Semi-Inclusive WG Summary

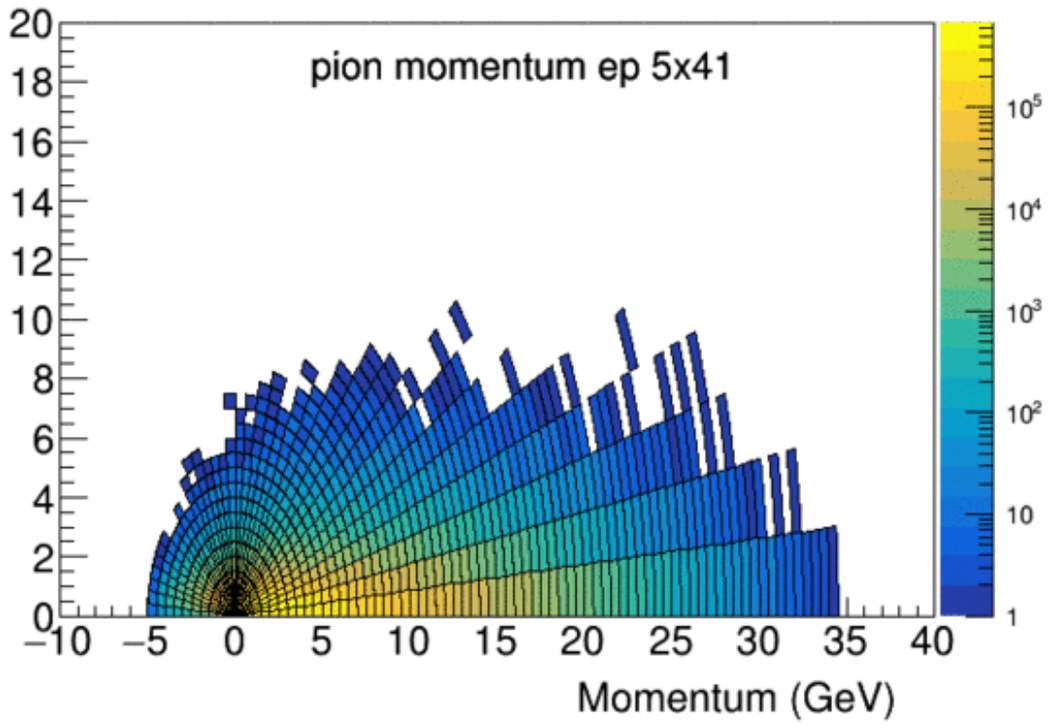
Ralf Seidl (RIKEN), Justin Stevens (William & Mary),
Alexey Vladimirov (Regensburg), Anselm Vossen (Duke),
Bowen Xiao (Central Normal University)

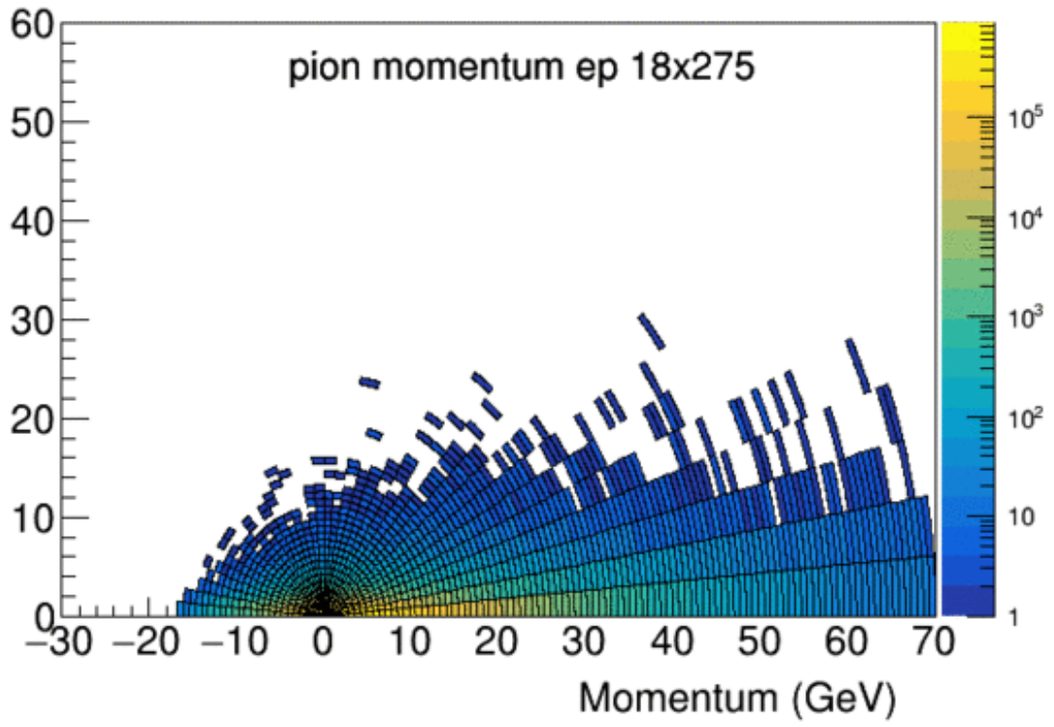
Broad program of reactions/topics

- **EIC workhorse:** Single and di-hadron SIDIS
  - unpol./helicity PDFs, transversity, TMDs, (n)FFs
- **Gluon Sivers:** di-hadron/di-jet SIDIS
- **Gluon Saturation:** di-hadron correlations
- **Λ production:** spin transfer, polarizing FF
- **Spectroscopy:** production of XYZ and P_c states

Single-hadron SIDIS

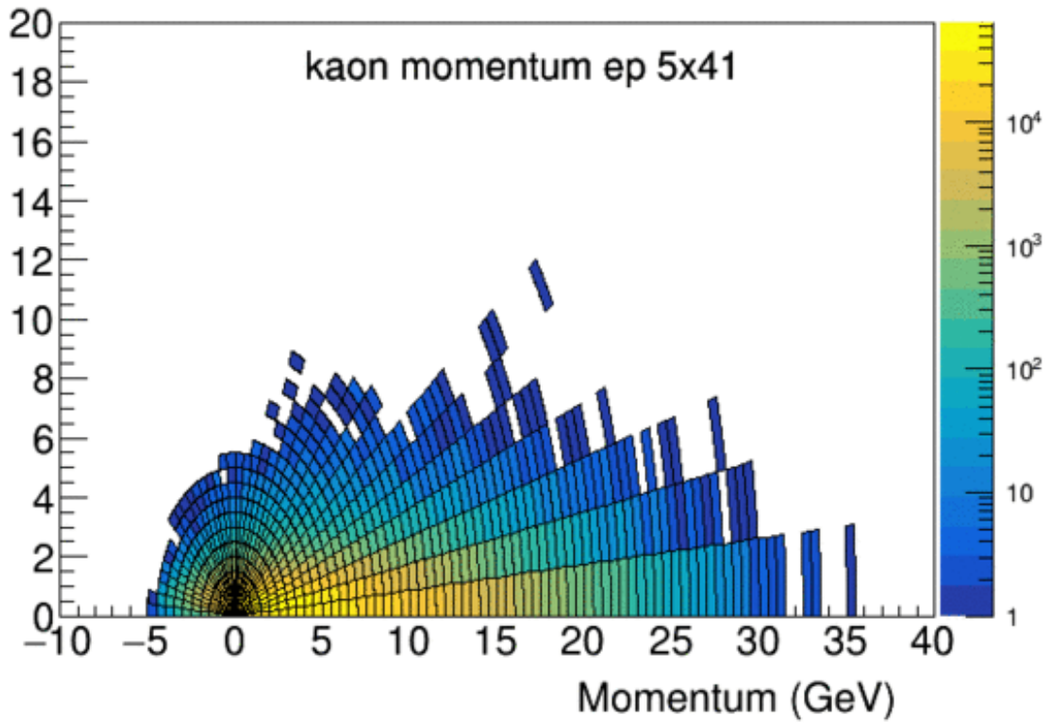
- Broad coverage in hadron-going phasespace, depending on CM energy
- Kinematic maps provided for detector WG
  - Provide most stringing π/K separation requirements

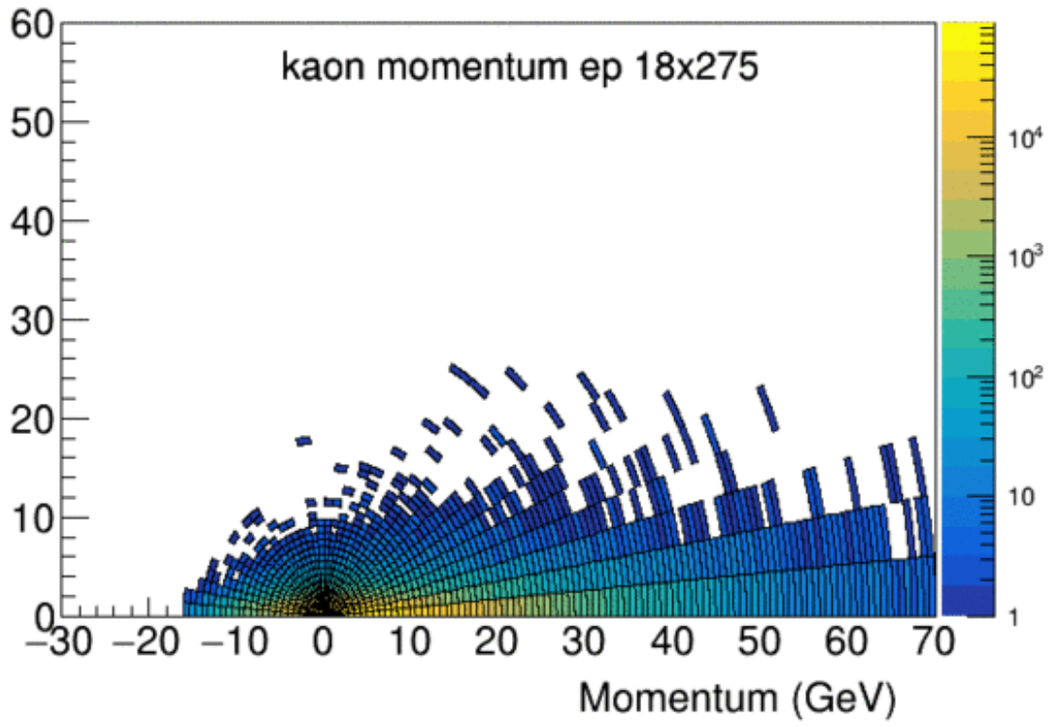




Single-hadron SIDIS

- Broad coverage in hadron-going phasespace, depending on CM energy
- Kinematic maps provided for detector WG
  - Provide most stringing π/K separation requirements



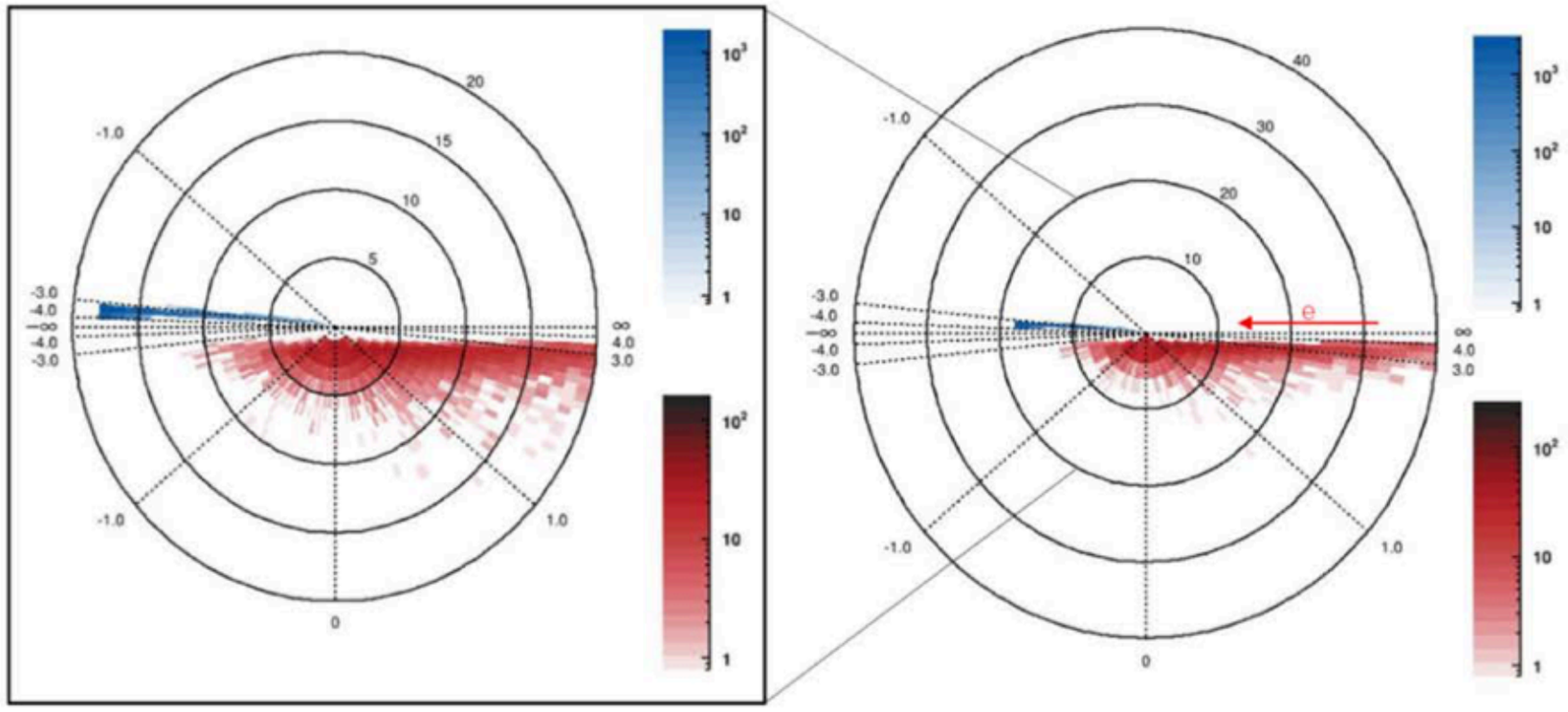


Di-hadron correlations: gluon sivers

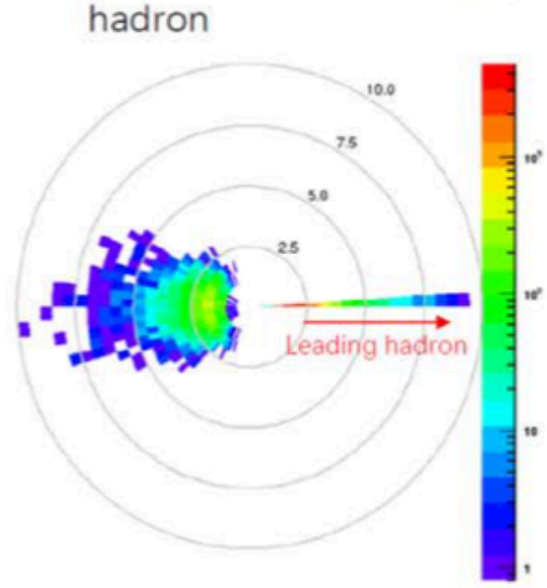
Gluon Sivers measurement requirement from charged dihadron channel

ep 18x275 GeV
0.01<y<0.95, 1<Q^2<2 GeV^2
charged hadron, |η|<4.5, p_T^*>1.4 GeV, z_h>0.1,
k^*_T/P^*_T<0.7, * indicates γ^*p c.m.s frame

p vs η for scattered electron and charged hadron pairs



p_T vs $\Delta\phi$ for associate hadron relative to leading hadron



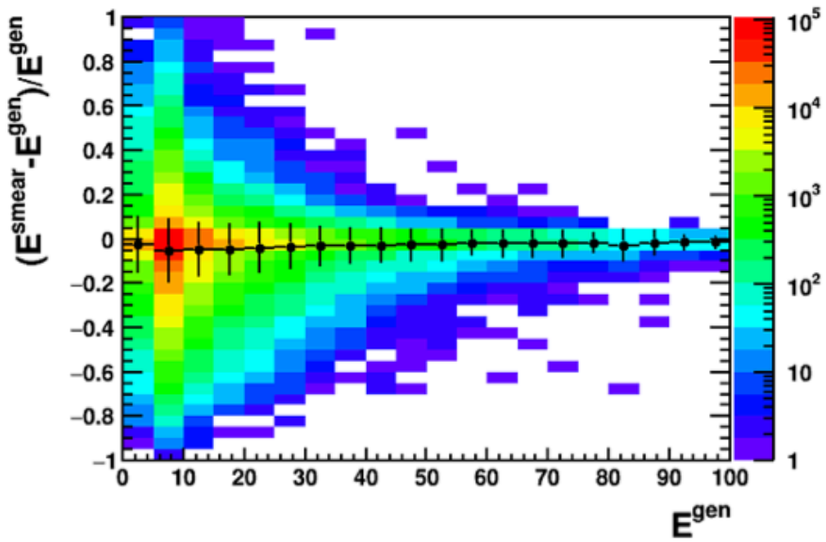
- **Hermetic acceptance for back-to-back di-hadrons**

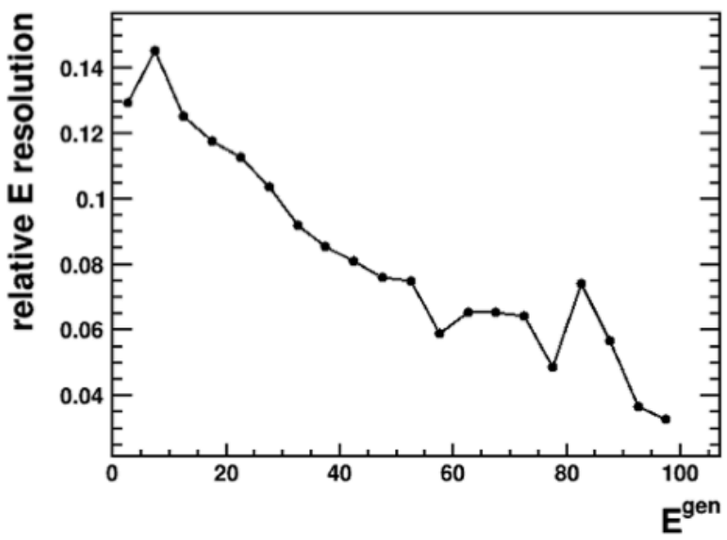
Liang Zheng: SIDIS YR Meeting

SIDIS/Jet cross checks

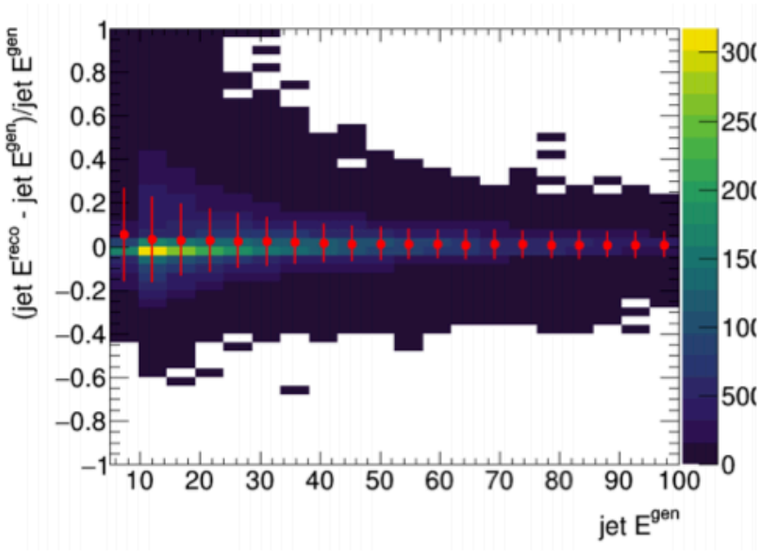
Cross check between eic-smear and DELPHES

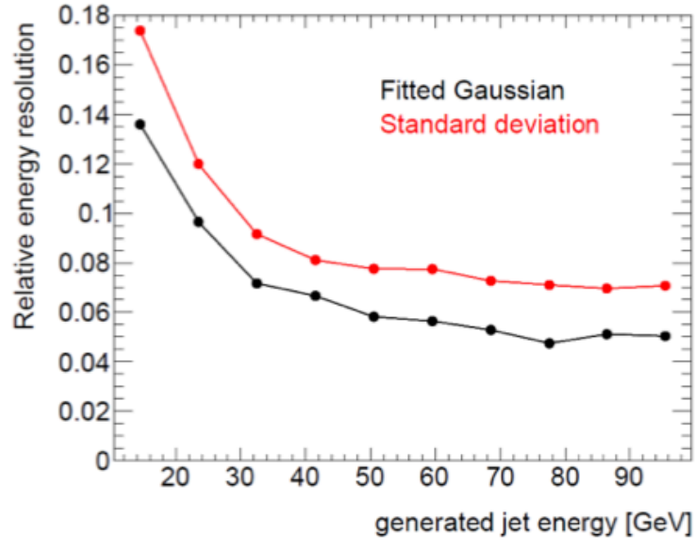
Behavior seems to be similar, the current framework predicts slightly smaller resolution





From Miguel Arratia Pavia YR talk





Liang Zheng: SIDIS YR Meeting

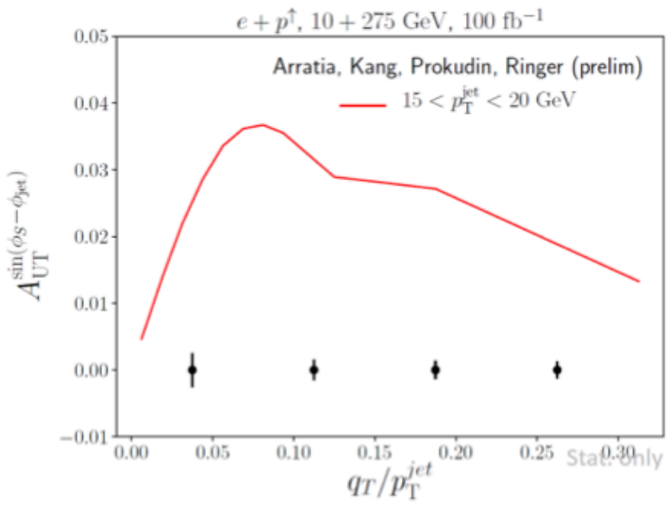
SIDIS/Jet cross checks

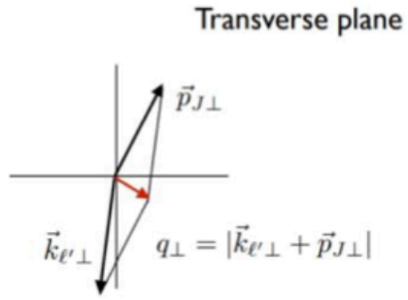
Dilution on jet single spin asymmetry with high Q^2

Miguel Pavia YR talk

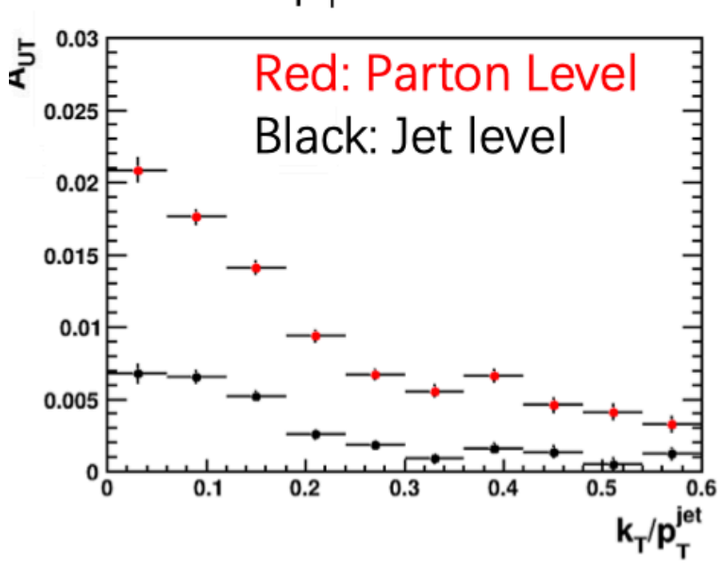
$$A_{UT} = < 2\sin(\phi_{jet} - \phi_S) >$$

ep 18x275, Q^2>50 GeV^2, 0.1<y<0.85
Generator level jet

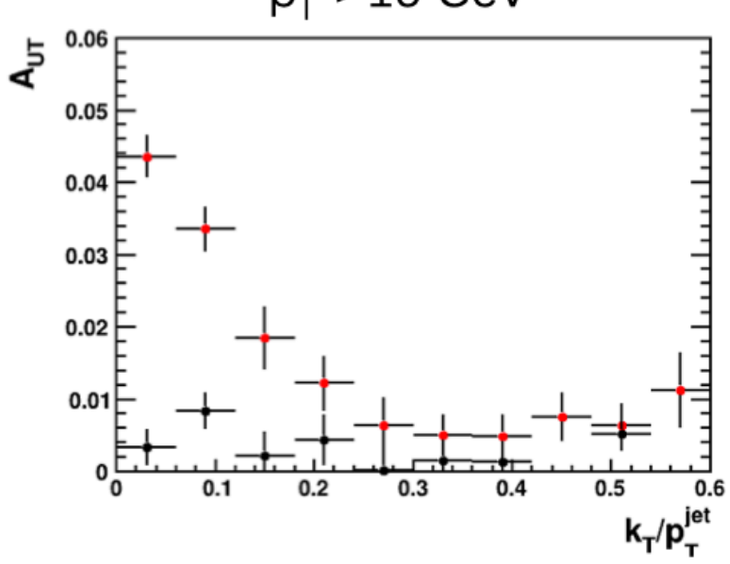




p_T^e<15 GeV



p_T^e>15 GeV



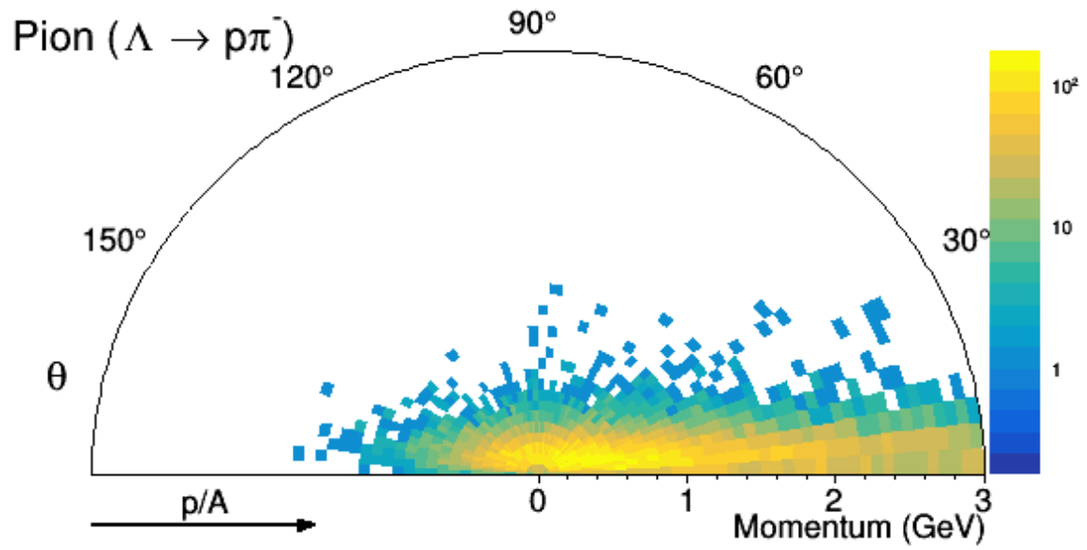
Asymmetry enlarged in the low pt bin, while high pt bin unchanged.

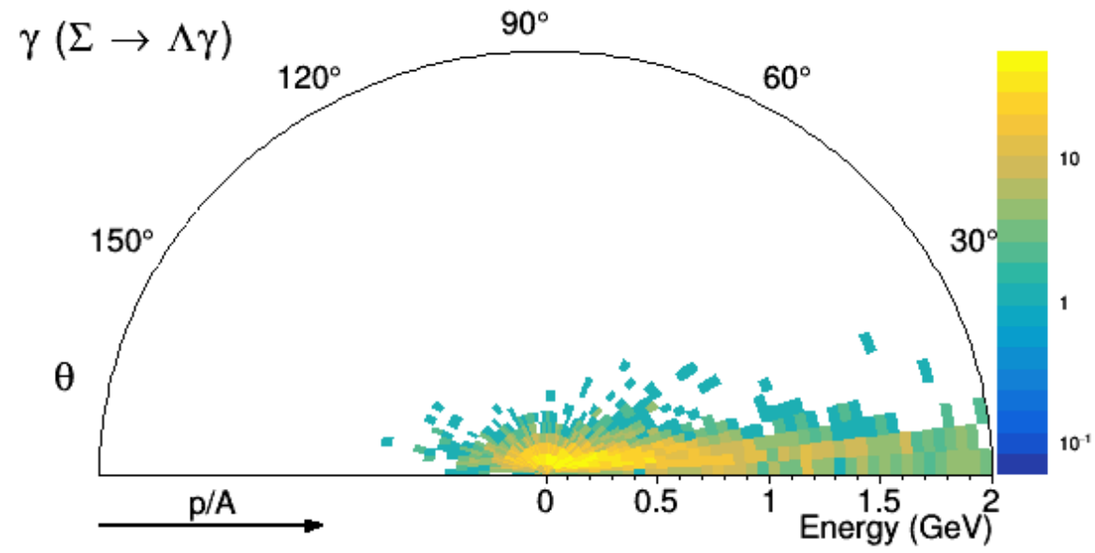
- **Gluon Sivers projections for di-jet in progress**
- **Testing new Centauro jet algorithm**

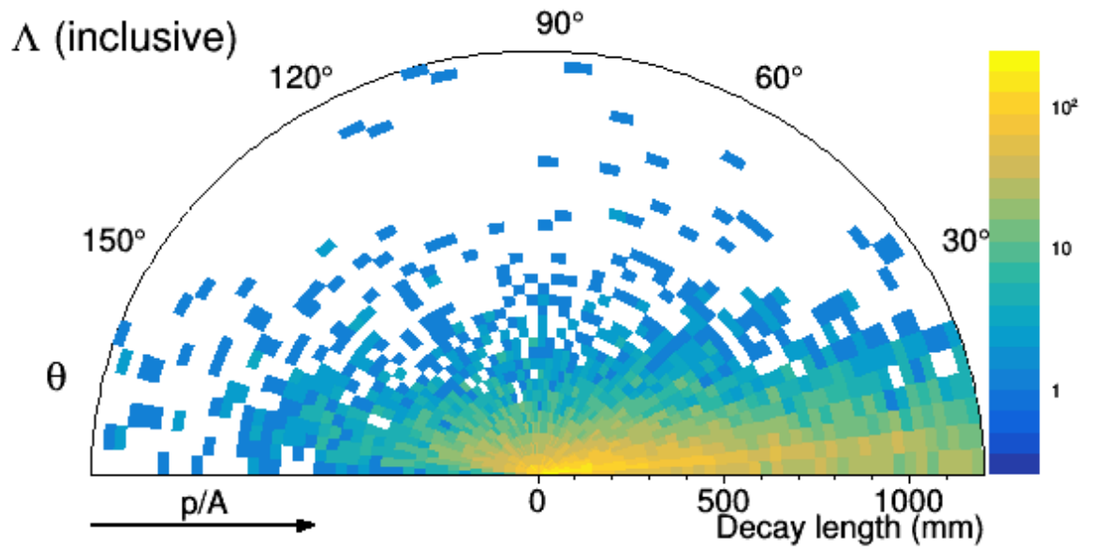
Liang Zheng: SIDIS YR Meeting

Λ measurements

- **Observables:**
  - spin transfer, pol. FF
  - spin-correlations $\Lambda - \bar{\Lambda}$
- **Detector implications:**
  - Soft pion detection
  - Control Σ feed down (calorimeter thresh.)
  - Displaced vertex



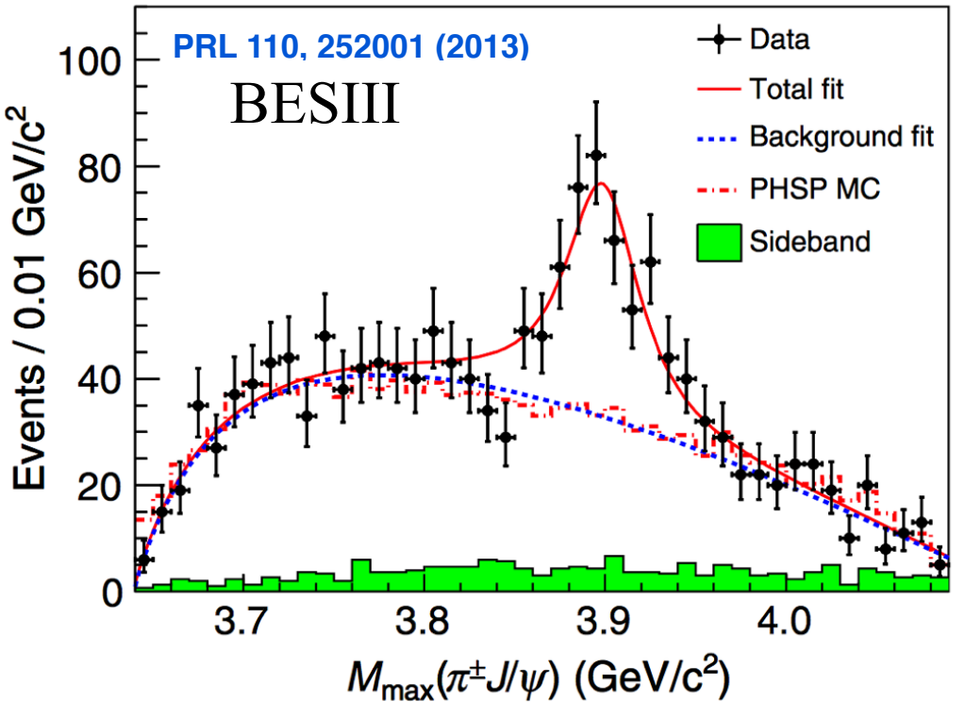


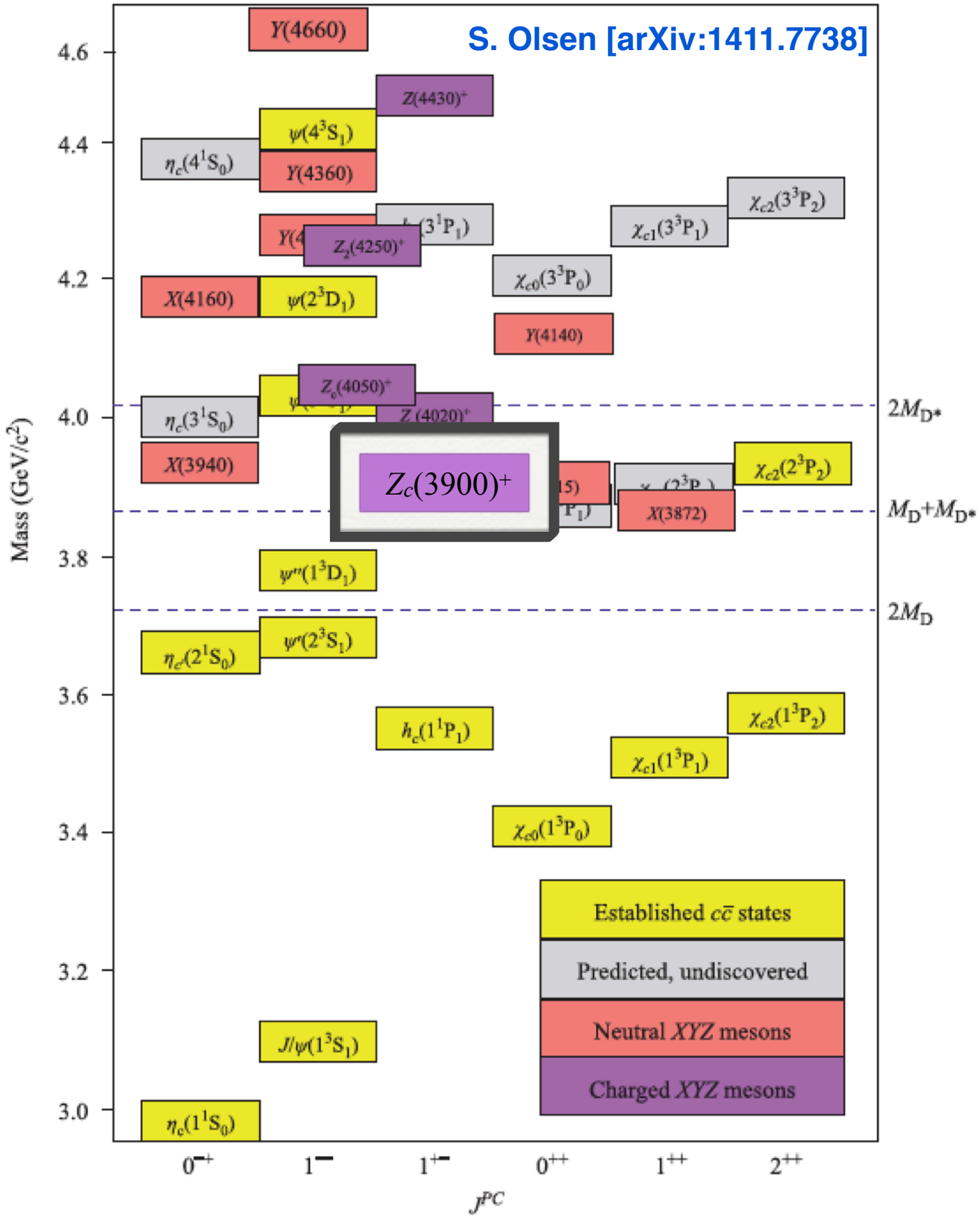


Spectroscopy

- Many new states observed in the last ~decade
- Not predicted by the standard charmonium models
- EIC provides complementary new production mechanism to aid in interpretation

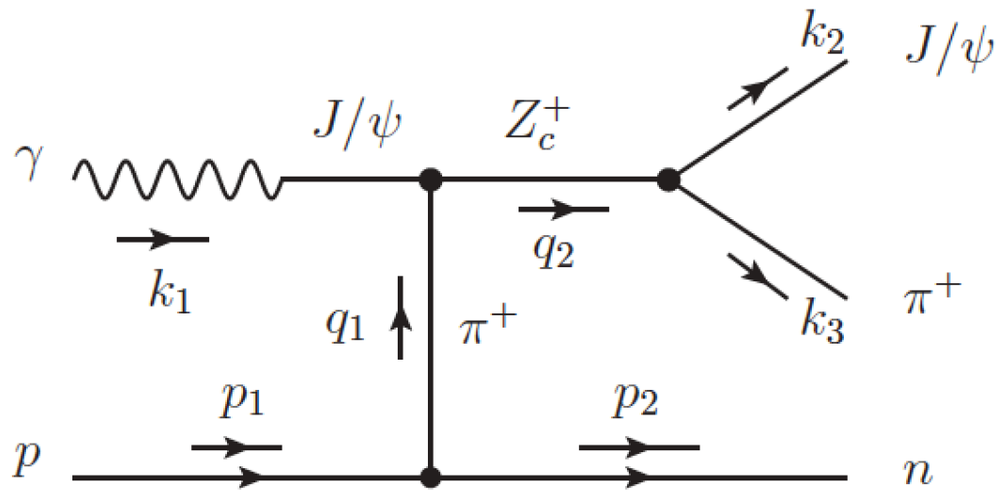
$$e^+e^- \to \pi^+\pi^- J/\psi \ (4260 \text{ MeV})$$



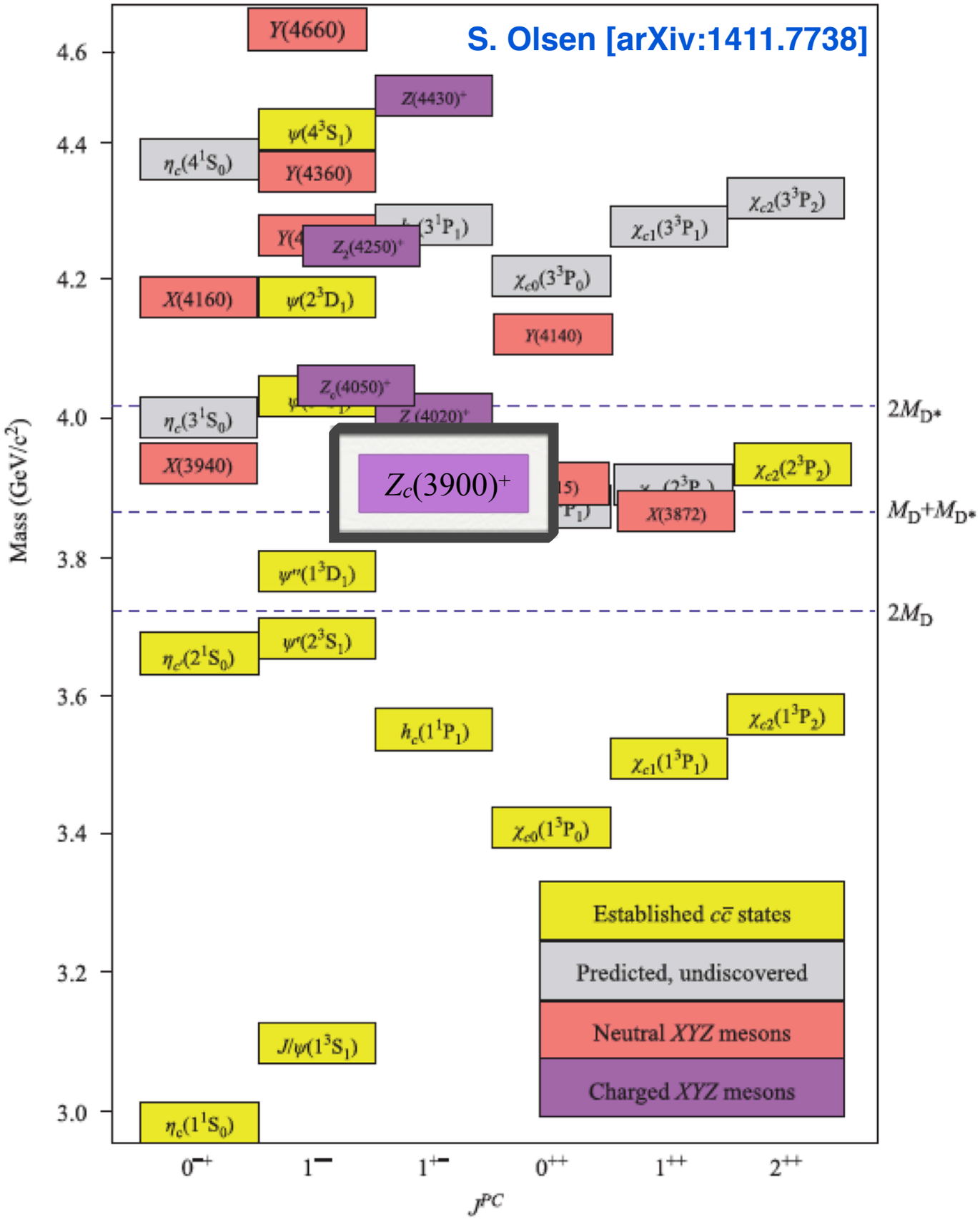


Spectroscopy

- Many new states observed in the last ~decade
- Not predicted by the standard charmonium models
- EIC provides complementary new production mechanism to aid in interpretation



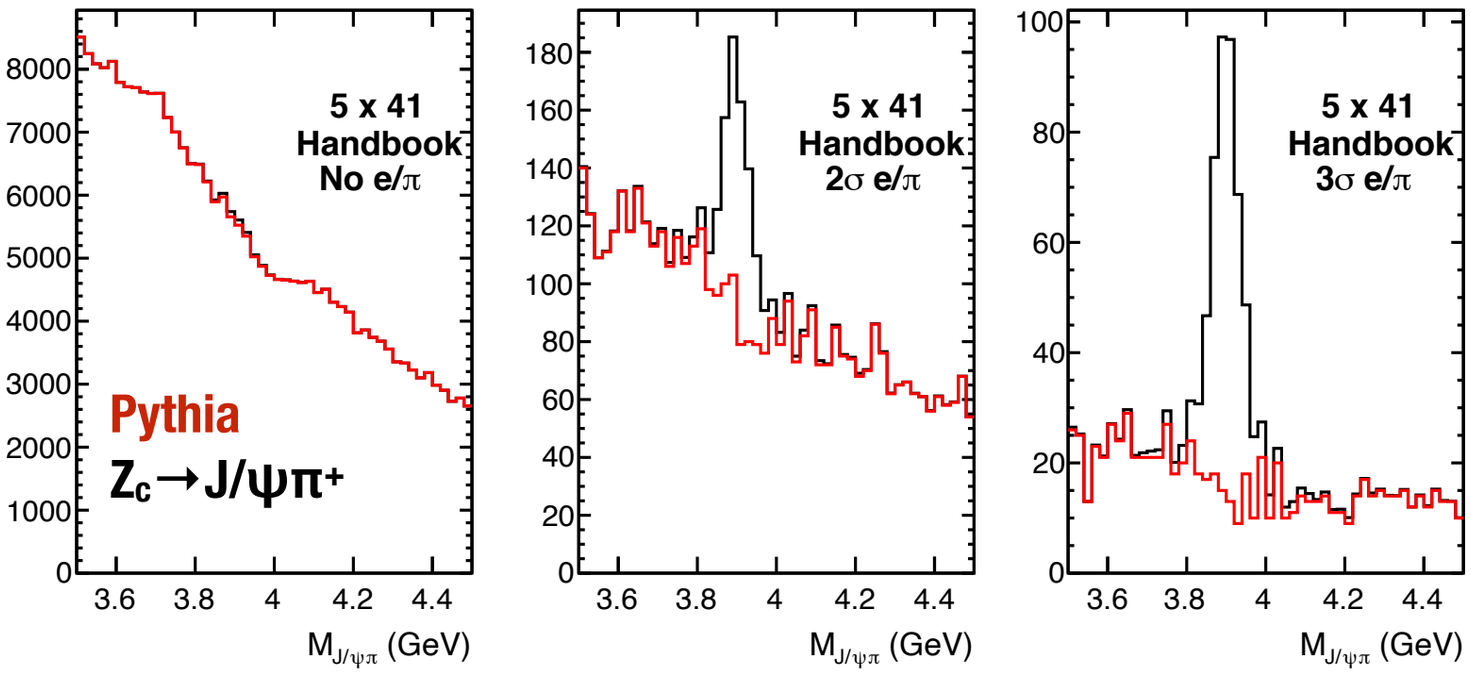
PRD 88 (2013) 114009

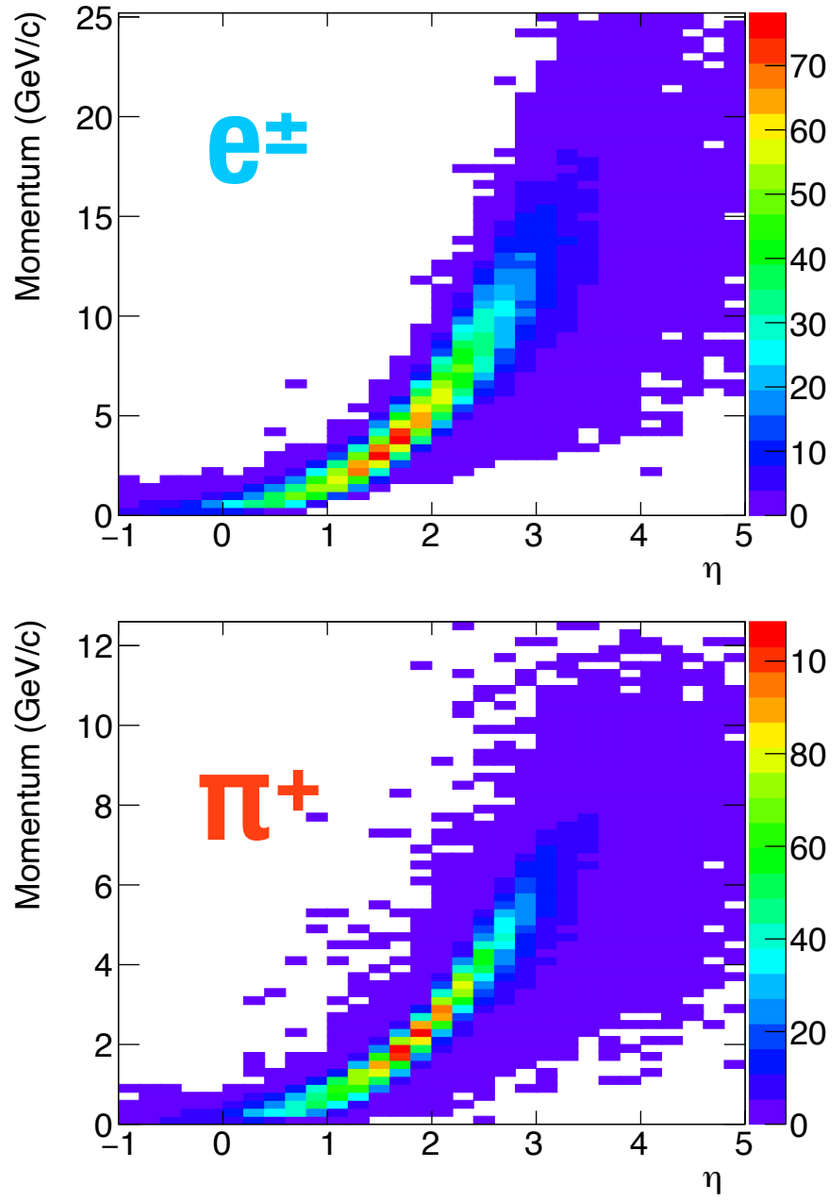


$Z_c^+(3900)$ at an EIC

$$Z_c^+ \to J/\psi\pi^+ \quad J/\psi \to e^+e^-$$

- Development of additional XYZ production models with JPAC
- First studies of backgrounds demonstrate e/π PID requirements





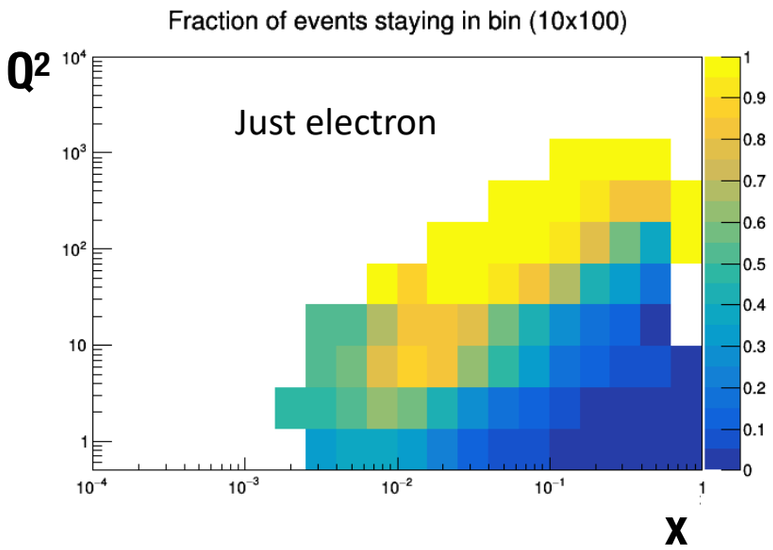
- Decay $e^{\pm}$ and π^+ boosted in proton direction: detector requirements can depend strongly on production with CM energy

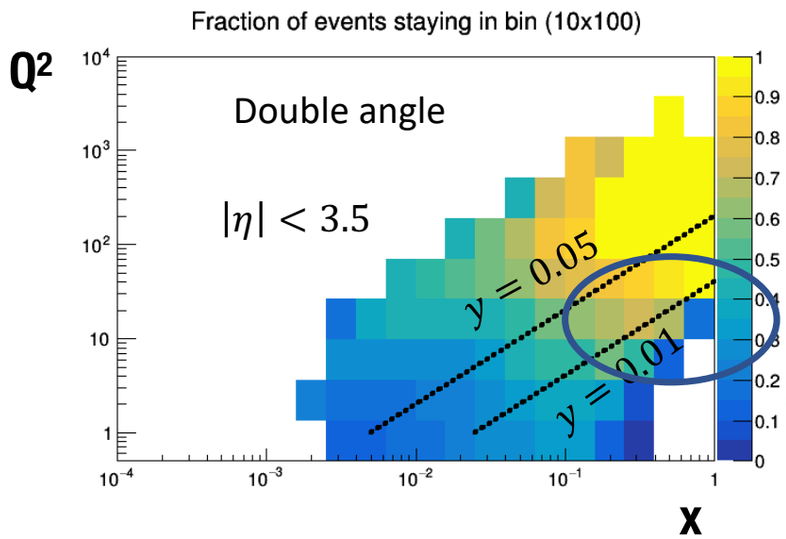
General semi-inclusive detector themes

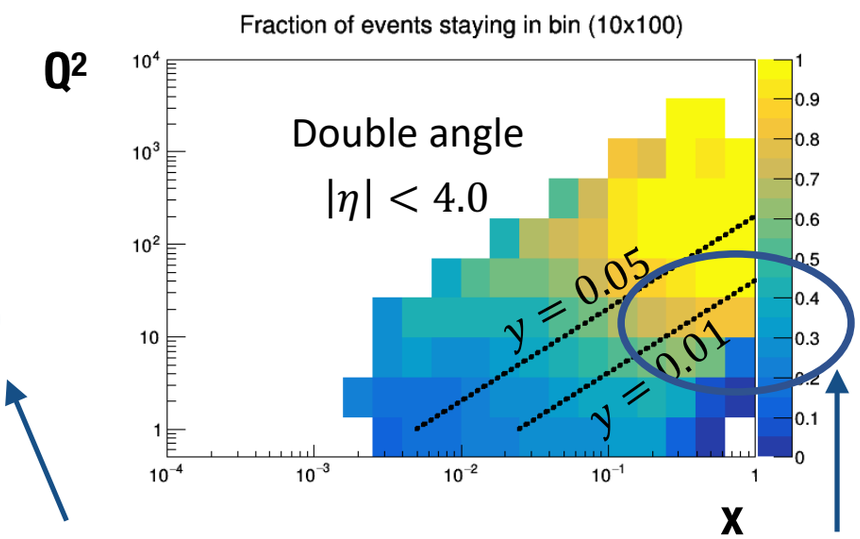
- Most studies using “Handbook” detector as implemented in eic-smear prior to the Pavia YR meeting
- **Tracking:** still need consistent implementation of 1.5 vs 3 T
  - Minimum p cutoff: di-hadron PW, Λ/HF (slow pions)
  - Momentum resolution: forward rapidity hadrons
- **Particle ID:** e/π/K/p separation
  - Purity of flavor separation in SIDIS (helicity/TMD/FF)
  - Background for spectroscopy and open charm
- **Displaced vertices:** important for open charm and Λ reconstruction and purity

Common detector requirements

- Kinematic recon. improves with calorimeter coverage





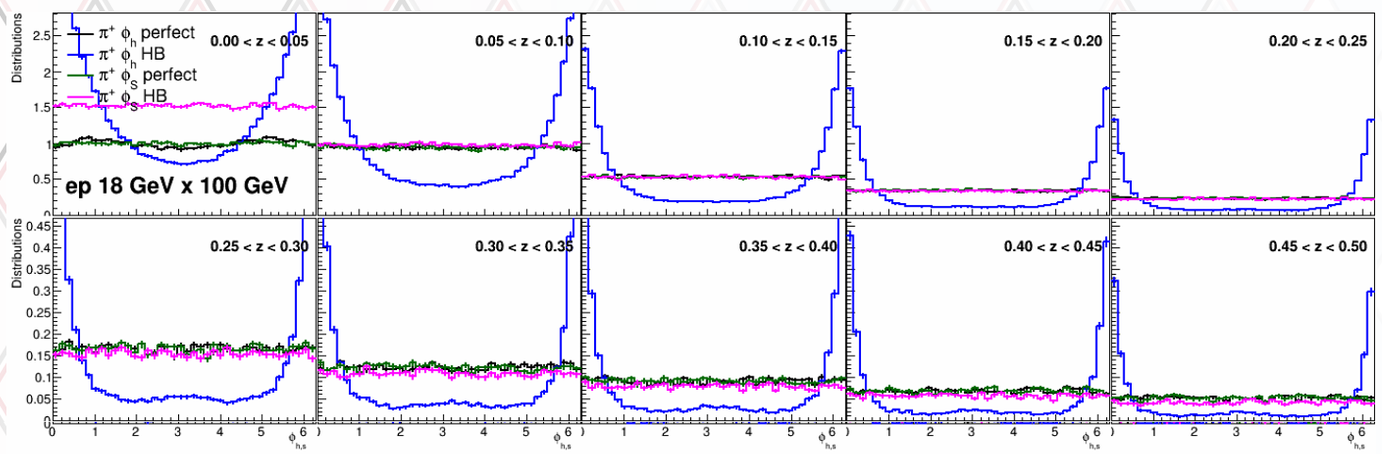


Extension to low y, improves with hermiticity

- Lepton resolution can smear boosts for hadrons

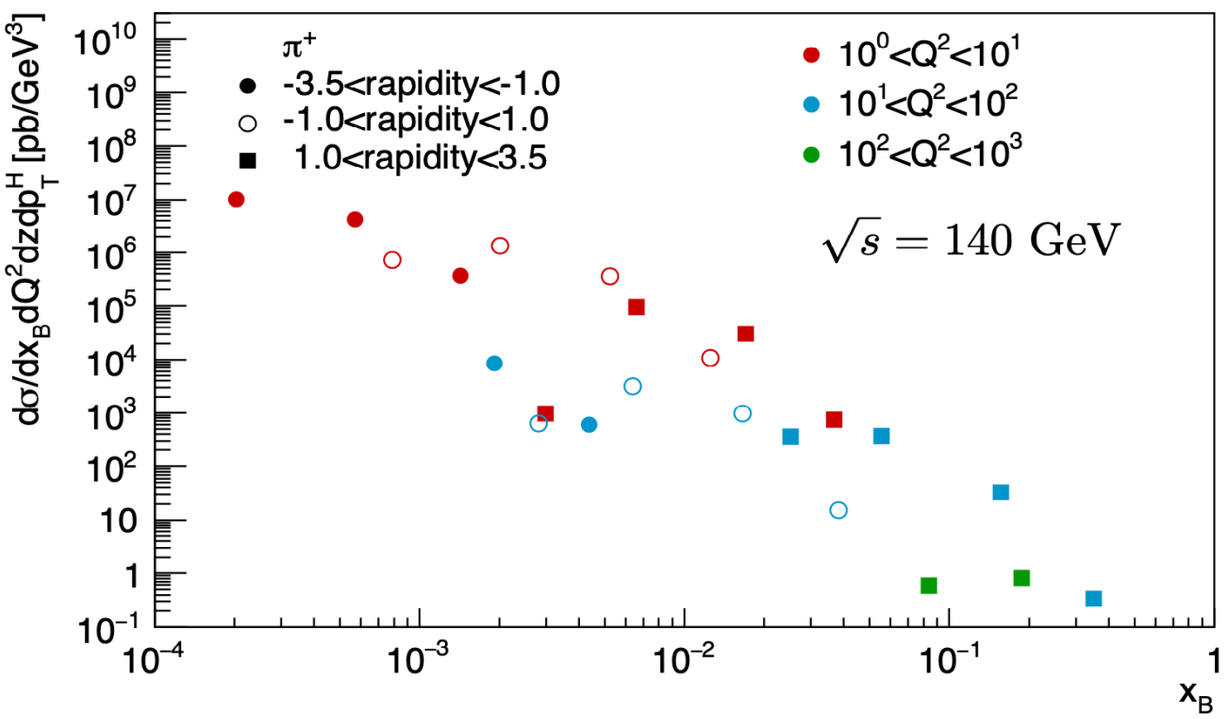
Angles in perfect detector and HB **= HandBook**

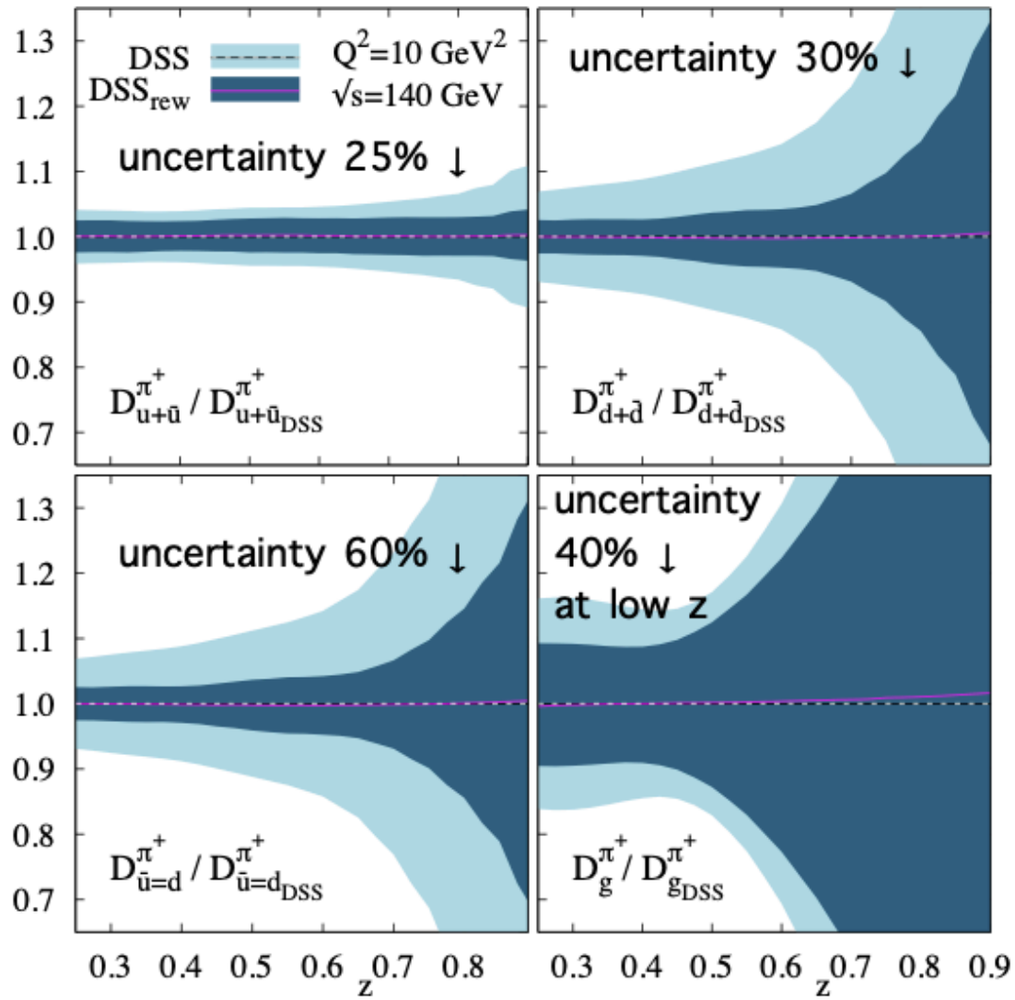
Smeared scattered lepton causes different boost→ ϕ_h often in-plane



More details: https://indico.bnl.gov/event/8549/contributions/37691/attachments/28154/43213/2020_05_18_YR_RCS.pdf

FF impact studies





- Published impacts studies assume wide PID coverage
- Tradeoffs between low p efficiency vs. high p reso.

PRD 99 (2019) 094004

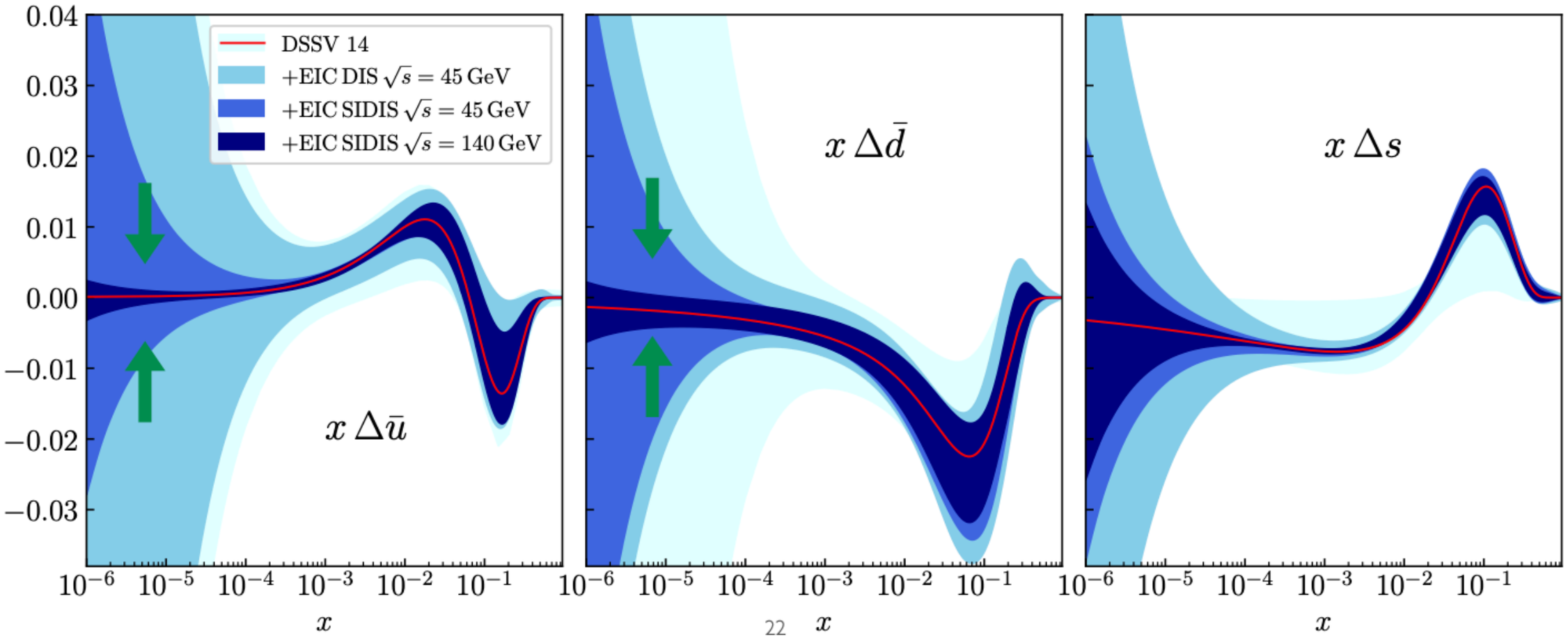
Charlotte Van Hulse: Temple Meeting

Helicity PDF impact studies

IMPACT OF SIDIS DATA

Stronger constraints on $\Delta\bar{u}$ (charge factor) and $\Delta\bar{s}$ (symmetry assumptions in DSSV framework) compared to $\Delta\bar{d}$

SIDIS @140 GeV pushes the growth ni the uncertainty at least a decade in x for $\Delta\bar{u}$ and $\Delta\bar{d}$ due to the wider kinematical coverage



22

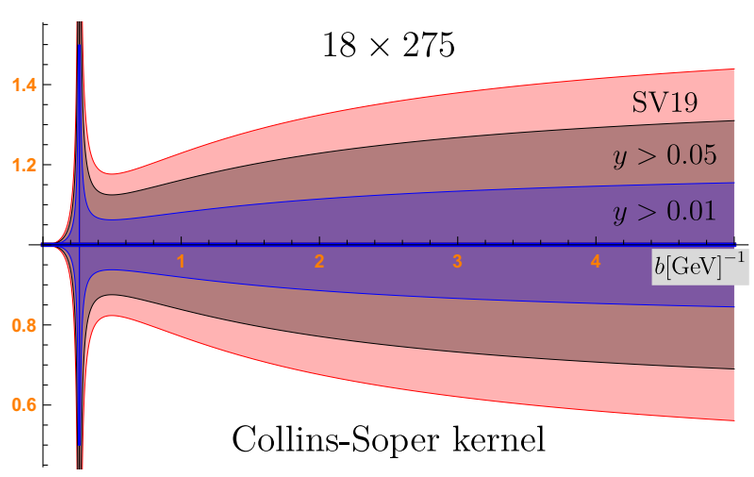
Ignacio Borsa: [SIDIS YR Meeting]

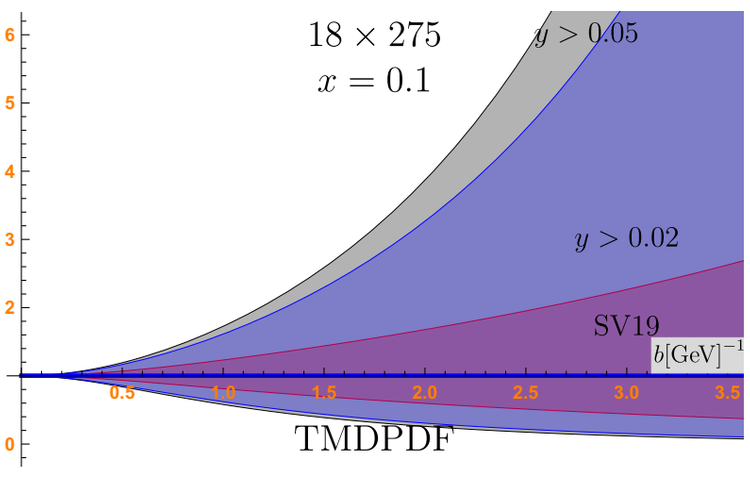
TMD impact studies

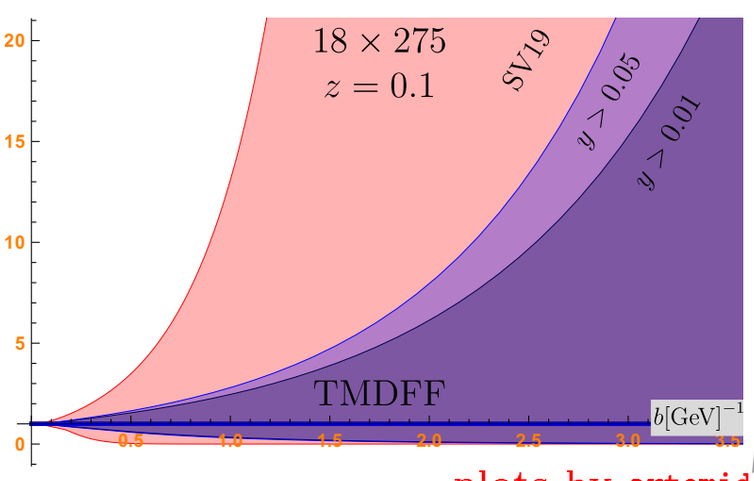
- Many groups involved (Pavia, JAM, etc.): one example

Impact studies are in progress

- First results for unpolarized sector and TMD evolution
  - Significant impact for unpolarized TMDFF and TMD evolution
- On-going studies
  - The flavor separation possibilities
  - Polarized distributions (Sivers!)
  - Detector specific impact
- Main problem: how to estimate impact on the unknown? (e.g. flavor separation)
  - Requires a lot of additional/preliminary studies.







plots by artemide

plots show EIC (18×275)-only vs. global fit

Alexey Vladimirov

b = Fourier conjugate to p_T

Summary

- Fast simulations for all reactions: towards detector req.
  - 3σ π/K separation over single-hadron phase space
  - e/π separation in hadron arm for J/ψ
  - Common requirements for hermiticity and e^- resolution
- Strong theory collaboration for impact studies ongoing
  - Helicity PDFs, TMDs, (n)FFs, transversity, etc.
  - Need smeared simulations with complementary detector assumptions (consistent implementation)
- SIDIS bi-weekly WG meetings: Monday @ 9:30 Eastern