GEn-II Analysis

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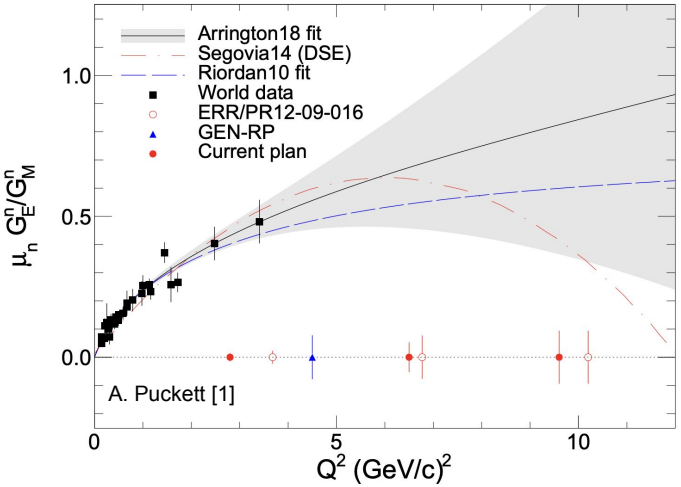
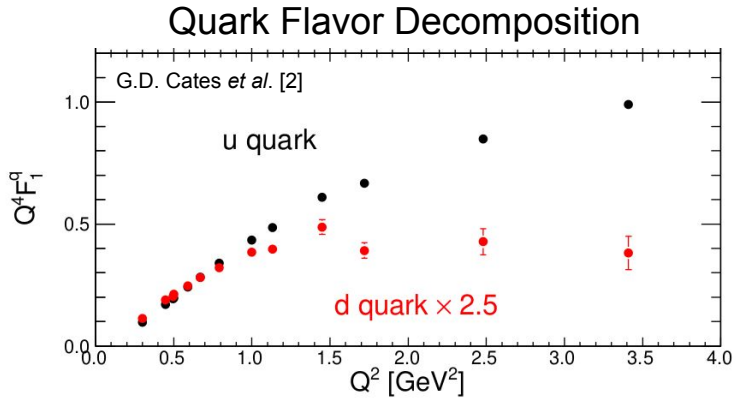
Neutron Electromagnetic Form Factor Ratio

- 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 9.8 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)

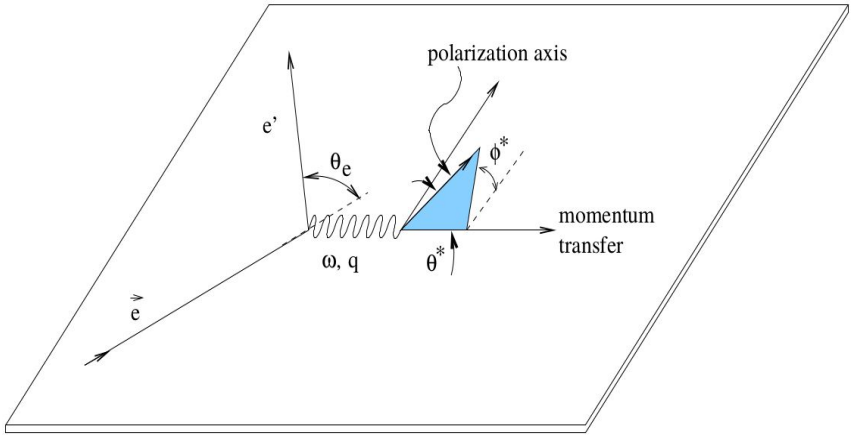
$$\sigma = \Sigma + h\Delta$$

- The spin asymmetry is then:

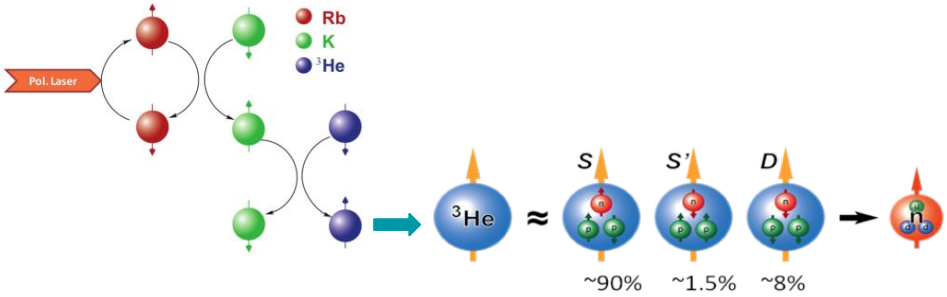
$$A_N = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-} = \frac{\Delta}{\Sigma}$$

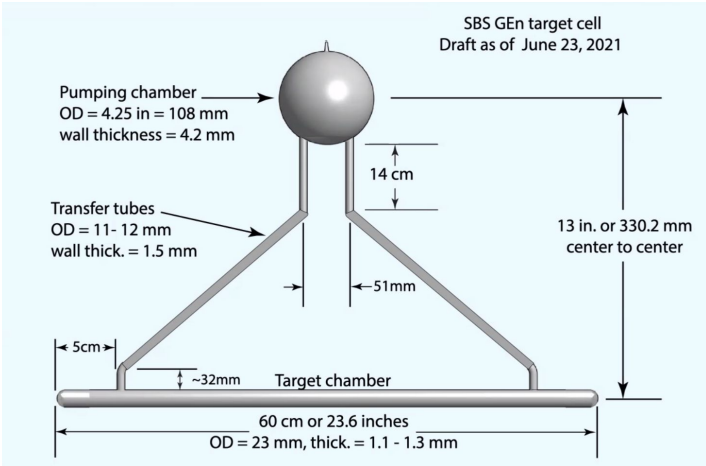
$$A_{\text{phys}} = -\frac{G_E^n}{G_M^n} \frac{2\sqrt{\tau(1+\tau)}\tan(\theta/2)\sin\theta^*\cos\phi^*}{\left(\frac{G_E^n}{G_M^n}\right)^2 + (\tau + 2\tau(1+\tau))\tan^2(\theta/2)}$$

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



Polarized ^{3}He Target

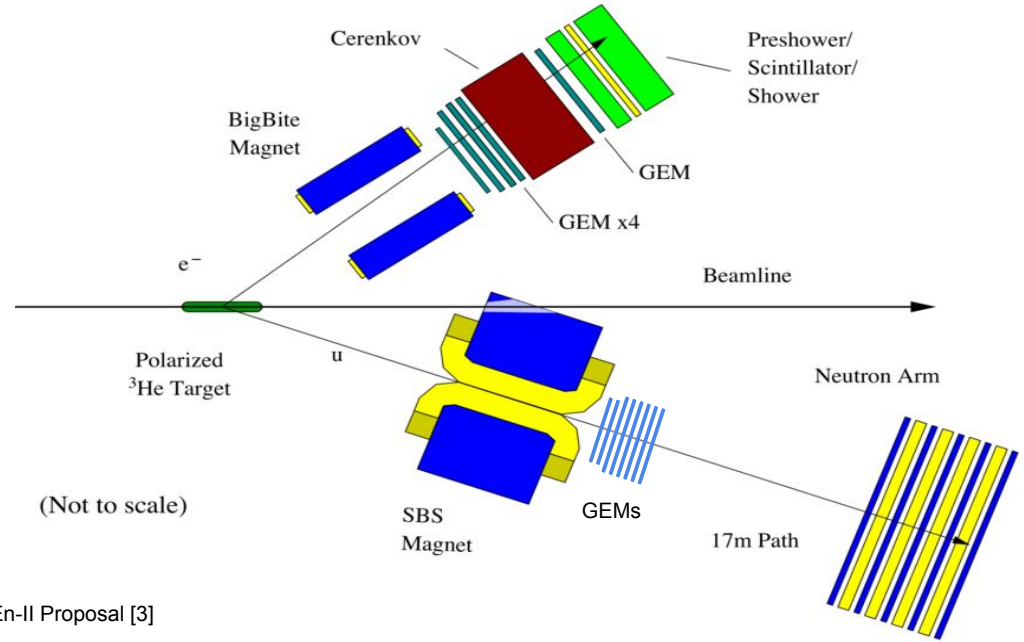




- Novel large target cell.
  - 60 cm length, 200 W lasers, 10 atm pressure.
- Convection is used to circulate gas from the pumping chamber to the target chamber.
- The target cells achieved ~45%, **world record for luminosity at this polarization**.
  - See Hunter Presley's talk soon.

SBS GEn-II Experiment

- Ran in October 2022 - March 2023 and again September - October 2023.
  - Will refer to two periods of time as GENa and GENb
- GEn-II experiment collided polarized electron beams onto a polarized ^{3}He target.
- Measure the neutron FF ratio at Q^2 = 3.0, 6.8, and 9.8 GeV^2.

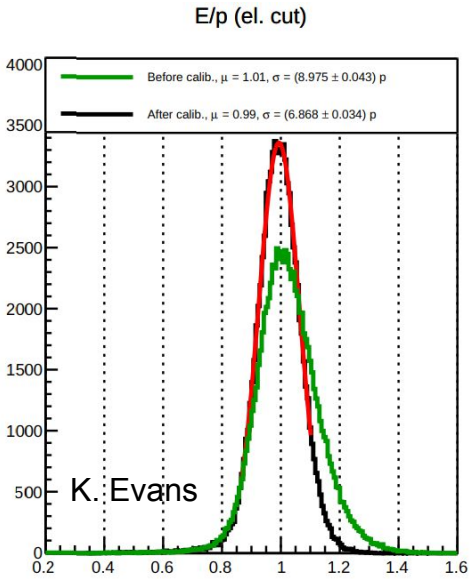


GEn-II Proposal [3]

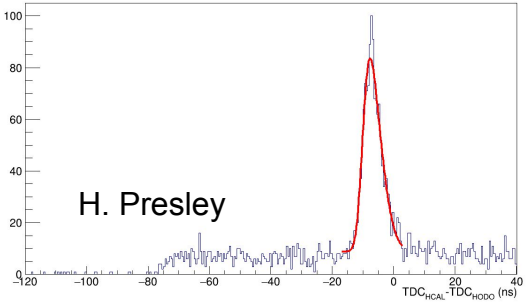
Detector Calibration

- First pass calibration complete for all data.

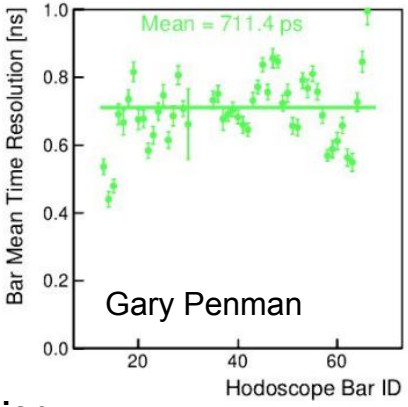
BBCal Energy Calibration



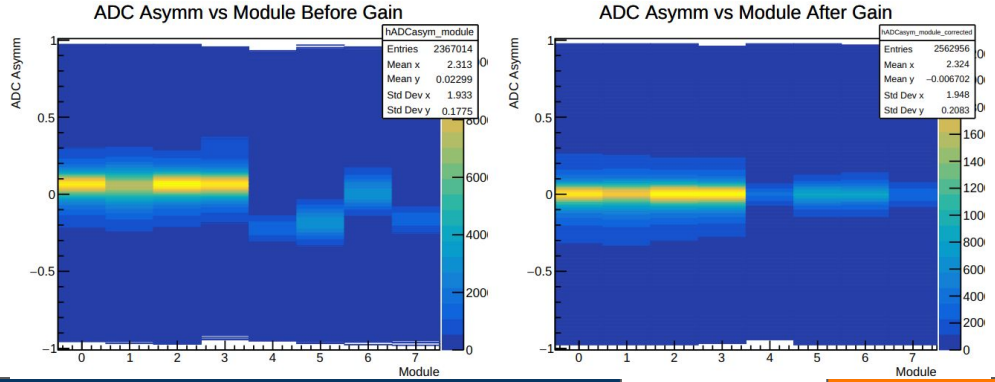
HCal TDC Alignment



Hodo Time Calibration

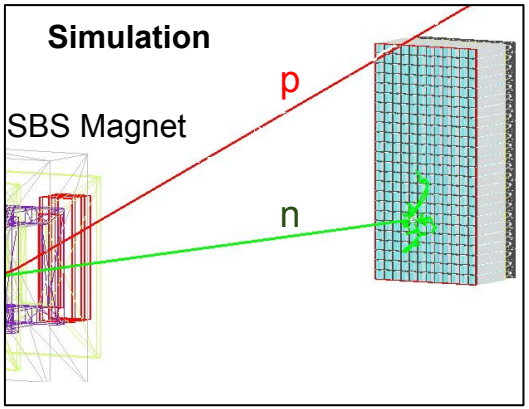


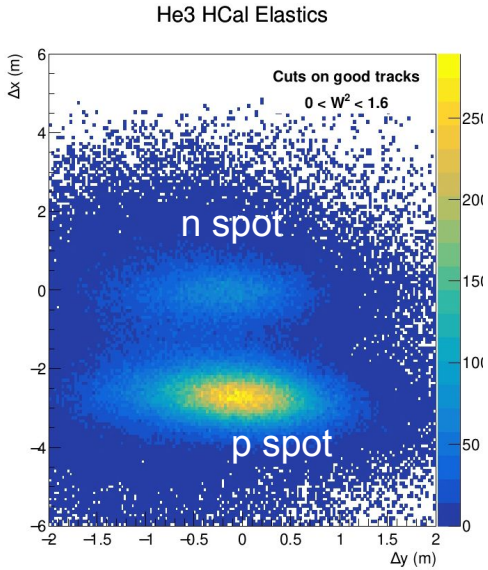
GEM Gain Calibration

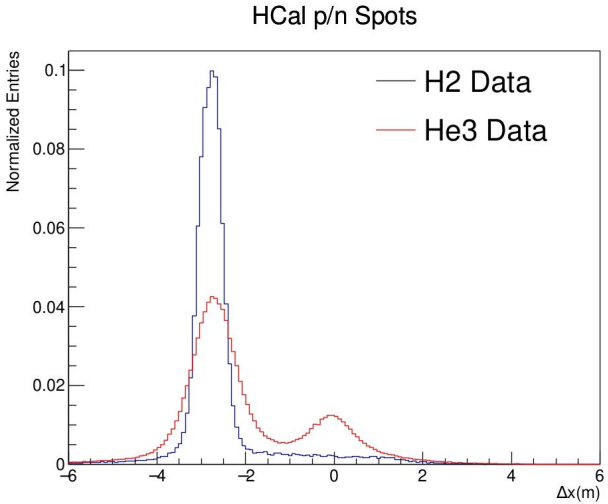


Hadron Proton/Neutron Separation

- Scattered hadrons travel 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.







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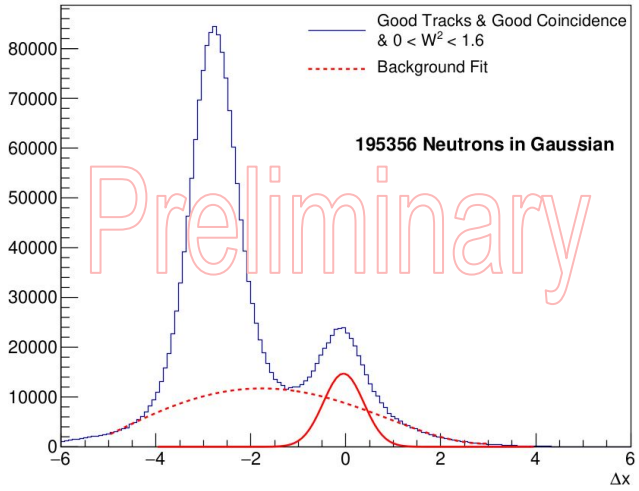
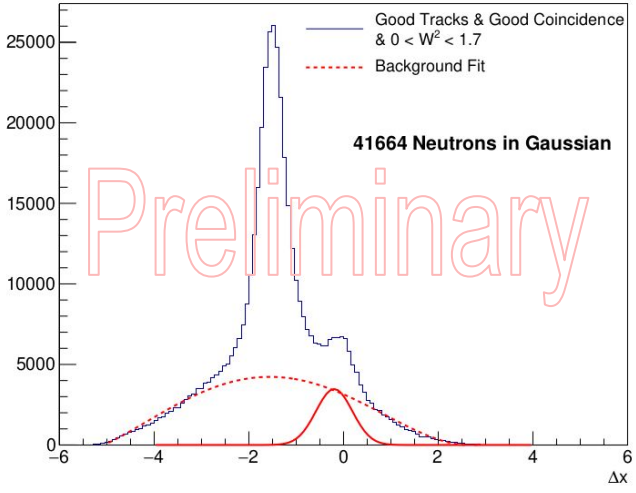
Neutron Yields

- Using a simple fit of two gaussians + 4th order polynomial.
  - More accurate reconstruction needs to be done.
- Less neutron/proton separation and larger background at higher Q^2.

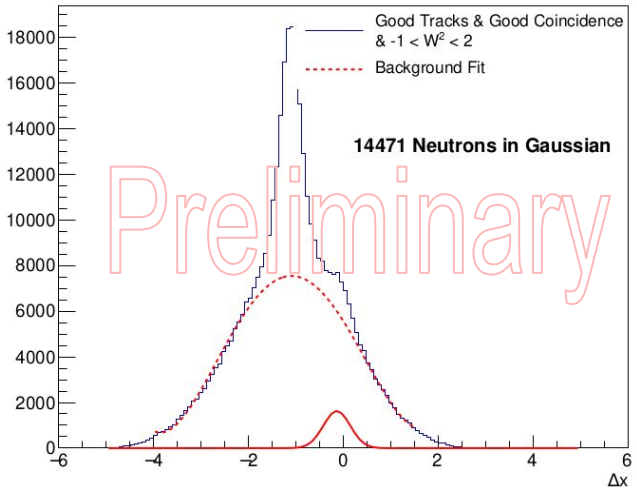
Q^2 = 3.0 All Data



Q^2 = 6.8 All Data



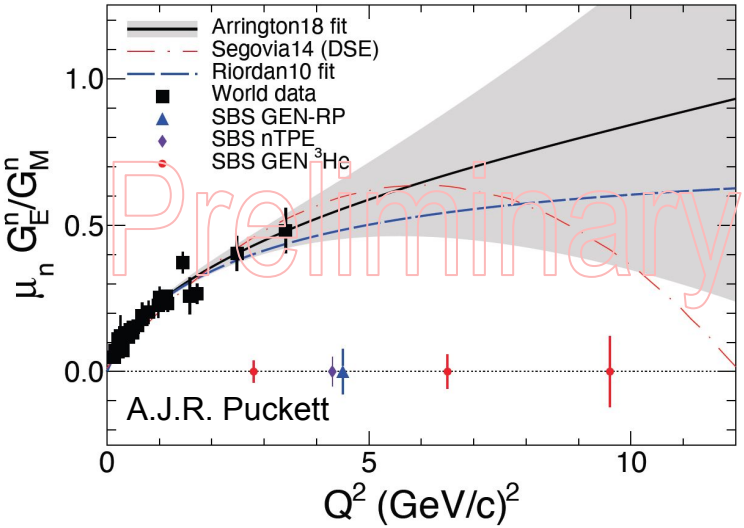
Q^2 = 9.8 All Data



Statistical Uncertainties

- Points show expected statistical uncertainties based on yields.
  - Number are not final, further calibrations to come, yields should improve.
- Overall good agreement with expectation from simulations.
  - Q^2 = 2.9 discrepancy not fully understood, but still plenty of events.
- Uncertainties look very good compared to world data.

	Q^2 = 3.0	Q^2 = 6.9	Q^2 = 9.8
Expected Neutrons	400k	34k	13k
Measured Neutrons	195k	42k	14k

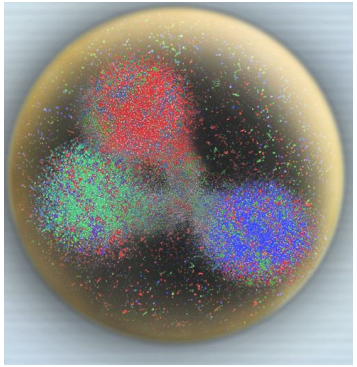


To Be Done

- General calibrations/timing etc.
- Calculate dilution factors.
- Analysis and DAQ dependent asymmetry factors.
- Pion asymmetry correction.
- Inelastic asymmetry correction.
- Proton asymmetry correction.
- Nuclear corrections.
- …

Conclusion

- GEN completed and all data analyzed in first pass calibrations.
  - Further calibrations underway.
- First look at statistics within expectations.
- Simulation close to being set up for full analysis.
  - Needs to be used to account for all asymmetry contributions.



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

[3] B. Sawatzky, V. Bellini, K. Gnanvo, D. Hamilton, M. Kohl, N. Piskunov, B. Wojtsekhowski (spokespersons), Jefferson Lab experiment E2-17-004 (GEn-RP): https://misportal.jlab.org/mis/physics/experiments/viewProposal.cfm?paperId=919