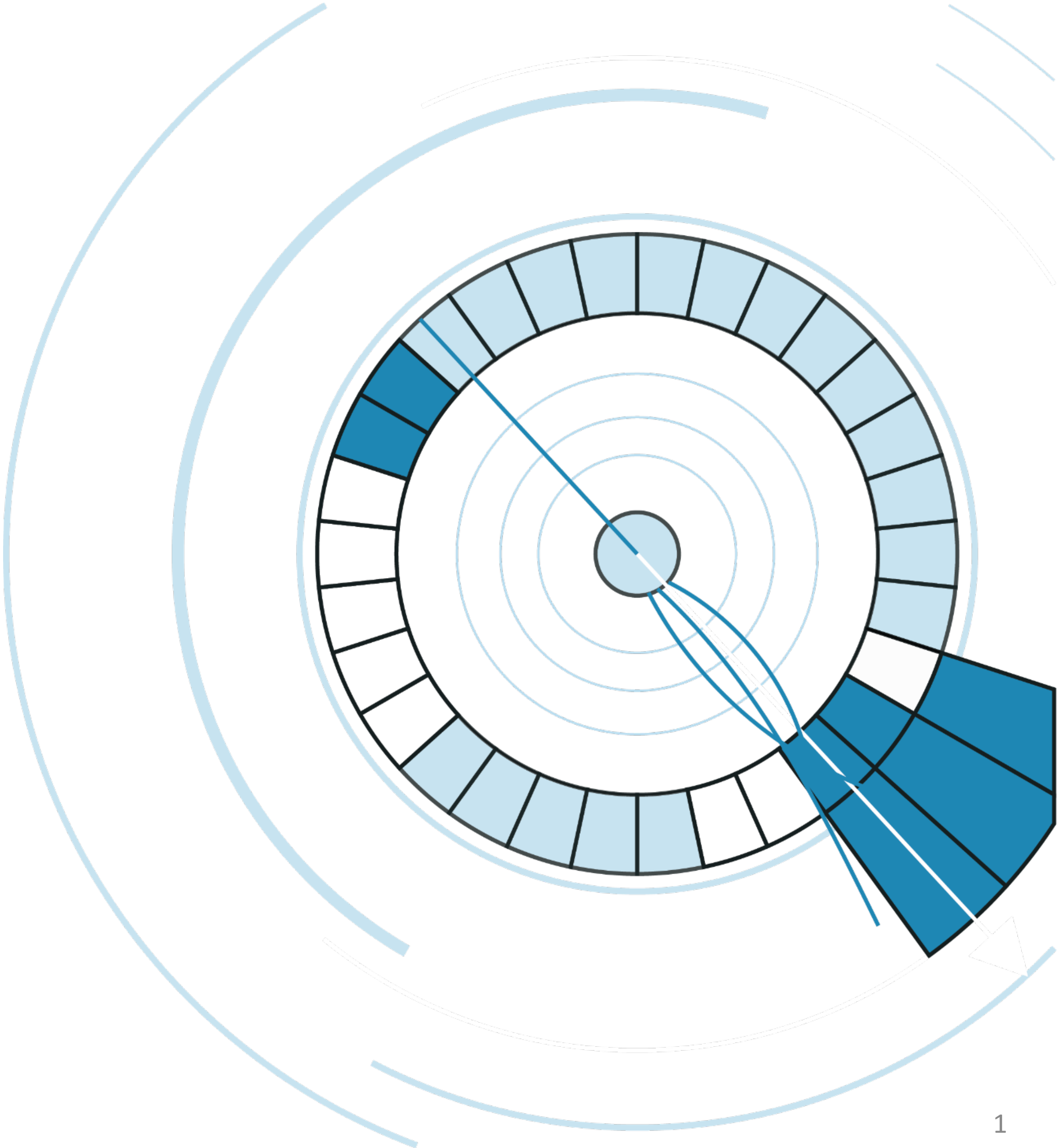
Jets for 3D imaging

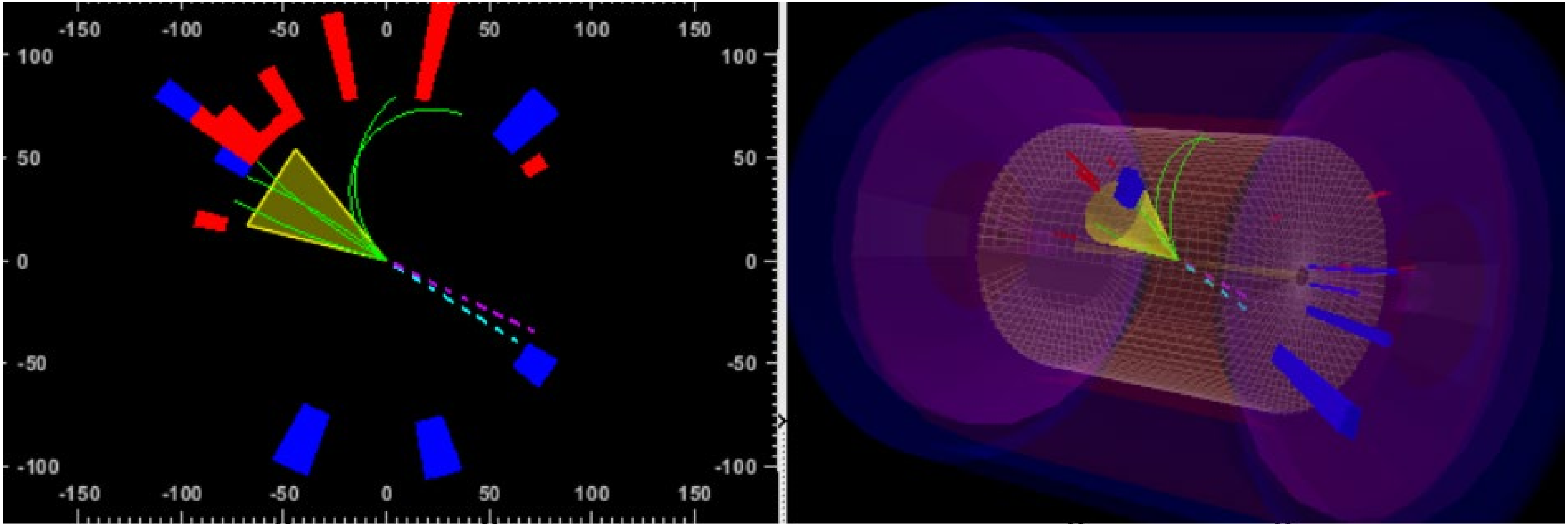
Miguel Arratia

UC RIVERSIDE
UNIVERSITY OF CALIFORNIA

Calorimetry group, May 19th 2020



Charged-current DIS at the EIC



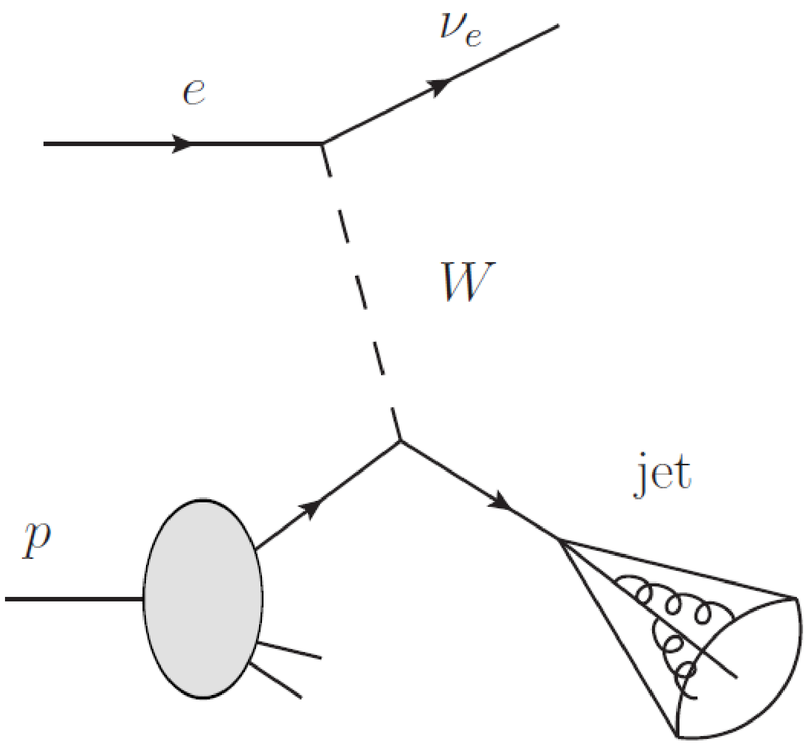
Delphes fast simulation of an EIC detector and Pythia8 charged-current DIS event

“Jacquet-Blondel Method”

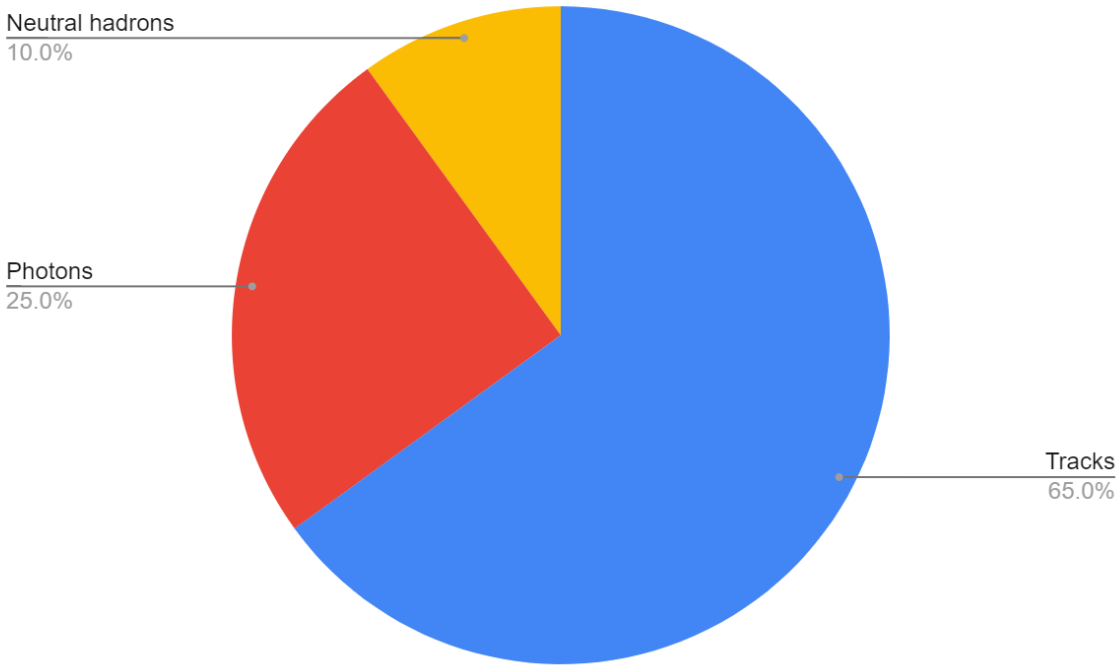
$$y_{\mathrm{JB}} = \frac{\sum_i (E_i - p_{Z,i})}{2\ E_e}, \qquad Q^2_{\mathrm{JB}} = \frac{(p_T^{\mathrm{miss}})^2}{1 - y_{\mathrm{JB}}} \qquad \text{and} \qquad x_{\mathrm{JB}} = \frac{Q^2_{\mathrm{JB}}}{s\ y_{\mathrm{JB}}},$$

I would rather call it “Missing Energy method”

- I propose we treat “Missing-Transverse-Energy” as a “physics 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.



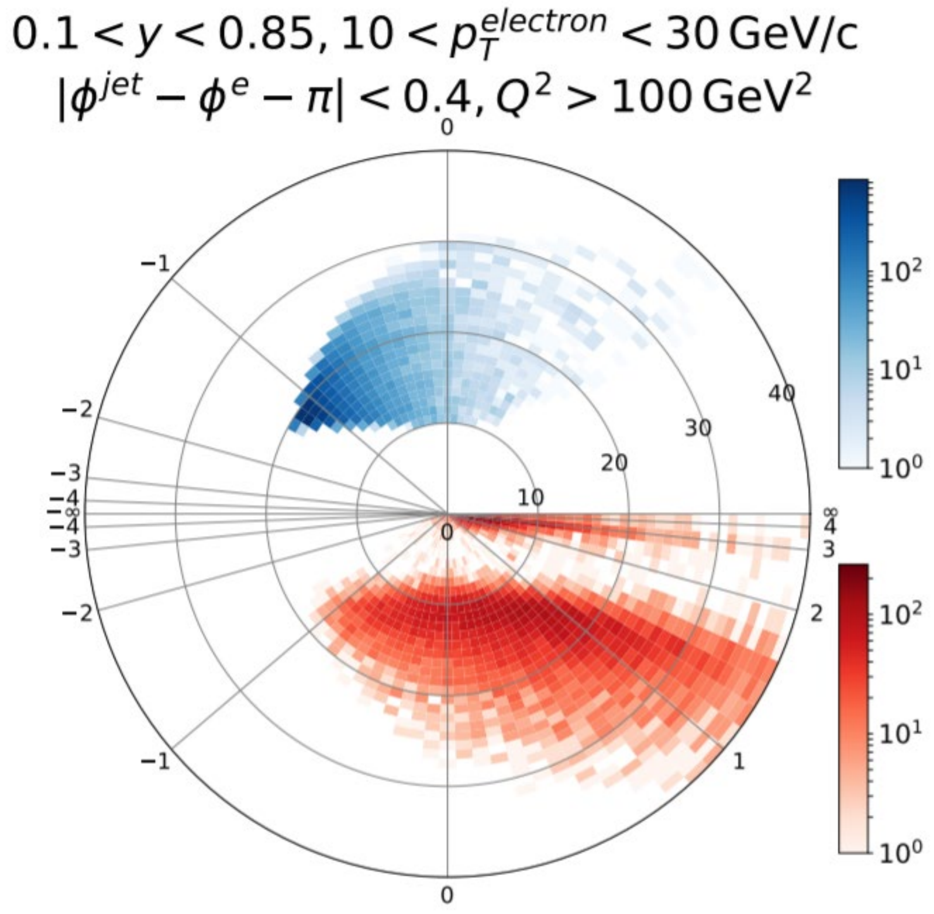
Jet/MET budget



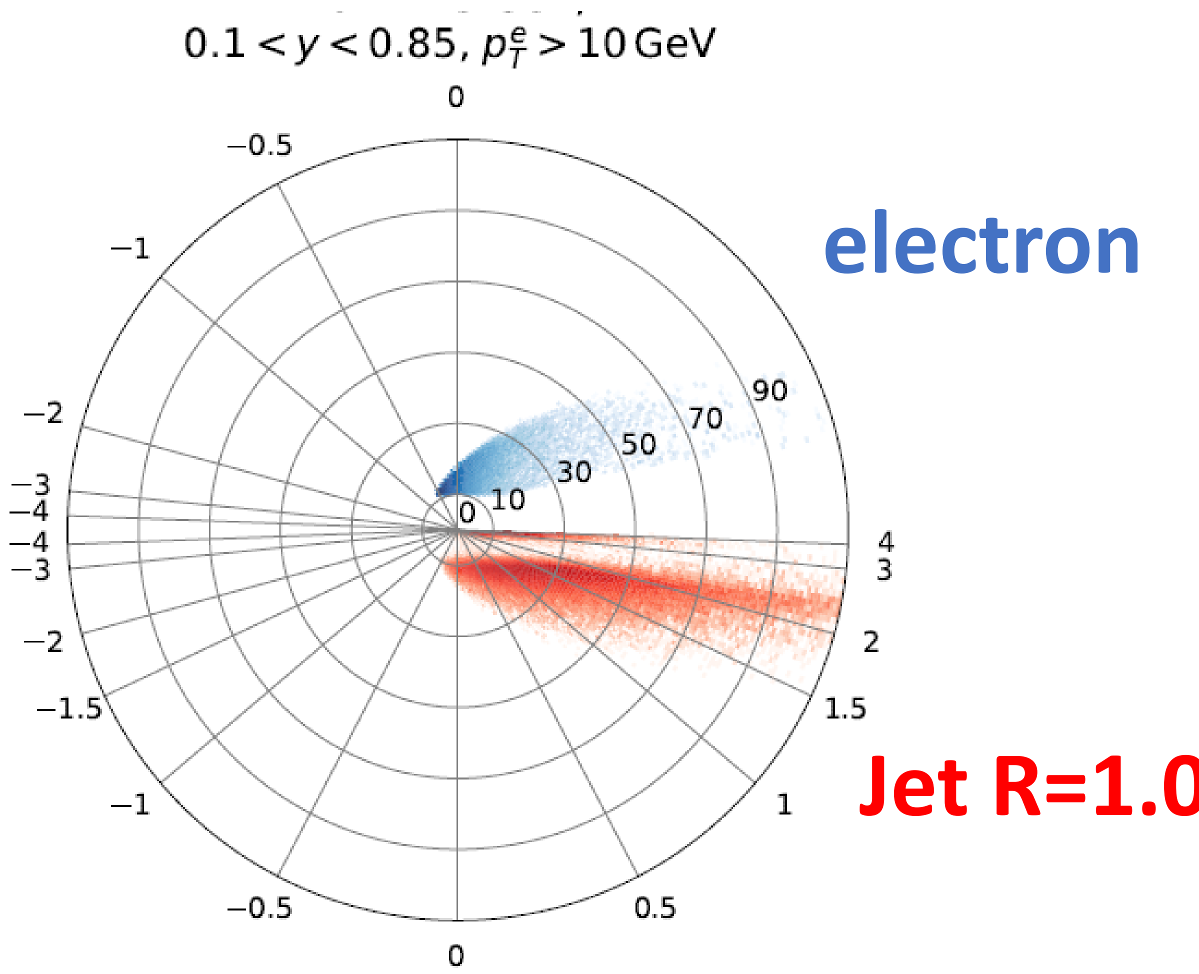
- For accurate jet and MET measurements, we need to be able to capture everything.
- Full HCAL coverage crucial: neutral hadrons, the last 10%, drive the resolution.
- Thresholds on both tracking and calorimetry are crucial.
- Tracking resolution negligible.
- ECAL resolution for photons will not be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

Jet kinematics

18+100 GeV

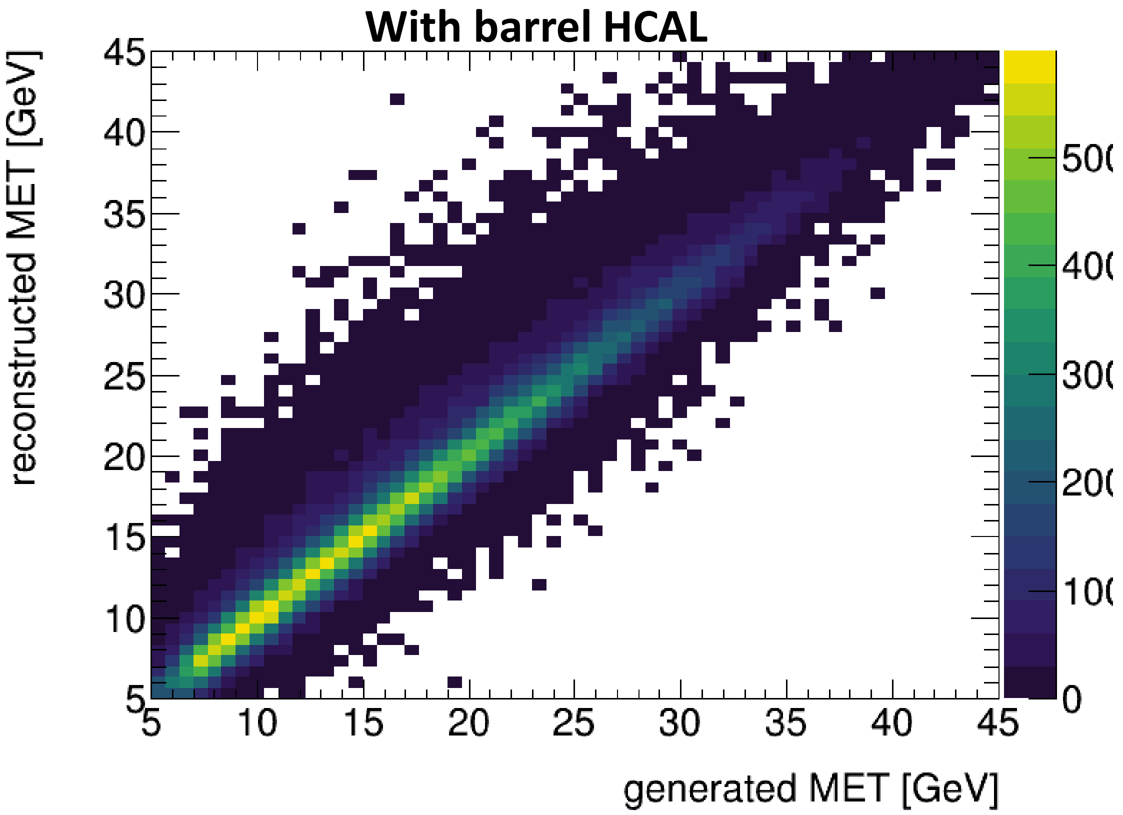


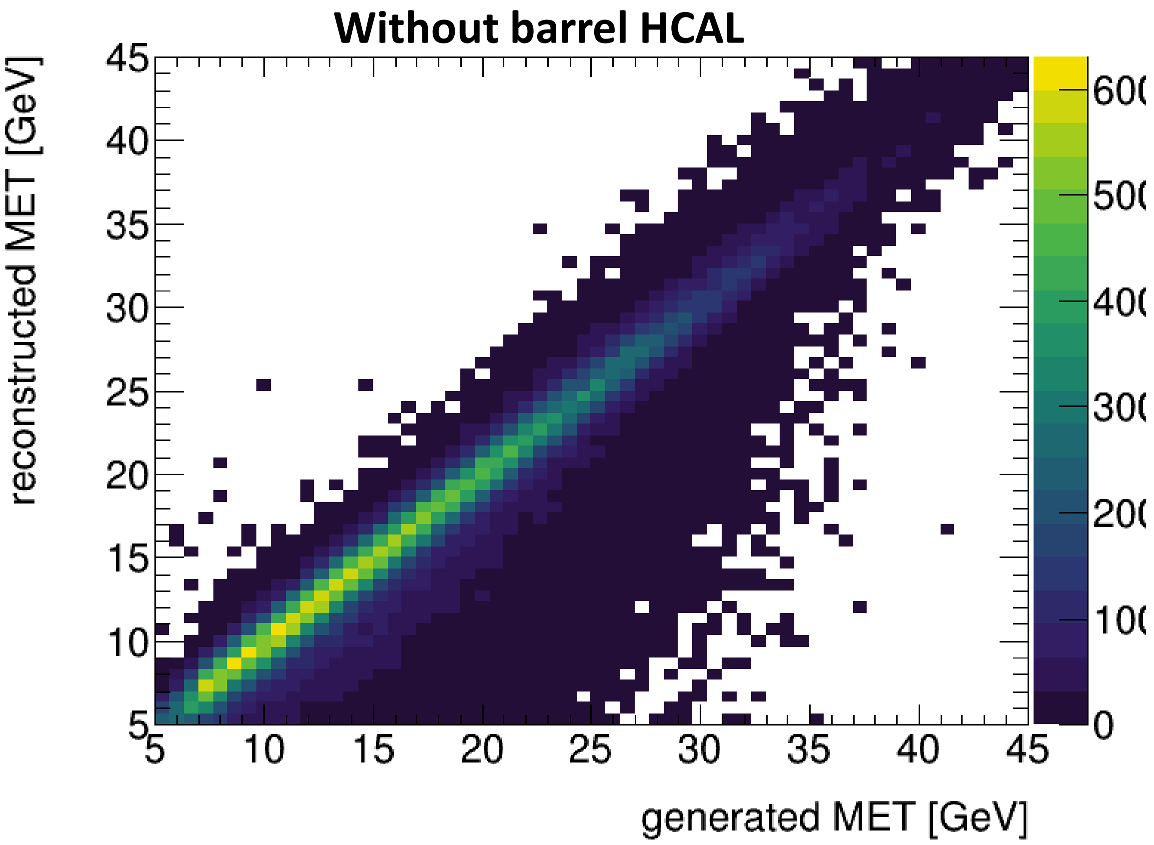
10+275 GeV



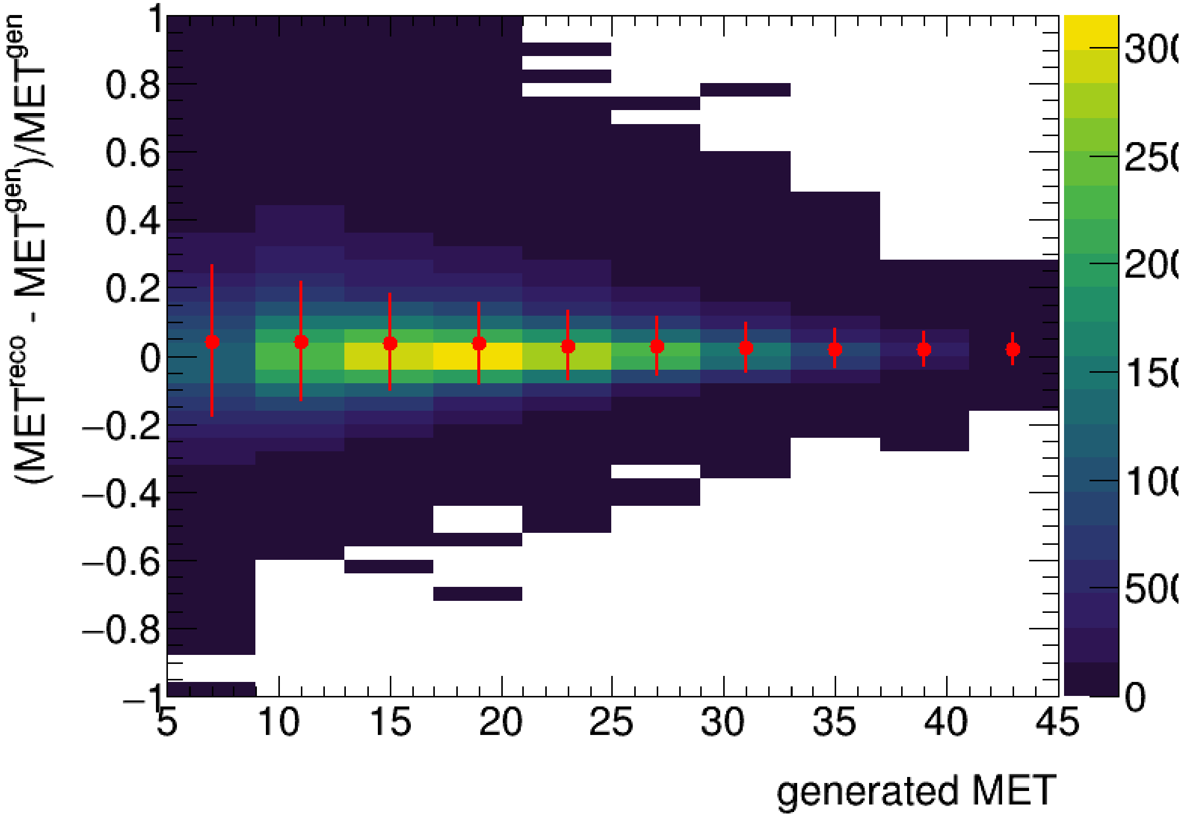
https://arxiv.org/pdf/1912.05931.pdf

Missing transverse-energy

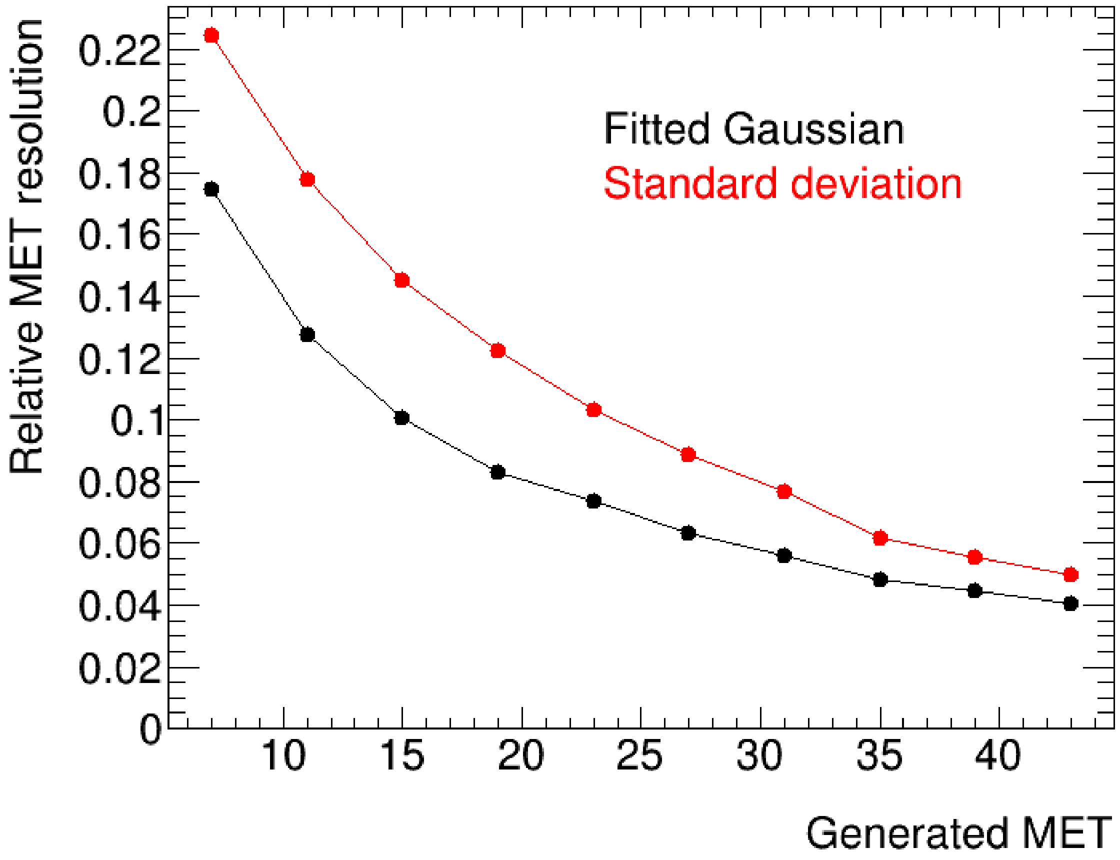




Neutrino pT



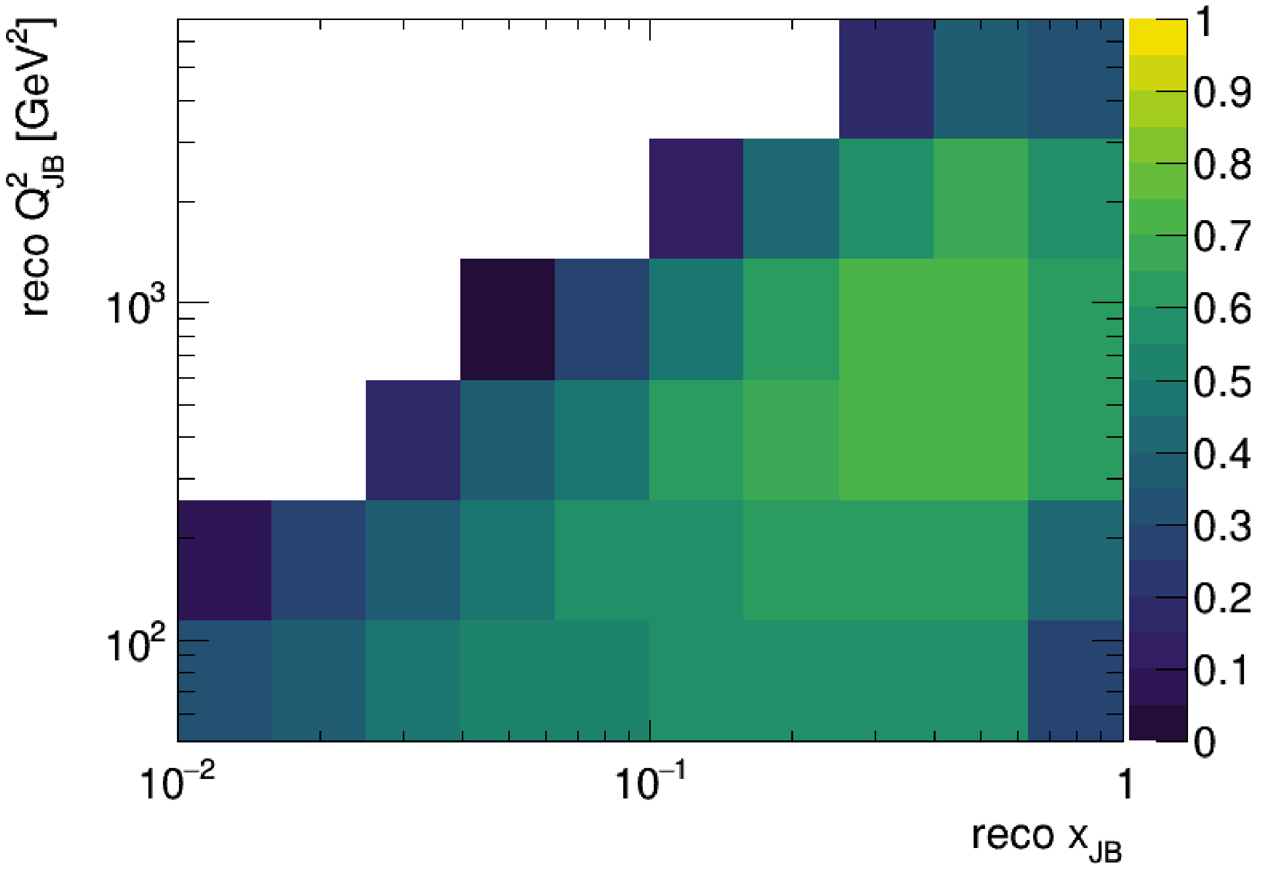
(MET^reco - MET^gen)/MET^gen
generated MET



Relative MET resolution
Fitted Gaussian
Standard deviation
Generated MET

Jacquet-Blondel Purity

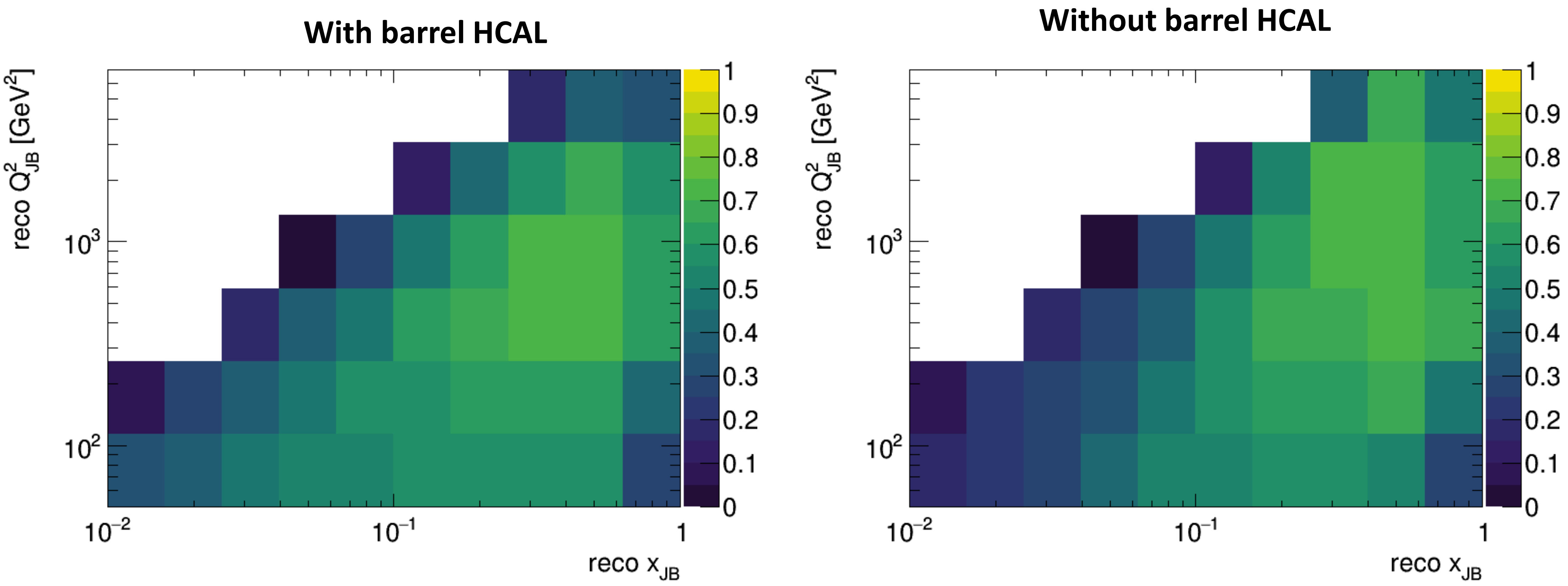
$$\text{purity} = (N_{gen} - N_{out})/(N_{gen} - N_{out} + N_{in})$$



- 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

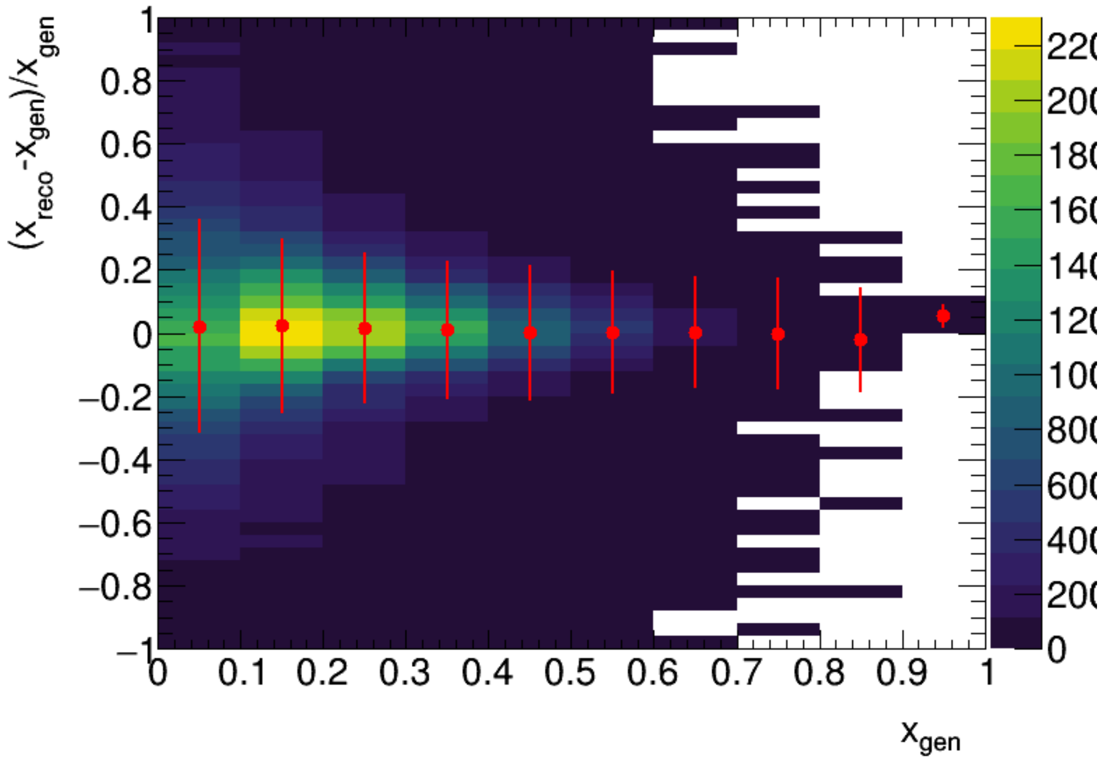
$$\text{purity} = (N_{gen} - N_{out})/(N_{gen} - N_{out} + N_{in})$$



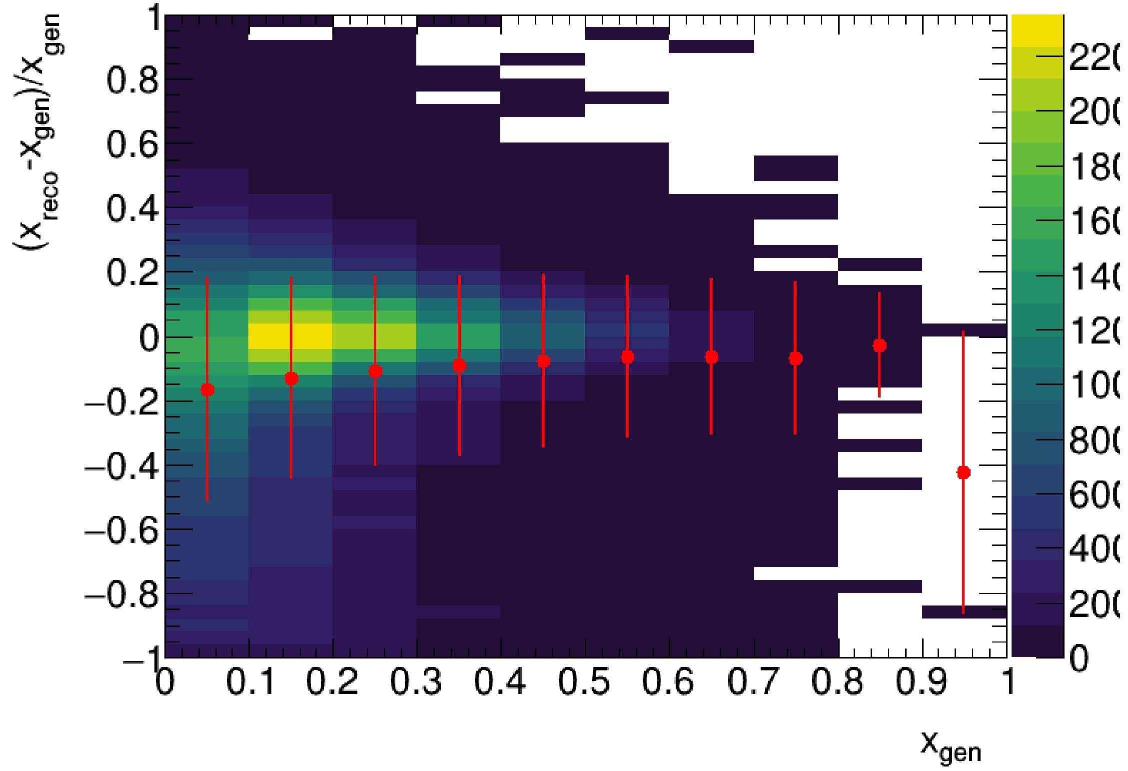
Bjorken x performance

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

With barrel HCAL



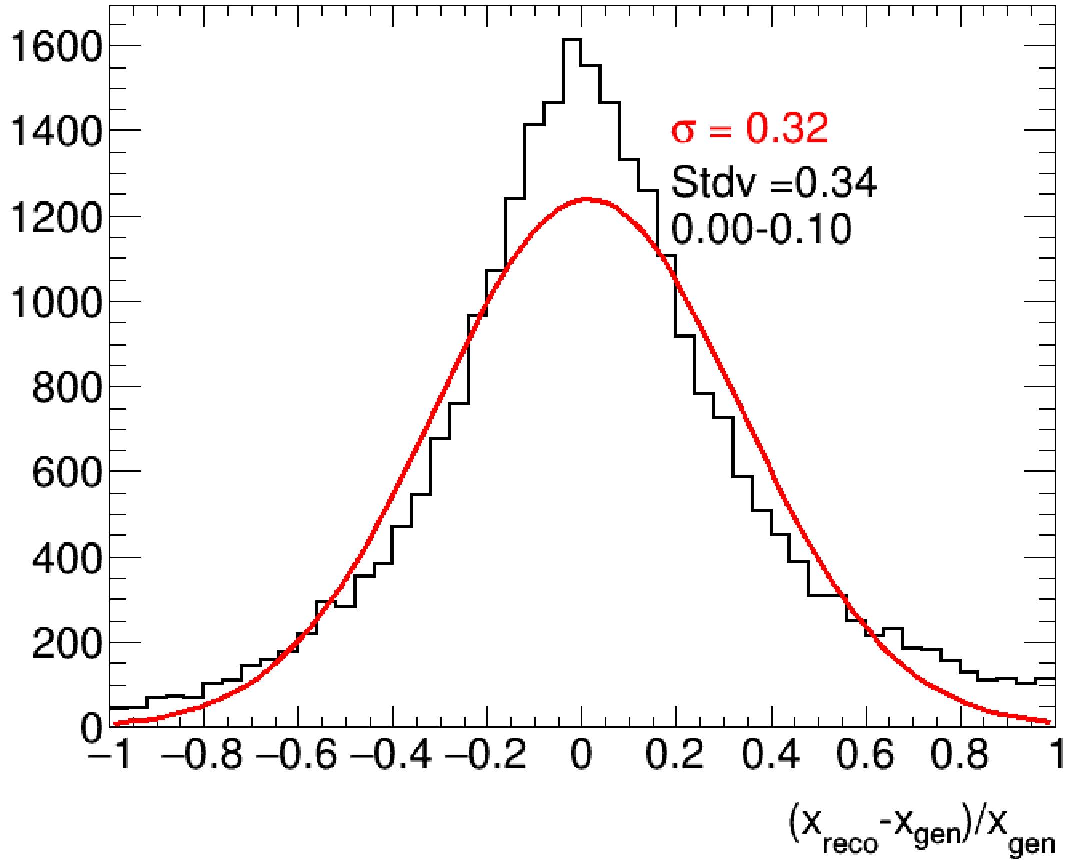
Without barrel HCAL



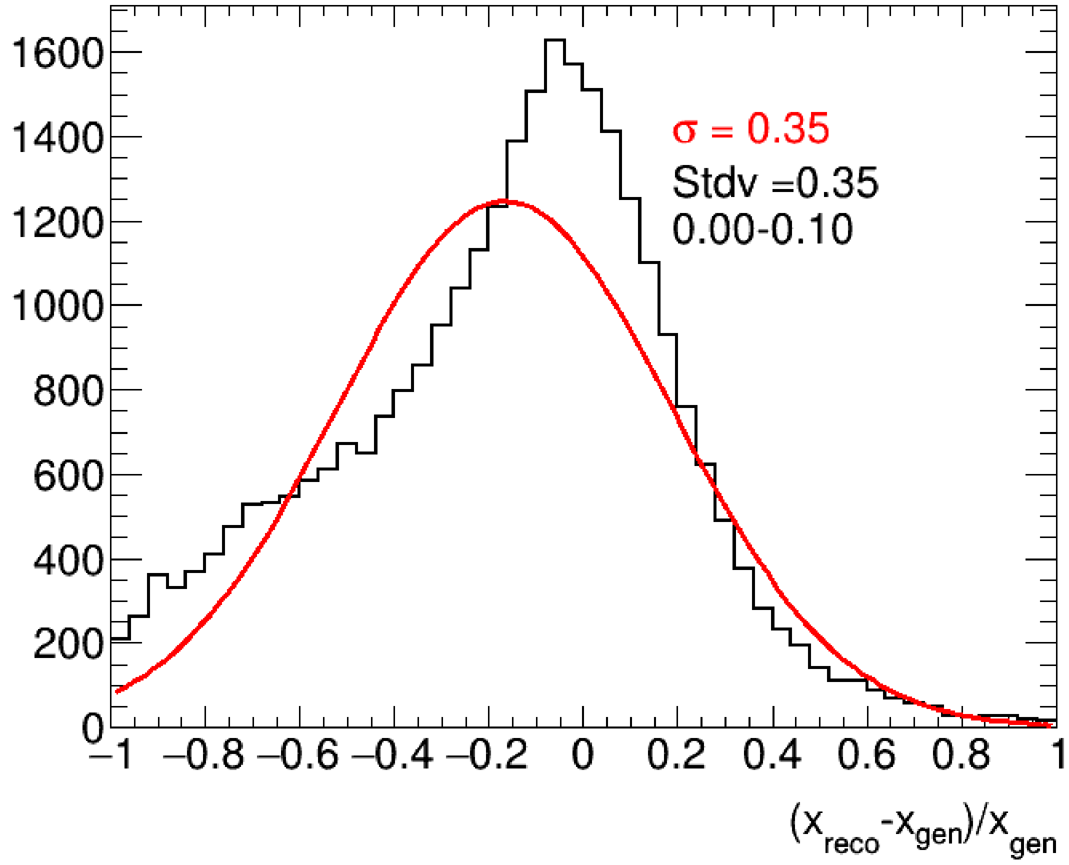
Strong bias at low x
(low jet energy)

Bjorken x reconstruction

With barrel HCAL

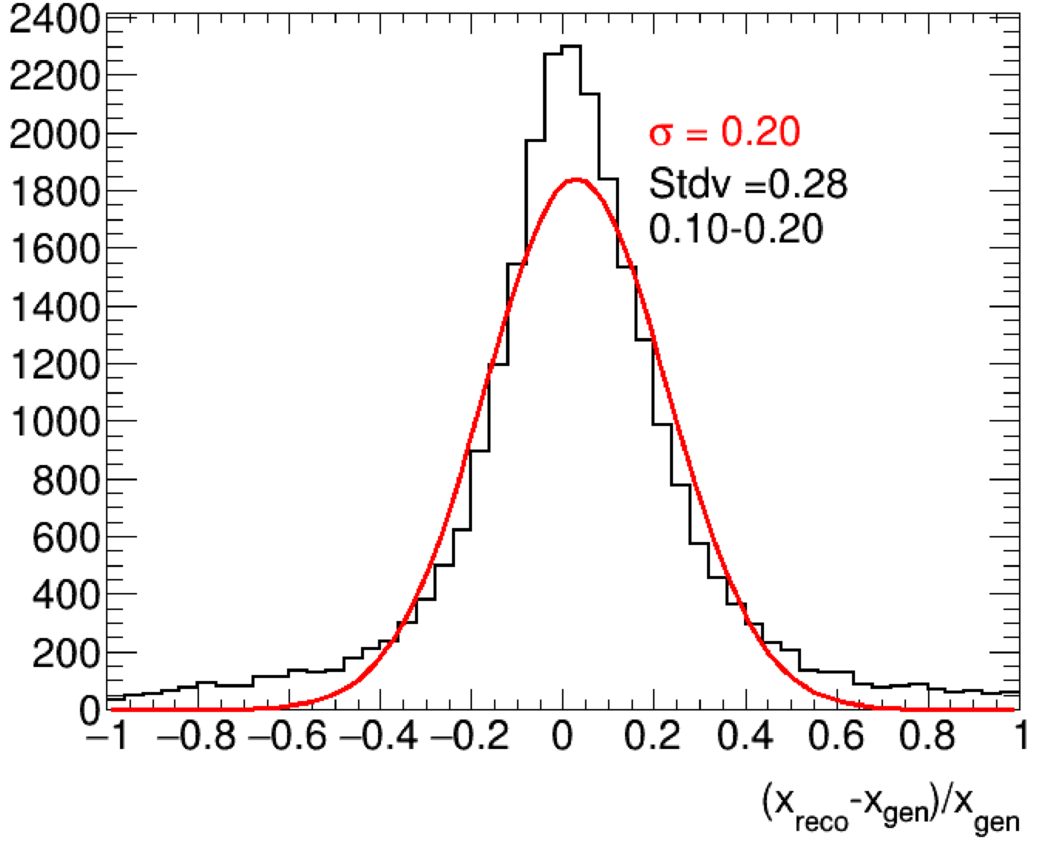


Without barrel HCAL

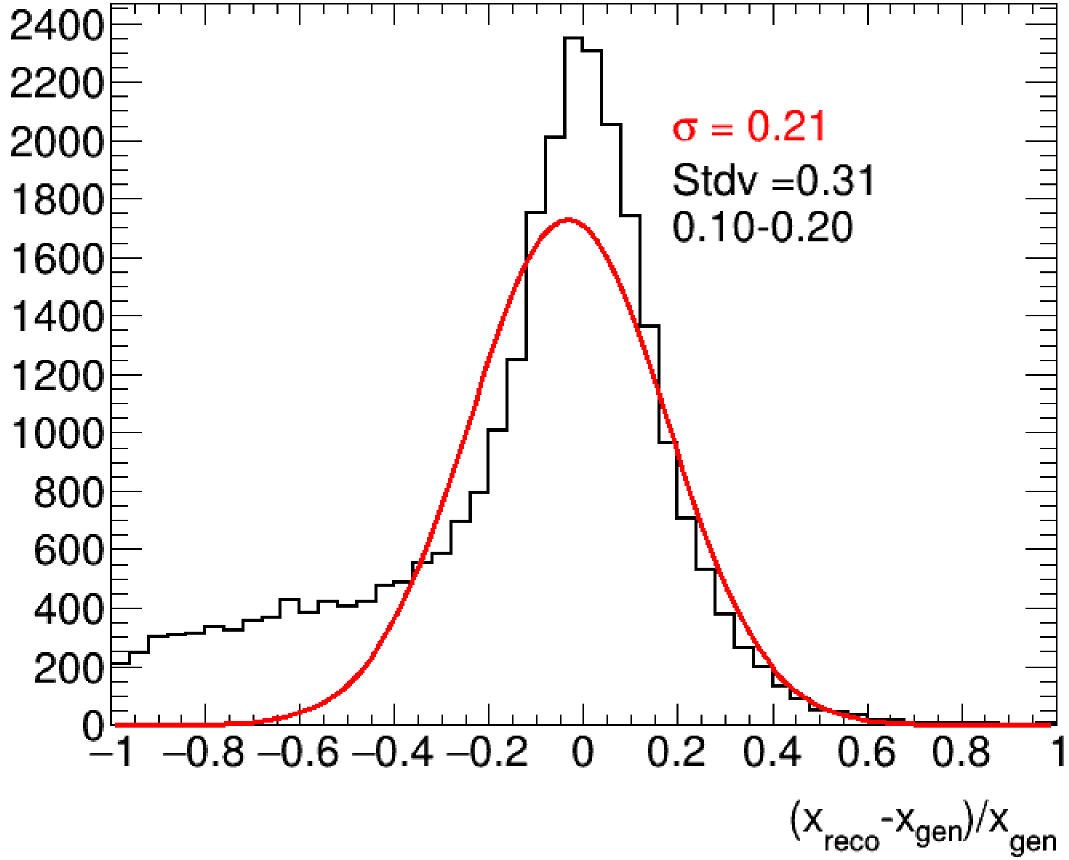


Bjorken x reconstruction

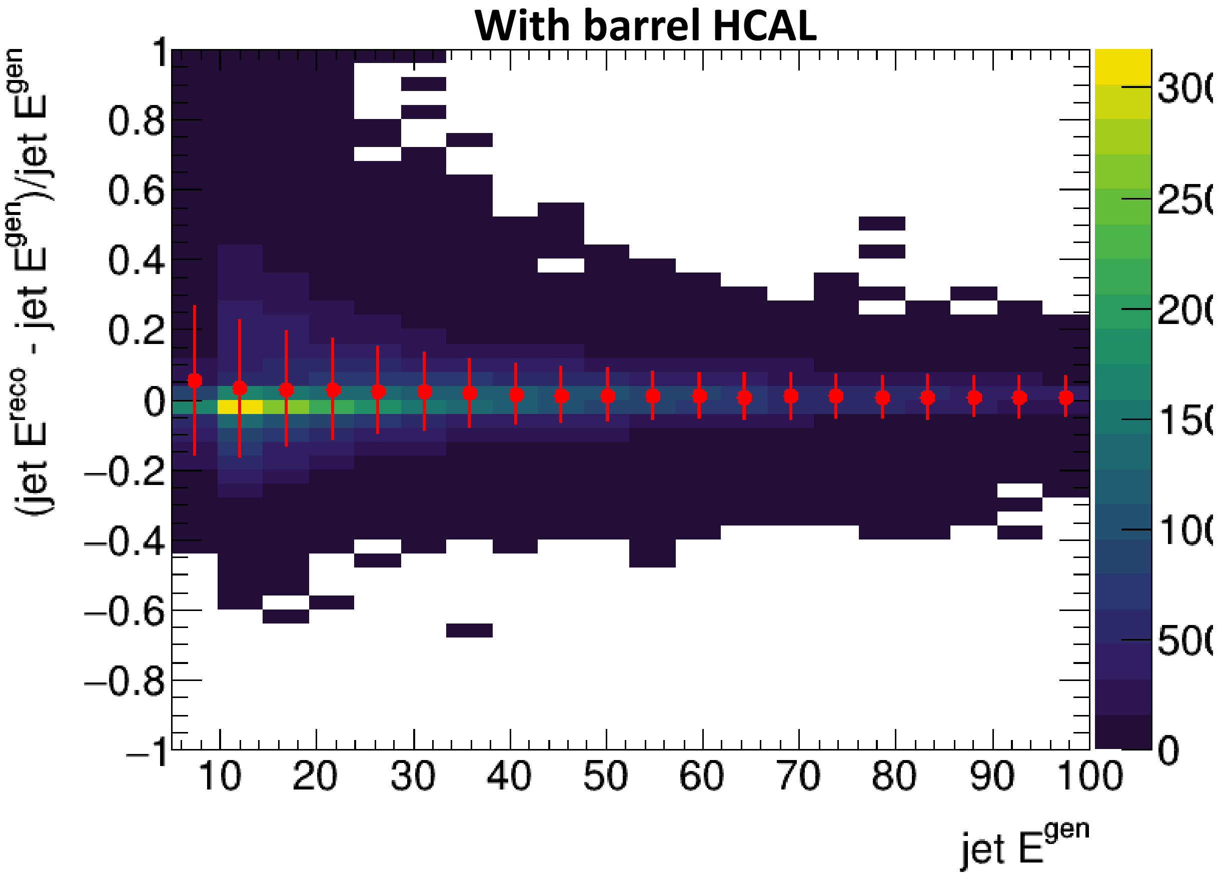
With barrel HCAL

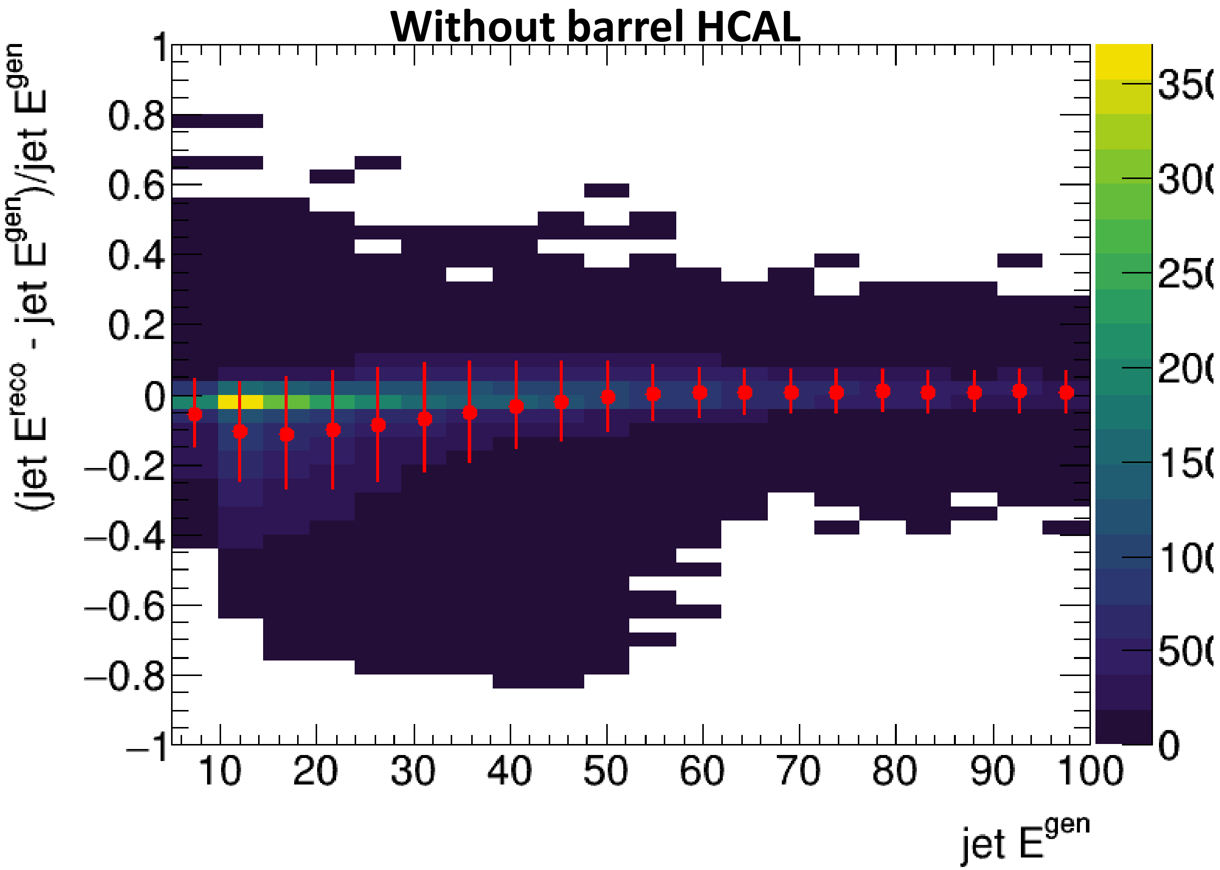


Without barrel HCAL



Jet energy resolution



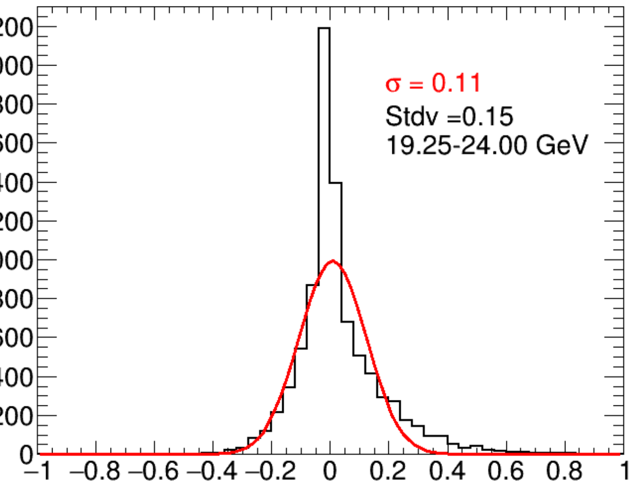


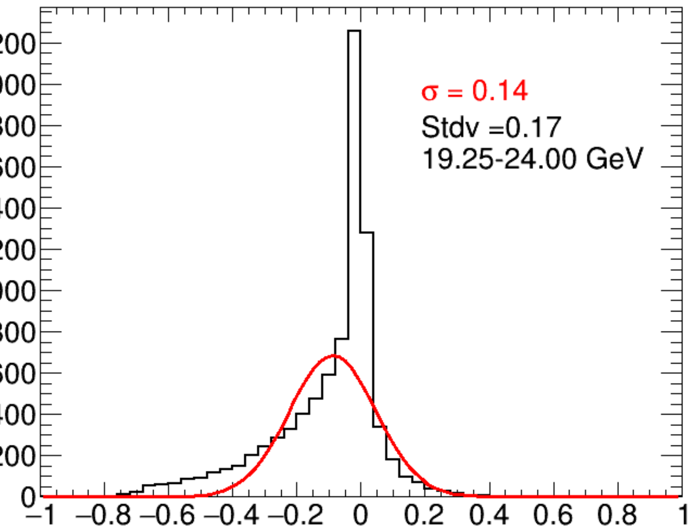
Strong bias at low jet energy

Jet energy resolution

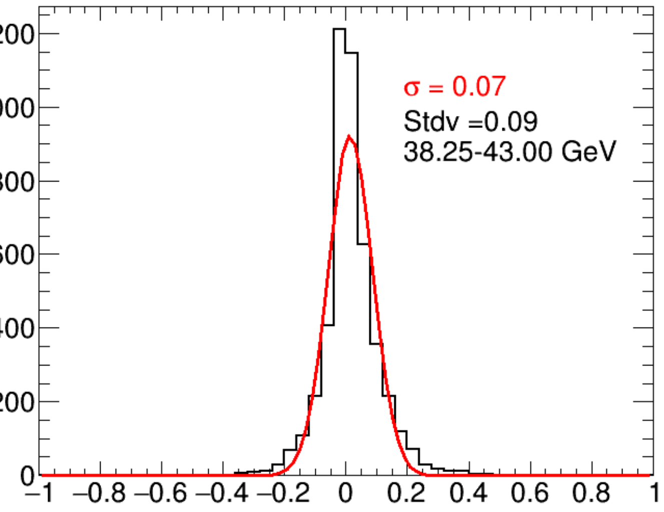
With barrel HCAL | **Without barrel HCAL**

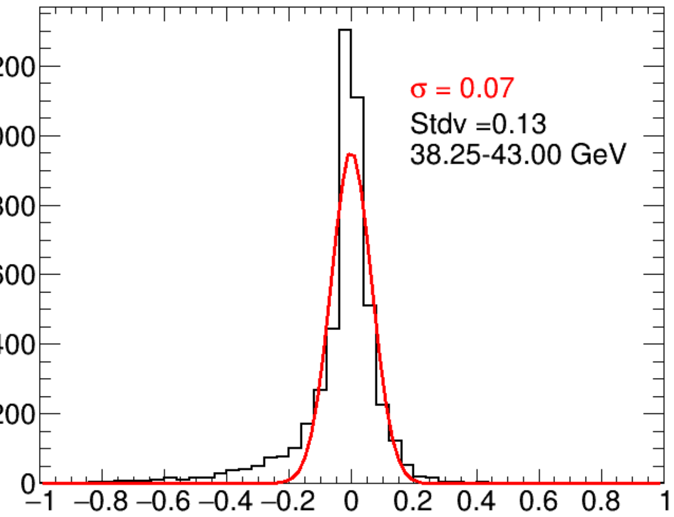
~20 GeV





~40 GeV

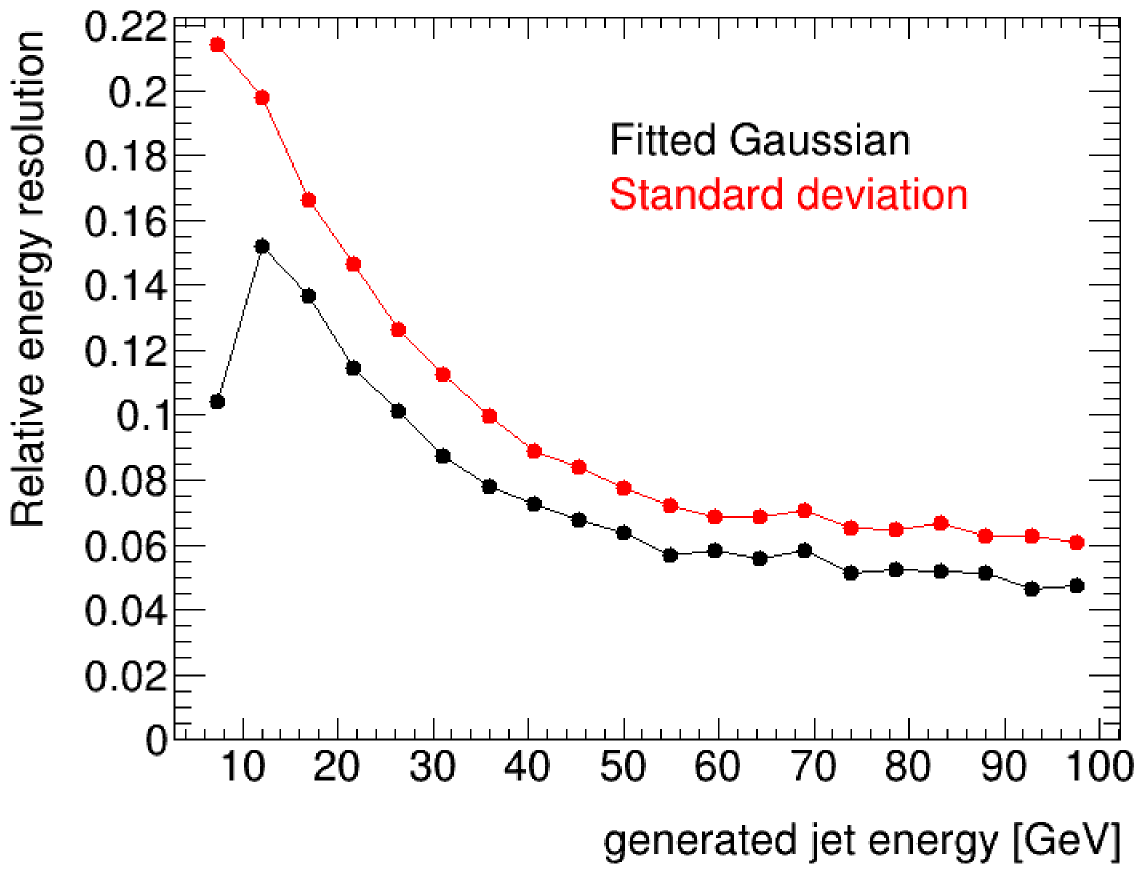




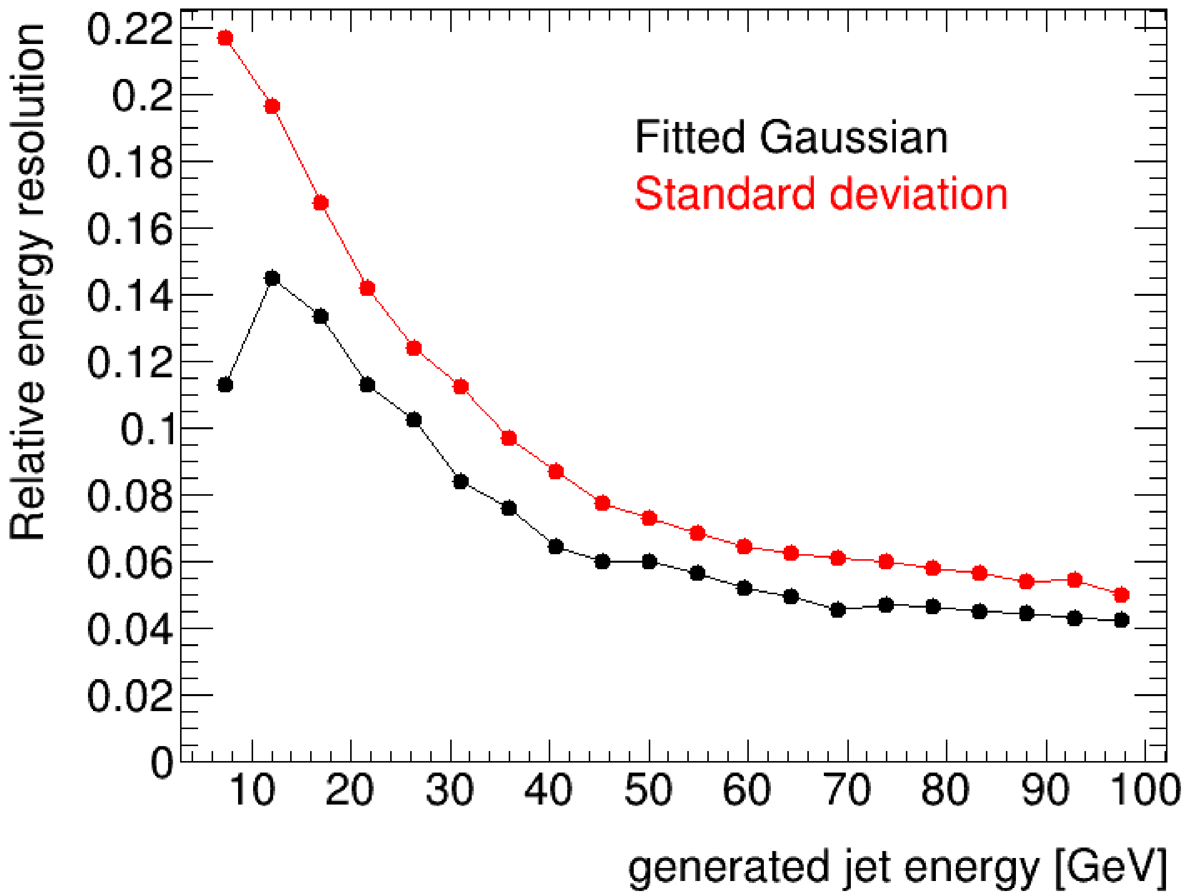
Similar conclusions than Page et al. PRD 101, 072003 (2020)

Jet energy resolution

50%/sqrt(E) + 10%

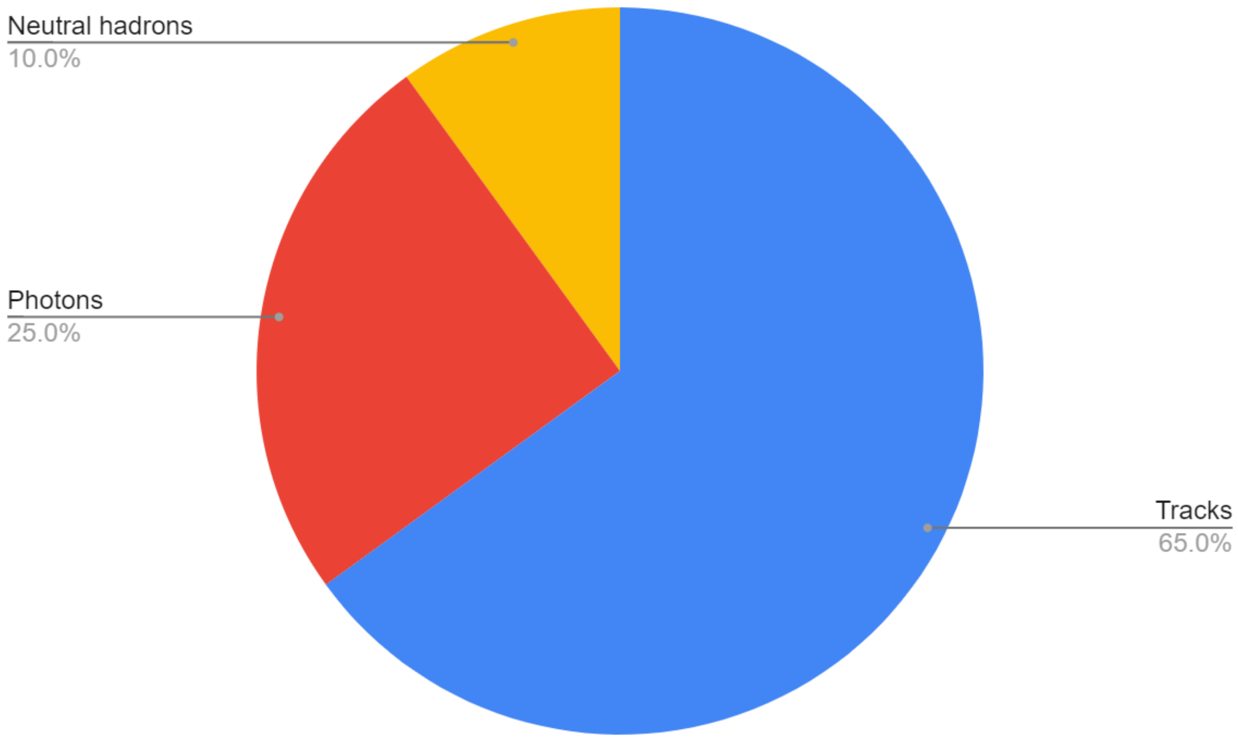


50%/sqrt(E) + 5%



Not strong effect, but need to revisit with more realistic tracking resolution

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



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

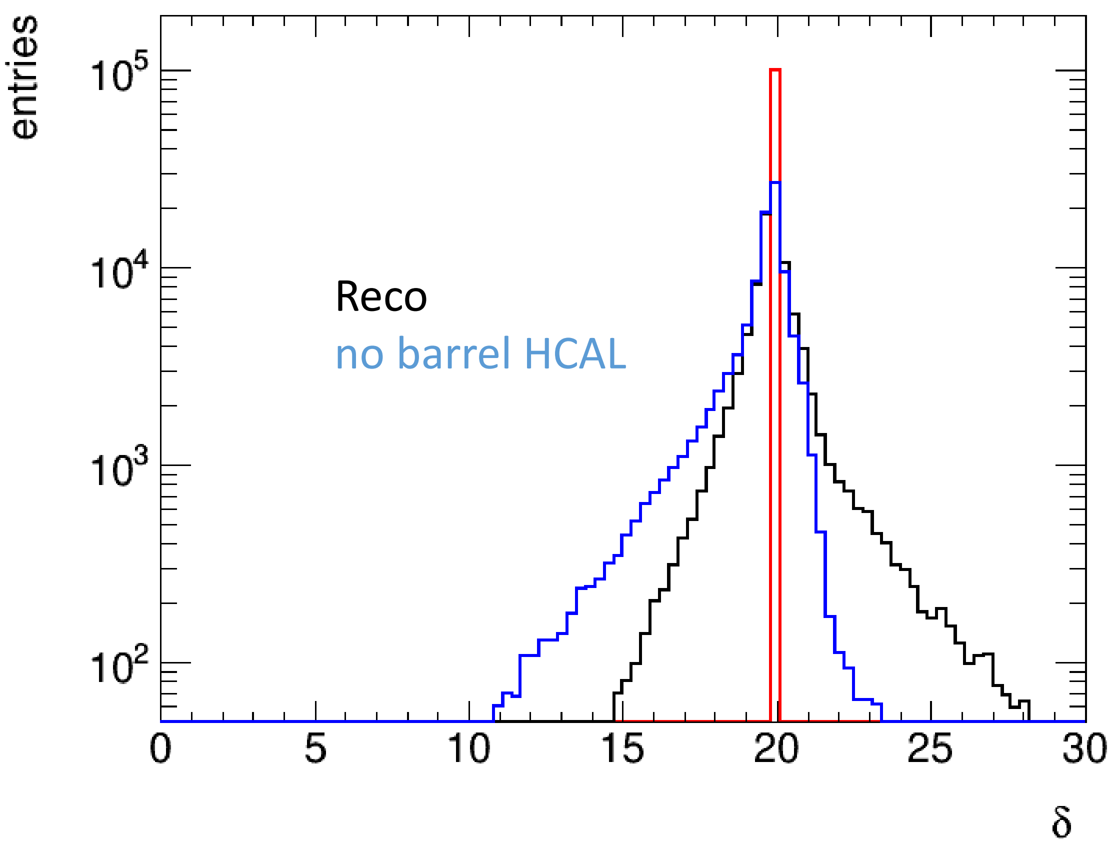
You can try to “correct“ for the missing neutral hadrons using MC, but then you become sensitive to things that are very difficult to model accurately:

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

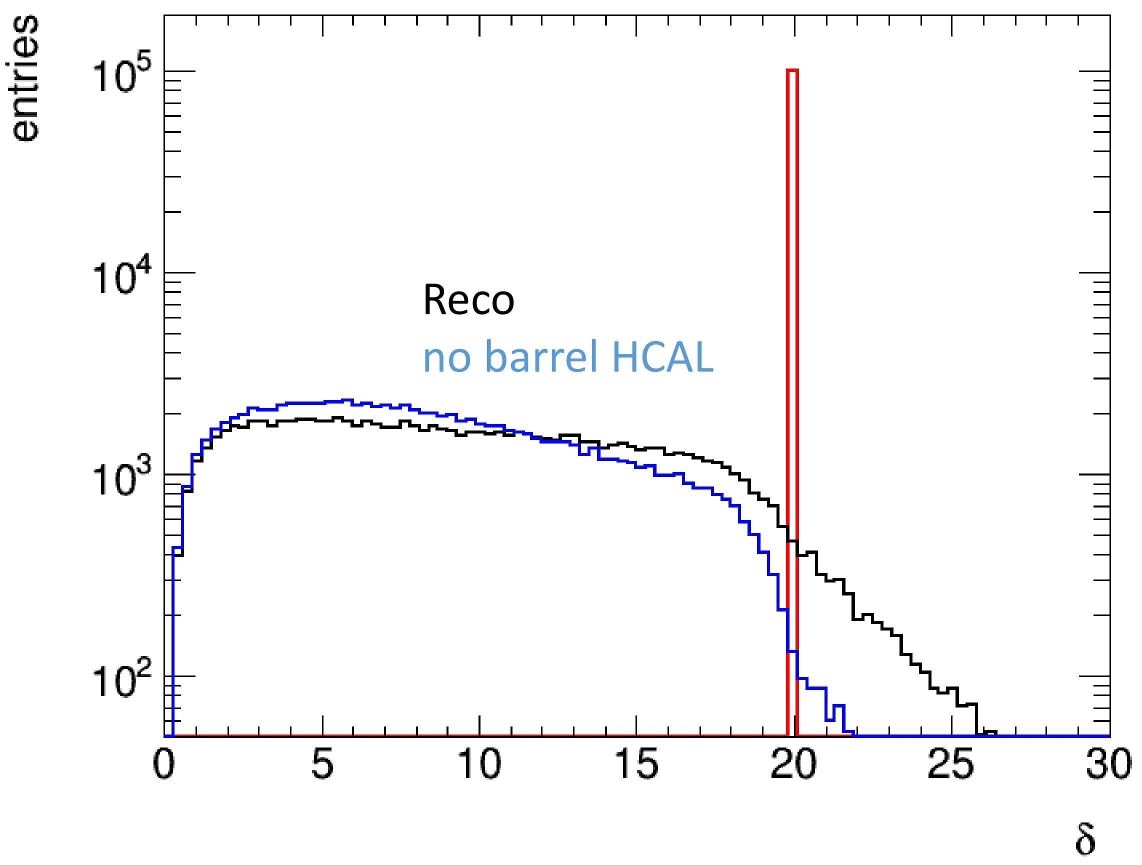
Background rejection

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

NC DIS

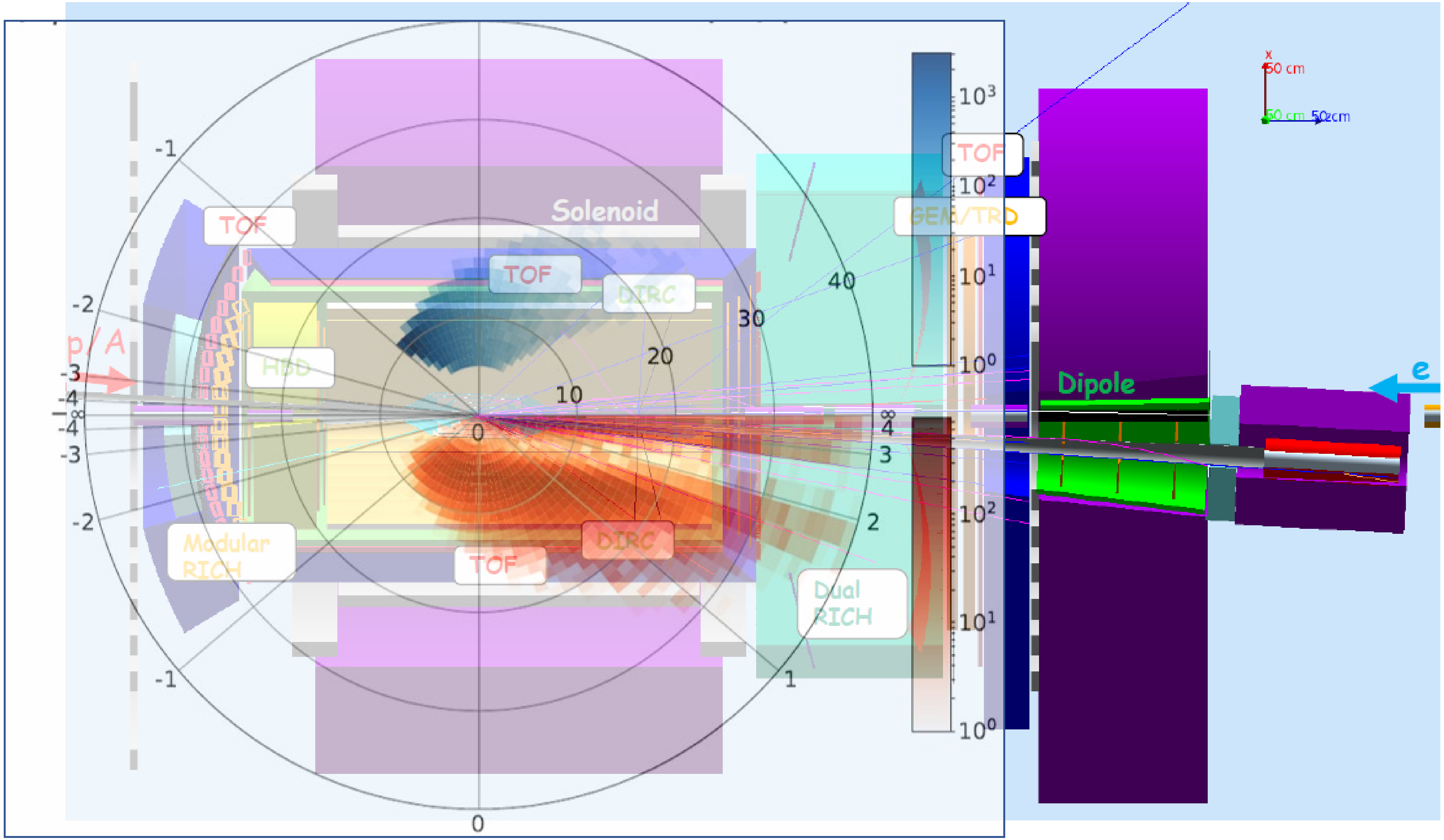


CC DIS



- 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

Mind the gap



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

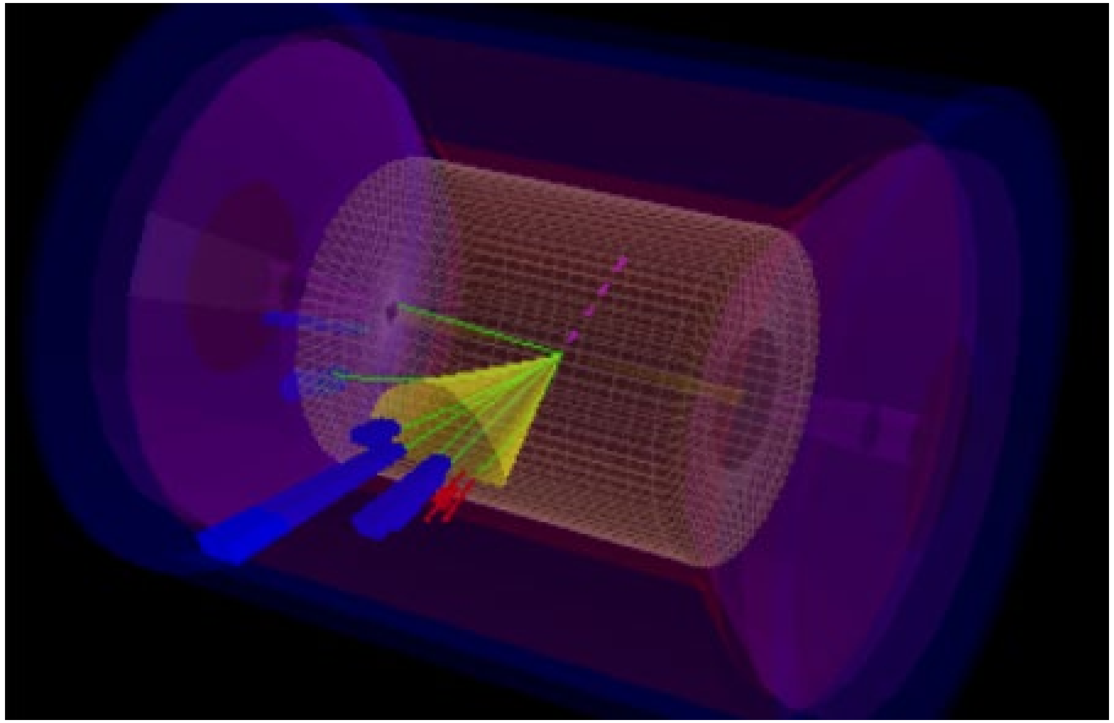
Backup

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