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Probing Strangeness in an Electron-Ion Collider Environment using ZEUS data at HERA

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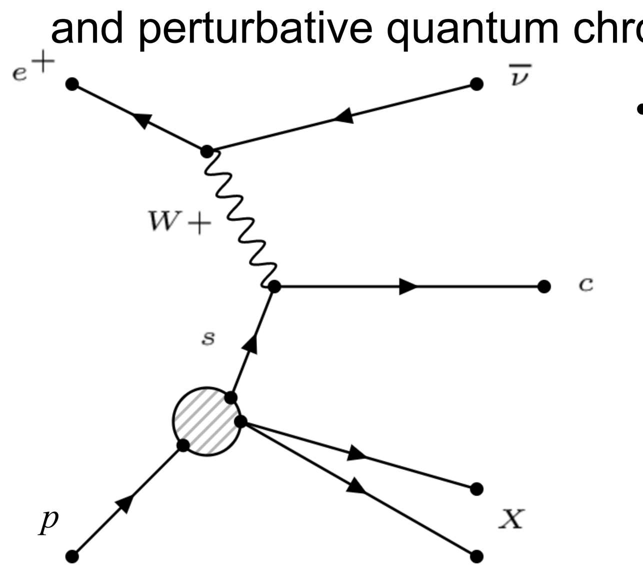
Motivation

- The main goal is to study the potential of the Electron-Ion Collider (EIC) in a similar environment by using the data taken by the **ZEUS** detector at **HERA**.
- Heavy-Flavor measurements provide a rich testing ground for the proton structure and perturbative quantum chromodynamics (pQCD).



- Charm cross section measurement in high-Q^2 charged current deep-inelastic scattering (CC DIS).
  → constraints on $s(x, Q^2)$
  - Process via down quark is also available, but Cabbibo-suppressed.
  - Due to the final state ν, a large missing p_T is expected.

- This analysis will serve as a complementary measurement at high-Q^2 to the previous analyses by CCFR/NuTeV and ATLAS.

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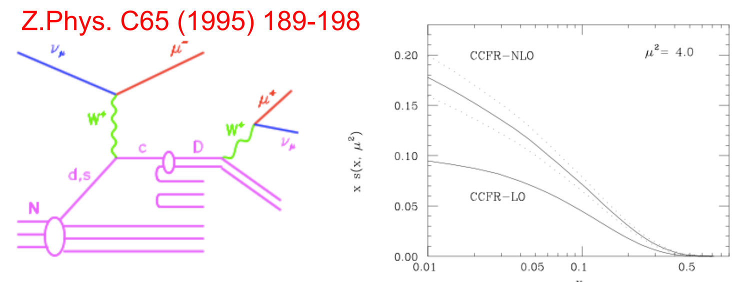

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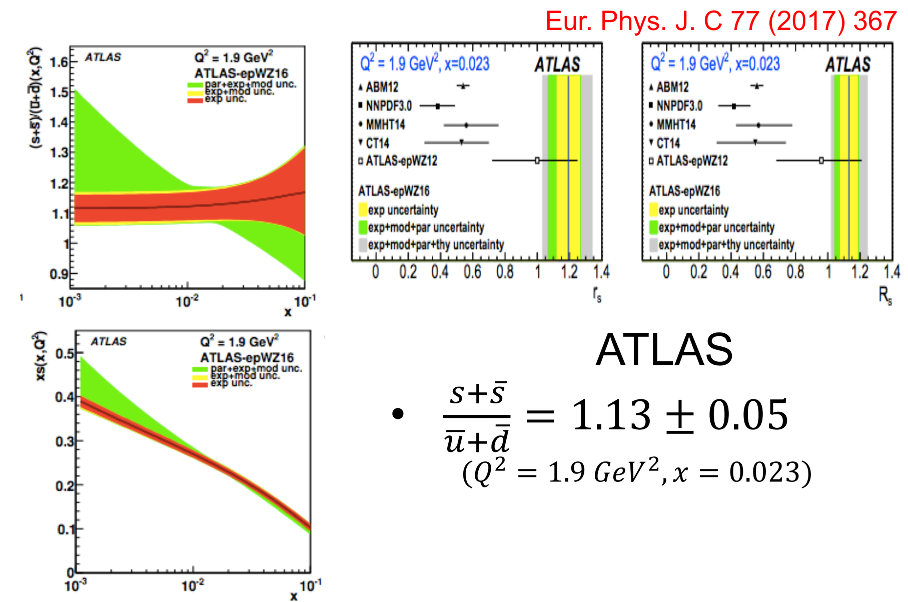
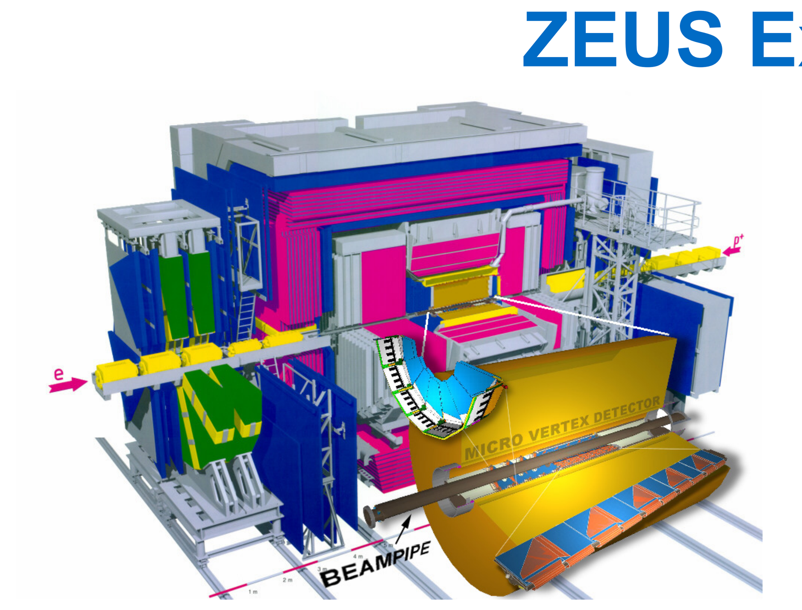


CCFR/NuTeV
- Opposite sign di-muon events in neutrino-nucleon collisions
- $\frac{\int_0^1 dx[xs+x\bar{s}]}{\int_0^1 dx[x\bar{u}+x\bar{d}]} = 0.477^{+0.05}_{-0.05}$
  ($Q^2 = 1 - 100\ GeV^2$)

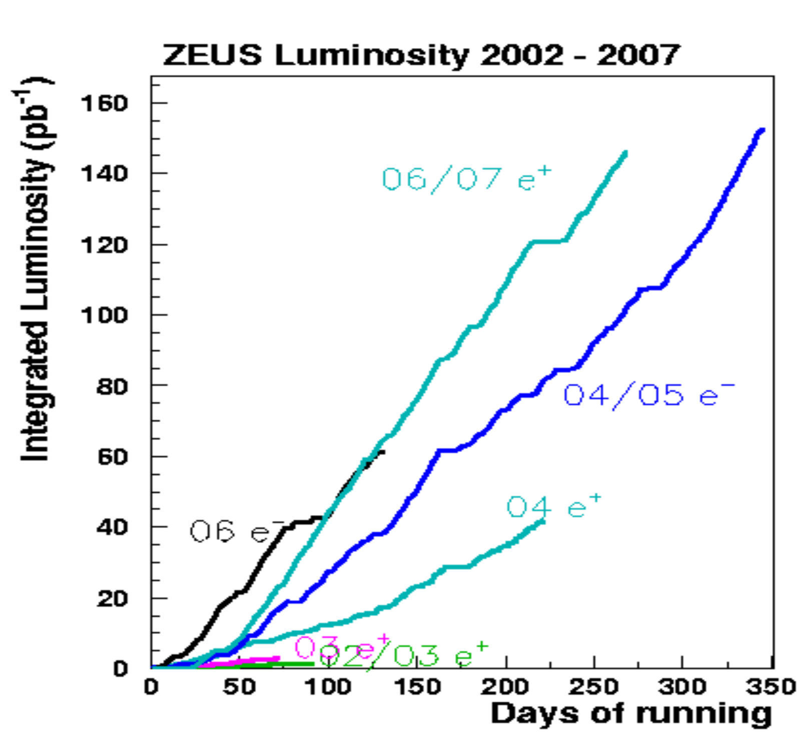
ATLAS
- $\frac{s+\bar{s}}{\bar{u}+\bar{d}} = 1.13 \pm 0.05$
  ($Q^2 = 1.9\ GeV^2, x = 0.023$)

ZEUS Experiment



HERA Upgrade (00-02)

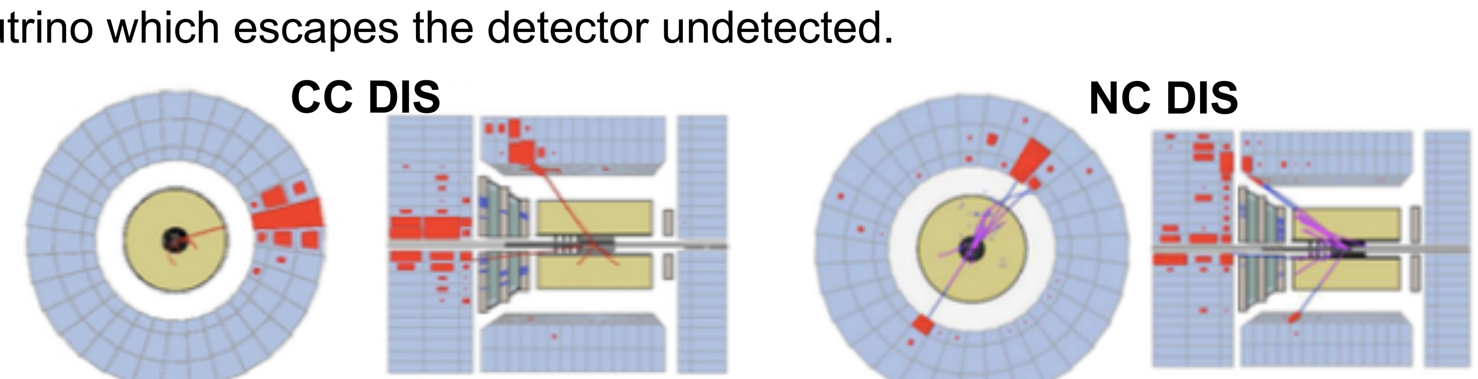
- Enhanced particle identification capabilities of the ZEUS detector upon installation of a micro-vertex detector (MVD).



- Increased Luminosity ($L \cong 360\ pb^{-1}$)
  - Positively- and negatively-charged collisions have about equal luminosity
    $L\ (e^+p) = 173\ pb^{-1}$
    $L\ (e^-p) = 185\ pb^{-1}$
  - Unpolarized ($P_e < 10\%$)
  - $\sqrt{s} = 318\ GeV$

Charged Current DIS (CCDIS)

- In CC DIS, a large missing transverse momentum p_T is observed due to the outgoing neutrino which escapes the detector undetected.

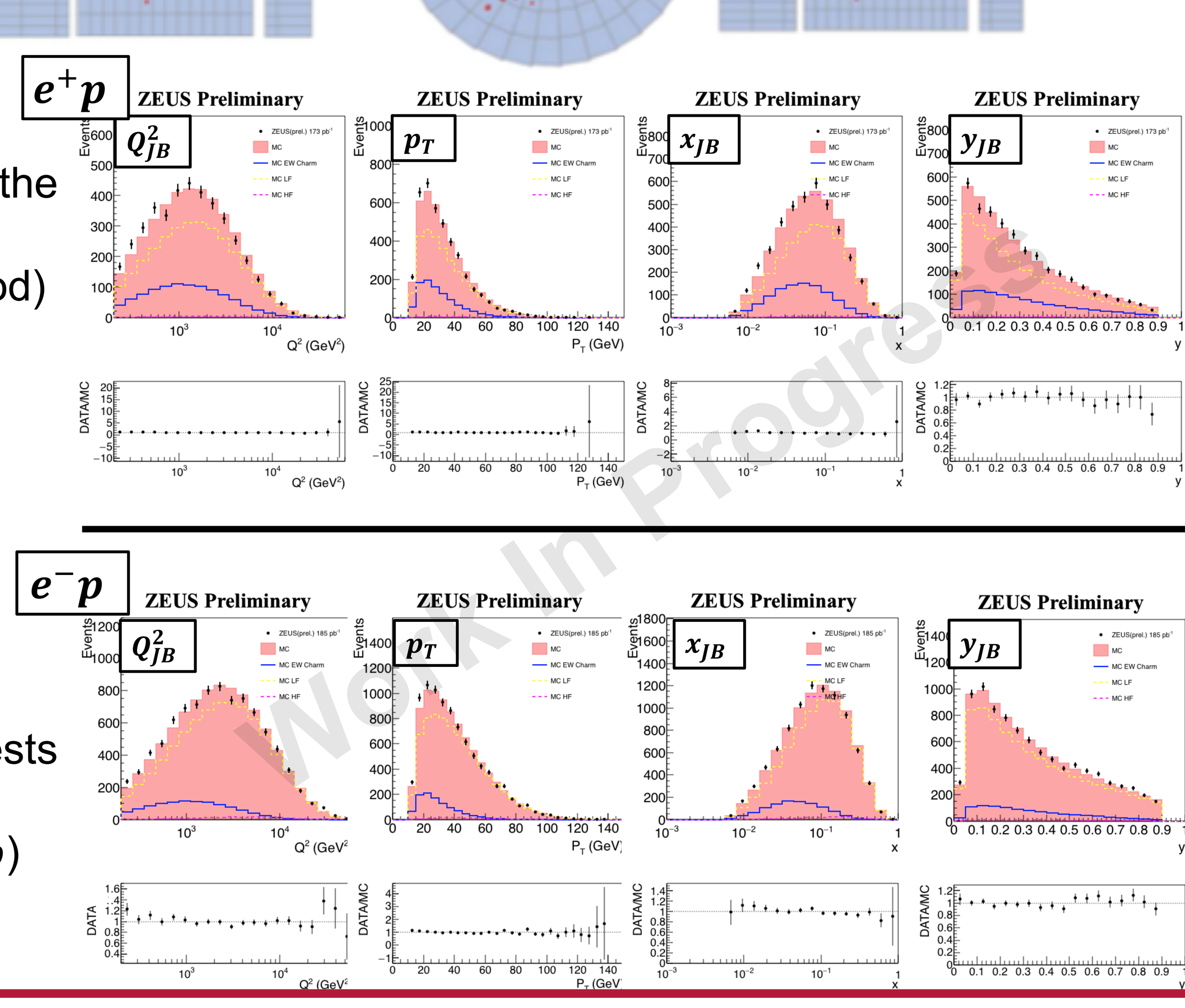


- Kinematic variables are reconstructed by using the hadronic final state. (Jacquet-Blondel Method)

$$y_{JB} = \frac{\Sigma_h(E - p_z)_h}{2E_{e,beam}}$$

$$Q^2_{JB} = \frac{p^2_{T,h}}{1 - y_{JB}}$$

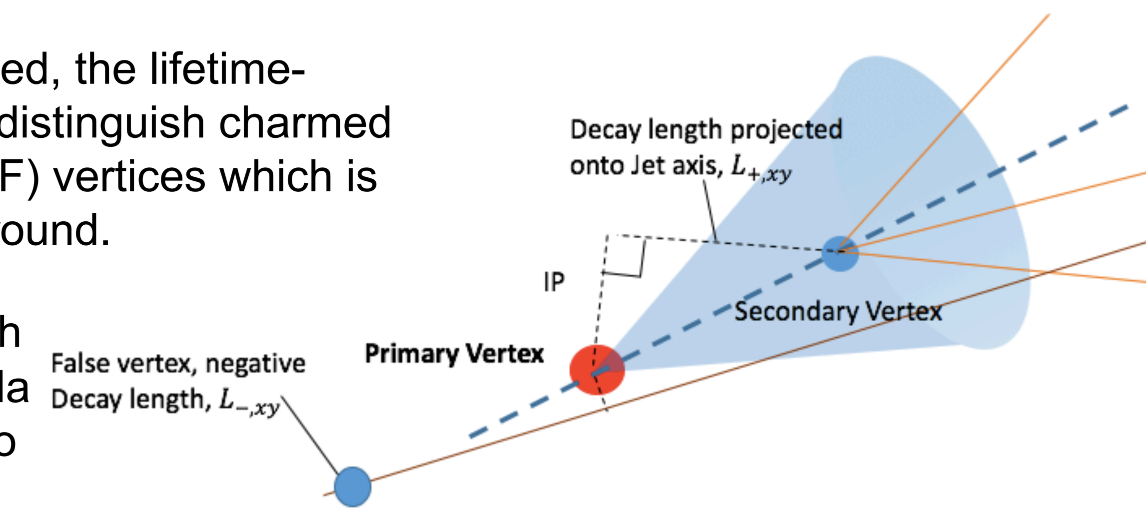
$$x_{JB} = \frac{Q^2_{JB}}{s y_{JB}}$$



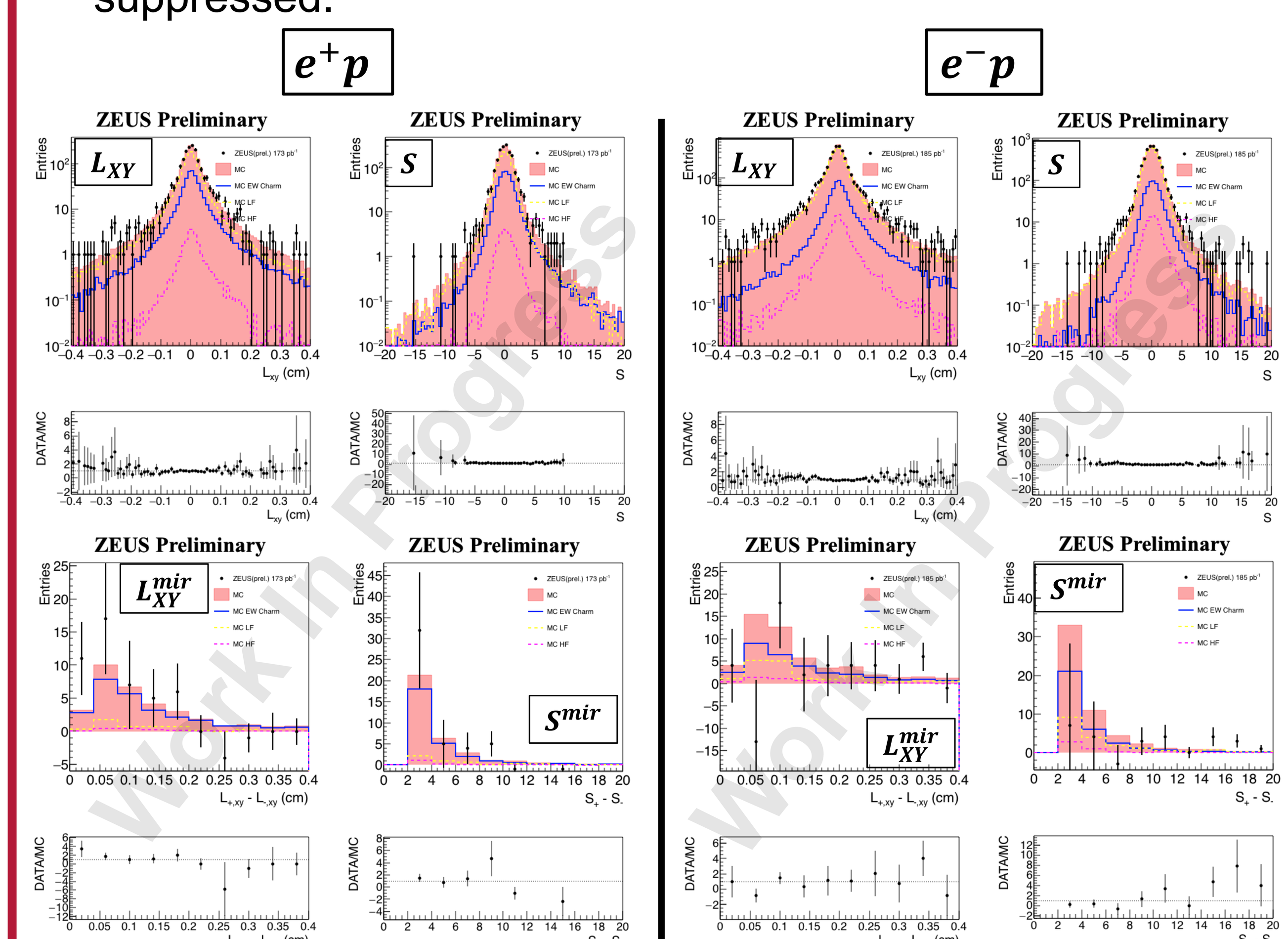
- The MC analysis suggests that the ZEUS data is consisted of ~15% (e^-p) or ~25% (e^+p) charm signal.

Charm Identification

- Once a CC event is identified, the lifetime-tagging method is used to distinguish charmed vertices from light-flavor (LF) vertices which is the major source of background.
- Long-lived LF hadrons such as kaons ($K^{\pm,0}$) and lambda baryons ($\Lambda^{\pm,0}$) contribute to the systematic uncertainty.



- Due to the short lifetime and the finite resolution of the vertex detector, the decay length distribution of **LF vertices** is **symmetric**, whereas that of **charmed vertices** is **asymmetric**.
- Mirroring the negative decay length distribution onto the positive, LF contribution is suppressed.



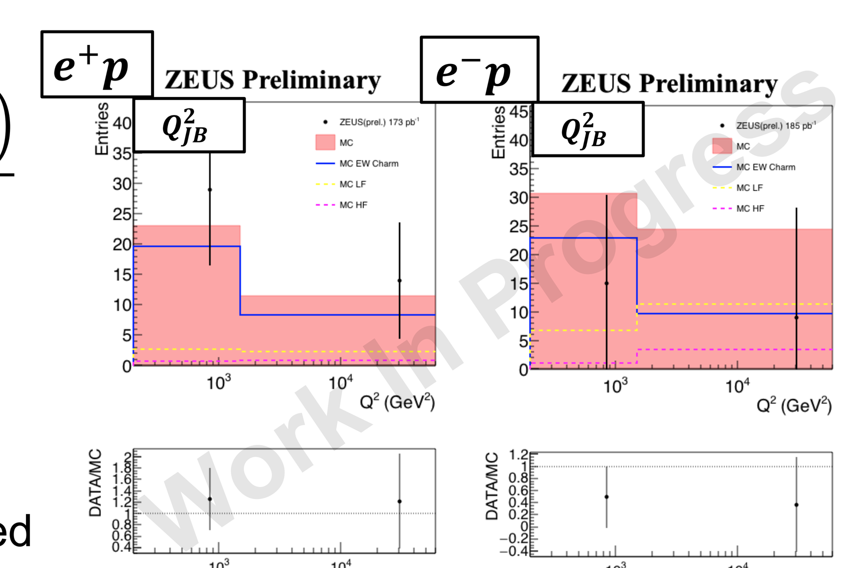
- Charm signal is extracted with overall statistics ~ 100 events.
- Low significance region rejected to reduce statistical uncertainty
- Due to their higher LF contribution, negatively-charged collisions suffer larger stat. unc. as well as LF background.

Measurement of Charm Cross section

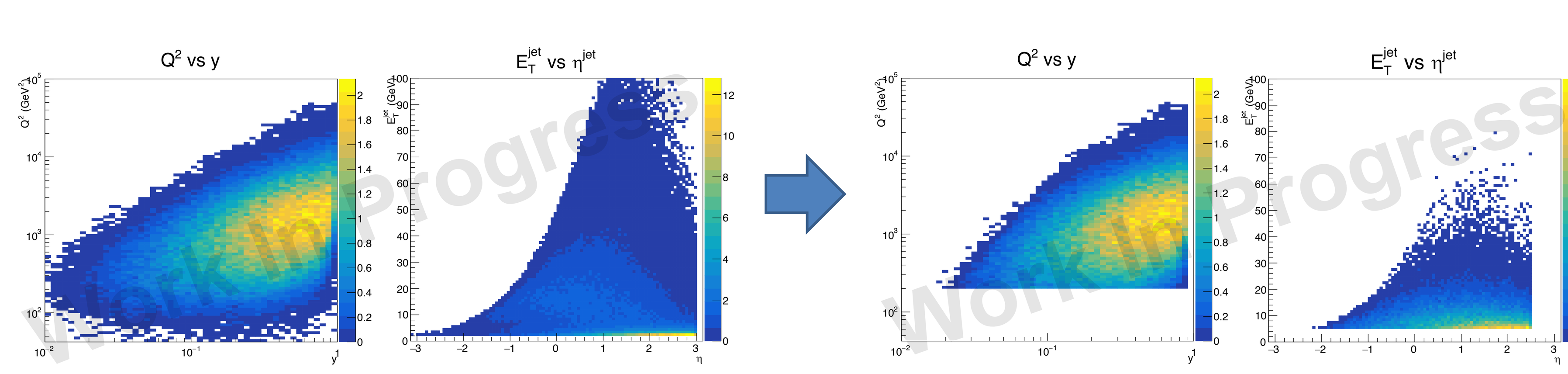
- Visible cross section is unfolded into two Q^2 bins:

$$\sigma^{EWc}_{vis,i} = \frac{N^{EWc}_i}{L} = \frac{\sum_j C^{-1}_{ij}\left(M_{meas,j} - M^{bg}_{meas,j}\right)}{A_i\ L}$$

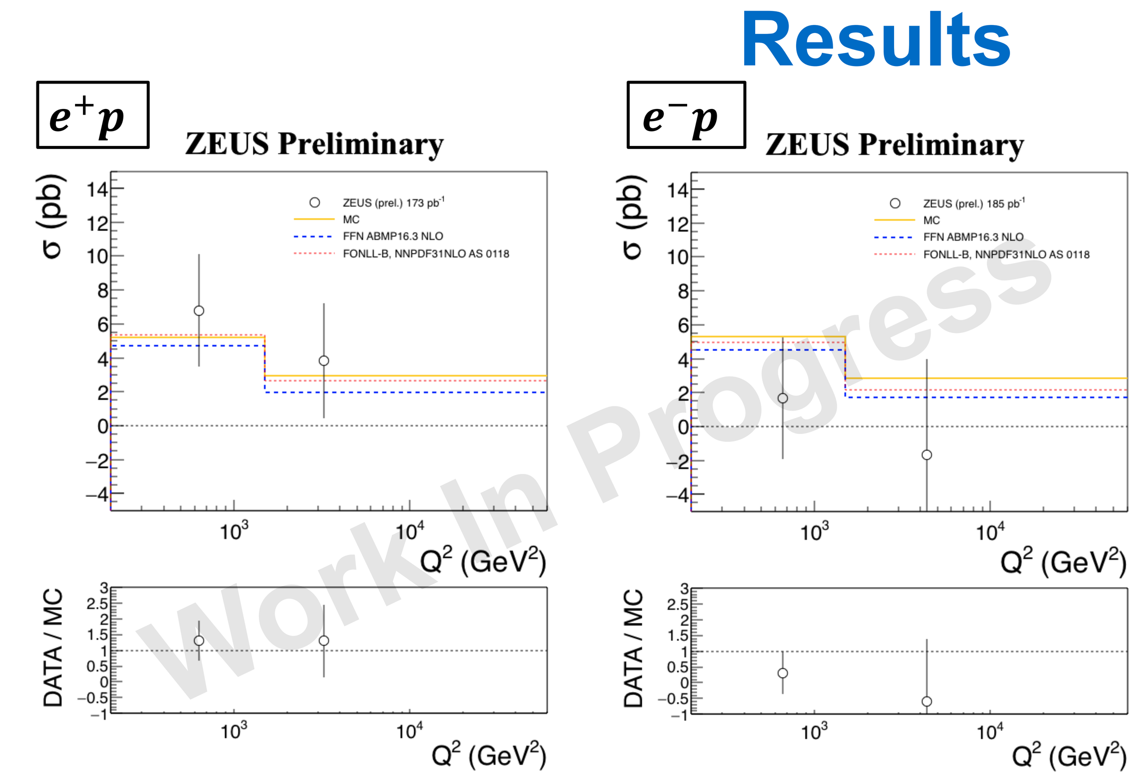
- $A_i = \epsilon_{trig}\epsilon_{detect}\epsilon_{PID} = N^{EWc}_{meas,i}/N^{EWc}_i$
- $C^{-1}_{ij} = inverse\ correlation\ matrix$
- $M^{bg} = background\ estimated\ from\ MC$



- Total cross section σ^{EWc} can be extrapolated from the visible cross section σ^{EWc}_{vis} via an extrapolation factor C_{ext}.



Results



- The strange quark content in proton can be measured in an Electron-Ion Collider environment via charm production in CC DIS.
- Further optimization on signal extraction is on-going in order to suppress LF background.
- A higher vertex detector resolution as well as luminosity will lead to measurements in lower x region.
- Channel-specific analysis (D/D*) will follow to further confine the strange quark content.