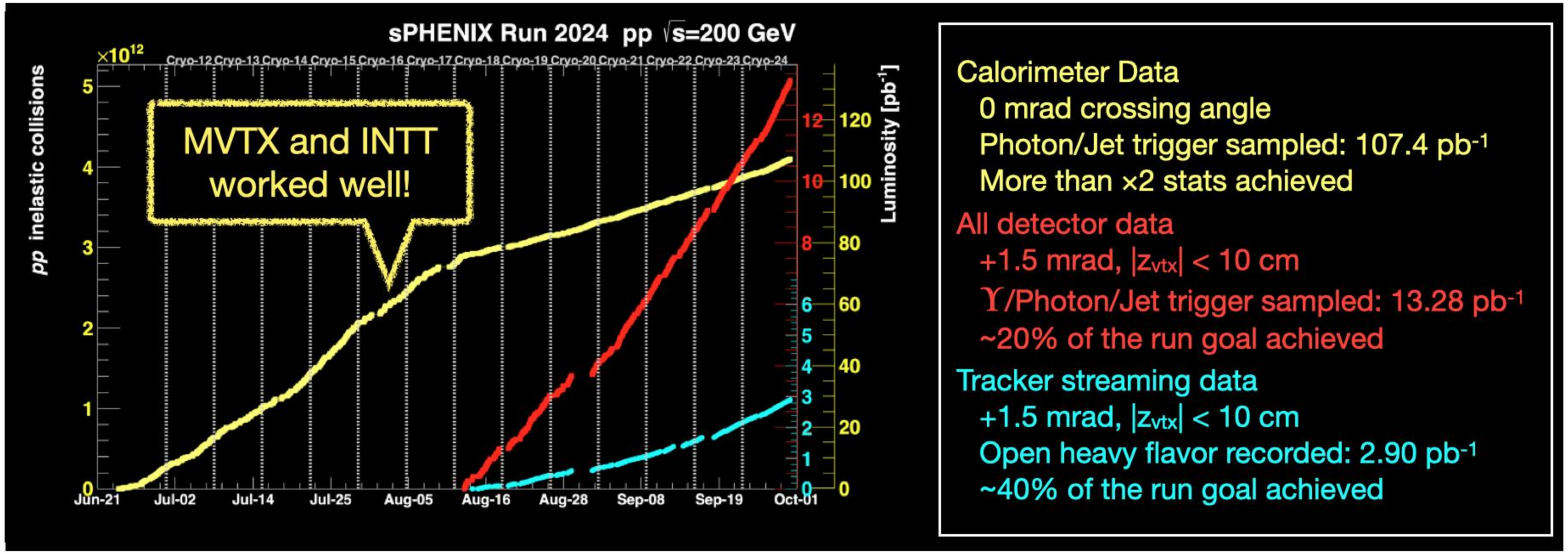
# Charged Track Reconstruction with Silicon Detector and Calorimeter on simulation

Author list (?)

# Motivation



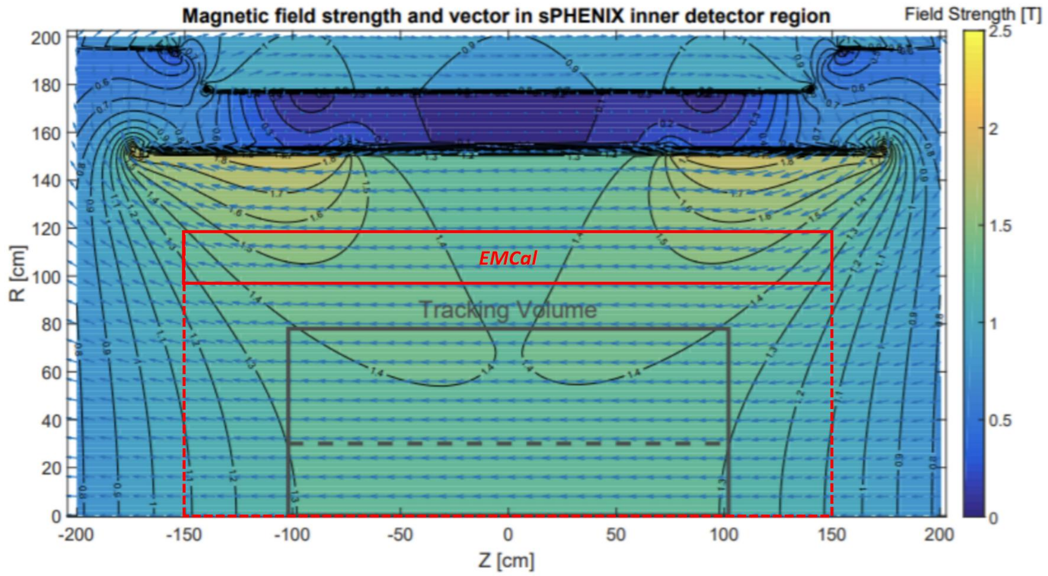

- More than half of pp collision measurements in 2024 was done without TPC.
- We collected **more than x2 luminosity for so-called Calorimeter data. MVTX and INTT also in the data taking. Why don't we take this advantage?**
- **The great possibility in Calorimeter data is analysis with both silicon detectors and calorimeters**. Lack of TPC makes a large impact to the tracking performance, but **if we can use calorimeter hits in the silicon tracking, the tracking performance, especially $p_T$ reconstruction, can be improved drastically.**
- Silicon + calorimeter tracking & calorimetry with Calorimeter data can be used for
  - **jet substructure**
  - **quarkonia**
  - **electron(s), hadron(s), etc.**
- Silicon + calorimeter tracking & calorimetry with Calorimeter data cannot be used for
  - streaming readout data
  - ultimate $p_T$ resolution

# Motivation

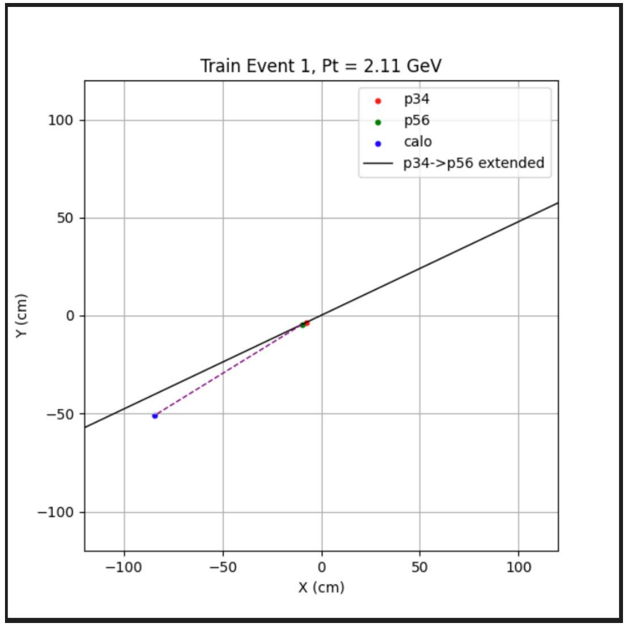
- More than half pp collision without TPC
- The pT reconstruction using only the silicon detector is not enough, especially in the high-pT region.
- Connect Sillicon and Calo(~100cm) to reconstruct the momentum will be better

# Principle

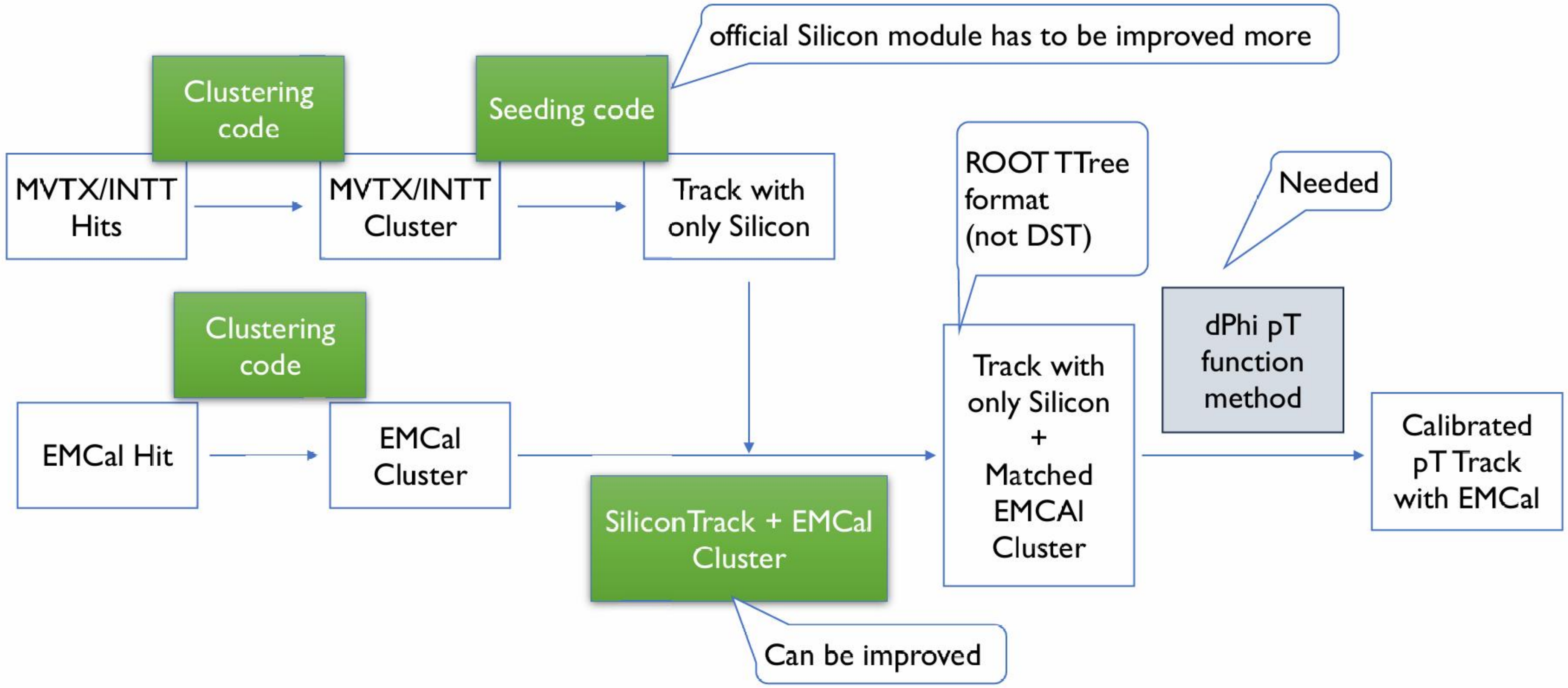
- Charged particles drifting in a magnetic field will bending;
- by using position information from silicon detector and calorimeter. We can extract the deflection magnitude to reconstruct pT.




$\Delta\phi$, Angle between two line
line1 connect oINTT and iINTT
line2 connect oINTT and Calo



# Work flow



official Silicon module has to be improved more
Clustering code
Seeding code
MVTX/INTT Hits
MVTX/INTT Cluster
Track with only Silicon
ROOT TTree format (not DST)
Needed
Clustering code
dPhi pT function method
EMCal Hit
EMCal Cluster
Track with only Silicon + Matched EMCAl Cluster
Calibrated pT Track with EMCal
SiliconTrack + EMCal Cluster
Can be improved

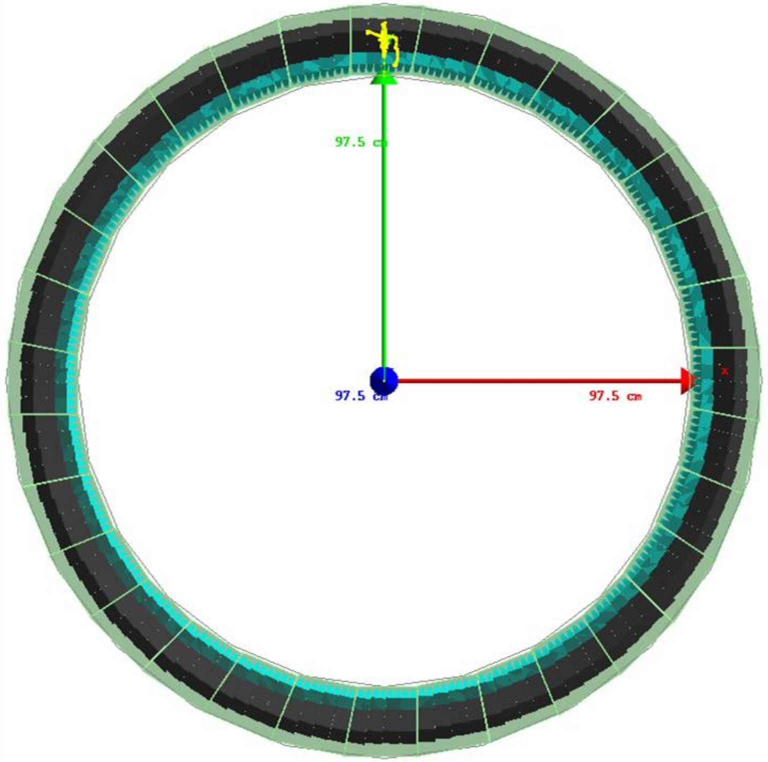
# EMCal position reconstruction

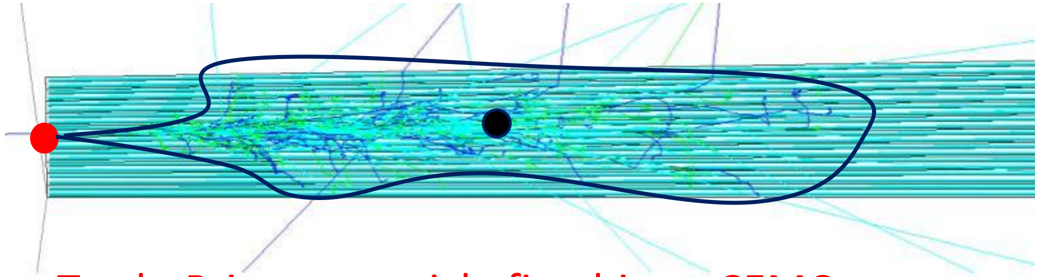
- Get truth and reco level electron position on EMCal
- Compare the phi angle of reco position and truth position
- Phi of cluster correction

# dphi(truth - reco)

dphi = phi of Primary particle first hit on CEMC

- phi of Cluster reco with tower inner face center



Truth: Primary particle first hit on CEMC

Reco:
cluster positon reco with geom center
cluster positon reco with innerface center

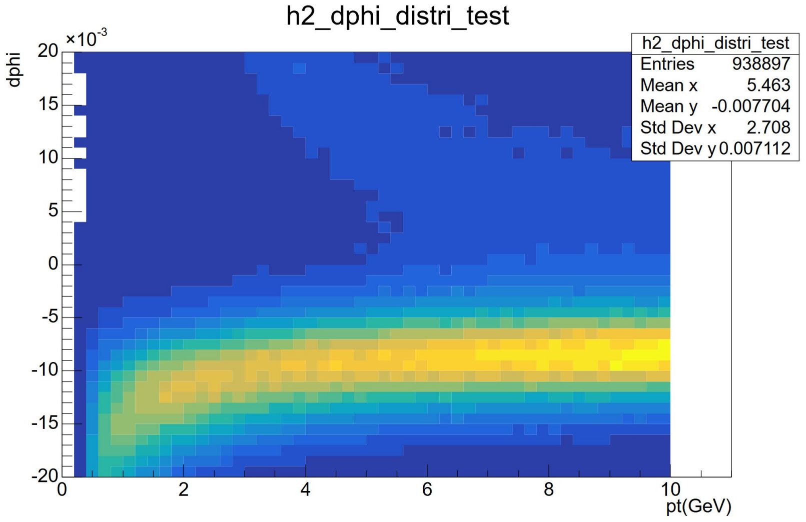
# Phi reconstruction and correction

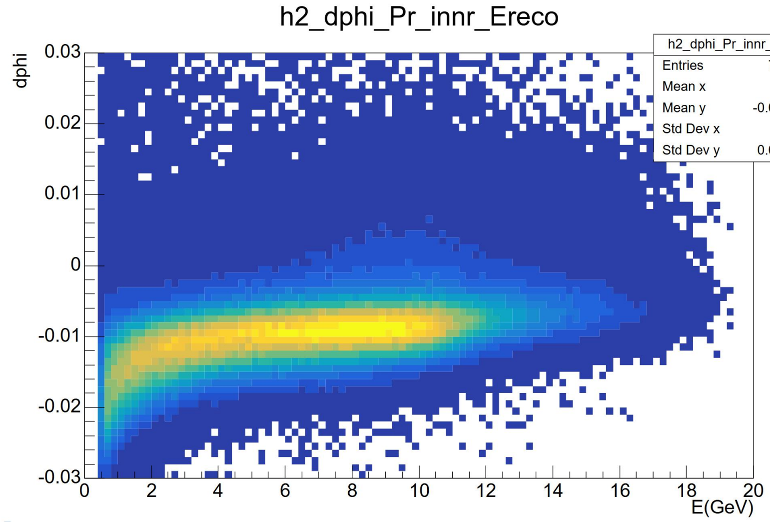
For using in real data, we need correct method base on observable variable

## dphi - truth pT

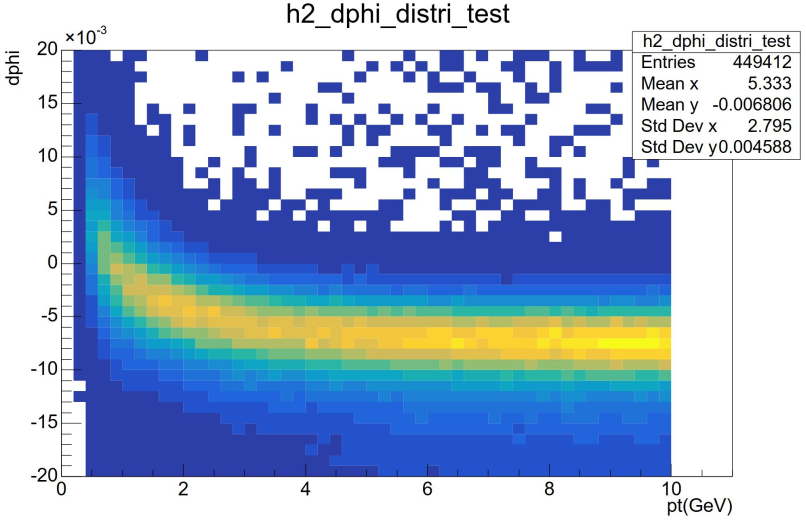
## dphi - reconstrution Energy

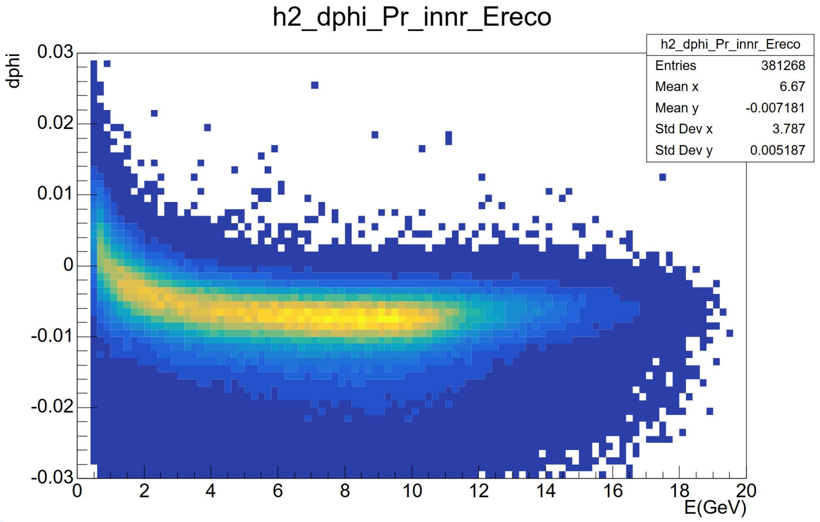
Electron




Positron

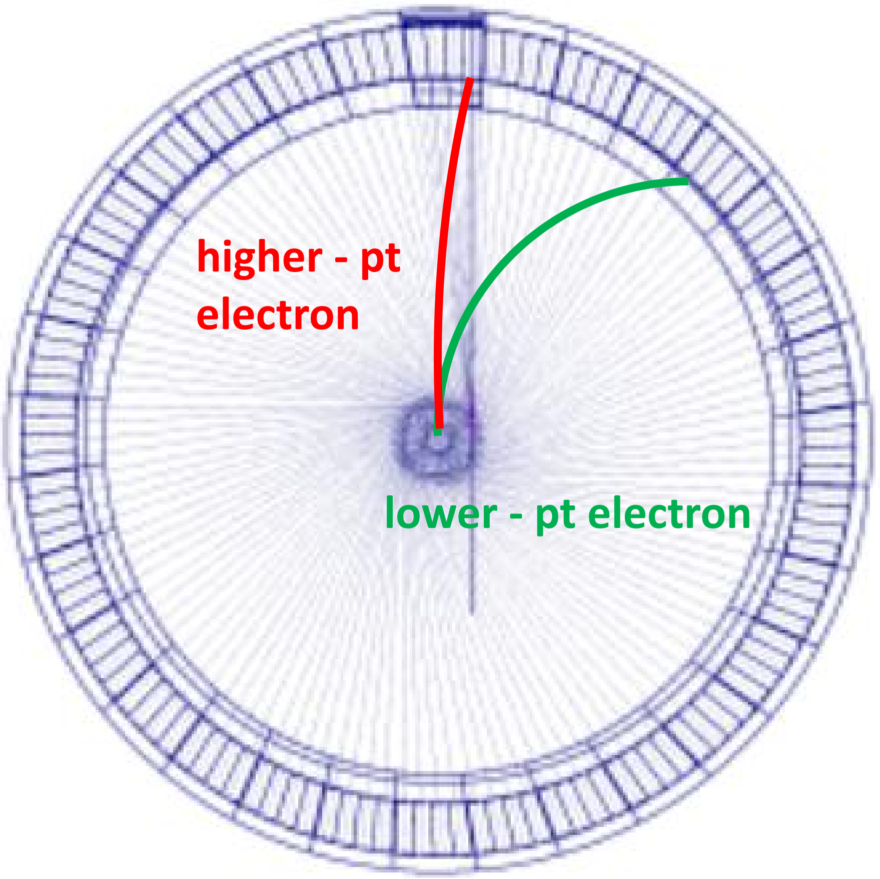


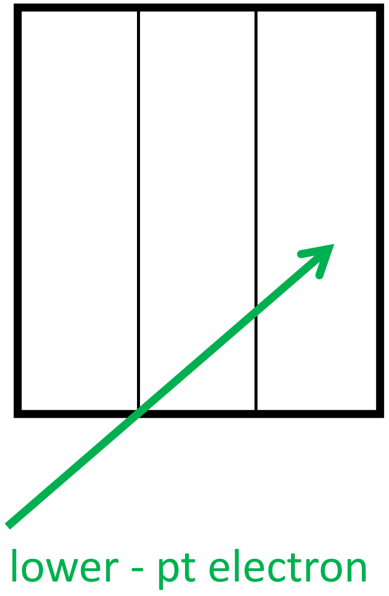



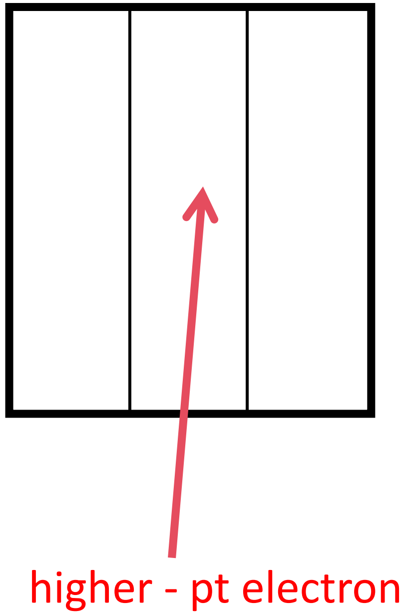

we can see the difference after correct Magnetic field from charge effect.

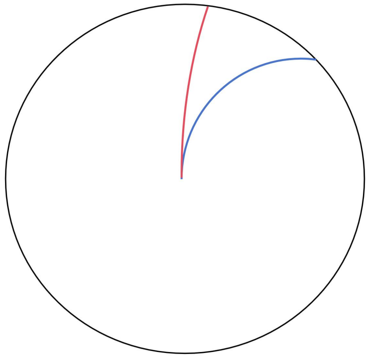
# Explanation of Magnetic effect on EMCal response

For low-pt electrons and positrons, the magnetic field significantly change their pt direction, causing them to hit the EMCal at a large angle.
In contrast, high-pt particles experience only a small change in incident direction and are less affected by the magnetic field.



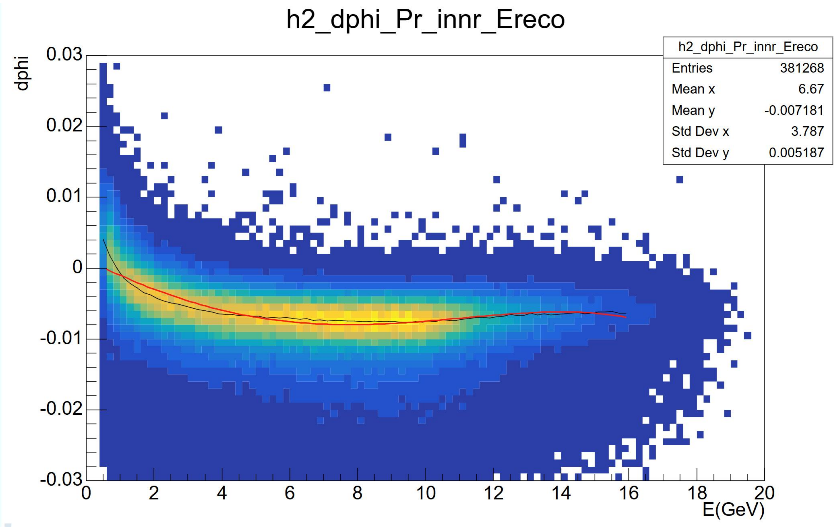



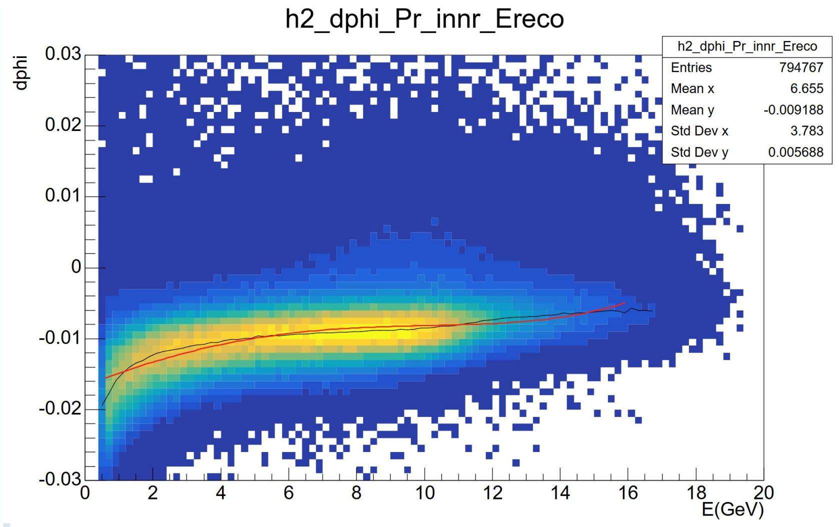



# Correction cluster position reco with tower inner face center

positron:




electron:

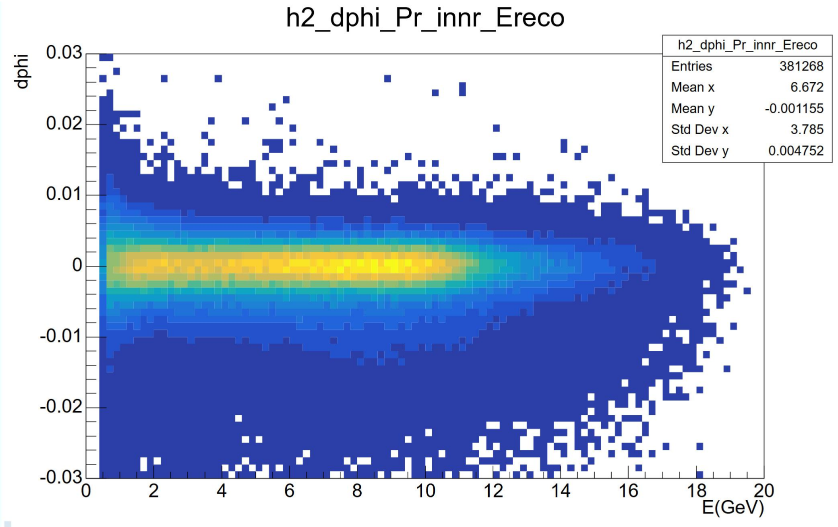


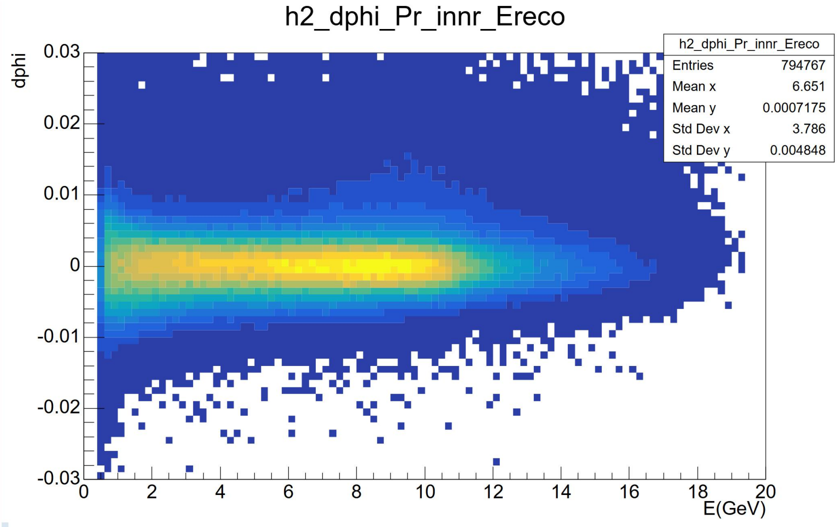

From dphi - reconstrution Energy distribution project each x-bin on y-axis, found the peak value.

Get the points(Energy, dphi peak value), show is black line, then fit the points with poly func to get the correction, the red line

**I use TGraph the black line interpolation by reconstruction cluster Energy to correct the phi reconstrution**

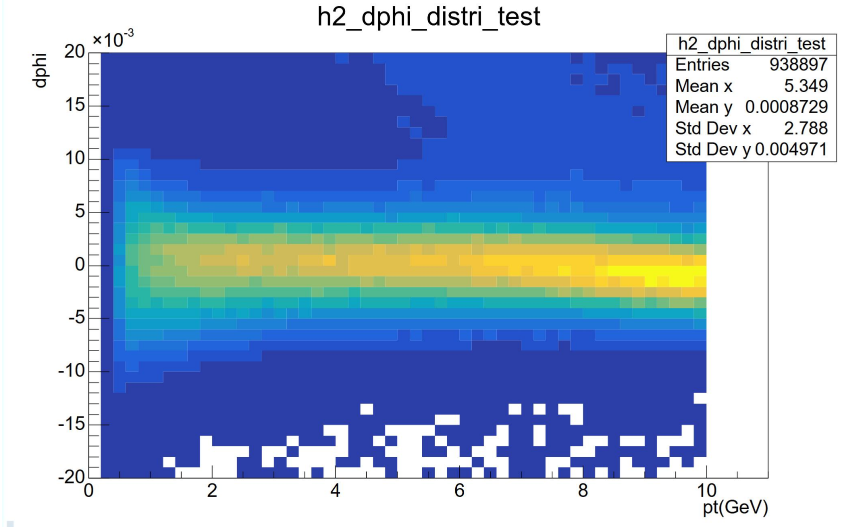
After correction



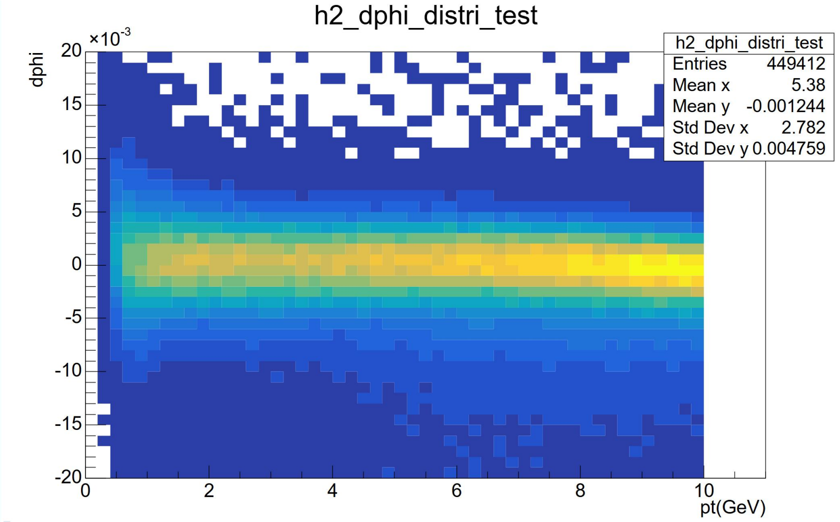



# dphi(truth - reco) vs pT

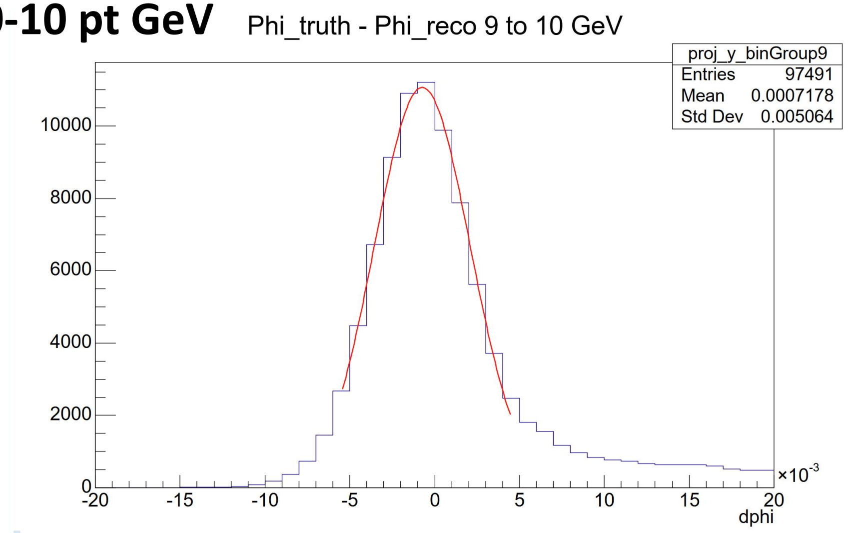
Electron

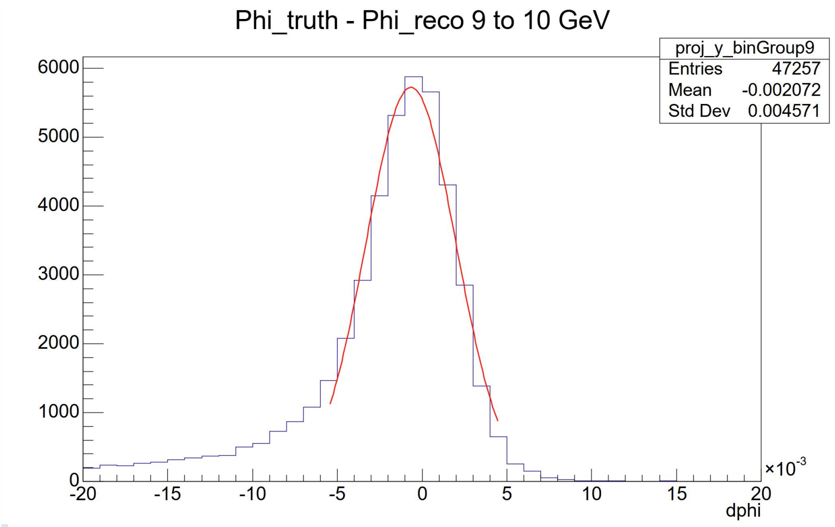



Positron




**10 bins for 0-10 pt GeV**



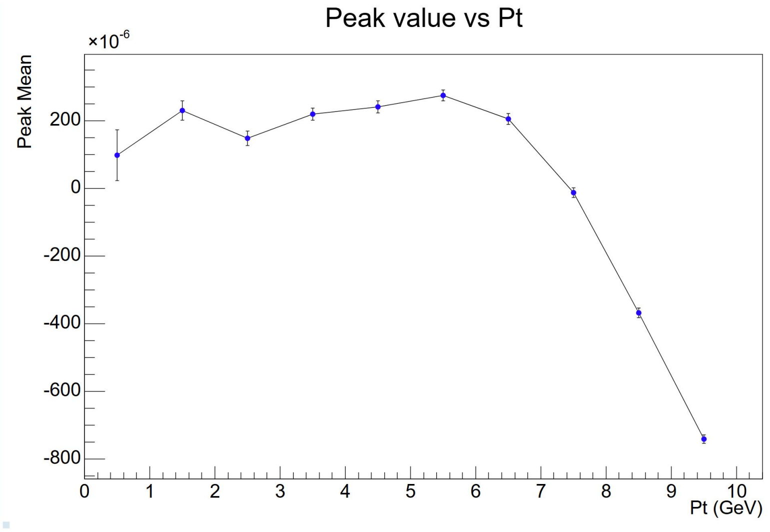



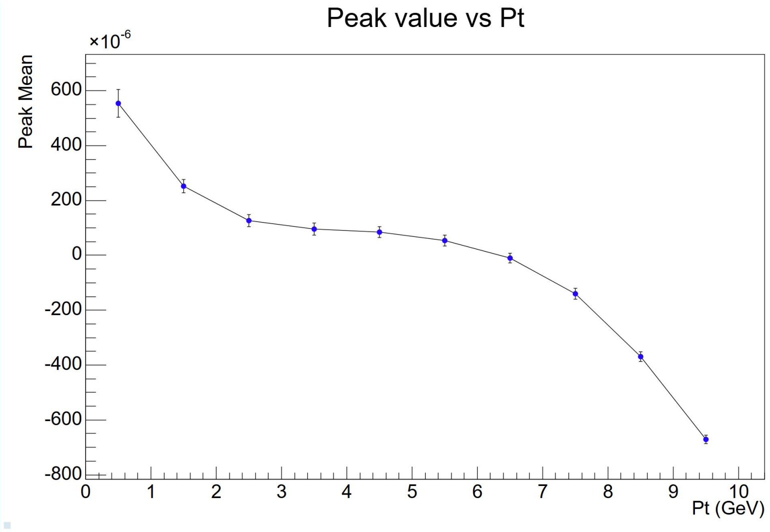

Fit to get peak value (bias) and width (resolution)

# phi reconstruction bias and resolution - pt

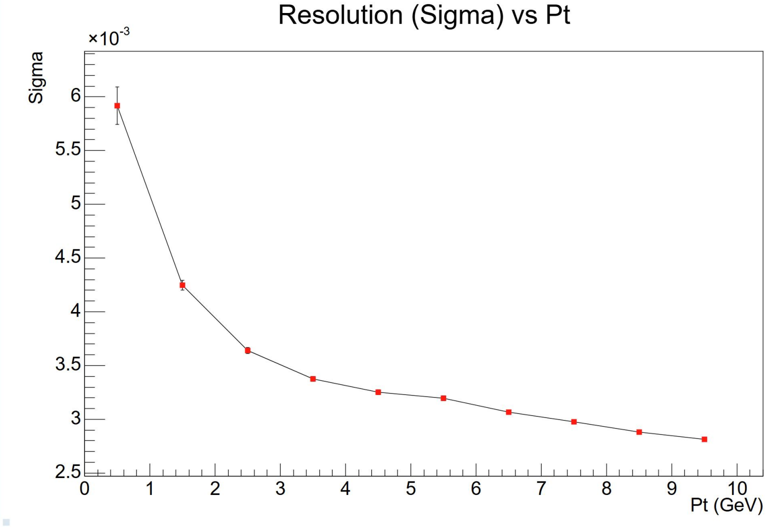
Electron

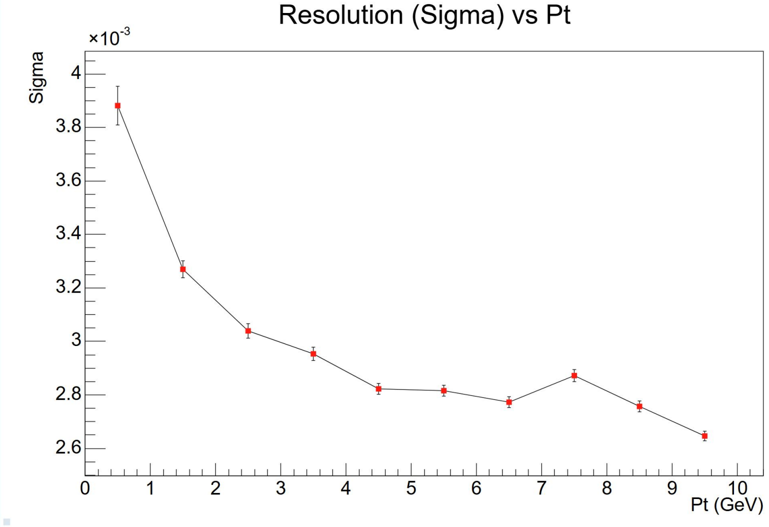
Positron




bias



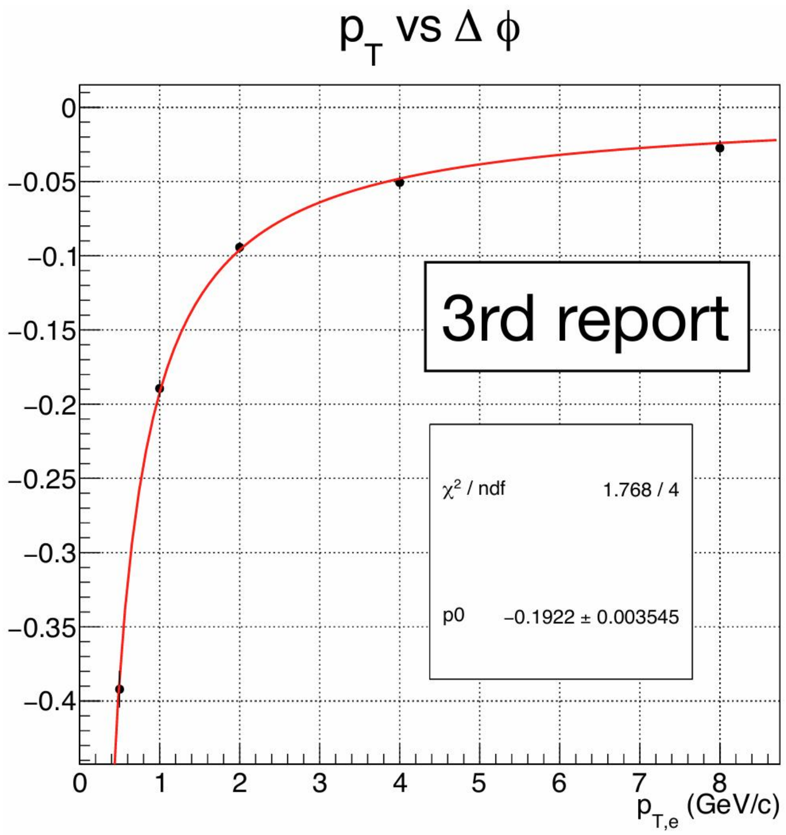

resolution

# Pt function of $\Delta\phi$ and $\eta$

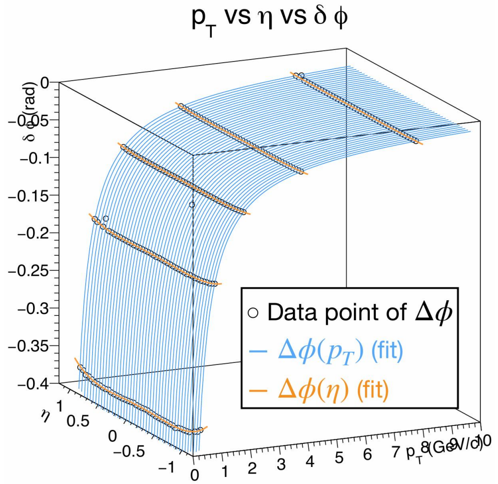
- $\Delta\phi$ def. with EMCal and INTT
- pT reconstrution from $\Delta\phi$
- Consider $\eta$-dependence as A correct factor $C(\eta) = pT \cdot \Delta\phi$
- Performance

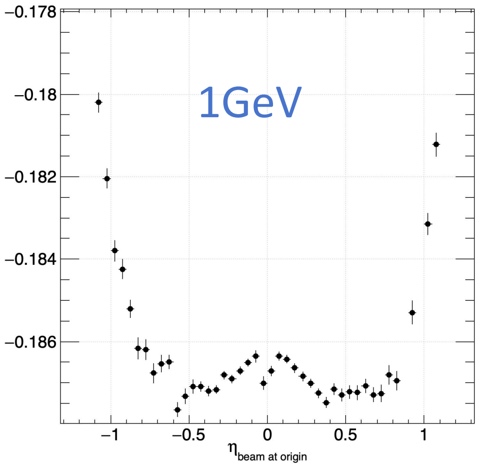
# pT reconstrution from Δϕ

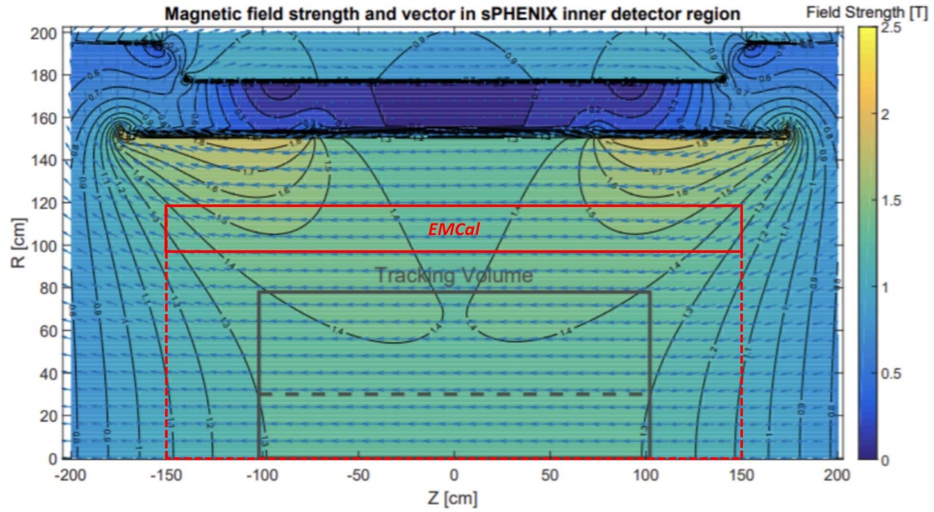
From position get Δϕ,
Fit the (truth pt, Δϕ) data point get: **pt = 0.1922/Δϕ**




**Δϕ have η-dependence,**
**Conside the effect**




Within the TPC region, the field can still be treated as uniform; however, in the EMCal it already looks somewhat distorted, showing an η-dependence.
This will introduce an η-dependence in the pT reconstruction from Δϕ. The 1 GeV plot on the left illustrates this.

# pt func of Δϕ and η

- Assume on func to calculate pt, Δϕ and η are separable,

  pT = F(Δϕ,η) = C(η)*f(Δϕ), and f(Δϕ) = 1/Δϕ.

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Then we want to get the C(η) from

- **C(η) = 〈pT·Δϕ〉**
- C_value = pT·Δϕ for each electron
- Fill the C_value on a TProfile, and fit the TI $f(x) = p_0 + p_1\,x + p_2\,x^2 + p_3\,x^3 + p_4\,x^4$

# pT·Δϕ - η distribution

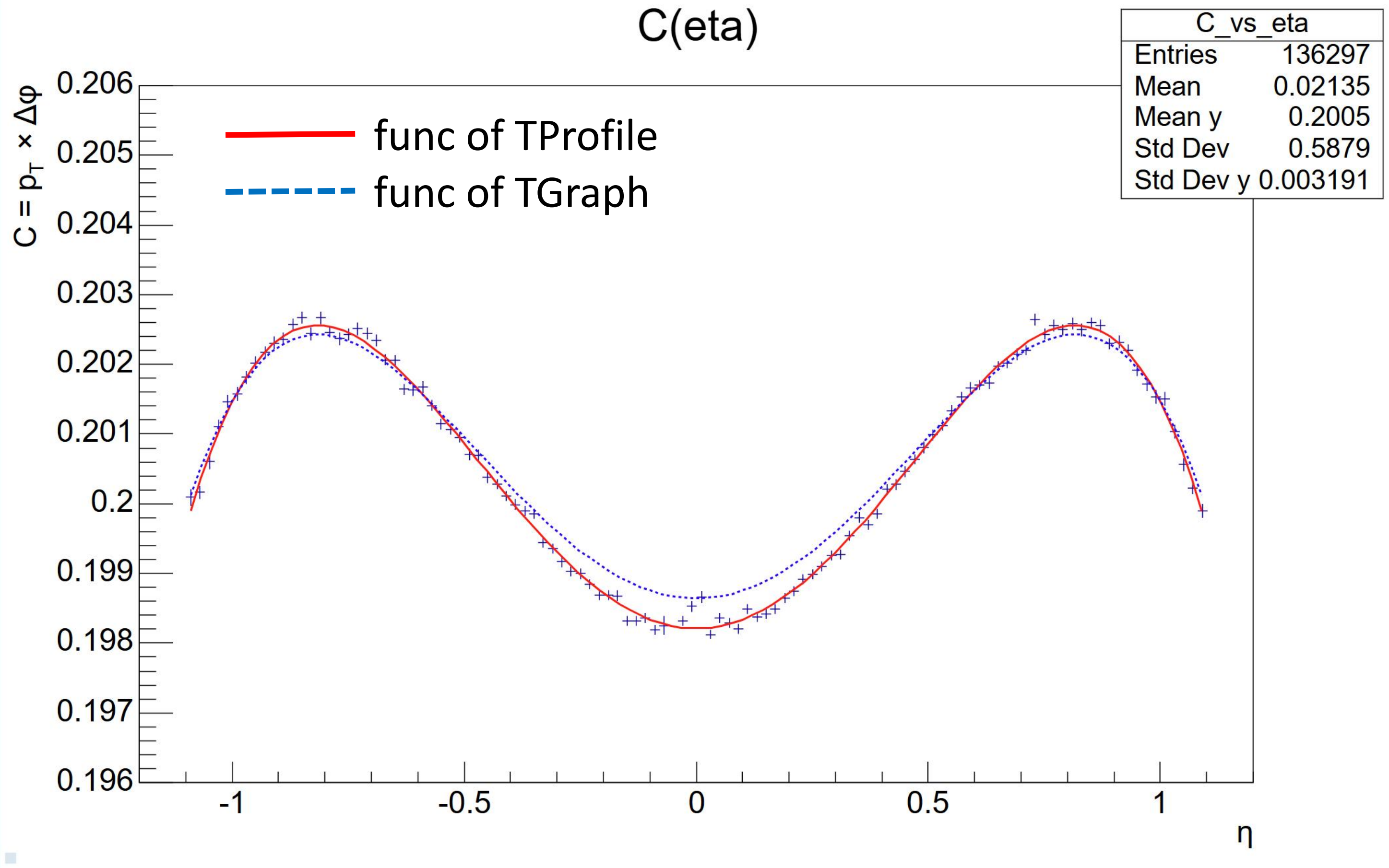
- loop the simulation data, for each electron
  - Get the **truth pT**, Get the primary particle eta **η**
  - Get the **Δϕ** from iINTT, oINTT reco and Primary particle first hit on CEMC position
  - calculate the **C_value = pT·Δϕ**
  - skip the very large and smale C_value, **if (Cval > 0.3 || Cval < 0.15) continue**
  - Fill a TProfile with η and pT·Δϕ**, TProfile *tpr1->Fill(eta, C_value)**
  - Fill a TGraph with η and pT·Δϕ points

$$f(x) = p_0 + p_1\, x^2 + p_2\, x^4$$

- Fit the TProfile with Poly4 func (5para. x^0-x^4)
  - loop xbins, if(profC->GetBinContent(ib) > 0.205) profC->SetBinError(ibin, 2e-1)
    adjust the error on odd bin, Minimize its impact on the fit.

- Fit the TGraph with Poly4 func (5para. x^0-x^4)
  - Advantage is that the fit is performed directly on the data points, without any binning.

# pt func of Δφ and η




$$f(x) = p_0 + p_1\, x^2 + p_2\, x^4$$

Func of TProfile:

| NO. | NAME | VALUE | ERROR |
|---|---|---|---|
| 1 | p0 | 1.98211e-01 | 1.35824e-05 |
| 2 | p1 | 1.30640e-02 | 7.62297e-05 |
| 3 | p2 | -9.81183e-03 | 7.37033e-05 |

Func of TGraph:

| | | | | |
|---|---|---|---|---|
| p0 | = | 0.198642 | +/- | 1.39234e-05 |
| p1 | = | 0.011377 | +/- | 7.67776e-05 |
| p2 | = | -0.0085433 | +/- | 7.38428e-05 |

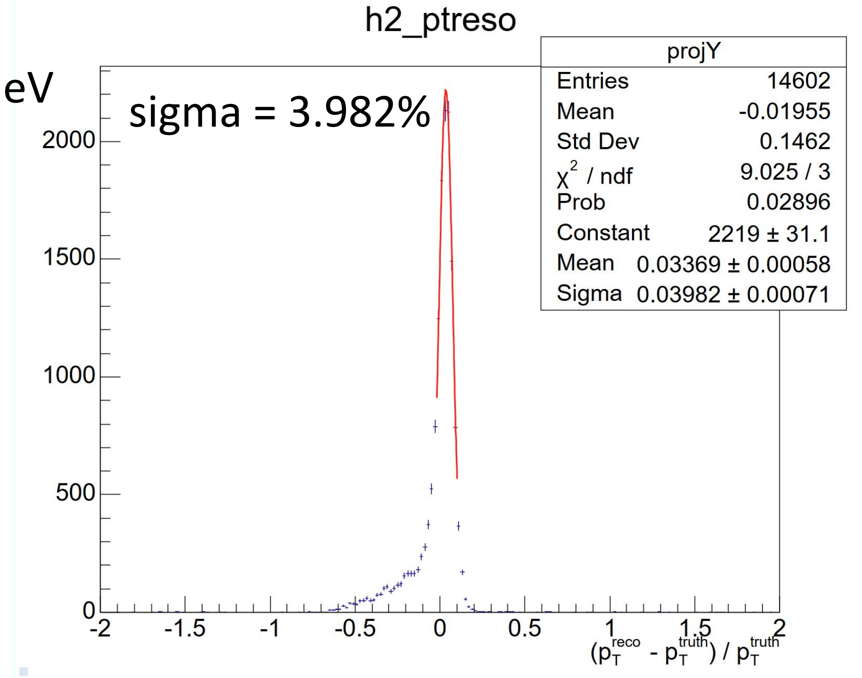
# ptFunc1 Performance

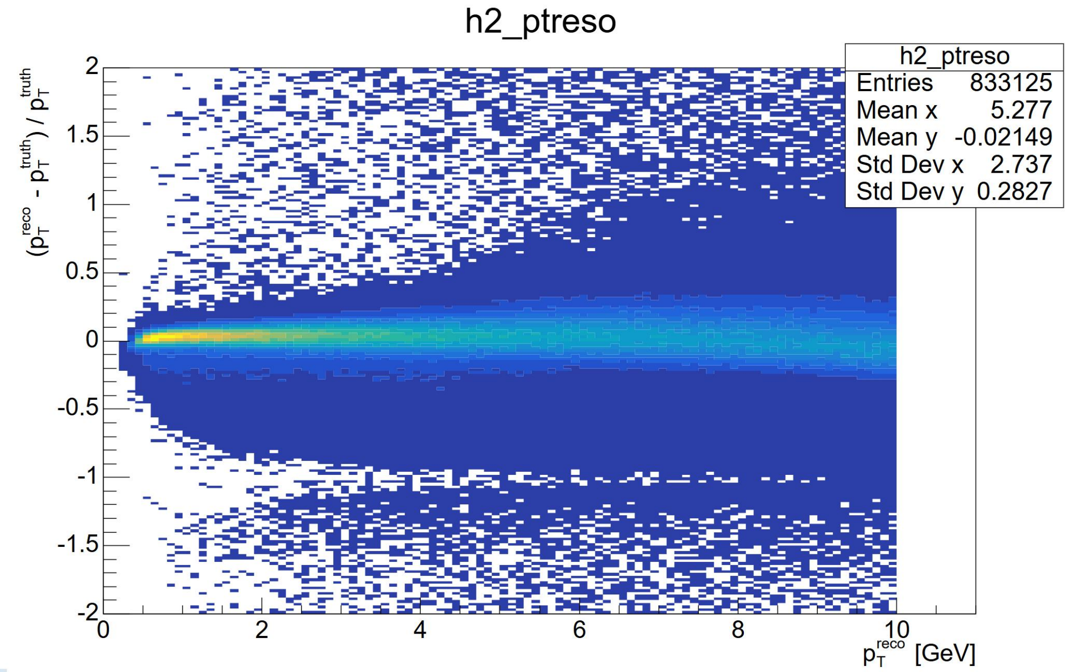
Angle between 2 lines
line connect EMC and oINTT
line connect iINTT oINTT

iINTT oINTT reconstruction position
Cluster reco with tower inner face center after correction

Func from TProfile

0.9-1.1 GeV




~4% pt resolution on 0.9-1.1GeV

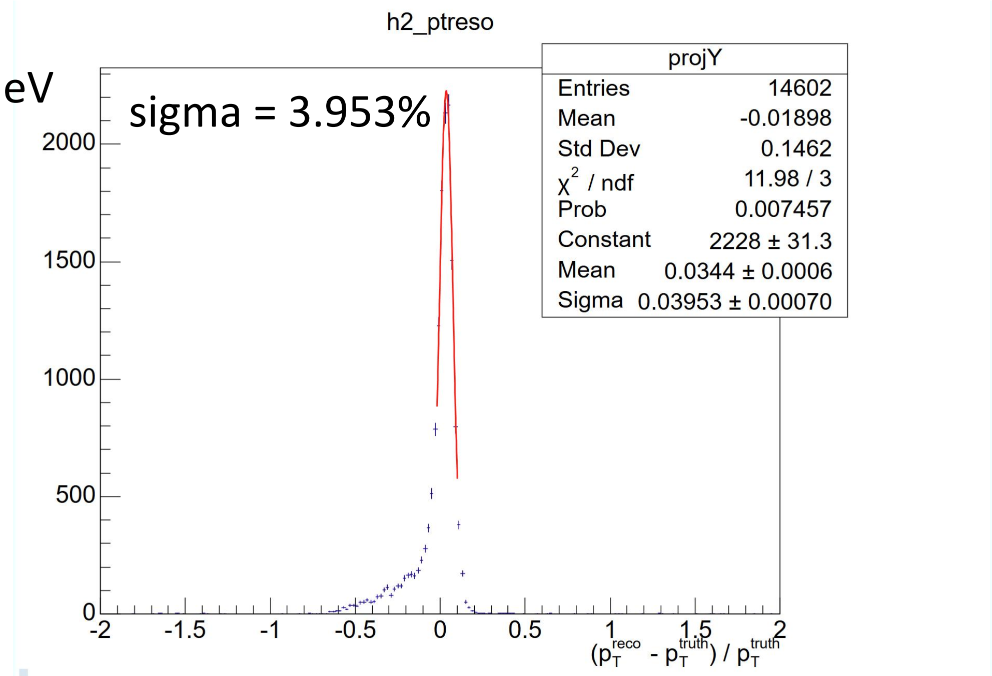
# ptFunc2 Performance

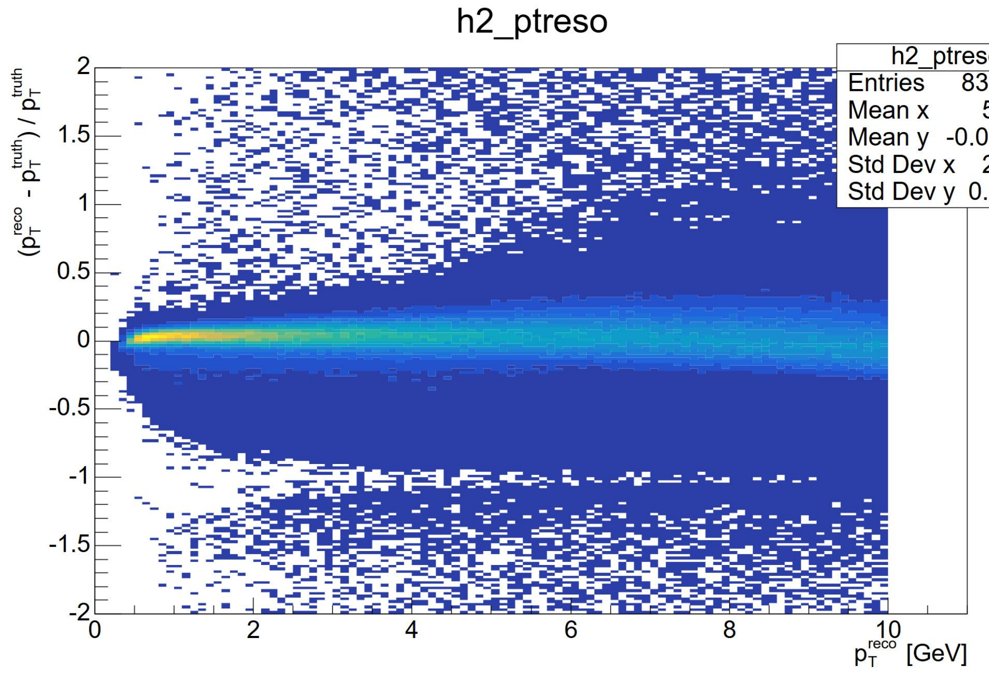
Angle between 2 lines
line connect EMC and oINTT
line connect iINTT oINTT

iINTT oINTT reconstruction position
Cluster reco with tower inner face center after correction

## Func from TGraph

0.9-1.1 GeV

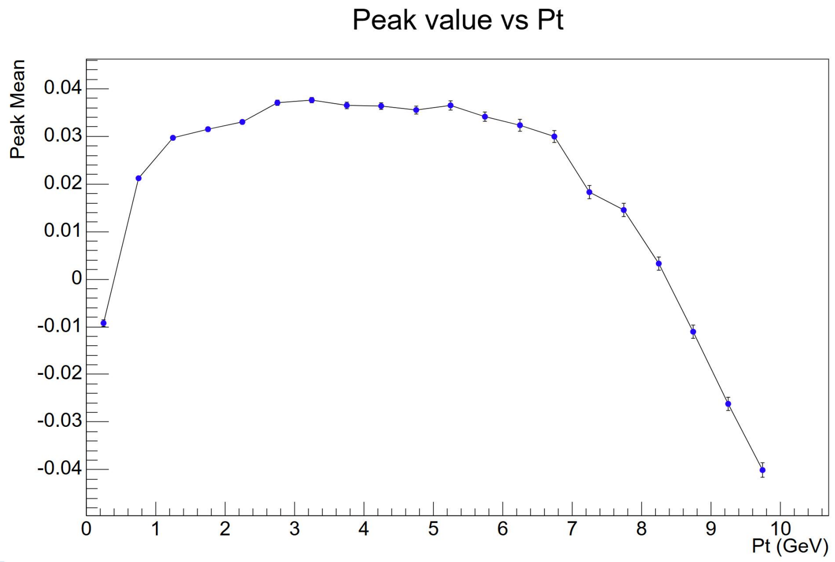


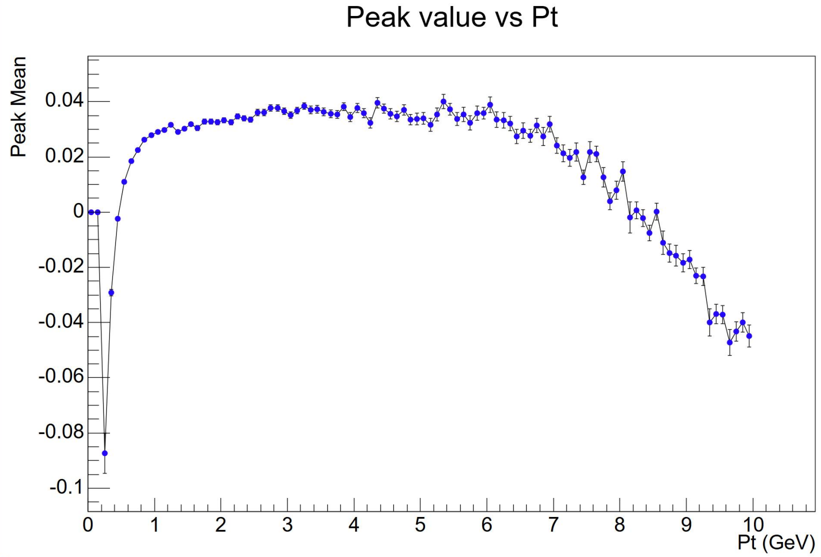



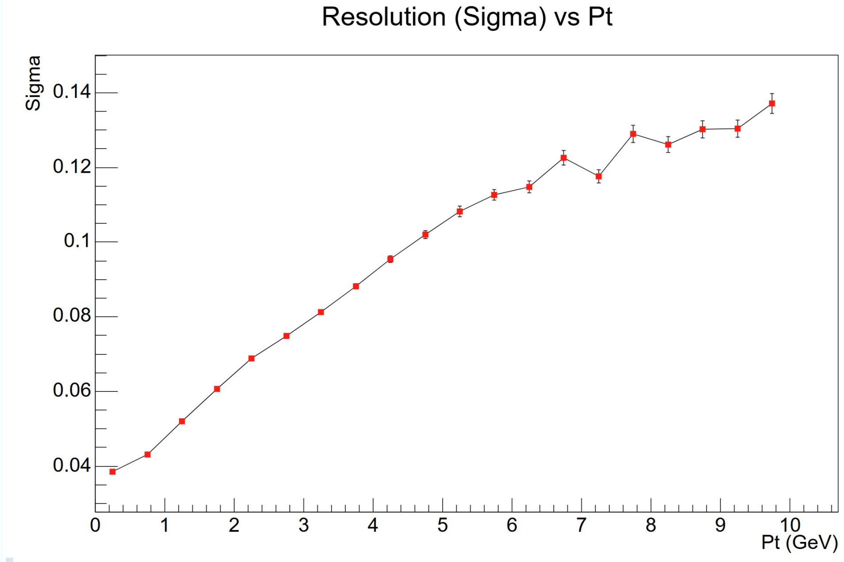

~4% pt resolution on 0.9-1.1GeV

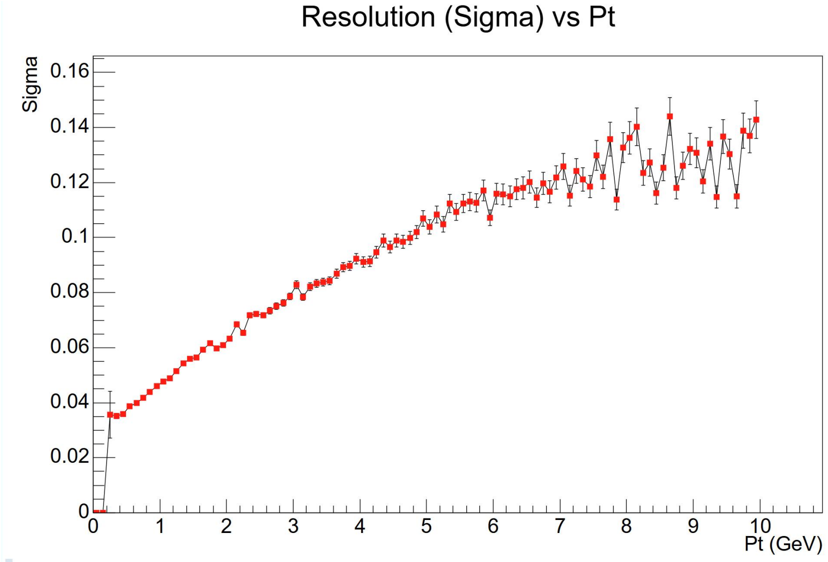
**Both two func have similar performance,**
**pt resolution about 4% on 0.9-1.1 GeV**

# Pt reconstruction bias and resolution - pt



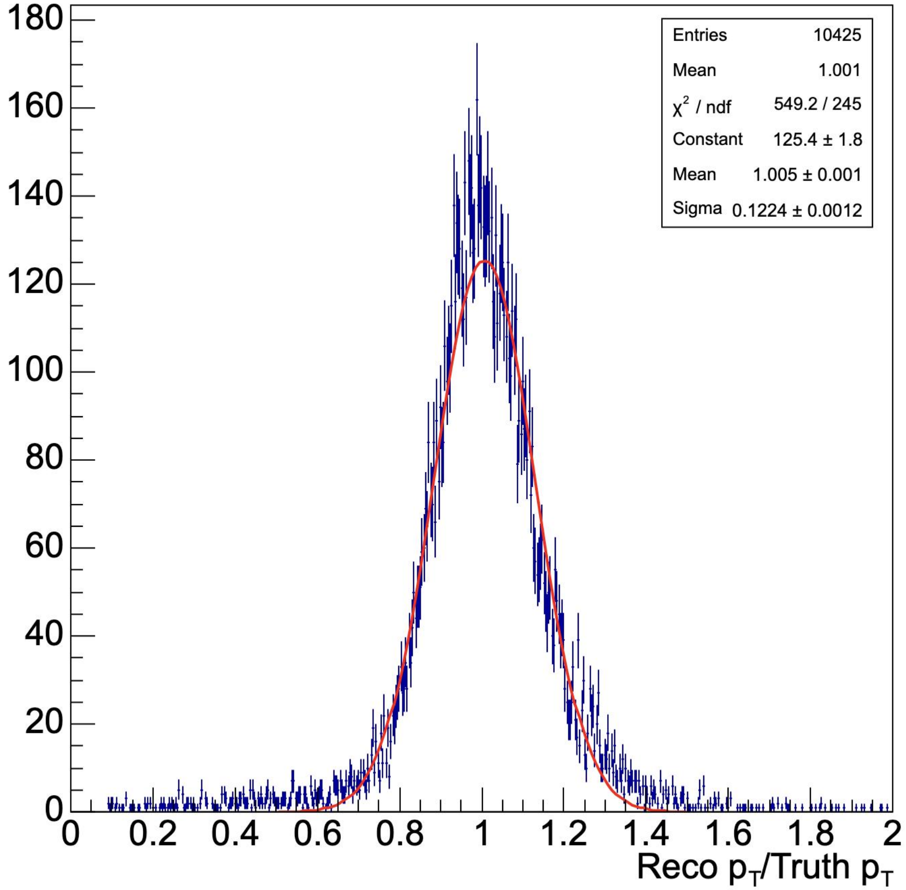




pt resolution increase with larger pt

# Performance

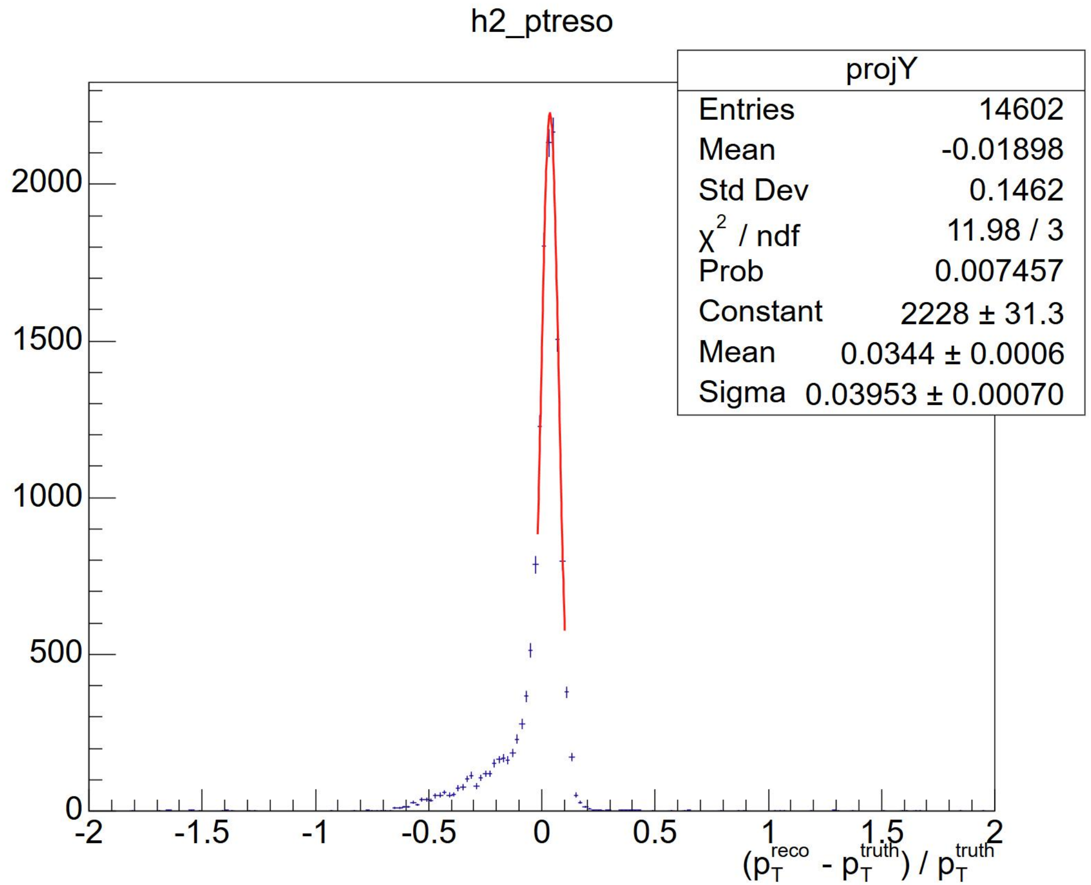
PHActsSiliconSeeding only

electron pT = [1 - 1.25] GeV/c

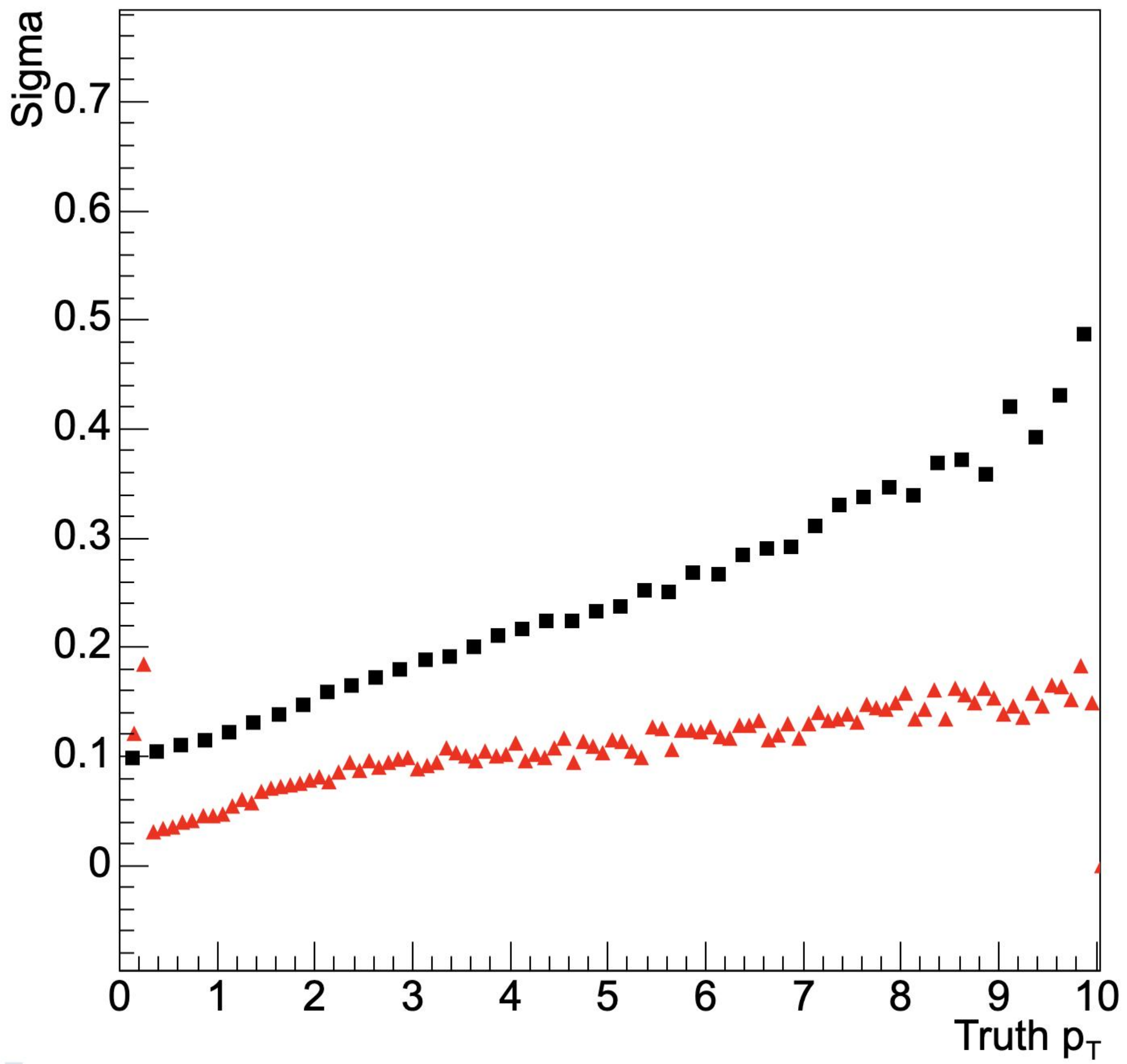



INTT-Calo

electron pT = [0.9 - 1.1] GeV/c



# Performance



performance summary:

**Both two func have similar performance,**
**pt resolution about 4% on 0.9-1.1 GeV**

# Thanks for your attention