$\vec{e}$-^{2}H Parity Violating Deep Inelastic Scattering at Jefferson Laboratory at 6 GeV

Ramesh Subedi[1], Xiaoyan Deng[1], Diancheng Wang[1], Xiaochao Zheng[1], Robert Michaels[2], and Paul Reimer[3]
for the Hall A collaboration

1 University of Virginia, 382 McCormick Rd., Charlottesville, VA 22904
2 Thomas Jefferson National Accelerator Facility, Newport News, VA 23606
3 Argonne National Laboratory, Argonne, IL 60439

Physics Motivation

- The goal of the experiment is to precisely measure an asymmetry of the parity violating deep inelastic scattering (PVDIS) with a polarized electron on an unpolarized liquid deuterium target. The physics asymmetry of the experiment is expected to be ~100 parts per million (ppm).
- With σ_+, σ_-, and $-Q^2$ being left-handed and right-handed electron cross-sections, and the square of the four-momentum transfer, respectively,

$$A_{pv} = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-} \cong Q^2\ [100\ ppm/GeV^2].$$

- The important possible extraction of the experiment will be an effective coupling constant combination $(2C_{2u} - C_{2d})$ with a high precision.

$$A_{pv} = \left(\frac{3G_F Q^2}{\pi\alpha^2\sqrt{2}}\right) \frac{2C_{1u}[1+R_C(x)] - C_{1d}[1+R_S(x)] + Y(2C_{2u}-C_{2d})R_V(x)}{5+R_S(x)+4R_C(x)}.$$

$$C_{1u} = g^e{}_a\, g^u{}_v = -\frac{1}{2}+\frac{3}{4}sin^2(\theta_w), \qquad C_{2u} = g^e{}_v\, g^u{}_a = -\frac{1}{2}+2sin^2(\theta_w).$$

$$C_{1d} = g^e{}_a\, g^d{}_v = \frac{1}{2}-\frac{2}{3}sin^2(\theta_w), \qquad C_{2d} = g^e{}_v\, g^d{}_a = \frac{1}{2}-2sin^2(\theta_w).$$

- Serves as an exploratory step for the 12-GeV PVDIS program.

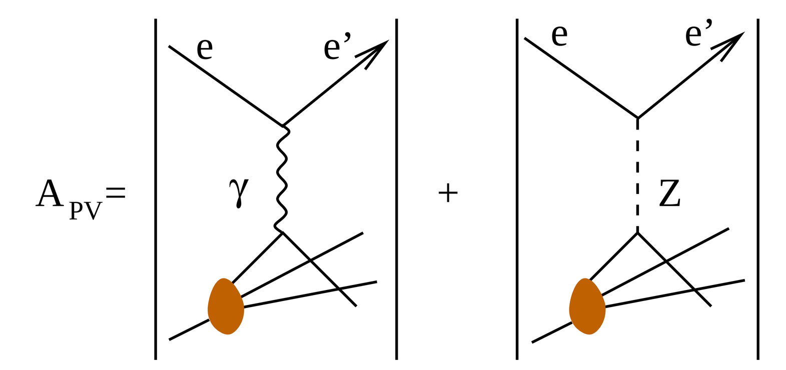

Fig.1: A diagram showing an electron interacting with a quark through a photon or a Z-boson. The interference term between the photon and the Z-boson exchanges gives A_{pv}.

Experiment Mock-up

- A mini-setup of data acquisition system has been developed as a preparation for the PVDIS experiment E08-011.
- The goal of the setup is to measure deadtime, pileup, and asymmetry of the PVDIS-trigger using scalers and TDCs.
- The deadtime is a minimum time interval which must separate two successive events so that these successive events can be recorded as distinct events. When two or more events occur in a time interval shorter than the deadtime (such as the gate-width of the discriminator), they are seen as a single event. The deadtime-measure is the collection of the ignored events.
- The events identified as being characteristic of two or more overlapping events give pileup. The pileup also results in a loss of events.
- The deadtime has been measured with a couple of different methods. A TDC was used to measure pileup.
- An asymmetry module with a known asymmetry was used as the input trigger to measure the asymmetry of the final trigger.
- A couple of narrow and wide gates have been used in this mini-setup.

Experiment Setup in the Hall

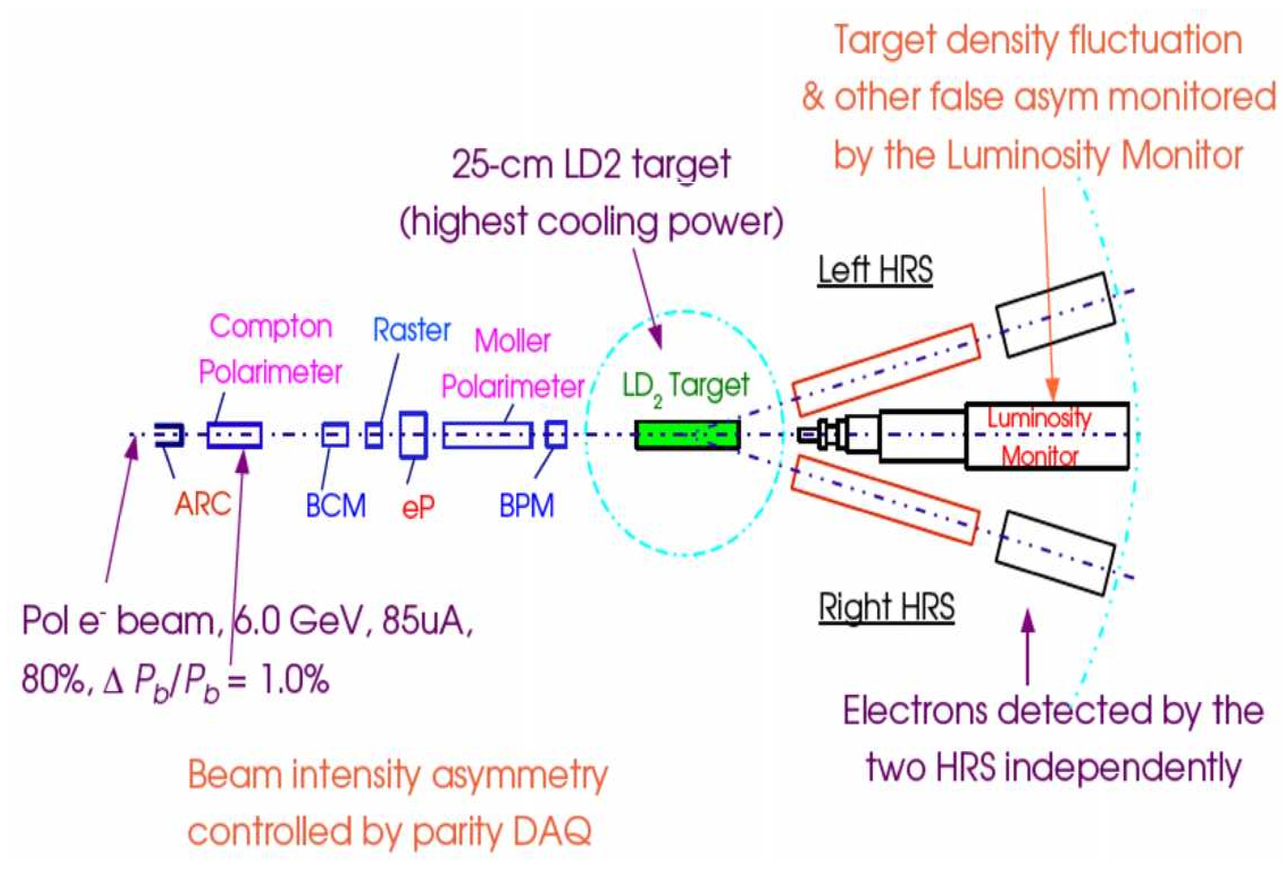

Fig.2: The instrumentation for the experiment in Hall A.

Deadtime Result

The deadtime from three methods was found to be consistent with each other. The dotted lines in the following plots represent the expected deadtime.

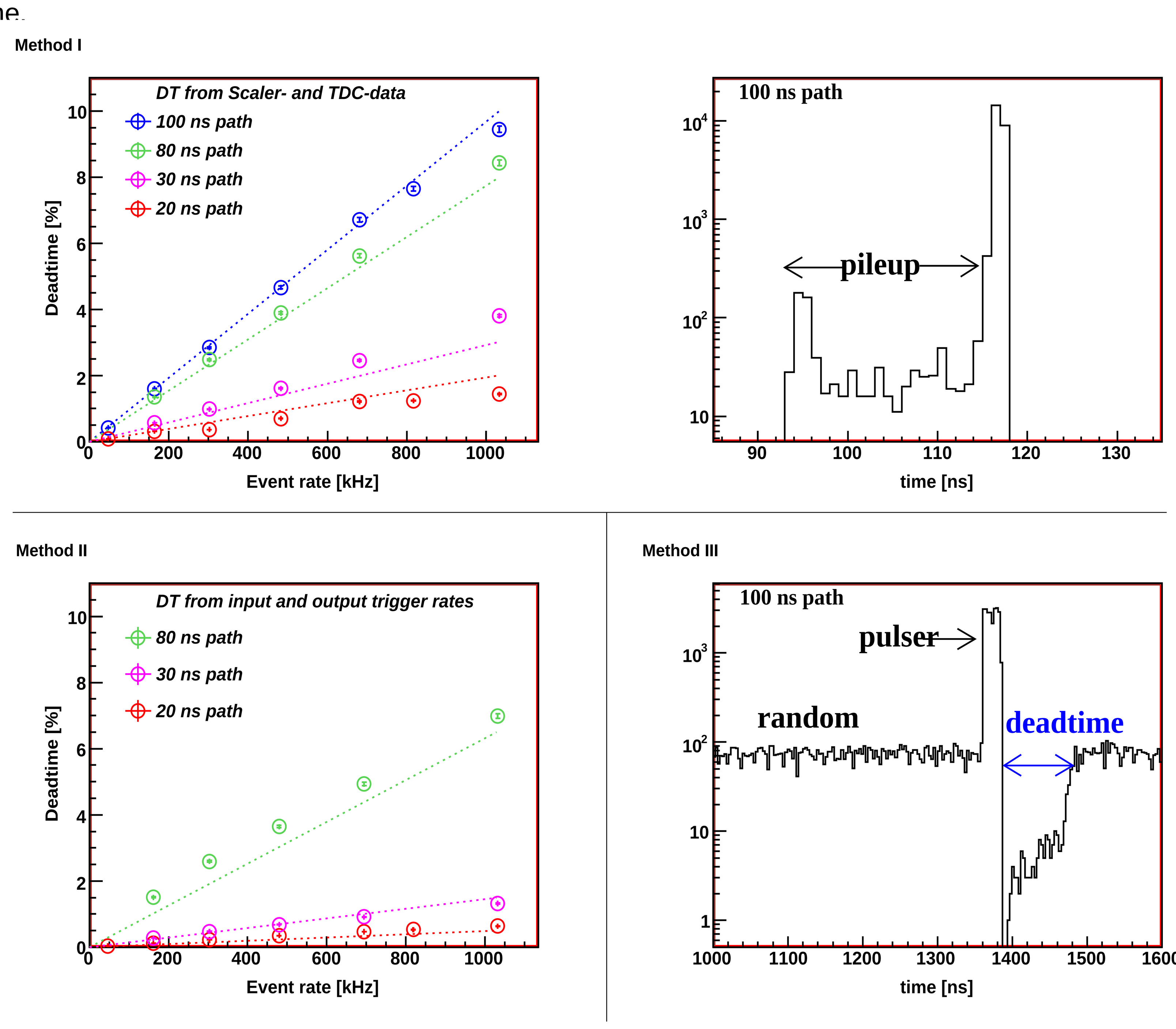

Fig.3: Top-left: deadtime obtained by using the scaler and TDC with a tagger. Top-right: timing spectrum of the output trigger with respect to a reference signal; in the absence of pileup, only the right-side peak would show up. Bottom-left: 2nd method to measure deadtime, in which the input and output trigger rates, obtained directly from the scaler, are used. There is a 15 ns deadtime that should be added to each point to compare this plot to the top-left plot. Bottom-right: deadtime obtained using a TDC.

Asymmetry Result

The asymmetry of the scale of the experiment (~ 100 ppm) was measured and compared to the expected asymmetry. The dashed line in the bottom figure represents the expected asymmetry to be equal to the observed one.

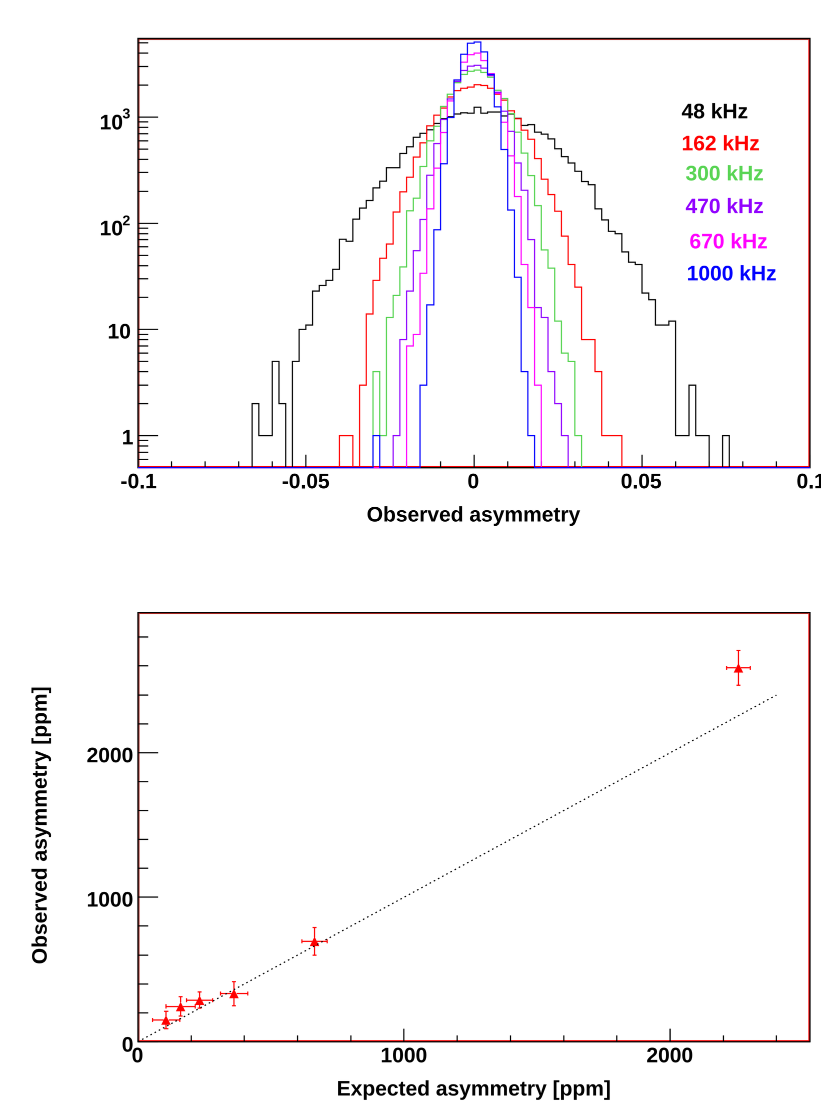

Fig.4: Top: width of asymmetry-histograms as a function of event rate. The higher the rate, the lower the width. These agree with the expected width $\sqrt{\frac{1}{RT}}$, where R is the trigger rate and T is the integration time per pair of helicity windows after vetoing the helicity transition regions. Bottom: observed an agreement between the expected and the observed asymmetries.

Reference:

[1] R. Michaels, P. Reimer, and X.-C. Zheng, $\vec{e}$-^{2}H Parity Violating Deep Inelastic Scattering (PVDIS) at CEBAF at 6 GeV, Jefferson Lab Hall A Proposal **E08-011.**