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# Improvements in Parity Quality Beam

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Center for Injectors and Sources

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# Center for Injectors and Sources

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- **Senior Technical Staff – P. Adderley, J. Hansknecht**
- **Junior Technical Staff – J. Clark**
  
- **PhD Students**
  - I. **J. Dumas (Joseph Fourier University, France): Polarized e+ Source**
  - II. **J. McCarter (University of Virginia): Photocathode Materials**
  - III. **K. Surles-Law (Hampton University, JLab staff): 200 kV Gun**
  
- **ODU Research Experience for Undergraduates (REU)**
  - I. **H. Graffius (West Virginia Wesleyan University)**
  - II. **R. Powell (West Virginia Wesleyan University)**
  - III. **M. Ricketts (Merced Community College, CA)**

# Outline

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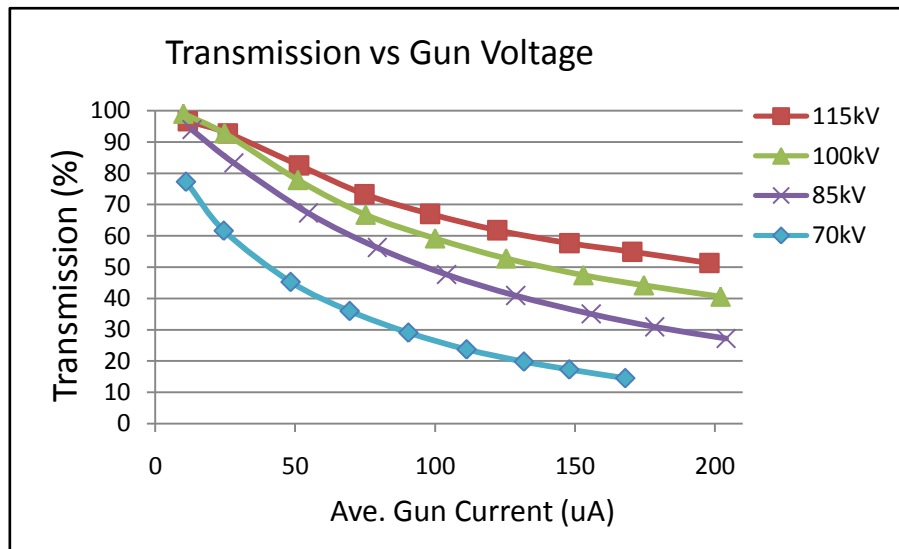
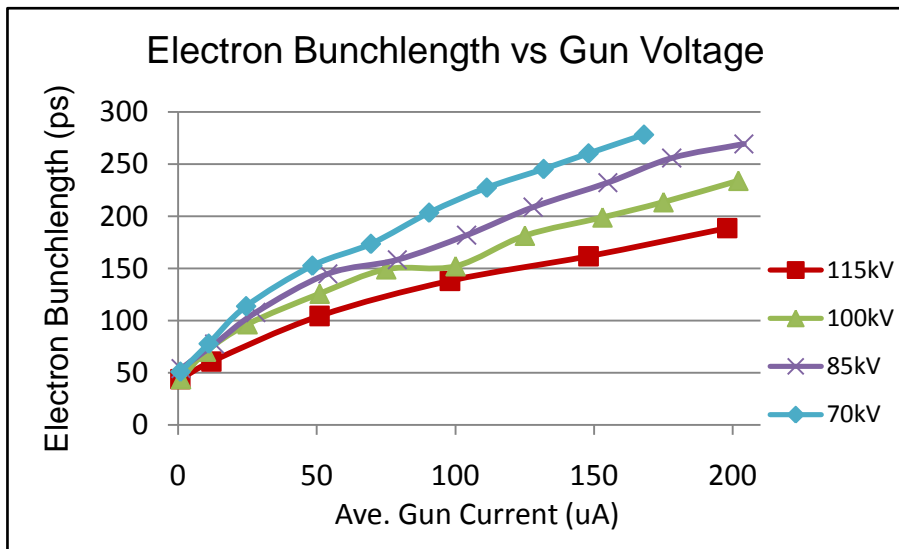
- **Upcoming Parity Violation Experiments**
- **Higher Gun Voltage & Inverted Gun for QWeak**
- **Two Wien Slow Helicity Reversal for PREx**
- **Fast Helicity Reversal**
- **Other Improvements**

# Upcoming Parity Experiments

Experiment	Hall	Start	Energy (GeV)	Current ( $\mu\text{A}$ )	Target	$A_{\text{pv}}$ (ppm)	Maximum Charge Asym (ppm)	Maximum Position Diff (nm)
HAPPEX-III	A	Aug 09	3.484	85	$^1\text{H}$ (25 cm)	$16.9 \pm 0.4$	1	10
PVDIS	A	Oct 09	6.068	85	$^2\text{H}$ (25 cm)	$63 \pm 3$	1	10
PREx	A	March 10	1.056	50	$^{208}\text{Pb}$ (0.5 mm)	$0.500 \pm 0.015$	$0.100 \pm 0.010$	2
QWeak	C	May 10	1.162	180	$^1\text{H}$ (35 cm)	$0.234 \pm 0.005$	$0.100 \pm 0.010$	2
Achieved							0.4	1

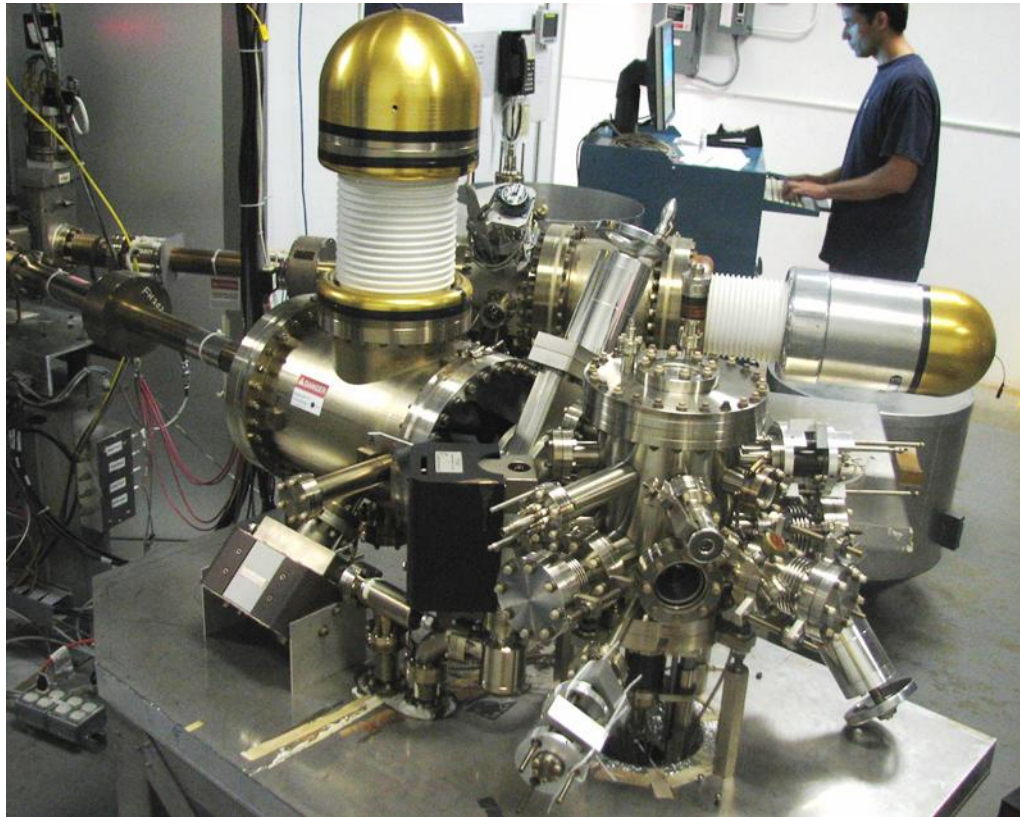
# Higher Voltage & Inverted Gun for QWeak

- 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



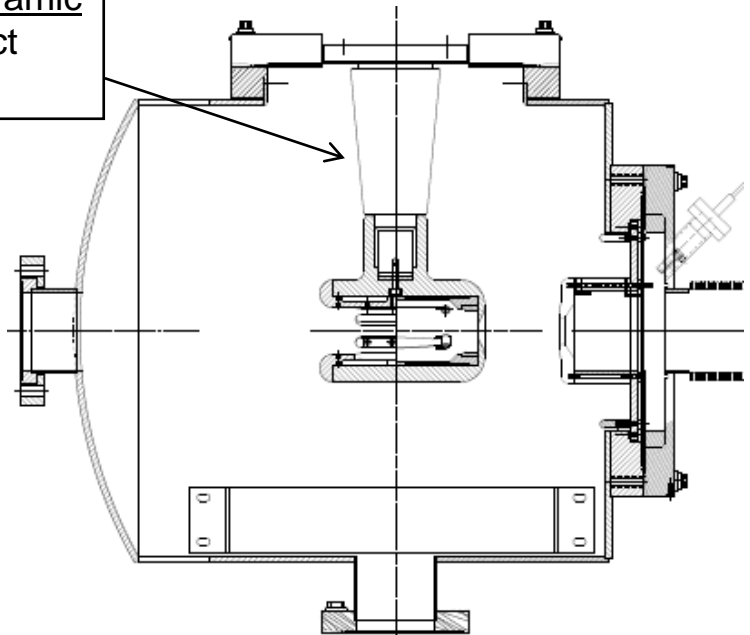
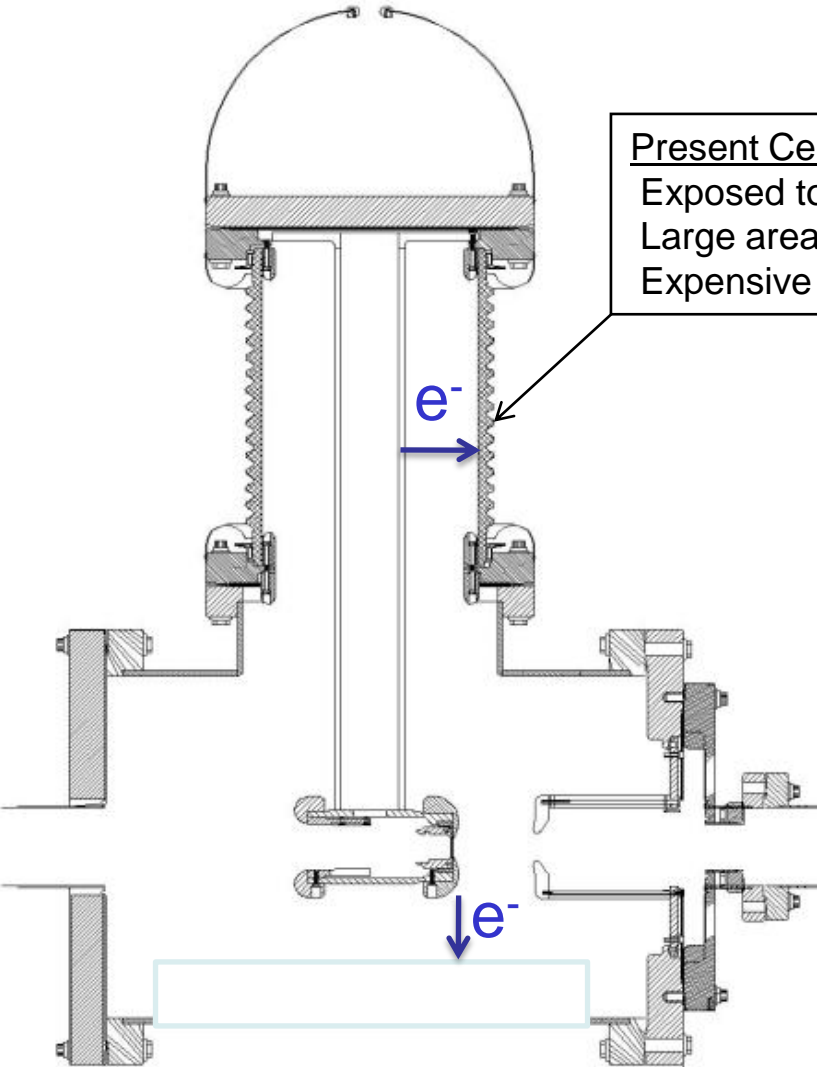
Want to move away from “conventional” insulator used on all GaAs photo-guns today: expensive, months to build, prone to damage from field emission.

Medical x-ray  
technology



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

New Ceramic  
Compact  
\$5k





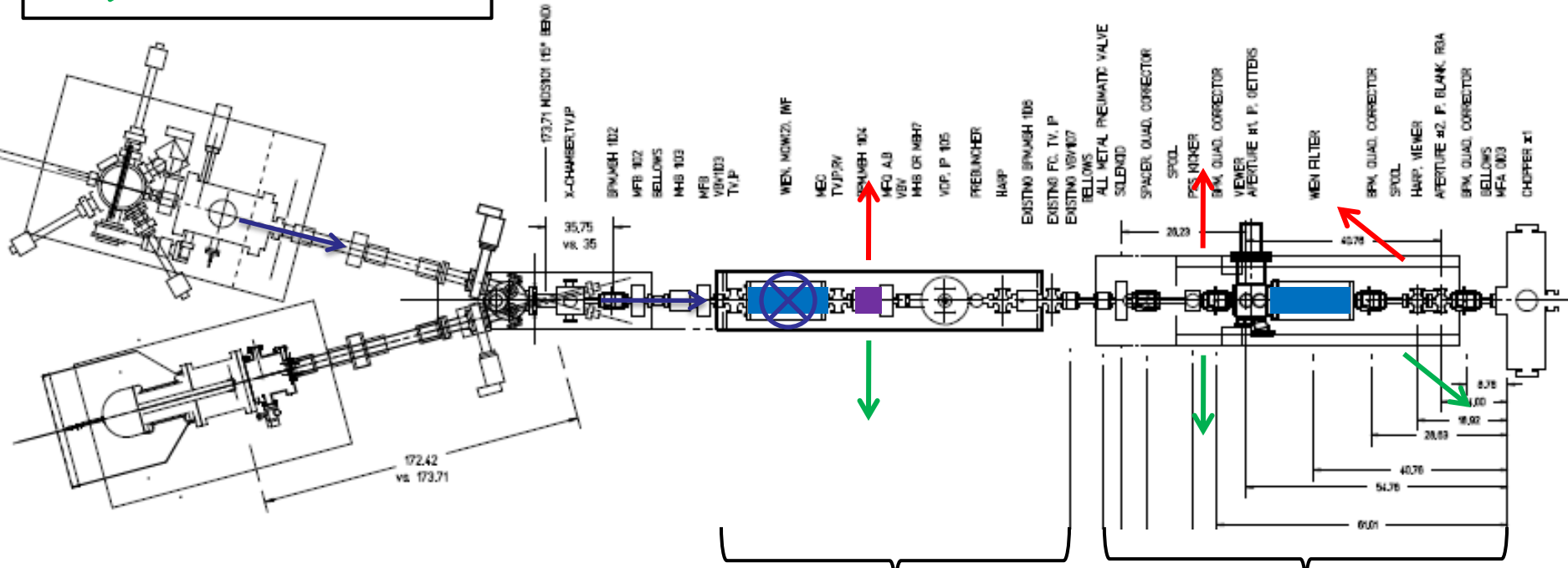
Inverted Gun

# Two Wien Slow Helicity Reversal for PReX

- **Insertable Half Wave Plate (IHP) 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**



 + Solenoid current  
 - Solenoid current

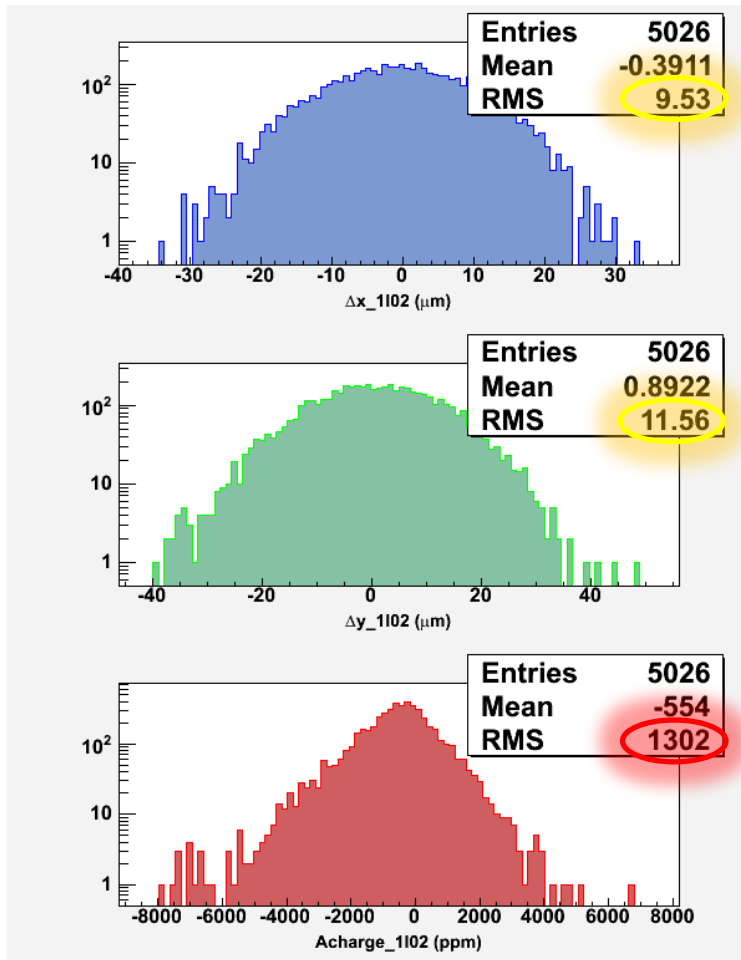


“Spin Flipper”  
 Vertical Wien =  $90^\circ$   
 Azimuthal Solenoid =  $\pm 90^\circ$

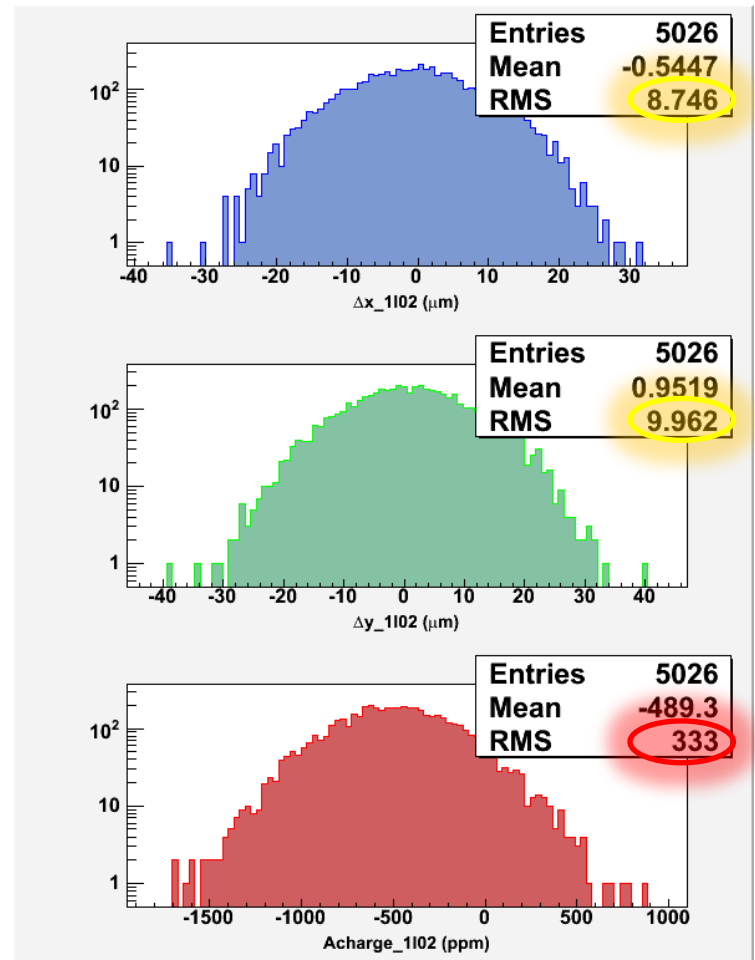
“Long. Pol. for Halls”  
 Horizontal Wien =  $-90^\circ \rightarrow +90^\circ$

# 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 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,  $T_{\text{Stable}} = 33.333$  ms,  
 $T_{\text{Settle}} = 500$   $\mu\text{s}$



1 kHz,  $T_{\text{Stable}} = 0.980$  ms,  
 $T_{\text{Settle}} = 60$   $\mu\text{s}$

## • 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:

Experiment	Frequency	Clock	Pattern
HAPPEX III & PVDIS	30 Hz	Line-Locked	Quartet
PREx	240 Hz	Line-Locked	Octet
QWeak	1 kHz	Free	Quartet

### ➤ 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

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- **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**