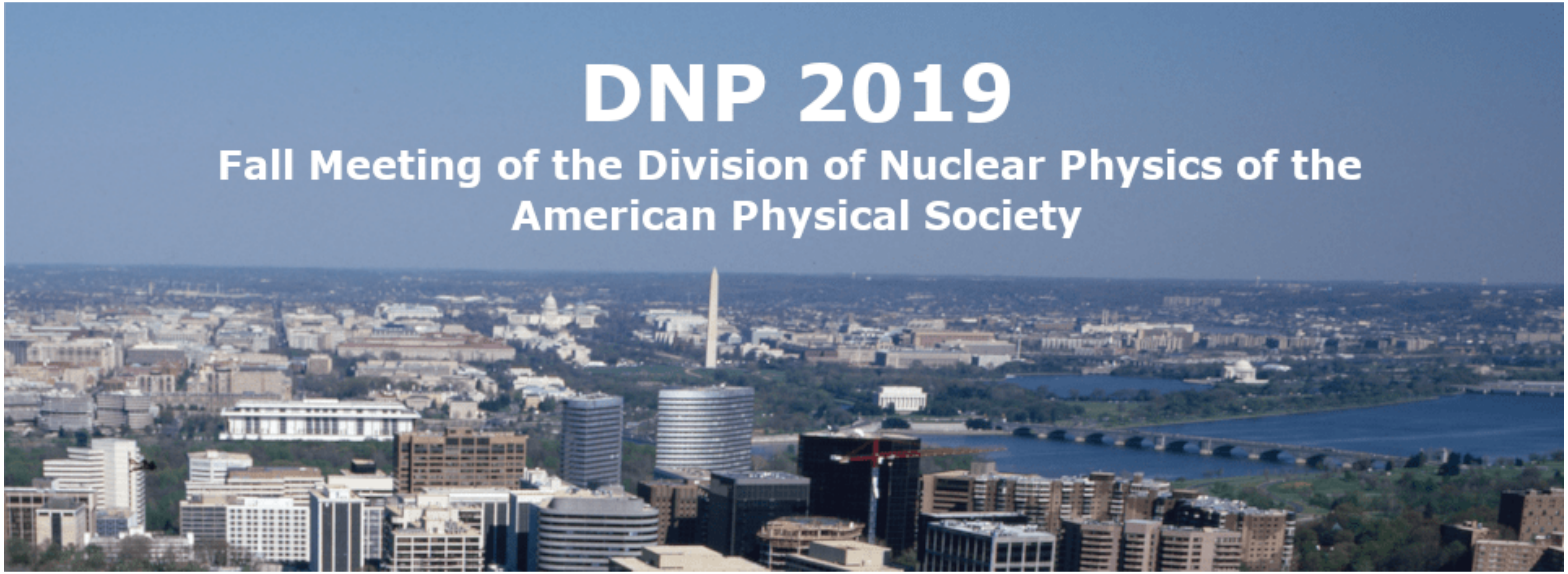

First Cross Section Results of D(e,e'p)n at Very High Recoil Momenta

October 16, 2019

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Spokespeople: Drs. Werner Boeglin and Mark Jones

Jefferson Lab
Exploring the Nature of Matter

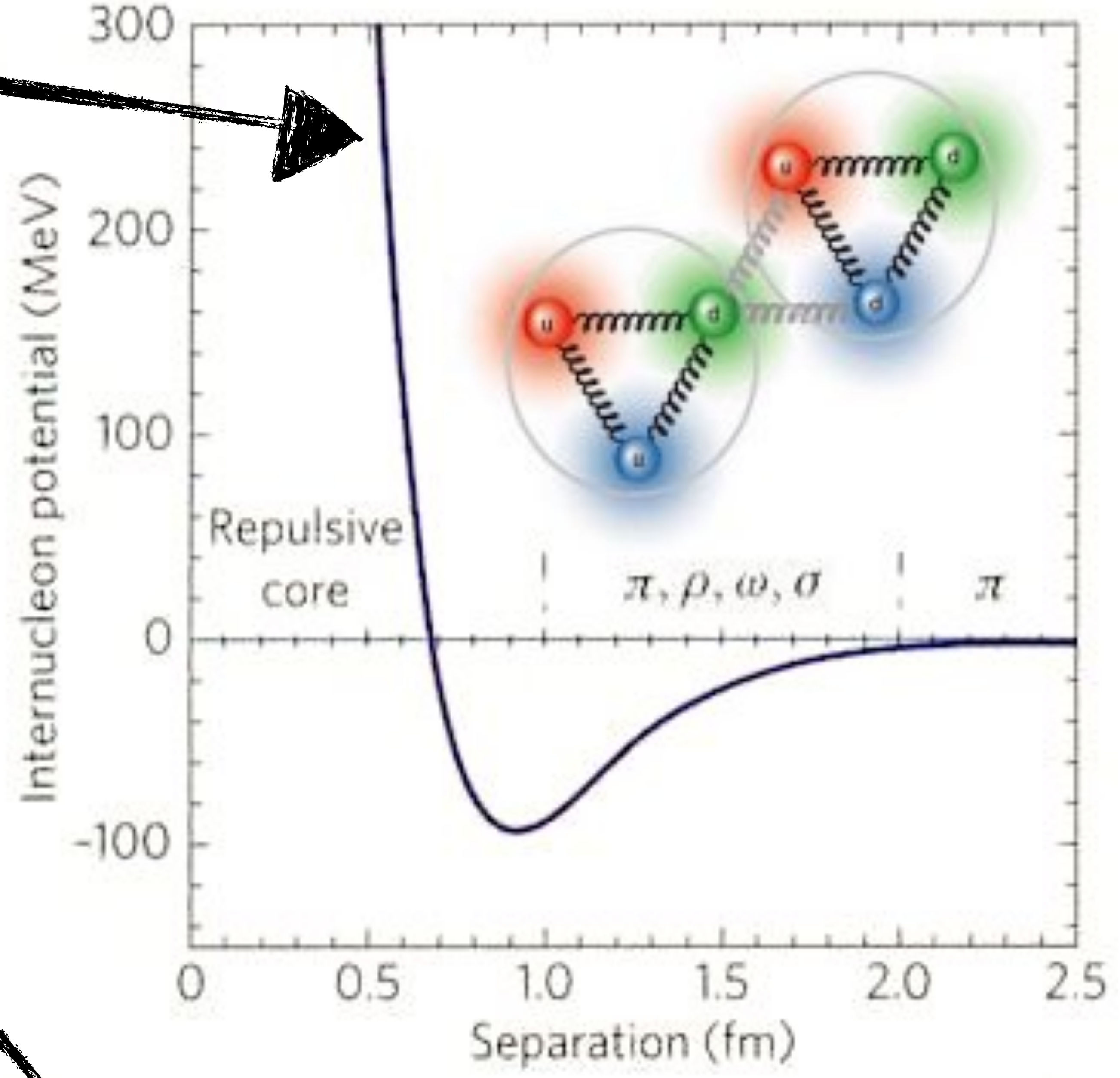
FIU

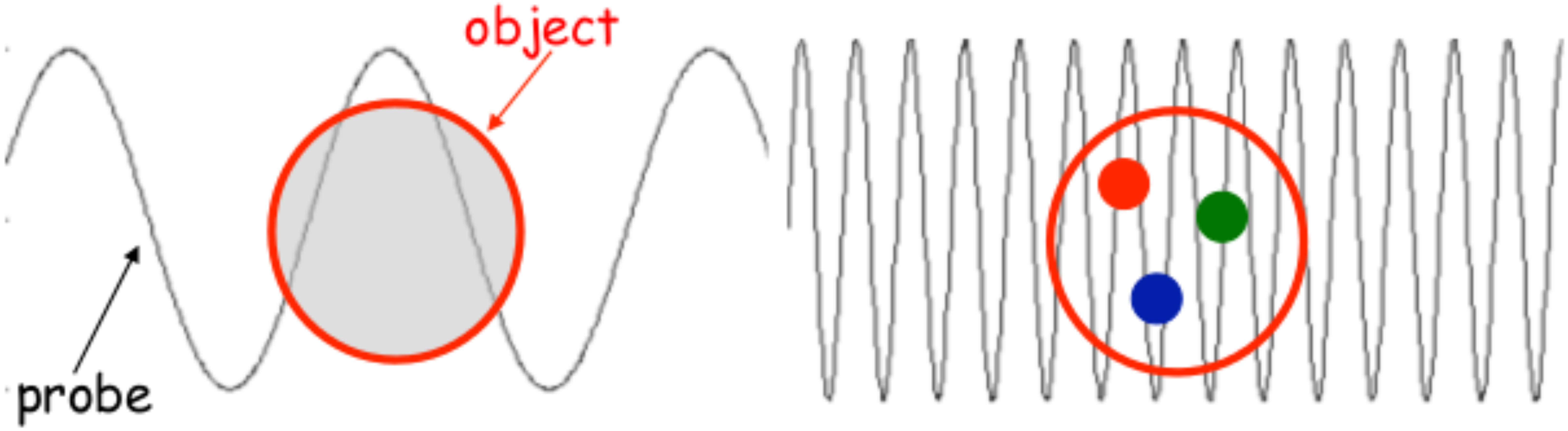
Hall-C

Motivation

- Short-range structure of the deuteron is currently not well understood.
- Most direct way to study the short-range structure of the deuteron is by probing its high momentum tails via D(e,e'p)n reaction at large momentum and energy transfers
- Extract momentum distributions from measured cross sections beyond 500 MeV/c recoil momentum at PWIA kinematics

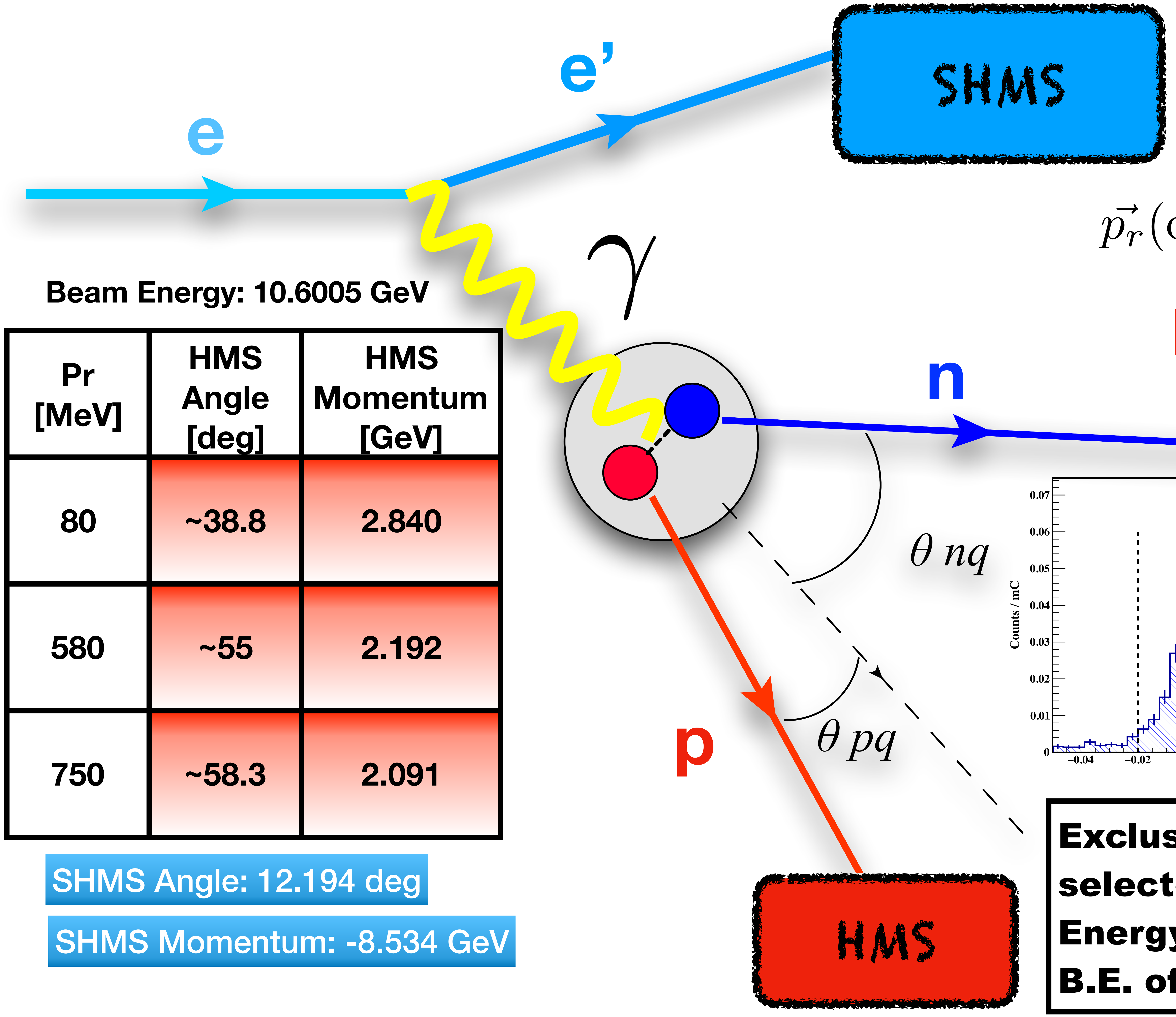
Illustrative NN Potential





Illustrative figure of low and high energy probe on an object

D(e,e'p)n Kinematics



Beam Energy: 10.6005 GeV

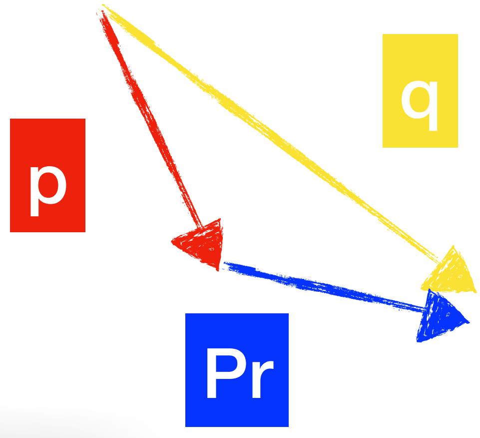
Pr [MeV]	HMS Angle [deg]	HMS Momentum [GeV]
80	~38.8	2.840
580	~55	2.192
750	~58.3	2.091

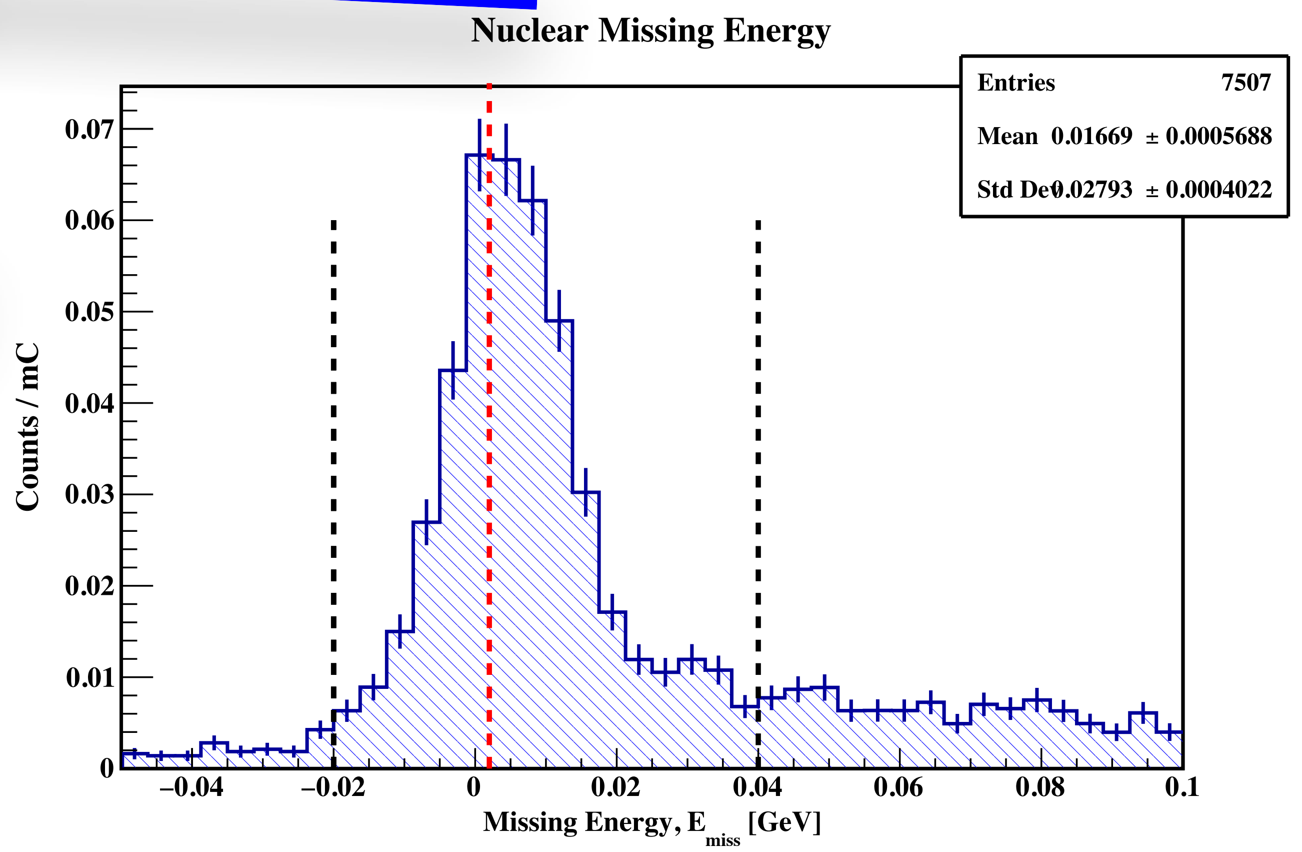
SHMS Angle: 12.194 deg

SHMS Momentum: -8.534 GeV

Neutron (recoil) momentum

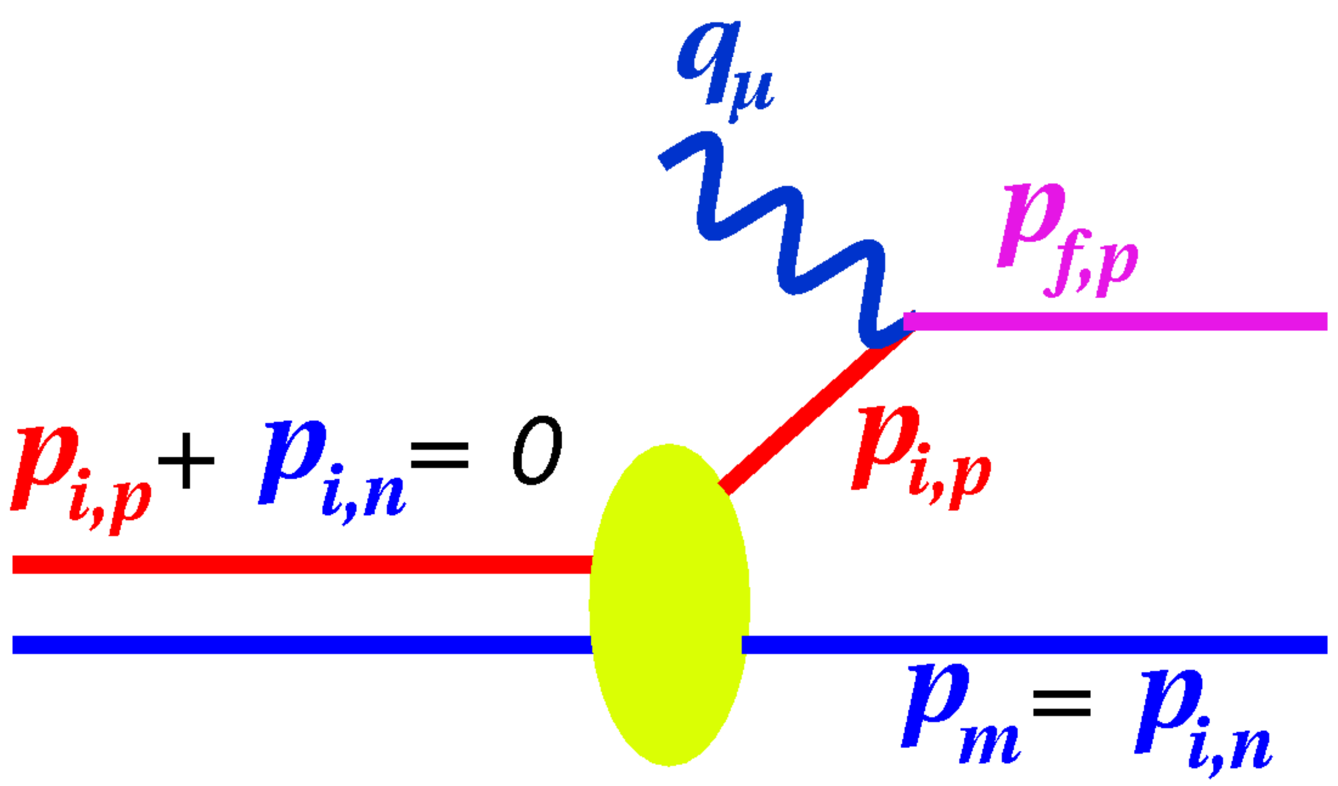
$$\vec{p_r}\,(\text{or } \vec{p_m}) \equiv \vec{q} - \vec{p_p}$$



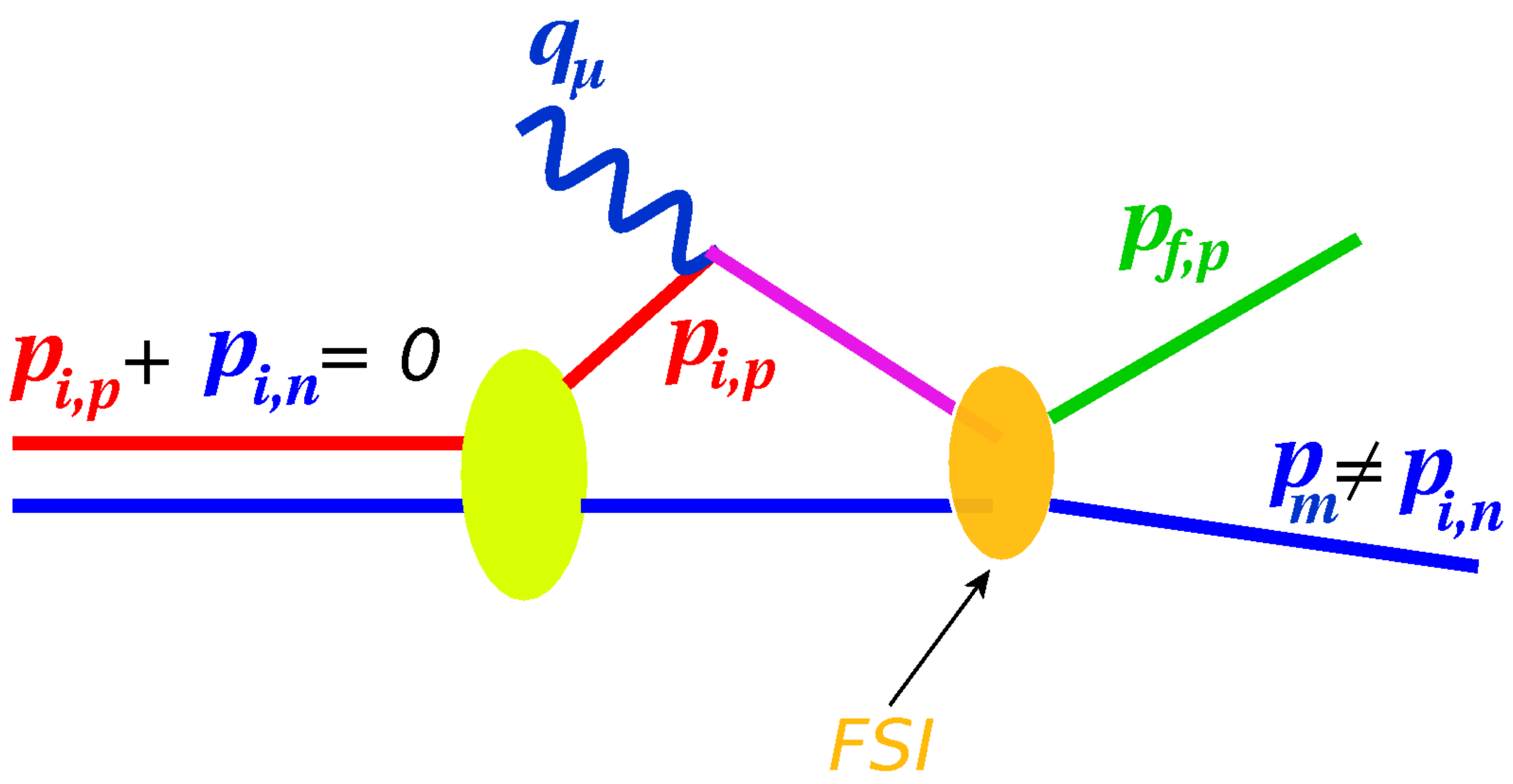


Exclusive reaction selected via Missing Energy Cut around the B.E. of the Deuteron

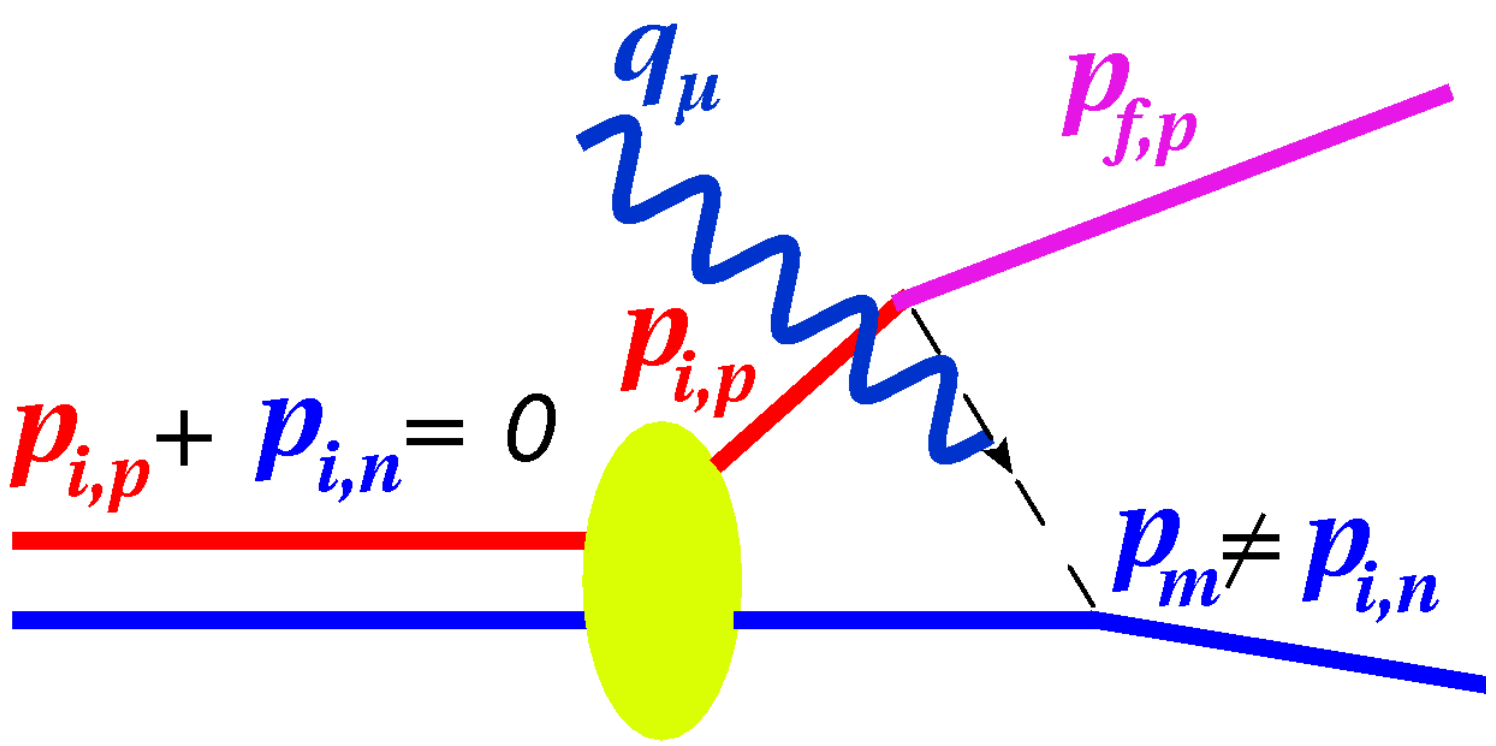
D(e,e'p)n Feynman Diagrams



Plane Wave Impulse Approximation (PWIA)

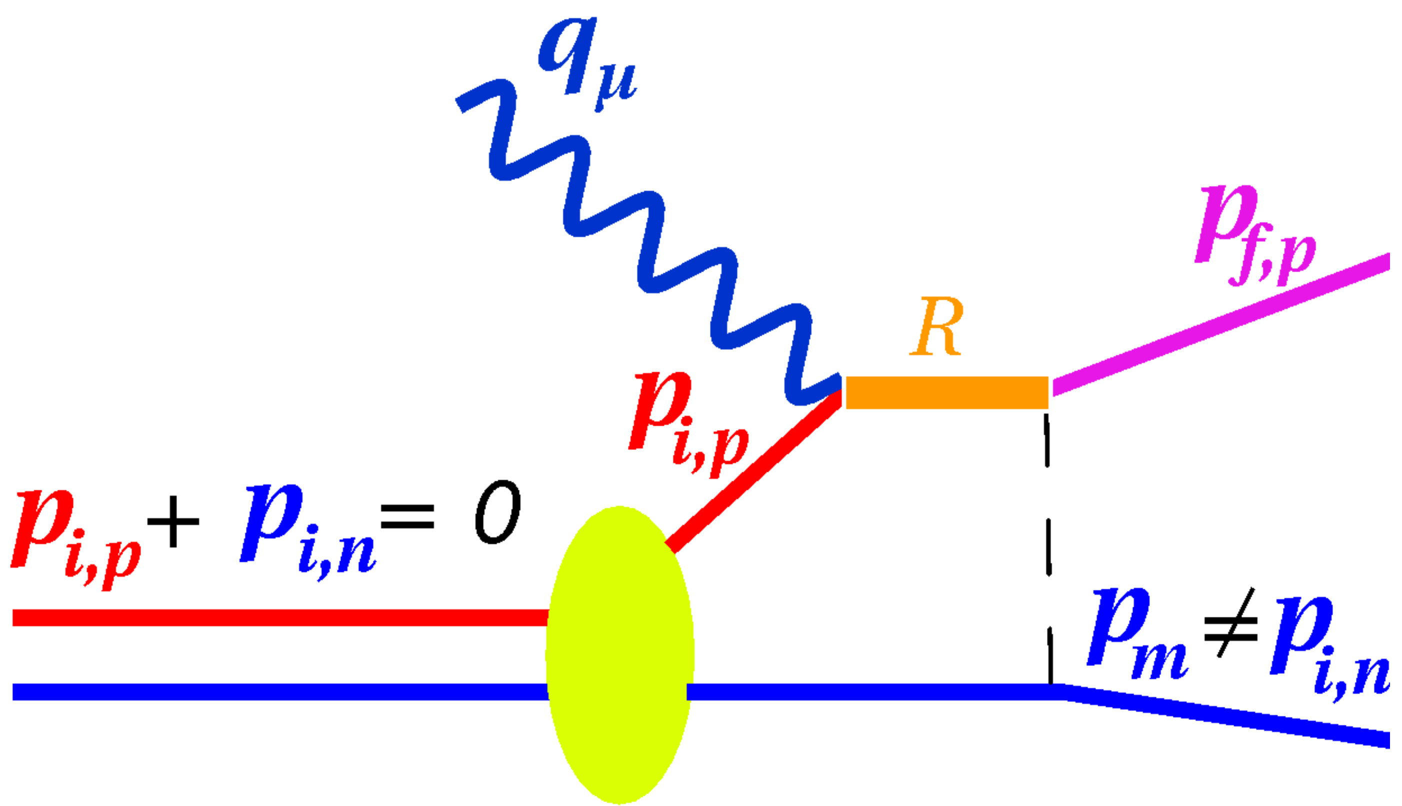


Final State Interactions (FSI)



Meson-Exchange Currents (MEC)

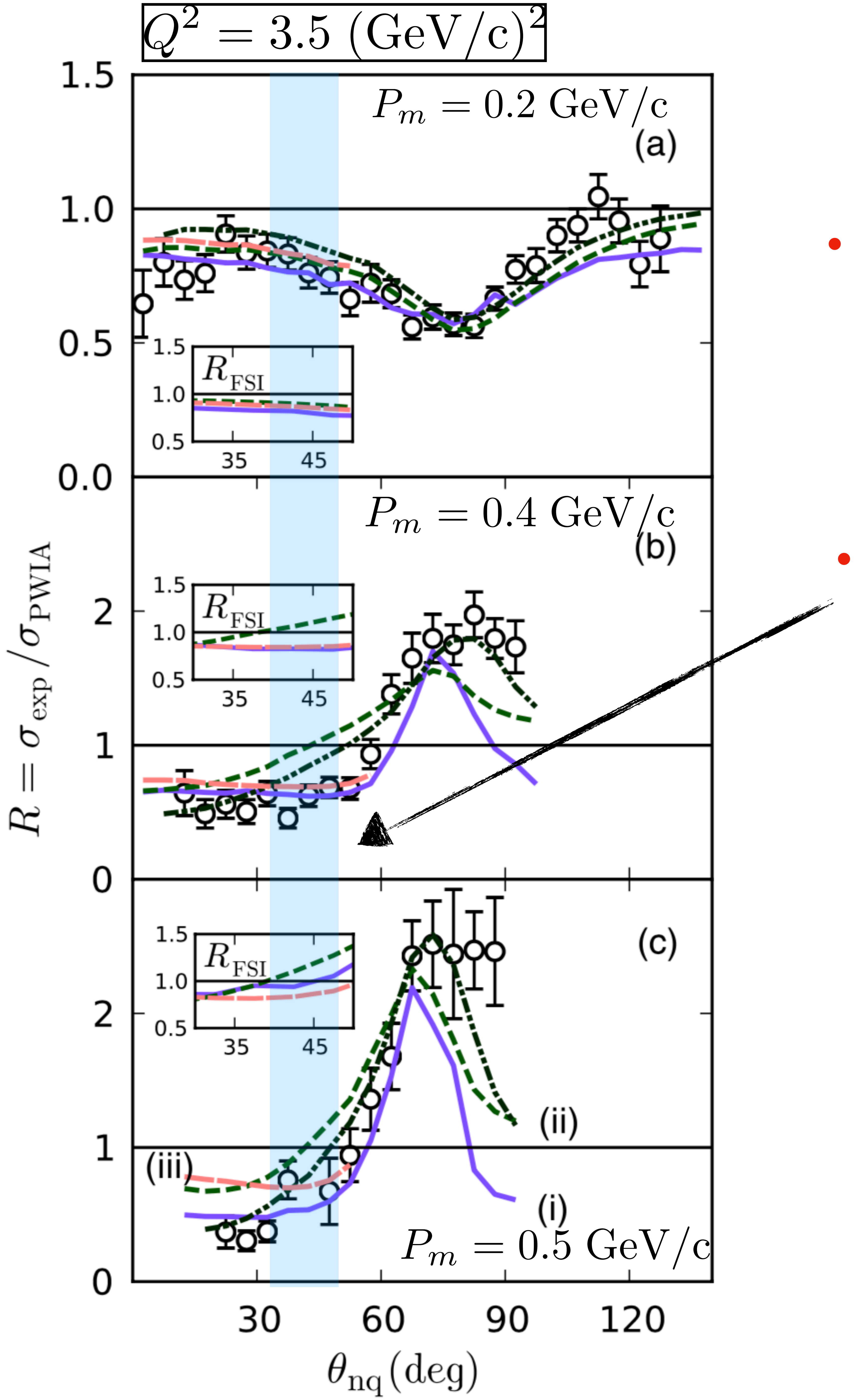
Suppressed at Large Q2



Isobar Configurations (IC)

Suppressed at x-Bjorken > 1

Previous Hall A D(e,e'p)n Experiment



- **The onset of GEA is established at large Q2 and recoil momenta, which predicts a strong angular dependence of FSI on recoil angles was verified experimentally**
- **Theory and data agree at recoil angles $\theta_{\mathrm{nq}} \sim 40$ deg, where the contribution of FSI to the cross section is reduced.**

DATA

CD-Bonn FSI (M. Sargsian)

JVO Model (J. Van Orden)

Paris FSI (J.M. Laget)

Paris FSI+MEC+IC(J.M. Laget)

W.U. Boeglin *et. al.* (For the Hall A Collaboration) Phys. Rev. Lett. **107,** 262501

Deuteron Momentum Distribution

Experiment

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

Theory

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

Factorization ONLY possible in PWIA

ep off-shell cross section

electron scatters off a bound proton within the nucleus; usually, de Forest σ_{cc1} or σ_{cc2} is prescribed

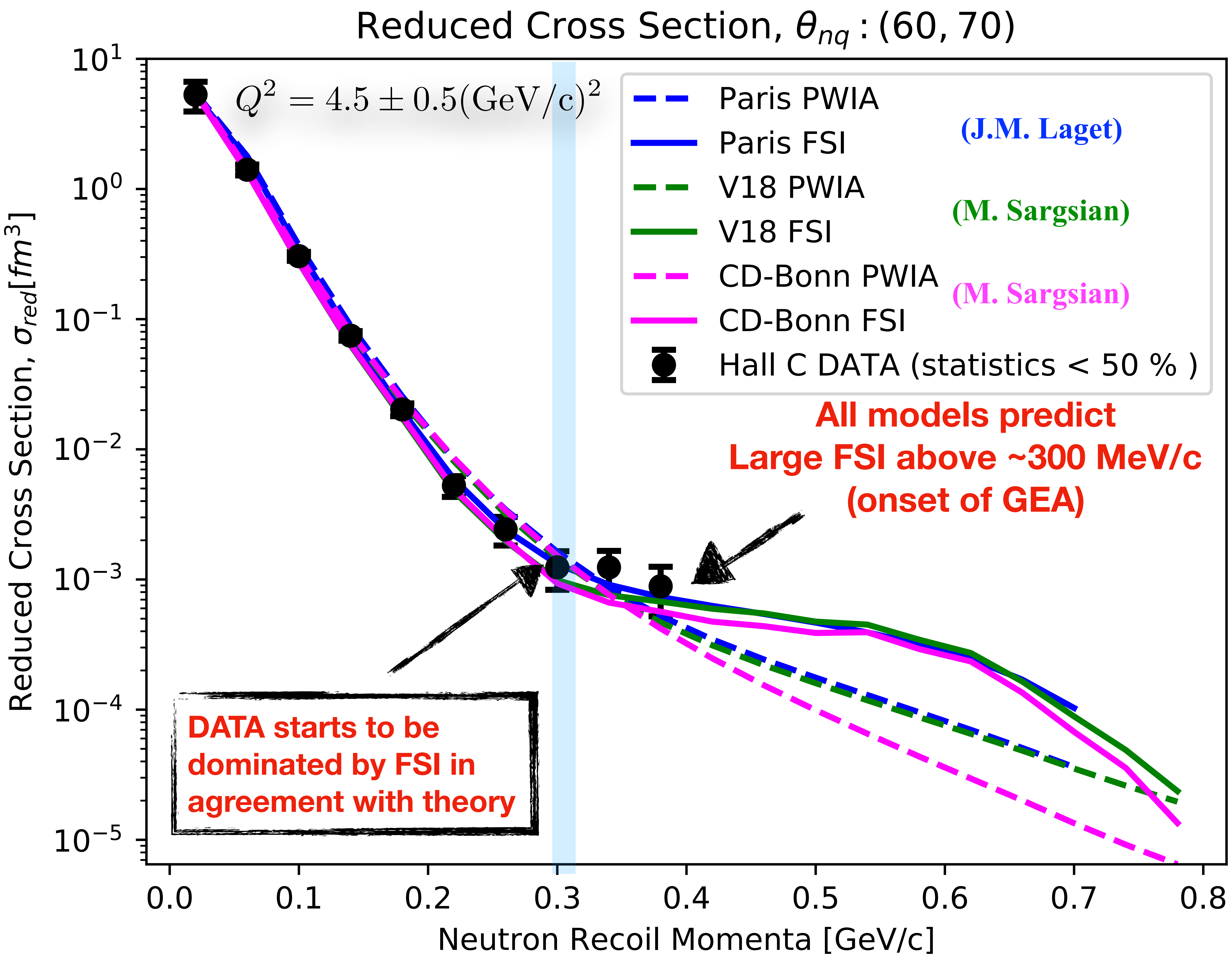
Spectral Function, $S(p_m)$

the momentum distribution inside the deuteron is interpreted as the probability density of finding a bound proton with momentum p_i

Reduced Cross Sections for This Experiment (Hall C)

Neutron Recoil Angles: (60, 70) deg

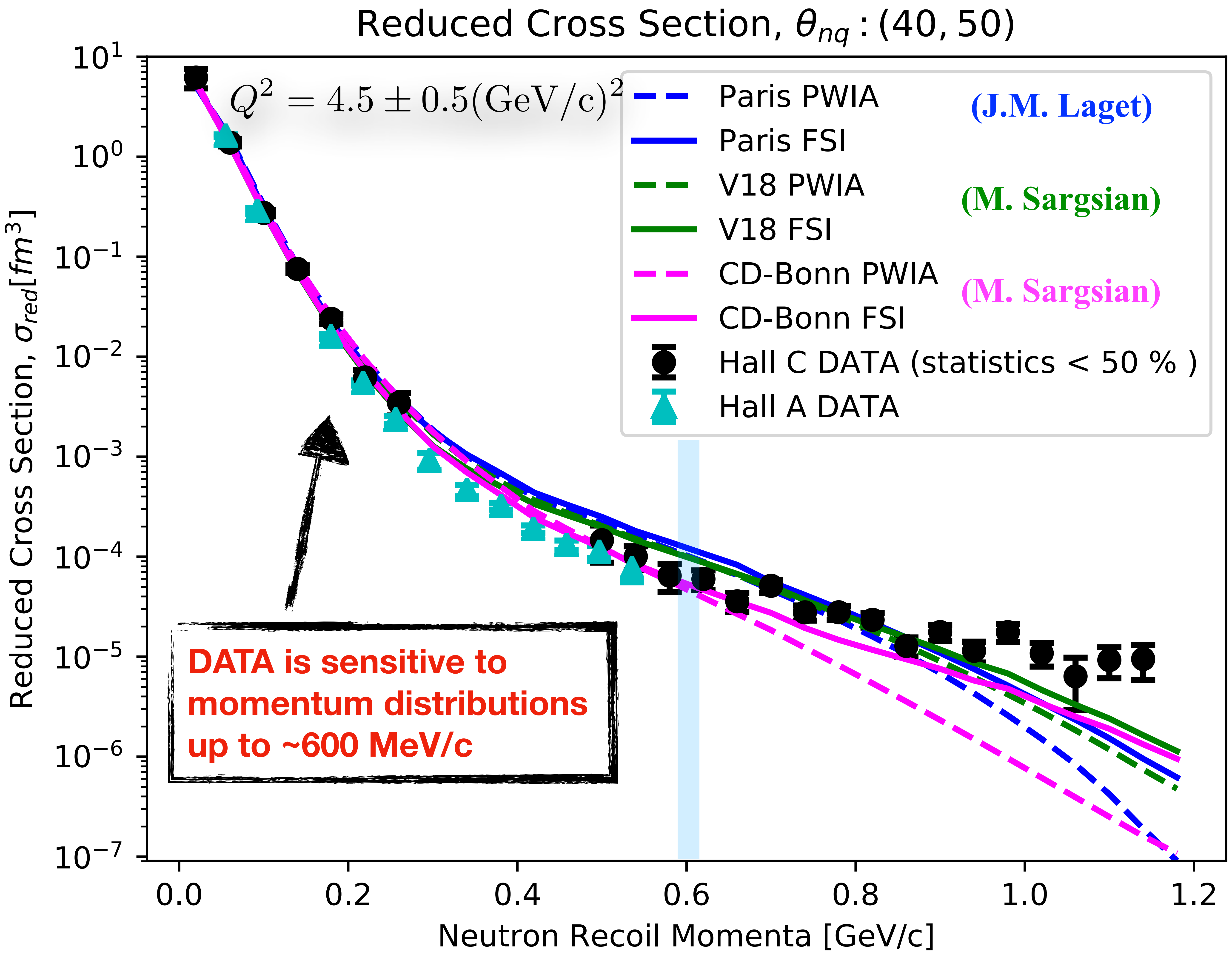
- **DATA is well described by the FSI theory curves, which shows FSI is modeled correctly.**



Reduced Cross Sections for This Experiment (Hall C)

Neutron Recoil Angles: (40, 50) deg

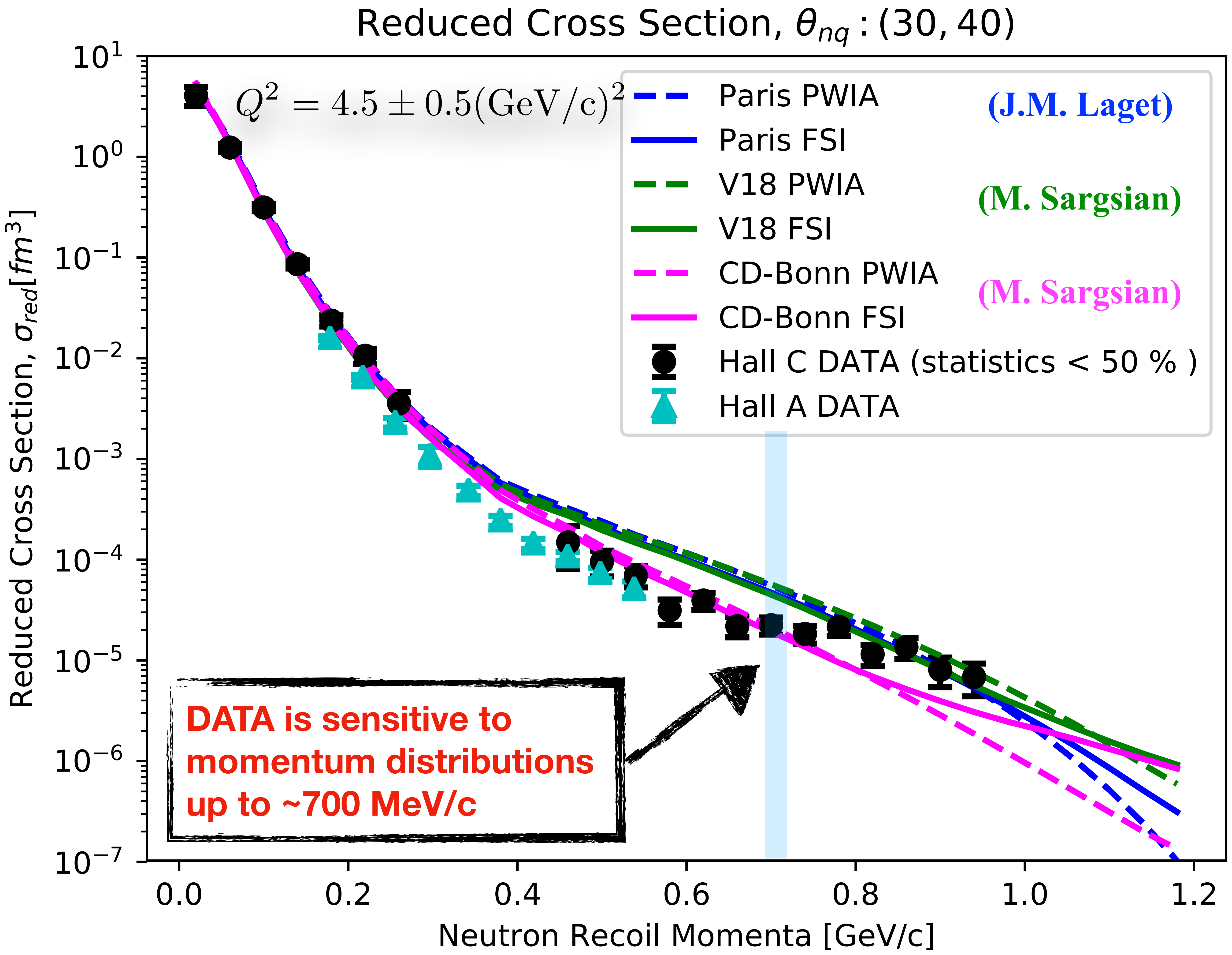
- The CD-Bonn potential starts to deviate from the V18 and Paris at ~ 300 MeV/c, and FSI start to dominate earlier, at ~600 MeV/c
- Data is better described by CD-Bonn as compared to the Paris or V18 over a wider range in recoil momenta, however it flattens out above 900 MeV/c



Reduced Cross Sections for This Experiment (Hall C)

Neutron Recoil Angles: (30, 40) deg

- **Momentum distributions are more sensitive to different models at smaller recoil angles, where FSI are small.**
- **DATA is NOT described by ANY model beyond 700 MeV/c recoil momentum**



SUMMARY

- **The experiment measured cross sections for the exclusive D(e,e'p)n reaction at Q2 = 4.5 (GeV/c)2 for neutron recoil momentum between 0.4 to 1.0 GeV/c and neutron recoil angles between 30 to 70 deg**

- **At recoil angles between 30-50 deg and neutron recoil momentum < 0.7 GeV/c , theories predict a reduced sensitivity to FSI and an enhanced sensitivity to the NN potential. The data agrees best with the GEA model using the CD-Bonn potential**

- **DATA was best described by CD-Bonn potential at smaller recoil angles and recoil momenta up to ~700 MeV/c**

Overall, given that this was a 6-day commissioning and statistically limited experiment, it has very interesting results, as no model seems to describe the data above recoil momenta of 700 MeV/c . This discrepancy is worth exploring further in the full experiment.

ACKNOWLEDGMENTS

I would like to thank my advisor and co-advisor, Drs. Werner Boeglin and Mark Jones for their constant support and useful discussions on this topic.

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- the Doctoral Evidence Acquisition (DEA) Fellowship to Carlos Yero
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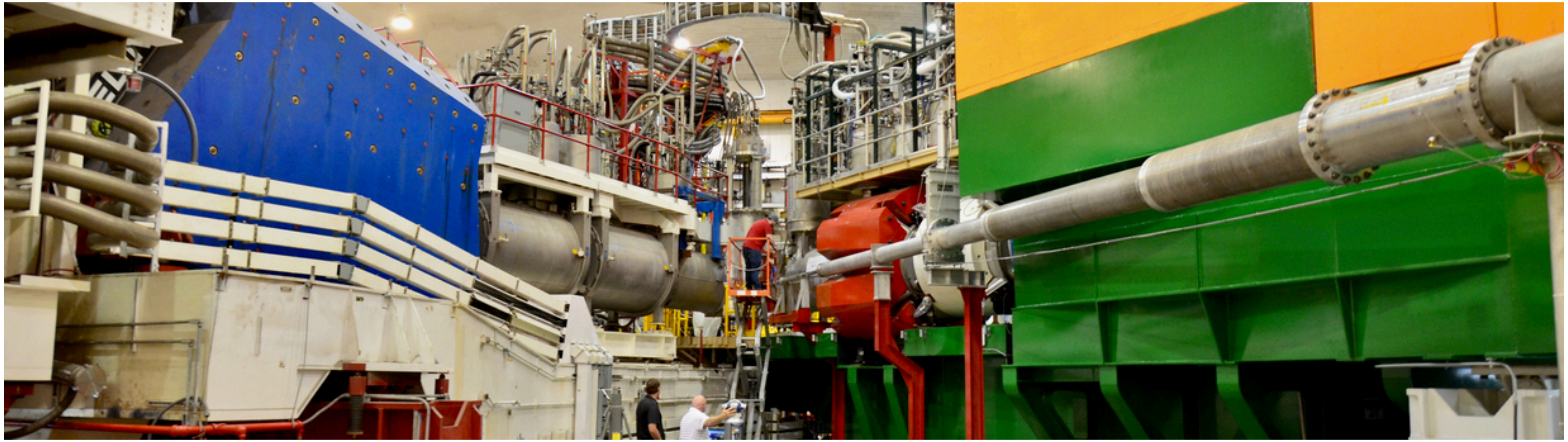

THANK YOU !