Jets for 3D imaging

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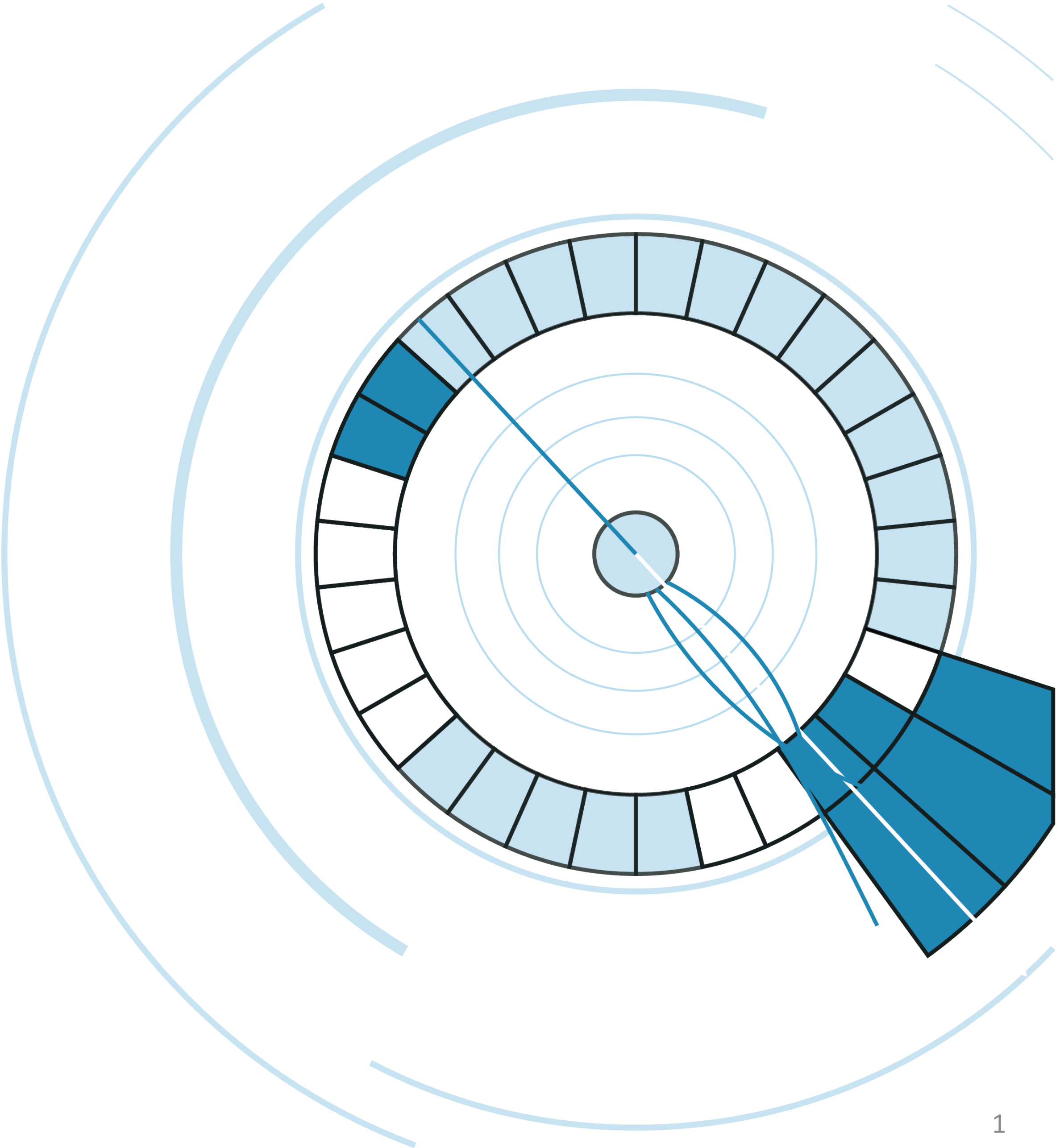


Fast simulation with Delphes3

DELPHES 3, A modular framework for fast simulation of a generic collider experiment
DELPHES 3 Collaboration (J. de Favereau *et al.*). Jul 24, 2013. 26 pp.
Published in **JHEP 1402 (2014) 057**
DOI: 10.1007/JHEP02(2014)057
e-Print: **arXiv:1307.6346 [hep-ex] | PDF**

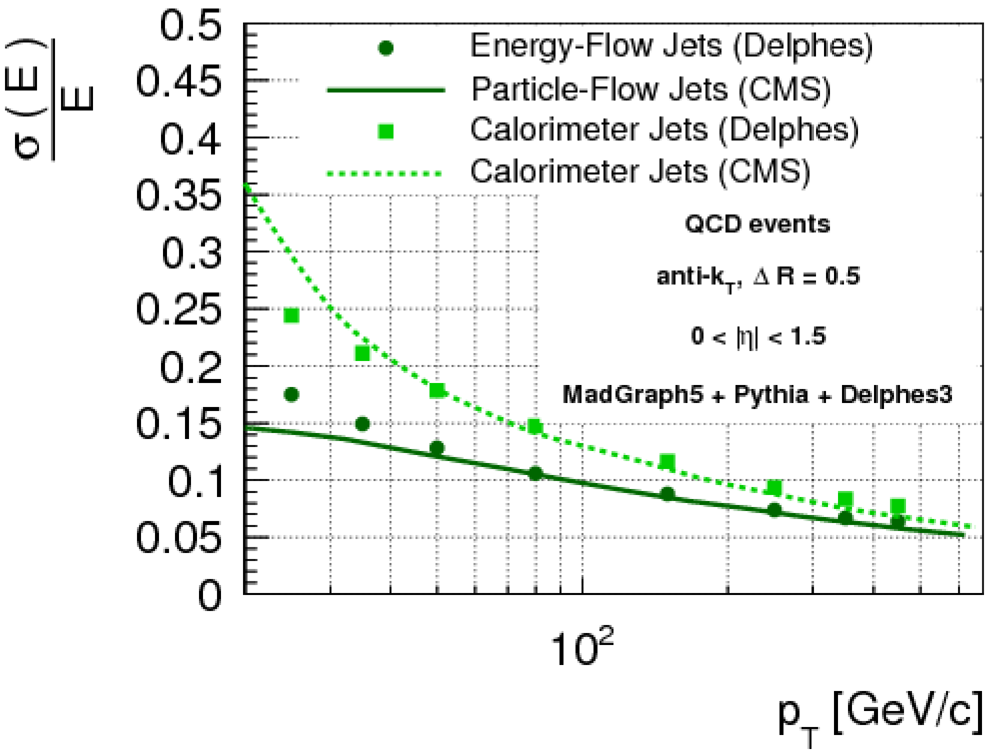
References | BibTeX | LaTeX(US) | LaTeX(EU) | Harvmac | EndNote
ADS Abstract Service; Link to Article from SCOAP3

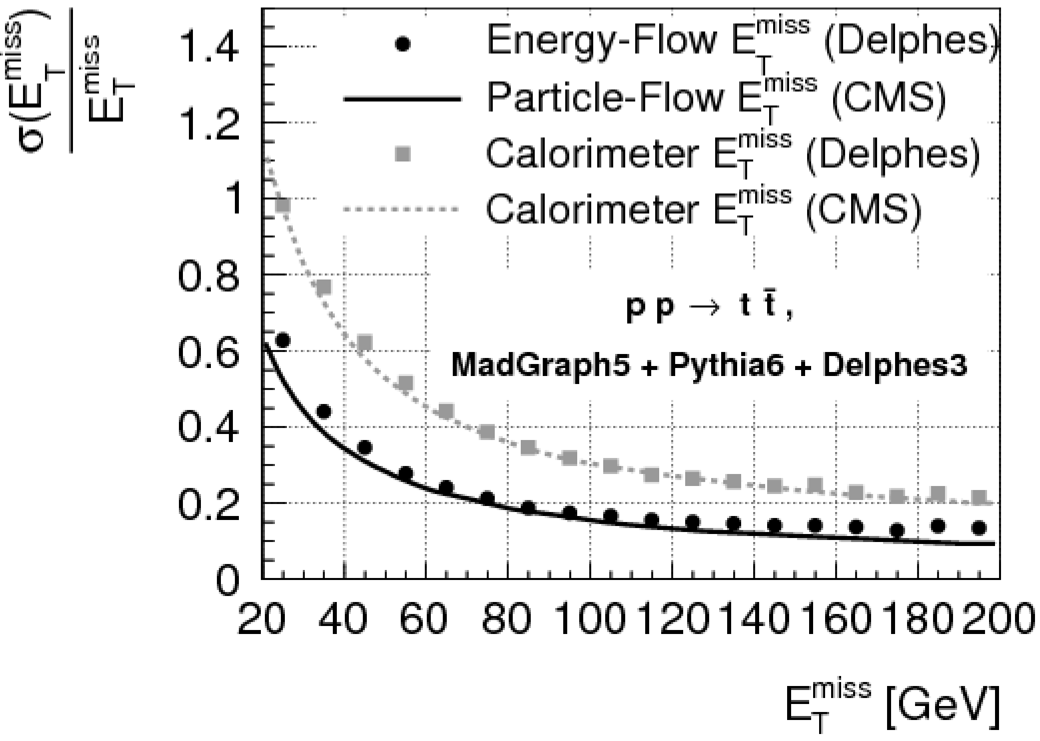
Detailed record - Cited by 1518 records 1000+

Citations include:
"Higgs Physics at the HL-LHC and HE-LHC" - Cepeda, M. et al. **CERN Yellow Rep.Monogr. 7 (2019)**
"Physics at a 100 TeV pp Collider: Standard Model Processes" - Mangano, M.L. et al. **CERN Yellow Rep. (2017)**
"FCC Physics Opportunities : Future Circular Collider Conceptual Design Report Volume 1" Eur.Phys.J. C79 (2019) no.6, 474
"The Compact Linear Collider (CLIC) - 2018 Summary Report" **CERN Yellow Rep.Monogr. 1802 (2018) 1-98**
Also several studies for ILC, CEPC…etc.

- It is based on parametrized tracking and calorimeter resolutions.
- Pythia8-Delphes3 can be run simultaneously. Accepts HEPMC and other formats as well
- It includes bending in magnetic field, granularity of calorimeters (not longitudinal segmentation though). PID efficiency/fake-rate, Jet reconstruction, particle flow, missing-energy, b-tagging, tau-tagging etc.

Jet/Met performance in Delphes vs CMS



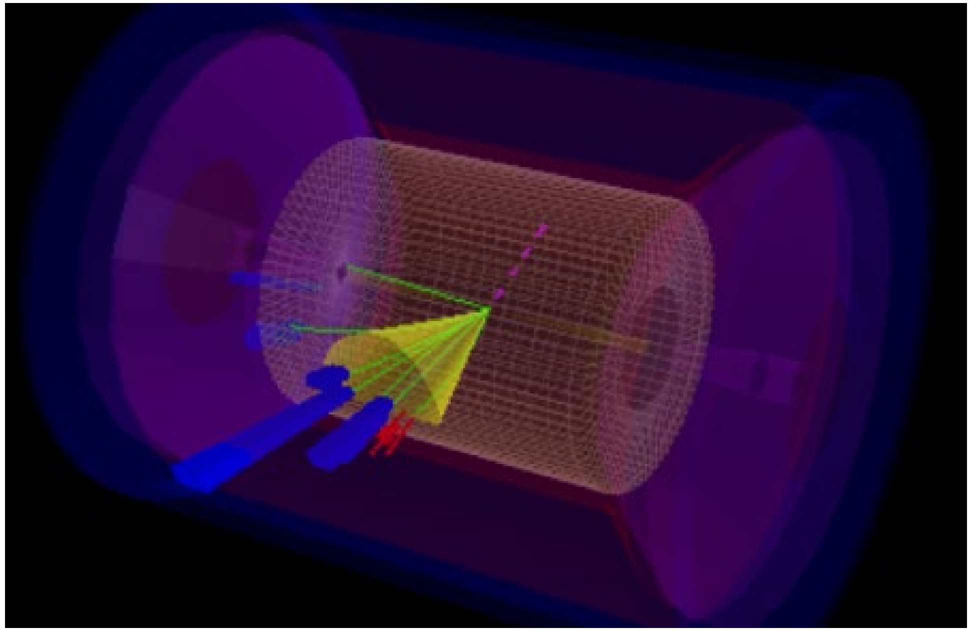


This is **not** by construction, it emerges from tracking and calorimetry resolution and granularity, as well as implementation of “particle flow”

EIC detector in Delphes

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

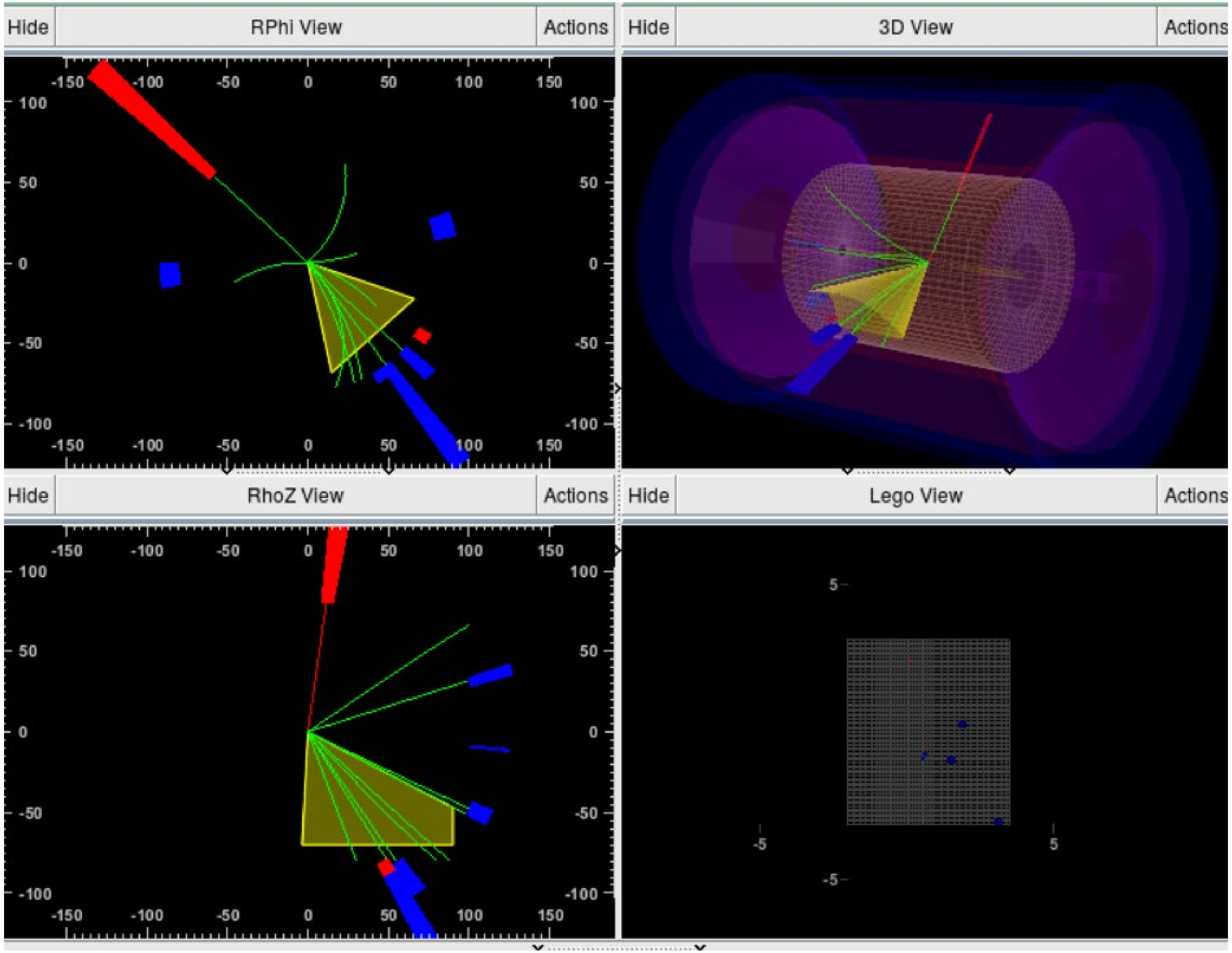
Tracking resolution, EMCAL resolution and HCAL resolution as in detector handbook.



In addition:

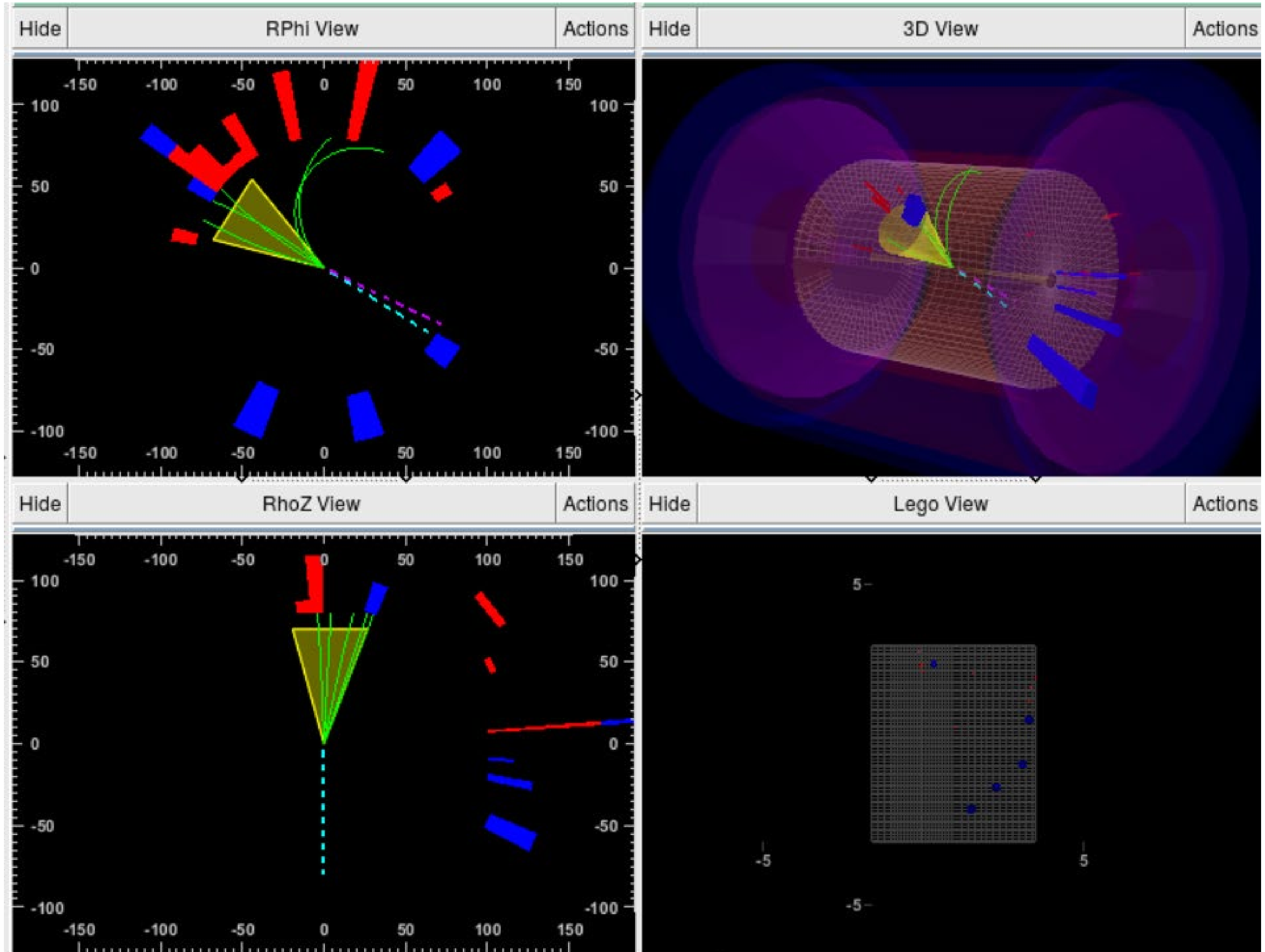
- B=1.5 T, R=0.80 m, L = 1 m
- EMCAL granularity (dphi x deta):
  0.0174 x 0.02 for |eta|<3.5
- HCAL granularity (dphi x deta):
  0.087 x 0.10 for |eta|<1.0
  0.174 x 0.20 for 1.0 |eta|<3.4
- HCAL resolution:
  100%/sqrt(E) + 10% in barrel
  50%/sqrt(E) + 10% in encap
- No PID yet, but it can be included (LHCb is in Delphes).
  Need parametrization of efficiency and mis-identification matrix

Neutral-current interaction, 100 GeV

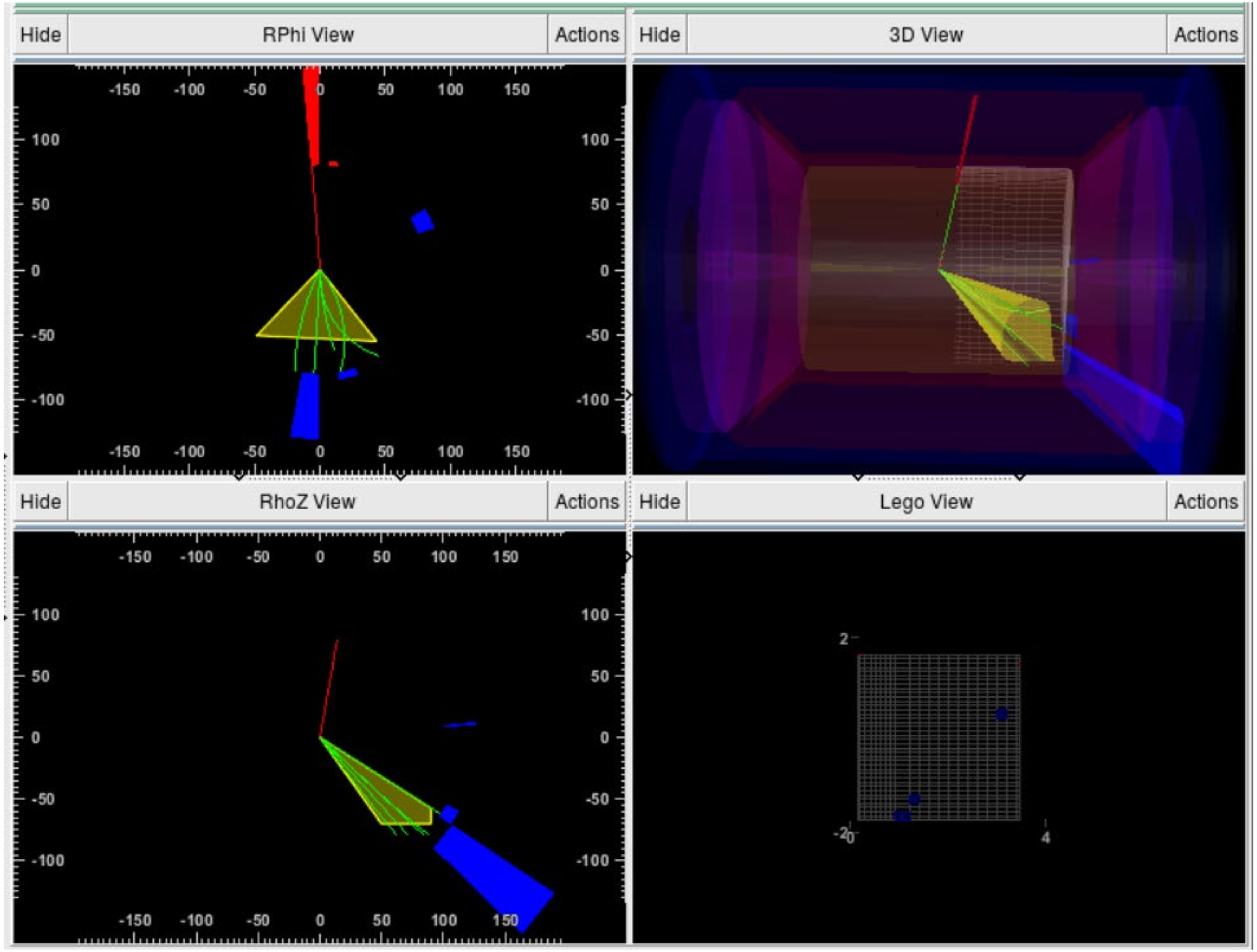


Charged-current interaction, 100 GeV

Reconstructed "missing transverse energy"

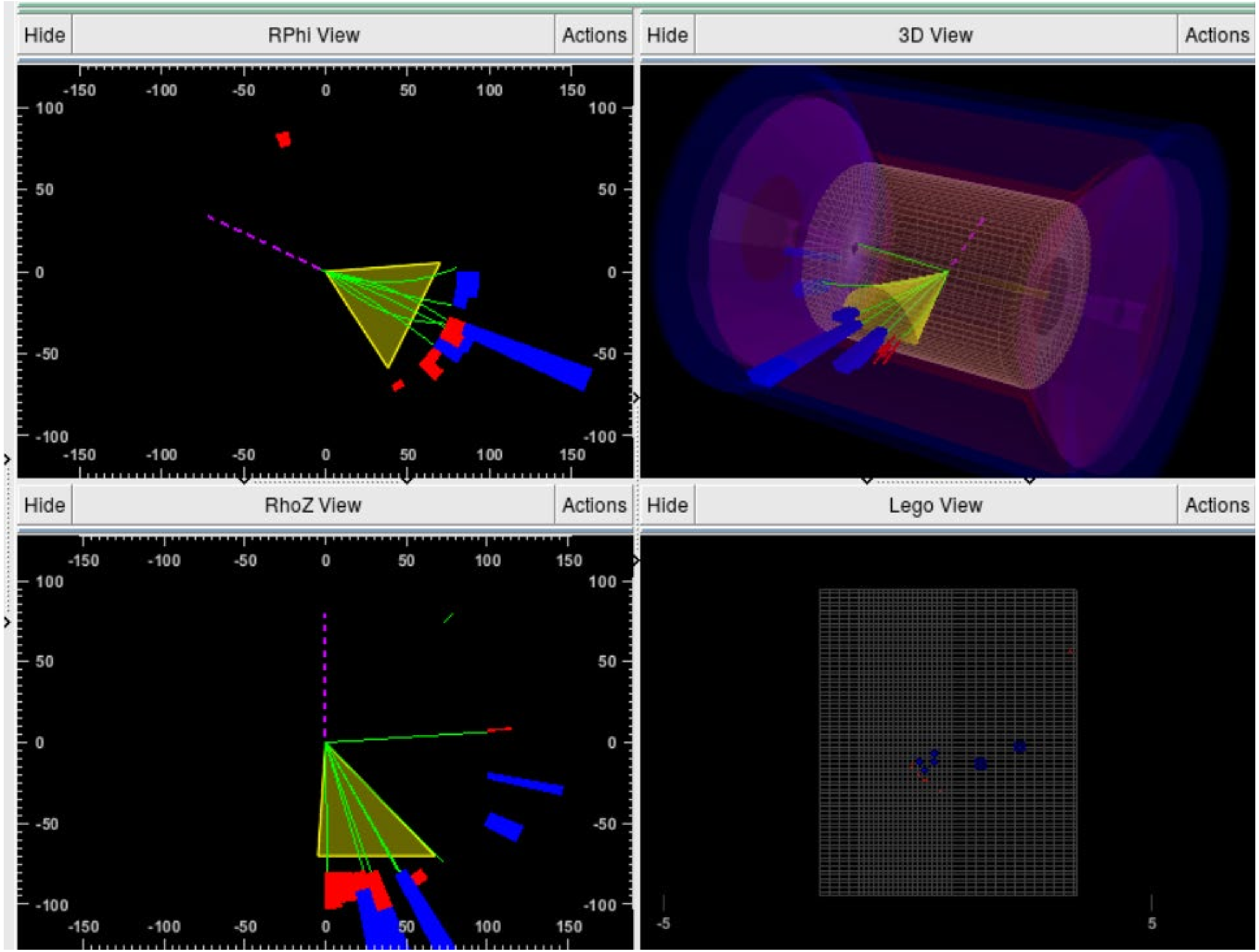


Neutral-current DIS , 63 GeV



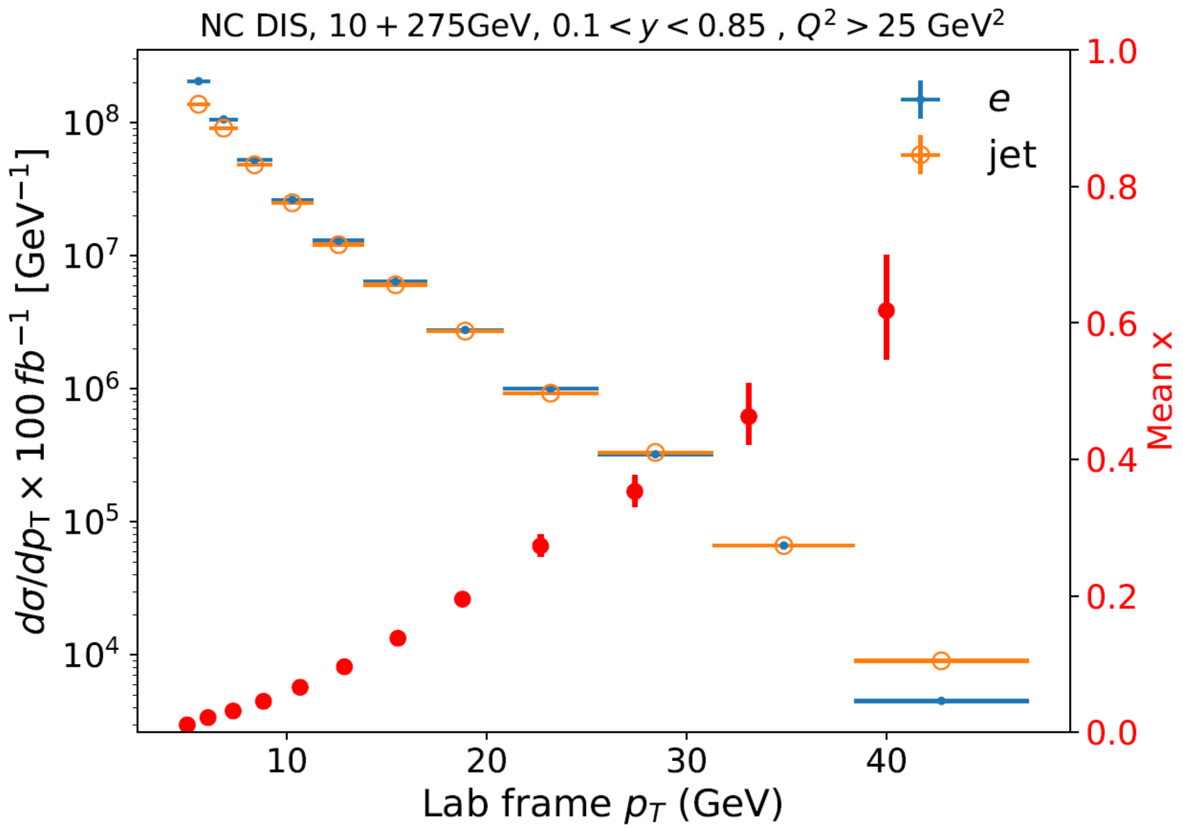
Charged-current event DIS , 63 GeV

Reconstructed “missing transverse energy”

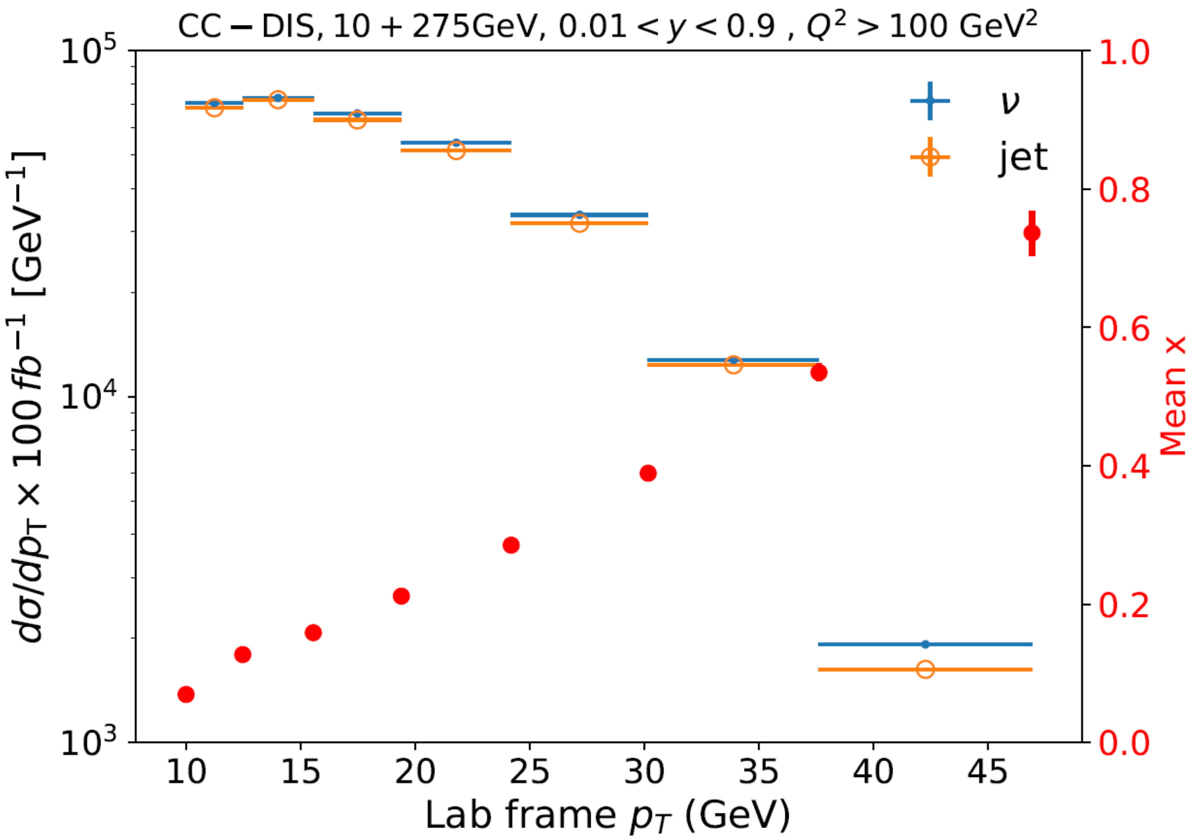


Jet cross-section (anti-kT, R=1.0)

Neutral-current events

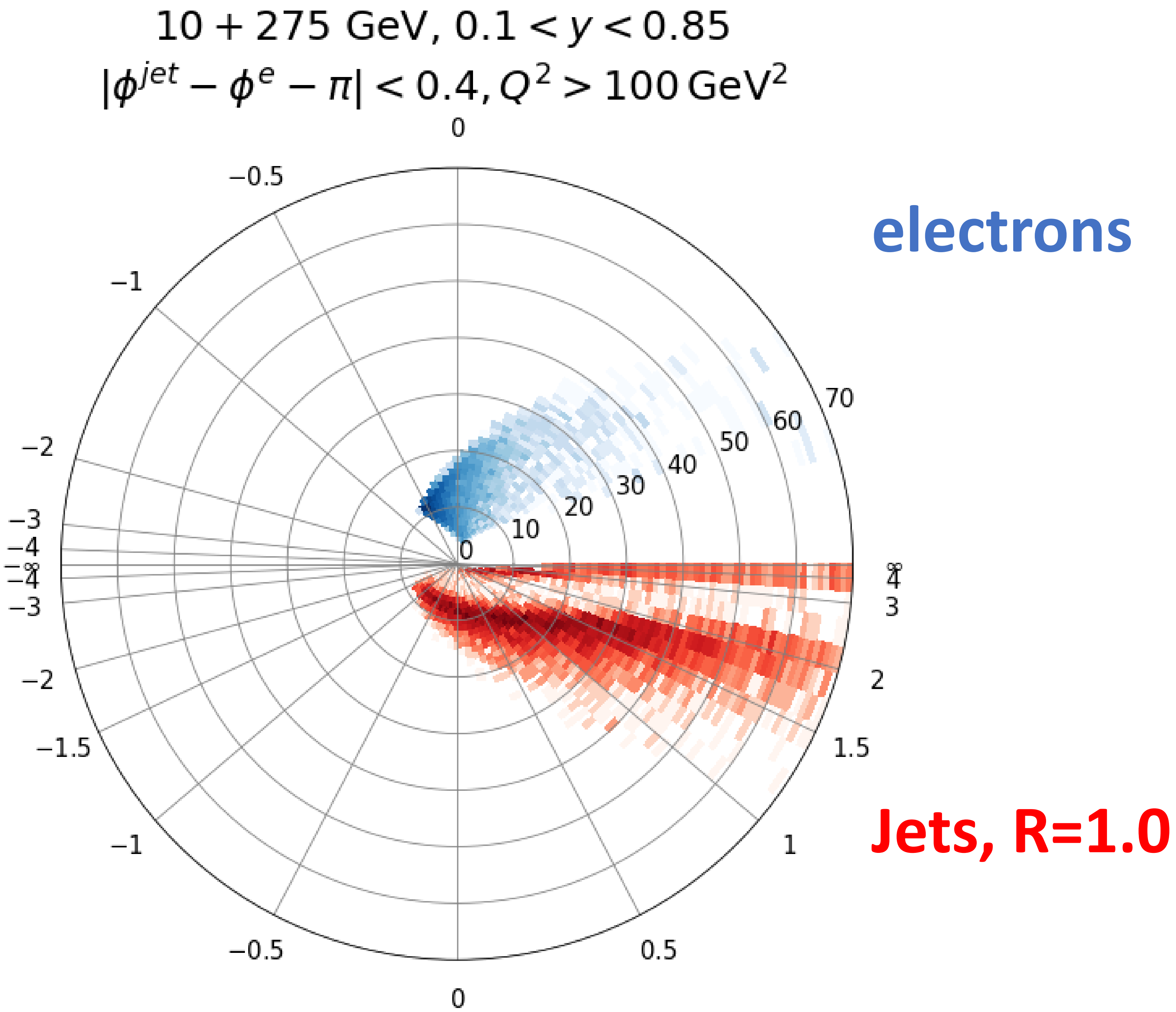


Charged-current events



- **Contributions beyond LO are very small (<10%), so Pythia8 (LO) provides an excellent approximation for both NC and CC DIS**

3-momentum vs polar angle



Electron method fails at low-y

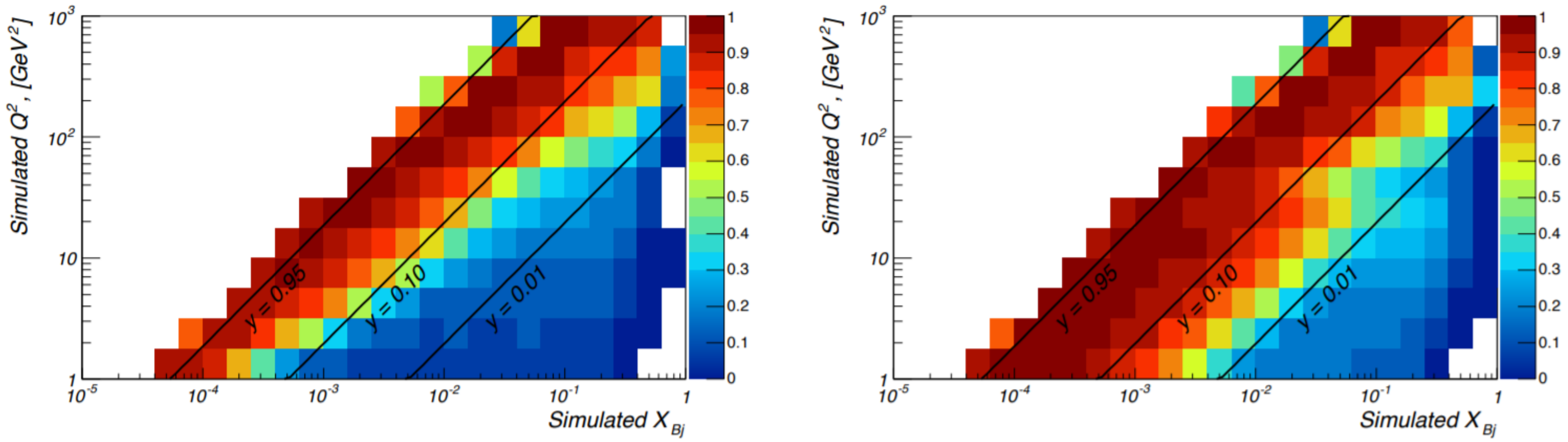


Figure 22: Inclusive DIS event migration in the {x, Q^2} kinematic plane. Pythia 20x250 GeV events, external bremsstrahlung turned off. Only the area with survival probability > 0.6-0.7 is suitable for the conclusive analysis. Left panel: only the tracker information is used to calculate scattered electron momentum. Right panel: same events, but a weighted mean of the tracker momentum and the crystal calorimeter energy is used. Calorimeter resolution is taken to be $\sigma_E/E \sim 2.0\%/\sqrt{E}$ for pseudo-rapidities below -2.0 and ~ $7.0\%/\sqrt{E}$ for the rest of the acceptance.

Jacquet- blondet method

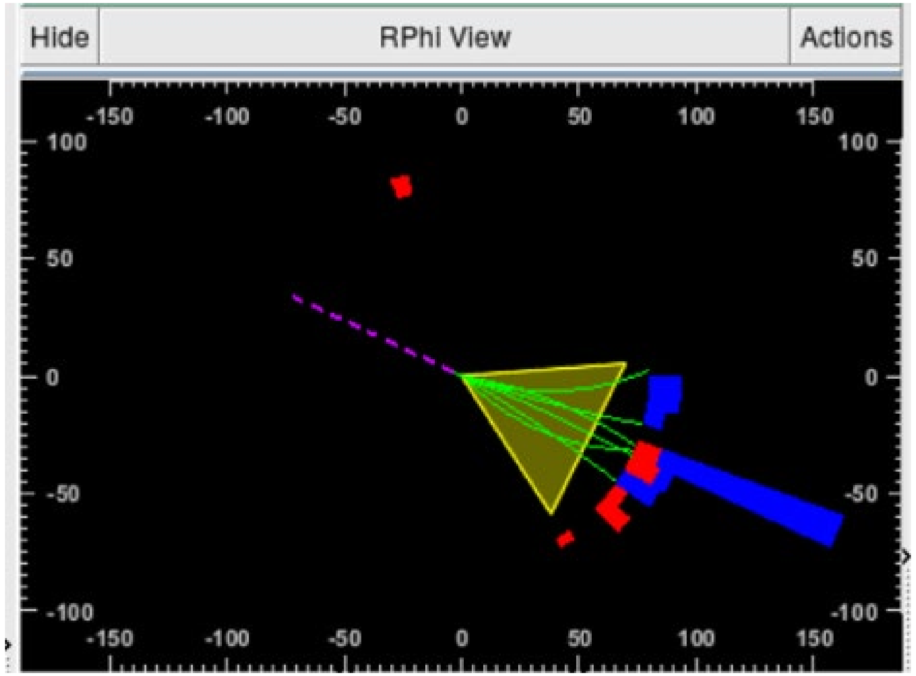
$$y_{\mathrm{JB}} = \frac{\sum_i (E_i - p_{Z,i})}{2\ E_e}, \qquad Q^2_{\mathrm{JB}} = \frac{(p_T^{\mathrm{miss}})^2}{1 - y_{\mathrm{JB}}} \qquad \text{and} \qquad x_{\mathrm{JB}} = \frac{Q^2_{\mathrm{JB}}}{s\ y_{\mathrm{JB}}},$$

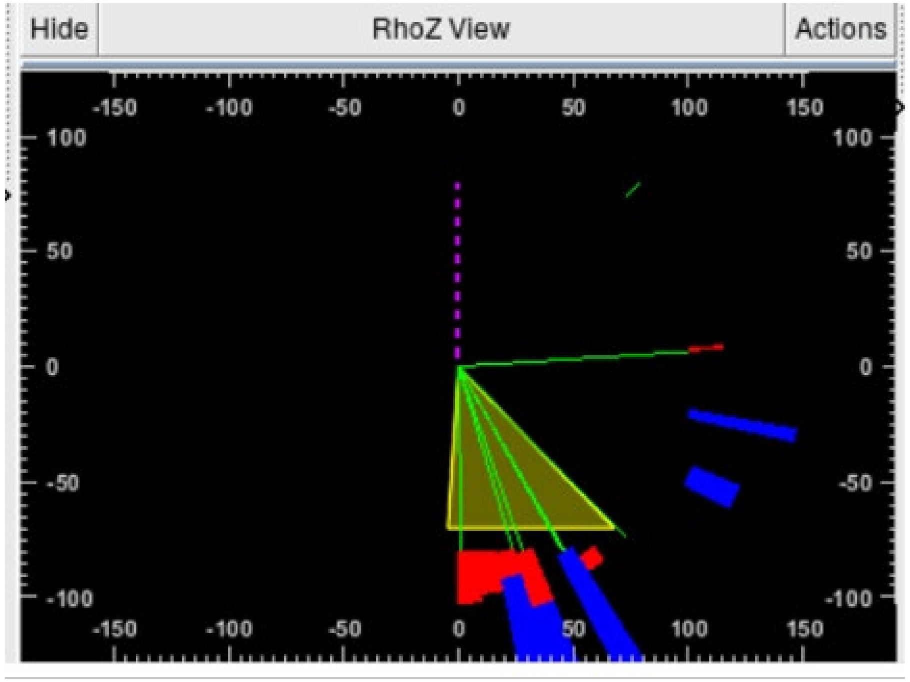
mation from the scattered lepton and the hadronic final state. At HERA, these methods were successfully used down to y of 0.005. The main reason this hadronic method renders better resolution at low y follows from the equation $x_{JB} = (E - p_z^{had})/E_e$, where $E - p_z^{had}$ is the sum over the energy minus the longitudinal momentum of all hadronic final-state particles and E_e is the electron beam energy. This quantity has no degradation of resolution for $y < 0.1$ as compared to the electron method, where $y_{JB} = 1 -$

- Neutrino energy (missing pT) is used in Jacquet-Blondel method, which is crucial for inclusive DIS.
- Default method at low-y in NC DIS, and only possibility in CC DIS.
- Missing energy performance is similar to jet performance in hermetic detector.

If you loose particles, pT miss (Q2) will be off

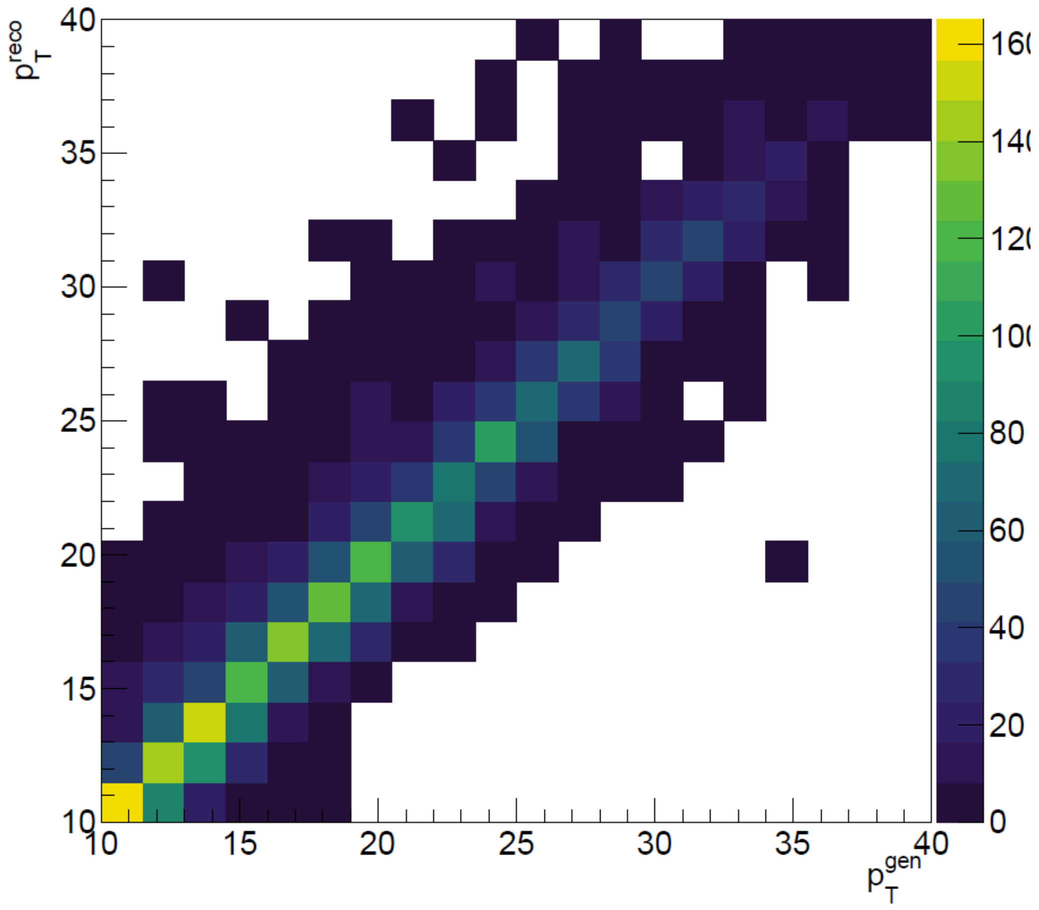
$$y_{\mathrm{JB}} = \frac{\sum_i (E_i - p_{Z,i})}{2\ E_e}, \qquad Q^2_{\mathrm{JB}} = \frac{(p_T^{\mathrm{miss}})^2}{1 - y_{\mathrm{JB}}} \qquad \text{and} \qquad x_{\mathrm{JB}} = \frac{Q^2_{\mathrm{JB}}}{s\ y_{\mathrm{JB}}},$$

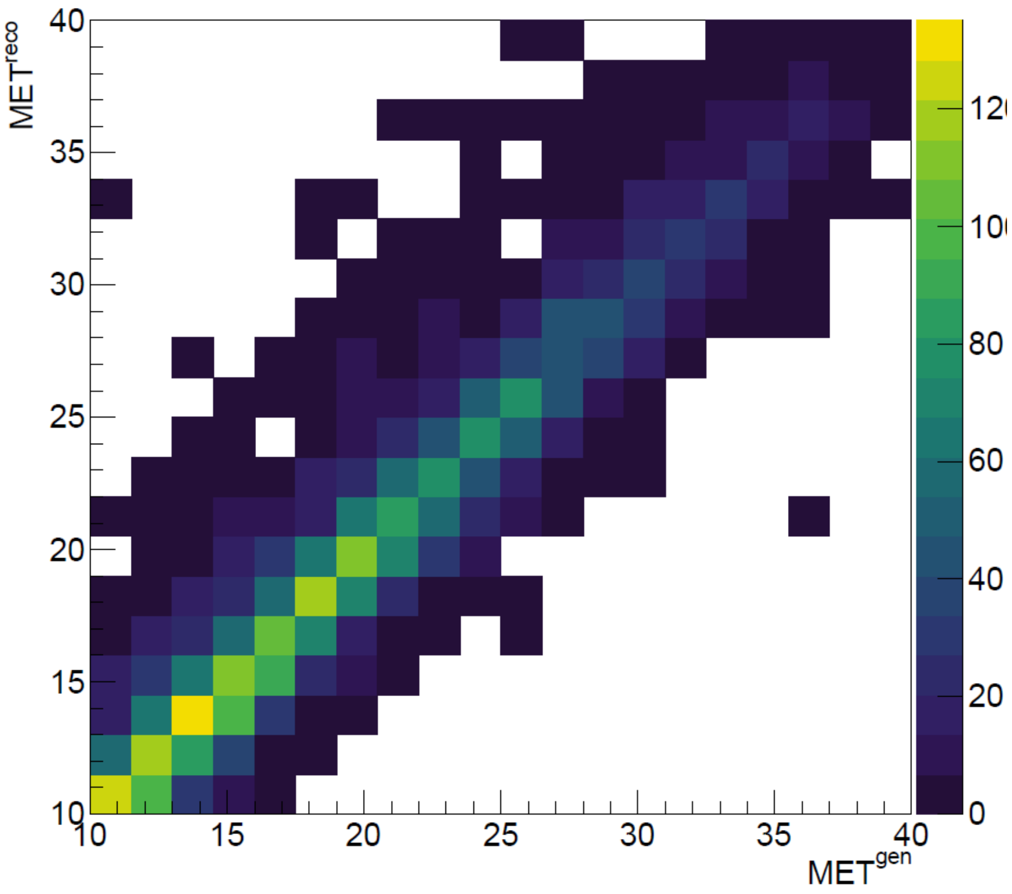




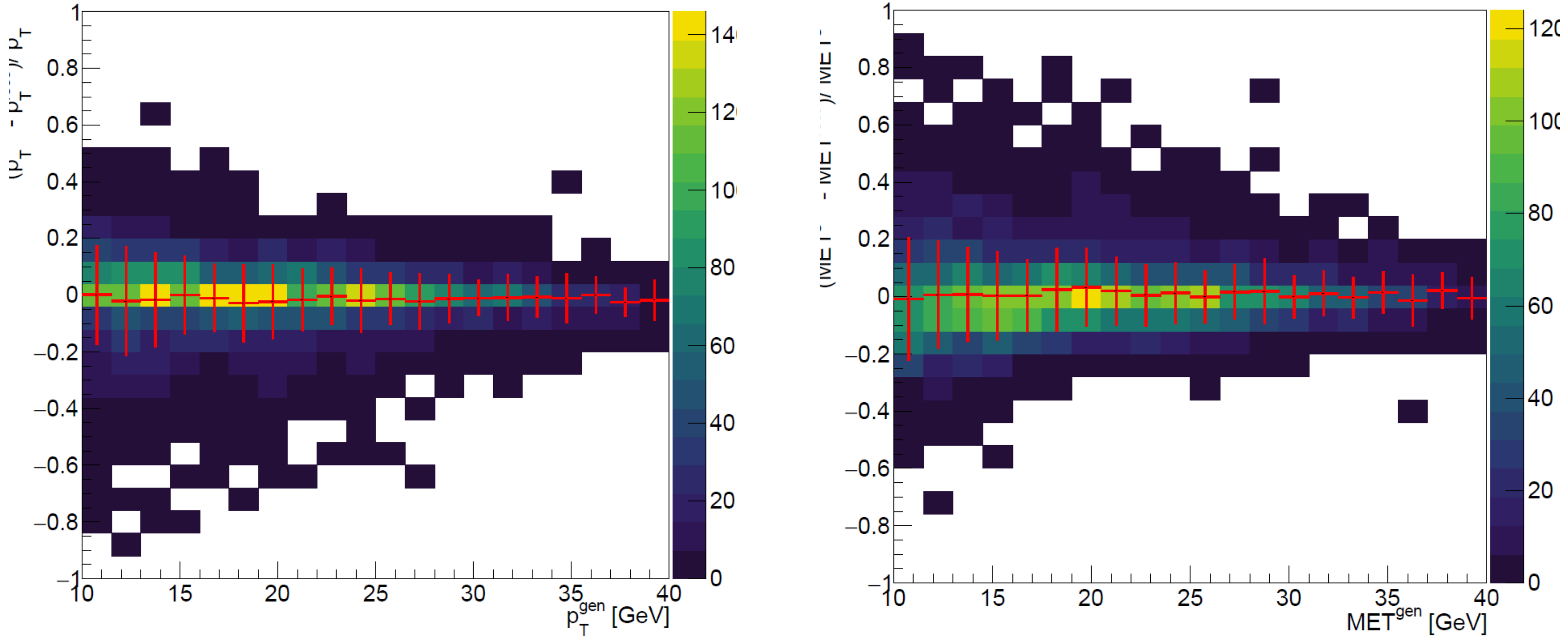
In this event, reconstructed “back-to-back” configuration in transverse plane, only because forward neutral hadrons were measured

Jet/MET performance

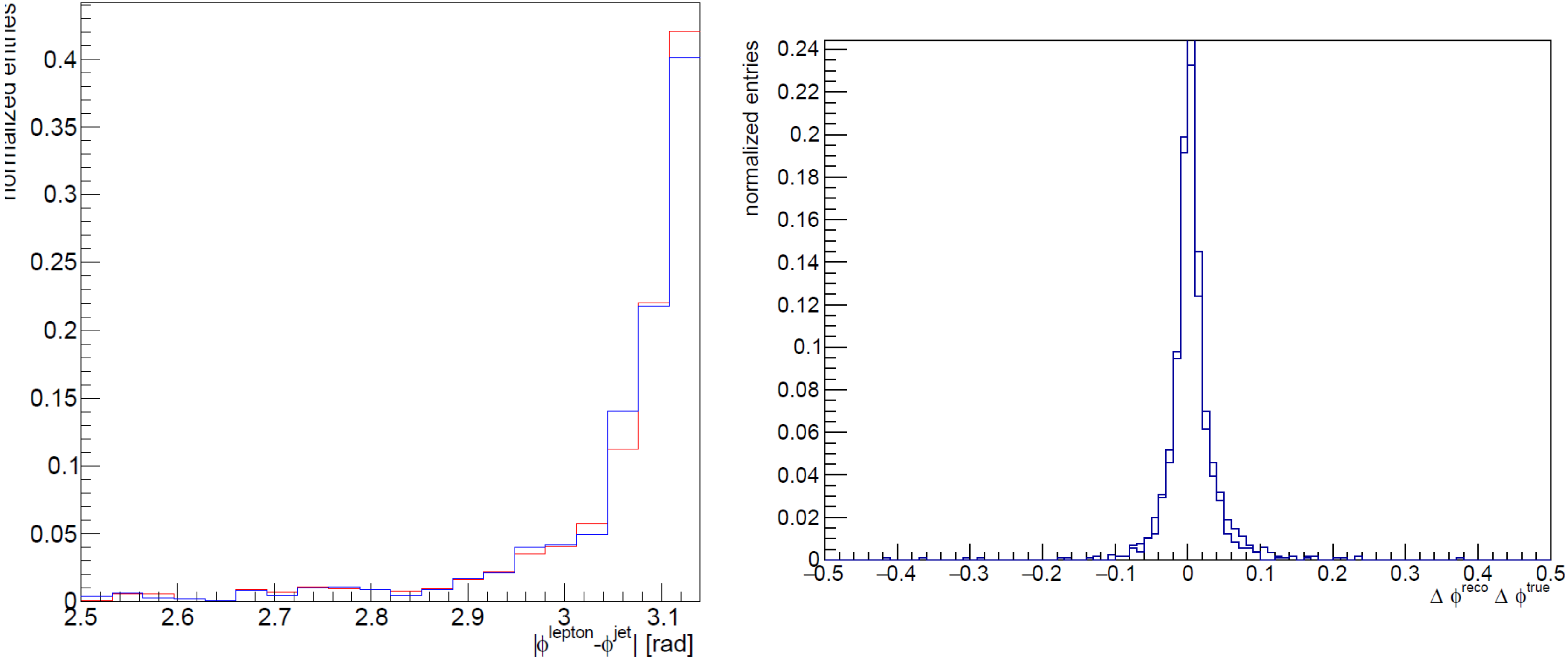




Jet/MET performance

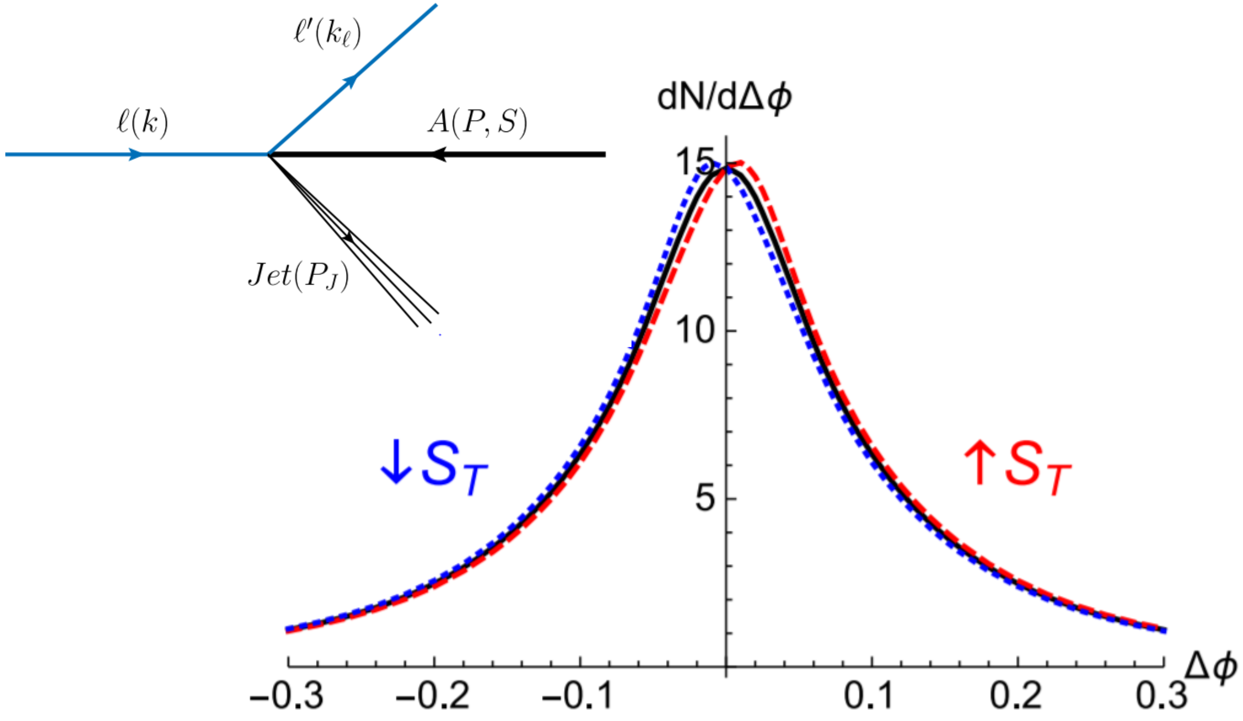


Azimuthal correlations (generated, reconstructed)



Quark Sivers effect with Jets

Liu, Ringer, Vogelsang, Yuan, PRL 122 192003 (2019)



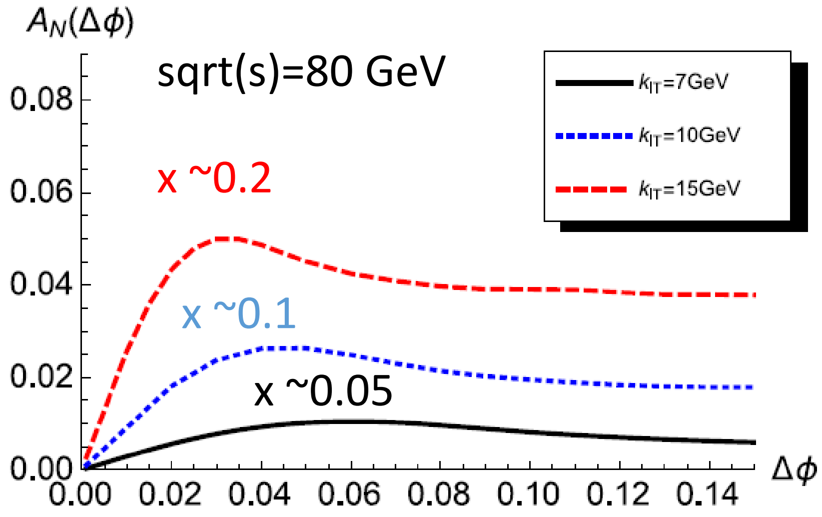


FIG. 3. The single transverse spin asymmetry as a function of $\Delta\phi = \phi_J - \phi_\ell - \pi$ for different lepton transverse momenta $k_{\ell\perp} = 7$, 10, and 15 GeV, respectively, which illustrates the transverse momentum dependence of the quark Sivers function.

"The advantage of the lepton-jet correlation as compared to the standard SIDIS processes is that it does not involve TMD fragmentation functions."

$$\frac{d^5\sigma(\ell p \to \ell' J)}{dy_\ell d^2k_{\ell\perp} d^2q_\perp} = \sigma_0 \int d^2k_\perp d^2\lambda_\perp x f_q(x, k_\perp, \zeta_c, \mu_F) \times H_{\mathrm{TMD}}(Q, \mu_F) S_J(\lambda_\perp, \mu_F)\, \delta^{(2)}(q_\perp - k_\perp - \lambda_\perp)\ .$$

Summary

- We have tool in place to systematically study HCAL granularity, resolution, and coverage.
- Lepton-jet azimuthal correlation (which is considered a “golden channel” in the Yellow report) is perhaps the most challenging channel, particularly with neutrinos.
- Looking forward to exchanges with this group.
- Open for new collaborators!