E06002: PREx Status Update

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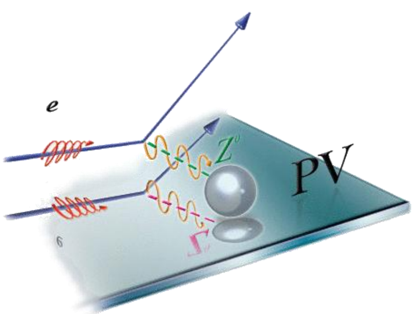
(For HAPPEX/PREx Collaboration)



Hall A Collaboration Meeting

June 12, 2009

Outline

- PREx & Its Physics Impact.
- Experimental Challenges.
- Ongoing developments.
    - Hall A Monte Carlo (HAMC)
    - PREx detectors
    - PREx Target
    - Cavity Position & Current Monitors
    - Luminosity Monitors & 18-bit ADCs
    - New Septum Magnet
    - Compton Polarimetry
- Summary & Outlook

PREx & Its Physics Impact

- A_{PV} ~ 600 ± 15 ppb, Q^2 ~ 0.01 GeV^2
- measures A_{PV} for 1.05 GeV electrons scattering from ^{208}Pb target at 5^0 to 3%.
- Extracts weak charge density & neutron density which gives neutron radius to 1%.
- This has many implications for nuclear structure, astrophysics, atomic parity non-conservation, and low energy tests of the Standard Model.

PREx & Its Physics Impact

- **PREx** (**P**b **R**adius **Ex**periment) uses parity violating electron scattering to accurately measure the neutron radius of ^{208}Pb.

$$A_{PV} = \frac{\left(\frac{d\sigma}{d\Omega}\right)_R - \left(\frac{d\sigma}{d\Omega}\right)_L}{\left(\frac{d\sigma}{d\Omega}\right)_R + \left(\frac{d\sigma}{d\Omega}\right)_L} = \frac{G_F Q^2}{2\pi\alpha\sqrt{2}}\left[1 - 4\sin^2\theta_W - \frac{\boxed{F_n(Q^2)}}{F_P(Q^2)}\right]$$

- Because the Z boson couples mainly to neutrons, A_{PV} can provide a clean measurement of R_n by studying the ratio of proton and neutron form factors.
- Proton form factor is well known, so we can extract the neutron density distribution from the neutron form factor.

$$F_n(Q^2) = \frac{1}{4\pi}\int d^3r \; j_0(qr)\,\rho_n(r)$$

Experimental Challenges

- Precision measurement of Q^2 ($\pm$ 0.7%)

  $\pm$ 0.02^0 accuracy in spectrometer angles.
- Precision beam polarimetry ($\Delta P_e/P_e \rightarrow \pm 1$ %)

  Upgrade Compton polarimeter: Green Fabry-Perot cavity, new GSO photon calorimeter, FADC based photon integration DAQ

  Upgrade Møller polarimeter: new iron foil, new FADC DAQ
- Need sub-100 ppm pulse-to-pulse electronics noise with improved Luminosity Monitors with new 18-bit ADCs.
- Need to control the helicity correlated beam asymmetry down to 100 ± 10 ppb, maintain beam position differences 1 ± 0.1 nm, double Wein slow helicity reversal, control transverse beam polarization below 1%
- Uses new Monte Carlo (HAMC), written in C++, based on LeRose's model of HRS transport.

  Septum collimator alignments/acceptances

  Spect. optics tuning and PREx detector size and positioning

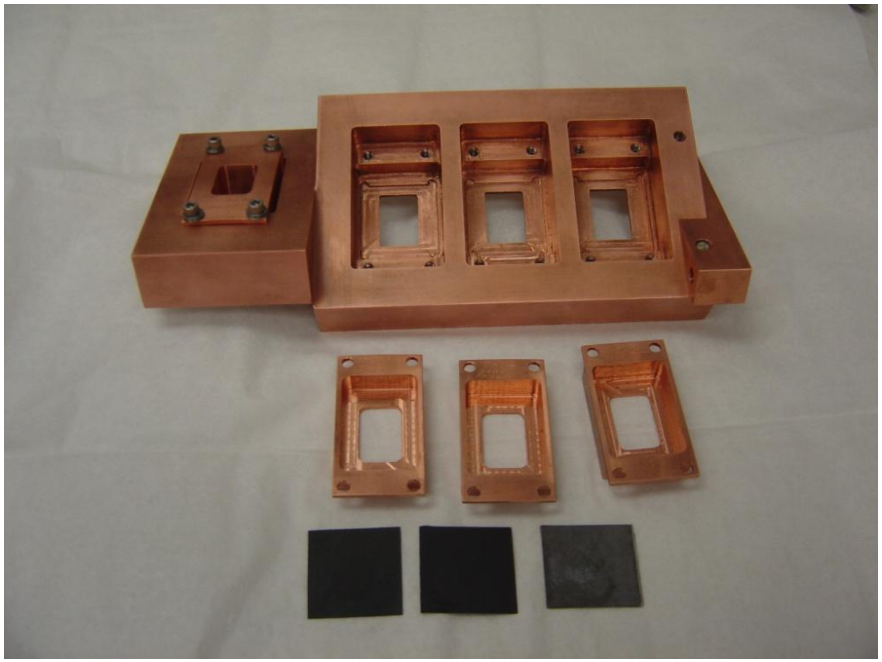
Hall A Monte Carlo (HAMC)

- C++ based MC developed by Bob Michaels to support the three upcoming parity experiments.
- Incorporates LeRose transport functions to provide focal plane distributions with realistic acceptance definitions at all apertures.
- Includes cold, warm, or no septum configurations with extended Hydrogen and PREx Pb targets.
- Uniform target sampling (vertex and scattering angles) with precision cross section weighting; includes external radiation, multiple scattering and resolution smearing.

PREx detectors

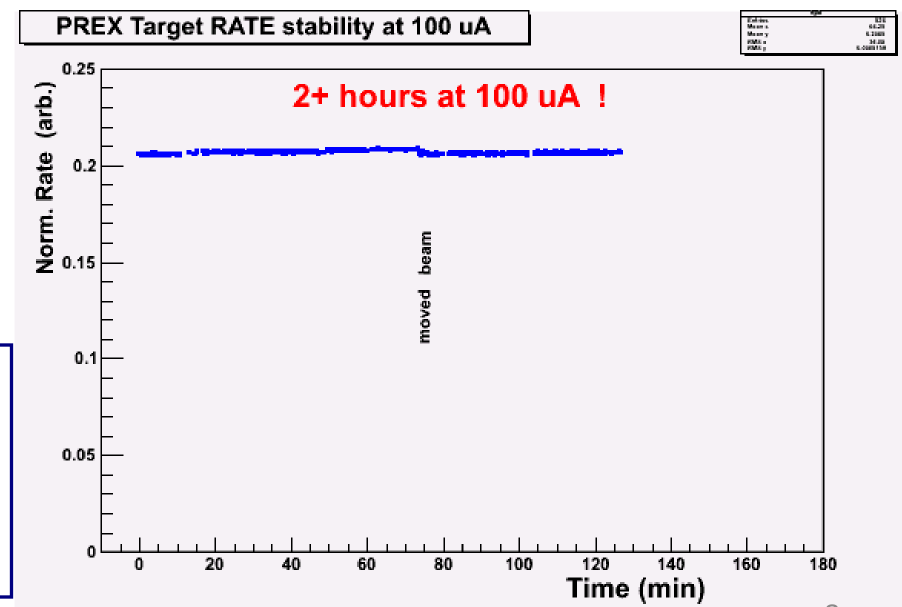
- Based on 2008 beam test, a new detector pair to be used for main Pb-elastic signal. These give best detection efficiency and pulse-height distributions with adequate resolution and minimal tails.
  - Attempt to improve resolution by replacing Alzak mirrors in light guide with anodized Al or Silver.
  - The x, y dimensions of the quartz determined from beam test data and HAMC. (11 x 14 cm)
  - Quartz thickness to be optimized with MC.
  - The spects of satellite detectors for A_T hole determined to be 7.6 x 0.8 cm.
- New HRS optics tune focuses elastic events both in x & y at the PREx detector location.

PREx Target



- Beam Current in proposal is 50 μA.
- **Target successfully tested up to 100 μA !**
- Main improvement: good contact between foils.

5 days	at	60 uA
1 shift	at	80 uA
3 hrs	at	100 uA

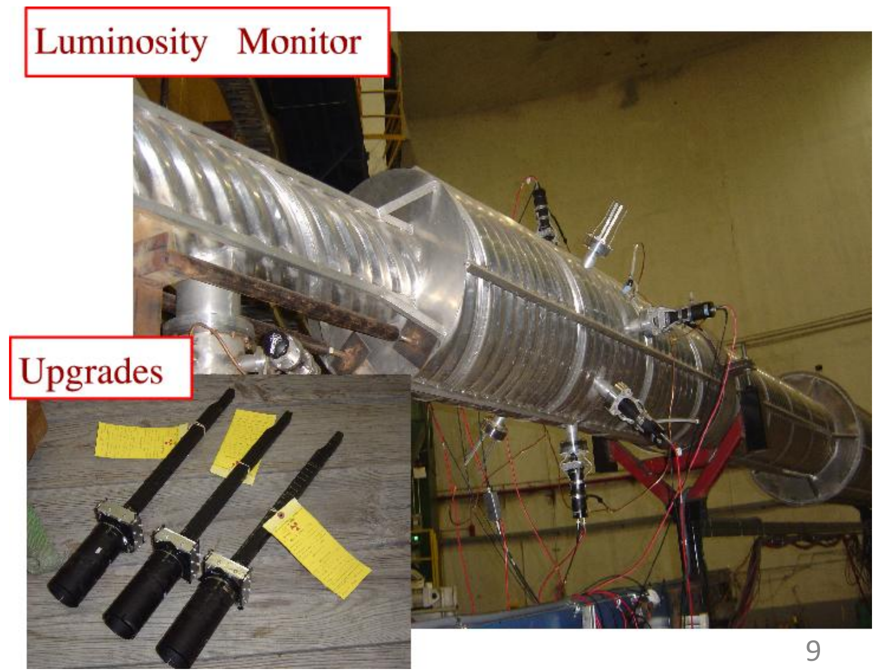


Cavity Position & Current Monitors

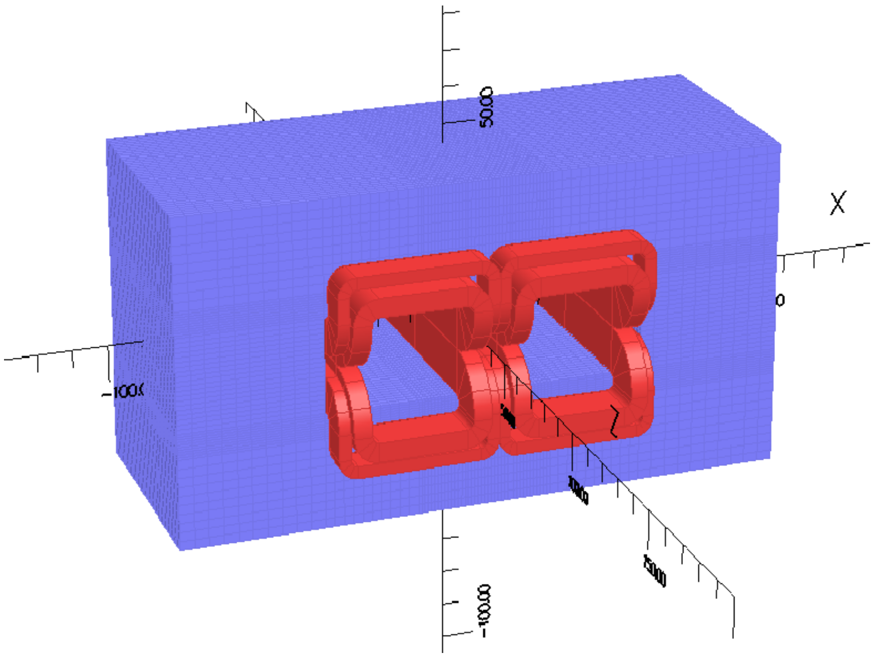
- Achieved 150 μm above 1 μA and 450 μm at 50 nA.
- John Musson's group is working on electronics to reach 0.1 nA and improve noise and ease of use. Should be available this summer.

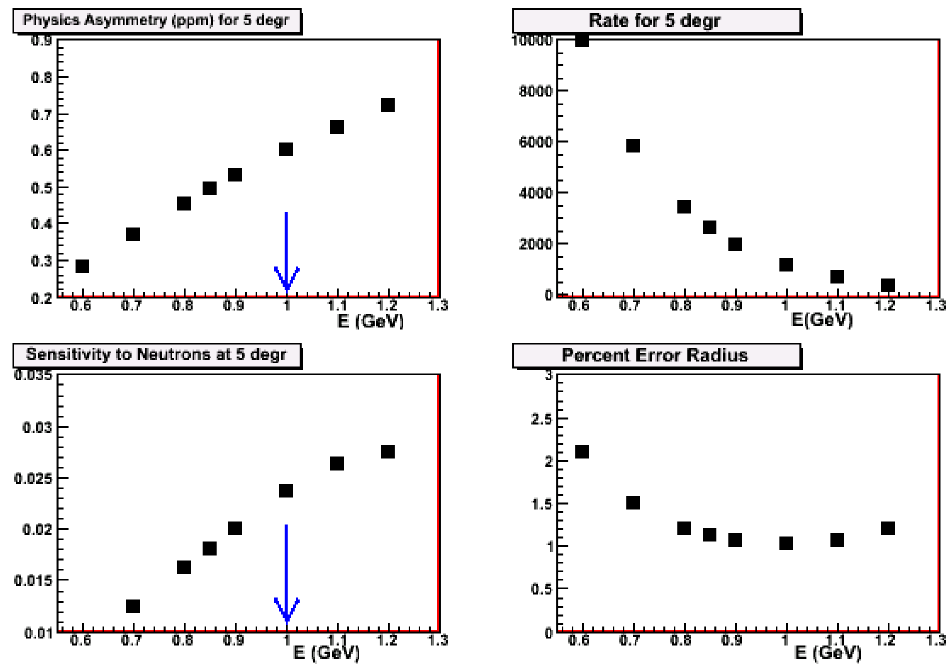
Luminosity Monitors & 18-bit ADCs

- 60 μA on thin ^{208}Pb target Individual Lumi asymmetry widths at 100 ppm
- Noise levels follow 1/sqrt(I).
- Concluded that shielding is essential.
- All the 18-bit ADCs are on hand.
- Comparing results with previous study done with 16-bit ADCs.
- Will need to modify 18-bit ADCs to match replaced 16-bit boards.



New Septum Magnet





Designed by Paul Brindza and Al Gavalya.

At 5^0 the new Optimal FOM is at 1.05 GeV (± 0.05).

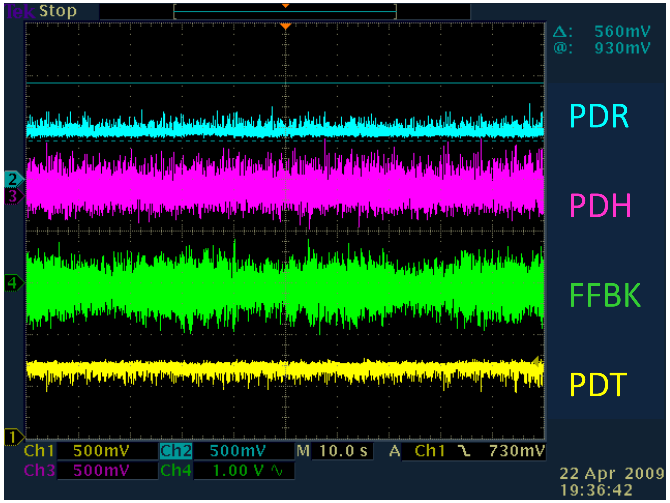
Higher E_{beam} helps with Compton polarimetry.

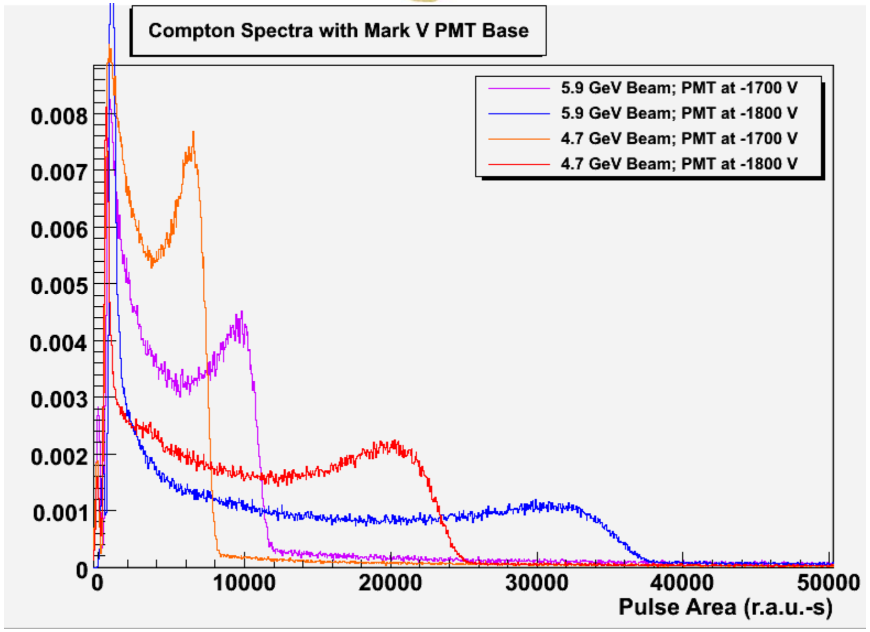
The septum magnet is being manufactured and will arrive in the Fall.

Compton Polarimetry

Green Cavity:

- Established a stable lock with 2,000 gain cavity.
- Demonstrated IPG fiber amplifier can be locked to the same cavity.





GSO calorimeter:

- GSO crystal has been calibrated at High-Intensity γ Source (HIγS) facility and installed in Hall A in December 2008.

DAQ:

- Old "French DAQ" and new "CMU DAQ" successfully combined and data is being analyzed in parallel.

Summary & Outlook

- Cavity monitors were tested successfully and new electronics will be ready by this Summer.
- New detector pair dimensions determined from beam test data and HAMC.
- New Septum will be ready by this Fall.
- Planned 240 Hz helicity flip scheme is being worked out.
- Green cavity development is on track
- Compton photon detector is making a good progress.
- Møller FADC DAQ is ongoing.
- Planning another PREx detector test during HAPPEX-III commissioning.
- JLab held PREx workshop in Summer 2008 wide range of issues are discussed.
- Other developments:

  Transverse Asymmetry (A_T)

  Helicity-correlated beam-asymmetry

  Polarized source studies

  Double Wein rotation

  Beam modulation system redesign
- **Goal: Complete all tests and ready to move in the Hall by Jan 2010.**