

Analysis of Athena full simulation (Reco)

Jinlong Zhang (Shandong University)

Aug 23, 2021

Files used:

<https://dtn01.sdcc.bnl.gov:9000/minio/eictest/ATHENA/RECO/master/DIS/NC/18x275/minQ2=1/>

eictest / ATHENA / RECO / master / DIS / NC / 18x275 / minQ2=1 / +

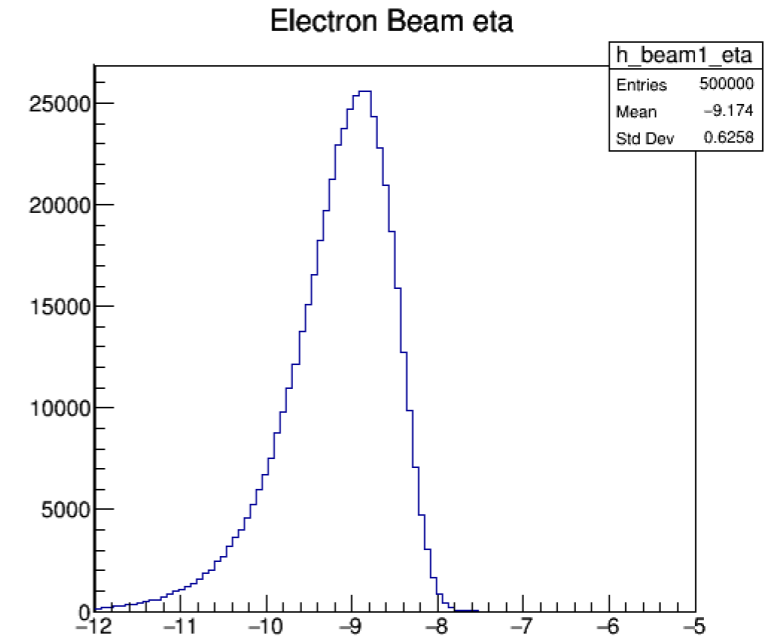
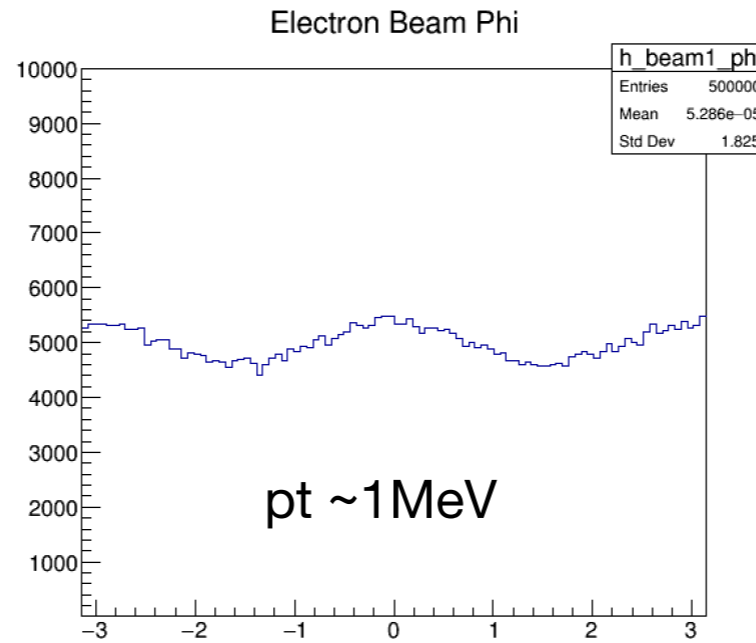
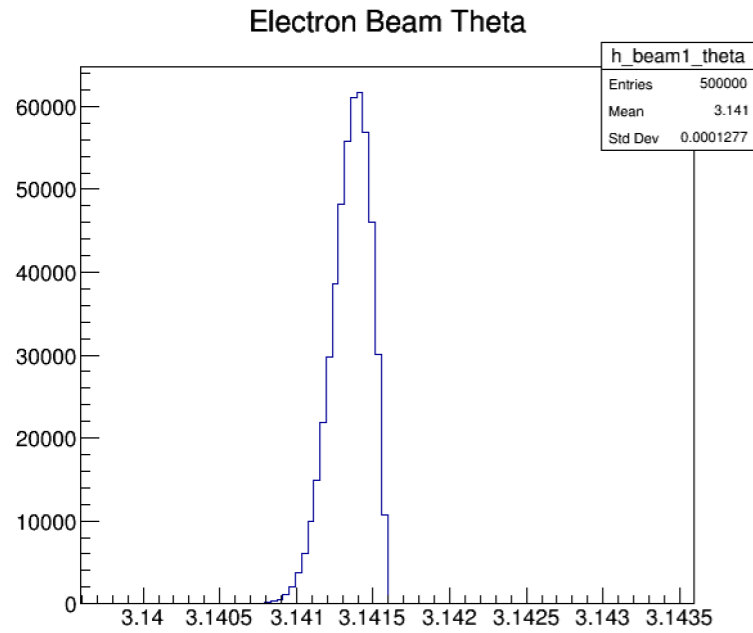
pythia8NCDIS_18x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1.0040.root

Name	Size	Last Modified	⌵
pythia8NCDIS_18x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1.0040.root	27.05 MB	Aug 19, 2021 11:37 AM	⋮
pythia8NCDIS_18x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1.0079.root	27.52 MB	Aug 19, 2021 11:37 AM	⋮
pythia8NCDIS_18x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1.0076.root	27.10 MB	Aug 19, 2021 11:37 AM	⋮

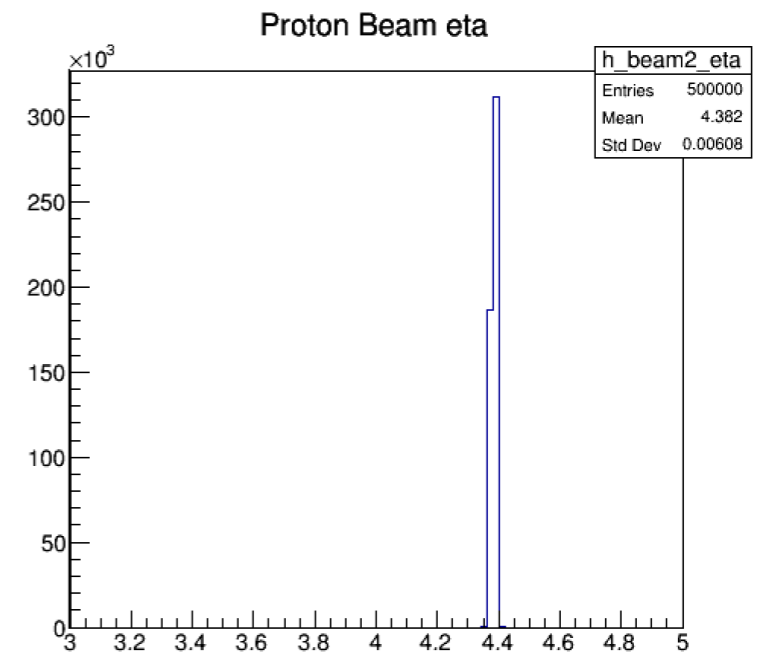
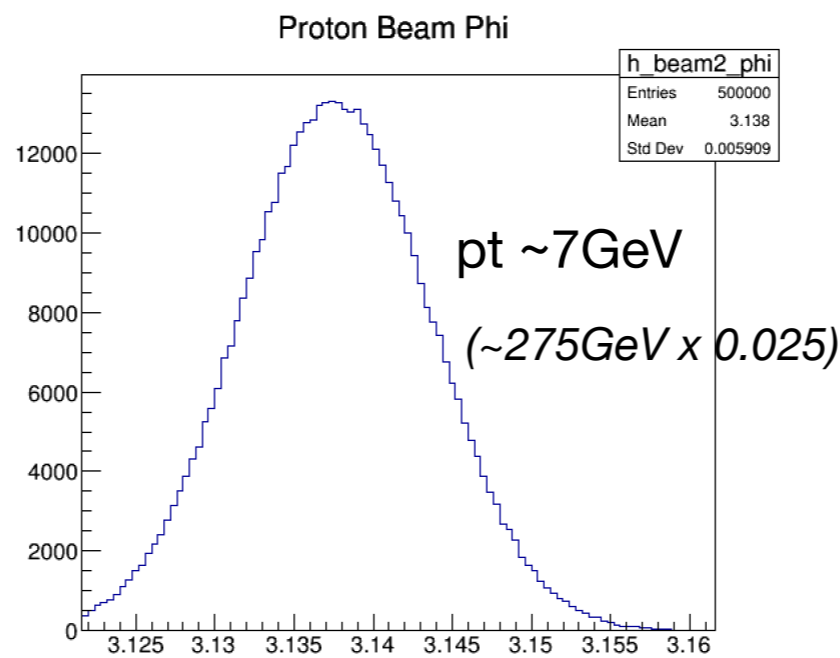
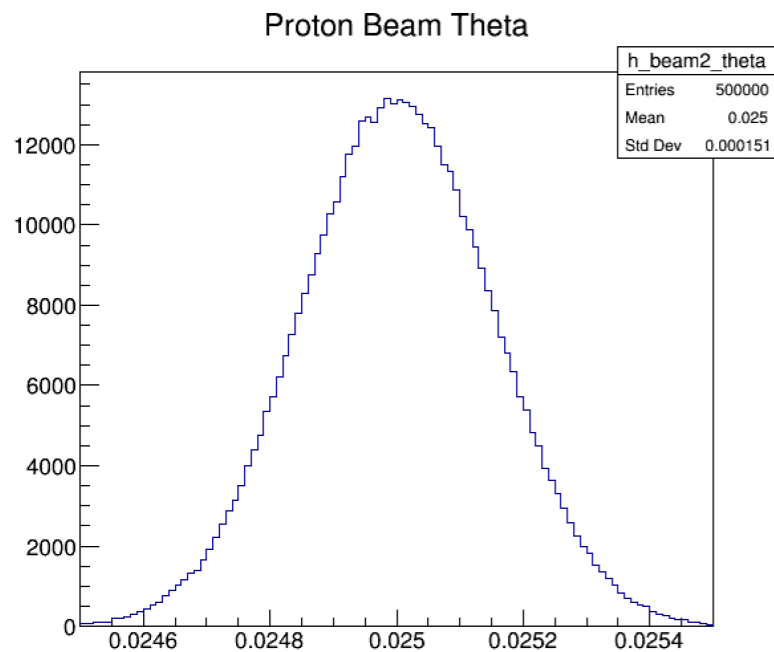
- beam crossing angle



Electron beam



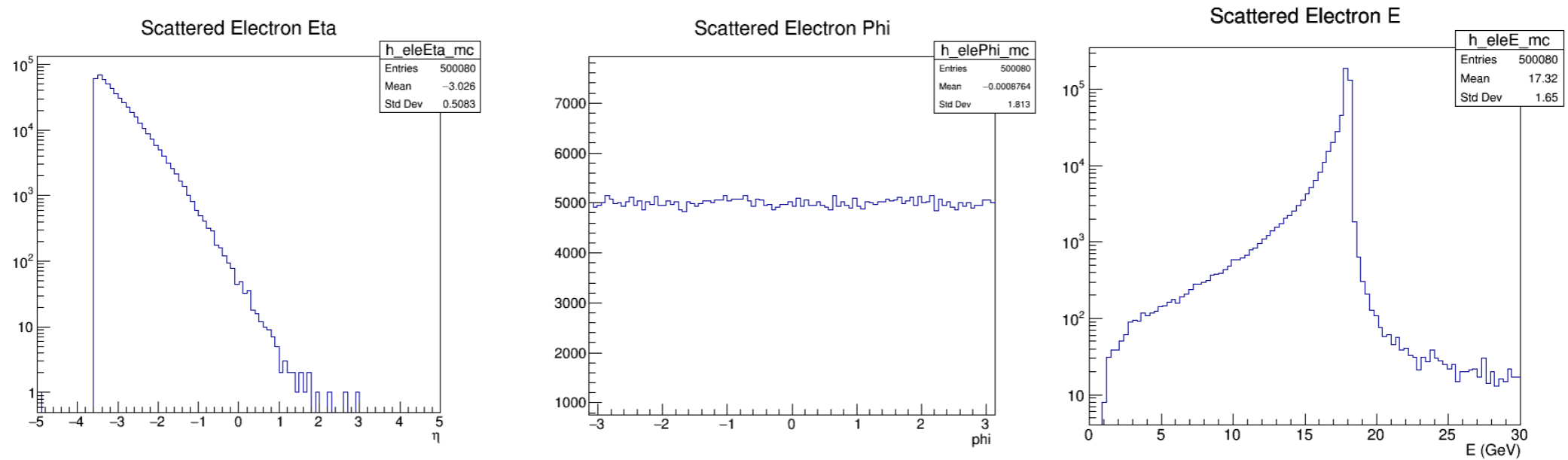
Proton beam



- Final state particles (truth level)

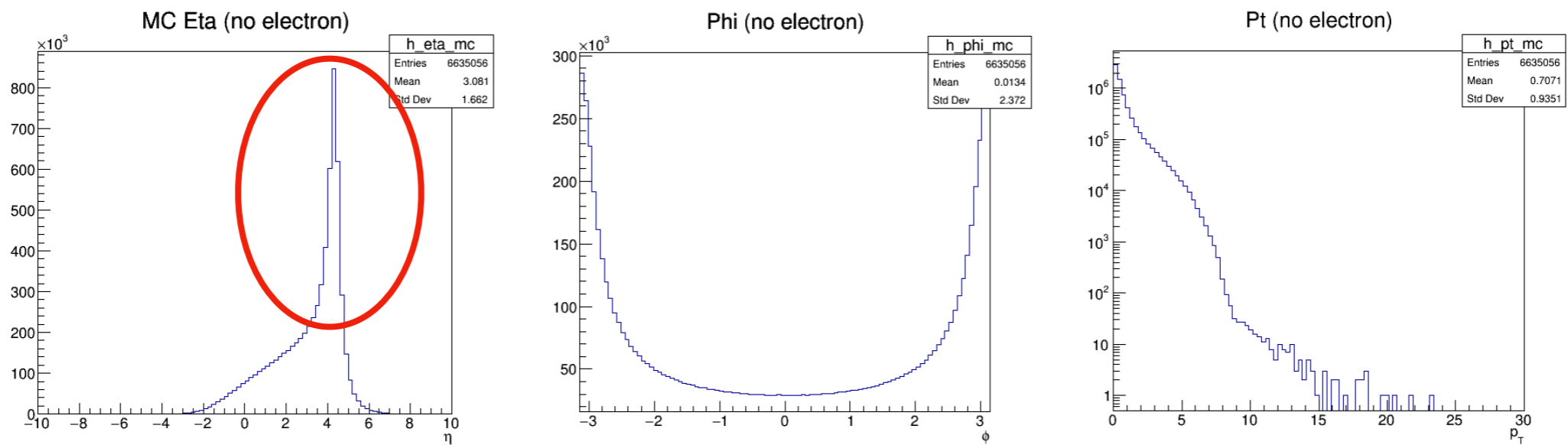


Scattered electrons



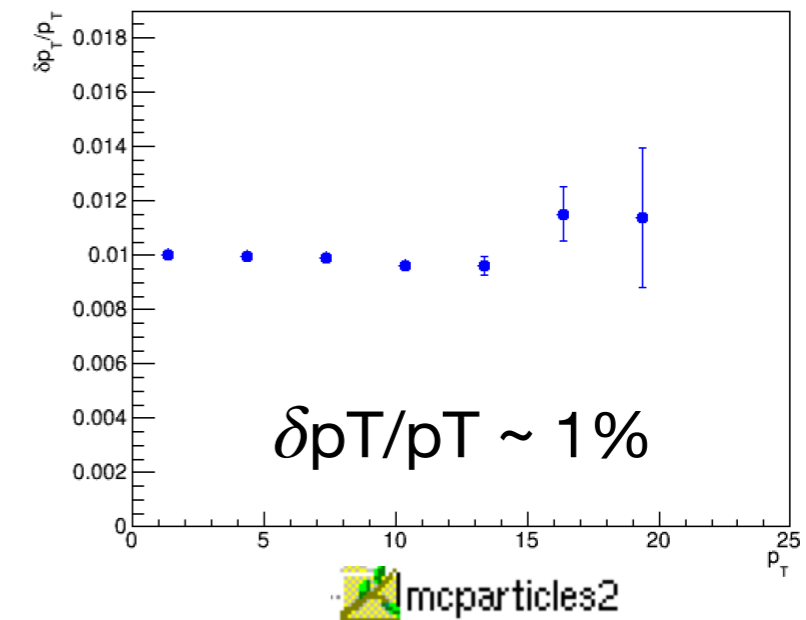
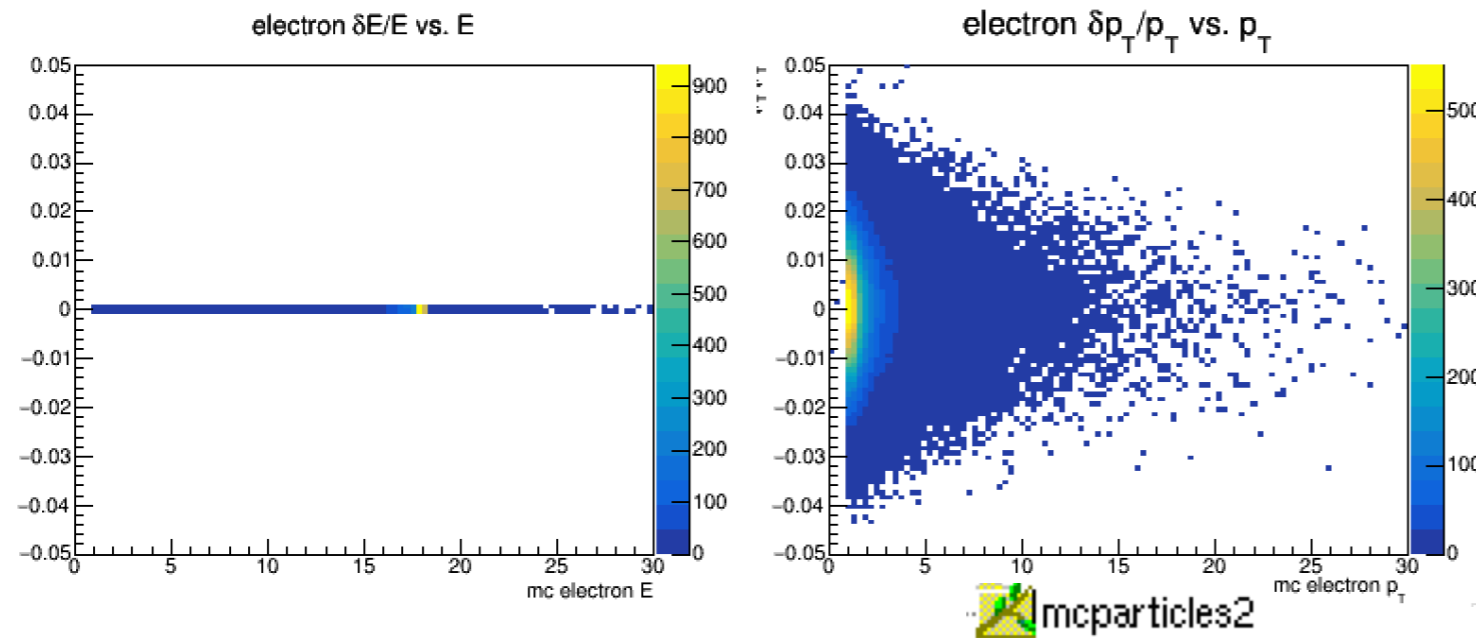
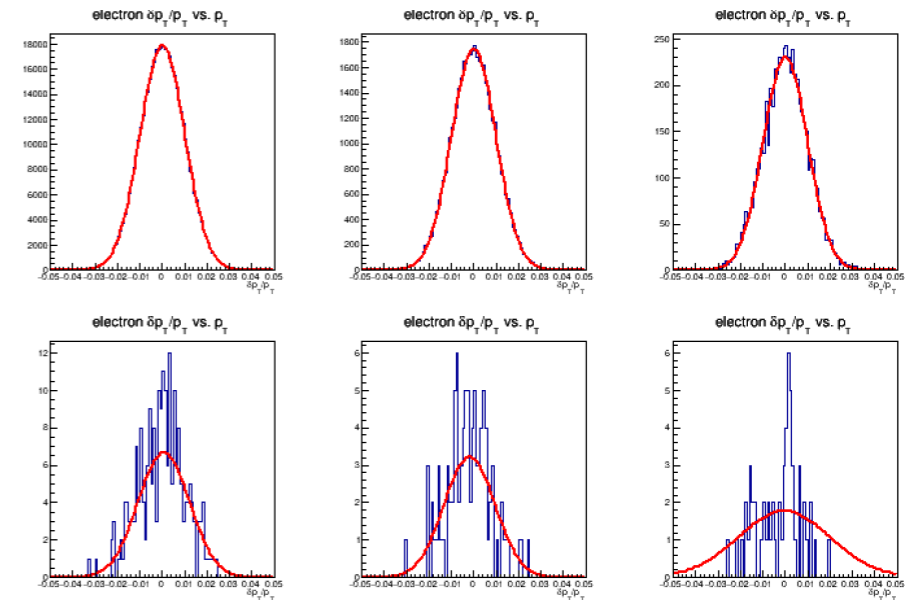
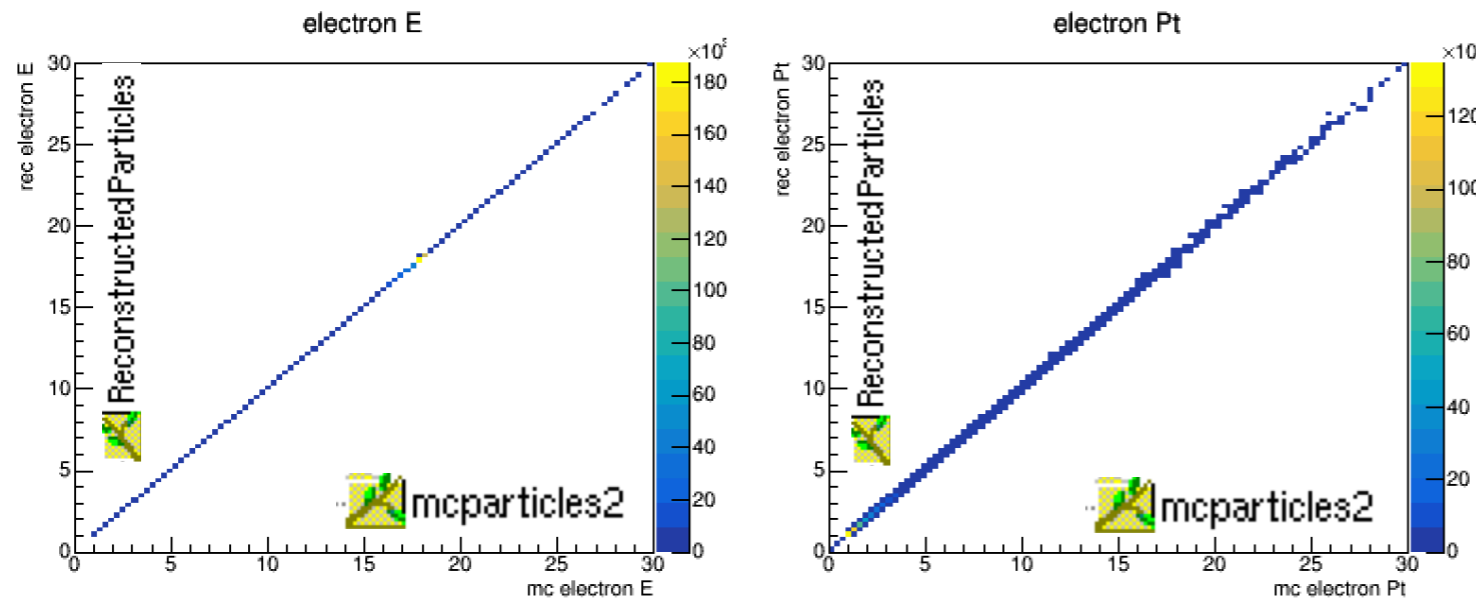
No visible effect from initial state pT

Other final state particles except for scattered electrons



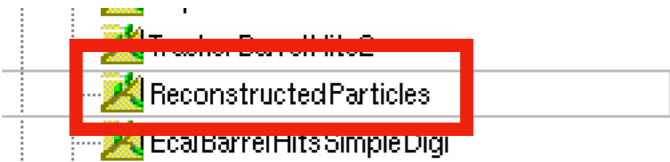
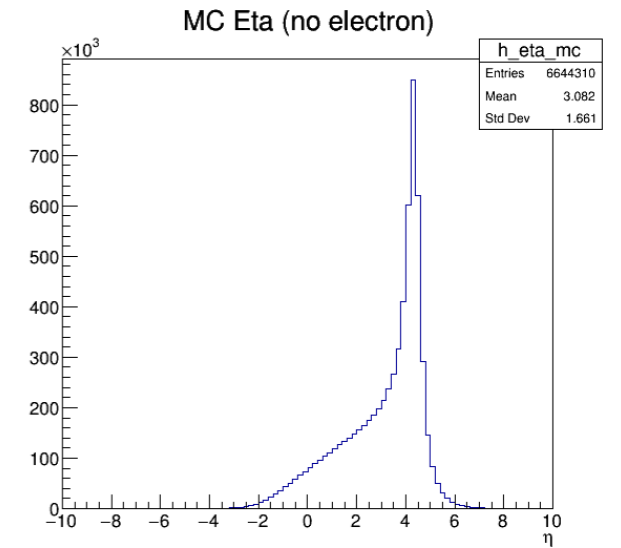
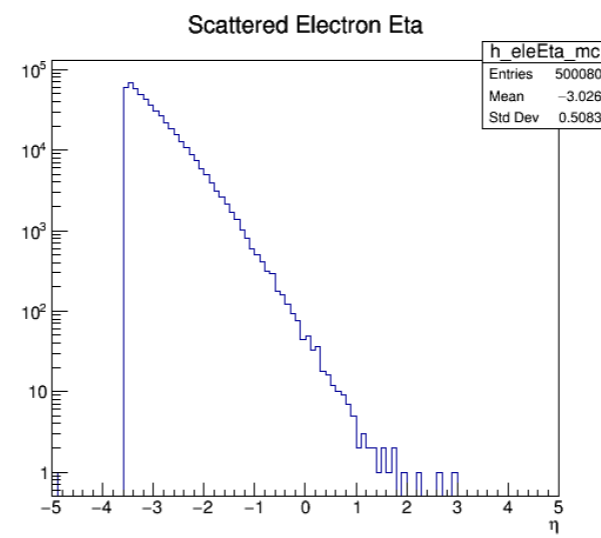
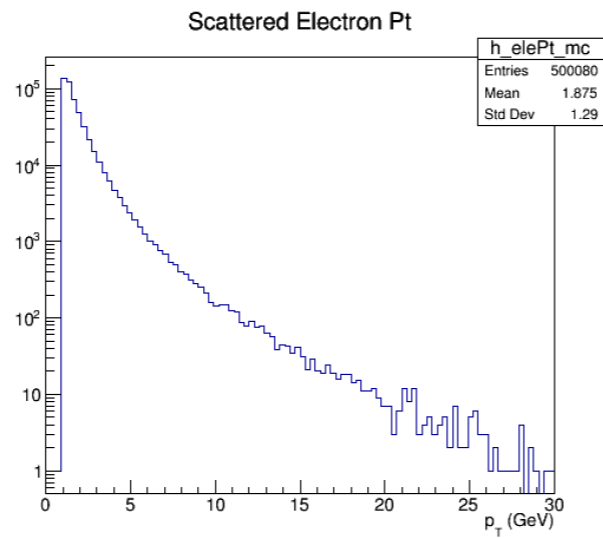
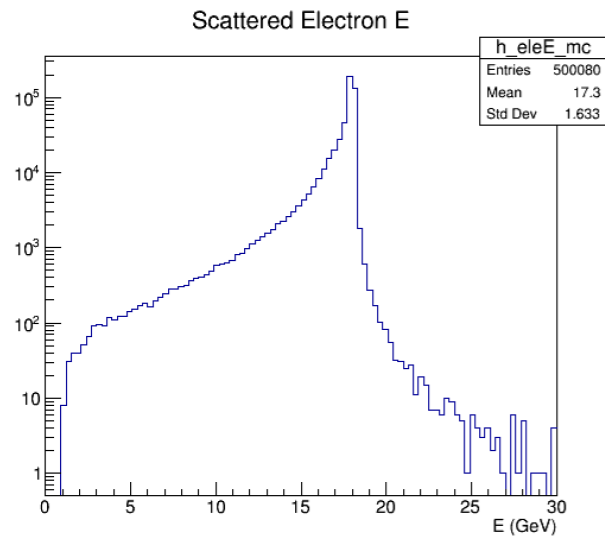
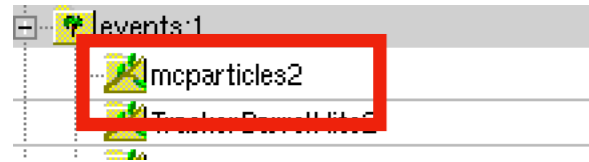
Significant beam angle effect at very forward region

- Energy and momentum resolutions

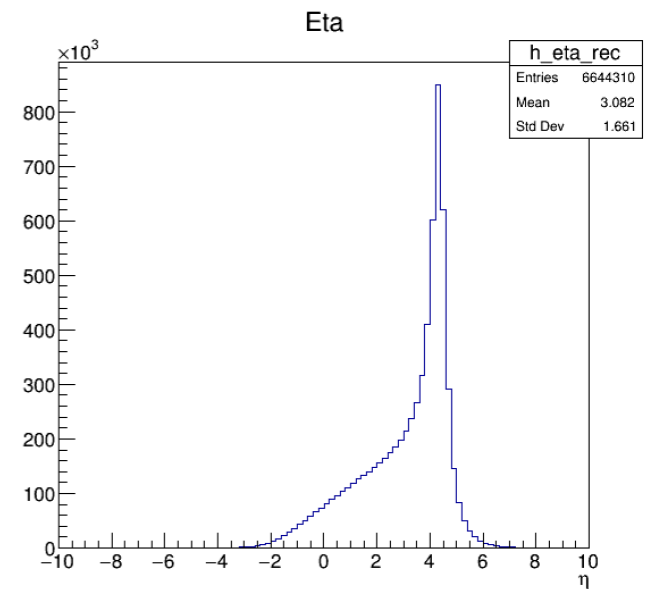
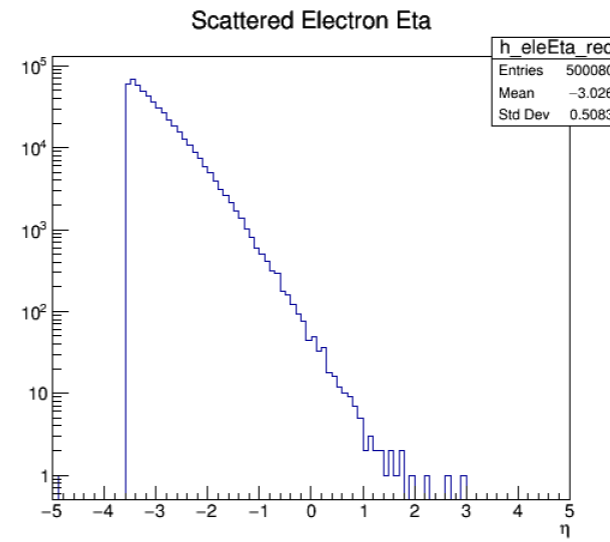
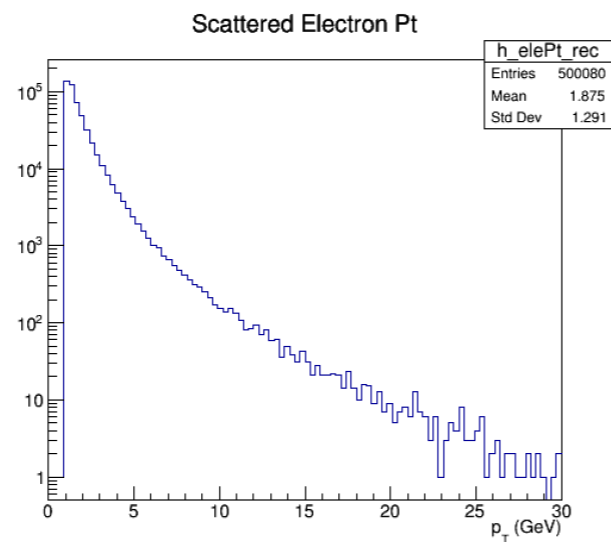
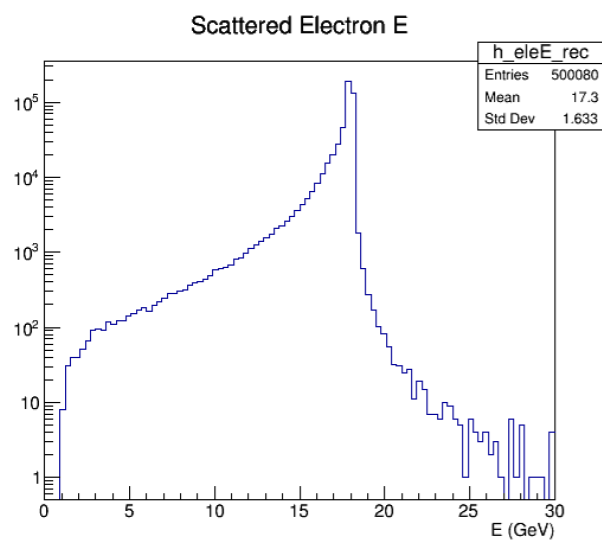


- no detector effect for energy
- momentum resolution doesn't depend on p_T

- ReconstructedParticles vs mcparticles2

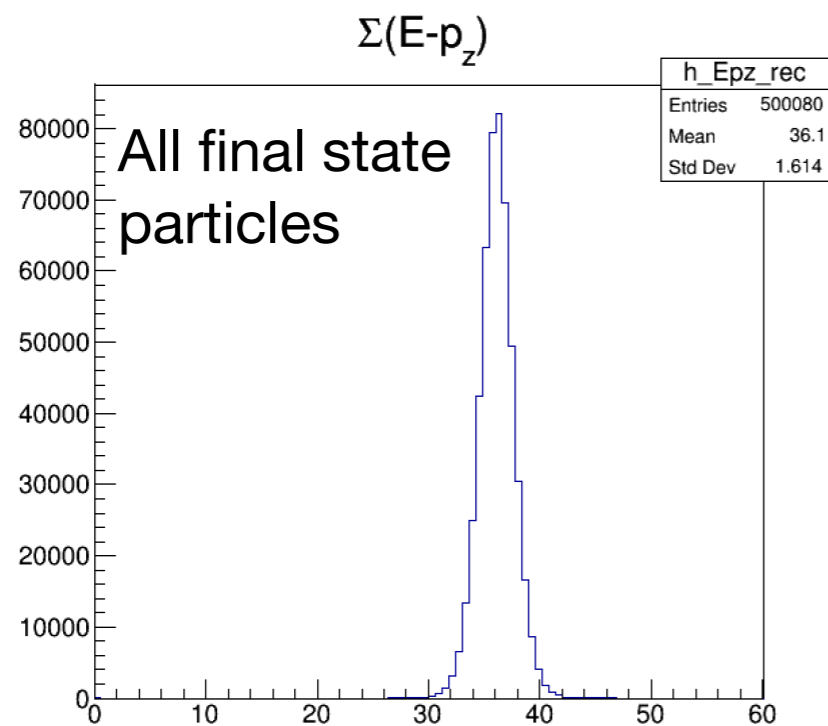
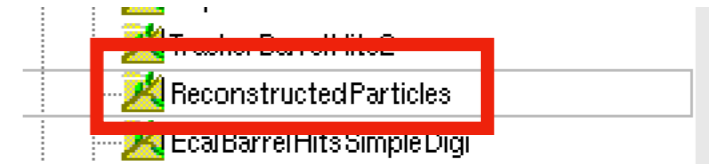


- No detector effect on Energy, Eta, Acceptance ??

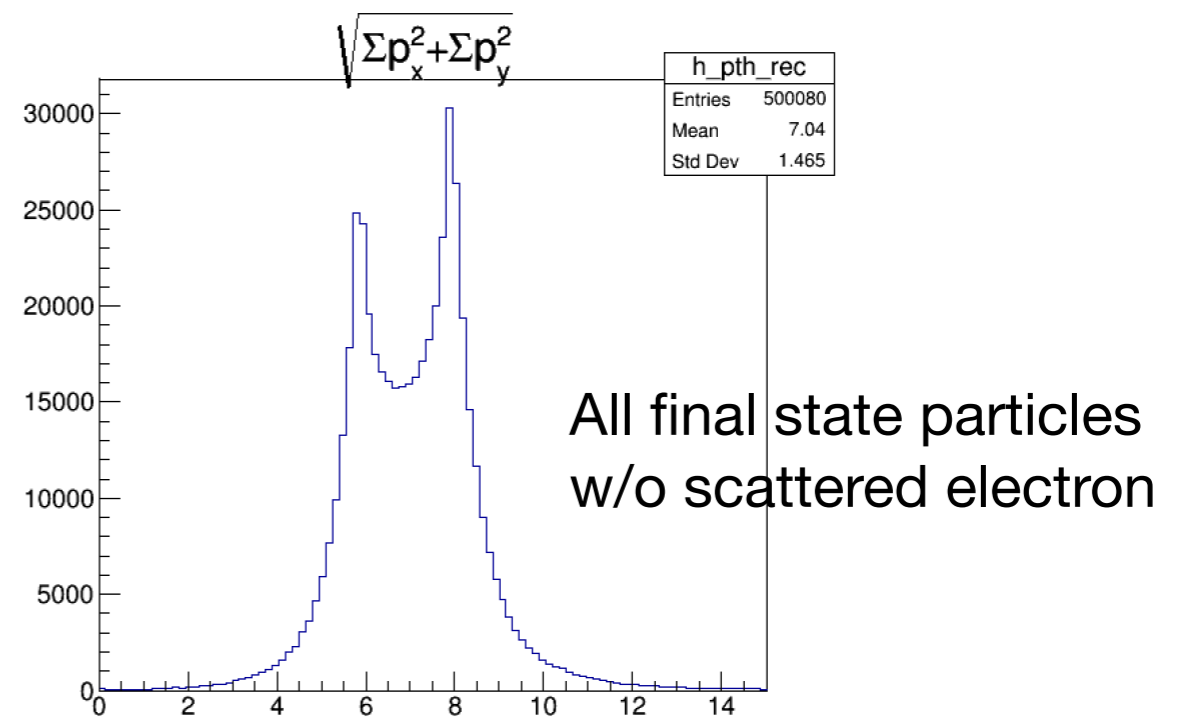


All $\Sigma(E-p_z)$ and hadronic $\sqrt{\Sigma p_x^2 + \Sigma p_y^2}$

Needed by kinematics reconstruction using hadronic methods



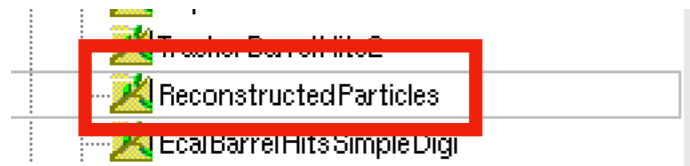
No visible impact from beam crossing angle



Strongly boosted

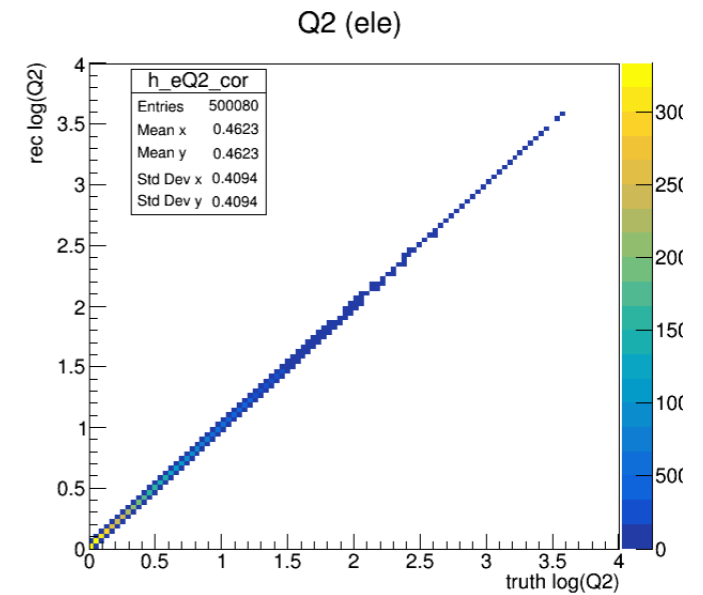
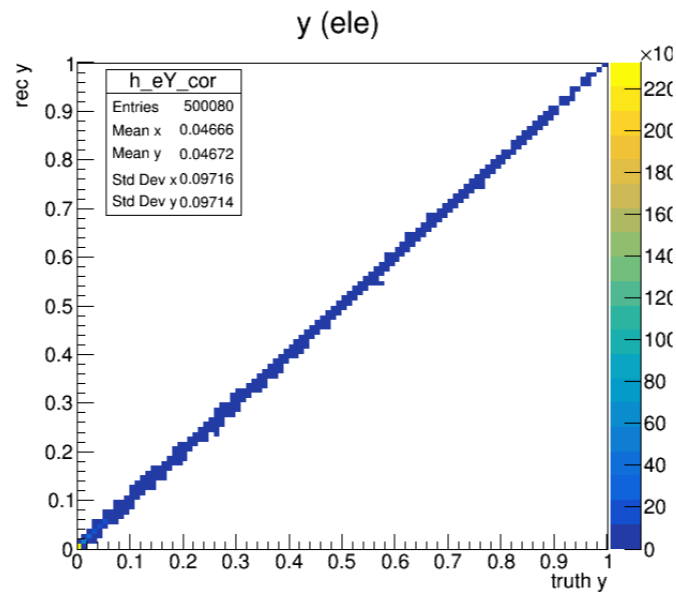
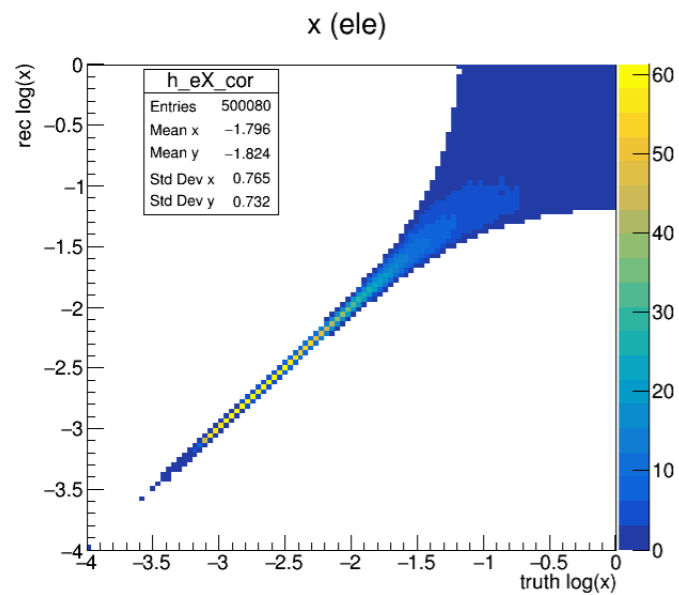
Boost back to head-on frame?

Electron method

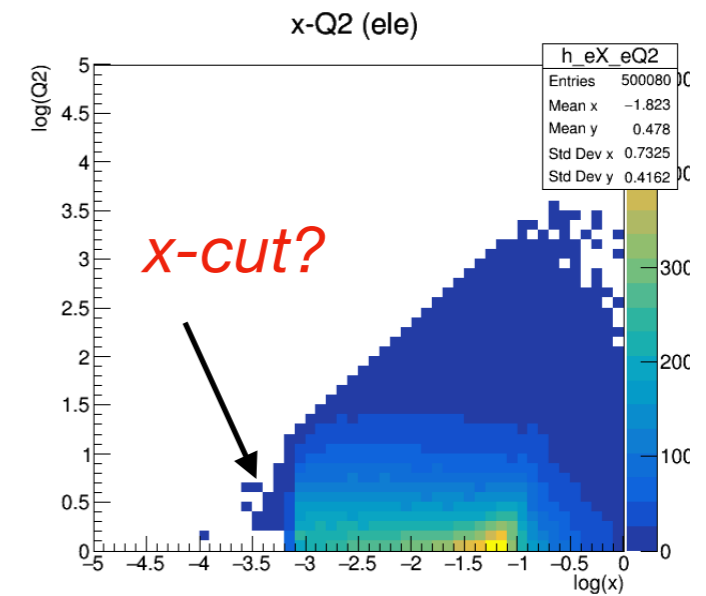
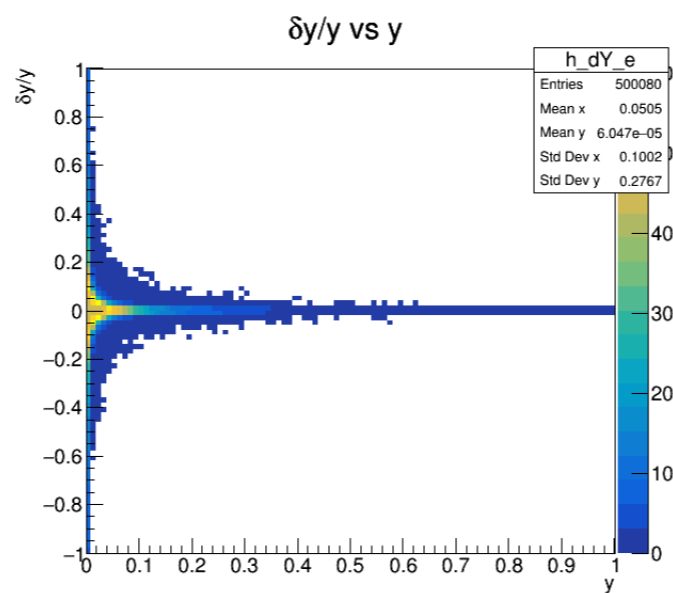
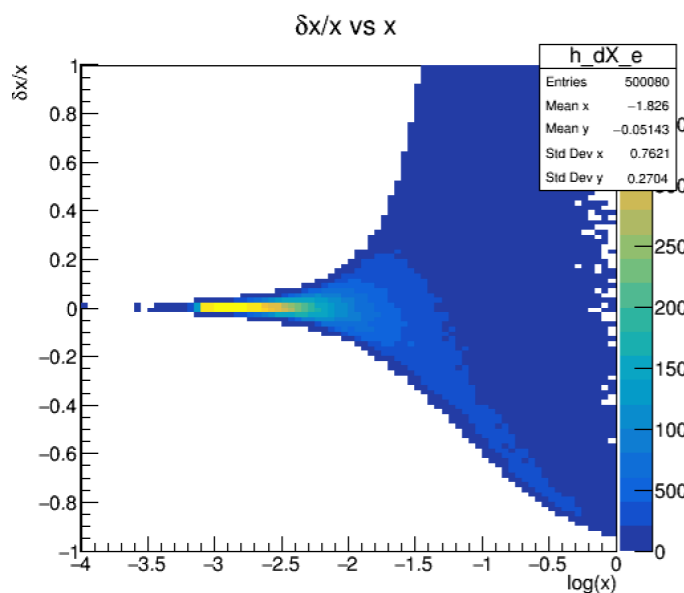


```
// electron method
void GetKinematics_e(TLorentzVector const &beam, TLorentzVector const &scat, Float_t cme,
                    Float_t *x, Float_t *y, Float_t *Q2)
{
    Float_t theta = TMath::Pi() - scat.Theta();
    //Float_t theta = scat.Theta();
    *y = 1 - scat.E()*cos(theta/2.)*cos(theta/2.)/ebeam.E();
    *Q2 = 2.*scat.E()*ebeam.E()*(1.-cos(theta));
    *x = *Q2/cme/(*y);
}

```

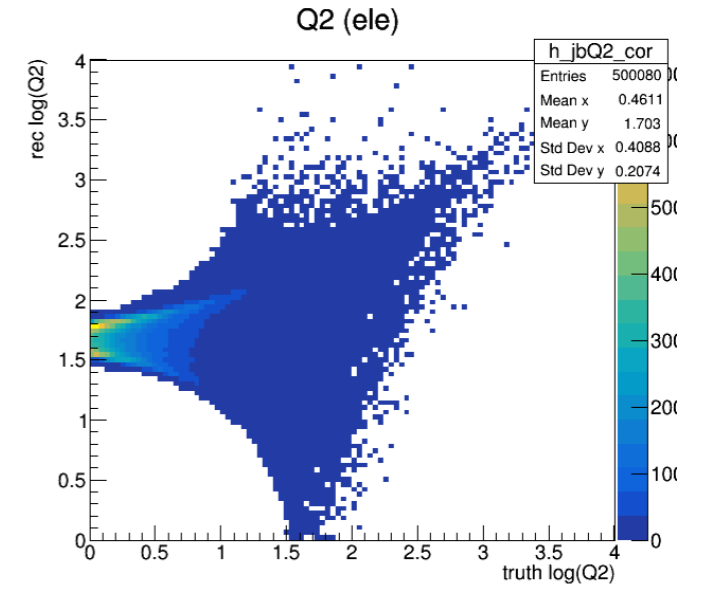
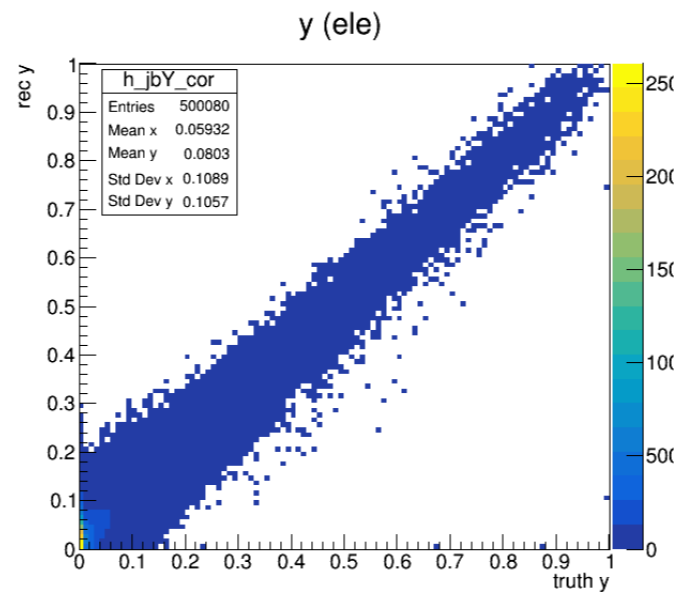
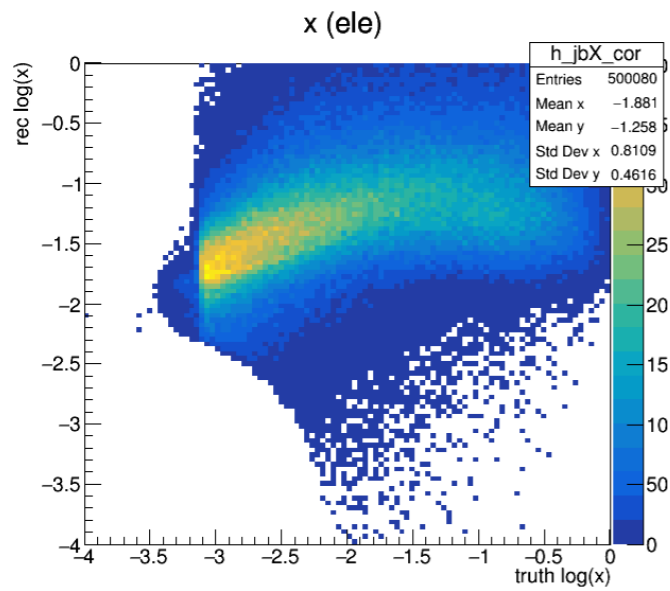
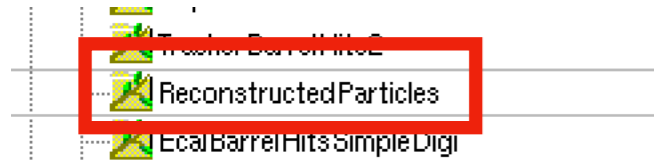


Truth x, y, Q2 using Lorentz vectors from *mcparticles2*

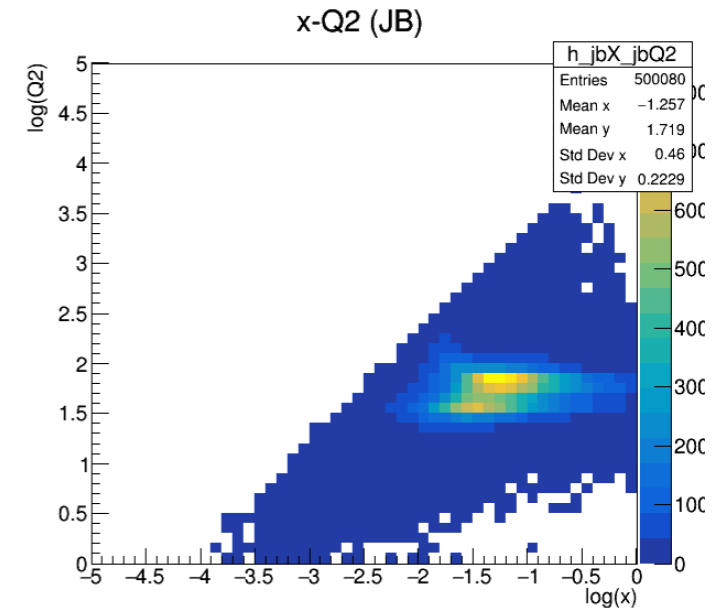
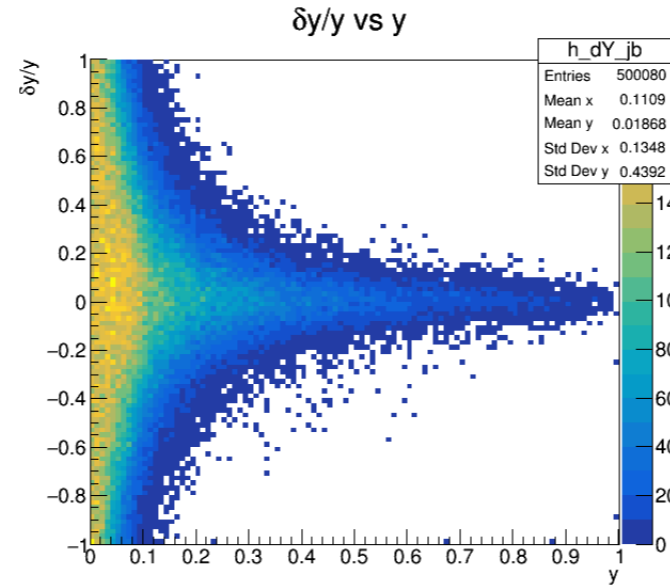
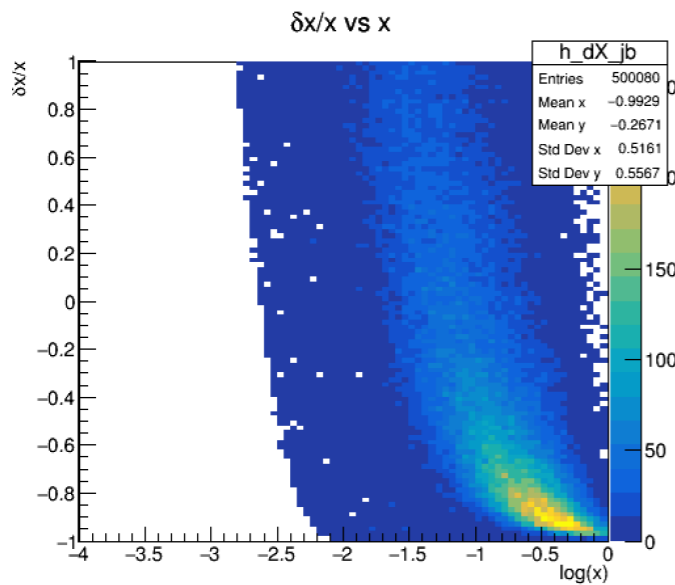


JB

```
// Jacquet-Bloded Method
void GetKinematics_jb(Float_t Epzh, Float_t pth, Float_t cme, TLorentzVector const &beam,
                    Float_t *x, Float_t *y, Float_t *Q2)
{
    *y = Epzh/2./ebeam.E();
    *Q2 = pth*pth/(1-*y);
    *x = *Q2/cme/(1-*y);
}
```

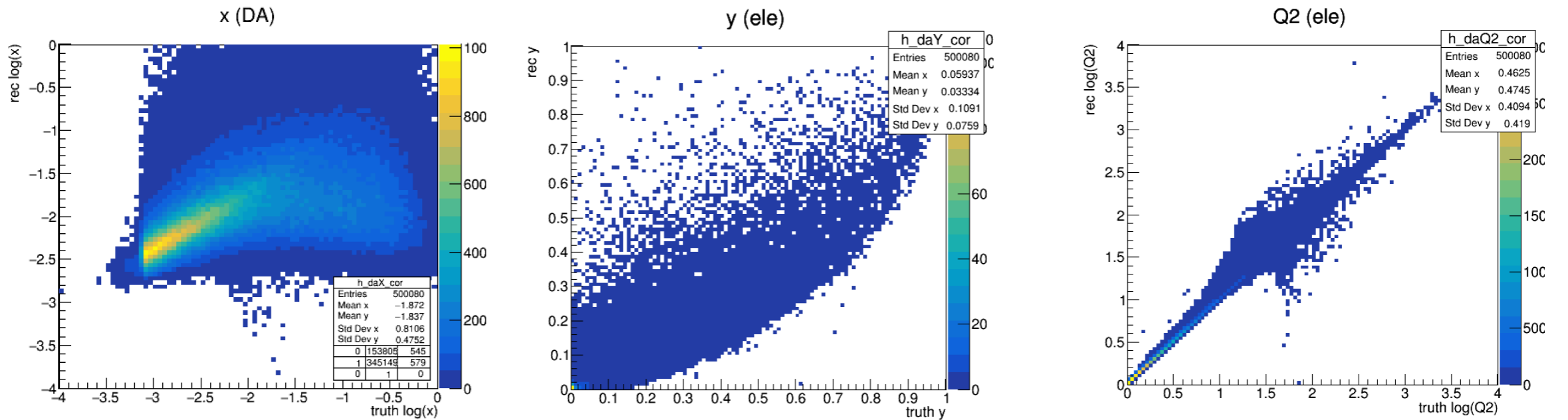
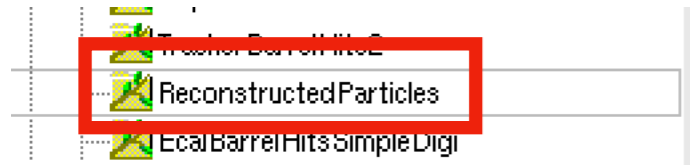


Truth x, y, Q2 using Lorentz vectors from *mcparticles2*

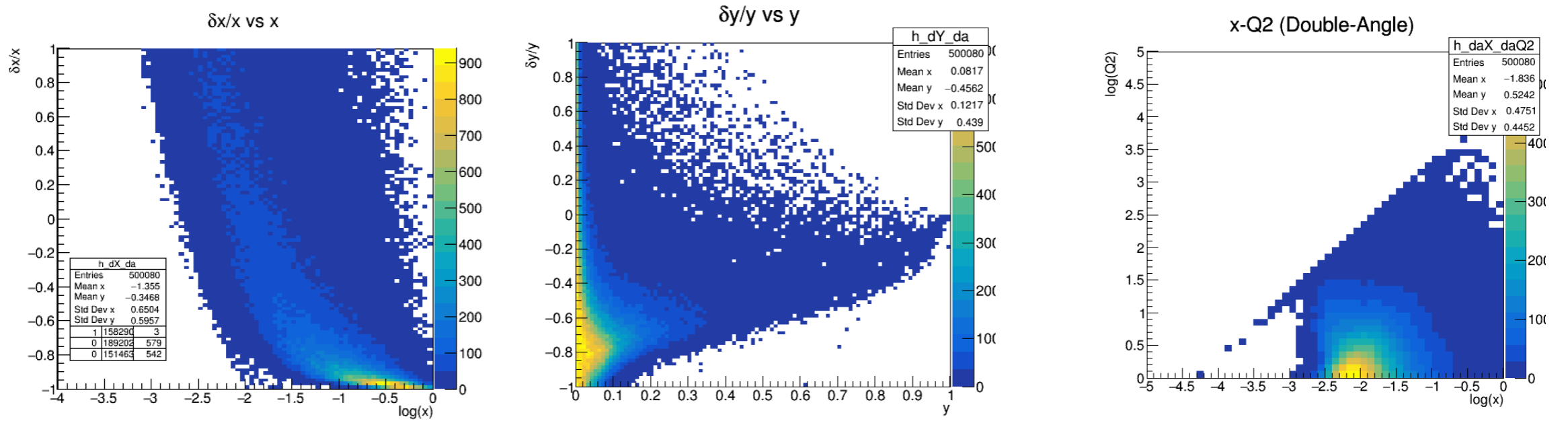


DA

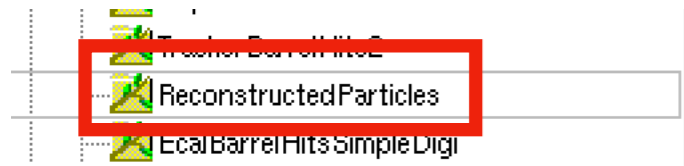
```
// double-angle method
void GetKinematics_da(Float_t Epzh, Float_t pth, Float_t cme, TLorentzVector const &beam,
                    TLorentzVector const &escat, Float_t *x, Float_t *y, Float_t *Q2)
{
    Float_t gamma = 2.*atan(Epzh/pth);
    //Float_t theta = TMath::Pi() - escat.Theta();
    Float_t theta = escat.Theta();
    *y = tan(gamma/2.)/(tan(theta/2.) + tan(gamma/2.));
    *Q2 = 4*beam.E()*beam.E()/tan(theta/2.)/(tan(theta/2.) + tan(gamma/2.));
    // *y = sin(theta)*(1-cos(gamma))/(sin(gamma)+sin(theta)-sin(theta+gamma));
    // *Q2 = 4.*escat.E()*escat.E()*sin(gamma)*(1.+cos(theta))/(sin(gamma)+sin(theta)-sin(theta+gamma));
    *x = *Q2/cme/( *y );
}
```



Truth x, y, Q2 using Lorentz vectors from *mcparticles2*

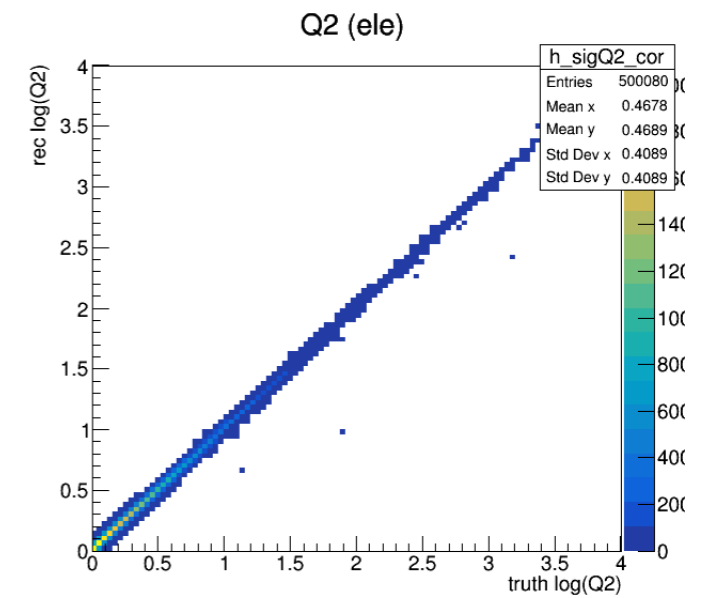
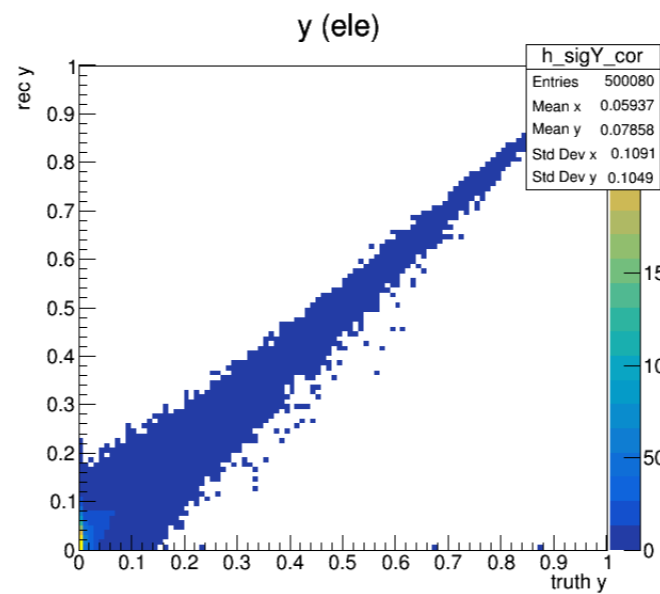
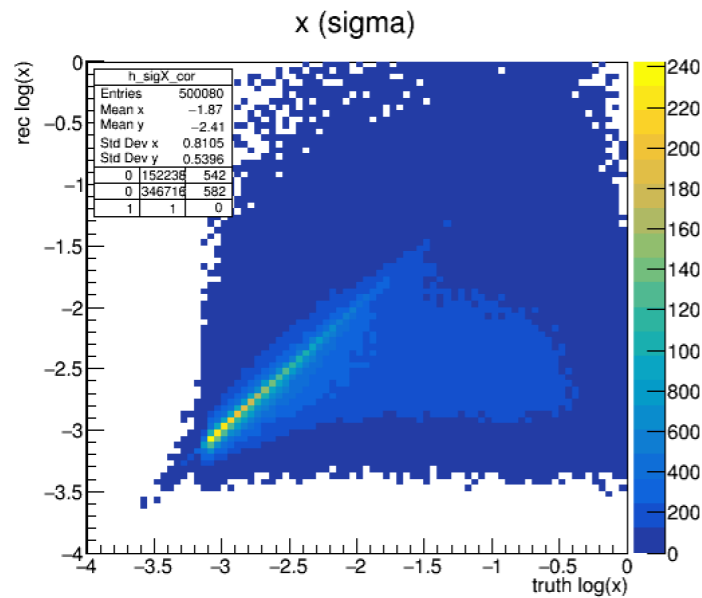


Sigma

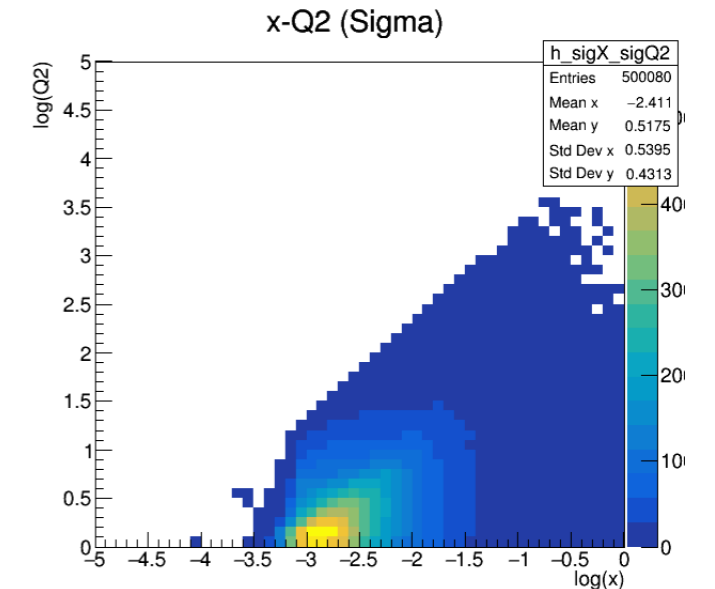
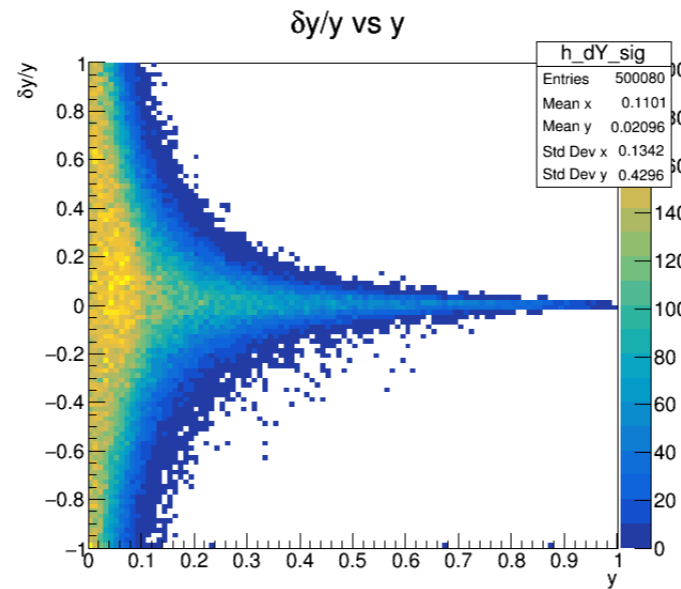
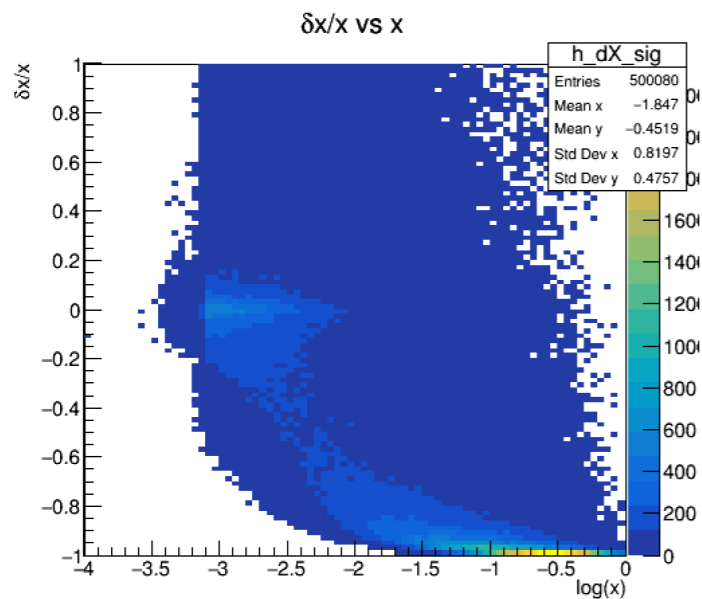


```
// sigma method
void GetKinematics_sigma(Float_t Epzh, Float_t cme, TLorentzVector const &escat,
    Float_t *x,Float_t *y,Float_t *Q2)
{
    Float_t Epz = escat.E() - escat.Pz();
    *y = Epzh/(Epzh+Epsz);
    *Q2 = escat.Pt()*escat.Pt()/(1. - *y);
    *x = *Q2/cme/(*y);
}

```

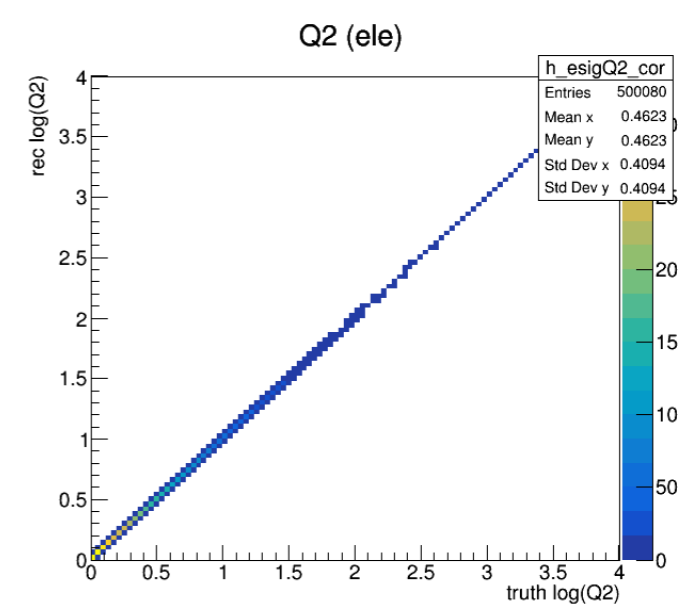
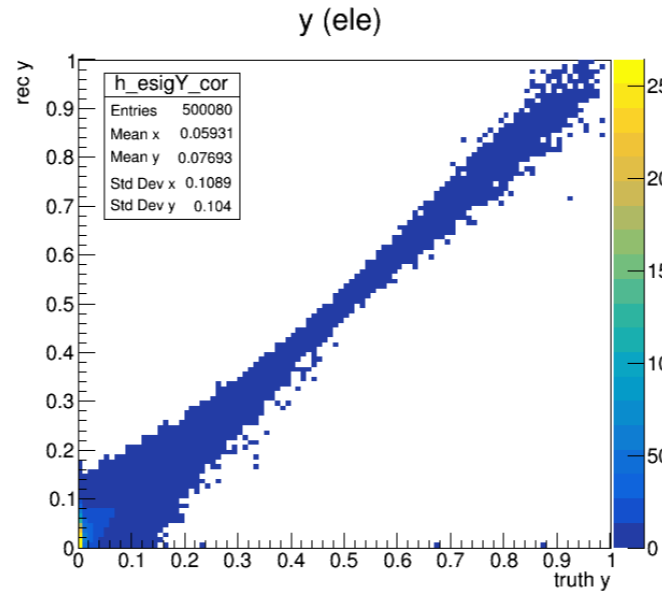
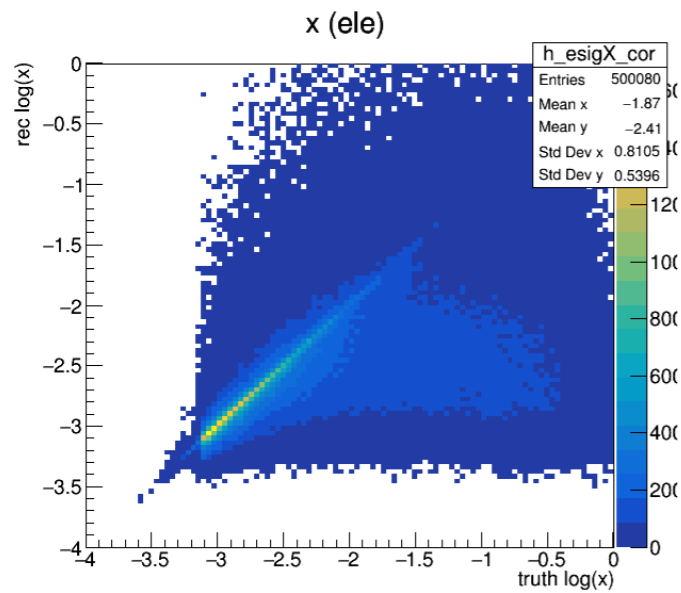
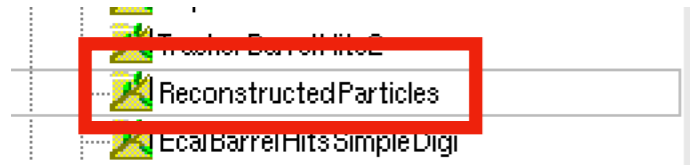


Truth x, y, Q2 using Lorentz vectors from *mcparticles2*

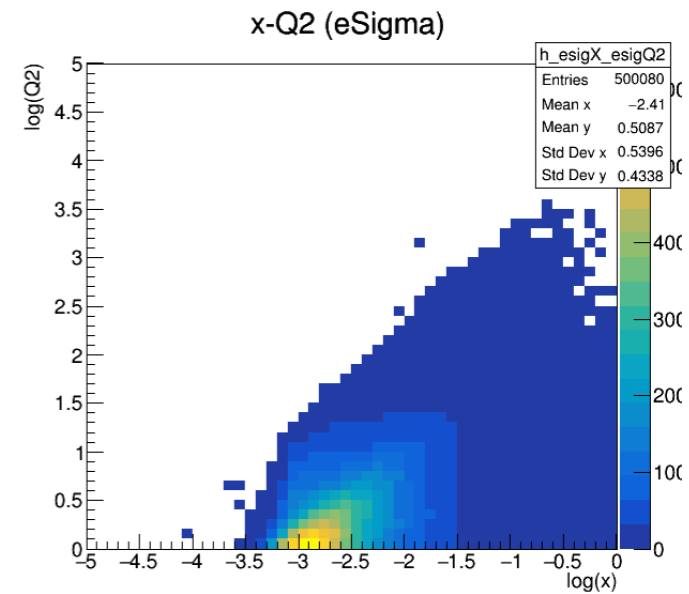
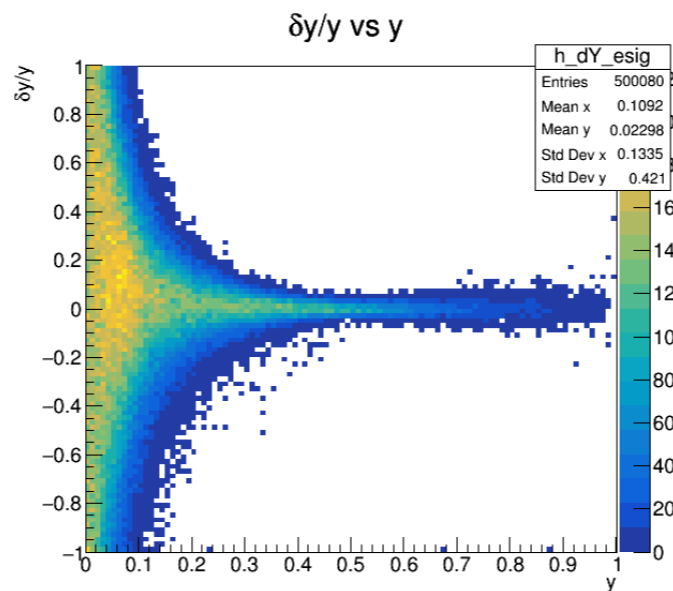
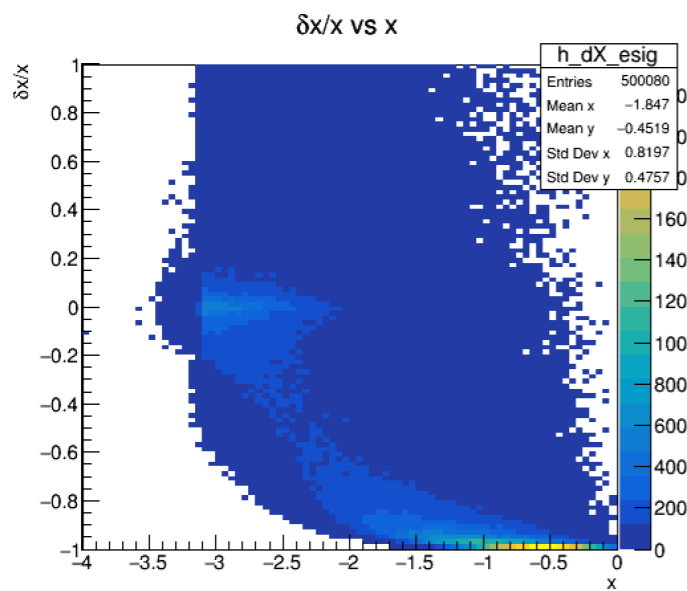


e-Sigma

```
// e-sigma method x from sigma, Q2 from e
void GetKinematics_esigma(Float_t Epzh, Float_t cme, TLorentzVector const &escat,
                          Float_t x, Float_t Q2, Float_t *y)
{
    Float_t Epz = escat.E() - escat.Pz();
    *y = Q2/cme/x;
}
}
```

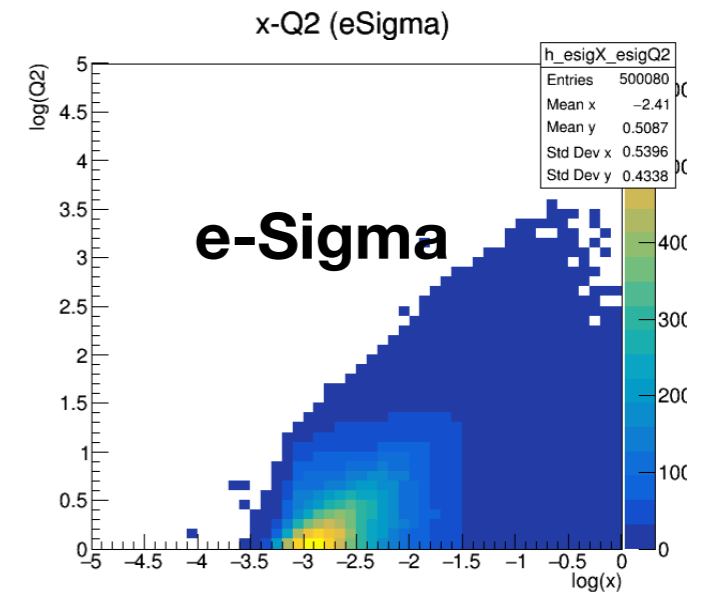
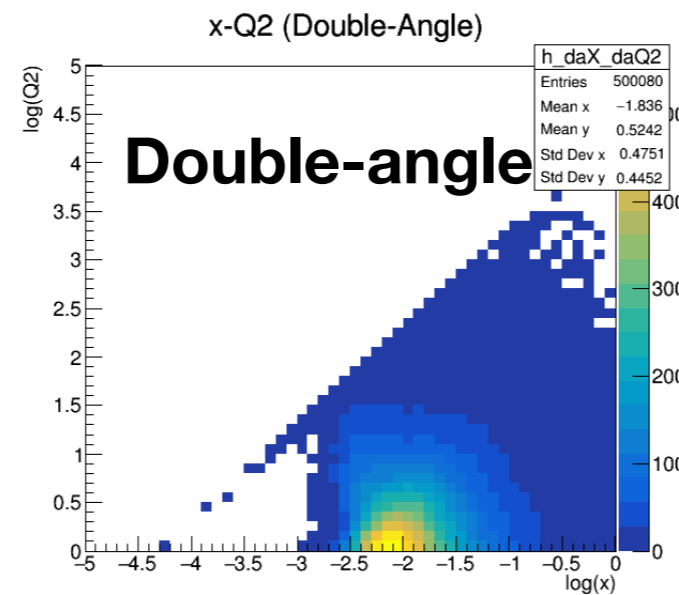
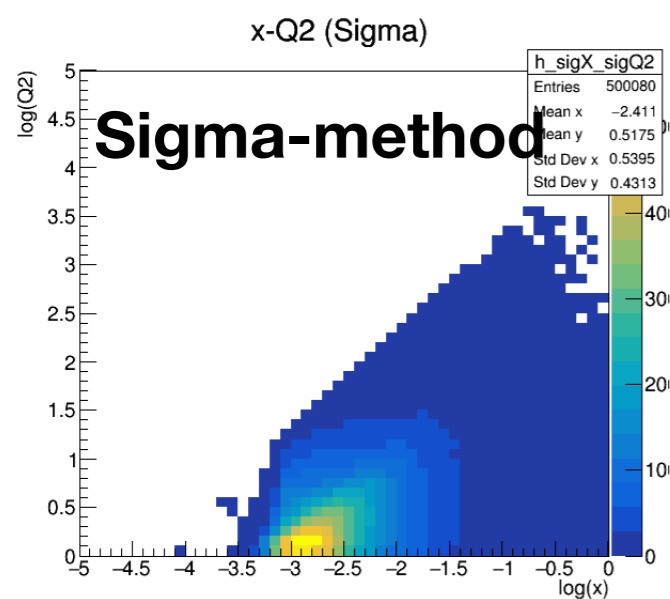
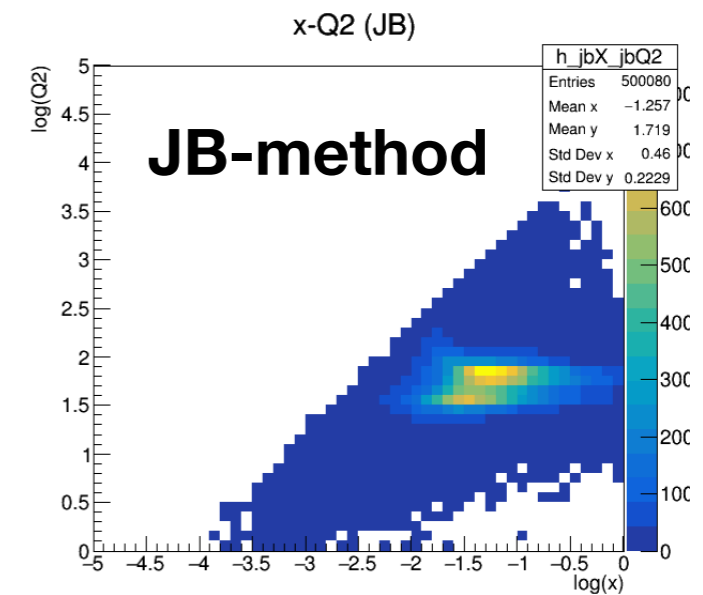
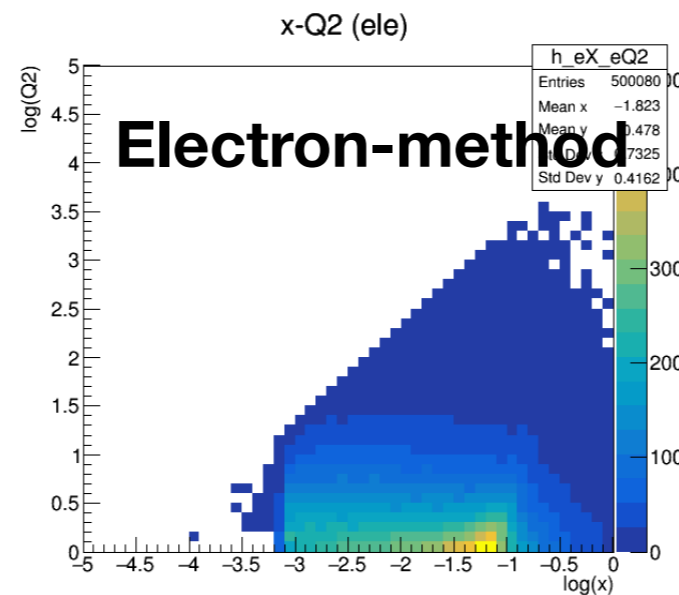
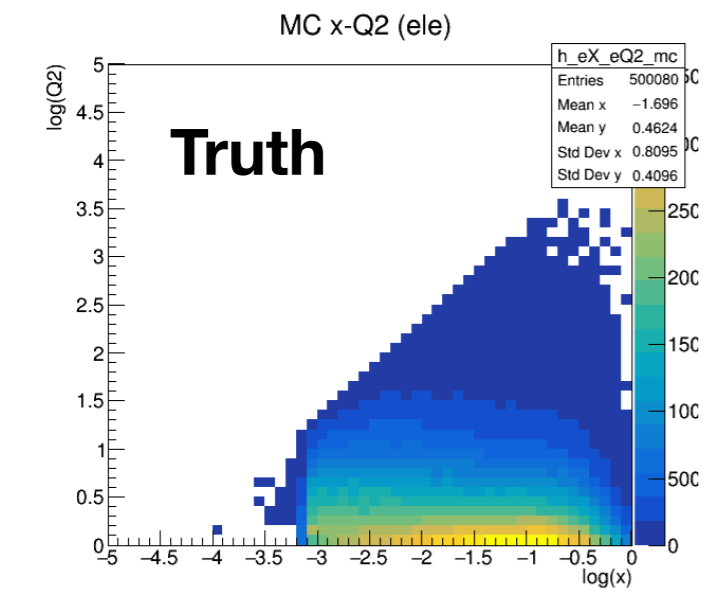


Truth x, y, Q2 using Lorentz vectors from *mcparticles2*



Kinematics reconstruction

Truth x, y, Q2 using Lorentz vectors from *mcparticles2*, others using *ReconstructedParticles*



Reconstructed x / truth x

By Ting Lin

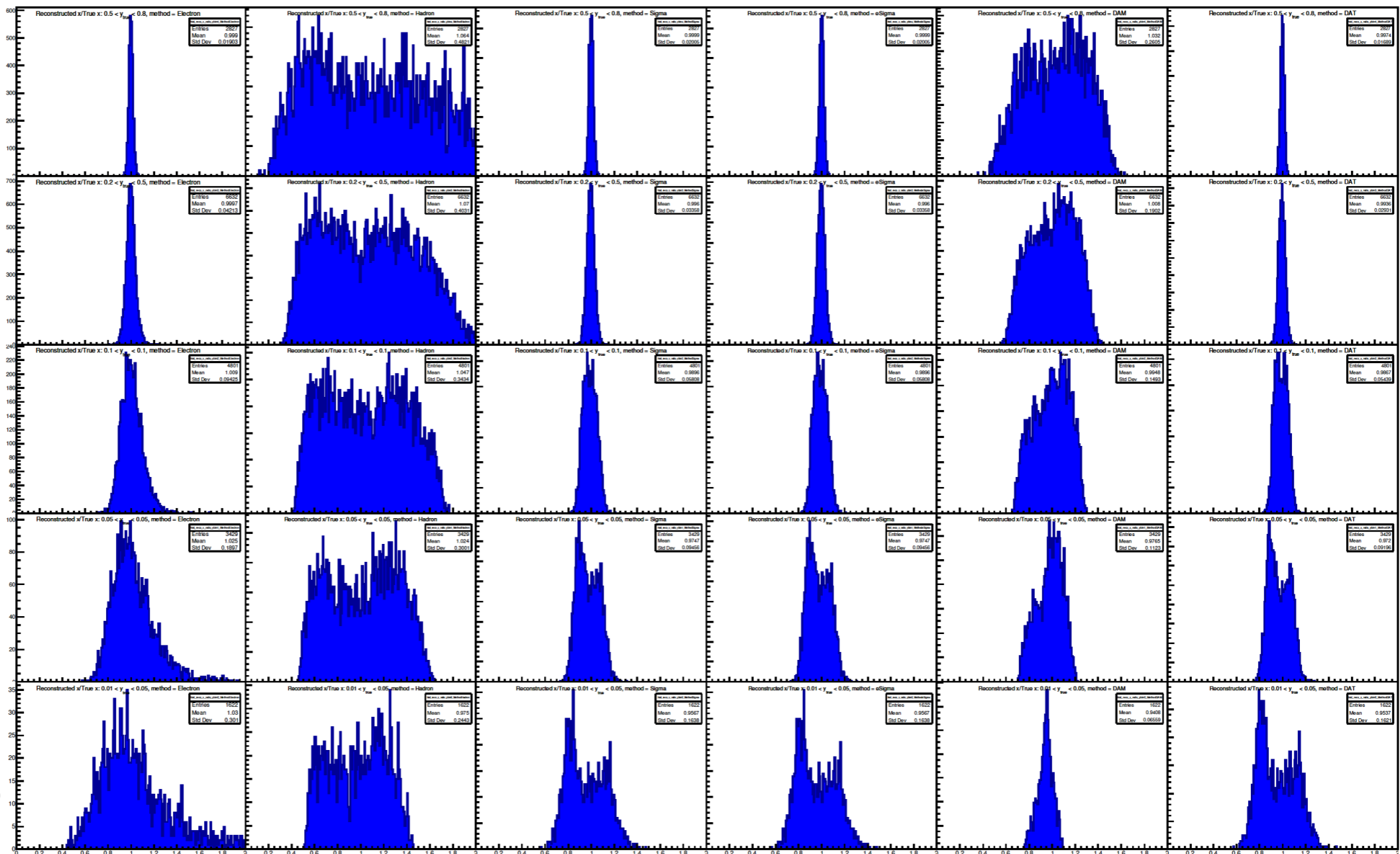
$0.5 < y < 0.8$

$0.2 < y < 0.5$

$0.1 < y < 0.2$

$0.05 < y < 0.1$

$0.01 < y < 0.05$



Electron

J-B

Sigma

e-Sigma

D-A

D-A pT

Reconstructed y / truth y

By Ting Lin

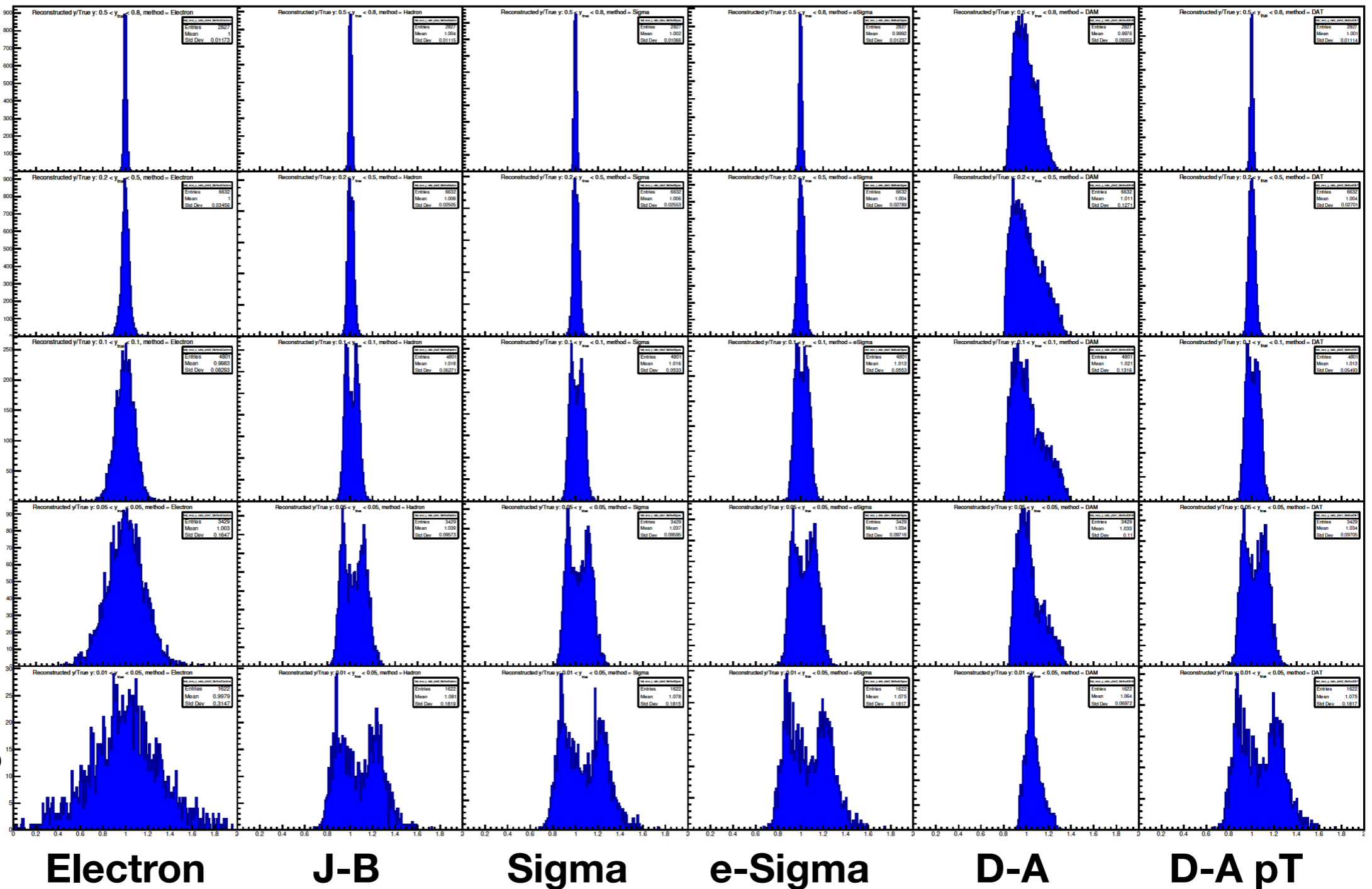
$0.5 < y < 0.8$

$0.2 < y < 0.5$

$0.1 < y < 0.2$

$0.05 < y < 0.1$

$0.01 < y < 0.05$



Reconstructed Q2 / truth Q2

By Ting Lin

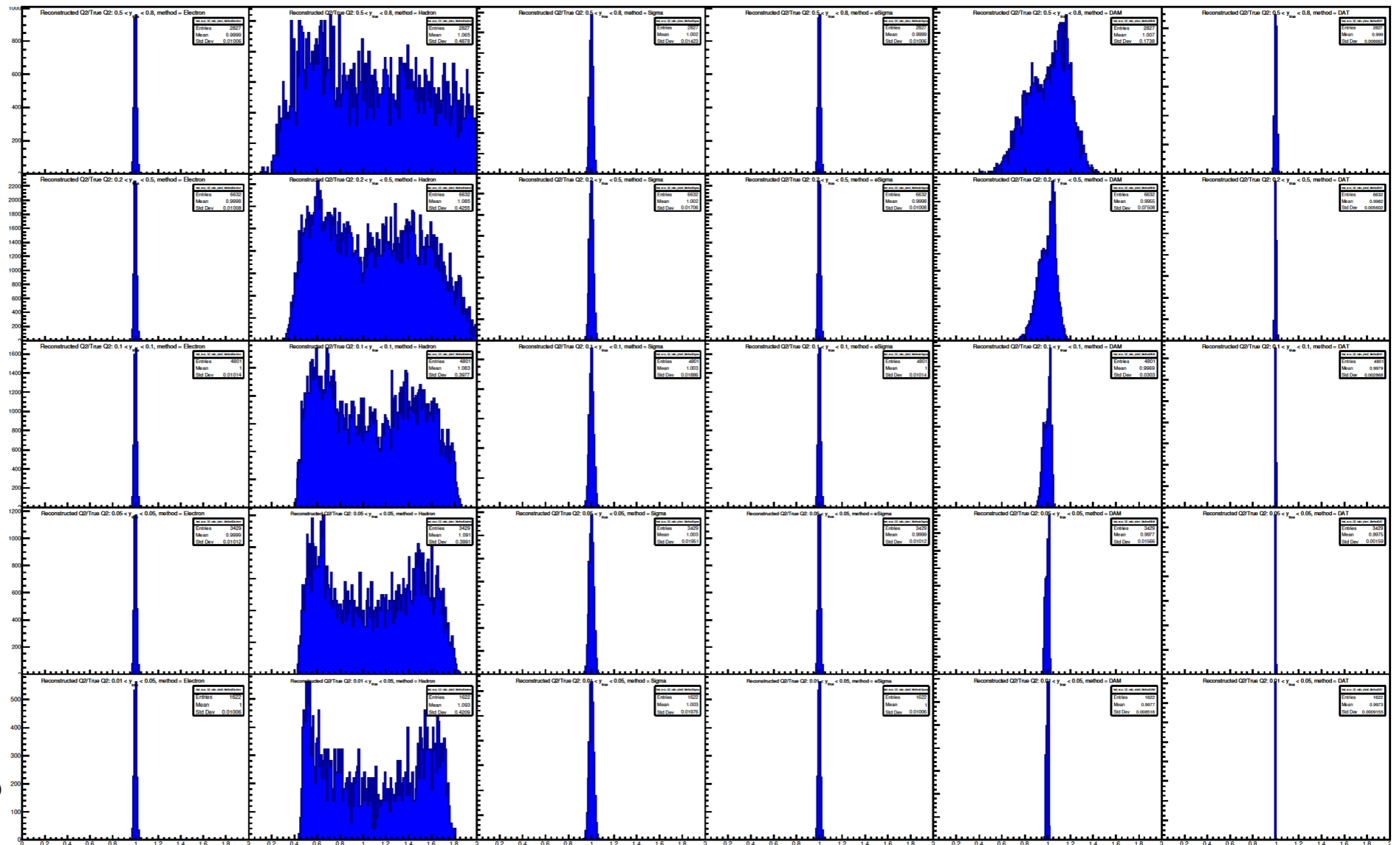
$0.5 < y < 0.8$

$0.2 < y < 0.5$

$0.1 < y < 0.2$

$0.05 < y < 0.1$

$0.01 < y < 0.05$



Electron

J-B

Sigma

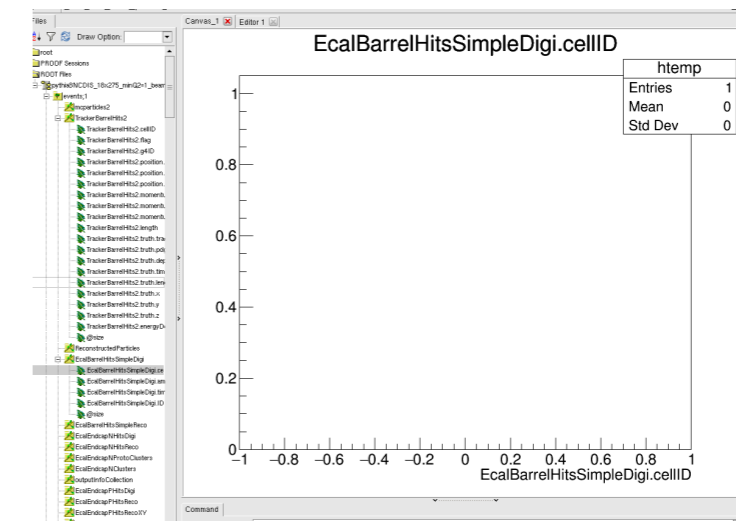
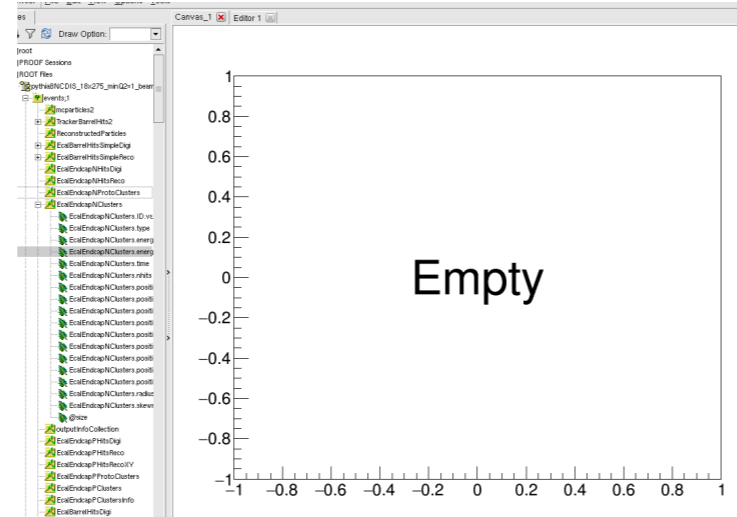
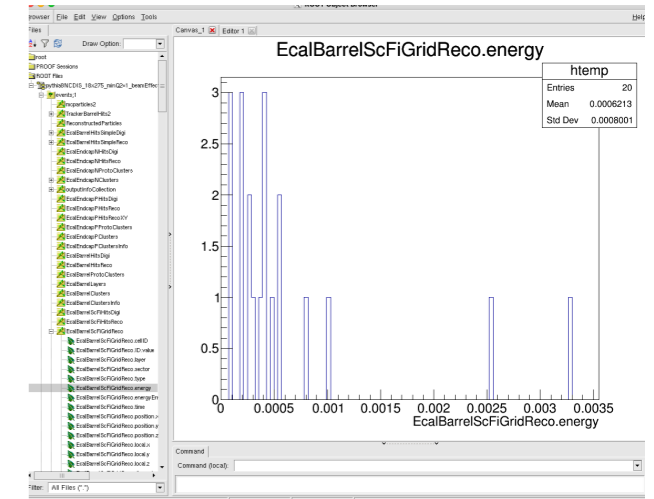
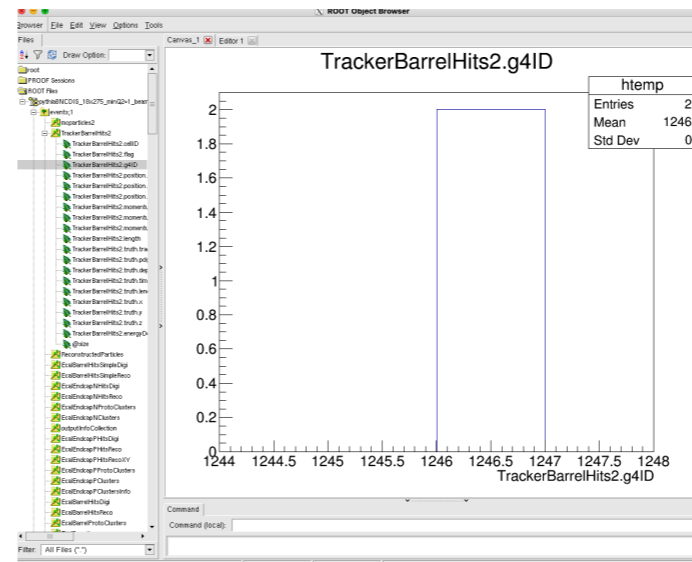
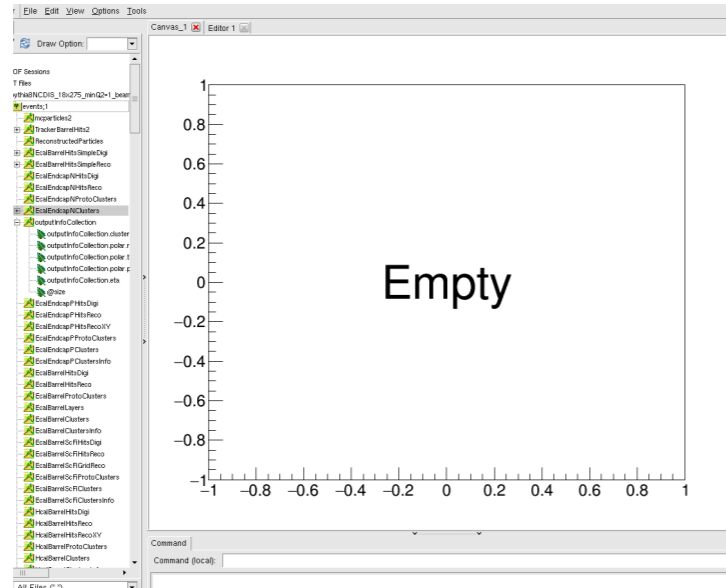
e-Sigma

D-A

D-A pT

Other branches

- PROOF Sessions
- ROOT Files
 - pythia8NCDIS_18x275_minQ2=1_beamEffect
 - events;1
 - mparticles2
 - Tracker BarrelHits2
 - ReconstructedParticles
 - Ecal Barrel Hits Simple Digi
 - Ecal Barrel Hits Simple Reco
 - Ecal Endcap N Hits Digi
 - Ecal Endcap N Hits Reco
 - Ecal Endcap N Proto Clusters
 - Ecal Endcap N Clusters
 - output Info Collection
 - Ecal Endcap P Hits Digi
 - Ecal Endcap P Hits Reco
 - Ecal Endcap P Hits Reco XY
 - Ecal Endcap P Proto Clusters
 - Ecal Endcap P Clusters
 - Ecal Endcap P Clusters Info
 - Ecal Barrel Hits Digi
 - Ecal Barrel Hits Reco
 - Ecal Barrel Proto Clusters
 - Ecal Barrel Layers
 - Ecal Barrel Clusters
 - Ecal Barrel Clusters Info
 - Ecal Barrel ScFi Hits Digi
 - Ecal Barrel ScFi Hits Reco
 - Ecal Barrel ScFi Grid Reco
 - Ecal Barrel ScFi Proto Clusters
 - Ecal Barrel ScFi Clusters
 - Ecal Barrel ScFi Clusters Info
 - Hcal Barrel Hits Digi
 - Hcal Barrel Hits Reco
 - Hcal Barrel Hits Reco XY
 - Hcal Barrel Proto Clusters
 - Hcal Barrel Clusters
 - Hcal Barrel Clusters Info
 - Hcal Endcap N Hits Digi
 - Hcal Endcap N Hits Reco
 - Hcal Endcap N Hits Reco XY
 - Hcal Endcap N Proto Clusters
 - Hcal Endcap N Clusters
 - Hcal Endcap N Clusters Info
 - Hcal Endcap P Hits Digi
 - Hcal Endcap P Hits Reco
 - Hcal Endcap P Hits Reco XY
 - Hcal Endcap P Proto Clusters
 - Hcal Endcap P Clusters
 - Hcal Endcap P Clusters Info
 - Tracker Barrel Raw Hits
 - Tracker Endcap Raw Hits
 - Vertex Barrel Raw Hits
 - Vertex Endcap Raw Hits
 - Tracker Barrel Rec Hits
 - Tracker Endcap Rec Hits
 - Vertex Barrel Rec Hits
 - Vertex Endcap Rec Hits
 - ReconstructedParticlesInitFromTruth
 - outputTrackParameters
 - DRICHits2



Most of other branches are (almost) empty, will they be filled?

Summary

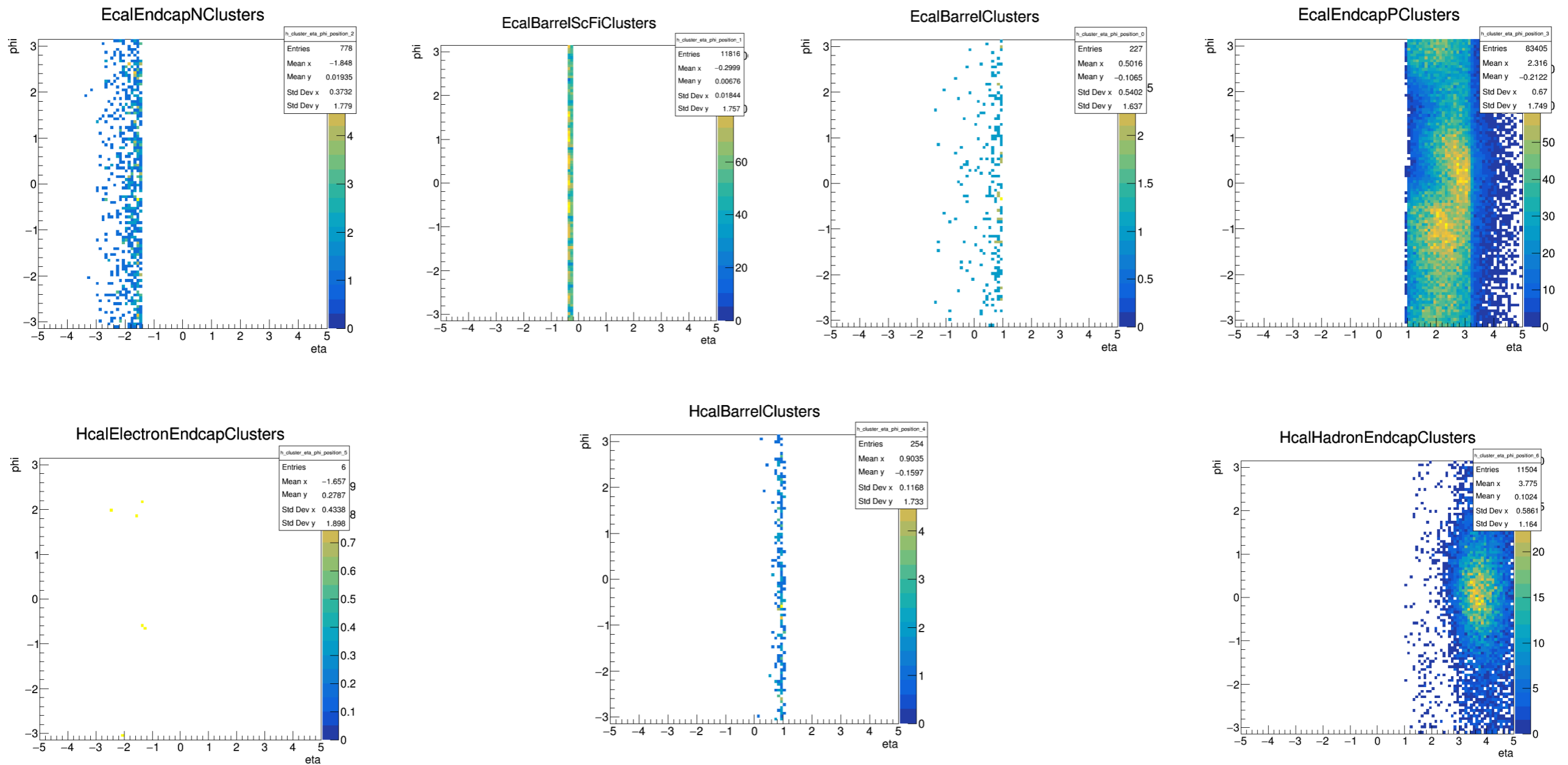
- Looked into ATHENA simulation files (Reconstruction_analysis)
 - Fully filled branches: mcparticles2 and ReconstructedParticles
 - Energy, acceptance, etc, are not reflected in ReconstructedParticles
 - Most of other branches are not (fully) filled
 - Initial state transverse momentum is not negligible for kinematics reconstruction. re-derive formulas or boost/rotate out system pT ??

References:

- EIC Tutorial page: https://eic.phy.anl.gov/tutorials/eic_tutorial/part5/reconstruction_analysis
- Wouter's Tutorial at (7/29) SIDIS Meeting
- Miguel's slides (6/28) and code (different input files, DIS (v2) vs. JETS(v1))
- Paul's HERA kinematics talk (5/24)

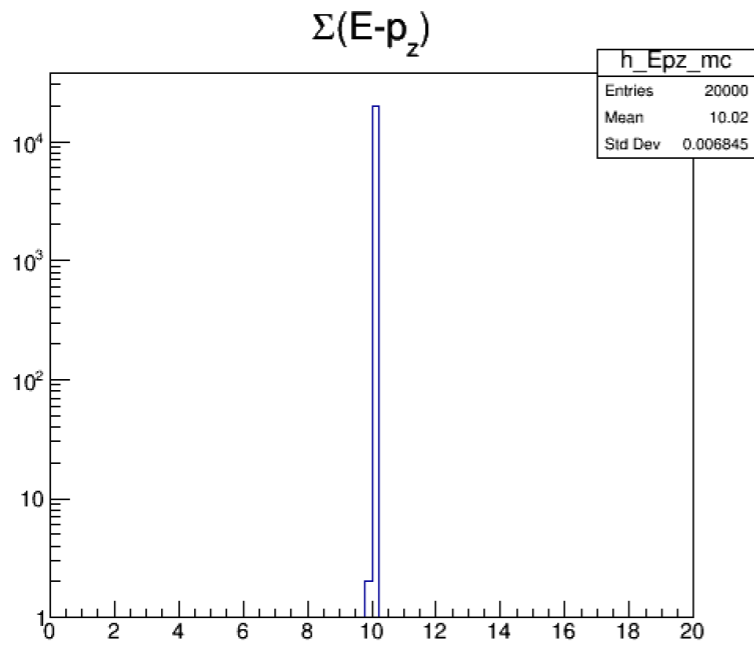
Backup

- How to use the calorimeter info? Directly use Clusters?
- Very low activity (< 1) on most of sub-calorimeter systems
- Narrow eta bands on EcalBarrelSciFi and HcalBarrel

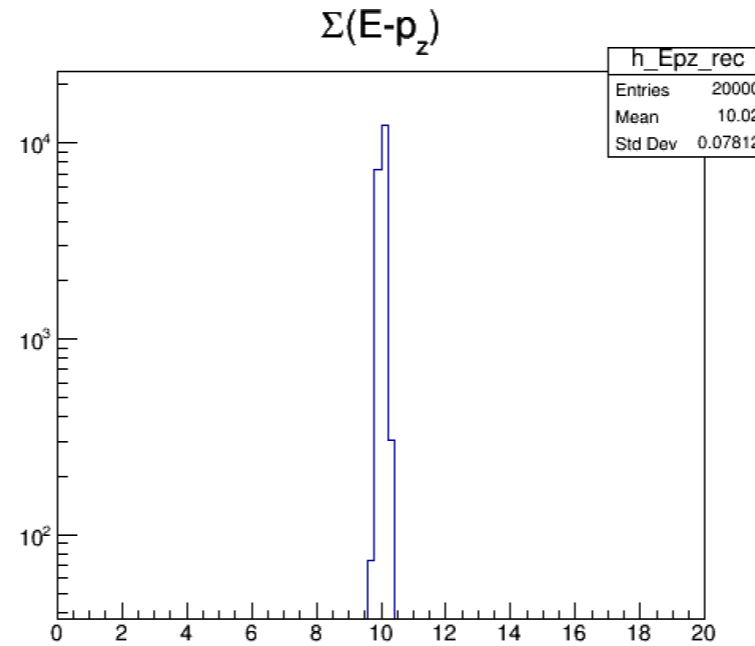


$\Sigma(E-p_z)$

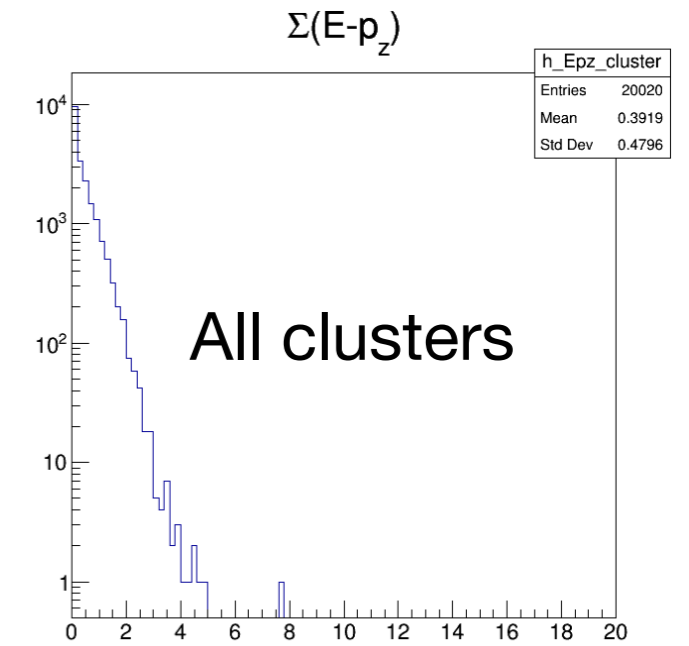
Electron missed ??



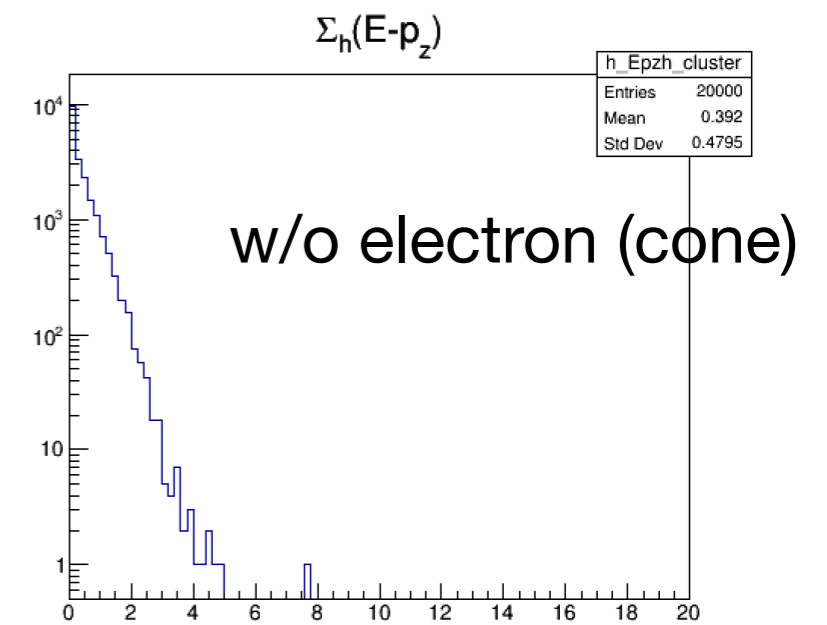
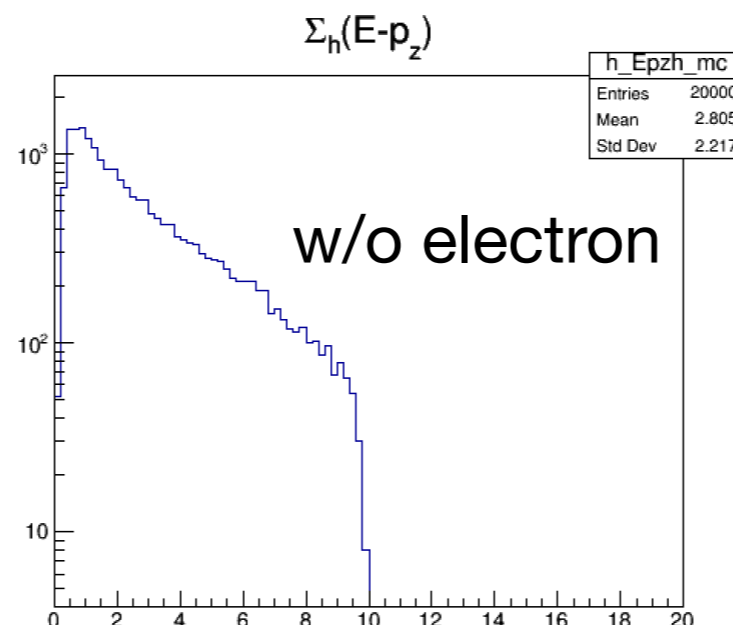
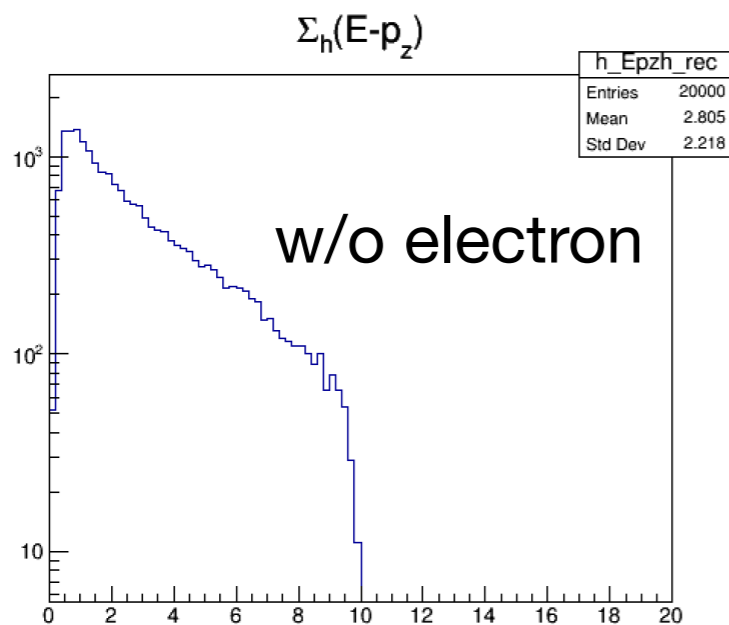
mcparticle2



ReconstructedParticle

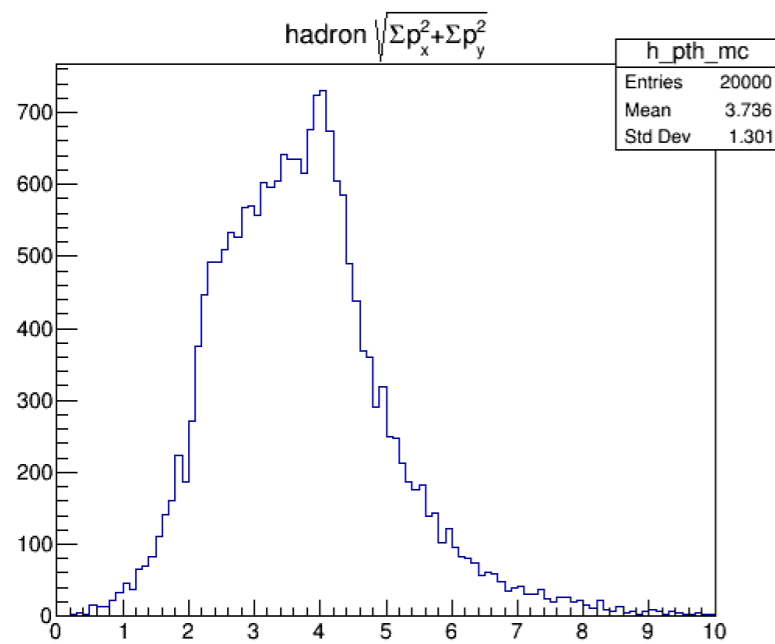


EcalEndcapNClusters
and etc

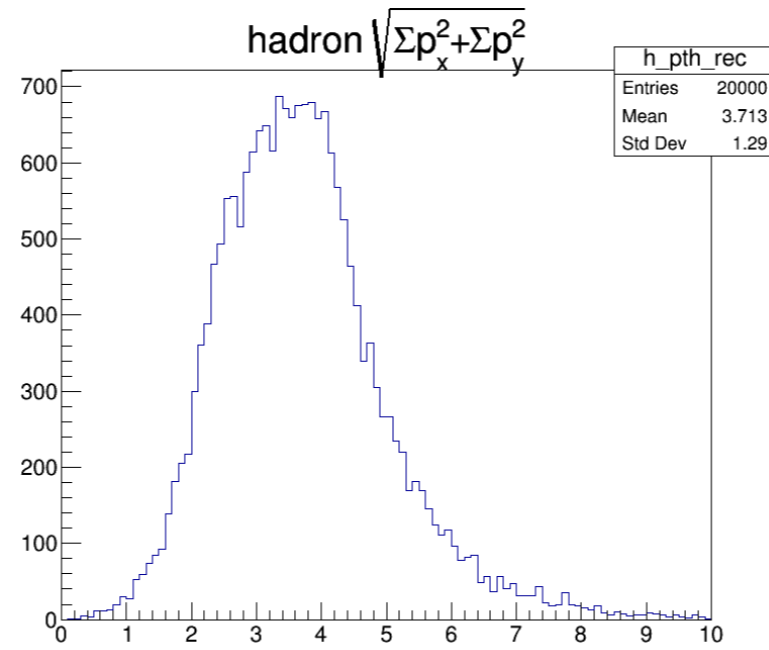


Hadron $\sqrt{\Sigma p_x^2 + \Sigma p_y^2}$

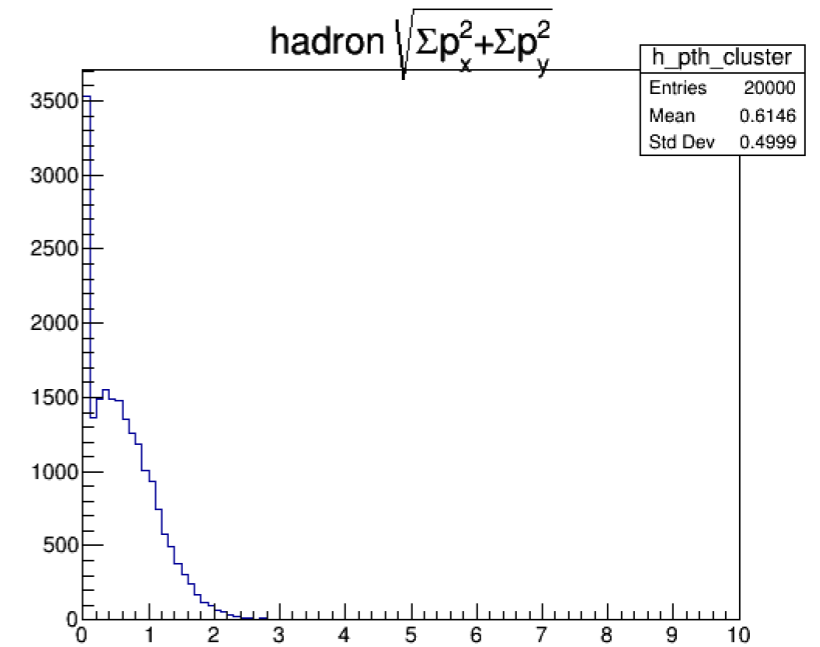
Some hadrons missed ??



mcparticle2



ReconstructedParticle



EcalEndcapNClusters
and etc

- How to use the calorimeter info? Directly use Clusters?
- Very low activity (< 1) on most of sub-calorimeter systems
- Scattered Electron seems not recorded by Ecal

