

Neutron transverse SSAs with BB+SBS in Hall A (E12-09-018)

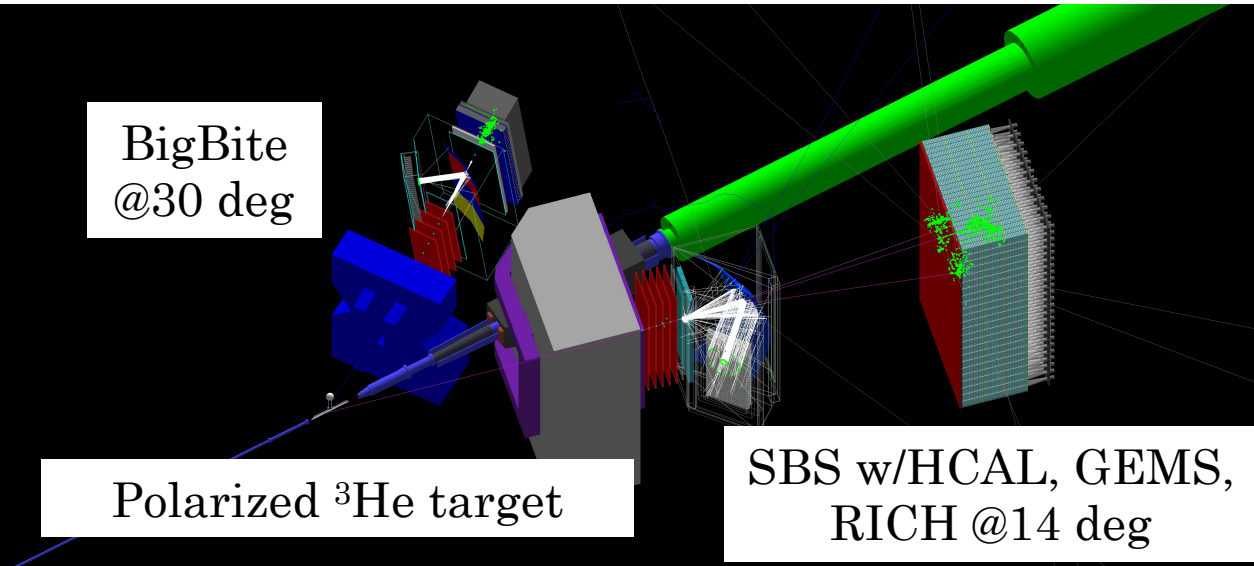
Andrew Puckett

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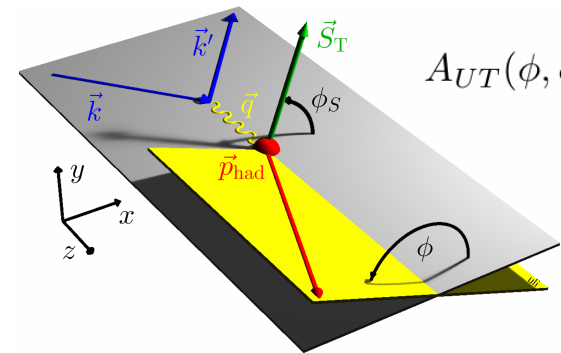
Workshop on TMD Studies: from JLab to EIC

May 7, 2021

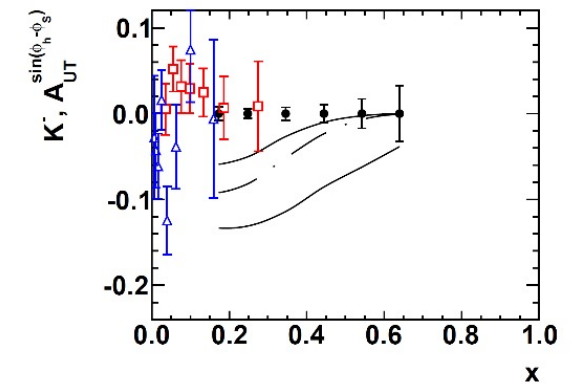
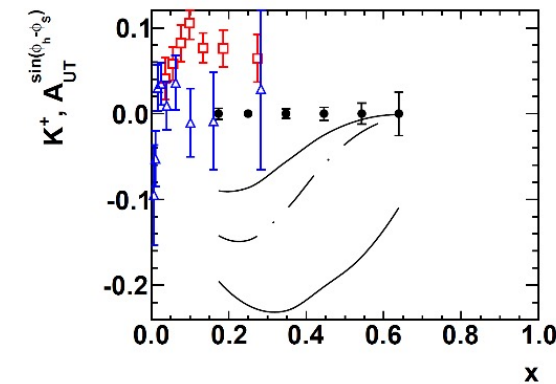
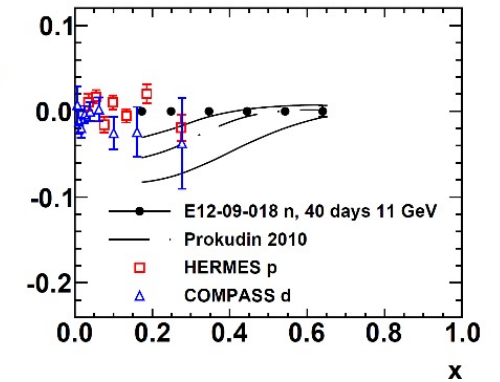
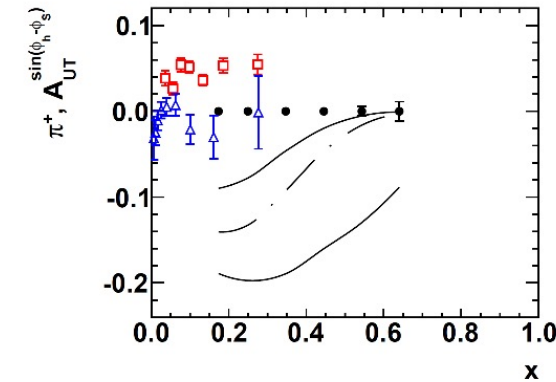
SBS SIDIS program: E12-09-018 (Transversity)



- E12-09-018 in Hall A: 40 (20) days production at $E = 11$ (8.8) GeV—significant Q^2 range at fixed x : approved A- rating PAC38
- Reach high x (up to ~ 0.7) and high statistical FOM ($\sim 1,000\times$ Hall A E06-010 @6 GeV)



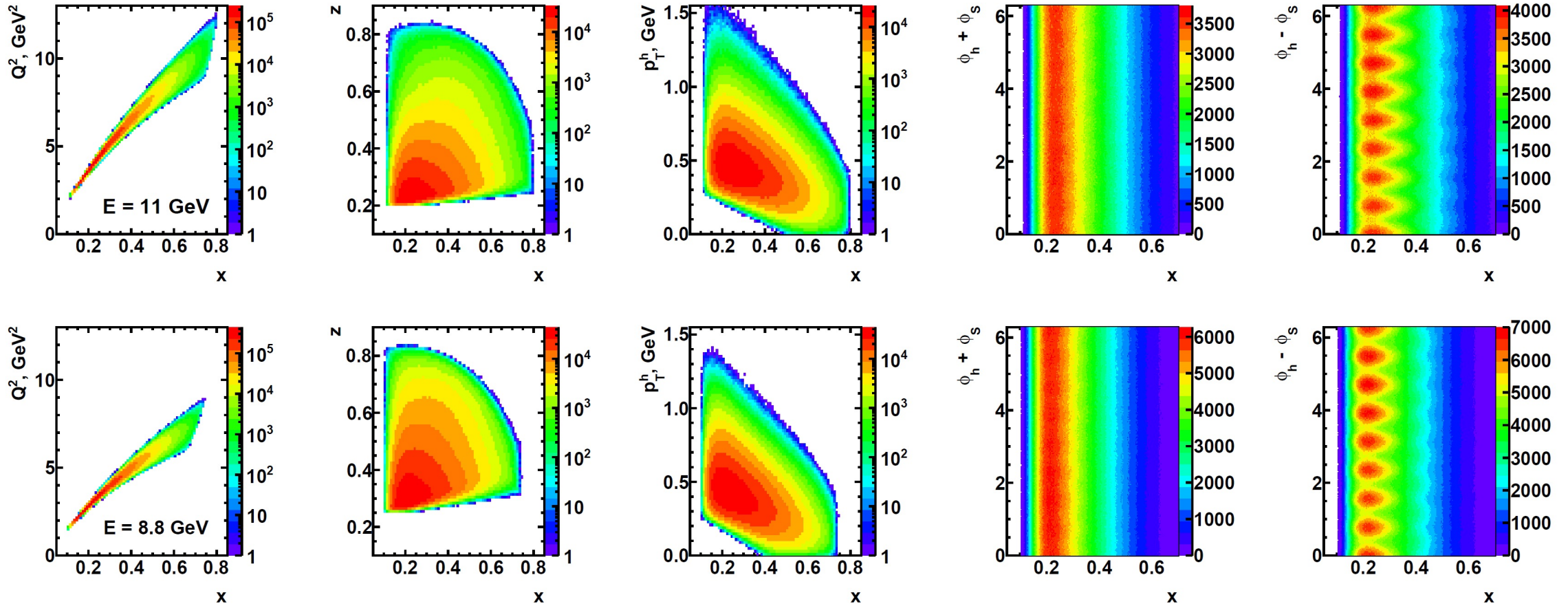
$$\begin{aligned}
 A_{UT}(\phi, \phi_S) &= \frac{1}{P_T} \frac{d\sigma(\phi, \phi_S) - d\sigma(\phi, \phi_S + \pi)}{d\sigma(\phi, \phi_S) + d\sigma(\phi, \phi_S + \pi)} \\
 &= A_{UT}^{Collins} \sin(\phi + \phi_S) + \\
 &\quad A_{UT}^{Sivers} \sin(\phi - \phi_S) + \\
 &\quad A_{UT}^{Pretz} \sin(3\phi - \phi_S)
 \end{aligned}$$



Example of projected E12-09-018 precision: neutron Sivers moments for charged pions and Kaons (11 GeV data only)

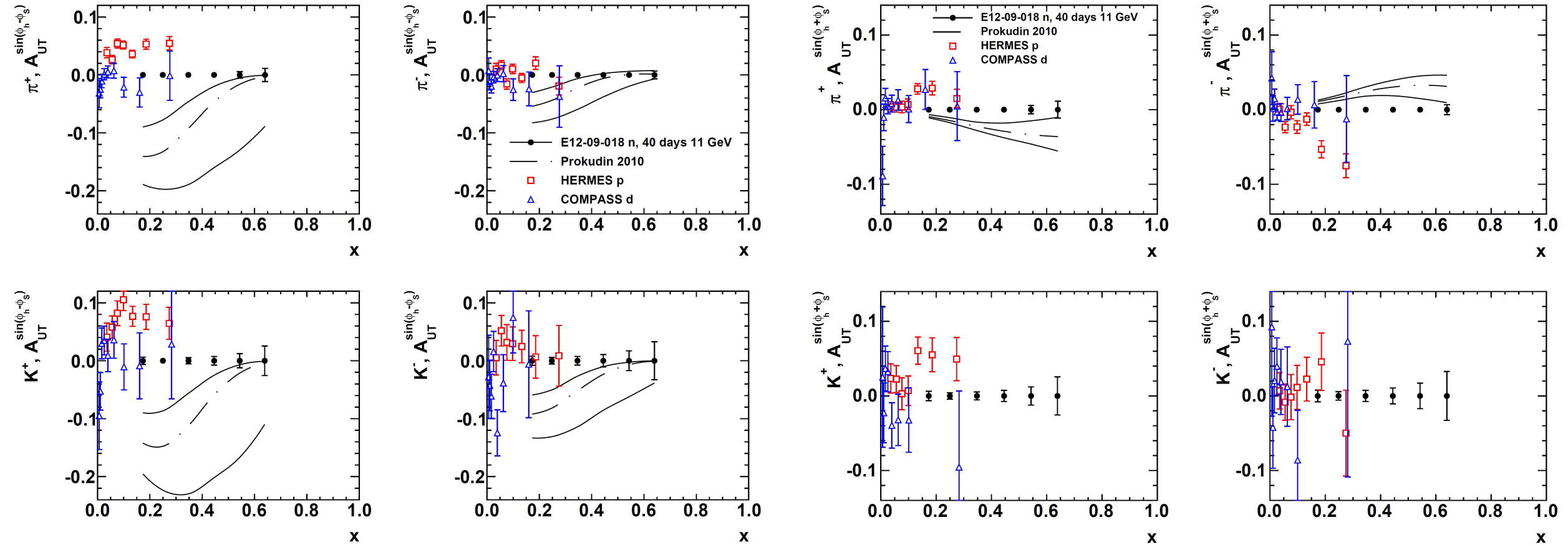
E12-09-018 STATUS: SBS program start fall 2021. E12-09-018 run \sim 2023 (tentative)

SIDIS Kinematic Coverage in E12-09-018: As Proposed



- Cuts applied are: $Q^2 > 1 \text{ GeV}^2$, $W > 2 \text{ GeV}$, $P_h \geq 2 \text{ GeV}$, $M_X \geq 1.5 \text{ GeV}$, $y \leq 0.9$
- E12-09-018 emphasizes precision neutron measurements at high Q^2 and large x : complementary kinematic coverage to aid eventual interpretation of future, higher-precision data at (mostly) lower Q^2 from SOLID

SBS+BB Projected Results (1D): neutron Collins and Sivers SSAs



Projected A_{UT}^{Sivers} vs. x (11 GeV data only)

Projected A_{UT}^{Collins} vs. x (11 GeV data only)

- E12-09-018 will achieve statistical FOM for the neutron $\sim 100X$ better than HERMES proton data and $\sim 1000X$ better than Hall A E06-010 neutron data. *Near-future more precise COMPASS deuteron data will sharpen expected impacts, urgency of E12-09-018*
- SBS installation underway. E12-09-018 could run as early as 2022; 2023 more likely.

3D and “4D” extraction of neutron SIDIS SSAs with SBS

- Right: projected neutron Sivers π^+ results for 3D binning (x,z,p_T) for $E = 11$ GeV, 40 days:

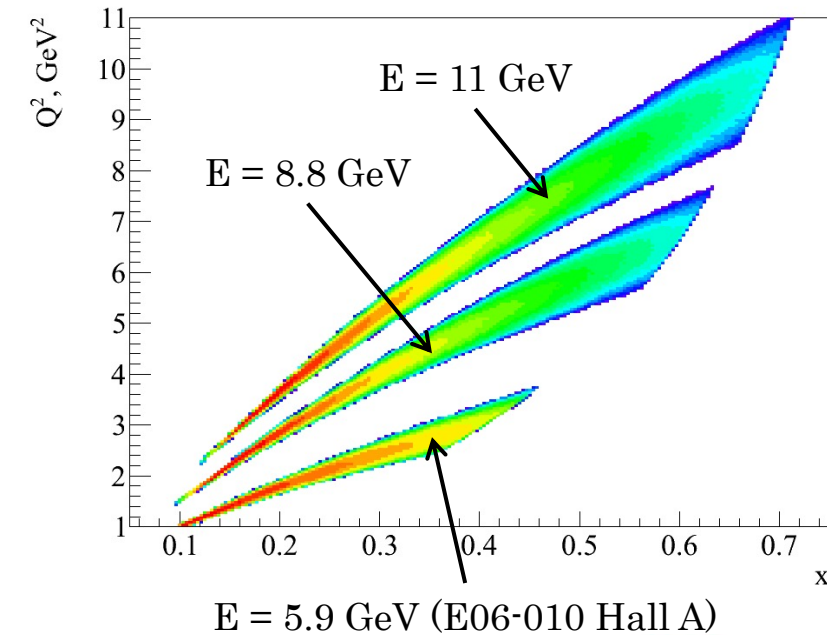
$$A_{UT}^{\sin(\phi_h - \phi_S)} \text{ for } \mathbf{n}(e, e' \pi^+) X :$$

$$0.1 \leq x \leq 0.7, \Delta x = 0.1$$

$$0.2 \leq z \leq 0.7, \Delta z = 0.1$$

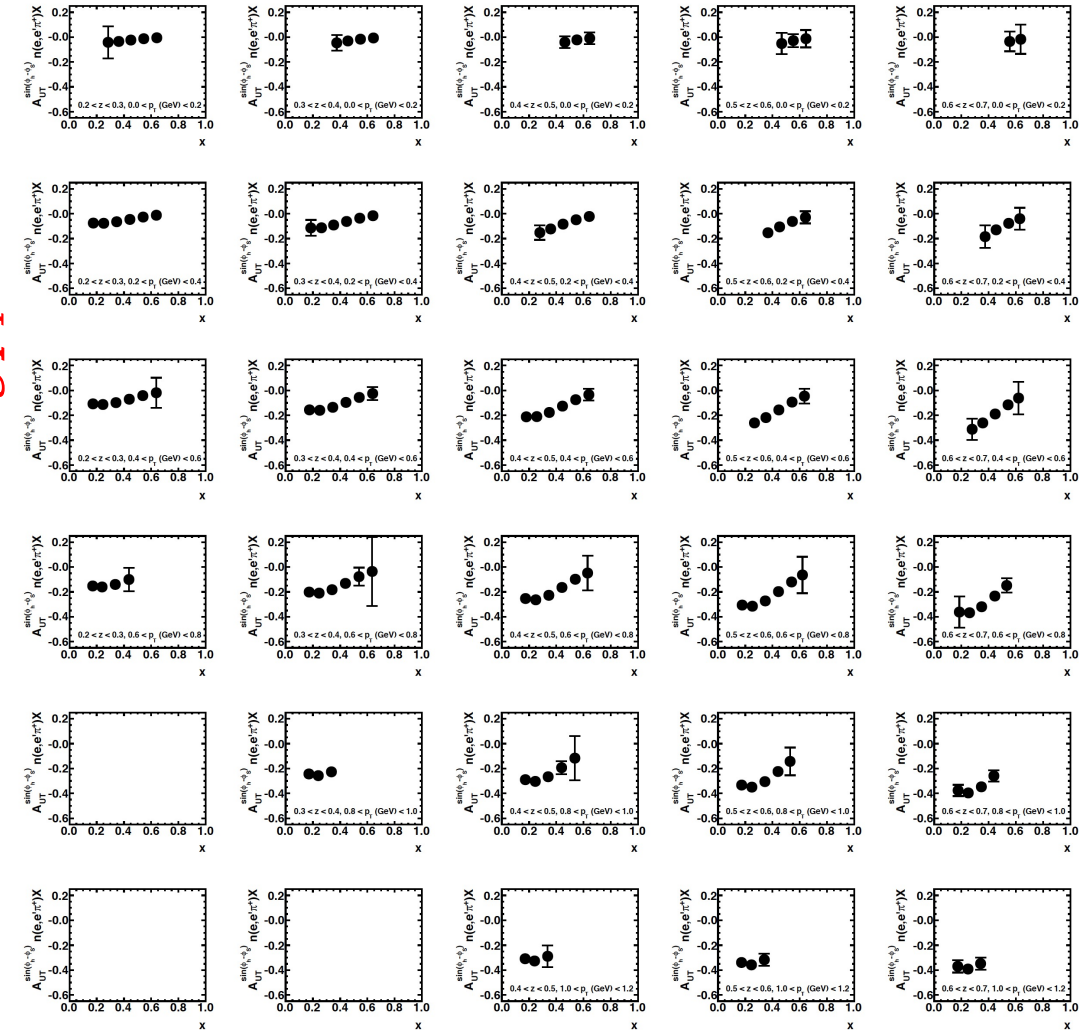
$$0 \leq p_T(\text{GeV}) \leq 1.2, \Delta p_T = 0.2 \text{ GeV}$$

- “4D” with Q^2 dependence from 20 days at 8.8 GeV:



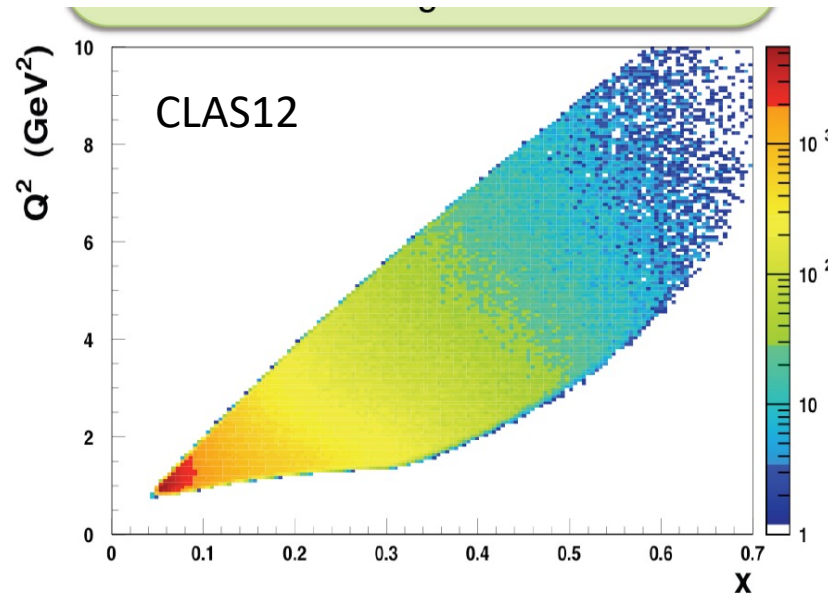
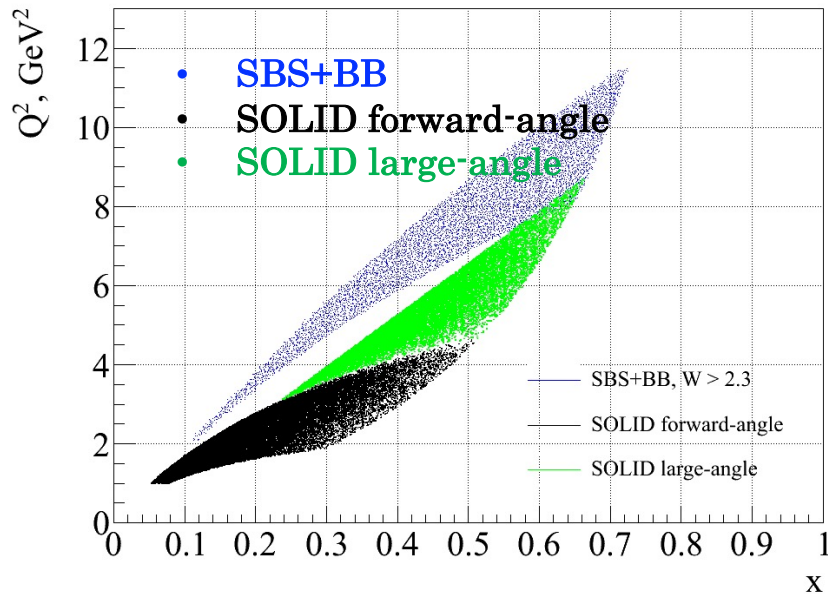
Increasing z →

← Increasing p_T



E12-09-018: Summary

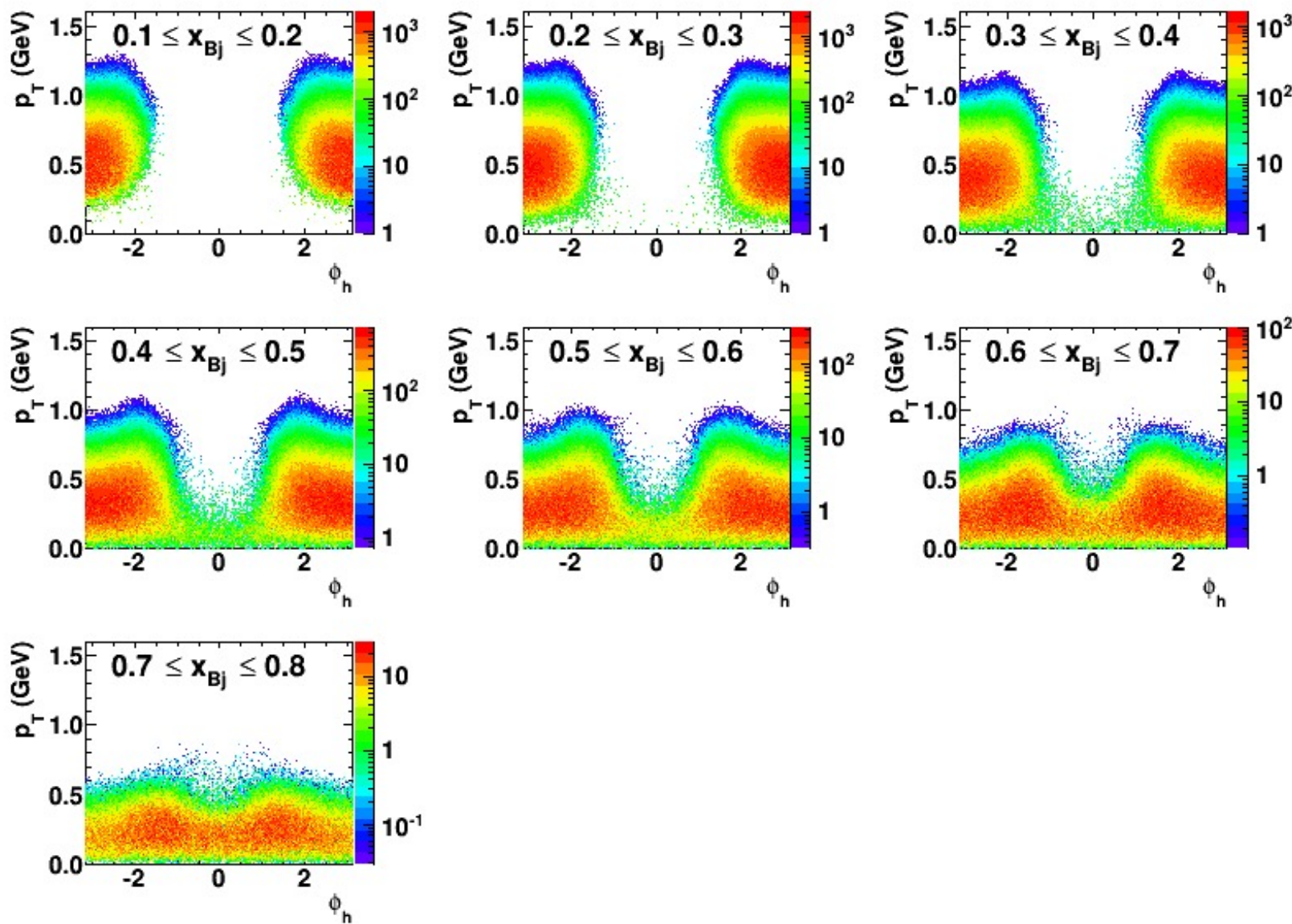
- With the bin sizes from previous slide, E12-09-018 will generate results in ~ 240 4D bins of (x, z, p_T, Q^2) , with $\vec{n}(e, e'\pi^+)X$ Collins/Sivers absolute statistical uncertainty 4% on average (most probable $\sim 1.5\%$). Of these, ~ 200 bins expected with absolute $\Delta A_{UT}^{\sin(\phi_h \pm \phi_S)} \leq 0.05$
- $\pi^+, \pi^-, K^+, K^-, \pi^0$ SSAs will all be measured simultaneously. π^0 statistics will be significantly less than π^+, π^- due to acceptance/resolution of SBS HCAL
- E12-09-018 optimized for high-luminosity, high x , and high $Q^2 \rightarrow$ complementary with SOLID
- Good coverage of entire relevant phase space for JLab 12 GeV in a single layout of the spectrometers
- Much more TMD physics would be possible with this collection of apparatus if beam time were available



For more details:

- Approved PAC38 proposal: <http://hallaweb.jlab.org/collab/PAC/PAC38/SBS-SIDIS.pdf>
- Detailed kinematics and uncertainty projections: <https://userweb.jlab.org/~puckett/PR1209018/KineTables/>

Backups



SBS+BB azimuthal coverage optimized for full coverage at high x , where statistics are most challenging