HAPPEX-III Issues

Proposed Measurement: HAPPEX High-Q^2

simulation required soon for 3.48 GeV

Configuration:

- 20 cm cryogenic Hydrogen Target
- 100 μA
- 80% polarization

Kinematics: E = 3.42 GeV, θ=13.7^o, E' = 3.1 GeV, Q^2 = 0.6 GeV^2

Rate: **1.1 MHz per arm** (3700 ppm width per arm, 2600 ppm per pair)

A_{PV} (assuming no strange vector FF):

A_{PV}^{NS} **= -22.1 ppm** ± 0.62 ppm (form factor/radiative correction)

Anticipated results:

δA_{PV} = 0.55 ppm (stat) ± 0.33 ppm (syst)

$\delta(G^s_E + 0.48\ G^s_M)$ = 0.0070 (stat) ± 0.0042 (syst) ± 0.0079 (FF)

Key Improvements over H-III

- **Precision polarimetry**
  - **Compton improvements: $\delta(P_{beam})$ = 1%**
- **Q^2 determination**
  - **Nuclear Recoil method: $\delta(Q^2)$ = 0.5%**
- **Linearity**
- **Background**

Experimental Error Budget

	$\delta A_{PV} / A_{PV}$	$\delta(G_E s + 0.48\, G_M s)$	
Polarization	1.0%	0.0028	*
Q^2 Measurement	0.8%	0.0022	*
Backgrounds	0.3%	0.0009	*
Linearity	0.6%	0.0017	*
Finite Acceptance	0.3%	0.0009	*
False Asymmetries	0.3%	0.0009	"easy" (big A_{pv})
Total Systematic	1.5%	0.0042	
Statistics	2.5%	0.0070	
Total Experimental	2.9%	0.0082	

* small improvement over H-II

* significant improvement over H-II

Estimated Precision

	$\delta A_{PV} / A_{PV}$	$\delta(G_E^s + 0.48 G_M^s)$
Total Systematic	1.5%	0.0042
Statistics	2.5%	0.0070
Total Experimental	2.9%	0.0082
Axial FF	1.5%	0.0042
EM FF	2.4%	0.0067
Total FF	2.8%	0.0079
TOTAL:	4.0%	0.011

H-III Critical Issues

- Compton Polarimetry *(many)
- Moller Polarimetry *(Javier)
- PMT Linearity
- Detectors, detector mounts *(Anatoly)
- Optics / Q^2 normalization
- Targets
- Transverse Asymmetry
- Effects of high luminosity

Compton Polarimeter

High intensity, low energy, sub-1% electron beam polarimetry

- Cavity
  - Will be IR, but must have a cavity working for H-III at ~1kW.
  - System presently functioning at about that level
- New Photodetector
  - Requires electron detector coincidence for calibration (probably).
  - High light yield from GSO, will enable high-precision counting at 3.5 GeV?
- Electron detector
  - “zero-crossing” method (practiced in H-II analysis) should be <1% systematic uncertainty
  - If e^- detector electronics fail, can old electronics be used?
- Software
  - Software upgrade on old DAQ halted awaiting new detector data
  - New (integrating) DAQ software has evolved significantly, but long road to production
- Integrating analysis
  - Response function test facility/plan

Moller Polarimeter

Upgrade to 1% at low currents for PREX

- Target / Magnet upgrade must occur together, for a functional polarimeter during H-III
- Compton cross-check, but also Wien angle optimization is critical!
- Addtional upgrades (post H-III): duty factor, DAQ, detectors to handle determination at higher cathode currents.

Transverse Asymmetry

- Expected (G0, H-III measurements) to be around 10 ppm (half of A_{PV})
- Horizontal transverse polarization is dangerous for unmeasurable vertical asymmetry:
    - 99.5% longitudinal -> 10% transverse
    - 50%(A^T) * 10%(pol) * 16% (vertical bite) * 10% (acceptance) = 0.08% systematic uncertainty
    - Harmless, unless acceptance cancellation is poor _and_ initial polarization is poor.
    - 99% L -> 15% T, 93% L -> 35% T. Measurement of size of A^T and vertical acceptance study will be required.
- Vertical transverse polarization less dangerous. Mott can measure to ~2%

H-III spin rotation

Hall	# of passes	Energy (MeV)
Linac		1140.00
A	3	3484.12
B	5	5764.12
C	4	4624.12

This tool is a little imprecise, but it seems that at 3.48 GeV (3 pass), Hall B will have 25% reduction in polarization if Hall A is optimized.

Source Angle	Theta-A	Theta-B	Theta-C	Pol-A(%)	Pol-B(%)	Pol-C (%)
0.00	21.78	59.52	35.05	76.67	6.08	-98.68
5.00	21.81	59.55	35.08	81.97	14.75	-96.89
10.00	21.83	59.57	35.11	86.65	23.32	-94.37
15.00	21.86	59.60	35.14	90.67	31.70	-91.13
20.00	21.89	59.63	35.16	94.00	39.85	-87.19
25.00	21.92	59.66	35.19	96.62	47.69	-82.59
30.00	21.94	59.69	35.22	98.50	55.17	-77.36
35.00	21.97	59.71	35.25	99.63	62.23	-71.55
40.00	22.00	59.74	35.27	100.00	68.82	-65.19
45.00	22.03	59.77	35.30	99.61	74.88	-58.33
50.00	22.06	59.80	35.33	98.46	80.37	-51.03
55.00	22.08	59.82	35.36	96.57	85.25	-43.34
60.00	22.11	59.85	35.39	93.94	89.48	-35.32
63.23	22.13	59.87	35.40	91.85	91.86	-29.99

Optics Calibration

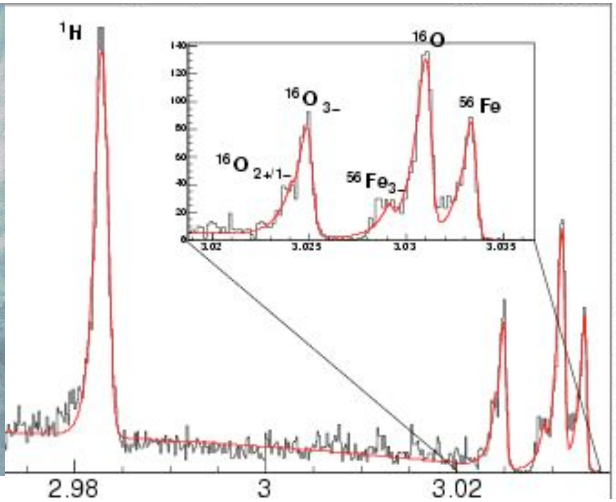
Goal: $\delta_{Q^2} < 0.5\%$

- Optics calibration
  - sieve/no sieve with C, tantalum... especially multi-foil
  - 3 pass

- Pointing (angle) measurement, **δθ < 0.25%**
  - required in near real-time for beam alignment? (maybe more important for PREX... "neutral axis")
  - requires 1 pass beam for sufficient rates
  - water cell + Ta, sieve
  - will additional 1-pass optics data be required?

Nuclear recoil, using water cell optics target: δp between elastic and excited state peaks reduces systematic error from spectrometer calibration.

At Q^2~0.1 GeV^2 (6°) in 2004:
Achieved δθ ~ 0.3%

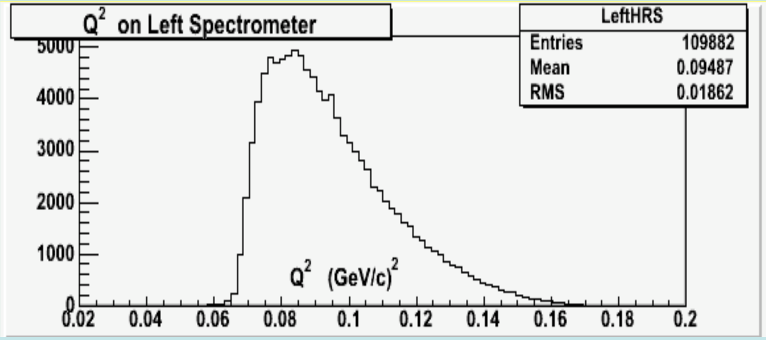


Measuring Q^2

Goal: $\delta_{Q^2} < 0.5\%$

- Central scattering angle must be measured to $\delta\theta < 0.25\%$
- Detector-response weighted rate distribution
- 1 MHz production rate -> 10 kHz rate over H elastic peak at 1uA
- Stability? Frequent remeasurement may be required

Q^2 measured using standard HRS tracking package, with reduced beam current



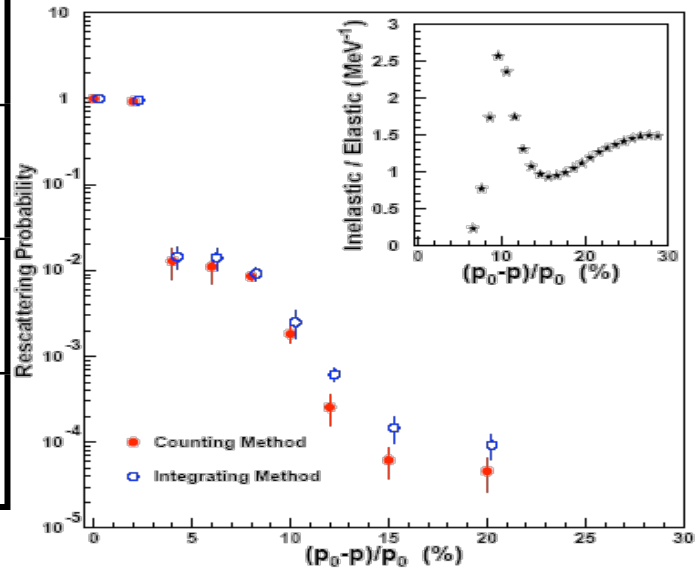
Also: Asymmetry distribution must be averaged over finite (detector weighted) acceptance

-> simulation task

Backgrounds

		Al Quasi-elastic	Spectrometer Rescatter
HAPPEX-I ($0.48\ GeV^2$)	**fraction**	**1.4%**	**0.2%**
	$\delta(A_{PV})/A_{PV}$	**0.3%**	**0.1%**
This proposal ($0.6\ GeV^2$)	**fraction**	**1.4%**	**0.4%**
	$\delta(A_{PV})/A_{PV}$	**0.3%**	**0.1%**

The probability of rescattering inside the spectrometer as measured by a dipole field scan



Measured using:

- Dedicated runs at low current
- Dedicated integrating runs

Also requires:

- careful target end-wall thickness measurements
- target density / gas target runs

Target

25 cm LH_2 cell
25 cm LD_2 cell

Need to minimize cell end-cap thickness
  Current guess: 7 mil (LH2)
  Careful measurement required. The more involved we are with Dave M's work, the better.

Other targets?
  BeO viewer
  multi-foil optics (C?)
  Ta optics

Coordinate target choice with Lead test?

PMT linearity

- 0.6% PMT linearity requirement
- Beam monitor linearity less stringent for H-III (~1% desired)

PMT bench tests Luis's apparatus. Who does it?

In situ system

- Beam intensity modulation
  - 5-10% intensity at few Hz

- LED test system
  - Offset (static) LED to level
  - Pulsing LED
  - Beam off studies and in situ studies

- LED system, detector modifications to be done!

Source/Helicity-Correlated Beam

- Required precision is comparable to HAPPEX-He.
- Careful configuration required, but not highest priority for H-III
- New Request: ability to modulate beam intensity by 5-10% in short calibration runs.
- The H-III setup is very important for PREX for training/ practice and for detailed understanding of the source. The lumi detectors and beam monitors will be high precision, and allow a careful study of what problems PREX might face.

Schedule

Install start 6/15,
“collab tests” 8/19
Commissioning 8/21
51 days from 8/26 - 10/25

A run-plan for commissioning must accommodate:

- 1-pass pointing measurement
- 1-pass PREX tests
- target-change
- 3-pass moller commissioning
- 3-pass optics

Are these compatible (cryo needed for PREX target?)

08/17/09	Monday	Restore		
08/18/09	Tuesday	Restore		
08/19/09	Wednesday	Collab Tests		
08/20/09	Thursday	Collab Tests		
08/21/09	Friday	1.14	Commission	3.484/100/p
08/22/09	Saturday	1.14	E05-109	3.484/100/p
08/23/09	Sunday	1.14	Happex III	3.484/100/p
08/24/09	Monday	1.14	Commission	3.484/100/p
08/25/09	Tuesday	1.14	Commission	3.484/100/p
08/26/09	Wednesday	1.14	E05-109	3.484/100/p
08/27/09	Thursday	1.14	E05-109	3.484/100/p
08/28/09	Friday	1.14	E05-109	3.484/100/p
08/29/09	Saturday	1.14	E05-109	3.484/100/p
08/30/09	Sunday	1.14	E05-109	3.484/100/p
08/31/09	Monday	1.14	E05-109	3.484/100/p
09/01/09	Tuesday	1.14	E05-109	3.484/100/p
09/02/09	Wednesday	1.14	E05-109	3.484/100/p

Summary, to-do list

- All things Compton (IR cavity, e-det, DAQ, photon detector)
- Moller upgrade
- HAPPEX detector refurbishment
- PMT linearity studies
- PMT linearity system design/construction
- Optics / Q^2 plan
- Simulation (scattering angle!)
- Auxilliary target selection
- Monitor cryotarget progress
- Beam Modulation system
- DAQ maintenance (Need to train a second black-belt!)
- Feedback / Slow Controls / monitors
- Analysis Chain
- Run plan, including commissioning and PREX test