

# Status Report: E05-103: Low Energy Deuteron Photodisintegration

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Hall A Collaboration Meeting  
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# Review of current theory and data

- ▶ At lower excitation energies, hadronic theory gives a good description of cross-section and polarization observables for deuteron photodisintegration
- ▶ Currently, the best description is from Schwamb and Arenhövel (solid green line in figure), who incorporate modern NN potentials and relativistic corrections
- ▶ Dashed line comes from Kang *et. al.* who performed a relativistic calculation, but did not include channel coupling

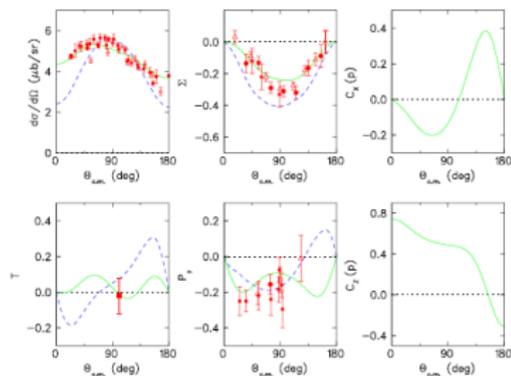


Figure: Photon Energy = 300 MeV

## 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  $\theta_{cm} = 90^\circ$ , but the data show a clear maximum
- ▶ Indicates a difficulty in describing the *imaginary* part of the interference between amplitudes
- ▶ Real part of interference and the sum and difference of amplitudes squared appear to be properly modeled
- ▶ No data for  $C'_x$  and  $C'_z$  (*a.k.a.*  $P_x^{c'}$  and  $P_z^{c'}$ ) in this energy region

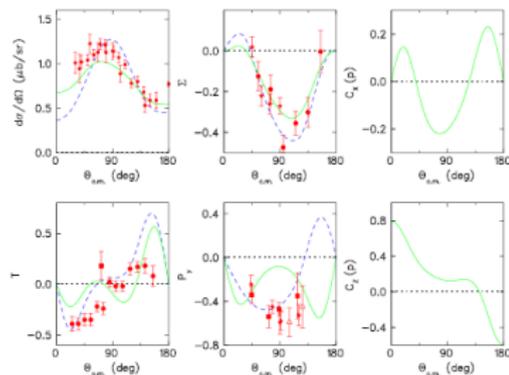


Figure: Photon Energy = 450 MeV

# Motivation

- ▶ Increasing disagreement between theory and data as excitation energy is increased
- ▶ For  $\theta_{cm} = 90^\circ$ , there is disagreement between 2 data sets ( $\triangle$  - Jlab and  $\diamond$  - Kharkov, which suffered from large backgrounds)
- ▶ 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

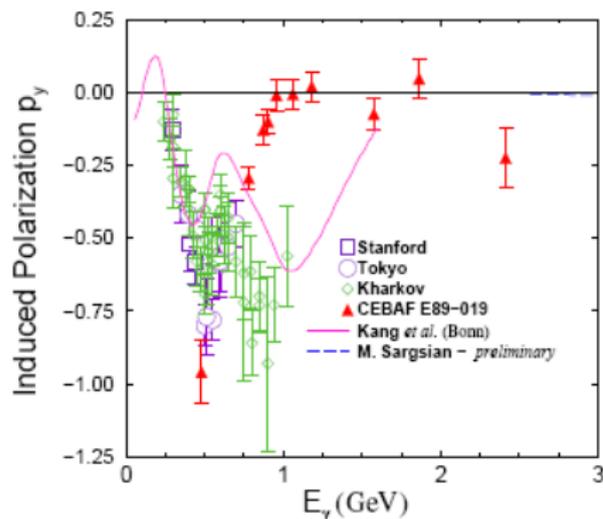
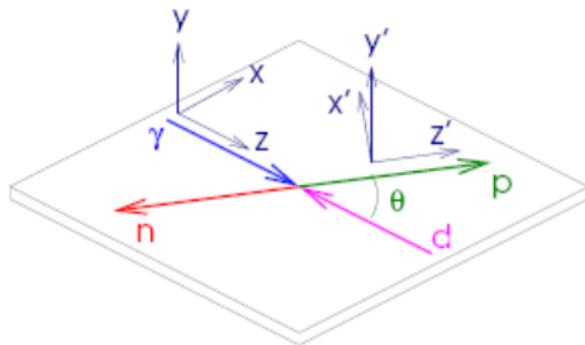


Figure:  $P_y$  at  $\theta_{cm} = 90^\circ$

# Observables

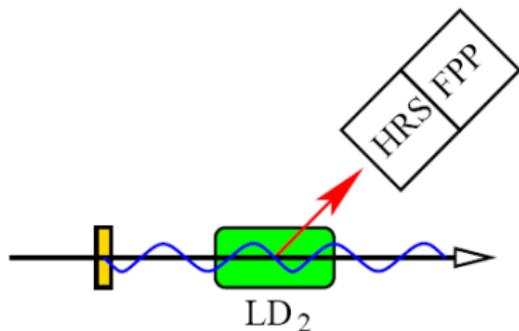
- ▶  $P_x^{c'}$   $\Rightarrow$  transferred polarization in reaction plane,  $\perp$  to  $\vec{p}$
- ▶  $P_y$   $\Rightarrow$  induced polarization,  $\perp$  to reaction plane
- ▶  $P_z^{c'}$   $\Rightarrow$  transferred polarization in reaction plane,  $\parallel$  to  $\vec{p}$
- ▶ Recoil Polarization Method for p(e,p)e elastic scattering allowed extraction of the form factor ratio:

$$\frac{G_E}{G_M} = -\frac{P'_x E + E'}{P'_z 2M_p} \tan \frac{\theta_e}{2} \quad (1)$$

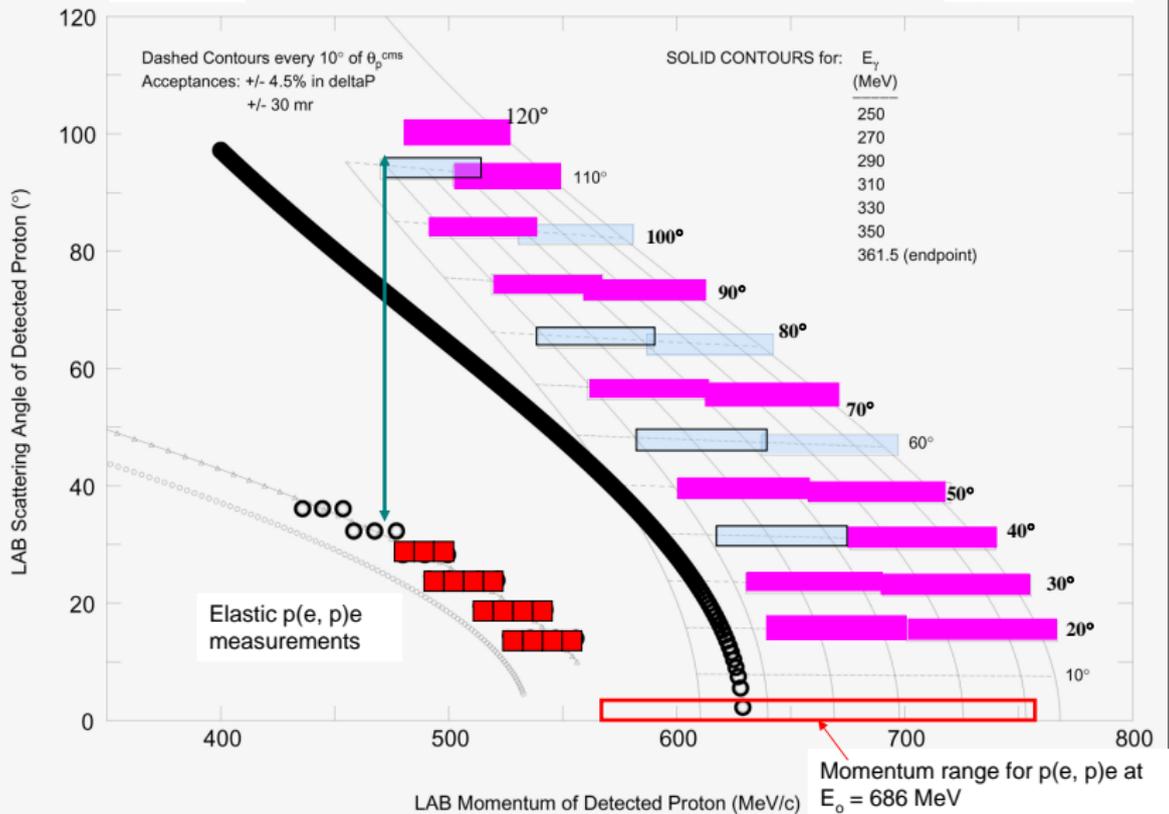


# Deuteron Photodisintegration Reaction

- ▶  $E_o = 362$  MeV, giving photon energy endpoint of 361.5 MeV
- ▶ 6 copper radiator positions: out, 1%-5% radiation lengths; 4% used for first 4 settings, then switched to the 5% to increase statistics
- ▶ Circularly polarized photon incident on 15 cm liquid deuterium target
- ▶ Singles measurement below pion production threshold
- ▶ FPP carbon analyzer thickness increased with proton momentum: S2 + (3/4", 3/4" + 1.5" and 3/4" + 3")

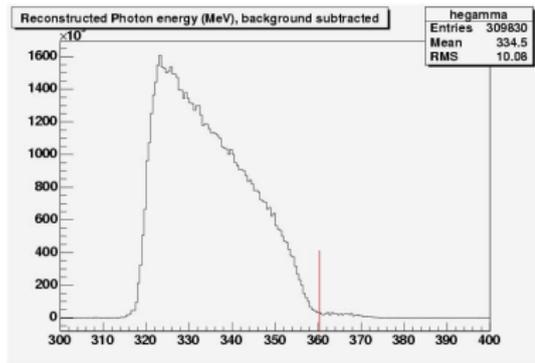


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Kinematics for  $d(\gamma,p)n$  $E_0=362$  MeV

# Background

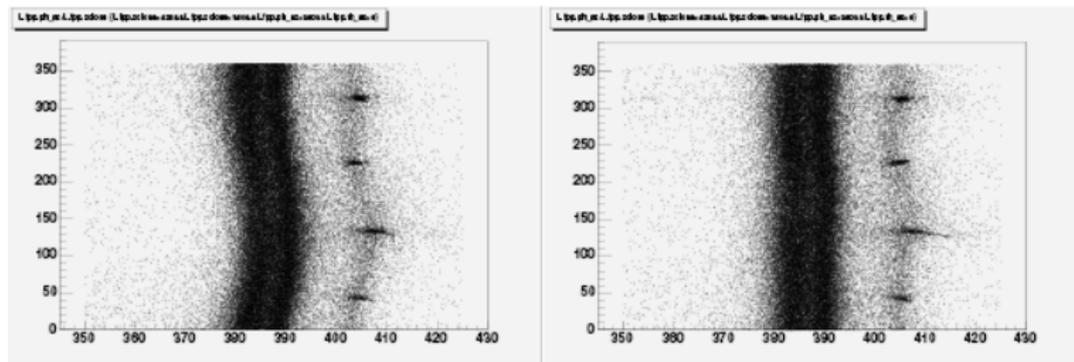
- ▶ In order to obtain clean  $\gamma$ d spectra, contributions from the end caps and electron beam had to be subtracted off
- ▶ Runs were taken on both deuterium and hydrogen targets with and without radiator



	Target	Radiator				
+	d	In	$\gamma$ d	ed	$\gamma$ Al	eAl
-	d	Out		ed		eAl
-	p	In	$\cancel{\gamma}$ p	$\cancel{e}$ p	$\gamma$ Al	eAl
+	p	Out		$\cancel{e}$ p		eAl
Total			$\gamma$ d			

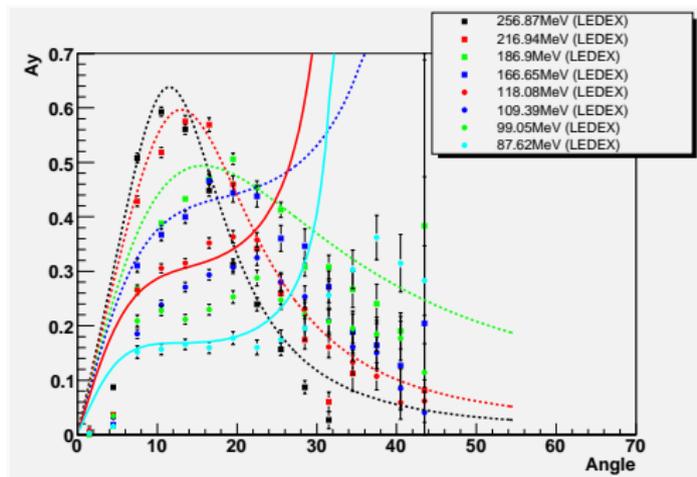
# FFP Alignment

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



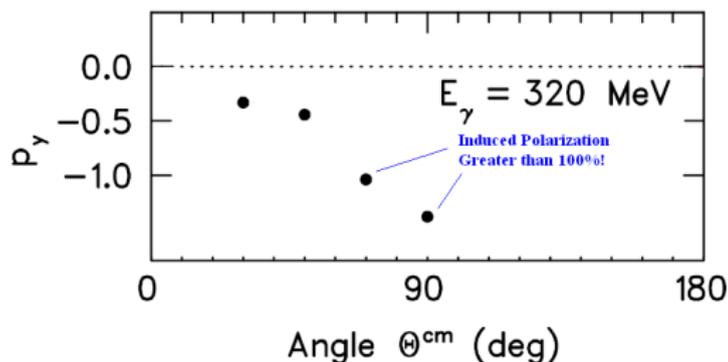
# Analyzing Power

- ▶ Low  $Q^2$  ep elastic scattering data was taken to parameterize the FPP Analyzing Power at low proton momentum
- ▶ McNaughton Parameterization (NIM A241, 1985, 435) does not fit the lower energy data beyond  $\theta_{fpp} = 25^\circ$ , indicating a need for extension to lower energies and higher angles (*new parameterization to be completed this summer*)



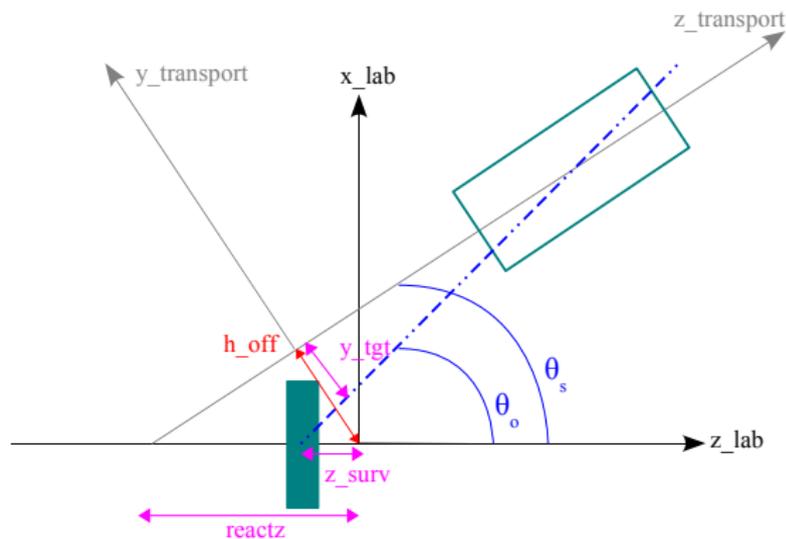
## False Asymmetry

- ▶ False asymmetries due to misalignments/inefficient areas in FPP cancel for transferred polarization, but are important for induced polarization
- ▶ Currently parameterized as a function of  $\delta p$  and  $\phi_{fpp}$  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
- ▶ Currently remove outer edges with conetest, may need to remove inefficient areas within the chamber area



# Spectrometer Mispointing

- ▶ Vernier reading does not necessarily correspond to actual spectrometer angle due to mispointing ( $y_{tgt}$ ) and target misalignment ( $z_{surv}$ )
- ▶ Before pointing offset was calculated, beam position was calibrated using Bull's Eye scan



# Spectrometer Mispointing

To verify offsets were correct, the reconstructed reaction point (intersection of beam and particle track at target) should agree with the target survey for carbon ( $z_{surv} = 0.00 \pm 0.50$  mm for LEDEX)

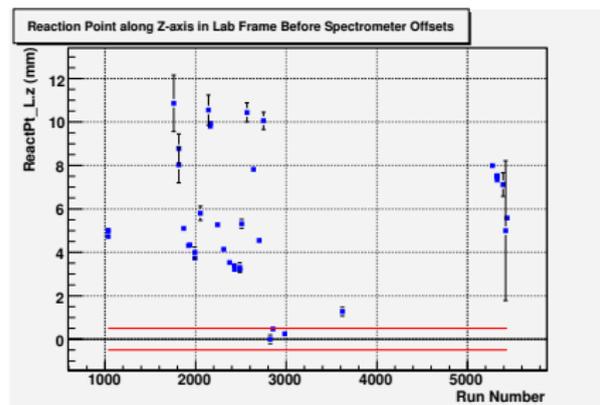


Figure: ReactPt\_L.z before offsets

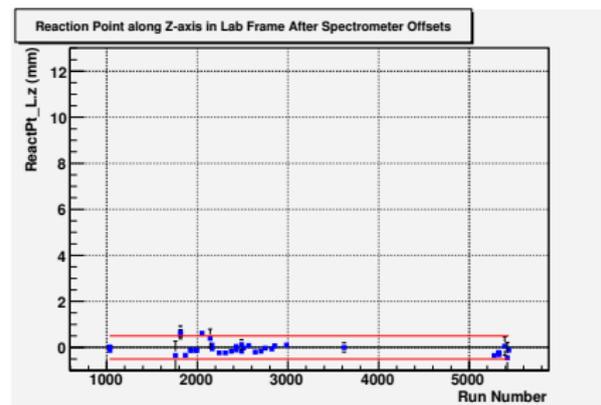


Figure: ReactPt\_L.z after offsets

# Preliminary Photodisintegration Results - J. Glister

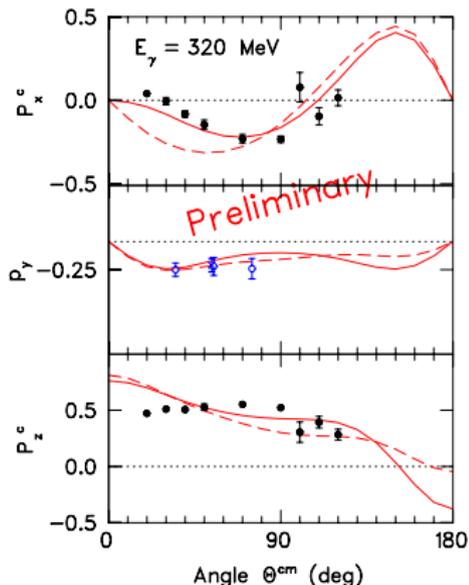
- ▶ Small statistical errors (systematics still to be determined):

$$dP_x^{c'} = 0.01 - 0.14$$

$$dP_y = 0.02 - 0.15$$

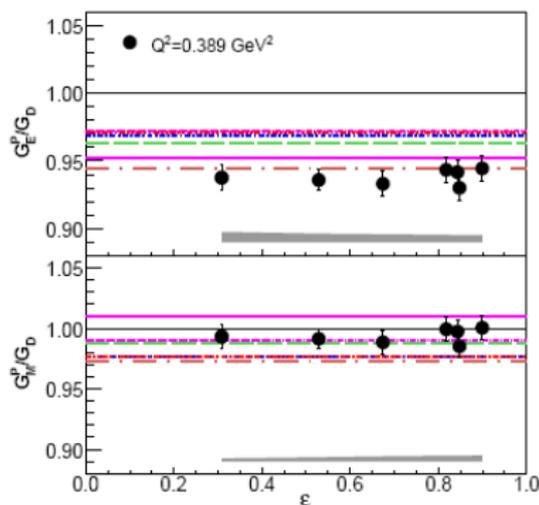
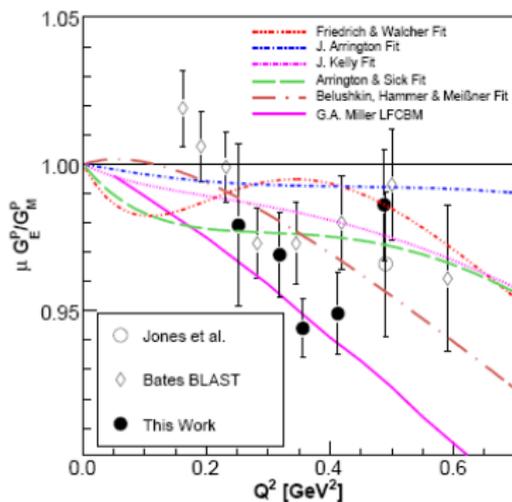
$$dP_z^{c'} = 0.02 - 0.75$$

- ▶ Curves are Schwamb and Arenhövel, dashed are more recent
- ▶ Analyzing Power from older calibrations - McNaughton
- ▶  $P_y$  not reported due to large effect of False Asymmetry, which has yet to be parameterized
- ▶ Finalized results expected 2008



# Low $Q^2$ ep Elastic Scattering - G. Ron

- ▶ Using the Recoil Polarization method, low  $Q^2$   $G_E/G_M$  form factor ratio was extracted from the FPP calibration data
- ▶ For low  $Q^2$ , fits get  $G_M$  about right but overestimate  $G_E$
- ▶ Indication of  $\sim 1\sigma$  effects in analysis / interpretation of parity violation, Zemach radius, DVCS
- ▶ Paper submitted to PRL June 2007



# Summary

- ▶ Transferred polarization data shows relatively good agreement with the Schwamb and Arenhövel theory
- ▶ 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 PRL submission and Hall A Proposal at PAC31