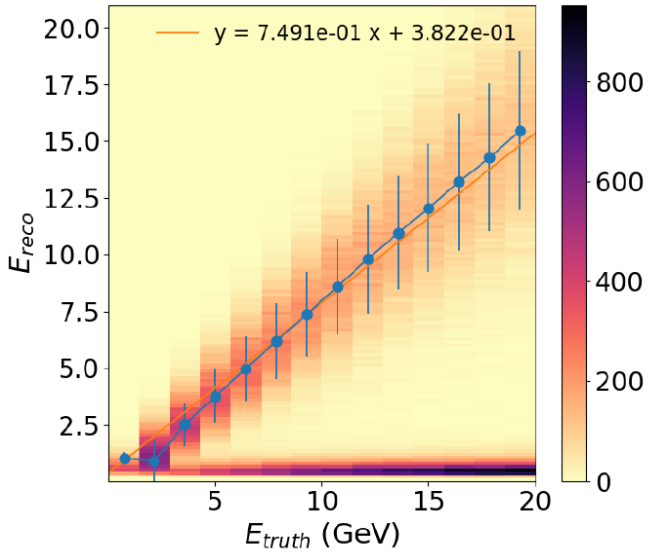
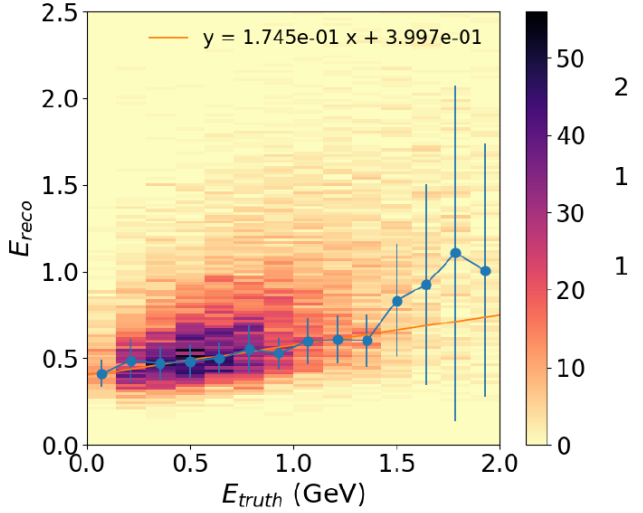
Before we start....

- EnergyPositionClusterMerger merge AstroPix and ScFi clusters by proximity in reconstructed energy.
- BUT AstroPix's E-resolution is not good.
- Recommendation: switch to merging by proximity in eta and phi

Ereco vs ETruth from AstroPix
Single track gamma simulation



Ereco vs ETruth from AstroPix
DIS Q2=1 GeV gamma simulation



Cluster resolution

With complete digitization chain and realistic events

Chun Yuen Tsang

Why revisit cluster resolution

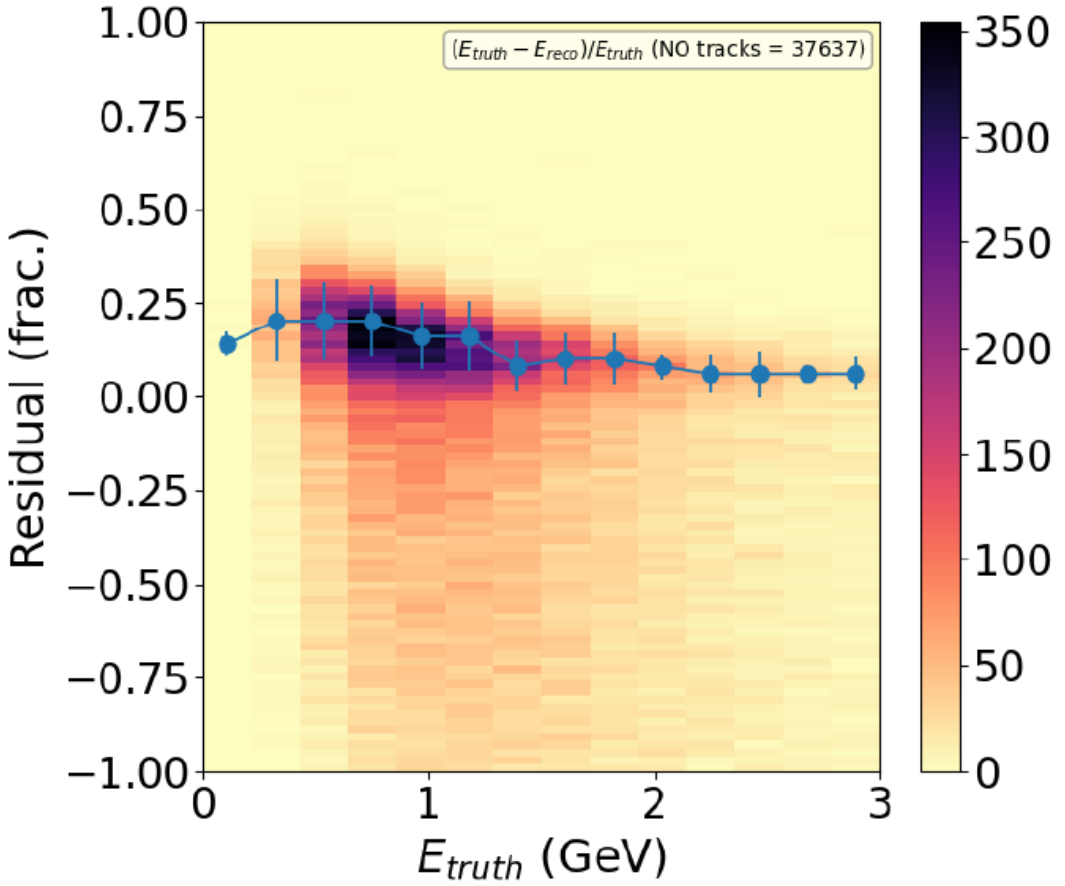
- In BIC meeting on May, I showed results from:
  - In complete digitization (Used true z for attenuation correction).
  - Single track gamma only.

- Now, I will show results with:
  - **Complete digitization chain.**
    - **See pull request: https://github.com/eic/EICrecon/pull/2732 and https://github.com/eic/EICrecon/pull/2770**
  - DIS Q2=1GeV, NC Q2 = 10 and 100 GeV.
  - Gamma and electron

- MC-reco association on cluster is made IF > 50% of cluster energy comes from that MC particle.

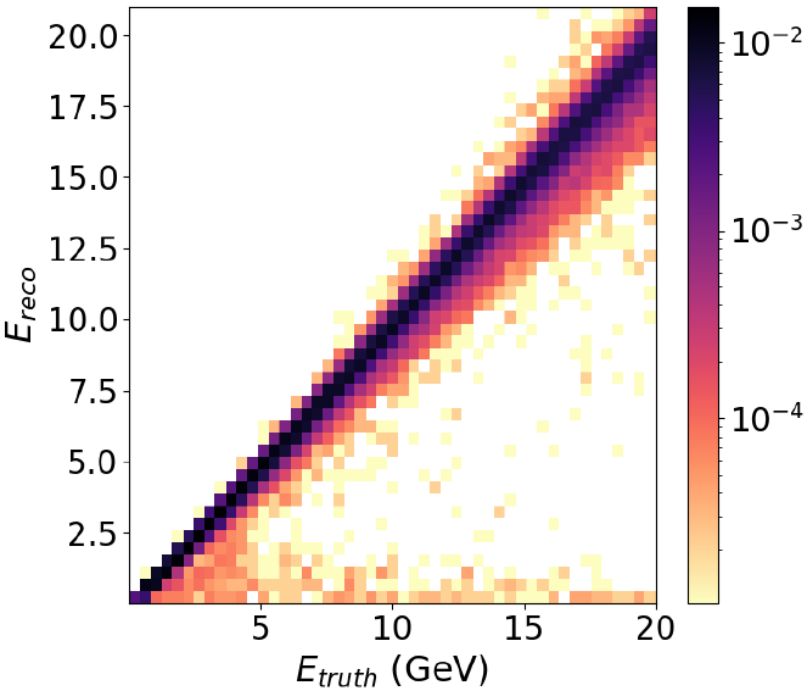
Definition of error bar

- Plot residual (Reco-Truth) vs E_Truth value, estimate width of each slice.
- For eta and phi:
  - Central value = 50th percentile.
  - Error bar = 68.3% confidence interval (CI)
- For energy:
  - Central value = mode (location of peak)
  - Error bar = Full width at 1/sqrt(e) max
    - Emulate 1 sigma in gaussian distribution.
- Want to avoid curve fitting as it very often fails.

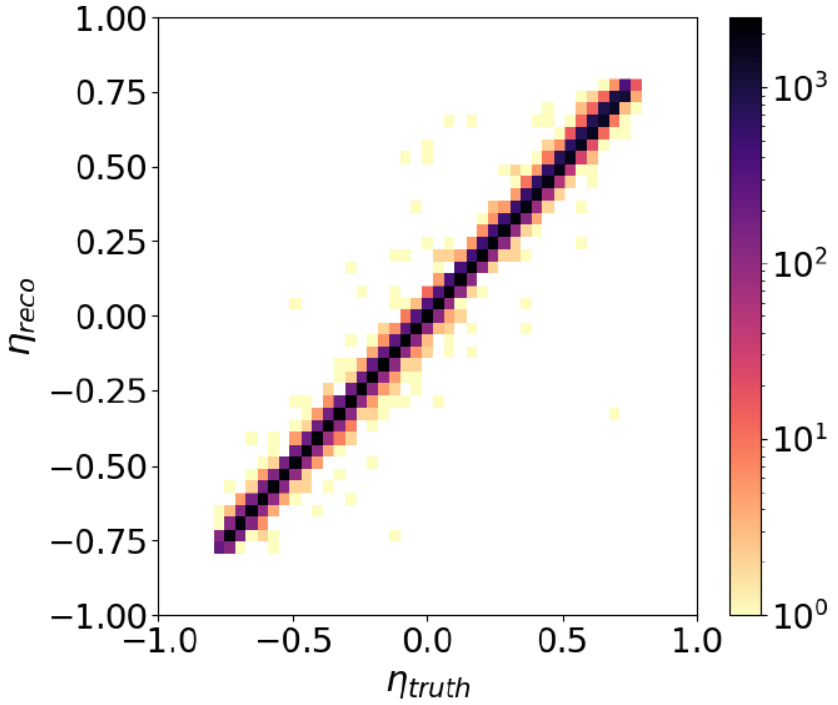


Single track gamma

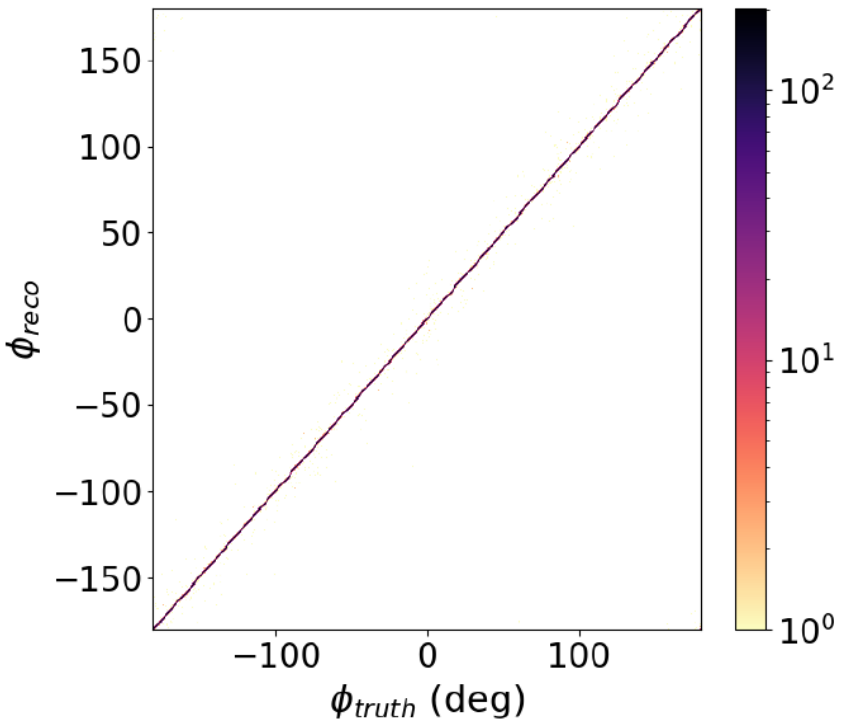
Energy



Eta



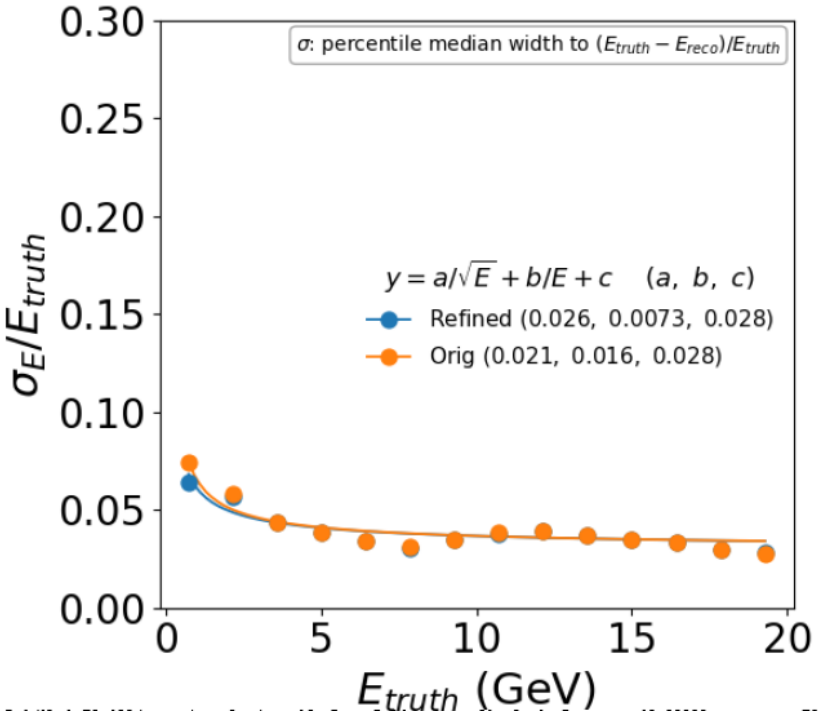
Phi



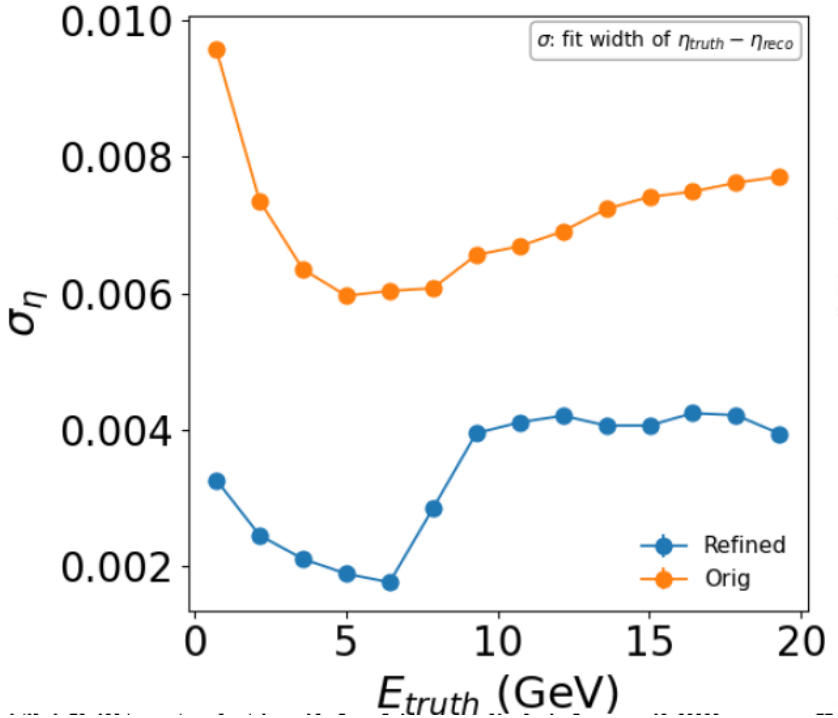
Single track gamma

Orange: ScFi, Blue: ScFi+AstroPix

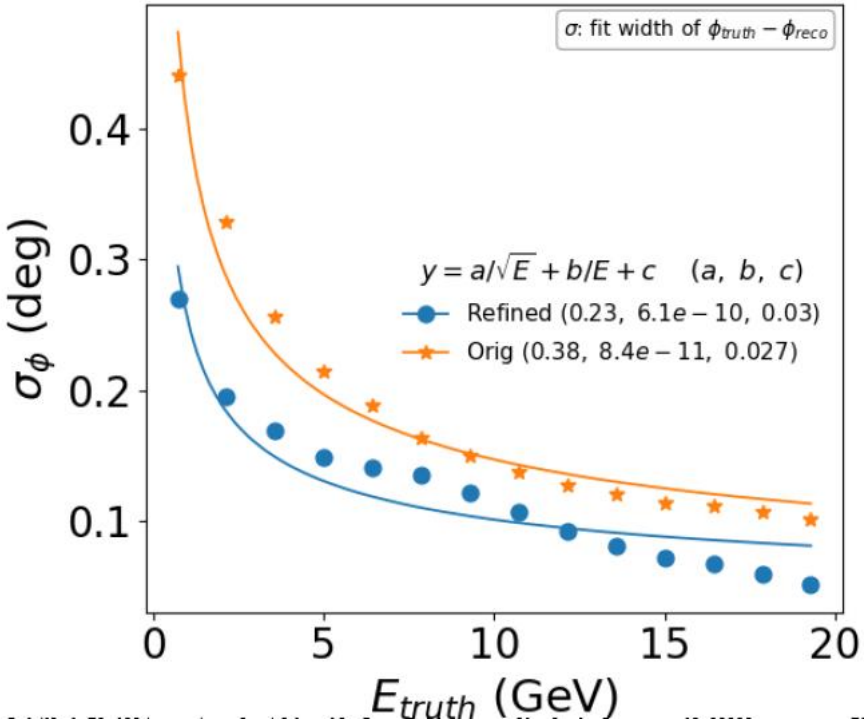
Fractional Energy



Eta err



Phi err



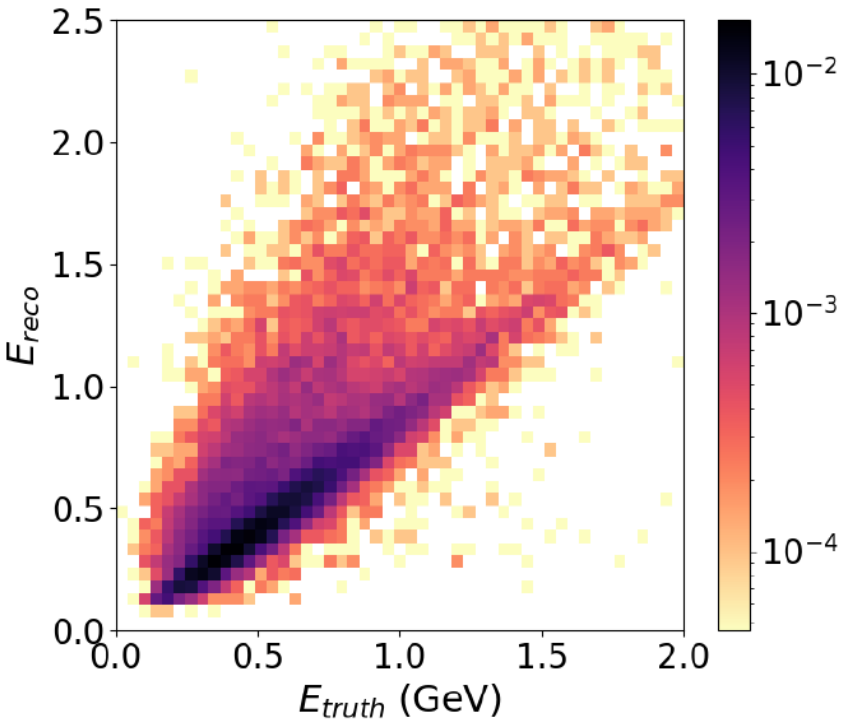
Performance on DIS Q2 = 1 GeV, NC Q2=10 and NC Q2=100 GeV events

- Only consider tracks at 50 < theta < 130 deg (|eta| < 0.76)

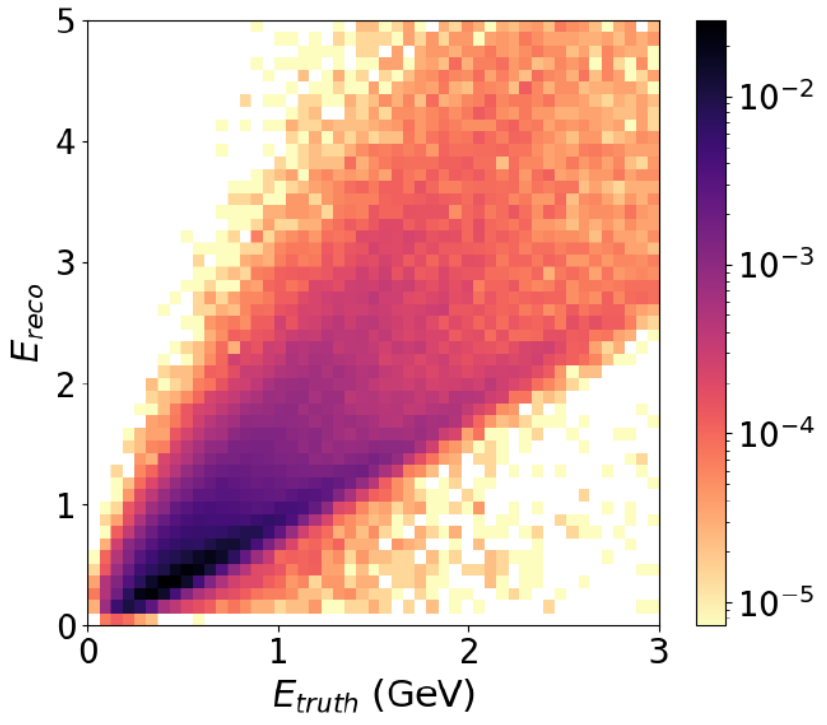
- MC-cluster association is made when more than half the energy of the cluster come from a particular MC shower.
  - By definition, E_reco/E_truth <= 2.
  - Clusters are often a mix of different particles.

Energy confusion matrices Gamma, ScFi only

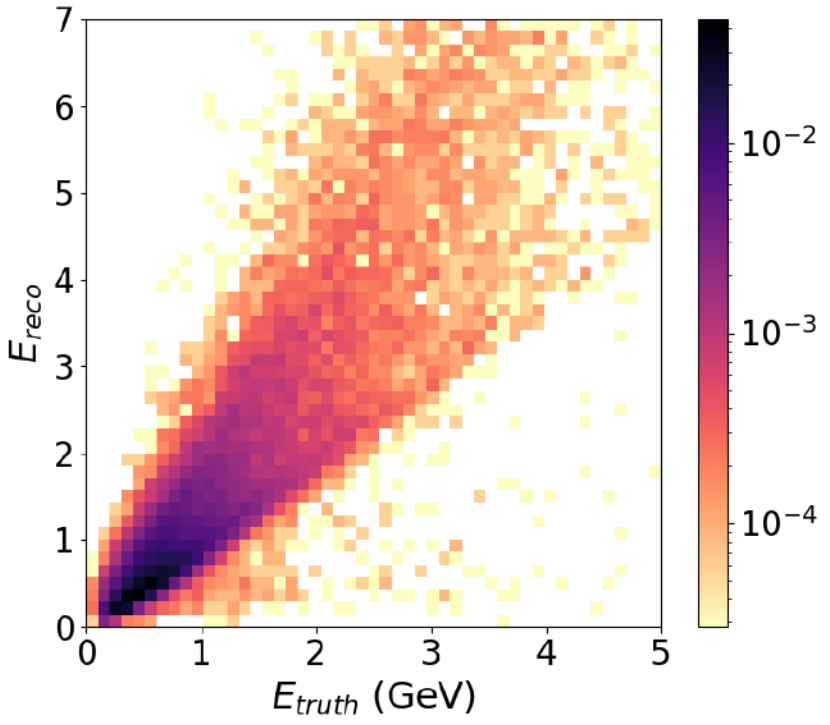
DIS Q2=1 GeV



NC Q2=10 GeV



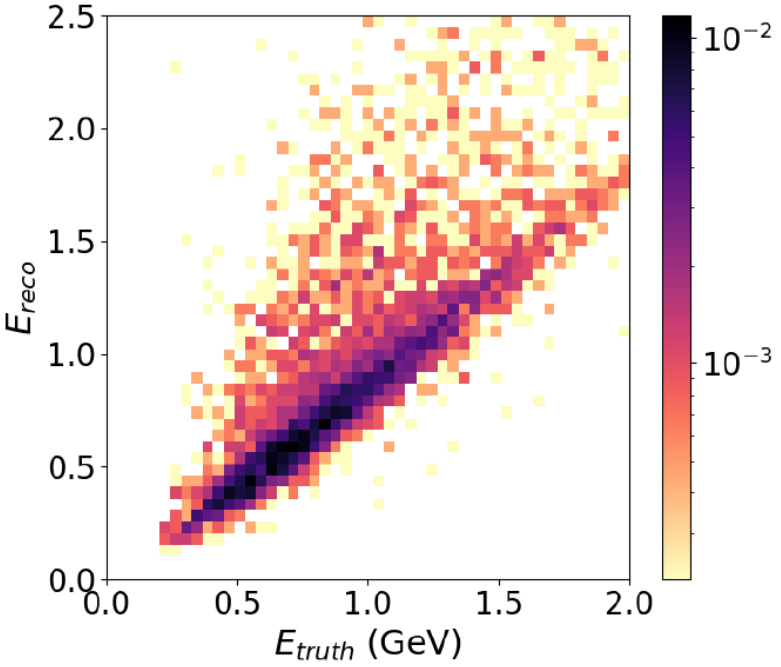
NC Q2=100 GeV



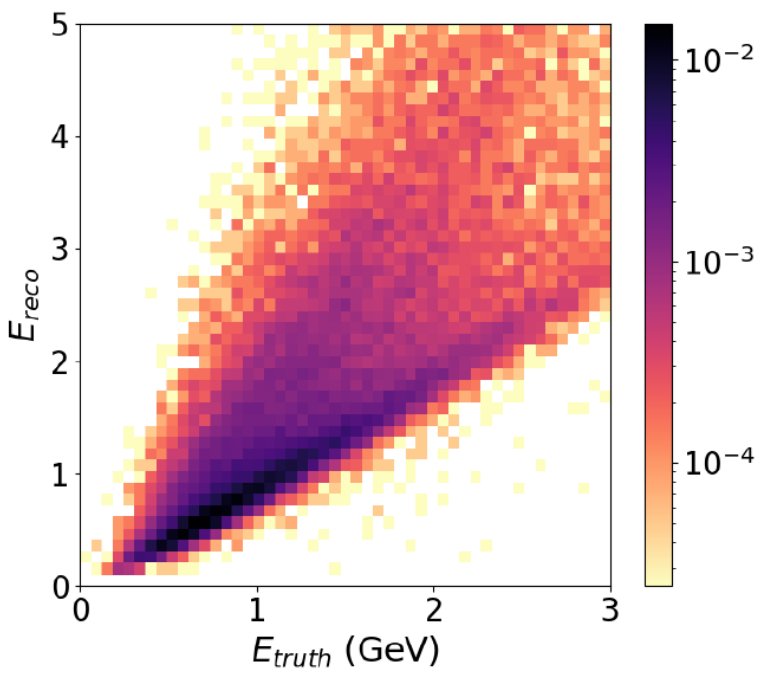
Energy confusion matrices Gamma, ScFi + AstroPix

Note: AstroPix don't change cluster energy, but it removes cluster if cluster match can't be made.

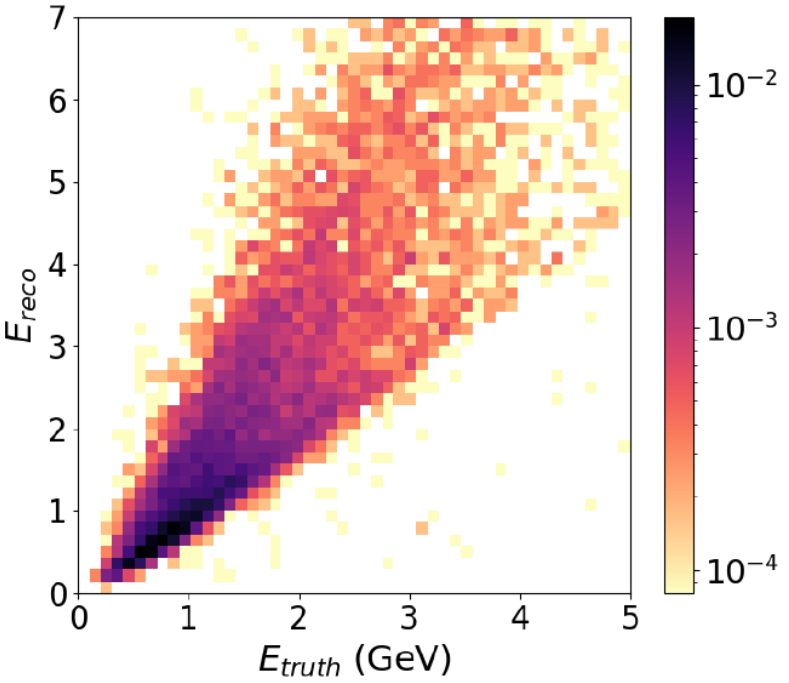
DIS Q2=1 GeV



NC Q2=10 GeV



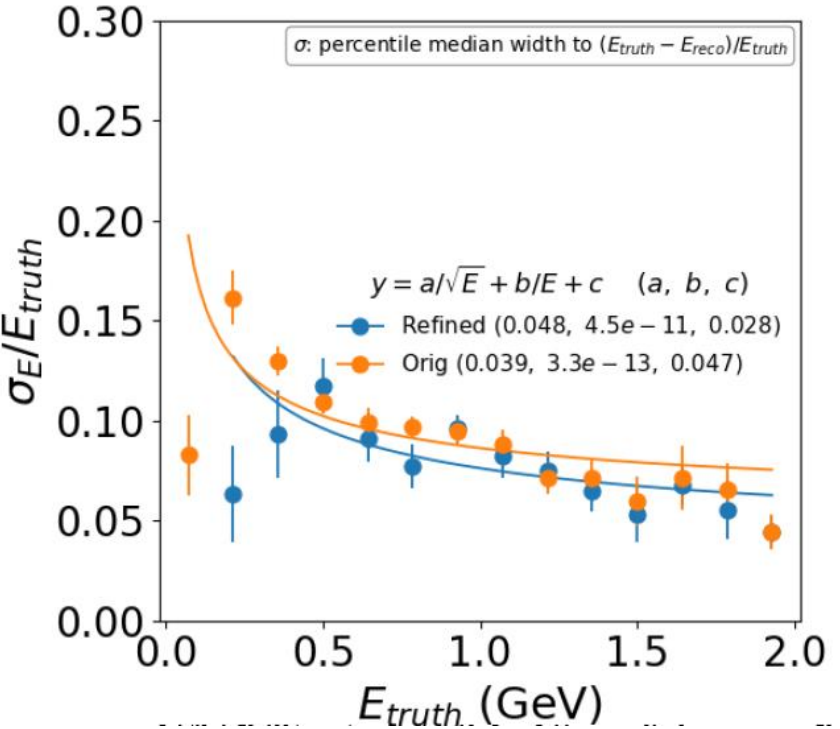
NC Q2=100 GeV



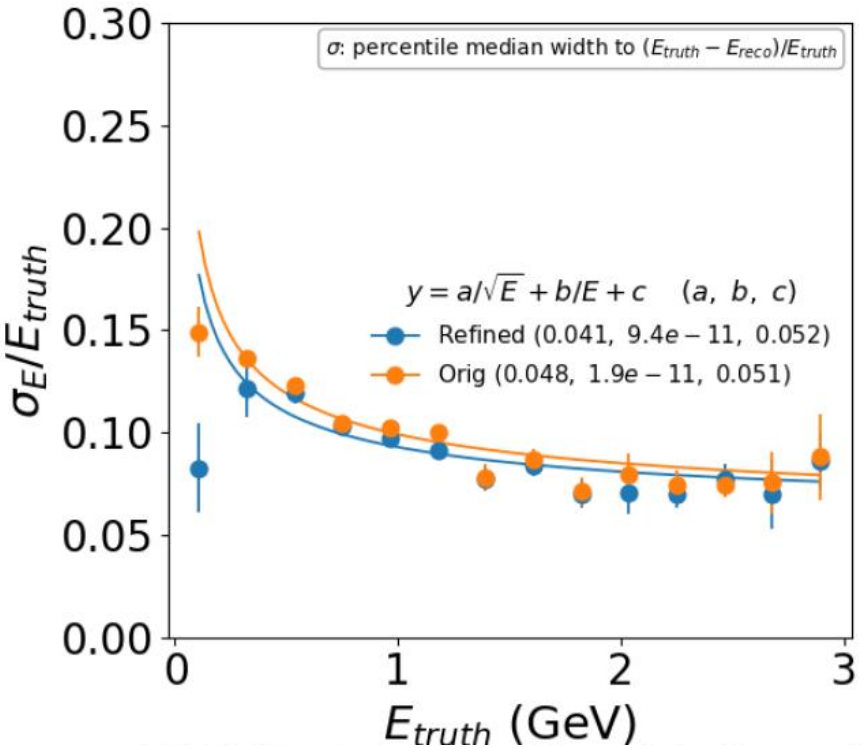
Energy resolution Gamma

Orange: ScFi, Blue: ScFi+AstroPix

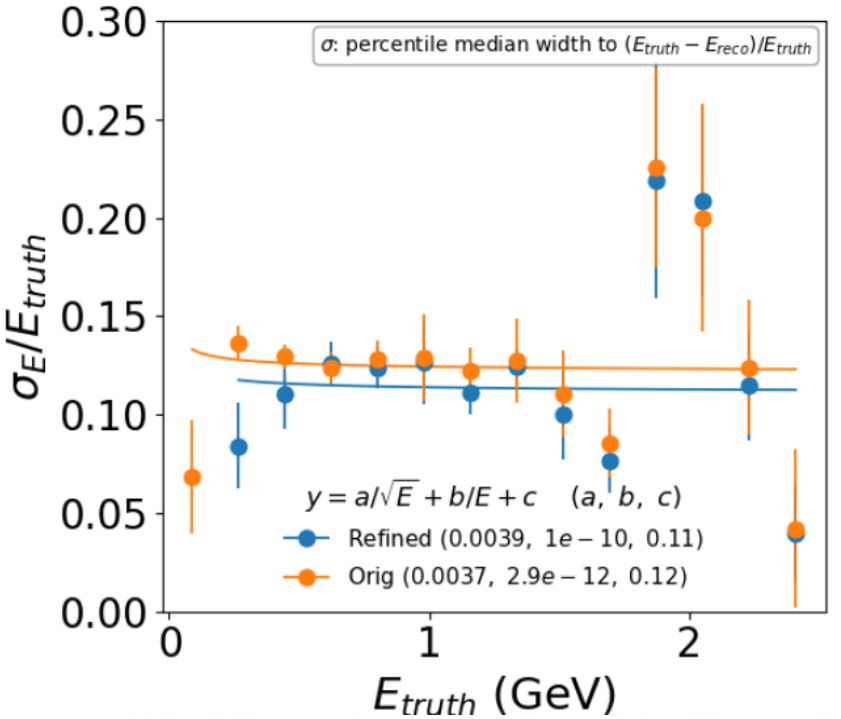
DIS O2=1 GeV



NC Q2=10 GeV



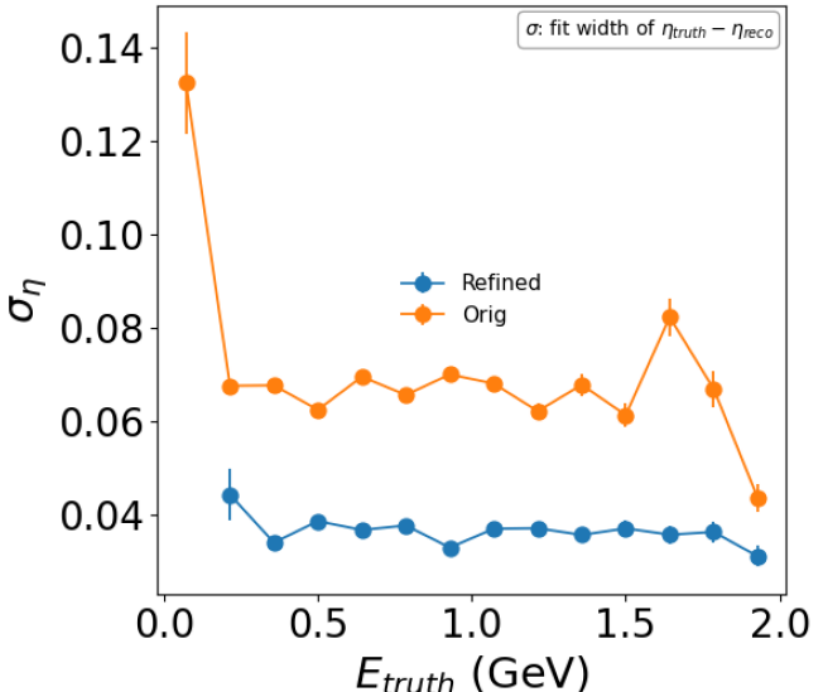
NC Q2=100 GeV



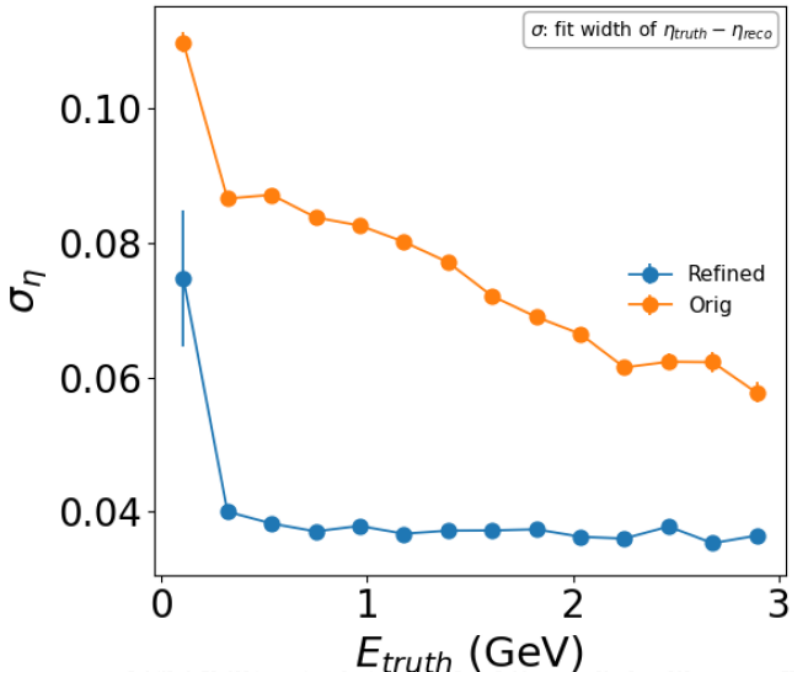
Eta resolution Gamma

Orange: ScFi, Blue: ScFi+AstroPix

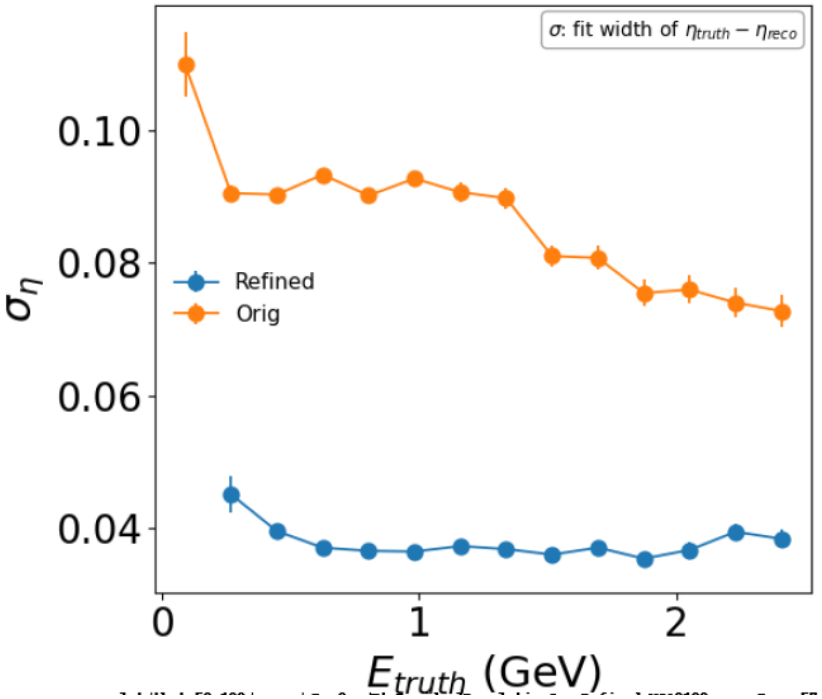
DIS Q2=1 GeV



NC Q2=10 GeV



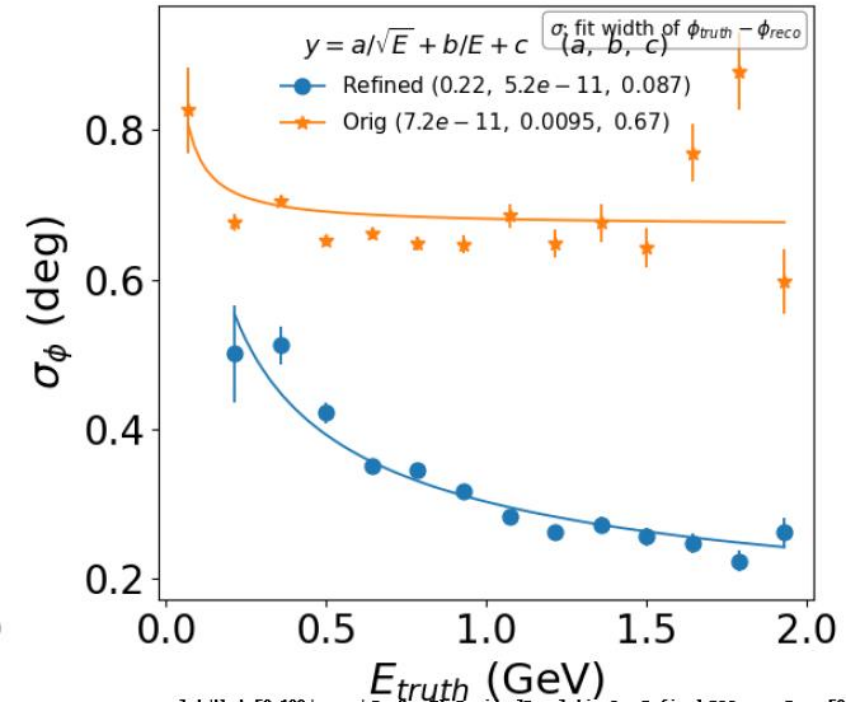
NC Q2=100 GeV



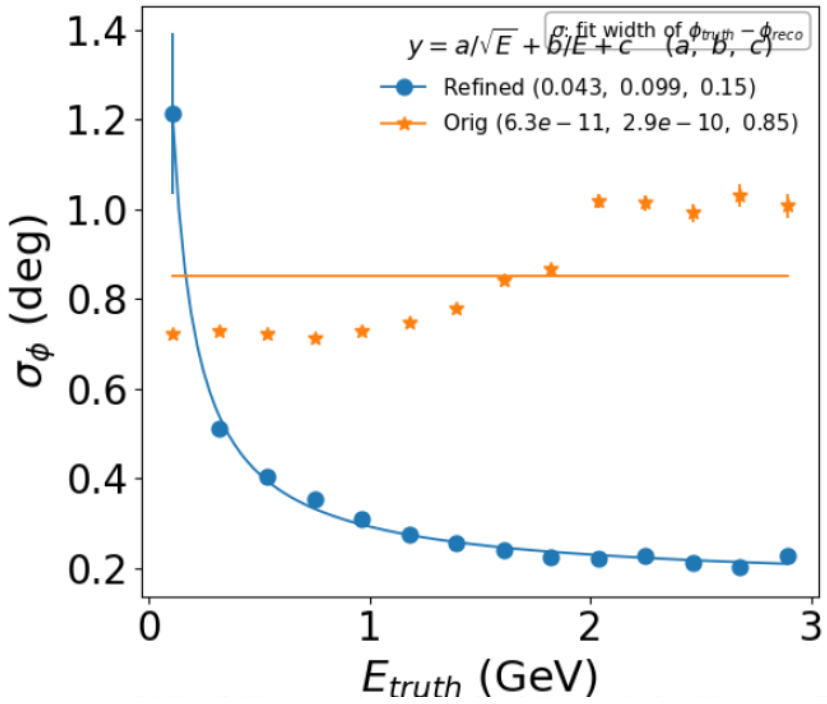
Phi resolution Gamma

Orange: ScFi, Blue: ScFi+AstroPix

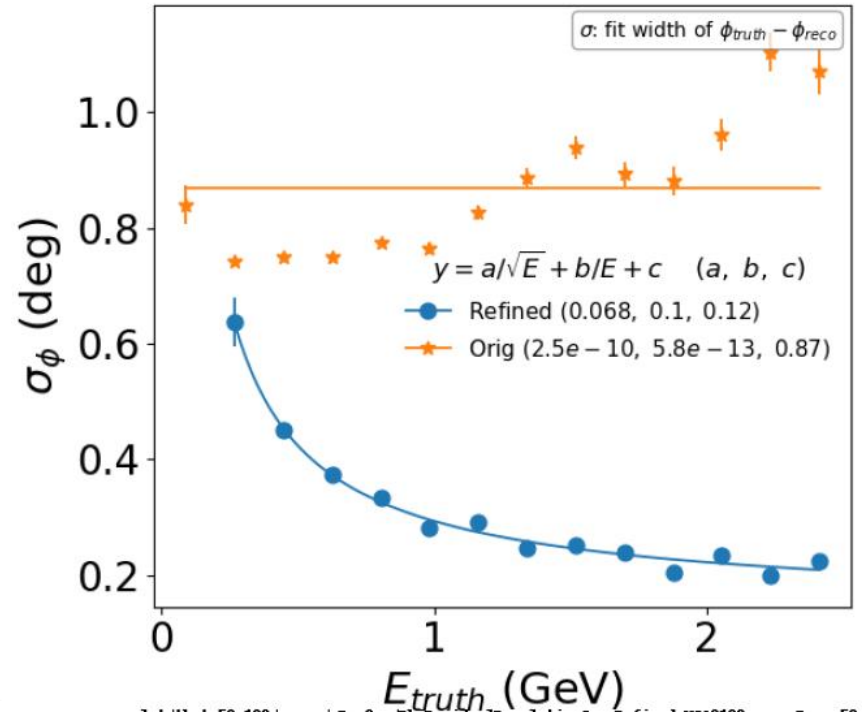
DIS Q2=1 GeV



NC Q2=10 GeV

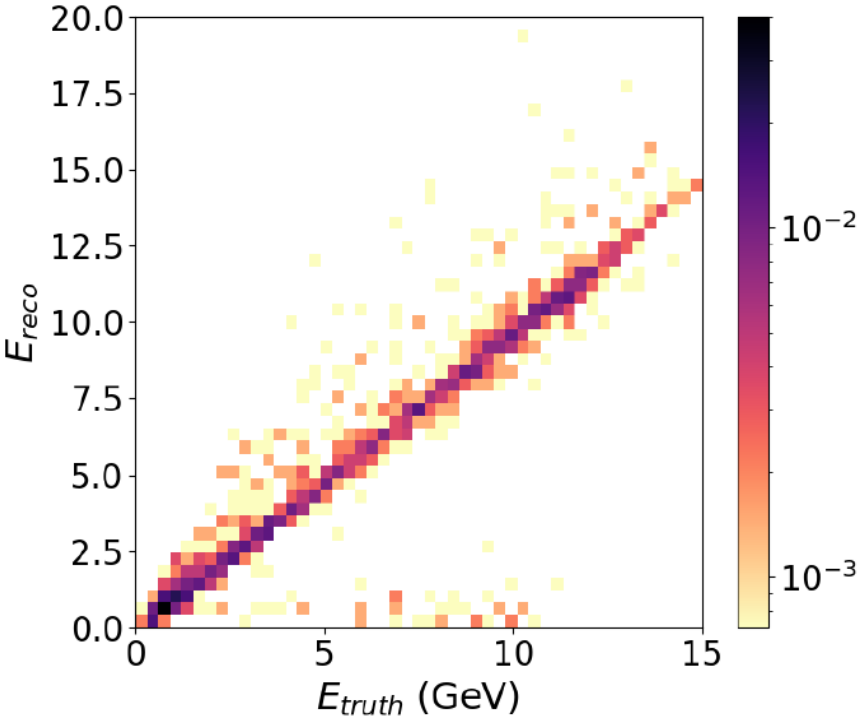


NC Q2=100 GeV

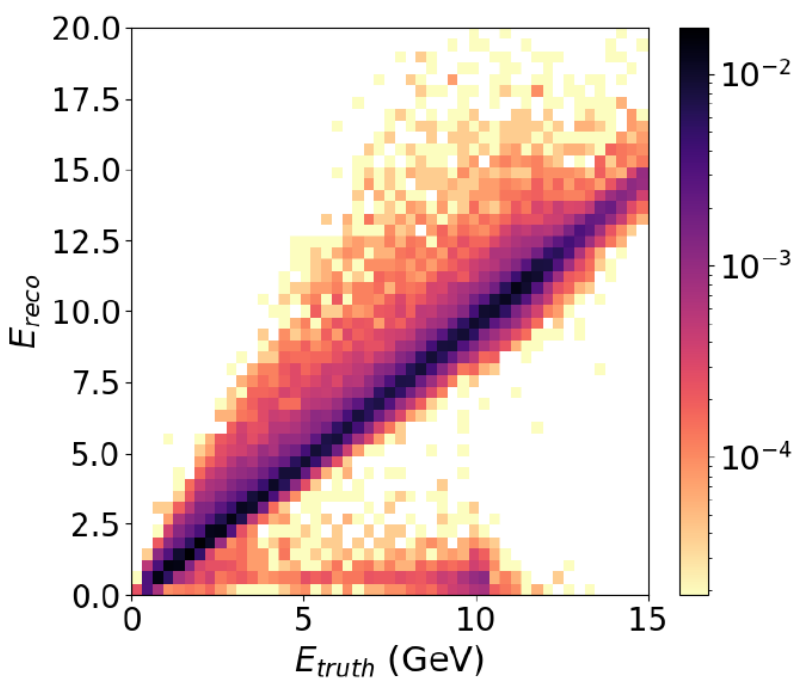


Energy confusion matrices e-, ScFi only

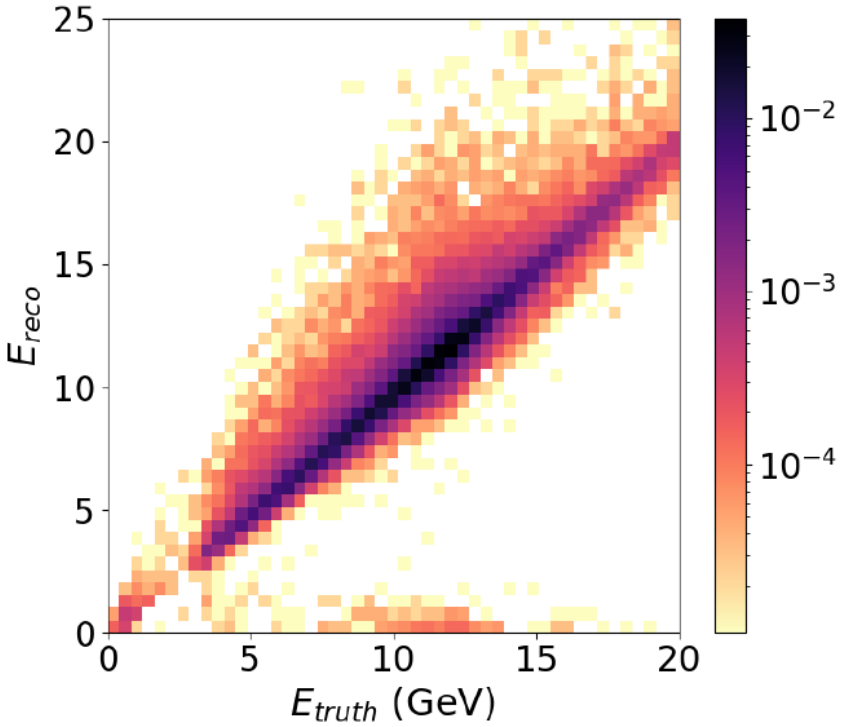
DIS Q2=1 GeV



NC Q2=10 GeV



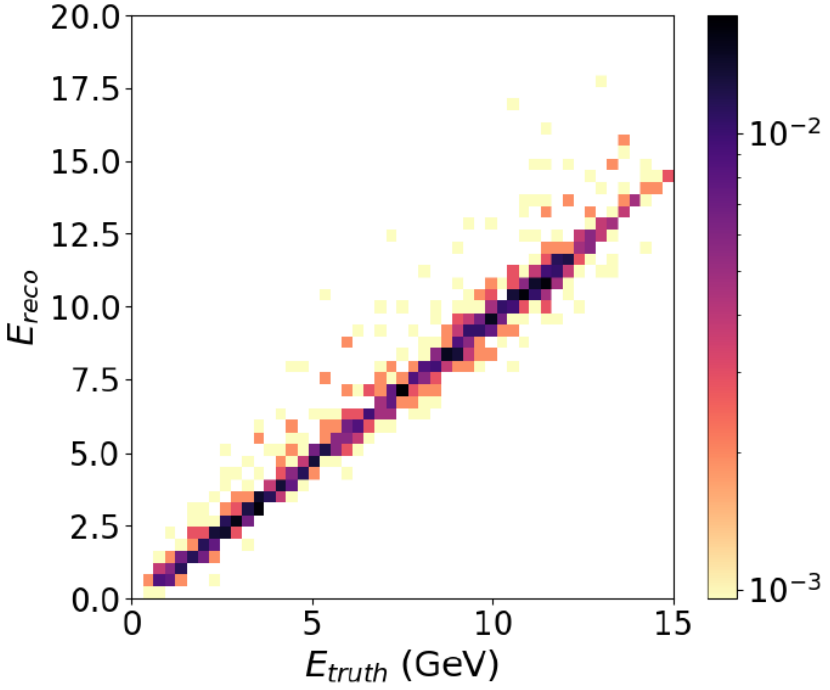
NC Q2=100 GeV



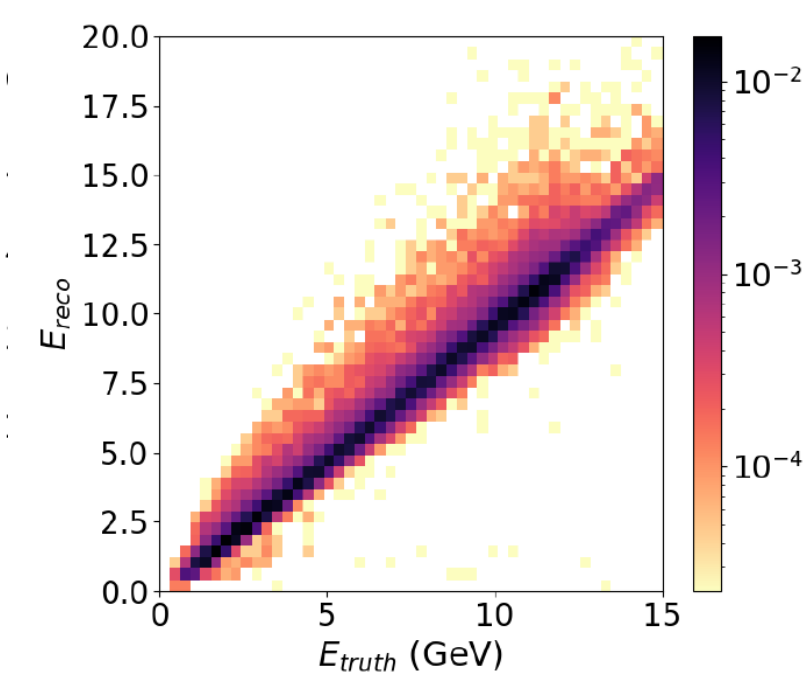
Energy confusion matrices Gamma, ScFi + AstroPix

Note: AstroPix don't change cluster energy, but it removes cluster if cluster match can't be made.

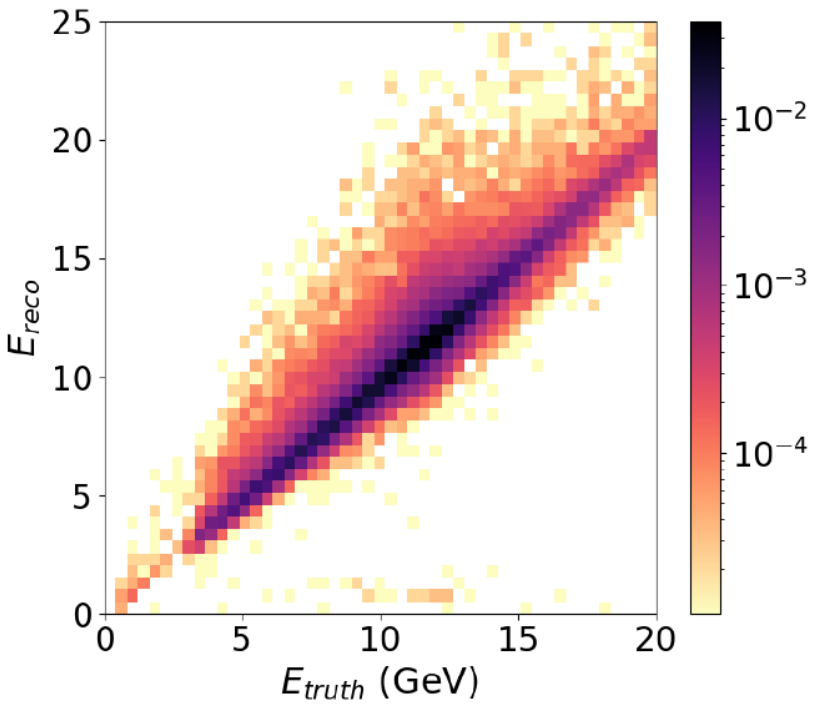
DIS Q2=1 GeV



NC Q2=10 GeV

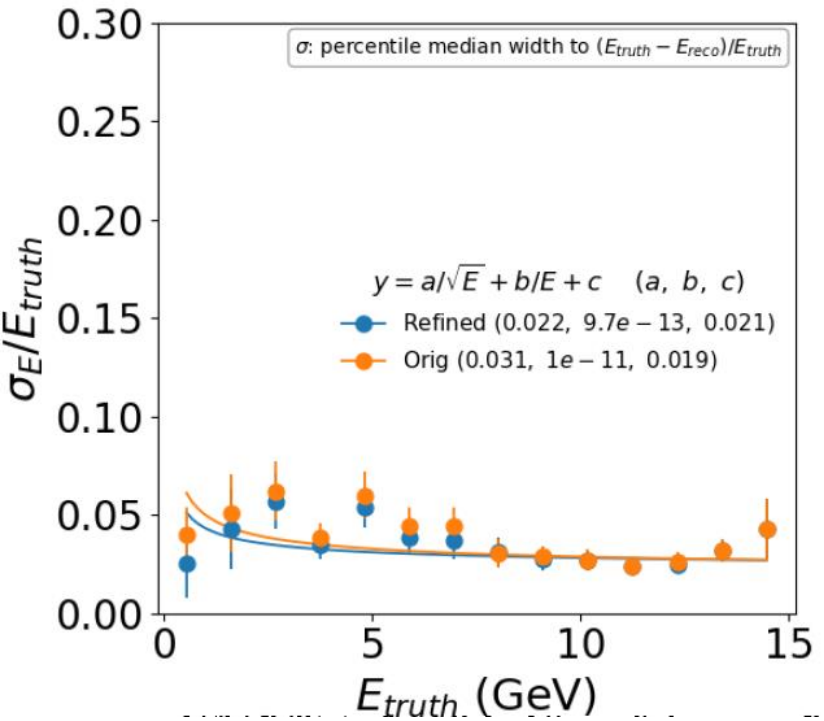


NC Q2=100 GeV

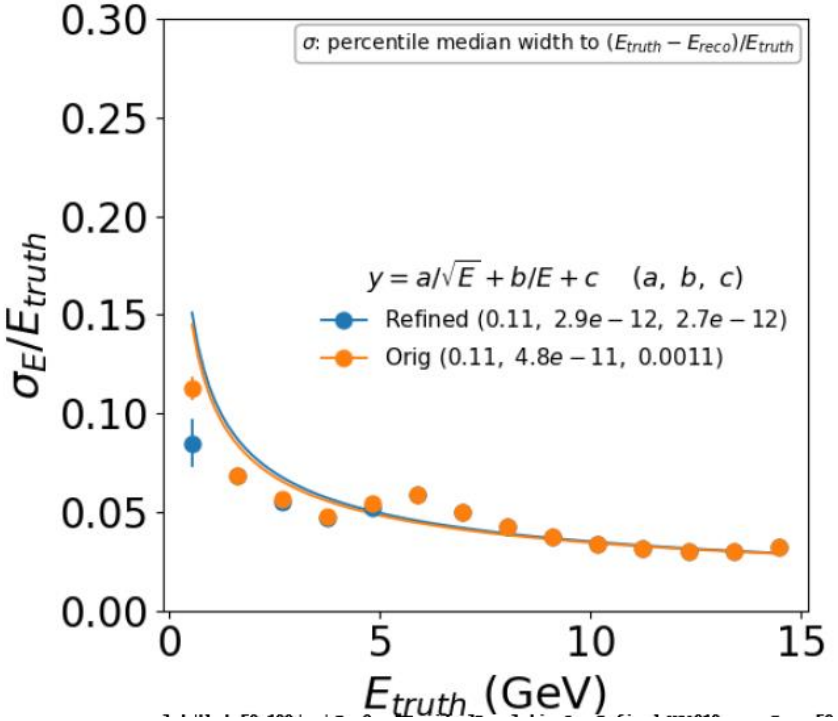


Energy resolution e-
Orange: ScFi, Blue: ScFi+AstroPix

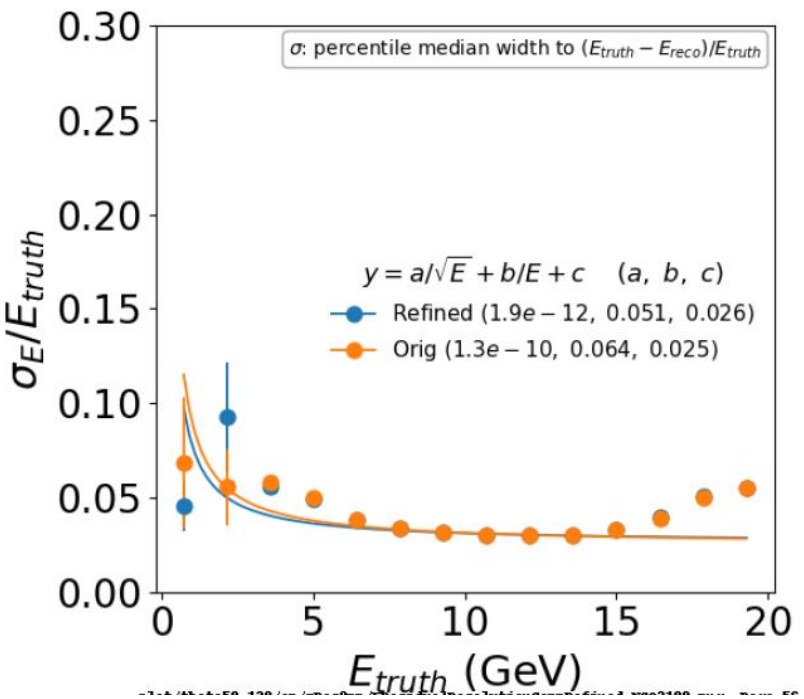
DIS Q2=1 GeV



NC Q2=10 GeV



NC Q2=100 GeV

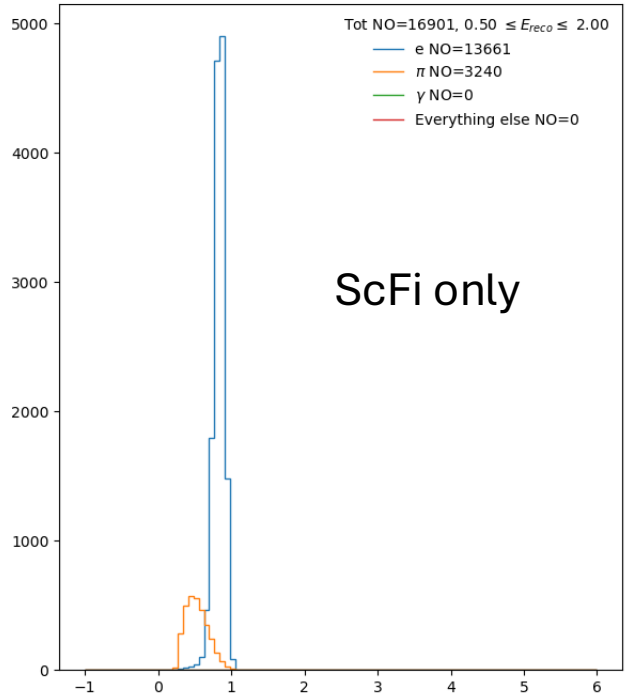


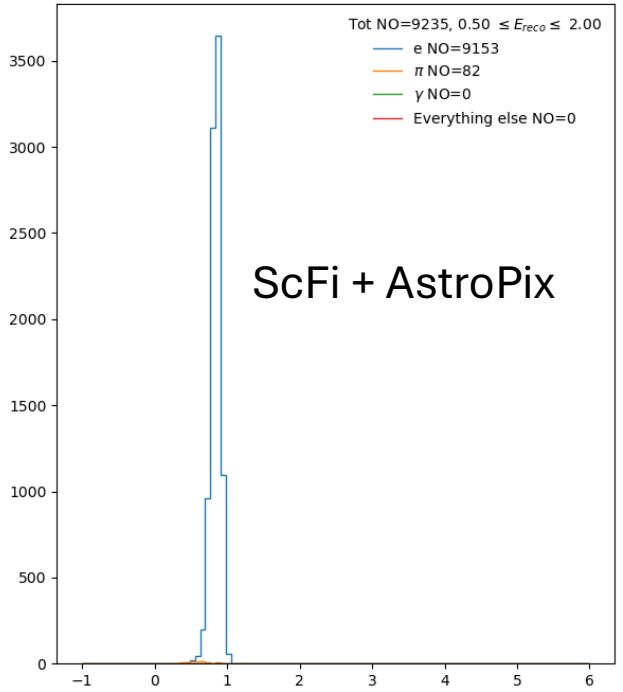
Key benchmark: Gamma Resolution at 1 GeV

Energy (Fractional)					DIS/Single track
Resolution	Single track	DIS Q2=1 GeV	NC Q2=10 GeV	NC Q2=100 GeV	
ScFi	0.079	0.0931	0.102	0.128	1.18
ScFi + AstroPix	0.069	0.089	0.0964	0.125	1.29
Phi (deg)					
Resolution	Single track	DIS Q2=1 GeV	NC Q2=10 GeV	NC Q2=100 GeV	
ScFi	0.419	0.67	0.733	0.77	1.6
ScFi + AstroPix	0.255	0.3	0.28	0.305	1.18
eta					
Resolution	Single track	DIS Q2=1 GeV	NC Q2=10 GeV	NC Q2=100 GeV	
ScFi	0.009	0.069	0.082	0.092	7.67
ScFi + AstroPix	0.0031	0.035	0.0377	0.0366	11.29

Misc1: NO Astropix cluster requirement is too high for pion

- Orange: Pions, Blue: Electrons



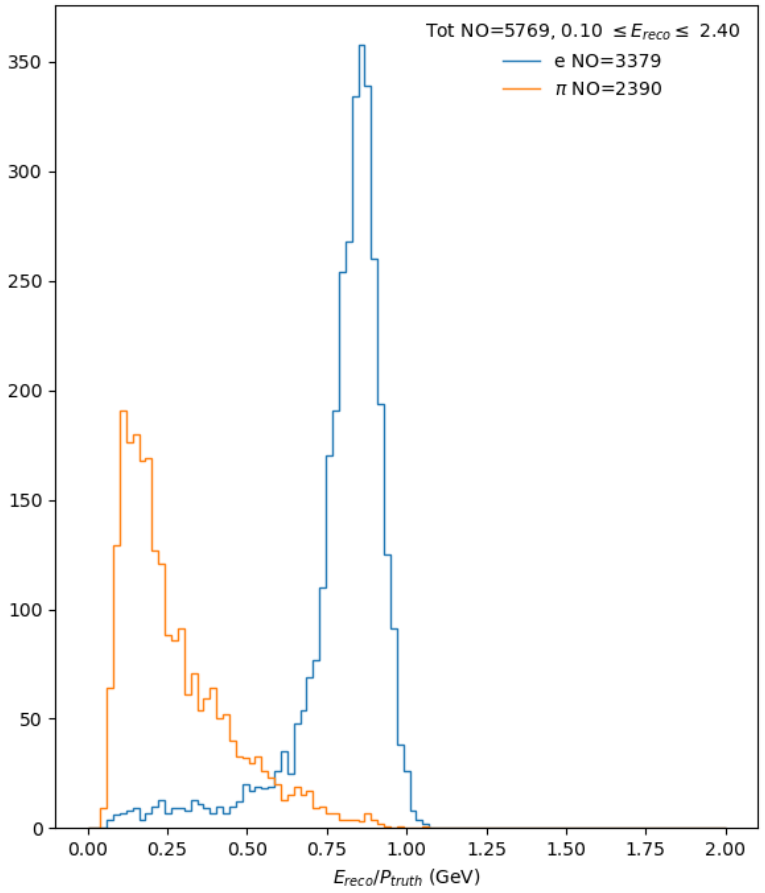


Reason: AstroPix required at least 10 pts for clusters

- Only 4 layers of AstroPix.
- Cut particles that do not form shower early on.
- Pi- is rejected.
- Could be used for physics?

```
app->Add(new JOmniFactoryGeneratorT<ImagingTopoCluster_factory>(
    "EcalBarrelImagingProtoClusters", {"EcalBarrelImagingRecHits"},
    {"EcalBarrelImagingProtoClusters"},
    {
        .neighbourLayersRange = 2, //  # id diff for adjacent layer
        .sameLayerDistTZ      = {2.0 * dd4hep::mm, 2 * dd4hep::mm},     //  # same layer
        .diffLayerDistEtaPhi  = {10 * dd4hep::mrad, 10 * dd4hep::mrad}, //  # adjacent layer
        .sameLayerMode        = eicrecon::ImagingTopoClusterConfig::ELayerMode::tz,
        .diffLayerMode        = eicrecon::ImagingTopoClusterConfig::ELayerMode::etaphi,
        .sectorDist           = 3.0 * dd4hep::cm,
        .minClusterHitEdep    = 0,
        .minClusterCenterEdep = 0,
        .minClusterEdep       = 100 * dd4hep::MeV,
        .minClusterNhits      = 10,
    },
    app // TODO: Remove me once fixed
    ));
```

Got pions back after updating cluster parameters



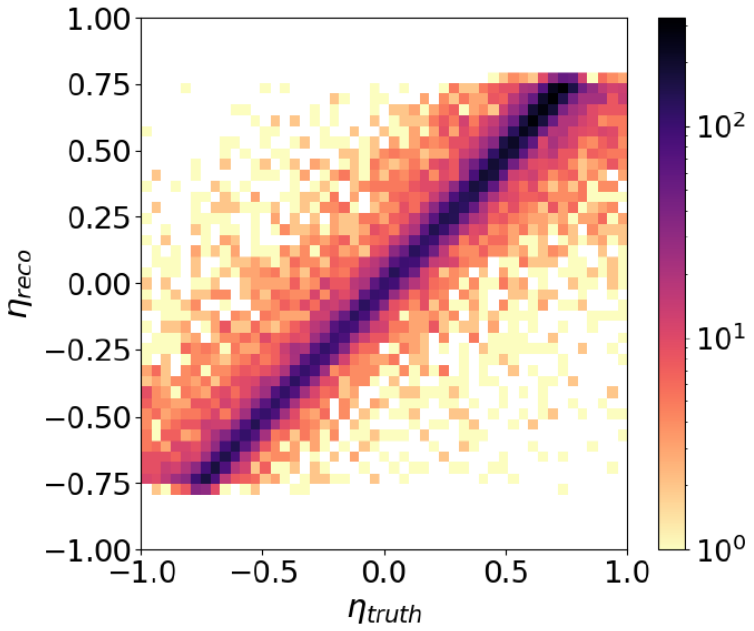

```
app->Add(new JOmniFactoryGeneratorT<CalorimeterIslandCluster_factory>(
    "EcalBarrelScFiProtoClusters", {"EcalBarrelScFiRecHits"}, {"EcalBarrelScFiProtoClusters"},
    {
        .adjacencyMatrix{},
        .peakNeighbourhoodMatrix{},
        .readout{},
        .sectorDist = 50. * dd4hep::mm,
        .localDistXY{},
        .localDistXZ = {80 * dd4hep::mm, 80 * dd4hep::mm},
        .localDistYZ{},
        .globalDistRPhi{},
        .globalDistEtaPhi{},
        .dimScaledLocalDistXY{},
        .splitCluster         = false,
        .minClusterHitEdep    = 5 * dd4hep::MeV,
        .minClusterCenterEdep = 20 * dd4hep::MeV,
        .transverseEnergyProfileMetric{},
        .transverseEnergyProfileScale{},
        .transverseEnergyProfileScaleUnits{},
    },
    app // TODO: Remove me once fixed
    ));
```

```
app->Add(new JOmniFactoryGeneratorT<ImagingTopoCluster_factory>(
    "EcalBarrelImagingProtoClusters", {"EcalBarrelImagingRecHits"},
    {"EcalBarrelImagingProtoClusters"},
    {
        .neighbourLayersRange = 2, //  # id diff for adjacent layer
        .sameLayerDistTZ      = {2.0 * dd4hep::mm, 2 * dd4hep::mm},     //  # same layer
        .diffLayerDistEtaPhi  = {50 * dd4hep::mrad, 50 * dd4hep::mrad}, //  # adjacent layer
        .sameLayerMode        = eicrecon::ImagingTopoClusterConfig::ELayerMode::tz,
        .diffLayerMode        = eicrecon::ImagingTopoClusterConfig::ELayerMode::etaphi,
        .sectorDist           = 3.0 * dd4hep::cm,
        .minClusterHitEdep    = 0,
        .minClusterCenterEdep = 0,
        .minClusterEdep       = 100 * dd4hep::MeV,
        .minClusterNhits      = 3,
    },
    app // TODO: Remove me once fixed
    ));
```

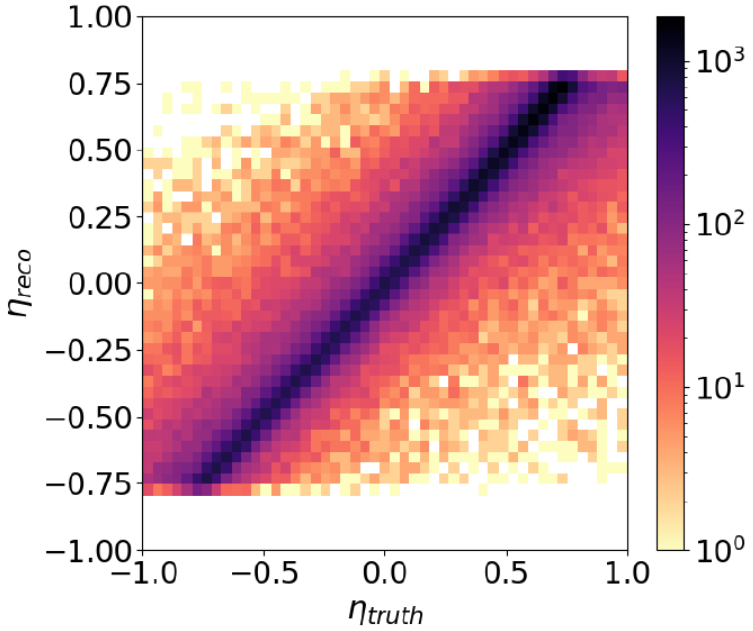
Backup

Eta confusion matrices
Gamma ScFi only

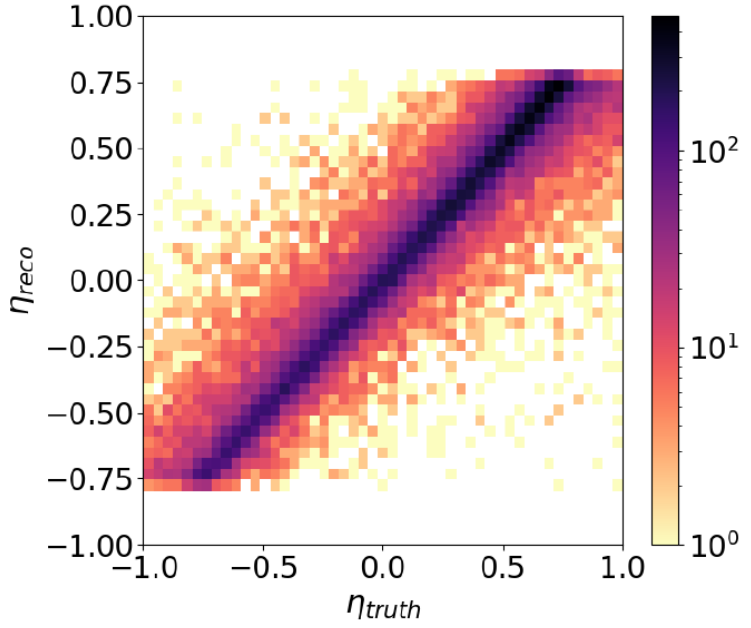
DIS Q2=1 GeV



NC Q2=10 GeV

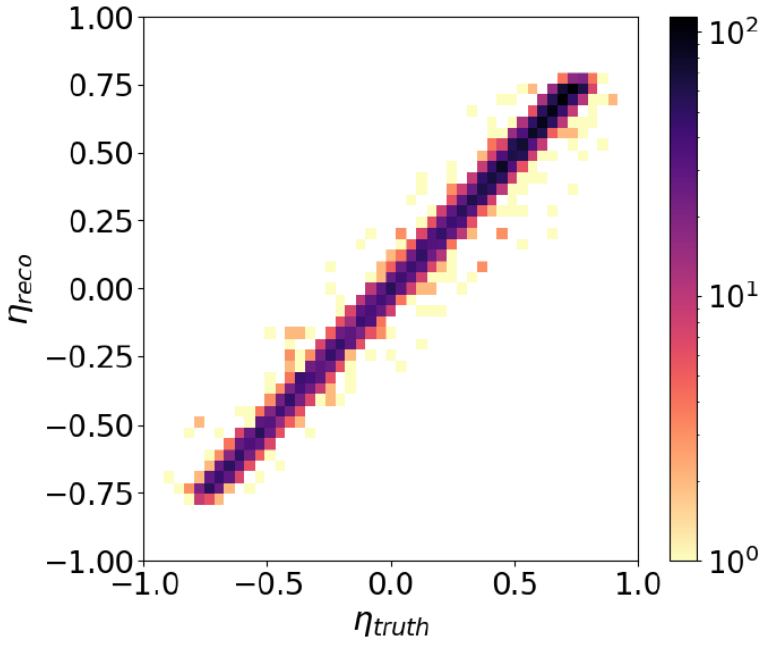


NC Q2=100 GeV

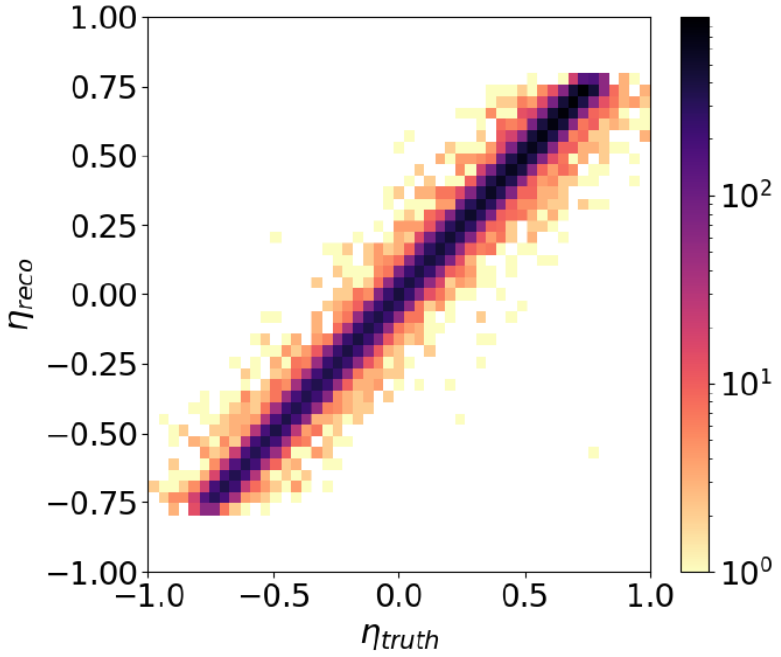


Eta confusion matrices
Gamma ScFi + AstroPix

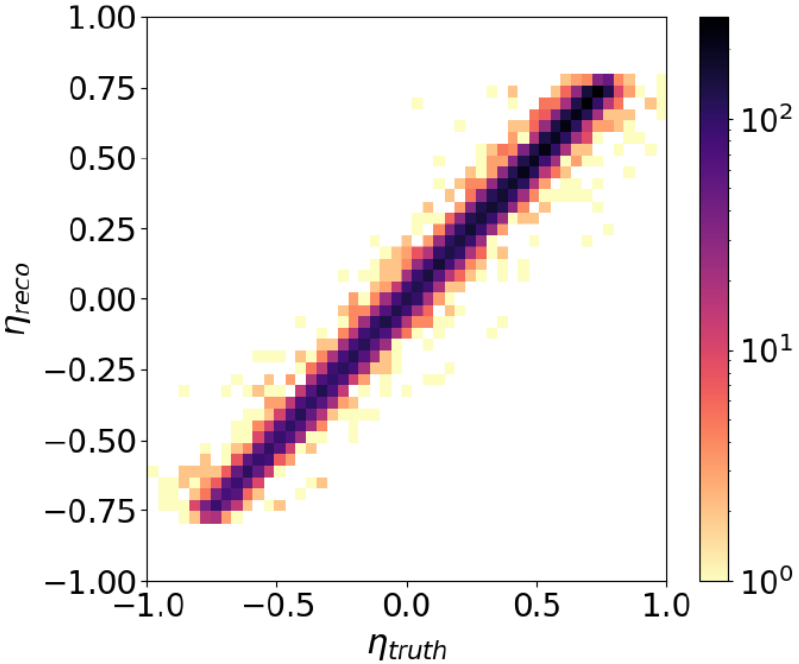
DIS Q2=1 GeV



NC Q2=10 GeV

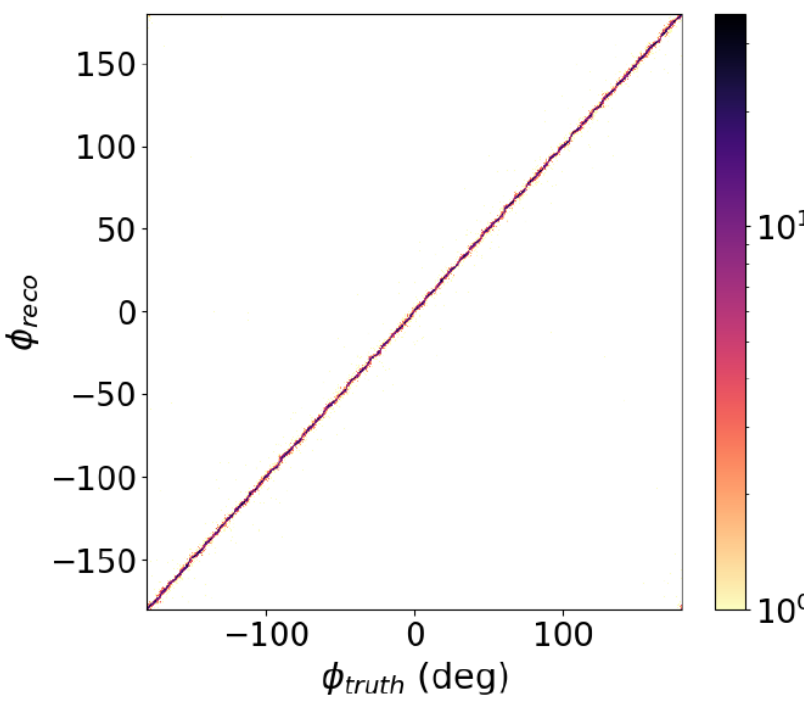


NC Q2=100 GeV

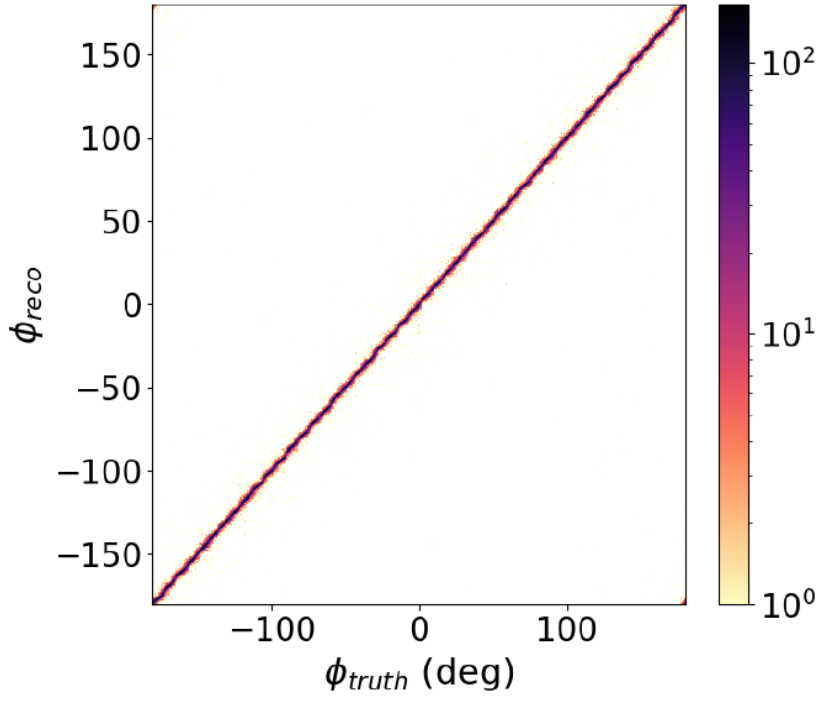


Phi confusion matrices
Gamma ScFi only

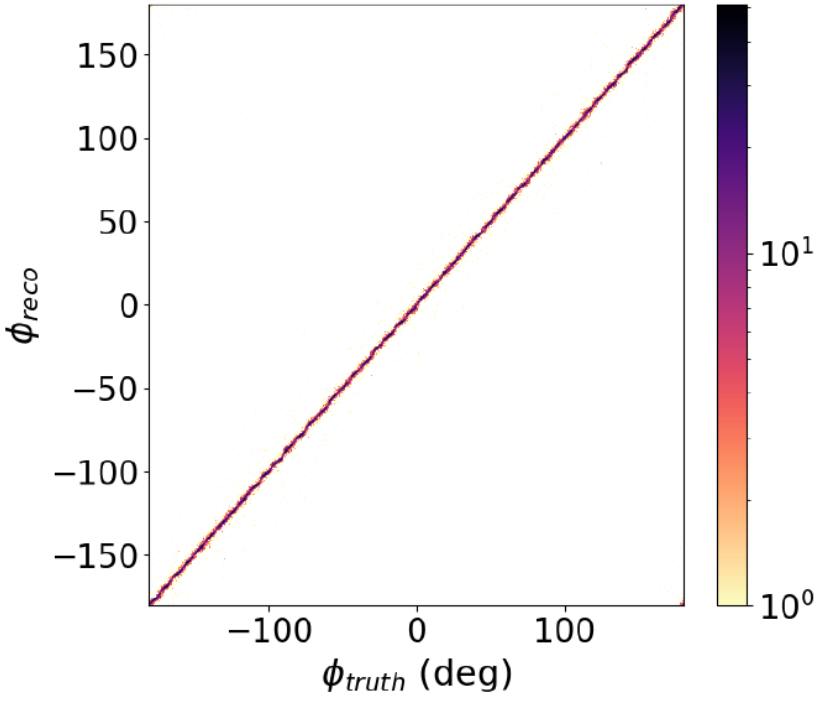
DIS Q2=1 GeV



NC Q2=10 GeV

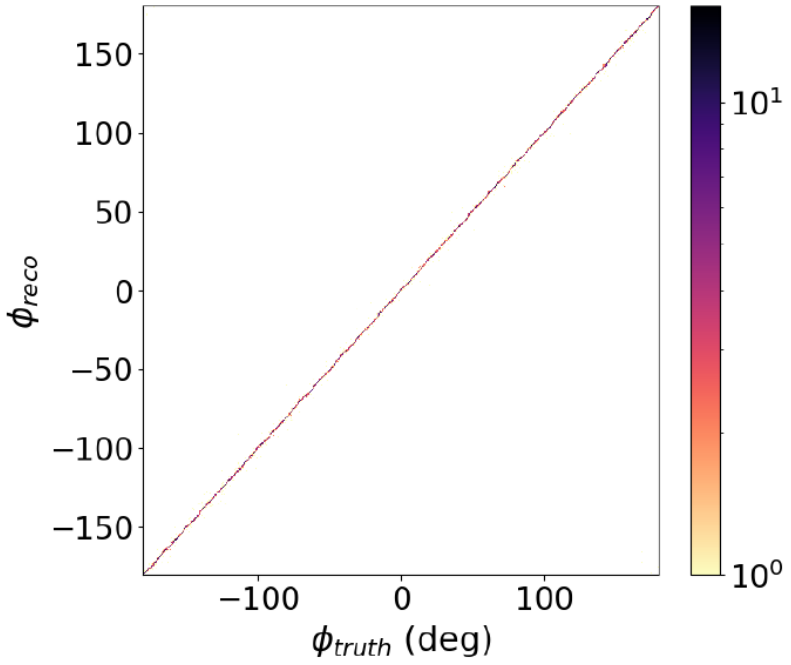


NC Q2=100 GeV

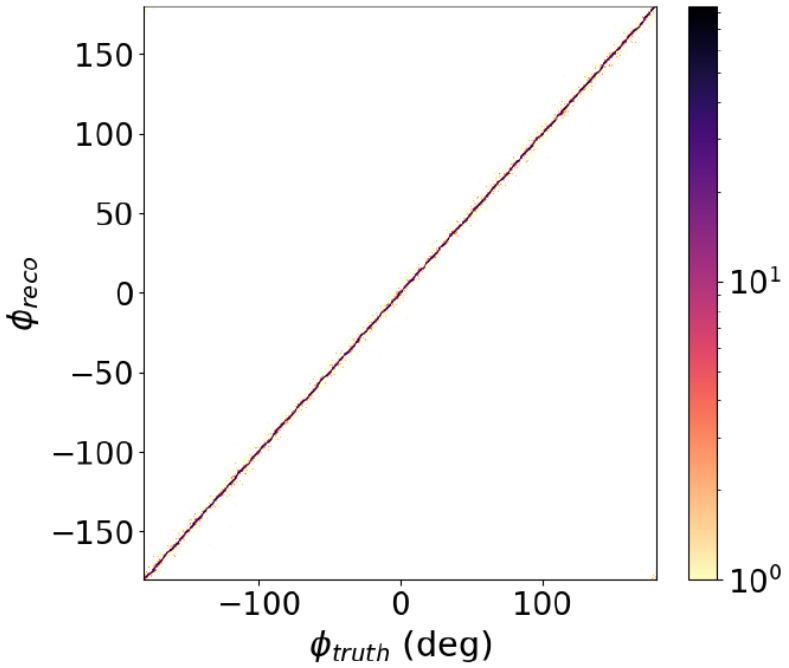


Phi confusion matrices
Gamma ScFi + AstroPix

DIS Q2=1 GeV



NC Q2=10 GeV



NC Q2=100 GeV