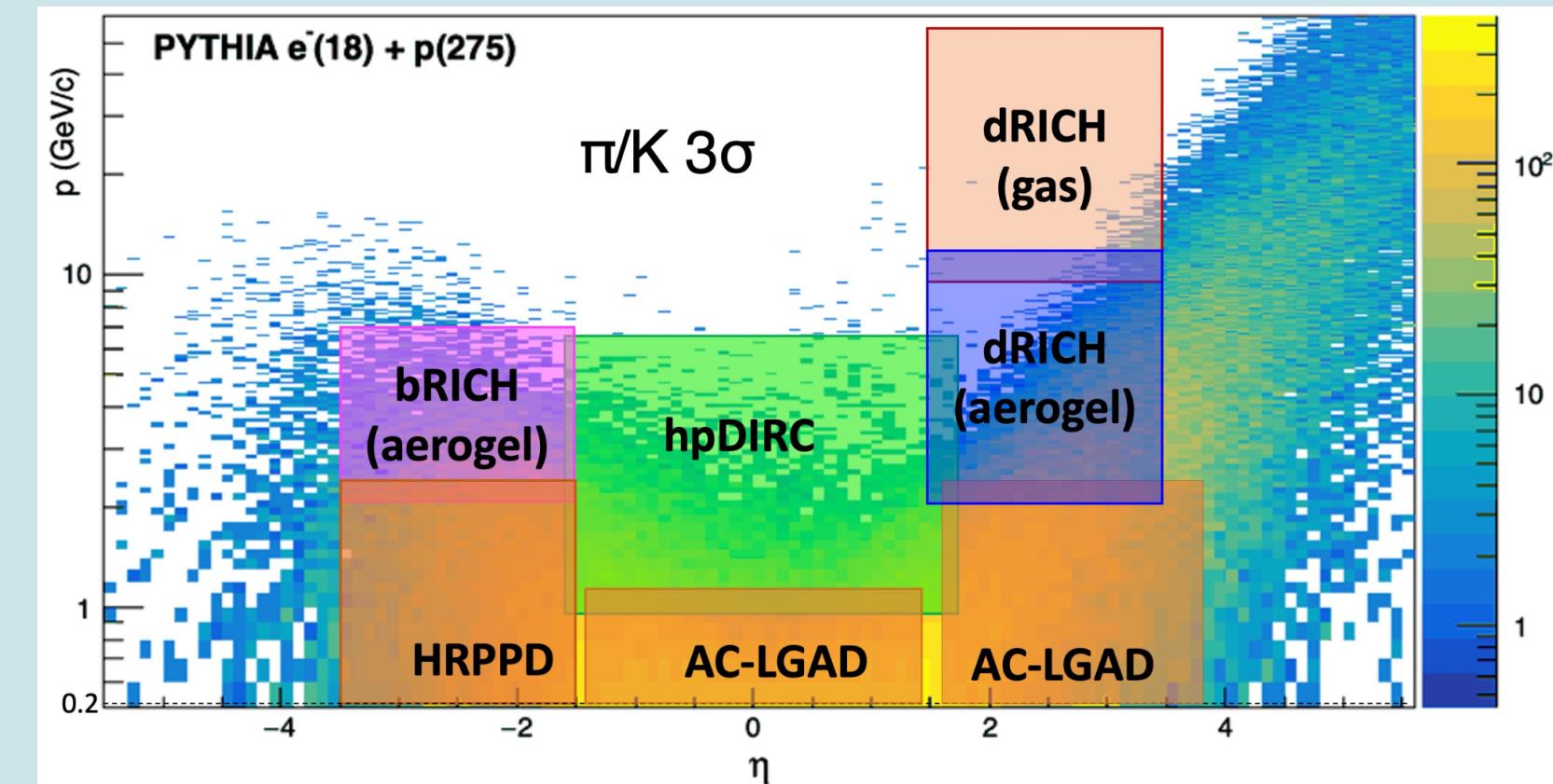# ePIC TOF

Satoshi Yano

Hiroshima University SKCM²

TOF in the ePIC detector

- TOF is a main PID detector covering low-p_T region
  - Barrel-TOF (BTOF): $-1.42<\eta<1.42$
  - Forward-TOF (FTOF): $1.74 < \eta < 3.83$

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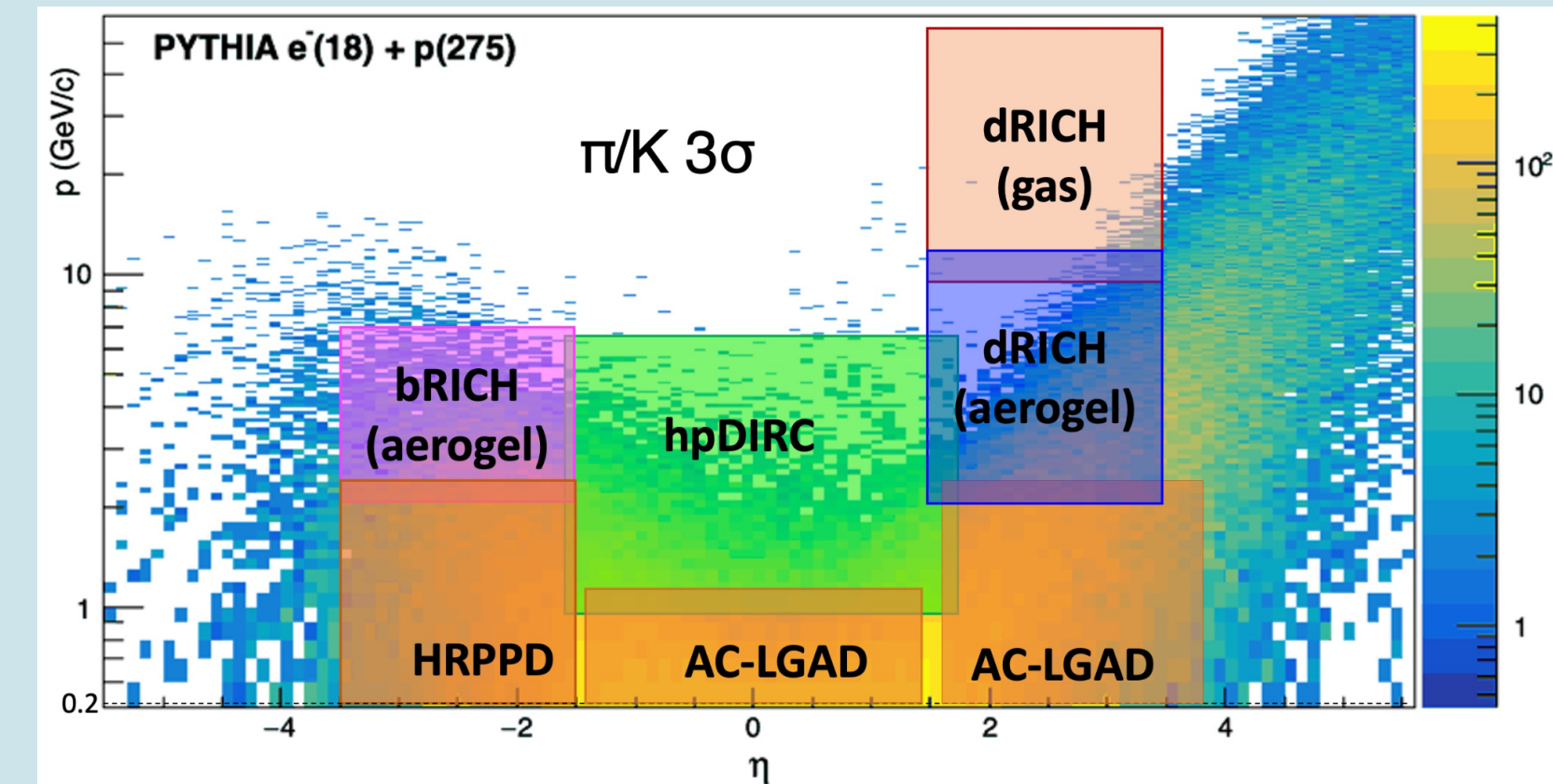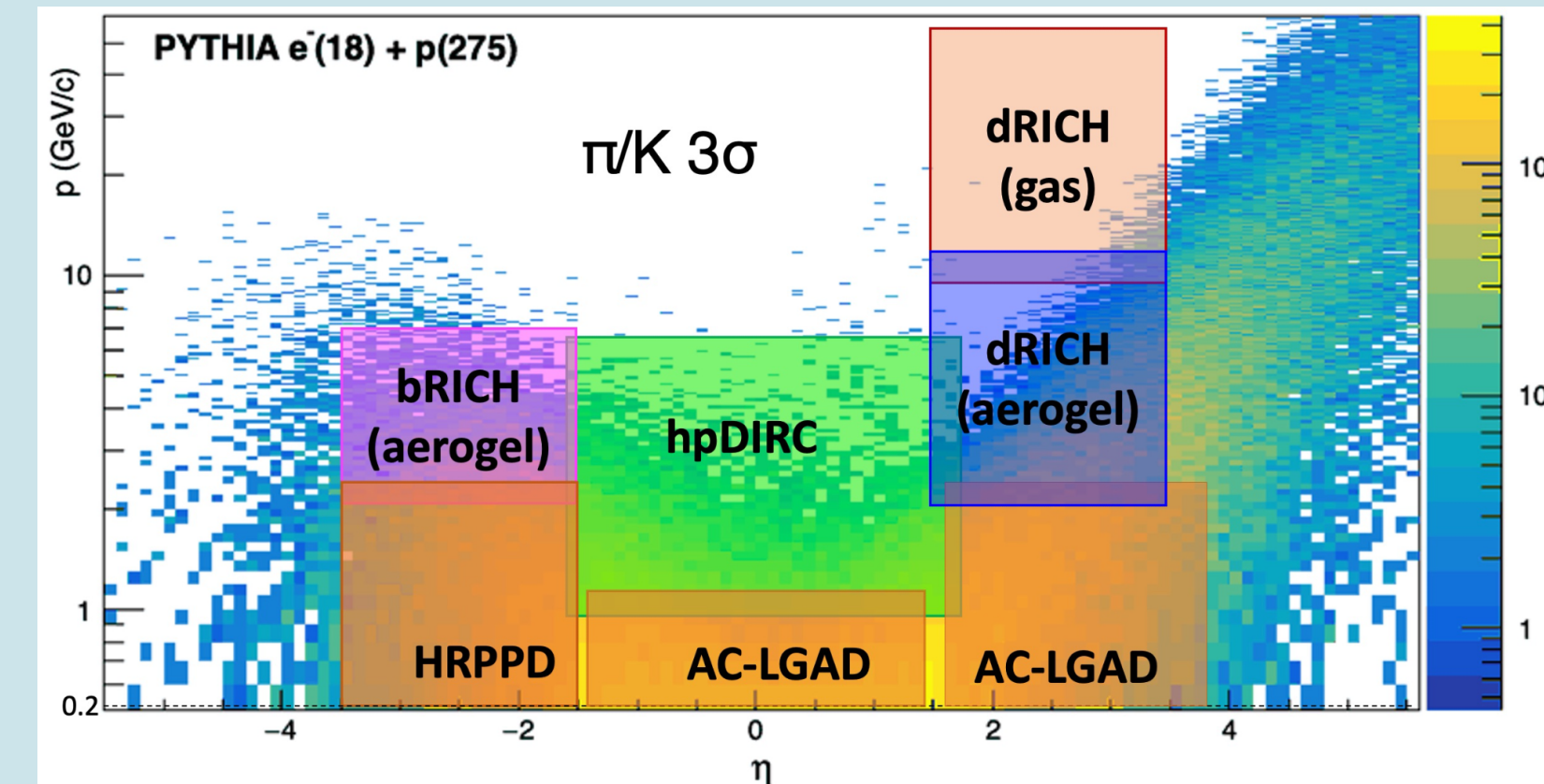 - Forward-TOF (FTOF): $1.74 < \eta < 3.83$

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Tracking detectors in ePIC

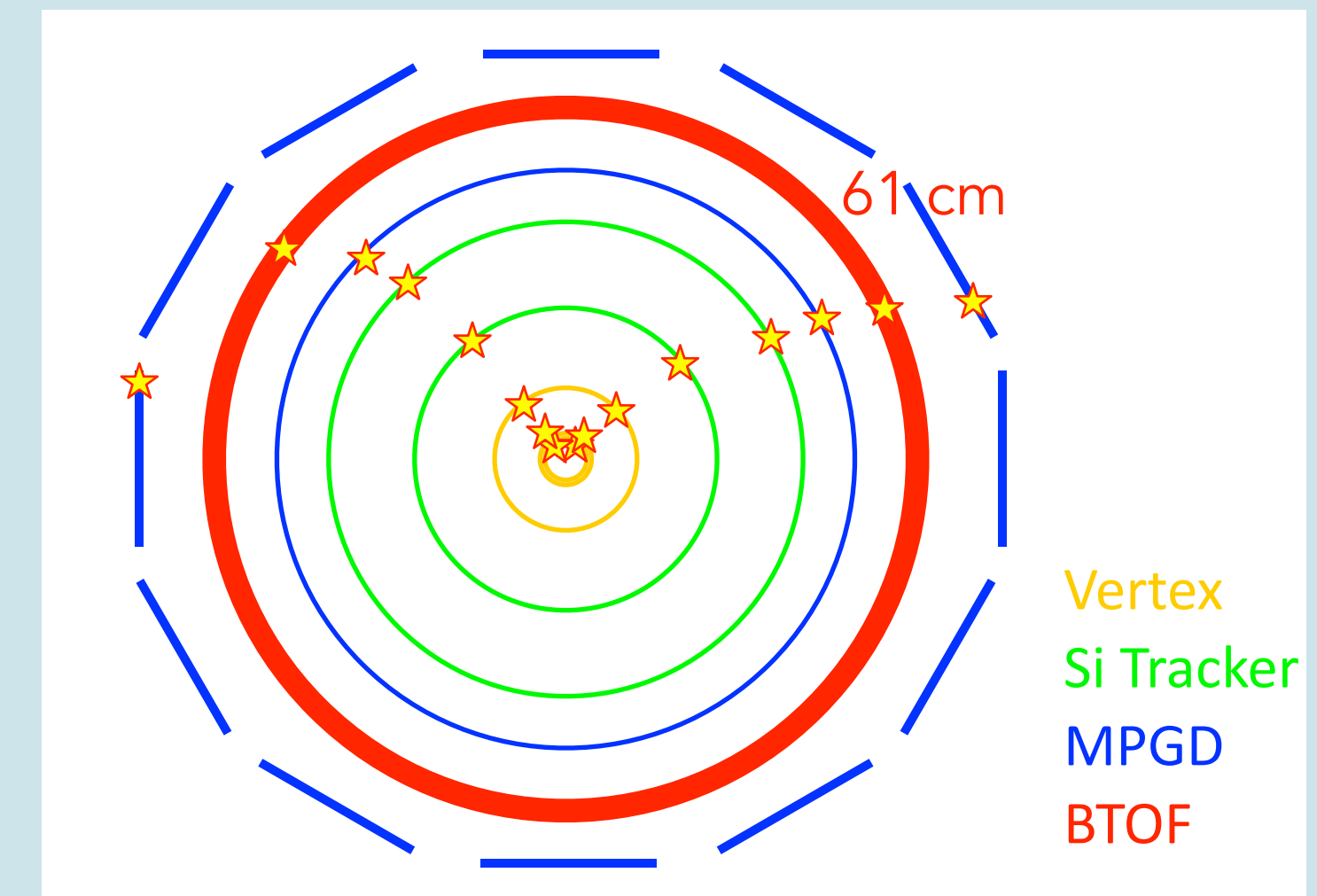# TOF in the ePIC detector

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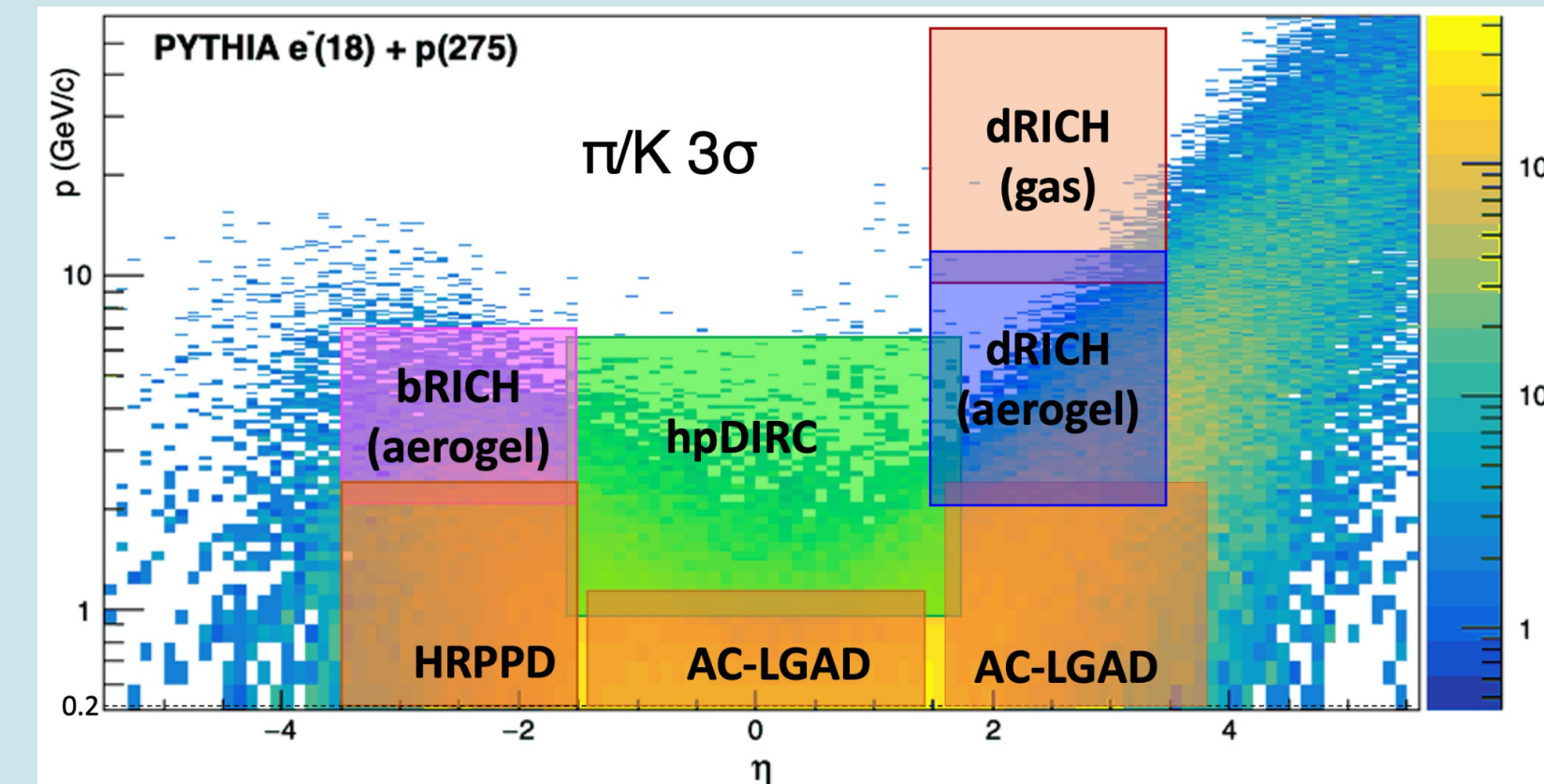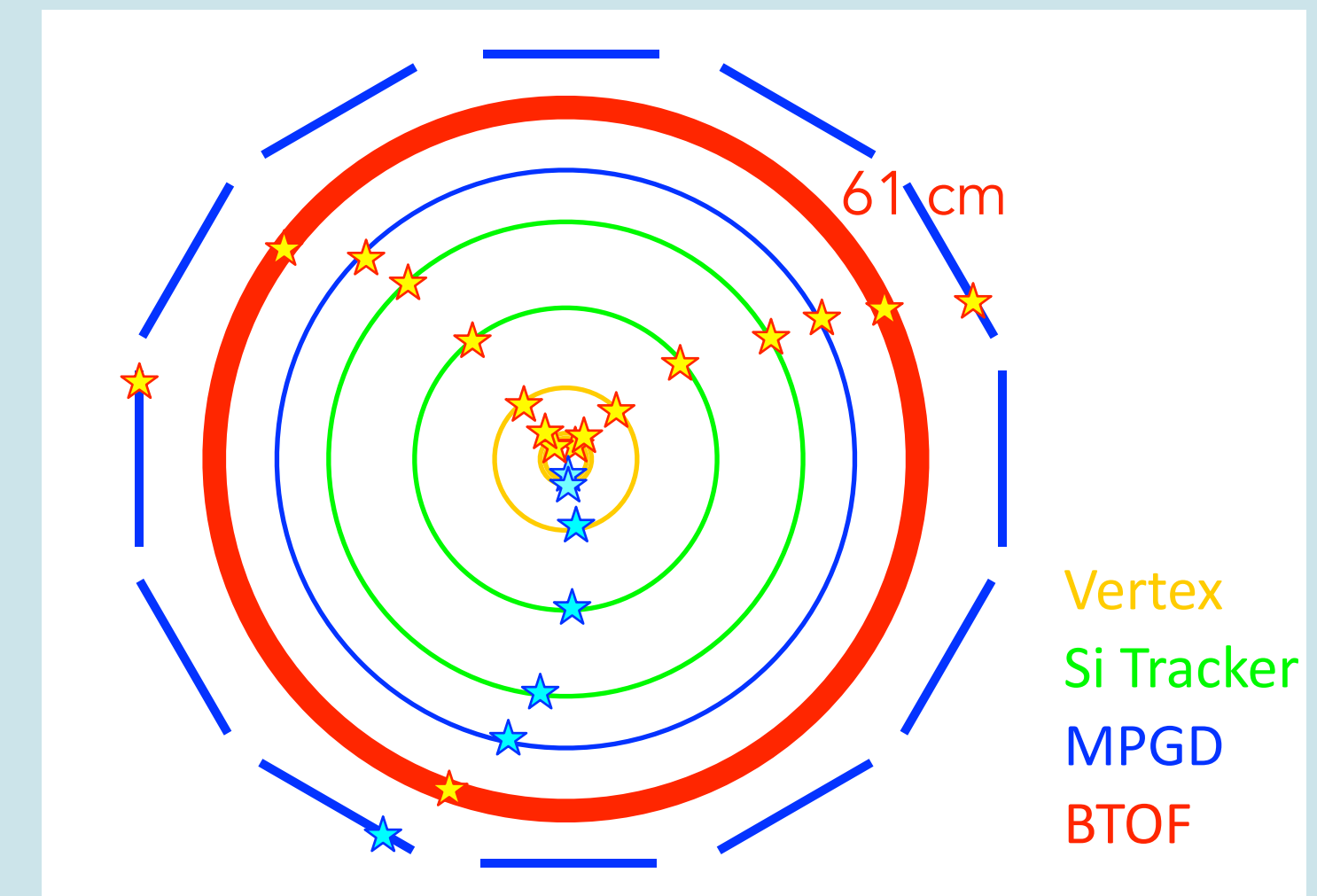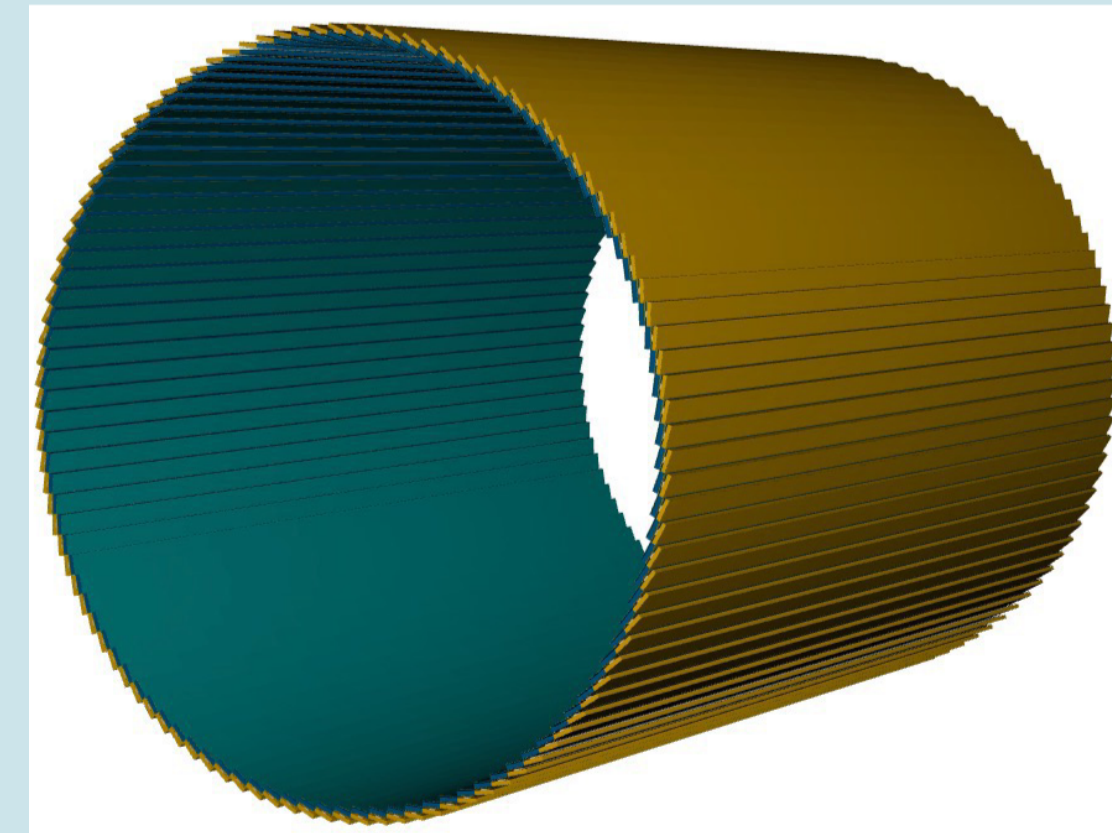**Tracking detectors in ePIC**

Detector Layout

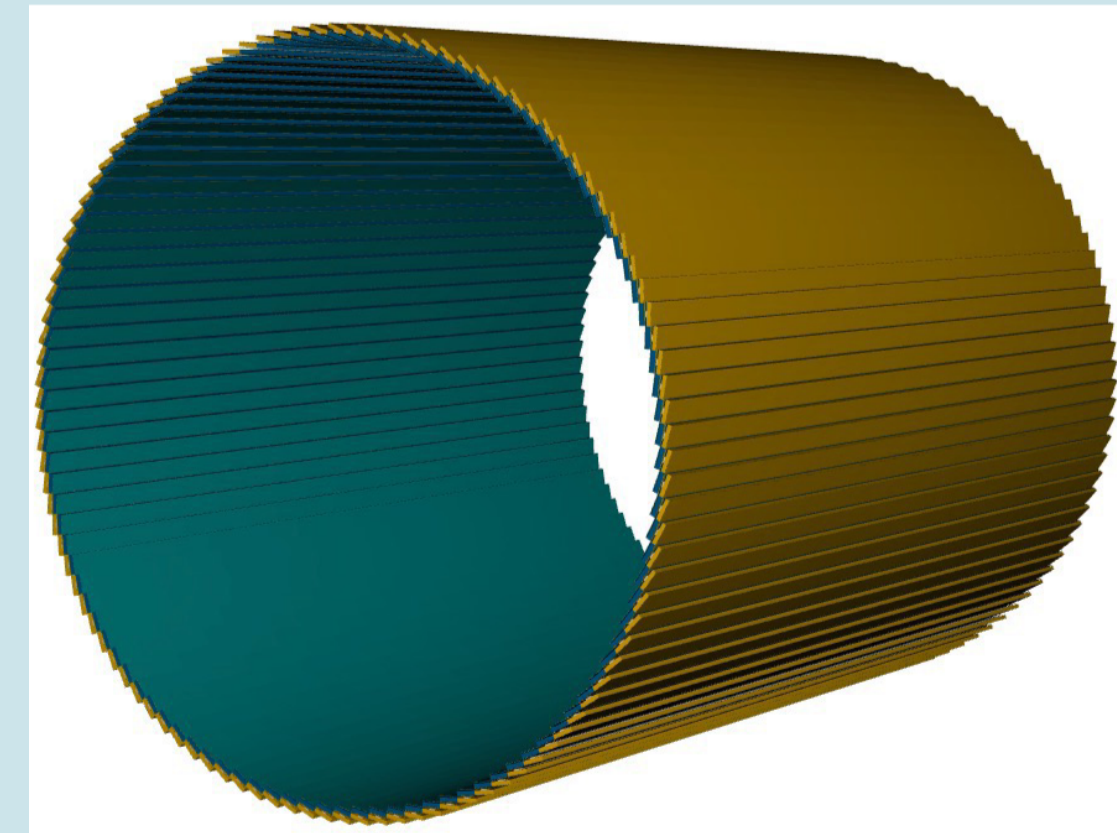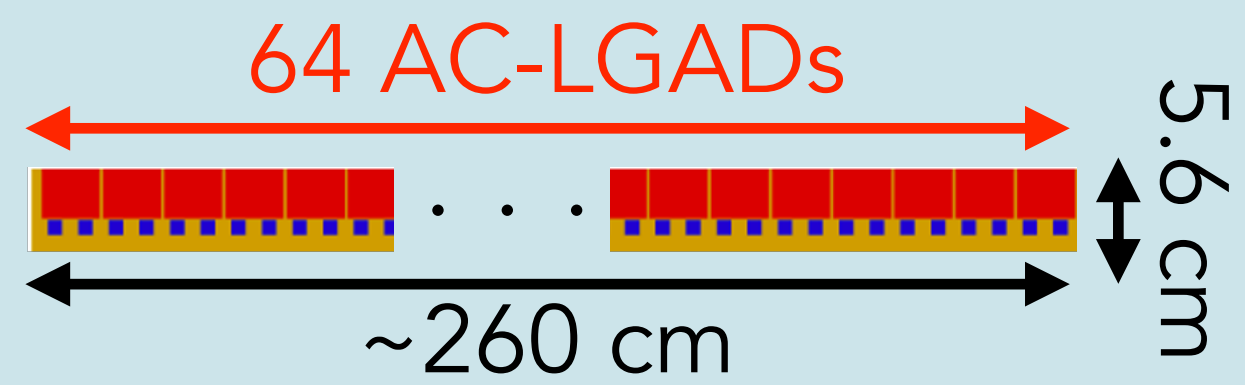- BTOF is composed of stave like structure to make a cylindric

BTOF shape

Detector Layout

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BTOF shape

Module top view

64 AC-LGADs

5.6 cm

~260 cm

Detector Layout

- BTOF is composed of stave like structure to make a cylindric
- Radius is 60 - 63 cm from the beam pipe covering -117<z<171 cm

BTOF shape

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64 AC-LGADs

5.6 cm

~260 cm

Cylindrical structure by modules

3 mm overlap in φ

63 cm

60 cm
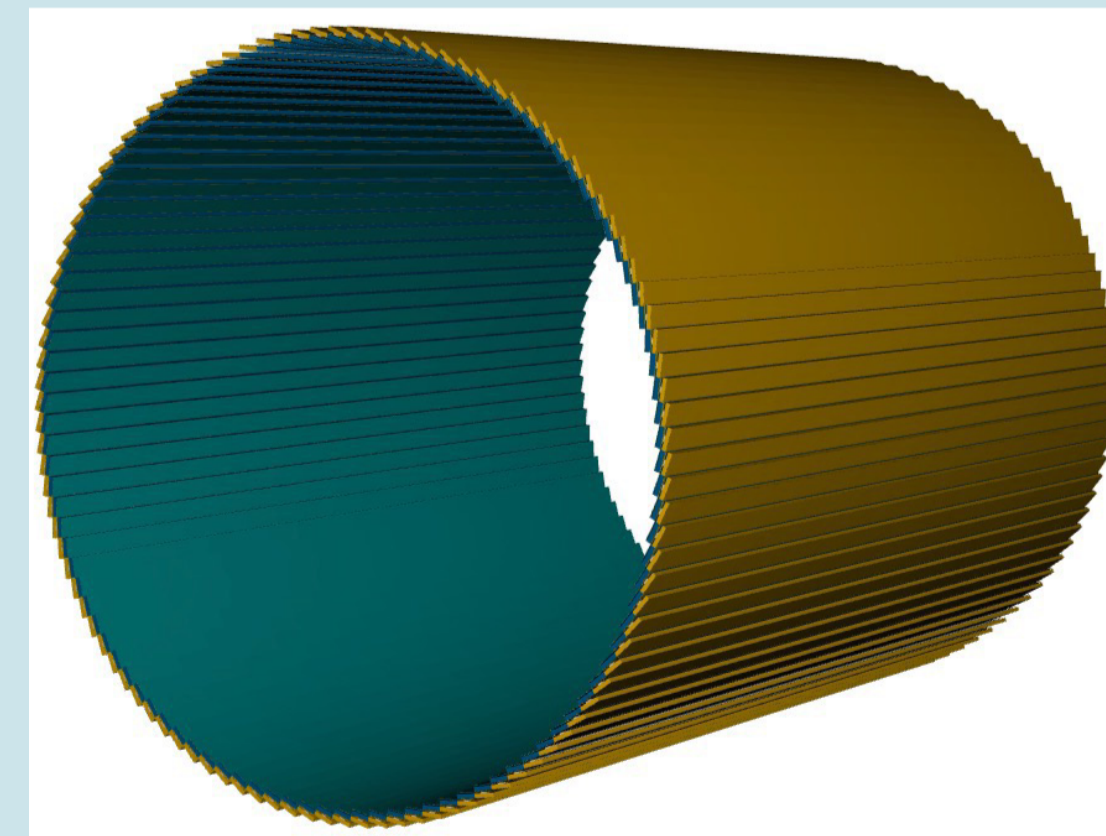
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BTOF shape

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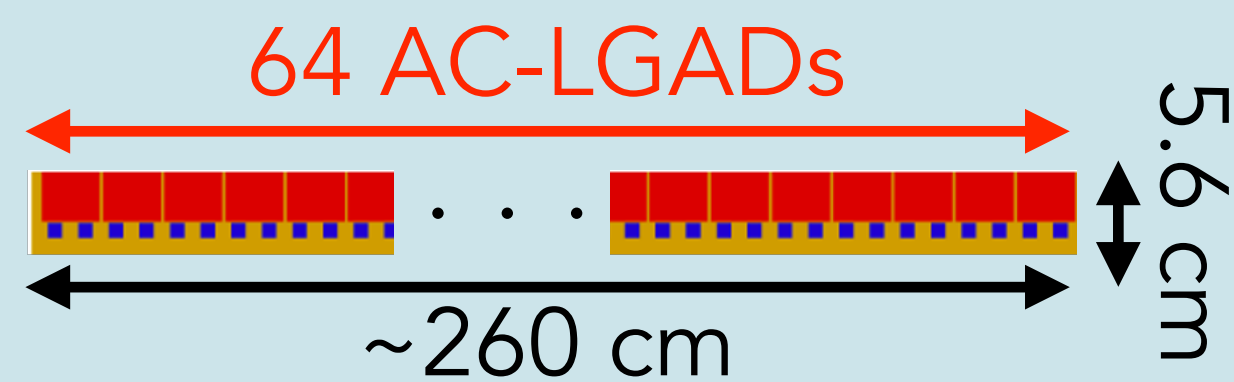
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Material budget of BTOF

Detector Layout

- BTOF is composed of stave like structure to make a cylindric

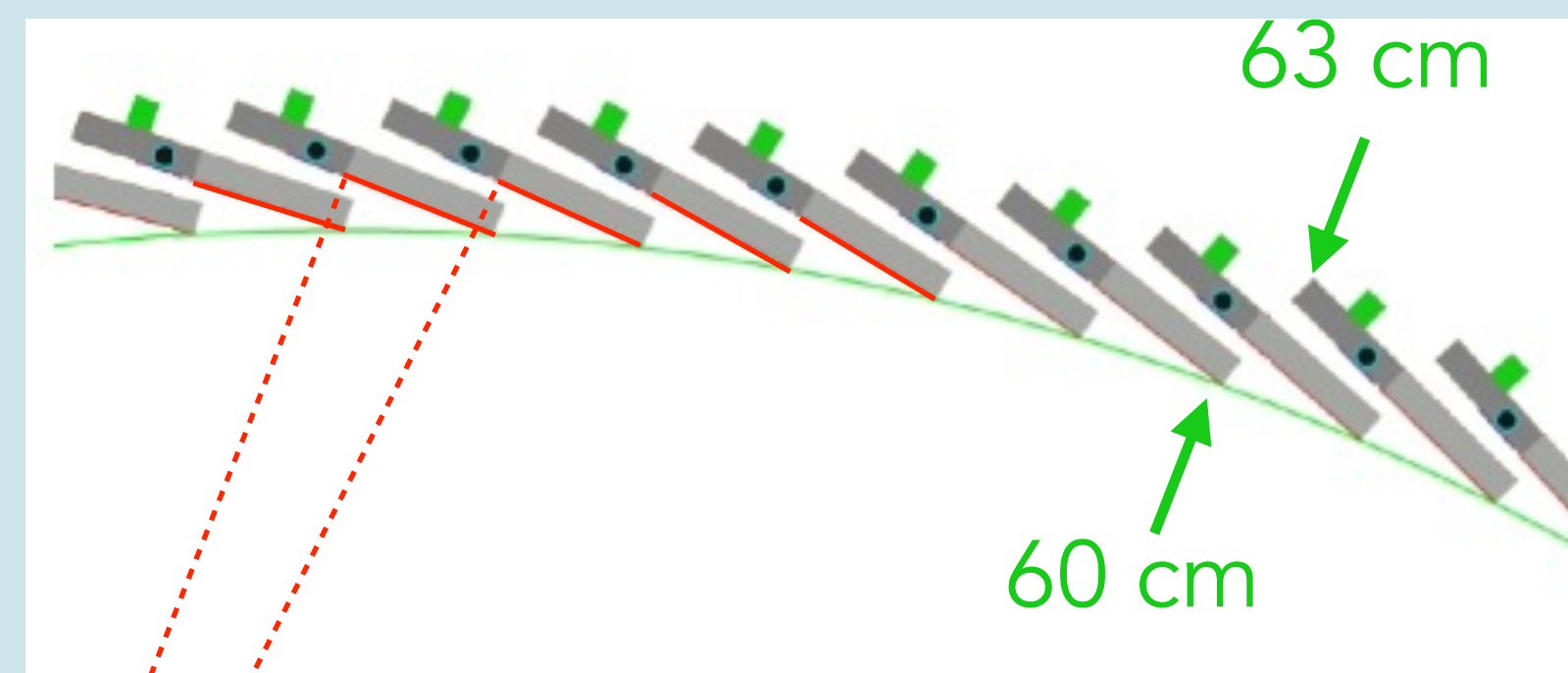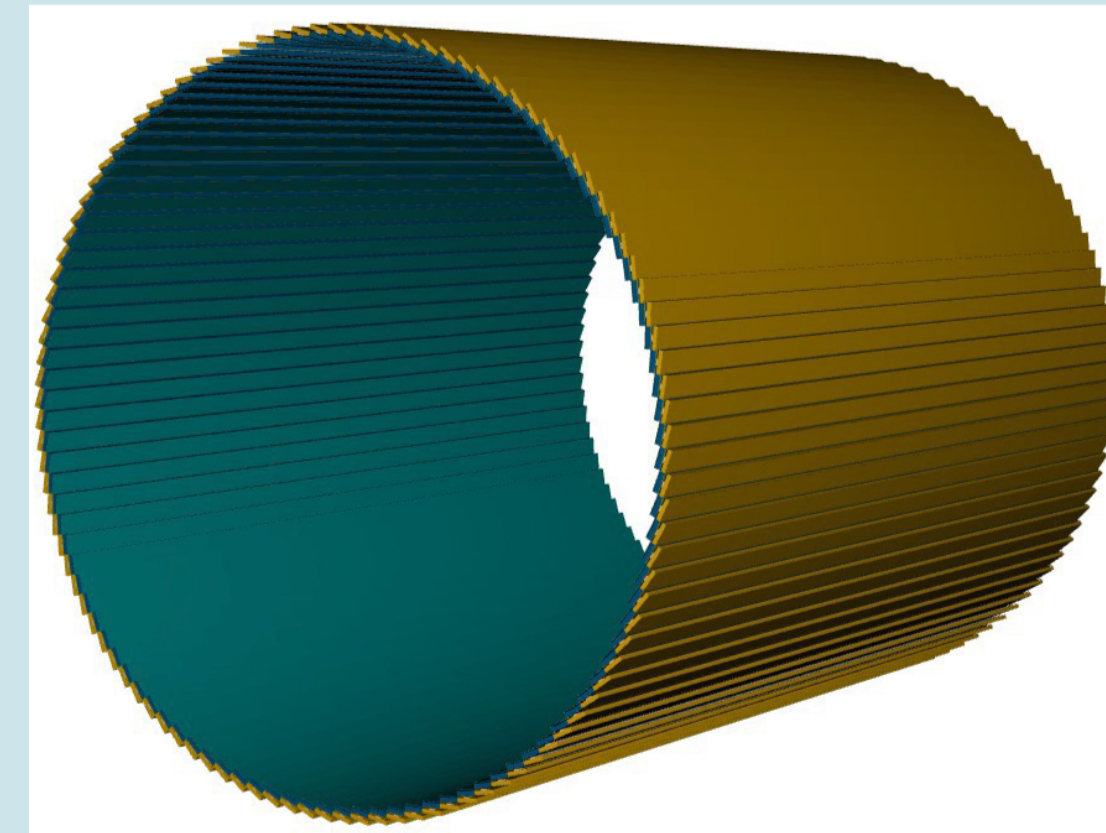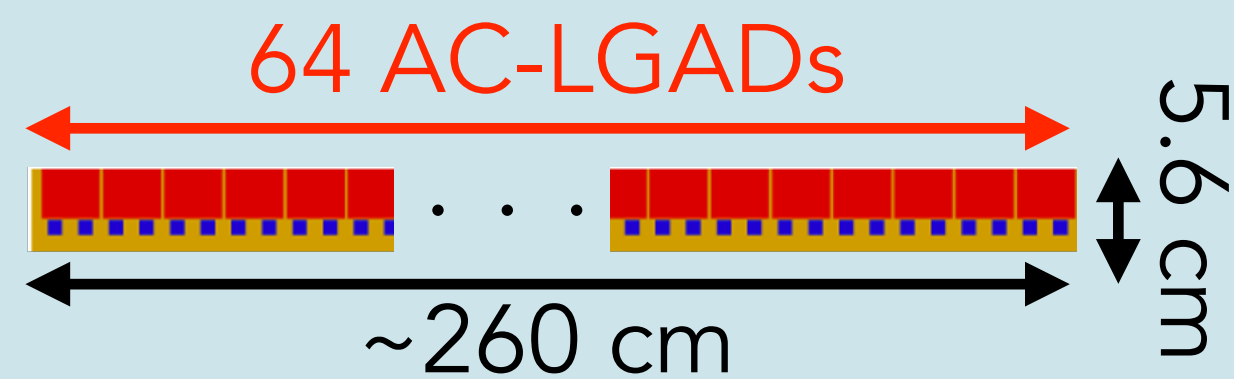- Radius is 60 - 63 cm from the beam pipe covering -117<z<171 cm

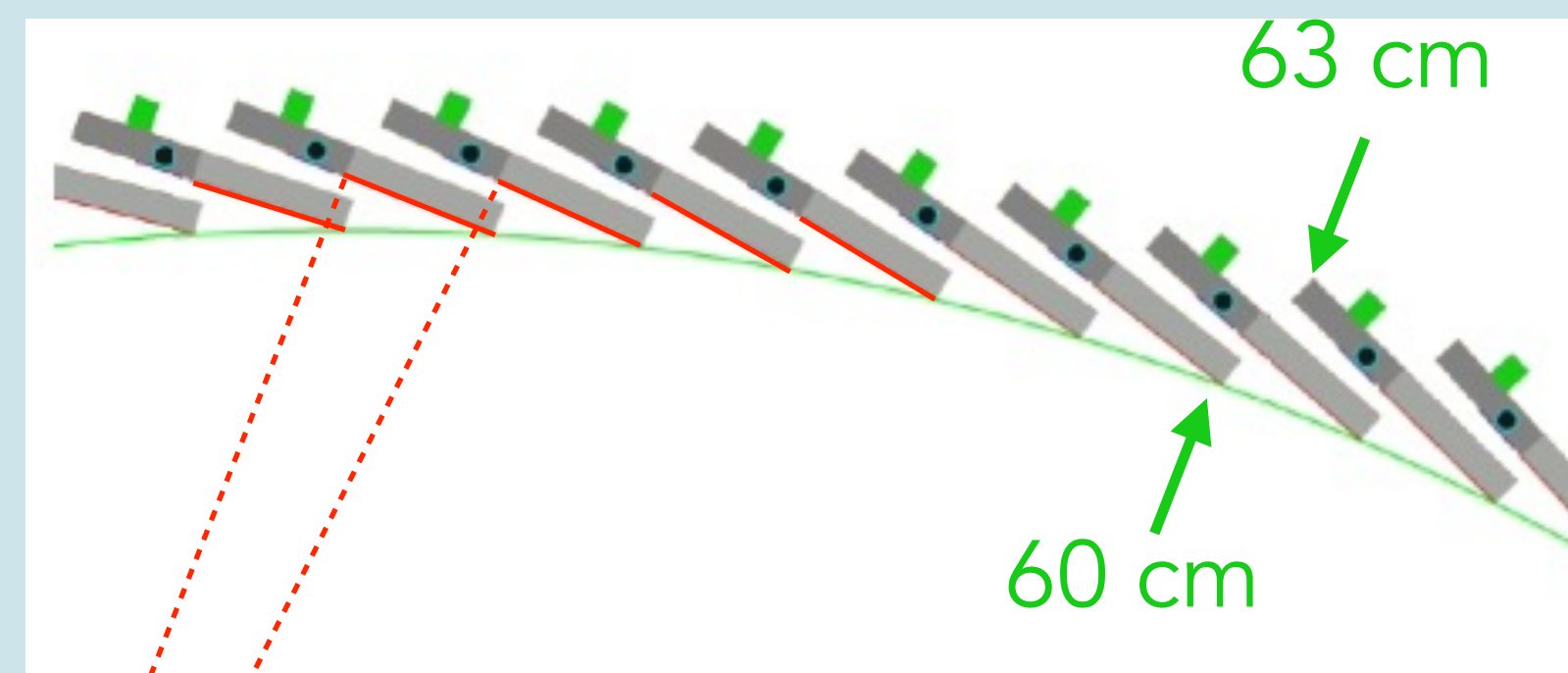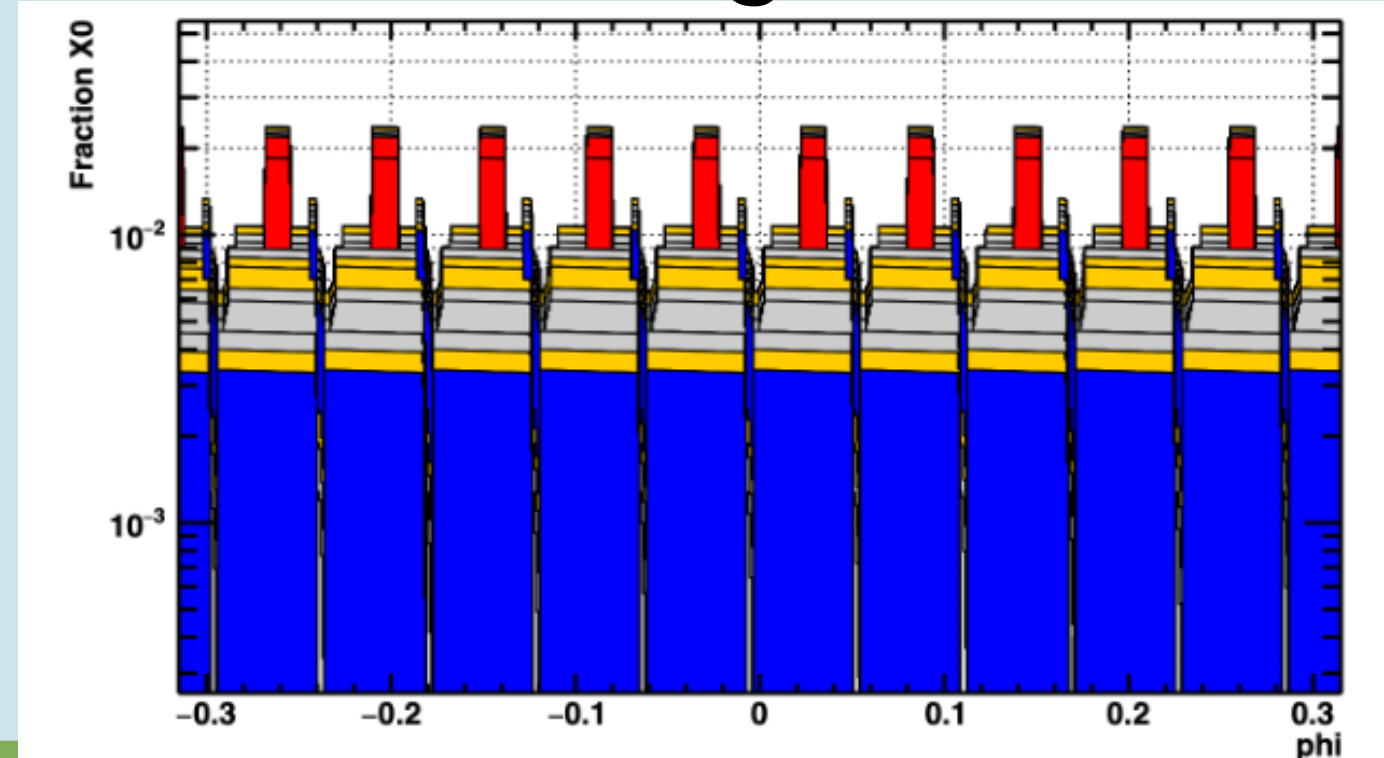- Total material budget in acceptance is 0.01 X/X_0

- FTOF is composed of modules to make a disk

- Radius is 8 - 67 cm from the beam pipe covering 1.74 < η < 3.83

- Total material budget in acceptance is 0.025 X/X_0

BTOF shape
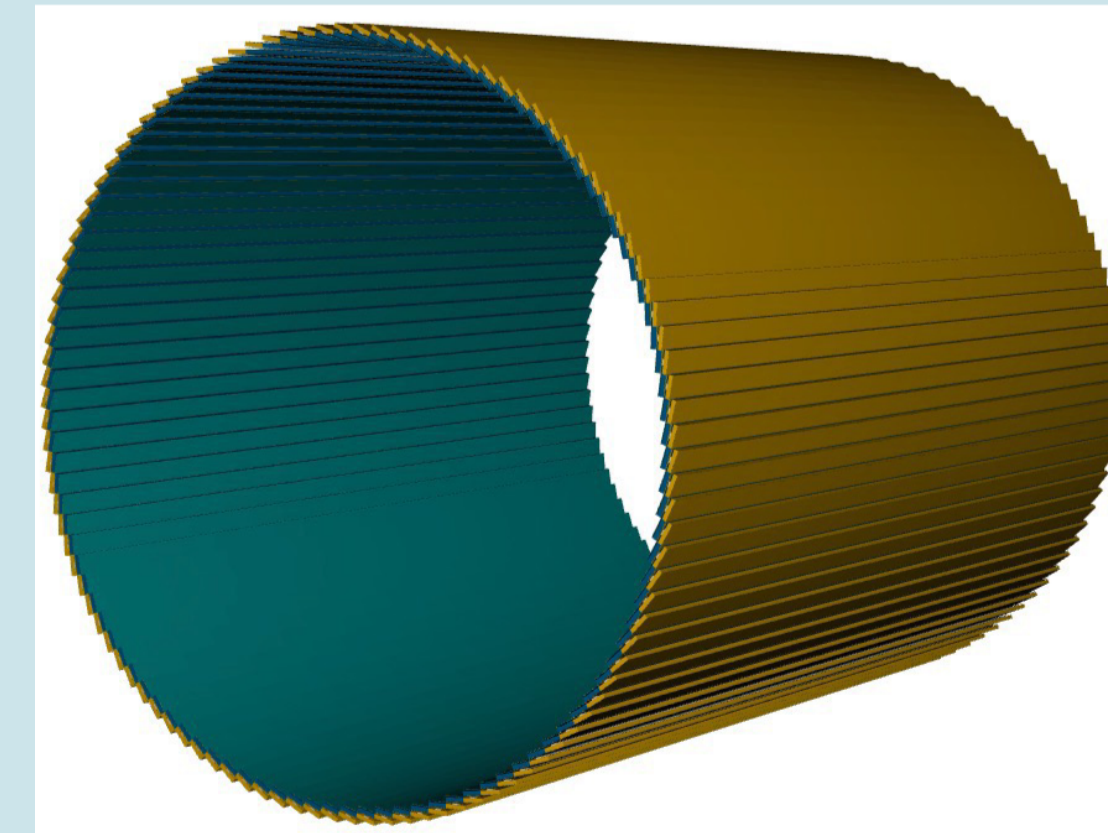
FTOF shape

Module top view

64 AC-LGADs

5.6 cm

~260 cm

Cylindrical structure by modules

3 mm overlap in Φ

63 cm

60 cm
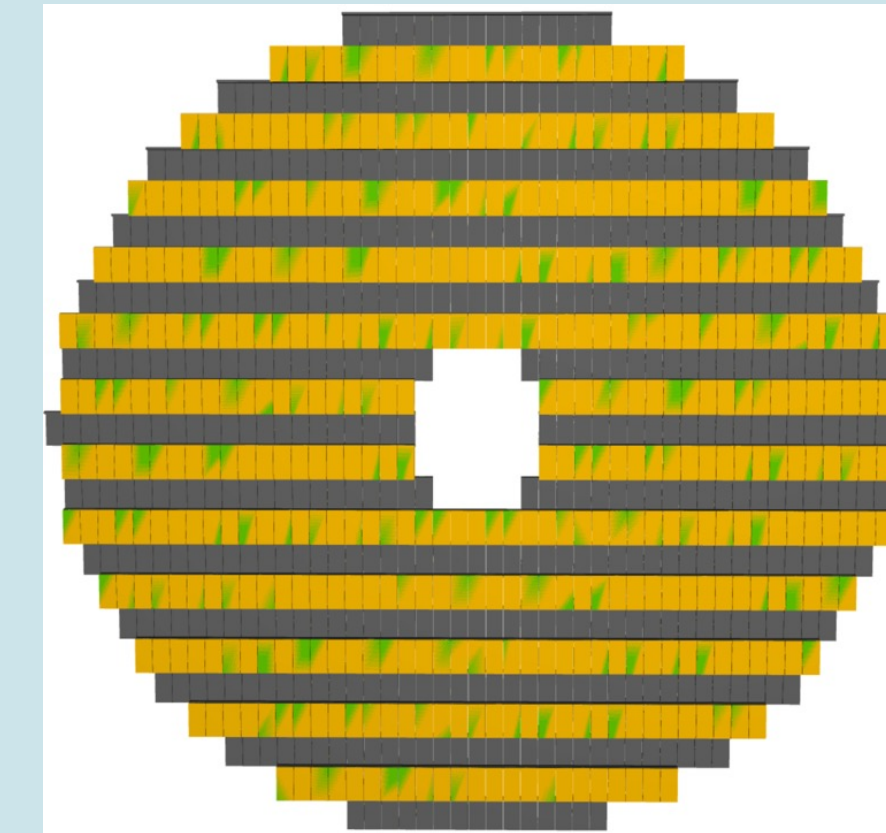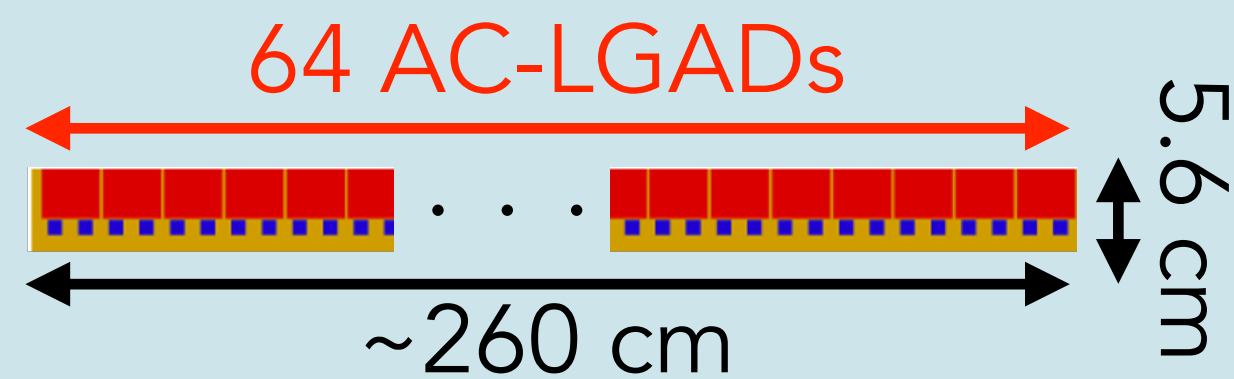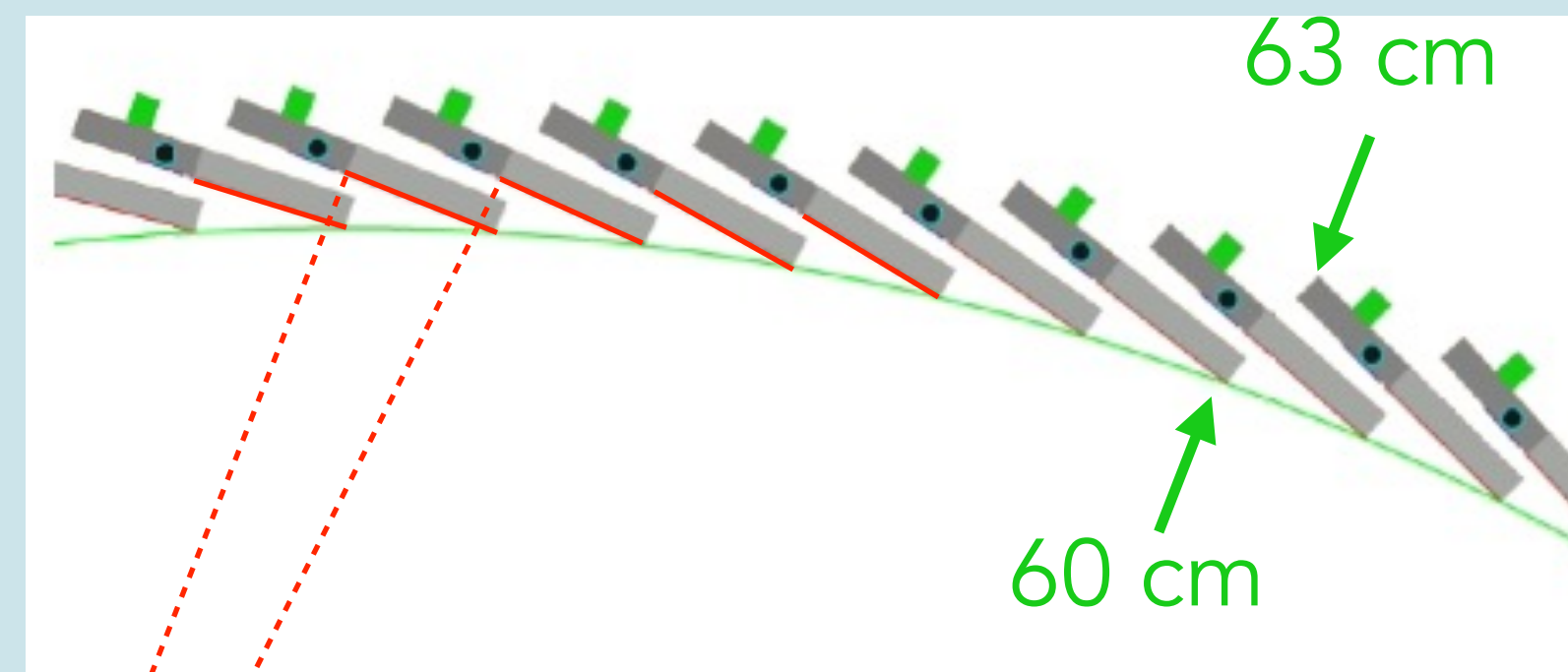
Material budget of BTOF

Momentum resolution of Craterlake
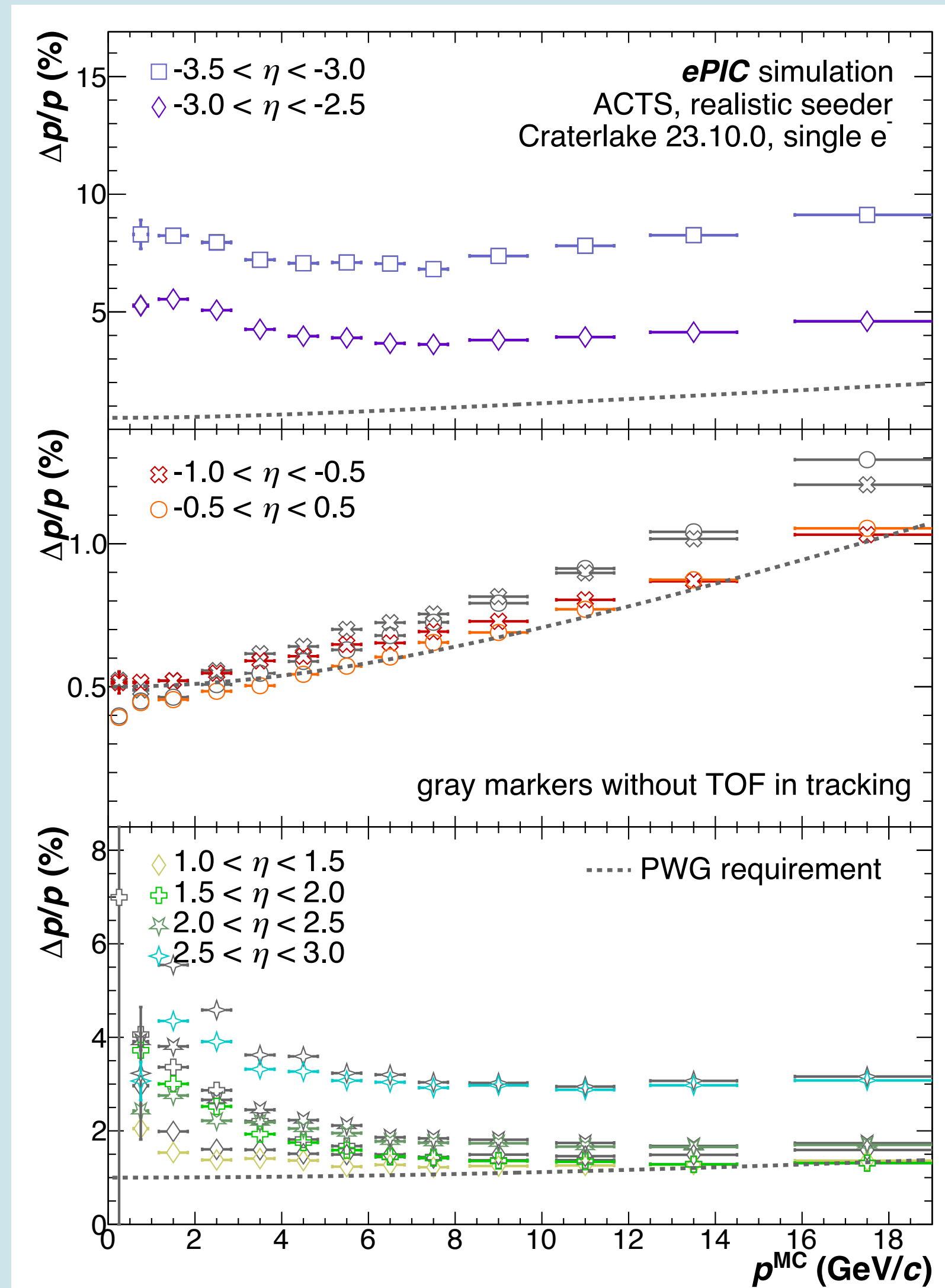
3

Momentum resolution of Craterlake
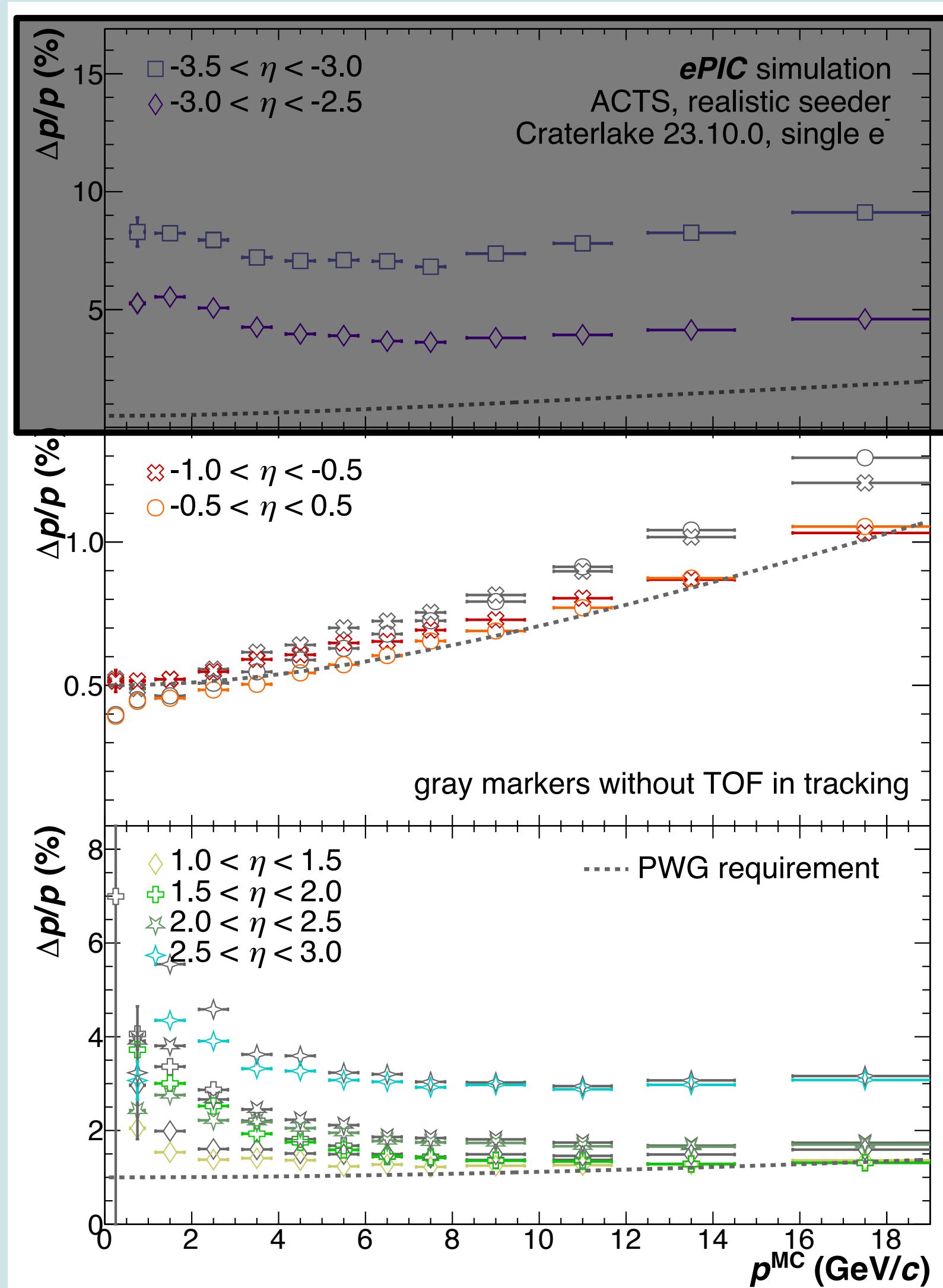
Momentum resolution of Craterlake

From Nicolas Schmidt (ORNL)'s presentation
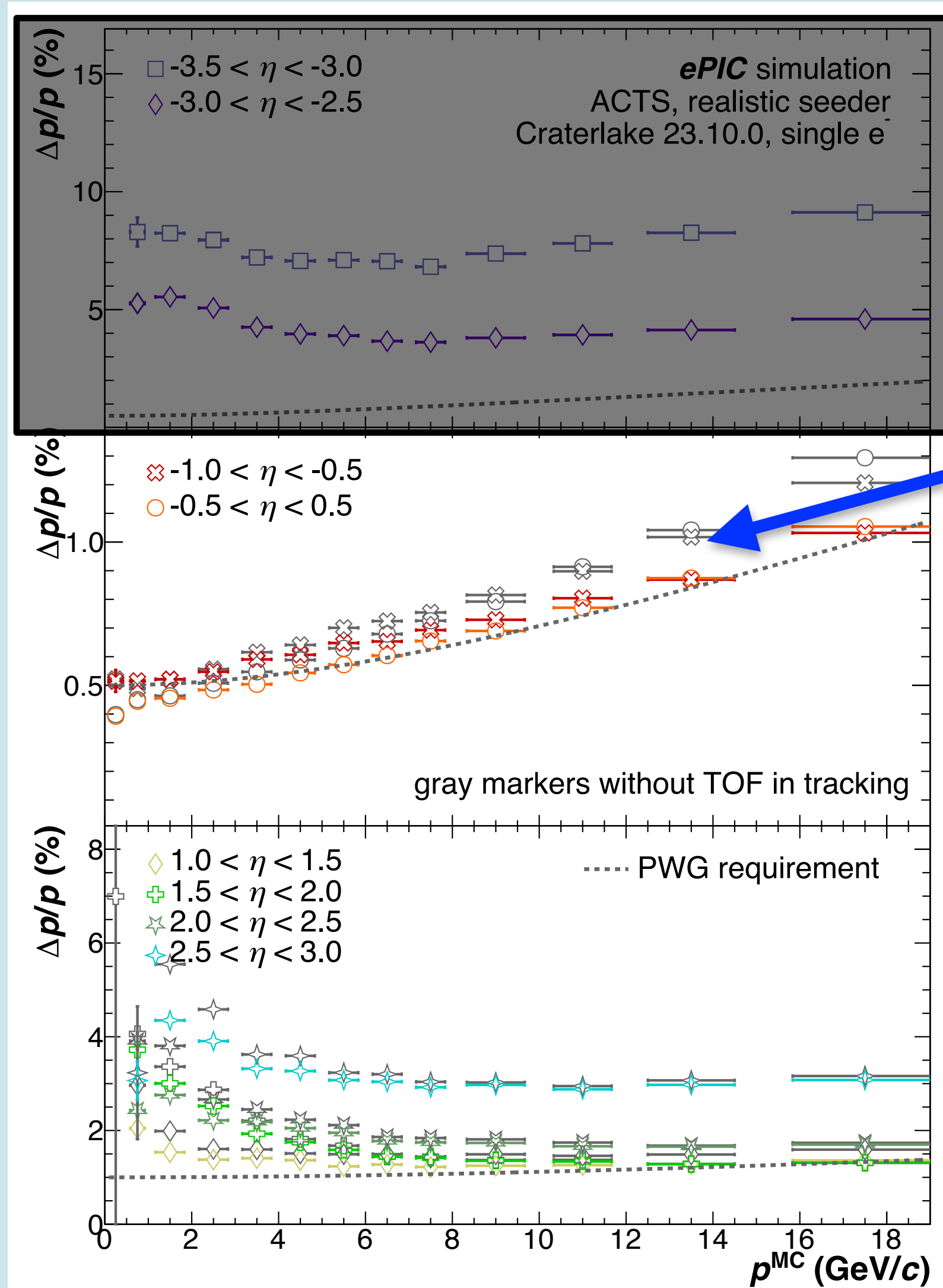
- High momentum particle momentum resolution is improved by BTOF

Momentum resolution of Craterlake

From Nicolas Schmidt (ORNL)'s presentation
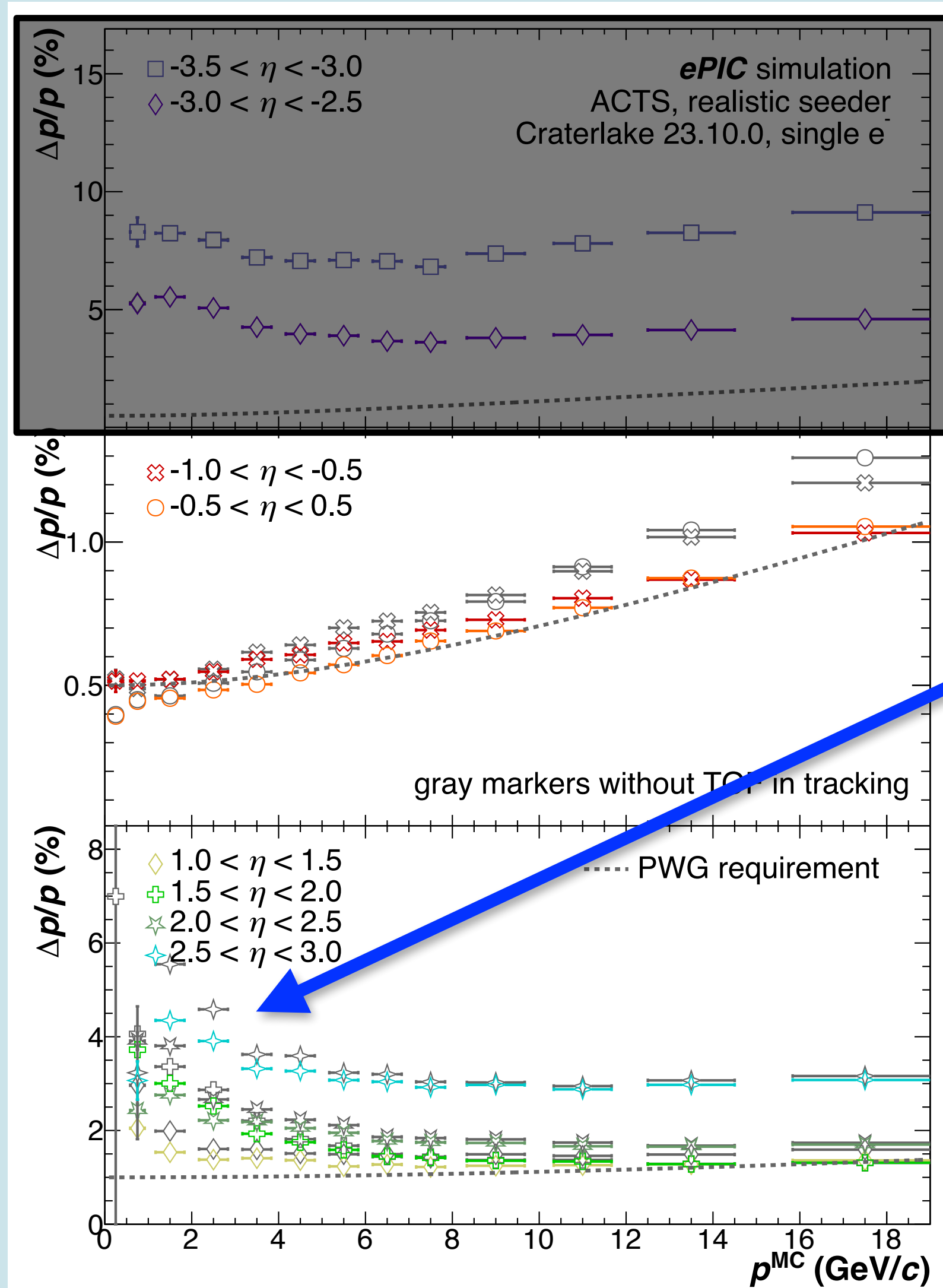
- High momentum particle momentum resolution is improved by BTOF
- Low momentum performance is improved at the forward rapidity

Angular resolution of Craterlake

$$C = \begin{bmatrix} \sigma^2(l_0) & \text{cov}(l_0, l_1) & \text{cov}(l_0, \phi) & \text{cov}(l_0, \theta) & \text{cov}(l_0, q/p) \\ . & \sigma^2(l_1) & \text{cov}(l_1, \phi) & \text{cov}(l_1, \theta) & \text{cov}(l_1, q/p) \\ . & . & \sigma^2(\phi) & \text{cov}(\phi, \theta) & \text{cov}(\phi, q/p) \\ . & . & . & \sigma^2(\theta) & \text{cov}(\theta, q/p) \\ . & . & . & . & \sigma^2(q/p) \end{bmatrix}$$
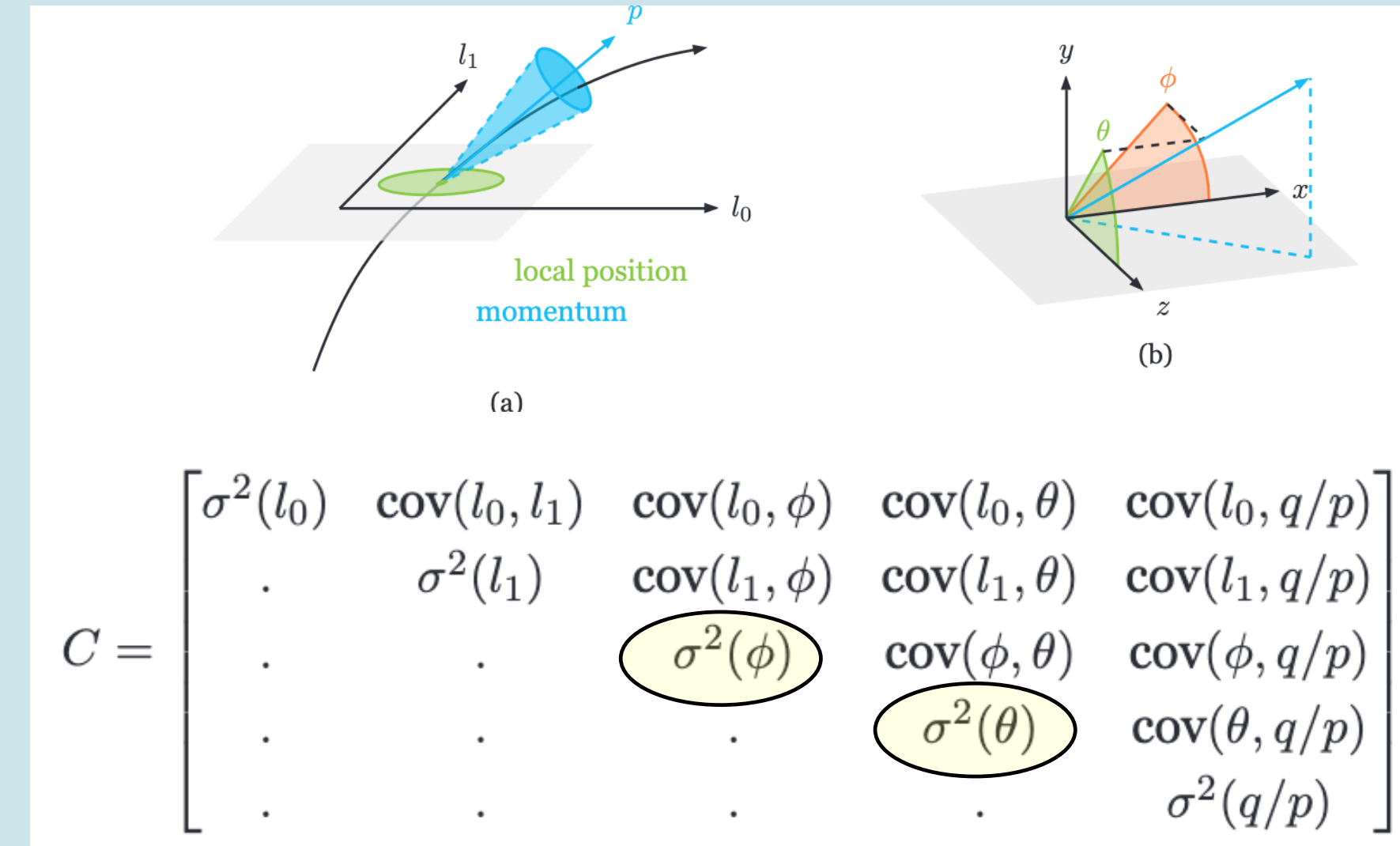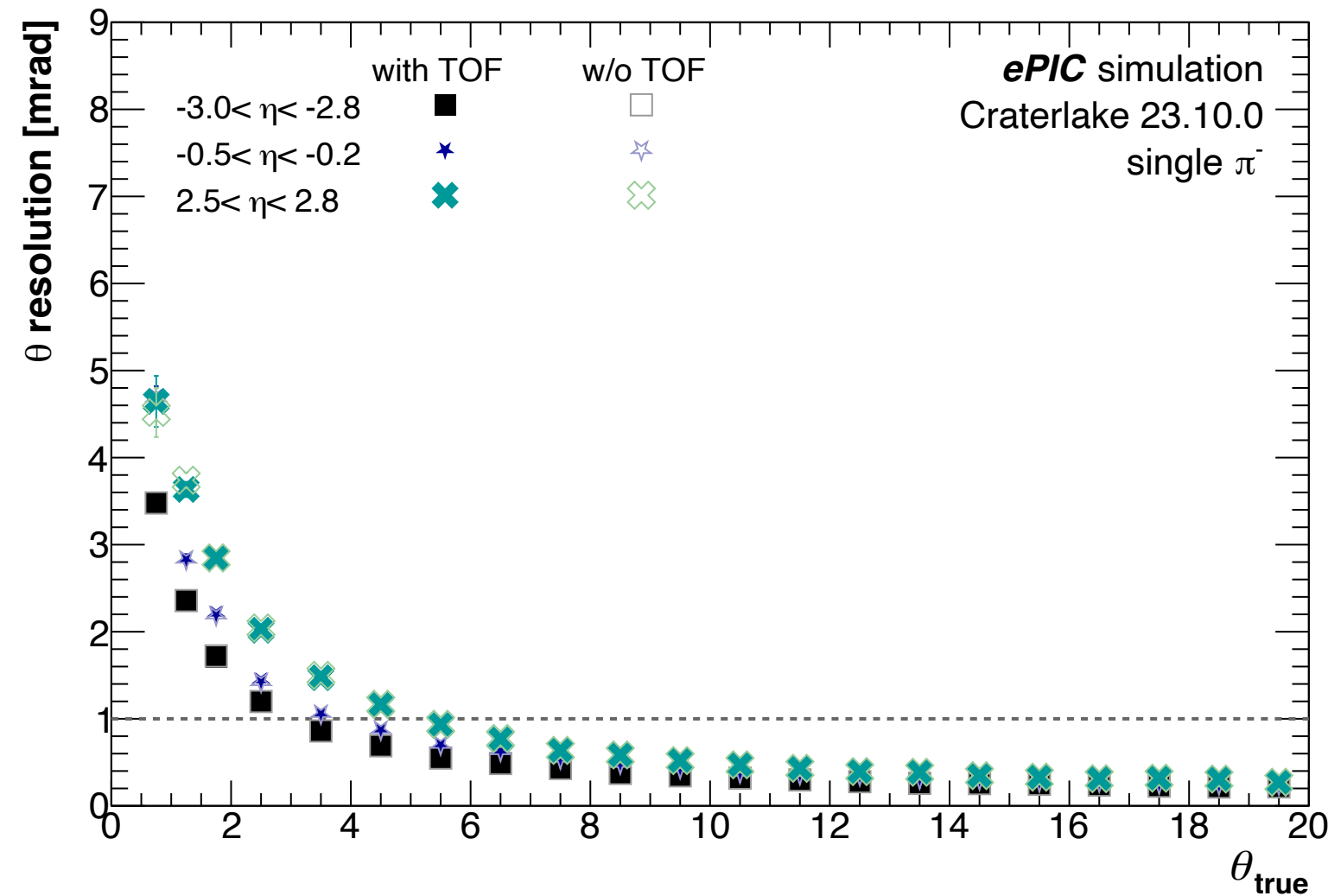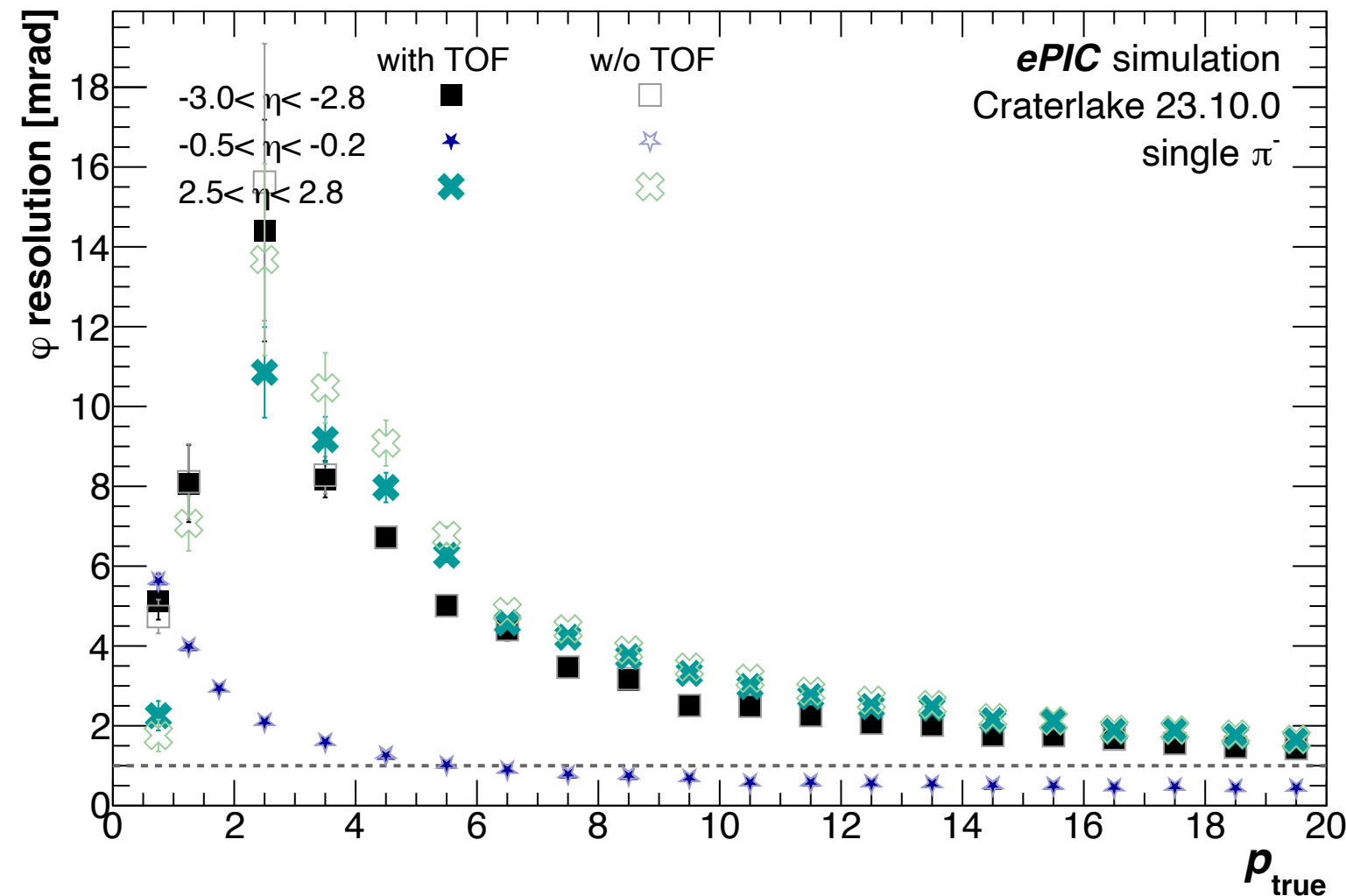
- BTOF hit doesn't have an impact on φ angle resolution, but FTOF has(?)

Angular resolution of Craterlake
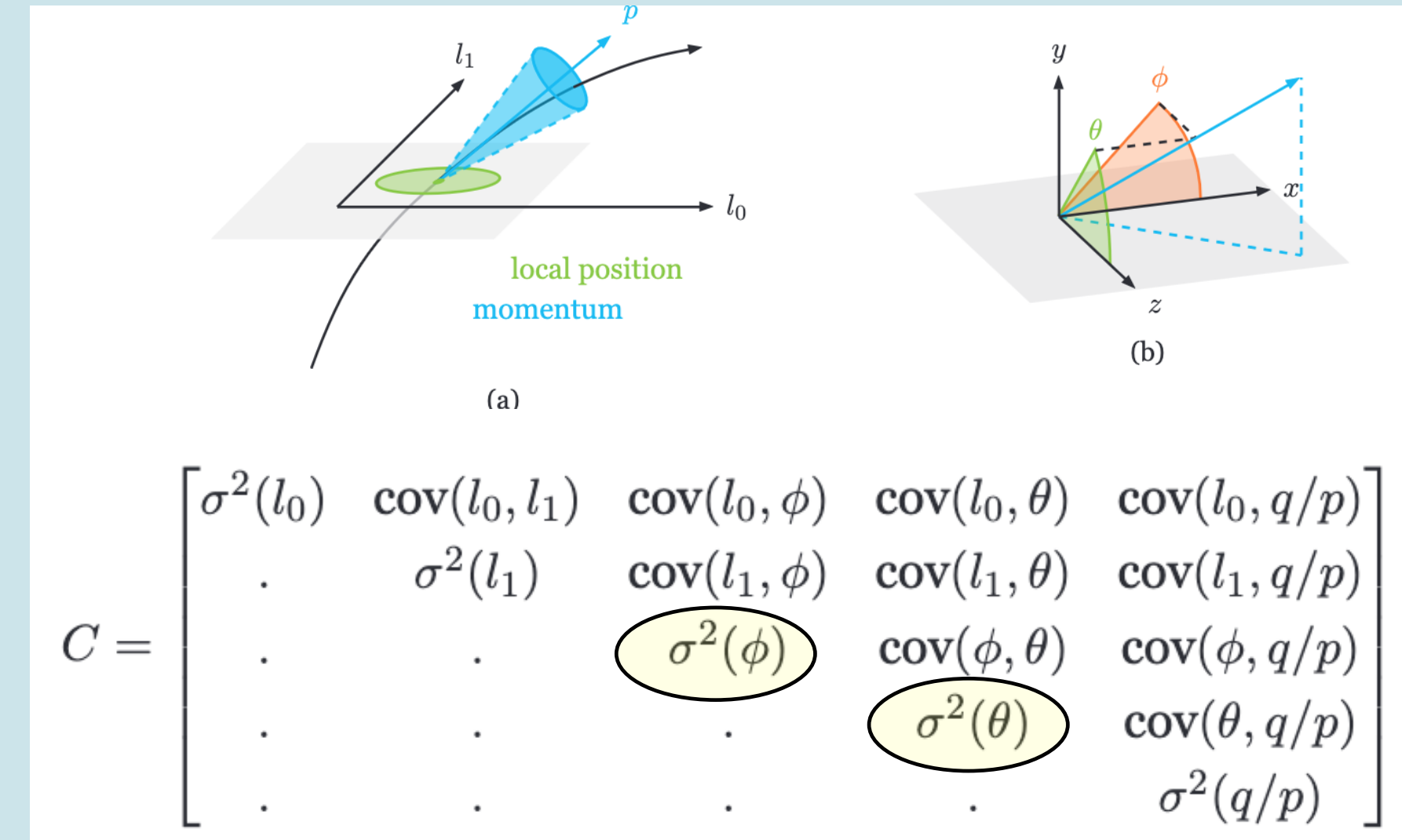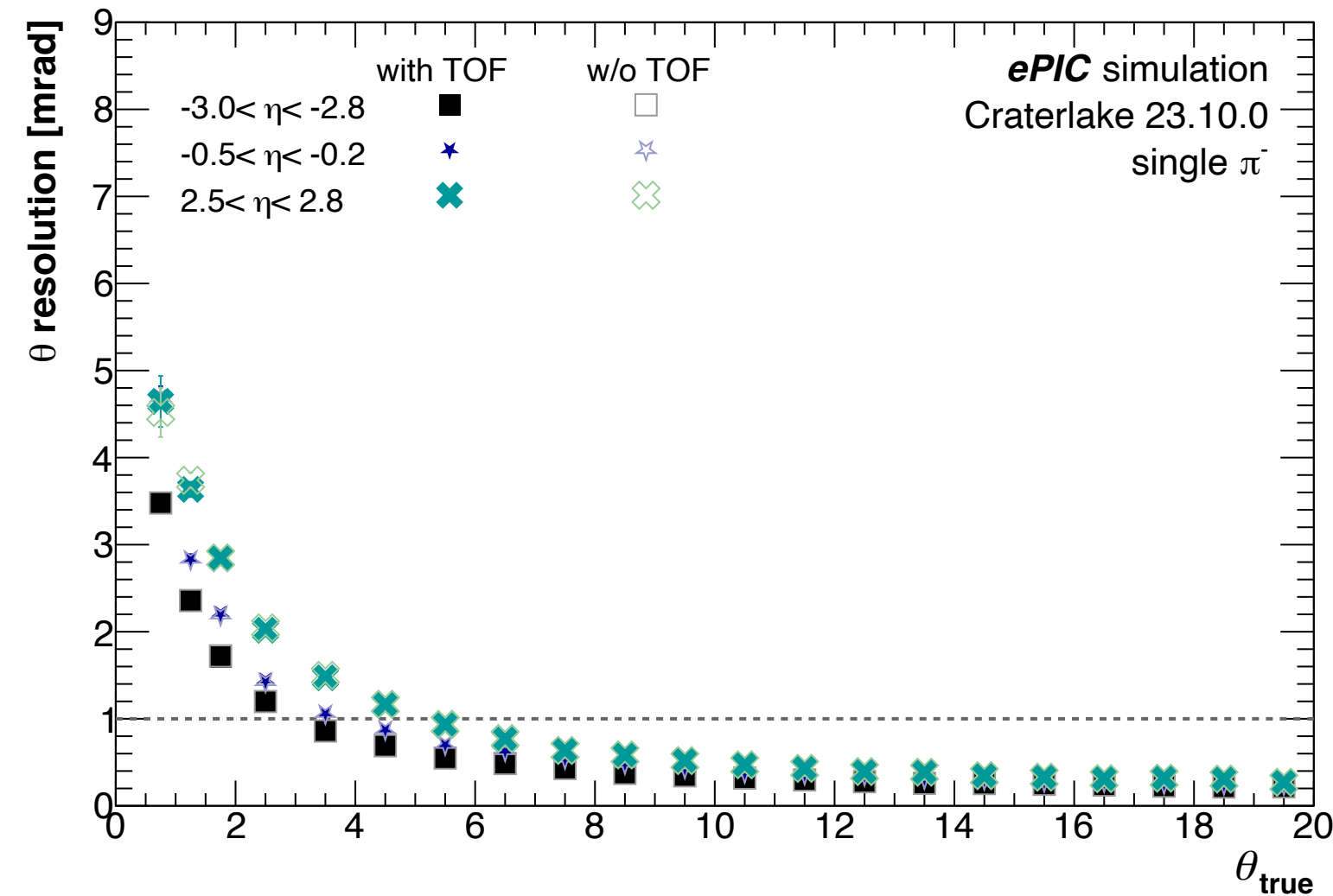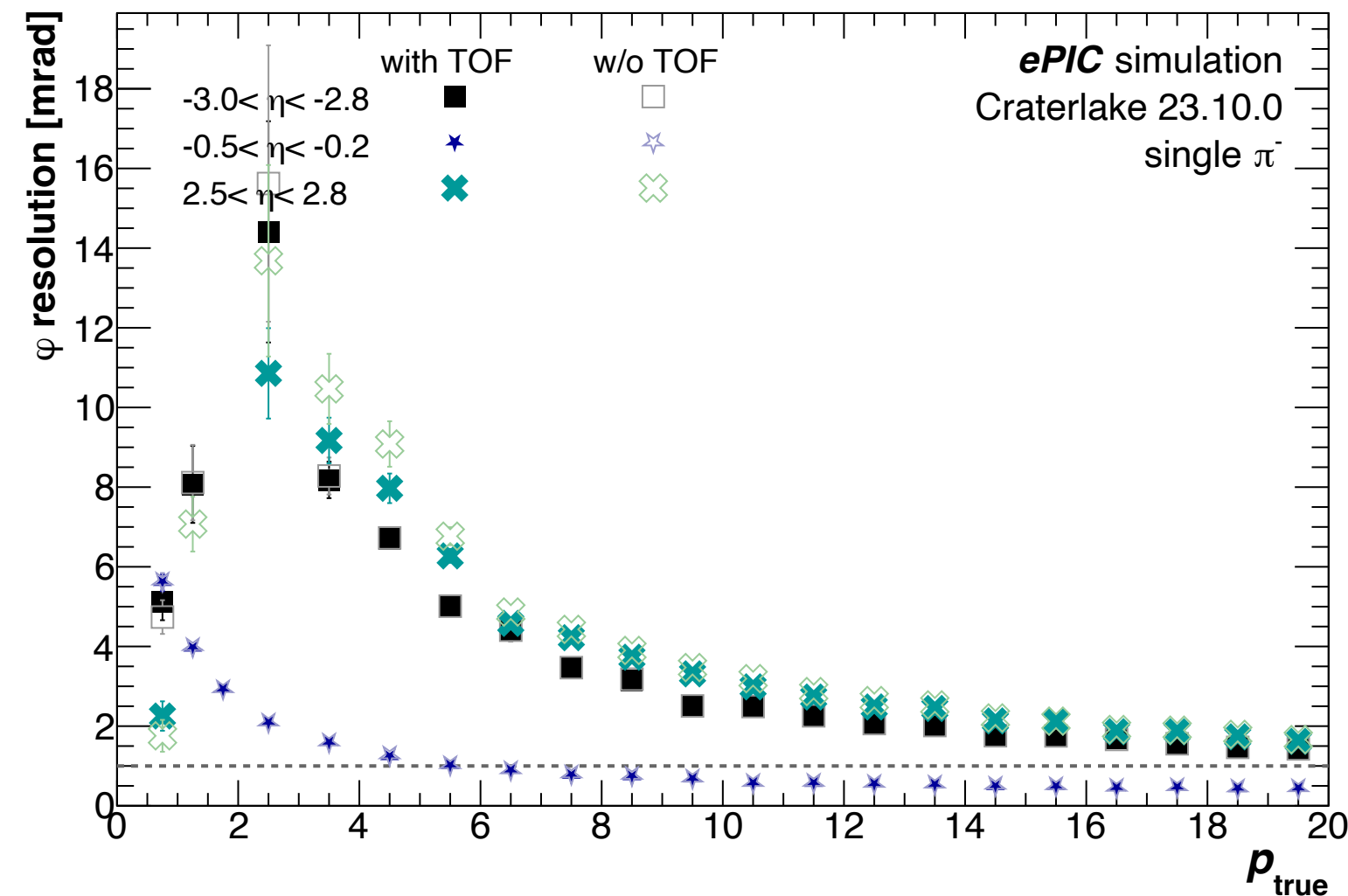
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- No impact from BTOF and FTOF in θ angle

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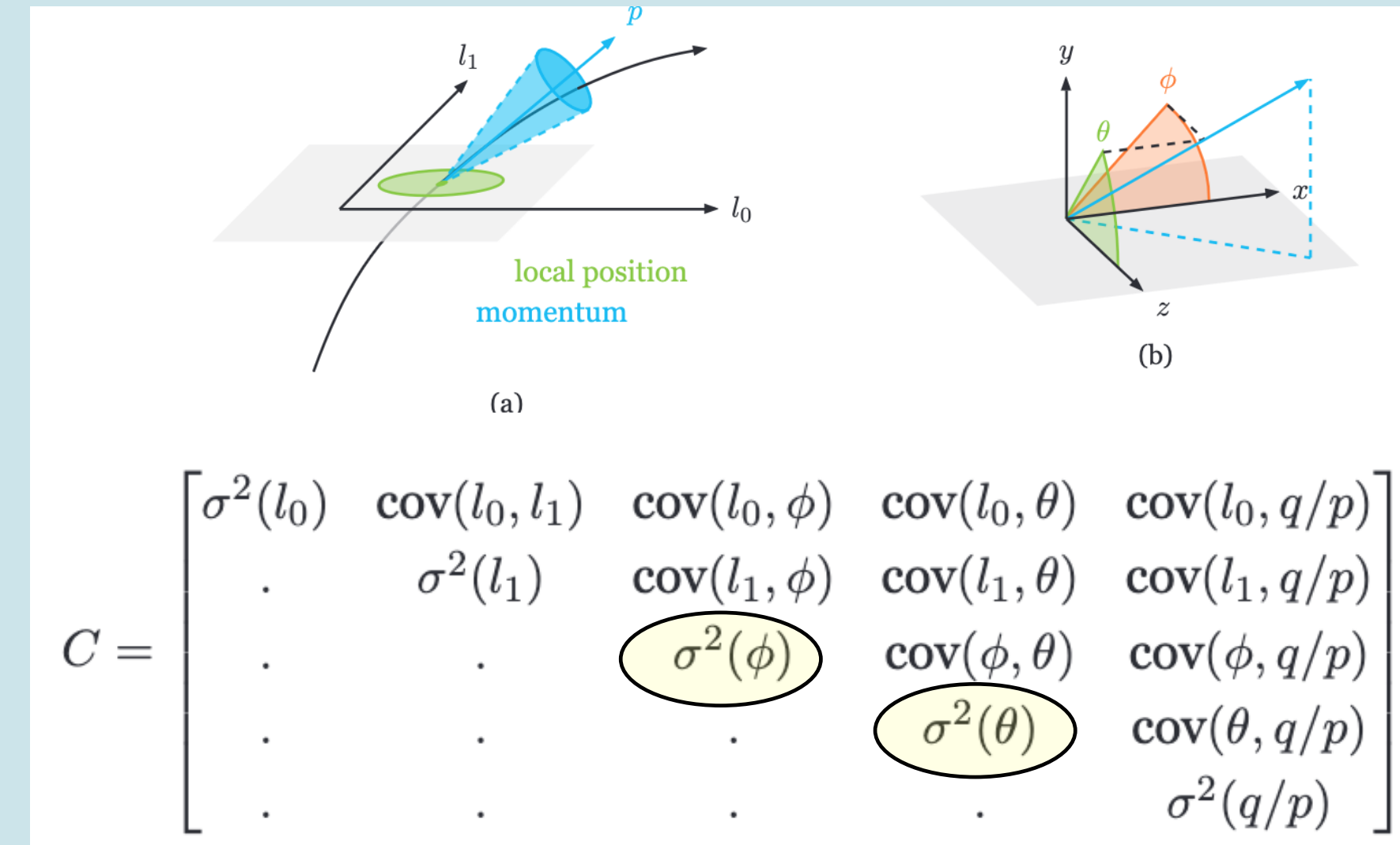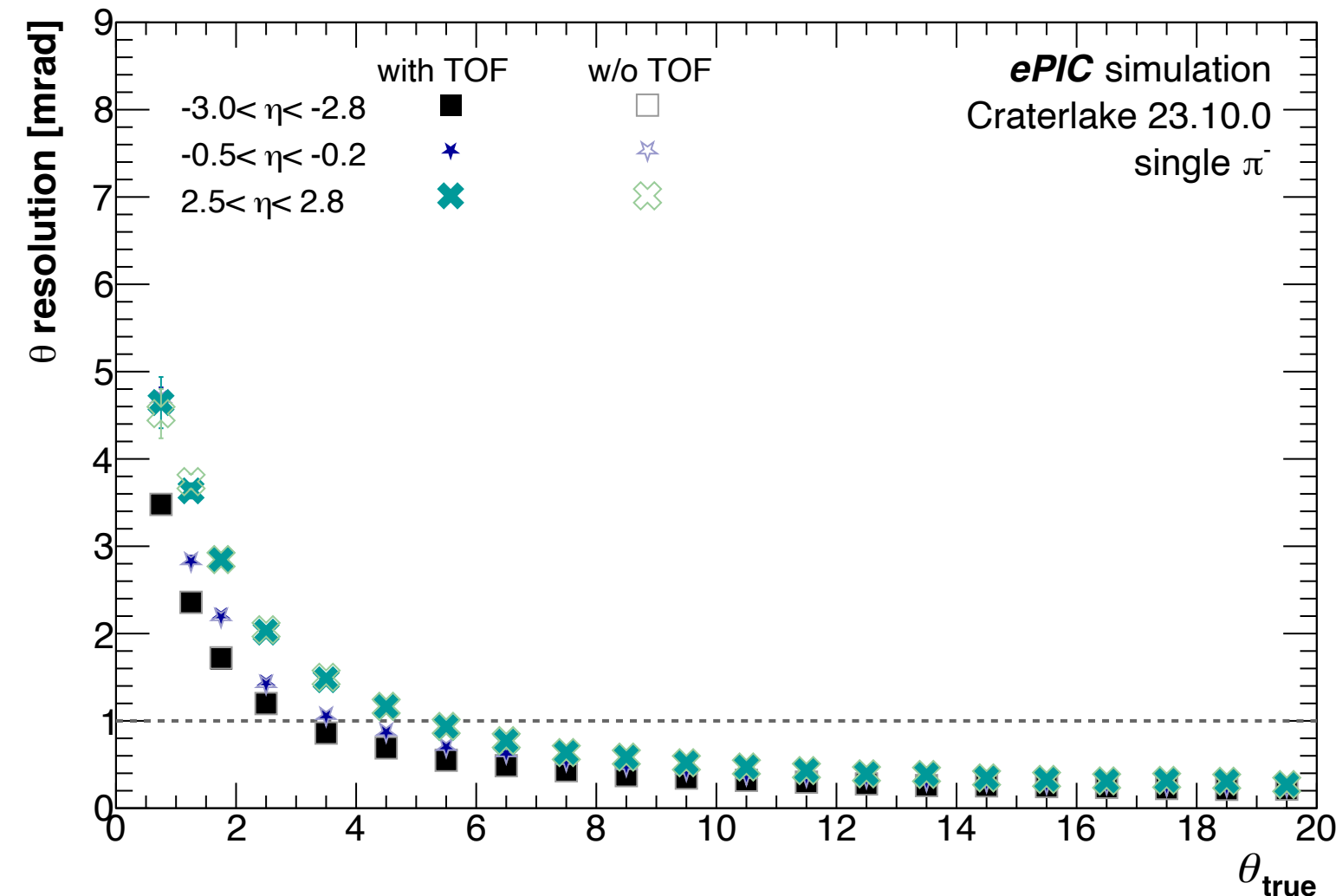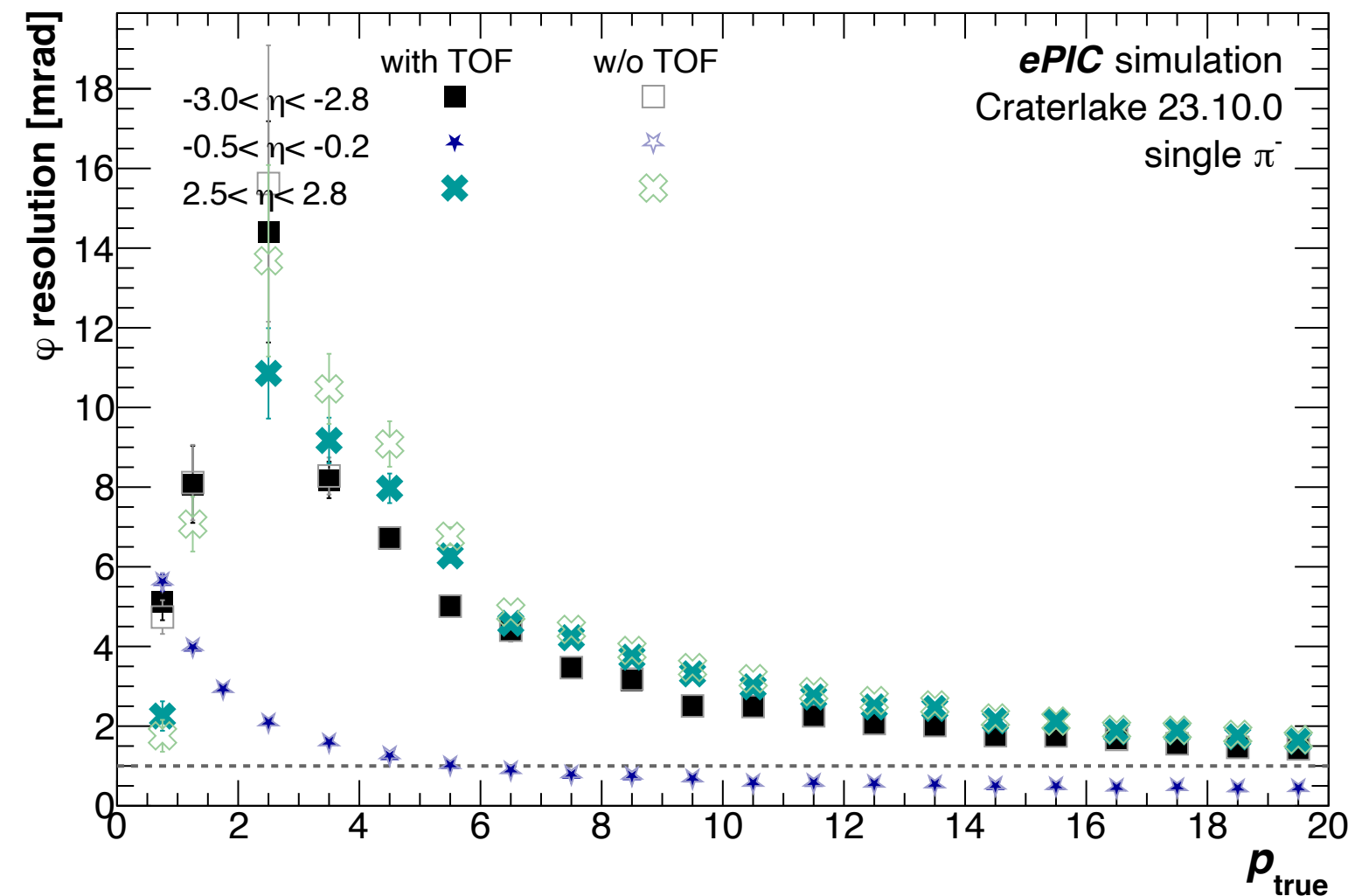
- BTOF hit doesn't have an impact on φ angle resolution, but FTOF has(?)
- No impact from BTOF and FTOF in θ angle
- A systematic study is necessary
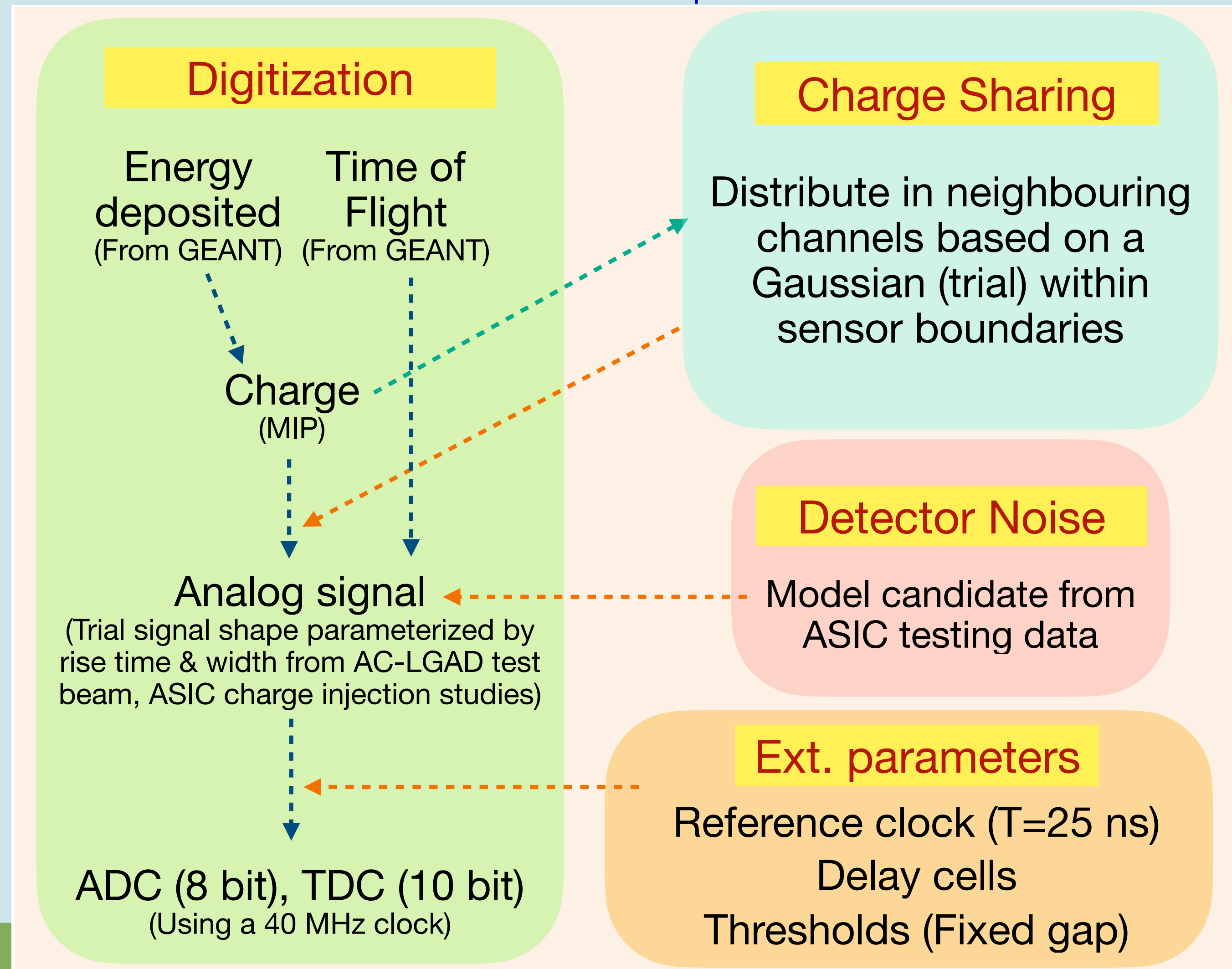
Charge sharing in the DD4hep simulation

Objectives

From Souvik Paul's presentation

Digitization

Energy deposited
(From GEANT)

Time of Flight
(From GEANT)

Charge
(MIP)

Analog signal
(Trial signal shape parameterized by rise time & width from AC-LGAD test beam, ASIC charge injection studies)

ADC (8 bit), TDC (10 bit)
(Using a 40 MHz clock)

Charge Sharing

Distribute in neighbouring channels based on a Gaussian (trial) within sensor boundaries

Detector Noise

Model candidate from ASIC testing data

Ext. parameters

Reference clock (T=25 ns)
Delay cells
Thresholds (Fixed gap)

Mimic the analog signal in the DD4hep simulation

[From Souvik Paul's presentation](#)

- Deposit energy in the active material is obtained from GEANT
  - The input charge is calculated from the energy
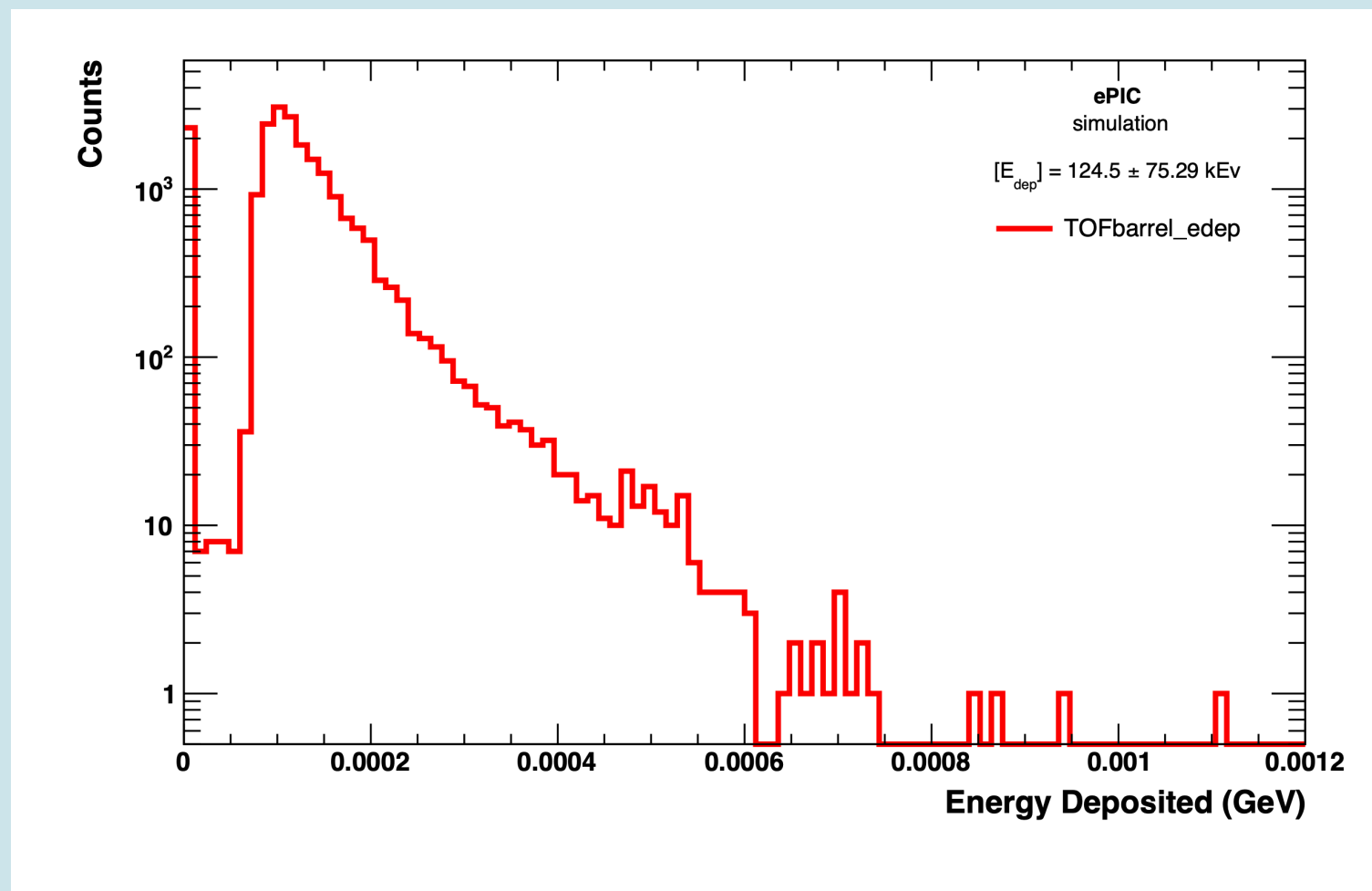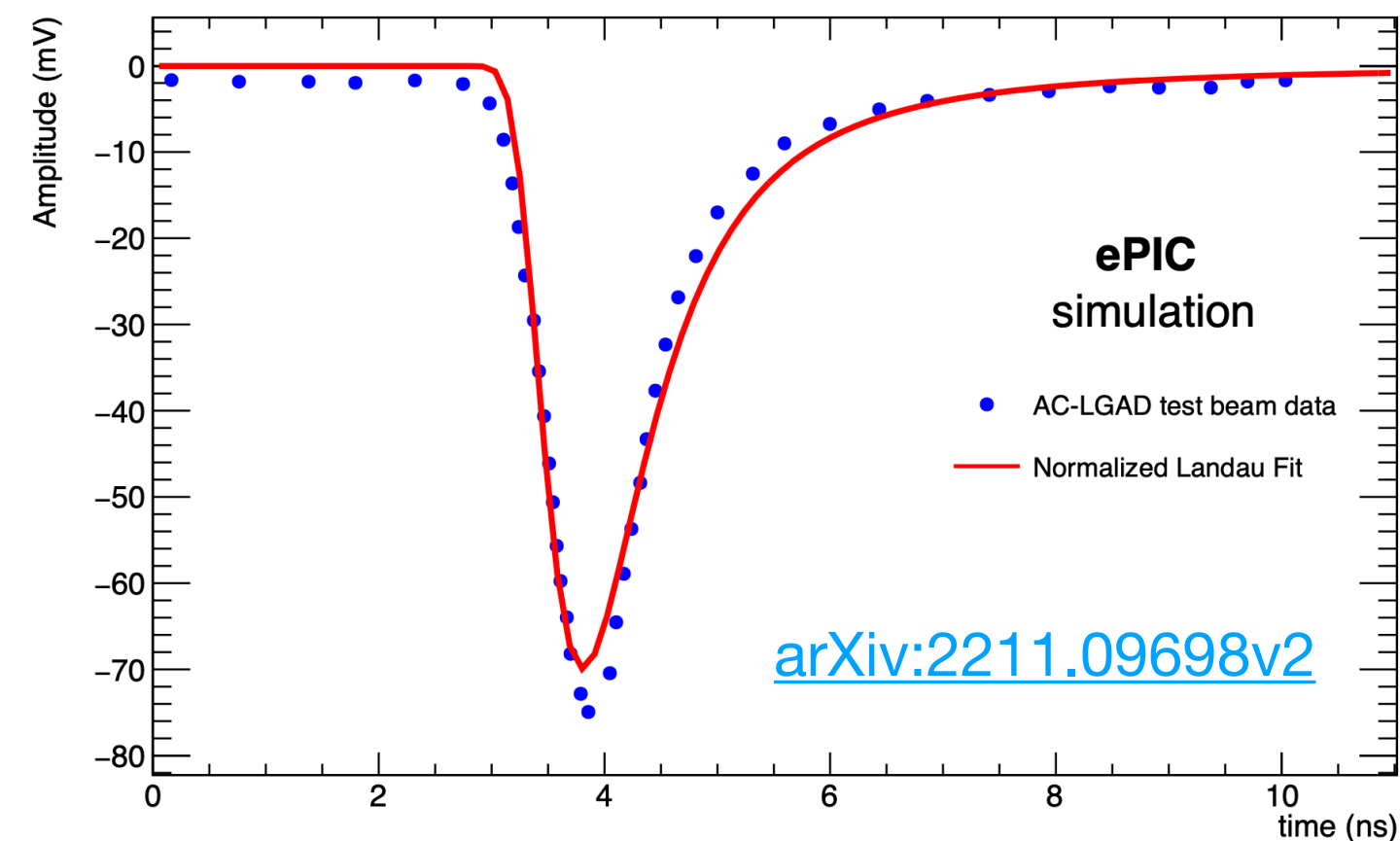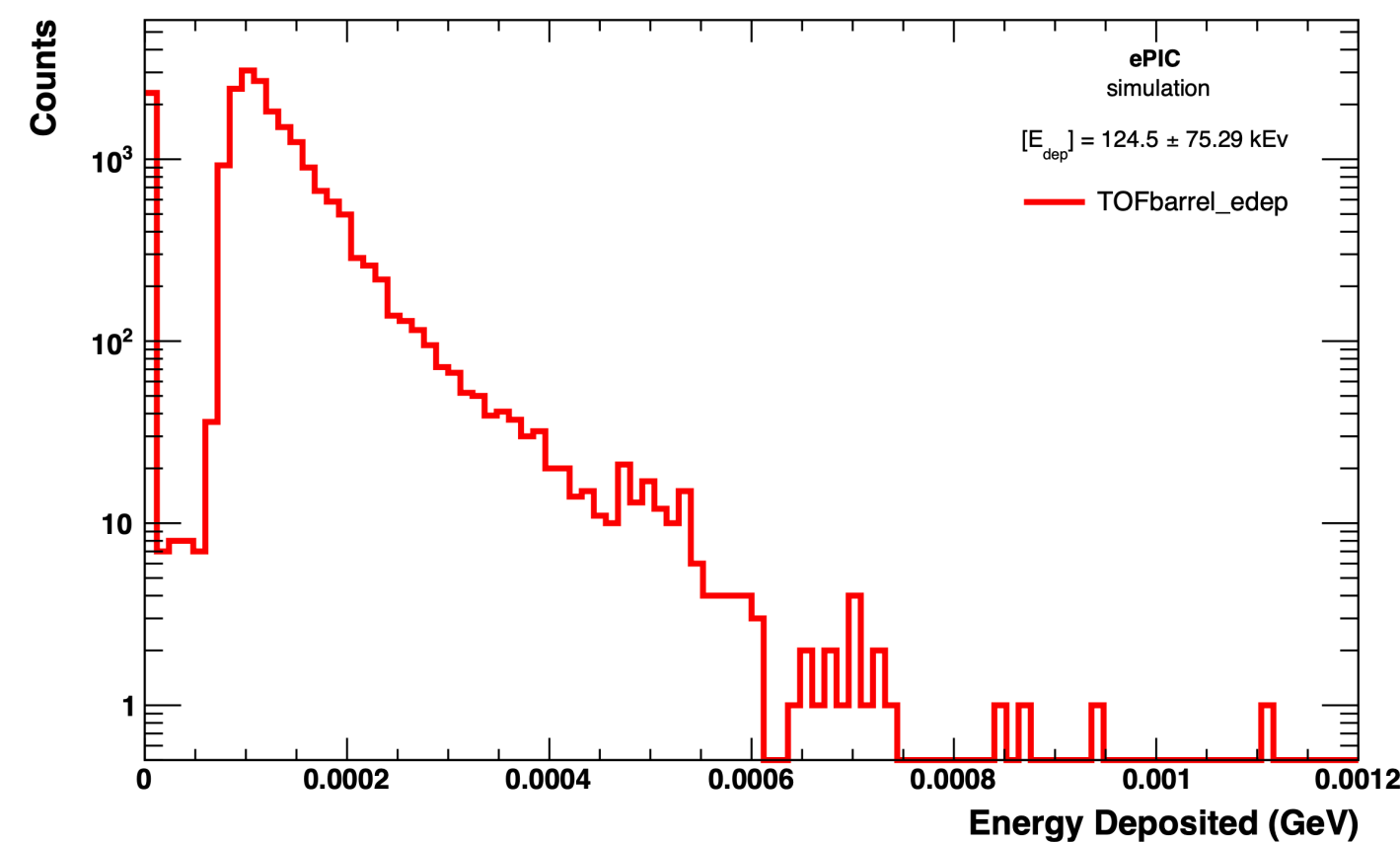
Mimic the analog signal in the DD4hep simulation

[From Souvik Paul's presentation](#)

- Deposit energy in the active material is obtained from GEANT
  - The input charge is calculated from the energy
- Realistic signal shape in the test beam is used

arXiv:2211.09698v2

BNL_EICROC test beam data

$Q(fC) = -0.3875 \cdot Q(DAC) + 24.911$

Mimic the analog signal in the DD4hep simulation
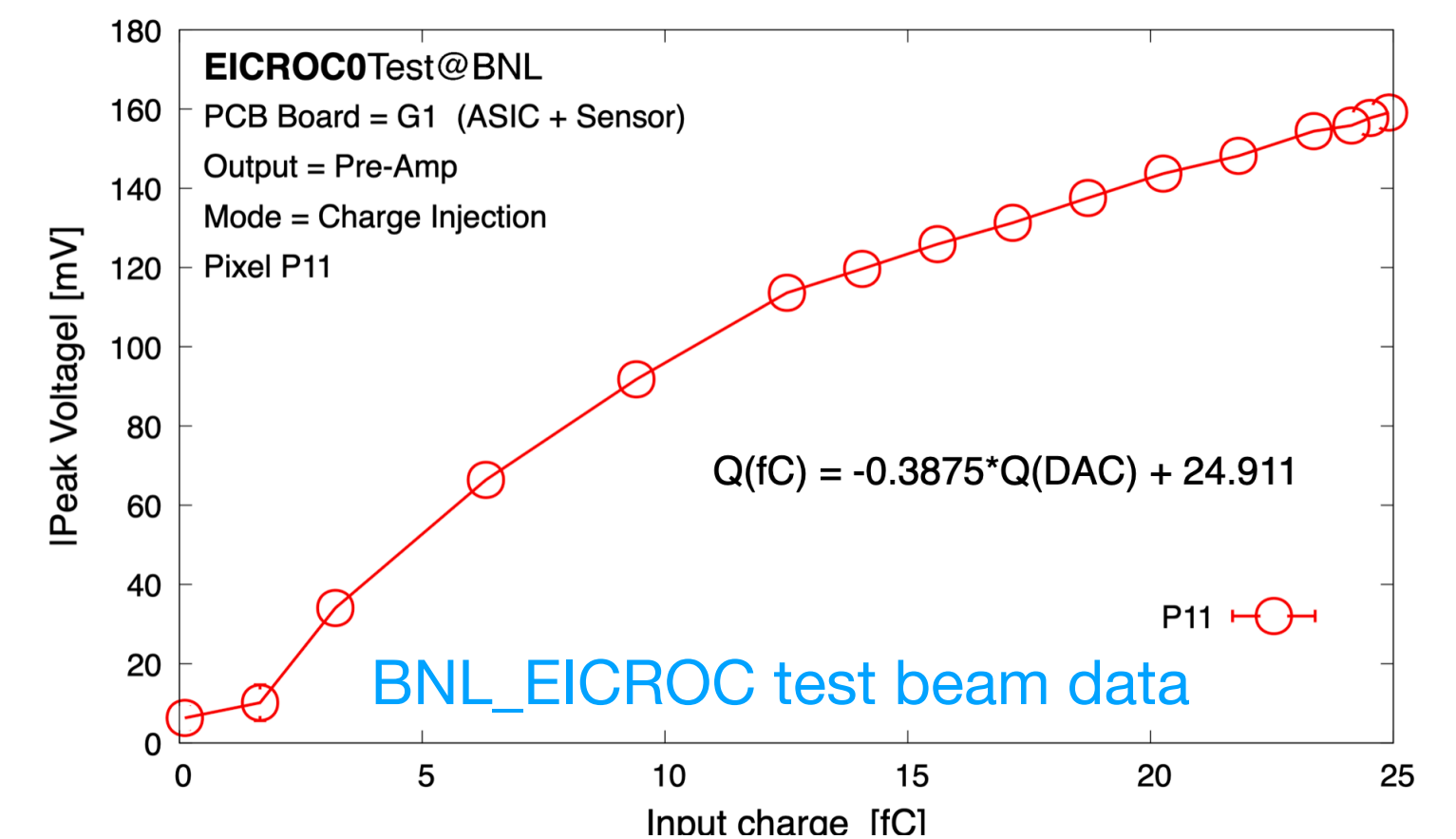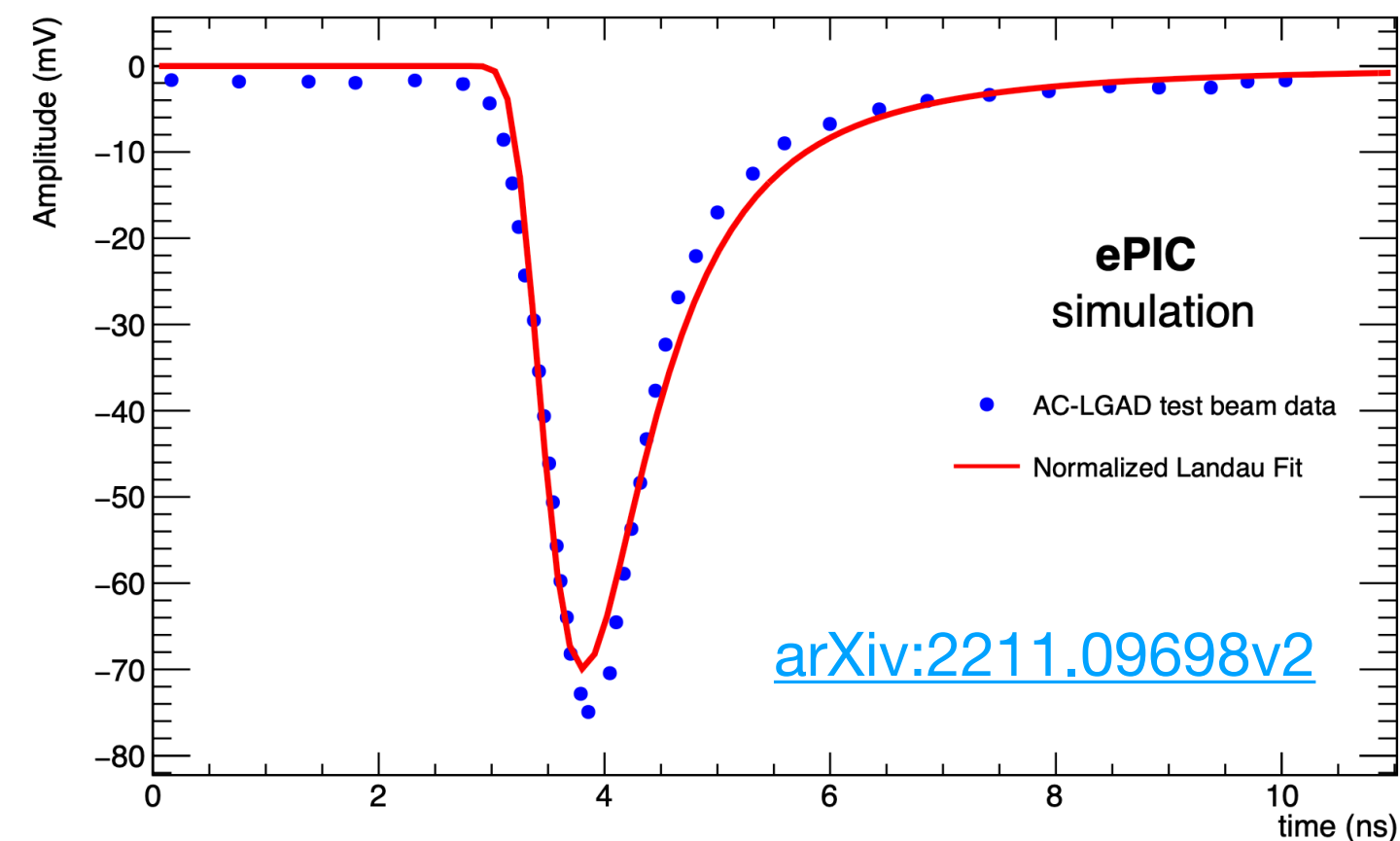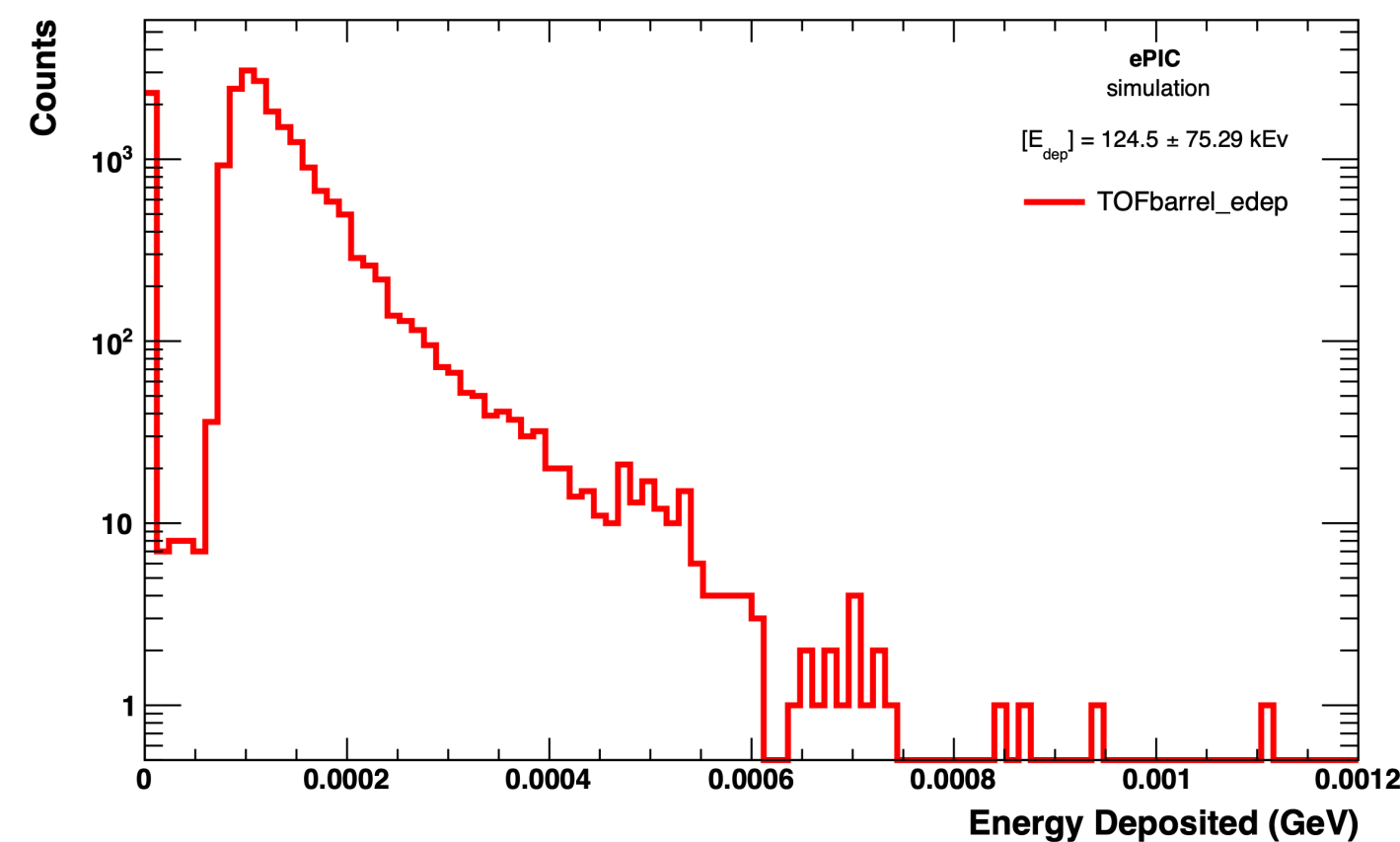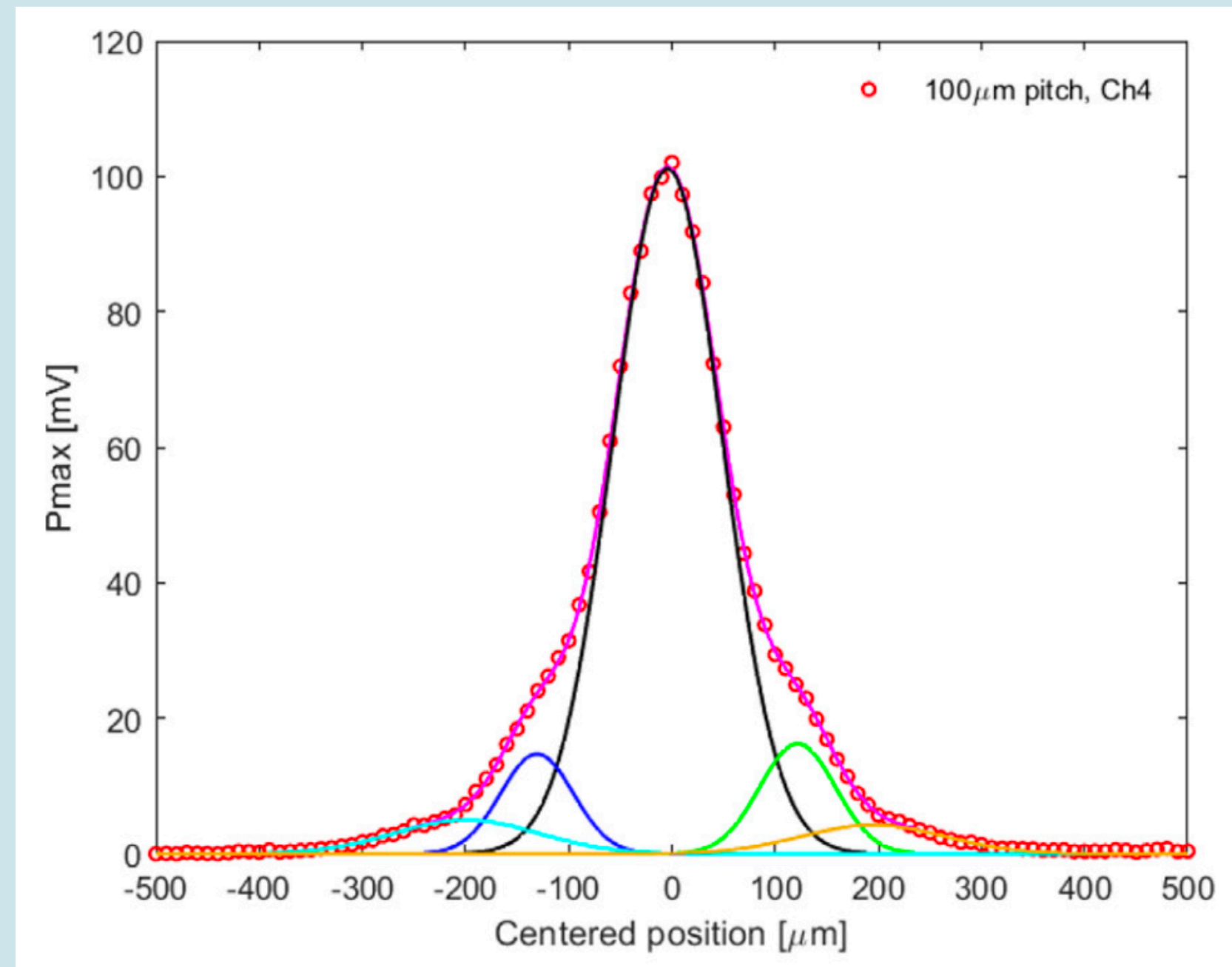
[From Souvik Paul's presentation](#)

- Deposit energy in the active material is obtained from GEANT
  - The input charge is calculated from the energy
- Realistic signal shape in the test beam is used
- The relationship between maximum voltage and input charge is ex...

BNL_EICROC test beam data

Charge distribution in sensor

- Charge distribution in sensor is extracted from data

Charge distribution in sensor

Charge Sharing
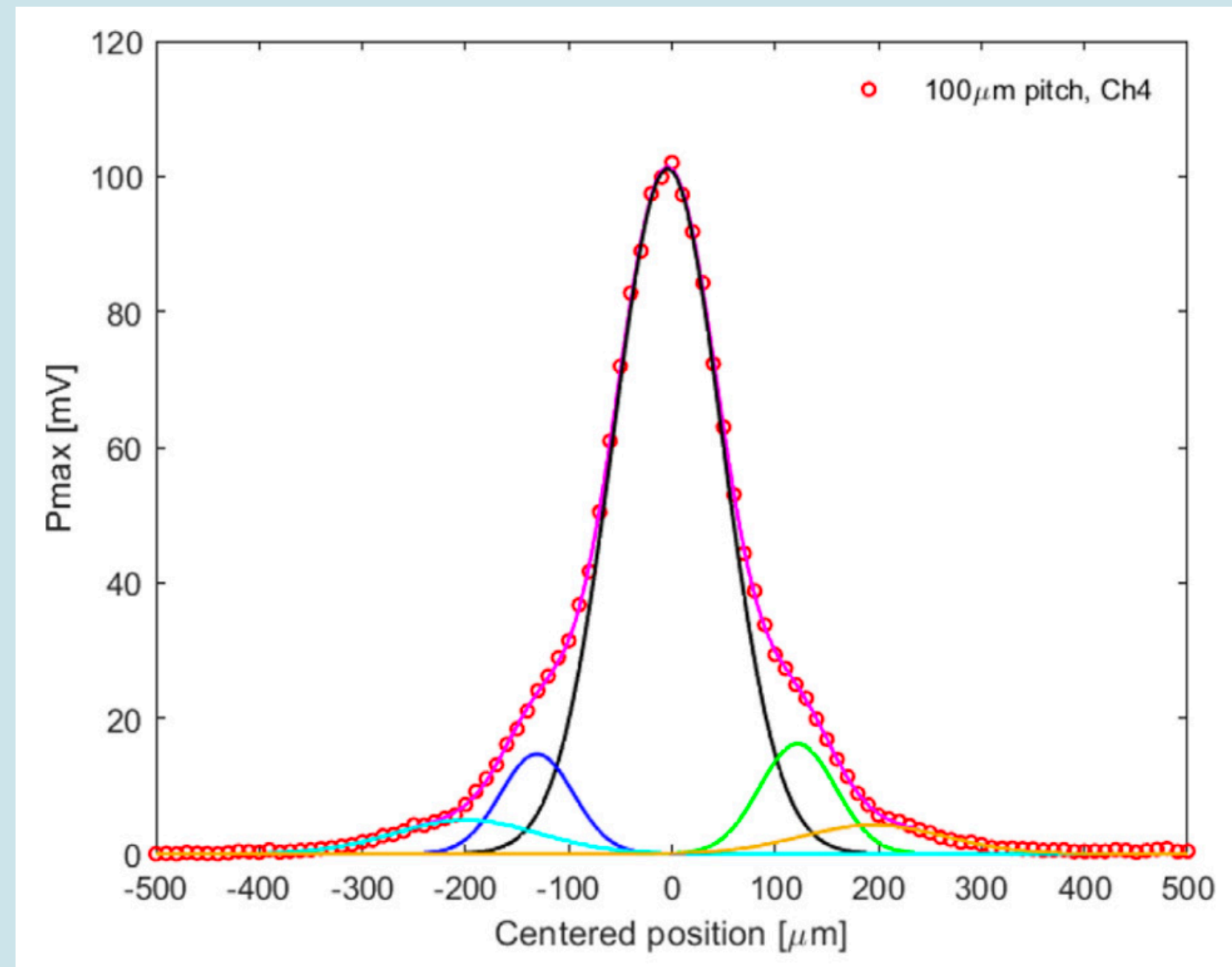
From Souvik Paul's presentation
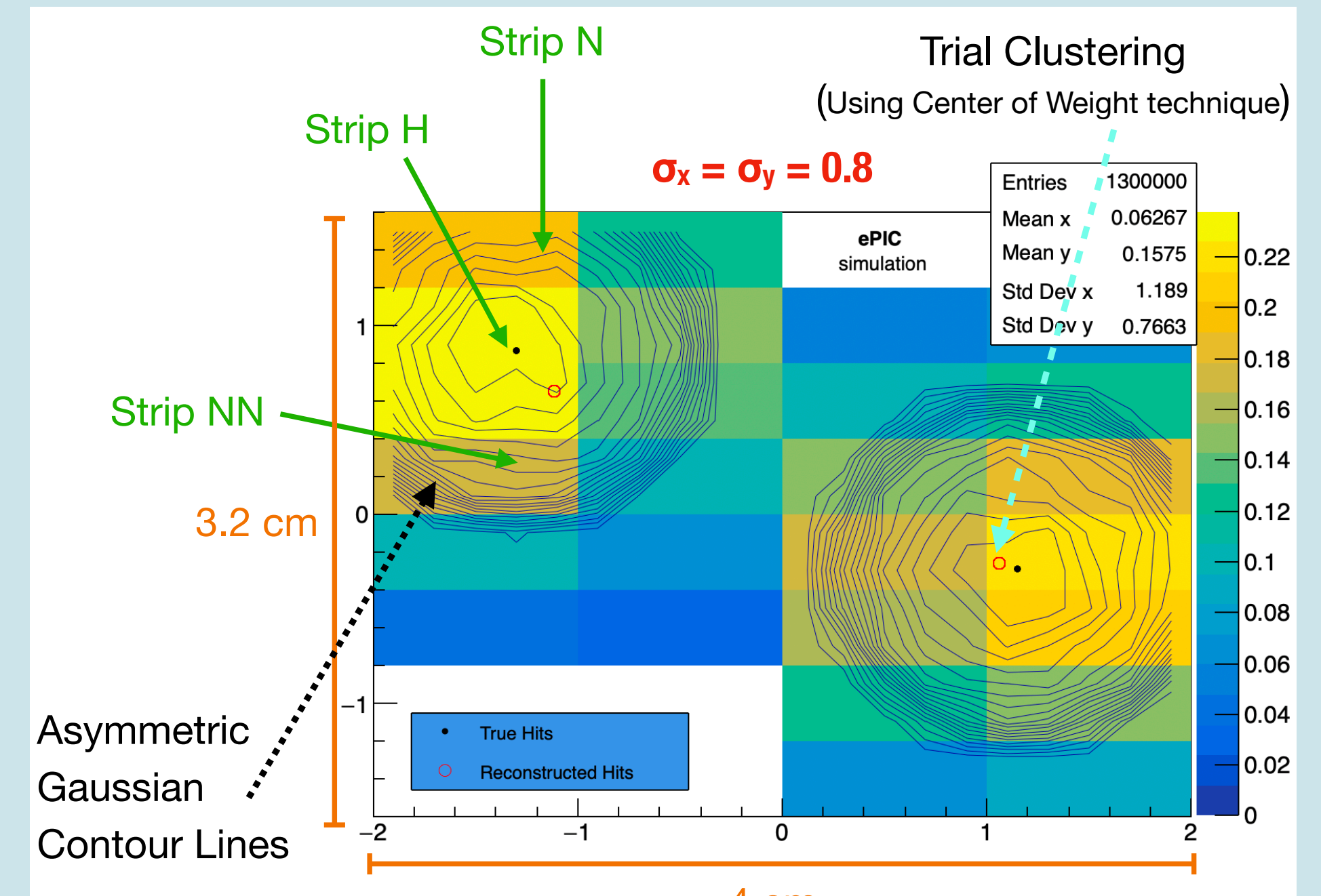
- Charge distribution in sensor is extracted from data
- Collected charge is calculated by each segment which is corresponding to readout metal

Barrel ToF   Strip Sensor

Endcap ToF   Pixel Sensor

Geometrical effects

Charge Sharing: Geometric effects

From Souvik Paul's presentation

Case-1

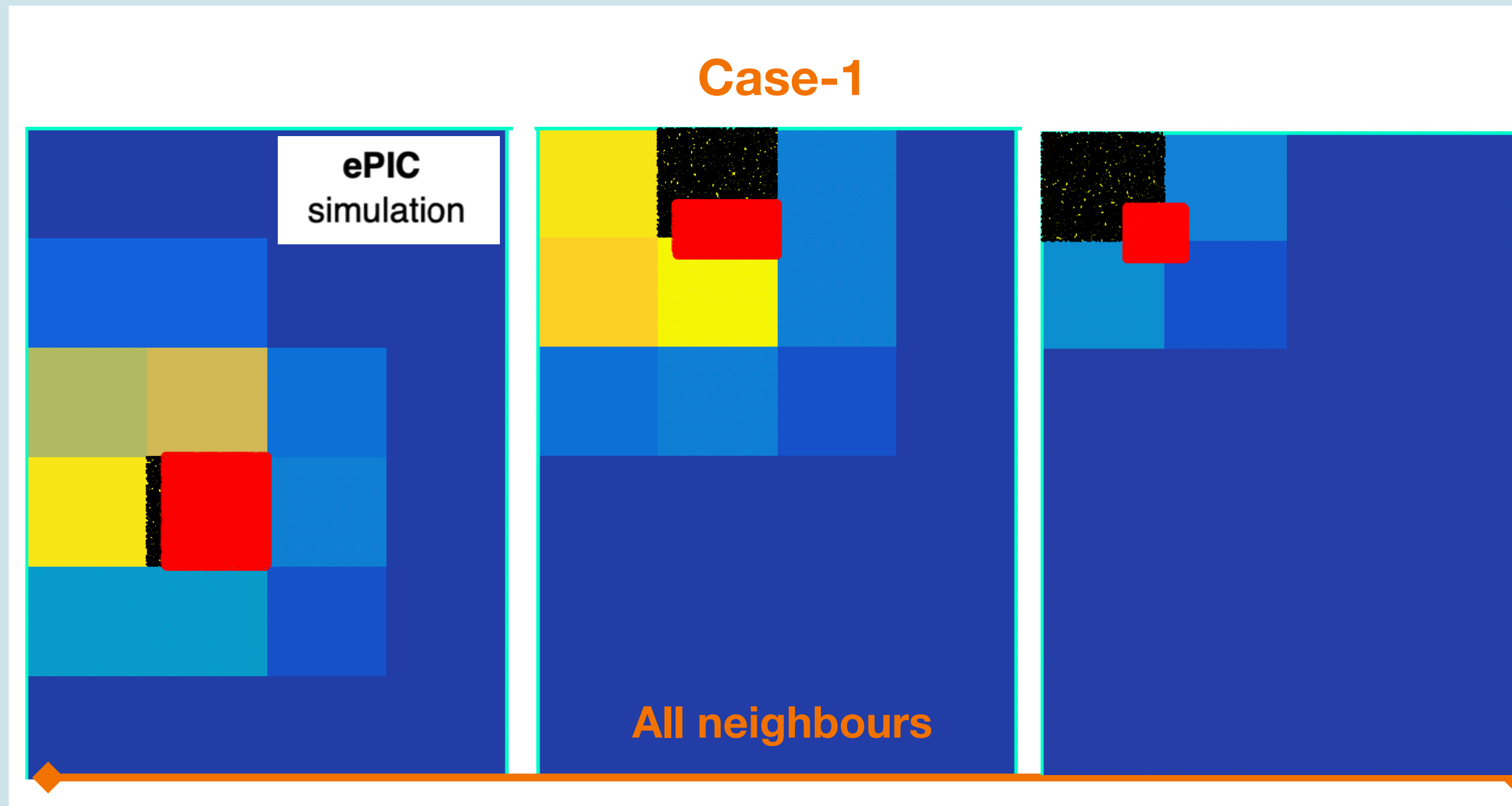ePIC simulation

All neighbours

Case-2

ePIC simulation

Nearest neighbours

● True Hits
○ Reconstructed Hits

● True Hits
○ Reconstructed Hits

● True Hits
○ Reconstructed Hits

● True Hits
○ Reconstructed Hits

- The position of the hit pixel and the number of charge-sharing neighbors affect the reconstruction accuracy of hits
  - Central pixel has 8 nearest neighbors, the edge pixel has 5 nearest neighbors and the corner pixel has 3 nearest neighbors.

Geometrical effects

From Souvik Paul's presentation

Case-1

ePIC simulation

All neighbours

Case-2

ePIC simulation

Nearest neighbours

- True Hits
- Reconstructed Hits

- The position of the hit pixel and the number of charge-sharing neighbors affect the reconstruction accuracy of hits
  - Central pixel has 8 nearest neighbors, the edge pixel has 5 nearest neighbors and the corner pixel has 3 nearest neighbors.
- Reconstruction accuracy decreases as the pixel hit position changes from central to corner

Geometrical effects
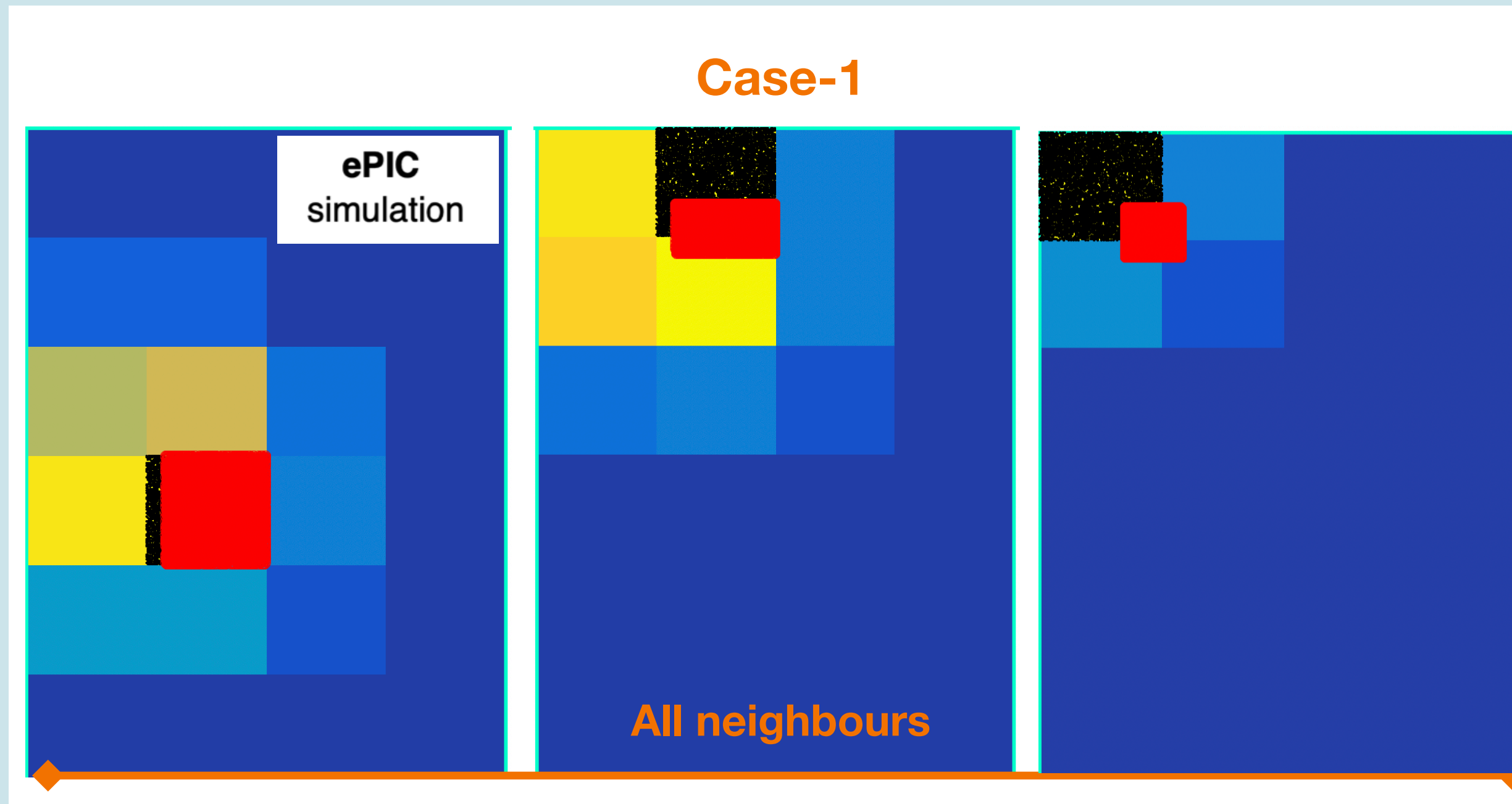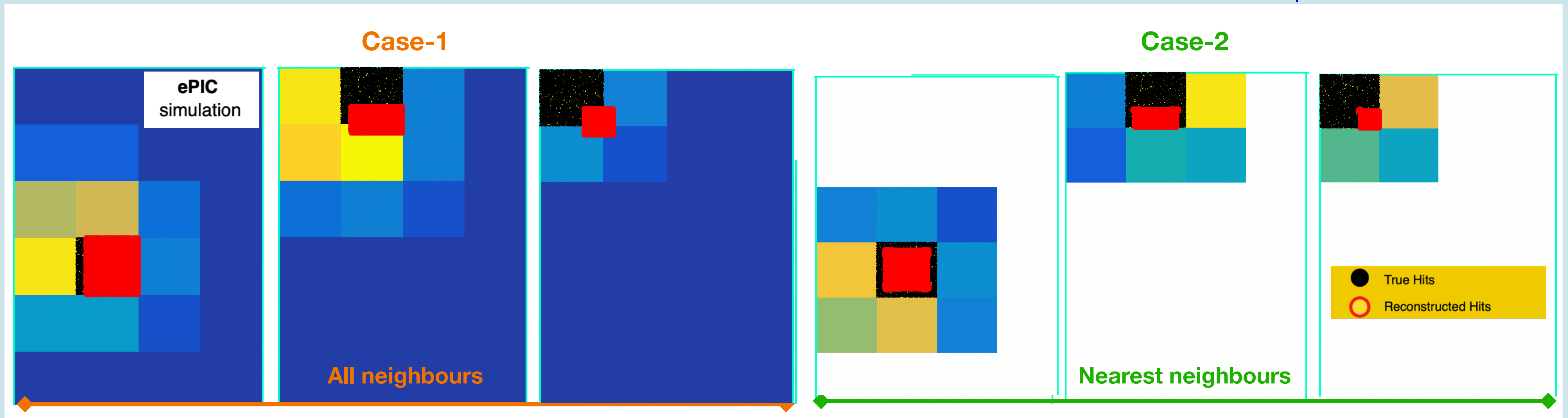
From Souvik Paul's presentation

- The position of the hit pixel and the number of charge-sharing neighbors affect the reconstruction accuracy of hits
  - Central pixel has 8 nearest neighbors, the edge pixel has 5 nearest neighbors and the corner pixel has 3 nearest neighbors.
- Reconstruction accuracy decreases as the pixel hit position changes from central to corner
- Reconstruction accuracy for Case-2 is greater than that for Case-1
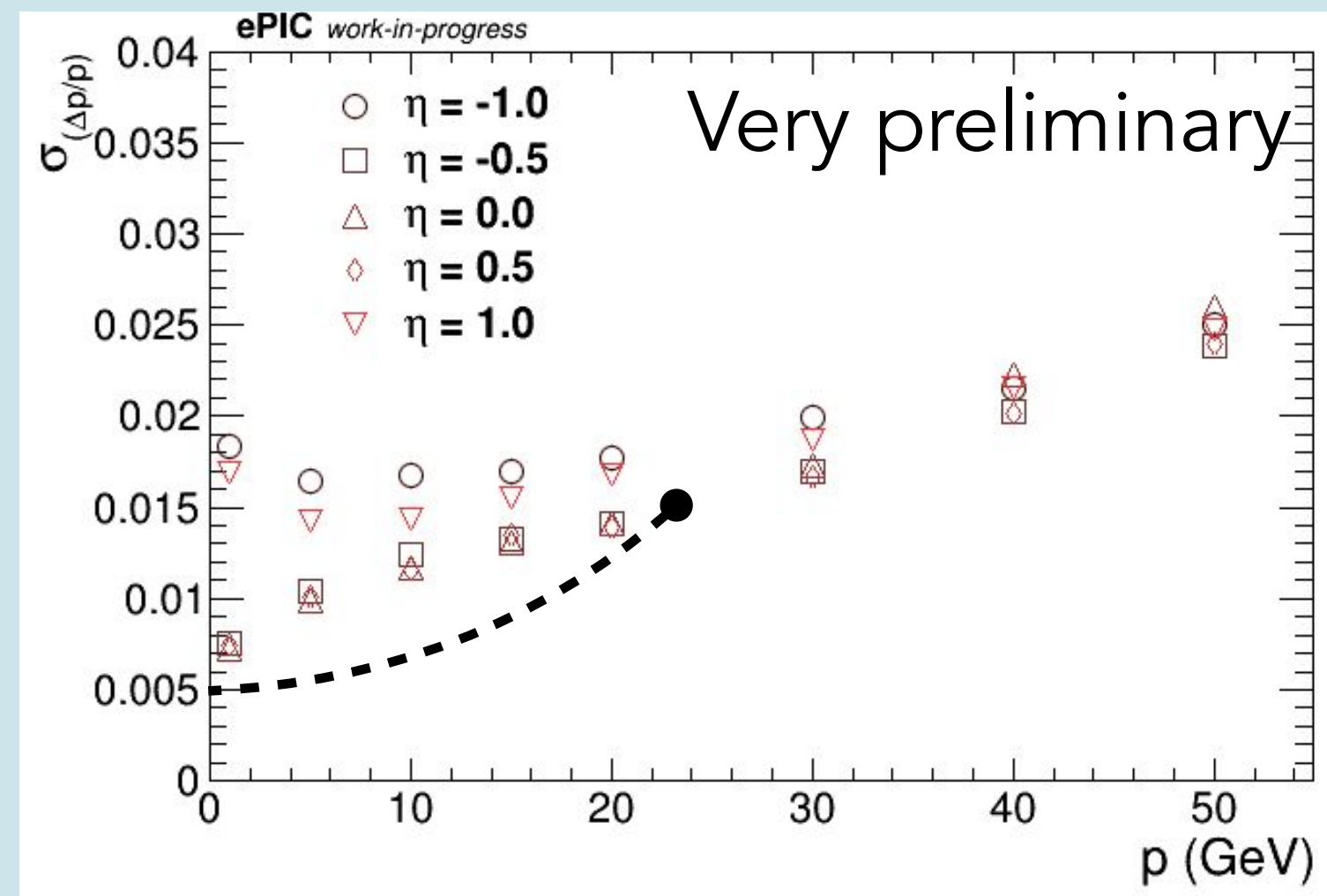
Summary

- High momentum tracking at mid-rapidity can be improved by BTOF

- Low momentum tracking at forward rapidity can be improved by FTOF

- More precise statistics study is mandatory

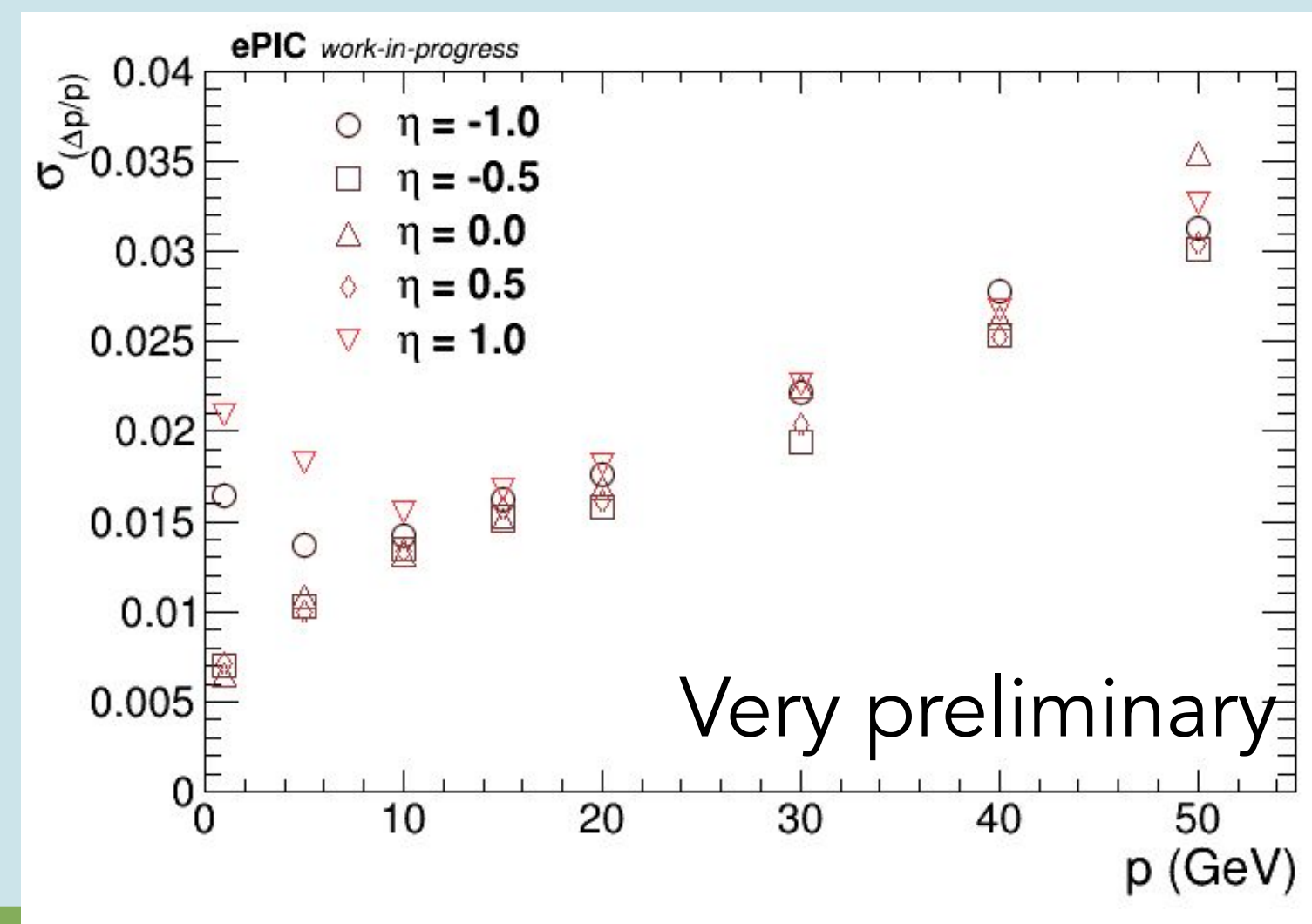- Attempt of the charge-sharing simulation in DD4hep has been stated

Back up

Very fresh result of new geometry configuration

w/ TOF

Very preliminary

w/o TOF

Very preliminary

...ity (Taiwan) team has
...udy

...be worse
...) GeV/c

...ematic study is