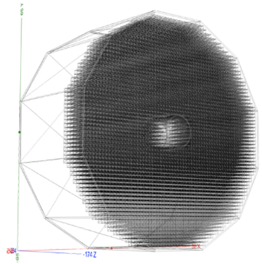
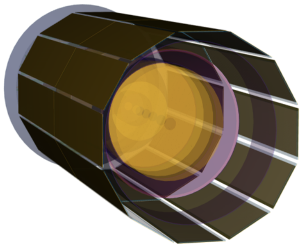
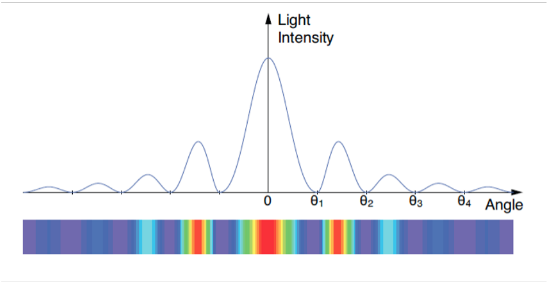
Diffractive ϕ in eAu at EPIC



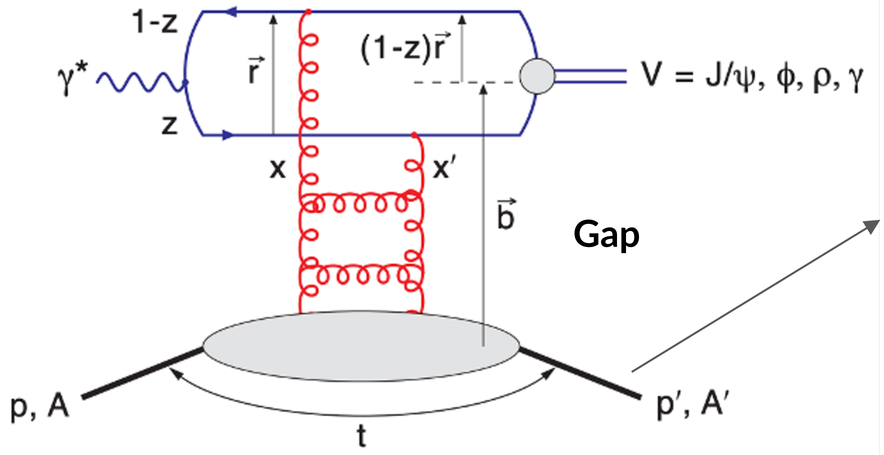




Kong Tu
BNL
Jan 11, 2022

Exclusive and diffractive vector meson production

- A sensitive probe to the gluon density, spatial distributions, and their fluctuations.



At NLO, things may look differently [arXiv:2203.11613]

Momentum (t) and position (b) are conjugate variable, and can be related by Fourier Transform:

$$F(b) = \frac{1}{2\pi}\int_0^\infty \mathrm{d}\Delta \Delta J_0(\Delta b)\sqrt{\frac{\mathrm{d}\sigma_{\mathrm{coherent}}}{\mathrm{d}t}(\Delta)}\Bigg|_{\mathrm{mod}}$$

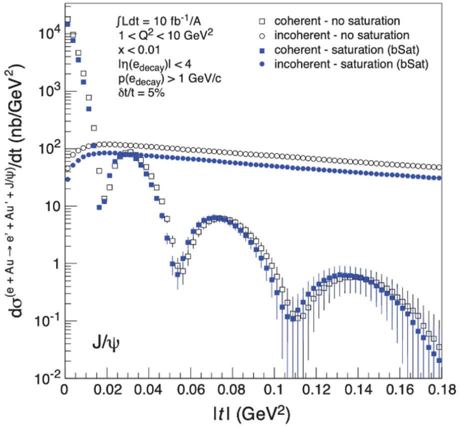
where $\Delta = \sqrt{-t}$

One of the golden measurements at the EIC

Diffractive VM timeline

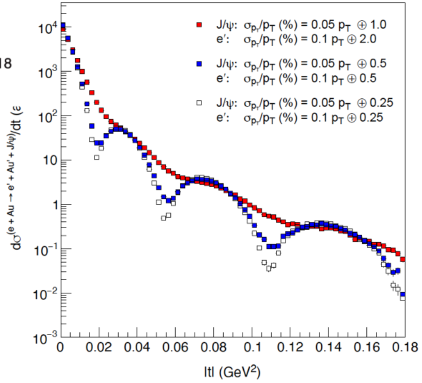
Time

2012 | 2019 | 2021 | 2022

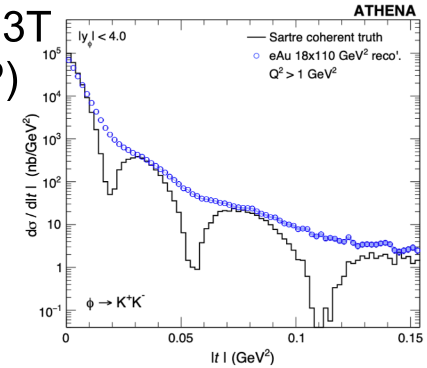


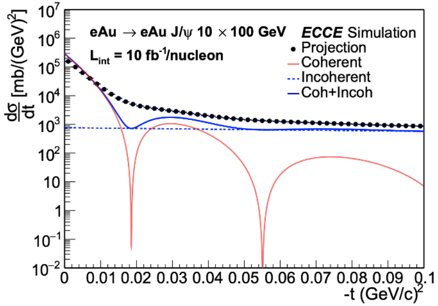
EIC White paper

EIC Yellow Report

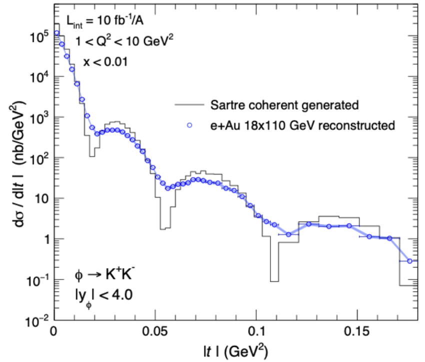


ATHENA 3T (DD4HEP)





ECCE 1.5T (Fun4all)



ATHENA 3T + 1% E reso. EMCal (DELPHES)

As of Jan. 11, 2022

EPIC detector:

- New magnet - 1.7T
- Two configurations (arches vs brycecanyon)
    - mRICH vs pfRICH;
    - SciGlass vs Imaging
- Tracking (5 layers, has been a lot of optimization.)
- Same Endcap ECal, $PbWO_4$
- New single software stack (DD4Hep, edm4eic, EICrecon, PODIO, etc)

All results and distributions shown later are brycecanyon & privately run*.

* to prepare for the analysis framework.

A very simple algorithm of finding scattered electron

MC level:

- Finding the leading p_T particle with status==1 and PDG==11.

RECO level:

- Finding the leading energy cluster in EcalEndcapNClusters.
- Finding the leading momentum track with charge < 0 in ReconstructedChargedParticles.
- Use energy from cluster, eta and phi from tracking, and assume electron mass = **a scattered electron 4 vector at RECO level**.
- Calibrate the **default** cluster energy by looking at RECO/MC energy

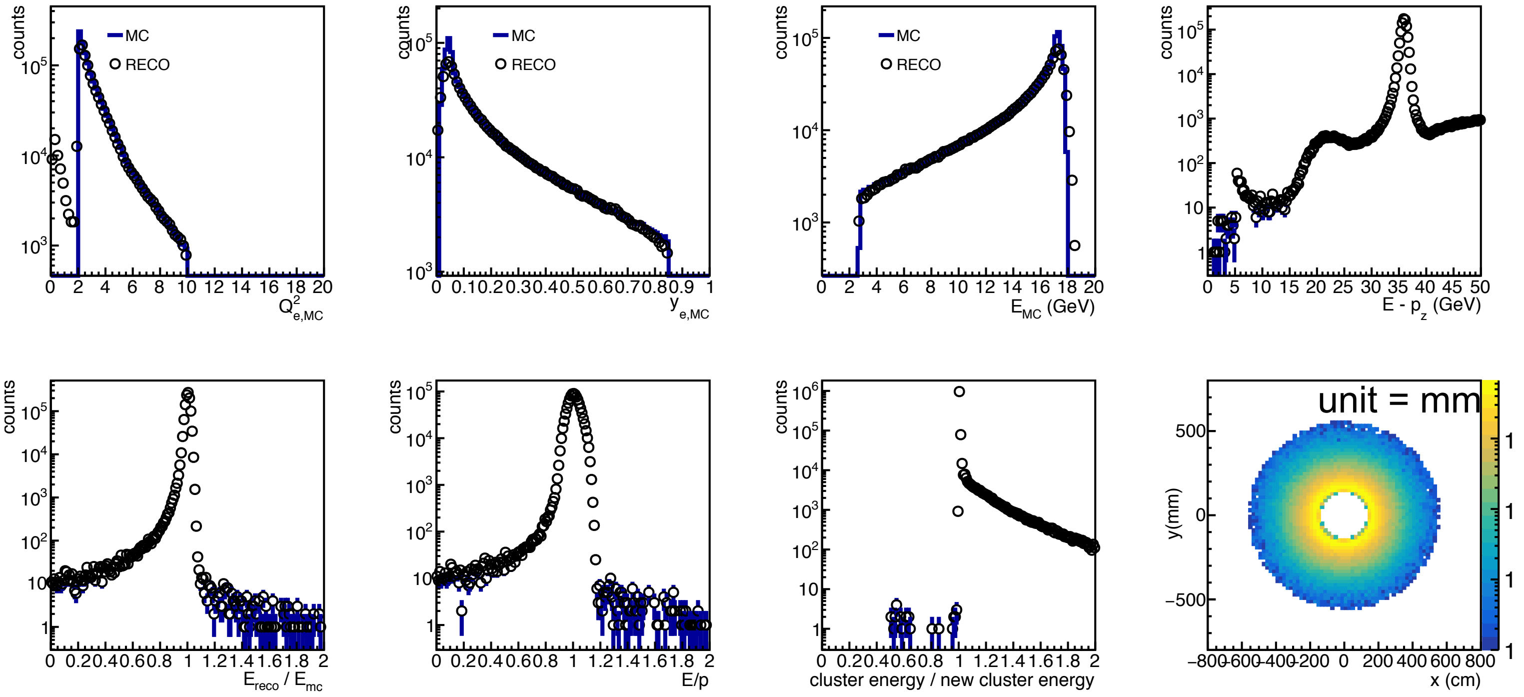
11-12AM & 1PM Dec 8 calorimeter meeting, a lot of good material/updates.
https://indico.bnl.gov/event/17709/

A detour - a simple (re)clustering.

Default backward EMcal clusters seem to have issues. See backup. We do a simple re-clustering, which is based on slides from this link.

1. Find the leading energy RecHit;
2. Sum up all the energy towers within a radius of 70mm. (50,60,65,70mm all have been tried, no so much difference).
3. Energy threshold is 10 MeV
4. Cluster position (x,y) = weighted average of all towers.
5. Select 150mm < R < 550mm for the cluster to ensure good acceptance.

DIS control plot ($Q^2 > 2$ GeV^2, $0.01 < y < 0.85$)



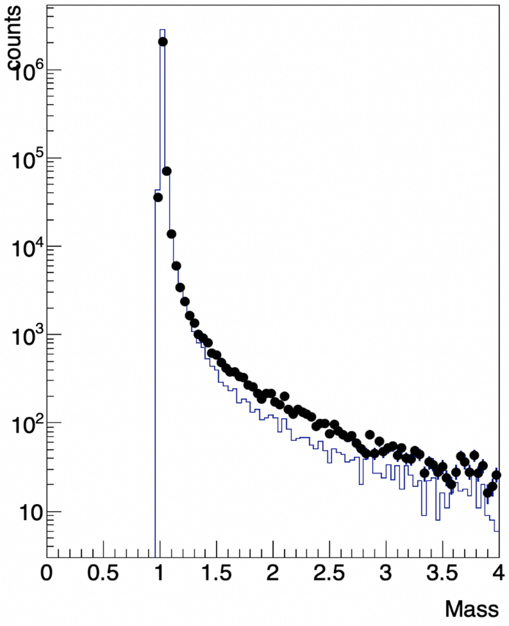
- Acceptance selection is important; Q^2 at 1 GeV^2 is too small for this selection.

New event and track selections

- $2 < Q^2 < 10$ GeV^2, $0.01 < y < 0.85$
- Good electron selections:
  - Leading cluster (new algorithm).
  - Energy calibration is ~ 4.5%
  - Select 150 mm < clusterRadius < 550 mm
  - Electron track (leading p_T, charge < 0, !association to K^-)
  - **0.8 < E/p < 1.18**

- DIS event selection:
  - **27 < E – Pz < 40 GeV**

- φ phase space:
  - daughter K |pseudorapidity| < 3.0;
  - Within 0.02 GeV of φ mass.
- Method L on the t reco. (e.g., $-t = -(\boldsymbol{p}_{A',corr} - \boldsymbol{p}_A)^2$)



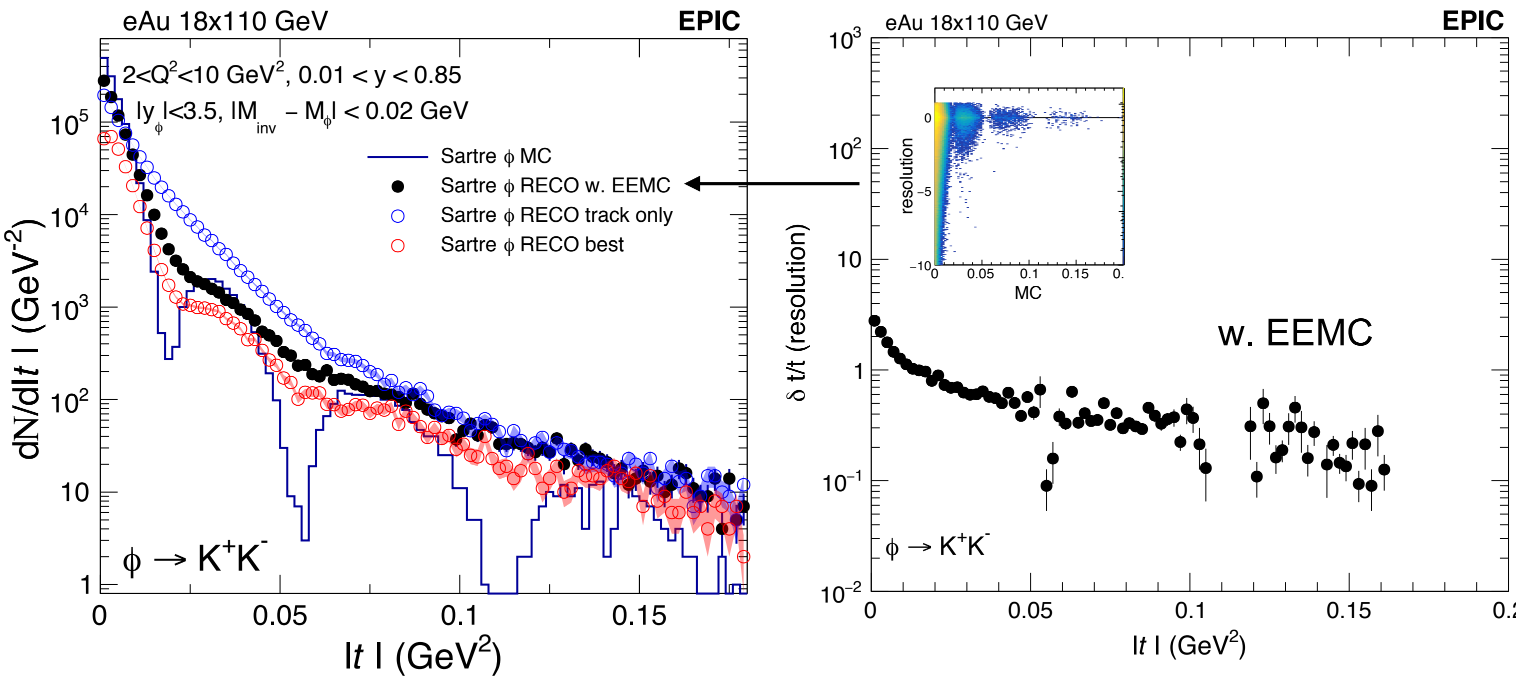
ϕ mass

EPIC Brycecanyon 22.11.2

Result

Legend details:

- w. EEMC: electron energy from EEMC, electron mass (PDG), angle (eta,phi) from tracking; φ→KK from tracking.
- Track only: e', φ→KK, all from tracking
- Best: average of the above 2 E-by-E.



- Much improved! -*t* resolution now looks promising, at least it's hopeful.
- Weighted average of the previous two methods after cutting on their E-by-E ratio (0.5 - 1.5)

Summary

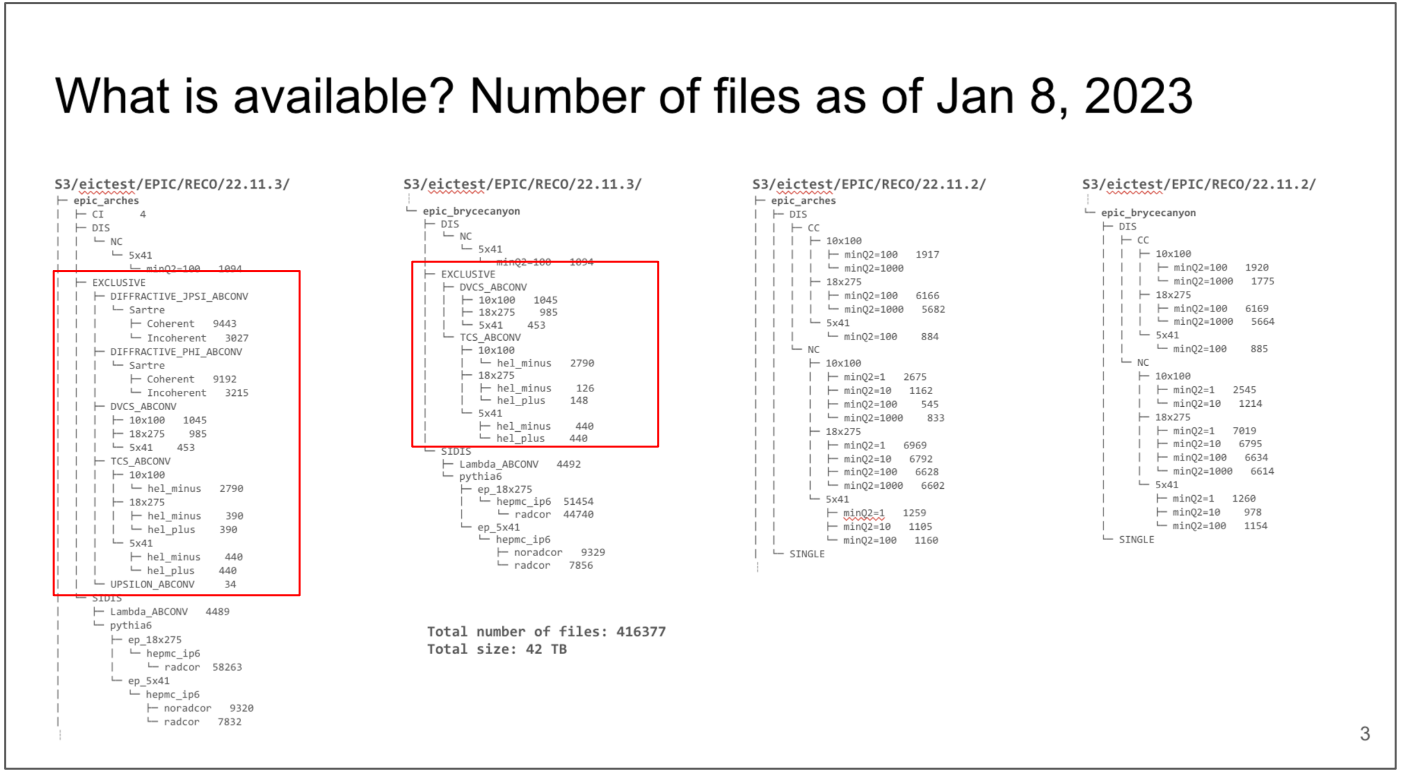
- First result from EPIC experiment on the diffractive φ in eAu.
- A lot of uncertainties at the moment. Especially the clustering. However, it provides the benchmark straight from the simulation output.
- **A simple (re)clustering seems to improve a lot. Acceptance is important.**
- Official sample ~~hopefully coming soon~~ already here → next to-do!
- Combining both EEMC and track-only method will give the best result.

- Exclusive group should start to prepare for analyzers/script. Just a thought, this group can have a git repo for common analysis tool, e.g., the SIDIS group.

Exclusive simulation campaign production

This is a reminder of what simulation samples are available.

See Wouter's slide for details.



What is available? Number of files as of Jan 8, 2023

```
S3/eictest/EPIC/RECO/22.11.3/
├─ epic_arches
│  ├─ CI      4
│  ├─ DIS
│  │  └─ NC
│  │     └─ 5x41
│  │        └─ minQ2=100   1094
│  ├─ EXCLUSIVE
│  │  ├─ DIFFRACTIVE_JPSI_ABCONV
│  │  │  └─ Sartre
│  │  │     ├─ Coherent   9443
│  │  │     └─ Incoherent   3027
│  │  ├─ DIFFRACTIVE_PHI_ABCONV
│  │  │  └─ Sartre
│  │  │     ├─ Coherent   9192
│  │  │     └─ Incoherent   3215
│  │  ├─ DVCS_ABCONV
│  │  │  ├─ 10x100   1045
│  │  │  ├─ 18x275    985
│  │  │  └─ 5x41    453
│  │  ├─ TCS_ABCONV
│  │  │  ├─ 10x100
│  │  │  │  └─ hel_minus   2790
│  │  │  ├─ 18x275
│  │  │  │  ├─ hel_minus    390
│  │  │  │  └─ hel_plus    390
│  │  │  └─ 5x41
│  │  │     ├─ hel_minus    440
│  │  │     └─ hel_plus    440
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│  └─ SIDIS
│     ├─ Lambda_ABCONV   4489
│     └─ pythia6
│        ├─ ep_18x275
│        │  └─ hepmc_ip6
│        │     └─ radcor   58263
│        └─ ep_5x41
│           └─ hepmc_ip6
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│              └─ radcor   7832
```

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   │  ├─ DVCS_ABCONV
   │  │  ├─ 10x100   1045
   │  │  ├─ 18x275    985
   │  │  └─ 5x41    453
   │  └─ TCS_ABCONV
   │     ├─ 10x100
   │     │  └─ hel_minus   2790
   │     ├─ 18x275
   │     │  ├─ hel_minus    126
   │     │  └─ hel_plus    148
   │     └─ 5x41
   │        ├─ hel_minus    440
   │        └─ hel_plus    440
   └─ SIDIS
      ├─ Lambda_ABCONV   4492
      └─ pythia6
         ├─ ep_18x275
         │  └─ hepmc_ip6  51454
         │     └─ radcor  44740
         └─ ep_5x41
            └─ hepmc_ip6
               ├─ noradcor   9329
               └─ radcor   7856
```

Total number of files: 416377
Total size: 42 TB

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│  │  │  │  └─ minQ2=1000
│  │  │  ├─ 18x275
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│  │  │  │  └─ minQ2=1000   5682
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│  │  │     └─ minQ2=100    884
│  │  └─ NC
│  │     ├─ 10x100
│  │     │  ├─ minQ2=1   2675
│  │     │  ├─ minQ2=10   1162
│  │     │  ├─ minQ2=100    545
│  │     │  └─ minQ2=1000    833
│  │     ├─ 18x275
│  │     │  ├─ minQ2=1   6969
│  │     │  ├─ minQ2=10   6792
│  │     │  ├─ minQ2=100   6628
│  │     │  └─ minQ2=1000   6602
│  │     └─ 5x41
│  │        ├─ minQ2=1   1259
│  │        ├─ minQ2=10   1105
│  │        └─ minQ2=100   1160
│  └─ SINGLE
```

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   │  │  │  └─ minQ2=1000   1775
   │  │  ├─ 18x275
   │  │  │  ├─ minQ2=100   6169
   │  │  │  └─ minQ2=1000   5664
   │  │  └─ 5x41
   │  │     └─ minQ2=100    885
   │  └─ NC
   │     ├─ 10x100
   │     │  ├─ minQ2=1   2545
   │     │  └─ minQ2=10   1214
   │     ├─ 18x275
   │     │  ├─ minQ2=1   7019
   │     │  ├─ minQ2=10   6795
   │     │  ├─ minQ2=100   6634
   │     │  └─ minQ2=1000   6614
   │     └─ 5x41
   │        ├─ minQ2=1   1260
   │        ├─ minQ2=10    978
   │        └─ minQ2=100   1154
   └─ SINGLE
```

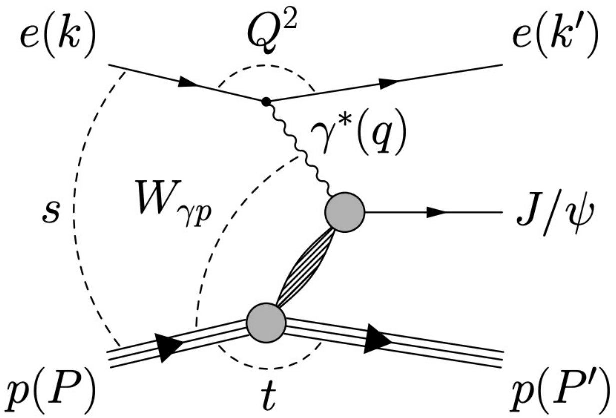
3

Backup

Experimental methods

- Method Exact (E): $-t = -(p_e - p_{e'} - p_{VM})^2 = -(p_{A'} - p_A)^2$
- Method Approximate (A) (UPCs) $-t = (p_{T,e'} + p_{T,VM})^2$
- Improved Method E: Method L $-t = -(p_{A',corr} - p_A)^2$,

where $p_{A',corr}$ is constrained by exclusive reaction.

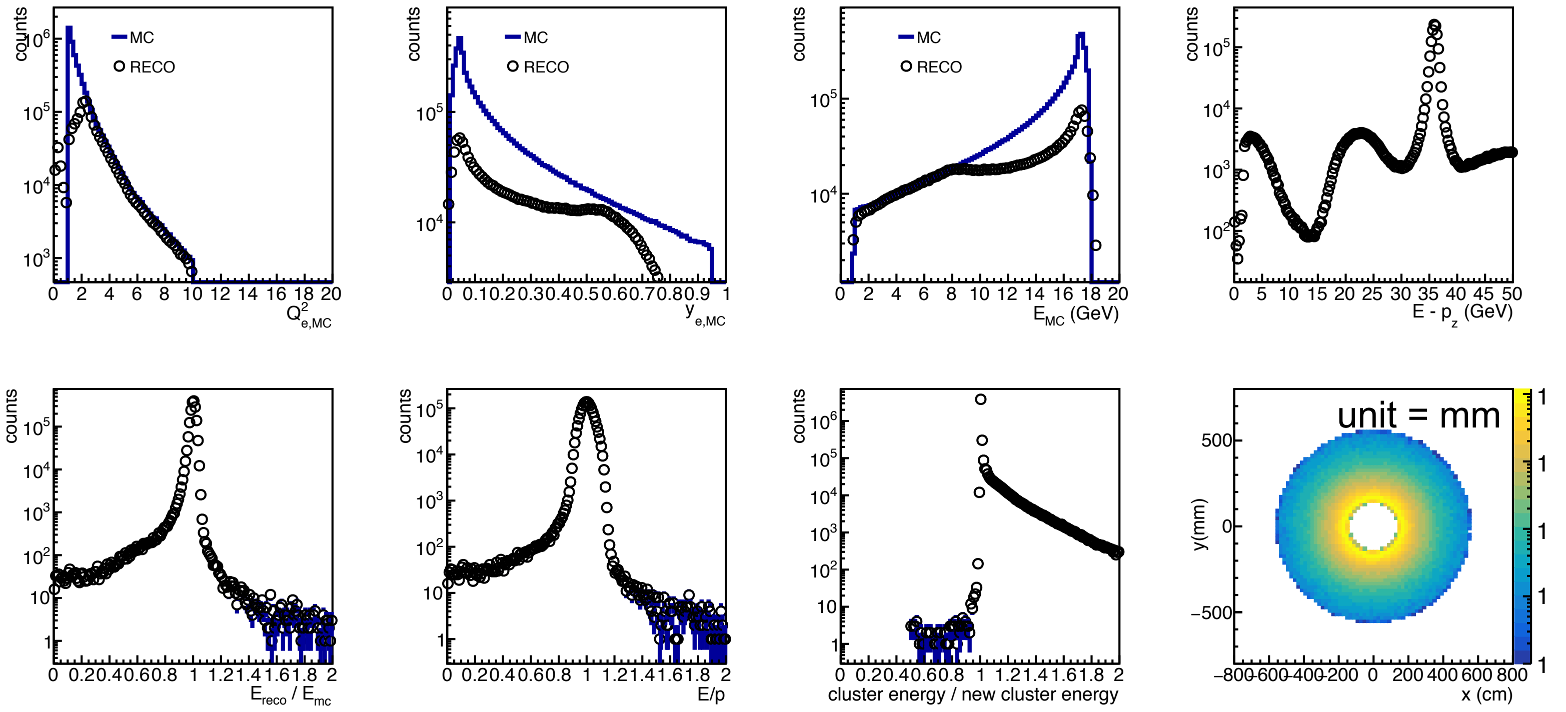


(p_{VM})

Best method concluded from the EIC Yellow Report – Method L

- Insensitive to beam effects, e.g., angular divergence and momentum spread.
- More precise than Method A for electroproduction

DIS control plot ($Q^2 > 1$, $0.01 < y < 0.95$)

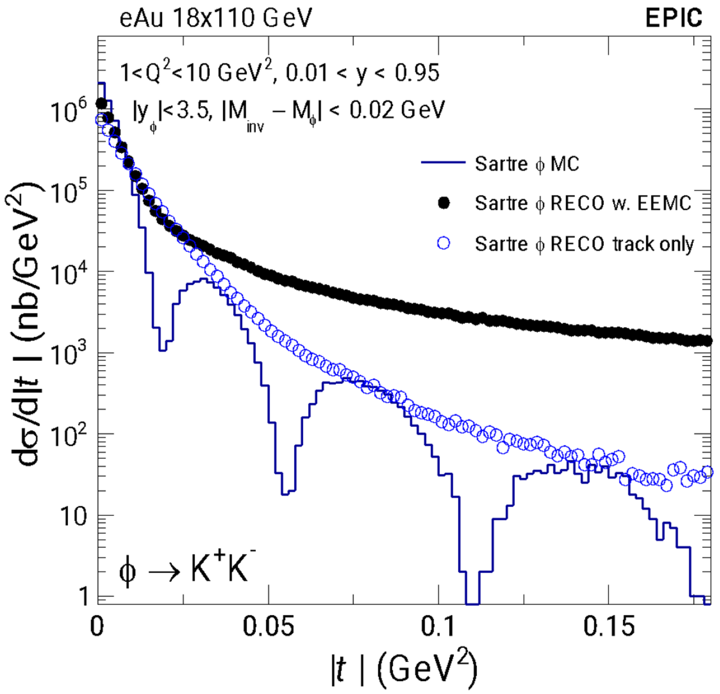


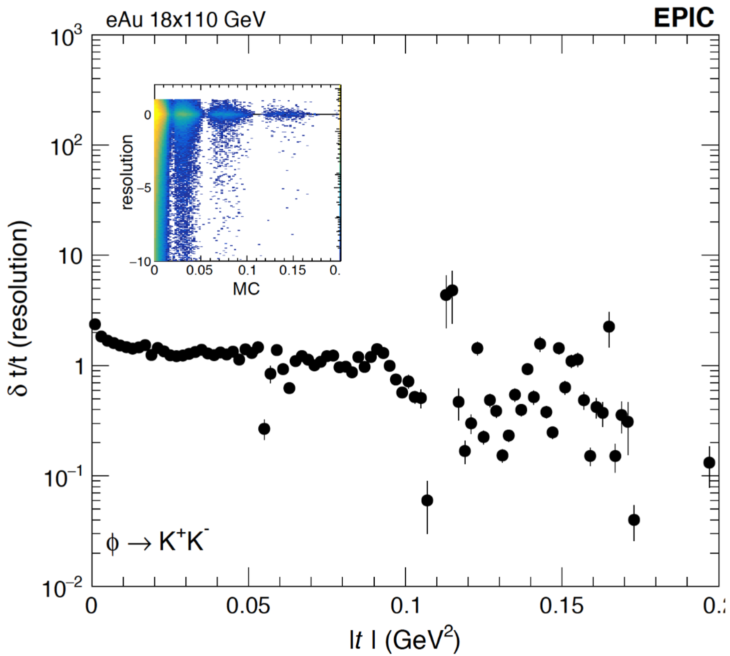
- Energy cluster distribution looks better! Event kinematics not so much→ Acceptance!

Result

Legend details:
- w. EEMC: electron energy from EEMC, electron mass (PDG), angle (eta,phi) from tracking; φ→KK from tracking.
- Track only: e', φ→KK, all from tracking

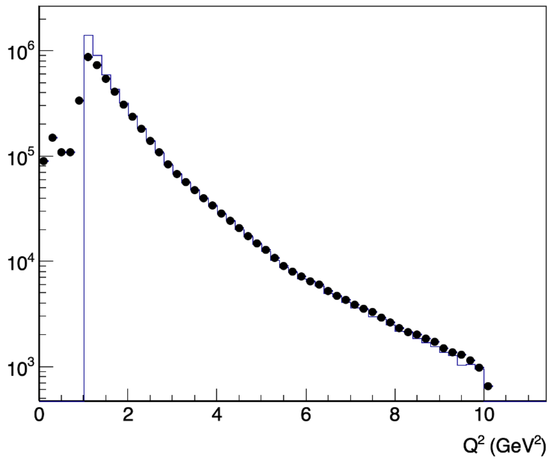
This is what the current status is. Tracking only, although better, still cannot do this measurement as we know since a while.



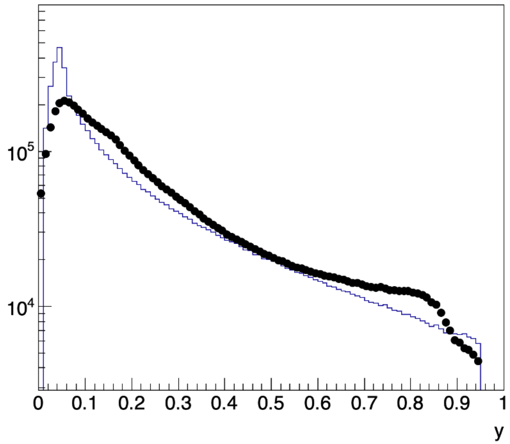


Study based on *unofficial* sample with EICrecon

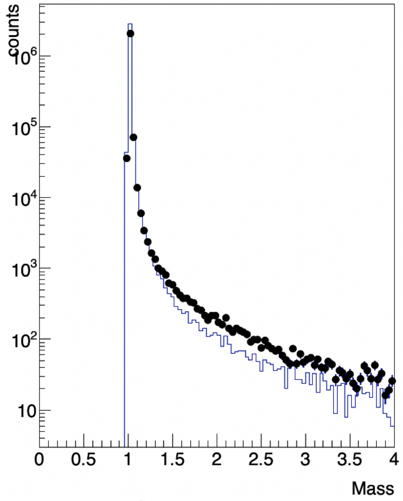
- Software - brycecanyon geometry + EICrecon
- Sample - same sample from ATHENA proposal (Sartre eAu → e'+φ+Au', 18x110 GeV) ~ 5M statistics. Privately run at BNL by Kong for preparing a quick test for the SimQA
- Immediately, issues found with the MCReco associations and **clustering** (see p3, link)
- <u>However, this provides a benchmark for the default outputs from these simulations.</u>



Q2 from electron

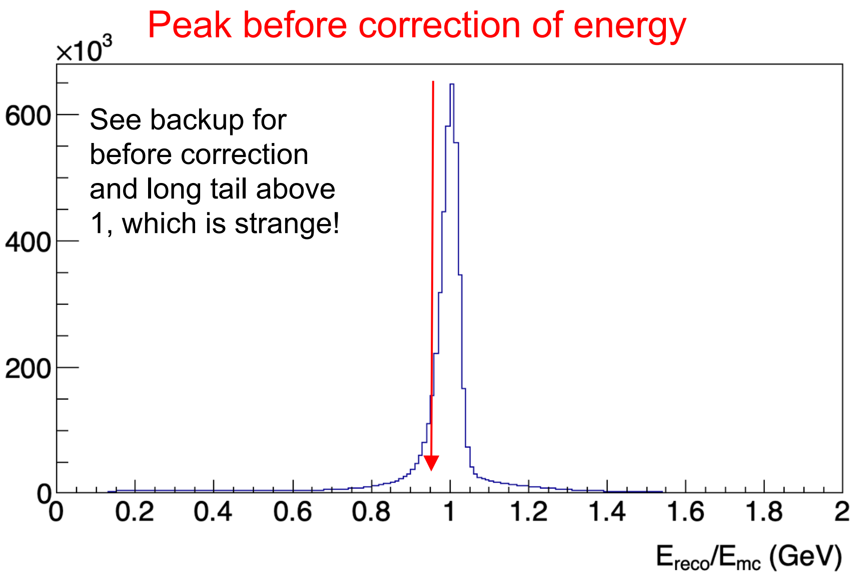


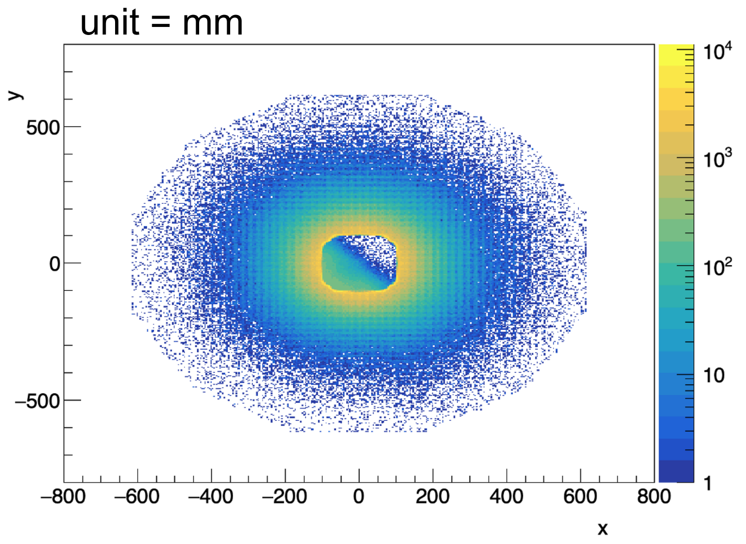
y from electron



ϕ mass

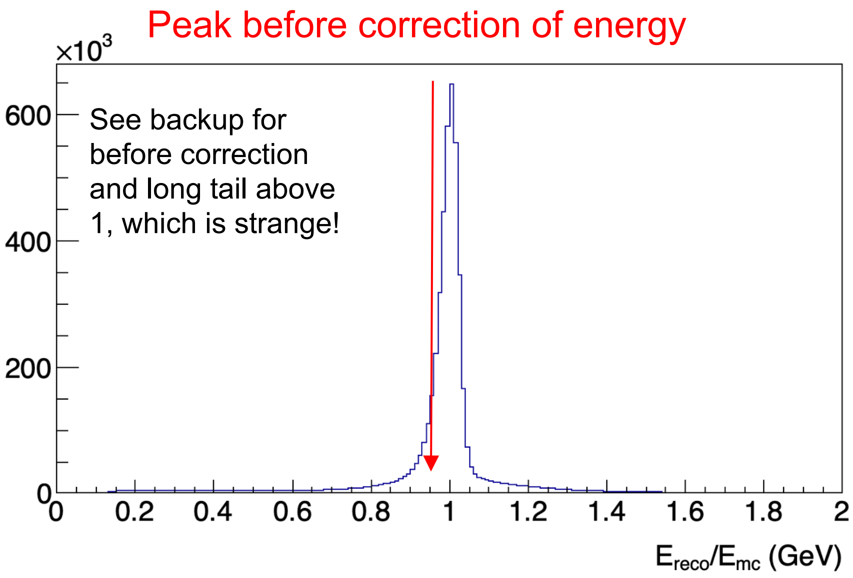
Backward EEMC - a first look

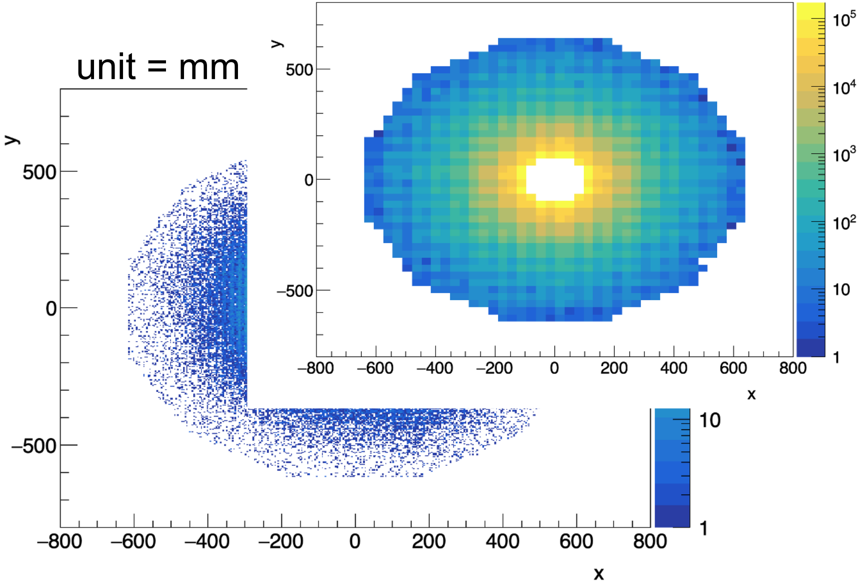




- Energy correction by 4.5% shift such that the ratio ~ 1.
- Asymmetric clusters inside the beampipe position, due to the algorithm of clustering. But still, a little concerning/puzzling.

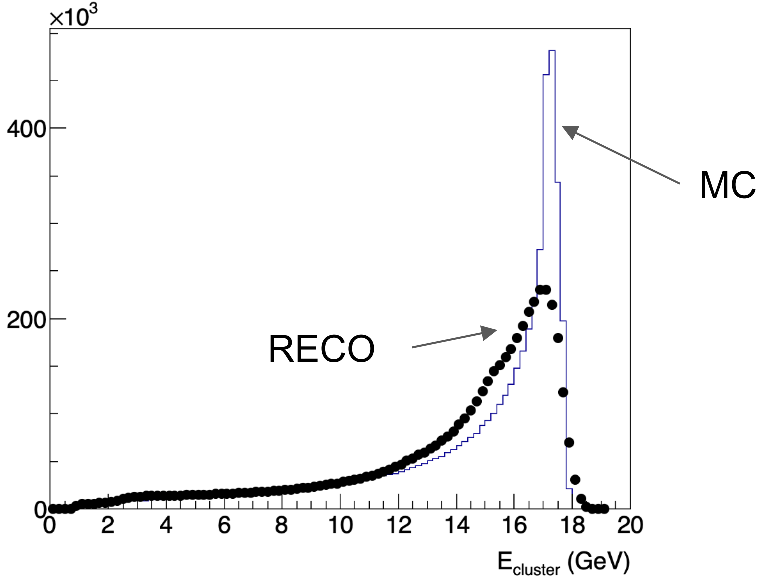
Backward EEMC - a first look

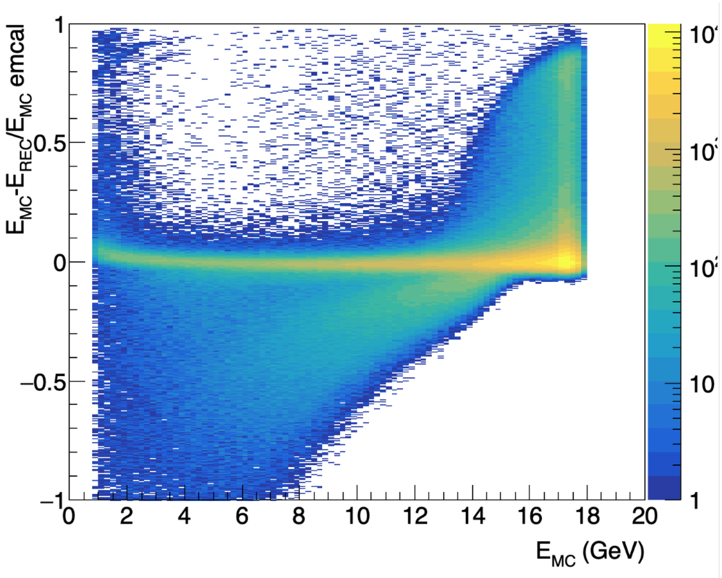




- Energy correction by 4.5% shift such that the ratio ~ 1.
- Asymmetric clusters inside the beampipe position, due to the algorithm of clustering. But still, a little concerning/puzzling.
- Cell/Tower distribution looks ok.

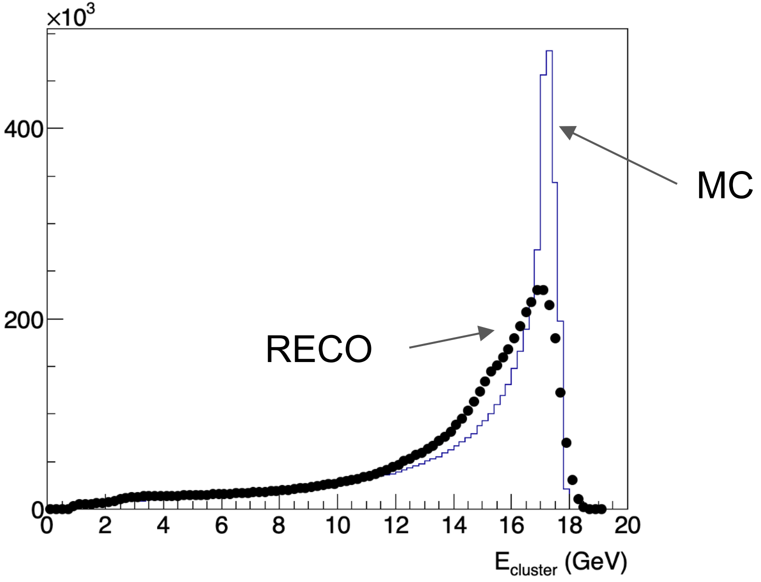
Leading cluster energy distribution and resolution

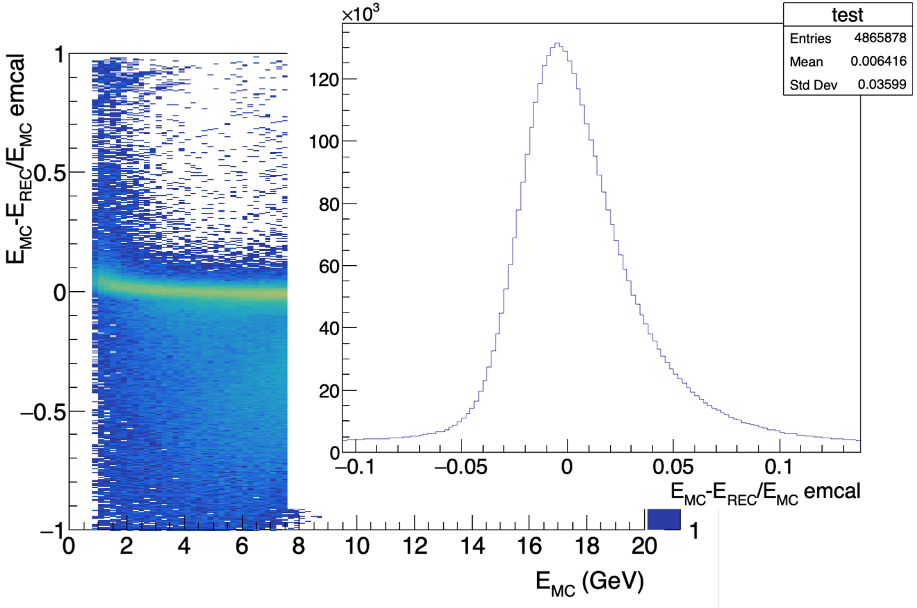




- The energy resolution looks not so good.

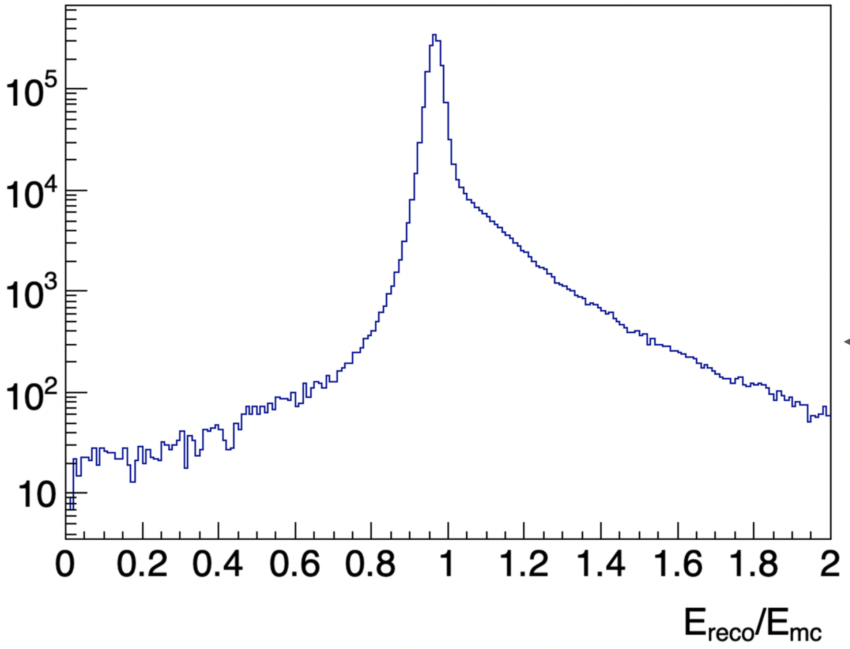
Leading cluster energy distribution and resolution





- The energy resolution looks not so good.
- Projection on a single slice of E_{MC} @ ~ 16 GeV.

Default clustering. Before energy correction, out of box ratio between reco/mc



Tail above 1 looks strange/wrong

“Best” method

- Combining “w.EEMC” and “track only”. Calculate the average of the 2 E-by-E, after selecting the correlated region.