Kinematic Reconstruction for Inclusive Scattering at EIC-ATHENA

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1. Motivations

- Inclusive cross section for electron-proton scattering is a function of kinematic variables (x, y, Q^2) $\rightarrow$ accurate reconstruction of these variables is vital at the future Electron-Ion Collider (EIC).
- Simulation studies using various reconstruction techniques demonstrate the ability of the ATHENA detector to accurately reconstruct the inclusive kinematics over the entire EIC phase space.

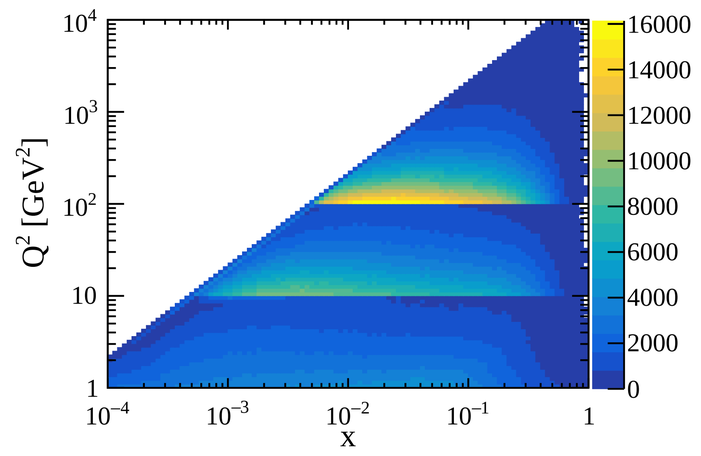
2. Kinematic Reconstruction in DIS

Kinematics of inclusive DIS processes are described in terms of scaling variable x, inelasticity y, and virtuality Q^2. Various reconstruction methods are available which require different measured quantities:

- **Electron method** — Scattered electron energy and angle.
- **Jacquet Blondel (JB) method** – Energy and angle of hadronic final state (HFS).
- **Double Angle method** — Scattered electron angle and HFS angle.
- **$\mathbf{e-\Sigma}$ method** — Scattered electron energy and angle, HFS energy and angle.

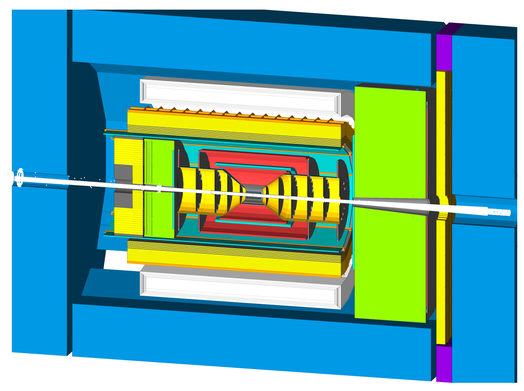
3. Simulation

- Neutral current DIS events for $18\,\mathrm{GeV}$ electrons incident on $275\,\mathrm{GeV}$ protons produced using Pythia8 event generator.



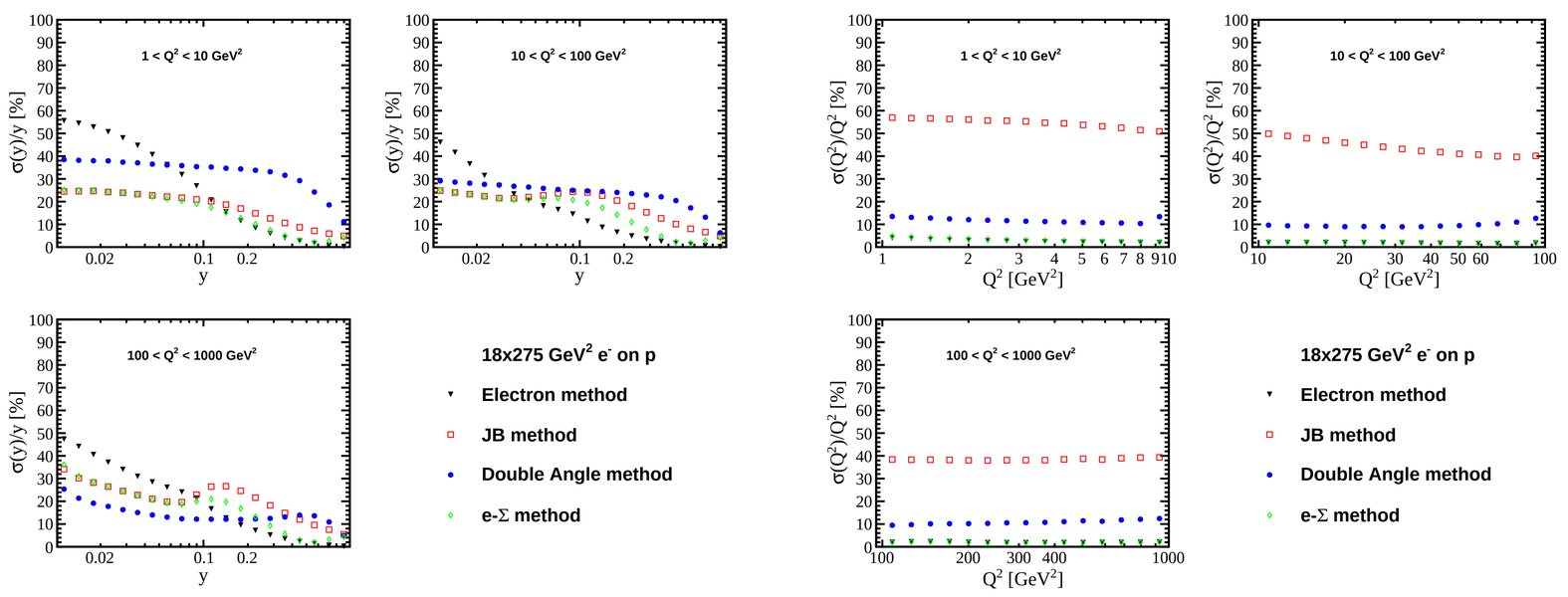
Number of events generated in each $x - Q^2$ bin as a function of x and Q^2. 15M events generated in total.

- Events propagated through detector description using Geant4 $\rightarrow$ particles reconstructed.
  - Charged particles from tracker.
  - Neutral particles from calorimeter clusters.



ATHENA Detector Visualisation.

4. Kinematic Resolutions

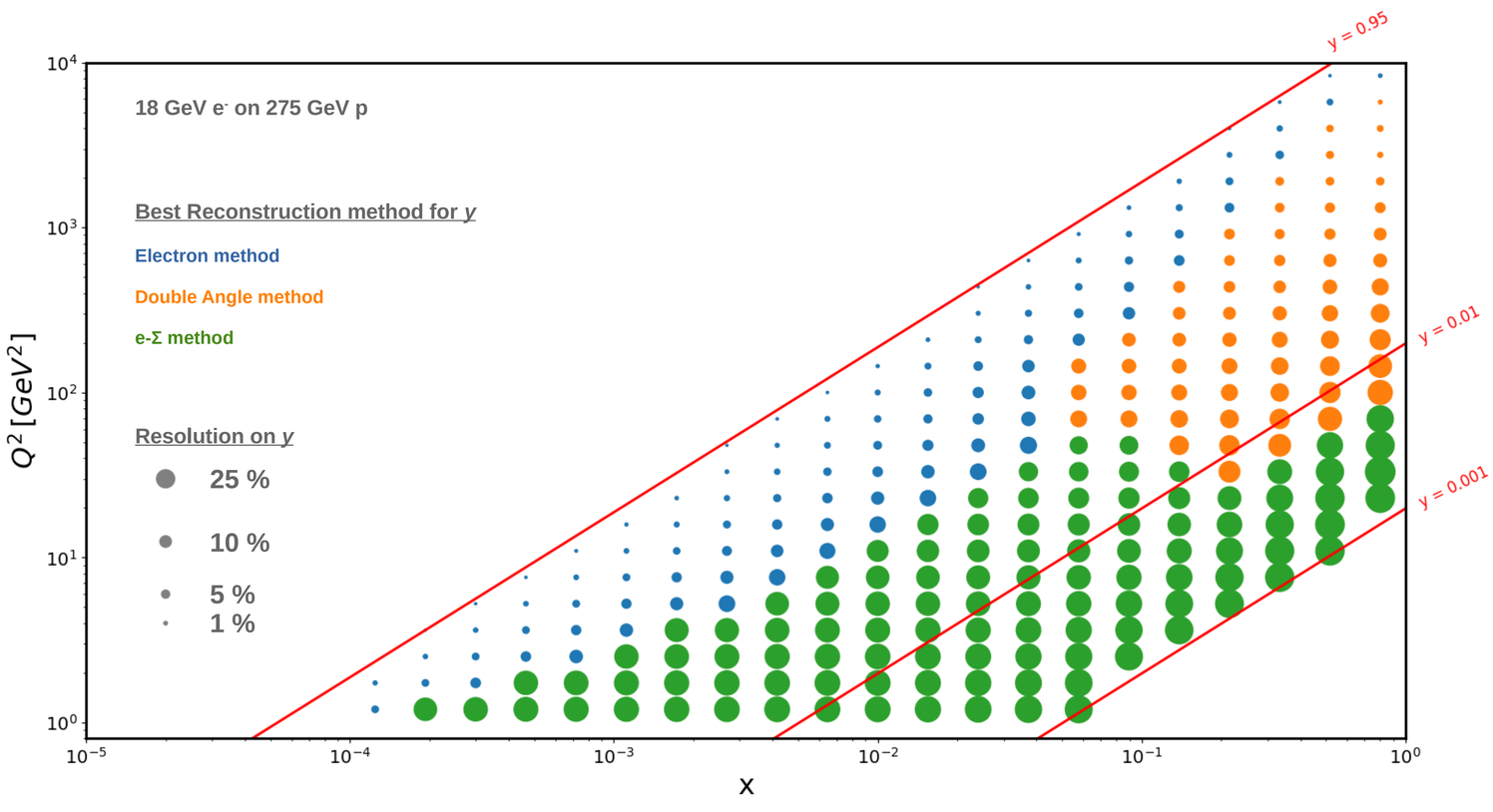


Resolution on y as a function of y in 3 ranges of Q^2.

Resolution on Q^2 as a function of Q^2 in 3 ranges of Q^2.

- The **Electron method** gives the best y resolution for $y \gtrsim 0.1$
- The **Double Angle method** gives the best y resolution at low y (large x) and large Q^2. This corresponds to events where the angles of the scattered electron and the HFS are large.
- The **$\mathbf{e-\Sigma}$ method** gives the best resolution at low y and low Q^2.
- The **Jacquet-Blondel method** never gives the best resolution, but is the only option for Charged Current scattering, in which the final state lepton is a neutrino.
- The **Electron method** and **$\mathbf{e-\Sigma}$ method** are equivalent in Q^2 reconstruction and provide the best resolution for this variable.

By choosing the best possible reconstruction method for a given $\mathbf{x - Q^2}$ bin, the following resolutions can be obtained:



5. Conclusions

- Using the $18 \times 275\,\mathrm{GeV}$ electron-proton beam configuration proposed for the future EIC, the detector configuration studied achieves a y resolution of $\sim 30\%$ or better over the considered phase space if the best reconstruction method is chosen.
- The Jacquet-Blondel method is the only option available for CC scattering, and also displays satisfactory y reconstruction performance for this detector configuration.
- Such a detector would fulfil the needs of the inclusive physics program at the EIC.

Acknowledgements

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