JLab Parity Violating Deep Inelastic Scattering Experiment: E08-011

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For
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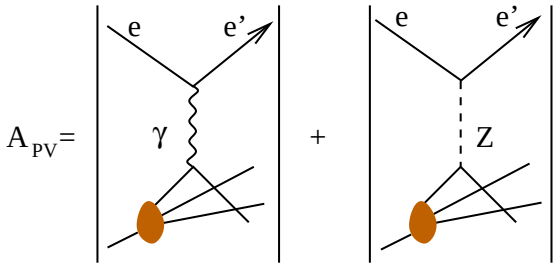
[Also see Krishna Kumar's plenary talk for a big picture of this talk.]

Introduction

- PVDIS (Parity Violating Deep Inelastic Scattering) experiment (E08-011) at JLab is scheduled to run October next year.
- The goal of the experiment is to precisely measure PVDIS asymmetry with a polarized electron on an unpolarized liquid deuterium target. The physics asymmetry of the experiment is expected to be $\sim$100 parts per million (ppm).
- With the cross-sections σ_L and σ_R for the left-handed and right-handed helicity electrons, and Q^2 as the (-)ve of the 4-momentum transfer squared, the measured parity violating asymmetry A_{expt} can be:

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

The interference term between the γ- and the Z-exchange gives the parity violating physics asymmetry A_{pv}:



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

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

$$C_{1u} = g^e_a g^u_v = -\frac{1}{2} + \frac{3}{4}\sin^2(\theta_w), \qquad C_{2u} = g^e_v g^u_a = -\frac{1}{2} + 2\sin^2(\theta_w).$$

$$C_{1d} = g^e_a g^d_v = \frac{1}{2} - \frac{2}{3}\sin^2(\theta_w), \qquad C_{2d} = g^e_v g^d_a = \frac{1}{2} - 2\sin^2(\theta_w).$$

  With P_e as the magnitude of beam polarization, $A_{expt} = P_e A_{pv}$.
- Serves as an exploratory step for the 12-GeV PVDIS program.

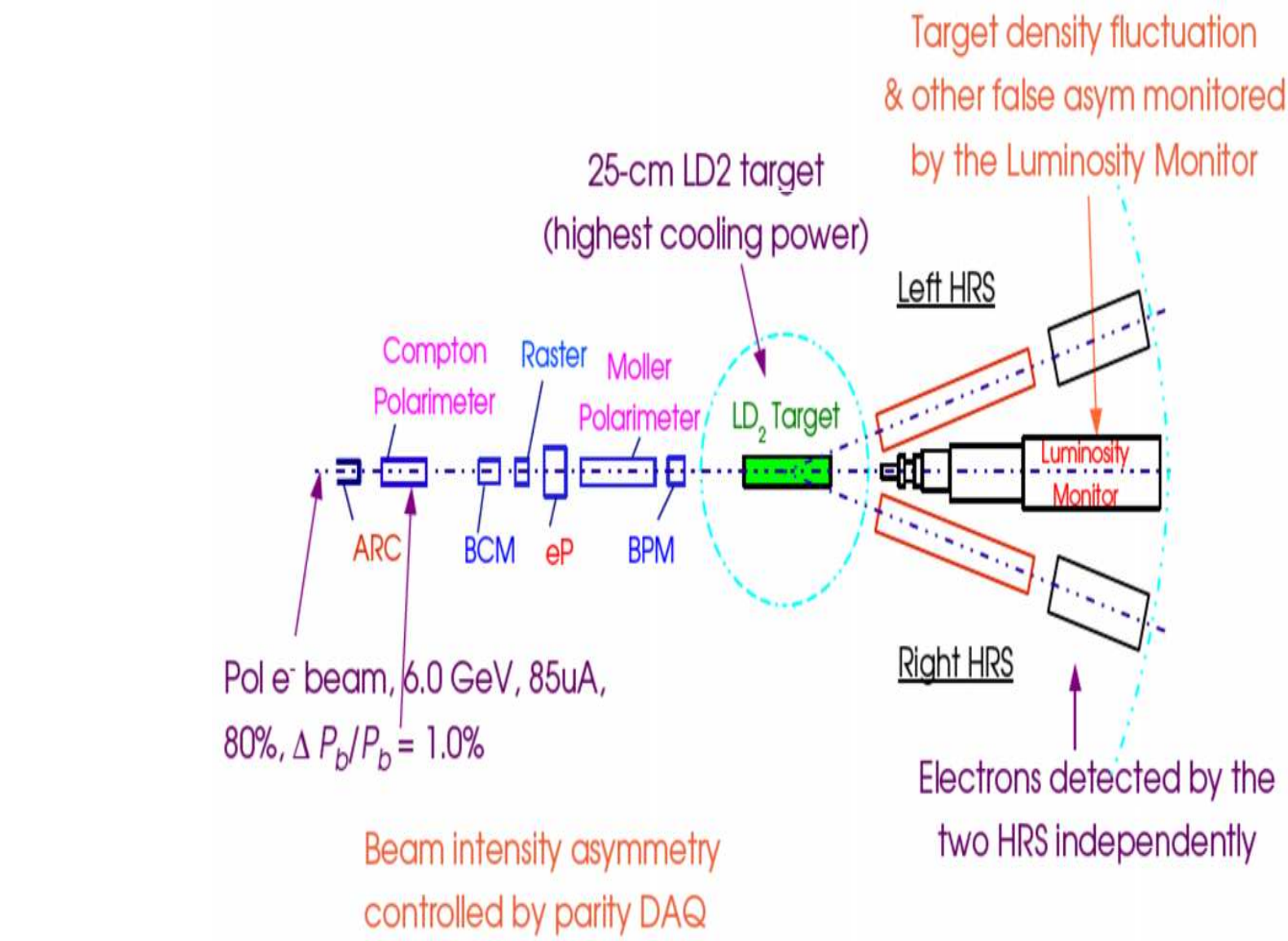


Fig.1: The instrumentation for the experiment in the hall (Hall A).

Experiment Preparation

- Did a series of tests using pulser and high rate PMT signals. Have a good handle on understanding deadtime, pileup, and asymmetry of the PVDIS-trigger.
  - Deadtime is the 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 gate-width (of the discriminator), they are seen as a single event. The collection of the ignored events make an account of the deadtime-measure.
  - The events identified as being characteristic of two or more overlapping events give pileup. The pileup-events result in a data-loss and spectrum distortion.
- Installed the scaler-based DAQ in the hall for a parasitic data-taking starting this month.

Deadtime

- Set two different gate widths using discriminators to produce different triggers of dissimilar deadtimes.
- Used TDCs to study pileup.
- Three different methods employed to measure deadtime.
  - Method I: Dead-zone observed in TDC-spectrum.
  - Method II: Using the input and output trigger rates.

$$Deadtime = [1 - \frac{output\ trigger\ rate}{input\ trigger\ rate}]$$

  - Method III: Using scaler-data and TDC-data.

$$Deadtime = [1 - \frac{(1 - pileup) * tagged\ trigger\ rate}{tagger\ rate}]$$

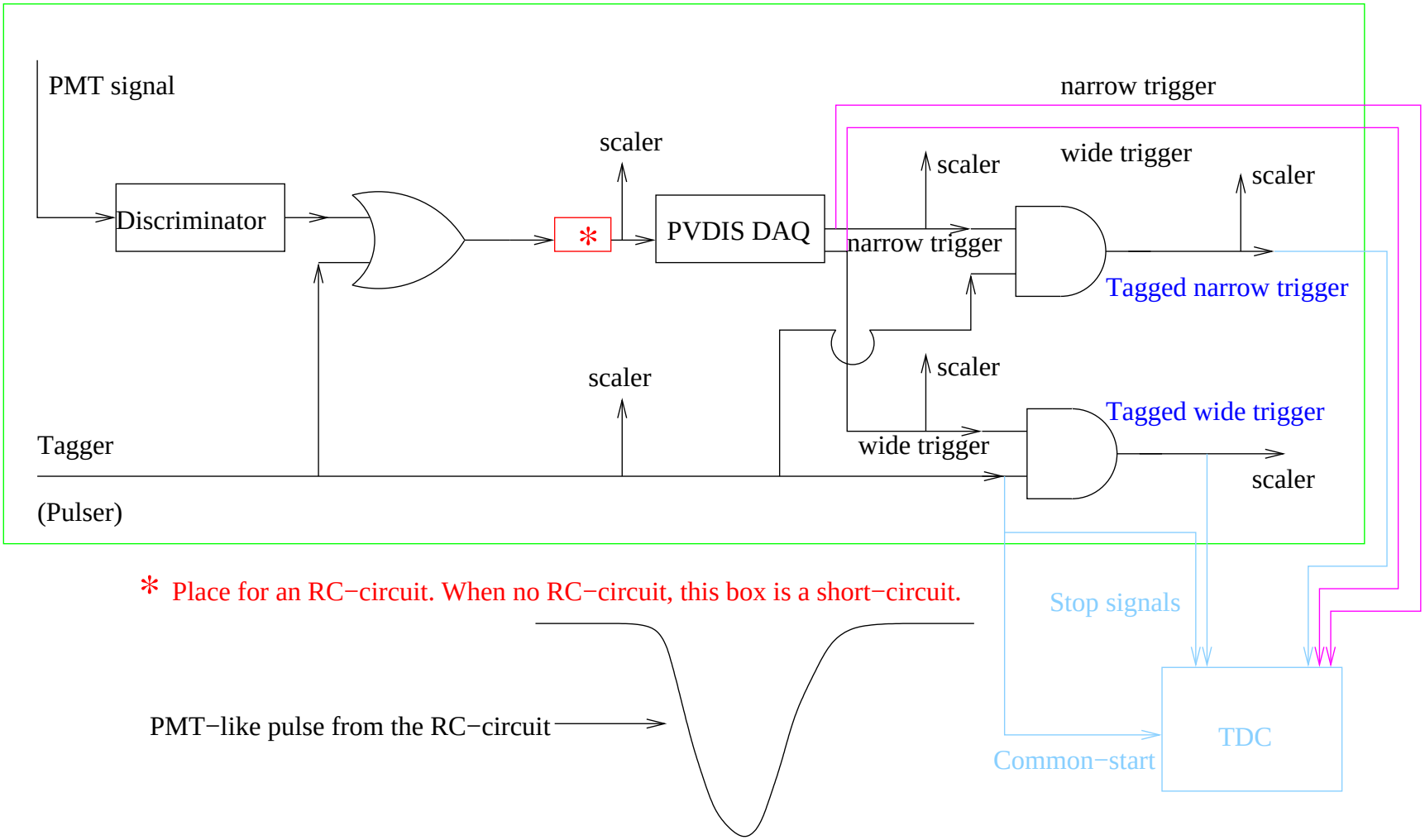


Fig.2: A diagram for the deadtime and pileup measurements.

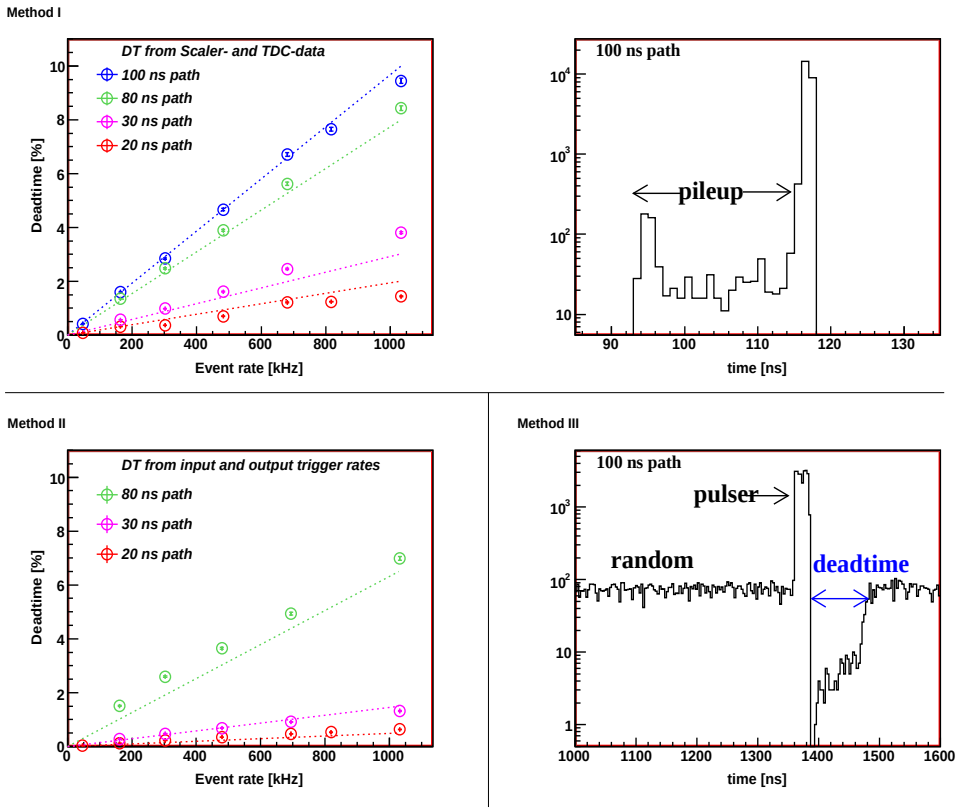


Fig.3: Top-left: deadtime obtained by using the scaler and TDC with a tagger. Top-right: timing spectrum of the output trigger with respect to a reference signal; in the absence of pileup, only the right-side peak would show up. Bottom-left: 2nd method to measure deadtime, in which the input and output 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.

- The scaler counting is deadtime-free. Any deadtime that may occur is the electronics deadtime of the modules that are used (before the scaler module) to carry signal to the scaler module.
- Found that the value of deadtime as exactly equal to the set value of the gate-width. All dashed lines in Fig.3 are expected deadtime values. The data-points are nicely overlapping to these lines.

Asymmetry

- Developed a technology to inject a known artificial low asymmetry by using JLab made asymmetry module to produce the asymmetry into the input signal to the PVDIS-setup.
- Able to measure asymmetry lower than expected in the real experiment ($\sim$100 ppm).

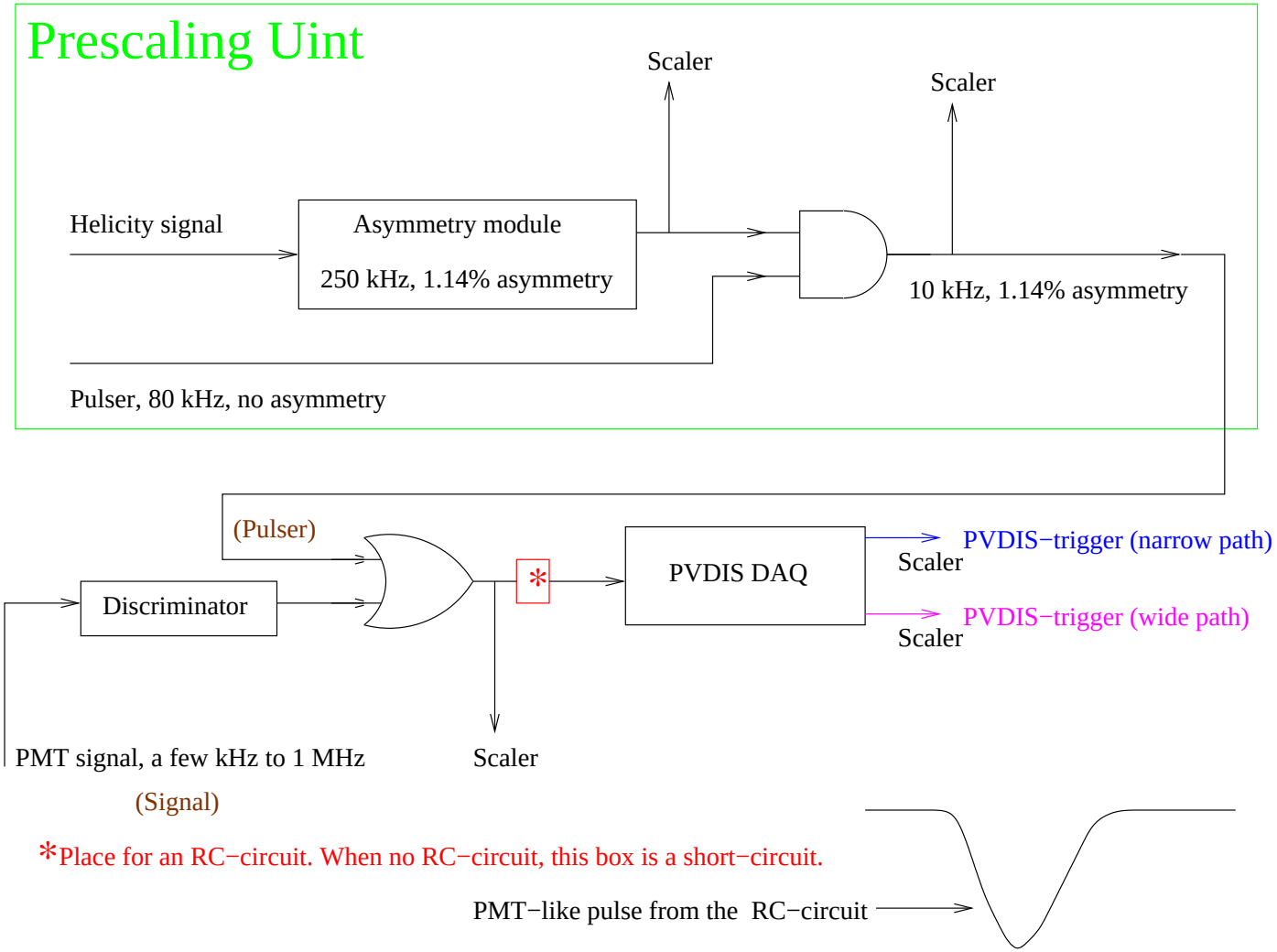


Fig.4: A diagram for the asymmetry measurement.

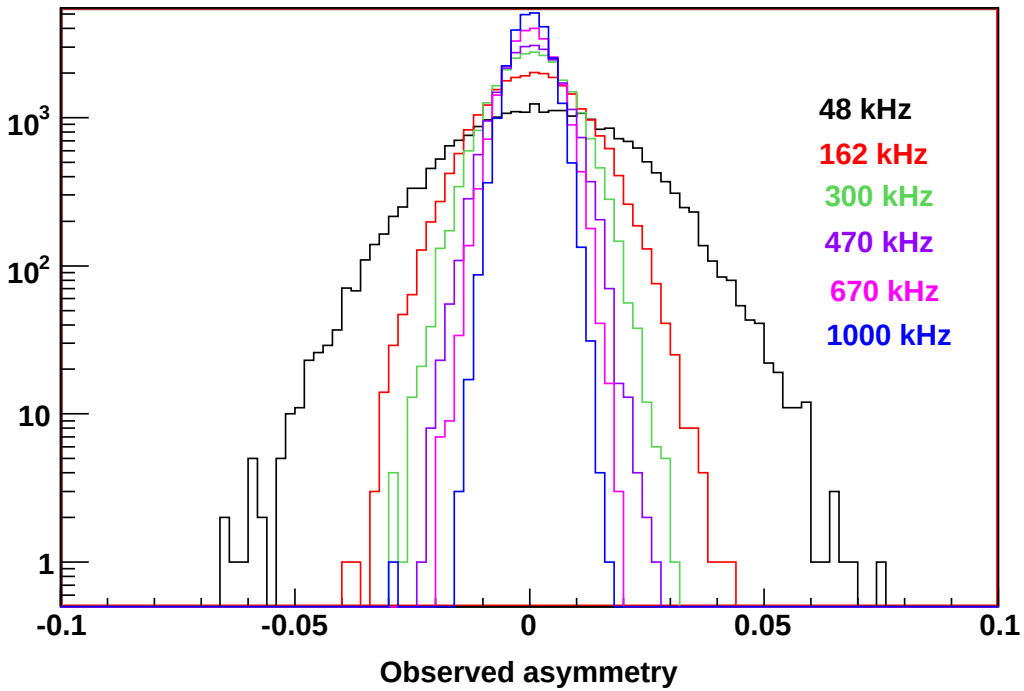


Fig. 5: Width of asymmetry-histograms as a function of event rate. The higher the rate, the lower the width. These agree with the expected width $\sqrt{\frac{1}{RT}}$, where R is the trigger rate and T is the integration time per pair of helicity windows.

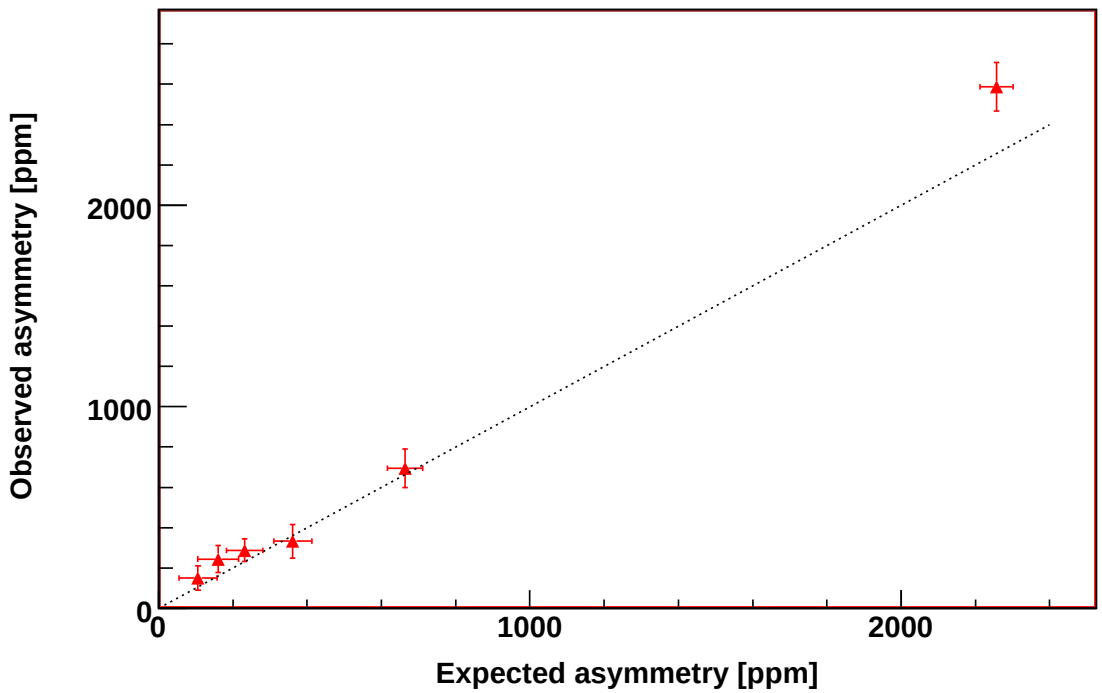


Fig. 6: Observed an agreement between the expected and the observed asymmetries.

Conclusion and Future Plans

- The test results, using pulser and high rate PMT singals, obtained from the deadtime and asymmetry measurements give confidence on the scaler-based DAQ (i.e. the PVDIS-setup).
- The PVDIS-setup has been installed in the detector hut of the right high-resolution spectrometer.
- The future plans include:
  - Taking parasitic data using the current PVDIS-setup in the hall.
  - Preparing identical PVDIS-setup for the left high-resolution spectrometer.
  - Working on flash ADCs to study pileup.