Measurement of ^{3}He Elastic Electromagnetic Form Factor Diffractive Minima Using Polarization Observables

On behalf of the E12-06-121 collaboration

Michael Nycz

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d_2^n Collaboration

^{3}He Elastic Scattering Form Factors

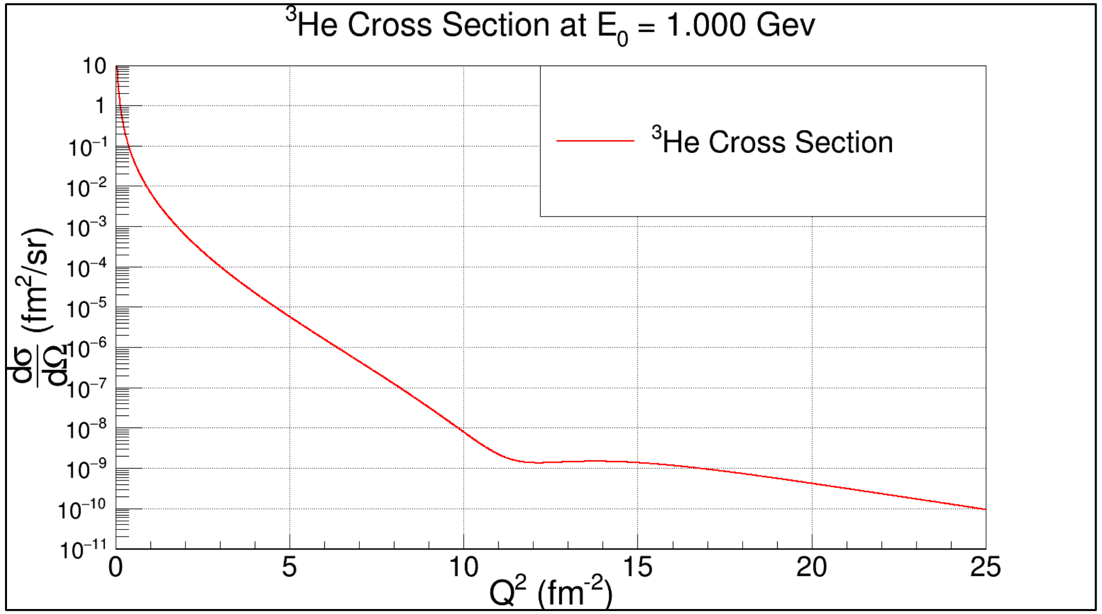
$$\left(\frac{d\sigma}{d\Omega}\right)_{\text{exp}} = \left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott}} \frac{1}{1+\tau}\left[G_E^2(Q^2) + \frac{\tau}{\epsilon} G_M^2(Q^2)\right]$$

Rosenbluth Separation

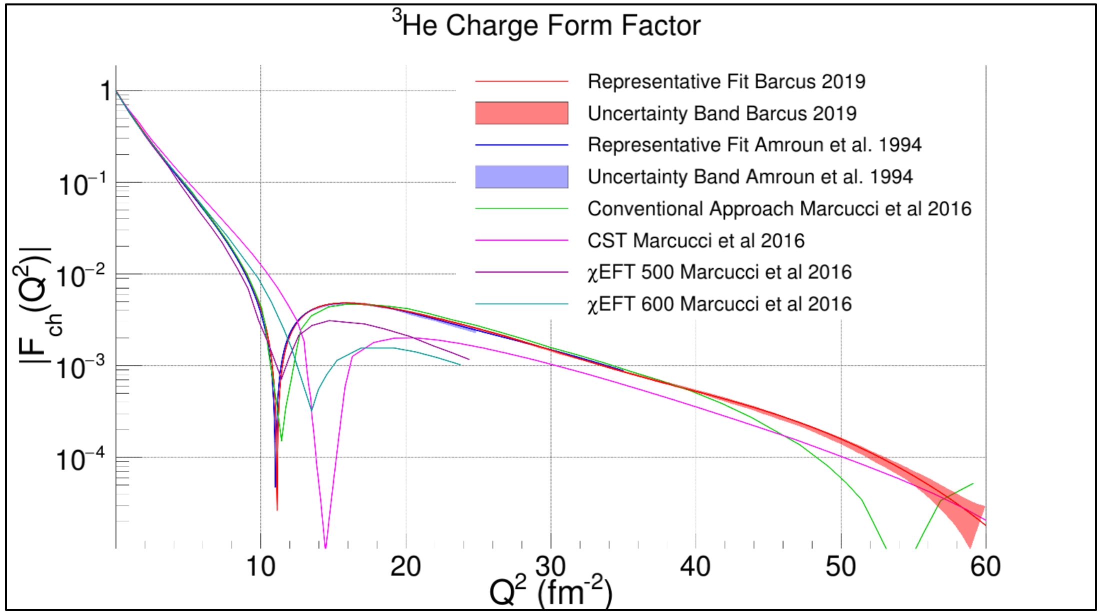
$$\left(\frac{d\sigma}{d\Omega}\right)_{\text{red}} = [\epsilon G_E^2(Q^2) + \ \tau G_M^2(Q^2)]$$

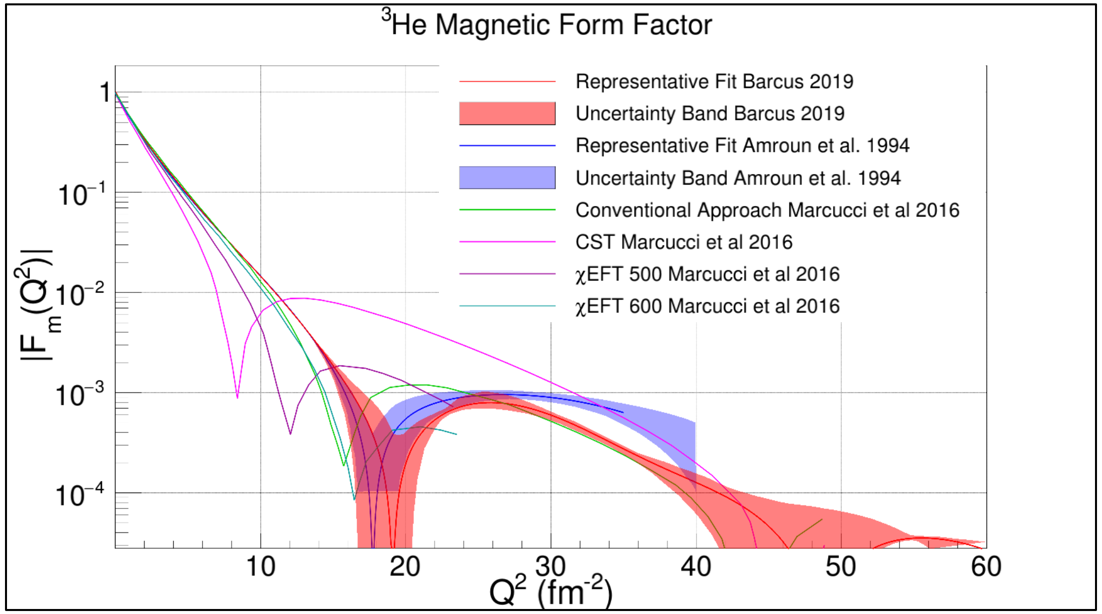
- G_E & G_M extracted from linear fit
  - G_E = slope
  - G_M = intercept
- Rosenbluth separations in diffractive minima are non-trivial

Fit to world data



Experimental and Theoretical Comparison

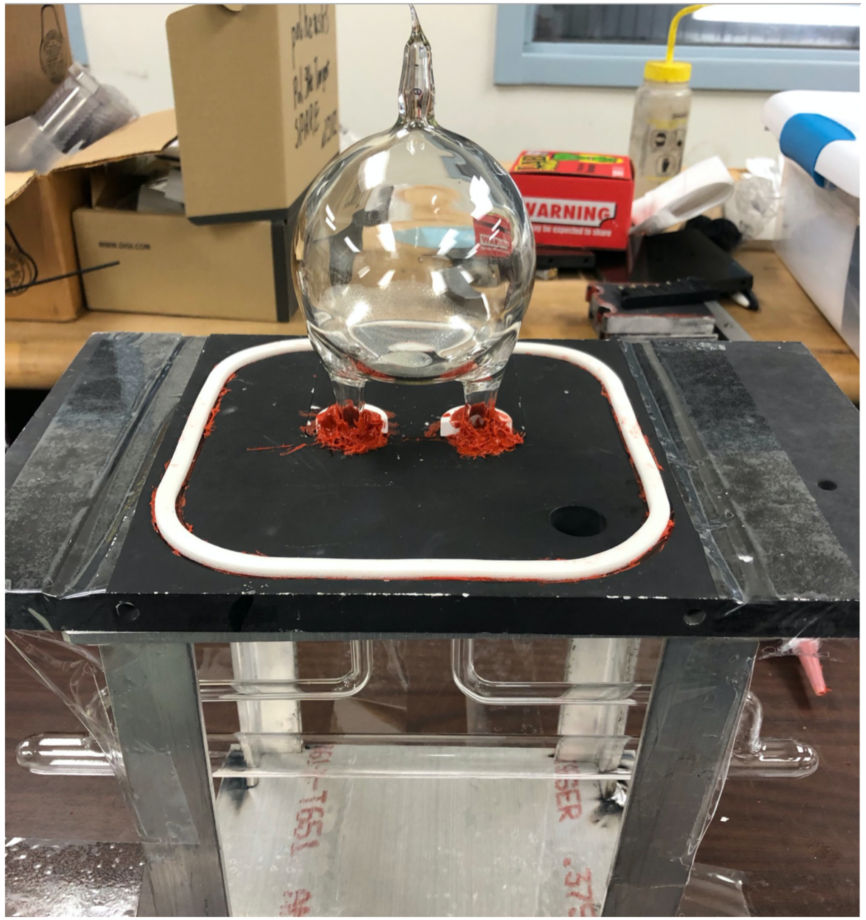




- **Discrepancies in location of minima of the electric and charge form factors**
- All high Q^2 Form Factor measurements are from unpolarized elastic scattering

Polarization Measurement

- How to disentangle these differences?
  - **Double-polarization measurement**
- An independent method to constrain the positions of the ^3He diffractive minima
- Help to explain the differences between theory and experimental results



Polarized ^3He target cell

Double Polarization Measurement

Polarized electron beam and polarized nucleon target

$$A_{phys} = \frac{-2\sqrt{\tau(1+\tau)}\tan\left(\frac{\theta}{2}\right)}{G_E^2 + \frac{\tau}{\epsilon}G_M^2}\left[\sin(\theta^*)\cos(\varphi^*)\,G_E\ \ G_M + \sqrt{\tau\left[1+(1+\tau)\tan^2\left(\frac{\theta}{2}\right)\right]}\cos(\theta^*)G_M^2\right]$$

$$A_{meas} = \frac{N^+ - N^-}{N^+ + N^-}$$

$$A_{meas} = P_t P_l\, A_{phys}$$

Where

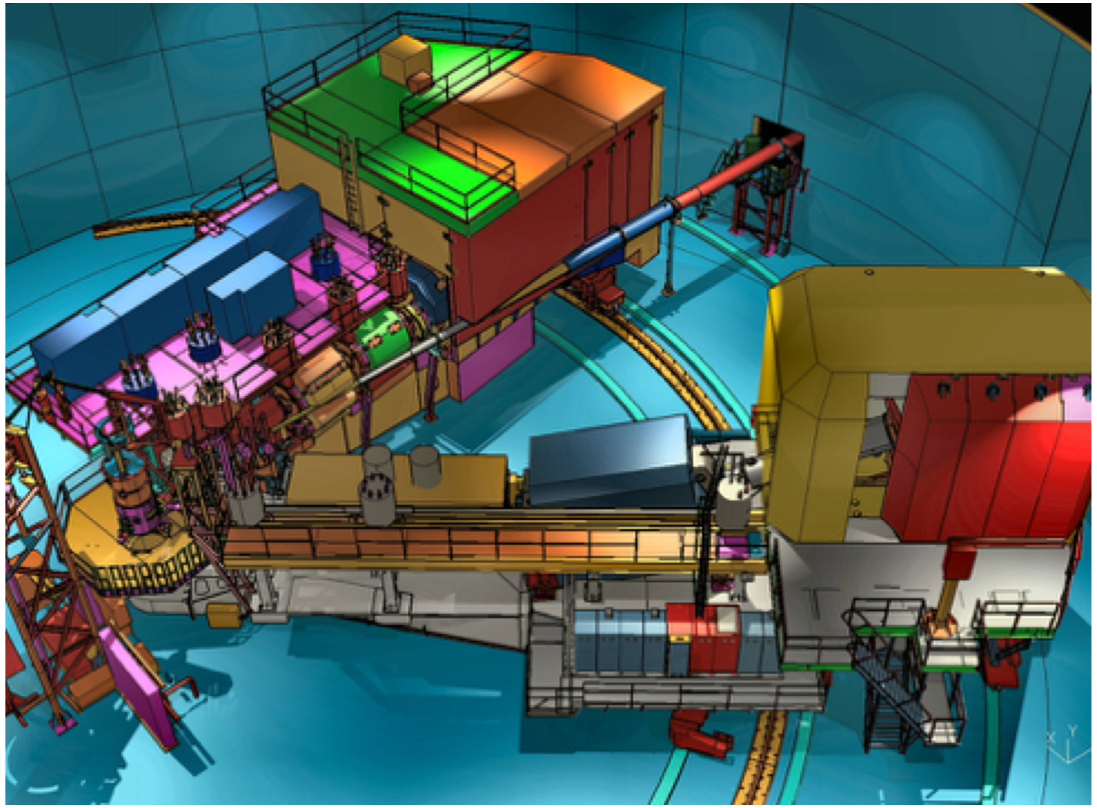
θ^*& φ^* - polar & azimuthal angles of polarization vector of target

P_t&P_l - Polarization of target and electron beam

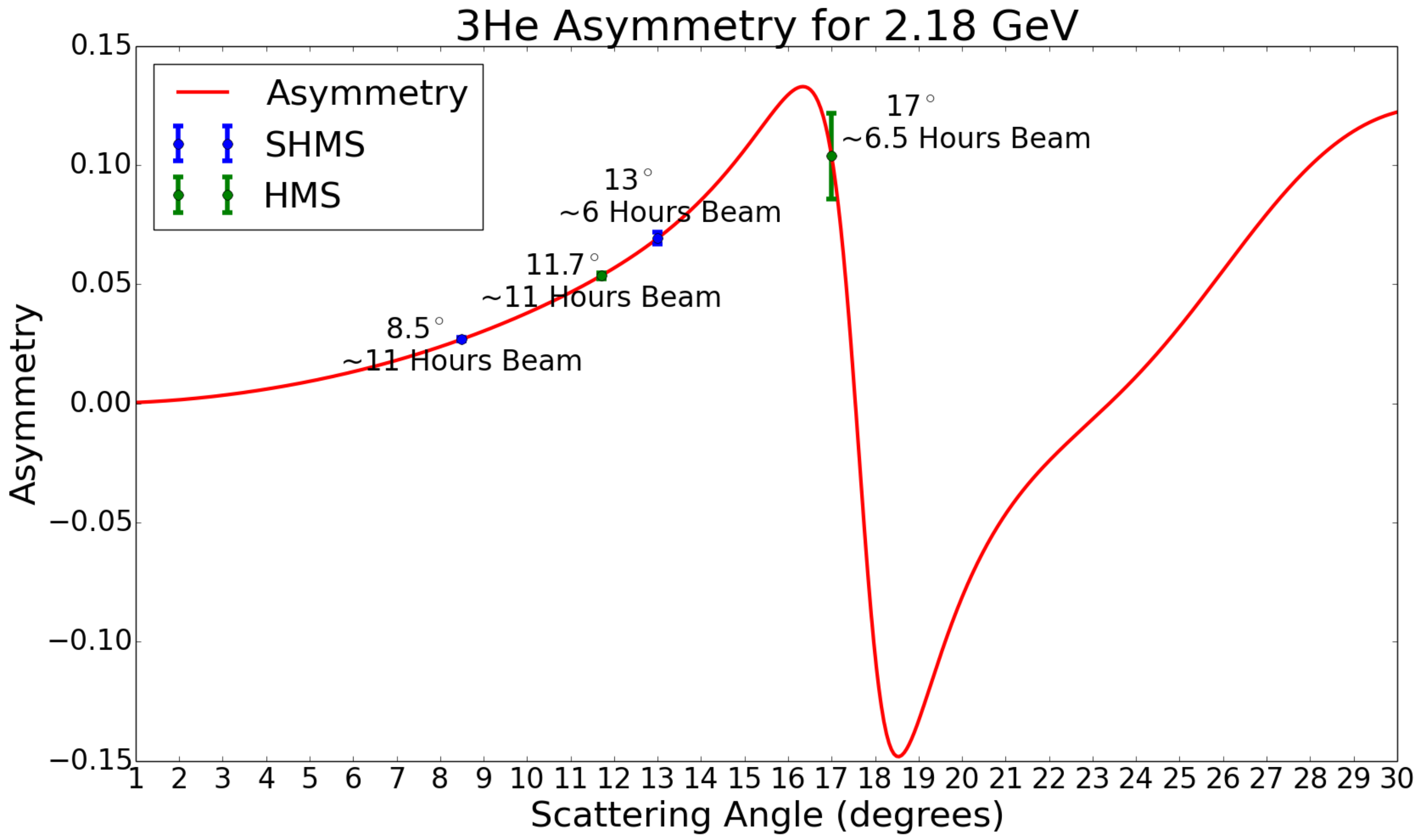
- Zero crossings of asymmetry correspond to diffractive minima

Experiment E12-06-121A

- Ran parasitically in Hall C during d_2^n
  - Configured with d_2^n planned 1st pass systematic measurements
- Target cells
  - Polarized ^{3}He cell
  - Reference ^{3}He cell
- Beam energy: 2.2 GeV
- Beam current: 30 μA (glass cells)
- Detect elastically scattered electrons independently in both HMS and SHMS



Measured Kinematic Points

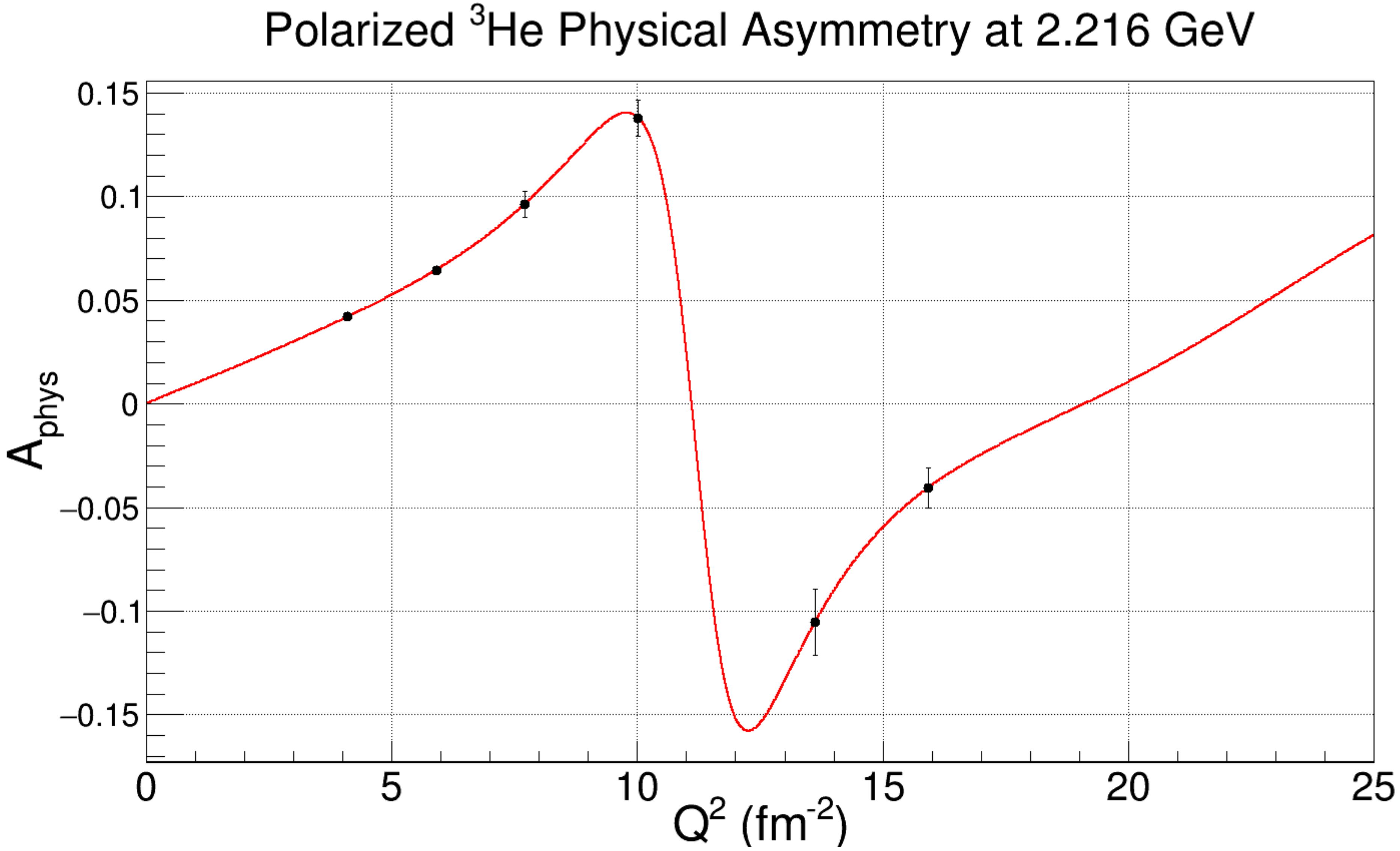


Summary

- Experiment E12-06-121A ran parasitically at the end of the d_2^n experiment during the Fall* 2020 run period
- **First high Q^2 asymmetry points measured**
- Analysis status
  - **First Pass calibrations already preformed by A_1^n and d_2^n students!**
  - Beginning stages of simulation
- Thank you to the Hall C Scientific and Technical staff as well as shift workers for their support!

Kinematics

Spectrometer	θ [°]	P_0 [GeV]	Q^2 [fm^{-2}]
SHMS	8.5	2.12	2.60
SHMS	13.0	2.12	6.10
HMS	11.7	2.08	4.88
HMS	17.0	2.08	10.25



Polarized ^{3}He Physical Asymmetry at 2.216 GeV
A_{phys}
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
0
5
10
15
20
25
Q^2 (fm^{-2})