SBS GEn-II Experiment Running and First Look at Data

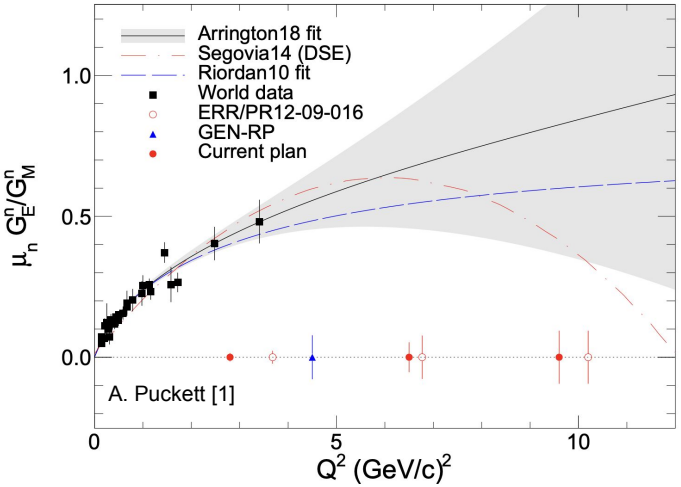
Sean Jeffas

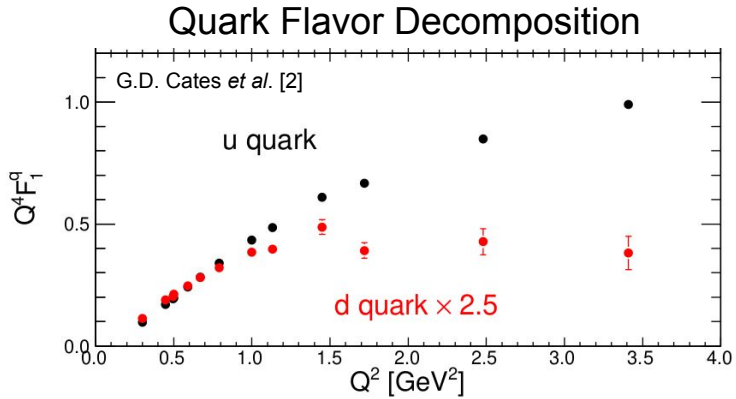
University of Virginia

Hall A Collaboration Meeting
January 27, 2023

Neutron Electromagnetic Form Factor Ratio

- Previous experiments measured the proton ratio G_E^p/G_M^p up to Q^2 = 8 GeV^2 and the neutron ratio G_E^n/G_M^n up to Q^2 = 3.5 GeV^2.
- Extend neutron data by almost 3x up to 9.7 GeV.
- Will give many insights into the quark structure.





Double Polarization Method

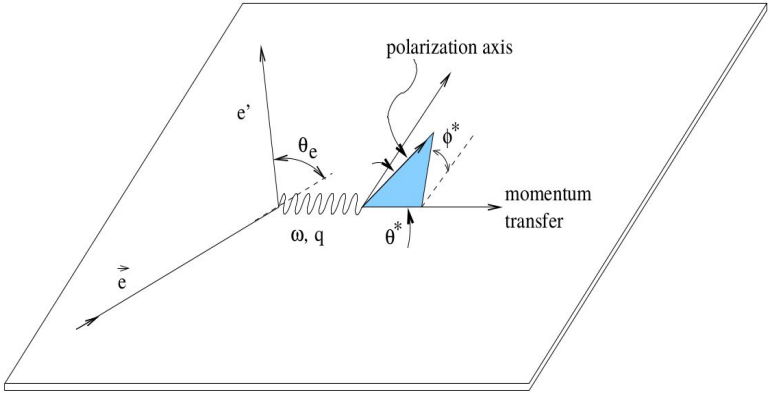
- With a polarized electron beam on a polarized neutron target the elastic scattering cross section can be written as the sum of two parts:
  - Σ corresponds to the unpolarized cross section.
  - Δ corresponds to the polarized cross section.
  - h is helicity (± 1)

$$\sigma = \Sigma + h\Delta$$

- The neutron spin asymmetry is then:

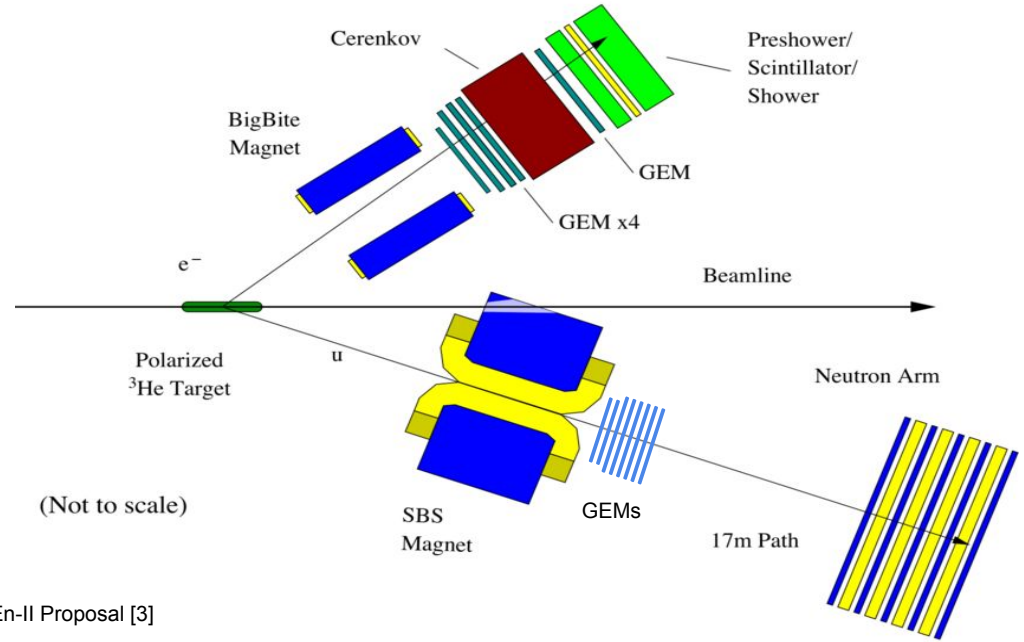
$$A_N = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-} = \frac{\Delta}{\Sigma}$$

$$A_N = -\frac{2\sqrt{\tau(\tau+1)}\tan(\theta/2)\frac{G_E^n}{G_M^n}\sin\theta^*\cos\phi^*}{\left(\frac{G_E^n}{G_M^n}\right)^2 + \tau + 2\tau(1+\tau)\tan^2(\theta/2))} - \frac{2\tau\sqrt{1+\tau+(1+\tau)^2\tan^2(\theta/2)}\tan(\theta/2)\cos\theta^*}{\left(\frac{G_E^n}{G_M^n}\right)^2 + \tau + 2\tau(1+\tau)\tan^2(\theta/2))}$$



SBS GEn-II Experiment

- Started in October 2022.
- GEn-II experiment will collide polarized electron beams onto a polarized ^{3}He target.
  - Same detector packages as used for GMn, **thanks fo all the GMn student work.**
- It will then measure the neutron FF ratio at Q^2 = 2.9, 6.6, and 9.7 GeV^2.



GEn-II Proposal [3]

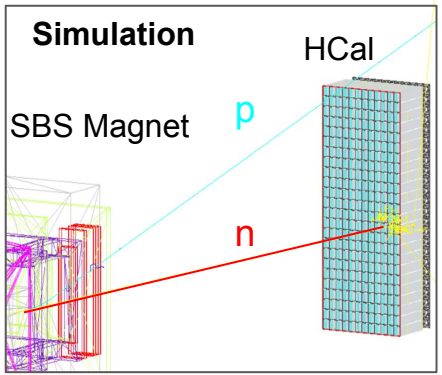
GEn Running

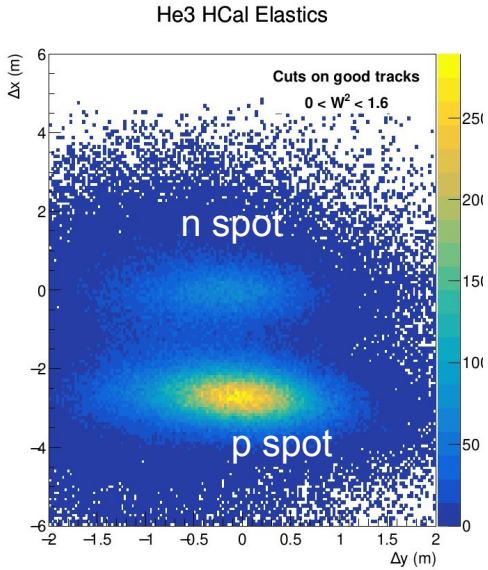
	Commissioning	Gen Q^2 = 2.9	GEn Q^2 = 6.6	Gen Q^2 = 9.7
Time Period	10/10/22 - 10/12/22	10/14/22 - 10/30/22	11/10/22 - 12/14/22	1/15/23 - ongoing
Expected Charge (C)	NA	15.55	60	160
Actual Charge (C)	NA	5.18	45.42	7.56
Average Polarization (in beam)	NA	25%	43.7%	43.7%

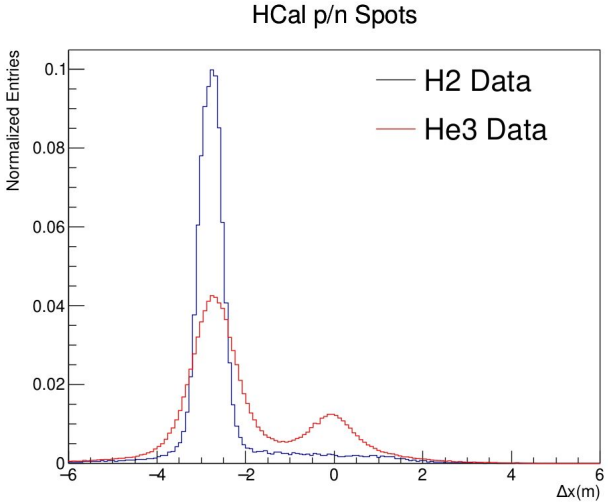
- Despite significant experiment downtime issues we are close to our statistics goals.
- Statistics goals assumed target polarization of 45%.
  - Near this goal for most of Q^2 = 6.6
  - Appears we will surpass this for Q^2 = 9.7, which is extremely good given the low statistics.
  - **Huge thanks to the GEn target group!**
  - See Arun's talk next for details on the ^{3}He target.

Proton/Neutron Separation

- Scattered hadrons are bent through the SBS magnet.
- Expected hadron position can be calculated from elastic electrons in BB.
- Can clearly separate protons and neutrons.
- SBS magnet set to full field for all of GEn, there is no need to save scattered protons.

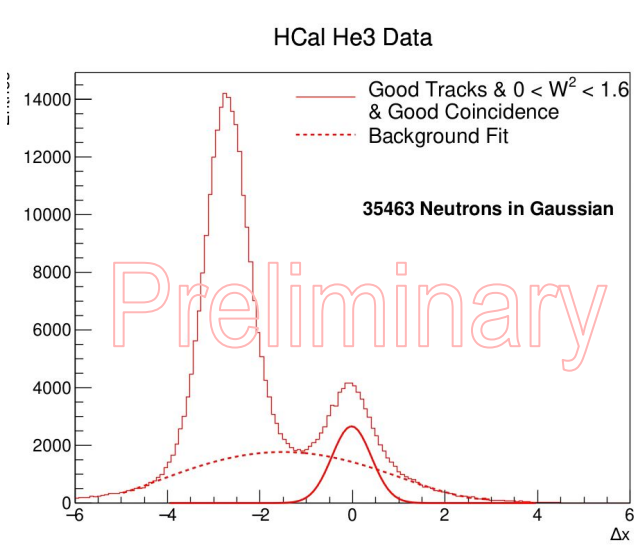


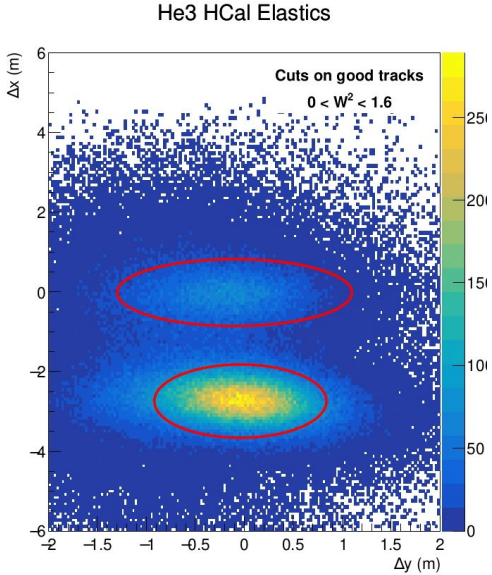


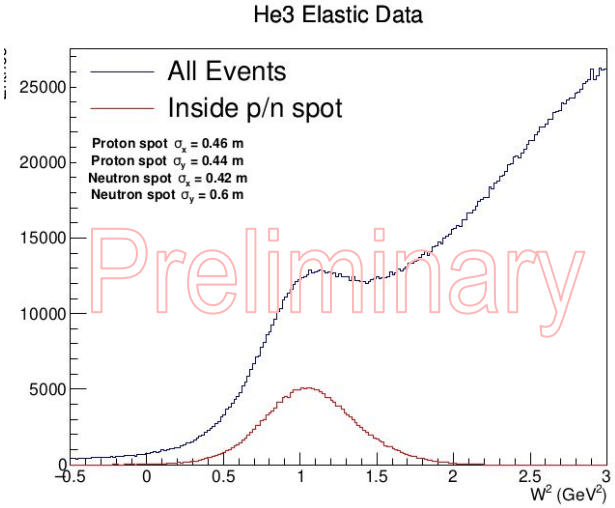


Q^2 = 2.9, Neutron Yield

- Only 20% of the total collected data is shown below.
- Using 4th order polynomial for background fit yields ~35,000 neutrons.
  - Expected ~30,000, very good agreement!
- Cutting on the p/n spots shows a clear elastic peak.





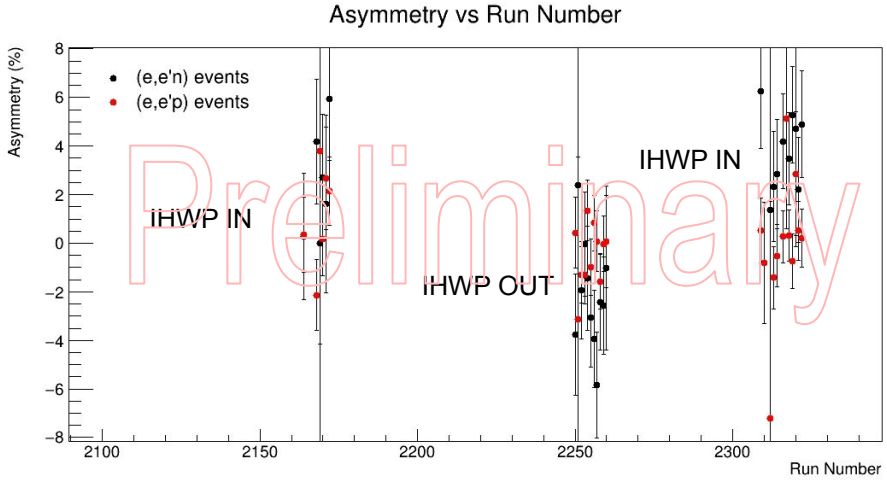


Sean Jeffas, University of Virginia

Q^2 = 2.9, Raw Asymmetries

$$A = \frac{Y_+ - Y_-}{Y_+ + Y_-}$$

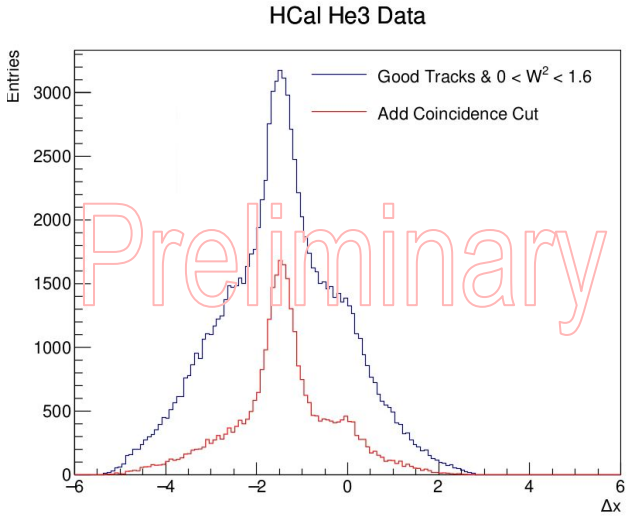
- Count helicity states of neutrons inside neutron spot.
- Very raw asymmetry results.
  - No charge or live time corrections.
- Neutron A_N ~3% is within the expected range, proton A_P consistent with 0%.
- Clearly see IHWP flip and sign matches expectation.

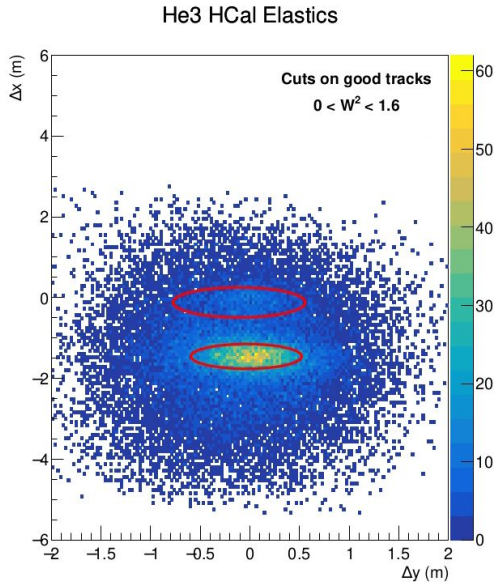


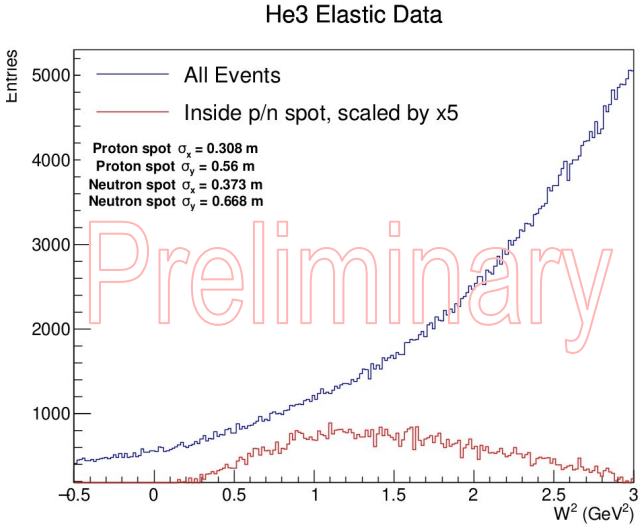
	(e,e'n)	(e,e'p)
Y_+	23716	71320
Y_-	22193	71047
A	3.31% +/- 0.47%	0.19% +/- 0.27%

Q^2 = 6.6, More Challenges

- ~10% of total data collected is shown below.
- Much more background, coincidence cut is extremely necessary.
- Too few events to see elastic peak so far.
- Lots more work to be done



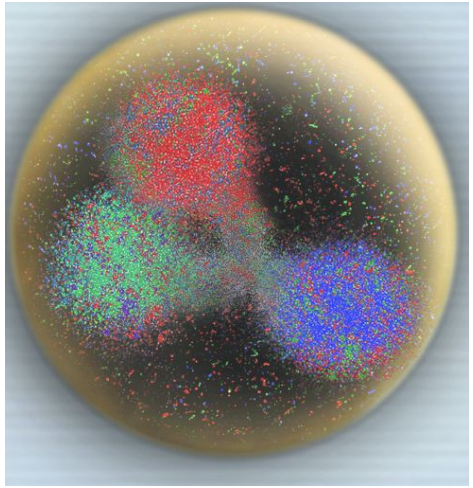




Sean Jeffas, University of Virginia

Summary

- GEn-II experiment will use double polarization to measure G_E^n/G_M^n.
- Will extend our Q^2 coverage from 3.5 to 9.7 GeV^2.
- Currently running at Q^2 of 9.7.
- Promising results so far and lots of work to be done going forward.



References

[1] Andrew Puckett, Details of updated SBS-GEN statistical uncertainty projections: https://sbs.jlab.org/cgi-bin/DocDB/private/ShowDocument?docid=354

[2] G.D. Cates, C.W. de Jager, S. Riordan, B. Wojtsekhowski, Phys. Rev. Lett. **106**, 252003 (2011)

[3] B. Wojtsekhowski, T. Averett, G. Cates, S. Riordan (spokespersons), Jefferson Lab experiment E12-09-016 - GEn(2): https://misportal.jlab.org/mis/physics/experiments/viewProposal.cfm?paperId=617

[4] Bogdan Wojtsekhowski , GEn 2020 Experimental Readiness Review: https://hallaweb.jlab.org/wiki/images/6/6c/GEn-ERR_overview%281%29.pdf