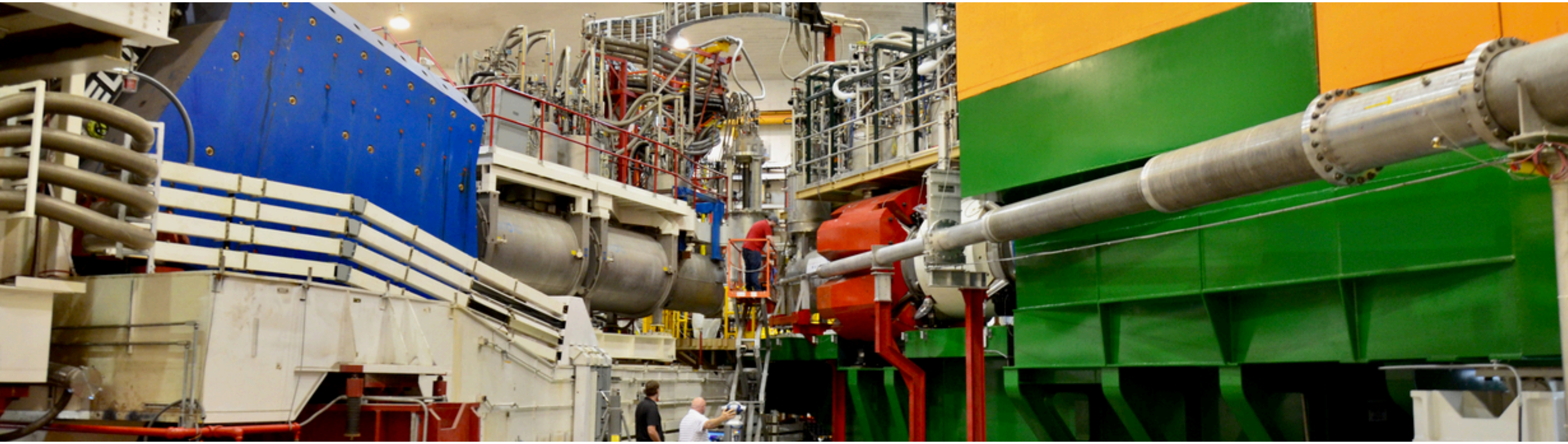


Deuteron Electro-Disintegration Experiment (E12-10-003)

Carlos Yero

Spokespeople: Drs. Werner Boeglin and Mark Jones

June 22, 2018

Jefferson Lab
Exploring the Nature of Matter

FIU

Hall-C

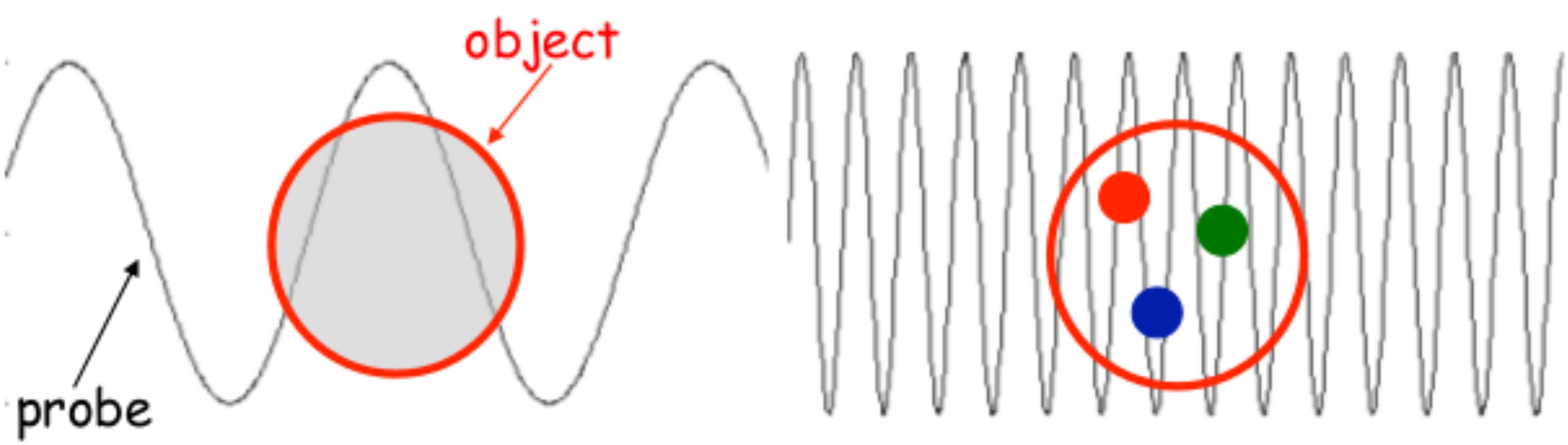
Motivation

- ☑ Study Deuteron at short ranges (< 1fm).

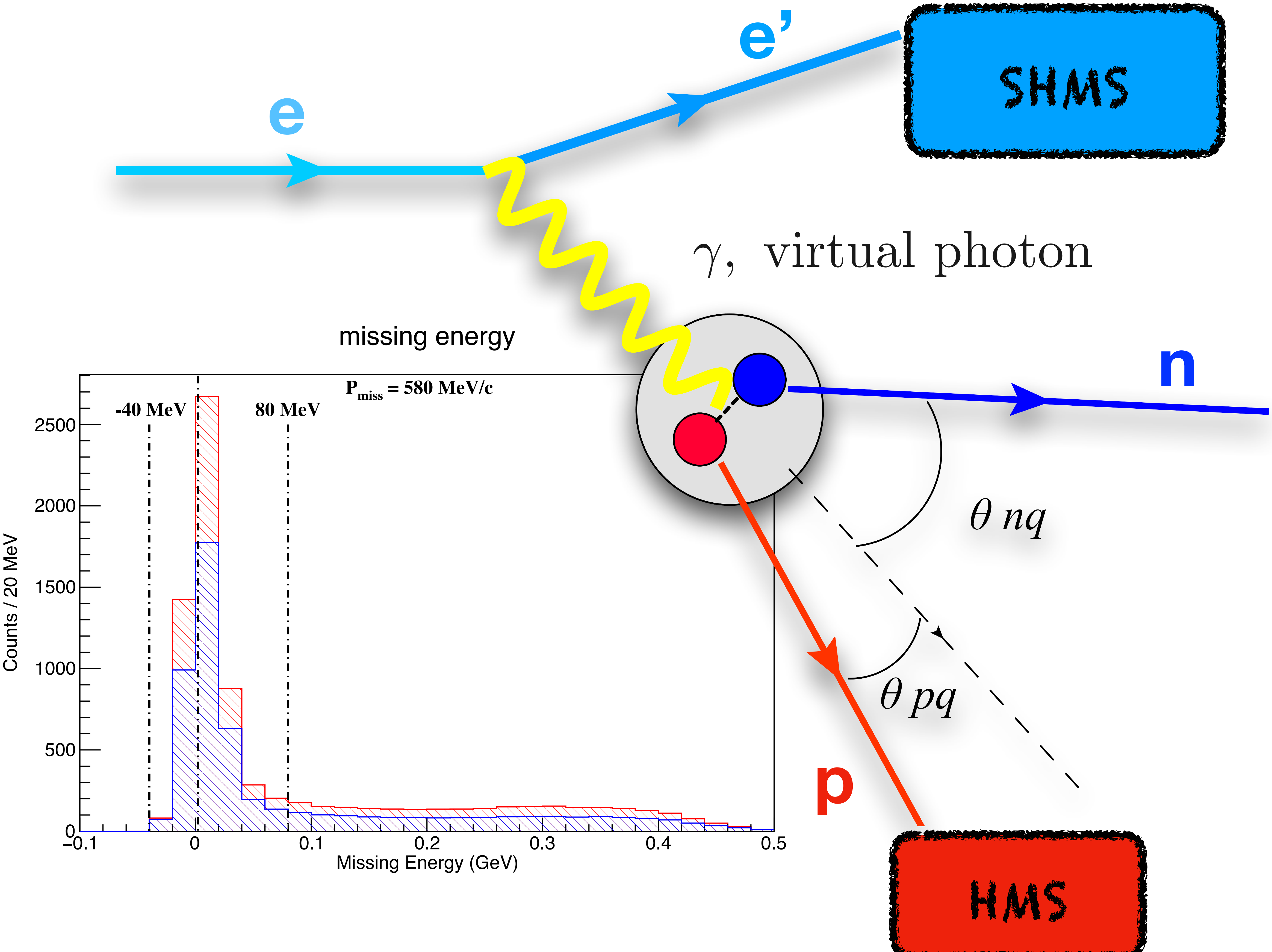
  High momentum transfers probe the Deuteron at smaller distances.
  Smaller inter-nucleon distances enables one to access the high momentum components of nucleons

- ☑ Extract D(e,e'p)n cross-section beyond 500 MeV/c missing momentum at high Q2

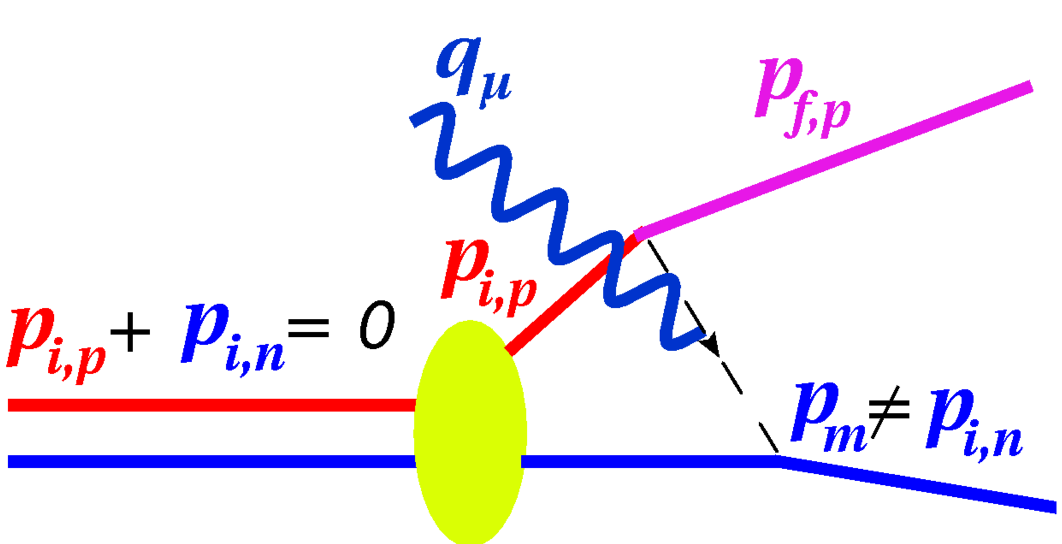
- ☑ Extract momentum distributions (not an observable) from cross sections.



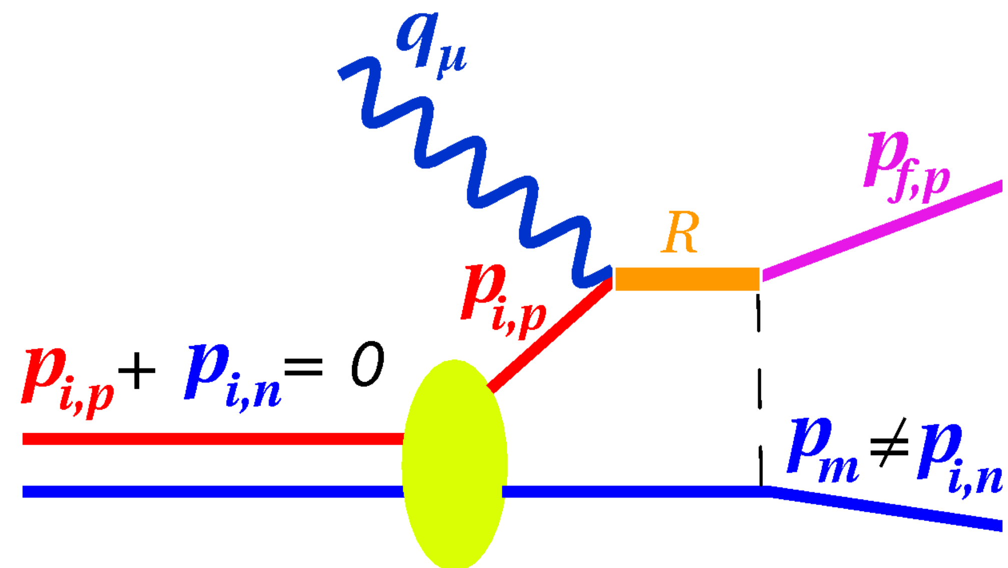
D(e,e'p)n Reaction Kinematics



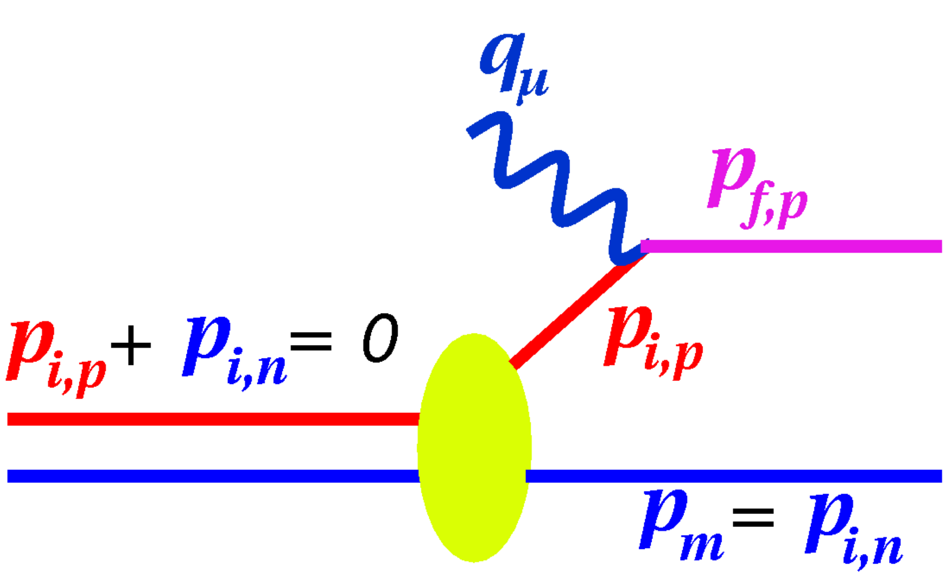
D(e,e'p)n Interactions



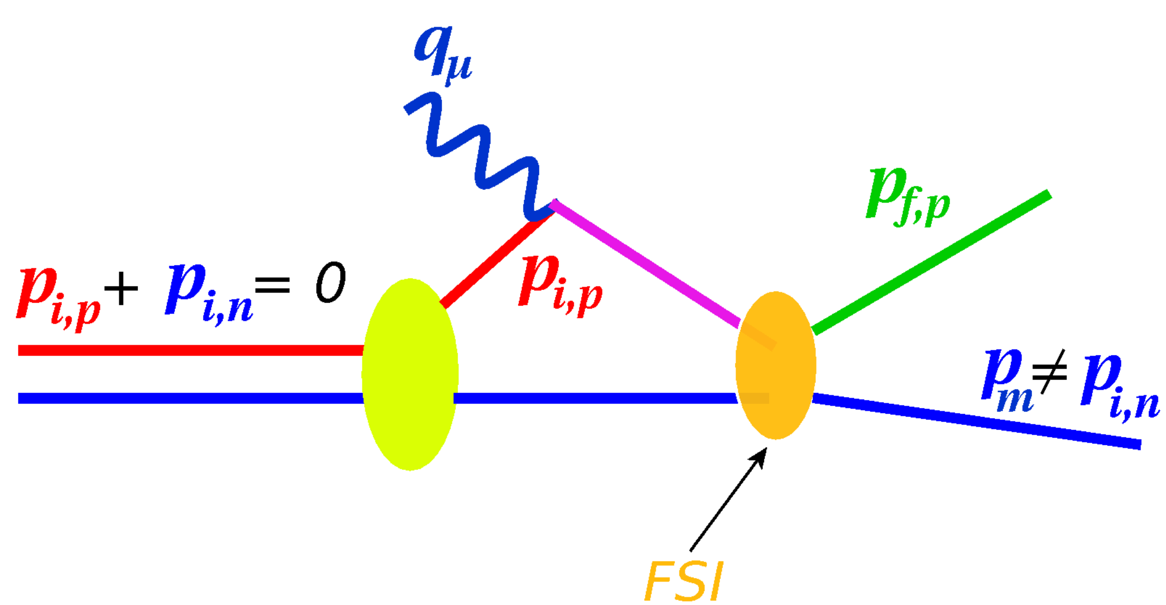
Meson-Exchange Currents (MEC)



Isobar Configurations (IC)



Plane Wave Impulse Approximation (PWIA)



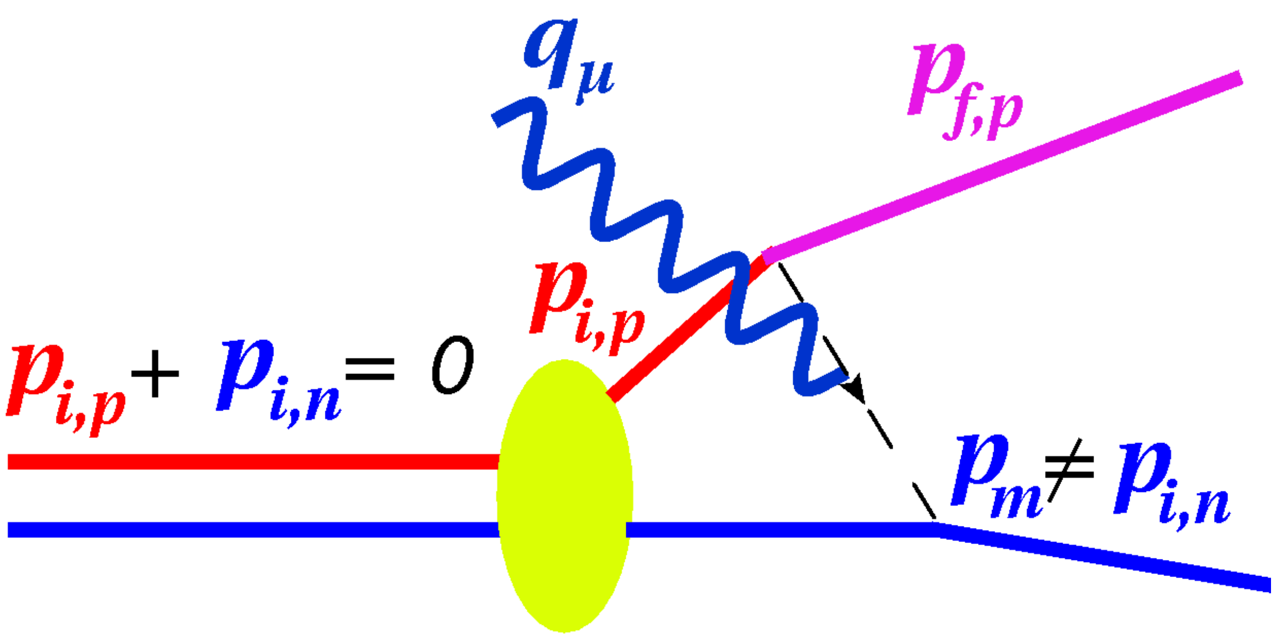
Final State Interactions (FSI)

Meson-Exchange Currents (MEC)

- ☑ Virtual photon couples with exchange meson between nucleons.
- ☑ Virtual meson may become real after photon absorption.
- ☑ Meson exchange propagator is proportional to

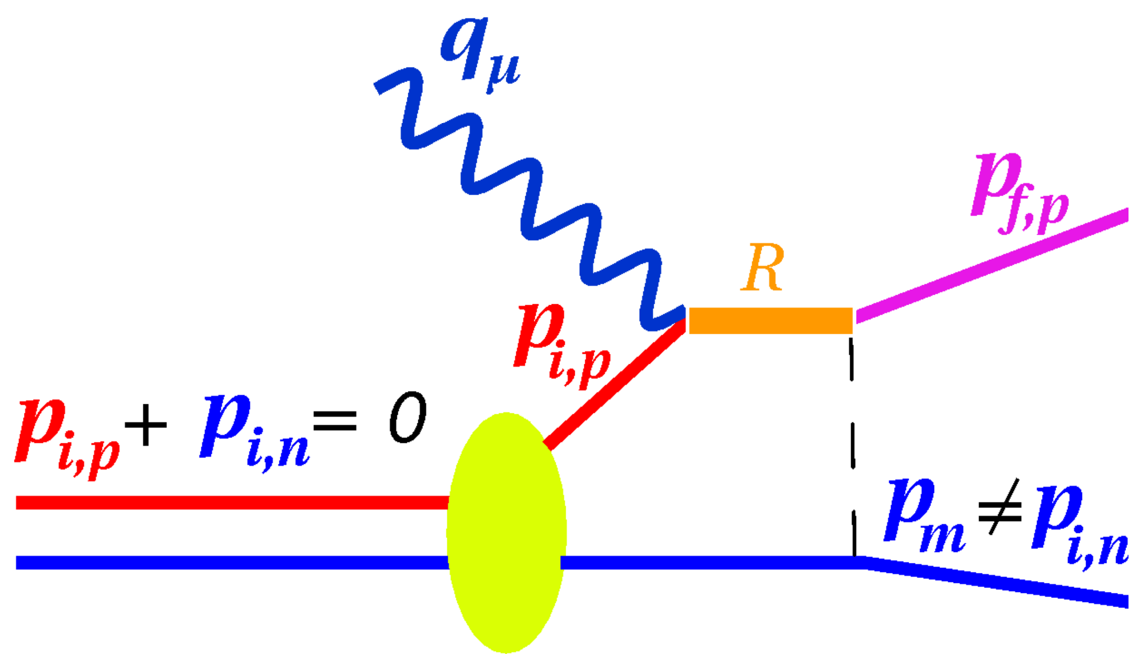
$$(1 + \frac{Q^2}{m^2_{meson}})^{-1}$$

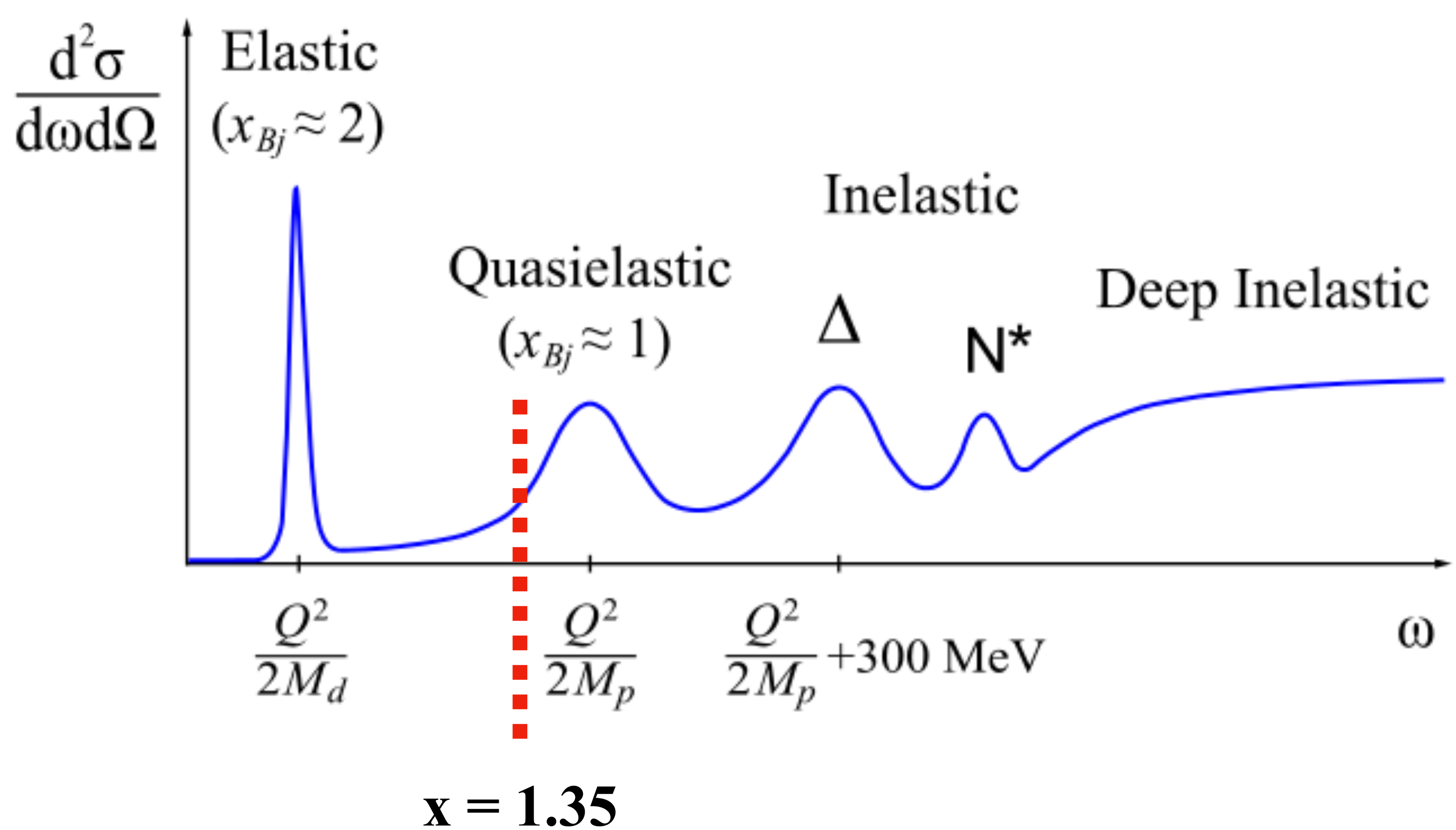
$\Longrightarrow$ MEC suppressed for $Q^2 \gg m^2_{meson}$



Isobar Configurations (IC)

- Virtual photon excites nucleon into resonance.
- Resonance de-excites through meson exchange with spectator nucleon.
- For high Q^2 and $x_{Bj} > 1$ ($x_{Bj} \equiv \frac{Q^2}{2M_p\omega}$) one is able to probe the lower ω region of the quasi-elastic peak to suppress Δ or N^* resonance



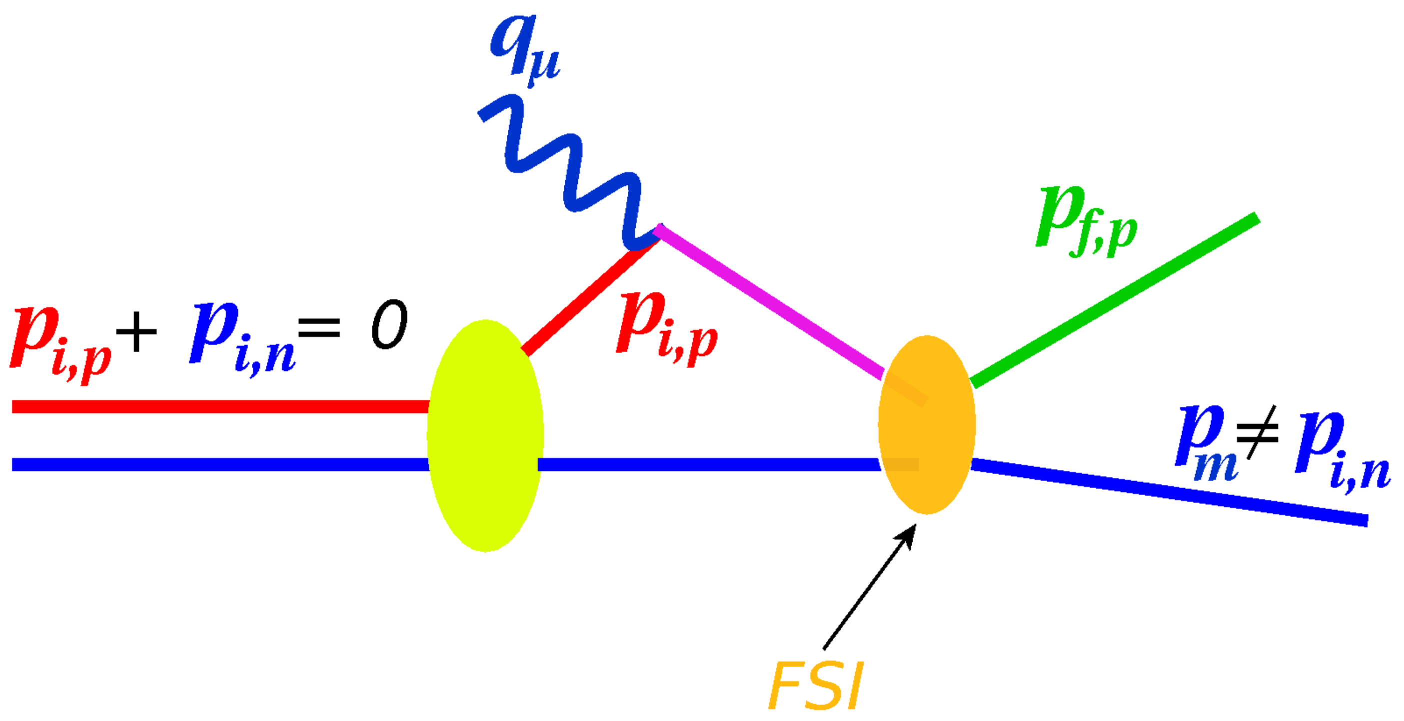


Final State Interactions (FSI)

- In final state, the nucleons are at short enough distances (~ 2 fm) and continue to interact

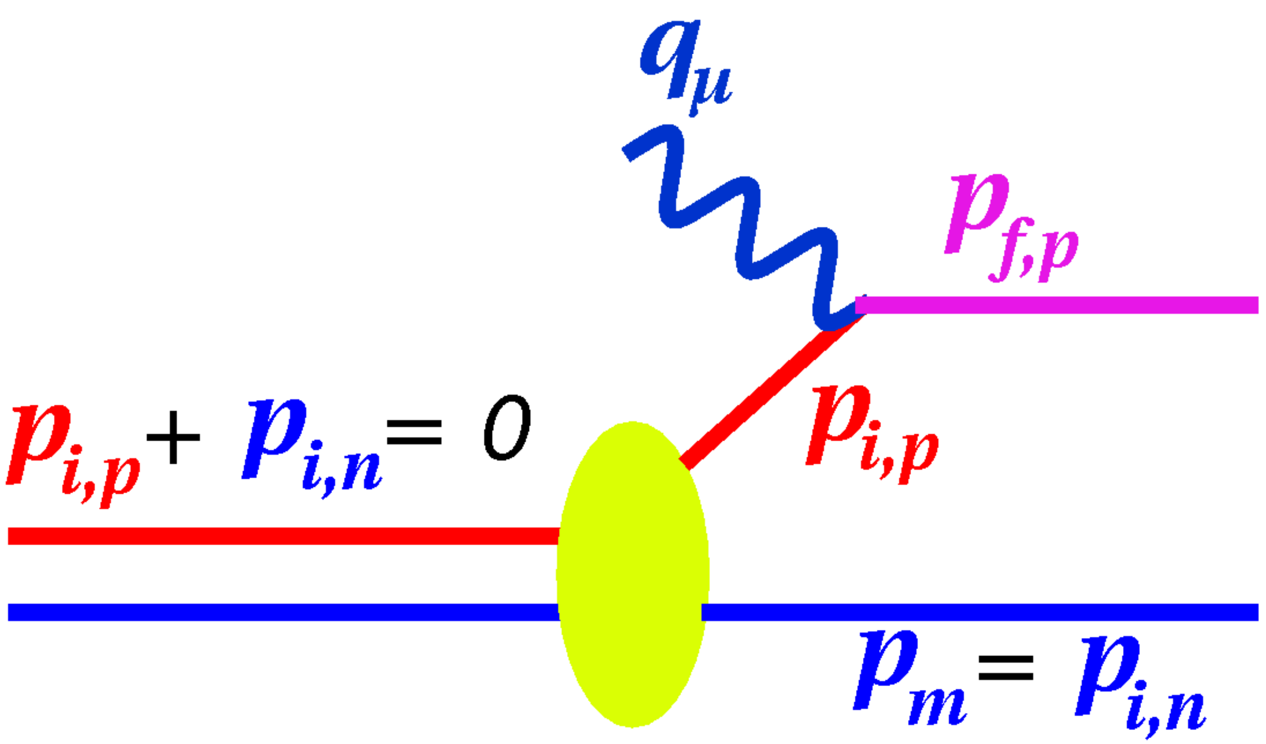
- Neutron re-scatters with a final momentum different than inside the deuteron

- FSI are still dominant, even at high momentum transfers and x > 1.
  Certain kinematics must be chosen to suppress this process



Plane Wave Impulse Approximation (PWIA)

- ☑ Virtual photon couples to proton
- ☑ The other nucleon is a spectator
- ☑ Final state particles treated as plane waves (free particles)
- ☑ Direct access to the deuteron momentum distribution (factorization)



Deuteron Momentum Distribution

$$\sigma_{exp} \equiv \frac{d^6\sigma}{d\omega d\Omega_e dT_p d\Omega_p} = K \cdot \boxed{\sigma_{ep}} \cdot \boxed{S(E_m, p_m)}$$

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

ep off-shell cross section

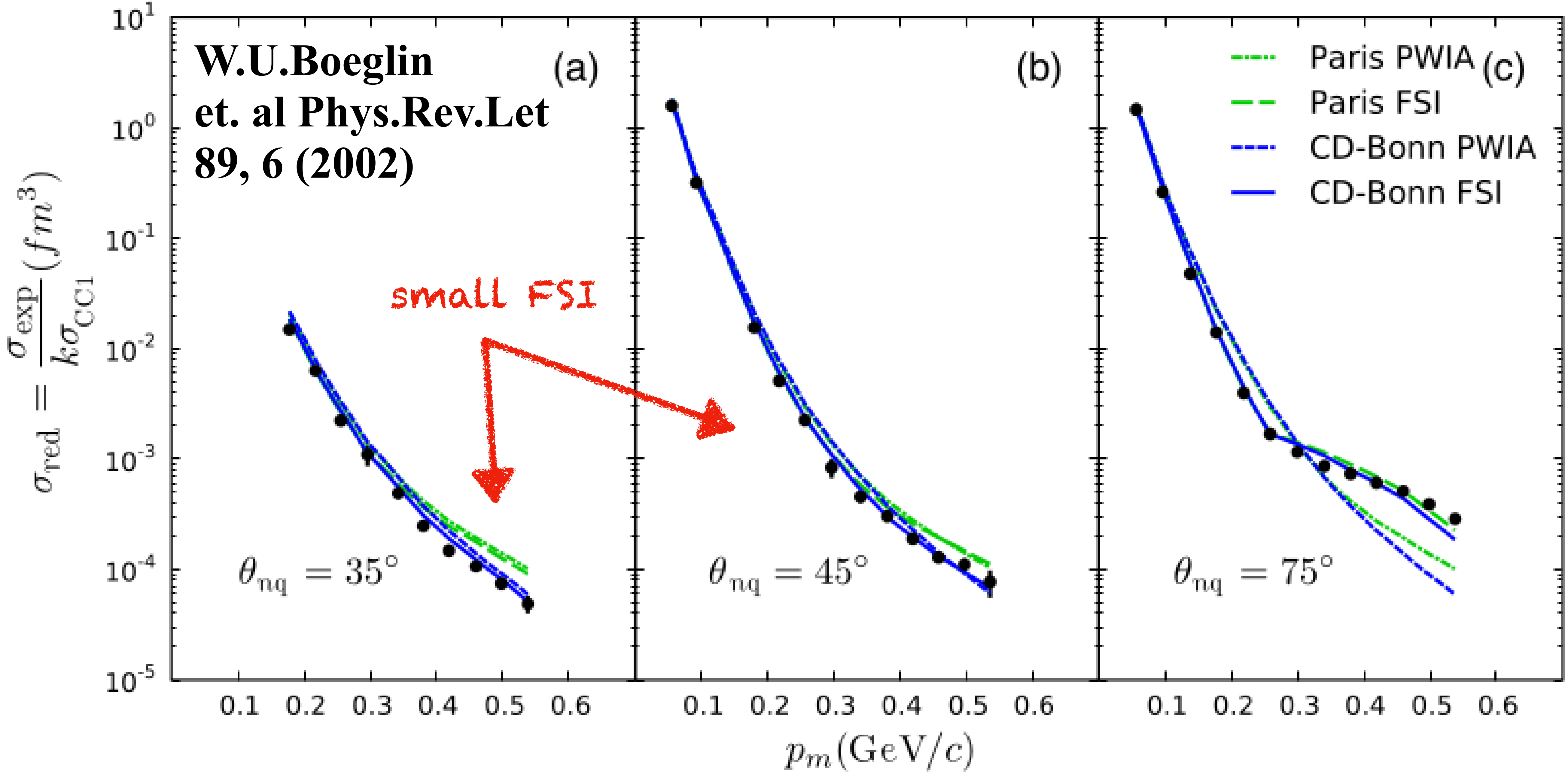
electron scatters off a bound proton within the nucleus; usually, de Forest σ_{cc1} or σ_{cc2} is prescribed

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

Experimental Support for D(e,e'p)n at Hall C

Previous D(e,e'p)n data from Hall A at $Q^2 = 3.25$ GeV^2



- ☑ E12-10-003 Experiment at Hall C focused at $\theta_{nq} \sim 40^o$ and $p_m \geq 500$ MeV/c at $Q^2 = 4.25$ GeV^2

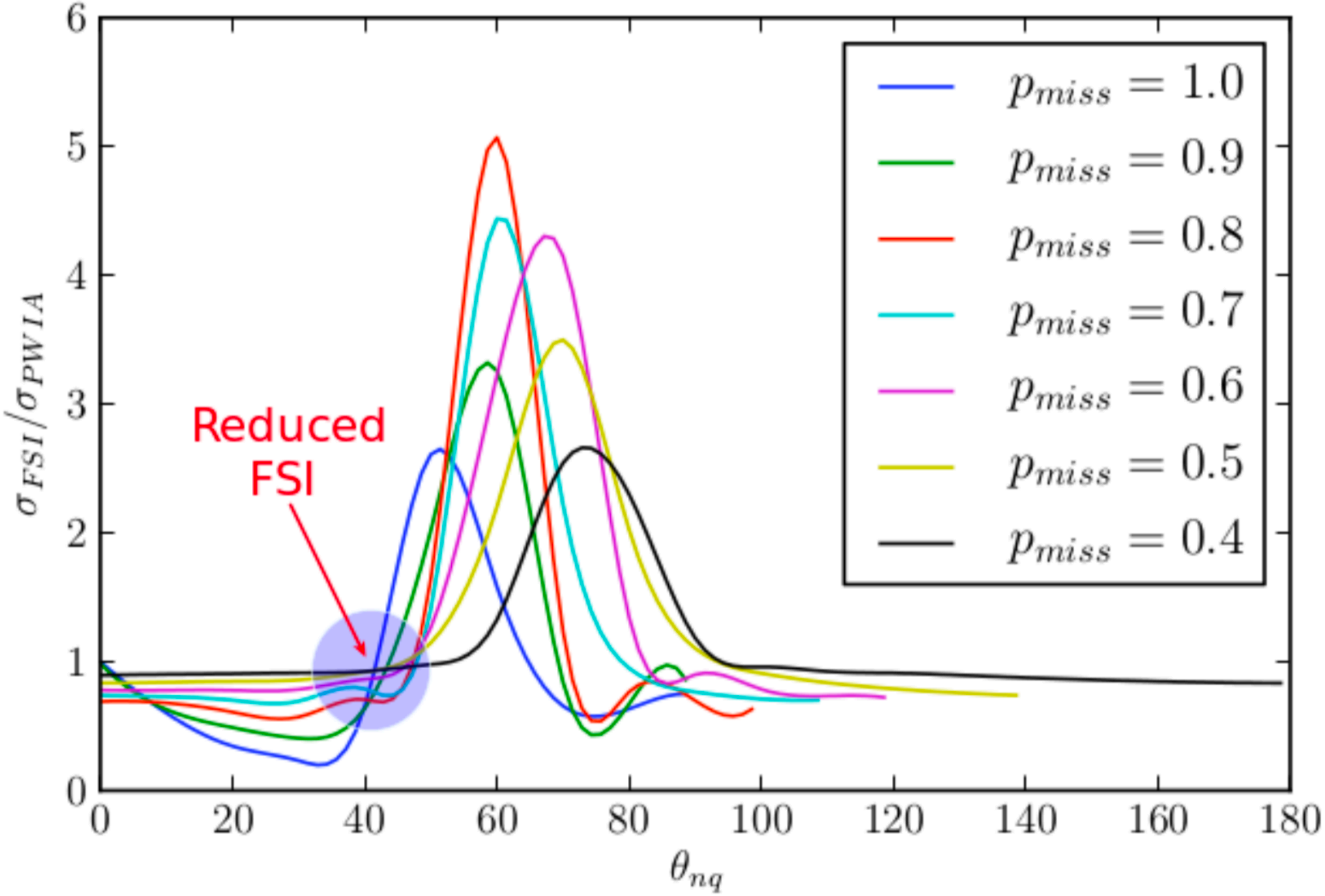
- ☑ Greater sensitivity of deuteron momentum distribution to different NN potential models (e.g. CD-Bonn, Paris, Laget, etc.)

D(e,e'p)n (E12-10-003) Theoretical Background

D(e,e'p)n Kinematics

$E_e = 11$ GeV
$Q^2 = 4.25\ (\mathrm{GeV/c})^2$
$x_{B_j} = 1.35$
$p_m = 0.5 - 1.0$ GeV/c
$\theta_{nq} = 35^\circ - 40^\circ$

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



Theoretical Calculation by: M. Sargsian

E12-10-003
RUN PLAN

And

Simulation Results

for

Missing Momentum Setting: 580 MeV/c

For detailed simulation results of this and other settings measured,
See BackUp Slides

RUN PLAN

H(e,e’p) Check

- Check Spectrometer Pointing
- Measure cross section as cross-check

D(e,e’p)n at Pm = 80 MeV/c

- Measure cross section as calibration for the higher missing momentum settings

D(e,e’p)n at High Missing Momentum

- Extract first cross-section measurements at missing momentum settings of 580 and 750 MeV/c

E12-10-003: Measured Kinematics

Target	SHMS angle	SHMS momentum	HMS angle	HMS momentum
LH2	12.2 deg	-8.70 GeV/c	37.3 deg	+2.938 GeV/c

Target	SHMS angle	SHMS momentum	HMS angle	HMS momentum
Al	12.2 deg	-8.70 GeV/c	37.3 deg	+2.938 GeV/c

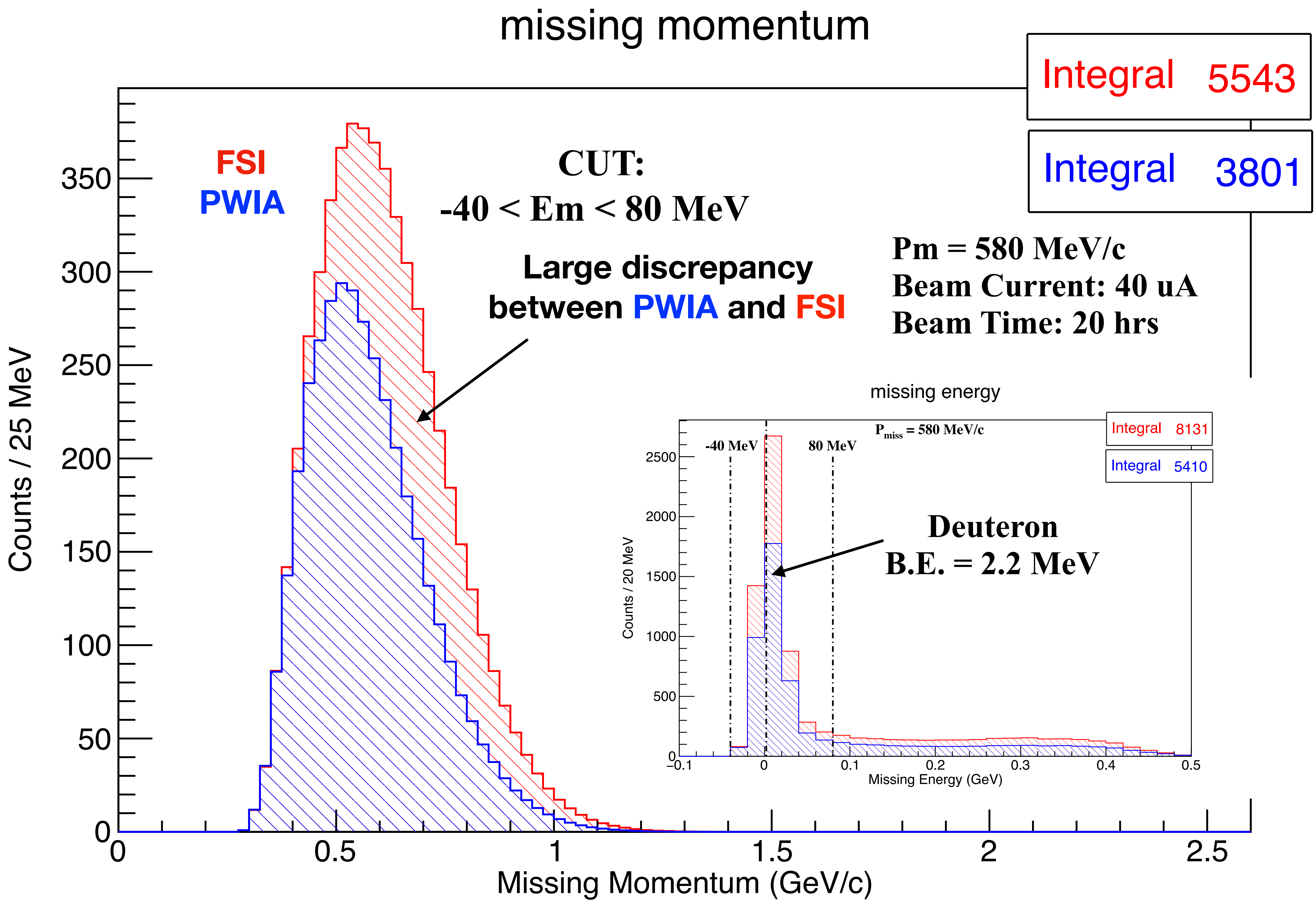
Target	SHMS angle	SHMS momentum	HMS angle	HMS momentum	Missing Momentum
LD2	12.2 deg	-8.70 GeV/c	38.896 deg	+2.844 GeV/c	80 MeV

Target	SHMS angle	SHMS momentum	HMS angle	HMS momentum	Missing Momentum
LD2	12.2 deg	-8.70 GeV/c	55.0 deg	+2.194 GeV/c	580 MeV
LD2	12.2 deg	-8.70 GeV/c	58.4 deg	+2.091 GeV/c	750 MeV

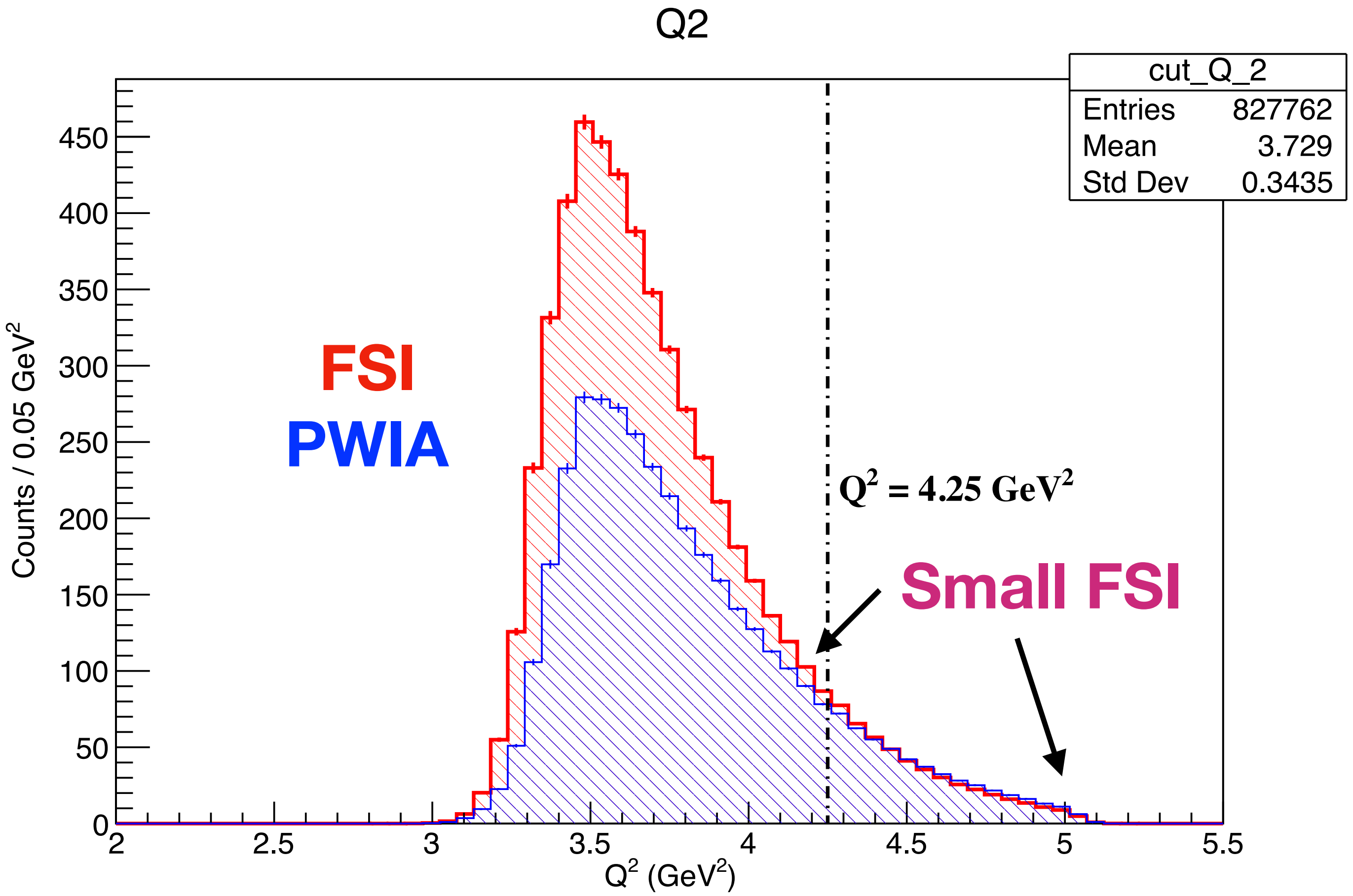
Minimum Charge Requirements MET:

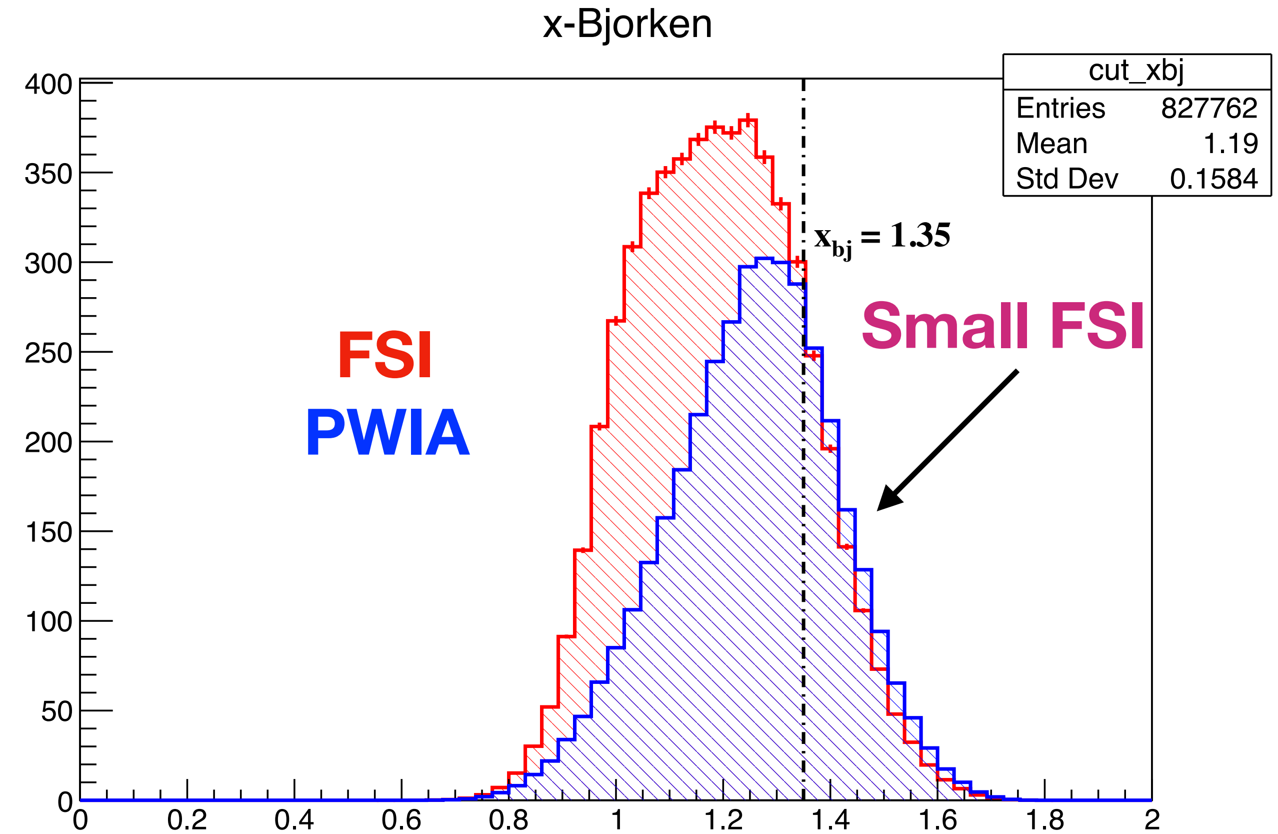
	Pm = 580 MeV/c	Pm = 750 MeV/c
Min Charge:	2880 mC	6048 mC
Obtained:	5049 mC	7865 mC

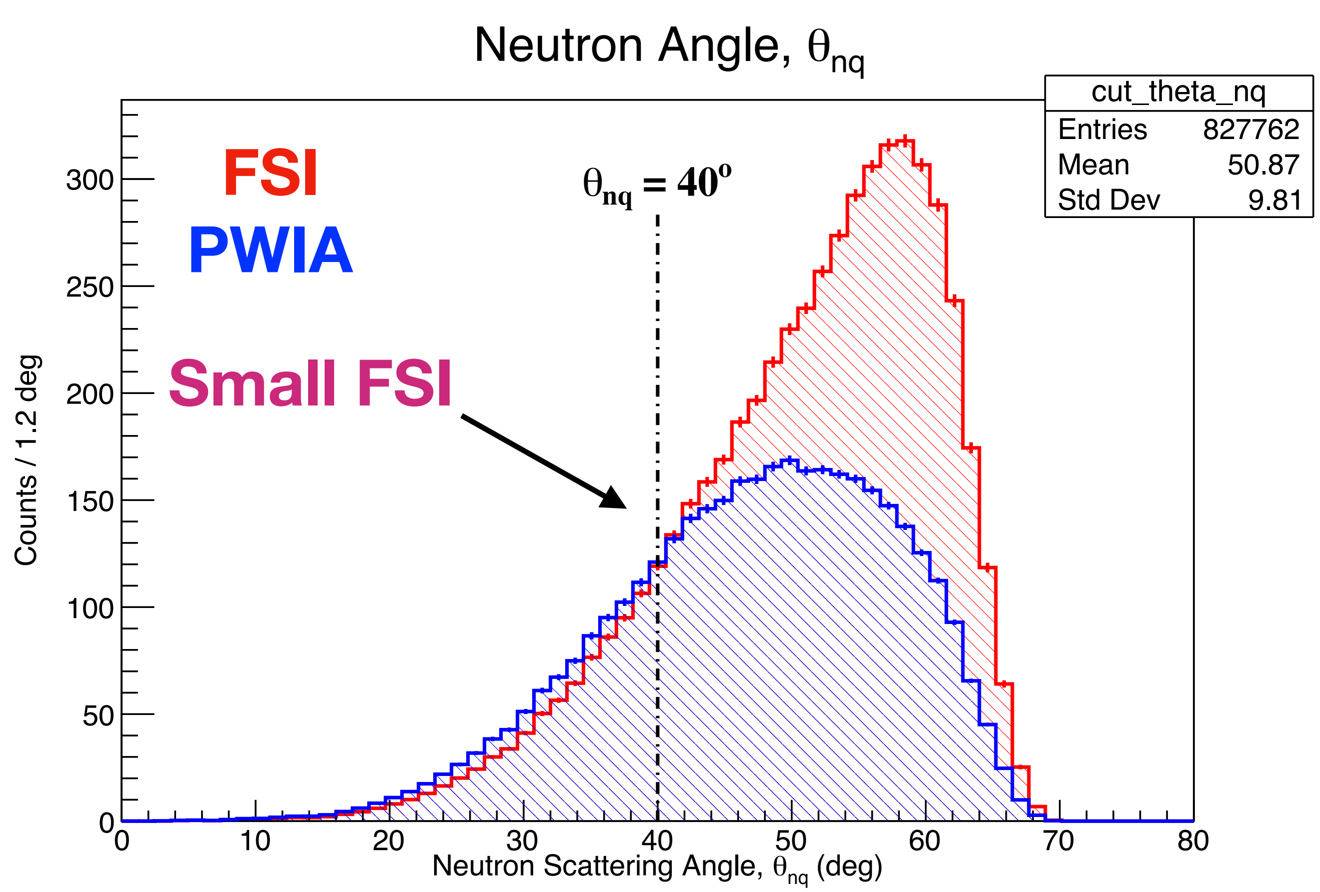
E12-10-003: Simulation Results

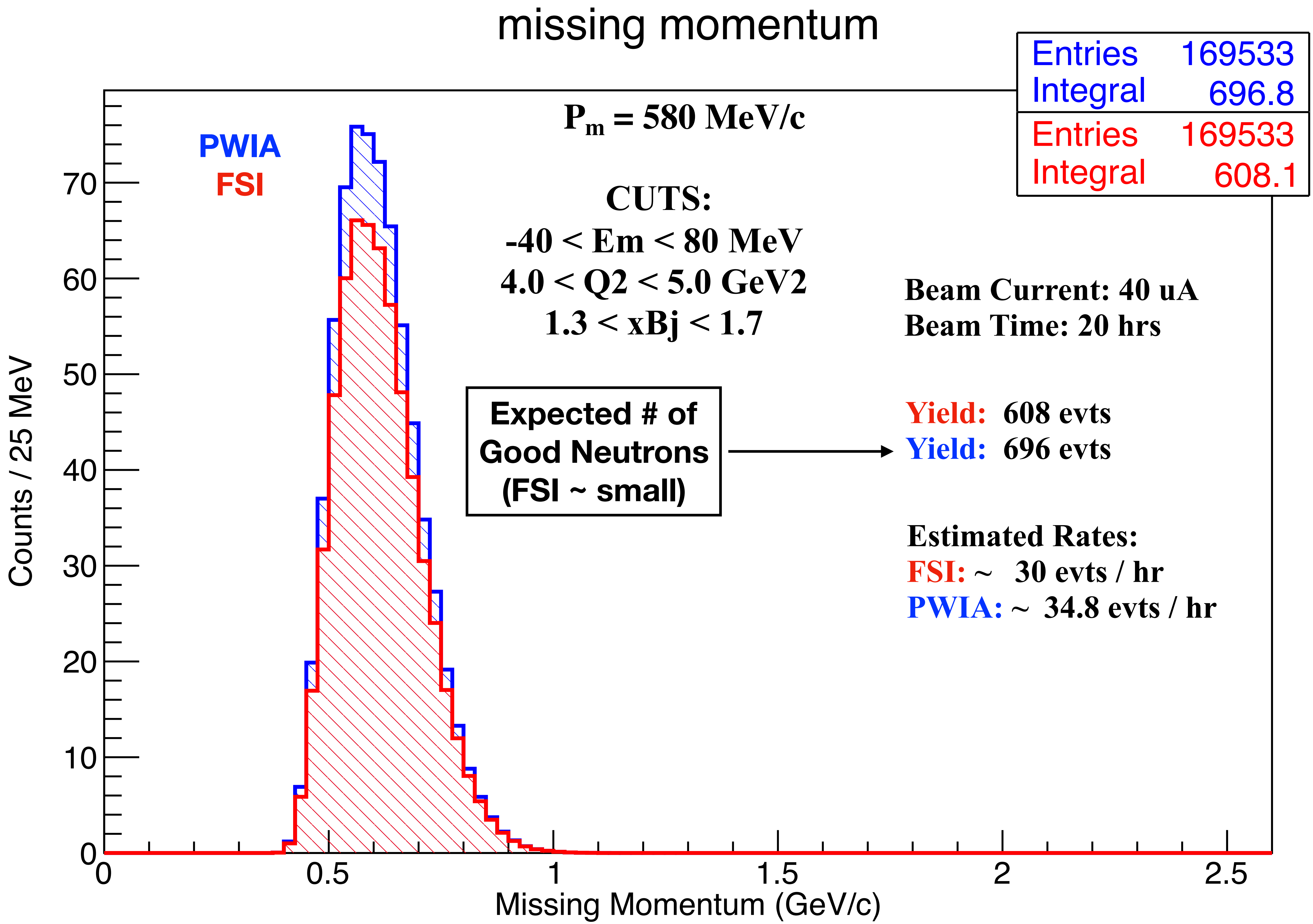


Missing Momentum = 580 MeV/c
CUT: -40 < Em < 80 MeV









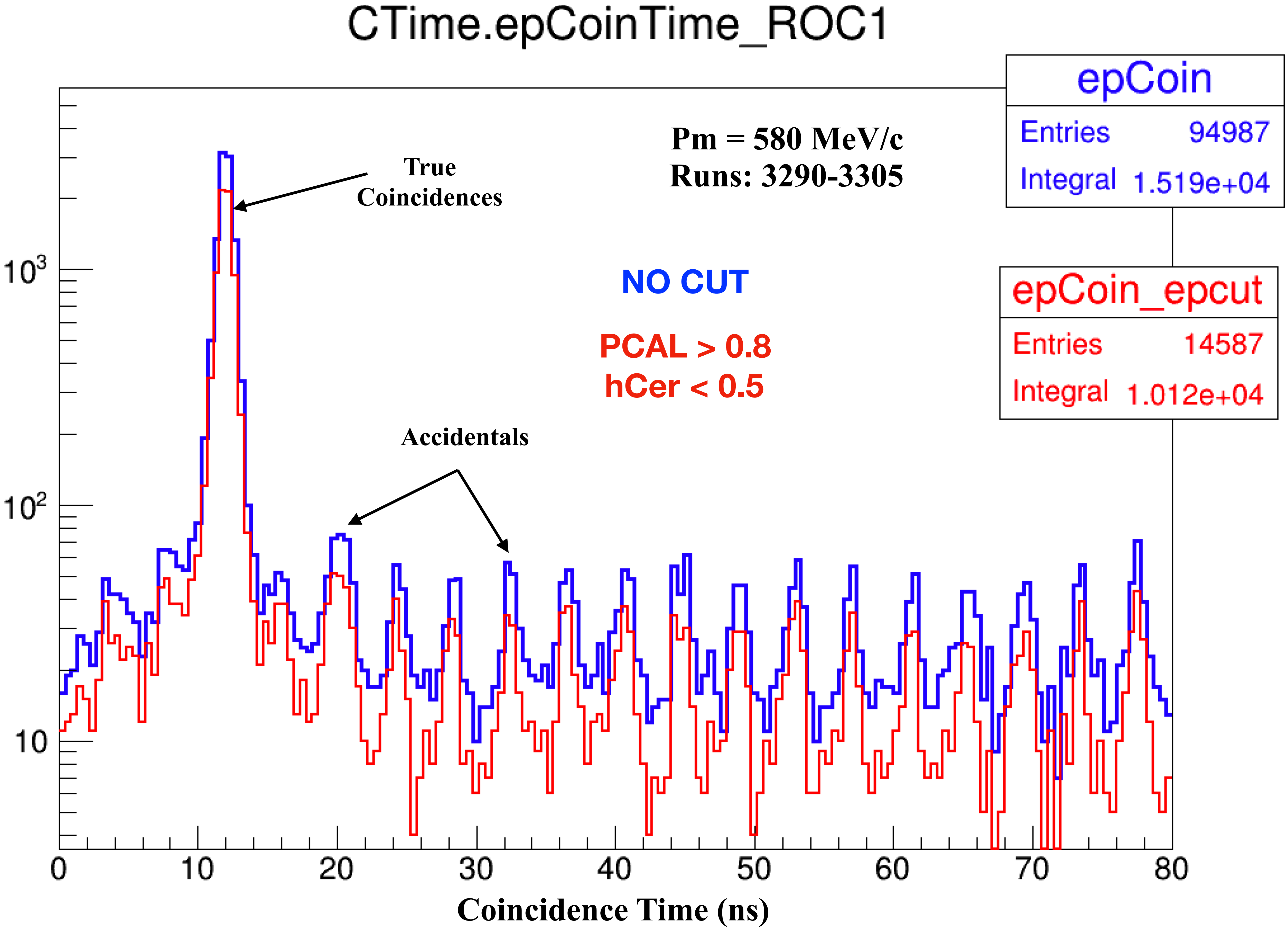
missing momentum
Entries 169533
Integral 696.8
Entries 169533
Integral 608.1
PWIA
FSI
P$_m$ = 580 MeV/c
CUTS:
-40 < Em < 80 MeV
4.0 < Q2 < 5.0 GeV2
1.3 < xBj < 1.7
Beam Current: 40 uA
Beam Time: 20 hrs
Expected # of Good Neutrons (FSI ~ small)
Yield: 608 evts
Yield: 696 evts
Estimated Rates:
FSI: ~ 30 evts / hr
PWIA: ~ 34.8 evts / hr
Counts / 25 MeV
Missing Momentum (GeV/c)
0
10
20
30
40
50
60
70
0.5
1
1.5
2
2.5

E12-10-003:

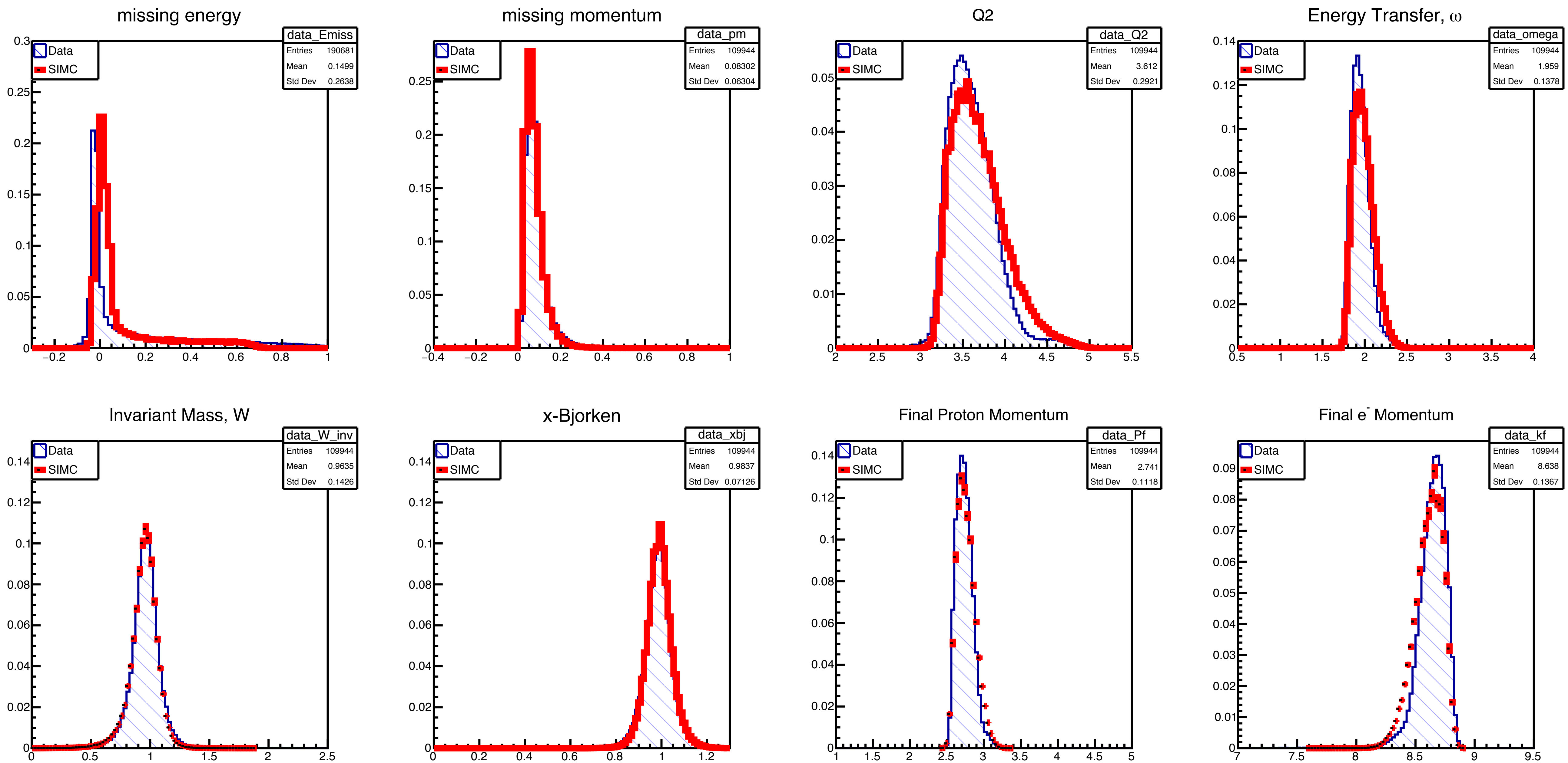
First Look at Experimental Results

For detailed first data results of this and other settings measured, See BackUp Slides

A First Look at Coincidence Times



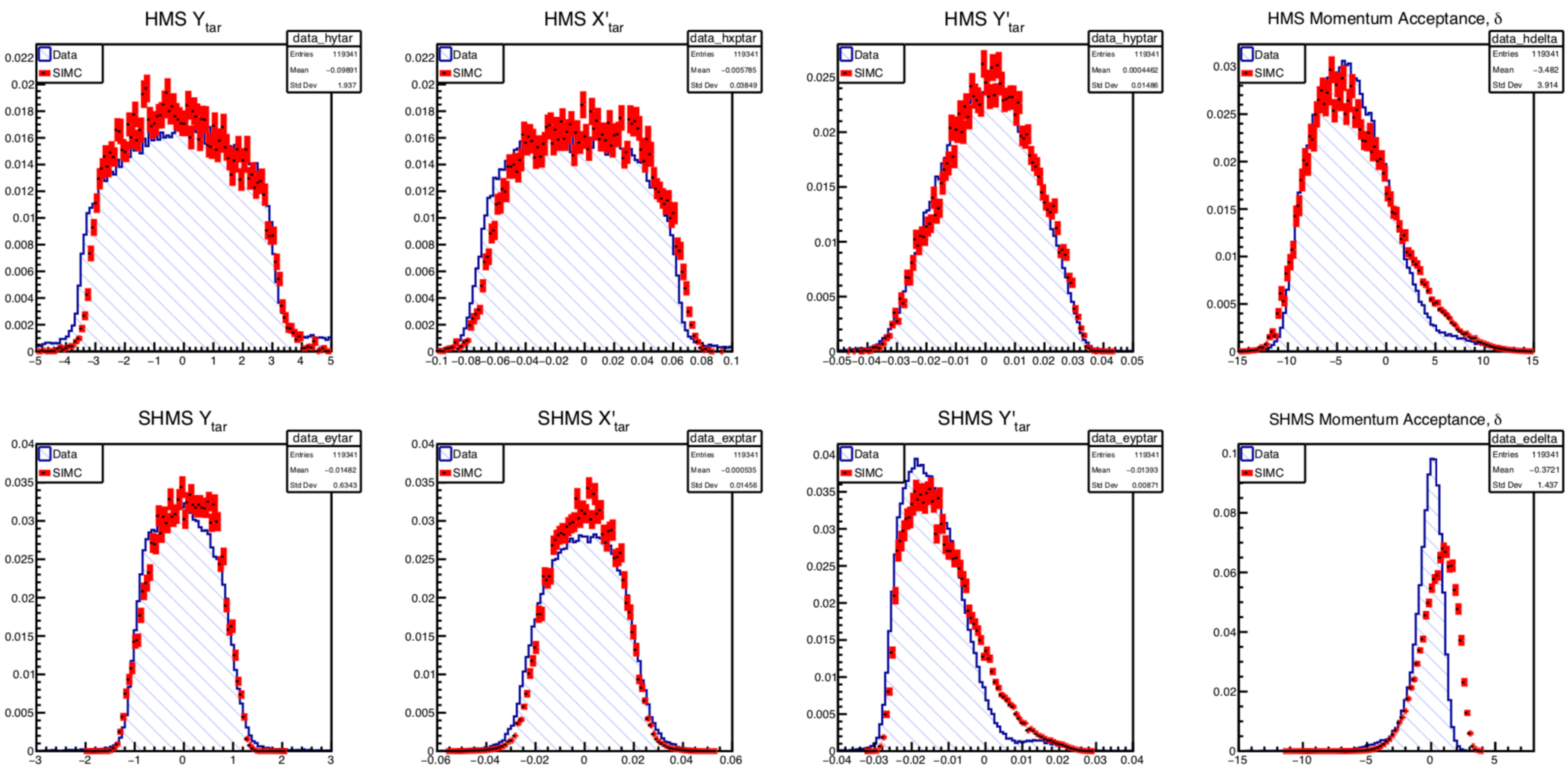
Kinematic Setting: 80 MeV Missing Momentum
SIMC/DATA Comparison with -60 < Em < 80 MeV



COSY delta-matrix with dipole 1.8% higher than quads.
The xp_tar/yp_tar and y_tar optimized by Holly Szumila-Vance from data.

SIMC/DATA are normalized to integral of one.

Kinematic Setting: 80 MeV Missing Momentum
SIMC/DATA Comparison with -60 < Em < 80 MeV
(Target Reconstructed)



Still, a lot of work needs to be done before analysis . . .

- ☑ Observed offsets between data and SIMC needs to be corrected

- ☑ Detector calibrations need to be done

- ☑ H(e,e’p) runs taken must be used to fine tune SHMS

BackUp Slides

For detailed SIMC/Data comparison of E12-10-003, follow this link:

https://hallcweb.jlab.org/wiki/images/7/70/FirstLook_DataSIMC_Deut.pdf

For detailed Simulation Results of E12-10-003, follow this link:

https://hallcweb.jlab.org/wiki/images/6/64/Updated_Yield_Estimates_PDF.pdf

Thank You!

Questions?