Preparing for Unblinding

Diancheng Wang

Slides 2~7: Summary slides.
Slides 8~34: Explanations and Details

Raw Asymmetry (Electron):

- Beam Current:
  - BCM pedestal calibrated using unser (slide 8).
  - Did charge Feedback. Charge asymmetry averaged to ~1.32ppm, due to some runs when Feedback was off (slide 10).
  - Asymmetry normalized to BCM, so no first order correction. Uncertainty??
- Beam Modulation (slide 9):
  - Dithering slopes measured to be < 5ppb/nm (slide 9);
  - Beam movement (diff's) averaged to be < 40nm (slide 10);
  - Dithering correction turned out small (slide 11). Uncertainty??;
- Statistical Quality of data checked (slide 11)
- Independent Analyses (Kai Pan)

??What systematic uncertainty to quote due to beam, or “False Asymmetry”, 0.2%??

Beam Polarization:

- Moller results (slide 16): 88.47% +/- 2.0% (syst, relative) (6.0GeV)

  90.4% +/- 1.7% (syst, relative) (4.8GeV)

- Compton result (slide 16): 89.45% +/- 1.92% (syst, relative)

  - Analyzing power calculated using GEANT4 Monte Carlo, systematic ~1.75% (relative) (slides 12, 14)
  - Question from last meeting: PMT nonlinearity **IS** tested for PVDIS (slide 13).
  - Laser polarization (slide 15), systematic ~0.8% (relative), quoted from HAPPEX3.

- Polarization corrected locally.

- First half of the experiment, only have Moller (2.0%).
- When Compton started working, using weighted average of Compton & Moller (1.39%), (weight is the systermatic uncertainty).

Deadtime:

- Explanation of the DAQ system(slides 17, 18).
- Methods to study deadtime:

  Data: FADC, Tagger, (only partial deadtime)
  Simulation: full scale, only way to get overall deadtime

- How the simulation works (slides 19-21)
- Checking the simulation:

  ✔ Compared with FADC data (slides 22, 23)
  ✔ Compared with Tagger data: pileup effect(slide 25), group deadtime(slide 26)

- Deadtime results from the simulation (slide 27), uncertainty ~30% relative.

  Kine #1: 1.5% +/- 0.44%
  Kine #2: 0.84% +/- 0.25%

- Deadtime is corrected run-by-run

Radiative Correction:

- Radiative correction is based on Hall A Monte Carlo (HAMC) (slide 28)
- Basics of HAMC is checked (slide 29)
- We took 4 resonace kinematics measurements to constrain radiative correcton (slide 30):
  - Res #3 (Delta) is 2-sigma away from theoretical models (slide 31). For future use, we apply a scale factor(A_data/A_theory) to the theory
  - Res #4, #5, #7: simulation agree well with data (slide 32)
  - All the resonance measurements are better than 15%, which is how much we claim on understanding resonance asymmetries.

- Radiative correction for DIS #1, #2 (slide 33):

  Kine #1: 1.028
  Kine #2: 1.020
- Uncertainty:

  Kine #1: 27.2% events from resonance, 15% relative uncertainty => 4.1% ????
  Kine #2: 3.6% events from resonance => 0.54%

- Kine #2 is used to extract C2's

Other Corrections:

- Transverse Asymmetry(slide 34): no correction

  Uncertainty: 0.19% for #1, 0.40% for #2

- Target Endcap(slide 34):

  Kine #1: 0.0165% +/- 0.0033%
  Kine #2: 0.0225% +/- 0.0045%

- Qsq Uncertainty (Kai Pan):

  Left Kine #1: 0.725%
  Left Kine #2: 0.575%
  Right Kine #2: 0.640%

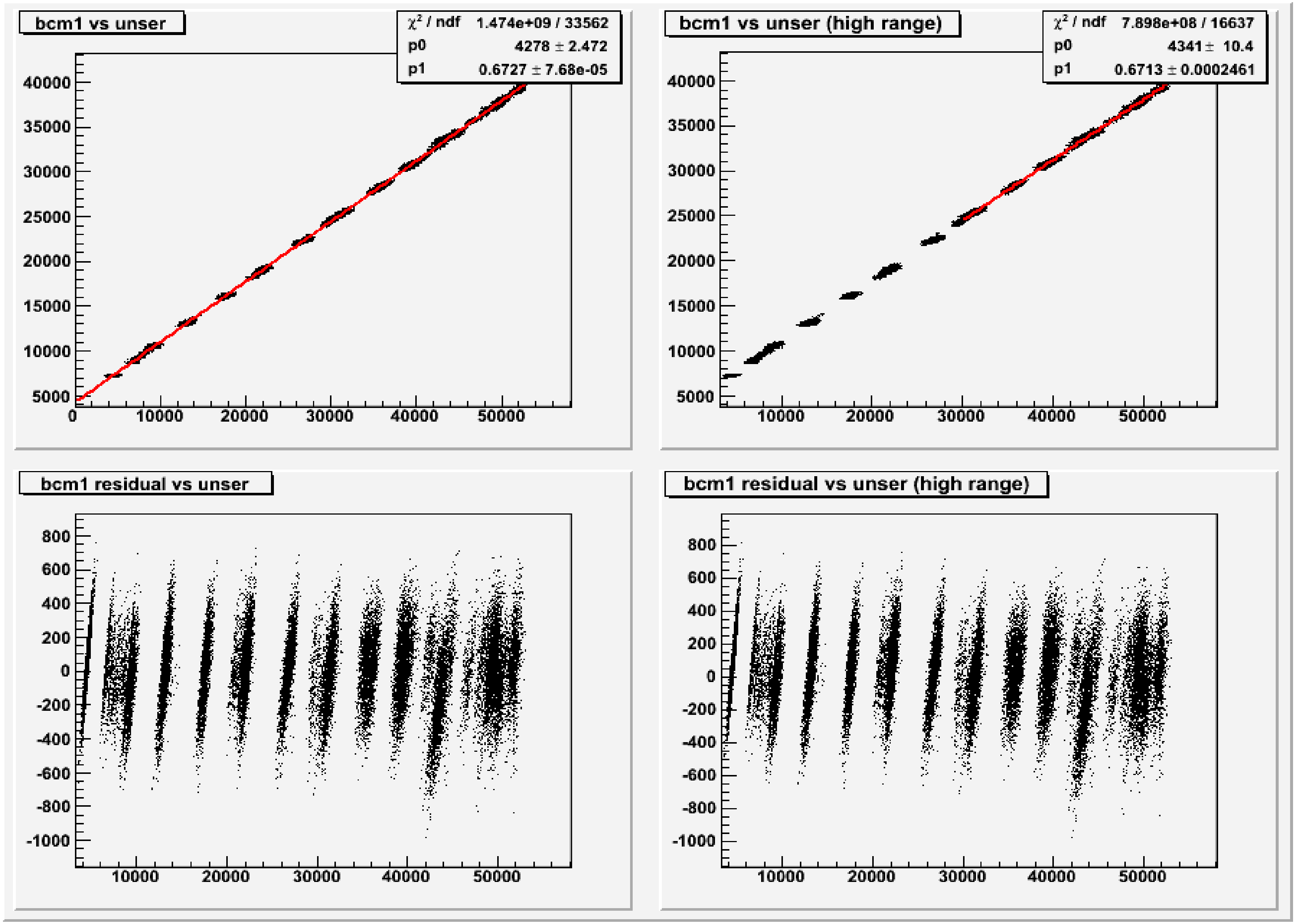
- PID Efficiency (Kai Pan): corrected run-by-run

  Left Kine #1: 0.048% +/- 0.0077%
  Left Kine #2: 0.051% +/- 0.065%
  Right Kine #2: 0.153% +/- 0.018%

Corrections and Uncertainties

	Source $\Delta A_d/A_d$	Left #1	Left #2	Right #2
	Raw Ad(ppm)	-66.44+/-2.68	-128.29+/-10.43	-128.53+/-6.58
Run-by-Run	$\Delta P_b/P_b$	13.4% +/-2.0%	11.9% +/-1.39%	12.6% +/-1.72%
Run-by-Run	Deadtime	1.50% +/-0.44%	0.84% +/-0.25%	0.85% +/-0.25%
Run-by-Run	PID efficiency	0.048% +/-0.008%	0.051% +/-0.066%	0.153% +/-0.018%
Global	Radiative Cor	?2.8% +/- 4.1%?	2.0% +/- 0.54%	2.0% +/- 0.54%
Global	Q2	0.725%	0.575%	0.640%
Global	Transverse Asym	0.190%	0.400%	0.400%
Global	Target Endcap	0.0165% +/-0.003%	0.0225% +/-0.005%	0.0225% +/-0.005%
Global	False Asymmetry	?0.2%?	?0.2%?	?0.2%?
Global	Pair Production	5E-4	4E-3	4E-3
Global	Pion dilution	<10-3	<10-3	<10-3

BCM Calibration

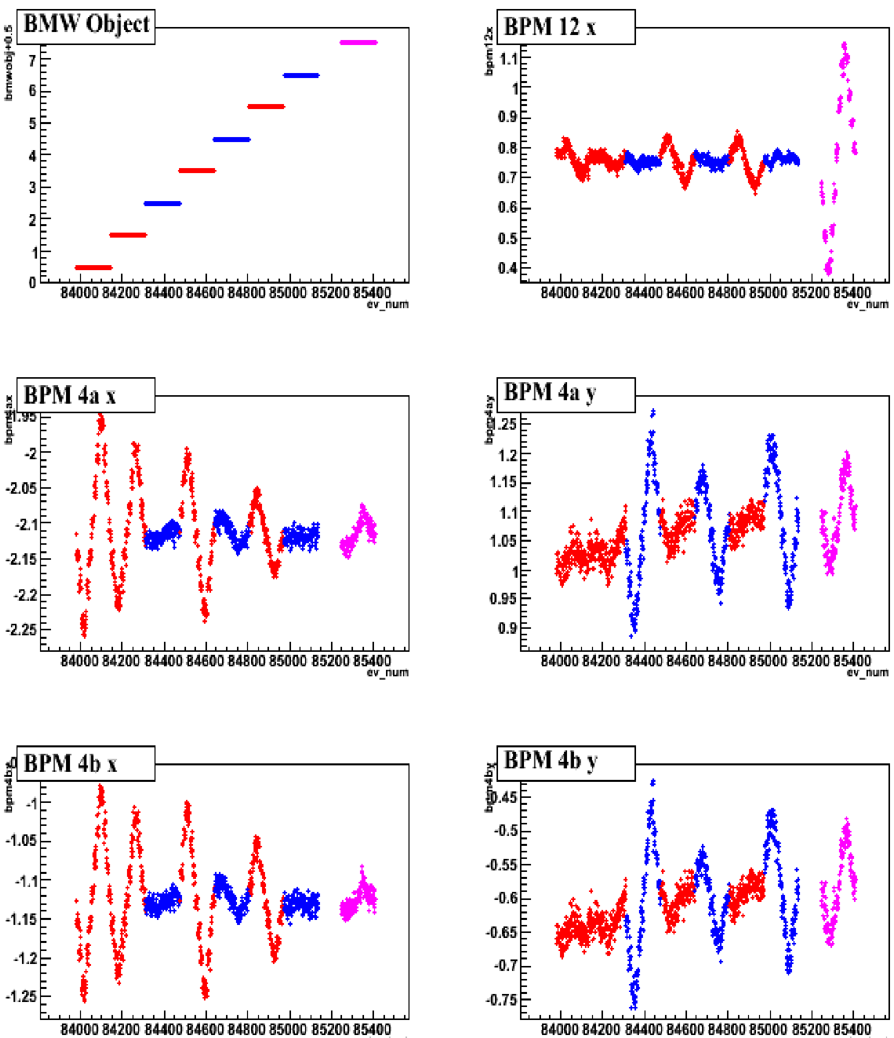


Beam Modulation

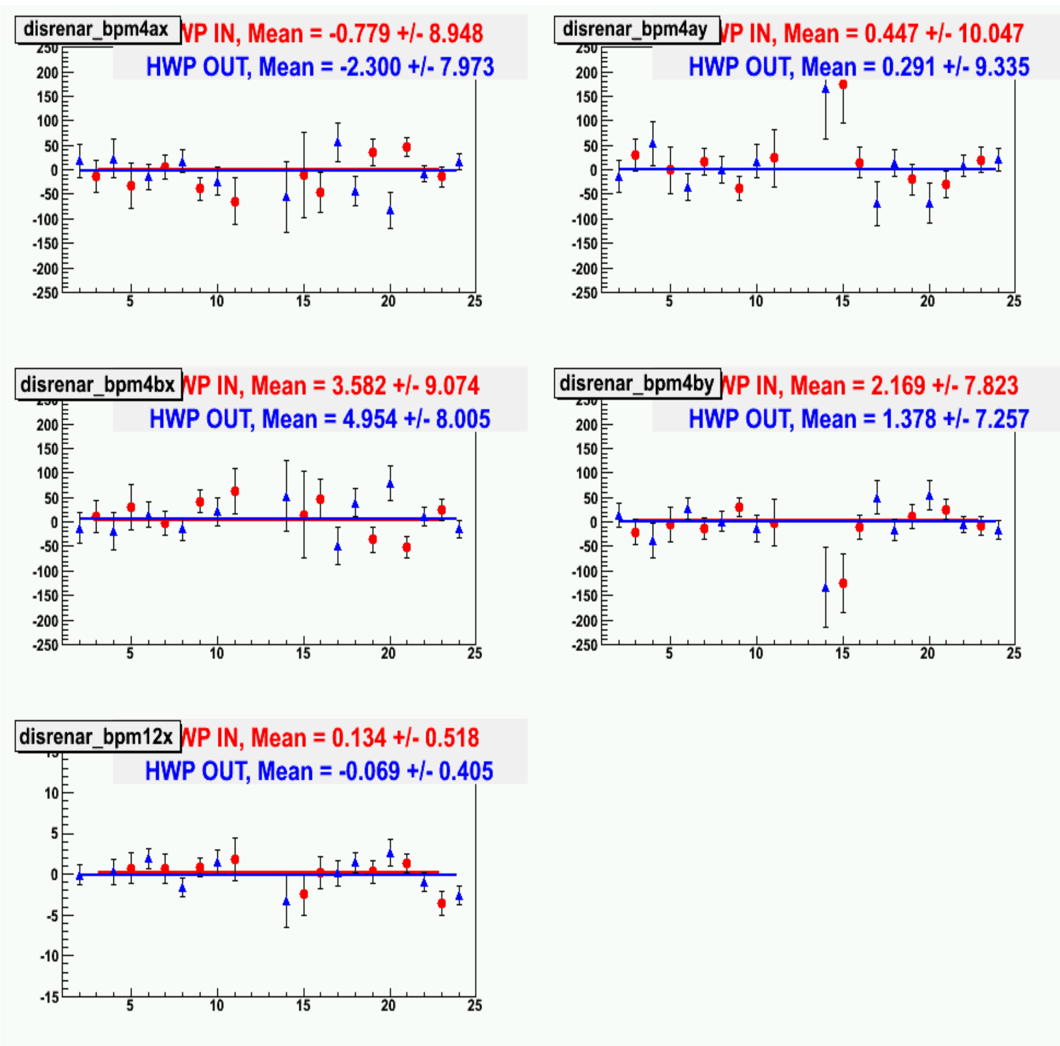
$$A_{mes} = A_{raw} - A_{beam} - \boxed{\sum \beta_i \Delta x_i}$$

Two independent methods:

- Dithering: intentionally vary the beam parameters
- Regression: use the natural motion of the beam

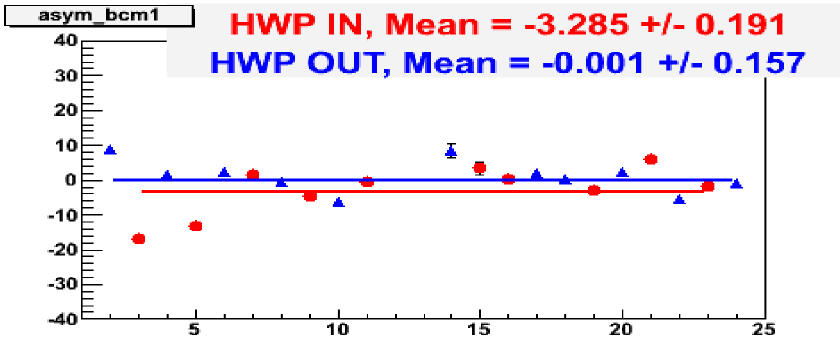


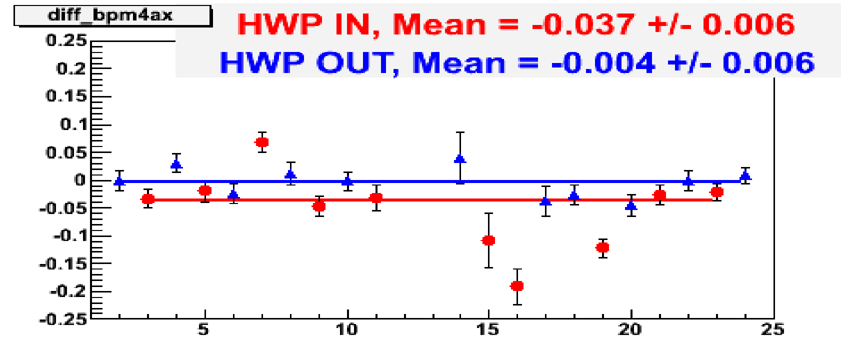
Dithering plots

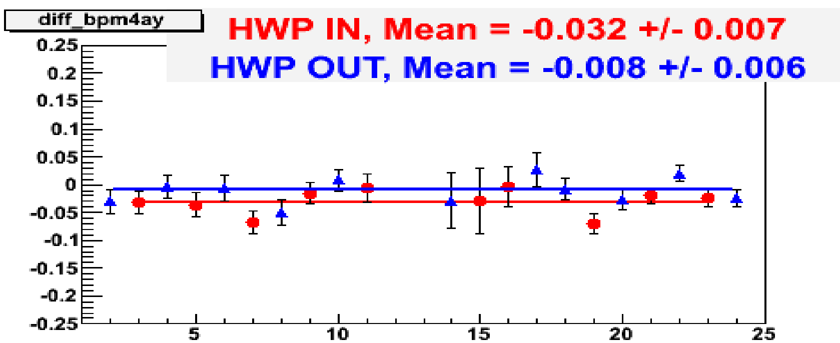


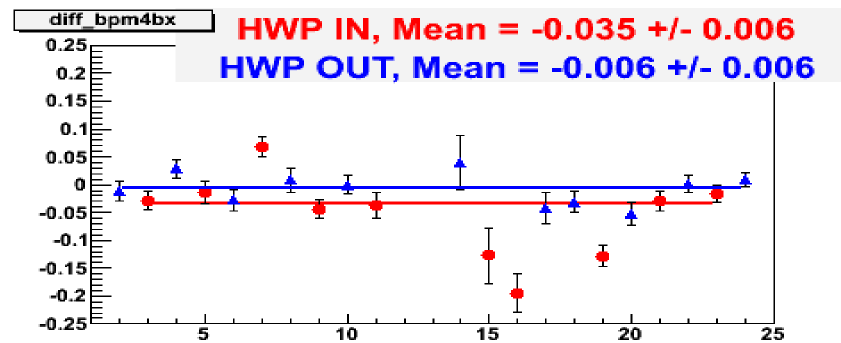
Dithering slopes (β_i's) history:

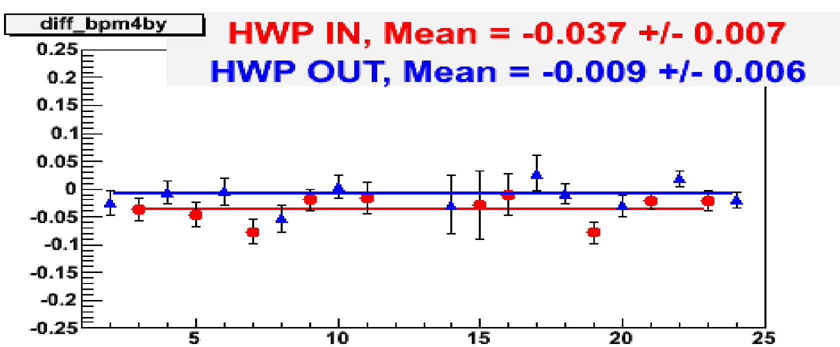
Beam Asymmetries

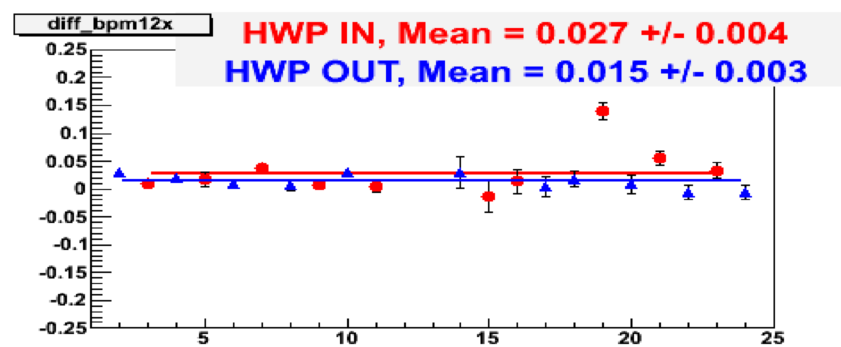




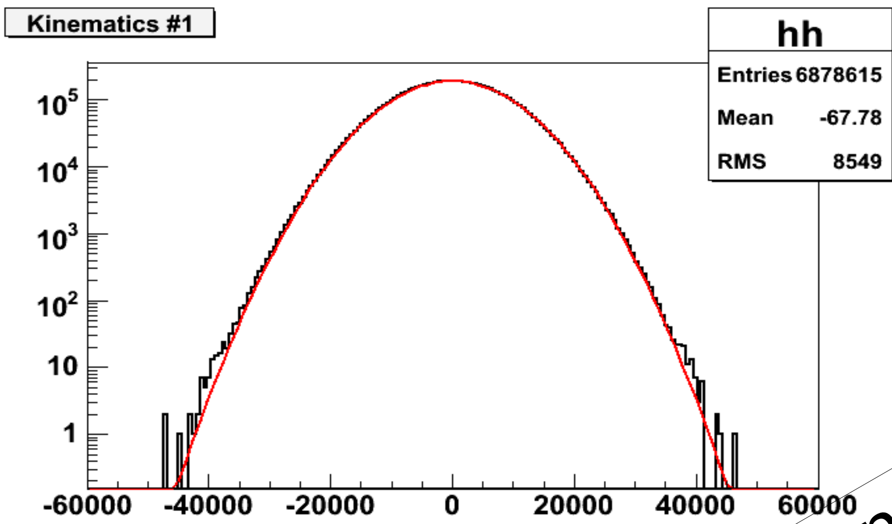


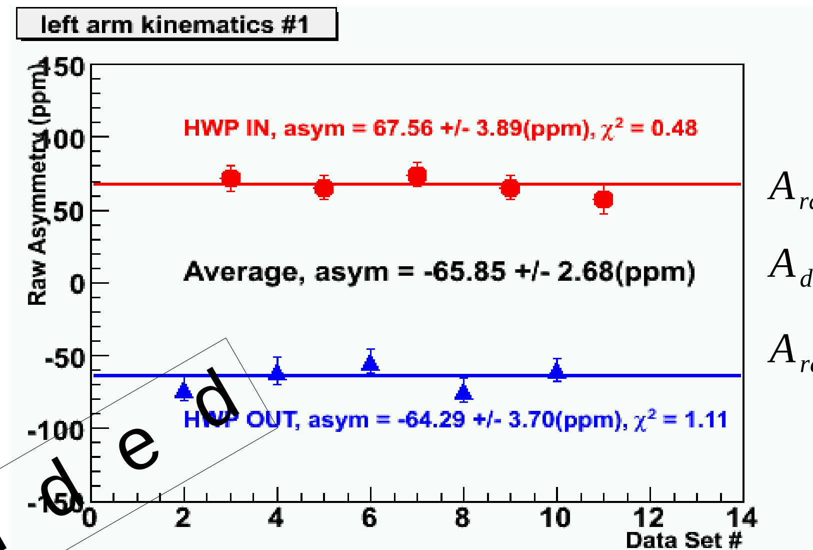






Raw Electron Asymmetries

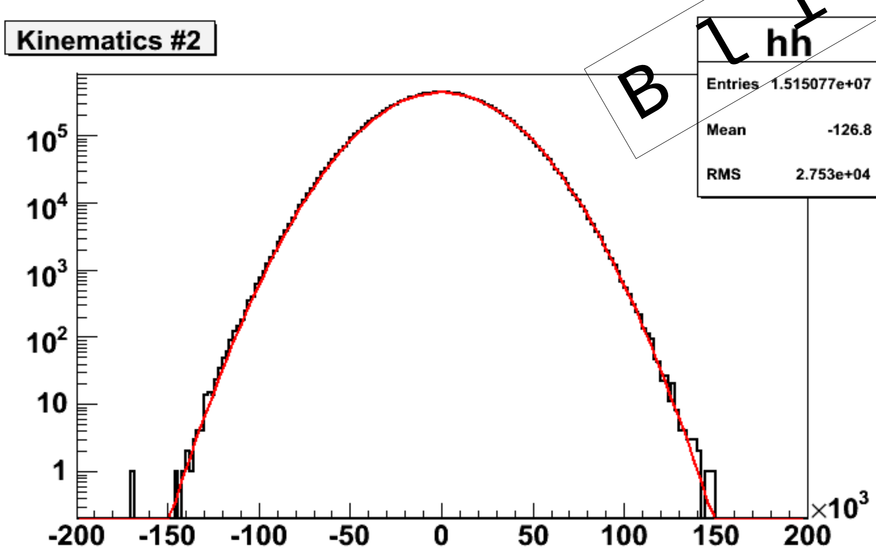


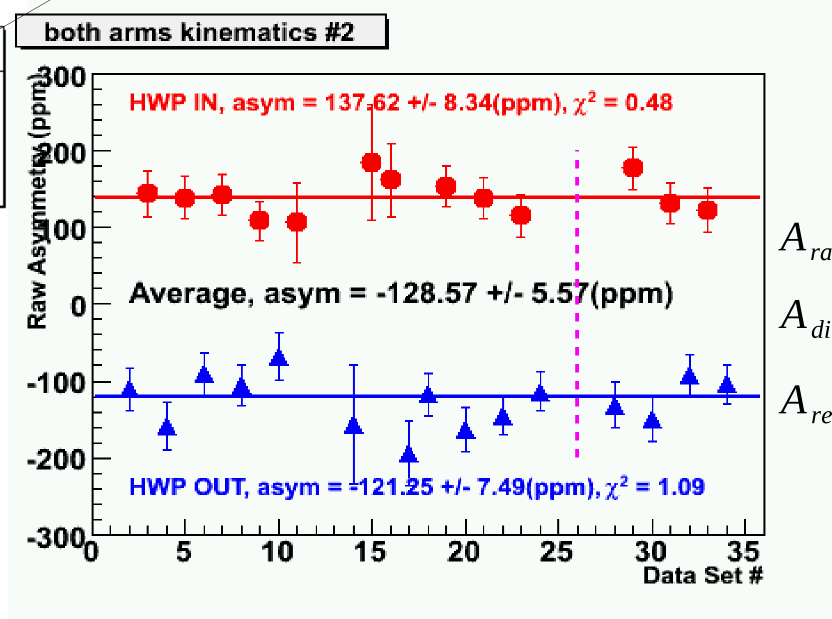


$A_{raw} = -65.85\text{ppm}$

$A_{dit} = -65.85\text{ppm}$

$A_{reg} = -65.93\text{ppm}$





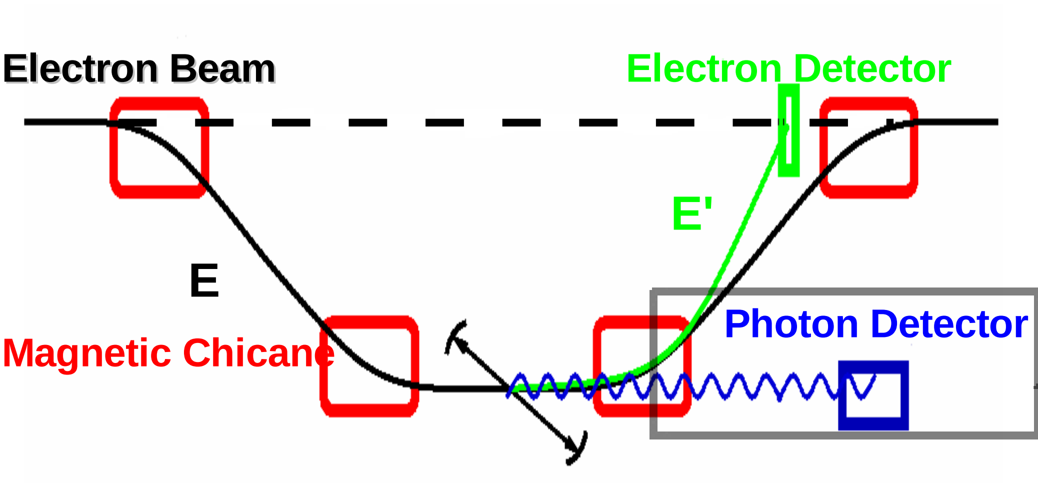
$A_{raw} = -128.57\text{ppm}$

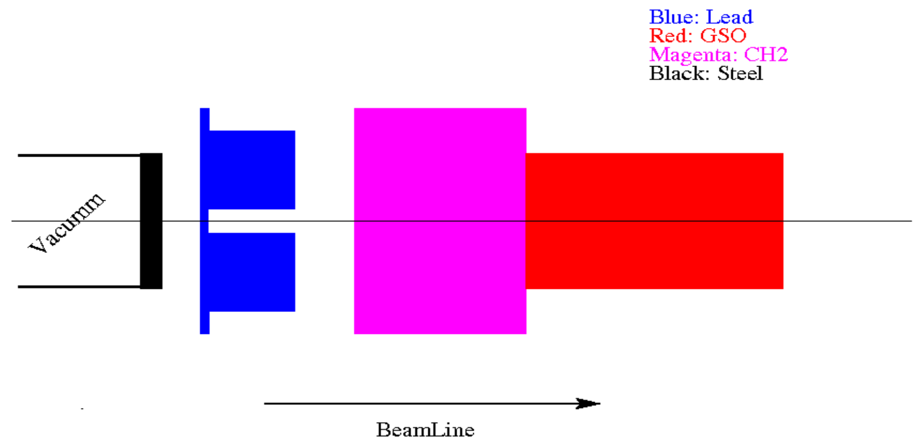
$A_{dit} = -128.52\text{ppm}$

$A_{reg} = -128.87\text{ppm}$

Doing two independent analyses, difference between the two is ~0.3ppm

Analyzing Power





Vacuum End Cap(steel): 0.05cm
Lead shielding thickness: 0.3 cm
Collimator: inner radius 0.5cm
outer radius 4.0 cm, length 5.0 cm
CH2: radius 5.0 cm, length 10.2 cm
GSO: radius 3.0 cm, length 15.0 cm

GEANT4 MC to calculate A_{th}

Inputs to the simulation:

- The experimental setup:
  - ➔Shielding, alignment.....
  - ➔Thickness of the lead shielding
  - ➔ Radius of the hole of the collimator
- Detector resolution, smearing
- Pileup Effect
- PMT nonlinearity

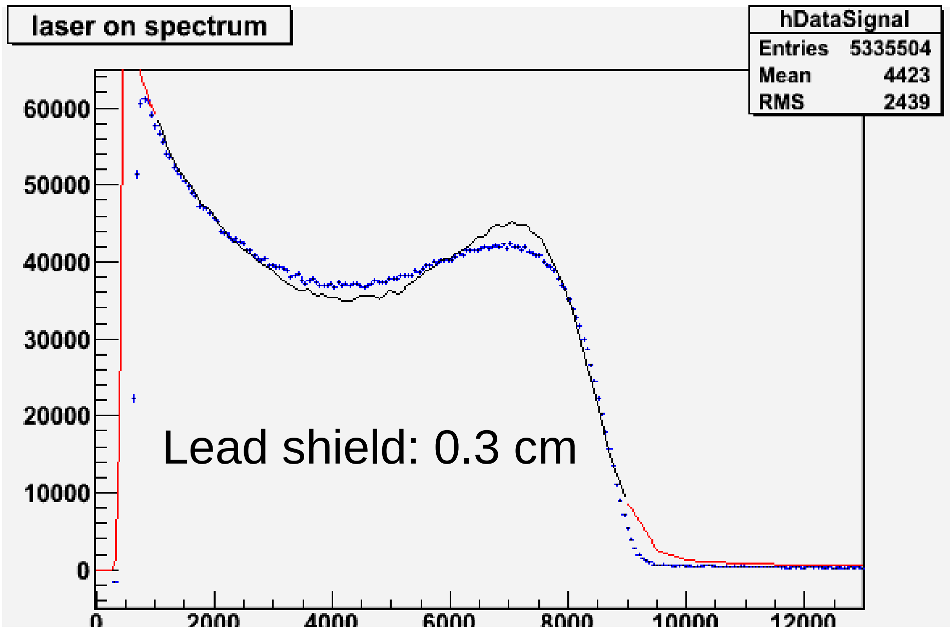
PMT Nonlinearity

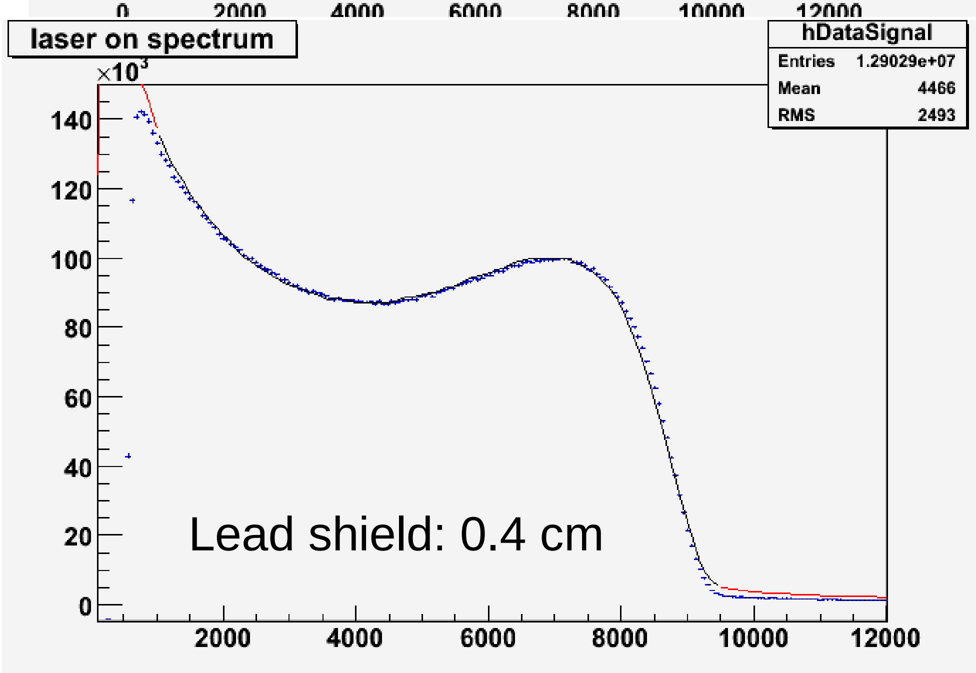
Megan's email:

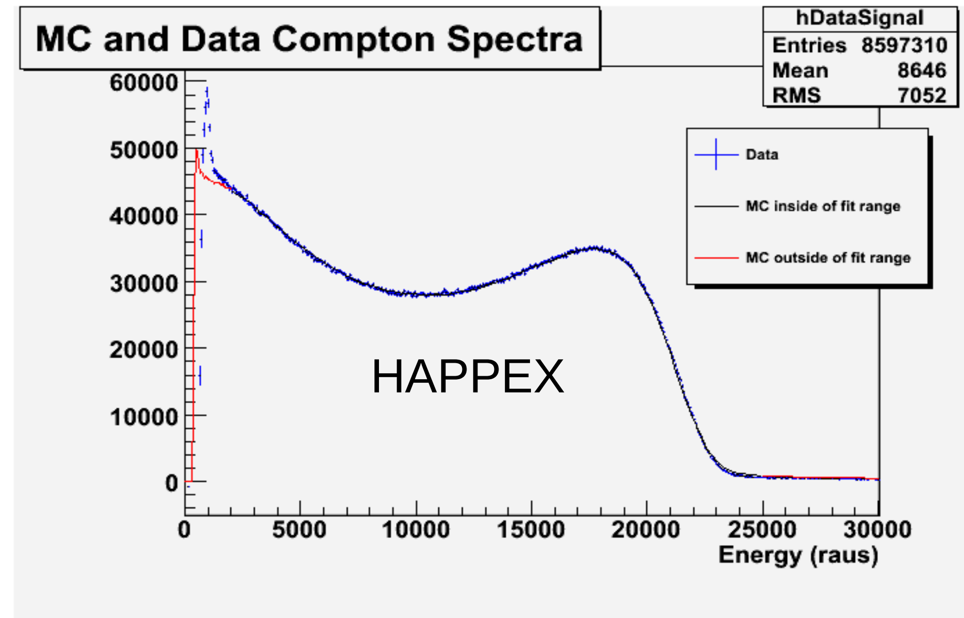
“ The macro MakeTree.C just makes a tree out of the MC ascii file with the inclusion of PMT linearity, which is something I have a function for based on nonlinearity tests I did during the run (using my miniMegans!). The updated (for PVDIS) version is attached, including PMT linearity at a couple of HVs”

PMT nonlinearity for PVDIS is mapped by a 7^{th} order polynomial fit, fitting parameters provided by Megan Friend.

Analyzing Power / GEANT4 Monte Carlo



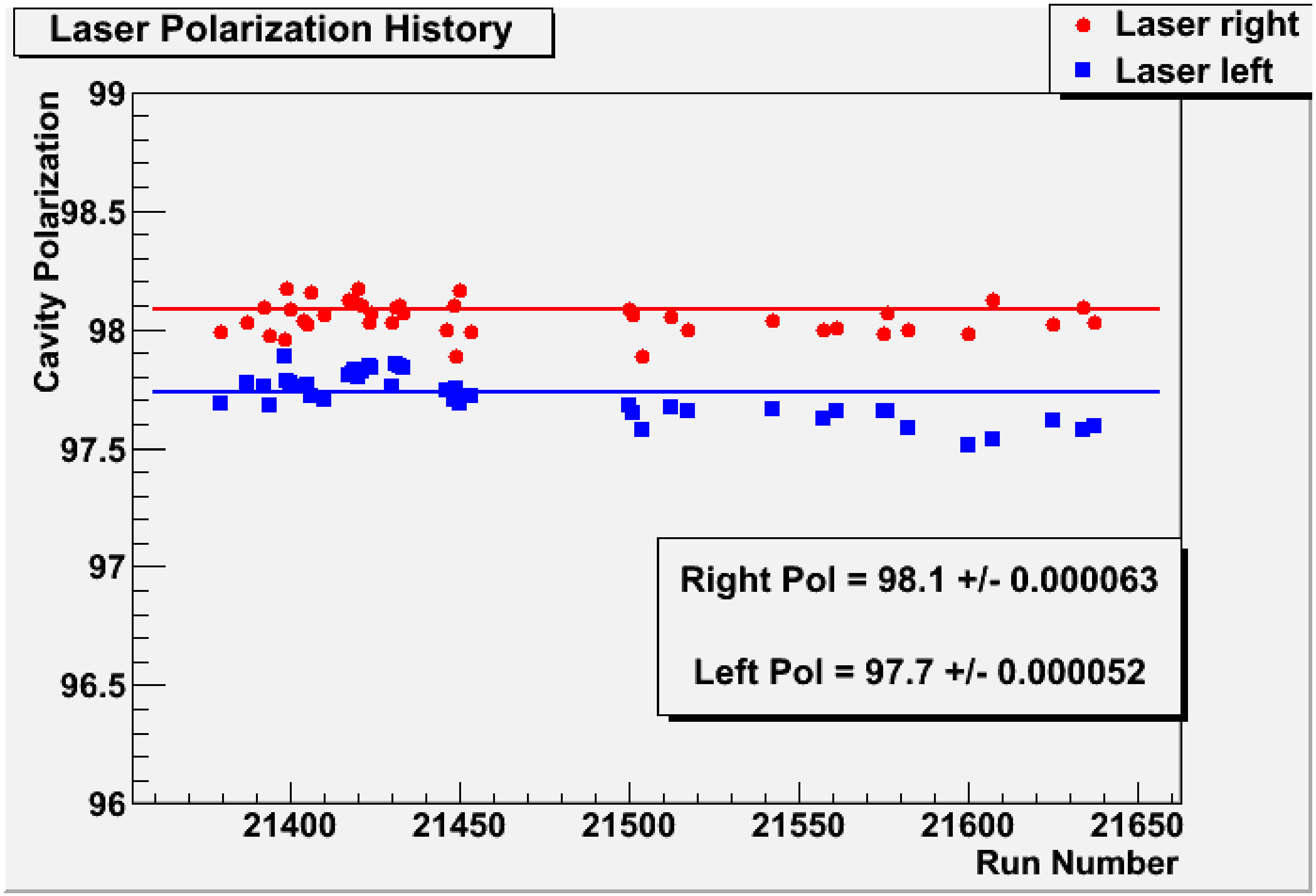




0.3cm: <Ath> = 0.04883
0.4cm: <Ath> = 0.04970

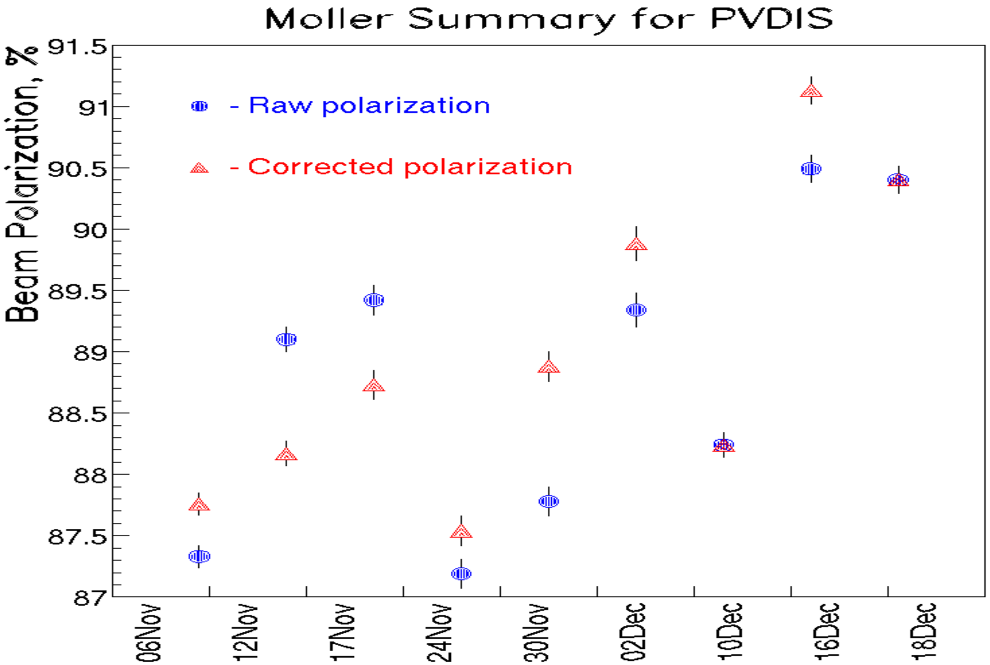
So <Ath> = 0.04970 +/- 1.75% (relative)

Laser Polarization



Beam Polarization (Compton/Moller)

$$A' = A_{measure} / Polarization$$



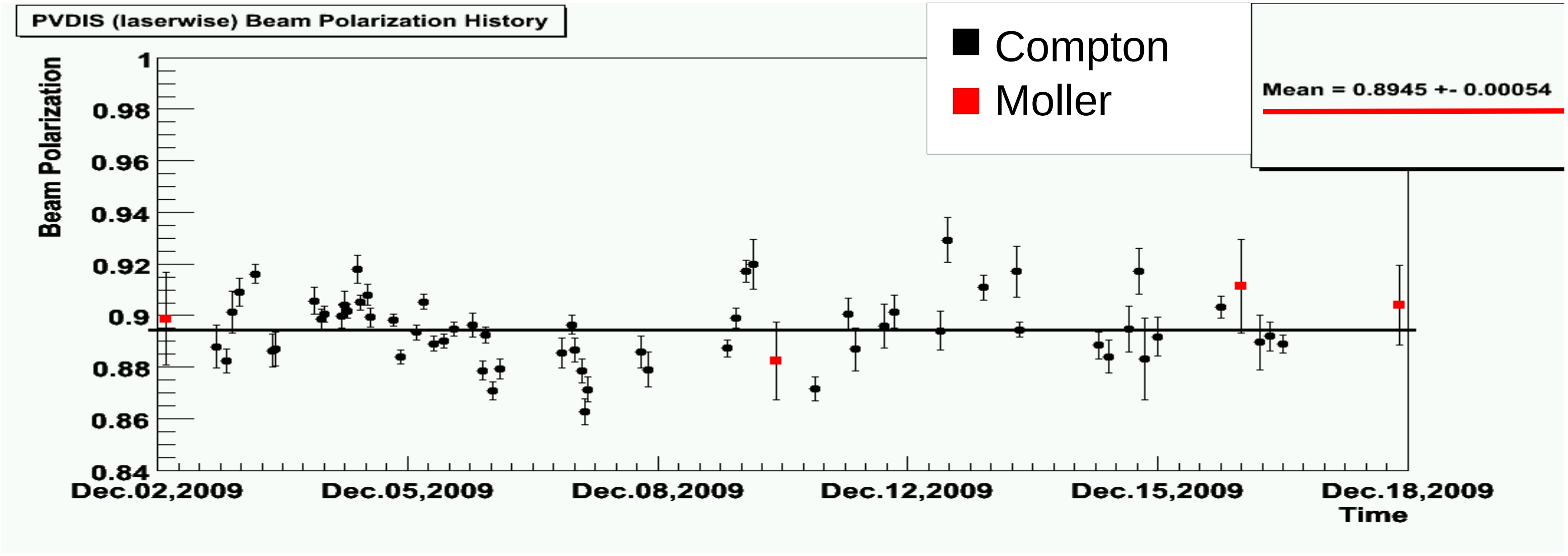
Moller: 88.47% +/- 2.0% (syst, relative) (6.0GeV)

90.4% +/- 1.7% (syst, relative) (4.8GeV)

Compton: 89.45% +/- 1.92% (syst, relative)

Systematic mainly from A_{th}

$$(A_{exp} = P_{\gamma} \times P_e \times A_{th})$$

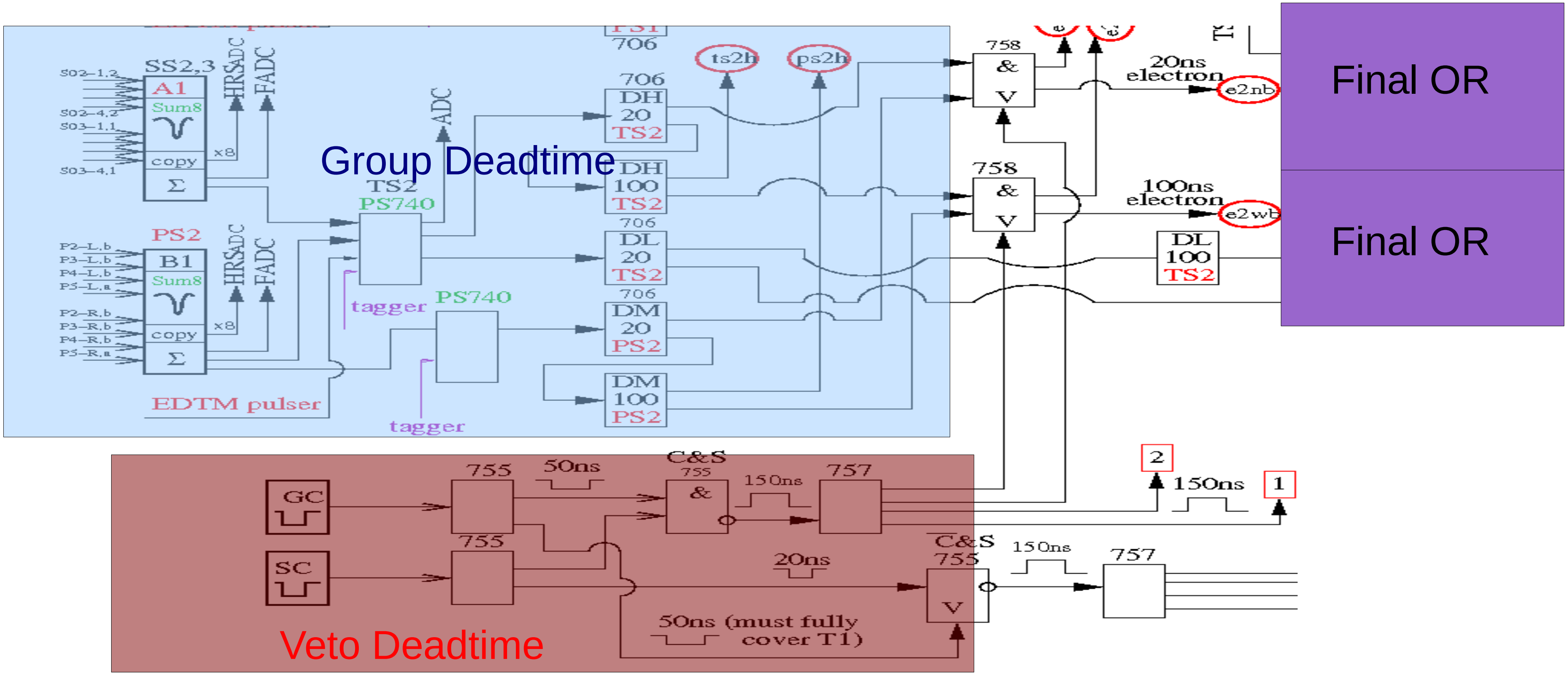


Deadtime Correction

Deadtime correction to asymmetry: $A' = A_{measure} / (1 - Deadtime)$

Deadtime Decomposition:

- Group Deadtime: proportional to group rate; narrow/wide path.
- Veto Deadtime: T1/GC rate; the same for all groups.
- Final OR: individual group triggers are ORed together to form final global trigger.
- Overall Deadtime: Veto DT ⊕ Group DT ⊕ Final OR DT



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- Overall Deadtime: Veto DT $\oplus$ Group DT $\oplus$ Final OR DT

Methods to study Deadtime:

- Theoretically, $Deadtime \propto Event\ Rate$
- FADC data: direct way to study veto deadtime, but low statistics.
- Tagger method: study group deadtime, compare with simulation.
- Software simulation: simulating all the signals and electronics, so everything.
  only way to get overall deadtime.

General Idea of Simulation

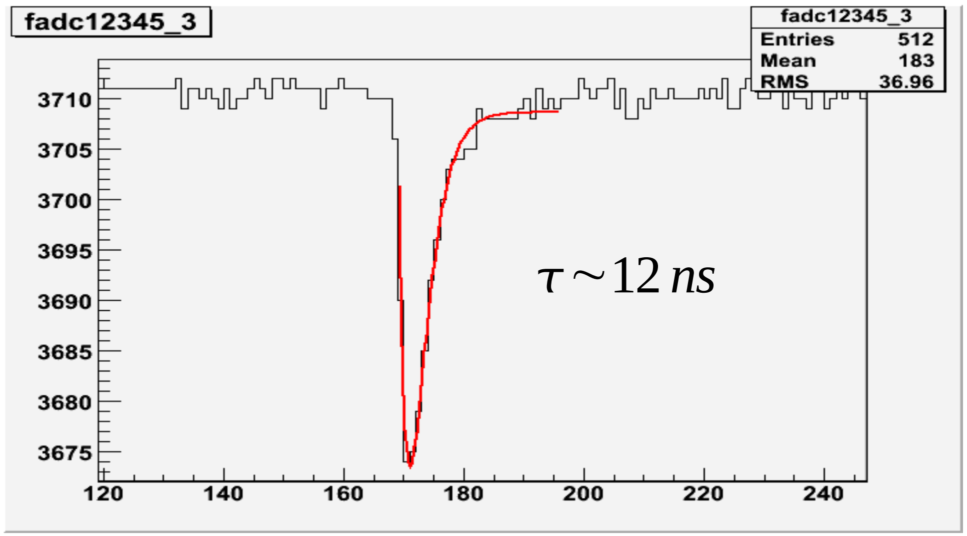
- ROOT/C++ Design;
- Simulates standard electronics (various electronic modules).
- Useful if you have a complex DAQ system (e.g. PVDIS).
- General idea:

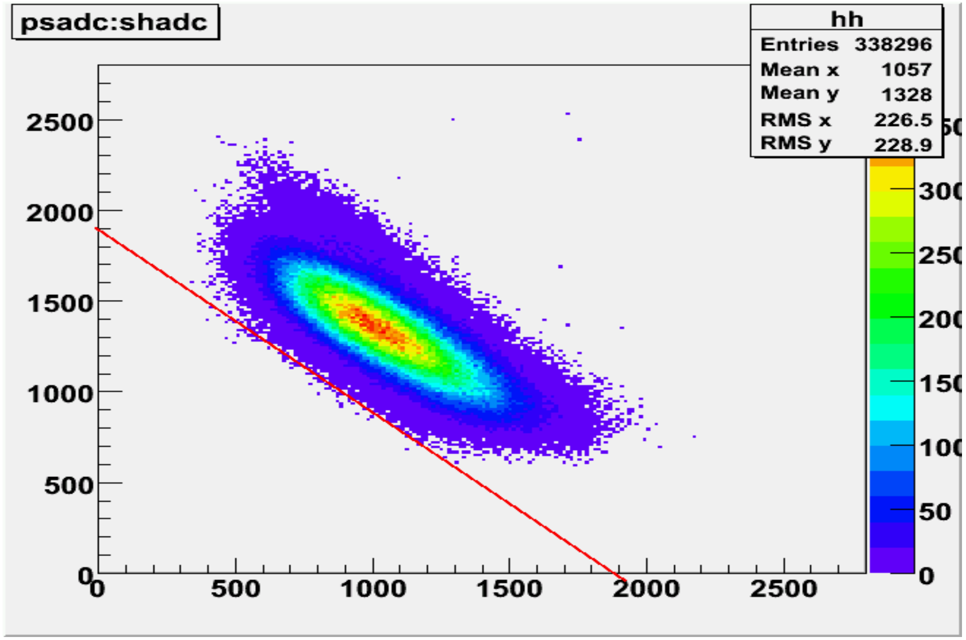
  At every time instance (1ns), **Physics** information is generated. **Detectors** (**Leadglass**, **Gas Cerenkov**, **T1** ...) simulates the detector response and generates signals, which are processed by the **DAQ** system (constructed by **Modules**). **I/O** controls input and output.
- Inputs:
  - Leadglass (ADC) signals from data, then converted into analogy signal:

    $$Analog\,signal \sim t \cdot e^{-\frac{t}{\tau}},\ where\ \tau\ needs\ to\ be\ calibrated$$
  - Physics signal rates. Also from data.
  - DAQ map.
- Output:
  - Rootfile containing all signal information with a time variable.
  - Can do post-hats analysis to get tdc spectrum, scaler counting, etc..
- It is NOT GEANT4 based, doesn't simulate particle interaction with materials.
- Efficiency: ~1hour to simulate 10ms. Maybe not fast enough for online monitoring...

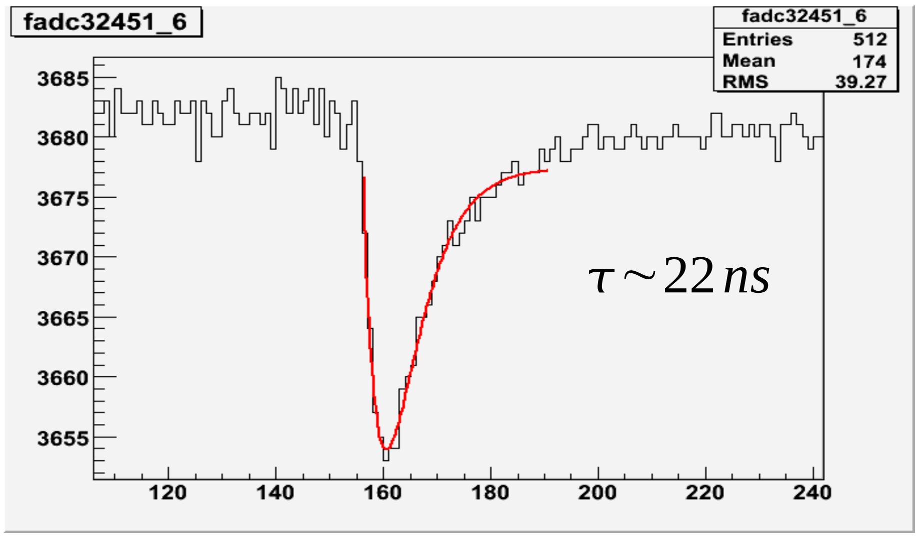
Time Constants Calibration

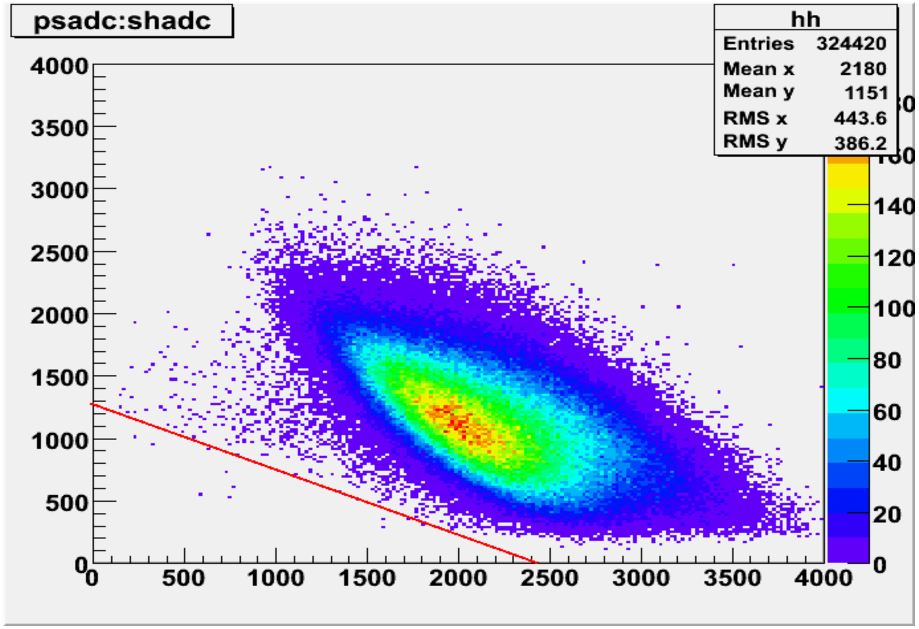
Right arm preshower PMTs:

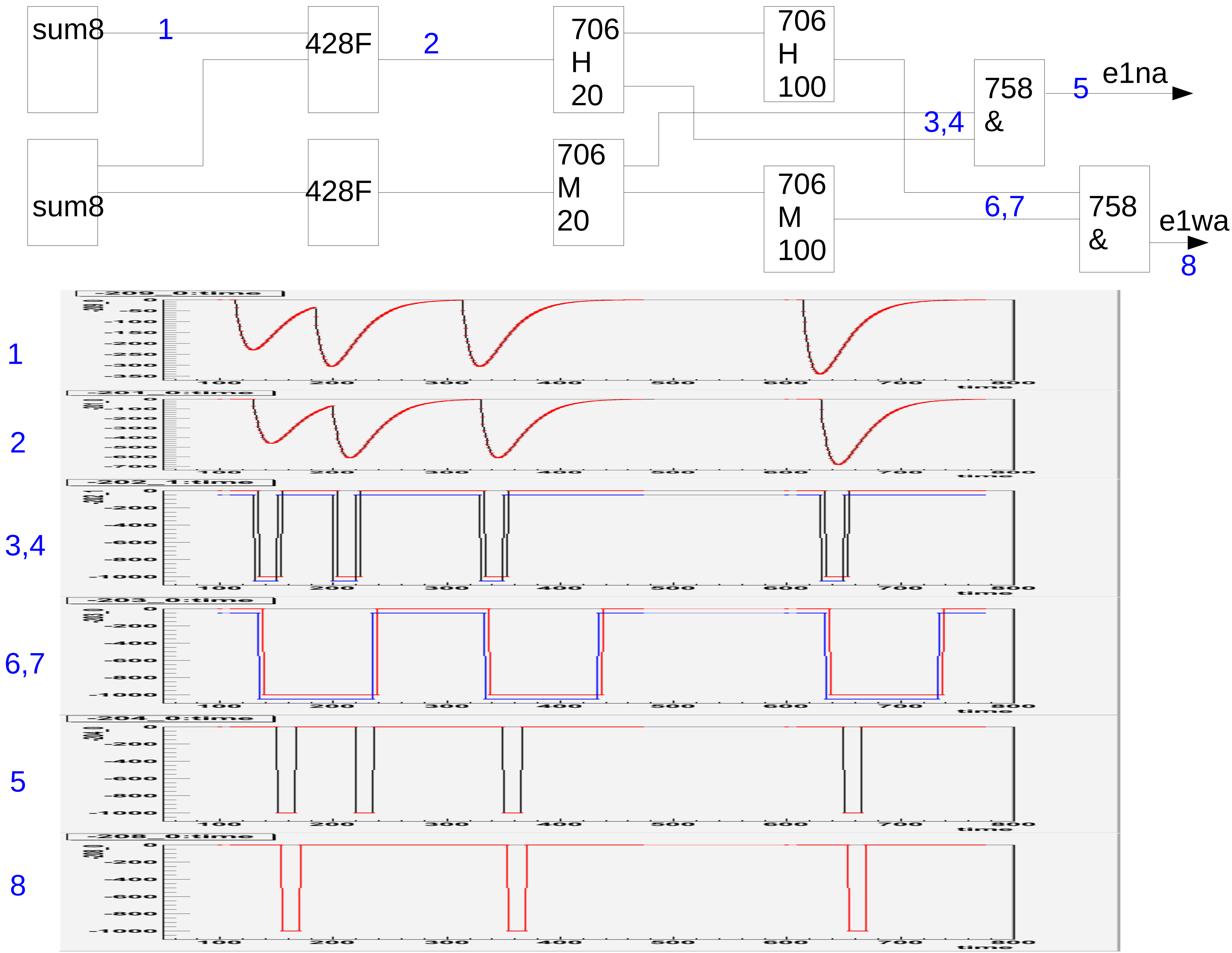




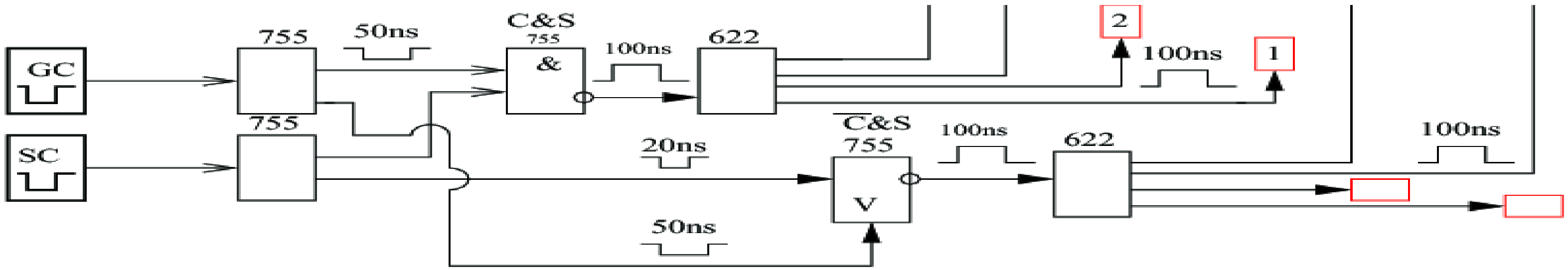
All Other Leadglass PMTs:

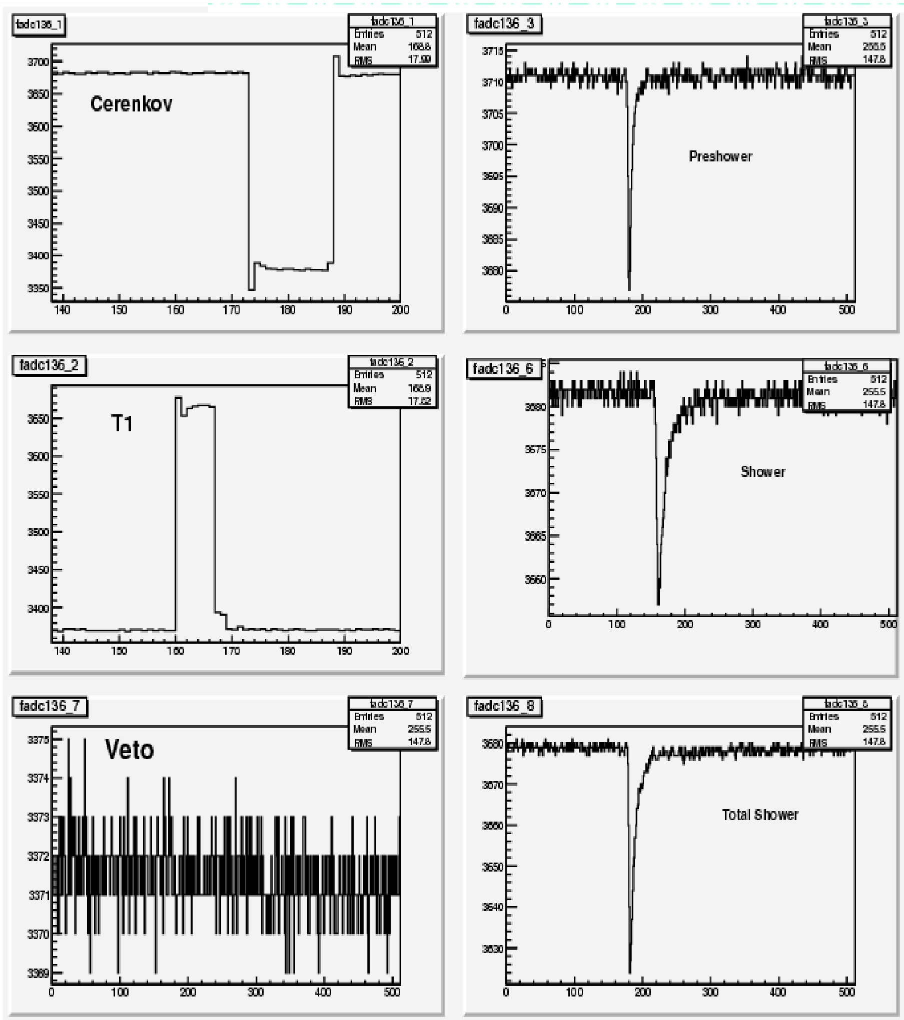


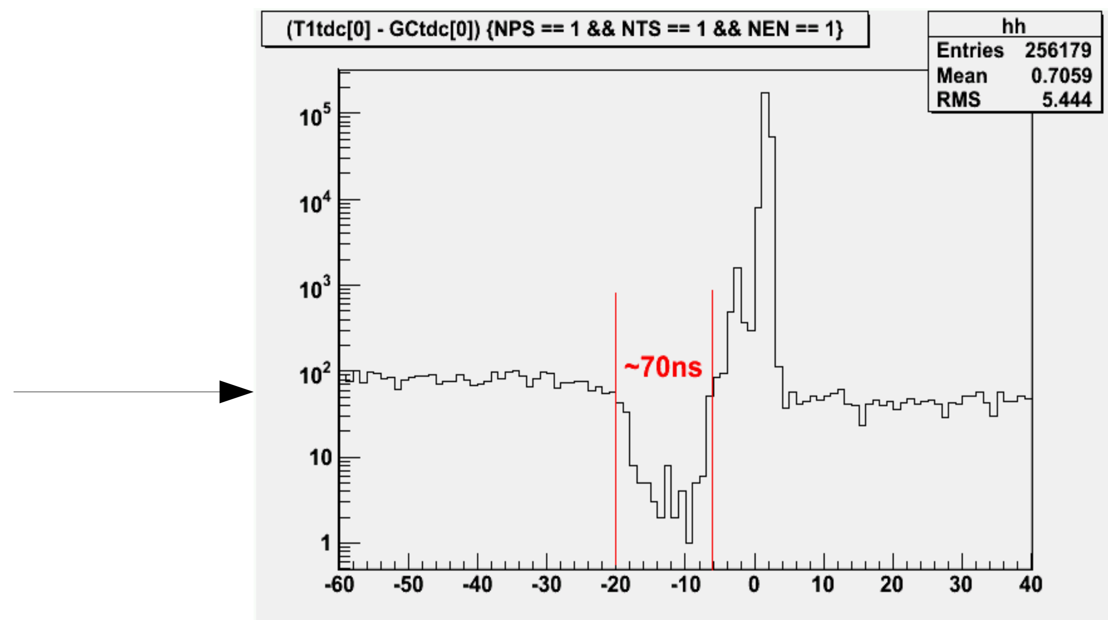



sum8
1
428F
2
706
H
20
706
H
100
758
&
5
e1na
3,4
sum8
428F
706
M
20
706
M
100
6,7
758
&
e1wa
8
1
2
3,4
6,7
5
8
100
200
300
400
500
600
700
800
time

Veto Deadtime/FADC Analysis



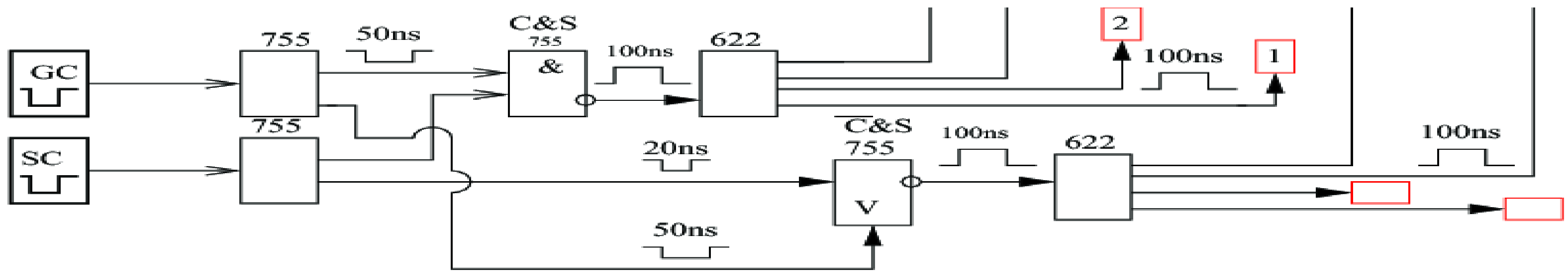


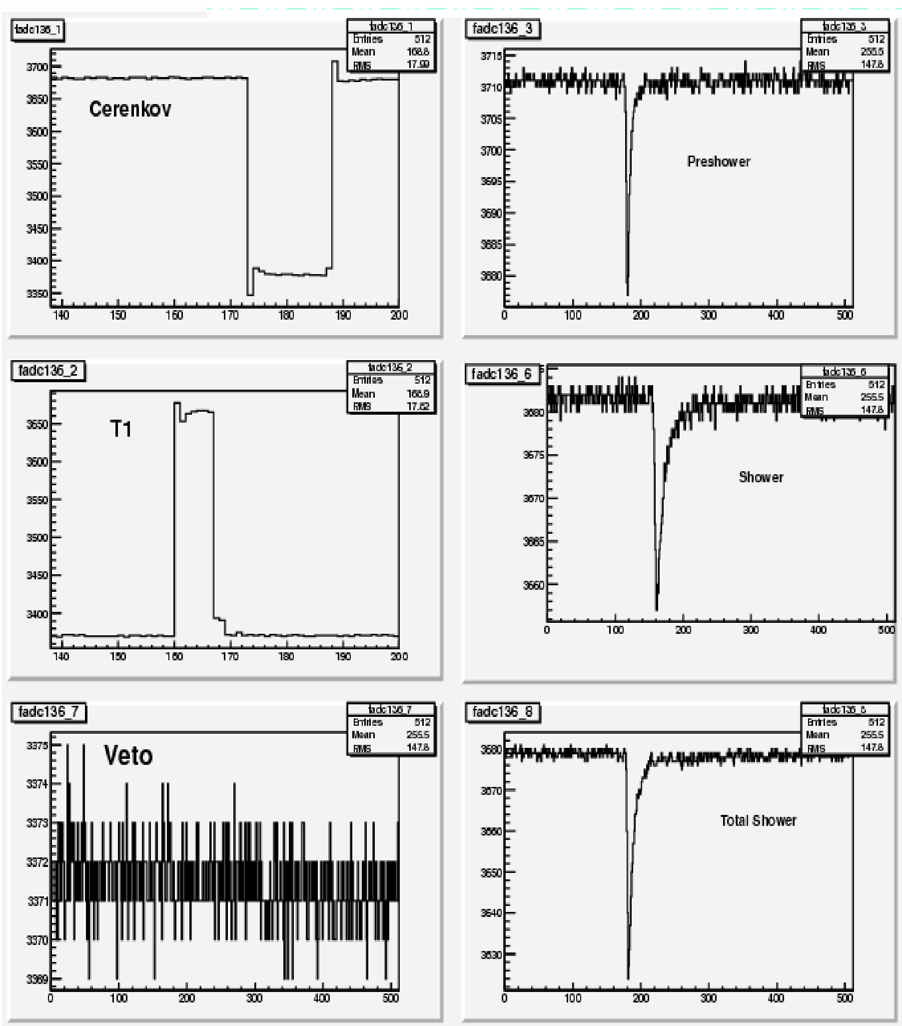


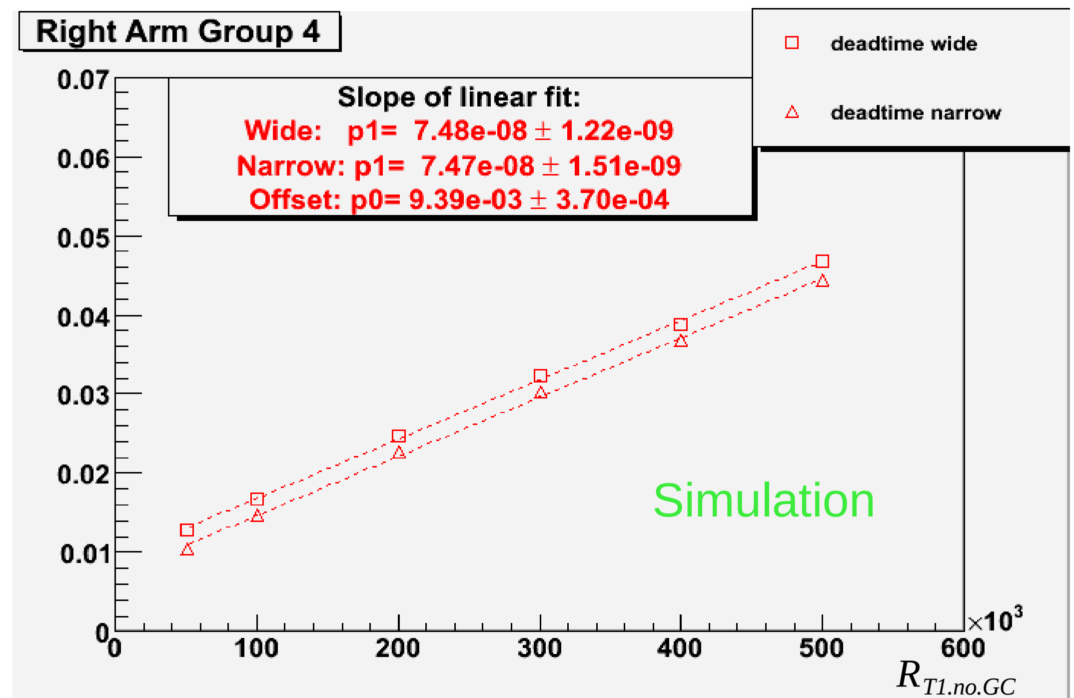
$$Veto\ Deadtime = R_{T1.no.GC} \times (W_{T1in} - W_{T1out})$$

Veto Deadtime is the same for narrow/wide path

Veto Deadtime/FADC Analysis





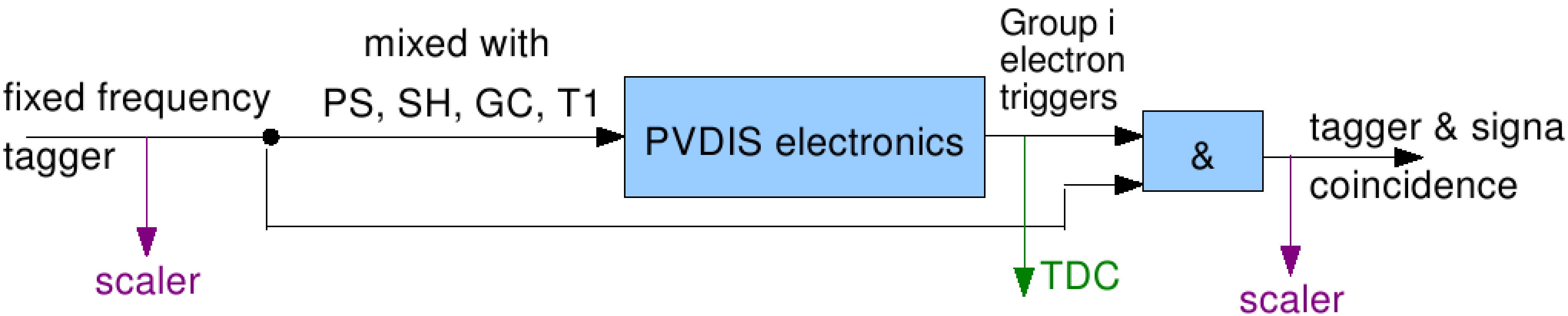


$$Veto\ Deadtime = R_{T1.no.GC} \times (W_{T1in} - W_{T1out})$$

Veto Deadtime is the same for narrow/wide path

Path Deadtime/Tagger Analysis

The Tagger method to measure deadtime:



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

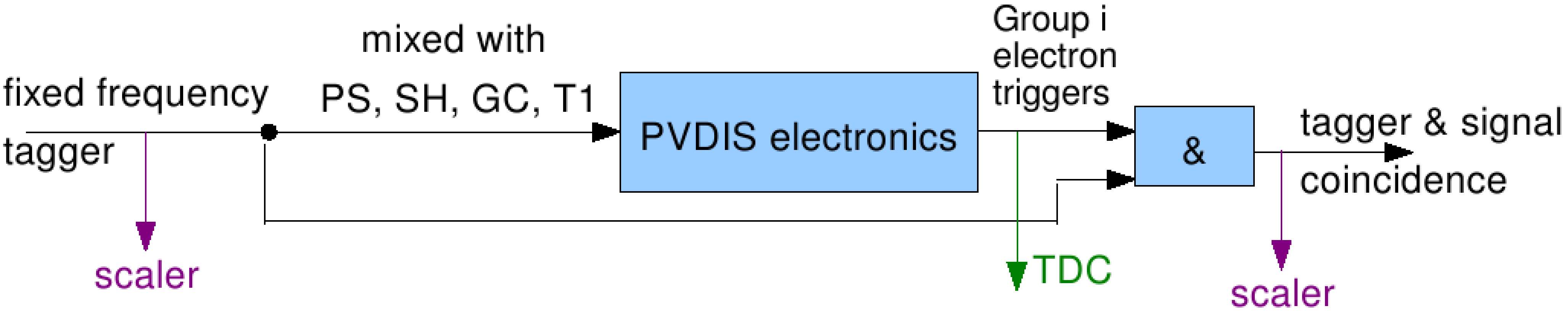
$$\equiv Fractional\ Loss + Pileup$$

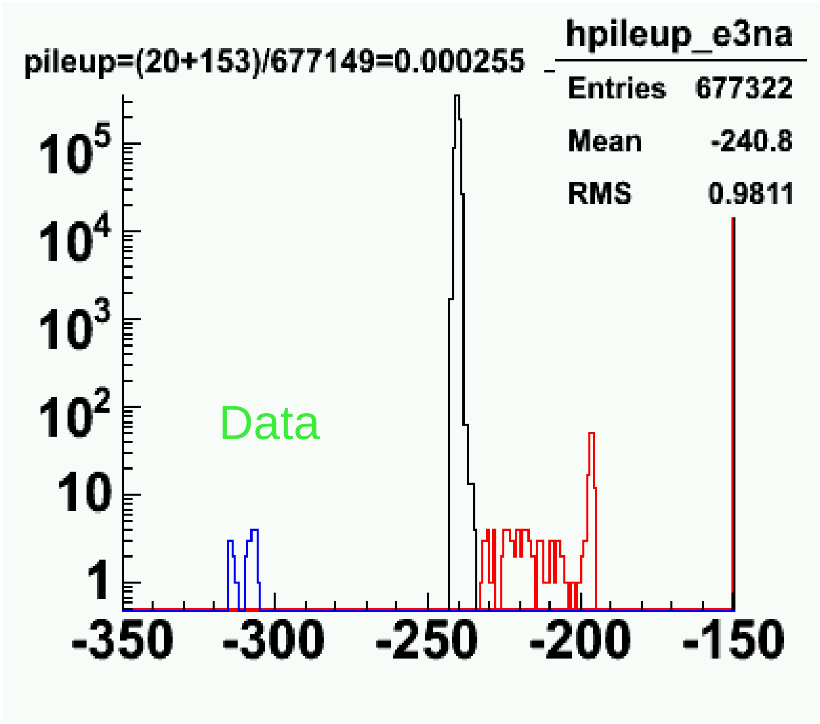
Measured by scaler
Different for narrow and wide path

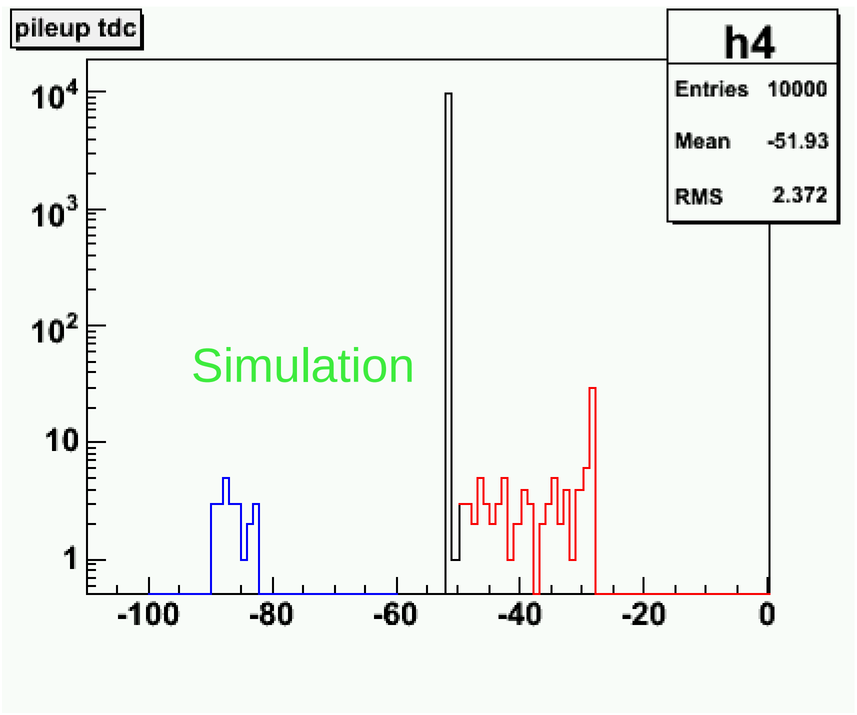
Measured by TDC
Same for narrow and wide path

Path Deadtime/Tagger Analysis

The Tagger method to measure deadtime:







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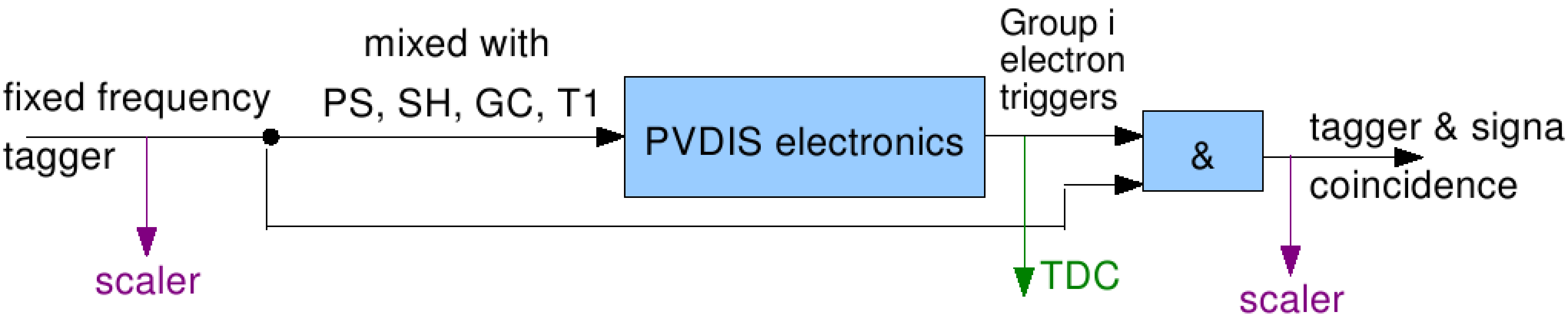
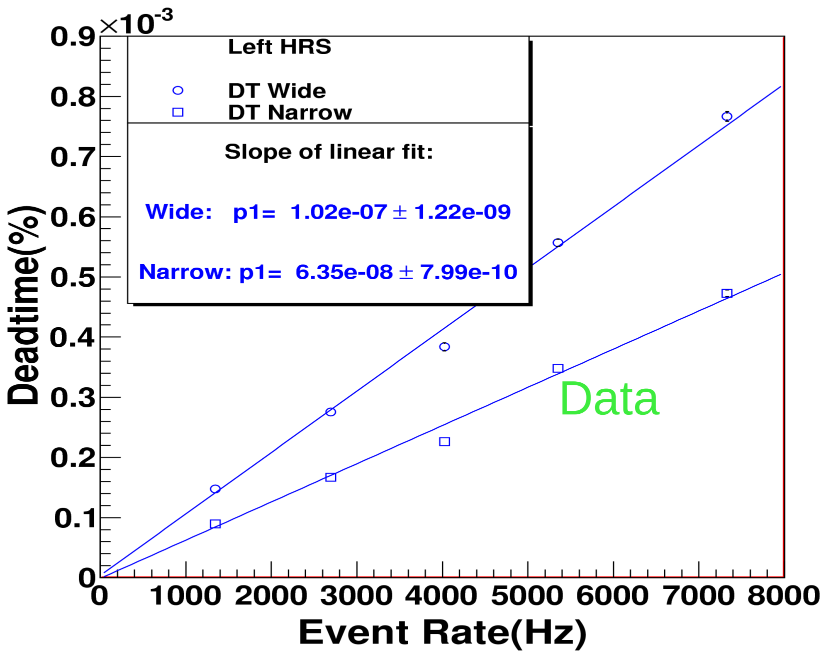
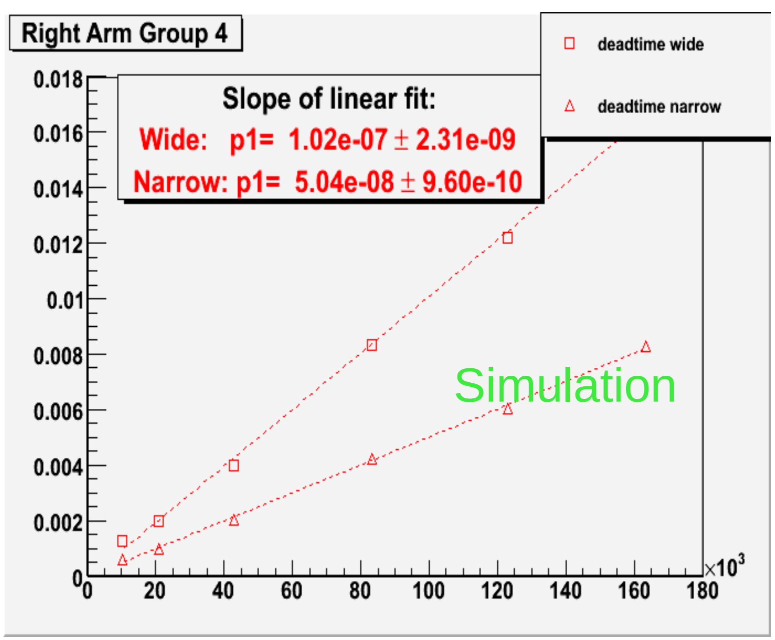
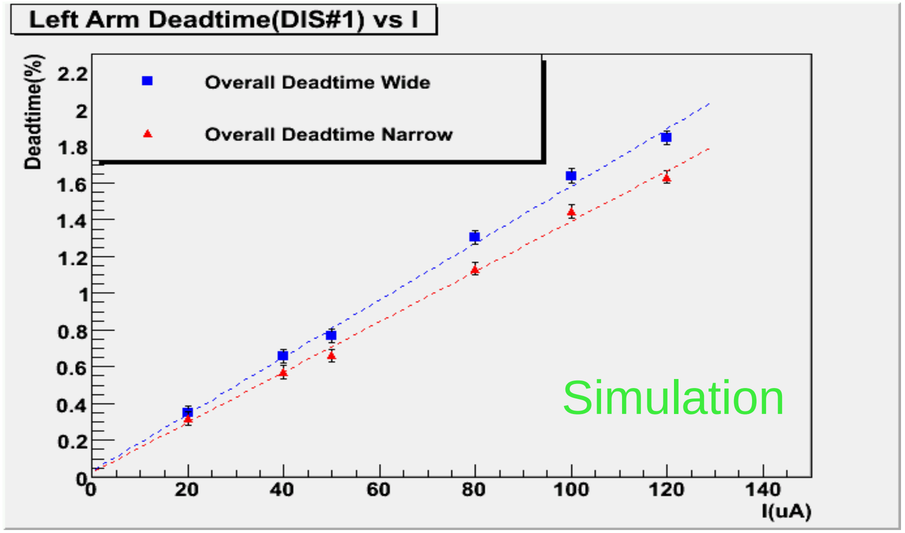


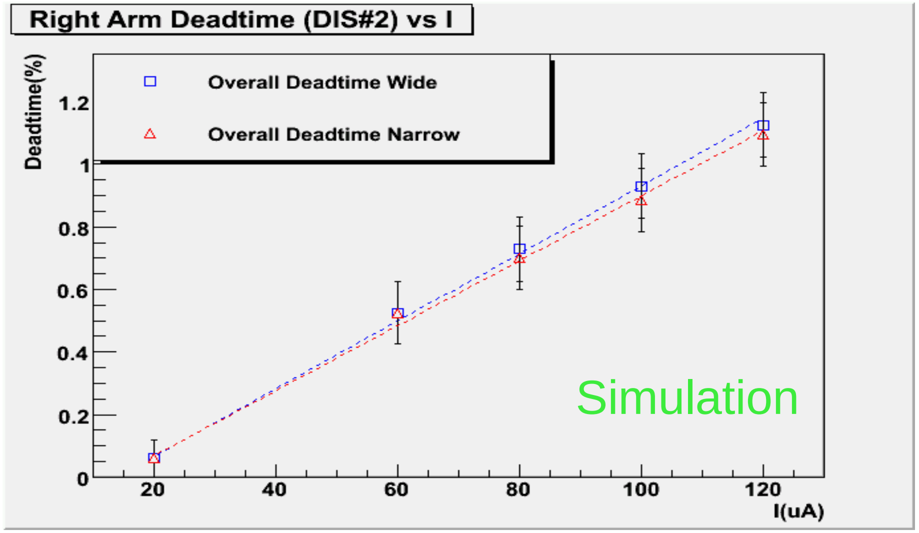




Deadtime Correction

Overall Deadtime:

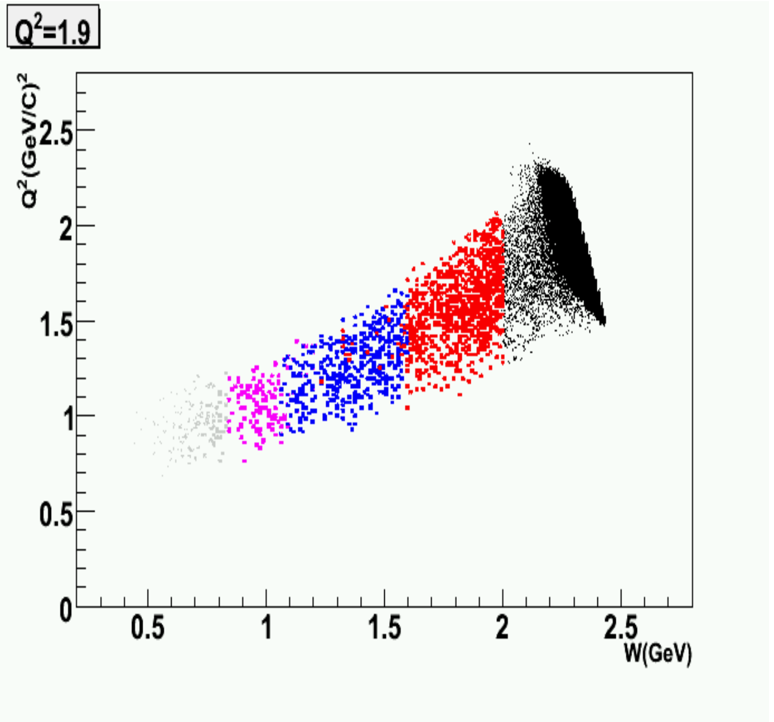




@100uA	RES #3	RES #4	RES #5	RES #7	DIS #1	DIS #2
Narrow	1.48% +/- 0.44%	2.22% +/- 0.67%	2.06% +/- 0.62%	0.73% +/- 0.22%	1.45% +/- 0.44%	0.89% +/- 0.27%
Wide	1.68% +/- 0.5%	2.62% +/- 0.79%	2.36% +/- 0.71%	0.8% +/- 0.24%	1.64% +/- 0.49%	0.93% +/- 0.28%

EM Radiative Corrections

- Based on Hall A Monte Carlo (HAMC)
- Prerequisites:
  - Radiation: Internal/External Bremsstrahlung, Ionization....
  - Acceptance
  - Simulation checked with data
- Inputs:



■ DIS: calculated using PDF fits (MRST/CTEQ).

■ Elastic ■ Quasi-Elastic : Data/Theoretical calculations

Resonance:

Some calculation (Misha Gorshteyn), which covers a large part of the resonance

■ Delta Resonance: Theoretical calculation (Lee & Tao).

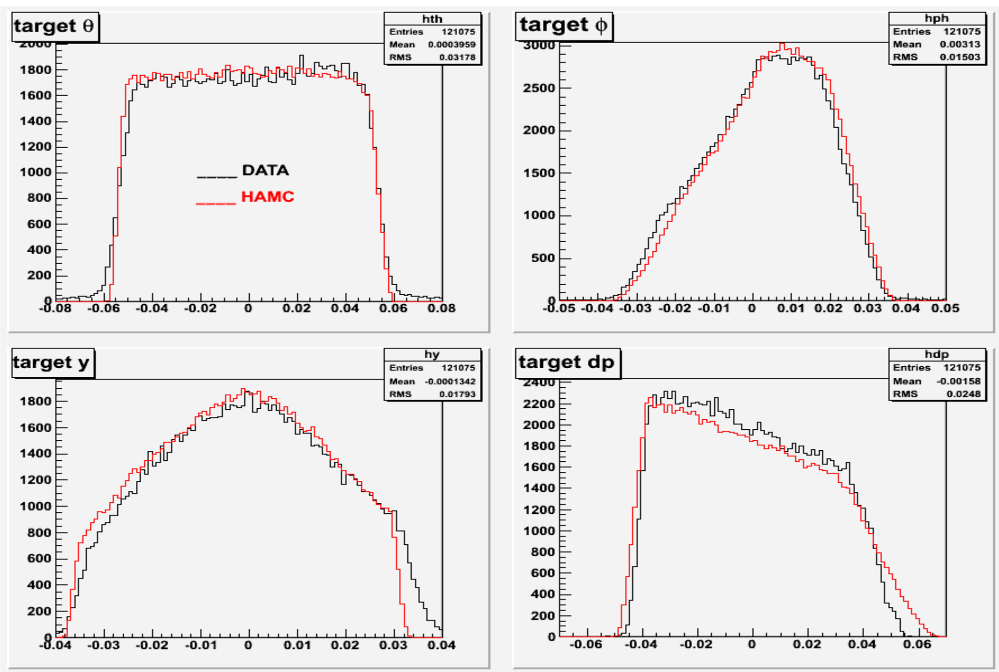
■ Other Resonance: No previous data
"Toy Model", eg. $$A_{toy} = A_{dis} \times \frac{\sigma_{res}}{\sigma_{dis}}$$

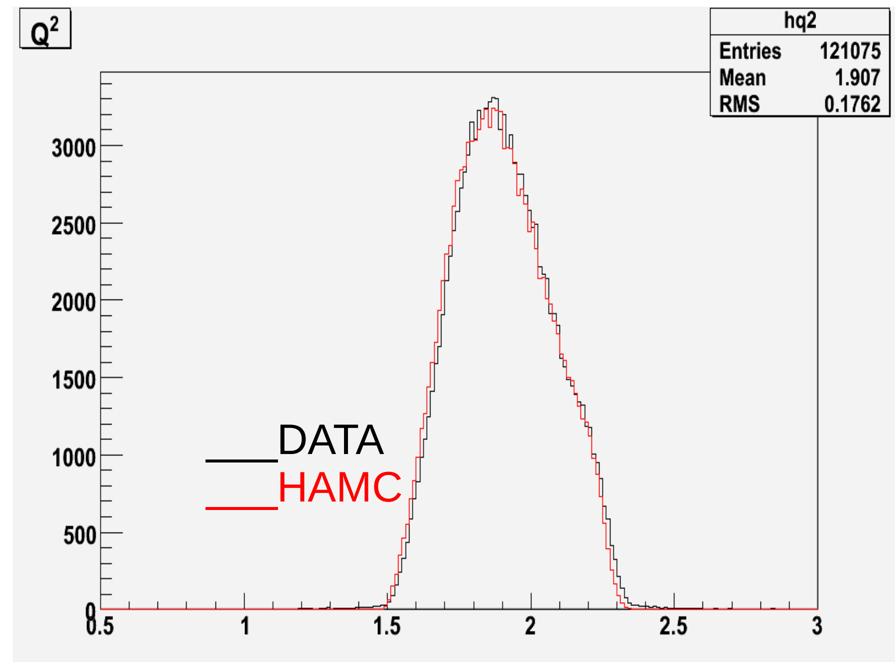
Use resonance data to constrain uncertainties.

Hall A Monte Carlo

A Monte Carlo simulation package developed to simulate the physics.

Basic checks of HAMC:

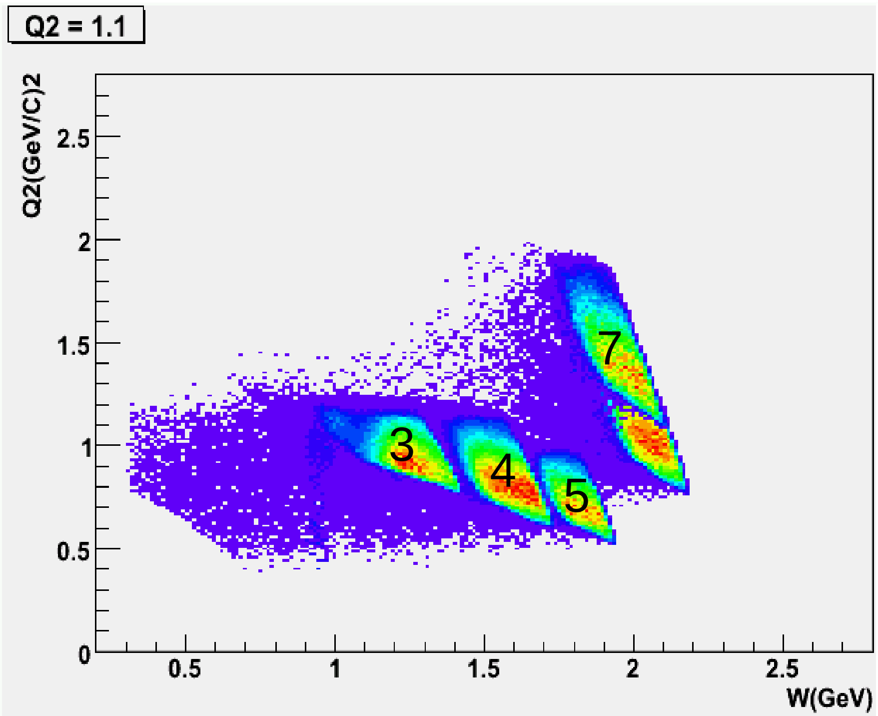


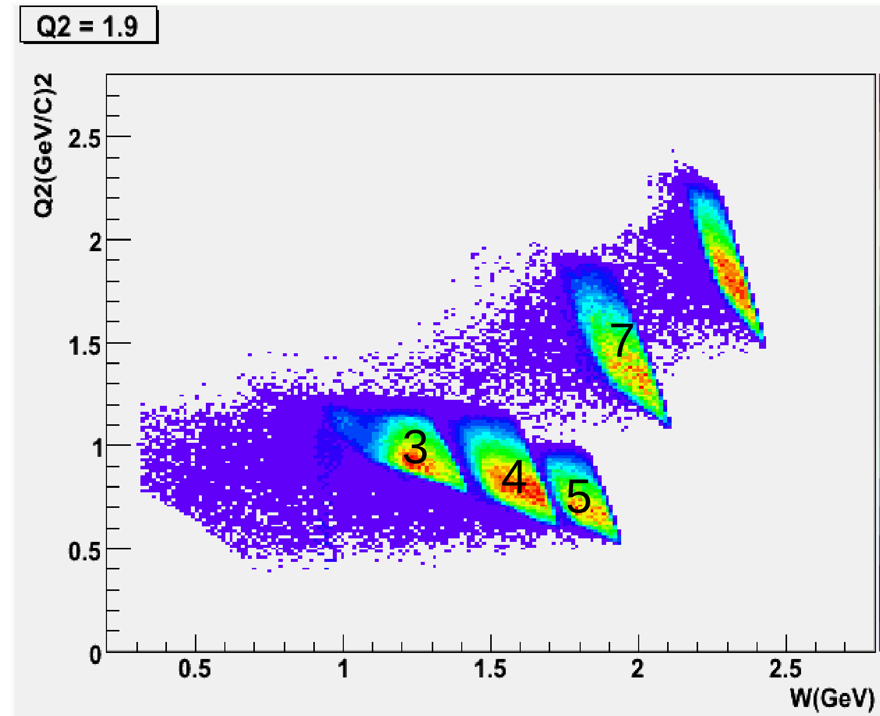


$$Q^2{}_{data} = 1.907$$

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

Resonance Kinematics

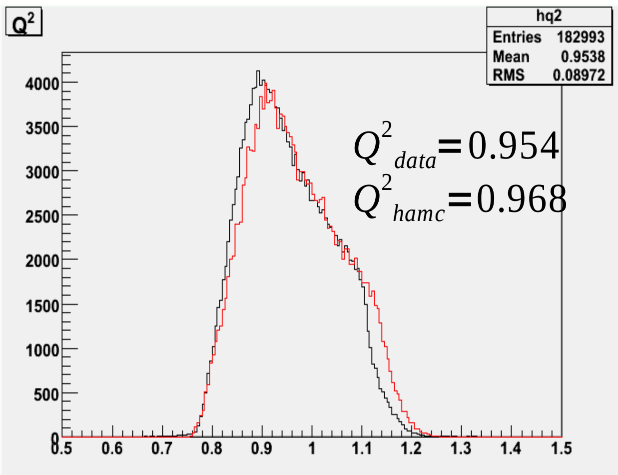


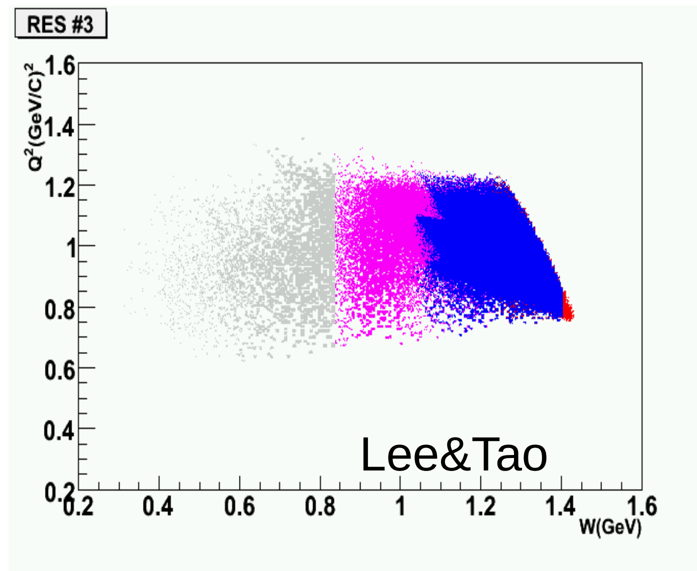


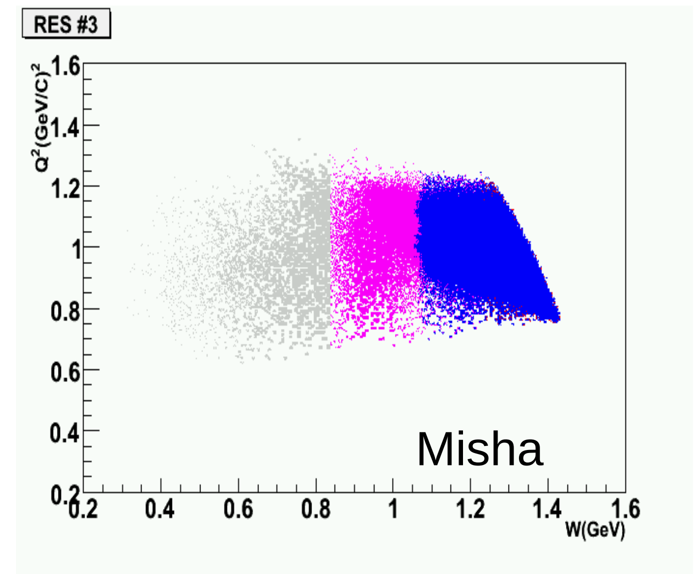
Kine#	E (GeV)	θ	E' (GeV)	e- rate (KHz)	A_d (ppm)	ΔA_d (ppm)
3 (Mistuned)	4.8	12.9	4.00(L)	1288	-66.3	7.8
4	4.8	12.9	3.55(L)	888	-73.4	6.9
5	4.8	12.9	3.10(R)	791	-60.9	5.15
7	6.0	15.0	3.66	280	-118.8	16.9

Res #3 / Delta Resonance

(Magnets Mistuned)

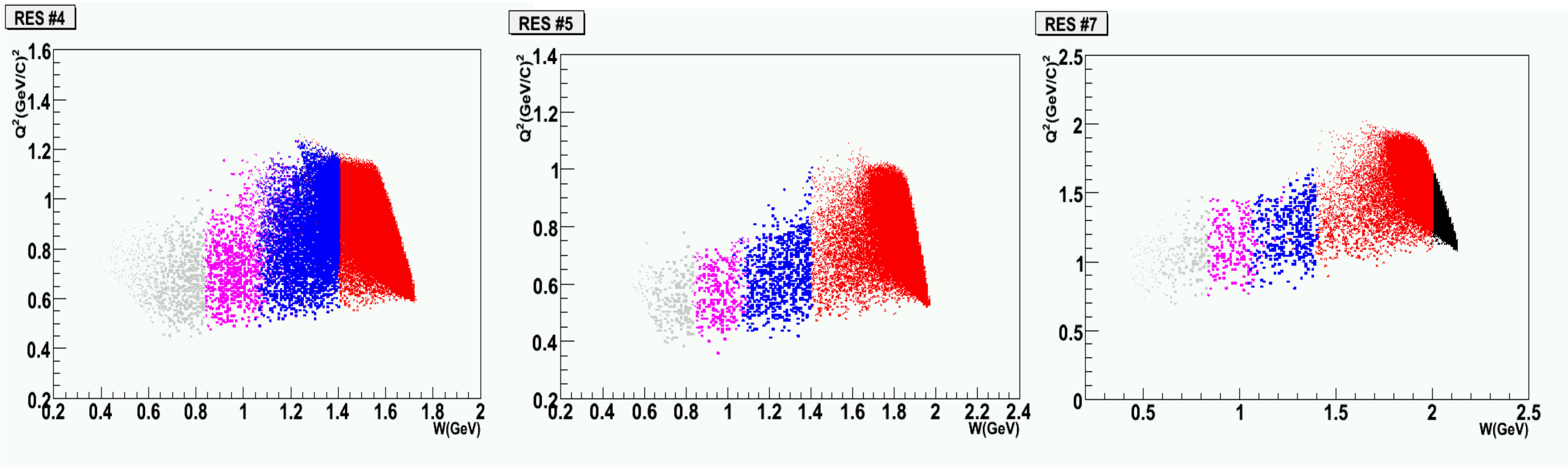






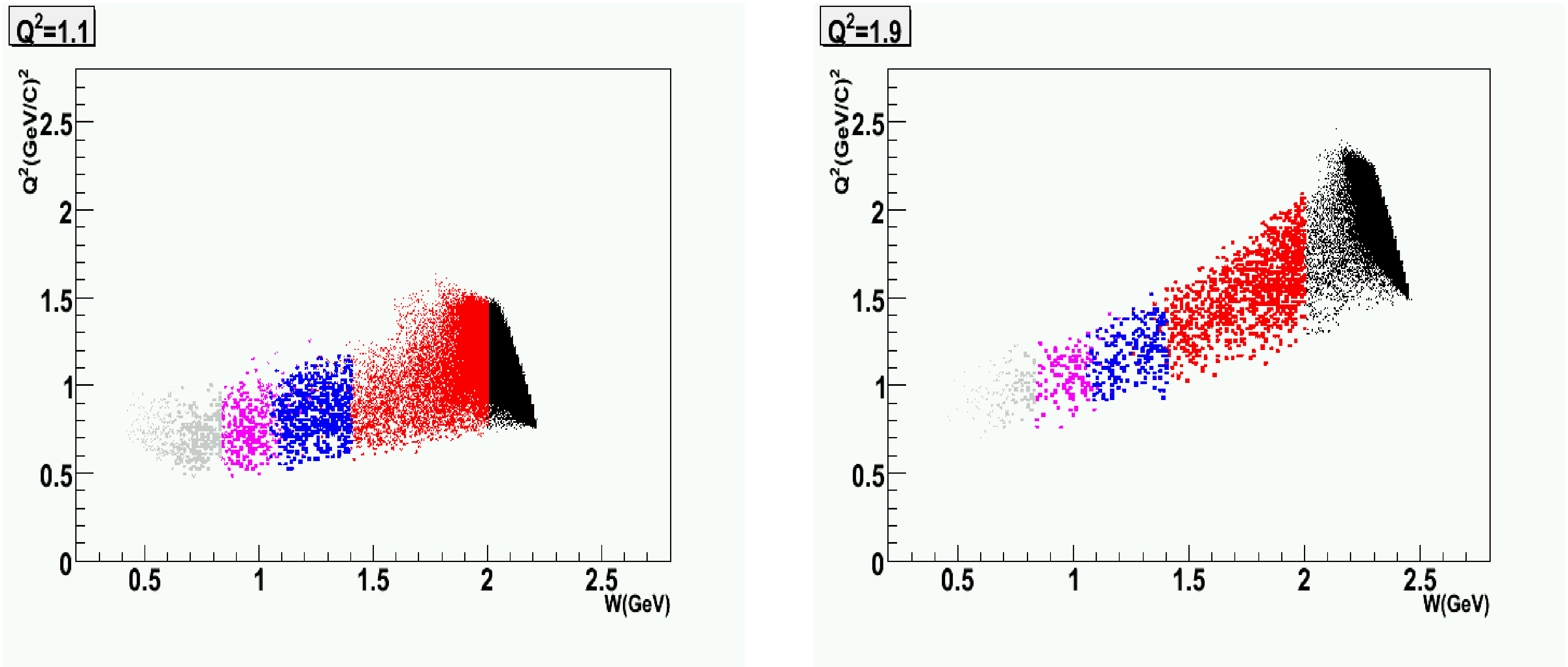
	Elastic	Quasi	Table	Dis	Toy	<Asym>	Data
Lee&Tao	80.4 (0.15%)	-46.4 (13%)	-89.4 (85.7%)	0	-49.9 (1.1%)	-83.11(ppm)	-66.258 +/-7.768 (ppm)
Misha	80.4 (0.15%)	-46.4 (12.3%)	-89.1 (87.6%)	0	0	-83.62(ppm)	

Resonance #4,5,7 / Lee&Tao



	Elastic	Quasi	Delta (scaled)	Dis	Toy	<Asym>	Data
Res #4	55.1 (0.03%)	-26.5 (1.5%)	-61.1 (5.95%)	0	-66.2 (92.5%)	-65.3 (ppm)	-73.4+/-6.9 (ppm)
Res #5	42.8 (0.02%)	-18.0 (1.5%)	-43.2 (1.6%)	0	-59.9 (96.8%)	-58.9 (ppm)	-60.9 +/- 5.15 (ppm)
Res #7	82.8 (0.05%)	-45.3 (0.88%)	-78.4 (0.99%)	-110.2 (27.9%)	-124.3 (70.2%)	-119.2 (ppm)	-118.8 +/- 16.9 (ppm)

DIS Radiative Corrections (Lee&Tao)

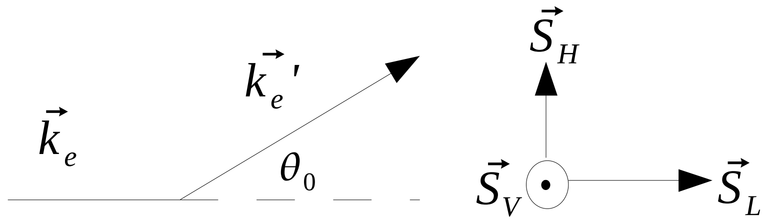


	Elastic	Quasi	Delta (scaled)	Dis	Toy	<Asym>	A_<qsq_vrt>	Correction Factor
Dis #1	57.6 (0.03%)	-26.9 (1.4%)	-57.3 (1.1%)	-87.5 (71.4%)	-95.3 (26.1%)	-88.6 (ppm)	-91.1 (ppm)	1.028
Dis #2	79.4 (0.05%)	-47.4 (0.85%)	-82.9 (0.84%)	-159.4 (95.5%)	-117.3 (2.8%)	-156.5 (ppm)	-159.6 (ppm)	1.020

Transverse Asymmetry / Backgrounds

- Transverse Asymmetry:

  Correction to A_d : $A_T \cdot [S_H \cdot \sin\theta_{tr} - S_v \cdot \sin\theta_0 \cdot \cos\theta_{tr}]$



$\vec{S}_e \cdot [\vec{k}_e \times \vec{k}_e{}']$

  - Measured A_T : 59.31 +/- 48.08 ppm (Kine #1)
    32.33 +/- 15.89 ppm (Kine #2)
  - Other Numbers: $|\theta_{tr}| < 27\,mrad$
    $S_V < 2\%$
    $S_H < 20\%$

  Systematic Error due to Transverse Asymmetry: 0.19% (Kine #1)
  0.40% (Kine #2)

- Backgrounds: Aluminum endcap from target cell
  - Kine #1: SM value AAl-Ad=-0.75ppm, will change Ameas by 0.0165% relative.
  - Kine #2: SM value AAl-Ad=-1.792ppm, will change Ameas by 0.0225% relaitive.
  - Uncertainty: 20% relative using SM numbers