Status Report: E05-103: Low Energy Deuteron Photodisintegration

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Hall A Collaboration Meeting
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Overview

- Review of current theory and data
- Kinematics and experimental setup
- New software and hardware
- Calibrations
- Preliminary results
- Future tasks
- Summary

Review of current theory and data

- At lower excitation energies, below few hundred MeV, hadronic theory gives good description of cross-section and polarization observables
- Currently, the best description is from Schwamb and Arenhövel, who incorporate modern NN potentials and relativity

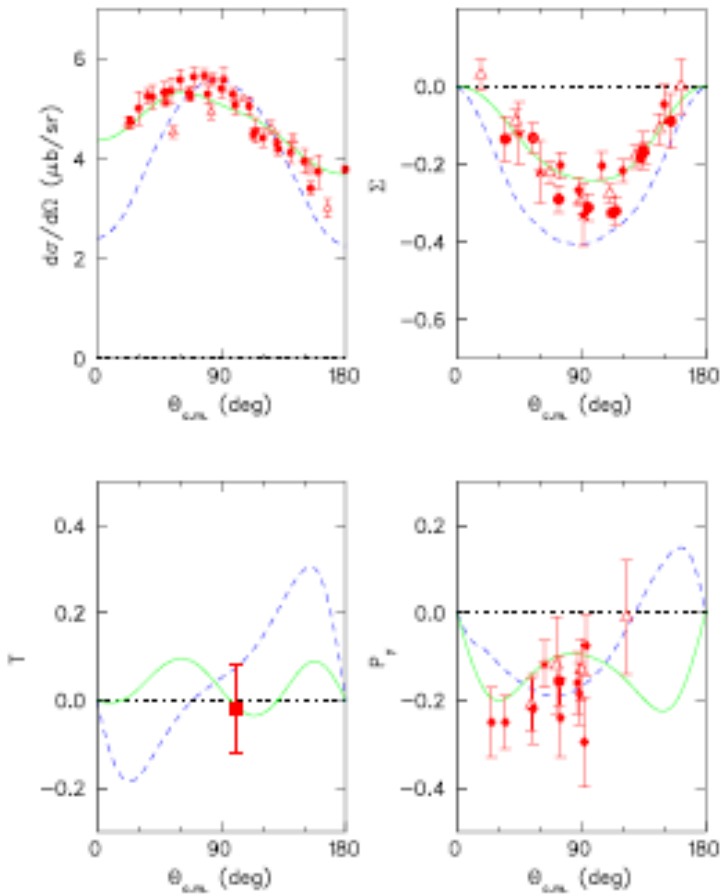


Figure: Photon Energy = 300 MeV

Review of current theory and data (Cont.)

- At higher photon energies, the theory breaks down for polarization observable P_y
- Theory predicts a minimum at $\theta_{cm} = 90^o$, but the data show a clear maximum
- Motivation of experiment was to provide high-precision polarization data in the 300-400 MeV energy region to provide clues as to what physics is missing in the hadronic theory or if quark models are needed

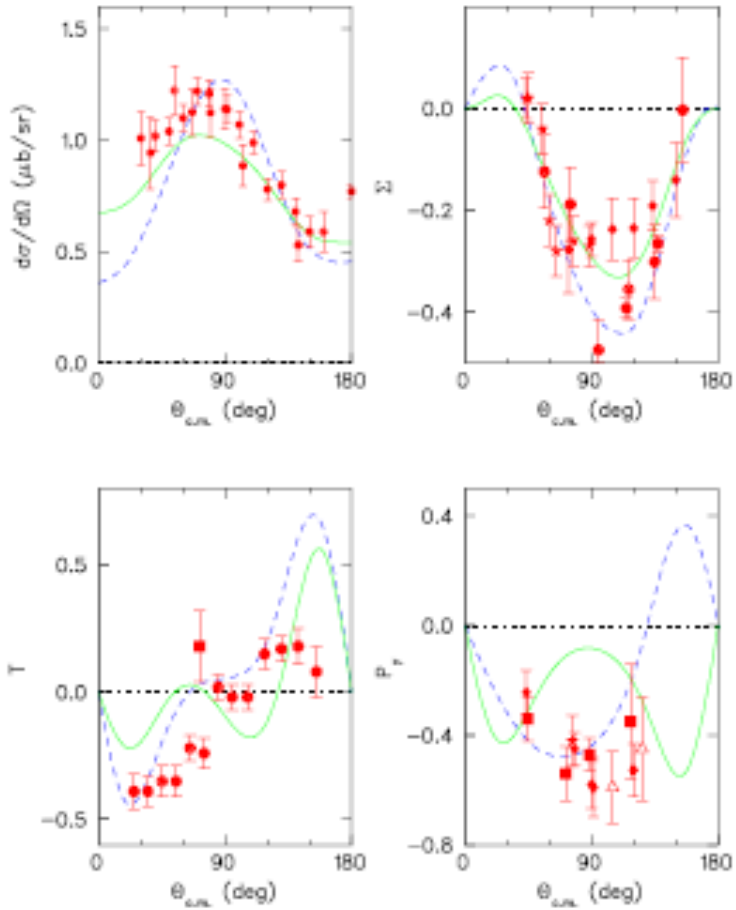
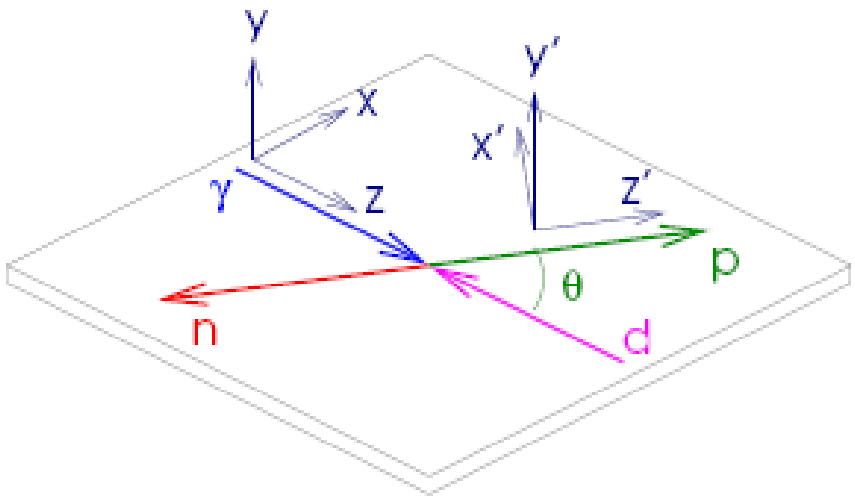


Figure: Photon Energy = 450 MeV

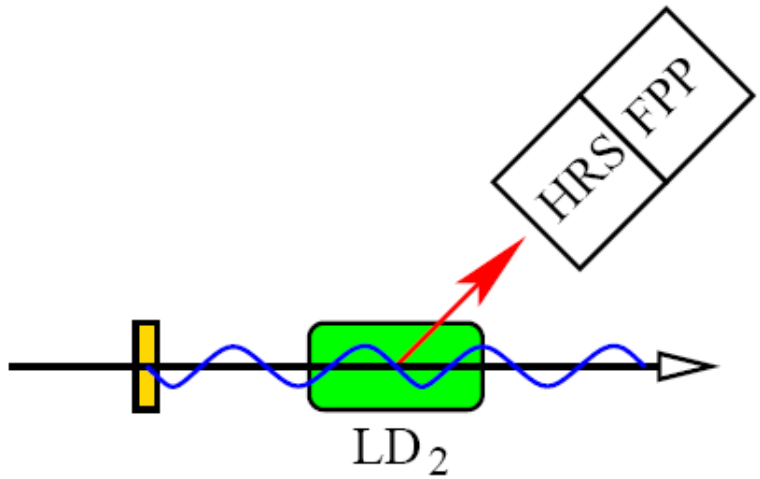
Observables

- $P_x^{c'} \Rightarrow$ transferred polarization in reaction plane, $\perp$ to $\vec{p}$
- $P_y \Rightarrow$ induced polarization, $\perp$ to reaction plane
- $P_z^{c'} \Rightarrow$ transferred polarization in reaction plane, $\parallel$ to $\vec{p}$



^{2}H(γ,p)n Reaction

- Circularly polarized photon incident on deuterium nucleus (15 cm liquid deuterium target)
- Singles measurement: neutron undetected, proton detected in left arm
- Reaction below pion production threshold: kinematics entirely determined by proton angle and momentum
- Focal plane polarimeter measured proton polarization, thickness increased with proton momentum: 3/4”, 3/4” + 1.5” and 3/4” + 3”



Kinematics

- E_beam = 362 MeV, photon energy endpoint of 361.5 MeV
- For each θ_{cm} angle, two spectrometer settings to obtain total of five 20 MeV bins in E_γ centered from 280 to 360 MeV
- As proton angle in increased, the momentum drops as well as the figure of merit, leading to an increase in uncertainty $\propto 1/\sqrt{f}$, so the higher momentum setting at $\theta_{cm} = 120^o$ was the practical limit

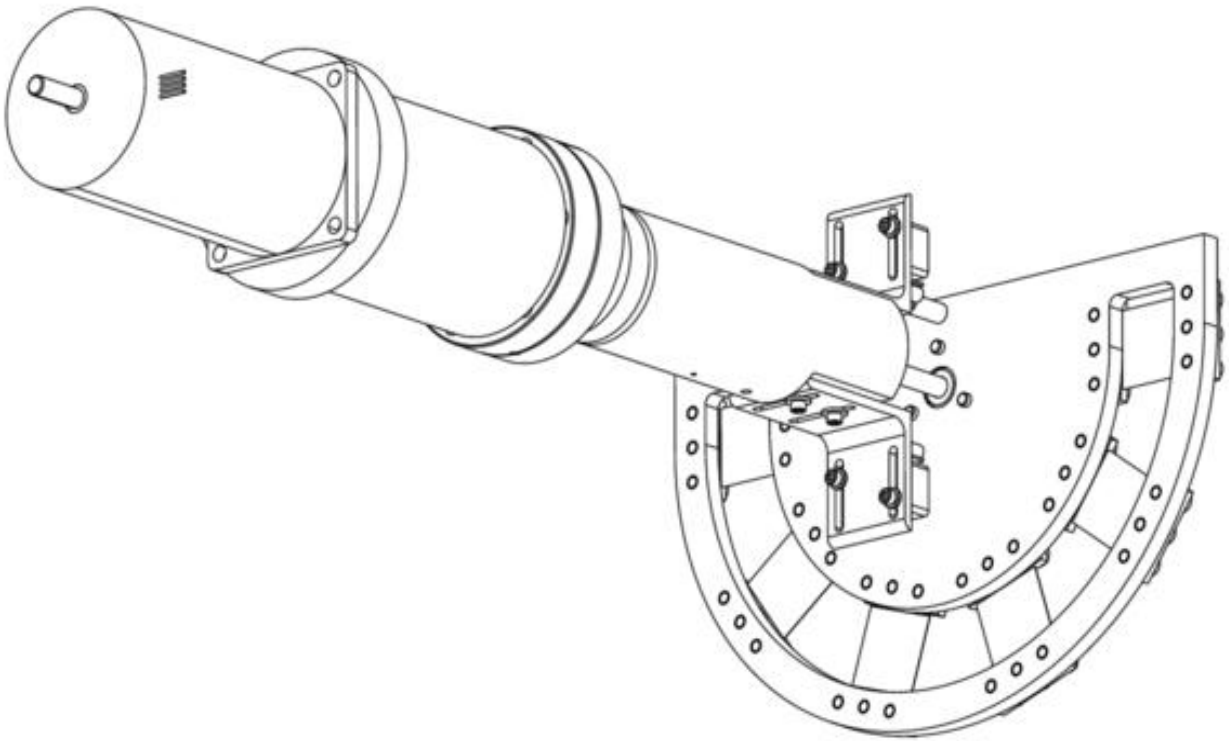
θ_{cm} (deg)	Low Energy ≈ 270 - 320 MeV	High Energy ≈ 320 - 370 MeV
20	√	√
30	√	√
40		√
50	√	√
60		
70	√	√
80		
90	√	√
100	√	
110		√
120		√

New Software and Hardware

- FPP software converted from ESPACE to new root C++ analyzer (J. Glister - see talk at Workshop)
- LEDEX library created to calculate single-arm kinematic variables for ep scattering and E_γ & θ_{cm} for deuteron photodisintegration (G. Ron)
- Calibration of calorimeter needed to have less than 1% accuracy at small currents (A. Freyberger, M. Bevins, J. Dumas & Y. Rousseau)
- Upgrade of Beam Charge Monitor electronics for operation at low current (J. Musson & E. McCullough)

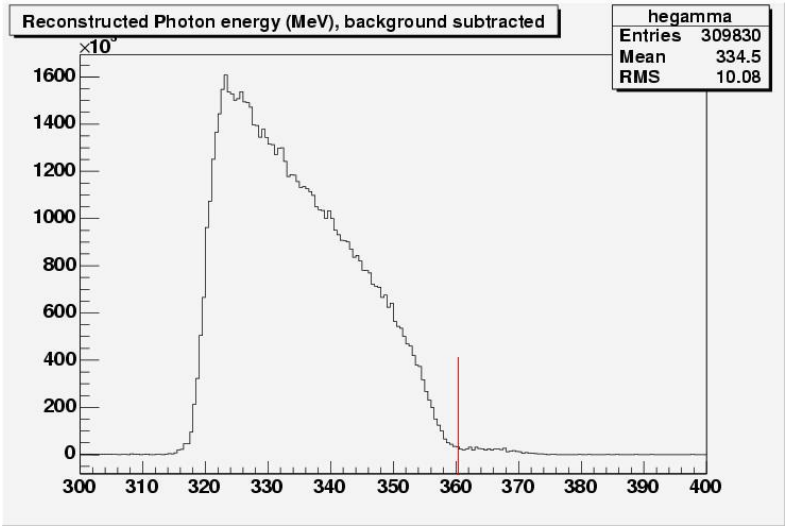
Bremsstrahlung Radiator

- Recommissioning of radiator for low-energy running (S. Esp, A. Gavalya, R. Gilman)
- 6 Radiator positions: out, 1%, 2%, 3%, 4% & 5% radiation lengths. 4% used for first 4 settings, then switched to the 5% to increase statistics



Background

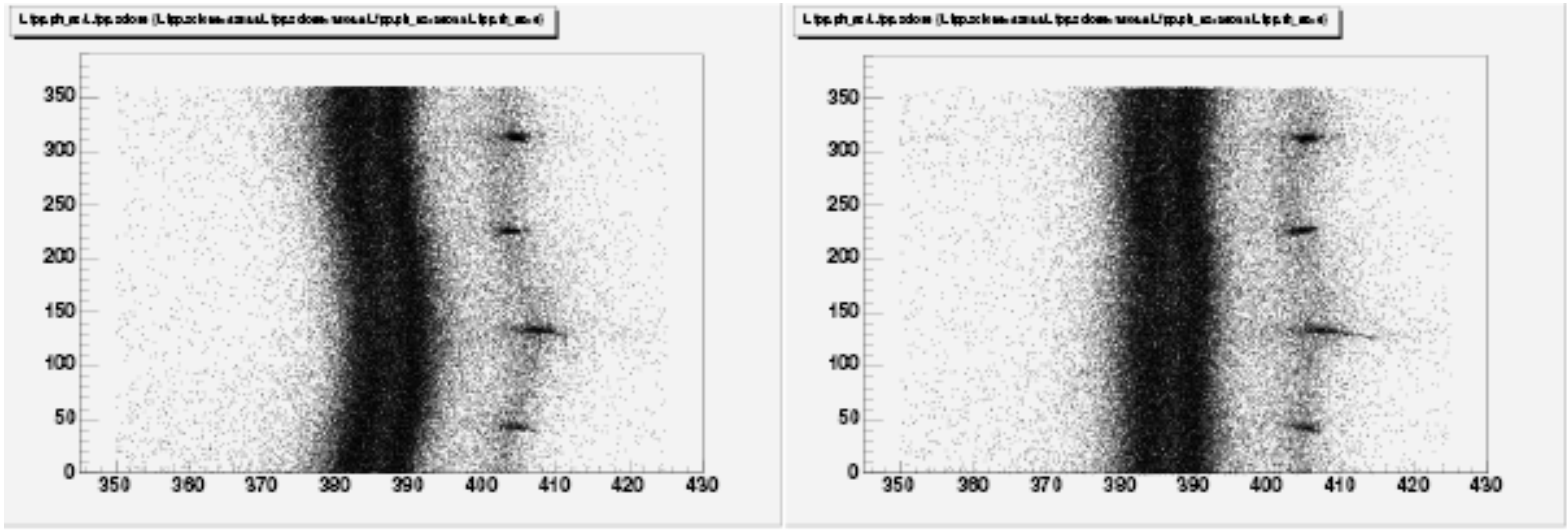
- In order to obtain clean γd spectra, contributions from the end caps and electron beam had to be subtracted off
- Runs were taken on both deuterium and hydrogen targets with and without radiator



	Target	Radiator				
+	d	In	γd	ed	γAl	eAl
-	d	Out		ed		eAl
-	p	In	~~γp~~	~~ep~~	γAl	eAl
+	p	Out		~~ep~~		eAl
Total			γd			

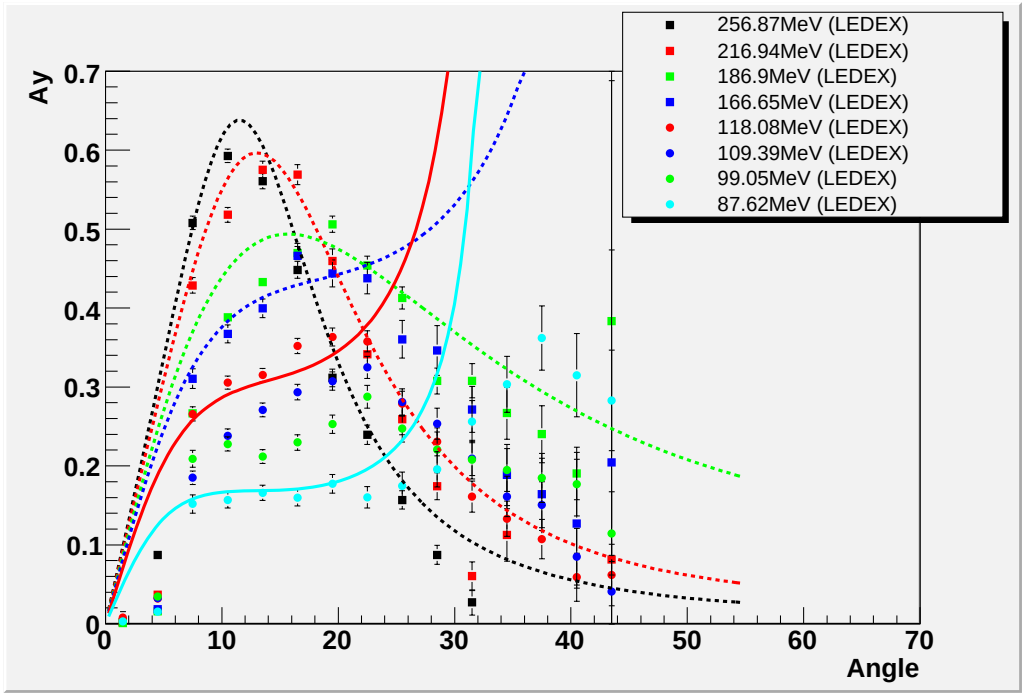
FPP Alignment

- Straight throughs taken to align the front FPP chambers to the vdc's as well as the rear to the front
- Plots below show the azimuthal scattering angle ϕ_{fpp} in the carbon vs. z of scatter



Analyzing Power

- Low Q^2 ep elastic scattering data was taken to parameterize the FPP Analyzing Power at low proton momentum
- Parameterization appears to fit the higher energy data better and does not extend beyond $\theta_{fpp} = 25^o$, indicating a possible need for extension to the McNaughton parameterization for lower energies and higher angles

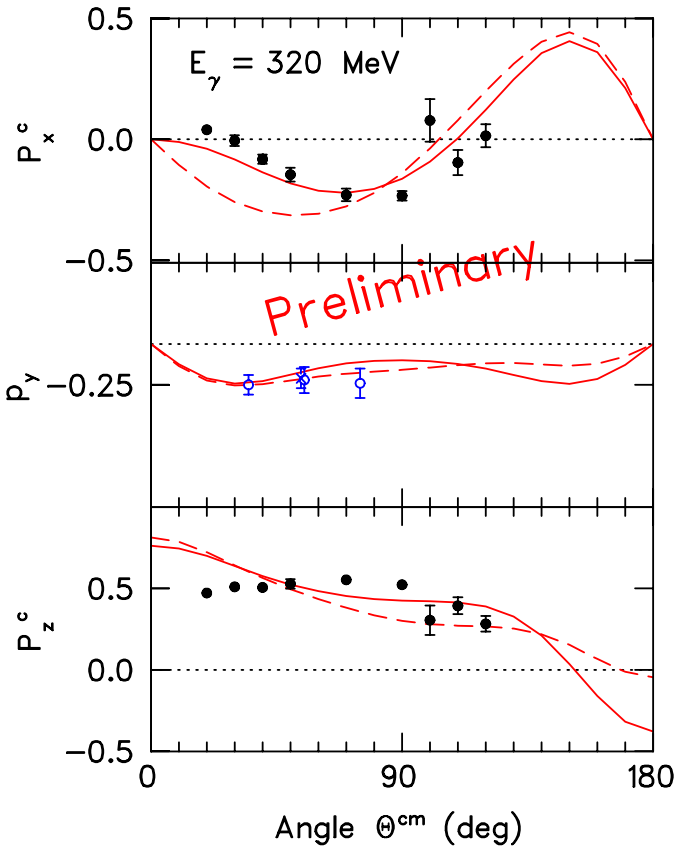


False Asymmetry

- Any misalignments or inefficient areas in the FPP chambers introduced instrumental (false) asymmetries
- False asymmetry cancels for transferred polarization, but is important for induced polarization
- Currently parameterized as a function of δp and ϕ_{fpp} down to p_p = 0.786 GeV/c (R. Roche) $\Rightarrow$ our highest p_p is 0.723 GeV/c
- Conetest may help eliminate FA at large scattering angle θ_{fpp}
- Currently remove outer edges with conetest, may need to remove inefficient areas within the chamber area

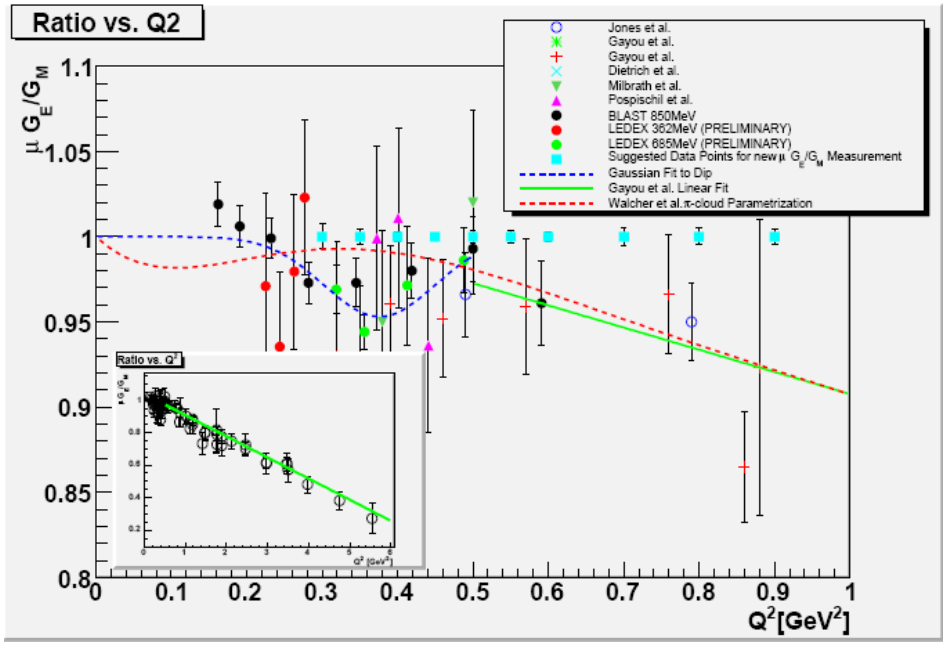
Preliminary Results

- Small statistical errors:
  $dP_x^{c'} = 0.01$ - 0.14
  $dP_y = 0.02$ - 0.15
  $dP_z^{c'} = 0.02$ - 0.75
- Systematic uncertainties still to be determined
- Analyzing Power from older calibrations - McNaughton Parameterization (NIM A241, 1985, 435)
- Curves are Schwamb and Arenhövel, dashed are more recent
- P_y not reported due to large effect of False Asymmetry, which has yet to be parameterized



Form Factor Ratio

- Using the Recoil Polarization method, low Q^2 G_E/G_M form factor ratio was extracted from the ep elastic scattering calibration data
- Data (green and red) indicate a deviation from one at low Q^2 - providing clue of peripheral proton structure
- Led to PAC31 Proposal 'Measurement of Proton Elastic Form Factor Ratio at Low Q^2' - talk by R. Gilman to follow



Future Tasks

Short term - Transferred polarization

1. Calibration of angles / Pointing offsets
2. BCM Calibrations
3. Check background subtraction
4. Energy loss in target
5. Parameterization of Analyzing Power
6. Calculation of beam polarization
7. Systematics of beam position, spin transfer method & alignment

Long term - Induced Polarization

1. Optimization of FPP alignment
2. False Asymmetry analysis

Summary

- Transferred polarization data shows relatively good agreement with the Schwamb and Arenhövel theory
- Situation may improve when new Analyzing Power and systematic uncertainties are incorporated
- Finalized transferred polarization data available soon, induced polarization will take longer due to false asymmetries
- Low Q^2 ep elastic scattering form factor ratio data show deviation from 1 which has led to a new Hall A Proposal