Cross-section Measurements of Electro-Disintegration of the Deuteron at High Four Momentum Transfers(Q^2) [E12-10-003]

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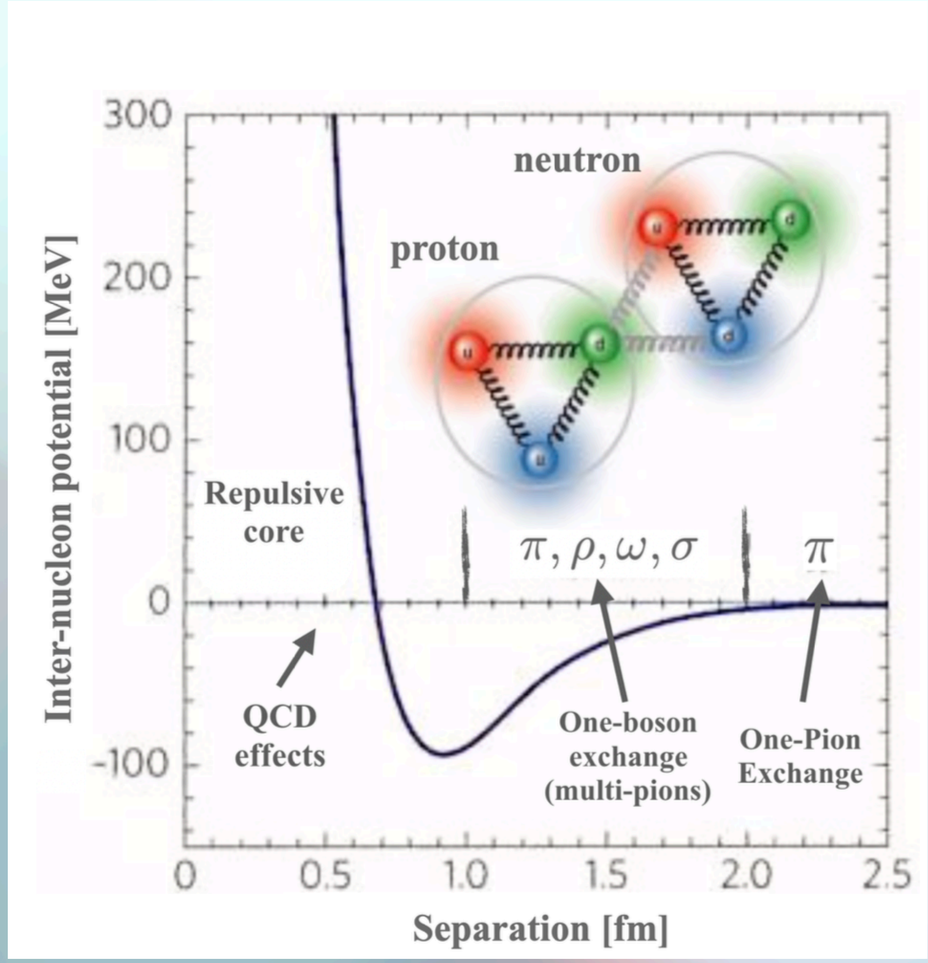
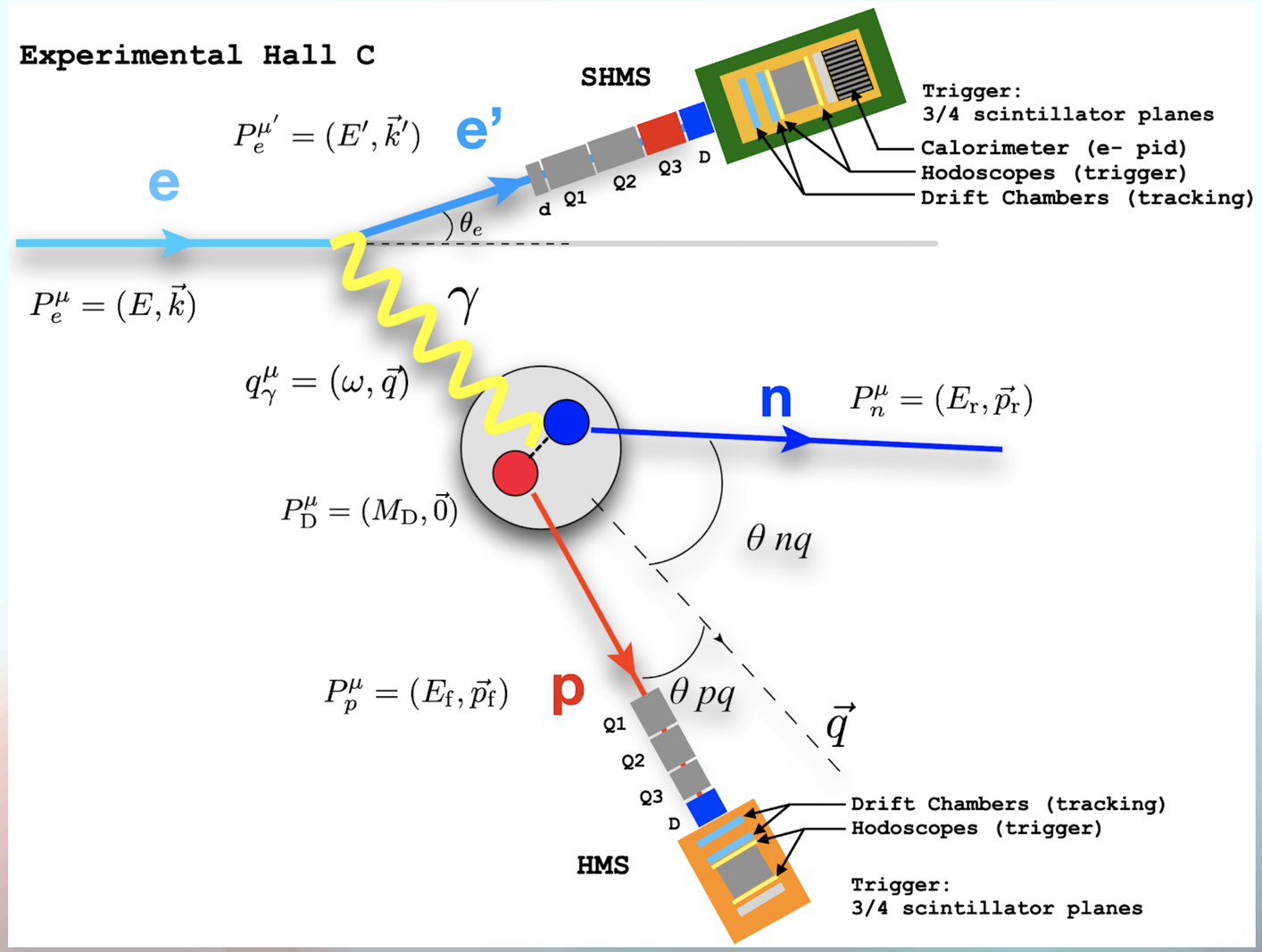
Motivation

- Effective tools for exploring nuclear structure and determining cross sections
- Ideal system to study Nucleon-Nucleon (NN) potential.
- Study Deuteron at short ranges (< 1fm).
- Extract D(e,e'p)n cross-section beyond 500 MeV/c Recoil momentum at high four momentum transfer (Q^2)



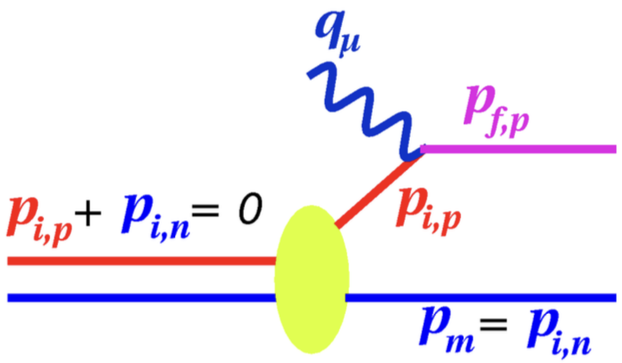
credit. Yero Thesis

D(e,e’p)n Kinematics

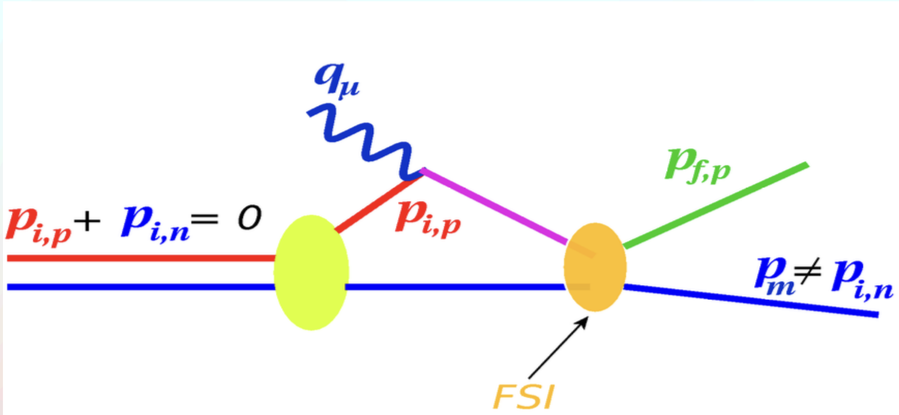


Feynman Diagram of D(e,e’p)n Reaction p.c.Yero Thesis

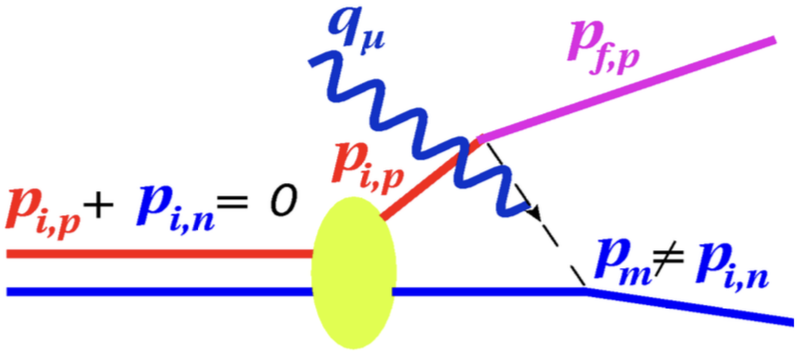
D(e,e'p)n Interactions



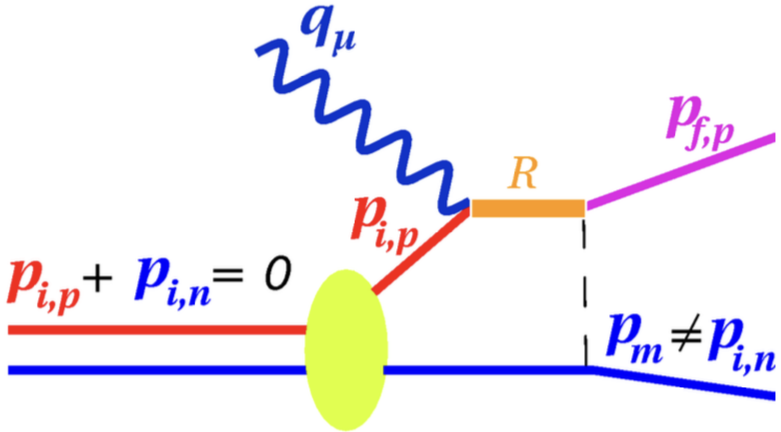
Plane Wave Impulse Approximation (PWIA)



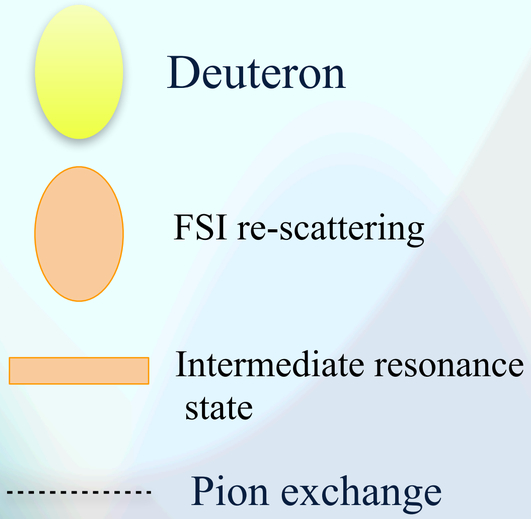
Final State Interactions (FSI)



Meson-Exchange Currents (MEC)

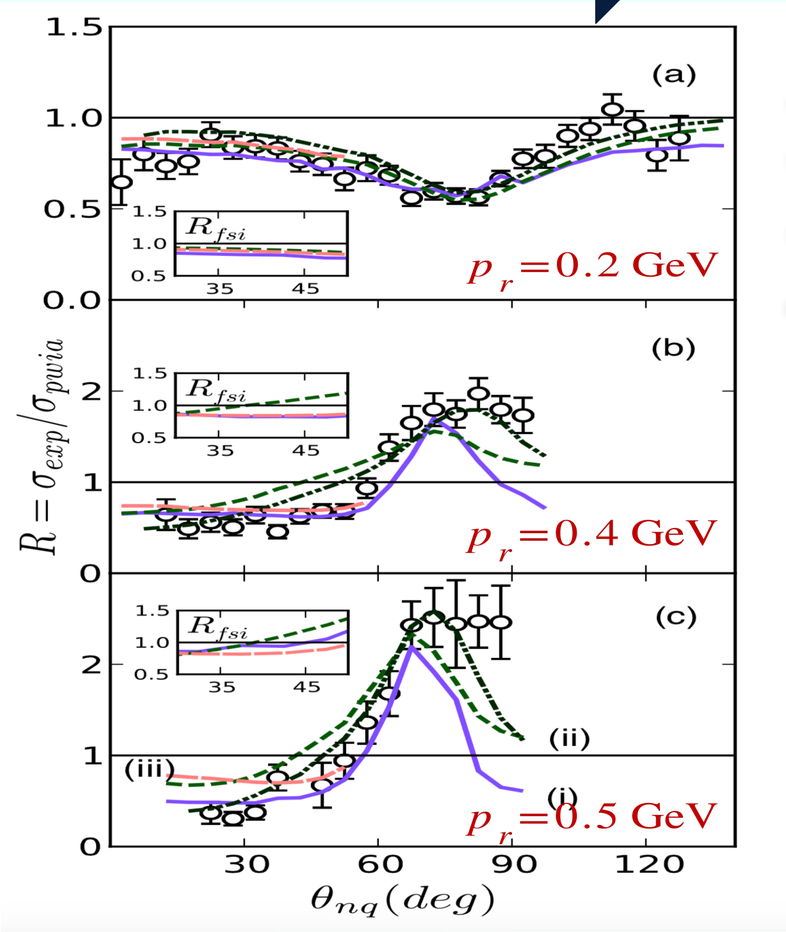


Isobar Configurations (IC)



p.c.Yero Thesis

Hall A Experiment (E01-020)



Experimental Data

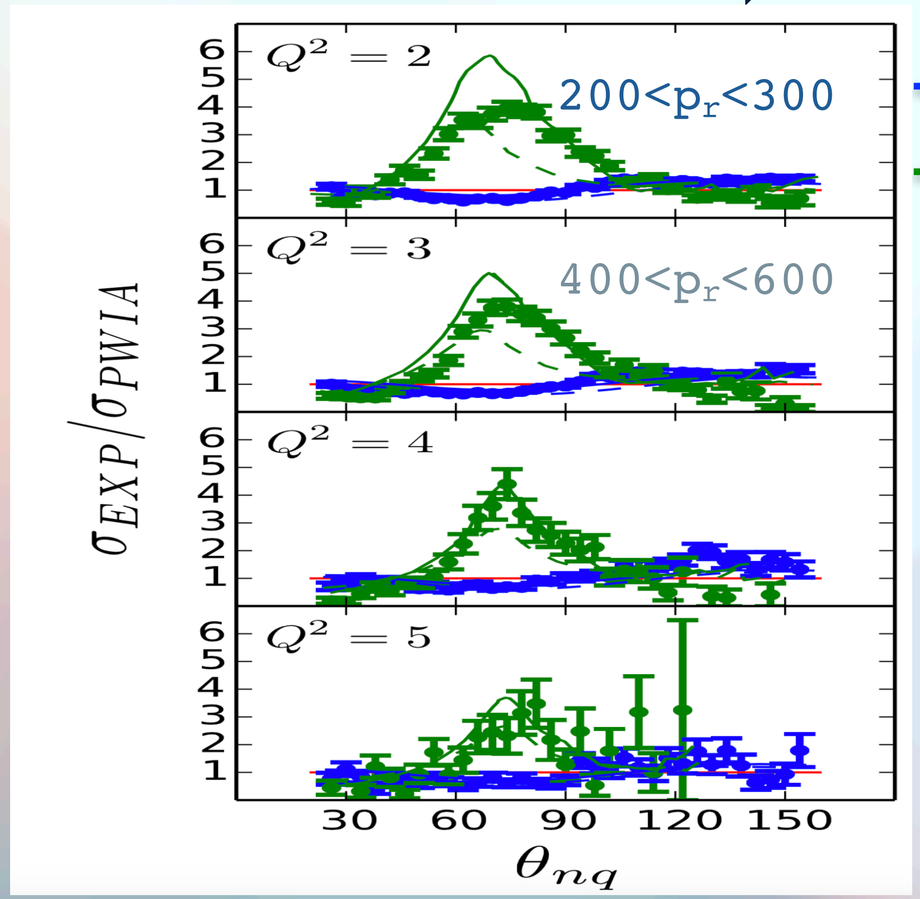
FSI

CD Bonn Potential

FSI+MEC+IC

W. U. Boeglin et al. (2011) 10.1103/PhysRevLett.107.262501

Hall B Experiment (CLAS)

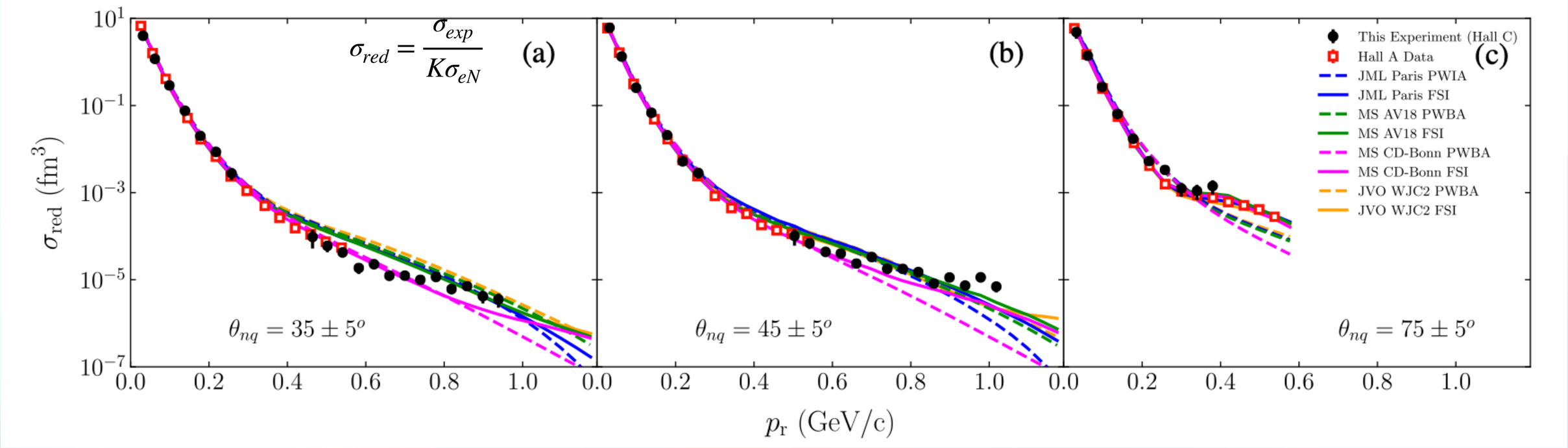


No FSI re-scattering

FSI re-scattering

K. S. Egiyan et al. (2007) 10.1103/PhysRevLett.98.262502

Hall C Experiment (E12-10-003)



C.Yero (2020) 10.1103/PhysRevLett.98.262502

- Hall C experiment reproduces results from previous Hall A.
- At p_m > 0.3 GeV/c (For θ_{nq}= 75), a bump indicates FSI.
- Data is best reproduced by CD-Bonn up to 700MeV/c, above 700MeV/c no calculation describes the data (θ_{nq}= 35,45)

Experiment 2023 Data Analysis

SIMC Weighted Yield Calculation:

$$Y_{\mathrm{SIMC}} = N_{\mathrm{SIMC}} \cdot W_{\mathrm{f}}$$

unweighted events

acceptance-normalized model cross-section weight

Data Yield Calculation:

$$Y_{DATA} = N_{DATA} \cdot \frac{f_{rad}}{Q \cdot \epsilon_{trk} \cdot \epsilon_{tgt} \cdot \epsilon_{pAbs} \cdot \epsilon_{LT}}$$

Uncorrected (e,e'p) events

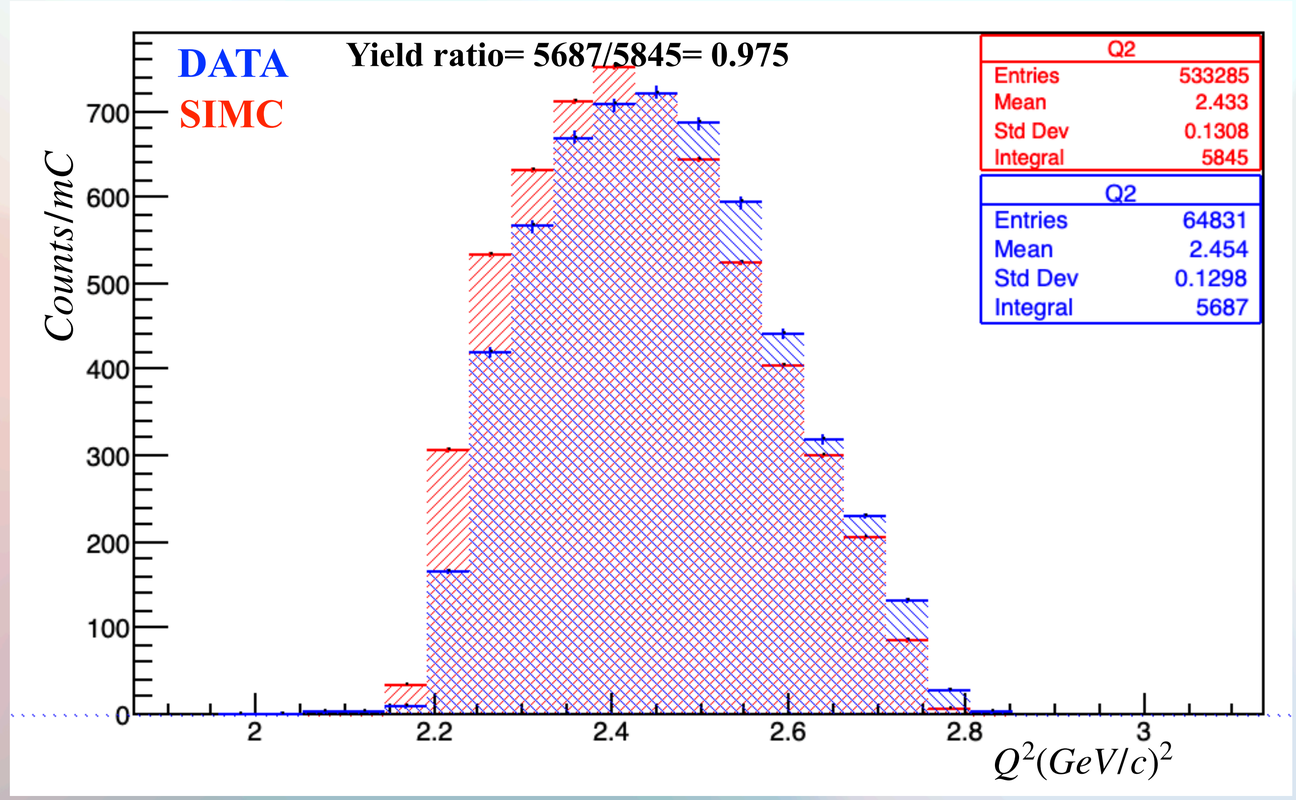
Charge

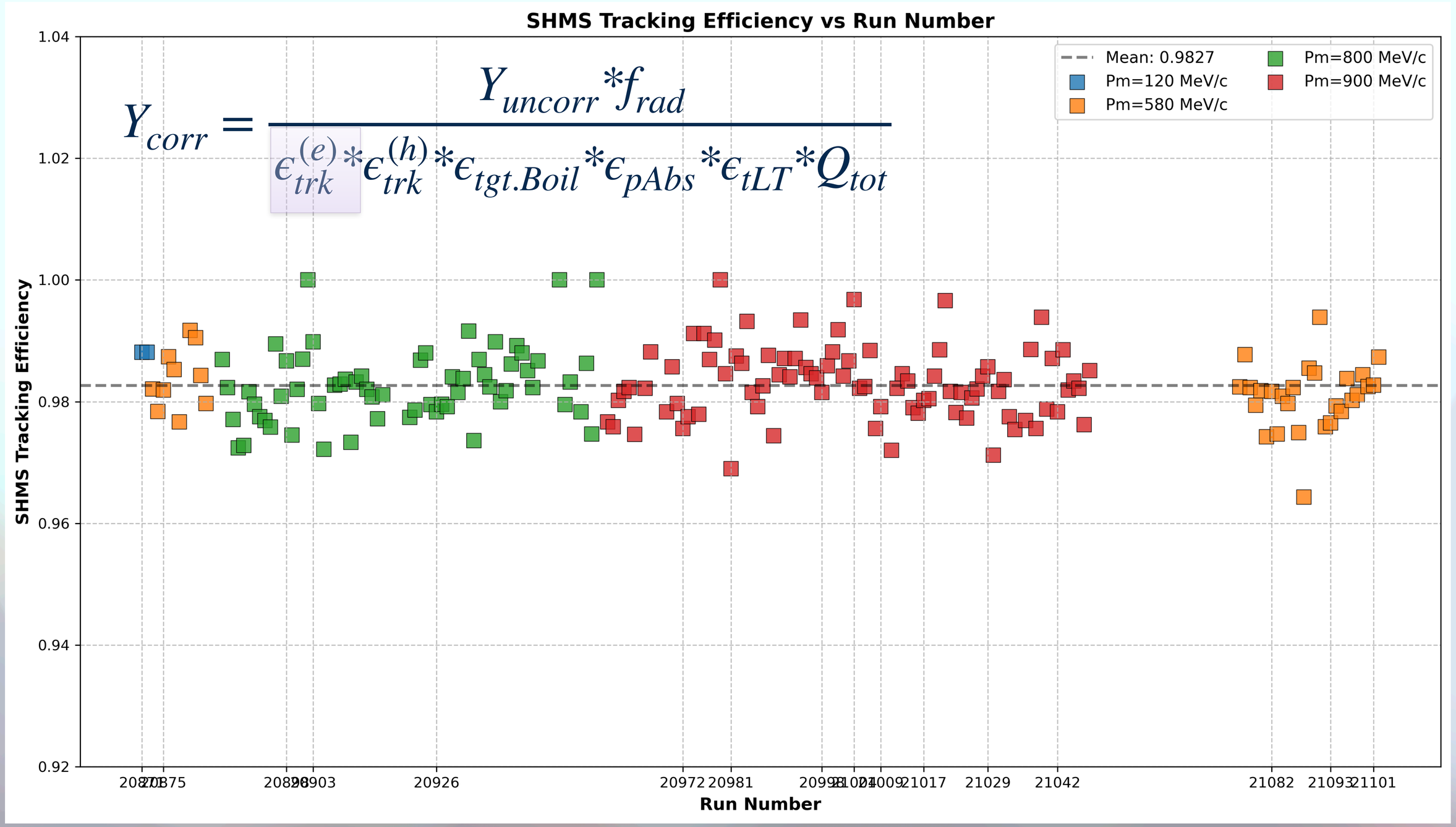
Track efficiency

Target boiling

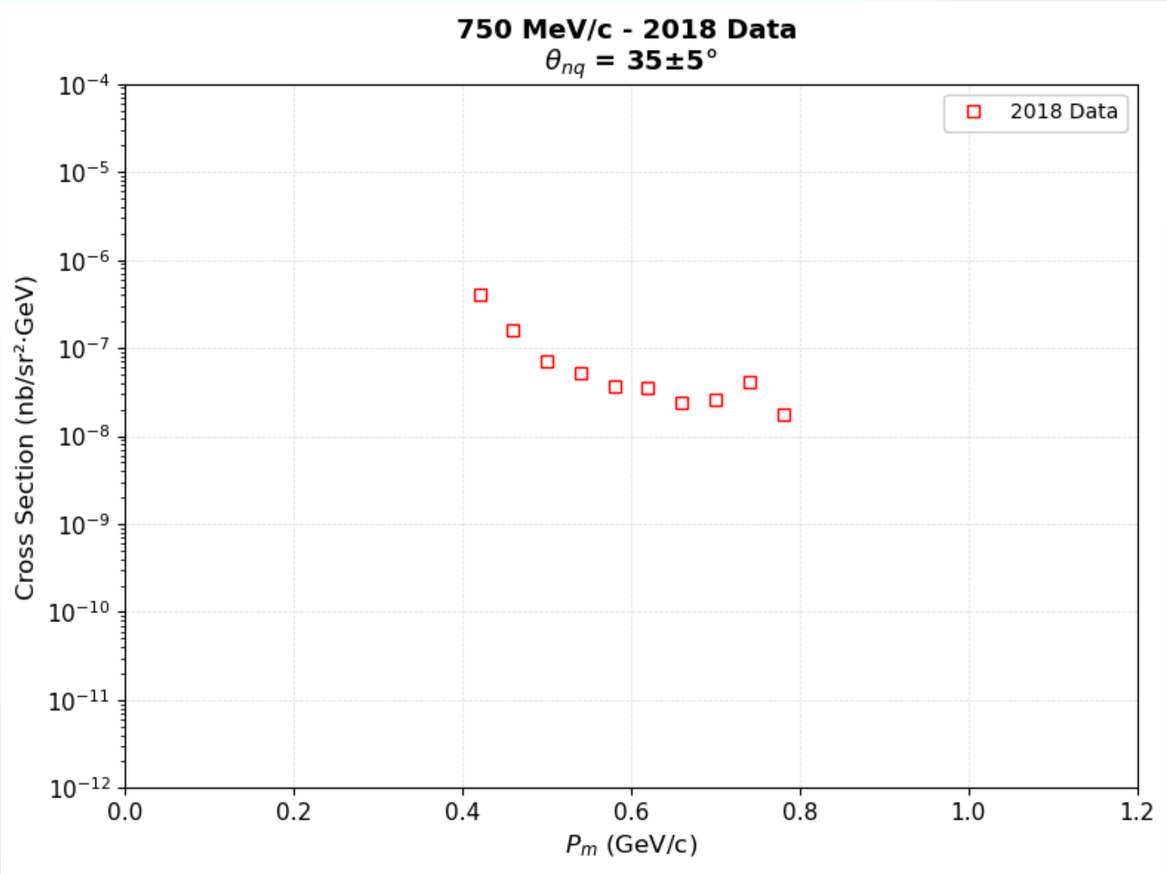
Proton absorption

DAQ live time




SHMS Tracking Efficiency vs Run Number
$Y_{corr} = \frac{Y_{uncorr} * f_{rad}}{\epsilon_{trk}^{(e)} * \epsilon_{trk}^{(h)} * \epsilon_{tgt.Boil} * \epsilon_{pAbs} * \epsilon_{tLT} * Q_{tot}}$
Mean: 0.9827
Pm=120 MeV/c
Pm=580 MeV/c
Pm=800 MeV/c
Pm=900 MeV/c
SHMS Tracking Efficiency
1.04
1.02
1.00
0.98
0.96
0.94
0.92
20875
20903
20926
20972
20981
21017
21029
21042
21082
21093
21101
Run Number

Deuteron cross-section

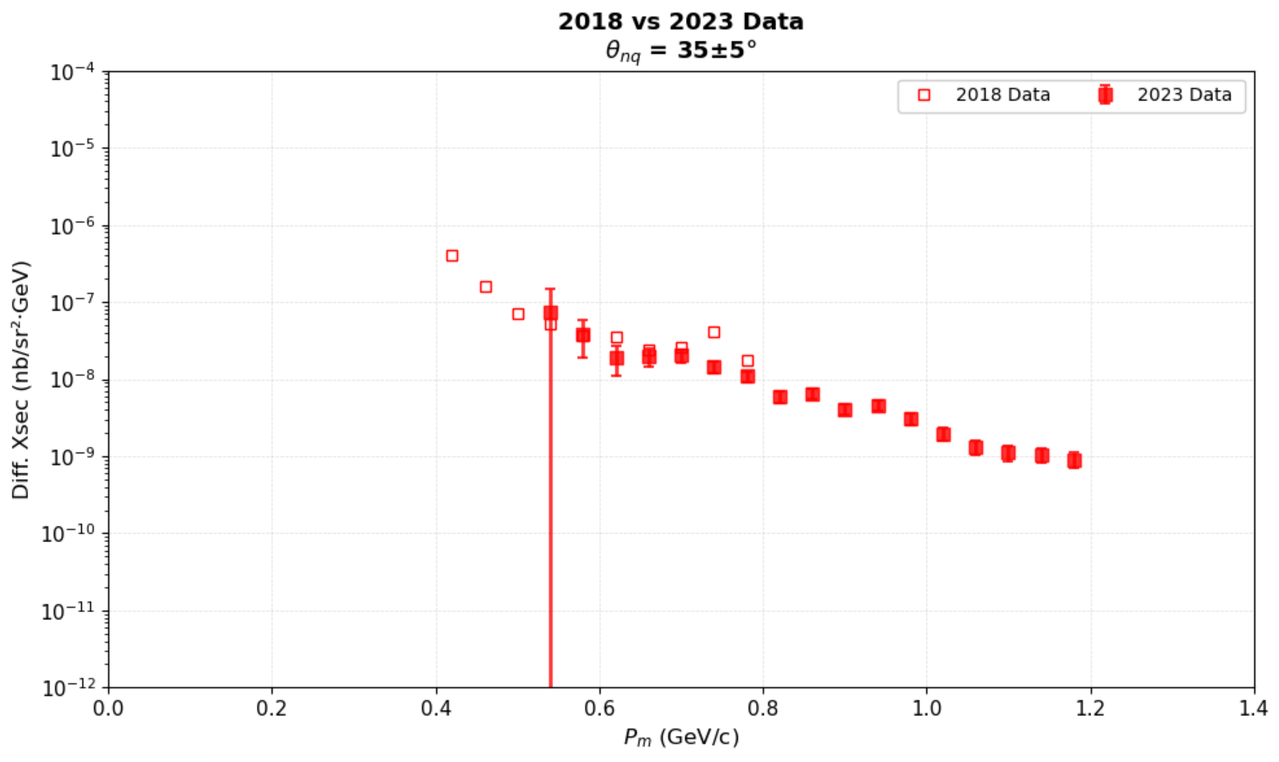


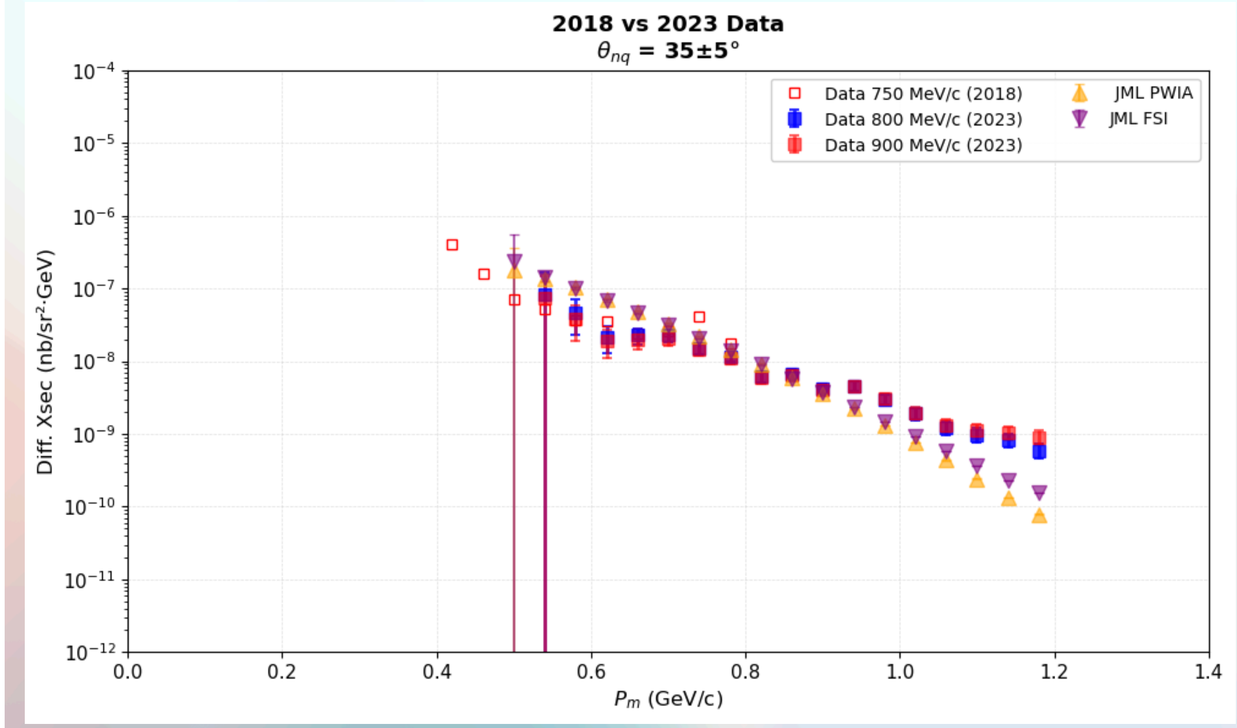
C.Yero (2020) 10.1103/PhysRevLett.98.262502

- Exp data cross-section from 2018
- Pm= 750MeV/c

- Bump at around 700 MeV/c which was also seen in other studies.
- A fully relativistic initial-pn state with the inclusion of non-nucleonic components, gives rise to the presence of a ‘P-wave’ (L=1) like structure (violating the angular condition).
- P-wave starts to dominate at ≈800 MeV/c causing a bump.

Deuteron cross-section



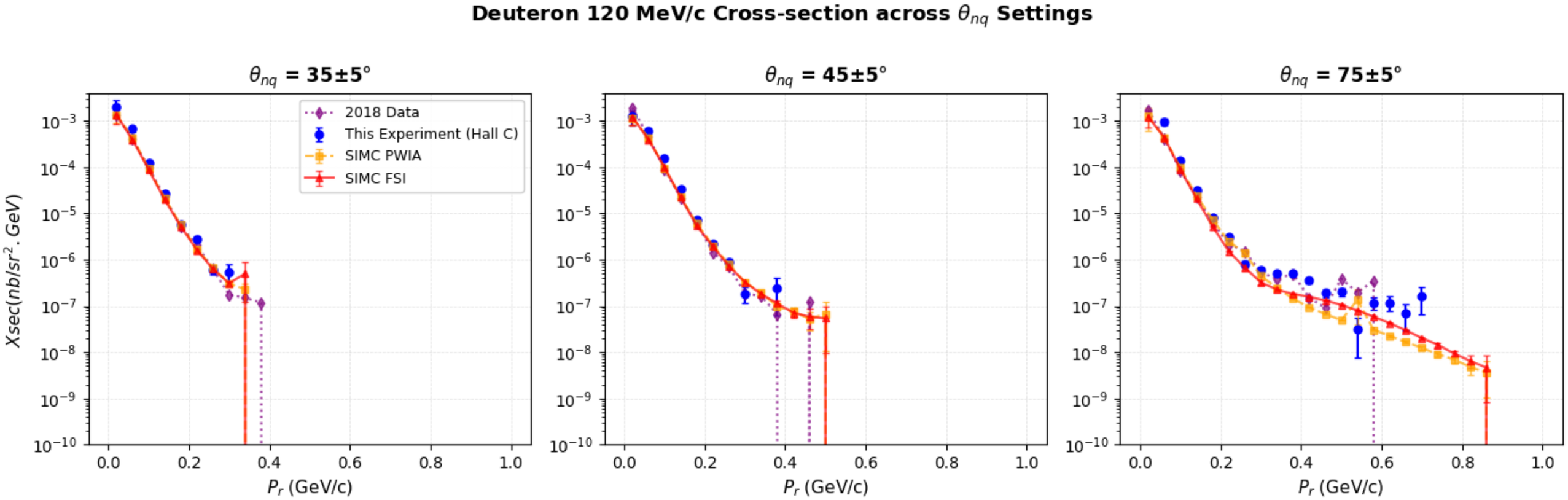


- Data Cross-sections along with JML FSI and JML PWIA.
- Pm= 900 MeV/c overlayed with 800 and 750 MeV/c data cross-sections.
- 2023 data reproduces 2018 exp data results and also produces cross-section to higher missing momentum till 1.2 GeV/c.

Any Questions?

Thank you for your attention.

Bonus Slides

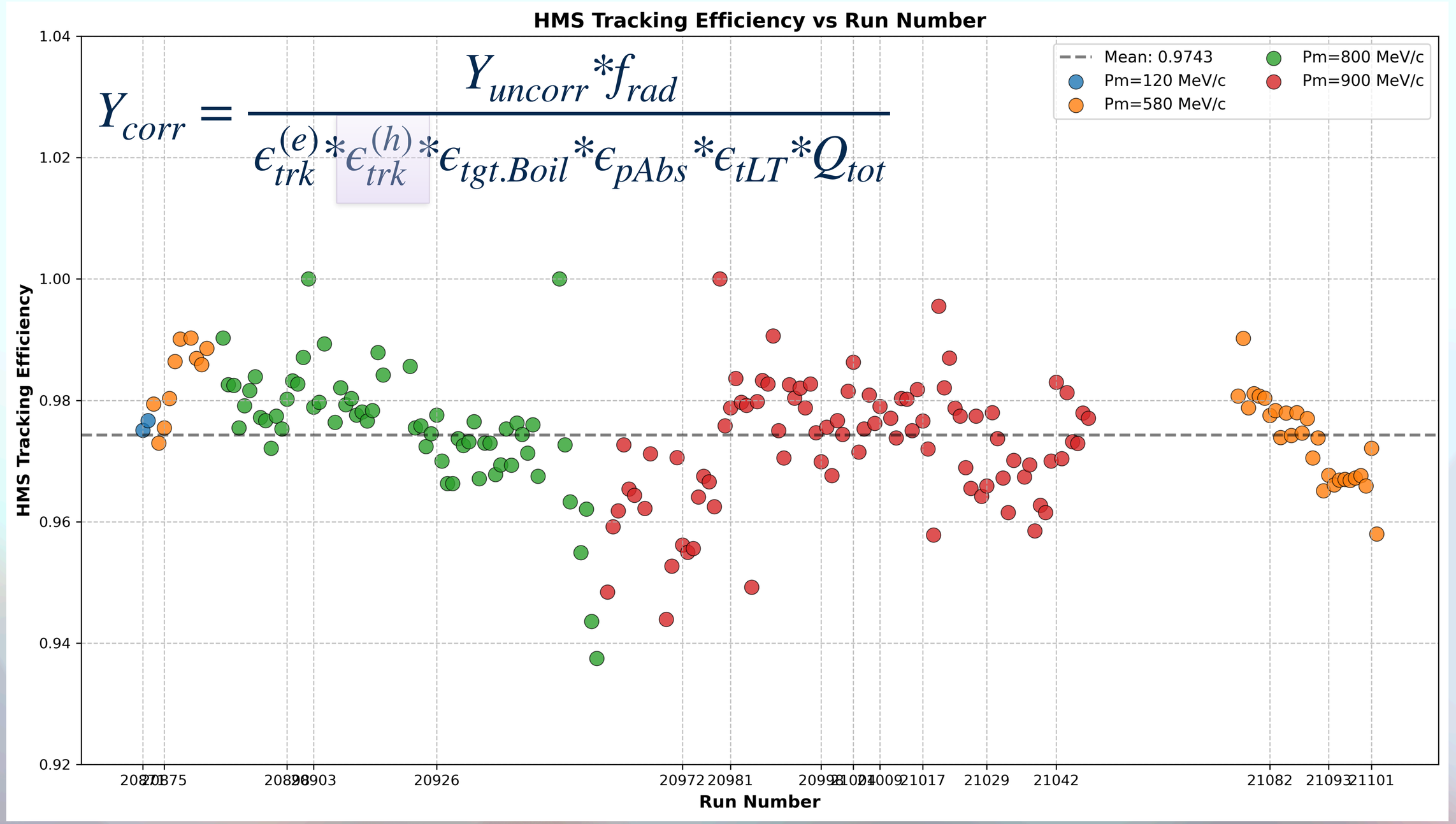


Corrections applied:

- Charge-normalized
- Tracking efficiency
- Live Time
- Radiative corrections

Corrections applied:

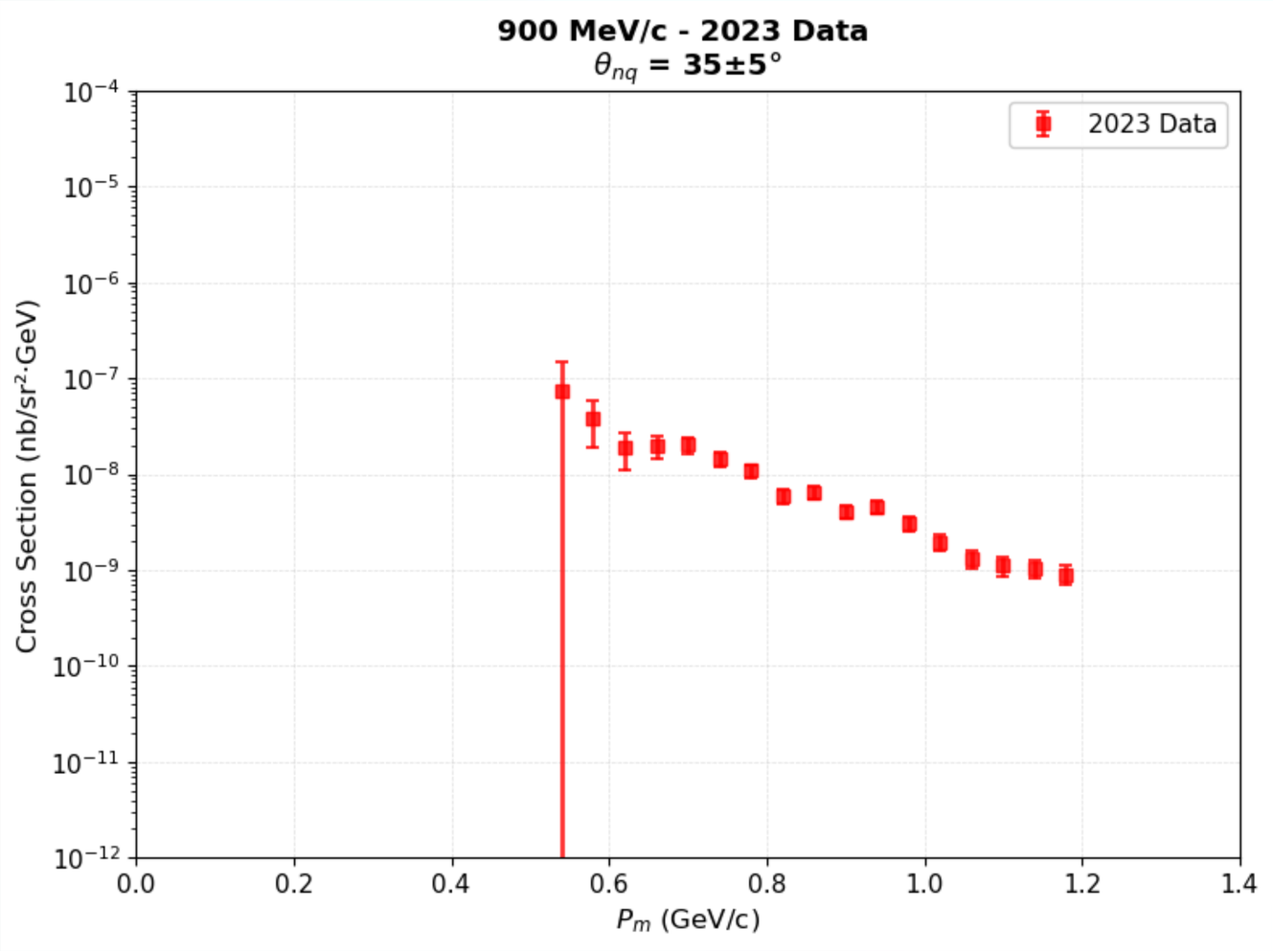
- Proton absorption
- Target boiling

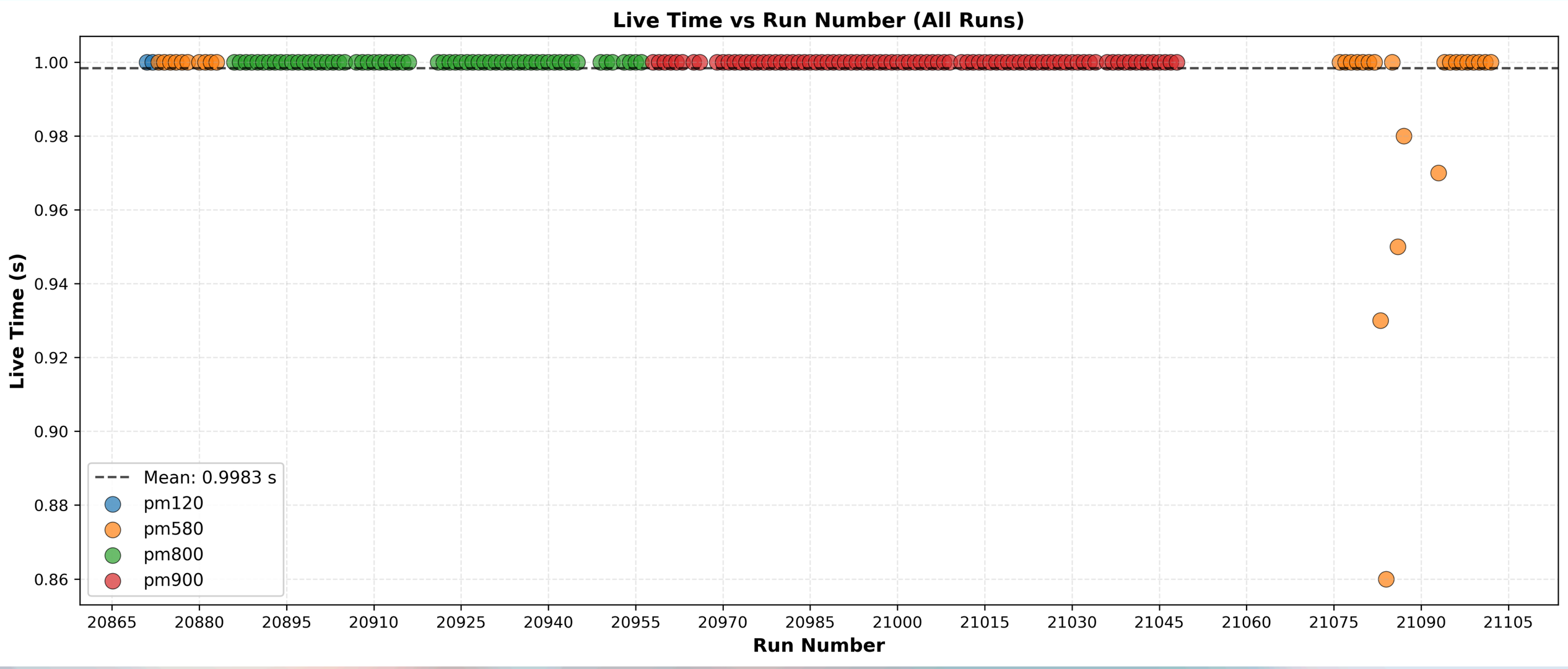

HMS Tracking Efficiency vs Run Number
$Y_{corr} = \frac{Y_{uncorr} * f_{rad}}{\epsilon_{trk}^{(e)} * \epsilon_{trk}^{(h)} * \epsilon_{tgt.Boil} * \epsilon_{pAbs} * \epsilon_{tLT} * Q_{tot}}$
Mean: 0.9743
Pm=120 MeV/c
Pm=580 MeV/c
Pm=800 MeV/c
Pm=900 MeV/c
HMS Tracking Efficiency
Run Number
1.04
1.02
1.00
0.98
0.96
0.94
0.92
20875
20903
20926
20972
20981
21017
21029
21042
21082
21093
21101

Deuteron cross-section

Deuteron cross-section

- Exp data cross-section from 2023
- Pm= 900 MeV/c
- Both models reproduce result in this kinematic regime





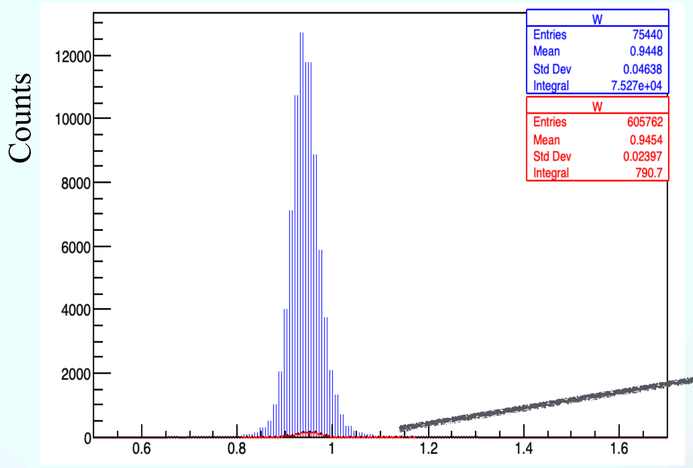
Runs from 21088-21092 were junk runs. Thus the data looks off.

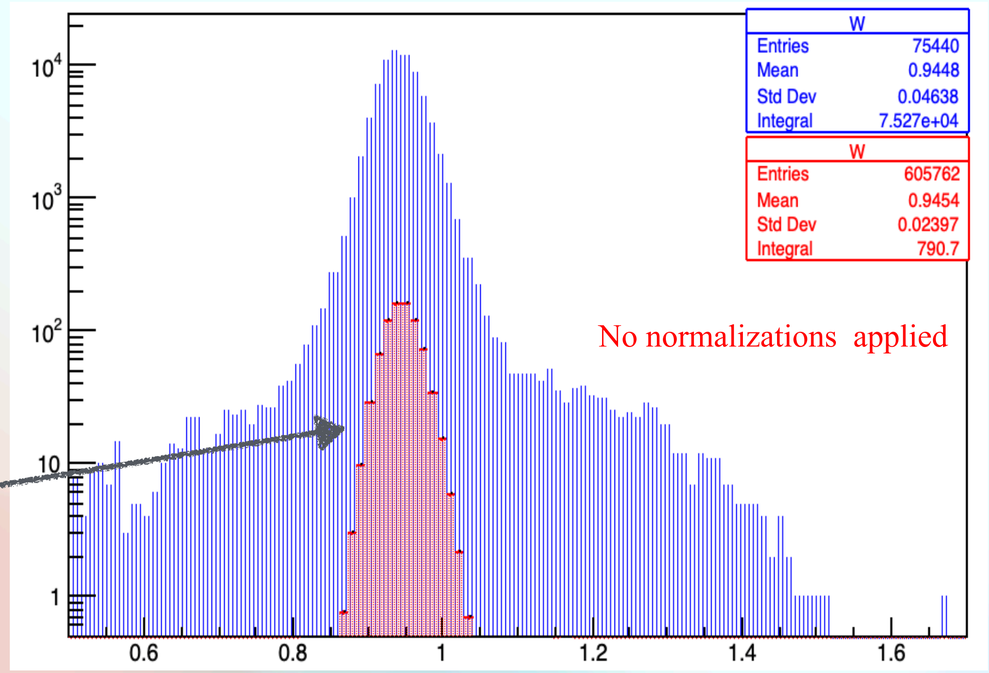
CODA crashed shortly after start of run 21088

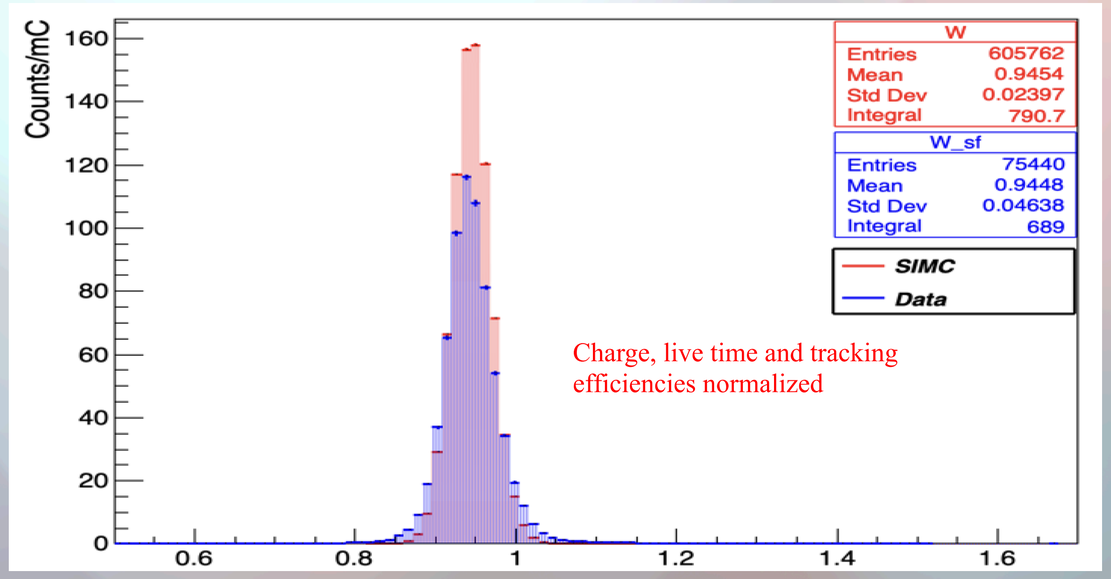
4151832 HCLOG kinney CODA crashed a few minutes after the start of **21088**; this time performed

cdaq - 2023-03-19 09:19

Data Yield

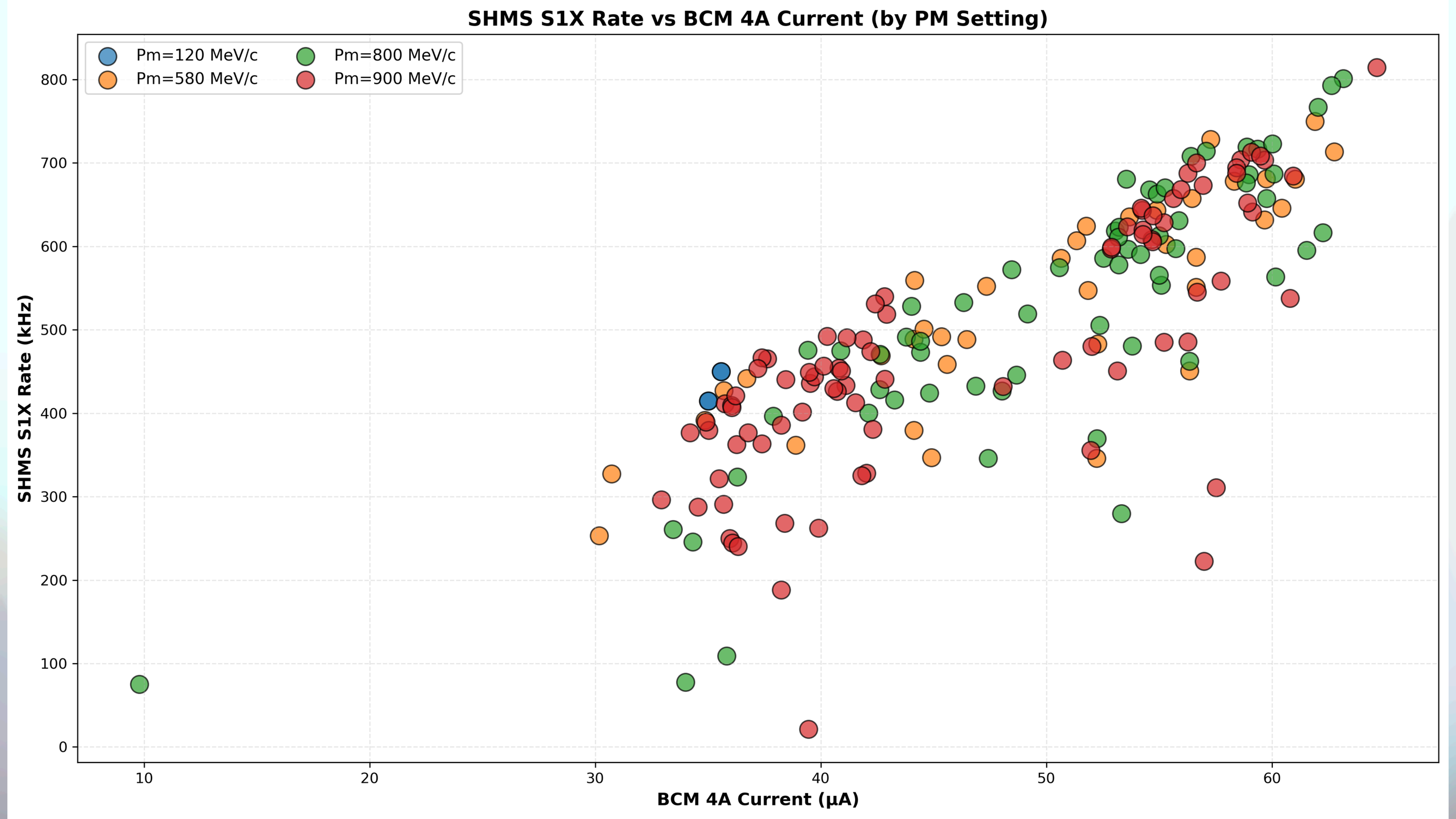


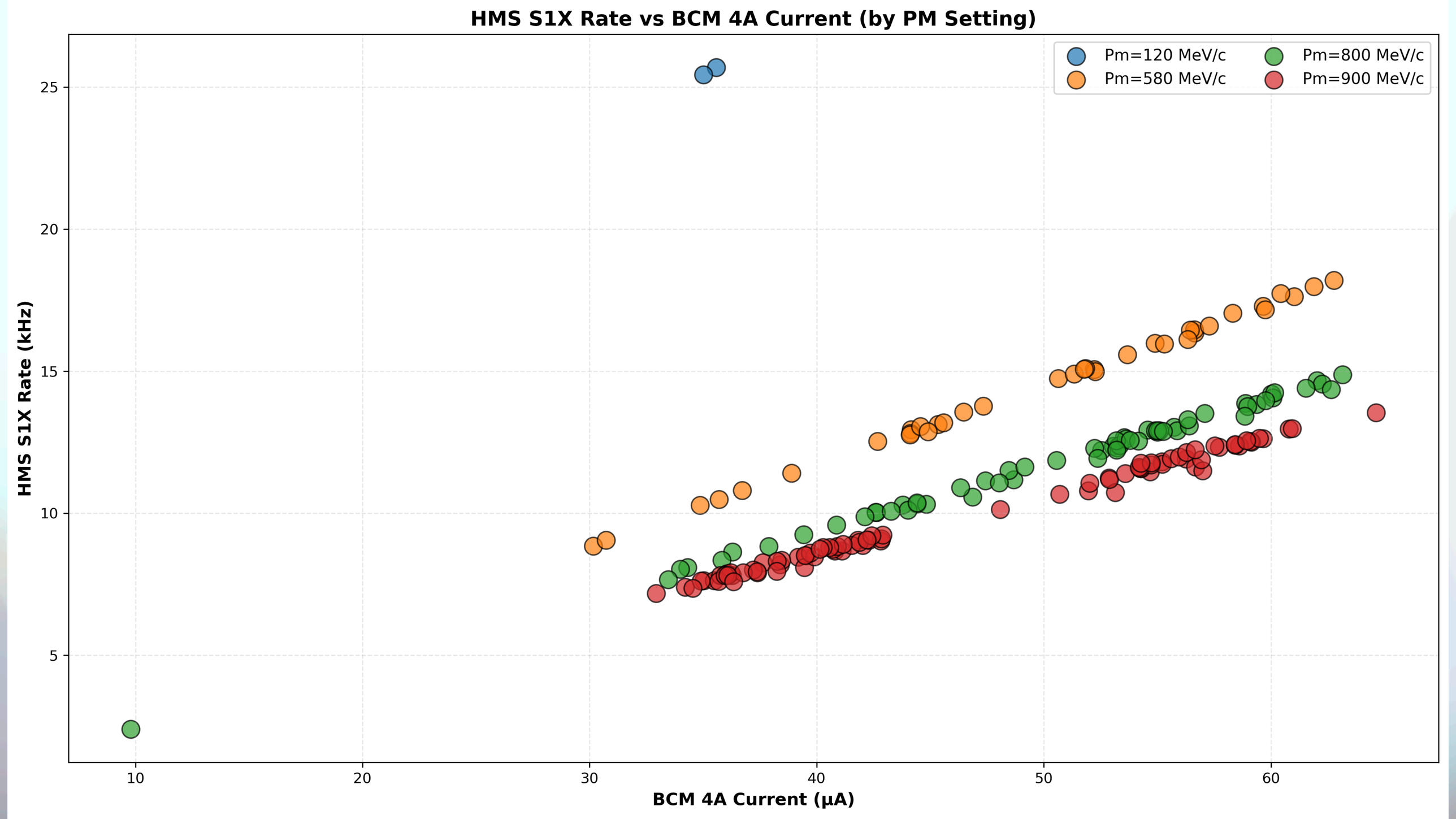




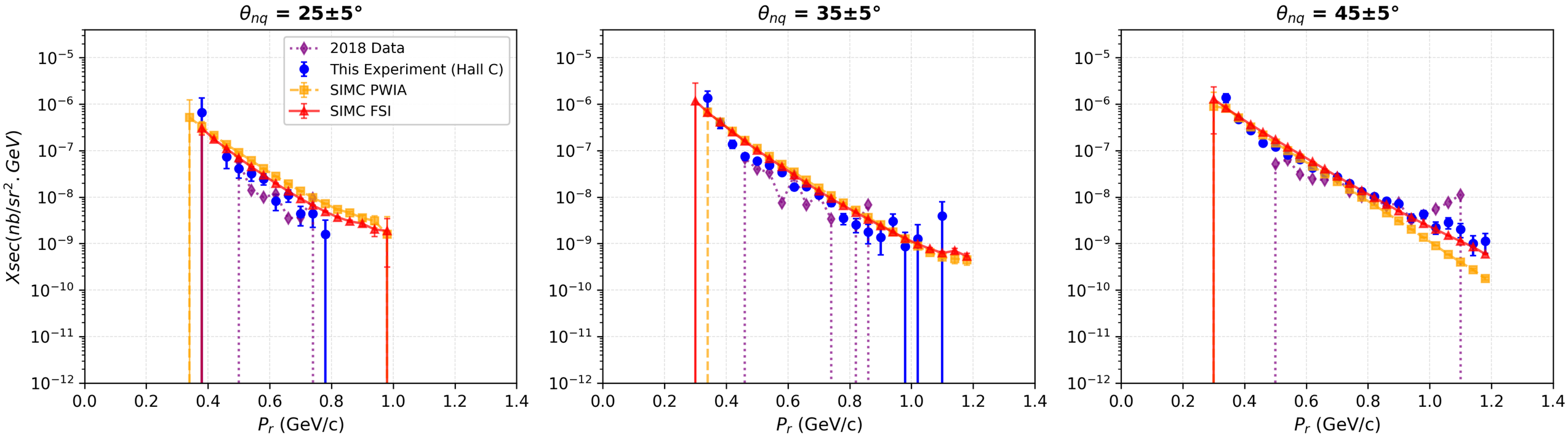
Corrections to be Applied

- Target Boiling
- Proton Absorption

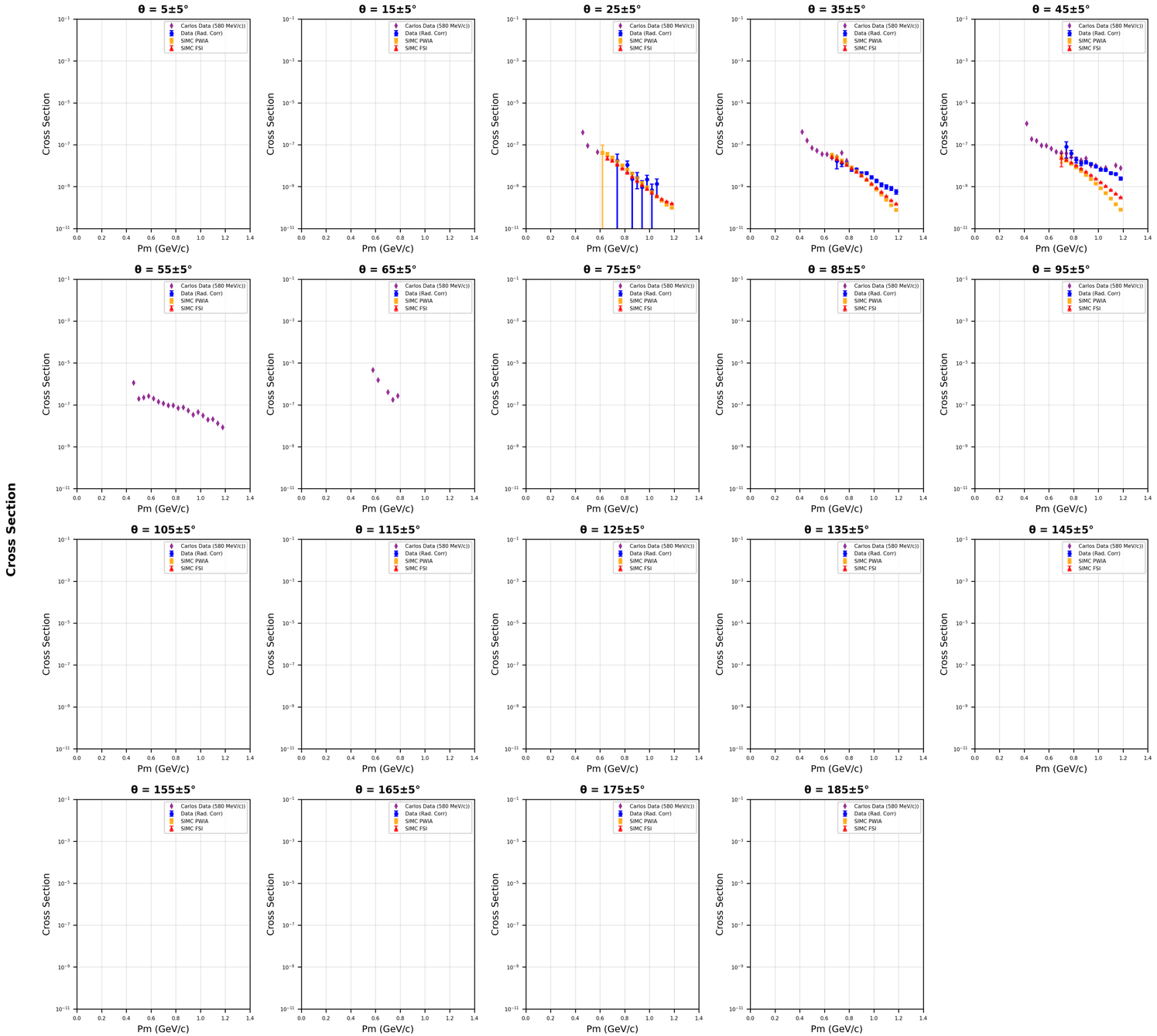

SHMS S1X Rate vs BCM 4A Current (by PM Setting)
Pm=120 MeV/c
Pm=580 MeV/c
Pm=800 MeV/c
Pm=900 MeV/c
SHMS S1X Rate (kHz)
BCM 4A Current (μA)
0
100
200
300
400
500
600
700
800
10
20
30
40
50
60


HMS S1X Rate vs BCM 4A Current (by PM Setting)
Pm=120 MeV/c
Pm=580 MeV/c
Pm=800 MeV/c
Pm=900 MeV/c
HMS S1X Rate (kHz)
BCM 4A Current (μA)
25
20
15
10
5
10
20
30
40
50
60

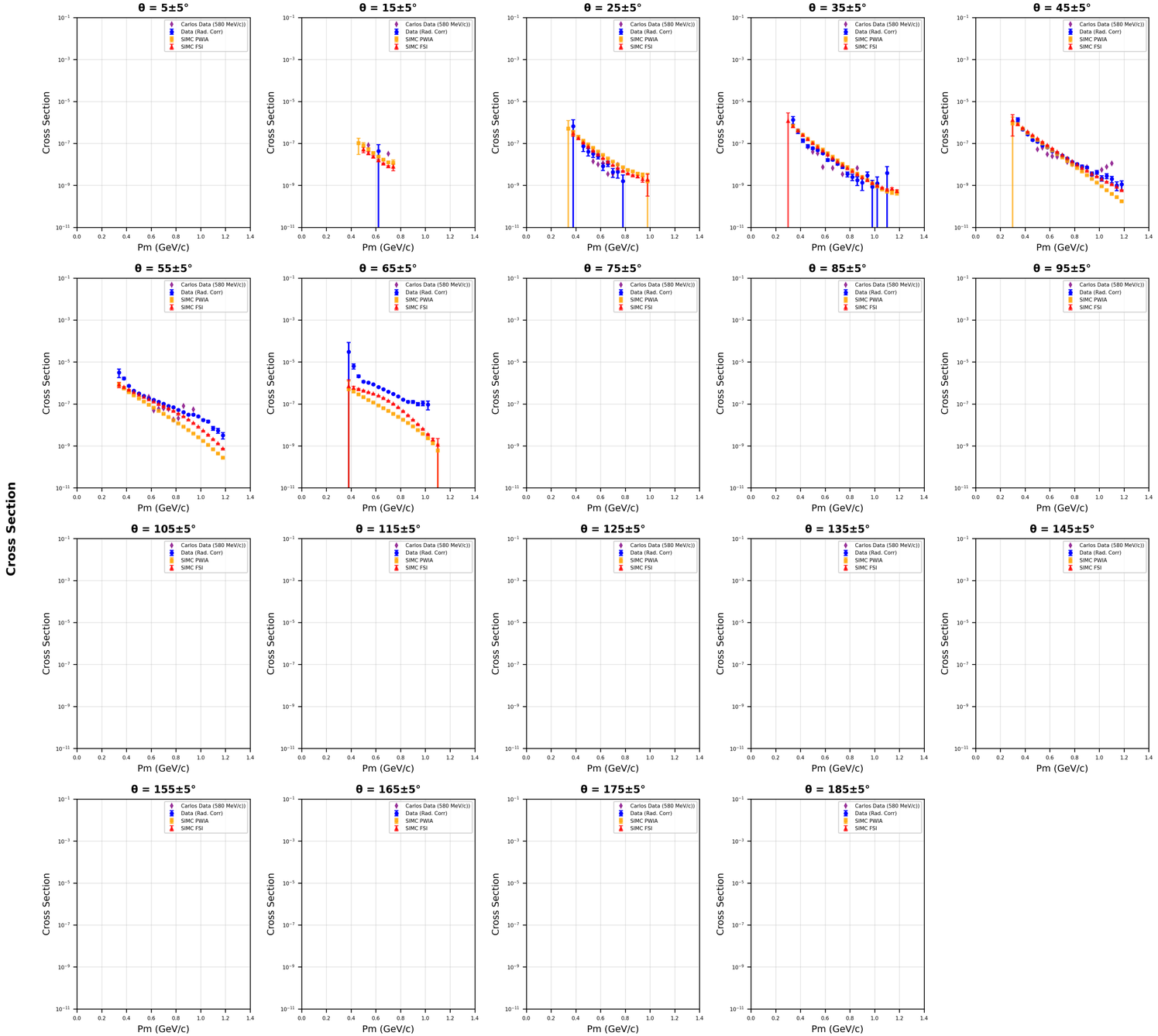
Deuteron 580 MeV/c Cross-section across θ_{nq} Settings



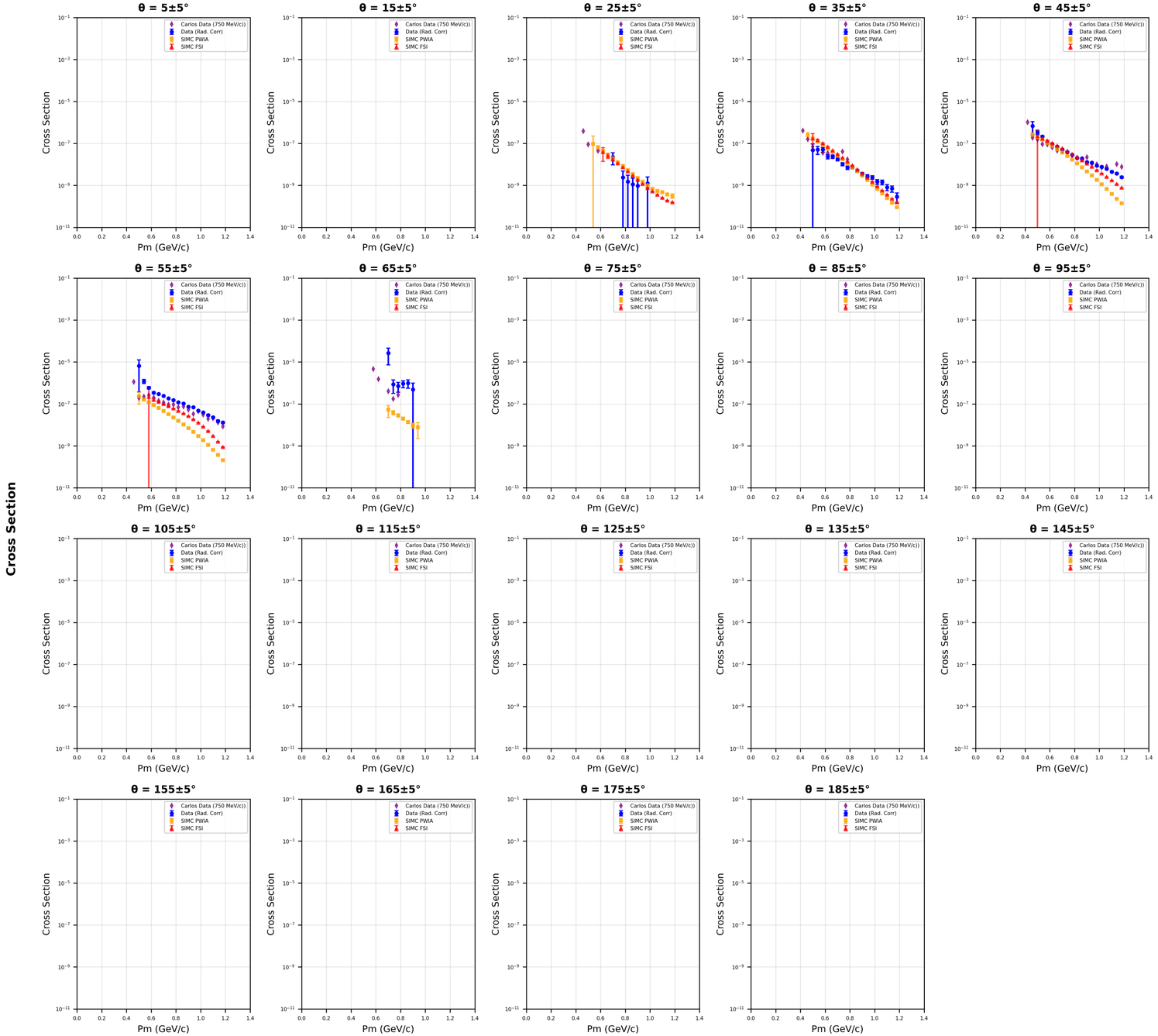
Deuteron Cross-section Projection 900 MeV/c



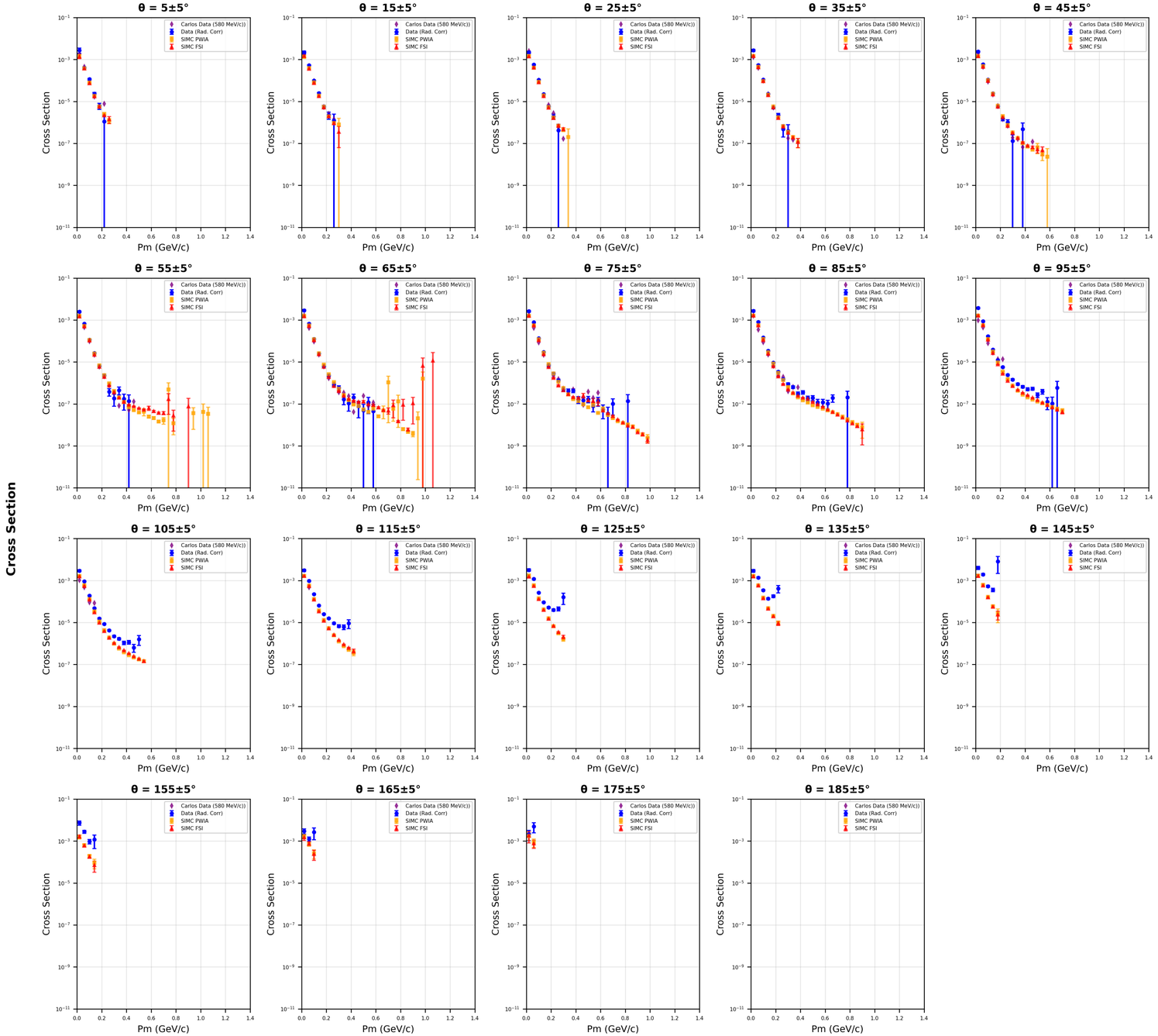
Deuteron Cross-section Projection 580 MeV/c



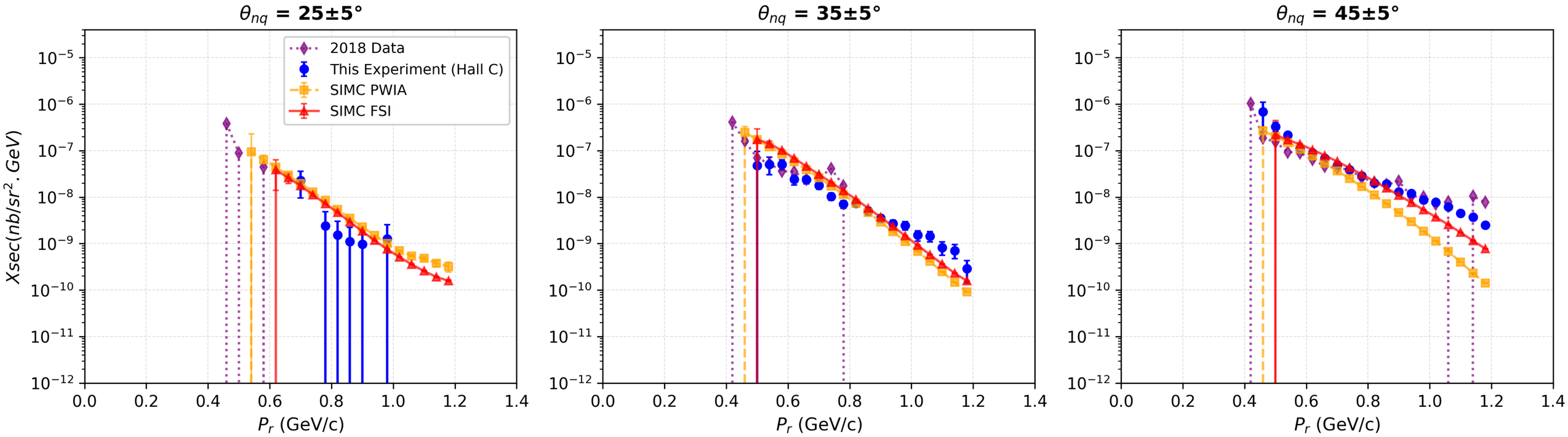
Deuteron Cross-section Projection 800 MeV/c



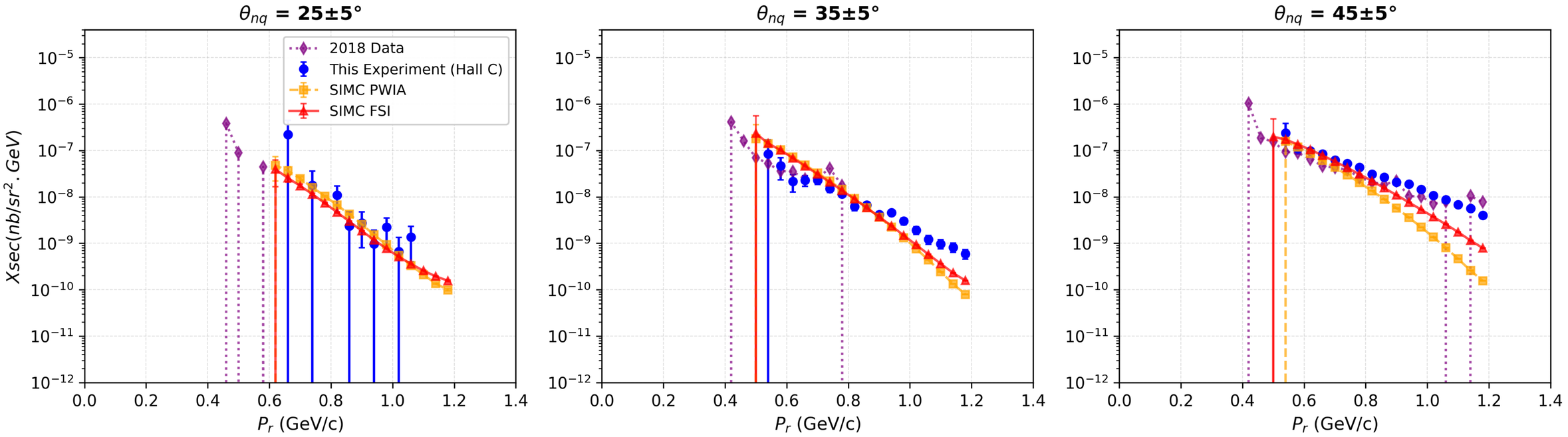
Deuteron Cross-section Projection 120 MeV/c

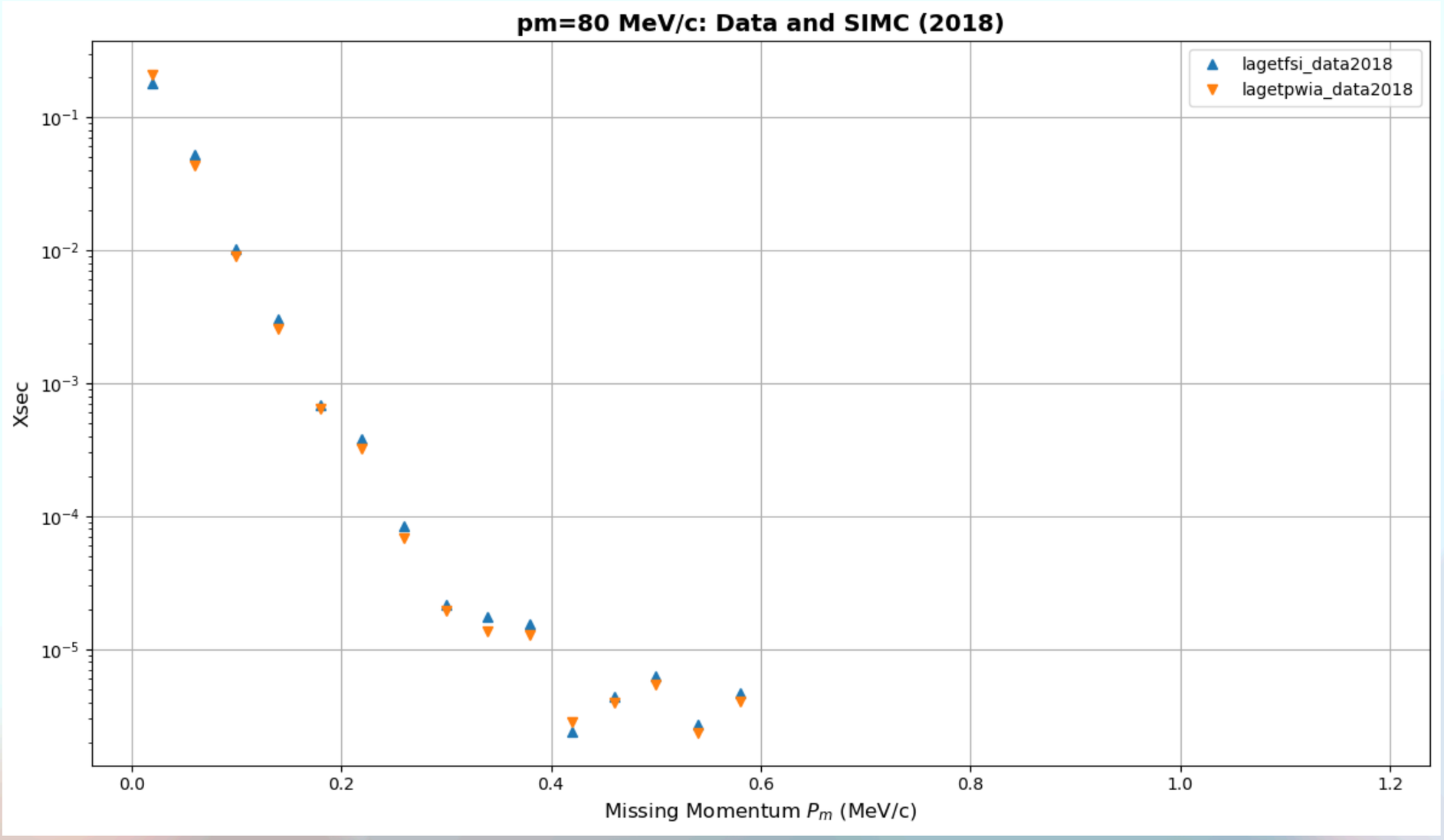


Deuteron 800 MeV/c Cross-section across θ_{nq} Settings

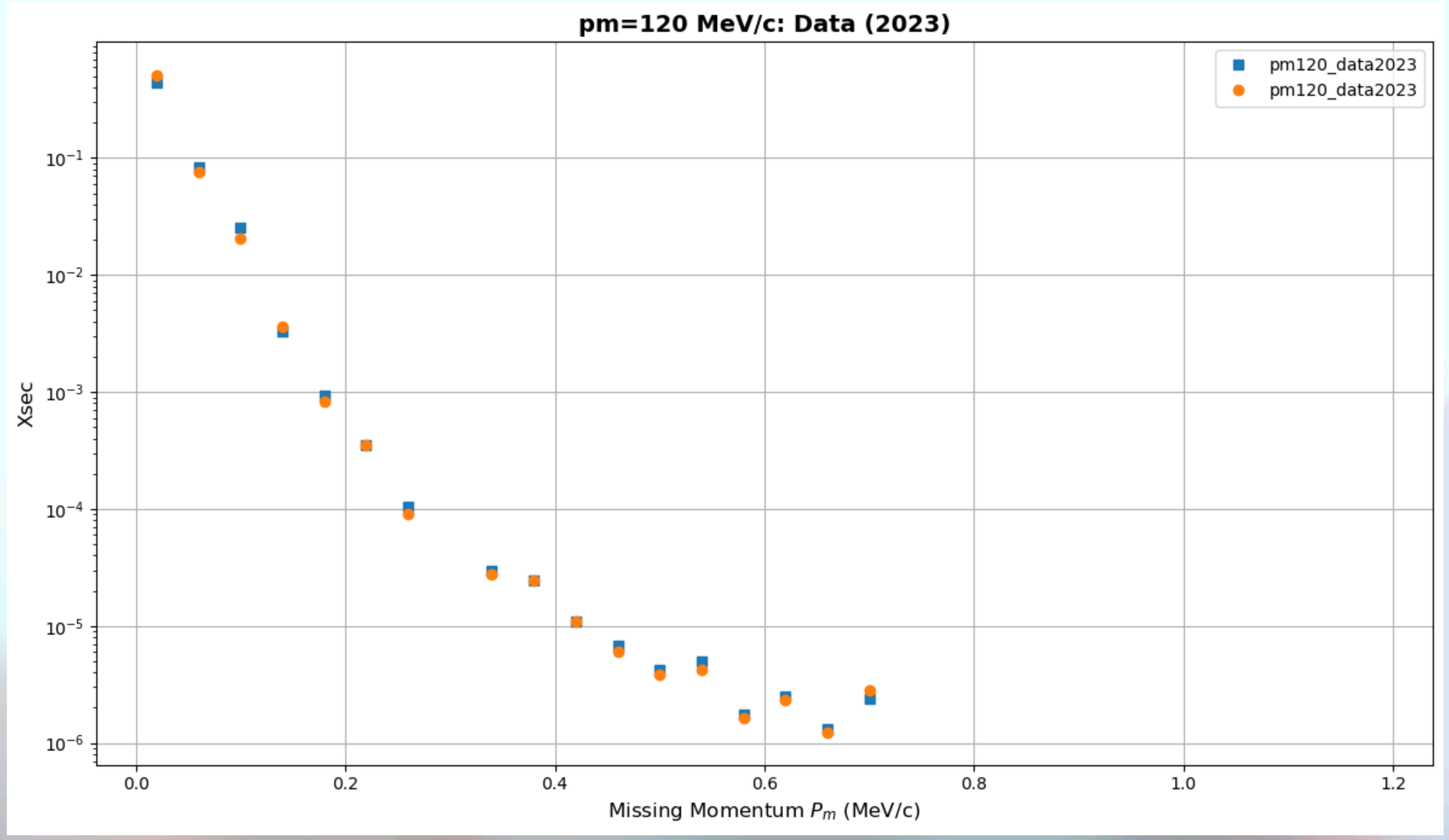


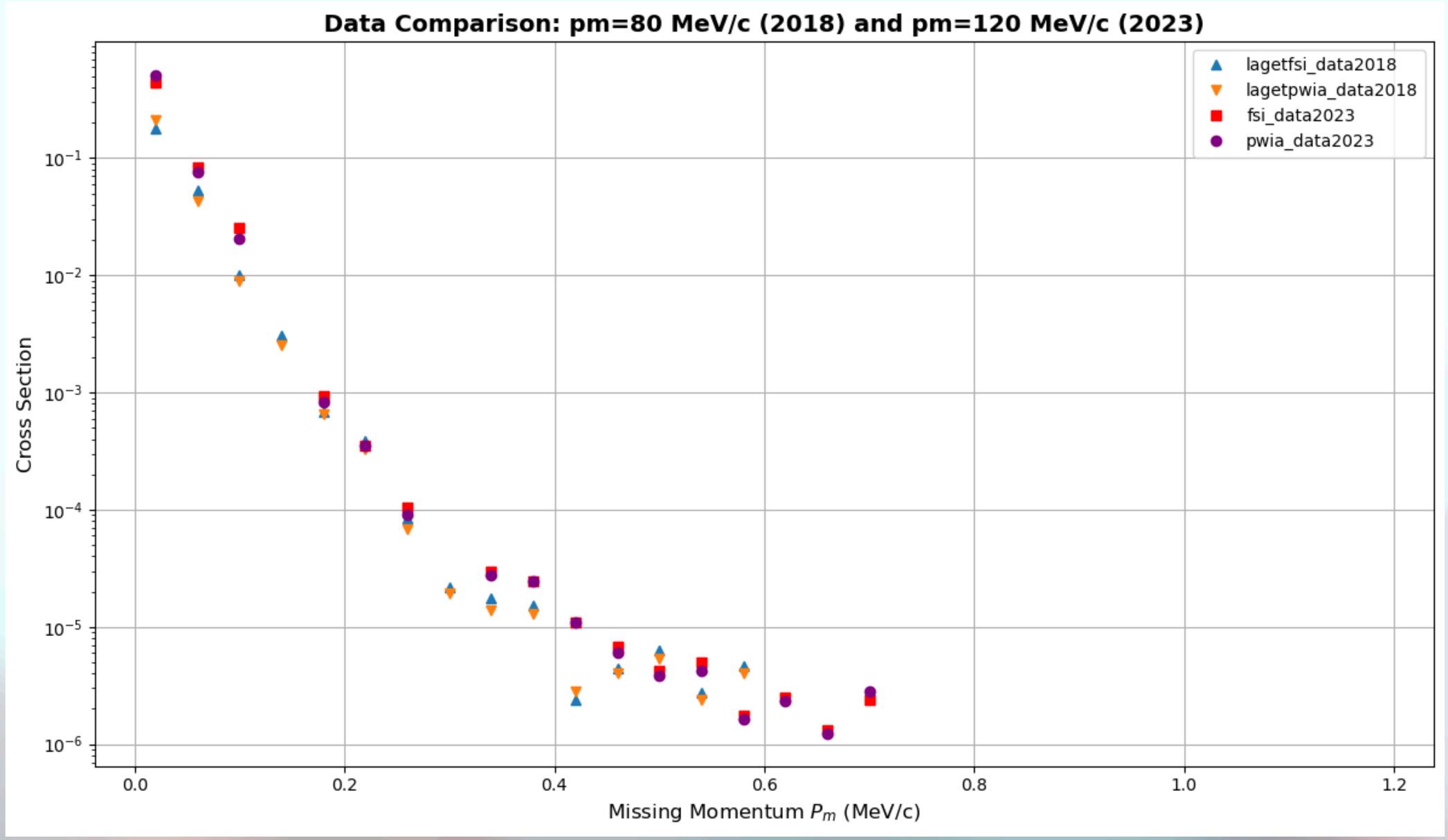
Deuteron 900 MeV/c Cross-section across θ_{nq} Settings




pm=80 MeV/c: Data and SIMC (2018)
lagetfsi_data2018
lagetpwia_data2018
Xsec
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Missing Momentum P_m (MeV/c)

2


pm=120 MeV/c: Data (2023)
pm120_data2023
pm120_data2023
Xsec
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Missing Momentum P_m (MeV/c)


Data Comparison: pm=80 MeV/c (2018) and pm=120 MeV/c (2023)
lagetfsi_data2018
lagetpwia_data2018
fsi_data2023
pwia_data2023
Cross Section
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Missing Momentum P_m (MeV/c)