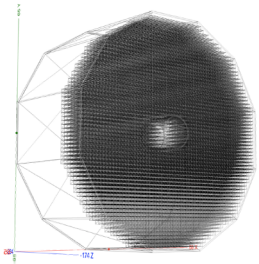
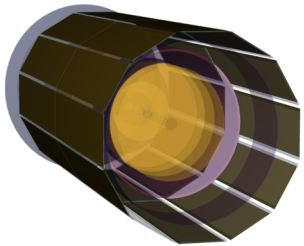
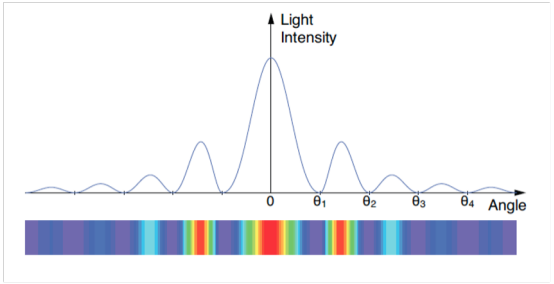
Diffractive ϕ in eAu at EPIC



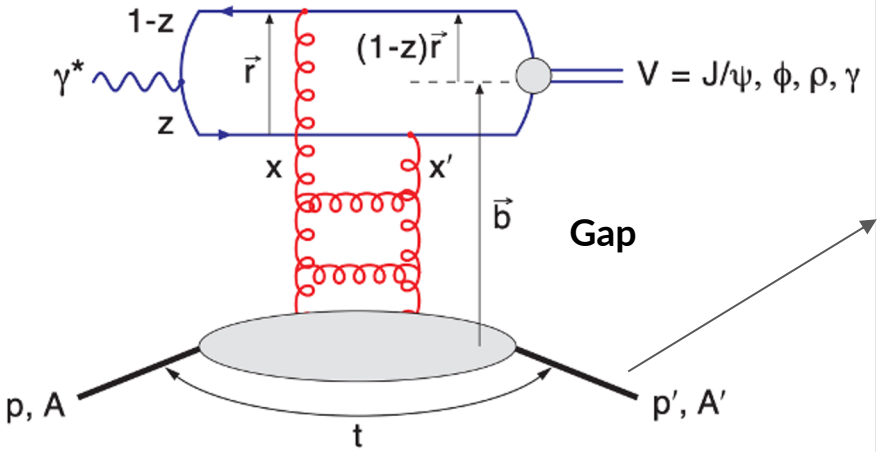




Kong Tu
BNL
Dec 12, 2022

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:

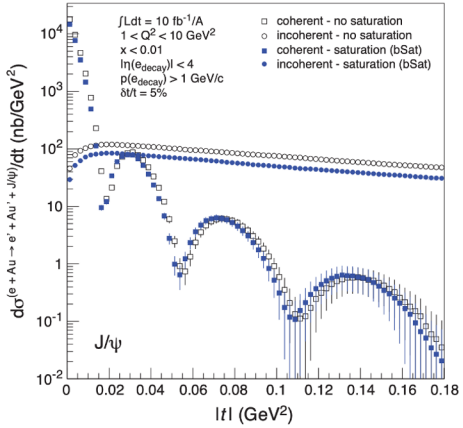
$$F(b) = \frac{1}{2\pi}\int_0^\infty \mathrm{d}\Delta\Delta J_0(\Delta b)\sqrt{\frac{\mathrm{d}\sigma_{\mathrm{coherent}}}{\mathrm{d}t}(\Delta)}\Big|_{\mathrm{mod}}$$

One of the golden measurements at the EIC

Diffractive VM timeline

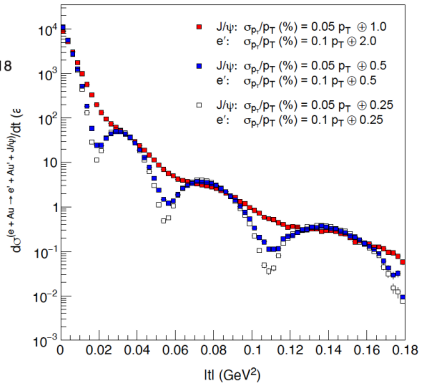
Time

2012 2019 2021 2022

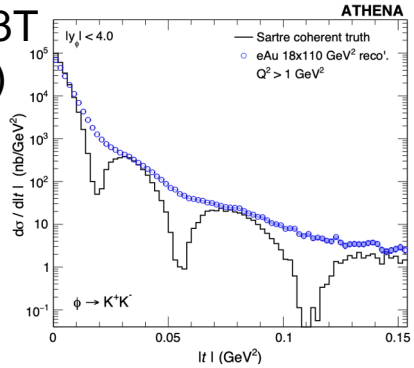


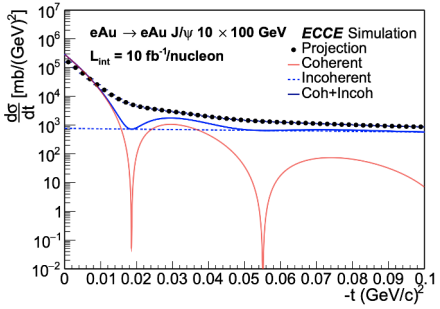
EIC White paper

EIC Yellow Report

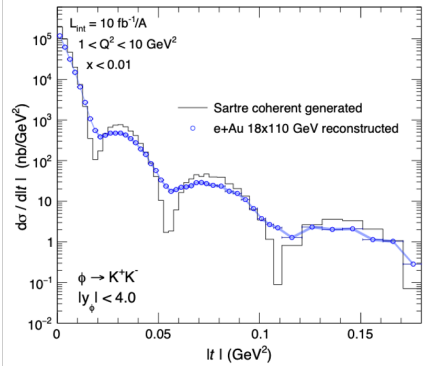


ATHENA 3T (DD4HEP)





ECCE 1.5T (Fun4all)



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

As of Dec. 12, 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)

Lessons learned:

- Challenge 1. Momentum transfer t resolution - Bottleneck: scattered electron
- Challenge 2. Incoherent background.

All results and distributions shown later are brycecanyon.

A very simple algorithm of finding scattered electron

MC level:

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

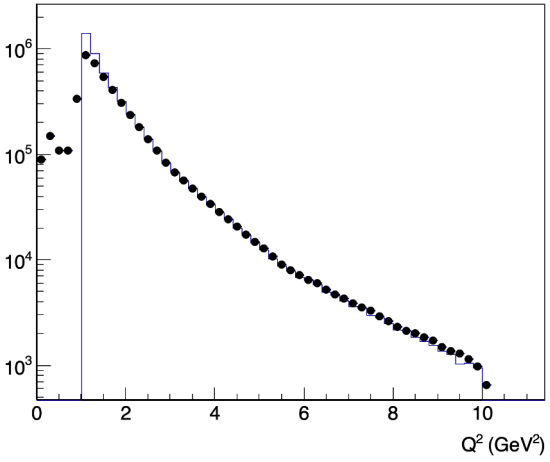
RECO level:

- 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

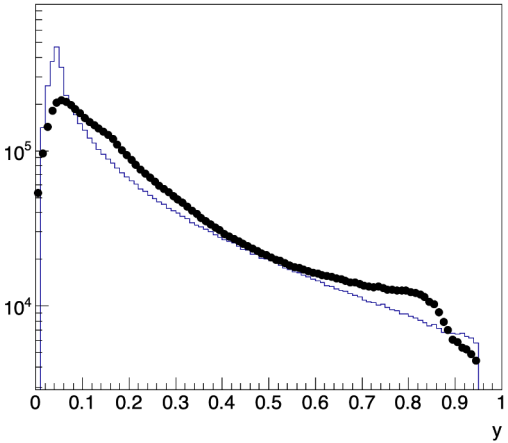
11-12AM & 1PM Dec 8 calorimeter meeting, a lot of good material/updates.
https://indico.bnl.gov/event/17709/

Study based on *unofficial* sample with EICrecon

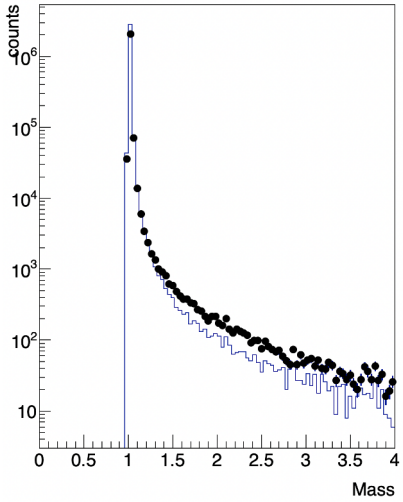
- Software - brycecanyon geometry + EICrecon
- Sample - same sample from ATHENA proposal (Sartre eAu → e'+φ+Au', 18x110 GeV) ~ 5M statistics. Privately run at BNL by Kong for preparing a quick test for the SimQA
- Immediately, issues found with the MCReco associations and **clustering** (see p3, link)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



Q2 from electron



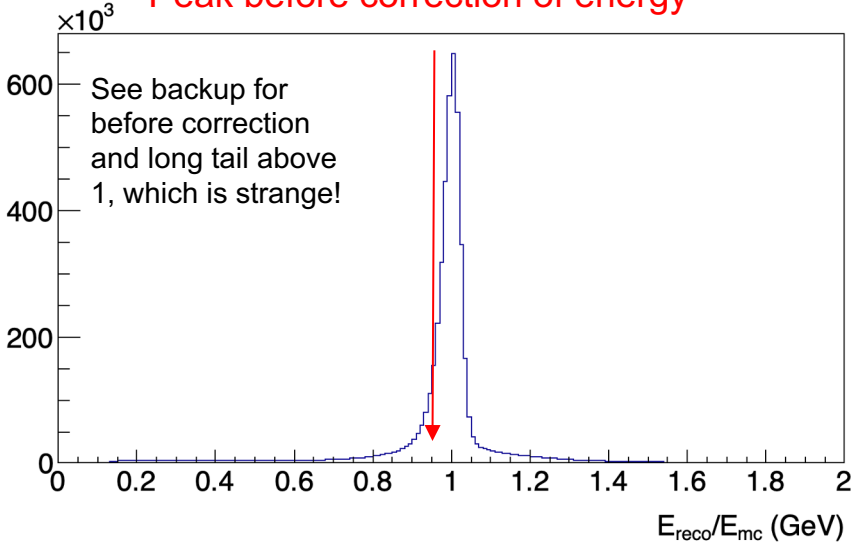
y from electron

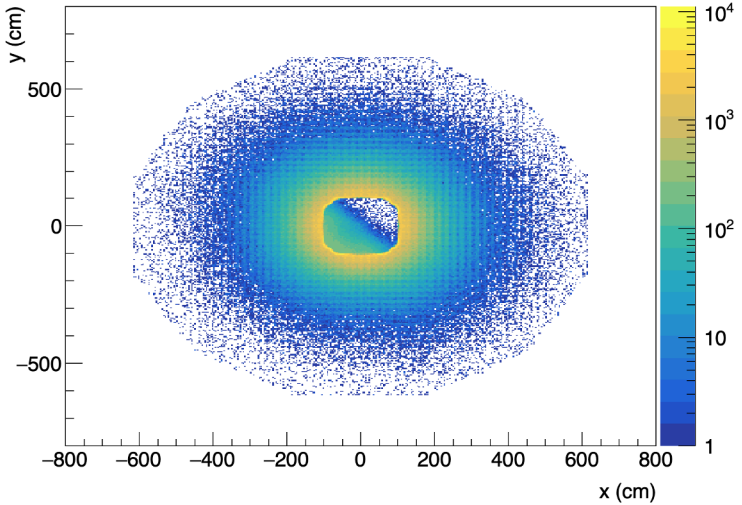


ϕ mass

Backward EEMC - a first look

Peak before correction of energy

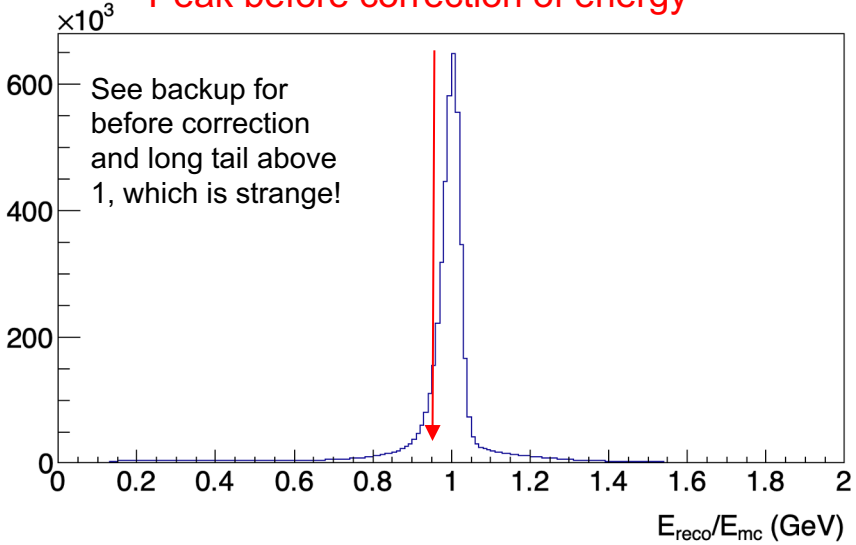


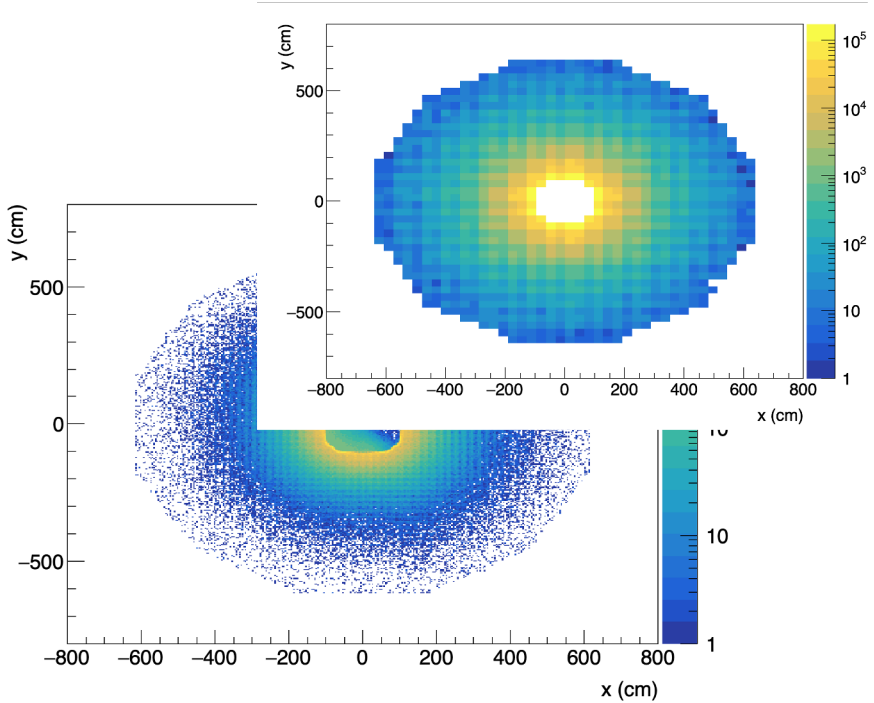


- Energy correction by 4.5% shift such that the ratio ~ 1.
- Asymmetric clusters inside the beampipe position, due to the algorithm of clustering. But still, a little concerning/puzzling.

Backward EEMC - a first look

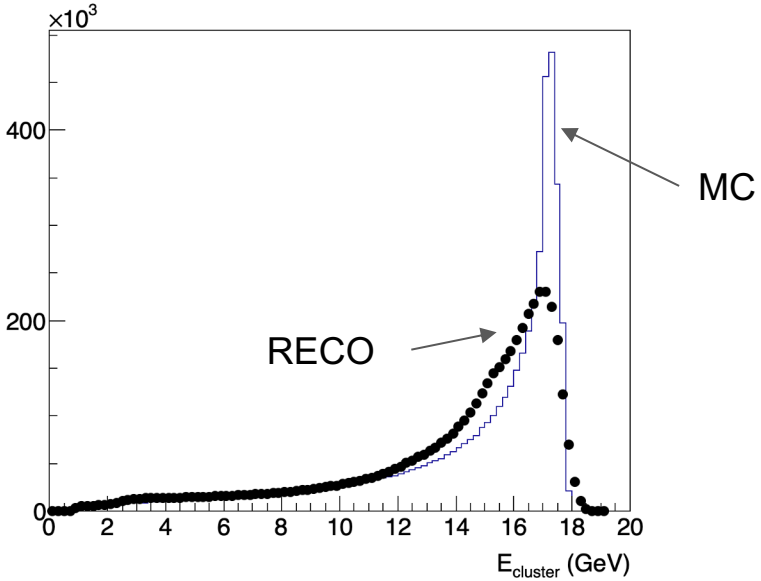
Peak before correction of energy

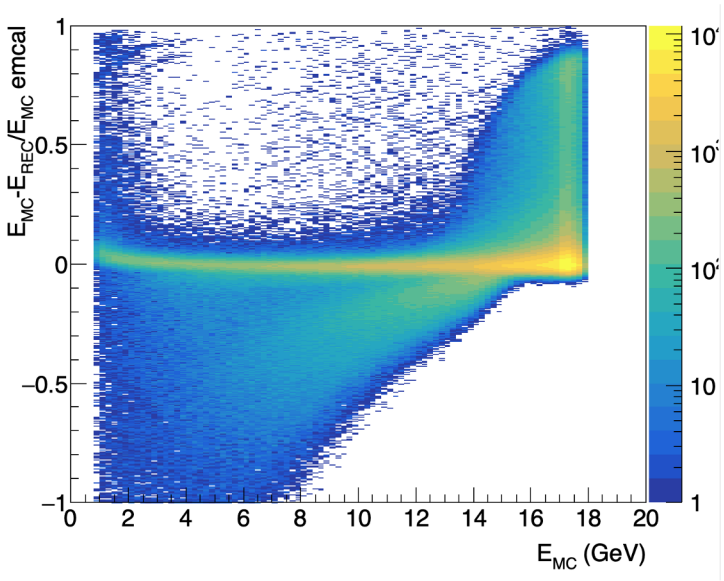




- Energy correction by 4.5% shift such that the ratio ~ 1.
- Asymmetric clusters inside the beampipe position, due to the algorithm of clustering. But still, a little concerning/puzzling.
- Cell/Tower distribution looks ok.

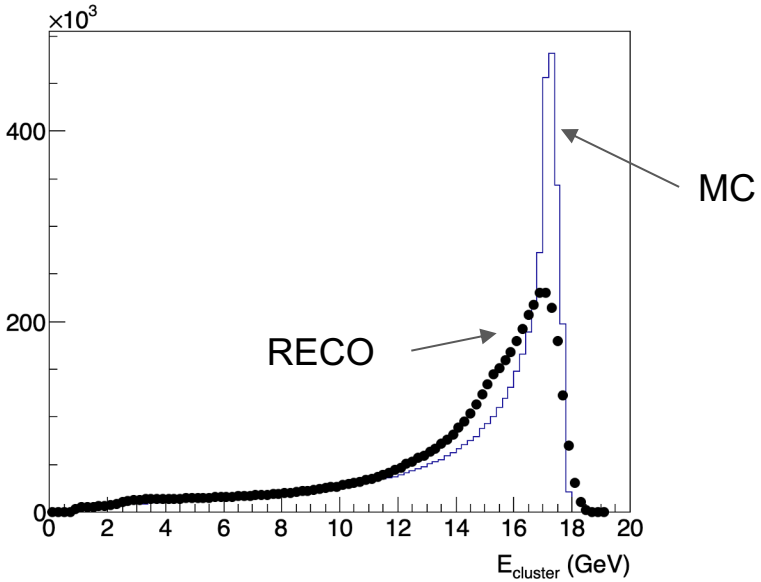
Leading cluster energy distribution and resolution

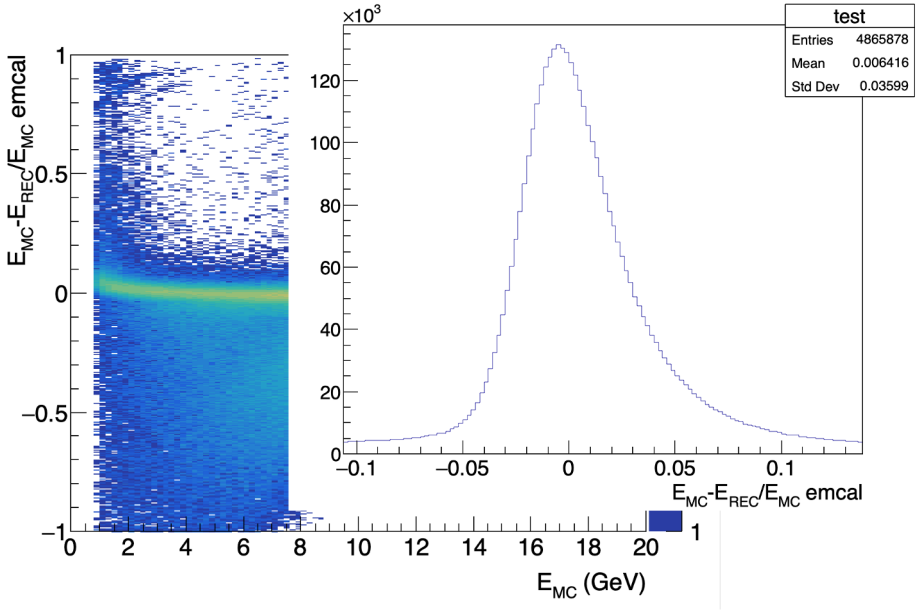




- The energy resolution looks not so good.

Leading cluster energy distribution and resolution





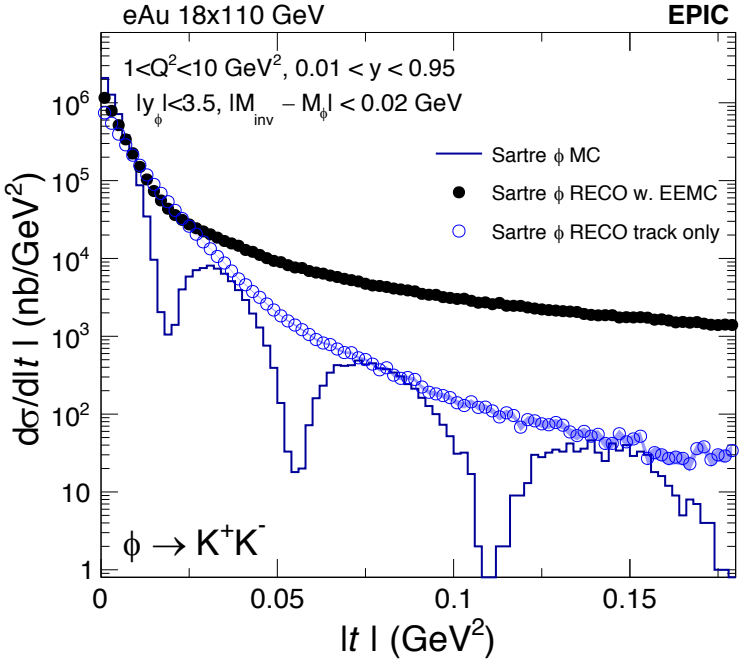
- The energy resolution looks not so good.
- Projection on a single slice of E_{MC} @ ~ 16 GeV.

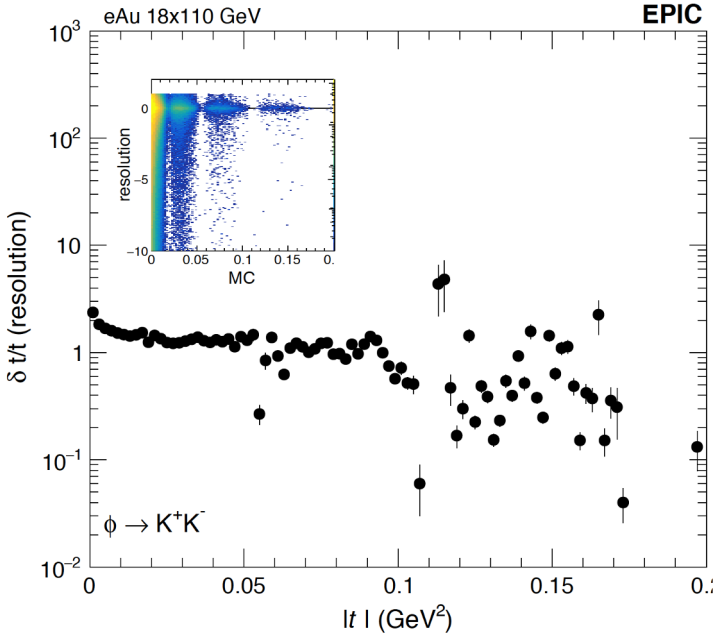
EPIC Brycecanyon 22.11.2

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

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



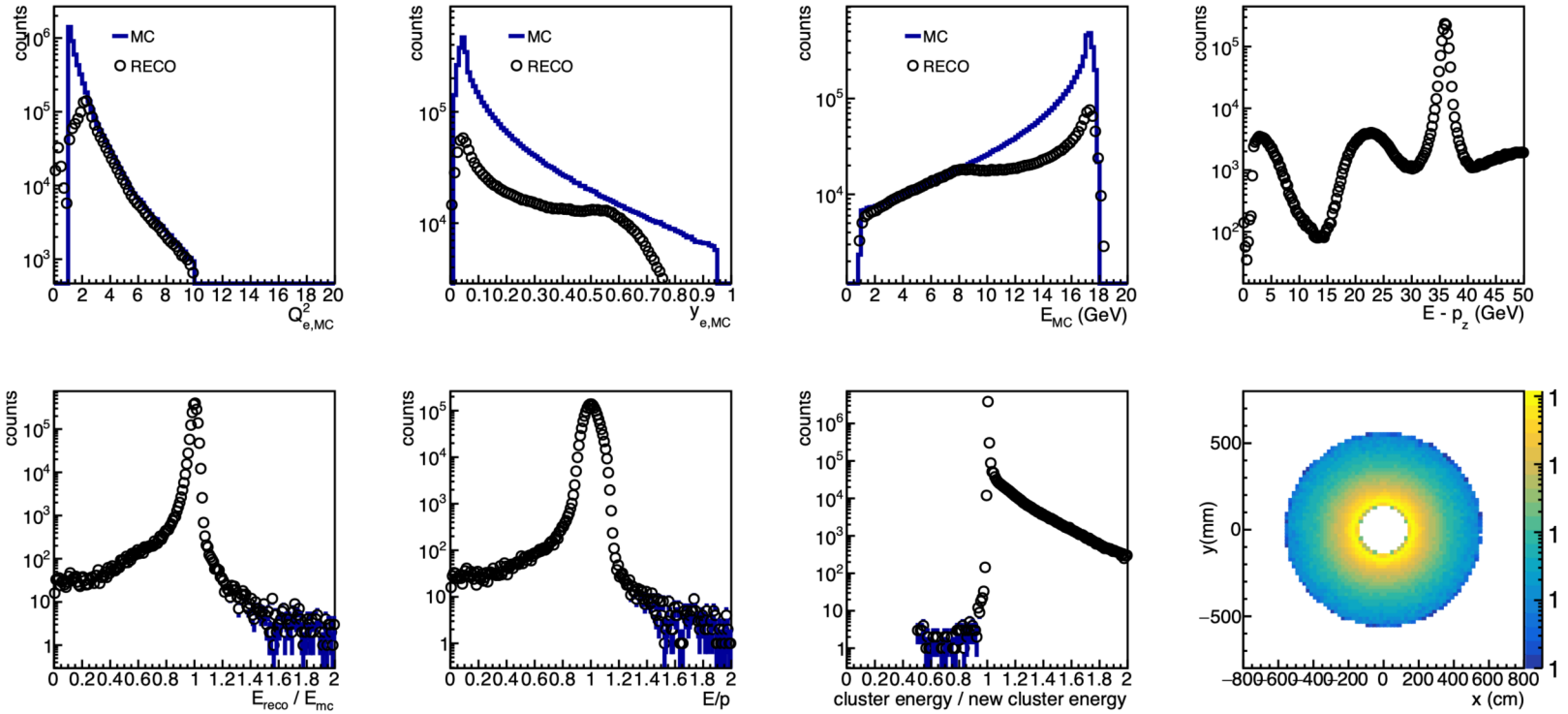


Now, let’s do a simple (re)clustering.

Similar to slides from link.

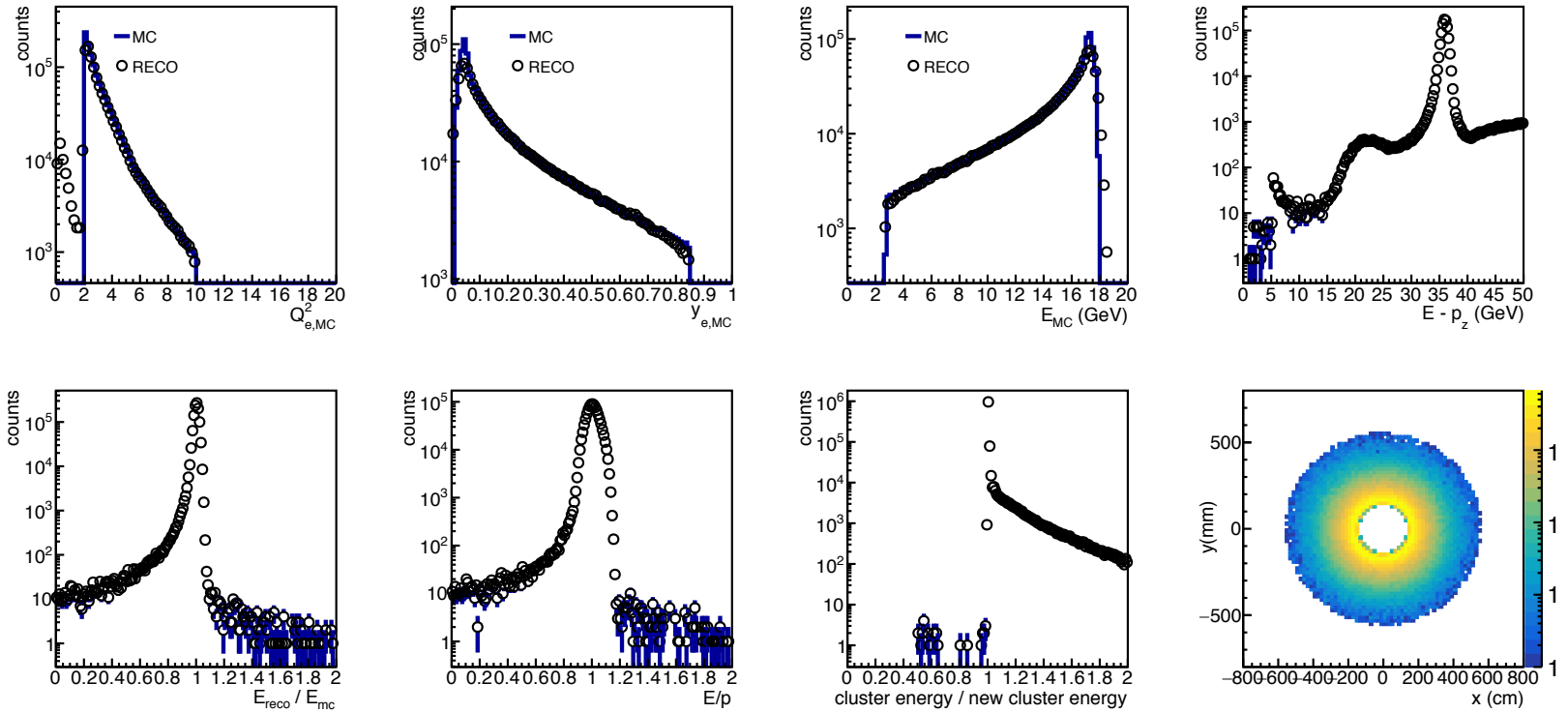
1. Find the leading energy RecHit;
2. Sum up all the energy towers within a radius of 70mm. (50,60,65,70mm all have been tried, no so much difference).
3. Energy threshold is 10 MeV
4. Cluster position (x,y) = weighted average of all towers.
5. Select 150mm < R < 550mm for the cluster to ensure good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

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



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

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



- Much improved! Acceptance selection is important; Q^2 at 1 is too small.

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**

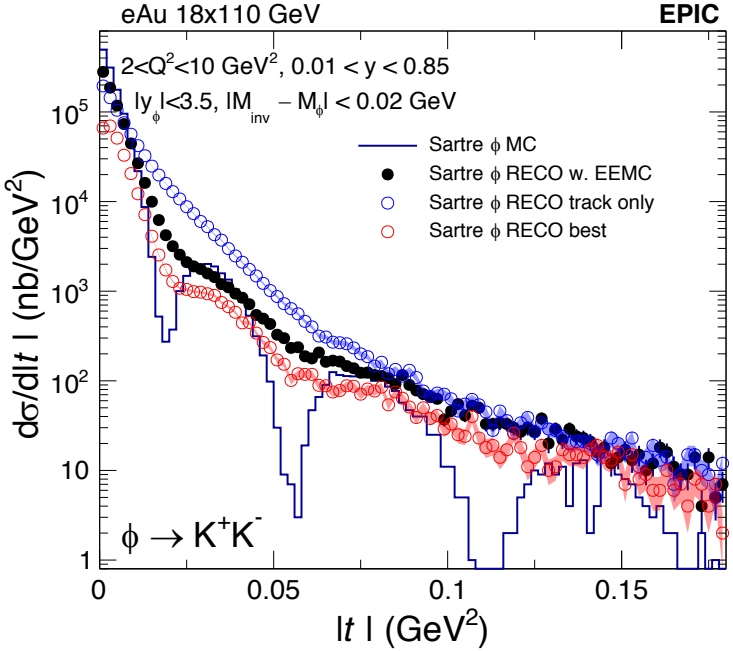
- DIS event selection:
  - **27 < E – Pz < 40 GeV**

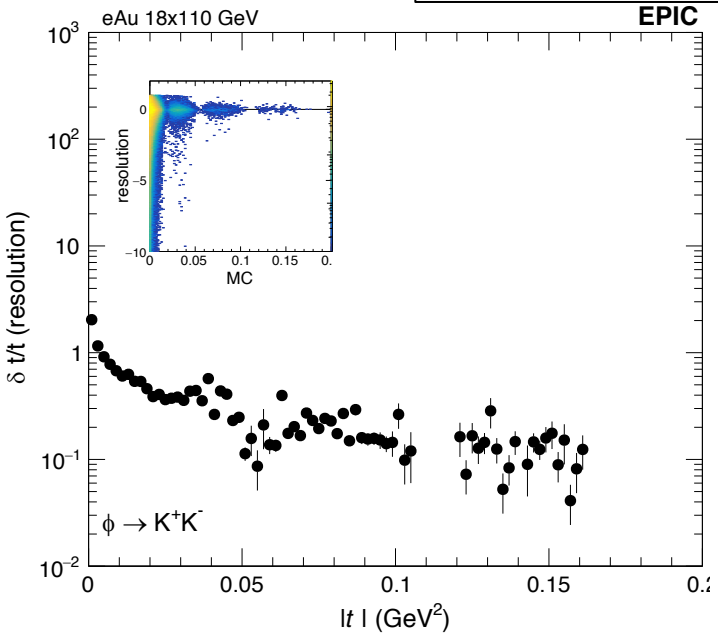
- φ phase space:
  - daughter K |pseudorapidity| < 3.0;
  - Within 0.02 GeV of φ mass.

EPIC Brycecanyon 22.11.2

Updated 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.

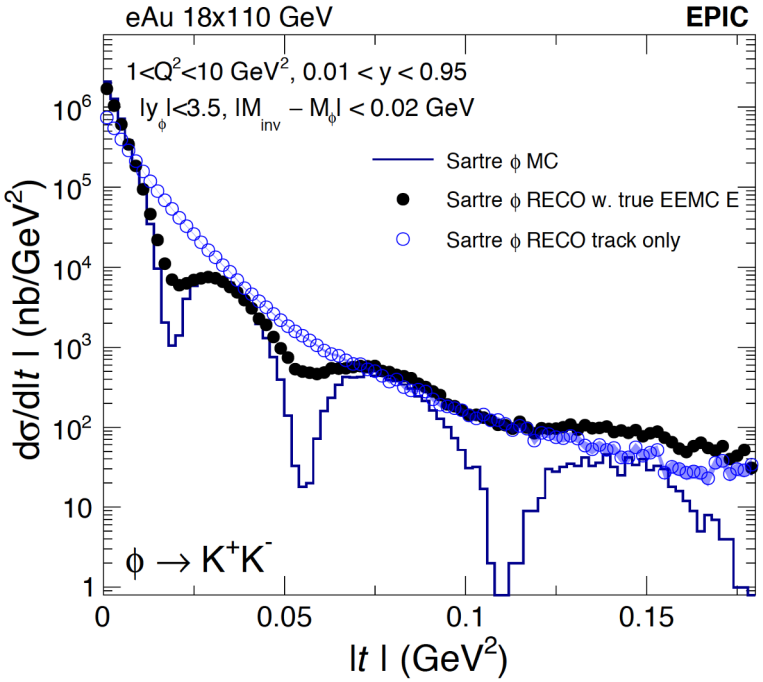


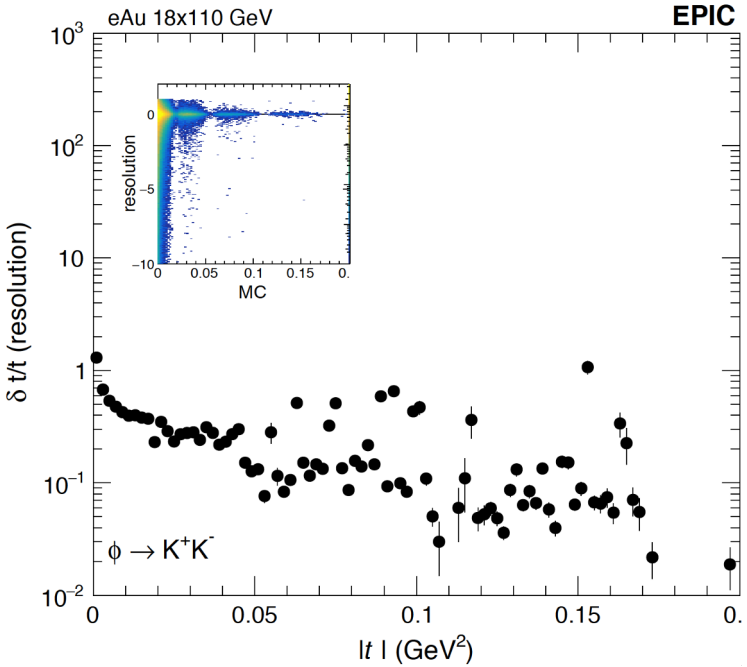


- Much improved! -*t* resolution now looks promising, at least it's hopeful.
- Weighted average of the previous two methods after cutting on their E-by-E ratio (0.5 - 1.5)

Target result

This is when the energy is replaced with true E, but kept everything else, the VM, tracking eta, phi, etc. → This level of precision is what we are targeting!





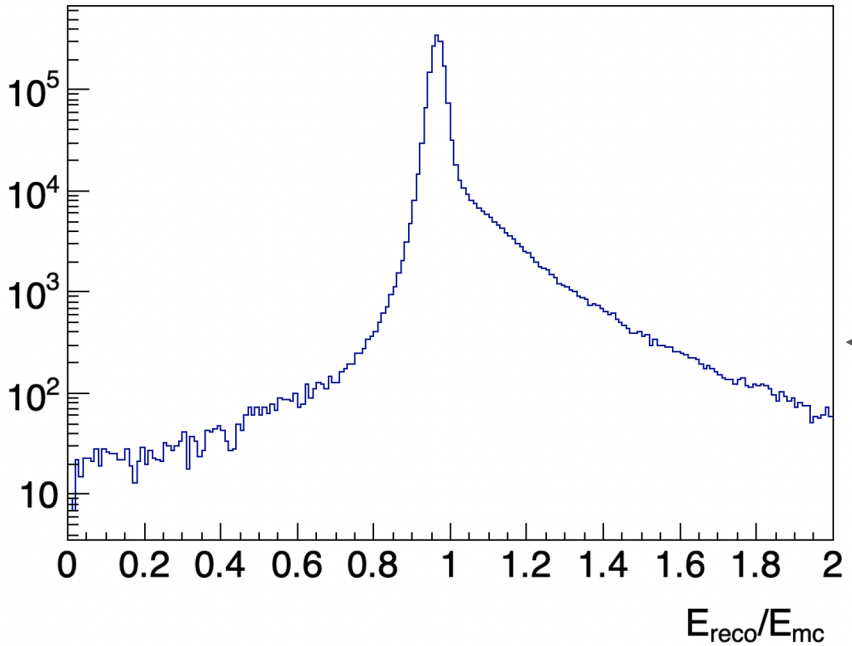
Summary

- 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.
- 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.

Backup

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.