Beam Studies of Helicity-Correlated Systematics

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Required Precision

HAPPEX-II: expected asymmetry 1.3 ppm $\pm$ 4.6%

$\Longrightarrow$ 60 ppb statistical precision

HAPPEX-He: $\sim$ 200 ppb

$< A_Q >$: 600 $\pm$ 18 ppb

$< \Delta x >$: 1.5 $\pm$ .15 nm

$\Longrightarrow\ \sigma_{\Delta x} < 6.5 \mu m$

To avoid higher order effects, keep corrections small:
($A_Q < 100$ ppm, $\Delta x < 100$ nm).

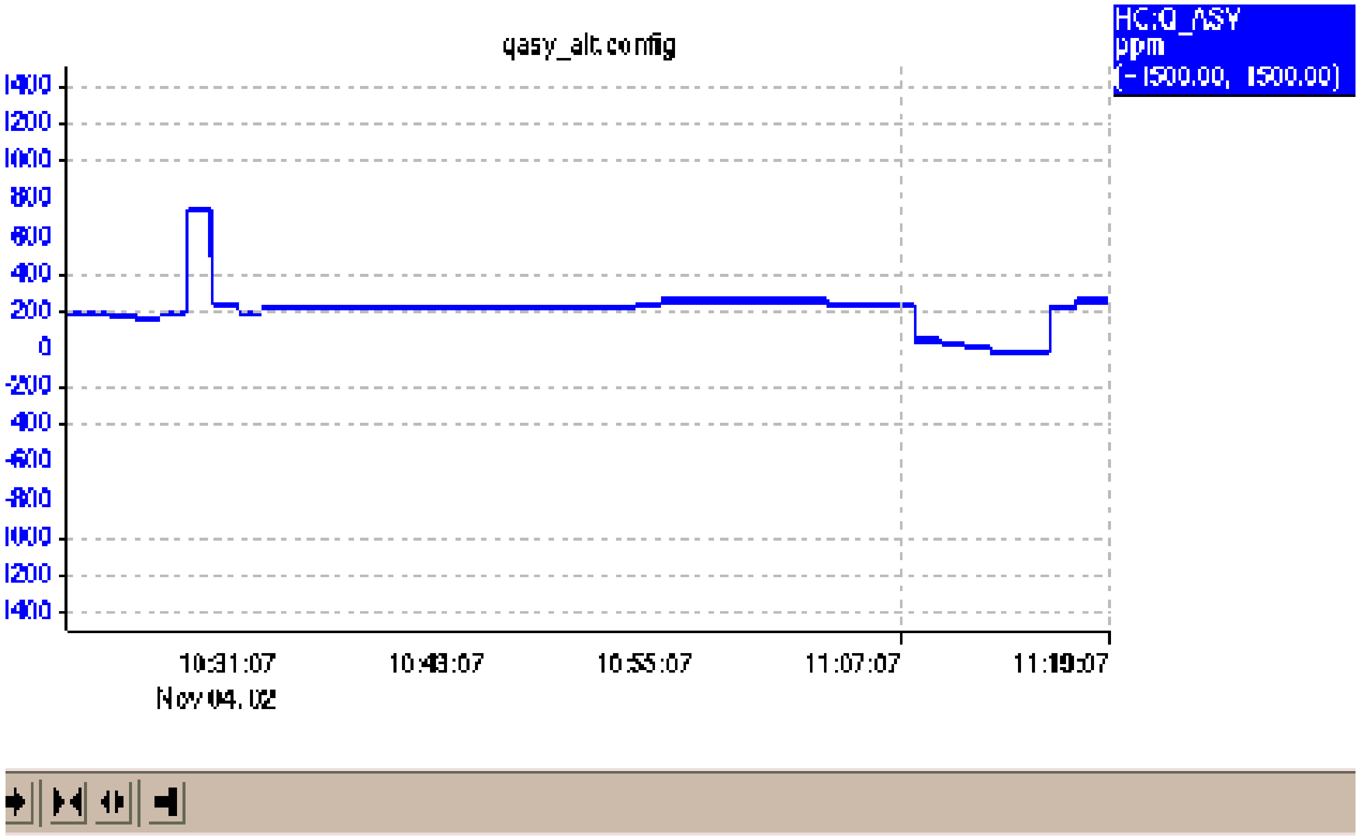
Catalog of tests

- June- dedicated and parasitic, 770 nm diode, Hall A & injector
  - Halfwave Plate Scan
  - IA, PZT studies
  - IA feedback
  - Forced gain on bpms
- September- parasitic with G0 tests, Tiger laser, injector only.
- October - parasitic, 840 nm diode, Hall A only.
  - IA, PZT studies
  - IA feedback
- November - parasitic, 770 nm diode, Hall A only.

- G0 tests: regularly during summer and autumn with MD, FacDev, and G0 commissioning run.

Charge Asymmetry in Hall C, CP Pockels Cell OFF

- ~ 300 ppm charge asymmetry measured in Hall C by the G0 collaboration with the CP Pockels cell OFF.
- This charge asymmetry vanished when in-time helicity electrical signals to DAQs (HAPPEX, G0, and Mott) in the injector region were removed, November 4.
- HAPPEX and G0 injector DAQs now served with delayed helicity via fiber.
- Mott will require in-time helicity. It is proposed that it will not receive the in-time helicity signal unless a Mott measurement is in progress, which is destructive on the beam.



BPM: Forced Gain or Auto Gain?

Forced Gain may be difficult: variations in “intrinsic” BPM gain requires distinct gain settings for each BPM, which is not allowed in the present software.

- Pedestals are more difficult to measure with Autogain

- Pedestal drift between pedestal measurements
- Pedestal changes due to difference in beam current

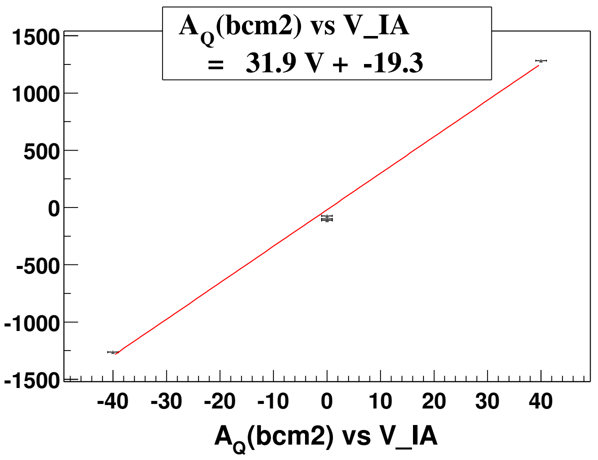
- Is there another mechanism for systematic error due to Autogain?

Intensity Attenuator System

- Intensity Attenuator (IA) Pockels cell: low voltage Pockels cell and $\lambda/10$ waveplate sandwiched between linear polarizers. Helicity correlated control of Pockels cell voltage provides control of charge asymmetry.

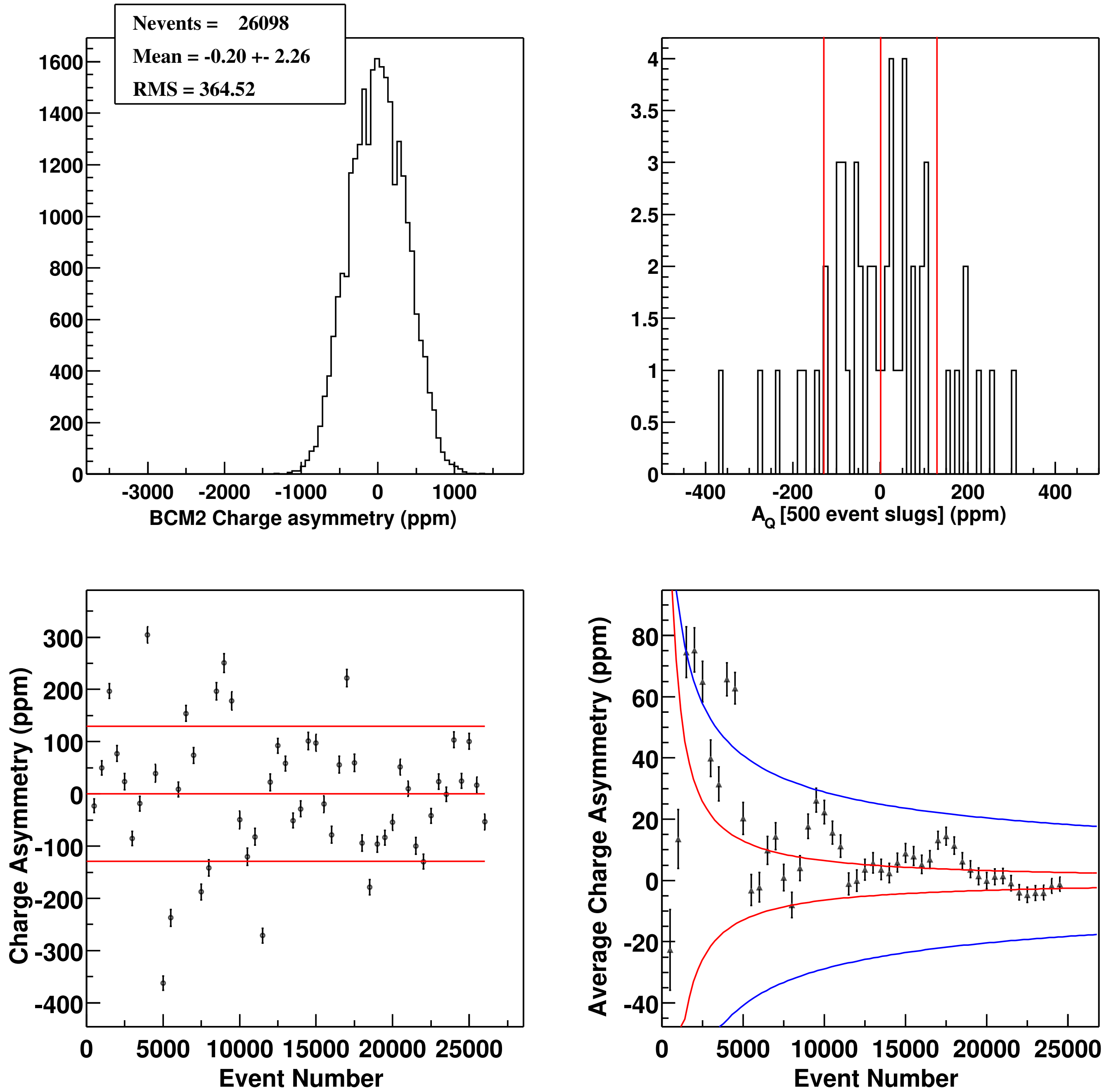
- One helicity state receives voltage on the Pockels cell from ± 50 V. At 0 Volts, the cell is inactive, with no difference between the two helicity states.

- Stable in all tests (30 ppm/Volt).



- This is a "Brute force" method which does not correct the underlying cause. To be coupled with "PITA" feedback (HAPPEX-style correction of polarization Pockels cell high-voltage setpoints) to limit the size of IA corrections.

IA feedback



Nevents = 26098
Mean = -0.20 +- 2.26
RMS = 364.52
BCM2 Charge asymmetry (ppm)
A_Q [500 event slugs] (ppm)
Charge Asymmetry (ppm)
Event Number
Average Charge Asymmetry (ppm)
Event Number

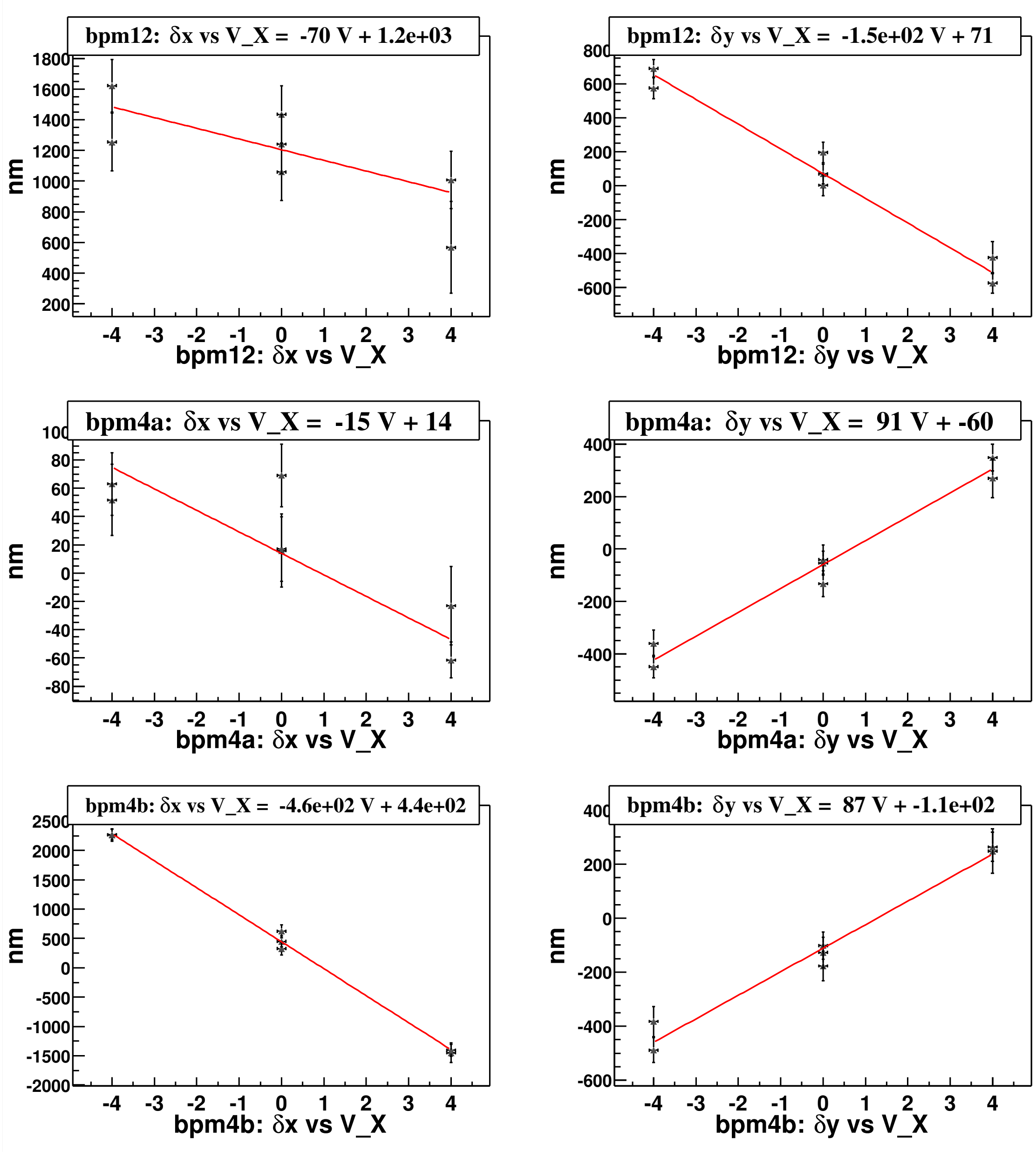
PZT mirror

PZT mirror system: piezo-electric actuated mirror deflects source laser to counteract helicity-correlated position differences.

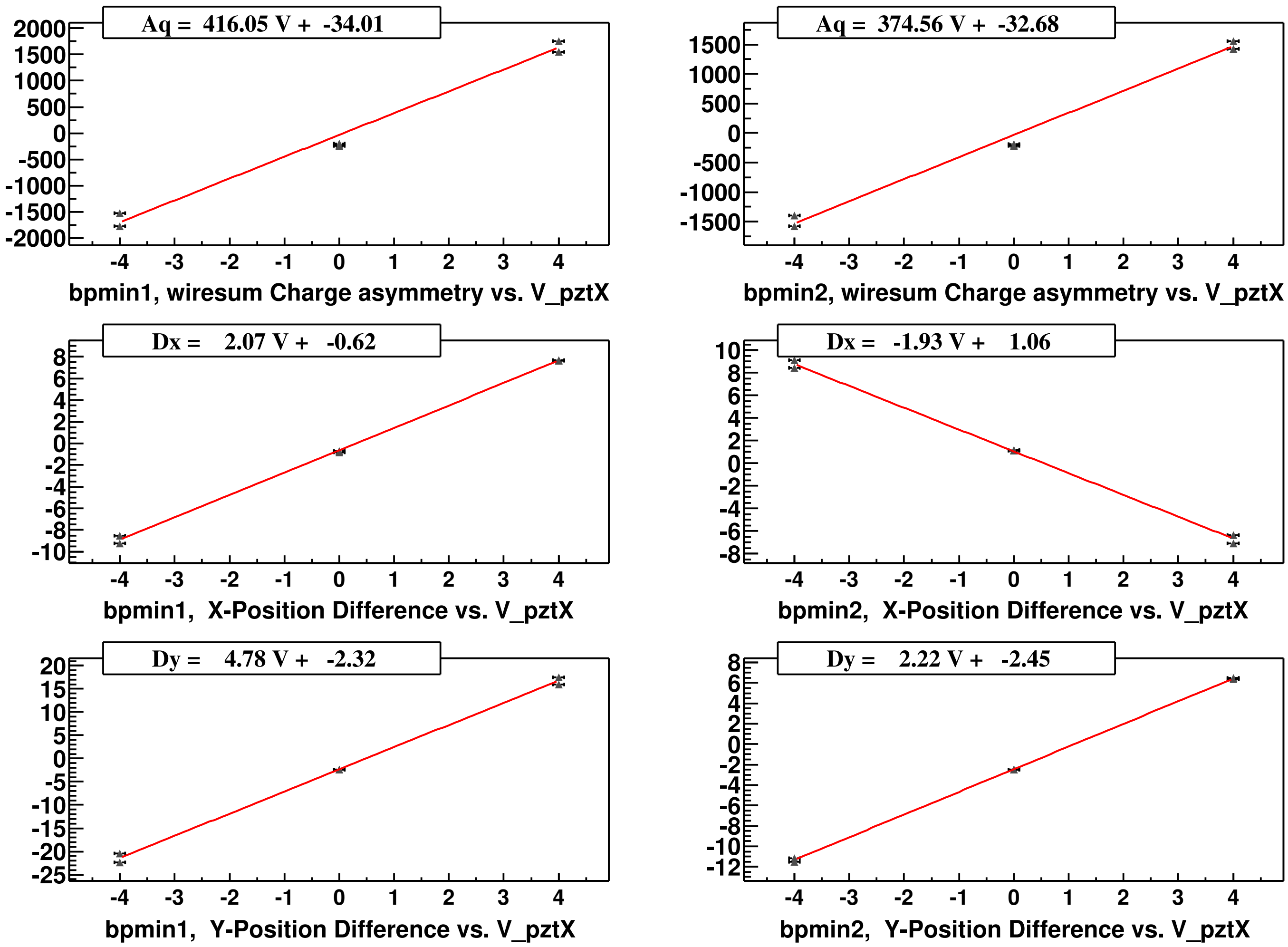
Similar system used at SAMPLE and E158

- Tests showed a reasonable stability over 12 hours (but not longer).
- Comparison of injector and Hall A BPMs give insight to adiabatic damping, although interpretation is clouded by the unknown beta functions at the BPMs.
- Important result: large coupling to A_Q

PZT X, Hall A BPMs



PZT X, Injector BPMs

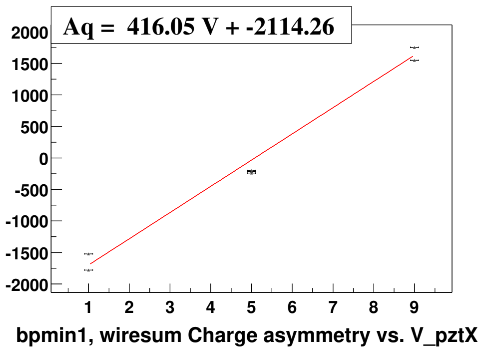


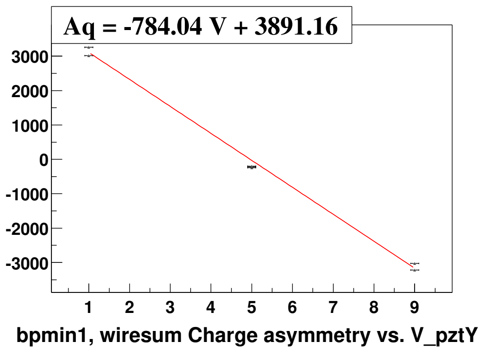
PZT coupling to A_Q

-Using a rough estimate of the movement of the laser spot on the cathode, the coupling is $\sim$ 20 ppm/ μm

- In the injector, the coupling is $\sim$.3 ppm/nm

- In Hall A, the coupling is $\sim$ 1 ppm/nm



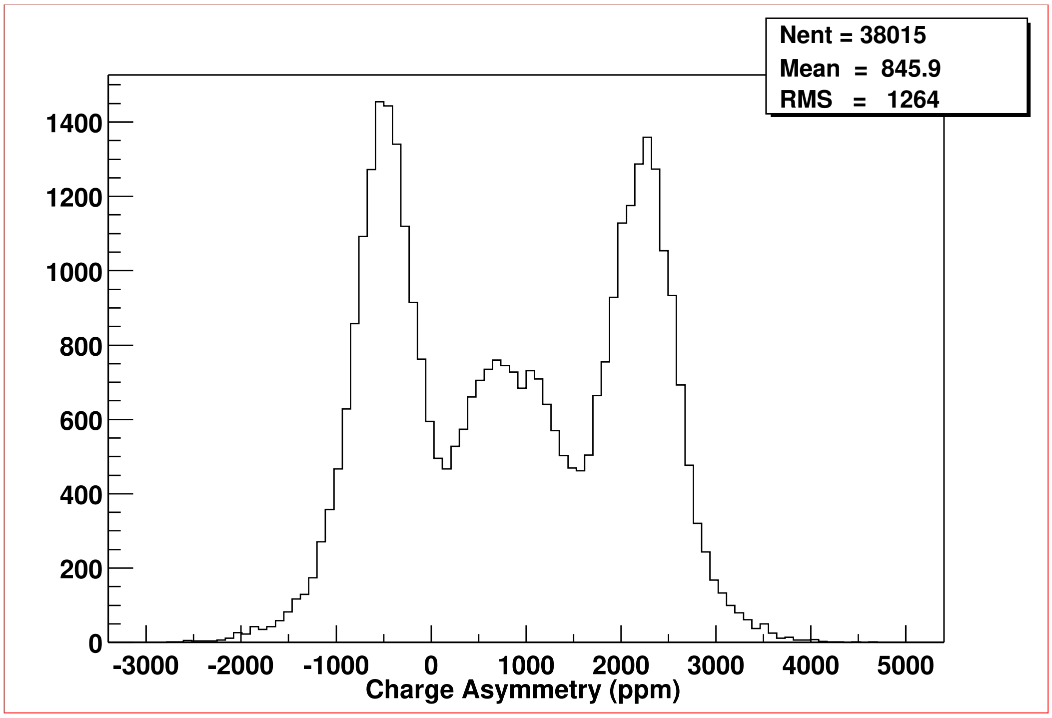


Possible Causes

- Clipping on injector aperture
- Quantum-efficiency “hole” on the cathode
- Phase gradients in the Pockels cell.

Multipeaking A_Q

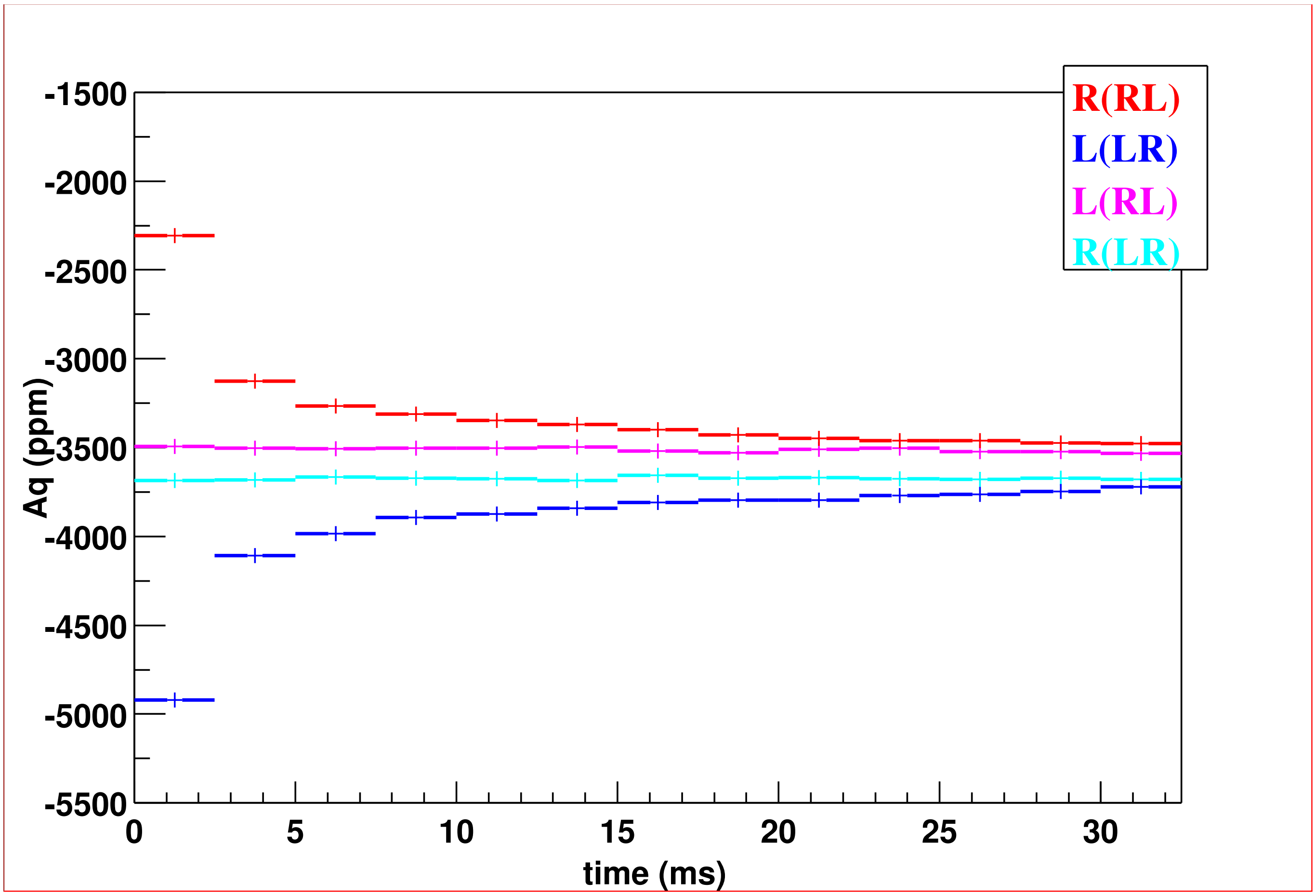
Similar to what was seen in HAPPEX, a multipeaked charge asymmetry distribution indicated a time-history effect in charge asymmetry.



Charge Asymmetry, Oct 13: High-polarization source in Hall A.

Charge Asymmetry in Hall A BCM1, versus time after trigger (November).

- Large splitting caused by "asymmetric" pairs (L-LR, R-RL). This is consistent with a long settle time on the Pockels cell high voltage or other switching effects such as ringing vibrational modes from piezo-electric induced mechanical shock.
- According to the source group, this effect is seen at the power supply using a scope. John Hansknecht also reports a different average voltage in each window for the same power supply setting when flipping at 15 HZ (instead of 30 Hz).
- Oversample=13, IT = 2.5 ms.
- No explanation has been offered for the difference in the "symmetric" pairs (R-LR and L-RL).
- Data from the "low-polarization" source
- Data taken after the in-time helicity signals in the injector region were disconnected. There is no information with the high-polarization source with those signals disconnected.



Effect of (asymmetric) switching

If the BCM signal does not sample the same events as the detector signal, a significantly asymmetric time-dependence can enter as a systematic error in the charge asymmetry correction.

The time difference between the BCM and detector was estimated at $20\mu s$ during HAPPEX using pulsed beam.

$$\delta A_Q = m_p \left[\left(V^R_{\text{t=0}} - V^R_{\text{t=33}} \right) + \left(V^L_{\text{t=0}} - V^L_{\text{t=33}} \right) \right] \frac{\delta t}{33.333 \text{ ms}}$$

δA_Q	=	systematic error in A_Q
m_p	=	Pita Slope, $\sim$ 50 ppm/V
δt	=	offset between signal arrival times

If $\delta t \sim 20\mu$s and $\left(V^R_{\text{t=0}} - V^R_{\text{t=33}} \right) + \left(V^L_{\text{t=0}} - V^L_{\text{t=33}} \right) =$1.5 V,
$\rightarrow \delta A_Q \sim 50$ ppb

Immediate Future

- Provide A_Q feedback for Spin Duality and Small-Angle GDH.
  - Ideally, dual-feedback (IA + PITA) to keep a well-groomed source.
  - Practice run for HAPPEX, testing feedback, online monitoring and prompt analysis software and procedures.
  - Test of EPICS interface to feedback devices.
  - Possible parasitic tests of PZT system.
- Take advantage of any Fac Dev time available
- Follow G0 tests, and participate when appropriate