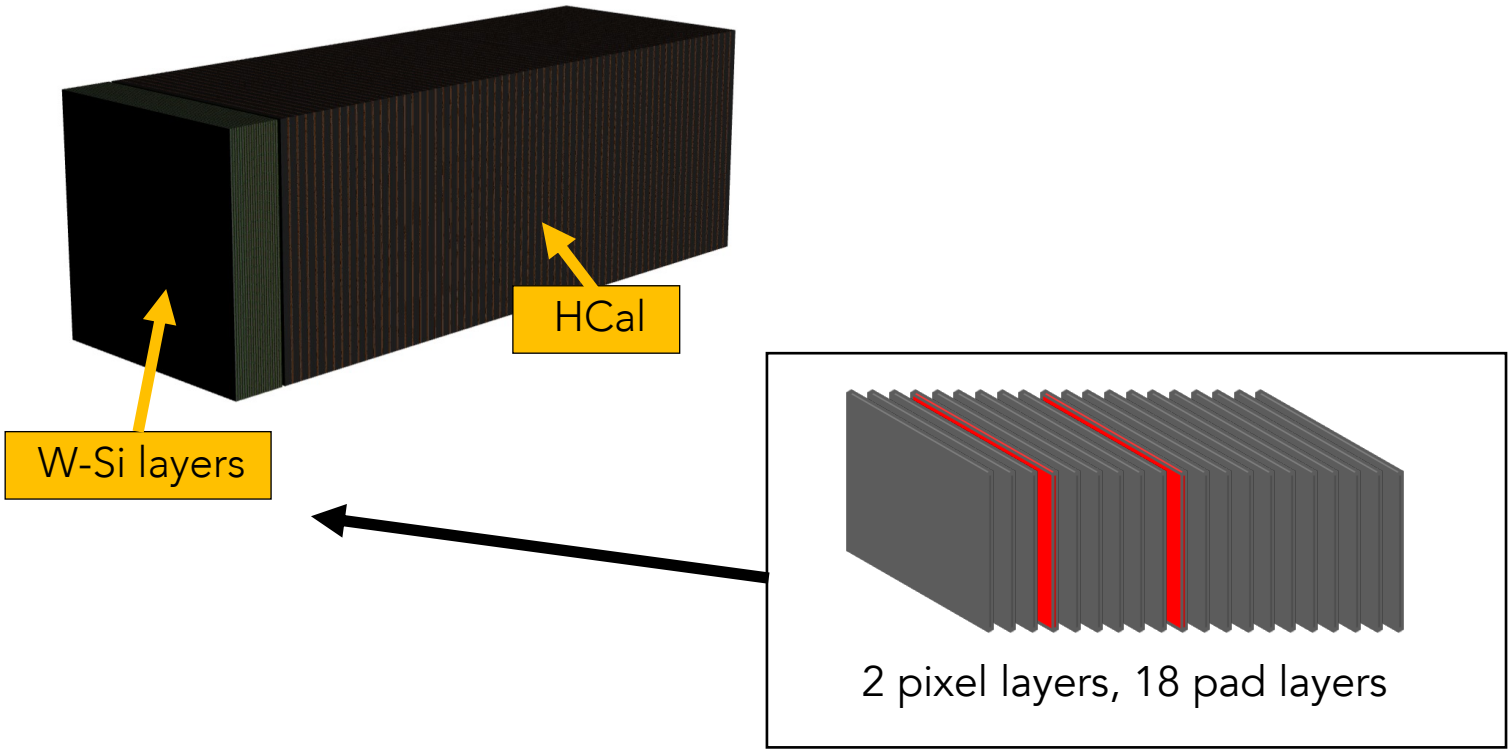
Pixel size does not have a significant impact on the tracking resolution

New idea?

- What is the optimal detector configuration to measure the Λ baryon?
  - Varying the detector configurations

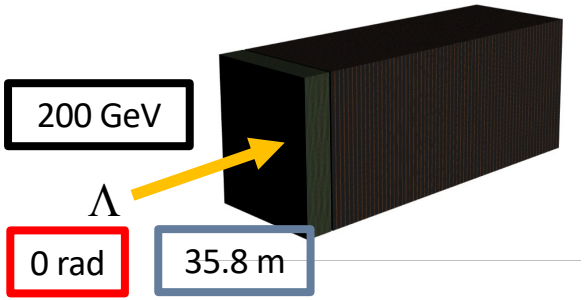
- **What is the optimal tracking algorithm to measure the Λ baryon?**
  - Developing the reconstruction procedures

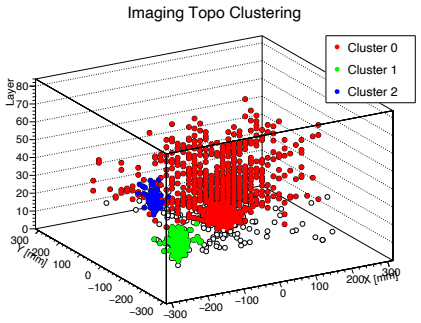
ZDC configuration

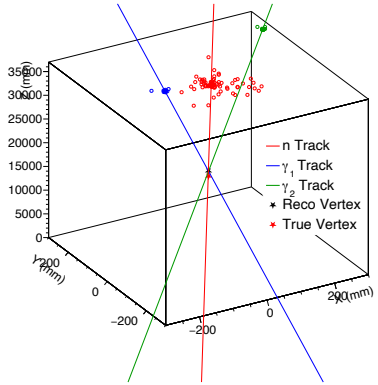


Λ reconstruction workflow

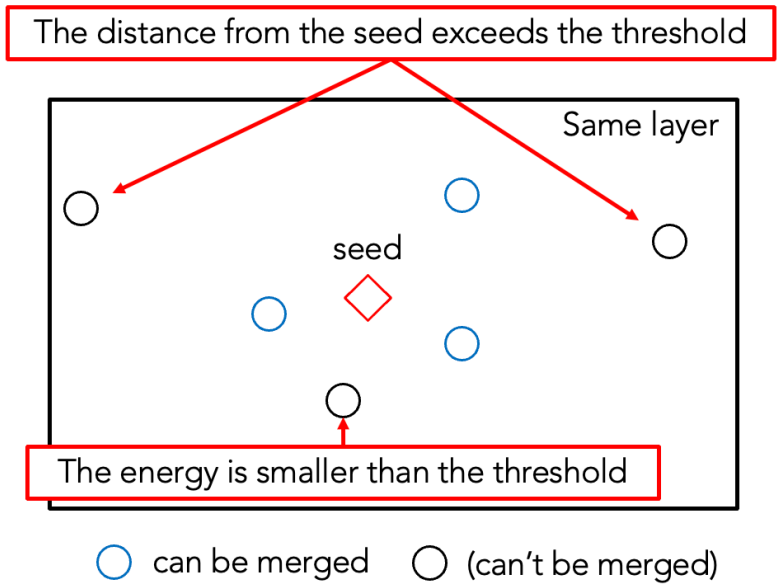
- Λ event generation with $\Lambda \rightarrow n + \pi^0$ decay channel
- Clustering with the Topological Clustering algorithm
- Track reconstruction of Λ decay products
- Momentum and energy reconstruction of Λ





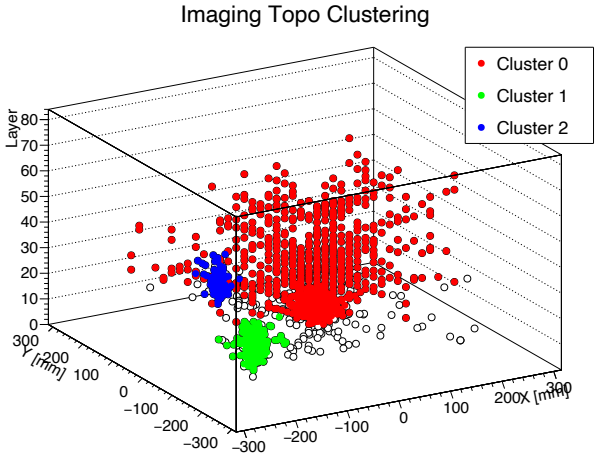


Clustering – Topological Clustering Algorithm



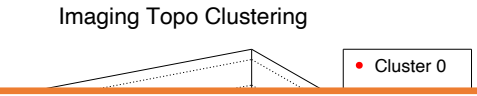
1. Find seed
   - ✓ E_{hit} > seed energy threshold
2. Find neighbor
   - ✓ E_{hit} > neighbor energy threshold
   - ✓ $\Delta x, \Delta y$ < distance from the seed threshold
3. Selection of the cluster
   - ✓ Select 4 highest-energy clusters
     - ✓ W-Si: 3, Hcal: 1
   - ✓ Merge two clusters if the distance ($\sqrt{dx_i^2 + dy_i^2}$) of their centers < 10 mm

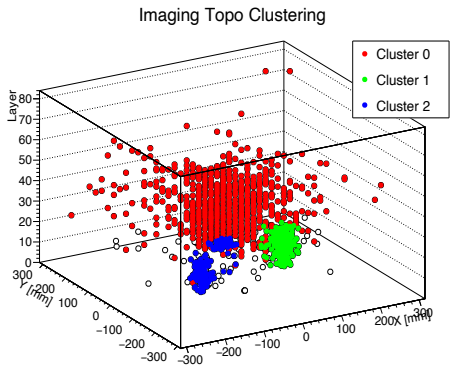
Clustering – Topological Clustering Algorithm



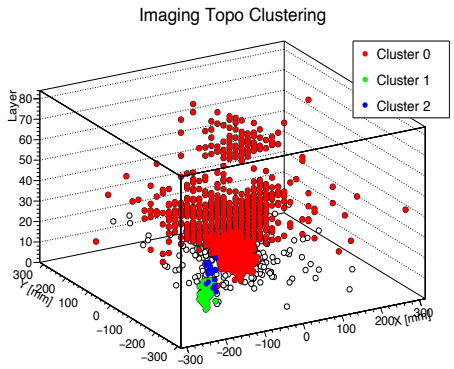
- 43% events have decay particles within the ZDC acceptance
- 32% events passed the clustering selection

Clustering – Topological Clustering Algorithm





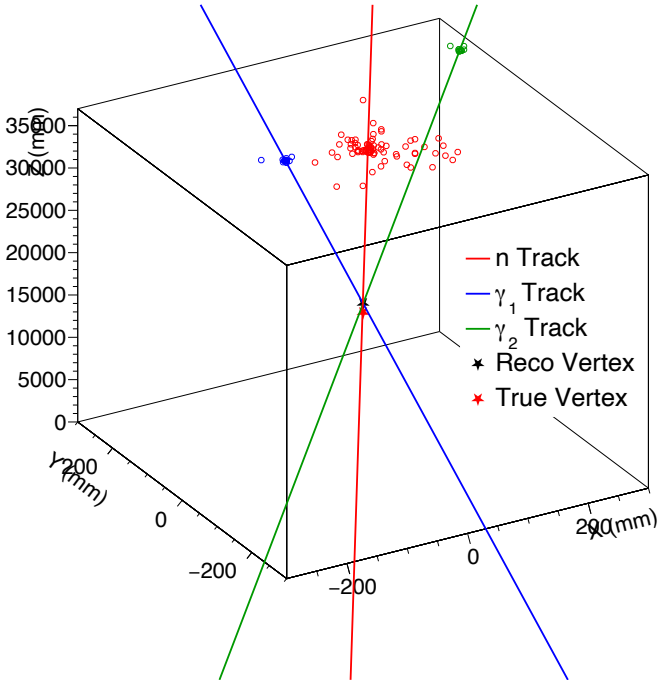
Neutron cluster is merged with a photon cluster



Photon cluster is merged with a neutron cluster, and noise makes a new cluster

Clustering is done well in most events, but some mis-clustered events still survive

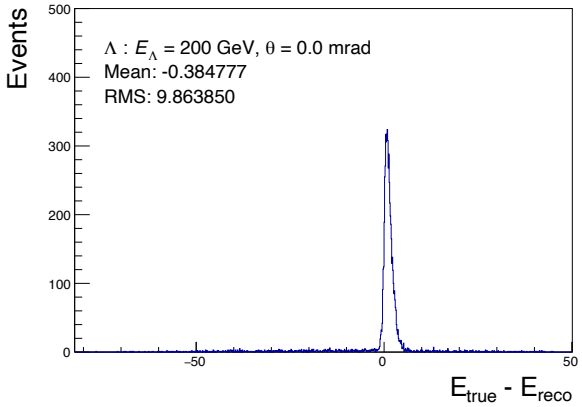
Track reconstruction – Least Square Method (LSM)



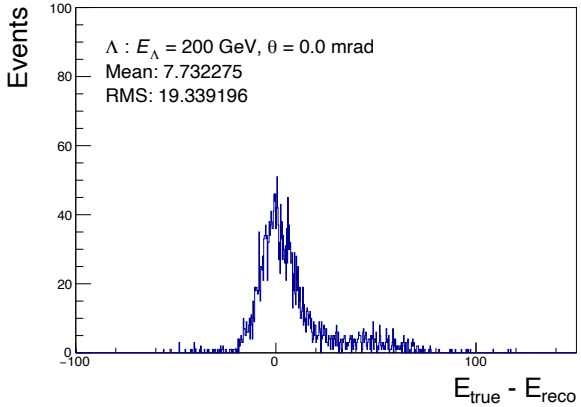
- Additional constraint that the tracks pass a common point

Energy resolution after clustering

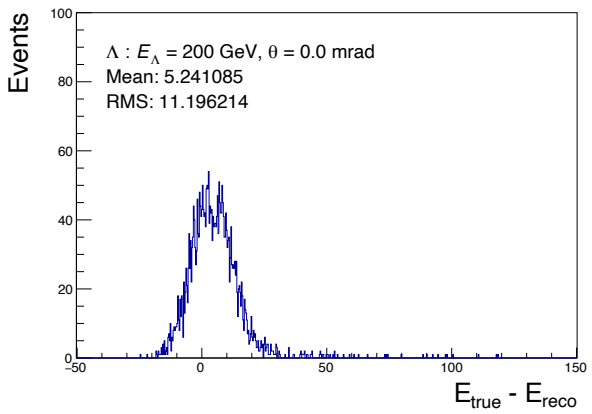
γ energy resolution



n energy resolution



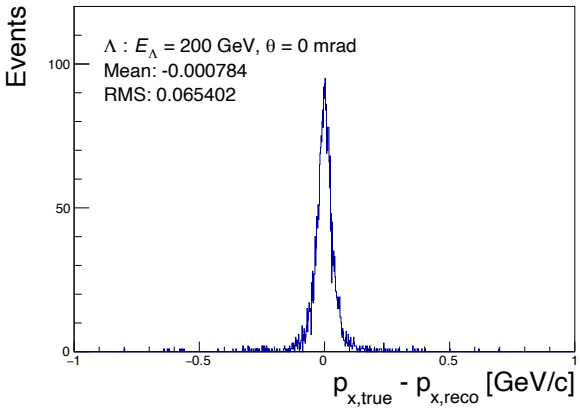
Λ energy resolution



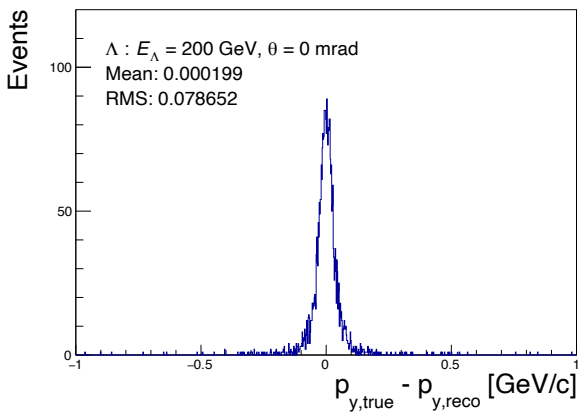
Some tails from mis-clustered events

Λ momentum resolution

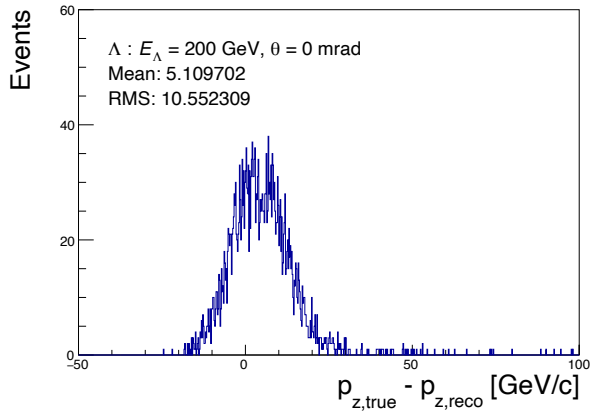
p_x resolution



p_y resolution



p_z resolution



p_z is largely shifted to positive

- Further optimization of clustering is needed
- Tracking based on convolutional neural network algorithm

Summary

- Λ baryon reconstruction is being explored using the W-Si layers in the ZDC
  - Pixel size does not significant affect the resolution
  - There is still a room for improvement in the software-side approach
  - Any further inputs on the detector configurations are welcomed