Run Group Proposal E12-10-006B/E12-11-007F

Measurement of the Unpolarized SIDIS Cross Section from a ^{3}He Target with SoLID

by

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SoLID Ad-Hoc Review Committee Report

Jian-Ping Chen, Z.-E. Meziani, Chao Peng, Arun Tadepalli, Xiaochao Zheng

➢ Our run group experiment parasitic to SoLID SIDIS experiments of

E12-10-006: Single Spin Asymmetries on Transversely Polarized ^{3}He (neutron): Rating A

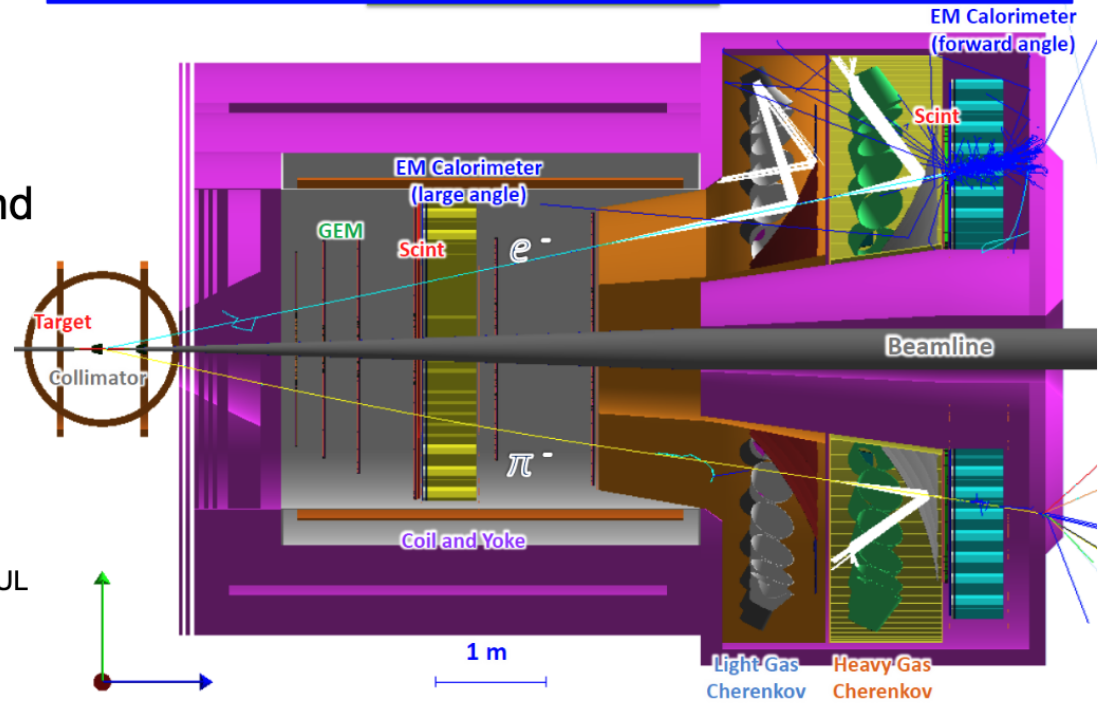
- Approved number of days:
  - *48 days (11 GeV) & 21 day (8.8 GeV)*
- 10 days requested for study of x-z factorization with Hydrogen/Deuterium gas using reference target cell
- 3 days of reference cell runs for optics and detector check
- 5 days of target overhead: spin rotation, polarization measurement
- 3 days requested with longitudinal target polarization to study systematics of potential A_{UL} contamination

SIDIS: $e + p \rightarrow e' + \pi^{\pm} + X$

E12-11-007: Single and Double Spin Asymmetries on Longitudinally Polarized ^{3}He (neutron): Rating A

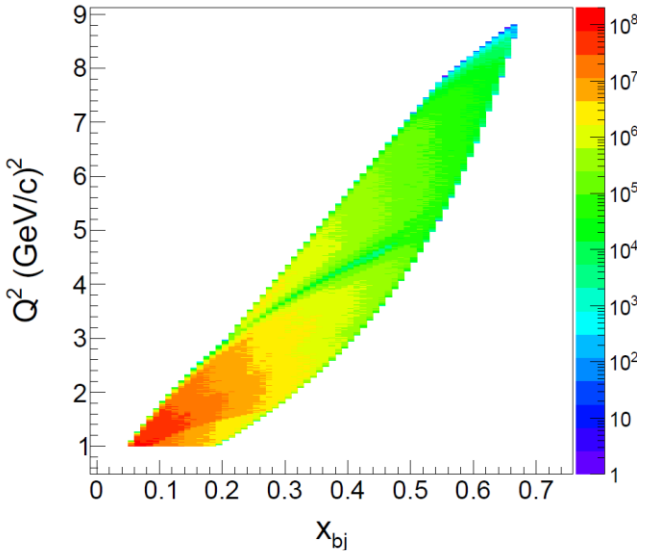
- Approved number of days:
  - *22.5 days (11 GeV) & 9.5 day (8.8 GeV)*

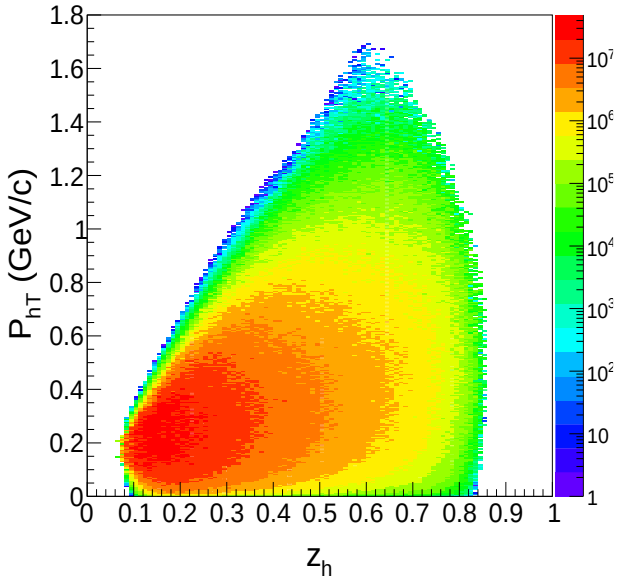
SoLID (SIDIS ^{3}He): 11 GeV & 8.8 GeV beam energies

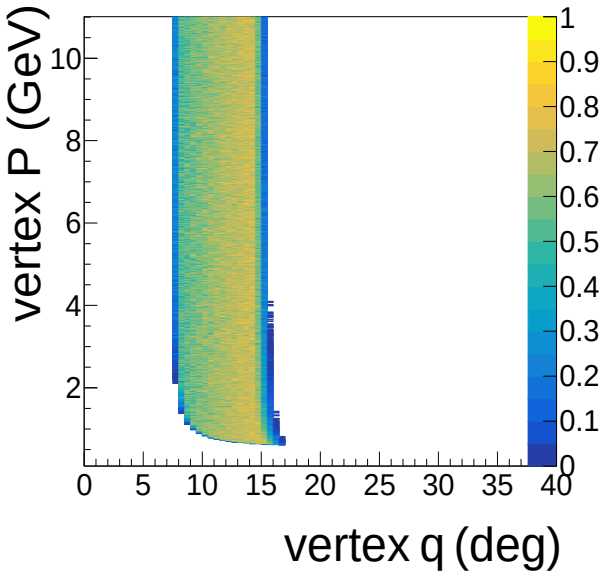


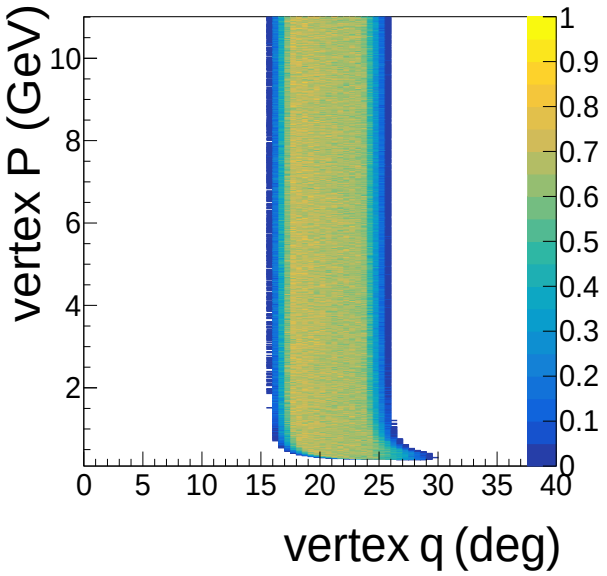
Kinematic Coverage

- Kinematic coverage examples of produced π^+ particles
  - *11 GeV and 8.8 GeV combined*
- *Phase-space correlation between* Q^2 and x_{bj} (*top-left*)
- *Phase-space correlation between* x_{bj} and z_h (*top-right*)
- Electron acceptance as function of angle and momentum forward angle (bottom left) and large angle (bottom right)







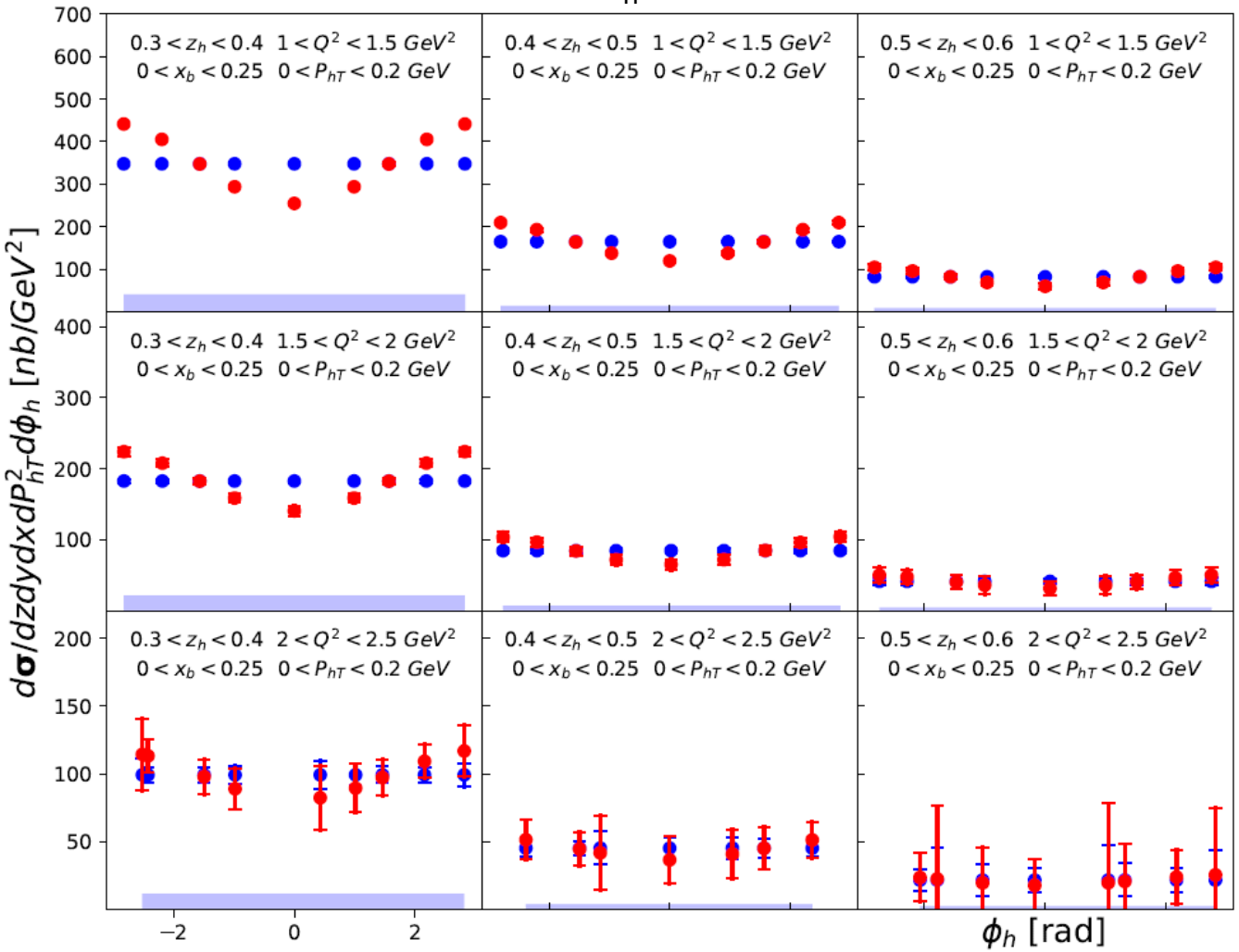


Unpolarized cross-section SoLID results

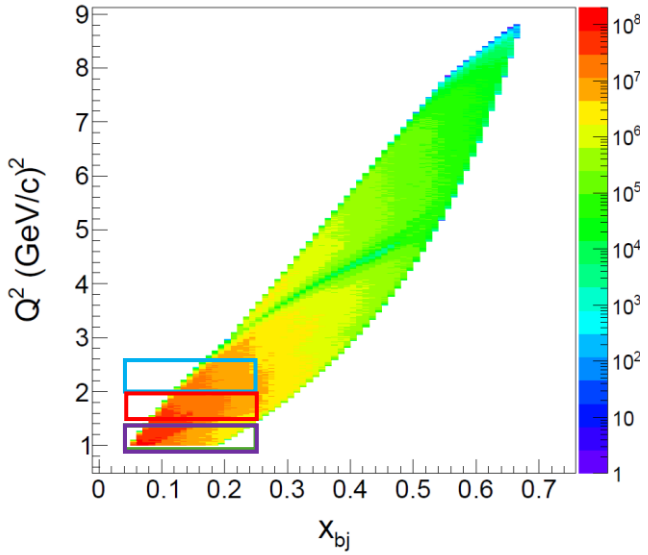
➢ Produced π^+ unpolarized cross section at **8.8 GeV** beam energy

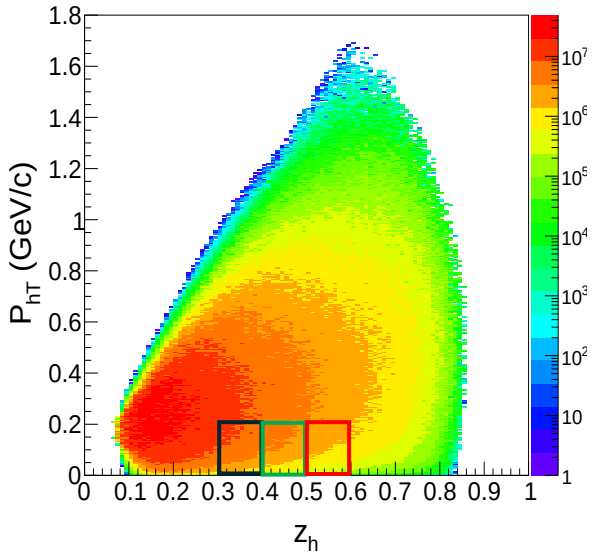
3 Z_h bins

3 Q^2 bins



SoLID low-Q^2 region, first x_{bj} and first P_{hT} bin ranges





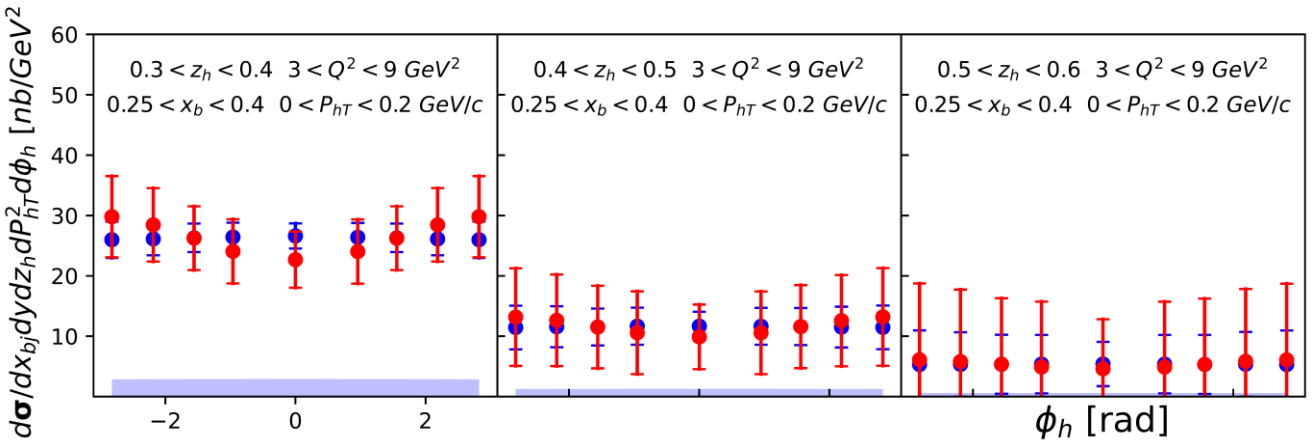
The cross section FUU,A (blue pseudo-data points) without the azimuthal modulations, and the cross section FUU (red pseudo-data points) with the azimuthal modulations are shown.

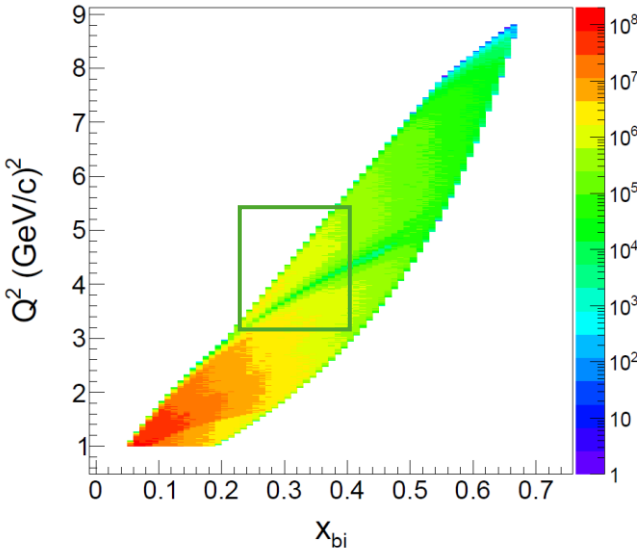
SoLID high-Q^2

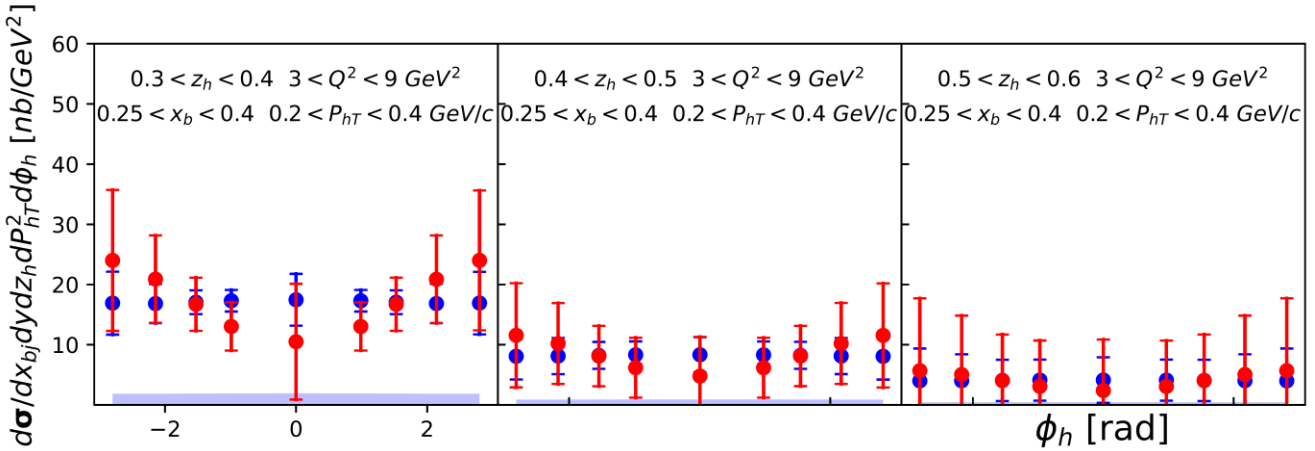
➢ Produced π^+ unpolarized cross section at **11 GeV** beam energy

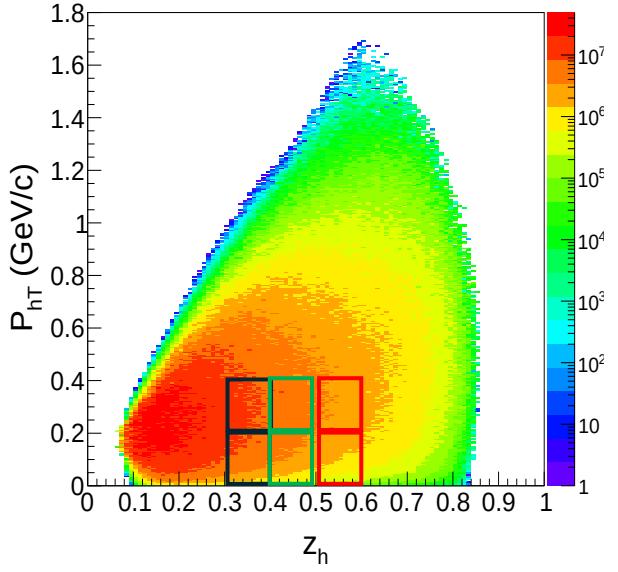
3 Z_h bins

2 Pt bins









The cross section FUU,A (blue pseudo-data points) without the azimuthal modulations, and the cross section FUU (red pseudo-data points) with the azimuthal modulations are shown.

Systematic uncertainties

Systematic uncertainty budget for unpolarized cross section

Sources	Uncertainty
Acceptance correction	6%
Pion detection efficiency	$< 4\%$
Electron detection efficiency	$< 2\%$
Overall detection efficiency	3%
Radiative corrections	2.5%
Radiative backgrounds	0.6%
Vector meson production	1%
Luminosity determination	2.5%
Resolution	3.5%
Total	<10%

Review Committee Summary

- The review committee applauds the effort of the proponents for refining their determination of the systematic errors as was recommended of the 2023 review. The proposal is much improved in describing and evaluating the systematic uncertainties of the proposal. Those are critical in the case of an absolute measurement of cross sections described in these proposals.
- **The committee unanimously recommends the proposal be deferred because the physics impact was not fully demonstrated**. The committee suggests the proponents to work with theory colleagues who specialize in global fits to evaluate the impact of the proposed measurements at the proposed precision. Already an expert group (Pavia group) that attended the collaboration meeting is willing to help explore the impact of the SoLID measurements of semi-inclusive deep inelastic scattering with all the theoretical requirements for a clean interpretation.
- The committee is willing to expedite the next review within the time frame of the next collaboration meeting (in approximately six months) rather than in a year. This should benefit the group to receive feedback and be prepared for the next PAC period well ahead of the PAC deadline for submission.

Review Committee Detailed Comments

- The proponents have done a nice job studying the systematics uncertainties. The proposed measurement of the elastic scattering cross section on hydrogen at 2.2 GeV to calibrate the acceptance is well justified. A similar justification for the 4.4 GeV incident energy will be important to include too. The committee further suggests to select a well-known process to calibrate the coincidence acceptance, single pion production (e,e'π) is such a process for calibration.
- It is good to see that the updated proposal included studies on the physics impact with the P_t width, the Cahn effects and the extraction of the Boer-Mulders function all enabled by the precision of the multi-dimensional ^{3}He SIDIS cross sections. However, this impact study need to be extended to show how the SIDIS cross sections on ^{3}He can contribute to the SIDIS extractions of the neutron. It is advisable to seek theory input from groups who perform global fitting such as the Pavia group and to illustrate the impact of this proposal.
- Another physics impact that needs exploration and could potentially add to the physics motivation is how ^{3}He SIDIS cross sections will help to study the nuclear dependence (EMC effects) on SIDIS/TMDs
- In the case of radiative corrections, the JLab theory group showed at the SoLID workshop that the QED/QCD combined effects could introduce an additional ϕ dependence (see presentation of Jia-Yu Zhang at the following page: \url{https://indico.phy.anl.gov/event/51/timetable/#20240619.detailed}). Will this affect the extractions of ϕ angular modulation? It will be useful to work with the JLab theory group to quantify those effects.
- The committee note that the proponents have pointed out that the request of beam energies of 2.2 GeV and 4.4 GeV for calibration (Table 6 of the proposal) is compatible with the other ^{3}He SIDIS experiments.