Hashir Rashad

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DVCS COLLABORATION MEETING 01/16/2016

EFFICIENCY STUDIES

OVERVIEW

- Electron ID Efficiency
    - Pion Rejector Gain Matching
    - Gas Cherenkov
- Trigger Efficiency
- Tracking Efficiency
    - Multi Track Correction
    - Multi Cluster Correction

ELECTRON ID

SUMMARY

- Pion Rejector layers were gain matched using a minimization method.

$$PRSumNormalized = \frac{PRL1Sum}{W1} + \frac{PRL2Sum}{W2}$$

- Events with Normalized PR SUM > 60% and Normalized PRL1 > 20% of full energy electron peak, are taken to be “PRElectrons”.
- Gas Cherenkov showed a beautiful poisson distribution.
- Gas Cherenkov Yield was 15 P.E, thanks to UV Paint
- Events with Np.e > 1.5 is considered to be “CerElectrons” which has an efficiency greater than 0.999995.
- Events passing both ID Cuts are considered High Energy Electron, Passing CER Cut failing PR Cut are considered medium energy electrons.
- PRL1<500 and PRL2 <500 (Non-Normalized Layer sums) and Np.e <1.5 are considered pions.

HALL A DVCS

TRIGGER EFFICIENCY

LHRS TRIGGER EFFICIENCY – FALL 2016 DATA

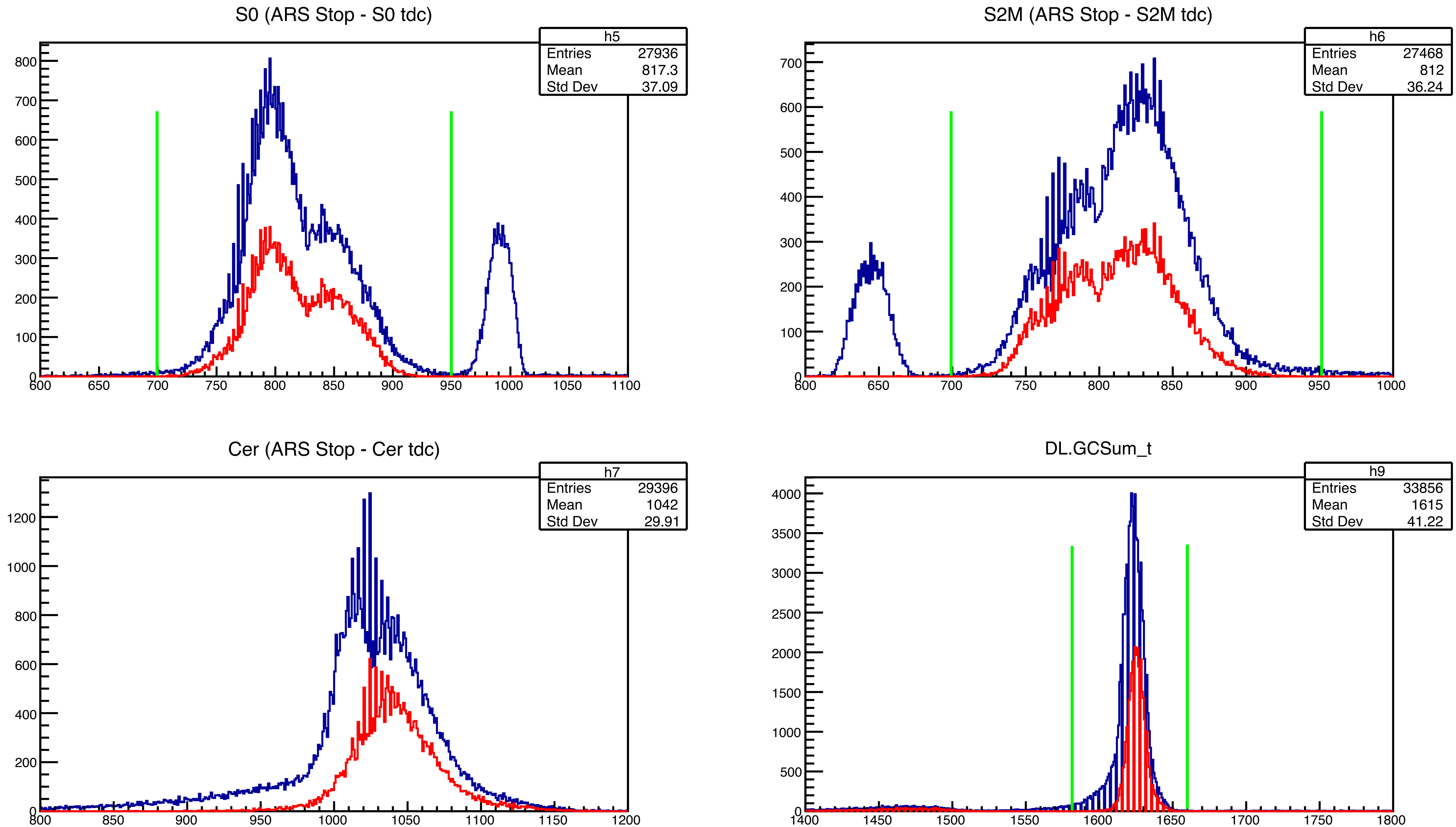
- Production DVCS Data is triggered by the coincidence between S2M and Cherenkov with DVCS Calorimeter
- Estimate the trigger efficiency of S0, S2 and Cherenkov detector independently
- To do this, Take three 15 min efficiency runs with each combination of above trigger detectors
- Estimate the efficiency of the detector by using the run taken without that detector in the trigger

TRIGGER EFFICIENCY – FALL 2016 DATA

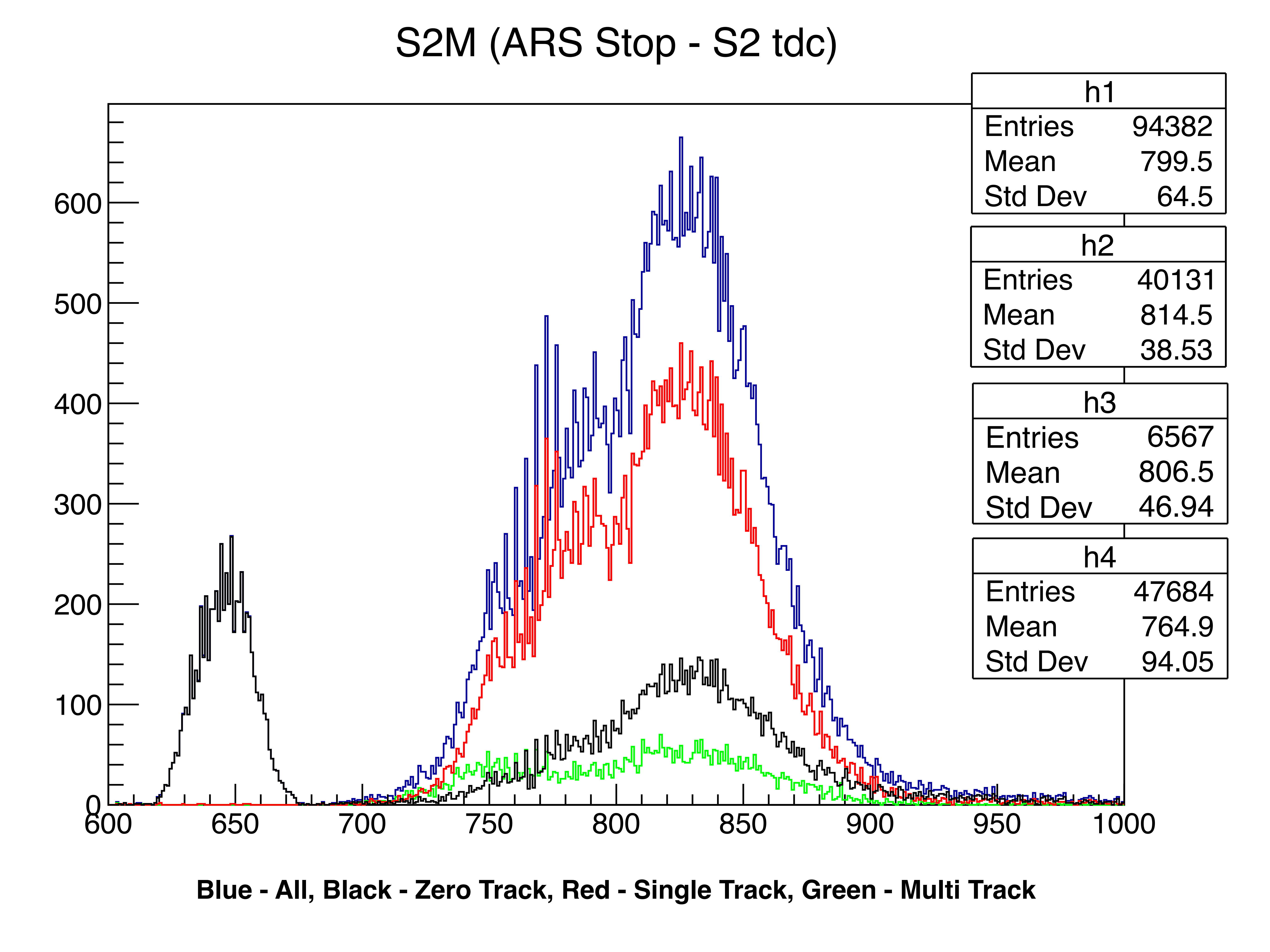
$$Trigger\ \mathrm{Efficiency} = \frac{nGoodSingleTrackElectronswithGoodTiming}{nGoodSingleTrackElectrons}$$

- Single Track = Number of VDC Tracks equals one
- PRElectron = More than 60% of PR Normalized Sum of Layer 1 and Layer 2 and PR Normalized Sum of Layer 1 more than 20% (MIP)
- CerElectron = More than 1.5 PE
- GoodCerADC = More than 1PE
- GoodTarget = Target Vertex +/- 0.075, Target delta +/- 0.05, Target Theta +/- 0.1, Target Phi +/- 0.06
- No EDTM
- Timing Cuts

Timing Spectra for each trigger



Blue - All Events, Red -Good Single Track Electrons
1-3 : High resolution DVCS TDC, 4 : LHRS TDC
Green Line indicates the cut region



S2M (ARS Stop - S2 tdc)
h1
Entries 94382
Mean 799.5
Std Dev 64.5
h2
Entries 40131
Mean 814.5
Std Dev 38.53
h3
Entries 6567
Mean 806.5
Std Dev 46.94
h4
Entries 47684
Mean 764.9
Std Dev 94.05
0
100
200
300
400
500
600
600
650
700
750
800
850
900
950
1000
Blue - All, Black - Zero Track, Red - Single Track, Green - Multi Track

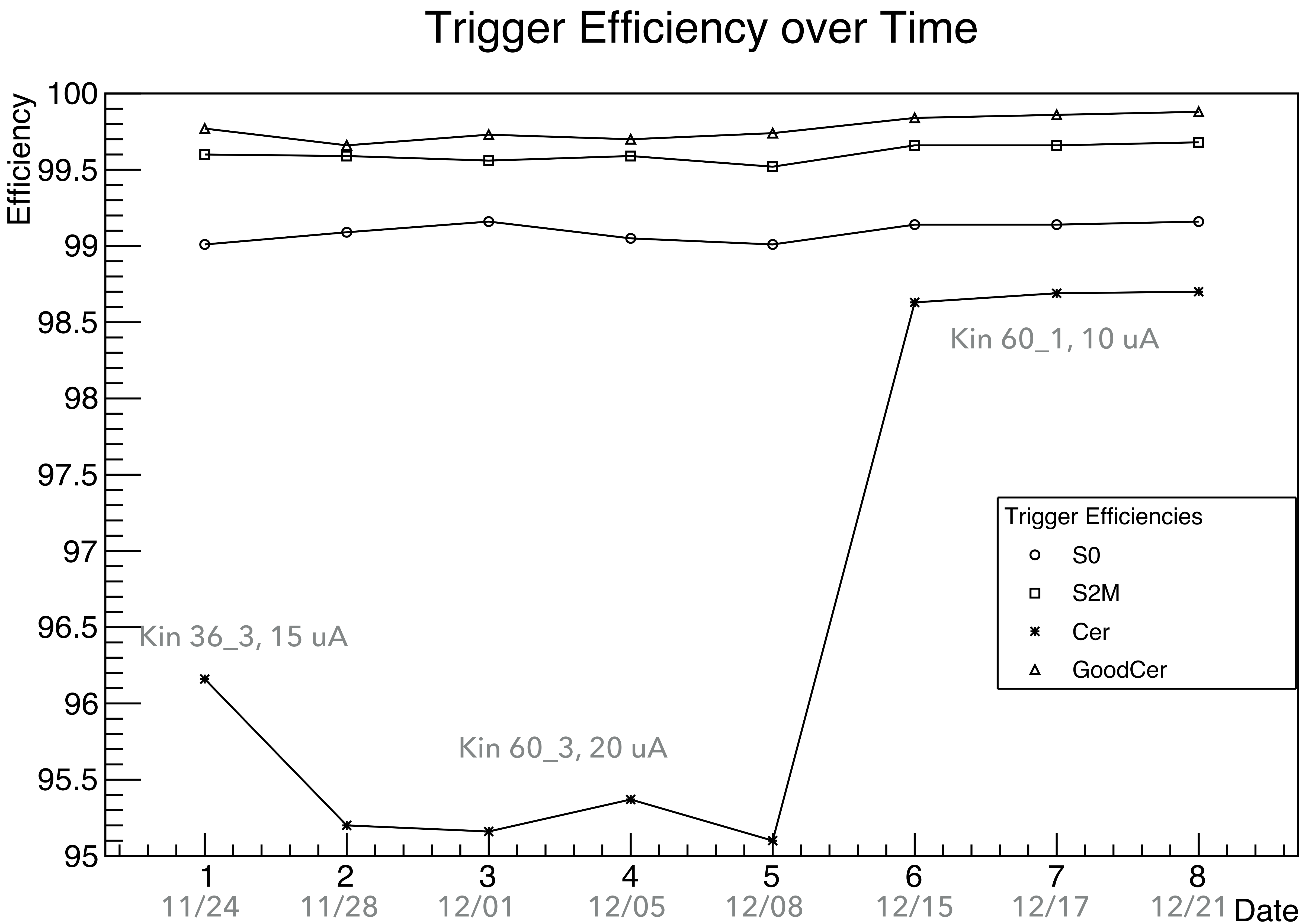
Efficiency Values

	11/24/16 (36_3, 15uA)	11/28/16 (60_3, 20uA)	12/01/16 (60_3, 20uA)	12/05/16 (60_3, 20uA)	12/08/16 (60_3, 20uA)	12/15/16 (60_1, 10uA)	12/17/16 (60_1, 10uA)	12/21/16 (60_1, 10uA)
S0	99.01	99.09	99.16	99.05	99.01	99.14	99.14	99.16
S2M	99.60	99.59	99.56	99.59	99.52	99.66	99.66	99.68
Cer	96.16	95.20	95.16	95.37	95.10	98.63	98.69	98.70
Cer_GoodCer	99.77	99.66	99.73	99.70	99.74	99.84	99.86	99.88
PR_SE	3.63	3.71	3.82	3.61	3.90	3.87	3.68	3.72

$$Cer = \frac{nGoodSingleTrackPRElectronwithGoodCerTime}{nGoodSingleTrackPRElectron}$$

$$cerGoodCer = \frac{nGoodSingleTrackPRElectronwithGoodCerADCandGoodCerTime}{nGoodSingleTrackPRElectronwithGoodCerADC}$$

PR_SE is the percentage of GoodPions from Cherenkov (Less than 1.5 P.E) being identified as High Energy Electrons in the Pion Rejector

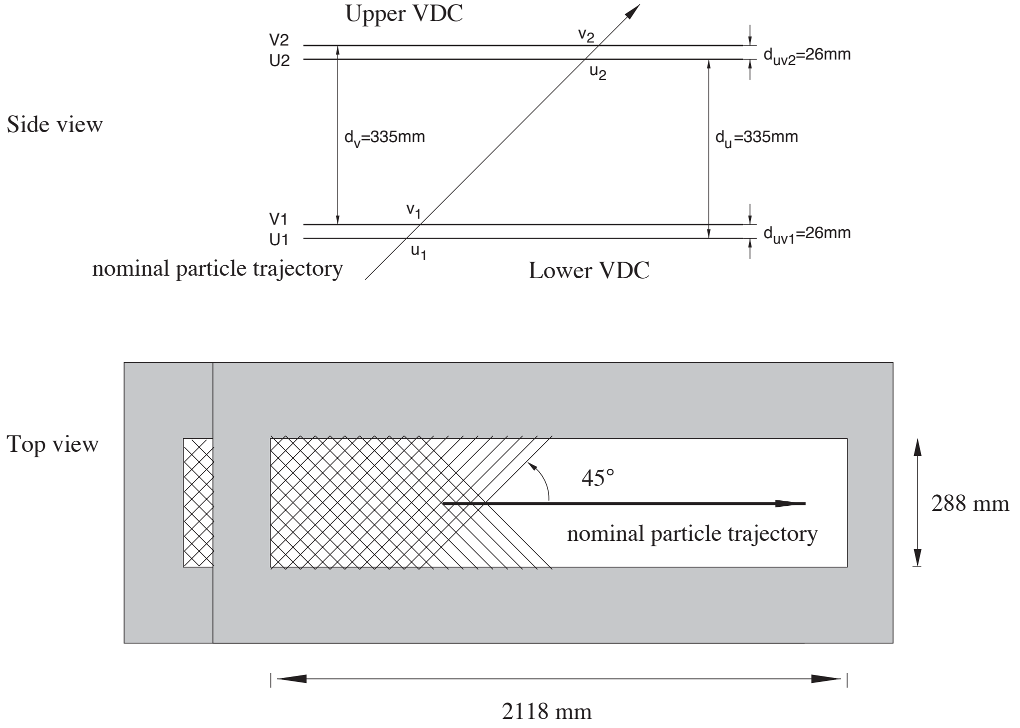

Trigger Efficiency over Time
Efficiency
100
99.5
99
98.5
98
97.5
97
96.5
96
95.5
95
1
2
3
4
5
6
7
8
11/24
11/28
12/01
12/05
12/08
12/15
12/17
12/21
Date
Kin 36_3, 15 uA
Kin 60_3, 20 uA
Kin 60_1, 10 uA
Trigger Efficiencies
S0
S2M
Cer
GoodCer

SUMMARY OF TRIGGER EFFICIENCY

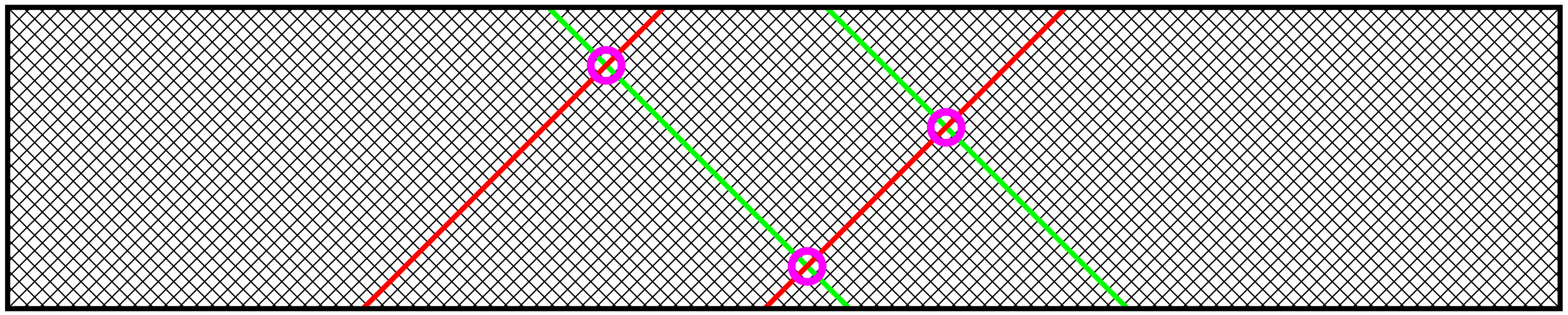
- DVCS has 99.7% Cherenkov trigger efficiency and 99.6% S2M Efficiency
- Efficiency remains uniform across the whole area of trigger detectors
- Efficiency stayed uniform over time.

HALL A DVCS

TRACKING



MULTIPLE CLUSTERS IN WIRE PLANES



A. (U1, V1, U2, V2) - Number of clusters on each planes

B. Following classes creates single track

   1. (1,1,1,1) - most accurate - 0M4S

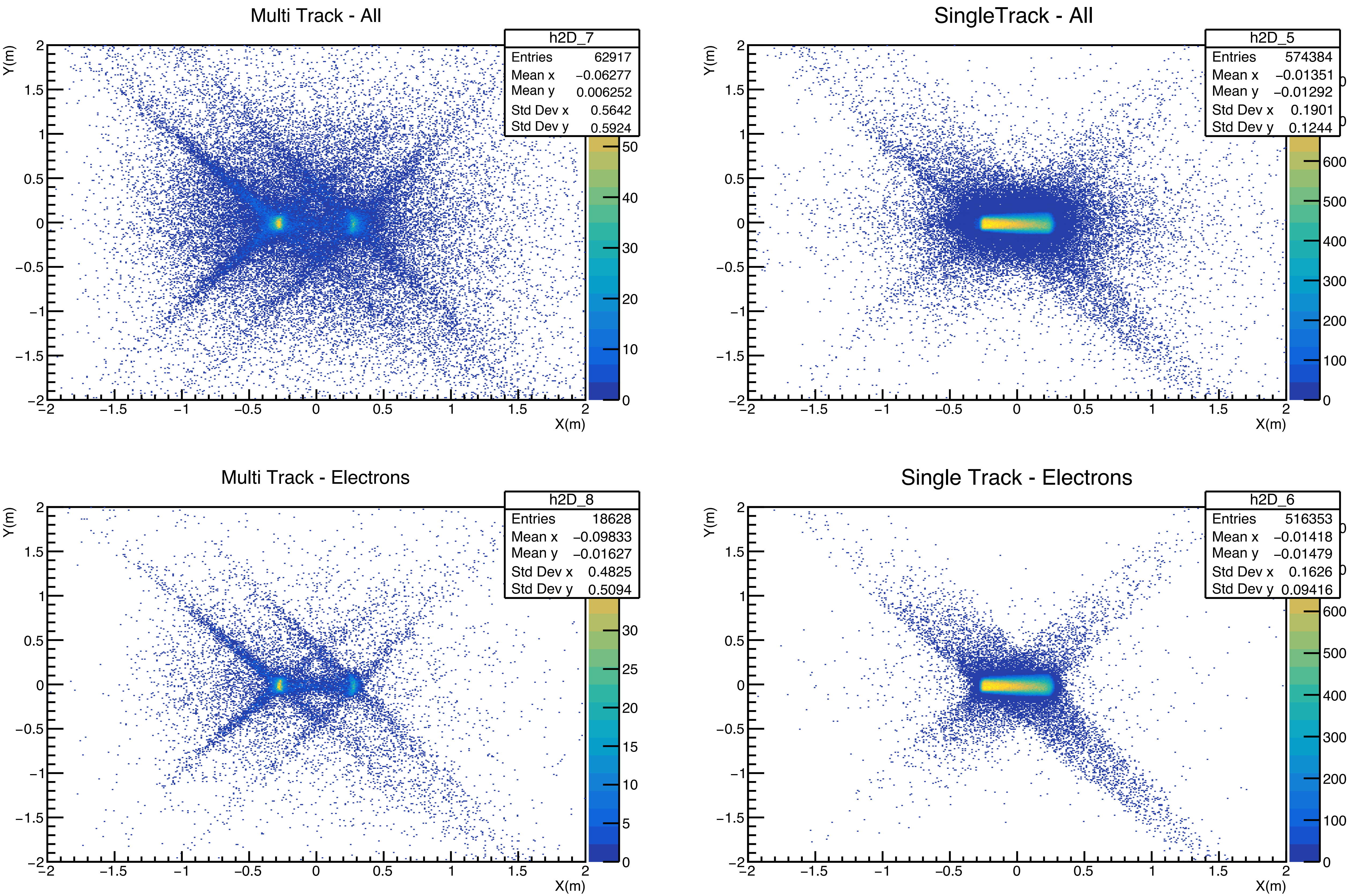
   2. (X,1,1,1),(1,X,1,1),(1,1,X,1) and (1,1,1,X) - mostly accurate - 1M3S

   3. (X,X,1,1) and (1,1,X,X) - varying degree of accuracy - 2M2S

C. Other combination of multi clusters, create Multi Track

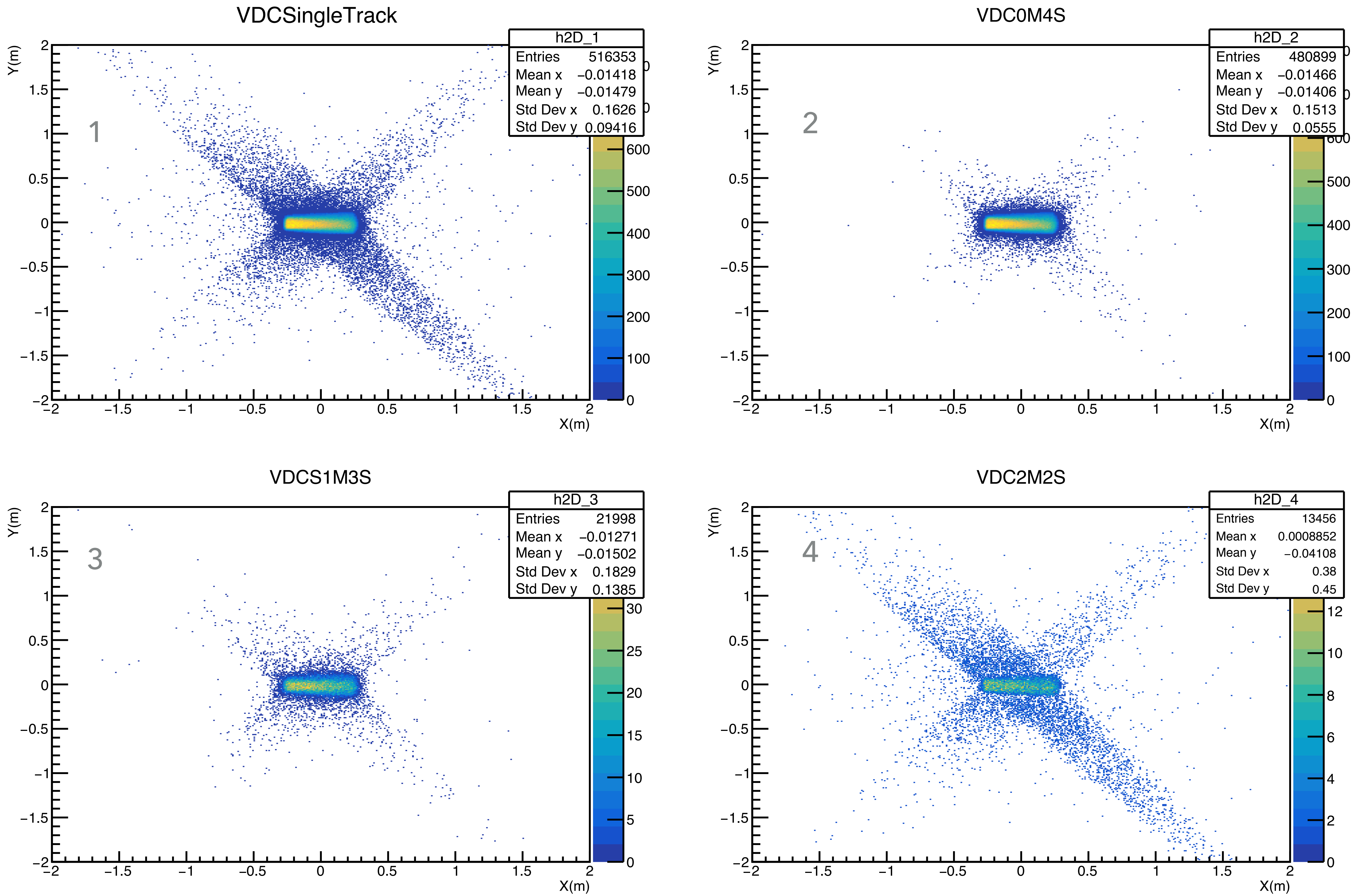
D. Multi Tracks doesn’t necessarily mean multiple particles, rather track candidates.

MULTI CLUSTER AND MULTI TRACK EVENTS : POSSIBLE ORIGIN - RUN 14228, KIN 36_2, EARLY NOVEMBER, 2016



Multi Track Electron Events at Q3 - Localization around the edges of Q3

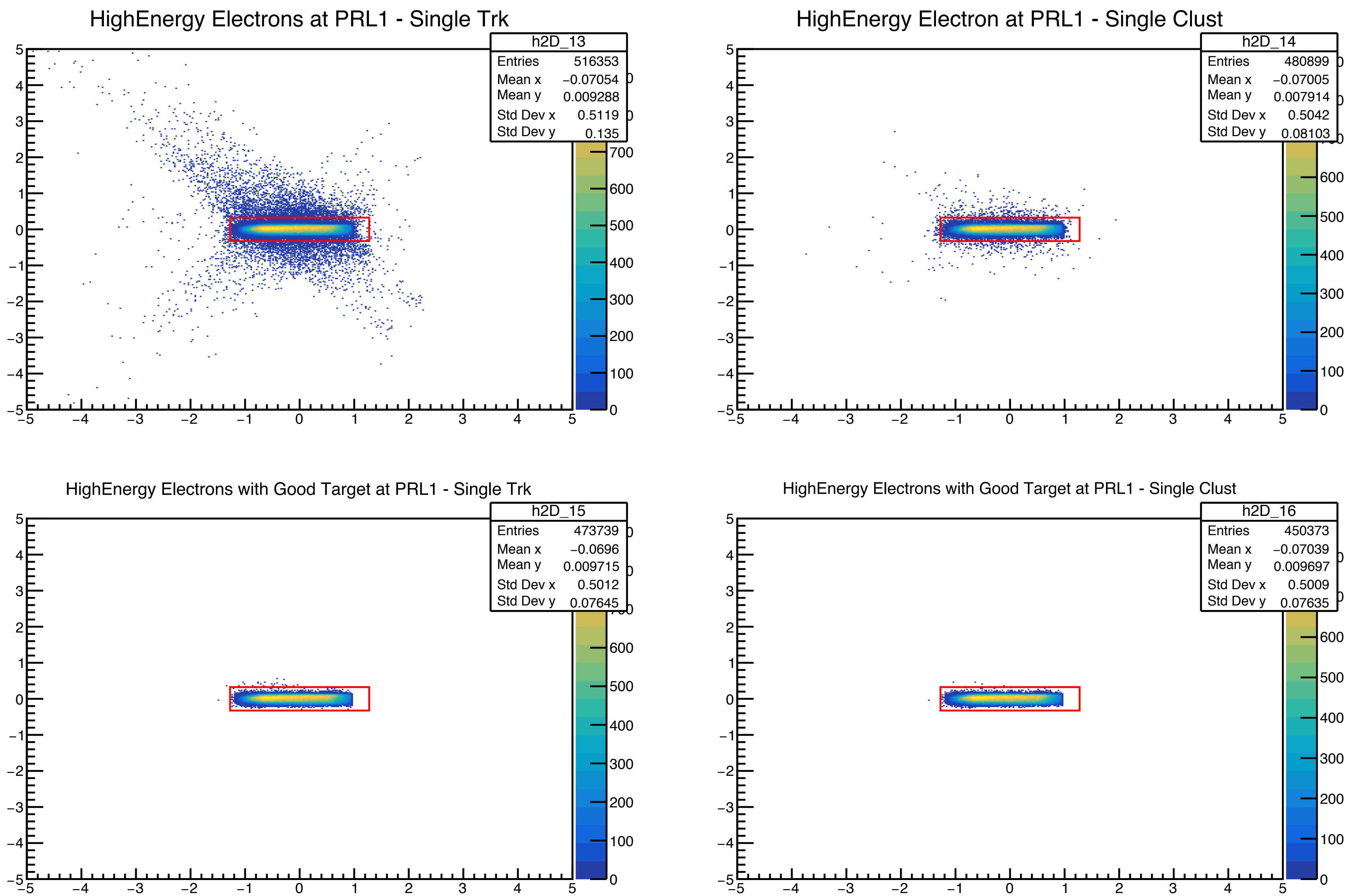
MULTI CLUSTER EVENTS : HIGH ENERGY ELECTRON



1 - All single Track, 2 - All Single Cluster, 3 - 1 multi Cluster, 4- 1 Chamber Multi Cluster

TRACK RECONSTRUCTION AT PION REJECTOR LAYER 1 - TARGET CUTS

- GoodTarget = Target Vertex +/- 0.075, Target delta +/- 0.05, Target Theta +/- 0.1, Target Phi +/- 0.06



Established Target cuts eliminates the poorly reconstructed track.

MULTI CLUSTER : SUMMARY OF OBSERVATION

- Large portion of 2M2S events gives low signal in the PR.
- Among the events that give a high signal in the PR, large number are poorly reconstructed (>1/3).
- No visible evidence of showering from Q3, but hints for good events being corrupted by a low energy shower particle
- Only about 35% of these events are passing both PID Cuts and Target Cuts, where as more than 90% of single cluster events pass both cuts
- Keep them after target cuts, risk loosing good but poorly reconstructed tracks.

- Only keep 0M4S Cluster (and 1M3S Cluster) tracks in analysis and make a correction to the 2M2S events
- Make a similar correction for Multi Track events

$$\eta_{MultiCluster} = 1 + \frac{N_{2M2S\ Electrons}}{N_{(0M4S+1M3S)\ Electrons}}$$

$$\eta_{MultiTrack} = 1 + \frac{N_{MultiTrack\ Electrons}}{N_{(0M4S+1M3S)\ Electrons}}$$

THANK YOU

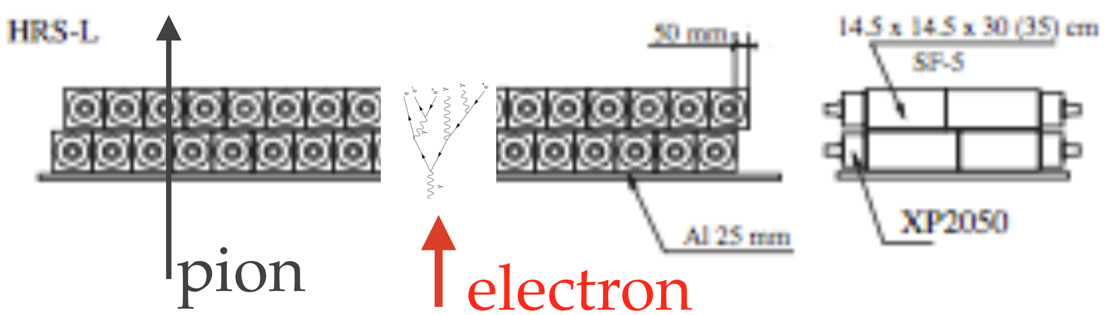
HALL A

ELECTRON ID

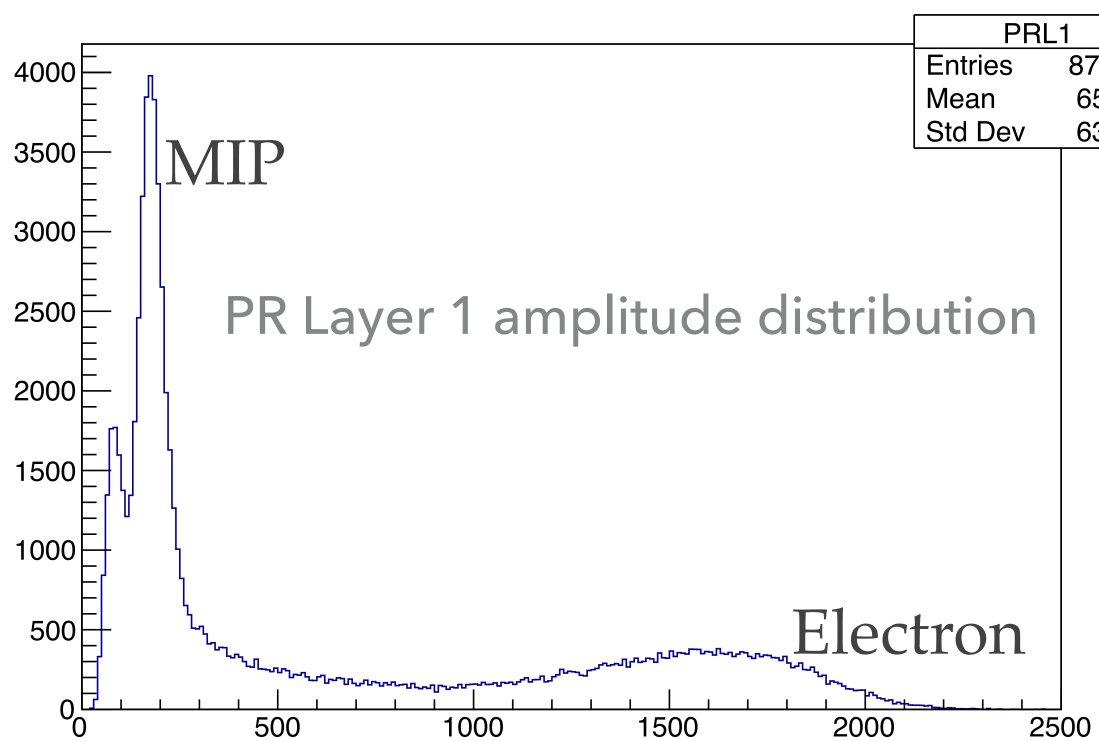
PID IN HALL A LHRS : PION REJECTOR AND GAS CHERENKOV

PION REJECTOR

2 LAYERS OF 34 PB-GLASS CRYSTALS ARRANGED IN 2 X 17

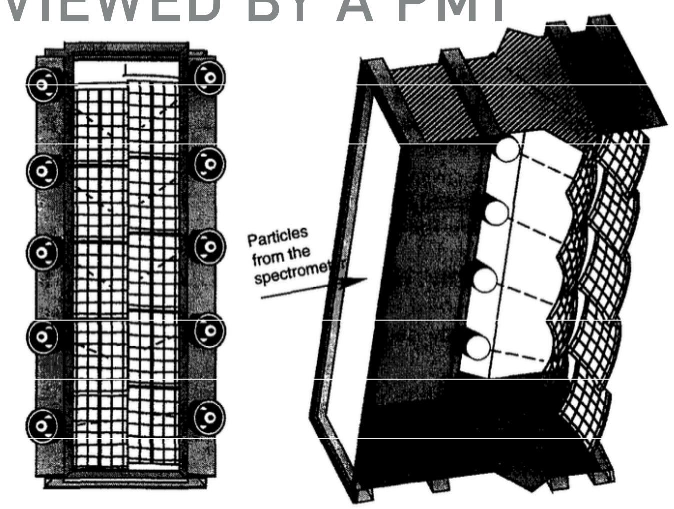


Radiation Length dictates that an electron deposits All/Most of it's energy but a pion is only a "Minimum Ionizing Particle" (MIP)

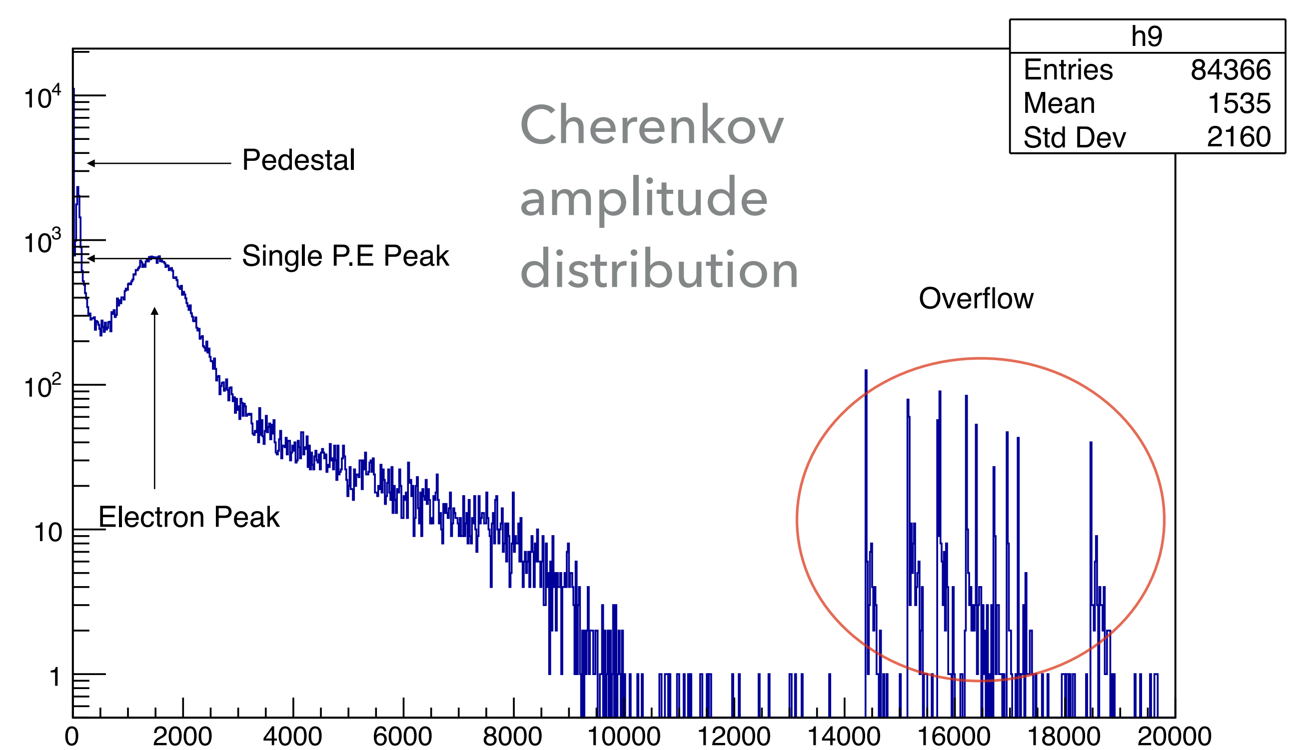


GAS CHERENKOV

CO_2 GAS, 10 SPHERICAL MIRRORS EACH VIEWED BY A PMT



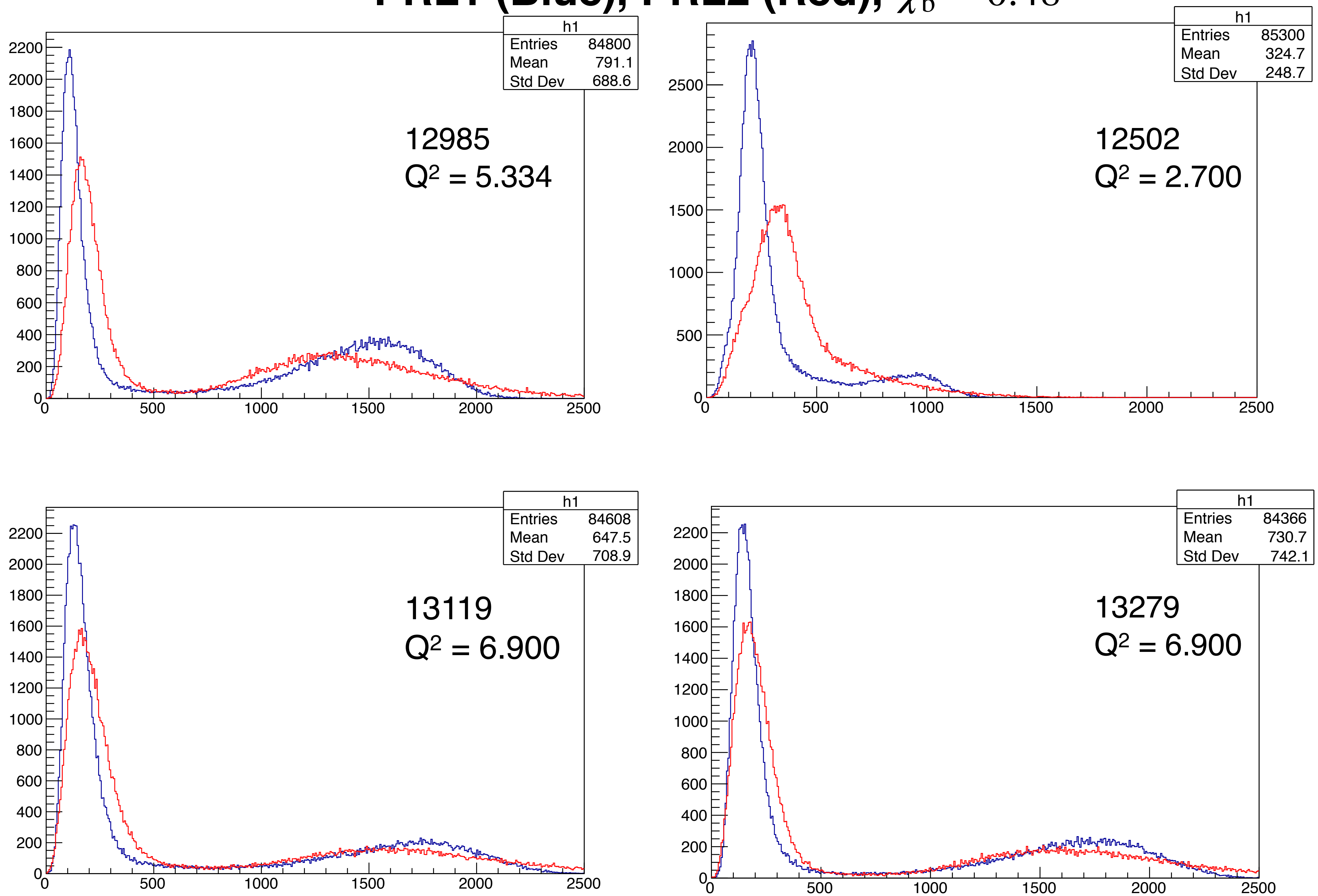
With atm CO_2, electrons produce ~15 photo-electrons, pions, muons, etc produce 0 or 1 p.e (from delta-ray).



PION REJECTOR GAIN MATCHING – 2016 SPRING RUN

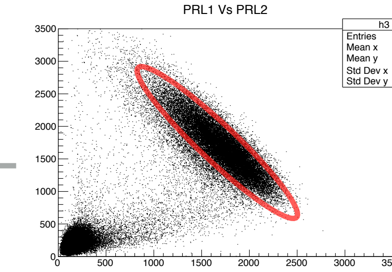
ALL 34 PHOTOTUBES OF EACH PION REJECTOR LAYERS ARE INDEPENDENTLY CALIBRATED, BUT THE GAIN BETWEEN THE LAYERS ARE NOT MATCHED

PRL1 (Blue), PRL2 (Red), $\chi_b = 0.48$

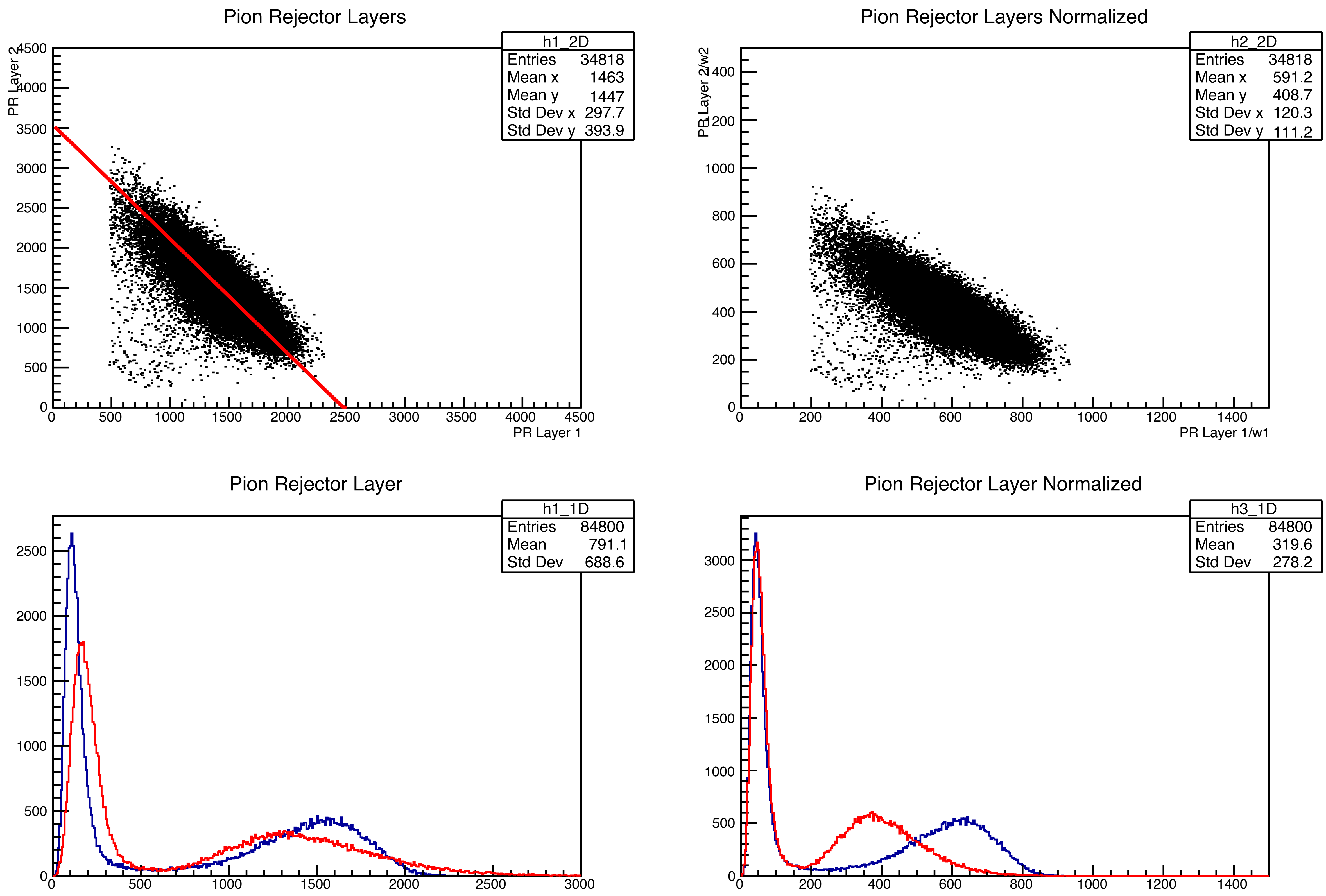


Pion rejector layers for different runs show the gain mismatch between layers and the change with kinematics.

PION REJECTOR GAIN MATCHING, RUN 12985 (0.48, 5.334)

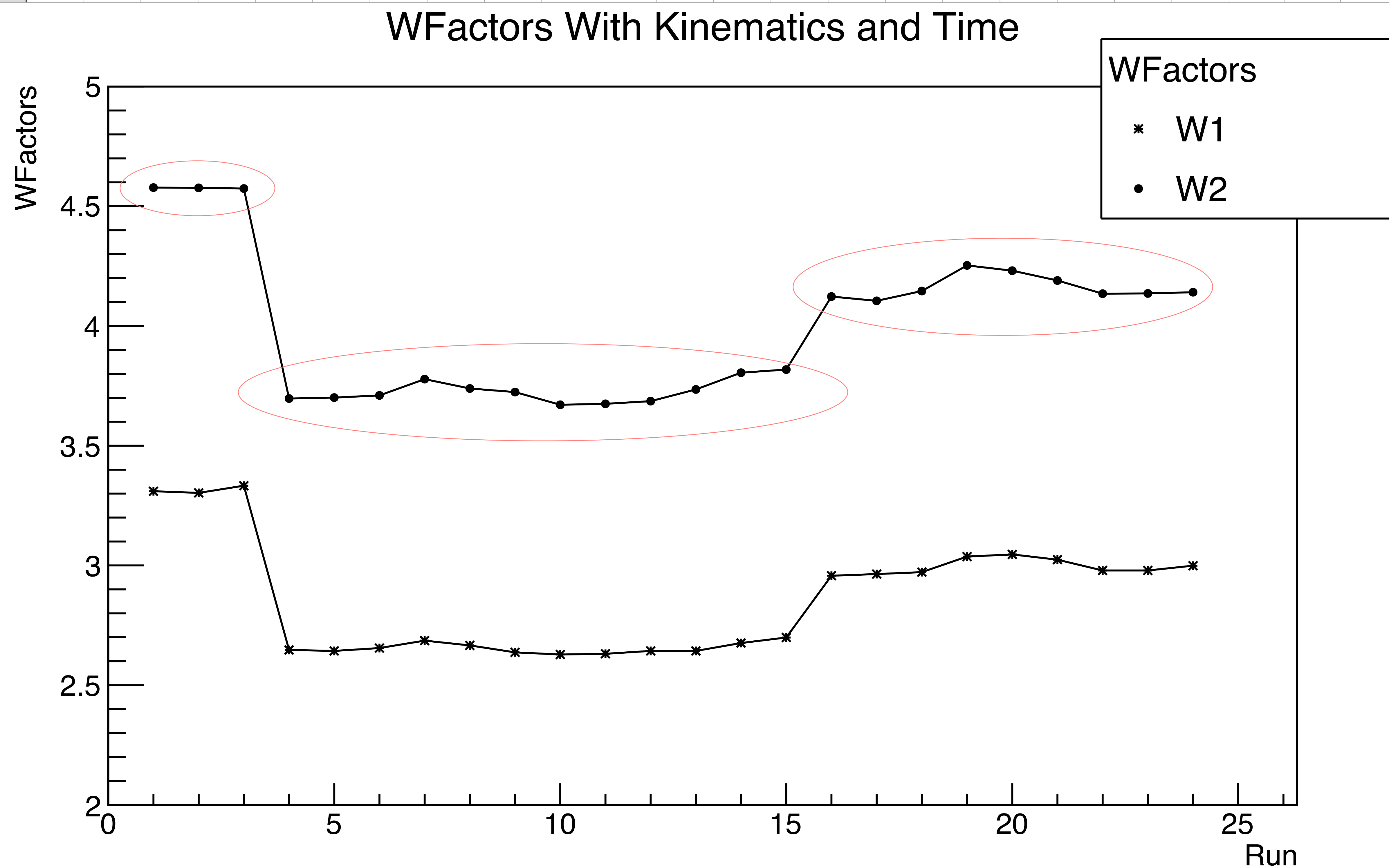


MINIMIZATION PROCEDURE TO EXTRACT WEIGHTING FACTORS FOR GAIN MATCHING



PR WEIGHTING FACTORS

Date	11/24/2016			11/28/2016			12/01/2016			12/05/2016			12/08/2016			12/15/2016			12/17/2016			12/21/2016		
Kin	Kin 36_3, 15 uA			Kin 60_3, 20 uA												Kin 60_1 10 uA								
Run #	14483	14484	14485	14586	14585	14584	14654	14653	14650	14762	14764	14763	14834	14833	14832	14979	14981	14980	15041	15042	15043	15112	15113	15114
W1	3.310	3.303	3.333	2.647	2.643	2.655	2.686	2.666	2.637	2.628	2.631	2.643	2.643	2.676	2.699	2.957	2.964	2.972	3.037	3.046	3.024	2.979	2.979	2.999
W2	4.578	4.577	4.574	3.697	3.701	3.710	3.778	3.739	3.724	3.671	3.675	3.686	3.735	3.805	3.818	4.123	4.105	4.146	4.253	4.231	4.190	4.135	4.136	4.141

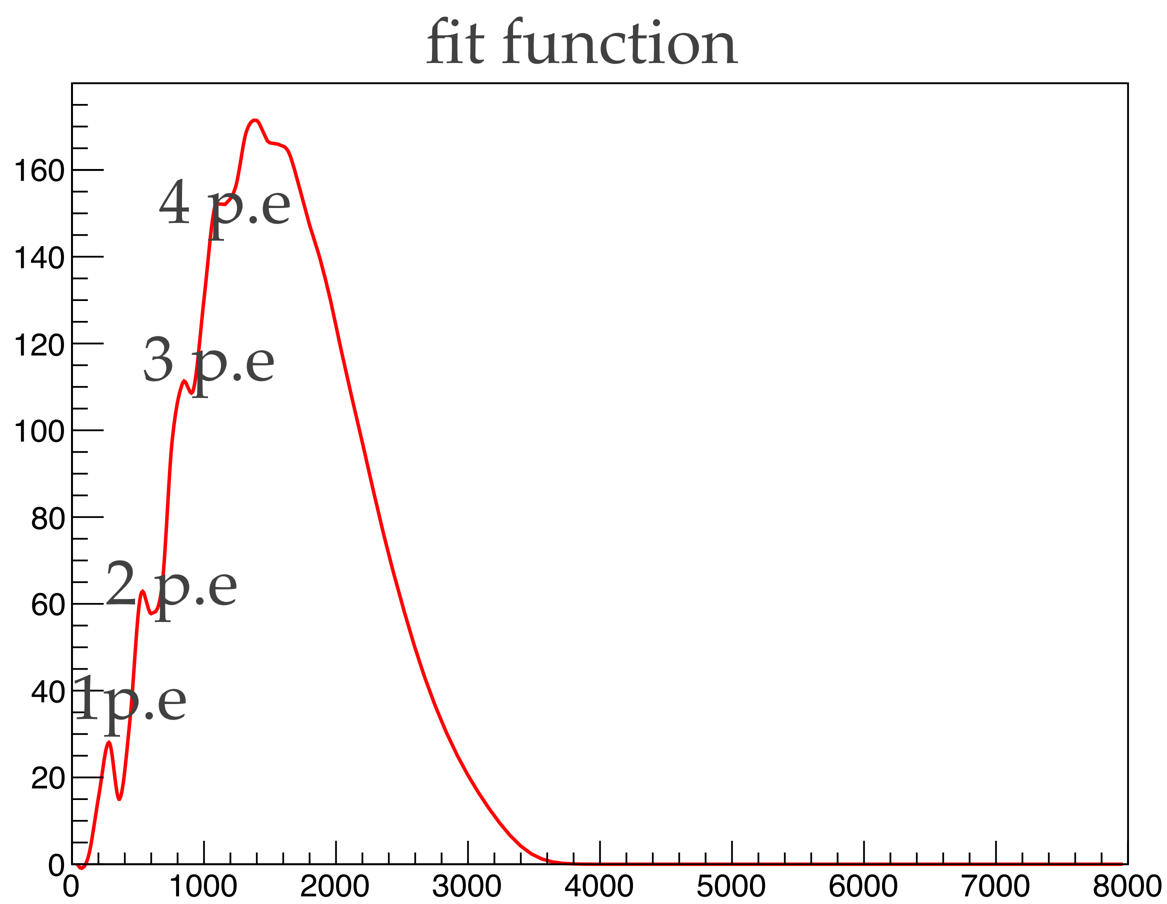


CHERENKOV POISSON FIT – 2014 DATA

- Estimate Cherenkov yield and efficiency of Electron ID, after the UV Paint and Verify the poison statistics

PMT Signals follows poisson statistics

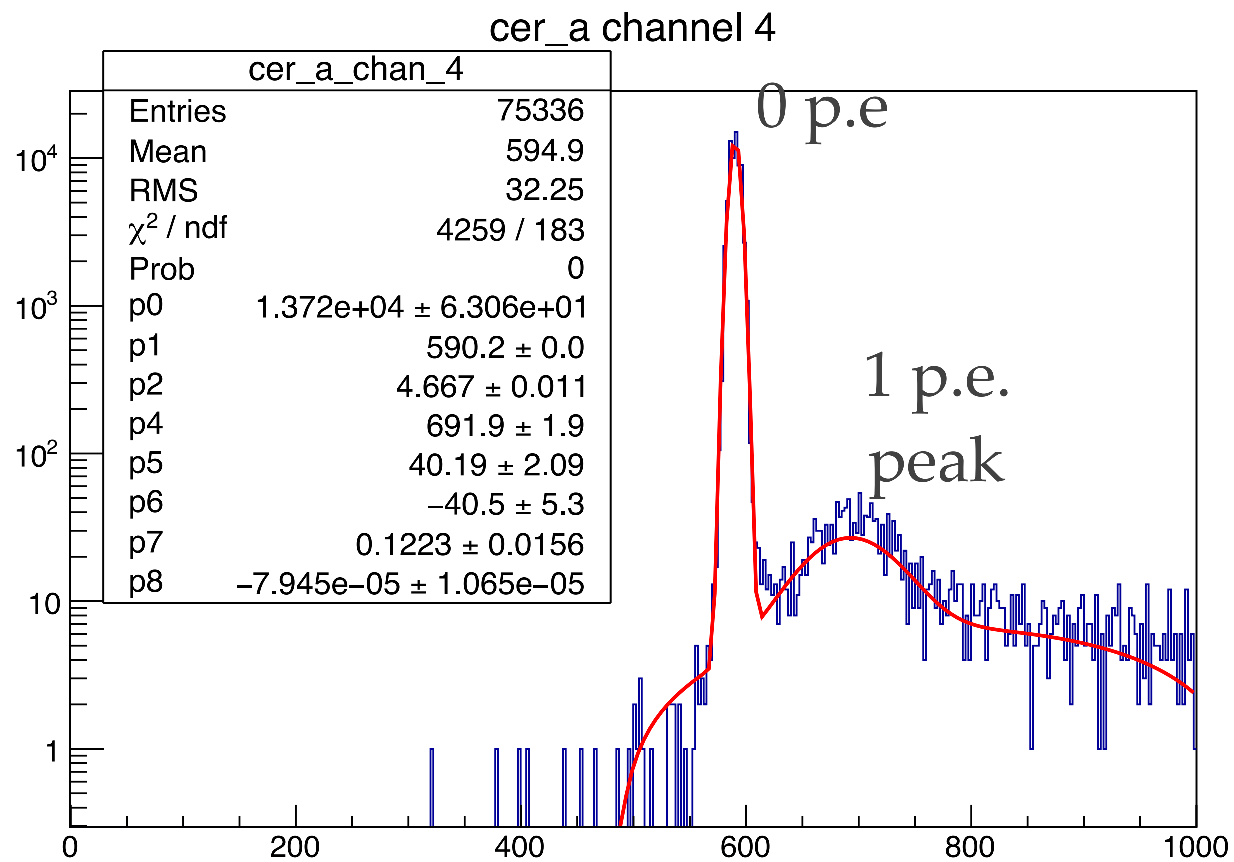
$$f(i) = N\sum_{n=0}^{\infty} e^{-\mu}\frac{\mu^n}{n!}\cdot Gauss(i, 100n, \sigma\sqrt{n})$$



- N - Total Number of events
- μ- mean number of photo electrons
- σ - Width of 1 photo electron peak
- n - number of photo electron
- 100n - calibrated (fixed) position of n-p.e. peak
- i-spectrum channel #

2 free Parameters - N and μ

CHERENKOV CALIBRATION – 2014 DATA



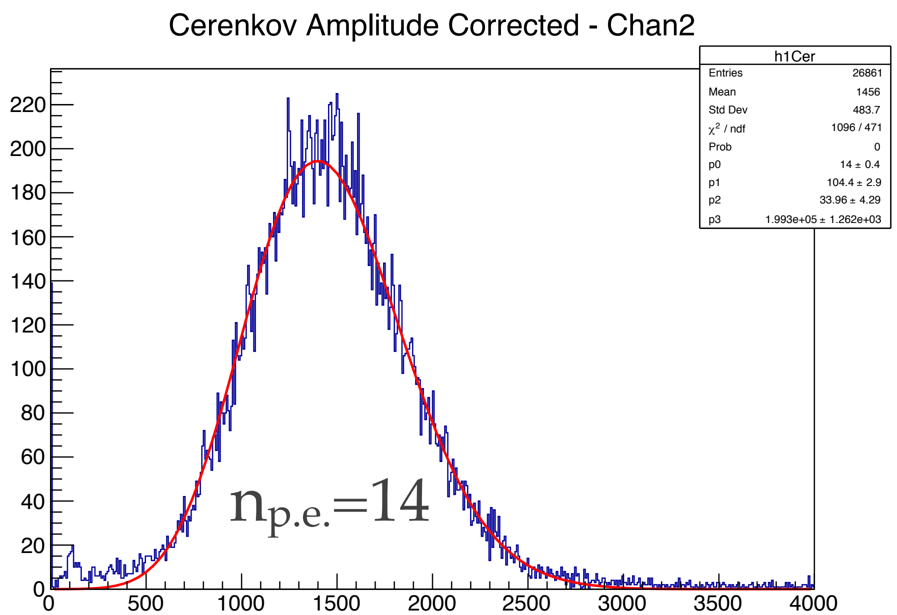
	Amplitude	Position	Width
Pedestal	13720	590	4.66
1P.E	21	692	40

Uncalibrated Cherenkov amplitude spectra of each individual PMT was fitted using a two part gaussian and a second order polynomial tail to determine pedestal and Single photo-electron peak positions and width.

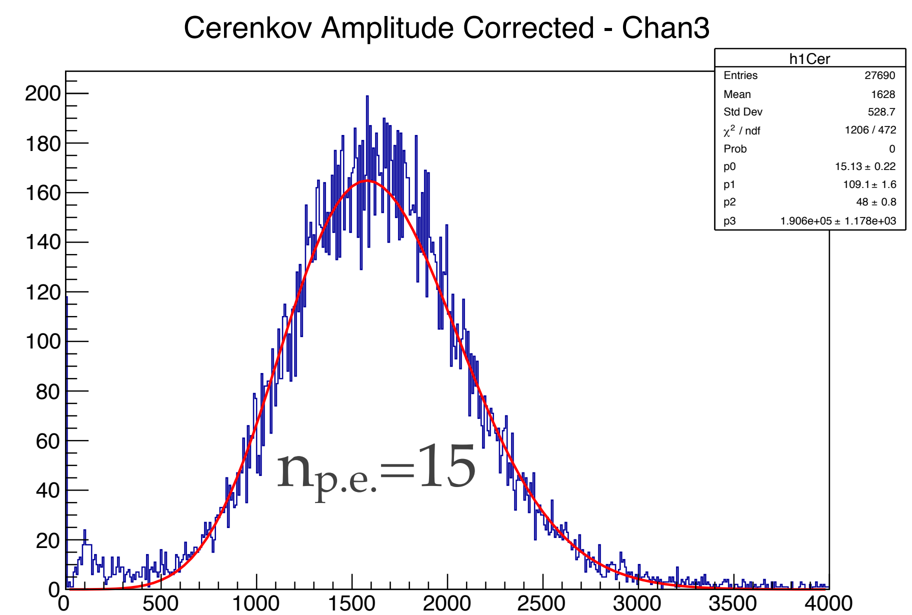
This information was used to make a Poison fit to the calibrated spectrum to check the performance of the phototubes.

POISSON FIT – 2014 DATA

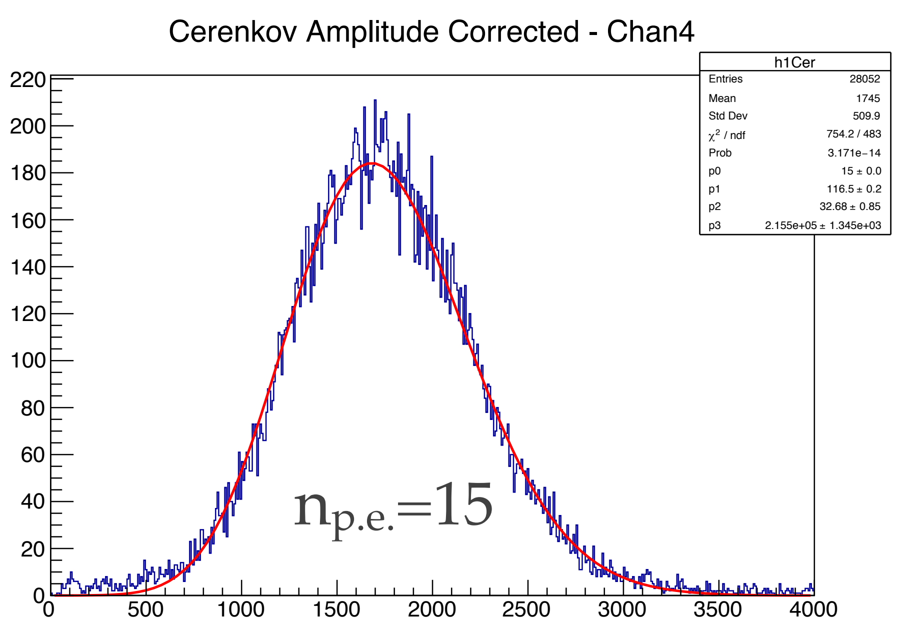
Poison Fit to individual pmt signals, selected for ≥ 90% of amplitude in one PMT



Chan 2

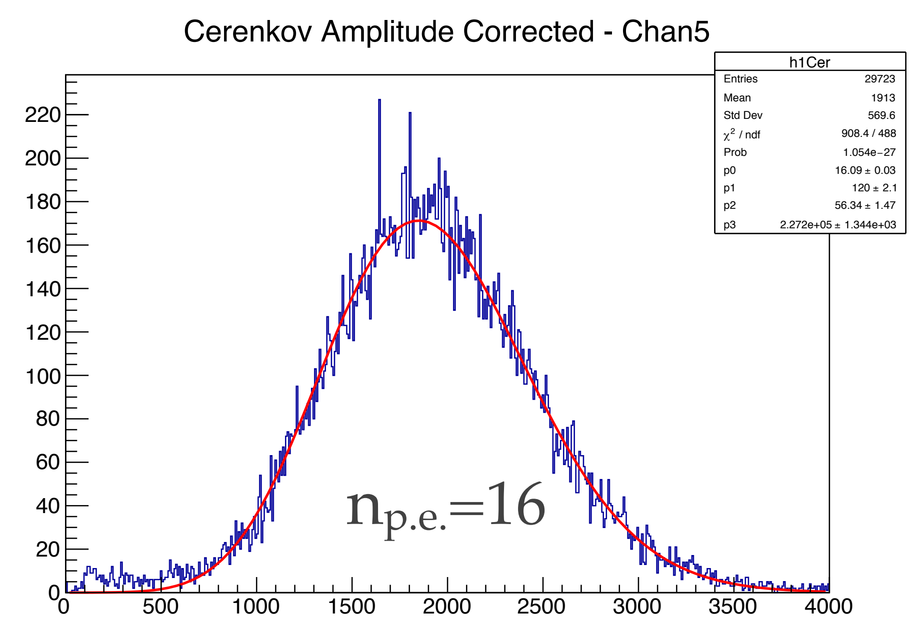


Chan 3



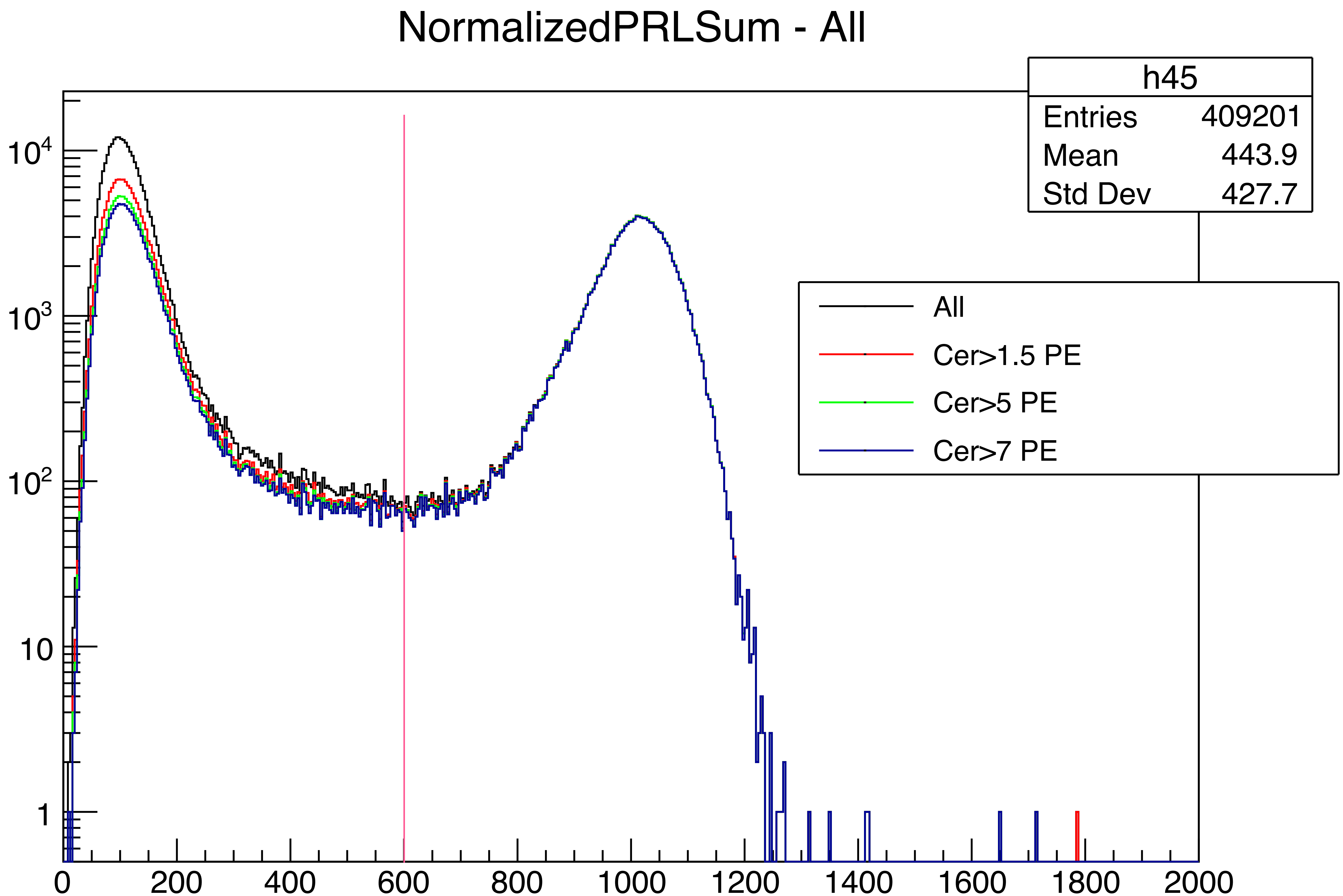
Chan 4

An ID cut at n≥ 1.5 P.E has an efficiency of > 0.999995



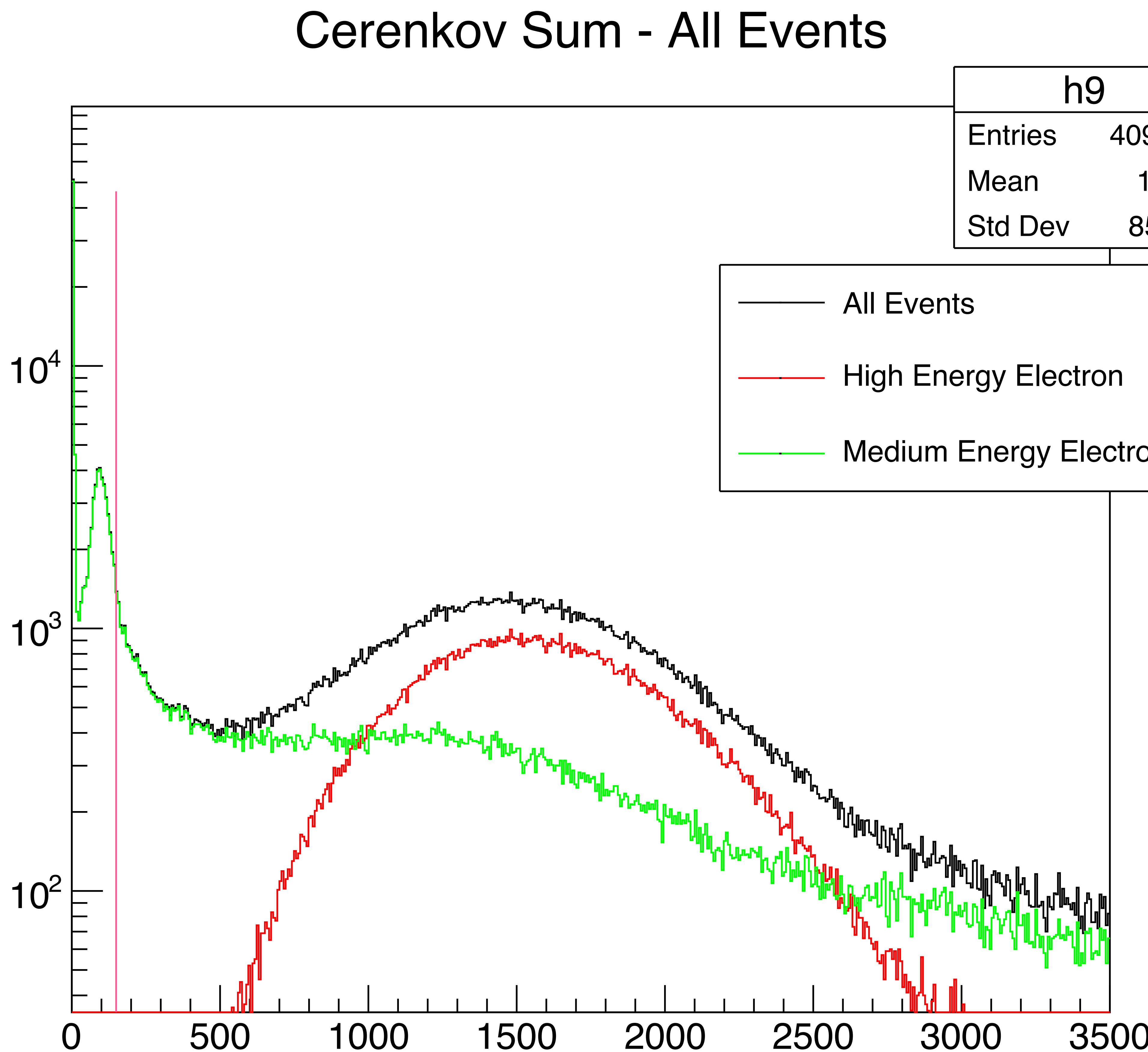
Chan 5

NORMALIZED PION REJECTOR SUM - RUN 13279, PRODUCTION 48_4



EVENTS, WITH PR NORMALIZED SUM GREATER THAN 600 AND NORMALIZED PRL1 GREATER THAN 200 are considered high energy electron

CHERENKOV AMPLITUDE SUM - RUN 13279, PRODUCTION 48_4



EVENTS WITH MORE THAN 1.5 PE IN THE CHERENKOV ARE CONSIDERED GOOD ELECTRON

NORMALIZED PRLSUM VS TRACK X