Parity Experiments and JLab Injector

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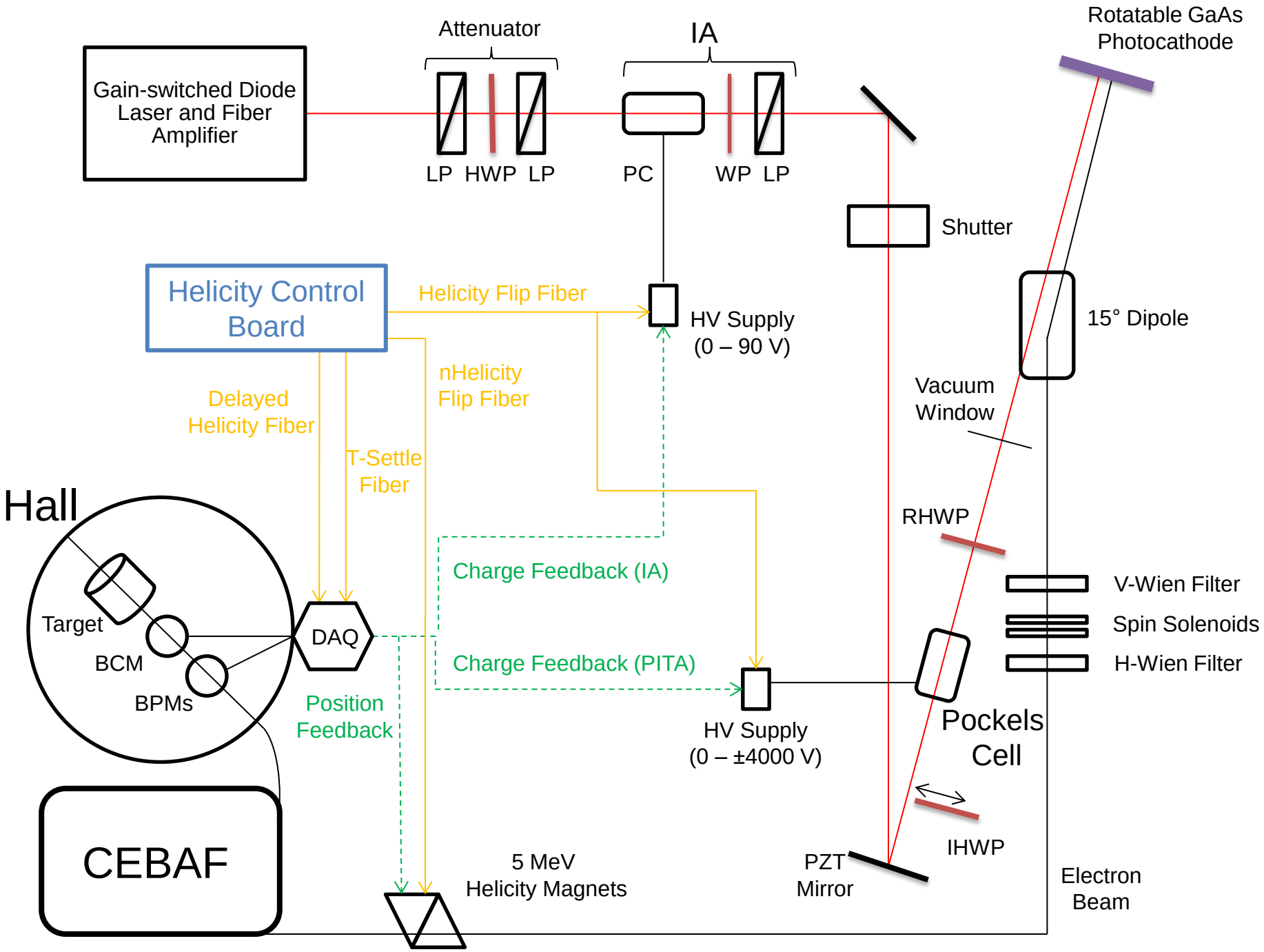
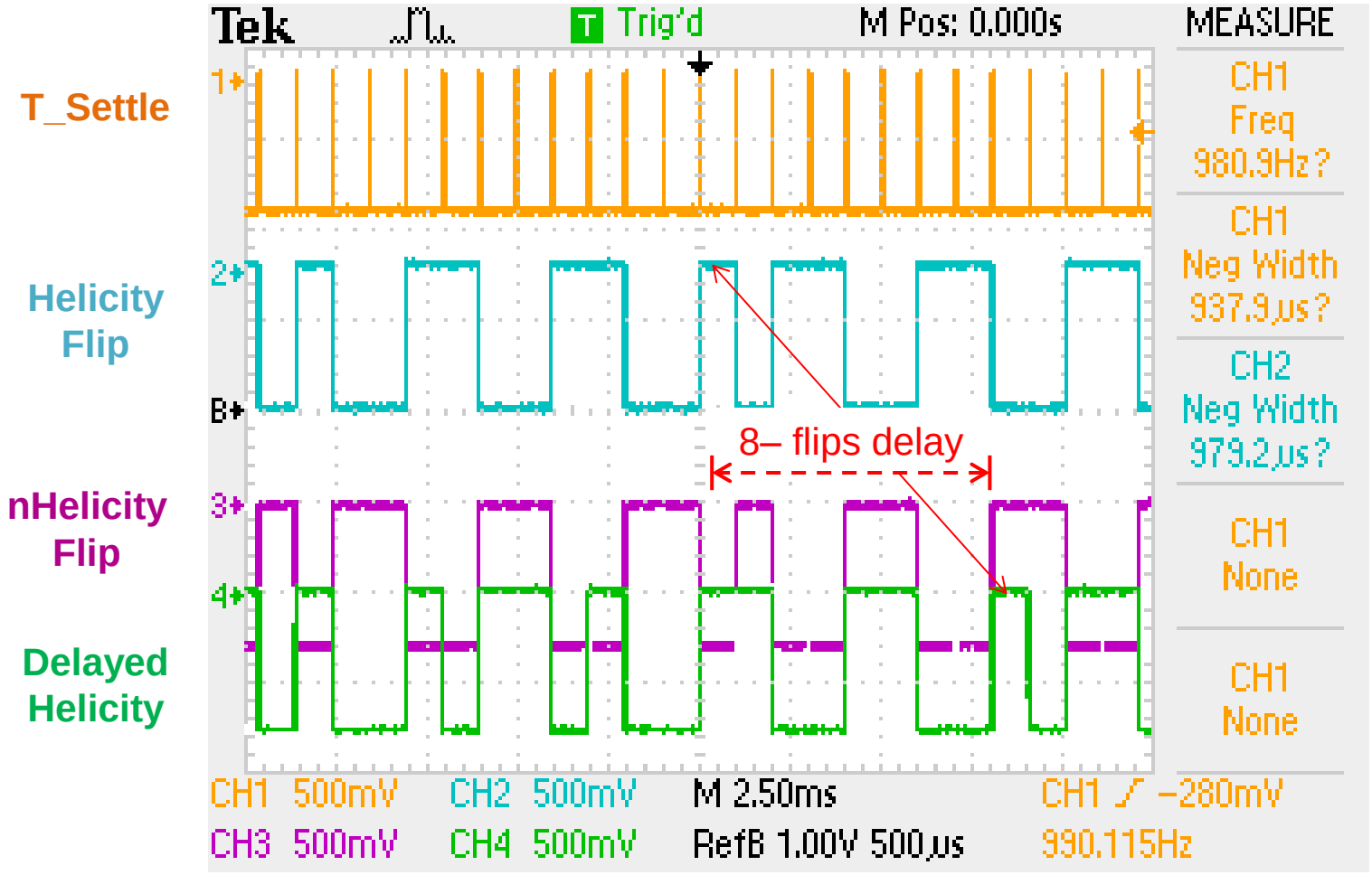
Experiment	Energy (GeV)	Pol (%)	I (μA)	Target	A_{pv} (ppb)	Charge Asym (ppb)	Position Diff (nm)	Angle Diff (nrad)	Size Diff (δσ/σ)
HAPPEx-I (Achieved)	3.3	38.8 68.8	100 40	^{1}H (15 cm)	15,050	200	12	3	
G0-Forward (Achieved)	3.0	73.7	40	^{1}H (20 cm)	3,000-40,000	300±300	7±4	3±1	
HAPPEx-II (Achieved)	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
Helicity Control Board
Helicity Flip Fiber
HV Supply (0 – 90 V)
15° Dipole
nHelicity Flip Fiber
Delayed Helicity Fiber
T-Settle Fiber
Vacuum Window
Hall
RHWP
Charge Feedback (IA)
V-Wien Filter
Spin Solenoids
H-Wien Filter
Target
BCM
BPMs
DAQ
Charge Feedback (PITA)
Position Feedback
HV Supply (0 – ±4000 V)
Pockels Cell
IHWP
CEBAF
5 MeV Helicity Magnets
PZT Mirror
Electron Beam


T_Settle
Helicity Flip
nHelicity Flip
Delayed Helicity
Tek
Trig'd
M Pos: 0.000s
MEASURE
CH1 Freq 980.3Hz?
CH1 Neg Width 937.9µs?
CH2 Neg Width 979.2µs?
CH1 None
CH1 None
8– flips delay
CH1 500mV
CH2 500mV
M 2.50ms
CH1 ⨍ -280mV
CH3 500mV
CH4 500mV
RefB 1.00V 500µs
990.115Hz

- 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 ($A_{physics}$):

$$A_{physics} = \frac{\frac{D^+}{I^+} - \frac{D^-}{I^-}}{\frac{D^+}{I^-} + \frac{D^-}{I^+}} \approx \frac{Weak}{EM}$$

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)