Improvements in Parity Quality Beam

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  II. J. McCarter (University of Virginia): Photocathode Materials
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  II. R. Powell (West Virginia Wesleyan University)
  III. M. Ricketts (Merced Community College, CA)
Outline

• Upcoming Parity Violation Experiments
• Higher Gun Voltage & Inverted Gun for QWeak
• Two Wien Slow Helicity Reversal for PREx
• 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 (25 cm)</td>
<td>16.9±0.4</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>PVDIS</td>
<td>A</td>
<td>Oct 09</td>
<td>6.068</td>
<td>85</td>
<td>$^2$H (25 cm)</td>
<td>63±3</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>PREx</td>
<td>A</td>
<td>March 10</td>
<td>1.056</td>
<td>50</td>
<td>$^{208}$Pb (0.5 mm)</td>
<td>0.500±0.015</td>
<td>0.100±0.010</td>
<td>2</td>
</tr>
<tr>
<td>QWeak</td>
<td>C</td>
<td>May 10</td>
<td>1.162</td>
<td>180</td>
<td>$^1$H (35 cm)</td>
<td>0.234±0.005</td>
<td>0.100±0.010</td>
<td>2</td>
</tr>
<tr>
<td>Achieved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Higher Voltage & Inverted Gun for QWeak

- 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

- Inverted Gun will be installed in July 2009

![Graphs showing Electron Bunchlength vs Gun Voltage and Transmission vs Gun Voltage](image-url)
Want to move away from “conventional” insulator used on all GaAs photo-guns today: expensive, months to build, prone to damage from field emission.
Medical x-ray technology

Present Ceramic
Exposed to field emission
Large area
Expensive ($50k)

New Ceramic
Compact
$5k

Inverted Gun
Two Wien Slow Helicity Reversal for PREx

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

• New: Slow helicity reversal of electron polarization using two Wien Filters and solenoid:
  I. Wien settings constant
  II. Solenoid rotates spin by $90^\circ$ with $B$ but focuses beam as $B^2$
     ➢ Maintain constant Injector and Accelerator configuration
  III. Cancels all helicity-correlated beam asymmetries from the Injector including spot size
  IV. Can be used up to maximum Gun voltage of 140 kV
  V. 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 → this reversal cancels line noise

- **Problem:**
  
  - There are other sources of noise at low frequencies, *i.e.*, target density fluctuations, beam current fluctuations
    → 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 $\mu$s

  ➢ Future Parity Experiment:

<table>
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<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>
</tr>
</tbody>
</table>

  ➢ 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.
Summary

• Jefferson Lab is an ideal place for parity violation experiments

• We are getting better with many improvements in parity quality beam

• Looking forward for even more demanding parity violation experiments at 12 GeV