Track projection results and scattered electron reconstruction/kinematics

Barak Schmookler

Outline

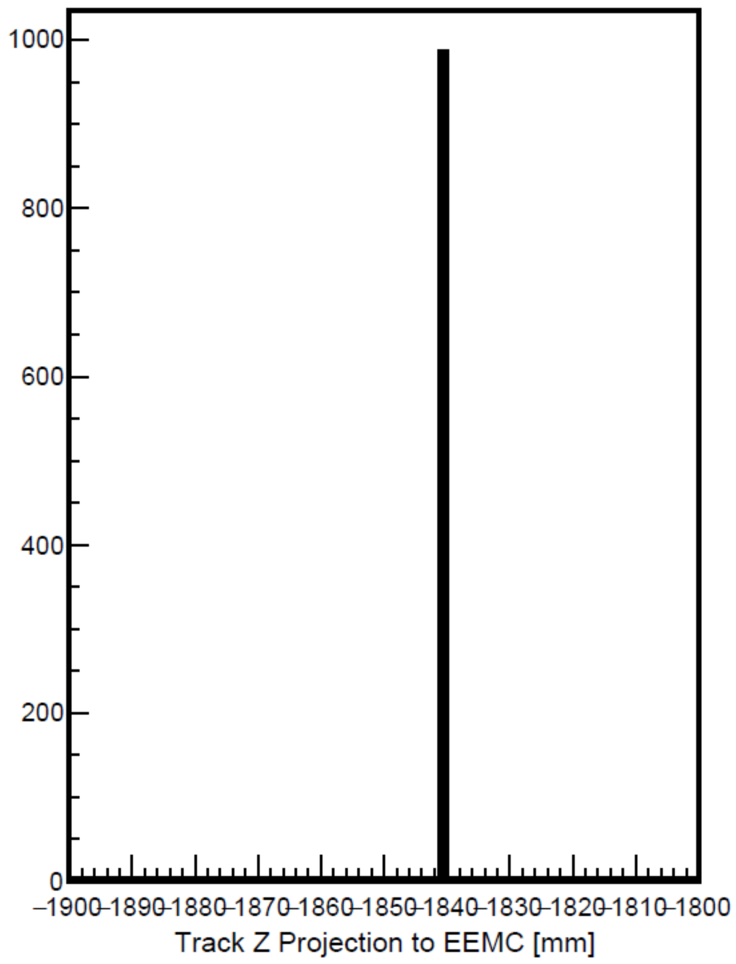
- ❑Track projection implementation and testing in *Juggler*
- ❑Comparison with S3 calorimeter results
- ❑Next steps
- ❑Scattered electron kinematics

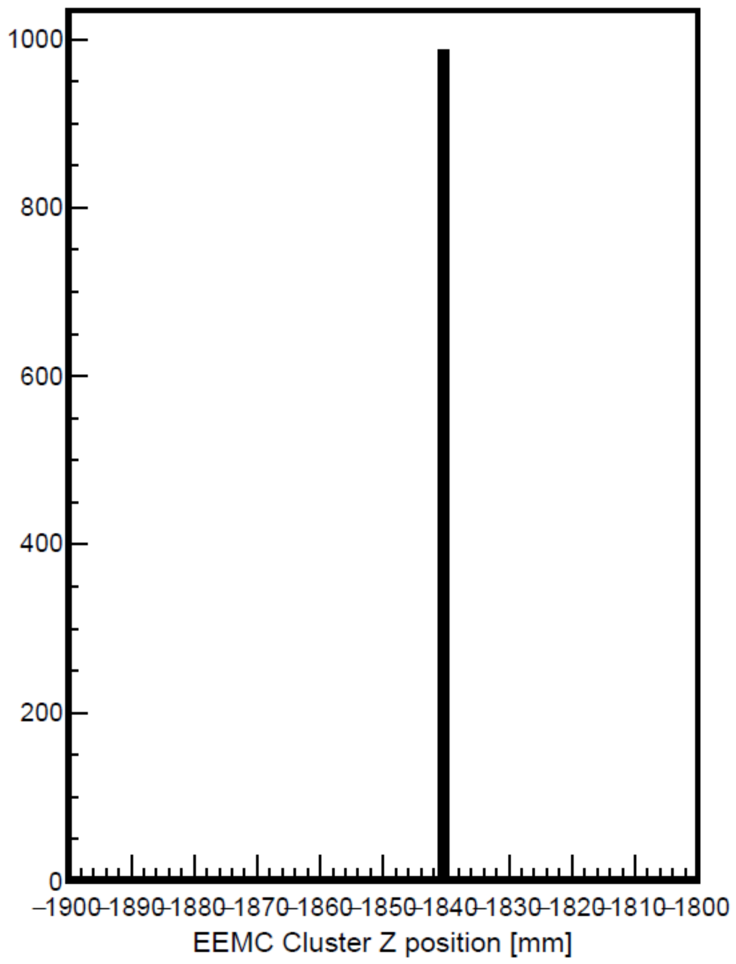
Track projection (propagation) implementation

- We need to project the reconstructed tracks to other sub-detectors.
- A standalone code using *Juggler* output the ACTS::Propagator class was written by Wenqing Fan.
- This was then implemented into a new *Juggler* class by Barak Schmookler. Results shown on the next pages use this class.
- The class has now been ported to an *EICrecon* class by Dmitry Romanov, and is being generalized for projections to other detectors. This will hopefully go into the next simulation campaign.
- Additional work to associate projection to track (trajectory) in output ROOT is ongoing.

Track Projection test: EEMC

Single Electrons generated:
1 GeV < E < 20 GeV
$160^\circ < \theta < 170^\circ$, $0^\circ < \phi < 360^\circ$





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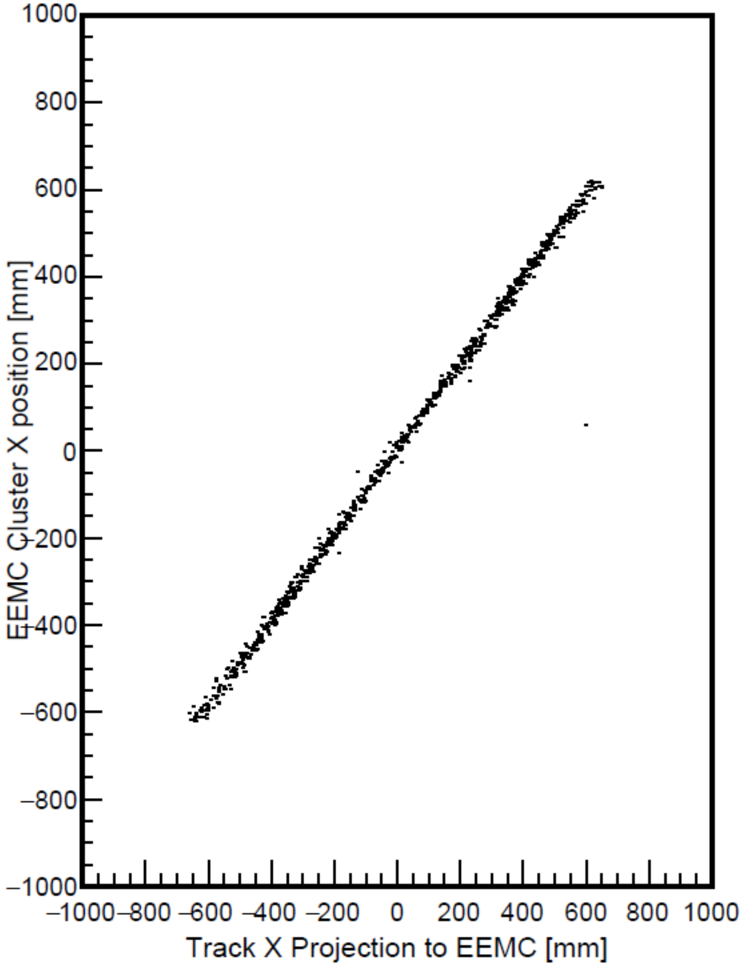

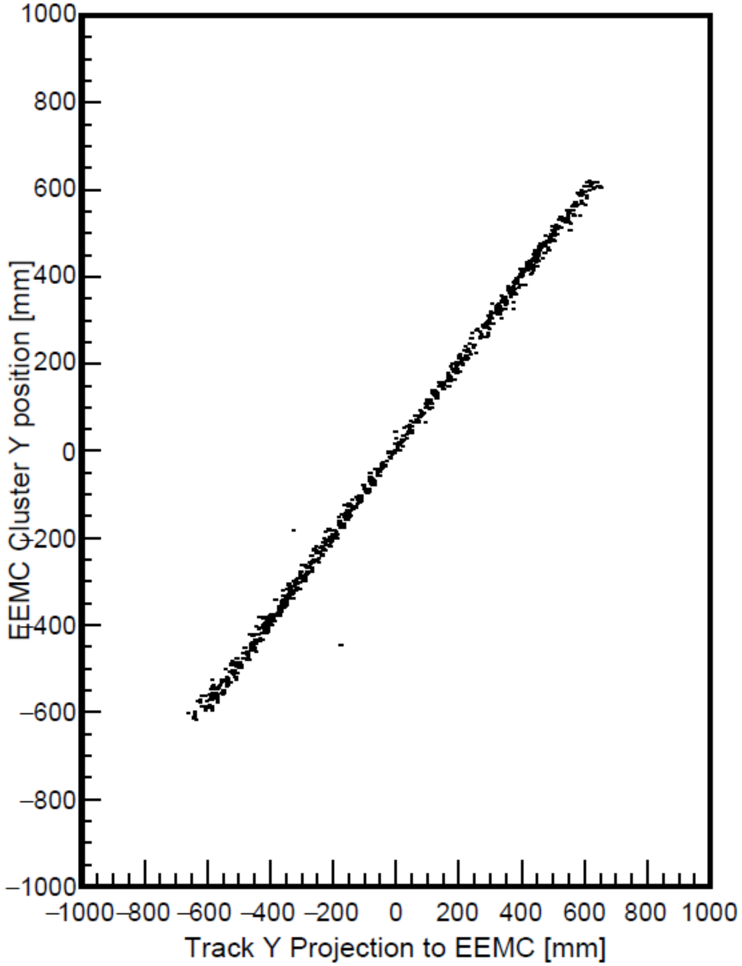

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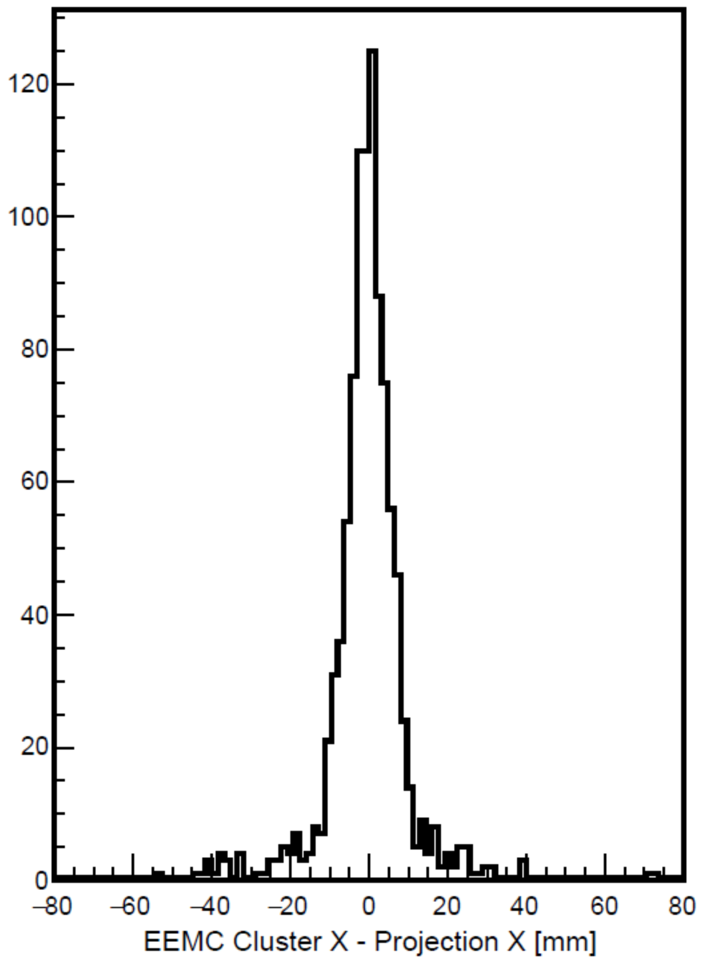

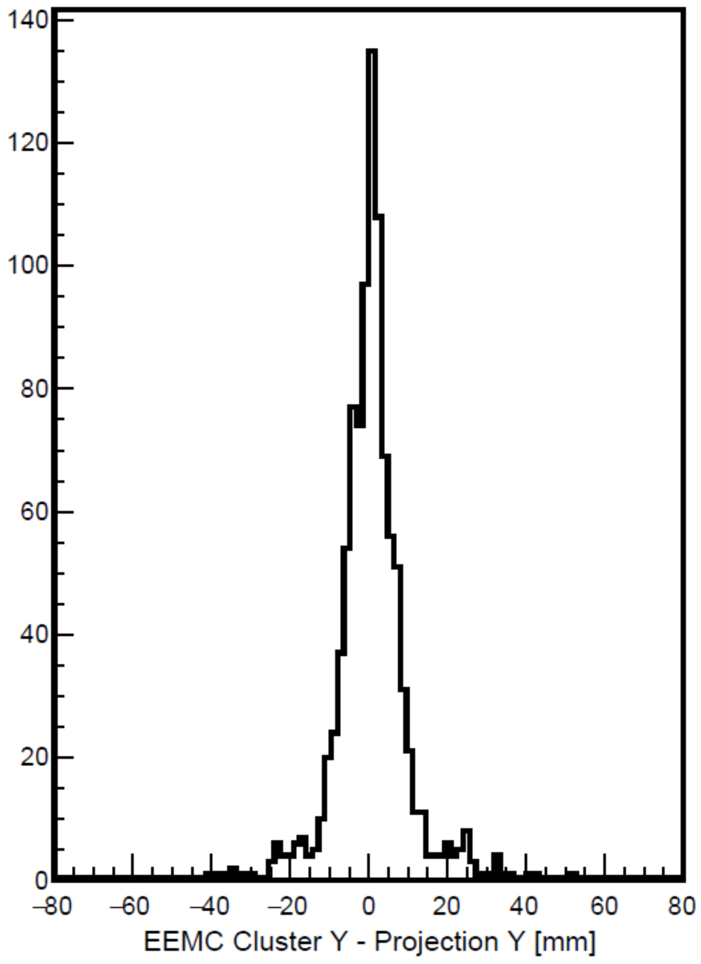

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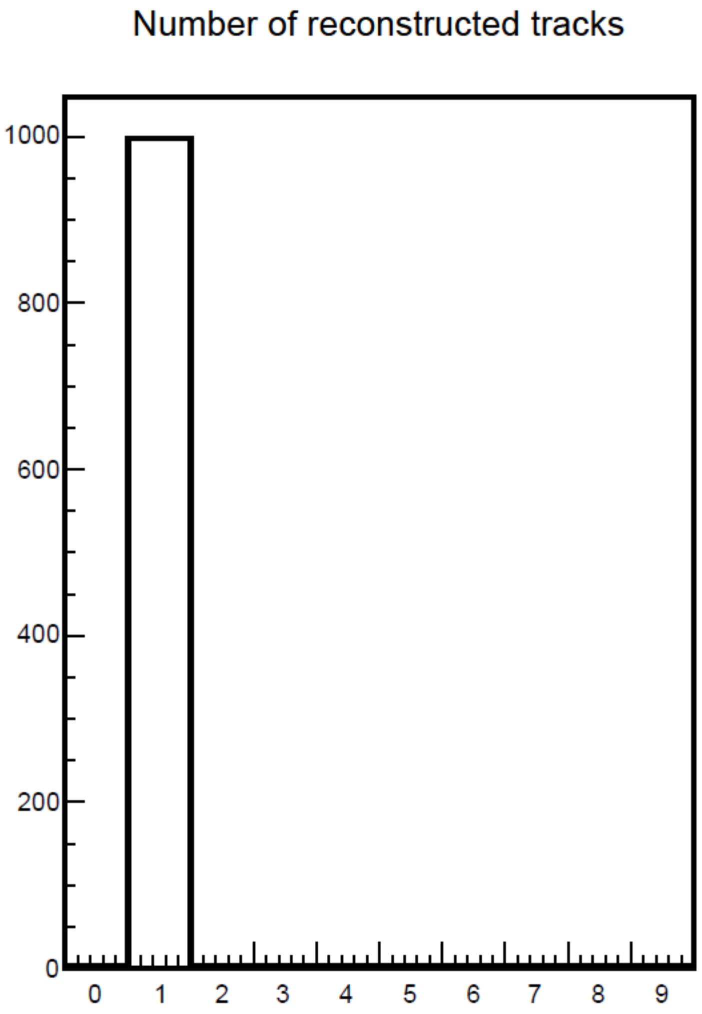

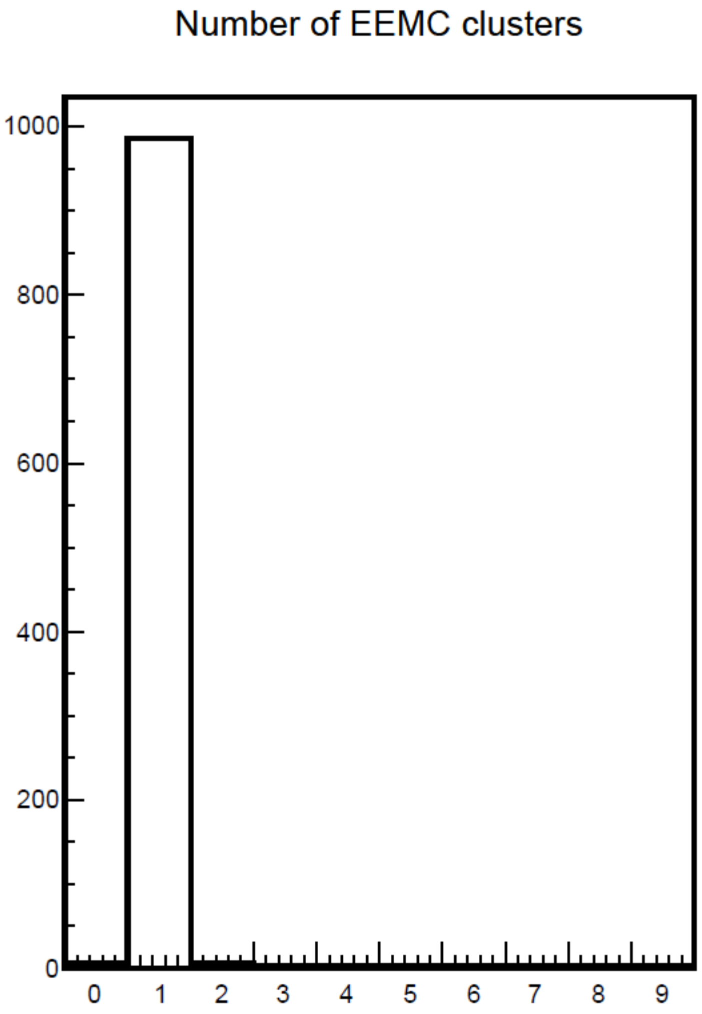

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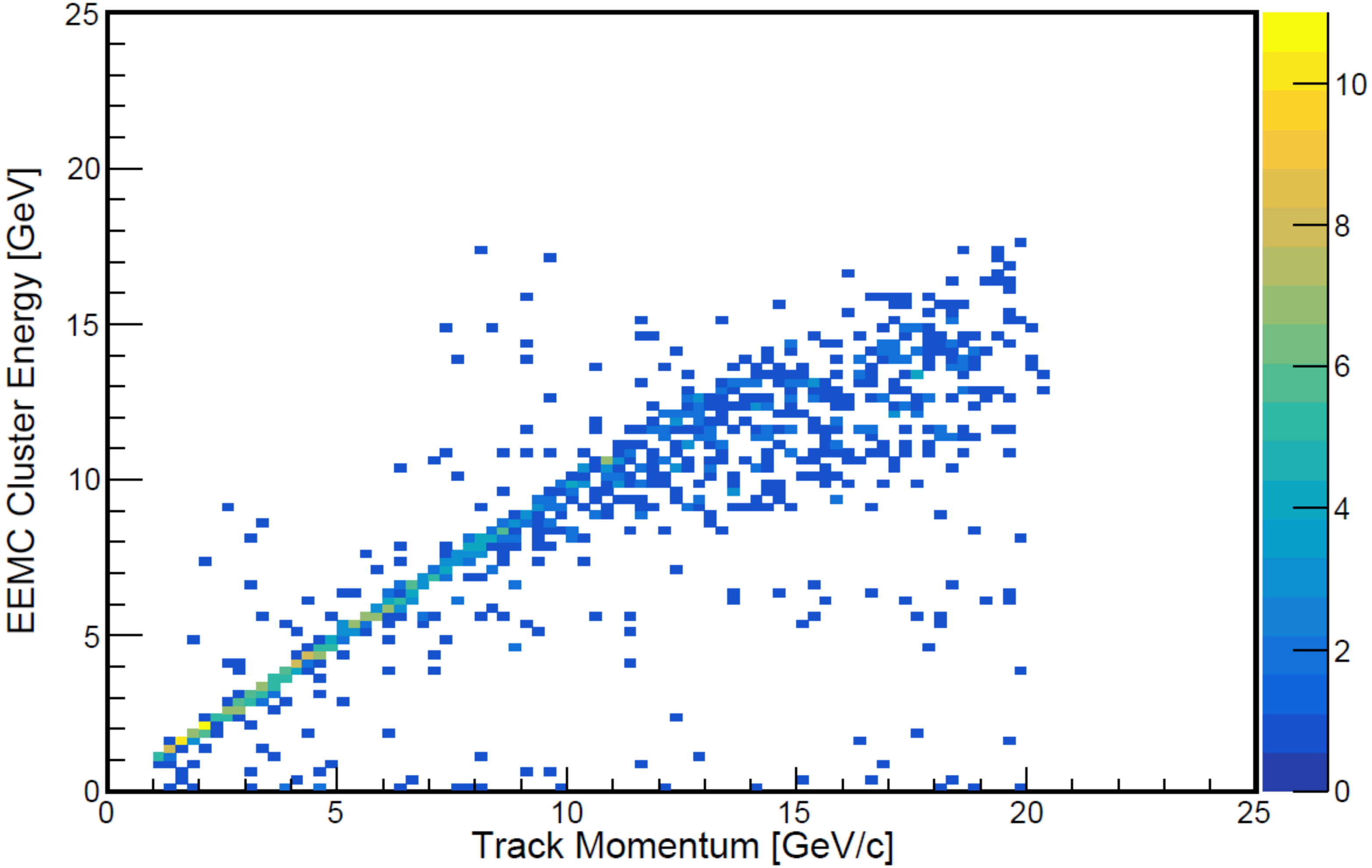

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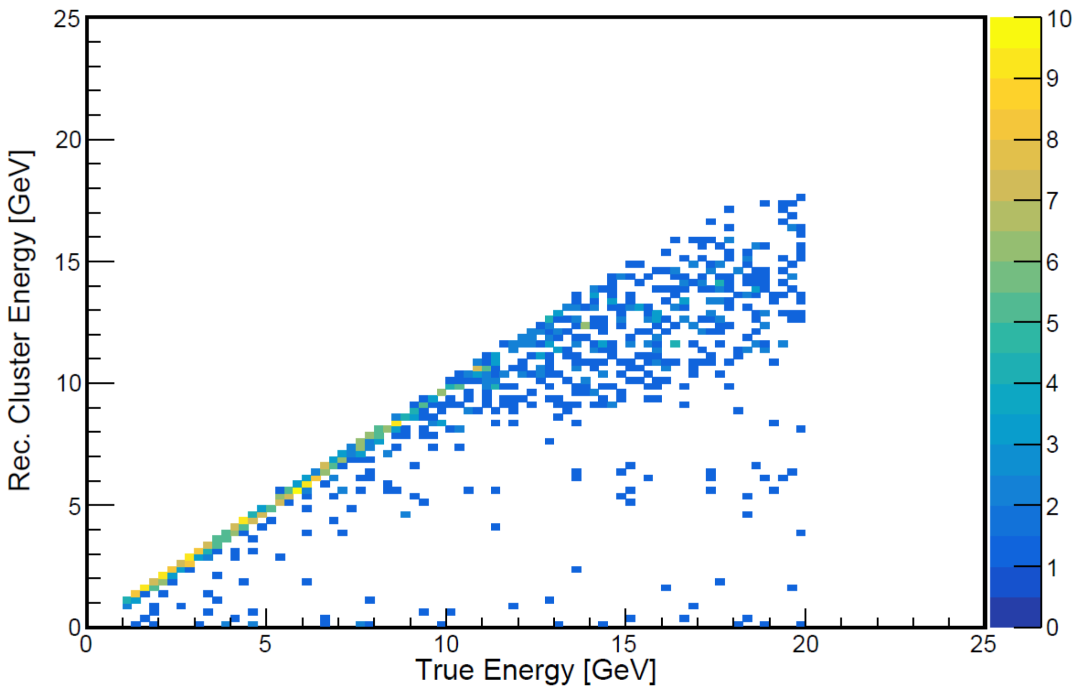
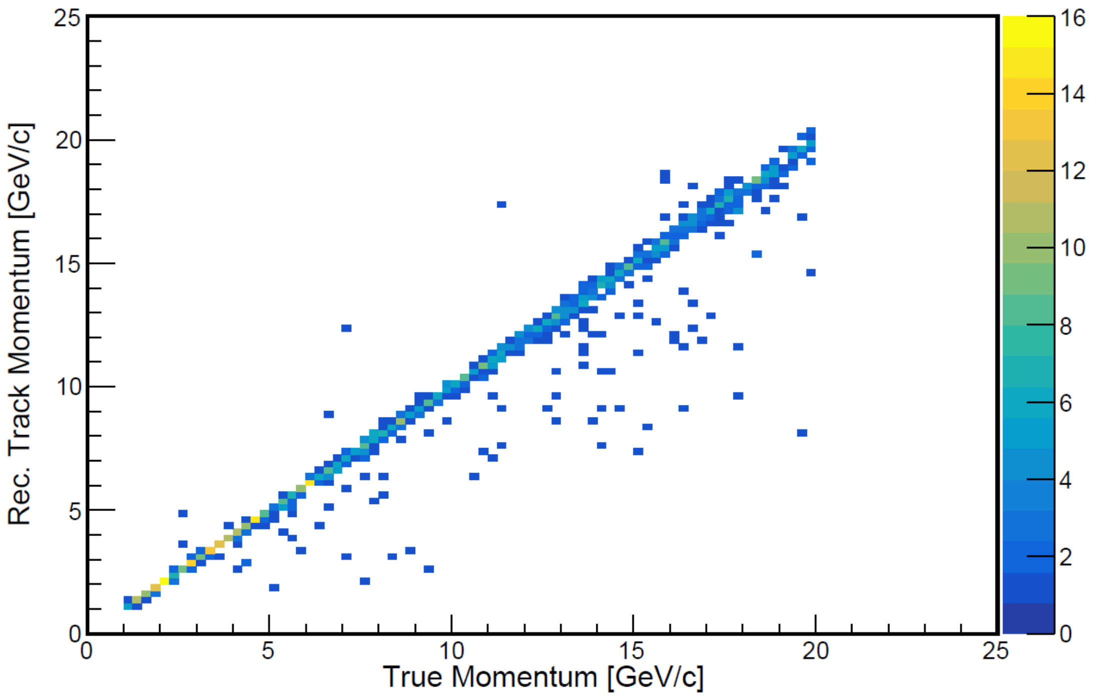
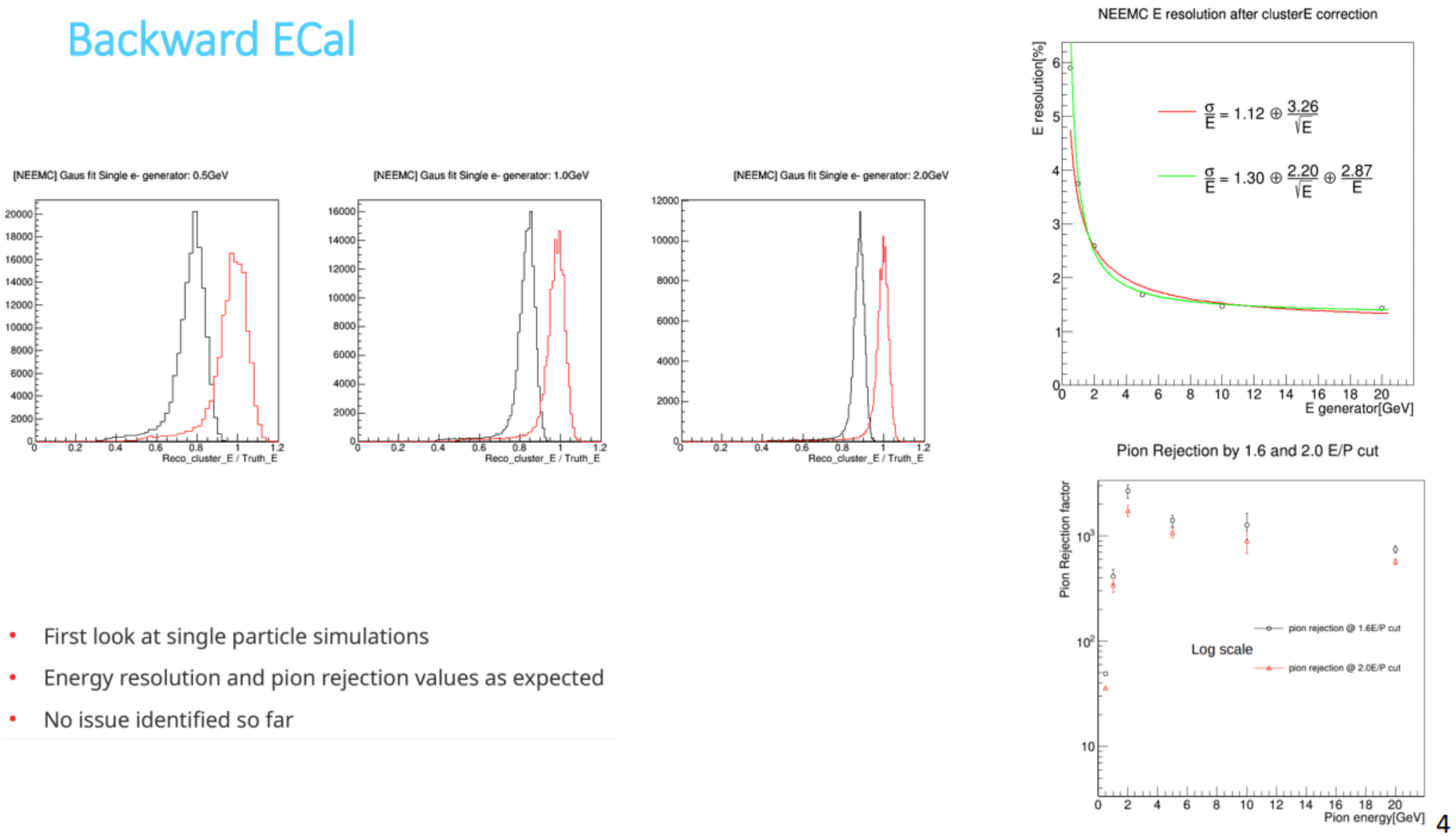




Comments

- The track projection itself looks very good!
- I see poor energy reconstruction and resolution for the EEMC for >10 GeV electrons if I use both the 'nightly' and the latest tagged geometry. This seems to disagree with the results from the calorimeter group.
- I used *Juggler* for all the above plots – using the calorimeter reconstruction benchmarks 'options' file.
- Need to test with *EICRecon* to see if effect persists.

<u>Slide from Calorimeter group</u>



Next steps

1. Repeat the above studies using the *EICRecon* framework. This will some effort, since we will need to write a 'factory' to save the track projections to our output ROOT files. Dmitry Romanov said he will help me do this next week.
2. After getting the *EICRecon* results, work with the calorimeter group to understand the resolution discrepancy.
3. Write a simple algorithm for scattered electron reconstruction (electron finder) based on track-to-cluster matching and an E/p cut. Inclusion of PID detectors can come later.

Scattered Electron kinematics

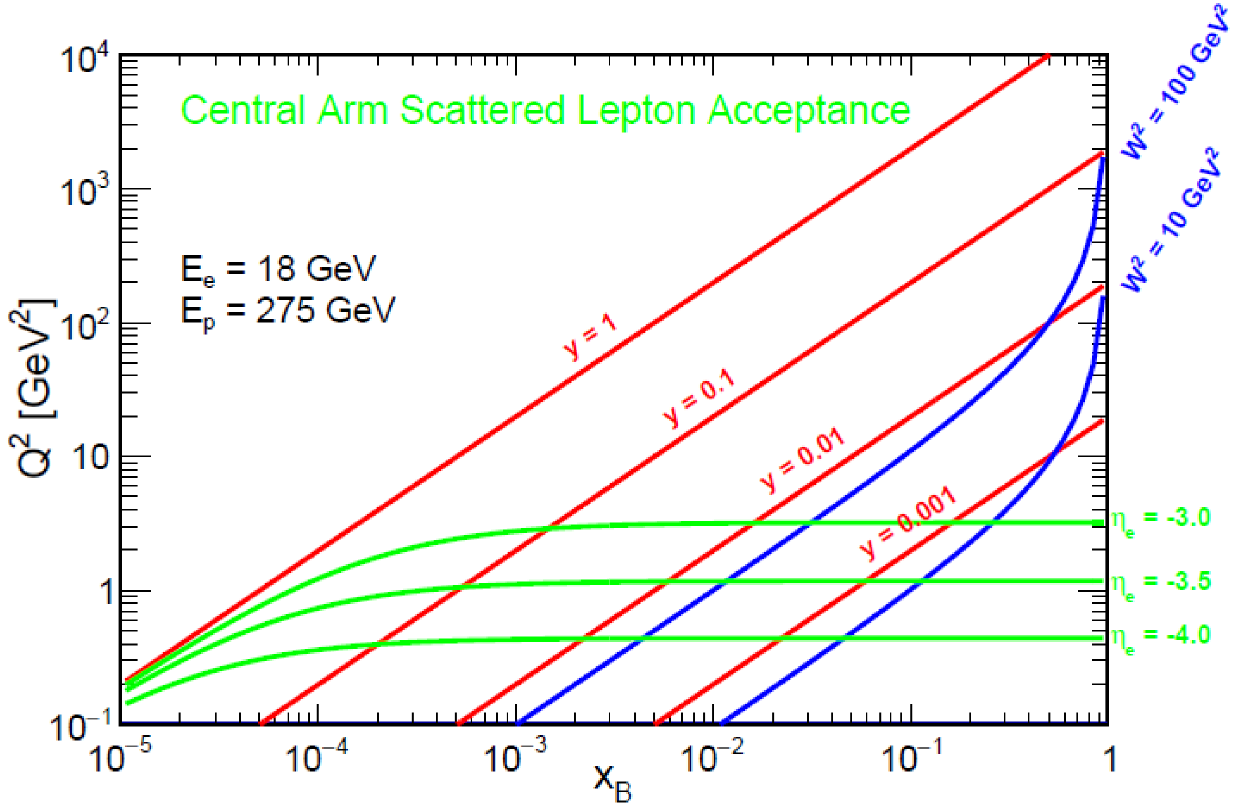
- For the beam energies that will be used at the EIC and considering scattered electrons in the pseudo-rapidity range of −4 < η < 4 (where $Q^2 \gg m_e^2$), we can relate the inclusive kinematic variables to the scattered electron angles and energies as

$$y_e = 1 - \frac{E'_e}{2E_e}(1 - \cos\theta_e) \ ,$$
$$Q^2_e = 4E_e E'_e \cos^2(\theta_e/2) \ ,$$
$$x_e = \frac{Q^2_e}{s y_e} \ .$$

- Note how neither Q^2 nor y depend explicitly on the proton beam energy.

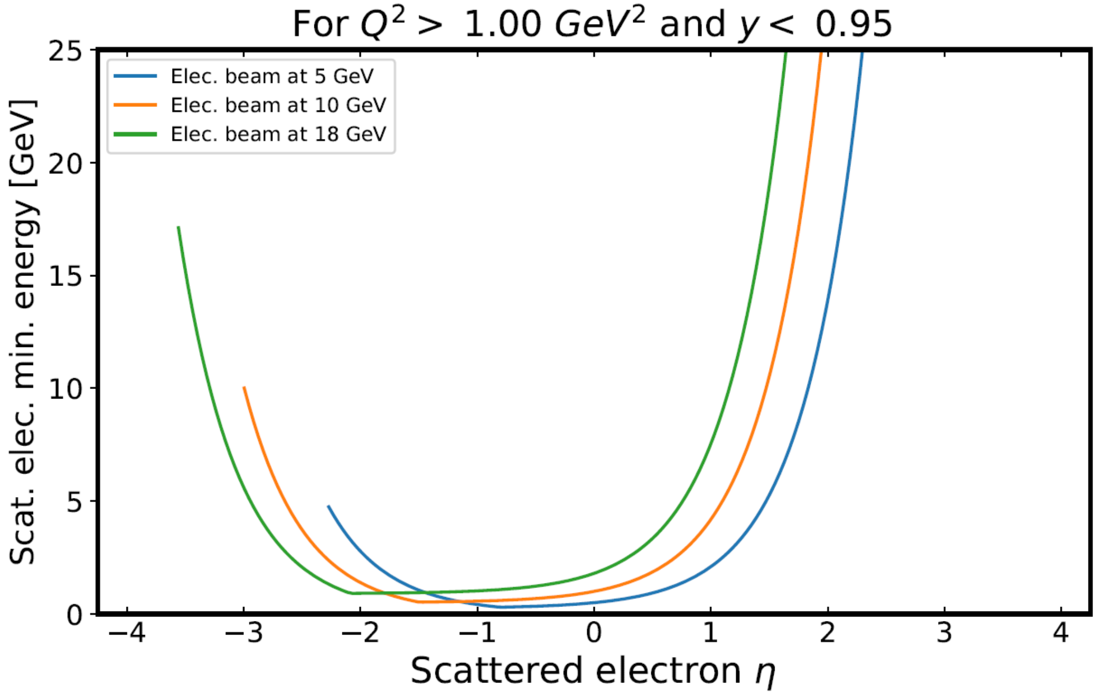
Electron Angular Acceptance

- For many EIC physics processes which have a requirement that $Q^2 > 1$ GeV^2, an angular acceptance of $\eta \gtrapprox -3.6$ will allow full coverage at the highest EIC beam energy setting. At lower energies, this same acceptance coverage would allow access to lower values of Q^2 (see next slide).
- Any processes which require $Q^2 < 1$ GeV^2 at the highest energy setting will need an extended acceptance below $\eta \approx -3.6$.
- For inclusive physics, coverage below $Q^2 = 1$ GeV^2 has strong motivations: to study the perturbative to non-perturbative transition; to give access to lowest possible x, which is well-aligned with the central EIC physics aims to study mass generation and dense systems of gluons; and to minimize the 'gap' in Q^2 coverage between the central detector and the far-backwards low-Q^2 tagger.

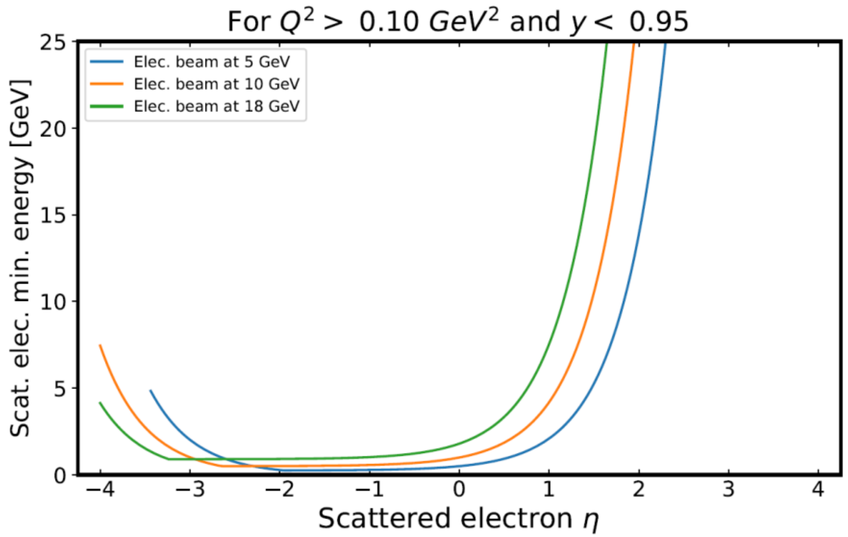


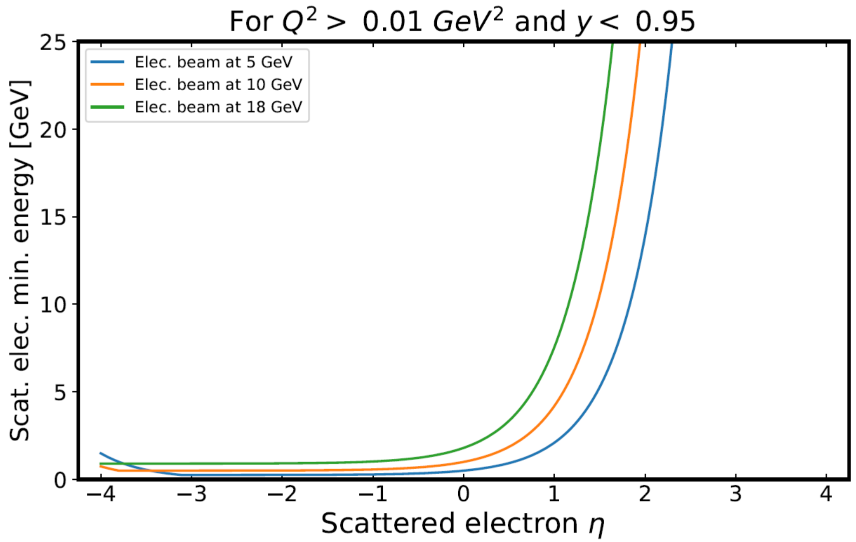
Electron Minimum momentum (energy)

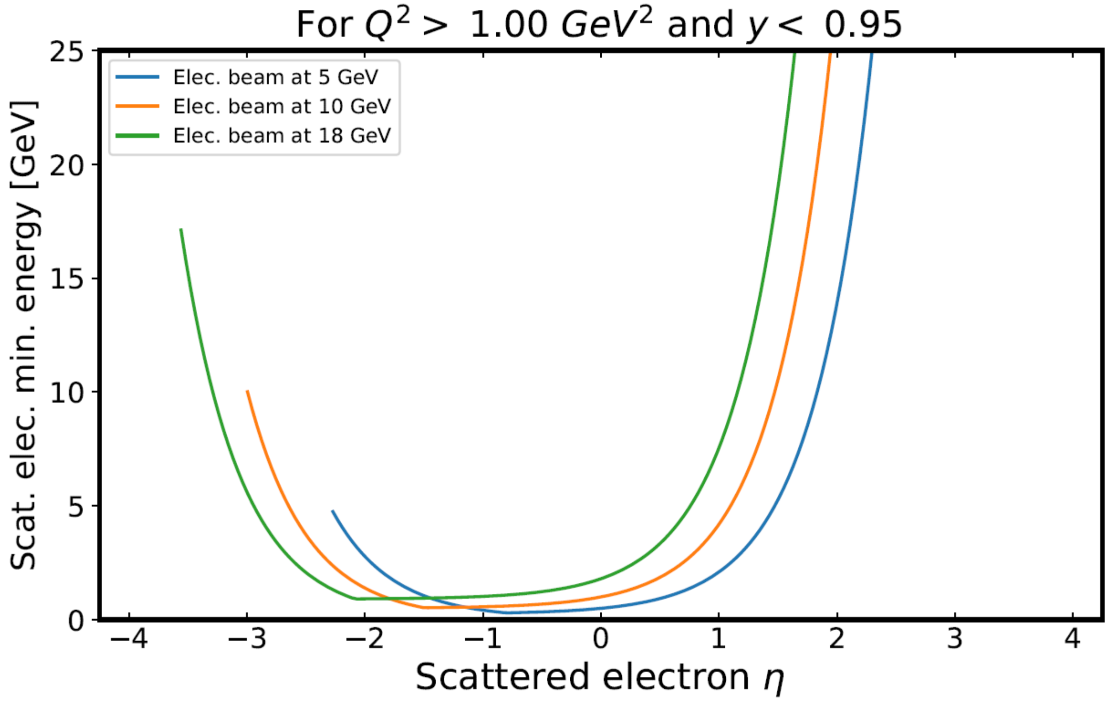
- Consider the case where the physics requires $Q^2 > 1$ GeV^2. The plot on the right shows as a function of η the minimum electron energy that satisfies both the $Q^2 > 1$ GeV^2 requirement and the $y < 0.95$ requirement.
- There are a few important features of this plot:
  1. The curves do not extend to the lowest possible values of pseudo-rapidities. This is because at the most negative values of η, the scattered electron can not be created at $Q^2 = 1$ GeV^2 (y would be negative), only at lower values of Q^2.
  2. Starting at the most negative η value that is allowed, each minimum energy curve decreases towards more positive values of η. For this left part of the curve, the minimum energy is exactly at the $Q^2 = 1$ GeV^2 limit (while still satisfying the $y < 0.95$ requirement).
  3. Moving towards more positive values of η, each minimum energy curve reaches a global minimum value and then begins to grow. Once the curve begins to increase towards more positive values of η, the minimum energy of the scattered electron is at the $y = 0.95$ limit (while still satisfying the $Q^2 > 1$ GeV^2 requirement).



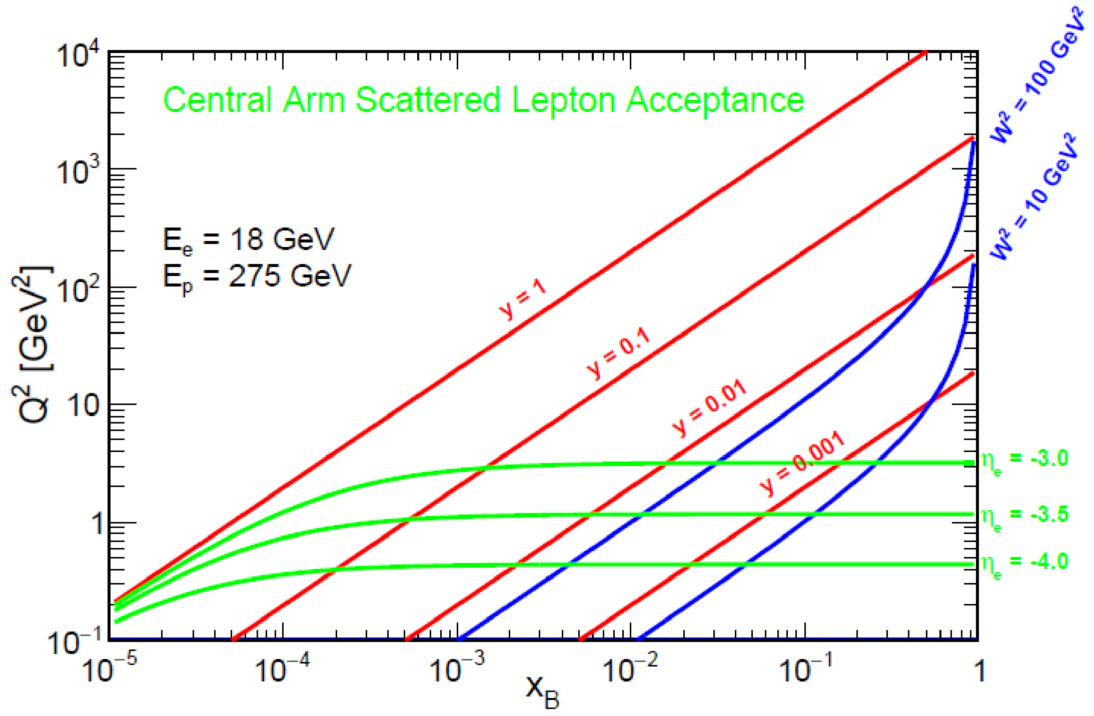
Scattered electron energy in backwards direction is quite large unless at very low Q^2

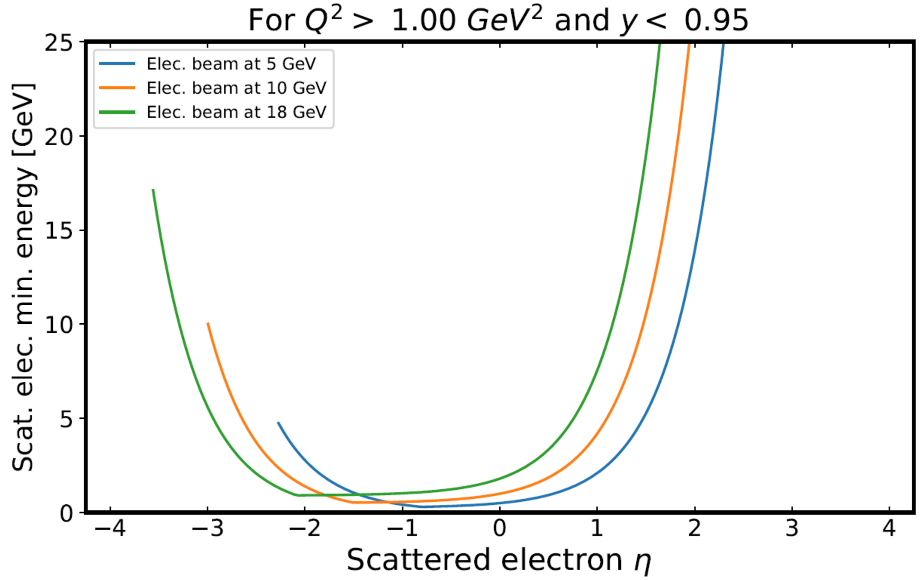


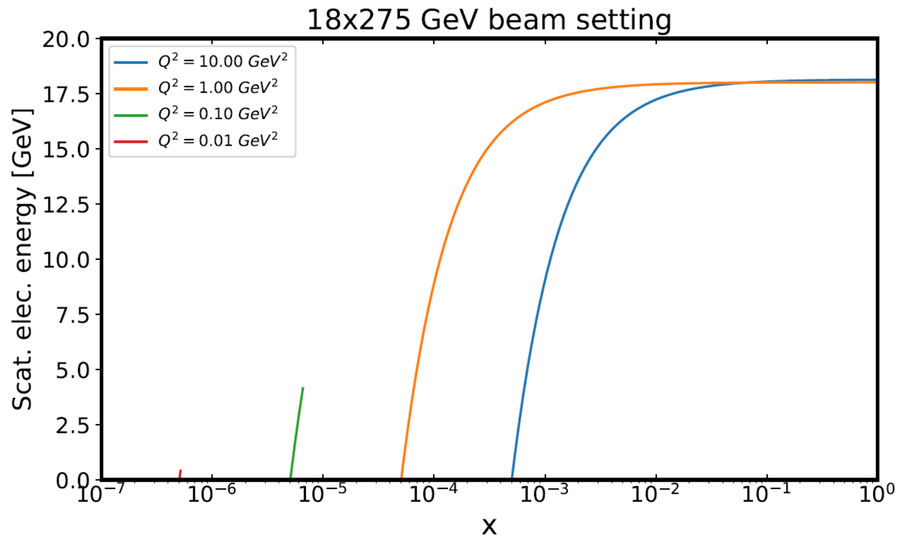




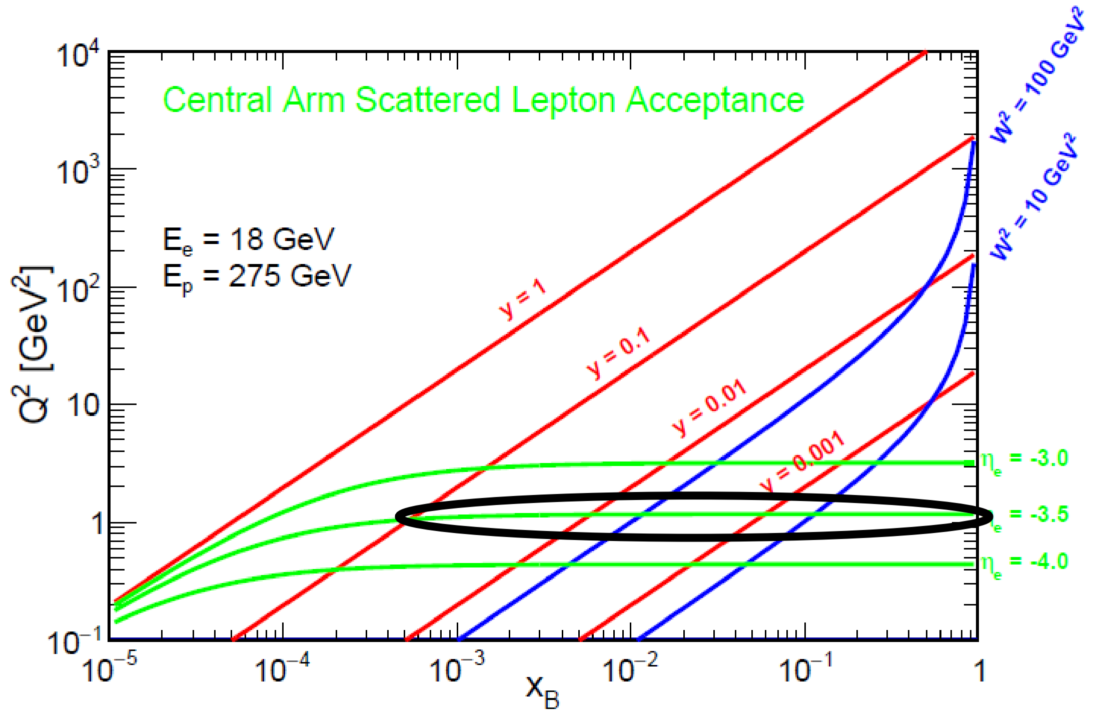
Comments

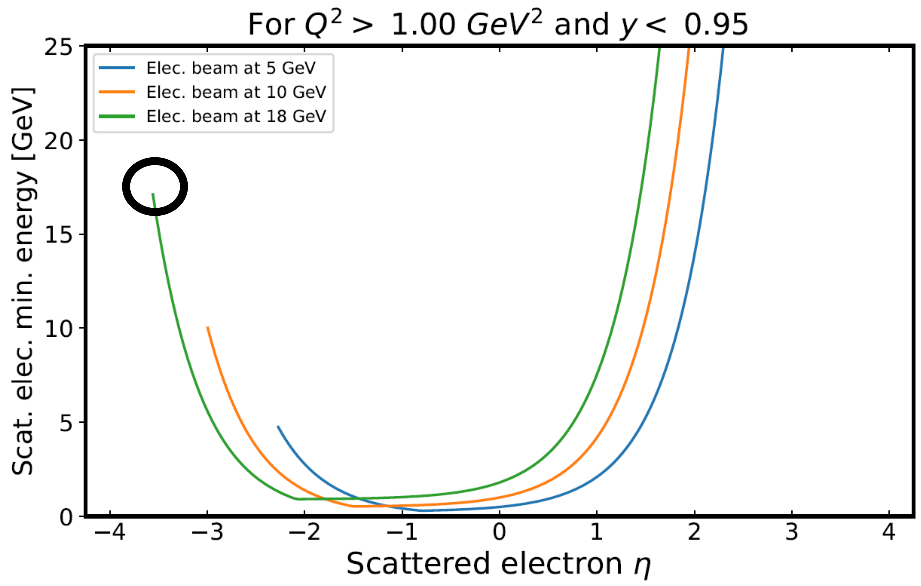

Central Arm Scattered Lepton Acceptance
E_e = 18 GeV
E_p = 275 GeV
Q^2 [GeV^2]
x_B
y = 1
y = 0.1
y = 0.01
y = 0.001
W^2 = 100 GeV^2
W^2 = 10 GeV^2
η_e = -3.0
η_e = -3.5
η_e = -4.0

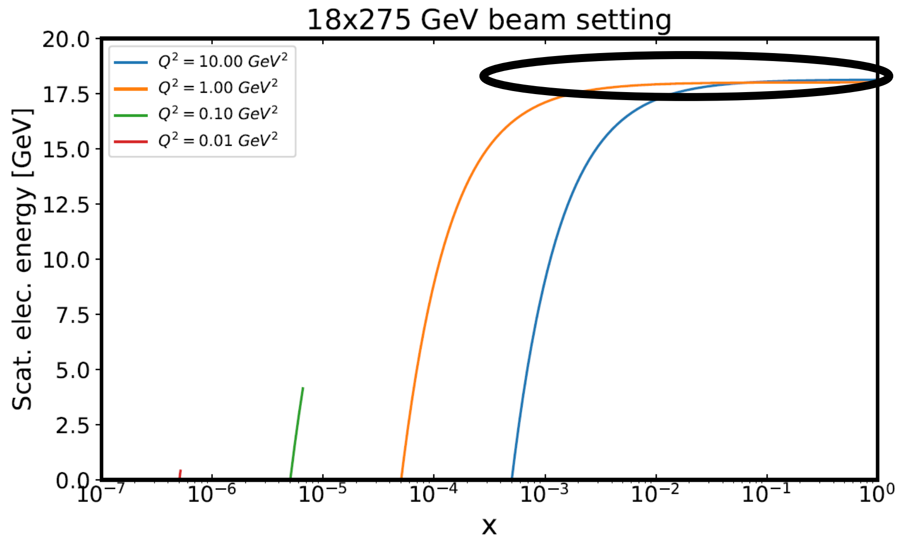

For $Q^2 >$ 1.00 GeV^2 and $y <$ 0.95
Elec. beam at 5 GeV
Elec. beam at 10 GeV
Elec. beam at 18 GeV
Scat. elec. min. energy [GeV]
Scattered electron η


18x275 GeV beam setting
$Q^2 = 10.00\ GeV^2$
$Q^2 = 1.00\ GeV^2$
$Q^2 = 0.10\ GeV^2$
$Q^2 = 0.01\ GeV^2$
Scat. elec. energy [GeV]
x

Comments



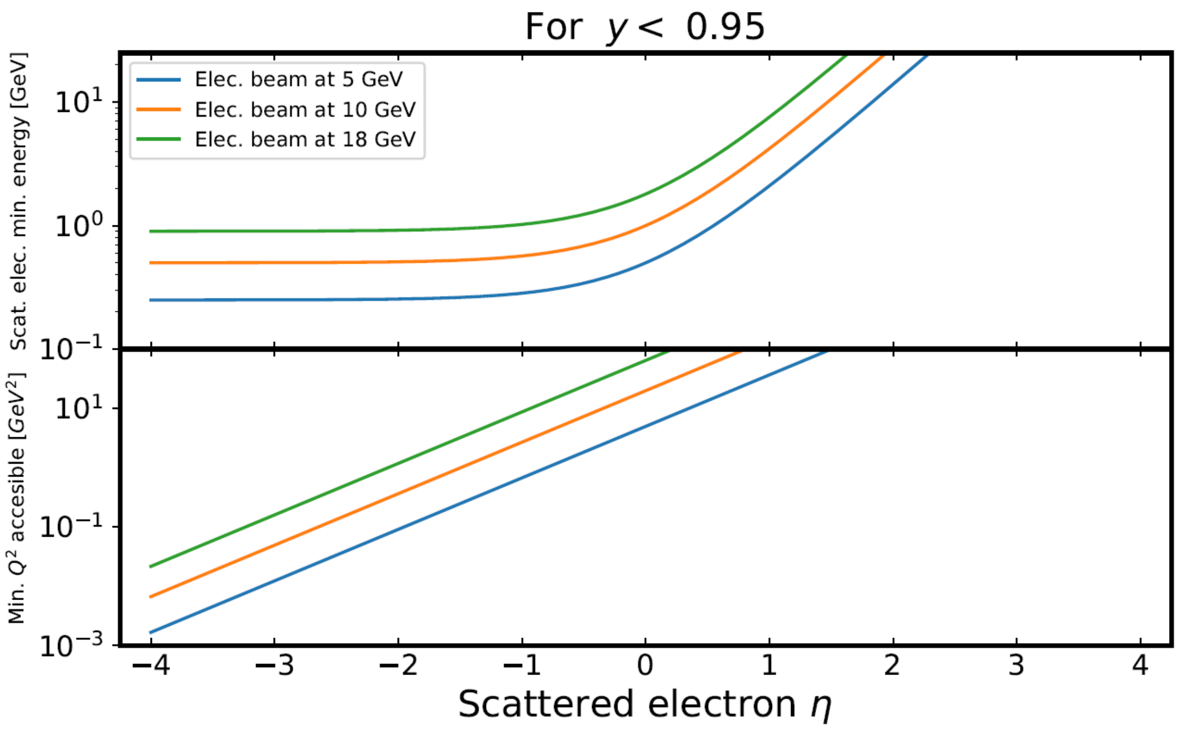




- For Q^2 = 1 GeV^2, the scattered electron energy is at almost a fixed energy for a large range of x. Reconstruction of x using the scattered electron is impossible here.
- Note how more central rapidities correspond to lower x at a fixed Q^2.

Comments on backwards tracking

- For the reconstruction of the scattered electron in the backwards part of the negative endcap, the track momentum will always be used for E/p cuts, and the reconstructed angle for Q^2 reconstruction.
- The scattered electron momentum (energy) reconstruction will probably rely on the tracking detector only for lower-Q^2 ($Q^2 << 1$ GeV^2) events. The question of how low in Q^2 we really need to measure is being studied by the Inclusive PWG now. Questions of pion background and beam divergence effects also need to be considered.



Comments on backwards tracking

$$t \simeq -(\vec{p}_{t,\psi} + \vec{p}_{t,e})^2$$

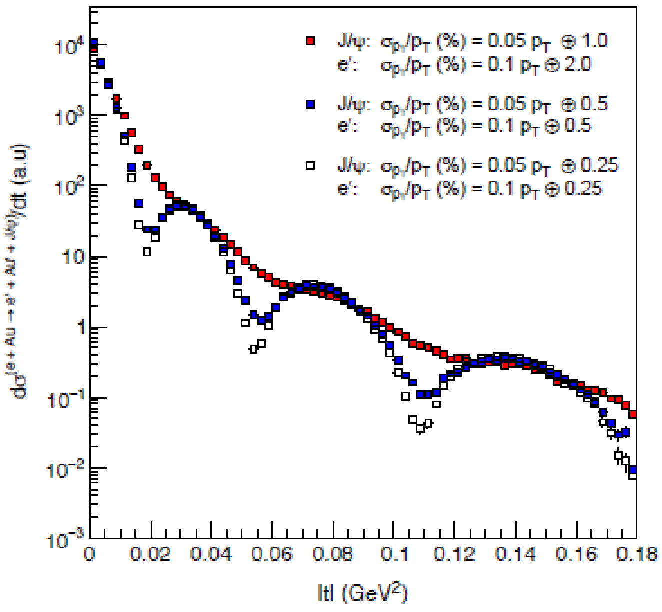


Figure 8.85: Illustration of the impact of different p_T resolutions on the coherent J/ψ production cross section, $d\sigma/dt$, for $1 < Q^2 < 10$ GeV^2.

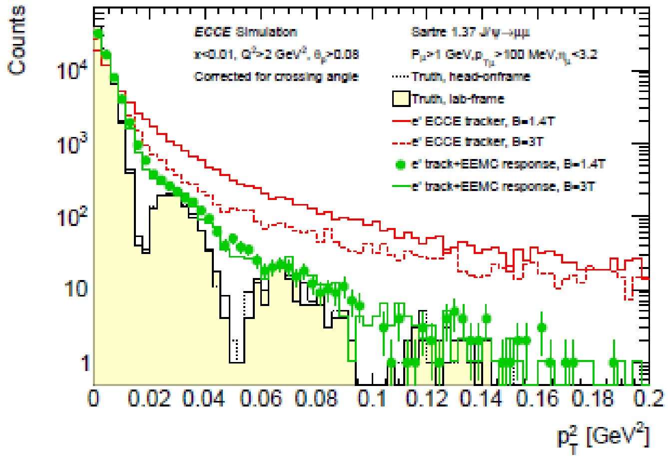


Figure 3.20: Simulation of the t dependence of the elastic diffractive J/ψ production in eA for 1.4 T and 3.0 T field strengths. Results are shown for analyses using information from the tracking (red lines) or tracing + calorimetry (green line and points) systems for the lepton momentum reconstruction. As can be seen, the t reconstruction resolution is dominated by the calorimetry resolution the field strength has small impact on this measurement.

Comments on backwards tracking

- Besides the scattered electron, other particles in the negative endcap need to be reconstructed for various physics processes.
- In addition, measurements of total E-p_z are important for reducing the sizes of photoproduction background and radiative corrections.