S (at 10^{o}): Energy Scan

For all the scans :

Black : Raw data
Red : Cherenkov ADC cut
Green : Cherenkov ADC cut + One hit in Hodoscope
Blue : Cherenkov ADC cut + One hit in Hodoscope + Lead Glass cut + Geometry cut

Cherenkov ADC cut :

Low cut at ADC = 300
High cut determined by mean + 5 sigma obtained by fitting the spectrum from Cherenkov detector

Lead glass cut :

Require ADC < 105

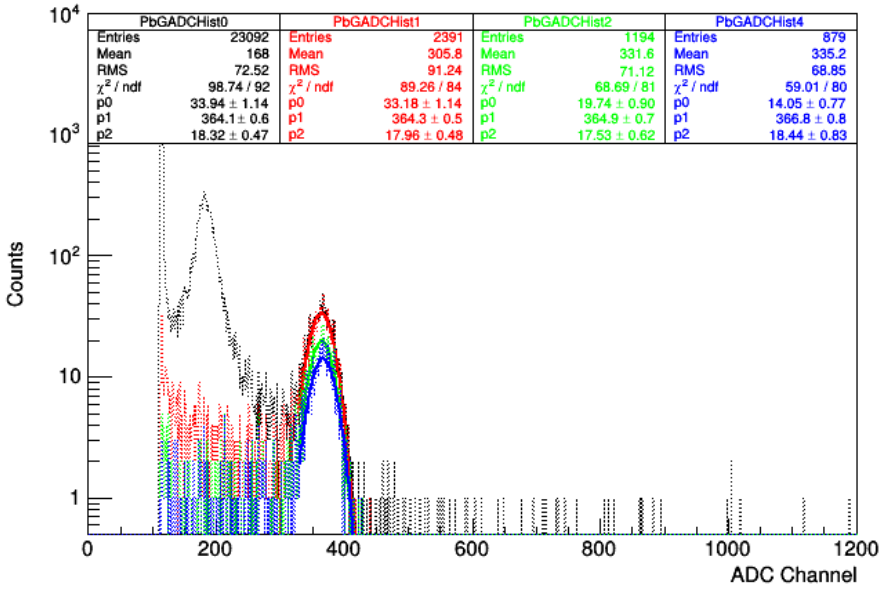
Geometry cut for S :

Remove X = 4 and Y = 3 and 7 for Hodoscope

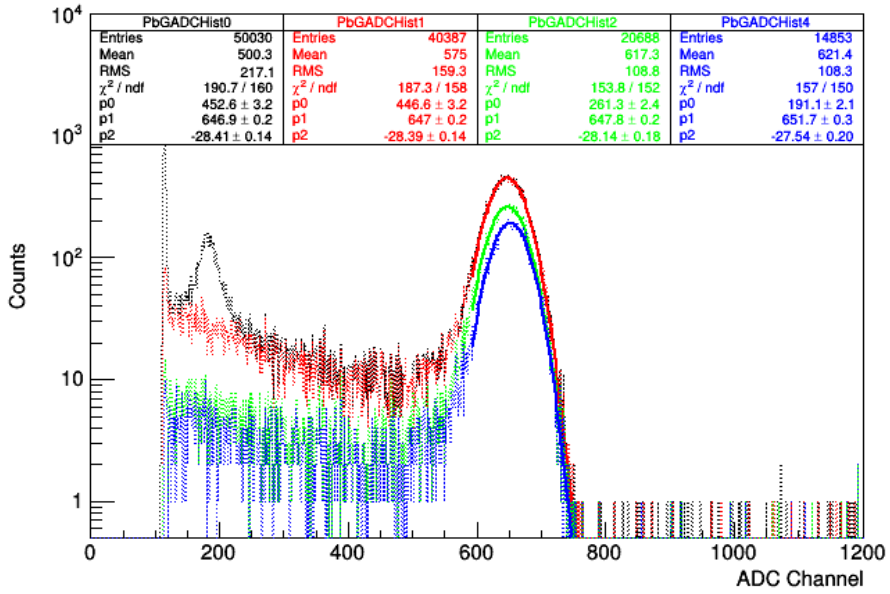
Note :

Energies 1 GeV and 2 GeV peaks for all combination of cuts if fitted within -2 sigma to +5 sigma of the mean. For all other energies, we use -5 sigma to +5 sigma of the mean.

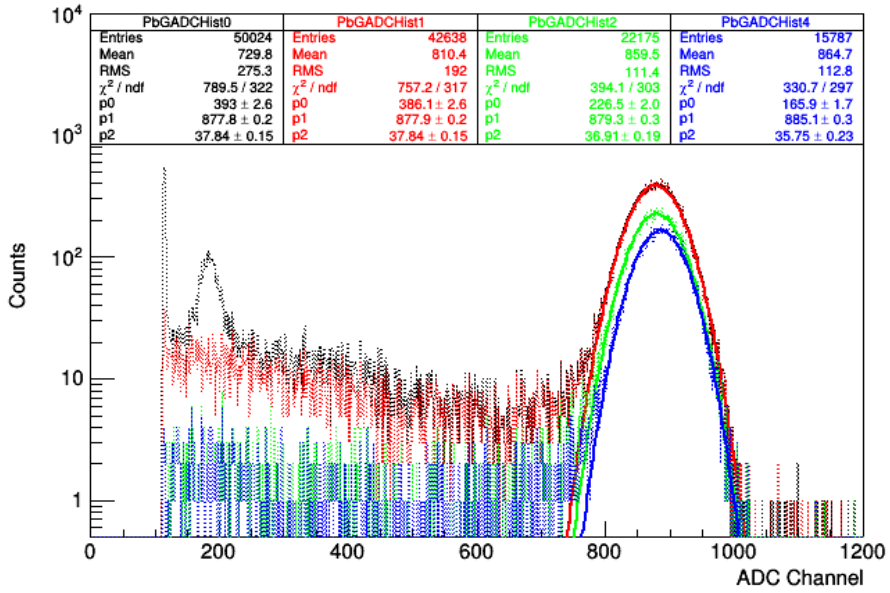
1 GeV


PbGADCHist0
Entries 23092
Mean 168
RMS 72.52
χ² / ndf 98.74 / 92
p0 33.94 ± 1.14
p1 364.1 ± 0.6
p2 18.32 ± 0.47
PbGADCHist1
Entries 2391
Mean 305.8
RMS 91.24
χ² / ndf 89.26 / 84
p0 33.18 ± 1.14
p1 364.3 ± 0.5
p2 17.96 ± 0.48
PbGADCHist2
Entries 1194
Mean 331.6
RMS 71.12
χ² / ndf 68.69 / 81
p0 19.74 ± 0.90
p1 364.9 ± 0.7
p2 17.53 ± 0.62
PbGADCHist4
Entries 879
Mean 335.2
RMS 68.85
χ² / ndf 59.01 / 80
p0 14.05 ± 0.77
p1 366.8 ± 0.8
p2 18.44 ± 0.83
Counts
ADC Channel

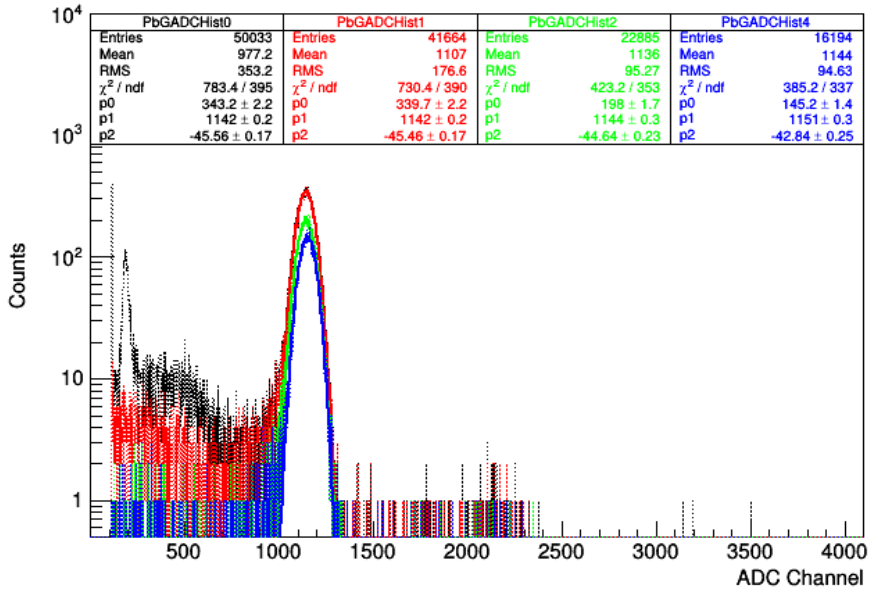
2GeV


PbGADCHist0
Entries 50030
Mean 500.3
RMS 217.1
χ² / ndf 190.7 / 160
p0 452.6 ± 3.2
p1 646.9 ± 0.2
p2 -28.41 ± 0.14
PbGADCHist1
Entries 40387
Mean 575
RMS 159.3
χ² / ndf 187.3 / 158
p0 446.6 ± 3.2
p1 647 ± 0.2
p2 -28.39 ± 0.14
PbGADCHist2
Entries 20688
Mean 617.3
RMS 108.8
χ² / ndf 153.8 / 152
p0 261.3 ± 2.4
p1 647.8 ± 0.2
p2 -28.14 ± 0.18
PbGADCHist4
Entries 14853
Mean 621.4
RMS 108.3
χ² / ndf 157 / 150
p0 191.1 ± 2.1
p1 651.7 ± 0.3
p2 -27.54 ± 0.20
Counts
ADC Channel

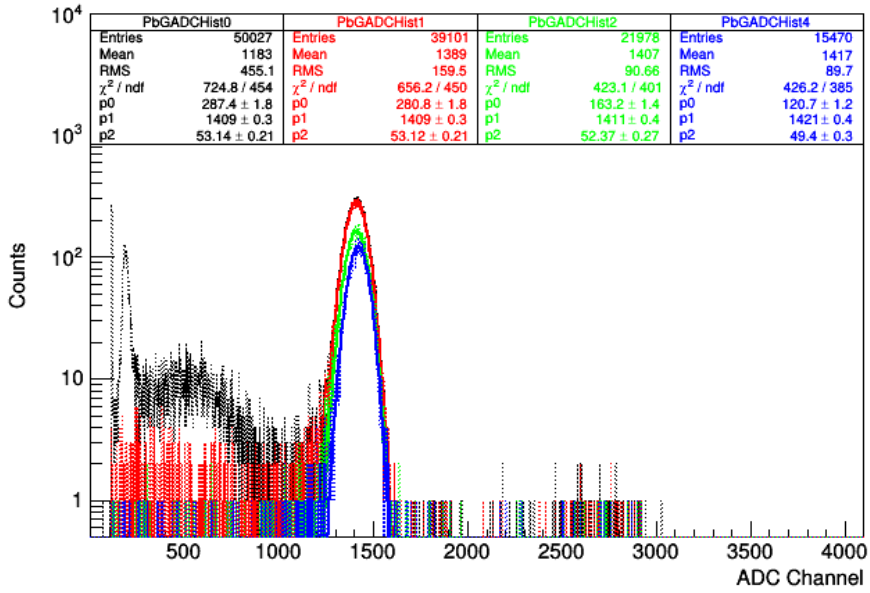
3 GeV


PbGADCHist0
Entries 50024
Mean 729.8
RMS 275.3
χ² / ndf 789.5 / 322
p0 393 ± 2.6
p1 877.8 ± 0.2
p2 37.84 ± 0.15
PbGADCHist1
Entries 42638
Mean 810.4
RMS 192
χ² / ndf 757.2 / 317
p0 386.1 ± 2.6
p1 877.9 ± 0.2
p2 37.84 ± 0.15
PbGADCHist2
Entries 22175
Mean 859.5
RMS 111.4
χ² / ndf 394.1 / 303
p0 226.5 ± 2.0
p1 879.3 ± 0.3
p2 36.91 ± 0.19
PbGADCHist4
Entries 15787
Mean 864.7
RMS 112.8
χ² / ndf 330.7 / 297
p0 165.9 ± 1.7
p1 885.1 ± 0.3
p2 35.75 ± 0.23
Counts
ADC Channel

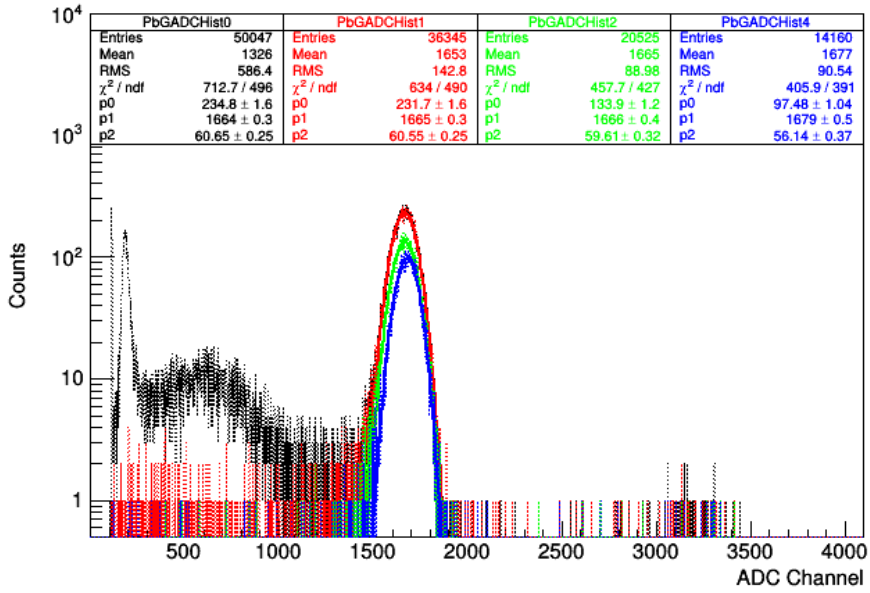
4 GeV


PbGADCHist0
Entries 50033
Mean 977.2
RMS 353.2
χ² / ndf 783.4 / 395
p0 343.2 ± 2.2
p1 1142 ± 0.2
p2 -45.56 ± 0.17
PbGADCHist1
Entries 41664
Mean 1107
RMS 176.6
χ² / ndf 730.4 / 390
p0 339.7 ± 2.2
p1 1142 ± 0.2
p2 -45.46 ± 0.17
PbGADCHist2
Entries 22885
Mean 1136
RMS 95.27
χ² / ndf 423.2 / 353
p0 198 ± 1.7
p1 1144 ± 0.3
p2 -44.64 ± 0.23
PbGADCHist4
Entries 16194
Mean 1144
RMS 94.63
χ² / ndf 385.2 / 337
p0 145.2 ± 1.4
p1 1151 ± 0.3
p2 -42.84 ± 0.25
Counts
ADC Channel

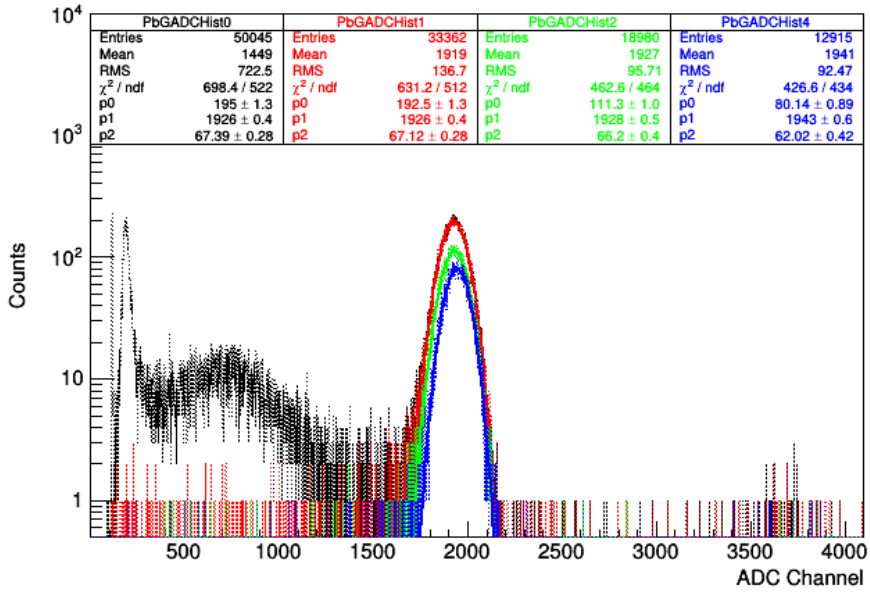
5 GeV


PbGADCHist0
Entries 50027
Mean 1183
RMS 455.1
χ² / ndf 724.8 / 454
p0 287.4 ± 1.8
p1 1409 ± 0.3
p2 53.14 ± 0.21
PbGADCHist1
Entries 39101
Mean 1389
RMS 159.5
χ² / ndf 656.2 / 450
p0 280.8 ± 1.8
p1 1409 ± 0.3
p2 53.12 ± 0.21
PbGADCHist2
Entries 21978
Mean 1407
RMS 90.66
χ² / ndf 423.1 / 401
p0 163.2 ± 1.4
p1 1411 ± 0.4
p2 52.37 ± 0.27
PbGADCHist4
Entries 15470
Mean 1417
RMS 89.7
χ² / ndf 426.2 / 385
p0 120.7 ± 1.2
p1 1421 ± 0.4
p2 49.4 ± 0.3
Counts
ADC Channel

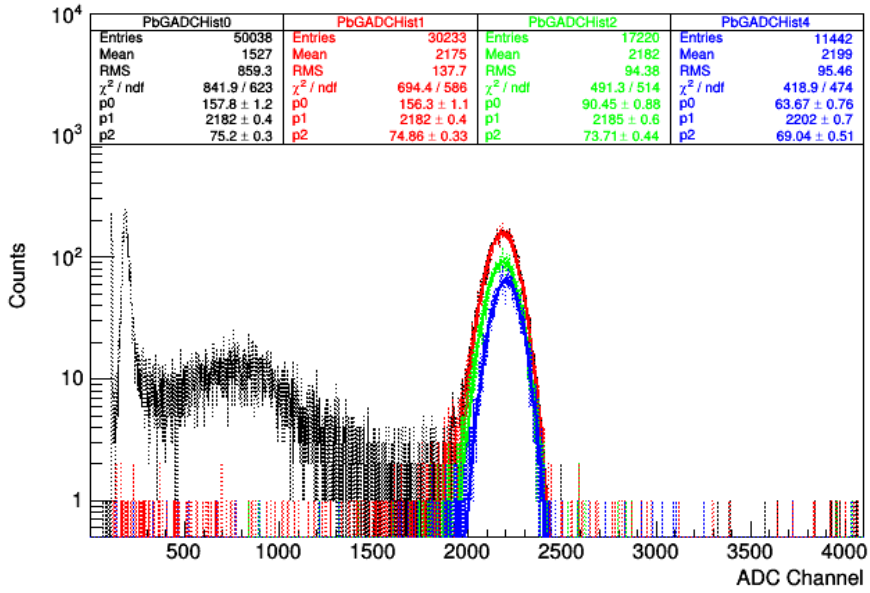
6 GeV


PbGADCHist0
Entries 50047
Mean 1326
RMS 586.4
χ² / ndf 712.7 / 496
p0 234.8 ± 1.6
p1 1664 ± 0.3
p2 60.65 ± 0.25
PbGADCHist1
Entries 36345
Mean 1653
RMS 142.8
χ² / ndf 634 / 490
p0 231.7 ± 1.6
p1 1665 ± 0.3
p2 60.55 ± 0.25
PbGADCHist2
Entries 20525
Mean 1665
RMS 88.98
χ² / ndf 457.7 / 427
p0 133.9 ± 1.2
p1 1666 ± 0.4
p2 59.61 ± 0.32
PbGADCHist4
Entries 14160
Mean 1677
RMS 90.54
χ² / ndf 405.9 / 391
p0 97.48 ± 1.04
p1 1679 ± 0.5
p2 56.14 ± 0.37
Counts
ADC Channel

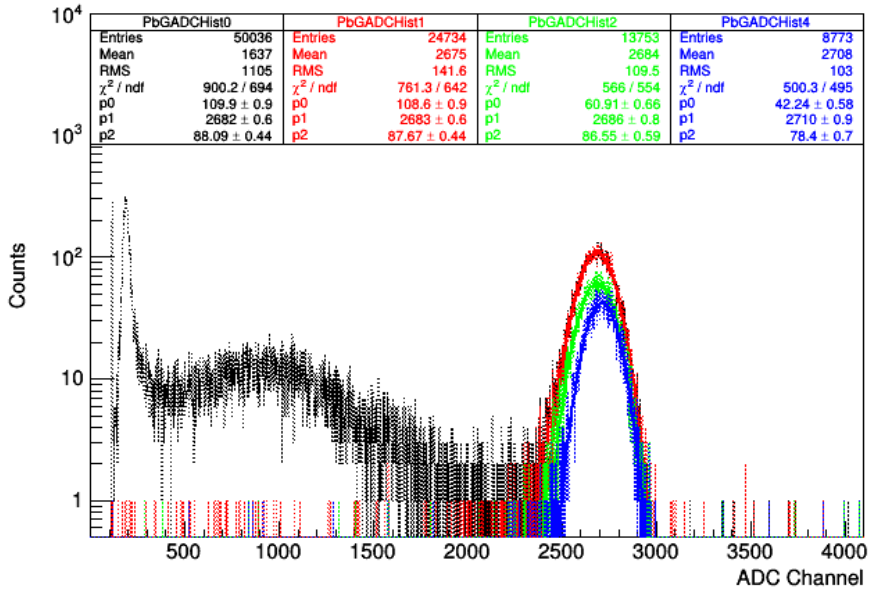
7 GeV


PbGADCHist0
Entries 50045
Mean 1449
RMS 722.5
χ² / ndf 698.4 / 522
p0 195 ± 1.3
p1 1926 ± 0.4
p2 67.39 ± 0.28
PbGADCHist1
Entries 33362
Mean 1919
RMS 136.7
χ² / ndf 631.2 / 512
p0 192.5 ± 1.3
p1 1926 ± 0.4
p2 67.12 ± 0.28
PbGADCHist2
Entries 18980
Mean 1927
RMS 95.71
χ² / ndf 462.6 / 464
p0 111.3 ± 1.0
p1 1928 ± 0.5
p2 66.2 ± 0.4
PbGADCHist4
Entries 12915
Mean 1941
RMS 92.47
χ² / ndf 426.6 / 434
p0 80.14 ± 0.89
p1 1943 ± 0.6
p2 62.02 ± 0.42
Counts
ADC Channel

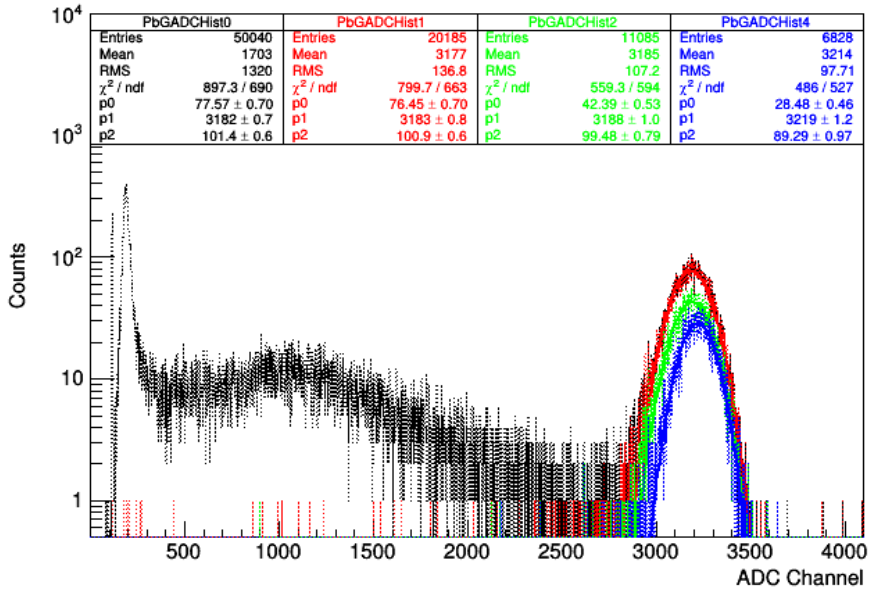
8 GeV


PbGADCHist0
Entries 50038
Mean 1527
RMS 859.3
χ² / ndf 841.9 / 623
p0 157.8 ± 1.2
p1 2182 ± 0.4
p2 75.2 ± 0.3
PbGADCHist1
Entries 30233
Mean 2175
RMS 137.7
χ² / ndf 694.4 / 586
p0 156.3 ± 1.1
p1 2182 ± 0.4
p2 74.86 ± 0.33
PbGADCHist2
Entries 17220
Mean 2182
RMS 94.38
χ² / ndf 491.3 / 514
p0 90.45 ± 0.88
p1 2185 ± 0.6
p2 73.71 ± 0.44
PbGADCHist4
Entries 11442
Mean 2199
RMS 95.46
χ² / ndf 418.9 / 474
p0 63.67 ± 0.76
p1 2202 ± 0.7
p2 69.04 ± 0.51
Counts
ADC Channel

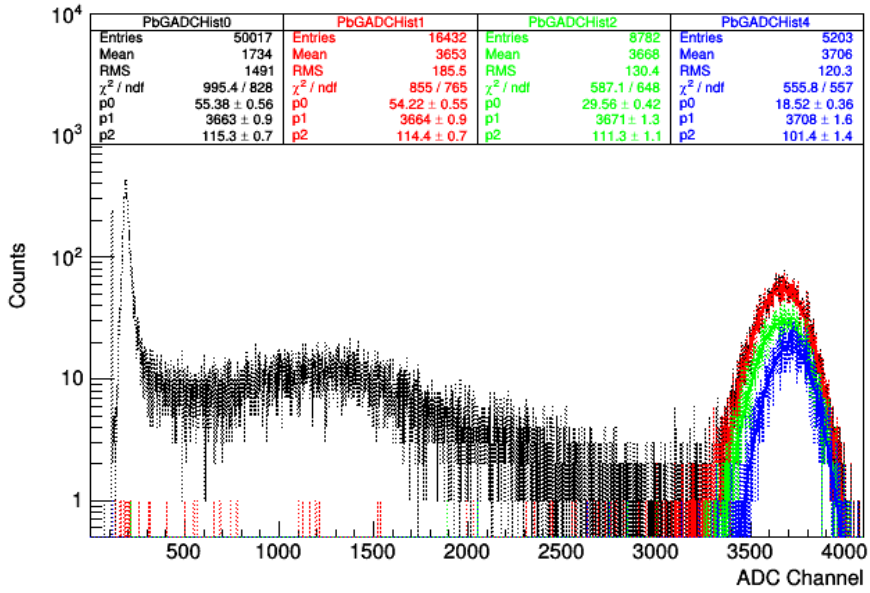
10 GeV


PbGADCHist0
Entries 50036
Mean 1637
RMS 1105
χ² / ndf 900.2 / 694
p0 109.9 ± 0.9
p1 2682 ± 0.6
p2 88.09 ± 0.44
PbGADCHist1
Entries 24734
Mean 2675
RMS 141.6
χ² / ndf 761.3 / 642
p0 108.6 ± 0.9
p1 2683 ± 0.6
p2 87.67 ± 0.44
PbGADCHist2
Entries 13753
Mean 2684
RMS 109.5
χ² / ndf 566 / 554
p0 60.91 ± 0.66
p1 2686 ± 0.8
p2 86.55 ± 0.59
PbGADCHist4
Entries 8773
Mean 2708
RMS 103
χ² / ndf 500.3 / 495
p0 42.24 ± 0.58
p1 2710 ± 0.9
p2 78.4 ± 0.7
Counts
ADC Channel

12 GeV


PbGADCHist0
Entries 50040
Mean 1703
RMS 1320
χ² / ndf 897.3 / 690
p0 77.57 ± 0.70
p1 3182 ± 0.7
p2 101.4 ± 0.6
PbGADCHist1
Entries 20185
Mean 3177
RMS 136.8
χ² / ndf 799.7 / 663
p0 76.45 ± 0.70
p1 3183 ± 0.8
p2 100.9 ± 0.6
PbGADCHist2
Entries 11085
Mean 3185
RMS 107.2
χ² / ndf 559.3 / 594
p0 42.39 ± 0.53
p1 3188 ± 1.0
p2 99.48 ± 0.79
PbGADCHist4
Entries 6828
Mean 3214
RMS 97.71
χ² / ndf 486 / 527
p0 28.48 ± 0.46
p1 3219 ± 1.2
p2 89.29 ± 0.97
Counts
ADC Channel

14 GeV

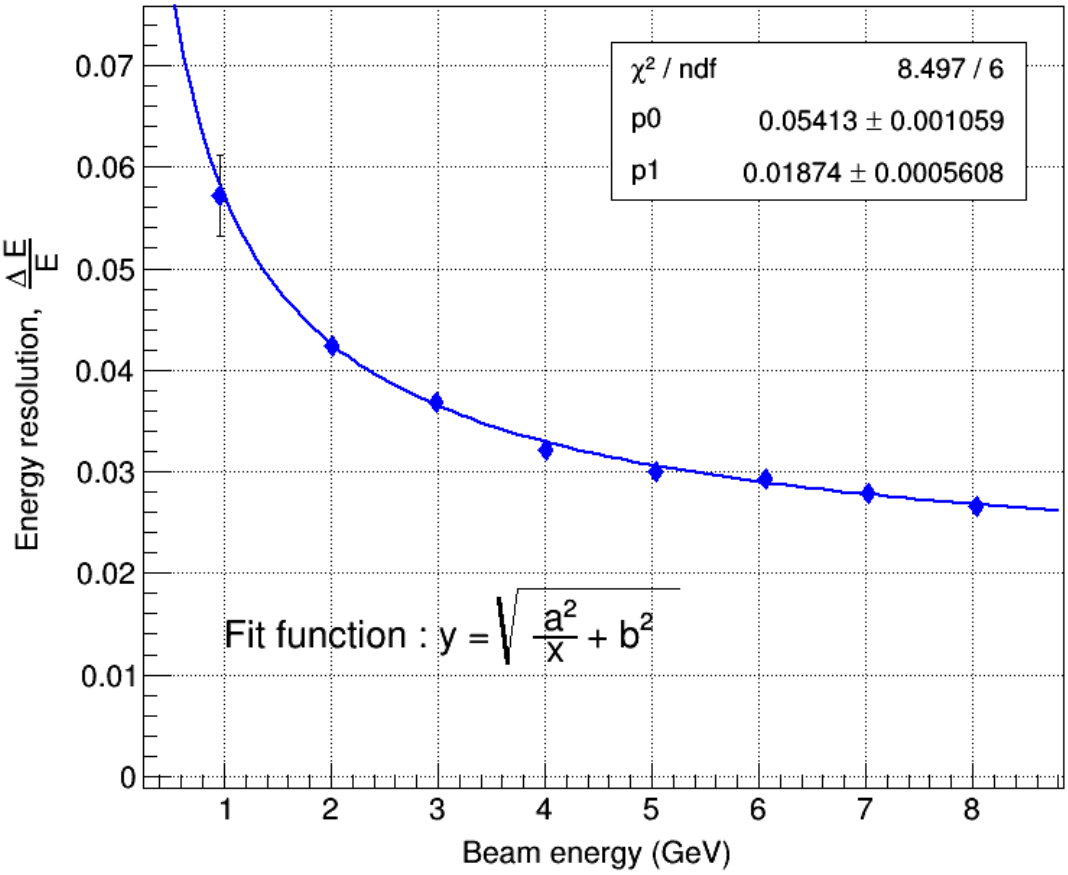


Similar scans were taken for

O : from 1 GeV to 8 GeV
W : from 1 GeV to 18 GeV
S (at 4^{o}) : from 1 GeV to 14 GeV

Results from scans

Lead Glass detector was used to estimate beam momentum spread.



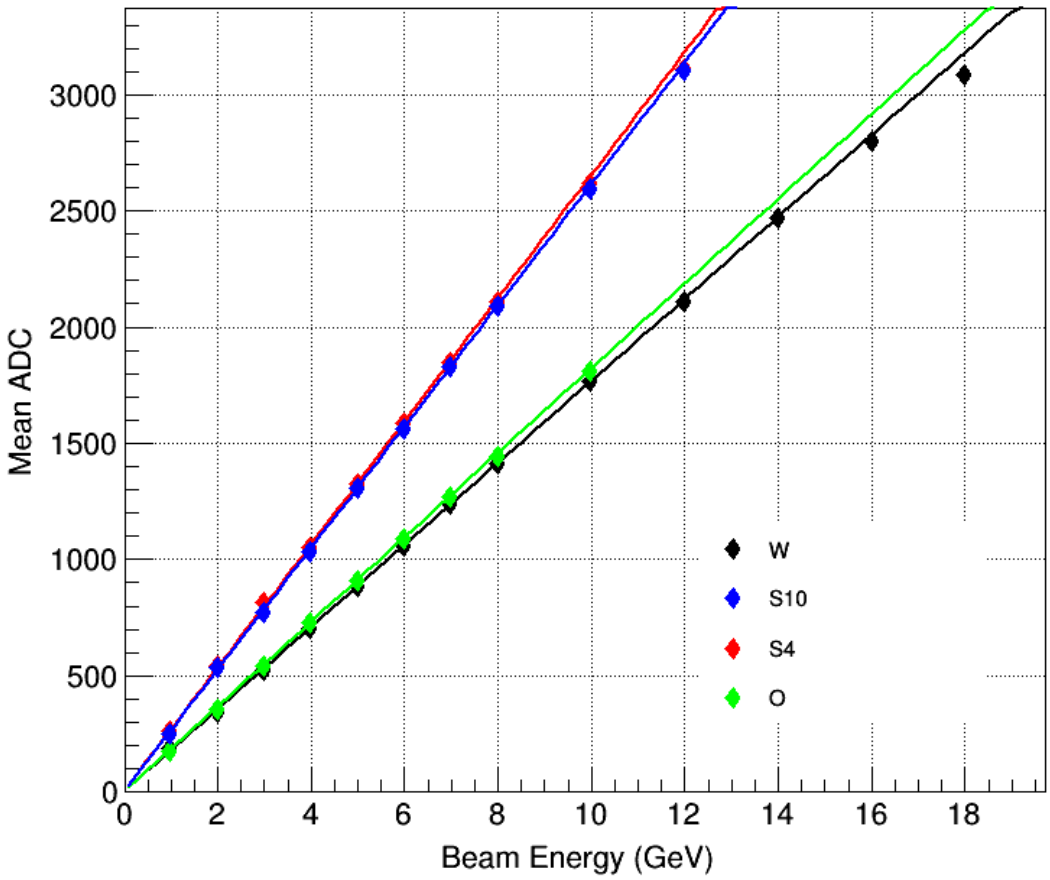
The energy here was corrected using the mean and sigma from the deviation of linearity plot of three EMCal detectors at every energy.

Corrected energy = Requested energy + Mean of deviations * Requested energy
Error in corrected energy = Requested energy * Sigma of the deviations

Requested Energy (GeV)	Corrected Energy (GeV)	Error in corrected energy (GeV)
1	0.965022	0.00992049
2	2.01495	0.0487485
3	2.99172	0.0342565
4	4.01683	0.0321163
5	5.03747	0.0318565
6	6.06115	0.0236581
7	7.03046	0.0584353
8	8.04142	0.0845307

Note : Energy was not corrected in the following analysis. All cuts were used (Cherenkov cut + One hit in Hodoscope + Lead glass cut + Geometry cut)

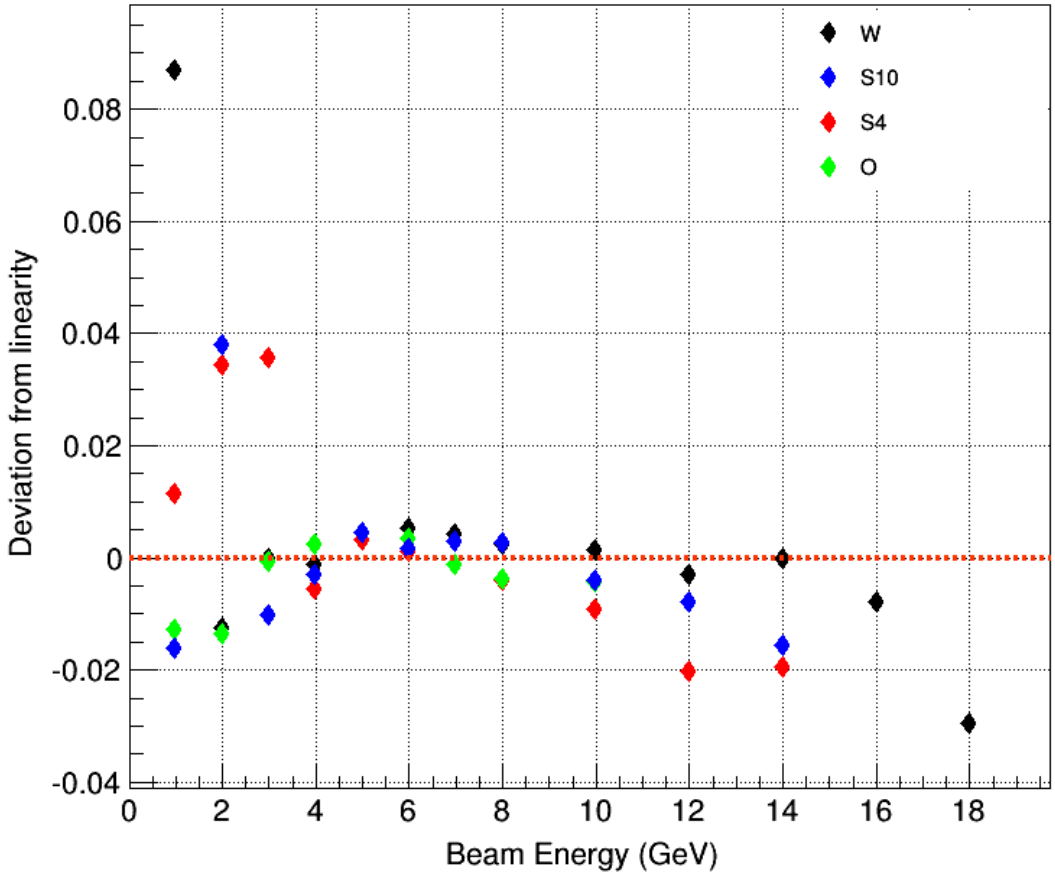
Linearity of response



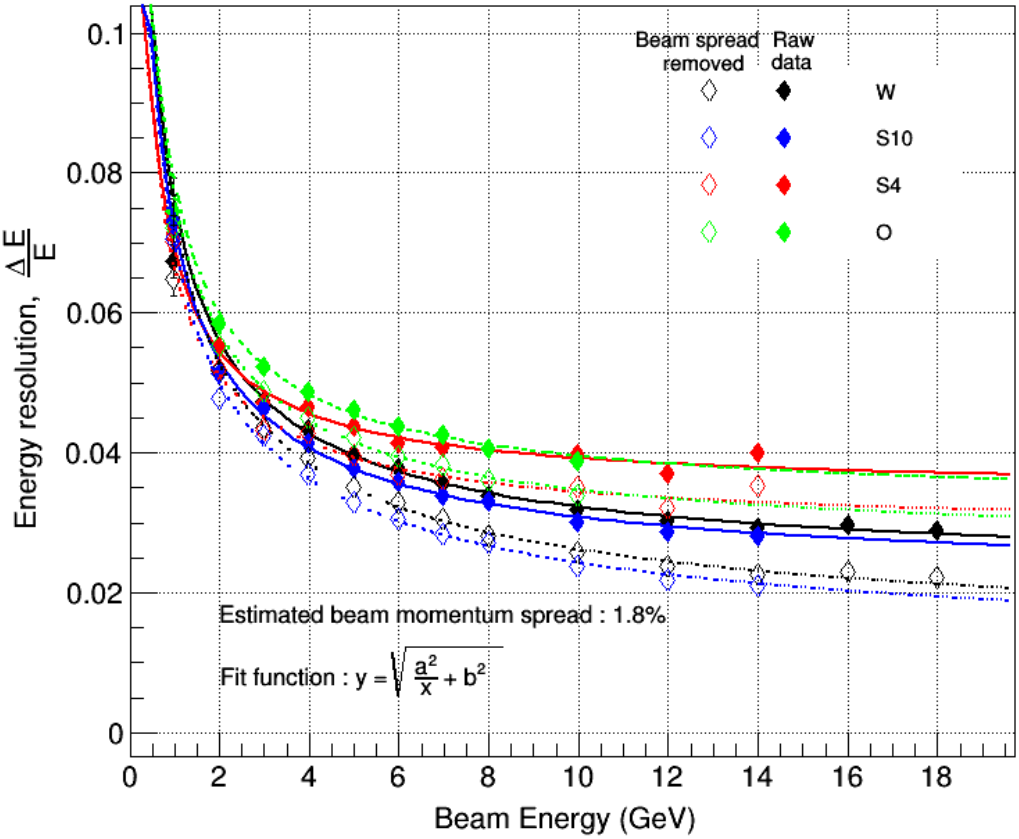
Fit function : y = slope * x

Detector	χ^2 / ndf	slope	error
W	4802 / 12	176.5	0.02
S10	8870 / 10	261.1	0.03
S4	6740 / 10	264.9	0.04
O	649.8 / 8	182	0.03

Deviation from linearity



Resolution of the detector



Detector		χ^2 / ndf	a (in %)	b (in %)
W	solid	44.46 / 11	7.23 ± 0.05	2.27 ± 0.03
	dashed	57.11 / 11	7.25 ± 0.05	1.26 ± 0.04
S10	solid	67.63 / 9	6.87 ± 0.05	2.17 ± 0.03
	dashed	84.88 / 9	6.91 ± 0.04	1.06 ± 0.05
S4	solid	45.97 / 9	5.97 ± 0.11	3.43 ± 0.04
	dashed	56.37 / 9	5.97 ± 0.10	2.87 ± 0.04
O	solid	23.32 / 7	7.16 ± 0.09	3.23 ± 0.04
	dashed	27.98 / 7	7.17 ± 0.09	2.62 ± 0.04

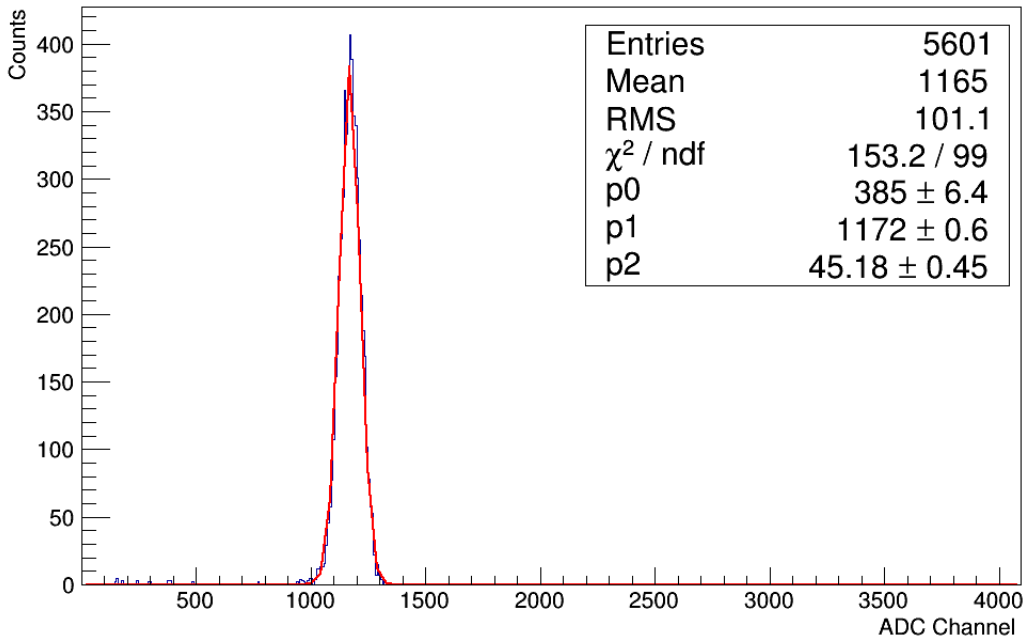
High Statistics Analysis

For all the following plots, the following cuts are taken unless mentioned :

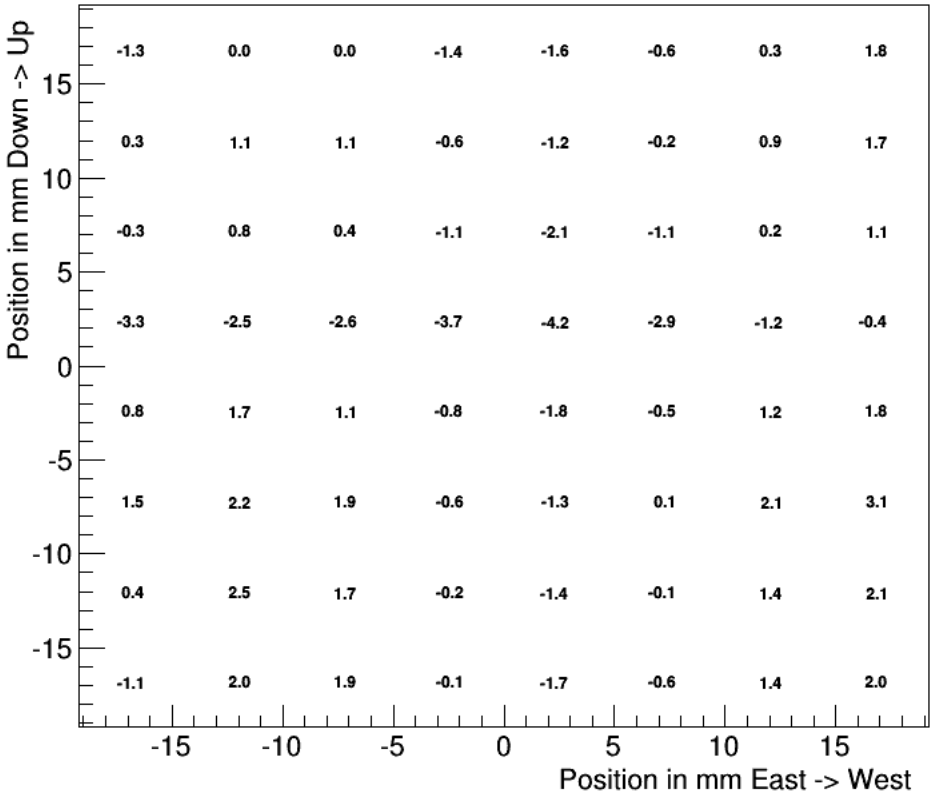
Cherenkov Cut
One hit in Hodoscope
Lead Glass cut

Uniformity across detector surface (S)

Sample fit in Hodoscope finger (2,5)

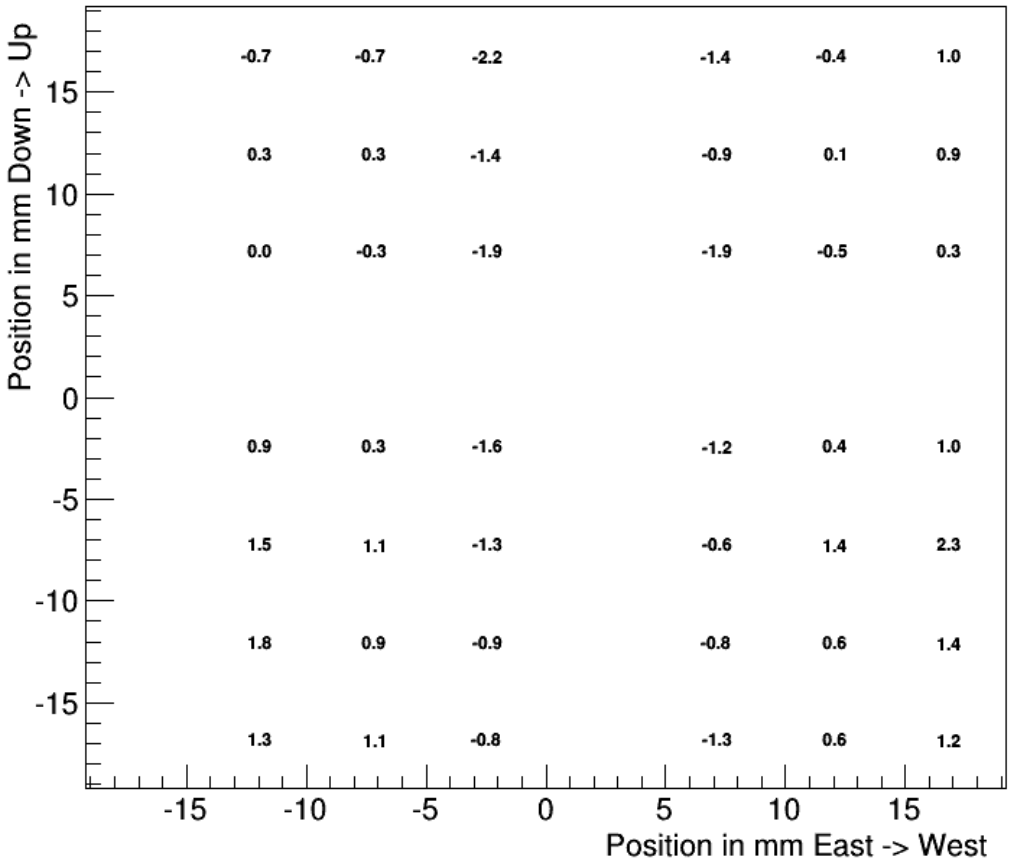


No geometric cut



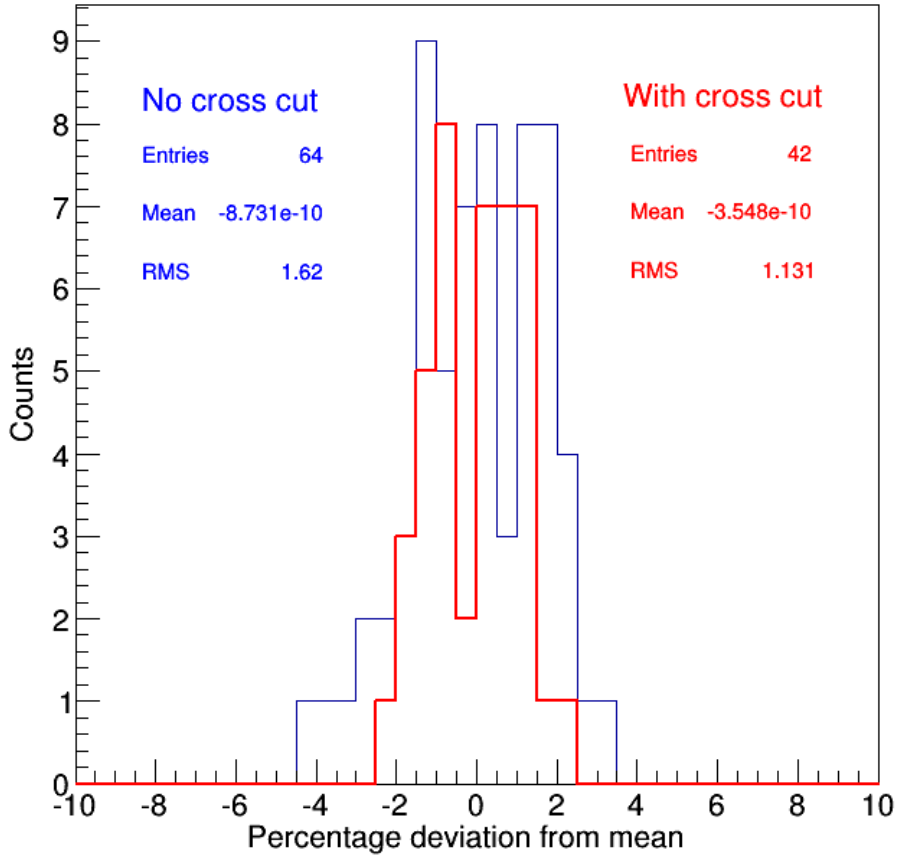
The numbers are in percentage

With geometric cut



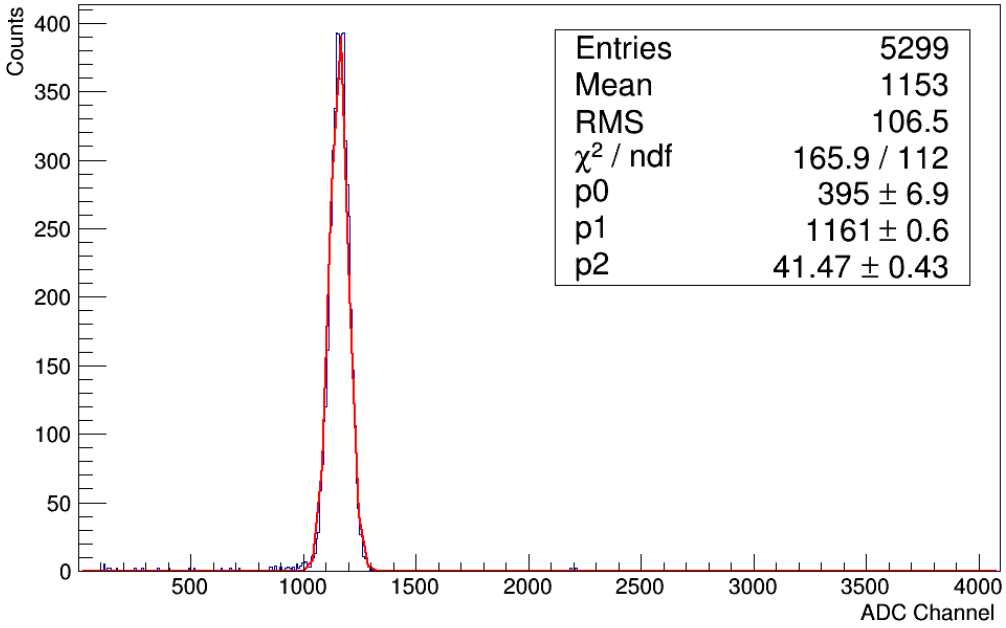
The numbers are in percentage

Comparison

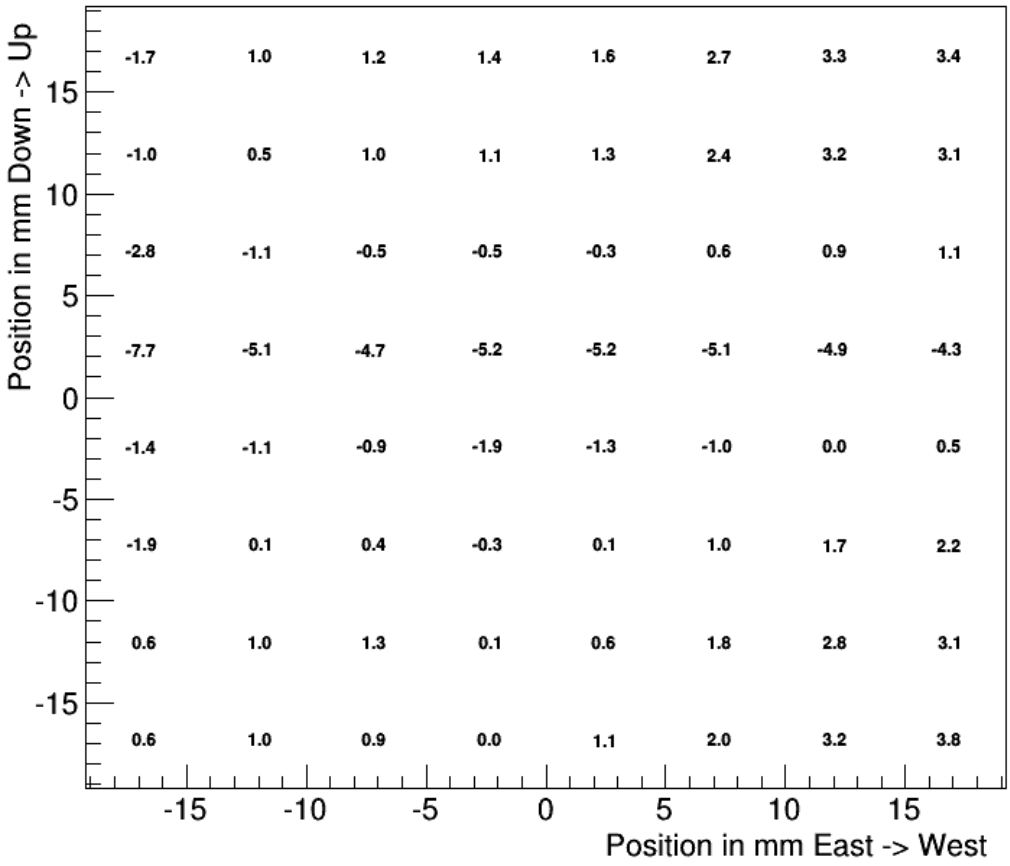

No cross cut
Entries 64
Mean -8.731e-10
RMS 1.62
With cross cut
Entries 42
Mean -3.548e-10
RMS 1.131
Counts
Percentage deviation from mean
0
1
2
3
4
5
6
7
8
9
-10
-8
-6
-4
-2
0
2
4
6
8
10

Uniformity across detector surface (SF)

Sample fit in Hodoscope finger (2,5)

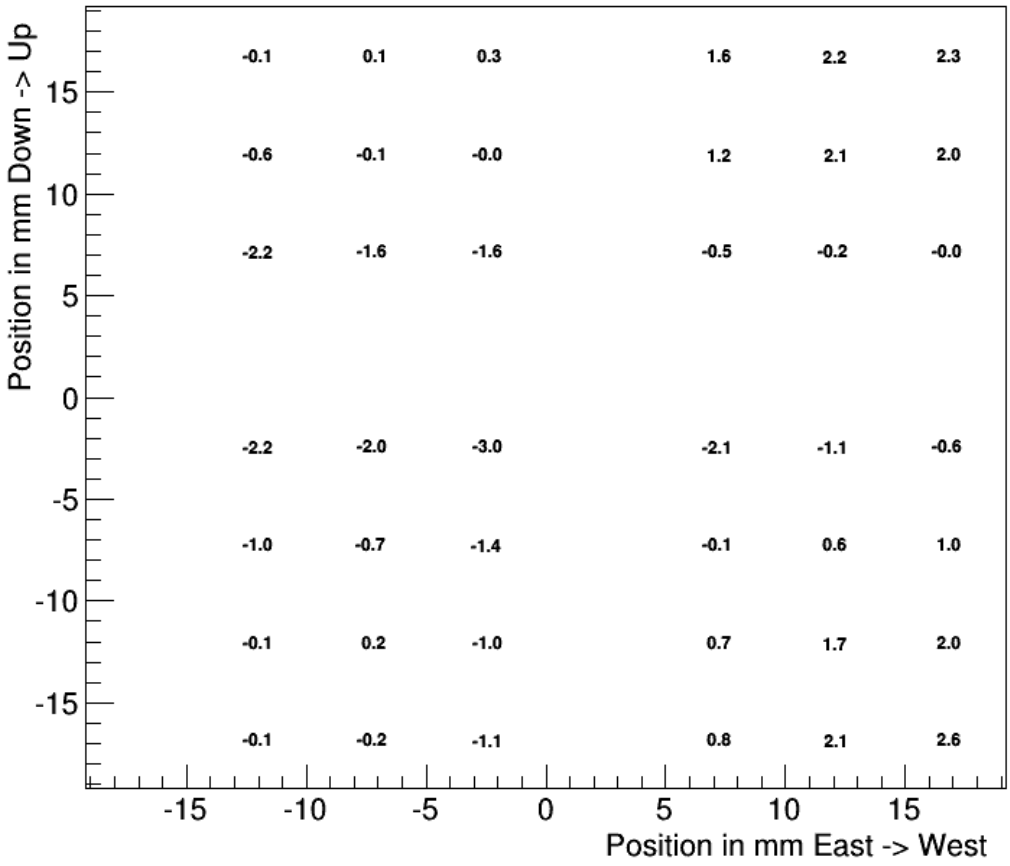


No geometric cut



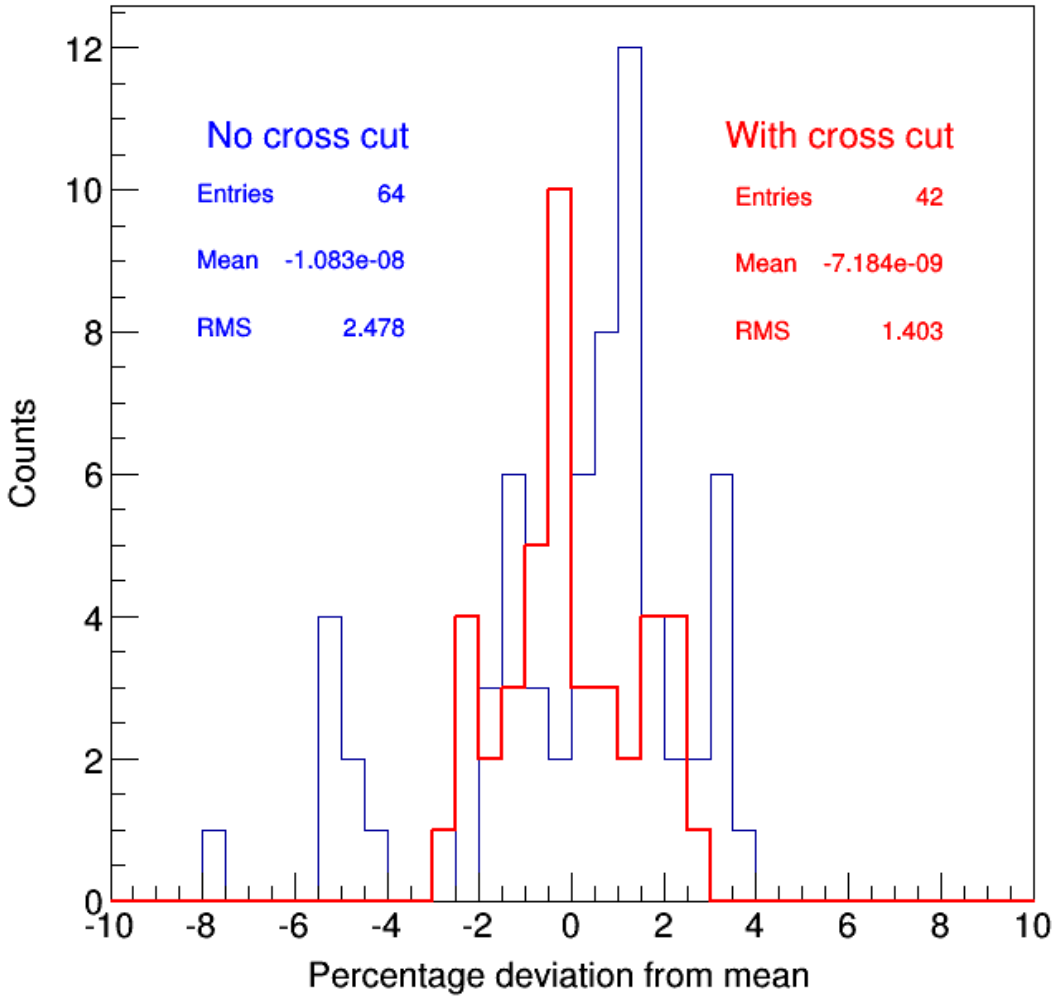
The numbers are in percentage

With geometric cut



The numbers are in percentage

Comparison


No cross cut
Entries 64
Mean -1.083e-08
RMS 2.478
With cross cut
Entries 42
Mean -7.184e-09
RMS 1.403
Counts
Percentage deviation from mean
0
2
4
6
8
10
12
-10
-8
-6
-4
-2
0
2
4
6
8
10