E99-115 & E00-114

HAPPEX Status Report

Overview:	*Theory and Measurement*
Update:	*Progress and Readiness*

Bryan Moffit

The College of WILLIAM & MARY

Strange Quarks in the Nucleon?

- Hints:
  - ⋆ EMC - “Nucleon Spin-Crisis”

- Evidence:
  - ⋆ Contribution to Nucleon’s Long. Momentum
  - ⋆ Contribution to Nucleon’s Mass from $\langle N|s\overline{s}|N\rangle$

- Theoretical Motivation $\langle N|s\gamma^{\mu}\overline{s}|N\rangle$:
  - ⋆ Isolation of $G^{s}_{E,M}$ through $N(\vec{e},e')$ scattering

HAPPEX-H

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

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

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

HAPPEX-He

$$A^{PV} = -\frac{A_0}{2}\left(2\sin^2\theta_W + \frac{G_E^s}{G_E^{p\gamma} + G_E^{n\gamma}}\right)$$

Theory cont'd

Leading nonzero moments of $G^s_{E,M}$:

$$\mu_s \equiv G^s_M(0) \qquad \rho_s \equiv \left[\frac{G^s_E}{d\tau}\right]_{\tau=0}$$

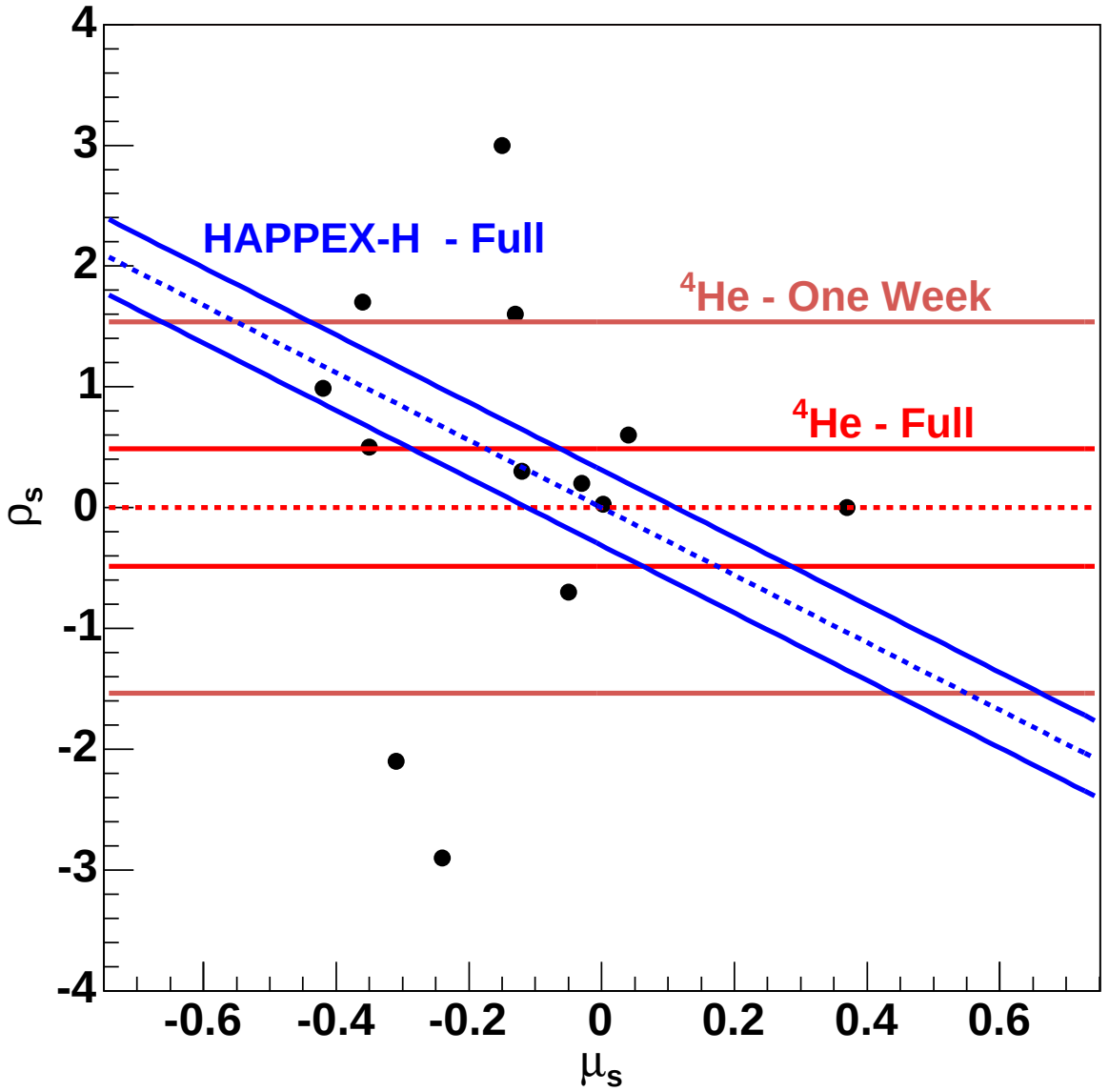
HAPPEX-H

$$A^{PV} \simeq \frac{A_0}{4}\left[\left(1-4\sin^2\theta_W\right)+\tau\left(\mu_n-\rho_s-\mu_p(\mu_n+\mu_s)\right)\right]$$

HAPPEX-He

$$A^{PV} \simeq -\frac{A_0}{2}\left(2\sin^2\theta_W+\rho_s\tau\right)$$

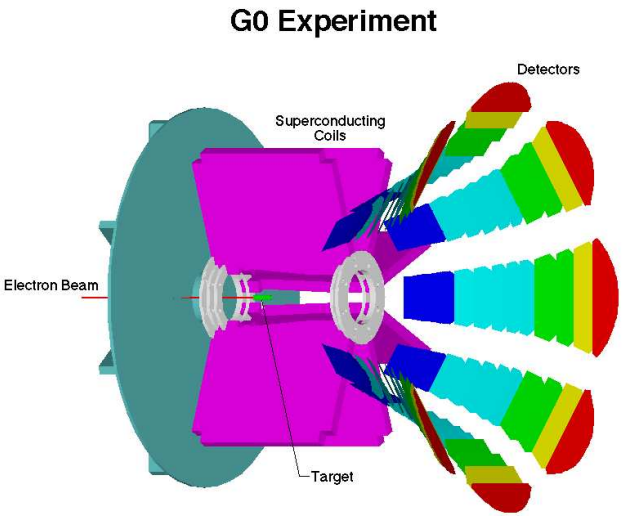
Impact


HAPPEX-H - Full
^{4}He - One Week
^{4}He - Full
ρ_s
μ_s
4
3
2
1
0
-1
-2
-3
-4
-0.6
-0.4
-0.2
0
0.2
0.4
0.6

Competition

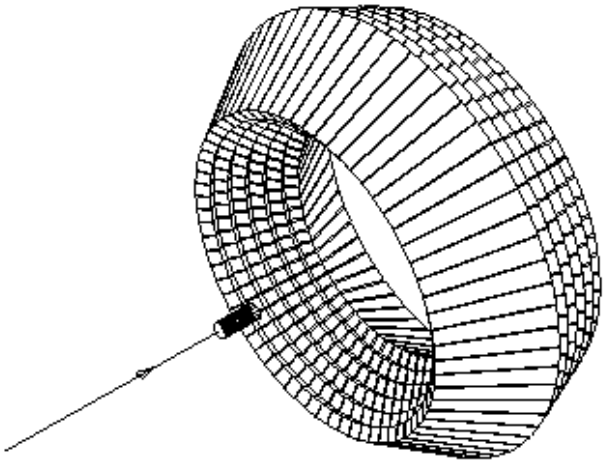
JLab G^0

- $5^\circ < \theta < 15^\circ$, $E_0 = 3$ GeV
  $0.16 < Q^2 < 0.95$ (GeV/c)^2



Mainz A4

- $\theta = 35^\circ$, $E_0 = 855$ MeV
  $Q^2 = 0.1 \;\; \& \;\; 0.225$ (GeV/c)^2

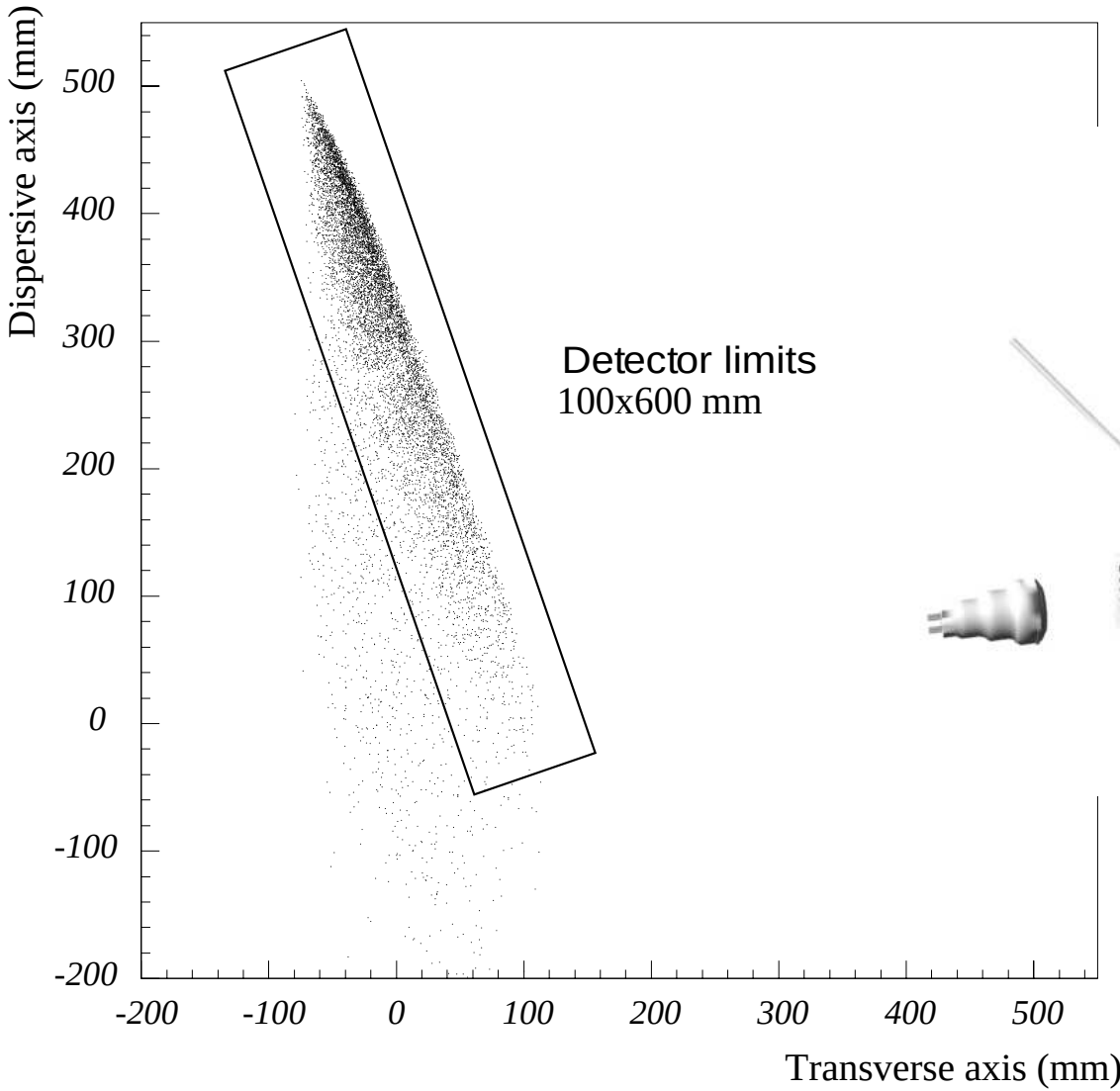


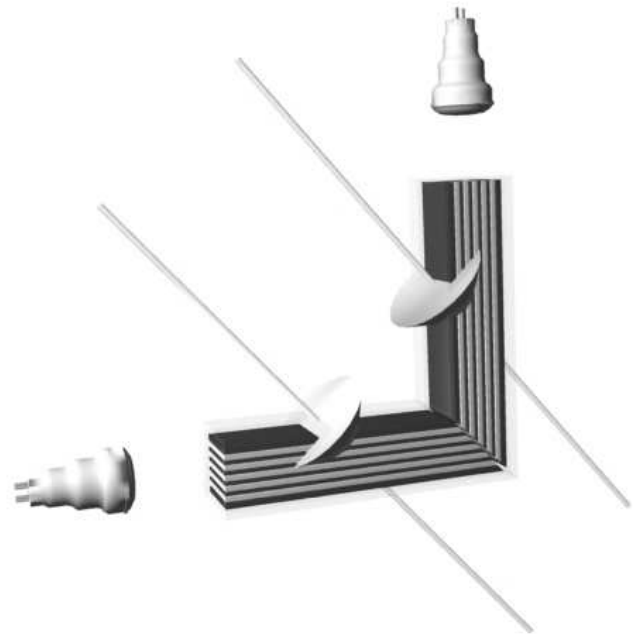
Upcoming HAPPEX Experiments

	A^{PV}	Relative Error	Precision
HAPPEX-H	1.2 ppm	5%	60 ppb
HAPPEX-He	8 ppm	3%	240 ppb

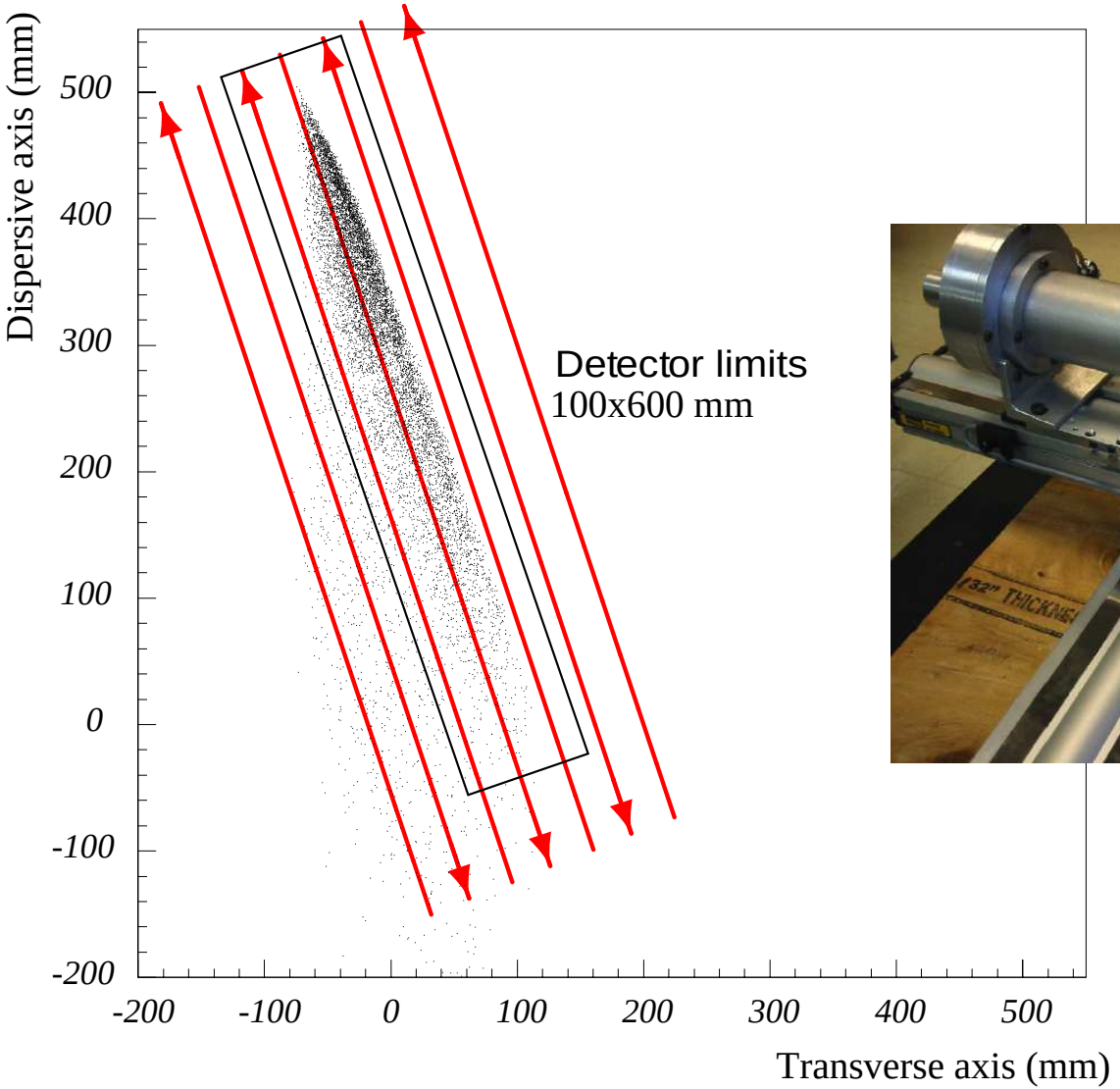
- Use HRS with septum magnets $\rightarrow \theta = 6^\circ$
- $Q^2 = 0.1$ (GeV/c)^2, $E_0 = 3.0$ GeV
- 100μA, 80% polarization
- Polarimetry: Hall A Møller & Compton (2%)

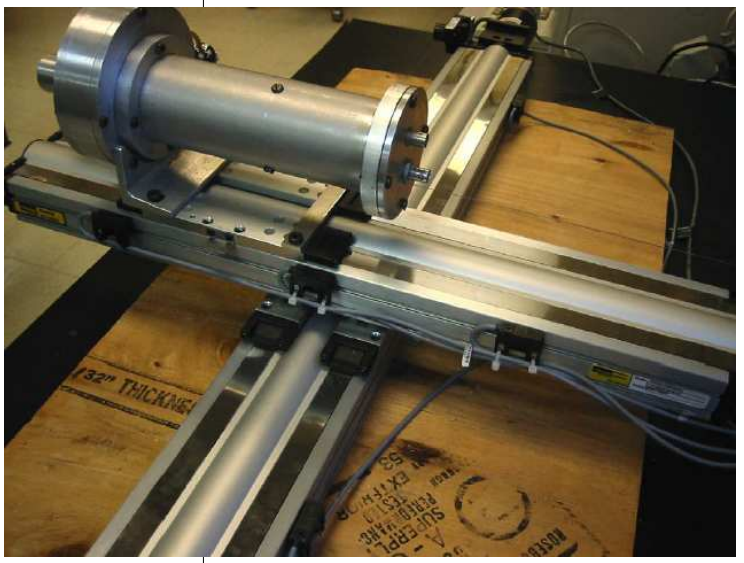
Detector


Dispersive axis (mm)
500
400
300
200
100
0
-100
-200
-200
-100
0
100
200
300
400
500
Transverse axis (mm)
Detector limits
100x600 mm

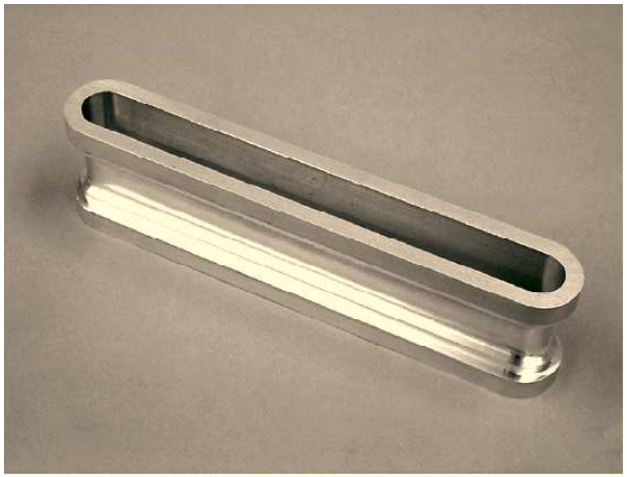


Profile Scanner

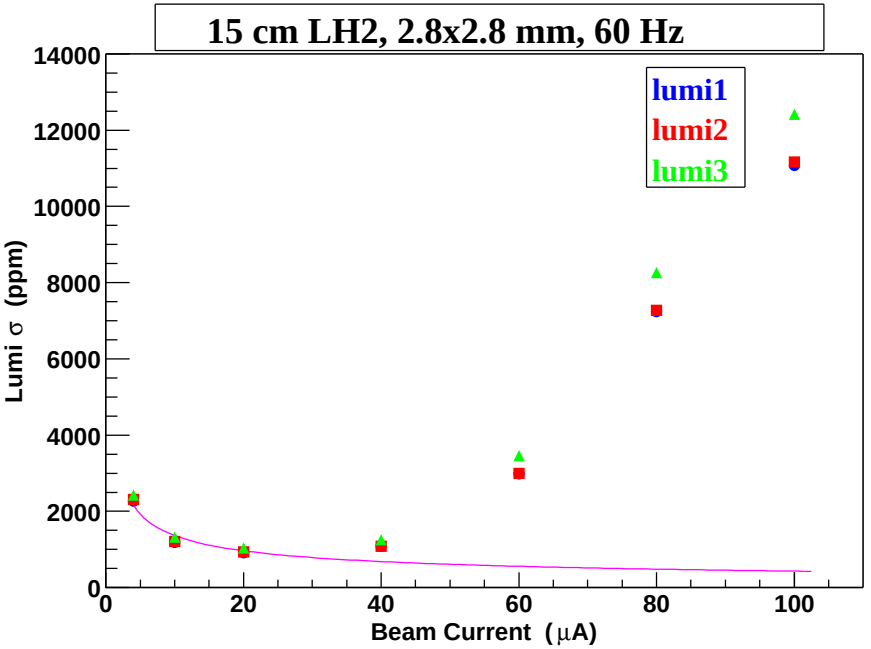




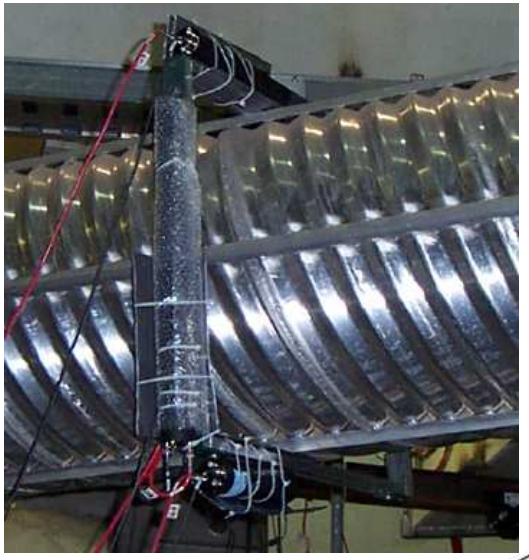
Cryo-Target

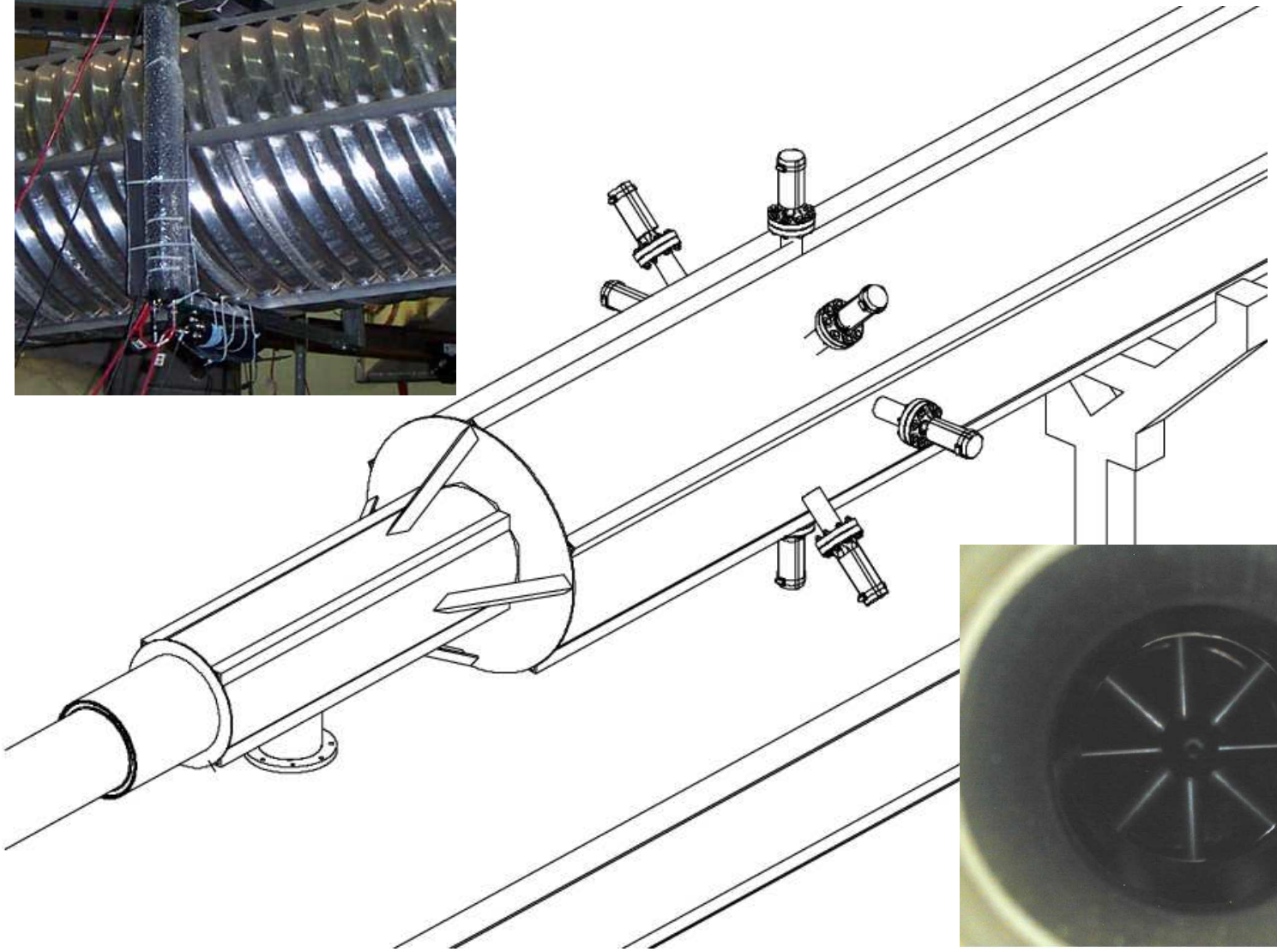


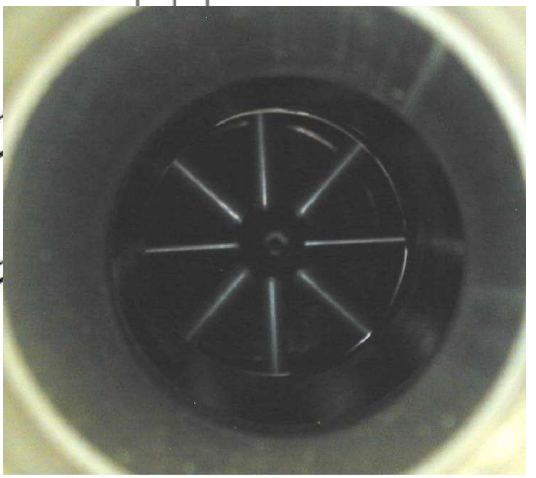
2002 Boiling Studies (TN-03-014)



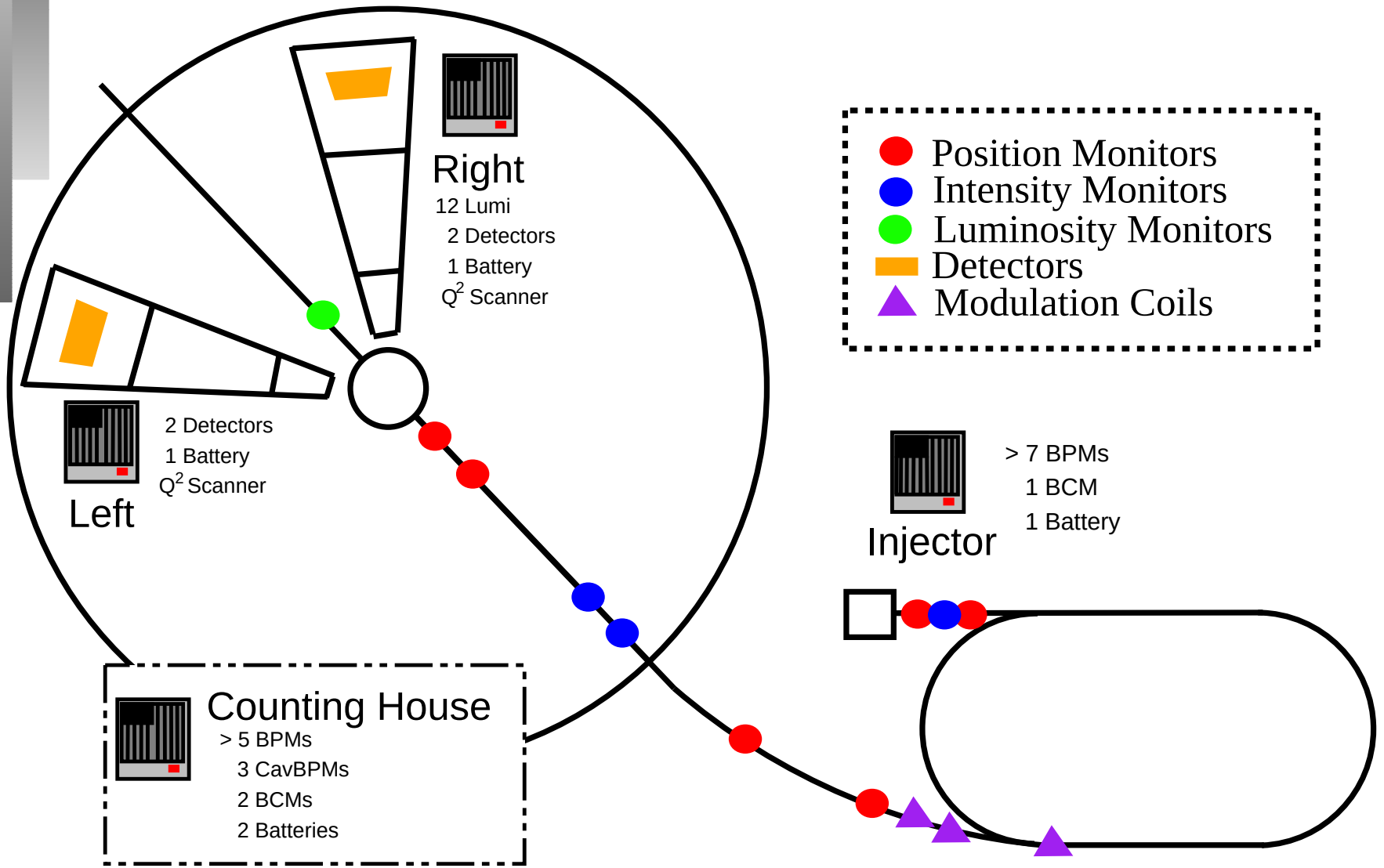
Luminosity Monitor





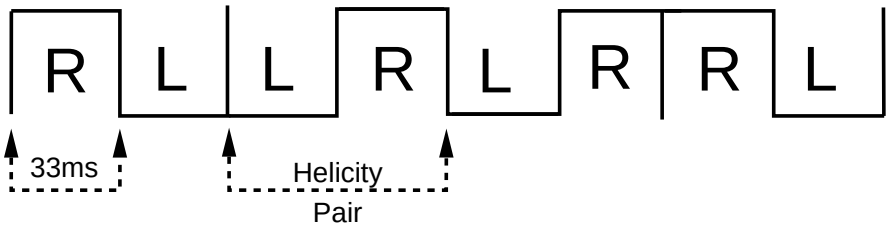


HAPPEX DAQ


Right
12 Lumi
2 Detectors
1 Battery
Q2 Scanner
Left
2 Detectors
1 Battery
Q2 Scanner
Position Monitors
Intensity Monitors
Luminosity Monitors
Detectors
Modulation Coils
Injector
> 7 BPMs
1 BCM
1 Battery
Counting House
> 5 BPMs
3 CavBPMs
2 BCMs
2 Batteries

Measurement & Corrections

Beam Helicity

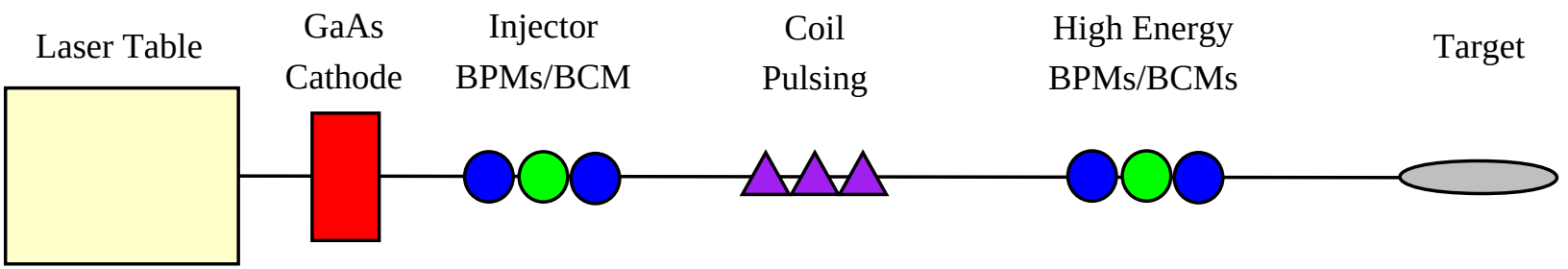


Integrated Detected Flux D

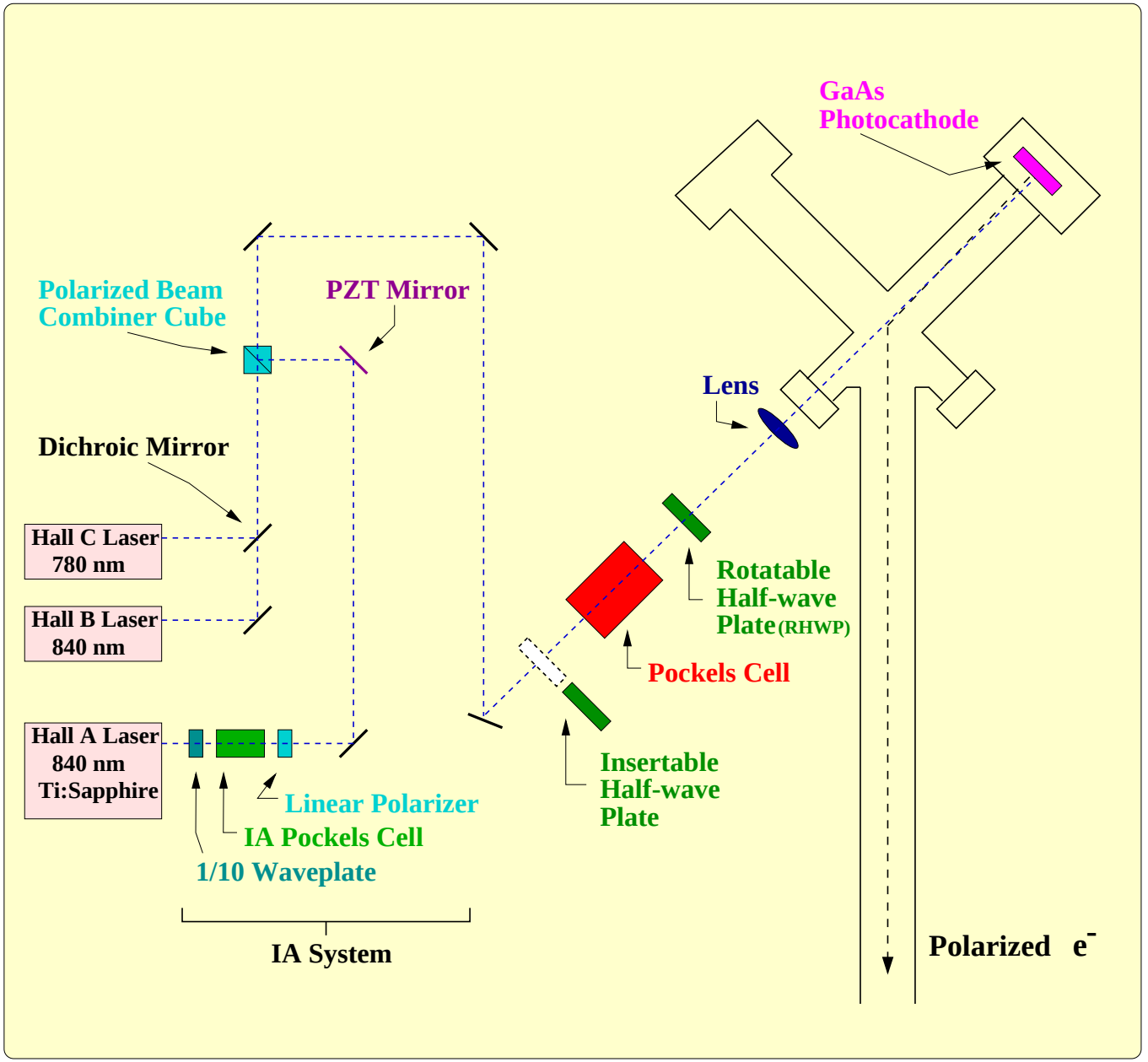
$$A_{det} = \frac{D_R - D_L}{D_R + D_L}$$

Corrected Asymmetry

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



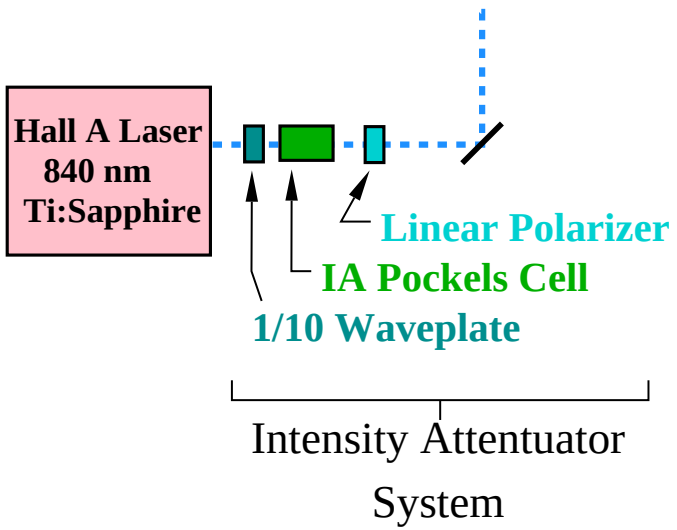
Laser Table

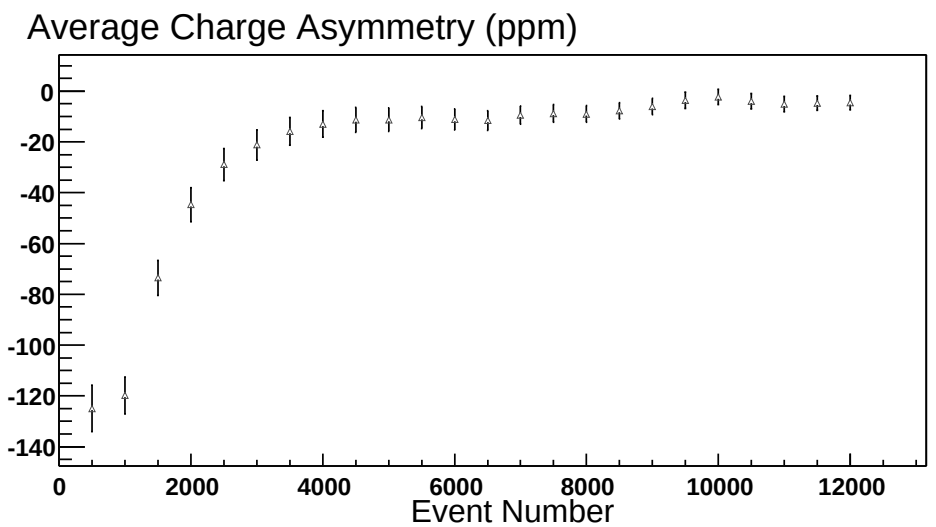

GaAs
Photocathode
Polarized Beam
Combiner Cube
PZT Mirror
Lens
Dichroic Mirror
Hall C Laser
780 nm
Hall B Laser
840 nm
Rotatable
Half-wave
Plate (RHWP)
Pockels Cell
Hall A Laser
840 nm
Ti:Sapphire
Insertable
Half-wave
Plate
Linear Polarizer
IA Pockels Cell
1/10 Waveplate
IA System
Polarized e-

Charge Asymmetry

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

Goal (Run Avg.): $A_Q \leq 0.6$ ppm





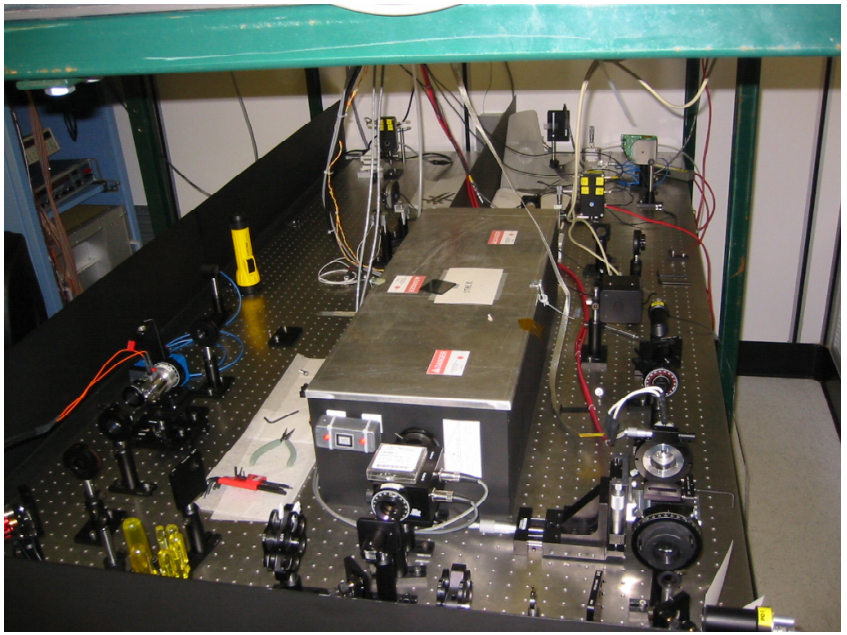
Spin-Duality (E01-012) @ $12\mu A$

$A_Q \sim 0.2$ ppm

Position Differences

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

Goal (Run Avg.): $\Delta x \leq 2$ nm @ target



ITS Laser Room

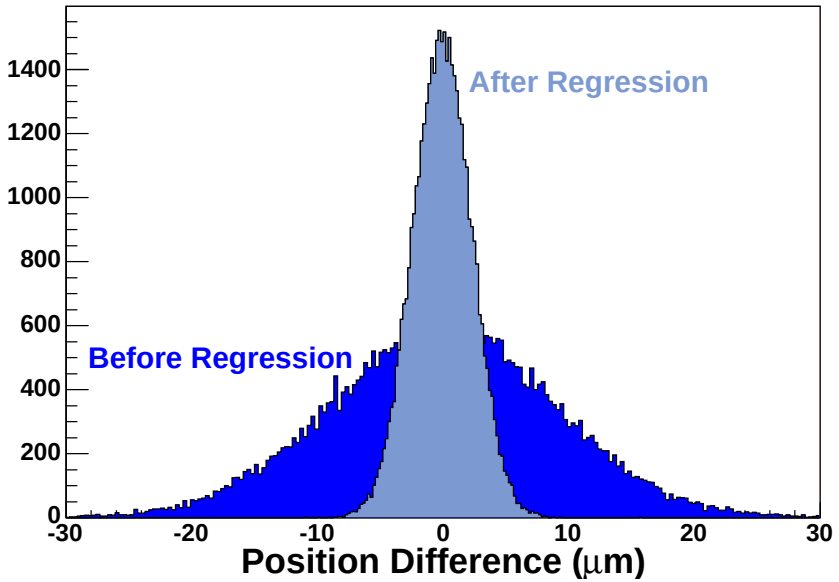
- Pockels Cells
- Ti-Sapphire Laser
- λ-plates
- HV Switches

Injector Beam Studies

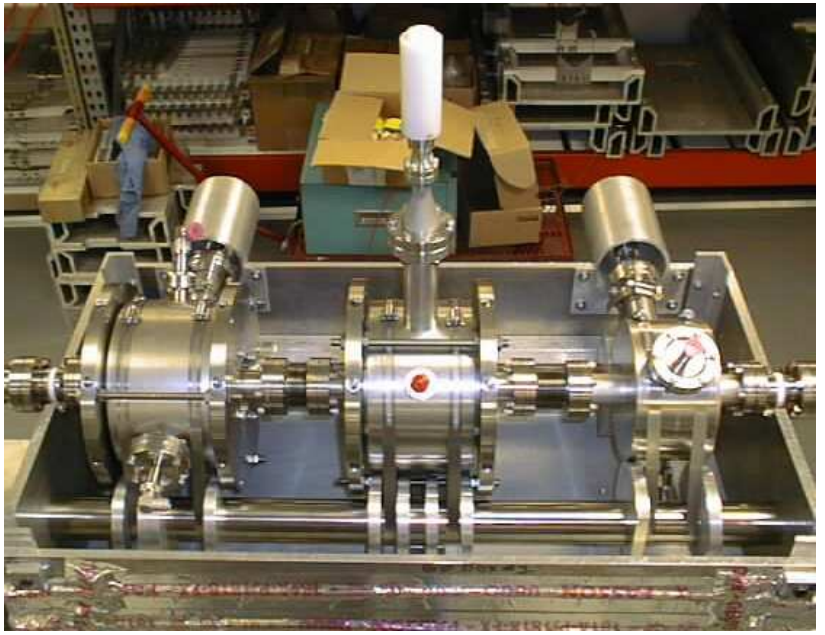
Adiabatic Damping

Position Resolution

Goal (30Hz): $\sigma_{\Delta x} \leq 1.2\mu$m in each BPM



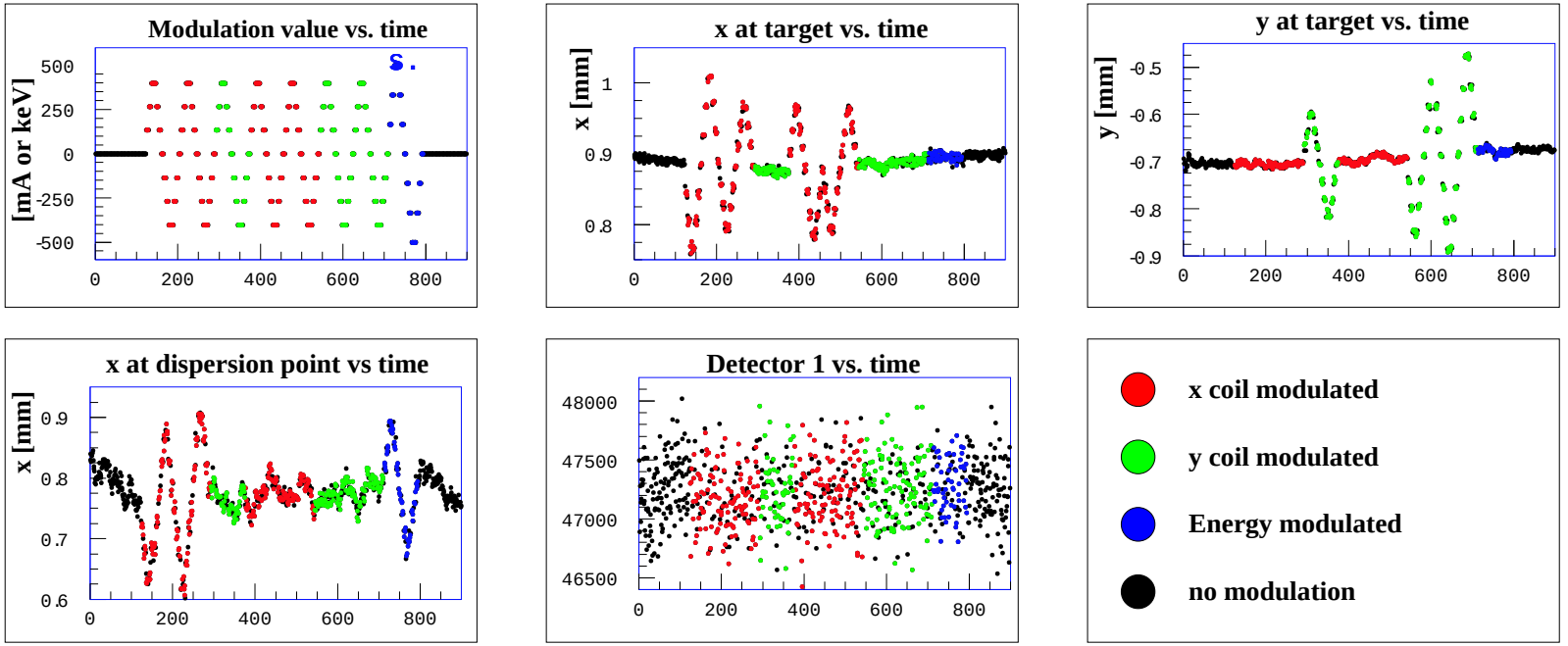
Stripline Position Monitor
Resolution $\sim 1.8\mu$m



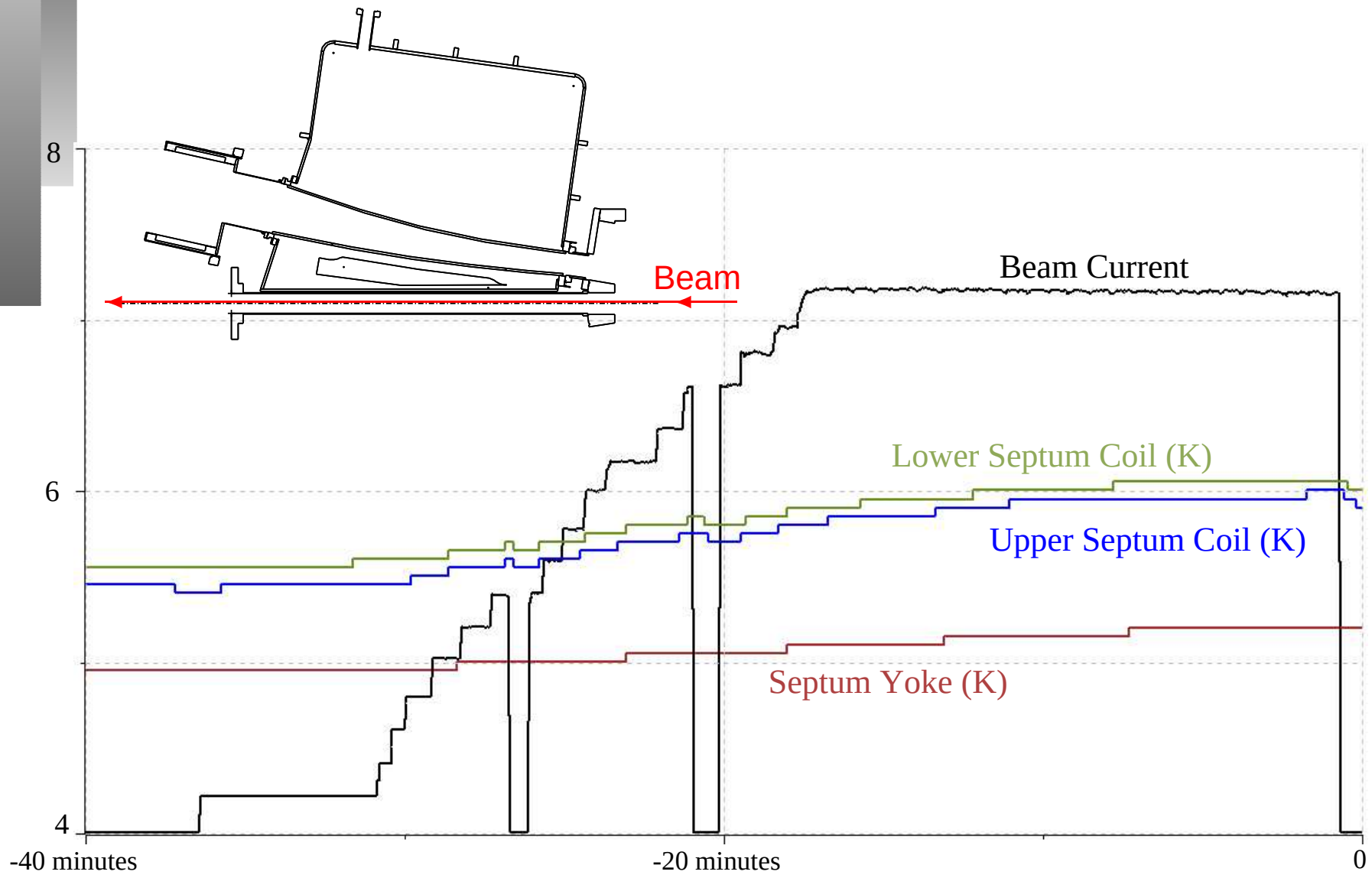
Cavity Position Monitors

Beam Modulation

$$A_{physics} \simeq A_{det} - A_Q + \alpha A_E + \sum_i \beta_i \Delta x_i \qquad \beta_i = \frac{\partial D}{\partial x_i}$$

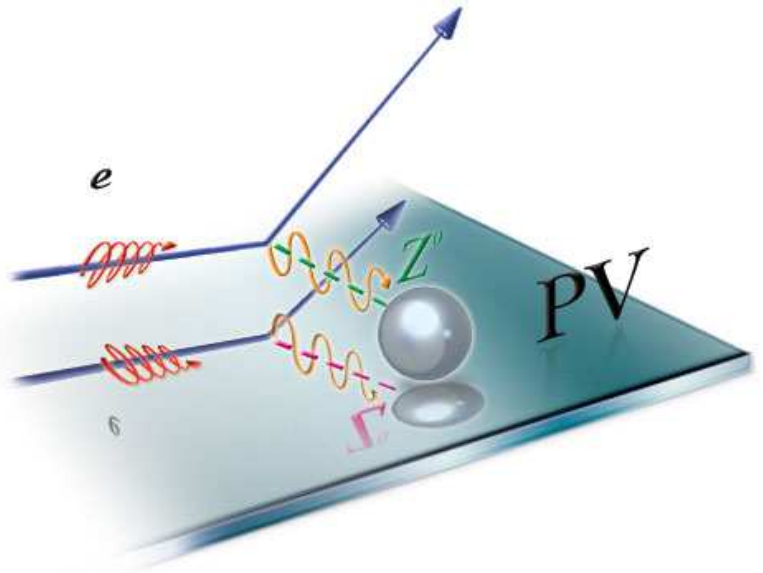


Septum Heating



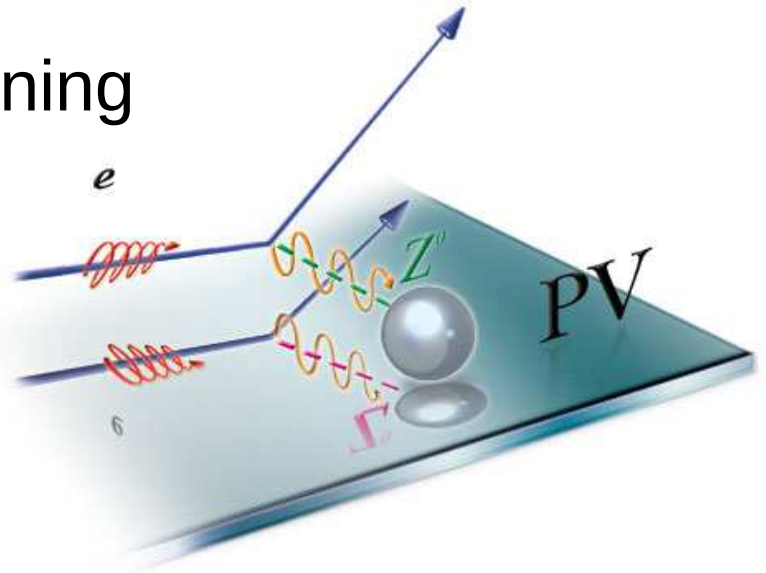
Summary & Conclusion

- Continuing Progress
  - ⋆ Minimizing Position Differences at the Source



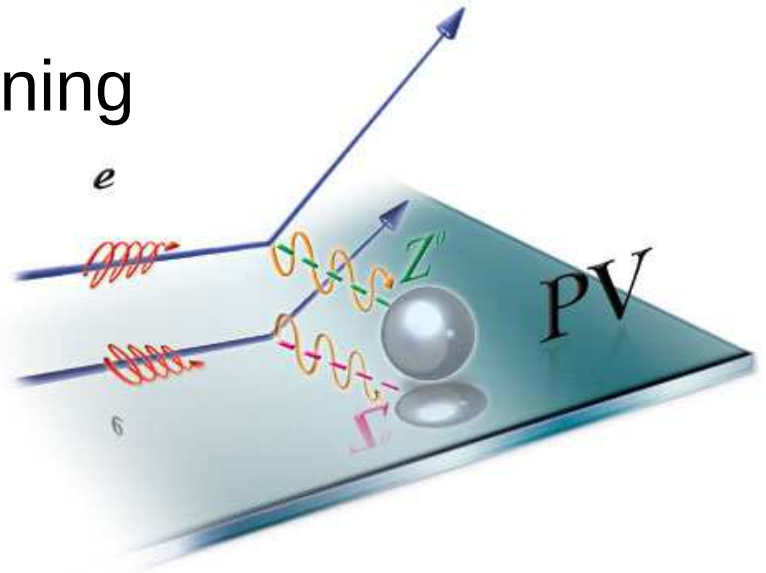
Summary & Conclusion

- Continuing Progress
  - ⋆ Minimizing Position Differences at the Source
- Planned Tests/Commissioning
  - ⋆ Septum Heating
  - ⋆ Beam Modulation
  - ⋆ Luminosity Monitors
  - ⋆ Cavity Monitors



Summary & Conclusion

- Continuing Progress
  - ⋆ Minimizing Position Differences at the Source
- Planned Tests/Commissioning
  - ⋆ Septum Heating
  - ⋆ Beam Modulation
  - ⋆ Luminosity Monitors
  - ⋆ Cavity Monitors



- Ready for Beam (April 2004)