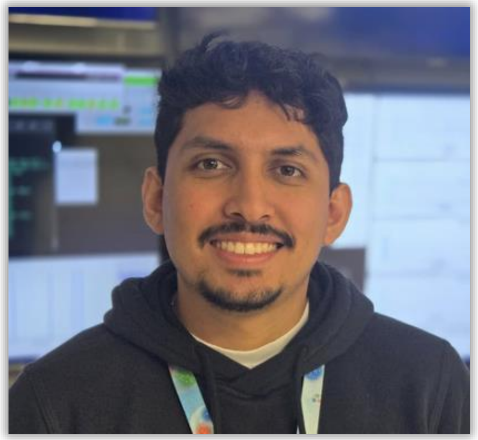
R-SIDIS Update

Provakar Datta
(on behalf of the R-SIDIS collaboration)

R-SIDIS Team (Core Group)

Graduate Students:

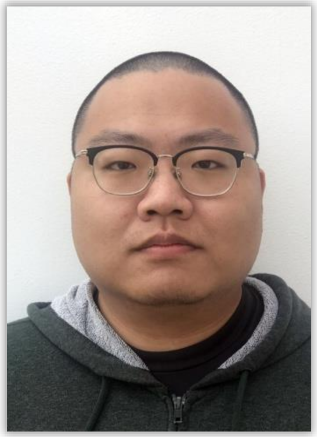
Ryan Elder, UTK



Julio Gutiérrez, UTK

Bhishm Joshi, NMSU

Radwan Parvez, UVA



Zichen Yin, MSU

SULI Student (Undergrad):

Valeria Robles

Postdocs and Staff Scientists:

- Debaditya Biswas, JLab
- Provakar Datta, LBNL (Analysis Coordinator)
- William Henry, JLab
- Hao Lu, UTK
- Casey Morean, JLab

Spokespeople:

- Peter Bosted, W&M
- Will Brooks, USM
- Rolf Ent, JLab
- Dave Gaskell, JLab
- Ed Kinney, CU
- Hamlet Mkrtchyan, Yereven

Components of the R-SIDIS Experiment

E12-06-104: Measurement of the ratio $R = \sigma_L/\sigma_T$ of longitudinal to transverse cross-section in pion and kaon electroproduction in the Semi-Inclusive Deep Inelastic Scattering (SIDIS) region.

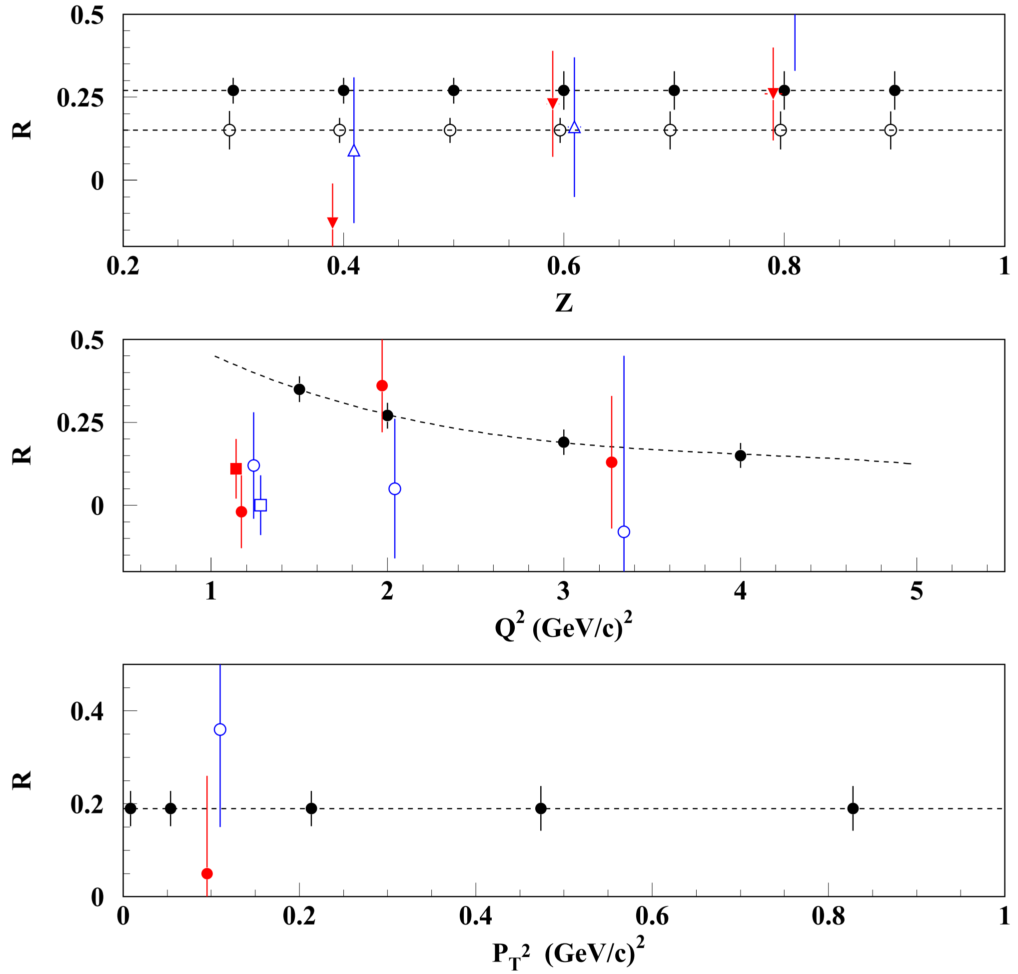
Spokespersons: P. Bosted (W&M), R. Ent (JLab), H. Mkrtchyan (Yerevan)

E12-24-001: Measurement of the Nuclear Dependence of $R = \sigma_L/\sigma_T$ in SIDIS

Spokespersons: P. Bosted (W&M), W. Brooks (USM), R. Ent (JLab), D. Gaskell (JLab), E. Kinney (U. Colorado), H. Mkrtchyan (Yerevan)

E12-06-104: Measurement Goals and Significance

Black: E12-06-104 projections
Red & **Blue**: Existing Cornell data from 1977 [C.J. Bebek et al, PRL 38 (1977) 1051]

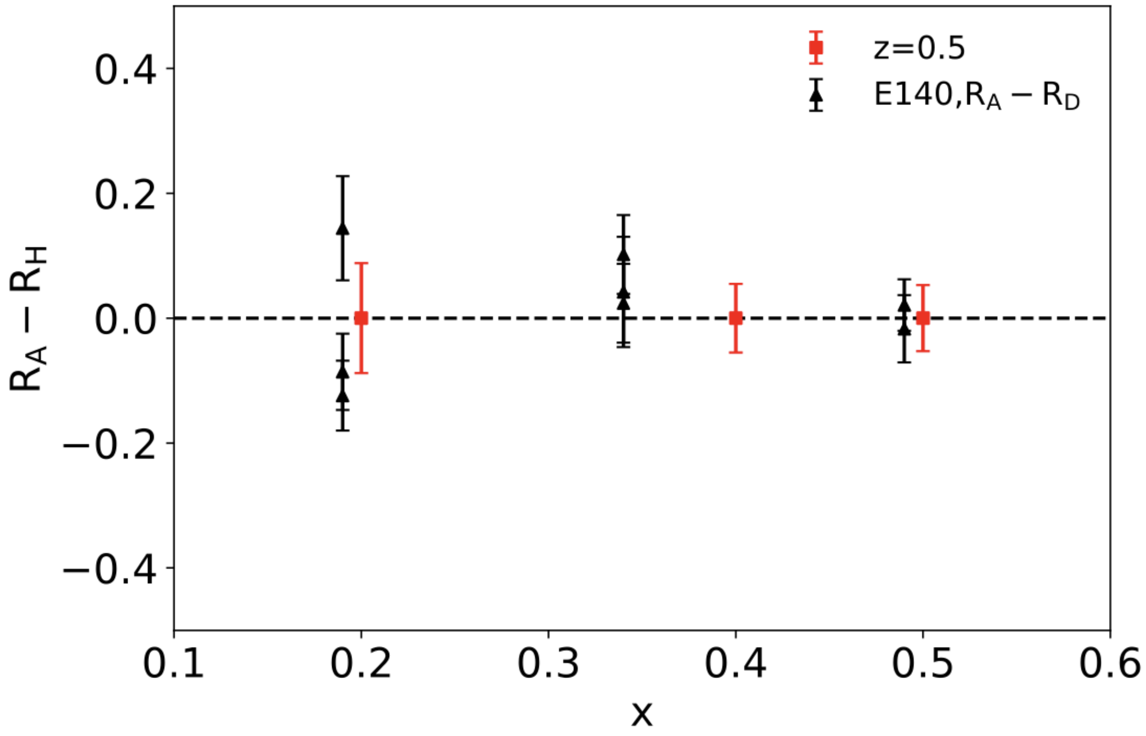


Plot from Dave Gaskell

- Direct extraction of R in SIDIS region
  - charged pions and kaons
  - ^1H and ^2H targets
- Are the following common assumptions used in SIDIS analysis valid?
  - $R_{SIDIS} = R_{DIS}$
  - $R^{^1H}_{SIDIS} = R^{^2H}_{SIDIS}$
  - $R^{\pi^+}_{SIDIS} = R^{\pi^-}_{SIDIS},\ R^{K^+}_{SIDIS} = R^{K^-}_{SIDIS}$
  - $R^{\pi^+}_{SIDIS} = R^{K^+}_{SIDIS}$
- How does R transition from low z to the exclusive limit ($z = 1$)?
- What is the P_T dependence?

E12-24-001: Measurement Goals and Significance

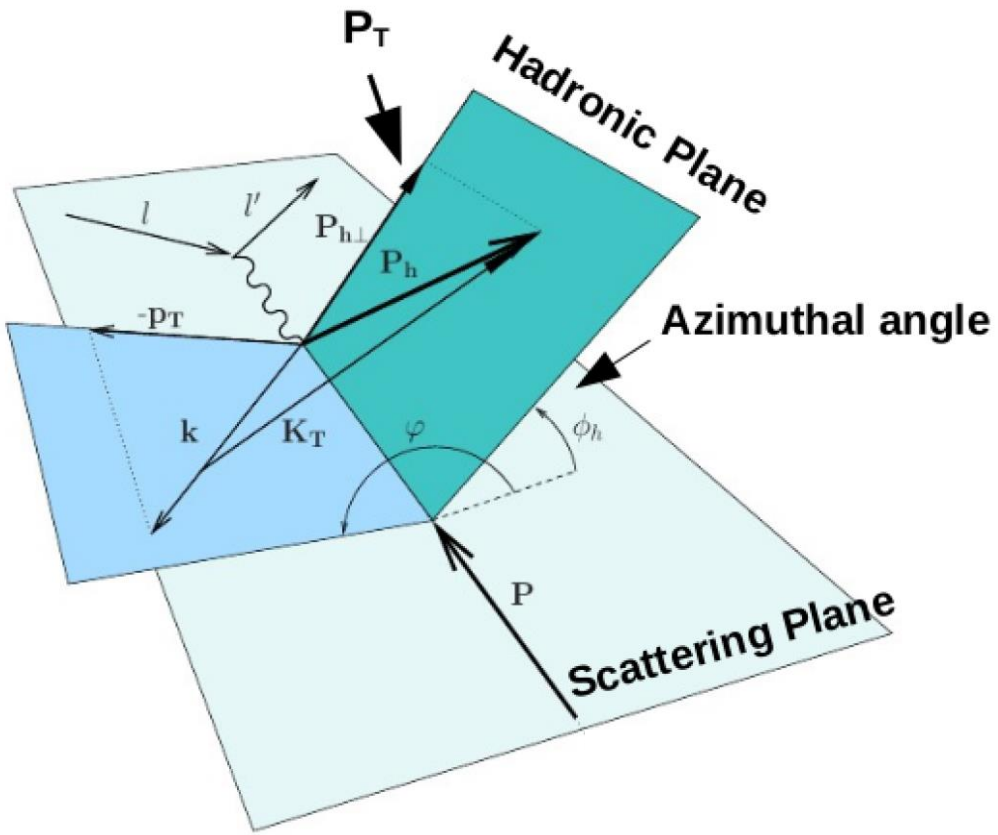
▲ SLAC E140: Nuclear Dependence of R in DIS
■ E12-24-001: Nuclear Dependence of R in SIDIS (projected precision)



Plot from Dave Gaskell

- Direct measurement of the nuclear dependence of R in SIDIS
  - Potential impact on measurements of hadron-attenuation
  - Potential impact on the determination of dilution factor for polarized target experiment
  - Possible interesting new physics
- Exploratory measurements of $x/Q^2, z,$ and P_T dependence at subset of ^{1}H or D measurements to determine if more comprehensive program merited.

Schematic of SIDIS Process (Fixed Target)



$l = (E_e, \mathbf{l})$, 4-mom of the incident e^-

$l' = (E'_e, \mathbf{l}')$, 4-mom of the scattered e^-

θ_e, e^- scattering angle

$\nu = (E_e - E'_e)$

$\epsilon = \left[1 + 2(1 + \nu^2/Q^2)\tan^2\left(\frac{\theta_e}{2}\right)\right]$, virtual photon polarization

$Q^2 = 4E_eE'_e\sin^2\left(\frac{\theta_e}{2}\right)$, 4-mom transferred to the struck nucleon

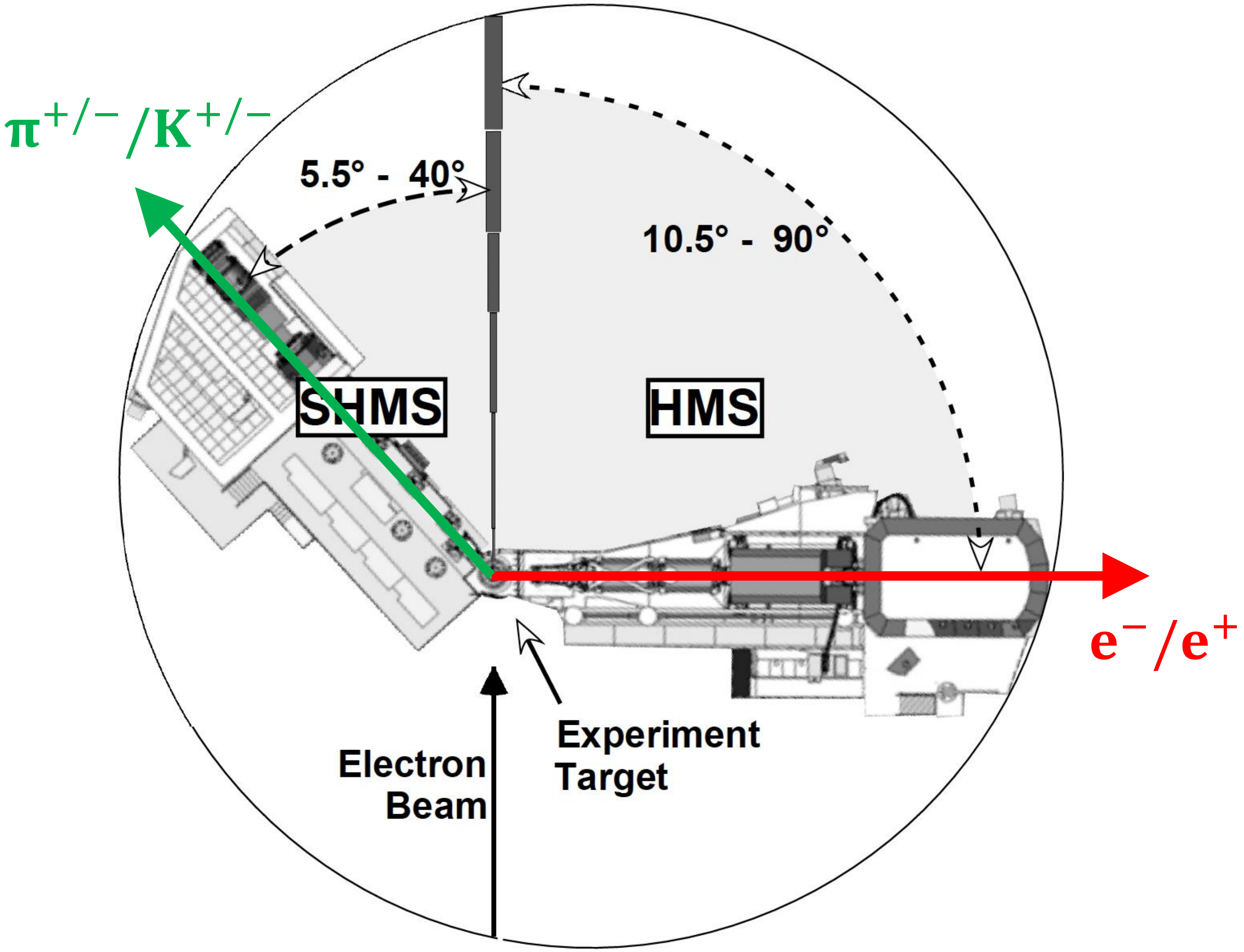
$x = \frac{Q^2}{2M\nu}$, Bjorken scaling variable

$P_T = P_{h\perp}$, pion (or kaon) transverse momentum

$z = \frac{P_h}{\nu}$, fractional pion (or kaon) momentum

ϕ_h, angle between leptonic and hadronic planes

Experimental Setup



Kinematic Coverage	
HMS Angle	16.8 – 30.0 deg
HMS Central Momentum	1.5 – 3.6 GeV/c
SHMS Angle	7.5 – 16.8 deg
SHMS Central Momentum	2.6 – 6.5 GeV/c

Available triggers:

- HMS Singles
- SHMS Singles
- HMS-SHMS Coincidence

Figure from arxiv.org/abs/2503.08706

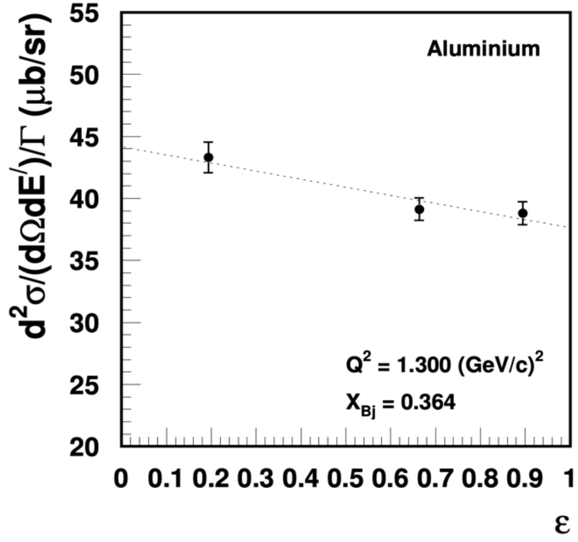
Measurement Technique: Rosenbluth (or L-T) Separation

Inclusive DIS Cross-Section:

$$\frac{d^2\sigma}{d\Omega\, dE'_e} = \Gamma_v \left[\sigma_T(x, Q^2) + \epsilon\, \sigma_L(x, Q^2)\right], \quad \text{where } \Gamma_v = \frac{\alpha}{2\pi^2 Q^2} \frac{E'_e}{E_e} \frac{K}{1-\epsilon}$$

Standard technique to separate σ_L and σ_T to get $R = \frac{\sigma_L}{\sigma_T}$:

- Measure cross-section at fixed ν (or, x and Q^2) but at different ϵ
- Plot cross-section vs. ϵ and fit line
- Slope = σ_L and Intercept = σ_T



Plot from Vladas Tvaskis' thesis

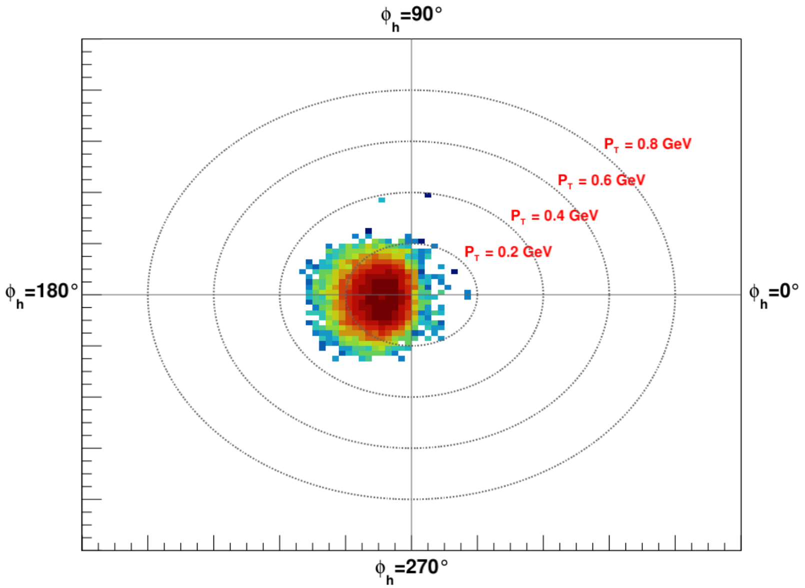
(Unpolarized) SIDIS Cross-Section:

$$\frac{d^5\sigma}{dx\, dQ^2\, dz\, dP_T^2\, d\phi_h} = \Gamma_v \left[\sigma_T(x, Q^2, z, P_T) + \epsilon\, \sigma_L(x, Q^2, z, P_T) + \sqrt{2\epsilon(1+\epsilon)}\, \sigma_{LT} \cos\phi_h + \epsilon\, \sigma_{TT} \cos 2\phi_h\right]$$

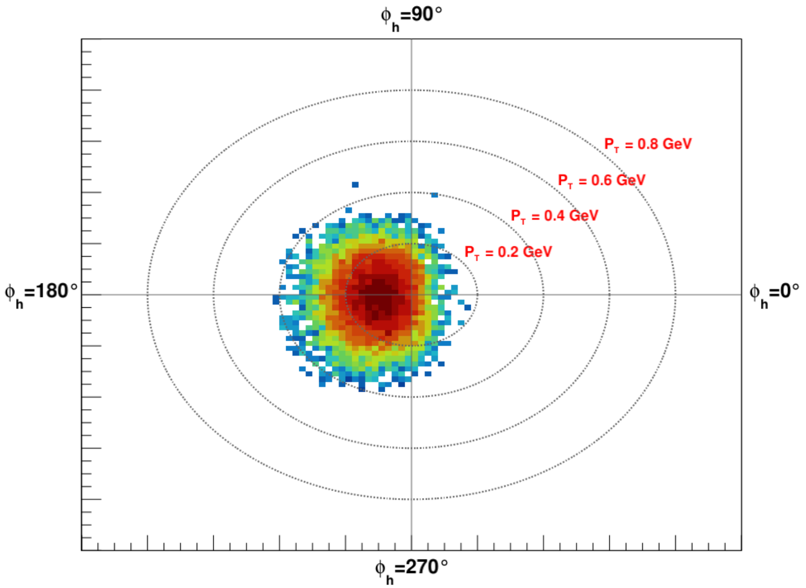
P_T Coverage and ϕ_h Dependence (from Simulation)

x = 0.44, Q^2 = 4.4 GeV^2

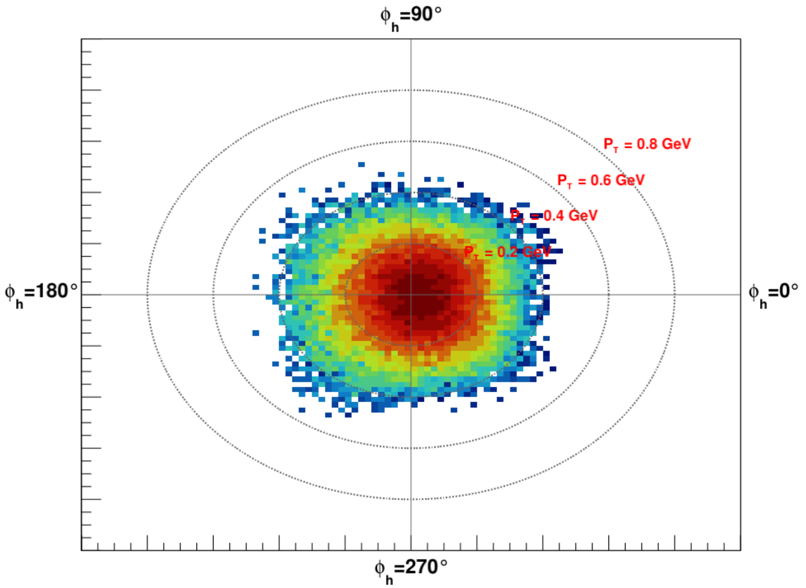
Beam Energy (E_e) = 6.5 GeV



E_e = 8.6 GeV



E_e = 10.7 GeV



SHMS and HMS can only be moved horizontally which limits the P_T range over which σ_L and σ_T can be extracted unambiguously.

Run Plan and the Status of Data Collection

x	Q^2, $(\mathrm{GeV/c})^2$	E_e, GeV	ϵ	z	θ_{pq}, deg	$A > 1$
0.16	1.6	6.5, 8.6	0.32, 0.65	0.5	2	No
0.22	2.2	6.5, 8.6	0.31, 0.64	0.5	2	No
0.25	3.3	8.6, 10.7	0.32, 0.59	0.36, 0.5, 0.67 0.5	2 5.2, 8.5	π^+ (all), π^- π^+ only
		10.7	0.59	0.5, 0.67	-0.8	Yes
0.31	3.1	6.5, 8.6, 10.7	0.3, 0.63, 0.78	0.5	-1, 2	π^+ only
0.44	4.4	6.5, 8.6, 10.7	0.28, 0.62, 0.77	0.52 0.4, 0.67	2	Yes No
		10.7	0.77	0.52 0.4, 0.67	-2, 0	Yes No

- Scan in x at fixed $z = 0.5$ and low P_T
- Scans in z at low P_T at two values of x
- Scan in P_T at fixed x and z
- Take both π^+ and π^- data:
  - at all settings on ^{1}H target
  - at a subset of settings on D, ^{12}C, and ^{64}Cu targets

Completed in 2025 (July 15th – Sept 3rd)

We completed 30-40% of the initially proposed physics program last year.

Analysis Status

A huge analysis effort is ongoing since the beginning of the run. Preliminary data quality checks and fine-tuning of detector calibrations were performed simultaneously with data collection.

Luminosity study was performed for cryotargets to quantify boiling effect.

Very preliminary physics results have been extracted for the following:

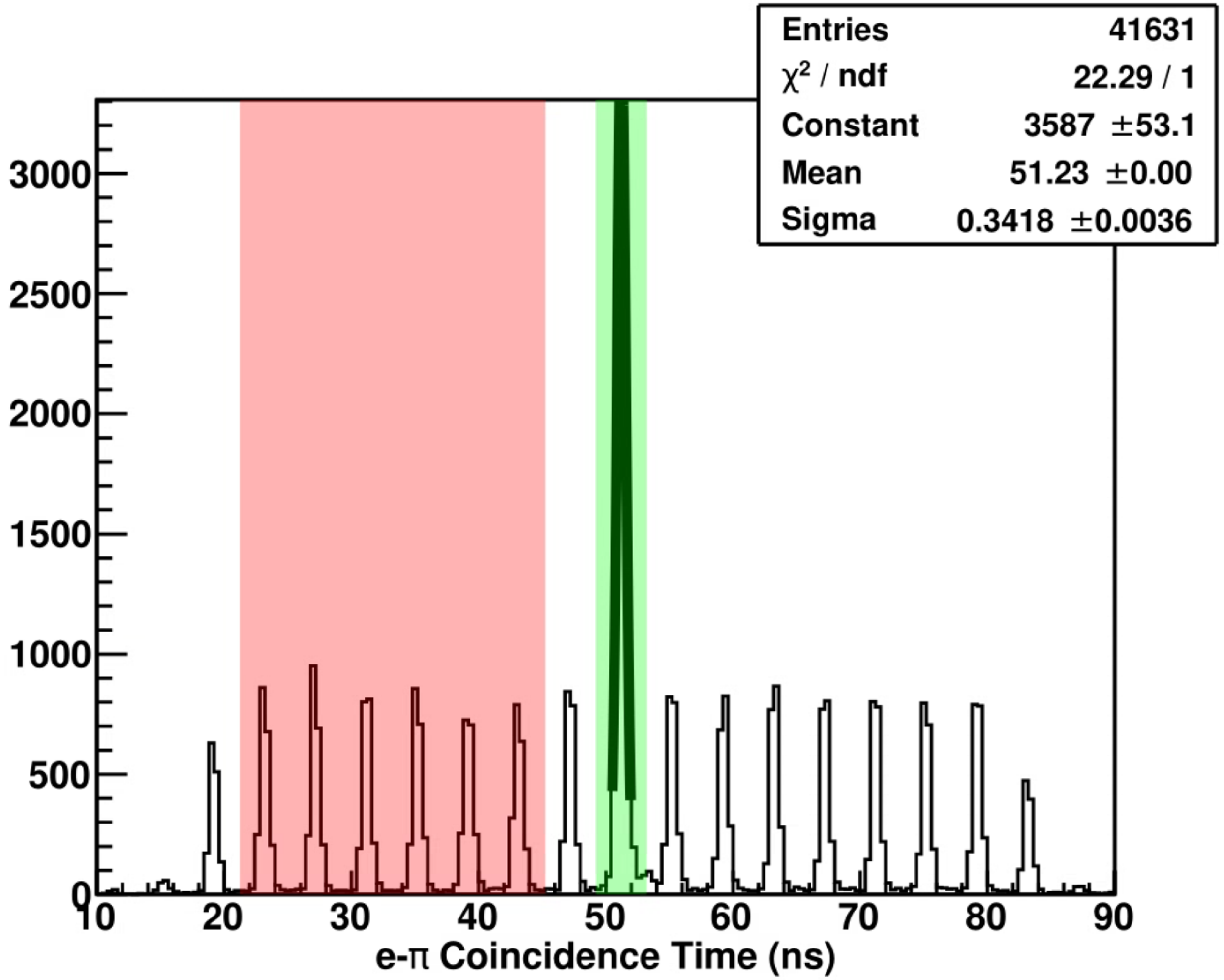
- DIS cross-section ratios from HMS singles data.
- Pion multiplicities from coincidence data.
- Beam Single Spin Asymmetries (SSA) from π^- electroproduction.

Preparation for another reconstruction pass is underway with the following improvements:

- Thorough checks of the quality of detector calibrations across all runs.
- Optimization of tracking parameters.
- Determination of kinematic offsets.

Following this reconstruction pass, the physics results will be updated using the existing analysis framework, together with a comprehensive evaluation of systematic uncertainties.

Online Statistics Counter: An Example from Run 25548



Analysis cuts:

- PID
- Acceptance

Event counts:

- Good coincidences : 8177
- Random coincidences : 2140
- Real coincidences : 6037

We kept track of the good physics events online and modified the run plan accordingly to maximize efficiency.

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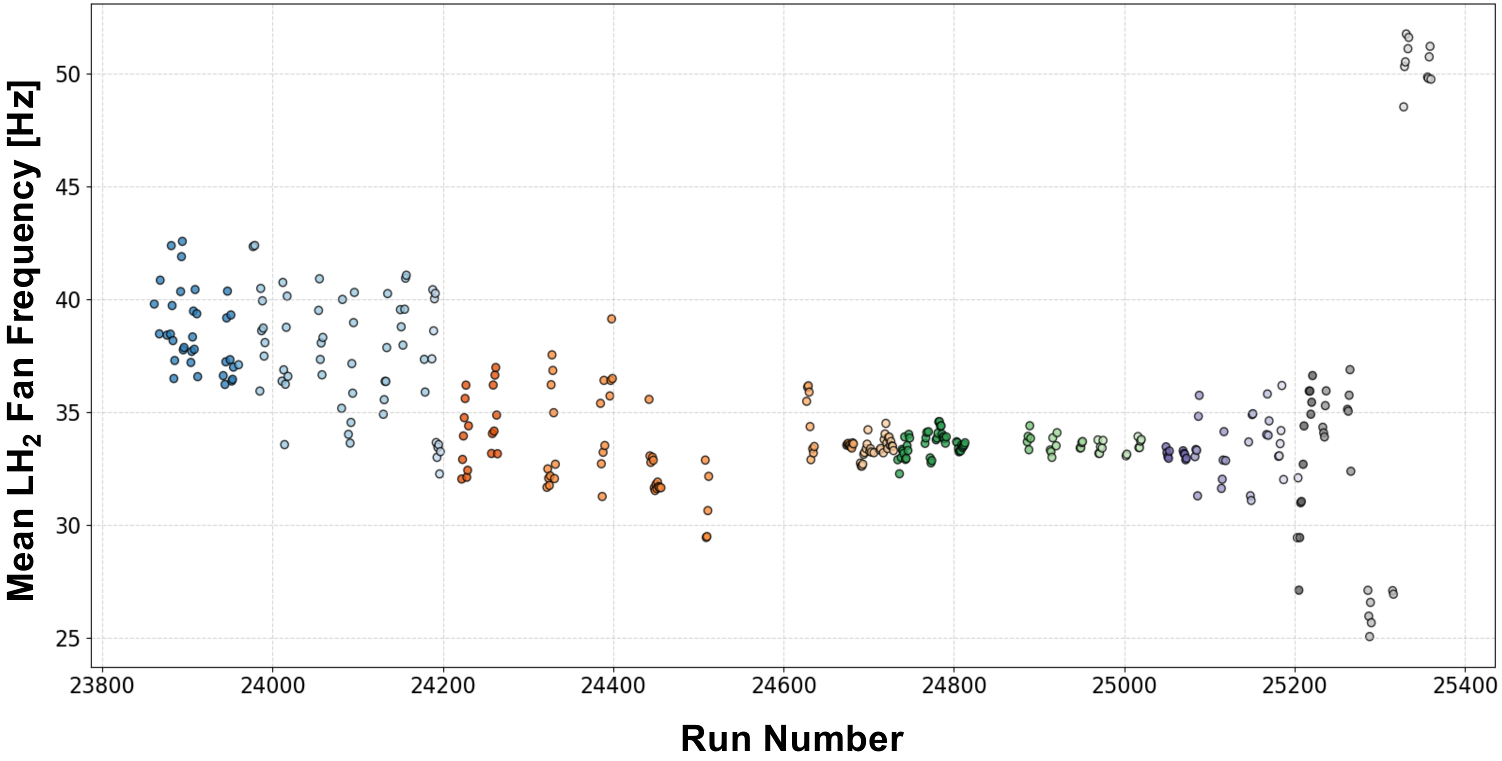
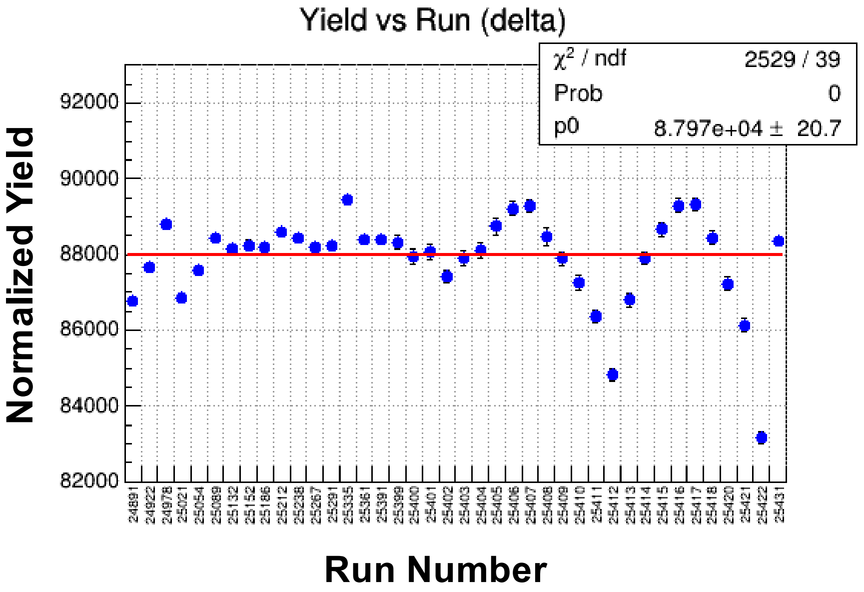
Unstable LH_2 Fan Frequency Issue – Description

Analysis by Julio Gutiérrez

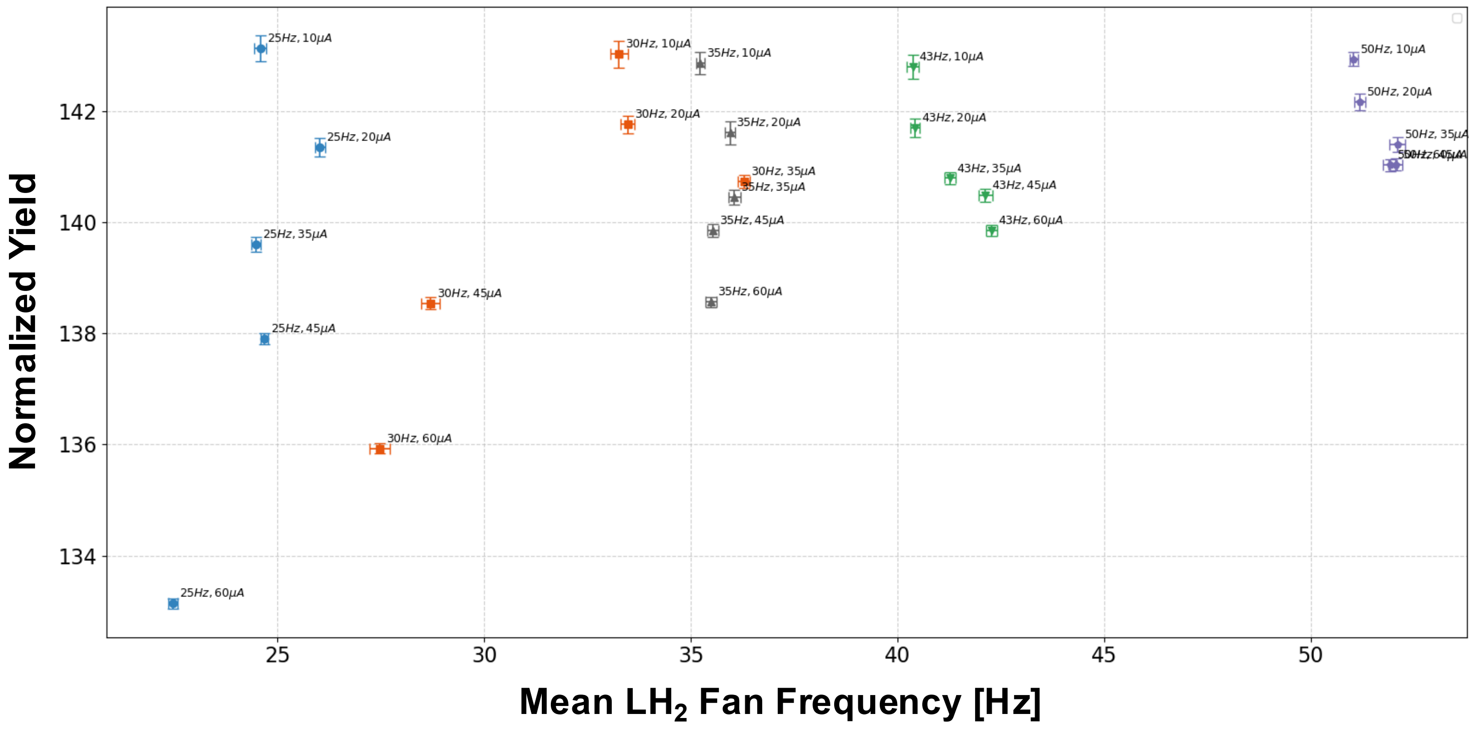


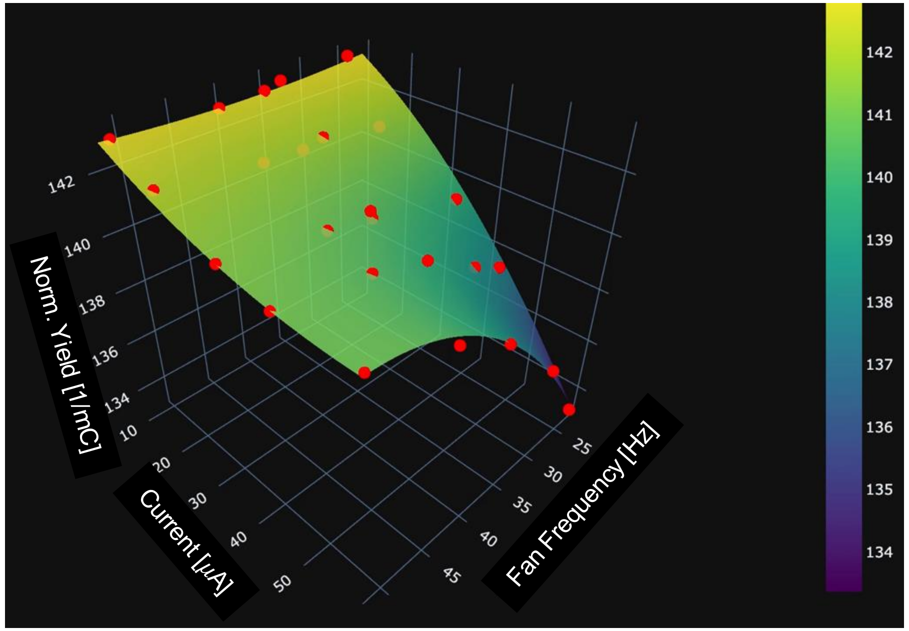


- The frequency of circulation of the LD_2 target was stable at ~ 40 Hz during run, as expected, while the same for the LH_2 target varied significantly!
- Such variation in the fan frequency introduced significant yield instability.

Unstable LH2 Fan Frequency Issue – Steps to Mitigation

Analysis by Julio Gutiérrez



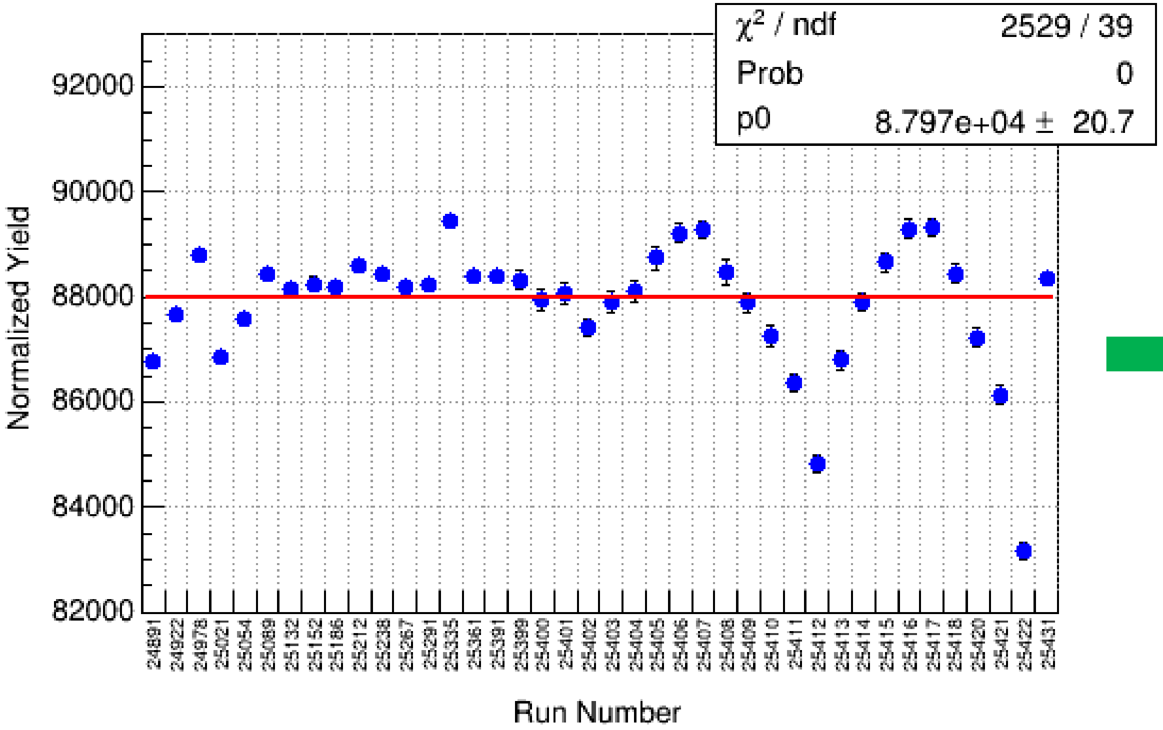


1. Took dedicated runs with different fan frequencies and beam currents.
2. Determined current and frequency dependence of normalized yields.
3. Perform a simultaneous fit to quantify the fan frequency and current dependance on yield using the following equation: $$Y(f,I) = (\alpha_2 I^2 + \alpha_1 I + \alpha_0) f^2 + (\beta_2 I^2 + \beta_1 I + \beta_0) f + (\gamma_2 I^2 + \gamma_1 I + \gamma_0)$$

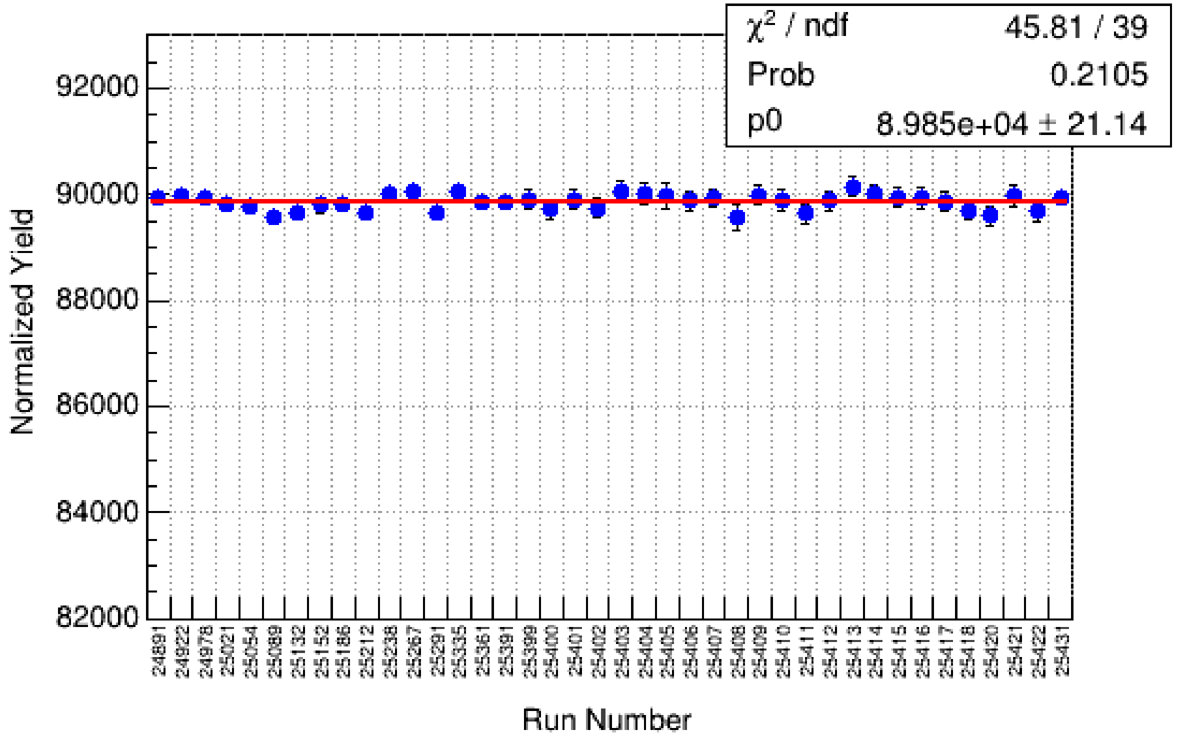
Unstable LH2 Fan Frequency Issue – Solved!

Analysis by Bhishm Joshi

No Fan Frequency Correction



With Fan Frequency Correction



Normalized yields across runs stabilize with the application of fan frequency correction.

Analysis Status

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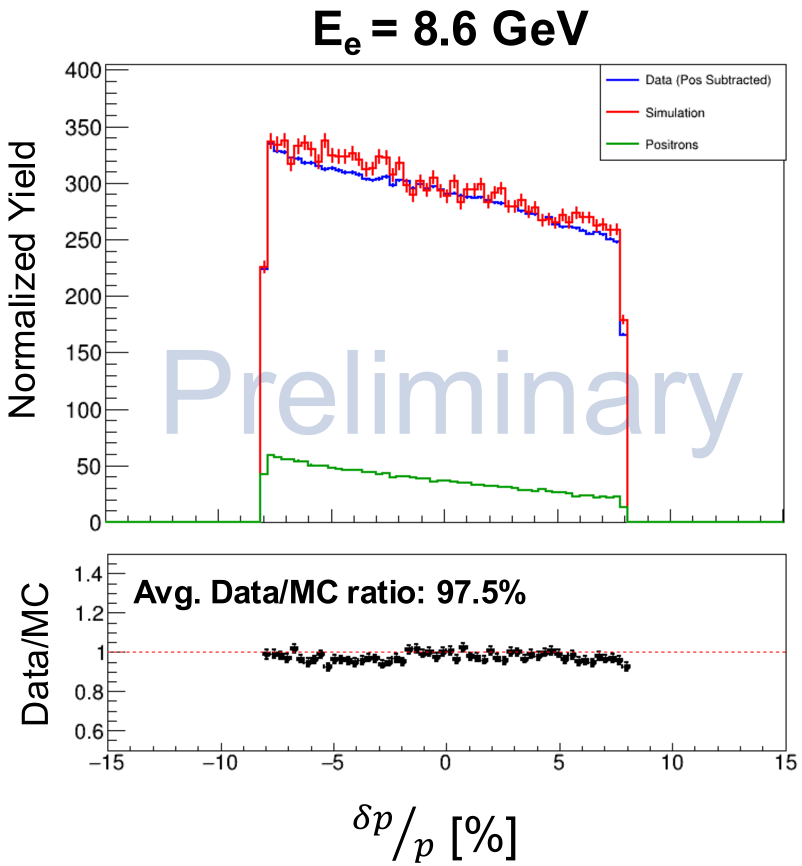
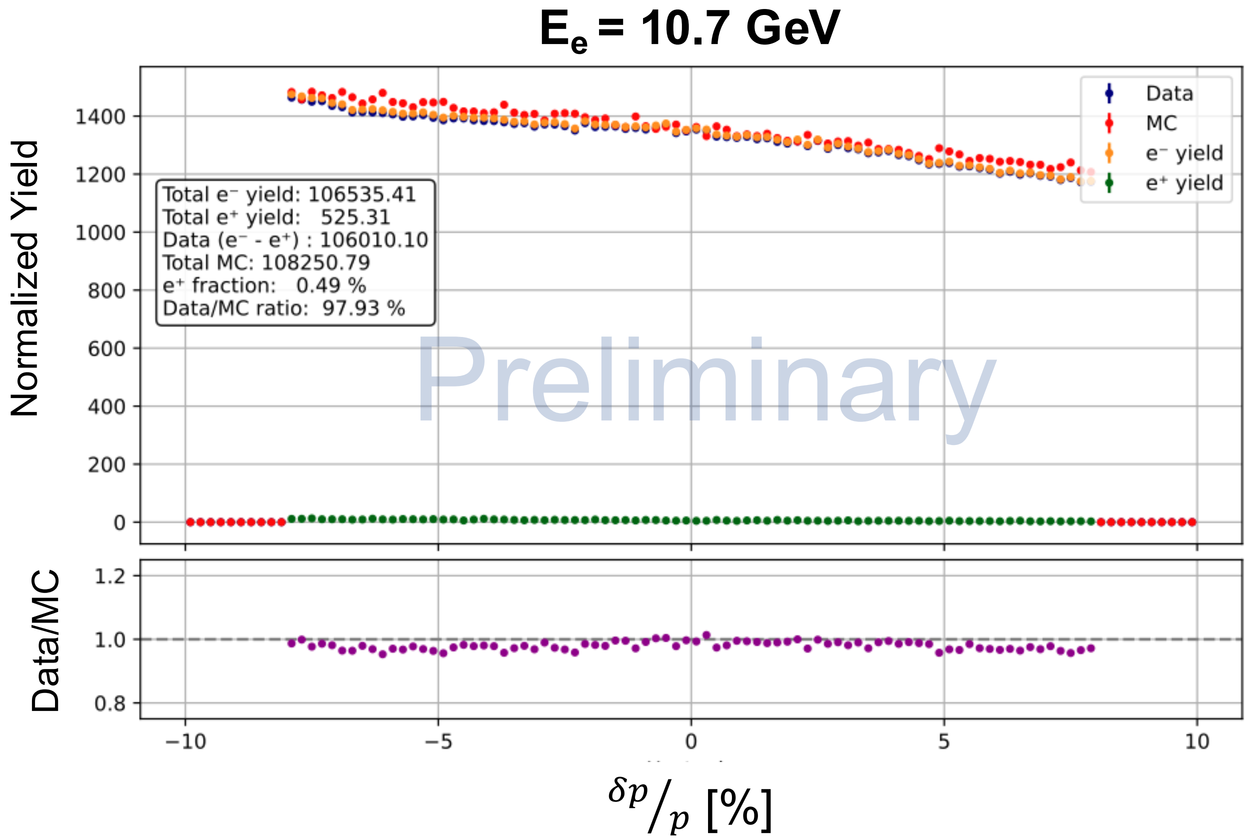
- Pion multiplicities from coincidence data.
- Beam Single Spin Asymmetries (SSA) from π^+ electroproduction.

DIS on ^{12}C – Data/MC Comparison

Analysis by Bhishm Joshi & Ryan Elder

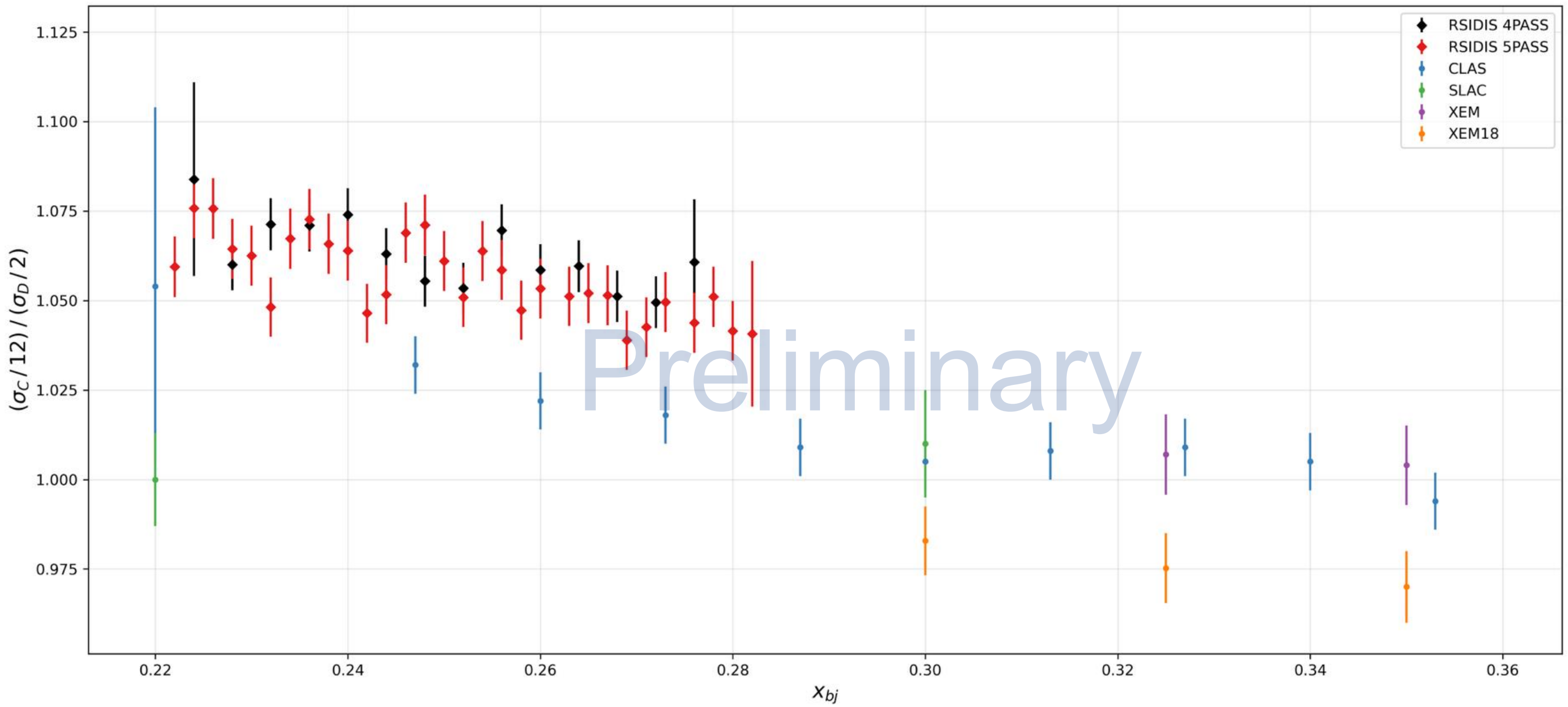




- Preliminary Data/MC comparison of DIS yields on ^{12}C at two different beam energies.
- In both cases, the yields matches within 3%, which is impressive at this early stage of analysis.

Per-Nucleon DIS Cross-section Ratio (^{12}C to D)

Analysis by Ryan Elder



- EMC ratio of carbon to deuterium at two different beam energies.
- The ratios agree within 3% with the world data.

Analysis Status

A huge analysis effort is ongoing since the beginning of the run. Preliminary data quality checks and fine-tuning of detector calibrations were performed simultaneously with data collection.

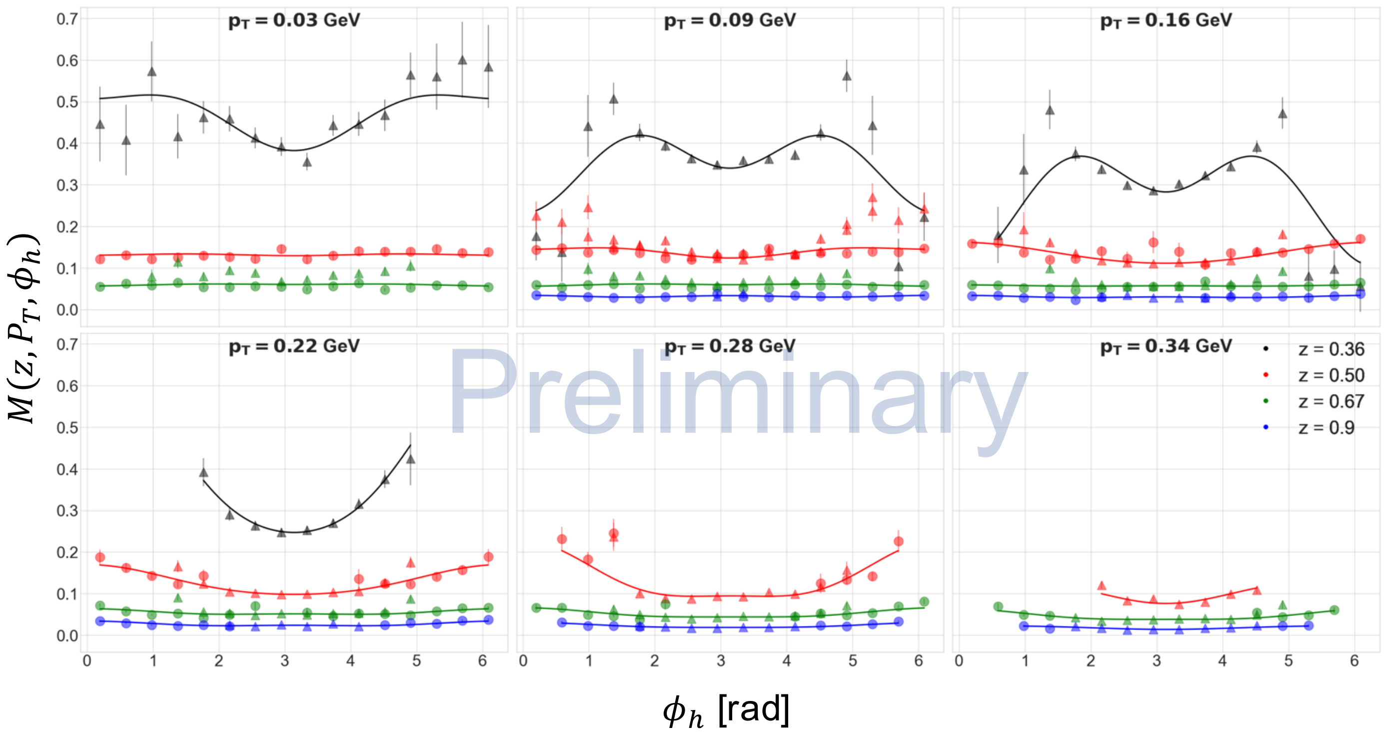
Luminosity study was performed for cryotargets to quantify boiling effect.

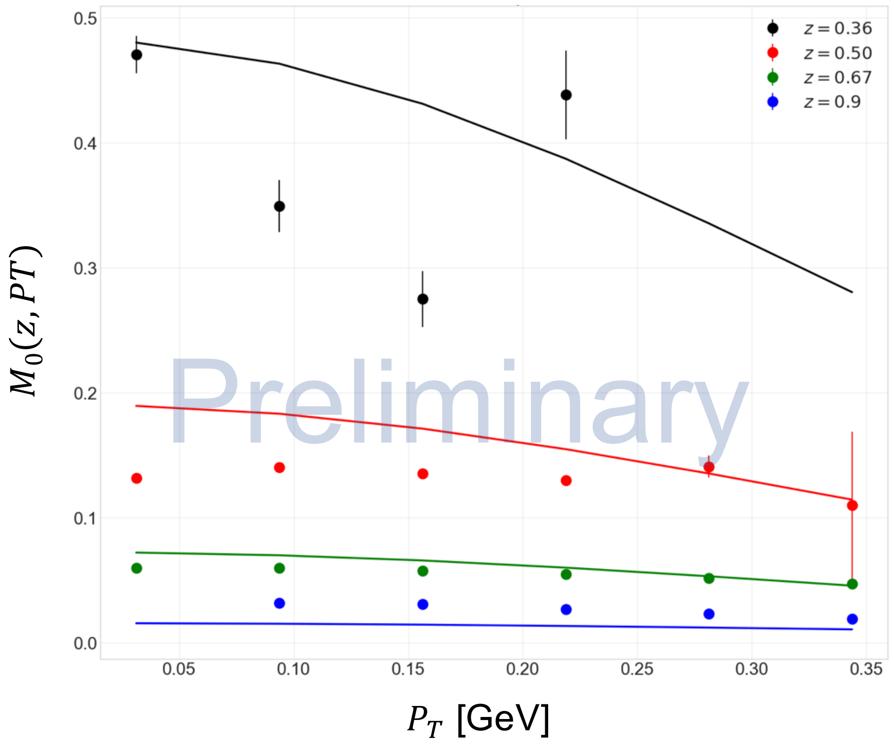
Very preliminary physics results have been extracted for the following:

- DIS cross-section ratios from HMS singles data.
- Pion multiplicities from coincidence data.
- Beam Single Spin Asymmetries (SSA) from π^+ electroproduction.

π^- Multiplicity vs. ϕ_h – LH_2 Data

Analysis by Julio Gutiérrez

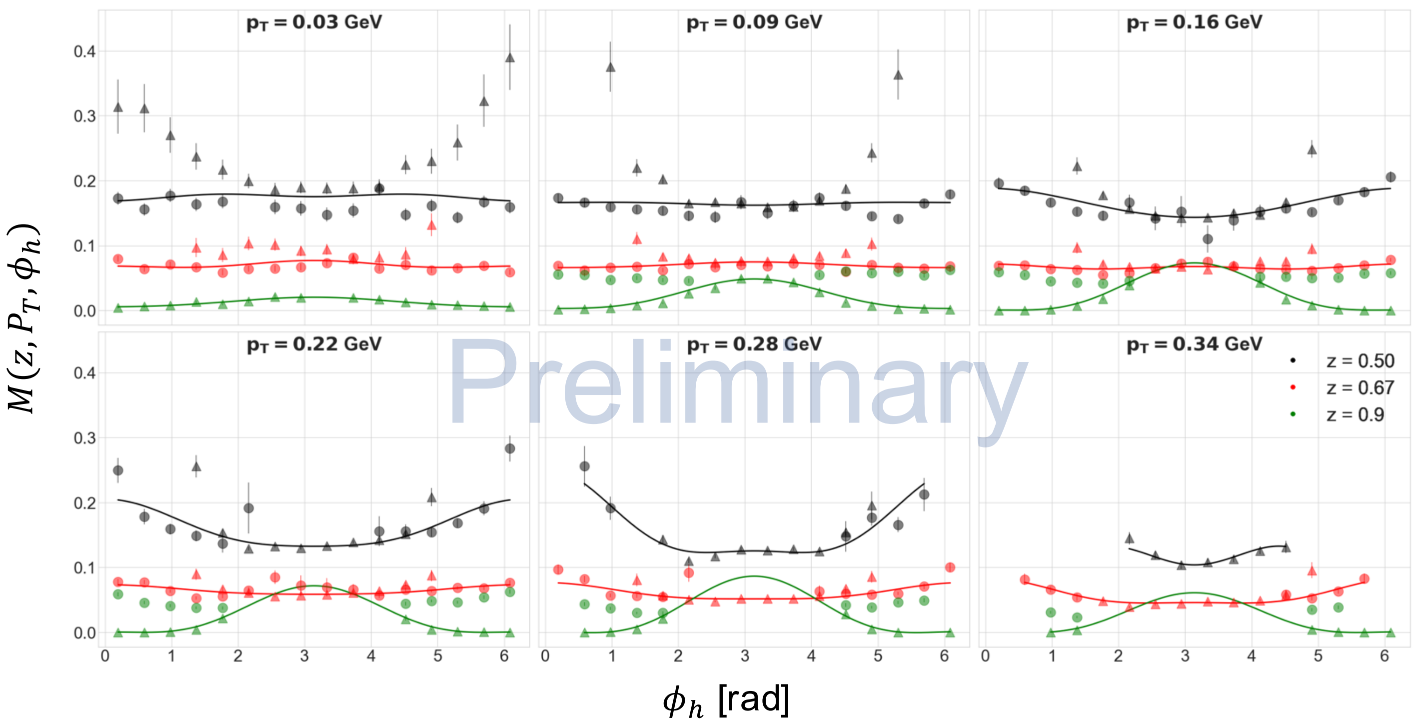


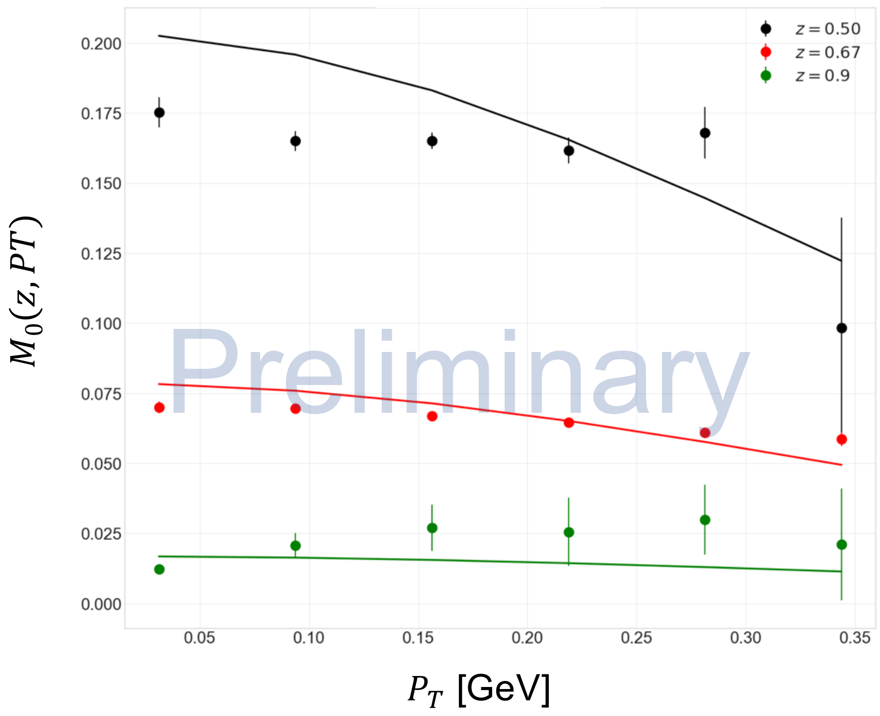


- π^- multiplicity as a function of ϕ_h for x = 0.25, Q^2 = 3.3 GeV^2 on hydrogen target at 10.7 GeV.
- Data at fixed z and P_T have been fitted with the function: $M_0[1 + A\cos(\phi_h) + B\cos(2\phi_h)]$
- The P_T dependence of the fit parameter M_0 agrees very well with the model for all z values except the lowest bin at z = 0.36, even at this early stage of analysis.

π^- Multiplicity vs. ϕ_h – LD_2 Data

Analysis by Julio Gutiérrez

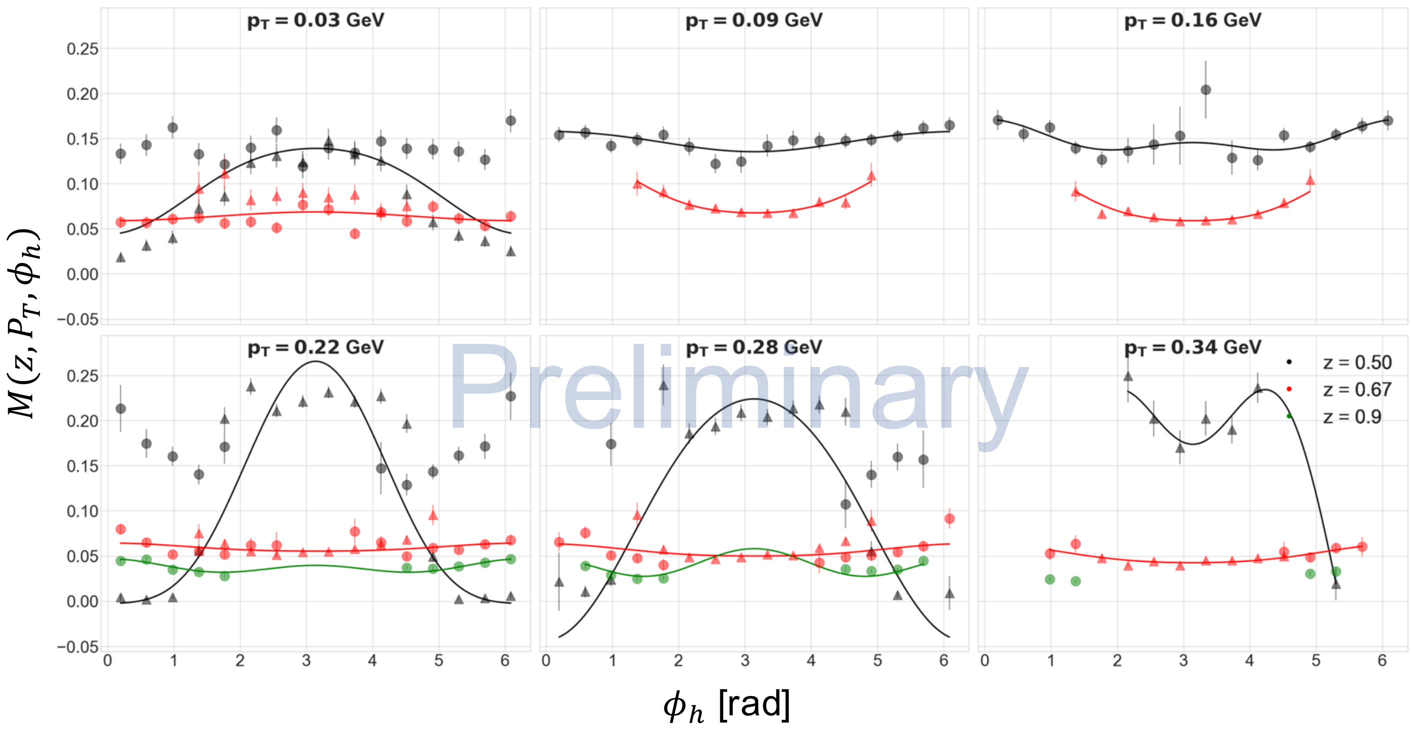


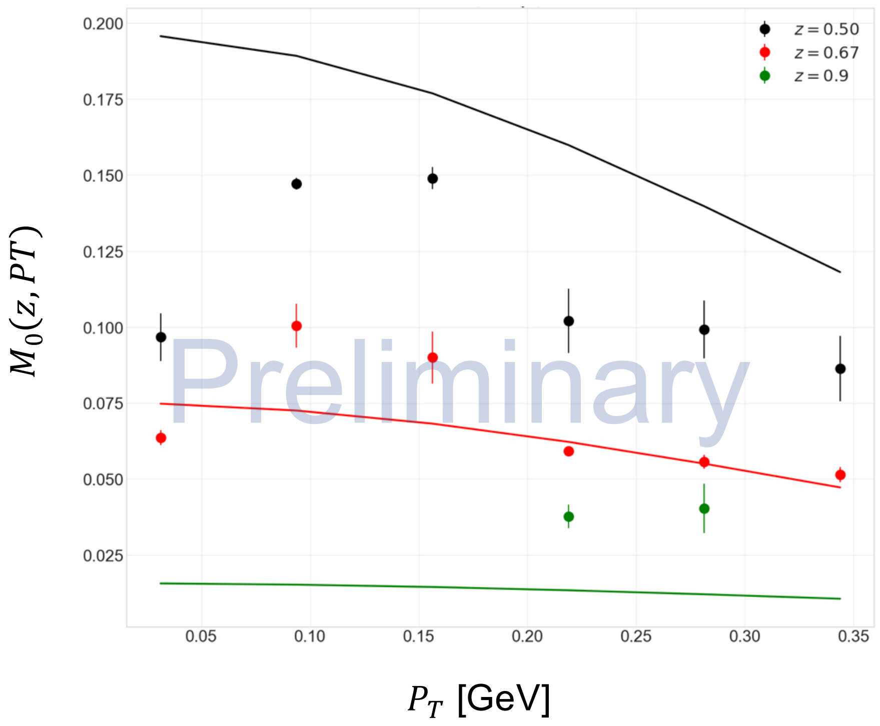


- π^- multiplicity as a function of ϕ_h for x = 0.25, Q^2 = 3.3 GeV^2 on deuterium target at 10.7 GeV.
- Data at fixed z and P_T have been fitted with the function: $M_0[1 + A\cos(\phi_h) + B\cos(2\phi_h)]$
- The P_T dependence of the fit parameter M_0 agrees reasonably well with the model for all z values. The agreement is expected to be even better after the next reconstruction pass.

π^- Multiplicity vs. ϕ_h – ^{12}C Data

Analysis by Julio Gutiérrez

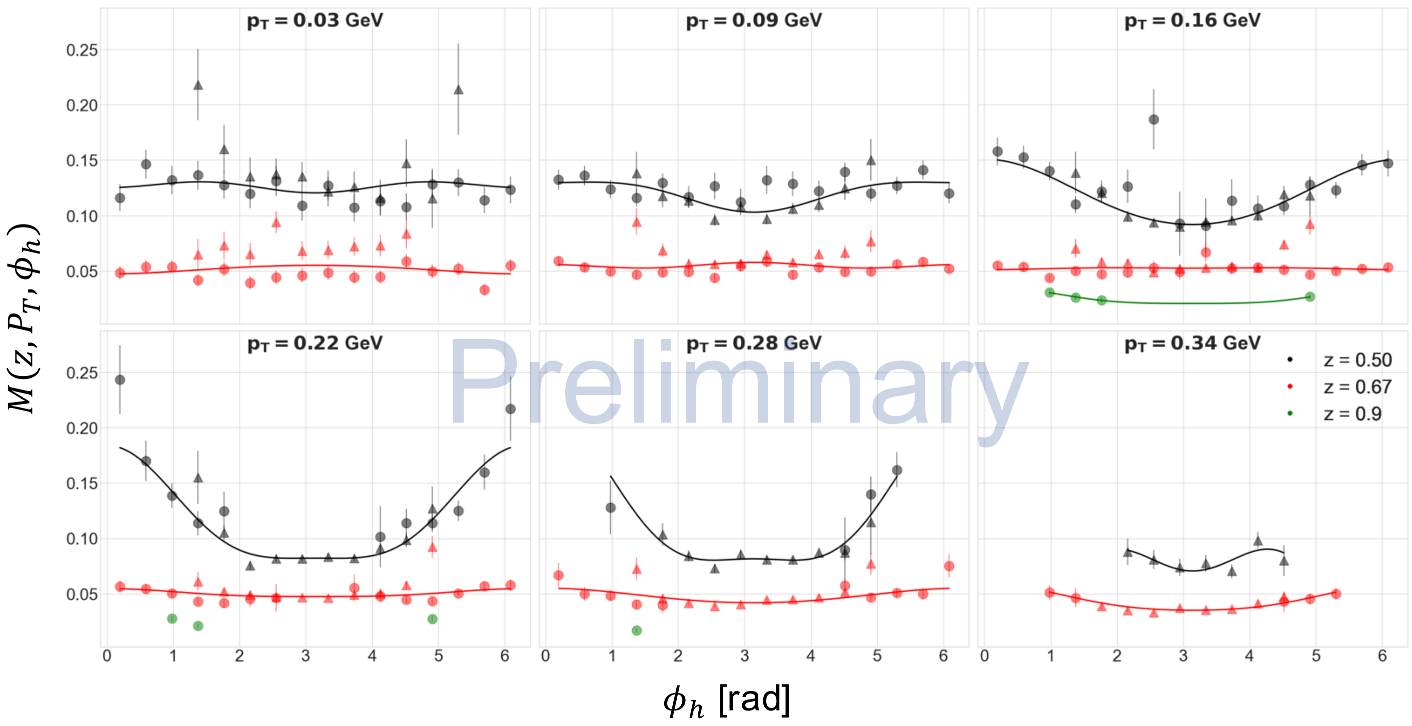


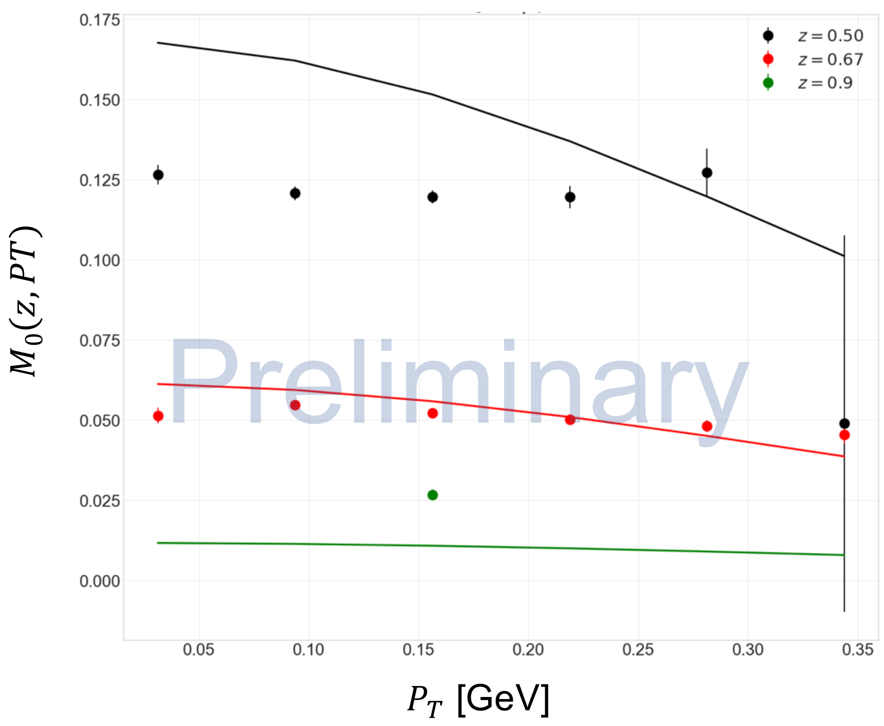


- π^- multiplicity as a function of ϕ_h for x = 0.25, Q^2 = 3.3 GeV^2 on carbon target at 10.7 GeV.
- Data at fixed z and P_T have been fitted with the function: $M_0[1 + A\cos(\phi_h) + B\cos(2\phi_h)]$
- The observed P_T dependence of M_0 is reasonably described by the model only at z = 0.67; deviations at other z points are likely due to low statistics and/or limited ϕ coverage.

π^- Multiplicity vs. ϕ_h – ^{64}Cu Data

Analysis by Julio Gutiérrez





- π^- multiplicity as a function of ϕ_h for x = 0.25, Q^2 = 3.3 GeV^2 on copper target at 10.7 GeV.
- Data at fixed z and P_T have been fitted with the function: $M_0[1 + A\cos(\phi_h) + B\cos(2\phi_h)]$
- Like carbon data, the observed P_T dependence of M_0 is reasonably described by the model only at z = 0.67; deviations at other z points are likely due to low statistics and/or limited ϕ coverage.

Analysis Status

A huge analysis effort is ongoing since the beginning of the run. Preliminary data quality checks and fine-tuning of detector calibrations were performed simultaneously with data collection.

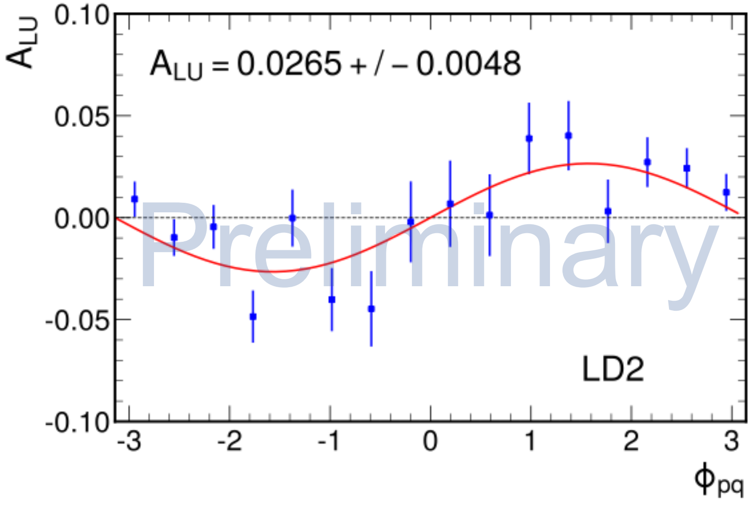
Luminosity study was performed for cryotargets to quantify boiling effect.

Very preliminary physics results have been extracted for the following:

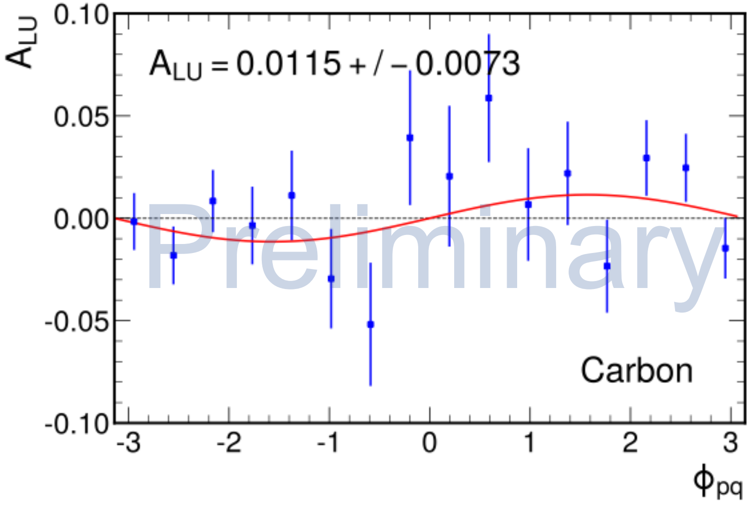
- DIS cross-section ratios from HMS singles data.
- Pion multiplicities from coincidence data.
- Beam Single Spin Asymmetries (SSA) from π^- electroproduction.

Beam Single Spin Asymmetries from π^- – Bonus Physics

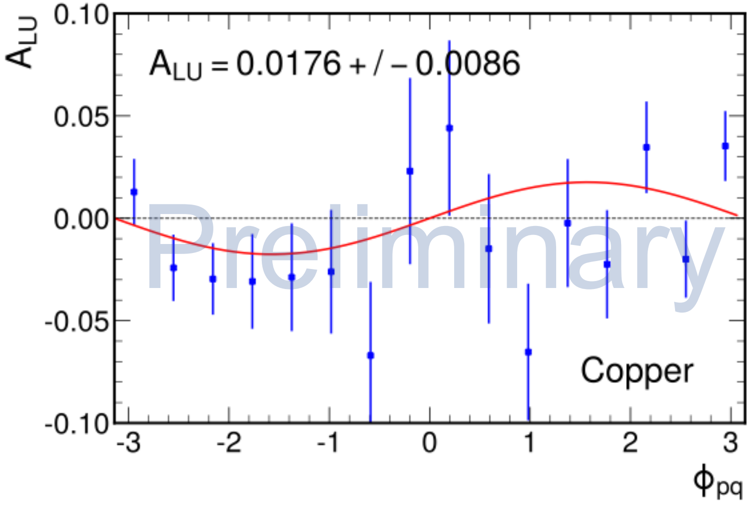
LD_2 Data



^{12}C Data



^{64}Cu Data



- Approx. 82% beam polarization allowed us to extract beam single spin asymmetries at 10.7 GeV.
- Plots by D. Gaskell using π^- electroproduction data at z = 0.5. Online replay of only a fraction of the dataset was used.

Tentative Run Plan for R-SIDIS Phase 2

x	Q^2, $(\text{GeV/c})^2$	E_e, GeV	ϵ	z	θ_{pq}, deg	$A > 1$
0.16	1.6	6.5, 8.6	0.32, 0.65	0.5	2	No
0.22	2.2	6.5, 8.6	0.31, 0.64	0.5	2	No
0.25	3.3	8.6, 10.7	0.32, 0.59	0.36, 0.5, 0.67 0.5	2 5.2, 8.5	π^+ (all), π^- π^+ only
		10.7	0.59	0.5, 0.67	-0.8	Yes
0.31	3.1	6.5, 8.6, 10.7	0.3, 0.63, 0.78	0.5	-1, 2	π^+ only
0.44	4.4	6.5, 8.6, 10.7	0.28, 0.62, 0.77	0.52 0.4, 0.67	2	Yes No
		10.7	0.77	0.52 0.4, 0.67	-2, 0	Yes No

To be completed this year

- The final phase of R-SIDIS (phase 2) is scheduled to run this summer from May 25th to June 29th.
- We will collect data at four remaining (x, Q^2) settings.

Shift-schedule will be active soon!

There will be FREE **donuts!**

Summary

- R-SIDIS experiment aims to perform direct measurement of $R = \frac{\sigma_L}{\sigma_T}$ in the SIDIS region in pion and kaon electroproduction and study its nuclear dependence!

- Due to unexpected downtime and budgetary constraints, only part of the R-SIDIS experiment was completed last year. The remaining data will be collected this summer, from May 25 to June 29.

- A huge effort of data analysis is ongoing since the beginning of the experiment. Preliminary physics results, extracted within just 3 months of data collection, are promising.

- Currently, efforts are ongoing to do another reconstruction pass with optimized kinematic offsets and best possible detector calibrations. Soon after that the physics results will be updated using the existing analysis framework, together with a comprehensive evaluation of systematic uncertainties.

Thank You for Your Attention!

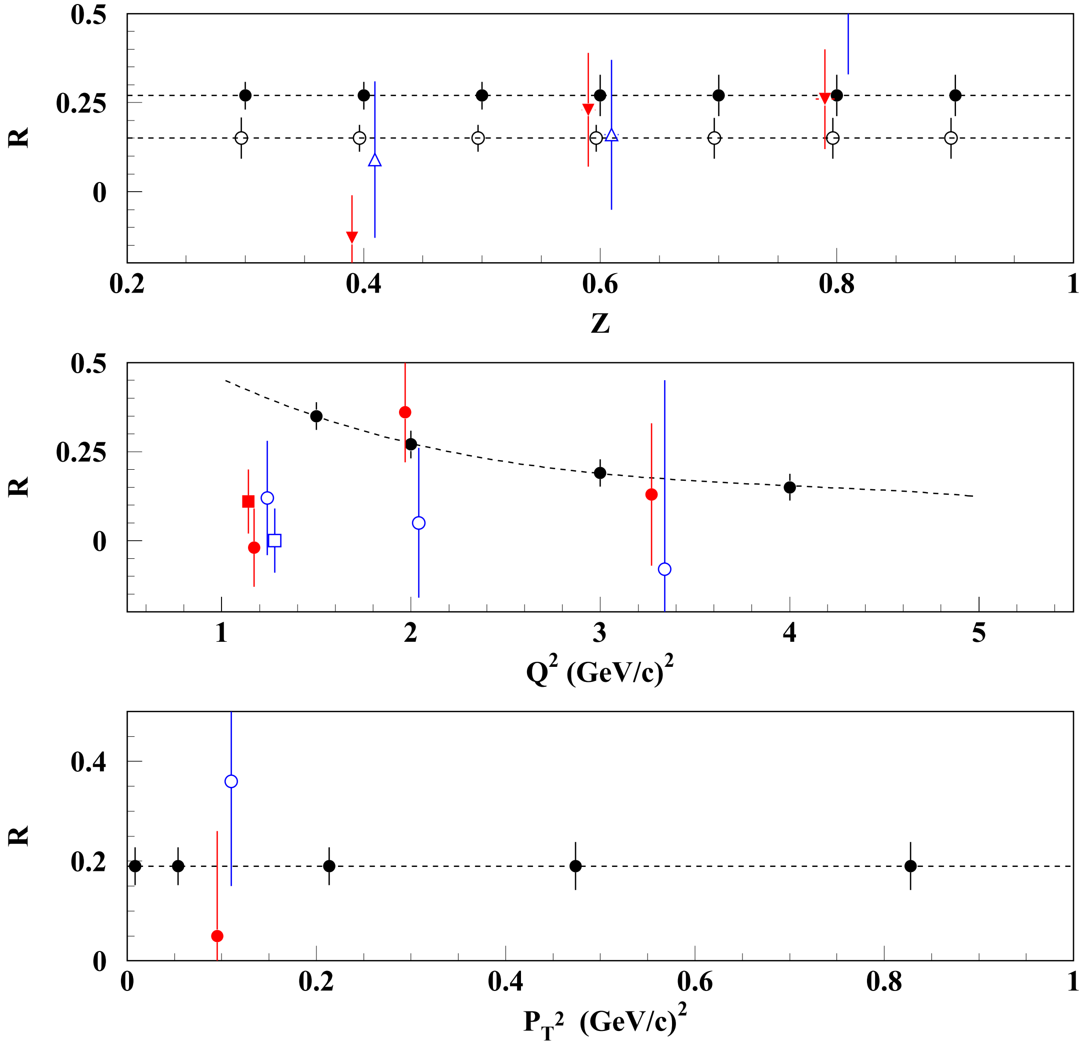
Questions? Comments?

Backup Slides

Sources of Systematic Uncertainties

Source	Type of systematic uncertainty pt-to-pt (%)	t-correlated (%)	scale (%)
Acceptance	0.4	0.4	1.0
Target Thickness		0.2	0.8
Beam Charge		0.2	0.5
HMS+SHMS Tracking	0.1	0.1	1.5
Coincidence Blocking		0.2	
PID		0.4	
π Decay	0.03		0.5
π Absorption		0.1	1.5
Monte Carlo Generator	0.2	1.0	0.5
Radiative Corrections	0.1	0.4	2.0
Offsets	0.4	1.0	
Quadrature Sum	0.6	1.6	3.3
Fpi-2 Values	0.9	1.9	3.5

E12-06-104 Projections



Projections for E12-06-104 vs existing Cornell Data (projections assume $R_{SIDIS} = R_{DIS}$)
Comparable 1.6% systematic uncertainties not indicated

Projections: Solid Black H, Open Black D π
Cornell:
Top panel: solid red (open blue) π^+ (π^-) on LH_2
Middle : solid red (open blue) dots are π^+ (π^-) on LH_2
solid red (open blue) squares are π^+ (π^-) on LD_2
Bottom : solid red (open blue) dots are for π^+ (π^-) on LH_2

SHMS and HMS Detector Layouts

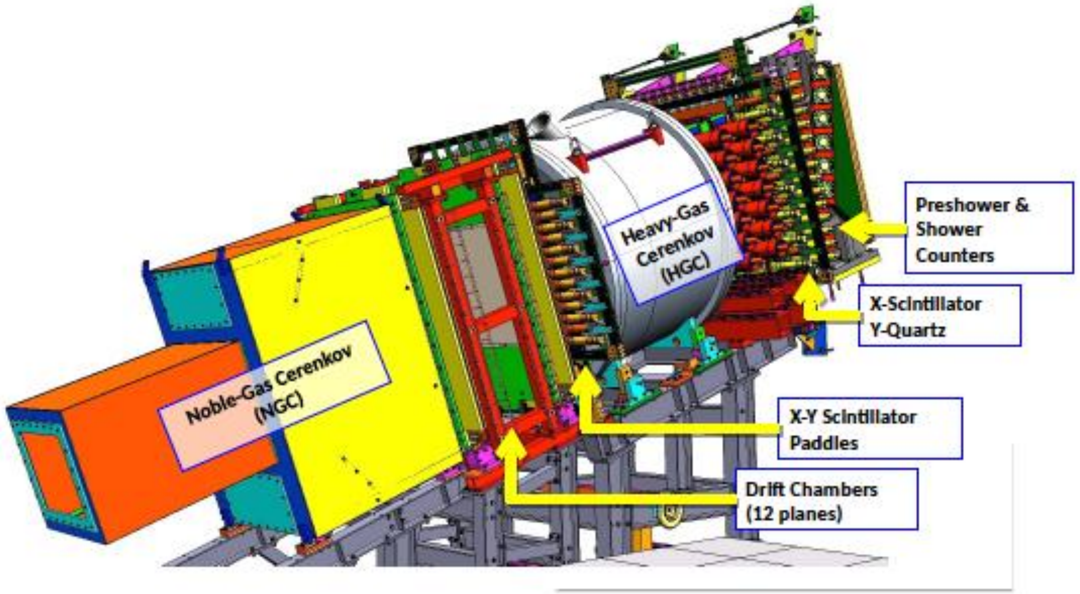


Figure 48: Typical detector layout for the SHMS.

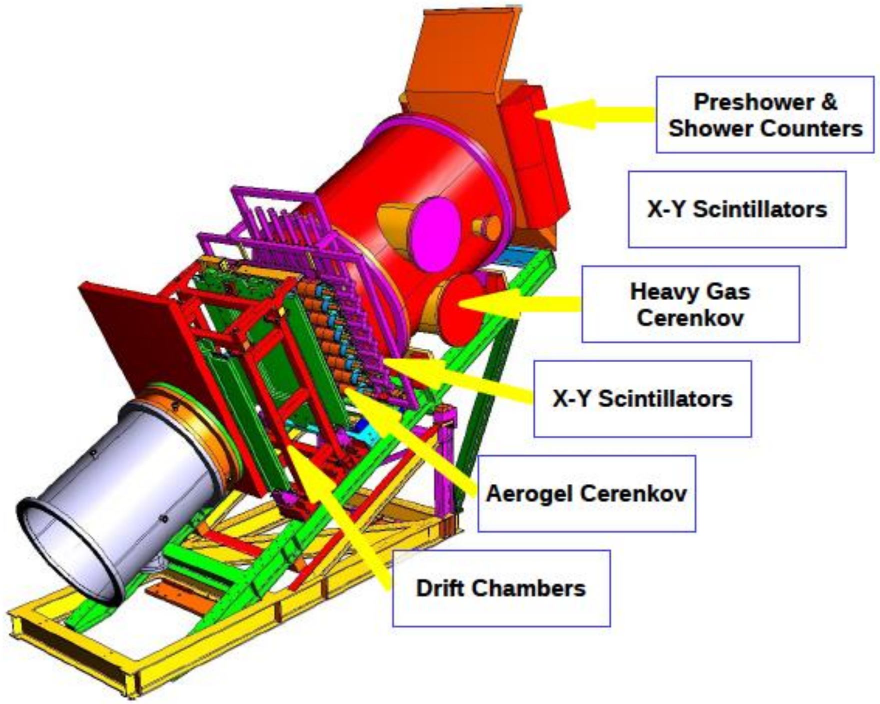


Figure 52: Typical detector layout for the HMS.

Plot from arxiv.org/abs/2503.08706

SHMS and HMS Detector Specifications

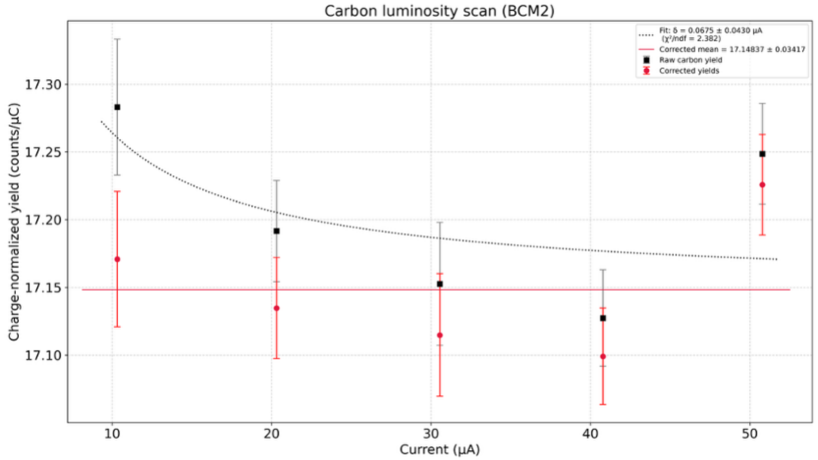
Parameter	*HMS Performance*	*SHMS Specification*
Range of Central Momentum	0.4 to 7.4 GeV/c	2 to 11 GeV/c
Momentum Acceptance	±10%	-10% to +22%
Momentum Resolution	0.1% – 0.15%	0.03% – 0.08%
Scattering Angle Range	10.5° to 90°	5.5° to 40°
Target Length Accepted at 90°	10 cm	50 cm
Horizontal Angle Acceptance	±32 mrad	±18 mrad
Vertical Angle Acceptance	±85 mrad	±50 mrad
Solid Angle Acceptance	8.1 msr	>4 msr
Horizontal Angle Resolution	0.8 mrad	0.5 – 1.2 mrad
Vertical Angle Resolution	1.0 mrad	0.3 – 1.1 mrad
Target resolution (ytar)	0.3 cm	0.1 - 0.3 cm
Maximum Event Rate	2000 Hz	10,000 Hz
Max. Flux within Acceptance	~ 5 MHz	~ 5 MHz
e/h Discrimination	>1000:1 at 98% efficiency	>1000:1 at 98% efficiency
π/K Discrimination	100:1 at 95% efficiency	100:1 at 95% efficiency

Boiling Correction for LD_2

Analysis by Julio Gutiérrez

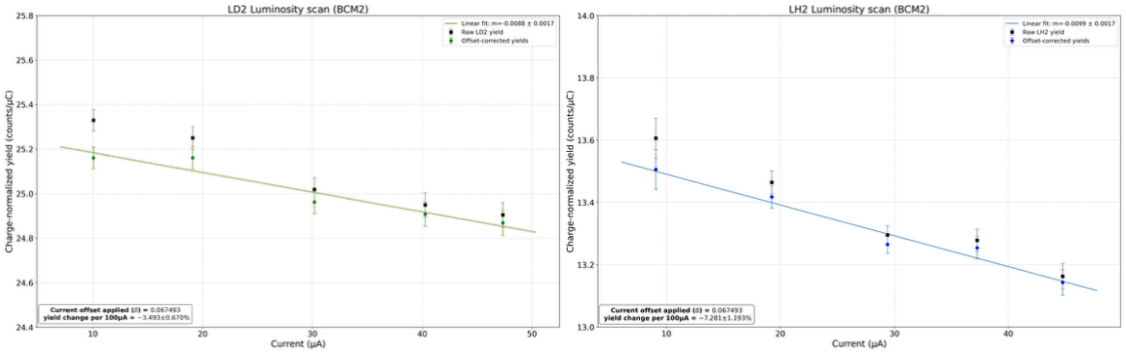
Luminosity studies

2. Perform chi-squared optimization to determine a global current offset that would "linearize" the corrected yield distribution $Y_{corr} = \frac{Y_{meas}}{1+\delta/I}$:



Luminosity studies

3. Apply the obtained offset to compute the boiling correction for liquid targets (in percentage of yield change per 100µA)



Author:	Julio Gil Gutierrez
Subject:	LH2 and LD2 luminosity studies

Edited: Thu Aug 21 22:50:26 2025 Edited: Thu Aug 21 22:50:23 2025 Edited: Thu Aug 21 22:50:18 2025

For this analysis, I first created a comparison plot of the charge-normalized yields measured in the Carbon luminosity scan runs as a function of the BCM2, BCM4A, and BCM4C measured currents. It was determined that BCM2 provided the most consistent measurements throughout the scan.

Next, using the same Carbon runs, I performed an optimization to determine the optimal current offset (δ) that would "linearize" the yield distribution according to Y_corr = Y_meas / (1+δ/I). The obtained offset was δ=0.067493.

Finally, I applied this offset using the expression above to the luminosity scan runs for LH2 and LD2 to determine the percentage yield change per 100 µA. The results obtained are the following:

LH2: - 7.281% / 100µA

LD2: -3.493% / 100µA

The low-current runs (3 µA and 7 µA) were excluded from this analysis because they were inconsistent with the rest of the yields and introduced significant uncertainty. A more detailed study of low-current behavior will be conducted in the future to complement this analysis.

Fan Frequency Correction Factors

Runs for Fan Frequency Scan:

25399	08/29	12:57	10.6716	35	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,2,-1,-1	HMSDIS	Fan speed scan: 50 Hz, 35 uA
25400	08/29	13:02	10.6716	45	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 50 Hz, 45 uA
25401	08/29	13:08	10.6716	60	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 50 Hz, 60 uA
25402	08/29	13:15	10.6716	60	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 43 Hz, 60 uA
25403	08/29	13:20	10.6716	45	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 43 Hz, 45 uA
25404	08/29	13:25	10.6716	35	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 43 Hz, 35 uA
25405	08/29	13:32	10.6716	20	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,2,-1,-1	HMSDIS	Fan speed scan: 43 Hz, 20 uA
25406	08/29	13:38	10.6716	10	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,0,-1,-1	HMSDIS	Fan speed scan: 43 Hz, 10 uA
25407	08/29	13:46	10.6716	10	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,0,-1,-1	HMSDIS	Fan speed scan: 35 Hz, 10 uA
25408	08/29	13:53	10.6716	20	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,1,-1,-1	HMSDIS	Fan speed scan: 35 Hz, 20 uA
25409	08/29	13:59	10.6716	35	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,2,-1,-1	HMSDIS	Fan speed scan: 35 Hz, 35 uA
25410	08/29	14:06	10.6716	45	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 35 Hz, 45 uA
25411	08/29	14:12	10.6716	60	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 35 Hz, 60 uA
25412	08/29	14:18	10.6716	60	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 30 Hz, 60 uA
25413	08/29	14:12	10.6716	45	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 30 Hz, 45 uA
25414	08/29	14:24	10.6716	35	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,2,-1,-1	HMSDIS	Fan speed scan: 30 Hz, 35 uA
25415	08/29	15:00	10.6716	20	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,1,-1,-1	HMSDIS	Fan speed scan: 30 Hz, 20 uA
25416	08/29	15:06	10.6716	10	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,0,-1,-1	HMSDIS	Fan speed scan: 30 Hz, 10 uA
25417	08/29	15:12	10.6716	10	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,0,-1,-1	HMSDIS	Fan speed scan: 25 Hz, 10 uA
25418	08/29	15:19	10.6716	10	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,1,-1,-1	HMSDIS	Fan speed scan: 25 Hz, 20 uA
!25419	08/29	15:25	10.6716	10	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,0,-1,-1	HMSDIS	JUNK
25420	08/29	15:25	10.6716	10	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,2,-1,-1	HMSDIS	Fan speed scan: 25 Hz, 35 uA
25421	08/29	15:32	10.6716	10	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 25 Hz, 45 uA
25422	08/29	15:38	10.6716	10	LH2	-3.642	16.750	+3.632	16.810	-1,-1,-1,3,-1,-1	HMSDIS	Fan speed scan: 25 Hz, 60 uA

Slides from Julio:

$$Y(f,I) = (\alpha_2 I^2 + \alpha_1 I + \alpha_0) f^2 + (\beta_2 I^2 + \beta_1 I + \beta_0) f + (\gamma_2 I^2 + \gamma_1 I + \gamma_0)$$

From here, we define our "reference" yield as the yield function $Y(f,I)$ evaluated at at zero current (i.e. the frequency dependance at zero current):

$$Y_{ref}(f) \coloneqq Y(f; I=0) = \alpha_0 f^2 + \beta_0 + \gamma_0$$

And we define the correction factor (for an arbitrary yield $Y(f,I)$) as:

$$C(f,I) = \frac{Y_{ref}(f)}{Y_{fit}(f,I)}$$

where, the obtained fitting coefficients are:

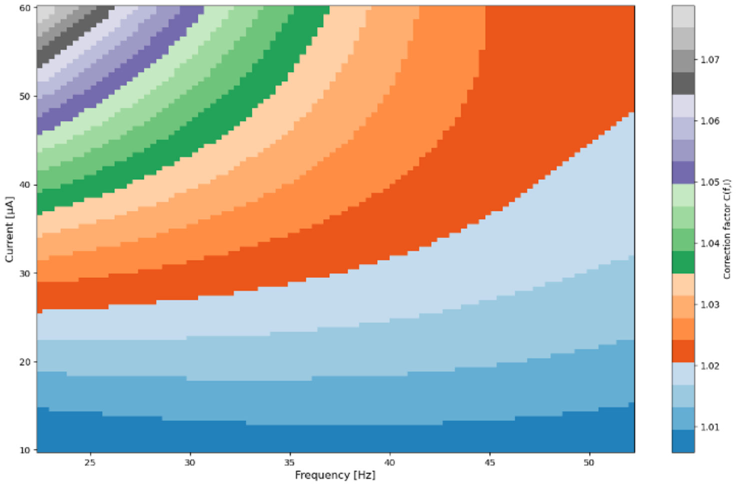
$$\begin{pmatrix} \alpha_2, \alpha_1, \alpha_0 \\ \beta_2, \beta_1, \beta_0 \\ \gamma_2, \gamma_1, \gamma_0 \end{pmatrix} = \begin{pmatrix} -4.63644107e{-}06 & 1.30424412e{-}04 & 7.98013139e{-}05 \\ 4.37559009e{-}04 & -1.09899399e{-}02 & -5.56375520e{-}03 \\ -9.31940585e{-}03 & 1.15703945e{-}01 & 1.43953881e{+}02 \end{pmatrix}$$

Fan speed studies

4. Extrapolate the correction factor to be applied to suppress the difference in fan frequency

$$Y_{ref}(f) \coloneqq Y(f; I=0) = \alpha_0 f^2 + \beta_0 + \gamma_0$$

$$C(f,I) = \frac{Y_{ref}(f)}{Y_{fit}(f,I)}$$



SIDIS Model in Simulation

$$\sigma_{SIDIS} = \sigma_{DIS}(x, Q^2, \epsilon) M_{SIDIS}(z, P_t, \phi^*, x, Q^2).$$

The z-dependence of the multiplicity function $M_{SIDIS}(z, P_t, \phi^*, x, Q^2)$ is given by:

$$\begin{aligned}
zM_{p\pi^+}(z,x,Q^2) &= (q_u^2 u D_f + q_u^2 \bar{u} D_u + q_d^2 d D_u + q_d^2 \bar{d} D_f + q_s^2 s D_u + q_s^2 \bar{s} D_u) / \sum (q_i)^2 \\
zM_{p\pi^-}(z,x,Q^2) &= (q_u^2 u D_u + q_u^2 \bar{u} D_f + q_d^2 d D_f + q_d^2 \bar{d} D_u + q_s^2 s D_u + q_s^2 \bar{s} D_u) / \sum (q_i)^2 \\
zM_{n\pi^+}(z,x,Q^2) &= (q_u^2 d D_f + q_u^2 \bar{d} D_u + q_d^2 u D_u + q_d^2 \bar{u} D_f + q_s^2 s D_u + q_s^2 \bar{s} D_u) / \sum (q_i)^2 \\
zM_{n\pi^-}(z,x,Q^2) &= (q_u^2 d D_u + q_u^2 \bar{d} D_f + q_d^2 u D_f + q_d^2 \bar{u} D_u + q_s^2 s D_u + q_s^2 \bar{s} D_u) / \sum (q_i)^2 \quad (3)
\end{aligned}$$

The P_t-dependence of the multiplicity functions was incorporated as:

$$M_{p/n\pi^\pm}(z, P_t, \phi^*, x, Q^2) = \frac{1}{2\pi} M_0(z, x, Q^2) b e^{-bP_t^2}, \quad (6)$$

i.e., a Gaussian distribution with the parameter $b = (0.12z^2 + 0.2)^{-1}$ GeV^{-2}, common to all processes with amplitude $M_0(z, x, Q^2)$. Note that we do not have any azimuthal dependence in this fit, consistent with the results of the present experiment. Also note that we do not have a factorized expression: the multiplicity function depends on the electron variables (x, Q^2, W), which we found necessary to describe the data of this experiment.

P. Bosted et al, arXiv:2510.03562

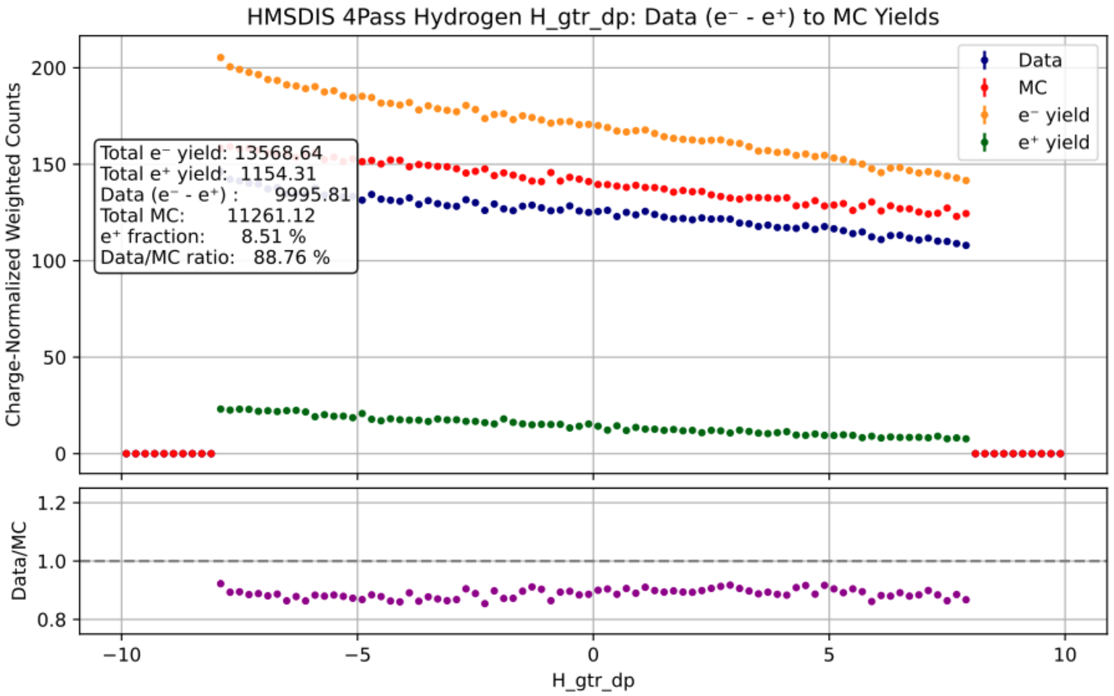
Beam SSA Formalism

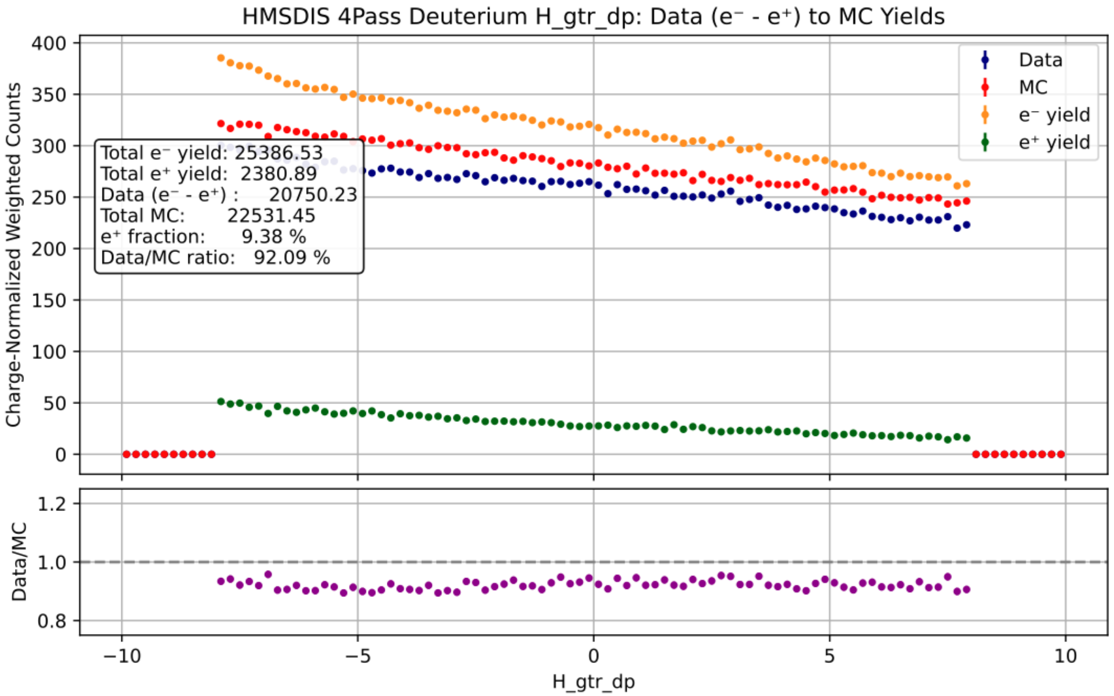
$$A_{LU}(Q^2, x_B, t, \phi) = \frac{\sqrt{2\epsilon(1-\epsilon)}\frac{\sigma_{LT'}}{\sigma_0}\sin\phi}{1+\sqrt{2\epsilon(1+\epsilon)}\frac{\sigma_{LT}}{\sigma_0}\cos\phi+\epsilon\frac{\sigma_{TT}}{\sigma_0}\cos 2\phi},$$

$$A_{LU} = \frac{1}{P}\left(\frac{Y^+ - Y^-}{Y^+ + Y^-}\right)$$

DIS on LH2 and LD2 – Data/MC Comparison

Analysis by Ryan Elder





R-SIDIS Part I (Slides from Mark Jones)

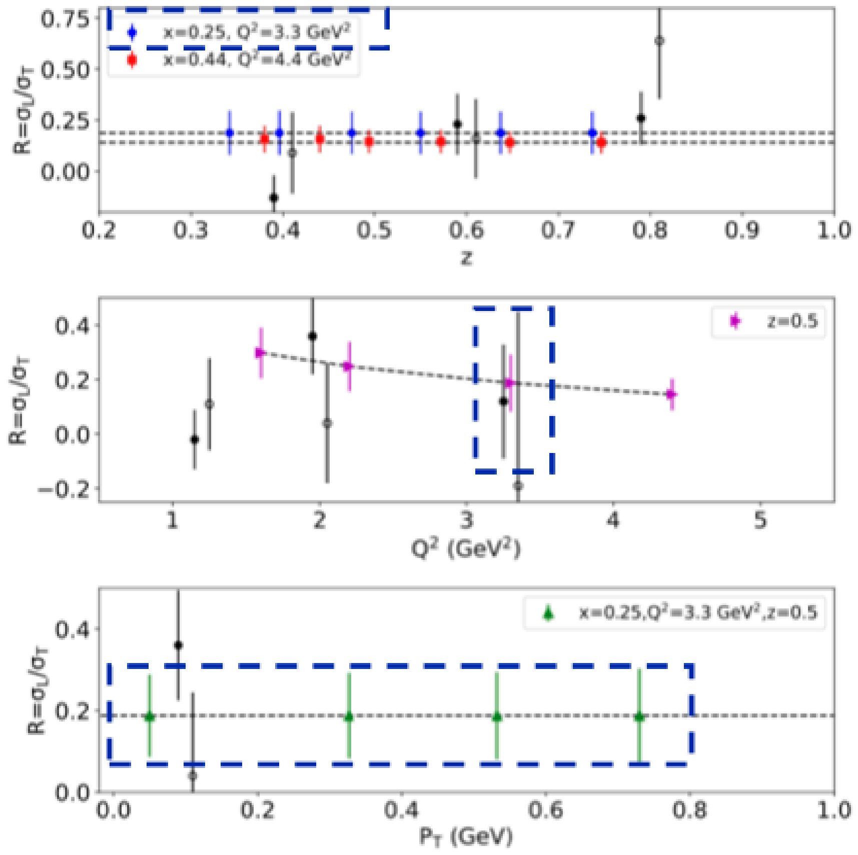
Hall C FY25 run: R-SIDIS

First half of R-SIDIS experiments (E12-06-104 and E12-24-001) completed

Goal: Measure $R=\sigma_L/\sigma_T$ in SIDIS, nuclear dependence

→ Took data at 2 beam energies (epsilon settings) for $x=0.25$, $Q^2=3.3\ \text{GeV}^2$
  - → z-scan for π+ and π- from H, D, C, Cu
  - → P_T scan at z=0.5 for p+ from H, D, C, Cu
  - → Measurements at z=1 for kinematics/radiation correction models input

→ Experiments will be completed during 2026 run
  - → z-scan at x=0.44
  - → complete x/Q^2-scan at z=0.5



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Jefferson Lab