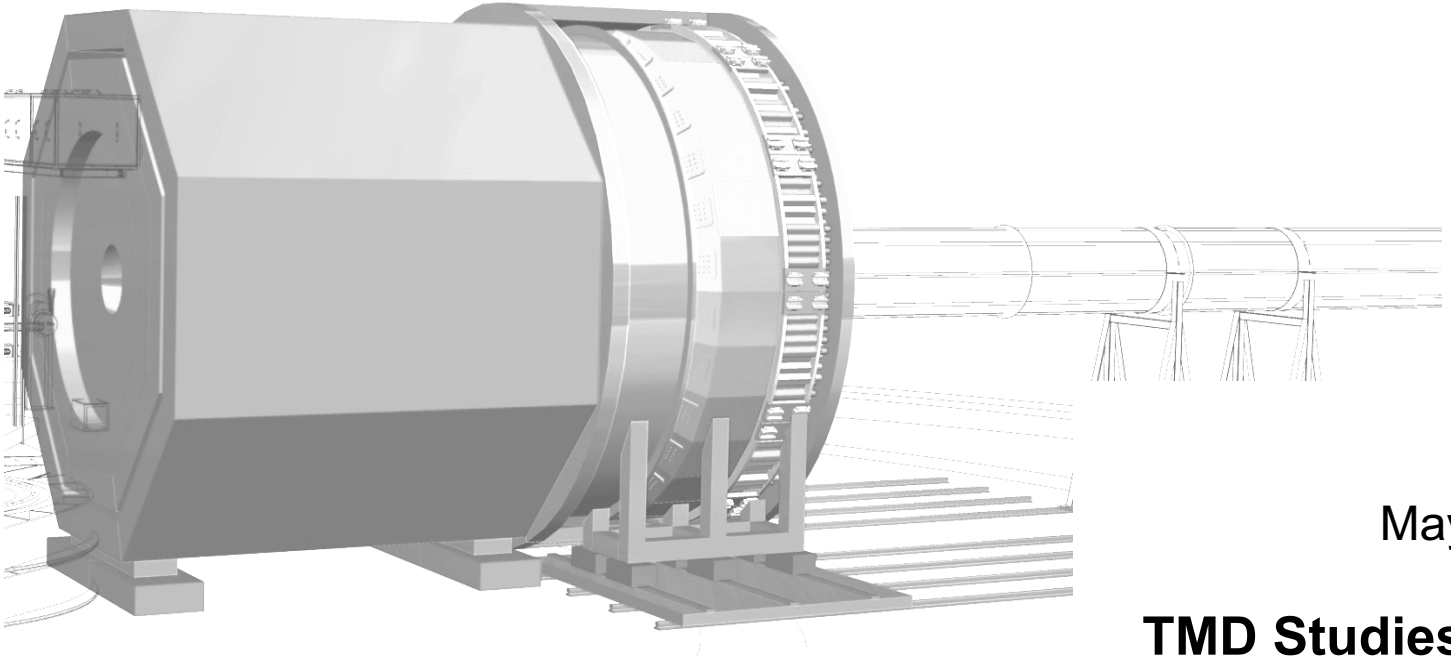
SIDIS with Solenoidal Large Intensity Device (SoLID) – Brief Overview



May 6-7, 2021

TMD Studies: from JLab to EIC

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On behalf of the SoLID Collaboration

SOLENOIDAL LARGE INTENSITY DEVICE

Acknowledgement: X. Li, T. Liu, V. Khachatryan, Z. Zhao, J.P. Chen, Z.-E. Meziani, P. Souder, Jianwei Qiu, X. Zheng, and many others in the SoLID collaboration, supported in part by the U.S. Department of Energy under contract number DE-FG02-03ER41231

SoLID@12-GeV JLab: QCD at the intensity frontier

SoLID will ***maximize*** the science return of the 12-GeV CEBAF upgrade by **combining...**

(DOE science review March 8-10, 2021)

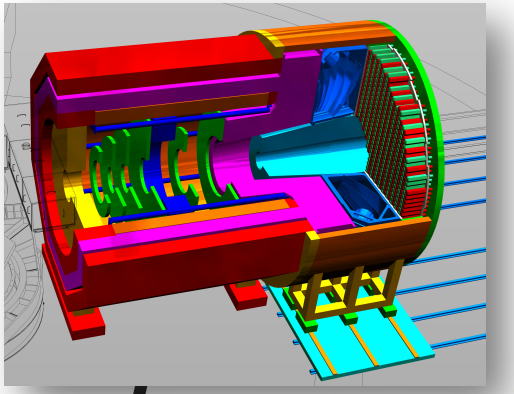
High Luminosity
$10^{37\text{-}39}$ /cm^2/s
[>100x CLAS12][>1000x EIC]

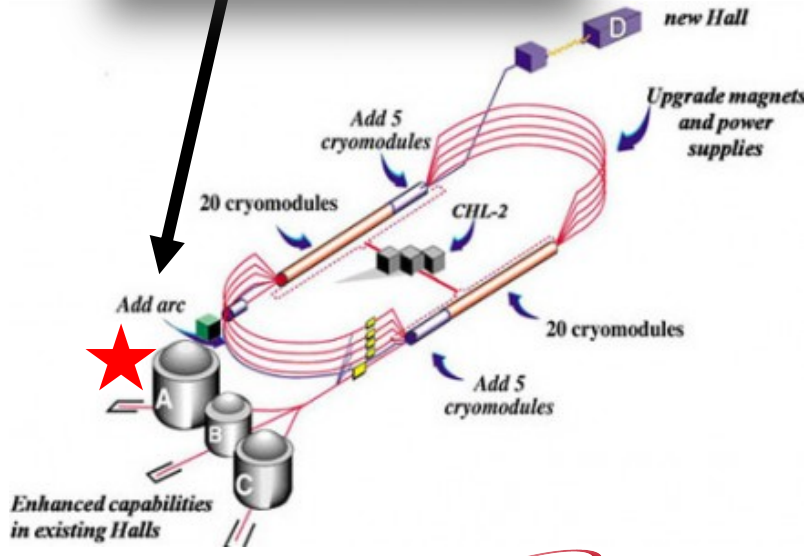
+

Large Acceptance
Full azimuthal ϕ coverage

Research at **SoLID** will have the ***unique*** capability to **explore** the QCD landscape while **complementing** the research of other key facilities

- Pushing the phase space in the search of new physics and of hadronic physics
- 3D momentum imaging of a relativistic strongly interacting confined system (**nucleon spin**)
- Superior sensitivity to the differential electro- and photo-production cross section of J/ψ near threshold (**proton mass**)

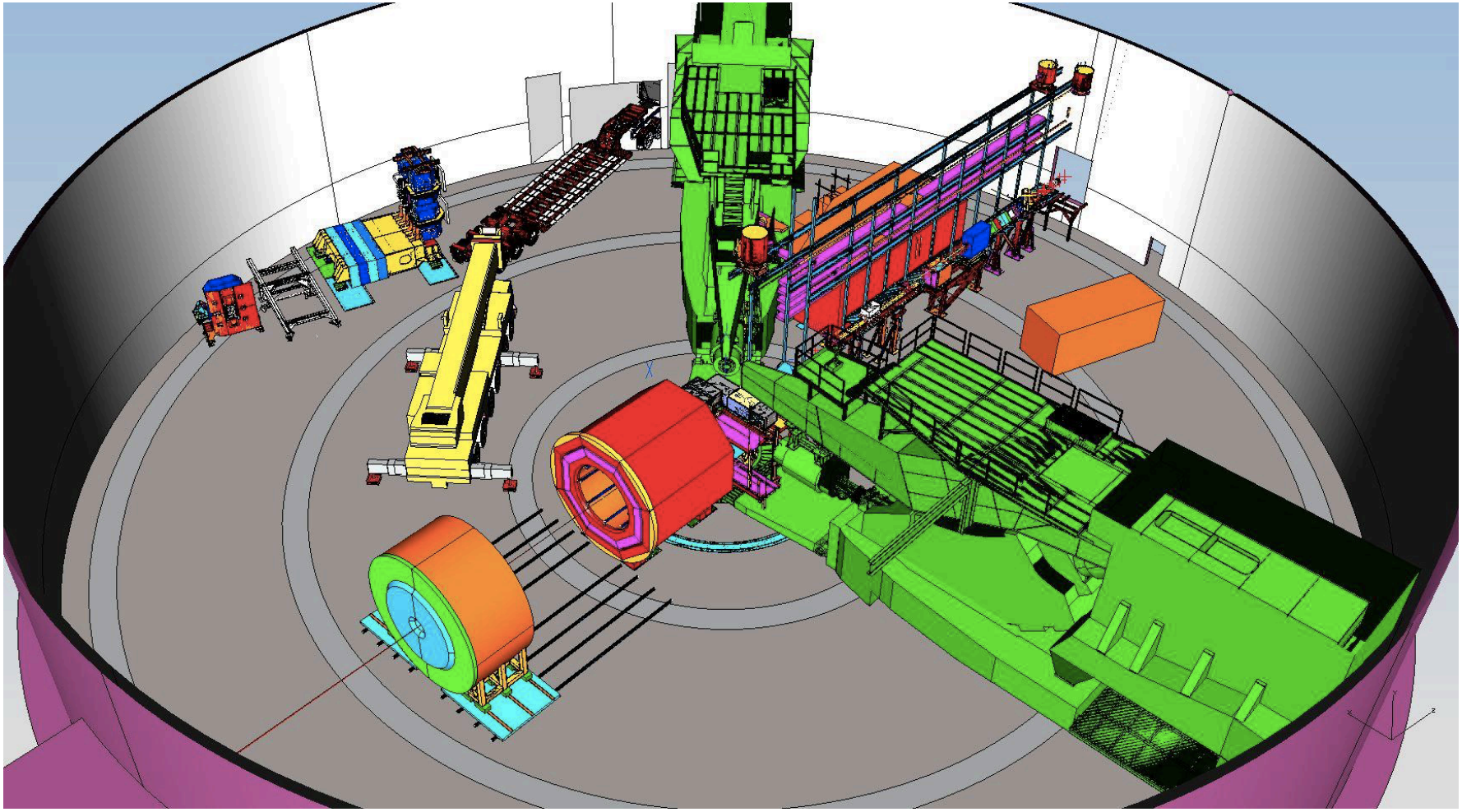




Synergizing with the pillars of EIC science (**proton spin** and **mass**) through high-luminosity valence quark tomography and precision J/ψ production near threshold

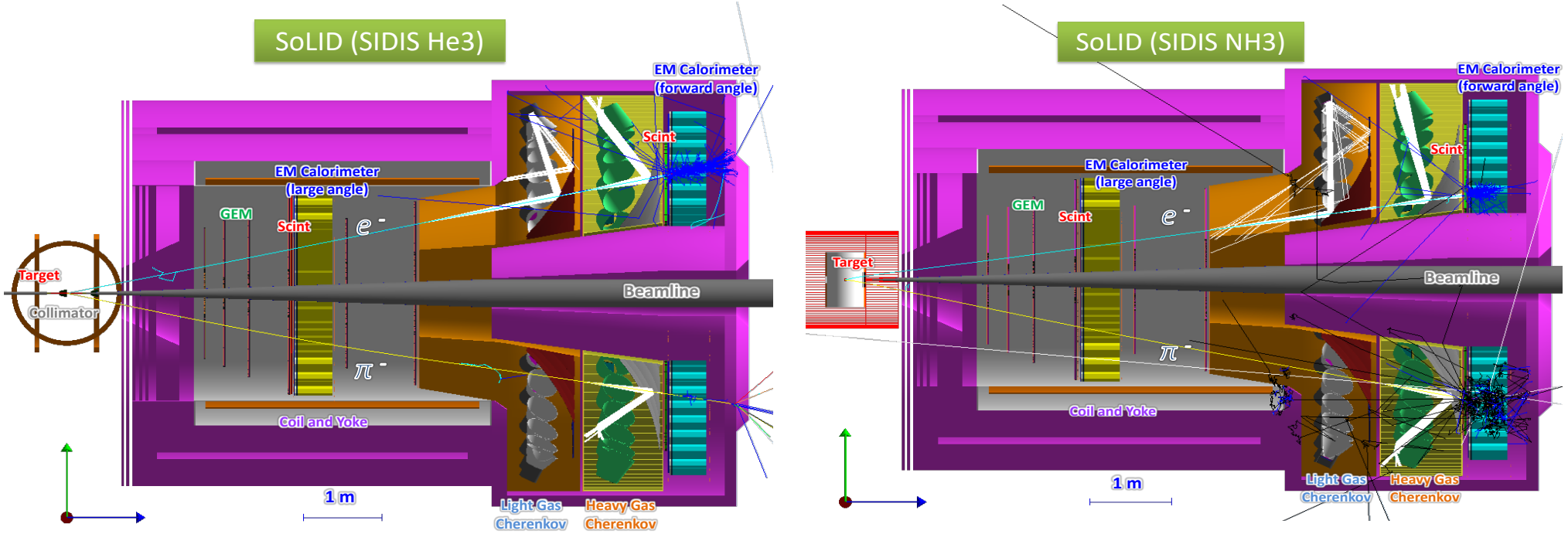
https://solid.jlab.org/

SoLID in Hall A



Plan for installing SoLID in Hall A with other equipment moved out of the way.

SIDIS with polarized "neutron" and proton @ SoLID



E12-10-006: Single Spin Asymmetries on Transversely Polarized ^{3}He @ 90 days
Rating A Spokespersons: J.P. Chen, H. Gao (contact), J.C. Peng, X. Qian

E12-11-007: Single and Double Spin Asymmetries on Longitudinally Polarized ^{3}He @ 35 days
Rating A Spokespersons: J.P. Chen (contact), J. Huang, W.B. Yan

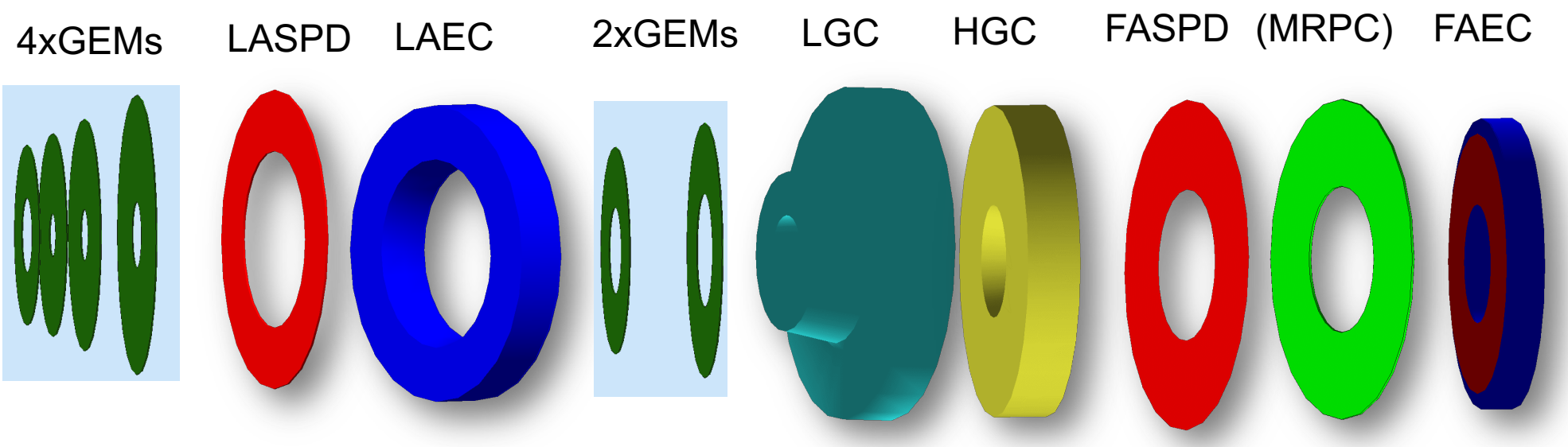
E12-11-108: Single Spin Asymmetries on Transversely Polarized Proton @ 120 days
Rating A Spokespersons: J.P. Chen, H. Gao (contact), X.M. Li, Z.-E. Meziani

Run group experiments approved for TMDs, GPDs, and spin

SoLID-SIDIS and Subsystems

- Coincidence detection of electrons and charged pions:
  good pid for electrons (LGC+EC); moderate PID for pions (HGC)
- ^{3}He target: transverse and longitudinal in-beam polarizations of ~60%;
  NH_3 target: in-beam transverse polarization ~70%
- Large acceptance with full azimuthal coverage @ pol. Lumi. 10^{36} cm^{-2} s^{-1} (^{3}He), 10^{35} cm^{-2} s^{-1} (NH_3); 4-d kinematic binning requires good momentum and angular resolutions – GEMs offer excellent tracking capability
- DAQ rate: up to 100 KHz (unpol. Lumi 10^{37} cm^{-2} s^{-1} (^{3}He))

SIDIS&J/Ψ :



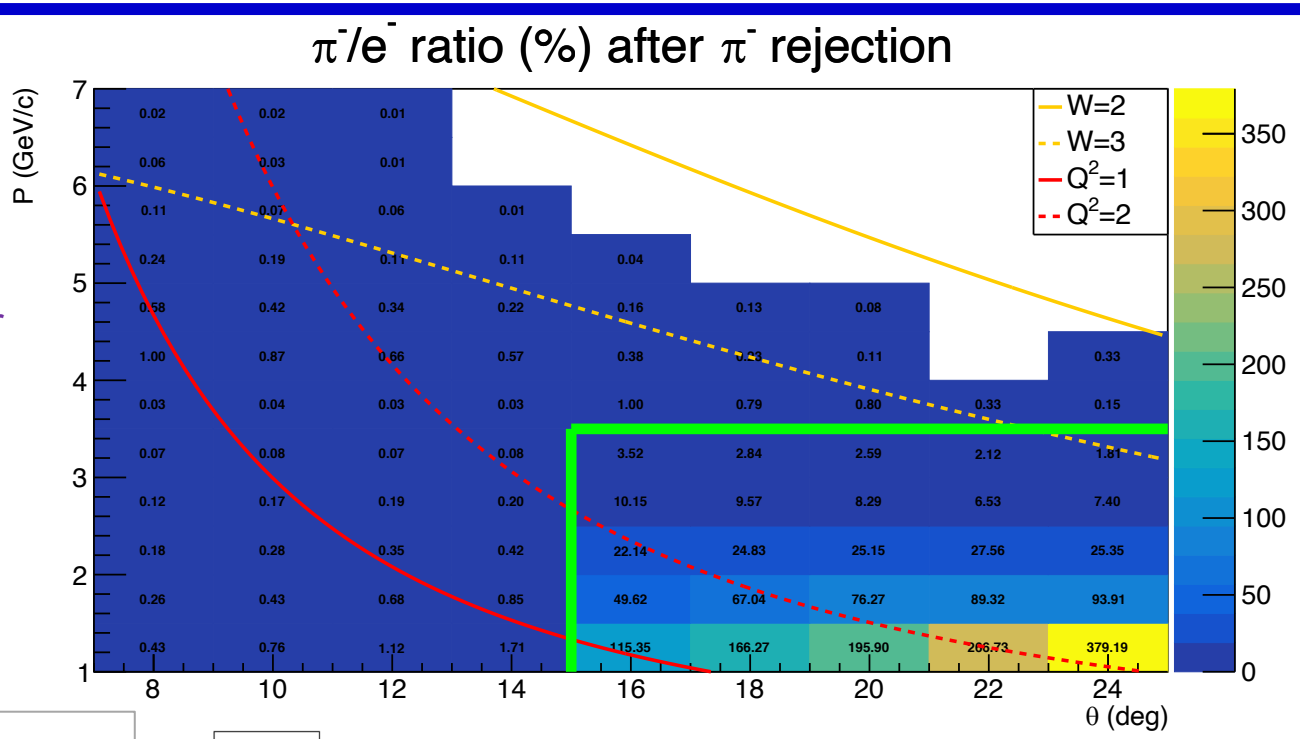
MRPC: enhanced configuration for kaon and improved pion detection

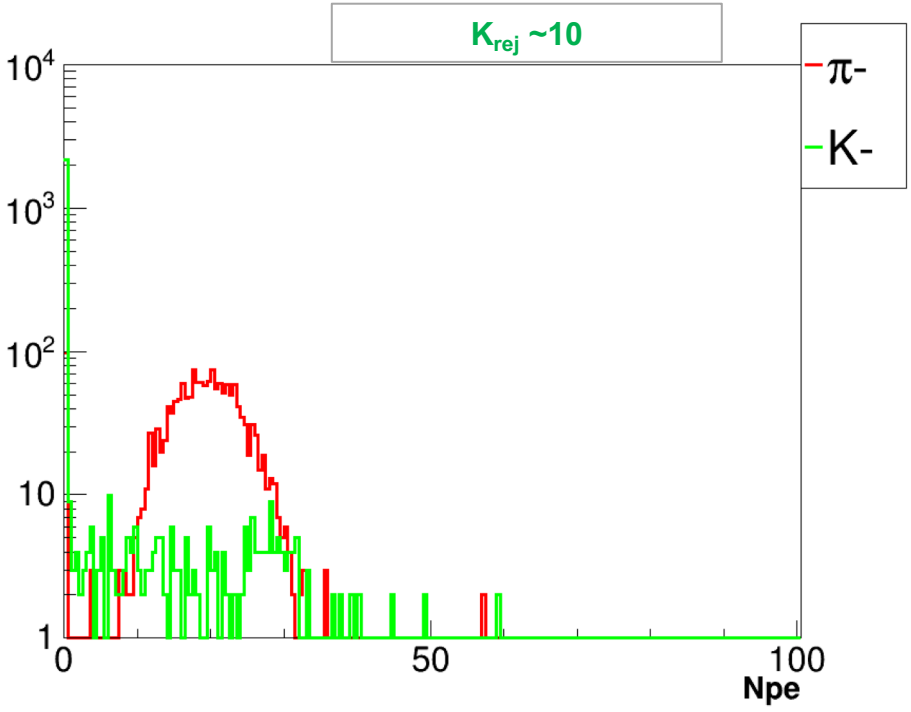
SoLID-SIDIS particle identification

Combined light gas Cherenkov and Calorimeter detector performance

HGC performance at 2.5-3.0GeV, 8-9deg

π efficiency (~0.9)





SoLID-SIDIS program: Large acceptance, Full azimuthal coverage + High luminosity

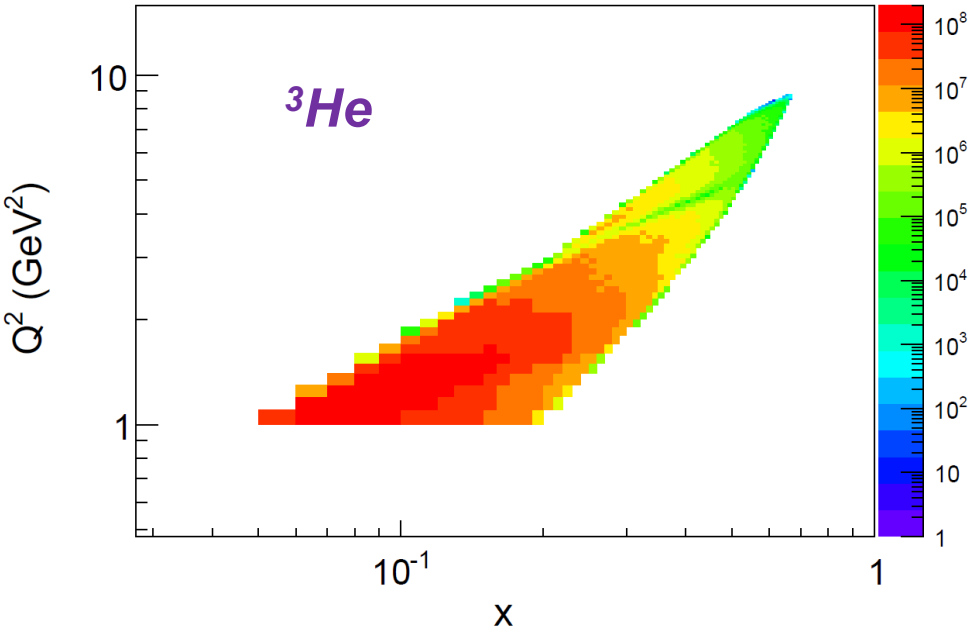
- 4-D mapping of asymmetries with precision

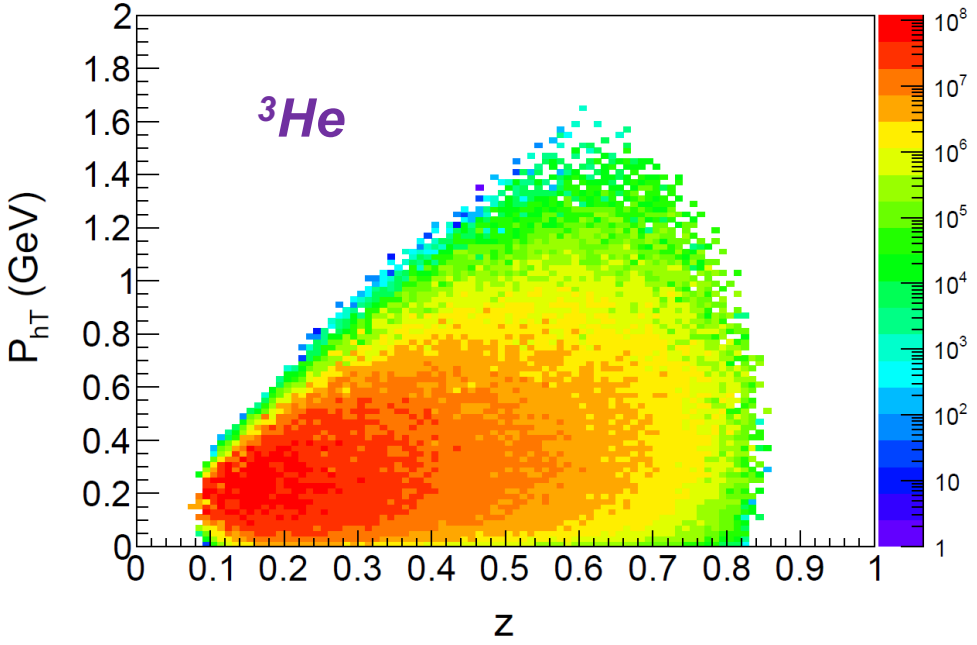
  $\Delta z = 0.05$, $\Delta P_T = 0.2$ GeV, $\Delta Q^2 = 1$ GeV^2, x bin sizes vary with median bin size 0.02 (statistical uncertainty for each bin: $\delta A \leq 0.02$)

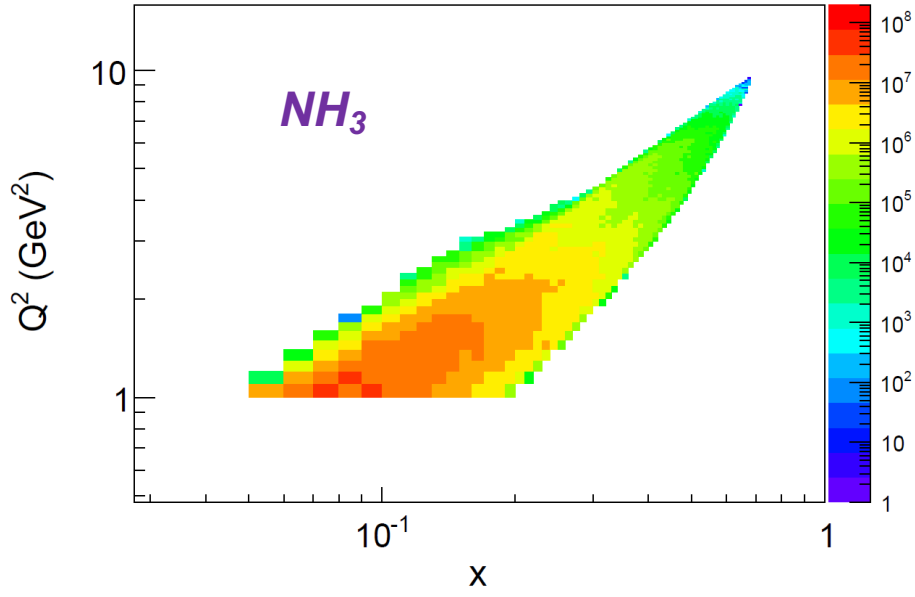
- DIS cuts:

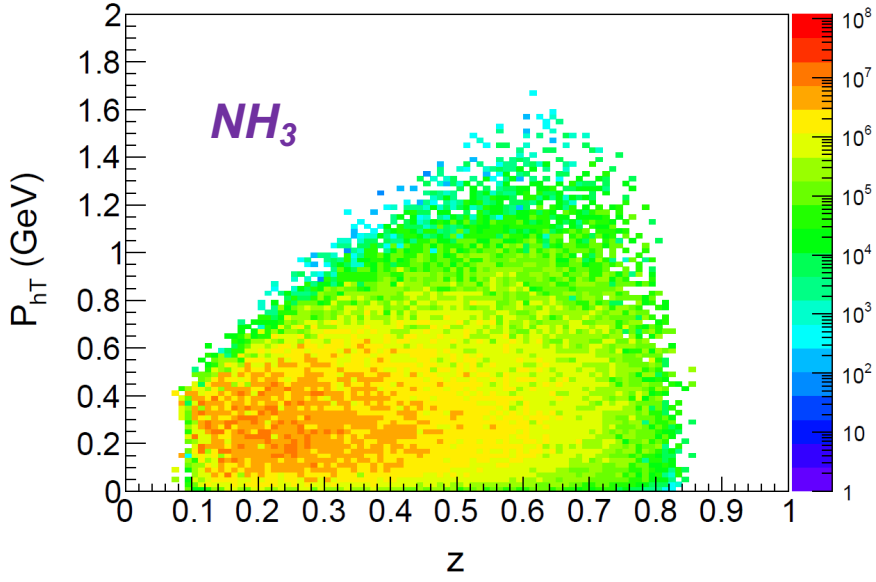
  $Q^2 > 1$ GeV^2, $W > 2.3$ GeV, $W' > 1.6$ GeV, $0.3 < z < 0.7$, $P_e > 3.0$ GeV for $\theta_e > 15$

SoLID-SIDIS Kinematic coverage

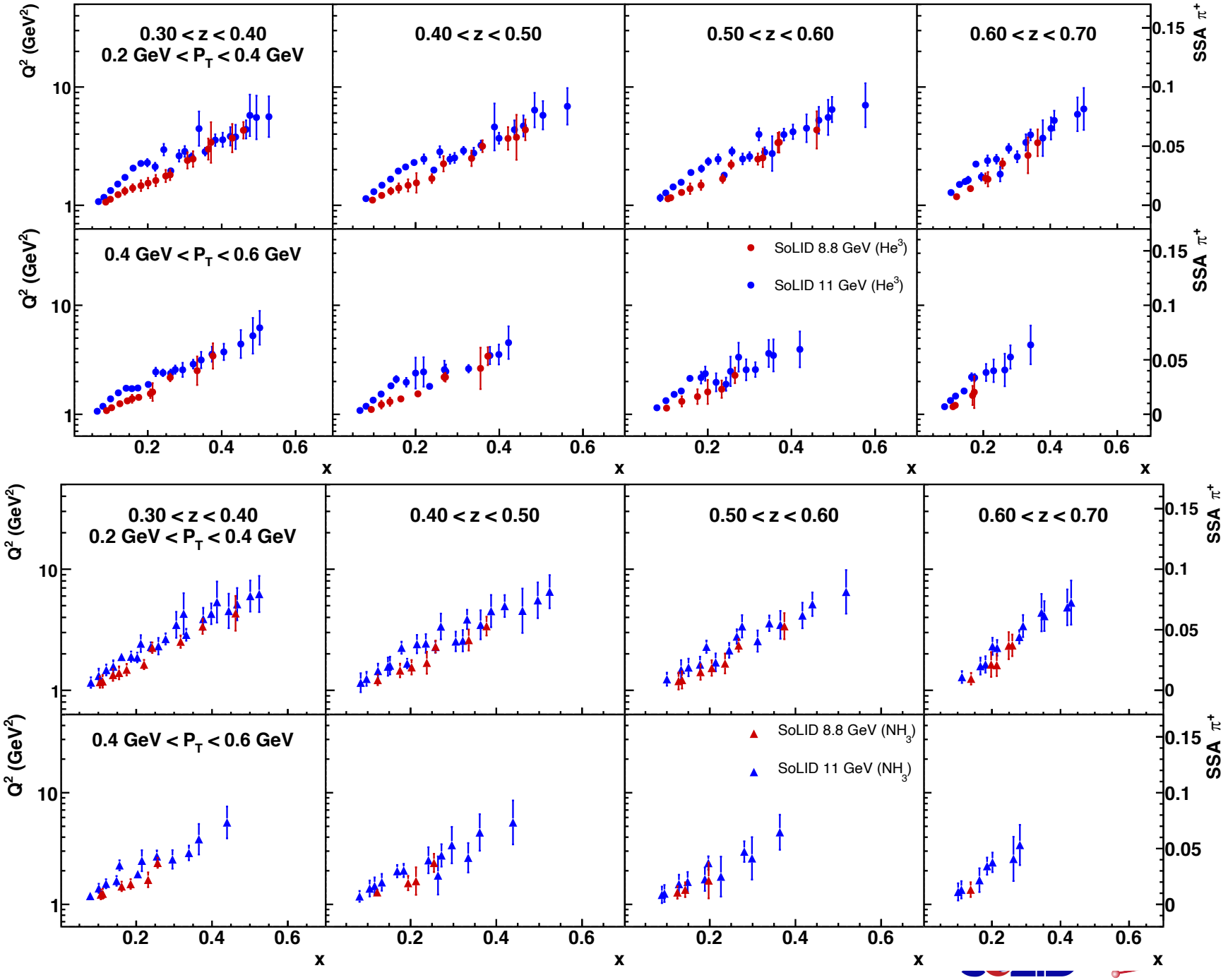








Projected SoLID data samples



Systematic uncertainties for transversely polarized ^3He and NH_3 targets

Source (Type): ^3He (preCDR and E12-10-006)	Collins π^+	Collins π^-	Sivers π^+	Sivers π^-
Raw asymmetry (Abs.) / Detector resolution (Abs.)	1.4×10^{-4} / $< 10^{-4}$	1.4×10^{-4} / $< 10^{-4}$	1.4×10^{-4} / $< 10^{-4}$	1.4×10^{-4} / $< 10^{-4}$
Target polarization (Rel.)	3% + 0.5%	3% + 0.5%	3% + 0.5%	3% + 0.5%
Random coincidence (Rel.)	0.2%	0.2%	0.2%	0.2%
Nuclear effects (Rel.)	4% + 1.2%	4% + 1.2%	5% + 1.2%	5% + 1.2%
Diffractive meson (Rel.)	3%	2%	3%	2%
Radiative corrections (Rel.)	2%	2%	3%	3%
Total (Abs.) / Total (Rel.)	1.4×10^{-4} / 6.3%	1.4×10^{-4} / 5.9%	1.4×10^{-4} / 7.3%	1.4×10^{-4} / 7.0%

Source (Type): NH_3 (preCDR and E12-11-108)	Collins π^+	Collins π^-	Sivers π^+	Sivers π^-
Raw asymmetry (Abs.) / Detector resolution (Abs.)	6.5×10^{-4} / $< 10^{-4}$	6.5×10^{-4} / $< 10^{-4}$	6.5×10^{-4} / $< 10^{-4}$	6.5×10^{-4} / $< 10^{-4}$
Target polarization (Rel.)	3% + 0.5%	3% + 0.5%	3% + 0.5%	3% + 0.5%
Random coincidence (Rel.)	0.2%	0.2%	0.2%	0.2%
Dilution (Rel.)	5%	5%	5%	5%
Diffractive meson (Rel.)	3%	2%	3%	2%
Radiative corrections (Rel.)	2%	2%	3%	3%
Total (Abs.) / Total (Rel.)	6.5×10^{-4} / 6.9%	6.5×10^{-4} / 6.5%	6.5×10^{-4} / 7.2%	6.5×10^{-4} / 6.9%

SoLID impact on tensor charge and confined motion

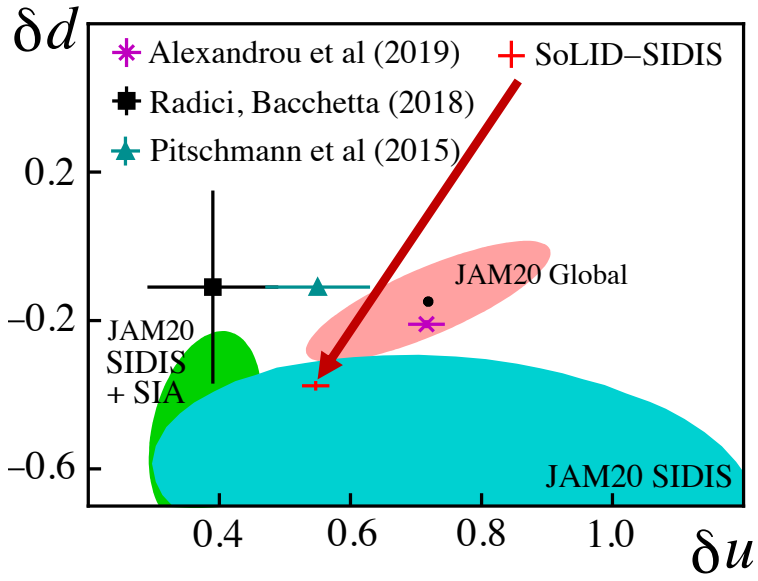
- Tensor charge: a fundamental QCD quantity to test lattice QCD
- Probe new physics combined with EDMs

$$\langle P,S|\bar{\psi}_q i\sigma^{\mu\nu}\psi_q|P,S\rangle = g_T^q\,\bar{u}(P,S)i\sigma^{\mu\nu}u(P,S)$$

$$g_T^q = \int_0^1 [h_1^q(x) - h_1^{\bar{q}}(x)]dx$$

$$d_n = g_T^d\, d_u + g_T^u\, d_d + g_T^s\, d_s$$

SoLID impact on tensor charge



FLAG review 2019: 1902.08191
Relative uncertainty 4% (u), 7% (d)

JAM20: arxiv:2002.08384

- Sivers: an example of TMDs
- Confined quark motion inside nucleon
- Quantum correlations between nucleon spin and quark motion
- QCD dynamics

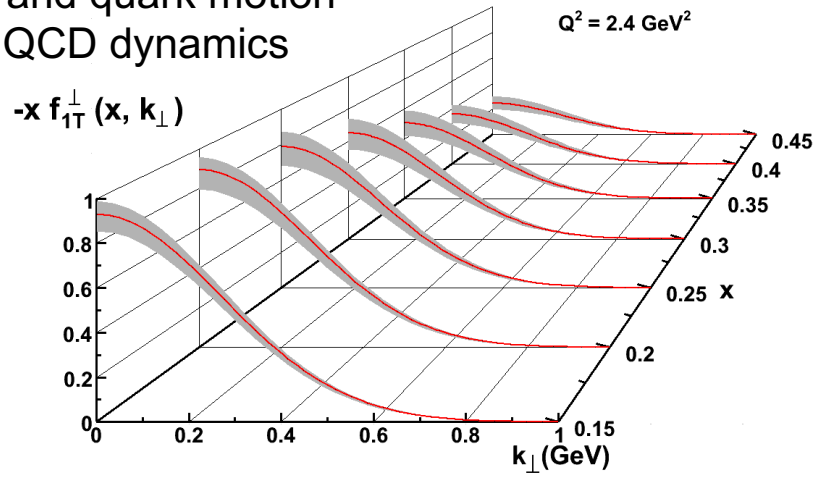


Image from J. Dudek et al., EPJA 48,187 (2012)

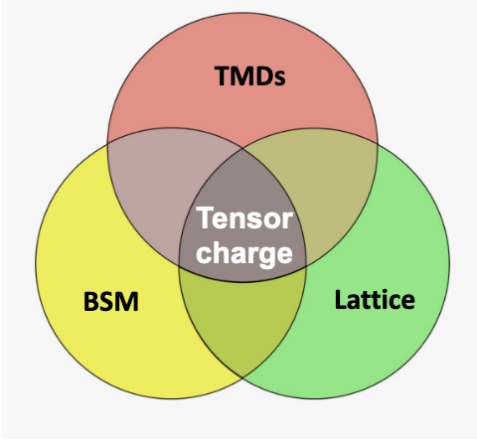


Image credit: D. Pitonyak