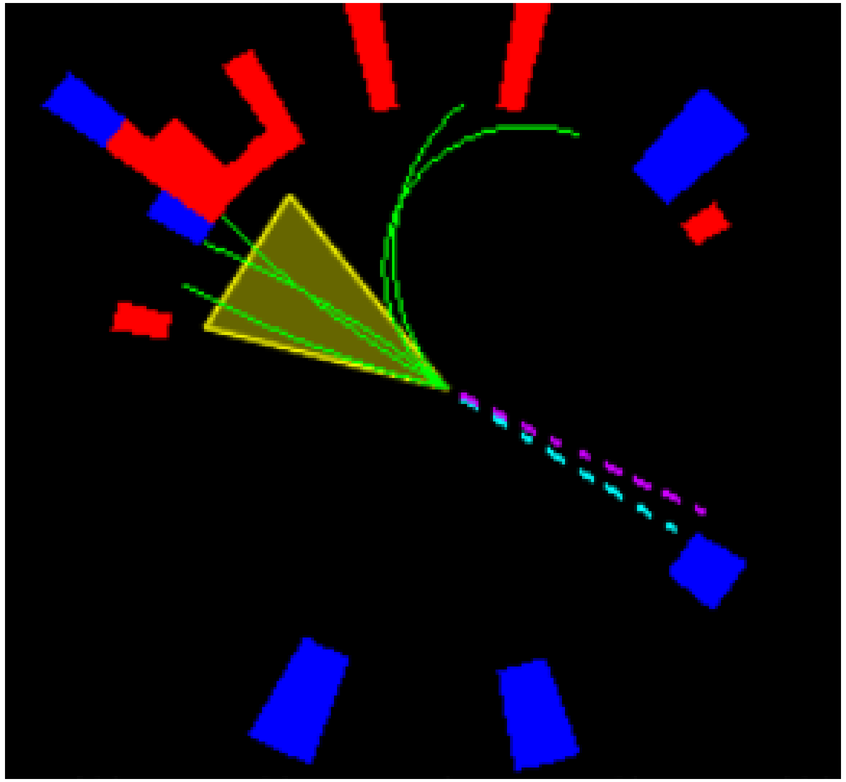
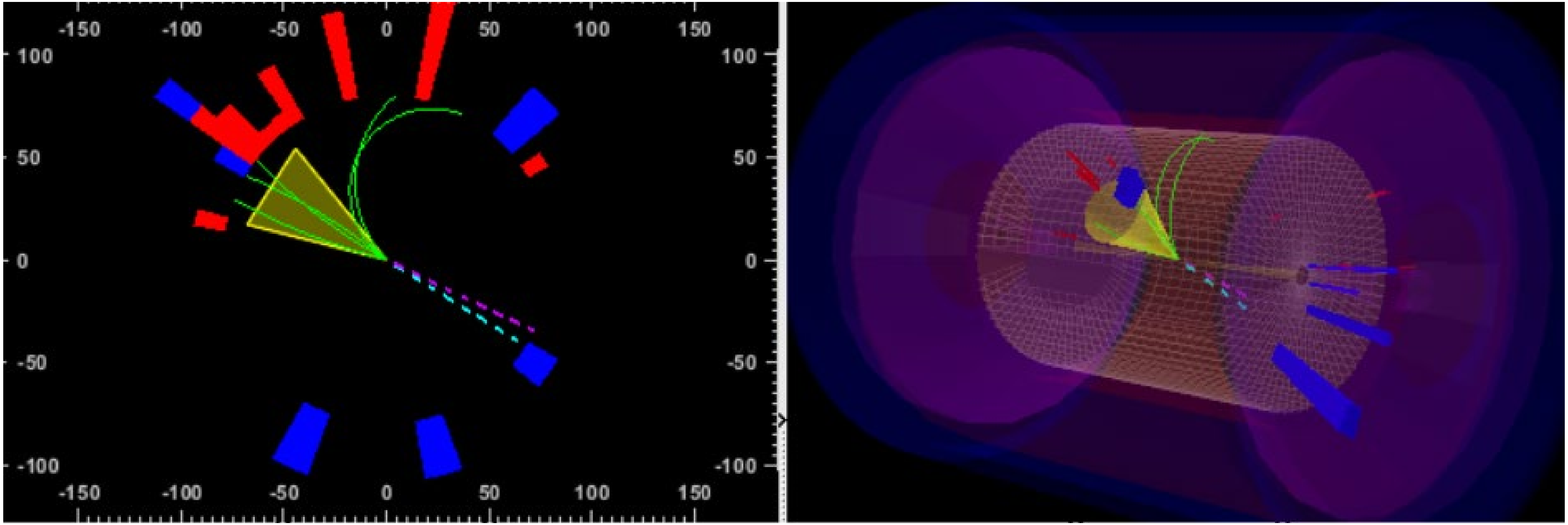
MET performance

Miguel Arratia



Pavia EIC YR workshop, May 19th 2020

Charged-current DIS at the EIC



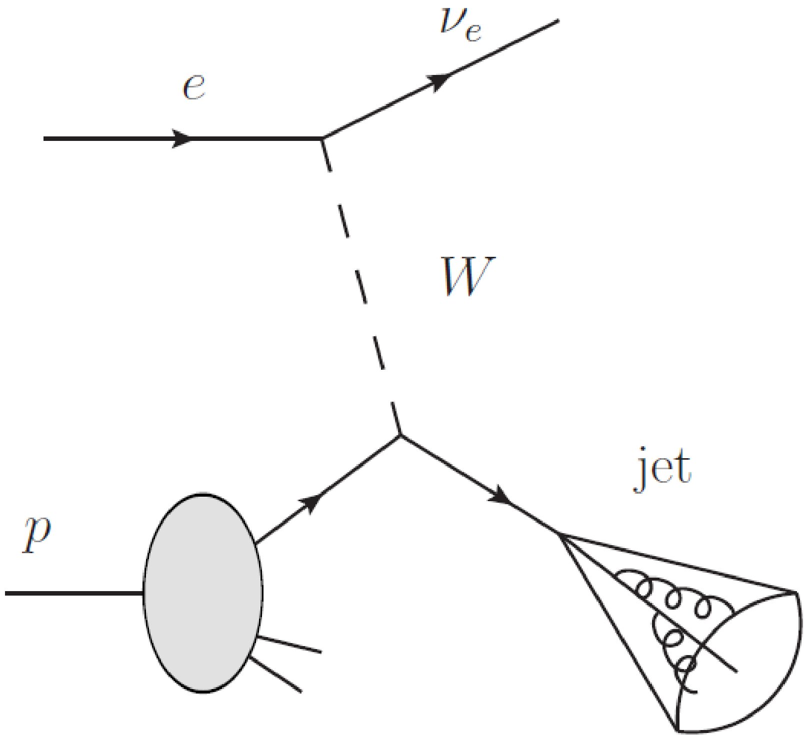
Delphes fast simulation of an EIC detector and Pythia8 charged-current DIS event
(see backup for details)

“Jacquet-Blondel Method”

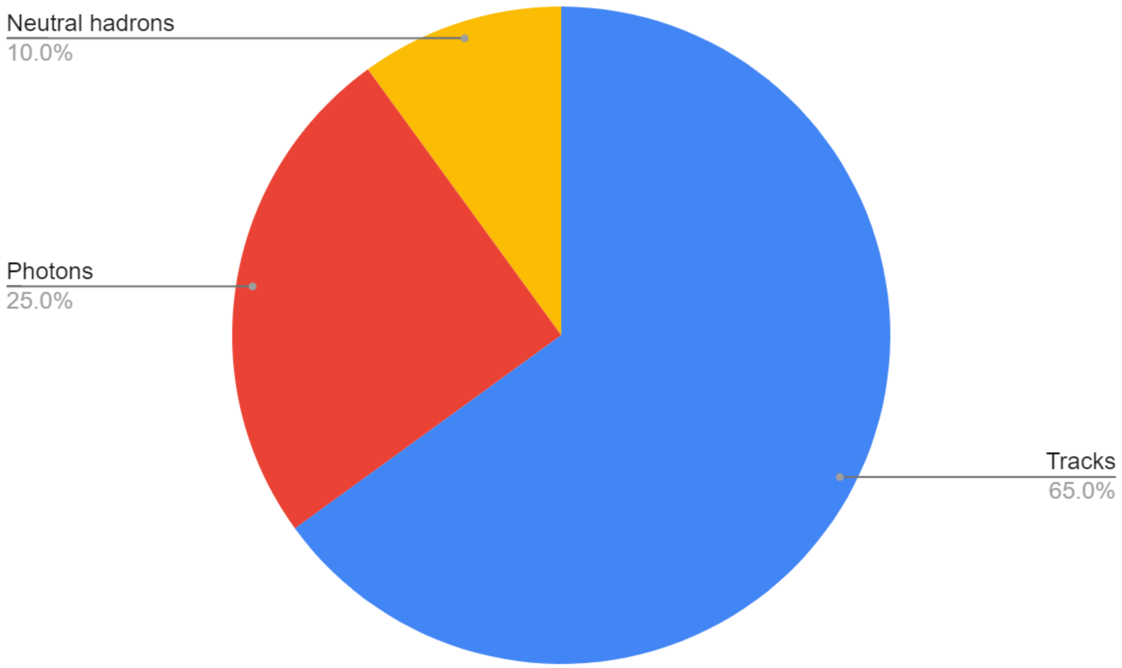
$$y_{\mathrm{JB}} = \frac{\sum_i (E_i - p_{Z,i})}{2\ E_e}, \qquad Q^2_{\mathrm{JB}} = \frac{(p_T^{\mathrm{miss}})^2}{1 - y_{\mathrm{JB}}} \qquad \text{and} \qquad x_{\mathrm{JB}} = \frac{Q^2_{\mathrm{JB}}}{s\ y_{\mathrm{JB}}},$$

I would rather call it “Missing Energy method”

- I propose we treat “Missing-Transverse-Energy” as an object, just like a jet (as done in HEP).
- Becomes evident what are the requirements: full calorimeter coverage, low thresholds.
- Natural object for TMD studies.

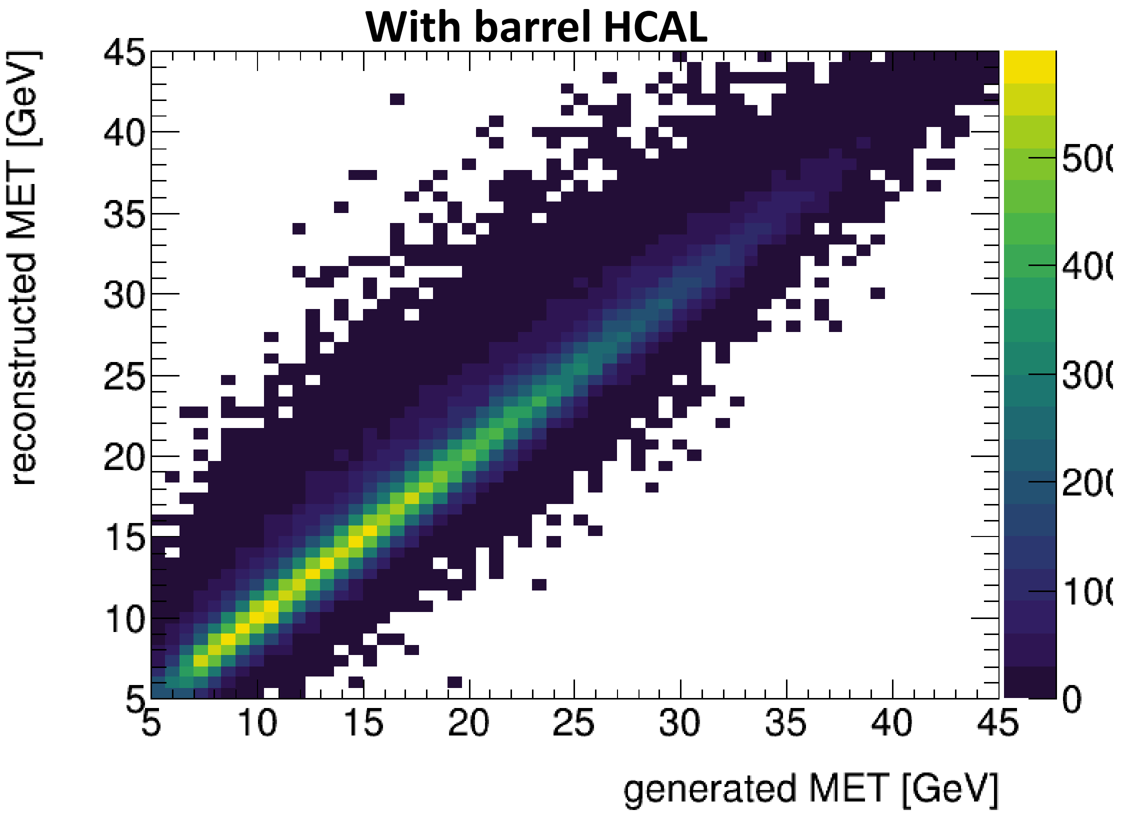


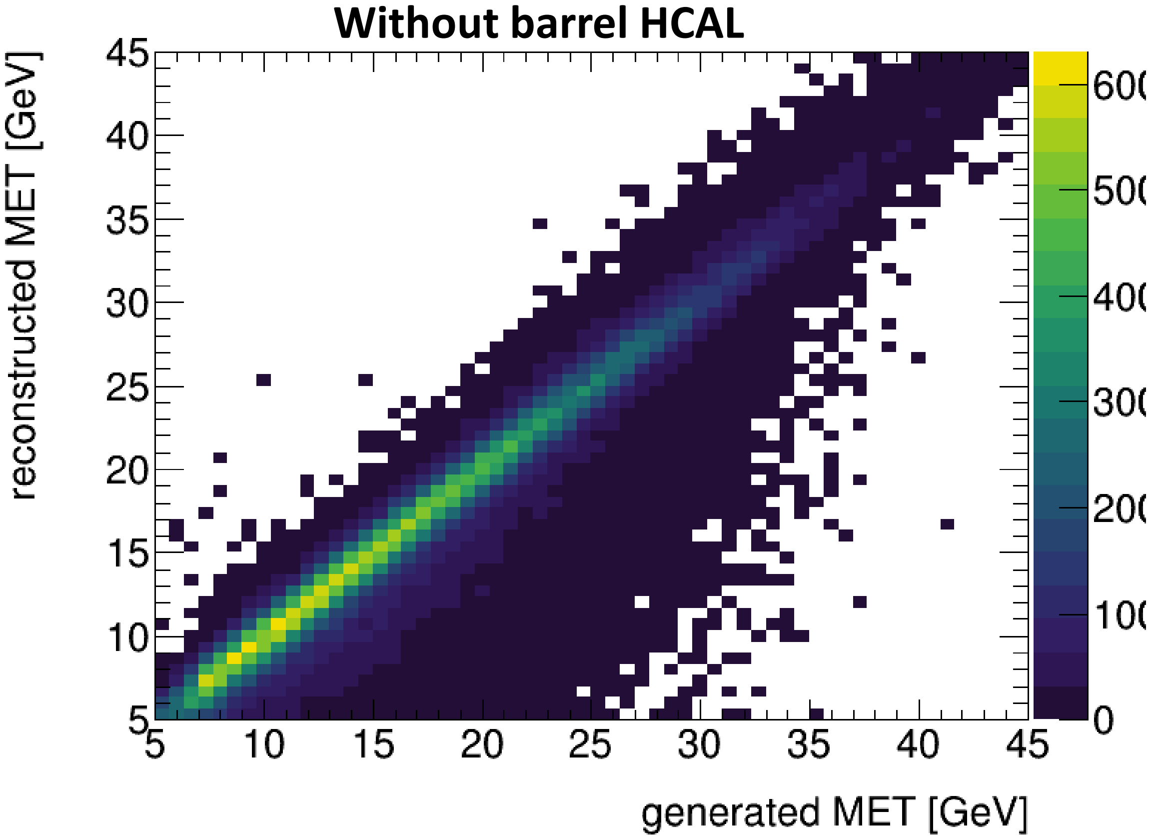
Jet/MET budget



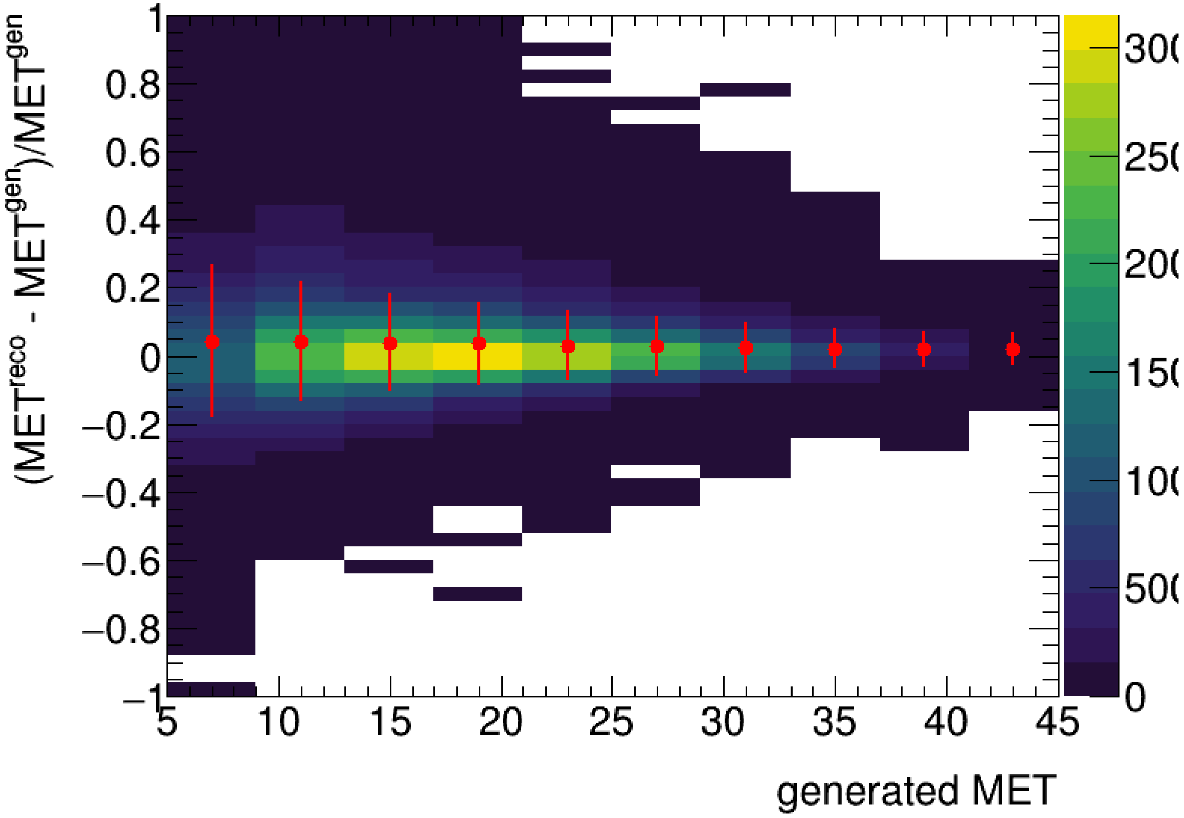
- For accurate jet and MET measurements, we need to be able to capture everything.
- Full HCAL coverage crucial: neutral hadrons, the last 10%, drive the entire resolution!
- Thresholds on both tracking and calorimetry are crucial.
- Tracking resolution negligible.
- ECAL resolution for photons will not be dominant.
- ECAL&HCAL resolution for neutral hadrons will be dominant

Missing transverse-energy

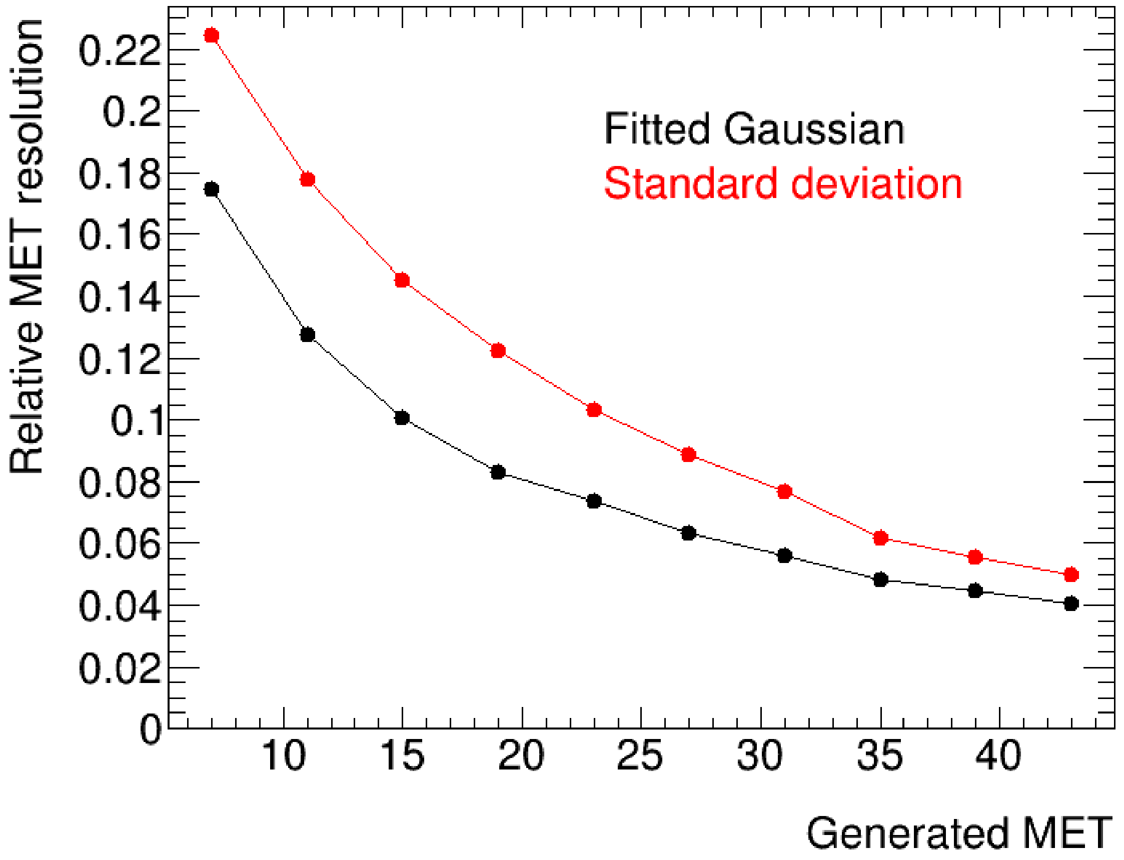




Neutrino pT



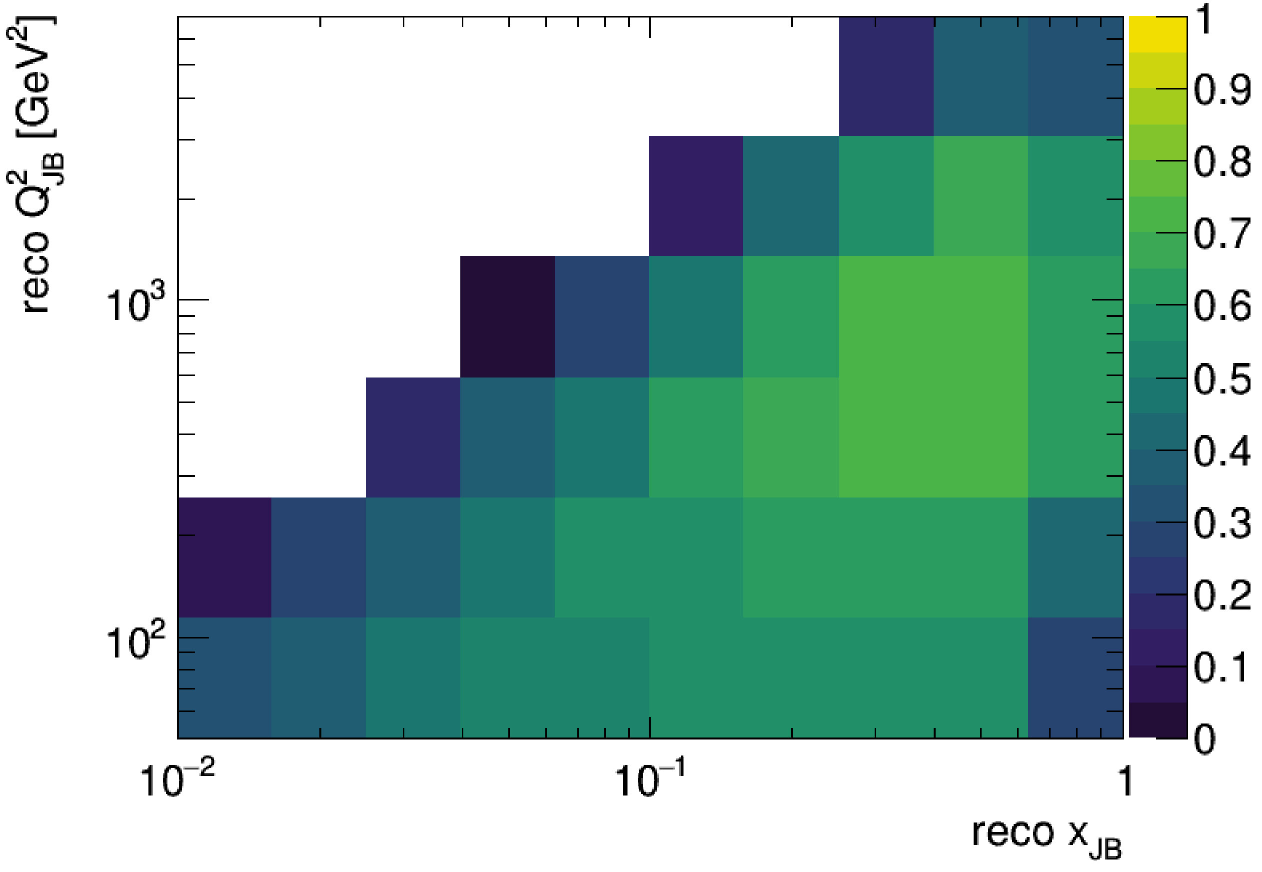
(MET^reco - MET^gen)/MET^gen
generated MET



Relative MET resolution
Fitted Gaussian
Standard deviation
Generated MET

Jacquet-Blondel Purity

$$\text{purity} = (N_{gen} - N_{out})/(N_{gen} - N_{out} + N_{in})$$

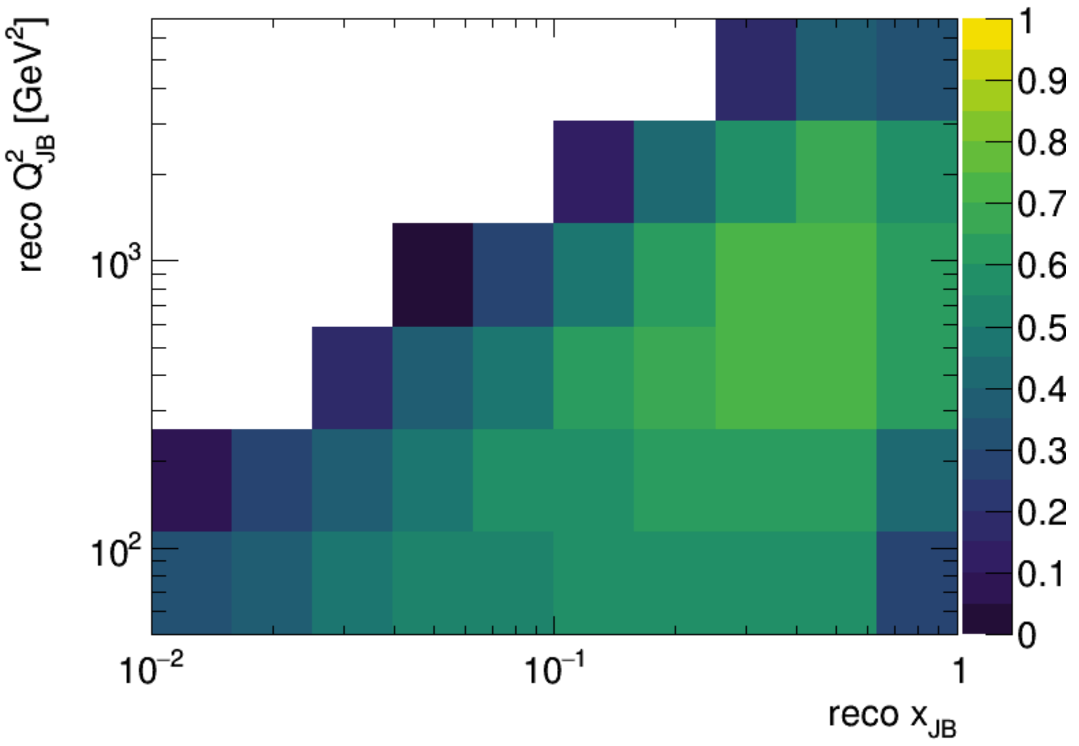


- Reasonable purity reached at high-x and high Q2. (similar conclusion reached in Aschenauer et al. Phys. Rev. D 88, 114025 (2013))
- This is one figure of merit, but one should not forget to consider non-Gaussian tails in response…

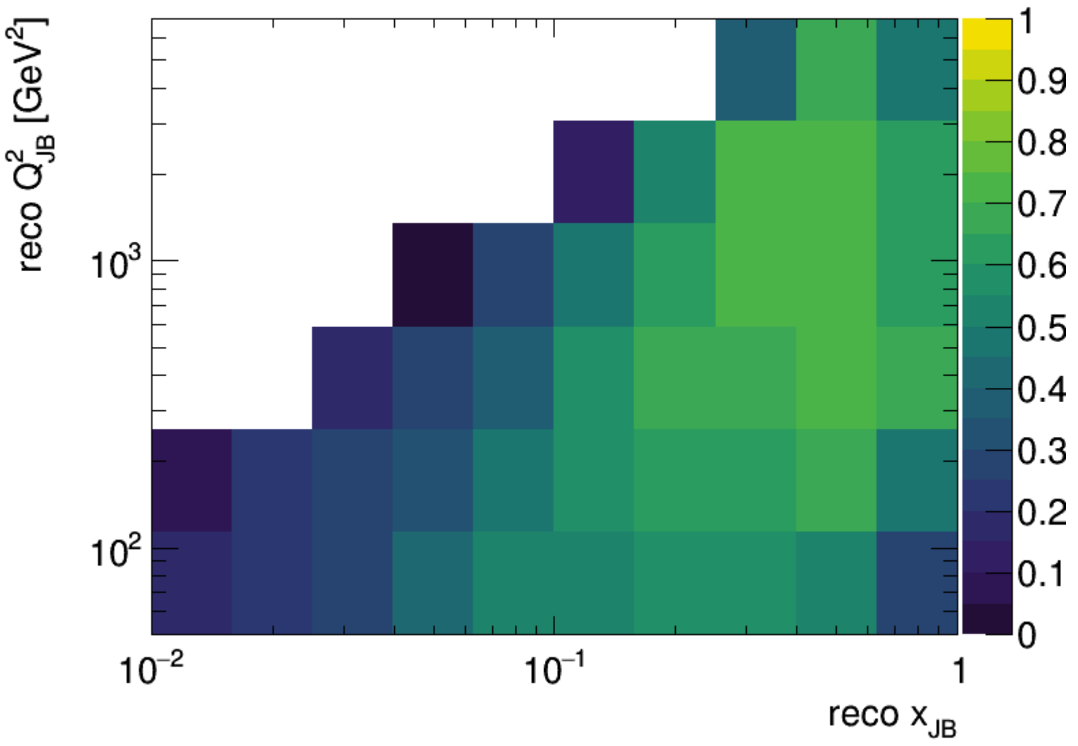
Jacquet-Blondel Purity

$$\text{purity} = (N_{gen} - N_{out})/(N_{gen} - N_{out} + N_{in})$$

With barrel HCAL

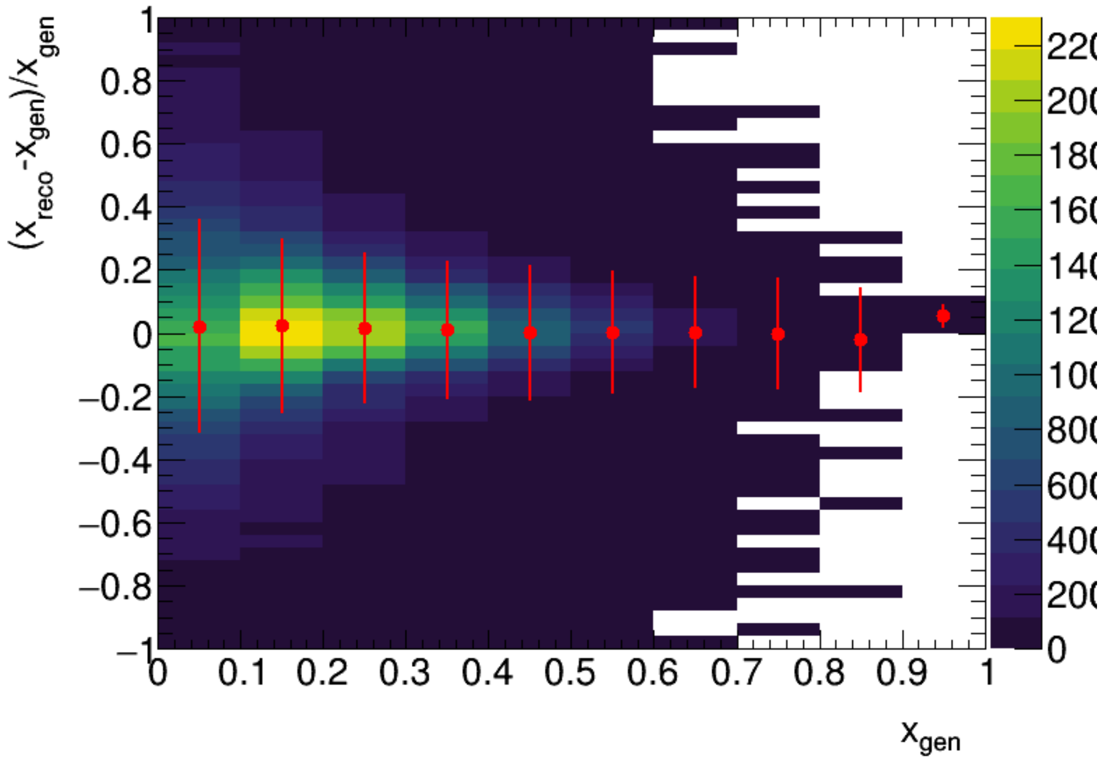


Without barrel HCAL

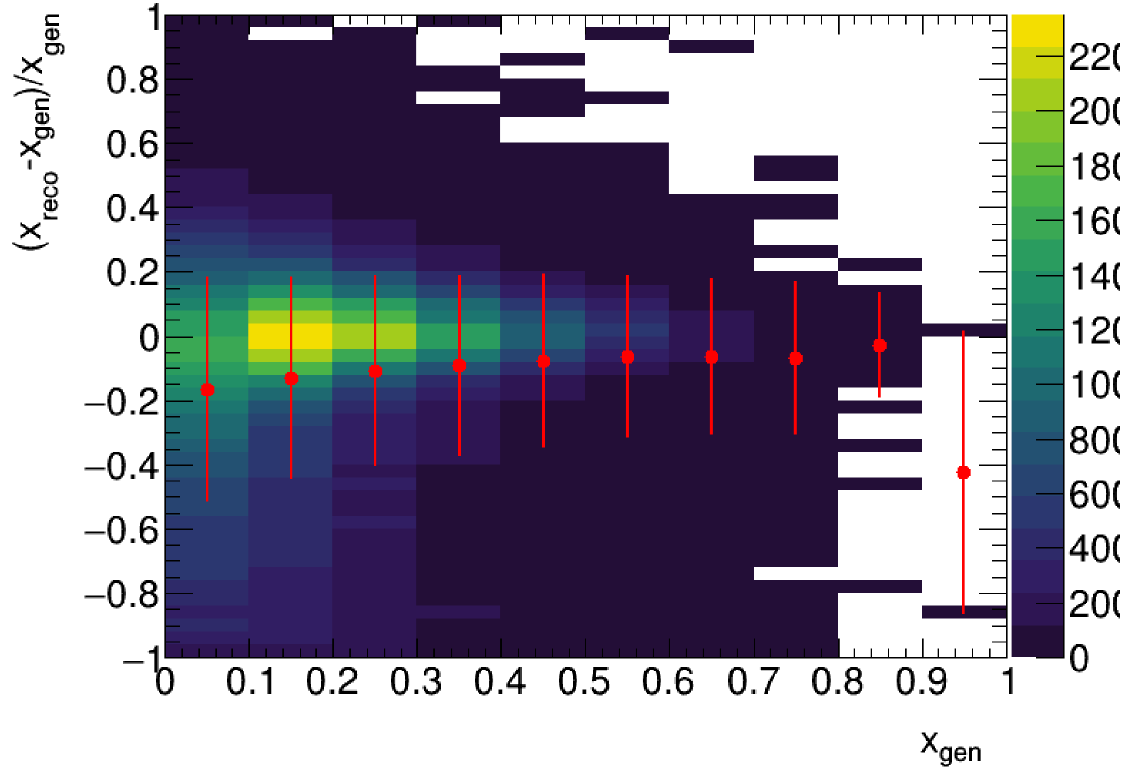


Bjorken x performance

With barrel HCAL



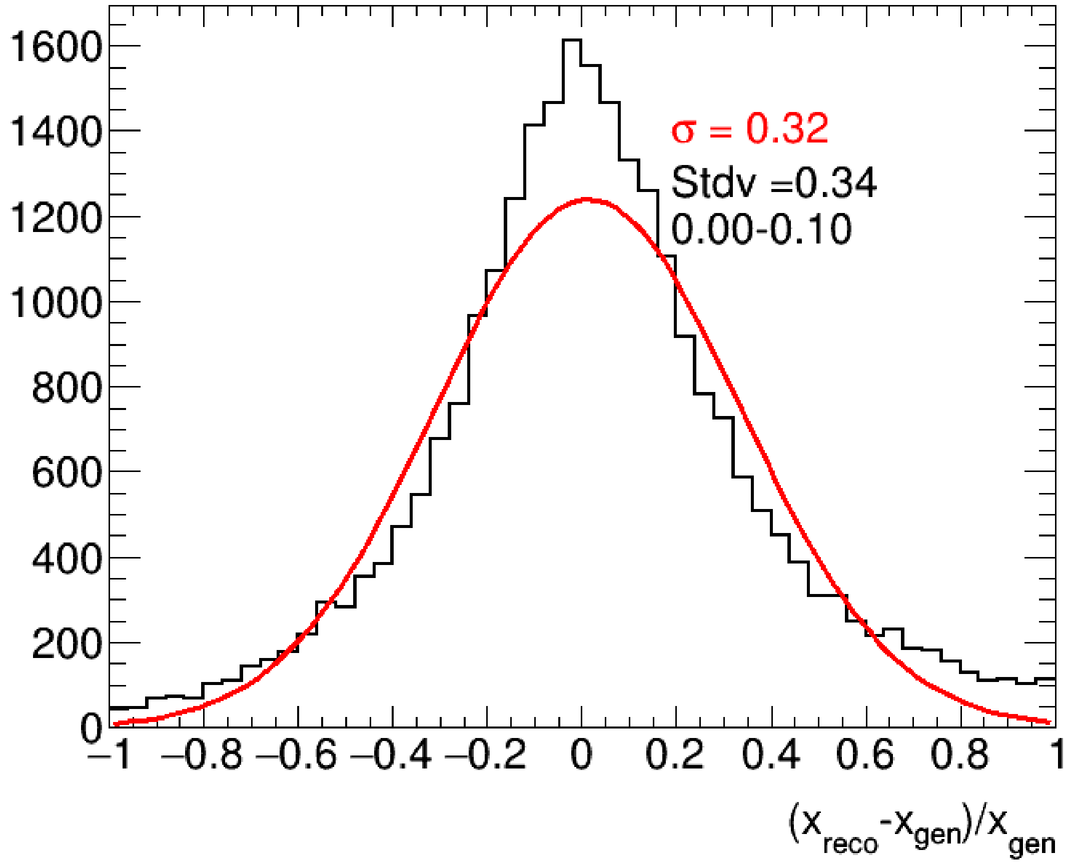
Without barrel HCAL



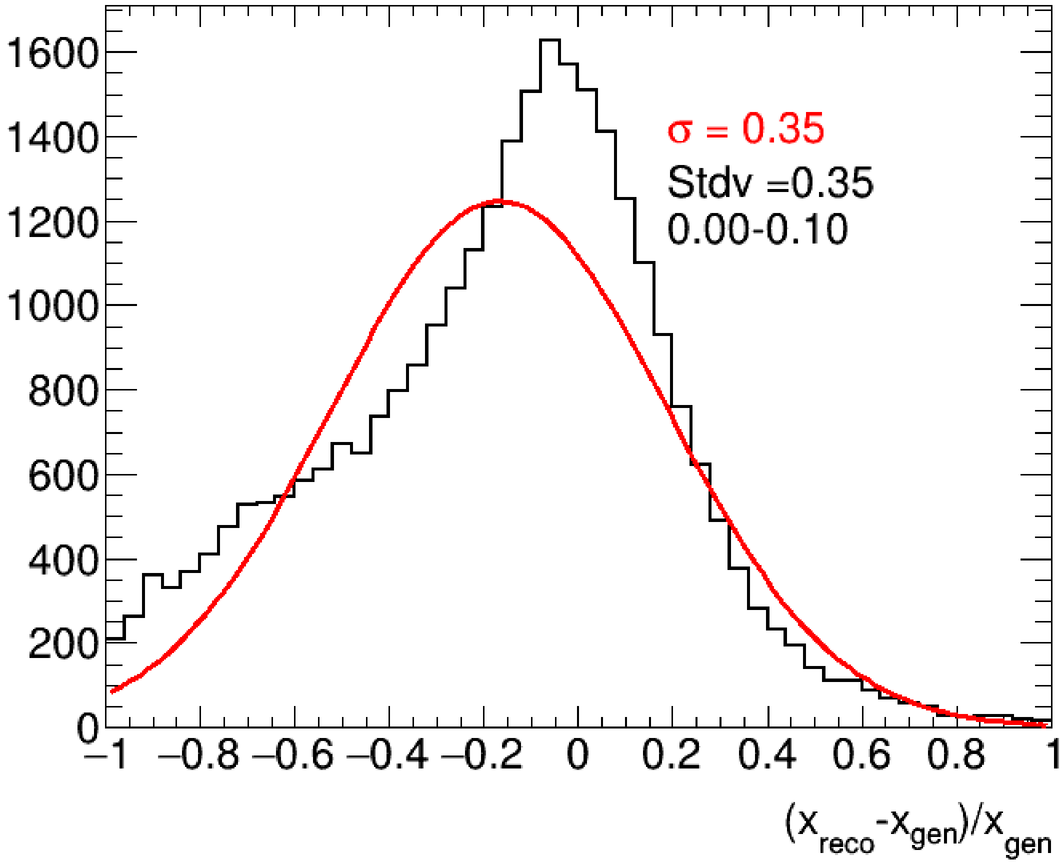
Strong bias at low x
(low jet energy)

Bjorken x reconstruction

With barrel HCAL

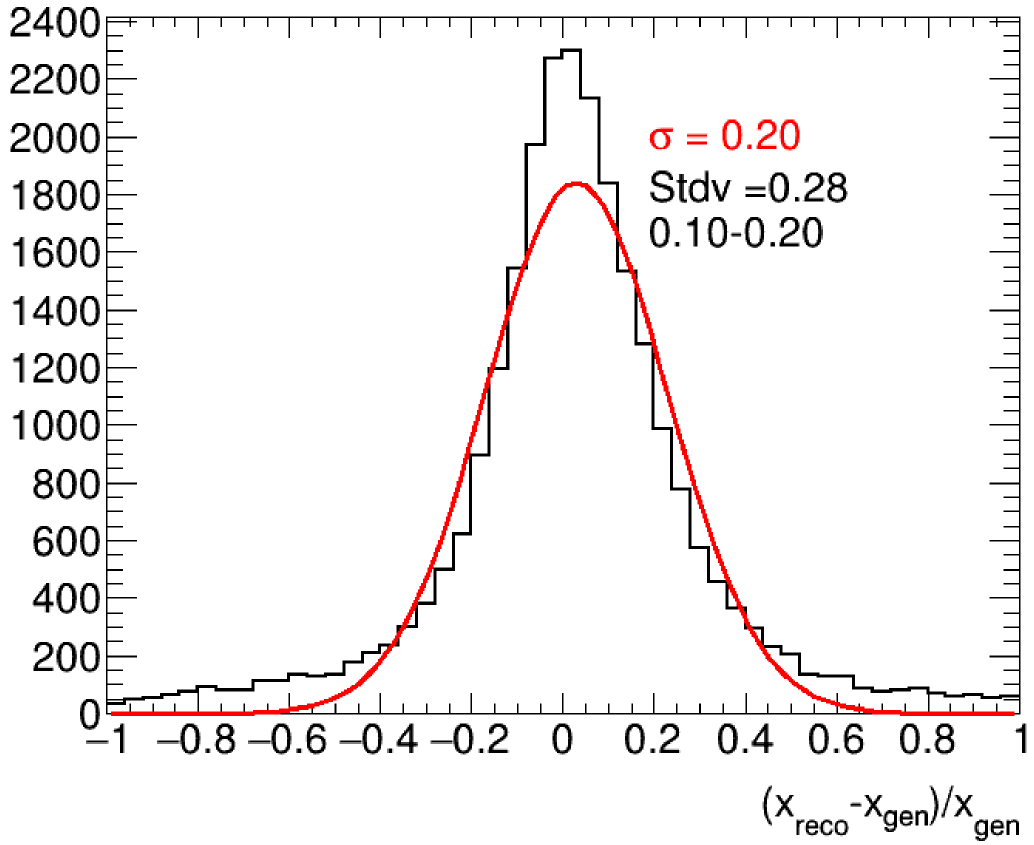


Without barrel HCAL

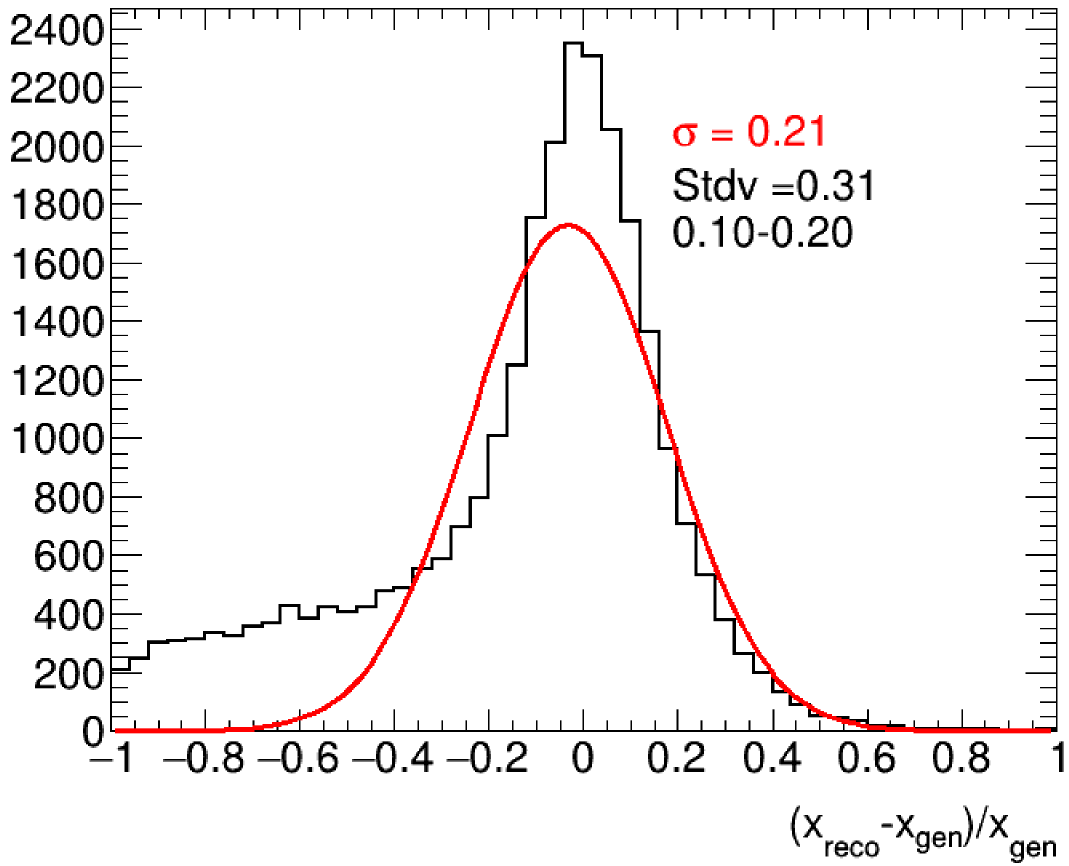


Bjorken x reconstruction

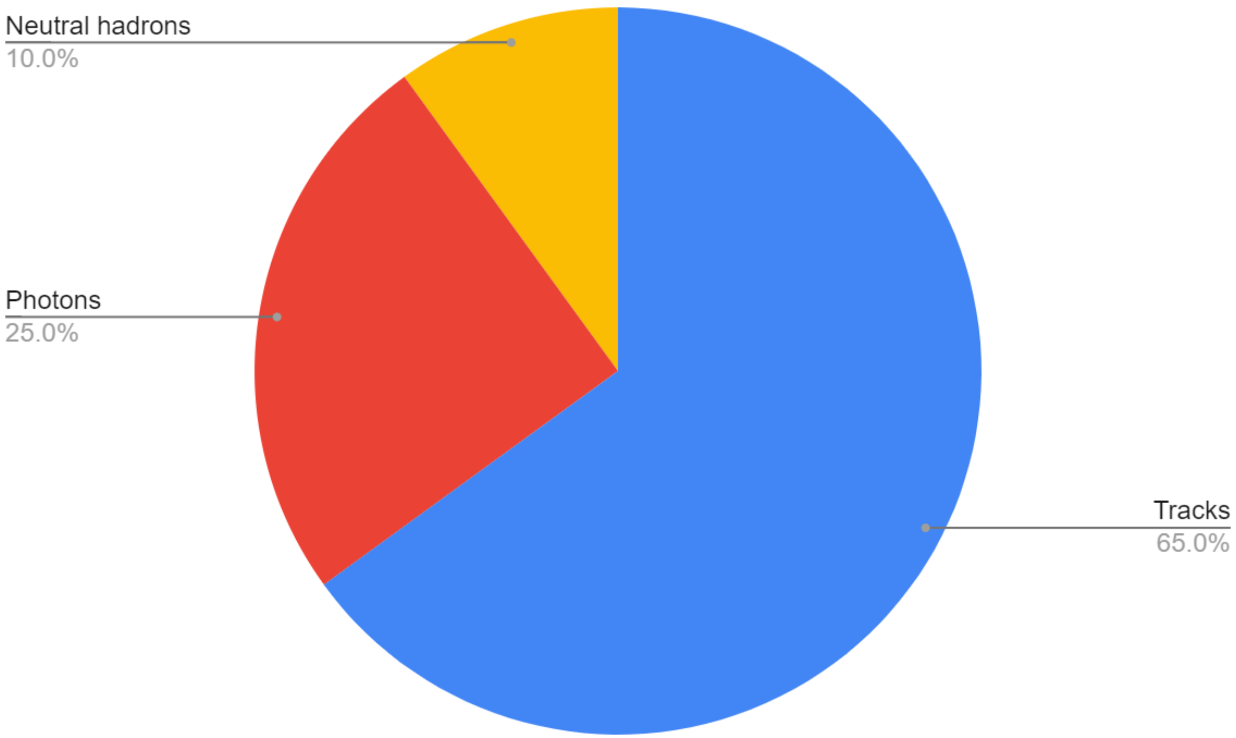
With barrel HCAL



Without barrel HCAL



What happens is you do not measure neutral hadrons in barrel?



Your response gets highly non-diagonal (non-Gaussian response).

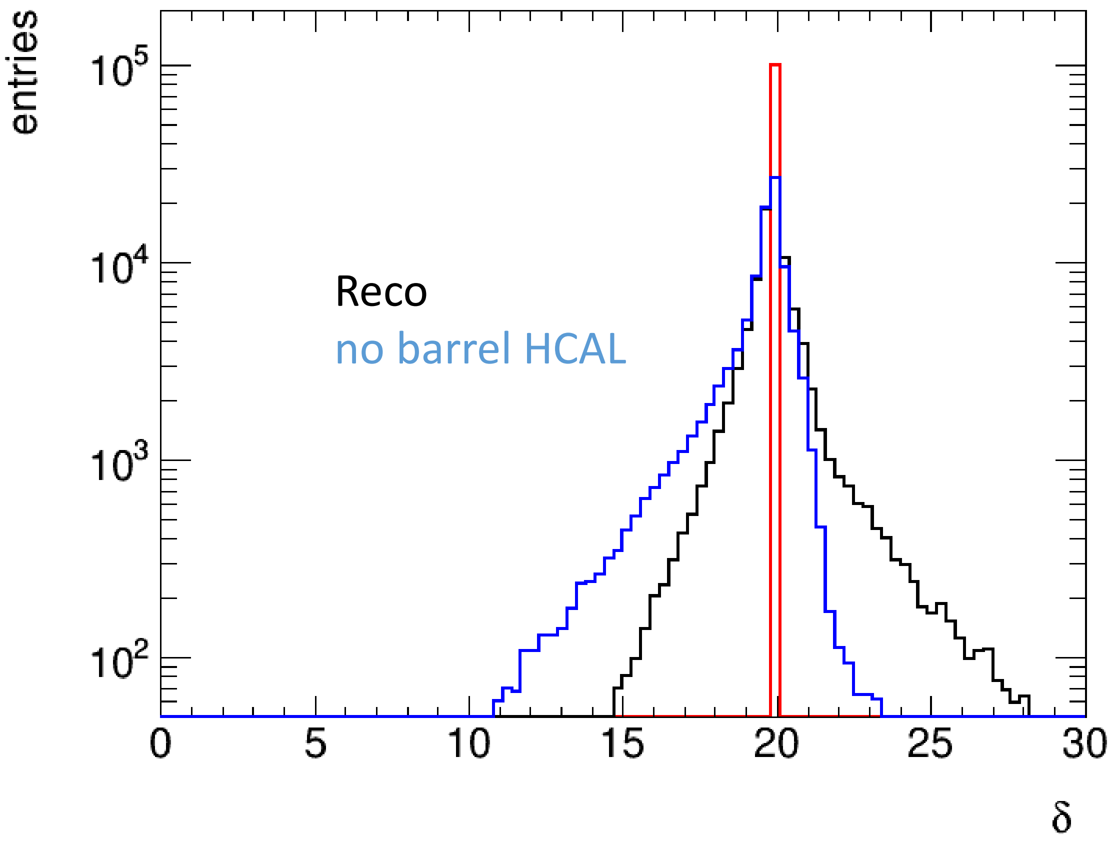
You can try to “correct“ for the missing neutral hadrons using MC, but then you become sensitive to things that are very difficult to model accurately:

- Physics modelling (fragmentation pattern)
- Detector modelling (material, etc)

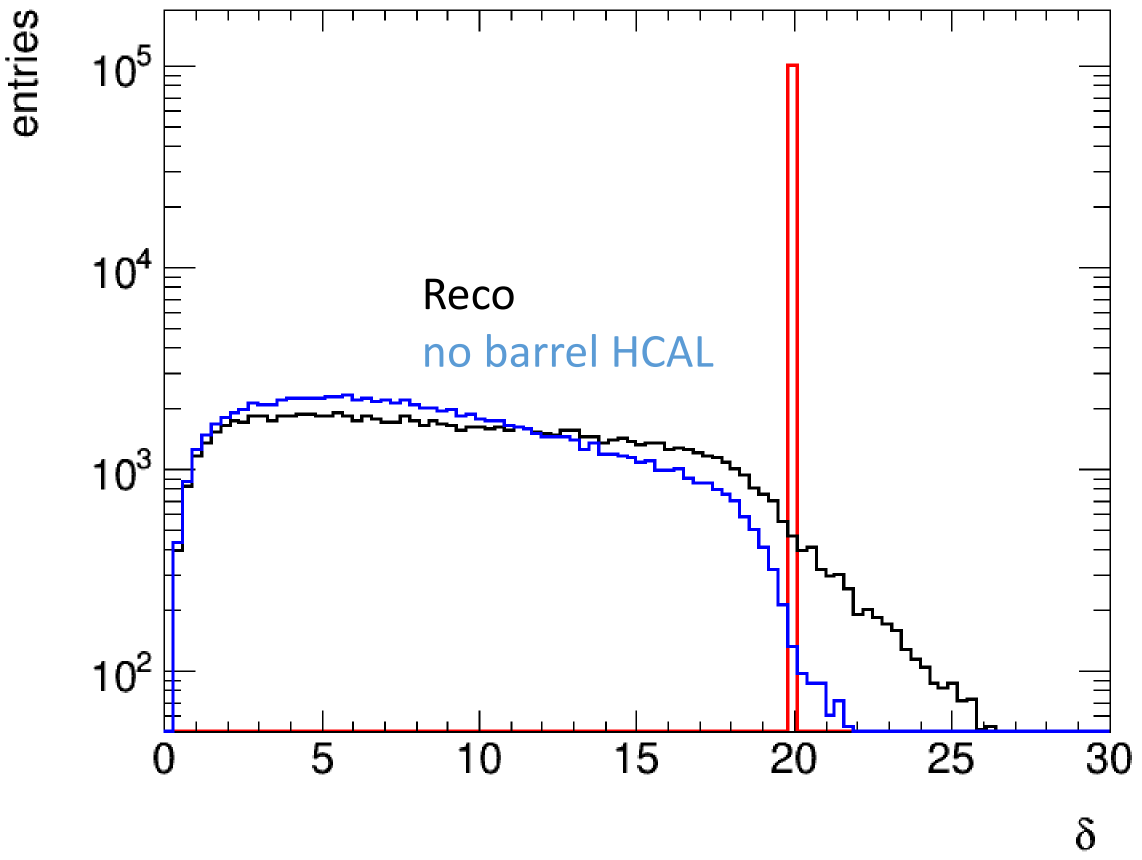
Background rejection

$$\delta = \sum_i E_i(1 - \cos\theta_i)$$

NC DIS

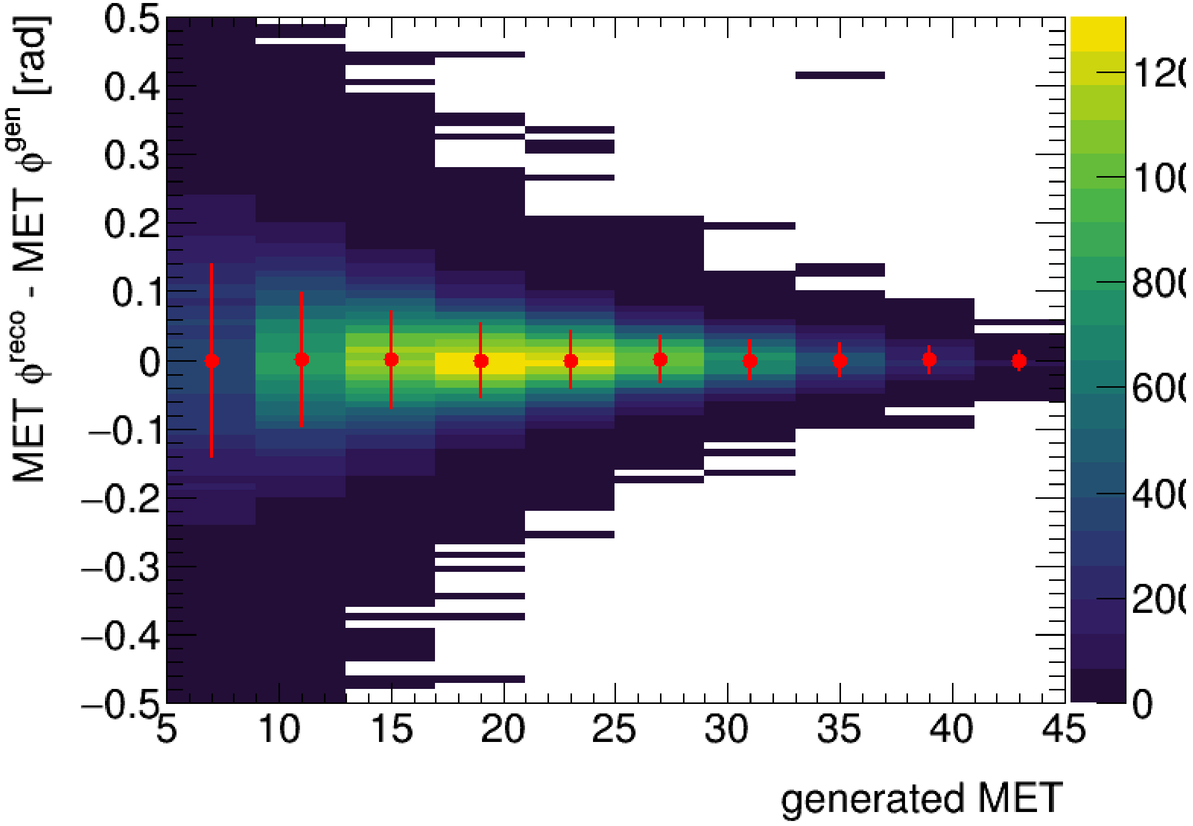


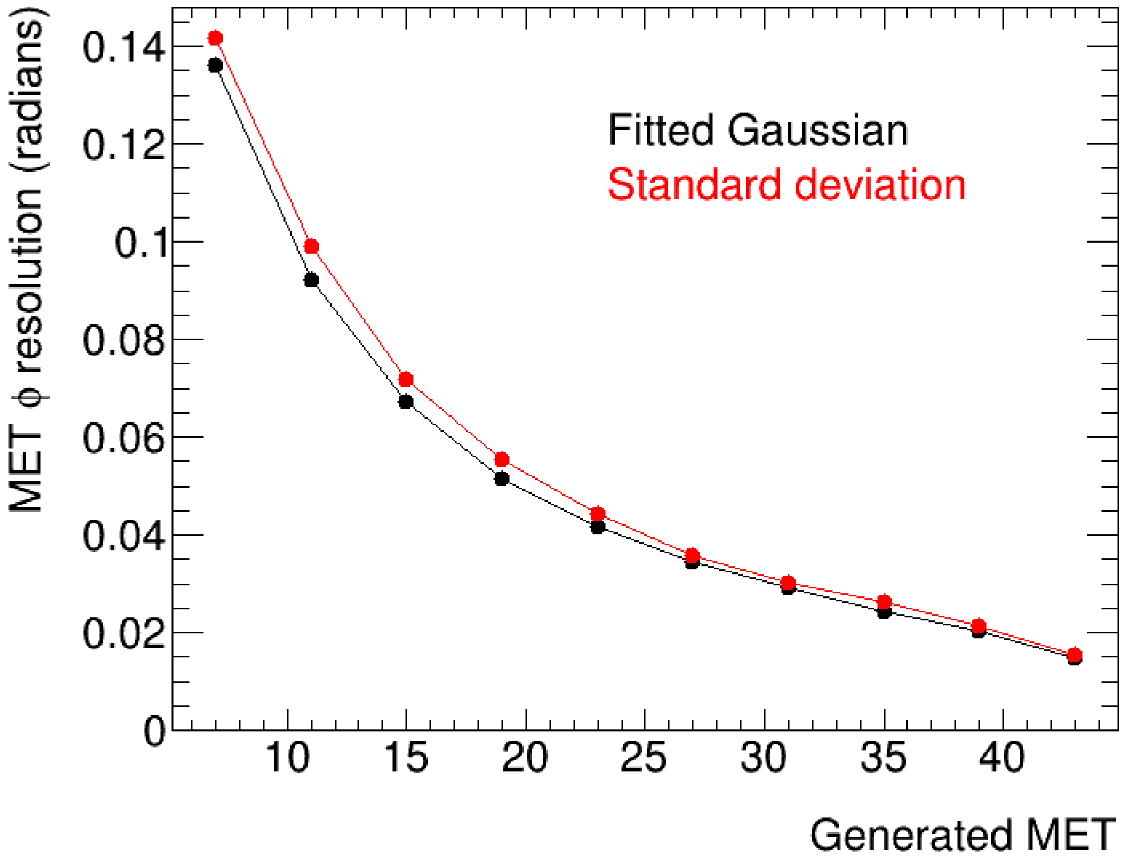
CC DIS



- If one misses track of electron but measures cluster (or viceversa), delta-cut useful to veto NC DIS. Ongoing studies to quantify impact in cross-section

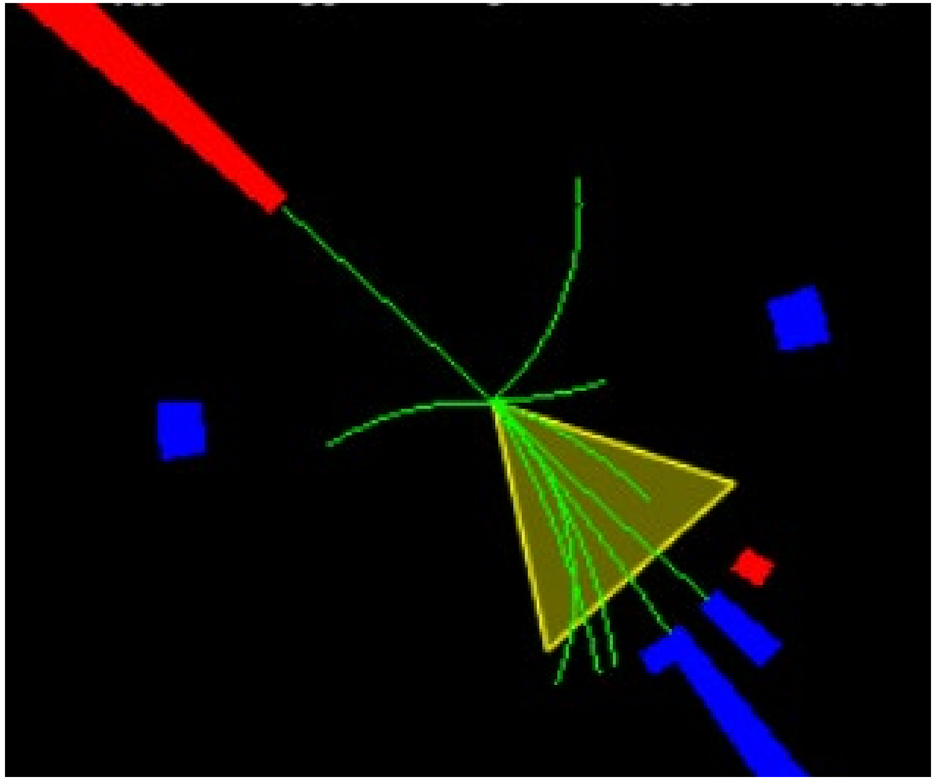
Neutrino azimuthal angle



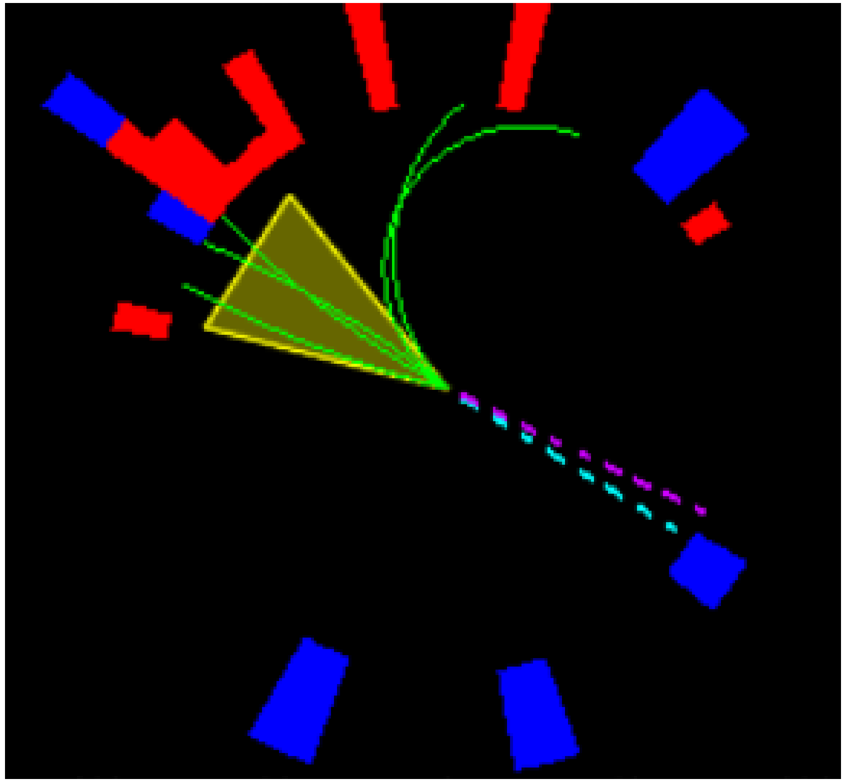


To do TMD physics with jets, we need accurate measurements of azimuthal angle between lepton and jet

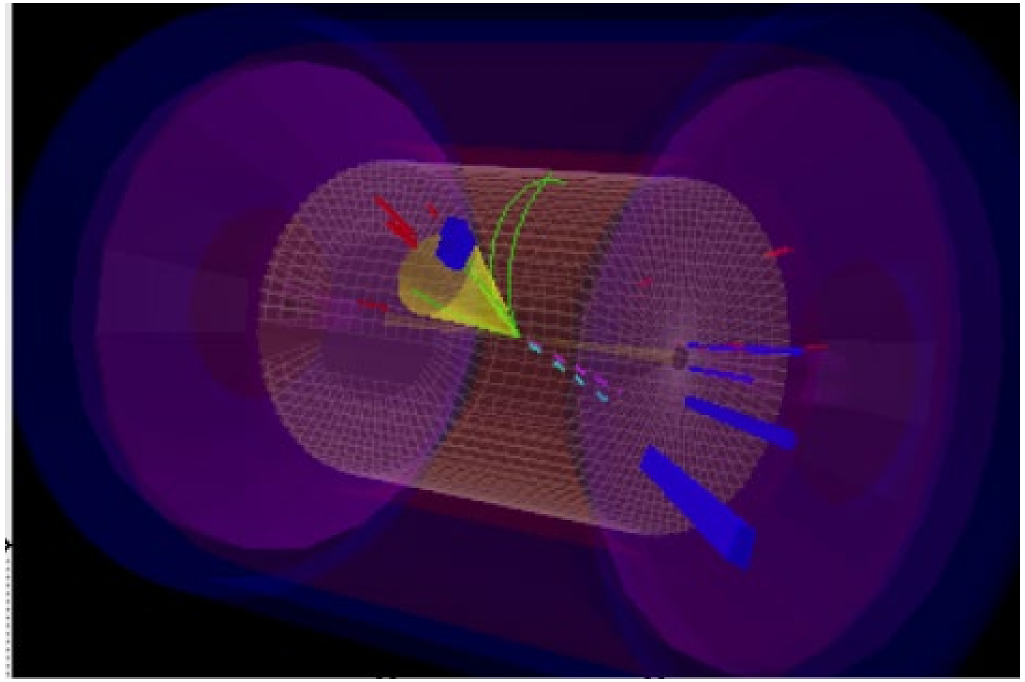
Electron-jet



Neutrino-jet

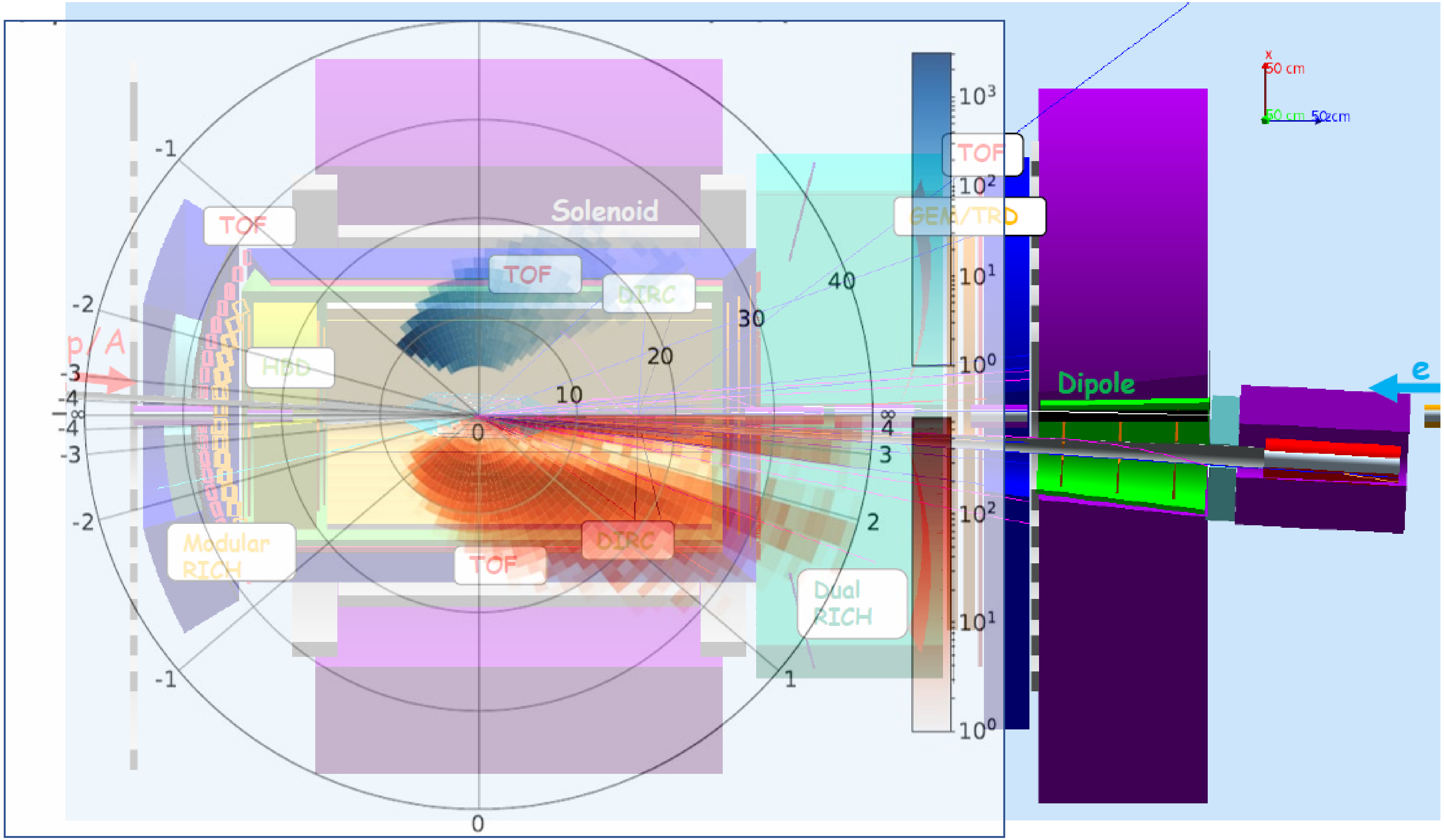


“a hermetic detector (also called a 4π detector) is a particle detector designed to observe ***all possible decay products*** *of an interaction between subatomic particles in a collider by* ***covering as large an area*** *around the interaction point as possible and incorporating multiple types of sub-detectors” Source:* Wikipedia



So by definition, BEAST and JLEIC are not hermetic (no full HCAL coverage)

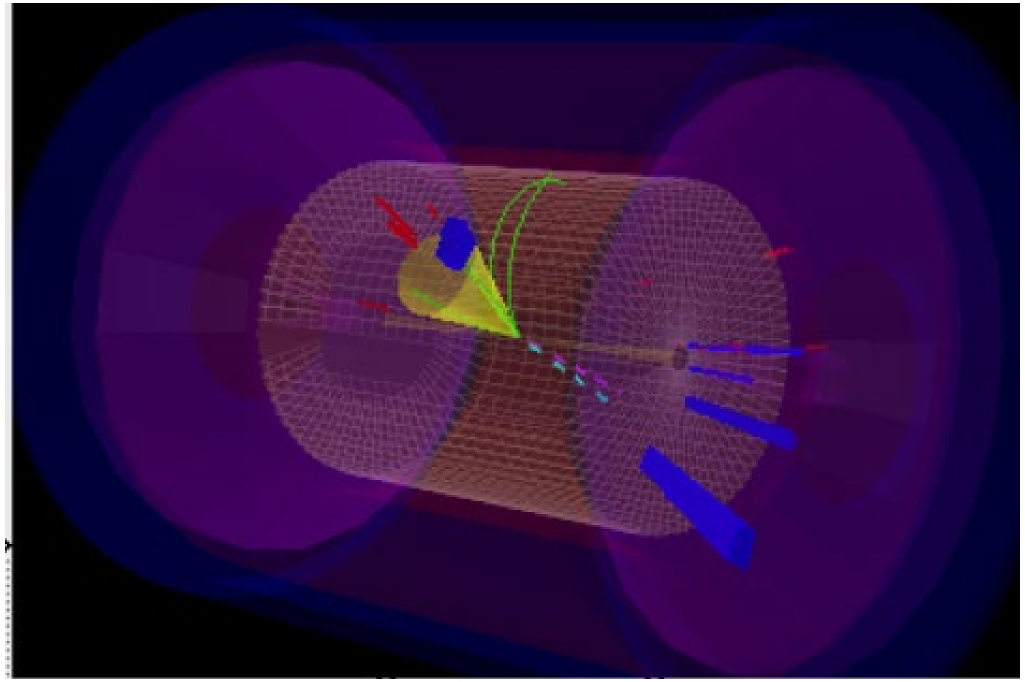
Mind the gap

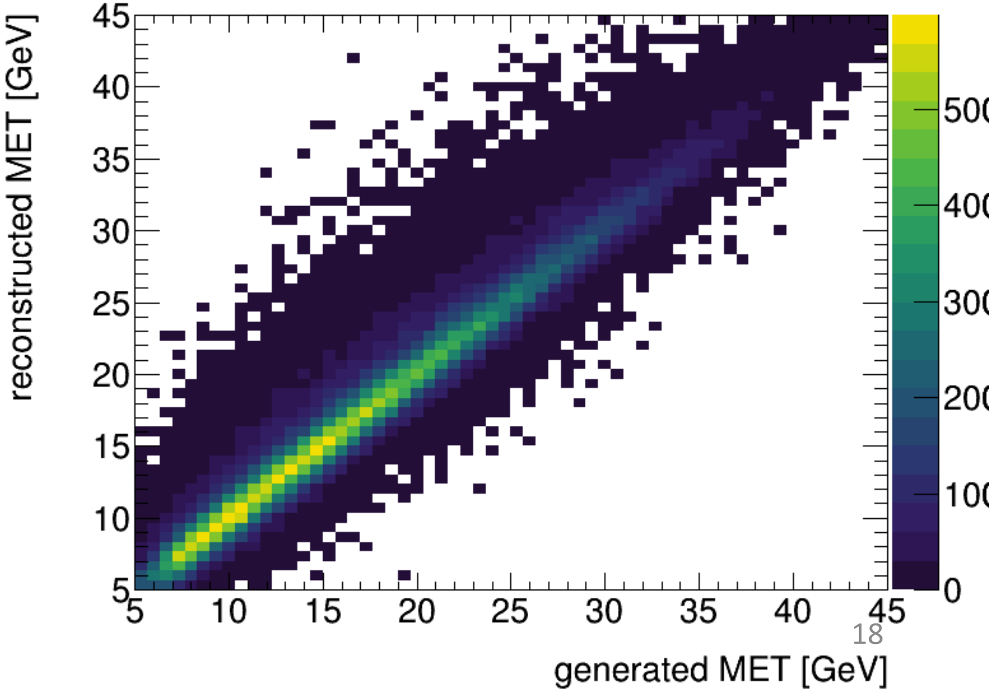


Solenoid
TOF
TOF
DIRC
DIRC
TOF
HBD
Modular RICH
Dual RICH
GEM/TRD
TOF
Dipole
p/A
e

Summary

- I propose to treat MET as a "physics object", just like jet. Study Jet/MET performance together.
- Keep in mind shape of response matrix, not just purity, because both will matter for charged-current measurements.
- HCAL everywhere absolutely required.
- Challenge is to measure as low MET as possible (lowest Q2).

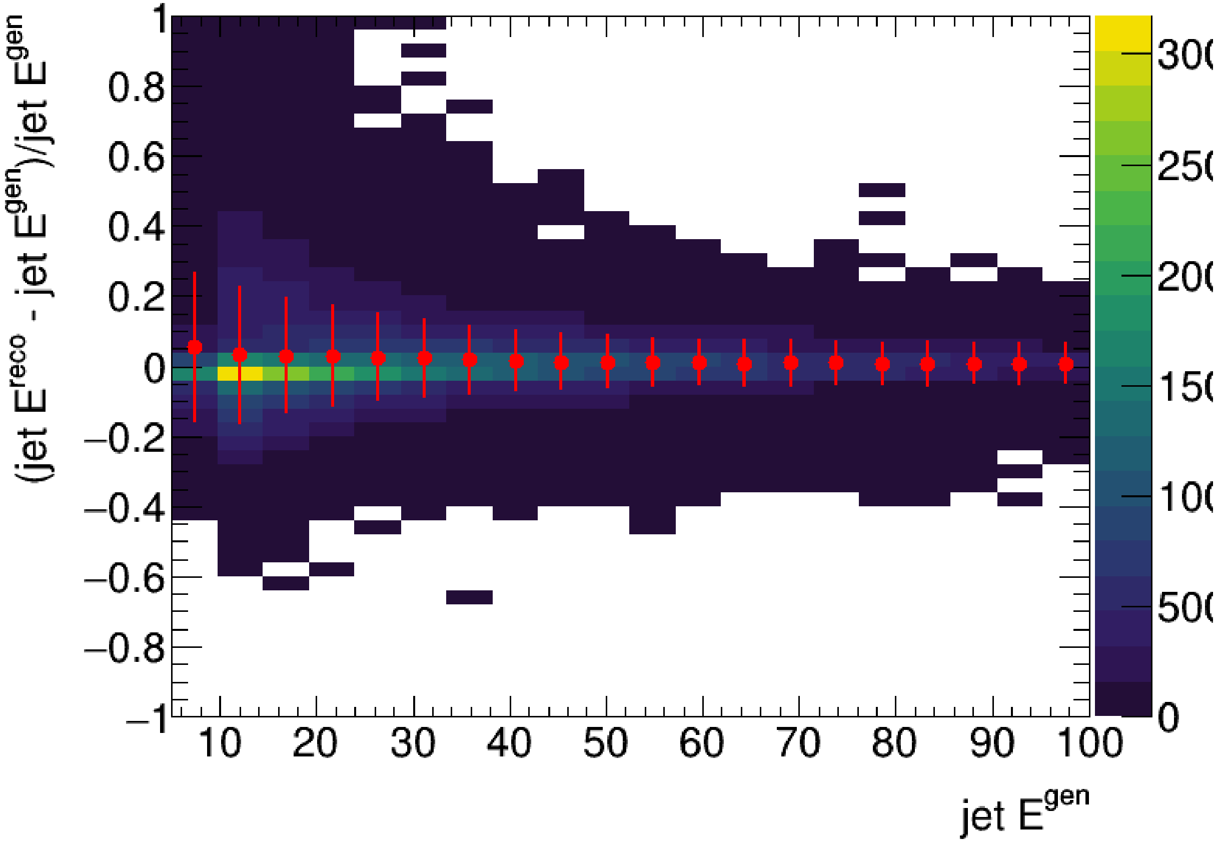




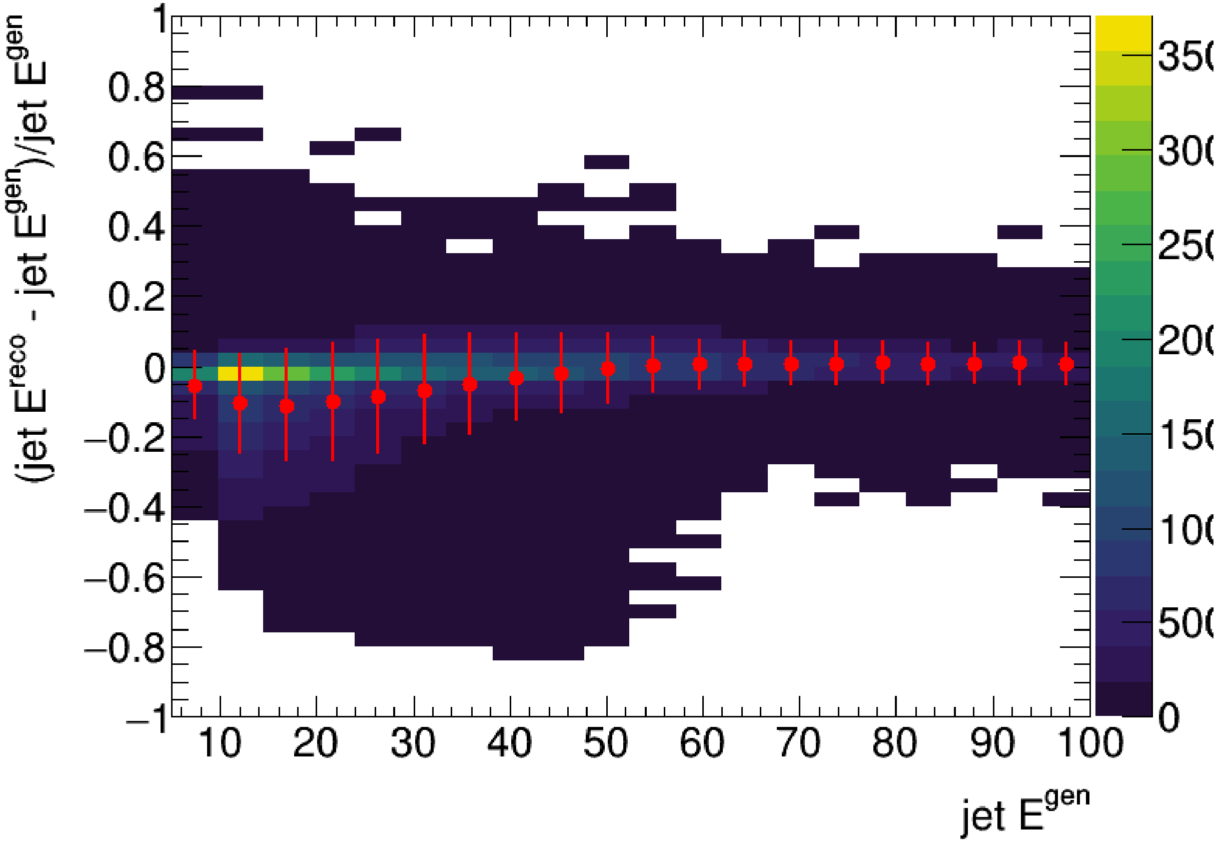
Backup

Jet energy resolution

With barrel HCAL



Without barrel HCAL



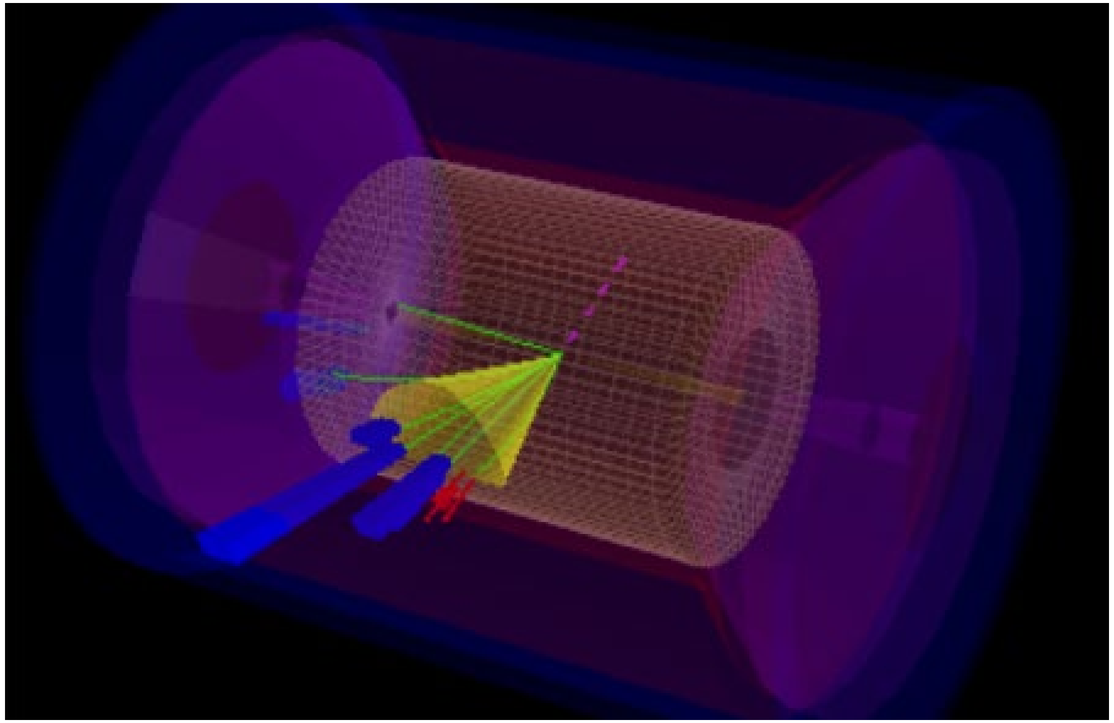
Strong bias at low jet energy

EIC detector in Delphes

https://github.com/miguelignacio/delphes_EIC/blob/master/delphes_card_EIC.tcl

Tracking resolution, EMCAL resolution and HCAL resolution as in EIC detector handbook.

In addition:



- B=1.5 T, R=0.80 m, L = 1 m
- EMCAL granularity (dphi x deta):
  0.02 x 0.02 for |eta|<3.5
- HCAL granularity (dphi x deta):
  0.1 x 0.1 for |eta|<1.0
  0.025 x 0.025 for 1.0 |eta|<4.0
  (10x10 cm2 at 3.6 m)
- HCAL resolution:
  100%/sqrt(E) + 10% in barrel (0.0—1.0)
  50%/sqrt(E) + 10% in encap (1.0—4.0)
- Tracking threshold 100 MeV pT;
  EMCAL threshold of 100 MeV; (noise ~ 30 MeV per tower)
  HCAL threshold of 500 MeV; (noise ~100 MeV per tower)
- No PID yet, but it can be included (LHCb is in Delphes).
  Need parametrization of efficiency and mis-identification matrix