PID and Asymmetries in 6GeV PVDIS

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PVDIS Collaboration Meeting

OUTLINE

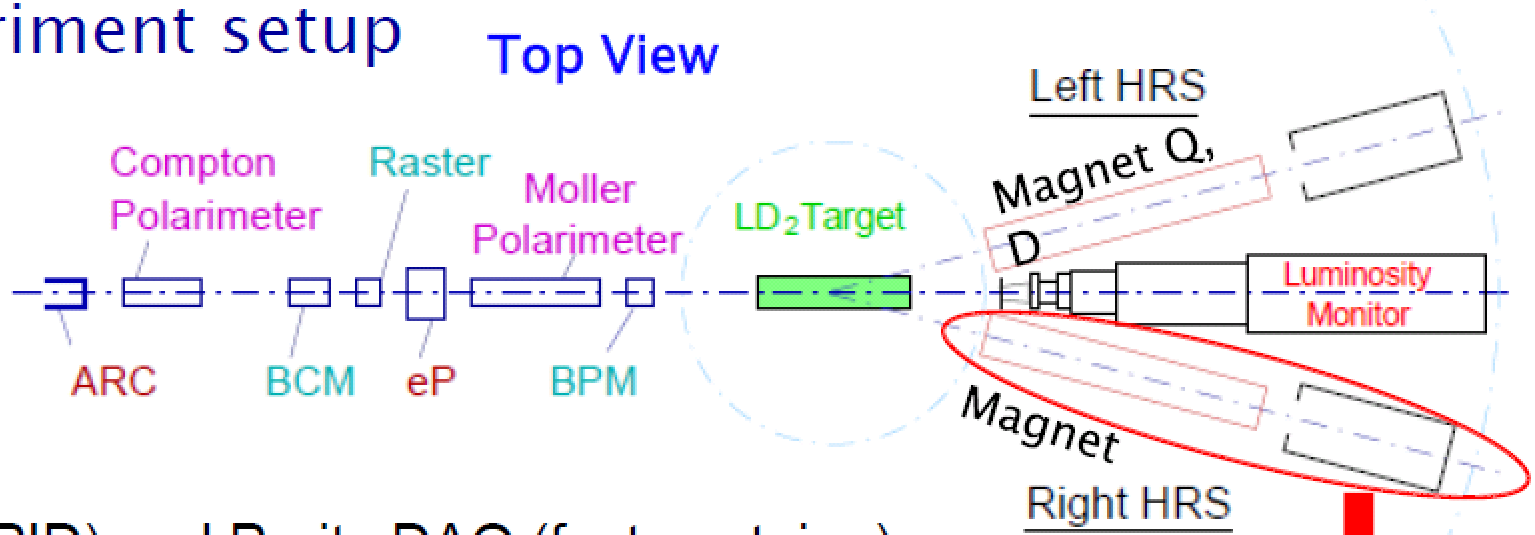
PID performance of DAQ

- optics
- electron efficiency
- pion rejection factor
- pion contamination in electron counter
- electron contamination in pion counter

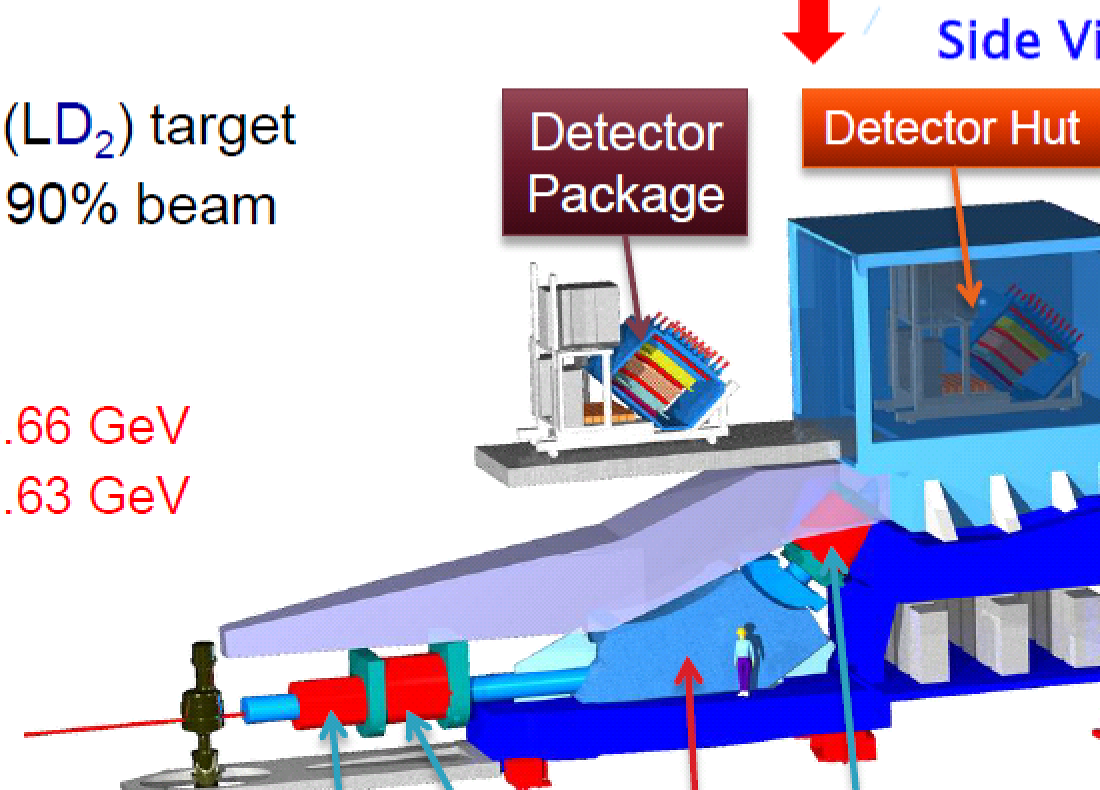
Asymmetries

- electron asymmetry (*blinded*)
- pion asymmetry (*unblinded*)
- transverse spin asymmetry (*unblinded*)
- positron asymmetry (*unblinded*)

Experiment setup

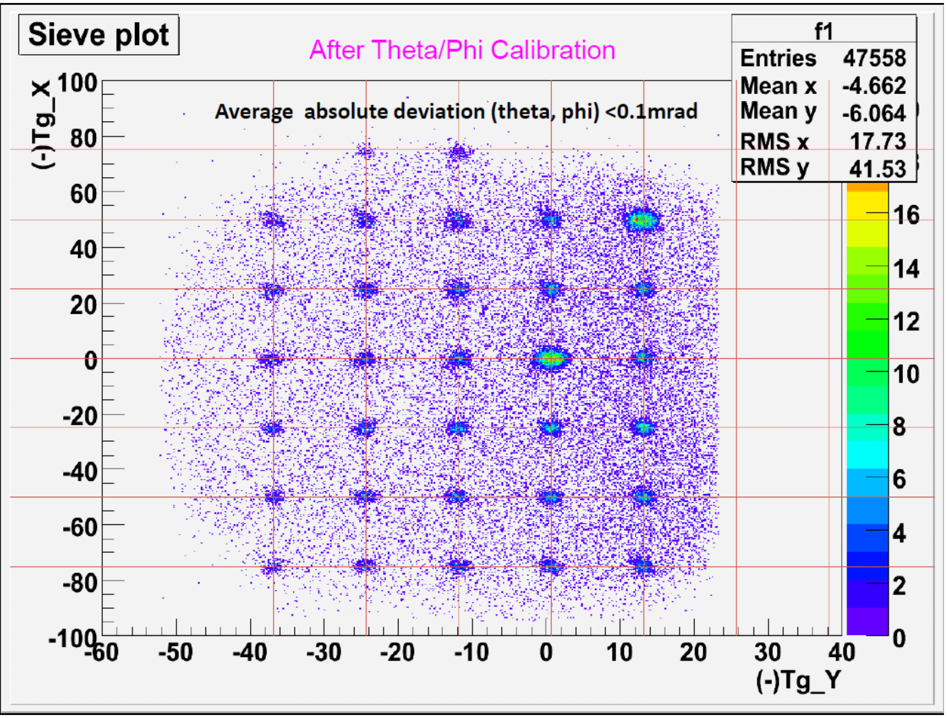


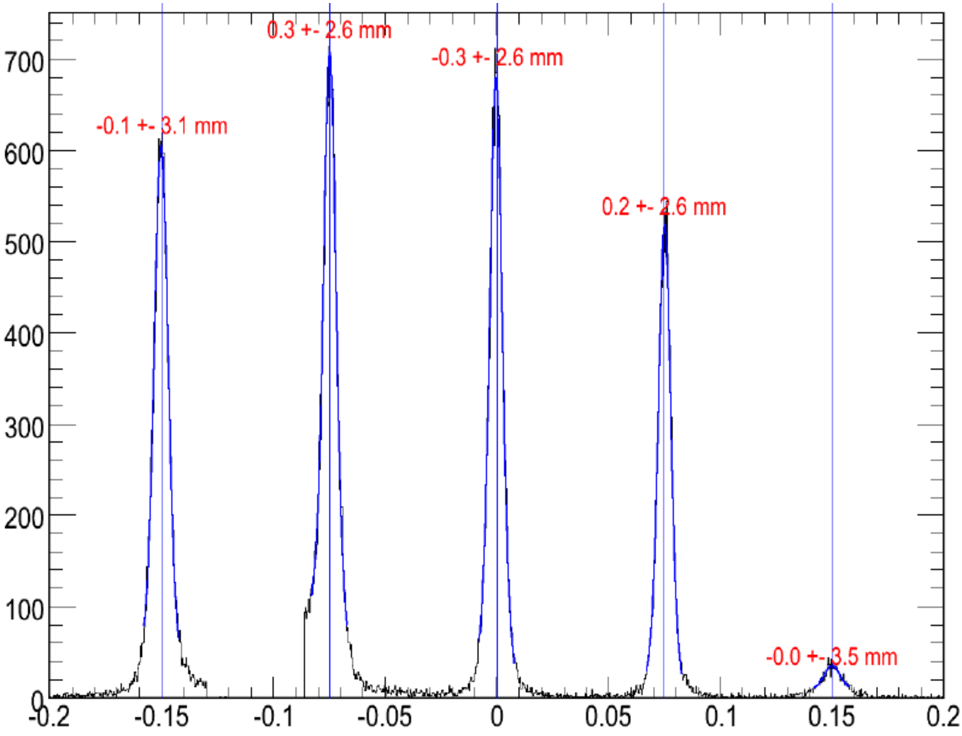
- HRS (PID) and Parity DAQ (fast coutning)
- Beam Energy 6.067 GeV
- 20 cm long liquid deuterium (LD_2) target
- 100 uA polarized beam with 90% beam polarization
- Two kinematics
  - Q^2=1.1(GeV)^2 ; 12.9^0 ; P_0 = 3.66 GeV
  - Q^2=1.9(GeV)^2 ; 20.0^0 ; P_0 = 2.63 GeV
- X = 0.25 ~ 0.3



Part 1 PID performance

DIS Run Optics



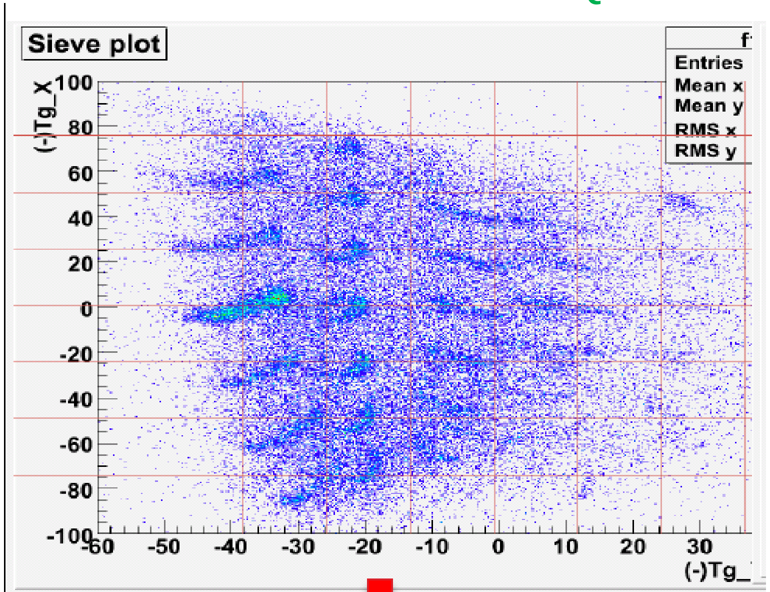


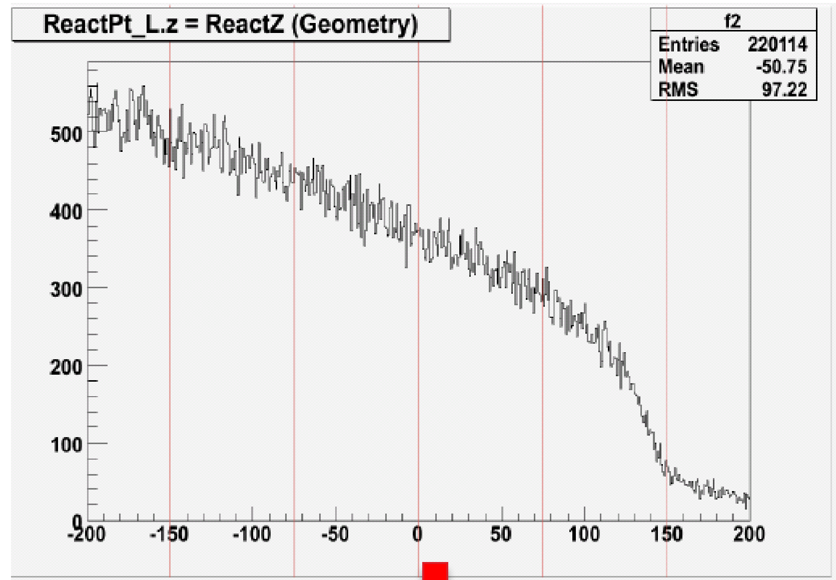
- DIS asymmetry is sensitive to Q^2, thus tracking reconstruction is important.
- After calibration, asymmetry uncertainty due to Q^2 reconstruction is <1%

Resonance Run Optics (magnet mistuned)   4/3.66/4/3.66 GeV (QQDQ)

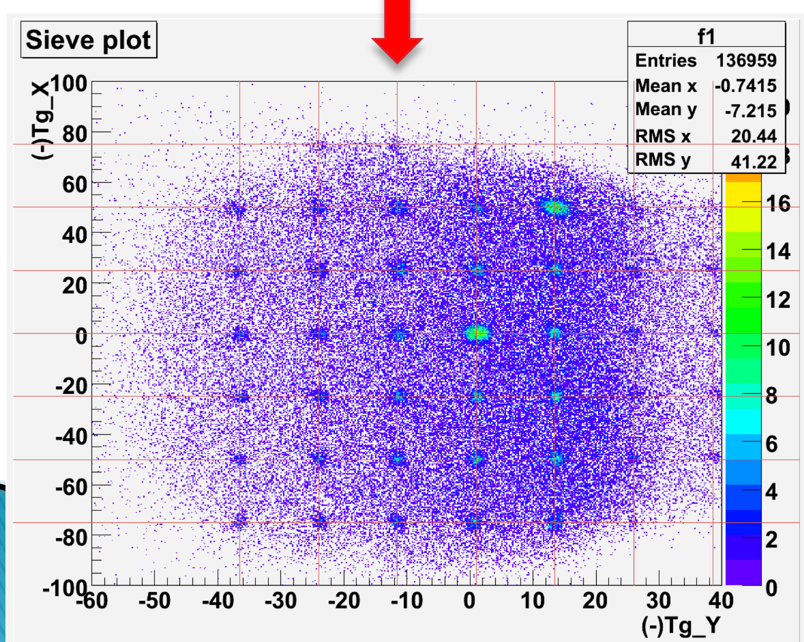
Total Q^2 uncertainty less than 1%

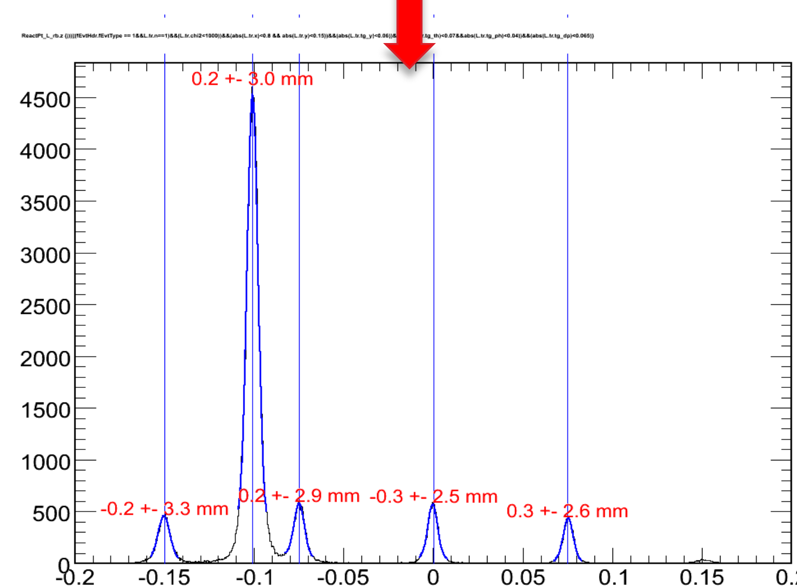
Before



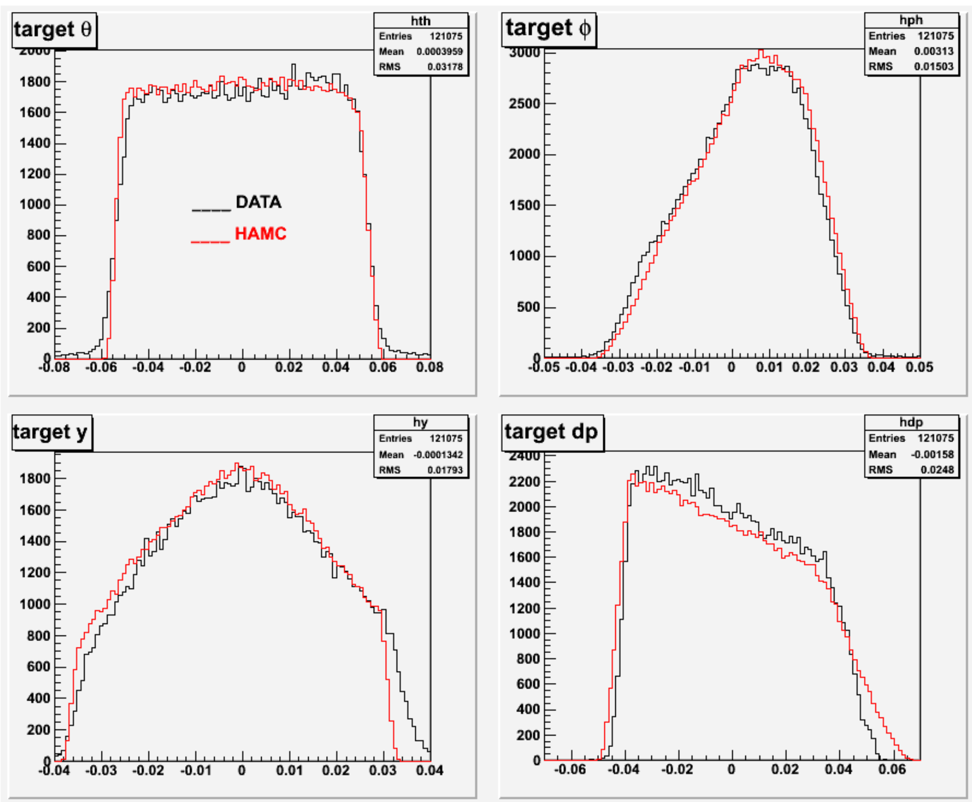


After



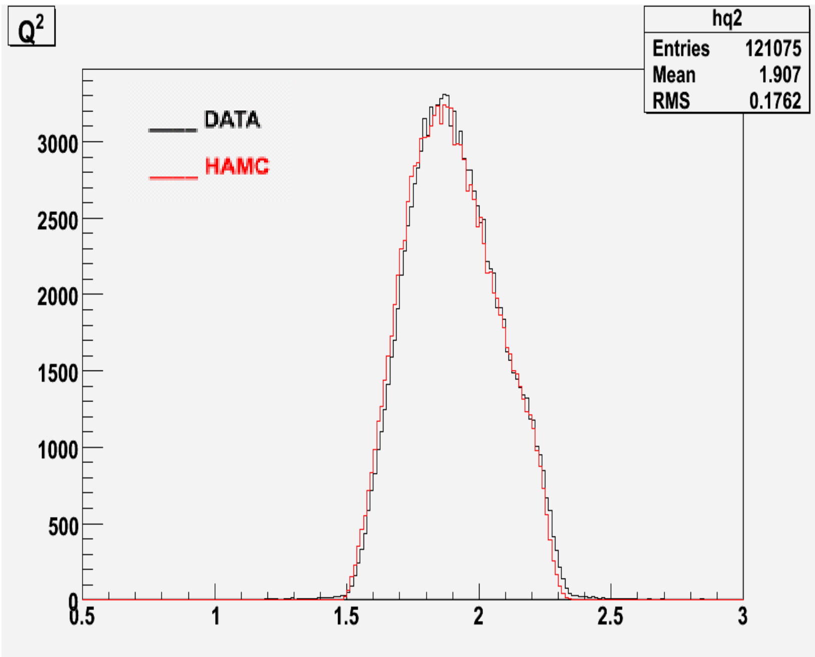


Q2 and acceptance comparison between data and hamc

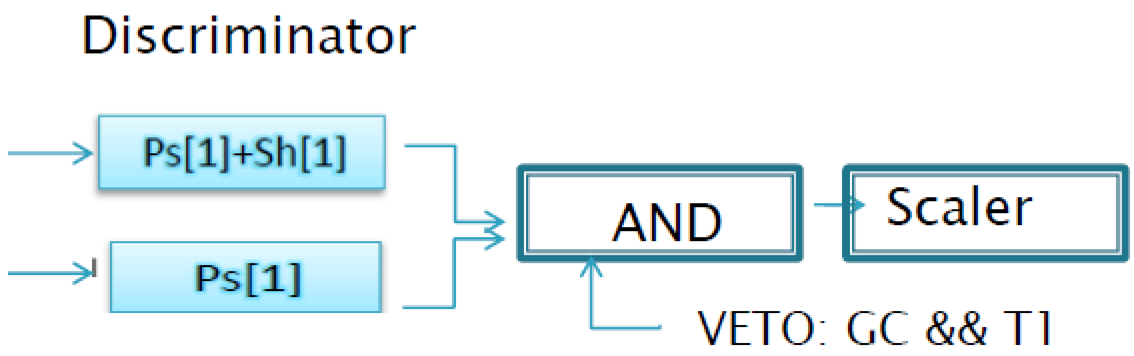


$$Q^2_{data} = 1.907$$

$$Q^2_{hamc} = 1.896$$



PID performance of Electron Counter



Shower && Preshower cut

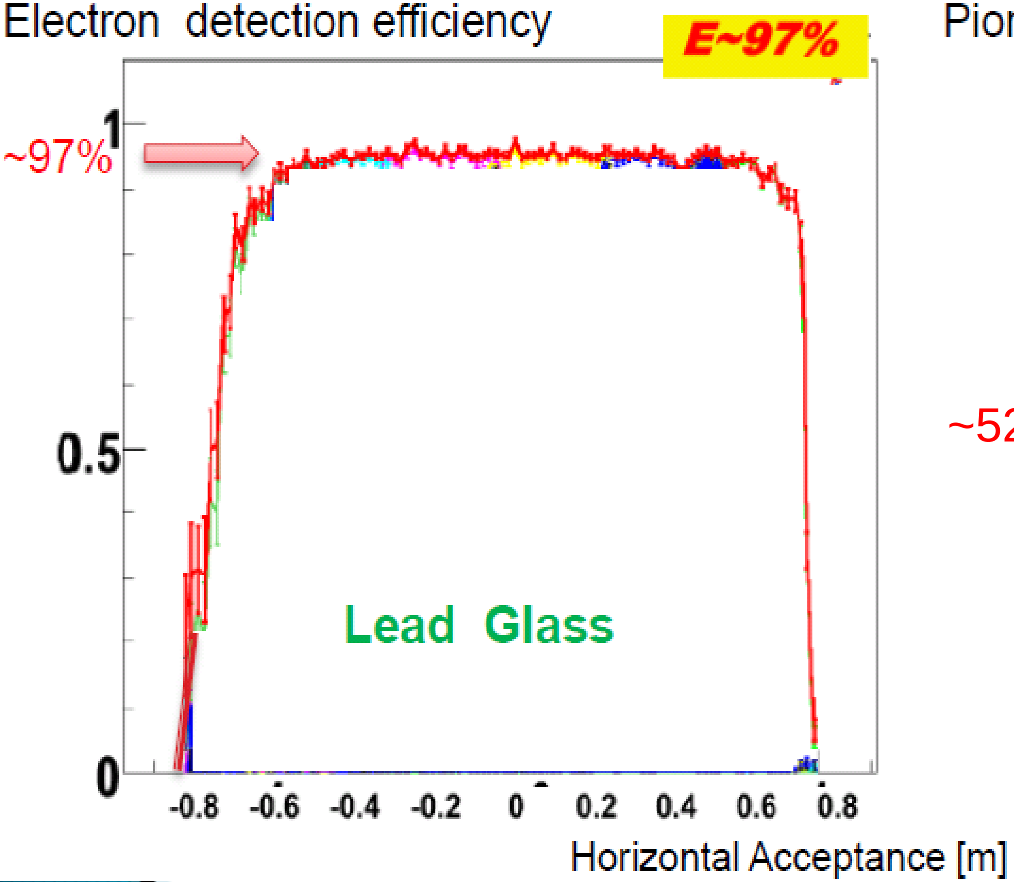
Gas Cerenkov cut

Overall PID = PID of Lead Glass * PID of Gas Cerenkov

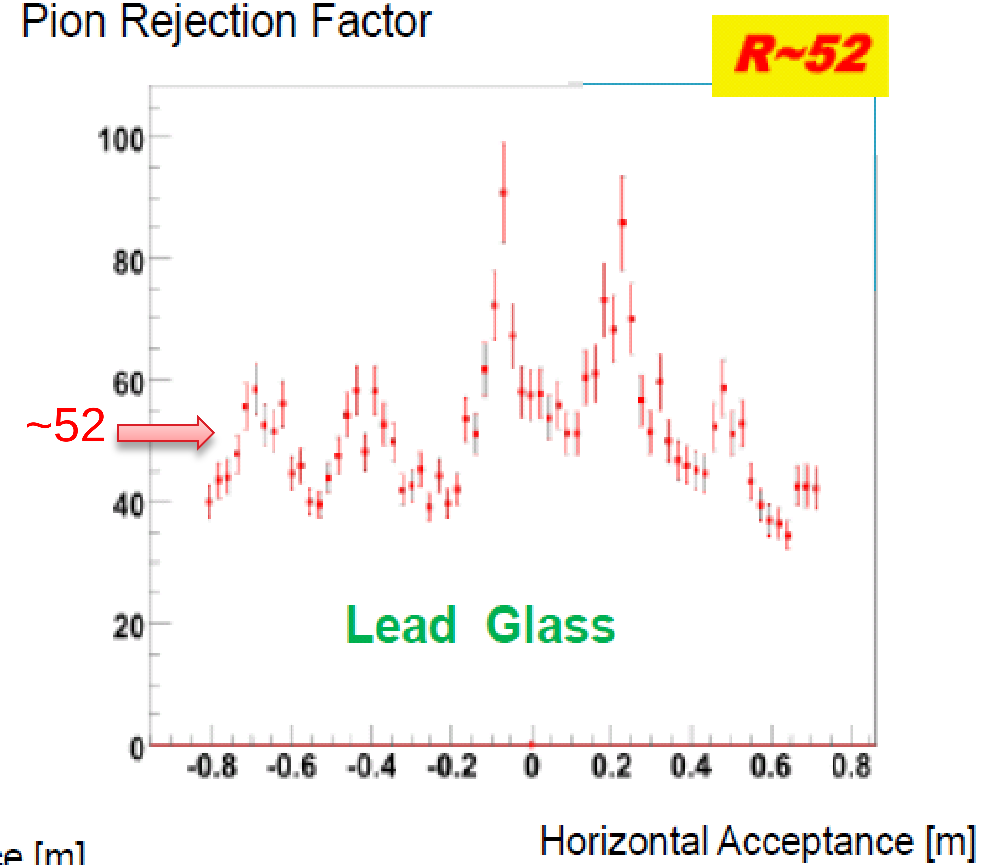
PID performance of Lead Glass

Example: Left arm Kinematics #1 (low rate)

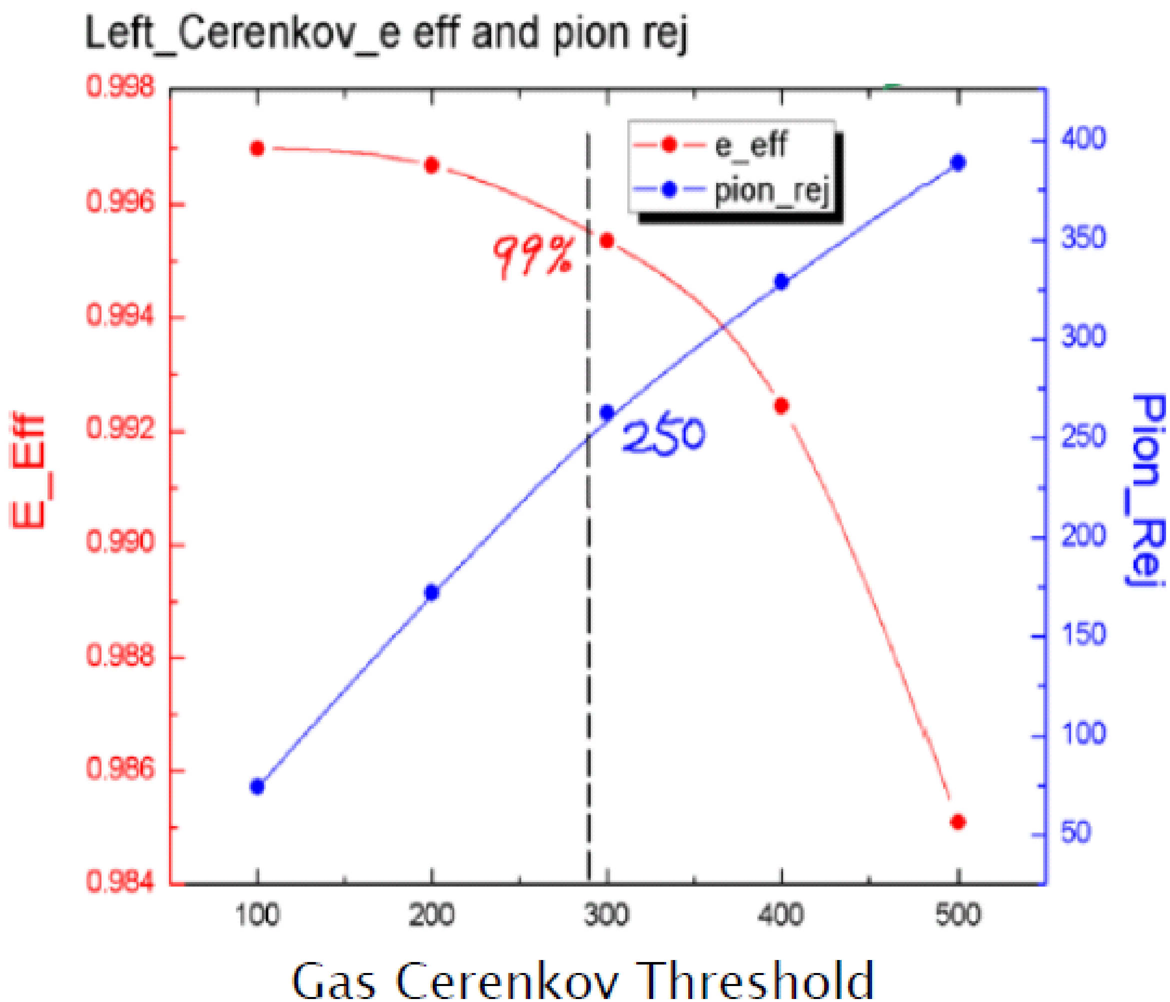
Electron detection efficiency



Pion Rejection Factor



PID performance of Gas Cerenkov



Electron efficiency ~ 99%

Pion Rejection Factor ~ 250

PID performance Table of Electron Counter

Left arm

	Lead glass	Gas Cherenkov	Overall
Electron efficiency	97%	99%	96%
Pion Rejection Factor	52	200	1e4

Right arm

	Lead glass	Gas Cherenkov	Overall
Electron efficiency	96%	99%	95%
Pion Rejection Factor	25	250	6250

Pion Contamination in Electron Counter

$$f = \left(\frac{\pi}{e}\right)_{Electron\ Counter} = \frac{R_\pi/rejection + (R_e \times VETO\ Width \times \eta^{e/cerenkov}) R_\pi \eta^{\pi/Lead\ Glass}}{R_e \times efficiency}$$

$R_\pi/rejection$ ⟷ Pion passes both GC and lead glass cut

150ns

$(R_e \times VETO\ Width \times \eta^{e/cerenkov}) R_\pi \eta^{\pi/Lead\ Glass}$ high rate effect

⟷ Electron and pion accidental coincidence. Electron opens GC VETO for pion, thus pion only need to pass Lead Glass Cut

	Left Kine #1	Left Kine #2	Right Kine #2
R_e	220 KHZ	20 KHZ	20 KHZ
$R_{pion}=R_{T1}-Re$	110 KHZ	62 KHZ	62 KHZ
Pion Rej	1e4	1e4	6250
Electron Eff	96%	96%	95%
f	4.0e-4	4.8e-4	8.4e-4

PID performance of Pion Counter

Electron Contamination in Pion Counter

$$f = \left(\frac{e}{\pi}\right)_{Pion\ Counter} = \frac{R_e/rejection + (R_\pi \times VETO\ Width \times \eta^{\pi/cerenkov}) R_e \eta^{e/Lead\ Glass}}{R_\pi \times efficiency}$$

$R_e/rejection$ ⟷ electron passes both pion VETO and lead glass cut

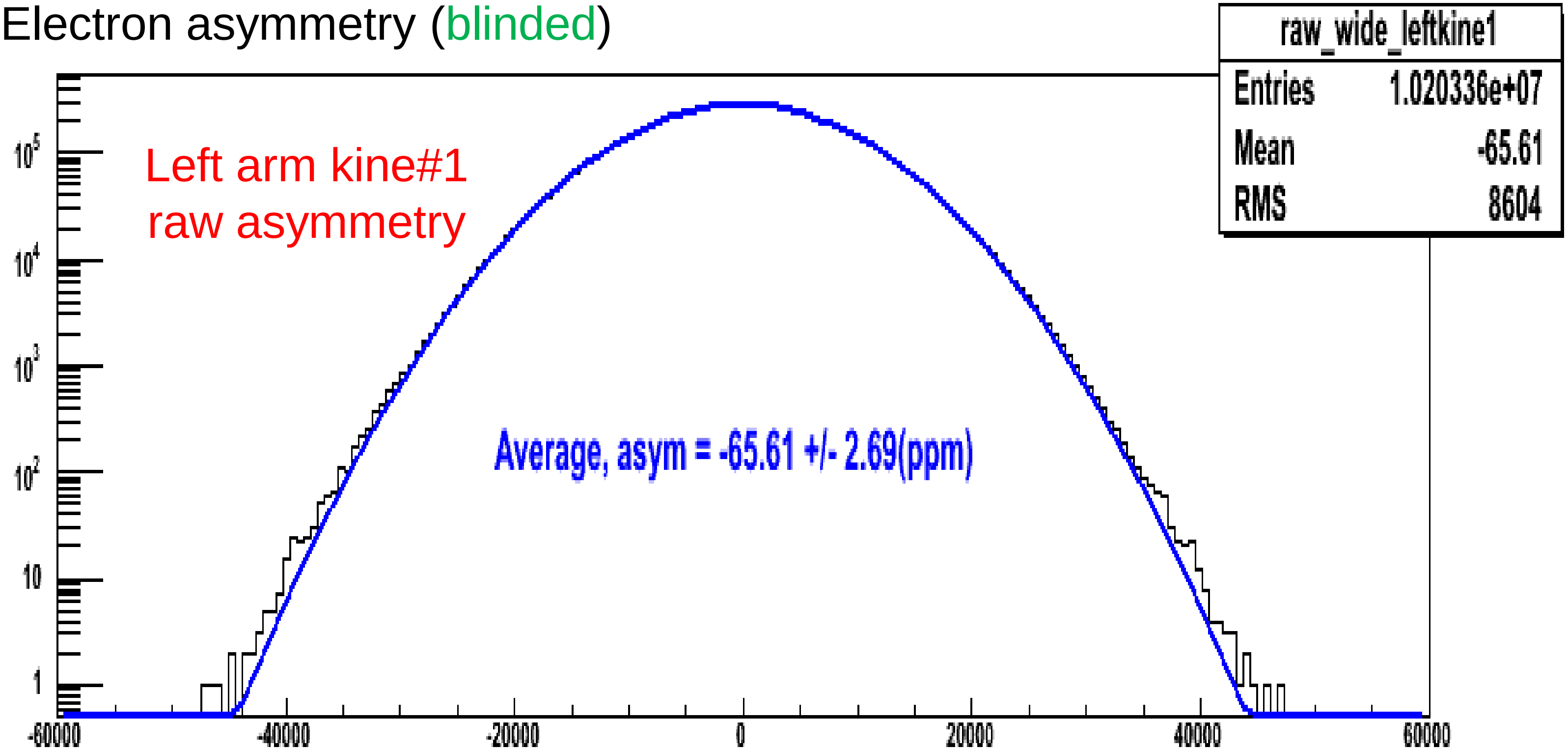
$(R_\pi \times VETO\ Width \times \eta^{\pi/cerenkov}) R_e \eta^{e/Lead\ Glass}$

⟷ Electron and pion accidental coincidence. Pion opens GC pion VETO for electron, thus electron only need to pass pion Lead Glass Cut

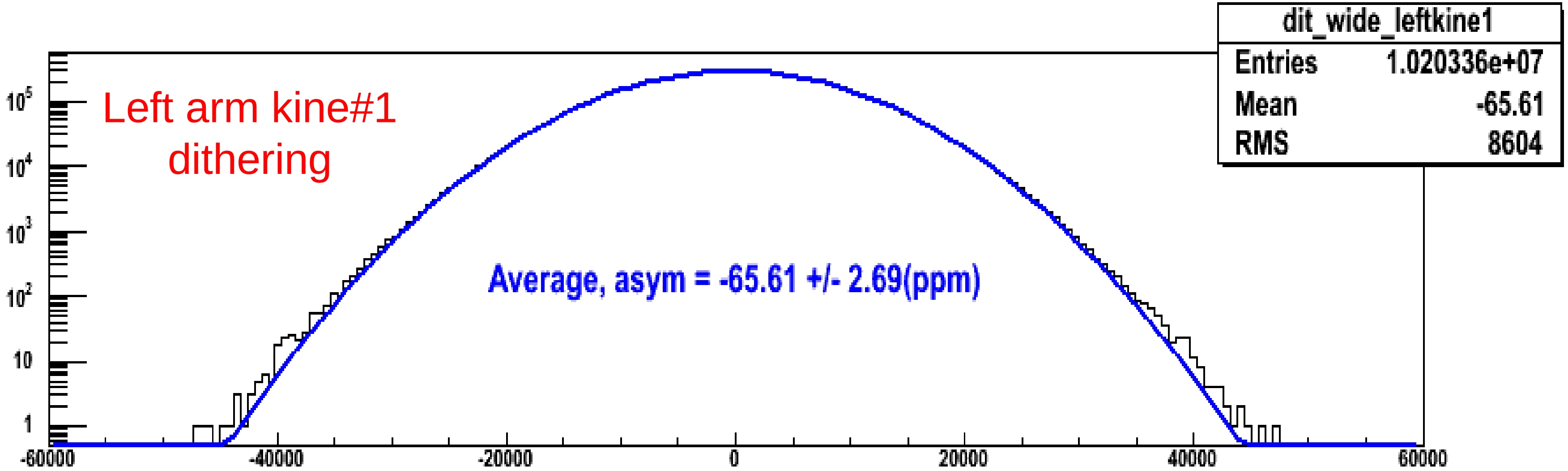
	Left Kine #1	Left Kine #2	Right Kine #2
R_e	220 KHZ	20 KHZ	20 KHZ
R_{pion}	110 KHZ	62 KHZ	62 KHZ
Pion Eff	~20%	~20%	~80%
Electron Rej	~50	~50	~50
f	0.40	0.048	0.012

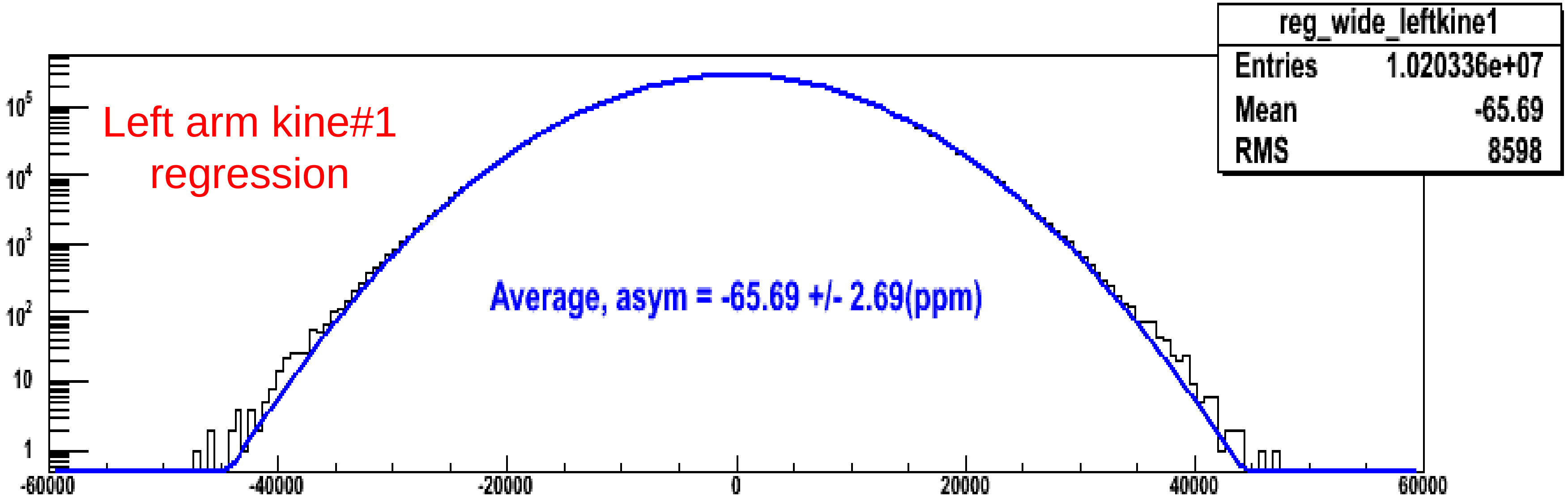
Part 2 **Asymmetries**

1. Electron asymmetry (blinded)



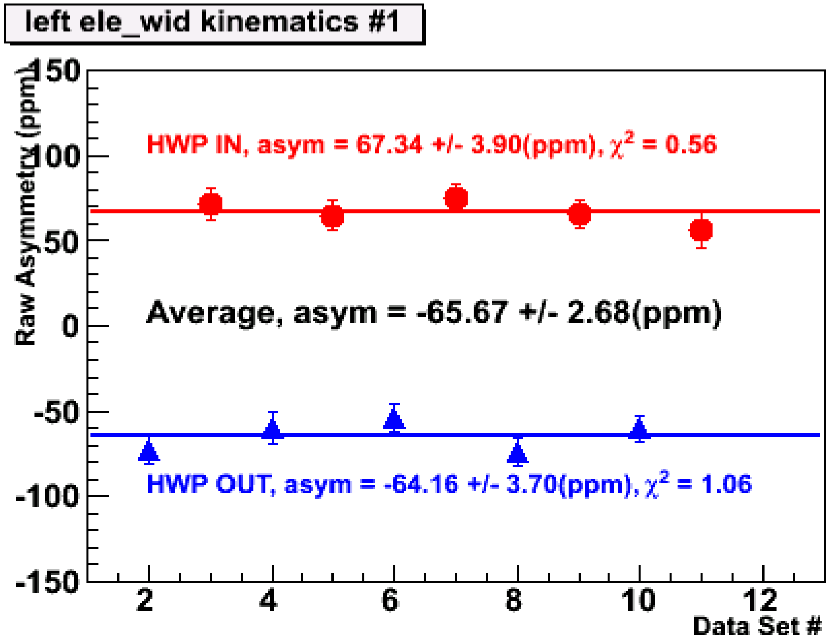
1. Small non-gaussian tail is due to different rate before and after DAQ threshold changing. Each slug (10 slugs) of runs forms very good gaussian shape.
2. Achieved statistics goal. Compared with theory prediction 90ppm, 2.69ppm error bar provides 3% relative uncertainty. On kine#2, this number is 4%.

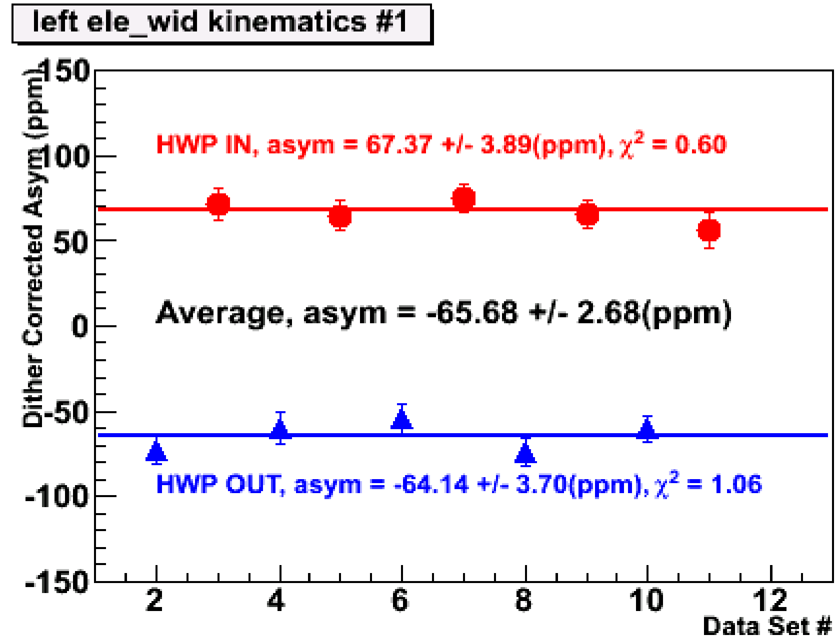




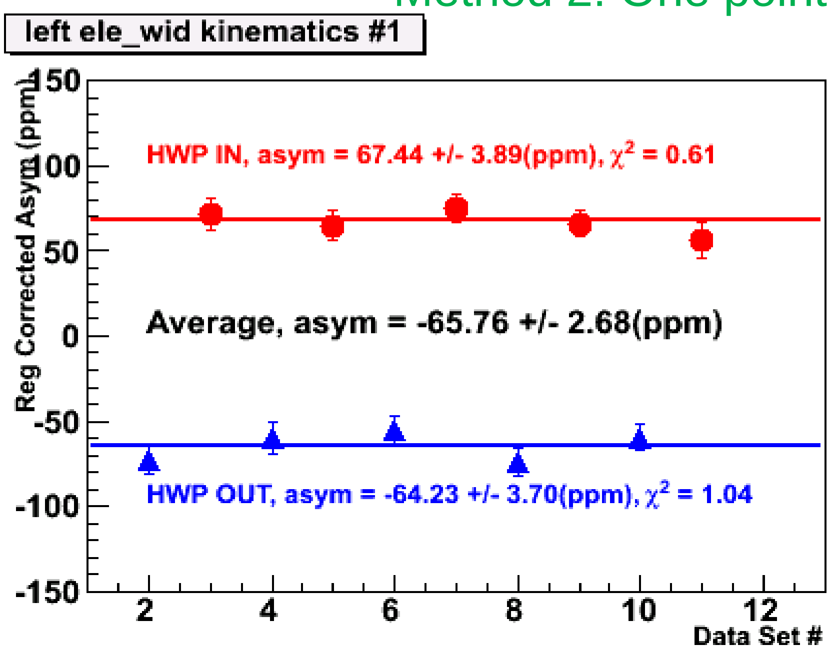
raw = -65.61 +/- 2.69 (ppm)
dit = -65.61 +/- 2.69 (ppm)
reg = -65.69 +/- 2.69 (ppm)

Dithering and regression correction is negligible.

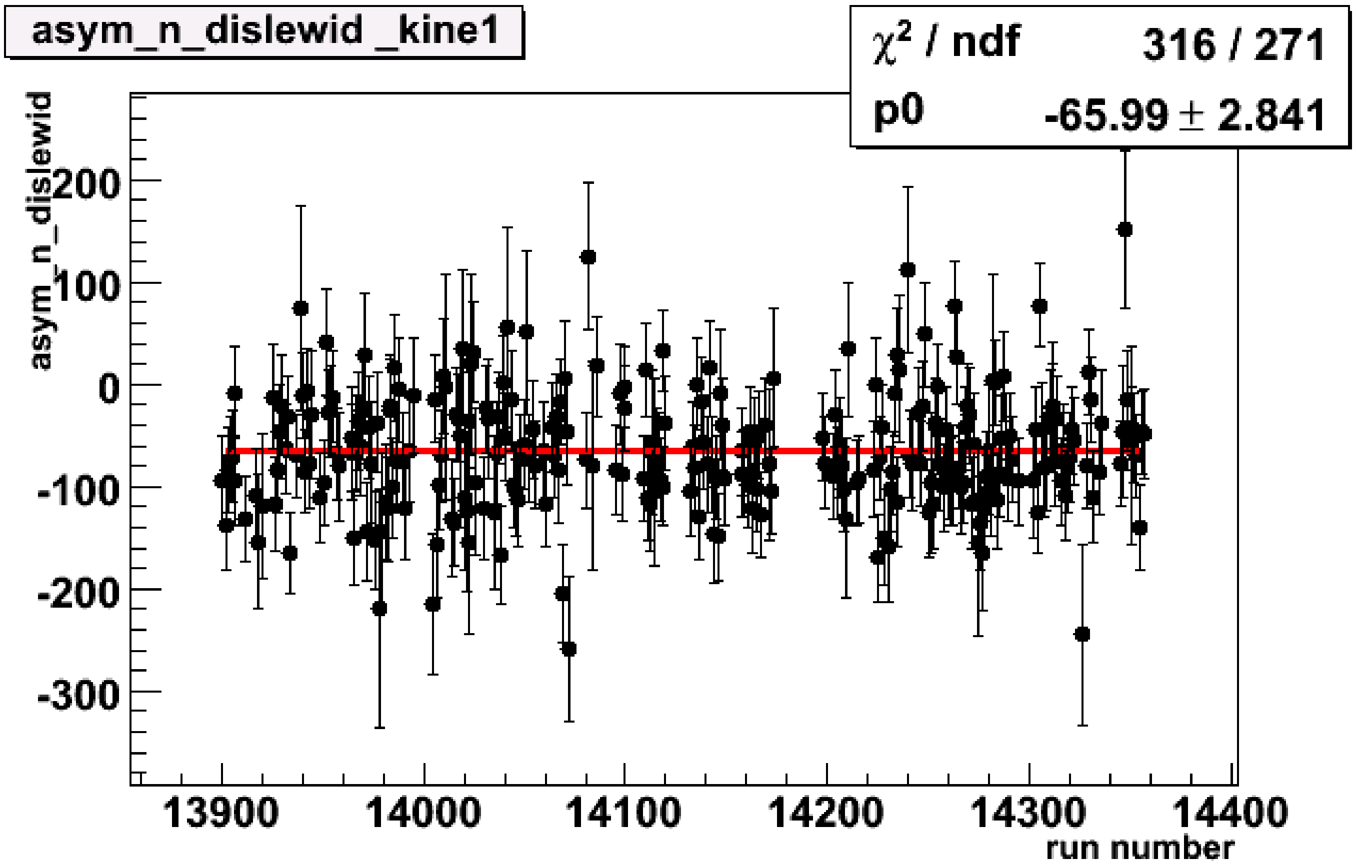




Method 2: One point is the asymmetry of one slug of runs.



Raw Asym:	-65.67 +/- 2.68(ppm)
Dither Corrected:	-65.68 +/- 2.68(ppm)
Regress Corrected:	-65.76 +/- 2.68(ppm)

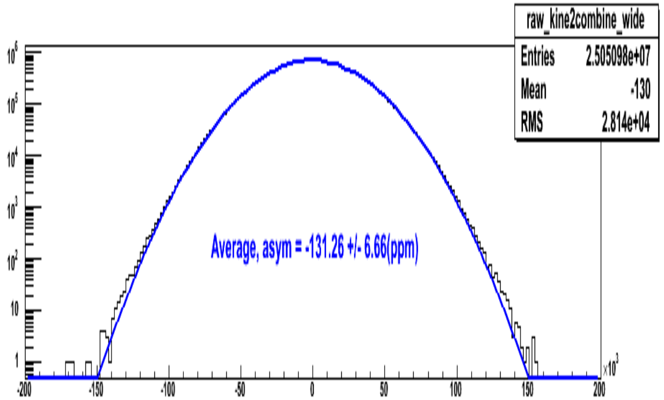


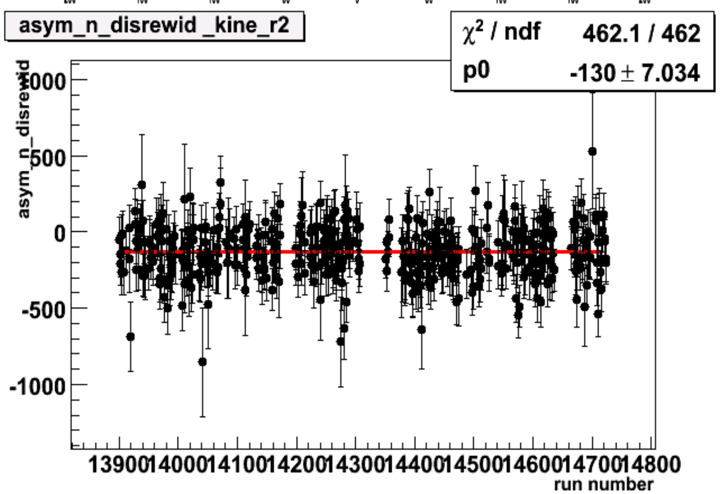
Method3: One point is the asymmetry from one run.

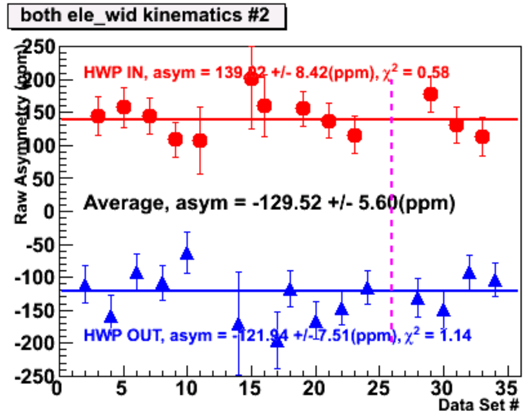
	Method 1	Method 2	Method 3
Asymmetry	-65.61+/- 2.69 ppm	-65.67+/- 2.68 ppm	−65.99+−2.84 ppm

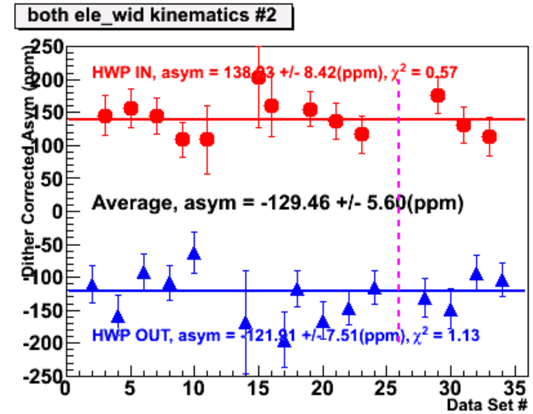
consistent

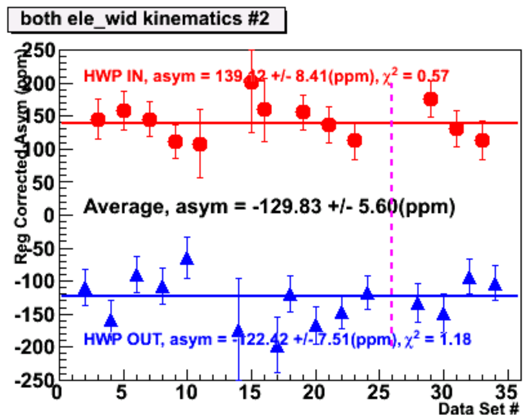
Kinematics #2









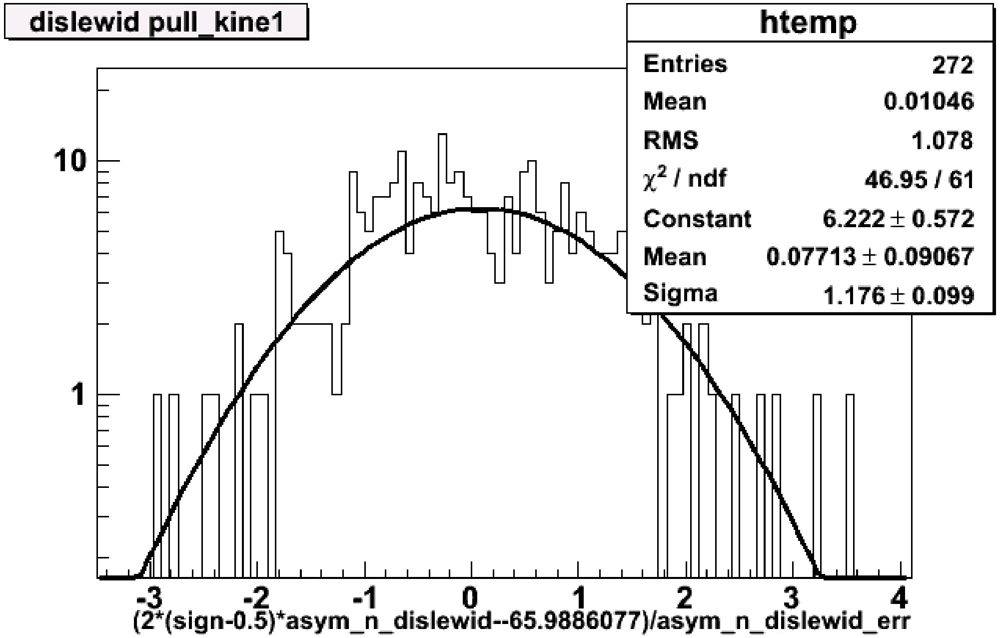


Raw Asym: -129.52 +/- 5.60(ppm)

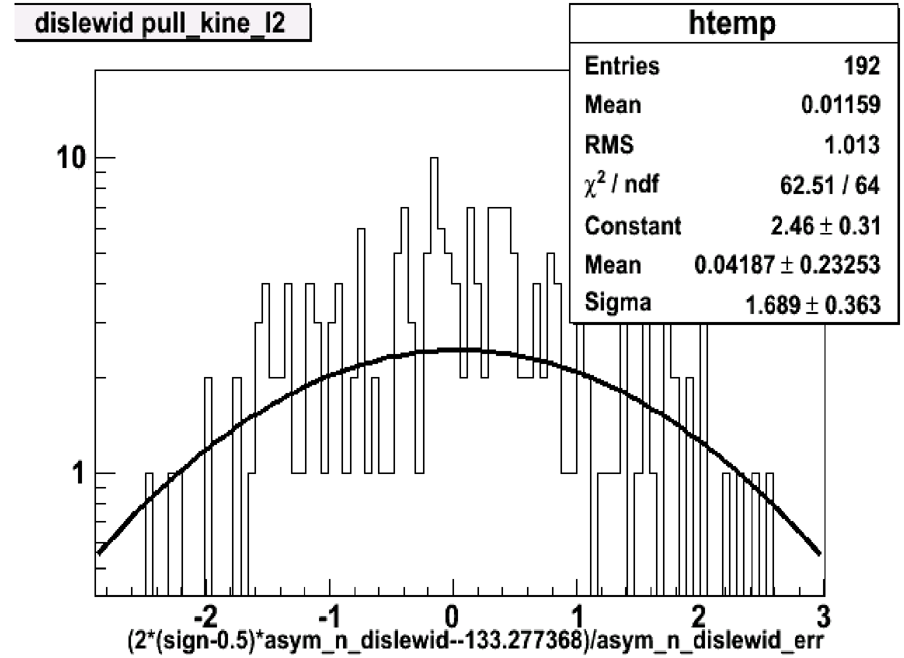
Dither Corrected: -129.46 +/- 5.60(ppm)

Regress Corrected: -129.83 +/- 5.60(ppm)

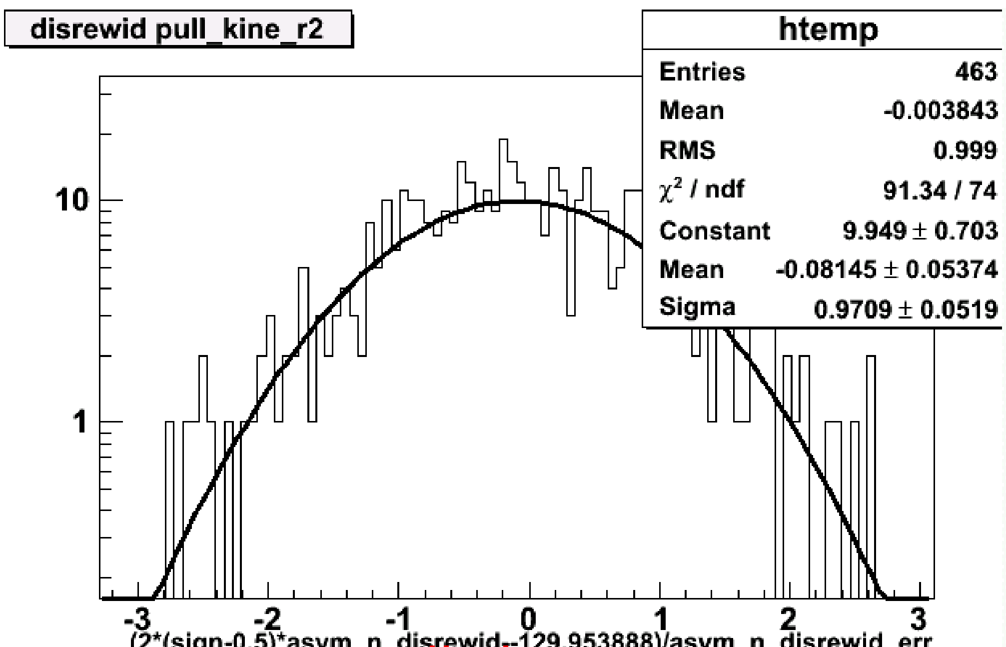
	Method 1	Method 2	Method 3
Asymmetry	-129.1+/- 5.61 ppm	-129.52+/- 5.60 ppm	-130+/-7.034 ppm



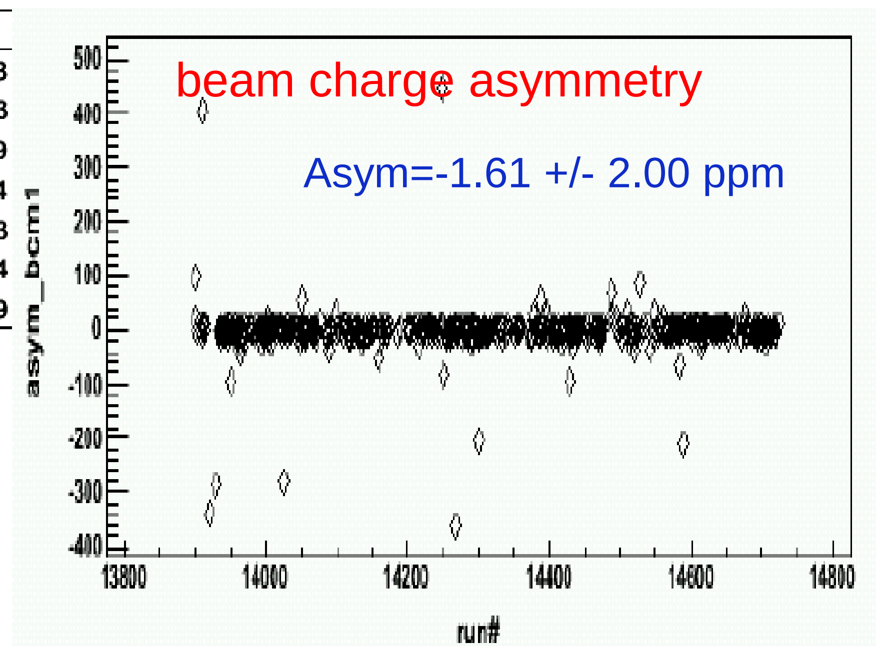
pull plot



pull plot



pull plot



Independent cross check consistent

	Kine#1	Kine#2
Kai	−65.61+/−2.69 (ppm)	−129.52+/− 5.60 (ppm)
Diancheng	−65.85+/−2.68 (ppm)	−128.57+/−5.57 (ppm)

Correction on Electron Asymmetry due to pion Contamination

$$A_e = \frac{N_e^+ - N_e^- + N_\pi^+ - N_\pi^-}{N_e^+ + N_e^- + N_\pi^+ + N_\pi^-}$$

$$A_e^{cor} = \frac{N_e^+ - N_e^-}{N_e^+ + N_e^-} \approx A_e + f \times (A_e - A_\pi)$$

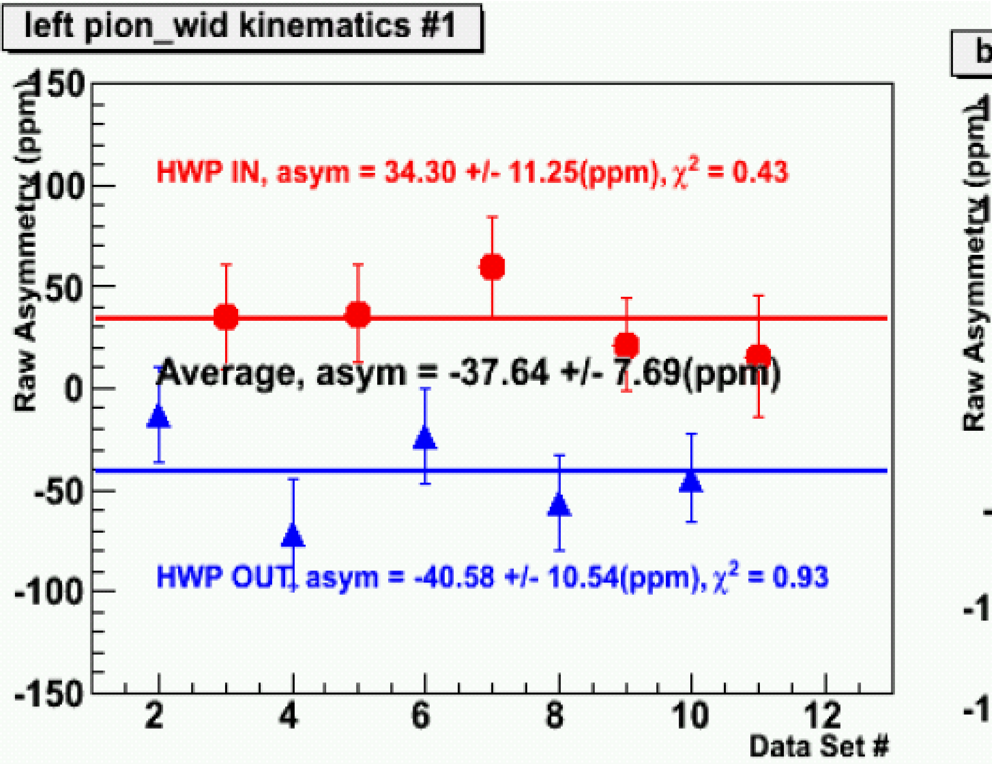
Pion Contamination factor $f = \frac{N_\pi^+}{N_e^+}$

Pion Contamination in Electron Counter

	Left kine#1	Left kine#2	right kine#2
f	3.85 e-04	4.38 e-04	8.84 e-04

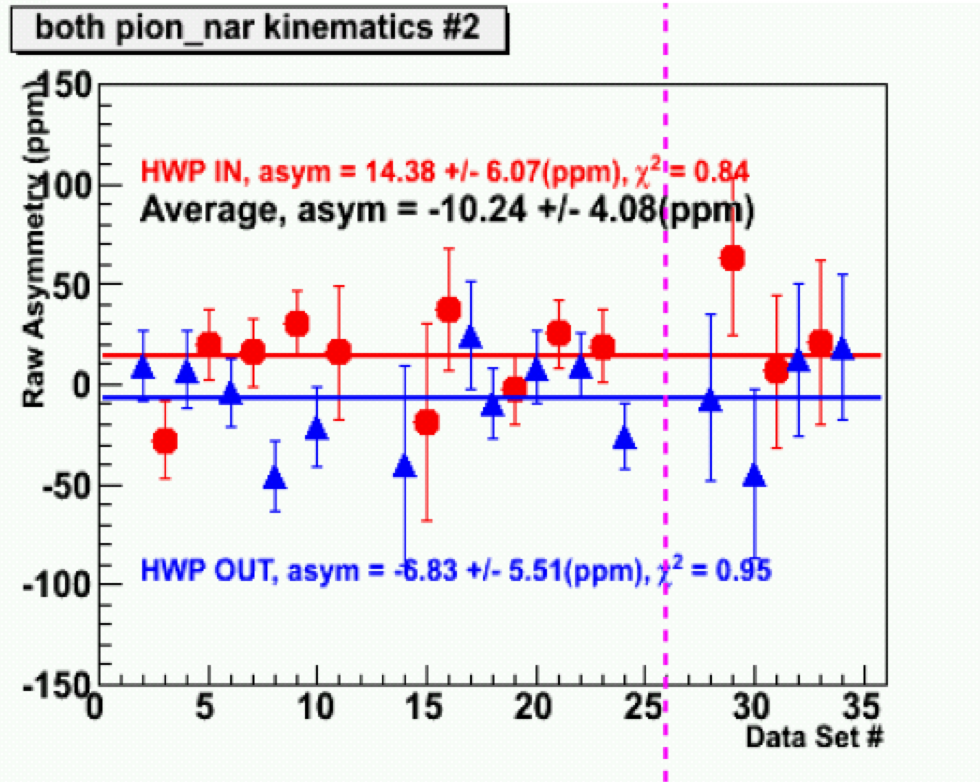
- Contamination factor suppresses the correction by a factor of 1e4.
- The correction due to pion asymmetry can contribute 0.1ppm at most.
- Non-zero Pion asymmetry doesn't matter much here.

2. Pion Asymmetry (unblinded)



Kinematics #1

−37.64 +/− 7.69 (ppm)



Kinematics #2

−10.24 +/− 4.08 (ppm)

Correction on Pion Asymmetry due to Electron Contamination

$$A_\pi = \frac{N_\pi^+ - N_\pi^- + N_e^+ - N_e^-}{N_\pi^+ + N_\pi^- + N_e^+ + N_e^-}$$

$$A_\pi^{cor} = \frac{N_\pi^+ - N_\pi^-}{N_\pi^+ + N_\pi^-} \approx A_\pi + f \times (A_\pi - A_e)$$

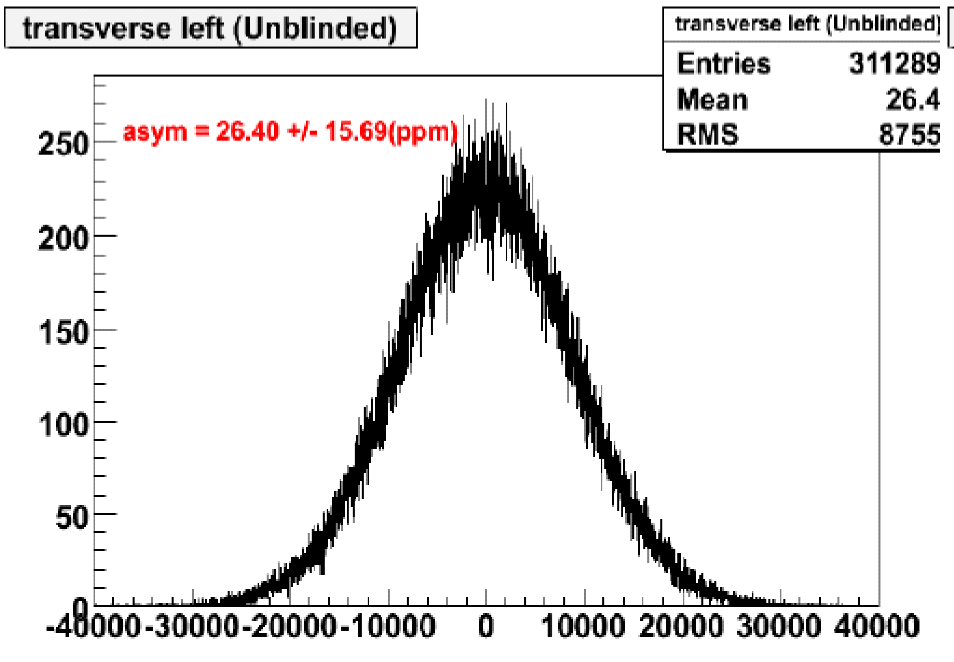
Electron Contamination factor $f = \frac{N_e^+}{N_\pi^+}$

	Kine #1	Kine #2
f	0.4	0.012
Ae	-81 ppm (theoretical prediction)	-144 ppm (theoretical prediction)
A_π	-37.6 (+/-) 7.7 ppm	-10.2 (+/-) 4.1 ppm
A_π^{cor}	-20.6 (+/-) 7.7 ppm	-8.6 (+/-) 4.1 ppm

Open discussion: none-zero pion asymmetry ?

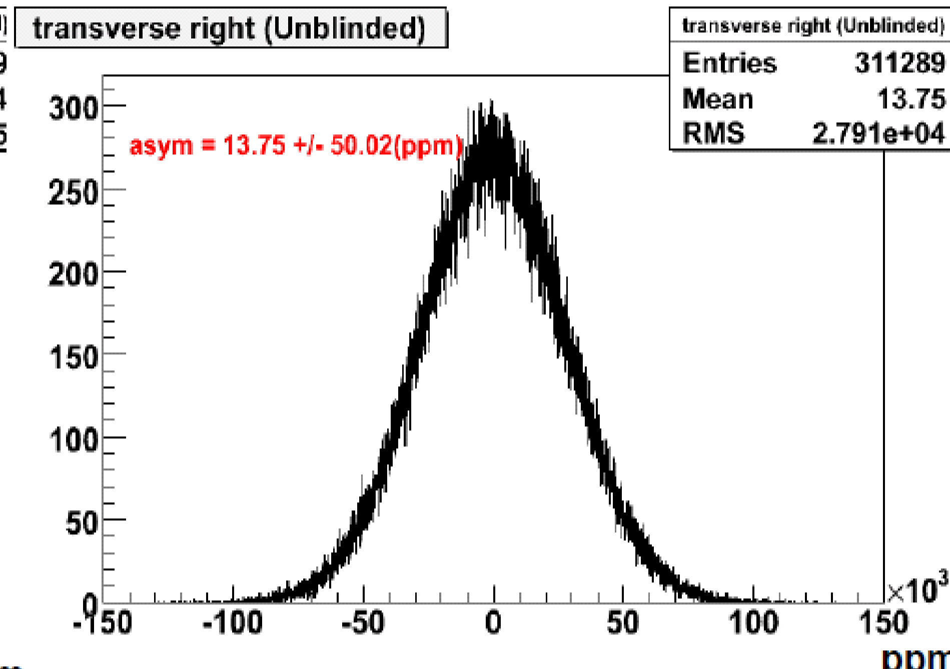
$e + u \xrightarrow{W^-} \nu_e + d$ ~ A=-1

3. Transverse Spin Asymmetry (A_T) (unblinded)



Kinematics #1

26.40 +/- 15.69 (ppm)

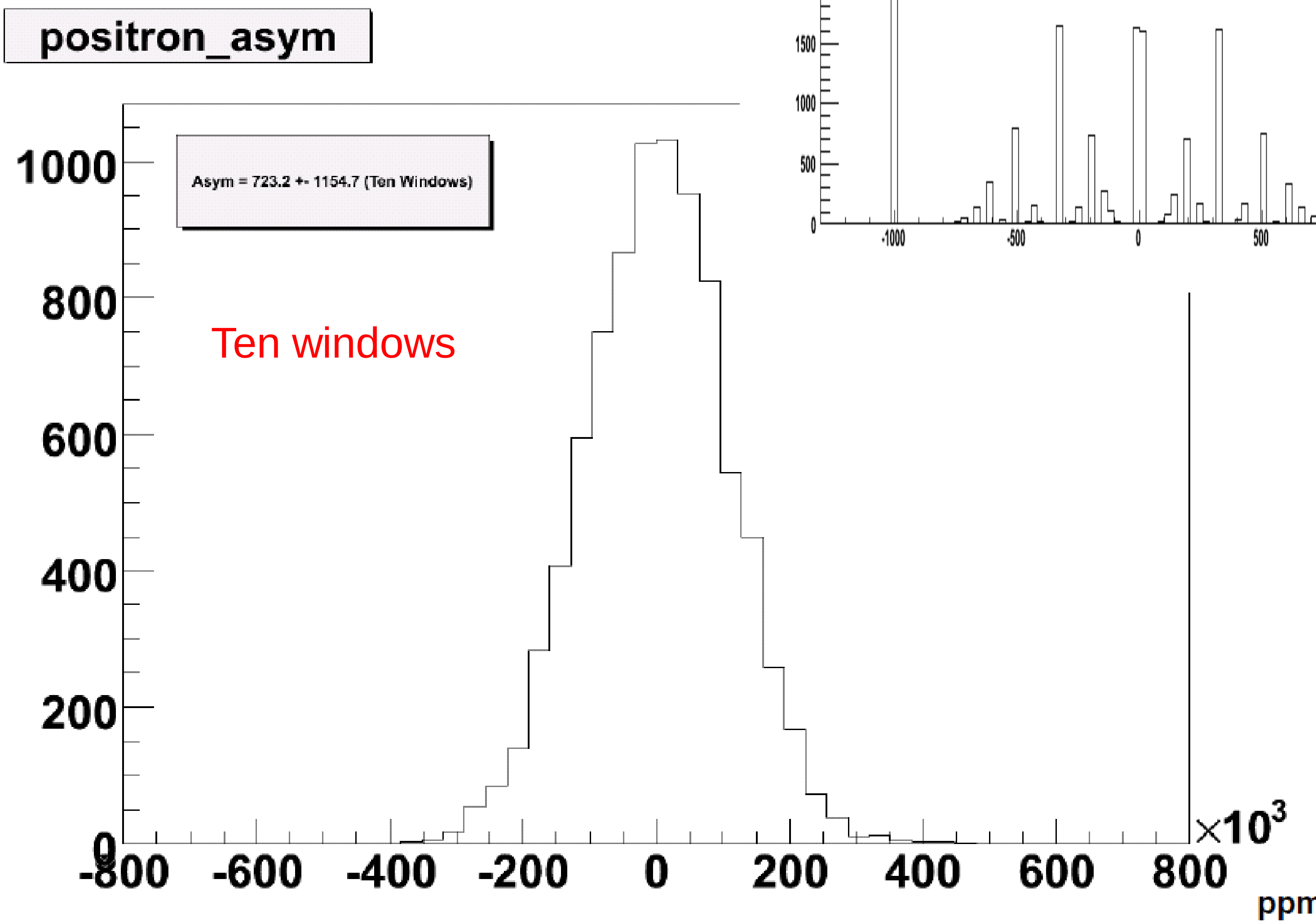


Kinematics #2

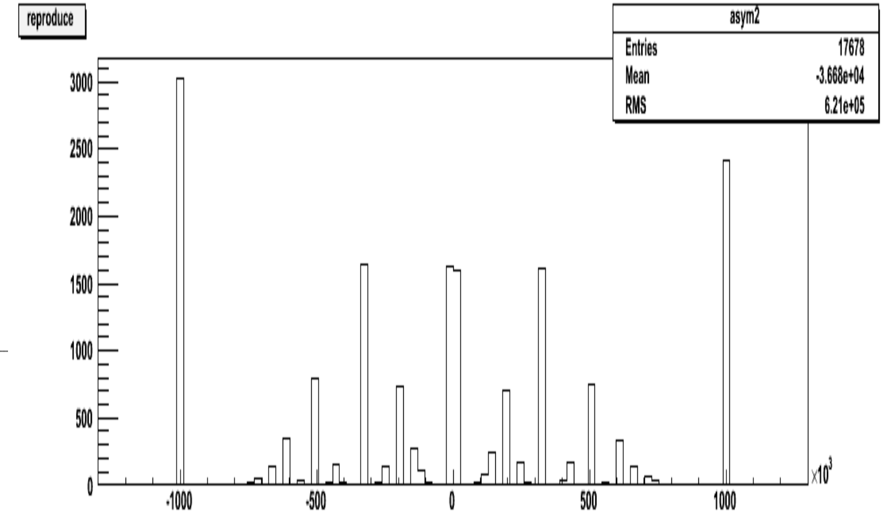
13.75 +/- 50.02 (ppm)

4. positron asymmetry

Kine #1



Ten windows



723.2 +/- 1154.7 (ppm)

Thanks!