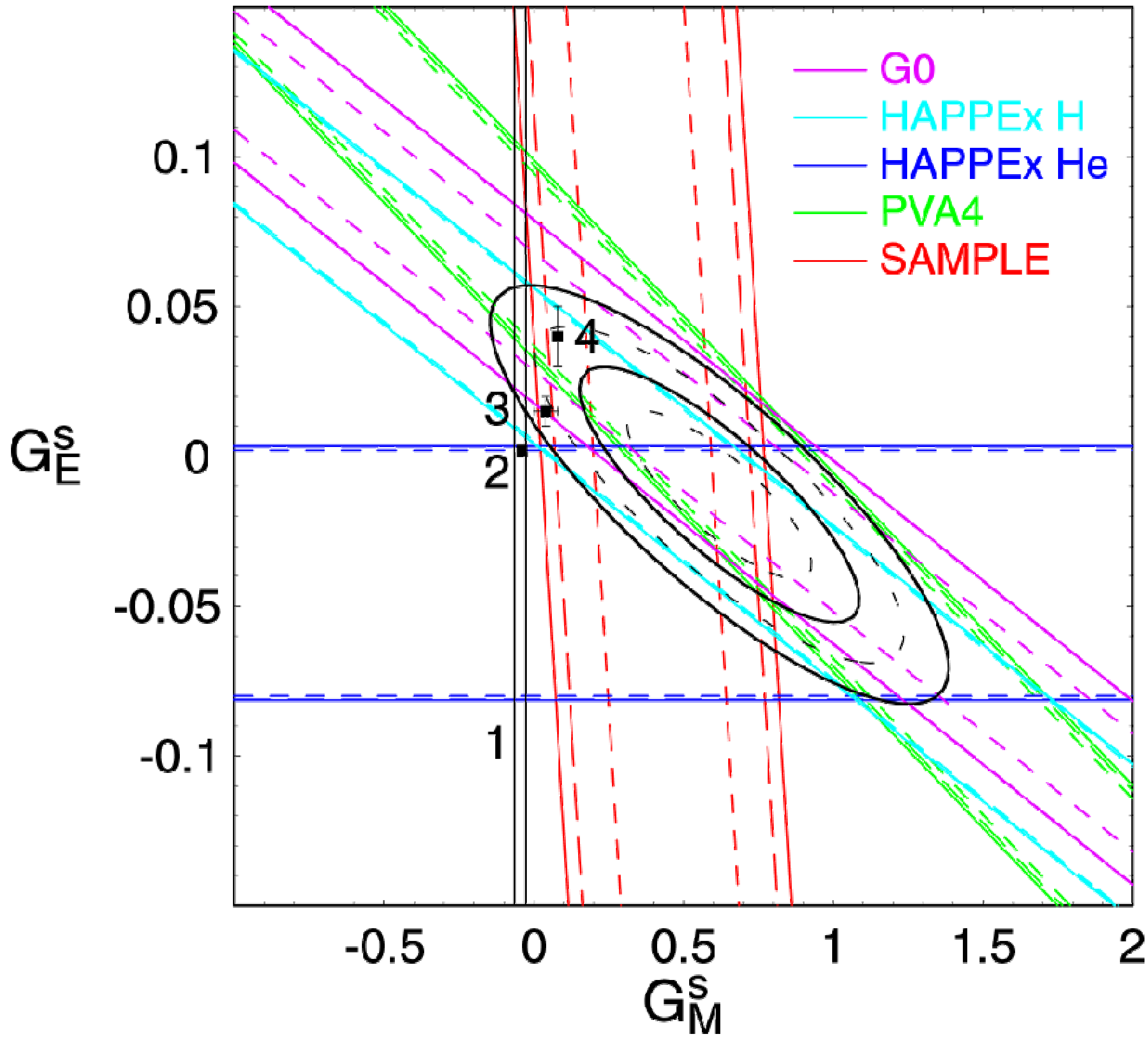
G0 Backward Angle Measurement at Q^2=0.23 GeV^2
PR 06-008: Update on PR 05-108

D. Beck, UIUC
PAC29, Jan 2006

Main points

- Strategy for Hall A/Hall C measurements established
  - HAPPEx: forward measurement at Q^2 = 0.63 GeV^2
  - G0: backward measurement at Q^2 = 0.63 GeV^2
- Follow-up technical issues raised by PAC 28
- Modify request
  - Eliminate Q^2 = 0.48 GeV^2 request
  - Summer run period shortened to 6 calendar weeks
  - Request time to run both H and D targets: total 68 days
- **Our best physics**

World Data @ $Q^2 = 0.1$ GeV^2



$G_E^s = -0.013 \pm 0.028$

$G_M^s = +0.62 \pm 0.31$

± 0.62 2σ

Contours

- - - - - 1σ, 2σ

—— 68.3, 95.5% CL

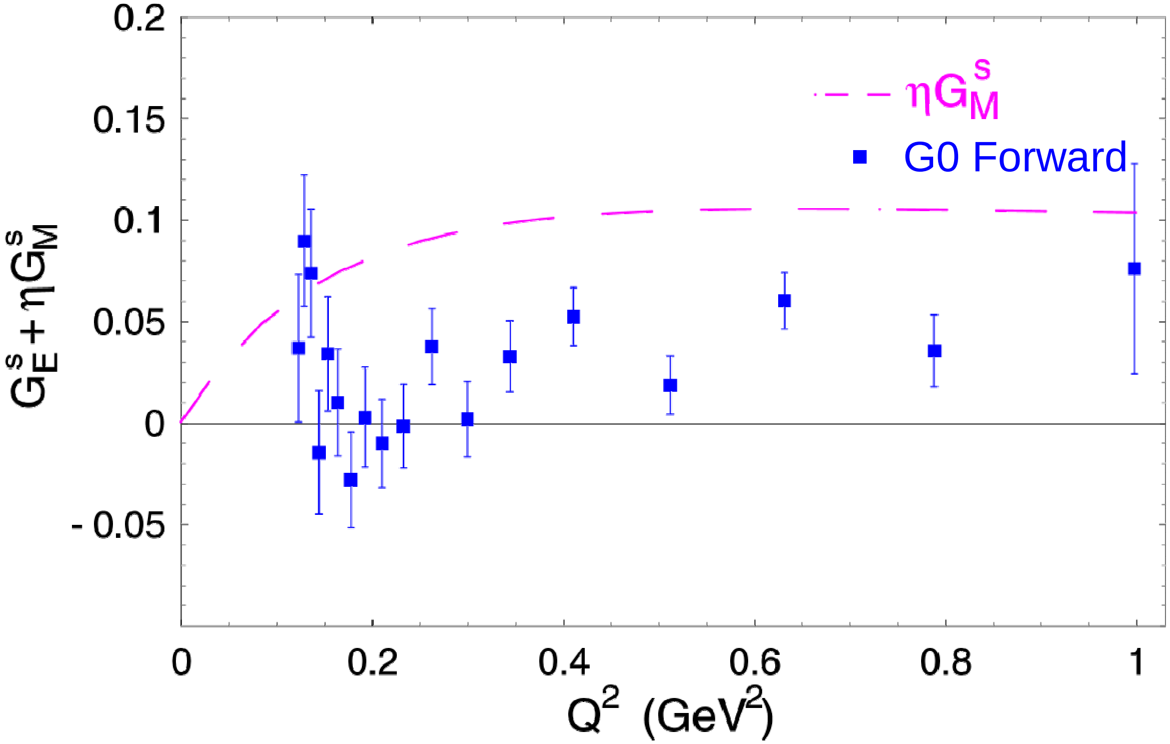
Theories

1. Leinweber, et al. PRL **94** (05) 212001
2. Lyubovitskij, et al. PRC **66** (02) 055204
3. Lewis, et al. PRD **67** (03) 013003
4. Silva, et al. PRD **65** (01) 014016

http://www.npl.uiuc.edu/exp/G0/Forward

Physics at $Q^2 = 0.23$ GeV^2

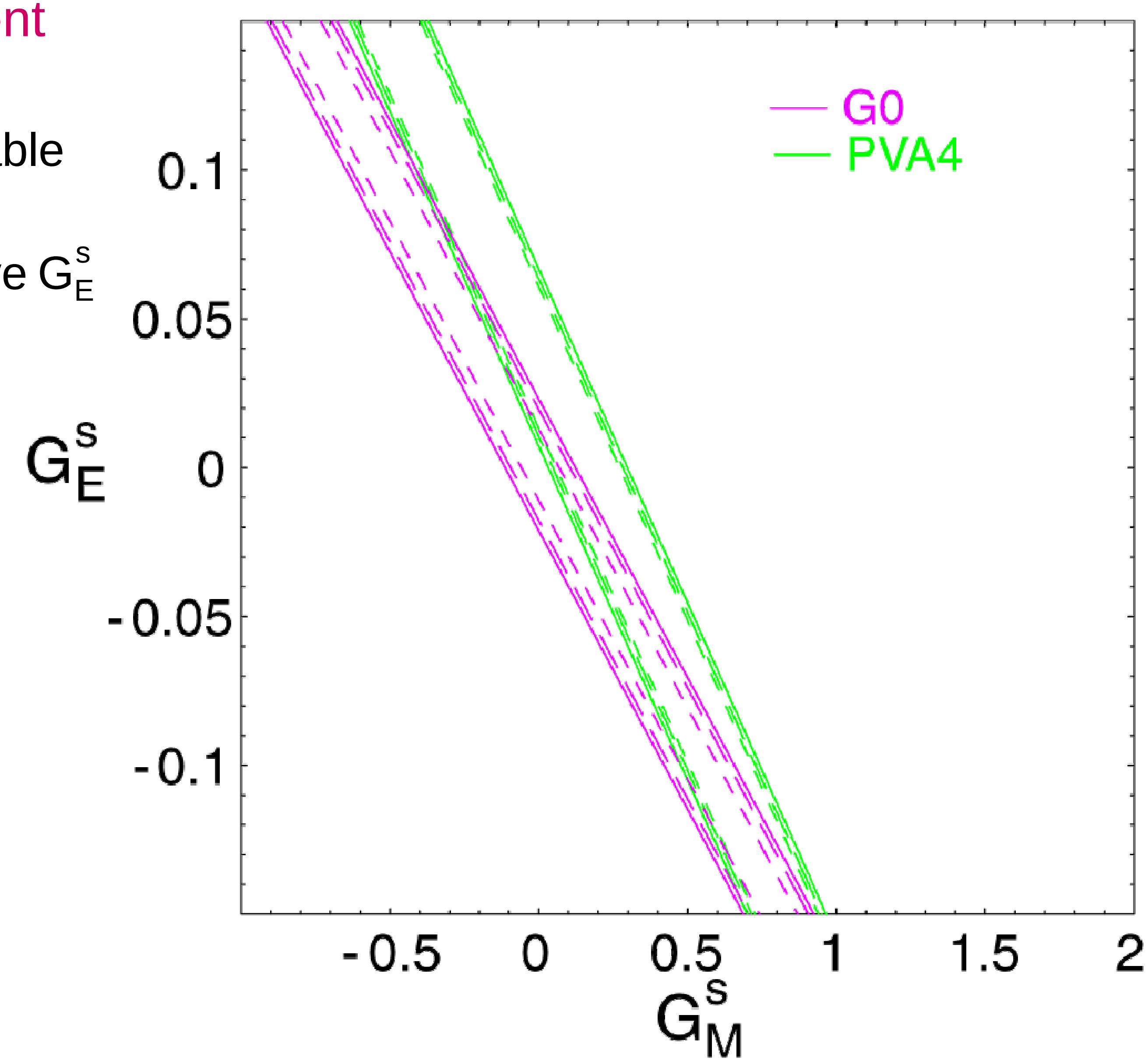
- 5 experiments at $Q^2 = 0.1$ GeV^2 set low Q^2 behavior of $G_E^s + \eta G_M^s$
  - $\eta \sim Q^2$



- Q^2 dependence of G0 data suggests $G_E^s < 0$ at medium Q^2
  - propose measurement at $Q^2 = 0.23$ GeV^2 where there is also forward Mainz measurement

World Data @ $Q^2 = 0.23$ GeV^2

- PVA4 measurement at $Q^2 = 0.23$ GeV^2
  - consistent probable value for G_M^s
  - supports negative G_E^s



http://www.npl.uiuc.edu/exp/G0/Forward

Theory Issue: 2γ Contributions

- 2 boson exchange diagrams contribute to asymmetry

$$A_{PV} \propto \frac{\left|\sum M_i\right|^2_{(h_e)}}{\left|\sum M_i\right|^2}$$

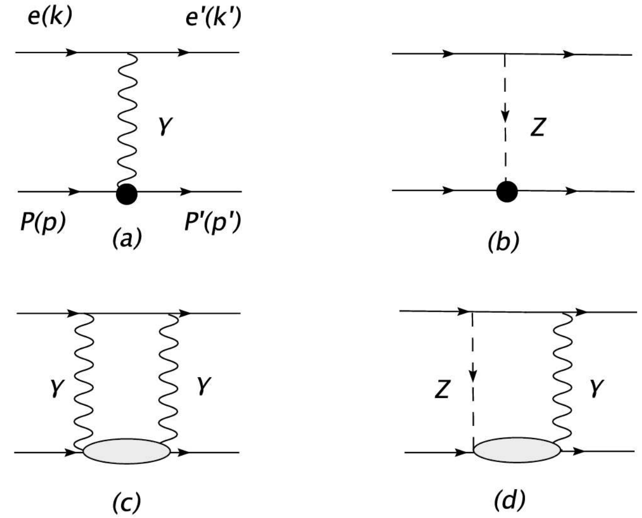


FIG. 1. (a),(b) Diagrams of the Born approximation, (c) two-photon exchange, and (d) the γZ box for elastic e-p scattering in a standard model of electroweak interactions. Corresponding cross-box diagrams are implied.

Afanasev & Carlson PRL **94** 212301.

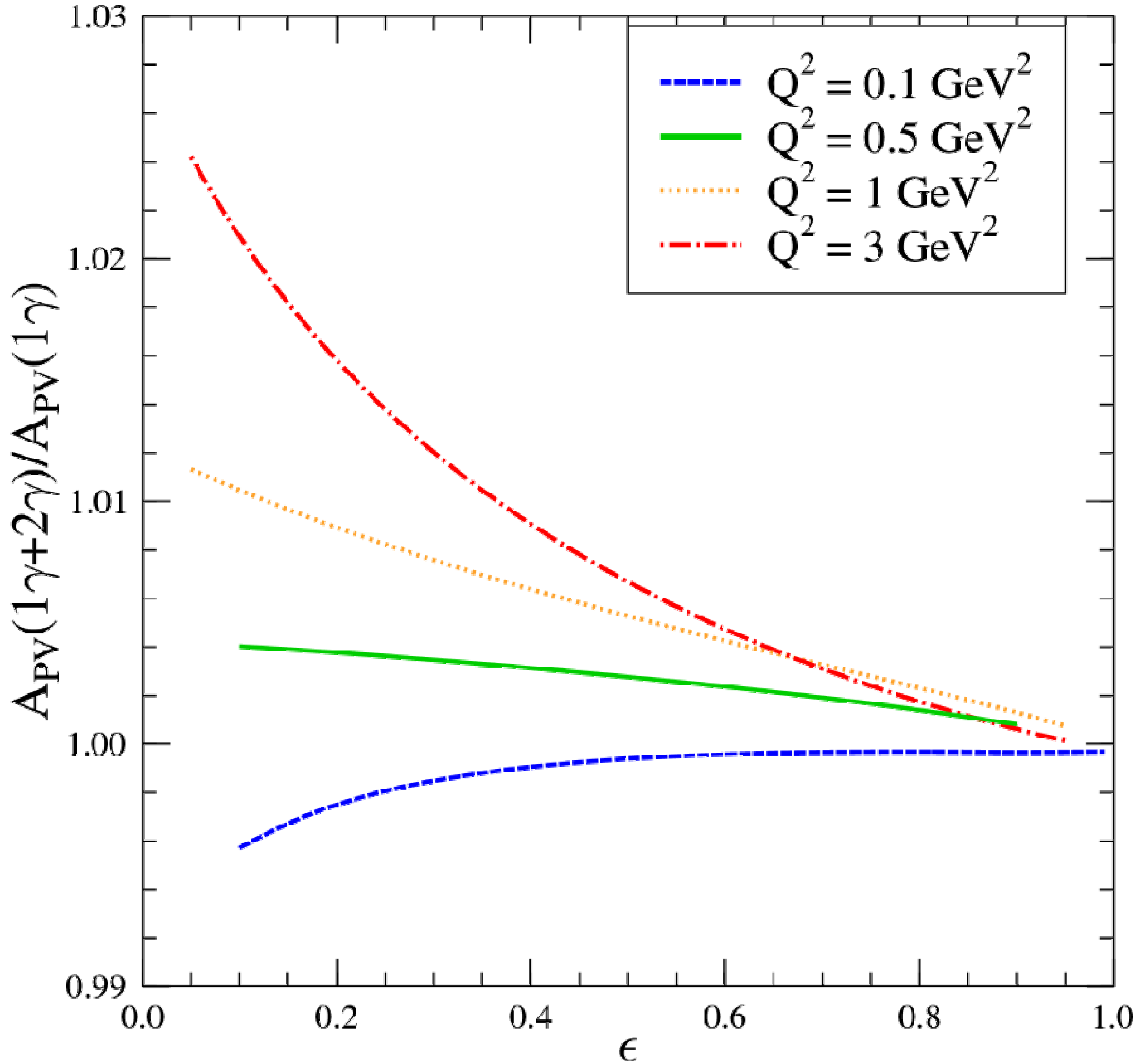
- Same terms enter as in 2g corrections to unpol[d], pol'n transfer
  - Y_{2g}, ΔG_E, ΔG_M
  - Guichon & Vanderhaegen, etc.

- Use calculation of Blunden, Melnitchouk & Tjon (PRC **72** 034612, priv. comm.)
  - nucleon pole only
  - Δ contrib. (PRL **95** 172503)

Theory Issue: 2γ Contributions

- Overall, effects on asymmetry very small
  - $Q^2 = 0.23$ GeV^2, $\varepsilon = 0.18$

- Individual contributions
  - $Y_{2g} = (4.6 \pm 4.6)$ (-4)
  - $\Delta G_E = -0.011 \pm 0.003$
  - $\Delta G_M = -0.004 \pm 0.004$



P. Blunden, priv. comm.

Theory Issue: 2γ Contributions

- Write asymmetry

$$A = A_0 + c_E G_E^s + c_M G_M^s + c_A G_A^e$$

- For proton asymmetry, how much do coefficients change given uncertainty in 2γ parameters?
  - $Q^2 = 0.23\ \text{GeV}^2$, $\varepsilon = 0.18$

	$\delta A/A$ (%)	$\delta c_E/c_E$ (%)	$\delta c_M/c_M$ (%)	$\delta c_A/c_A$ (%)
ΔG_E	0.006	-0.58	0	0
ΔG_M	-0.23	0	-0.23	-0.23
$Y_{2\gamma}$	0.056	0	0.055	0.057

Technical Issues from PAC28

"The TAC raised a number of technical issues concerning installing, commissioning, and running the G0 low-energy back-angle experiment. In order to address these issues, the collaboration is asked to work with the Laboratory to develop:

1. A well motivated table of beam requirement including halo, helicity-correlated modulations, intensity, and polarization.
2. Detailing of detectors and apparatus performance criteria.
3. Discussions of background criteria including radiation levels at detectors.
4. A run plan including
   a) milestones and times for achieving 1, 2, and 3.
   b) count rates and running times to achieve statistical uncertainties.
   c) auxiliary measurements and times to control systematic uncertainties."

PAC28: Issue 1

- Beam specifications (Appendix B)
  – developed in collaboration with Accelerator Division (Joe Grames)
  – general criterion: max false asymmetry is few % of min asymmetry (13 ppm for H)
  – specs relaxed x2 relative to forward run
    - most forward specs exceeded by significant factor

- Experiment sensitivities

	Forward Angle	Backward Angle	Backward Spec
$\frac{1}{Y}\frac{\partial Y}{\partial x}$	1%/mm	1%/mm	40 nm
$\frac{1}{Y}\frac{\partial Y}{\partial \theta}$	-2.5%/mrad	-0.19%/mrad	4 nrad
$\frac{E}{Y}\frac{\partial Y}{\partial E}$	-3.6	-2.7	5×10^{-8}

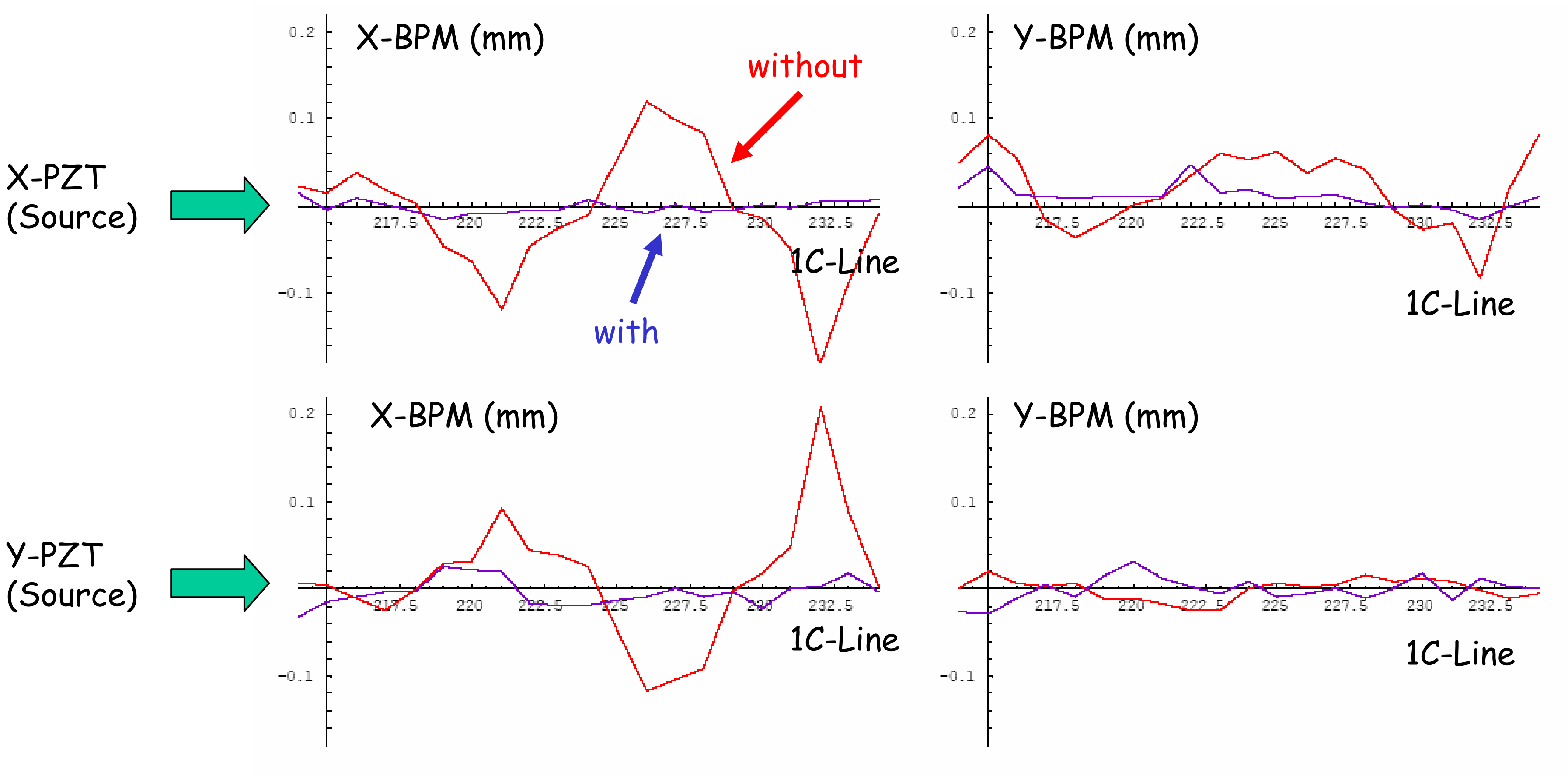
PAC28: Issue 1

- Halo spec: same as regularly achieved in forward measurement
  - < $1x10^{-6}$ outside 3 mm radius

- Two main sources
  - target cell entrance
    - same situation as forward run
    - monitor with calibrated aperture/halo monitor system
  - upstream aperture
    - detectors upstream of magnet for backward measurement
    - upper limit based on rates for routine forward angle running
      - 4 kHz (c.f. ~150 kHz real rate) in FPD 1
      - 100 Hz increase in accidental rate

PAC28: Issue 1

- "Adiabatic damping" in injector important for helicity correlated beam position difference, charge asymmetry



Y. Chao, Accelerator Division (from J. Grames)

PAC28: Issue 2

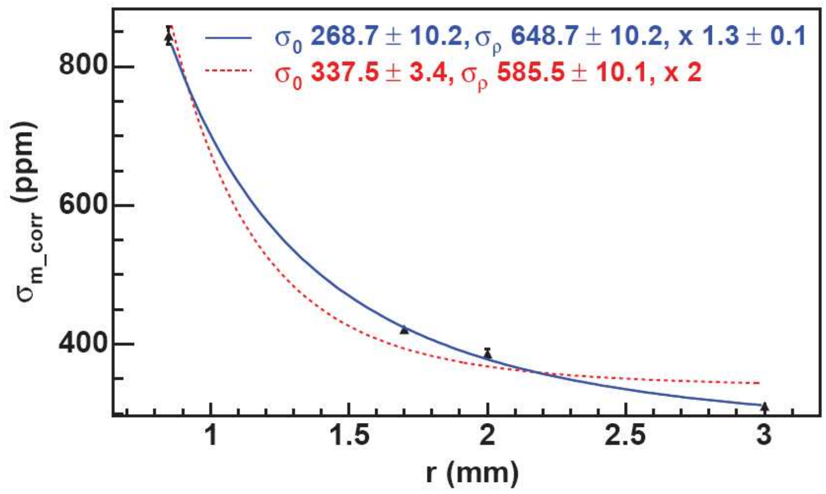
- Apparatus performance criteria

Subsystem	Description	H/D	Criterion
Target	Boiling	H	$(\delta A/A)_{tb} < 430$ ppm
		D	$(\delta A/A)_{tb} < 350$ ppm
	Minimum power	H	460 W
		D	550 W
	Operating range	H	19 ± 1 K
		D	22.5 ± 1 K
	z position		2 mm
Magnet	Minimum current		2440 A
Detectors	CED/FPD Threshold		$< 1/3$ m.i.p. ($> 5\sigma$)
	Anode current		$< 80\mu$A
	Cherenkov efficiency		$> 85\%$
	Cherenkov rejection	D	> 2
	Overall dead-time		$< 20\%$

PAC28: Issue 2

- Target performance
  - successful operation demonstrated with liquid deuterium, Dec. 05
  - based on cooling power vs. coolant flow need
    - 12 g/s for LD2 (22 K – 3 K sub-cooled)
    - estimate 18 g/s for LH2 (19 K – 3 K sub-cooled)
      - smaller ΔT
  - target survey mostly complete
  - target boiling: $\sigma_{boiling} \leq \sigma_{stat}/3$
    - based on forward measurements with changing rastered beam spot size

$\sigma_{boiling}$ = 300 ppm at I_{beam} = 80 μA ✓

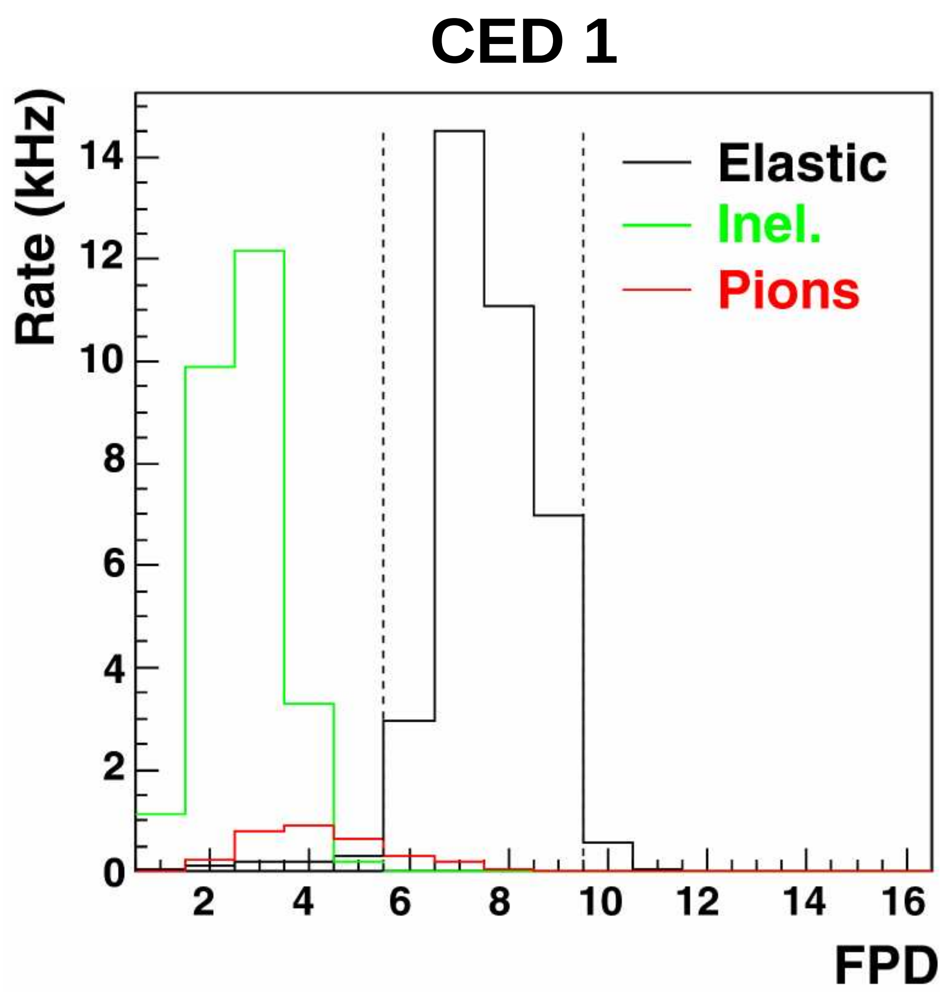


PAC28: Issue 2

- Physics background
  - ‘inelastic’ electrons, pions
  - max 1.3 MHz/octant (D)

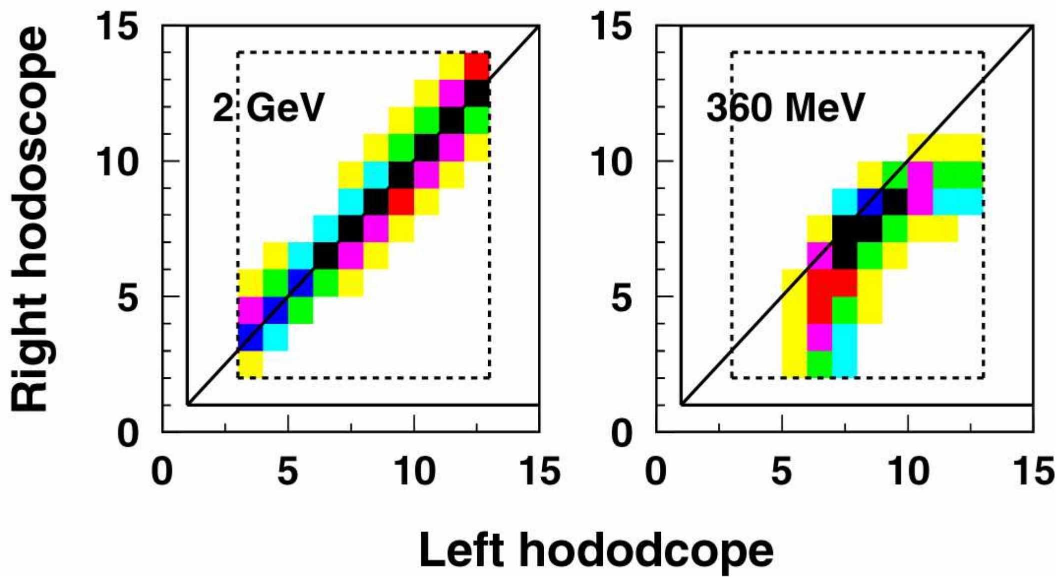
- Elastic locus
  - 3% inelastic electrons
  - 0.2/10% pions (H/D)
    - before Cherenkov

  - detailed simulation of A_{el} background correction
  - can use wire chamber, stepping magnetic field for dilution
    - $\Delta A_{sys}/A \sim 1.5\%$



PAC28: Issue 2

- Møller polarimeter
  - low energy requires
    - change of Q1 position (687 MeV)
    - change in tune
- Expected precision
  - rely on cross calibration with 5 MeV Mott polarimeter
    - 1.5%
  - overall expect ~2.4%
  - could chk with 687 MeV beam
    - pol’n changes slowly
    - 360 is “1/2” x 687 MeV

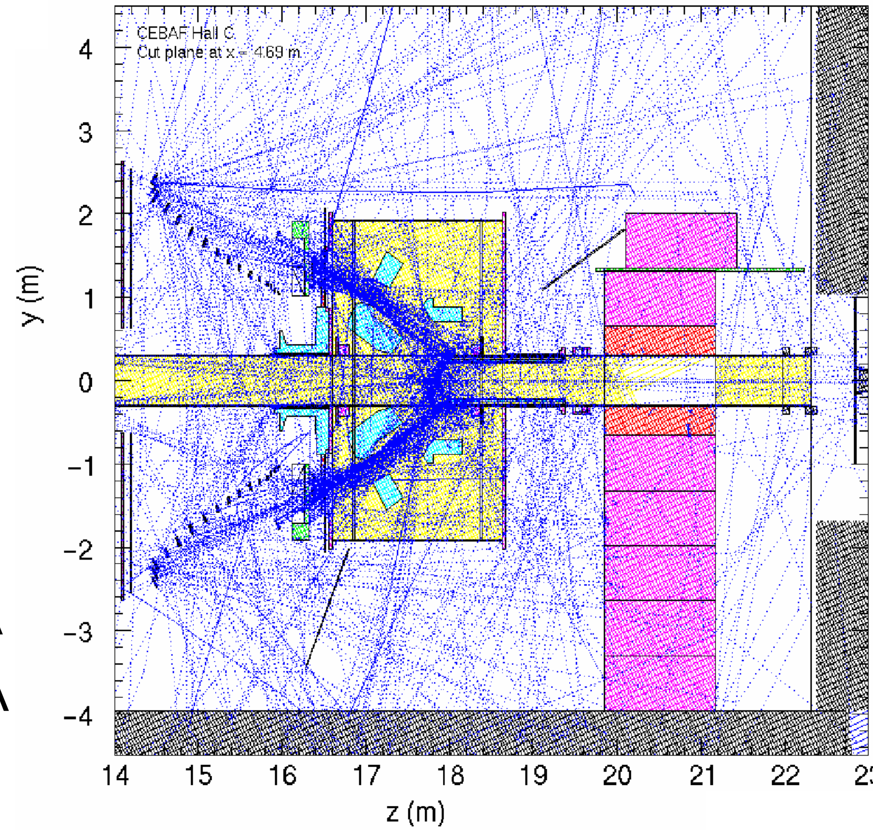


Comparison of Møller tunes

PAC28: Issue 3

- Hall background
  - combined G0 geometry with std. JLab Hall C simulation
  - track charged particles, neutrons, γs
  - shield ‘avoidable’ background

- Conclusions (D, 80 μA)
  - FPD anode currents ~40-60 μA
  - CED anode currents ~20-60 μA
  - maximum charged particle singles ≤ forward angle



Example simulation
γ’s striking a detector (E_γ > 10 keV)

PAC 28: Issue 4

- Plan for establishing performance criteria

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	Overall dead-time		$< 20\%$

- Recheck of established criteria (green, yellow)
  - 10 days of commissioning for 687 MeV (Mar. 15 ~ Apr. 7)

PAC 28: Issue 4

Subsystem	Description	H/D	Criterion
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	Anode current		$< 80\mu$A ←
	Cherenkov efficiency		$> 85\%$
	Cherenkov rejection	D	> 2
	Overall dead-time		$< 20\%$ ←

- Hall background related
  - simulations indicate very little difference between 687, 360 MeV
  - if currents, rates too high (c.f. forward angle run)
    - establish source if possible
    - add amplifiers, shielding if possible (reduce beam current)

PAC 28: Issue 4

- Detailed plan for 687 MeV commissioning
  - organization based on that for forward angle run
  - activities begin with most rudimentary: beam → luminosity/halo monitors → target → detectors → electronics (repeat)

- Luminosity monitor, halo monitor checkout (1 shift)
- Target (with beam) (start with hydrogen) (3)
  - target centering (halo)
  - operating range
  - boiling contribution
  - flyswatter contribution
- CED (/FPD) (5)
  - minimum ionizing i.d.
  - gain adjustment (CED 9)
  - background rates, anode currents
  - timing tuneup
  - threshold study
- Cherenkov (3)
  - gain adjustment
  - ADC spectrum, good electron i.d.
  - background rates, anode currents
  - choose logic? (sum, majority)
  - timing tunep
  - threshold study
  - position dependence
  - electron efficiency, pion rejection (may need LD2)
- Wire chamber checkout, measurements (2)
- Moller commissioning (2)
- Electronics (3)
  - FB working early for detector checks
  - coincidence counting
  - coincidence window widths
  - multihit
  - deadtime tests (changing beam currents, Wells plots)
  - pions
- DAQ/Software (2)
  - triggers (see timing tunep)
  - diagnostic hists
  - on-line asymmetries (esp. beam-related)
  - blinding factor (will be present at beginning)
- Beam (6)
  - beam specifications list – chk esp. helicity-correlated properties
  - centering and symmetry survey (beam/target placement – Joe)
  - BPM, BCM calibrations
  - feedback checkout
  - coil pulsing
  - halo (incl. calibration with “Hall B beam” if time)
  - mini-spin dance in conjunction with Moller commissioning
  - false asymmetries

PAC 28: Issue 4

- Count rates and run times

	H	D
Measurement time	30 d	30 d
Count rate	4.5 MHz	6.8 MHz
Statistical uncertainty	3.0%	1.7%
Total uncorrelated systematic uncertainty	1.6%	1.6%
$\Delta Q^2/Q^2$	1.0%	1.0%
$\Delta P_e/P_e$	2.4%	2.4%
Model uncertainties	see update	

PAC 28: Issue 4

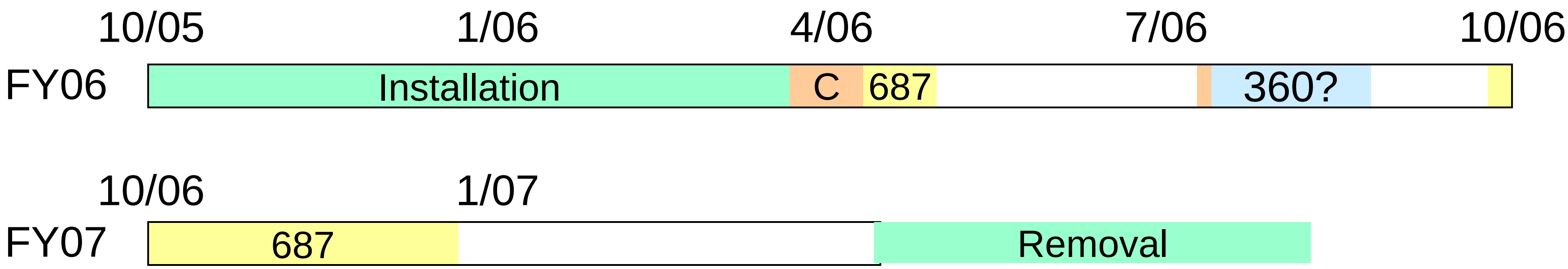
- Auxiliary measurements

	Frequency (1/d)	Time/meas (h)	Total (d)
Beam polarization	1/3	4	3.3
Beam energy	1/14	4	0.7
Beam current	1/14	2	0.4
“Coil pulsing”	15	0.01	0.4
Transverse asymmetry			2
Reverse polarity			1
Total			7.8

Beam Request

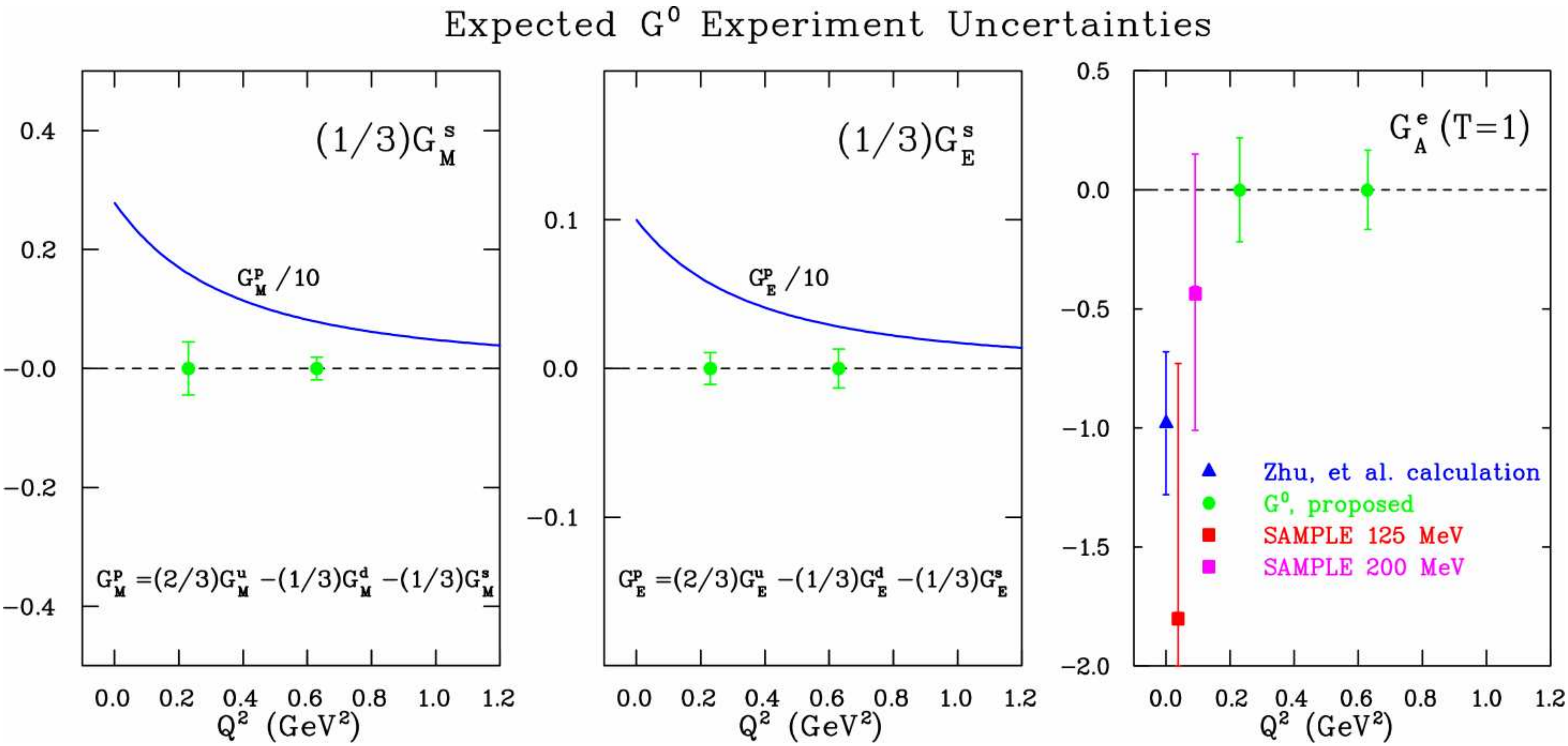
Commissioning	3.6 d
Hydrogen	30
Deuterium	30
Auxiliary	4.8
Total	68.4 d

Present Schedule



Summary

- Important physics issue at $Q^2 = 0.23\ GeV^2$
  - make use of forward G0, PVA4 measurements at same Q^2



$\Delta G_M^s = 0.13$ $\Delta G_E^s = 0.032$ $\Delta G_A^e = 0.22$