E08-011

Measurement of Deuteron PVDIS Asymmetry at 6 GeV

Xiaochao Zheng

for Hall A Parity Collaboration

- Physics Motivation and Beam Time Allocation
- Timeline: from June 2003 to 9am today
- Online Data Analysis
- Summary and Outlook

The Collaboration

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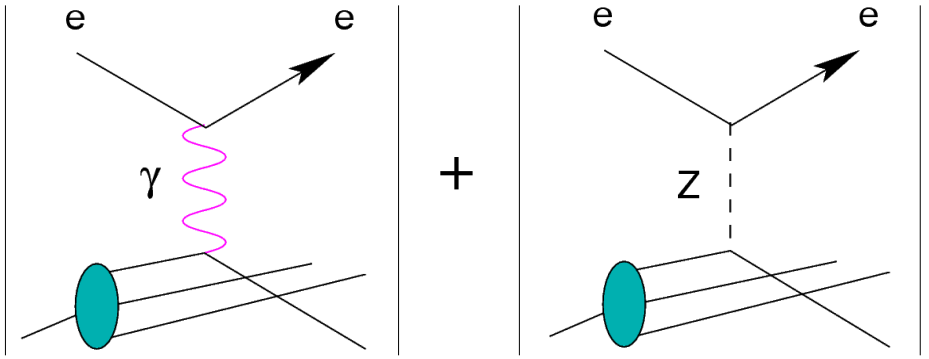
The Hall A Collaboration

ANL, Calstate, FIU, JLab, Kentucky, Louisiana Tech, U. of Ljubljana (Slovenia), MIT, UMD, UMass, UNH, Universidad Nacional Autonoma de Mexico, Ohio U., Randolph-Mason C., Smith C., Syracuse, Temple U., UVa, W&M, Yerevan Phys. Inst.(Armenia)

PVDIS Asymmetries

$A_{PV} =$ 

- Deuterium:

$$A_d = (540\ ppm)Q^2 \frac{2C_{1u}[1+R_C(x)] - C_{1d}[1+R_S(x)] + Y(2C_{2u} - C_{2d})R_V(x)}{5 + R_S(x) + 4R_C(x)}$$

$$C_{1u} = g_A^e g_V^u = -\frac{1}{2} + \frac{4}{3}\sin^2(\theta_W) \qquad C_{2u} = g_V^e g_A^u = -\frac{1}{2} + 2\sin^2(\theta_W)$$

$$C_{1d} = g_A^e g_V^d = \frac{1}{2} - \frac{2}{3}\sin^2(\theta_W) \qquad C_{1u} = g_A^e g_V^u = -\frac{1}{2} + \frac{4}{3}\sin^2(\theta_W)$$

In the SM, tree level

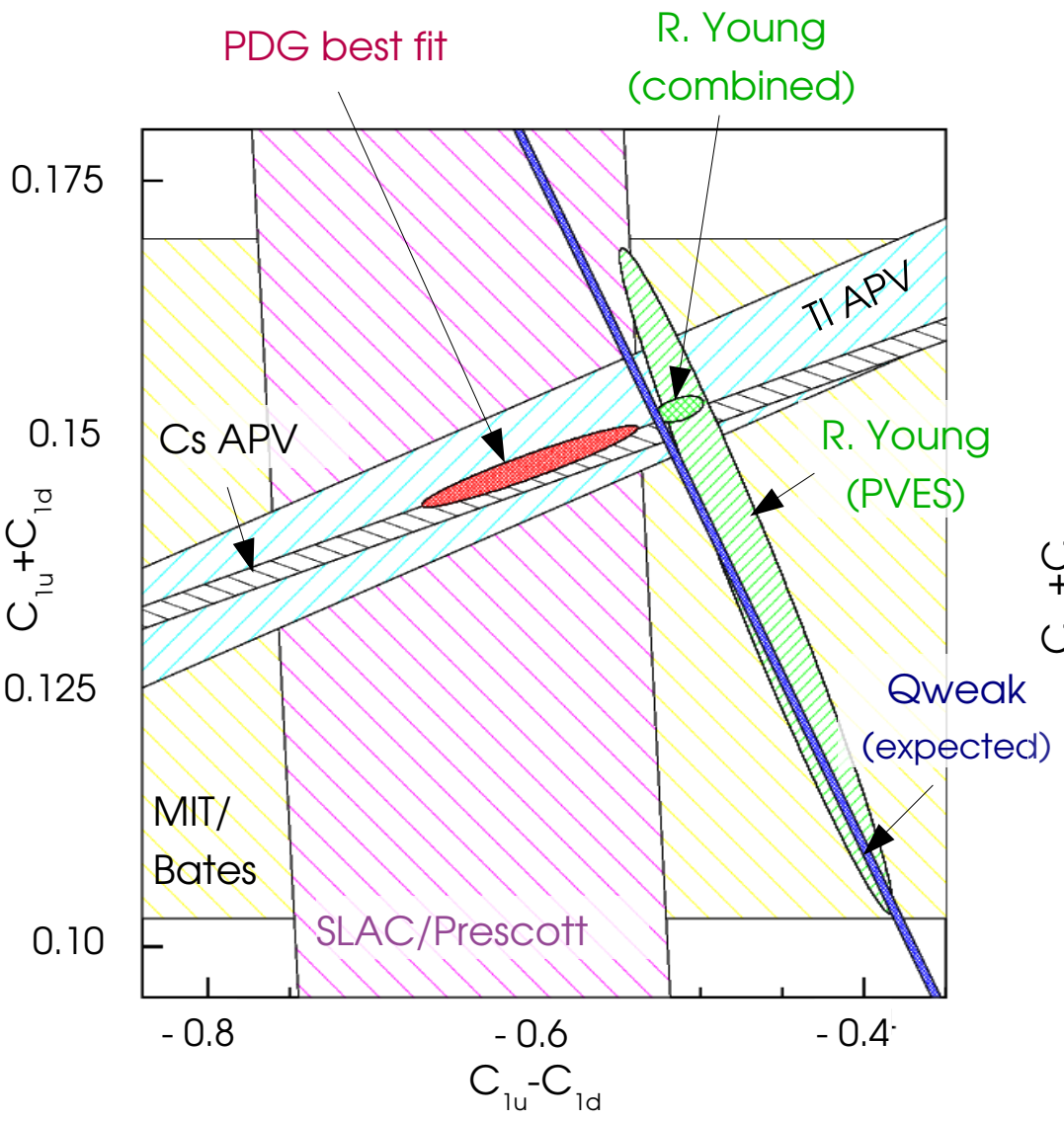
- PVDIS provides an opportunity to study both electroweak Standard Model via the extraction of $C_{1,2q}$ (and $\sin^2\theta_W$), and hadronic effects.
- The 6 GeV experiment is an exploratory step of this program.

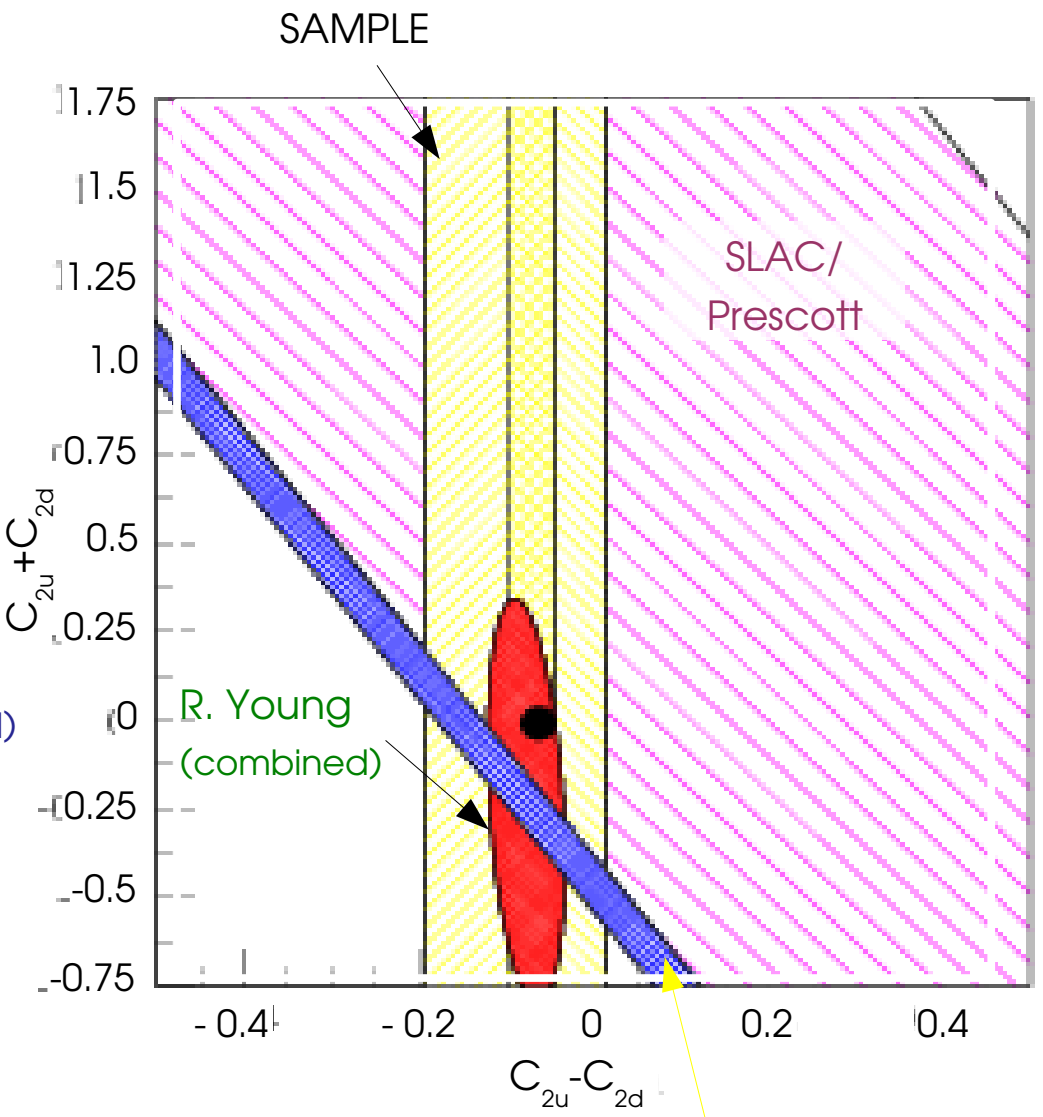
The Physics of PVDIS at 6 GeV

- First appeared as LOI03-106 in June 2003 (PAC24), then as E05-007 in PAC27 and E08-011 in PAC33.
- Total requested 46+4 days
  - PAC27: 13 days approved (A-);
  - PAC33: 32 days approved (A-).
- Measure PVDIS asymmetry on a deuterium target, A_d, at Q^2=1.10 and 1.90 GeV^2 to 2% (stat.) -> 3% with approved 32 days;
  - From Q^2=1.10 can help to investigate if there are significant HT effects; — "Baseline" measurement for the future 12 GeV program.
  - If HT is small, from Q^2=1.90 GeV^2 can extract $2C_{2u}$-C_{2d} to ±0.033, a factor of 7.4 improvement; -> factor of 5-6 improvement with approved 32 days.
- Scheduled to run Oct. 29 – Dec. 22, 2009 (5 days switchover, 4 days commissioning, production started Nov. 8th).

The 6 GeV E08-011

all are 1 σ limit





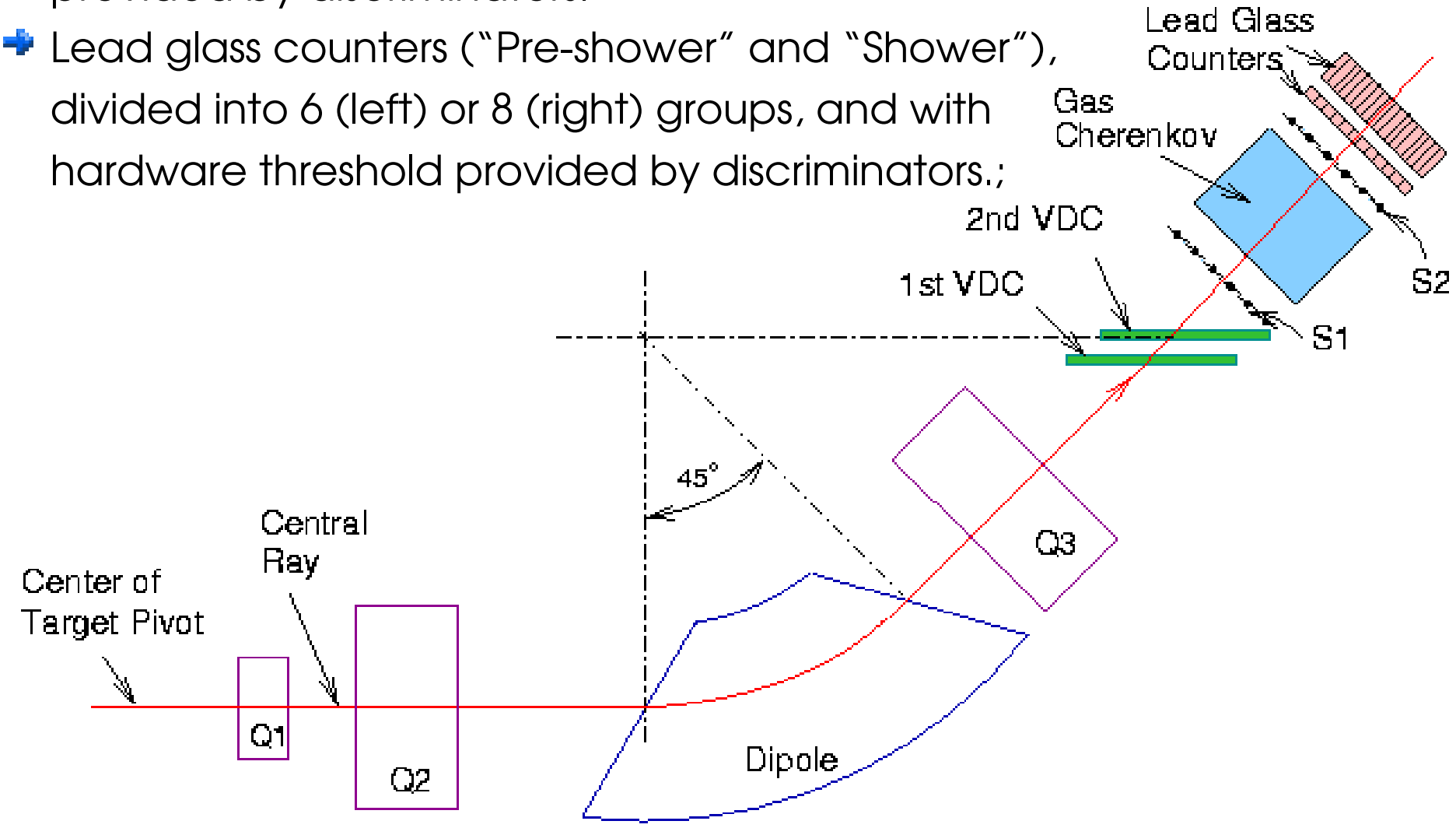
Expected: JLab 6 GeV PV-DIS E08-011 (assuming small hadronic effects **and a 3% statistical error. Current expetation is 4%!**) X. Zheng, Hall A Collaboration Meeting, Dec. 2009

A New Fast-Counting DAQ

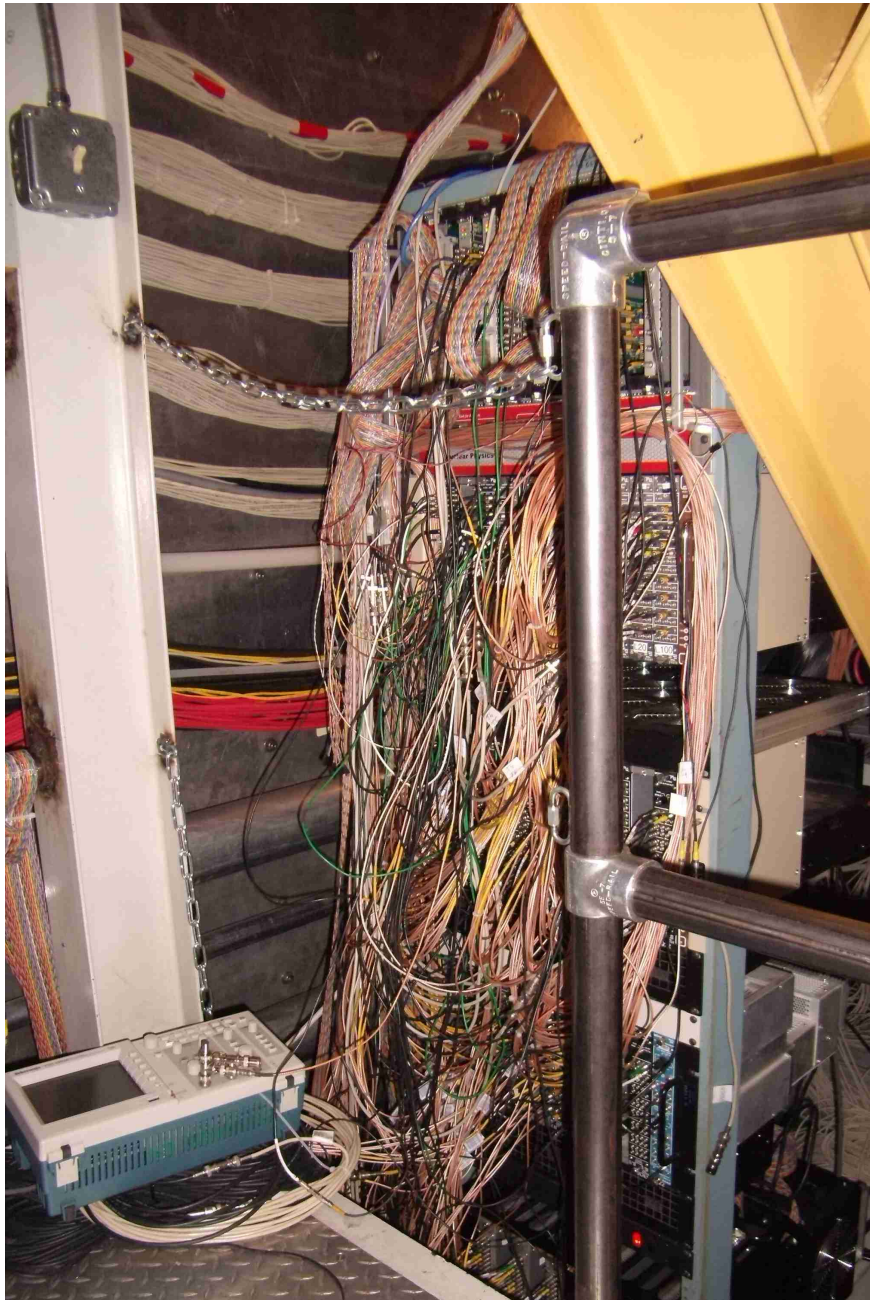
- A new fast-counting DAQ is required:
  - Hardware-based PID, scaler counting up to 1MHz;
  - Full event information sampled at lower rates by HRS DAQ for kinematics, efficiencies and PID analysis;
- *DAQ was tested off-line July-September 2008, including measurement of known asymmetries and 3 independent deadtime measurements.*
- *Installed in the Right HRS and tested parasitically April-June 2009 (polarized ^{3}He experiments), including 16 hours of 6 GeV beam up to 100uA on a thin carbon target on June 16.*
- *Duplicated and installed in the Left HRS in July 2009.*

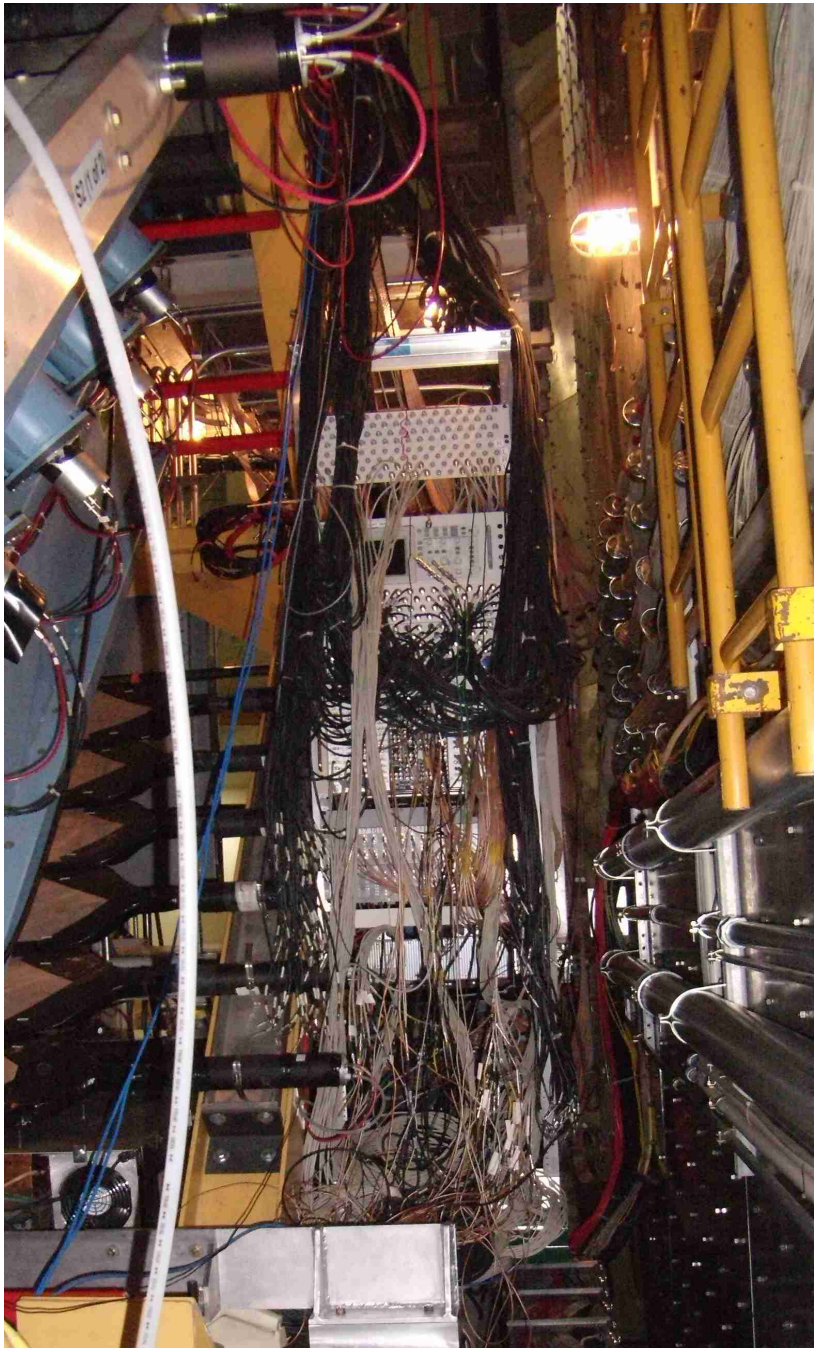
A new fast-counting DAQ

- Inputs:
  - Scintillators ("T1");
  - Gas cherenkov (GC), with hardware threshold provided by discriminators.
  - Lead glass counters ("Pre-shower" and "Shower"), divided into 6 (left) or 8 (right) groups, and with hardware threshold provided by discriminators.;



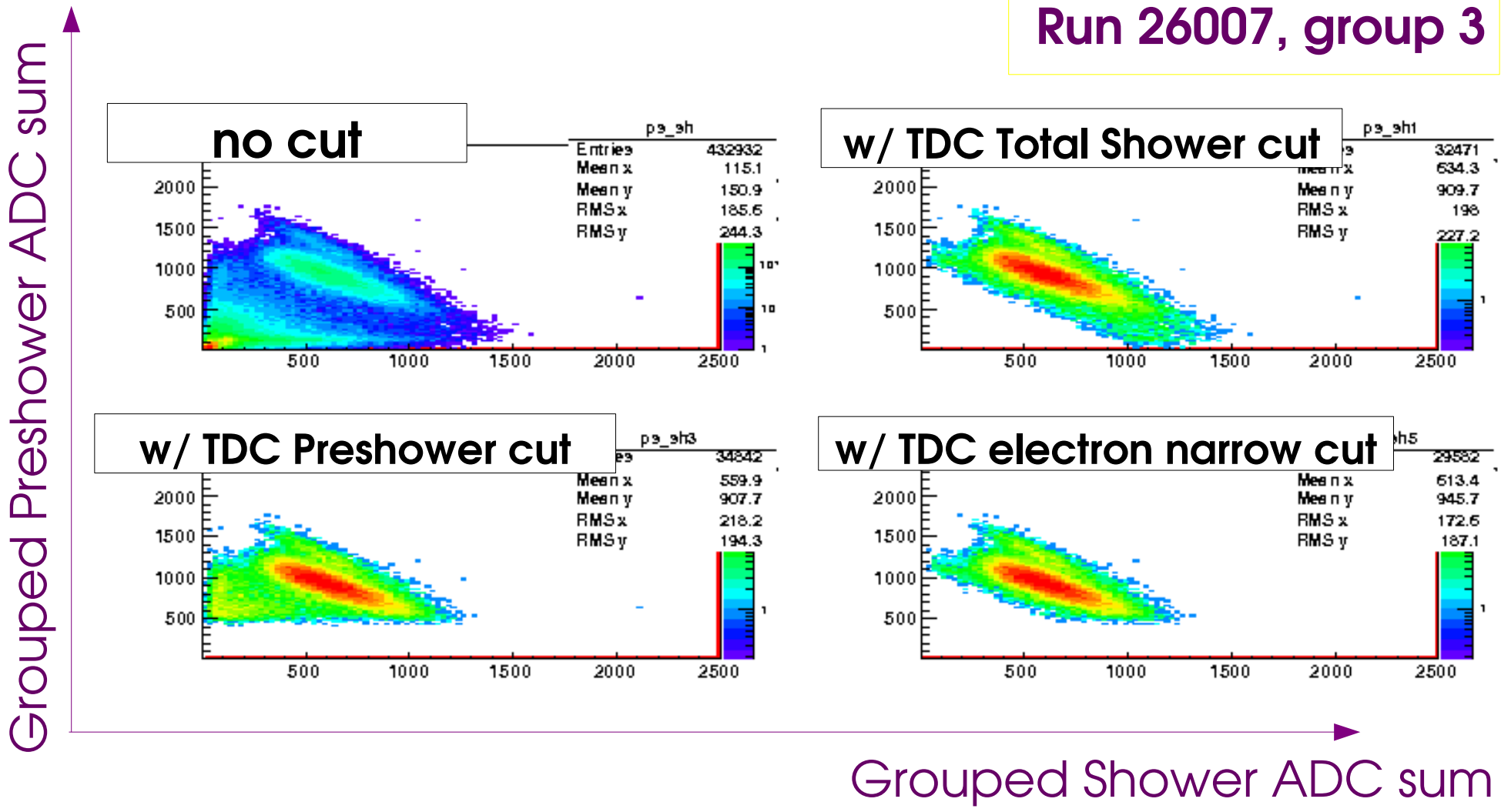
PVDIS DAQ in Situ (Right Arm)



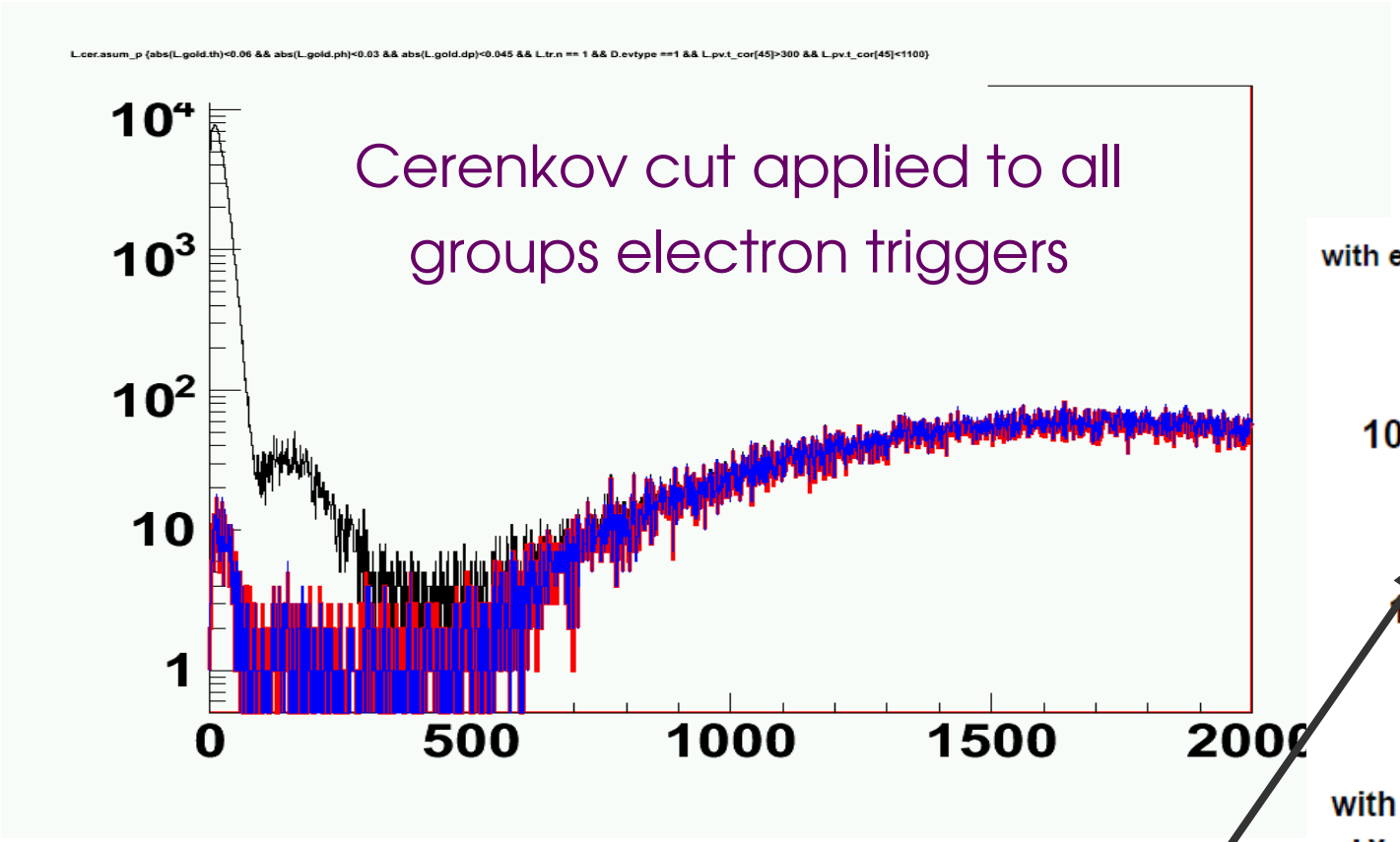


Performance Check using fbTDC info in RHRS DAQ

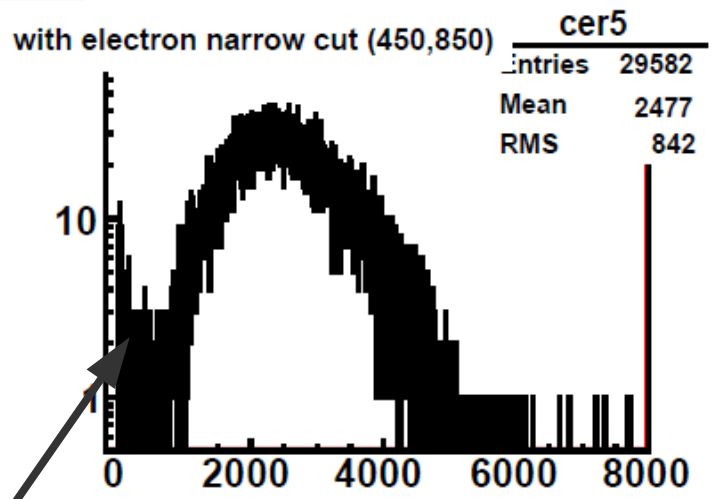
Run 26007, group 3



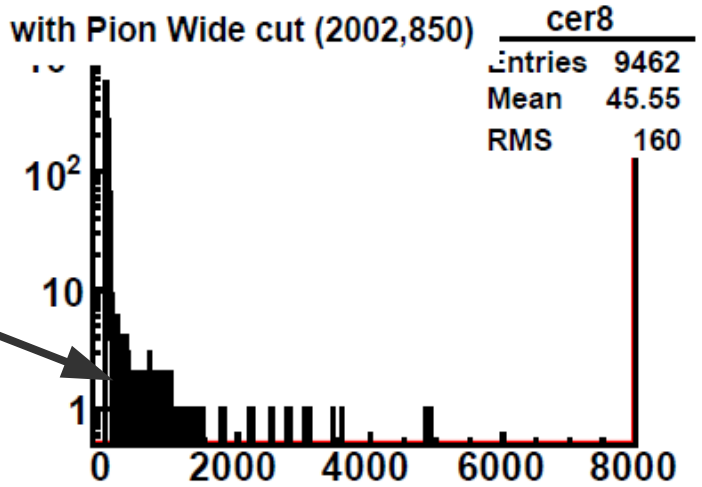
Performance Check using fbTDC info in RHRS DAQ



Run 26007

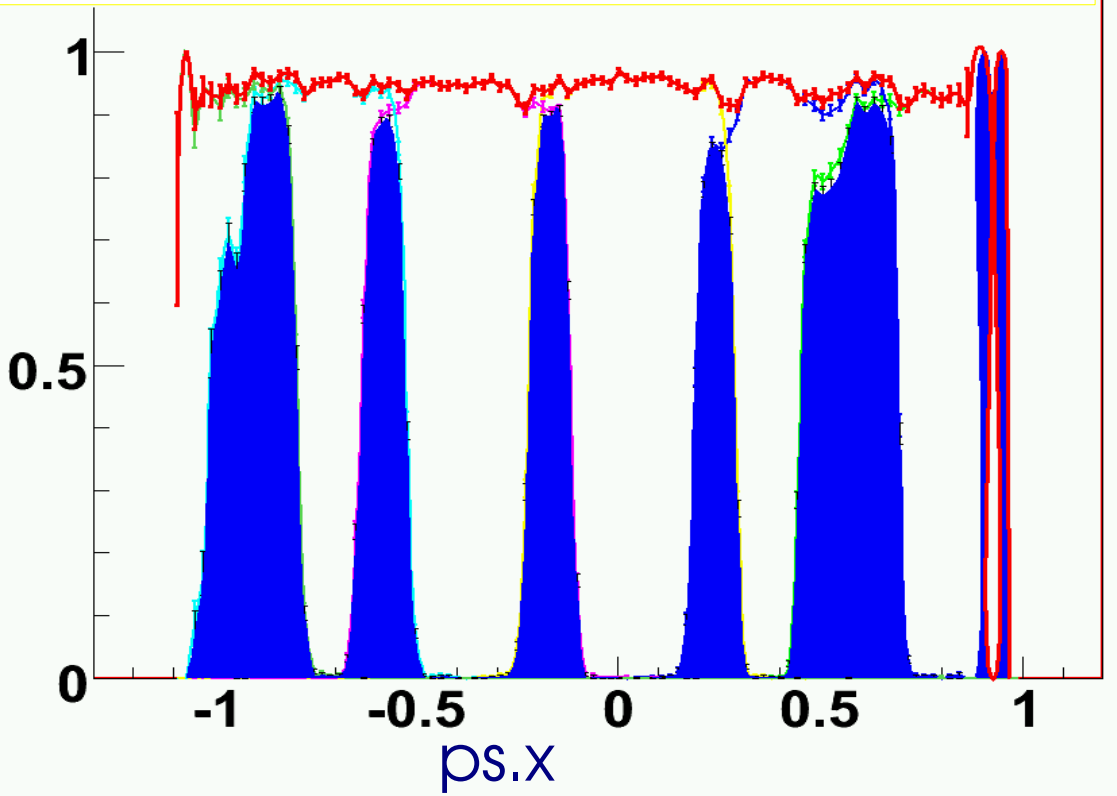


Group #3 electron and pion triggers



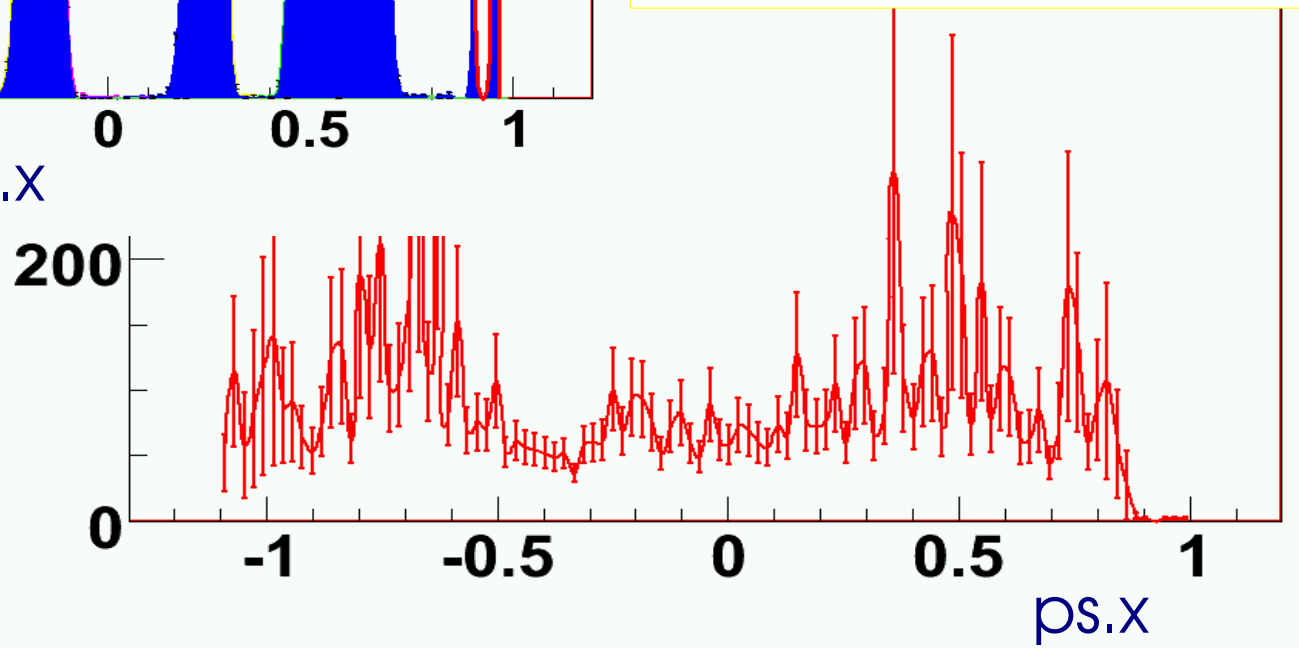
Lead Glass PID Check using fbTDC info in RHRS DAQ

electron narrow trigger PID efficiency, run 26007



- eff=N^e_1/N^e_0, electron samples N^e_0=(GC>800)
- rej=N^π_0/N^π_1, pion samples N^π_0=(GC<1)

pion rejection factor, run 26007



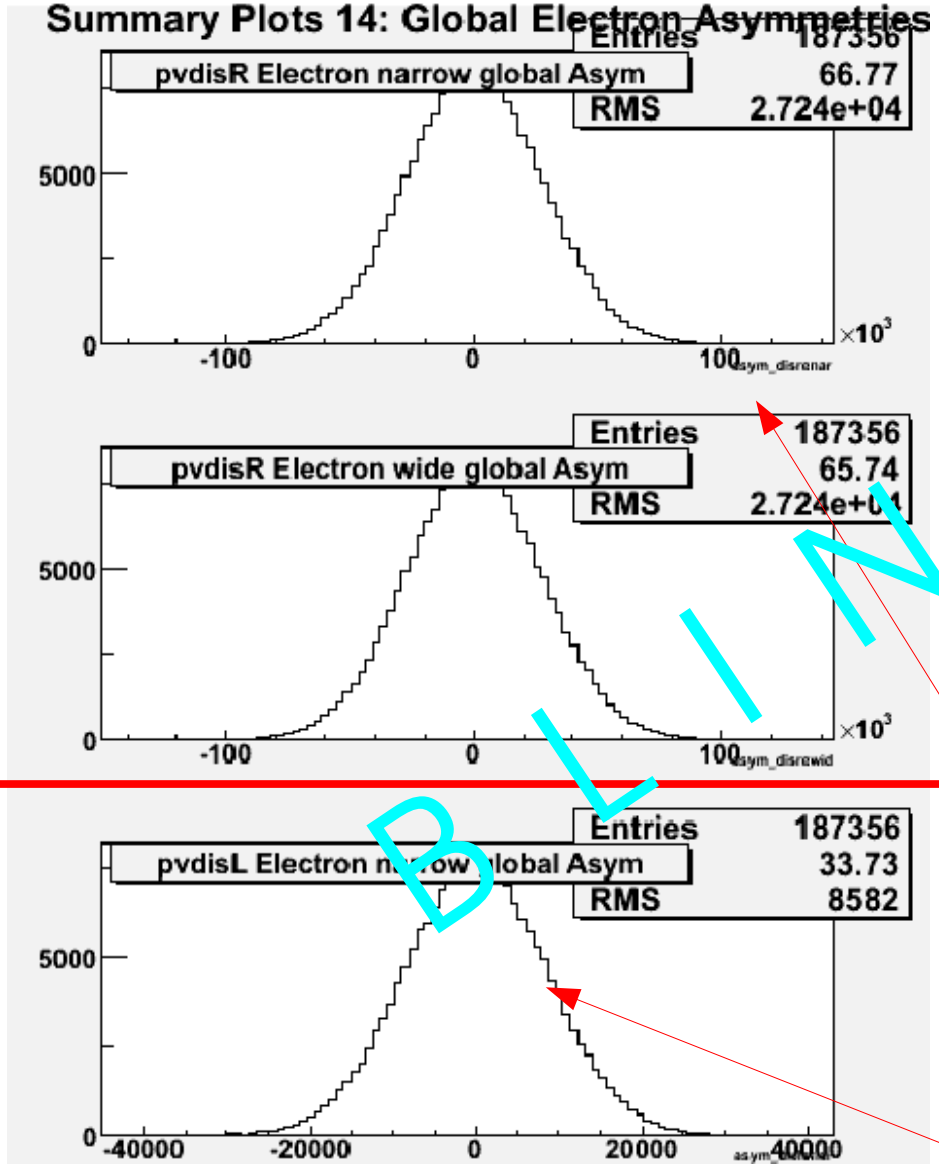
- Both agree with expections
- Checked with VDC ON runs daily.

PVDIS General Run Information

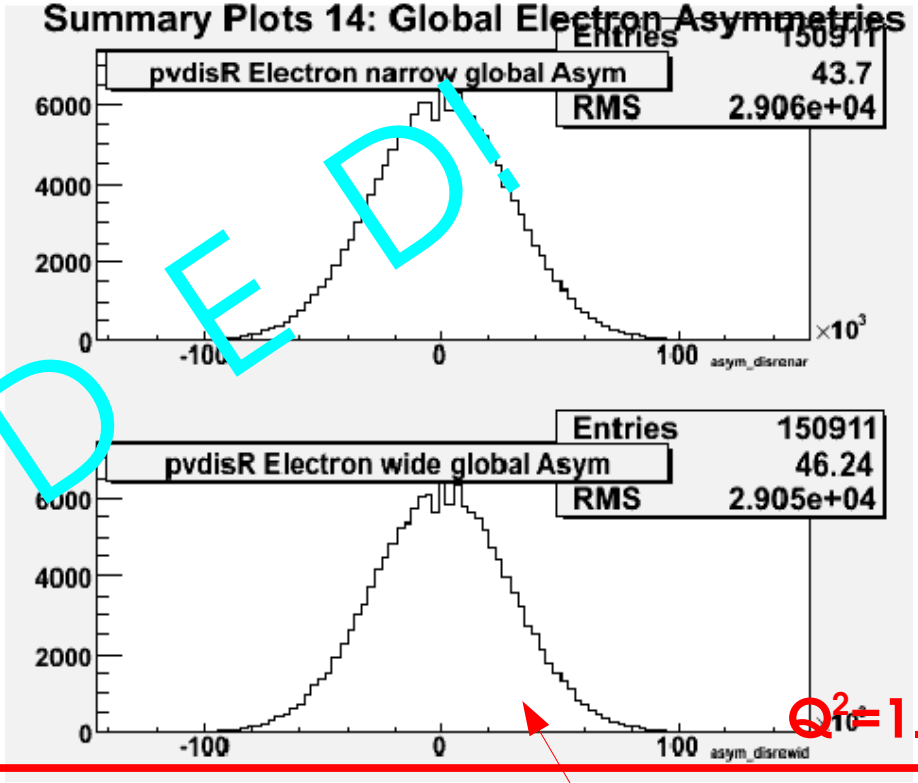
- Beam polarization shared with Hall B and monitored by Moller and Compton (photon-only). Moller results ~87%;
- Beam vertical polarization measured to be <2%;
- Beam charge asymmetry controlled by "parity feedback";
- Target boiling noise monitored by Lumi;
- Beam IHWP switched every 1M helicity pairs ("slugs");
- Deadtime measurement, analysis in progress;
- Other background or systematics measurements:
  - pion asymmetries measured continuously by PVDIS DAQ, consistent with zero so far;
  - Al dummy and positive polarity runs (8 hours), rate agree with calculation;
  - transverse beam polarization running (12 hours), systematic uncertainty under control;

Transverse Beam Polarization (Dec. 2)

slug12



slug13



BLINDED!

Q^2=1.9

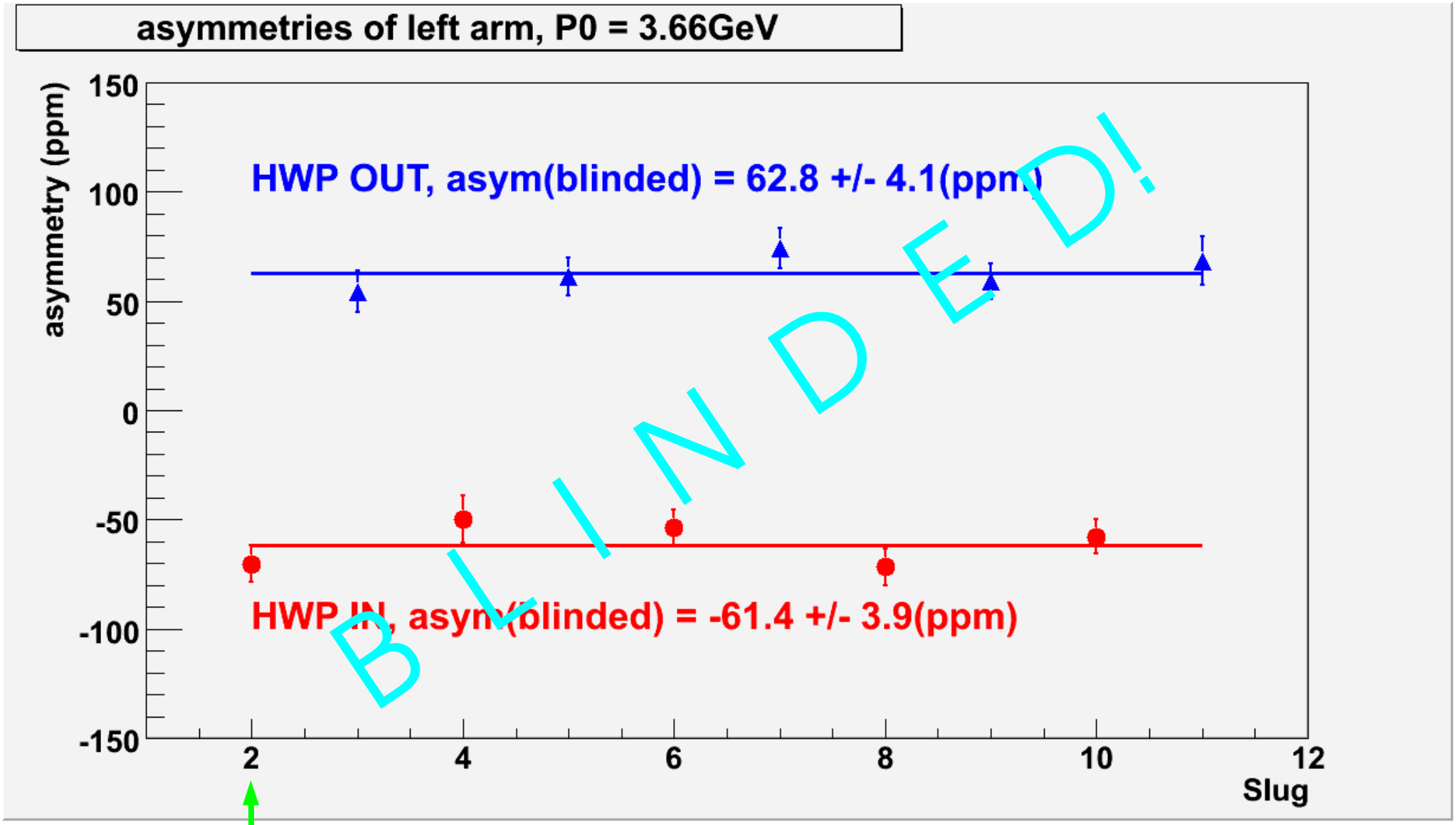
Q^2=1.1

$$\Delta A_T = \frac{2.724\text{E+4}}{\sqrt{187356}} \approx 63\ ppm$$

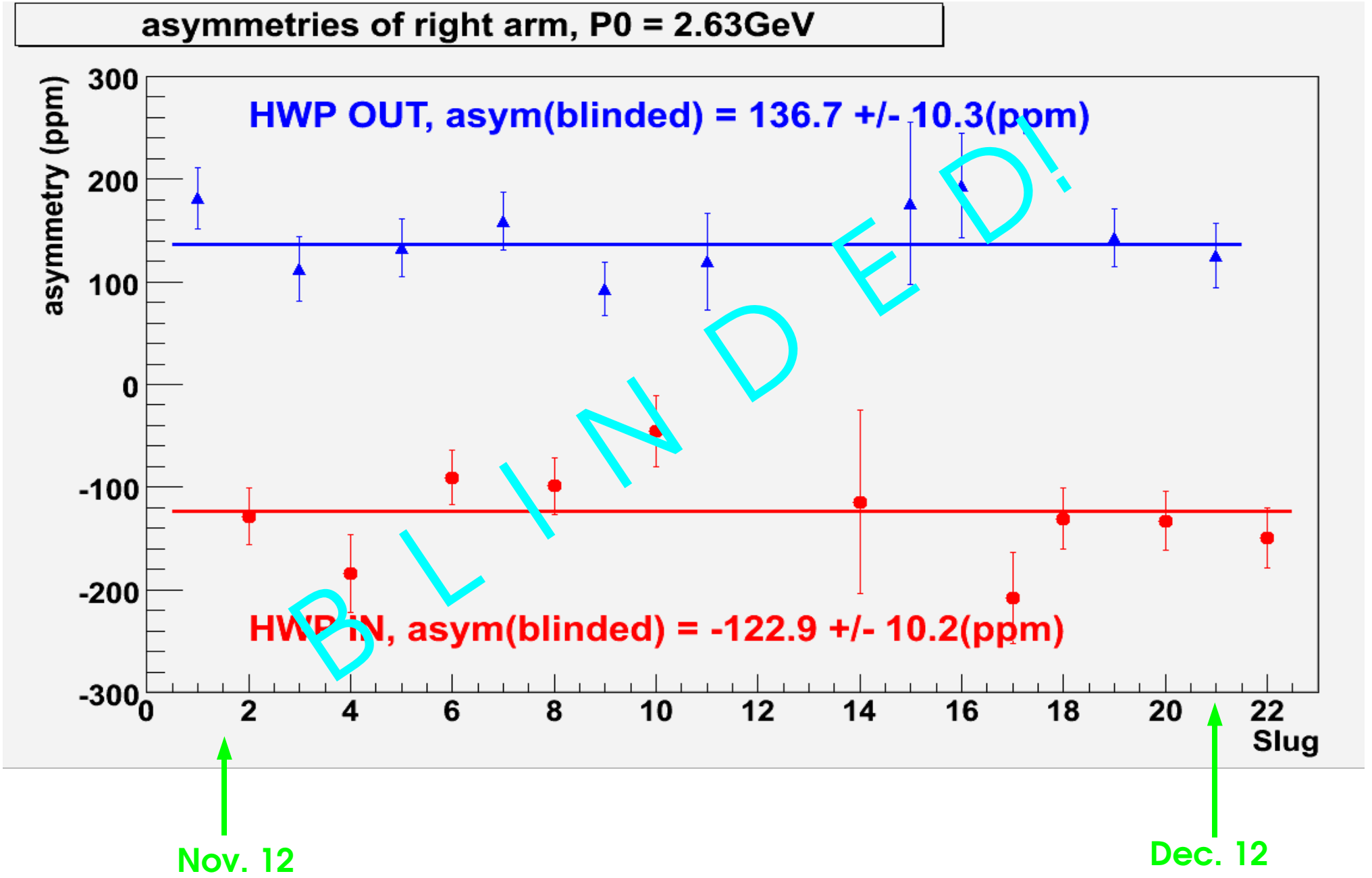
$$\Delta A_T = \frac{2.904\text{E+4}}{\sqrt{150911}} \approx 75\ ppm$$

$$\Delta A_T = \frac{8582}{\sqrt{187356}} \approx 20\ ppm$$

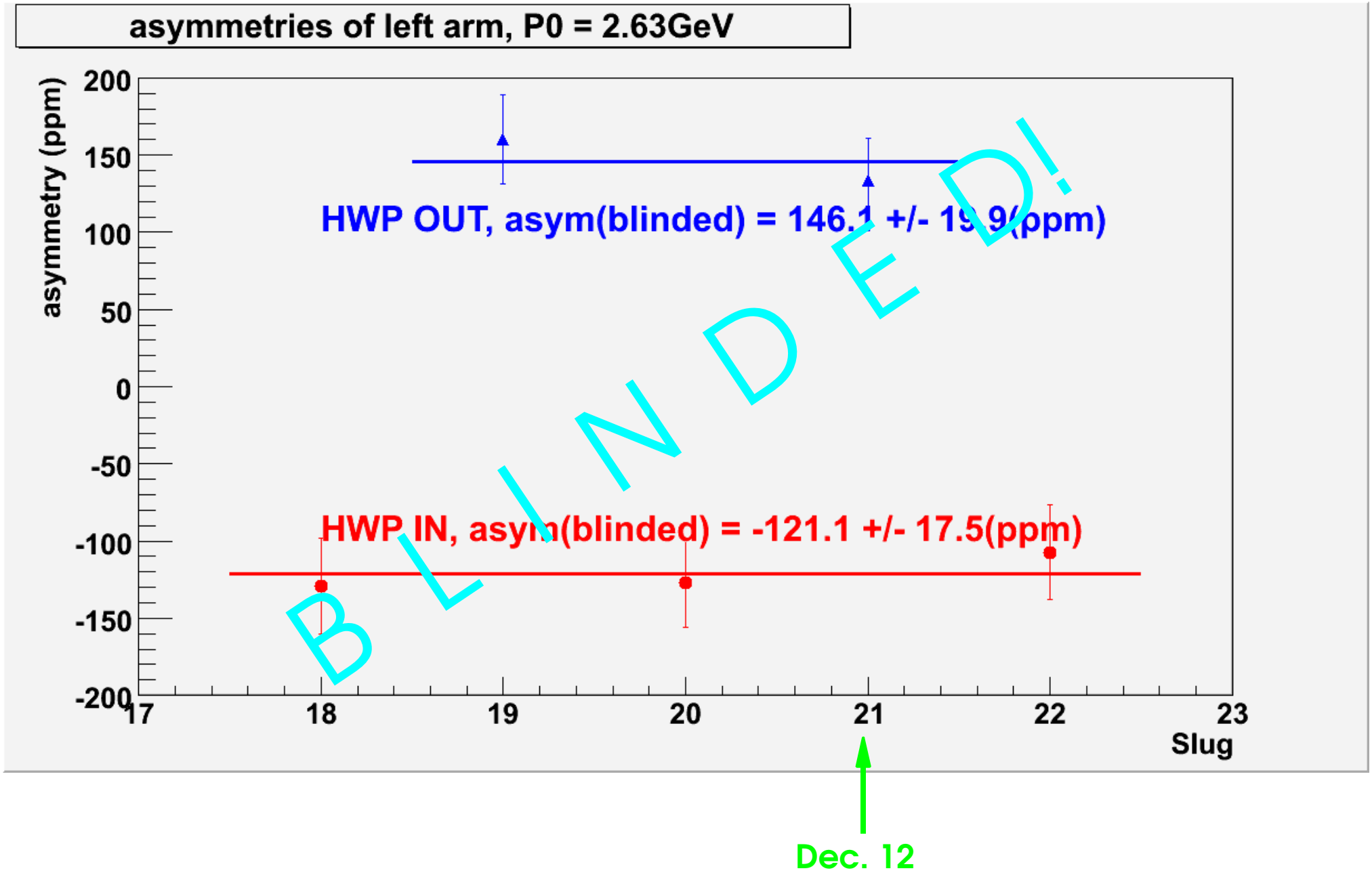
Online Asymmetries, Q^2=1.1, Left arm only



Online Asymmetries, Q^2=1.9, Right arm



Online Asymmetries, Q^2=1.9, Left arm



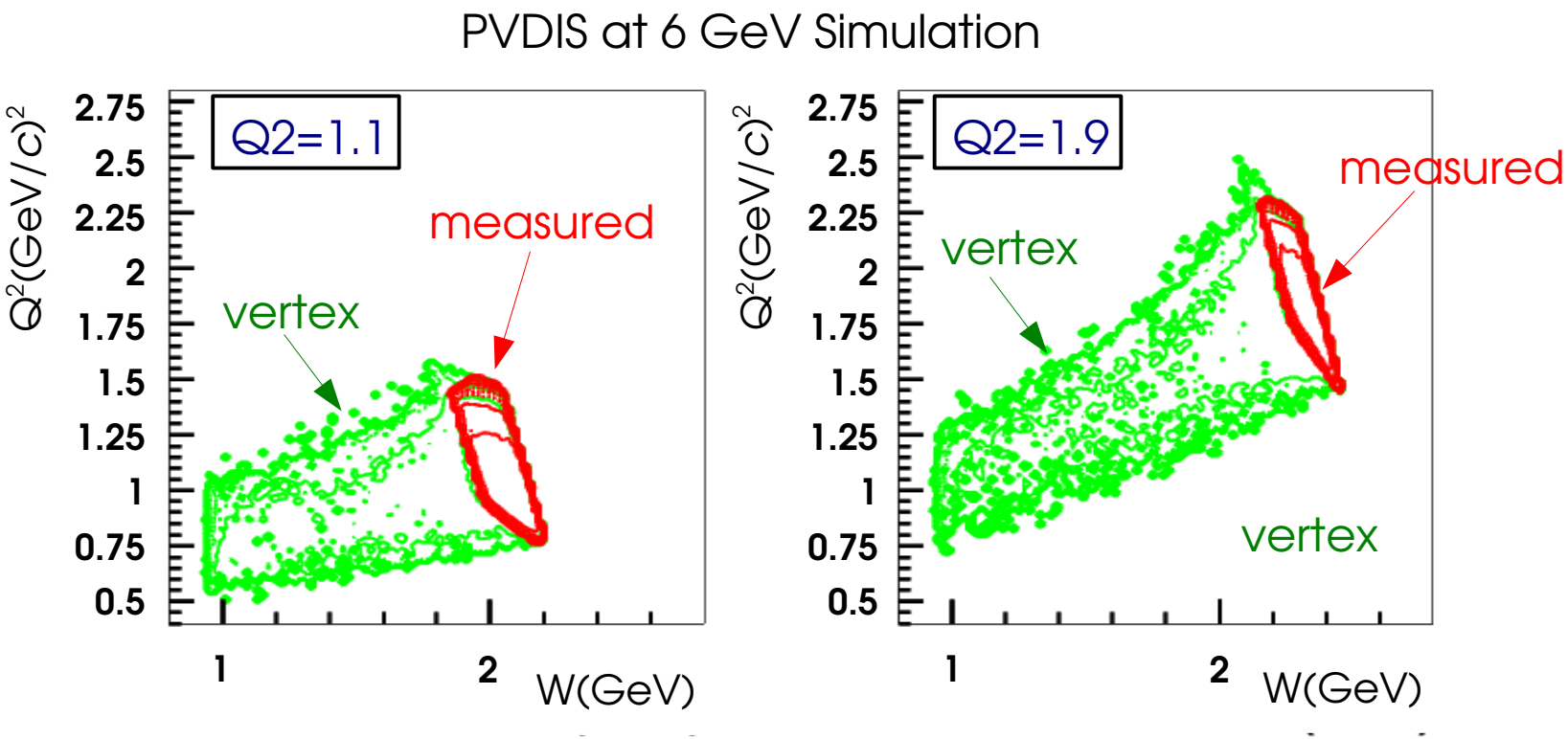
Deadtime Measurement

- Multiple methods planned:
  - tagger method (fractional loss + timing "pileup" correction);
  - rate scan method;
  - By observing TDC "deadzone";
  - The DAQ consists of 2 "paths", with discriminator width 30 and 100ns wide, respectively.

Deadtime Measurement

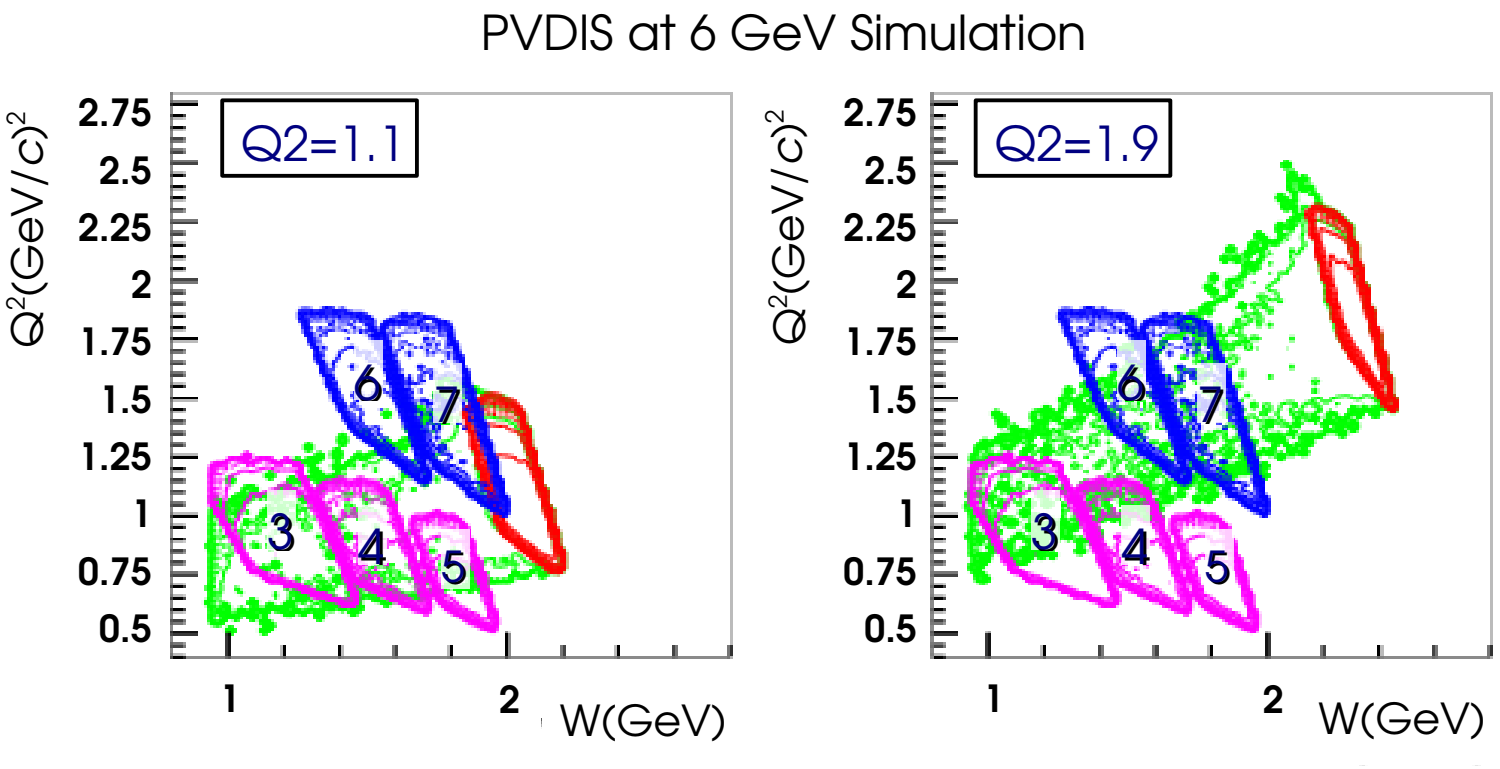
- Tagger method results:
  - Well understood, tagger "see" the same loss as electron signals;
    - Before Nov. 26, deadtime of all groups proportional to T1 rate, up to 1.4% loss on left arm. Error bar should be well below 0.5%.
    - After Nov. 26, deadtime proportional to group rates (Preshower or Total Shower).
      - "Narrow path" sees 50-70ns deadtime (dominated by input width);
      - "Wide path" sees 100-110ns deadtime (as expected).
      - Highest loss is for left arm at the lower Q^2 point: ~0.5%
      - Higher Q^2 point has much less deadtime: <0.05%.
      - Error bar should be a fraction of it (dominated by "pileup" correction").
- Rate scan method:
  - Need to know BCM nonlinearity.

Outlook (Resonance Runs: Dec. 17-22)



- Resonance events contribute up to 15%
- No reliable way to calculate PV asymmetry at low W and Q^2
- Almost impossible to calculate resonance structure
- Will measure resonance PV asymmetry to control ΔA_d below 1%.

Outlook (Resonance Runs: Dec. 17-22)



adjusted to balance L/R HRS

Kine#	E (GeV)	θ	E' (GeV)	e- rate (KHz)	A_d (ppm)	$\Delta A_d/A_d$	Beam time (hours)
3	4.8	12.5	4.00(L)	1288	-68.7	5%	28.6
4	4.8	12.9	3.55(L)	888	-67.7	5%	42.6
5	4.8	12.9	3.10(R)	791	-60.6	5%	59.8
6	4.8	19.0	2.77(R)	105	-120.7	8%	44.6
7	6.0	14.0	4.00	280	-113.0	8%	19.0

RES beam time: 4days

larger now by 50%

X. Zheng, Hall A Collaboration Meeting, Dec. 2009

Outlook (Analysis)

- w-months for asymmetry extraction;
- x-months for deadtime analysis;
- y-months or 0.y years for radiative correction;
- z-months or 0.z years for extracting C_{2q} and higher twists.
- Total: N-years before unblinding. (Note: It took 2 years for G0 to unblind).

- End of run party: Dec. 22 (Tuesday) 12noon-4pm, ResFac common room

We may not make the most important discovery, but we are certainly the first to move both HRSs by hand drills, exclusively throughout the experiment!

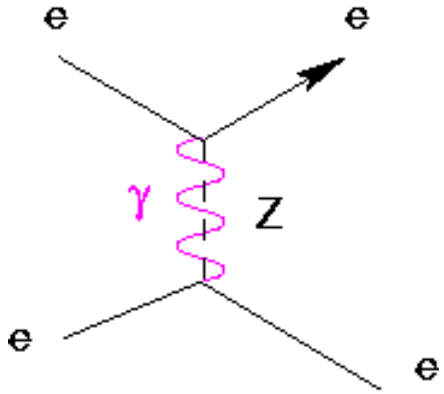

DANGER

MVP of the Experiment

Backup Slides

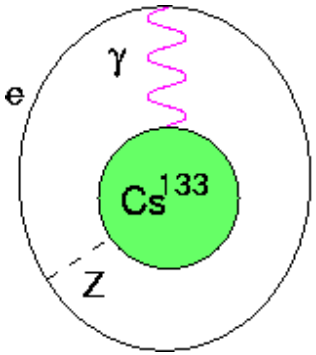
PV DIS and Other SM Test Experiments

- *E158/Moller (SLAC)*



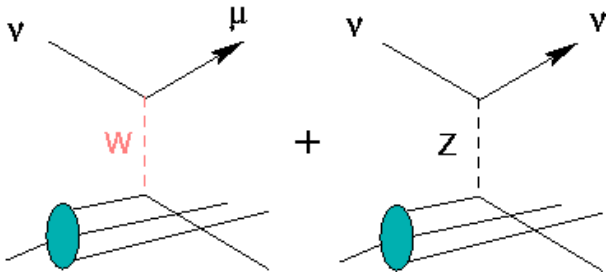
  - Purely leptonic

- *Atomic PV*



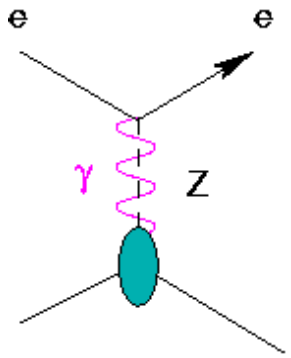
  - Coherent Quarks in the Nucleus
  - $-376C_{1u} - 422C_{1d}$
  - Nuclear structure?

- *NuTeV (FNAL)*



  - Weak CC and NC difference
  - Nuclear structure?
  - Other hadronic effects?

- *Qweak (JLab)*

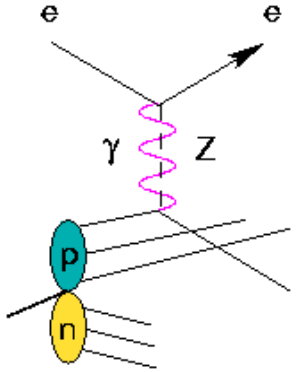


  - $2\,(2C_{1u}+C_{1d})$
  - Coherent quarks in the proton

Different Experiments Probe Different Parts of Lagrangian,

PVDIS is the only one accessing C_{2q}

- *PVDIS (JLab)*



  - $(2C_{1u}-C_{1d})+Y(2C_{2u}-C_{2d})$
  - Isoscalar quark scattering

Cartoons borrowed from R. Arnold (UMass)

Kinematics

Kinematics	I	II
x_{bj}	0.25	0.3
Q^2 (GeV/c)^2	1.11	1.9
E_{beam} (GeV)	6.0	6.0
E' (GeV)	3.66	2.63
$\theta(^o)$	12.9°	20.0°
W^2 (GeV)^2	4.16	5.30
Y	0.470	0.716
R_C	<0.001	0.001
R_S	0.052	0.041
R_V	0.872	0.910
A_d (measured, ppm)	-91.3	-160.7
e^- rate/HRS (kHz)	269.8	25.1
π^-/e^- ratio	0.9	6.4
e^+/e^- ratio	0.073%	0.463%
Total rate/HRS (kHz)	513.0	186.2

Expected Uncertainties on A_d

Source \ $\Delta A_d/A_d$	Q^2=1.1 GeV^2	Q^2=1.9 GeV^2
$\Delta P_b/P_b$=1%	1.0%	1.0%
Deadtime correction	0.3%	0.3%
Target endcap contamination	0.4%	0.4%
Target purity	<0.02%	<0.02%
Pion background	<0.2%	<0.2%
Pair production background	<0.2%	<0.2%
Systematics	1.36%	1.36%
Statistical	2.11%	2.09%
Total	2.52%	2.49%

now 5mil Al
(was 3mil Be)