SMD Gain Calibration For Local Polarimeter

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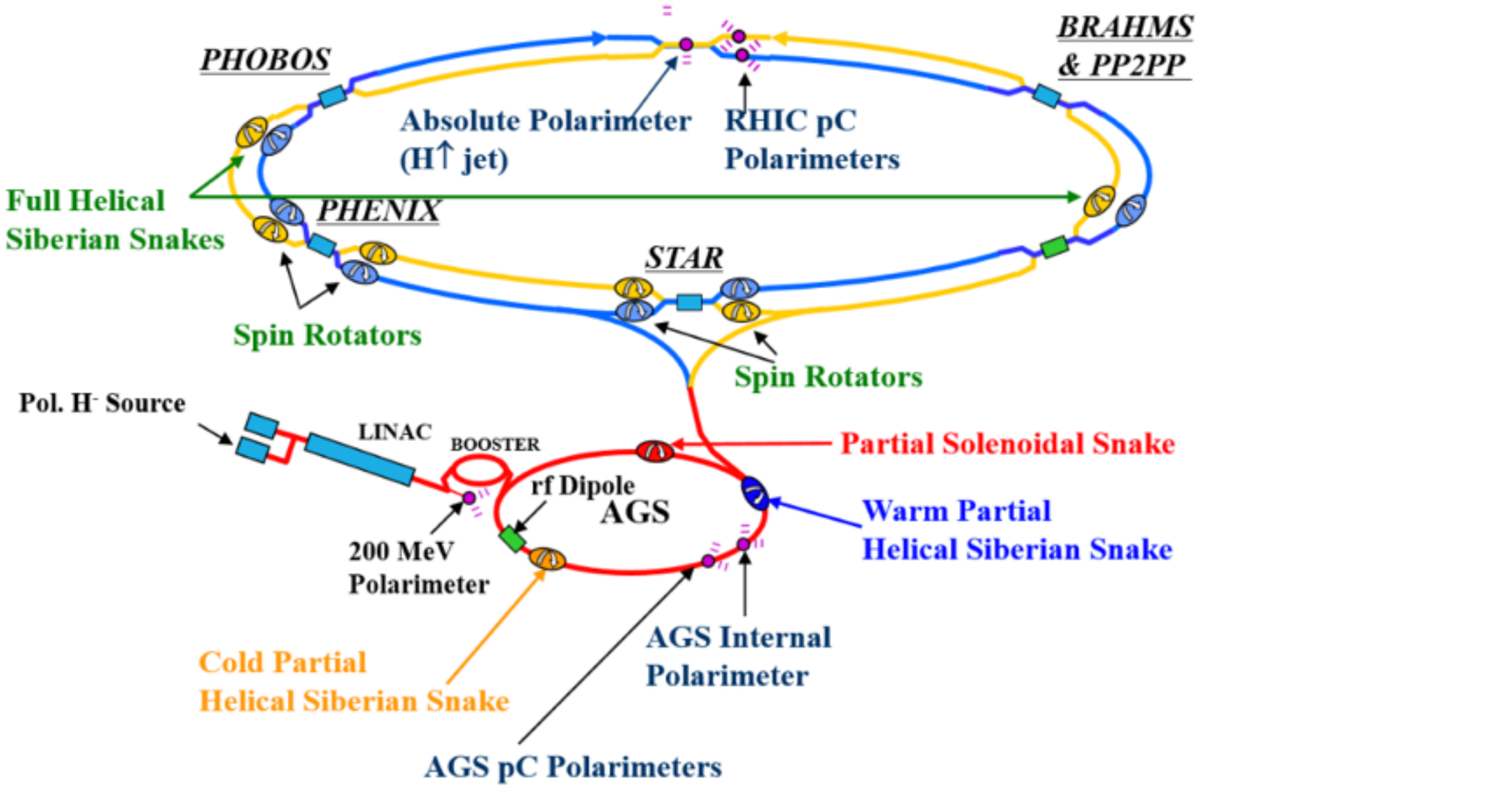
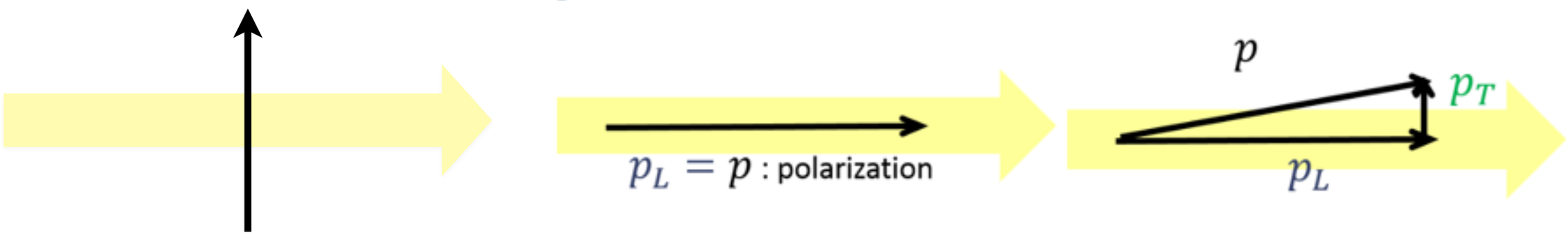
Motivation

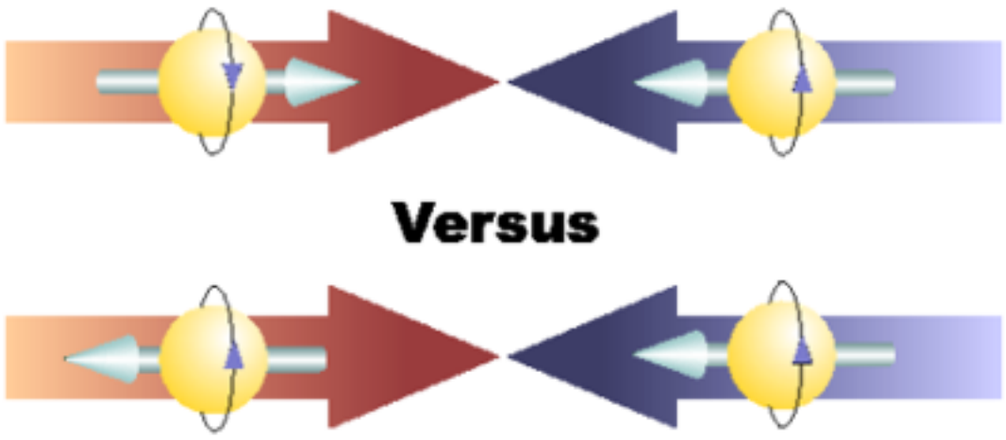

PHOBOS
BRAHMS
& PP2PP
Absolute Polarimeter
(H↑ jet)
RHIC pC
Polarimeters
Full Helical
Siberian Snakes
PHENIX
STAR
Spin Rotators
Spin Rotators
Pol. H⁻ Source
LINAC
BOOSTER
Partial Solenoidal Snake
rf Dipole
AGS
Warm Partial
Helical Siberian Snake
200 MeV
Polarimeter
Cold Partial
Helical Siberian Snake
AGS Internal
Polarimeter
AGS pC Polarimeters

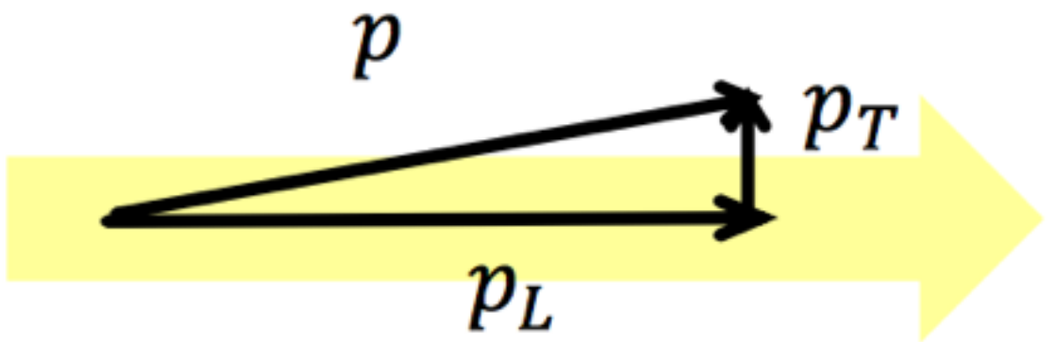

$p_L = p$: polarization
p
p_T
p_L

Necessity of Local polarimeter

$$A_{LL} = \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}}$$

measurement for gluon polarization





$$A_{LL}^{measured} \equiv \frac{1}{p^Y}\frac{1}{p^B}\frac{N_{++} - RN_{+-}}{N_{++} + RN_{+-}}$$

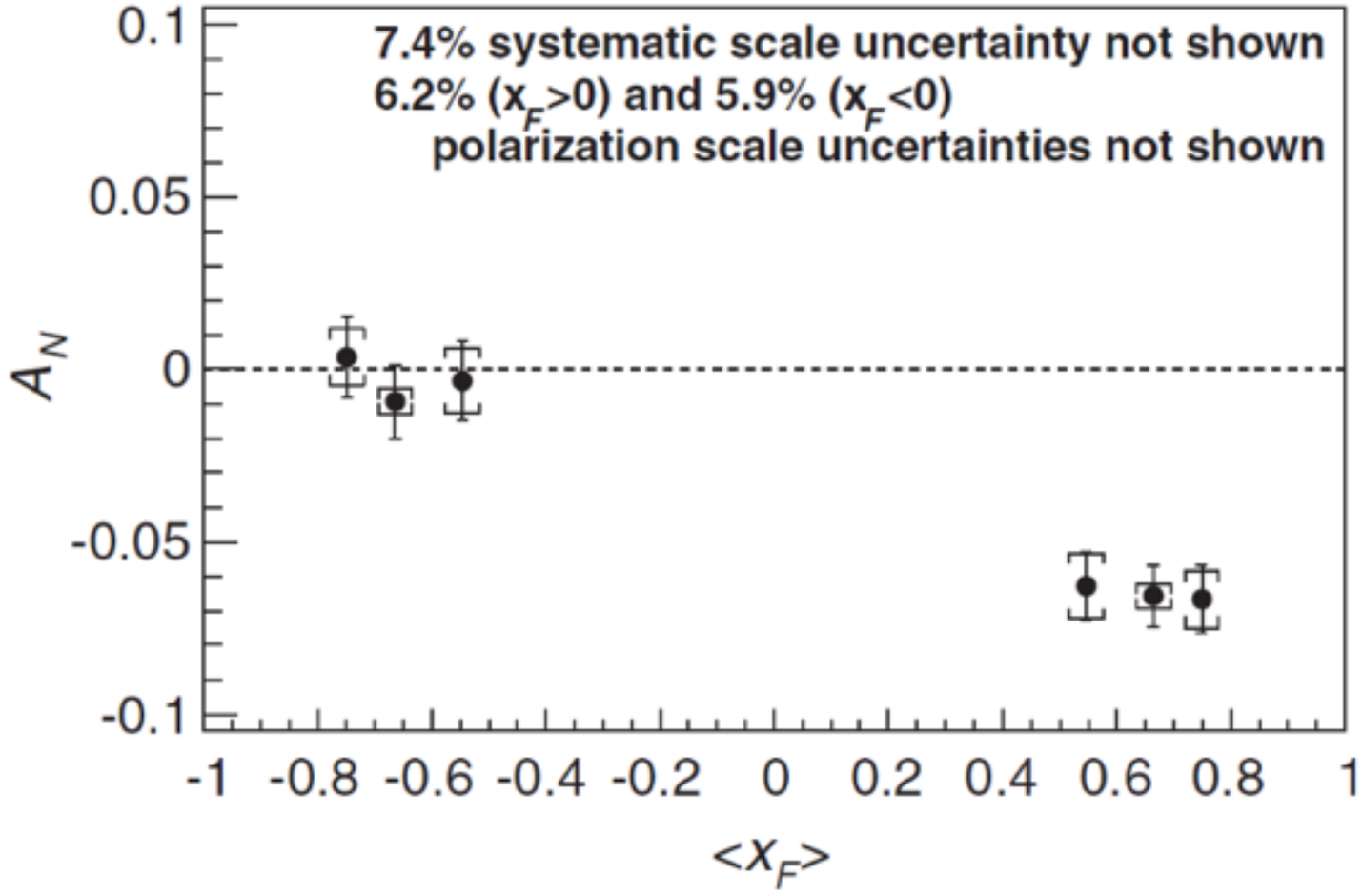
$$\cong \frac{1}{p^Y}\frac{1}{p^B}\left(p_L^Y p_L^B A_{LL} + p_T^Y p_T^B A_{TT}\right)$$

Yellow, Blue: two colliding beam

- A_{LL} measurement
  - main systematic uncertainties : R(relative luminosity), P_T
  - A_{LL} is very small -> contribution from A_{TT} might not be negligible.

AN of forward neutron production

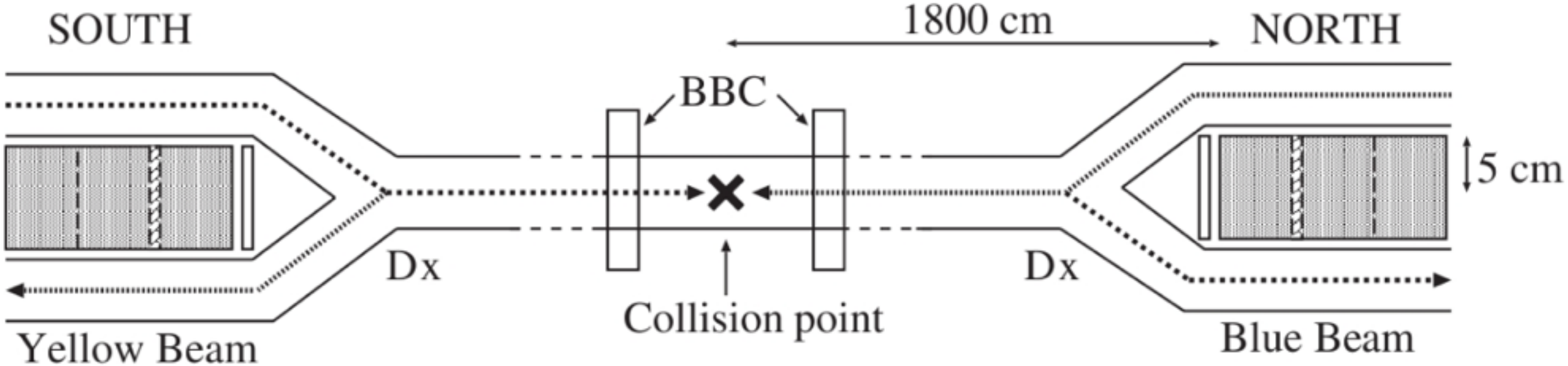
$$A_N \equiv \frac{\sigma_L^{\uparrow} - \sigma_L^{\downarrow}}{\sigma_L^{\uparrow} + \sigma_L^{\downarrow}} = \frac{\sigma_L^{\uparrow} - \sigma_R^{\uparrow}}{\sigma_L^{\uparrow} + \sigma_R^{\uparrow}}$$



$\frac{p_T}{p} \approx 1$ → A_N would be observed.

$\frac{p_T}{p} \approx 0$ → A_N will be 0.

Local polarimeter

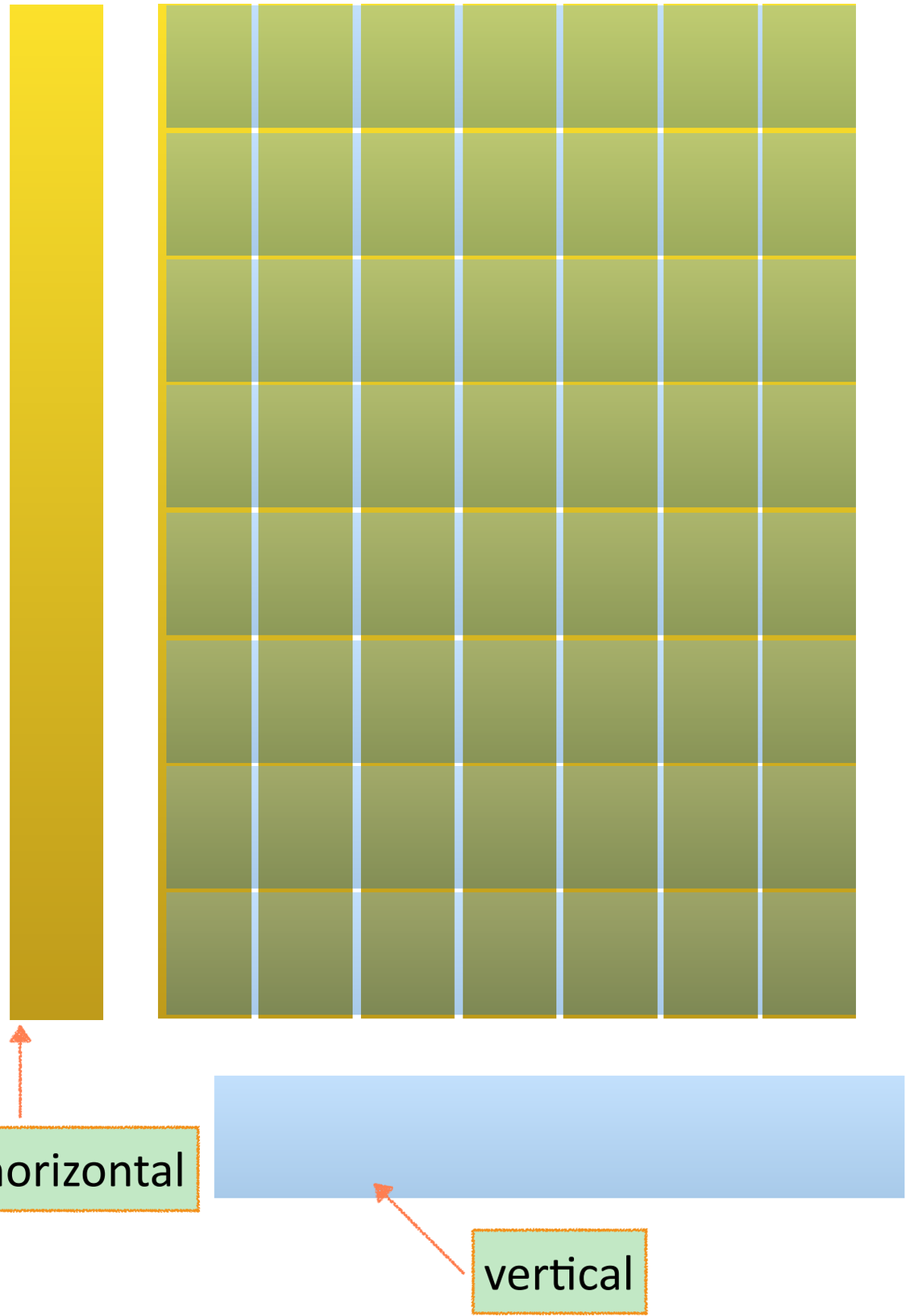


- Zero Degree Calorimeter : Neutron energy measurement

- Shower Max Detector : Reconstruct a neutron X-Y position using shower profile

  -Position calculation : $\frac{\sum_{i=1}^{\#\text{hit SMD}} (\text{smd energy})_i \times (\text{smd position})_i}{\sum_i (\text{smd energy})_i}$

SMD composition and principle



- SMD is composed of 15 block bar scintillators
  - 7 horizontal detector
  - 8 vertical detector

- When particle go through a detector, particle deposit energy.
  The energy is changed
  charge(Q) -> amplify(gain) -> ADC

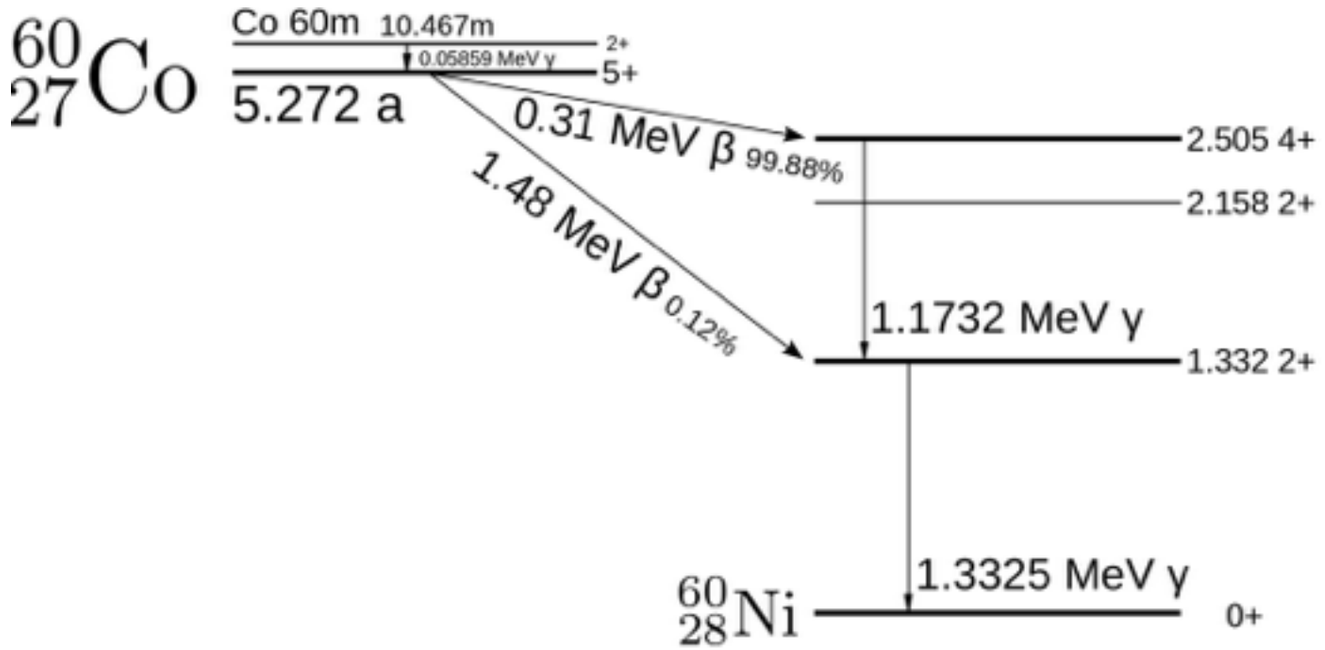
  $$Q * gain = ADC$$

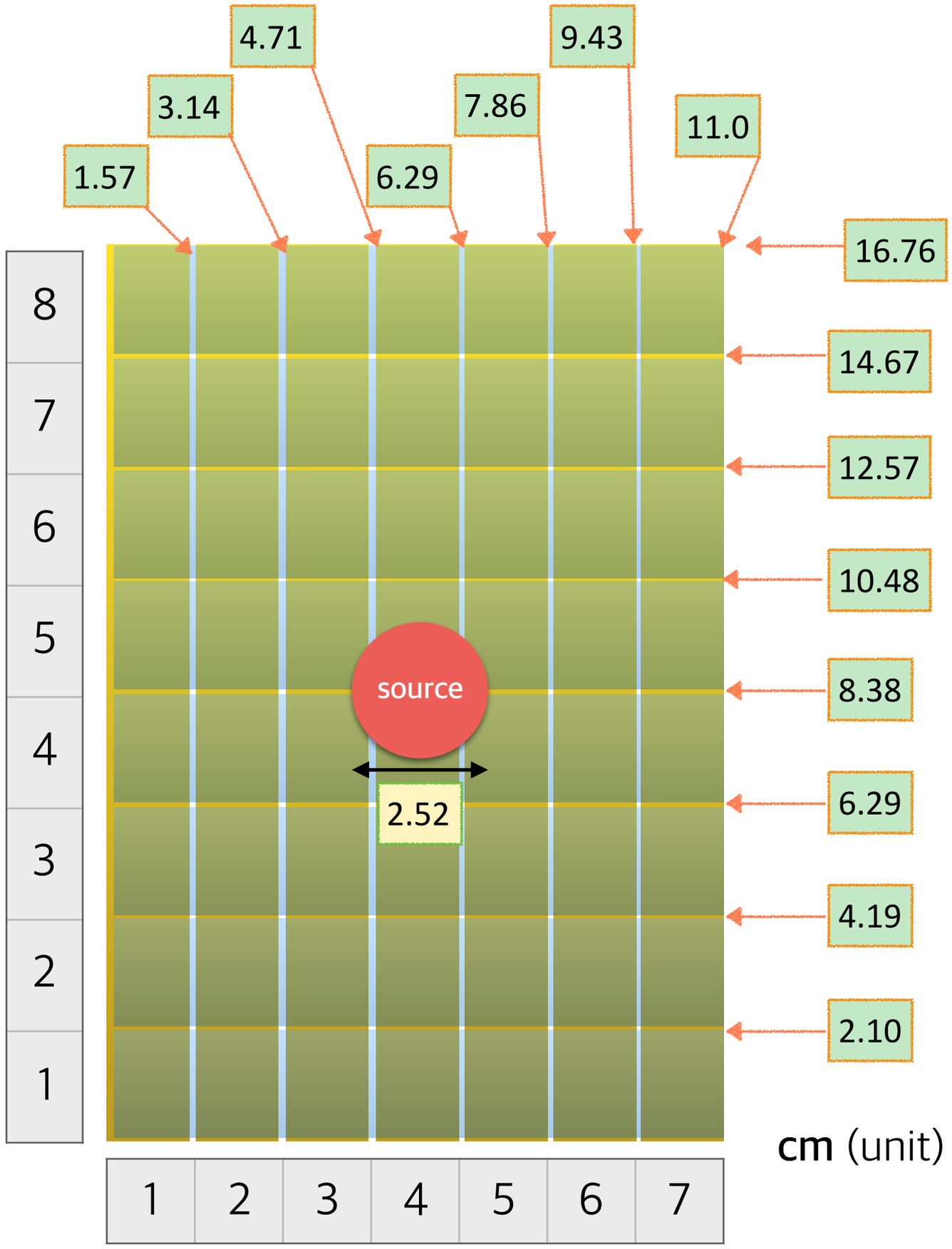
- This is why We have to match gain.

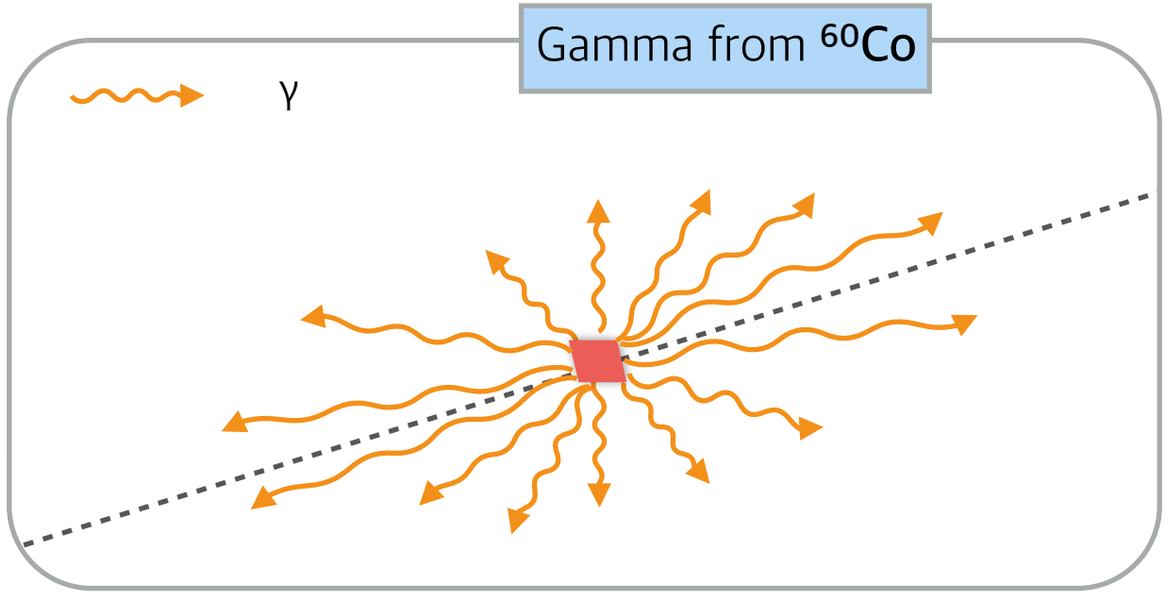
Experimental information

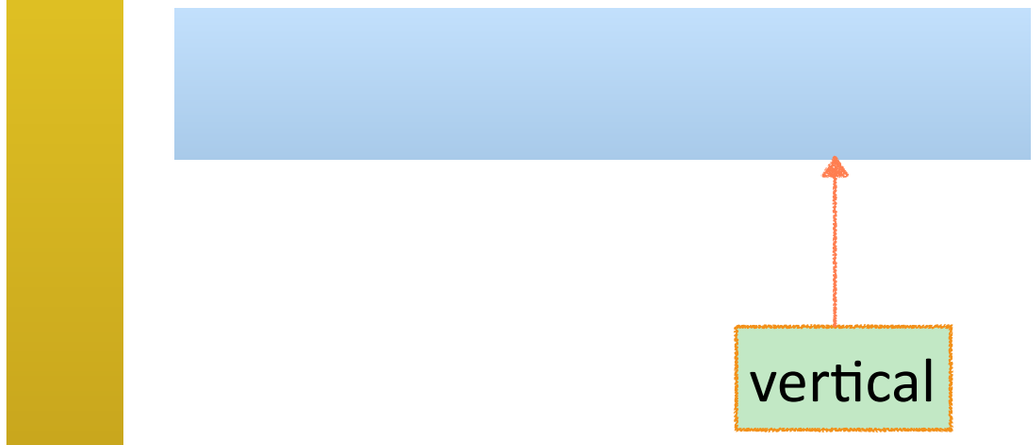
- SMD is compose of 2 layers (vertical and horizontal)
- We only test horizontal detectors.
- SMD horizontal detectors are compose of 7 detectors.
- We take ~1000events at each detectors.

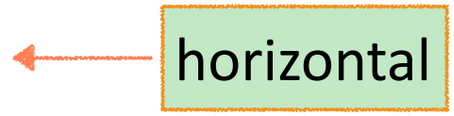
Source	Decay particle	Decay energy (MeV)
^{60}Co	γ	1.173, 1.332



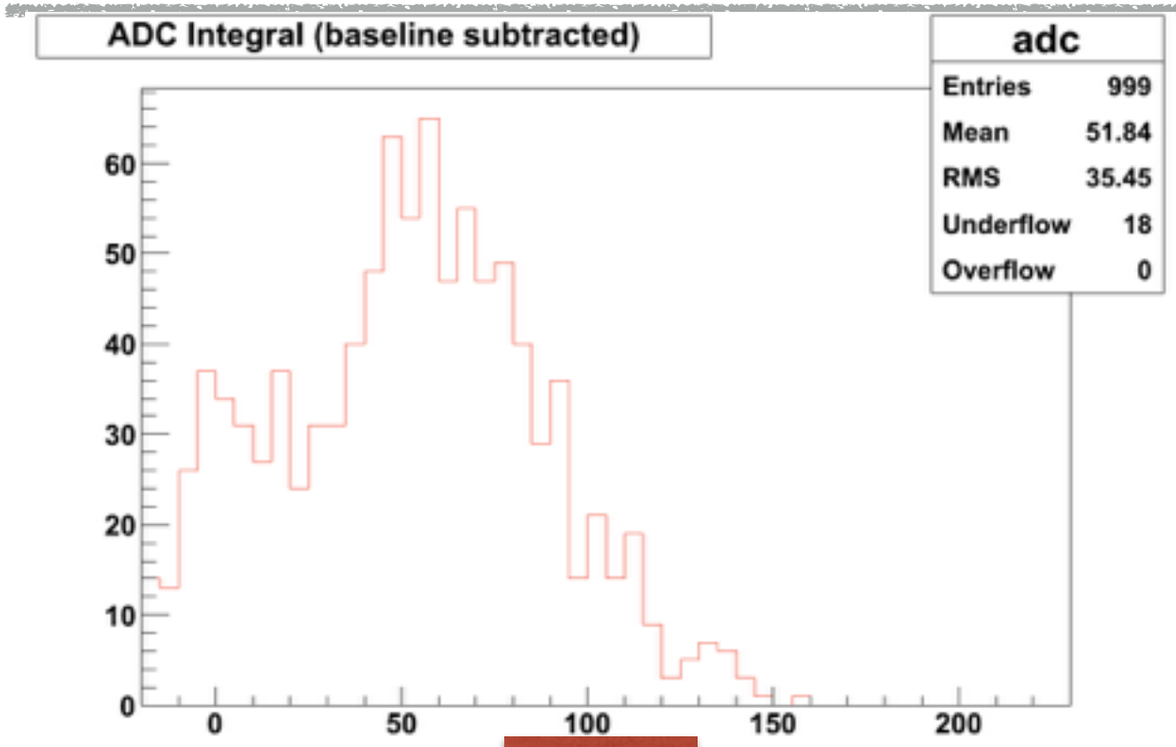

4.71
3.14
1.57
9.43
7.86
6.29
11.0
16.76
14.67
12.57
10.48
8.38
6.29
4.19
2.10
source
2.52
8
7
6
5
4
3
2
1
1
2
3
4
5
6
7
cm (unit)


Gamma from 60Co
γ

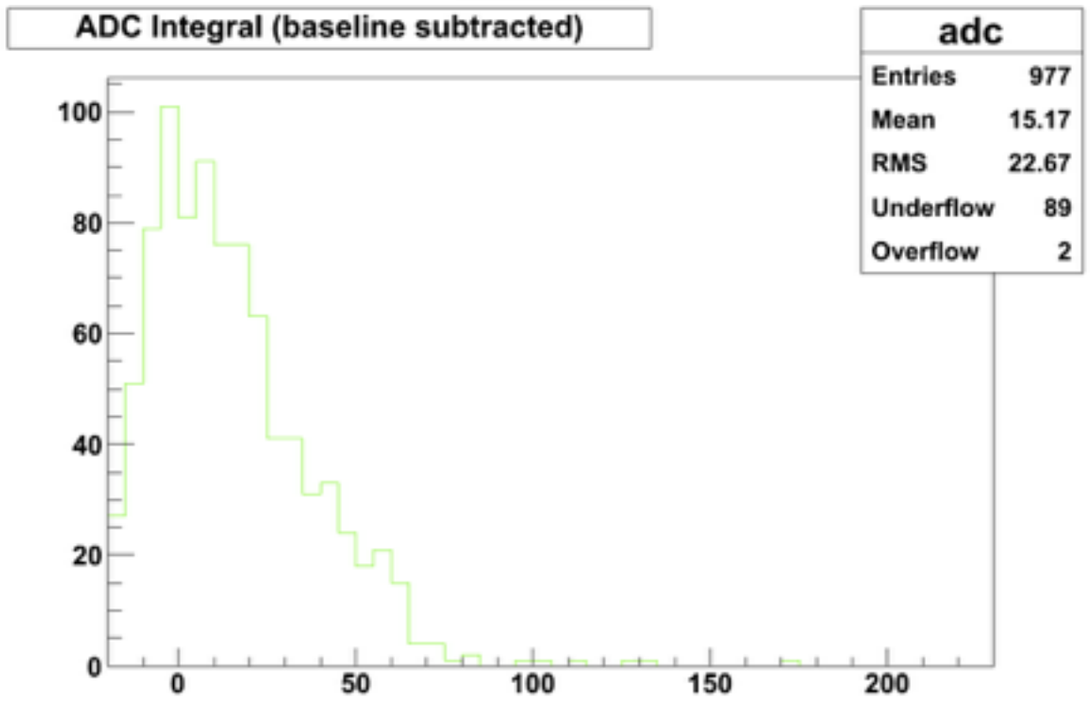

vertical


horizontal

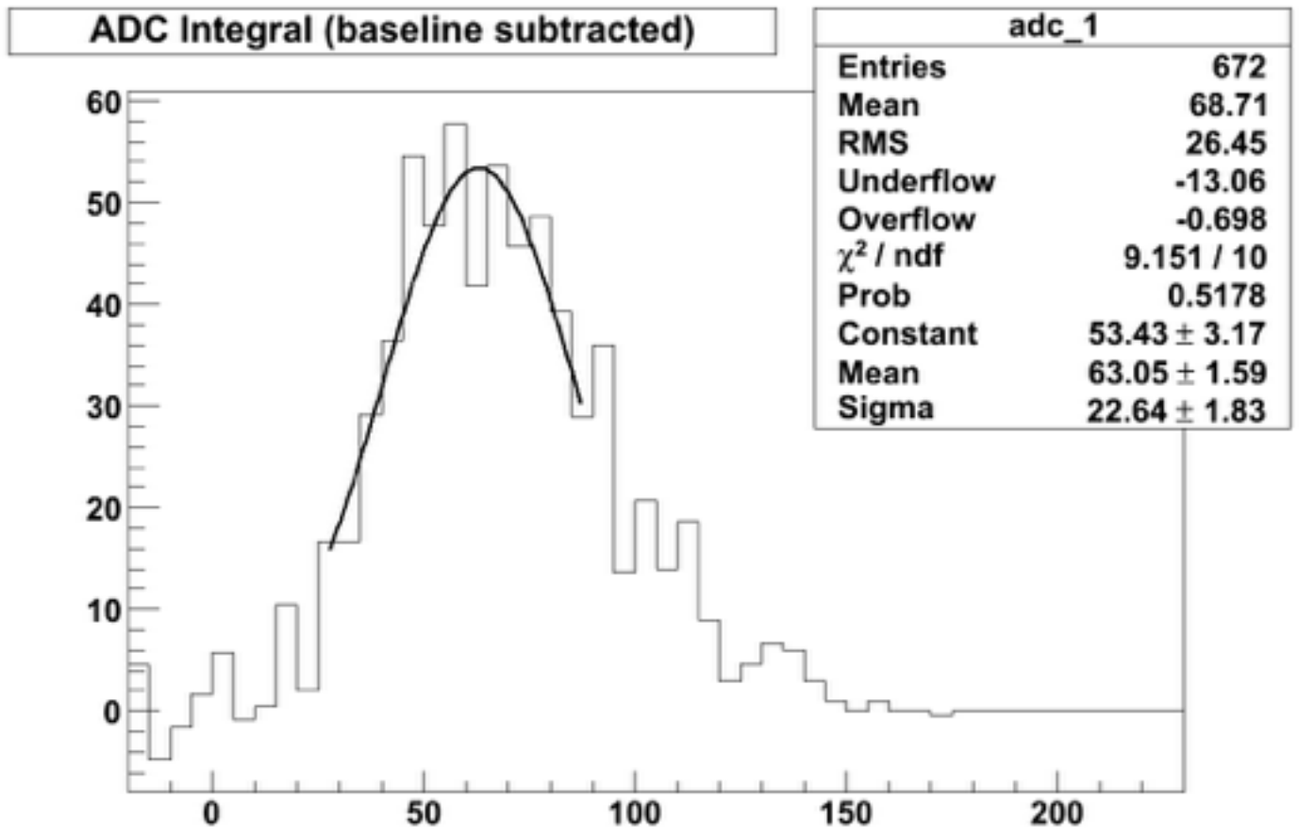
Gain calculation



source



cosmic

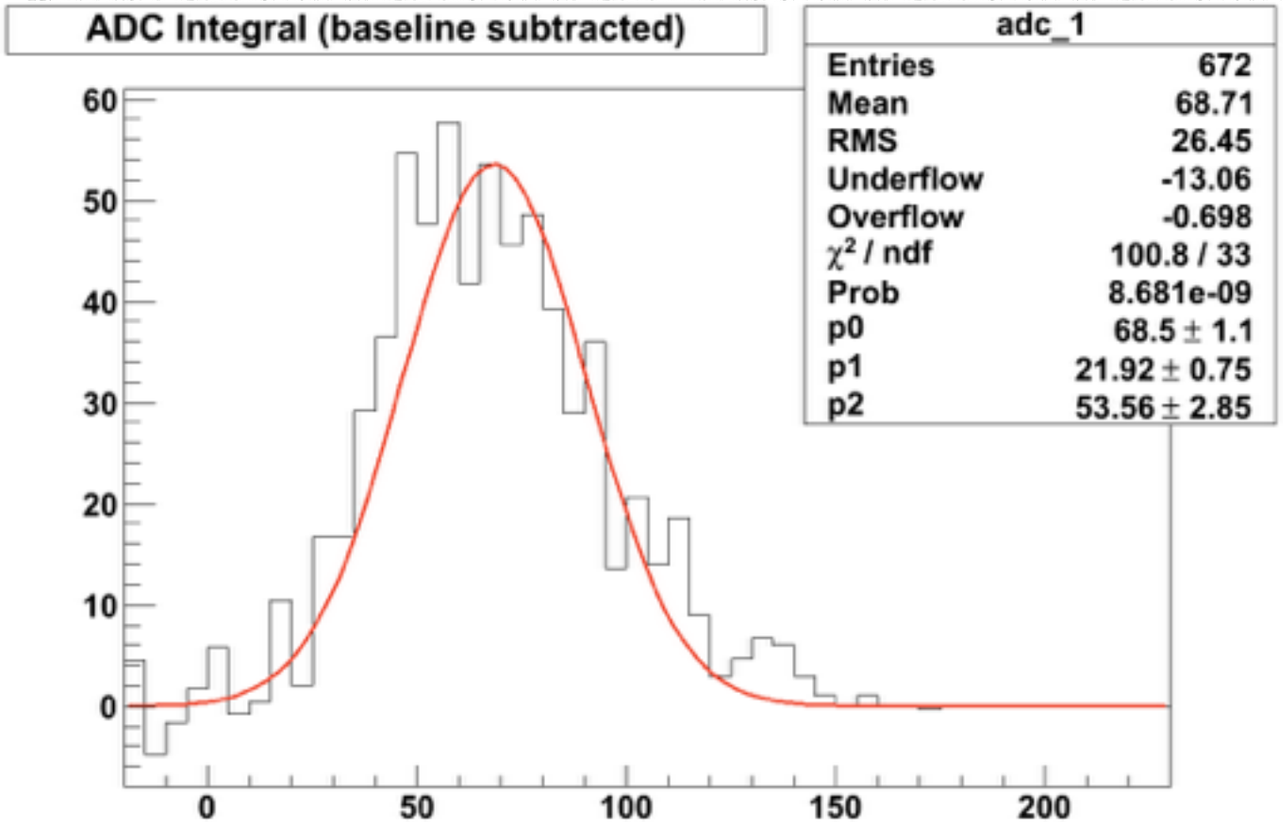


subtraction result

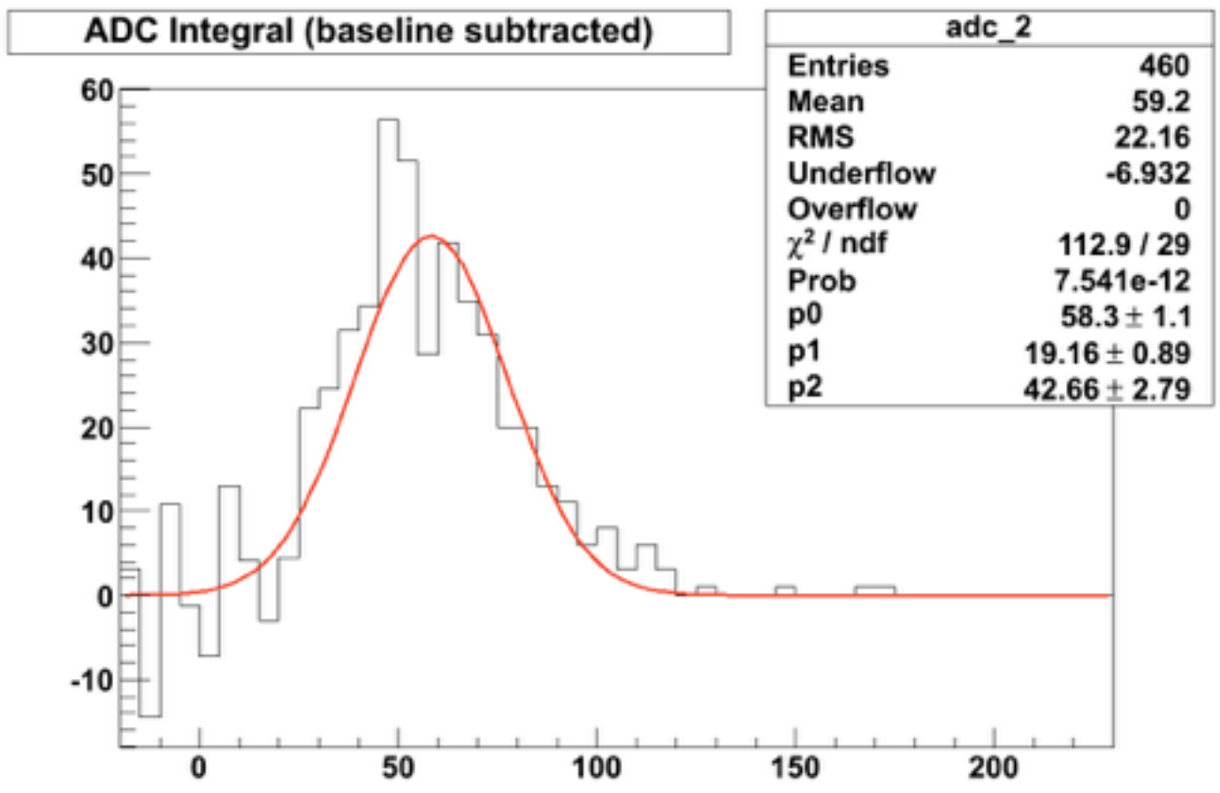
Source - (ratio * Cosmic) = Subtraction result

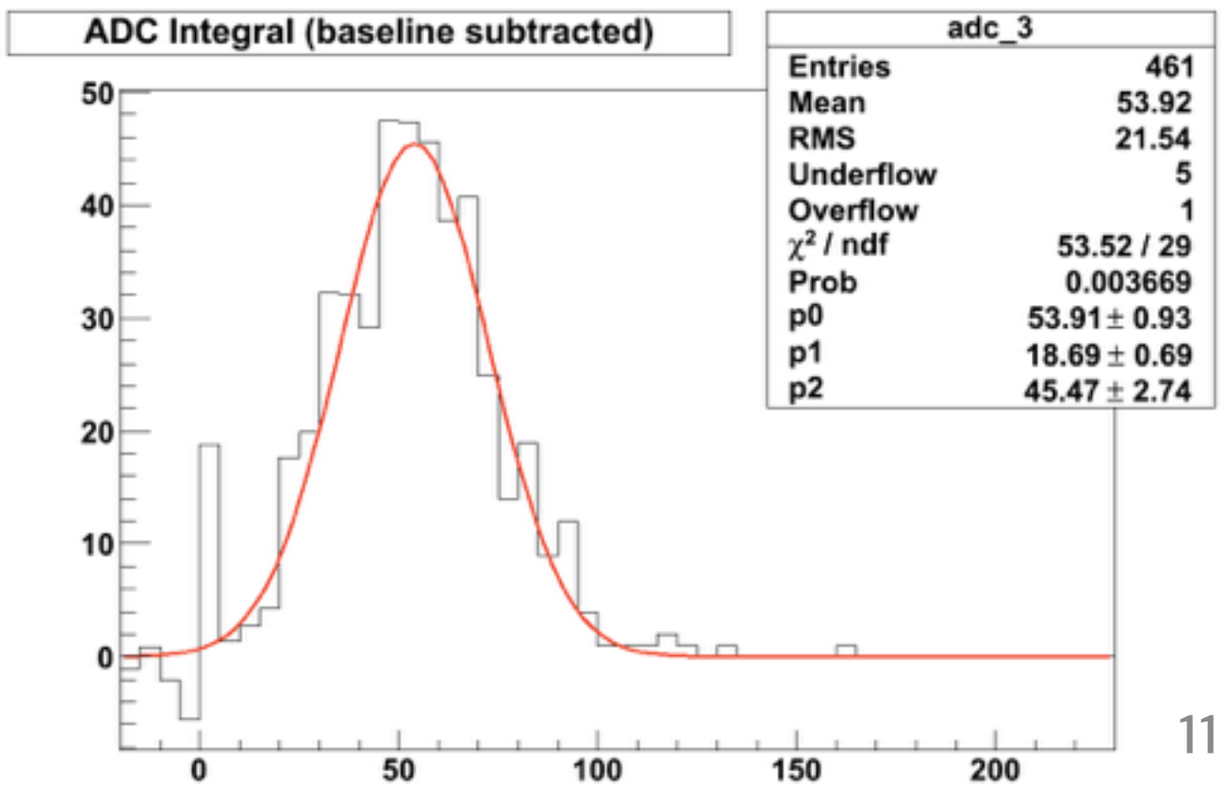
Detector 1

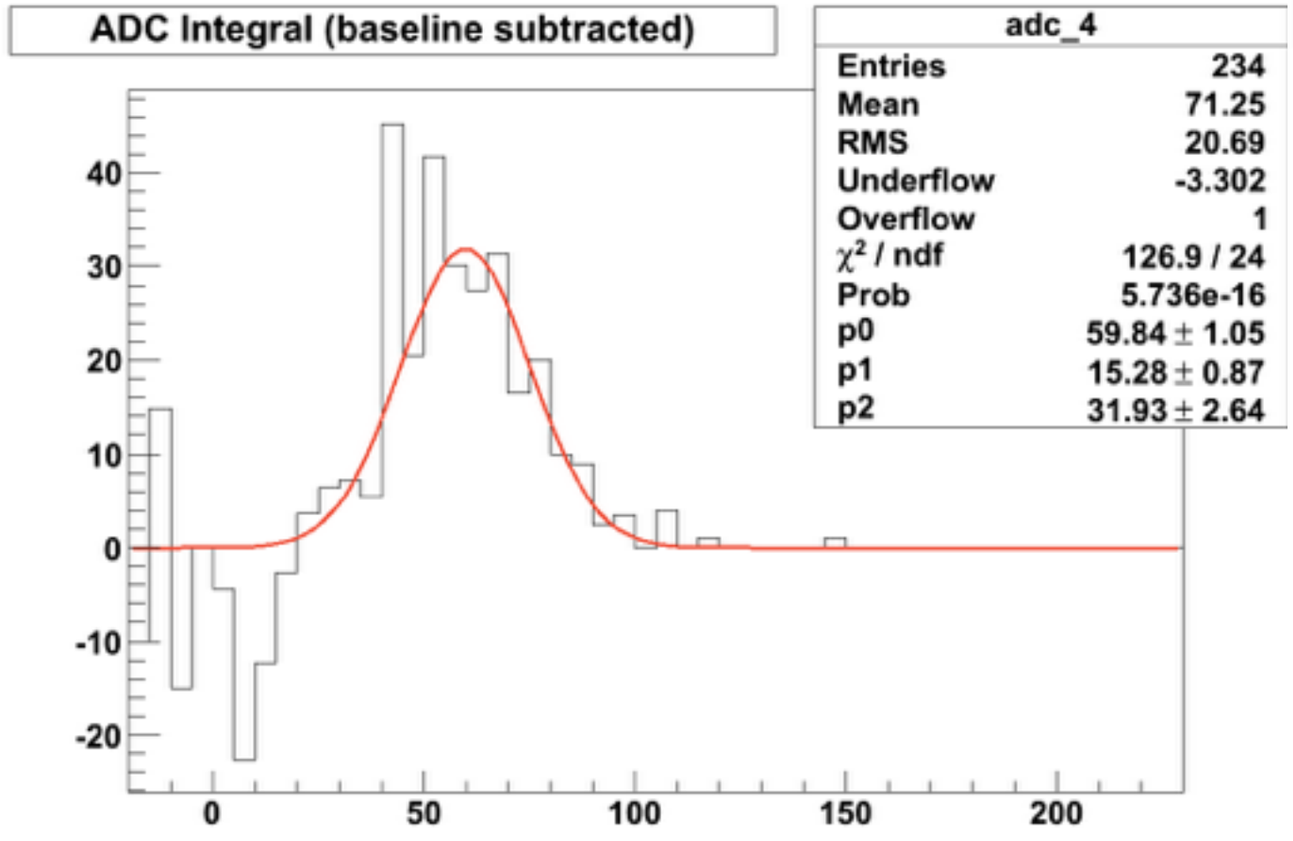
Gaussian fitting

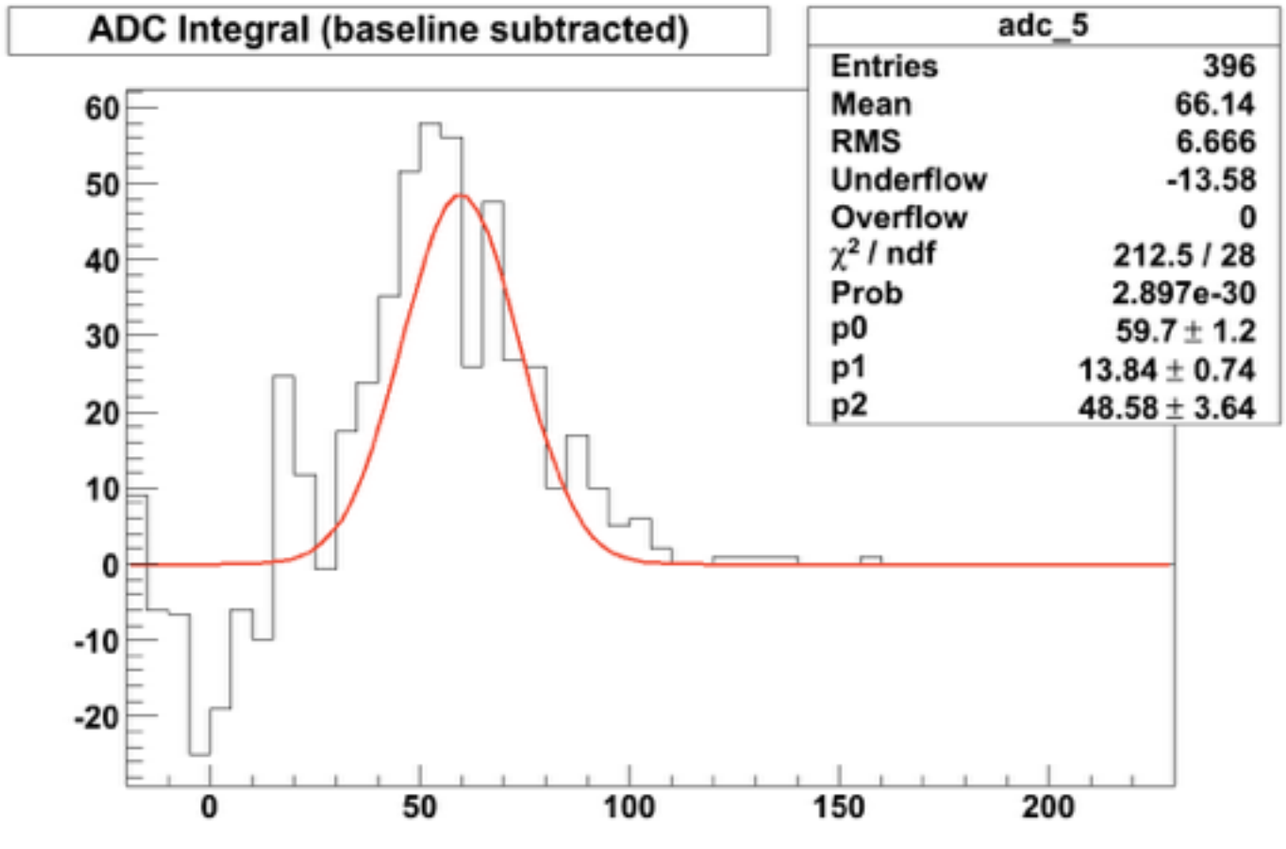


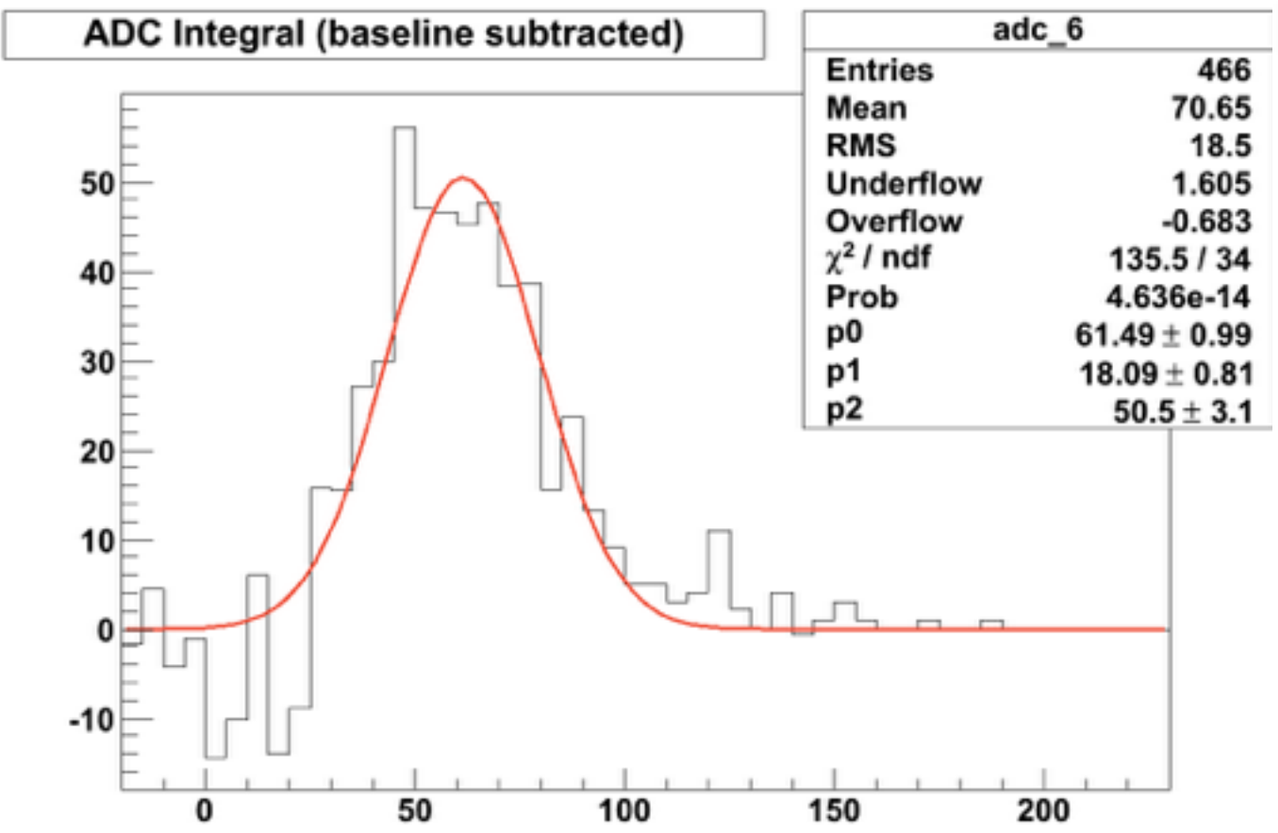
Parameters	explain
P0 (gain)	Gaussian Mean Value
P1	Gaussian Sigma
P2	Amplitude of Gauss fit

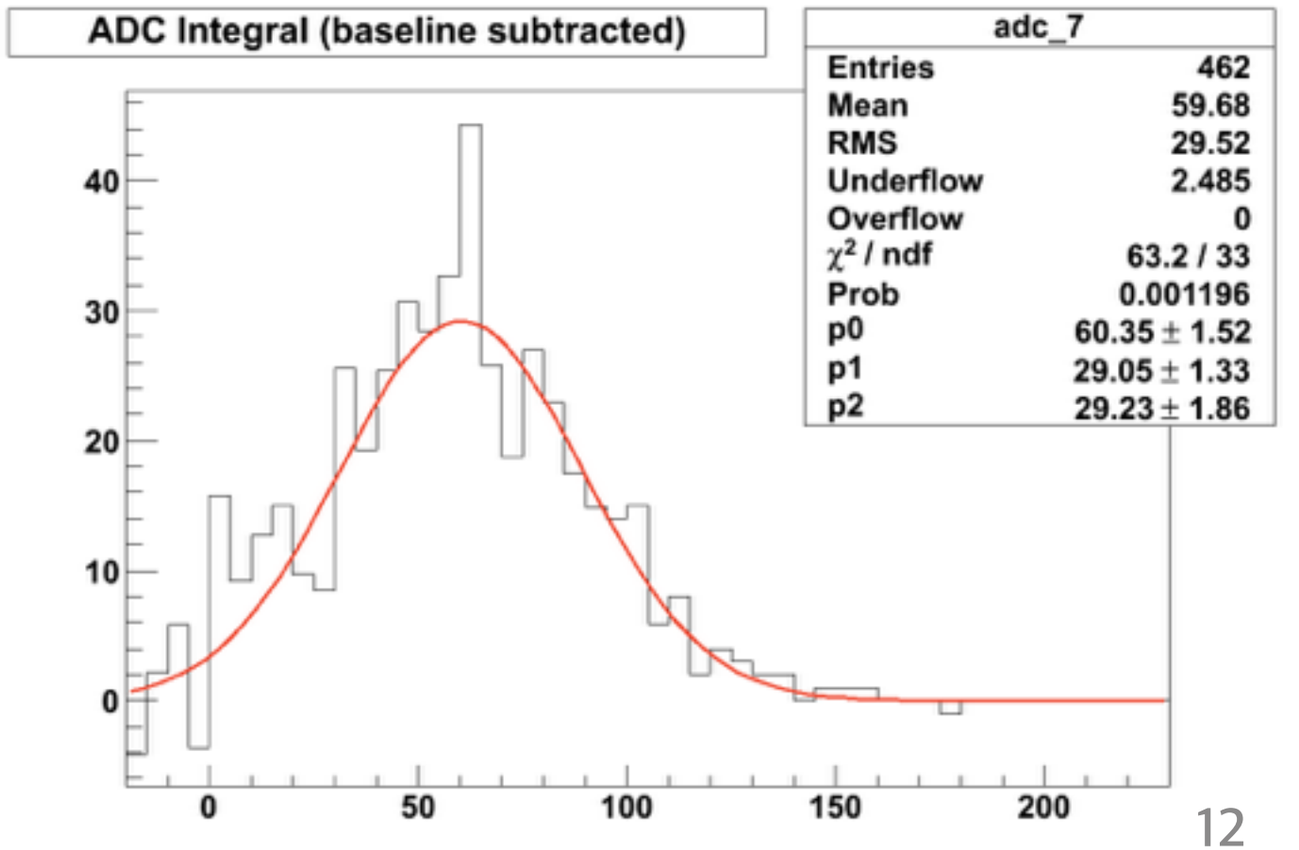





ADC Integral (baseline subtracted)
adc_4
Entries 234
Mean 71.25
RMS 20.69
Underflow -3.302
Overflow 1
χ² / ndf 126.9 / 24
Prob 5.736e-16
p0 59.84 ± 1.05
p1 15.28 ± 0.87
p2 31.93 ± 2.64


ADC Integral (baseline subtracted)
adc_5
Entries 396
Mean 66.14
RMS 6.666
Underflow -13.58
Overflow 0
χ² / ndf 212.5 / 28
Prob 2.897e-30
p0 59.7 ± 1.2
p1 13.84 ± 0.74
p2 48.58 ± 3.64


ADC Integral (baseline subtracted)
adc_6
Entries 466
Mean 70.65
RMS 18.5
Underflow 1.605
Overflow -0.683
χ² / ndf 135.5 / 34
Prob 4.636e-14
p0 61.49 ± 0.99
p1 18.09 ± 0.81
p2 50.5 ± 3.1


ADC Integral (baseline subtracted)
adc_7
Entries 462
Mean 59.68
RMS 29.52
Underflow 2.485
Overflow 0
χ² / ndf 63.2 / 33
Prob 0.001196
p0 60.35 ± 1.52
p1 29.05 ± 1.33
p2 29.23 ± 1.86

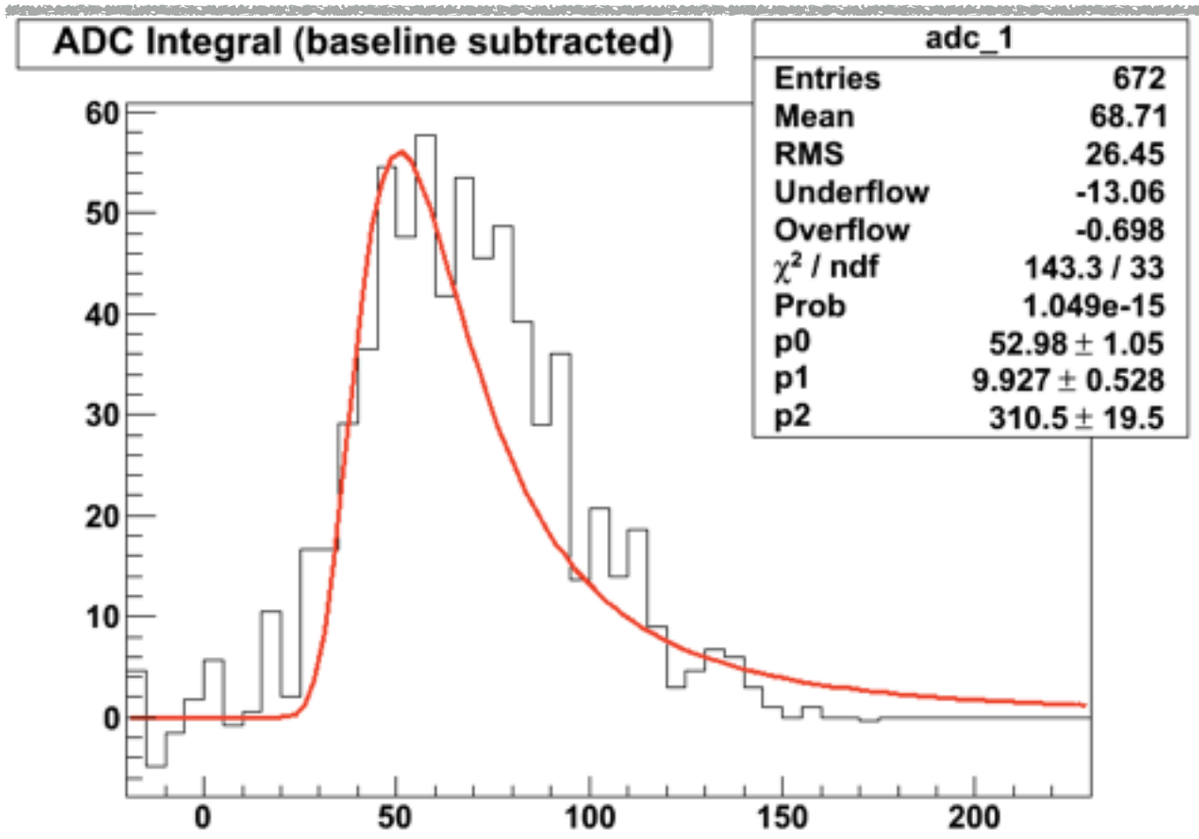
Gain from Gaussian fitting

	D1	D2	D3	D4	D5	D6	D7
Mean	68.5	58.3	53.91	59.84	59.7	61.49	60.35
χ^2 /ndf	3.055	3.893	1.846	5.288	7.589	3.985	1.920

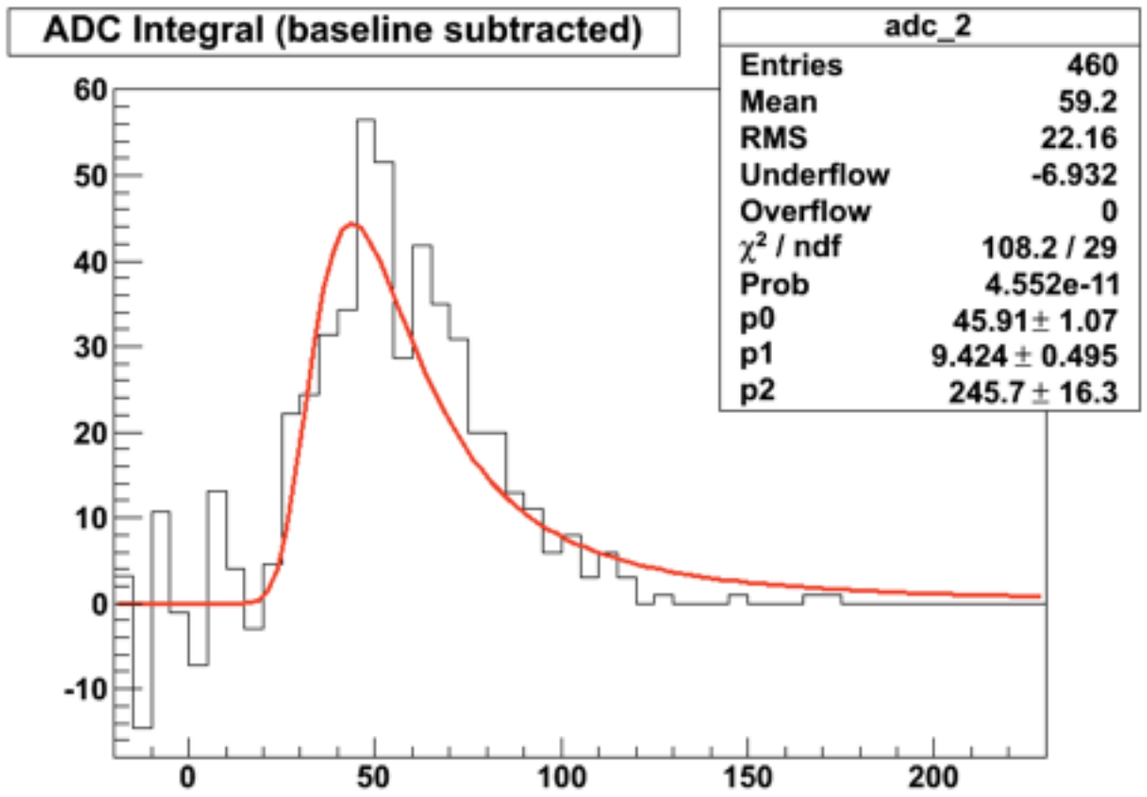
Normalize

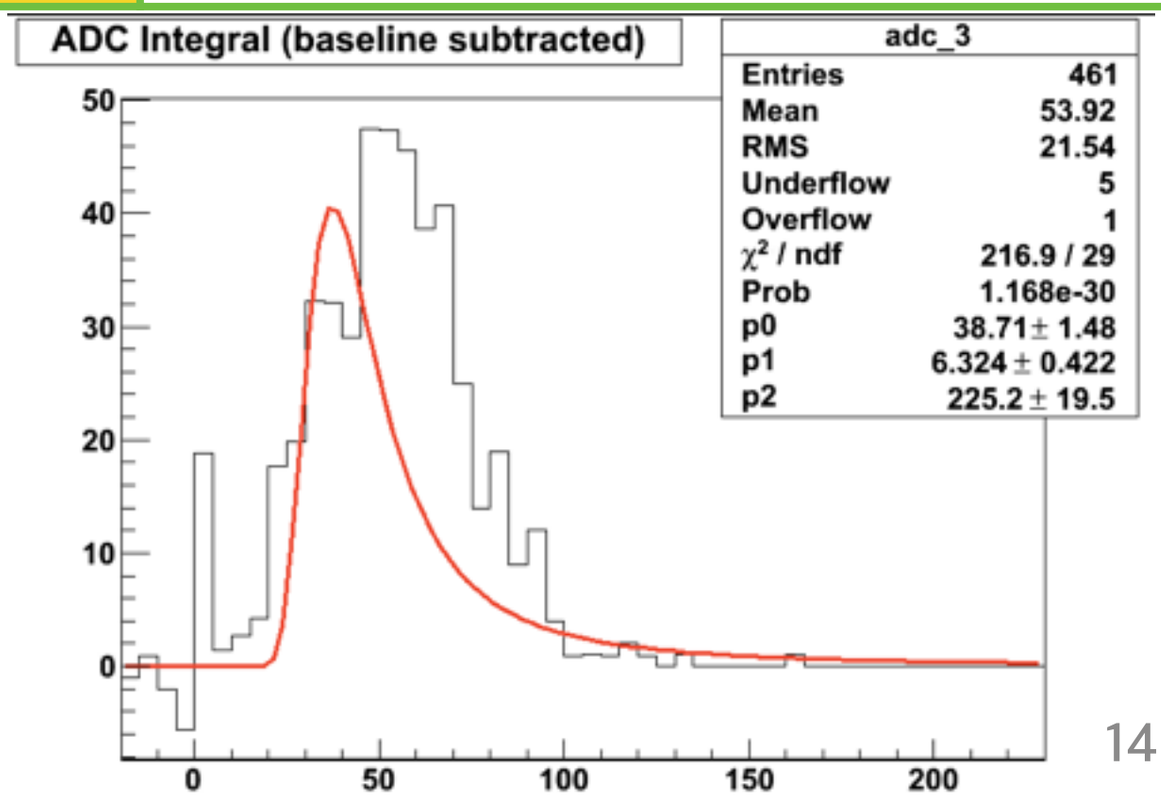
	D1	D2	D3	D4	D5	D6	D7
Mean	1.136	0.9668	0.894	0.9924	0.99	1.02	1.001
χ^2 /ndf	3.055	3.893	1.846	5.288	7.589	3.985	1.920

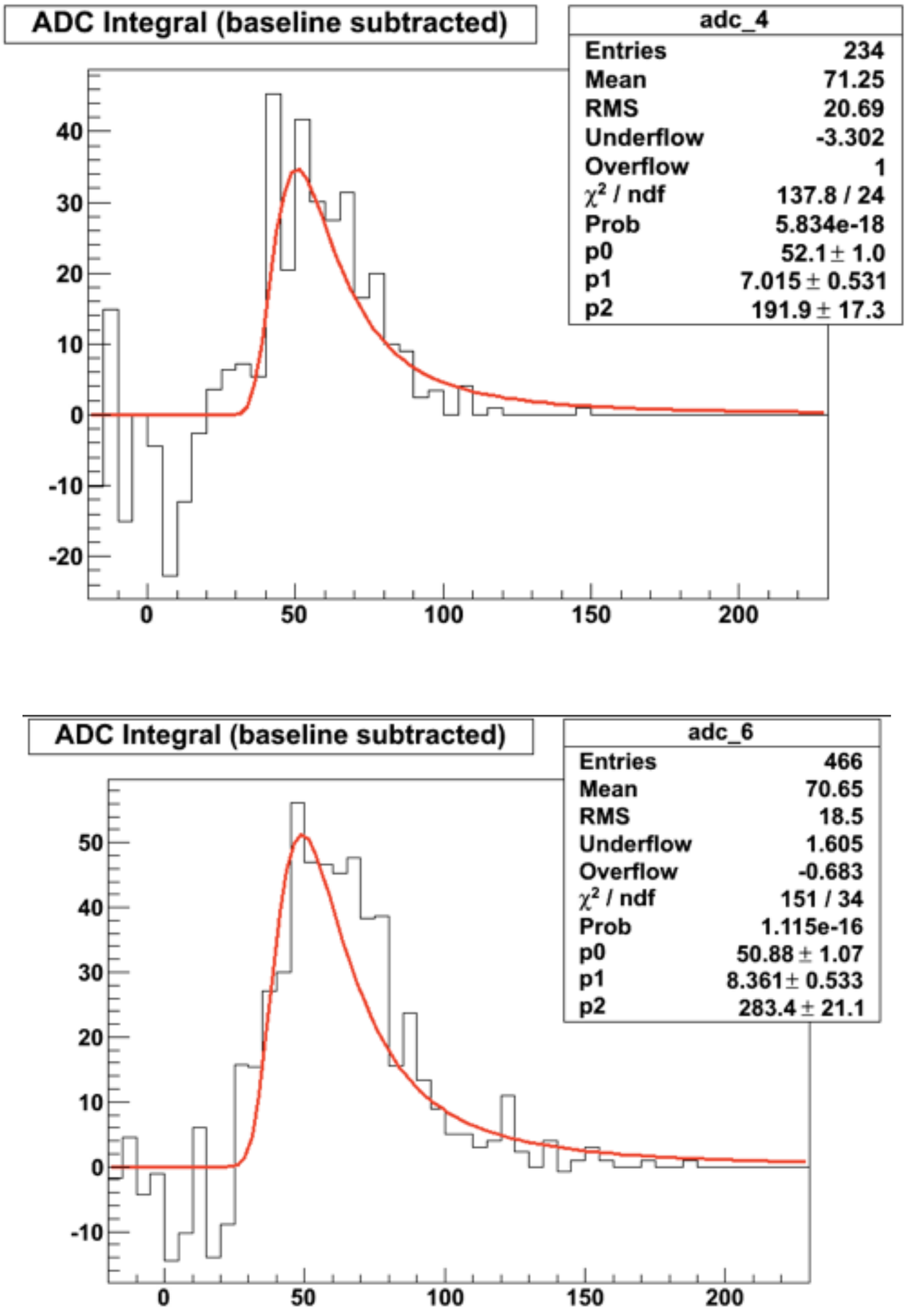
Landau fitting

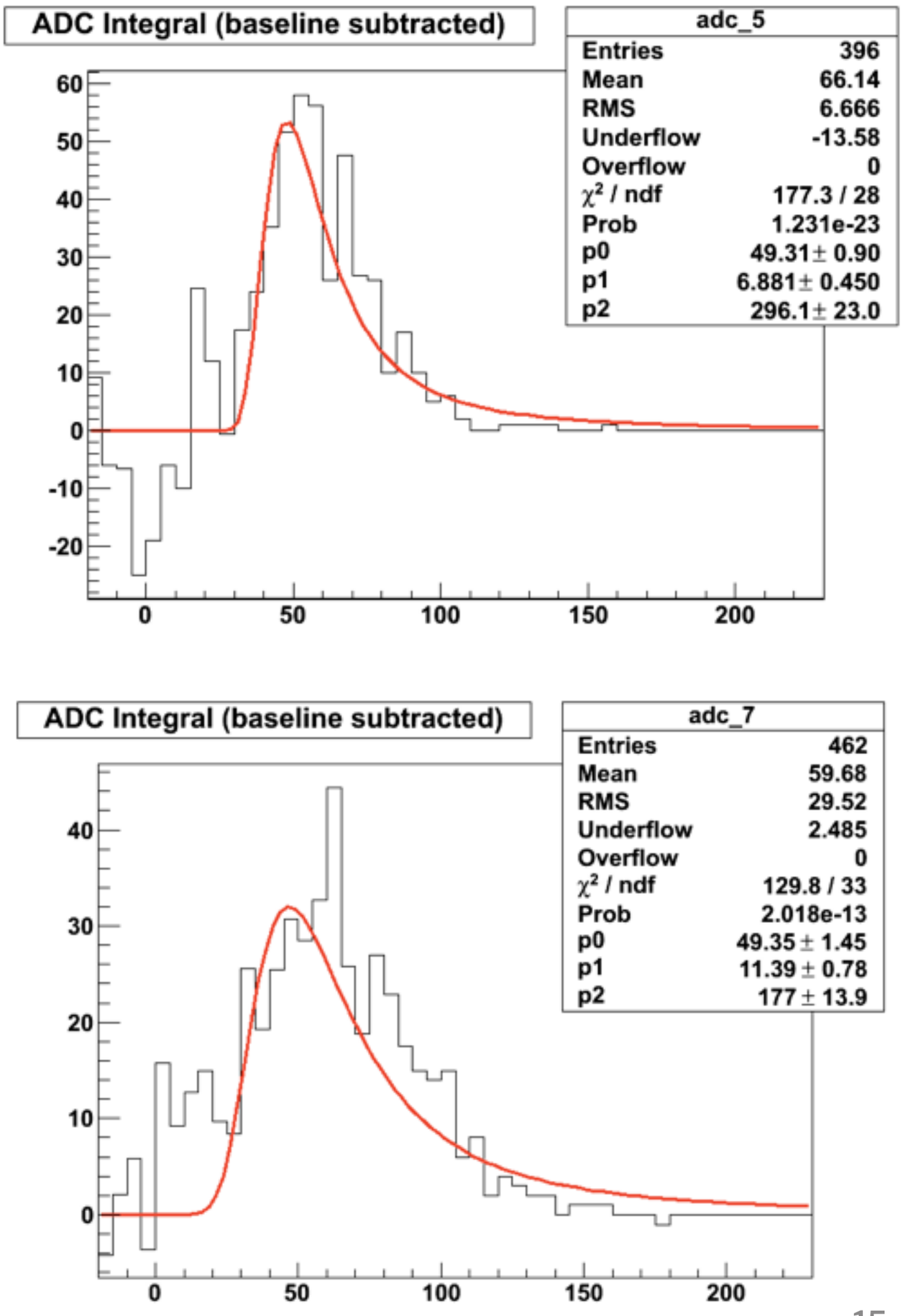


Parameters	explain
P0 (gain)	Mean value of Bethe-Bloch energy loss (Relativistic Gain)
P1	Landau Width (according to sigma in gauss distribution)
P2	Amplitude of landau fit






ADC Integral (baseline subtracted)
adc_4
Entries 234
Mean 71.25
RMS 20.69
Underflow -3.302
Overflow 1
χ² / ndf 137.8 / 24
Prob 5.834e-18
p0 52.1 ± 1.0
p1 7.015 ± 0.531
p2 191.9 ± 17.3


ADC Integral (baseline subtracted)
adc_5
Entries 396
Mean 66.14
RMS 6.666
Underflow -13.58
Overflow 0
χ² / ndf 177.3 / 28
Prob 1.231e-23
p0 49.31 ± 0.90
p1 6.881 ± 0.450
p2 296.1 ± 23.0

ADC Integral (baseline subtracted)
adc_6
Entries 466
Mean 70.65
RMS 18.5
Underflow 1.605
Overflow -0.683
χ² / ndf 151 / 34
Prob 1.115e-16
p0 50.88 ± 1.07
p1 8.361 ± 0.533
p2 283.4 ± 21.1

ADC Integral (baseline subtracted)
adc_7
Entries 462
Mean 59.68
RMS 29.52
Underflow 2.485
Overflow 0
χ² / ndf 129.8 / 33
Prob 2.018e-13
p0 49.35 ± 1.45
p1 11.39 ± 0.78
p2 177 ± 13.9

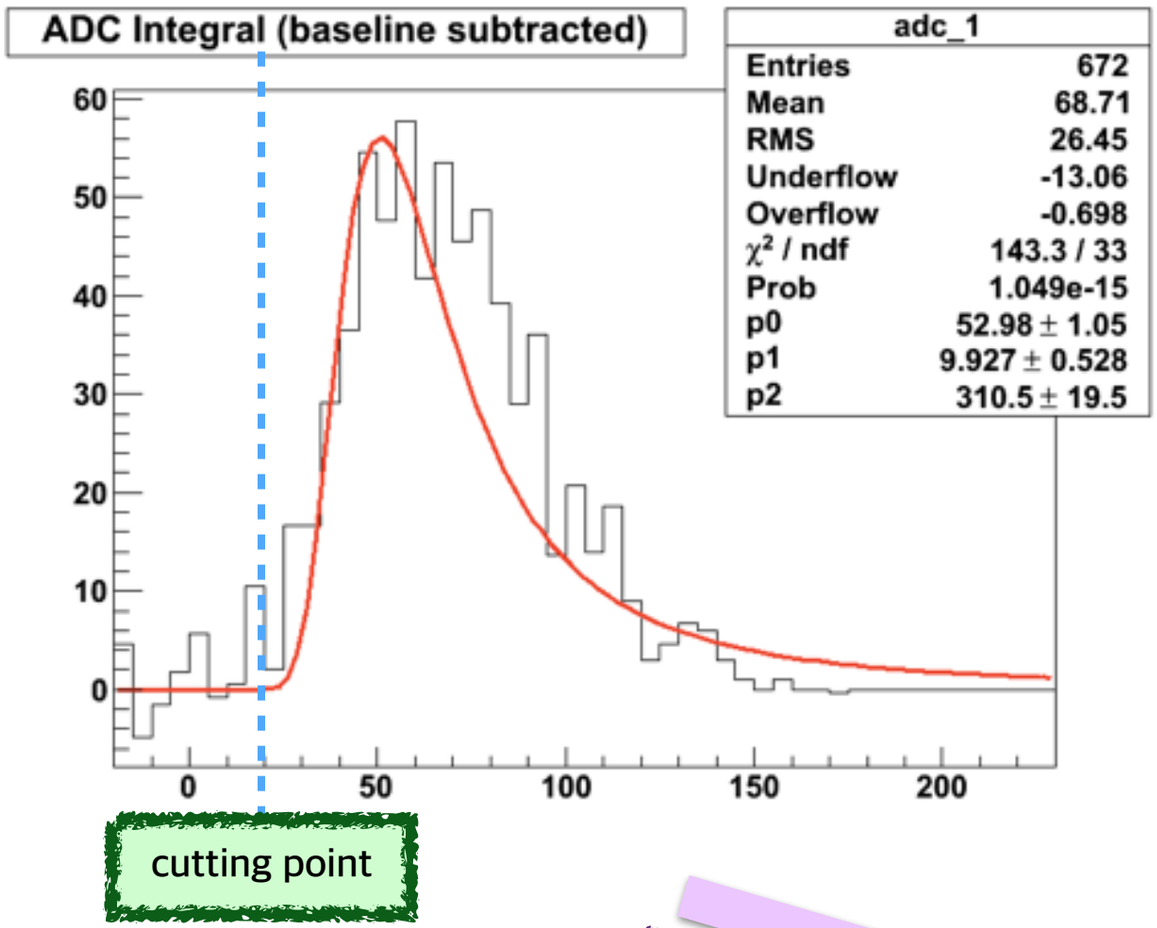
Gain from Landau fitting

	D1	D2	D3	D4	D5	D6	D7
MPV	52.98	45.91	38.71	52.1	49.31	50.88	49.35
χ^2 /ndf	4.342	3.731	7.479	5.742	6.332	4.441	3.933

Normalize

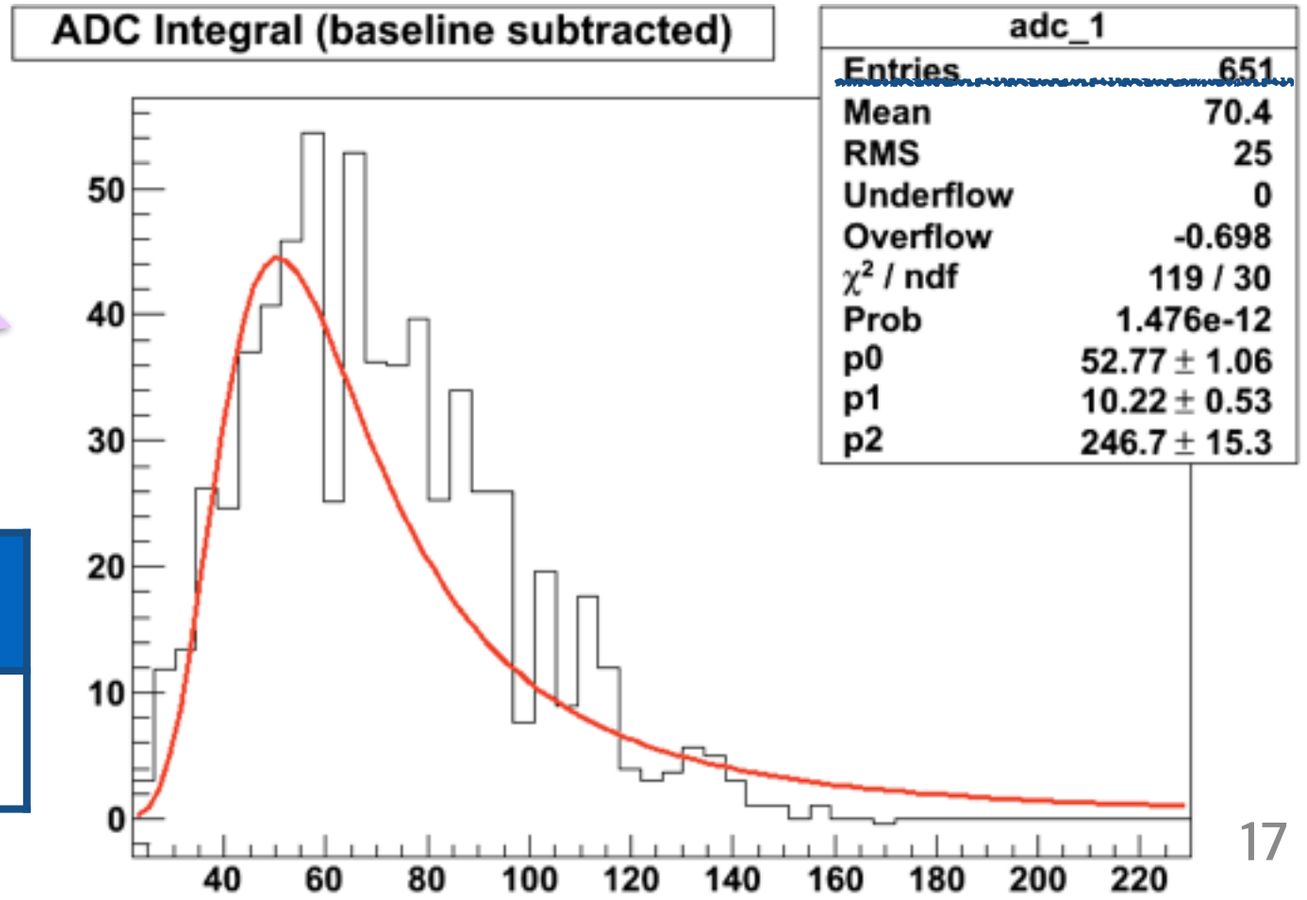
	D1	D2	D3	D4	D5	D6	D7
MPV	1.0933	0.9474	0.7988	1.075	1.018	1.05	1.018
χ^2 /ndf	4.342	3.731	7.479	5.742	6.332	4.441	3.933

Cutting method

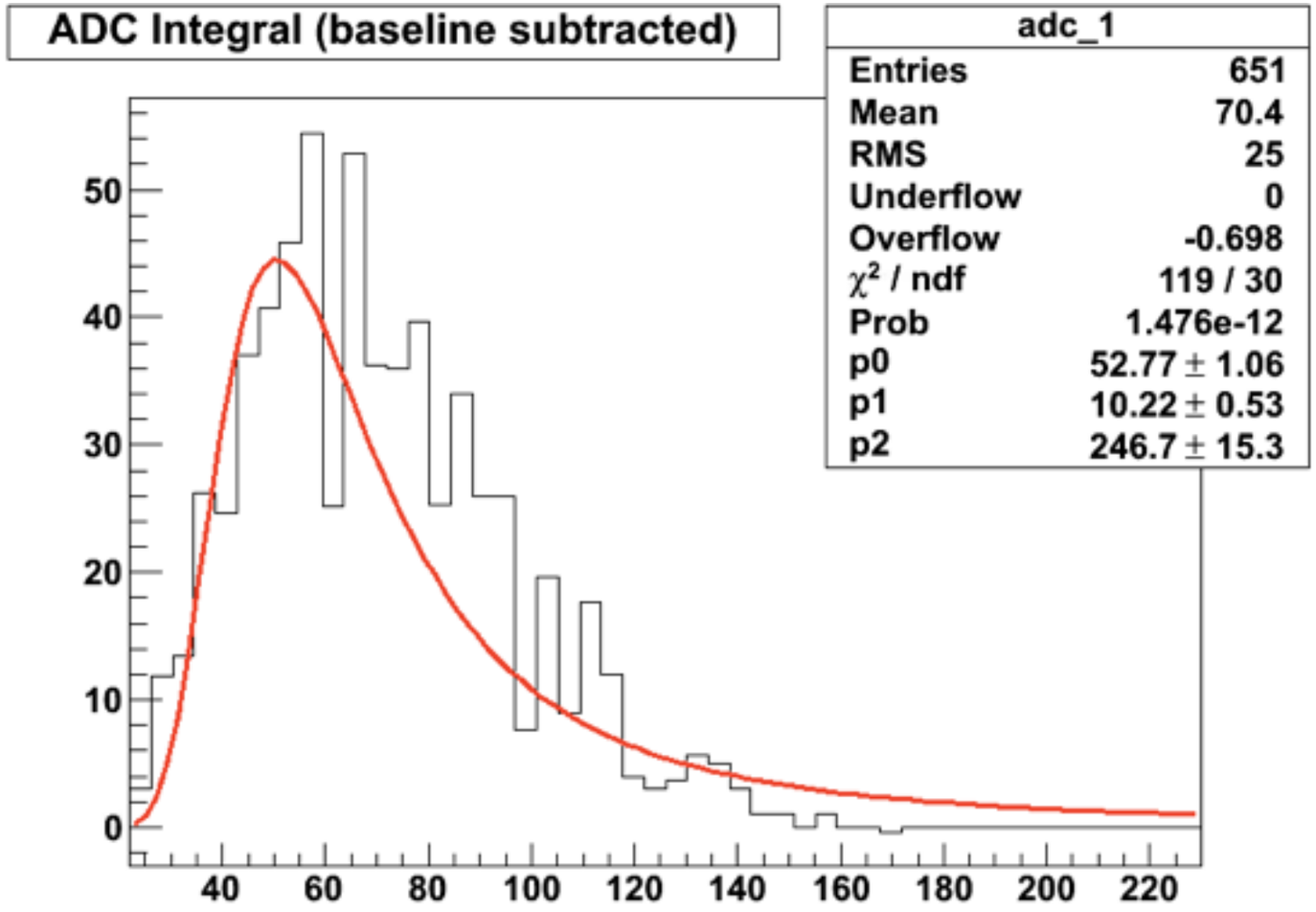


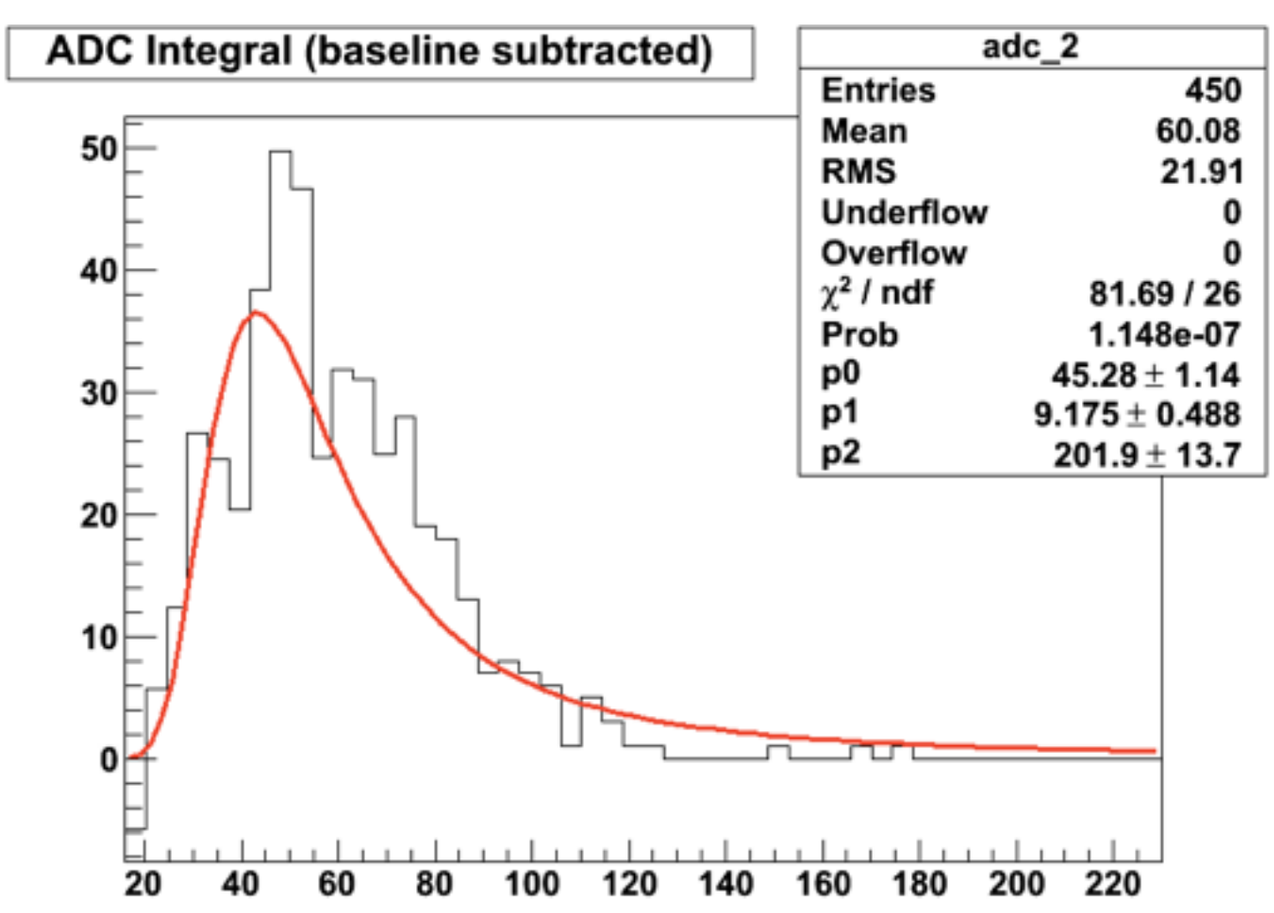
	explain
Cutting point	starting point of Landau distribution
New distribution	Get entries over cutting point
Gain	Mean values

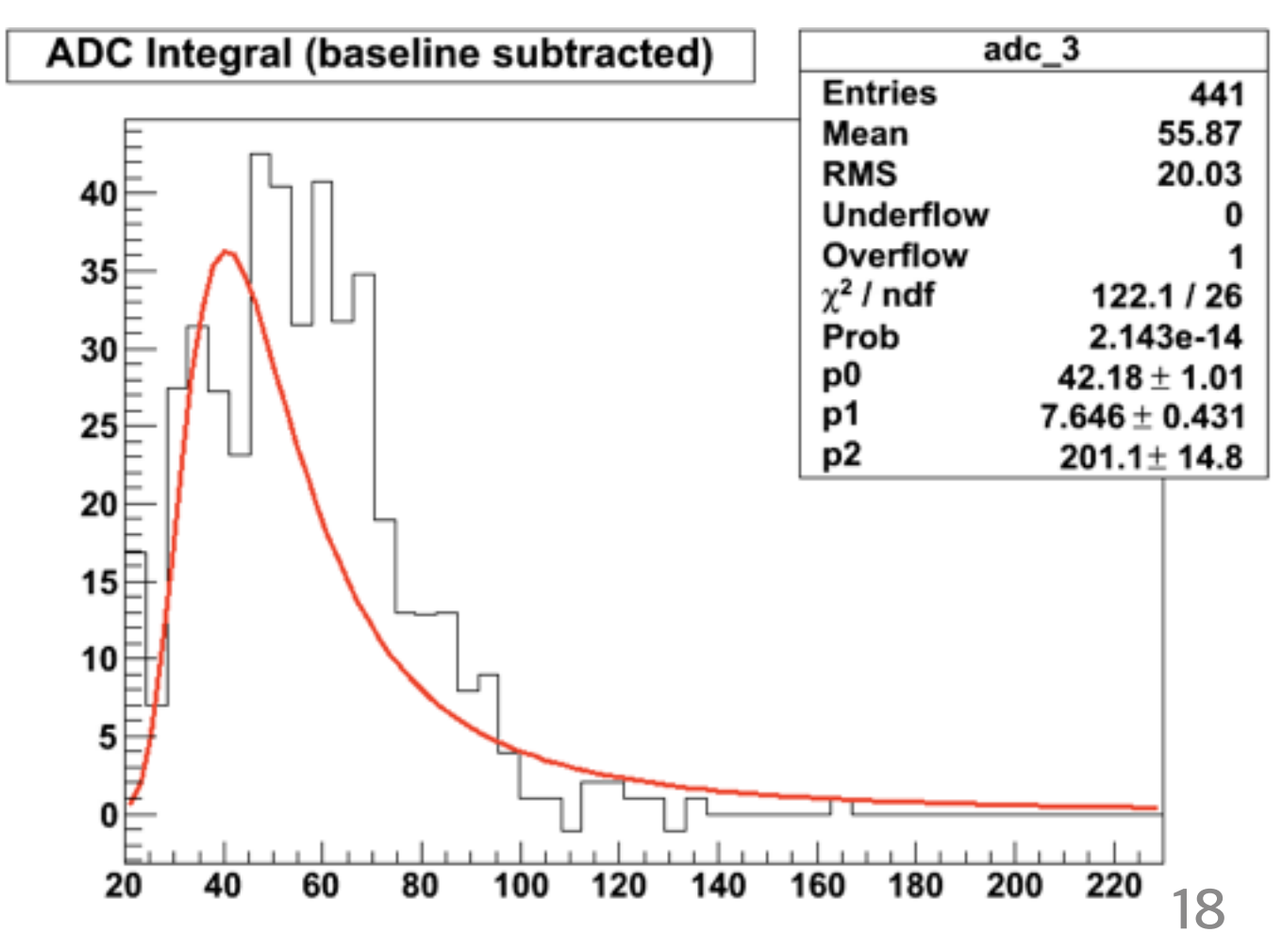
New distribution

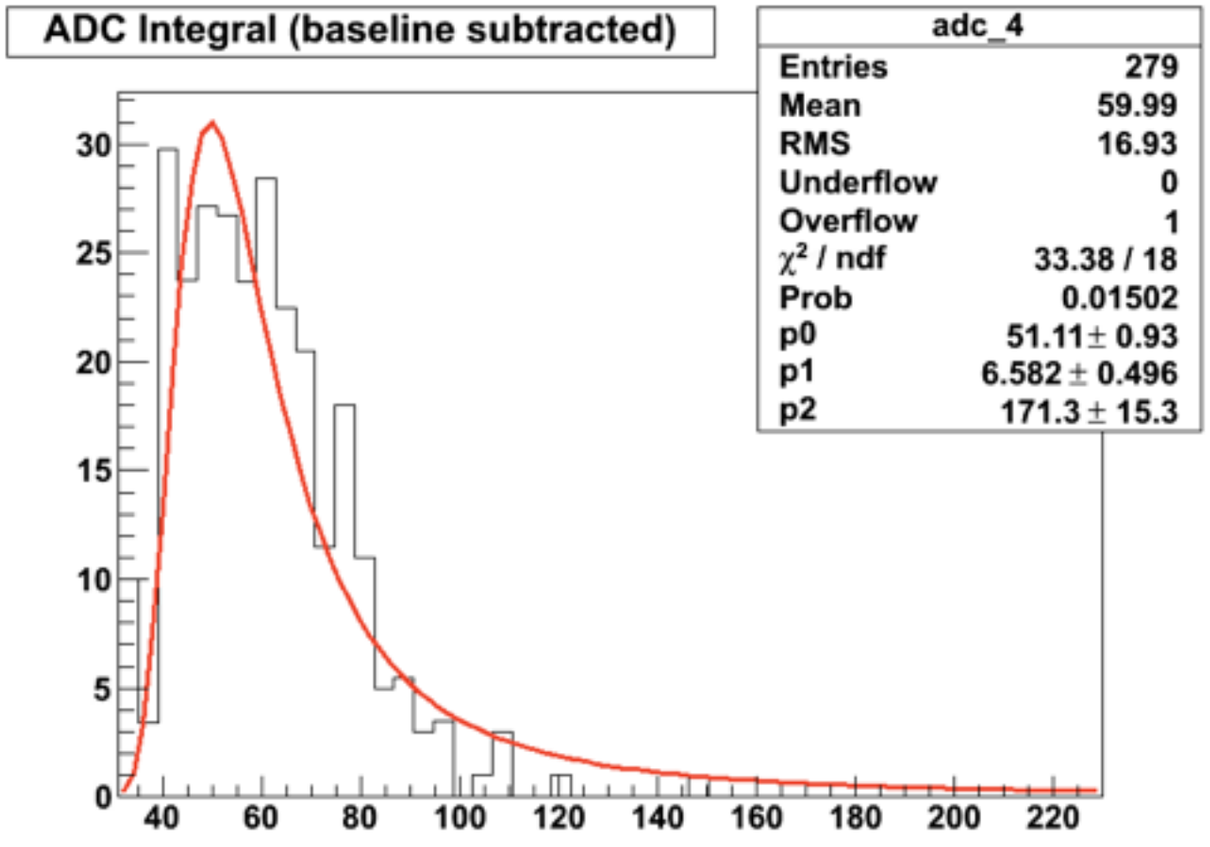


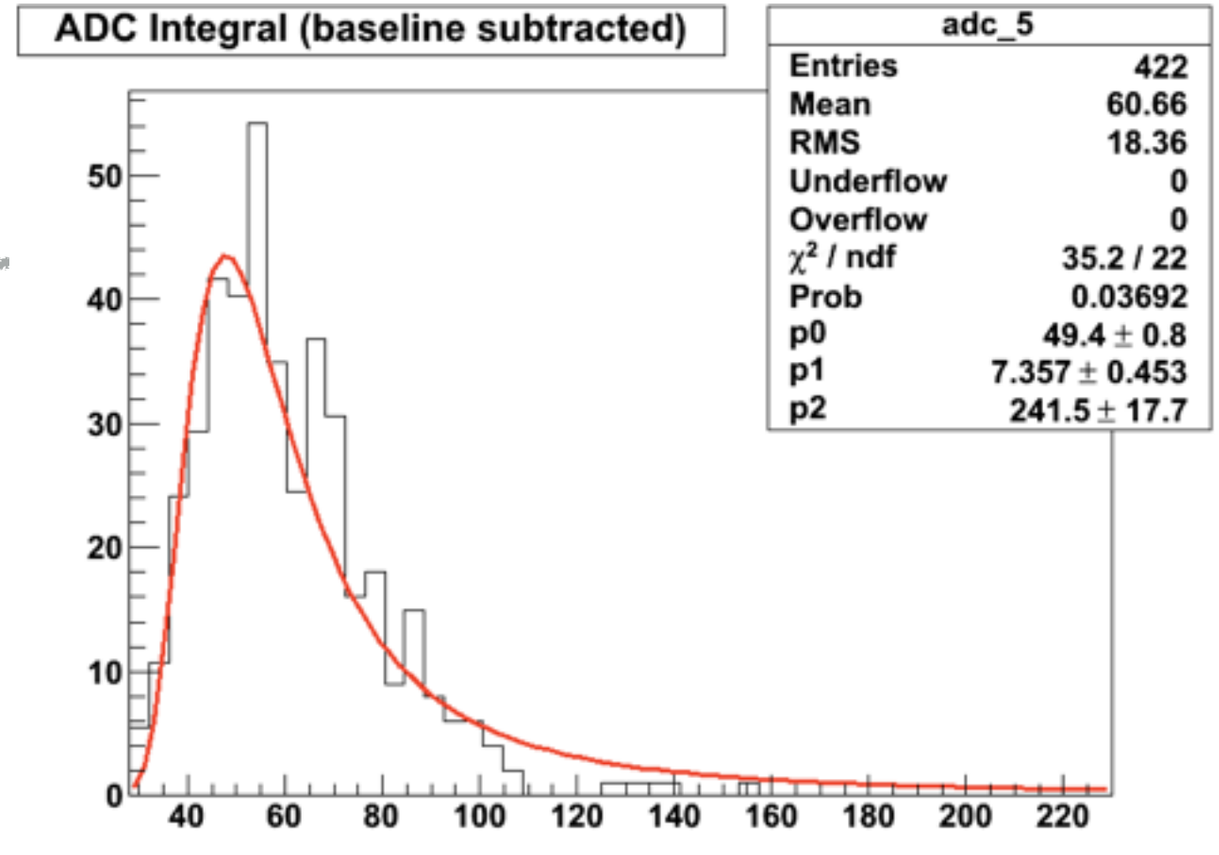
	D1	D2	D3	D4	D5	D6	D7
Cutting point	22	16	20	31	28	26	15

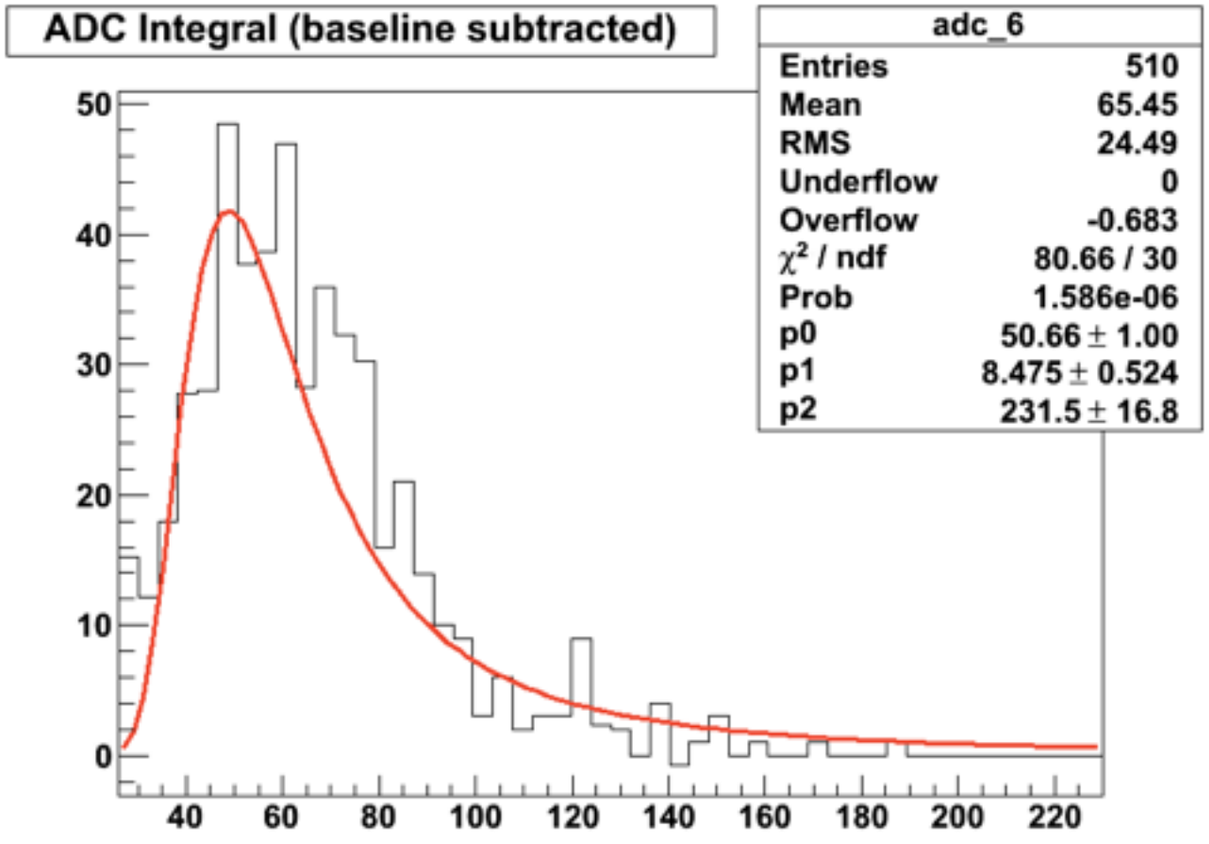

ADC Integral (baseline subtracted)
adc_1
Entries 651
Mean 70.4
RMS 25
Underflow 0
Overflow -0.698
χ² / ndf 119 / 30
Prob 1.476e-12
p0 52.77 ± 1.06
p1 10.22 ± 0.53
p2 246.7 ± 15.3

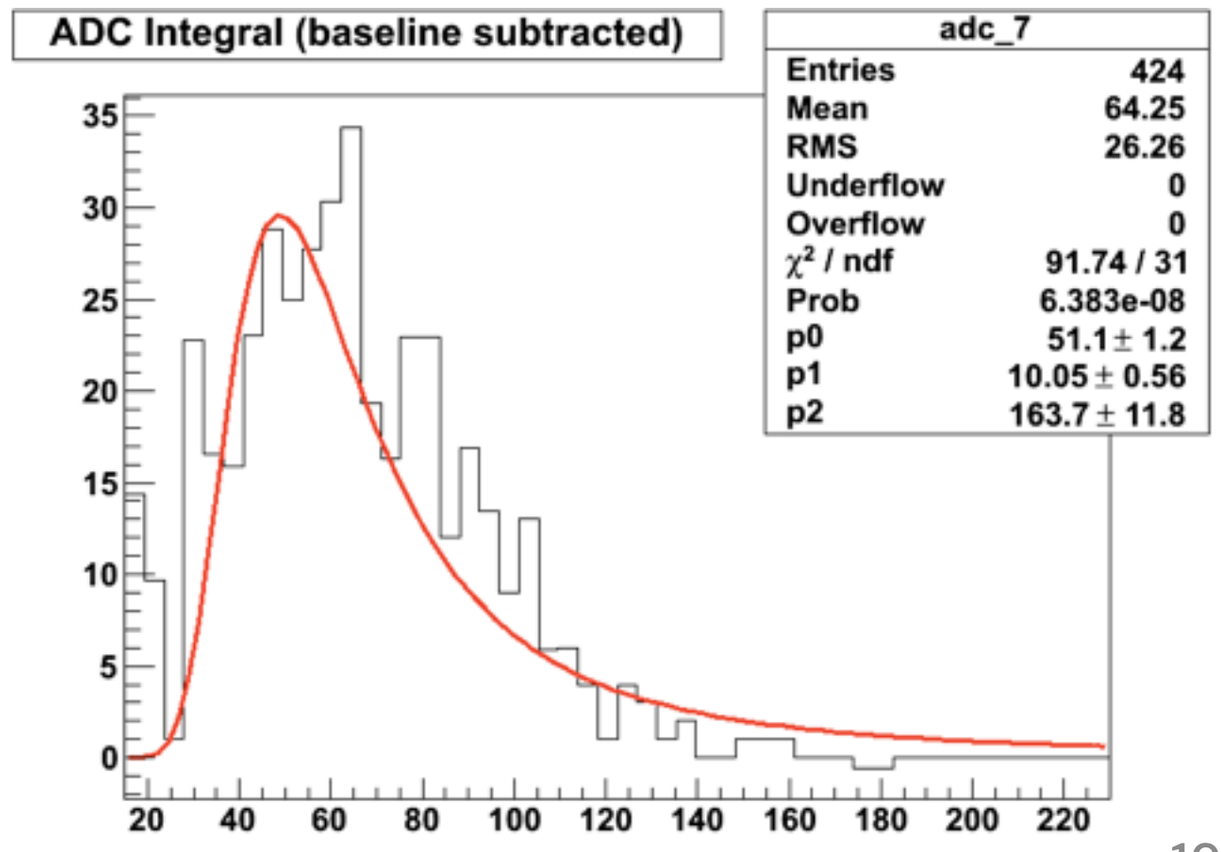

ADC Integral (baseline subtracted)
adc_2
Entries 450
Mean 60.08
RMS 21.91
Underflow 0
Overflow 0
χ² / ndf 81.69 / 26
Prob 1.148e-07
p0 45.28 ± 1.14
p1 9.175 ± 0.488
p2 201.9 ± 13.7


ADC Integral (baseline subtracted)
adc_3
Entries 441
Mean 55.87
RMS 20.03
Underflow 0
Overflow 1
χ² / ndf 122.1 / 26
Prob 2.143e-14
p0 42.18 ± 1.01
p1 7.646 ± 0.431
p2 201.1 ± 14.8


ADC Integral (baseline subtracted)
adc_4
Entries 279
Mean 59.99
RMS 16.93
Underflow 0
Overflow 1
χ² / ndf 33.38 / 18
Prob 0.01502
p0 51.11 ± 0.93
p1 6.582 ± 0.496
p2 171.3 ± 15.3


ADC Integral (baseline subtracted)
adc_5
Entries 422
Mean 60.66
RMS 18.36
Underflow 0
Overflow 0
χ² / ndf 35.2 / 22
Prob 0.03692
p0 49.4 ± 0.8
p1 7.357 ± 0.453
p2 241.5 ± 17.7


ADC Integral (baseline subtracted)
adc_6
Entries 510
Mean 65.45
RMS 24.49
Underflow 0
Overflow -0.683
χ² / ndf 80.66 / 30
Prob 1.586e-06
p0 50.66 ± 1.00
p1 8.475 ± 0.524
p2 231.5 ± 16.8


ADC Integral (baseline subtracted)
adc_7
Entries 424
Mean 64.25
RMS 26.26
Underflow 0
Overflow 0
χ² / ndf 91.74 / 31
Prob 6.383e-08
p0 51.1 ± 1.2
p1 10.05 ± 0.56
p2 163.7 ± 11.8

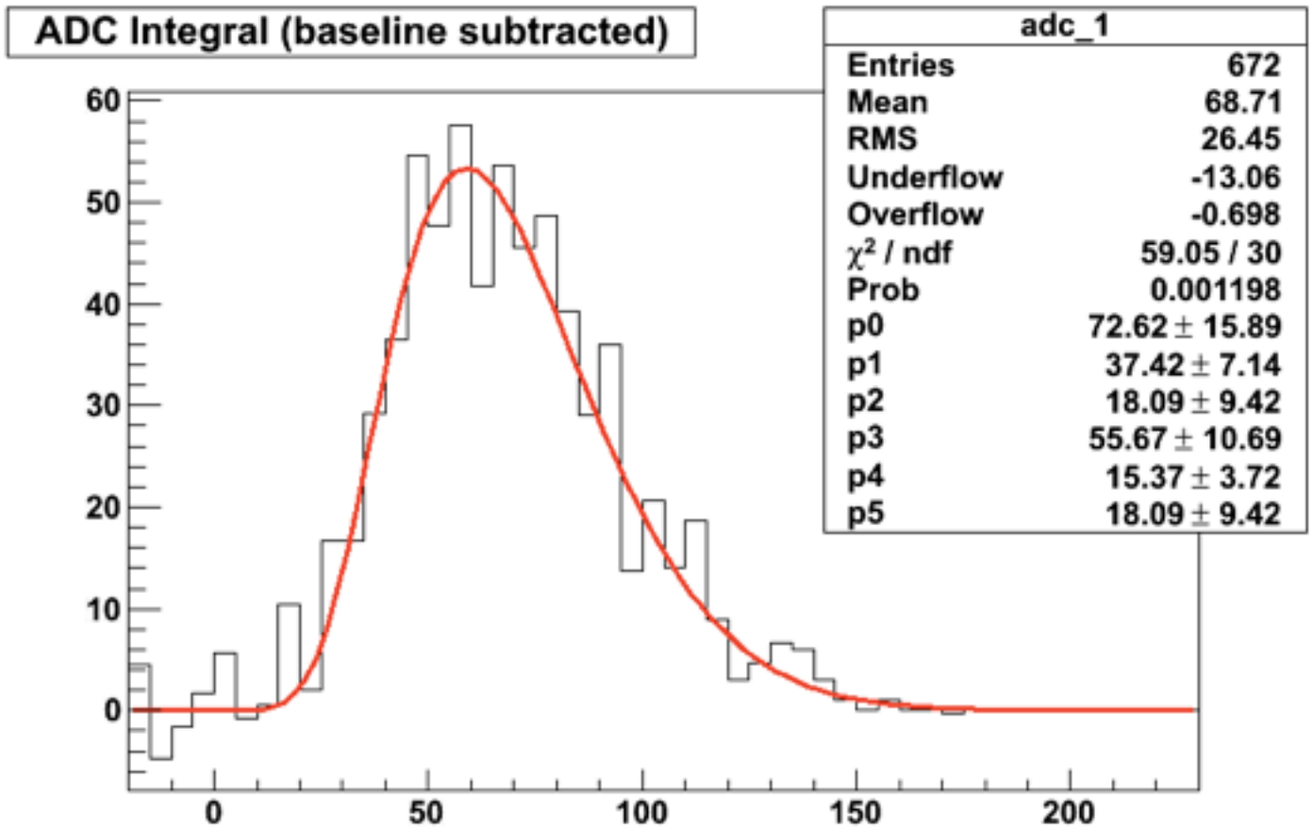
Gain from cutting method

	D1	D2	D3	D4	D5	D6	D7
Mean	70.4	60.08	55.87	59.99	60.66	65.45	64.25
χ^2 /ndf	3.967	3.142	4.696	1.854	1.6	2.689	2.959

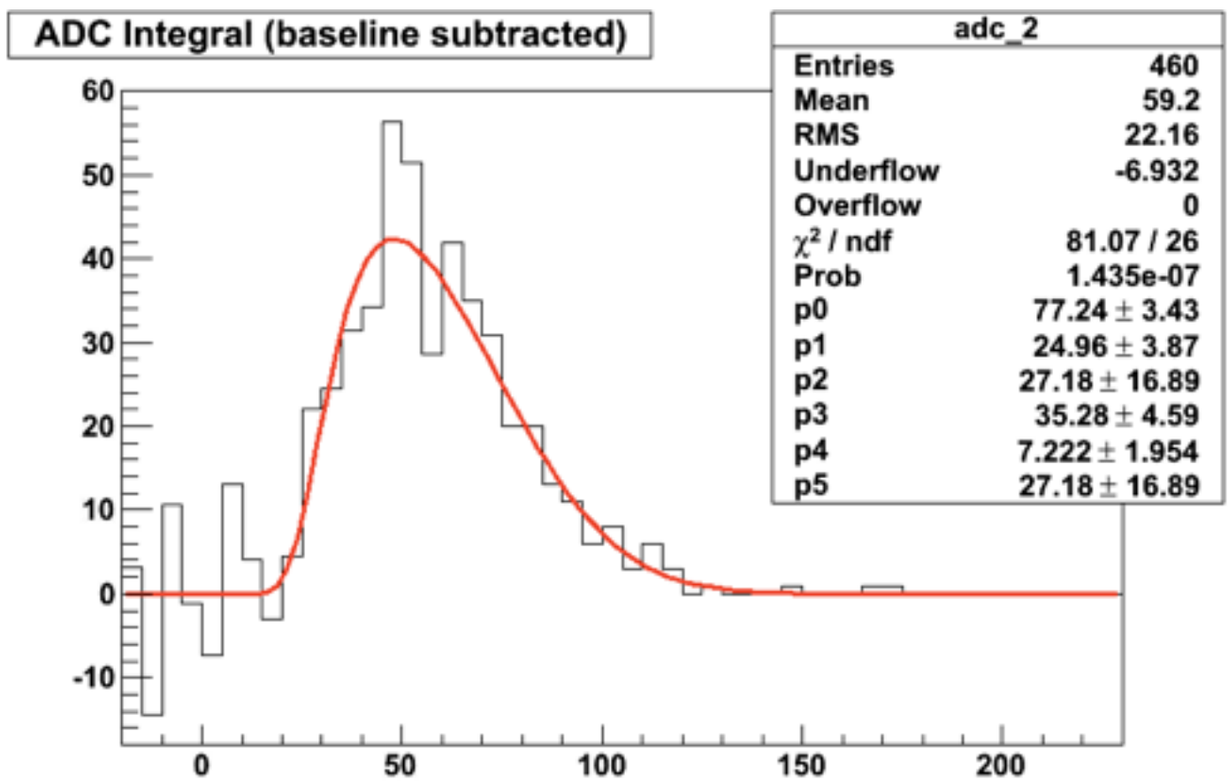
Normalize

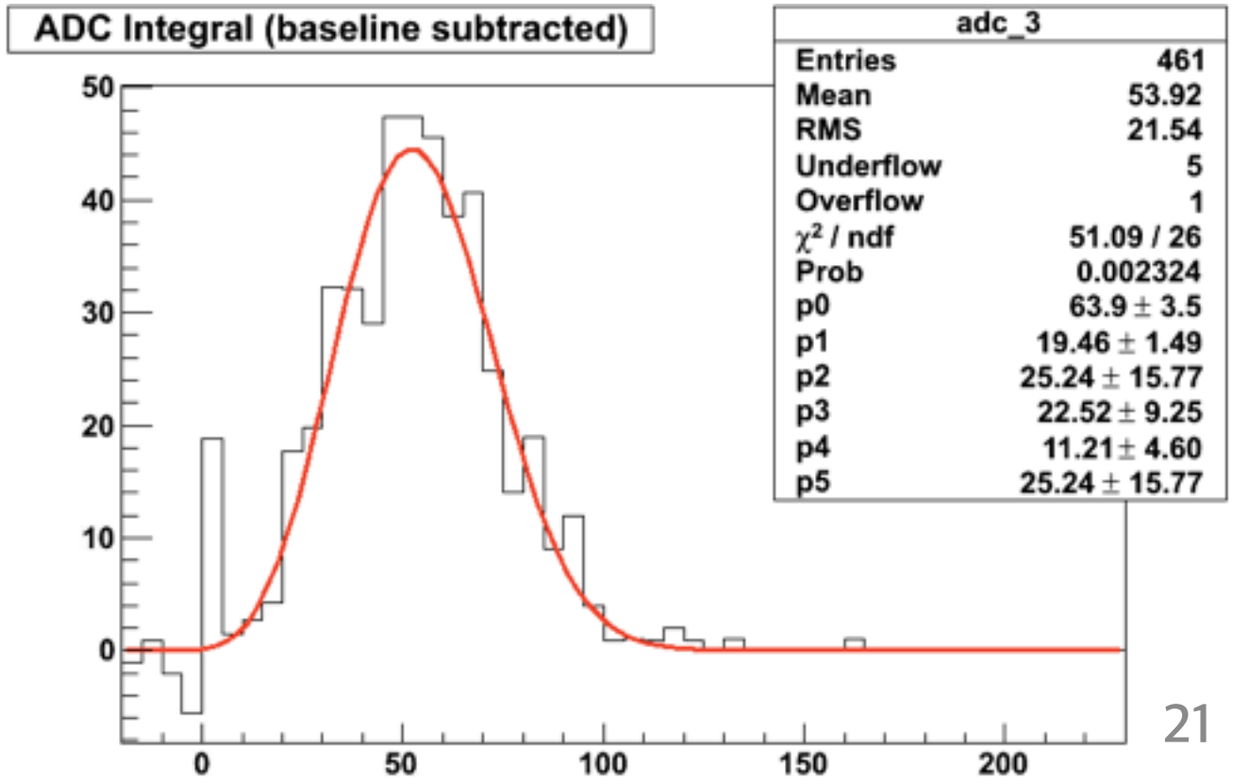
	D1	D2	D3	D4	D5	D6	D7
Mean	1.128	0.963	0.8955	0.9615	0.9723	1.049	1.03
χ^2 /ndf	3.967	3.142	4.696	1.854	1.6	2.689	2.959

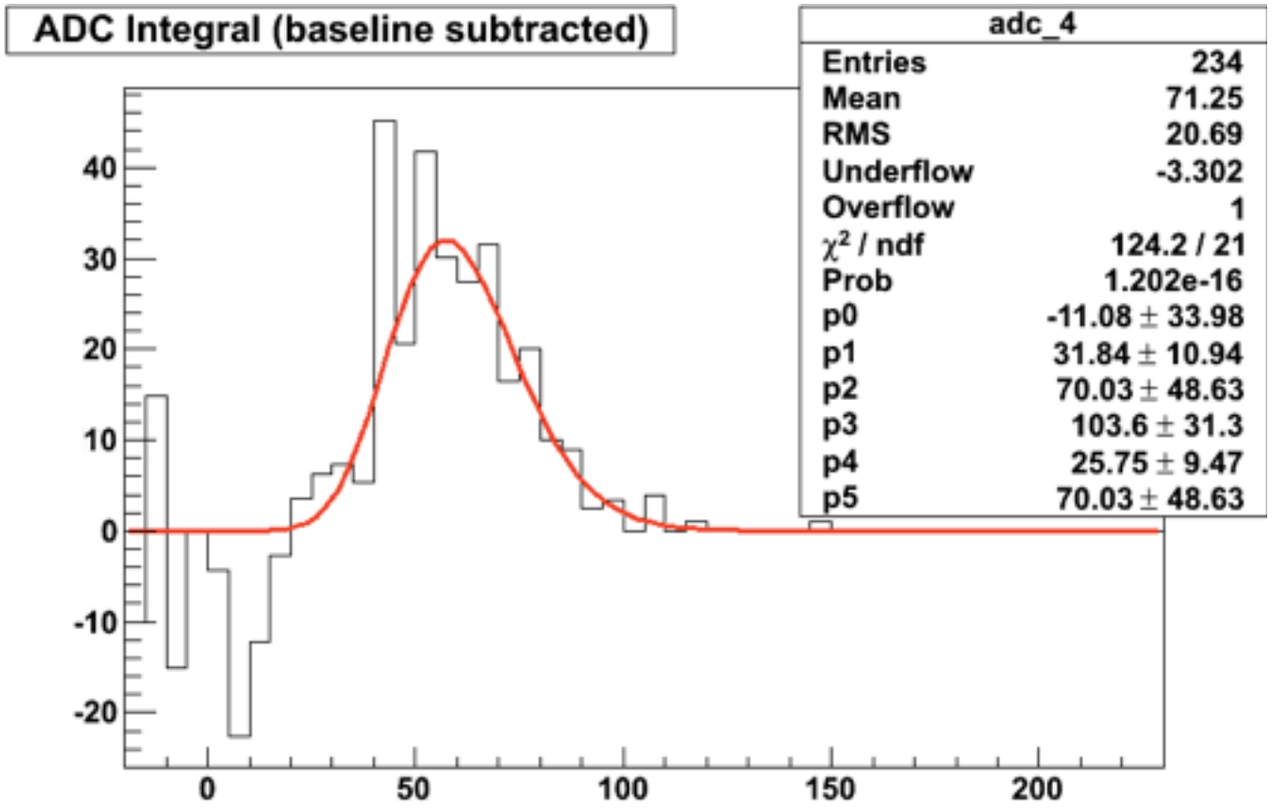
Convoluted Landau and Gaussian fitting

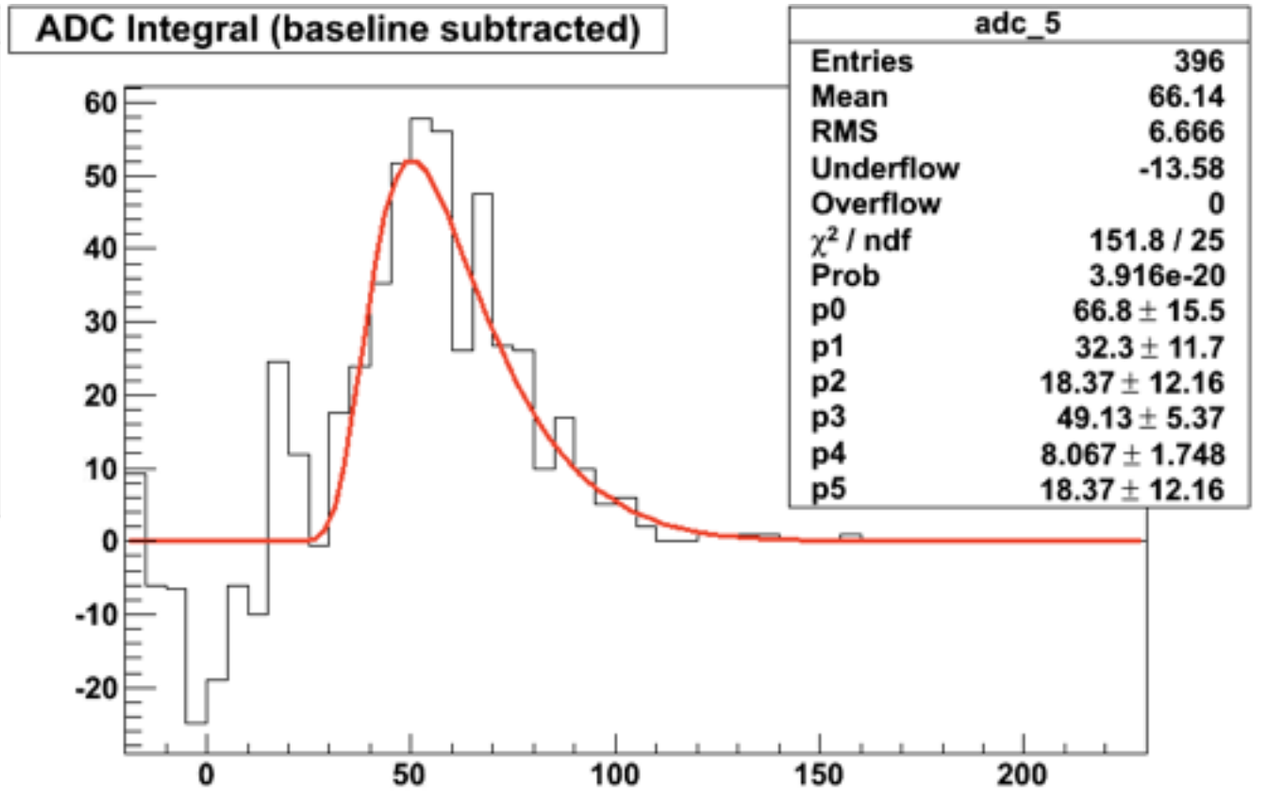


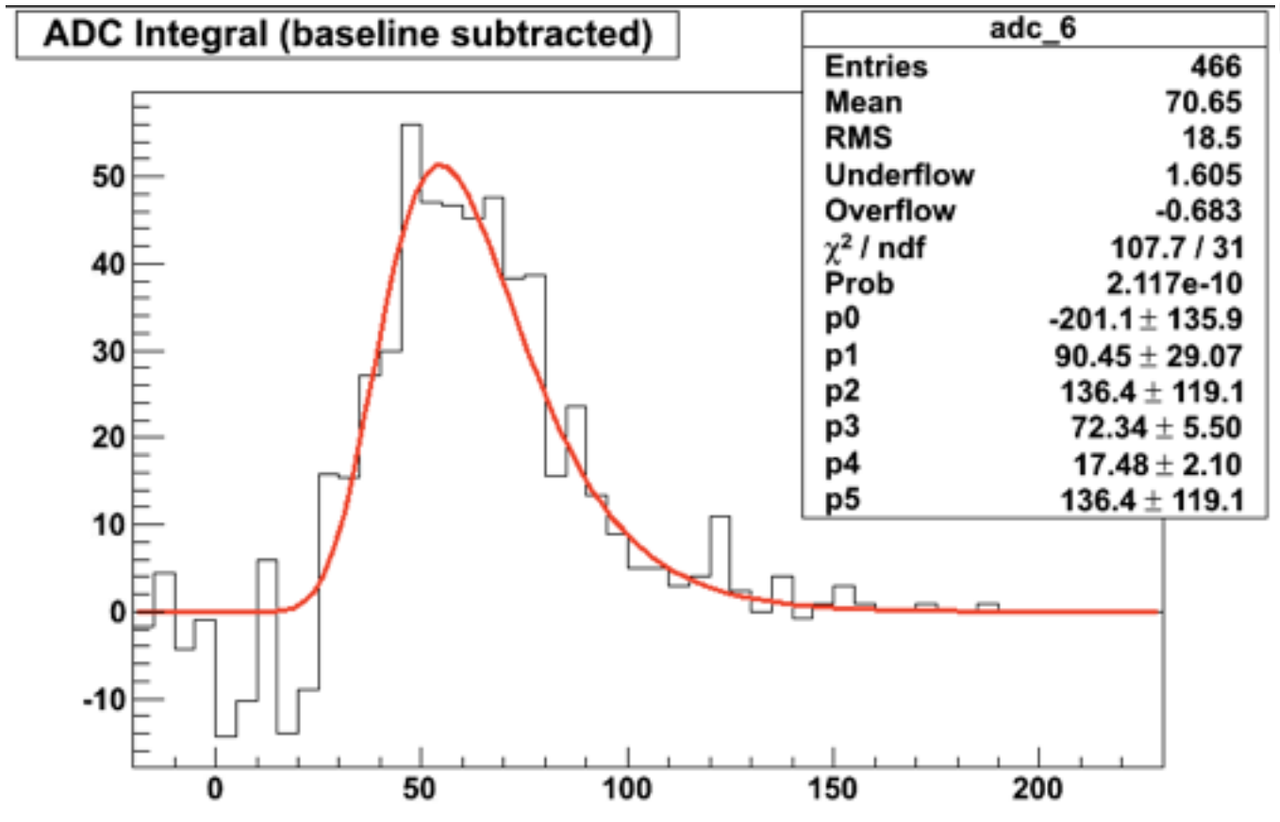
	explain
Fit Function	f(x) = Gauss(x) × Landau(x)
Gain	Maximum x value in f(x)

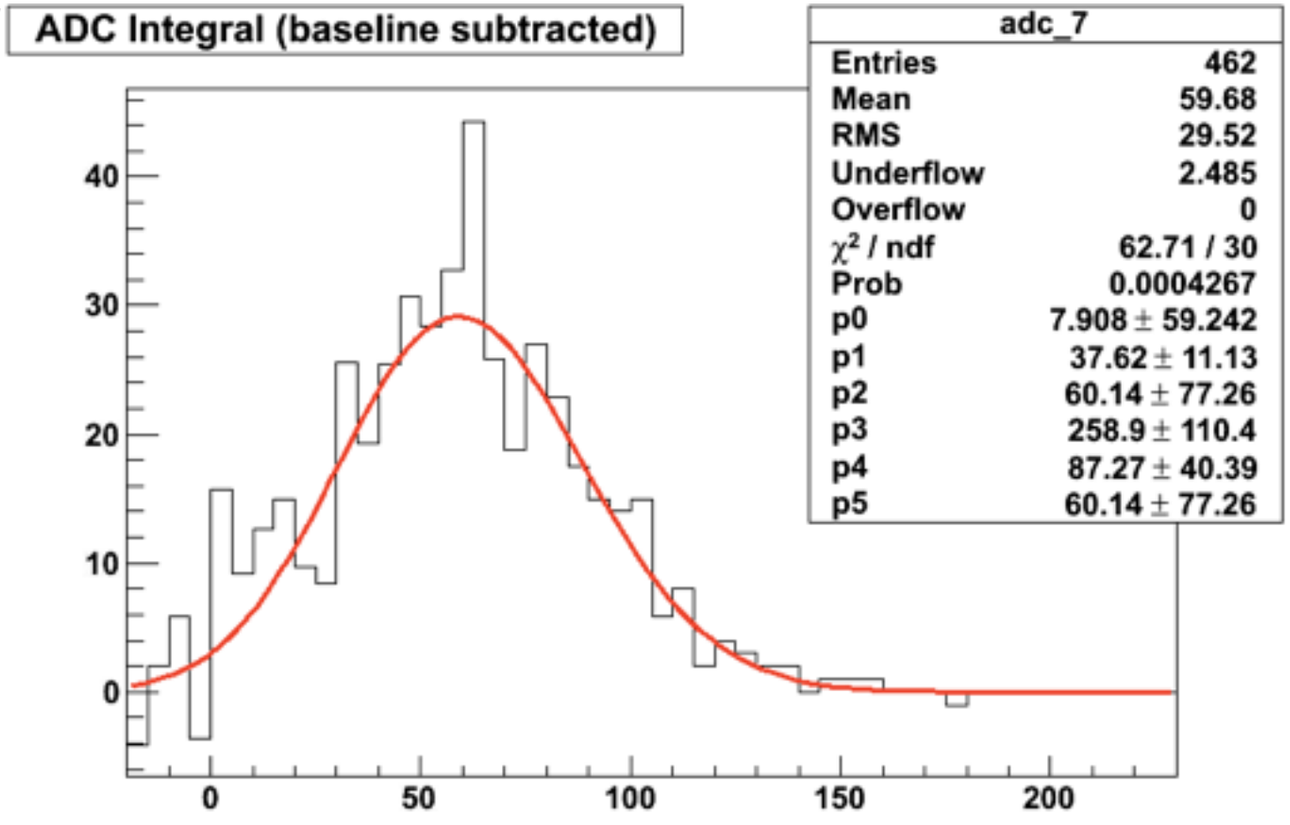





ADC Integral (baseline subtracted)
adc_4
Entries 234
Mean 71.25
RMS 20.69
Underflow -3.302
Overflow 1
χ² / ndf 124.2 / 21
Prob 1.202e-16
p0 -11.08 ± 33.98
p1 31.84 ± 10.94
p2 70.03 ± 48.63
p3 103.6 ± 31.3
p4 25.75 ± 9.47
p5 70.03 ± 48.63


ADC Integral (baseline subtracted)
adc_5
Entries 396
Mean 66.14
RMS 6.666
Underflow -13.58
Overflow 0
χ² / ndf 151.8 / 25
Prob 3.916e-20
p0 66.8 ± 15.5
p1 32.3 ± 11.7
p2 18.37 ± 12.16
p3 49.13 ± 5.37
p4 8.067 ± 1.748
p5 18.37 ± 12.16


ADC Integral (baseline subtracted)
adc_6
Entries 466
Mean 70.65
RMS 18.5
Underflow 1.605
Overflow -0.683
χ² / ndf 107.7 / 31
Prob 2.117e-10
p0 -201.1 ± 135.9
p1 90.45 ± 29.07
p2 136.4 ± 119.1
p3 72.34 ± 5.50
p4 17.48 ± 2.10
p5 136.4 ± 119.1


ADC Integral (baseline subtracted)
adc_7
Entries 462
Mean 59.68
RMS 29.52
Underflow 2.485
Overflow 0
χ² / ndf 62.71 / 30
Prob 0.0004267
p0 7.908 ± 59.242
p1 37.62 ± 11.13
p2 60.14 ± 77.26
p3 258.9 ± 110.4
p4 87.27 ± 40.39
p5 60.14 ± 77.26

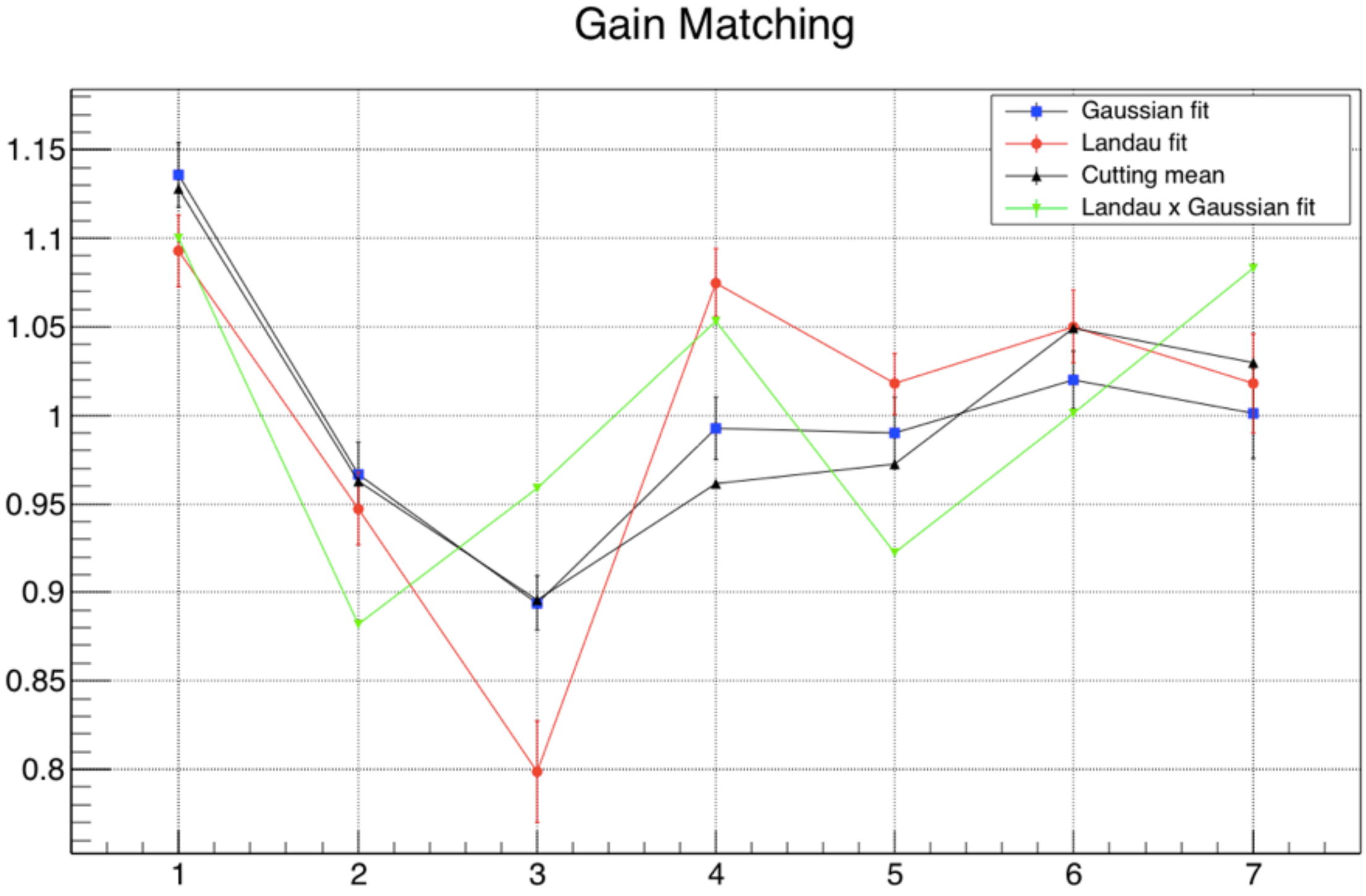
Gain from convoluted Landau and Gaussian fitting

	D1	D2	D3	D4	D5	D6	D7
Maximum values	58.89	48.01	52.20	57.30	50.19	54.49	58.93
χ^2 /ndf	1.968	3.118	1.965	5.914	6.072	3.474	2.09

Normalize

	D1	D2	D3	D4	D5	D6	D7
Maximum values	1.100	0.8821	0.959	1.053	0.9221	1.001	1.083
χ^2 /ndf	1.968	3.118	1.965	5.914	6.072	3.474	2.09

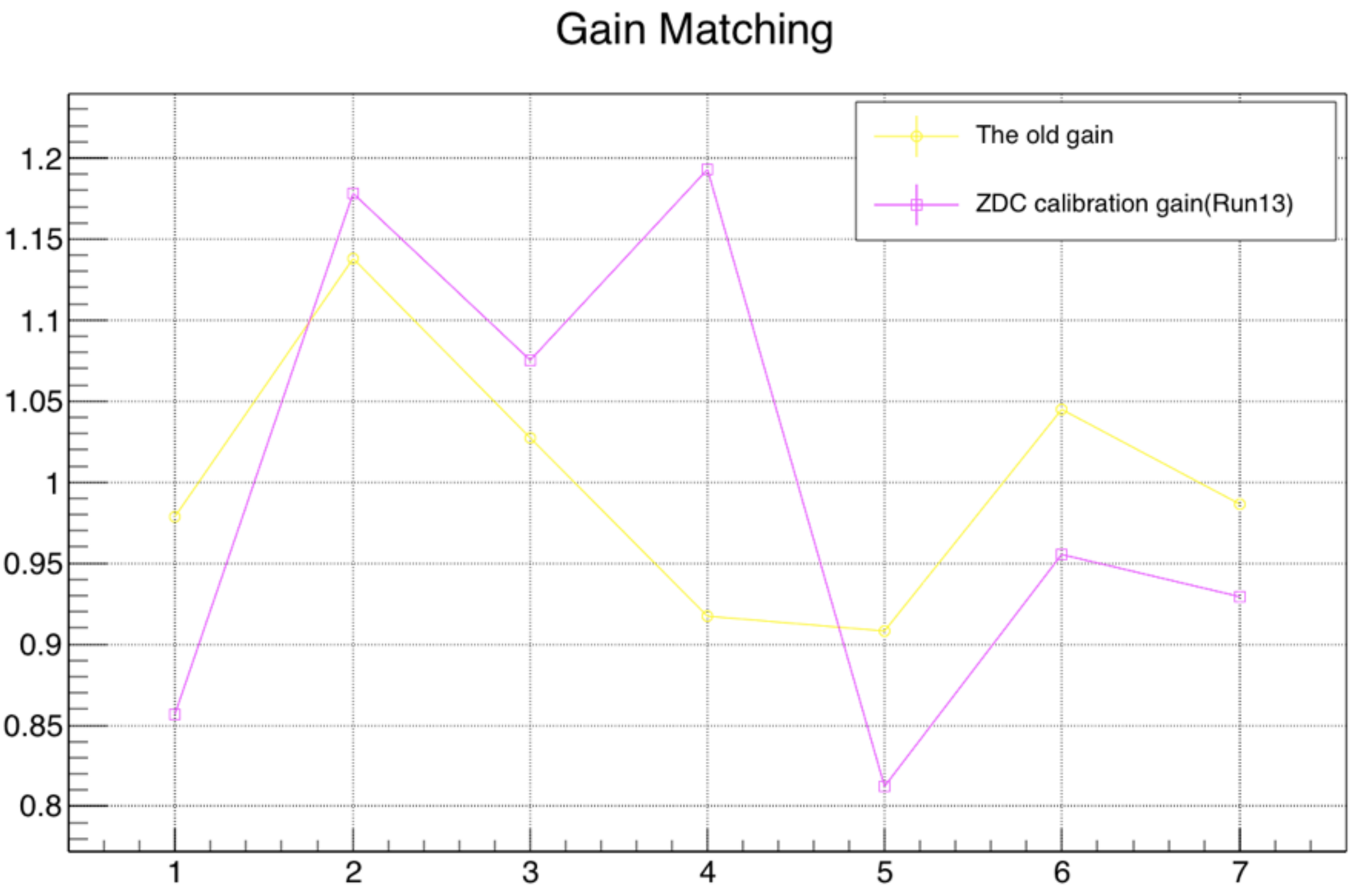
SMD gain Calibration



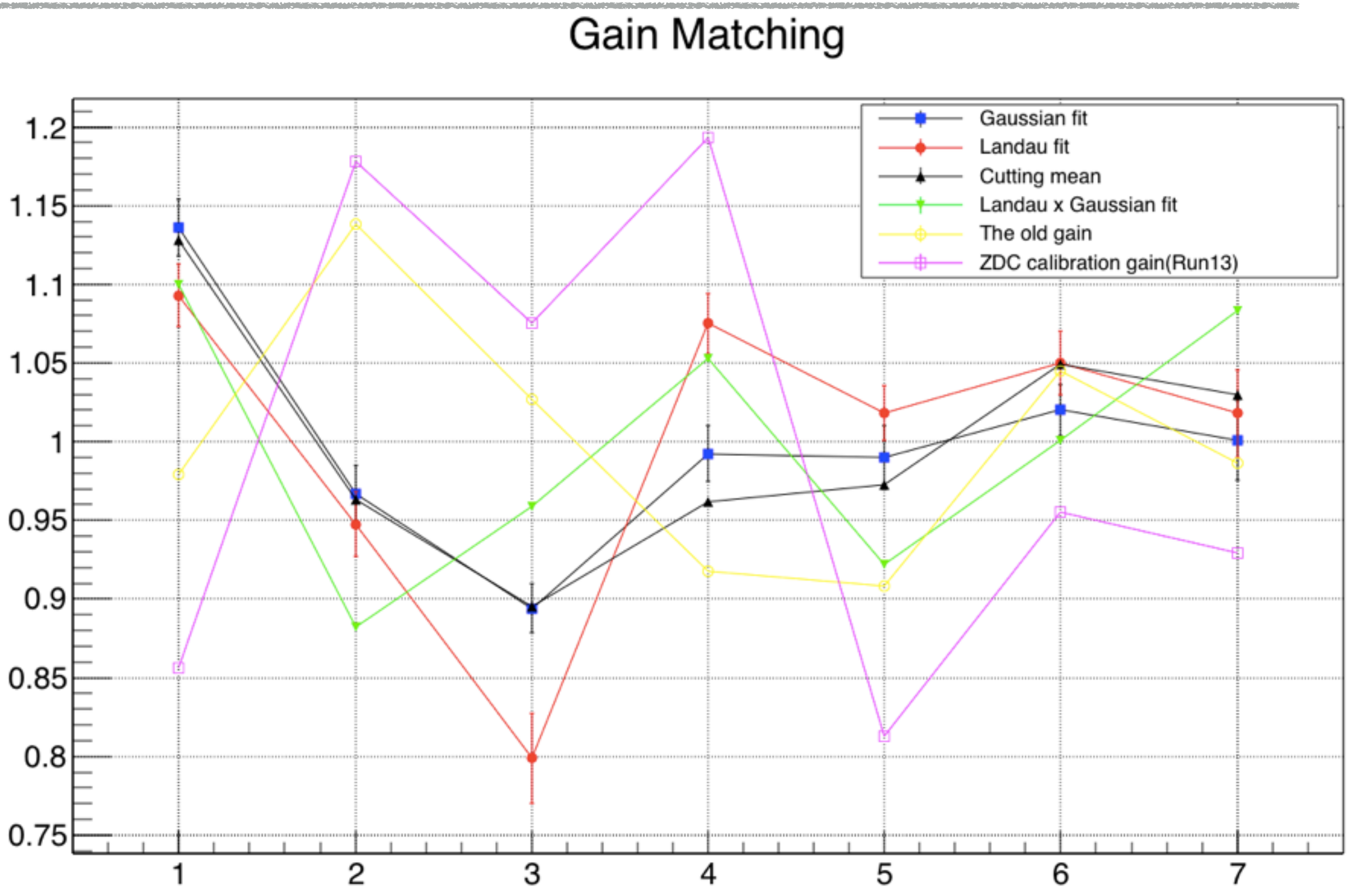
Gaussian and Landau fit points have error bar

But this errors don't represent statistical error accurately because χ^2 of those fit is not 1.

Old gains


Gain Matching
The old gain
ZDC calibration gain(Run13)
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
1
2
3
4
5
6
7

Comparison of new and old gains



Gaussian and Landau fit points have error bar

But this errors don't represent statistical error accurately because χ^2 of those fit is not 1.

Summary & Plan

- There are 4 New gains from 4 gain calculation methods.
- Old Gain and new gain show different tendency for relative gain.
- Compare run12 A_N by using new gain with old gain and choose the best one.
- Run12 Localpol Analysis with new gain.