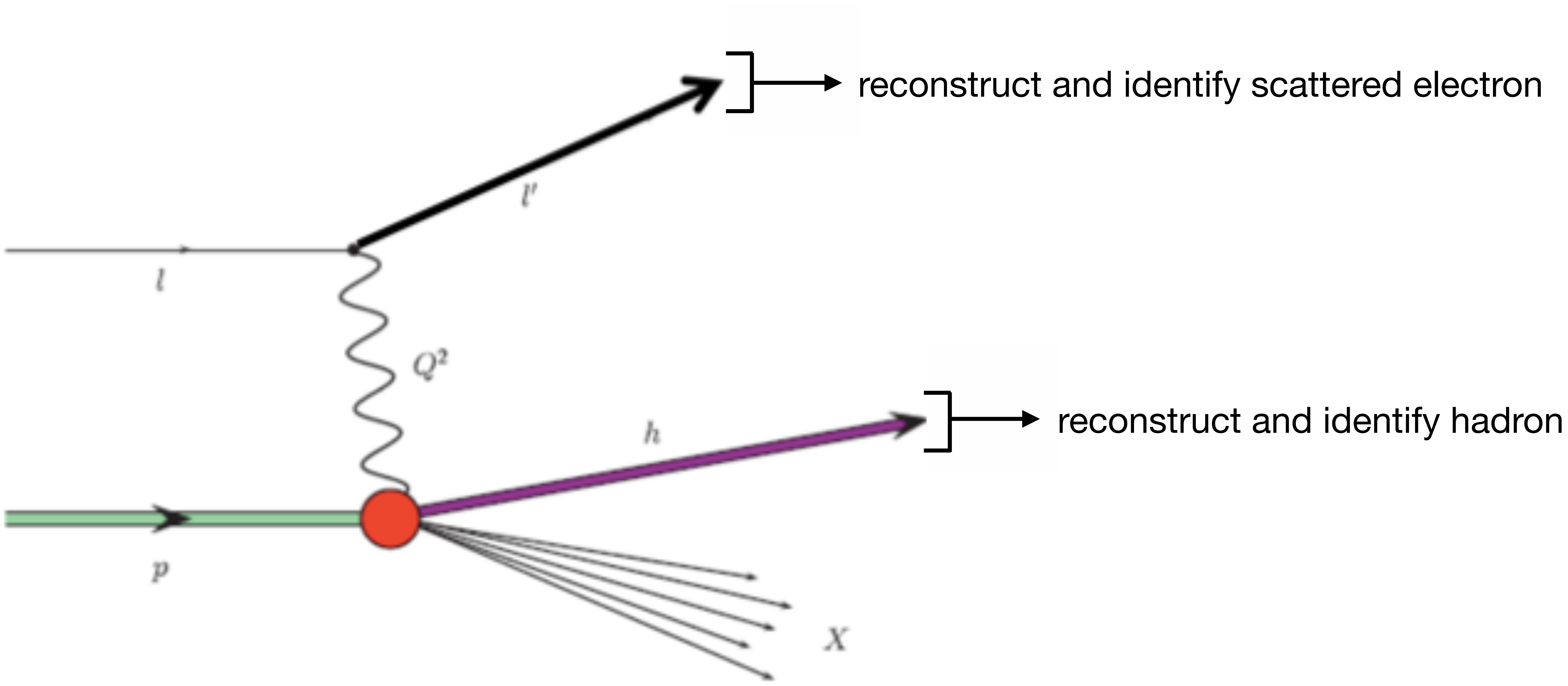
Minimum set for key measurements for Detector-II: SIDIS processes

Charlotte Van Hulse

Detector 2 meeting
November 8, 2022

SIDIS, in a nutshell



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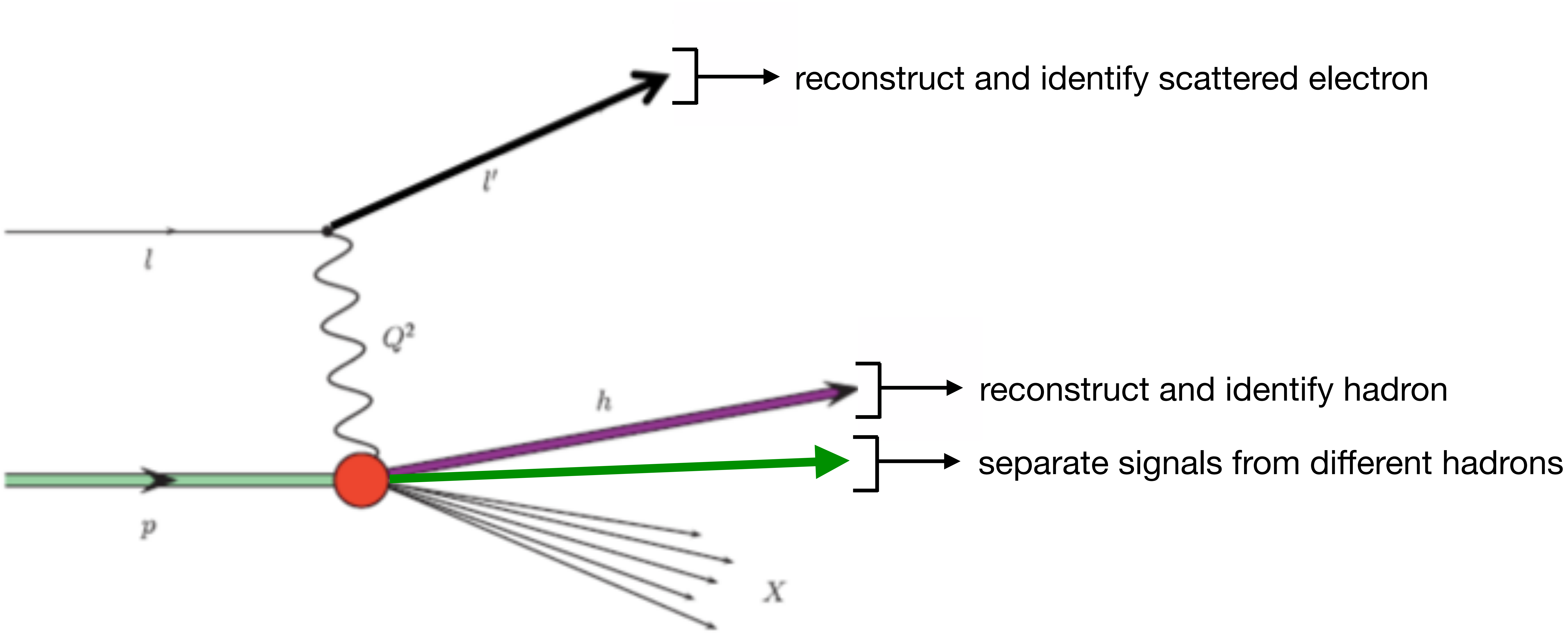
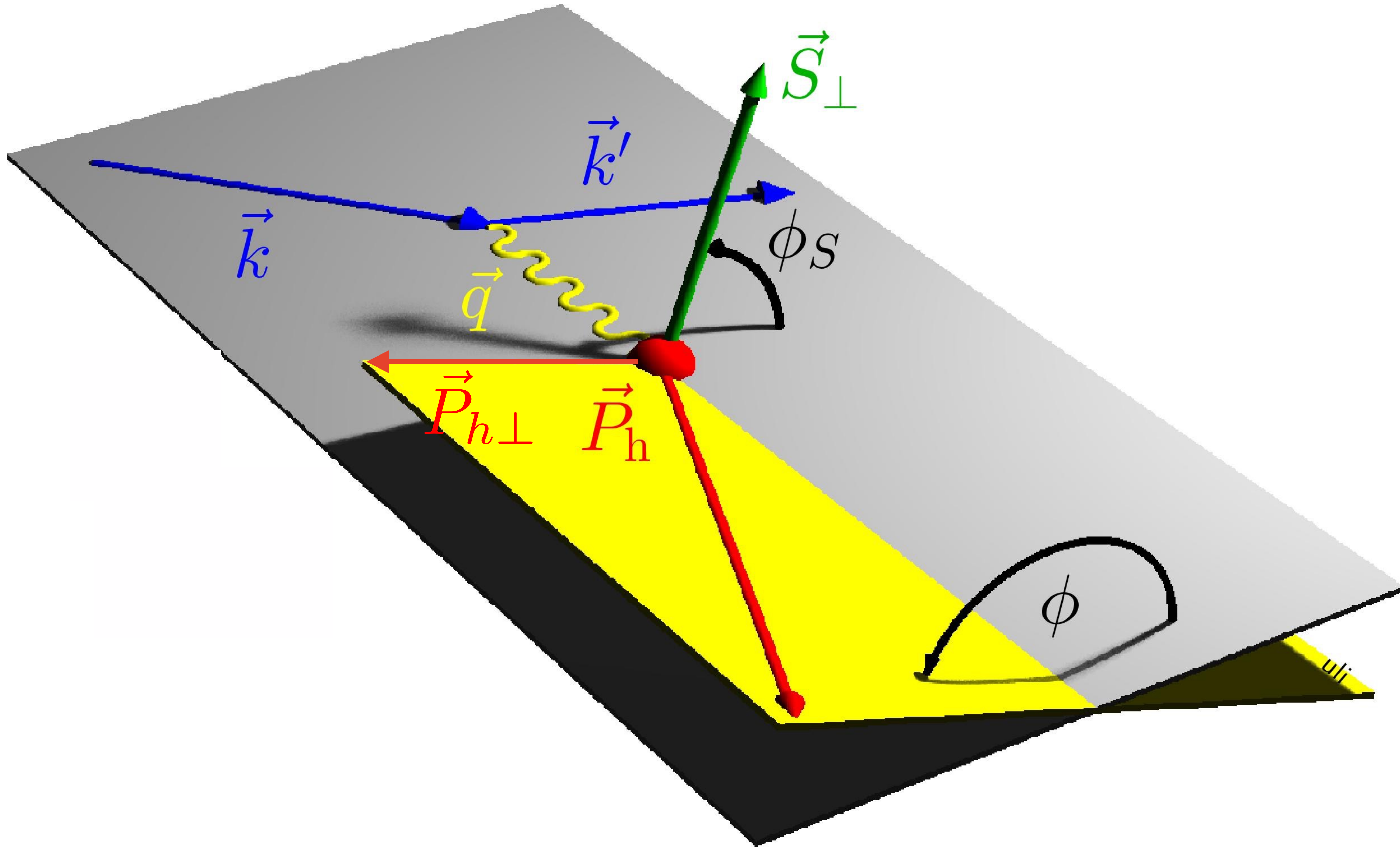


SIDIS variables

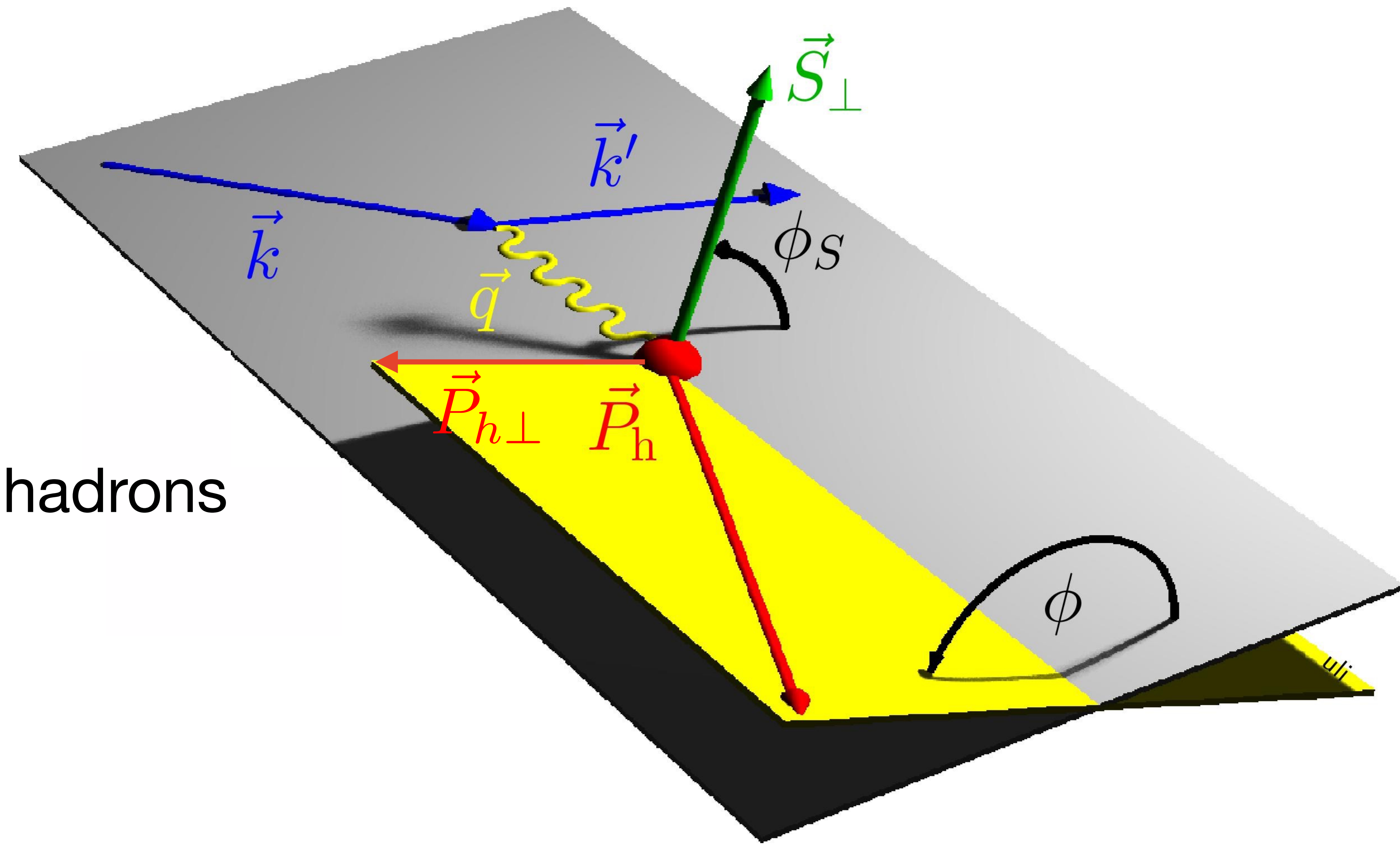
- multi-dimensional binning in $x, Q^2, z, P_{h\perp}, \phi_S, \phi$



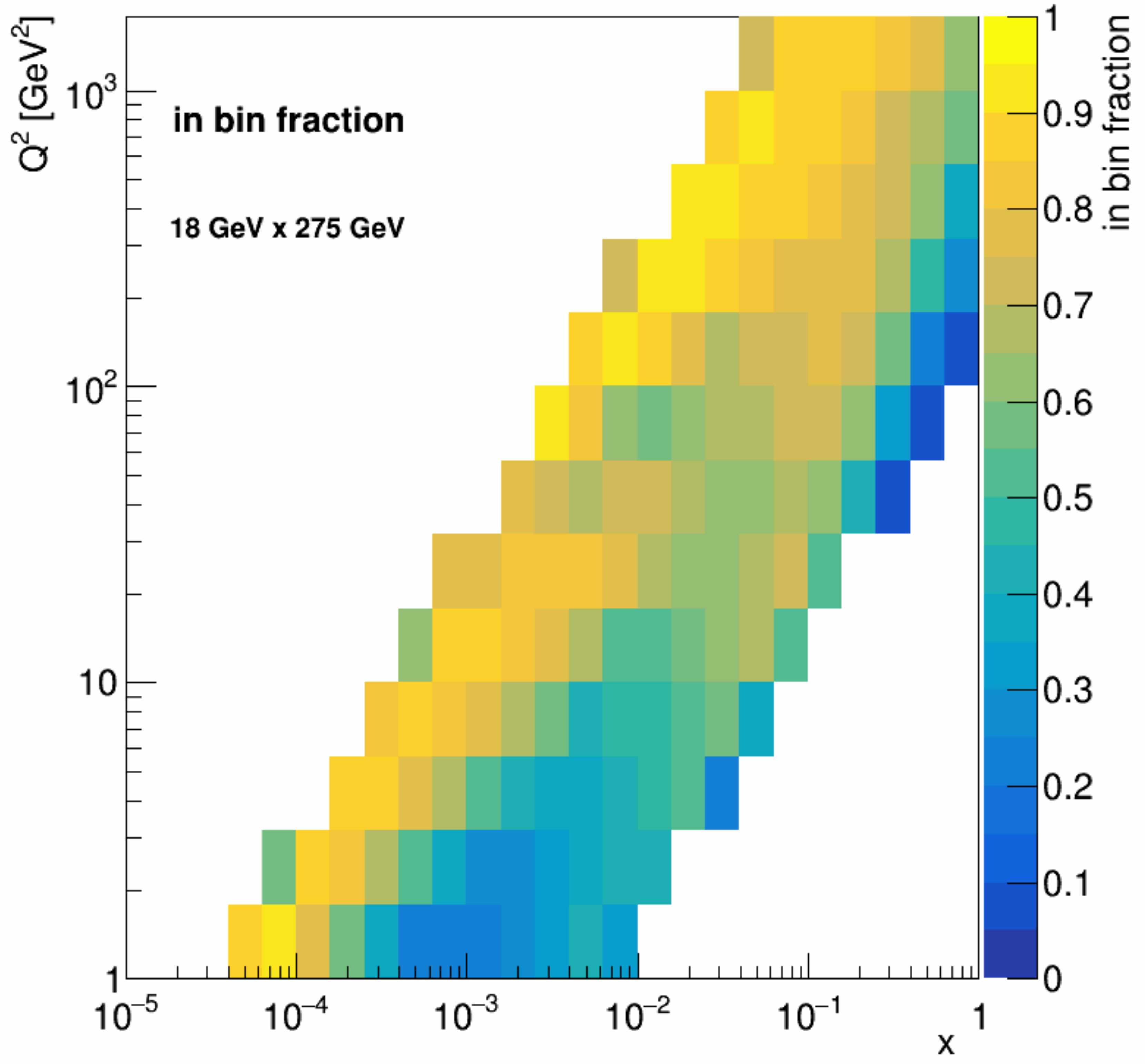
SIDIS variables

- multi-dimensional binning in $x, Q^2, z, P_{h\perp}, \phi_S, \phi$

- reconstruction of variables via scattered lepton and/or detected hadrons



Reconstruction via scattered lepton (high y) and double-angle method (low y)

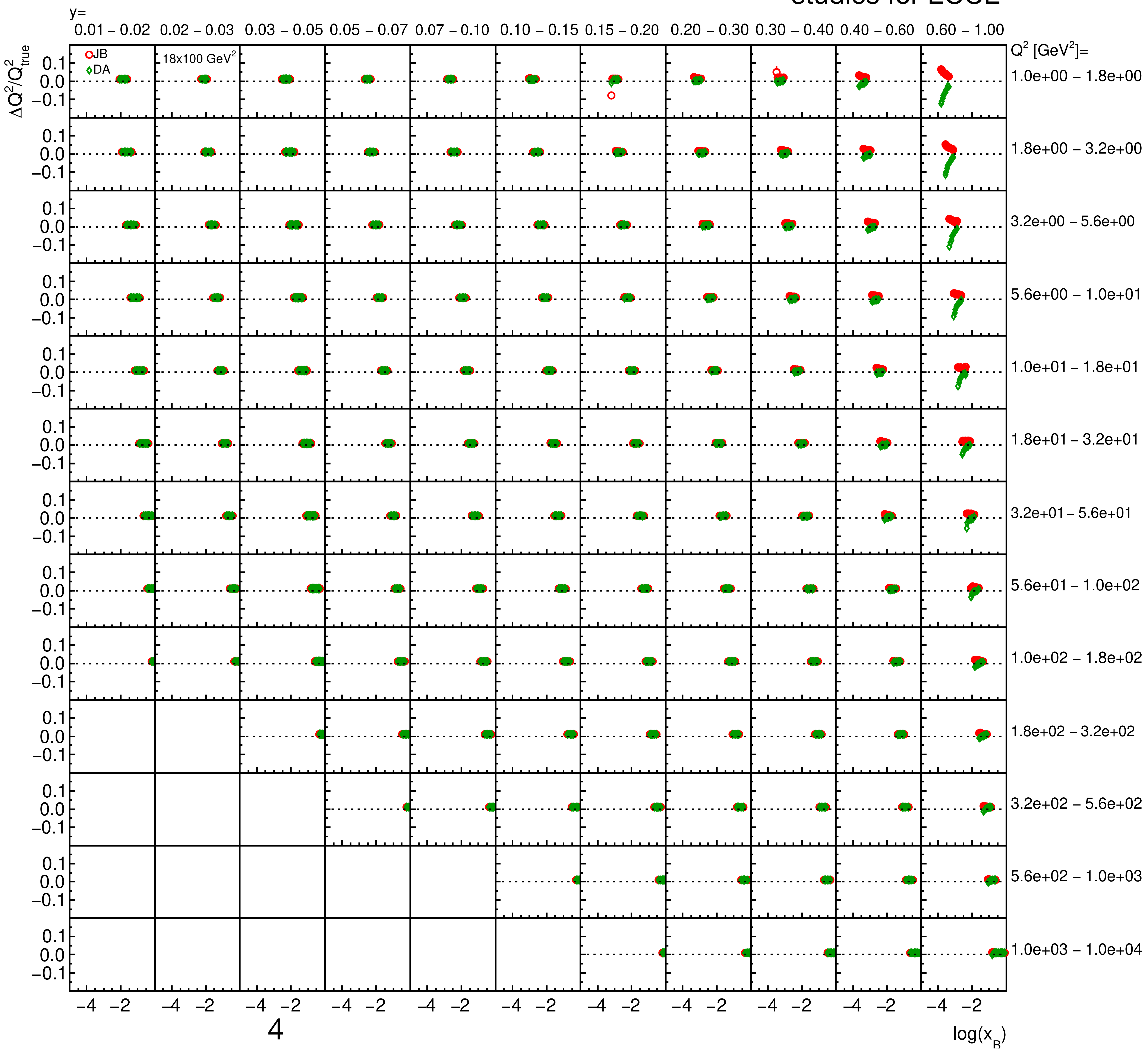


Can an e-side HCAL help?

Relative difference in Q^2

with and without eHCAL

studies for ECCE



Can an e-side HCAL help?

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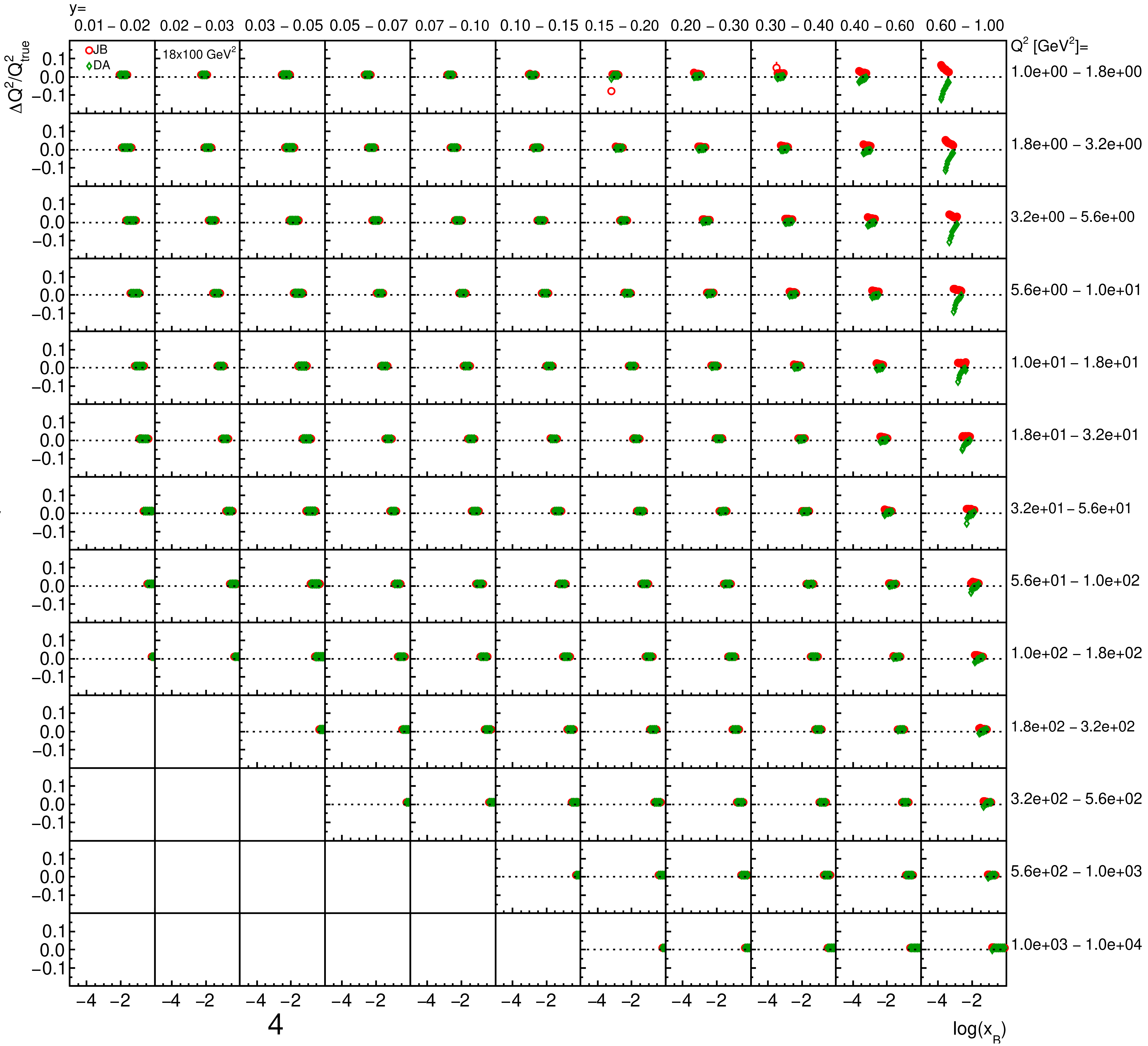


Absence/presence of EHCAL visible

for hadronic methods for x_B and Q^2 at high y

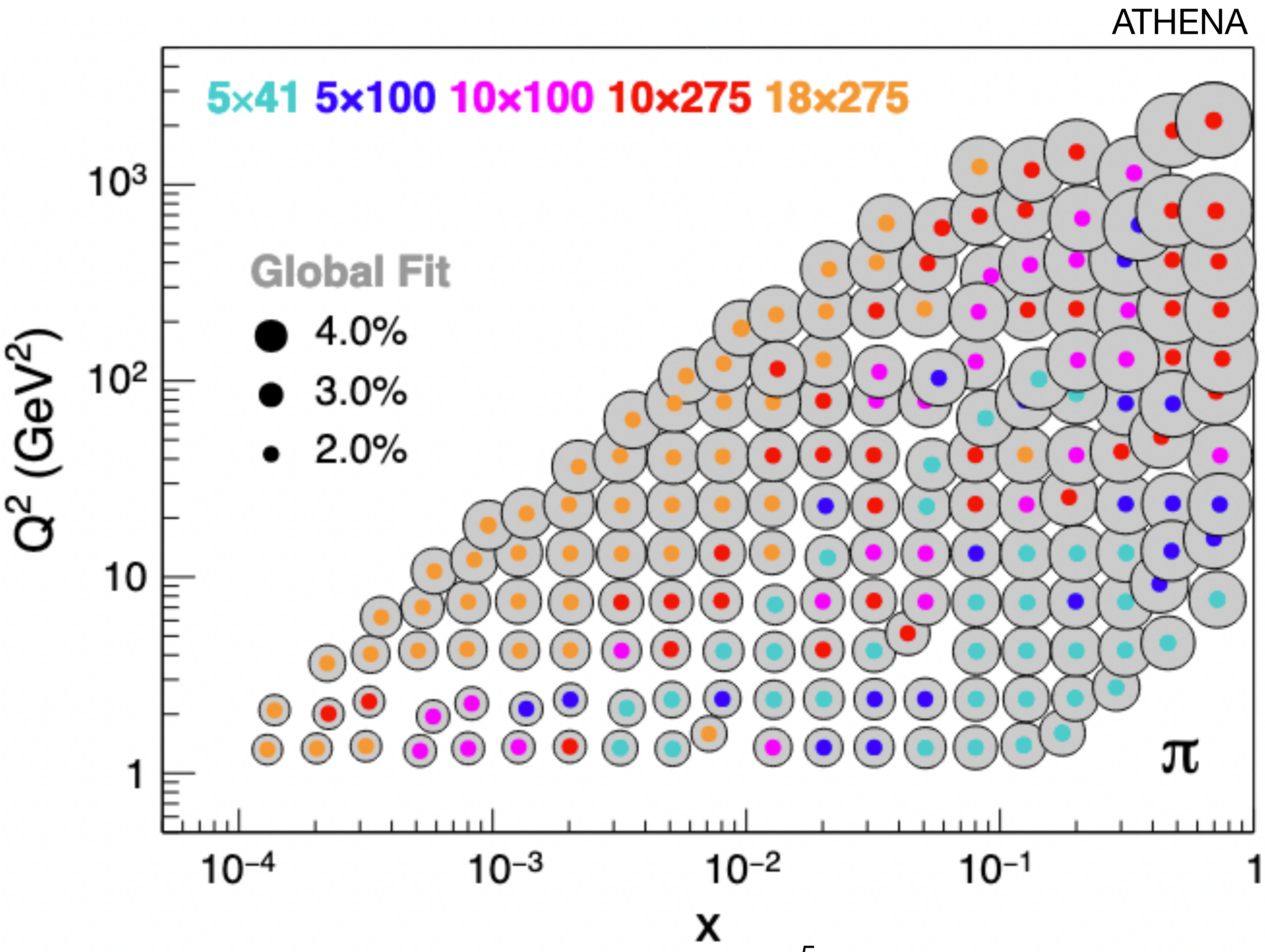
(where e-method works well)

↓

Not very useful from that perspective

(x,Q²) coverage

Large lever-arm in Q^2 over large x range
→ Q^2 evolution of TMD PDF

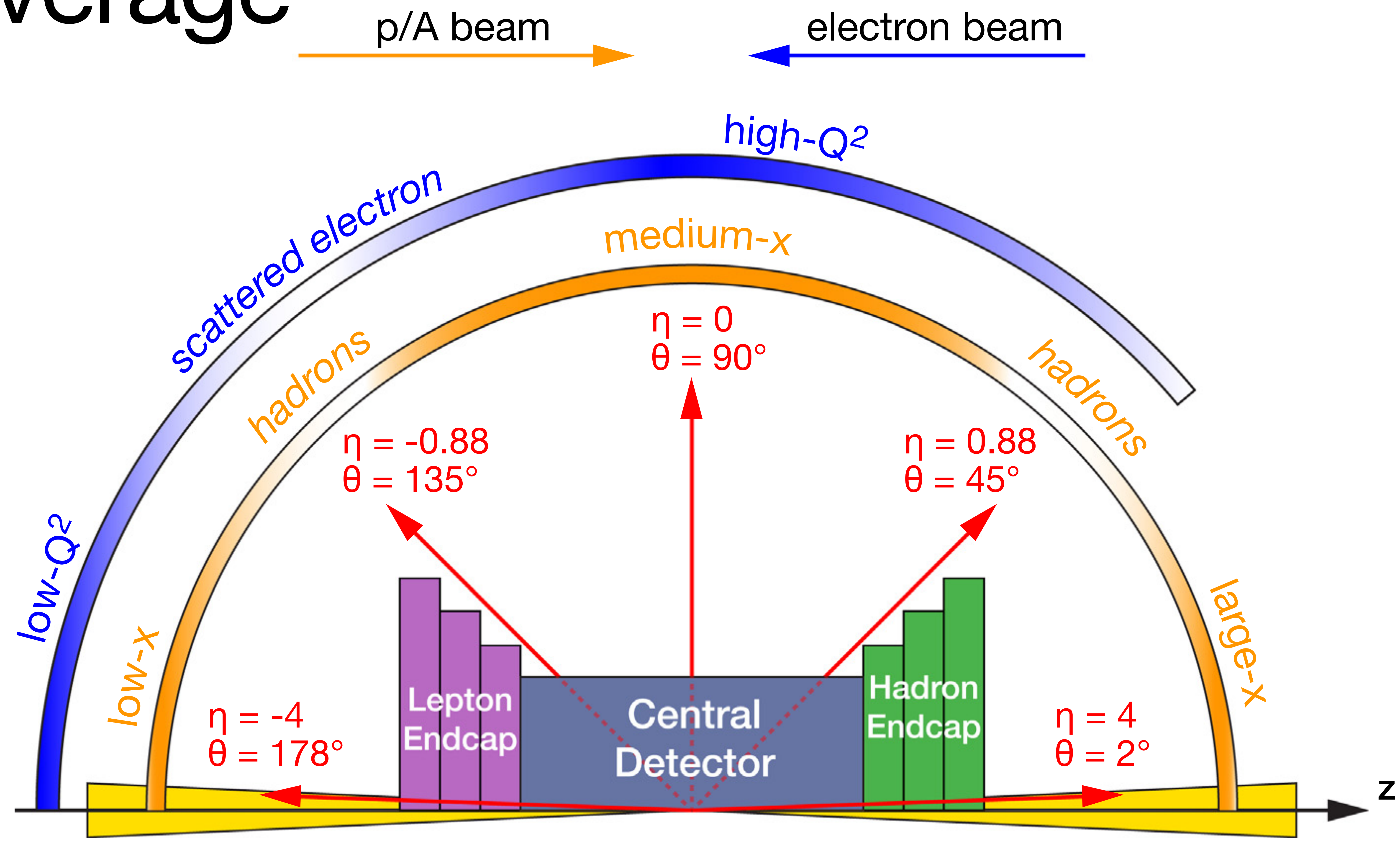


Fit:
A. Bacchetta et al.,
JHEP 06 (2017) 081,
JHEP 06 (2019) 051 (erratum)

EIC uncertainties dominated by assumed
3% point-to-point uncorrelated uncertainty
3% scale uncertainty

Theory uncertainties dominated by TMD evolution.

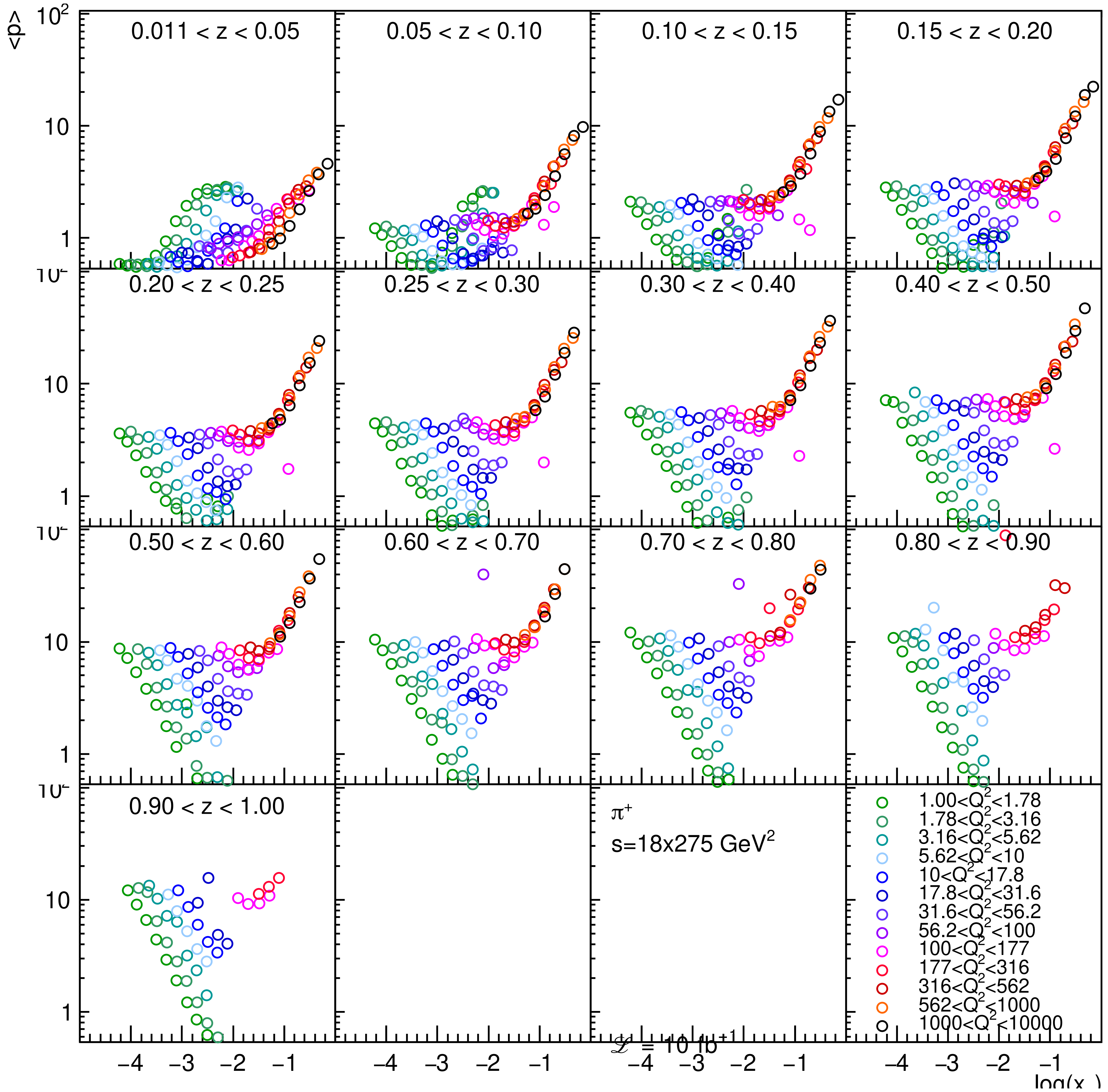
SIDIS, coverage

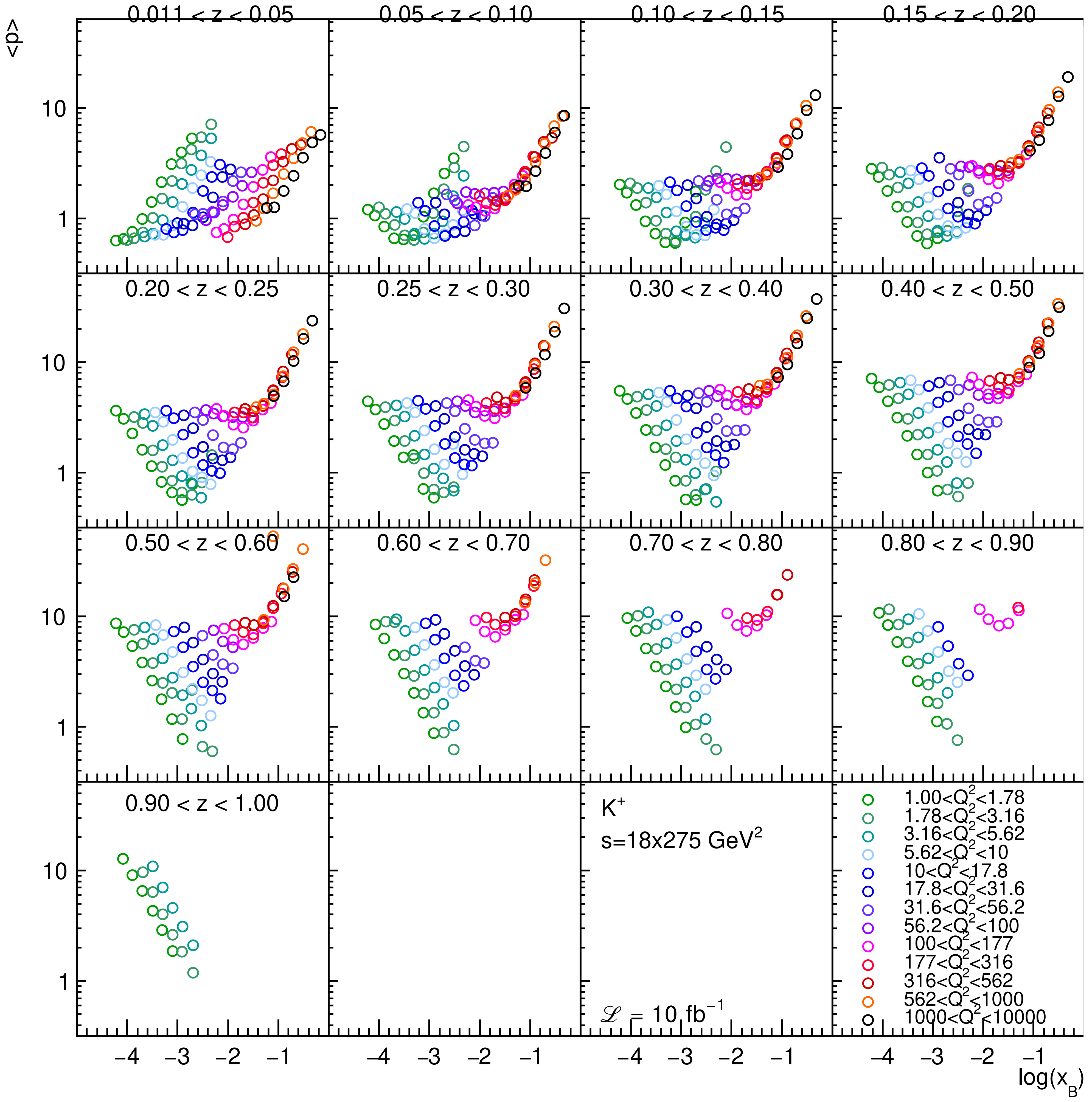


- hadron reconstruction and identification over entire coverage
  —> PID detectors, separating electrons, pions, kaons and protons
- tracking
- hadron calorimeters (for jets)
- vertexing for heavy-flavour decays

Momentum coverage of hadrons

studies for ECCE



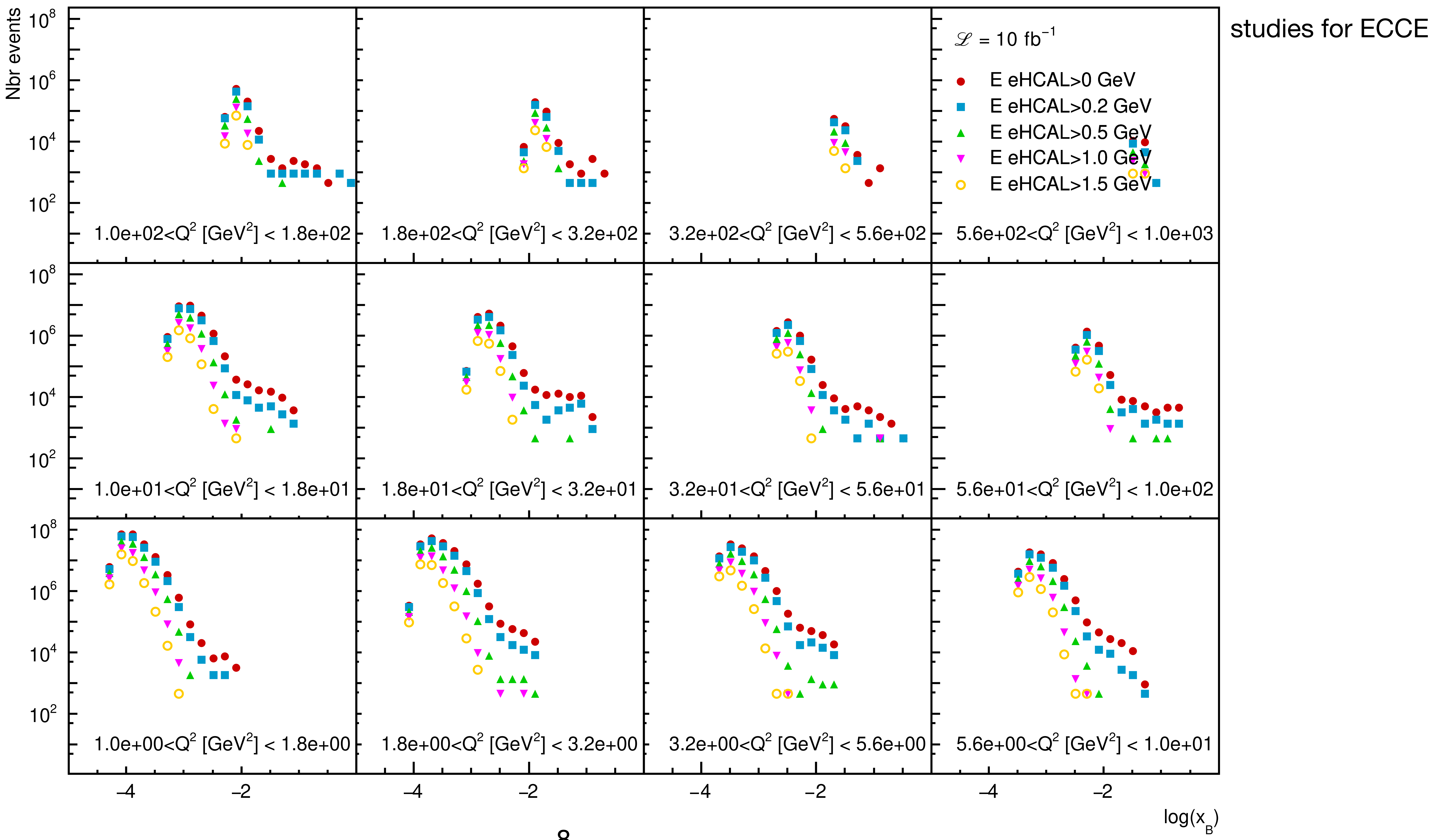


Need to reconstruct and identify hadrons for momenta down to ~0.1 GeV/c (in central region) and up to above 10 GeV (in forward region), depending on pseudo-rapidity region.

e-side HCAL : hit distributions

Fractional number of DIS events with signal in EHCAL (for particles without track)
E_ehcal>0.0 GeV: 15%
E_ehcal>0.2 GeV: 12%
E_ehcal>0.5 GeV: 7%
E_ehcal>1.0 GeV: 3%
E_ehcal>1.5 GeV: 2%

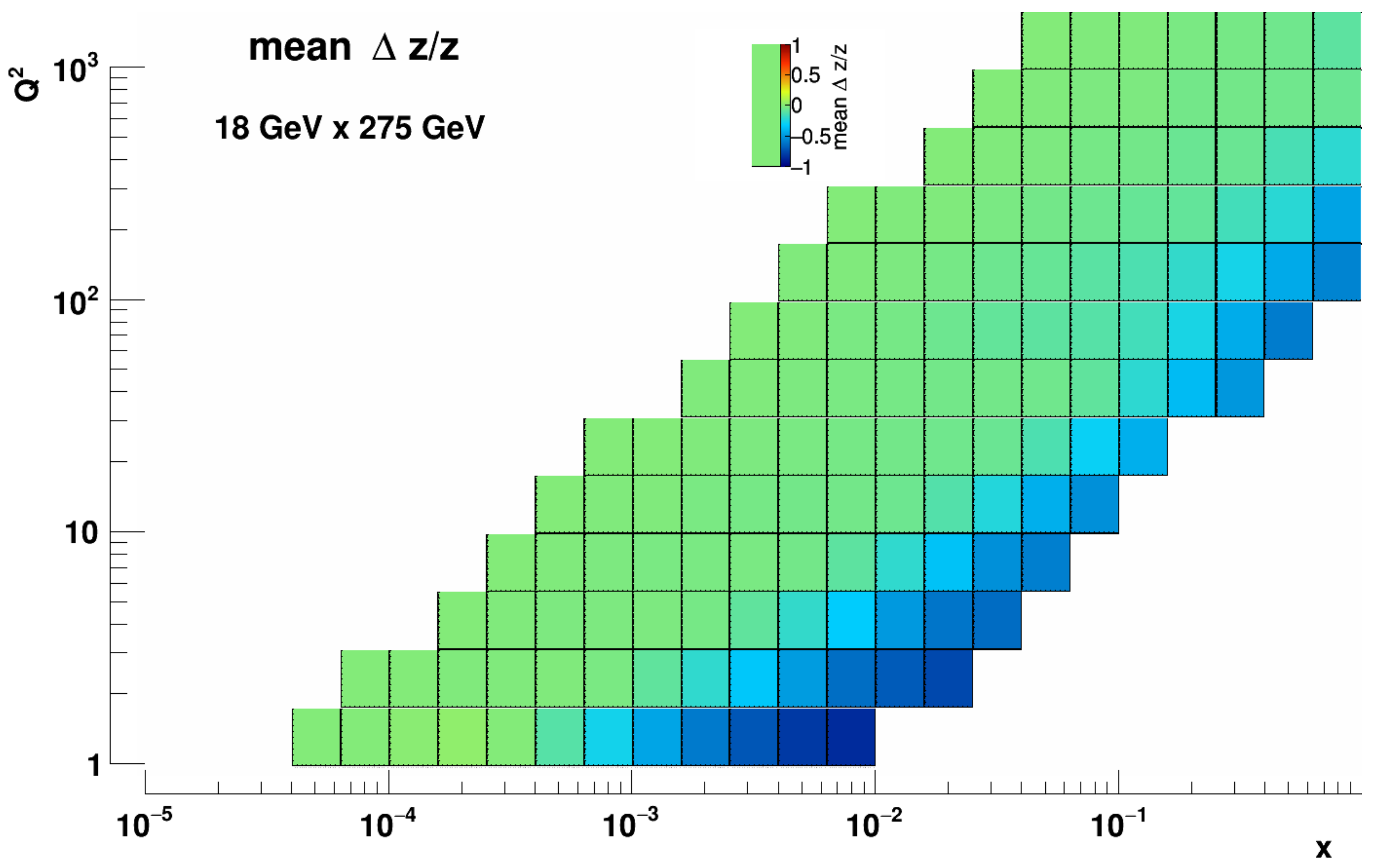
18x275 GeV²

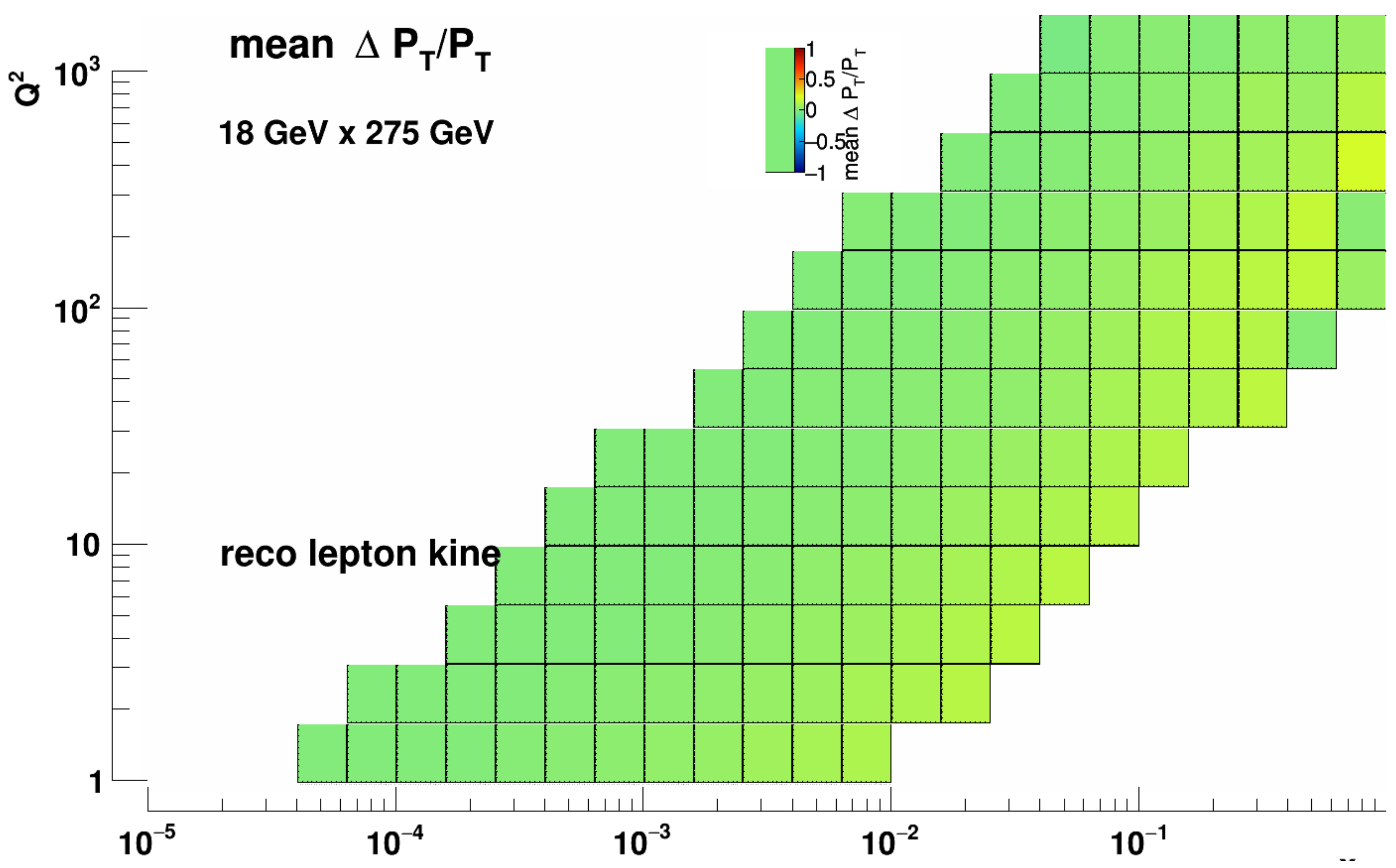


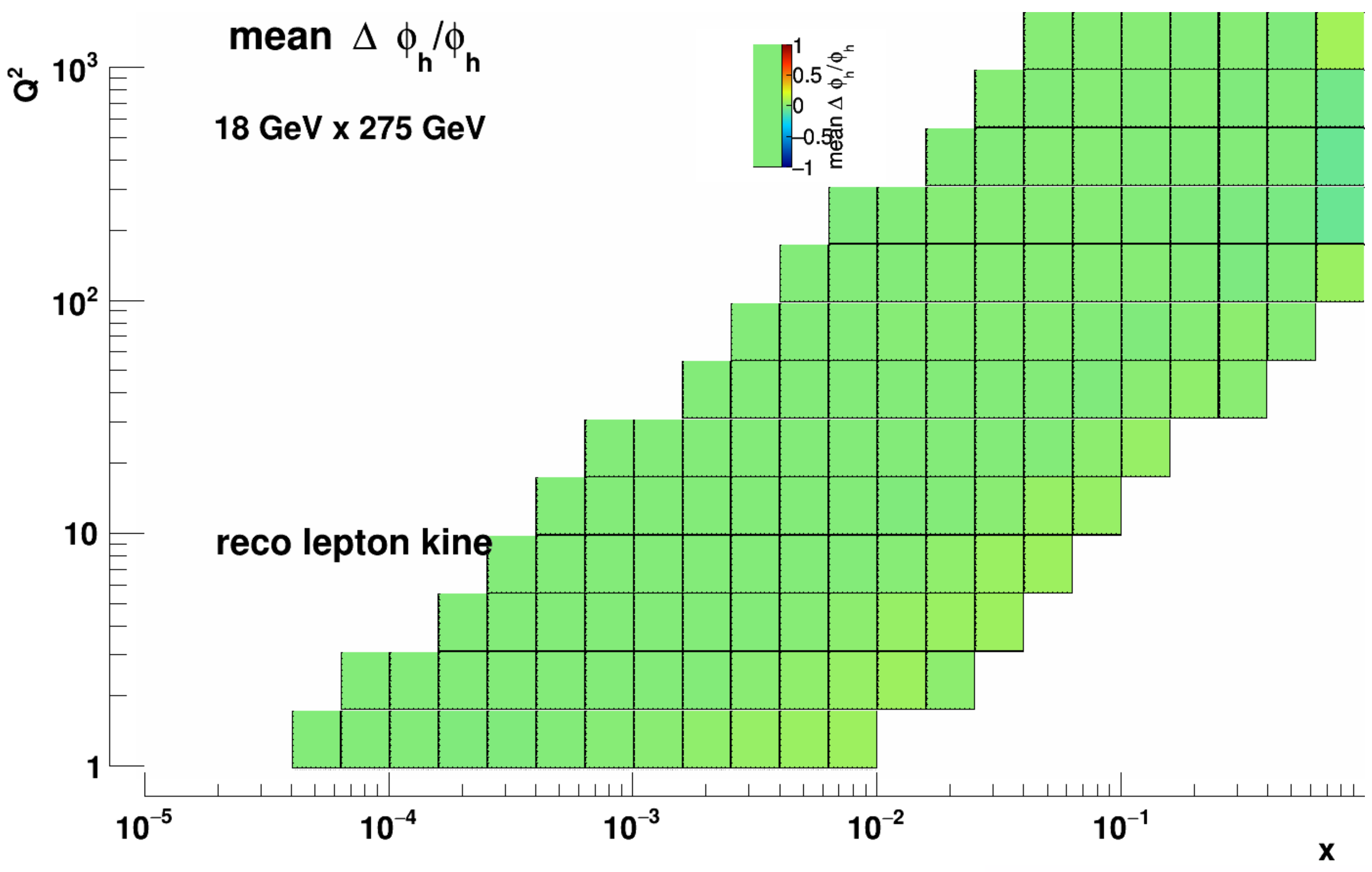
Resolutions

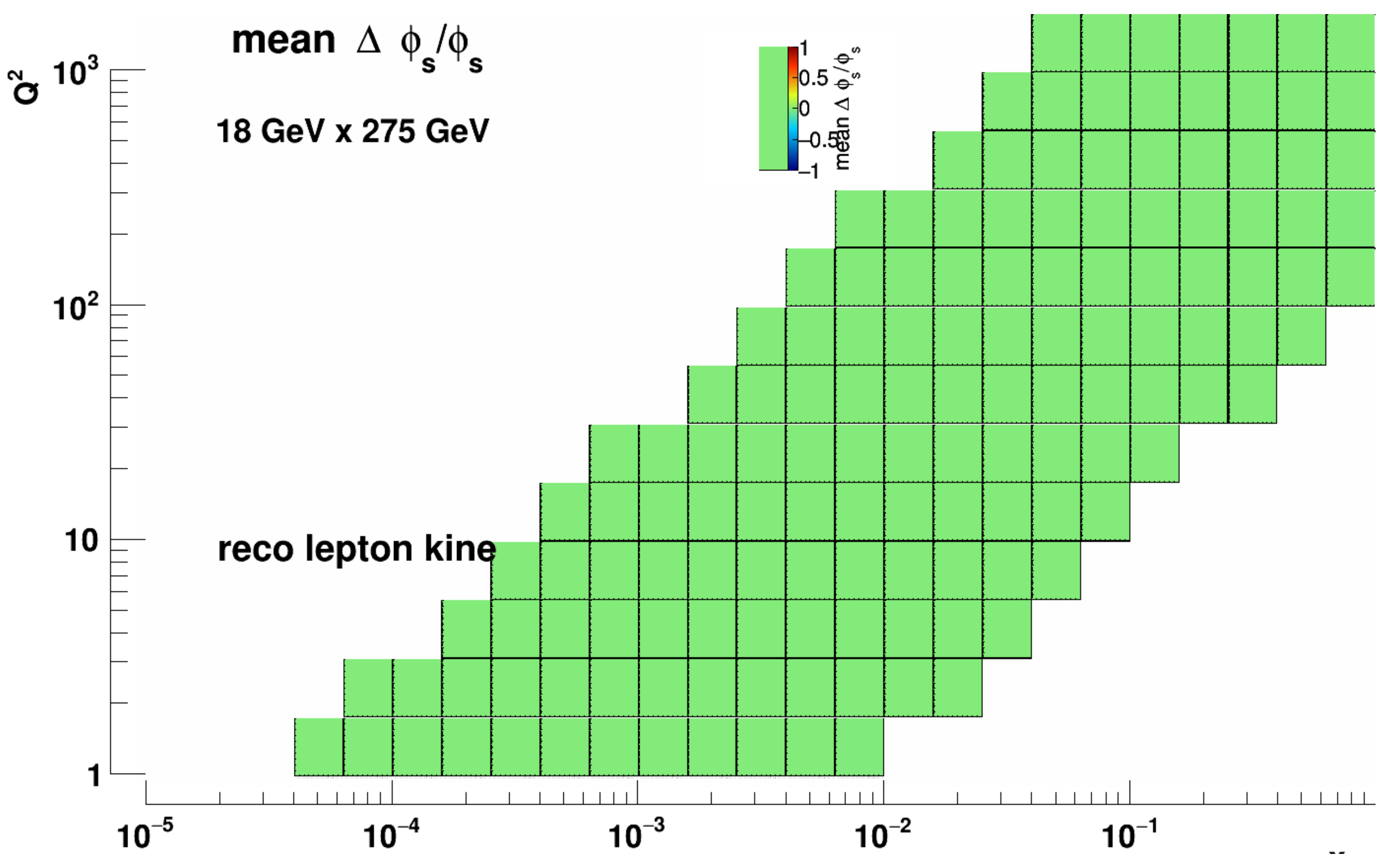
studies performed for ECCE
reconstruction via e-method

studies for ECCE   R. Seidl

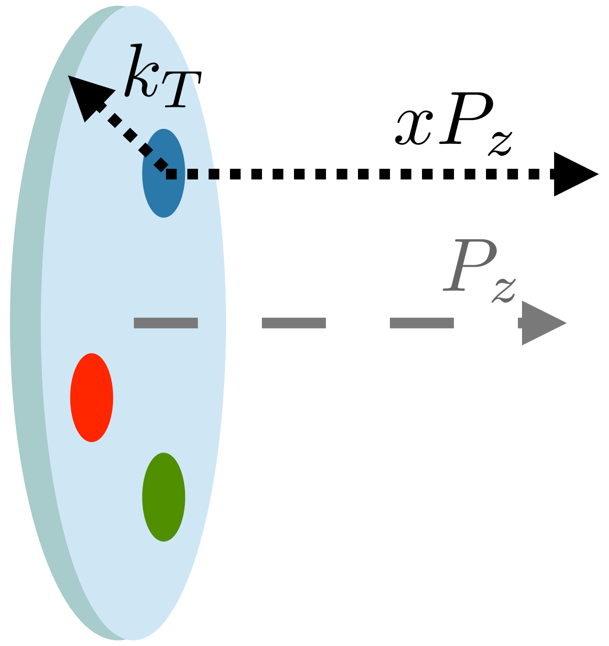




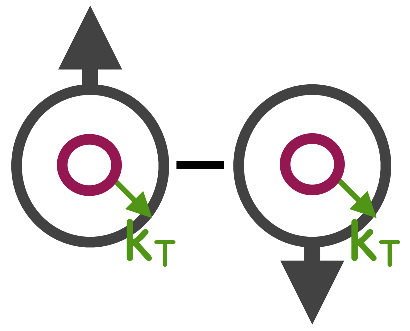




3D spin-dependent momentum structure of the nucleon



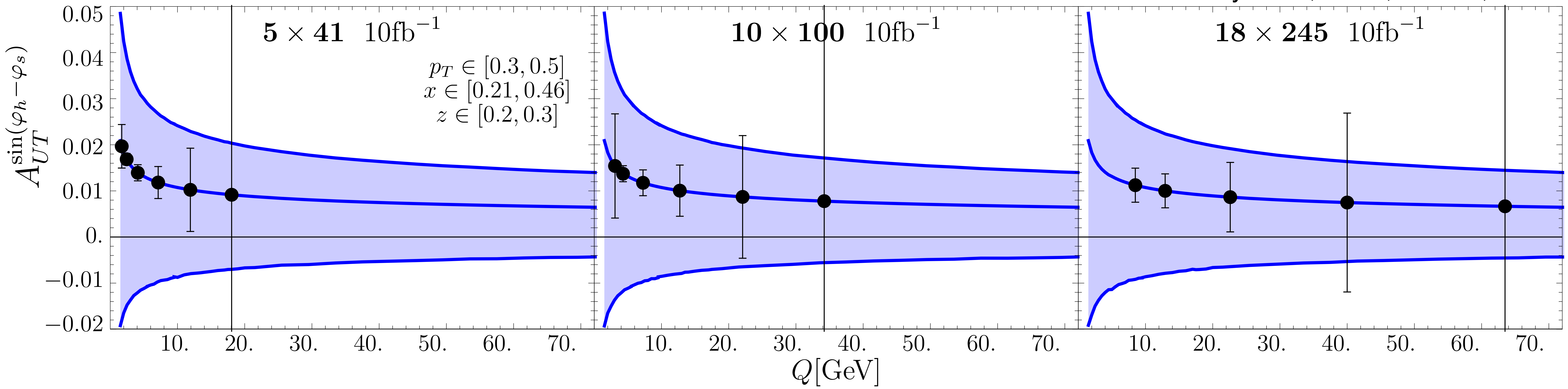
Semi-inclusive measurements, with hadron reconstruction and pid down to low p_T (~100 MeV for π)



Sivers asymmetry

- Low x and Q^2: asymmetry well below 1% → need high precision
- TMD evolution

ECCE
Parametrisation: M. Bury et al., JHEP, 05:151, 2021

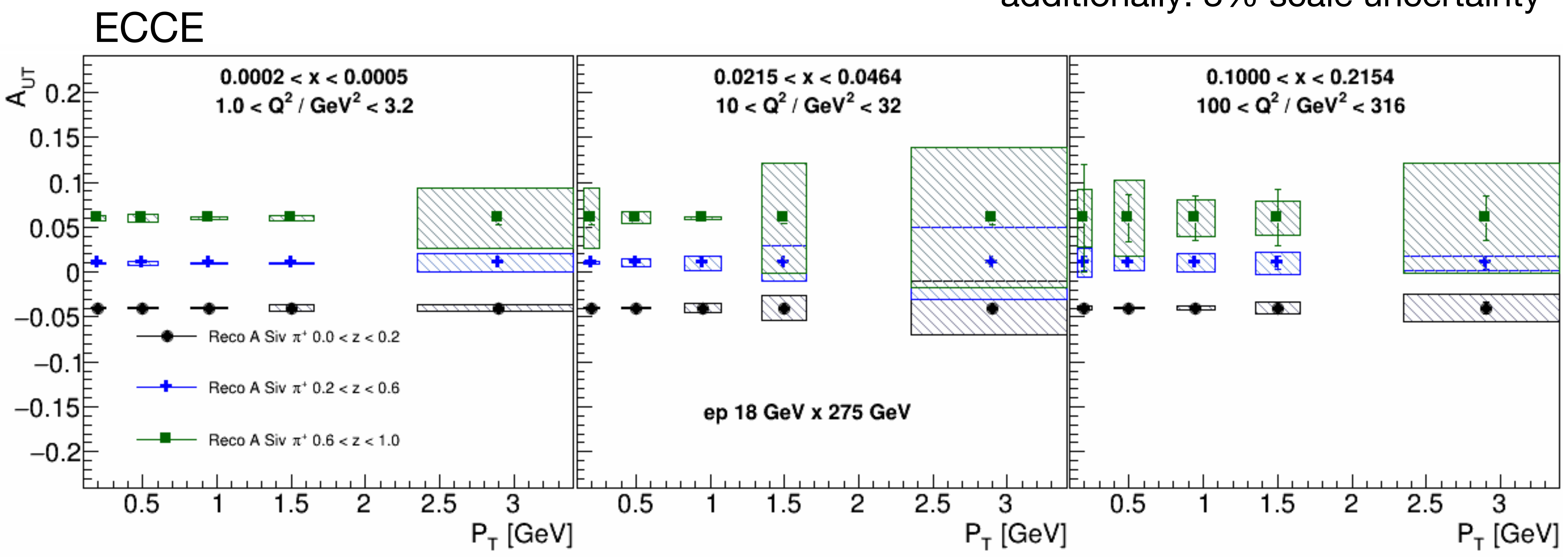


Decrease of asymmetry with increasing Q^2 → need high precision (<1%) to measure asymmetry at high Q^2

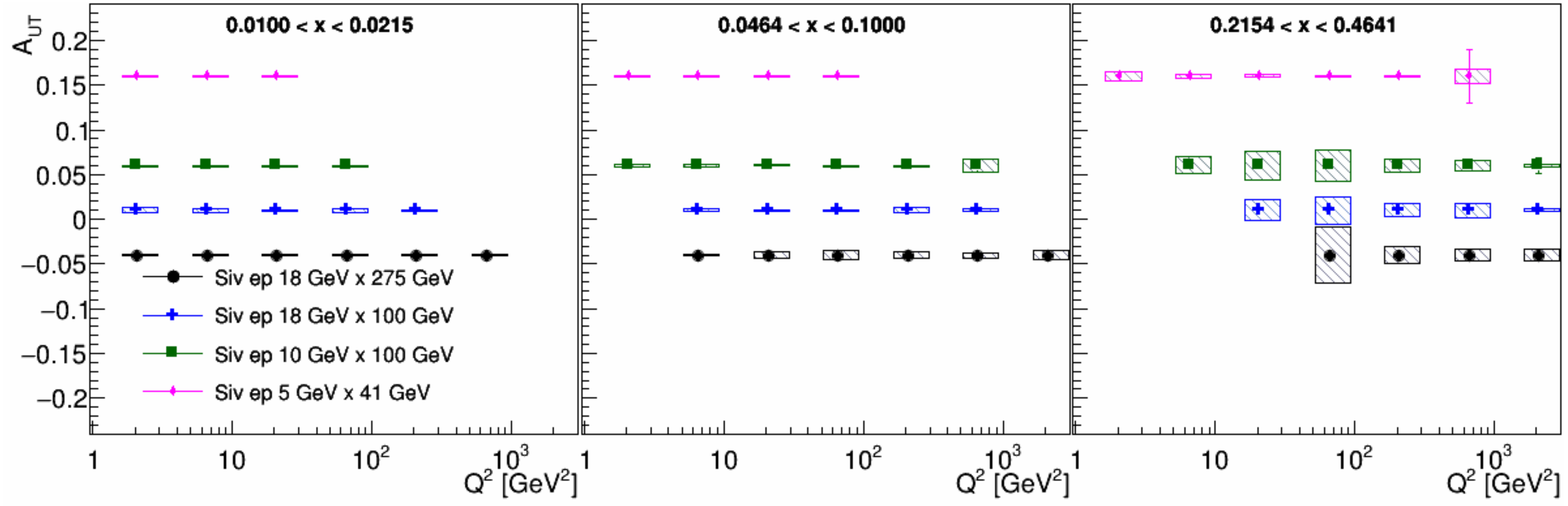
Uncertainties Sivers asymmetry

- Beam polarisations set to 70%.
- systematic uncertainty= |generated - reconstructed|
- additionally: 3% scale uncertainty

- Low x and Q^2: small statistical uncertainty.
- For not too large P_T (and z) statistical uncertainty well below 1%.
- Systematic uncertainties increase with P_T (and z) likely because of higher smearing effects.



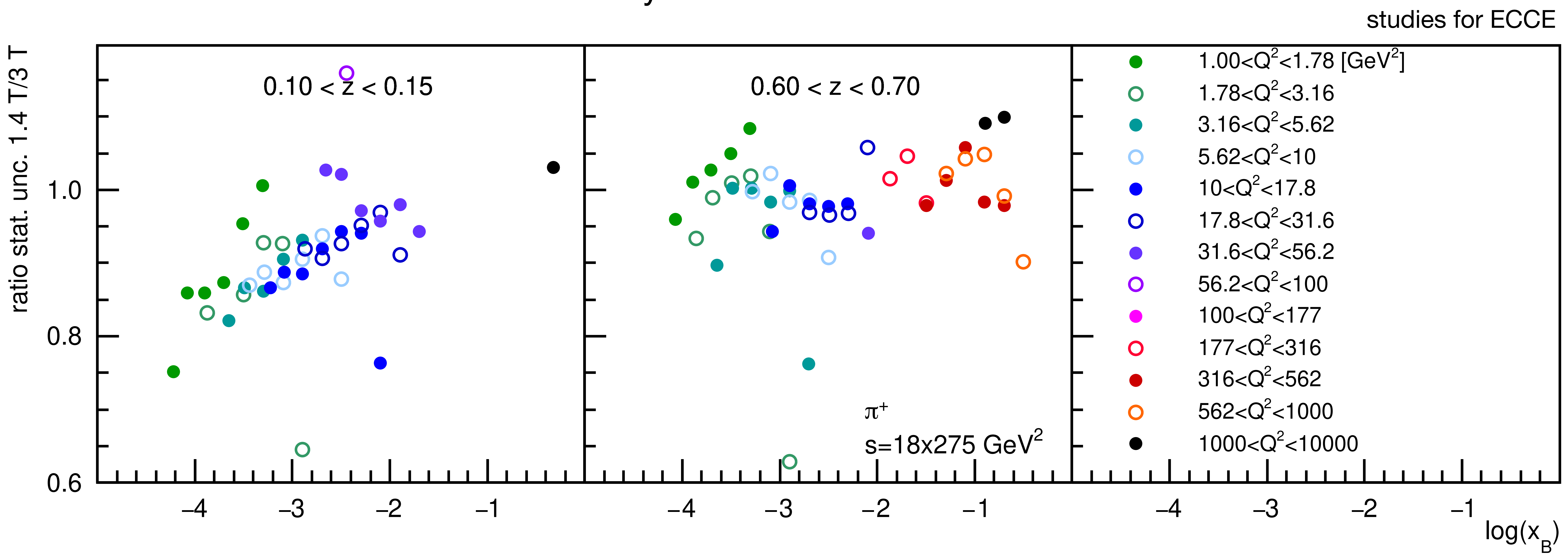
- Intermediate and high x: good coverage in Q^2, complementarity at different COM energies.



Influence of the magnetic field: example for A_{LL}

- No change in kinematic coverage observed between 1.4 and 3.0 T magnet

- Influence on statistical uncertainty:



→ lower magnetic field brings some advantage at low x_B but 1.4 T or 3.0 T both appropriate

Summary

- SIDIS measurements require:
  - electron and hadron reconstruction and PID in $-4 \lesssim \eta \lesssim 4$

    → tracking detectors

    → particle identification to separate electrons, charged pions, kaons and protons

    Cherenkov radiation: medium to high-p range for e, π, K, p

    dE/dx low-p π, K, p

    TOF for low-to-medium-p π, K, p

    transition radiation for e/h with p> 2 GeV

    calorimeter for e/h separation

    → calorimeters for jet physics

    → good vertex, for heavy-flavour decays

  - resolution: studies required to quote minimum needed resolution, but ECCE-like detector satisfies needs