Forward-Angle Parity-Violating Electron Scattering from the Proton

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The HAPPEX Collaboration

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California State University, Los Angeles - Syracuse University - DSM/DAPNIA/SPhN CEA Saclay - Thomas Jefferson National Accelerator Facility - INFN, Rome - INFN, Bari - Harvard University - Indiana University - University of Virginia - University of Massachusetts - Florida International University - University of New Hampshire - Massachusetts Institute of Technology - College of William and Mary

Theory - HAPPEX-H

$$A^{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L} \qquad \left\{ A_0 = \frac{-G_F Q^2}{\sqrt{2}\pi\alpha} \right\}$$

$$= A_0 \frac{\epsilon G_E^{p\gamma} G_E^{pZ} + \tau G_M^{p\gamma} G_M^{pZ} - \frac{1}{2}\left(1 - 4\sin^2\theta_W\right)\epsilon' G_M^{p\gamma} G_A^{pZ}}{\epsilon (G_E^{p\gamma})^2 + \tau (G_M^{p\gamma})^2}$$

$$G_{E,M}^{pZ} = \frac{1}{4}\left(G_{E,M}^{p\gamma} - G_{E,M}^{n\gamma}\right) - \sin^2\theta_W G_{E,M}^{p\gamma} - \frac{1}{4}G_{E,M}^{s}$$

Leading nonzero moments of $G_{E,M}^{s}$:

$$\mu_s \equiv G_M^s(0) \qquad \rho_s \equiv \left[\frac{G_E^s}{d\tau}\right]_{\tau=0}$$
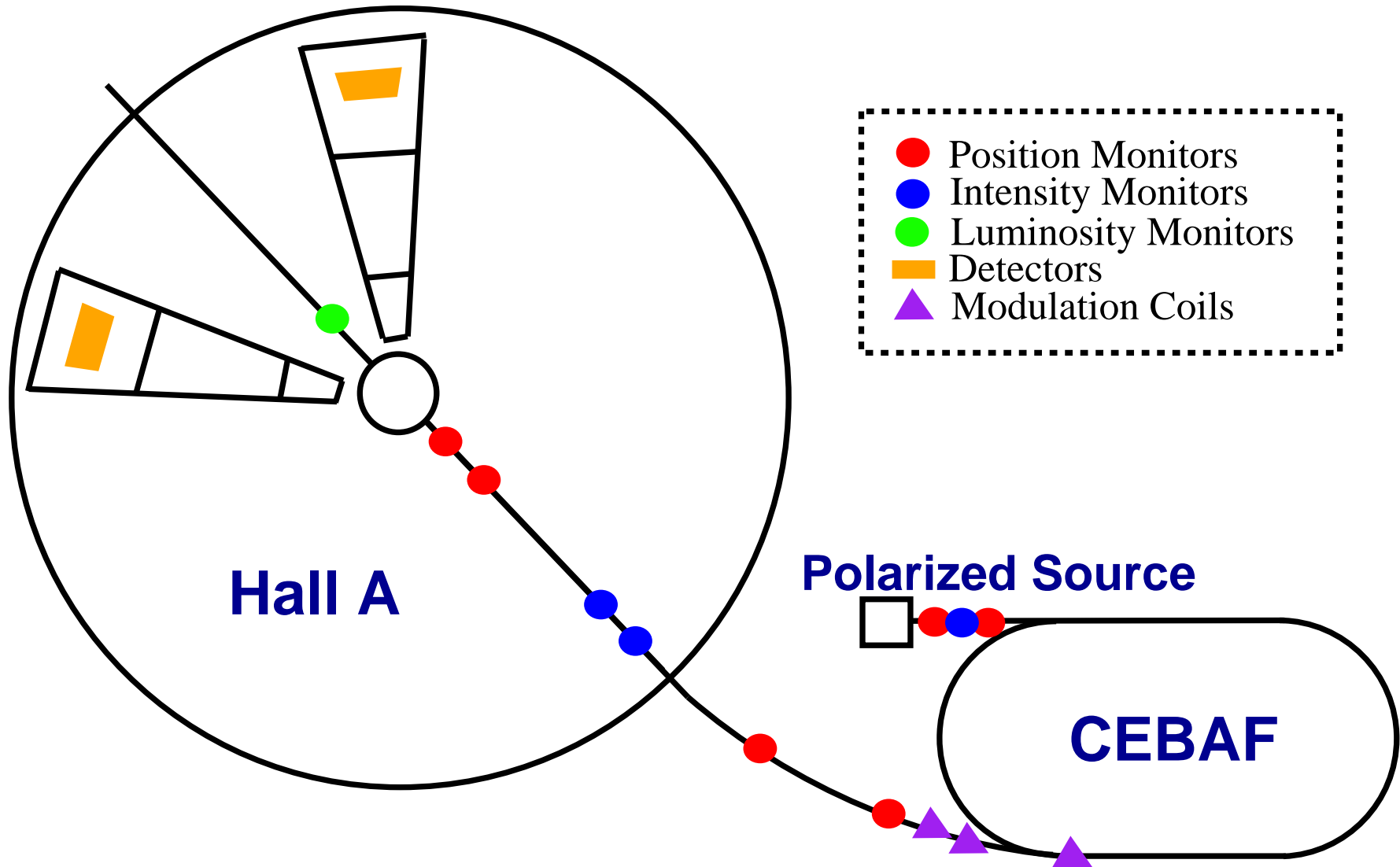
$$A^{PV} \simeq \frac{A_0}{4}\left[\left(1 - 4\sin^2\theta_W\right) + \tau\left(\mu_n - \rho_s - \mu_p(\mu_n + \mu_s)\right)\right]$$

Kinematics and Errors

	A^{PV}	Stat. Error	Syst. Error
HAPPEX-H	-1.4 ppm	0.08 ppm (5.7%)	0.04 ppm (2.9%)

- Hall A at Jefferson Lab in Virginia

- $Q^2 = 0.1$ (GeV/c)^2, $E_0 = 3.0$ GeV

- Septum magnets $\rightarrow \theta = 6°$

- 38μA, 80% polarization

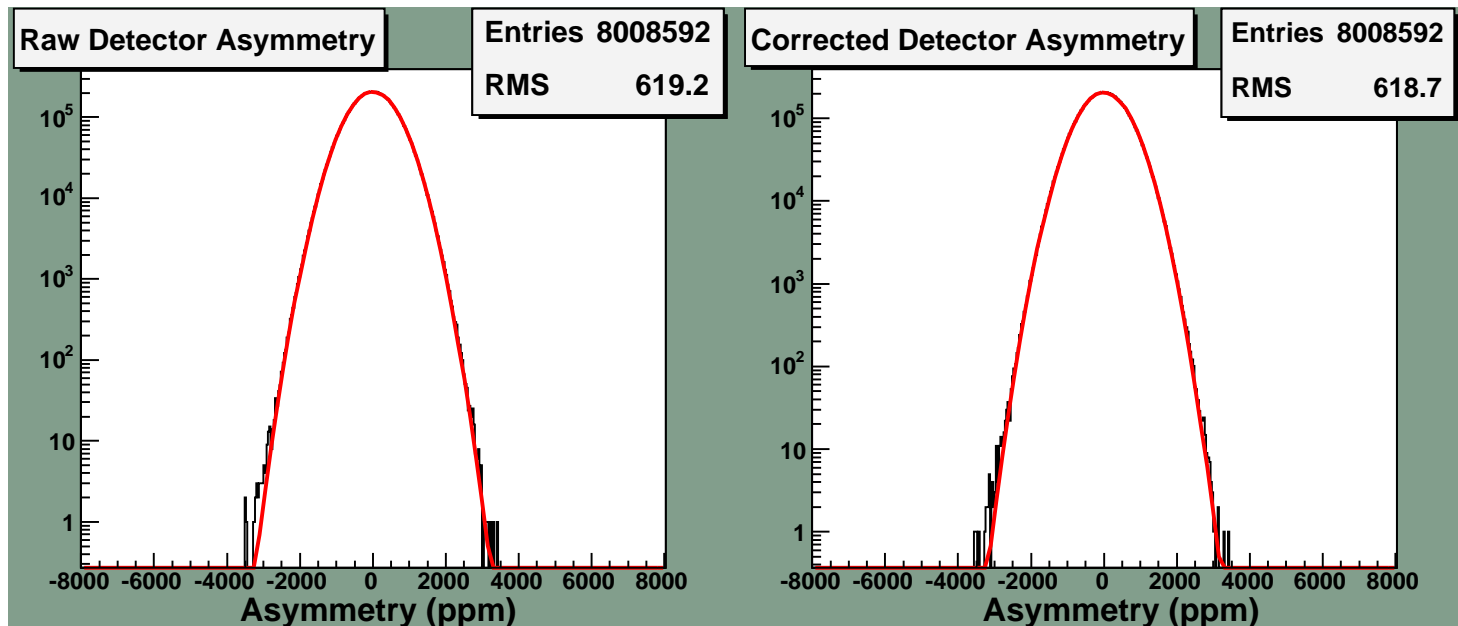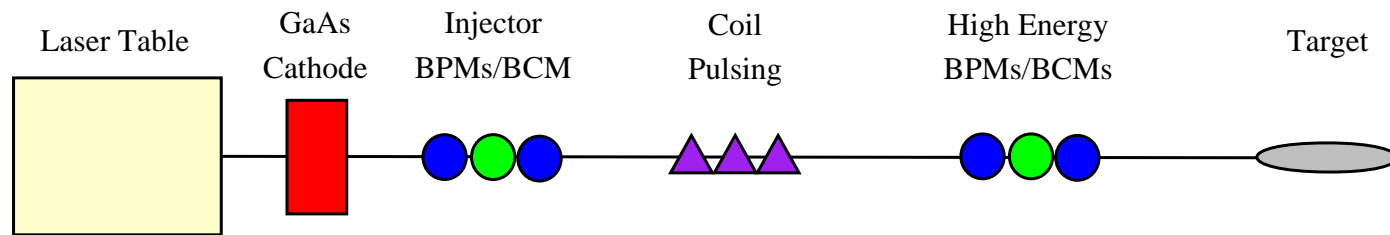- Polarimetry: Hall A Møller & Compton (2%)
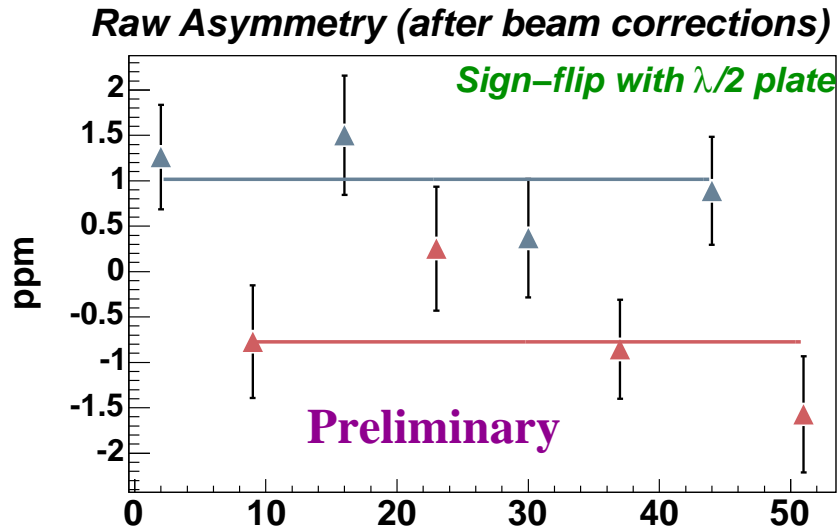
Experimental Setup

Control of Helicity-correlated Beam Systematics

Corrected Asymmetry

$$A_{physics} \simeq A_{det} - A_Q + \alpha A_E + \sum_i \beta_i \Delta x_i$$

Raw Asymmetry Result

Raw Asymmetry (after beam corrections)

$$A_{raw} = -0.89 \pm 0.22\,(\text{stat})\ \text{ppm}$$

A_{raw} correction ~ 0.06 ppm

Raw Asymmetry Corrections

	Magnitude	Approx. Correction
Charge Asymmetry	-1.7 ppm	-1.7 ppm (2% alinearity)
Energy Asymmetry	23 ppb	-140 ppb
Position Difference	-7 nm	< 5 ppb
Angle Difference	-10 nrad	80 ppb

Hydrogen Result

Theory (no strange quarks): $A_{PV} = -1.43 \pm 0.09 \, (\text{FF}) \, \text{ppm}$

PRELIMINARY!

$$A_{PV} \text{ (after all corrections)}$$
$$-1.10 \pm 0.27 \, (\text{stat}) \pm 0.10 \, (\text{syst}) \, \text{ppm}$$

$$\mathbf{G_E^s + 0.08 G_M^s} = 0.034 \pm 0.028 \, (\text{stat}) \pm 0.010 \, (\text{syst}) \pm 0.009 \, (\text{FF})$$
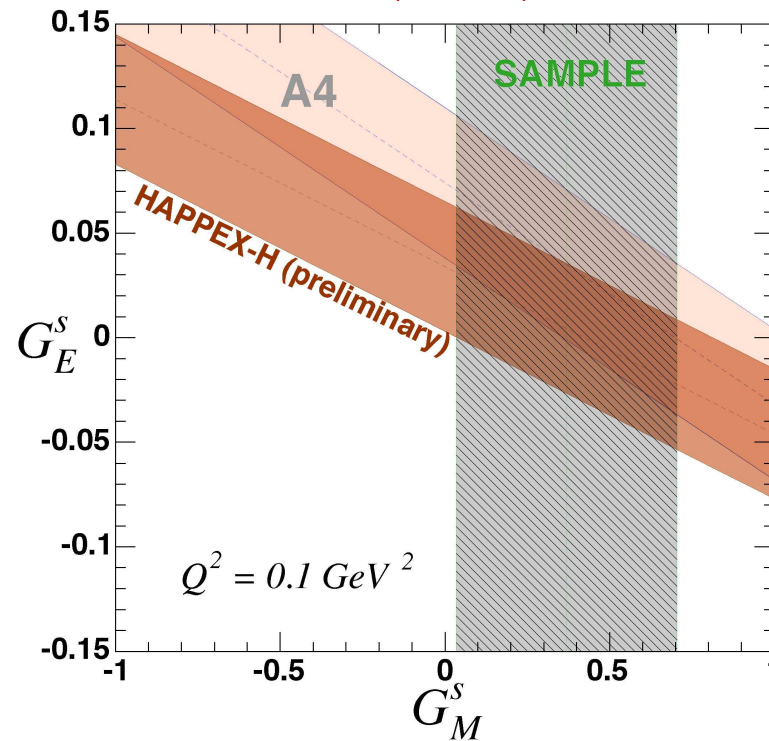
Conclusion and Future Plans

- Successful ^1H run from June 24-July 26 2004

- Remainder of statistics in Fall 2005
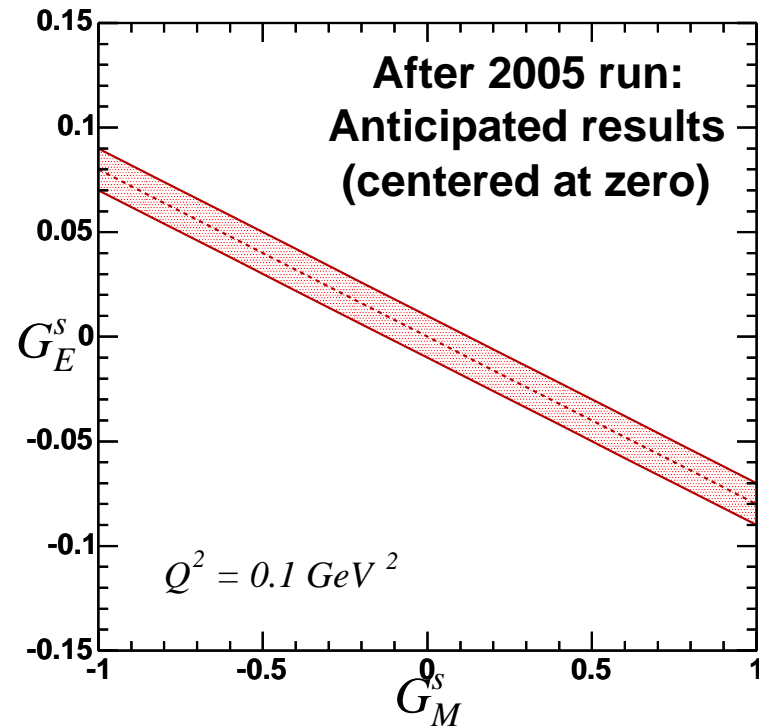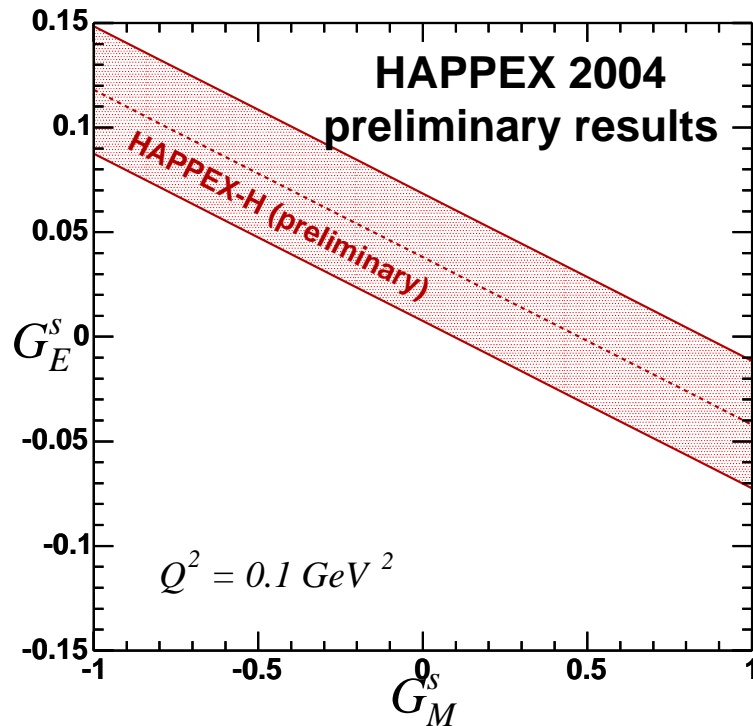
Error Budget

False Asymmetries	83 ppb
Polarization	22 ppb
Linearity	22 ppb
Radiative Corrections	22 ppb
Q^2 Uncertainty	24 ppb
Al QE background	10 ppb
Rescattering background	30 ppb
Total	100 ppb