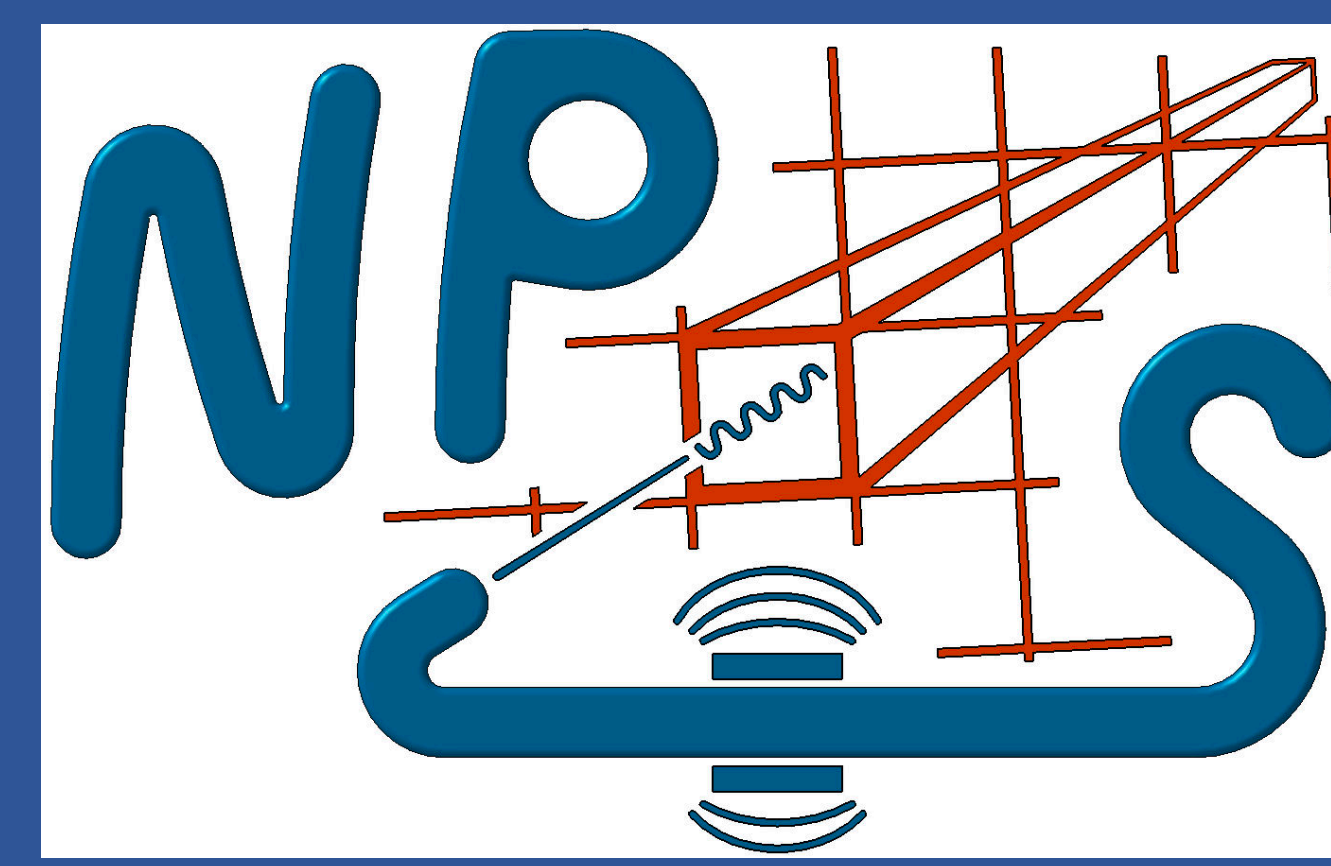


Deep Inelastic Scattering Cross Section Extraction In NPS Experiments

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Abstract

The NPS experiment in Experimental Hall C consists of 8 approved experiments divided in two run groups. The E12-13-010 and E12-22-006 in the first run group running in 2023/2024 mainly aim at Deeply Virtual Compton Scattering process with exclusive measurement. With the help of High Momentum Spectrometer (HMS) as the electron arm and Neutral Particle Spectrometer (NPS) as the photon arm, one can extract the cross section and more importantly, the GPD terms at different kinematics.

As the normalization check, using the same experimental setup, one can also extract the DIS cross section, which has been extensively measured before. The extraction method is based on the previous Hall C F2 experiment E12-10-002 and the analysis carried out by William Henry¹.

Kinematics and HMS

x_B	0.2			0.36			0.5			0.6		
Q^2 (GeV ²)	2.0	3.0	3.0	3.0	4.0	5.5	3.4	4.8	5.1	6.0	6.0	6.0
E_b (GeV)	6.4	8.5	10.6	6.4	8.5	10.6	8.5	10.6	6.4	8.5	10.6	
k' (GeV)	1.07	3.16	5.26	2.60	1.96	4.05	6.15	2.57	4.67	2.45	4.87	6.96
θ_e (deg)	31.3	15.7	10.9	19.0	28.3	17.0	12.3	24.7	16.4	26.6	16.5	12.3
θ_{Calo} (deg)	5.80	8.92	10.37	5.94	11.24	14.38	16.0	9.91	12.1	7.44	19.9	21.4
D_{Calo} (m)	6	4	6	3	4	3	4	3	4	3	3	3
I_b (μ A)	11	5	50	11	28	50	28	50	28	50	28	50
θ_{min} (GeV ²)	0.04			0.16			0.17			0.37		
θ_{min} (GeV ²)	0.1			0.6			0.55			0.4		
$2\sigma_{M_2}$	1			1			1			1		
H ₂ Days	1	1	1	1	2	1	1	3	5	3	2	5
D ₂ Days	1	1	1	1	2	1	1	3	5	3	2	5

DVCS Kinematics for the 2023-2024 NPS run (E12-13-010 & E12-22-006)

Acceptance for HMS

Central momentum: 0.5 - 7.5 GeV
Momentum acceptance: $-8 < dp/p < 8$
Angular range: 10.5 - ~90 degrees
Solid angle acceptance: 8 msr

Extraction Methods²

$$\frac{d\sigma}{d\Omega dE'} = \frac{N - BG}{L} * \frac{1}{\epsilon} * \frac{1}{A(\theta, E')} * \frac{1}{\Delta E' \Delta \Omega}$$

The general cross section equation can be describe above, with ϵ = total efficiency, A = Acceptance, L = integrated luminosity. N-BG = Electron counts with background subtraction/passed analysis cuts. At this point, one can directly extract the cross section with proper bin centering corrections, given the Acceptance of the spectrometer is known. This method is called the Acceptance Method.

For the method we are going to use, one can combine N-BG and efficiency term to get the Yield for data:

$$Y_{data} = \frac{N - BG}{\epsilon}$$

And the cross section can be rewritten as:

$$Y_{data} = L * d\sigma^{data} * (\Delta E' \Delta \Omega) * A(\theta, E')$$

If we use a cross section model(F1F221) to simulate the Monte Carlo data, we will have:

$$Y_{MC} = L * d\sigma^{MC} * (\Delta E' \Delta \Omega) * A_{MC}(\theta, E')$$

Assuming two Acceptances are the same, by taking the ratio, we will have the cross section of the data:

$$d\sigma_{data} = d\sigma_{MC} * \frac{Y_{data}}{Y_{MC}}$$

This is called the MC ratio method.

Y_{data} in actual experiment

$$Y_{data} = \frac{N^{e^-} - BG}{\epsilon_{total} E_{LT} C_{LT}} * PS$$

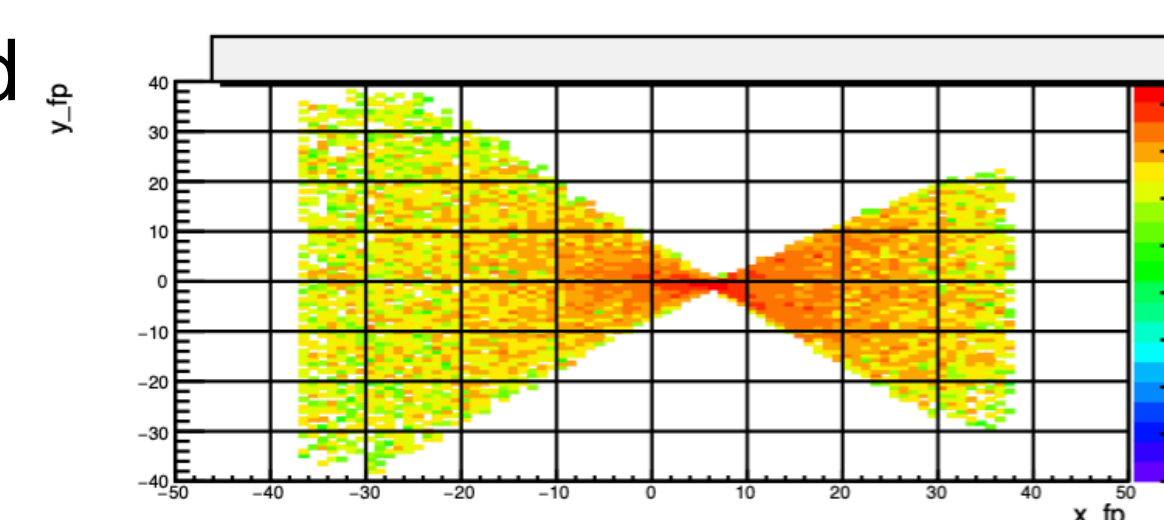
E_{LT} and C_{LT} = electronic and computer live time.
 PS = pre-scale factor of the DAQ.

BG = Pion contamination and dummy subtraction (contribution from the target cell wall)

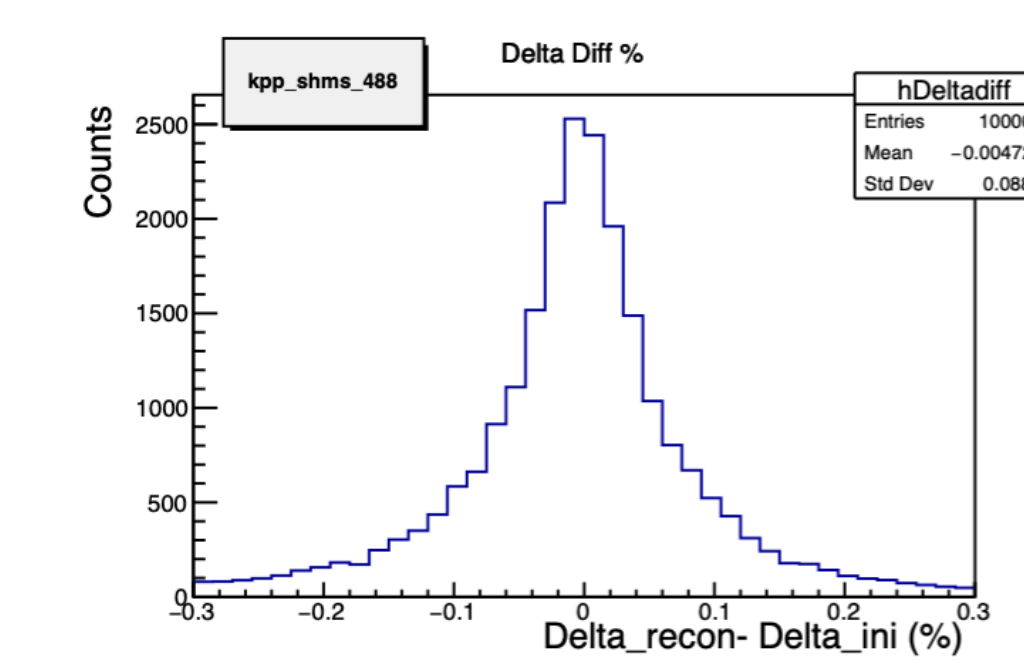
These information can be either acquired by the data acquisition system production file in Hall C or by running on the aluminum dummy target.

Y_{mc} simulation

The “pure” acceptance yield is simulated using Hall C mc-single-arm code by randomly generating the interaction points within the target within the central momentum acceptance cut of HMS/SHMS. Then the code carries the electron through all the detectors, counts the number which reach the focal plane with the reconstructed vertex variables.



Focal plane position hits y vs x for SHMS

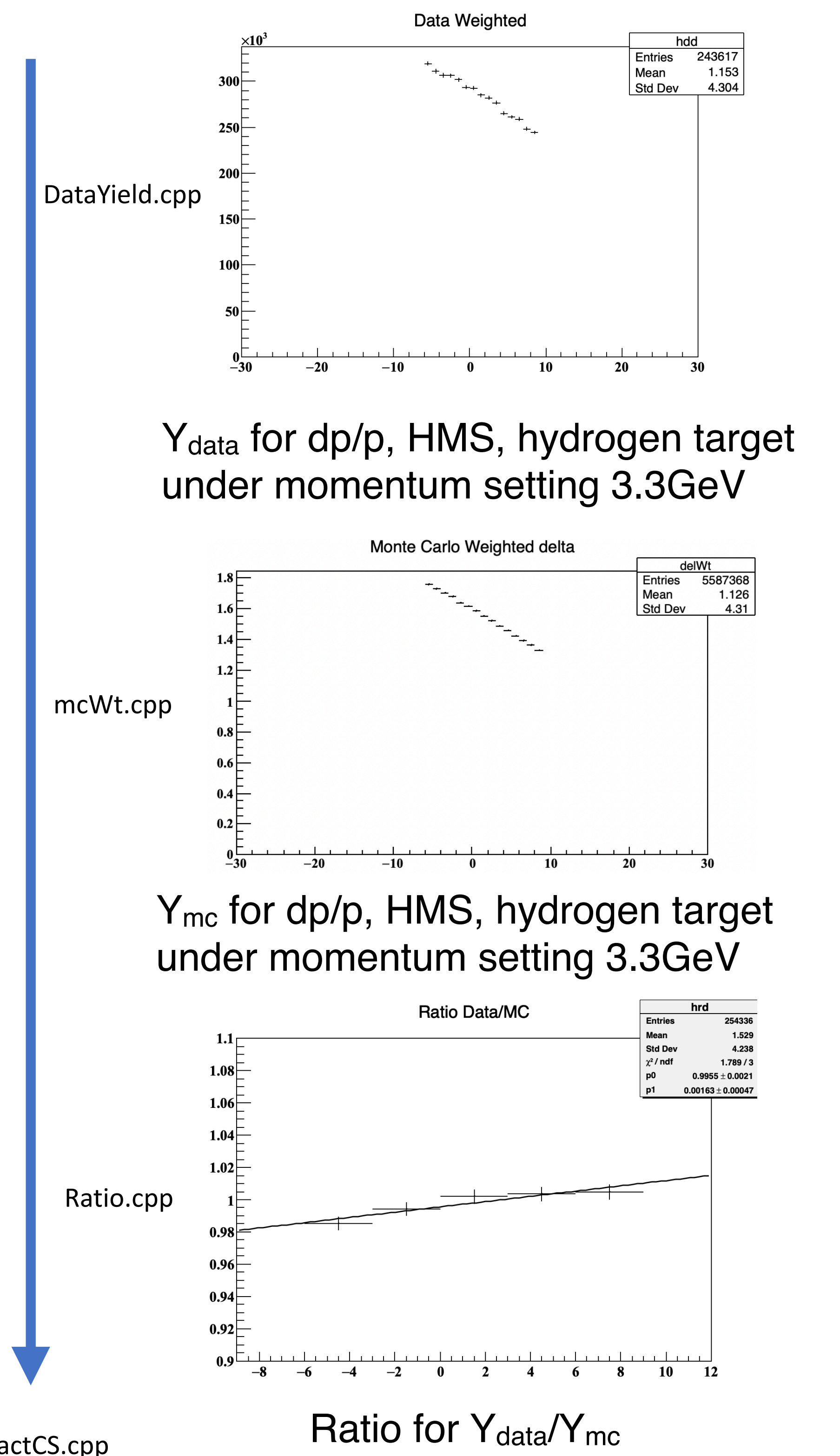


Reconstructed dp/p difference at the vertex, SHMS

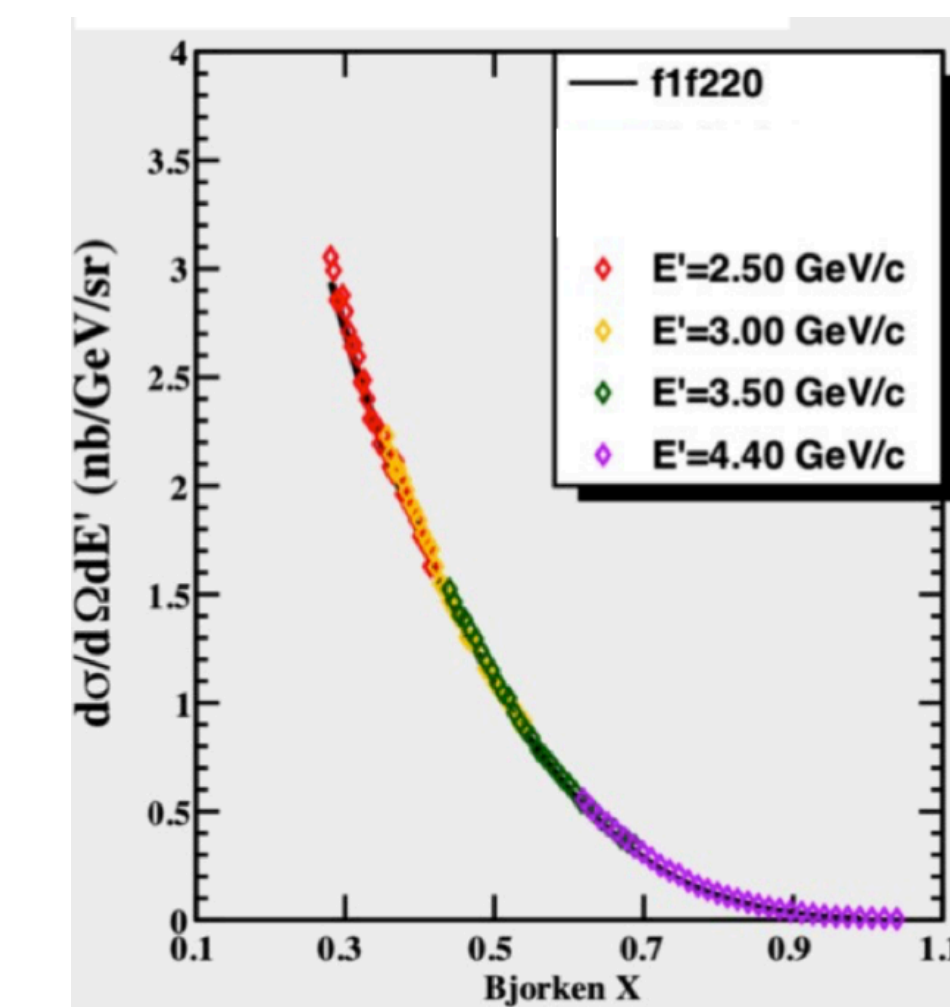
The “physics” part is added by the Hall C RC-external code with F1F221 Model, which calculates the full cross section/born cross section/Ratio at given Kinematics grid. This is applied as weight when plotting the desired Y_{mc} using interpolation between grid points after scaling with the L_{data}/L_{mc} ⁴.

The charge symmetric background contribution is later added to the Y_{mc} to match with the data.³

Example in code flow³



ExtractCS.cpp



Example of the final cross section over different central momentum in x_B on Deuterium target, SHMS at 25 degrees¹.

References/Acknowledgements

1. William Henry, 2022 Summer Hall A/C Collaboration Meeting
4. F2 ELOG, <https://hallcweb.jlab.org/eologs/E12-10-002+Preparations/>

2. M. Eric Christy, Hall A/C Software Meeting 2017, Extraction of Inclusive Cross Sections

3. William Henry, F2 Update for Winter Hall C Collaboration Meeting

