Polarized Injector Update

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Center for Injectors and Sources

QWeak Collaboration Meeting
July 17-18, 2009
Outline

• Higher Gun Voltage & Inverted Gun
• Two Wien Slow Helicity Reversal
• Fast Helicity Reversal
• Other Improvements
# Upcoming Parity Experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Hall</th>
<th>Start</th>
<th>Energy (GeV)</th>
<th>Current (µA)</th>
<th>Target</th>
<th>$A_{pv}$ (ppm)</th>
<th>Maximum Charge Asym (ppm)</th>
<th>Maximum Position Diff (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAPPEx-III</td>
<td>A</td>
<td>Aug 09</td>
<td>3.484</td>
<td>85</td>
<td>$^1$H</td>
<td>16.9±0.4</td>
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<td>10</td>
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<td>(25 cm)</td>
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<tr>
<td>PVDIS</td>
<td>A</td>
<td>Oct 09</td>
<td>6.068</td>
<td>85</td>
<td>$^2$H</td>
<td>63±3</td>
<td>1</td>
<td>10</td>
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<td>(25 cm)</td>
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<tr>
<td>PREx</td>
<td>A</td>
<td>March 10</td>
<td>1.056</td>
<td>50</td>
<td>$^{208}$Pb</td>
<td>0.500±0.015</td>
<td>0.100±0.010</td>
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<tr>
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<td>(0.5 mm)</td>
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<tr>
<td>QWeak</td>
<td>C</td>
<td>May 10</td>
<td>1.162</td>
<td>180</td>
<td>$^1$H</td>
<td>0.234±0.005</td>
<td>0.100±0.010</td>
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<td>(35 cm)</td>
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<tr>
<td>Achieved</td>
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<td></td>
<td></td>
<td>0.4</td>
<td>1</td>
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</table>
Higher Voltage & Inverted Gun

- Increase gun voltage up to 150 kV to reduce space charge emittance growth at higher bunch charge (higher current)

- Beam quality including transmission improves

- Problem: Field emission at higher voltage degrades lifetime → solution: Inverted Gun
Move away from “conventional” insulator used on all GaAs photo-guns today: expensive, months to build, prone to damage from field emission.
Present Ceramic
Exposed to field emission
Large area
Expensive ($50k)

Medical x-ray technology

New Ceramic
Compact
$5k

Inverted Gun
- Inverted Gun installed on July 14, 2009, beam in two weeks
Two Wien Slow Helicity Reversal

- Insertable Half Wave Plate (IHWP) provides slow helicity reversal of laser polarization:
  1. Cancels Electronic cross talk and Pockels Cell Steering
  2. Residual Linear polarization effects do not cancel
  3. Spot size asymmetry, which we cannot measure, does not cancel

- New: Slow helicity reversal of electron polarization using two Wien Filters and solenoid:
  1. Wien settings constant
  2. Solenoid rotates spin by $\pm 90^\circ$ with $\pm B$ but focuses beam as $B^2$
    - Maintain constant Injector and Accelerator configuration
  3. Cancels all helicity-correlated beam asymmetries from the Injector including spot size
  4. Can be used up to maximum Gun voltage of 140 kV
  5. Will be installed in January 2010
**Spin Flipper**
- Vertical Wien = 90°
- Azimuthal Solenoid = ± 90°

**Long. Pol. for Halls**
- Horizontal Wien = -90° → +90°
Fast Helicity Reversal

- We have been using 30 Hz helicity reversal:
  I. Power line 60 Hz frequency is major source of noise in parity experiments
  II. For 30 Hz reversal, $T_{\text{Stable}} (= 33.333 \text{ ms})$ contains exactly two cycles of 60 Hz line noise $\rightarrow$ this reversal cancels line noise

- Problem:
  - There are other sources of noise at low frequencies, i.e., target density fluctuations, beam current fluctuations
  $\rightarrow$ Cause larger widths of helicity correlated distributions, double-horned distributions

- Solution: Use fast helicity reversal (faster than 30 Hz)
- Studied beam properties at 1 kHz (Oct 2008 – April 2009)
  - Fast reversal of helicity Pockels Cell was possible using new optically-driven fast high voltage switch designed by J. Hansknecht
30 Hz, T_Stable = 33.333 ms, T_Settle = 500 µs

1 kHz, T_Stable = 0.980 ms, T_Settle = 60 µs
Summary of Fast Helicity Reversal Studies

Fast Helicity Reversal is needed:

I. Huge reduction of noise from target density fluctuations
II. Reduces noise on beam current by factor of 4
III. Reasonable reduction in beam position noise

Achieved Pockels Cell T_settle of 60 µs

Future Parity Experiment:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Frequency</th>
<th>Clock</th>
<th>Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAPPEx III &amp; PVDIS</td>
<td>30 Hz</td>
<td>Line-Locked</td>
<td>Quartet</td>
</tr>
<tr>
<td>PREx</td>
<td>240 Hz</td>
<td>Line-Locked</td>
<td>Octet</td>
</tr>
<tr>
<td>QWeak</td>
<td>1 kHz</td>
<td>Free</td>
<td>Quartet</td>
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</tbody>
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New Helicity Board to be installed in July 2009
Other Developments

- **Charge Feedback:** Ability to do Charge Feedback using either Pockels Cell or Intensity Attenuator without or with the option to correct for Pockels Cell hysteresis

- **Helicity Magnets:** Ability to do Position Feedback using the newly commissioned helicity magnets located in the 5 MeV region of the Injector

- **Pockels Cell Motion:** Pockels Cell is equipped with remote controlled x & y translational stage for minimizing position differences while measuring the position differences of electron beam

- **Photocathode Rotation:** With Load-Locked Gun, now we can zero the offset term in the charge asymmetry caused by the vacuum window birefringence by rotating the photocathode