Normal beam spin asymmetries during the G^0 forward angle measurement

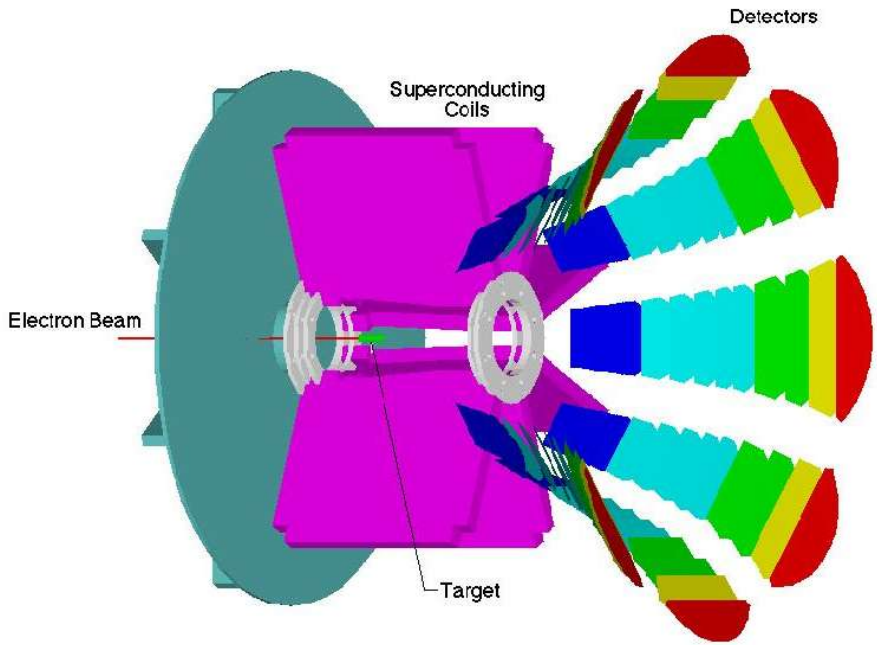
P. M. King
(UIUC)

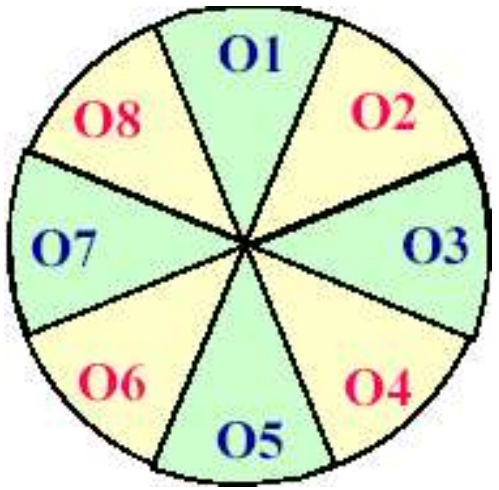
for the G^0 collaboration

The G^0 Experiment is supported by the U.S. National Science Foundation (NSF) under grant PHY94-10768, the U.S. Department of Energy (DOE), the Natural Sciences and Engineering Research Council (NSERC) of Canada, and the Centre National de la Recherche Scientifique (CNRS) of France through the Institut National de Physique Nucléaire et de Physique des Particules (IN2P3).

The G^0 Forward Angle Measurement

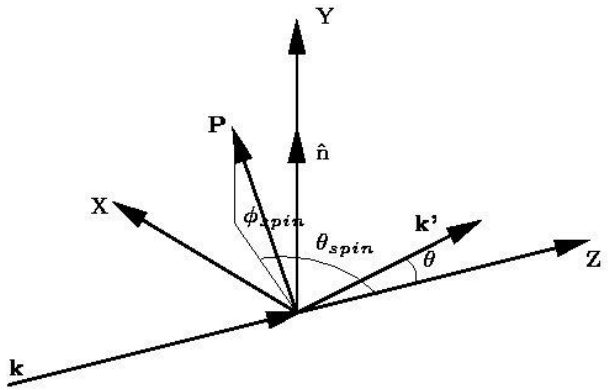
- Runs in Hall C at JLab: 3 GeV longitudinally polarized electrons scatter from a 20 cm LH_2 target, are momentum analyzed by a superconducting magnet, and are detected in 8 azimuthally symmetric detector packages with 16 detectors in each octant.
- Parity violating asymmetries of 2-20 ppm are measured.





Octant Layout (looking DS)

Physics Motivation



- The asymmetry results from two-photon exchange producing a cross section dependence on the angle between the polarization vector, **P**, and the scattering plane:

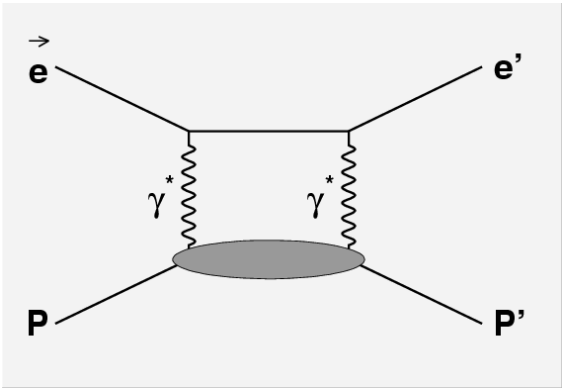
$$\sigma = \sigma_0 \left[1 + A_n \mathbf{P} \cdot \hat{\mathbf{n}} \right]$$

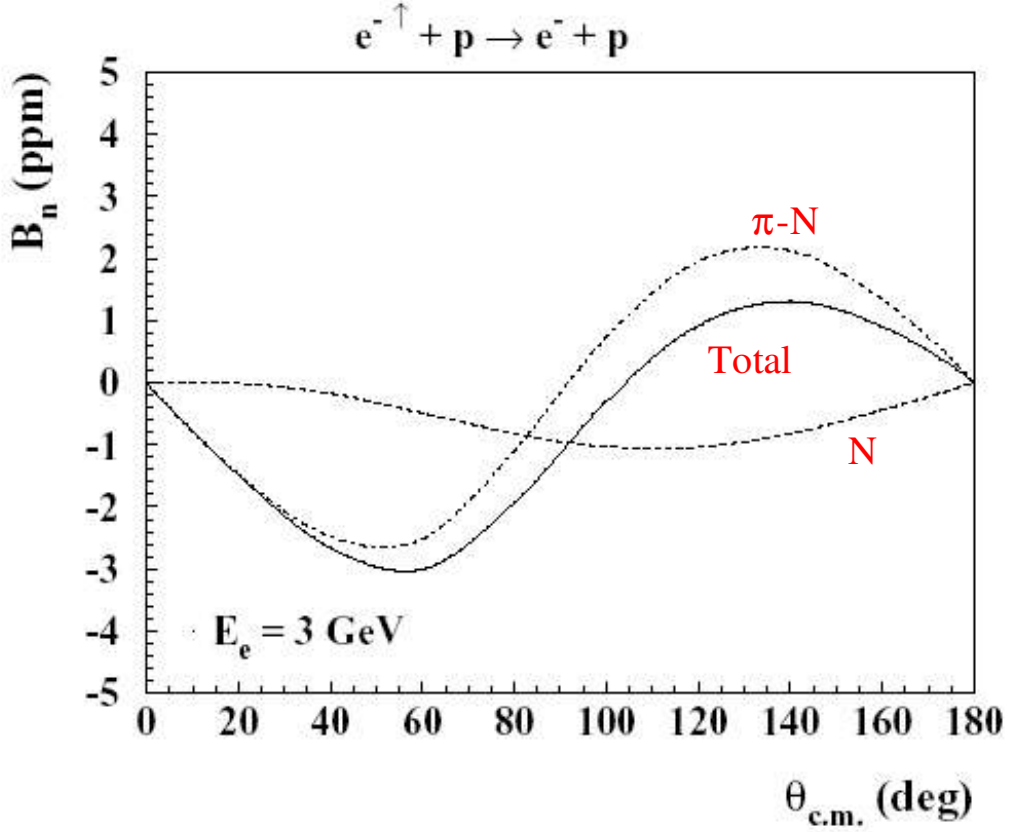
- If the electron is not longitudinally polarized, the normal beam spin asymmetry will contribute to the asymmetry measured by the G^0 detectors:

$$A_{meas}(\theta, \phi) = P \cos(\theta_{spin}) A_{PV}(\theta) + P \sin(\theta_{spin}) \sin(\phi - \phi_{spin}) A_n(\theta)$$

A Prediction from Theory

- The predictions of the asymmetry are sensitive to the intermediate state.

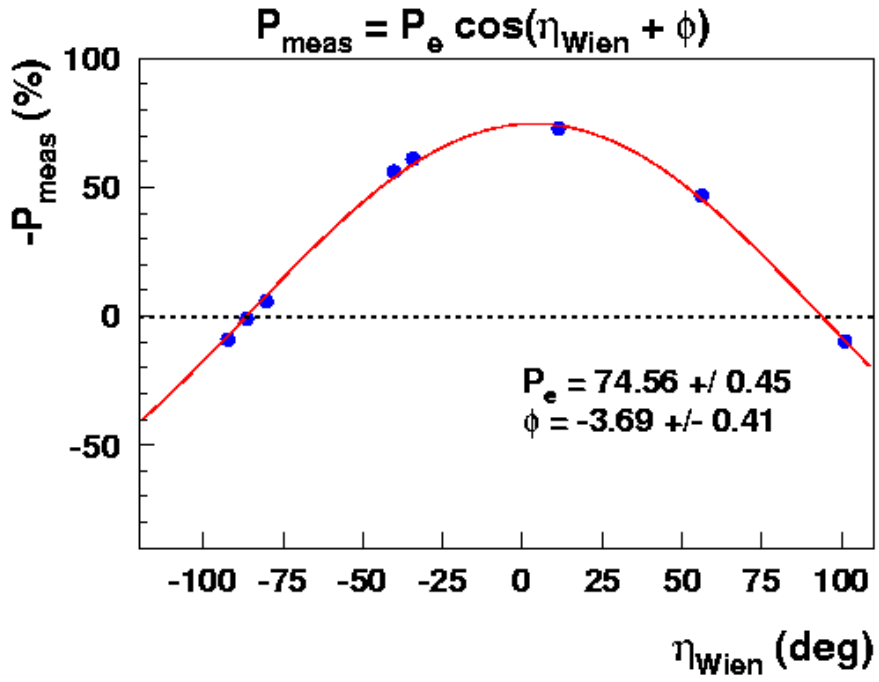




- Calculation at the G^0 beam energy using the elastic state, and π-N intermediate states with W<2 GeV. (B. Pasquini & M. Vanderhaeghen, hep-ph/0405303)
- G0 covers the θ_{CM} range of 19-38 degrees

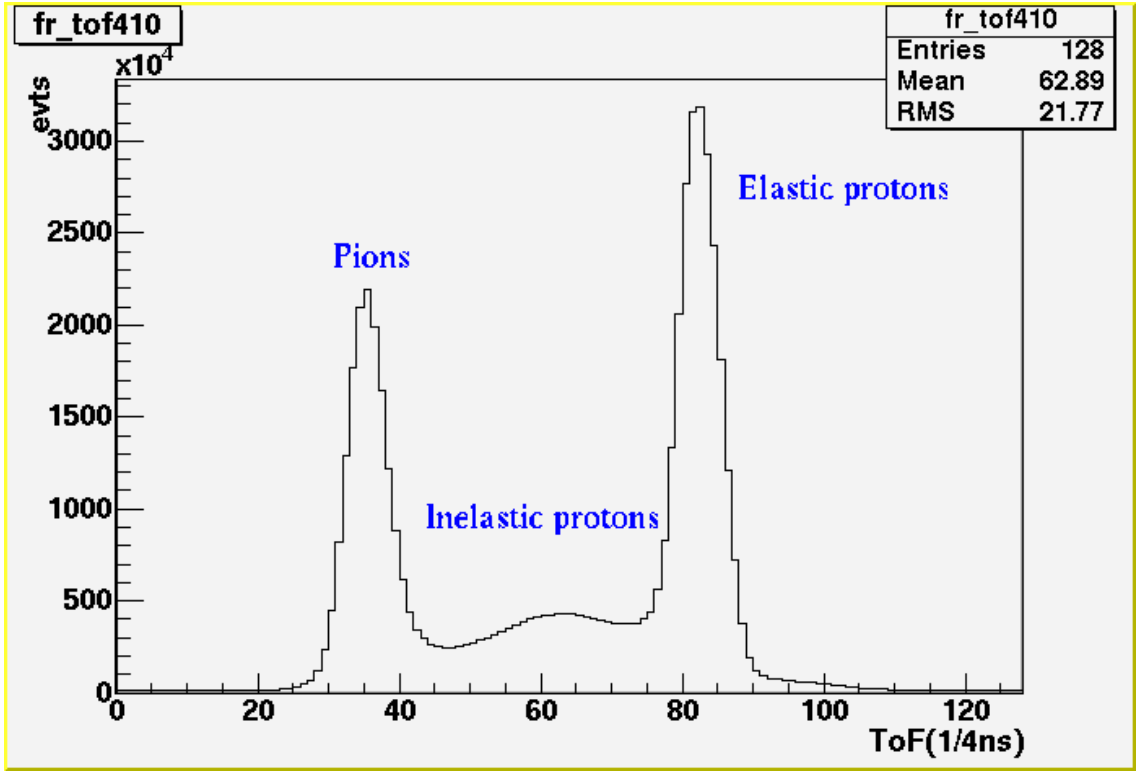
Transverse Beam Polarization

- The beam spin was oriented in the horizontal plane (acc. plane)
  - Total precession through the machine was ~23π
  - Hall C Moller is only sensitive to longitudinal beam polarization
  - Injector spin direction was at an angle of -85°; determined by finding the Wien angle which gave the minimum Moller asymmetry



G^0 Apparatus

- Detector, magnet, and target configuration identical to standard G^0
- Particle identification was done by making time-of-flight cuts in the histograms:



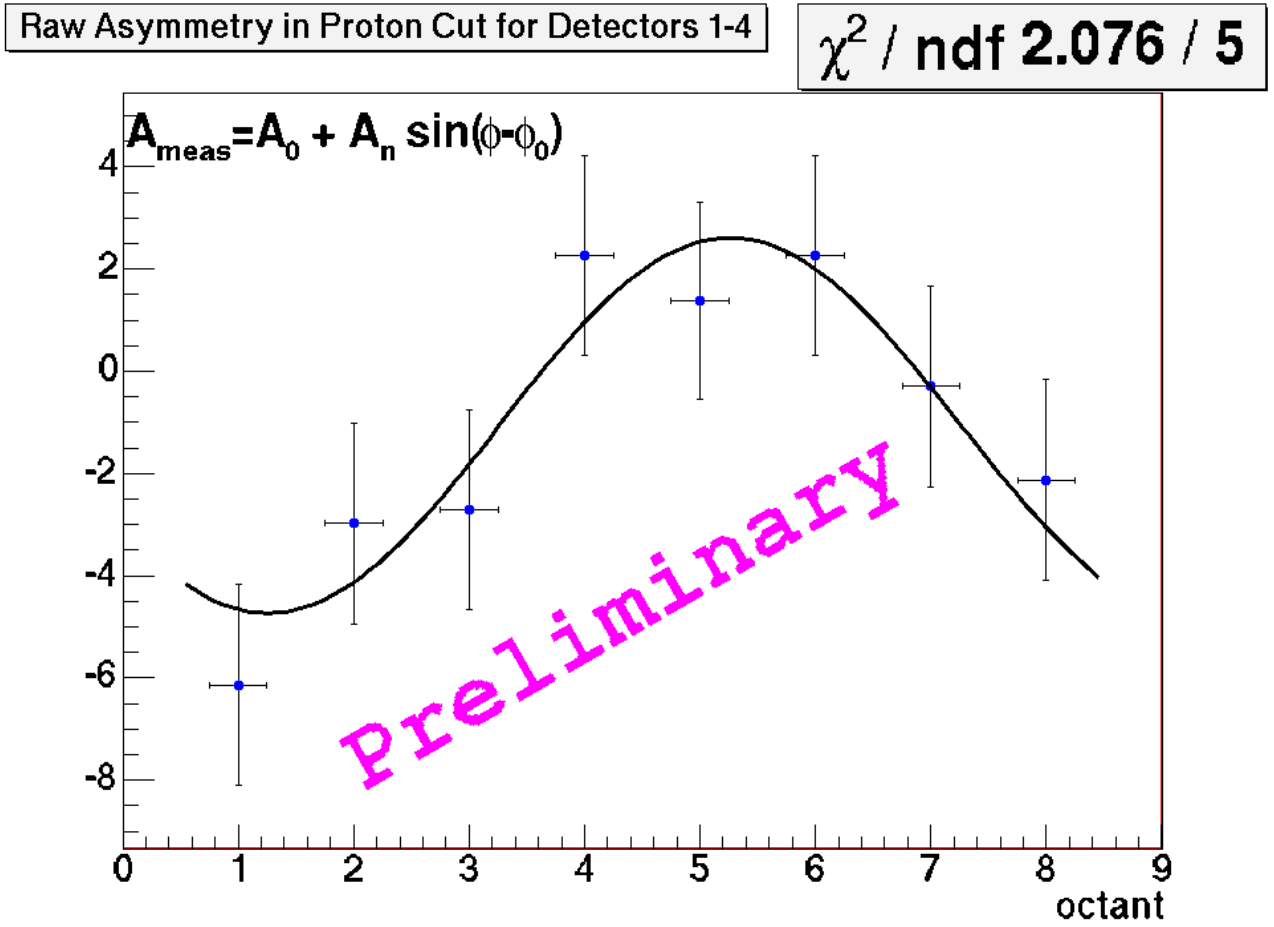
G0 Beam Normal Measurements

- Data collection: 22-26 March 2004
  - LH2 target
    - After parity quality cuts: 2.736 C, IHWP in; 1.311 C, IHWP out.
  - Al target
    - After parity quality cuts: 0.147 C, IHWP in; 0.045, IHWP out.
- Elastic proton kinematic coverage:

Detectors	$\langle Q^2 \rangle$	$\langle \theta_{CM} \rangle$	Proj. Stat. Error
1-4	0.13	19.03	1.3 ppm
5-8	0.17	21.65	1.3 ppm
9-12	0.25	26.12	1.3 ppm
13-14	0.38	32.35	2.4 ppm
15	0.6	37.4	2.9 ppm

- Also collected data in the pion and inelastic peaks

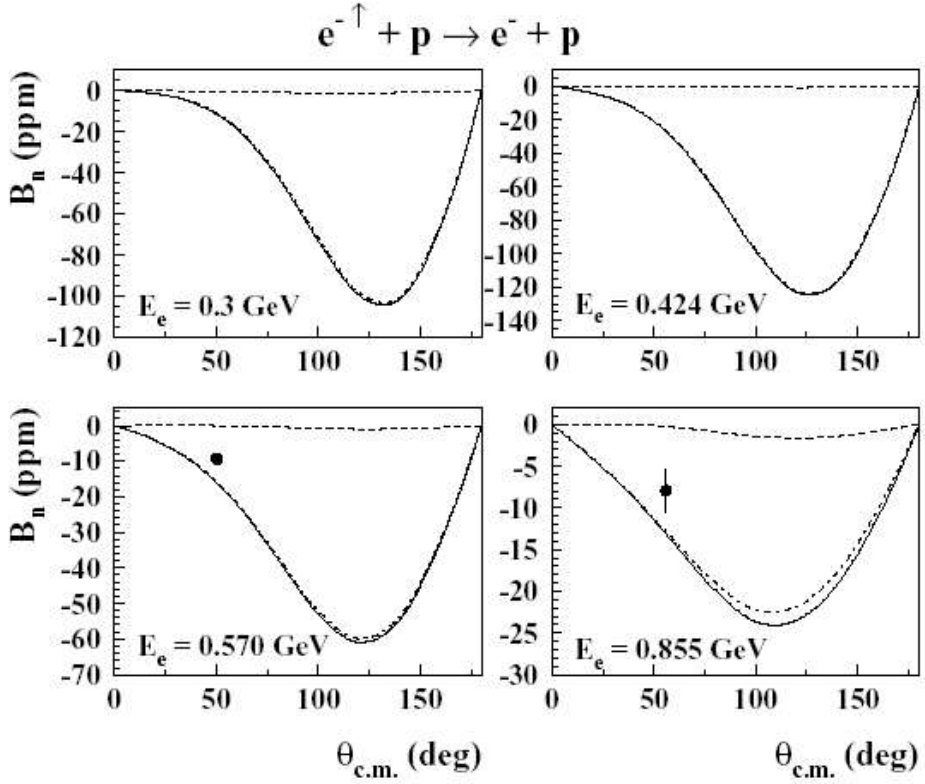
Raw Asymmetries & Required Corrections



- Hydrogen data only. Does not include background corrections, target wall subtraction, beam polarization, detector alignment corrections, beam parameter regression.

Future Plans

- Proposal to make beam normal asymmetry measurements during the G0 backward angle configuration
- The goal is to make three measurements with 3ppm precision at θ_{CM} of about 130° at beam energies of 0.424, 0.585, and 0.799 GeV



Calculations from B. Pasquini & M. Vanderhaeghen (hep-ph/0405303); Data from A4 collab.

Conclusions

- We have made measurements of the beam normal asymmetry for elastic e-p scattering at a beam energy of 3 GeV for center of mass angles of 19-38 degrees.
- The final statistical precision on these measurements will be a few ppm.
- We plan to make measurements at backward angles, with center of mass angles of about 130 degrees, at beam energies of 799, 585, and 424 MeV. The projected statistical error is 3 ppm.