Proton Recoil Polarization in the $^{4}He(e,e'p)^{3}H$, $^{2}H(e,e'p)n$, and $^{1}H(e,e'p)$ Reactions

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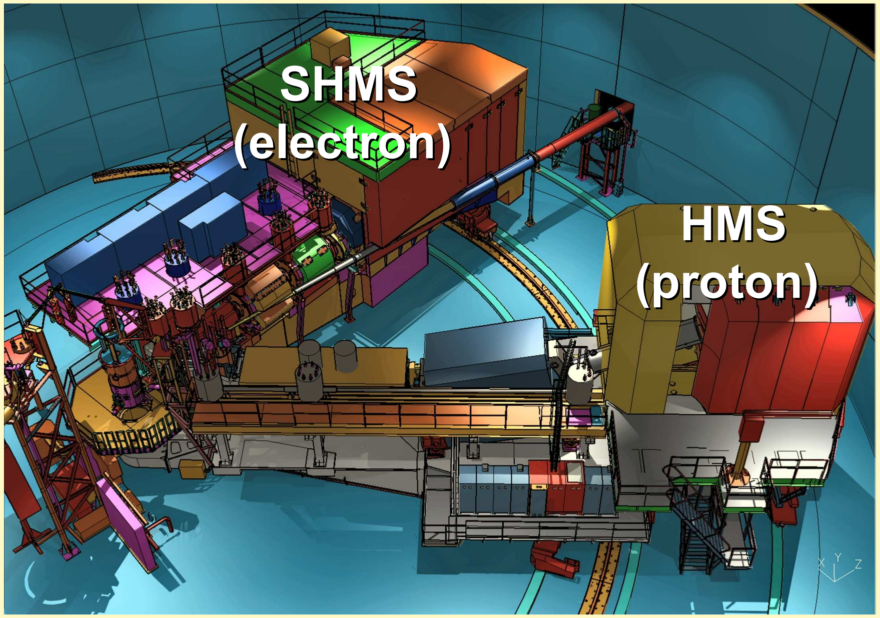
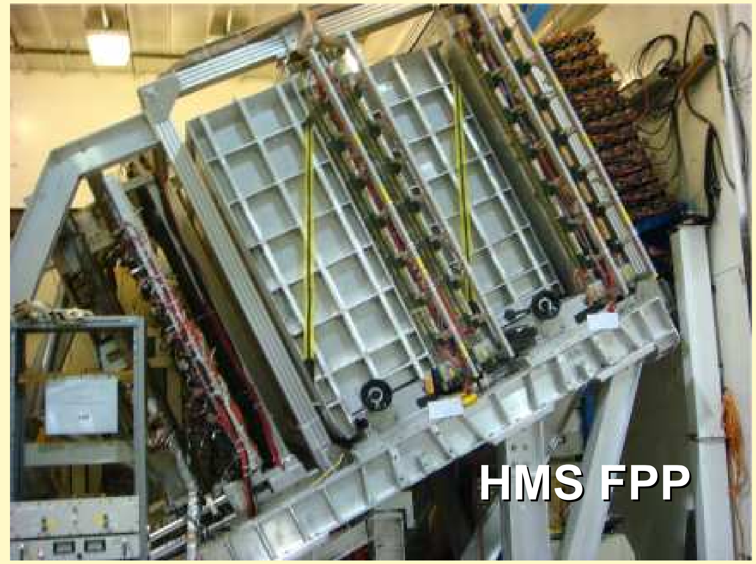
Scientific Objectives

- Investigate the role of nuclear medium modifications via proton recoil polarization in quasielastic (e,e'p) $^{4}He, ^{2}H, ^{1}H(\vec{e}, e'\vec{p})$
- High sensitivity to nucleon structure while at same time least sensitive to conventional nuclear medium effects.

Key features	Impact
Wide coverage of proton virtualities at Q^2=1.0 GeV^2	Study the momentum (virtuality) dependence of nucleon medium effects
^{4}He, ^{2}H, ^{1}H targets	Study the density dependence of nucleon medium effects
High-precision data point of the proton recoil polarization in $^{4}He(e,e'p)^{3}H$ at Q^2=1.8 GeV^2	Compare free and bound proton recoil polarizations where models predict largest sensitivity to effect of in-medium form factors

Kinematic Settings





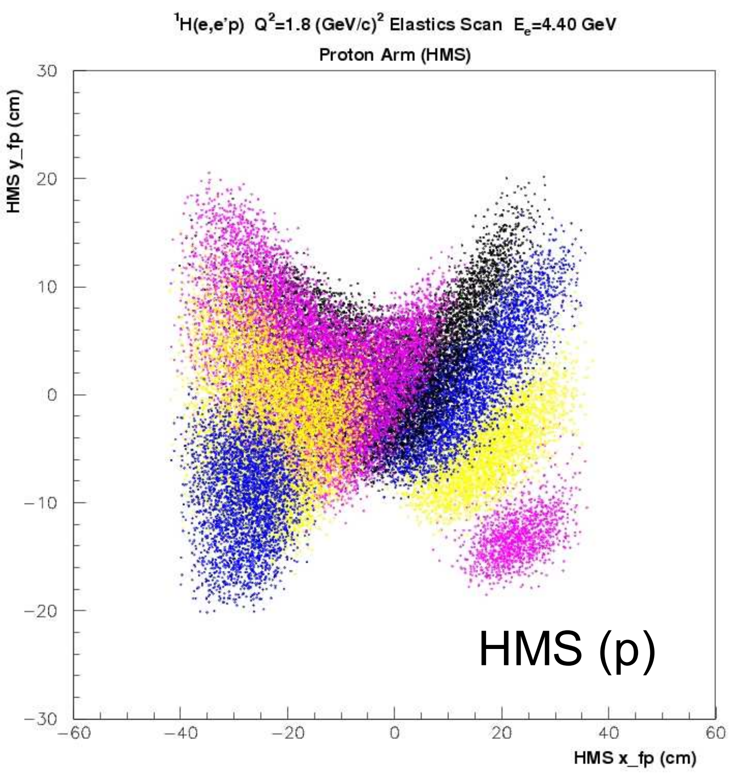
- **Q^2=1.0:** 1-pass 2.25 GeV beam, measure ^{1}H, ^{2}H, ^{4}He(e,e'p)
  - Approved for 25 days, beam currents 25-75μA
- **Q^2=1.8:** 2-pass 4.40 GeV beam, measure ^{1}H, ^{4}He(e,e'p)
  - Approved for 12.4 days, 75μA
- **Scattered electron in SHMS in undemanding kinematics:**

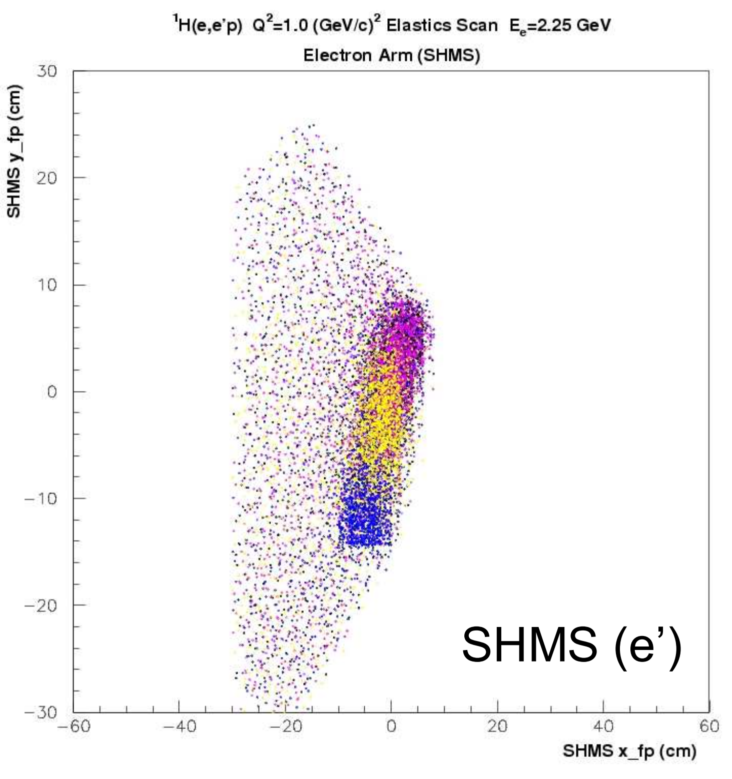
  $1.68 < P_{SHMS} < 3.44$ GeV/c $\quad 19.85^o < \theta_{SHMS} < 29.75^o$
- **Hall C Focal Plane Polarimeter in HMS:**

  $0.83 < P_{HMS} < 1.15$ GeV/c $\quad 43.99^o < \theta_{HMS} < 57.42^o$

$^1H(e,e'p)$ Scans a Key Part of the Experiment

- **Coincidence scans at both Q^2=1.0, 1.8 $(GeV/c)^2$.**
- Scans allow instrumental asymmetries of FPP to be studied, and provide a reference for the polarization-transfer ratios.
- The e-p coincidence data could also be extremely useful for understanding the SHMS optics, detector & trigger efficiencies.





- Colors indicate 7 different HMS settings in each scan.
- SHMS setting could also be varied to give good coverage for optics checks.

Our Contributions to Construction/Commissioning

Construction:

- GH building SHMS Heavy Gas Cerenkov.

Commissioning:

- General assistance with Hall C commissioning, manpower.
- We will in addition help the Hall C Collaboration understand the SHMS optics, coincidence trigger, and detector efficiencies through the analysis of our data (particularly the $^{1}H(e,e'p)$ elastic coincidence scans).

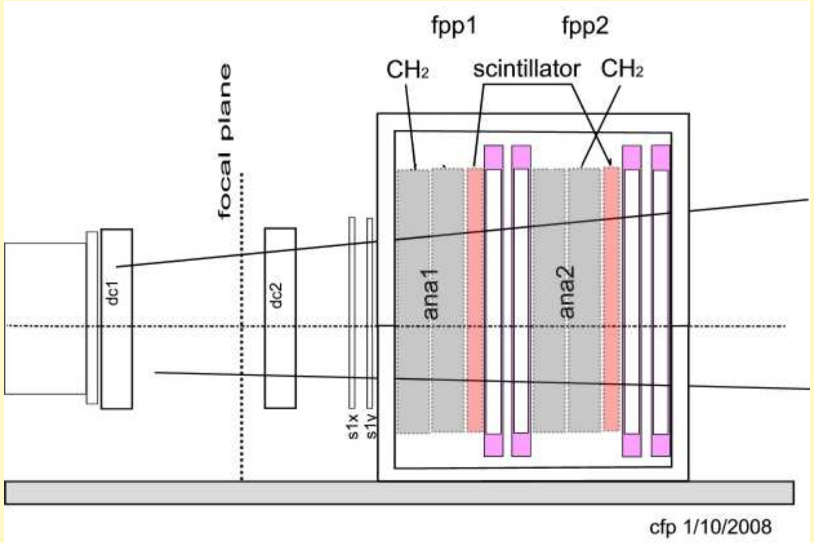
We <u>are open</u> to inviting additional hall users and staff to participate in the experiment.

→ Already working with Gep Collaboration

Readiness: Planned work on FPP CH_2 Analyzers

- **Because of low proton momentum in the HMS, need thinner CH_2 analyzers for some kinematic settings.**
- S0 scintillator which replaced S2 in Gep-III is also not optimal.
  - covers too little of HMS focal plane and increases multiple scattering.

- Plan new FPP analyzers:
  - Each FPP analyzer will consist of two removable 20cm CH2 layers, and a 5cm scintillator layer.
  - Can restack existing CH2, but need 8 scintillator bars for each layer.



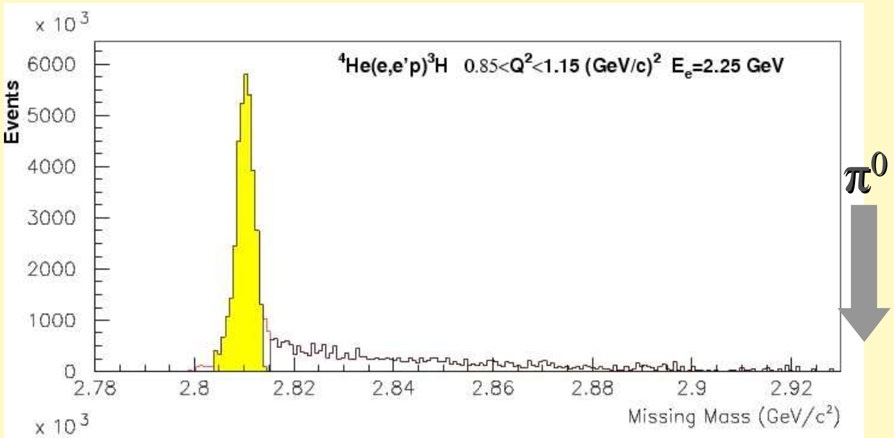
- Will provide efficient triggering across focal plane while preserving good missing mass resolution.
  - Improved triggering also desirable for other FPP experiments.
- A straightforward project expected to take ~6 months.

A Potential Commissioning Experiment

- **Double Ratio Experiment insensitive to absolute flux uncertainties** (luminosity, global detector efficiencies, solid angles)
  - Our `signal' is the modulation of φ-distribution relative to flat, unpolarized baseline

$$R = \left(\frac{P'_x}{P'_z}\right)_A \Bigg/ \left(\frac{P'_x}{P'_z}\right)_H$$

- **SHMS optics requirements not particularly demanding:**
  - p(e,e'p) coincidences easier to understand than single arm (e,e')
  - Only need SHMS to determine q-vector to 5mrad to know P'_x to 1%.
  - SHMS settings:
    P<3.5 GeV/c, θ>19^o
  - Missing mass resolution requirements are modest



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Broader Benefits to Hall C

- Although our experiment is able to meet its physics goals without a detailed knowledge of detector efficiencies and electron spectrometer optics, the data we acquire will be very useful for the calibration of those experiments to follow.

- **Detailed $^{1}H(\vec{e},e'\vec{p})$ scans needed to determine FPP instrumental asymmetries very useful for:**
  - **Debugging SHMS+HMS coincidence trigger.**
  - **Determining SHMS detection efficiencies (both global and local).**
  - **Can we reproduce previously measured cross sections?**

- For similar reasons, an $^{16}O(\vec{e},e'\vec{p})$ experiment was one of the HRS^2 commissioning experiments in Hall A.

Pros

- Polarization transfer technique insensitive to most errors.
- $^{1}H(e,e'p)$ coincidence scans useful for detailed determination of SHMS optics, efficiencies, etc.
- We desire 1-2 pass beam, which is otherwise undersubscribed.
- Scheduling flexiblity:
  - Since Q^2=1.0, 1.8 measurements have separate hydrogen elastics scans, they **do not** need to be run consecutively.
  - Don't even need to keep FPP in HMS between the two runs.

Cons

- Require installation of FPP in HMS, with straightforward modifications to optimize the FPP analyzers for low momentum.
- Otherwise, the experiment is relatively simple, with little concern that the experiment cannot run early.