ProtoDUNE commissioning

ProtoDUNE sim/reco

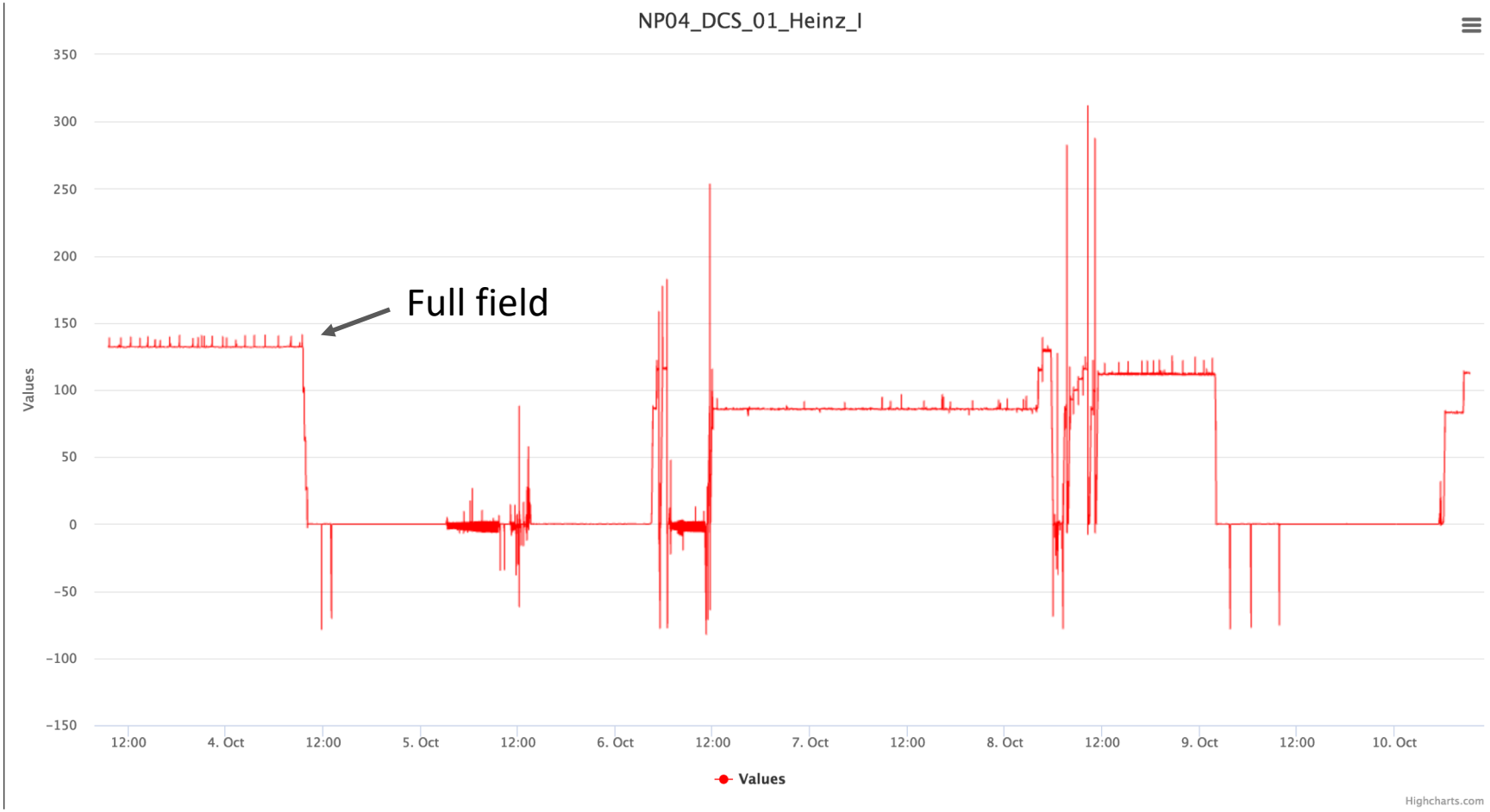
David Adams
BNL
October 10, 2018

Detector status

The protoDUNE detector is being commissioned

- LAr purity continues to improve (I assume)
  - Clear evidence of beam-induced signals
- HV usually at 180 kV (500 V/cm)
  - Current spikes are seen: few percent every hour or more
  - Ramped all or partly down for much of last week when beam was off
- Data taken with beam (but not in the last week)
  - List of runs I have studied is at https://wiki.dunescience.org/wiki/ProtoDUNE_commissioning_runs_(dla)
  - Not attempting to capture all physics runs
  - Please let me know if I have missed anything interesting
- Tracks evident and plentiful with field on
  - See following displays
- Noisy channels
  - Clear feature of event displays
  - Presumably contribute to the ROIs (recob::Wire) output by dataprep
  - Complicate studies of noise in quieter channels

HV current for the last week



Topics

Update of detector display

Beam signal in APA3z

FEMB 302 timing

Geometry issue: rotated APAs

Noisy channels

- Geometry update

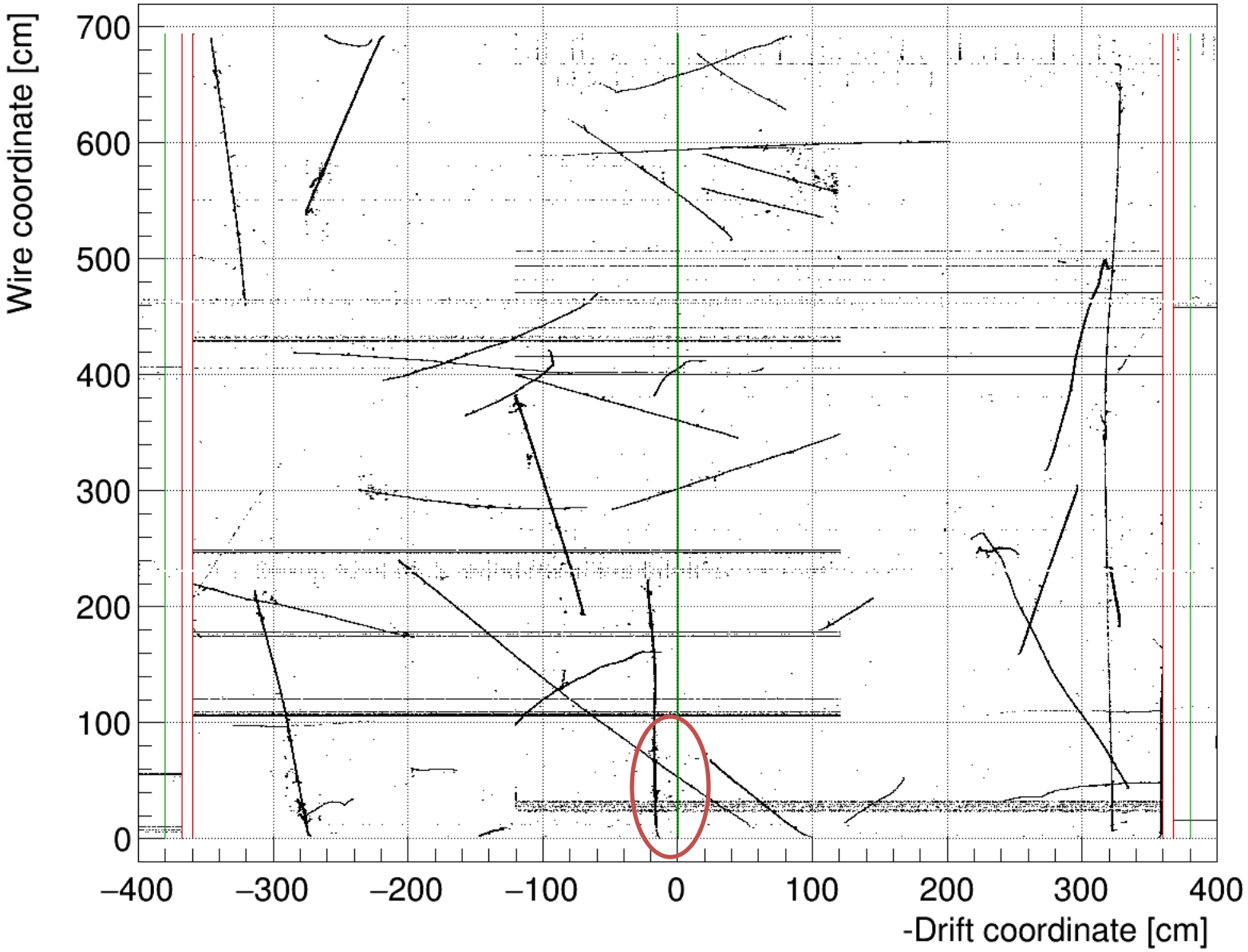
Detector display

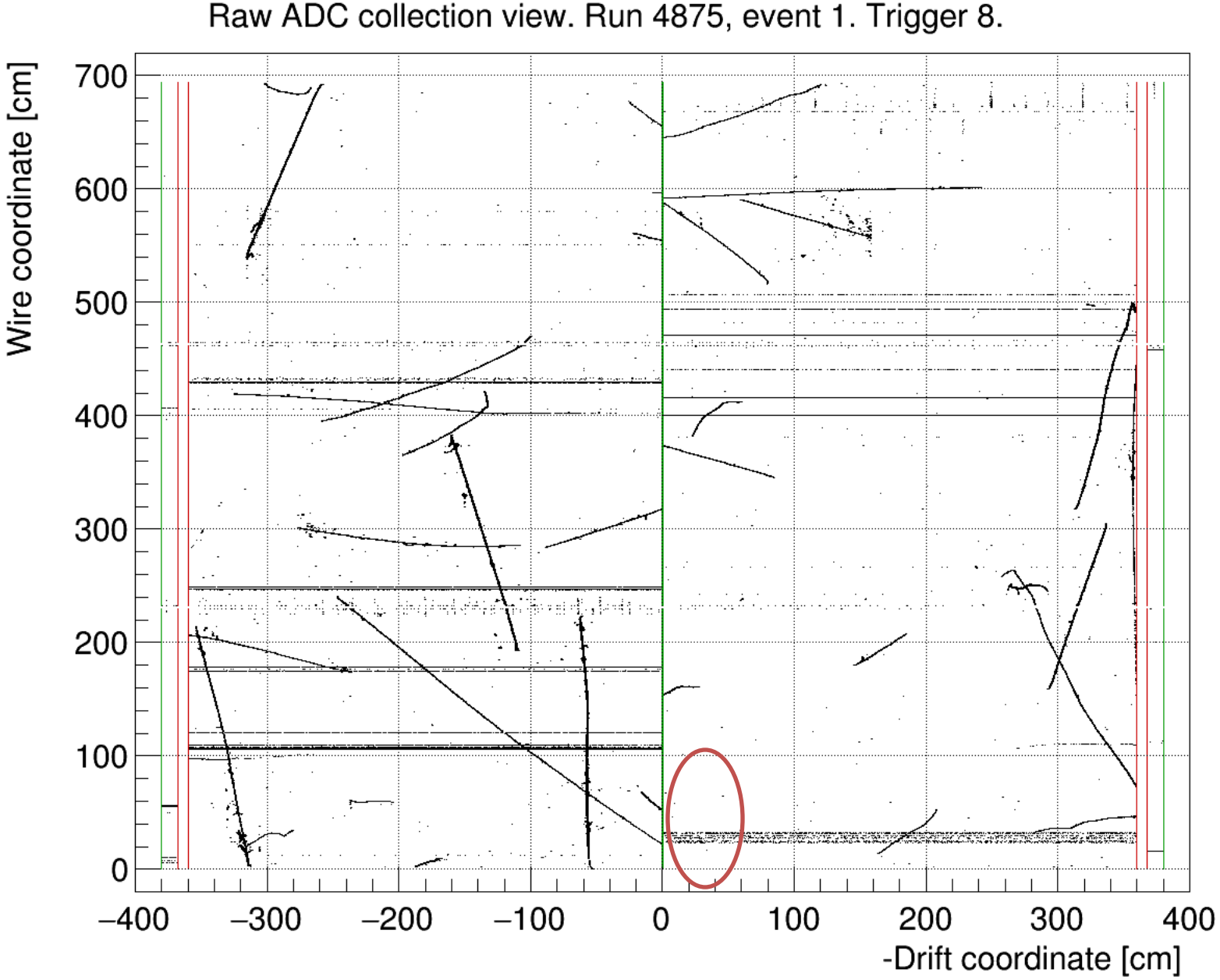
Update of detector display

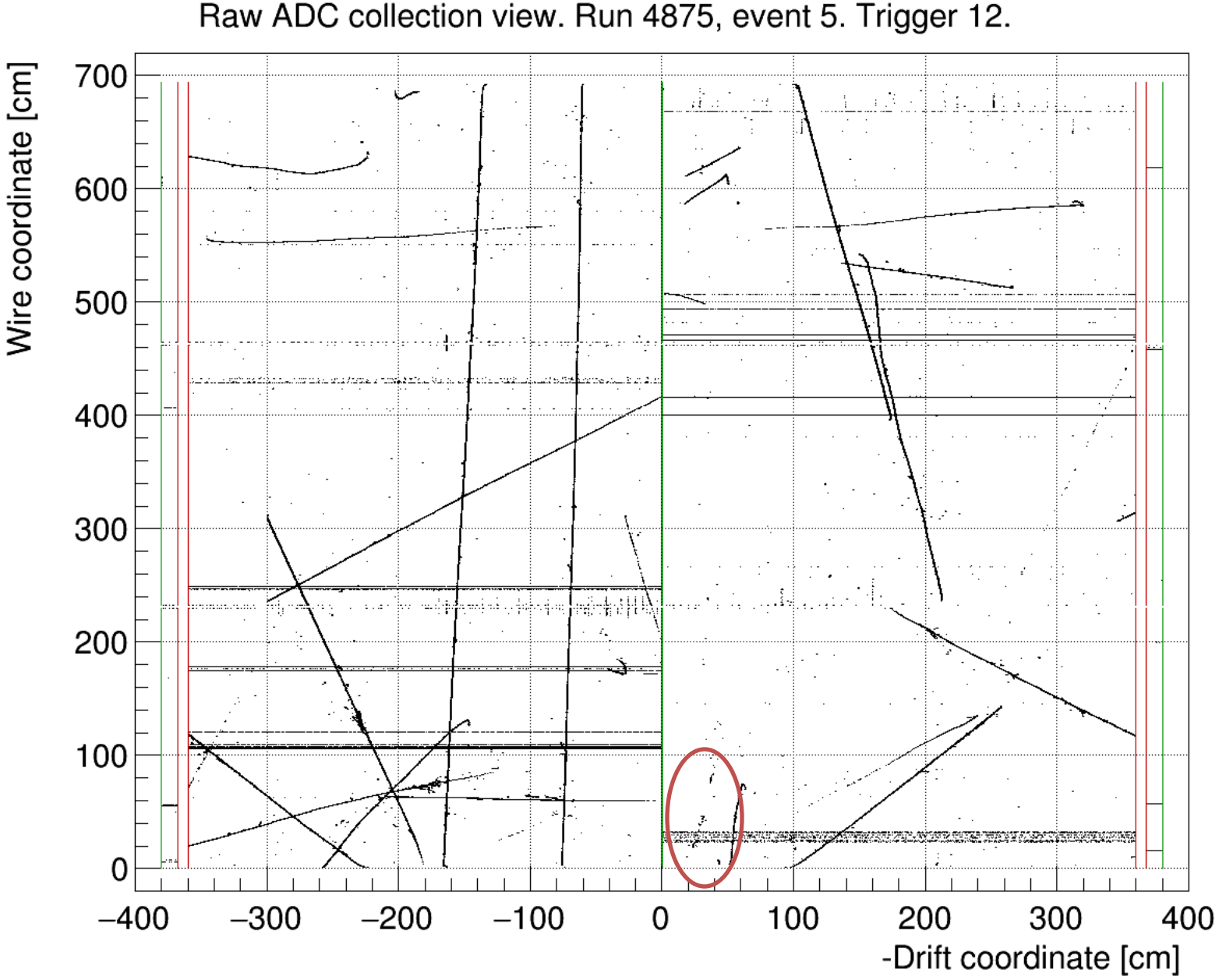
Detector display has been updated

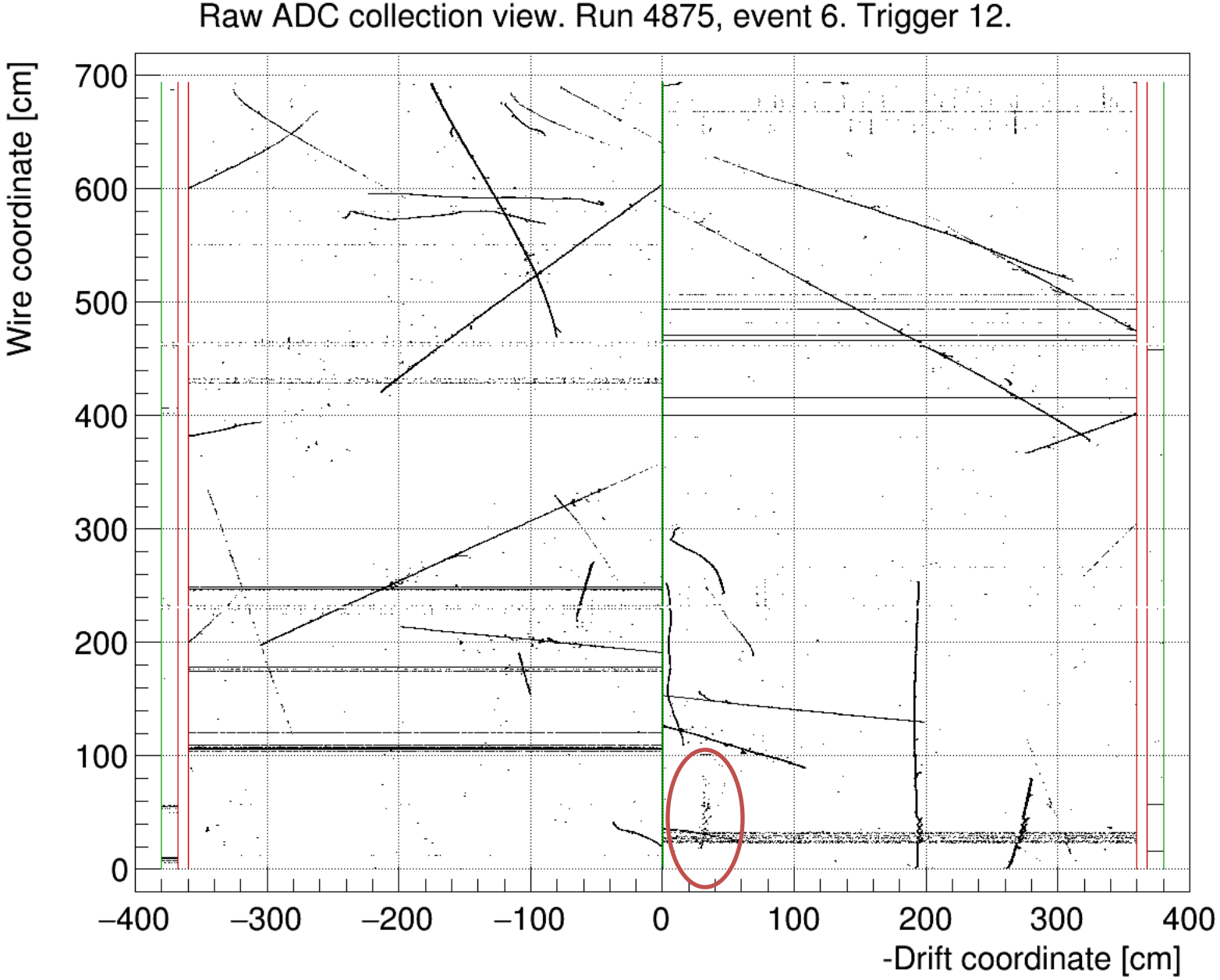
- Now includes 500 tick trigger offset
  - So prompt beam tracks are at the right position
  - Of course cosmics (and halo?) will still be offset
- Only ticks in the TPC volume (cathode to anode) are shown
  - Not visible: 500 ticks before anode and 200 ticks after cathode
- Labels include the trigger index
  - 12 = beam trigger
  - 8-11 = fake, e.g. random trigger
- Mods should be in dqm this week
  - If desired, any of the changes can be overridden in fcl
- Examples follow

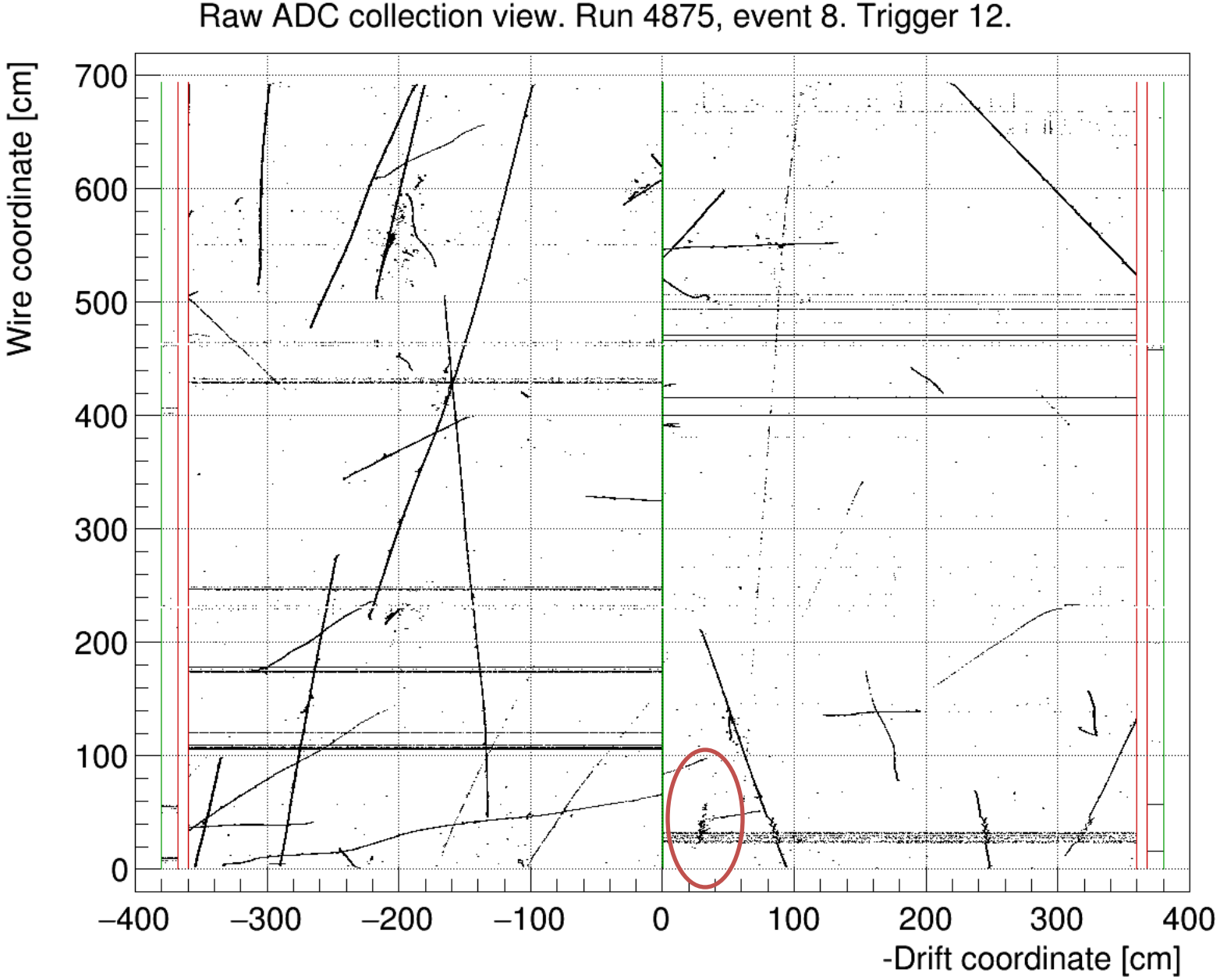
Old style display




Raw ADC collection view. Run 4875, event 1. Trigger 8.
Wire coordinate [cm]
700
600
500
400
300
200
100
0
−400
−300
−200
−100
0
100
200
300
400
-Drift coordinate [cm]


Raw ADC collection view. Run 4875, event 5. Trigger 12.
Wire coordinate [cm]
700
600
500
400
300
200
100
0
−400
−300
−200
−100
0
100
200
300
400
-Drift coordinate [cm]


Raw ADC collection view. Run 4875, event 6. Trigger 12.
Wire coordinate [cm]
700
600
500
400
300
200
100
0
−400
−300
−200
−100
0
100
200
300
400
-Drift coordinate [cm]


Raw ADC collection view. Run 4875, event 8. Trigger 12.
Wire coordinate [cm]
700
600
500
400
300
200
100
0
−400
−300
−200
−100
0
100
200
300
400
-Drift coordinate [cm]

APA 3z displays

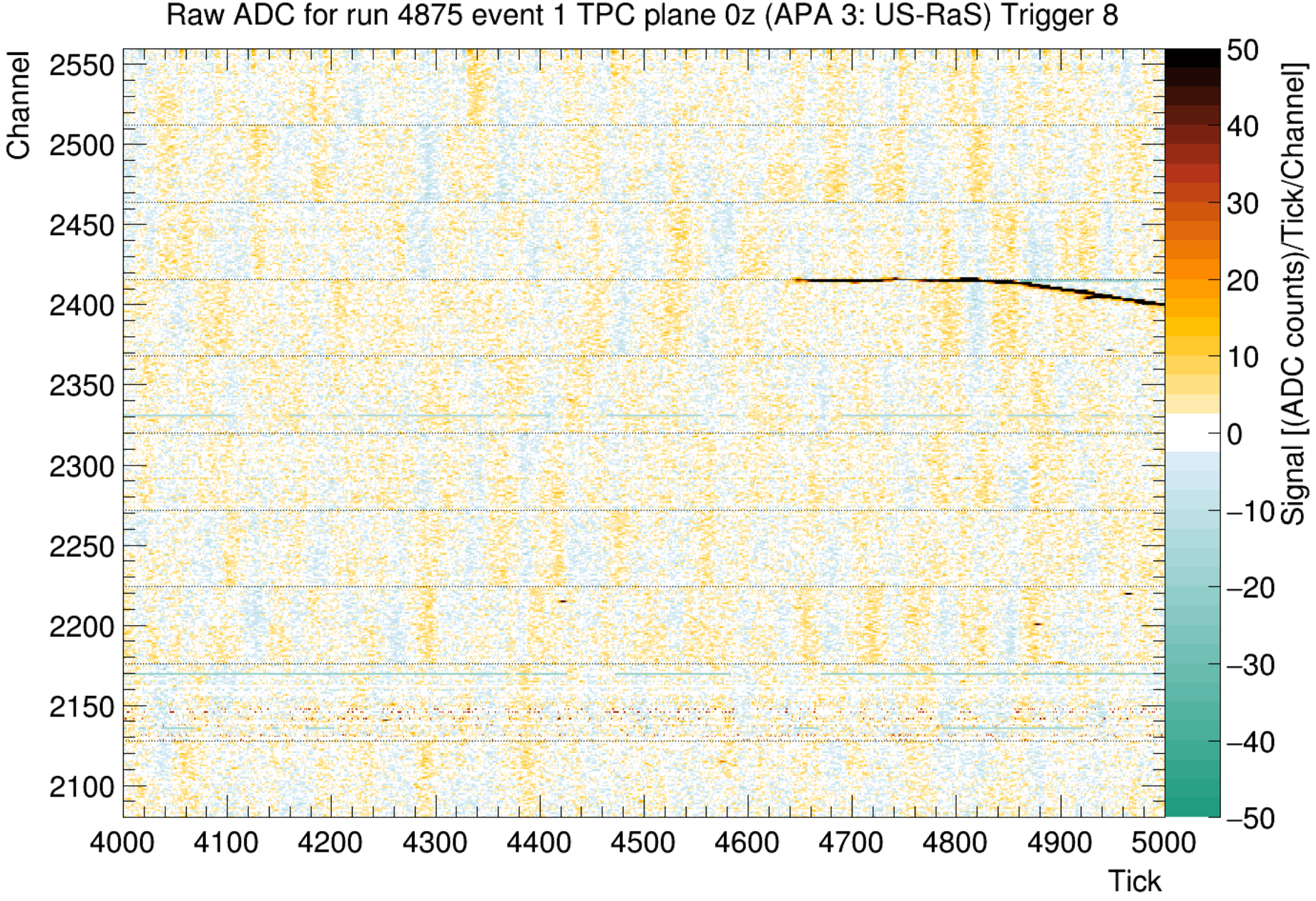
APA 3z displays

Preceding detector displays are very useful

- Show clear evidence of beam
- Can be rapidly scanned by eye to find interesting events

Channel-tick display of APA 3z is similarly useful

- Lacks length dimensions but has lower threshold and color scale
- Zooms in on the APA where the beam enters
- Note z means TPC-side collection
- Changes in new release:
  - Tick range is shifted to show beam
  - Trigger index is added to the title
- Some examples follow
  - Displacement between edge of detector and start of signal is about what we expect from space charge effect (M. Mooney)


Raw ADC for run 4875 event 1 TPC plane 0z (APA 3: US-RaS) Trigger 8
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
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30
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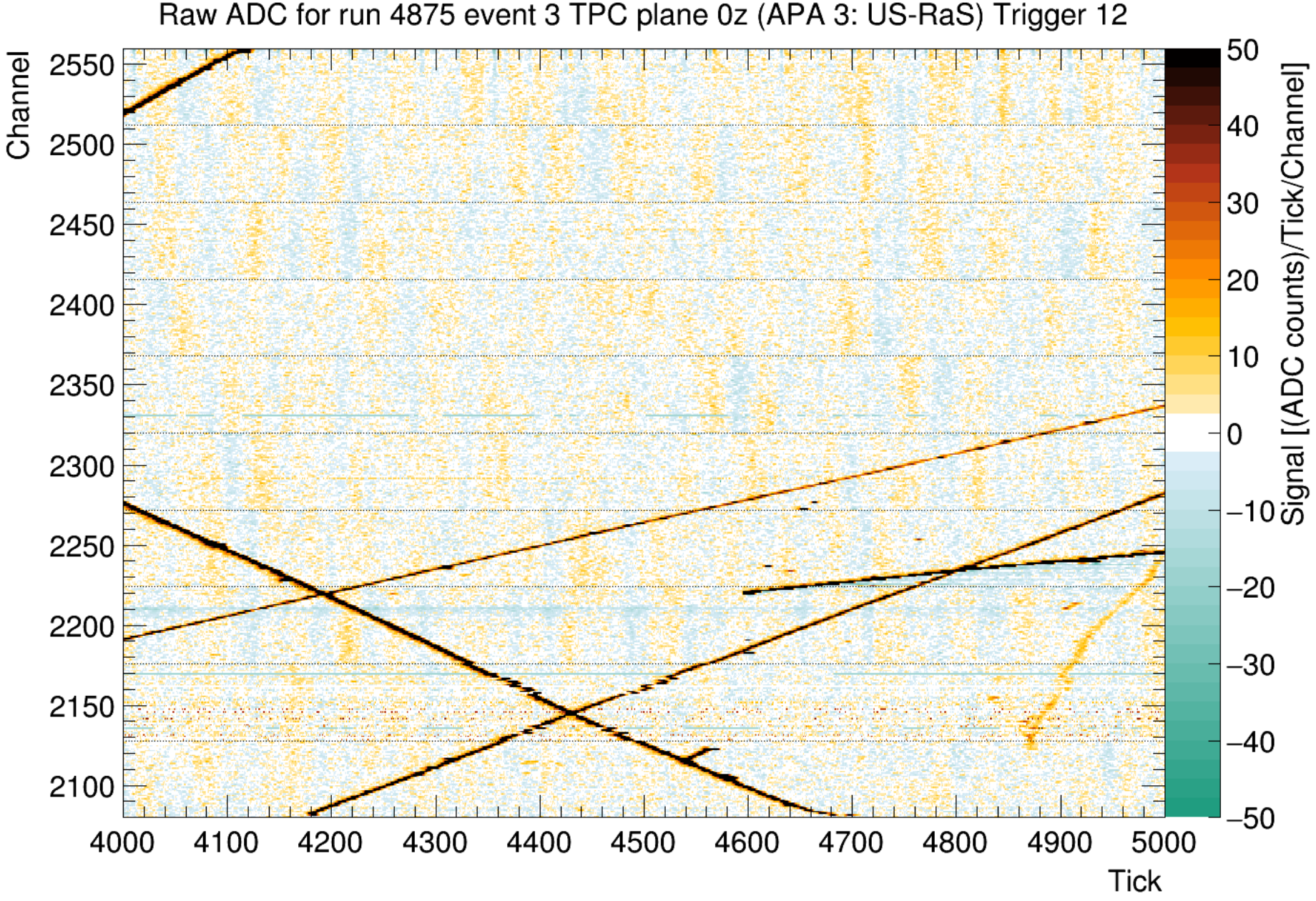
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 3 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
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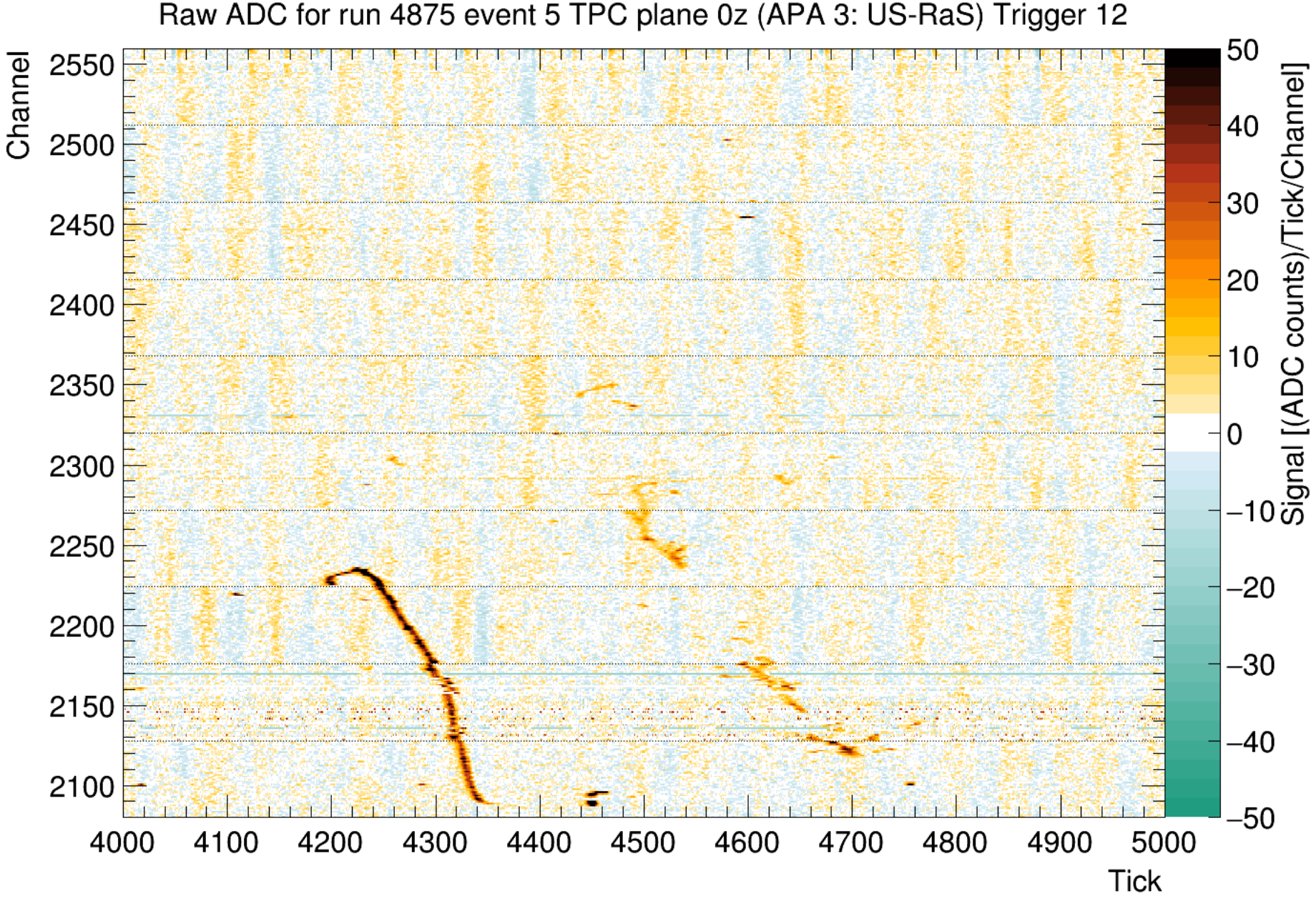
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 5 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
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40
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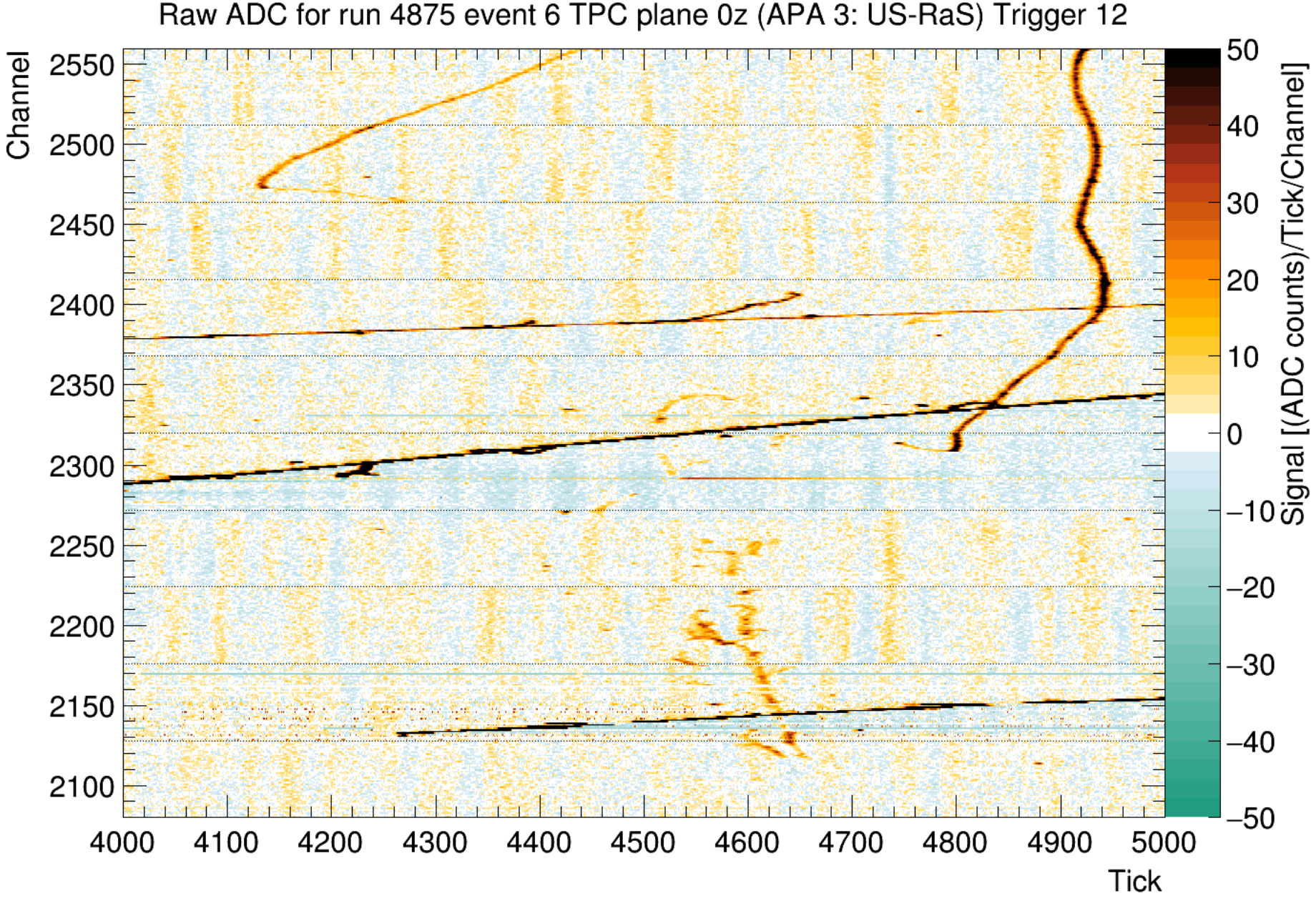
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 6 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
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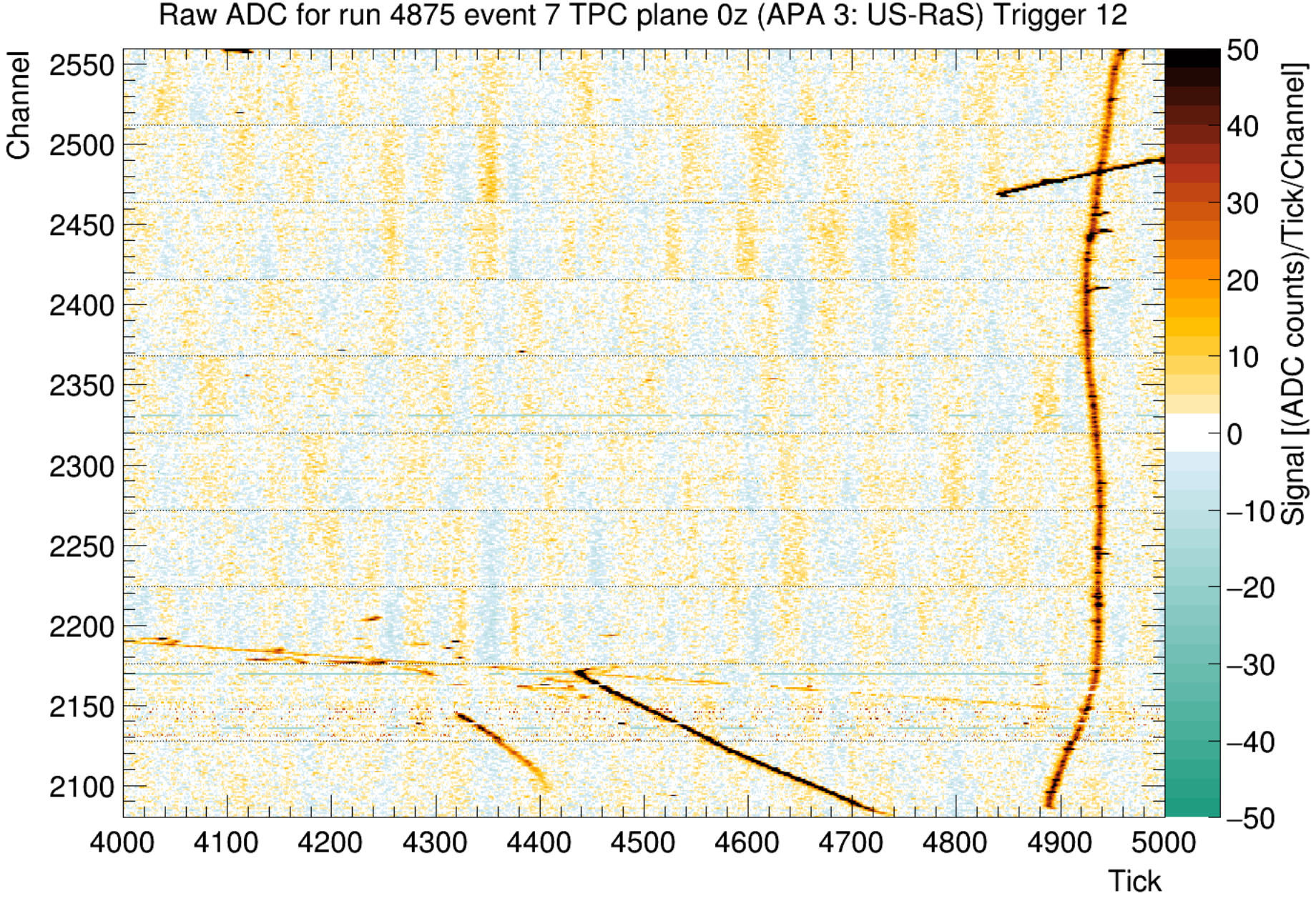
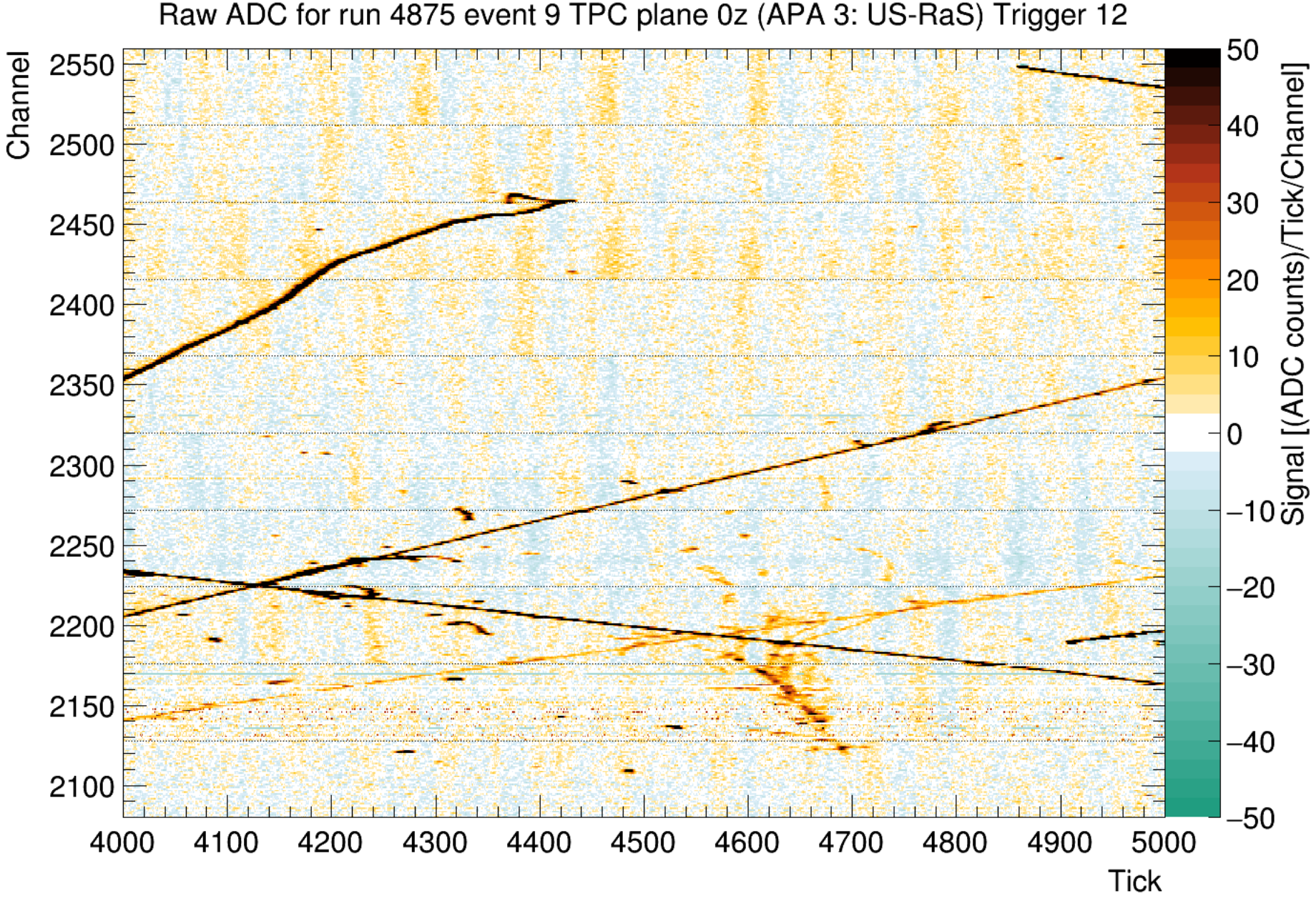
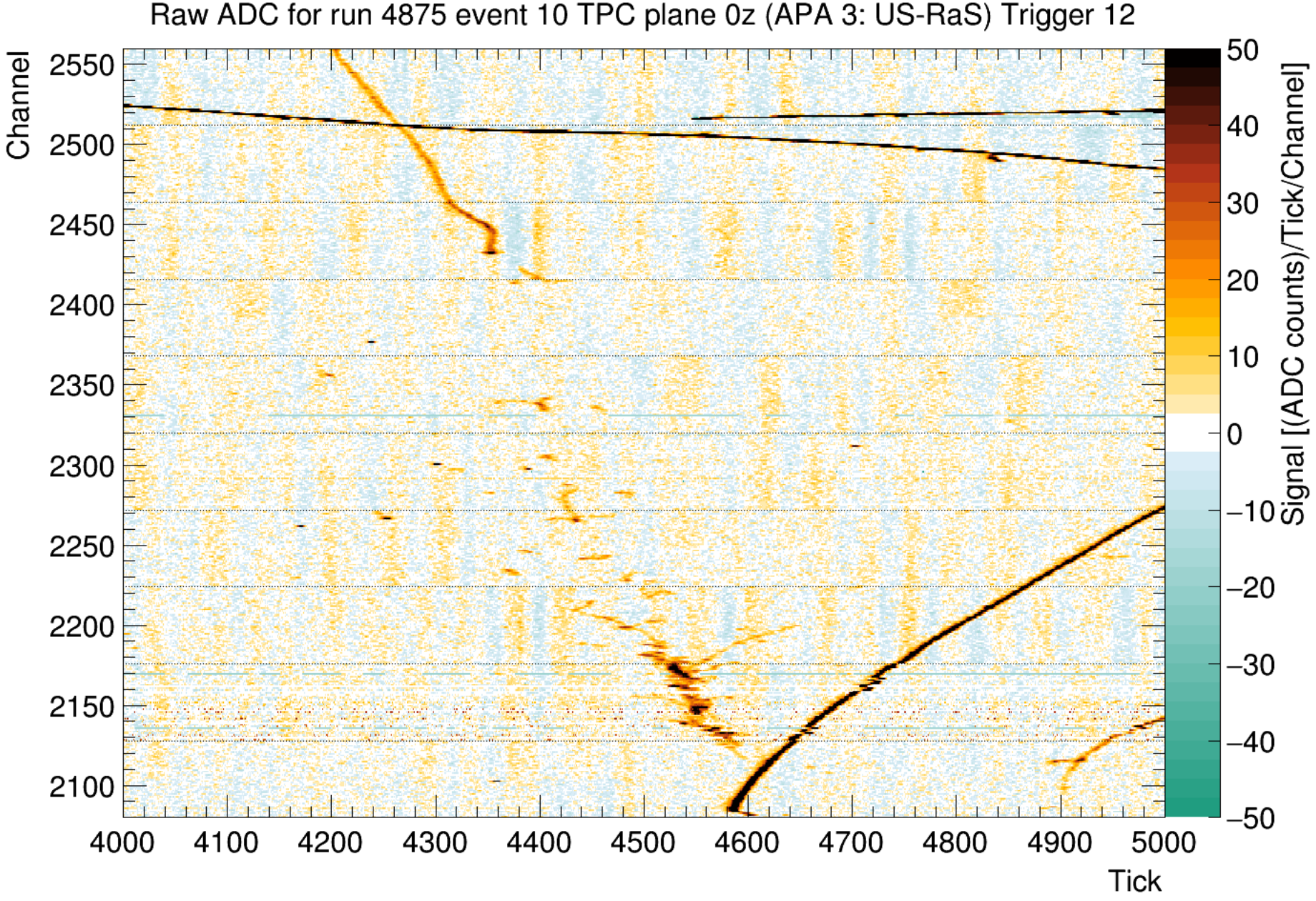
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 7 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 9 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 10 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
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40
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20
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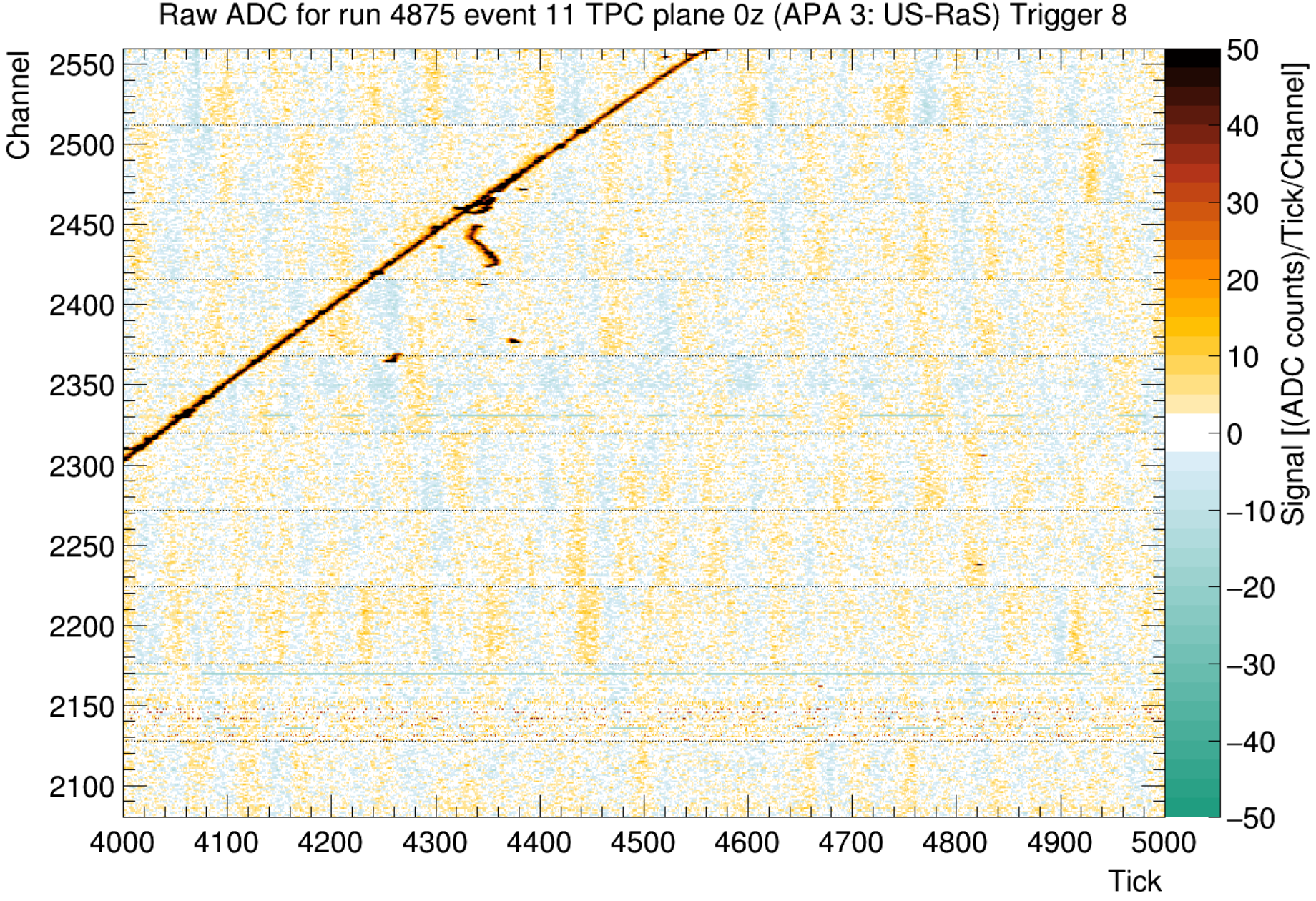
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 11 TPC plane 0z (APA 3: US-RaS) Trigger 8
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
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40
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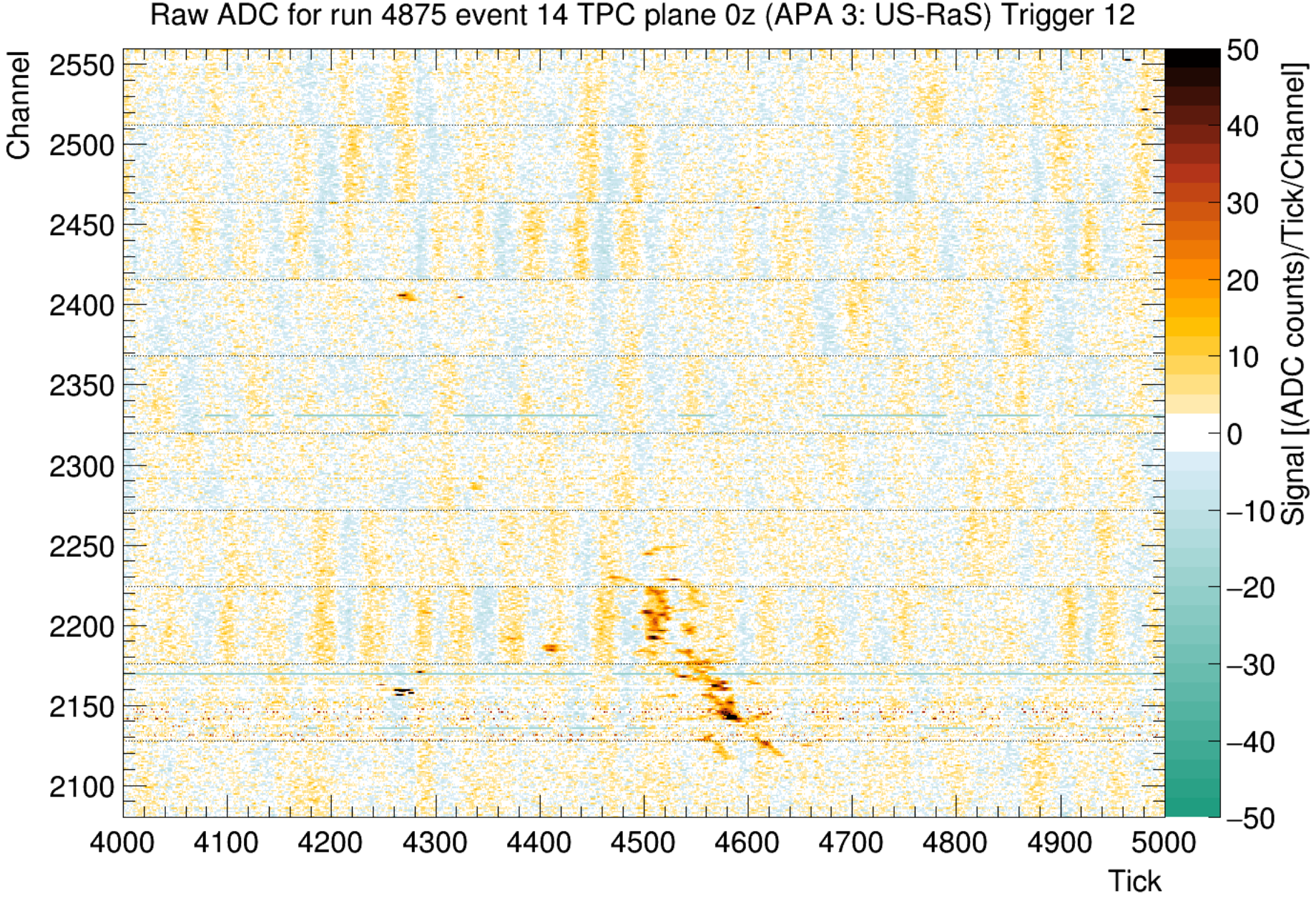
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 14 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
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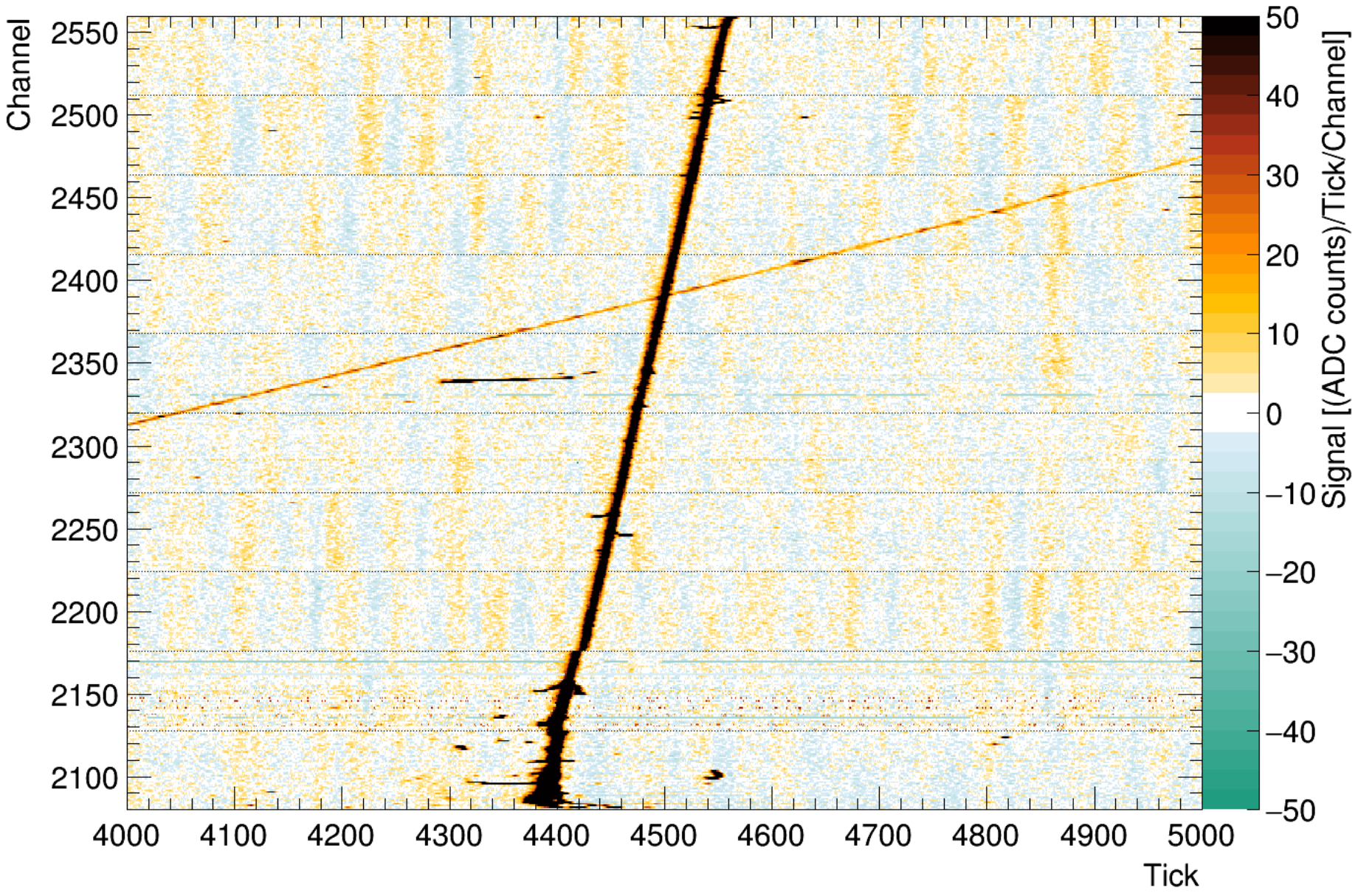
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 17 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
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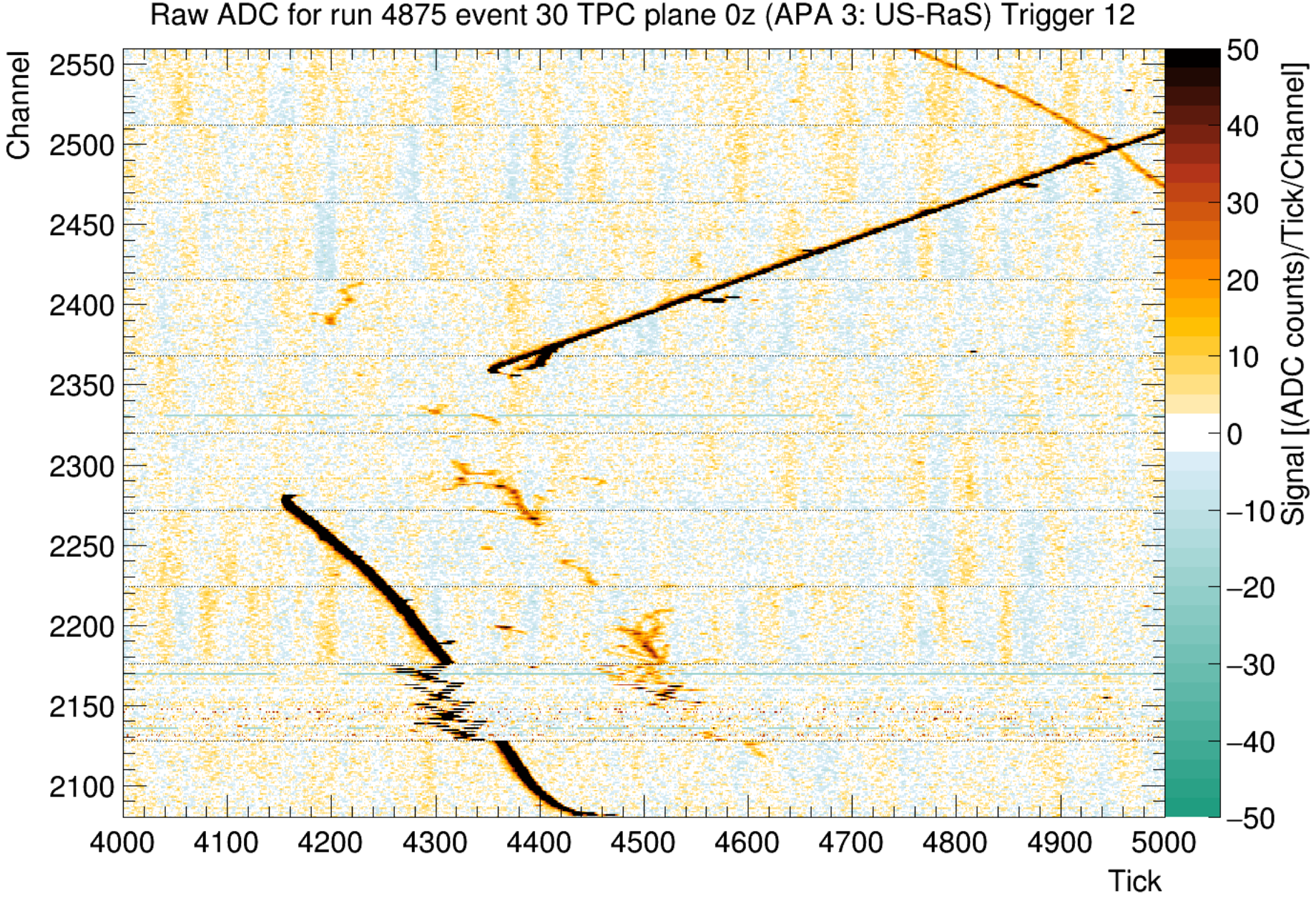
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 30 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
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4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
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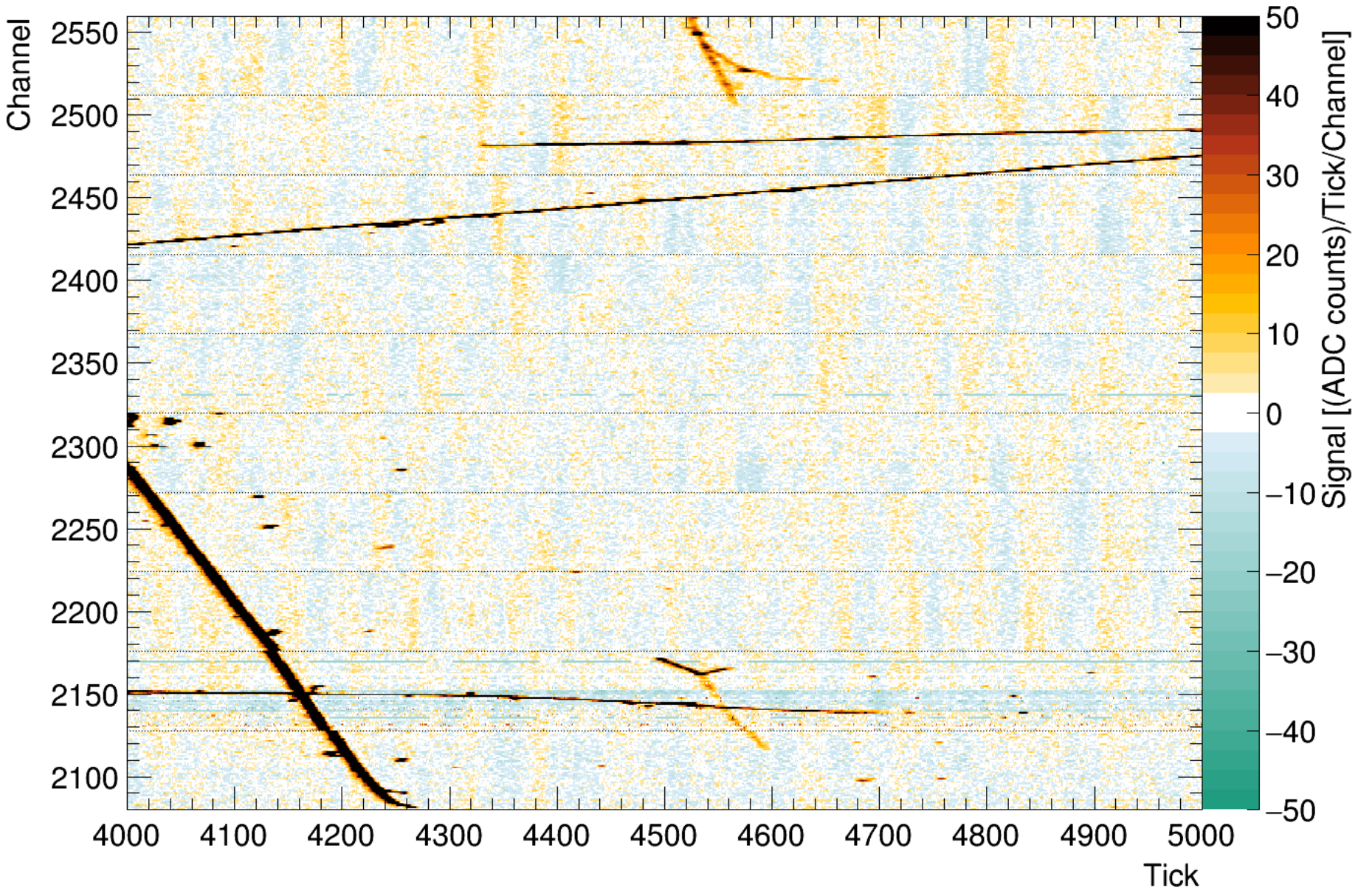
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

And more than just electrons…


Raw ADC for run 4875 event 144 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
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2350
2300
2250
2200
2150
2100
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4100
4200
4300
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4500
4600
4700
4800
4900
5000
Tick
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−10
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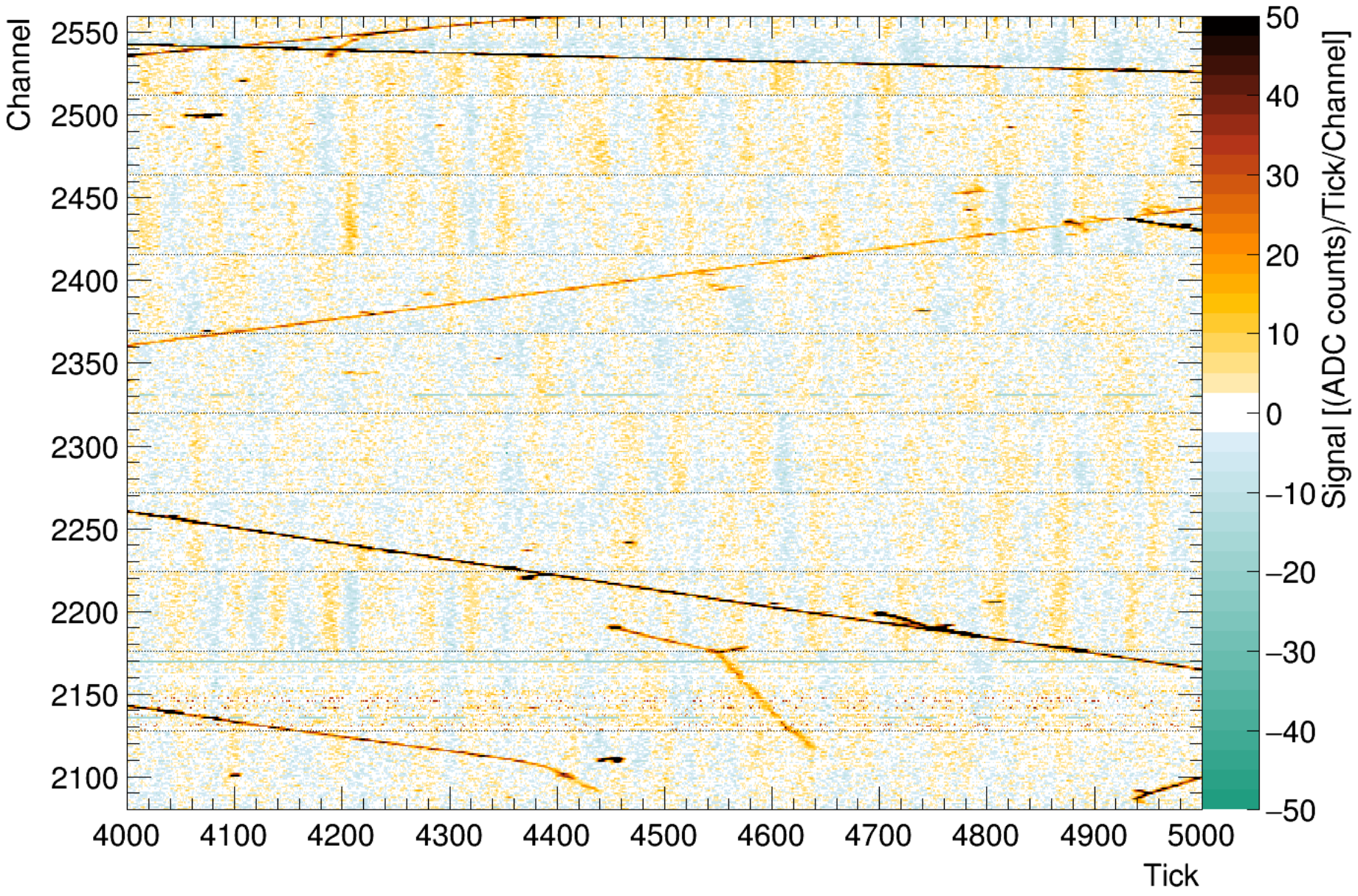
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 295 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
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2250
2200
2150
2100
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4300
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4600
4700
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Tick
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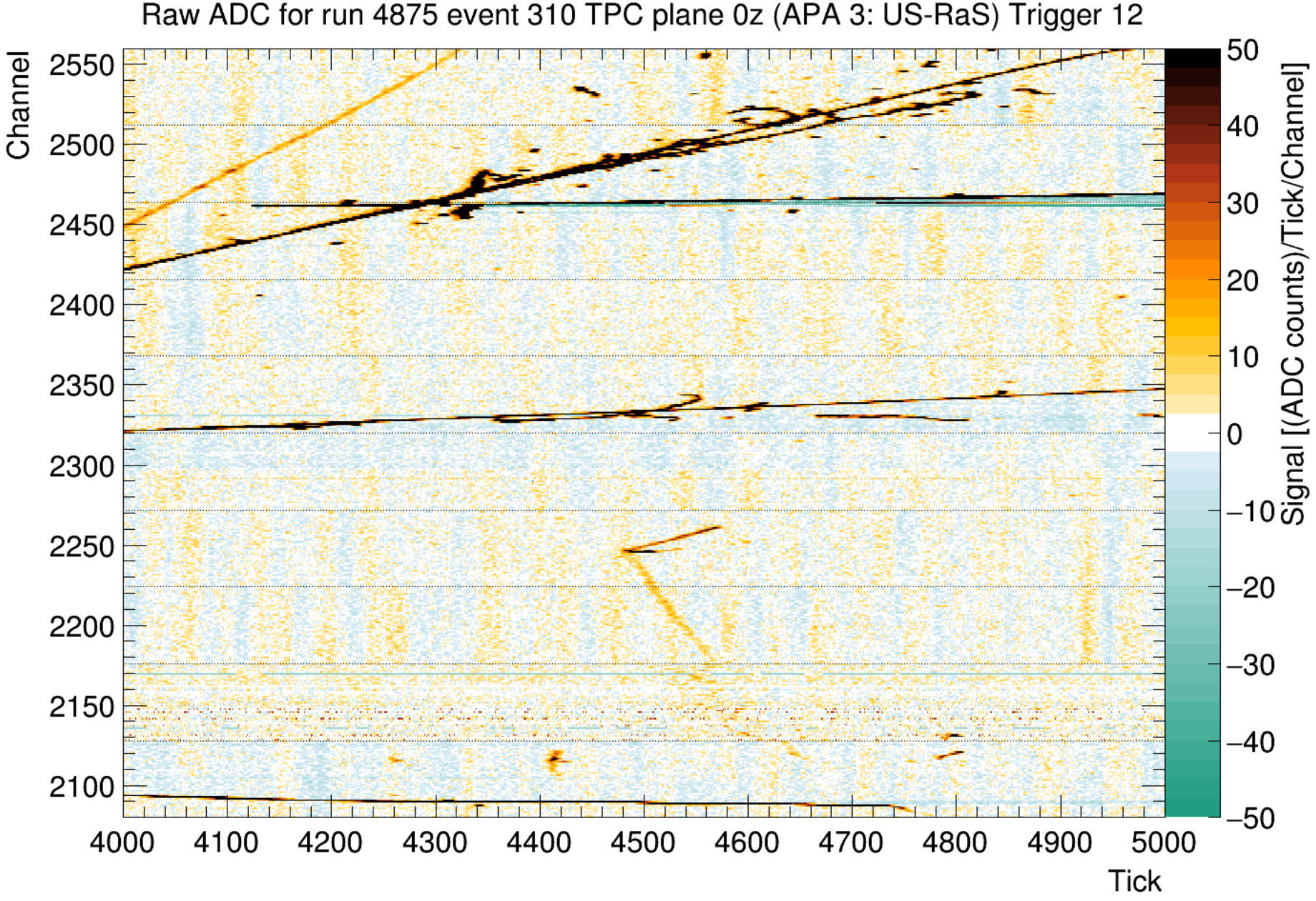
−40
−50
Signal [(ADC counts)/Tick/Channel]


Raw ADC for run 4875 event 310 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
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2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
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4600
4700
4800
4900
5000
Tick
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−10
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−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

FEMB 302 timing

FEMB 302 timing

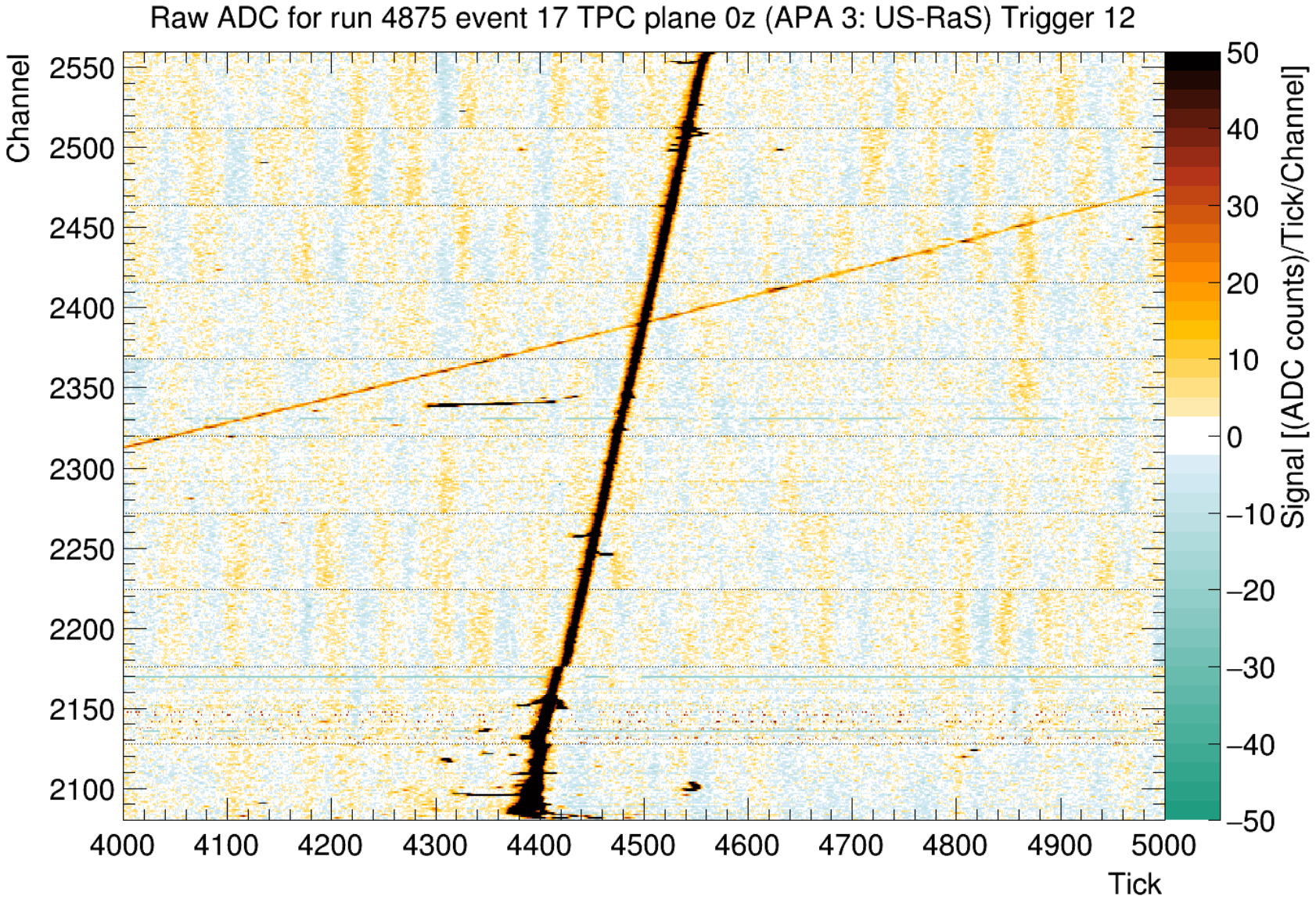
FEMB 302 does not receive timing signal

- Due to broken connector in LAr
- FEMB timing signal used in its place
- Preceding displays show timing is off w.r.t. other FEMBs
  - Also channel-to-channel variations within the FEMB
  - And event-to-event variation

Fix in unpacker

- The unpacker tries to find the times offset for each channel (?) by looking at the bad data in the last ticks
  - Change is in this week's release (v07_07_00_01) and on by default
- Results are shown for a couple events in the following
  - Old = plot from last week
  - No fix = new reco with timing fix disabled
    - physics.producers.tpcrawdecoder.RCEFIX302: false
  - New = New reco with fix enabled (default)

Old


Raw ADC for run 4875 event 17 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
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2350
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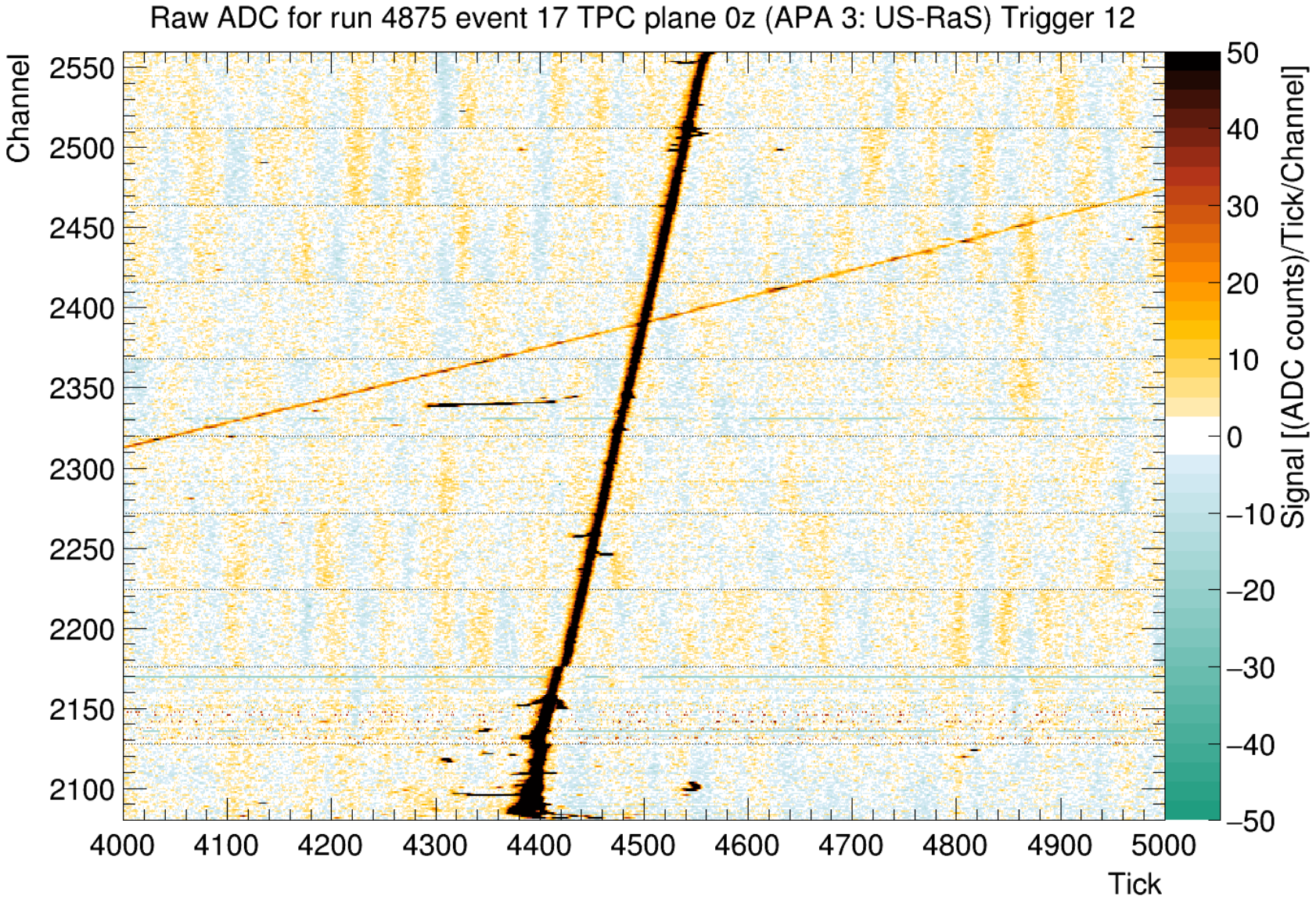
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

No fix


Raw ADC for run 4875 event 17 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
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2300
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2200
2150
2100
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4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
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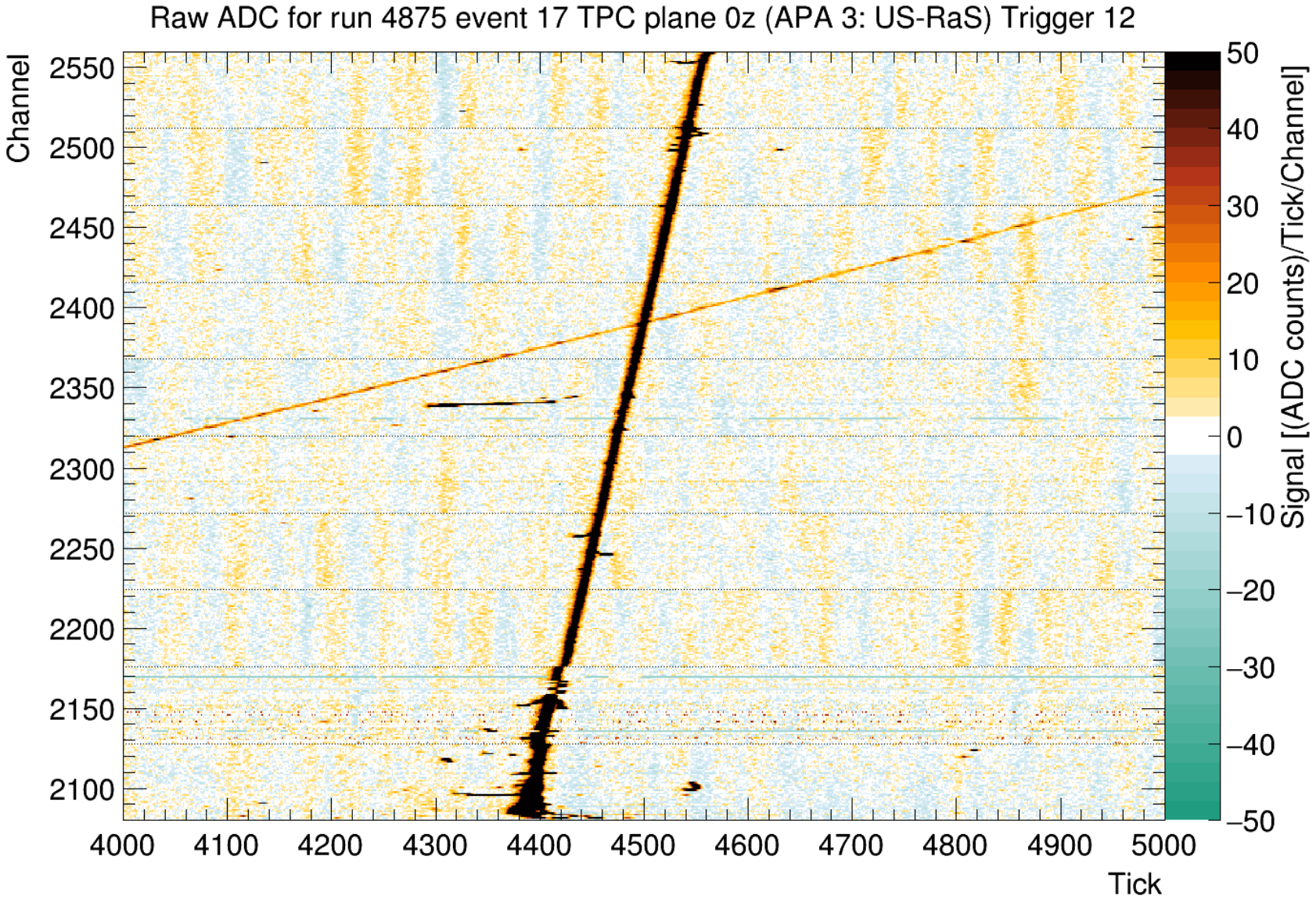
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

New


Raw ADC for run 4875 event 17 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
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2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
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Tick
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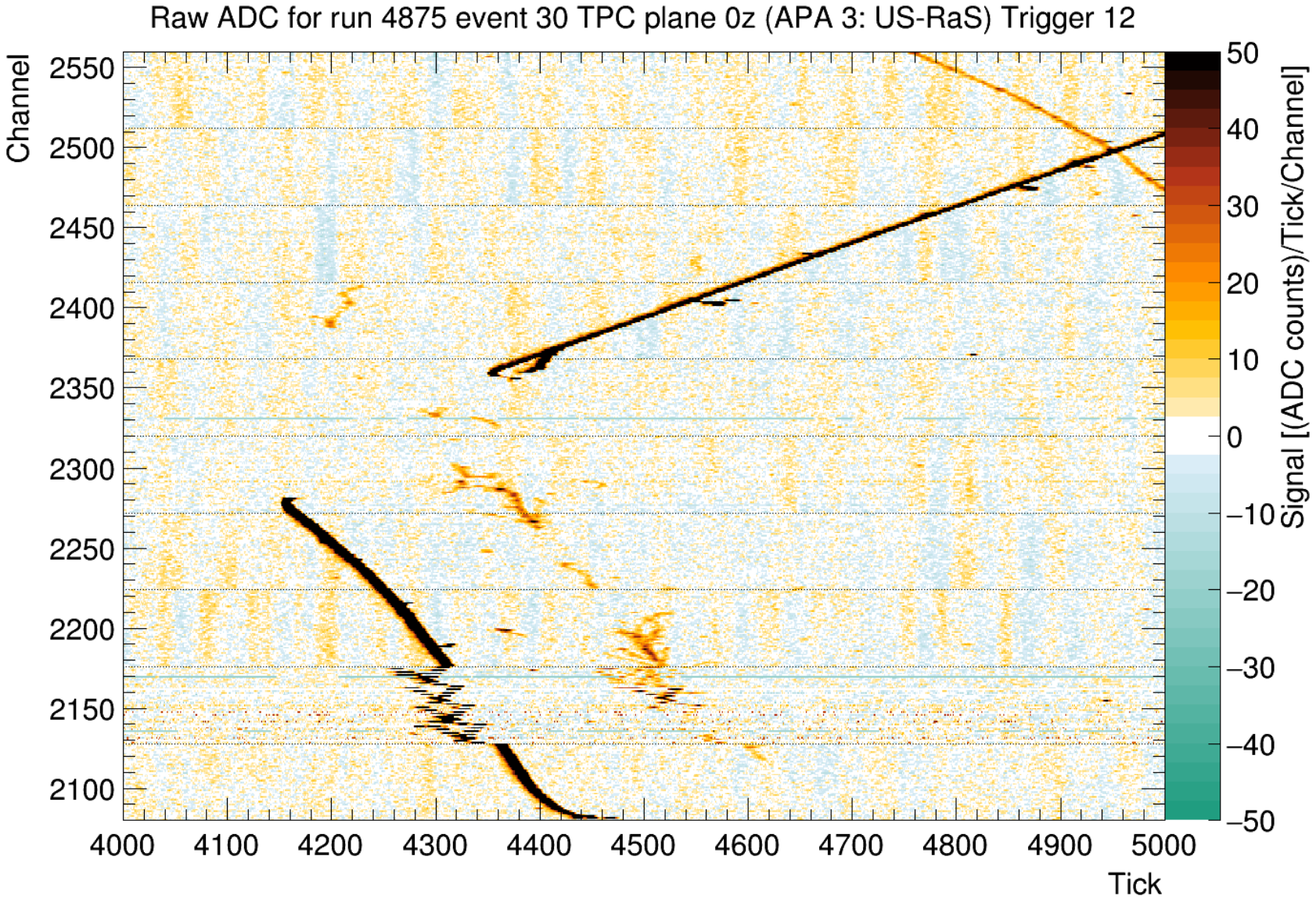
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

Old


Raw ADC for run 4875 event 30 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
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2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
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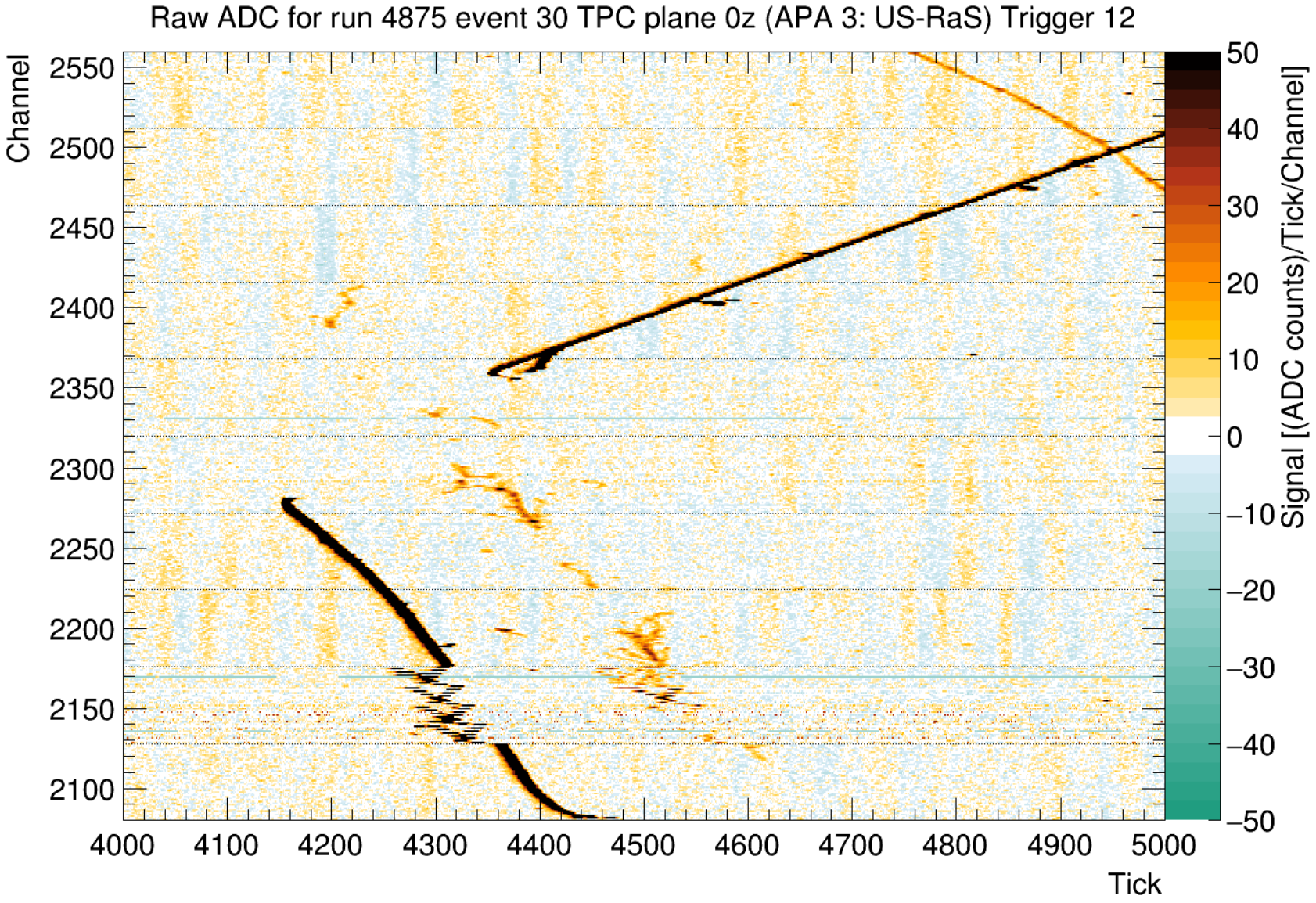
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

No fix


Raw ADC for run 4875 event 30 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
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2300
2250
2200
2150
2100
4000
4100
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4300
4400
4500
4600
4700
4800
4900
5000
Tick
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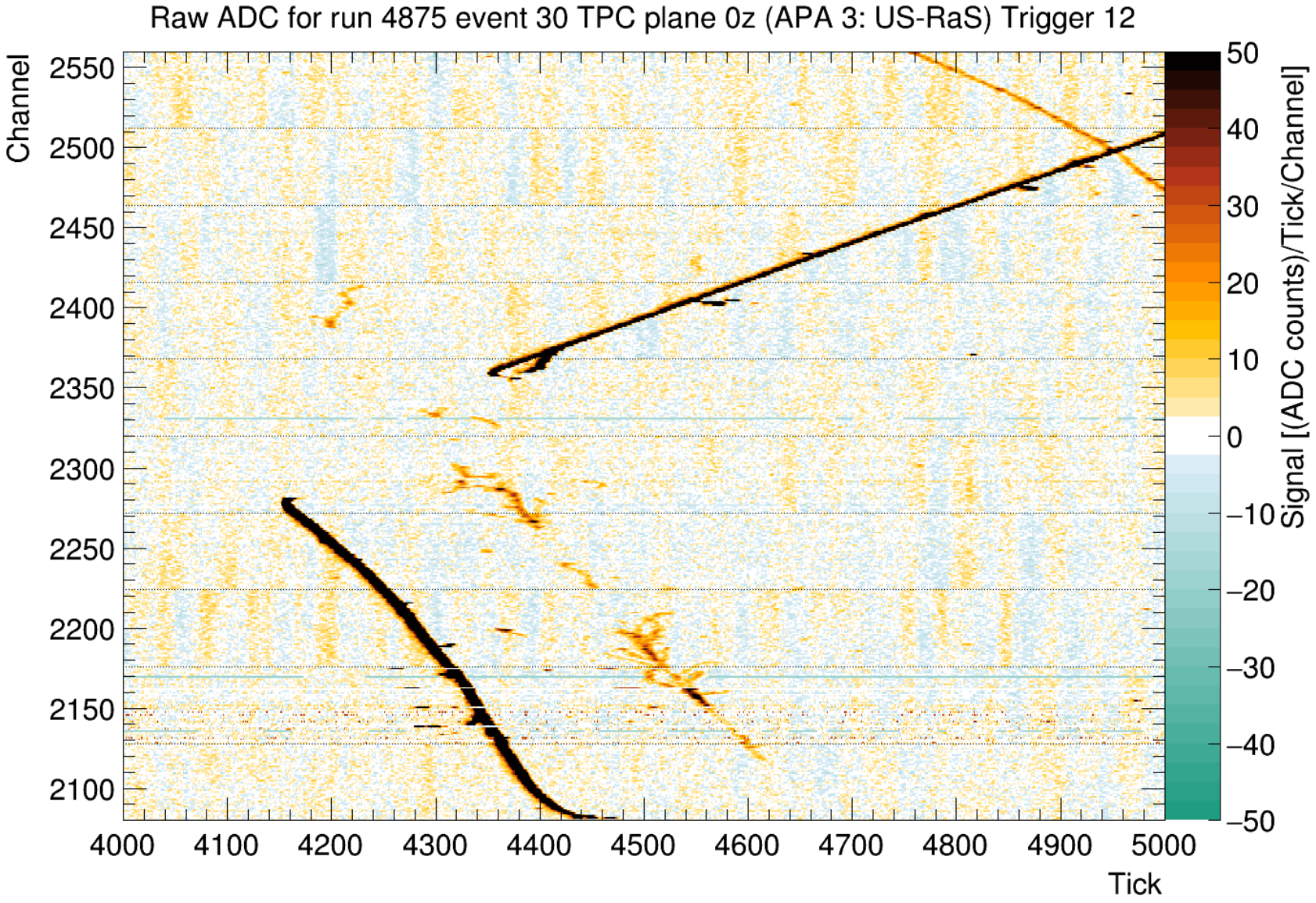
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

New


Raw ADC for run 4875 event 30 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
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2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
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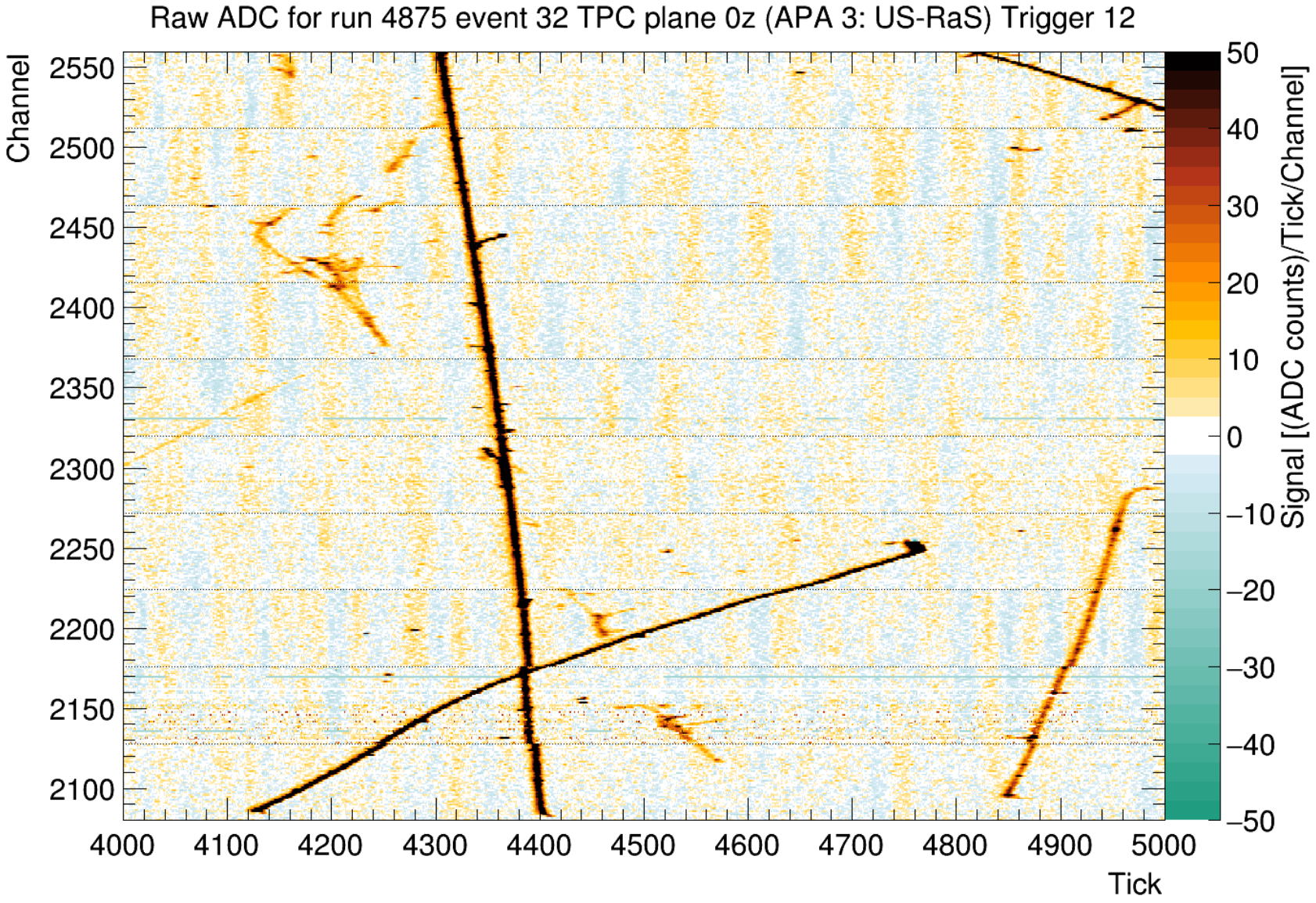
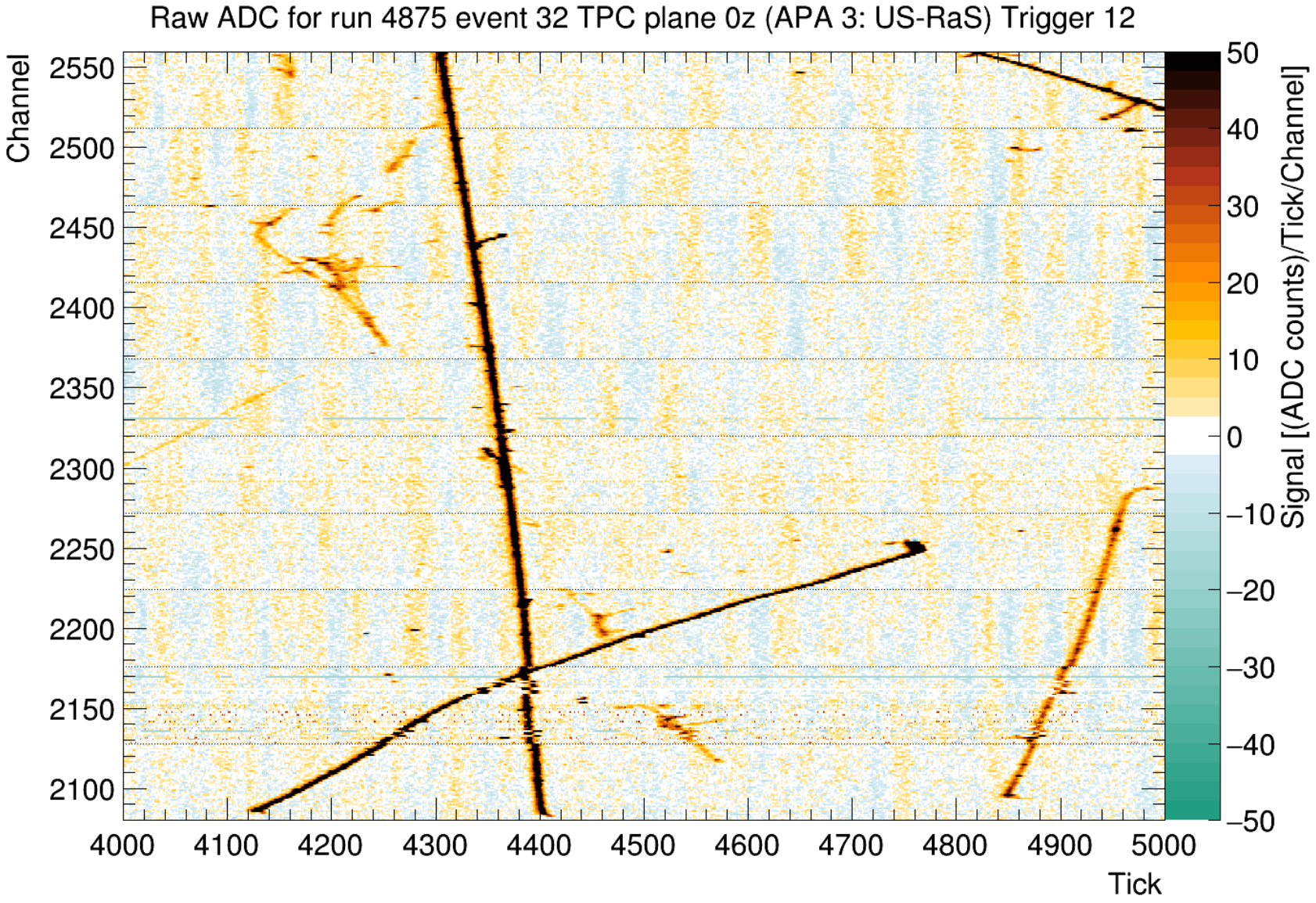
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

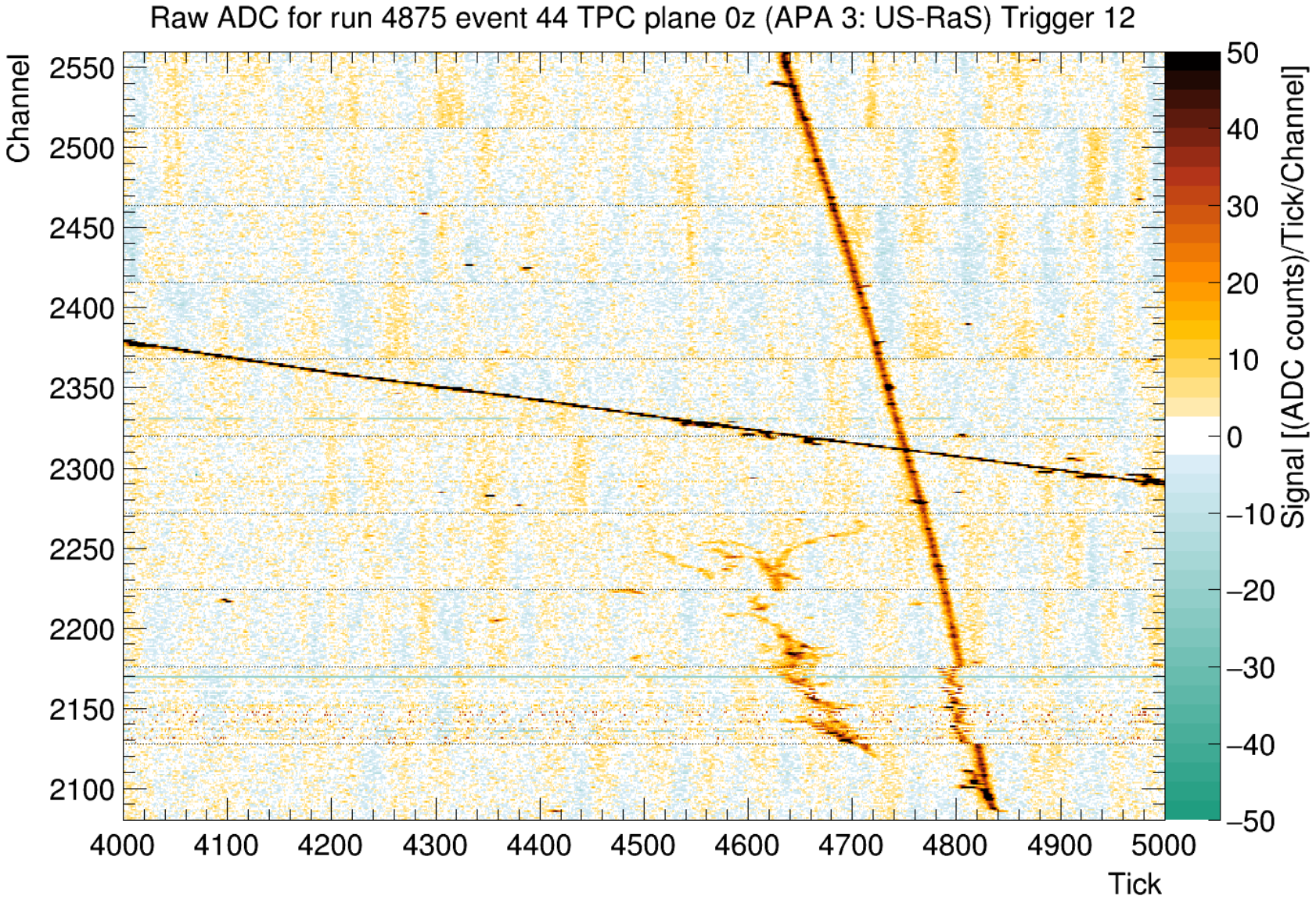
No fix


Raw ADC for run 4875 event 32 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

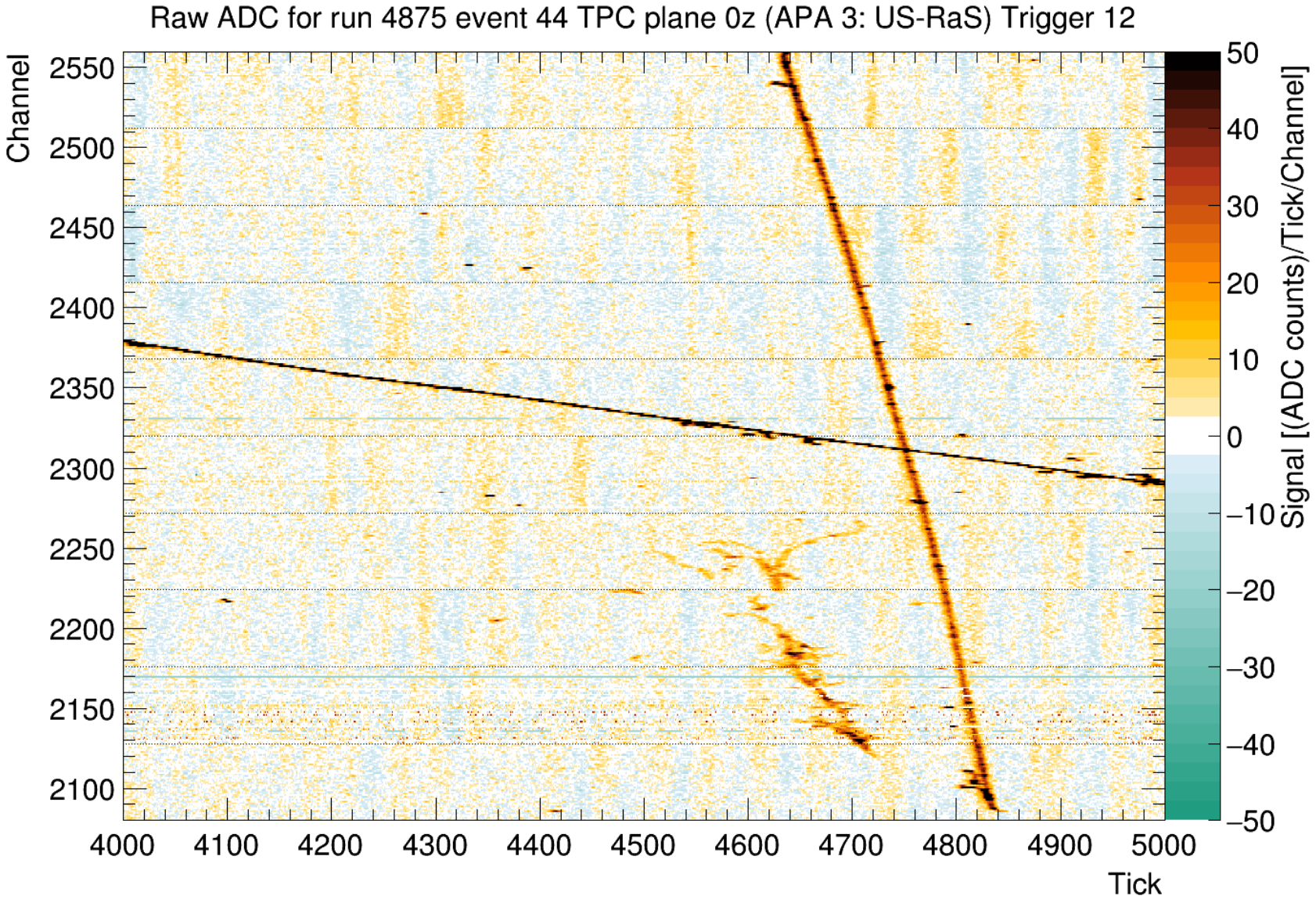
New


Raw ADC for run 4875 event 32 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

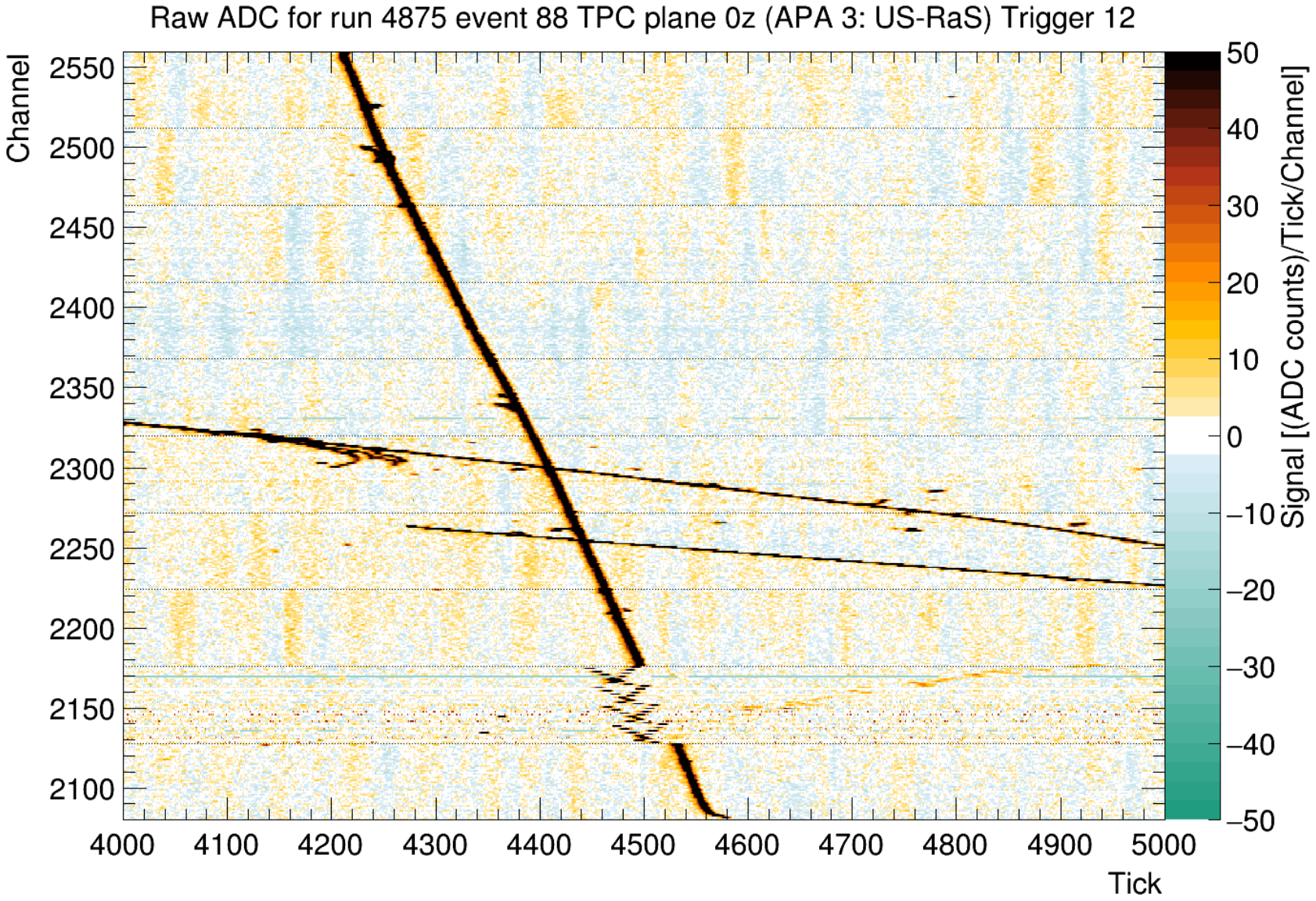
No fix


Raw ADC for run 4875 event 44 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

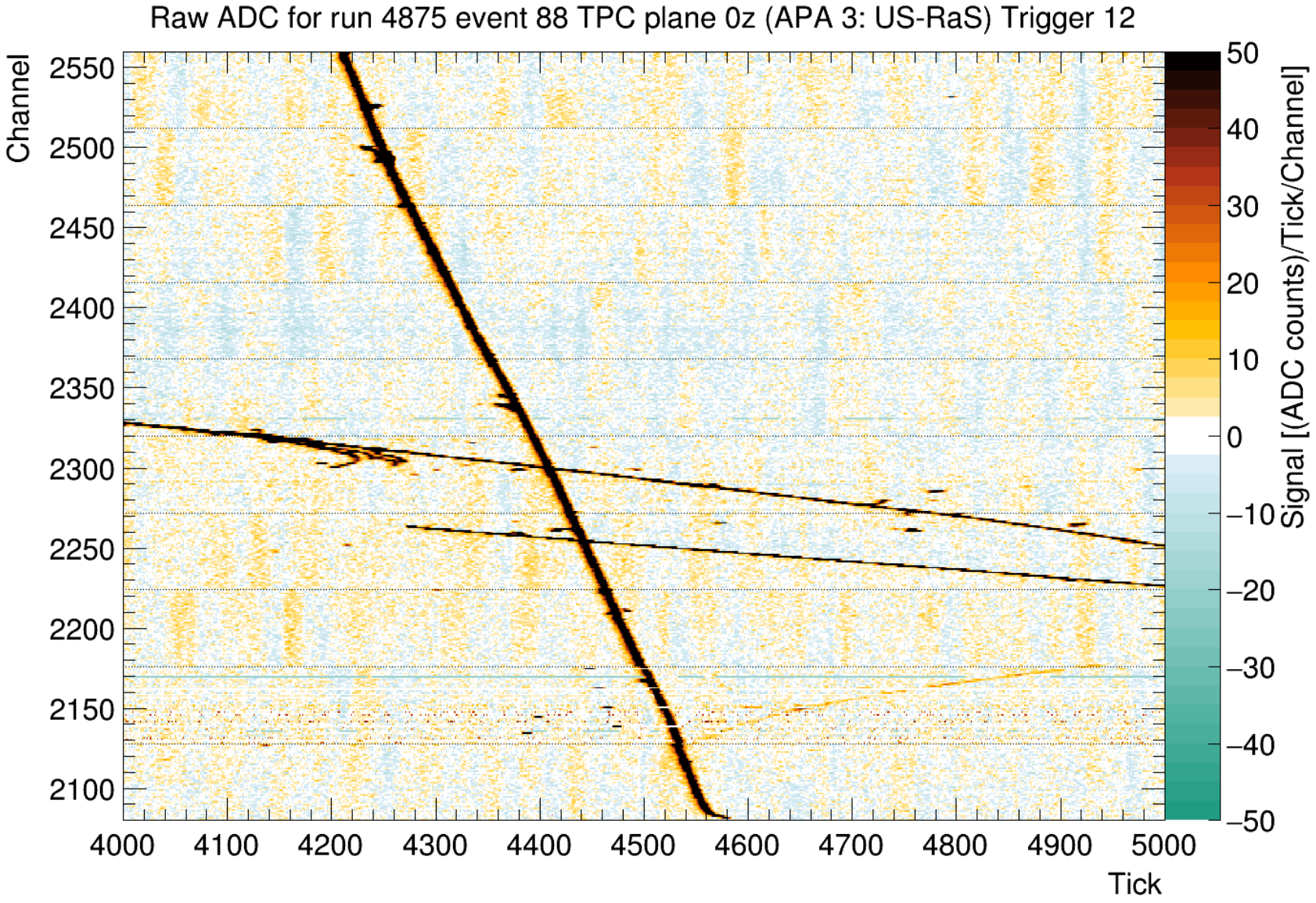
New


Raw ADC for run 4875 event 44 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

No fix


Raw ADC for run 4875 event 88 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

New


Raw ADC for run 4875 event 88 TPC plane 0z (APA 3: US-RaS) Trigger 12
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]

Comments on timing fix

New reco without fix looks same as old reco

FEMB 302 timing variations are seen

- Signals may appear up to 25 ticks (2 cm) early

Fix has some effect

- Brings some channels to about the right time
  - Overcorrects by a couple ticks?
- Other channels in the same event are not corrected at all

Geometry

Geometry: rotated APAs

The protoDUNE geometry/cabling is described here:

https://wiki.dunescience.org/wiki/ProtoDUNE_geometry

- This is wrong but will be fixed soon

Rotated APAs

- Description is correct for the beam right side (APAs 1-3)
- CE group had expected APAs on left side to be rotated by 180 deg about the vertical
  - See comment on figure on the above page
  - But it turns out this was not done
- Our cable map appears to be OK
  - I.e. the mapping of online data to offline channel numbers
  - Presumably because mapping is based on crate, WIB , etc. and the cold-to-warm cabling is also rotated
- This is an issue when looking at plots, data from BNL CE group
  - FEMB labels like 502 are n longer flipped left to right
    - TPC side is B-side for APAs 1-3 and A-side for APAs 4-6

Geometry: channel ranges

Dataprep makes use of named channel ranges

- A range is a contiguous set of channel number
  - With a name and one or more labels
- Tool ProtoDuneChannelRanges defines the ranges
  - APAS: apa1, apa2, …, apa6
  - APA (offline): tps0, tps1, tps6
    - tps0 = apa3, etc.
  - APA planes: tpp0u, tpp0v, …, tpp5z, tpp5c
  - FEMB blocks: femb101u, femb101v, …, femb620x
    - Note full FEMB does not have contiguous channels
  - Offline channel: femb101u01, femb101u02, …, femb620x48
    - Range is a single channel
- Many dataprep tools plot ranges specified by names
  - E.g. plot only the noise for apa3, tpp0z or femb302x

Exe pdChannelRange can be used to see the range for a name:

```
dune-dev> pdChannelRange femb302x
femb302x: [2128, 2176) FEMB block 302x, US-RaS
```

- Need fix from today to get left side correct

Bad channels

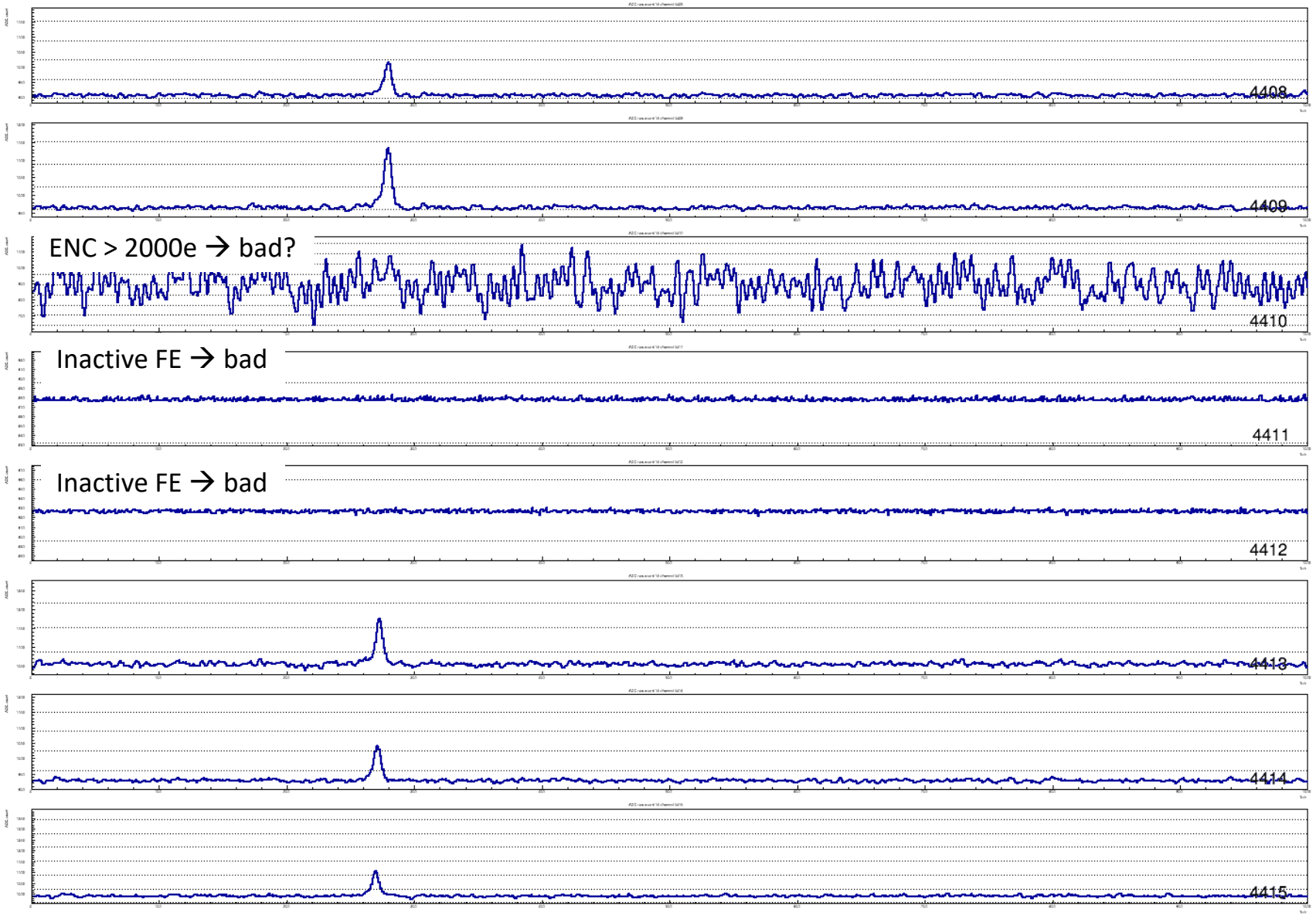
Bad channels

I (slowly) look at bad channels

- List from BNL CE group checked all 15360 channels with pulser data
- I have started checking these with recent artDAQ data
  - Summarized in table below

BNL CE label	# ch	# bad	# sticky	# good
Inactive FE	4	3		
Inverted gain	2			
Broken connection pre FE	34			
Significant stuck bits	45		1	1
ENC > 2000e	3	1		

Example waveforms with three bad channels



Sticky codes

Sticky codes

There are some sticky codes

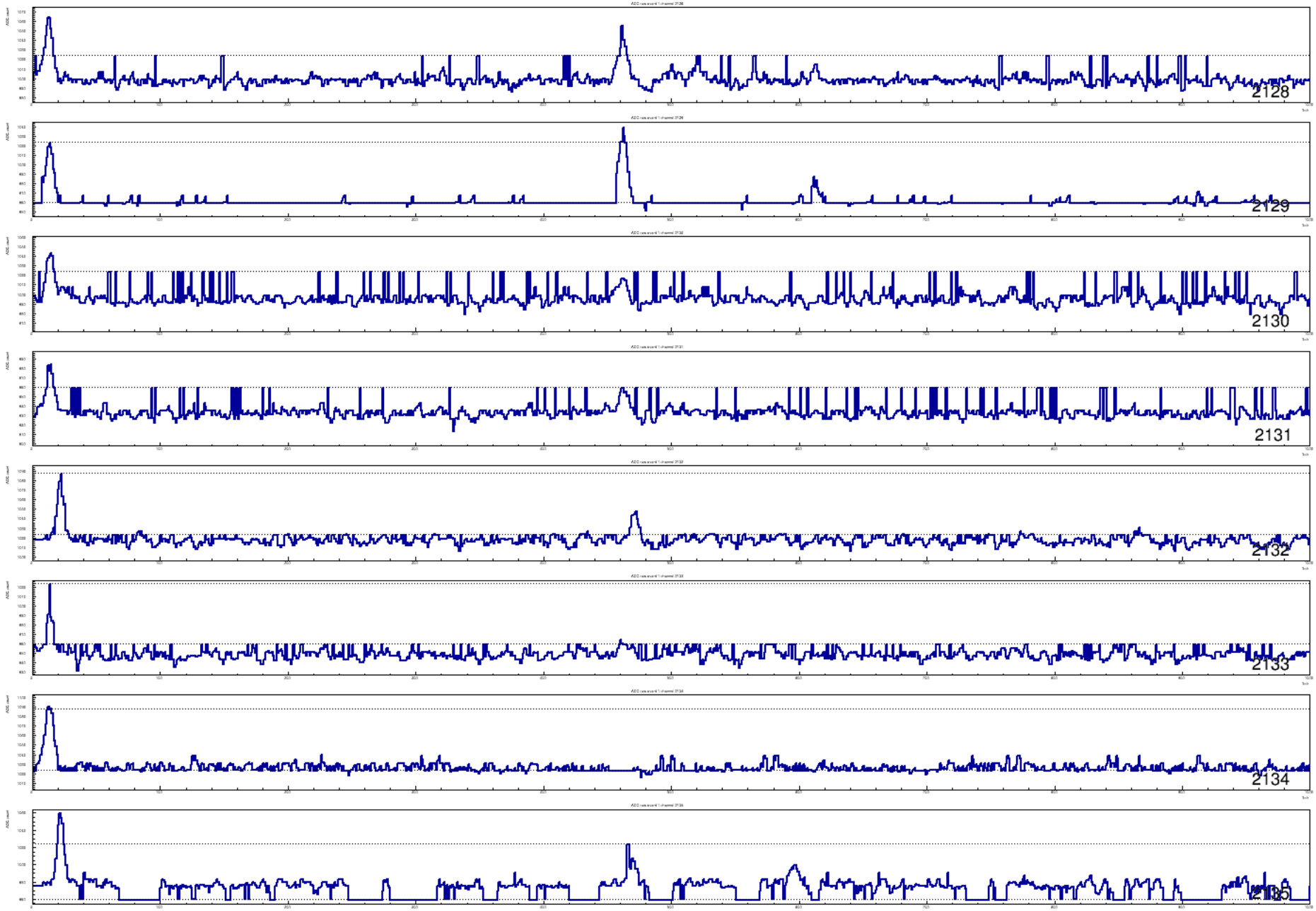
- FEMB 302x waveforms shown on following pages
- Flag some channels as bad and mitigate others

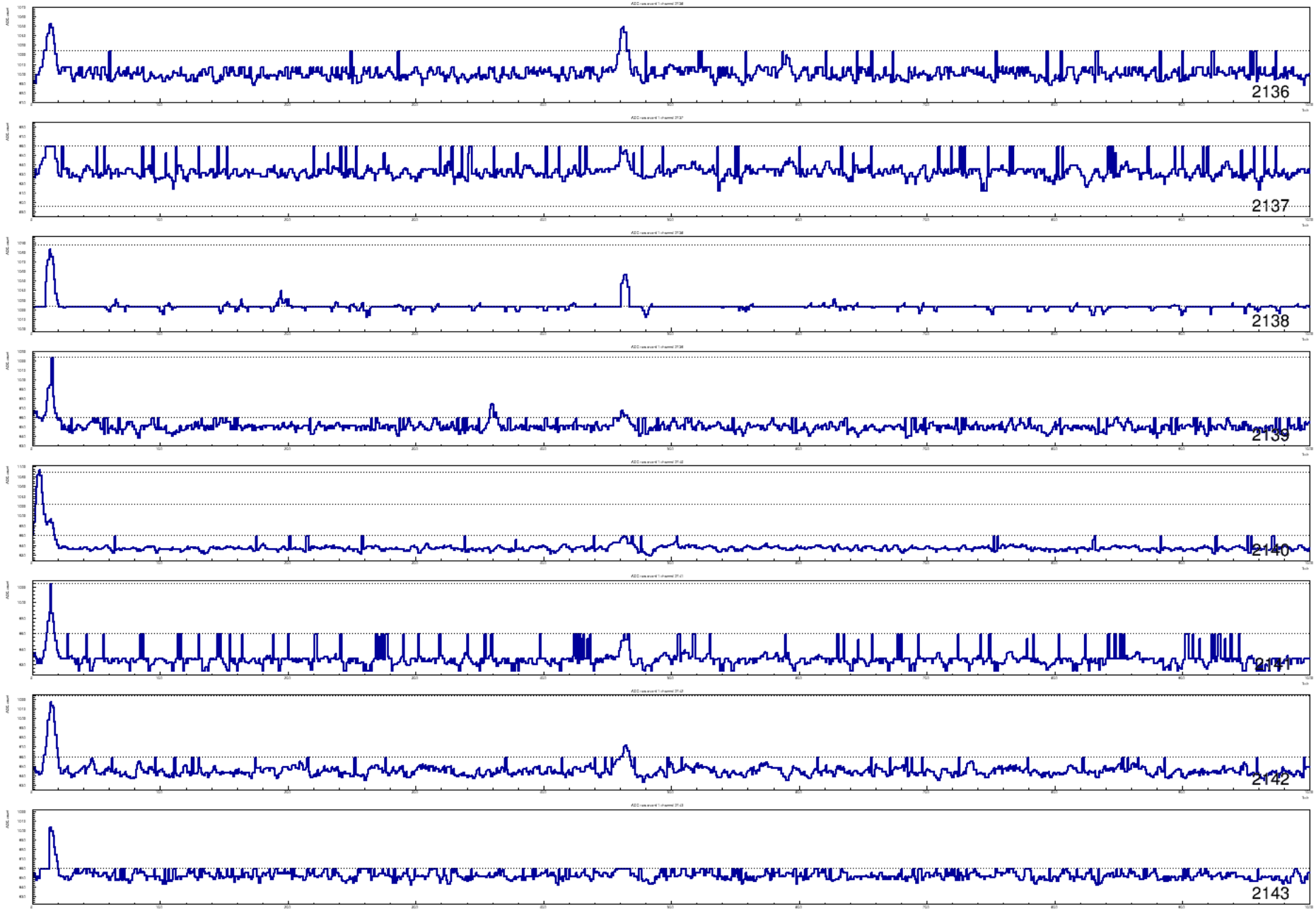
Generating list of sticky codes for each channel

- New tool FclStickCodeFlagger
  - Holds list of sticky codes
  - Sets configurable flag in dataprep
    - New flags: AdcStuck, AdcStuckPedestal

Separately add tool(s) to act on these flags

- E.g. linear interpolation from nearest not-sticky neighbors
- Or set code to pedestal value


2128
2129
2130
2131
2132
2133
2134
2135


2136
2137
2138
2139
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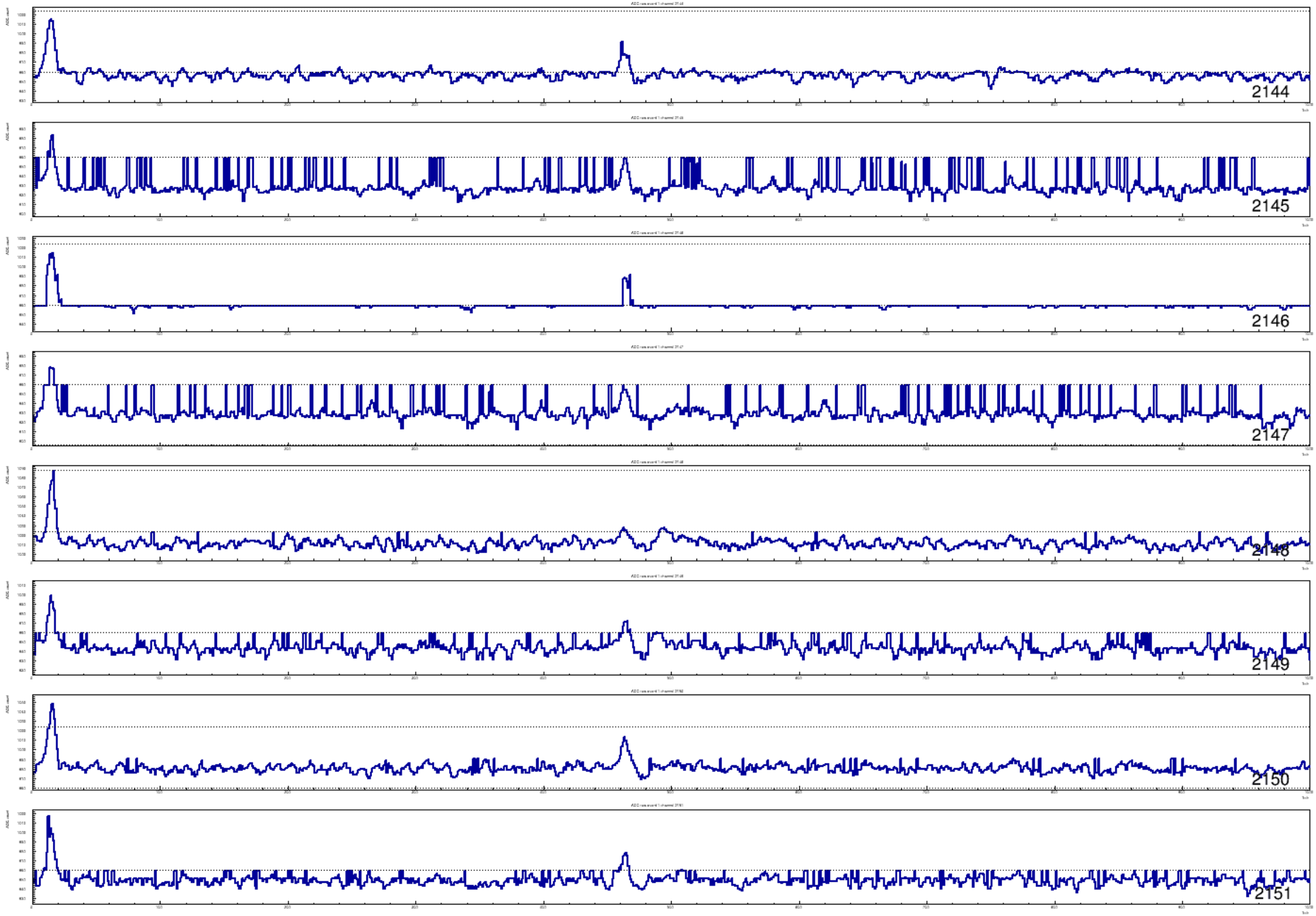
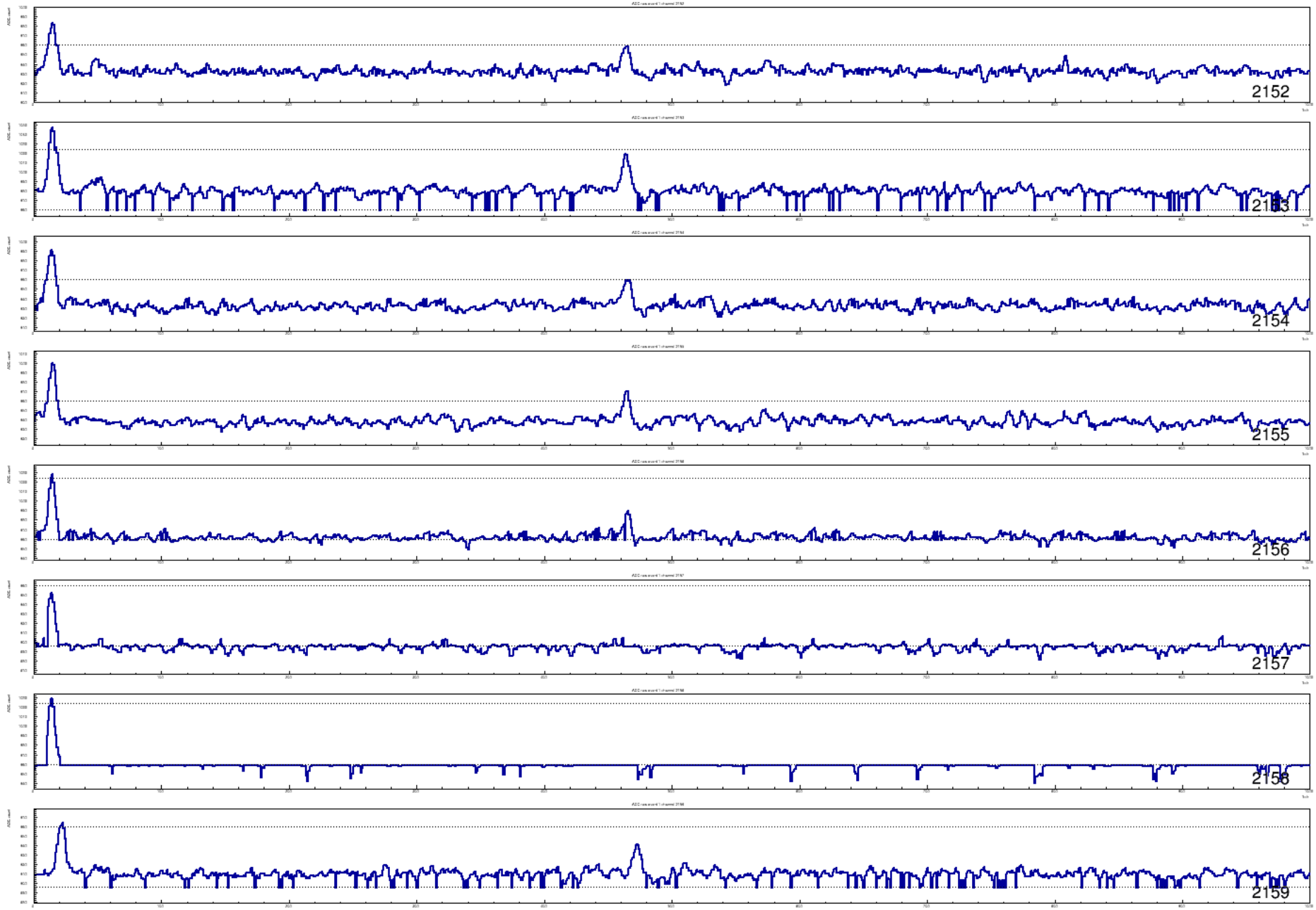
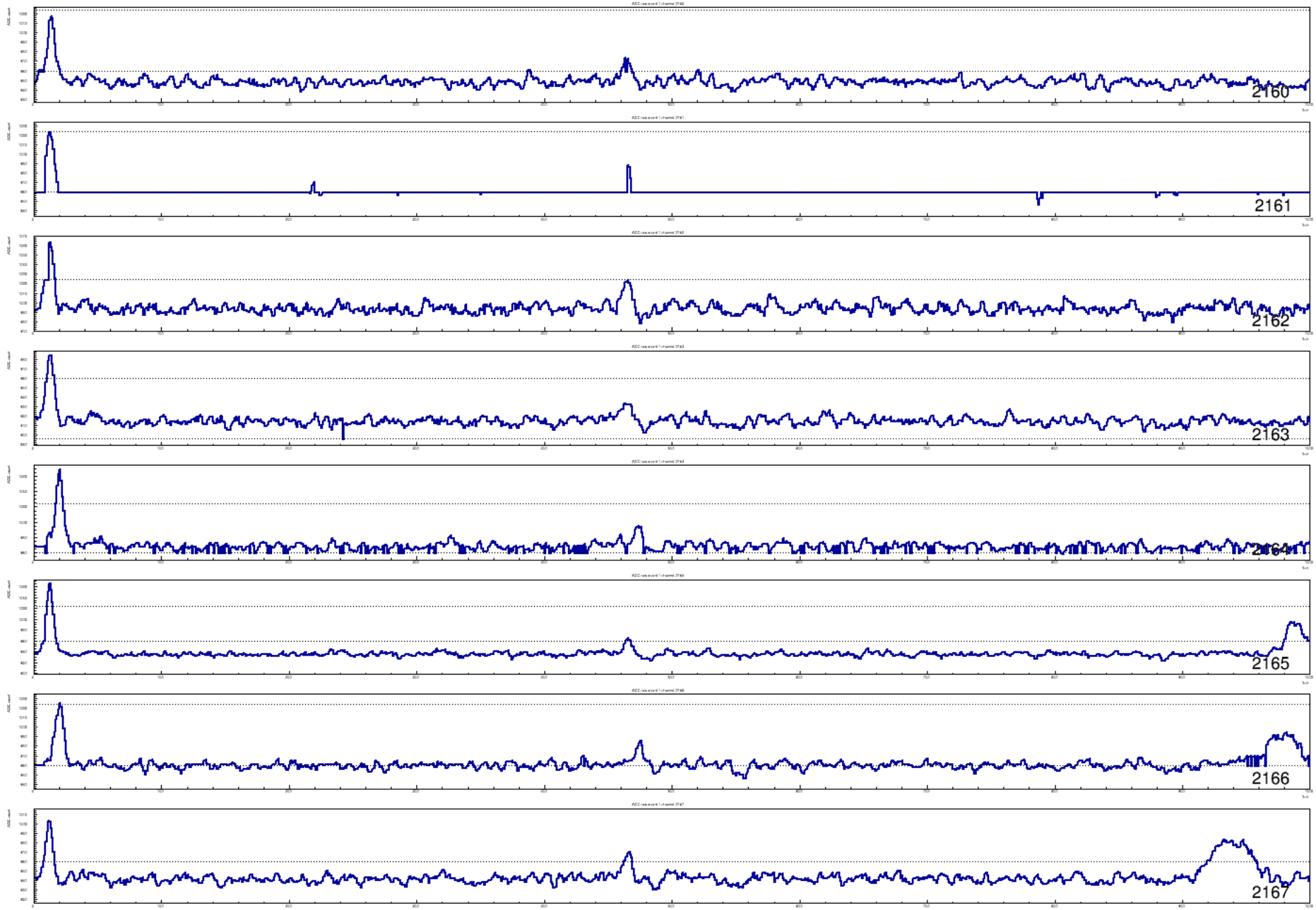
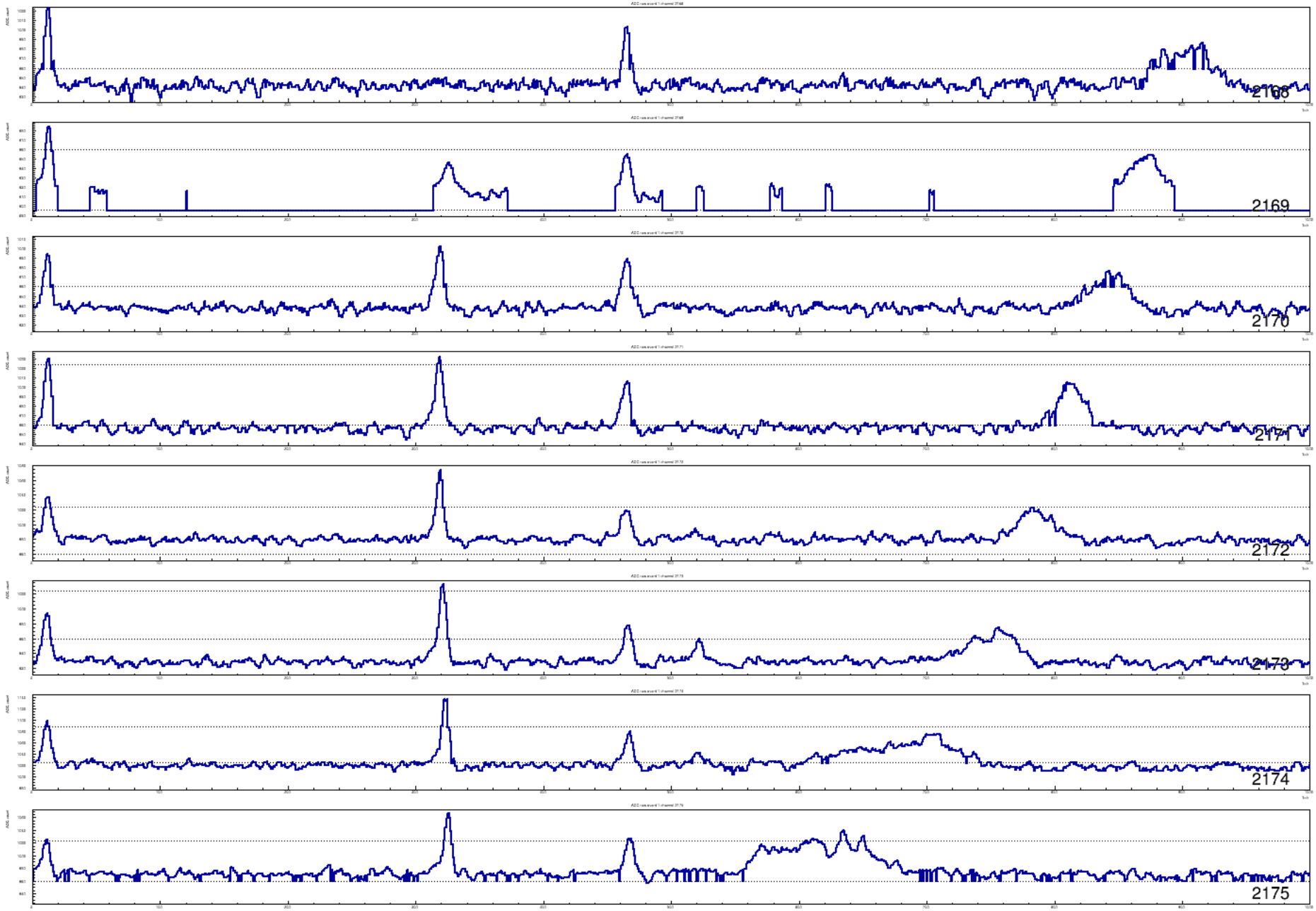
2141
2142
2143


2144
2145
2146
2147
2148
2149
2150
2151


2152
2153
2154
2155
2156
2157
2158
2159


2160
2161
2162
2163
2164
2165
2166
2167


2168
2169
2170
2171
2172
2173
2174
2175