SoLID-SIDIS Projection and Comparison with SBS+CLAS12

Zhihong Ye

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SIDIS Projection Procedure

- Generate SIDIS events:

✓ Uniformly generate SIDIS events within a pre-defined phase-space which is slightly larger than the SoLID-SIDIS acceptance:

Electron: θ_min = 7 degrees, θ_max = 30 degrees,
Φ_min = 0 degrees, Φ_max = 360 degrees
P_min = 0.0 GeV/c, P_max = E0 (8.8 or 11 GeV)

Hadron: θ_min = 7 degrees, θ_max = 30 degrees,
Φ_min = 0 degrees, Φ_max = 360 degrees
P_min = 0.0 GeV/c, P_max = 6.0 GeV/c

✓ SIDIS cuts are applied to select the valid SIDIS events:

$0.3 < z < 0.7$, $1.0 < Q2 < 10\ GeV^2$, $W >= 2.3\ GeV$, $Wp >= 1.6\ GeV$

Hence two numbers are needed to know:

total generated events and total accepted events.

✓ Cross section values and dilution are calculated for each event.

SIDIS Projection Procedure

- Calculate weight-factor for each event:

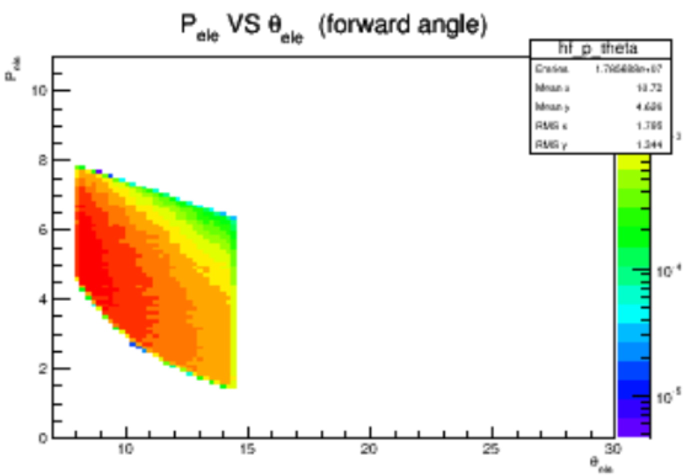
$$weight = XS * PSF / Nsim$$

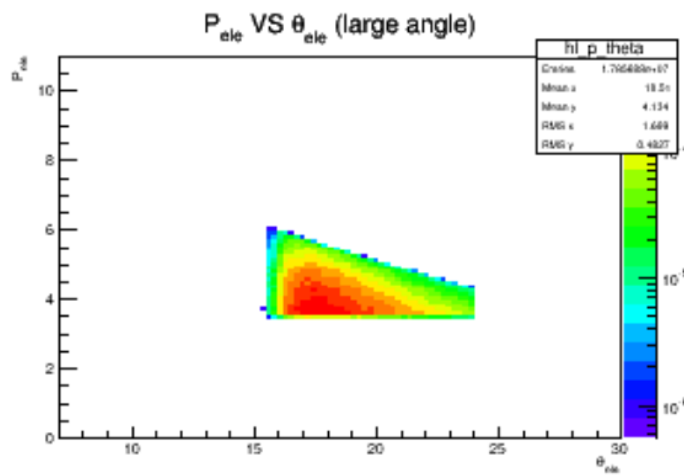
where XS is the cross section value. Nsim is the total simulated events (including accepted and non-accepted). PSF is the phase-space factor, given by the product of electron phase-space and hadron phase-space:

$$PSF = \{[\cos(\theta\_min) - \cos(\theta\_max)]*[\Phi\_max - \Phi\_min]*[P\_max-P\_min]\}^{e}$$
$$*\{[\cos(\theta\_min) - \cos(\theta\_max)]*[\Phi\_max - \Phi\_min]*[P\_max-P\_min]\}^{h}$$

- Apply the SoLID acceptance:

The SoLID-SIDIS acceptance is given as a 2D-histogram (P vs. Theta) for electrons or hadrons, separately.





For each event with given P&θ for electron or hadron, find the average acceptance value in the histogram

SIDIS Projection Procedure

- Apply more weighting factors:

  The final weight-factor that applies on each generated event to get the "projected" events that we can obtain from the experiment is:

  weight_final = weight * Luminosity * Beam_Time * Acceptance
  * $Polarization^2$ * $Eff\_neutron^2$ * $Dilution^2$ * Eff_Det

Where:

- weight = XS * PSF / Nsim. (make sure the unit of XS is "cm2" not "nbar")
- Luminosity = 1e36 cm^{-2} s^{-1}
- Beam_Time = 48 days * 24 * 60 *60 s (for E0 = 11 GeV)
  21 days * 24 * 60 *60 s (for E0 = 8.8 GeV)
- Acceptance = (Accpt_forward_e + Accpt_large_e) * (Accpt_forward_h + Accpt_large_h)
- Polarization = 60% / sqrt(2), where the last factor accounts for diff Asym.
- Eff_neutron = 86.5%, effective neutrons in He3 target
- Dilution ~ 20% but is calculated for each bin.
- Eff_Det = 85% is the overal detector efficiency for electrons and hadrons

SIDIS Projection Procedure

- Binning:

1, Data is binned on (Q2, z) first by defining the ranges of cuts for each bin:

Q2[8] = {1., 2., 3., 4., 5., 6., 8., 10.};

z[9] = {0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7};

Data wihtin each (Q2, z) is saved into a smaller ROOT file for futhre binning.

2, In each (Q2, z), futhre bin the data into (pt, x) bins:

pt[9] = {0., 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6};

→ Two or more bins will be combined untill N_{raw}>=5x10^{6,} where N_{raw} is the event counts in the bin before corrected by polarization and dilution.

x-bins are determined by making #event in each bin N_{raw}>=2x10^{6,} but not more than 8 x-bins in each pt bin;

3, The number of events in each (Q2, z, pt, x) then is given as:

N = Σ (Nraw * Acceptance XS) → vary event-by-event

* Dilution^2 → vary bin-by-bin

* (PSF/Nsim*Luminosity *Beam_Time Polarization^2*Eff_neutron^2 * Eff_Det)

→ fixed constants

- Obtain the Statistical errors in each (Q2, z, pt, x) bin:

With the known #events in each bin, the statistical error is given as:

δ = 1./sqrt(N) * Coeff,

where Coeff → corrections for Azmuthal coverages of Sivers, Collins and Pretzelocity

SoLID-SIDIS compared with SBS & CLAS12

Factor	SoLID E12-10-006 (A) (neutron)	SBS E12-09-018 (A-) (only neutron approved)	SoLID E12-11-108, A (proton)	CLAS12 C12-11-111 (only proton conditional approved)
Targets	He3 (“n”)	He3 (“n”)	NH3(“p”)	HDice (“p”)
Polarization (P)	65% (60% in beam)	65% (<60% in beam)	70%	60%
Dilution-Factor (f)	0.15~0.3	0.15~0.3	0.13	0.33*80%
Polarized Lumonisity (L)	1.0x10^{36} $cm^{-2}s^{-1}$	2.7x10^{36} $cm^{-2}s^{-1}$	1.0x10^{35} $cm^{-2}s^{-1}$	1.4x10^{33} $cm^{-2}s^{-1}$ (quoted: 5.10^{33} $cm^{-2}s^{-1}$
Solid-Angle (Ω_e Ω_h)*	0.067 (e: θ→8°~25°, Φ→0°~360°. h: θ→8°~14.5°, Φ→ 0°~360°)	Quoted: 0.0026 (h-SBS: θ→26.5°~35°, Φ→-24°~24° e-BB: θ→10°~19.5°, Φ→ -30°~30°)	0.067 (e: θ→8°~25°, Φ→0°~360°. h: θ→8°~14.5°, Φ→ 0°~360°)	1.32sr (e: θ→6.5°~40°, Φ→0°~360° * 80%. h: θ→5°~40°, Φ→ 0°~360° * 80%)
*FOM in the same kine. (L*P2*f2*Omega)*	5.43x10^{32}	5.69x10^{31}	5.55x10^{31}	4.64x10^{31} (if same acceptance, 2.35x10^{30})
SIDIS π^+ EventsP^2*f^2*	100M	0.21M	5.06M	3.07M

Based on the 1-D Projection results

SBS Coverage

BigBite:

counter, a two-layer electromagnetic calorimeter and a scintillator hodoscope. The value of the solid angle for 60 cm long target was found to be of 45 msr.

$\Omega_{e\pi}$ = 0.0019 (0.0024sr)

SBS:

For the proposed SIDIS experiment, the magnet will be placed at the distance 245 cm from the target to the return yoke, providing a solid angle of 42(53) msr. The magnet inter-

From their kinematic coverage plot:

$\Theta_e \rightarrow$ 0.465~0.620 rad (26.64°~35.52°)
$\Phi_e \rightarrow$ -0.42~0.42 rad (-24° ~ 24°)

$\Theta_\pi \rightarrow$ 0.175~0.340 rad (10°~19.5°)
$\Phi_\pi \rightarrow$ -0.52~0.52 rad (-30°~30°)

$\Omega_{e\pi}$ = 0.0029sr

Distance from the target to the detector, cm	417
Central angle θ_c , degree	14
horizontal range: $\Delta\theta_h$, degree	± 3.6
vertical range: $\Delta\theta_v$, degree	± 12
angular resolution: σ_{θ_c}, degree	0.02
vertex resolution (along beam), cm	0.2
momentum resolution σ_p/p	0.001×p[GeV]

???

Table 3.1: The parameters of SBS in the SIDIS experiment.

Table 5.1: DIS events selection, kinematical cuts and mai

	Unit	Proposed Exp.	HERMES	HallA 6 GeV
Q^2	GeV^2	> 1	> 1	> 1.31
W	GeV	2.3	> 3	> 2.33
W'	GeV	> 1.5		> 1.5
y		< 0.9	< 0.95 ≥ 0.1	
z		> 0.2 < 0.7	> 0.2 < 0.7	

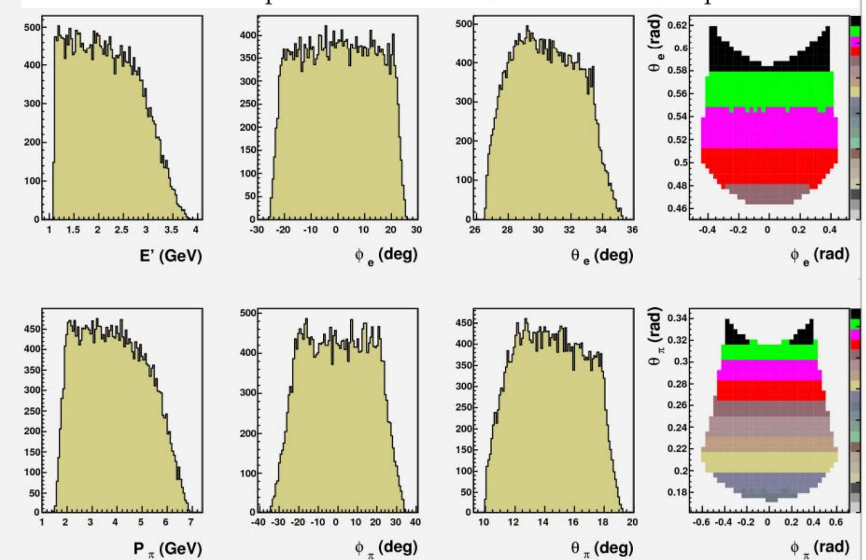
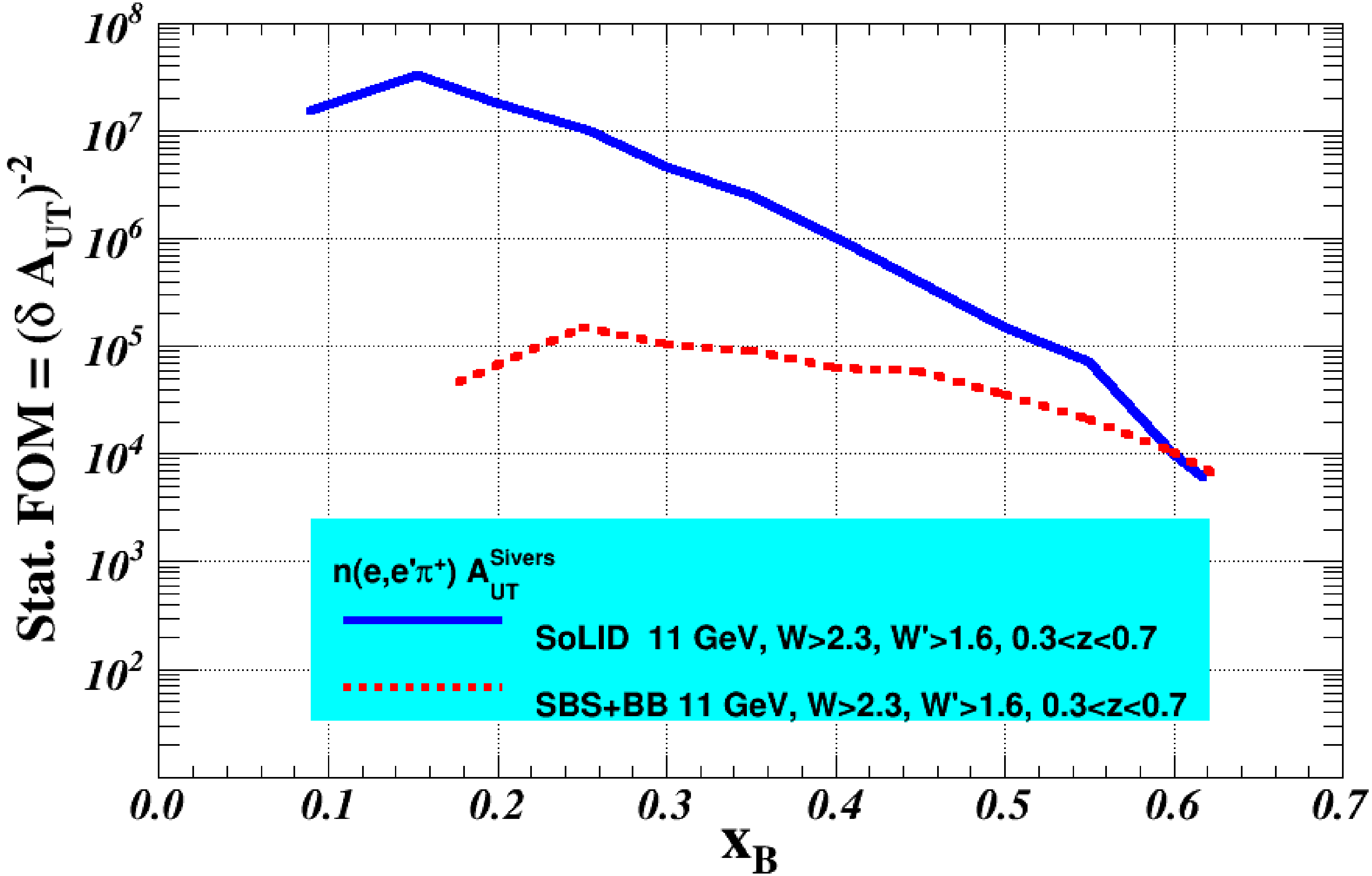
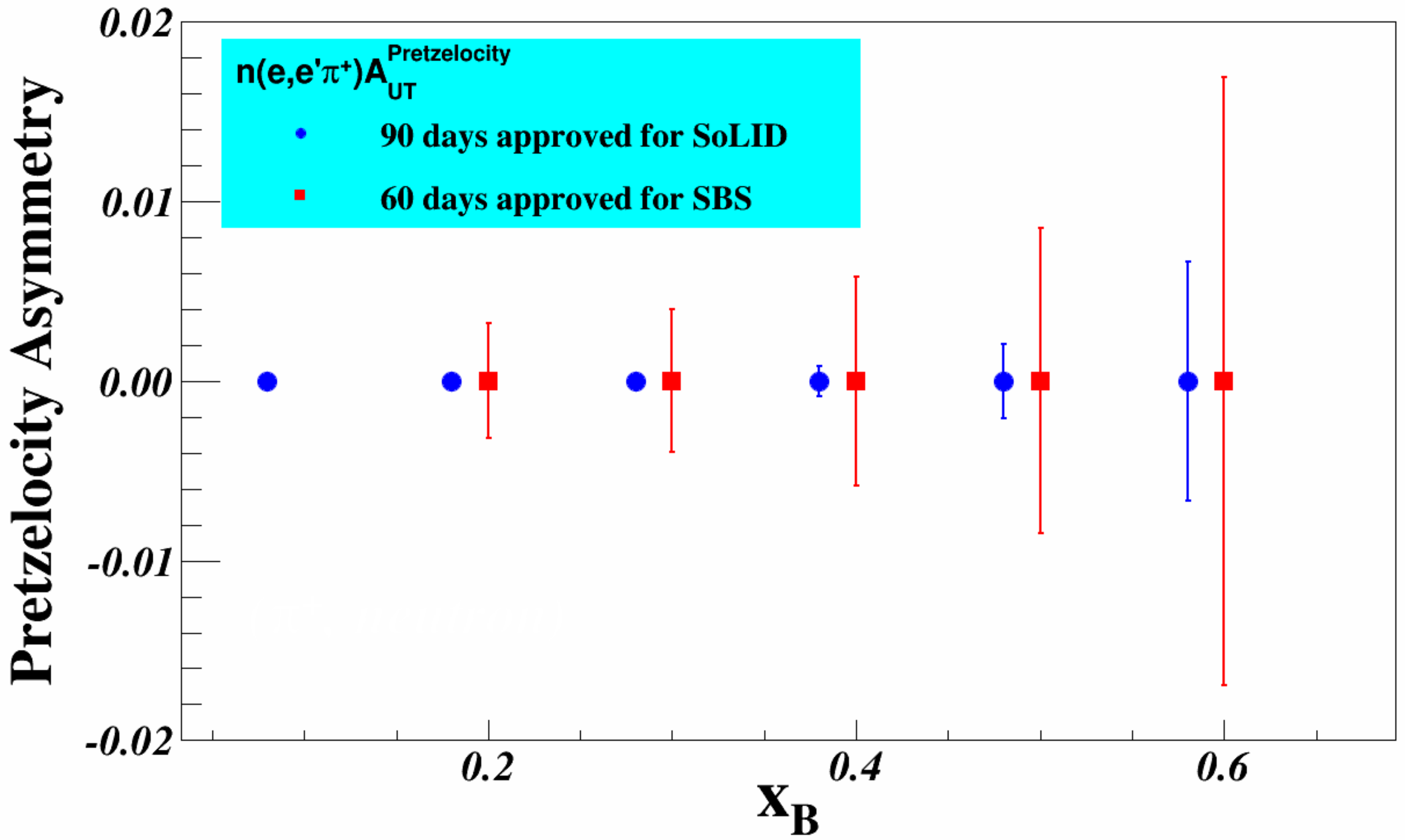


Figure 5.1: 11 GeV kinematics, phase space of the two detected particle momenta and angles, with the SIDIS cuts applied.

SoLID / SBS comparison



SoLID vs. SBS Neutron-SIDIS Comparison



SoLID bins are to match the SBS ones and
thus are not optimized for SoLID kinematics

SoLID vs. SBS Neutron-SIDIS Comparison

SBS:

- 3D binning: $0.1 < x < 0.7$, $0.2 < z < 0.7$, $0 < p_T$ (GeV) < 1.2
- Typically 120 bins, dependence on Q2 gives fully-differential analysis

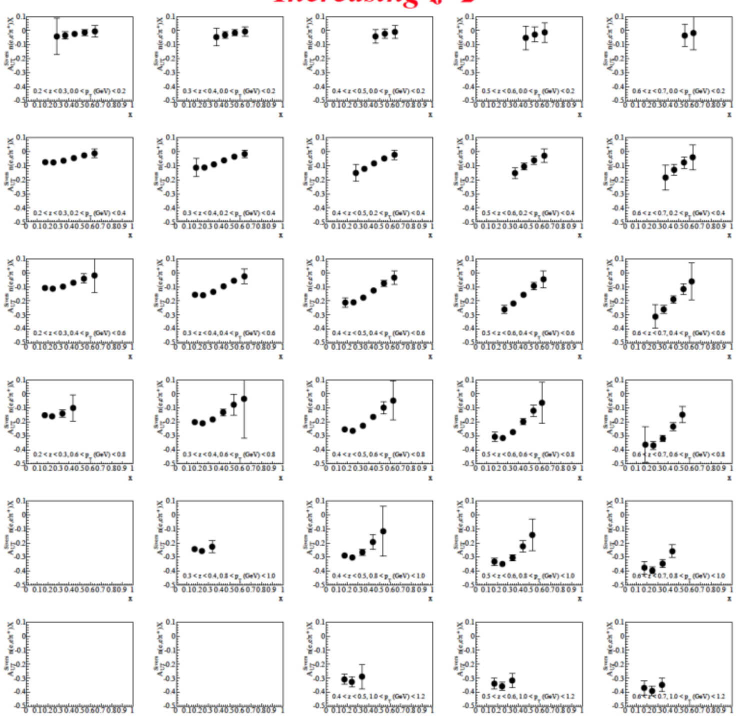
SoLID:

- 4D-MAPPING: $0.05 < x < 0.6$, $0.3 < z < 0.7$, $0 < p_T$ (GeV) < 1.0, $1.0 < Q^2 < 7.0$ GeV^2
- 1400 bins

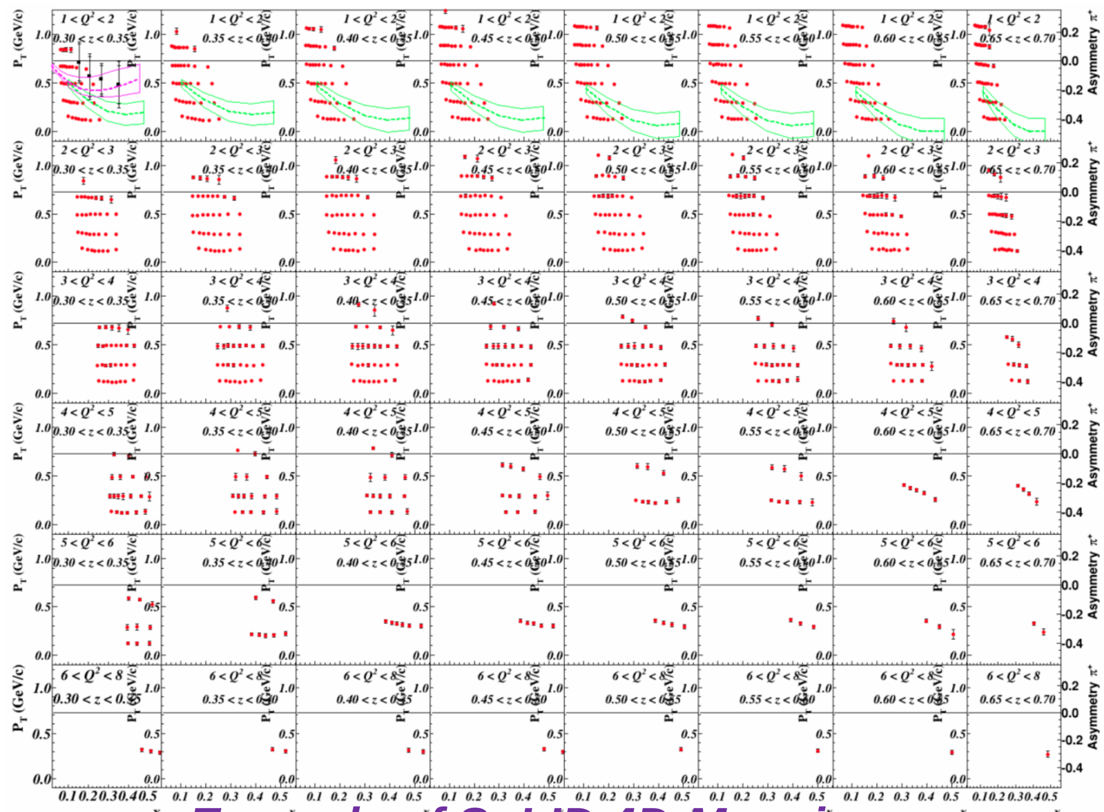
SBS 3D-Mapping

Increasing z →

← *Increasing p_T*



Sivers A_{UT}, $n(e,e'\pi^+)X$ vs. x, 40 days @ 11 GeV



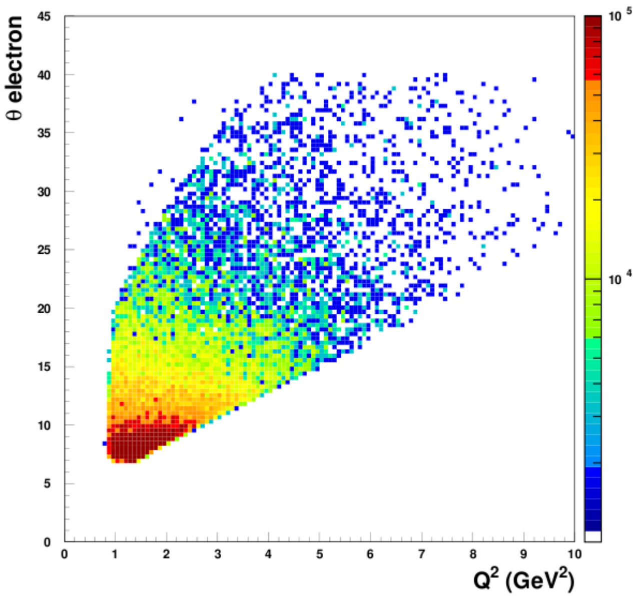
Example of SoLID 4D-Mapping

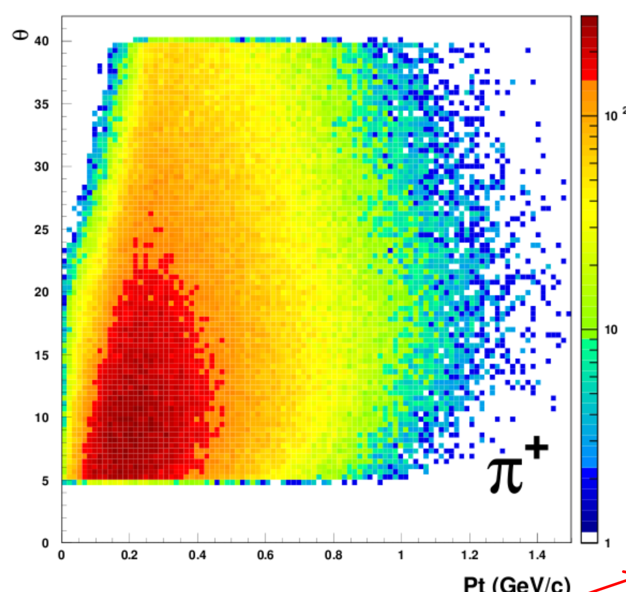
CLAS Coverage

$\Theta_\pi \to 5^o \sim 40^o$
$\Phi_\pi \to 360^o * 80\%$ (20%gaps)

$\Theta_e \to 6.5^o \sim 40^o$
$\Phi_e \to 360^o * 80\%$ (20%gaps)

$\Omega_{e\pi} = 1.32sr$





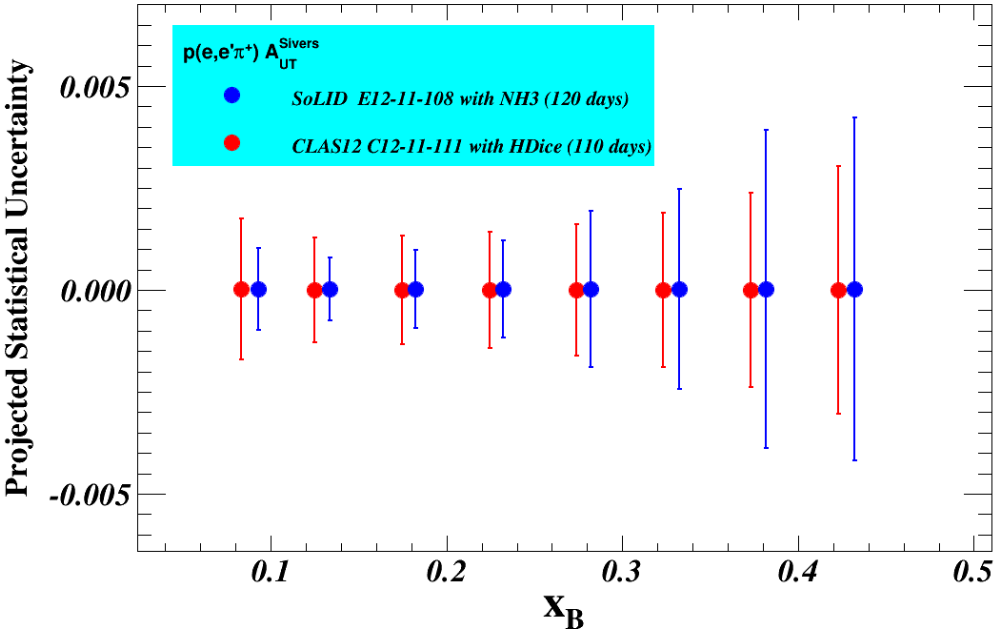
SoLID-SIDIS Cuts:
W>2.3GeV (W2>5.29GeV2)
+ Wp > 1.6GeV

accounting for calibration runs, empty target runs, and supportive tests). The expected number of SIDIS pions and kaons within the kinematic limits: $Q^2 > 1$ GeV^2 (corresponding to $x > 0.05$), $W^2 > 4$ GeV^2, $0.10 < y < 0.85$ and $0.3 < z < 0.7$ are:

17.6 M, 5.8 M and 3.9 M for π^+, π^-, and π^0, respectively, and 1.9 M and 0.4 M for K^+ and K^-, respectively. A squared missing mass greater than 2 GeV^2 was required

From their 1D projection stat. error bars: N(π+)=3.07M, N(π-)=0.87M;
The proposal didn't mention whether they are corrected by Pol&Dilution or not.

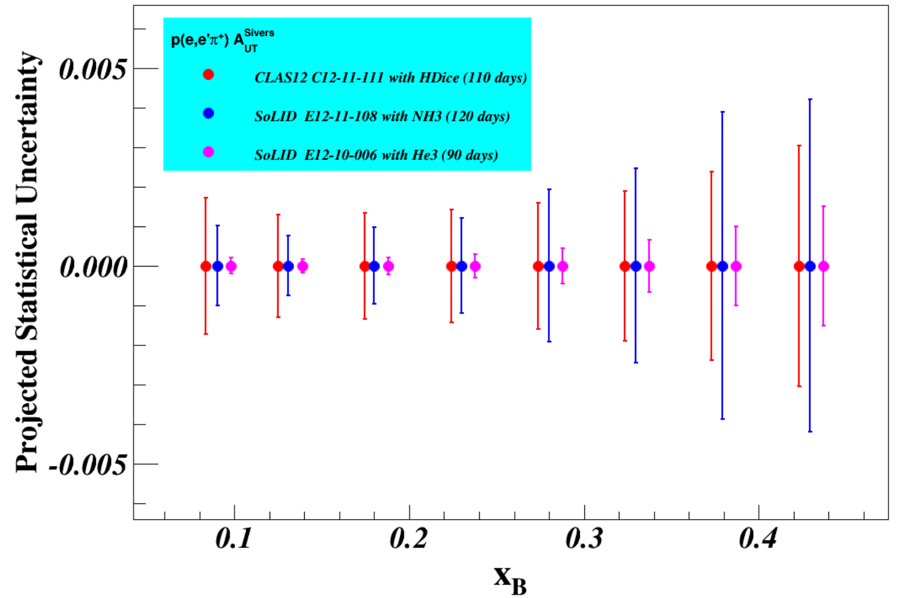
SoLID vs. CLAS12 Proton-SIDIS Comparison



SoLID bins are to match the CLAS12 ones and thus are not optimized for SoLID kinematics.

CLAS12 has two differences:
1, different acceptance;
2, difference DIS-cut, W>2 compared with W>2.3 for us

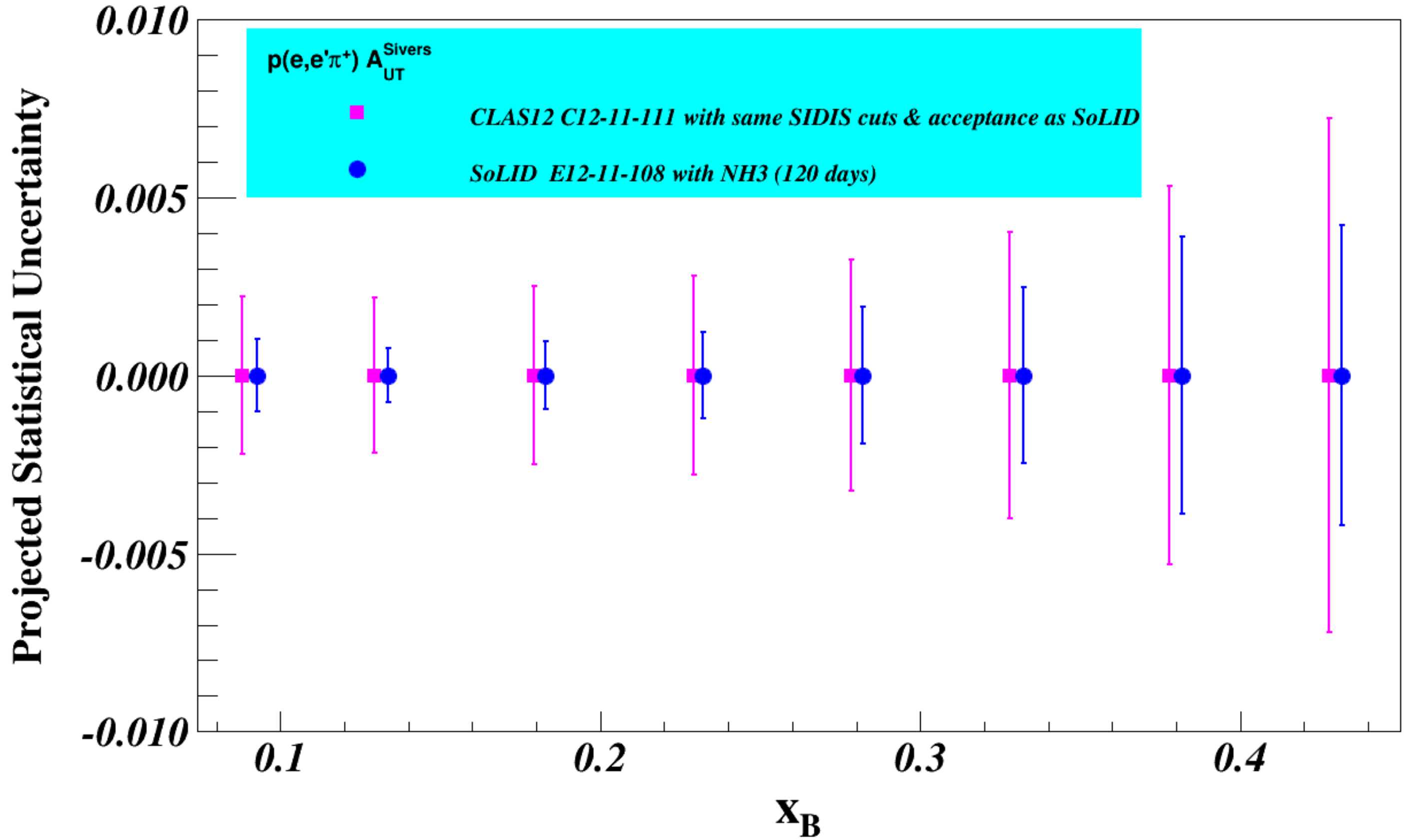
Neutron-SIDIS Projection with the CLAS12 binning
(There is no CLAS12-neutron proposal)



SoLID vs. CLAS12 Proton-SIDIS Comparison

For CLAS12 binning: Run our own "projection" for CLAS12:

(1) Use our generator to generate SIDIS events with CLAS12's full acceptance.
(2) Assuming wihtin the momentum and theta range, the CLAS12 acceptance is uniform.
(3) Do the 1D binning with their bins, cuts and acceptance ranges.
(4) Do the same 1D binning with SoLID's cuts and acceptances.
(5) Look for the scaling factor between (3) and (4) for each bin.
(6) Apply the factor onto their actual projection, bin-by-bin.



SoLID vs. CLAS12 Proton-SIDIS Comparison