Physics observables and tracking requirements

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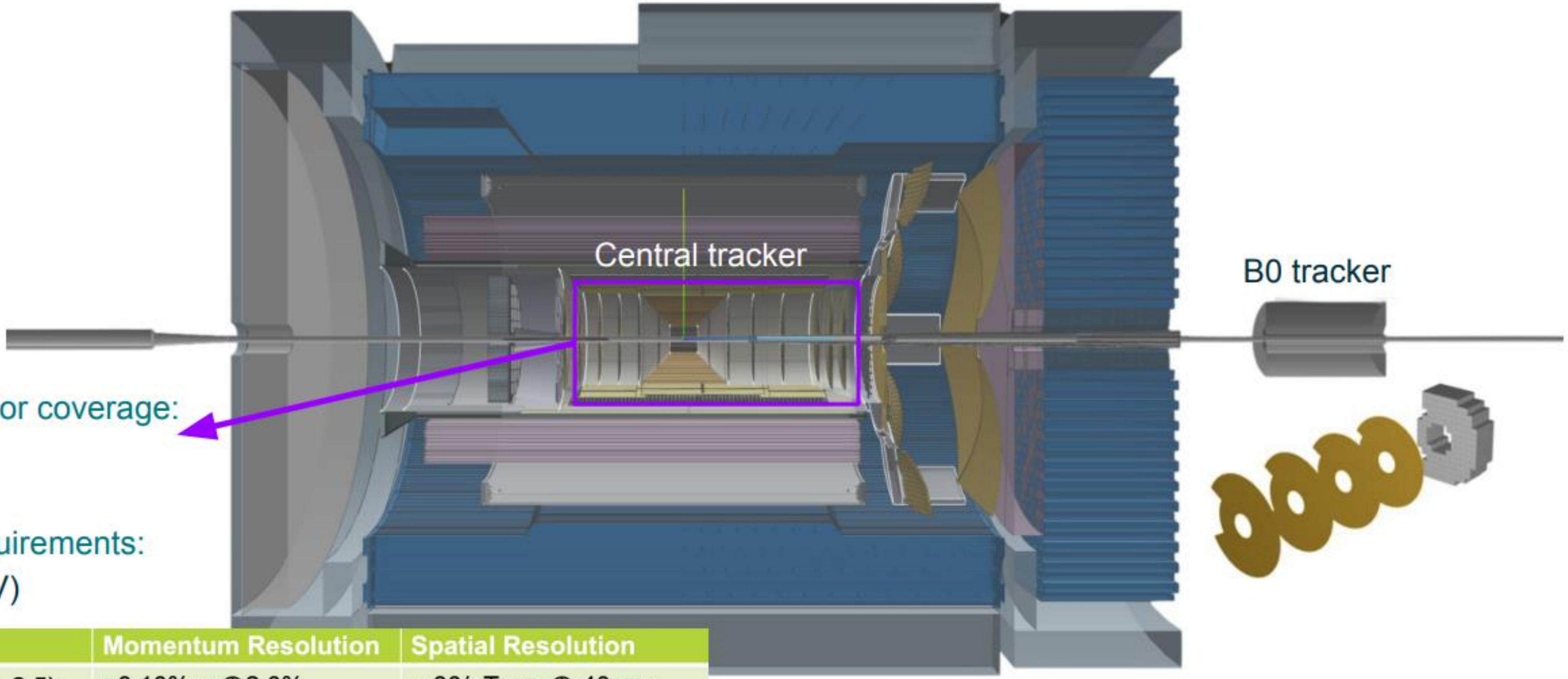
EIC Tracking Requirements



*Central detector coverage:
$-4 < \eta < 4$

Resolution requirements:
(for pT<15 GeV)

	Momentum Resolution	Spatial Resolution
Backward (-3.5 to -2.5)	~0.10%×p⨁2.0%	~ 30/pT µm ⨁ 40 µm
Backward (-2.5 to -1.0)	~ 0.05%×p⨁1.0%	~ 30/pT µm ⨁ 20 µm
Barrel (-1.0 to 1.0)	~0.05%×p⨁0.5%	~ 20/pT µm ⨁ 5 µm
Forward (1.0 to 2.5)	~0.05%×p⨁1.0%	~ 30/pT µm ⨁ 20 µm
Forward (2.5 to 3.5)	~0.10%×p⨁2.0%	~ 30/pT µm ⨁ 40 µm

Motivation

1. Are there (or can we determine) any updates to the tracking requirements?
   - For the electron endcap, the momentum requirement set in the YR will be missed. This requirement assumed that the scattered electron momentum (energy) would be reconstructed from the tracking detector, not from the EEEMC.
   - DIRC track angular resolution requirement
2. What are the best physics observables to demonstrate the sufficiency of the current tracking layout? Should these be higher-level physics observables (e.g. cross sections) or lower-level observables (e.g. kinematic resolution).

Example from YR: Study of total E-p_z resolution and cuts

- By conservation of energy and momentum, the sum of E-p_z of all final-state particles will be equal to twice the electron beam energy.
- The total reconstructed E-p_z will significantly differ from twice the electron beam energy if
  1. We have an event with low Q^2 where we don’t detect the scattered electron (photoproduction).
  2. We have an event where Initial state QED radiation (ISR) is a significant fraction of the electron beam energy.
- To reduce backgrounds from photoproduction and ISR, many analyses at HERA applied a cut on the reconstructed total E-p_z. This cut was determined by the total E-pz resolution for signal events.

HERA example

A Precision Measurement of the Inclusive *ep* Scattering Cross Section at HERA

H1 Collaboration

Abstract

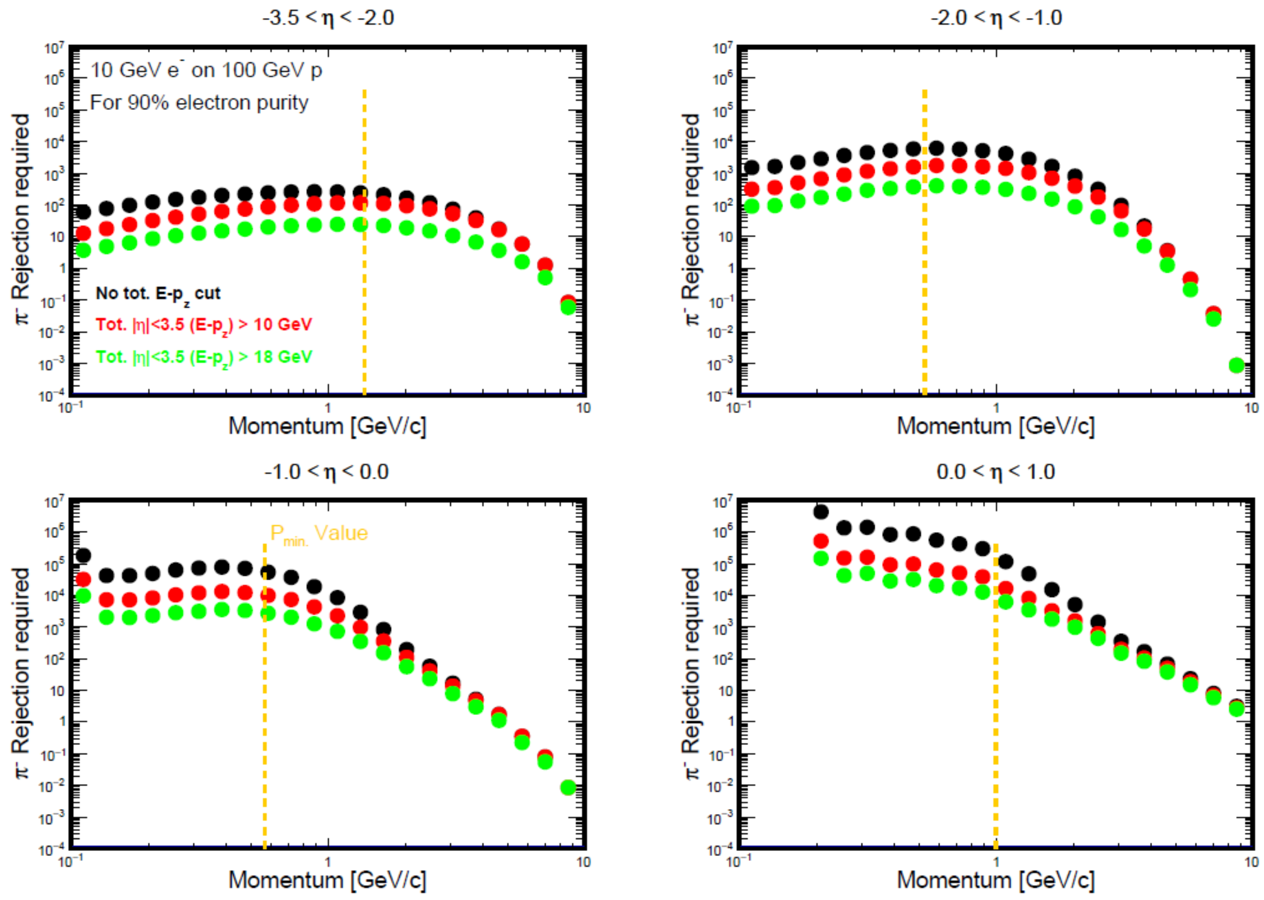
A measurement of the inclusive deep inelastic neutral current e^+p scattering cross section is reported in the region of four-momentum transfer squared, $12\,\mathrm{GeV}^2 \leq Q^2 \leq 150\,\mathrm{GeV}^2$, and Bjorken x, $2 \cdot 10^{-4} \leq x \leq 0.1$. The results are based on data collected by the H1 Collaboration at the ep collider HERA at positron and proton beam energies of $E_e = 27.6\,\mathrm{GeV}$ and $E_p = 920\,\mathrm{GeV}$, respectively. The data are combined with previously published data, taken at $E_p = 820\,\mathrm{GeV}$. The accuracy of the combined measurement is typically in the range of 1.3 – 2%. A QCD analysis at next-to-leading order is performed to determine the parton distributions in the proton based on H1 data.

Description	Requirement
Kinematic Range	$Q_e^2 > 10\,\mathrm{GeV}^2$
Scattered positron energy	$E'_e > 11\,\mathrm{GeV}$
SpaCal cluster radius	$R_{\log} < 4\,\mathrm{cm}$
Energy in hadronic SpaCal section	$E_h/E'_e < 0.15$
BDC validation	≥ 4 linked hits, BDC-SpaCal radial match < 2.5 cm
Radial cluster position	$r_{\mathrm{Spac}} < 73\,\mathrm{cm}$
Vertex z position	$\lvert z_{\mathrm{vtx}} \rvert < 35\,\mathrm{cm}$
Transverse momentum balance	$P_T^h/P_T^e > 0.3$
Longitudinal momentum balance	$E - P_z > 35\,\mathrm{GeV}$
QED Compton Rejection	Topological veto

Table 1: Event selection criteria.

Impact of total E-p_z cut on pion background to scattered electron

- Plots to the right show the rejection factor after applying certain cuts on total E-p_z. The sum is over generated particles within the main detector acceptance.
- The effect of this cut is more pronounced at lower momentum, as expected.
- This shows that the final requirement on the detector performance will depend on the total E-p_z resolution of the detector.



YR fast simulation for reconstruction of total E-p_z

η range	Tracker σ_p/p [%]	EmCal σ_E/E [%]	HCal σ_E/E [%]	σ_θ [Rad]	σ_ϕ [Rad]
-4.0 – -2.0	$0.1 \cdot p \bigoplus 0.5$	$2/\sqrt{E} \bigoplus 1.0$	$50/\sqrt{E}$		
-2.0 – -1.0	$0.05 \cdot p \bigoplus 0.5$	$7/\sqrt{E} \bigoplus 1.0$	$50/\sqrt{E}$		
-1.0 – +1.0	$0.05 \cdot p \bigoplus 0.5$	$12/\sqrt{E} \bigoplus 1.0$	$85/\sqrt{E} \bigoplus 7.0$	$0.01/\left(p \cdot \sqrt{\sin\theta}\right)$	0.01
+1.0 – +2.5	$0.05 \cdot p \bigoplus 1.0$	$12/\sqrt{E} \bigoplus 1.0$	$50/\sqrt{E}$		
+2.5 – +4.0	$0.1 \cdot p \bigoplus 2.0$	$12/\sqrt{E} \bigoplus 1.0$	$50/\sqrt{E}$		

Charged particles

Photons

Neutral hadrons

General comments:

1. Parameterization based on Yellow Report detector matrix, with minor changes.
2. We only study events where the scattered electron is reconstructed.
3. We use the tracker to reconstruct the momentum (energy) of the scattered electron for this study.
4. When the radiated photon is within the detector acceptance, we assume it is separated from the scattered electron and can be treated as any other photon.
5. For all particles, we use a minimum P_t acceptance of P_t > 0.25 GeV/c.

YR fast simulation for reconstruction of total E-p_z

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-1.0 – +1.0	$0.05 \cdot p \bigoplus 0.5$	$12/\sqrt{E} \bigoplus 1.0$	$85/\sqrt{E} \bigoplus 7.0$	$0.01/\left(p \cdot \sqrt{\sin\theta}\right)$	0.01
+1.0 – +2.5	$0.05 \cdot p \bigoplus 1.0$	$12/\sqrt{E} \bigoplus 1.0$	$50/\sqrt{E}$		
+2.5 – +4.0	$0.1 \cdot p \bigoplus 2.0$	$12/\sqrt{E} \bigoplus 1.0$	$50/\sqrt{E}$		

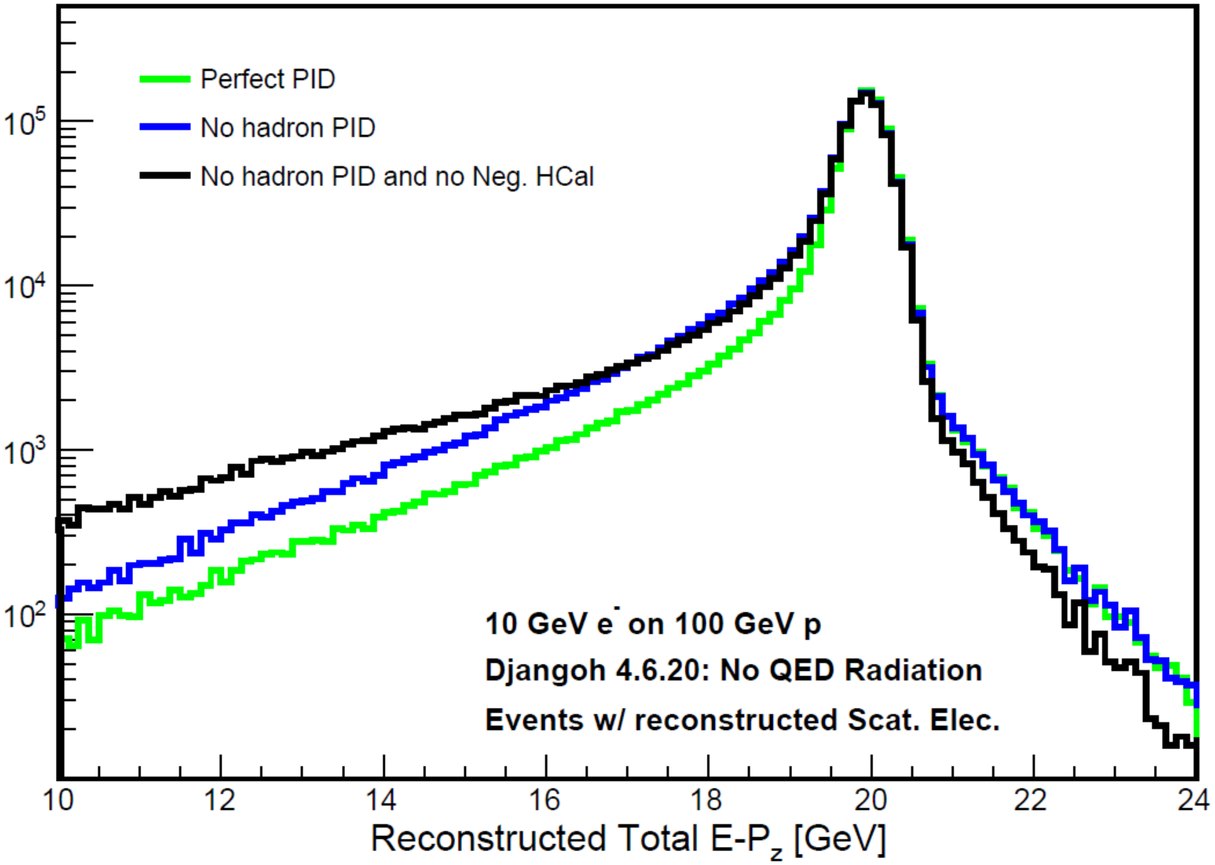
Charged particles
Photons
Neutral hadrons

We studied three different detector settings within the above detector configuration:

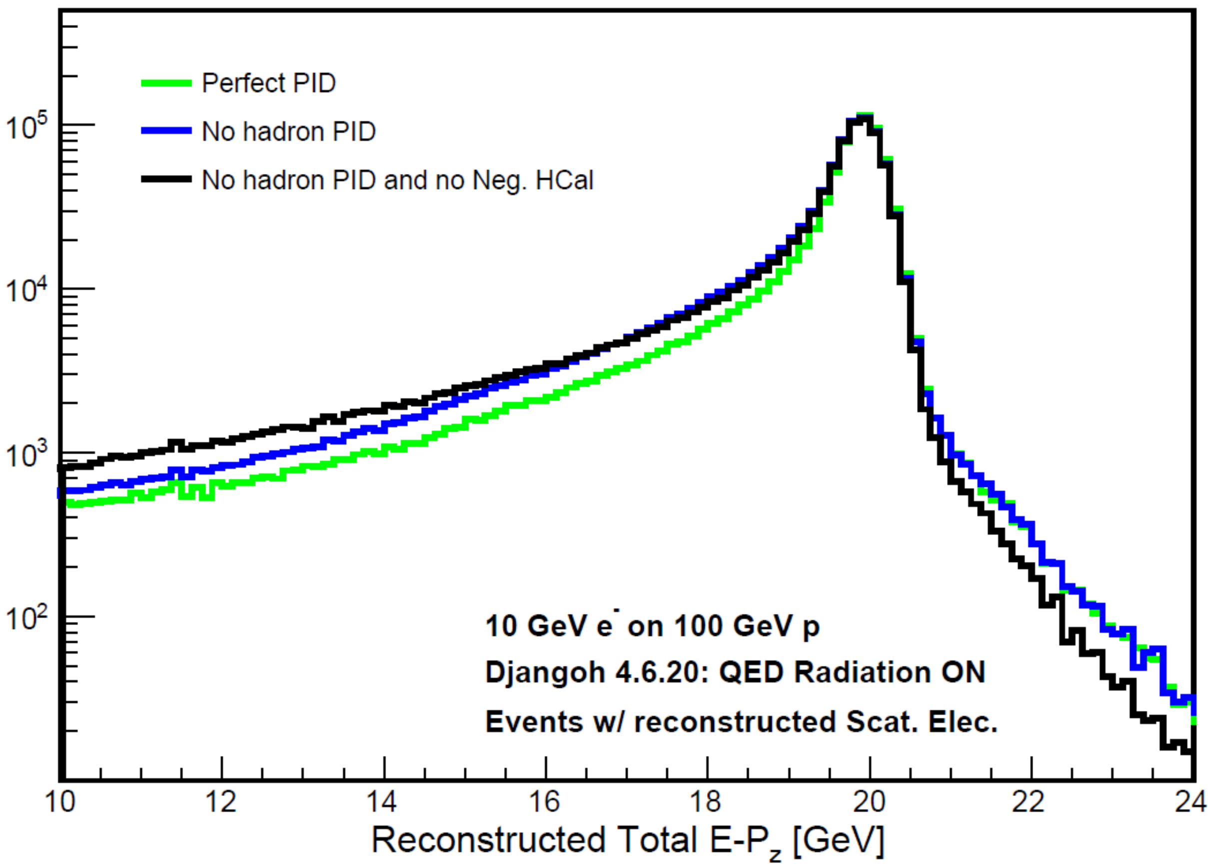
1. Perfect PID for all reconstructed particles.
2. No hadronic PID: for charged particles other than electrons and positrons, reconstruct particle using charged pion mass; for neutral hadrons, reconstruct using zero mass.
3. No hadronic PID and no backwards HCal: same as setting 2, with HCal from -4 < eta < -1 removed.

Fast simulation reconstruction results

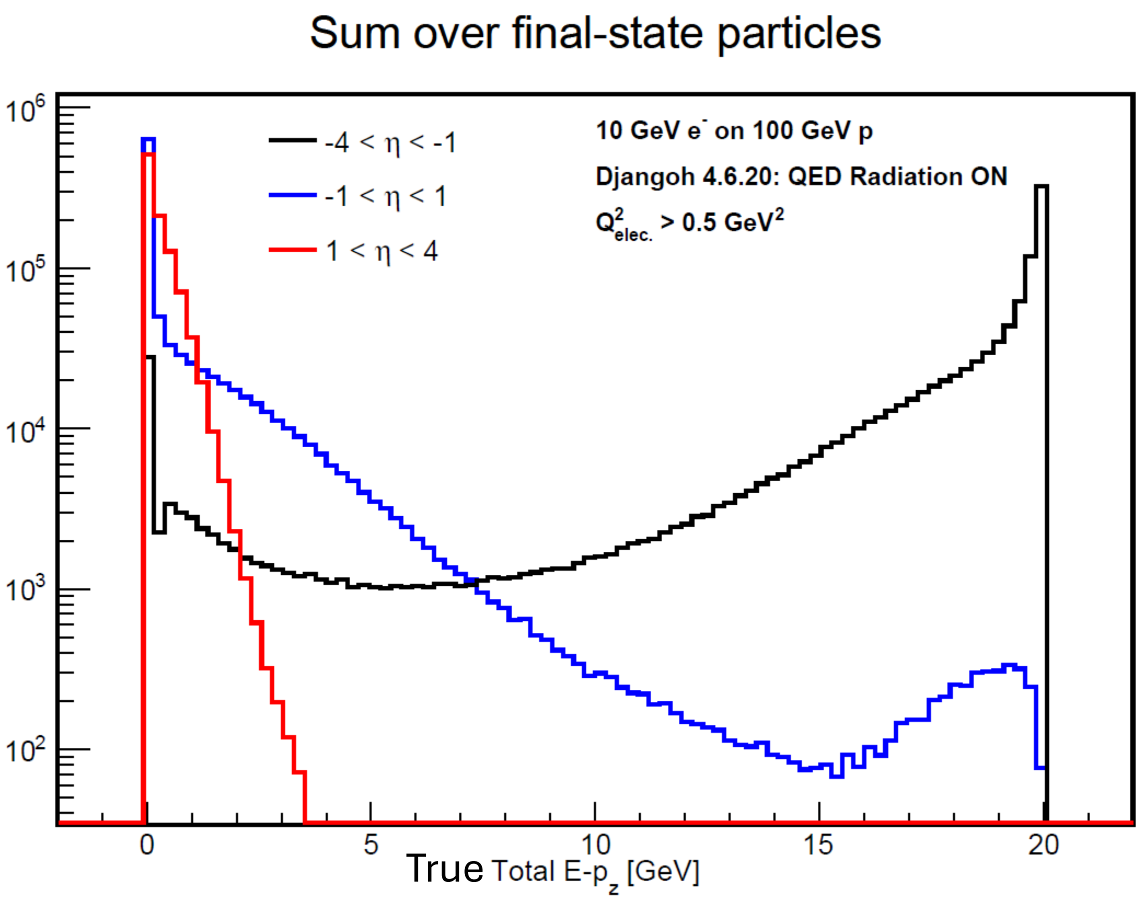
No QED effects included

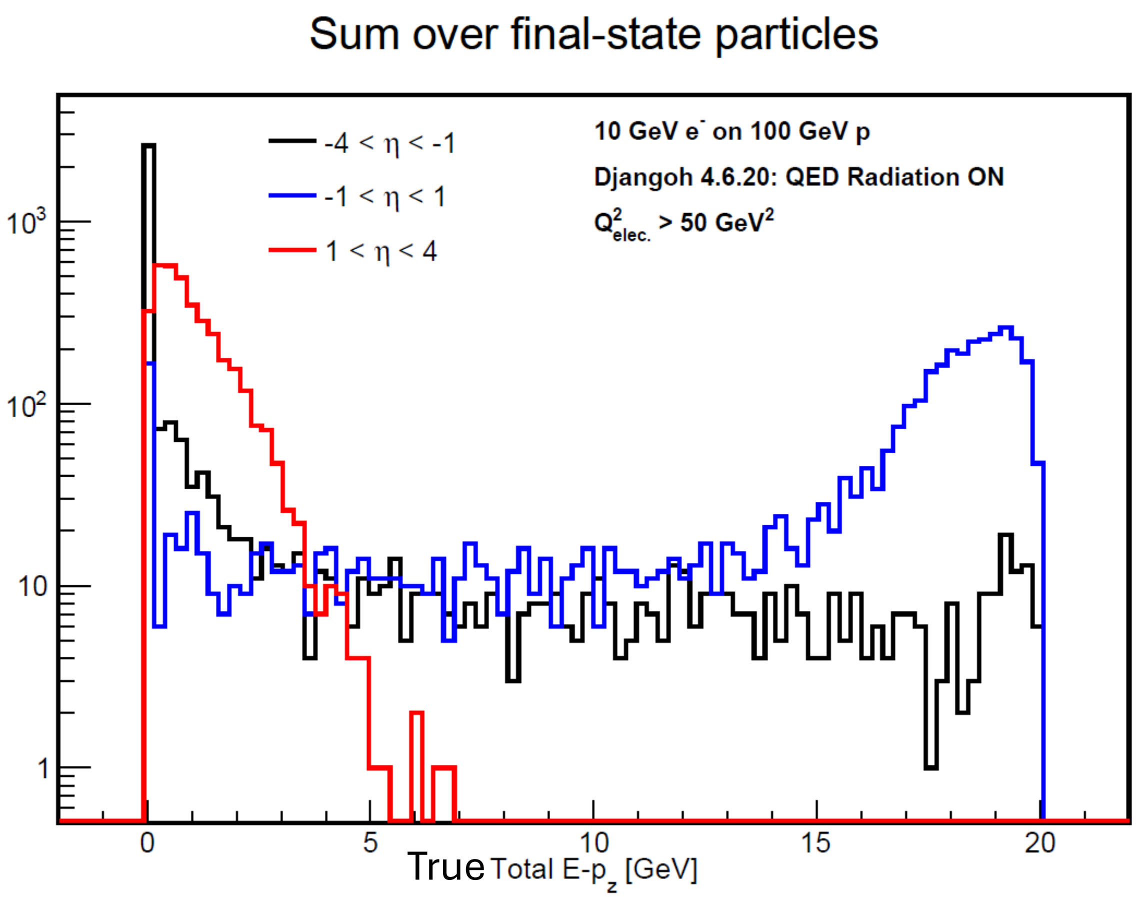


QED effects turned ON



Where in the detector does most of the total E-p_z go?





Distribution of the total E-p_z in the detector depends strongly on the scattered electron kinematics.

Questions to consider

- ➢What is our current resolution on the total E-p_z in ePIC for different classes of signal events? How much of that resolution comes from the tracking detectors?
- ➢What total E-p_z cut should be applied for different physics analyses and how will that cut impact the size of the photoproduction background and QED radiative corrections.

Discussion: What are some good observables?

1. Total E-pz resolution (discussed above)
2. Diffractive phi in eA (slides by Kong)
3. Heavy-flavor reconstruction (slides by Rongrong)
4. Charged jet reconstruction performance (some ongoing and previous studies)
5. SIDIS charged hadron P_t resolution with respect to the virtual photon direction
6. Reconstruction of Upsilon mass states (shown in pre-TDR)
7. Others...