Calibration and bad channels with new protoDUNE data

ProtoDUNE sim/reco

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December 11, 2019

Updated 14:15 EST

Introduction

I have been looking at the recent cosmic runs

- Initially only CRT trigger
    - To capture horizontal muons
- Now CRT plus 1 Hz random
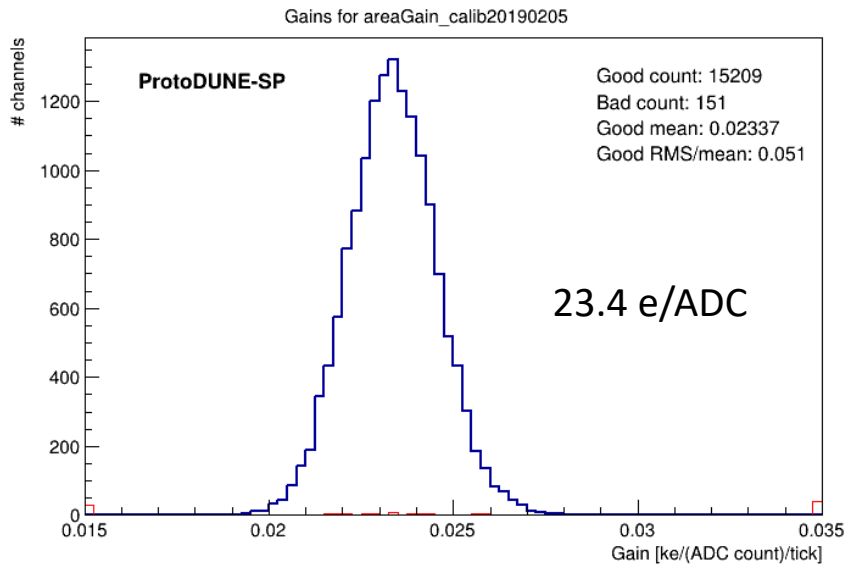   - Latter provide unbiased monitor of detector performance

Studies

- Signal strength
    - Showed last week
- Pulser calibration
    - Update follows
- New bad channels
    - Update follows

New calibration

Old calibration

Old calibration

- Dec 2018 data
- February evaluation of mean are for each channel and signed pulser setting
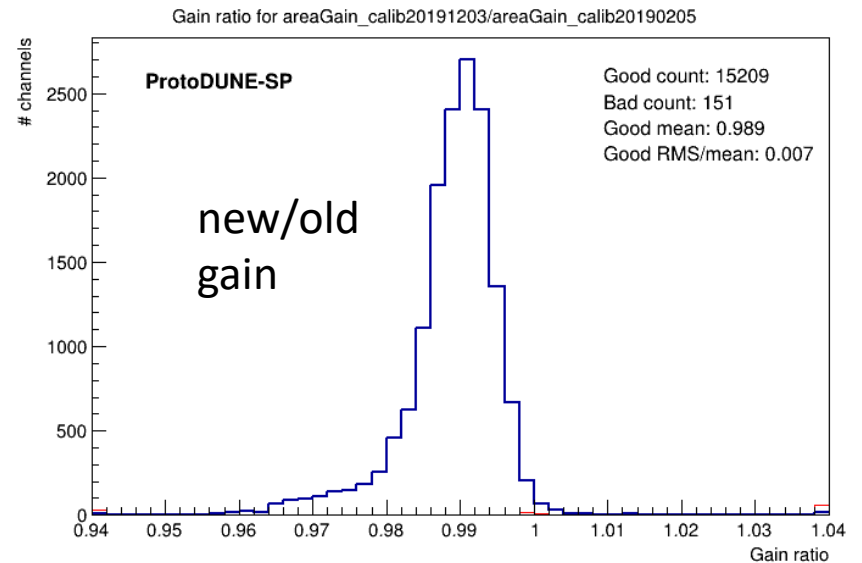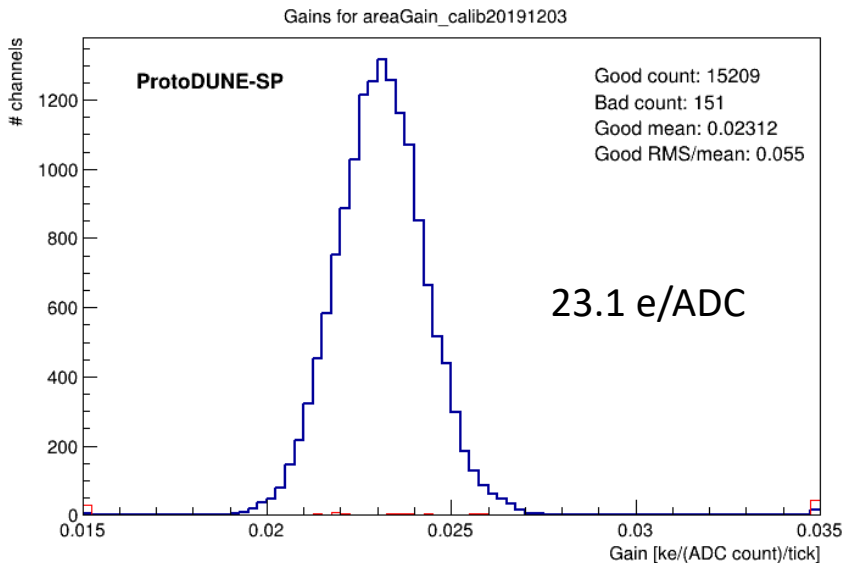- Gain distribution below

23.4 e/ADC

New calibration

Calibration data

- External pulser data taken Nov 28
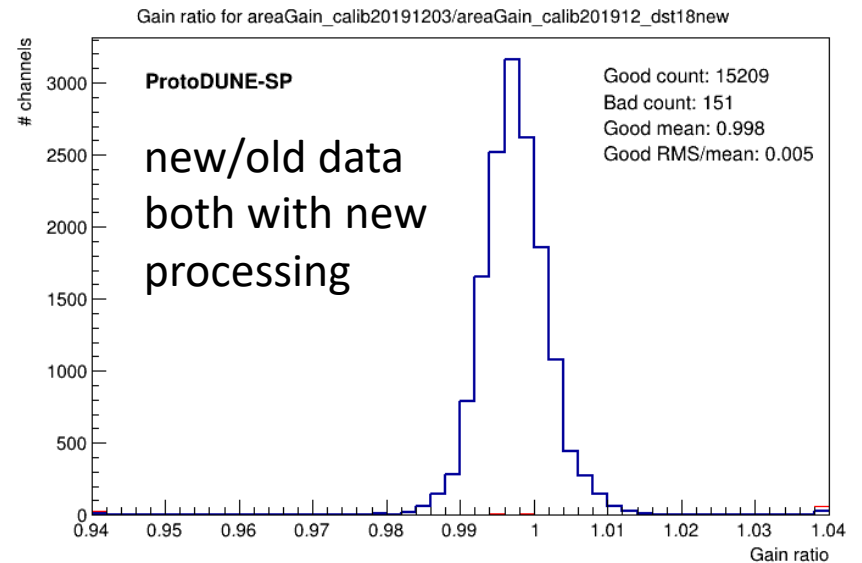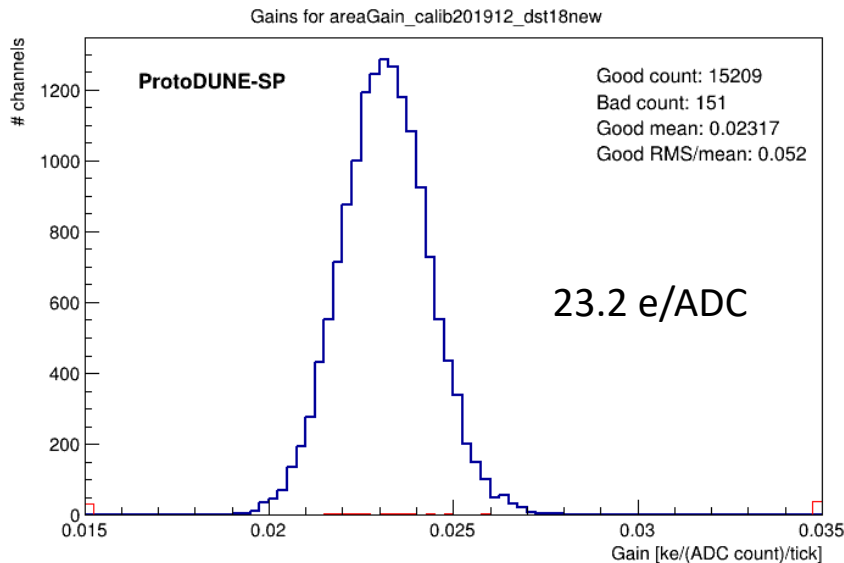
Calibration

- I processed this as for the Dec 2018 data
  - See DUNE-doc-15523 for the old calibration
- New gains are 1% lower
- new/old channel-by-channel RMS is 0.7% (including low tail)

Gains for areaGain_calib20191203

ProtoDUNE-SP

Good count: 15209
Bad count: 151
Good mean: 0.02312
Good RMS/mean: 0.055

23.1 e/ADC

Gain [ke/(ADC count)/tick]

Gain ratio for areaGain_calib20191203/areaGain_calib20190205

ProtoDUNE-SP

Good count: 15209
Bad count: 151
Good mean: 0.989
Good RMS/mean: 0.007

new/old
gain

Gain ratio

New processing and calibration old raw data

New processing of old raw data

- December 2018 data
- Reevaluate area measurements
  - ROI finding, area evaluation, mean evaluation
- Fit to get gains
- Gains for new data are now 0.2% lower than old data
 - And tail gone from ratio distribution

23.2 e/ADC

new/old data both with new processing

What happened?

Bug fixed in ROI finder

- Early last March a bug was fixed in the ROI finder
  - This is after calibration was performed
- Tails of ROIs were being cut off
  - Effect on calibration pulses is ROI ends 10 ticks after end of signal
  - Instead of the intended 20 ticks

Calibration pulse shape

- The calibration pulses have a small after pulse
- Larger window is picking up more of this
- Thus pulse areas are systematically larger with the new processing
  - ➔ evaluated gains are systematically lower

v08_11_00

ROI pos area run 6045 APA plane 1z
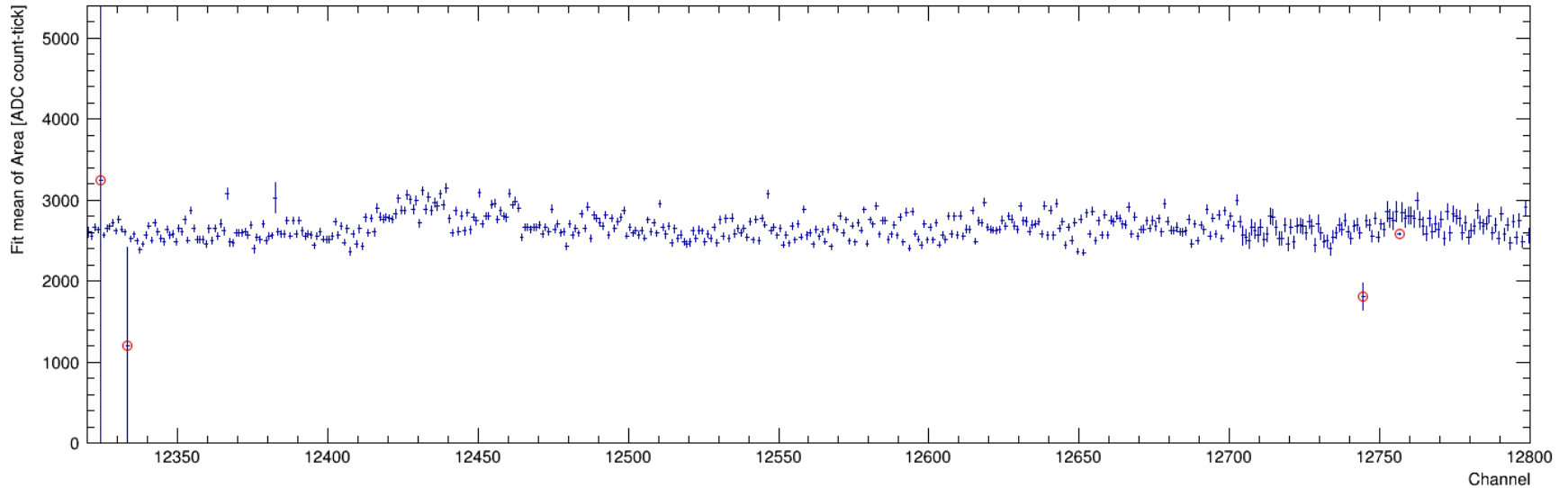
Above shows APA1z mean areas for dunetpc v08_11_00

- Release before bug fix in ROI finder
- Narrow ROIs

v08_12_00

ROI pos area run 6045 APA plane 1z
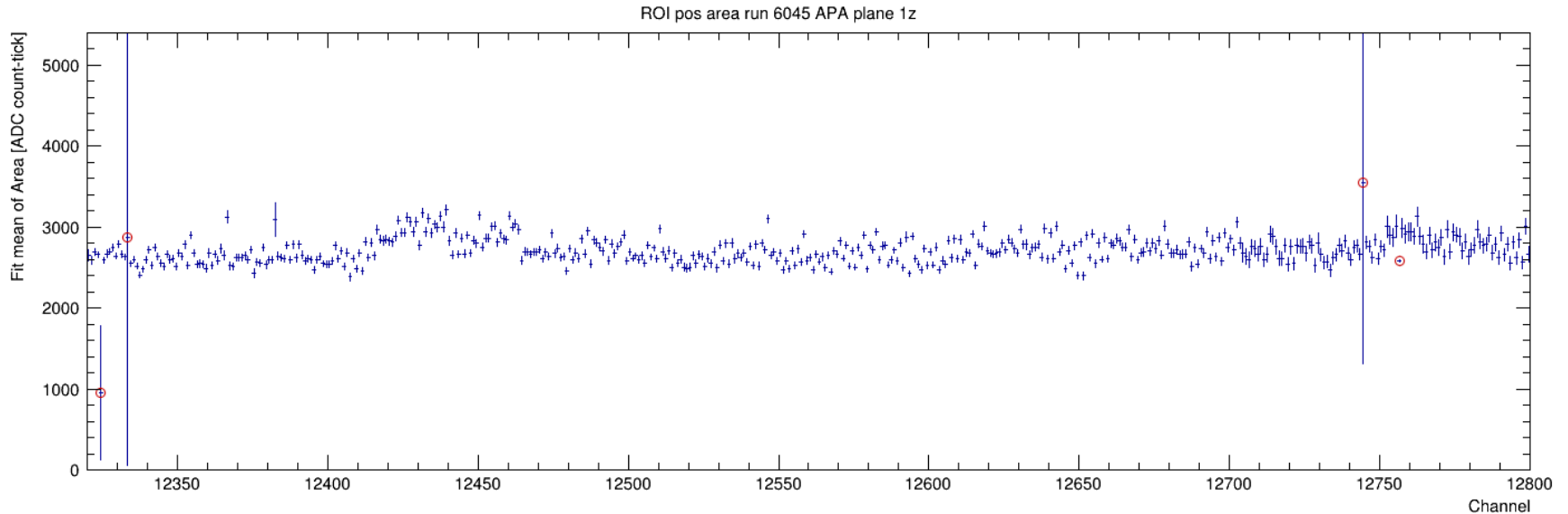
Above shows APA1z mean areas for dunetpc v08_12_00

- Release after bug fix in ROI finder
- Wide ROIs: (-10, +20) extension beyond |ADC| > 100

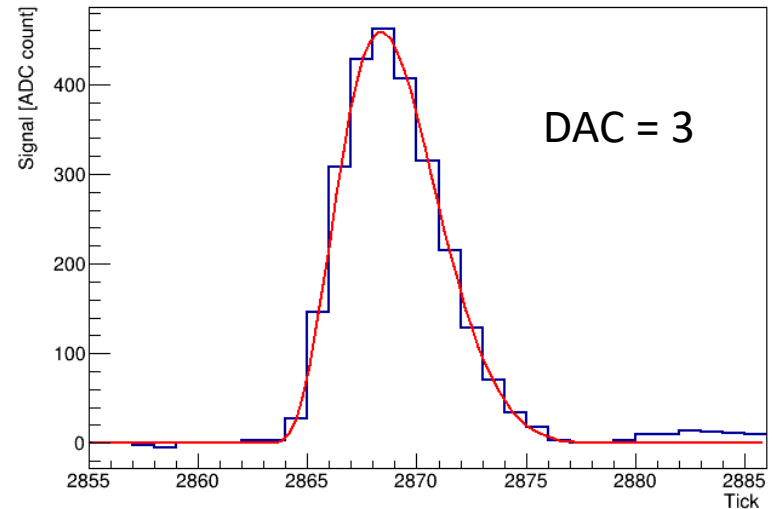# New new calibration

New new calibration

Pulse shapes

- Top plot shows a "typical" od ROI from the pulser
  - Red is fit to CE signal
  - Before ROI bug fix
- Bottom shows the full pulser signal (plus and minus)

New new calibration

- Threshold 100 ADC counts
- ROI window (-5, +8)
- So ROIs are even narrower than the original calibration

Run 6045 event 1 channel 12320 ROI 5

DAC = 3

Run 10493 event 1 channel 12320 ROI 5

DAC = 4
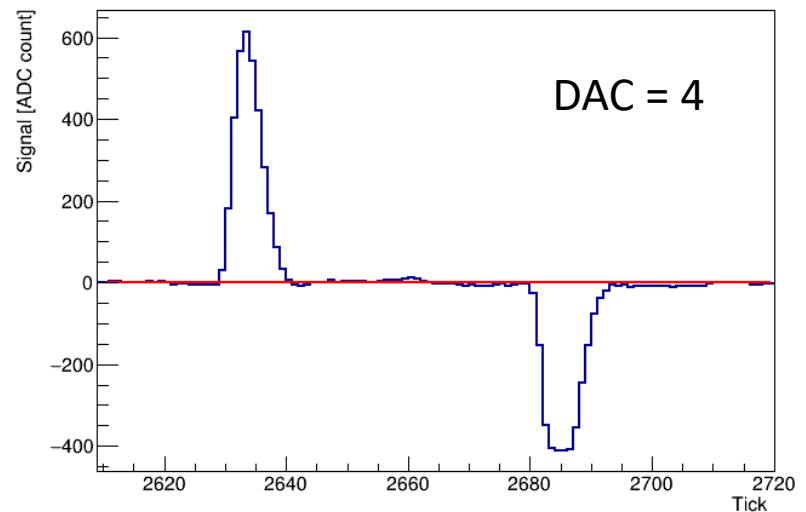
Dec 2018 pulser data

New new calibration with November data

- I.e. with tight (-5, 8) window
- Left plot is the gain distribution
- Right plot is the ratio to original Feb calibration
  - I.e. compared to the same data with wider (and buggy) ROI window

23.5 e/ADC
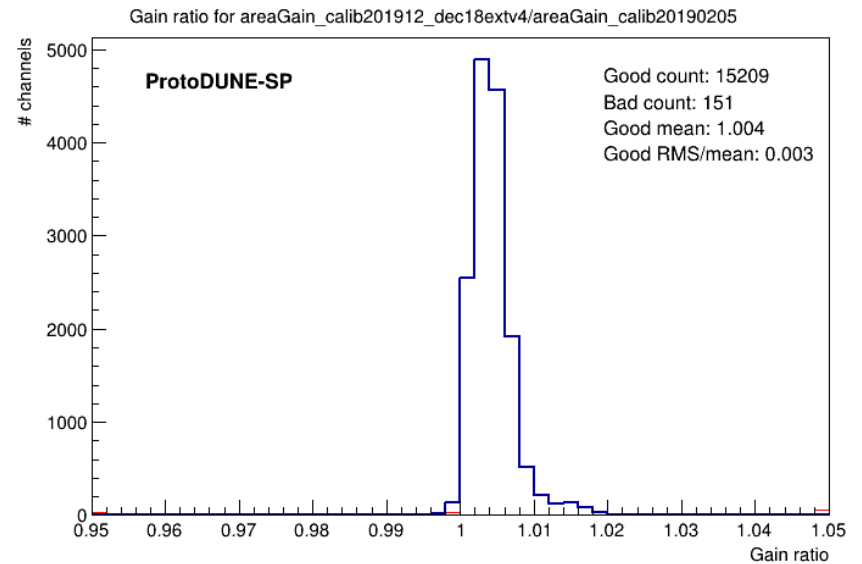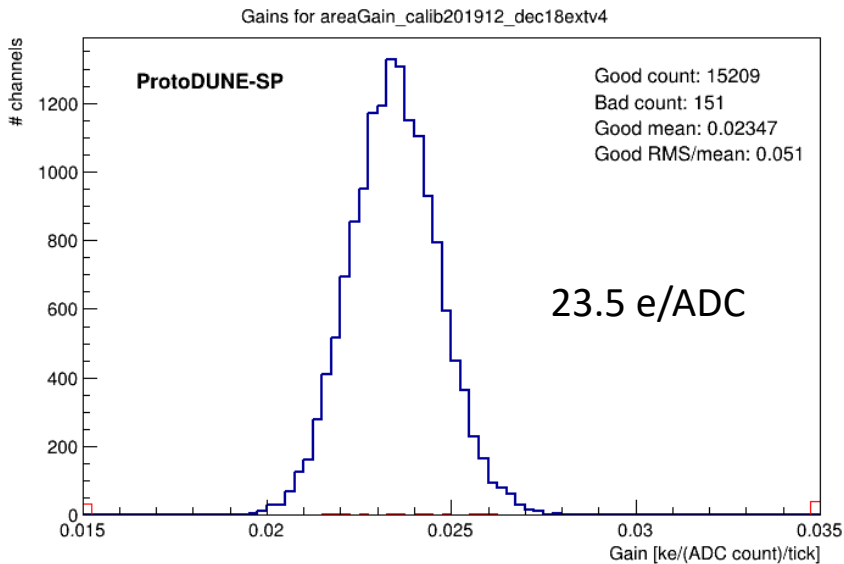
# Nov 2019 pulser data

New new calibration with November data

- I.e. with tight (-5, 8) window
- Plot on left is the gain distribution
- Plot on right is the ratio to the same calibration using Dec 2018 data
  - Shift is 0.13 %
  - RMS is 0.4 %
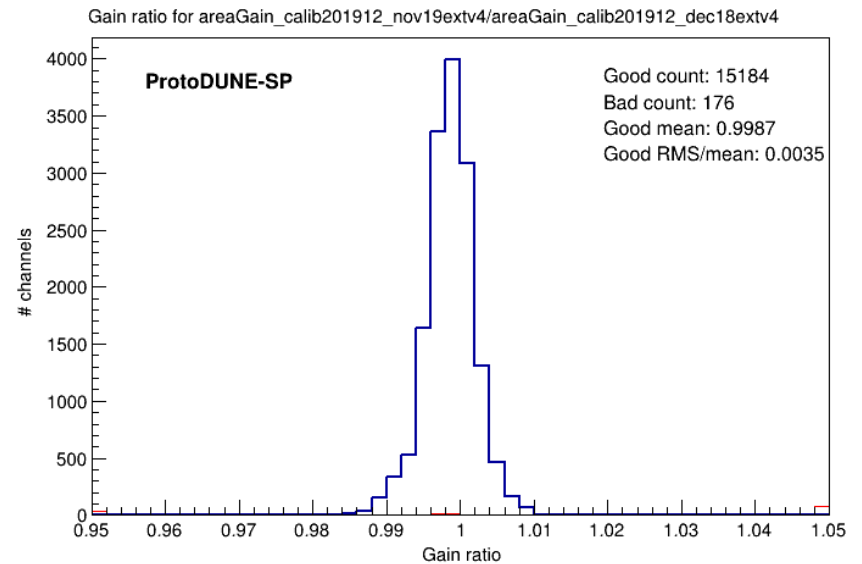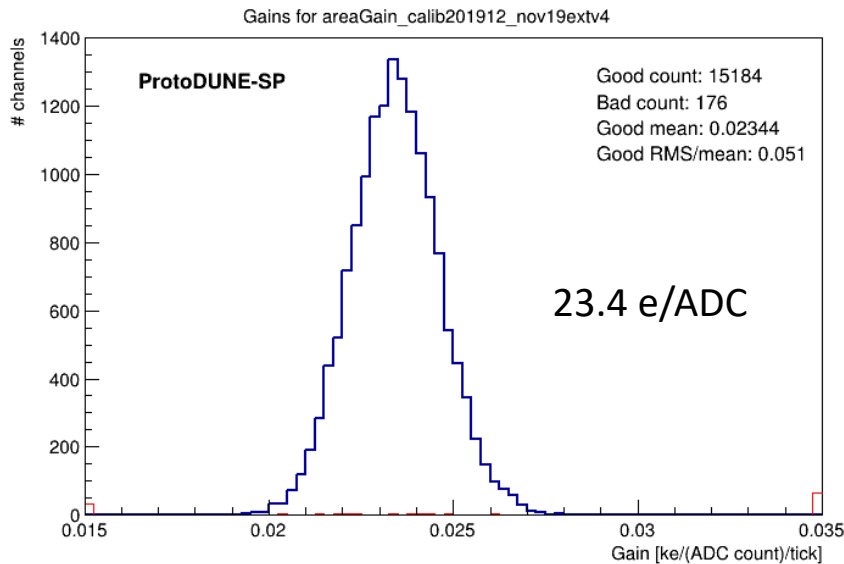
April 2019 pulser data

New new calibration with April data

- I.e. with tight (-5, 8) window
- Plot on left is the gain distribution
- Plot on right is the ratio to the same calibration using Dec 2018 data
  - Shift is 0.01 %
  - RMS is 0.3 %
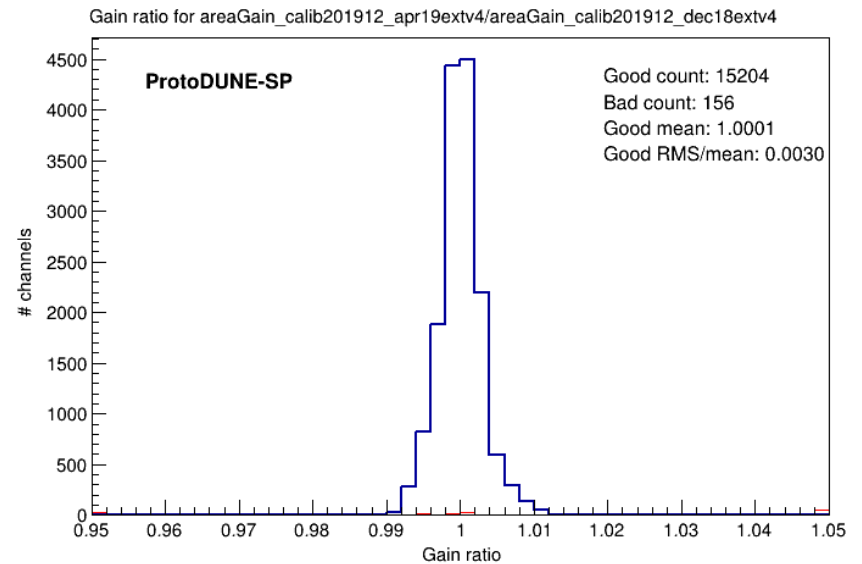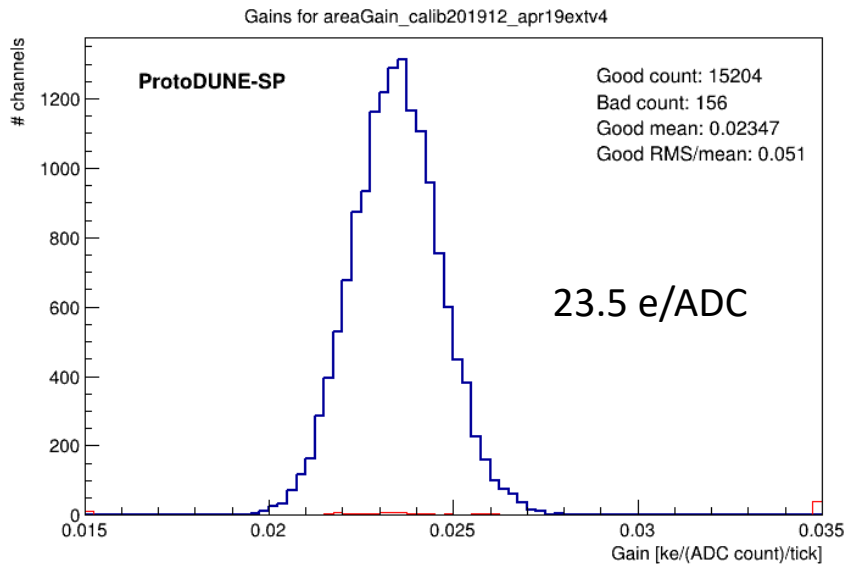
Bad channels

Bad channels

Bad channel observations (update of last week)

- 17+6 more bad channels (not bad in 2018)
  - 17 were shown in Nov 27 DRA meeting
    - 16 from one ASIC
  - 5 dead, 1 very noisy
- 16 look noisy in hand scan of pulser distributions
  - Not classified as noisy in channel status
    - We should do a more comprehensive check (all DAC settings) and develop automated procedure if we want to classify these as noisy
  - 2 new (near pedestal) sticky codes
    - Mitigating these might help
- 20 channels with nonlinear response
  - 3 blocks of 6 (ASIC) look shifted
    - Not flagged
  - 2 channels have jump(s)
    - Flagged as noisy
- My (updated) notes are on the following page
- Plots for all the above follow

```
Run 10492                              Runs 5461 and 10527 pedestal WFs
Dec 11, 2019
-----------
1u 10573 wide (50-->80), low tail (5%)   WFs look fine                          GOOD
1u 10831 wide (95-->134)                 Both WFs sticking to pedestal zero     GOOD
1u 11001 low RMS                         Good in old run, now dead              BAD *
1u 11014 low RMS                         Good in old run, now dead              BAD *
1u 11018 low RMS                         Good in old run, now dead              BAD *
1v 11315 wide (55-->99)                  WFs look fine                          GOOD
1v 11501 low RMS                         Good in old run, now dead              BAD *
1v 11773 wide (55-->103)                 Many SC near pedestal for both         GOOD
1c 12252 very wide (55-->390), bad shape  Pulser mostly stuck on one value for both  GOOD
1z 12382 very wide (43-->370), bad shape  Many SCs. New SC and worse in new run.   GOOD, add SC

3u   426 wide (55-->100), low tail (1%)  Many SC near pedestal. Better now.     GOOD
3v   867 wide (55-->100)                 Both pedestals fine.                   GOOD
3v  1522 wide (65-->125)                 Both sticking near pedestal.           GOOD
3z  2330 wide (41-->72), low tail (1%)   Both pedestals look fine.              GOOD
3z  2333 wide (40-->99), high tail (2%)  New SC. Old is fine.                   GOOD, add SC

4u 12938 wide (70-->150)                 Pedestals look fine.                   GOOD
4v 13748 wide (65-->87)                  Pedestals look fine.                   GOOD

5z  4232 low RMS                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4234 low RMS                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4236 missing                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4238 missing                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4240 missing                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4242 missing                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4472 missing                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4473 split peak varies with DAC      Nonlinear response                     NOISY *
5z  4474 missing                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4476 missing                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4478 missing                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4480 missing                         Big pulser offset in new data.         Recalibrate varying offset?
5z  4482 missing                         Big pulser offset in new data.         Recalibrate varying offset?

6u  7715 very wide (55-->2300)           Pedestal was fine, now very noisy (amp?)  BAD *
6u  8234 wide (50-->100)                 Both pedestals sticking.               GOOD
6u  8290 tails (10%)                     Both pedestal mostly stuck             GOOD
6c  9941 tails (5%)                      SC bad goes to very bad.               GOOD
6c 10033 missing (tail @ ADC < 500)      OK then. Now dead (I think)            BAD *
6z  9545 low RMS                         Big pulser offset in new data.         Recalibrate varying offset?
6z  9547 low RMS                         Big pulser offset in new data.         Recalibrate varying offset?
6z  9549 low RMS                         Big pulser offset in new data.         Recalibrate varying offset?
6z  9551 low RMS                         Big pulser offset in new data.         Recalibrate varying offset?
6z  9553 low RMS                         Big pulser offset in new data.         Recalibrate varying offset?
6z  9555 low RMS                         Big pulser offset in new data.         Recalibrate varying offset?
6z  9641 low tail                        Big nonlinearity in pulser response.   NOISY *
```
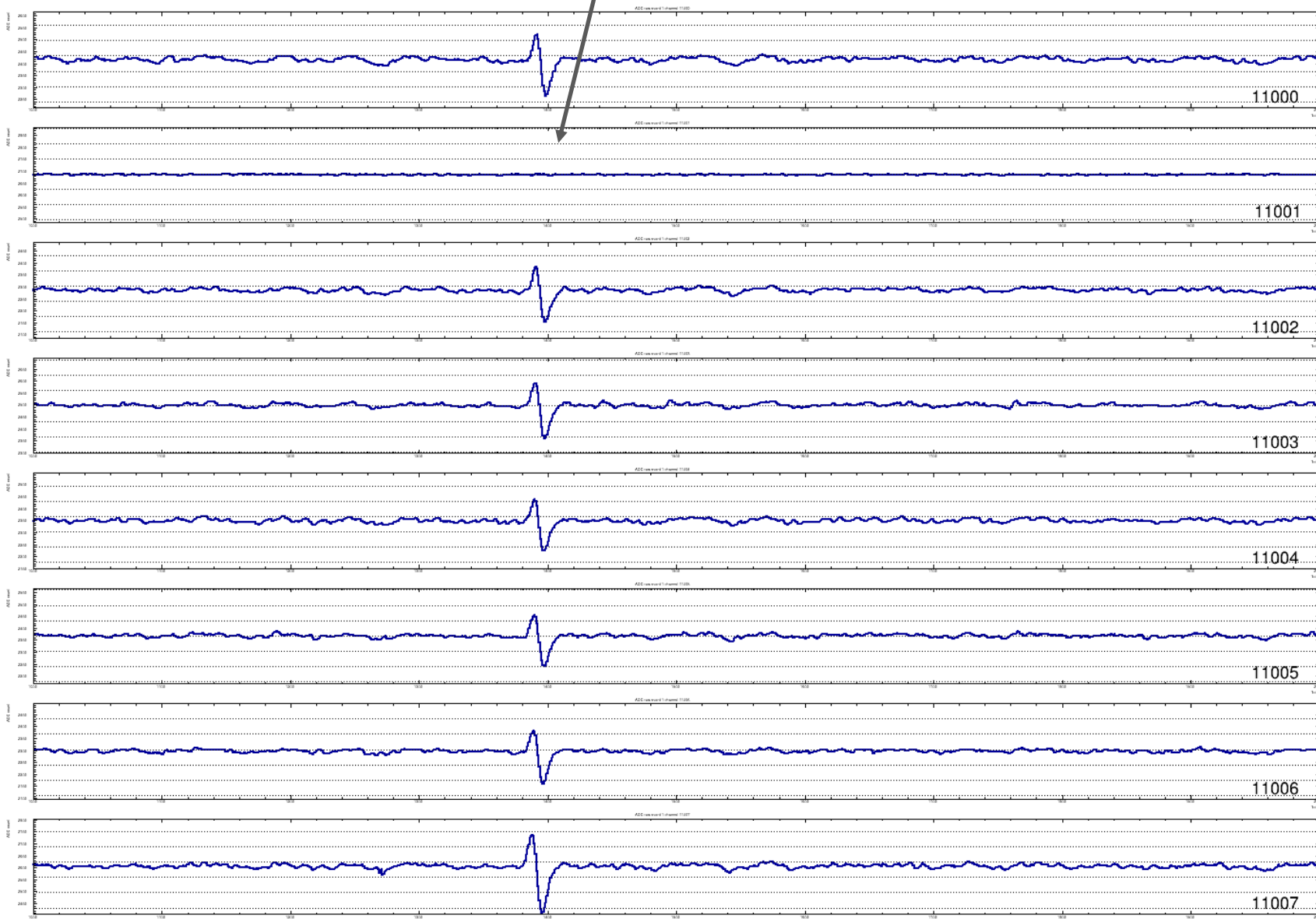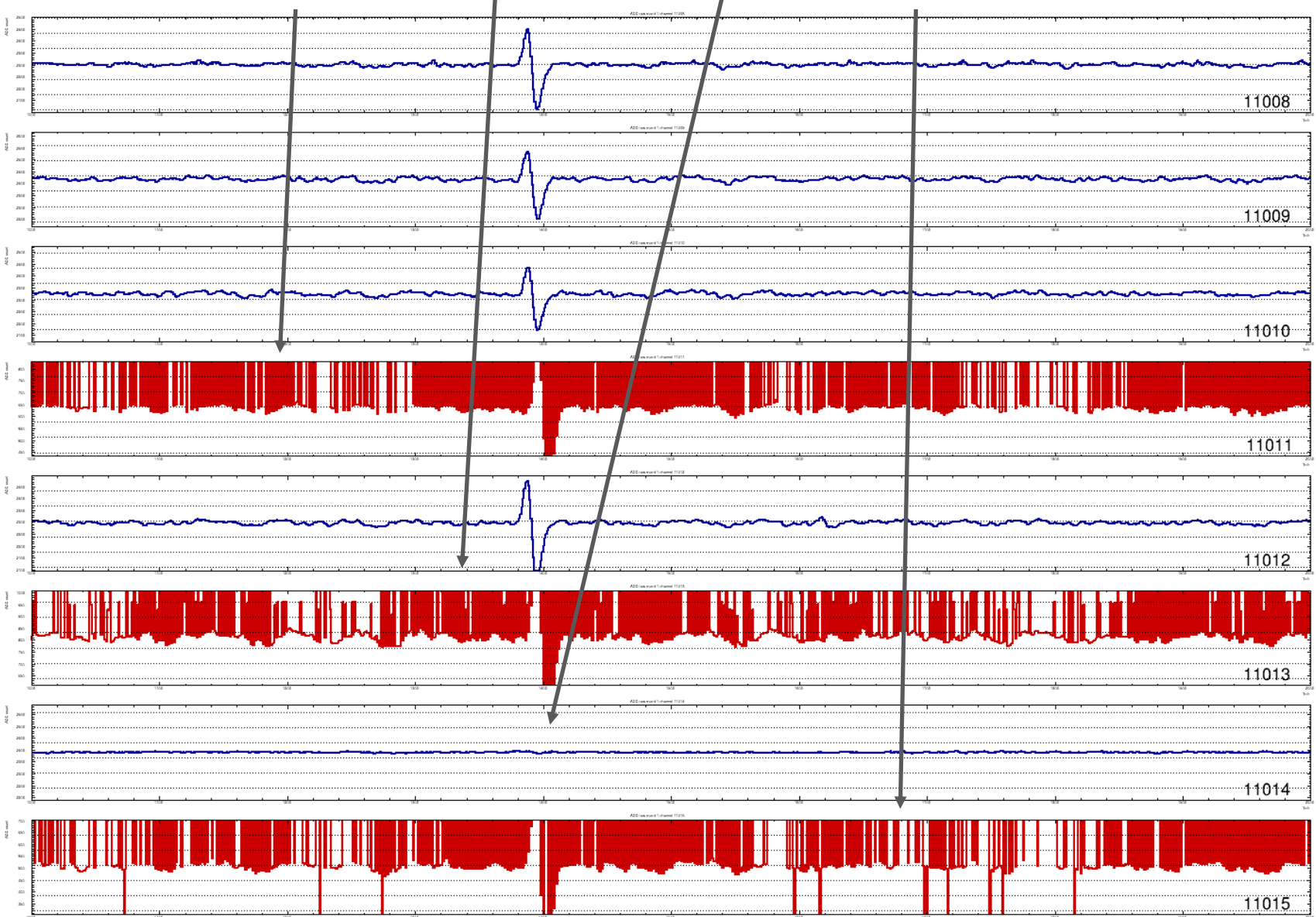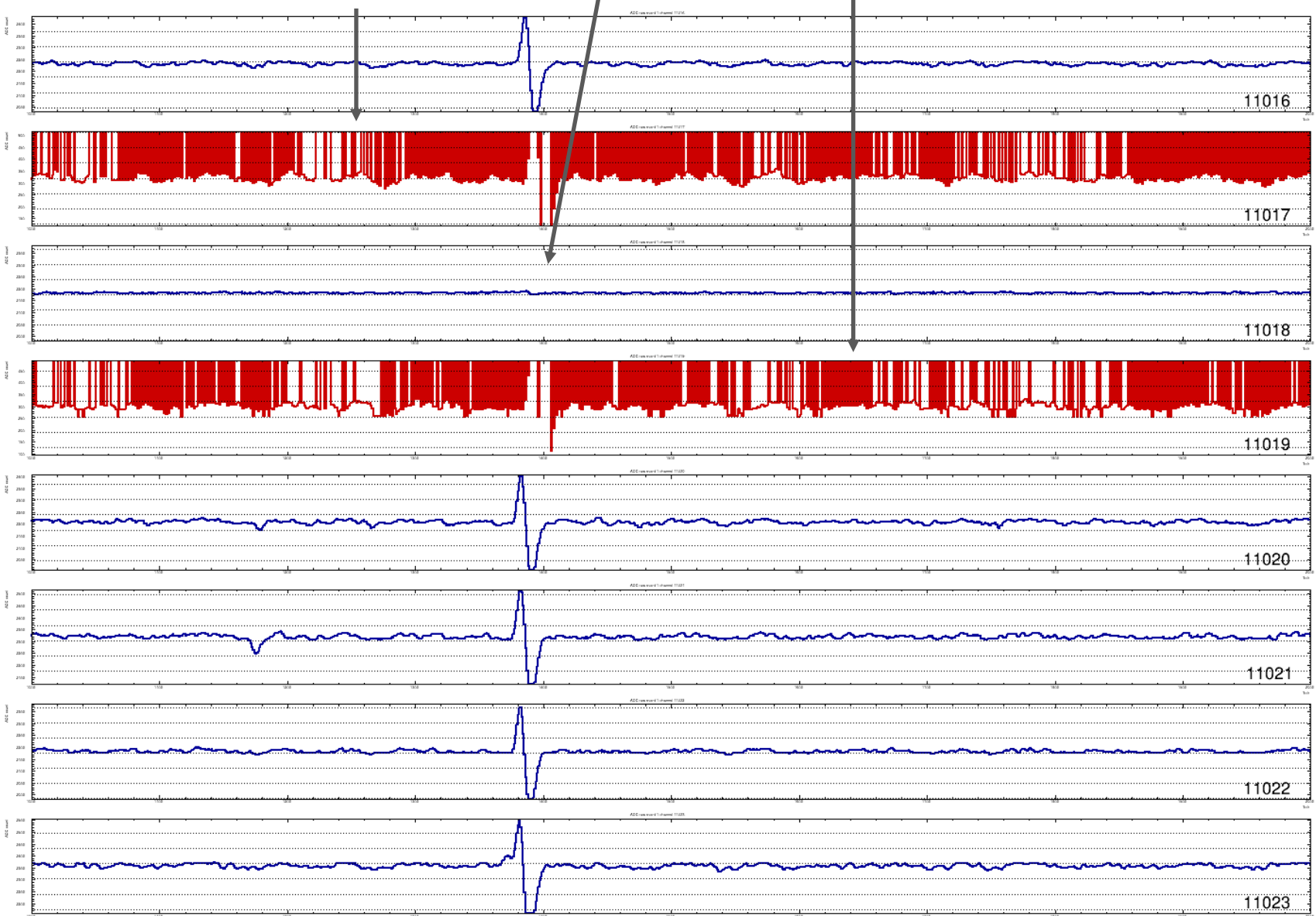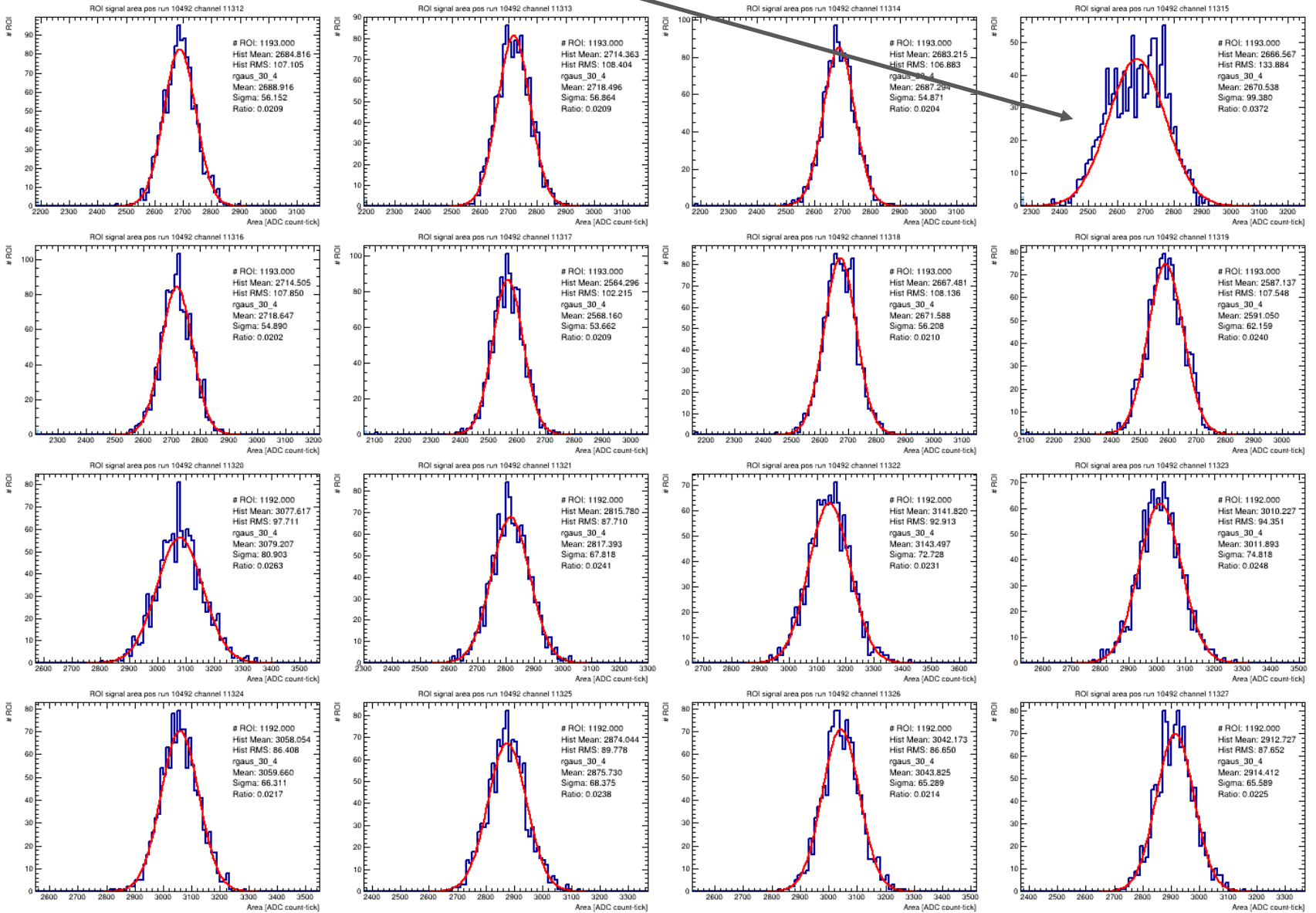
Waveforms

10573 good
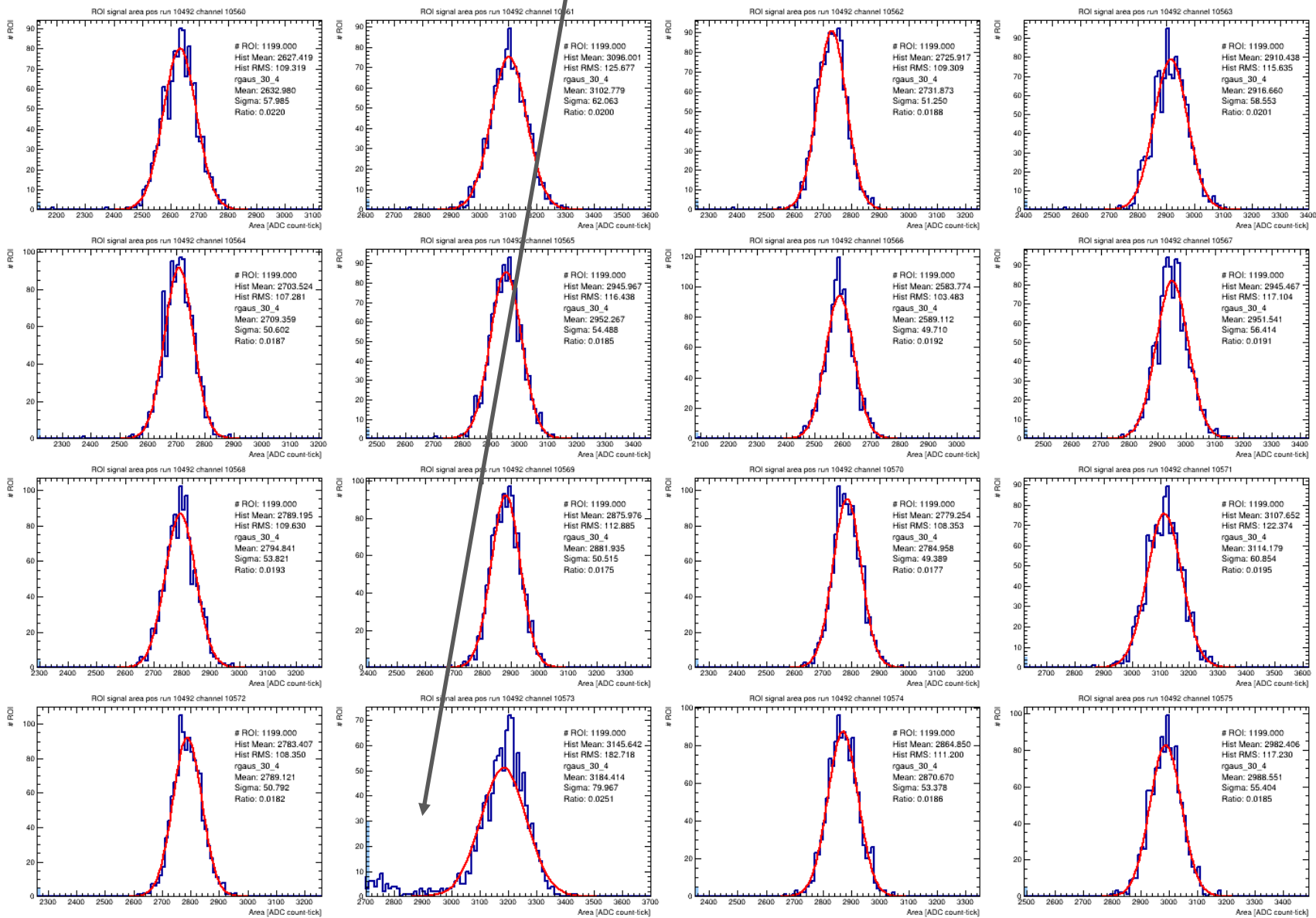
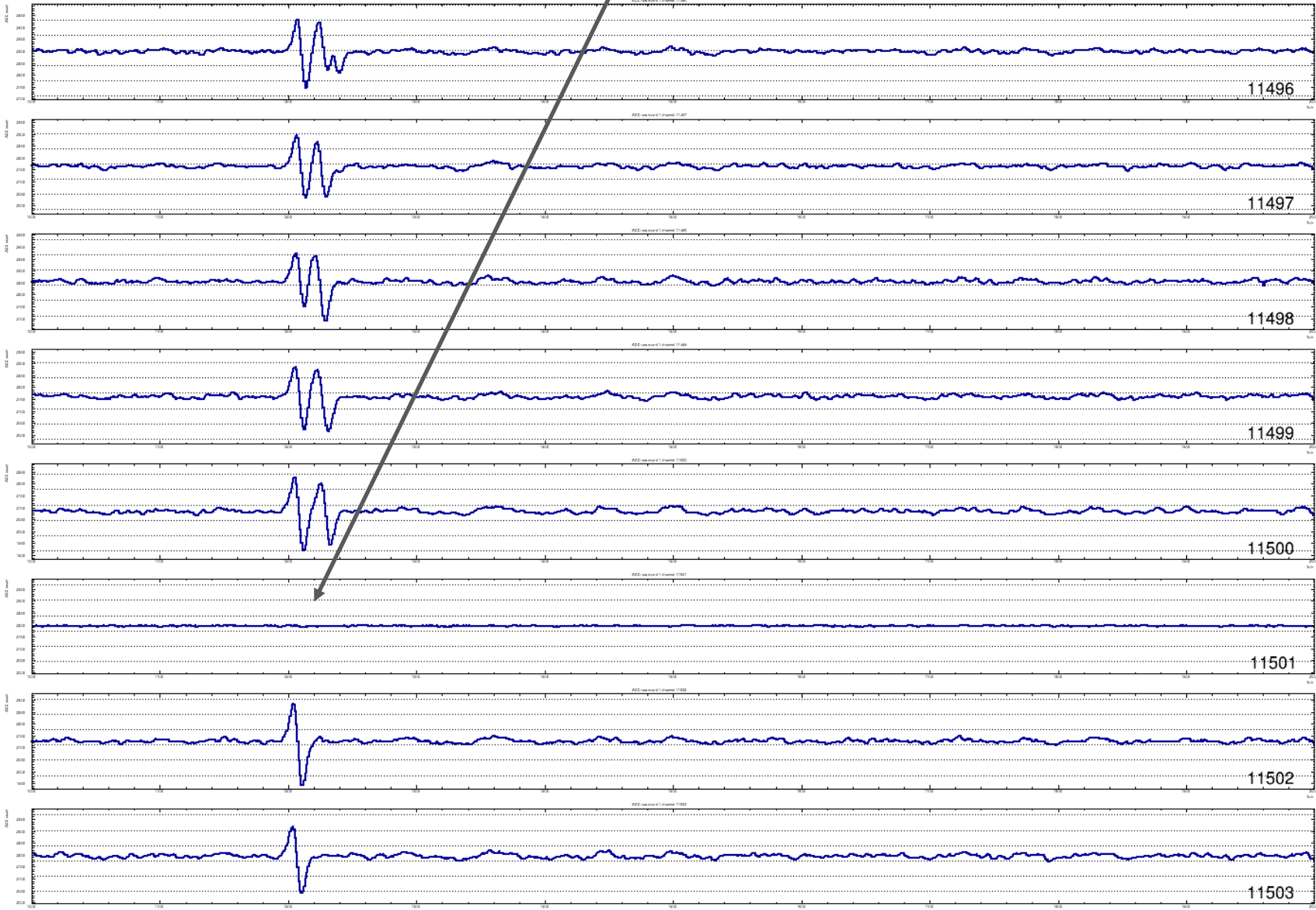# 10831 good
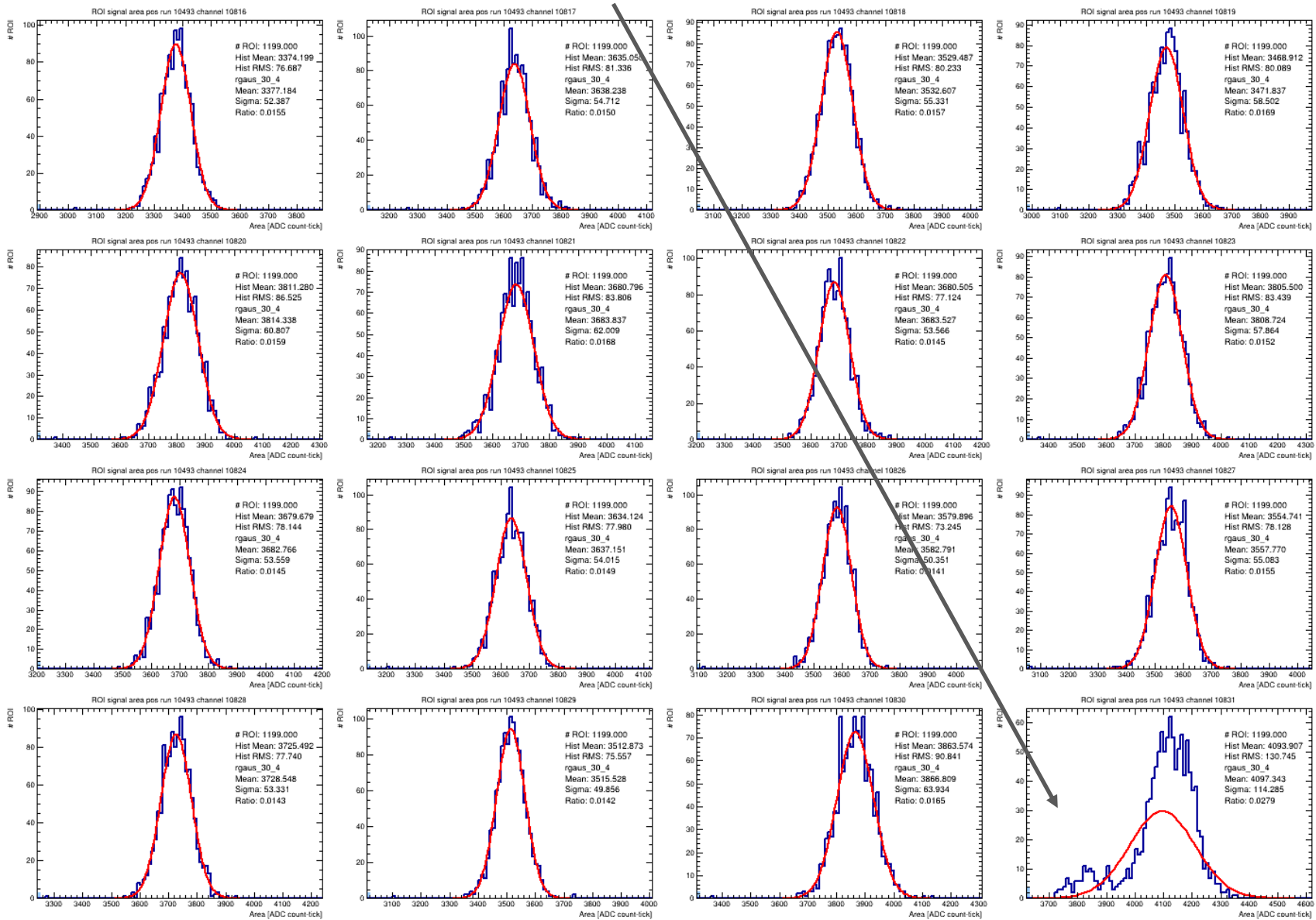
11001 bad

(11011), (11013), 11014, (11015) bad
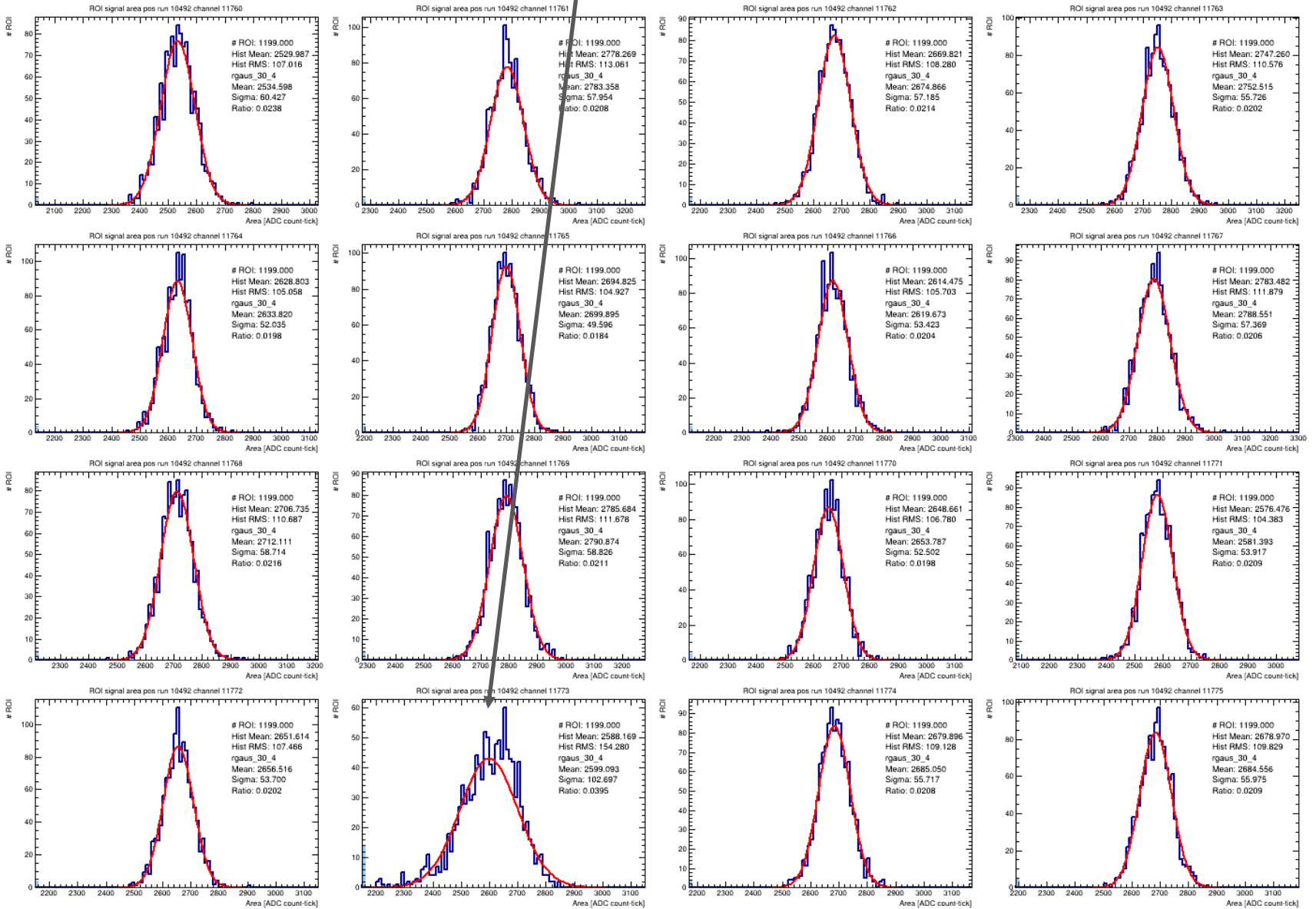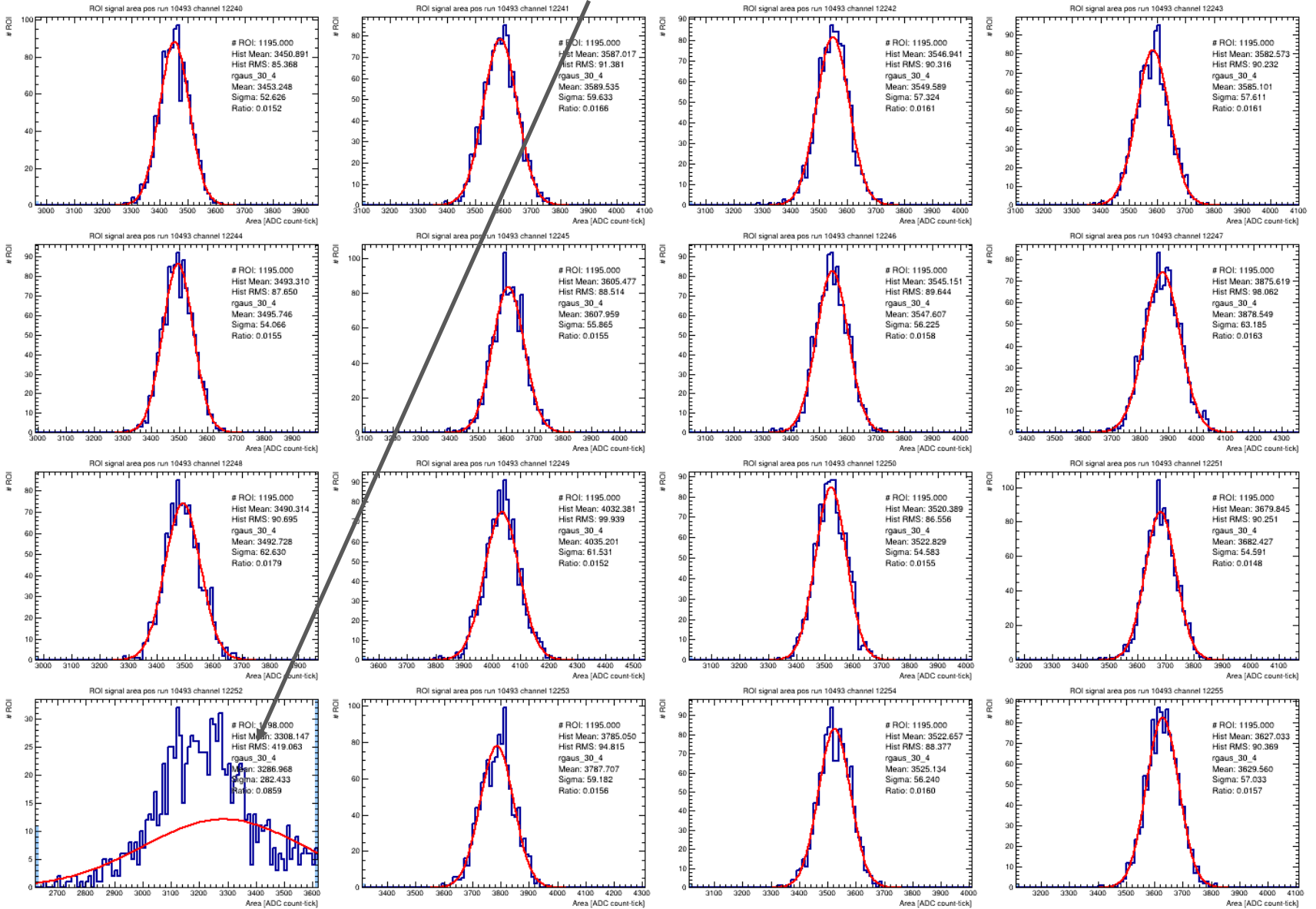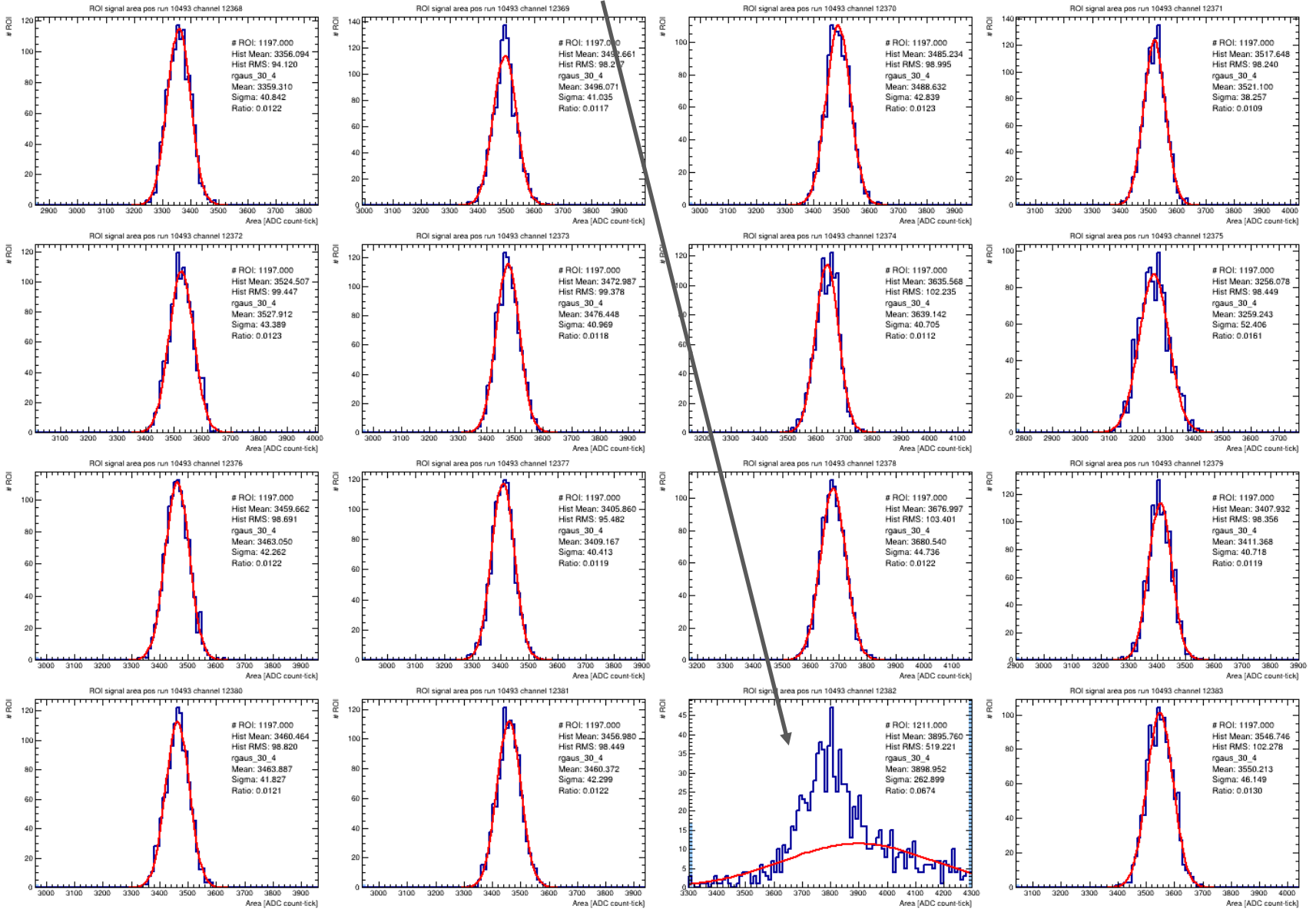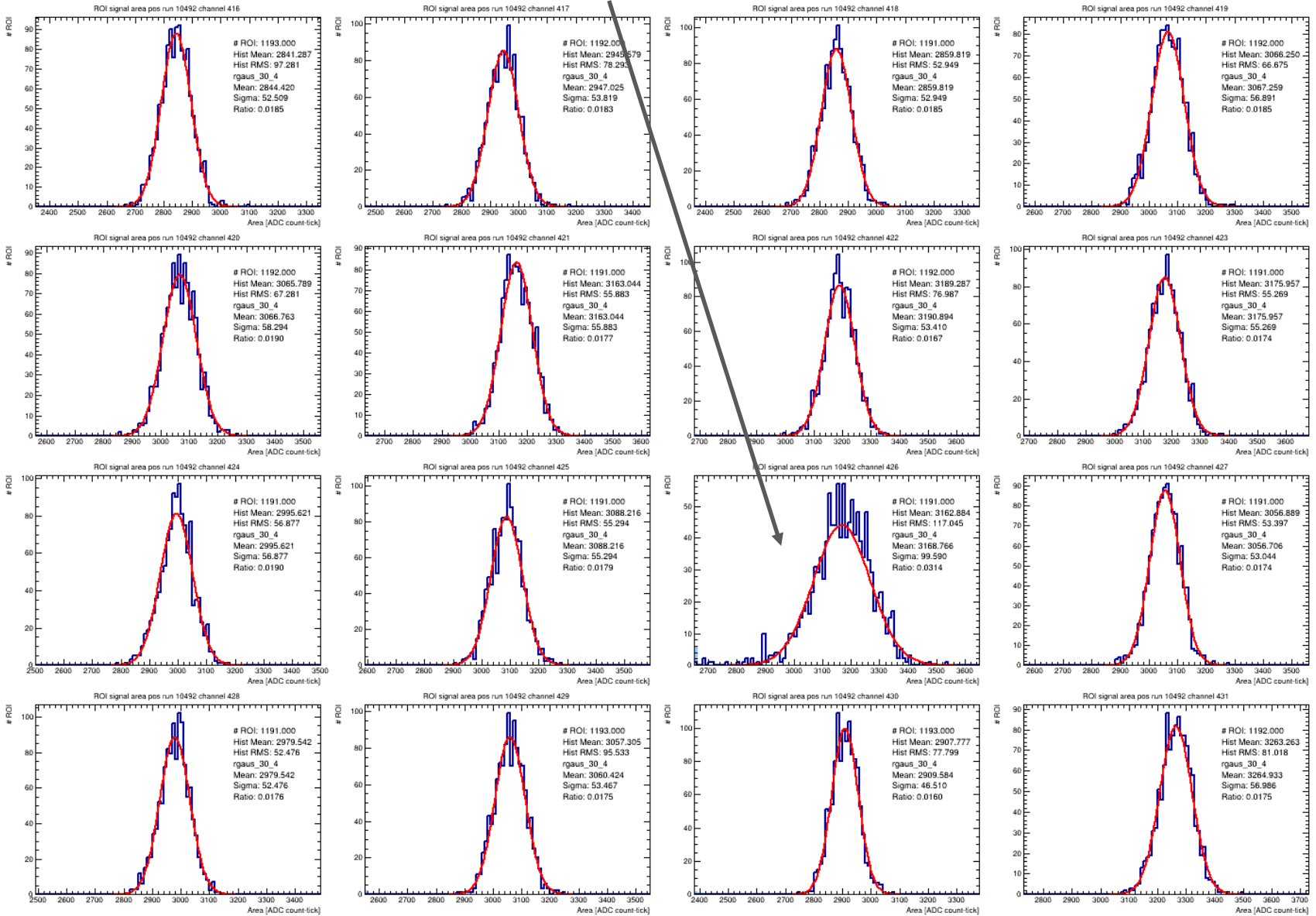
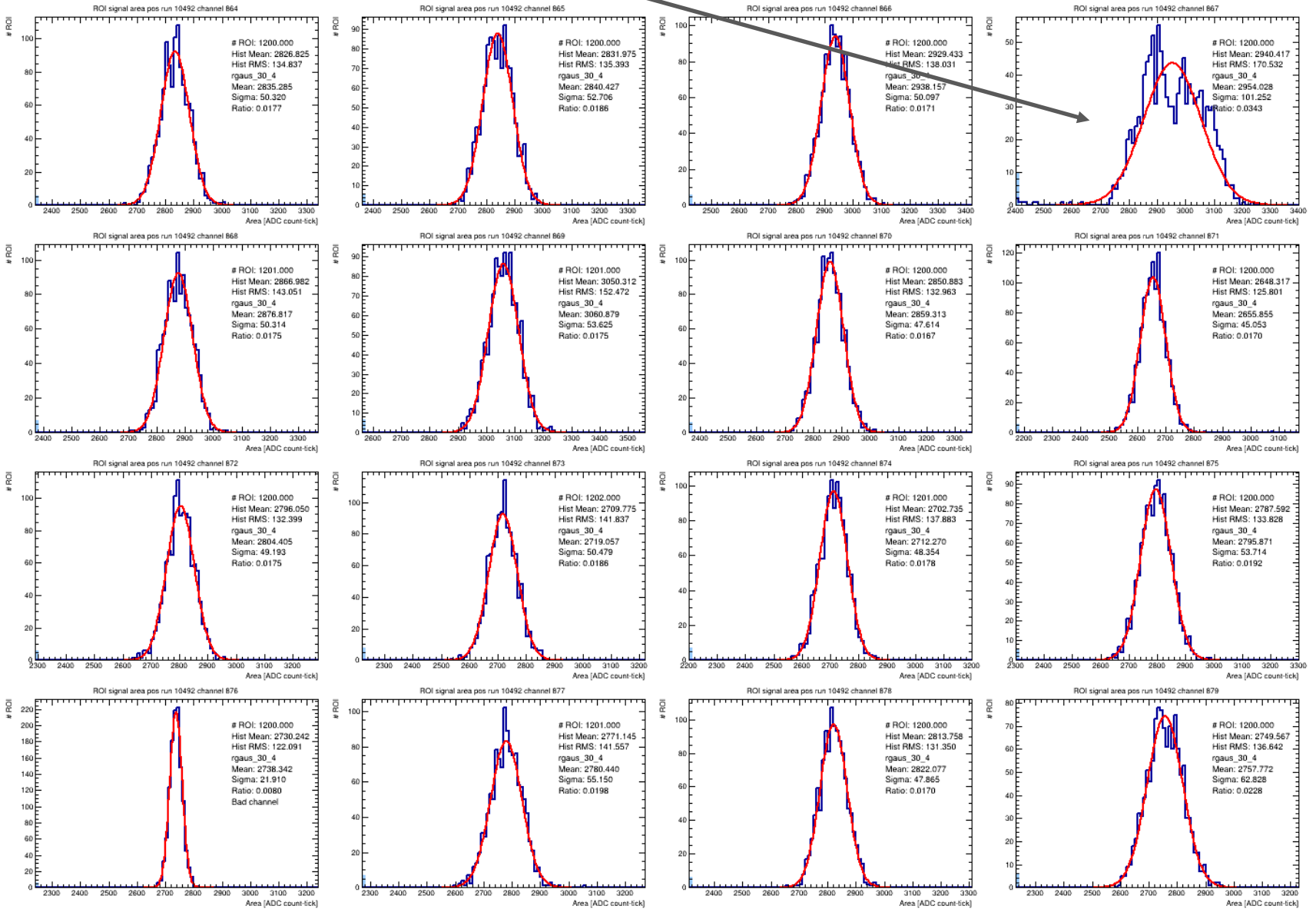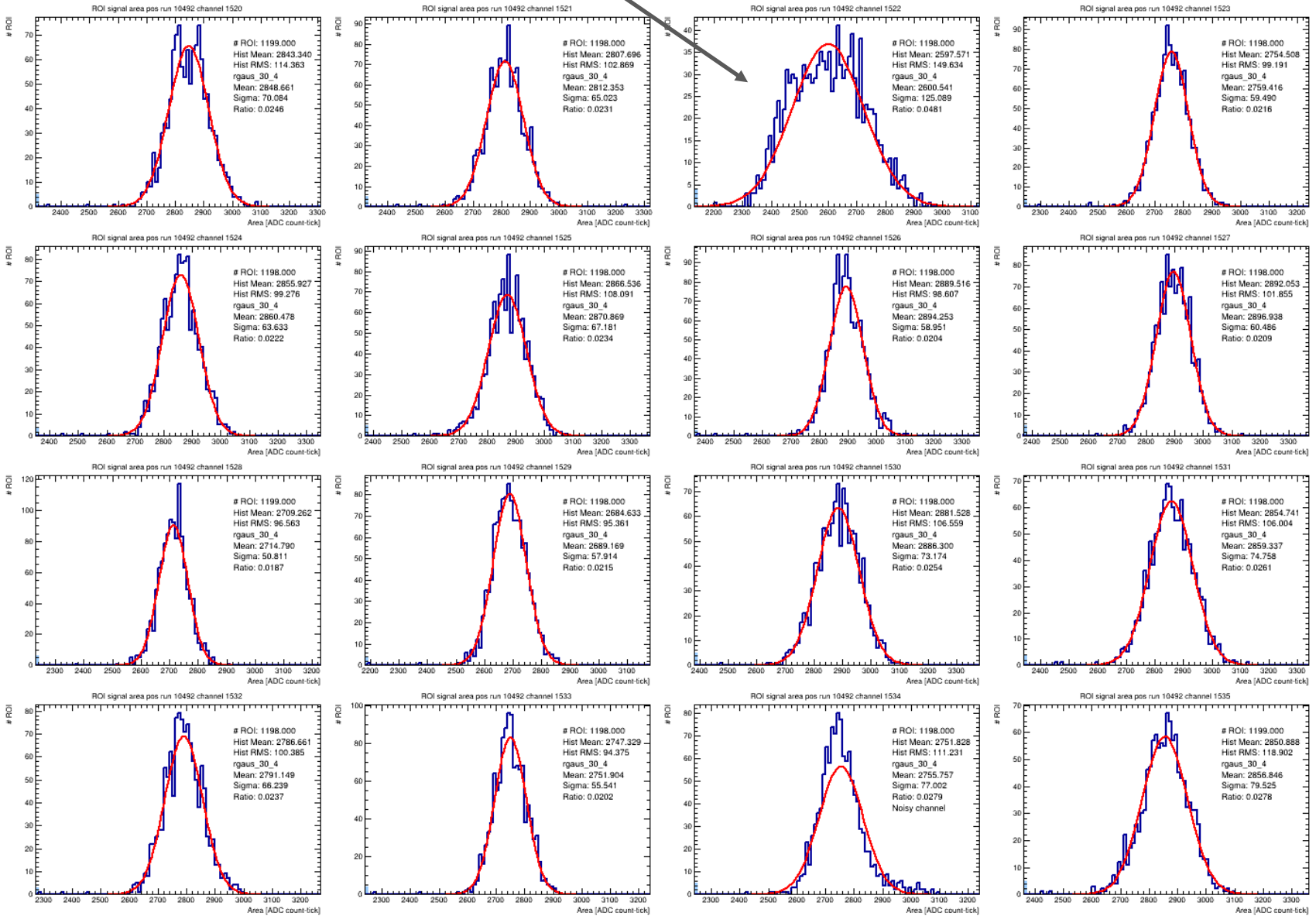# (11017), 11018, (11019) bad
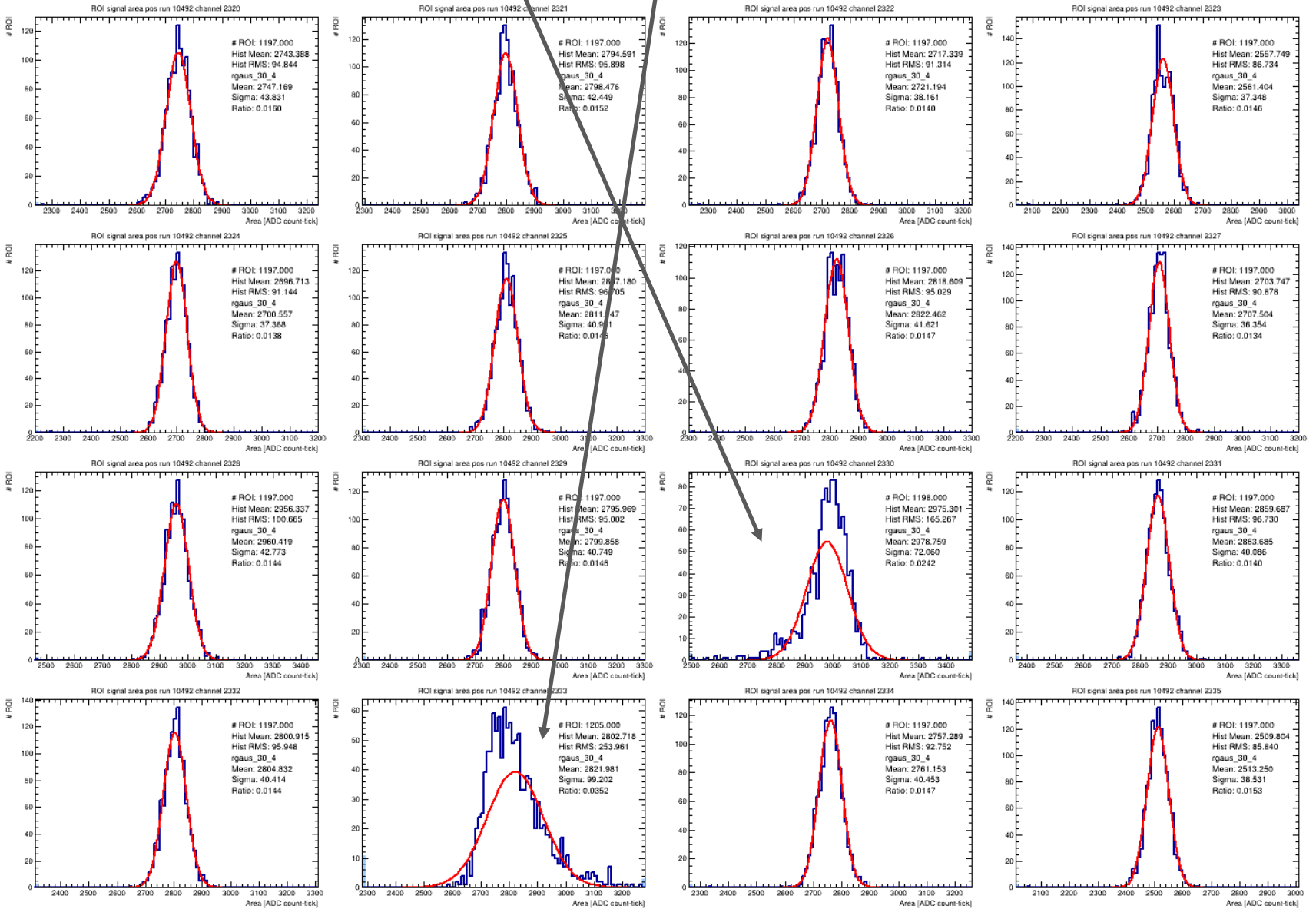
11315 good
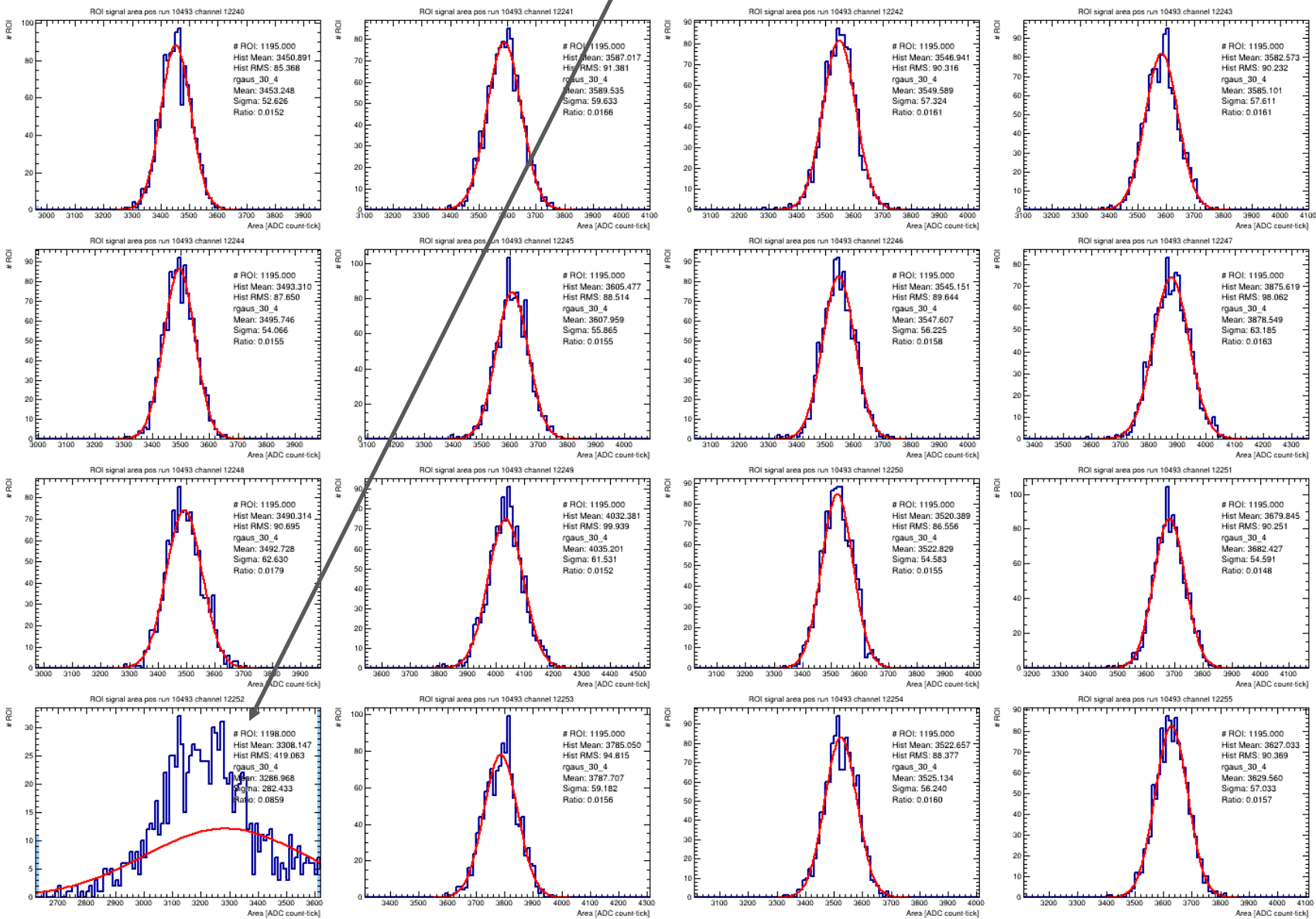
11501 bad

11773 good
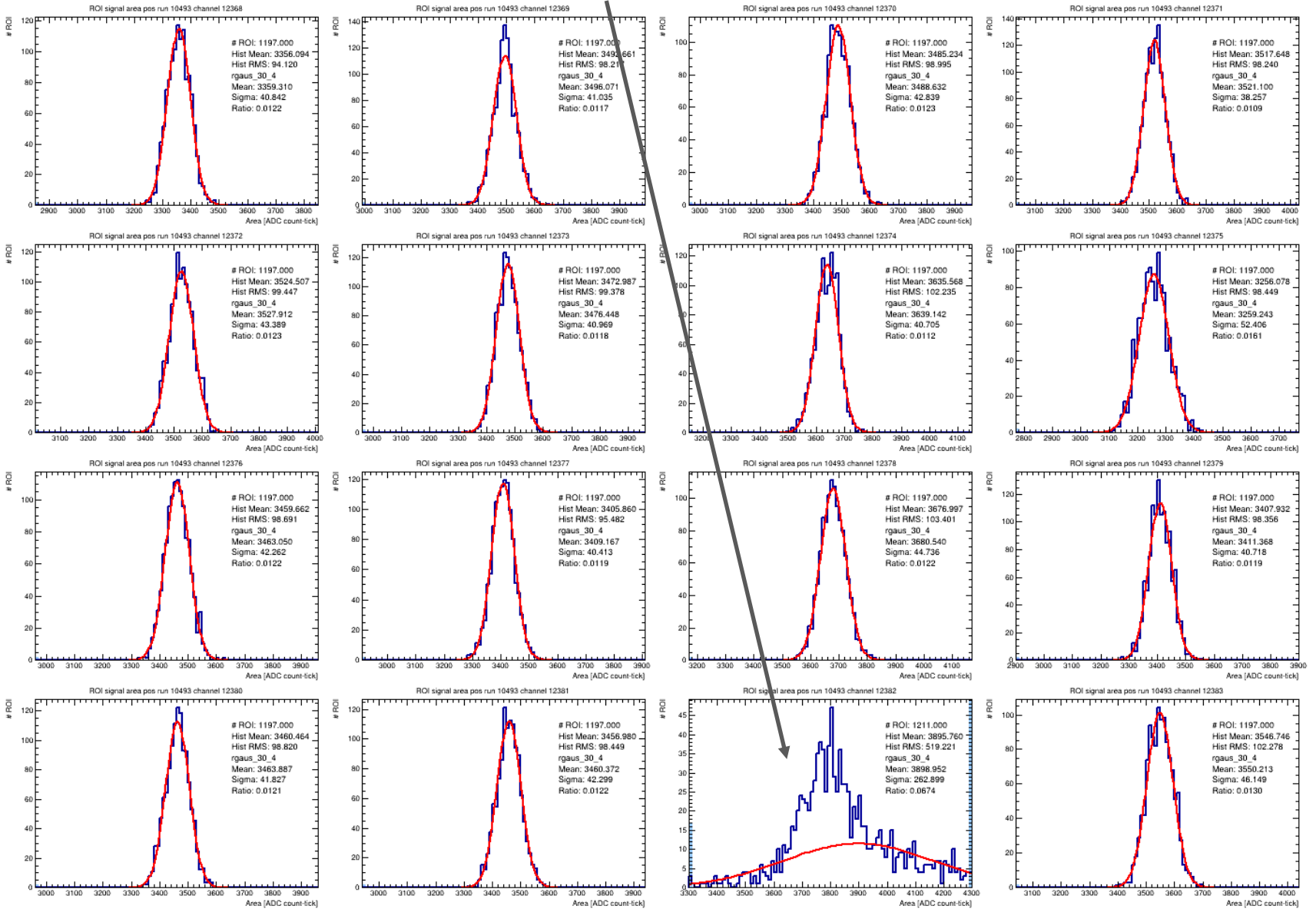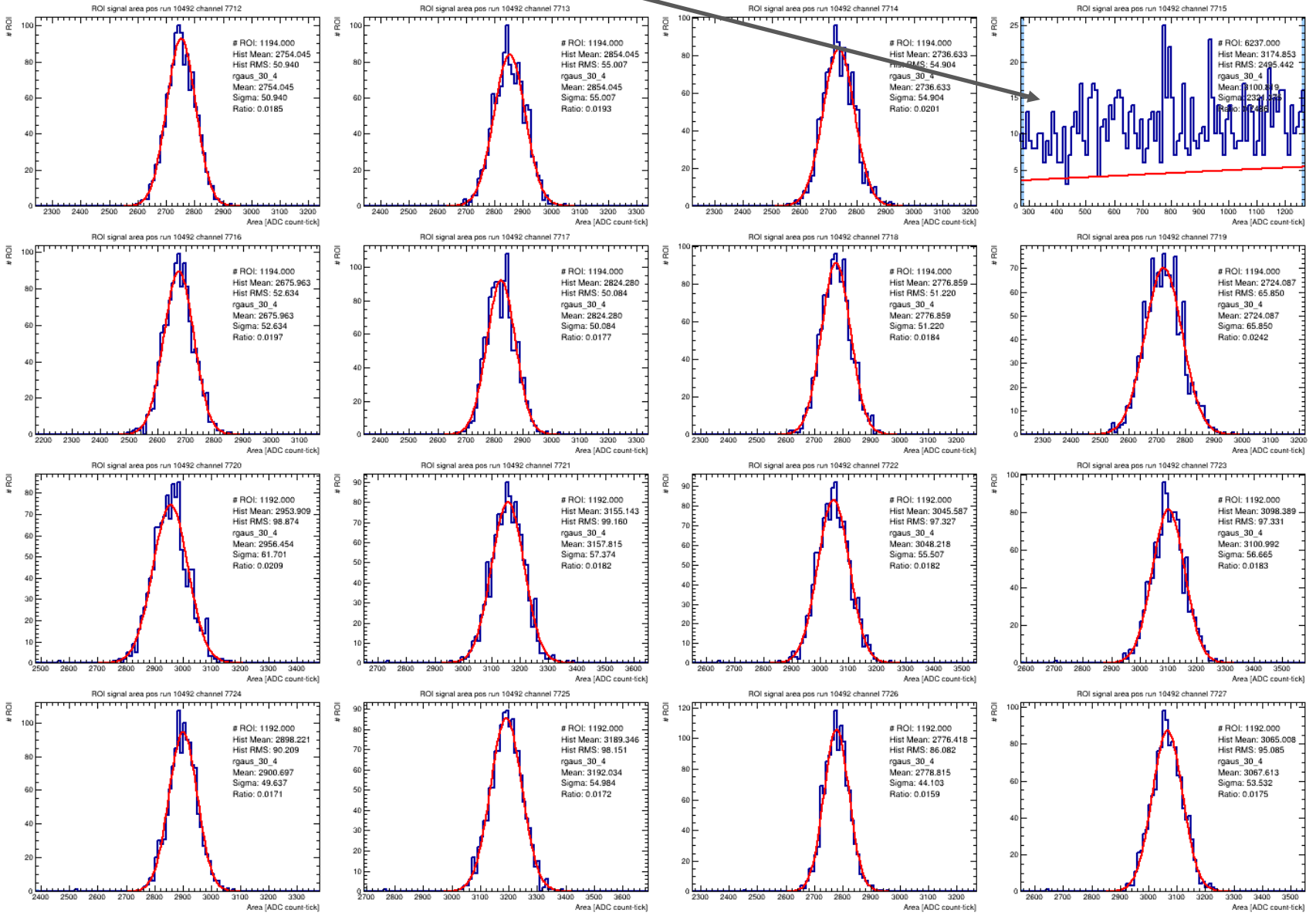
12252 good

12382 good

426 good

867 good

1522 good

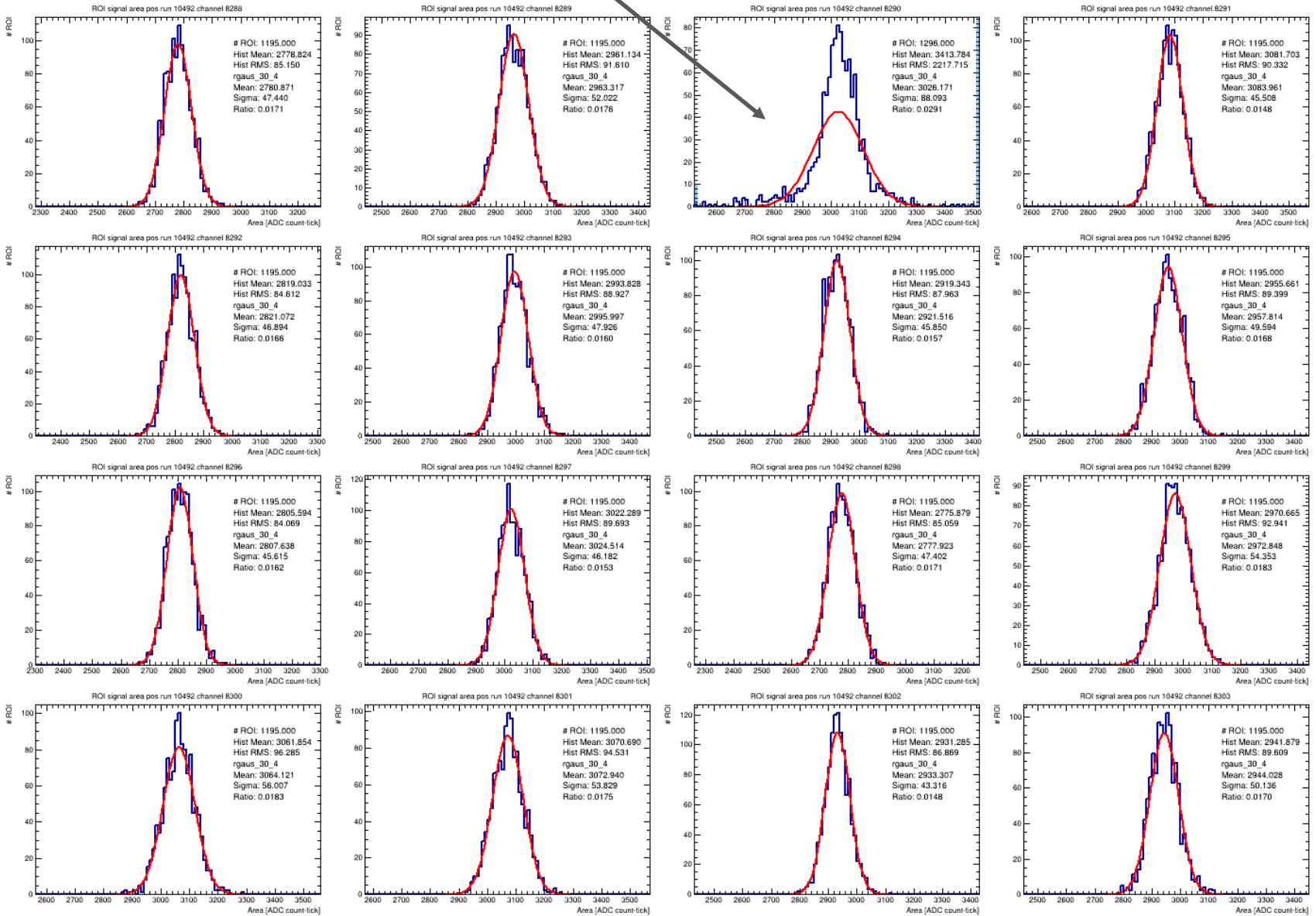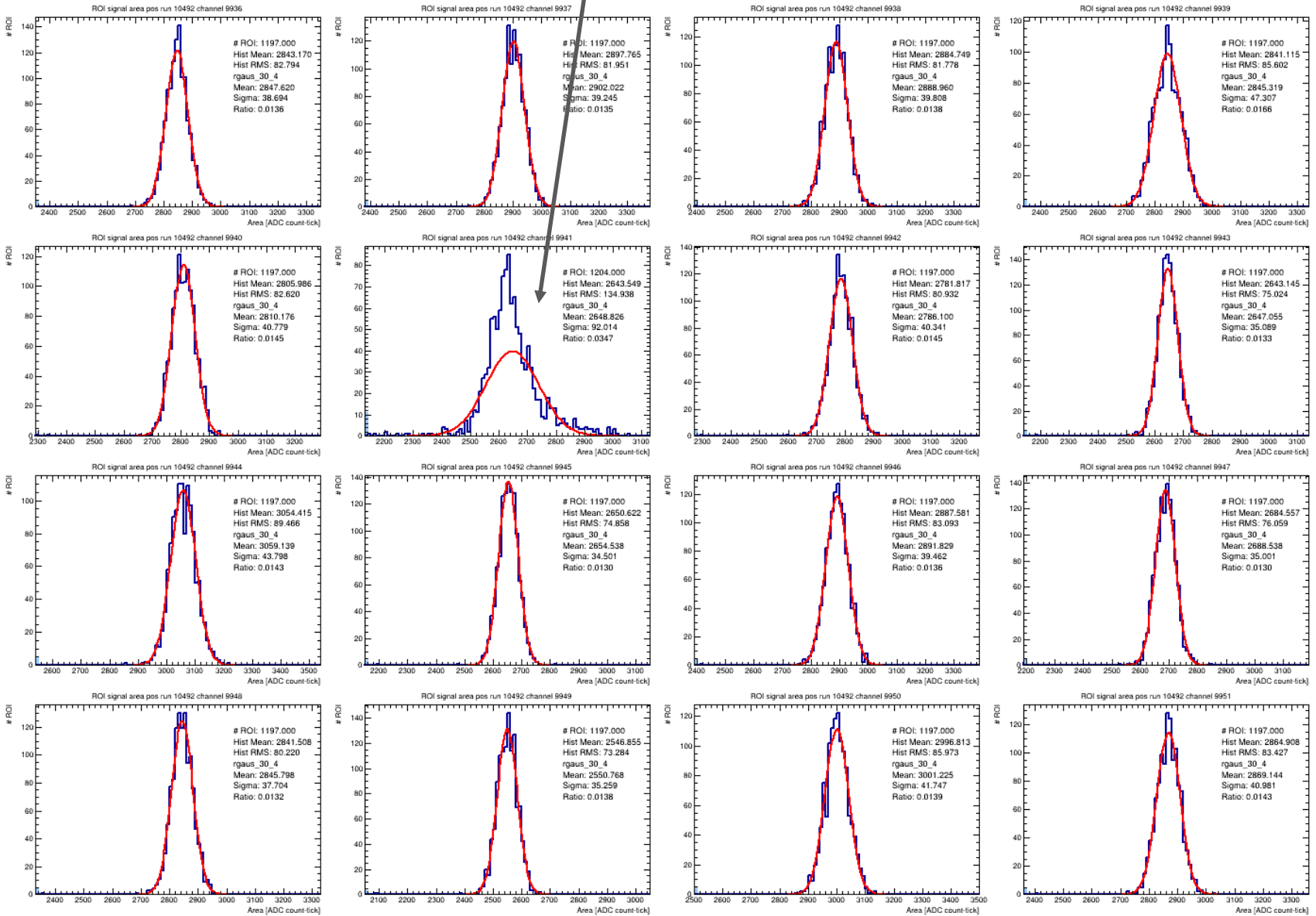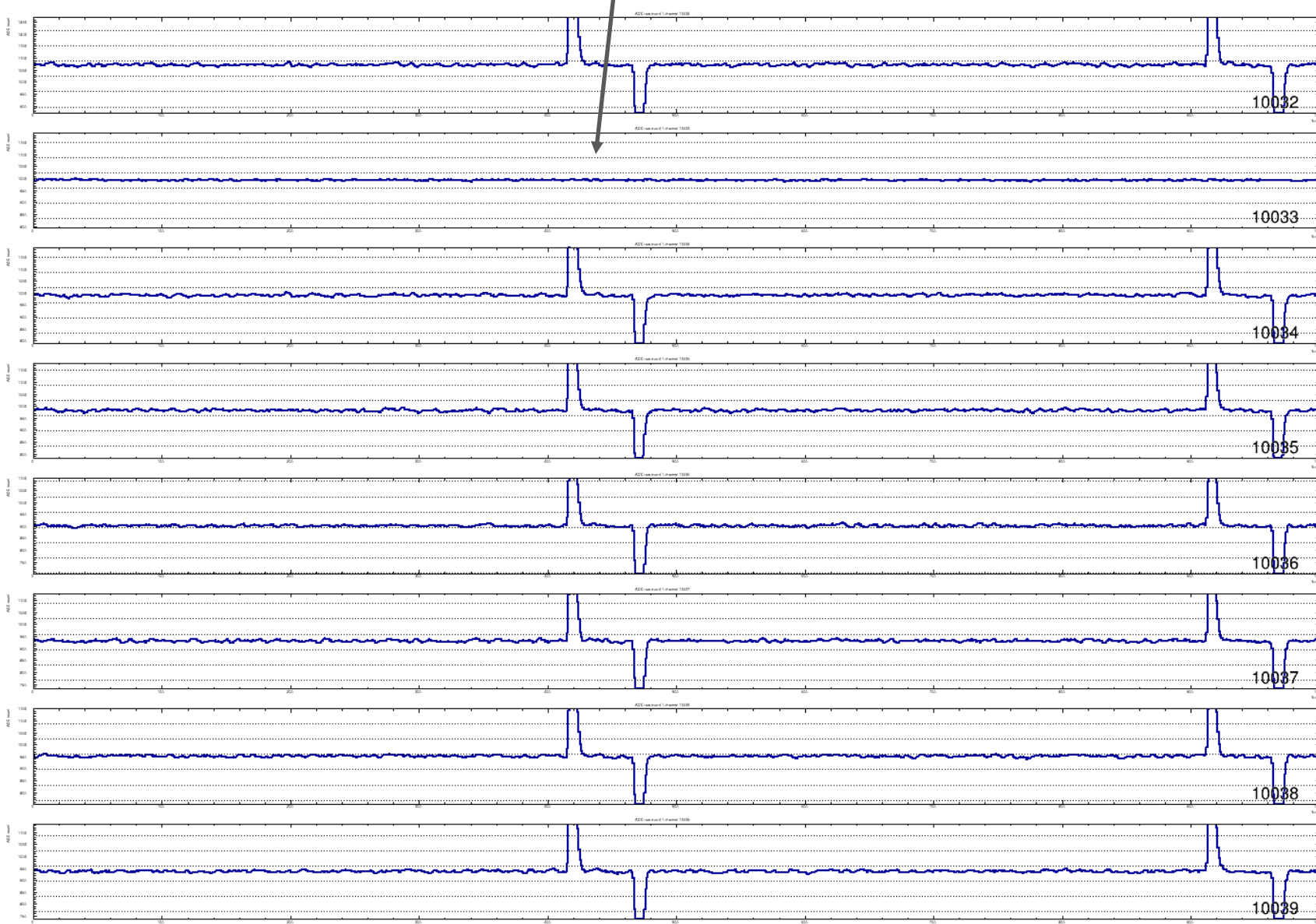# 2330, 2333 good

12938 good

13748 good

7715 bad

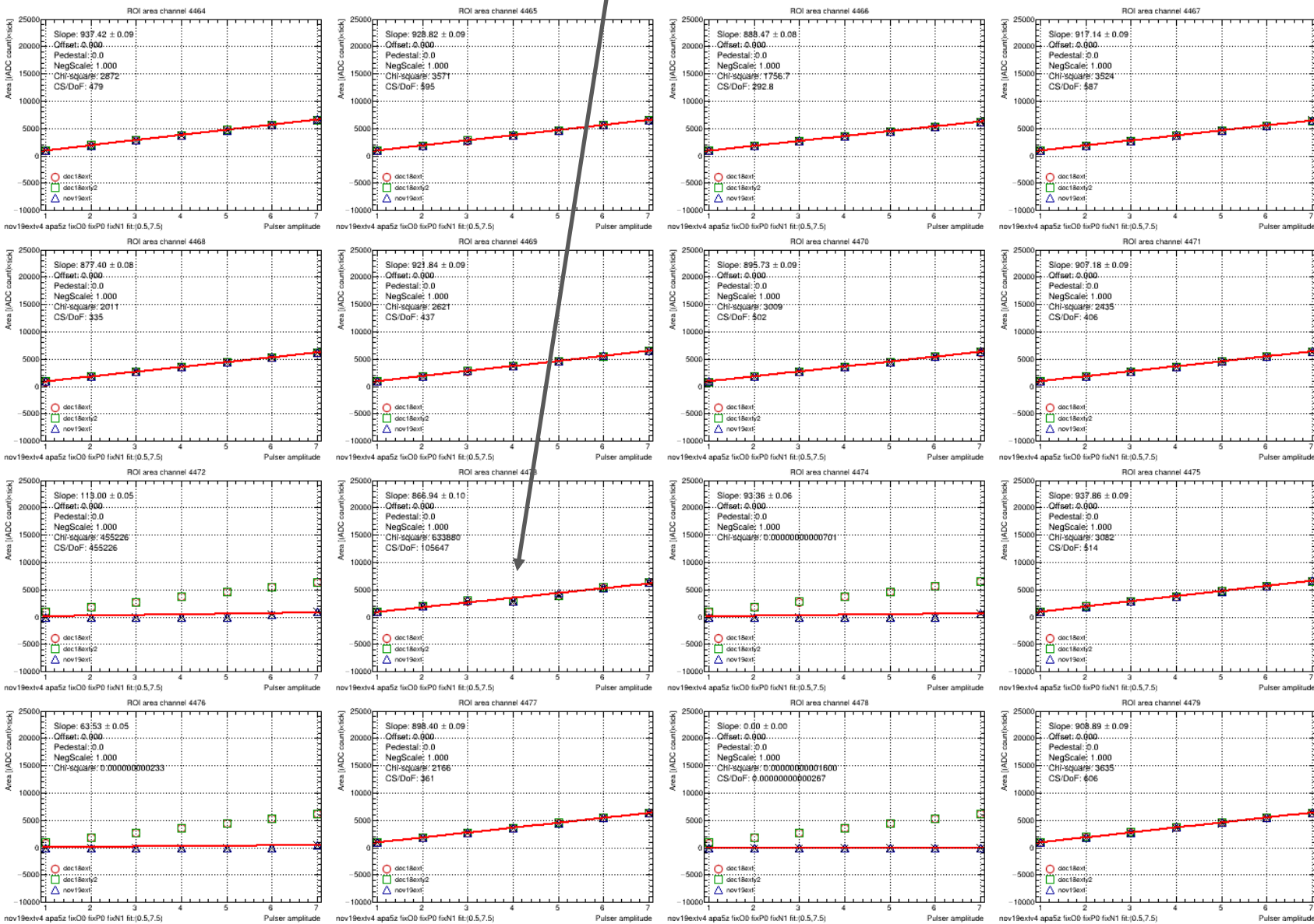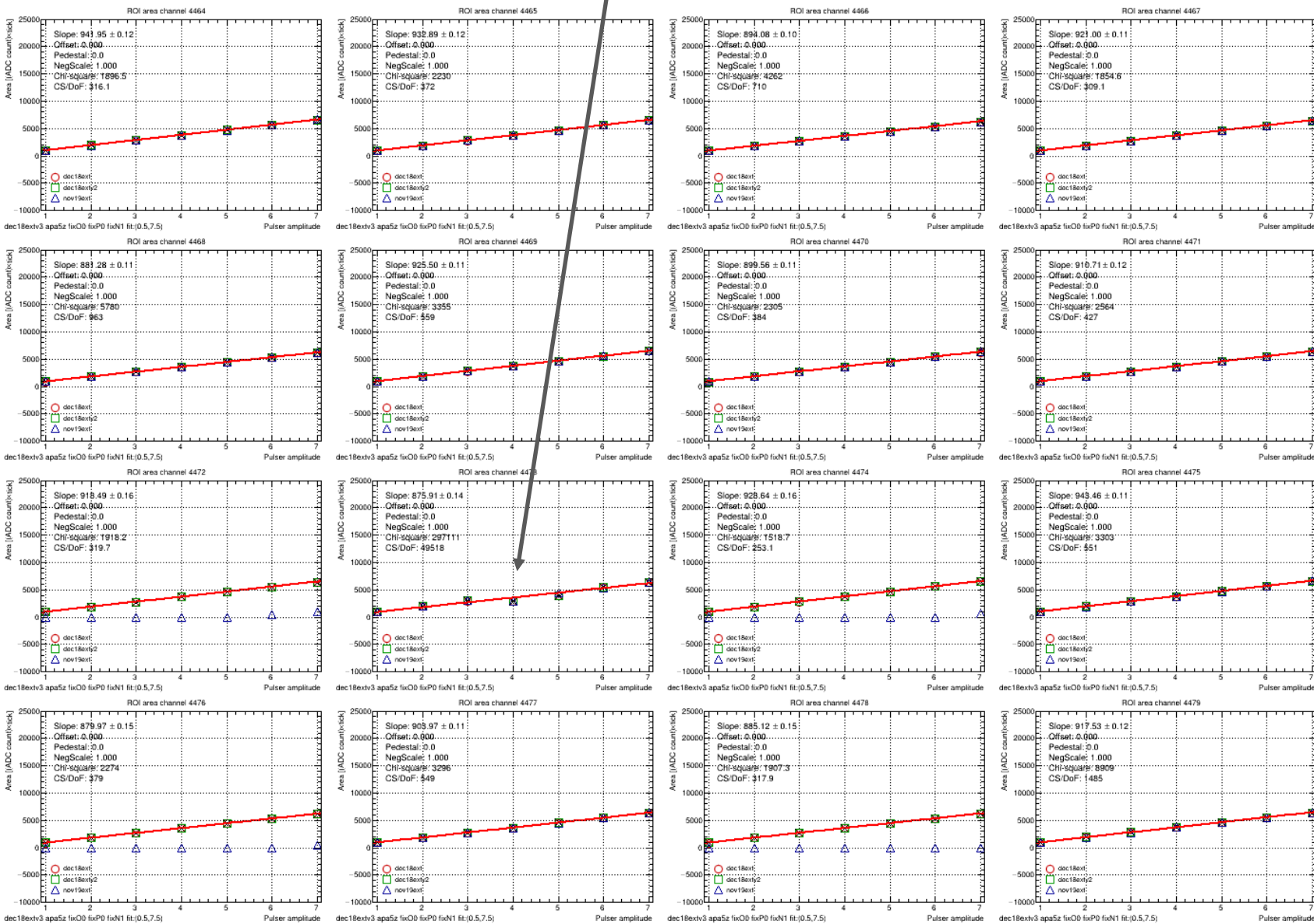# 7715 bad
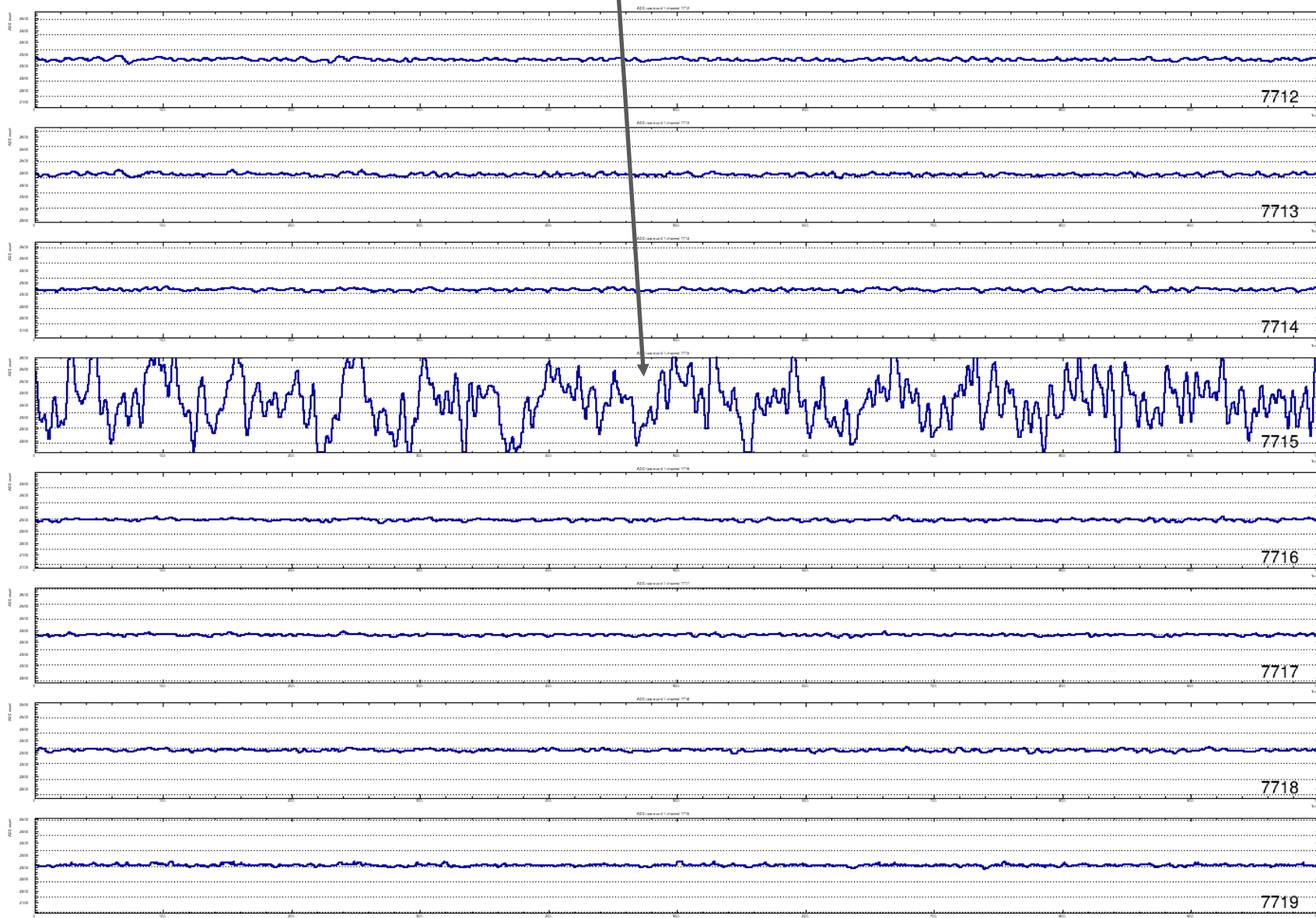
8234 good
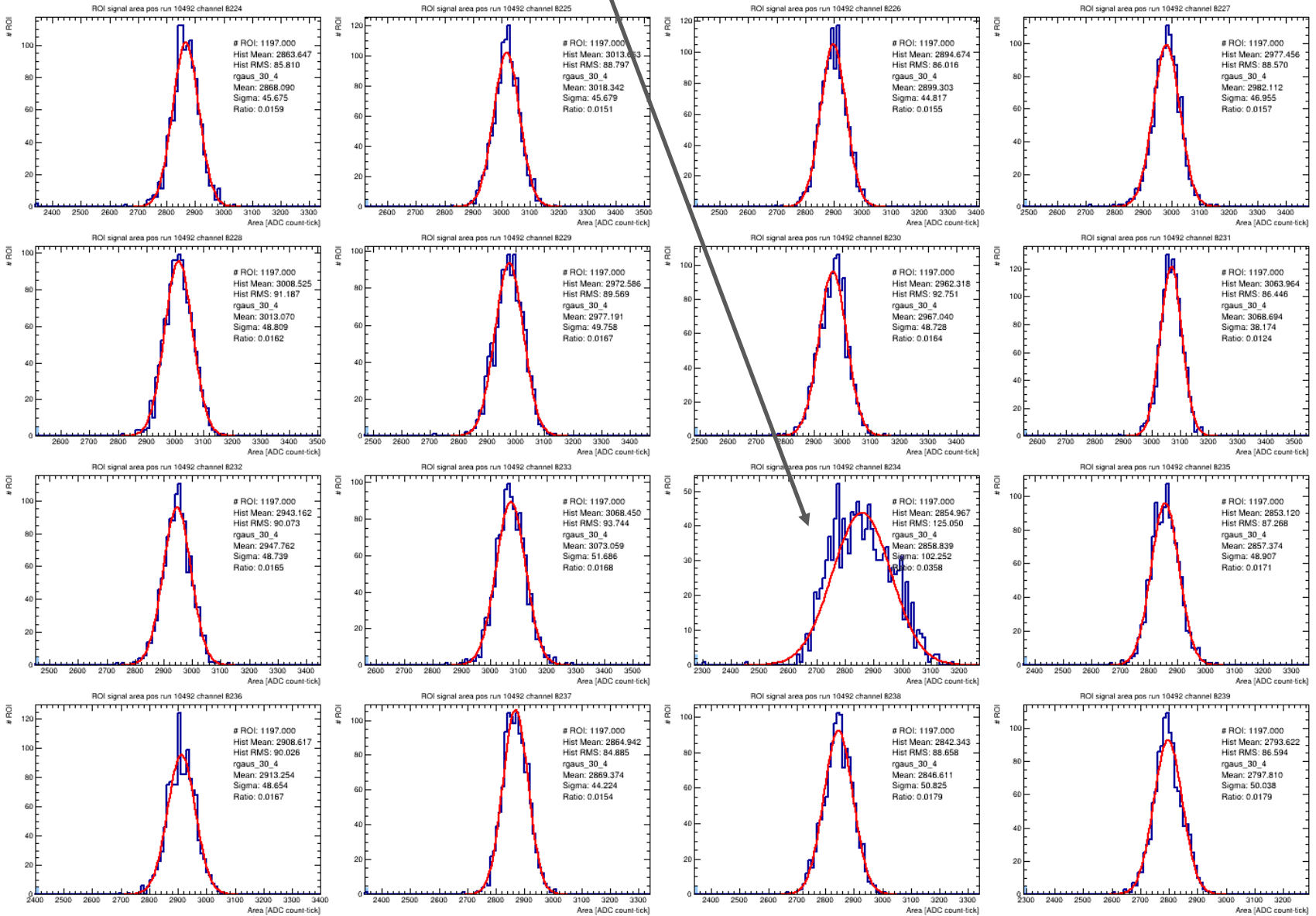
8290 good

9941 good

10333 bad

4473

4473 noisy
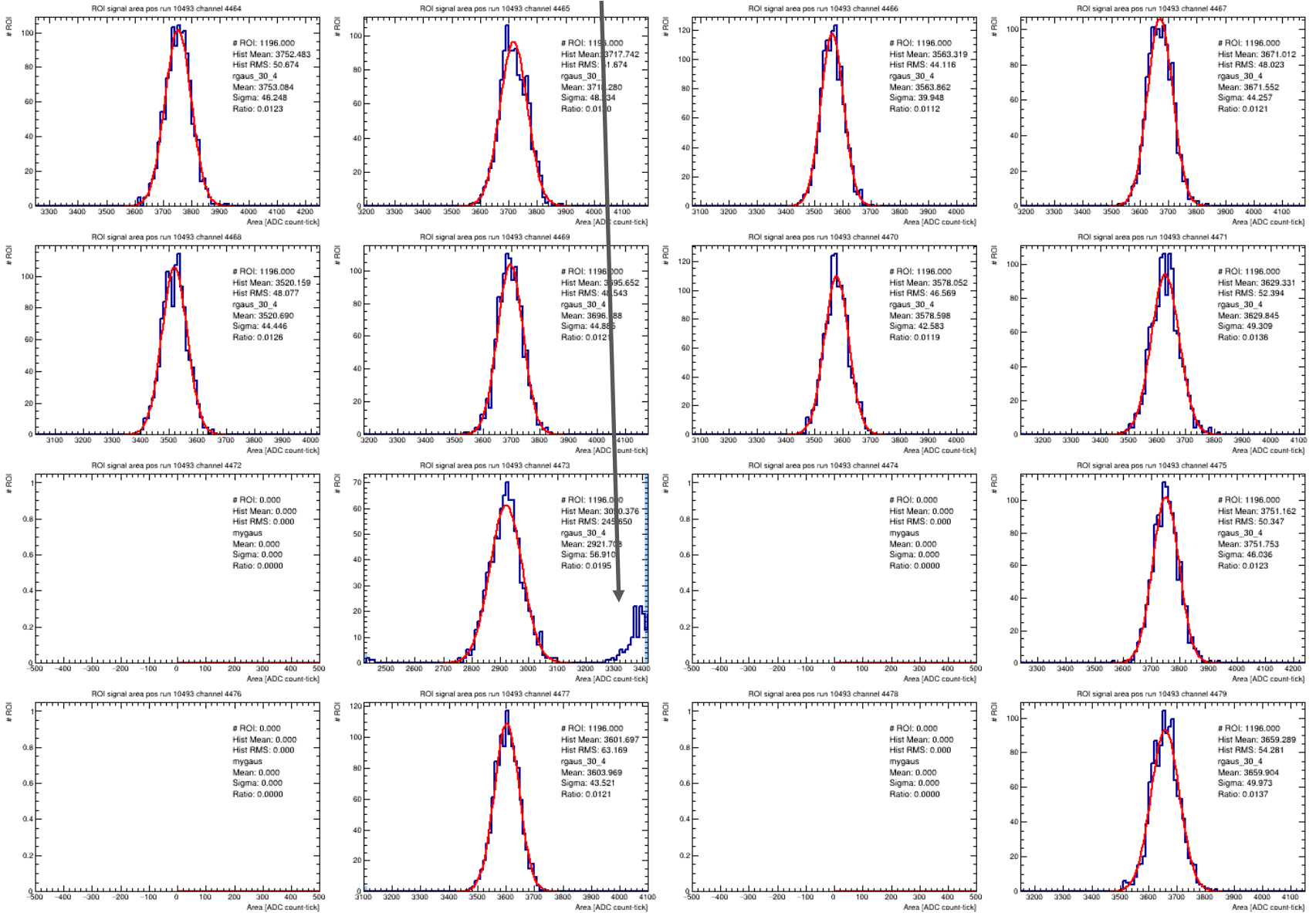
4473 noisy

4473 noisy
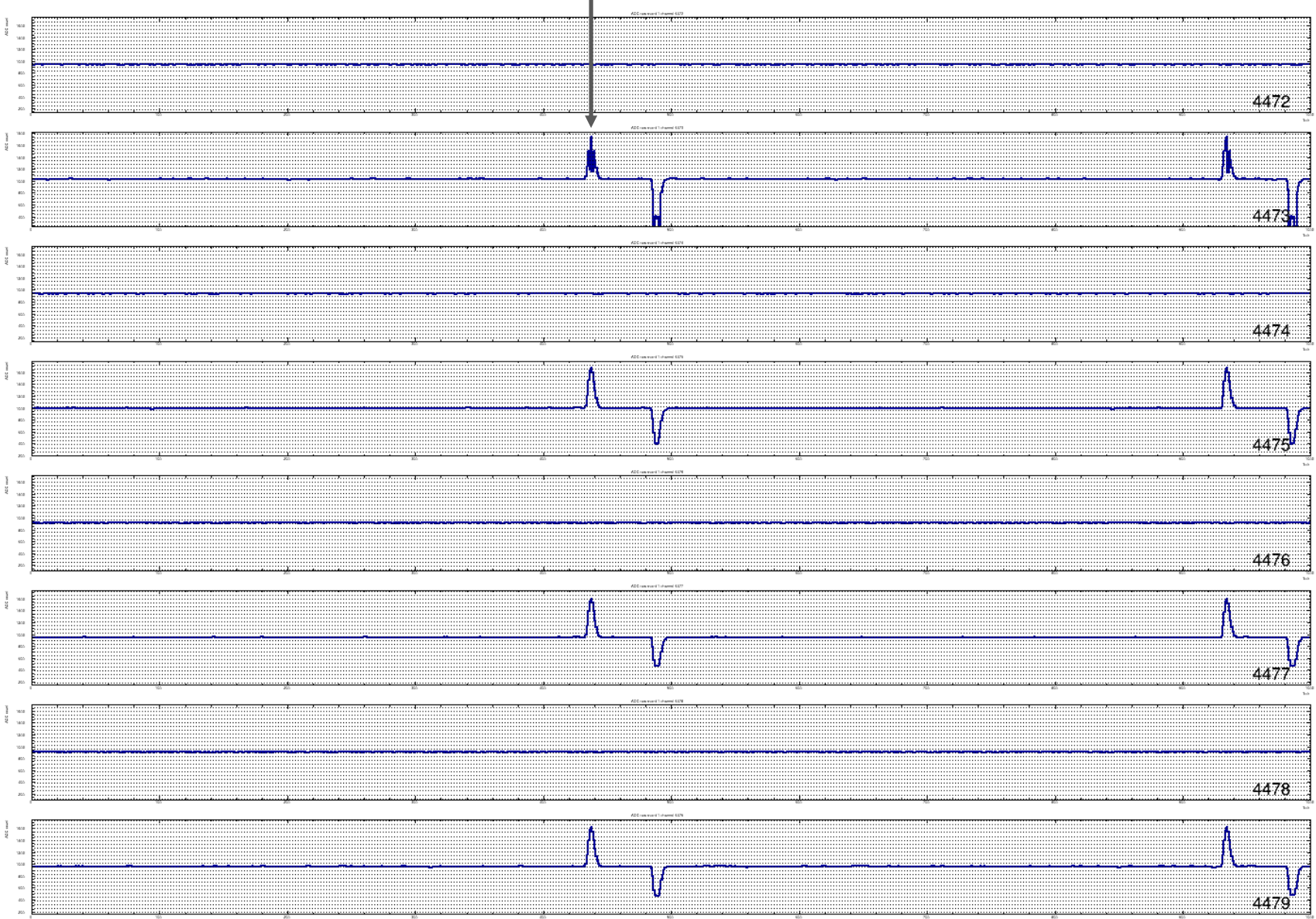
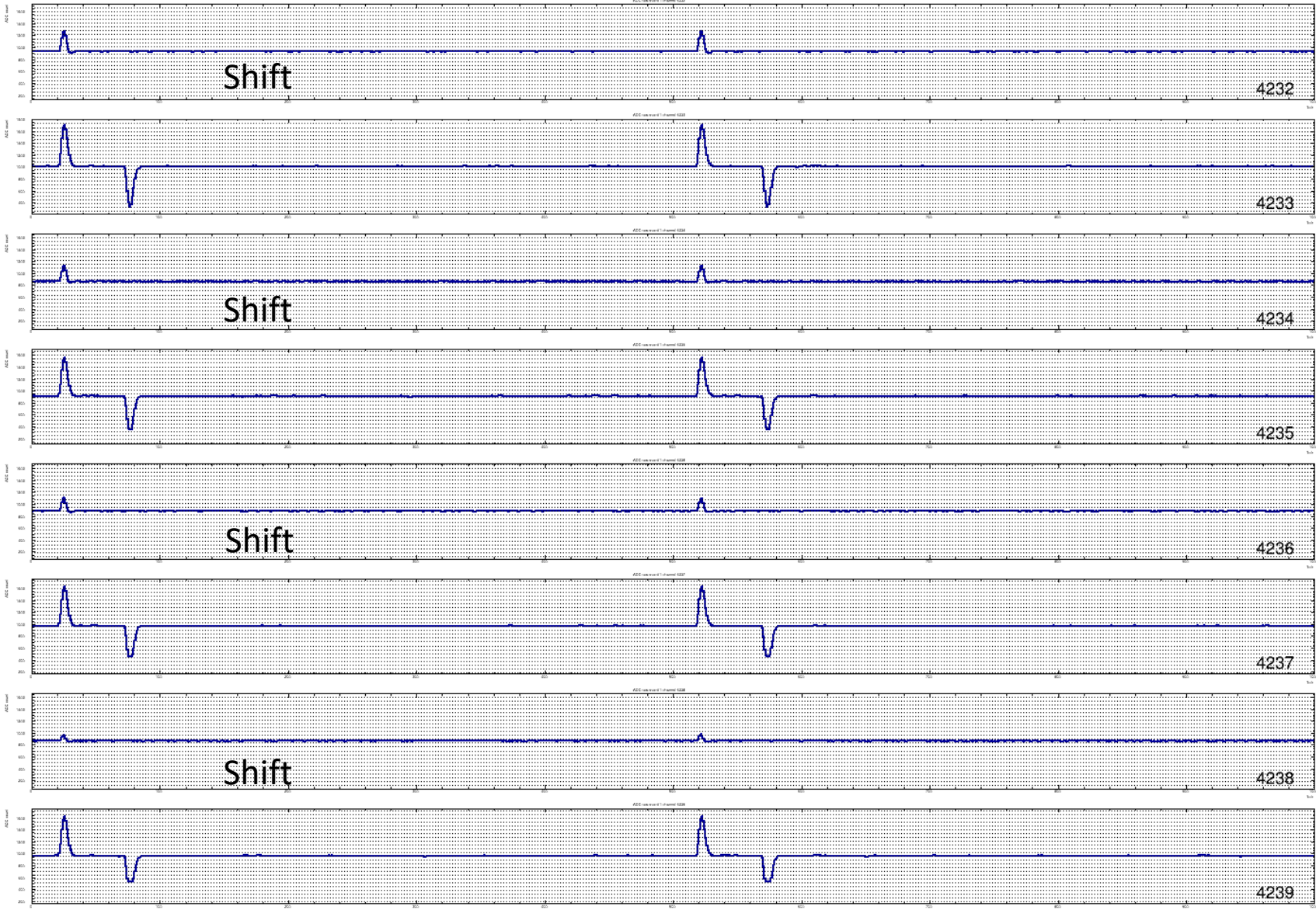# 4473 noisy

4473 noisy
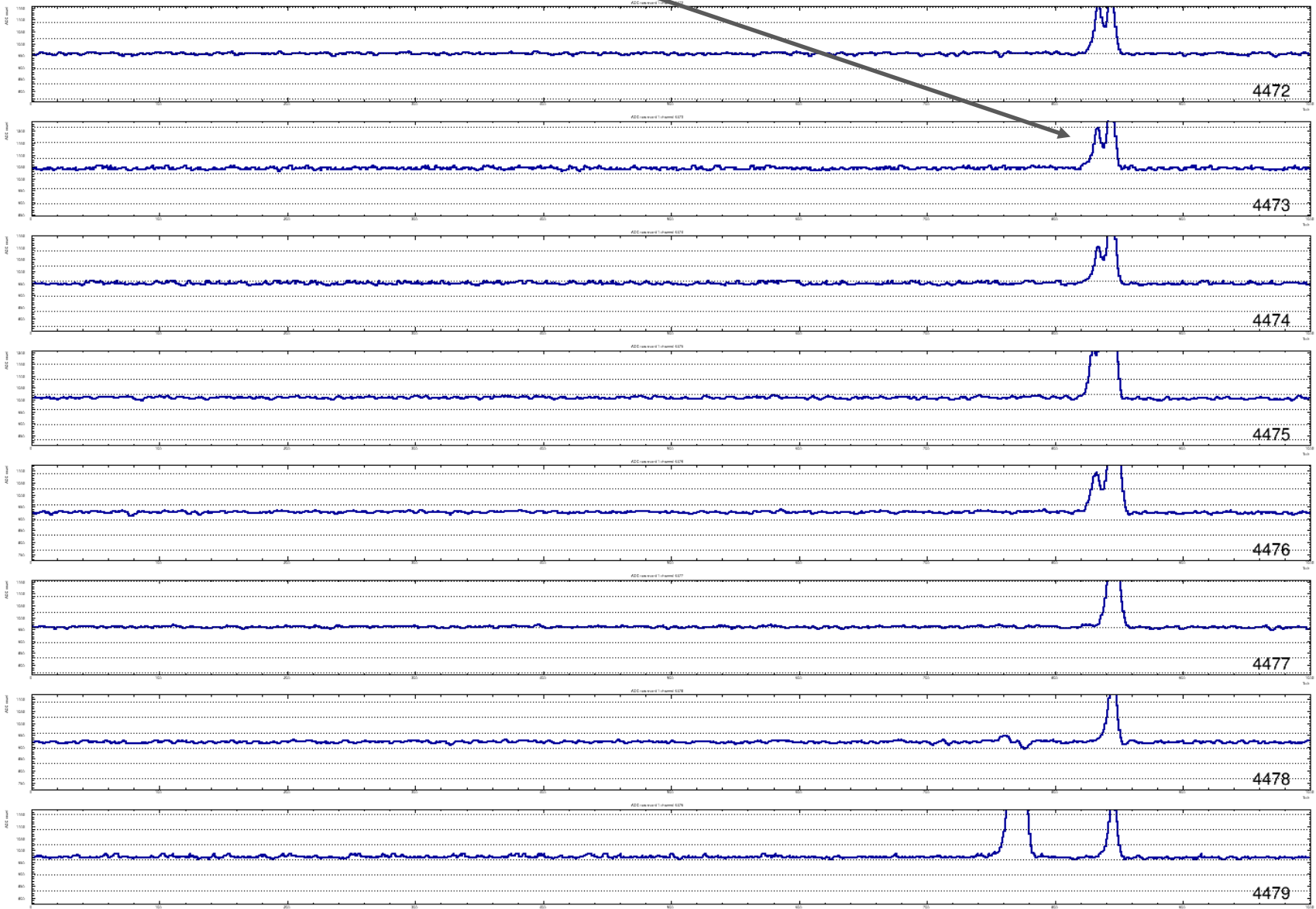
9641
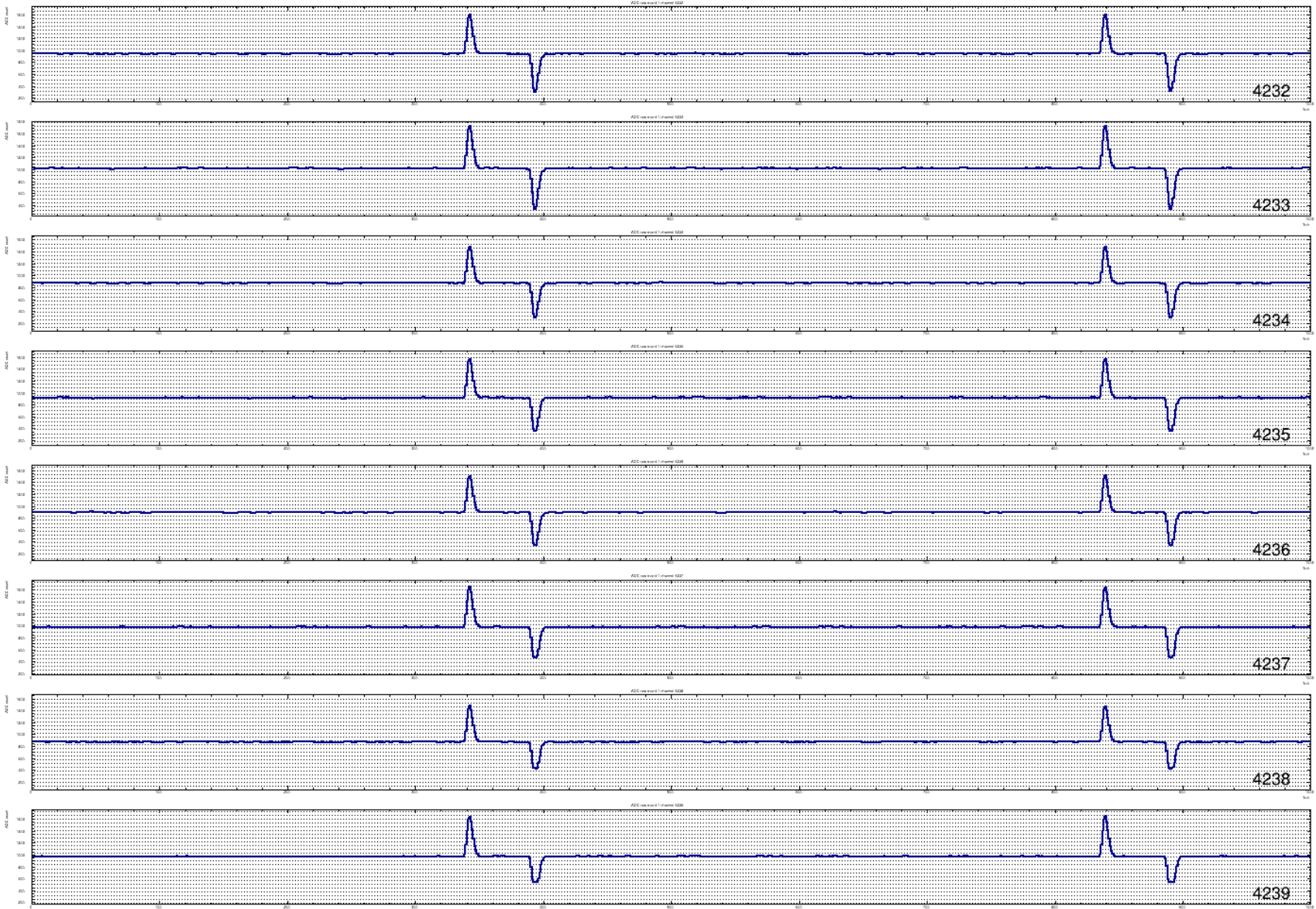
9641 noisy
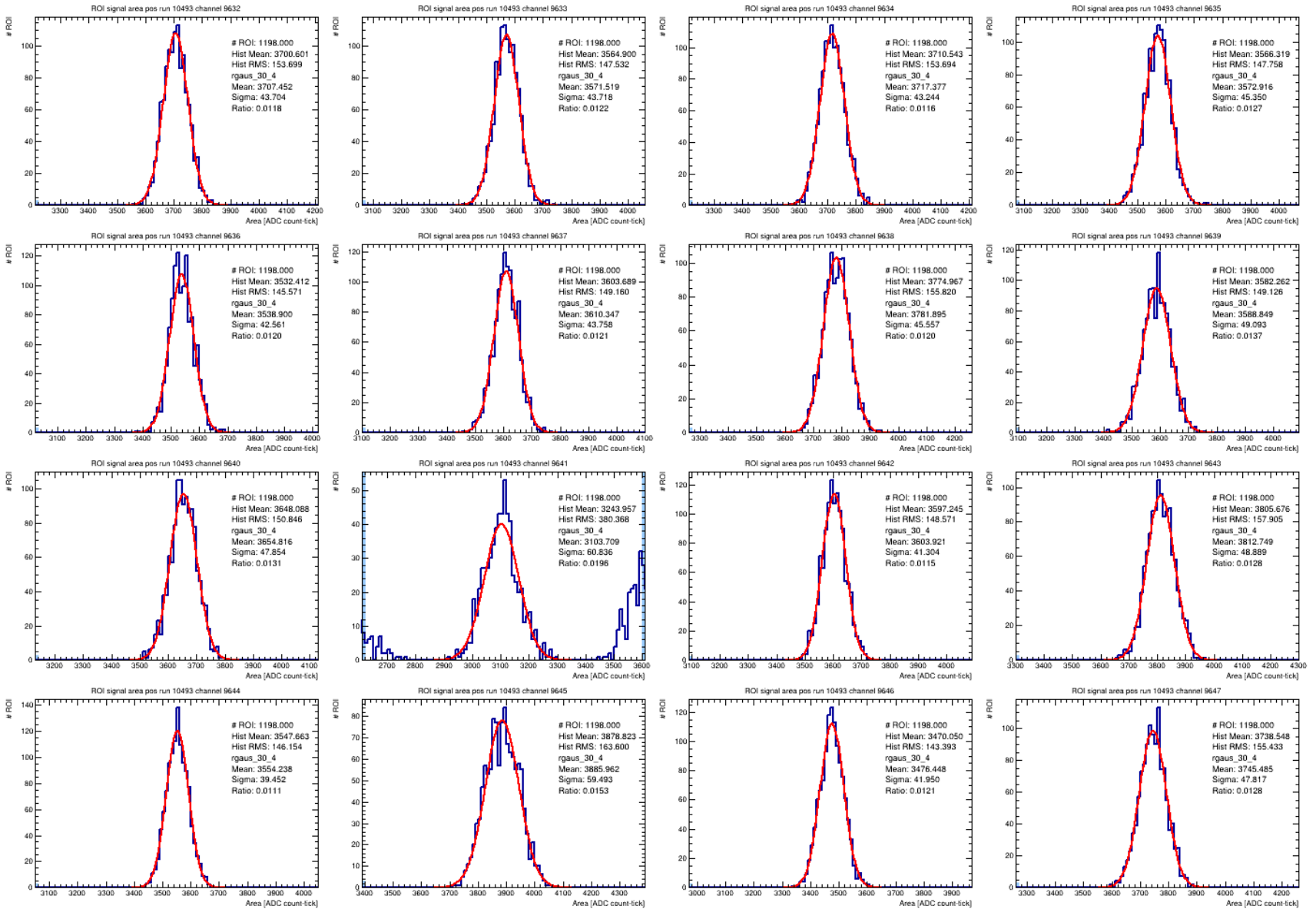
9641 noisy
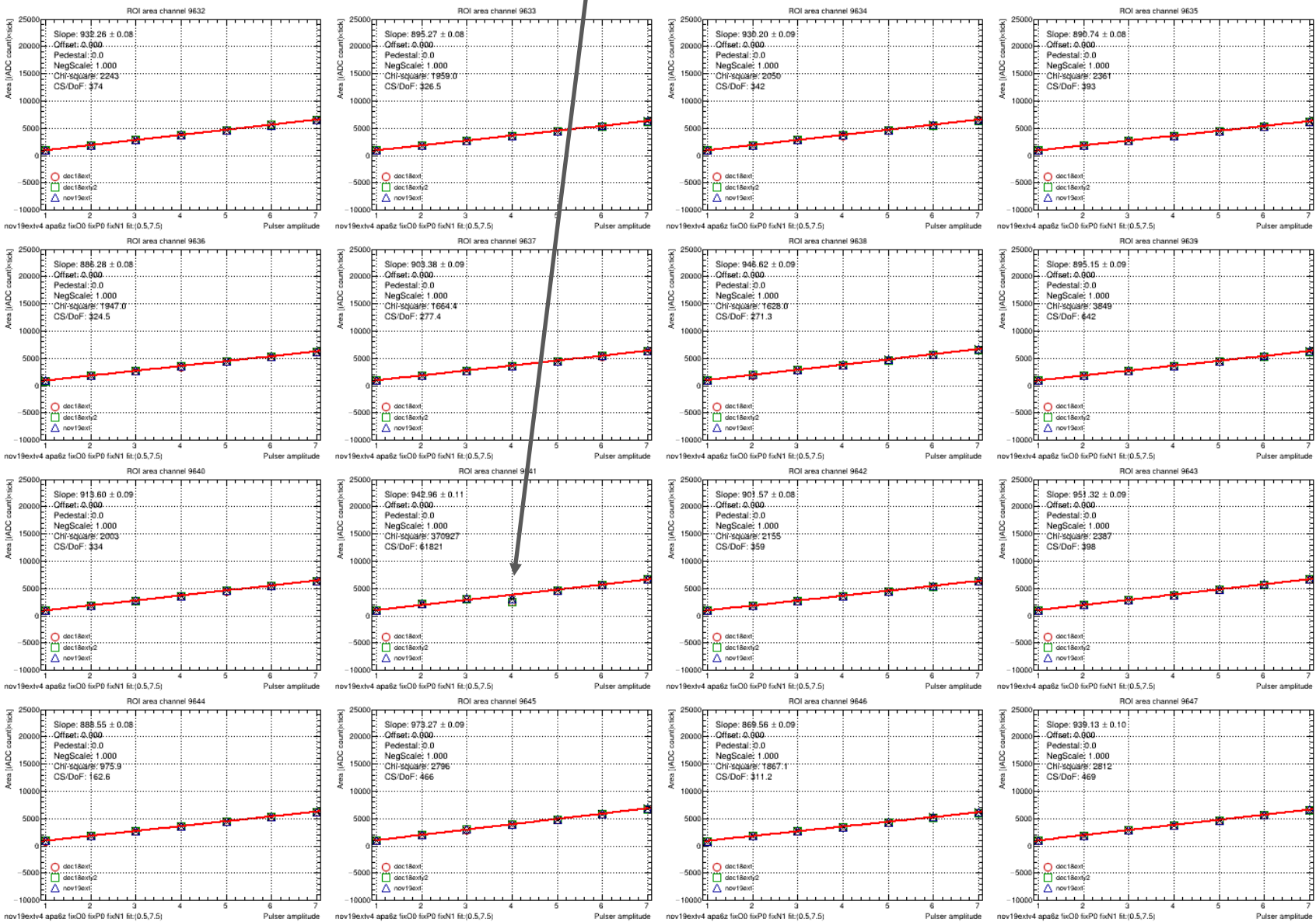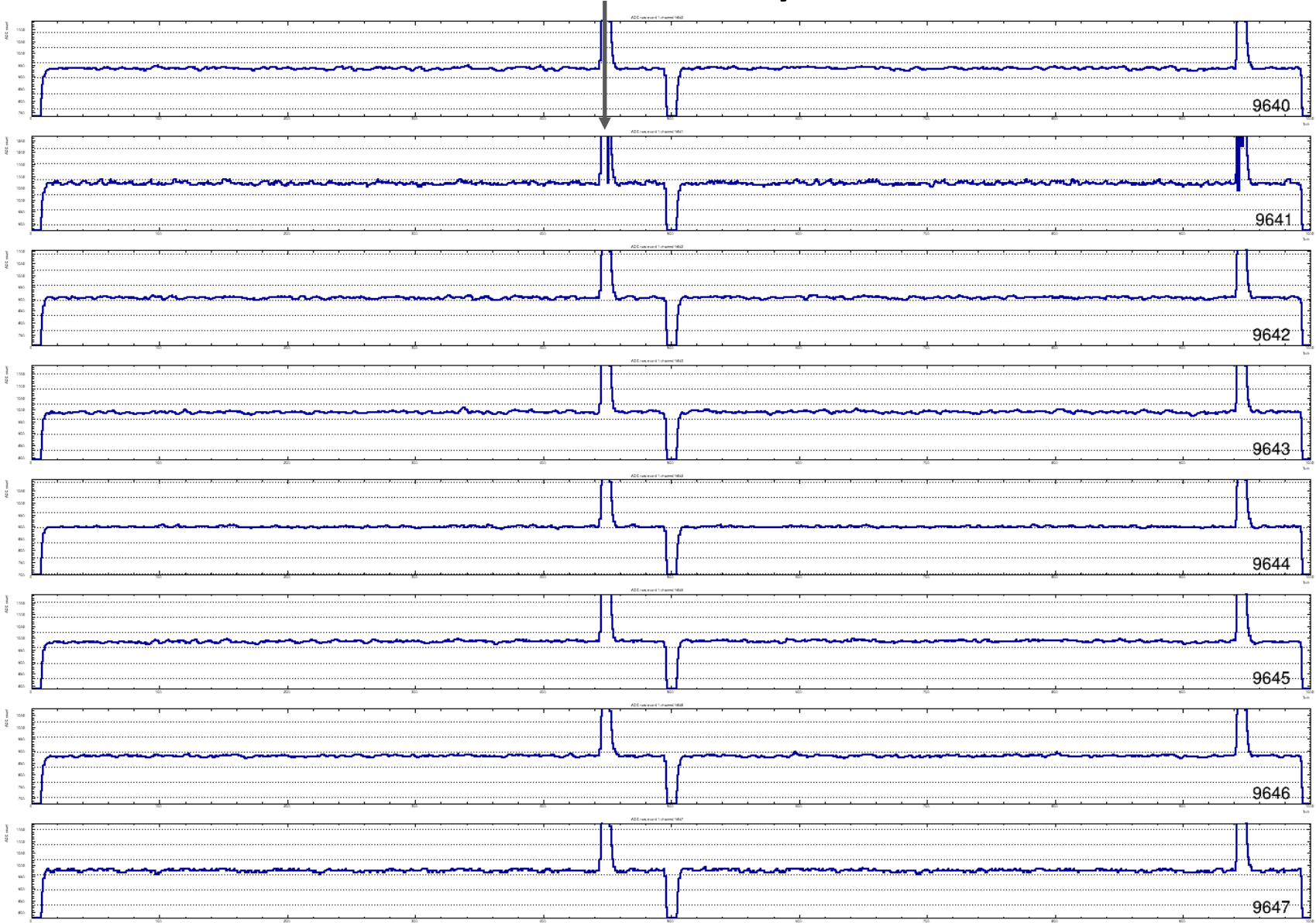
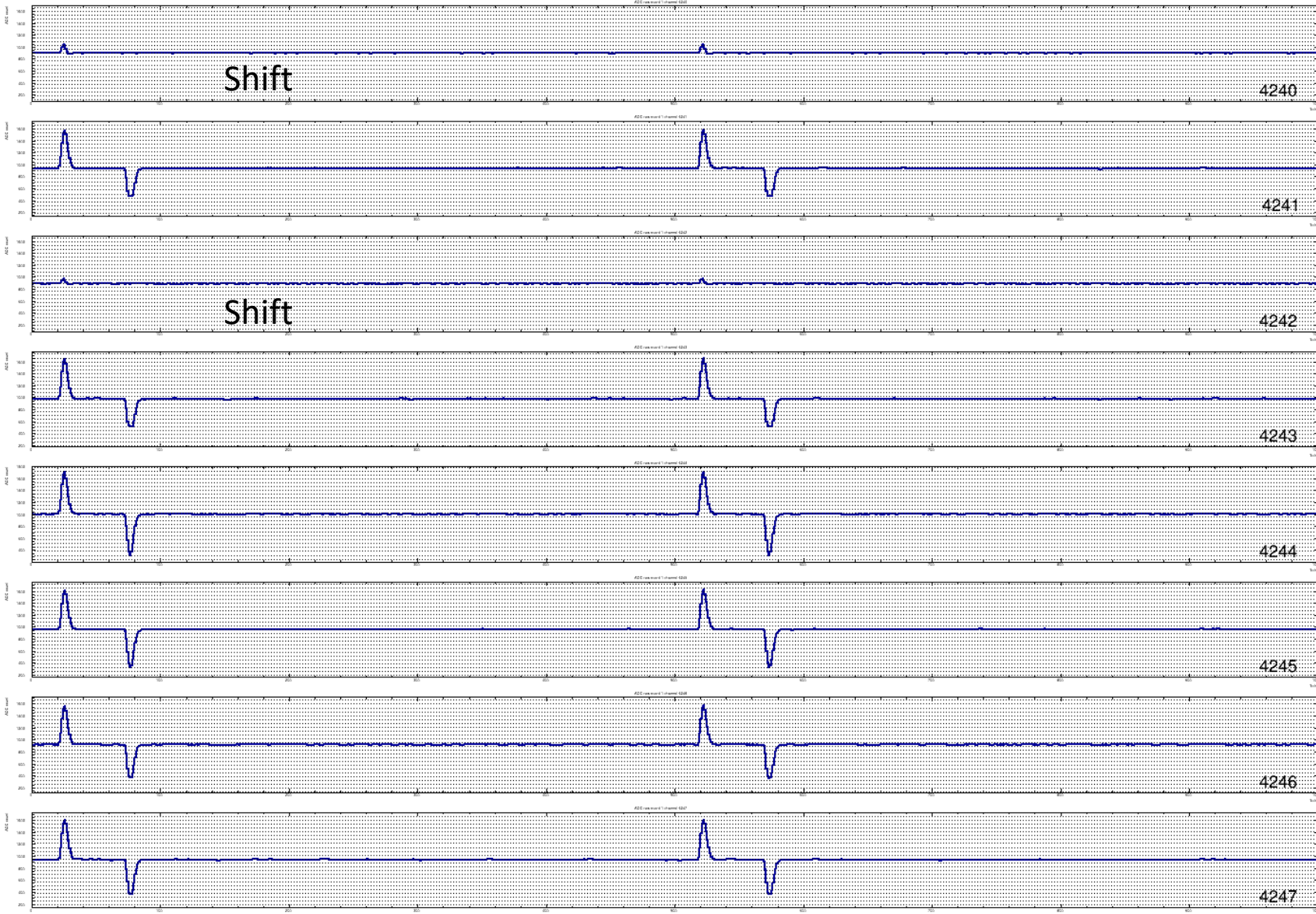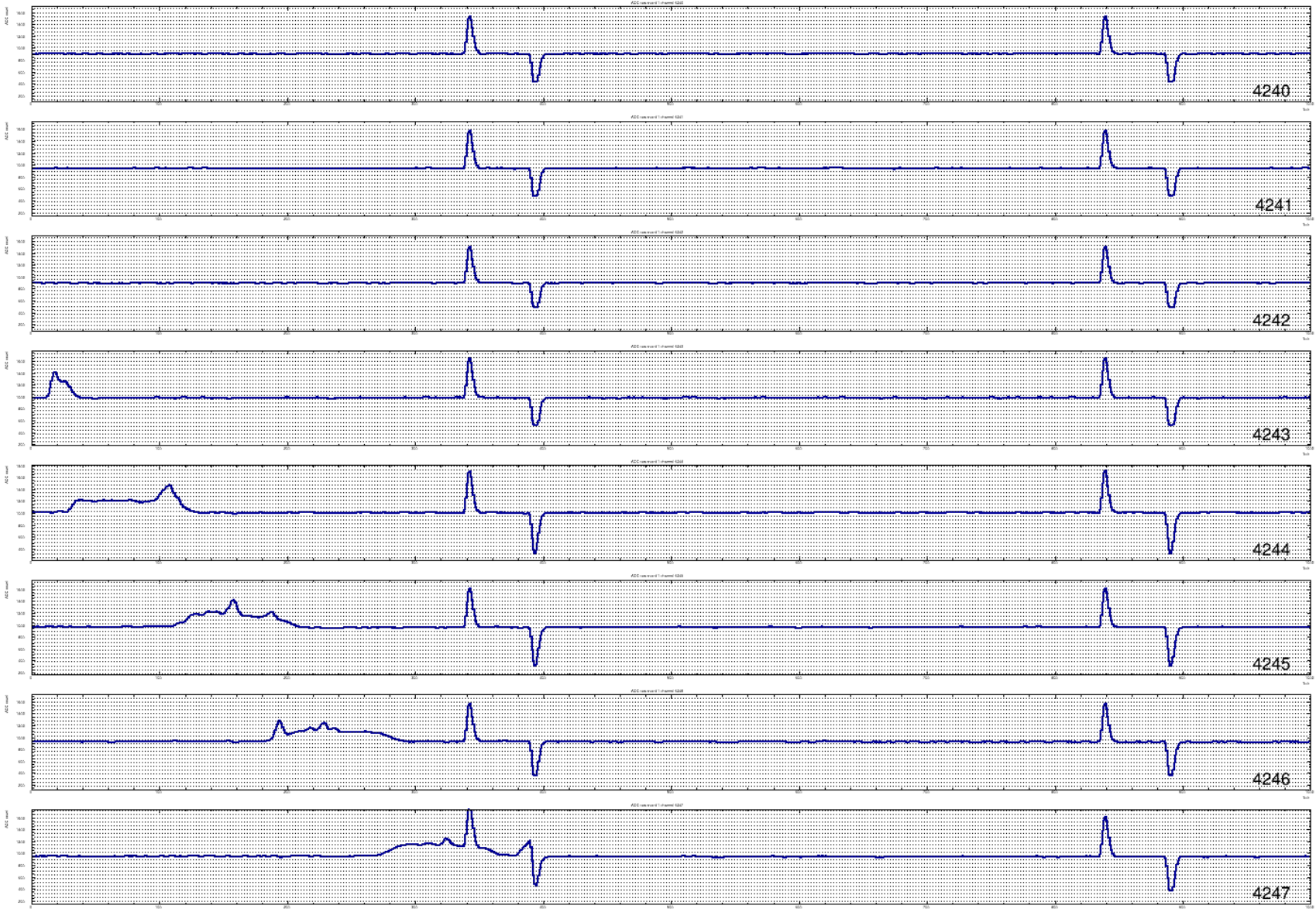# 9641 noisy

9641 noisy
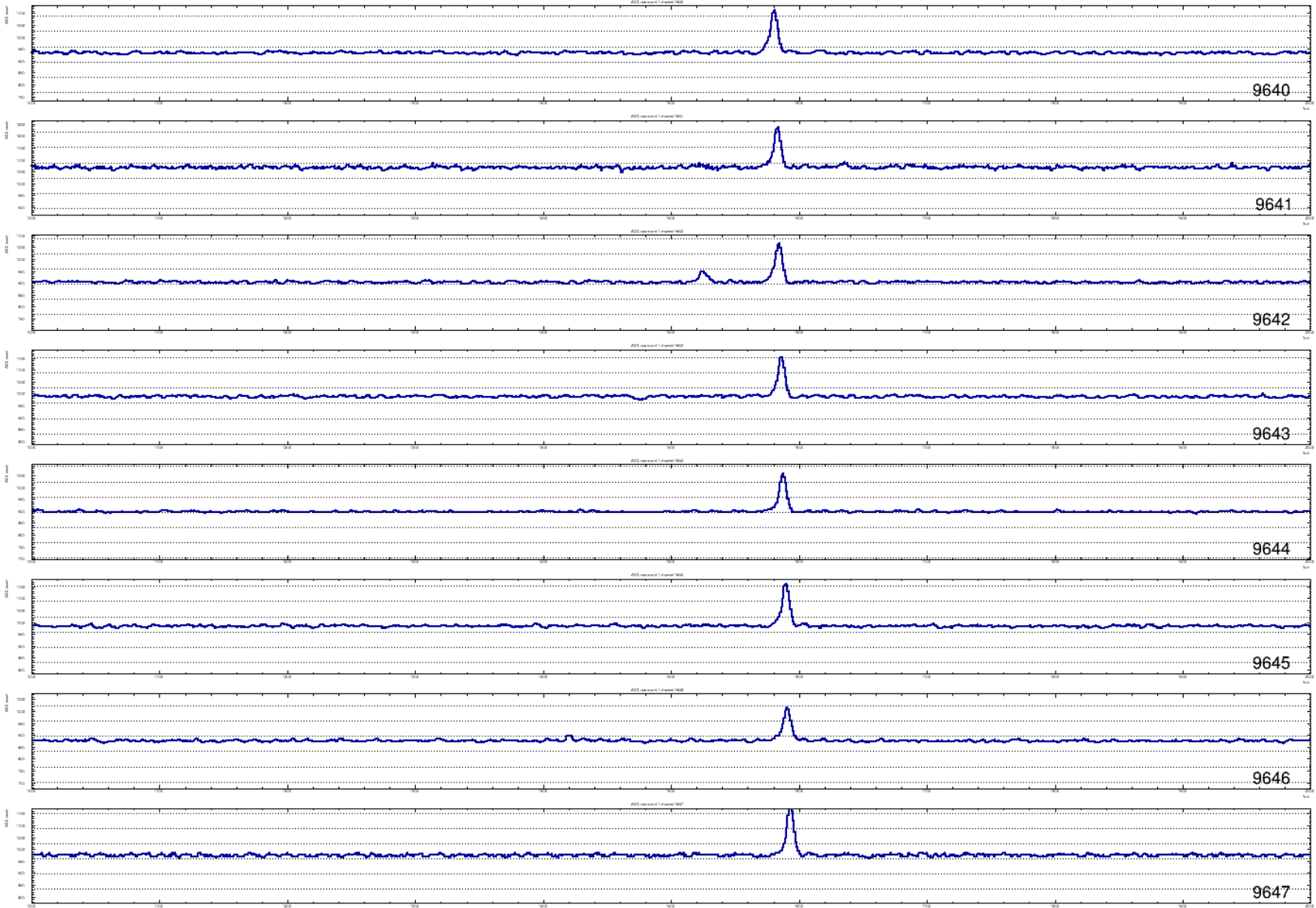
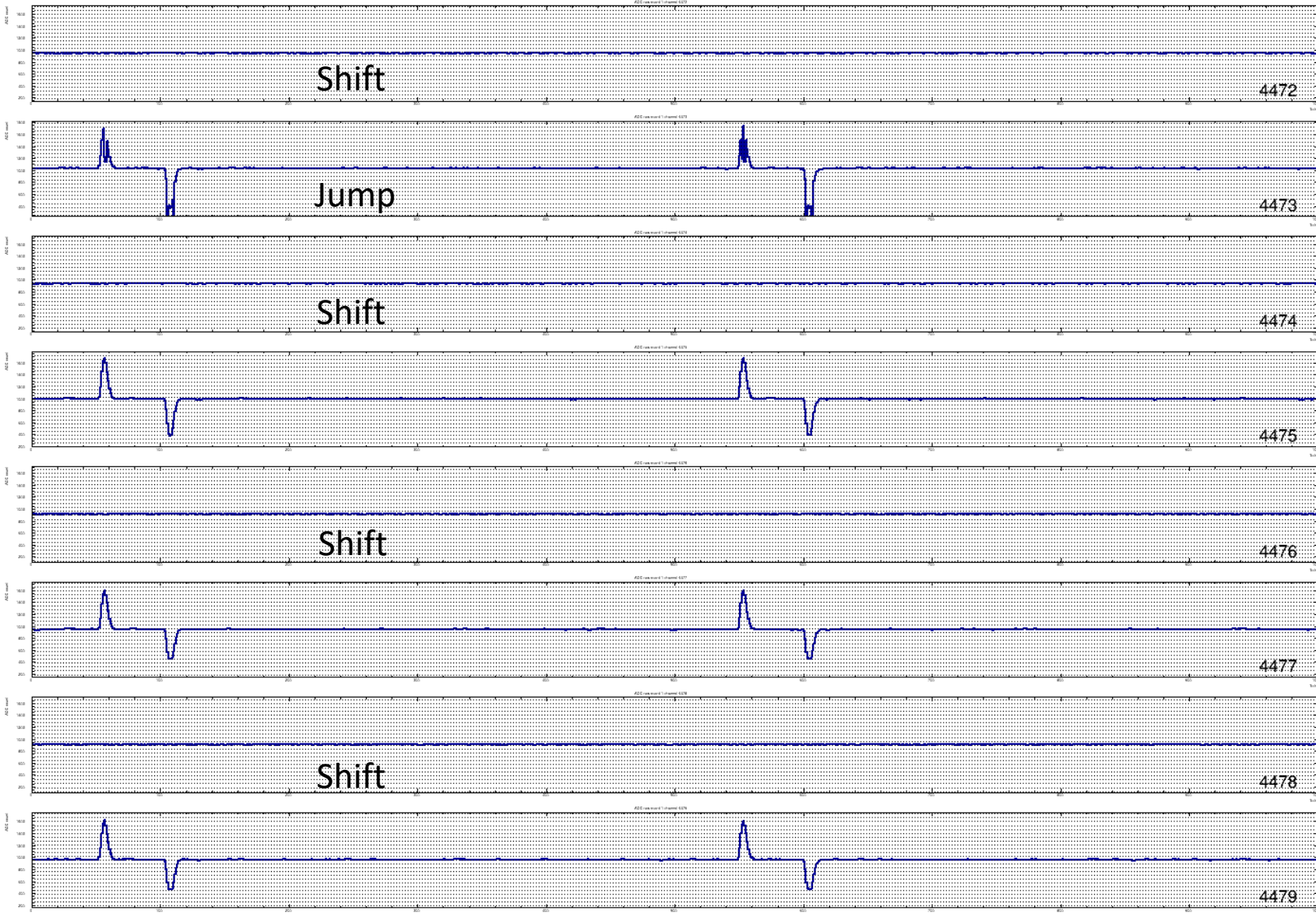# 4232, 4234, 4236, 4238, 4240, 4242
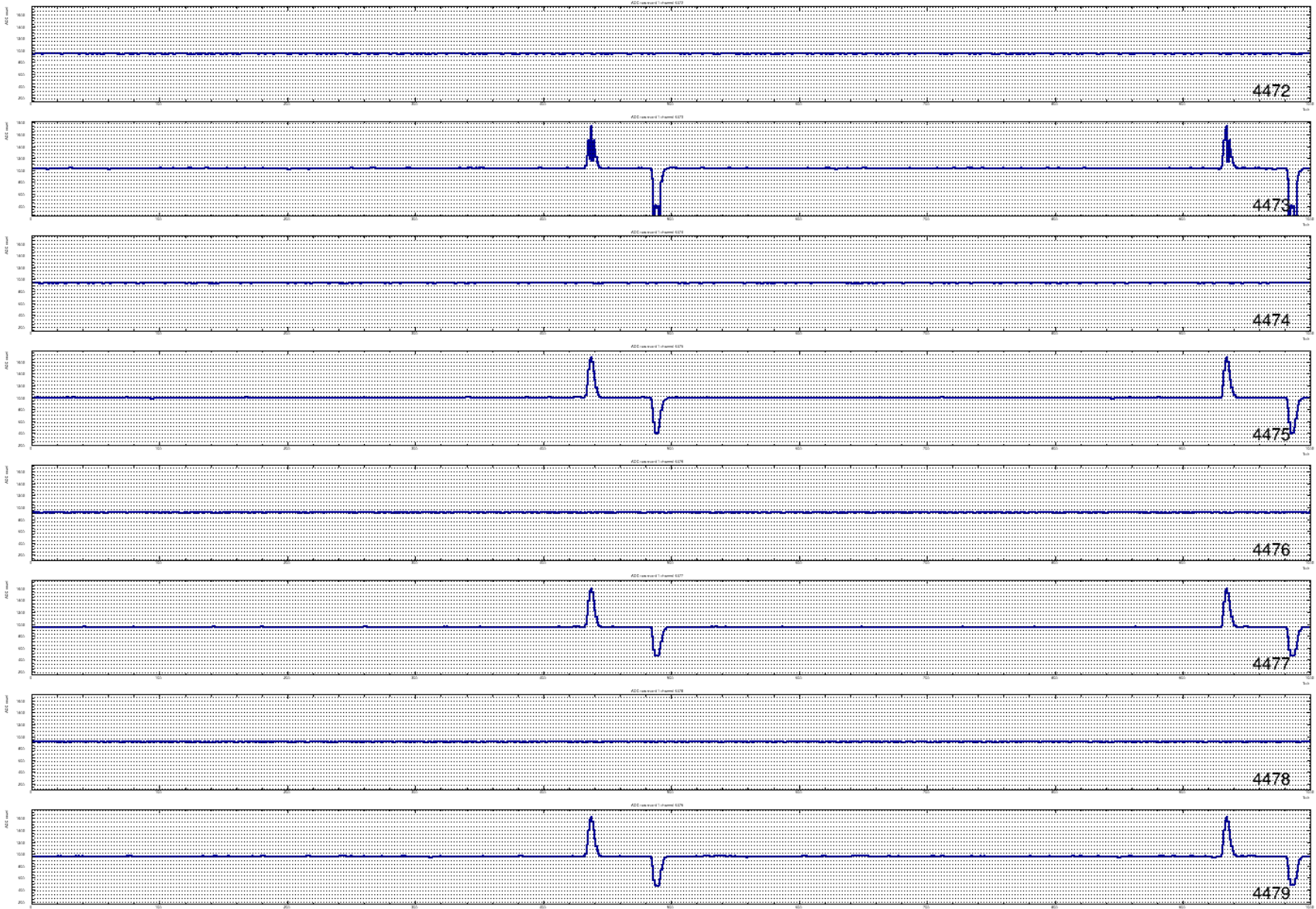
First run

Second run

First run

Second run

4472, 4473, 4474, 4476, 4478, 4480, 4482

First run

Shift

4472

Jump

4473

Shift

4474

4475

Shift

4476

4477

Shift

4478

4479

Second run

First run

Shift

4480

Shift

4481

4482

4483

4484

4485

4486

4487
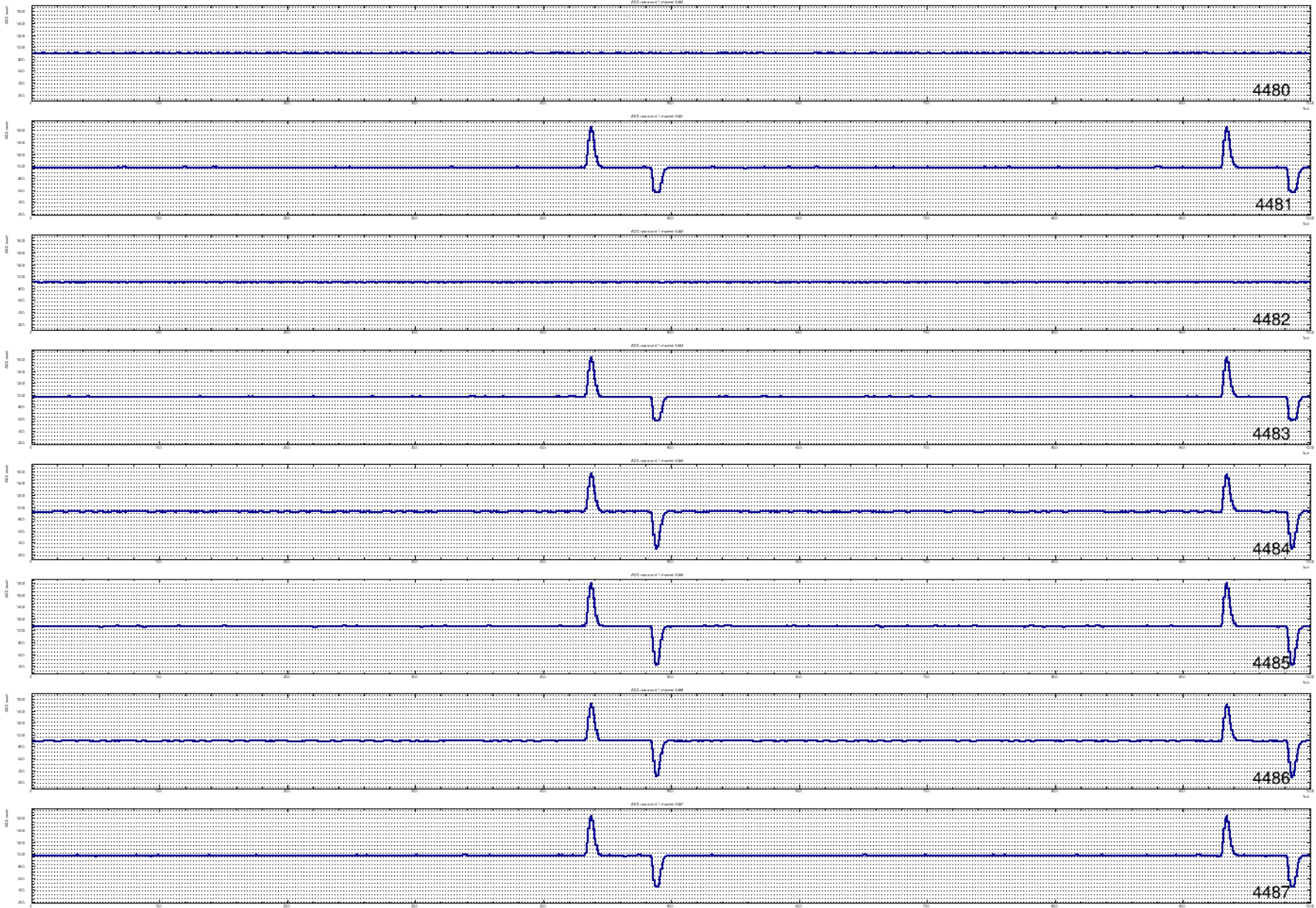
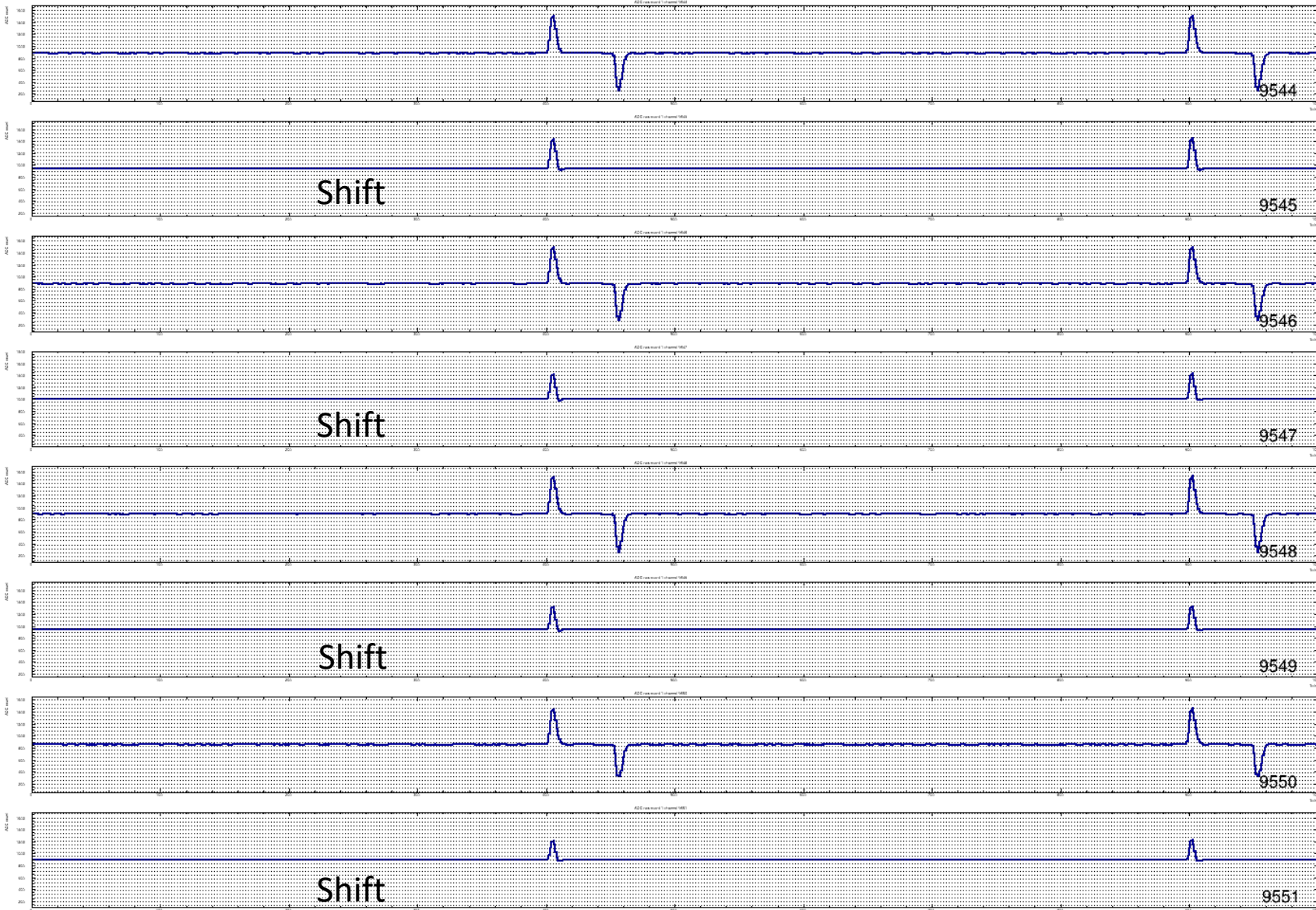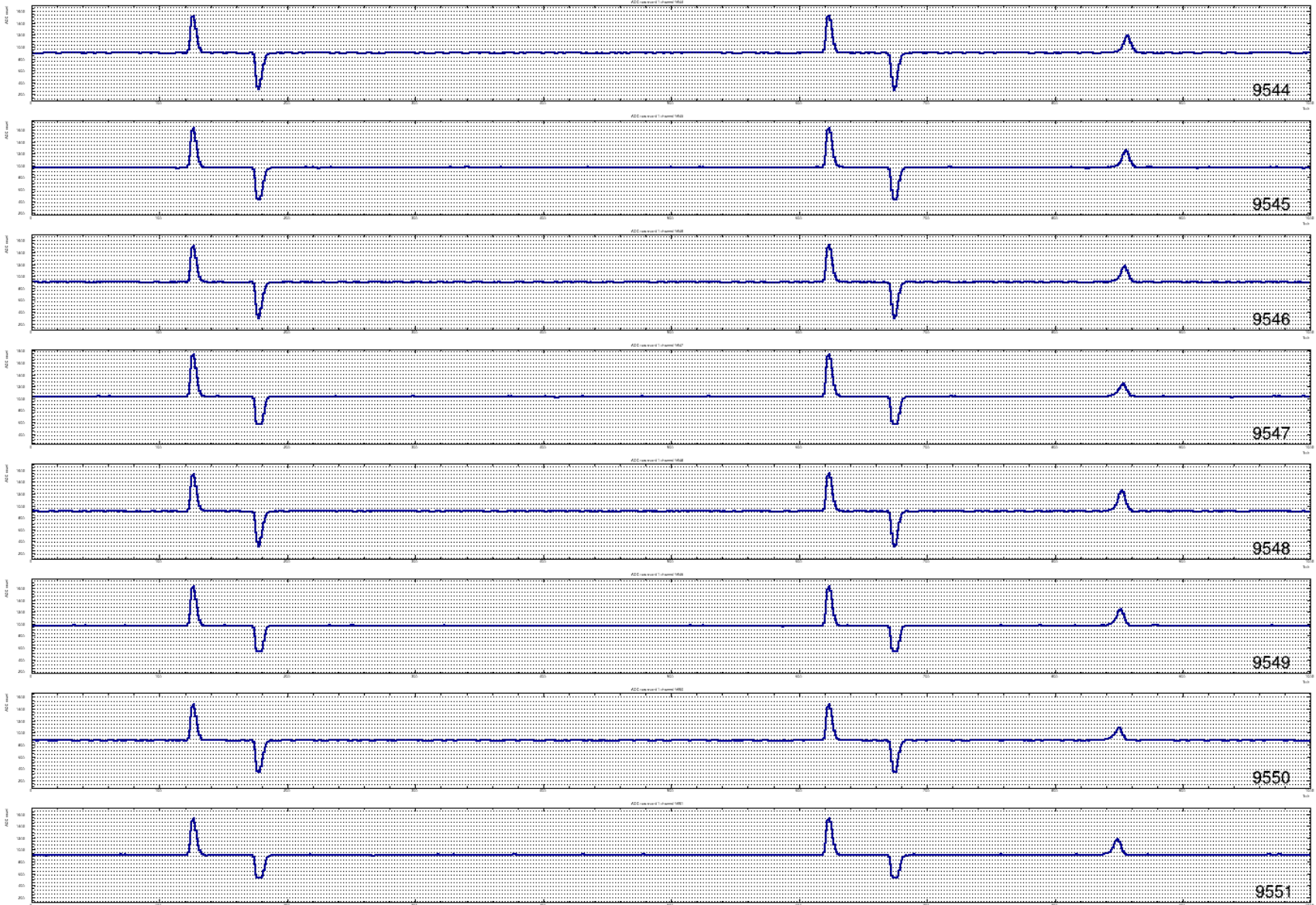# Second run

9545, 9547, 9549, 9551, 9553, 9555

First run

Second run

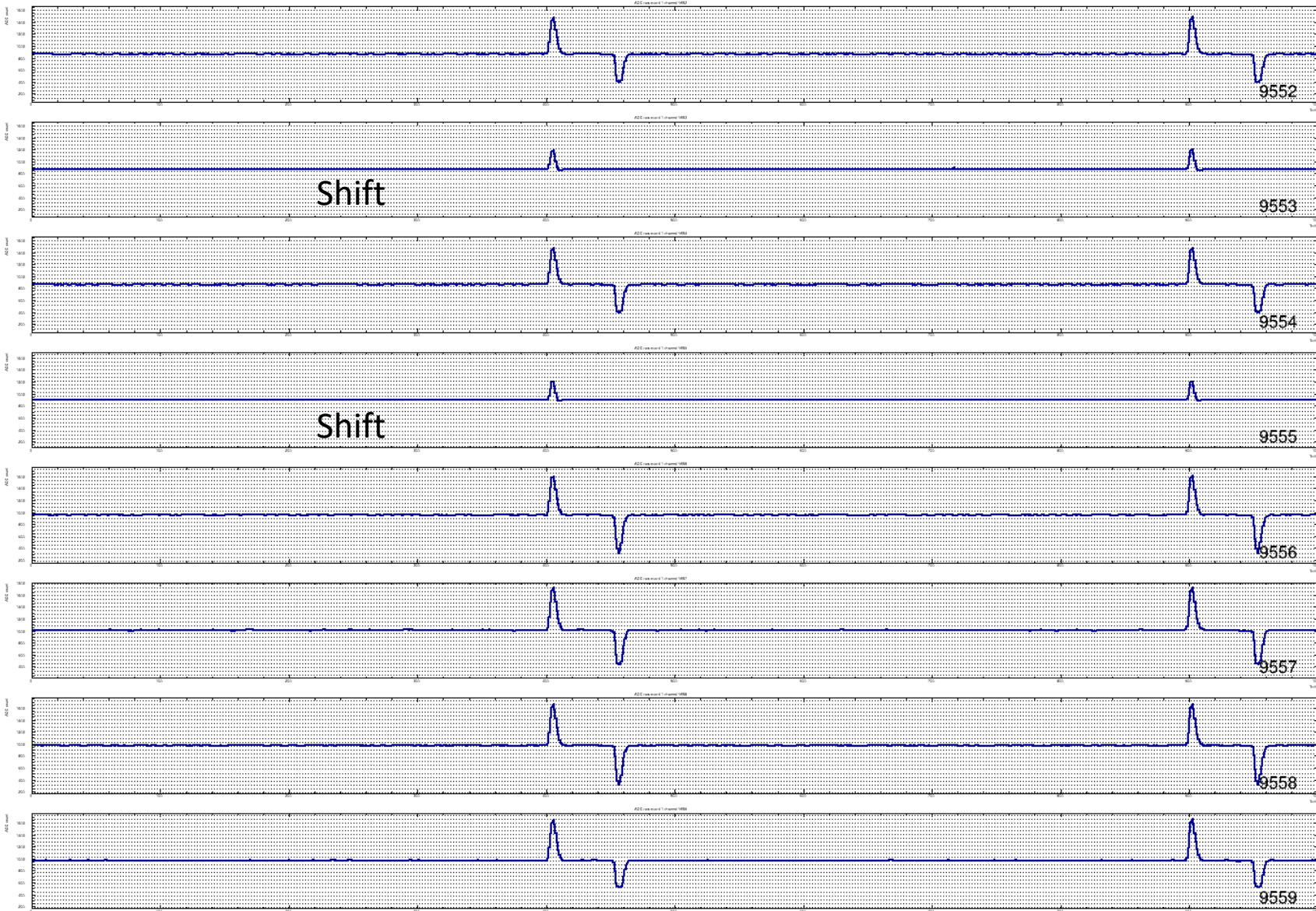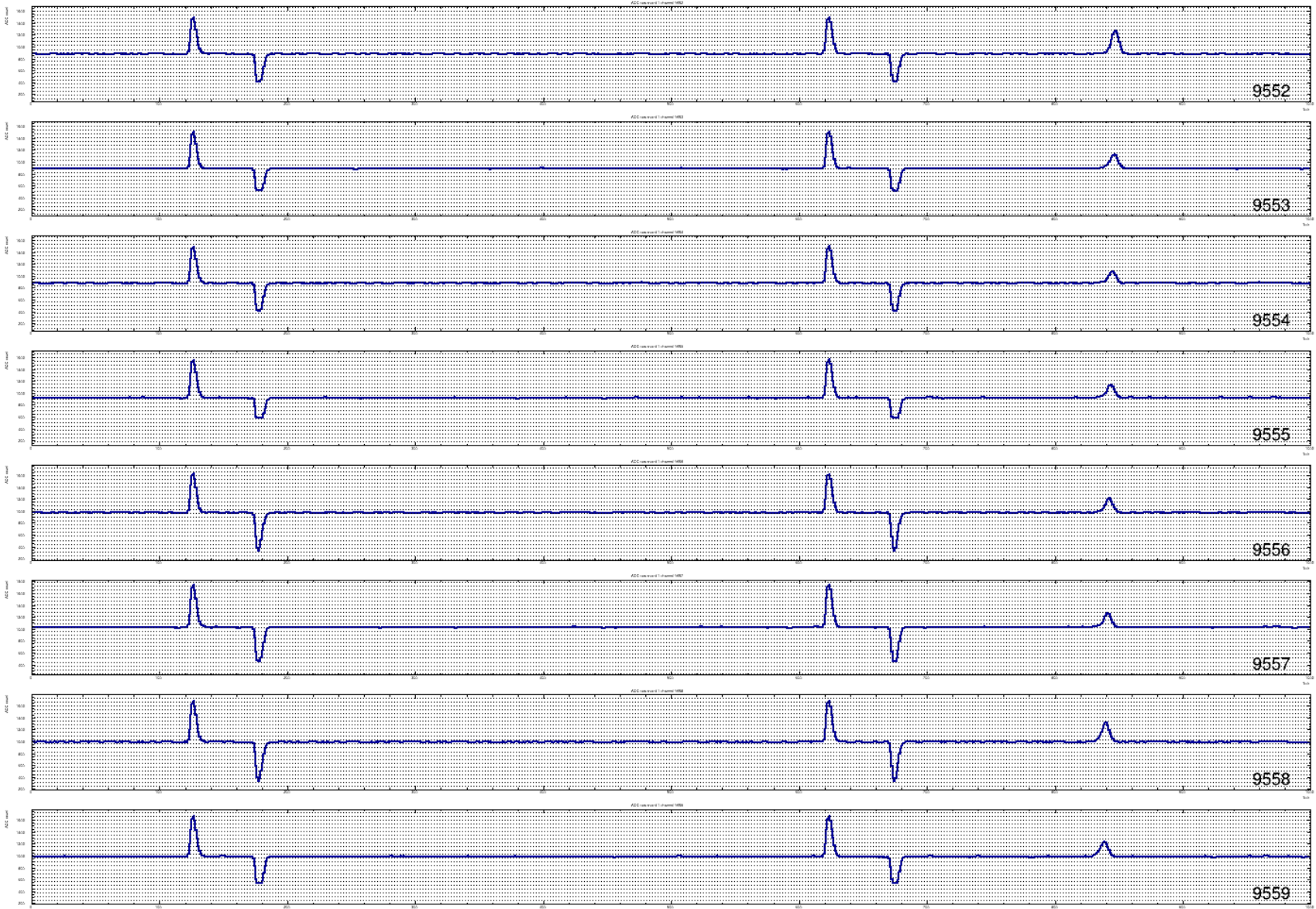# First run

Shift

Shift

Second run

Comments on bad pulser channels

Two channels have bad pulser waveforms: 4473, 9641

- Bad shapes
- Big nonlinearity evident in gain plots
- Problem persists over the course of the run
- But track response is qualitatively OK
- Both are flagged noisy

18 channels have big offsets in gain plots in Nov 2019 pulser data

- Apparently all six collection channels in each of three ASICs
- Two of the ASICs (12 channels) recovered in run taken later
- Channels are not flagged as bad or noisy
  - Presumably we can use the older calibrations for these