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

Summer 2022 Hall A/C Collaboration Meeting

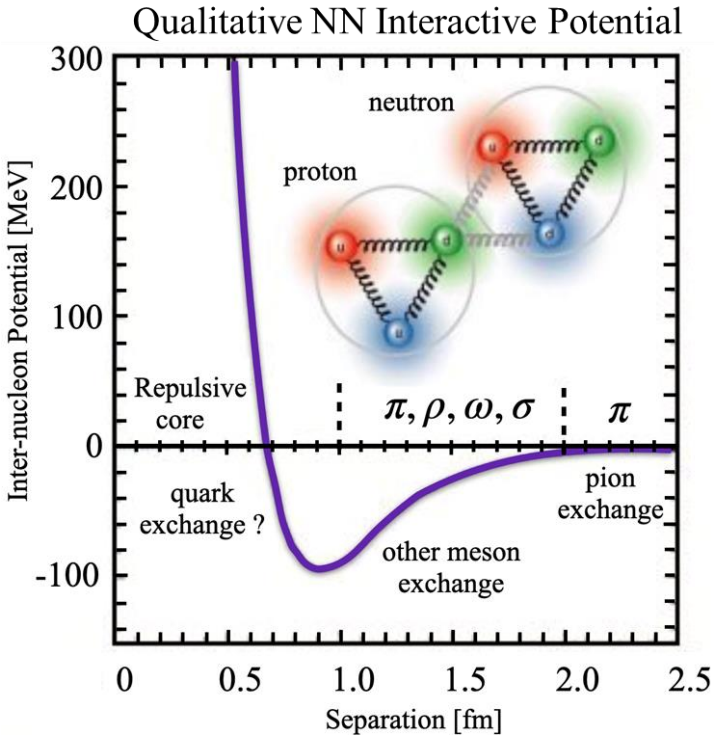
C. Yero
(Spokesperson)
Old Dominion University

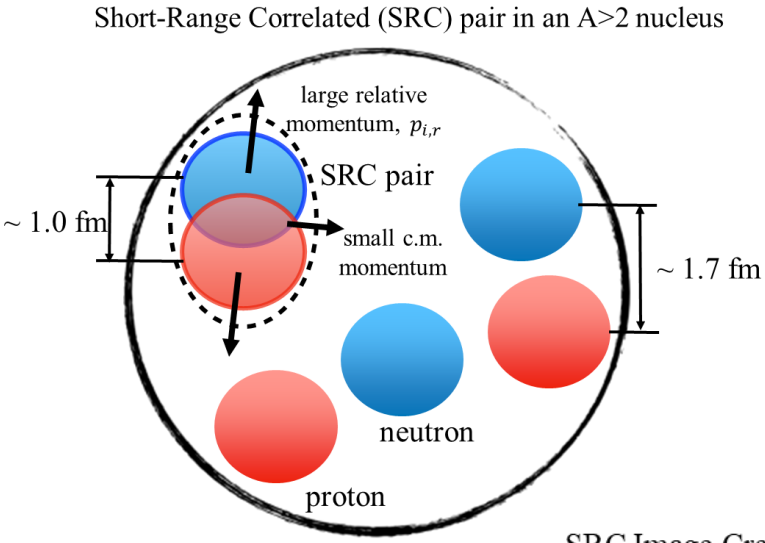
M.K. Jones
(Spokesperson)
Thomas Jefferson National Accelerator Facility

W.U. Boeglin
(Spokesperson, contact)
Florida International University

Motivation for experiment

- NN interaction NOT well understood at the sub-Fermi (<1 fm) distance scale
- Non-nucleonic degrees of freedom, relativistic treatment of deuteron becomes important
- Deuteron most simple np bound system
  - d(e, e'p)n ideal for probing repulsive part of NN interaction
- Solid understanding of final state interactions (FSI) required, theoretical calculations of FSI not as reliable for A>2





SRC Image Credit:
Dr. Lawrence Weinstein

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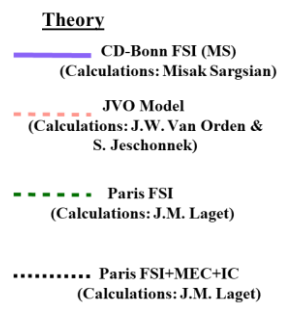
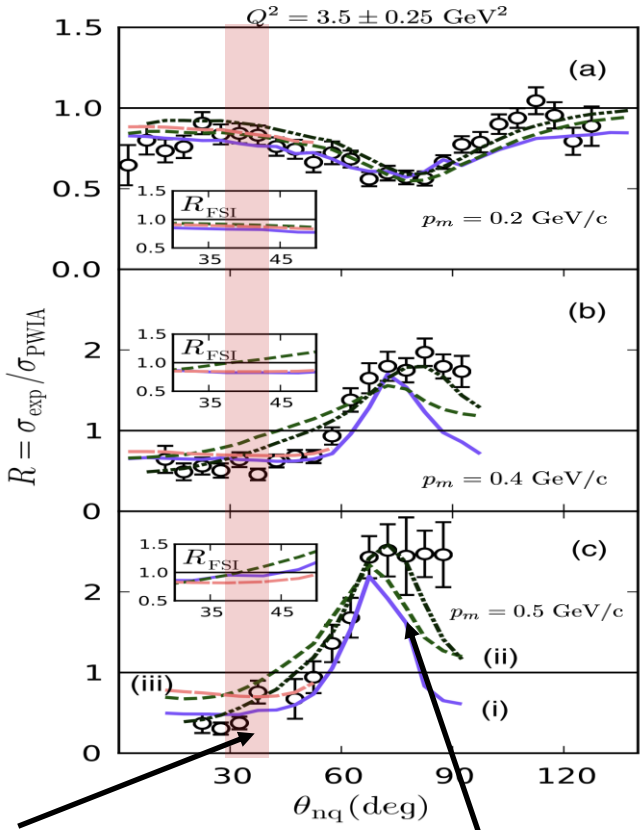
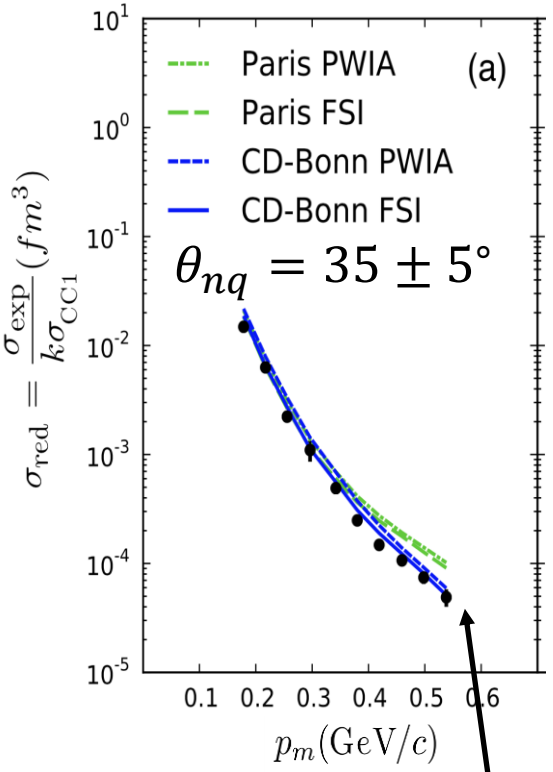
Previous Hall A experiments

JLab Hall A (2011)







Reduced FSIs at ~40 deg (R ~ 1)
genuine momentum distributions probed

FSI peaks at ~70 deg, predicted by:

1. Misak Sargsian using the Generalized Eikonal Approximation or GEA)
2. J.M. Laget using a diagrammatic approach

small FSI, enhanced sensitivity of cross-section to different models

data above ~500 MeV/c needed to probe repulsive part of the NN interaction

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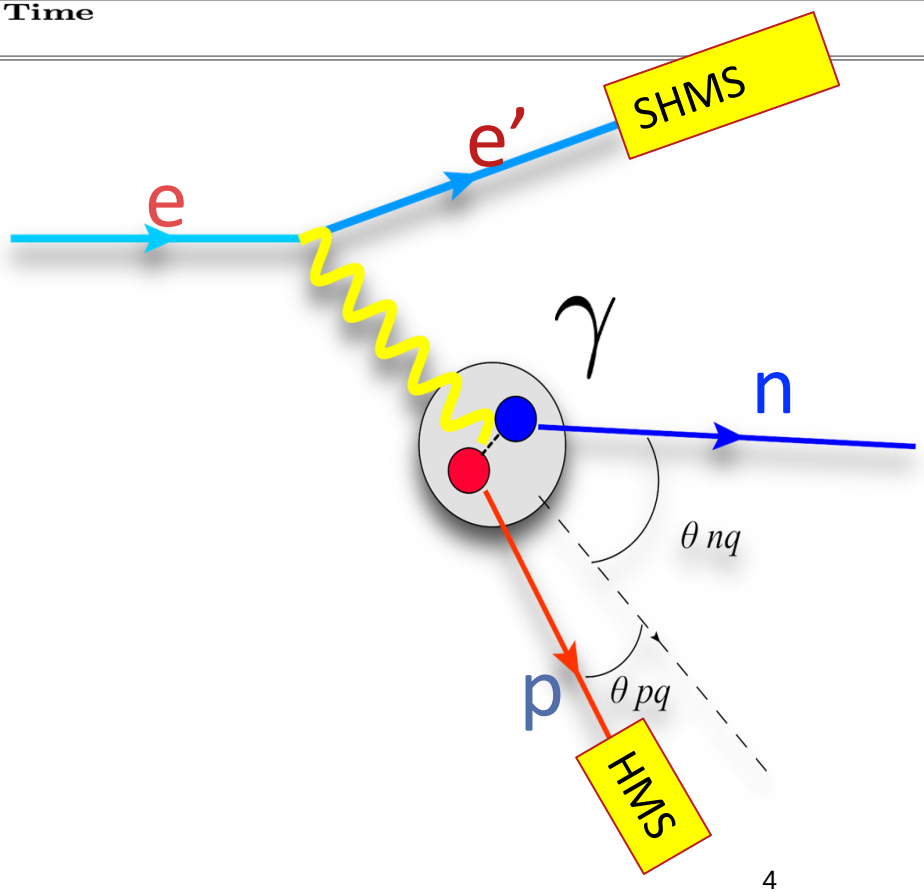
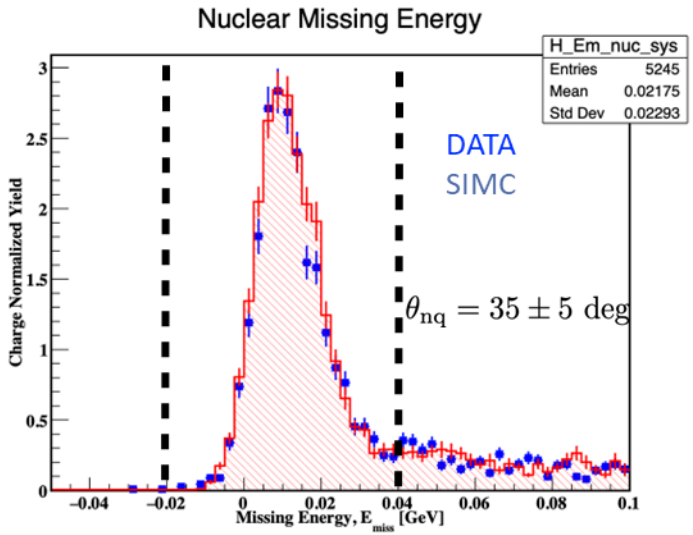
D(e,e'p) commissioning experiment

d(e, e'p)n commissioning kinematics

Beam Energy: 10.6 GeV
Beam Current: 45-60 μA

p_m (GeV/c)	k_f (GeV/c)	θ_e (deg)	$\|\vec{q}\|$ (GeV/c)	p_f (GeV/c)	θ_p (deg)	θ_{pq} (deg)	Charge (mC)	Time (hrs)
0.08	8.534	12.19	2.89	2.84	38.8	1.21	142.14	1.48
0.58	8.534	12.19	2.89	2.19	54.99	11.2	3618.6	36
0.75	8.534	12.19	2.89	2.09	58.39	14.7	8307.2	84
Total Charge							12068	
optics checkout								
hydrogen elastics								
proton absorption								22.6
Total Time								144 hrs (3 PAC days)





Exclusive d(e, e'p)n reaction selected via Missing Energy Cut

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Published results of commissioning experiment

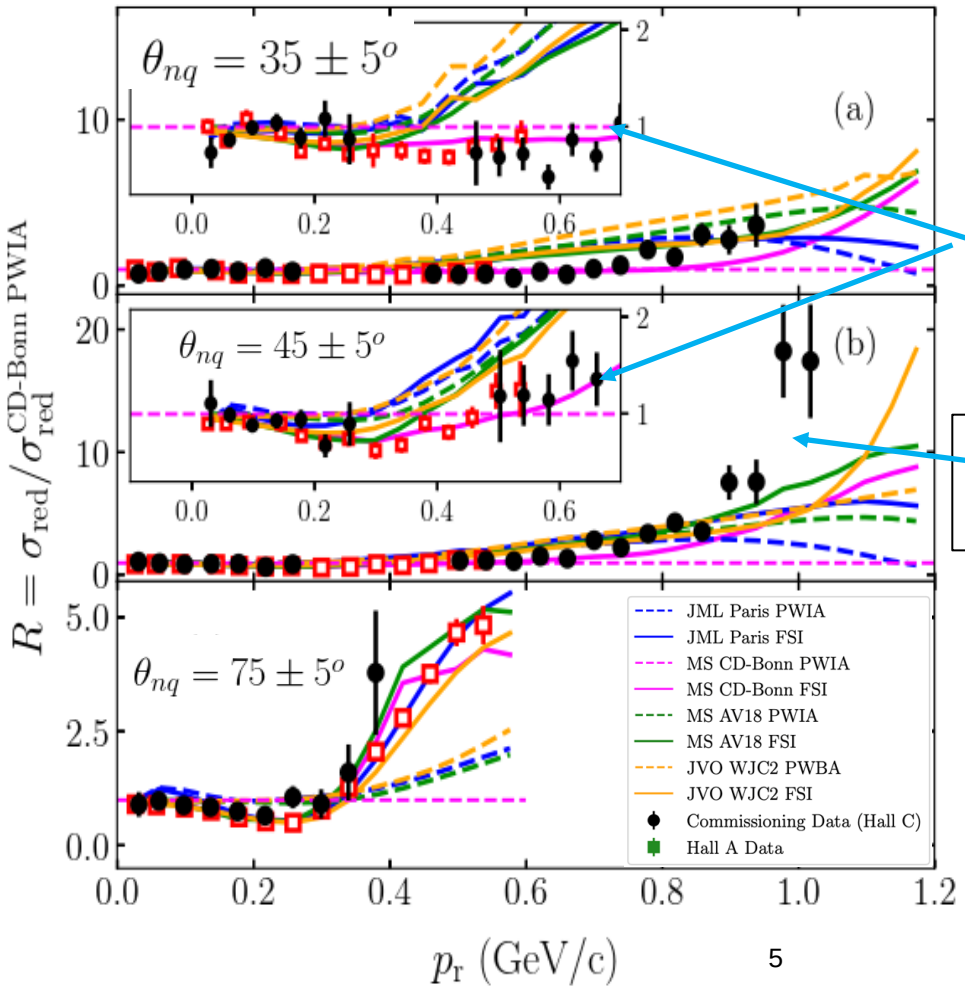
"Probing the Deuteron at Very Large Internal Momenta" C. Yero et al. PhysRevLett 125, 262501 (2020)

- Only 3 days of beam.
- PAC approved remaining 18 days.
- PAC rating increased to A-

Definition of "Reduced Cross Sections"

$$\sigma_{exp} \equiv \frac{d^5\sigma}{d\omega d\Omega_e d\Omega_p} = K \cdot \sigma_{ep} \cdot S(p_m)$$

$$S(p_m) \approx \sigma_{red} \equiv \frac{\sigma_{exp}}{K\sigma_{ep}}$$



CD-BONN NN potential and
MS theory (magenta) explains data for $p_r < 600$

- No theory cannot explain data for $p_r > 0.6$
- Need to complete experiment to explore if trend continues to $p_r > 1.1$

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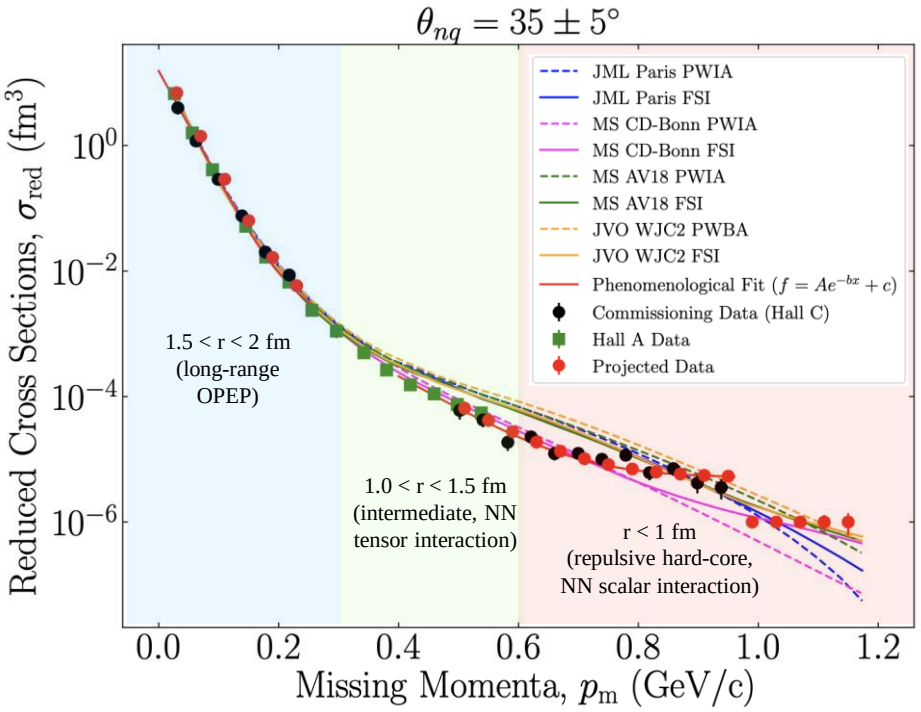
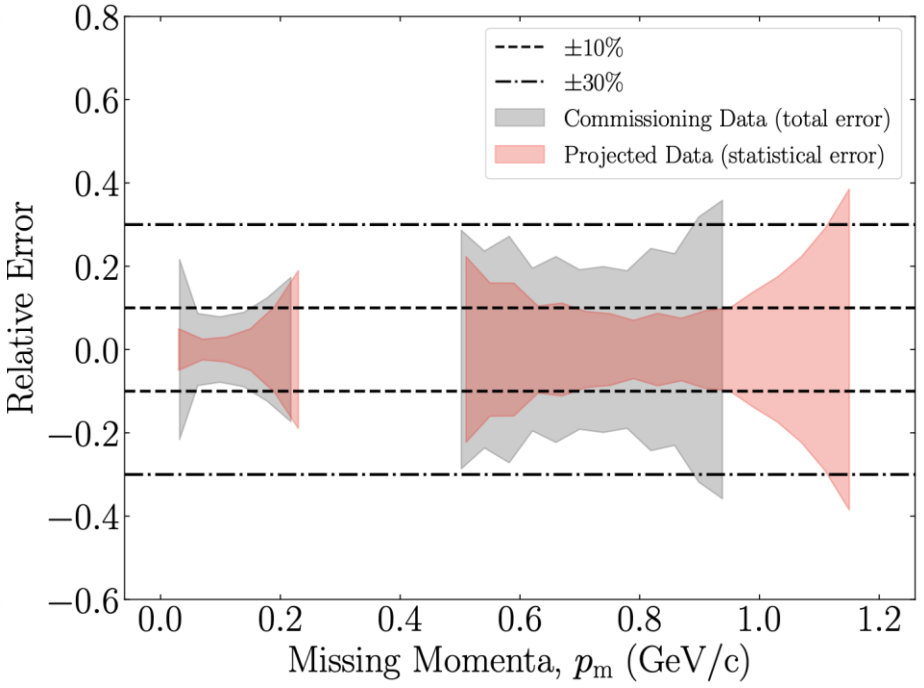
E12-10-003 Projected Data





- **Phenomenological Fit**
  - overlay projected data/errors on phenomenological fit curve to commissioning data
  - above ~900 MeV/c, no fit was made (no data), projected data conservatively placed at placed at 10^{-6}

- **Projected Data / Errors (Assuming 18 PAC days allocated)**
  - simulated d(e, e'p)n reaction using central settings: 0.120, 0.580, 0.700, 0.800, 0.900 (based on Jean-Marc Laget Paris FSI calculations)
  - actual inefficiencies from commissioning applied to simulated yields for realistic statistical error estimates
  - yield corrections applied to correct for differences between the measured data and JML Paris FSI model
  - **projected statistical error improvement down to ~10 % between** $p_m \sim 600 - 1000$ **MeV/c**

Summary and D(e,e'p) Run plan

- Schedule to run from Feb 10th-Mar 19th 2023
- Will share a shift schedule with CAFÉ, X >1 and EMC experiments.
- Please join the experiments

Beam Energy: 10.6 GeV
Beam Current: 70 μA

p_m (GeV/c)	k_f (GeV/c)	θ_e (deg)	$\|\vec{q}\|$ (GeV/c)	p_f (GeV/c)	θ_p (deg)	θ_{pq} (deg)	Charge (mC)	Time (hrs)
0.12	8.335	12.59	3.06	3.05	38.63	2.24	252	1.0
0.58	8.922	12.17	2.66	2.26	54.96	9.92	6048	24.0
0.7	8.922	12.17	2.66	2.19	57.41	12.37	27216	108.0
0.8	8.922	12.17	2.66	2.12	59.39	14.34	27216	108.0
0.9	8.922	12.17	2.66	2.05	61.33	16.30	42084	167.0
Total Charge							102816	
optics checkout								
hydrogen elastics								
target boiling								
proton absorption								24
Total Time								432 hrs (18 PAC days)