Parity Violating Deep Inelastic Scattering Experiment: E08-011

"PVDIS Issues/Plans"

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For
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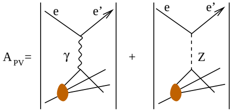
Introduction

- Scheduled to run in late October 2009.
- Will take data at two Q^2 points.
  - Q^2=1.11 $(GeV/c)^2$: θ=12.9°, E=6.0 GeV, E'=3.66 GeV, x=0.25.
  - Q^2=1.90 $(GeV/c)^2$: θ=20.0°, E=6.0 GeV, E'=2.63 GeV, x=0.30.
- The goal of the experiment is to precisely measure PVDIS asymmetry with a polarized electron on an unpolarized liquid deuterium target. The minimum physics asymmetry of the experiment is expected to be $\sim$100 parts per million (ppm).
- Using the measured asymmetry, we can investigate:
  - coupling constant combination ($2C_{2u} - C_{2d}$), see latter slides.
  - hadronic correction, $C(x)$, from higher-twist effects: $A_{PV}(x, Q^2) = A_{PV}(x)(1 + C(x)/Q^2)$,
  - charge symmetry violation (csv), need 11 GeV beam for precision: $\delta u(x) = u^p(x) - d^n(x), \quad \delta d(x) = d^p(x) - u^n(x)$, $\delta A_{PV}/A_{PV} = 0.28(\delta u - \delta d)/(u + d) = 0.28 R_{CSV}$.

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



- With the cross-sections σ_L and σ_R for the left-handed and right-handed helicity electrons, the measured parity violating asymmetry A_{expt} can be:

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

- 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.

The important outcome of the experiment will be the extraction of $(2C_{2u} - C_{2d})$, shown in Eqn.(1), with a high precision.

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

with the effective coupling constants $C_{1,2q}$:

$$C_{1u} = g_a^e g_v^u = -\frac{1}{2} + \frac{3}{4}sin^2(\theta_w) \sim -0.19, \quad (2)$$

$$C_{1d} = g_a^e g_v^d = \frac{1}{2} - \frac{2}{3}sin^2(\theta_w) \sim 0.34, \quad (3)$$

$$C_{2u} = g_v^e g_a^u = -\frac{1}{2} + 2sin^2(\theta_w) \sim -0.04, \quad (4)$$

$$C_{2d} = g_v^e g_a^d = \frac{1}{2} - 2sin^2(\theta_w) \sim 0.026, \quad (5)$$

where G_F is the Fermi weak coupling constant, Y is kinematical factor, R_s and R_v being sea- and valence- quark distribution functions (see proposal E08-011 for detail).

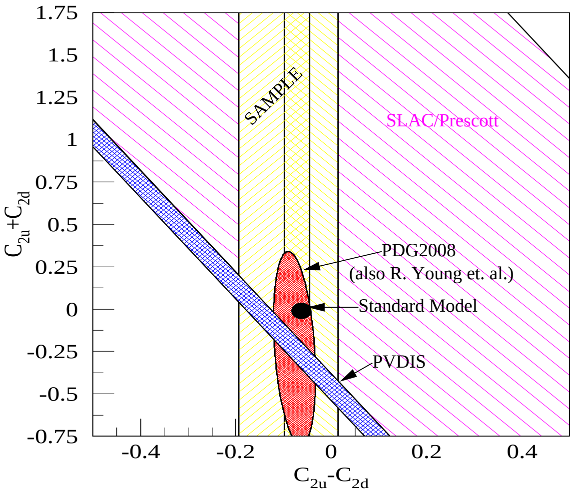


Fig. 1: Current experimental knowledge of C_{2q}. The PVDIS band corresponds to the best-fit central value of PDG (also R. Young et al.)

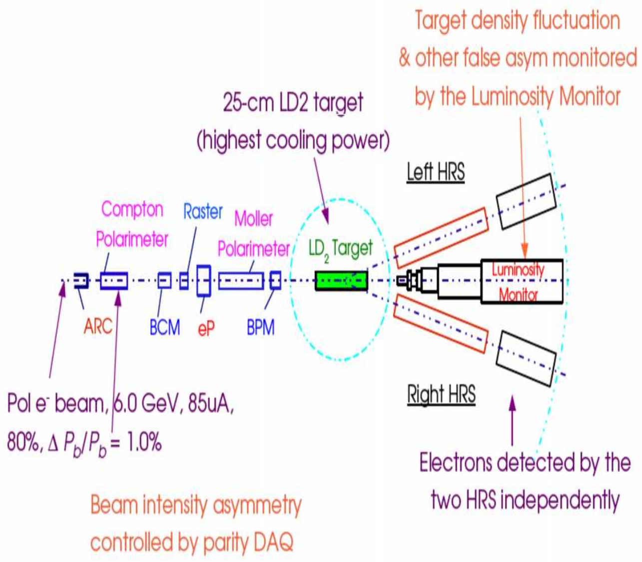


Fig.2: The instrumentation for the experiment in the hall.

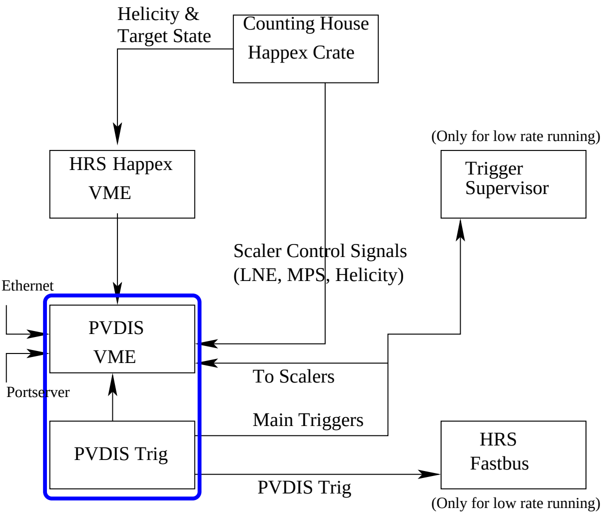
Activity in short

1. Fall 2007 - Summer 2008: Fully cabled two relay racks of PVDIS DAQ and tested with pulser/PMT by determining deadtime/pileup in multiple ways and also determined asymmetry by using artificial asymmetry input.
2. Sept 2008: Installed the relay racks in RHRS so as to be ready for parasitic test during Transversity that started in Oct 2008.

1. (Diancheng) working on C^{++}-based simulation for the parity experiments and also debugging Compton electron detector.
2. There's continuous debugging of the PVDIS-DAQ, see Xiaoyan's talk for an update.

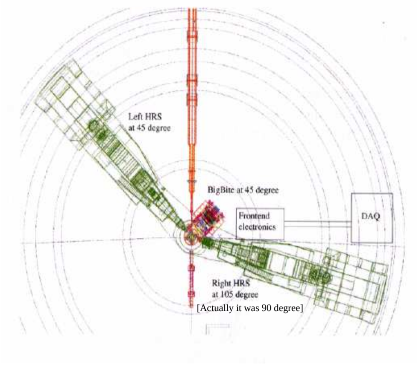
PVDIS relay rack location in RHRS

PVDIS Trigger Layout



Issues

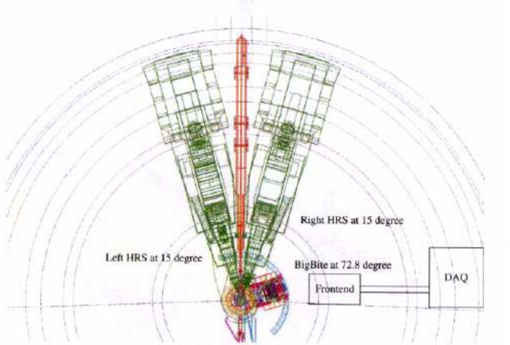
Wanted to do parasitic test during Tansversity last Fall but failed because of not observing any signal rate since the positioning of RHRS was at a backward angle and also that Q1 was inoperative. This was the floor plan for Transversity and d_{2n} experiments:



A_y and ^{3}He(e,e'd) kinematics are useful to test PVDIS DAQ for both high and low rate runnings.

- Can go as high as 25 kHz during A_y for about a day.
- Constant 4 kHz rate during whole ^{3}He(e,e'd) running.
- We are very optimistic for the parasitic test this time.

The following is the floor plan for A_y and $^3He(e,e'd)$ experiments.



E [GeV]	E' [GeV/c]	θ_{sc} [deg]	Q^2 [GeV/c]^2	$\lvert\vec{q}\rvert$ [GeV/c]	θ_{pq} [deg]	(e,e') Rate [kHz]	L/R
1.268	1.2283	12.55	0.0744	0.2757	75.5	86.65	Y/N
1.268	1.2146	14.65	0.1	0.3209	73.18	39.76	Y/N
1.268	1.2049	16	0.118	0.3498	71.71	25.78	Y/Y
1.268	1.1733	19.9	0.178	0.432	67.58	8.464	Y/Y
1.268	1.1613	21.25	0.2	0.46	66.2	5.577	N/Y
1.268	1.052	32	0.405	0.6723	56.01	0.490	N/Y
2.468	2.3221	12.55	0.274	0.5433	68.24	12.86	Y/N
2.468	2.362	15	0.397	0.6389	73.04	4.514	Y/N
2.468	2.265	15	0.381	0.6498	64.46	4.503	Y/N
2.468	2.2398	16	0.428	0.6931	62.97	2.945	Y/Y
2.468	2.2015	17.45	0.5	0.7557	60.88	1.747	Y/Y
2.468	2.133	19.9	0.629	0.8608	57.51	0.691	Y/Y
2.468	2.0683	22.1	0.75	0.9539	54.66	0.316	N/Y
2.468	1.8559	29	1.15	1.234	46.81	0.039	N/Y
3.668	3.3547	12.55	0.588	0.8284	61.64	2.771	Y/N
3.668	3.2692	14.35	0.748	0.9525	58.28	1.120	Y/N
3.668	3.1856	16	0.905	1.067	55.4	0.535	Y/Y
3.668	3.1355	16.95	0.999	1.133	53.81	0.319	Y/Y
3.668	2.8694	21.75	1.5	1.462	46.68	0.046	N/Y

High Rate

High Rate

3He(e,e'd) May 11 to June 14

A Typical Rate Check for Ay and 3He(e,e'd) experiments.

The Main Objectives

1. Use PVDIS-scalers to study deadtime and asymmetry.
2. Study all PVDIS triggers using Fastbus TDC in RHRS DAQ. Use this information for timing check, deadtime, and pileup studies. Can also explore other uses of this info.
3. May use PVDIS-TDCs to study deadtime and pileup. [Alternative]
4. Hook up Flash ADC in RHRS-Fastbus and use it for the pileup study. [FADC already used during d_{2n} using Podd Analyzer]
5. Trigger RHRS DAQ by partial PVDIS triggers [T3, T4, T5, T6] and check these triggers.
6. Use PAN (parity analyzer) for data analysis since PVDIS crate is already hooked up to the Happex crate.

Expectation

- Want to see ”good electron” and ”good pion” triggers.
- The leadglass, gas-cherenkov, and scintillator detectors are used in logical combinations to form various triggers.
- The triggers are counted in scalers and integrated over the helicity period. This is the “ production PVDIS DAQ”, i.e., the main physics result comes from this.

- Want to confirm that the PVDIS DAQ works. This is the most important goal and it is vital that we do the following with parasitically during the next few months:

- learn to setup the gains, thresholds, and logic.
- verify the efficiency, uniformity and quality of PID.
- use detailed HRS analysis to confirm each trigger type.
- develop procedure to monitor data quality.

Expectation contd.

- When data appear in scalers it becomes an integrating DAQ, hence it is joined with the HAPPEX DAQ. This will allow us to readout all the beamline information, the delayed helicity, and to use the same analysis code and methods as HAPPEX.
- We also want to confirm that we can see asymmetries that have statistical noise, and that we can measure charge asymmetry that agrees with HAPPEX.
- We want to use the HRS DAQ with standard Podd analysis to confirm in detail, by running at low rate, that the production DAQ works. We can't use this at high rate though.

We only care about the rate in RHRS at the moment so as to check the following:

Run Plan

1. Shower/preshower gain matching/HV adjusting: look ok in cosmics, needs fine-tuning only.
2. See if the trigger due to different group is working (use scaler info).
3. See if the timing of corresponding part of different group is the same (use Fastbus TDC info).
4. Use RHRS runs to analyze PID performance of preshower,shower and gas-cherenkov. Quantify electron efficiency and pion rejection factor for different cuts of preshower, total-shower and gas-cherenkov.

Run Plan contd.

1. Plot gas-cherekov ADC spectrum and shower vs preshower ADC spectrum (2D) for (a) all events and (b) events with PVDIS main triggers only. The difference between (a) and (b) should be clear-cut for each of these ADC histogram. The discriminator threshold would correspond to the (b)-histograms. Check if this is the case.
2. If cannot observe bullet-1 result, change discriminator threshold to higher (or lower) values until we reach that expectation.
3. After completing bullet-1 expectation (observe the cuts), change each of the discriminator threshold by a factor of two, repeat bullet-1 and see if the cuts shift accordingly.
4. Use results of sub-bullet-4 of previous slide and requirement from the proposal, determine where we should set the cuts.
5. Use results of bullet-1, 3, and 4 to determine the threshold for discriminators with high, medium and low thresholds.

Run Plan contd.

1. Currently the main triggers plugged in into the RHRS Trigger Supervisor come from group 5. Can walk through different groups using opportunistic access.
2. Achieve all the “main objectives” and “expectations” mentioned earlier.

Other Plans/Wishes

1. We have to complete the parasitic test of RHRS-PVDIS DAQ during this April-June Running.
2. Need to assemble a LHRS-PVDIS-DAQ during June-July which will be basically the copy of the RHRS-PVDIS-DAQ so that we may not have to test it in the real-beam for its performance. This will be installed in the Hall (LHRS) in July/August.
3. It would be nice if we could confirm the leadglass detectors do not get radiation-damaged during Happex-III so that we could continue parasitic testing [but NOT jeoperdizing PVDIS]!

Conclusion

Very optimistic to the parasitic test this time.

Success of this test drives the preparation for the LHRS PVDIS-DAQ so as to be ready by early August for the PVDIS experiment which will start late October.