Development of a 2-m RPC for LEPS2 Spectrometer

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Contents

LEPS2 facility

SPring-8

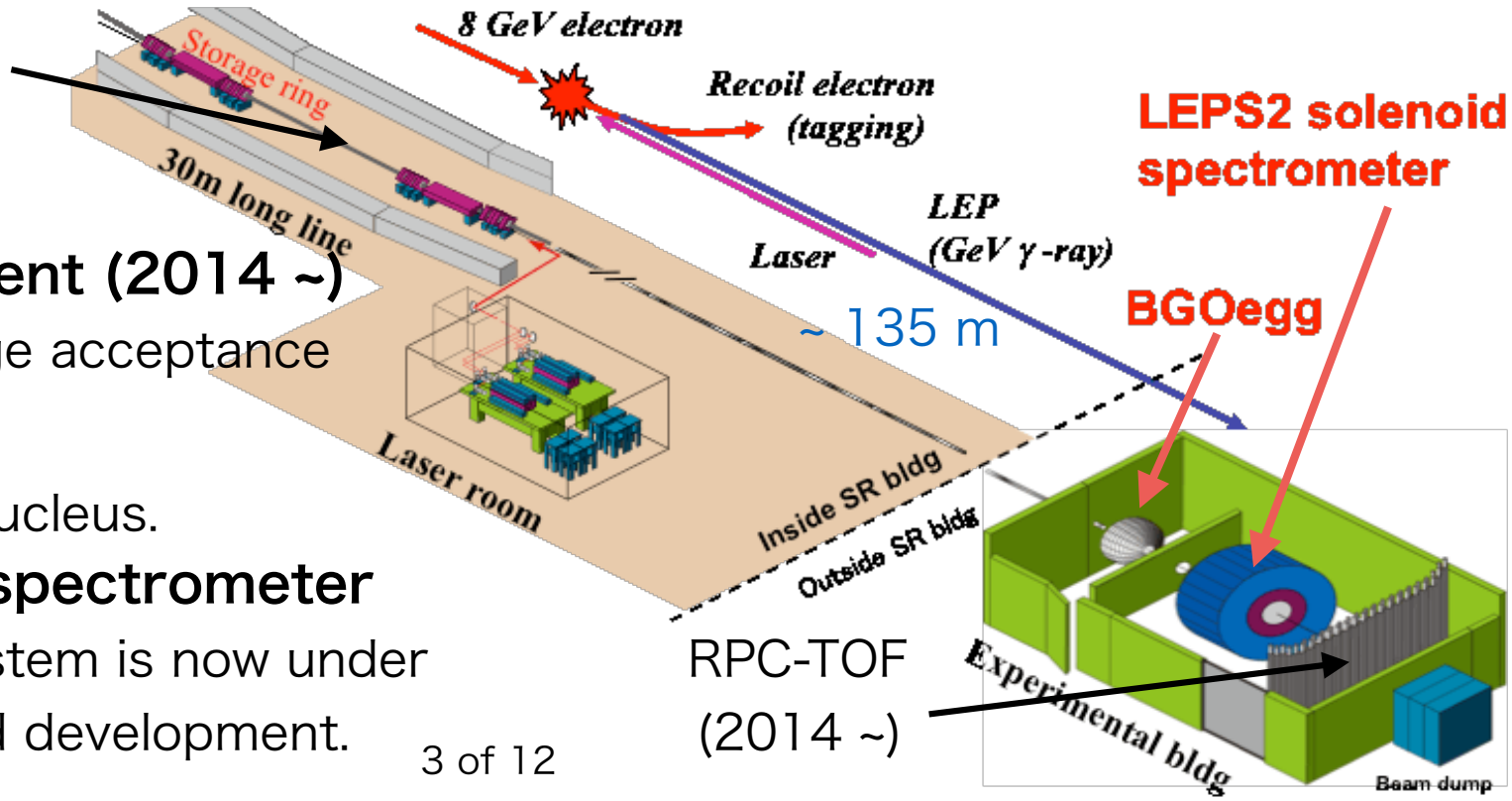
Super Photon ring-8 GeV

A 3rd-generation synchrotron facility with the highest energy in the world.

SPring-8

LEPS2 facility (LEPS2 = 2nd Laser Electron Photon beamline at SPring-8)

Backward Compton Scattering



Status

BGOegg experiment (2014 ~)

BGOegg is a large acceptance calorimeter

Search for η'- nucleus.

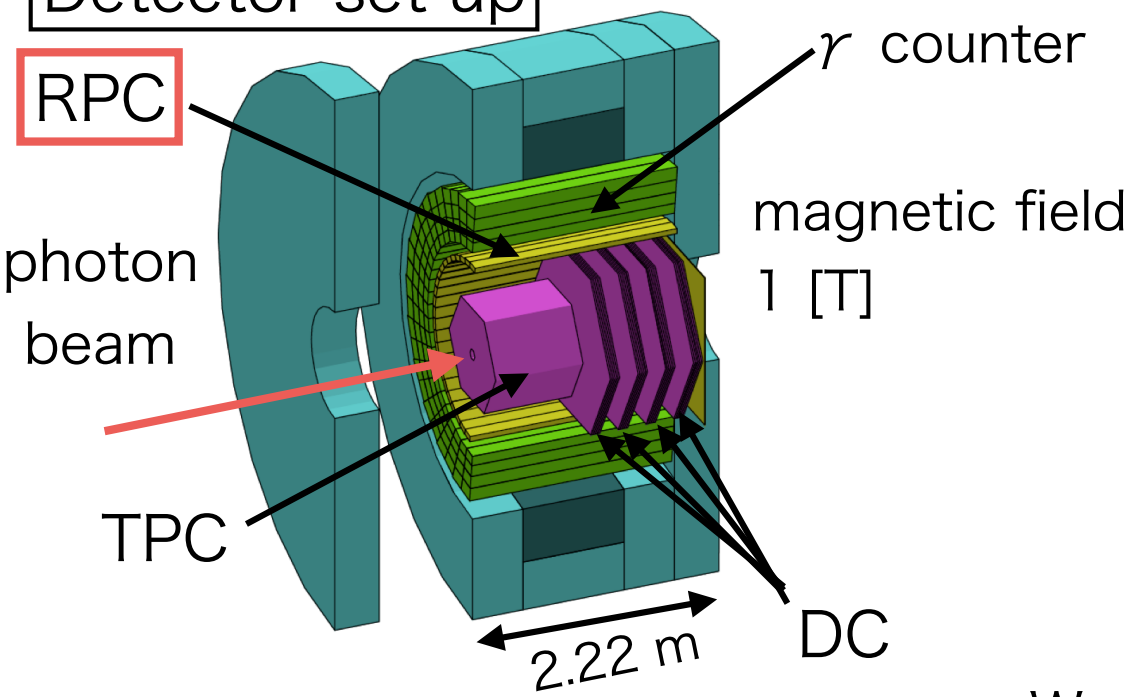
LEPS2 solenoid spectrometer

The detector system is now under construction and development.

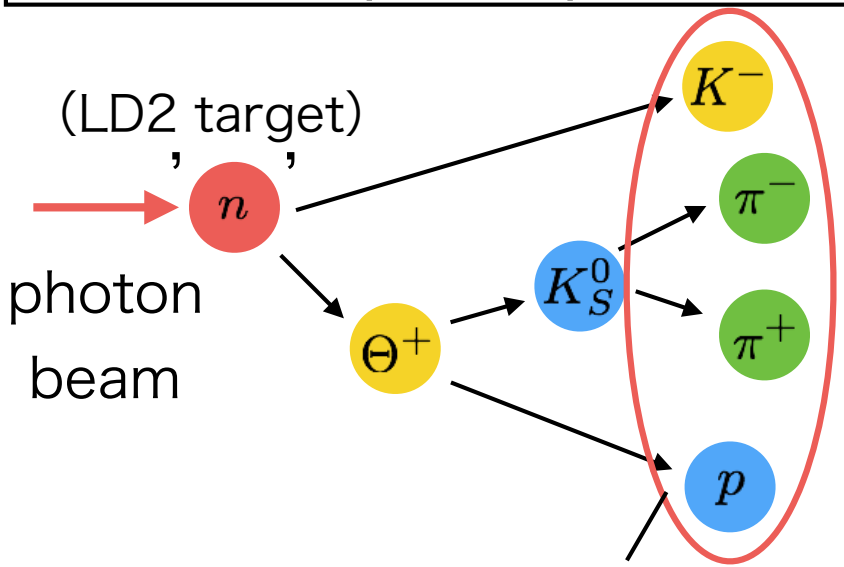
RPC-TOF (2014 ~)

LEPS2 solenoid spectrometer

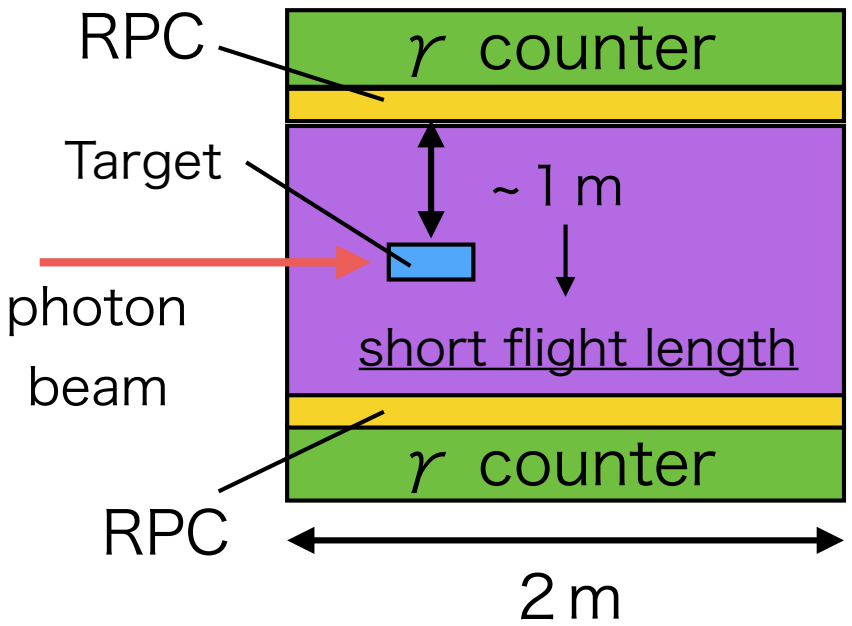
Detector set up



Main objective :
Search for pentaquark Θ^+



We need to detect these all particles.

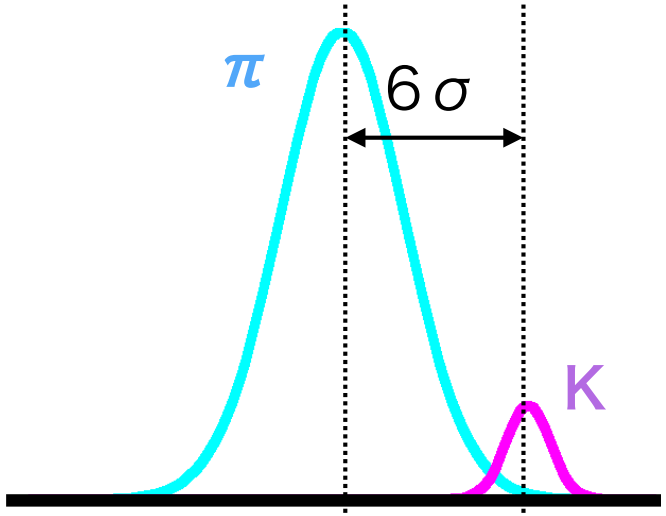


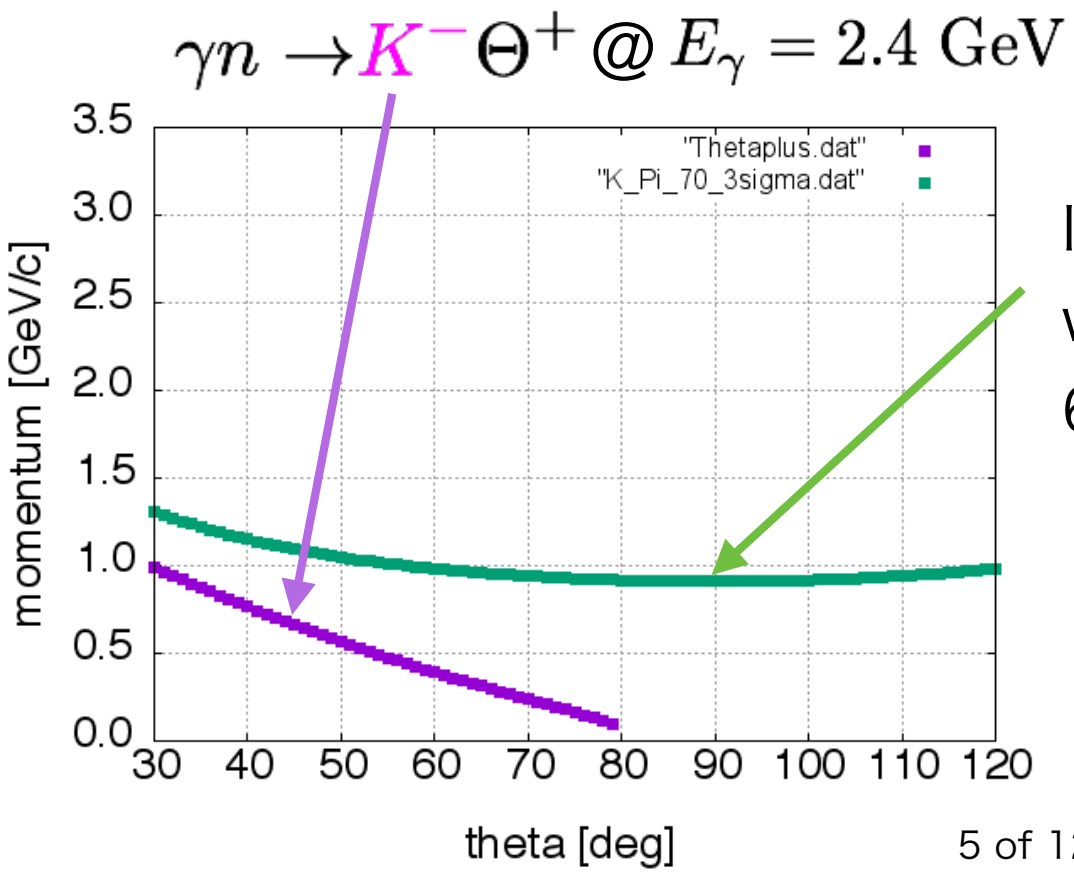
Resistive Plate Chambers will be used as barrel TOF counters for the π/K separation (less than 1 GeV/c).

Requirement for barrel RPC

The production ratio of π to K is almost 100.

Then, we need the 6σ time resolution for the good π/K separation.





If the time resolution is **70 ps**, we can identify the kaon with 6σ below green line.

Requirement for RPC :

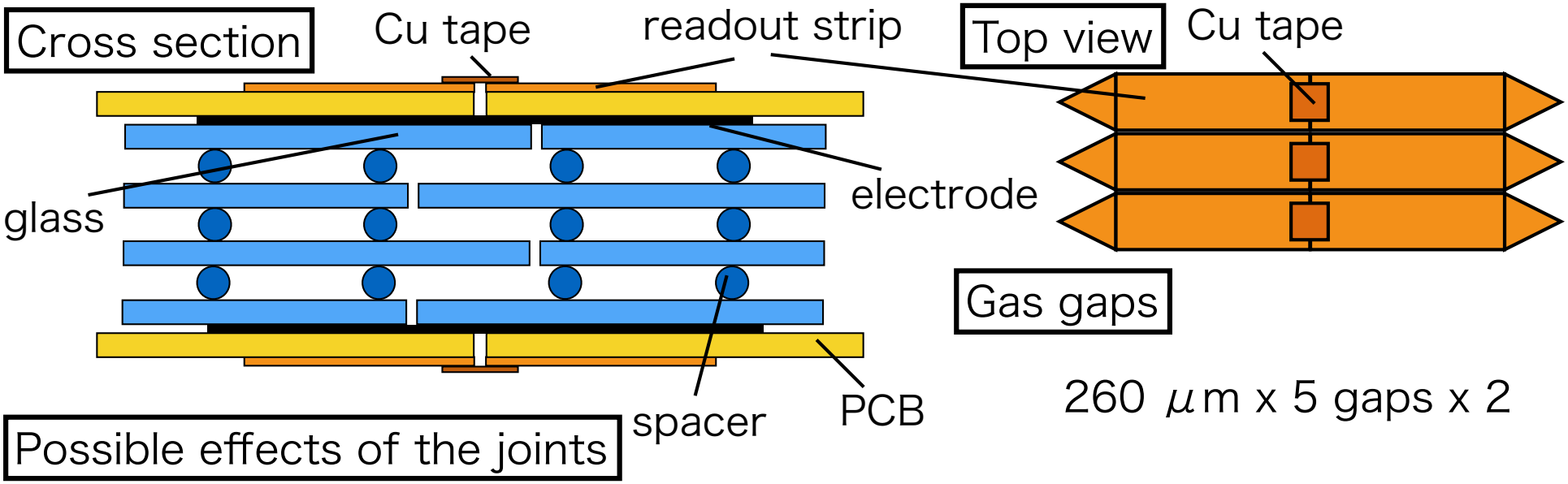
Length : 2 m

Time resolution : ~ 70 ps

The effect of the joints of parts

We want to reduce the number of readout channels.
We need the 2 m RPC, but the commercially available size of glasses and readout strips are 1 m.

-> <u>We have to connect two glasses and strips</u>

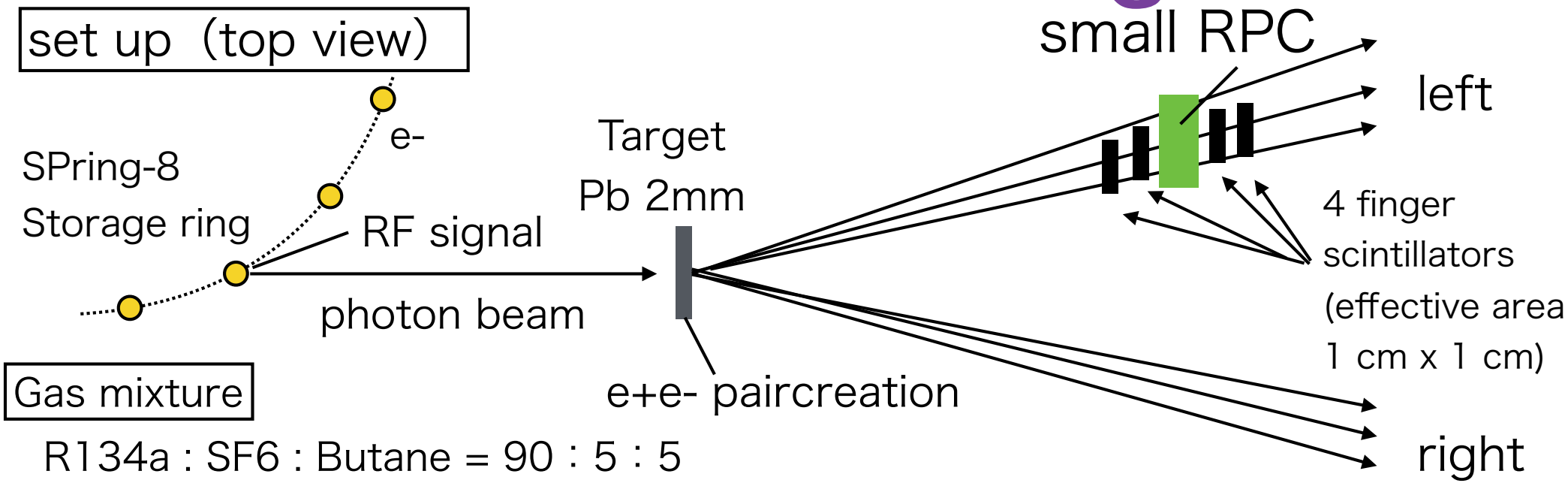


- joints of strips -> Reflection of the signal? -> Bad resolution?
- joints of glasses -> non-uniform electric field -> Low gain?
- Discharge at the joints of glasses?

We tested such effects with a small RPC(25 cm x 22 cm x 3 cm).

Performance test using e beam

set up (top view)

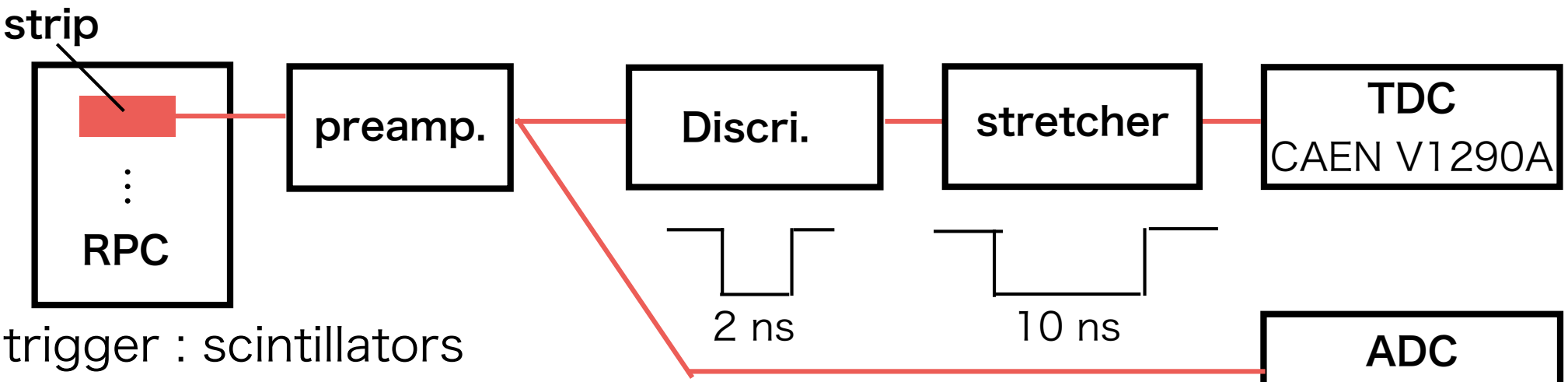


Gas mixture

R134a : SF6 : Butane = 90 : 5 : 5

readout electronics

same as the electronics of RPCs of BGOegg exp.



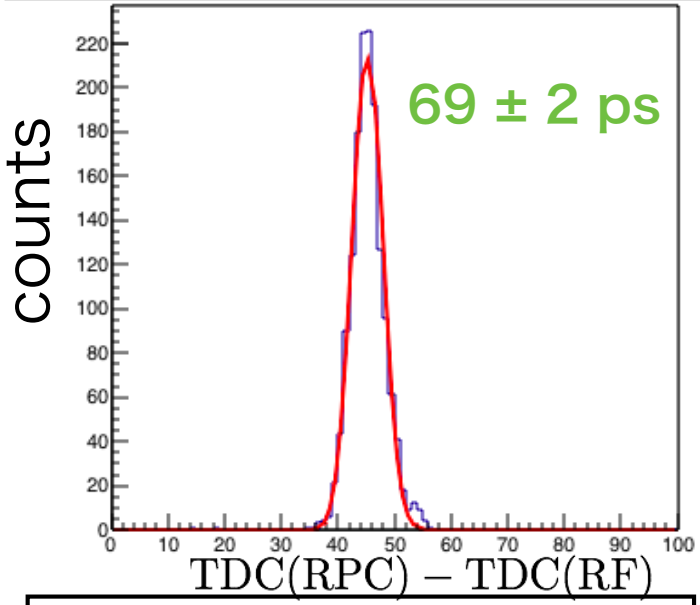
trigger : scintillators

TOF start : RF signal (very good resolution. ~ 10 ps)

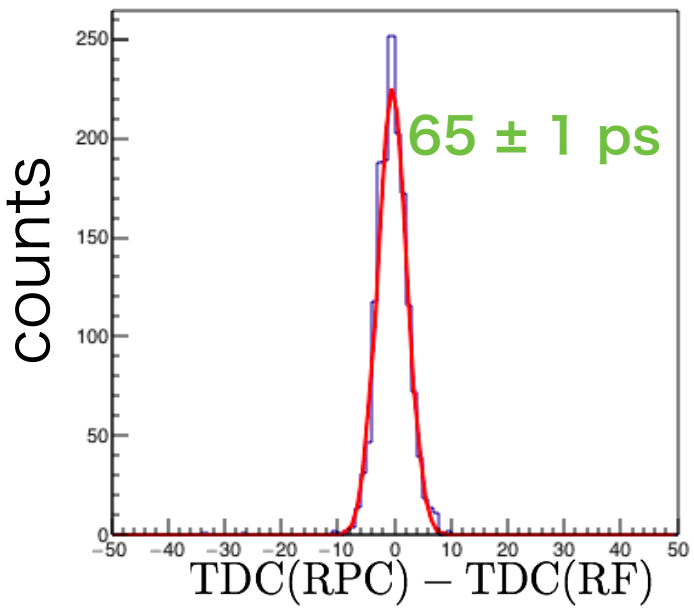
RPC strip readout : both side

The results of small RPC

Before slewing correction

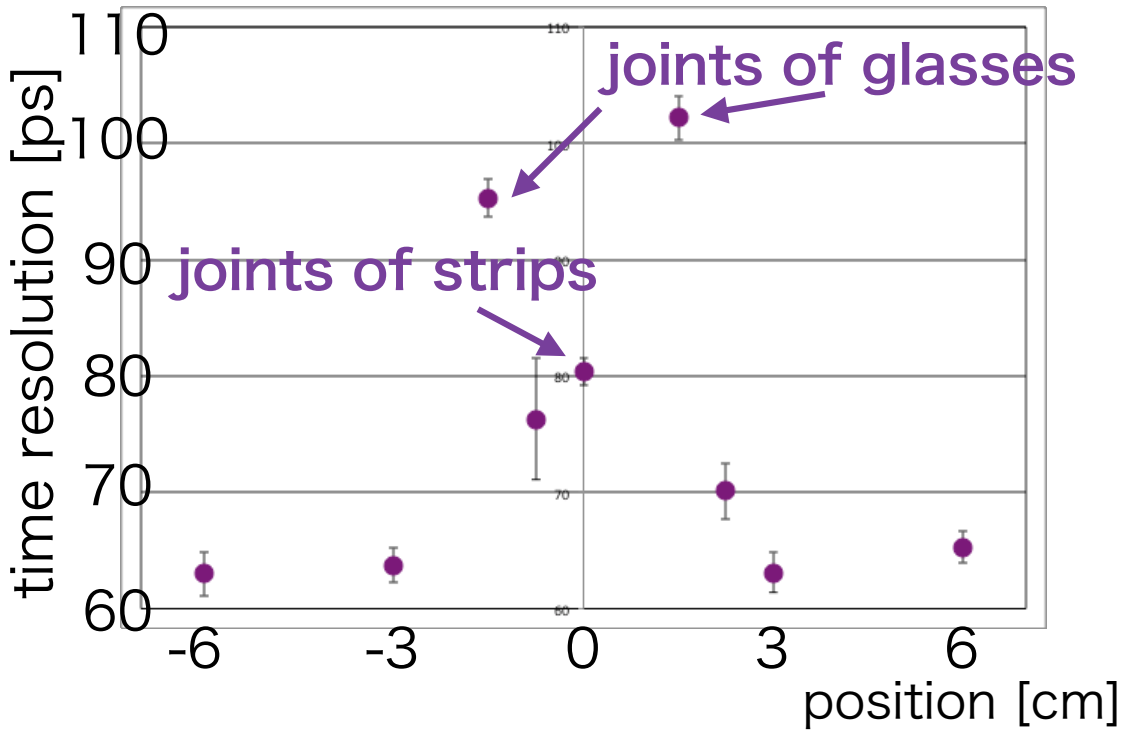


After slewing correction



Time resolution

$$\left[\frac{\mathrm{TDC_L(RPC)} + \mathrm{TDC_R(RPC)}}{2}\right] - \mathrm{TDC(RF)}$$

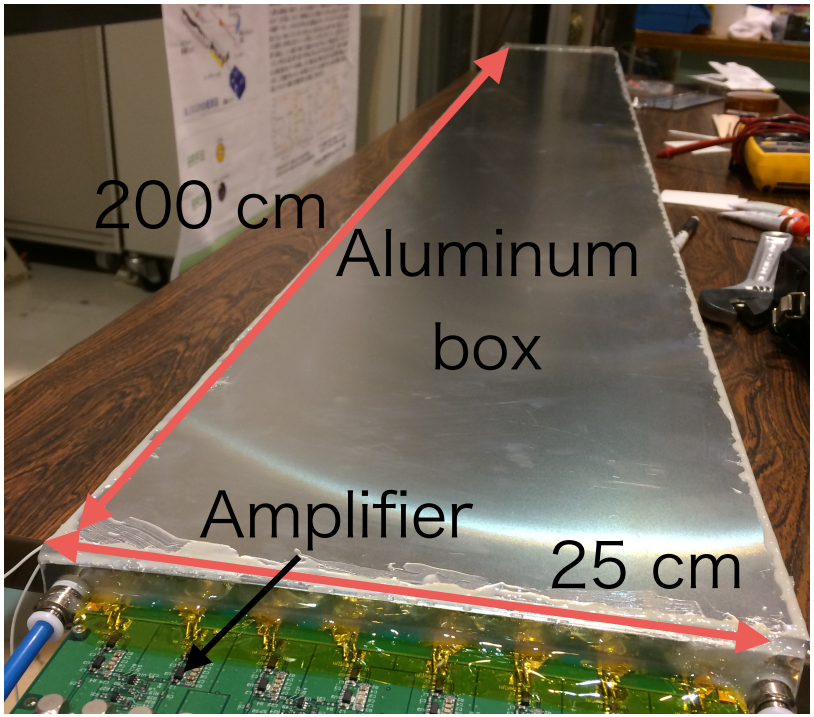


Only on the joint places, the time resolutions are not good, but the deterioration of other places can not be seen.

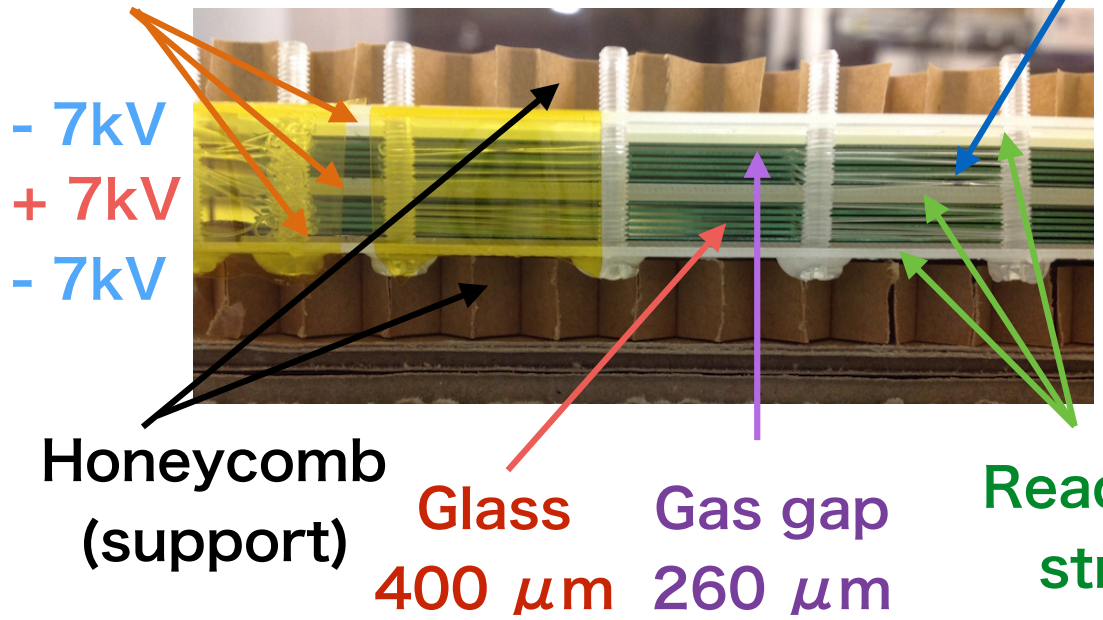
-> We decide to construct a 2-m RPC with joints

2-m prototype RPC

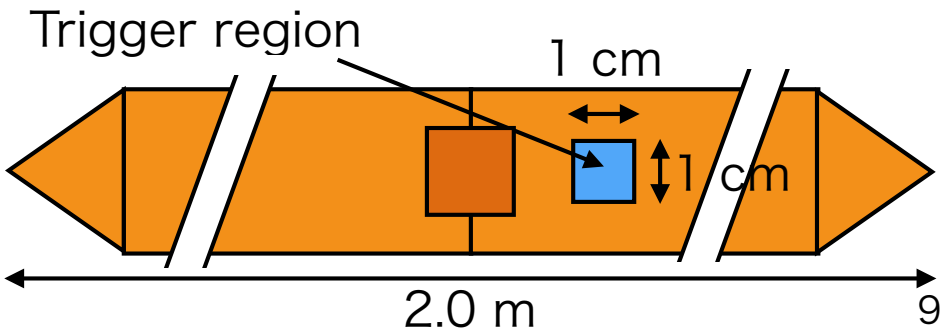
Top view



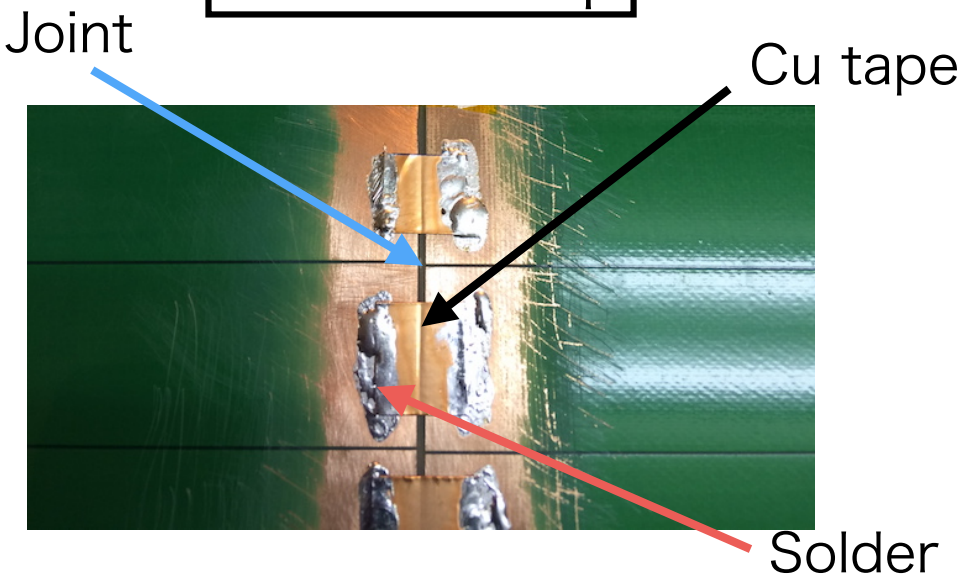
cross section



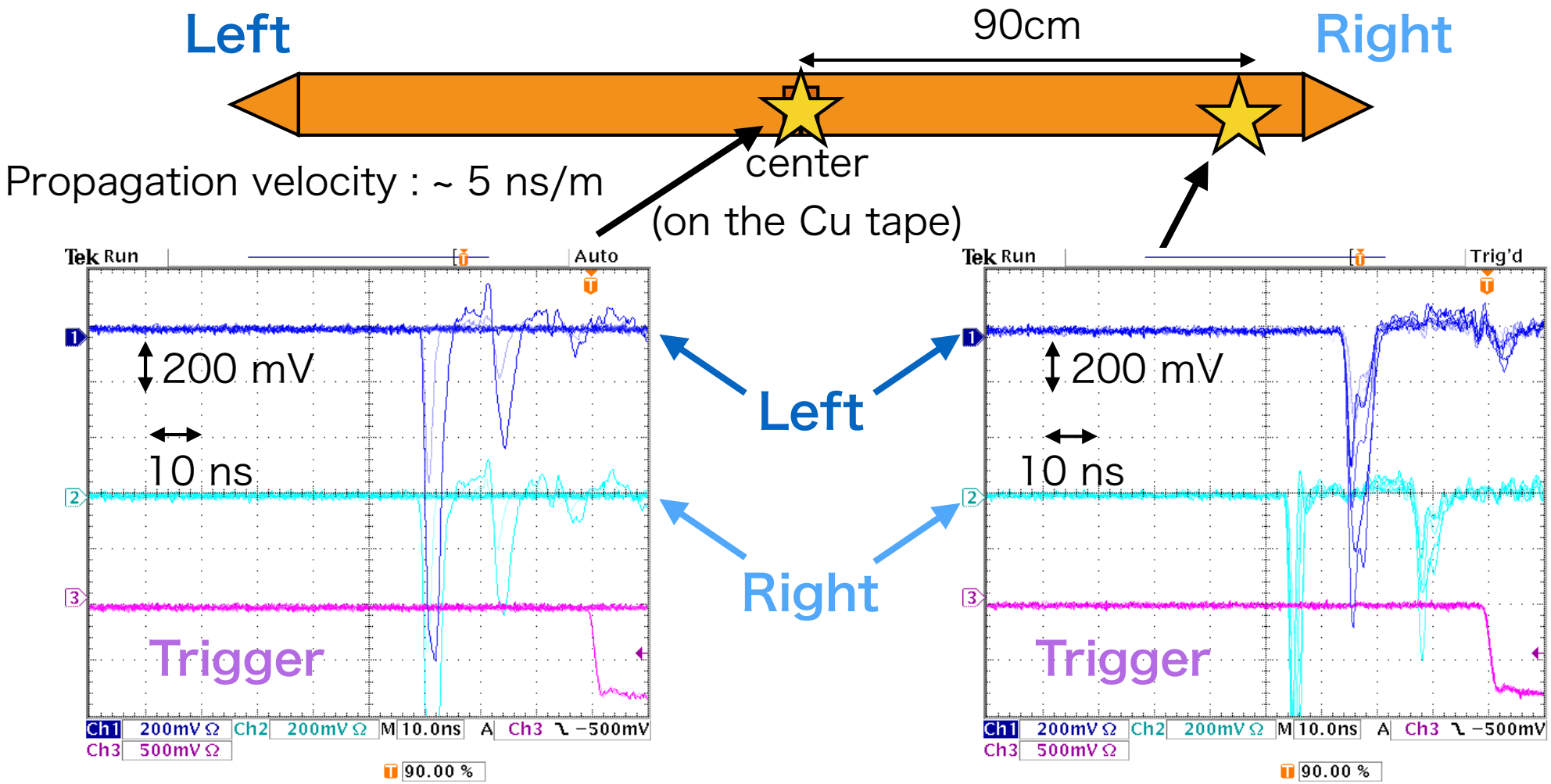
We have performed the beam test for this to study the position dependence of the time resolution.



readout strip



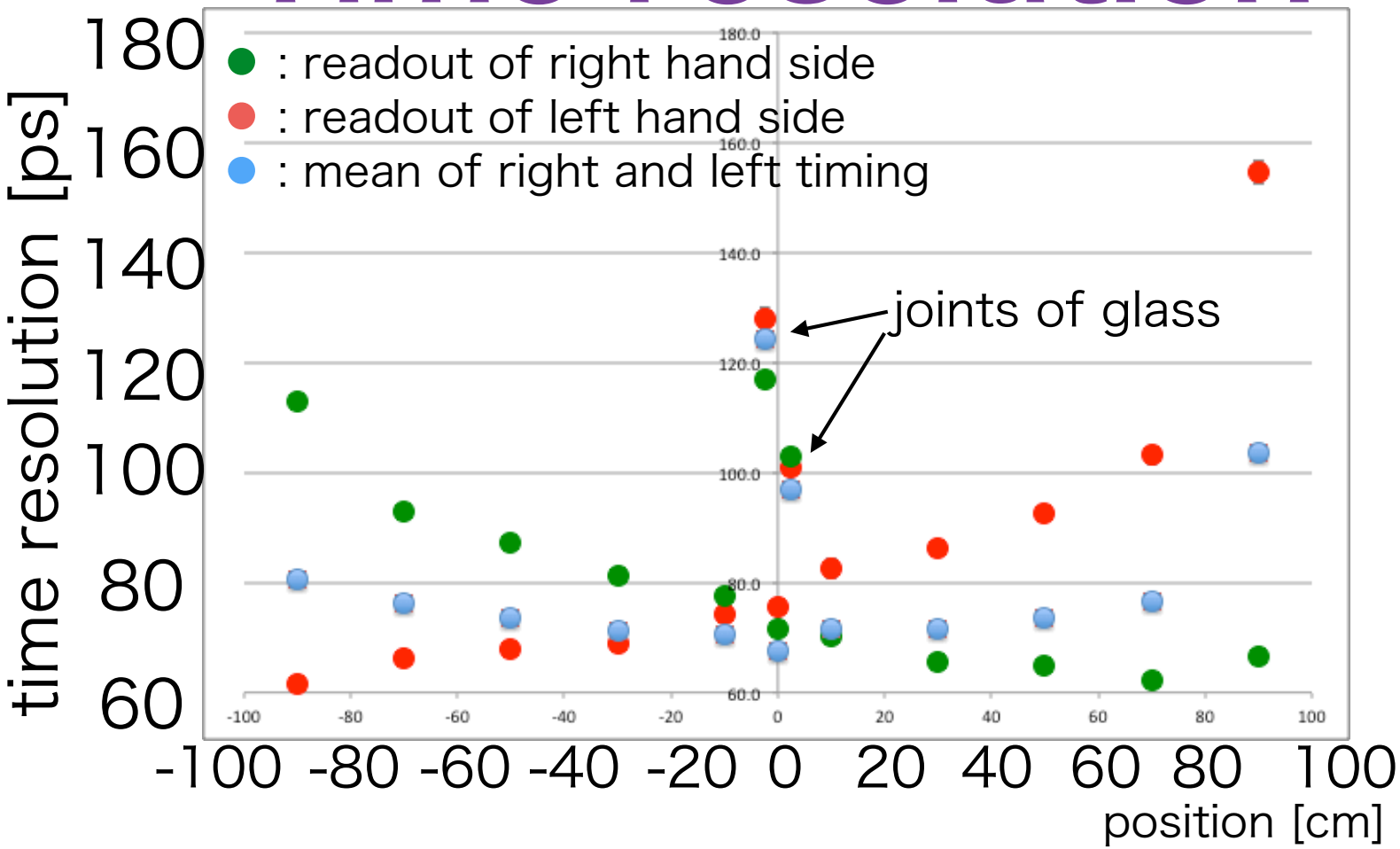
Signal propagation



Pulse shapes vary with hit positions.

The signal from the far side has wider width.

Time resolution



The time resolution is strongly dependent on the propagation length of signal.

Even when using the mean time, the time resolution does not satisfy the target value (~ 70 ps).

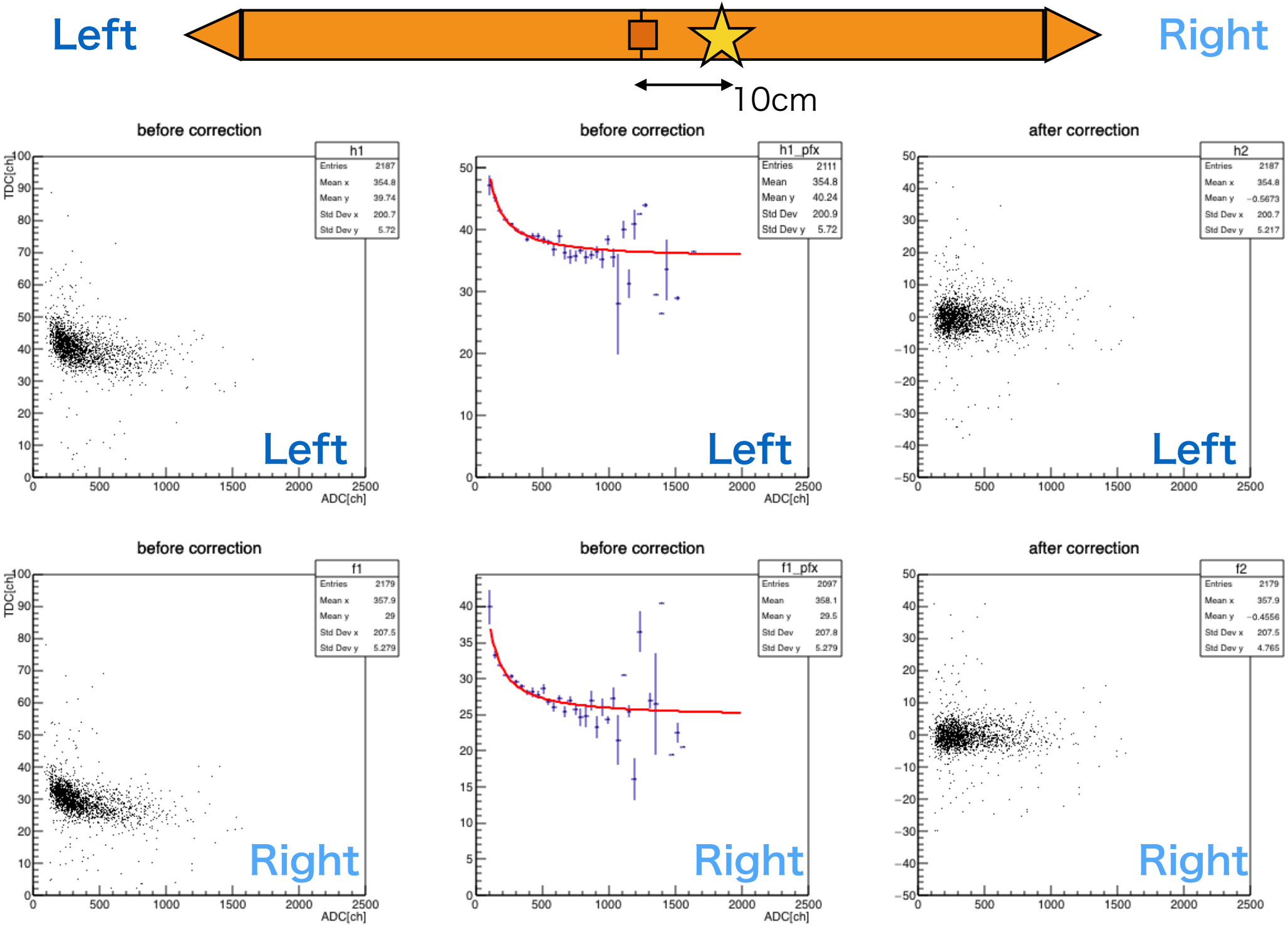
But, the time resolution of the near side are almost less than 70 ps

Summary

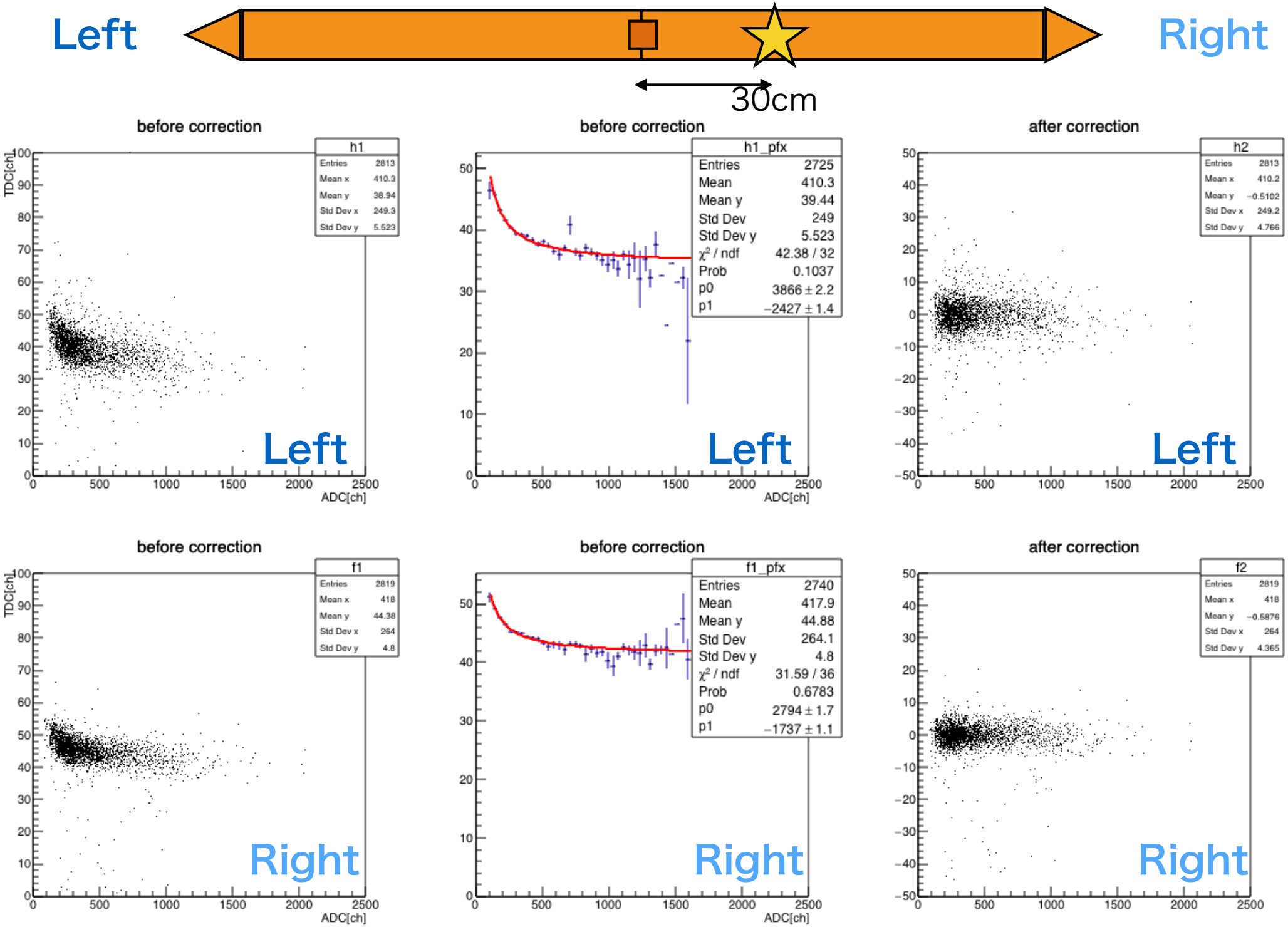
- We have developed a 2-m RPC for the LEPS2 solenoid spectrometer.
- The effect of the joints of glasses and strips in the RPC were studied using small RPC.
  - Only the joint places, the time resolution became worse. But the deterioration of other places can not be seen.
- We have made a 2-m prototype RPC by connecting glasses and strips with a 1-m length.
  - As the propagation length is longer, the time resolution becomes worse -> the time resolution of the mean time does not satisfy the target value(~ 70 ps).
  - But, the time resolutions of near side are almost less than 70 ps -> If the hit position can be determined by using other detectors, we may use the near side signal.
  - As for the efficiency, now under analysis.

Thank you!

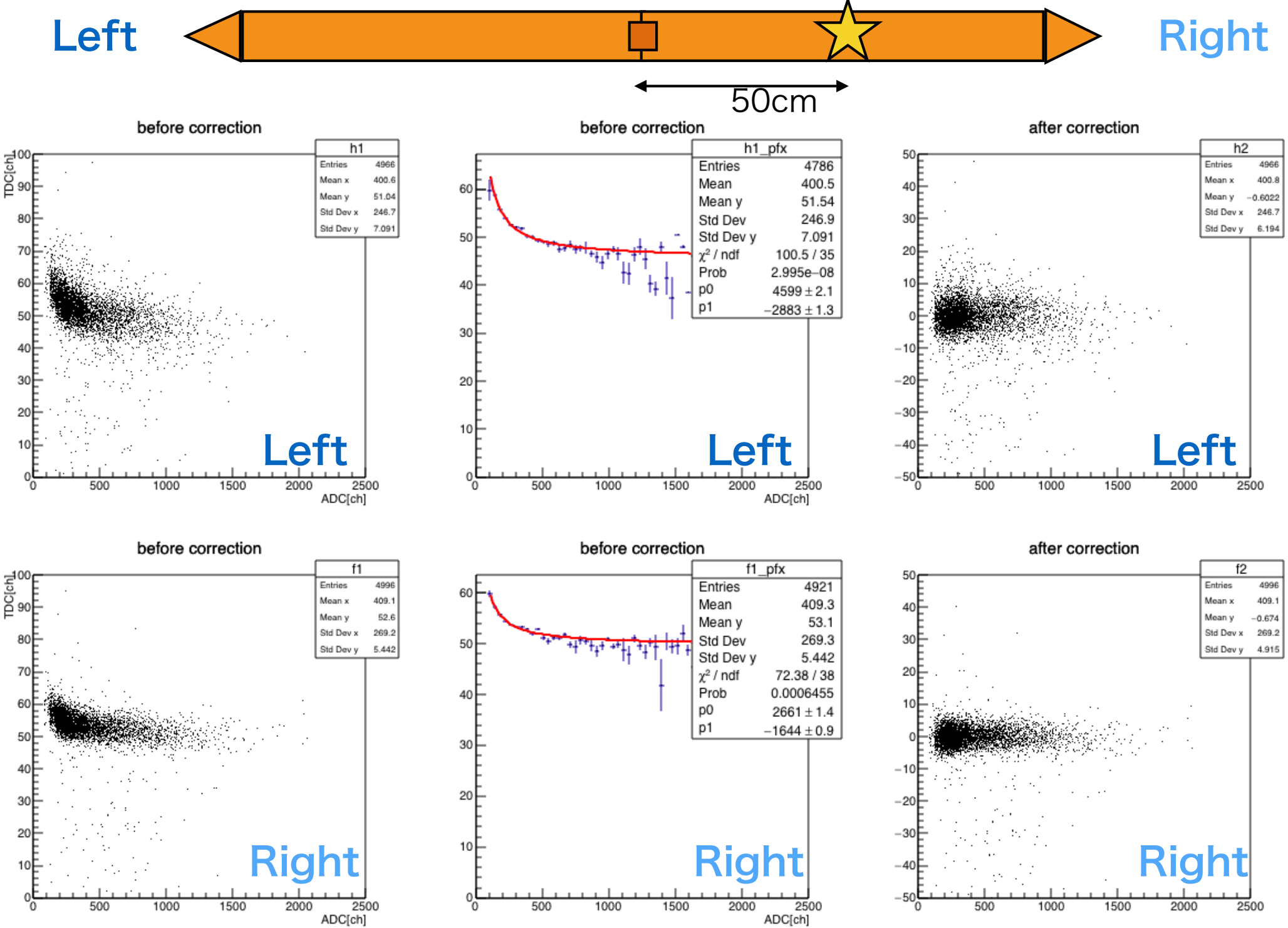
back up


Left
Right
10cm
before correction
h1
Entries 2187
Mean x 354.8
Mean y 39.74
Std Dev x 200.7
Std Dev y 5.72
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 2111
Mean 354.8
Mean y 40.24
Std Dev 200.9
Std Dev y 5.72
ADC[ch]
Left
after correction
h2
Entries 2187
Mean x 354.8
Mean y −0.5673
Std Dev x 200.7
Std Dev y 5.217
Left
before correction
f1
Entries 2179
Mean x 357.9
Mean y 29
Std Dev x 207.5
Std Dev y 5.279
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 2097
Mean 358.1
Mean y 29.5
Std Dev 207.8
Std Dev y 5.279
ADC[ch]
Right
after correction
f2
Entries 2179
Mean x 357.9
Mean y −0.4556
Std Dev x 207.5
Std Dev y 4.765
Right

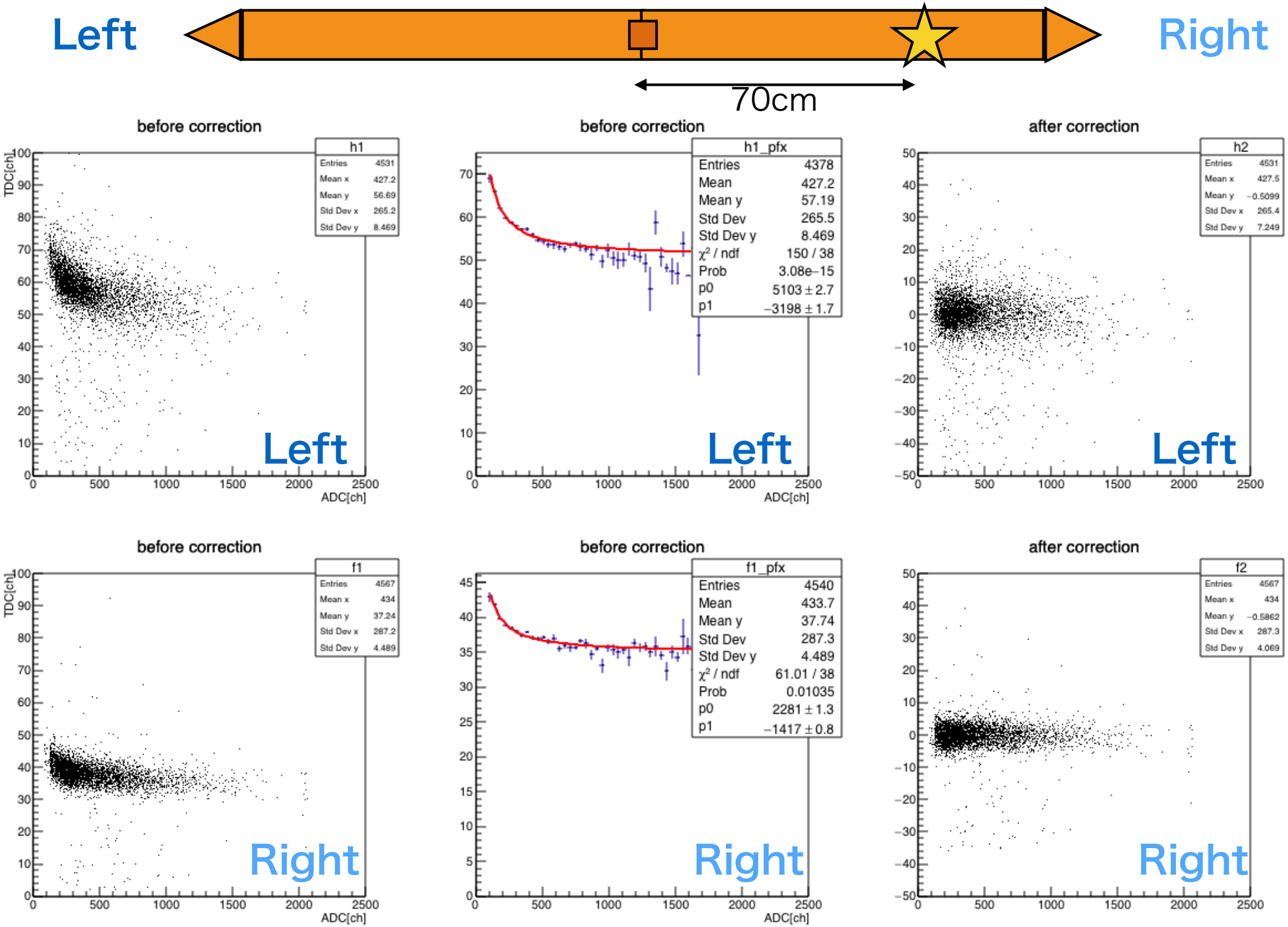
run14555


Left
Right
30cm
before correction
h1
Entries 2813
Mean x 410.3
Mean y 38.94
Std Dev x 249.3
Std Dev y 5.523
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 2725
Mean 410.3
Mean y 39.44
Std Dev 249
Std Dev y 5.523
χ² / ndf 42.38 / 32
Prob 0.1037
p0 3866 ± 2.2
p1 −2427 ± 1.4
ADC[ch]
Left
after correction
h2
Entries 2813
Mean x 410.2
Mean y −0.5102
Std Dev x 249.2
Std Dev y 4.766
Left
before correction
f1
Entries 2819
Mean x 418
Mean y 44.38
Std Dev x 264
Std Dev y 4.8
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 2740
Mean 417.9
Mean y 44.88
Std Dev 264.1
Std Dev y 4.8
χ² / ndf 31.59 / 36
Prob 0.6783
p0 2794 ± 1.7
p1 −1737 ± 1.1
ADC[ch]
Right
after correction
f2
Entries 2819
Mean x 418
Mean y −0.5876
Std Dev x 264
Std Dev y 4.365
Right

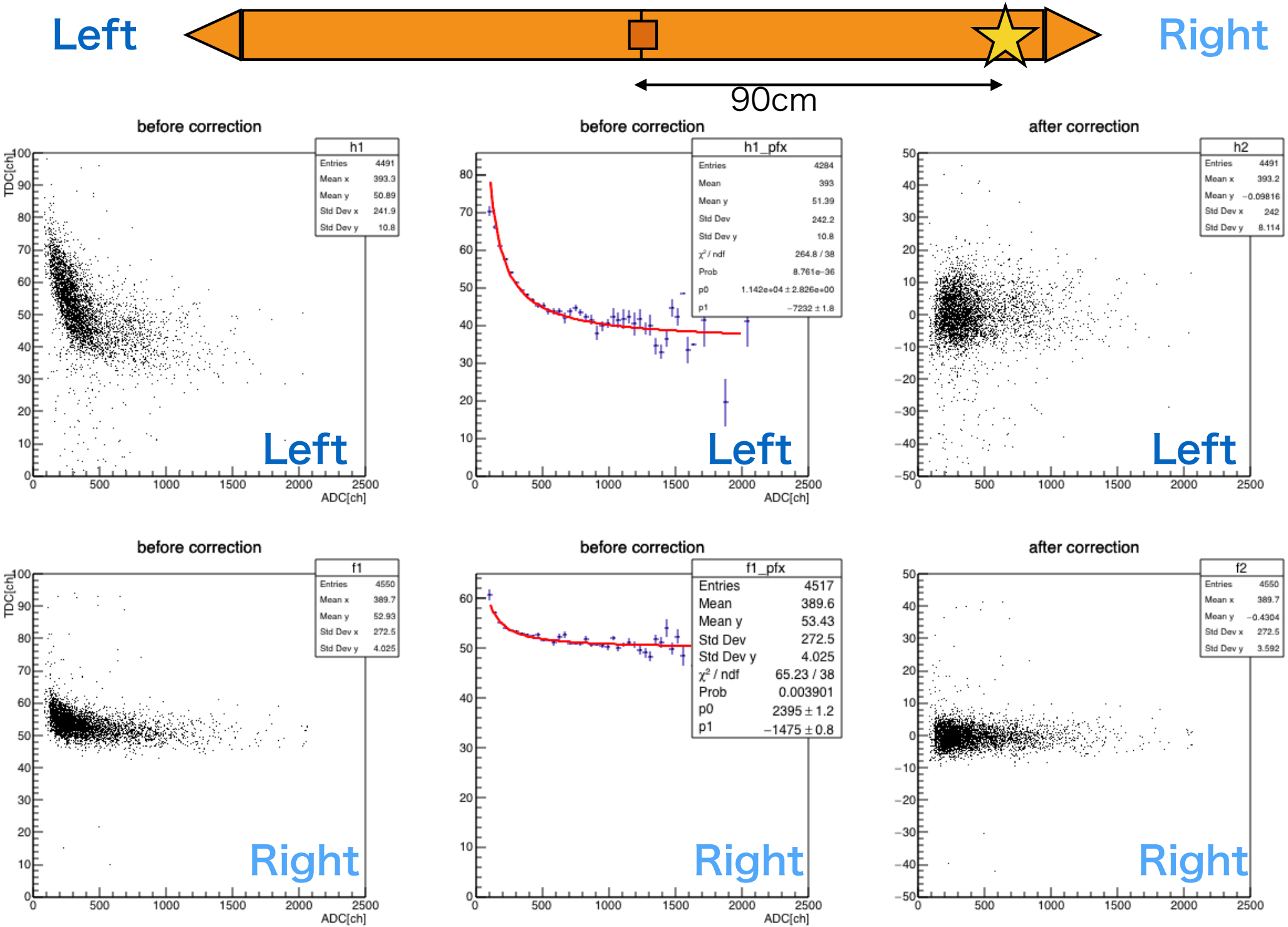
run14557


Left
Right
50cm
before correction
h1
Entries 4966
Mean x 400.6
Mean y 51.04
Std Dev x 246.7
Std Dev y 7.091
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 4786
Mean 400.5
Mean y 51.54
Std Dev 246.9
Std Dev y 7.091
χ² / ndf 100.5 / 35
Prob 2.995e−08
p0 4599 ± 2.1
p1 −2883 ± 1.3
ADC[ch]
Left
after correction
h2
Entries 4966
Mean x 400.8
Mean y −0.6022
Std Dev x 246.7
Std Dev y 6.194
Left
before correction
f1
Entries 4996
Mean x 409.1
Mean y 52.6
Std Dev x 269.2
Std Dev y 5.442
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 4921
Mean 409.3
Mean y 53.1
Std Dev 269.3
Std Dev y 5.442
χ² / ndf 72.38 / 38
Prob 0.0006455
p0 2661 ± 1.4
p1 −1644 ± 0.9
ADC[ch]
Right
after correction
f2
Entries 4996
Mean x 409.1
Mean y −0.674
Std Dev x 269.2
Std Dev y 4.915
Right

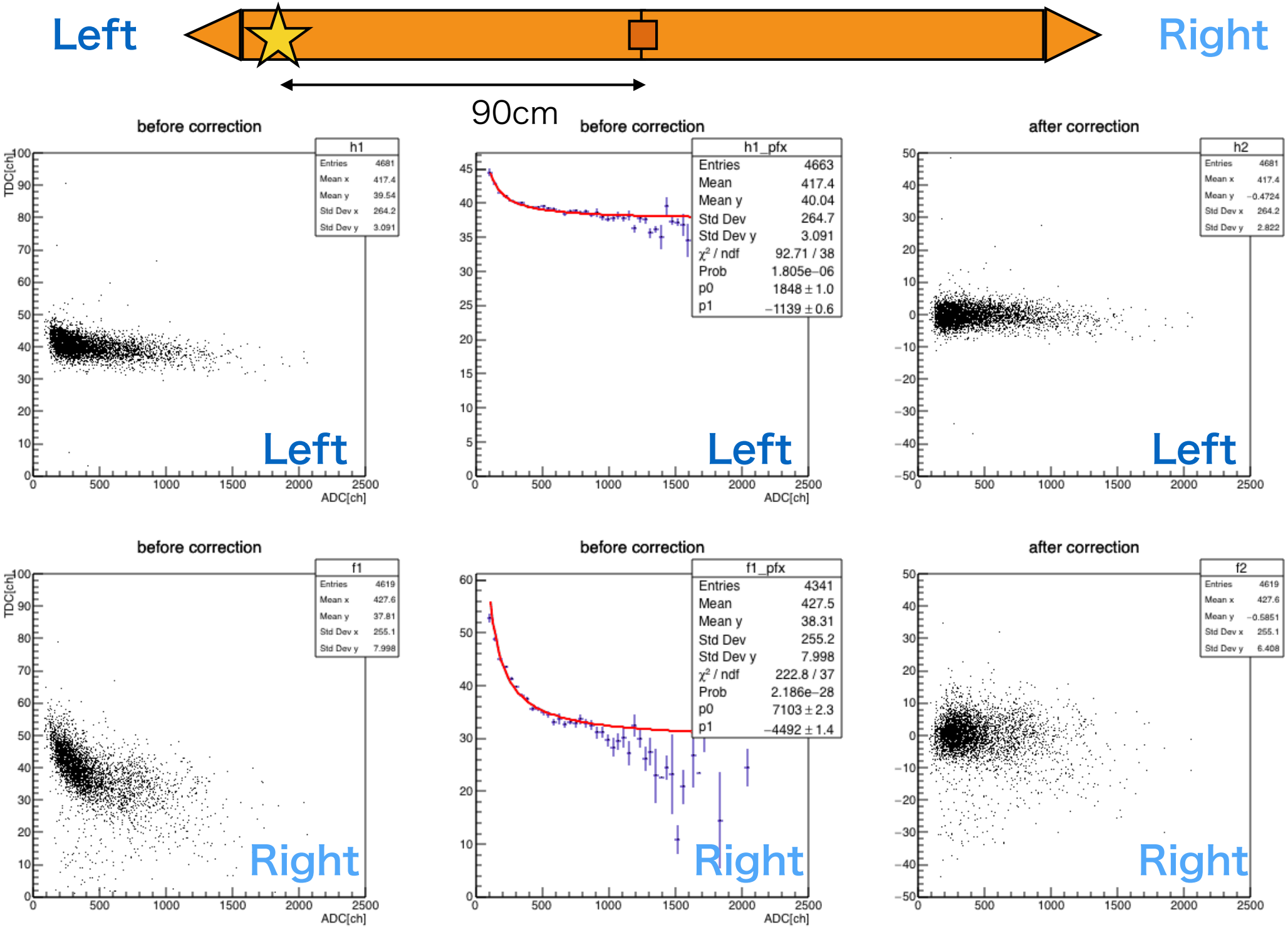
run14558


Left
Right
70cm
before correction
h1
Entries 4531
Mean x 427.2
Mean y 56.69
Std Dev x 265.2
Std Dev y 8.469
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 4378
Mean 427.2
Mean y 57.19
Std Dev 265.5
Std Dev y 8.469
χ² / ndf 150 / 38
Prob 3.08e−15
p0 5103 ± 2.7
p1 −3198 ± 1.7
ADC[ch]
Left
after correction
h2
Entries 4531
Mean x 427.5
Mean y −0.5099
Std Dev x 265.4
Std Dev y 7.249
Left
before correction
f1
Entries 4567
Mean x 434
Mean y 37.24
Std Dev x 287.2
Std Dev y 4.489
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 4540
Mean 433.7
Mean y 37.74
Std Dev 287.3
Std Dev y 4.489
χ² / ndf 61.01 / 38
Prob 0.01035
p0 2281 ± 1.3
p1 −1417 ± 0.8
ADC[ch]
Right
after correction
f2
Entries 4567
Mean x 434
Mean y −0.5862
Std Dev x 287.3
Std Dev y 4.069
Right

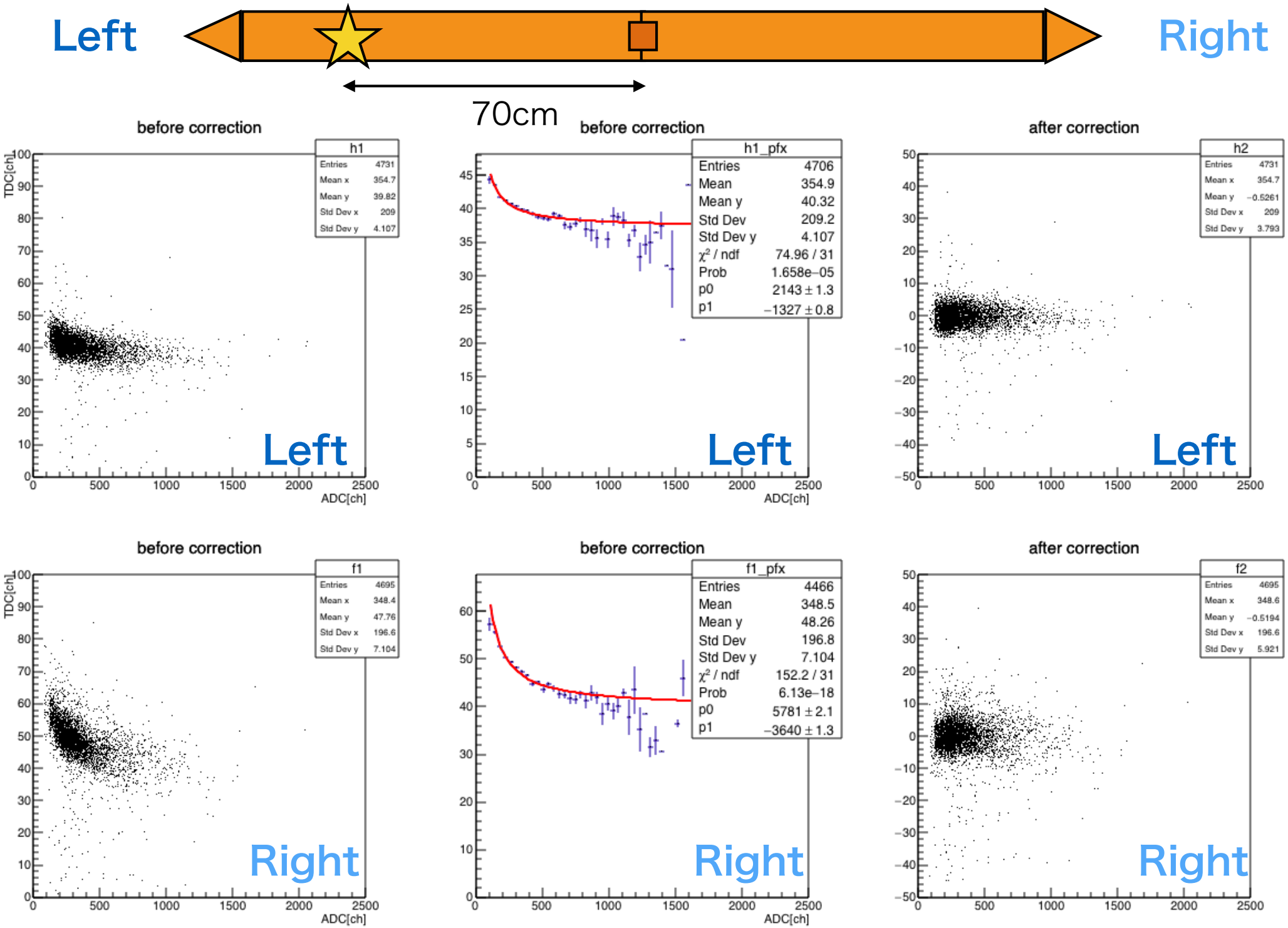
run14559


Left
Right
90cm
before correction
h1
Entries 4491
Mean x 393.3
Mean y 50.89
Std Dev x 241.9
Std Dev y 10.8
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 4284
Mean 393
Mean y 51.39
Std Dev 242.2
Std Dev y 10.8
χ² / ndf 264.8 / 38
Prob 8.761e−36
p0 1.142e+04 ± 2.826e+00
p1 −7232 ± 1.8
ADC[ch]
Left
after correction
h2
Entries 4491
Mean x 393.2
Mean y −0.09816
Std Dev x 242
Std Dev y 8.114
Left
before correction
f1
Entries 4550
Mean x 389.7
Mean y 52.93
Std Dev x 272.5
Std Dev y 4.025
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 4517
Mean 389.6
Mean y 53.43
Std Dev 272.5
Std Dev y 4.025
χ² / ndf 65.23 / 38
Prob 0.003901
p0 2395 ± 1.2
p1 −1475 ± 0.8
ADC[ch]
Right
after correction
f2
Entries 4550
Mean x 389.7
Mean y −0.4304
Std Dev x 272.5
Std Dev y 3.592
Right

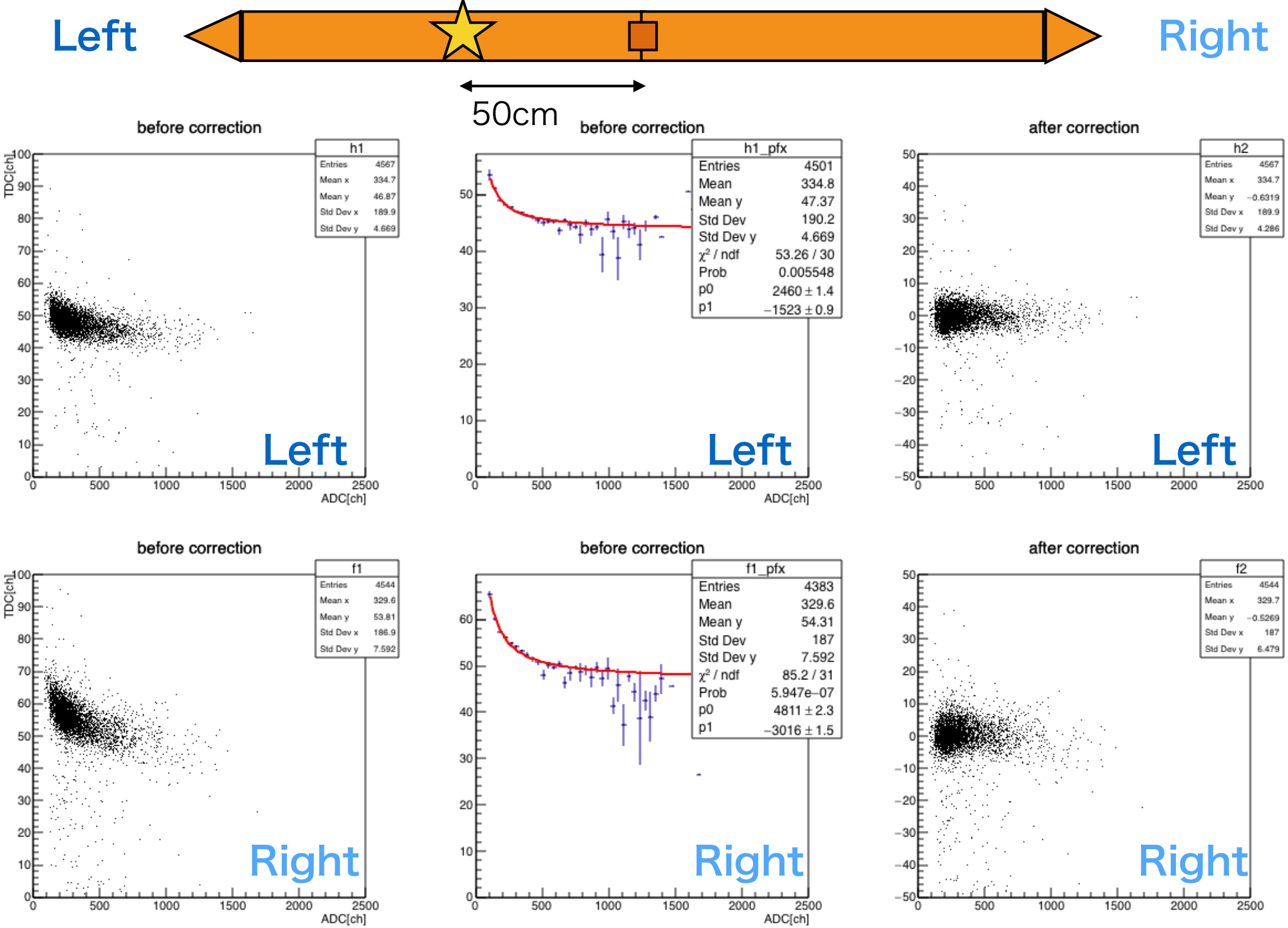
run14560


Left
Right
90cm
before correction
h1
Entries 4681
Mean x 417.4
Mean y 39.54
Std Dev x 264.2
Std Dev y 3.091
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 4663
Mean 417.4
Mean y 40.04
Std Dev 264.7
Std Dev y 3.091
χ² / ndf 92.71 / 38
Prob 1.805e−06
p0 1848 ± 1.0
p1 −1139 ± 0.6
ADC[ch]
Left
after correction
h2
Entries 4681
Mean x 417.4
Mean y −0.4724
Std Dev x 264.2
Std Dev y 2.822
Left
before correction
f1
Entries 4619
Mean x 427.6
Mean y 37.81
Std Dev x 255.1
Std Dev y 7.998
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 4341
Mean 427.5
Mean y 38.31
Std Dev 255.2
Std Dev y 7.998
χ² / ndf 222.8 / 37
Prob 2.186e−28
p0 7103 ± 2.3
p1 −4492 ± 1.4
ADC[ch]
Right
after correction
f2
Entries 4619
Mean x 427.6
Mean y −0.5851
Std Dev x 255.1
Std Dev y 6.408
Right

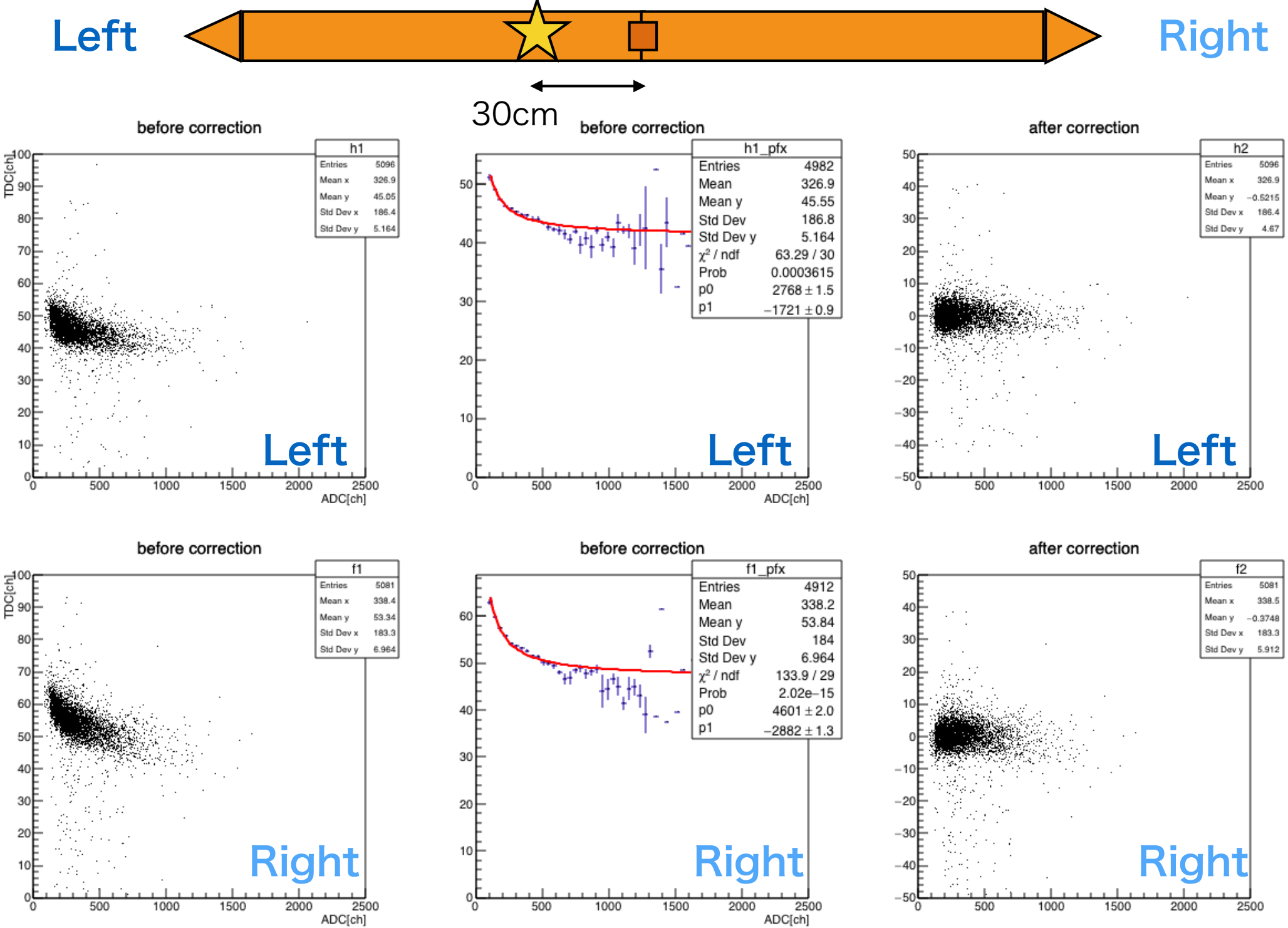
run14561


Left
Right
70cm
before correction
h1
Entries 4731
Mean x 354.7
Mean y 39.82
Std Dev x 209
Std Dev y 4.107
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 4706
Mean 354.9
Mean y 40.32
Std Dev 209.2
Std Dev y 4.107
χ² / ndf 74.96 / 31
Prob 1.658e−05
p0 2143 ± 1.3
p1 −1327 ± 0.8
ADC[ch]
Left
after correction
h2
Entries 4731
Mean x 354.7
Mean y −0.5261
Std Dev x 209
Std Dev y 3.793
Left
before correction
f1
Entries 4695
Mean x 348.4
Mean y 47.76
Std Dev x 196.6
Std Dev y 7.104
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 4466
Mean 348.5
Mean y 48.26
Std Dev 196.8
Std Dev y 7.104
χ² / ndf 152.2 / 31
Prob 6.13e−18
p0 5781 ± 2.1
p1 −3640 ± 1.3
ADC[ch]
Right
after correction
f2
Entries 4695
Mean x 348.6
Mean y −0.5194
Std Dev x 196.6
Std Dev y 5.921
Right

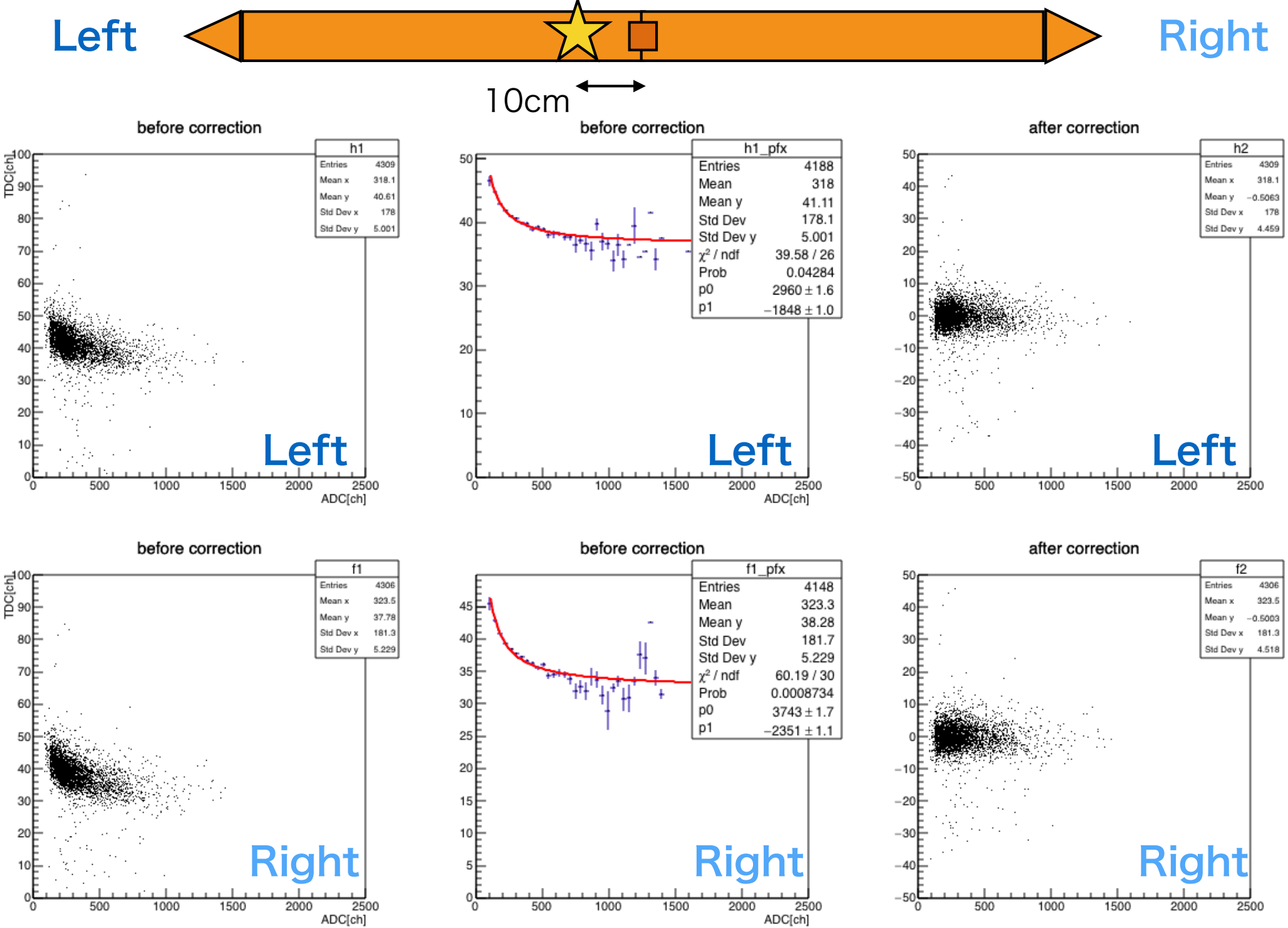
run14563


Left
Right
50cm
before correction
h1
Entries 4567
Mean x 334.7
Mean y 46.87
Std Dev x 189.9
Std Dev y 4.669
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 4501
Mean 334.8
Mean y 47.37
Std Dev 190.2
Std Dev y 4.669
χ² / ndf 53.26 / 30
Prob 0.005548
p0 2460 ± 1.4
p1 −1523 ± 0.9
ADC[ch]
Left
after correction
h2
Entries 4567
Mean x 334.7
Mean y −0.6319
Std Dev x 189.9
Std Dev y 4.286
Left
before correction
f1
Entries 4544
Mean x 329.6
Mean y 53.81
Std Dev x 186.9
Std Dev y 7.592
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 4383
Mean 329.6
Mean y 54.31
Std Dev 187
Std Dev y 7.592
χ² / ndf 85.2 / 31
Prob 5.947e−07
p0 4811 ± 2.3
p1 −3016 ± 1.5
ADC[ch]
Right
after correction
f2
Entries 4544
Mean x 329.7
Mean y −0.5269
Std Dev x 187
Std Dev y 6.479
Right

run14566


Left
Right
30cm
before correction
h1
Entries 5096
Mean x 326.9
Mean y 45.05
Std Dev x 186.4
Std Dev y 5.164
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 4982
Mean 326.9
Mean y 45.55
Std Dev 186.8
Std Dev y 5.164
χ² / ndf 63.29 / 30
Prob 0.0003615
p0 2768 ± 1.5
p1 −1721 ± 0.9
ADC[ch]
Left
after correction
h2
Entries 5096
Mean x 326.9
Mean y −0.5215
Std Dev x 186.4
Std Dev y 4.67
Left
before correction
f1
Entries 5081
Mean x 338.4
Mean y 53.34
Std Dev x 183.3
Std Dev y 6.964
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 4912
Mean 338.2
Mean y 53.84
Std Dev 184
Std Dev y 6.964
χ² / ndf 133.9 / 29
Prob 2.02e−15
p0 4601 ± 2.0
p1 −2882 ± 1.3
ADC[ch]
Right
after correction
f2
Entries 5081
Mean x 338.5
Mean y −0.3748
Std Dev x 183.3
Std Dev y 5.912
Right

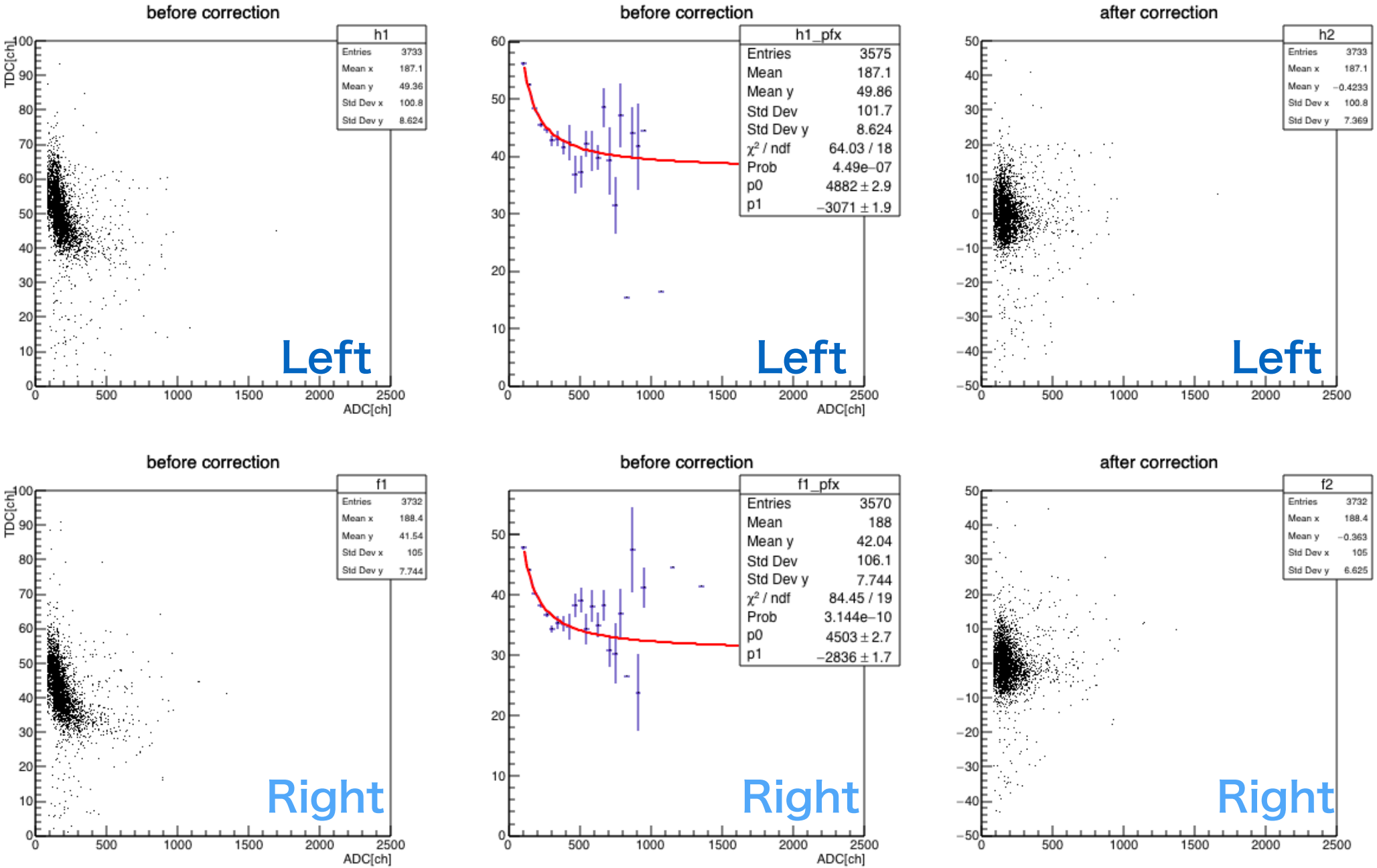
run14568


Left
Right
10cm
before correction
h1
Entries 4309
Mean x 318.1
Mean y 40.61
Std Dev x 178
Std Dev y 5.001
TDC[ch]
ADC[ch]
Left
before correction
h1_pfx
Entries 4188
Mean 318
Mean y 41.11
Std Dev 178.1
Std Dev y 5.001
χ² / ndf 39.58 / 26
Prob 0.04284
p0 2960 ± 1.6
p1 −1848 ± 1.0
ADC[ch]
Left
after correction
h2
Entries 4309
Mean x 318.1
Mean y −0.5063
Std Dev x 178
Std Dev y 4.459
Left
before correction
f1
Entries 4306
Mean x 323.5
Mean y 37.78
Std Dev x 181.3
Std Dev y 5.229
TDC[ch]
ADC[ch]
Right
before correction
f1_pfx
Entries 4148
Mean 323.3
Mean y 38.28
Std Dev 181.7
Std Dev y 5.229
χ² / ndf 60.19 / 30
Prob 0.0008734
p0 3743 ± 1.7
p1 −2351 ± 1.1
ADC[ch]
Right
after correction
f2
Entries 4306
Mean x 323.5
Mean y −0.5003
Std Dev x 181.3
Std Dev y 4.518
Right

run14569

Left Right

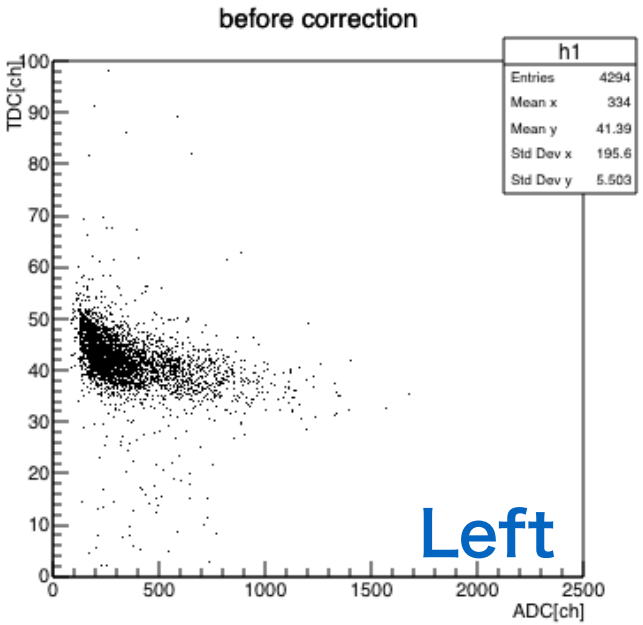
On the left-joints of glasses

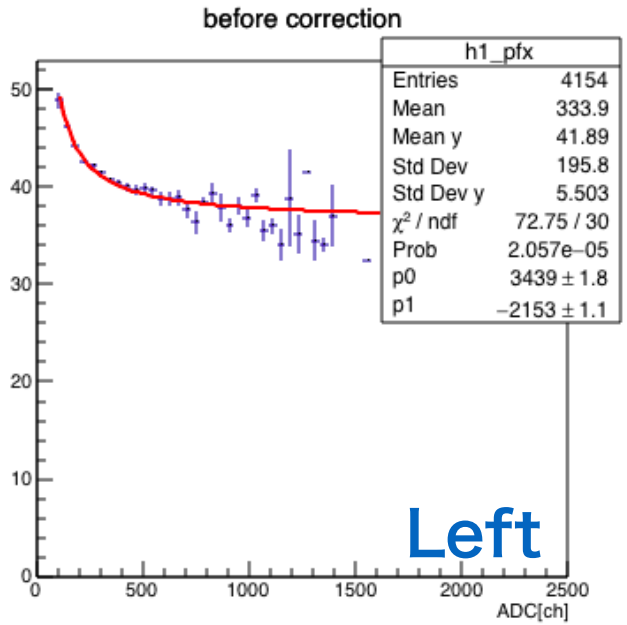


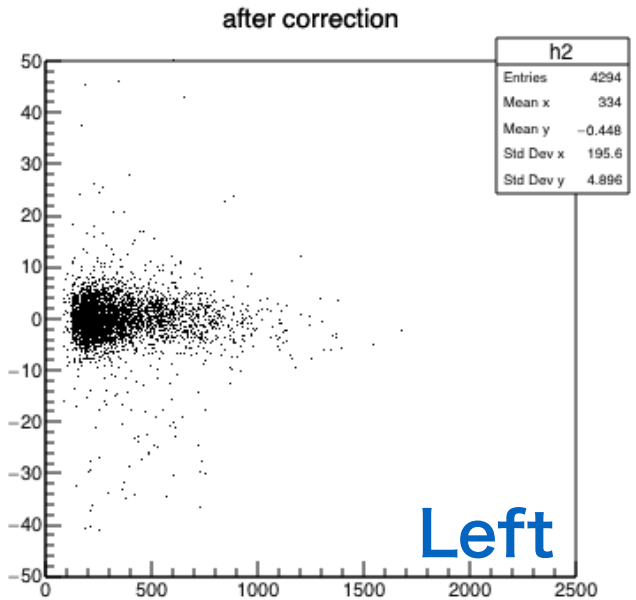
run14570

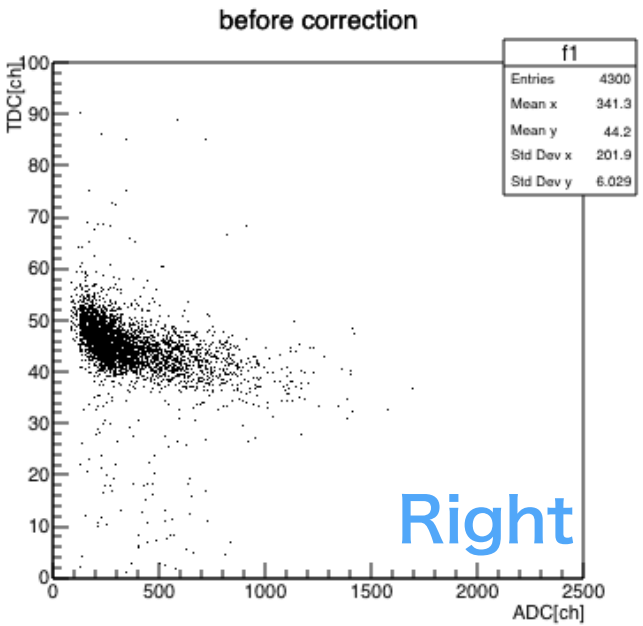
Left  Right

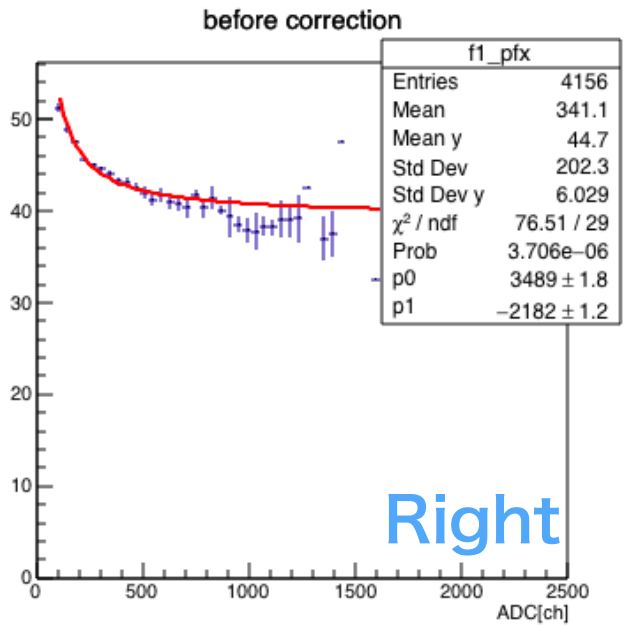
On the center of the strip

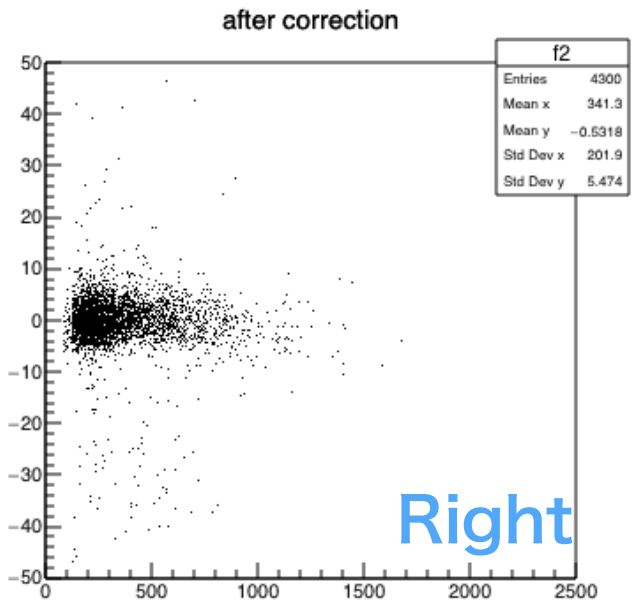






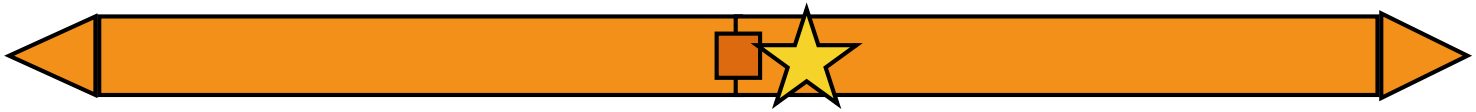






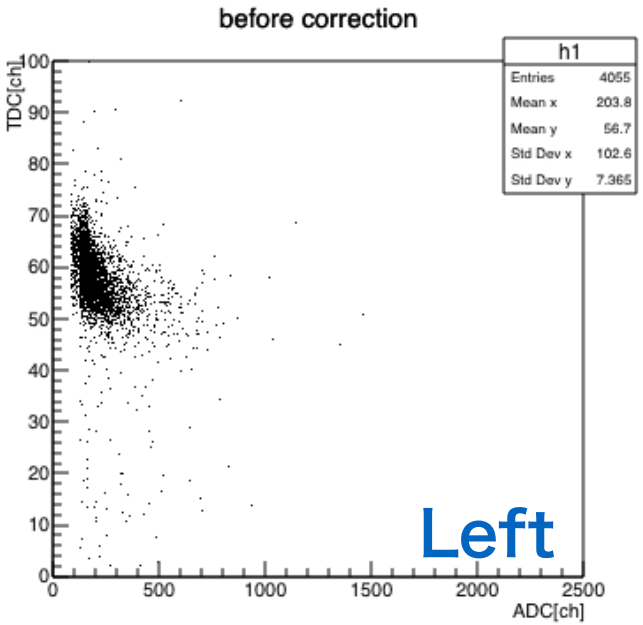
run14574

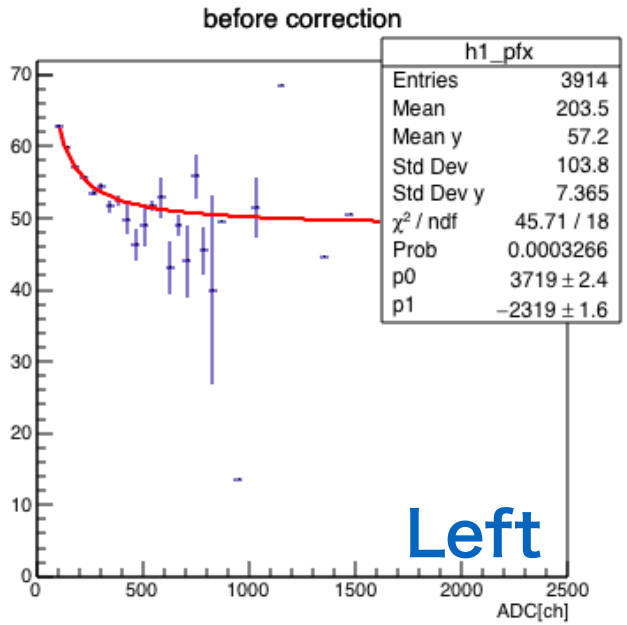
Left

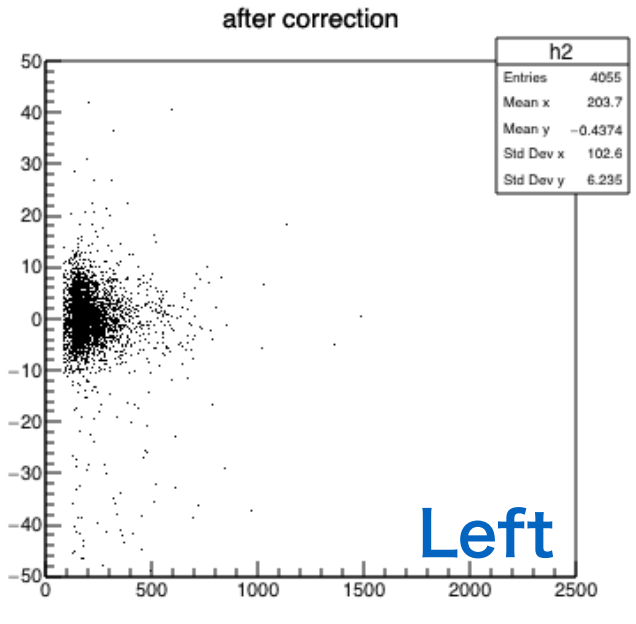


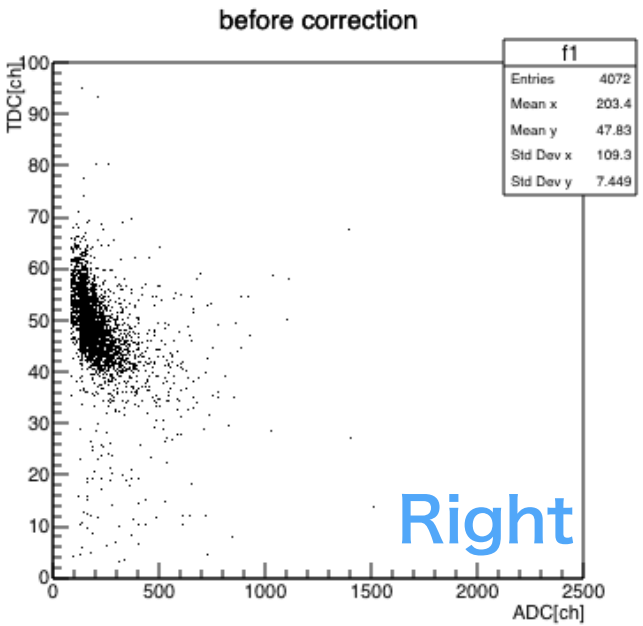
Right

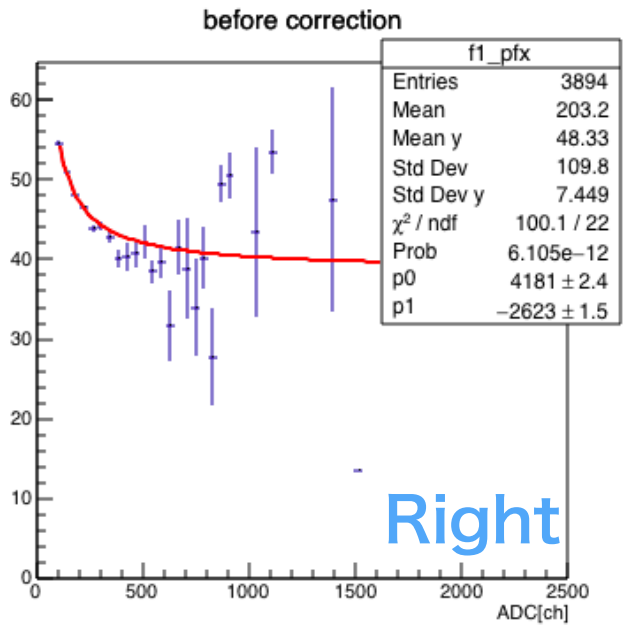
On the right-joints of glasses

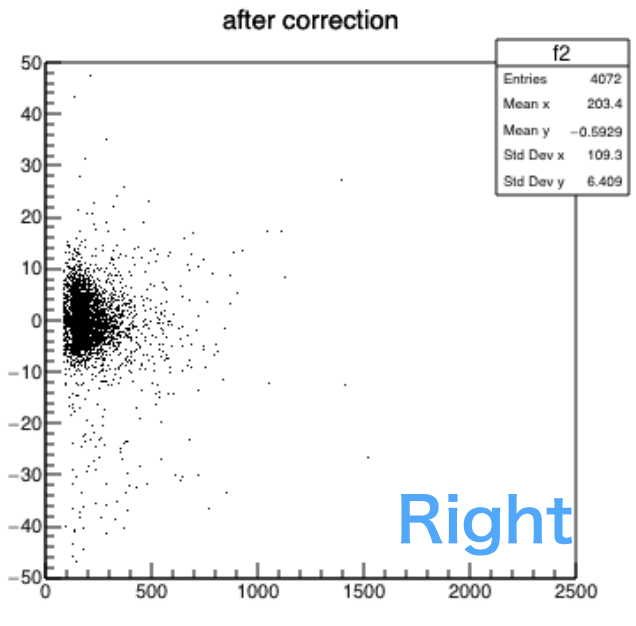








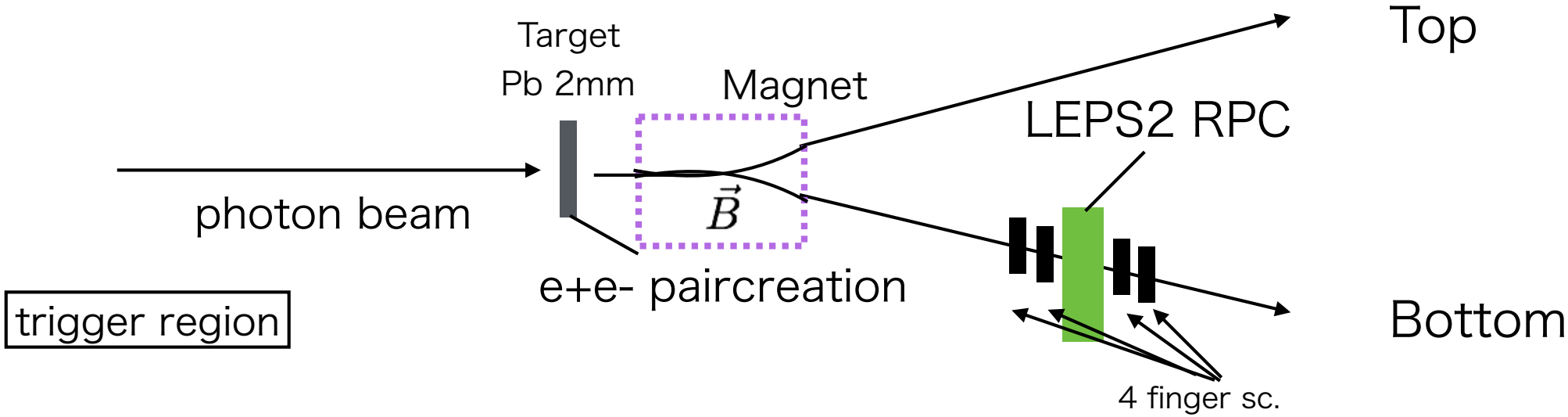


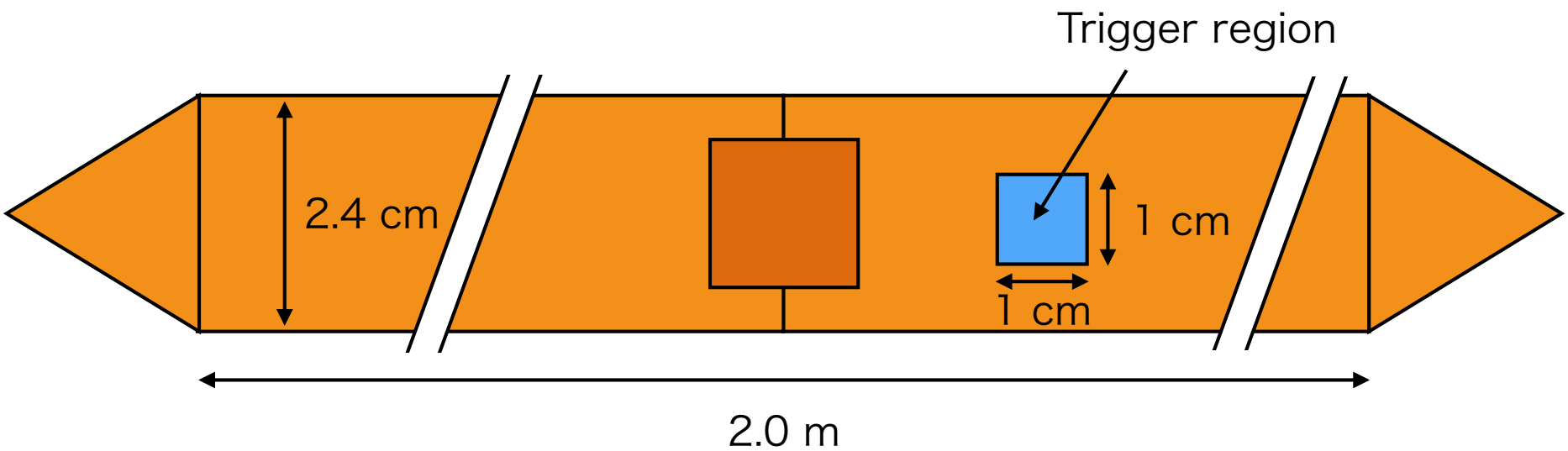


run14575

Test experiment of 2 m prototype RPC

Set up (side view)



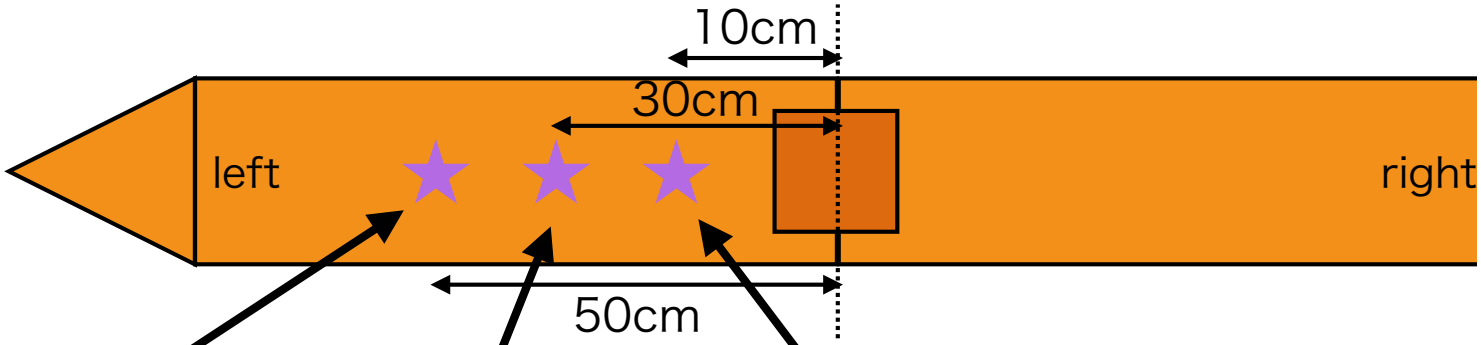


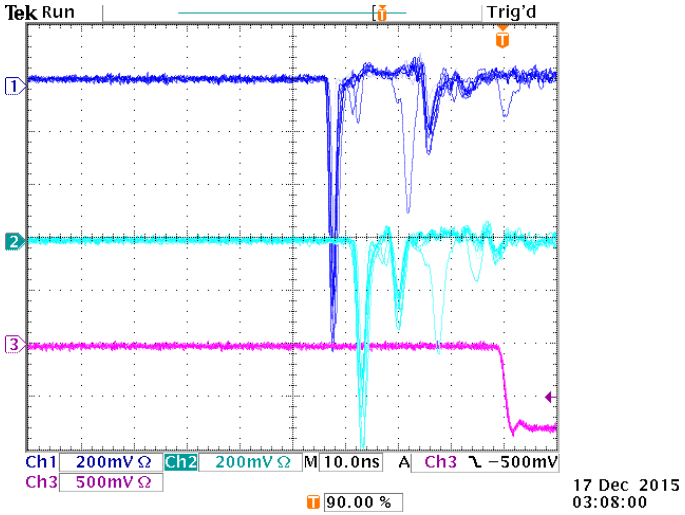
Signal

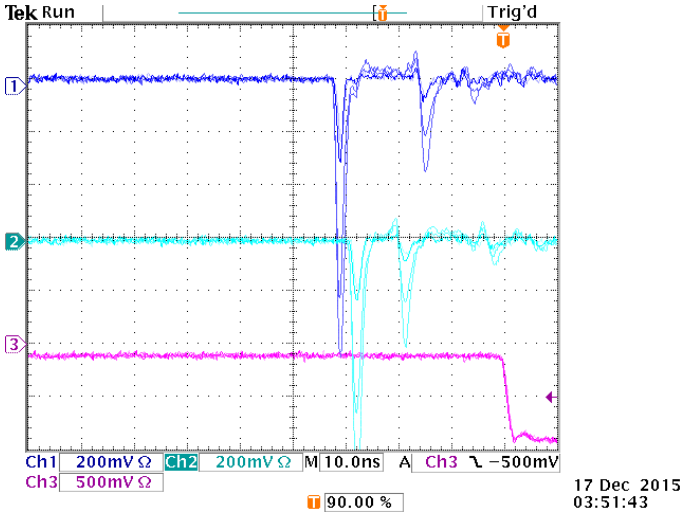
ch1 left

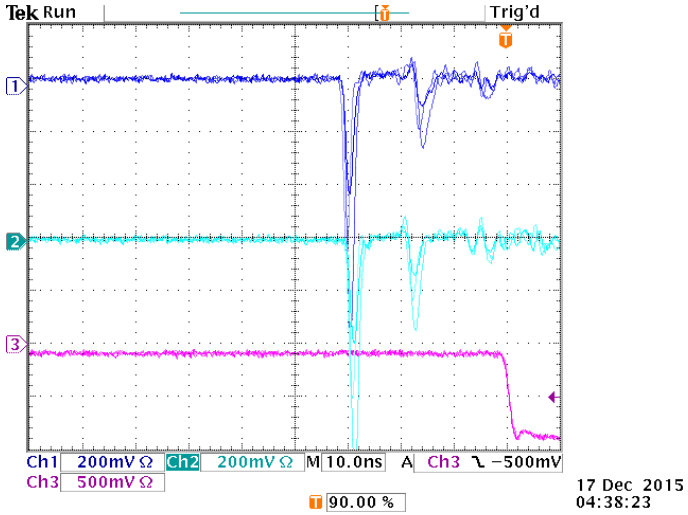
ch2 right

ch3 trigger





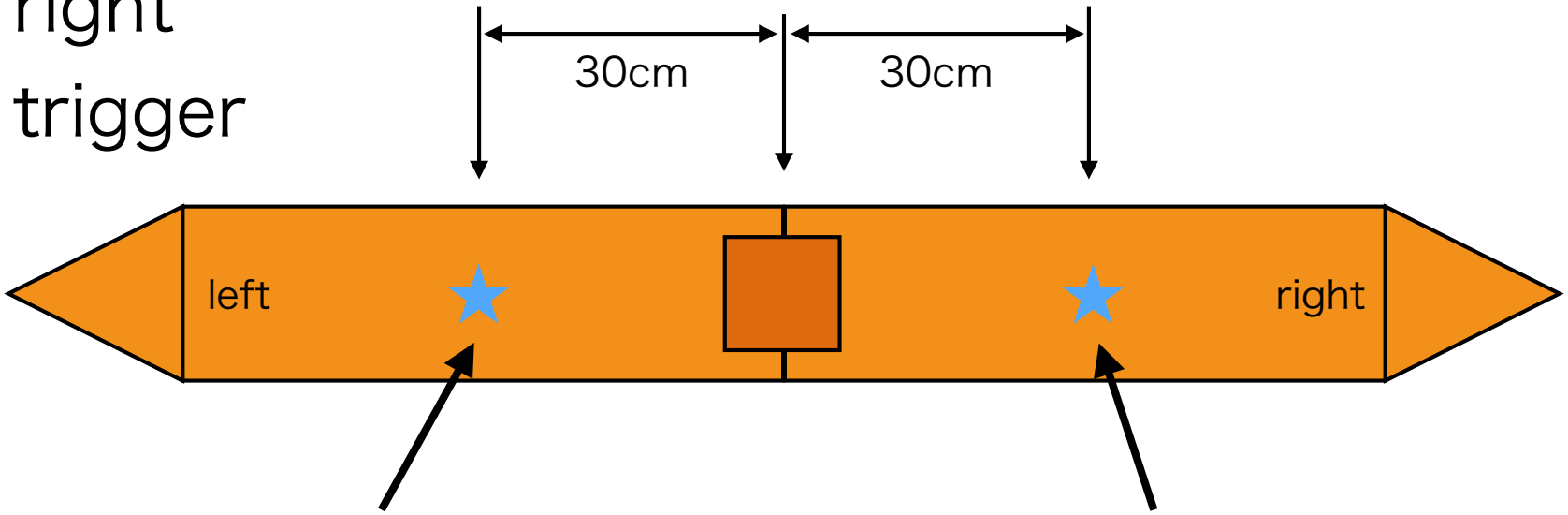


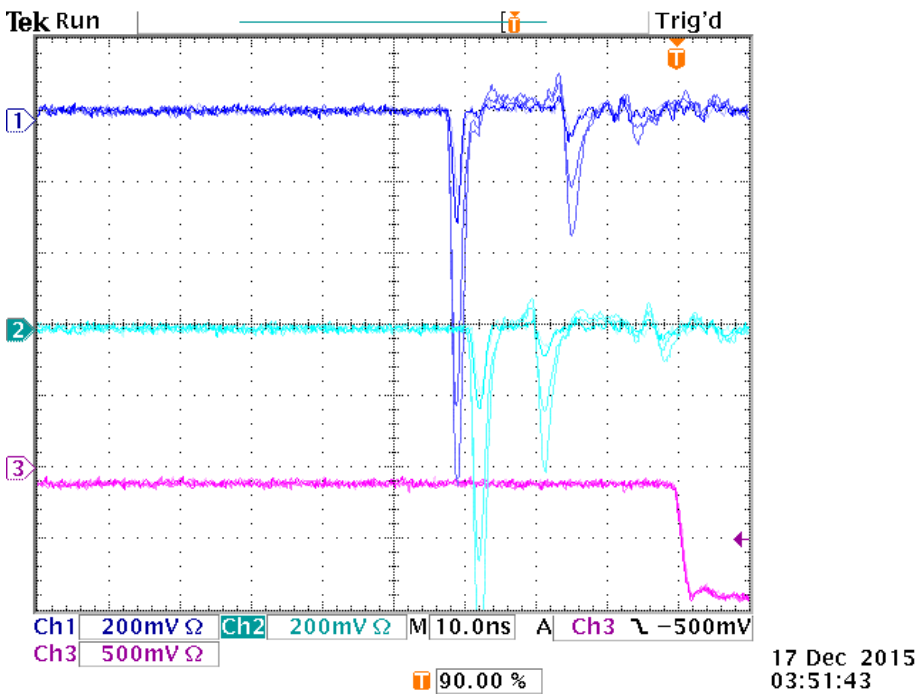


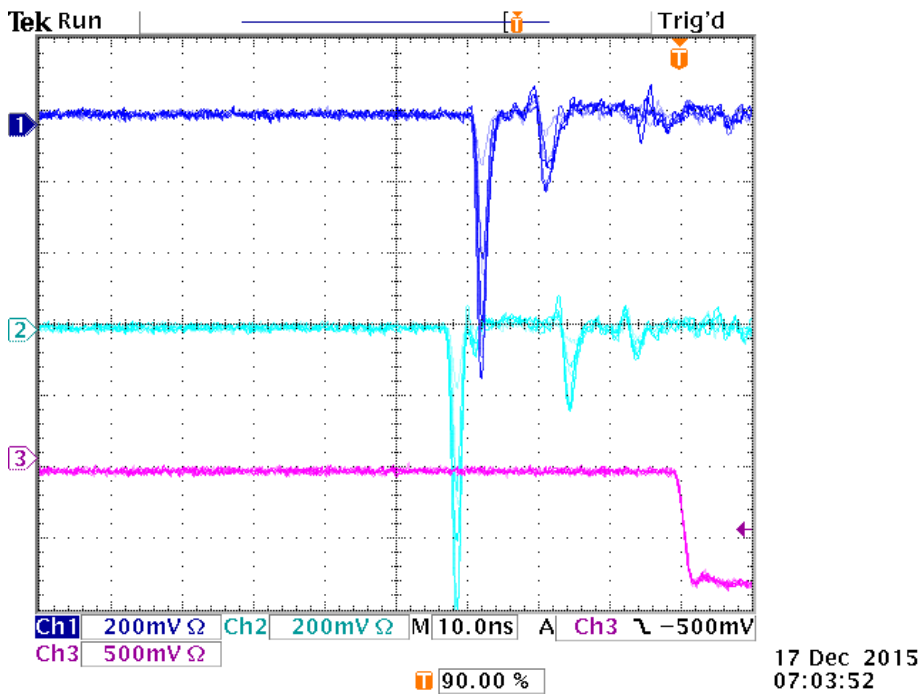
ch1 left

ch2 right

ch3 trigger



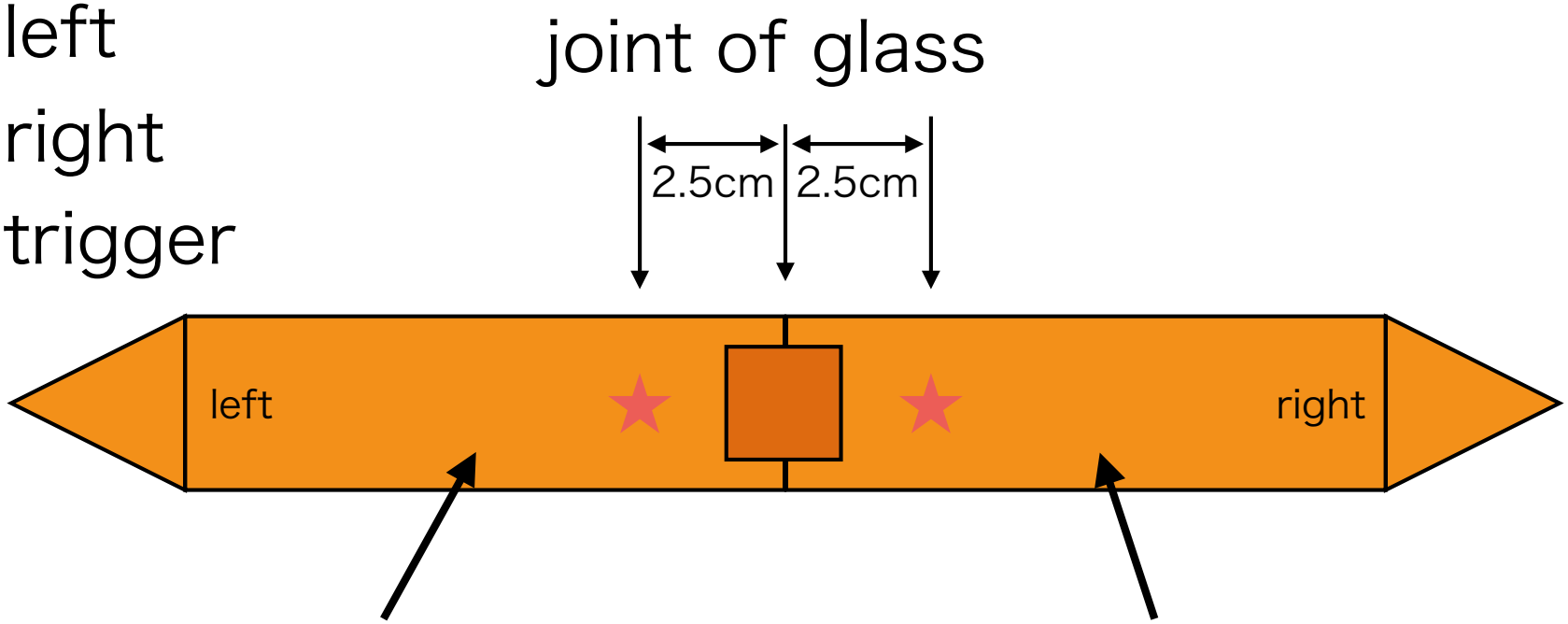


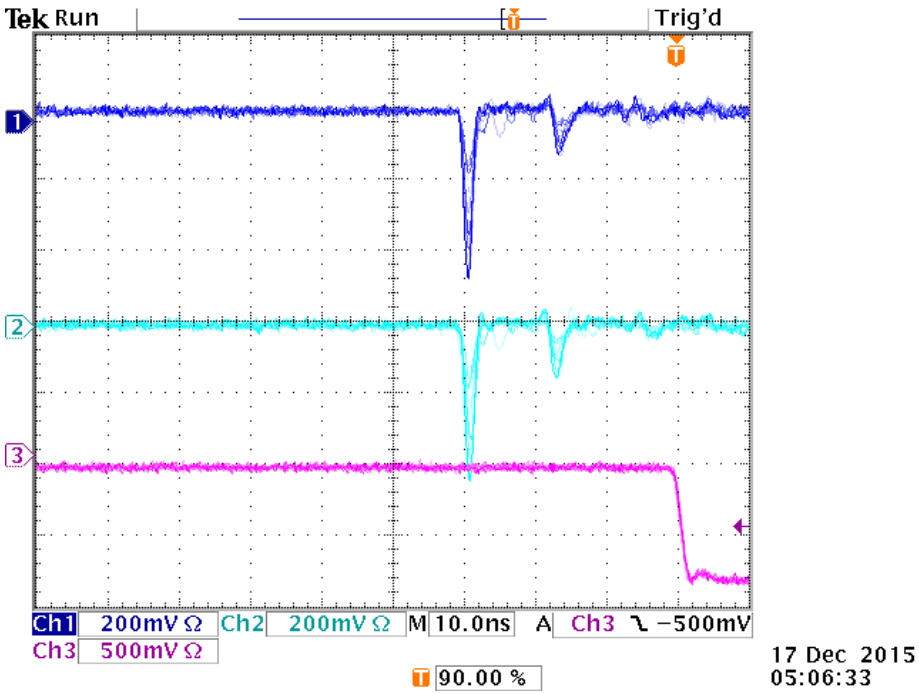


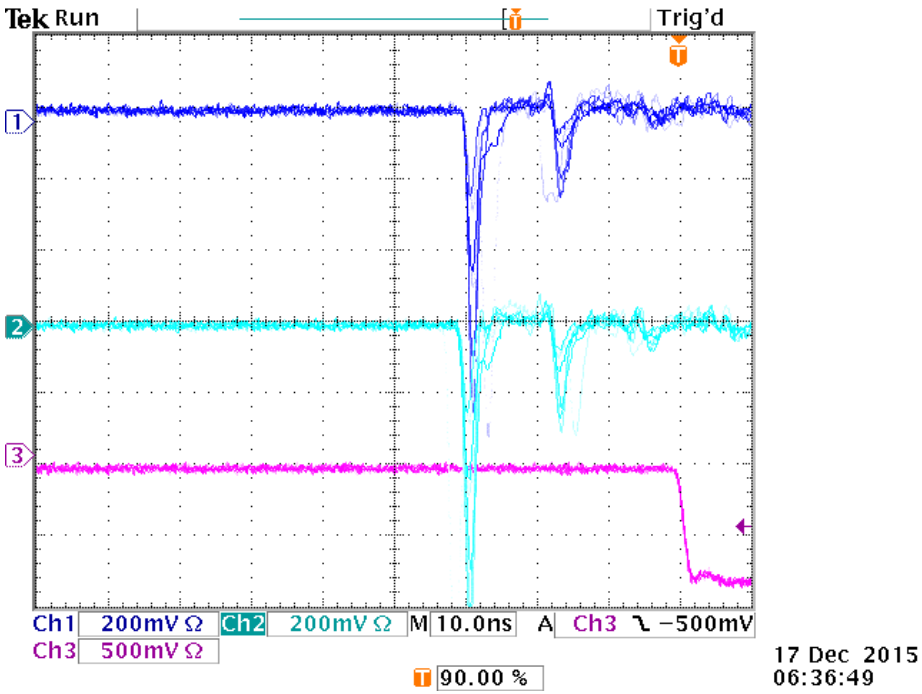
ch1 left

ch2 right

ch3 trigger







ADC distribution