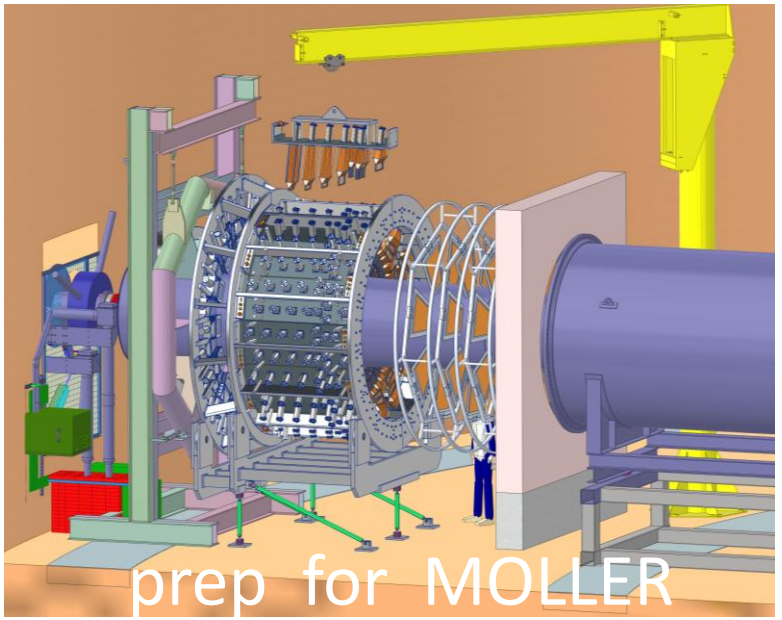
Hall A Update

- Recent publications
- Current activity
- Future

Robert Michaels

Acting Deputy Hall A/C



GMp and two photon effects in electron-proton scattering

Results published March 11, 2022 in Phys. Rev. Lett. 102002

$$\sigma_R = \tau\, G_M^2(Q^2) + \varepsilon\, G_E^2(Q^2) = \sigma_T + \varepsilon\, \sigma_L$$
$$= G_M^2(Q^2)(\tau + \varepsilon\, RS(Q^2)/\mu_p^2),$$
$$G_M = \mu_p (1 + a_1\tau)/(1 + b_1\tau + b_2\tau^2 + b_3\tau^3),$$
$$RS = 1 + c_1\tau + c_2\tau^2.$$

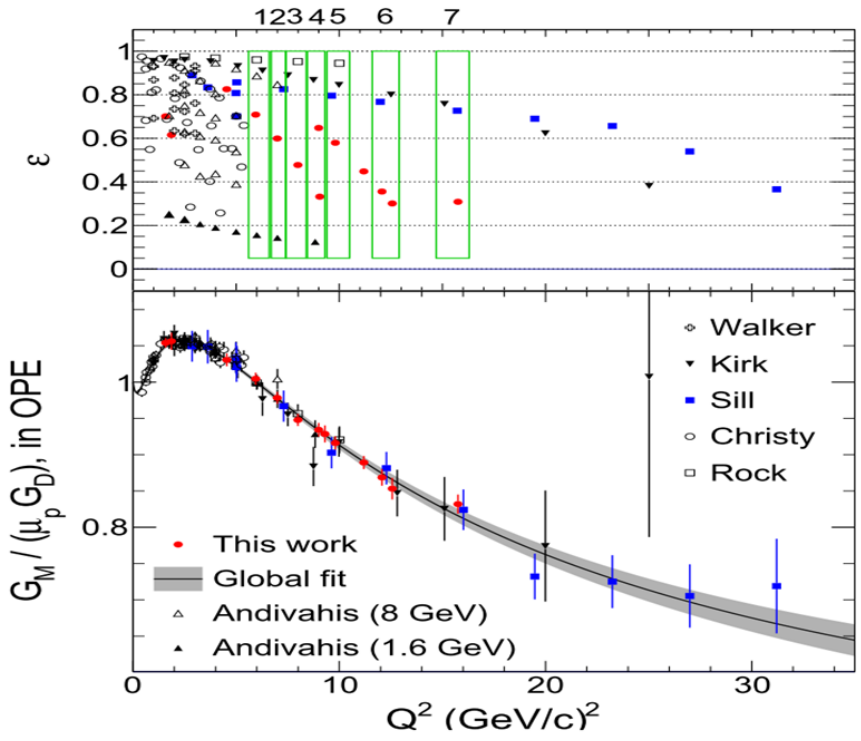
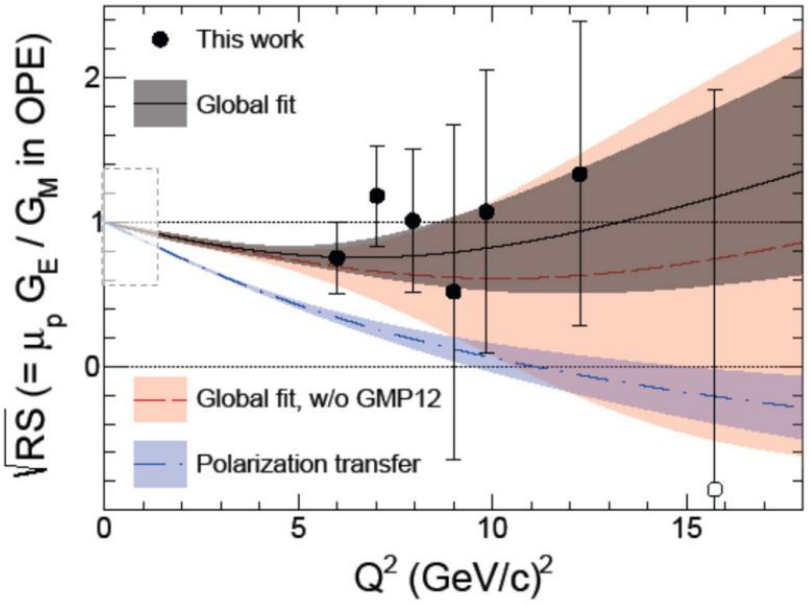


FIG. 1. (Top) Kinematics of elastic e-p cross section data used in the global fit and Rosenbluth separations; the boxes (1-7) indicate the groupings of points for the Rosenbluth separations. (Bottom) The effective proton magnetic form factor, normalized by the standard dipole $\mu_p G_D$, obtained from the cross section measurements of GMp12 and Refs. [4–6, 20, 35, 39], with symbols as indicated in the plot's legend. The curve shows the result of our global fit, with the gray shaded area indicating the 68% confidence interval.

Global fit to Sill, Andivahis, Christy, and GMp12, all with updated RC, plus direct LT separation points (do not reflect the full high Q^2 data set)

Minimal low-Q^2 data included: fit focused on high-Q^2 behavior



New data, updated RC: $\langle\Delta_{2\gamma}\rangle$ = 4.2 ± 2.0% (for Q^2>6 GeV^2)

Indications of TPE over full Q^2 range

F_2^n/F_2^p from MARATHON experiment in Hall A

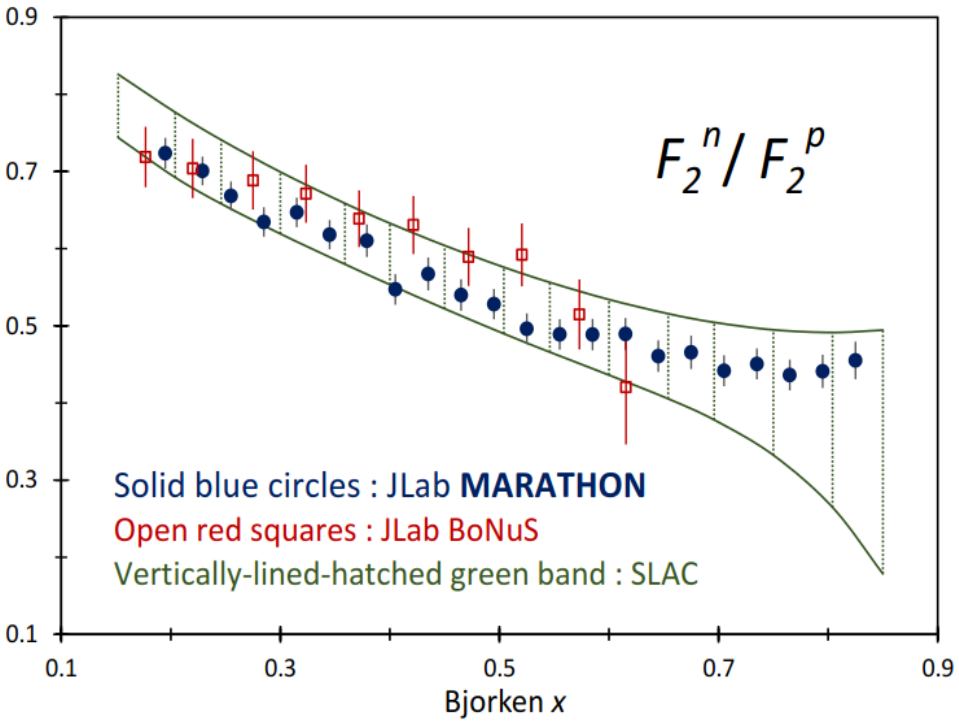
Results published March 31, 2022 in Phys. Rev. Lett. 128, 132003

Measured ^{3}He and ^{3}H cross sections in DIS kinematics using the LHRS and RHRS

Extracted ratio of neutron to proton structure functions

$$\frac{F_2^n}{F_2^p} = \frac{2R^* - \sigma^{^3He}/\sigma^{^3H}}{2\sigma^{^3He}/\sigma^{^3H} - R^*}$$

R* is near 1 with small theoretical uncertainty



SLAC represented by green band since extraction sensitive to the NN potential used in the deuteron wave function

F_2^n/F_2^p predicted by models

Model	F_2^n/F_2^p
SU(6)	2/3
NJL	0.43
DSE-1	0.49
CQM	0.25
pQCD	3/7

Table from C. D. Roberts, R. J. Holt, S. M. Schmidt Physics Letters B, 727, 2013,p249-254

Beam Normal Single Spin Asymmetry, A_n

Results published April 8, 2022 in Phys. Rev. Lett. 128, 142501

- Ancillary measurements to the main PREX-2 and CREX parity violating asymmetry experiments.
- Sensitive to interference between imaginary part of the two-photon and one-photon exchange.
- A_n for ^{12}C, ^{40}Ca, ^{48}Ca are non zero and match the theory calculation.
- A_n for ^{208}Pb is near zero in agreement with previous PREX results in conflict with theoretical calculation.

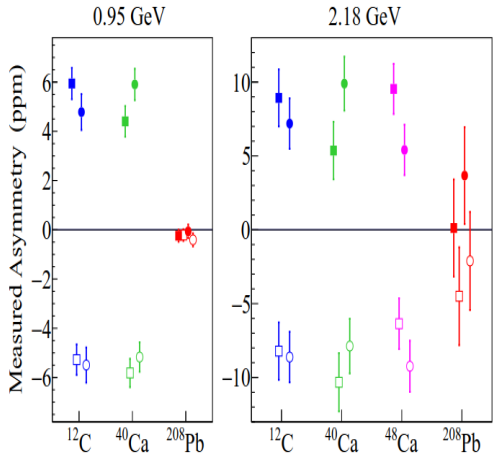


FIG. 1. Measured asymmetries, corrected for beam fluctuations and sign-corrected for slow helicity reversals, demonstrating consistency over 4 configurations. Data from the left (right) HRS is shown with filled (open) symbols, while circles (squares) represent the half-wave $\lambda/2$ plate in (out) configuration.

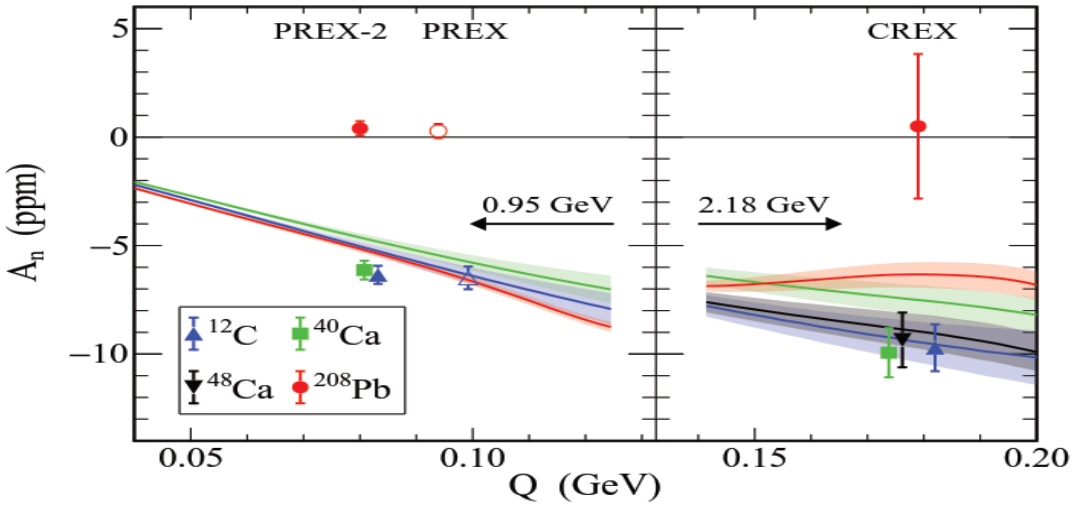
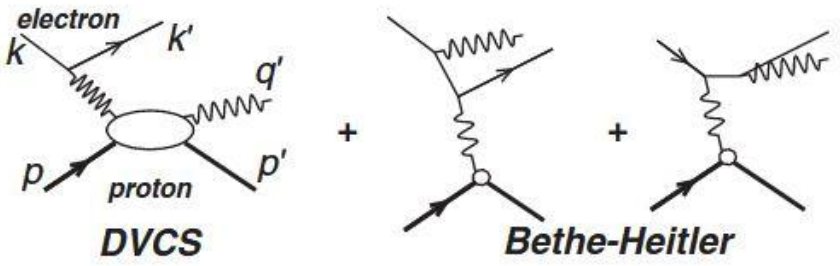


FIG. 2. A_n measurements from PREX-2, PREX (open circle and triangle, previously published [20]) and CREX, at beam energies of 0.95 GeV, 1.06 GeV and 2.18 GeV respectively. The solid lines show theoretical calculations from [26] at 0.95 GeV and 2.18 GeV. Overlapping points are offset slightly in Q to make them visible.

Jefferson Lab

DVCS (PRL 128.252002)



Deeply virtual Compton scattering cross sections at high x_B. Sensitive to GPDs of the nucleon.

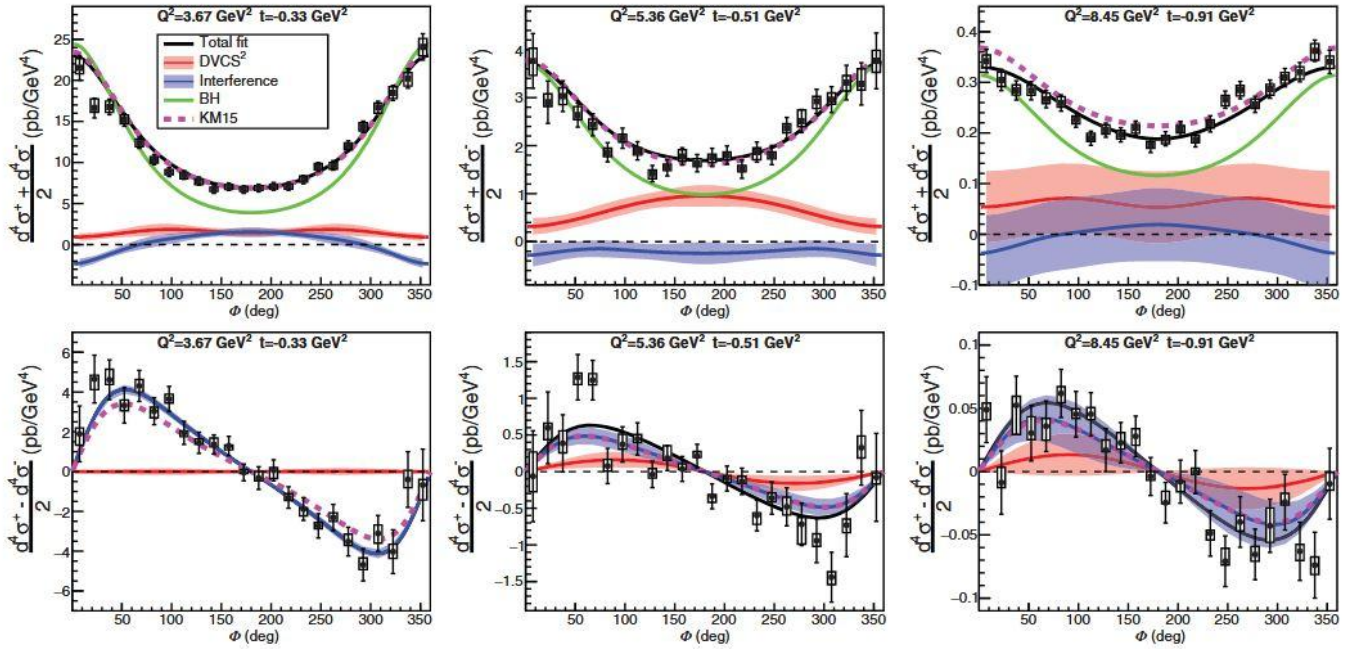
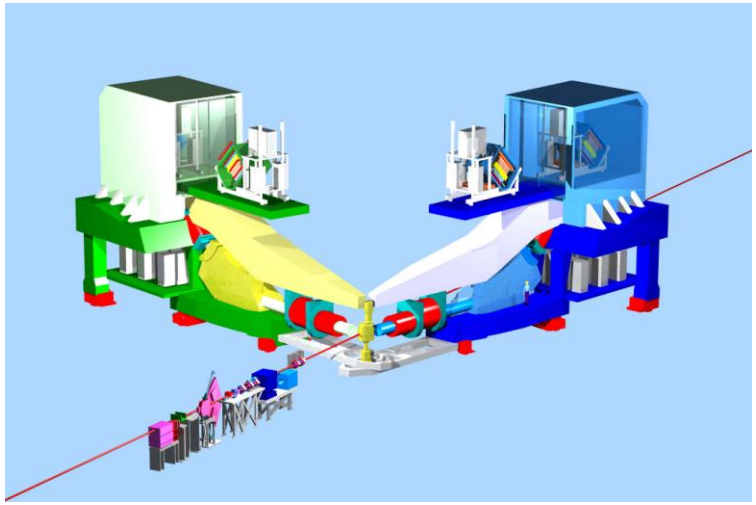


FIG. 3. Helicity-independent (top) and helicity-dependent (bottom) DVCS cross section at $x_B = 0.36$ (left), $x_B = 0.48$ (center), and $x_B = 0.60$ (right) for the values of Q^2 and t indicated on the top of each figure. Bars around the points indicate statistical uncertainty and boxes show the total systematic uncertainty, computed as the quadratic sum of the point-to-point and correlated systematic uncertainties.

^{40}Ar(e,e'p) (PRD 105 11202)



High Resolution Spectrometers (HRS)

Experiment E12-14-012 using HRS in Hall A. Reduced cross section results in a spectral function needed for interpretation of neutrino interactions in liquid argon detectors.

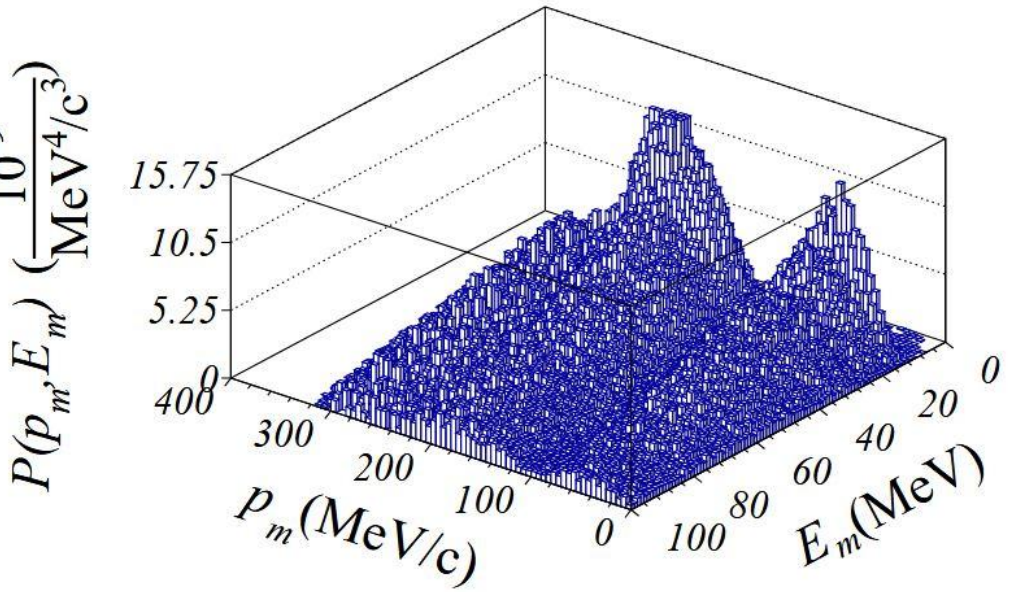


FIG. 10. Reduced cross section as function of missing energy and missing momentum.

Jefferson Lab

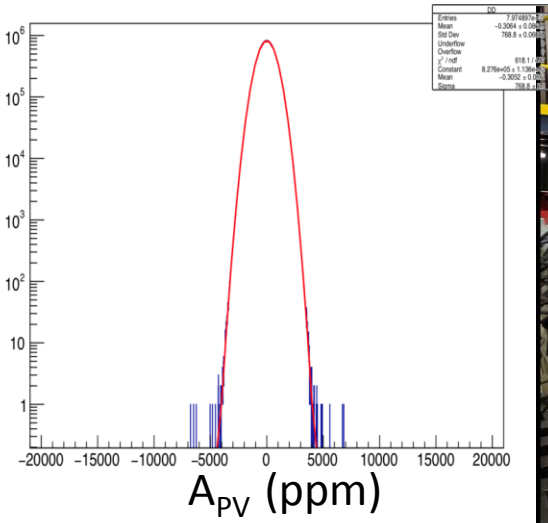
PREX and CREX

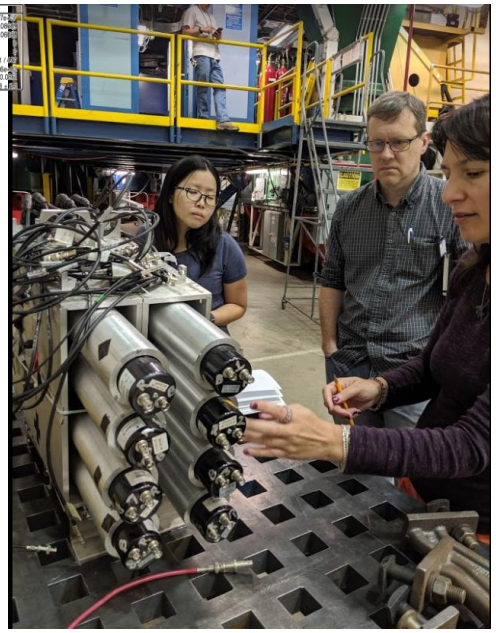
^{208}Pb ^{48}Ca

$$A_{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} \sim 10^{-4} \times Q^2 \sim 10^{-6}$$

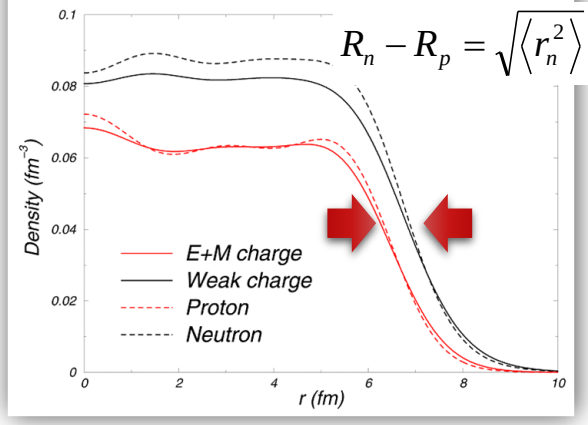
Electroweak Asymmetry in Elastic Electron-Nucleus Scattering : Extract R_n

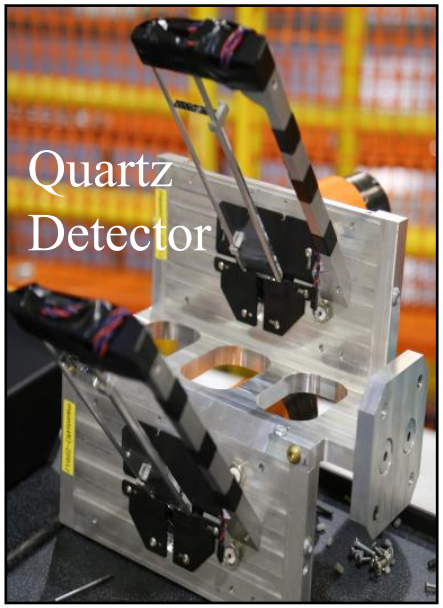
- PREX-II PRL 126, 172502 (2021)
- CREX accepted by PRL, arXiv:2205.11593





C. J. Horowitz ^{208}Pb

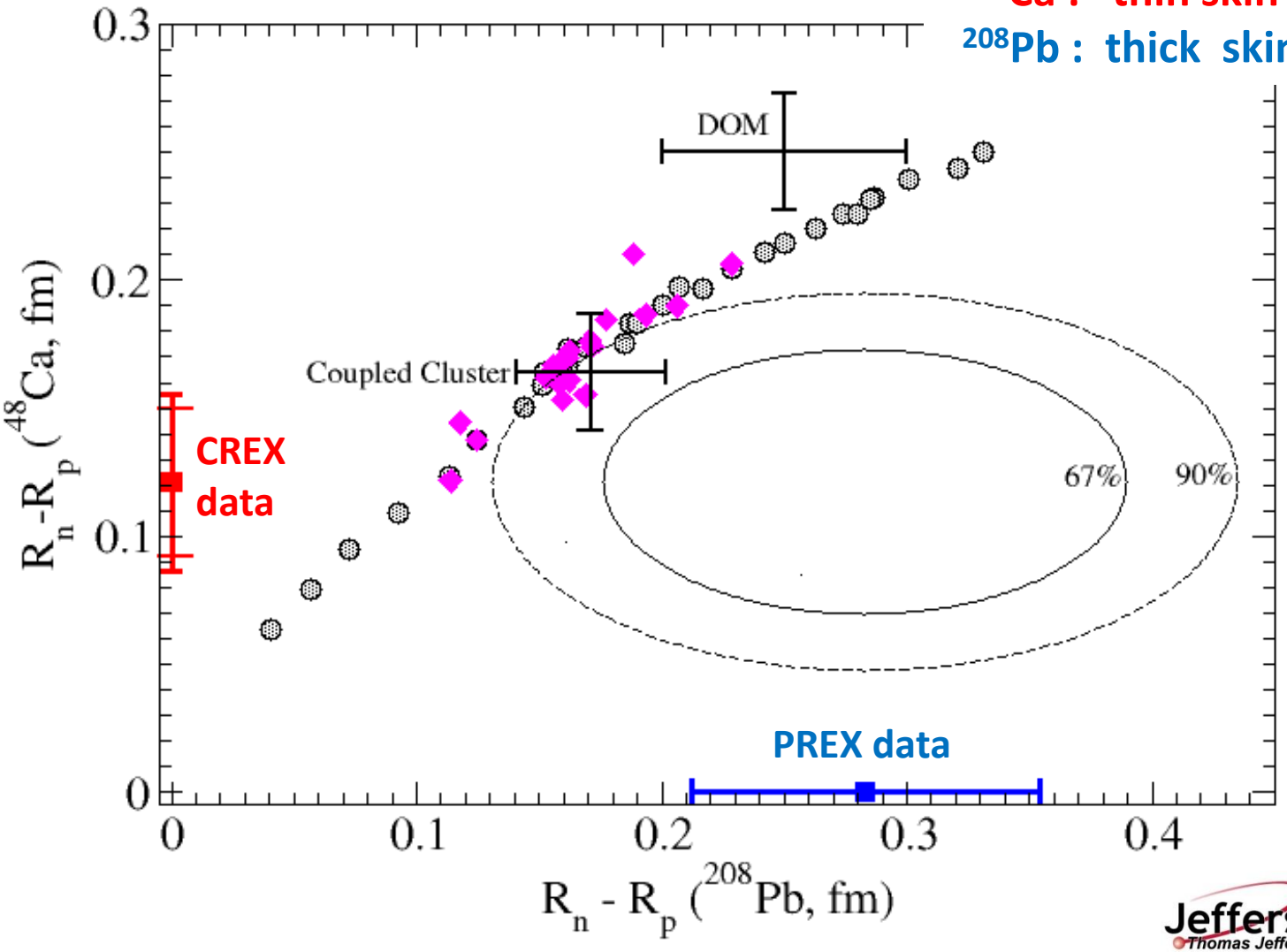




Jefferson Lab
Thomas Jefferson National Accelerator Facility

Neutron Skins vs Theory

^{48}Ca : thin skin
^{208}Pb : thick skin
} compared to models

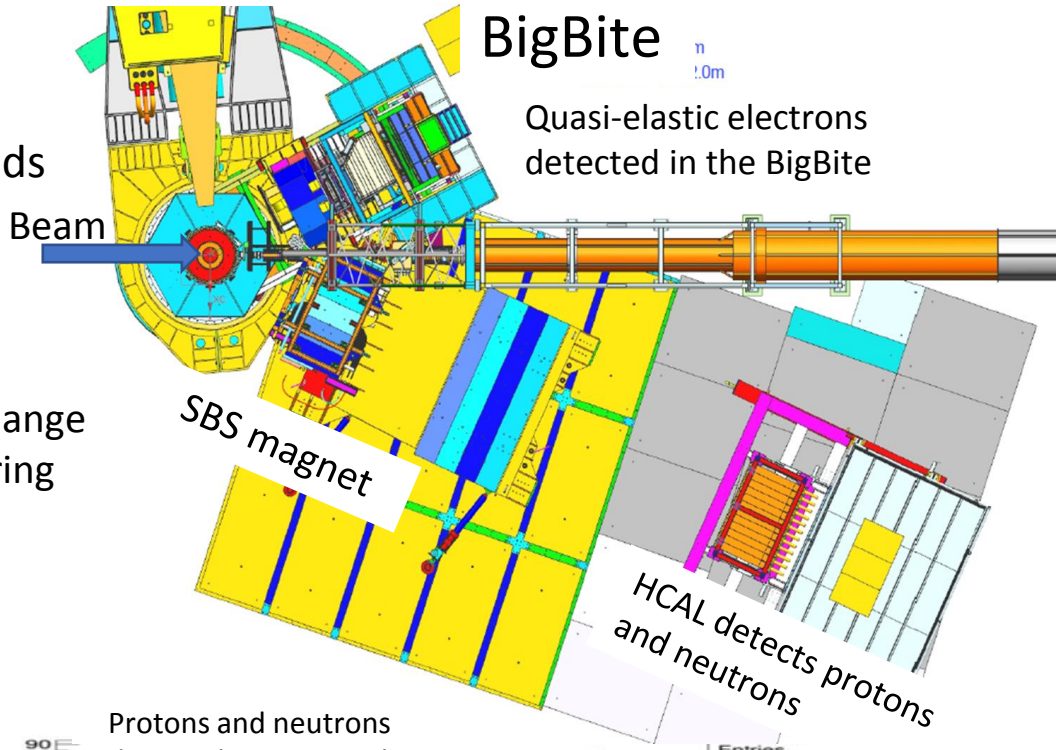


Jefferson Lab
Thomas Jefferson National Accelerator Facility

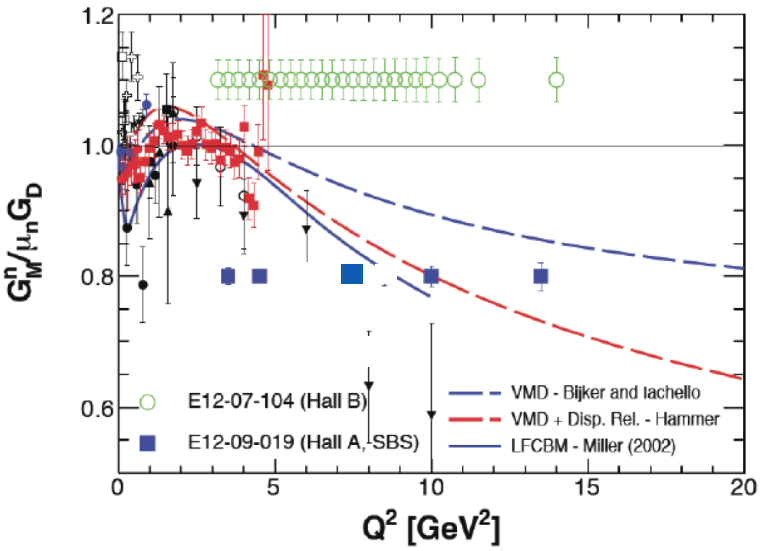
Hall A Experiment that ran Oct 2021 to Feb 2022

E12-09-019 Neutron Magnetic Form Factor, GMn

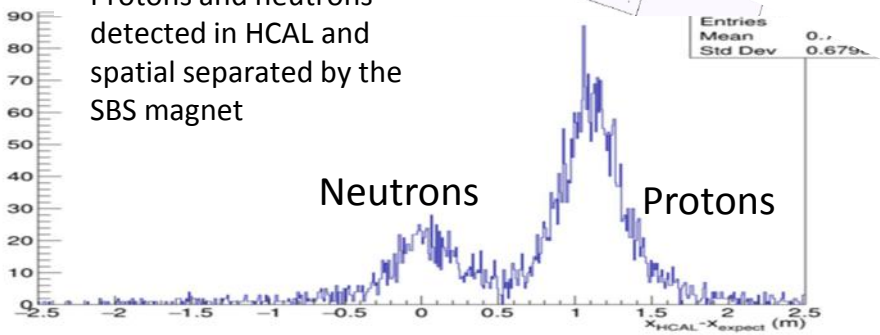
- Simultaneously measure yields of D(e,e'p) and D(e,e'n) scattering
- Extract GMn from the ratio of the yields



- Measured Q^2 = 3, 4.5, 7.5, 10 and 13.6 GeV^2
- Measured Q^2 = 4.5 at two beam energies
  - First measurement of two-photon exchange contribution to electron-neutron scattering



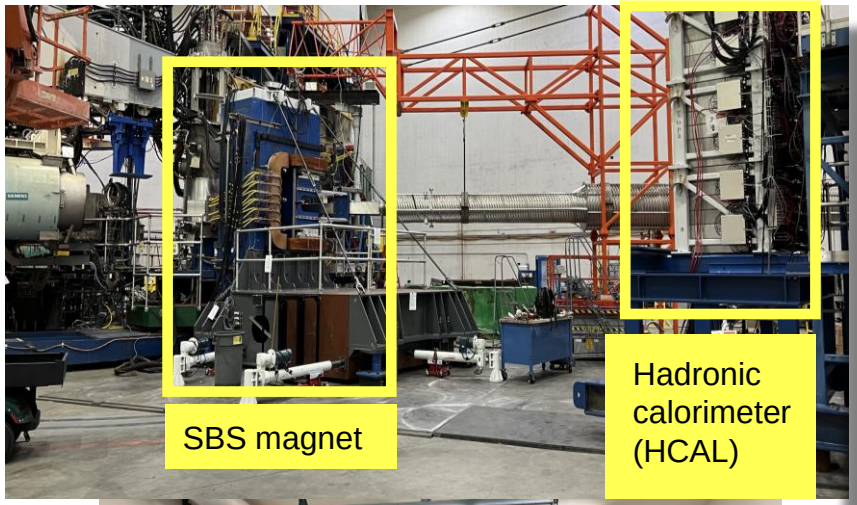
Protons and neutrons detected in HCAL and spatial separated by the SBS magnet



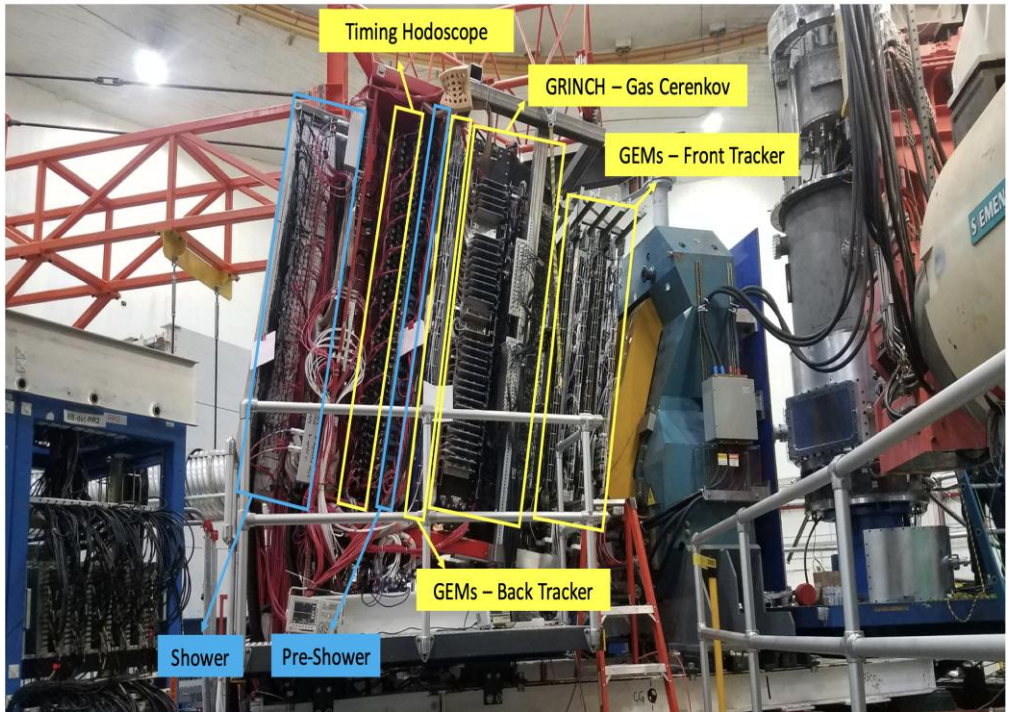
Measured position – Expected position (m)

Hall A Preparing for GeN for upcoming run period

E12-09-016 Neutron Electromagnetic Form Factor, GEn



BigBite Spectrometer



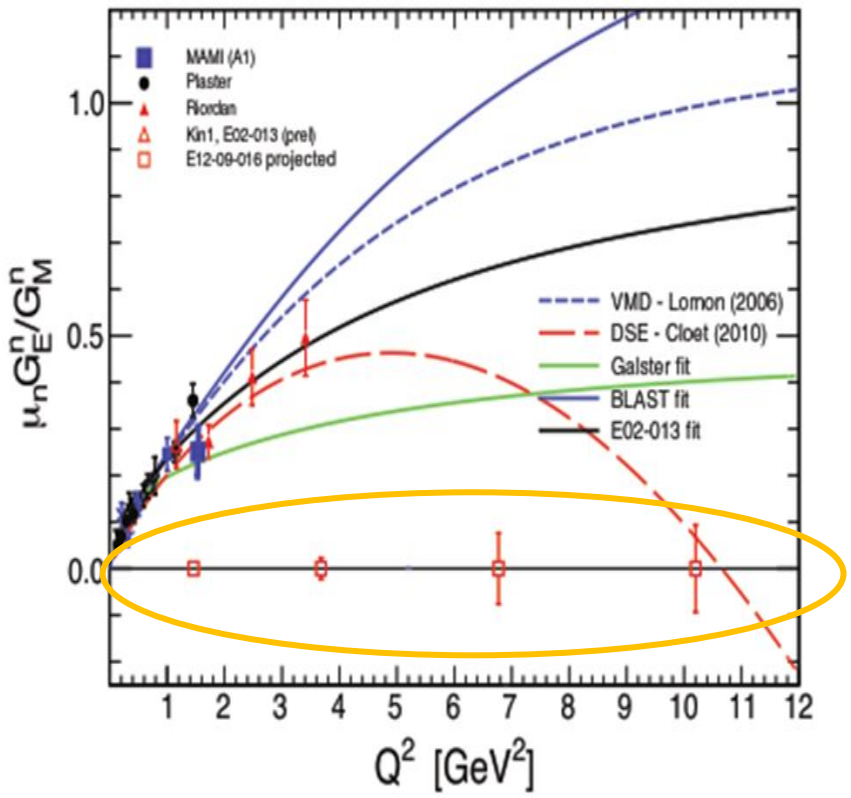
Hall A Preparing for GeN for upcoming run period

E12-09-016 Neutron Electromagnetic Form Factor, GEn

Use the same BigBite and SBS+HCAL setup to measure quasi-free scattering on polarized 3He

Extract GEn from asymmetry in polarized electron on polarized neutron scattering

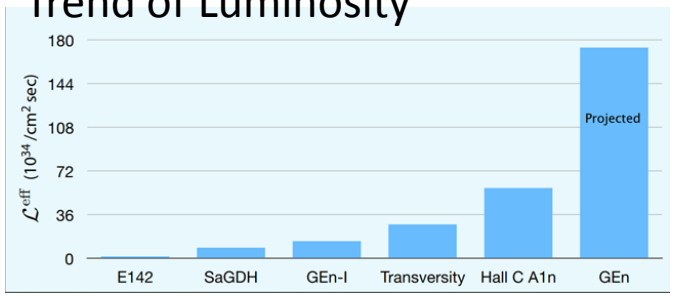
$$A_{phys} = A_{\perp} + A_{\parallel} = \frac{a \cdot G_E G_M \sin\theta^\star \cos\phi^\star}{G_E^2 + c \cdot G_M^2} + \frac{b \cdot G_M^2 \cos\theta^\star}{G_E^2 + c \cdot G_M^2}$$

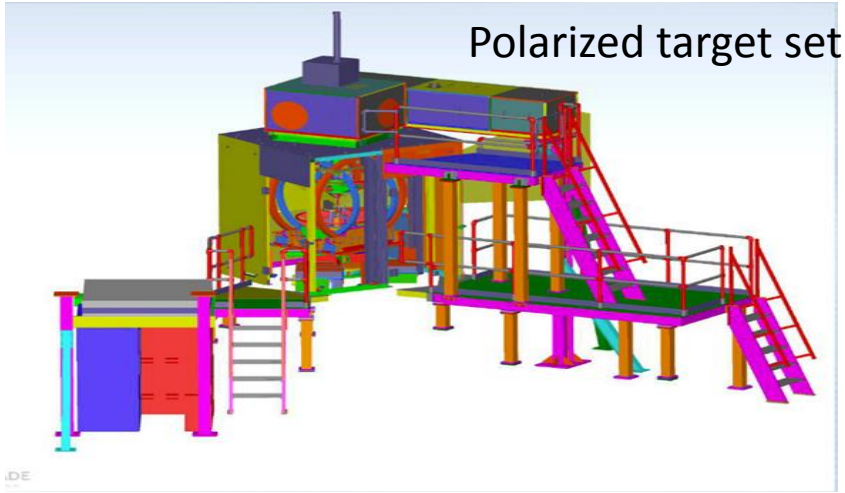


Polarized 3He target

- 60cm long (40cm in Hall C)
- 55-60% polarization
- 60μA (30μA in Hall C)

Trend of Luminosity





Jefferson Lab

3He Target Cell Work for GeN

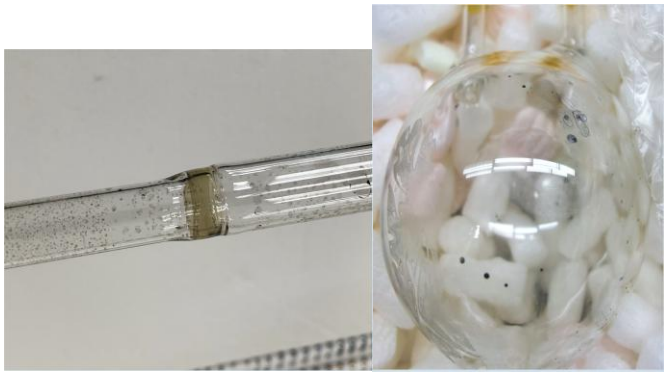
- Three usable cells (Ukraine, Tiger, Pristine) with 7-10 hour lifetime.

- Target cell Hunter filling now. Has smaller pumping chamber.

Target cell Ukraine

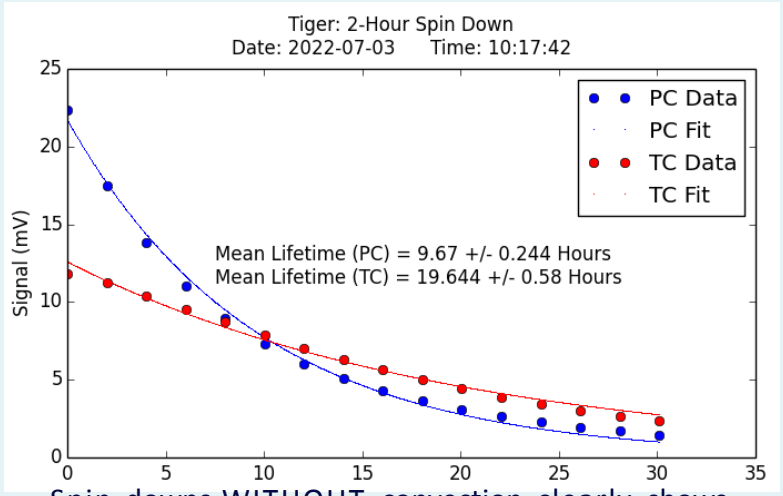
- Target cell is 60cm in length compared to 40cm for the A1n/d2n cells.
- Overall volume is roughly twice that of A1n/d2n cells allowing increased FoM (by ~2 at 60 μA)

SBS GEn polarized ^{3}He target production issues

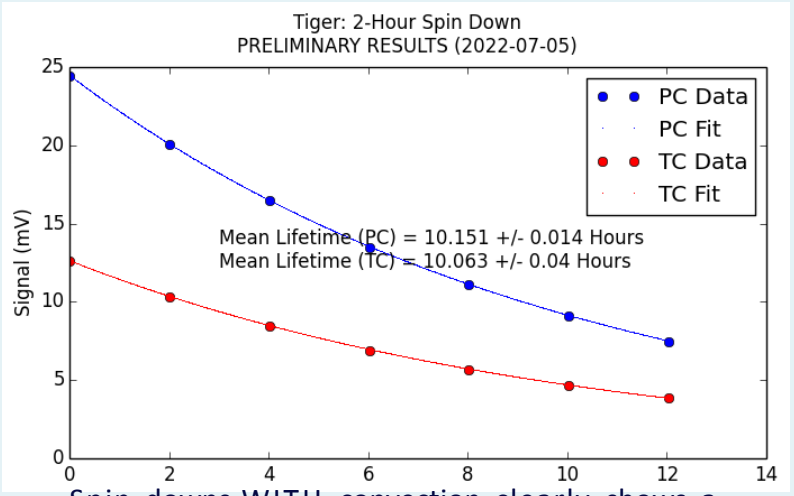


Contamination (black spots) – solved with an oxygen baking technique.

"Mystery problem" remains: appears to be due to stress in pumping chamber. Test with cell "Hunter" (smaller chamber).



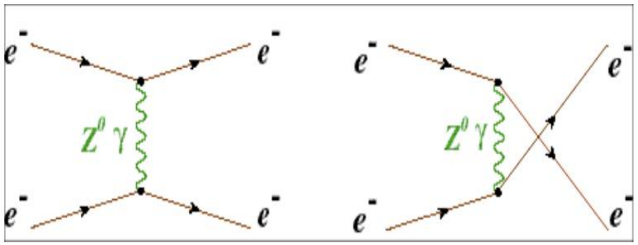
Spin-downs WITHOUT convection clearly shows faster relaxation in the pumping chamber.

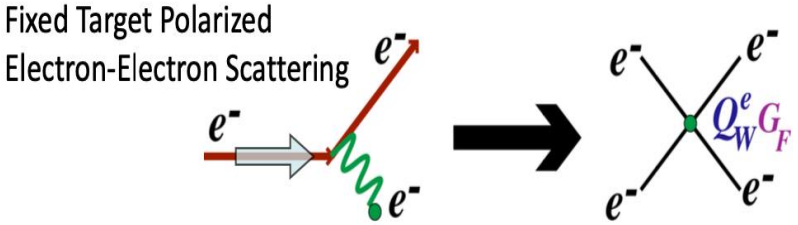


Spin-downs WITH convection clearly shows a volume averaged relaxation rate.

Recent spin-down tests of both target-cells Tiger and Ukraine clearly indicate that the "mystery problem" is in the pumping chamber, and stress due to the large size is the clear front-runner as to a hypothesis. Target cell Hunter, to be filled Sunday, July 10th, is meant to confirm or disprove this hypothesis.

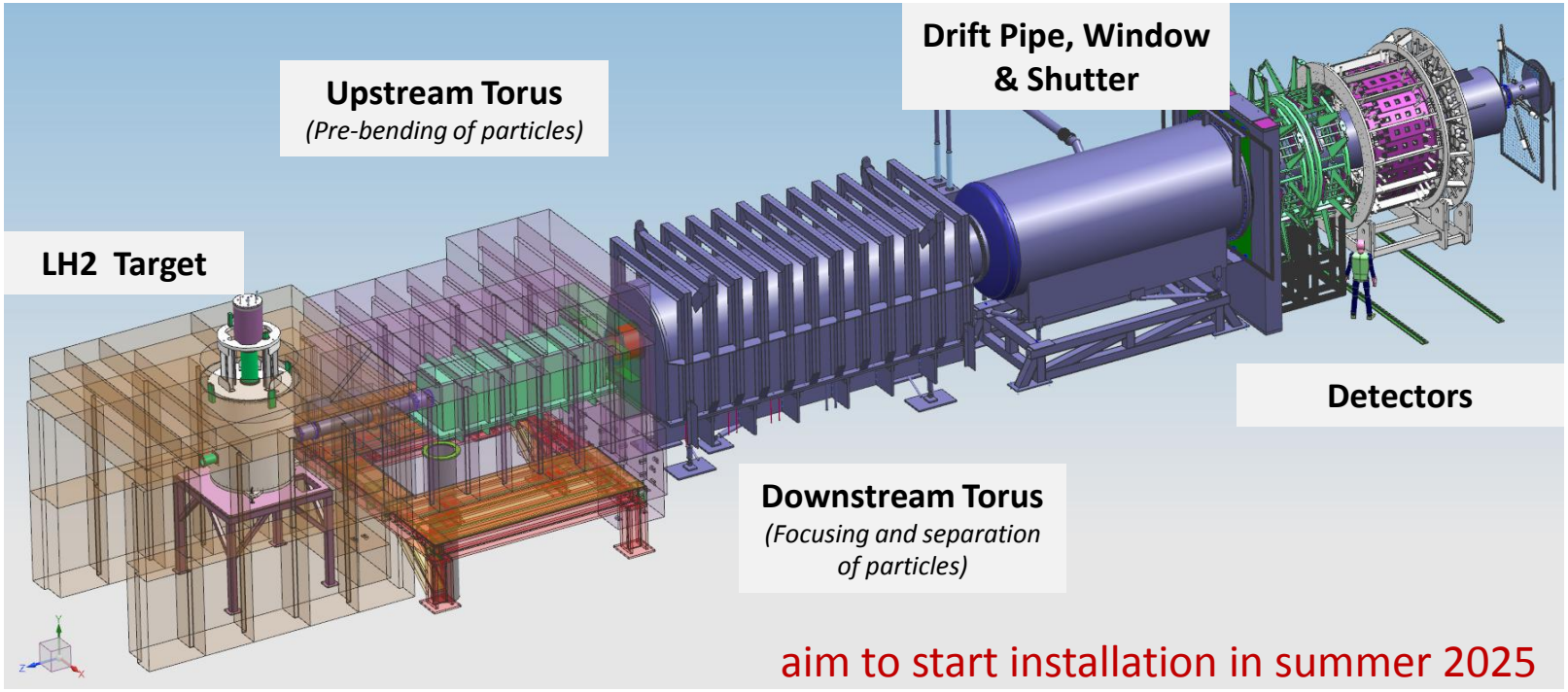
MOLLER – a precision measurement of A_{PV} in e^-e^- scattering





$$A_{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} = -mE \frac{G_F}{\sqrt{2}\pi\alpha} \frac{16\sin^2\Theta}{(3+\cos^2\Theta)^2} Q_W^e$$

$$Q_W^e = 1 - 4\sin^2\theta_W \sim 0.075$$



Jefferson Lab

MOLLER Activity: Prototyping of torus coil

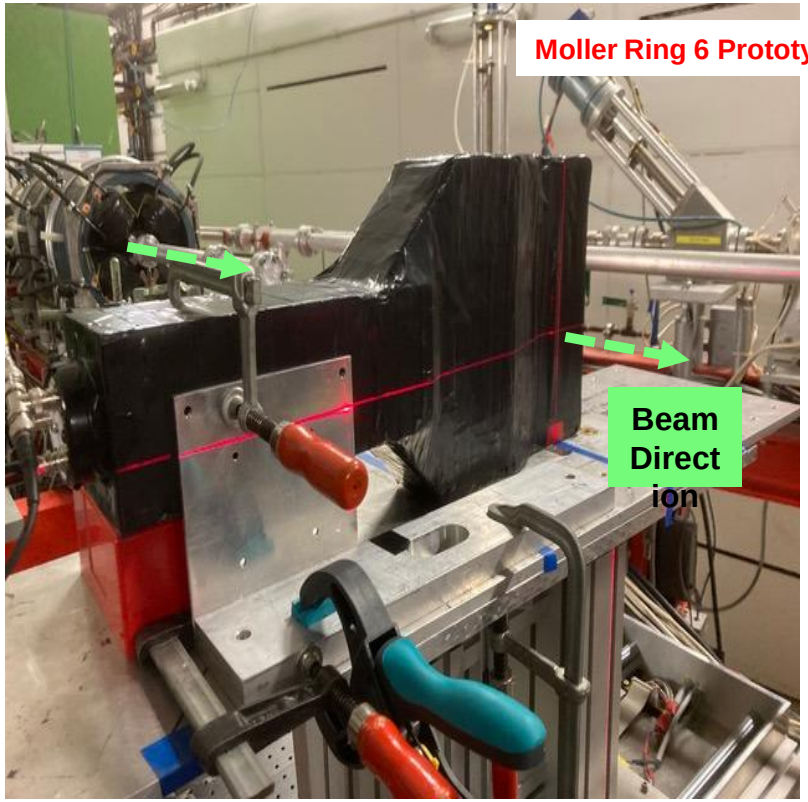
Coil winding mandrels

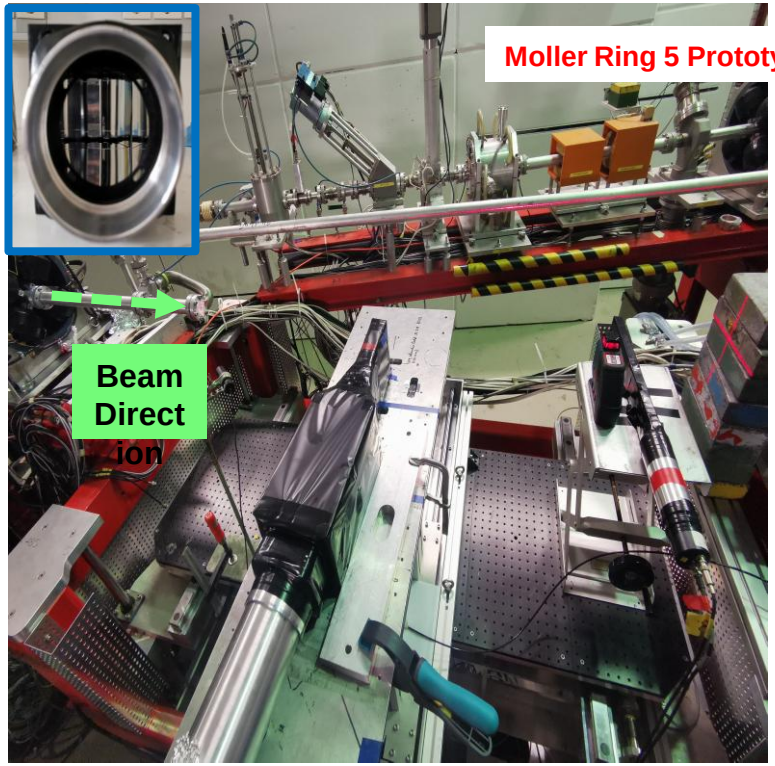
Brazing Qualification Parts

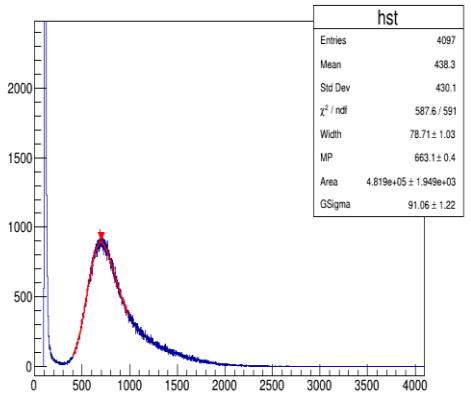
Conductor Insulation Wrapping

Sub-coil 1, 2 and 3 after winding

MOLLER : Beam test at Mainz – Check detectors & electronics

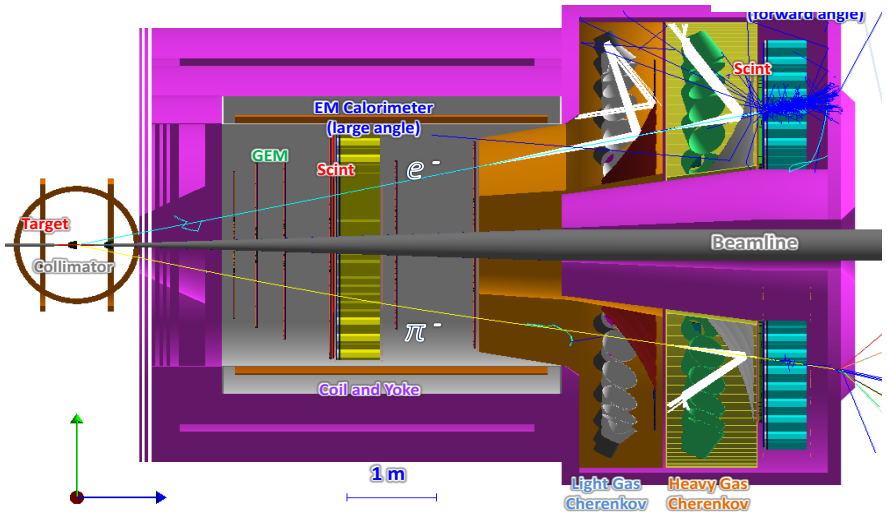






SoLID

A large solid-angle high-luminosity apparatus with several approved experiments.



Beam tests in hall C

e^-

Ecal (preshower + shower), GEMs, cherenkov, SPDs, and scintillators

The end