

Status of SIDIS studies

**ECCE IB meeting
September 13**

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Ralf Seidl (RIKEN)**

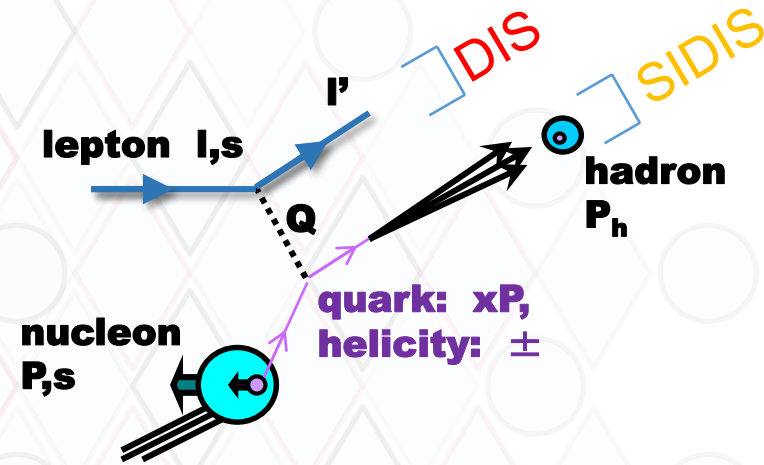
Analysis notes to accompany proposal

- [Kinematics smearing note](#): ~80% done
- [Sivers/Collins note](#): ~70% done (requires Impact studies)
- [Unpol TMD note](#): ~40% done
- Helicity note
- IFF note?
- Others

Will require to rerun over final simulation, provide data to theorists

Exp. Physics analysis strategy

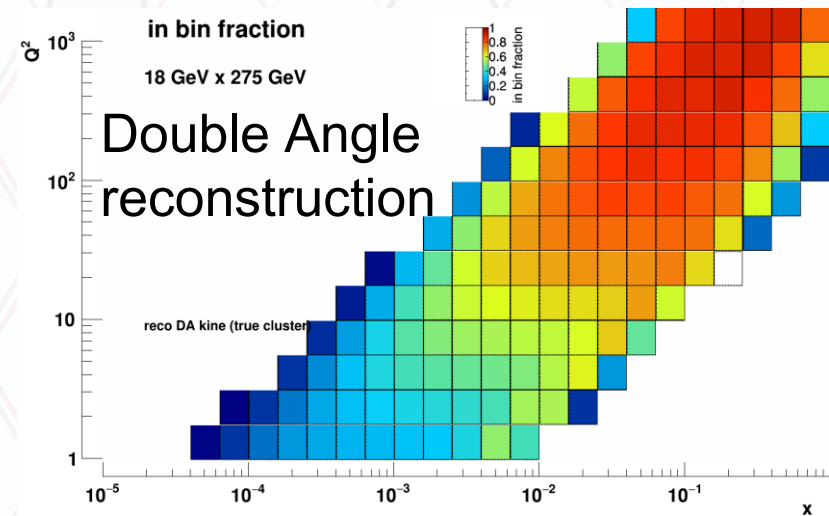
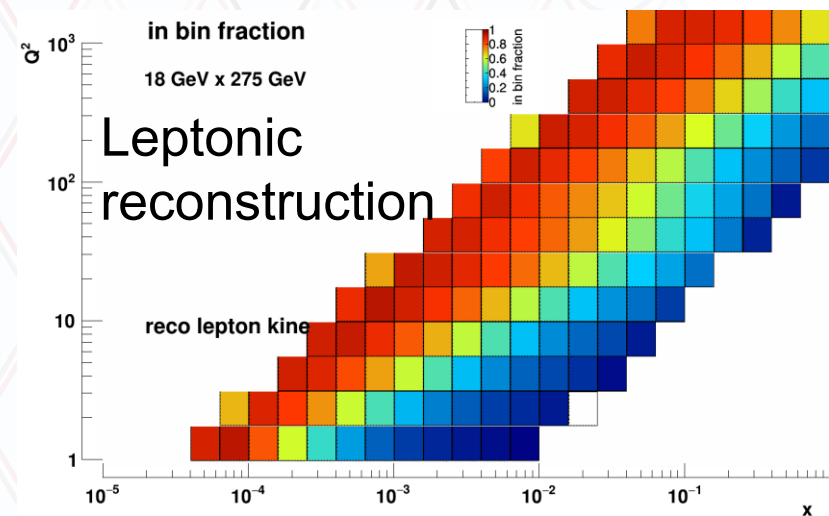
- For any (SI)DIS analysis:
 - Find **DIS** kinematics: easiest case via scattered lepton l' (other methods include hadronic final state)
 - Calculate **DIS** variables: x, y, Q^2, W^2, ϕ_s (around virtual photon in proton rest frame, wrt to scattering plane)
 - Select DIS events (typically $Q^2 > 1 \text{ GeV}^2, W^2 > 10 \text{ GeV}^2, 0.01 < y < 0.95$)
 - Search for final state hadrons \rightarrow **SIDIS**
 - Calculate **SIDIS** variables: z, P_{hT} (wrt to virtual photon in proton rest frame), ϕ_h (around virtual photon in proton rest frame, wrt to scattering plane)



$$\begin{aligned}
 q &= l - l' && \text{Momentum transfer} \\
 Q^2 &= -q^\mu q_\mu \\
 x &= \frac{Q^2}{2p \cdot q} && \text{Parton momentum fraction*} \\
 y &= \frac{q \cdot p}{l \cdot p} && \text{Inelasticity} \\
 W^2 &= M_p^2 + (1 - x)Q^2/x && \text{Mass of had final state} \\
 z &= \frac{p \cdot P_h}{p \cdot q} && \text{SIDIS hadron momentum fraction}
 \end{aligned}$$

DIS kinematic reconstruction examples

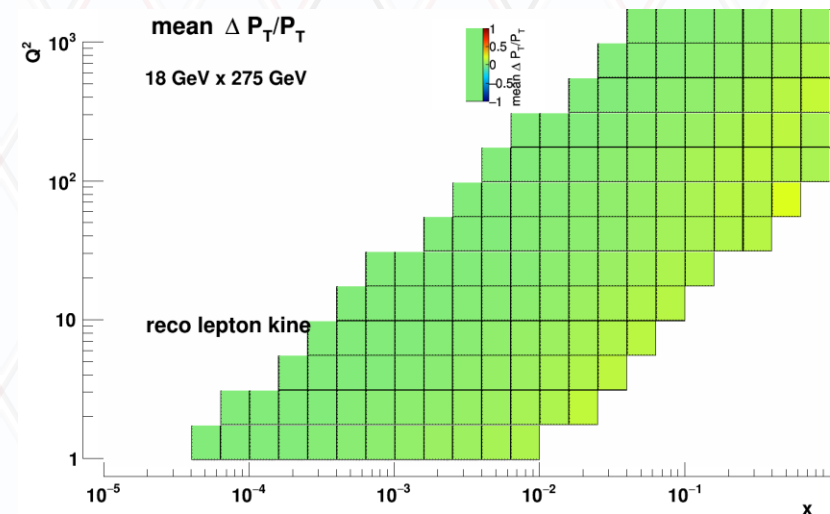
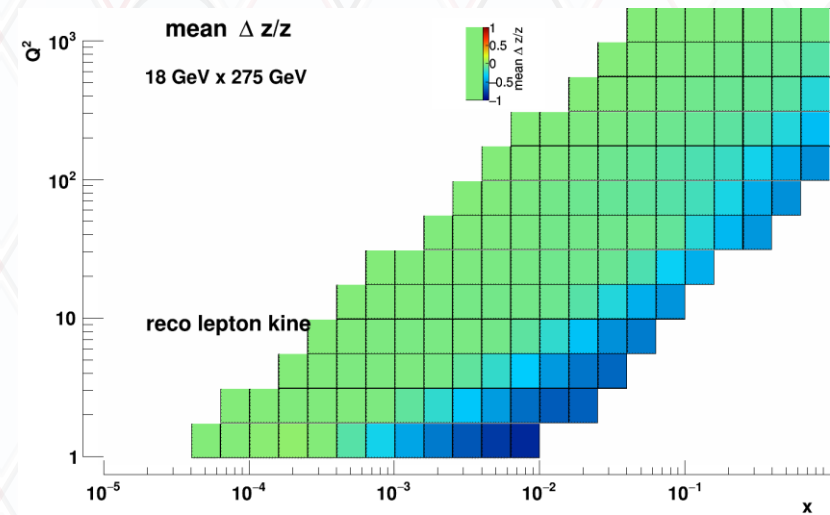
- Full Pythia6+GEANT simulations of the ECCE detector used for various (SI)DIS kinematic resolutions and for various reconstruction methods (lepton, Jaquet-Blondel, Double Angle, etc)
- x and y resolutions suffer from lepton method at lower y, partially recoverable in double angle method (hybrid of scattered lepton + hadronic final state)



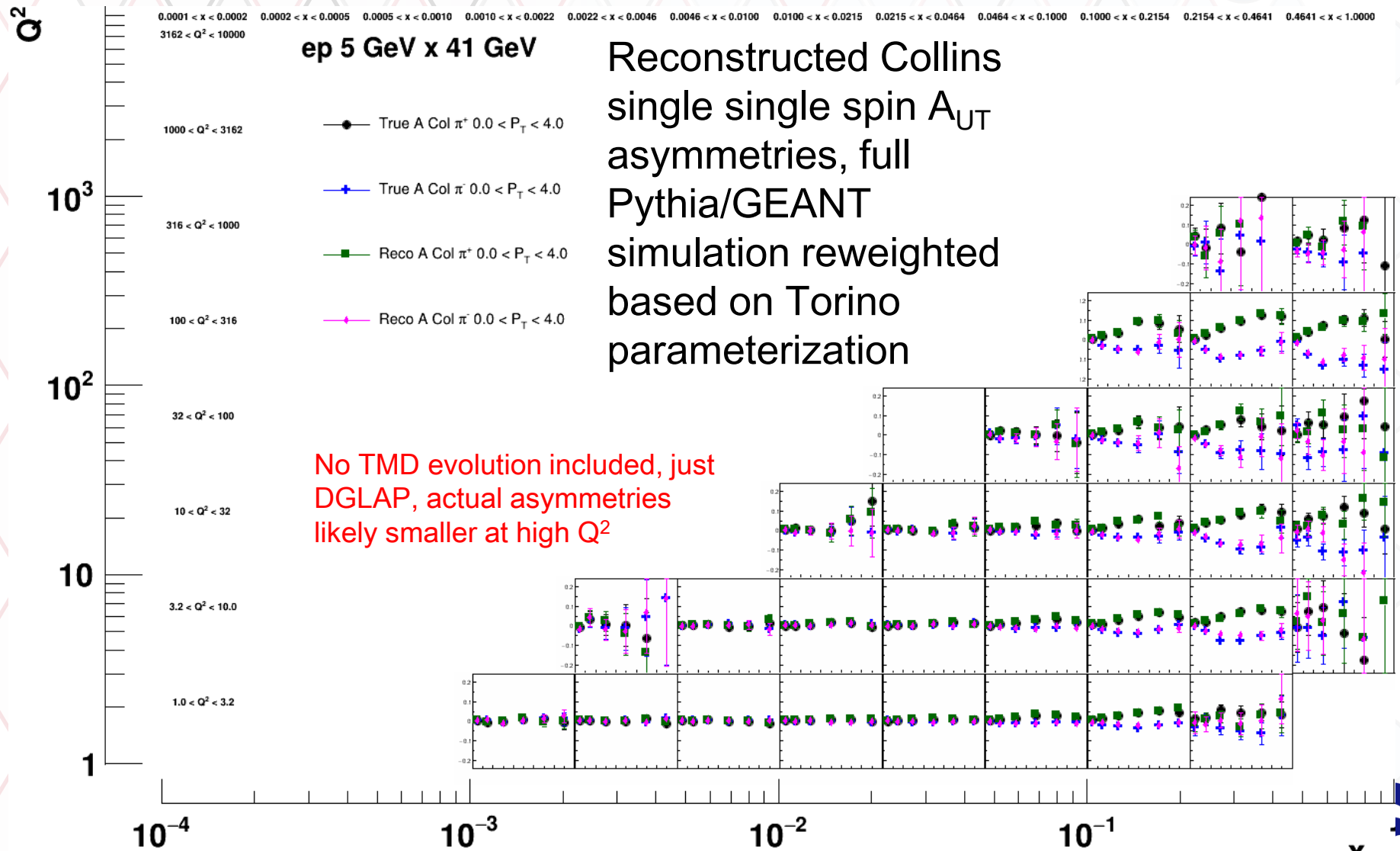
Fraction of DIS events that stay in their x - Q^2 bins

Example of SIDIS resolutions studies

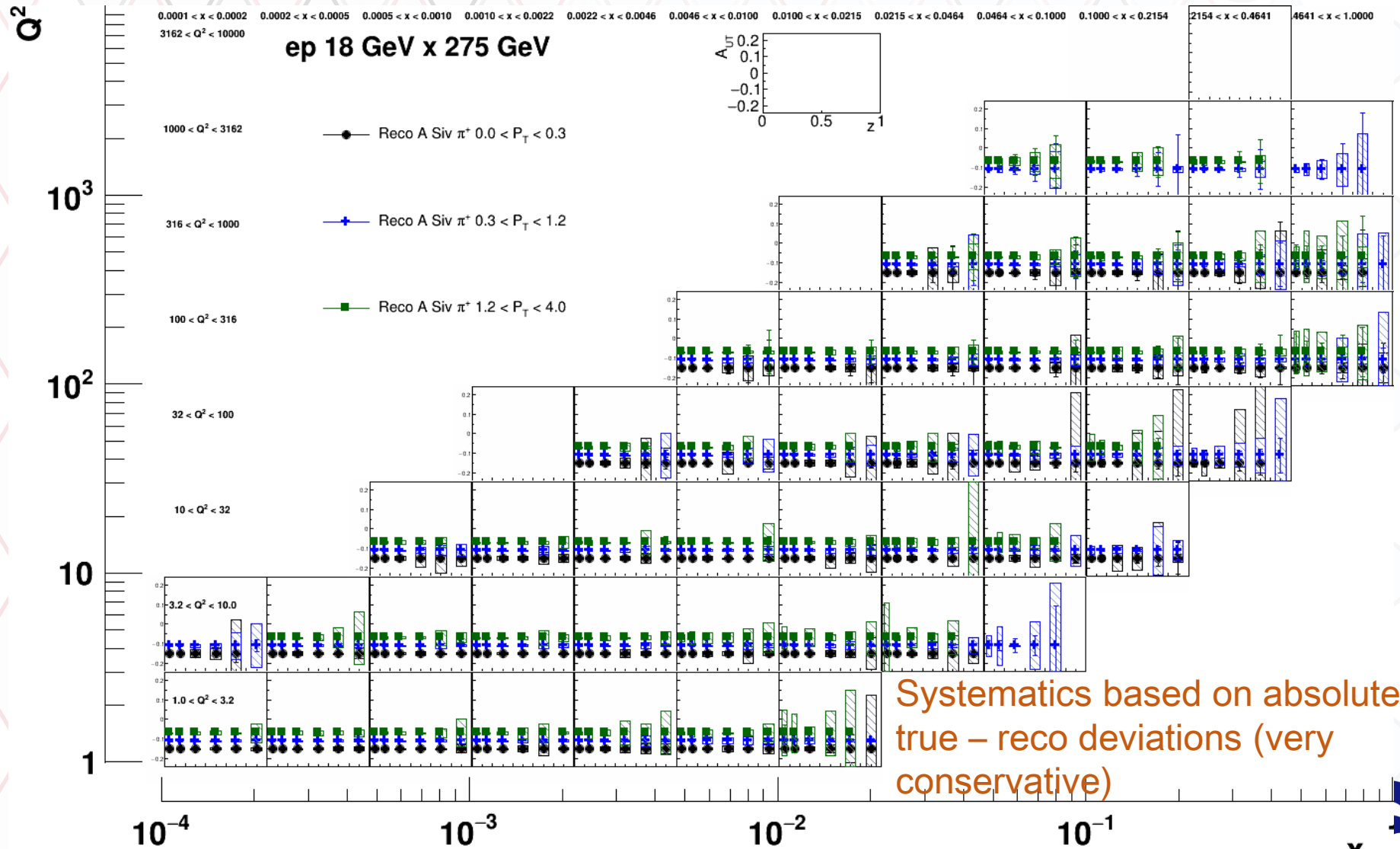
- Full Pythia6+GEANT simulations of the ECCE detector for various (SI)DIS kinematic resolution and reconstruction methods:
 - z resolution suffers in lepton method at lower y , partially recoverable in double angle method
 - p_T and azimuthal angles ϕ_h , ϕ_S very robust



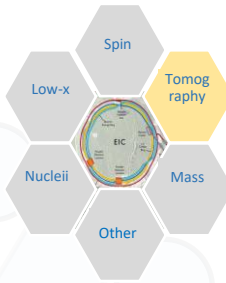
Example on actual physics variables: single spin asymmetries



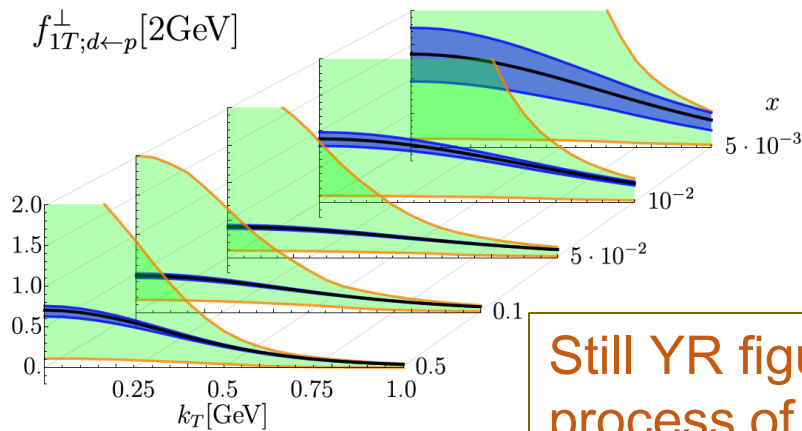
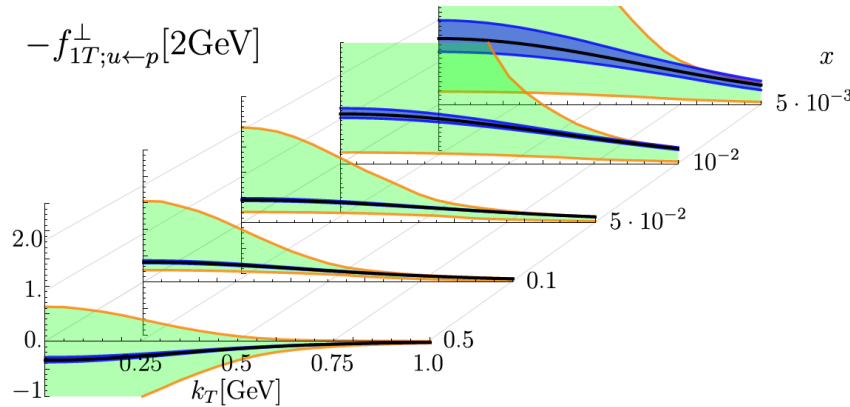
A_{UT} projections for 10fb^{-1} , Sivers π^+



→ EIC impact for Sivers Functions



- Precise nucleon image in momentum space for quarks, sea-quarks and gluons

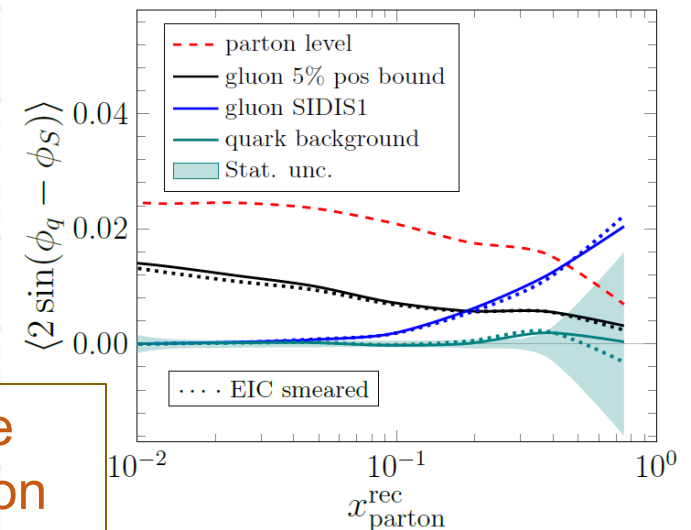


YR: Fig 7.53
Vladimirov, et al

9/07/2021

Still YR figures – in the process of re-evaluation using full ECCE simulations

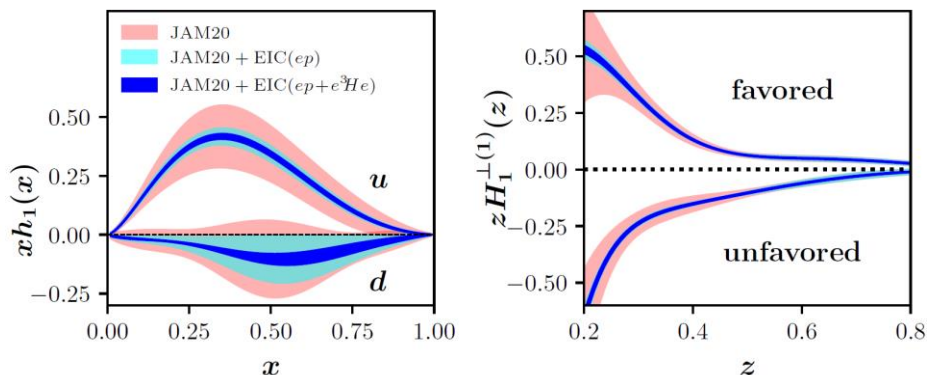
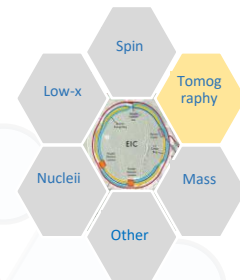
R.Seidl: ECCE



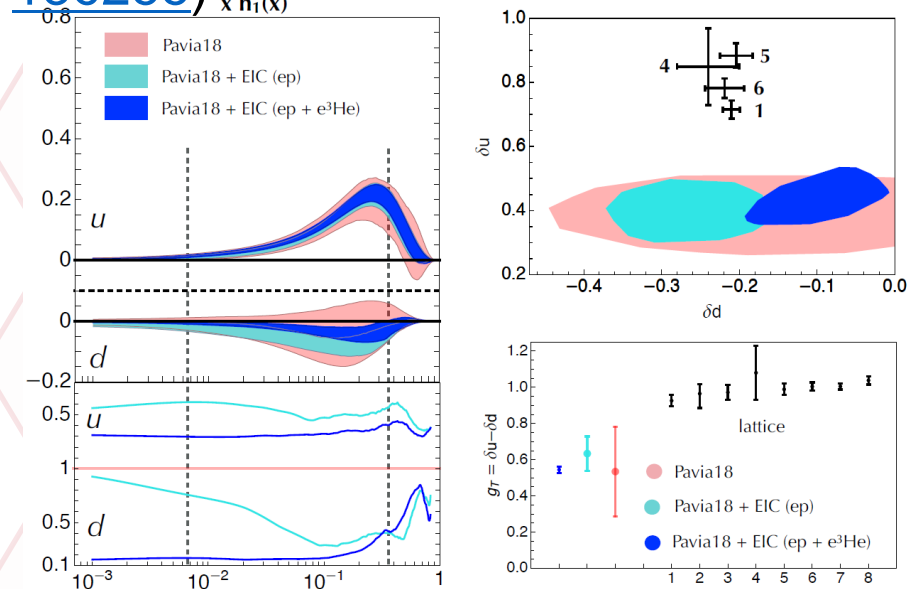
YR: Fig 7.55
Xiao, et al

→ Tensor charges

Still YR figures – in the process of re-evaluation using full ECCE simulations



Single hadron channel (YR: Fig 7.54
[Gamberg et al *Phys.Lett.B* 816 \(2021\) 136255](#))



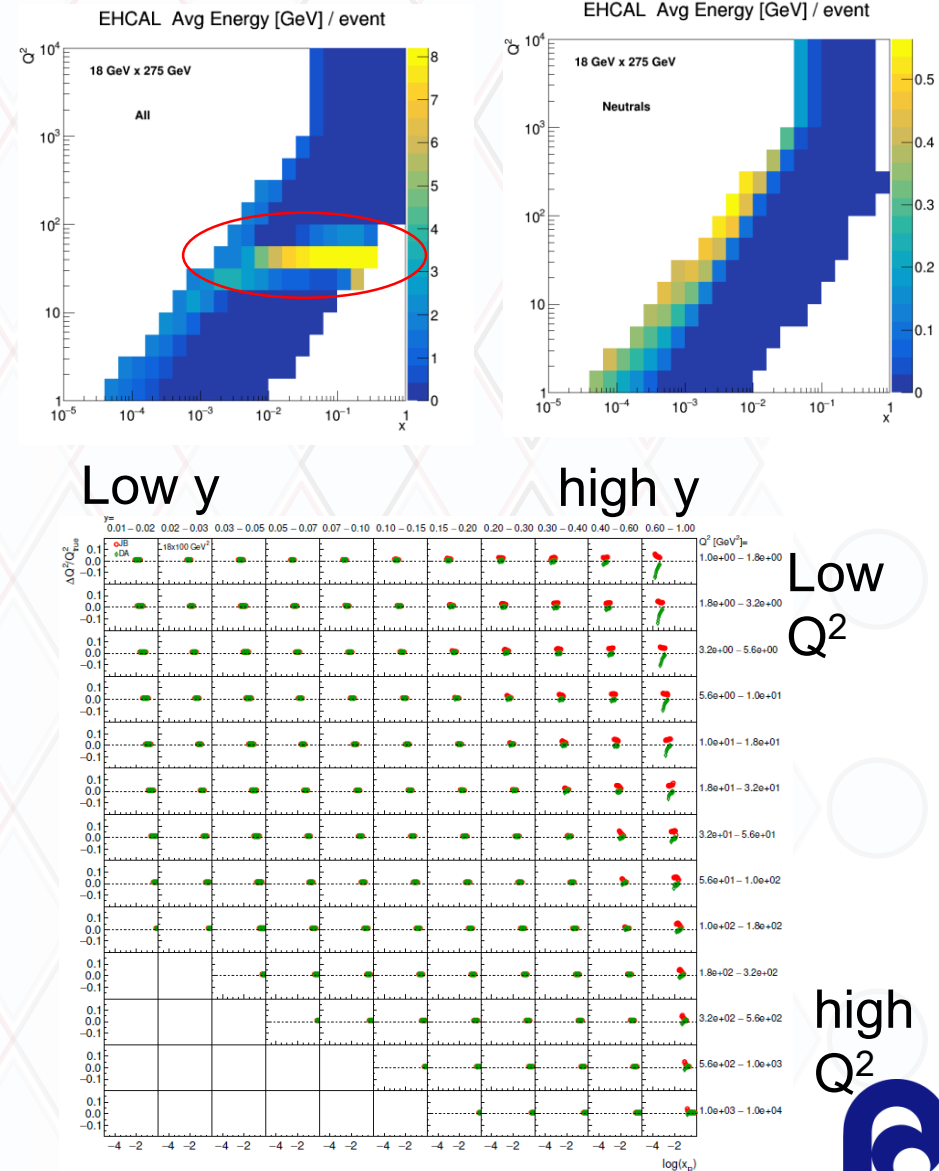
Di-hadron channel (YR: Fig 7.56, Radici)

- Precise determination of tensor charges via Collins and di-hadron channels
- Better precision than lattice → potential access to BSM physics in case of discrepancies
- Preform full integrals, study role of sea quark transversity

Ongoing studies: EHCAL need?

- Expectation: Backward region covers mostly lower x , high- y kinematics where lepton DIS kinematic reco is excellent
- Some other x - Q^2 region seen where there is relevant energy deposit in EHCAL, but only from charged particles
- Impact on DA/JB kinematic reconstruction very small and only visible at higher y , as expected

→ from kinematic reconstruction point of view
no need for EHCAL (but potential impact on eID needs to be addressed by Calorimeter experts)



TODO List

- Re-iterate physics studies after next simulation campaign → Provide the pseudo-data to theorists for impact studies → add to notes
- Finalize notes and plots
- So far no time to work on implementation of PID parameterizations, plan to include π/K , K/p π/p likelihood ratios in Evaluator output for available detector components: mRICH, DIRC, dRICH, (not available so far: TOF)