

Parity Violating Deep Inelastic Scattering at Jlab 6 GeV

Diancheng Wang

University of Virginia

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- ✚ The Physics of PVDIS
- ✚ Experimental Setup and Expected Uncertainties
- ✚ On-Going Data Analysis:
 - ◆ Compton Polarimetry Analysis
 - ◆ Deadtime of the Fast-Counting DAQ

The Physics of PVDIS at 6 GeV (E08-011)

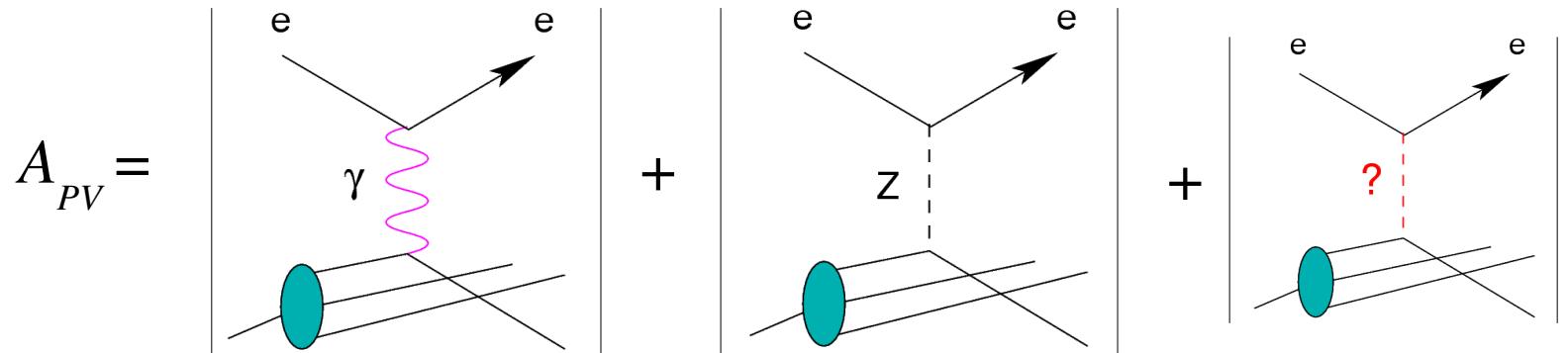
Measure PVDIS asymmetry on a deuterium target, A_d , at $Q^2=1.1$ and 1.9 GeV^2 to 4% (stat.);

From $Q^2=1.1$ can help to investigate if there are significant HT effects;
— “Baseline” measurement for the future 12 GeV program.

If HT is small, from $Q^2=1.9 \text{ GeV}^2$ can extract $2C_{2u}-C_{2d}$ to ± 0.060 , a factor of 4 improvement;

Kinematics	x_{bj}	$Q^2 (\text{GeV}/c)^2$	$E_{\text{beam}} (\text{GeV})$	$E' (\text{GeV})$	$\theta(^{\circ})$	$W^2 (\text{GeV})^2$	$A_d (\text{ppm})$
I	0.25	1.11	6.0	3.66	12.9°	4.16	-91.3
II	0.3	1.9	6.0	2.63	20.0°	5.3	-160.7

PVDIS Asymmetries



Deuterium:

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

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

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

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

$$C_{2d} = g_V^e g_A^d = \frac{1}{2} - 2 \sin^2(\theta_W)$$

Can extract $C_{1,2q}$ (and $\sin^2\theta_W$) – discover new physics beyond the SM

Mass limit:

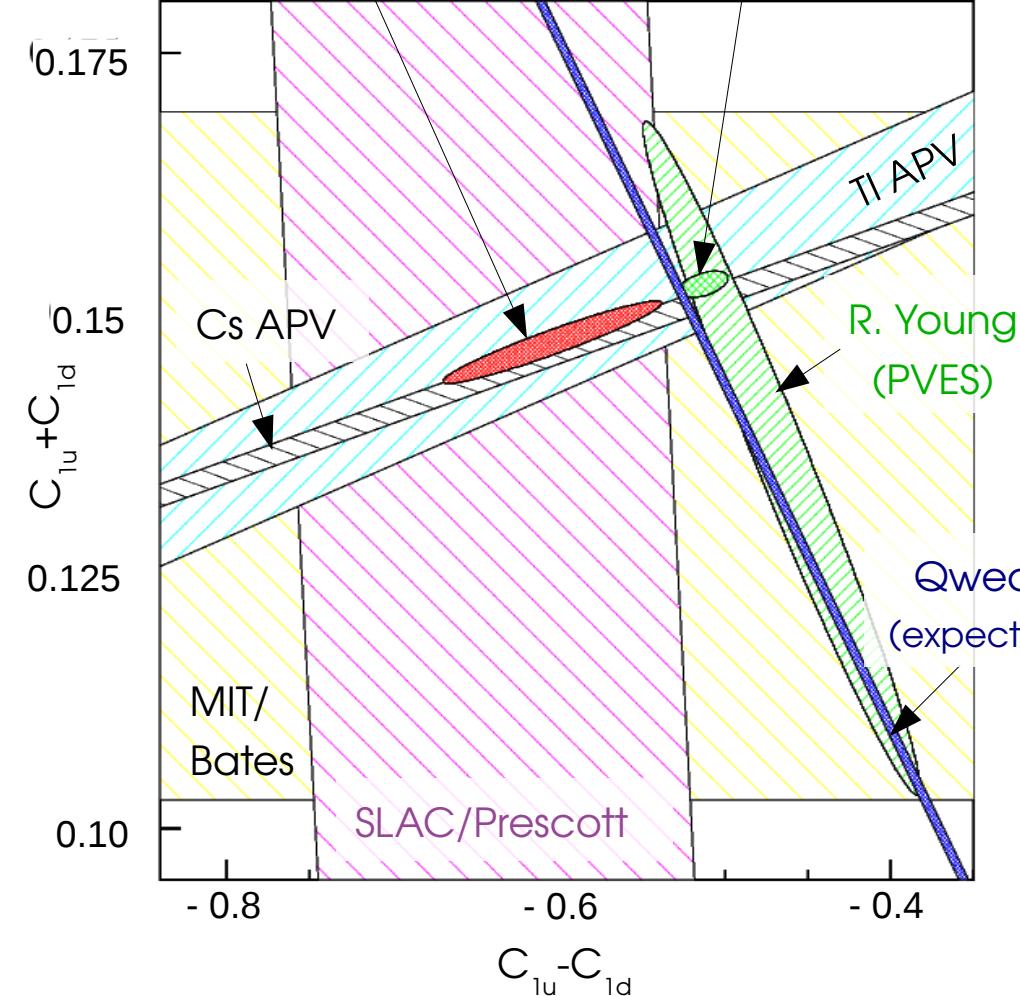
$$\frac{\Lambda}{g} \approx \frac{1}{[\sqrt{8} G_F |\Delta(2C_{2u} - C_{2d})|]^{1/2}} \approx 0.74 \text{ TeV}$$

Current Knowledge on $C_{1,2q}$

all are 1σ limit

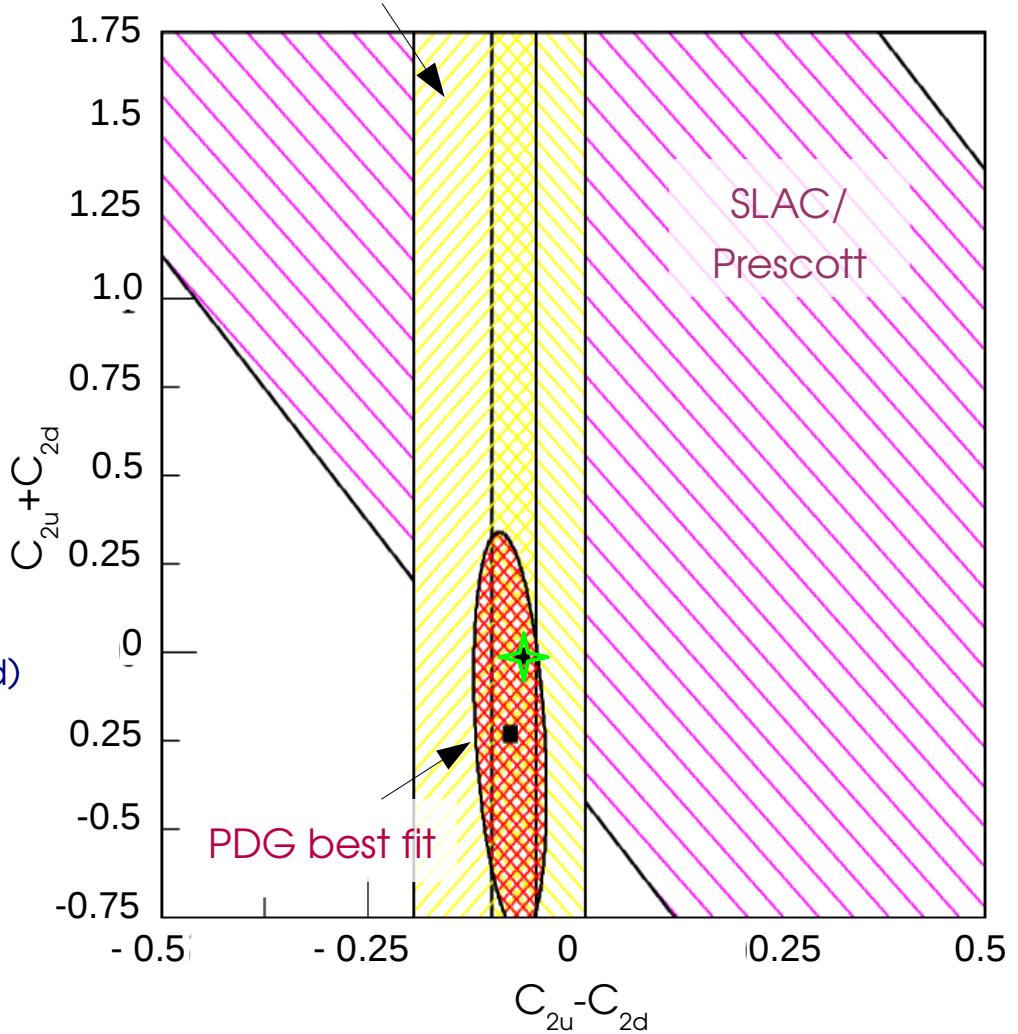
PDG best fit

R. Young
(combined)



• Best: $\Delta(2C_{2u} - C_{2d}) = 0.24$

SAMPLE

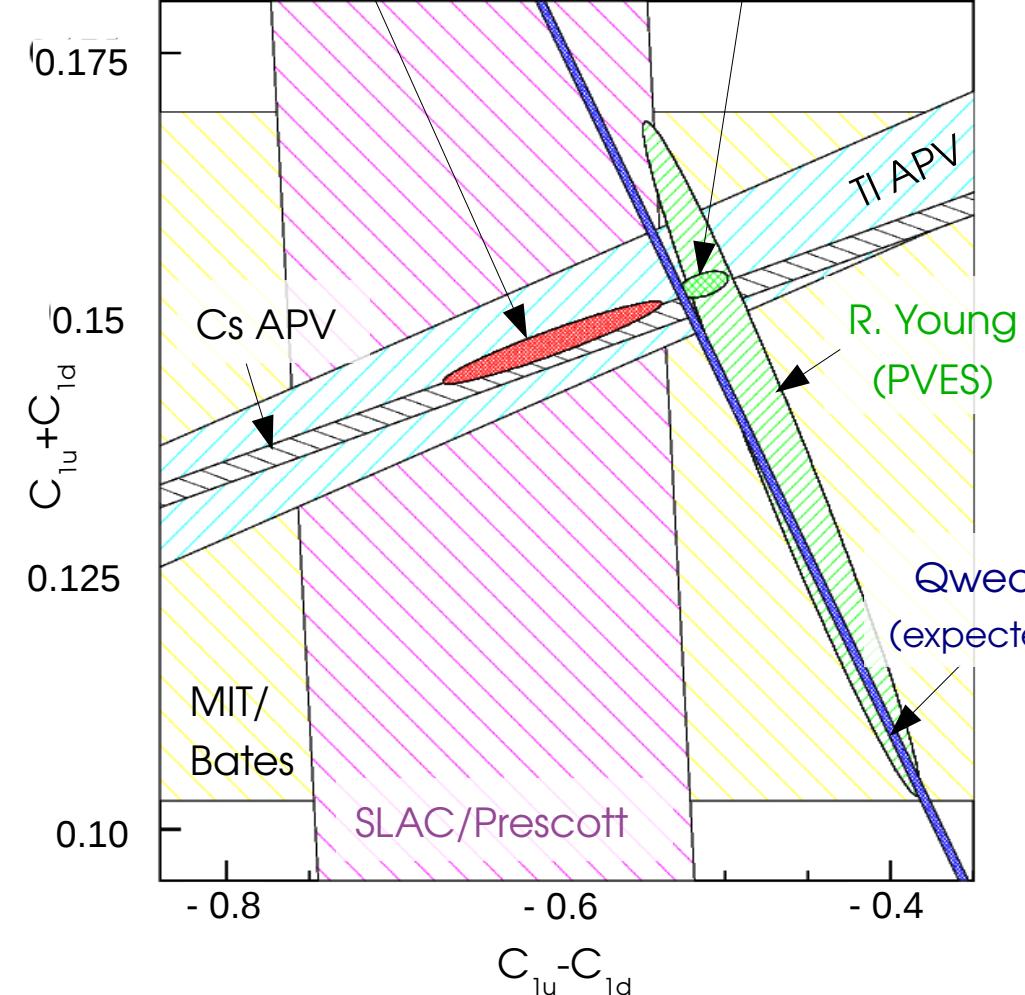


The 6 GeV E08-011

all are 1σ limit

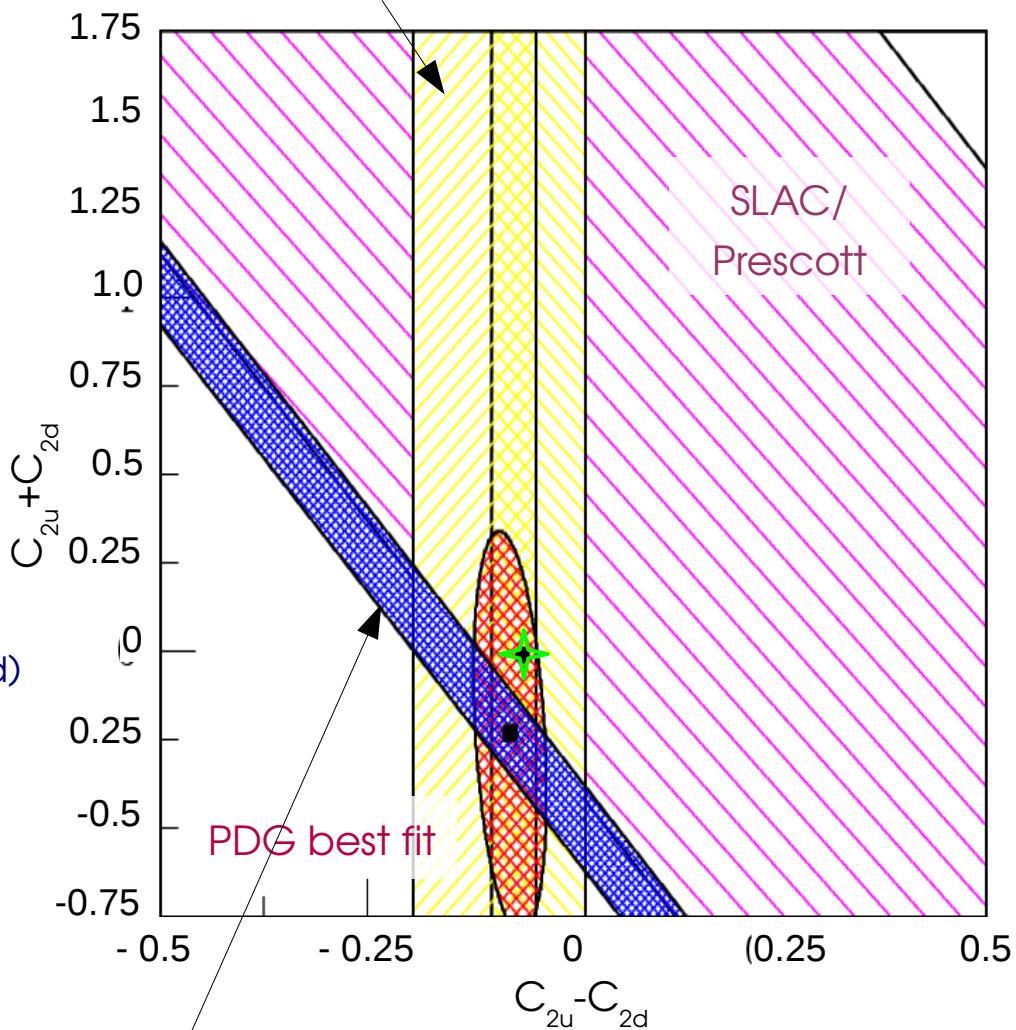
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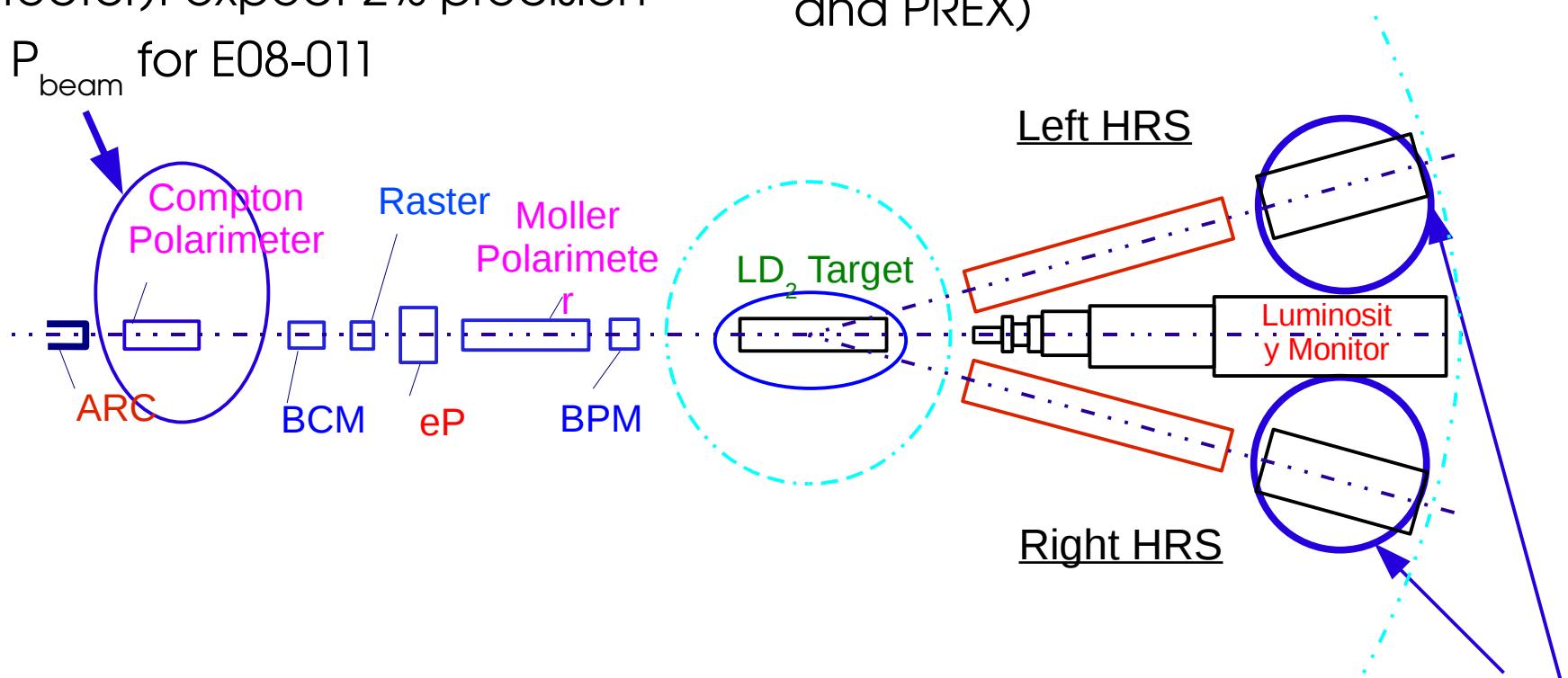


Expected: JLab 6 GeV PV-DIS E08-011
(assuming small hadronic effects and a
4% stat error on Ad)

In Addition to the Standard Hall A Setup

- ✚ New methods used (photon integration and new electron detector): expect 2% precision on P_{beam} for E08-011

Also needed for two other PV experiments in Hall A (HAPPEX-III and PREX)

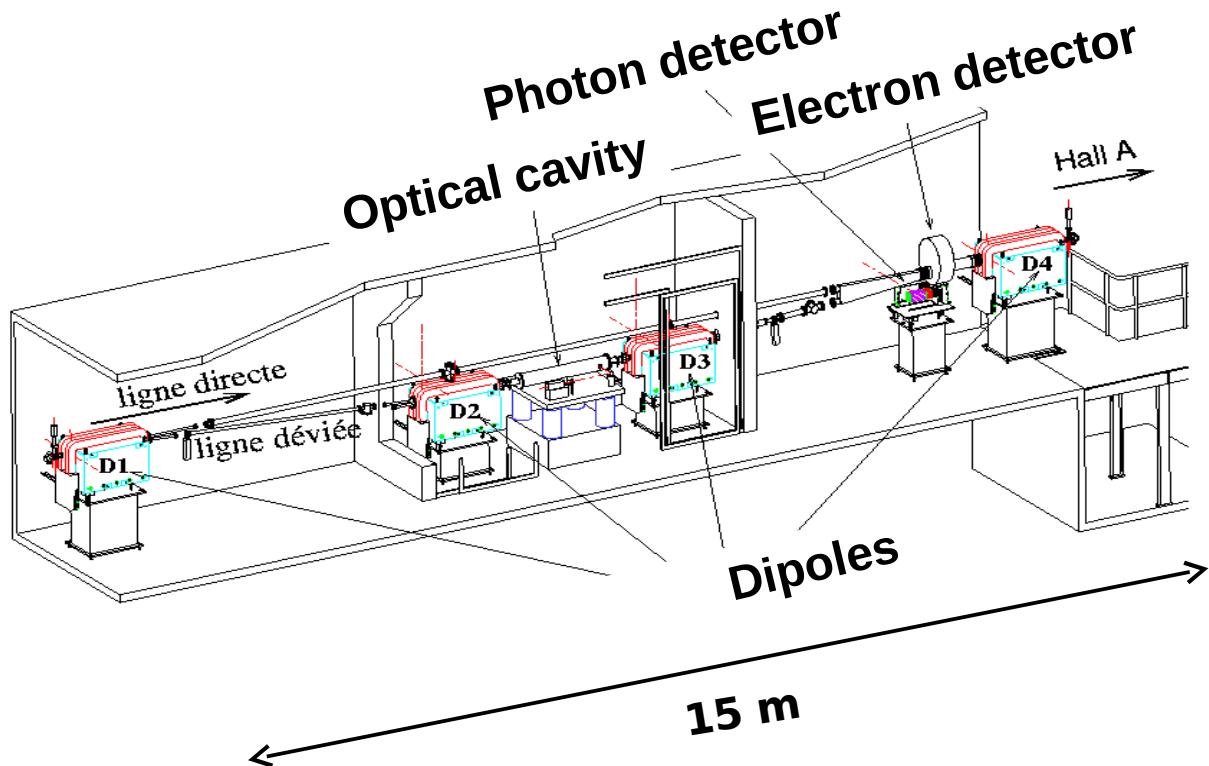


- ✚ Regular HRS data acquisition (DAQ) count up to 4KHz (PVDIS 400KHz);
- ✚ Integration method won't work for DIS;
- ✚ Need a new fast-counting DAQ, design goal: 1MHz with on-line particle identification (PID); **Never been done before!**

Expected Uncertainties on A_d

Source \ $\Delta A_d / A_d$	$Q^2 = 1.1 \text{ GeV}^2$ $Q^2 = 1.9 \text{ GeV}^2$	
$\Delta P_b / P_b = 1\%$	2.0%	2.0%
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	2.08%	2.08%
Statistical	3.0%	4.0%
Total	3.7%	4.5%

Hall A Compton Polarimeter



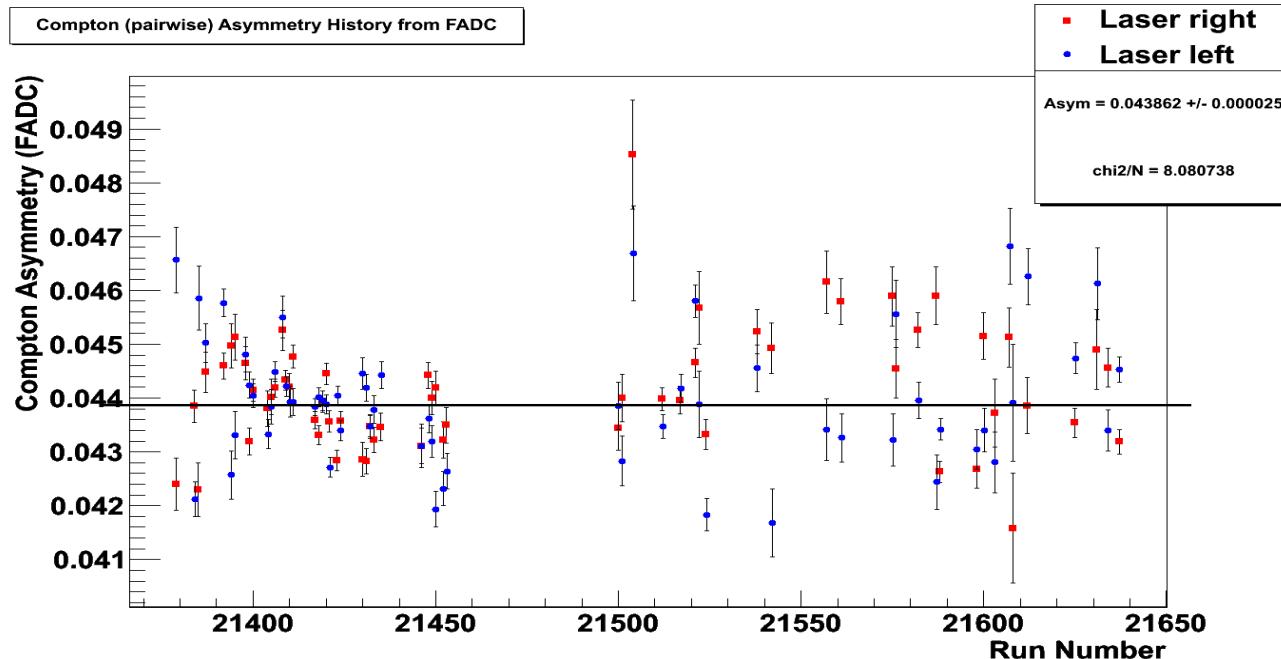
$$A_{\text{exp}} = P_e P_\gamma A_l$$

Where:

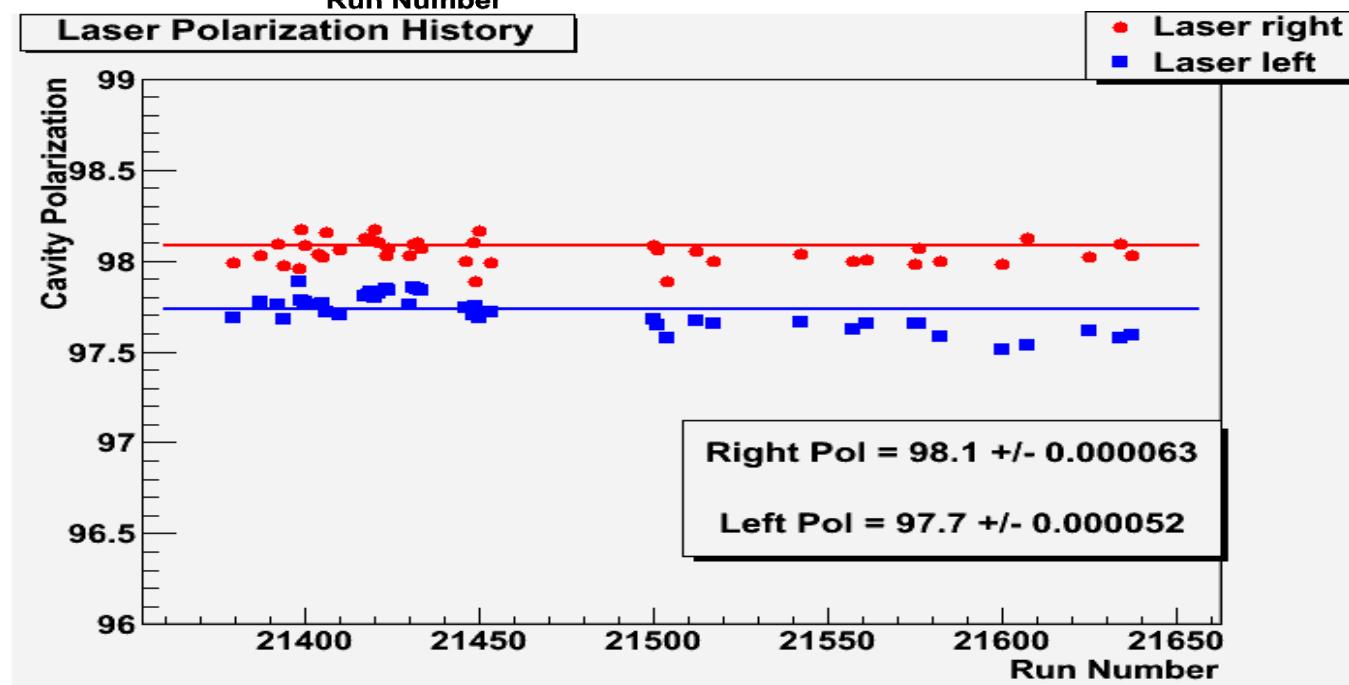
- ✚ P_e beam polarization
- ✚ A_{exp} measured asymmetry
- ✚ P_γ laser polarization
- ✚ A_l theoretically calculated

- ➊ A_{exp} is extracted from data
- ➋ P_γ measured by laser polarimetry
- ➌ Monte Carlo simulation to calculate A_l , taking into account the whole geometry of the setup.

Compton Asymmetry History from FADC



Expected Precision: 2%



A new fast-counting DAQ

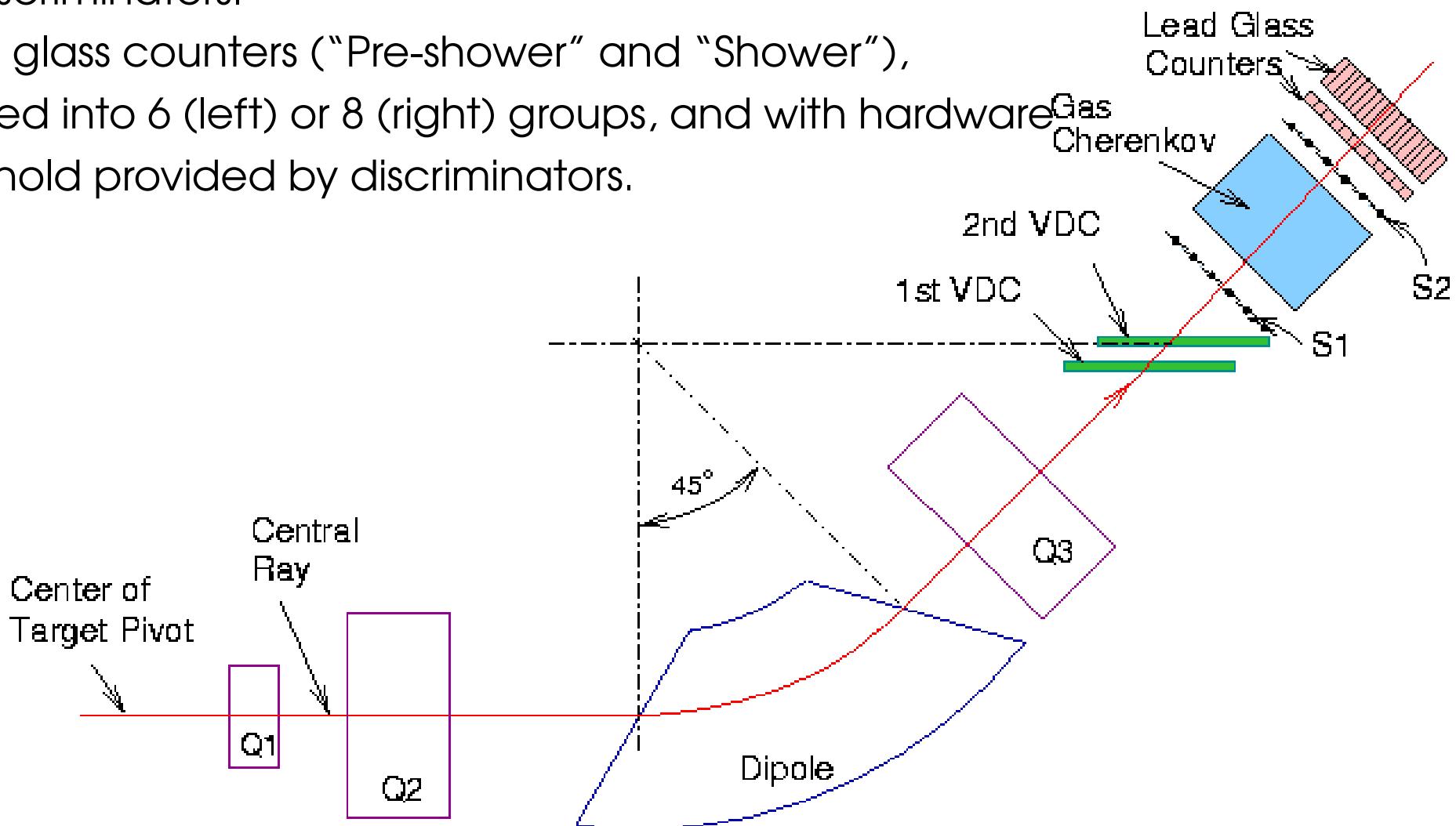
Inputs:

Scintillators (“T1”);

Gas cherenkov (GC), with hardware threshold provided by discriminators.

Lead glass counters (“Pre-shower” and “Shower”),

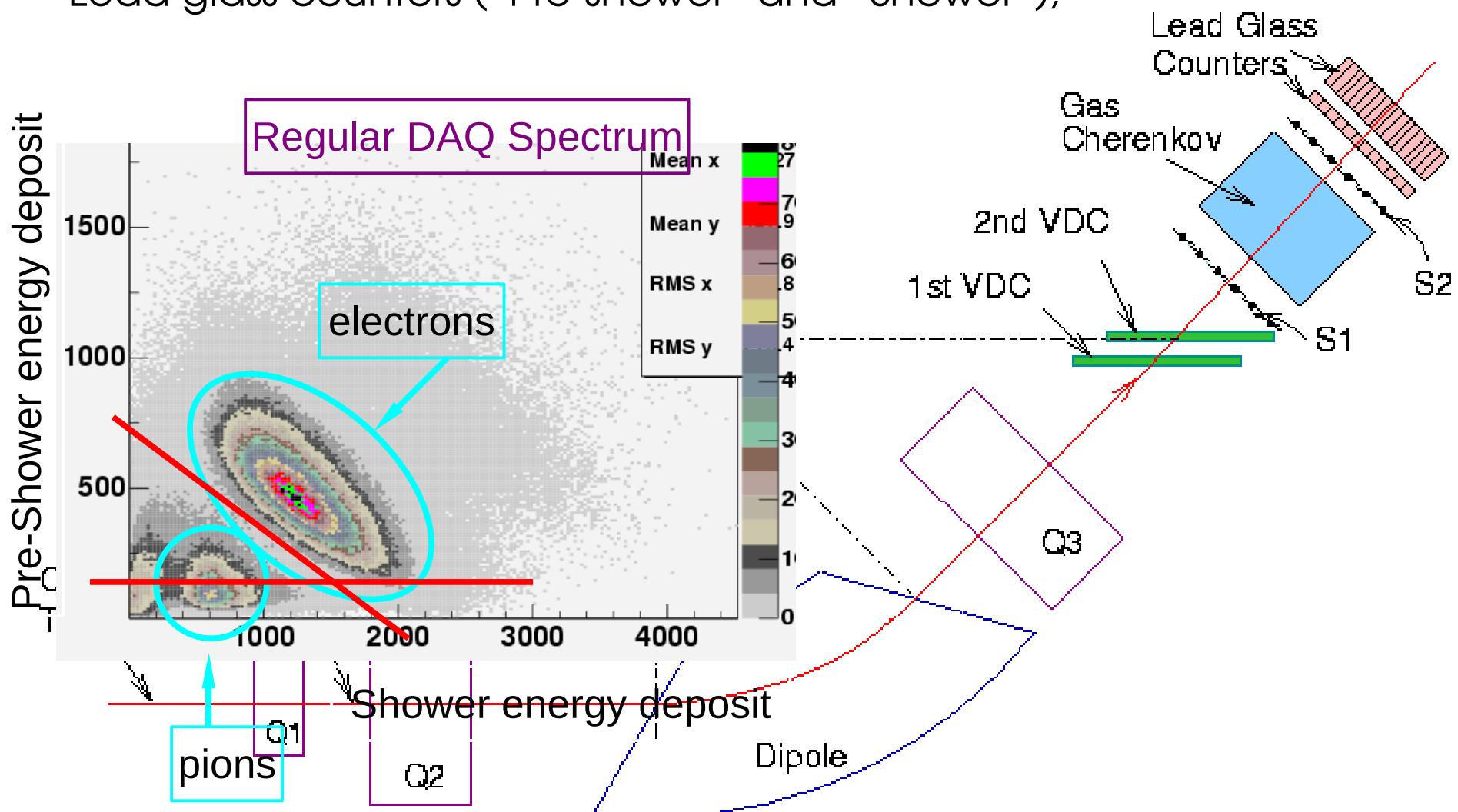
divided into 6 (left) or 8 (right) groups, and with hardware threshold provided by discriminators.



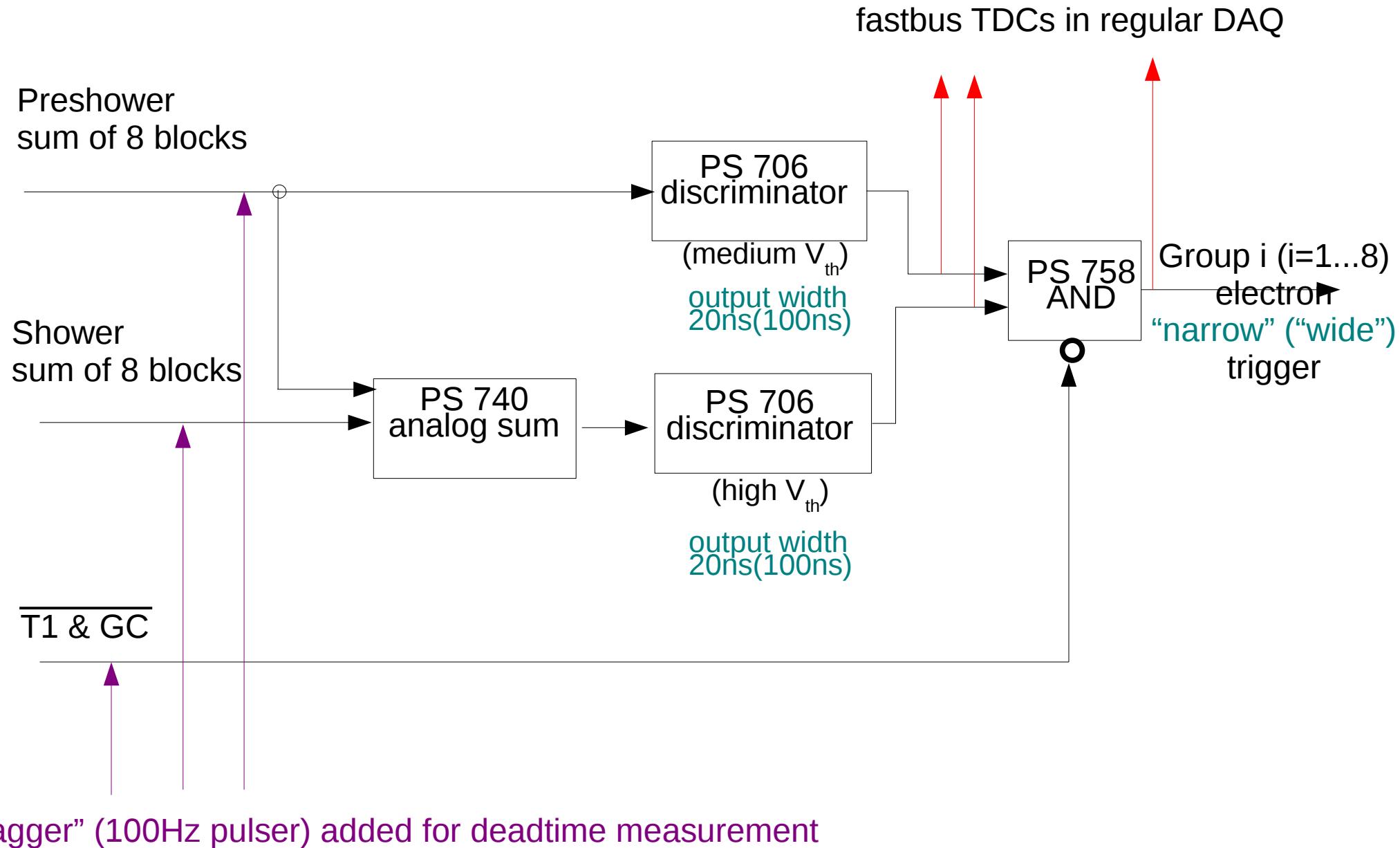
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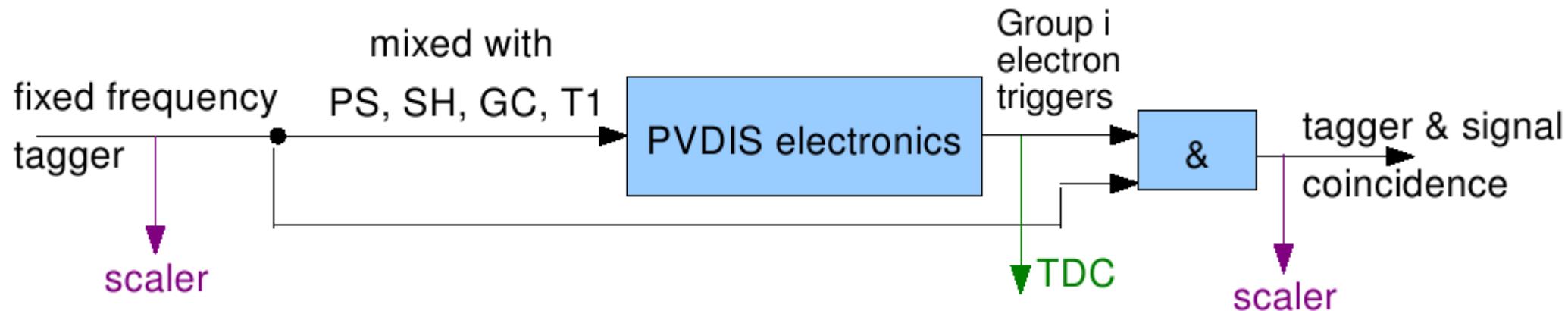


PVDIS DAQ Design



Deadtime of the Fast-Counting DAQ

The Tagger method to measure deadtime:



$$\text{Deadtime} = \frac{R_{\text{tagger}} - R_{\text{tagger \& signal}}(1 - \text{Pileup})}{R_{\text{tagger}}} \approx \frac{R_{\text{tagger}} - R_{\text{tagger \& signal}}}{R_{\text{tagger}}} + \text{Pileup}$$

≡ Fractional Loss + Pileup

Measured by scaler

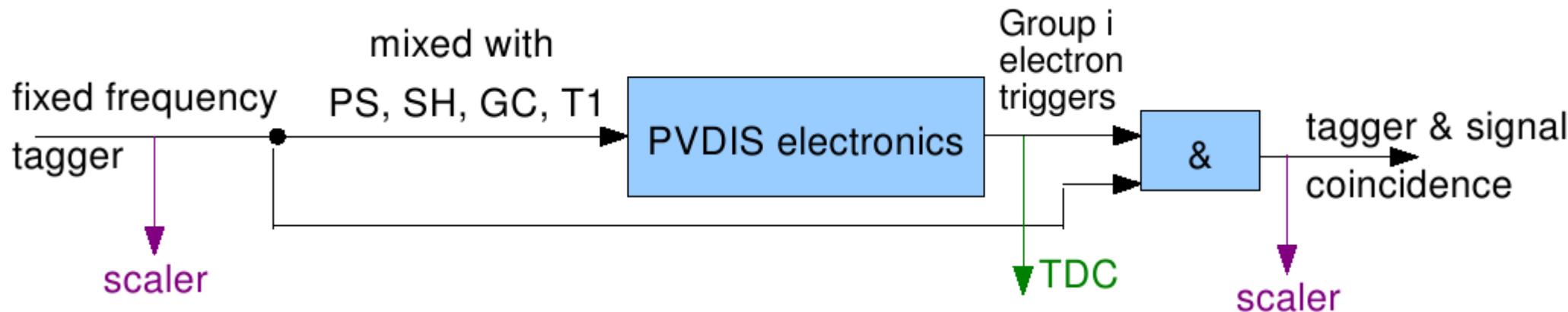
Different for narrow and wide path

Measured by TDC

Similar for narrow and wide path

Deadtime of the Fast-Counting DAQ

The Tagger method to measure deadtime:



$$\text{Deadtime} = \frac{R_{\text{tagger}} - R_{\text{tagger} \& \text{signal}}(1 - \text{Pileup})}{R_{\text{tagger}}} \approx \frac{R_{\text{tagger}} - R_{\text{tagger} \& \text{signal}}}{R_{\text{tagger}}} + \text{Pileup}$$

$\equiv \text{Fractional Loss} + \text{Pileup}$

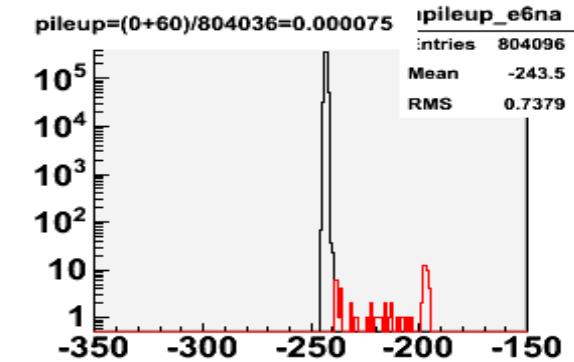
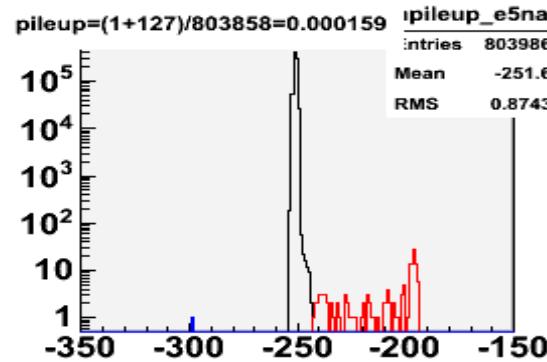
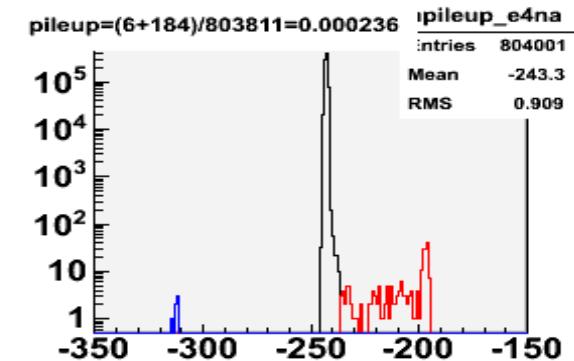
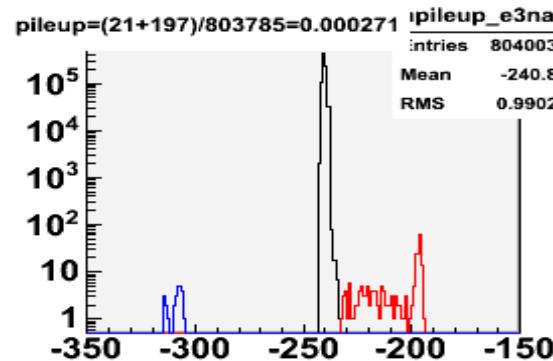
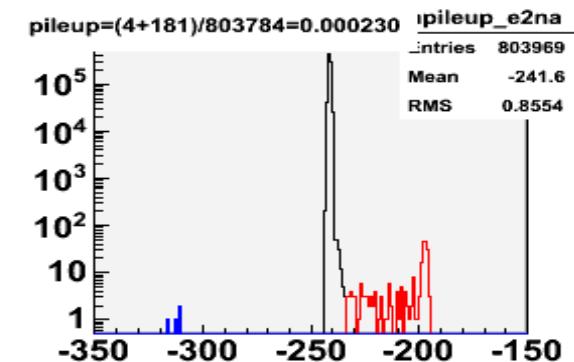
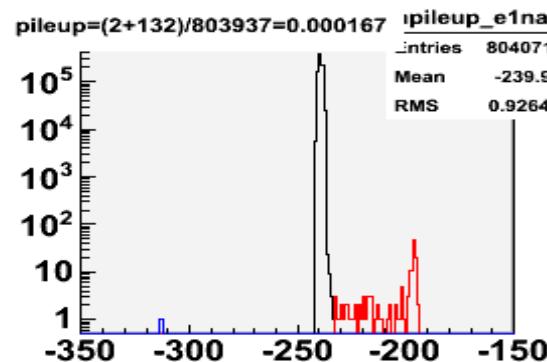
In theory: $\text{Deadtime} (\%) = \text{Rate} \times \text{Width}$

Where Width is the **widest** width throughout the whole path

- For wide path, width = 100ns
- For narrow path, width = signal width ~ 60ns

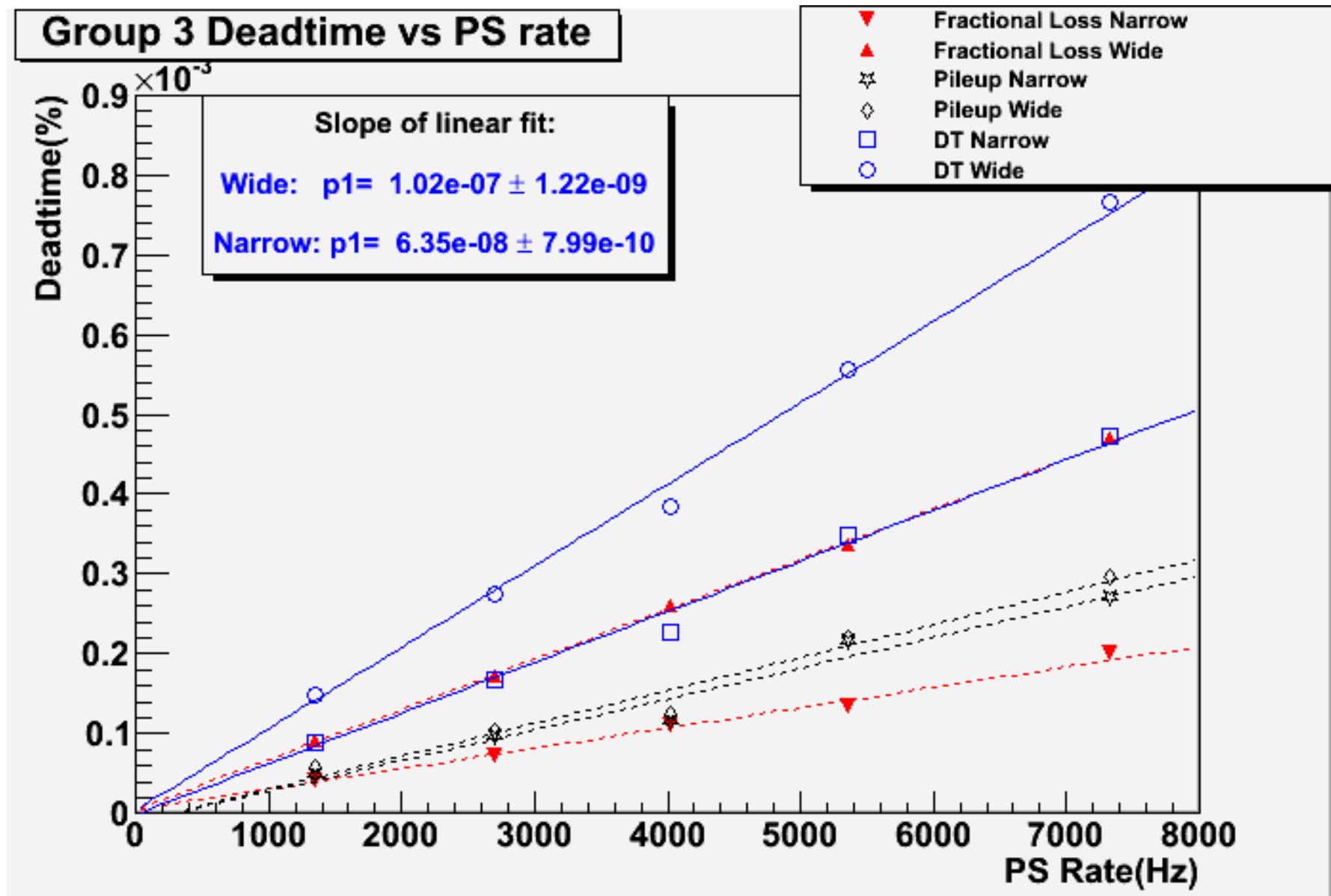
TDC Pileup Spectrum, Left Arm

$$\text{Pileup (\%)} = \frac{\text{Red} + \text{Blue}}{\text{Black}}$$

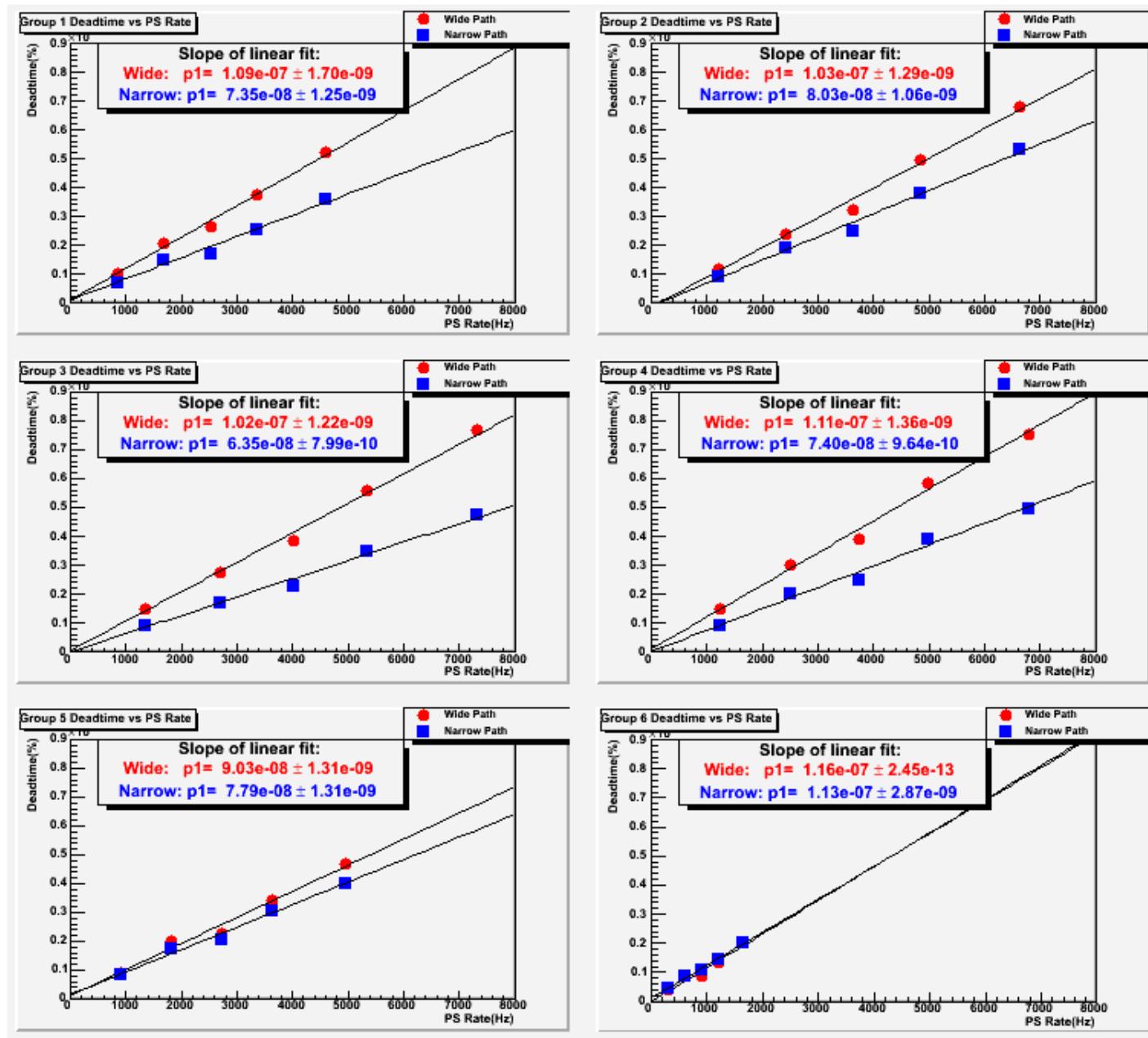


Time

Deadtime Measurement (Tagger Method)



Deadtime Measurement (Tagger Method)



Deadtime of the Fast-Counting DAQ

Rate Scan method to measure the deadtime

$$Rate = aI(1 - DT) \quad DT = aI \times w$$

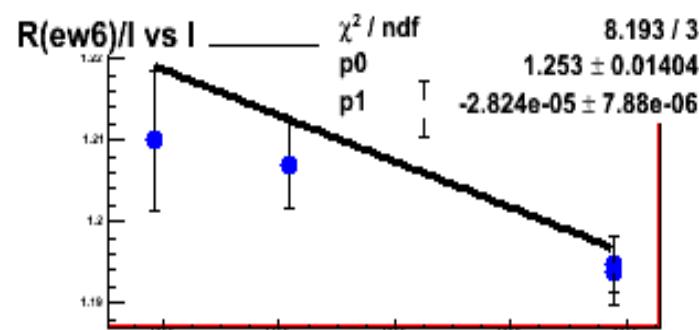
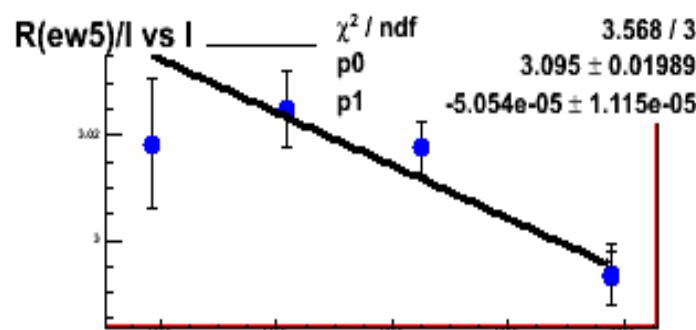
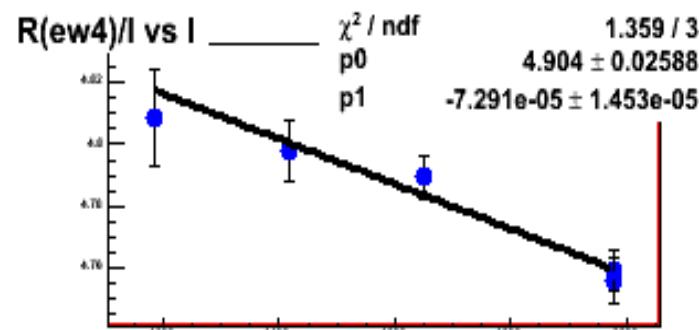
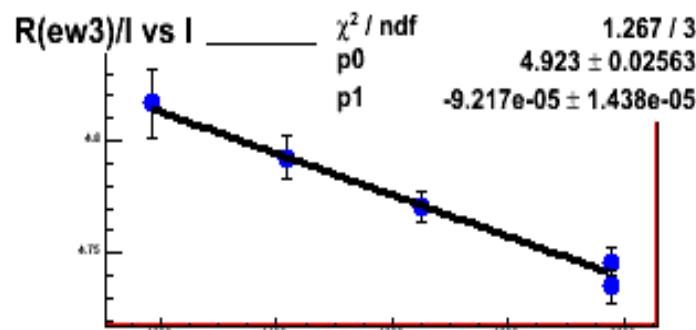
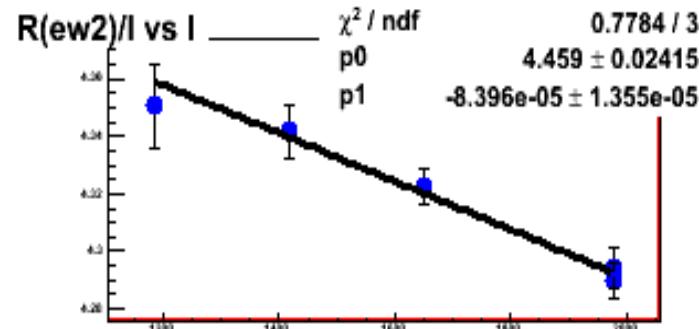
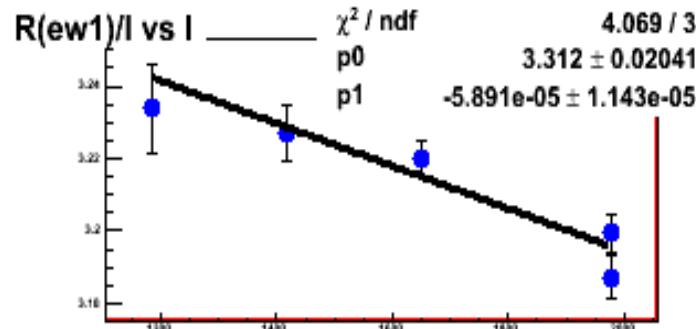
Where a is a positive constant related to cross section, acceptance and etc. w is deadtime expressed in width.

Then

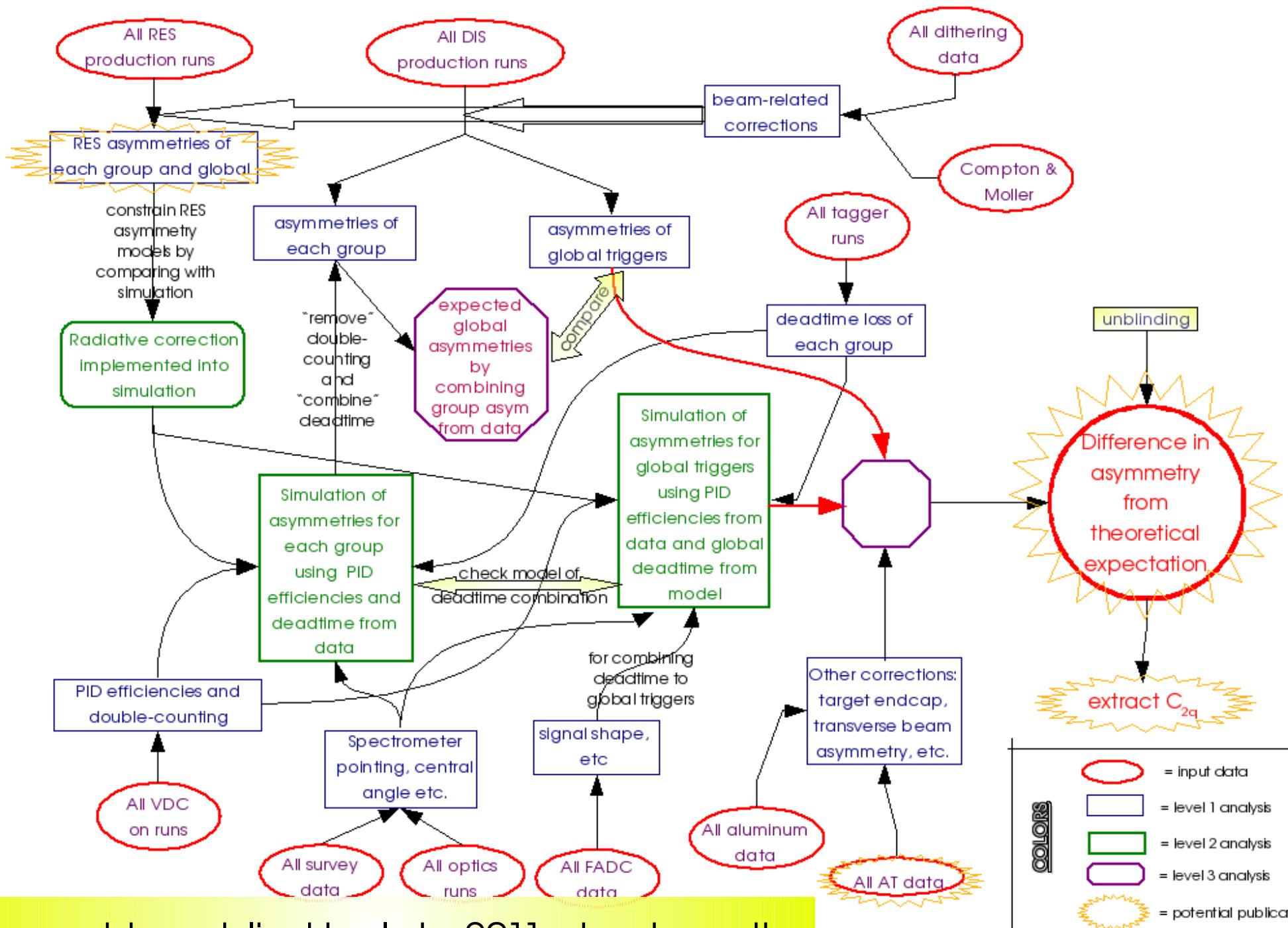
$$\frac{Rate}{I} = a - a^2 w \times I$$

1. Plot Rate/I vs I
2. Do a linear fit, get fitting parameters $pol0$ and $pol1$
3. $w = -pol1/pol0^2$

Deadtime Measurement (Rate Scan Method)



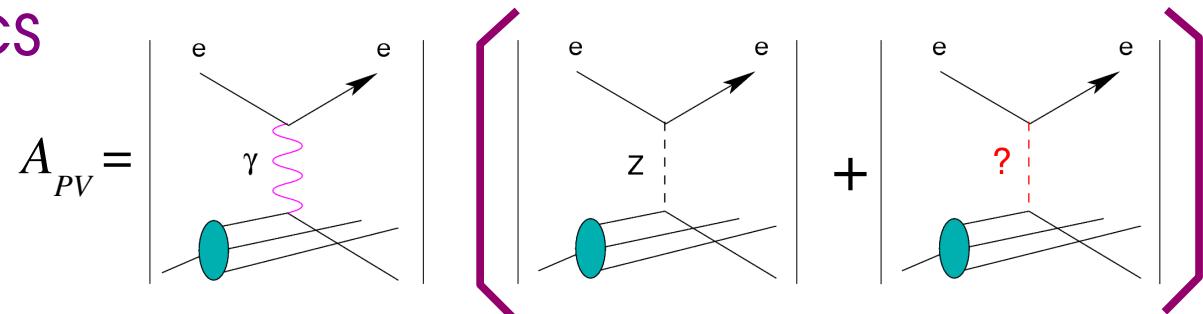
E08-011 PVDIS Analysis Flow Chart



expect to unblind by late 2011, stay tuned!

Extra Slides

PV DIS and New Physics



- Interaction of new physics:

$$\mathcal{L}[V(e) \times A(q)] = \mathcal{L}_{SM}^{PV} + \mathcal{L}_{NEW}^{PV}$$

$$\mathcal{L}_{SM}^{PV} = -\frac{G_F}{\sqrt{2}} \bar{e} \gamma_\mu e \sum_q C_{2q} \bar{q} \gamma^\mu \gamma^5 q$$

$$\mathcal{L}_{NEW}^{PV} = \frac{g^2}{4 \Lambda^2} \bar{e} \gamma_\mu e \sum_f h_A^q \bar{q} \gamma^\mu \gamma^5 q$$

- \oplus g : coupling constant; Λ : mass scale, h_A^q : effective coefficients;
- Sensitive to: Z' searches, compositeness, leptoquarks
- Mass limit of the proposed measurement:

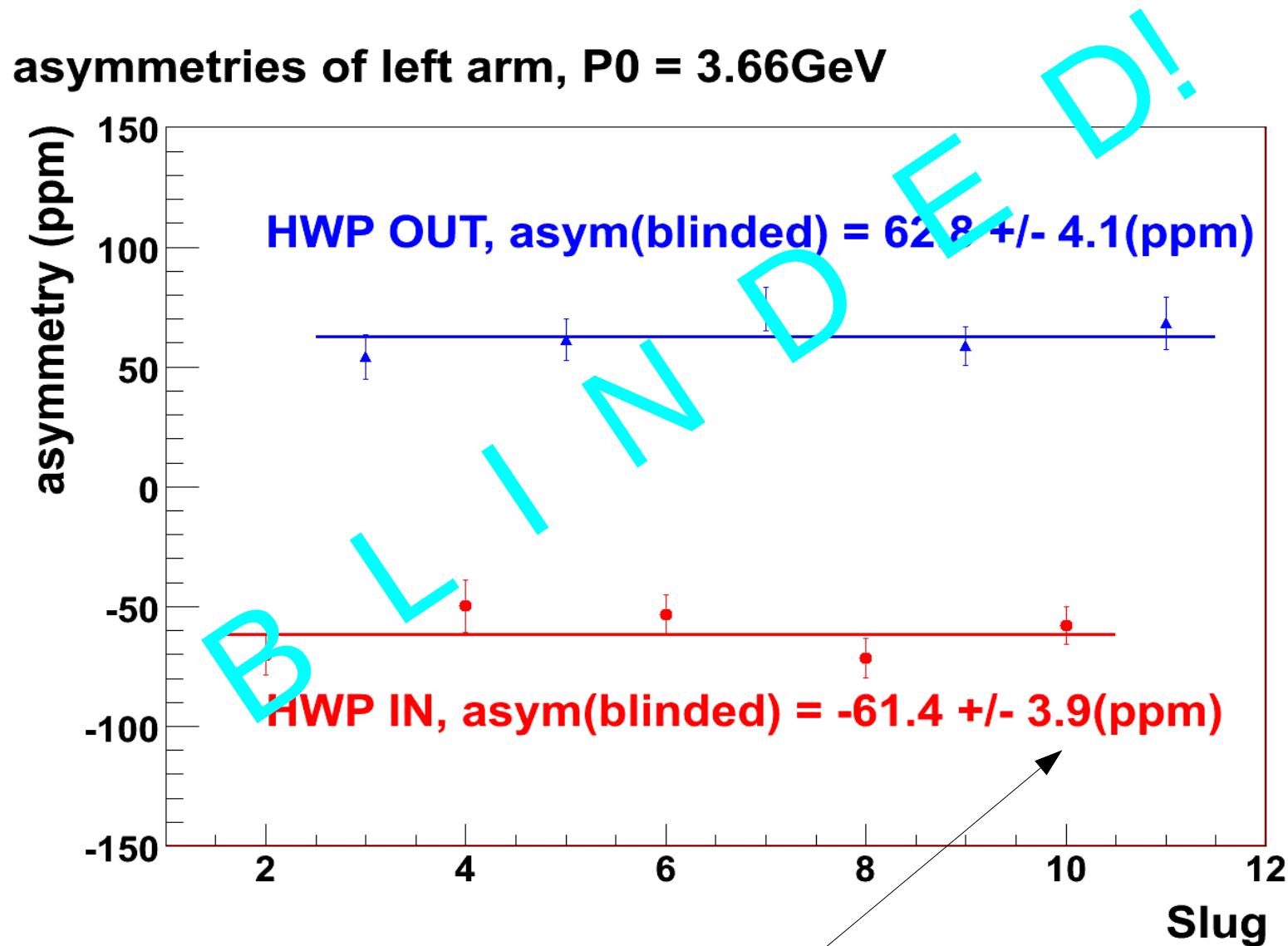
$$\frac{\Lambda}{g} \approx \frac{1}{[\sqrt{8} G_F |\Delta(2C_{2u} - C_{2d})|]^{1/2}} \approx 1.0 \text{ TeV}$$

- \ominus Some new physics can affect C2, but not C1.

Kinematics

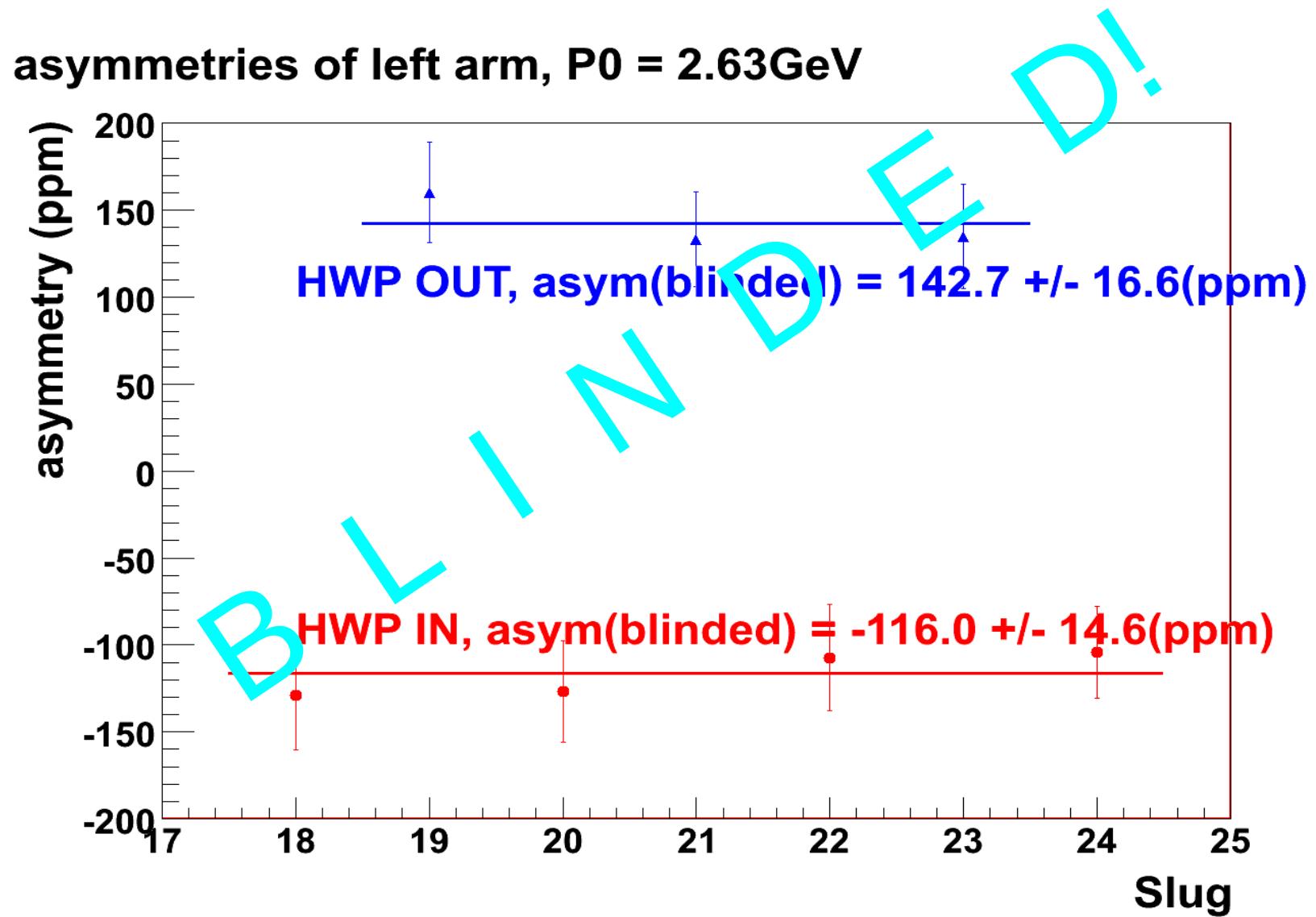
Kinematics	I	II
x_{bj}	0.25	0.3
Q^2 (GeV/c) ²	1.11	1.9
E_{beam} (GeV)	6.0	6.0
E' (GeV)	3.66	2.63
$\theta(^{\circ})$	12.9°	20.0°
W^2 (GeV) ²	4.16	5.30
Y	0.470	0.716
R_c	<0.001	0.001
R_s	0.052	0.041
R_v	0.872	0.910
A_d (measured, ppm)	-91.3	-160.7
e^- rate/HRS (kHz)	269.8	25.1
π^-/e^- ratio	0.9	6.4
e^+/e^-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

Online Asymmetries, Q2=1.1, Left Arm Only

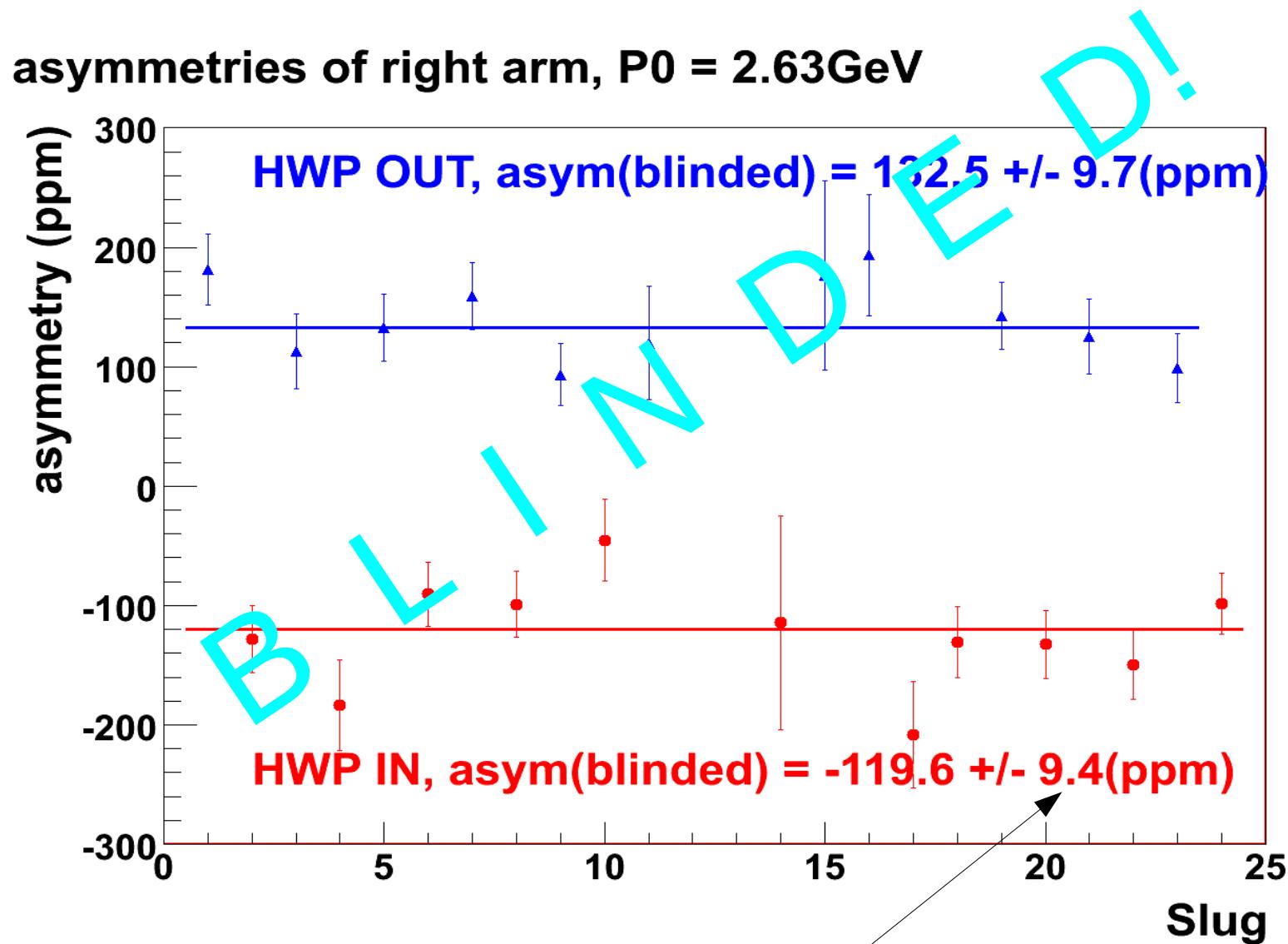


will provide a ~3% relative uncertainty compared to the calculated 90 ppm

Online Asymmetries, Q2=1.9, Left Arm



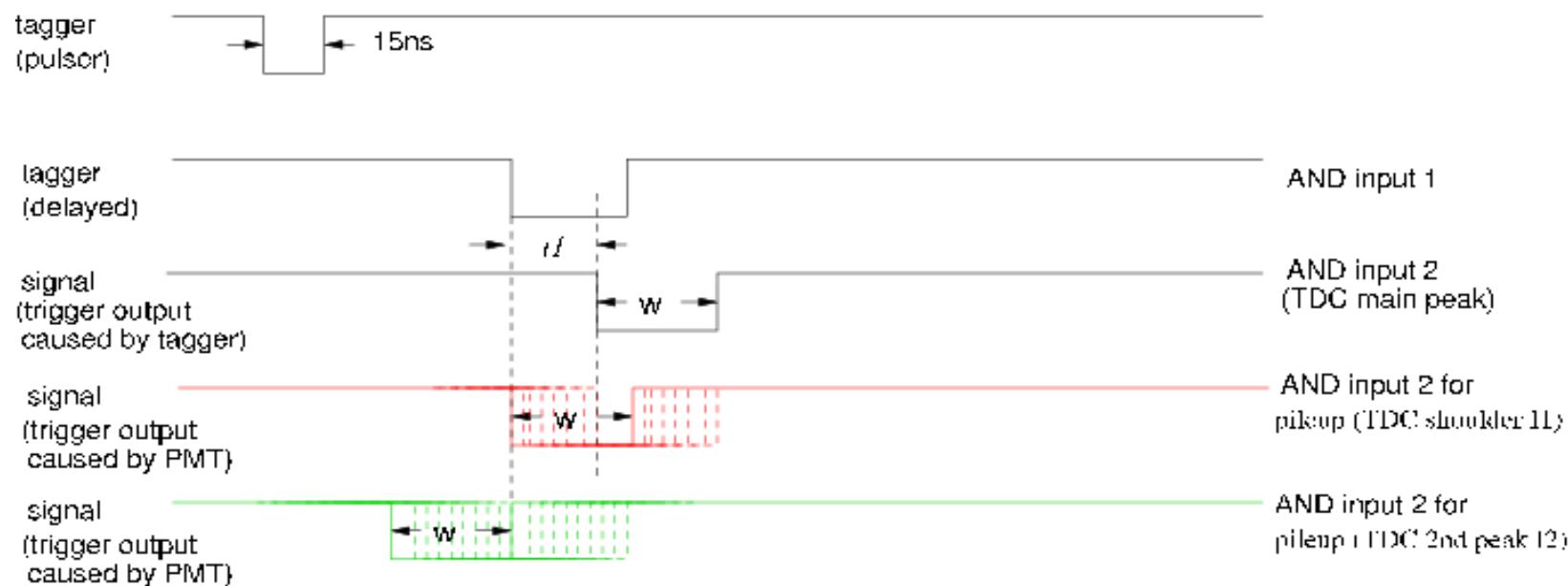
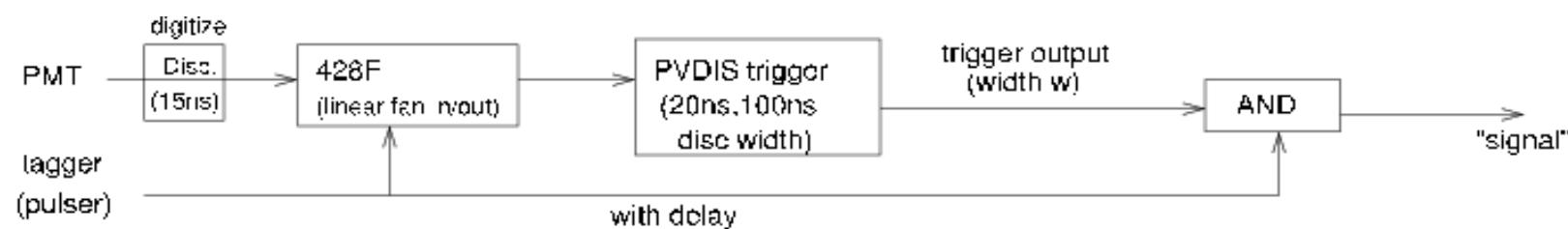
Online Asymmetries, Q2=1.9, Right Arm



will provide a ~4% relative uncertainty compared to the calculated 161 ppm

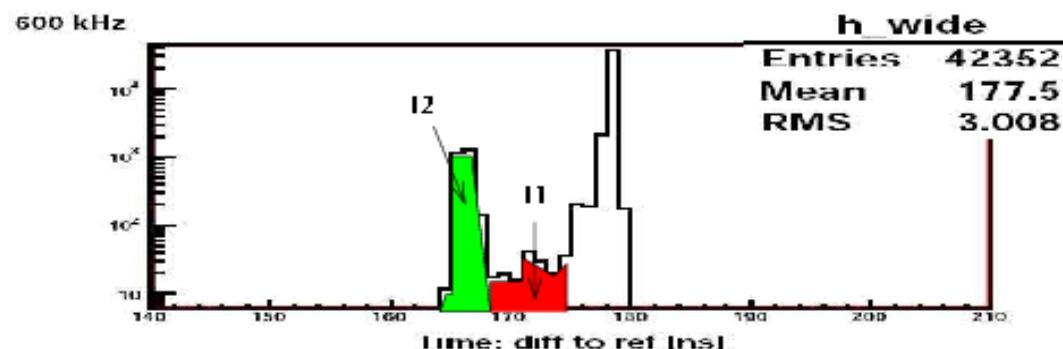
PVDIS General Run Information

- ✚ 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 (1 pair=66ms) (“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), rates agree with calculations;
 - Transverse beam polarization running (12 hours), **best DIS transverse measurement so far**, systematic uncertainty under control;
 - Random coincidence measurements.



$$I1=R*t1$$

$$I2=R*w$$



Lumi_sum/I vs I

χ^2 / ndf

0.3976 / 3

p0

4884 ± 4.286

p1

-0.102 ± 0.002657

