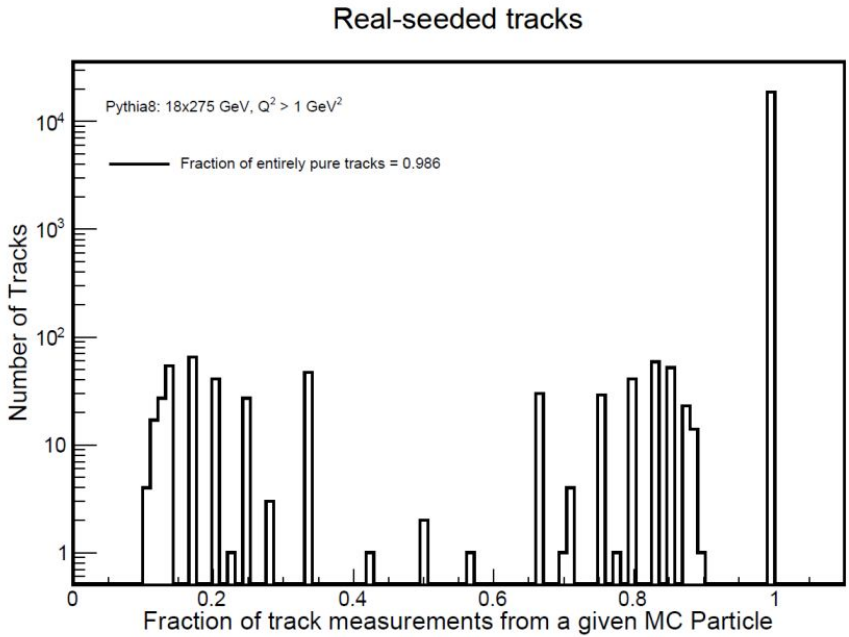
Recent tracking and vertexing updates

Barak Schmookler and Ernst Sichtermann

Track reconstruction activities

- Study of track purity in DIS events using newly implemented hit-based track to MC particle matching (slides).
- Study of detector hits not used in reconstructed track (slides). Work by Shujie Li. Two issues: MPGD thresholds (fixed) and last hit-point not being used by CKF (under investigation).
- Study of seeding efficiency at lower momentum (slides). Work by Jeetendra Gupta. Next step: study seeding code to understand why certain lower-momentum particles are not forming seeds. May need to discuss with Acts developers.
- Finished tracking detector benchmark for DIS events.
- Real-seeding tracking is now default tracking mode (EICRecon PR #1605); and update to Acts version (v33).



SVT and MPGD software activities

- Update to MPGD threshold (EICRecon PR #1619) and justification for updated value (slides).
- Update to SVT OB simulation geometry using CAD files (slides). Work by Tuna Tasali and Sam Henry. Status: Code to create DD4HEP geometry from CAD files with automatic script implemented, but some bugs still present.
- Implementation of noise hits in SVT layers (slides). Work by Mito Funatsu. Conclusions / next steps: Implementation of noise hits into EICRecon digitization factory is challenging. Plan is to discuss with DD4Hep developers on how to use DD4Hep noise tools.

Vertexing activities

- Added link between reconstructed vertex and associated tracks (EICRecon PR #1576). Work by Xin Dong.
- Created PrimaryVertices collection, which applies loose primary vertex requirements and sorts vertices according to number of associated particles (EICRecon PR #1609).
- Analysis code to calculate track parameters at DCA w.r.t primary vertex and study of D0 reconstruction in DIS events (slides). Work by Rongrong Ma. Next step: find Acts-based method to calculate DCA between 2 tracks.
- Creation of vertexing benchmark for DIS events. Work by Khushi Singla.

Software tasks (near term)

Compiled by Shujie Li

- Update SVT geometry:
  - Disks and beampipe openings – Shujie Li
  - Outer barrel update to new design – Sam Henry (et al.)
  - Inner barrel curved surface – Shujie Li
  - Sensor inactive areas – Shujie Li
- Include BIC in tracking – Wouter Deconinck
- Resolve seed-finder inefficiency at low momentum – Barak Schmookler, Jeetendra Gupa
- Include SVT noise hits in digitization – Mito Funatsu, Beatrice Liang-Gilman
- Resolve CKF not using the hit from the outermost MPGD – NA
- Develop secondary vertex finding and reconstruction – Rongrong Ma, Xin Dong

Preliminary Design Report

- Caveat: feedback from ePIC internal review is not factored into what follows,
- The tracking section is currently empty – no request received to date,
- We will proceed under the assumption that a section will be needed for the December 1 version,
- Two of our current observations:
  - SVT and MPGD sections contain partial information on tracking performance originating from within the tracking working group; among the missing elements is the efficiency (and purity) in the anticipated hit environment,
  - Chapter 2, in its current form, seems to fall short of demonstrating the necessity of the (high-level, tracking) instrument performance requirements,

Preliminary Design Report – Tracking-related figures (selected)

Chapter 8, SVT section:

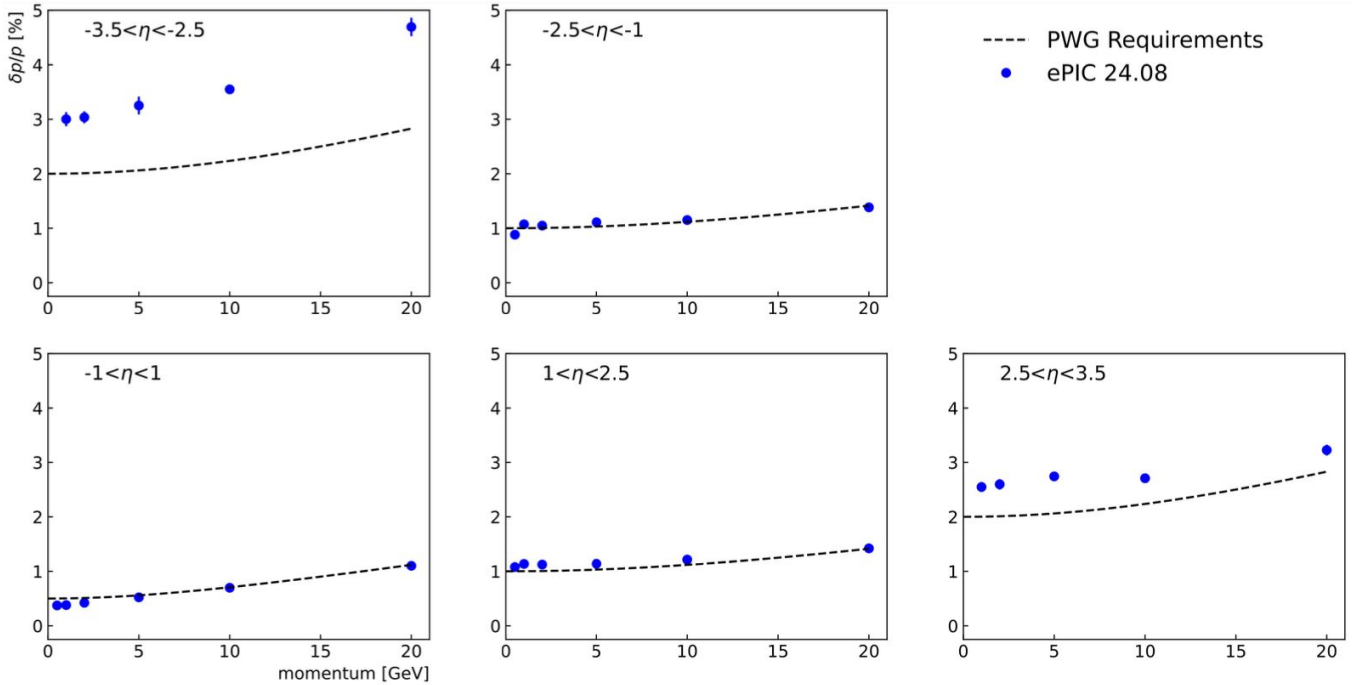


Figure 8.9: Relative momentum resolution versus total momentum for charged pions (points) together with physics requirements (curves) in different pseudorapidity ranges as indicated. The results are based on full GEANT simulations using the ePIC software stack and ACTS-based track finding and reconstruction using optimized parameters.

Preliminary Design Report – Tracking-related figures (selected)

Chapter 8, SVT section:

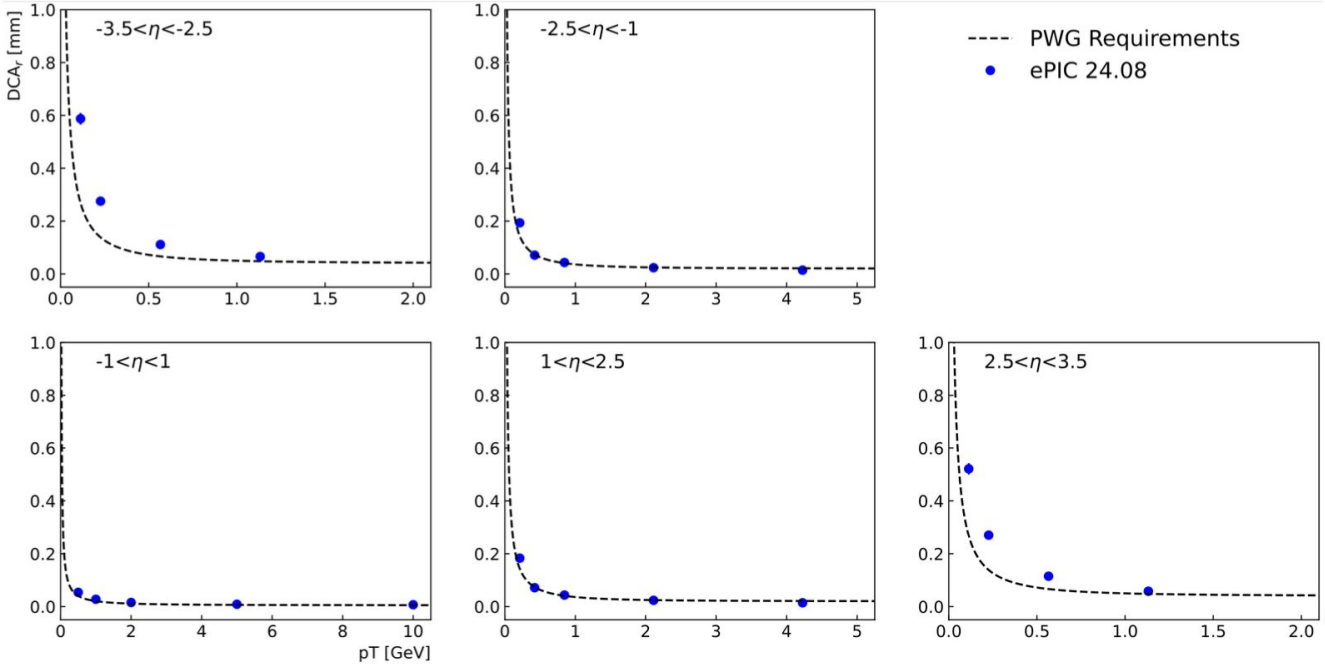


Figure 8.10: Distance of closest approach in the radial direction between reconstructed charged pion trajectories and the event origin versus transverse pion momentum (points) together with physics requirements (curves) in different pseudorapidity ranges as indicated. The results are based on full GEANT simulations using the ePIC software stack and ACTS-based track finding and reconstruction using optimized parameters.

Preliminary Design Report – Tracking-related figures (selected)

Chapter 8, MPGD section:

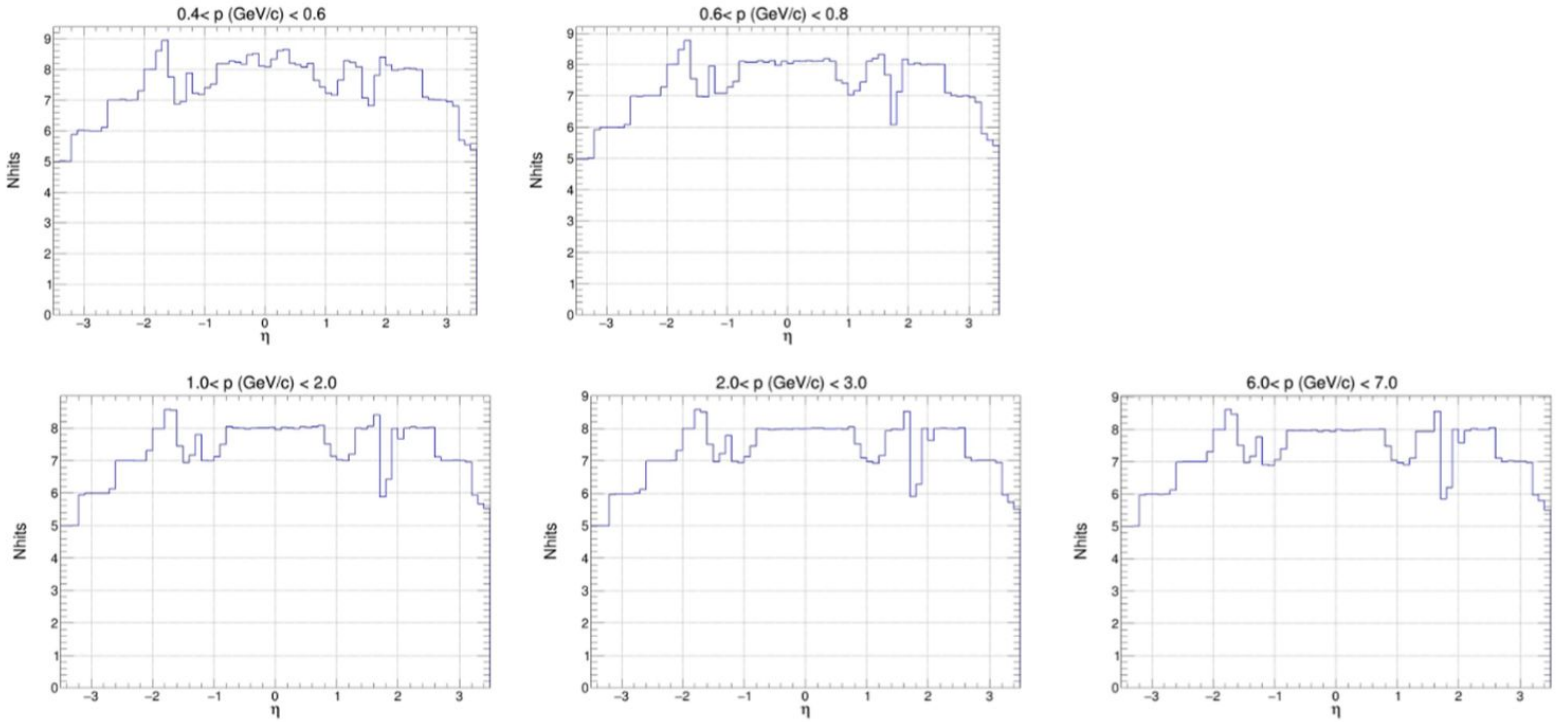


Figure 8.20: Total tracker hits vs. η for various momentum ranges.

Preliminary Design Report – Tracking-related figures (selected)

Chapter 2, Kinematic reconstruction section:

Figure 2.1 shows the y resolution at ePIC as a function of x_B and Q^2 for 18 GeV on 275 GeV ep collisions. As can be seen, the optimal reconstruction method changes with kinematics. These resolutions result from reconstructing the electron momentum strictly from tracking detectors. The resolution could be further improved by using the electromagnetic calorimeter clusters to reconstruct the electron energy. This is particularly important for electrons scattered into the backwards ECAL.

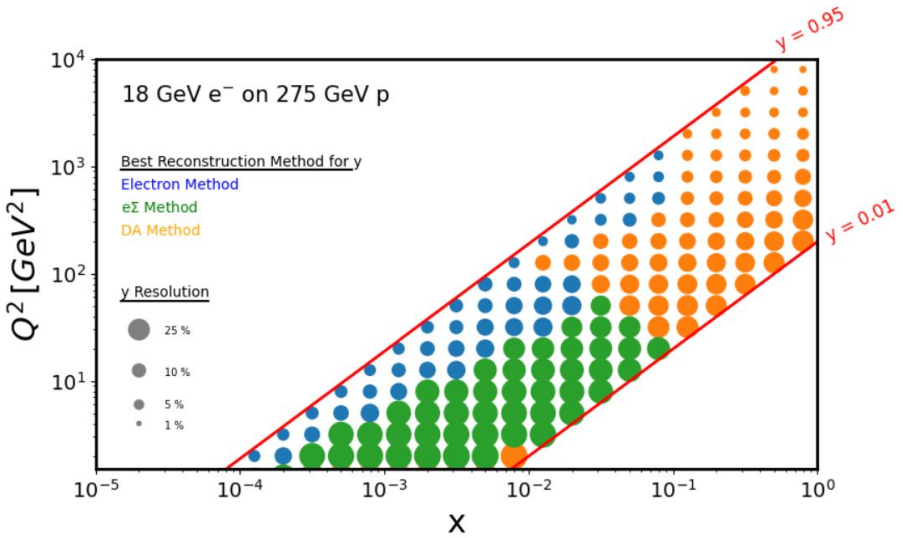


Figure 2.1: y Resolutions.

Preliminary Design Report – Tracking-related figures (selected)

Chapter 2, Gluon saturation section:

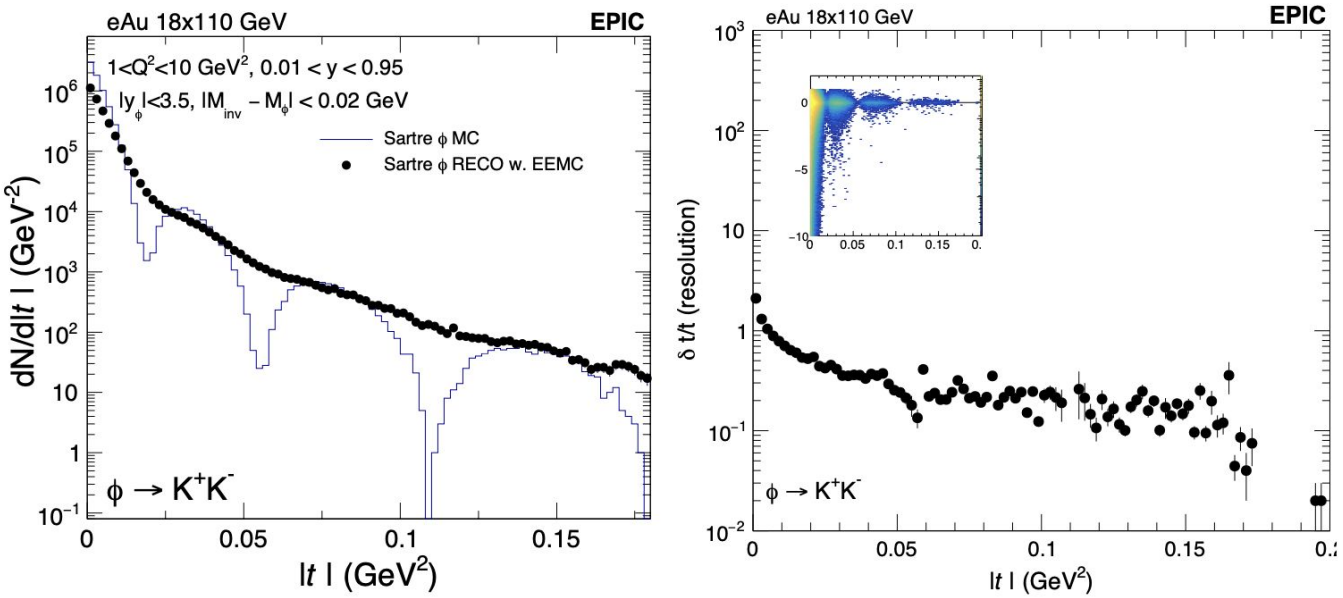


Figure 2.13: Left: differential distribution of the momentum transfer $|t|$ of coherent ϕ meson electroproduction in electron-gold collisions with 18x110 GeV. The Monte Carlo model is provided by Sartre and the reconstructed distribution is obtained from full ePIC simulation with the official August 2024 simulation campaign. Right: the momentum transfer t reconstruction resolution as a function of the true t.

Preliminary Design Report – Tracking-related figures (selected)

Chapter 2, Upsilon reconstruction section:

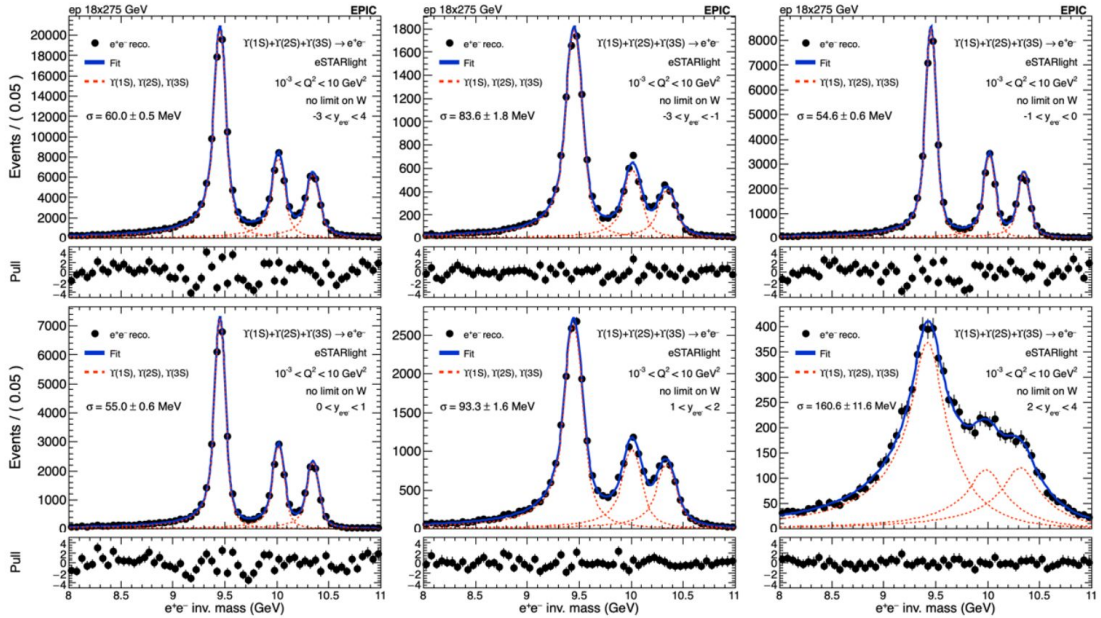


Figure 2.6: The reconstructed mass distribution of the Υ three states in the electron channel from the electron-proton collisions at $18 \times 275\ GeV$, utilizing the tracker with realistic seeding. The top left plot shows the invariant mass distribution of the Υ three states in the rapidity range from -3 to 4. The other plots display invariant mass distribution for specific rapidity intervals: (top middle) $-3 < y < -1$, (top right) $-1 < y < 0$, (bottom left) $0 < y < 1$, (bottom middle) $1 < y < 2$, and (bottom right) $2 < y < 4$. The resolution of the Υ three states is indicated on each plot as σ.

Preliminary Design Report

- As said, we will proceed under the assumption that a tracking section will be needed for the December 1 version,

- Such a December 1 tracking section is likely to stay relatively close to the instrument sections, as a matter of it existing in Chapter 8 and pragmatism:
  - Seemingly unrealistic to assume that e.g. secondary vertex finding and reconstruction will be far enough along by December to link to, say, an open charm measurement even though effort is ongoing,
  - Workforce shortages have not been resolved and have, in some cases, become worse since the Summer in view of ongoing semesters.