Update on the reconstruction with full simulation

Jinlong Zhang (SDU)
Nov 1, 2021

- Crossing angle effect in kinematics reconstruction
- Electron finding from calorimeter clusters

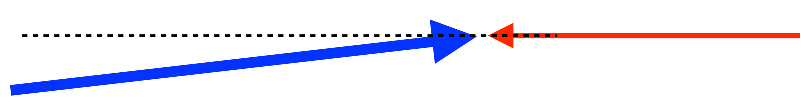
Dataset:

https://dtn01.sdcc.bnl.gov:9000/minio/eictest/ATHENA/RECO/acadia-v1.0-alpha/DIS/NC/18x275/minQ2=1/

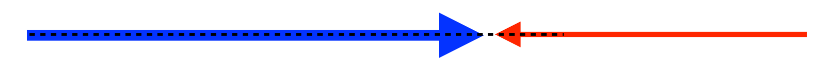
77 files, produced (uploaded to S3) on Aug 28-30

Lab frame to head-on frame

Lab frame

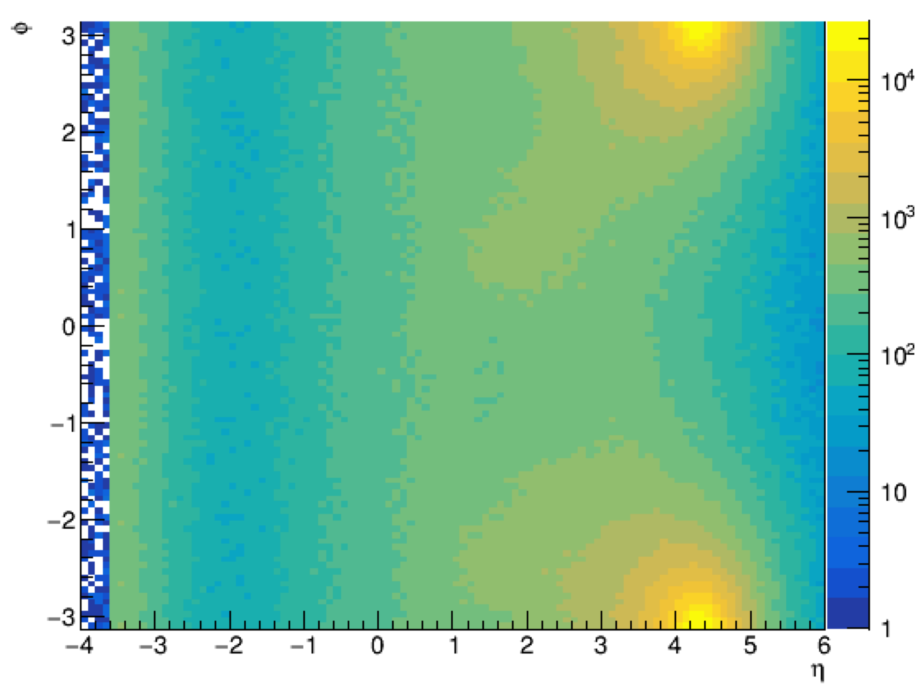


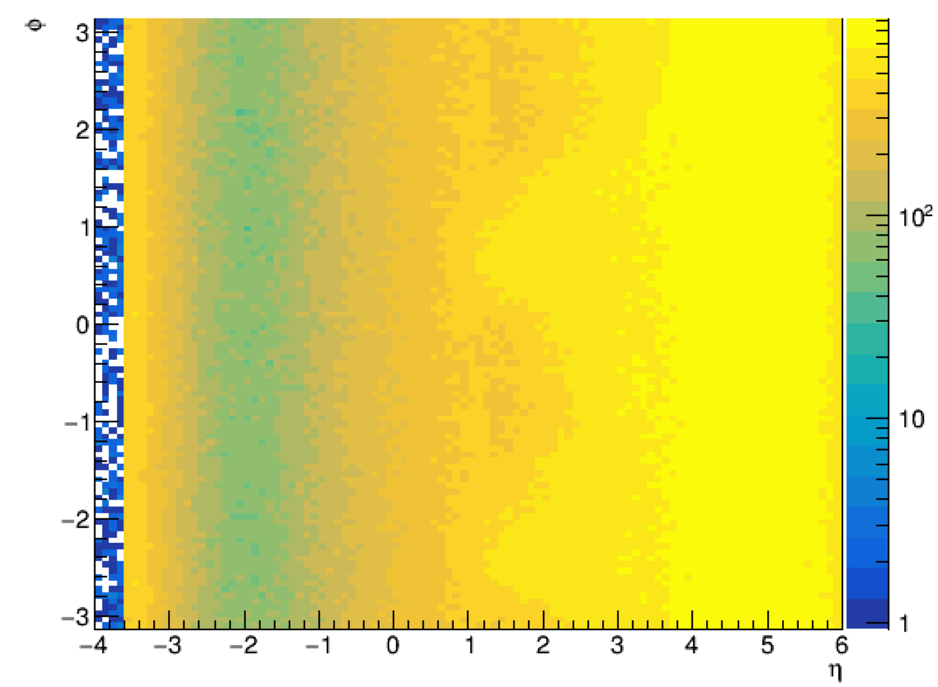
Head-on frame



TLorentzRotation lab2headon = TLorentzRotation().RotateY(12.5e-3).Boost(sin(12.5e3),0,0)

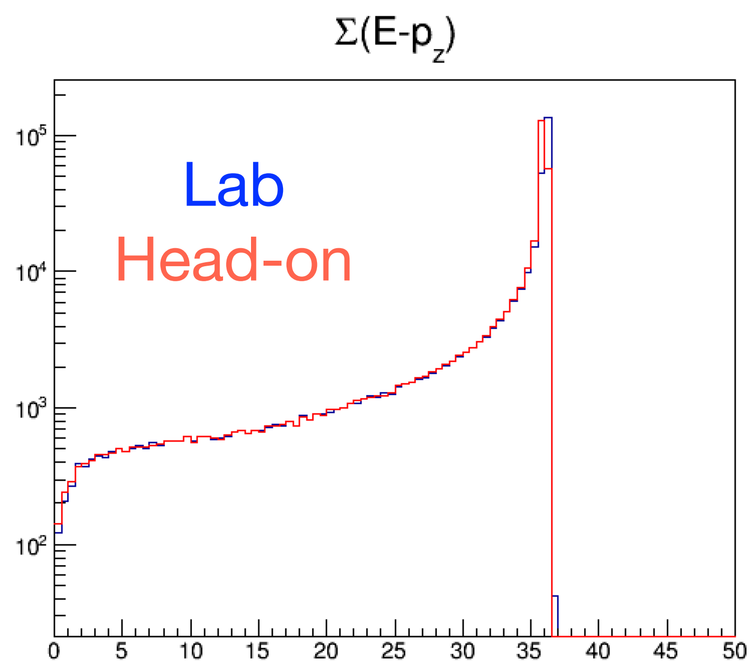
— J. Huang 7/8/21

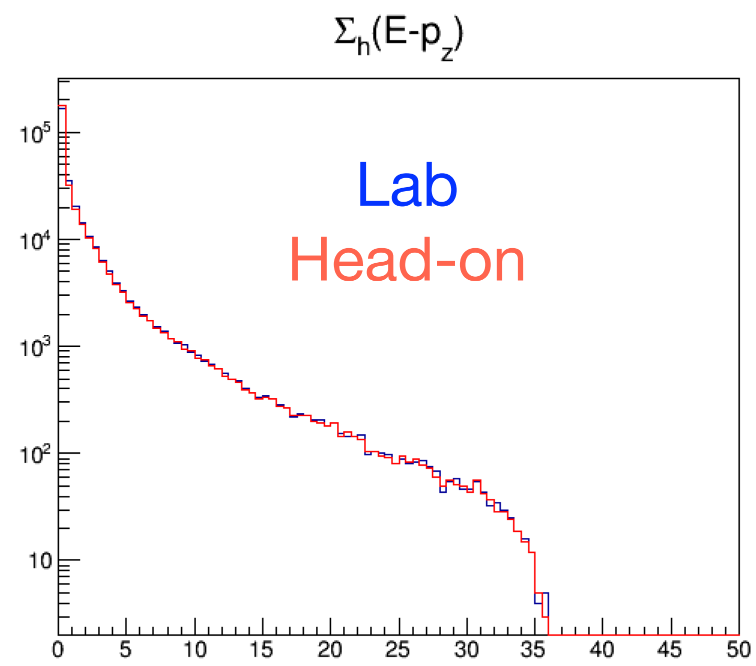


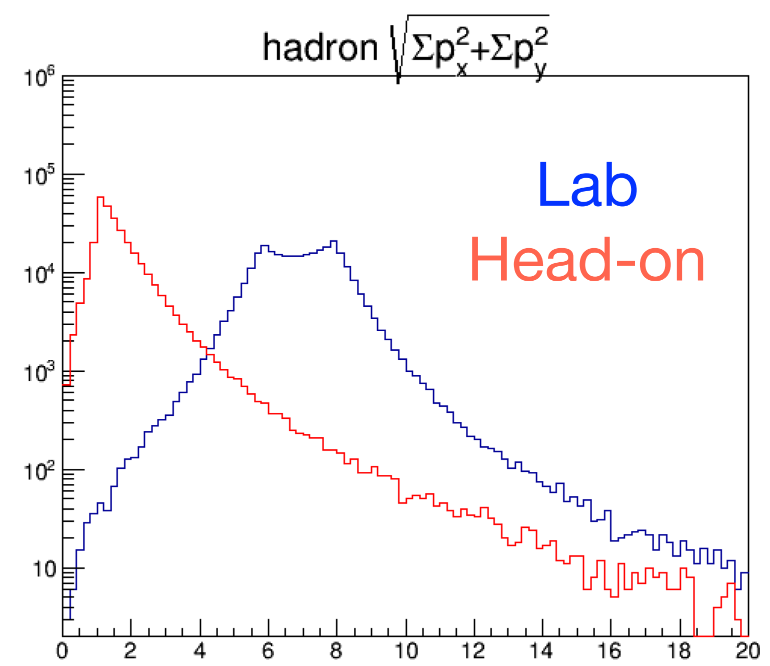


Eta-phi from branch: *mcparticles2*

Variables used in kinematics reconstruction







- small impacts on E-pz, but huge impact on hadronic p_T

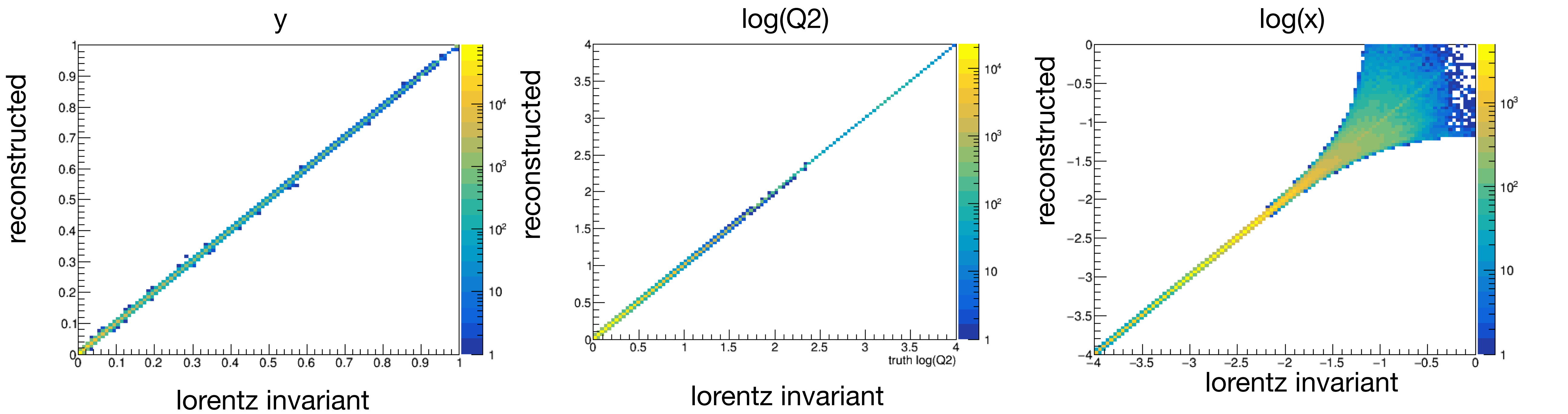
Electron method

$$y = 1 - \frac{E'}{E}\cos^2\frac{\theta}{2} \qquad Q^2 = 2EE'(1 - \cos\theta) \qquad x = \frac{Q^2}{sy}$$

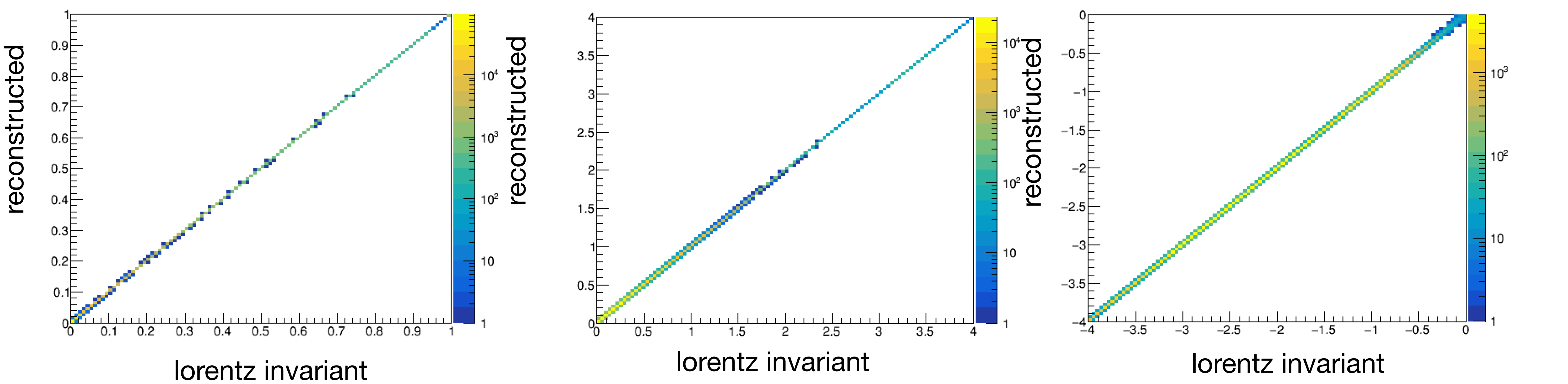
```
// electron method
void GetKinematics_e(TLorentzVector const &ebeam,TLorentzVector const &escat, Float_t cme,
    Float_t *x,Float_t *y,Float_t *Q2)
{
  Float_t theta = TMath::Pi() - escat.Theta();
  *y = 1 - escat.E()*cos(theta/2.)*cos(theta/2.)/ebeam.E();
  *Q2 = 2.*escat.E()*ebeam.E()*(1.-cos(theta));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

Electron method

Lab



Head-on



Jacquest-Bloded Method

$$y = \frac{\Sigma_h (E - p_z)}{2E}$$

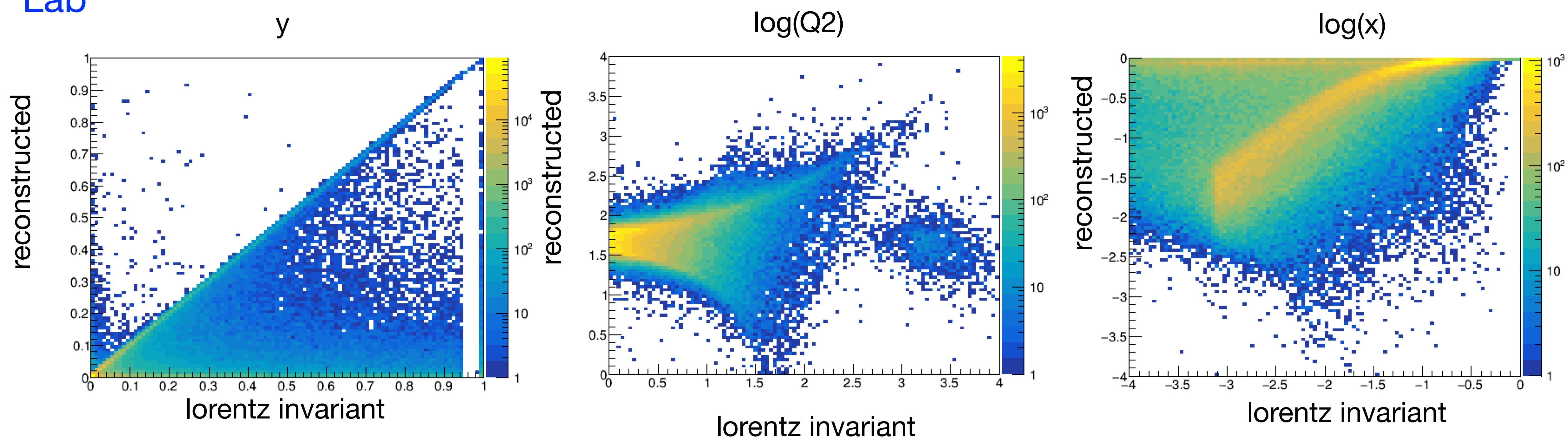
$$Q^2 = \frac{(\Sigma_h p_x)^2 + (\Sigma_h p_y)^2}{1 - y}$$

$$x = \frac{Q^2}{sy}$$

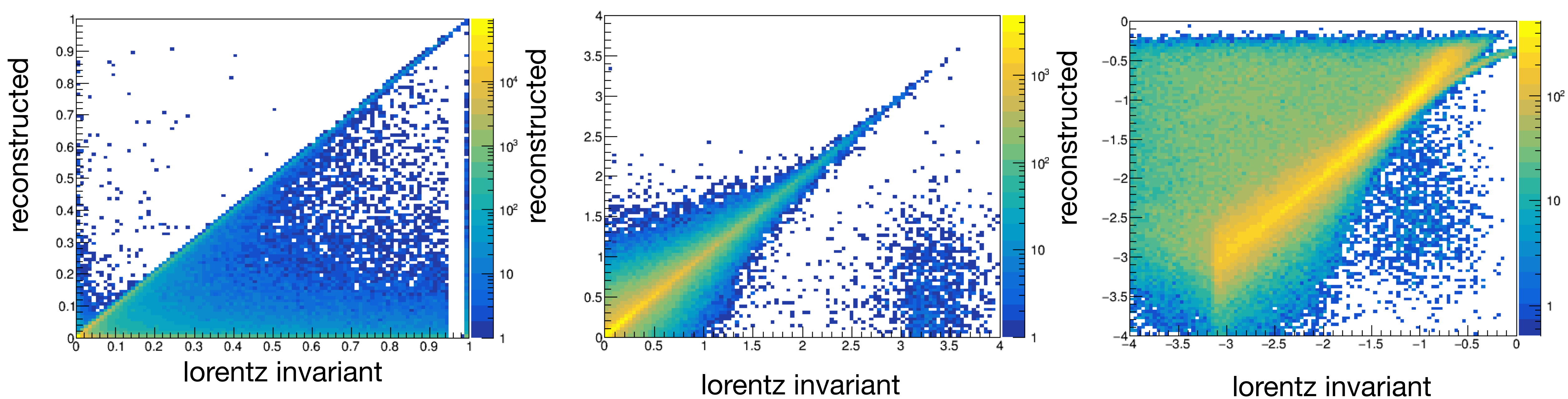
```
// Jacquest-Bloded Method
void GetKinematics_jb(Float_t Epzh, Float_t pth, Float_t cme, TLorentzVector const &ebeam,
    Float_t *x,Float_t *y,Float_t *Q2)
{
  *y = Epzh/2./ebeam.E();
  *Q2 = pth*pth/(1-*y);
  *x = *Q2/cme/(*y);
}
```

Jacquest-Bloded Method

Lab



Head-on



Double angle Method

$$y = \frac{\tan\frac{\gamma}{2}}{\tan\frac{\theta}{2} + \tan\frac{\gamma}{2}} \qquad Q^2 = \frac{4EE'}{\tan\frac{\gamma}{2}(\tan\frac{\theta}{2} + \tan\frac{\gamma}{2})} \qquad x = \frac{Q^2}{sy}$$

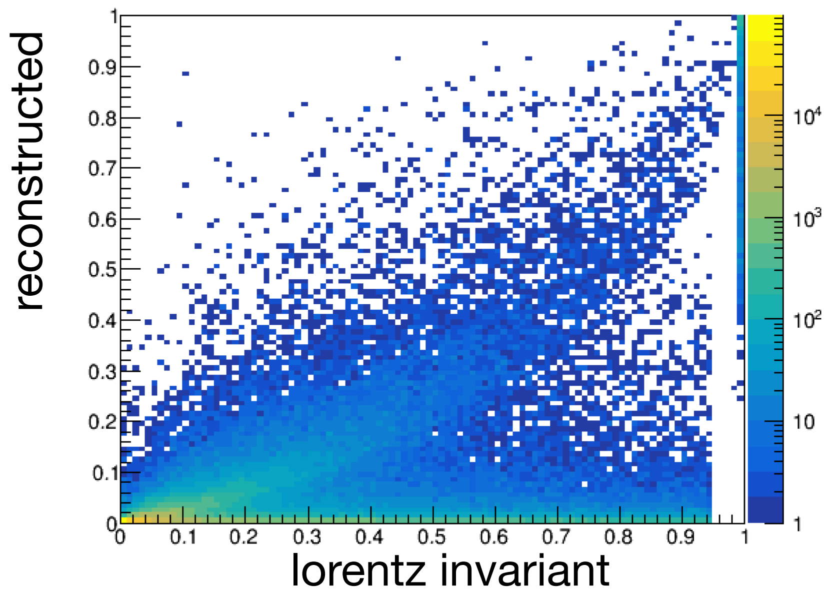
$$*\gamma = 2\mathrm{arctan}\frac{\Sigma_h(\mathrm{E} - \mathrm{p_z})}{\sqrt{(\Sigma_h \mathrm{p_x})^2 + (\Sigma_h \mathrm{p_y})^2}}$$

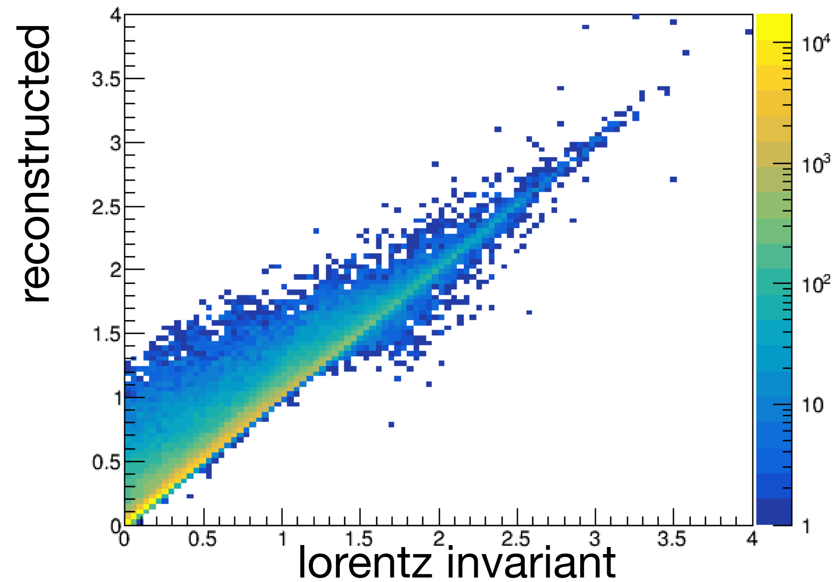
```
// double-angle method
void GetKinematics_da(Float_t Epzh, Float_t pth, Float_t cme, TLorentzVector const &ebeam,
    TLorentzVector const &escat, Float_t *x,Float_t *y,Float_t *Q2)
{
  Float_t gamma = 2.*atan(Epzh/pth);
  Float_t theta = escat.Theta();
  *y = tan(gamma/2.)/(tan(theta/2.) + tan(gamma/2.));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

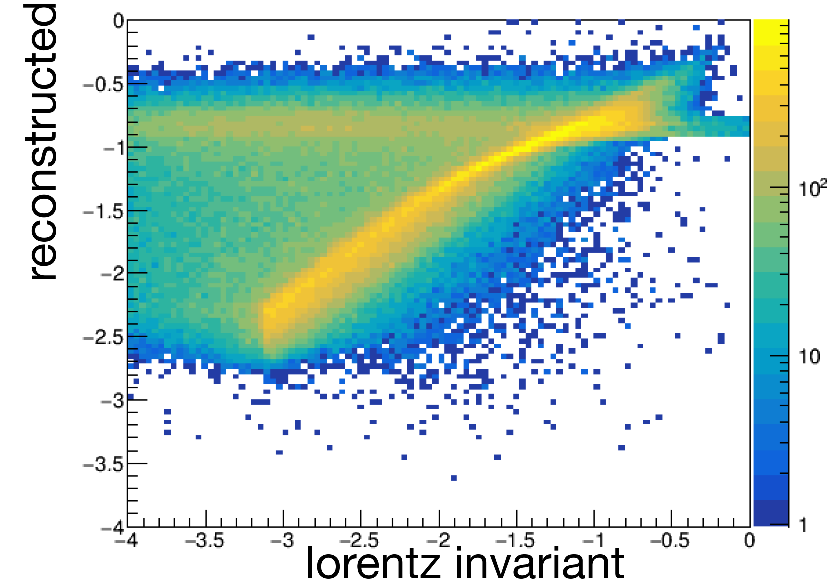
Double angle Method

Lab

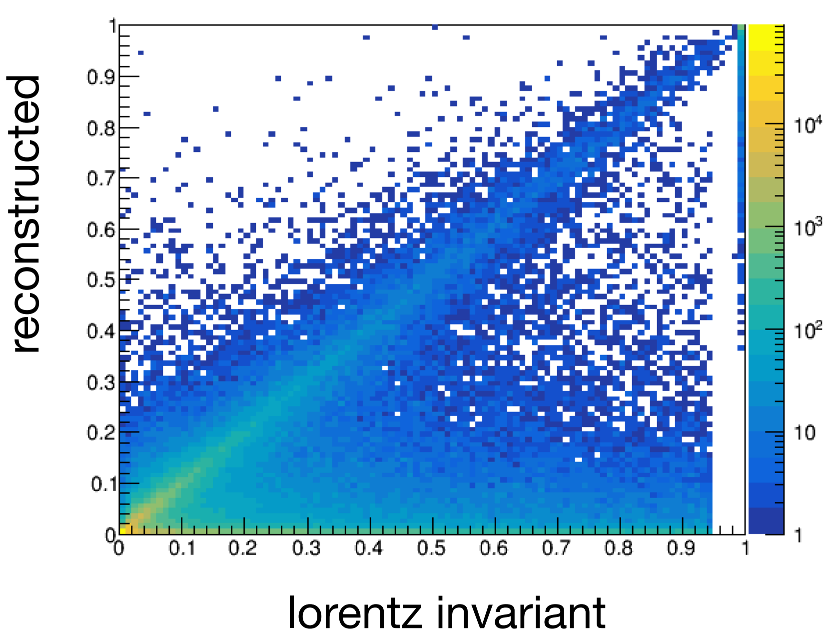
y | log(Q2) | log(x)

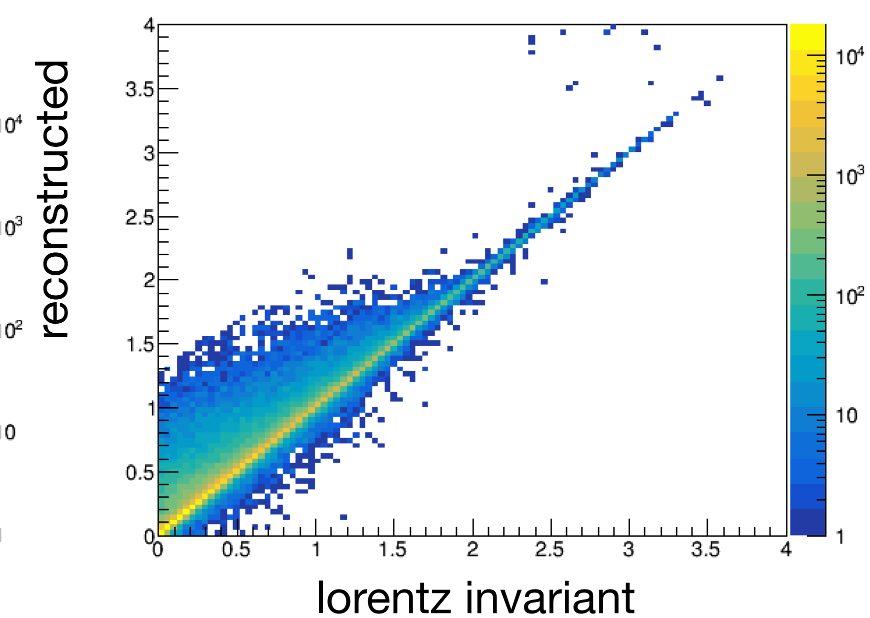


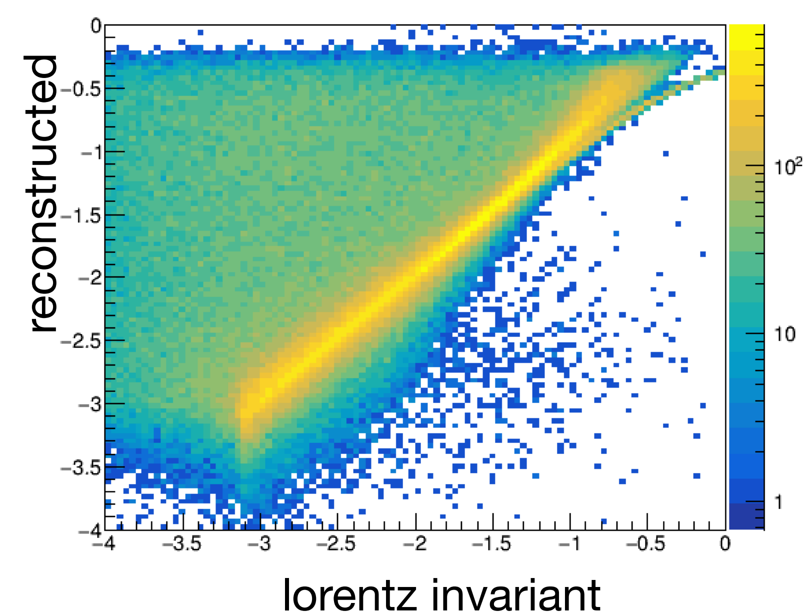




Head-on







Sigma method

$$y = \frac{\Sigma_h (E - p_z)}{\Sigma_{h+e} (E - p_z)}$$

$$Q^2 = \frac{(p_x^e)^2 + (p_y^e)^2}{1 - y}$$

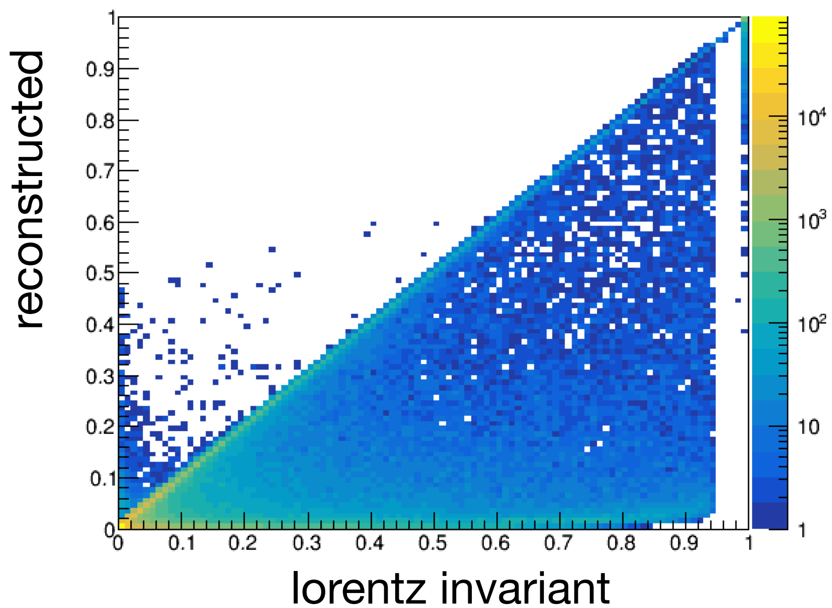
$$x = \frac{Q^2}{sy}$$

```
// 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+Epz);
  *Q2 = escat.Pt()*escat.Pt()/(1. - *y);
  *x = *Q2/cme/(*y);
}
```

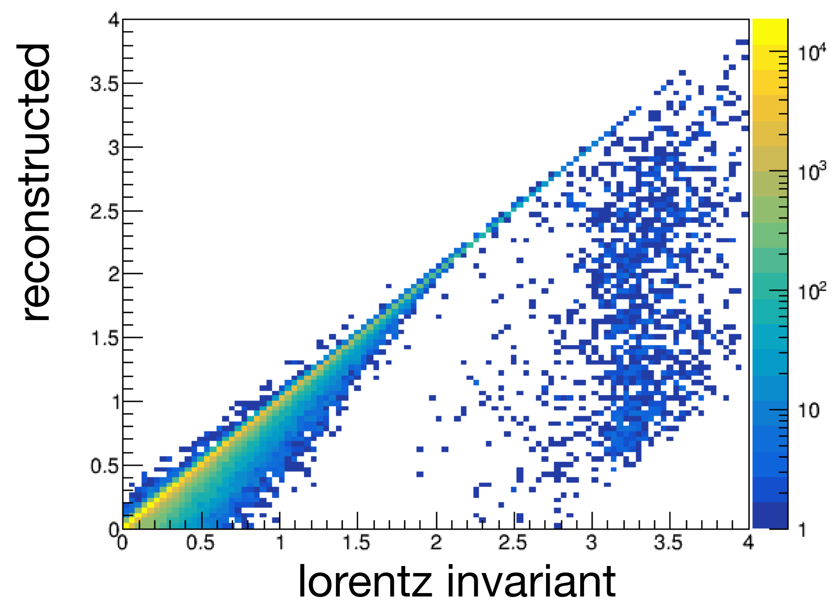
Sigma method

Lab

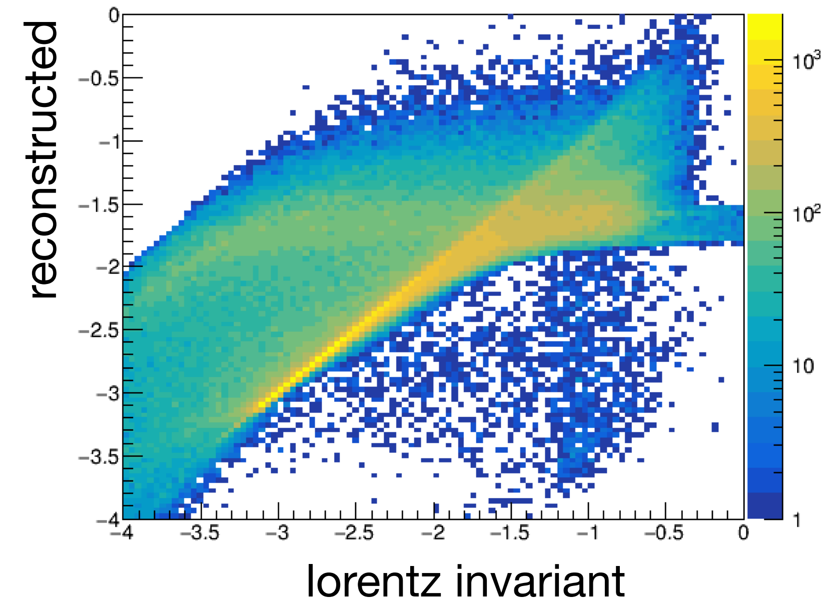
y



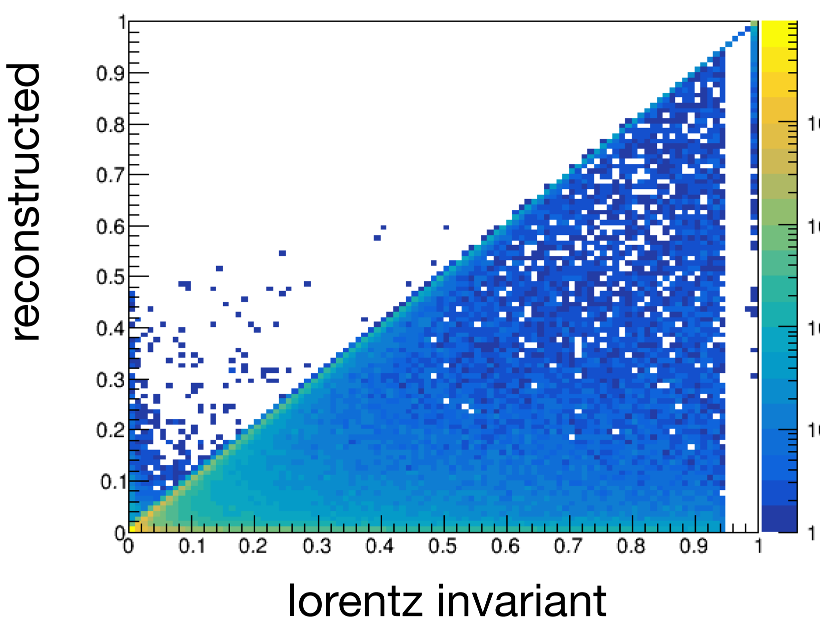
log(Q2)

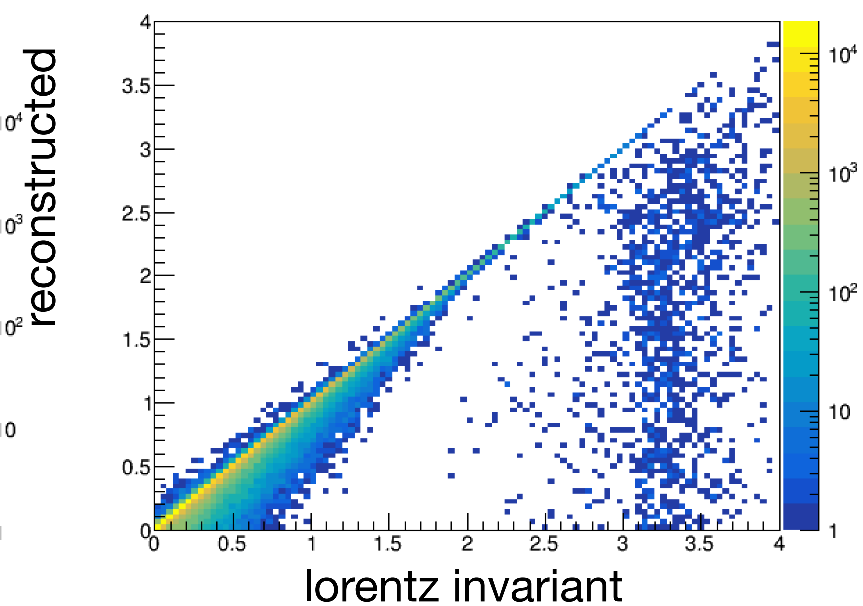


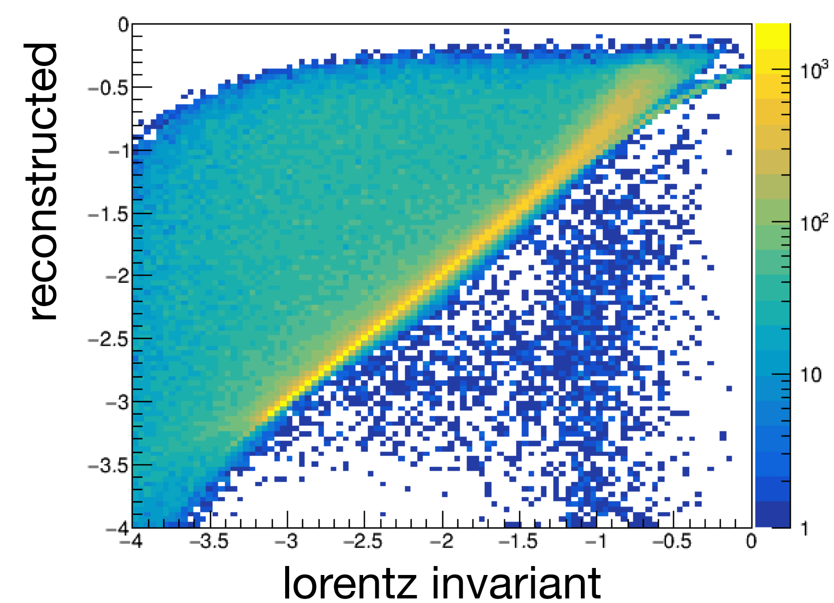
log(x)



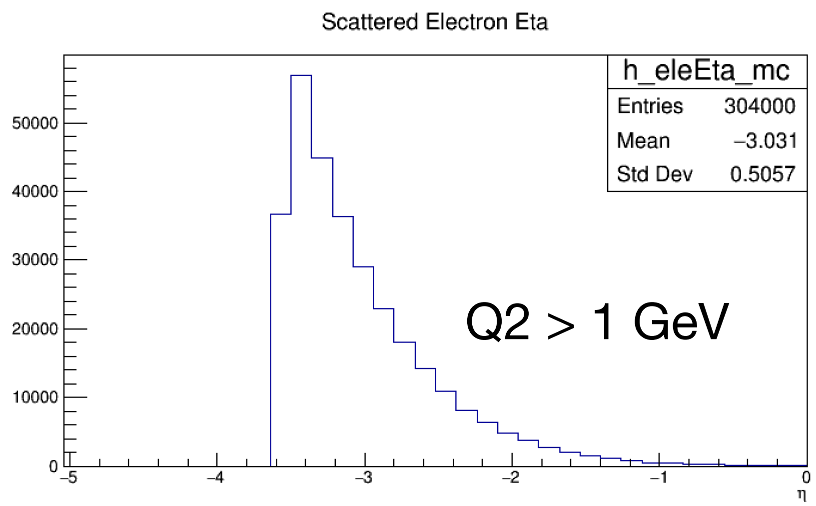
Head-on

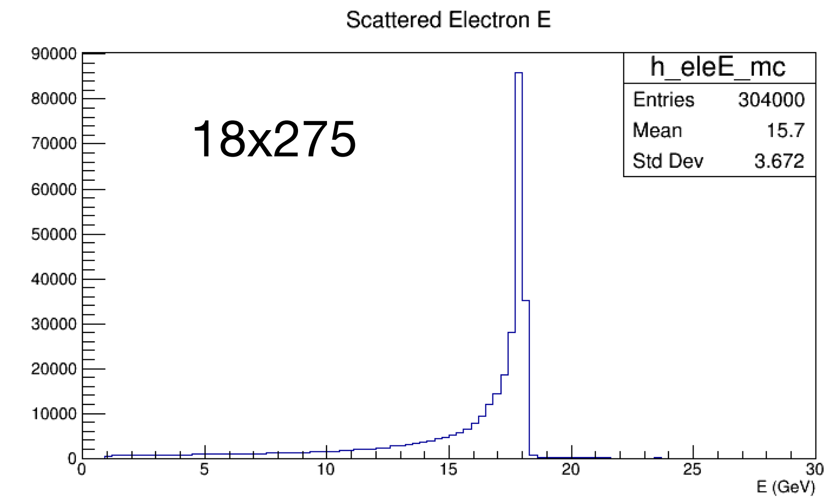


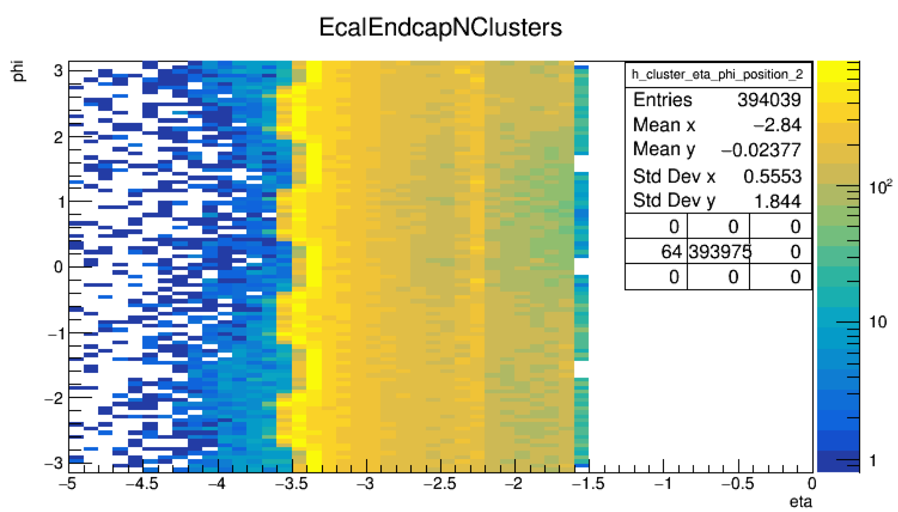


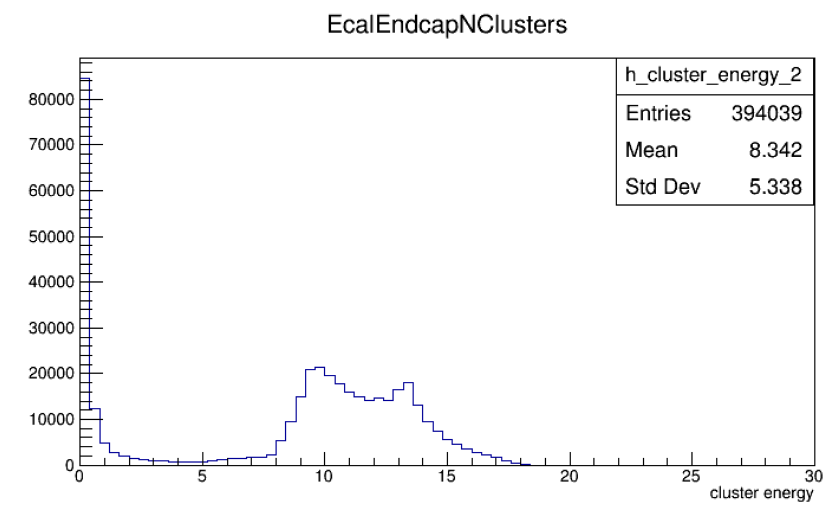


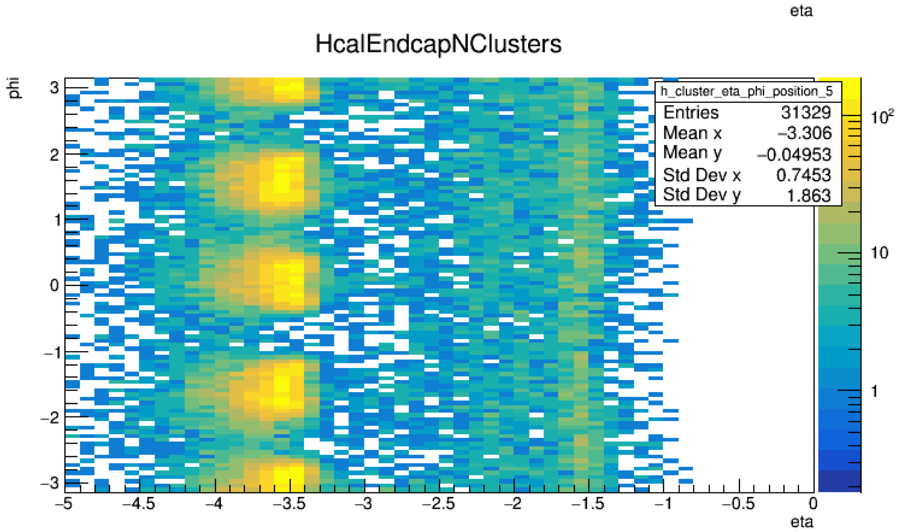
Endcap cluster matching to scattered electron

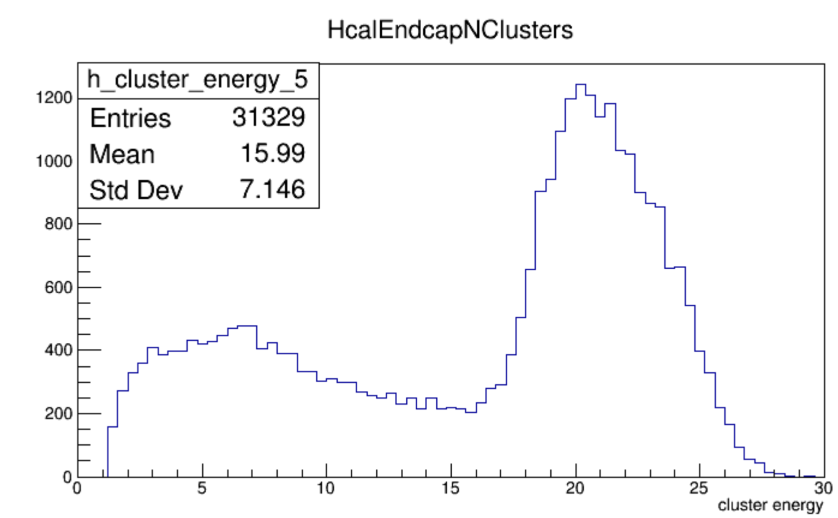




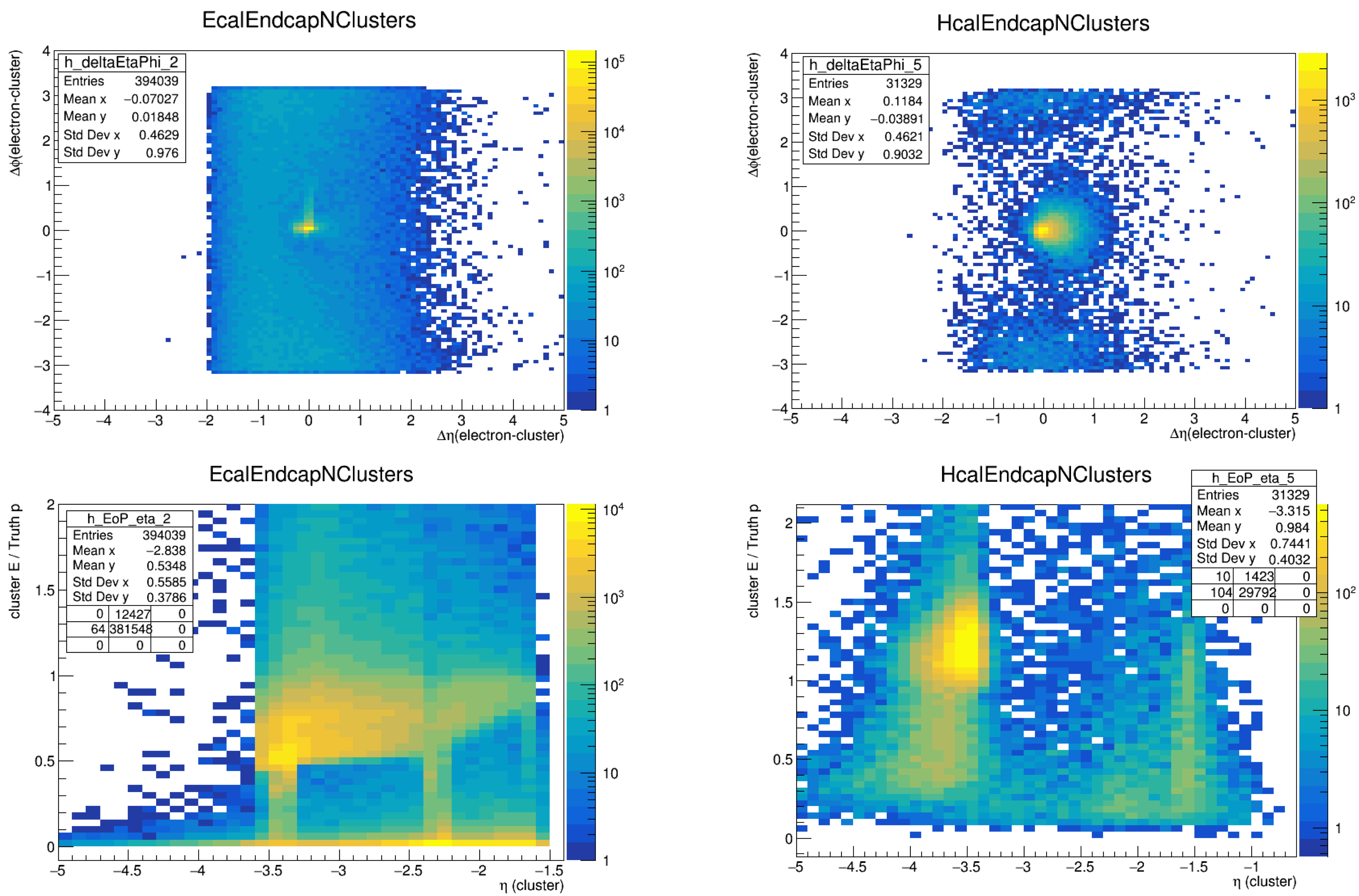






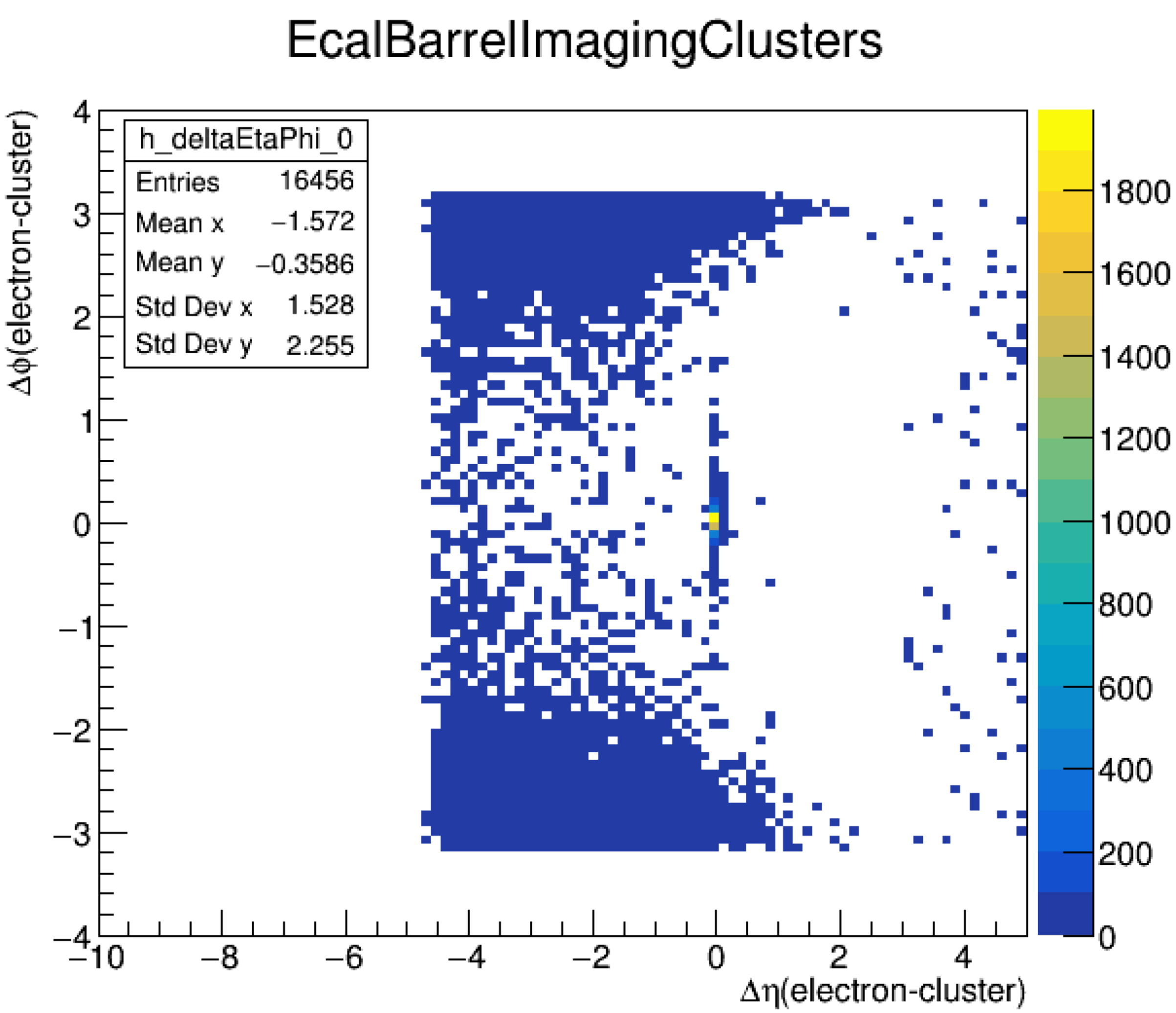


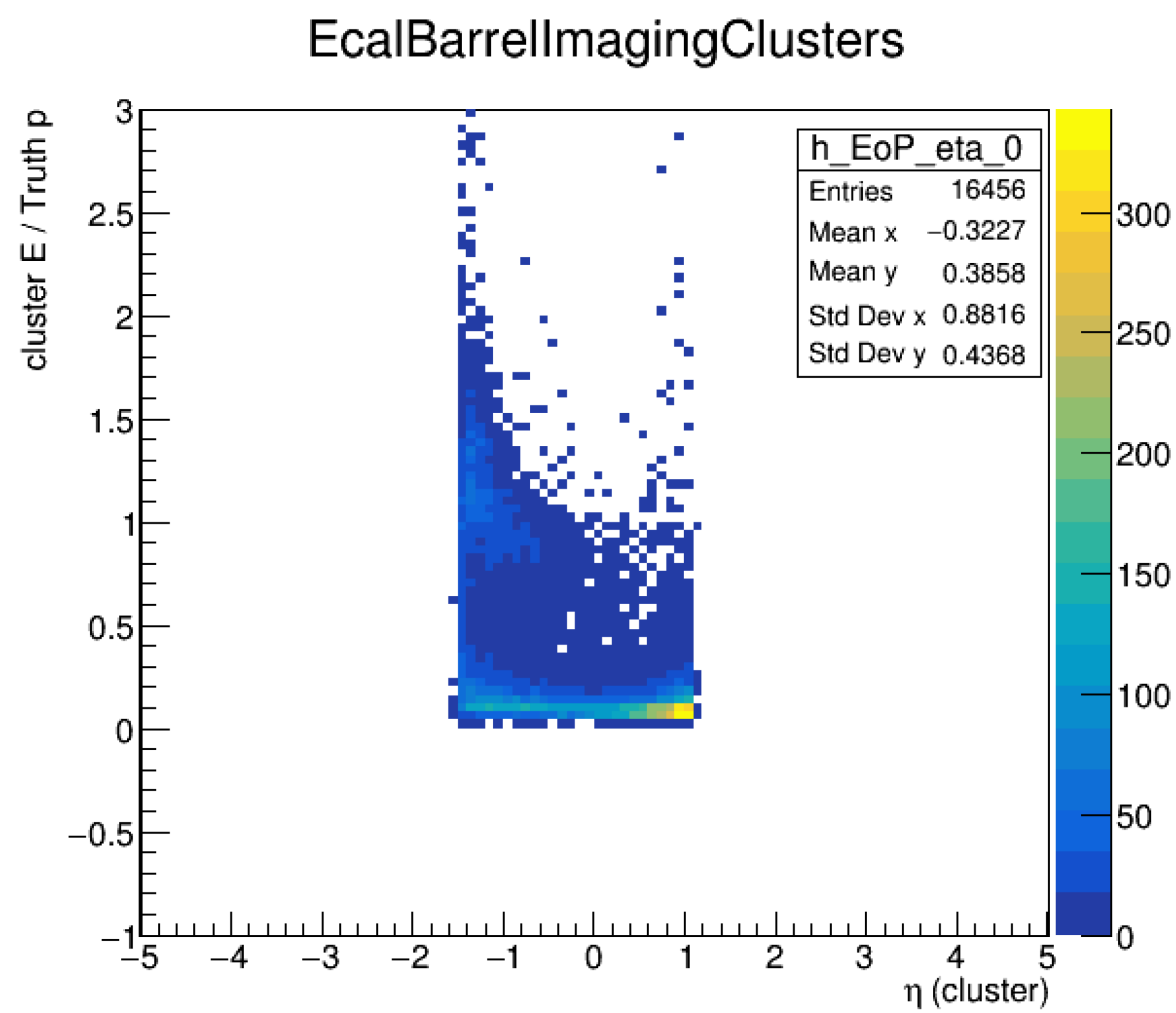
Endcap cluster matching to scattered electron



record electron eta-phi
But off calibrated

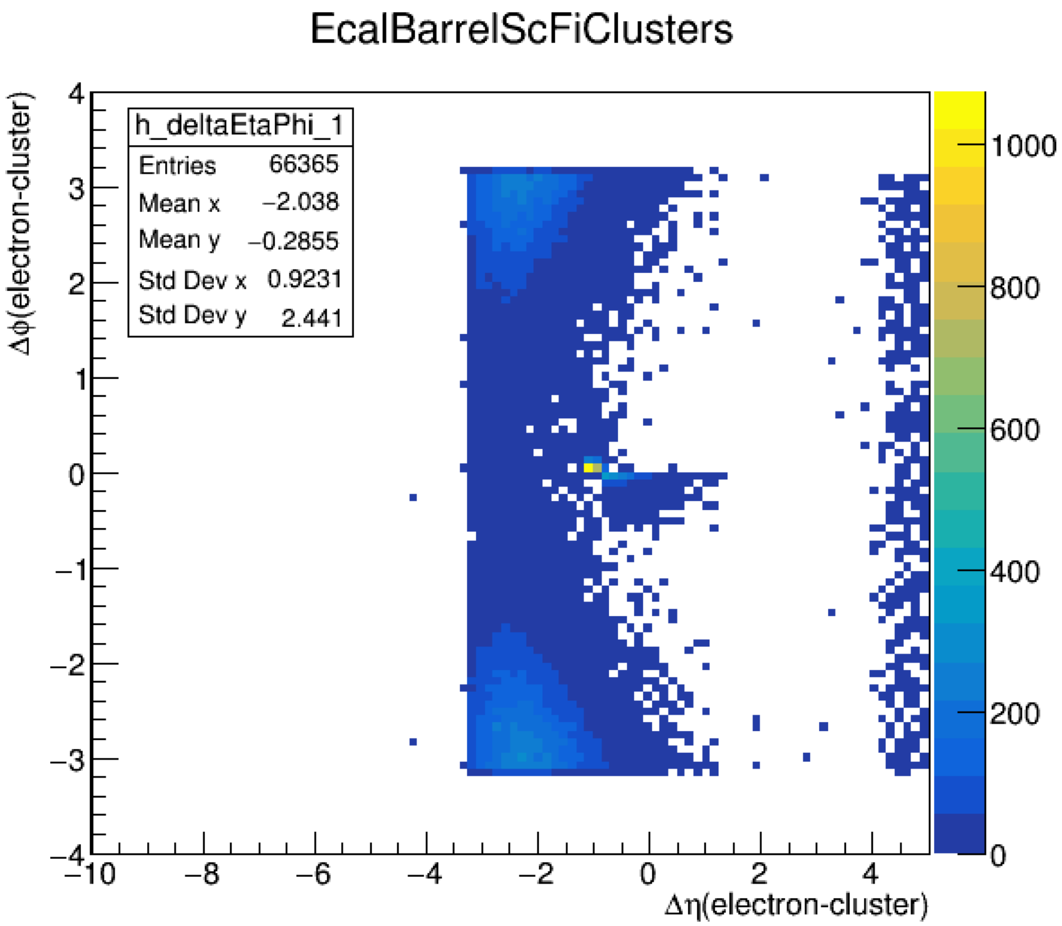
Barrel Imaging cluster matching to scattered electron

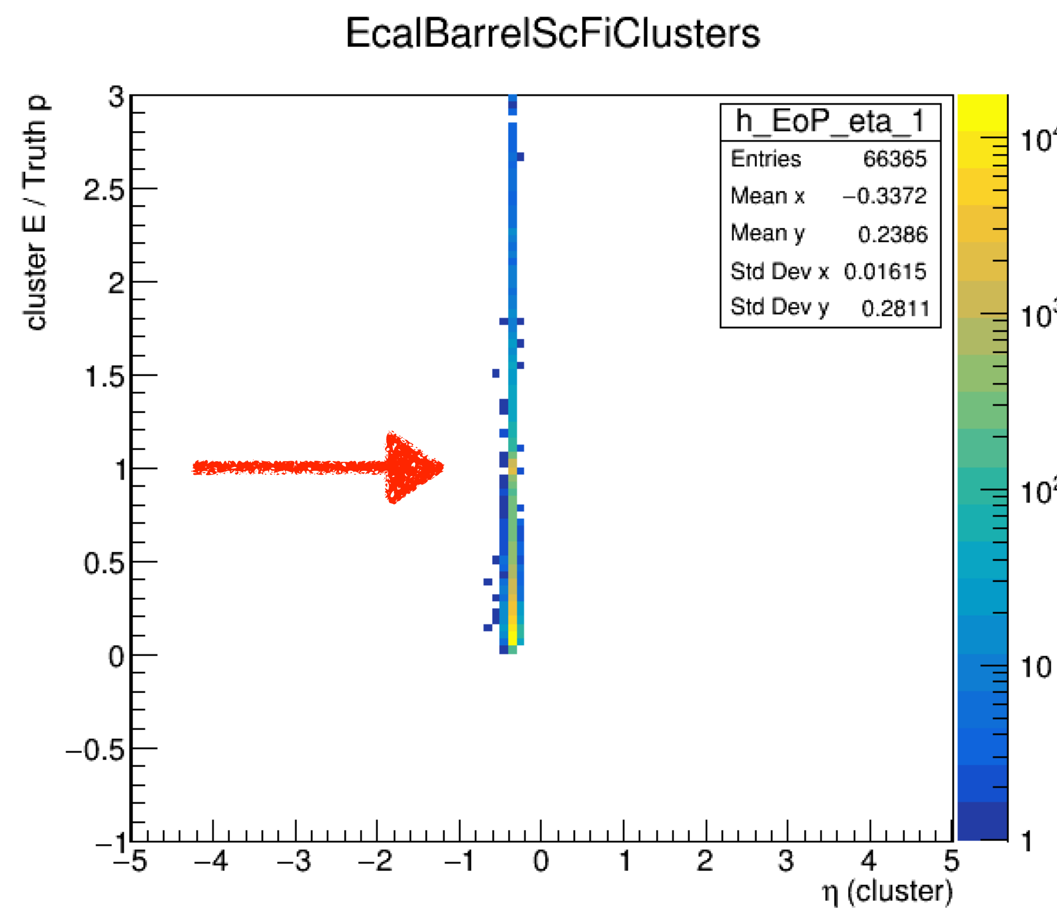




Imaging Layer: record electron eta-phi

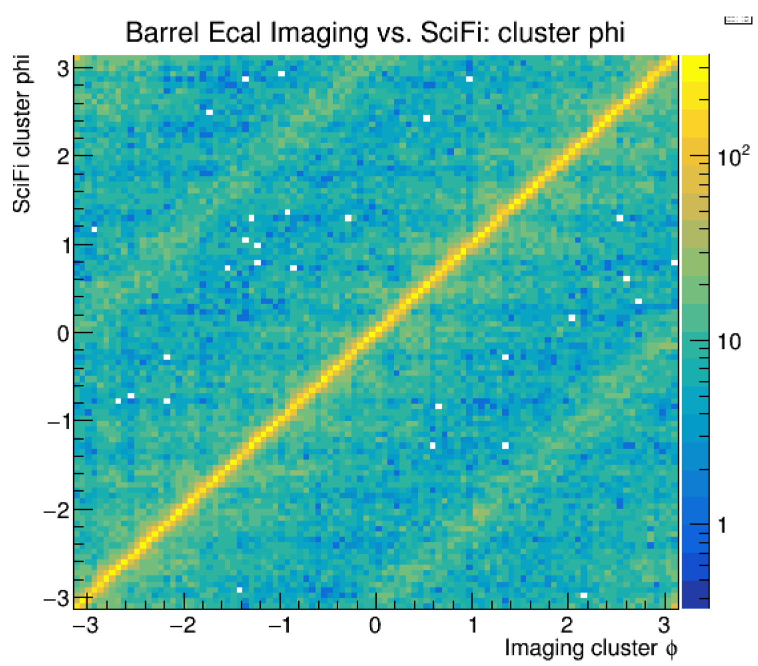
Barrel SciFi cluster matching to scattered electron

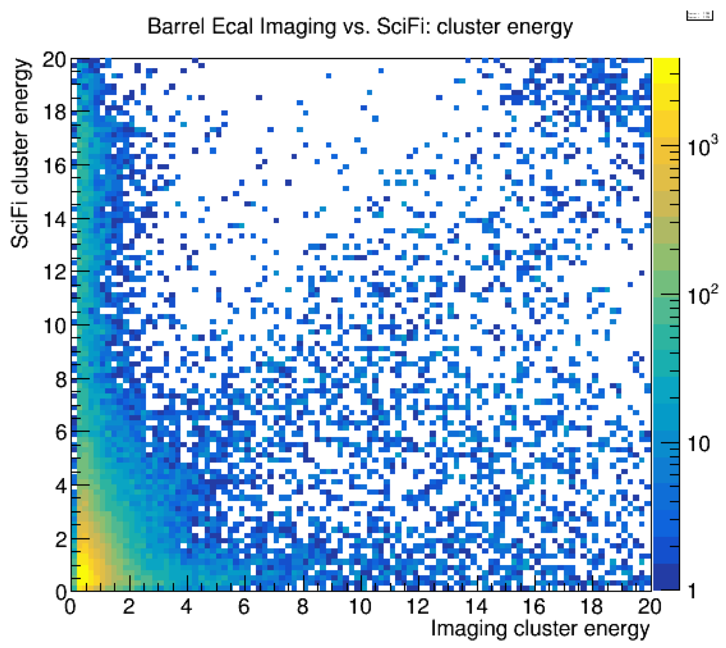


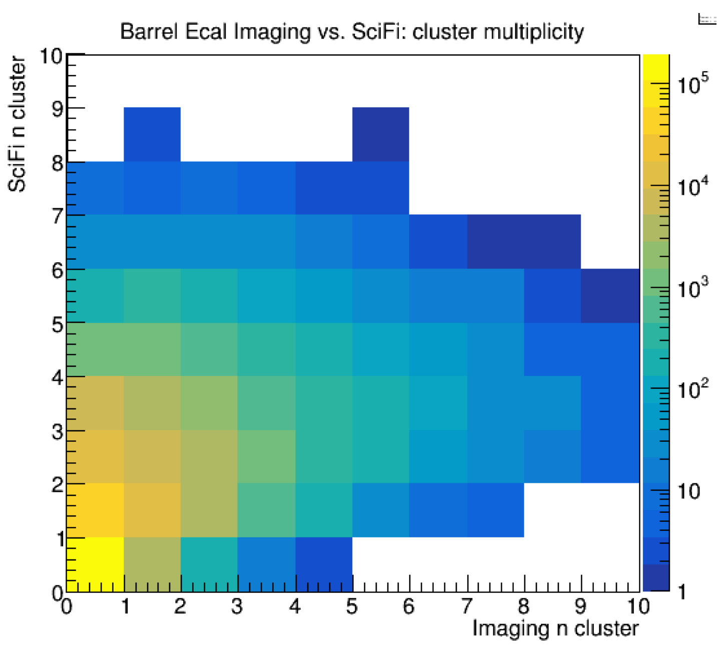


SciFi Layer: record electron phi and energy

Barrel ECal Imaging vs. SciFi



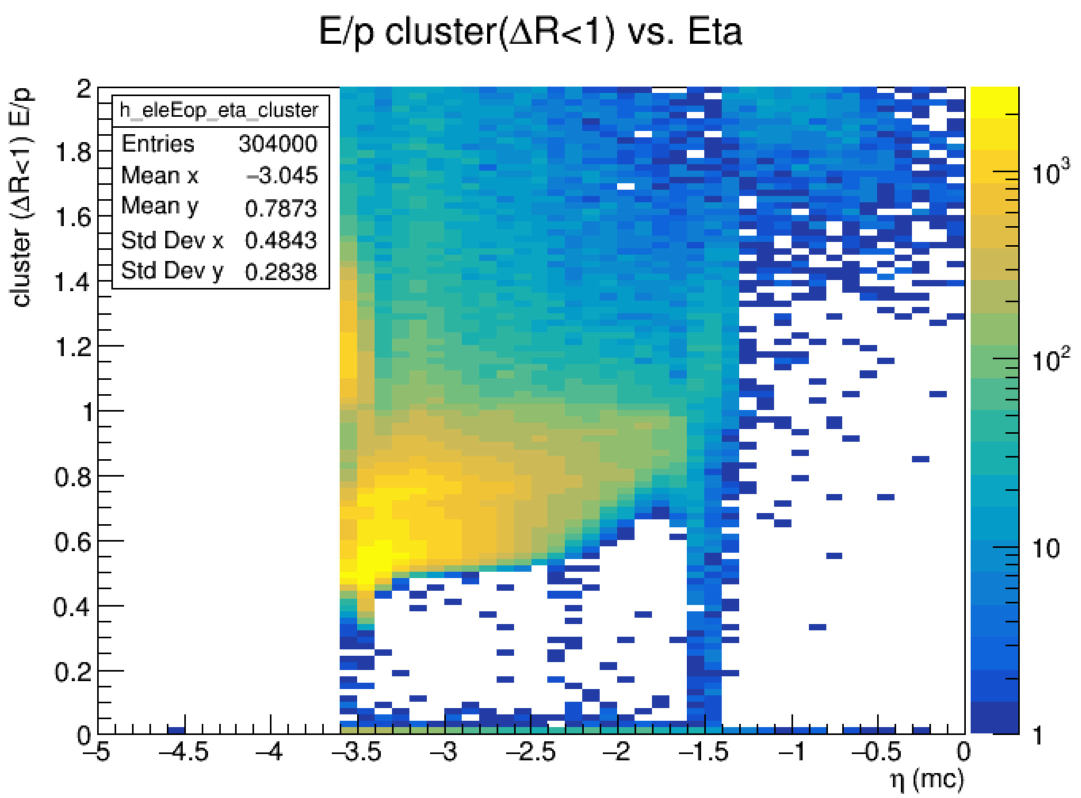


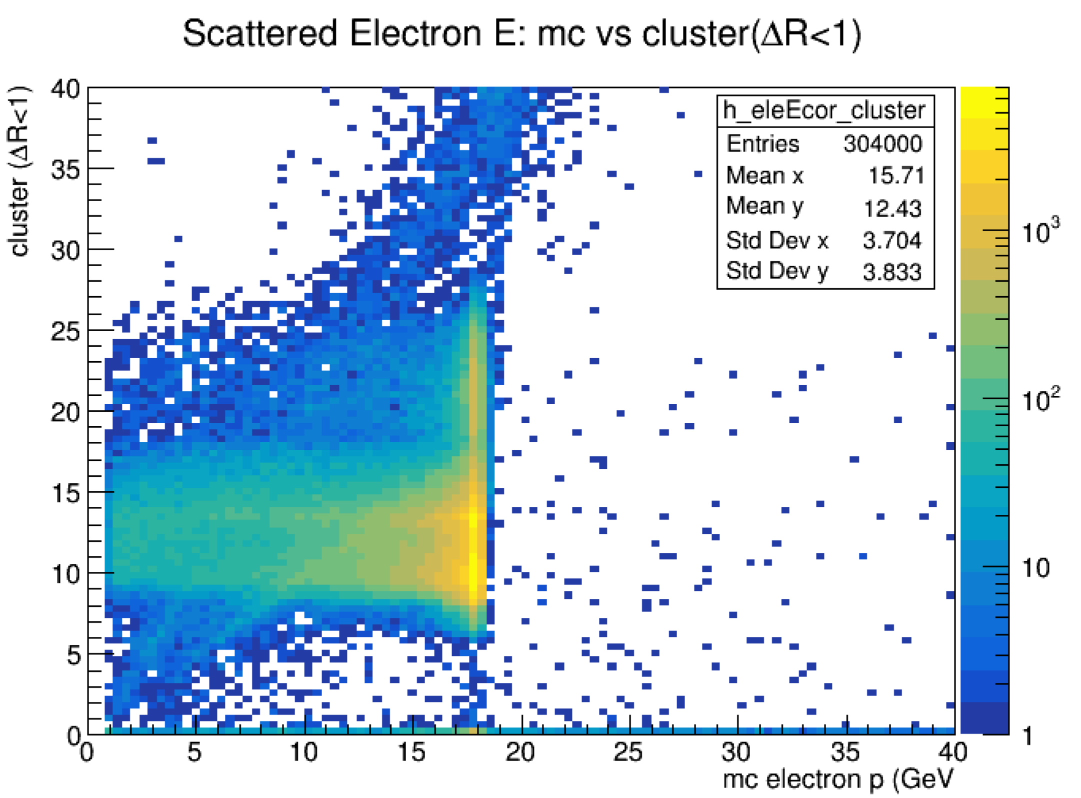


- **Nicely correlated in phi**
- **Weak correlation of energy**
- **Weak correlation of multiplicity**

Electron in $\eta - \phi$ Patch

Based on mc eta-phi, summing over all cluster energy in a near cone ($\Delta R < 1$)

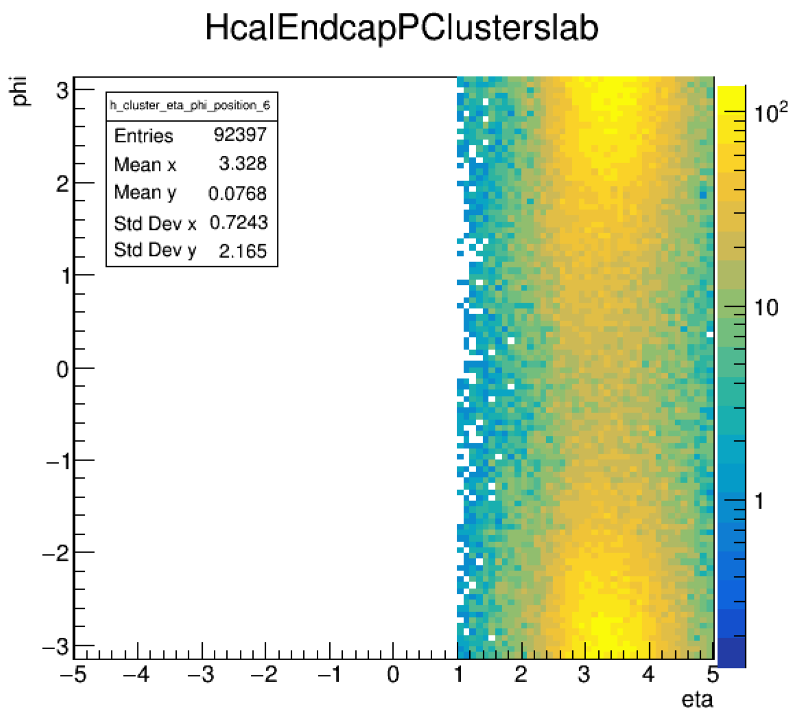


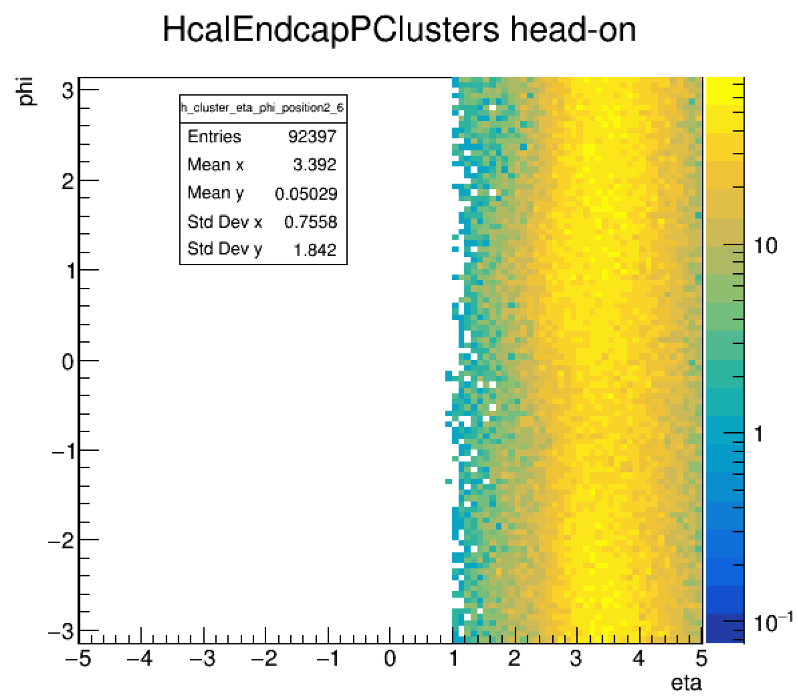


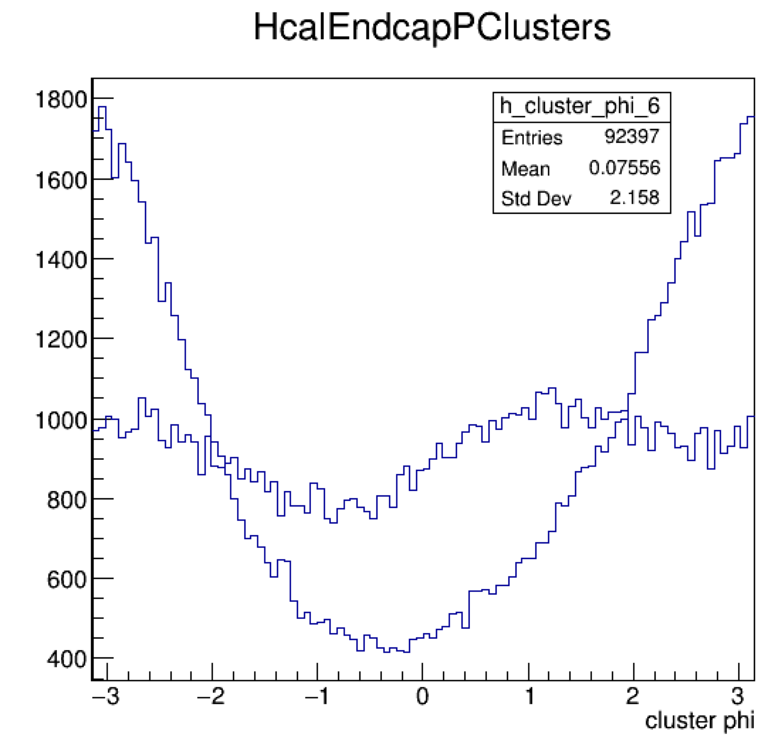
Summary

- Shift back to head-on frame is necessary for kinematics reconstruction, especially for hadronic methods
- Looked into the calorimeter cluster branches and tried to find electron
    - acadia-v1.0-alpha production is not ready for electron finding

Proton Endcap







TLorentzRotation lab2headon = TLorentzRotation().RotateY(12.5e-3).Boost(sin(12.5e3),0,0)

- **Assuming zero mass for in Lorentz rotation**