ECCE unpolarized TMD measurements
impact paper preparation

ECCE bi-weekly meeting

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Theory/Pheno contributions:

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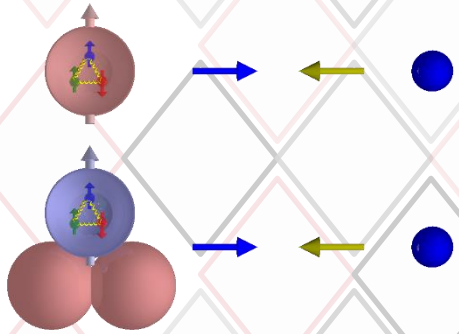
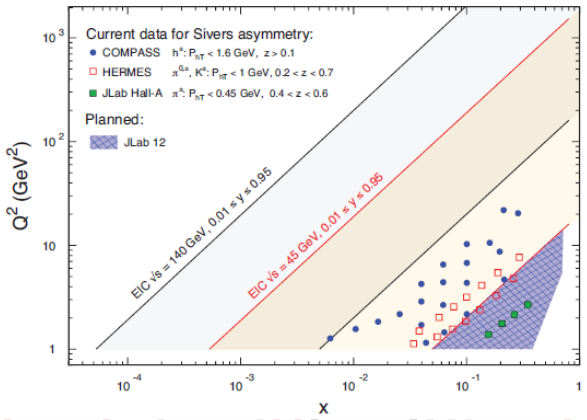
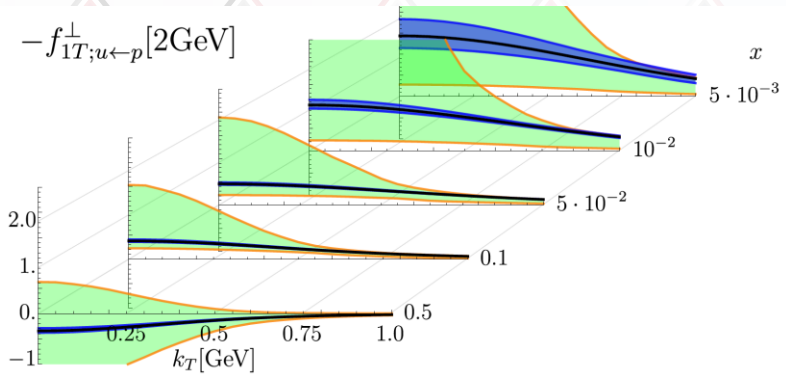
Motivation: 3D Transverse spin and momentum structure

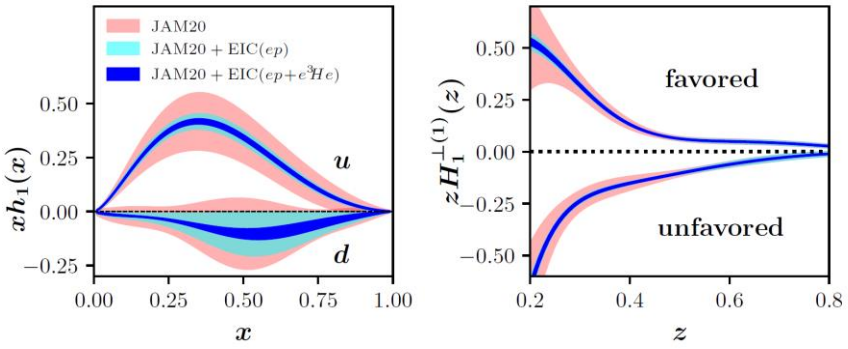


Deliverables	Observables	What we learn	Stage I	Stage II
Sivers & unpolarized TMD quarks and gluon	SIDIS with Transverse polarization; di-hadron (di-jet)	Quantum Interference & Spin-Orbital correlations	3D Imaging of quarks valence+sea	3D Imaging of quarks & gluon; Q^2 (P_{hT}) range QCD dynamics
Chiral-odd functions: Transversity; Boer-Mulders	SIDIS with Transverse polarization	3rd basic quark PDF; novel hadronization effects	valence+sea quarks	Q^2 (P_{hT}) range for detailed QCD dynamics



From EIC Yellow Report:

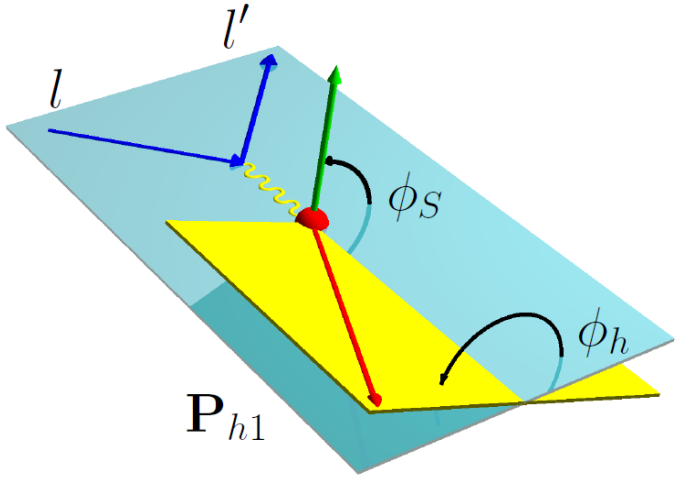




Gamberg et al *Phys.Lett.B* 816 (2021) 136255

Motivation

- Unpolarized TMD distribution and Fragmentation functions are the baseline for all polarized TMD measurements
- Relevant even to heavy boson production (H, W, Z) at LHC
- Also relevant to low-x physics
- Scale dependence in TMD regime still poorly known (as TMD evolution contains non-perturpartive parts)
- Understanding the regions of applicability between TMD, collinear frameworks and target fragmentation, etc



- SIDIS sensitive to convolution of intrinsic transverse momentua from PDF and FF
- Unlike jets (PDF only), detected SIDIS pions/kaons/etc provide flavor sensitivity

ECCE simulation setup and binning

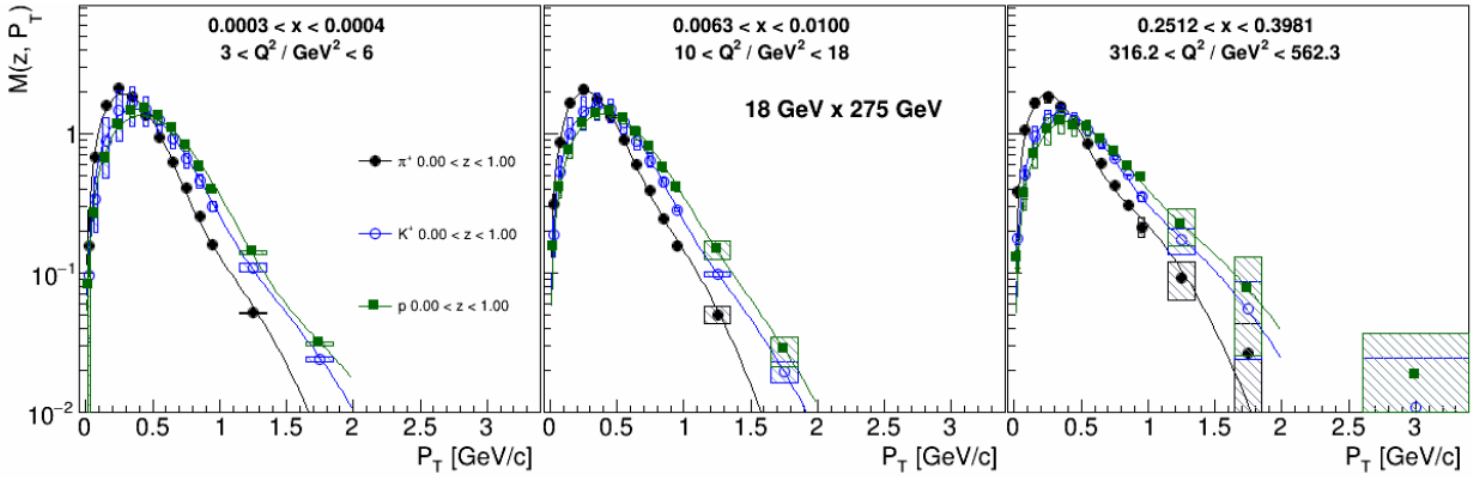
- pythiaeRHIC (Pythia 6) simulations for e+p collisions at 4 energies similar to YR
- Generator output simulated through GEANT4 (prop4)
- Analyzed via slightly modified EventEvaluator TTrees
- Scattered lepton ($|\eta|<3.5$) DIS kinematic reconstruction using reco track momenta (assuming perfect eID)
- DIS cuts: $0.01<y<0.95$, $Q^2>1$, $W^2>10\text{GeV}^2$
- SIDIS cuts: pions and kaons ($|\eta|<3.5$), using true PID (assuming successful unfolding)
- 25x13x12x12 kinematic bins (x,Q^2,z,P_T)

Energy	Q^2 range	events	Luminosity (fb^{-1})
18x275	1 - 100	38.71M	0.044
	>100	3.81M	1.232
18x100	1 - 100	14.92M	0.022
	>100	3.72M	2.147
10x100	1 - 100	39.02M	0.067
	>100	1.89M	1.631
5x41	1 - 100	39.18M	0.123
	>100	0.96M	5.944

Kinematic variable	Bin boundaries
x	$1.0x10^{-5}$, $1.59x10^{-5}$, $2.51x10^{-5}$, $3.98x10^{-5}$, $6.31x10^{-5}$, $1.0x10^{-4}$, $1.59x10^{-4}$, $2.51x10^{-4}$, $3.98x10^{-4}$, $6.31x10^{-4}$, $1.0x10^{-3}$, $1.59x10^{-3}$, $2.51x10^{-3}$, $3.98x10^{-3}$, $6.31x10^{-3}$, $1.0x10^{-2}$, $1.59x10^{-2}$, $2.51x10^{-2}$, $3.98x10^{-2}$, $6.31x10^{-2}$, $1.0x10^{-1}$, $1.59x10^{-1}$, $2.51x10^{-1}$, $3.98x10^{-1}$, $6.31x10^{-1}$, 1.0
Q^2	$1.0x10^{0}$, $1.78x10^{0}$, $3.16x10^{0}$, $5.62x10^{0}$, $1.0x10^{1}$, $1.78x10^{1}$, $3.16x10^{1}$, $5.62x10^{1}$, $1.0x10^{2}$, $1.78x10^{2}$, $3.16x10^{2}$, $5.62x10^{2}$, $1.0x10^{3}$, $1.0x10^{4}$
z	0., 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0
P_T	0, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5, 2.0, 4.0

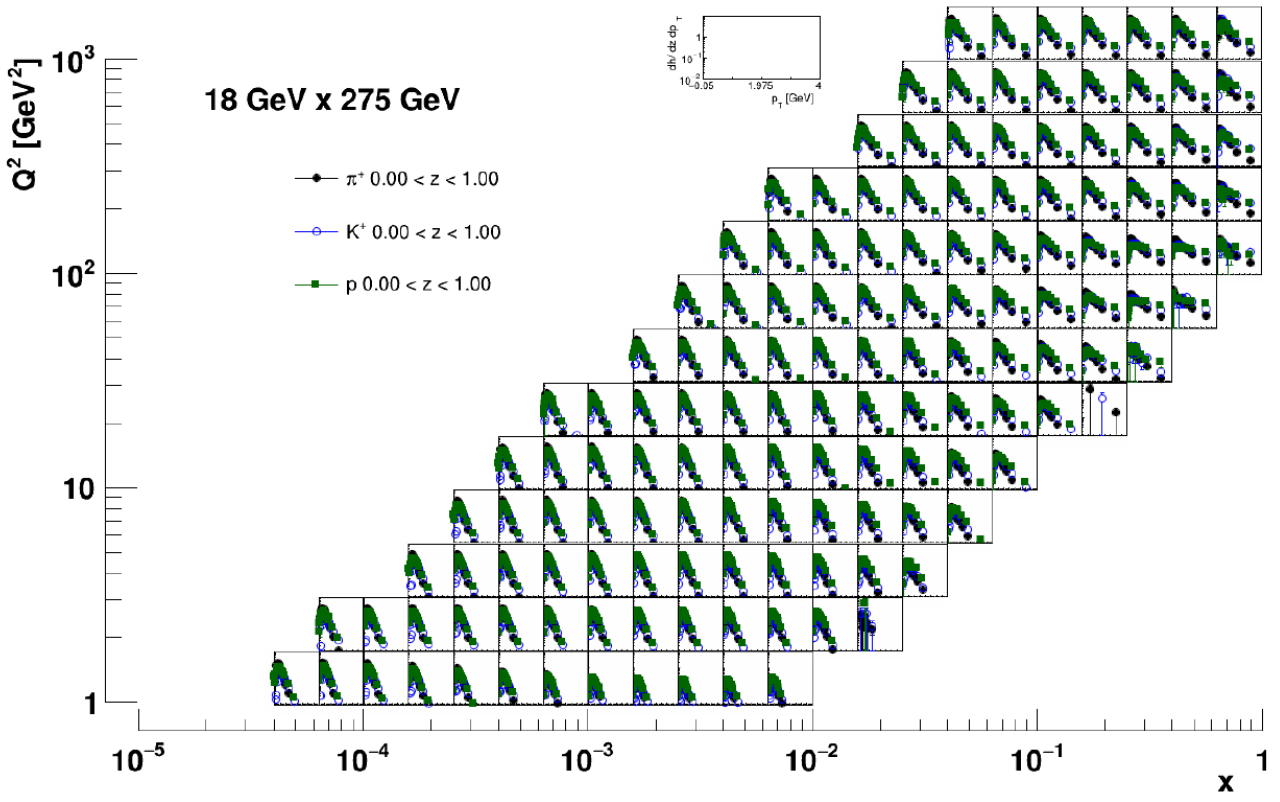
Example figures

- Examples in 3 x and Q^2 bins: Multiplicities for pions, kaons and protons vs P_T (integrated over z)
- Fits of double-Gaussians for low/high P_T behavior also shown



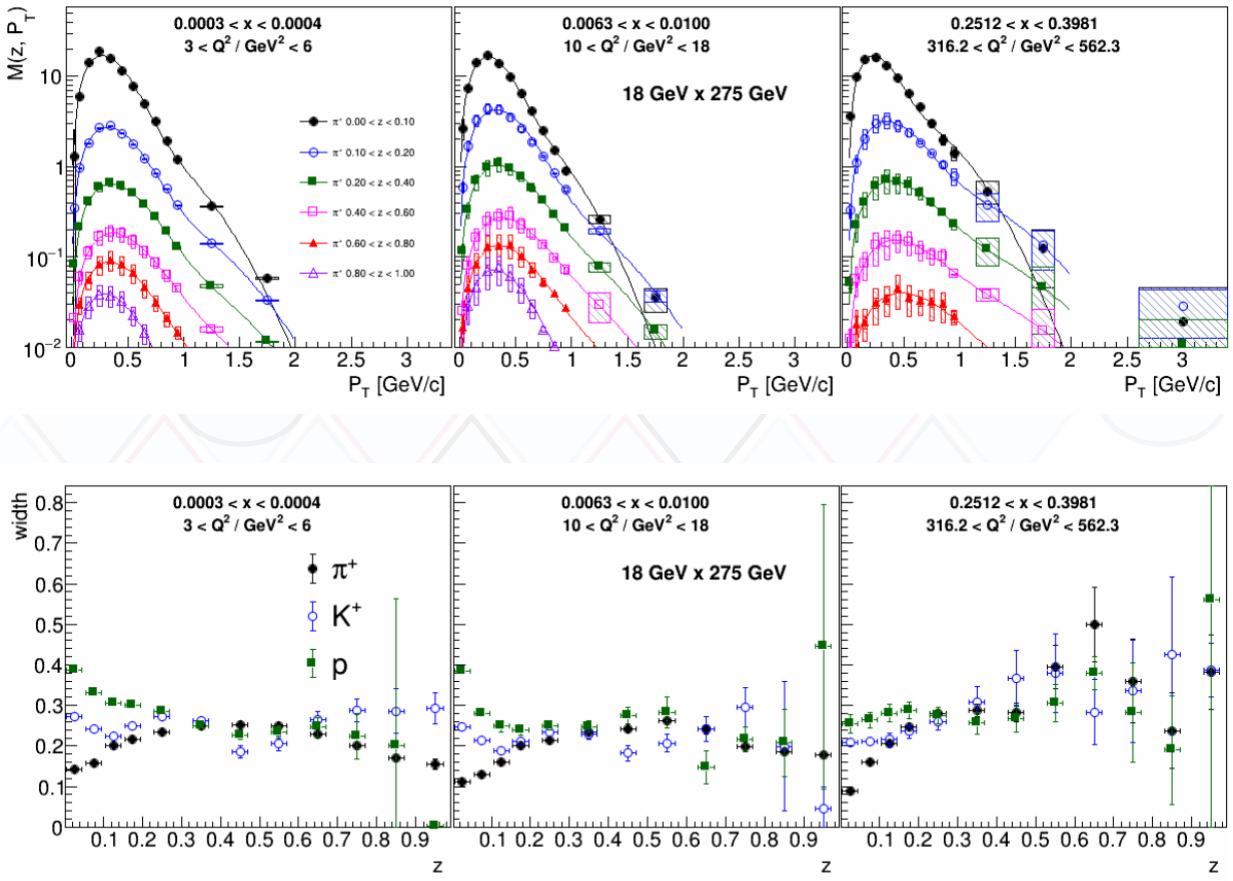
All Multiplicities at highest energies

- Pion, kaon and proton multiplicities shown in all x-Q^2 bins as a function of P_T (integrated over z)



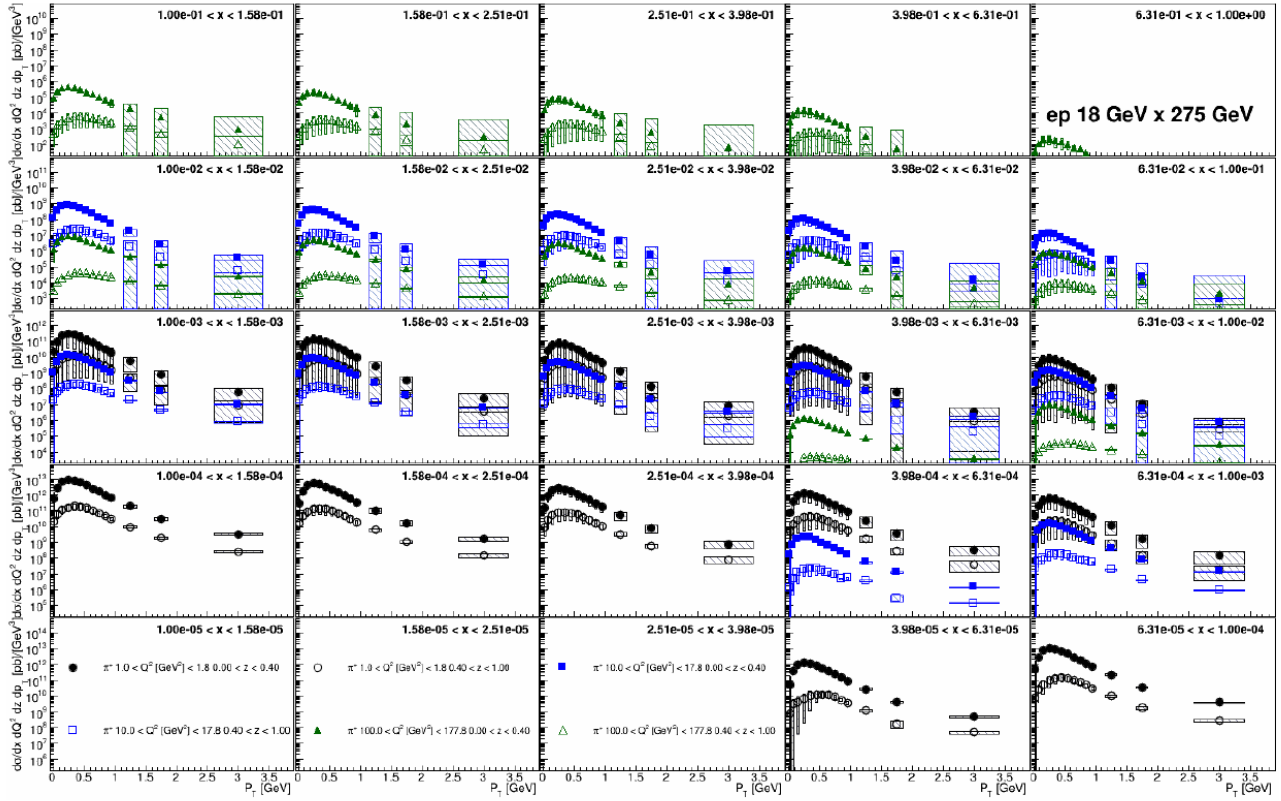
z-dependence of multiplicities and widths

- Top: Explicit z dependence of select pion multiplicities in 3 x-Q^2 bins, including the double-Gaussian fits
- Bottom: behavior of the narrow Gaussian widths vs z for pions, kaons and protons
- Small z discrepancies likely due to target fragmentation



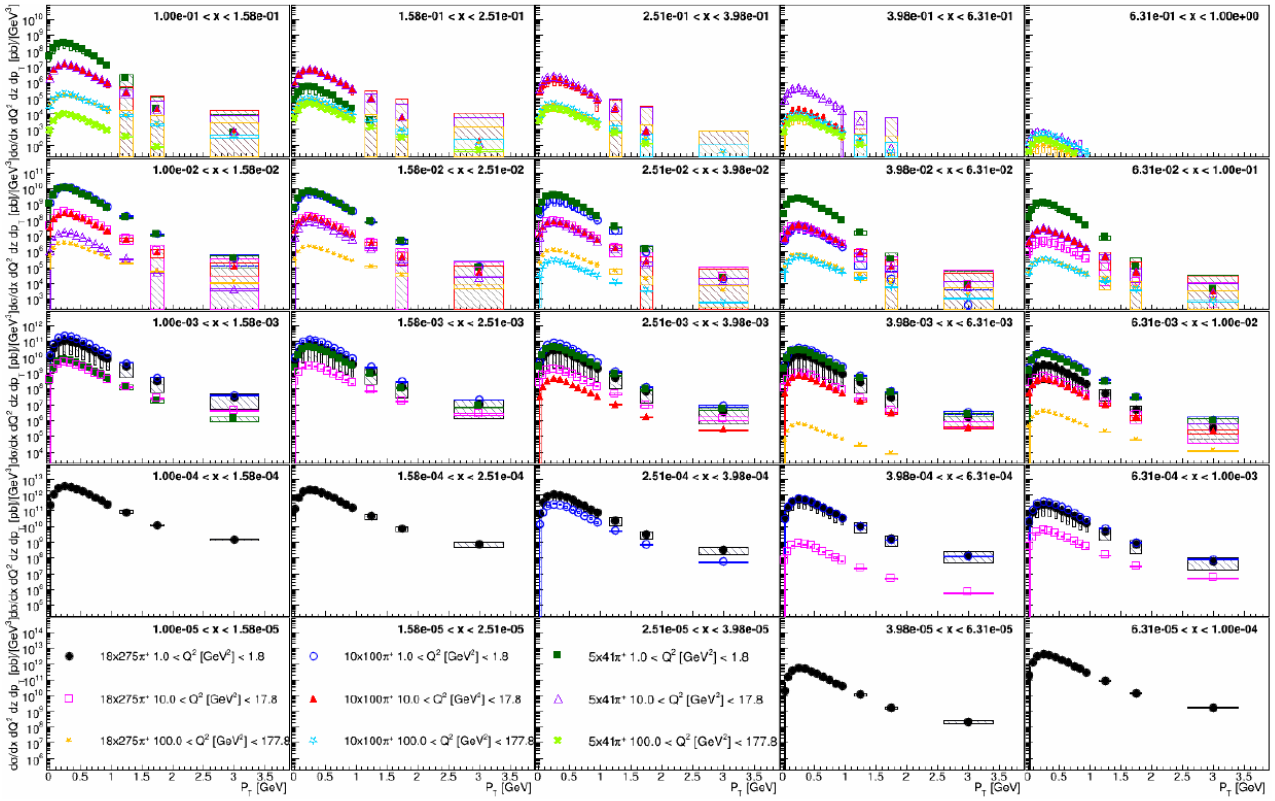
Cross sections

- Example of P_T dependent cross sections for pions, separated into high/low z for several x and Q2 bins



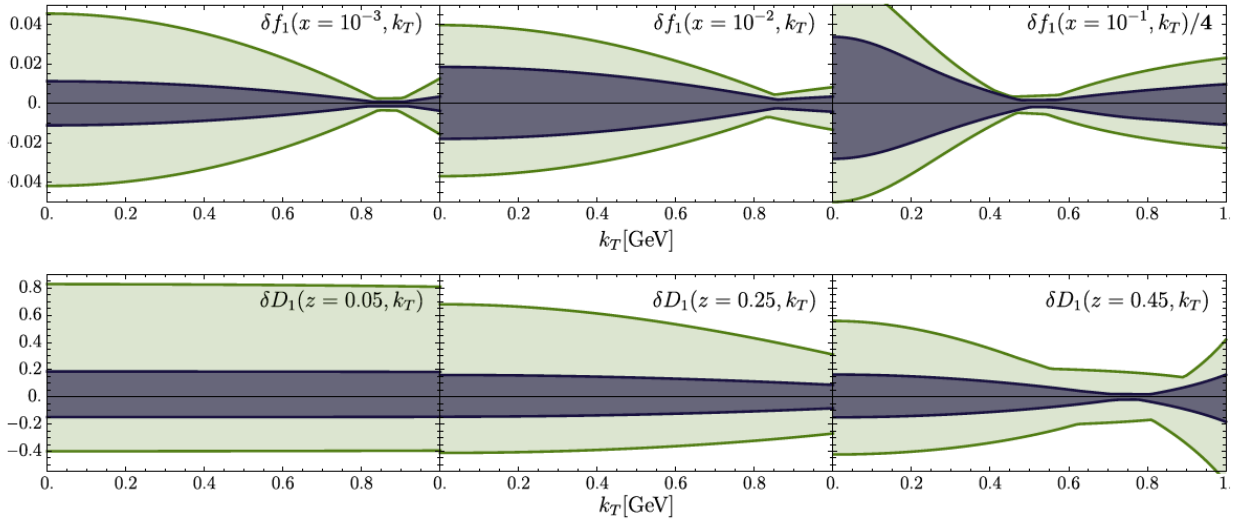
Combination of several collision energies

- Z-integrated PT dependent cross sections for several x and Q2 bins and various collision energies



Impact for unpolarized TMD functions

- Similar to YR impact studies following the latest SV global fit (https://arxiv.org/abs/1912.0653 2) for the unpolarized TMDs based on the existing SIDIS +DY data
- Impact figure still that from YR, needs to be replaced (but little differences expected)



Summary

- Unpolarized TMD SIDIS paper essentially ready
- Some reduction in introduction (removal of motivational figure 1 from note)

- Follow up on these studies as ECCE detector evolves and consider studying the proper unfolding of kinematic smearing as well as particle identification
- Consider more explicit TMD evolution studies
- Authorlist provided with paper template still leaves many institution names empty -- theory contributors added by hand