Deuteron Electro-Disintegration at Very High Missing Momenta (E12-10-003)

HALL C WINTER COLLABORATION MEETING

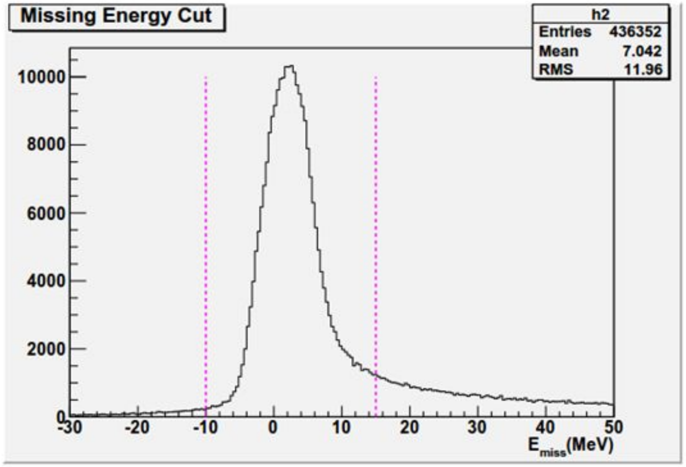
Date: January 21, 2017

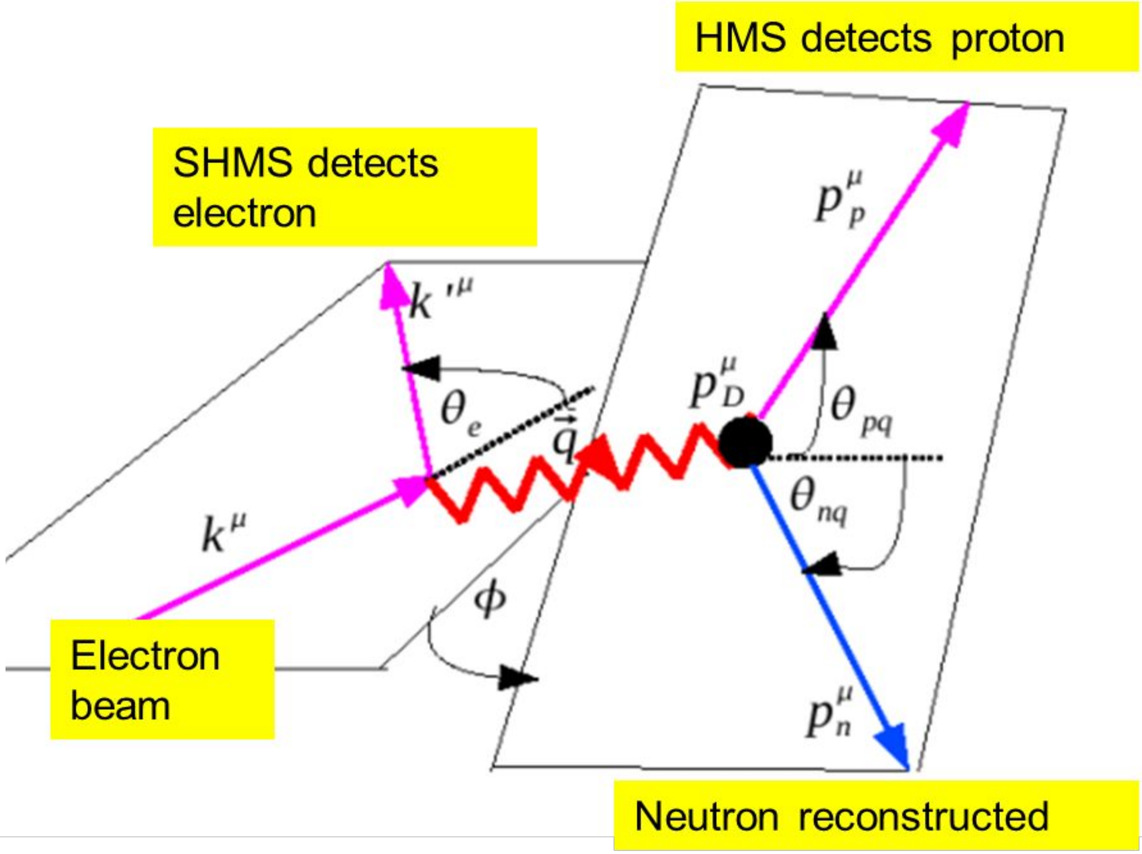
Spokespersons: W. Boeglin (FIU) and M Jones (Jlab)

Graduate Student: Carlos Yero (FIU)

Beam time is 3 PAC days at beam energy of 10.6 GeV

Study the D(e,e'p)n exclusive reaction by using cut on missing energy.

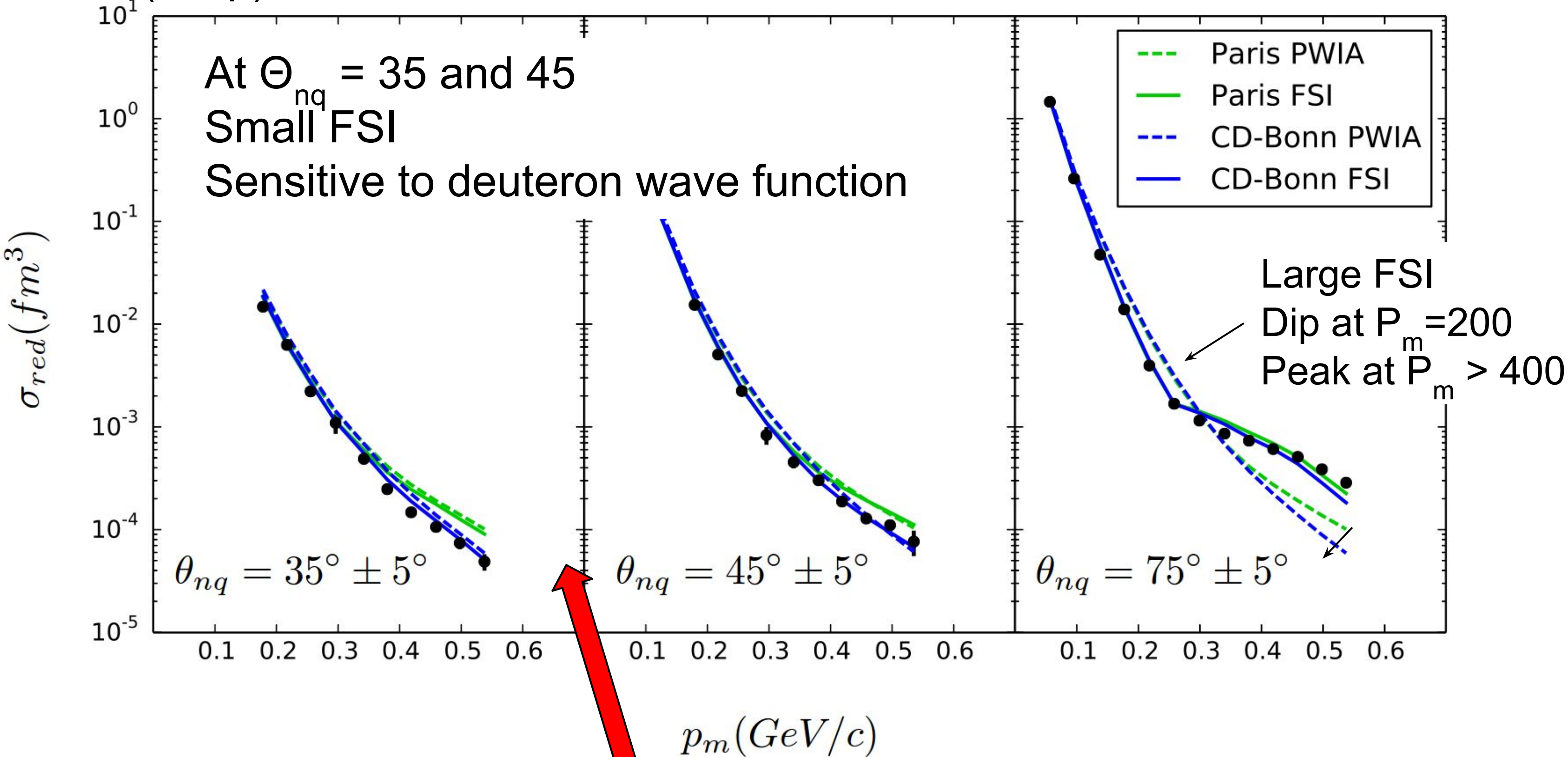




Previous Hall A experiment

Compare reduced cross section to theoretical calculation of only PWIA, PWIA+FSI with different NN potentials. In PWIA, σ_{red} maps the momentum distribution.

Data for d(e,e'p) n reaction at $Q^2 = 3.25$ GeV^2.

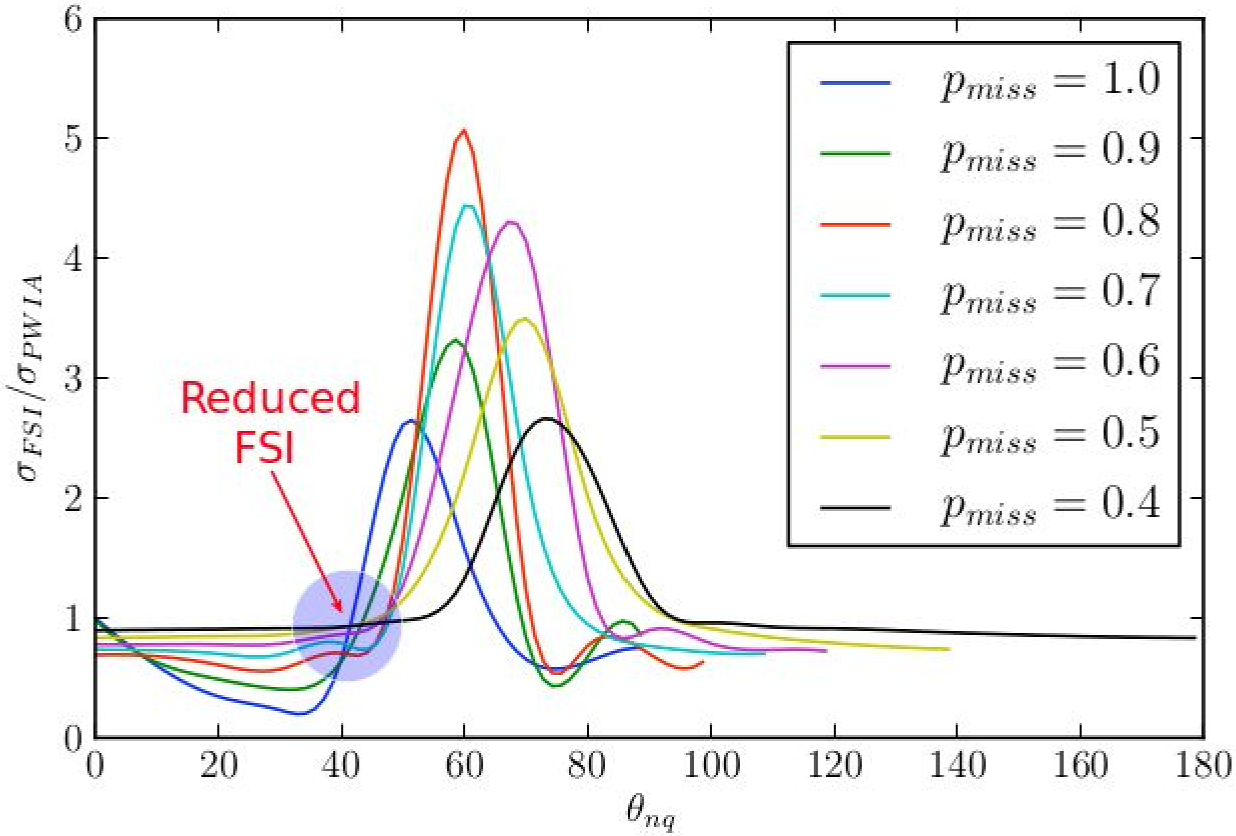


New Hall C will focus at θ_{nq} ~ 40^o and p_m > 500 at Q^2 = 4.25 where the difference to NN potential is larger

D(e,e'p)n Theoretical Support

<u>D(e,e'p)n Kinematics</u>
E_{BEAM} = 11.0 GeV
Q^2 = 4.25 $(GeV/c)^2$
x_{Bj} = 1.35
p_m = 0.5 - 1.0 GeV/c
θ_{nq} = 40°

W.U. Boeglin et. al
Int.J.Mod.Phys. E24
(2015) no.03,
1530003



At $\theta_{nq} \sim 40^o$, FSI have weak dependence on p_{miss}

Calculation: M. Sargsian

E12-10-003 Collaboration

Motivation:

- Investigate short range structure of the deuteron (high momentum components)
- Explore a new kinematical region of the 2-nucleon system above p_m> 500
- No Deuteron data exist at these kinematics!
- Short range correlation studies cover similar region on missing momenta
- Models are able to reproduce the present data within 20%.
- Signs of a dependence on NN potential at highest missing momentum

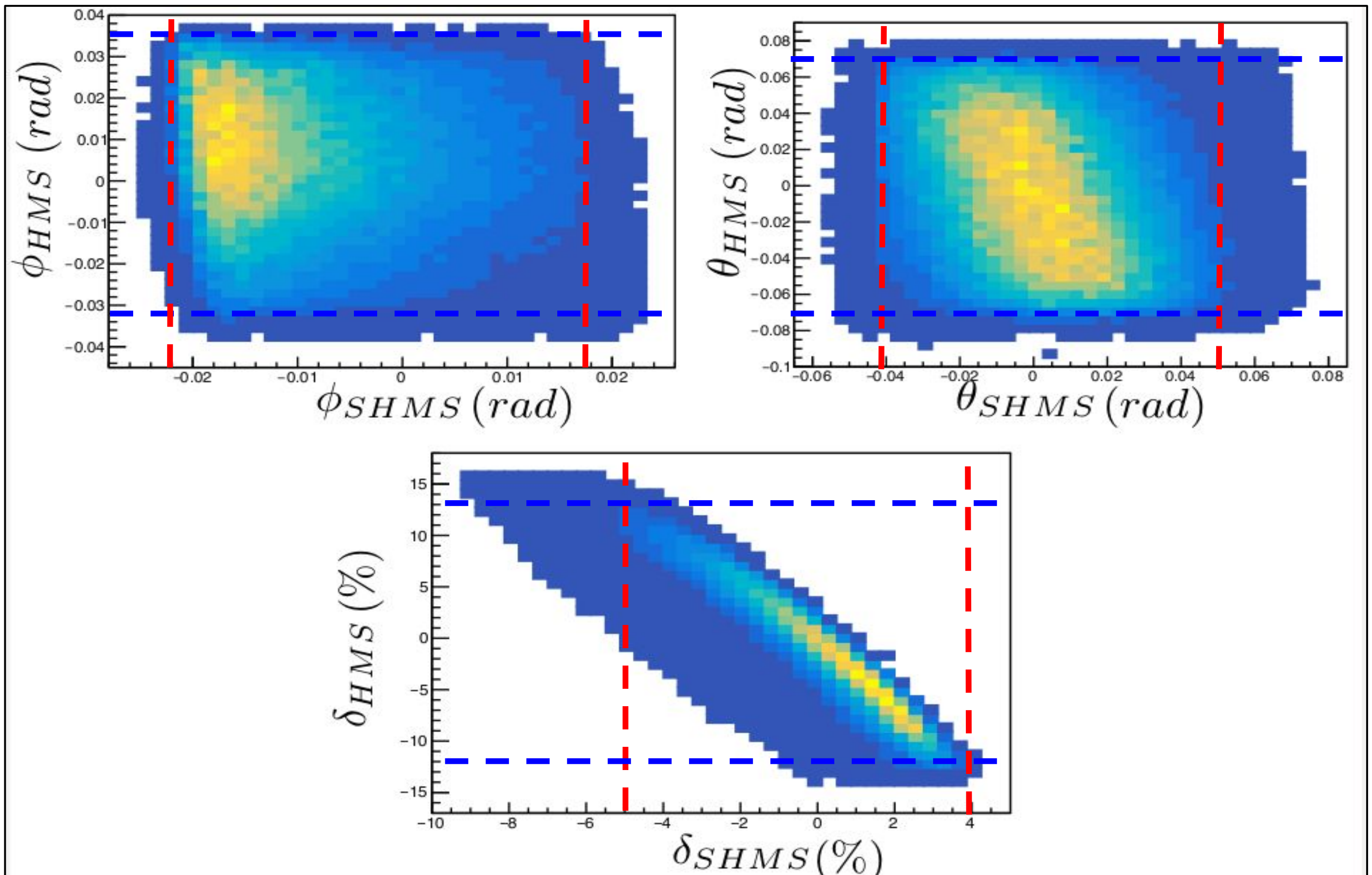
The experiment will:

- Determine cross sections at missing momenta above 0.5 GeV/c
- Measure at well defined kinematic settings at Q^2 = 4.25
- Selected kinematics to minimize contributions from FSI
- Selected kinematics to minimize effects of delta excitation

Outline a scaled down version of the experiment for the Hall C commissioning period.

Spectrometer Acceptance Requirements During D(e,e'p)n Commissioning

- D(e,e'p)n will **NOT** use the full SHMS Acceptance
- SIMC kinematic setting: p_{miss} = 500 MeV

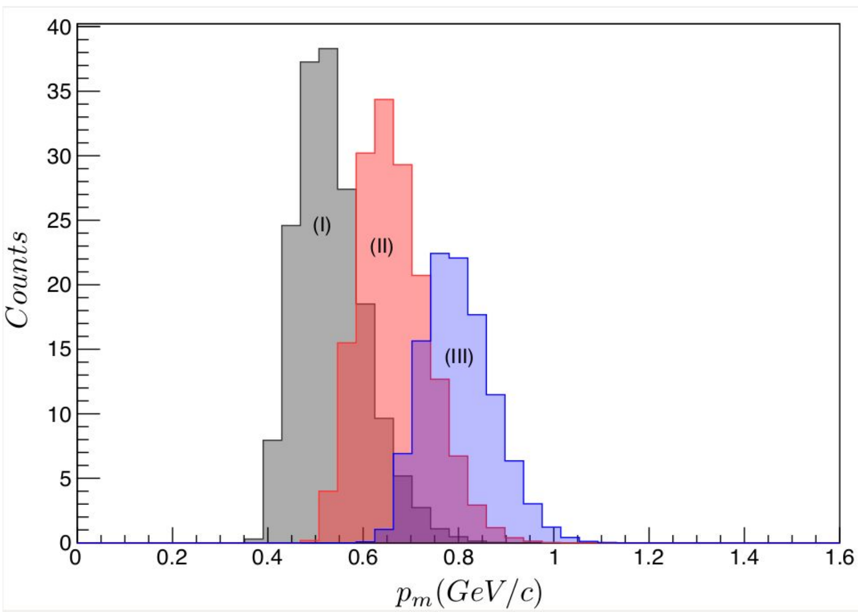


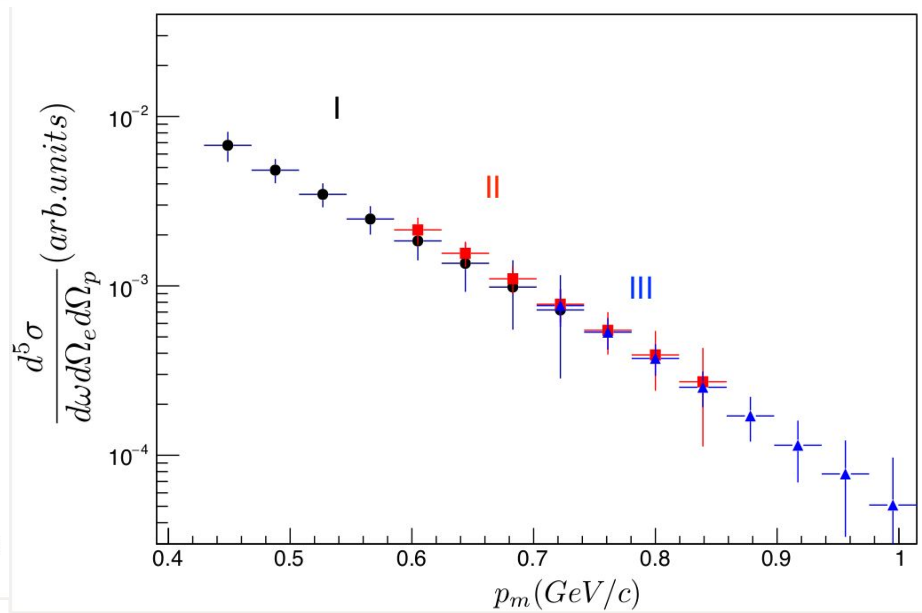
Kinematics and Beam Time

Beam:
Energy: 10.6 GeV
Current: 70μA
Target:
LD_2 (10 cm)

Electron arm *fixed* at:
SHMS at p_{cen} = 8.92 GeV/c
$\theta_e = 12.17^o$ $Q^2 = 4.25\ (GeV/c)^2$
x = 1.35 $\theta_{nq} \sim 40^o$

Vary Proton arm to measure :
p_m = 0.5, 0.65, 0.8 GeV/c
HMS $2.12 \le p_{cen} \le 2.3$ GeV/c
Angles: $59.6^o \ge \theta_p \ge 53.1$





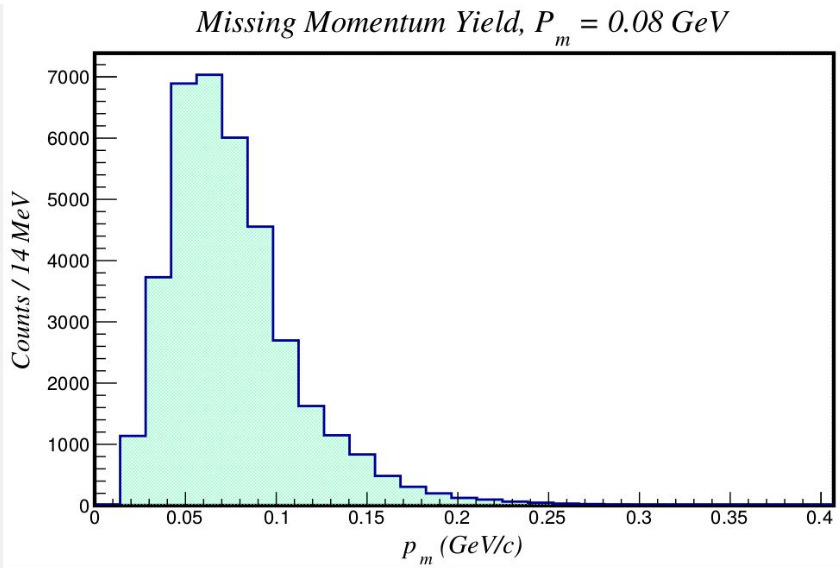
SIMC Results (Radiative Corr.)	Statistical Uncertainties
I. p_m = 0.5 (GeV/c), beam time 8 hours	16.1 %
II. p_m = 0.65 (GeV/c), beam time 18 hours	17.0 %
III. p_m = 0.8 (GeV/c), beam time 36 hours	20.9 %

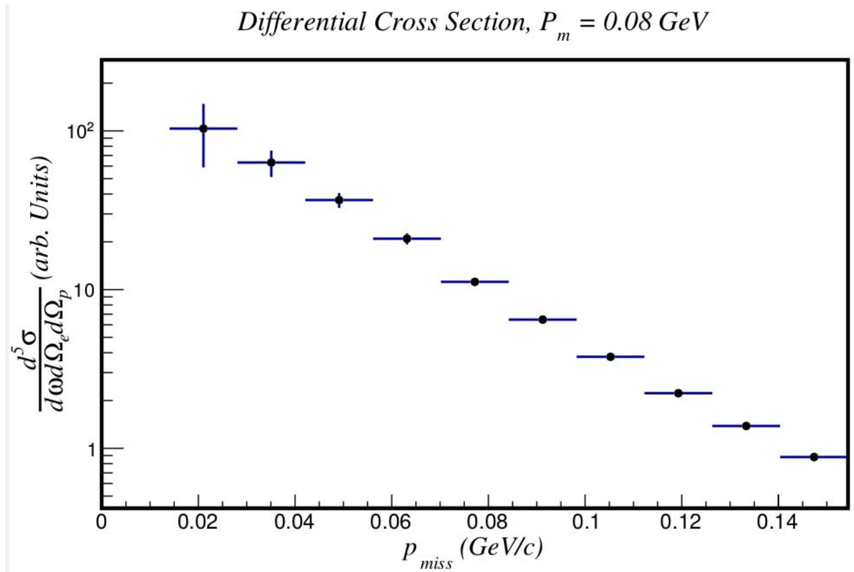
Calibration Run Kinematics

Beam:
Energy: 10.6 GeV
Current: 70μA
Target:
LD_2 (10 cm)

Electron arm *fixed* at:
SHMS at p_{cen} = 8.44 GeV/c
$\theta_e = 12.51^o$ $Q^2 = 4.25\ (GeV/c)^2$
x = 1.05 $\theta_{nq} \sim 59^o$

Proton arm to measure:
p_m = 0.08 GeV/c
HMS at p_{cen} = 2.94 GeV/c
Angle: $\theta_p = 39.14^o$





SIMC Results (Radiative Corr.) — Statistical Uncertainty

p_m = 0.08 - 0.1 (GeV/c), beam time 1 hour — (1.29 - 1.9) %

- compare to real data at same kinematics for cross-calibration

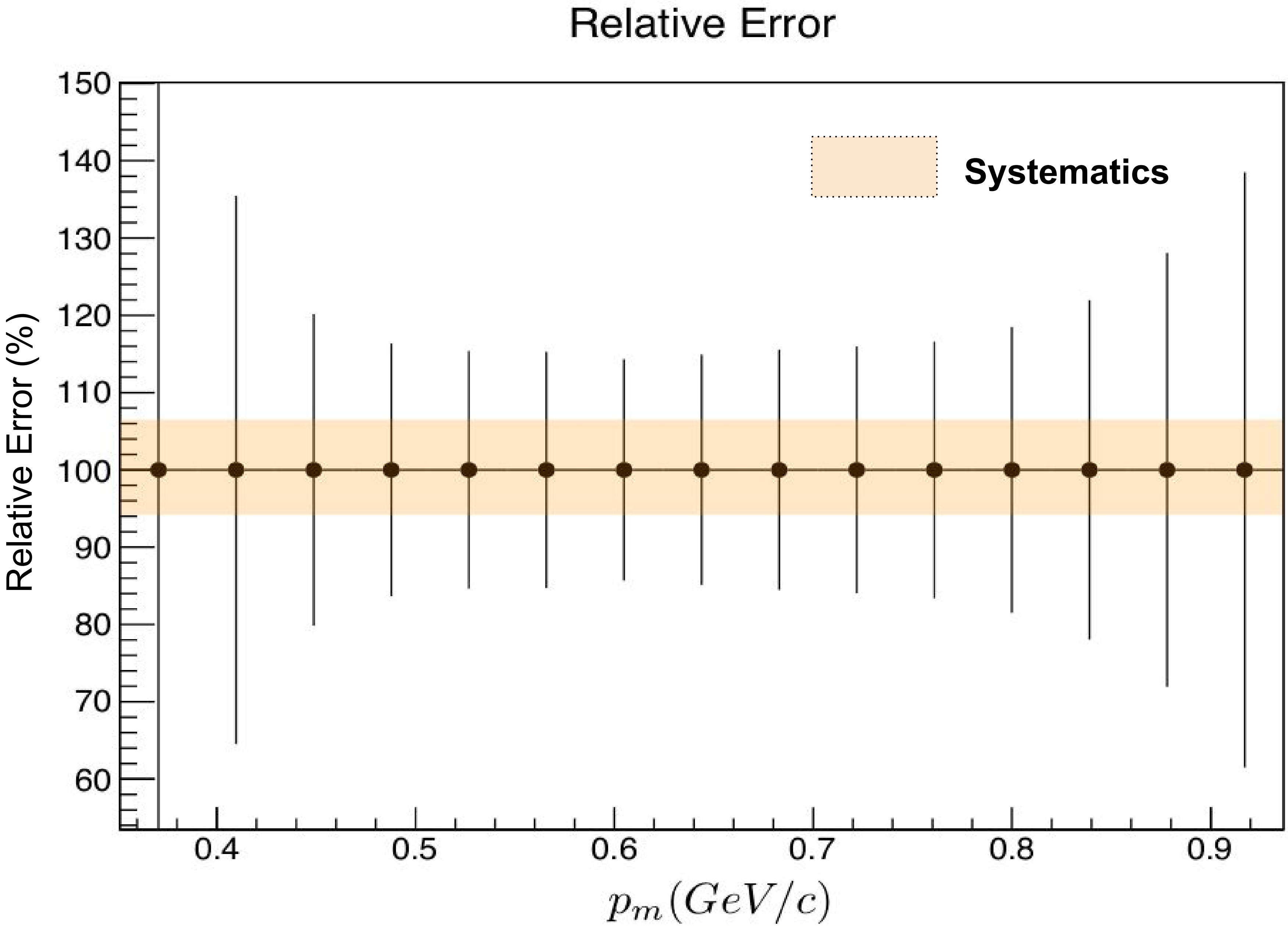
Yields and Cross-Section Sensitivity to Kinematic Uncertainties

Kinematic Variable	Symbol	Conservative Kinematic Uncertainty	Optimum Kinematics Uncertainty
Beam Energy E_{BEAM}	$\Delta E / E$	1×10^{-3}	5×10^{-4}
Electron Final Momentum $\mathbf{k_f}$	$\Delta P / P$	1×10^{-3}	5×10^{-4}
Proton Final Momentum $\mathbf{P_f}$	$\Delta P / P$	1×10^{-3}	5×10^{-4}
Electron Scattering Angle θ_e	$\Delta\theta$	$\mp$ 1 mrad	$\mp$ 0.2 mrad
Proton Scattering Angle θ_p	$\Delta\theta$	$\mp$ 1 mrad	$\mp$ 0.2 mrad

- **Investigate small variations of kinematic variables on yields and final cross-section for systematics**

Systematics @ P_{miss} = 0.80 GeV

P_{miss}(GeV/c)	Total Error in $d\sigma/d\Omega$ (%)	$E_{INCIDENT}$(%)	E_{FINAL}(%)	$\Delta\theta_e$(%)	$\Delta\theta_p$(%)
0.69	7.4	1.1	0.6	7.0	2.2
0.72	7.6	1.2	0.7	7.1	2.3
0.76	7.8	1.2	0.8	7.2	2.5
0.80	8.1	1.3	0.9	7.5	2.7
0.84	8.5	1.3	1.0	7.8	2.9
0.88	9.0	1.4	1.1	8.2	3.1
0.91	9.5	1.5	1.2	8.6	3.4
0.95	10.2	1.6	1.3	9.2	3.7
0.99	11.2	1.8	1.4	10.0	4.1


Relative Error
Systematics
Relative Error (%)
150
140
130
120
110
100
90
80
70
60
0.4
0.5
0.6
0.7
0.8
0.9
$p_m (GeV/c)$

Summary

- First meaningful data at very high missing momenta obtainable during commissioning period
- Systematic errors due to uncertainties in kinematic variables are smaller than statistical
- Requirements on initial spectrometer performance realistic
- 3 days of beam time required
- Good opportunity to obtain new early physics results.

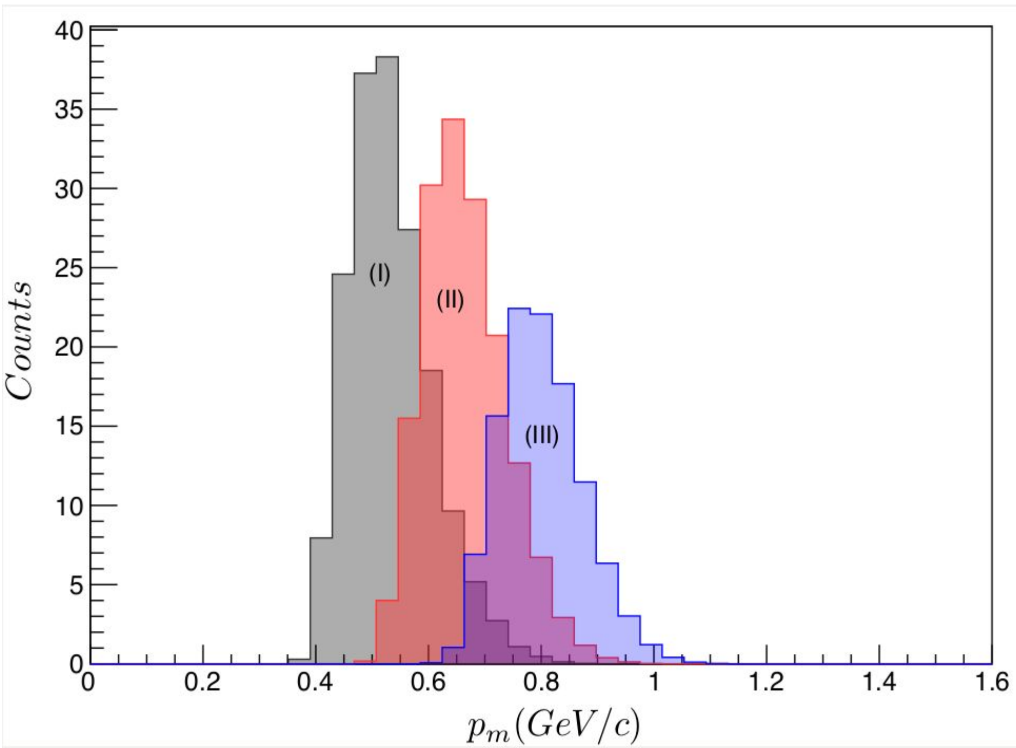
Acknowledgements

Thanks to Drs. W.U. Boeglin, M. Jones and M. Sargsian for their contributions to the D(e,e’p)n experiment and theory.

Nuclear Regulatory Commission (NRC) graduate fellowship recipient Carlos Yero was supported by the NRC fellowship grant No: NRC-HQ-84-14-G-0040 to FIU and by the DOE grant DE-SC0013620

BACKUP SLIDES

Cuts Applied to Extract Yield



Kinematic Cuts:

-10 MeV ≤ E_{miss} ≤ 25 MeV

$35^o < \theta_{nq} < 45^o$

$1.30 < x_{Bj} < 1.40$

$3.1 \leq Q^2 \leq 5.2$

Solid Angle Cuts:

e-arm (SHMS) $|dx/dz)_{target}| = |\theta_{target}| \leq 0.05$ rad

$|dy/dz)_{target}| = |\phi_{target}| \leq 0.025$ rad

p-arm (HMS) $|dx/dz)_{target}| = |\theta_{target}| \leq 0.08$ rad

$|dy/dz)_{target}| = |\phi_{target}| \leq 0.035$ rad

Momentum Acceptance Cuts:

e-arm (SHMS) $-8\% \leq \delta_e \leq 4\%$

p-arm (HMS) $-15\% \leq \delta_p \leq 15\%$

Systematics @ P_{miss} = 0.5 GeV

- Systematics governed by electron scattering angle θ_e

P_{miss}(GeV/c)	Total Error in dσ/dΩ (%)	$E_{INCIDENT}$(%)	E_{FINAL}(%)	$\Delta\theta_e$(%)	$\Delta\theta_p$(%)
0.41	8.1	1.4	0.3	7.7	1.9
0.45	7.3	1.2	0.3	6.9	1.8
0.49	6.8	1.1	0.4	6.4	1.8
0.53	6.6	1.0	0.5	6.2	1.8
0.56	6.5	1.0	0.5	6.1	1.9
0.60	6.6	1.0	0.6	6.1	2.0
0.64	6.7	1.0	0.7	6.2	2.1
0.68	6.9	1.0	0.7	6.3	2.2
0.72	7.4	1.1	0.8	6.6	2.4

Systematics @ P_{miss} = 0.65 GeV

P_{miss}(GeV/c)	Total Error in $d\sigma/d\Omega$ (%)	$E_{INCIDENT}$(%)	E_{FINAL}(%)	$\Delta\theta_e$(%)	$\Delta\theta_p$(%)
0.53	7.0	1.1	0.4	6.6	1.7
0.57	6.8	1.1	0.5	6.4	1.8
0.61	6.8	1.0	0.6	6.4	2.0
0.64	6.8	1.0	0.6	6.4	2.1
0.68	7.0	1.1	0.7	6.5	2.2
0.72	7.3	1.1	0.8	6.7	2.4
0.76	7.5	1.1	0.9	6.9	2.6
0.80	7.9	1.2	0.9	7.2	2.7
0.84	8.3	1.3	1.0	7.5	2.9