
Polarized Injector Update

Riad Suleiman
Center for Injectors and Sources

QWeak Collaboration Meeting
July 17-18, 2009

Outline

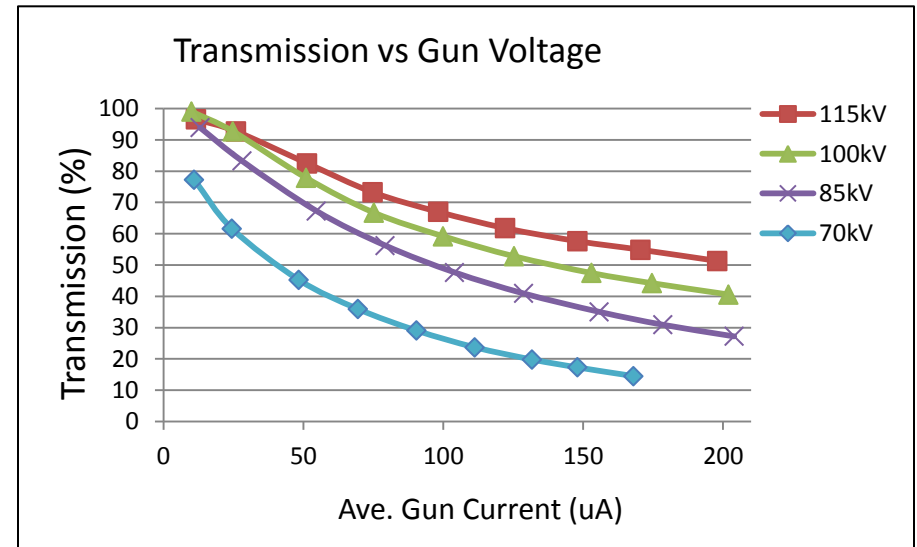
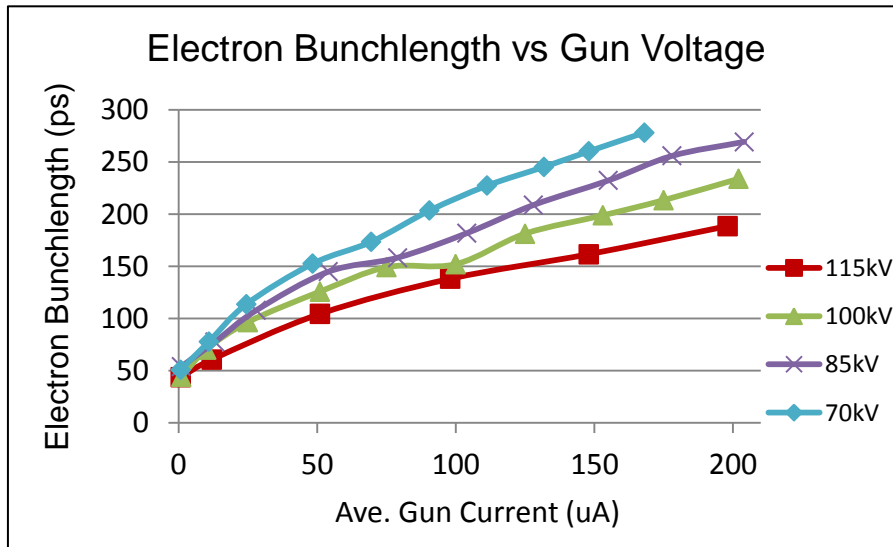
- Higher Gun Voltage & Inverted Gun
- Two Wien Slow Helicity Reversal
- Fast Helicity Reversal
- Other Improvements

Upcoming Parity Experiments

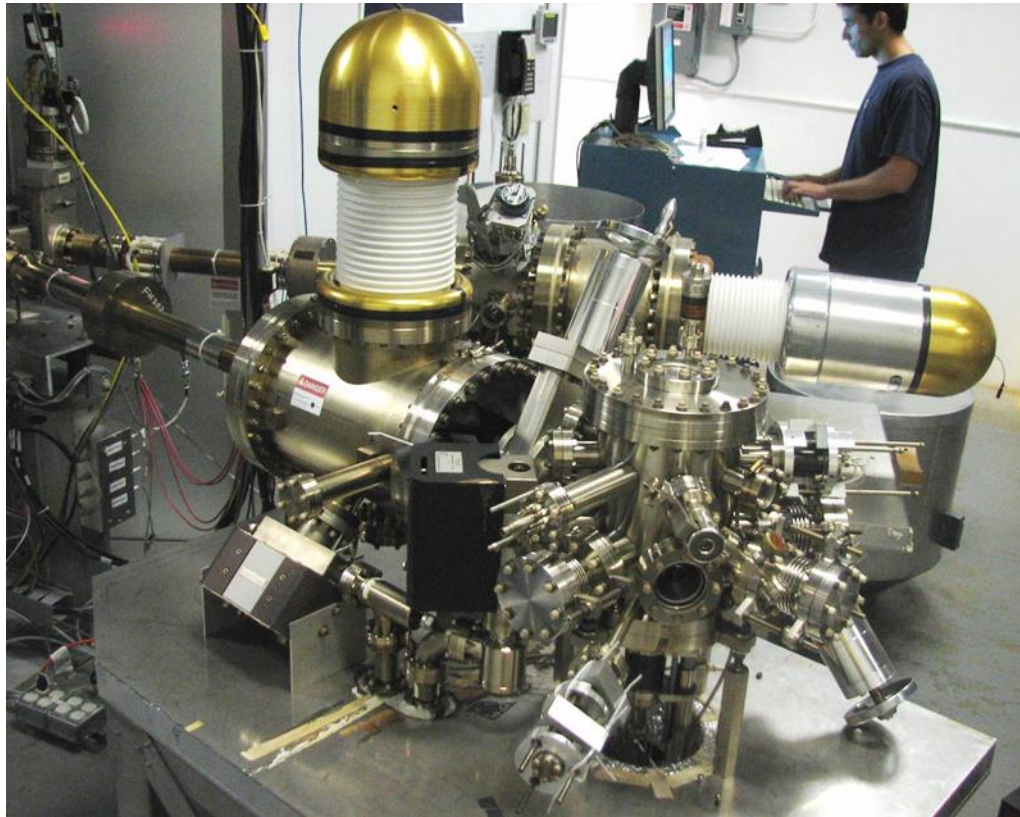
Experiment	Hall	Start	Energy (GeV)	Current (μA)	Target	A_{pv} (ppm)	Maximum Charge Asym (ppm)	Maximum Position Diff (nm)
HAPPEX-III	A	Aug 09	3.484	85	^1H (25 cm)	16.9 ± 0.4	1	10
PVDIS	A	Oct 09	6.068	85	^2H (25 cm)	63 ± 3	1	10
PREx	A	March 10	1.056	50	^{208}Pb (0.5 mm)	0.500 ± 0.015	0.100 ± 0.010	2
QWeak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

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



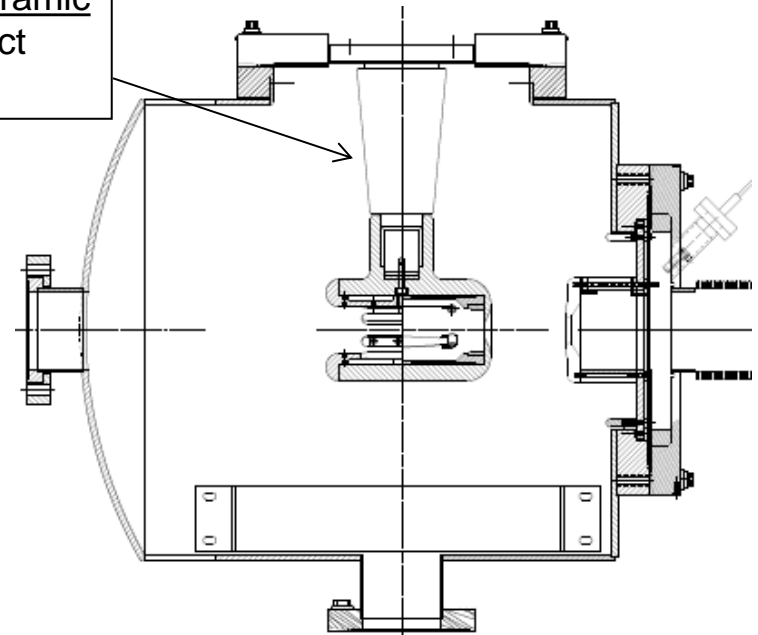
Move away from “conventional” insulator used on all GaAs photo-guns today: expensive, months to build, prone to damage from field emission.

Medical x-ray
technology

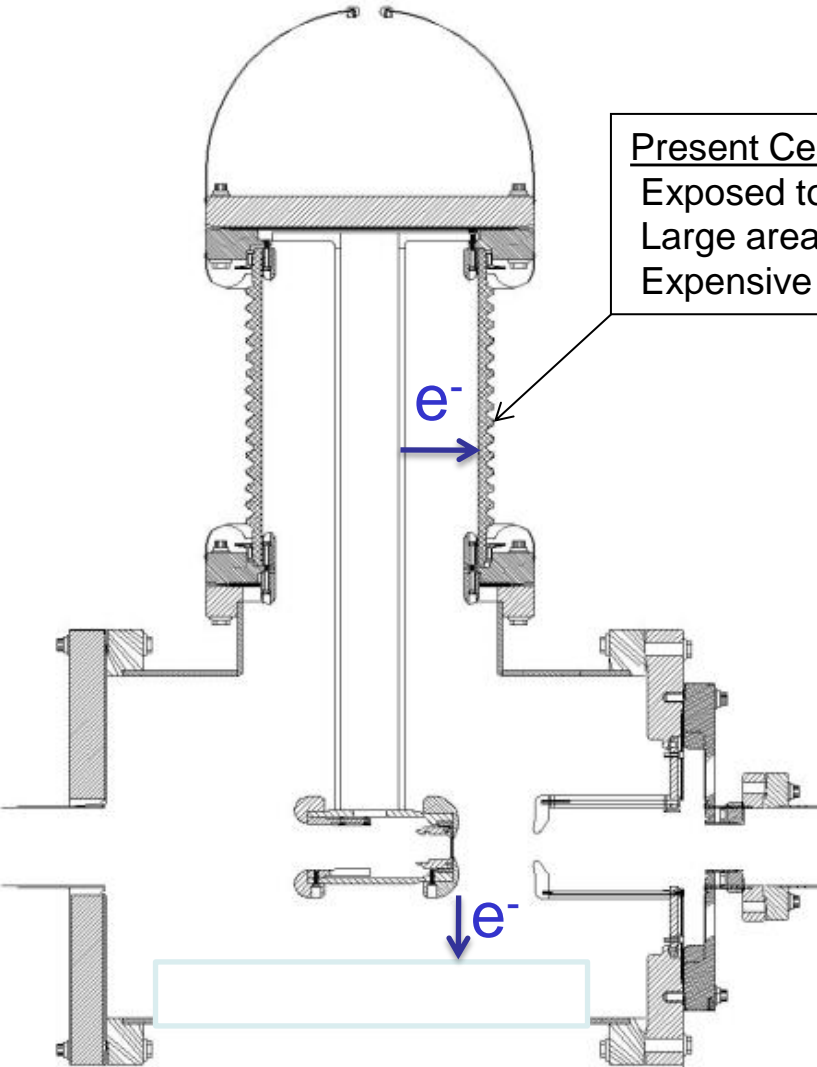


Present Ceramic
Exposed to field emission
Large area
Expensive (\$50k)

New Ceramic
Compact
\$5k



Inverted Gun





- Inverted Gun installed on July 14, 2009, beam in two weeks

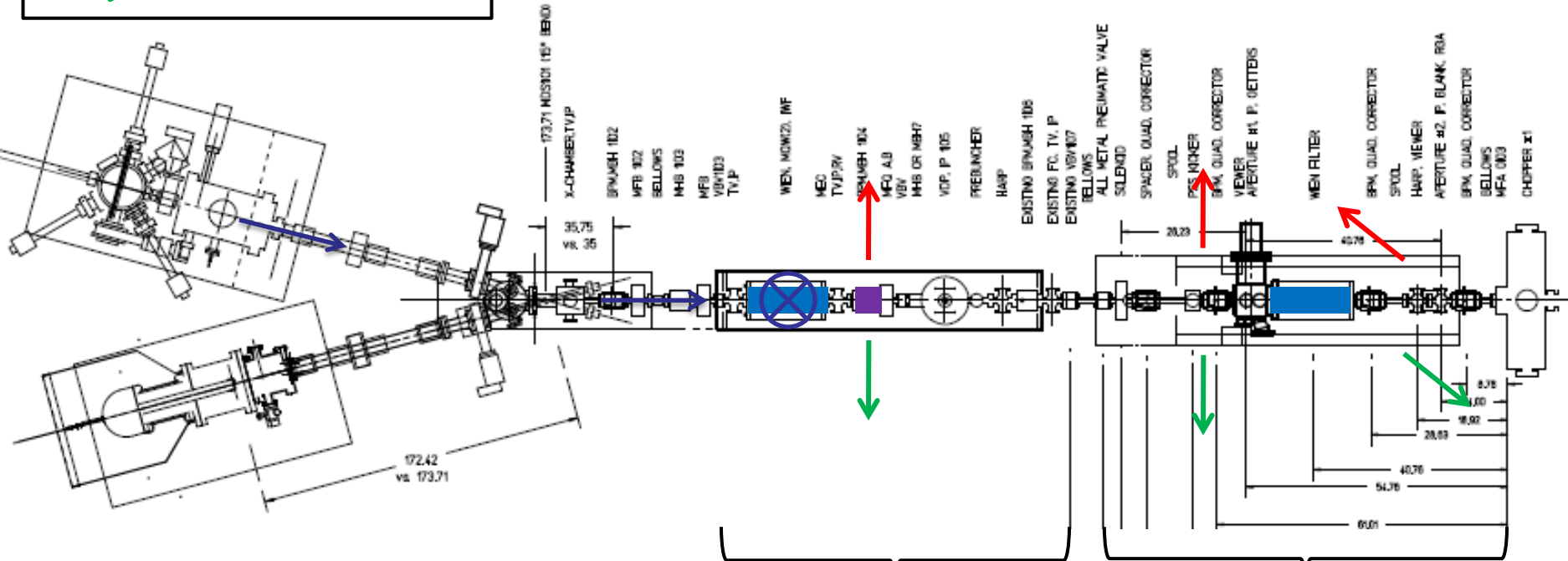


Two Wien Slow Helicity Reversal

- **Insertable Half Wave Plate (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 $\pm 90^\circ$ with $\pm B$ 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

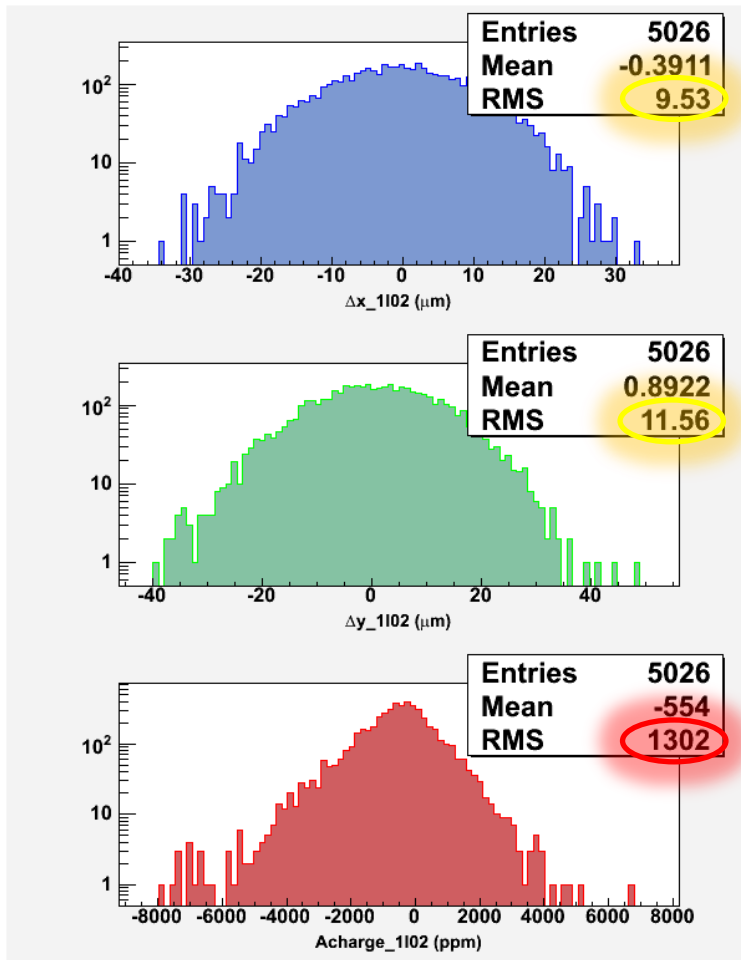


“Spin Flipper”
Vertical Wien = 90°
Azimuthal Solenoid = $\pm 90^\circ$

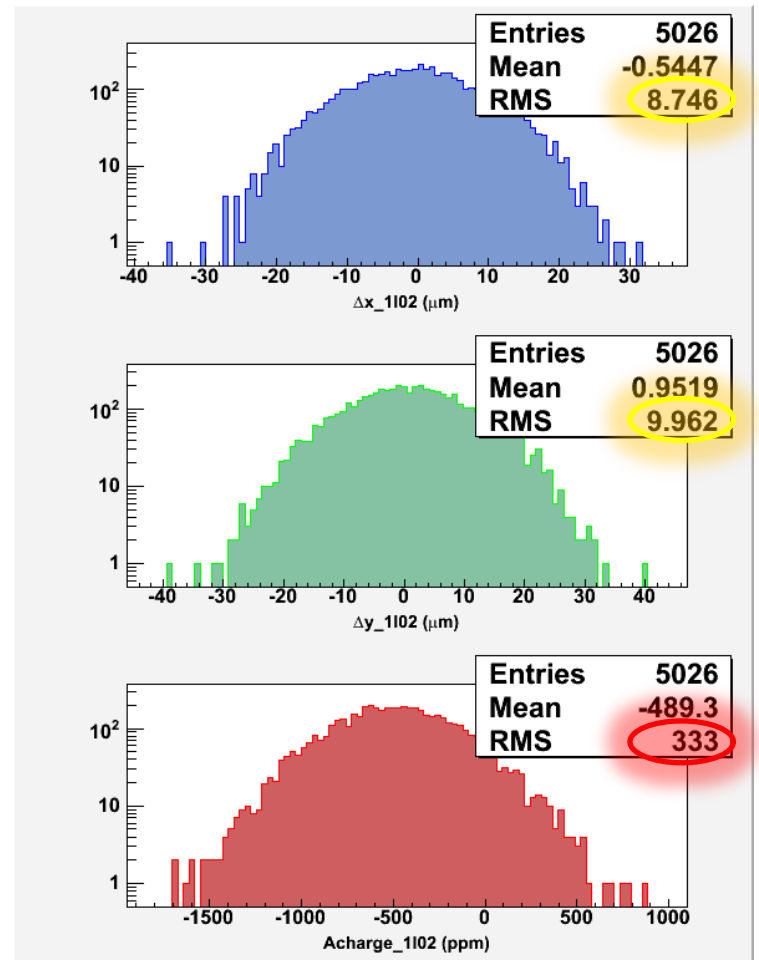
“Long. Pol. for Halls”
Horizontal Wien = $-90^\circ \rightarrow +90^\circ$

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_{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,
 $T_{\text{Settle}} = 500$ μs



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