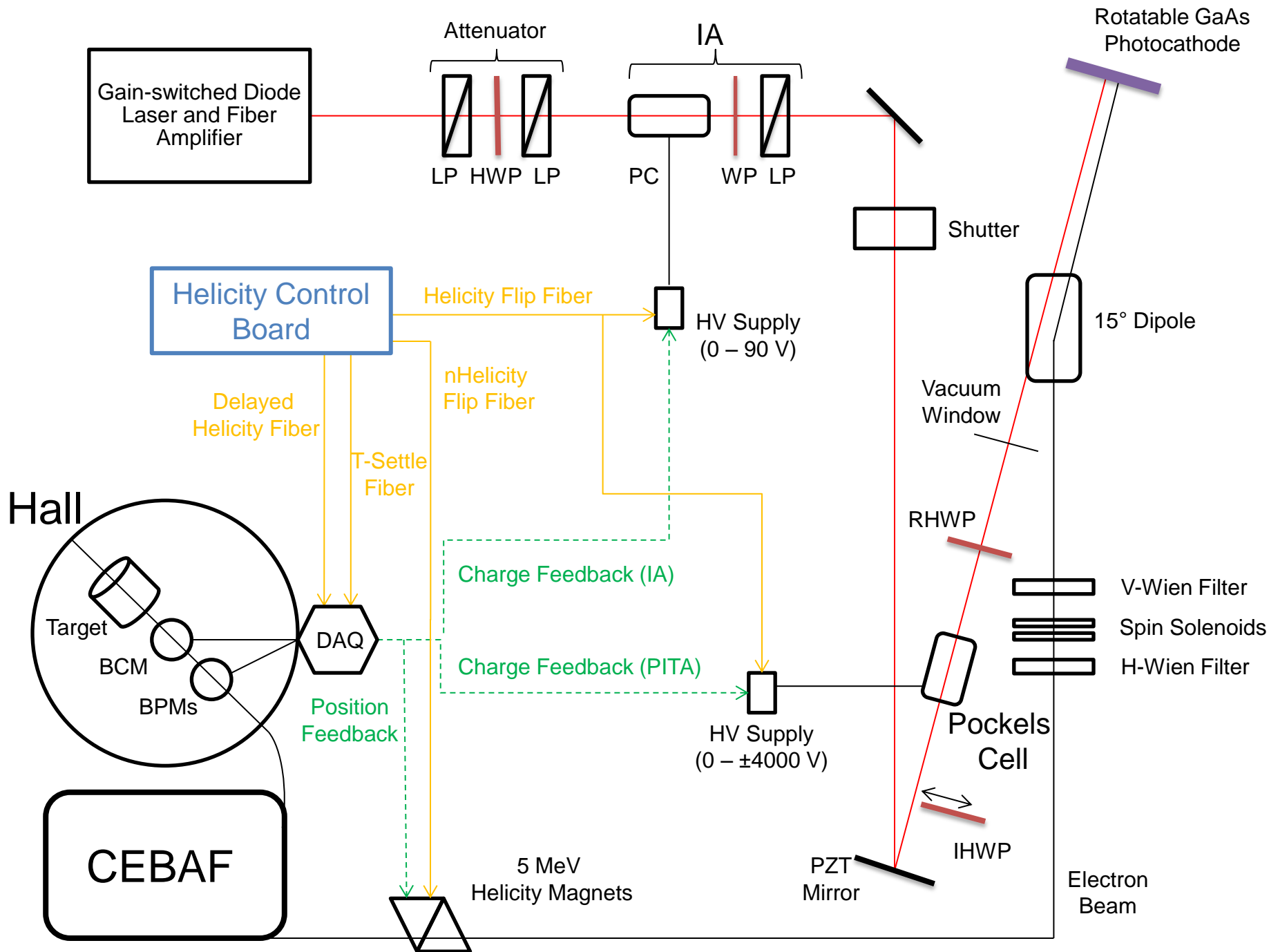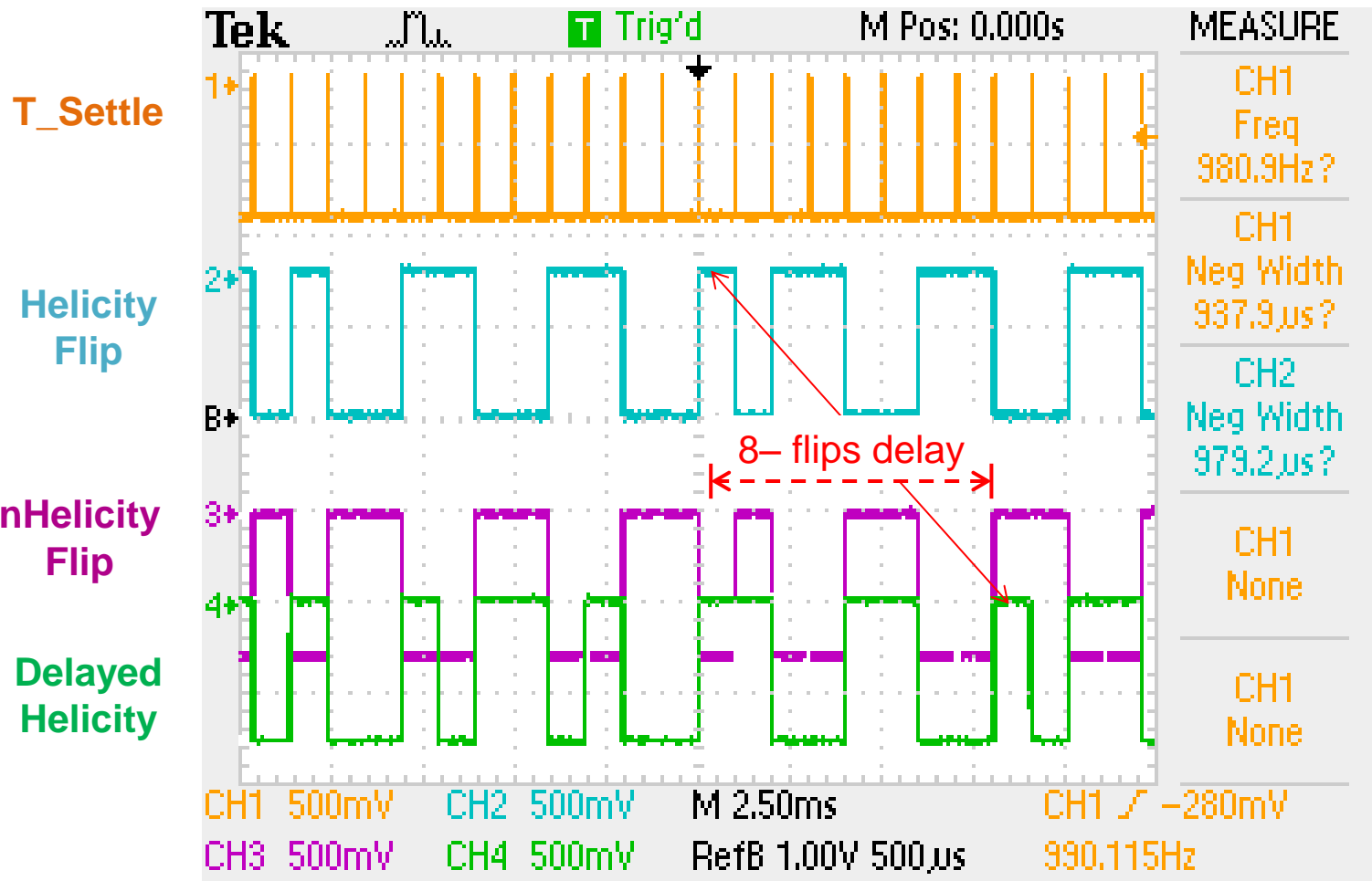# Parity Experiments and JLab Injector

Riad Suleiman

February 5, 2016

Experiment	Energy (GeV)	Pol (%)	I (μA)	Target	A_{pv} (ppb)	Charge Asym (ppb)	Position Diff (nm)	Angle Diff (nrad)	Size Diff ($\delta\sigma/\sigma$)
HAPPEx-I (Achieved)	3.3	38.8 68.8	100 40	^{1}H (15 cm)	15,050	200	12	3	
G0-Forward (Achieved)	3.0	73.7	40	^{1}H (20 cm)	3,000-40,000	300±300	7±4	3±1	
HAPPEx-II (Achieved)	3.0	87.1	55	^{1}H (20 cm)	1,580	400	2	0.2	
HAPPEx-III (Achieved)	3.484	89.4	100	^{1}H (25 cm)	23,800	200±10	3	0.5±0.1	10^{-3}
PREx-I (Achieved)	1.056	89.2	70	^{208}Pb (0.5 mm)	657±60	85±1	4	1	10^{-4}
QWeak-I (Achieved)	1.155	89.0	180	^{1}H (35 cm)	281±46	8±15	5±1	0.1±0.02	10^{-4}
QWeak	1.162	90	180	^{1}H (35 cm)	234±5	<100±10	<2±1	<30±3	$<10^{-4}$
PREx-II	1.0	90	70	^{208}Pb (0.5mm)	500±15	<100±10	<1±1	<0.3±0.1	$<10^{-4}$
MOLLER	11.0	90	85	^{1}H (150 cm)	35.6±0.74	<10±10	<0.5±0.5	<0.05±0.05	$<10^{-4}$

Gain-switched Diode Laser and Fiber Amplifier

Attenuator

LP HWP LP

IA

PC WP LP

Rotatable GaAs Photocathode

Shutter

15° Dipole

Helicity Control Board

Helicity Flip Fiber

HV Supply (0 – 90 V)

Delayed Helicity Fiber

nHelicity Flip Fiber

T-Settle Fiber

Vacuum Window

RHWP

Charge Feedback (IA)

Hall

Target

BCM

BPMs

DAQ

Charge Feedback (PITA)

V-Wien Filter

Spin Solenoids

H-Wien Filter

Position Feedback

HV Supply (0 – ±4000 V)

Pockels Cell
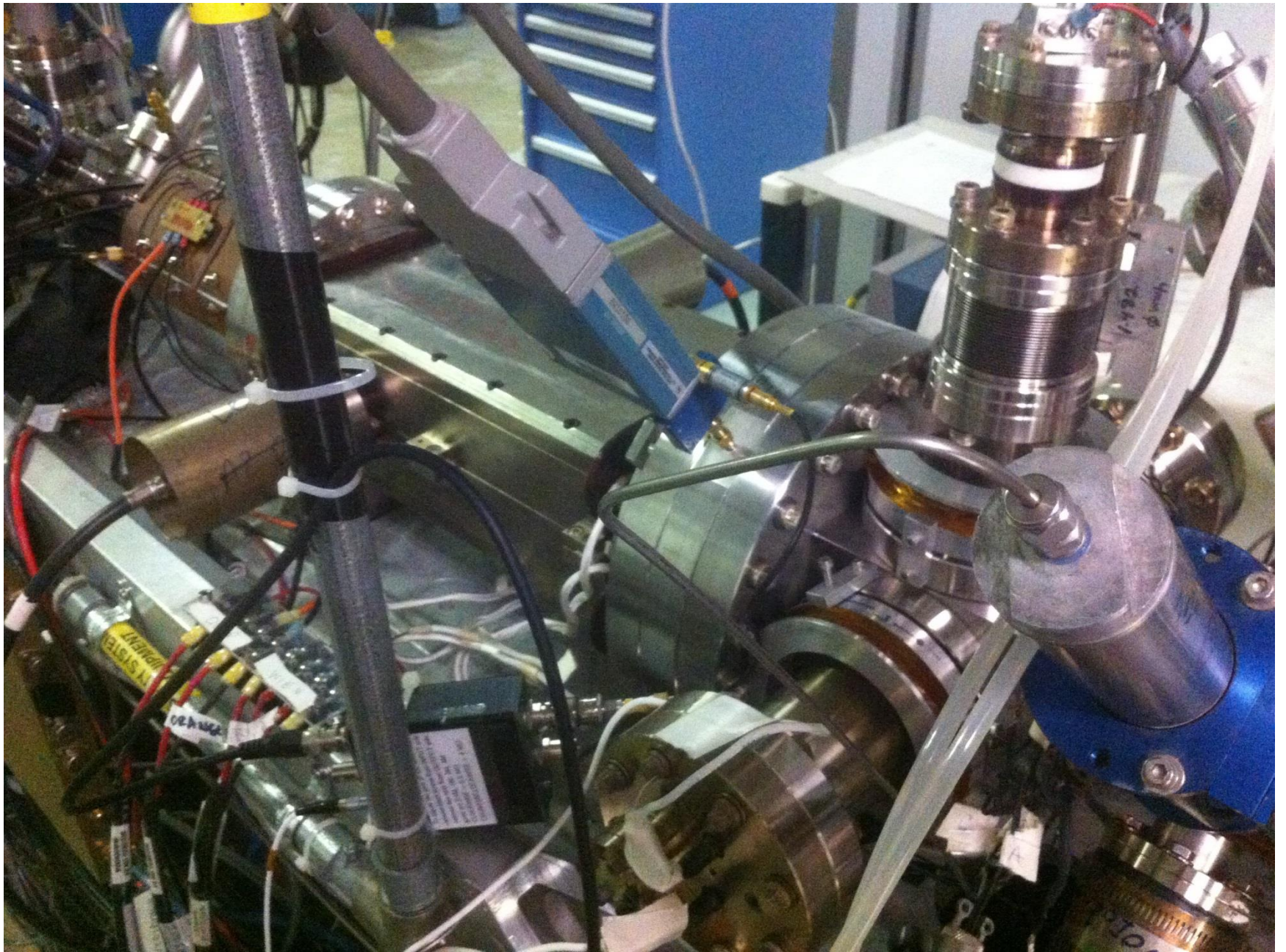
CEBAF

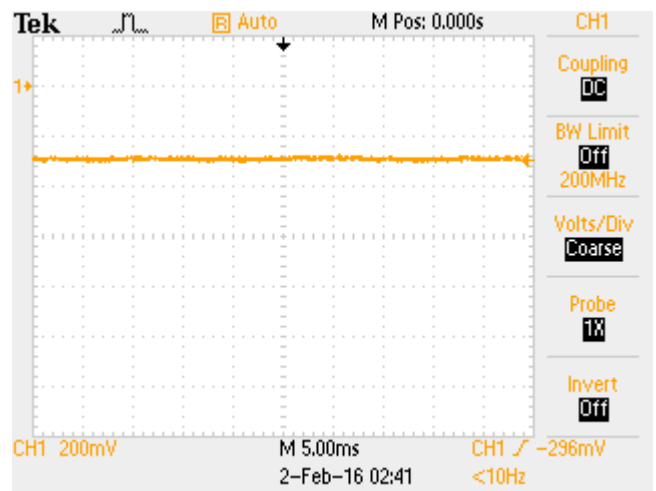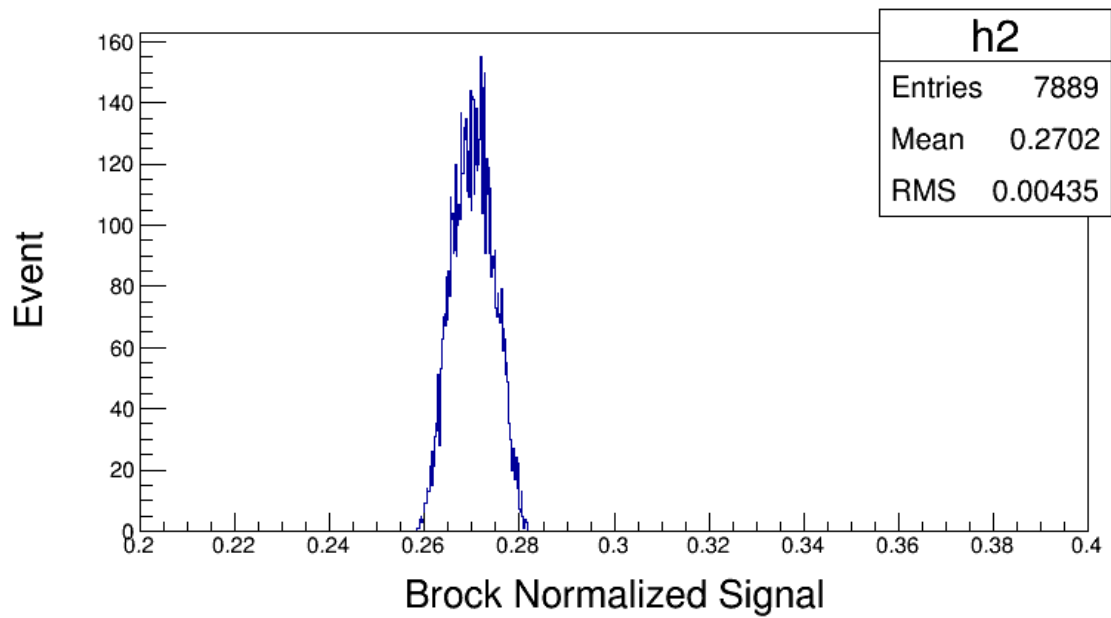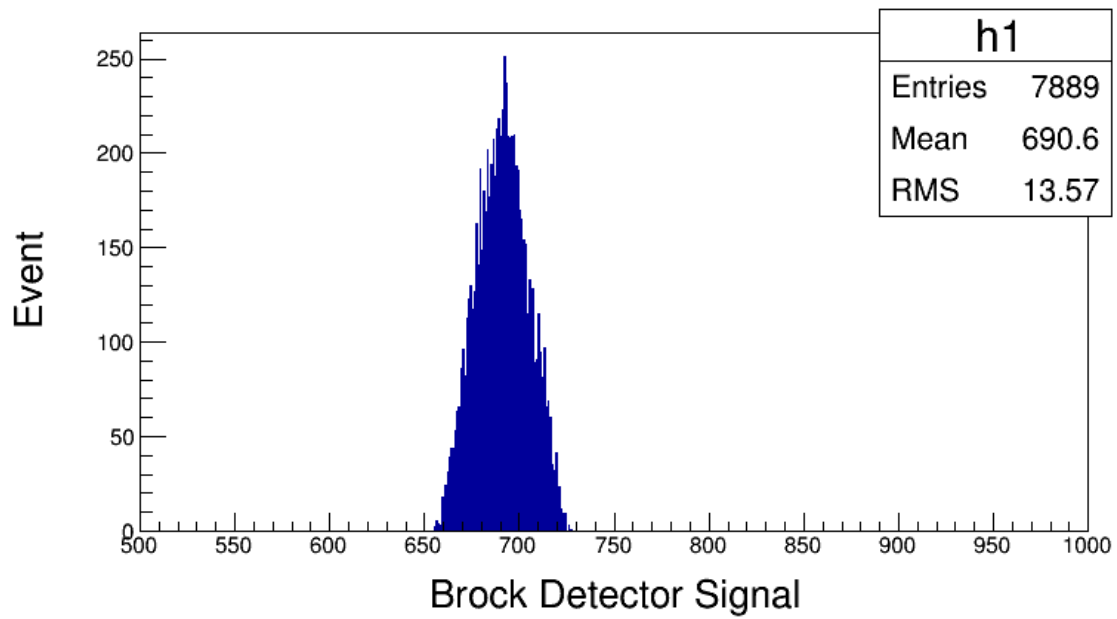5 MeV Helicity Magnets

PZT Mirror

IHWP

Electron Beam

- ## How to carry out a parity violation experiment:
  - Scatter longitudinally polarized electrons off un-polarized target (i.e., Hydrogen, Deuterium, Helium, Lead)
  - Reverse the beam helicity (±) with Pockels Cell, measure detected signals ($D^\pm$) and currents ($I^\pm$), calculate physics asymmetry ($A_{physics}$):
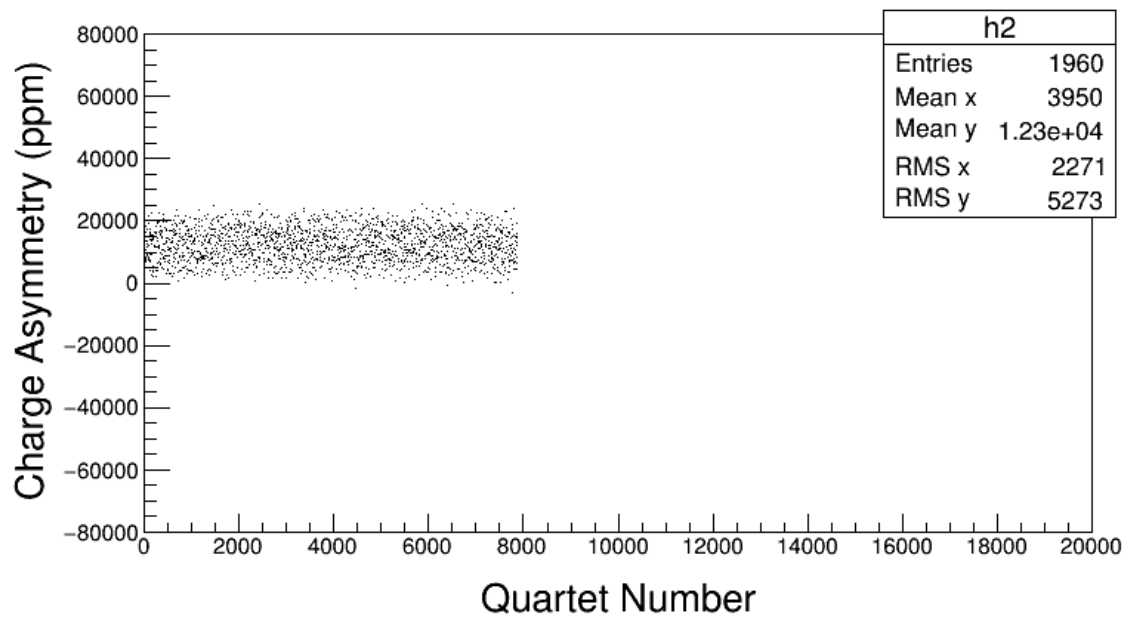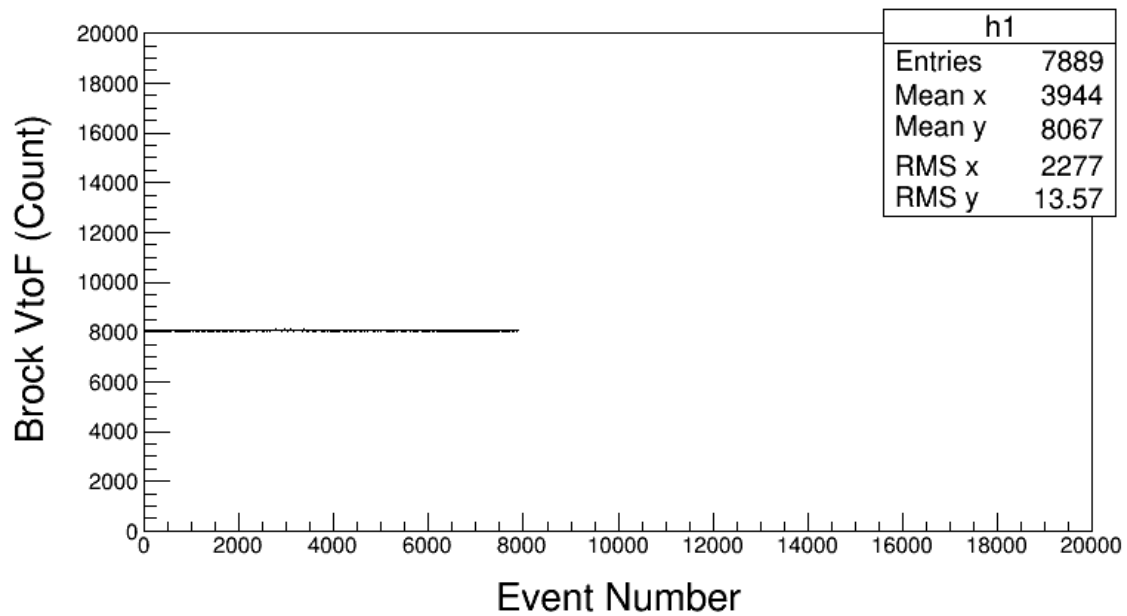
$$A_{physics} = \frac{\dfrac{D^+}{I^+} - \dfrac{D^-}{I^-}}{\dfrac{D^+}{I^-} + \dfrac{D^-}{I^+}} \approx \frac{Weak}{EM}$$

1/15th of a second

  - Repeat the whole experiment: Millions of measurements
  - Statistical distribution of these measurements is Gaussian: Mean is average asymmetry and error is width of Gaussian divided by square root of number of asymmetry measurements
  - Average asymmetry is very small (1-50 ppm)

h1	
Entries	7889
Mean	690.6
RMS	13.57

Brock Detector Signal

h2	
Entries	7889
Mean	0.2702
RMS	0.00435

Brock Normalized Signal

Top panel (h1): Brock VtoF (Count) vs Event Number

h1	
Entries	7889
Mean x	3944
Mean y	8067
RMS x	2277
RMS y	13.57

Bottom panel (h2): Charge Asymmetry (ppm) vs Quartet Number

h2	
Entries	1960
Mean x	3950
Mean y	1.23e+04
RMS x	2271
RMS y	5273

χ^2 / ndf	0.6725 / 3
p0	87.97 ± 36.66
p1	−3.768 ± 0.01847