ProtoDUNE TPC data: FEMB 302 timing correction

ProtoDUNE sim/reco

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BNL

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Introduction

FEMB 302 does not receive the timing clock signal

- All other FEMBs use this signal to synchronize their TPC clocks
- Event displays clearly show FEMB 302 is off by a few ticks
  - If uncorrected
  - No evidence of problems for any other FEMBs

Correction introduced last December

- Tool pdsp_timingMitigate, class AdcTimingMitigator
- Two params: relative clock rate and a tick offset
- Corrected value is linear interpolation using the surrounding values from a scaled, offset tick counter
- Params were set looking a few event displays in December
  - Rate factor 0.9995, offset 3 ticks
- Last week showed more accurate and precise measurement of rate factor using pulser data: 0.99927…

Tuning the timing correction

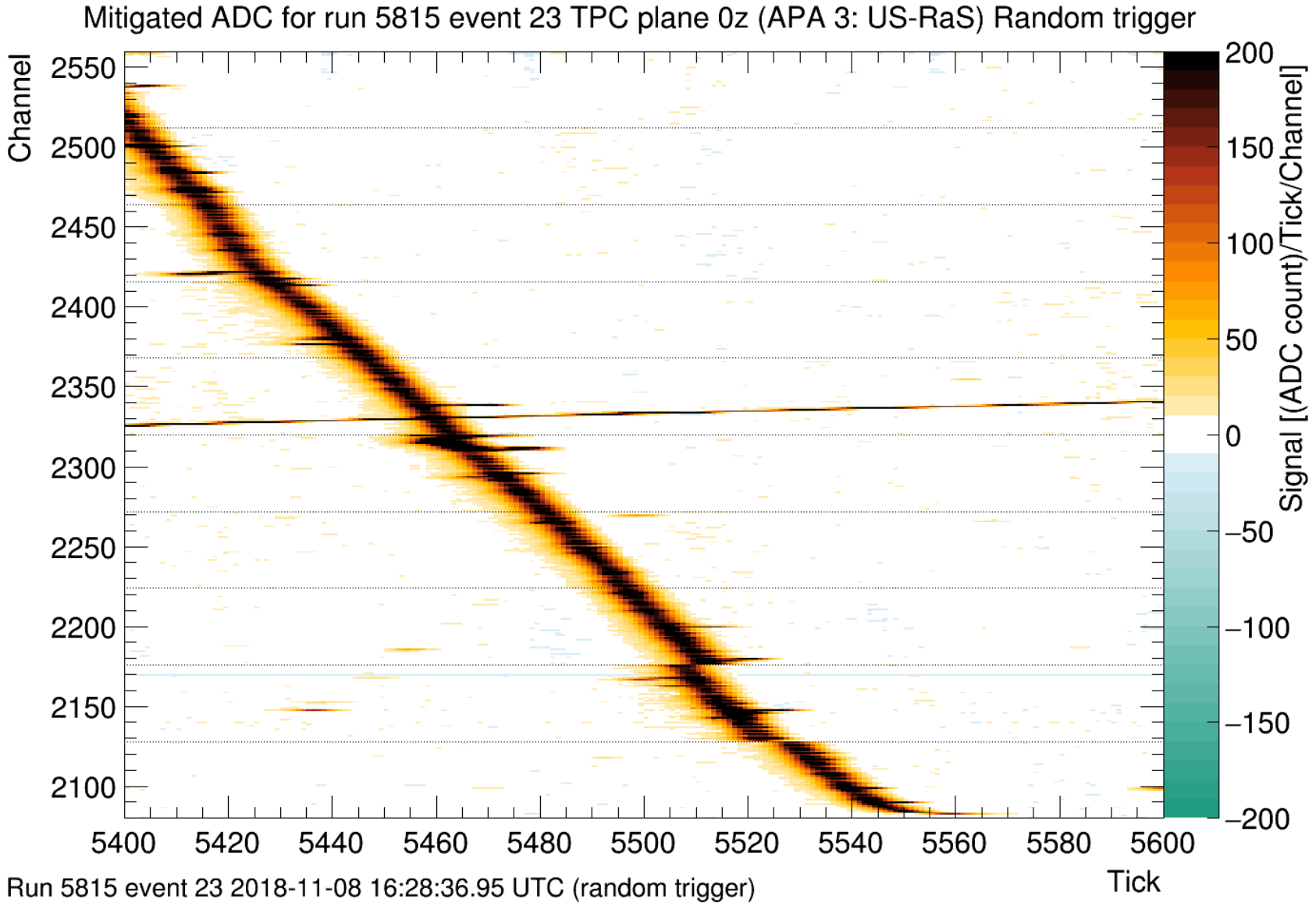
Here try to tune the timing correction

- Use the rate factor from the pulser measurement: 0.9993
- See if we can find a pulser offset that works across the tick range
  - I.e. from 0 to 6000 ticks
  - Revisit this if we start taking data with a much longer window
    - (as we should)
- Following plots show displays for many events varying params
  - I picked out tracks nearly parallel to the wire planes
  - Many plots. I did not want to only show those giving a consistent (and thus biased) result

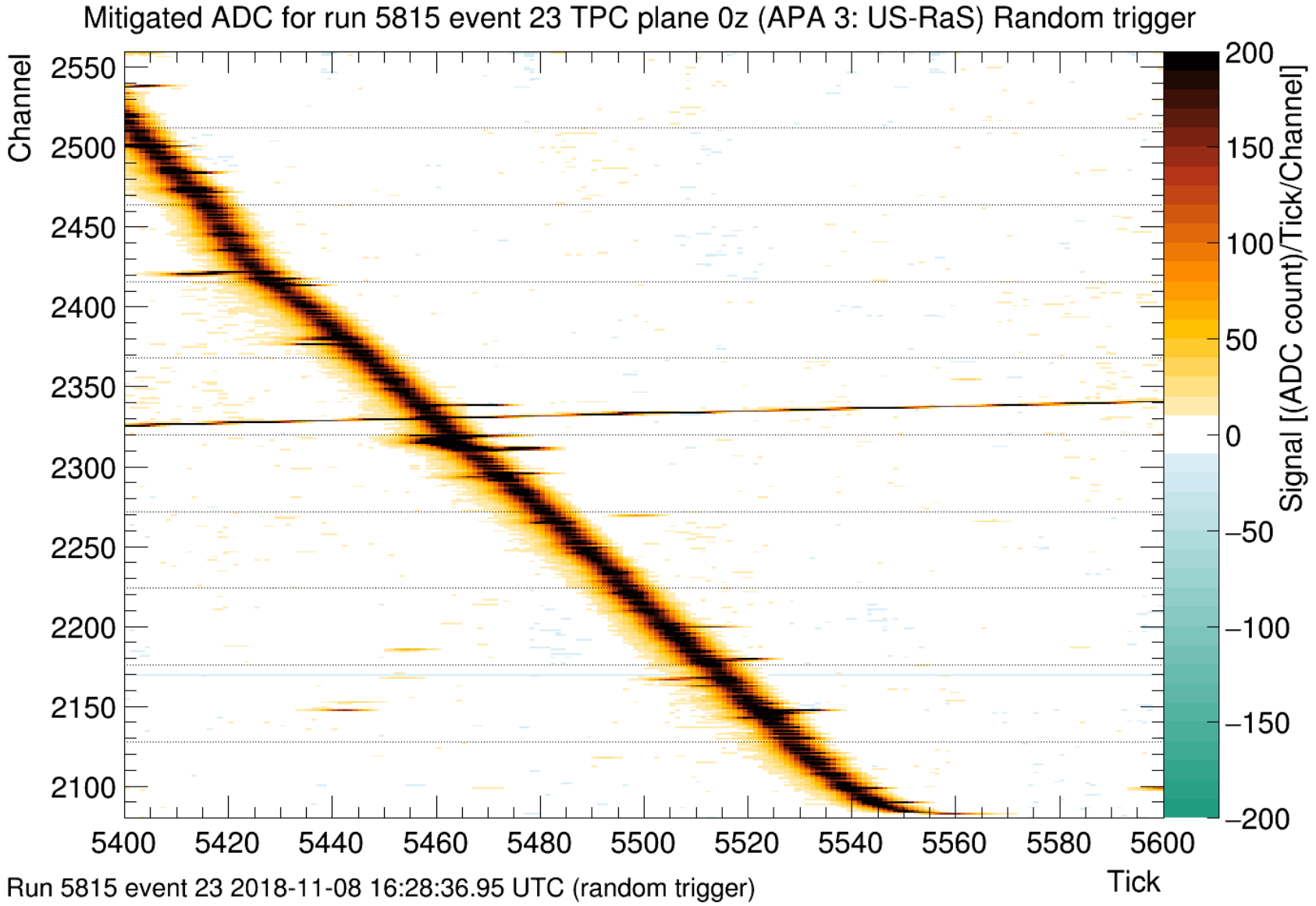
Start with events from run 5815

Event 23 z5400-5600

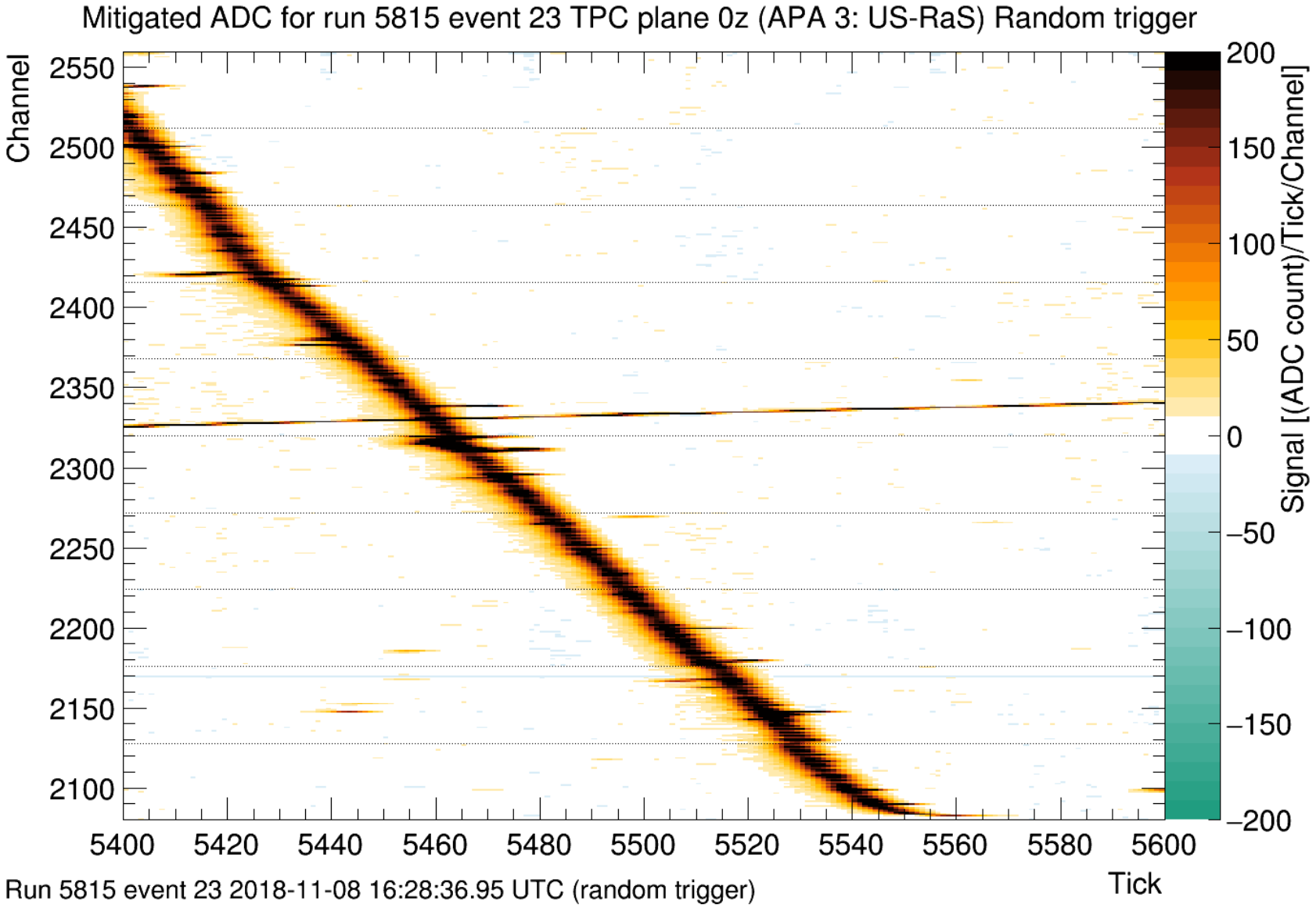
1.0, 0 (no correction)



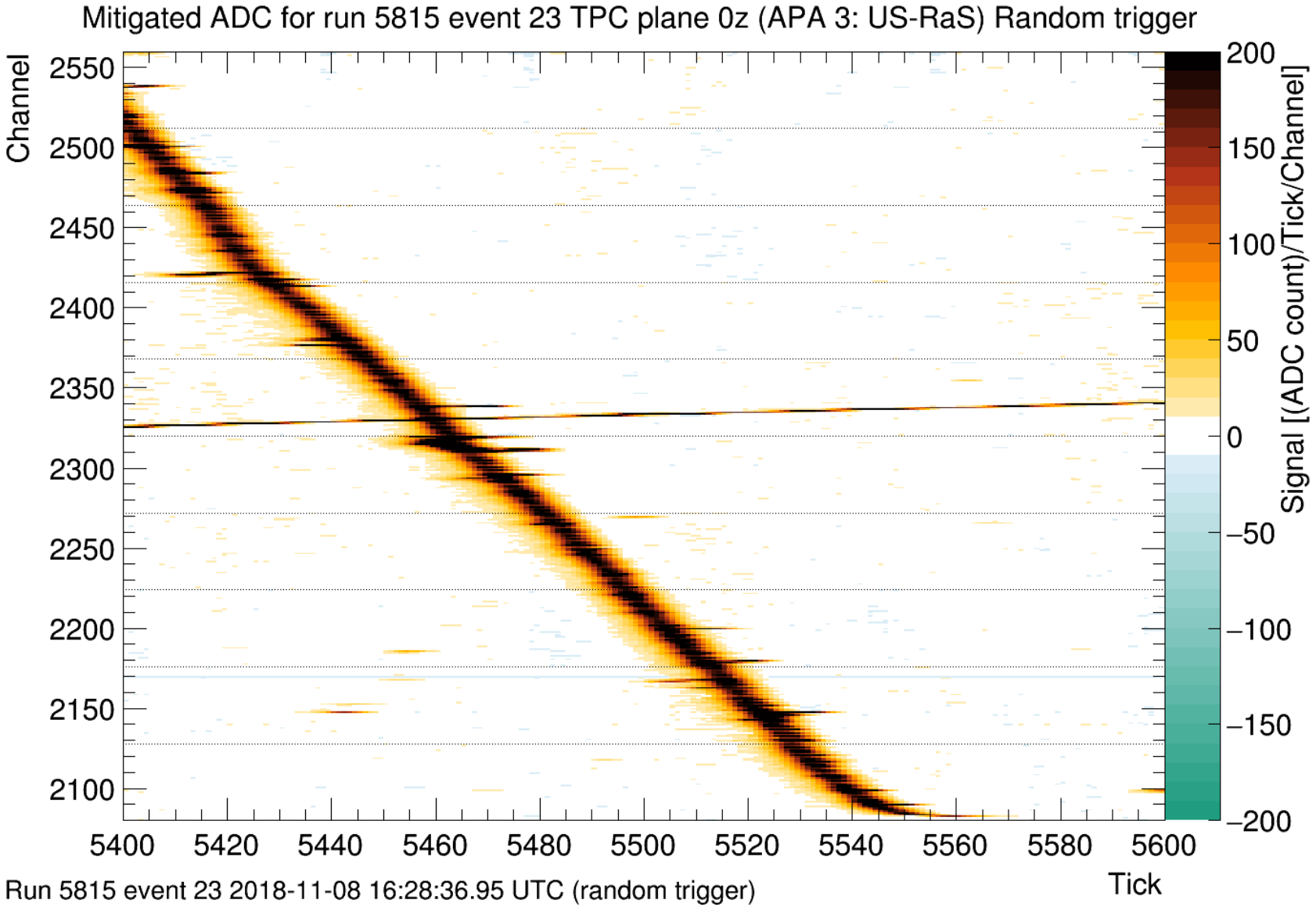
0.9995, 3 (Dec 2018 correction)



0.9993, 3


Mitigated ADC for run 5815 event 23 TPC plane 0z (APA 3: US-RaS) Random trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5400
5420
5440
5460
5480
5500
5520
5540
5560
5580
5600
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

0.9993, 2


Mitigated ADC for run 5815 event 23 TPC plane 0z (APA 3: US-RaS) Random trigger
Channel
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2200
2150
2100
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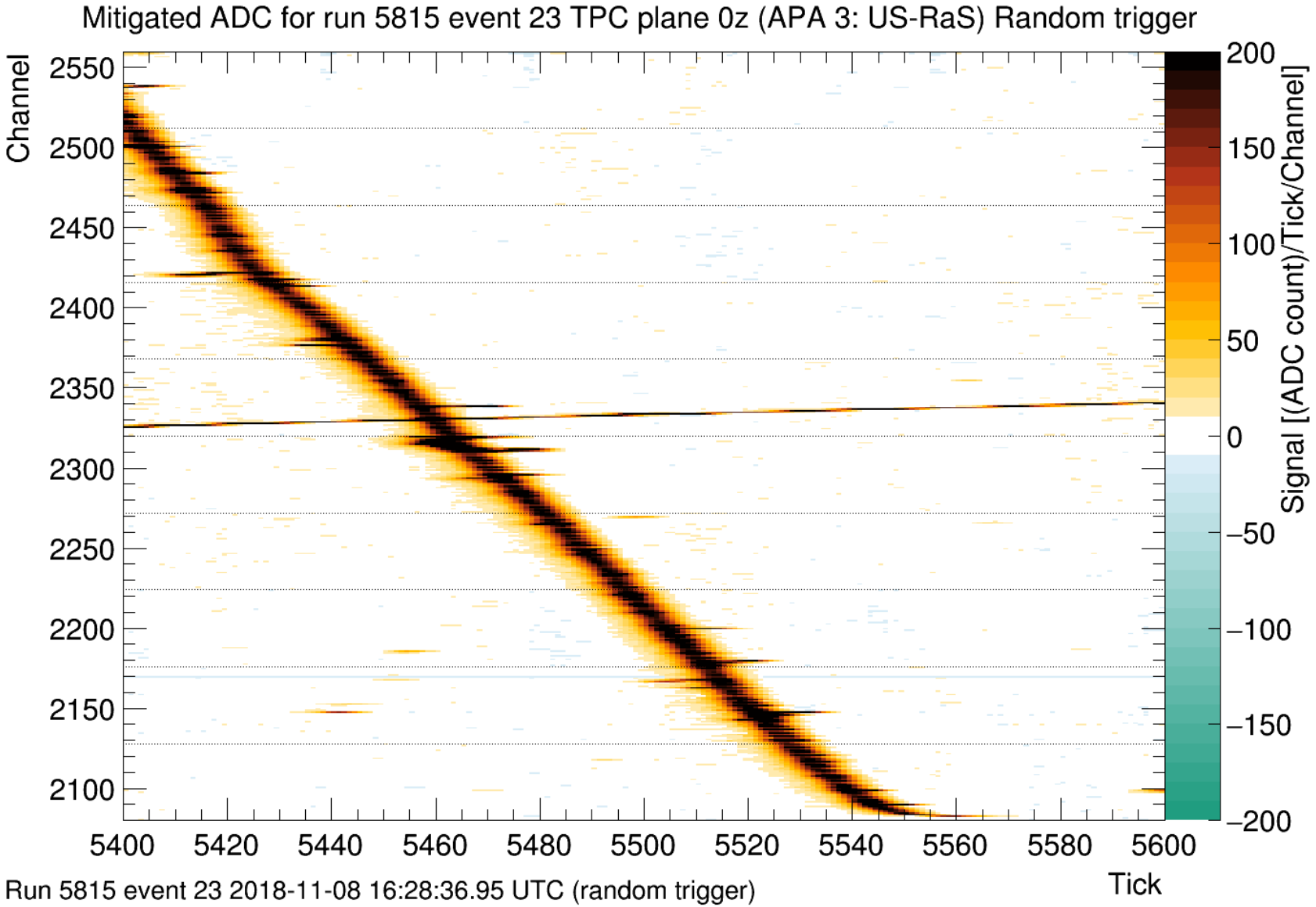
5460
5480
5500
5520
5540
5560
5580
5600
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

0.9993, 1


Mitigated ADC for run 5815 event 23 TPC plane 0z (APA 3: US-RaS) Random trigger
Channel
2550
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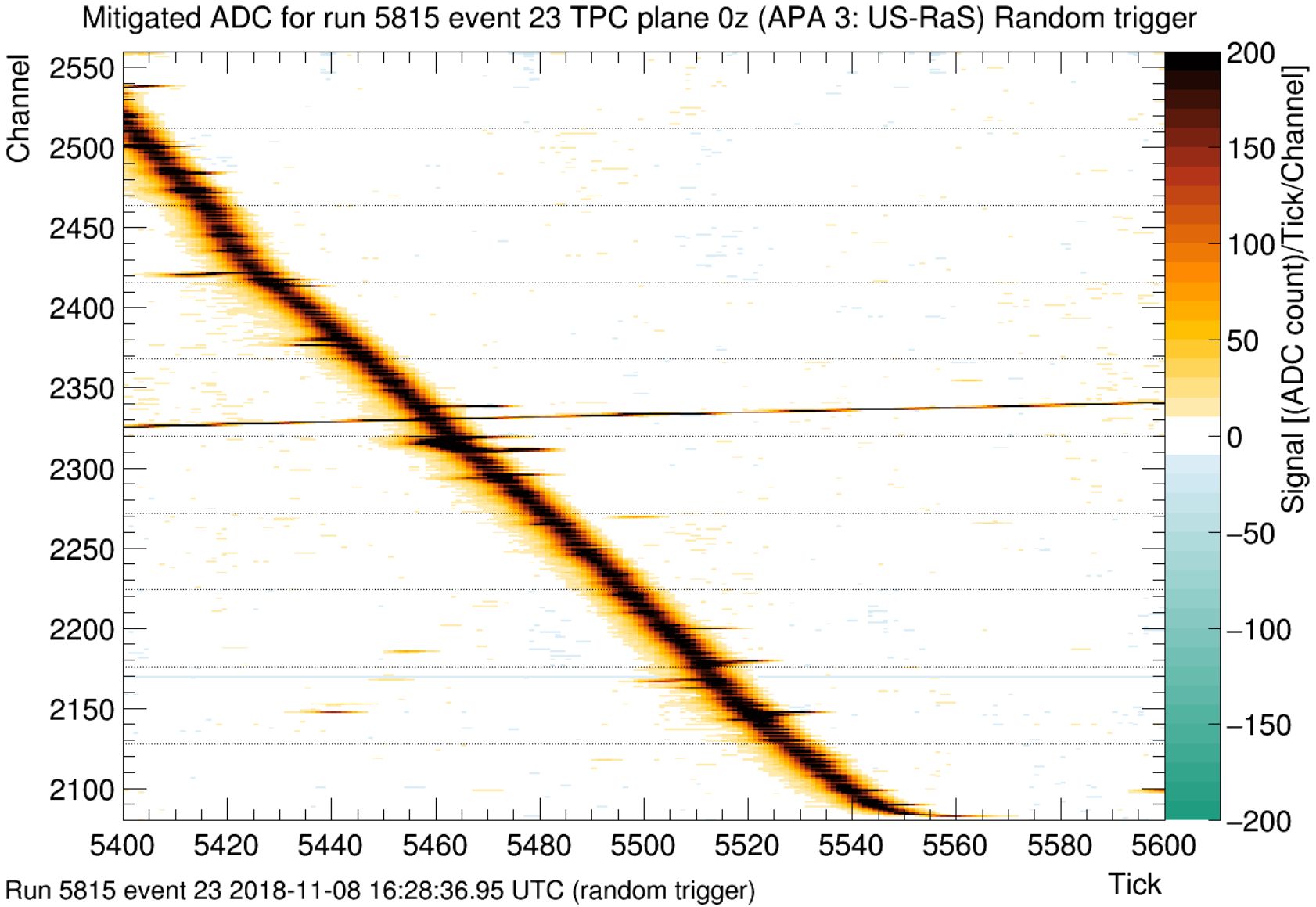
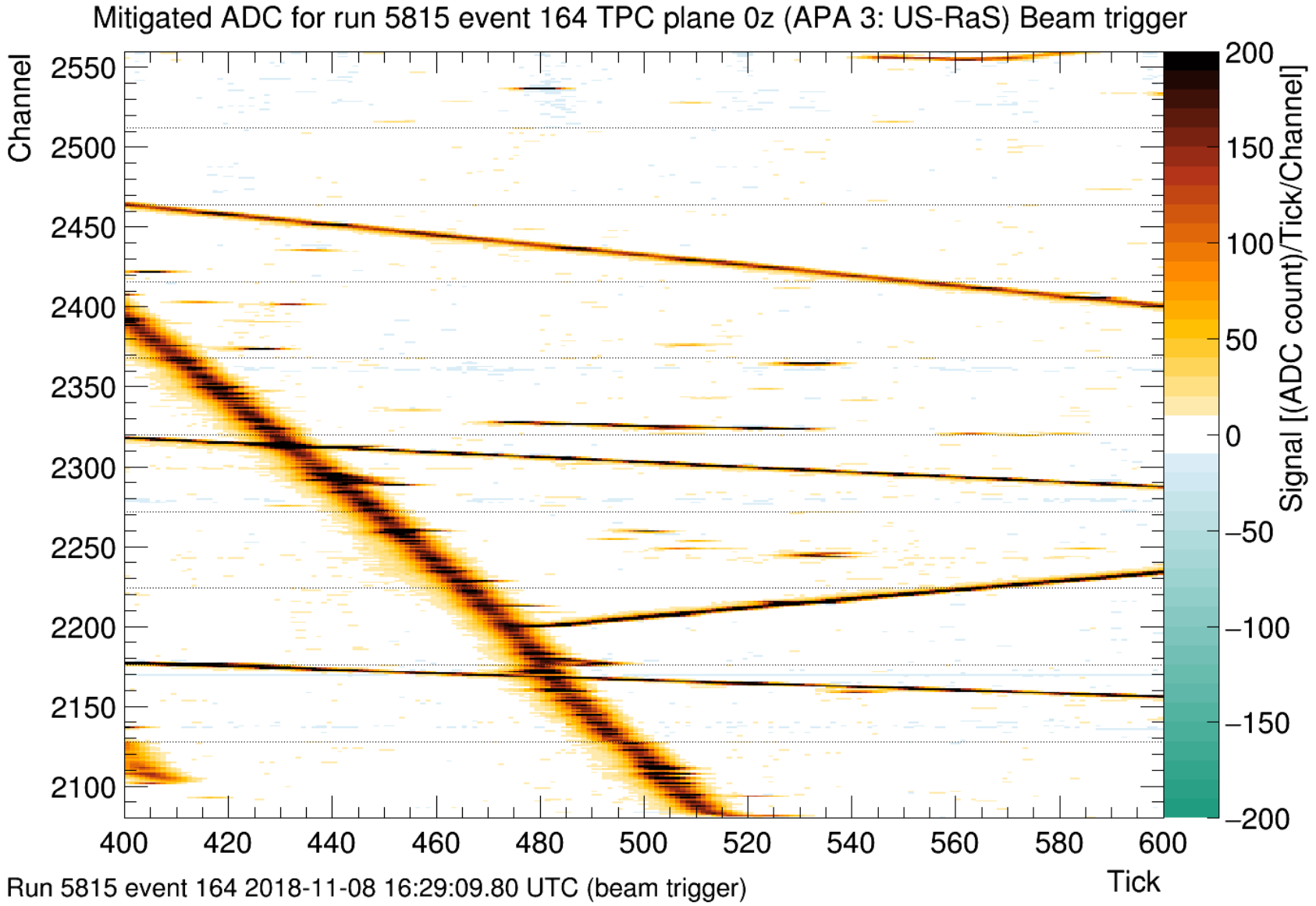
2200
2150
2100
5400
5420
5440
5460
5480
5500
5520
5540
5560
5580
5600
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

0.9993, 0

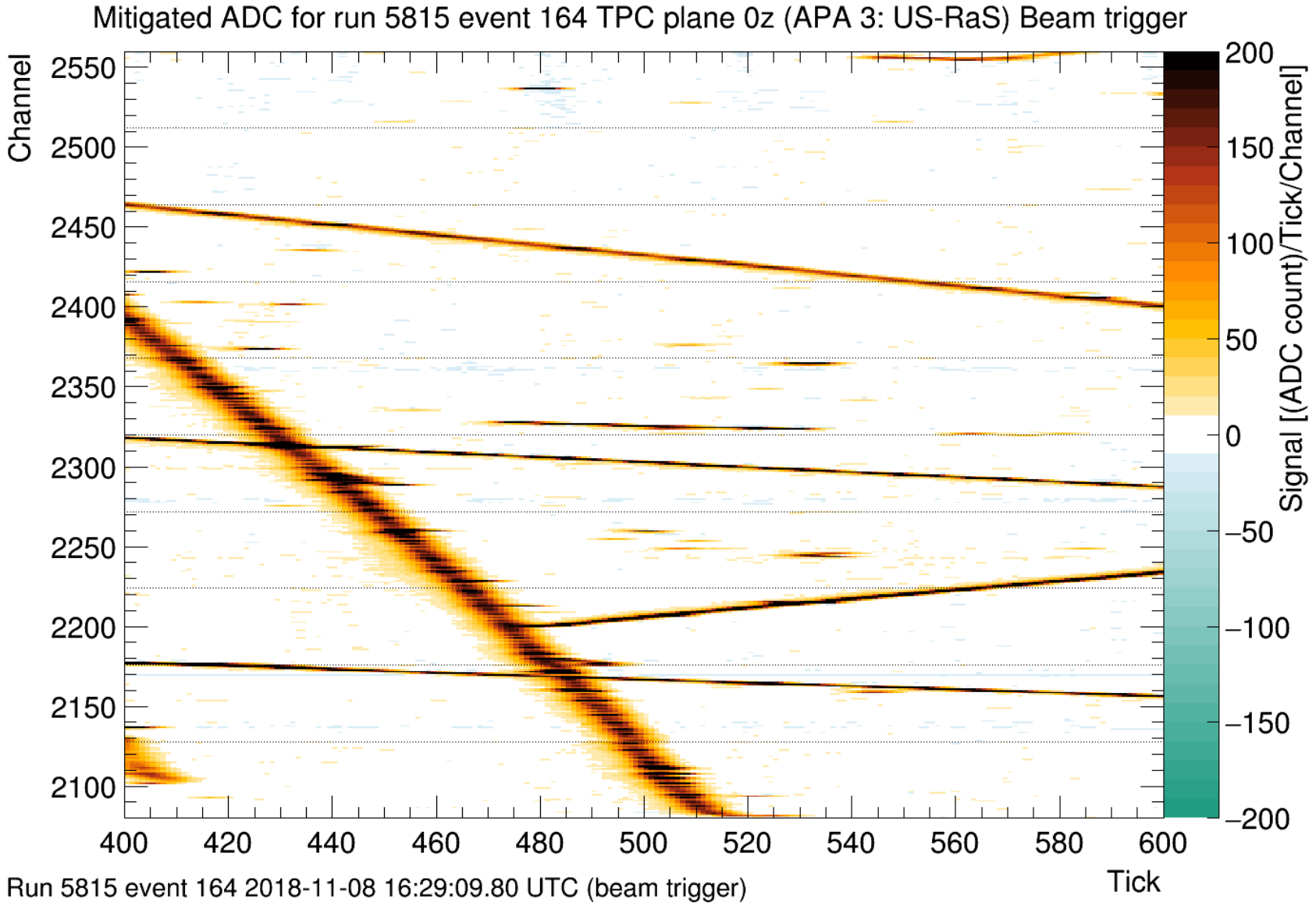

Mitigated ADC for run 5815 event 23 TPC plane 0z (APA 3: US-RaS) Random trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5400
5420
5440
5460
5480
5500
5520
5540
5560
5580
5600
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

Event 164 z400-600

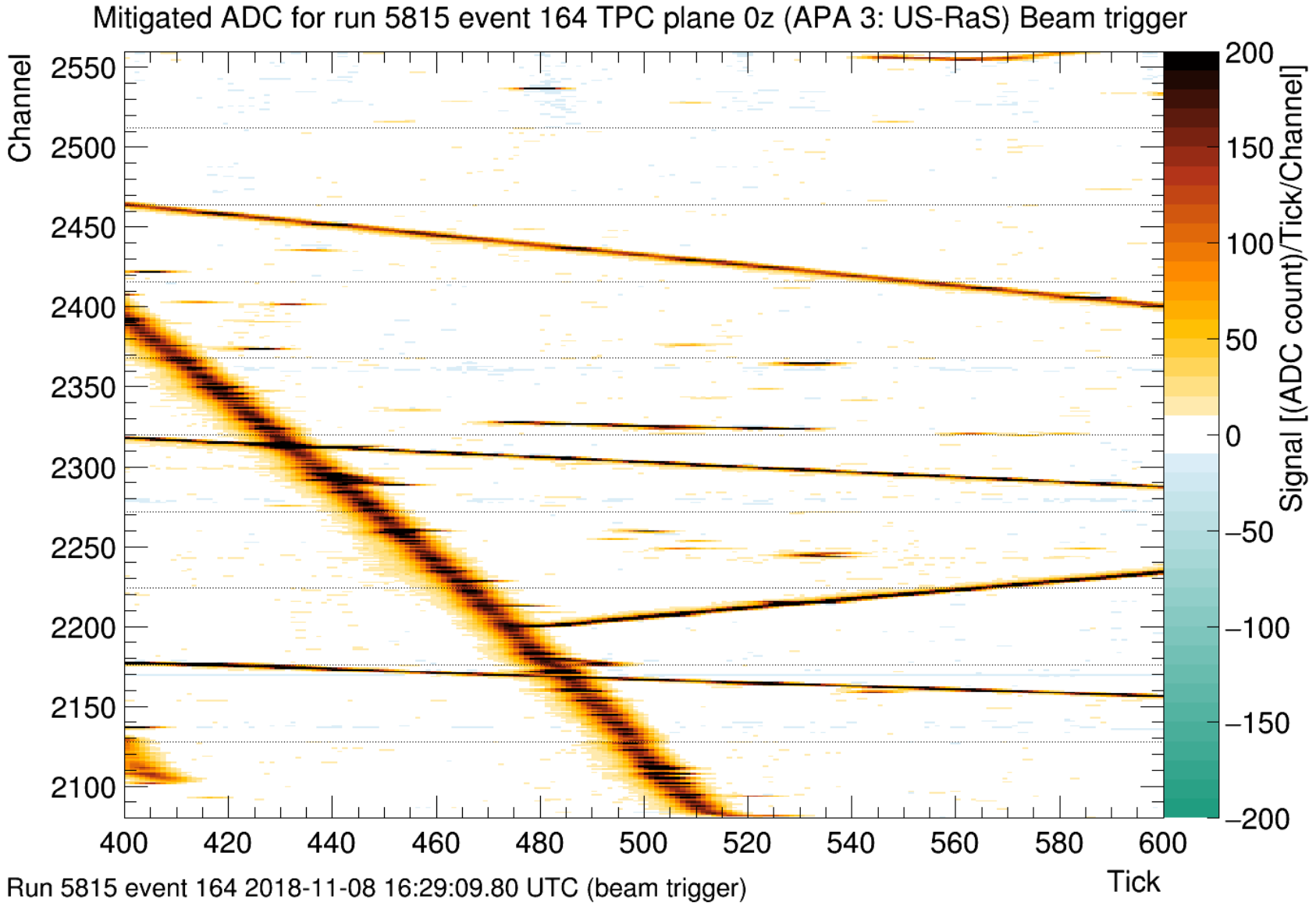
1.0, 0 (no correction)



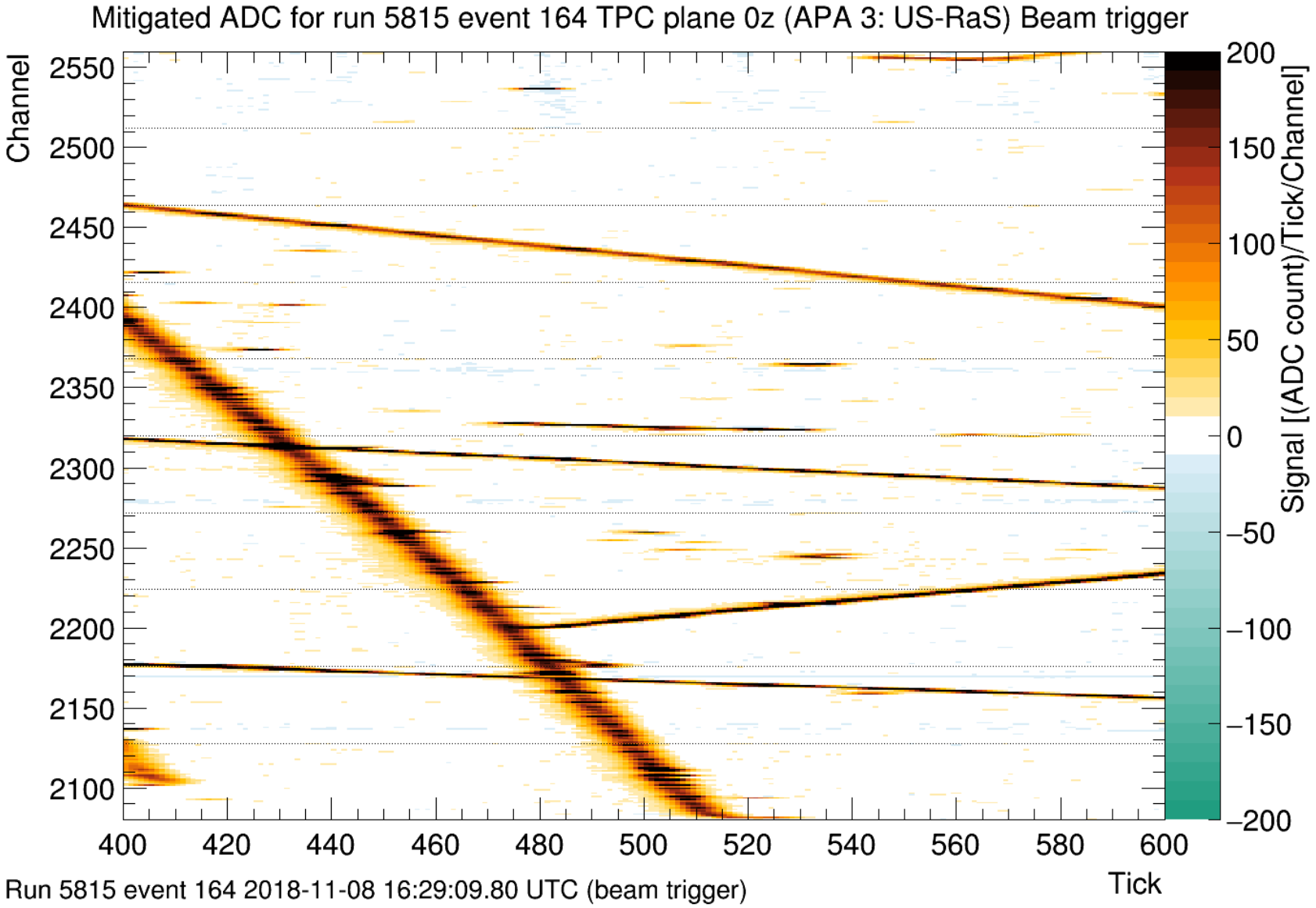
0.9995, 3 (Dec 2018 correction)



0.9993, 3


Mitigated ADC for run 5815 event 164 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
400
420
440
460
480
500
520
540
560
580
600
Tick
Signal [(ADC count)/Tick/Channel]
200
150
100
50
0
−50
−100
−150
−200
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

0.9993, 2


Mitigated ADC for run 5815 event 164 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
400
420
440
460
480
500
520
540
560
580
600
Tick
200
150
100
50
0
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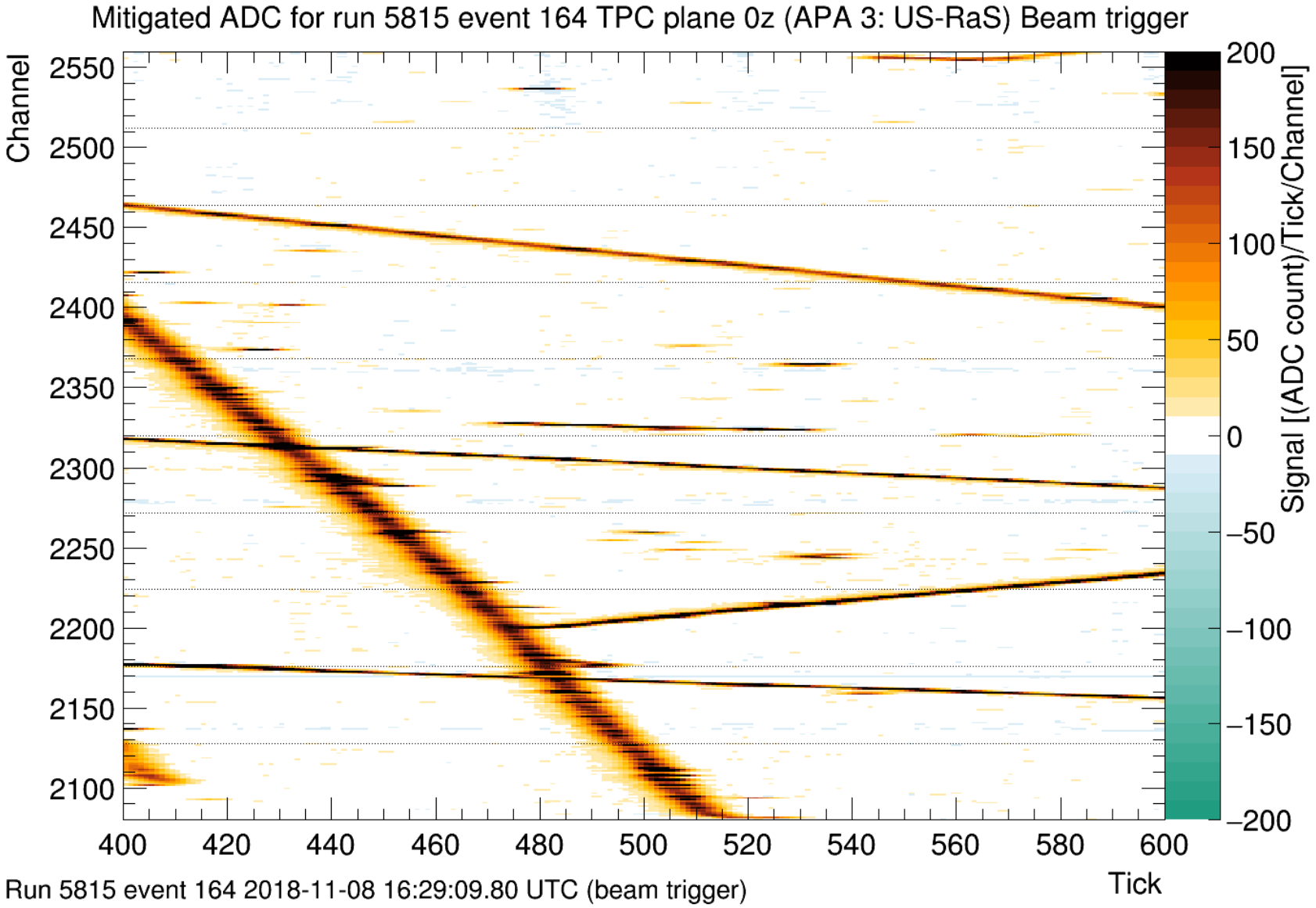
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

0.9993, 1


Mitigated ADC for run 5815 event 164 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
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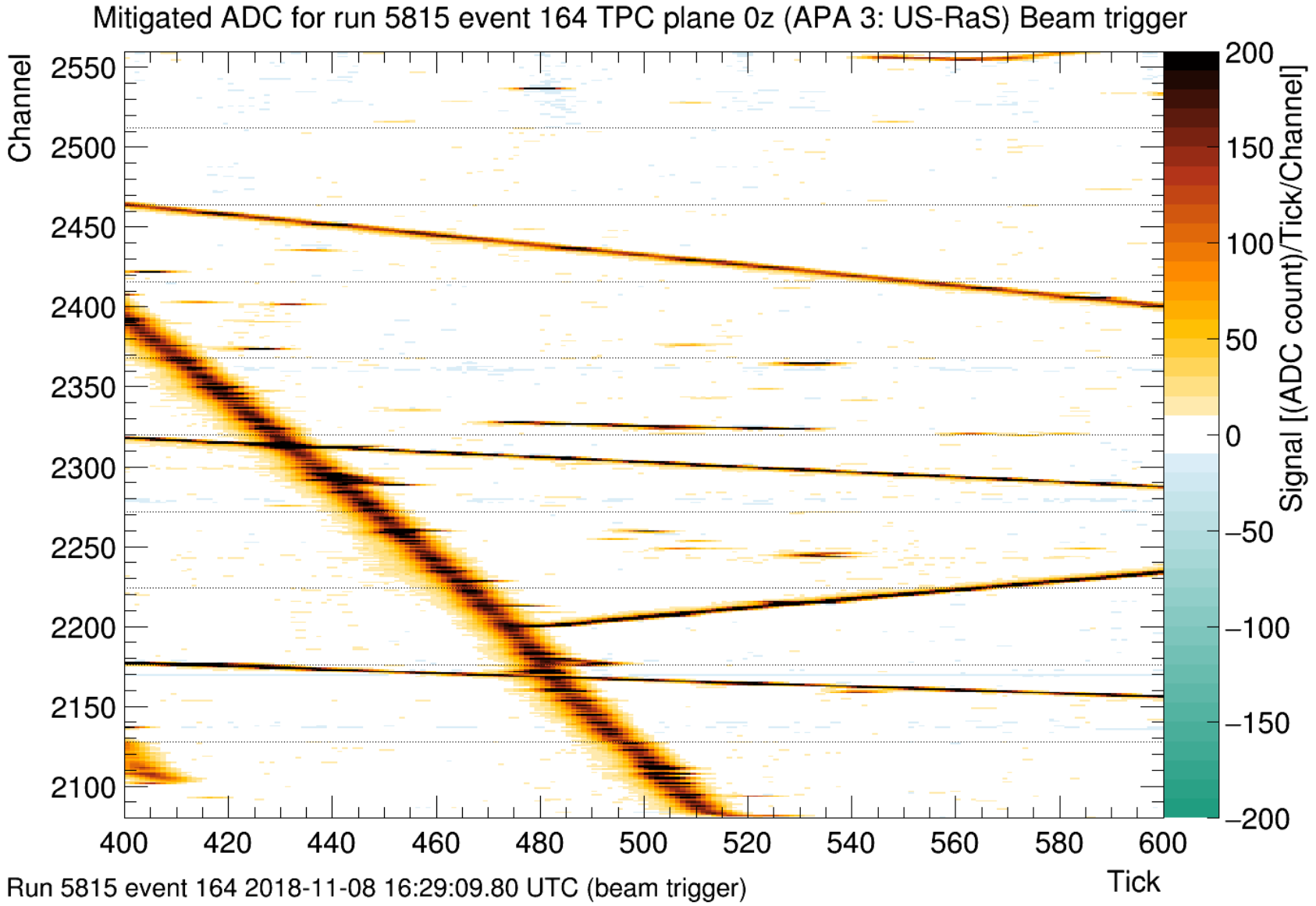
2400
2350
2300
2250
2200
2150
2100
400
420
440
460
480
500
520
540
560
580
600
Tick
Signal [(ADC count)/Tick/Channel]
200
150
100
50
0
−50
−100
−150
−200
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

0.9993, 0


Mitigated ADC for run 5815 event 164 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
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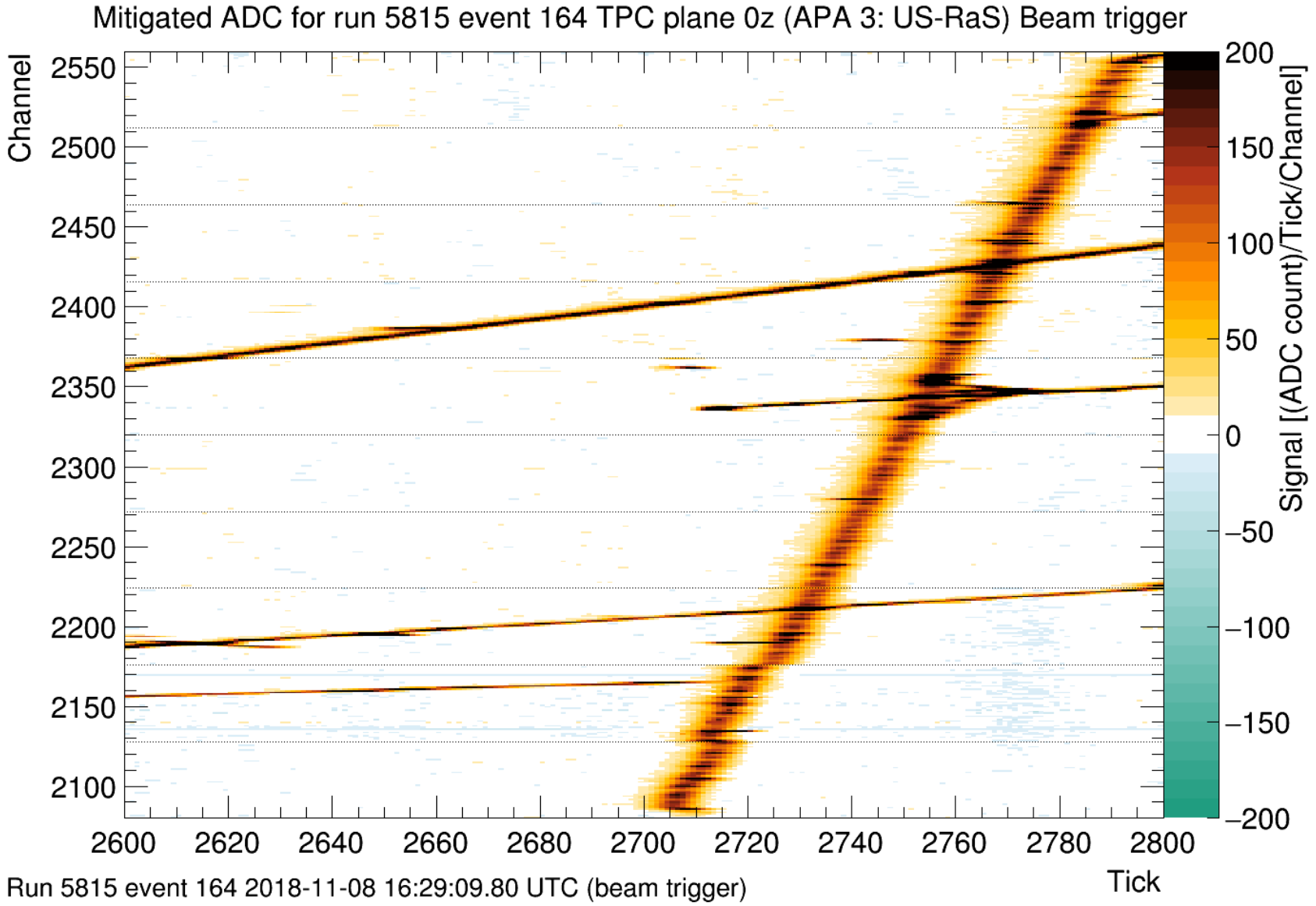
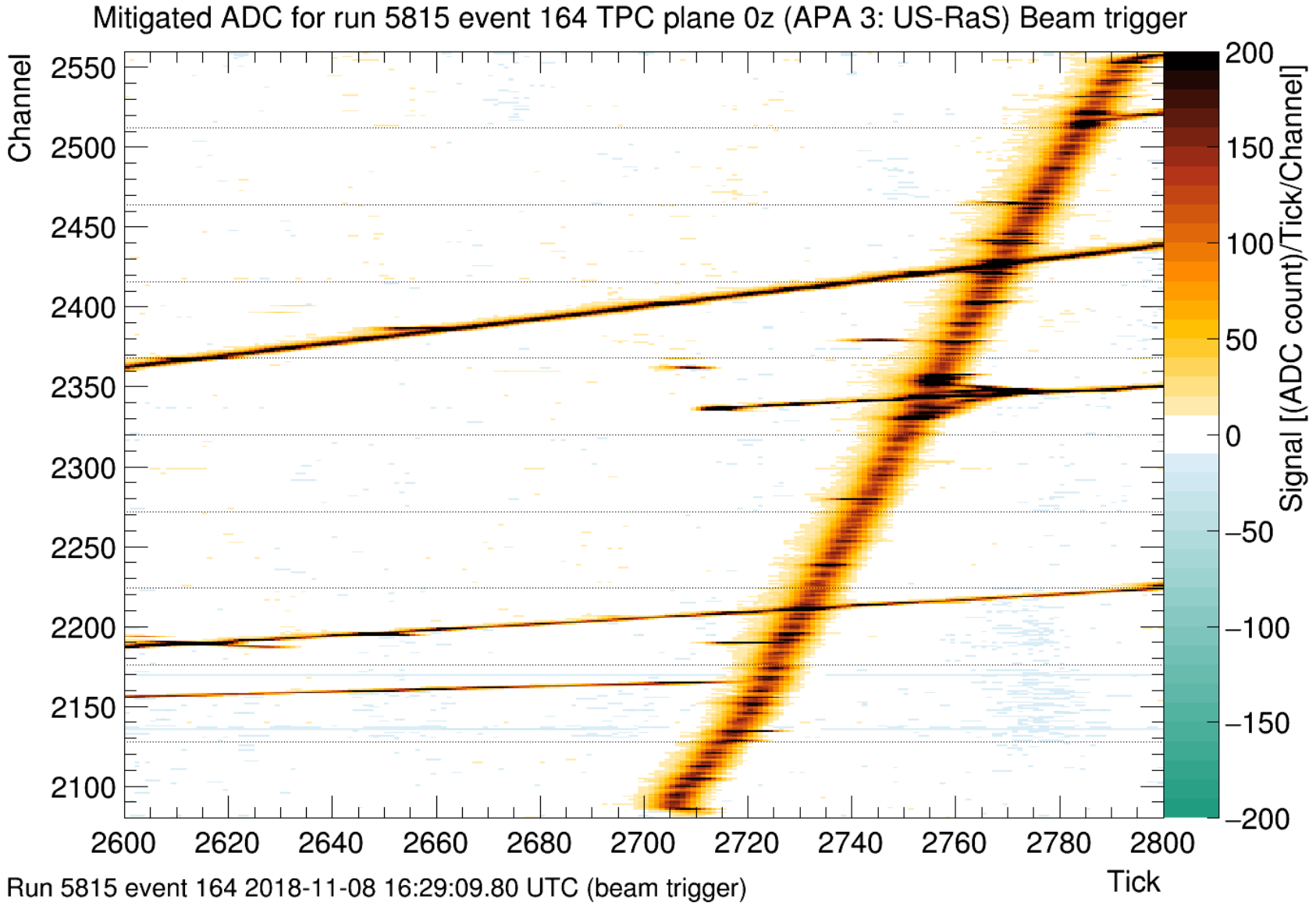
2250
2200
2150
2100
400
420
440
460
480
500
520
540
560
580
600
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

Event 164 z2600-2800

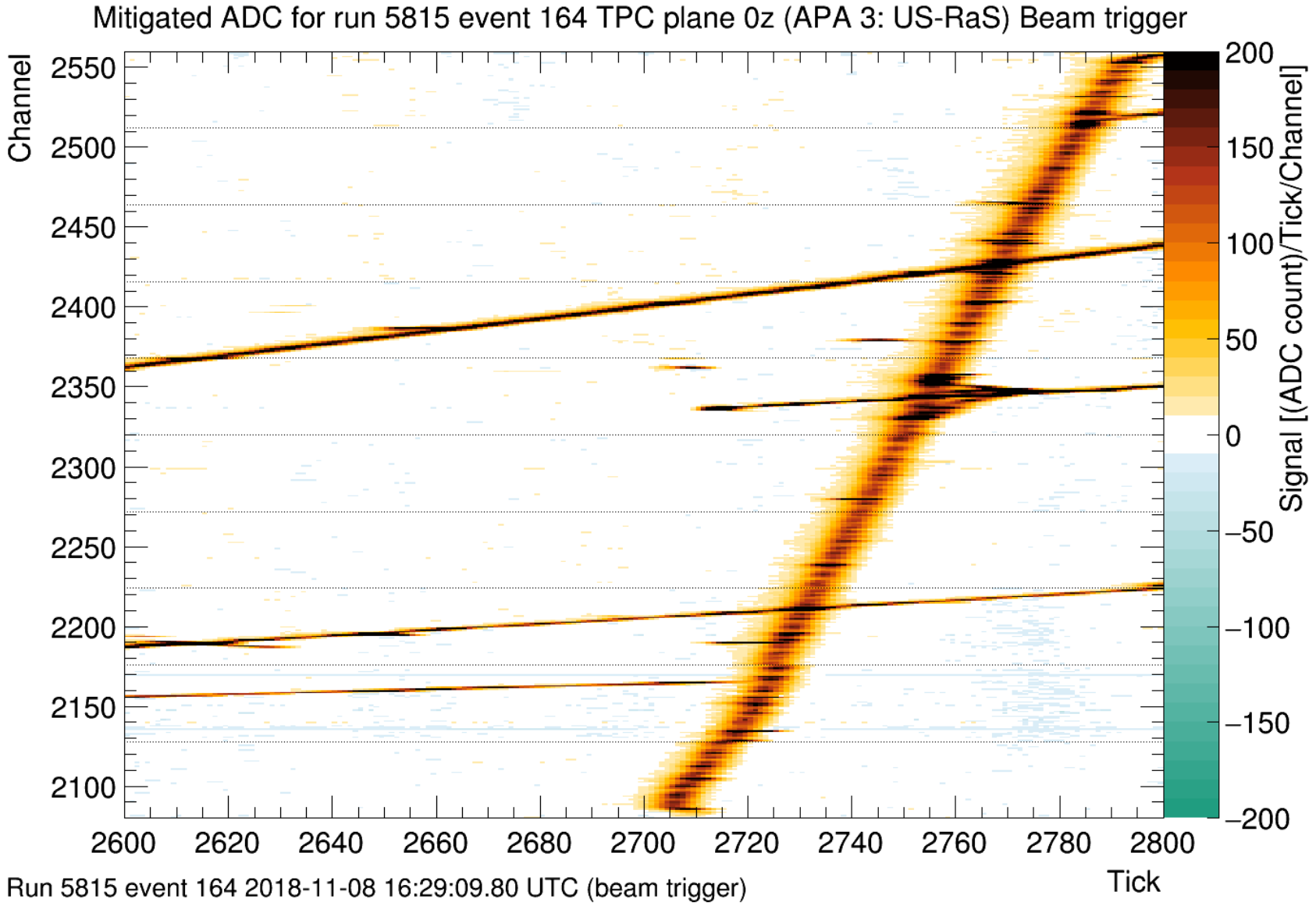
1.0, 0 (no correction)



0.9995, 3 (Dec 2018 correction)



0.9993, 3


Mitigated ADC for run 5815 event 164 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
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2500
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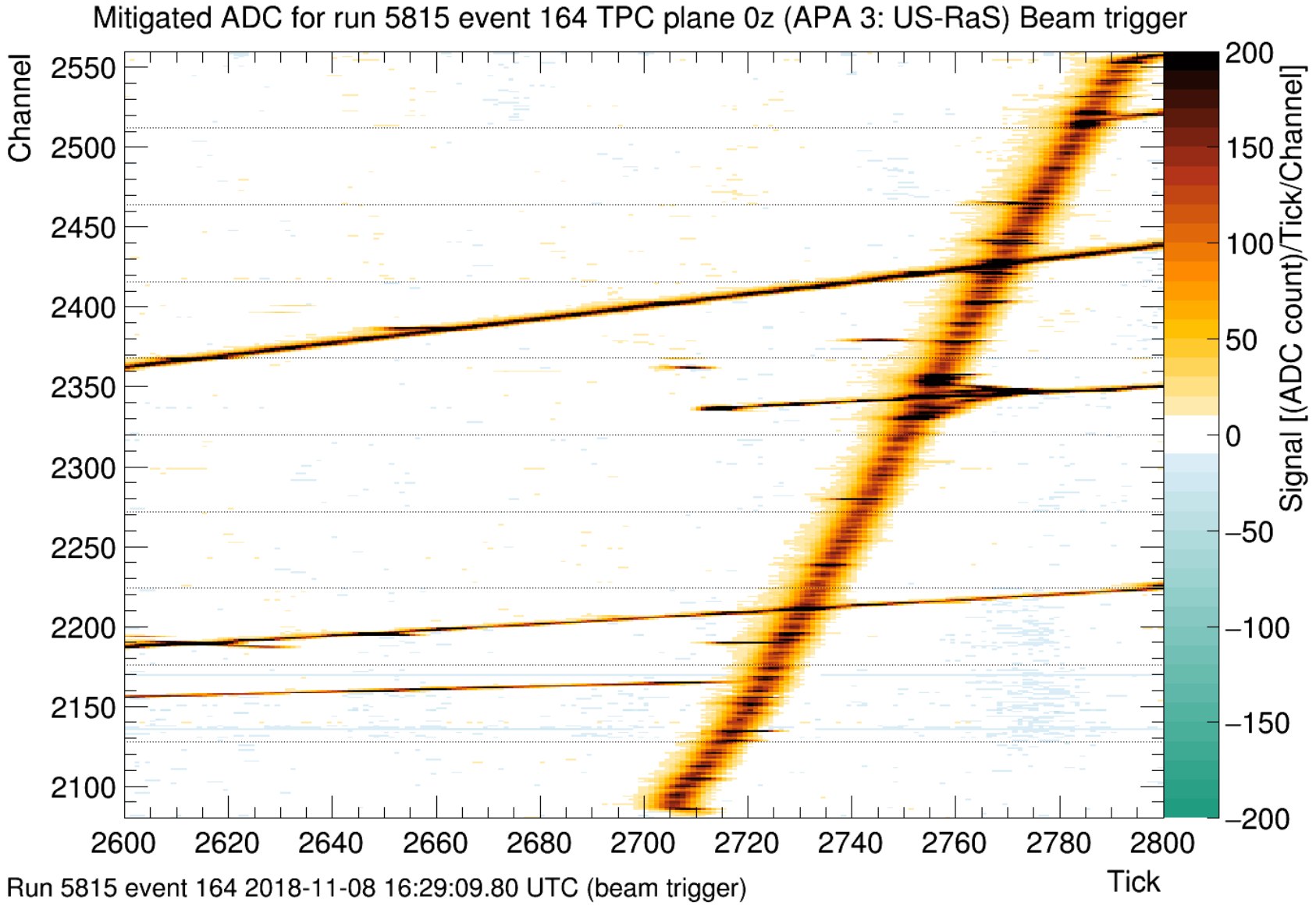
2400
2350
2300
2250
2200
2150
2100
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

0.9993, 2


Mitigated ADC for run 5815 event 164 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
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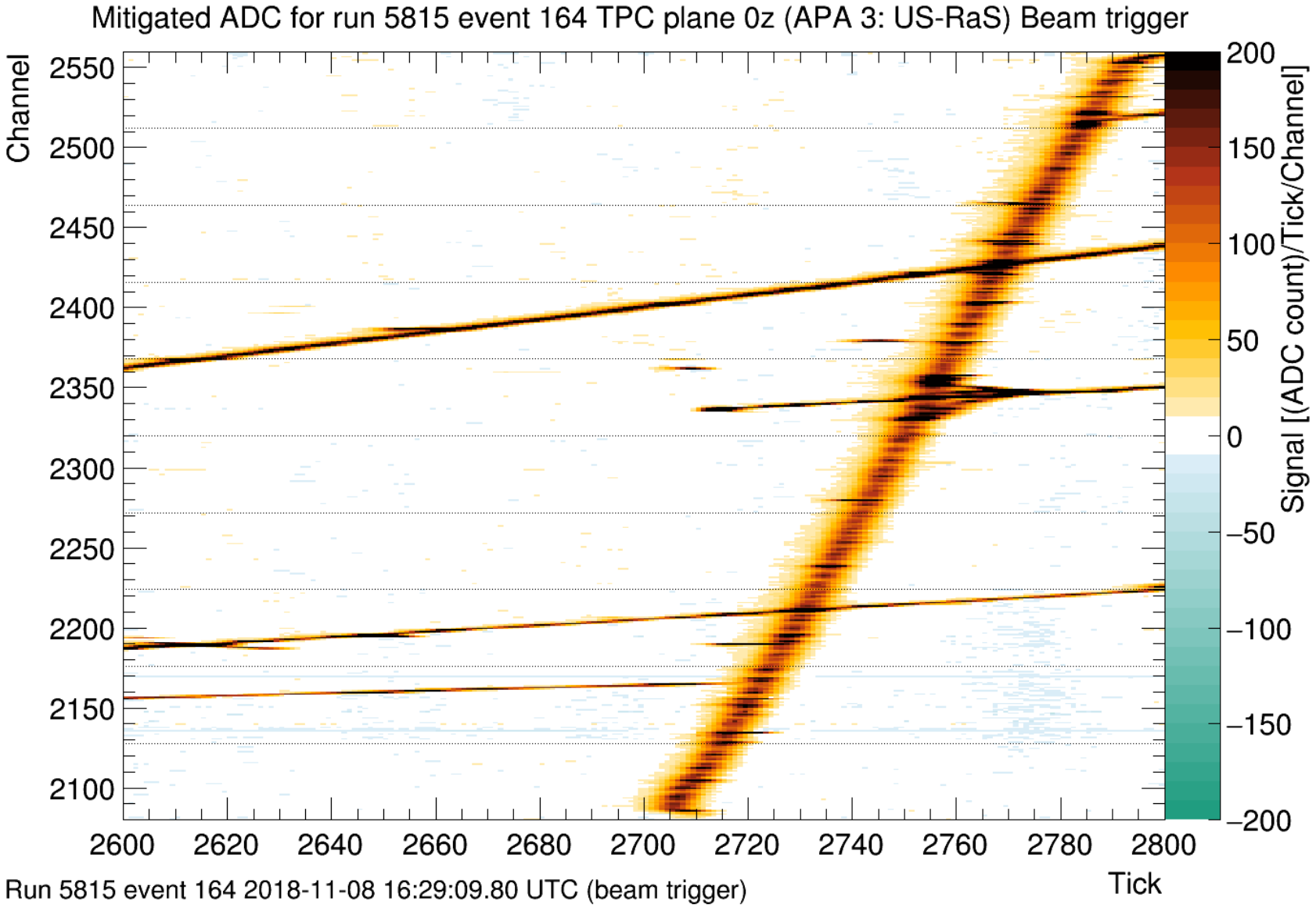
2450
2400
2350
2300
2250
2200
2150
2100
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

0.9993, 1


Mitigated ADC for run 5815 event 164 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
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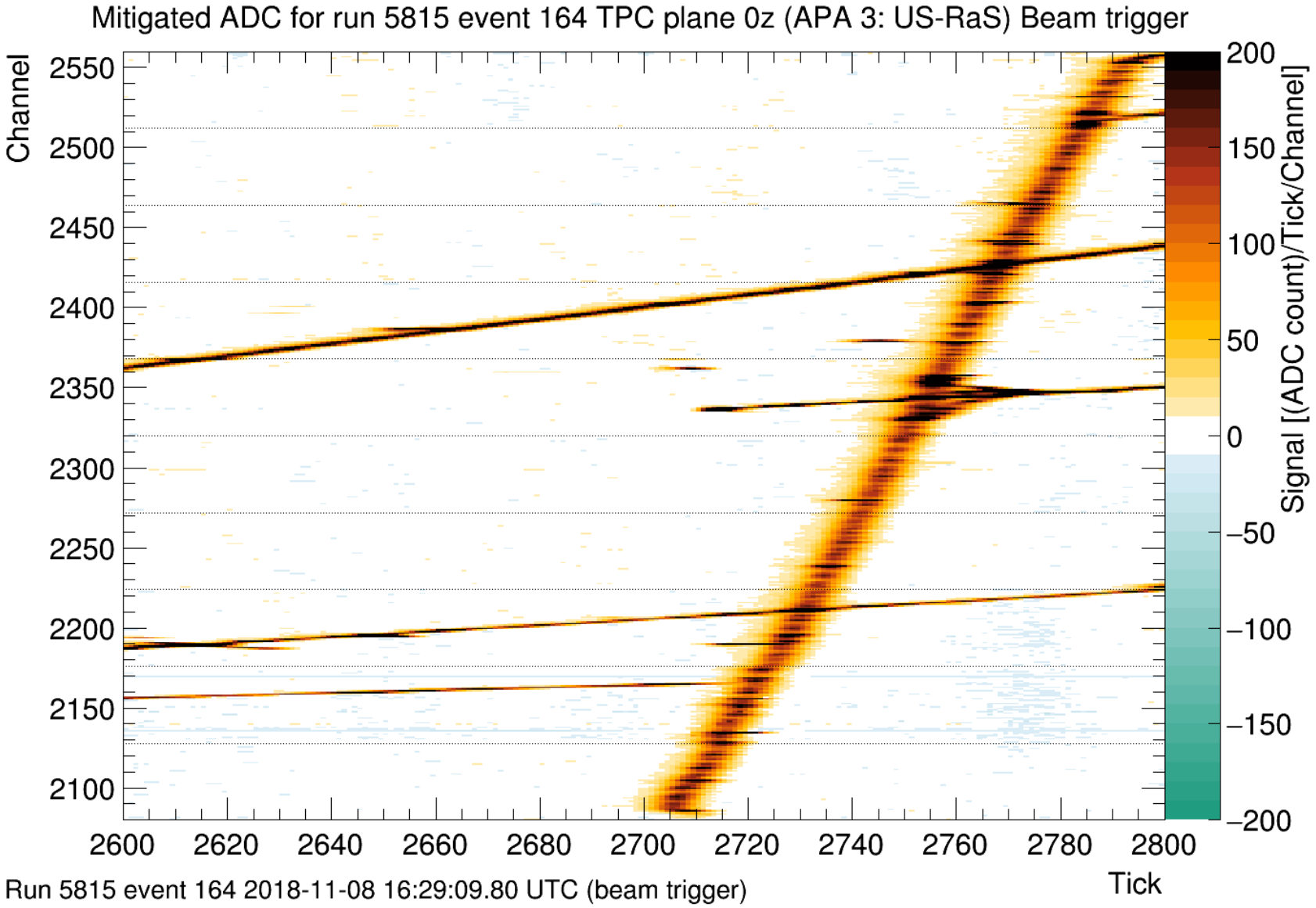
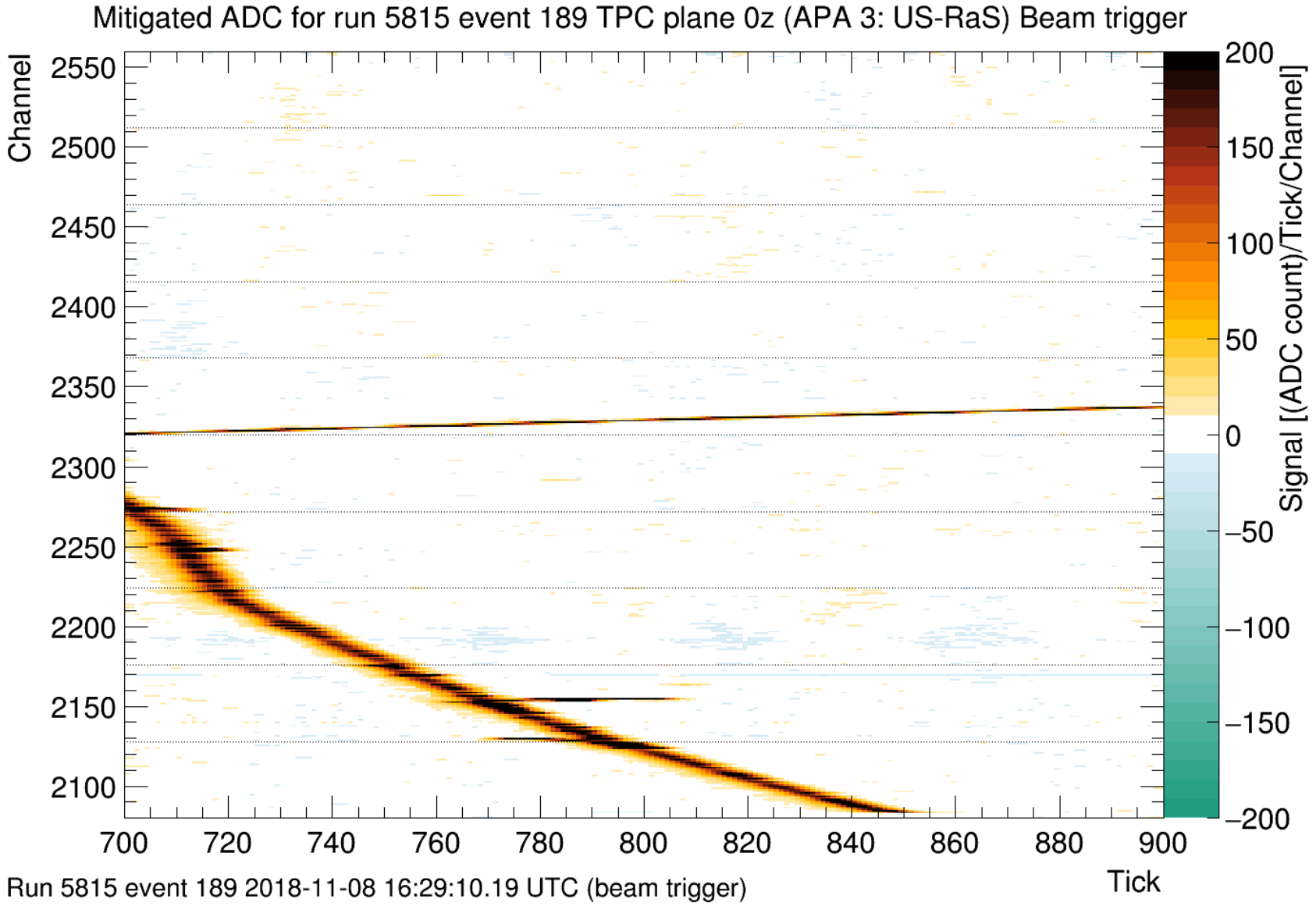
2400
2350
2300
2250
2200
2150
2100
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

0.9993, 0

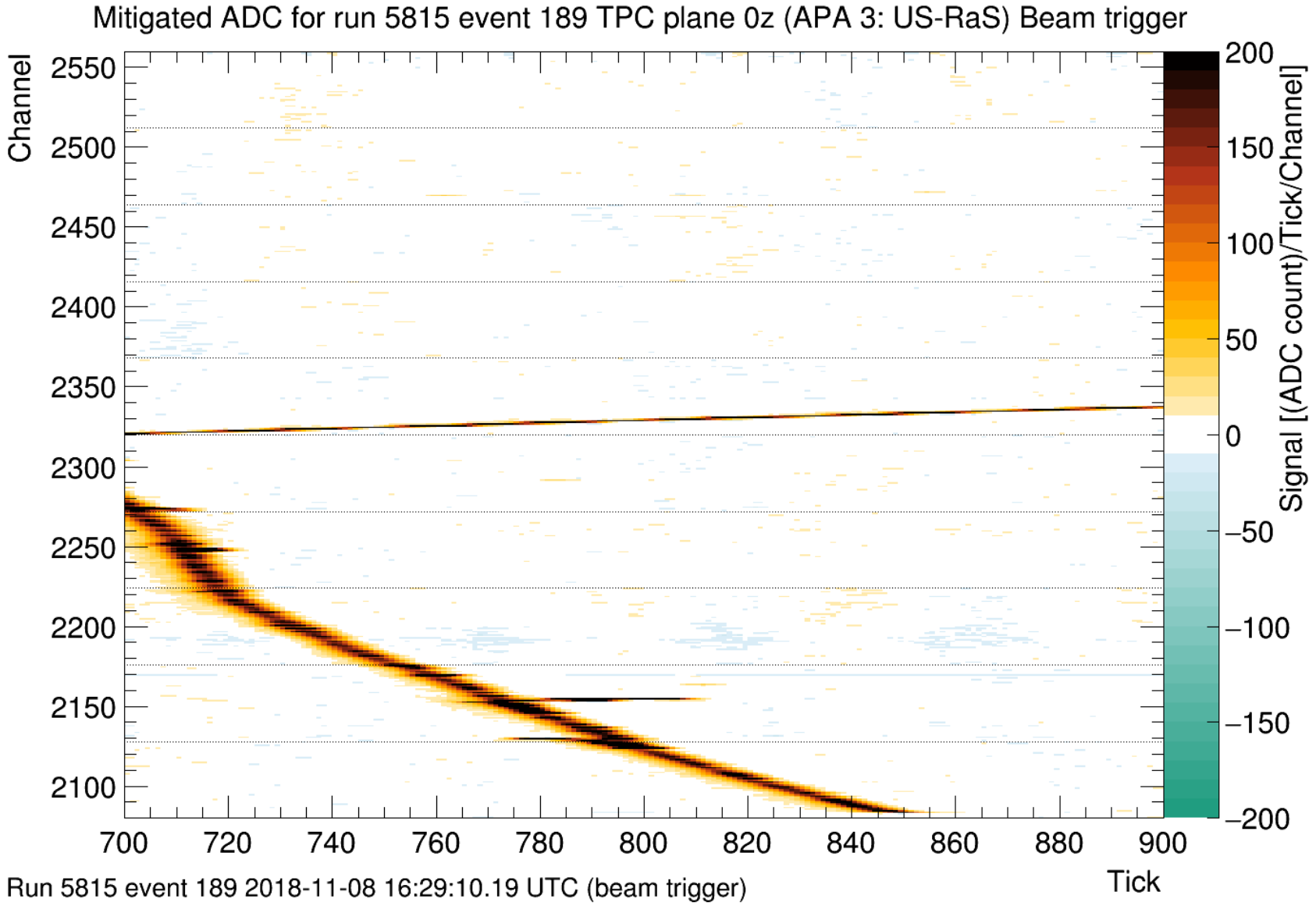

Mitigated ADC for run 5815 event 164 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

Event 189 z700-900

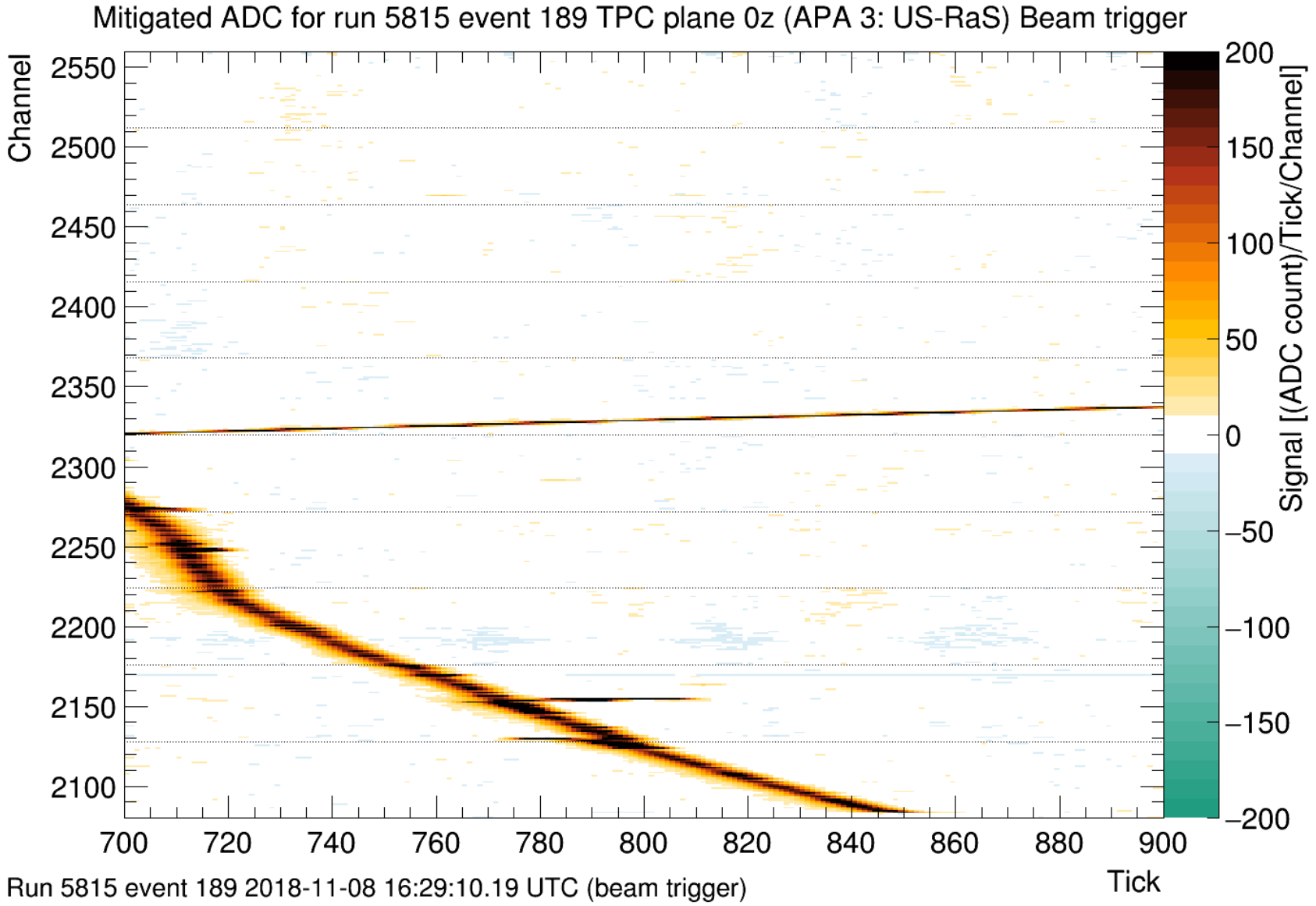
1.0, 0 (no correction)



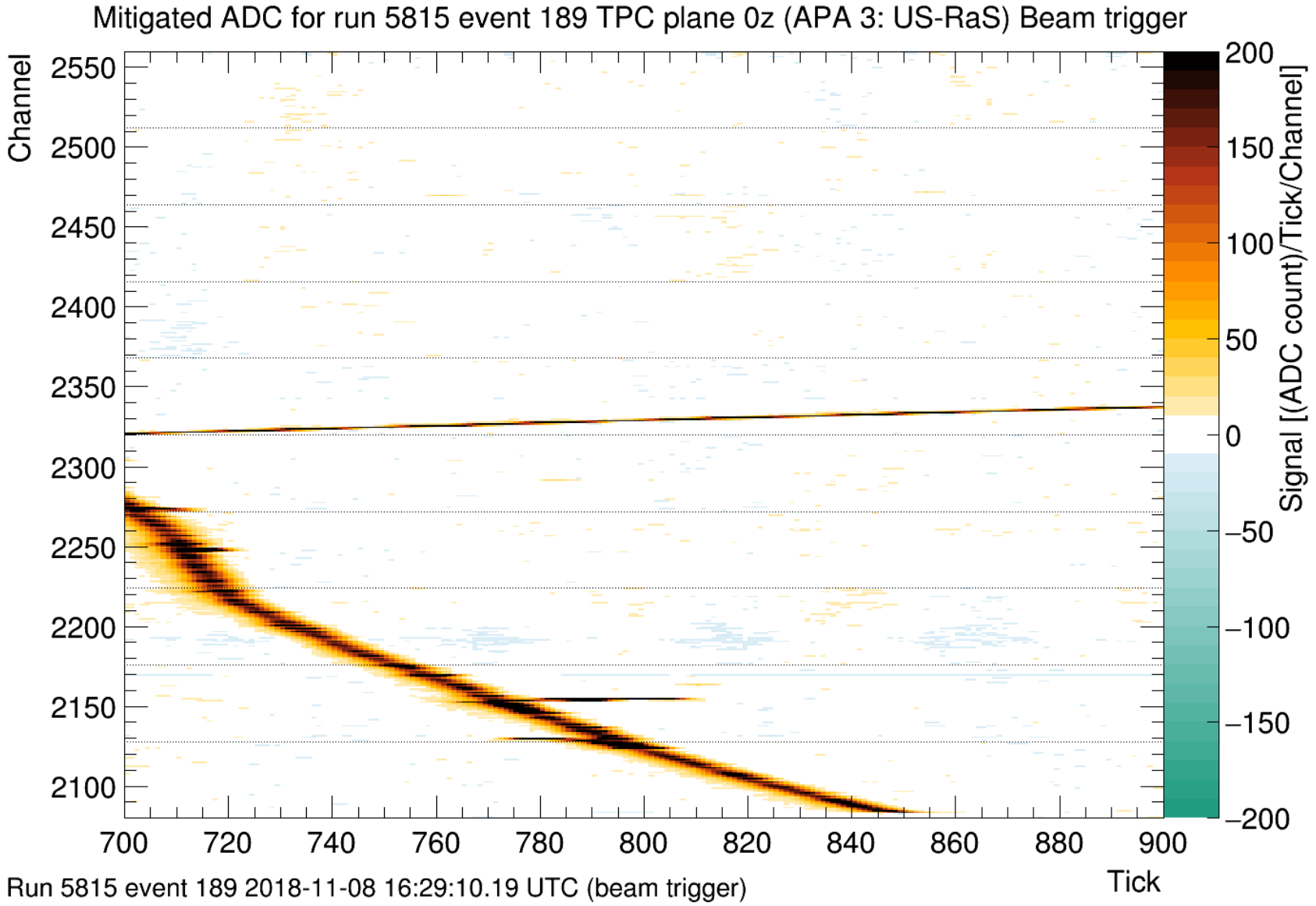
0.9995, 3 (Dec 2018 correction)



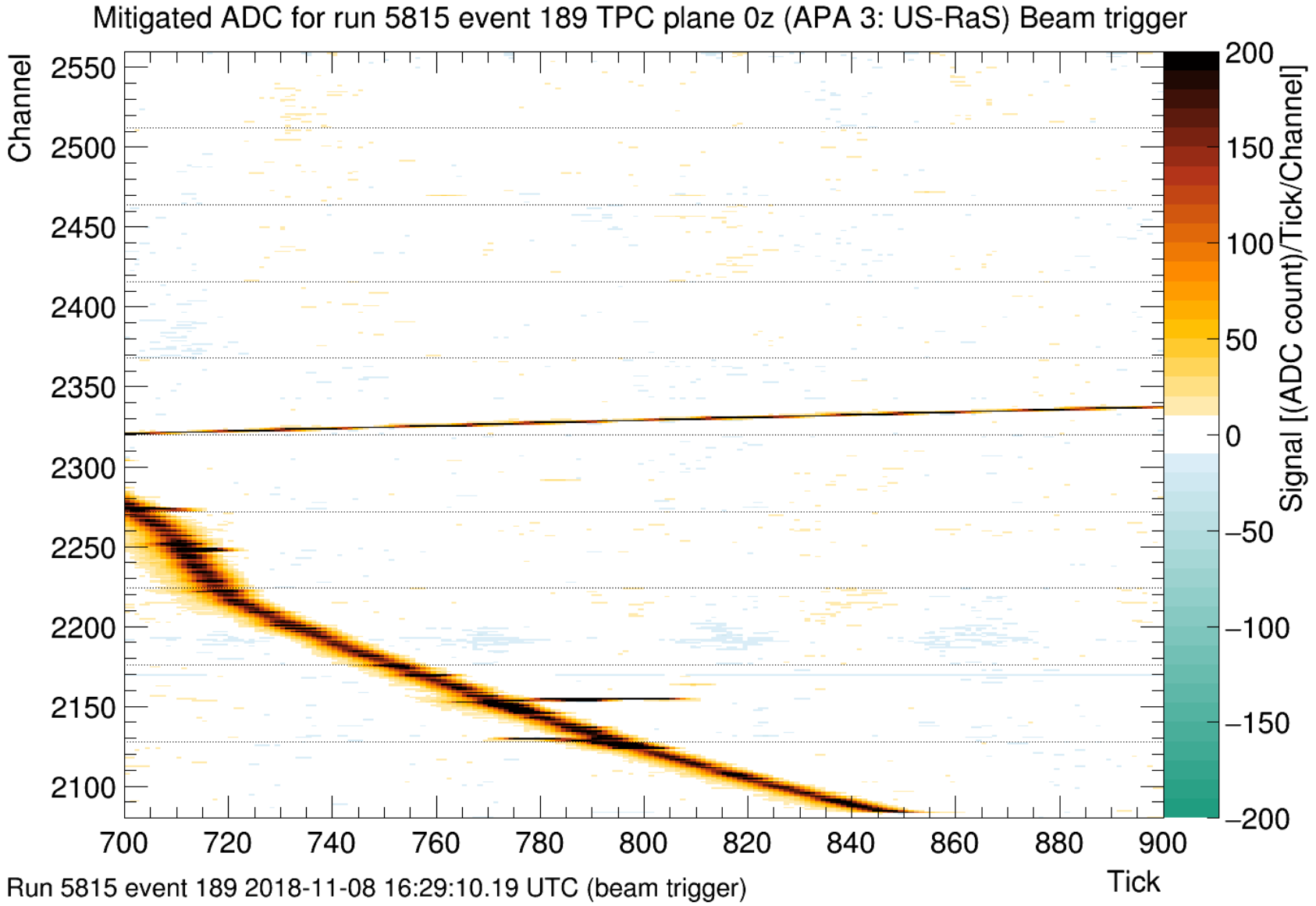
0.9993, 3


Mitigated ADC for run 5815 event 189 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
700
720
740
760
780
800
820
840
860
880
900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 189 2018-11-08 16:29:10.19 UTC (beam trigger)

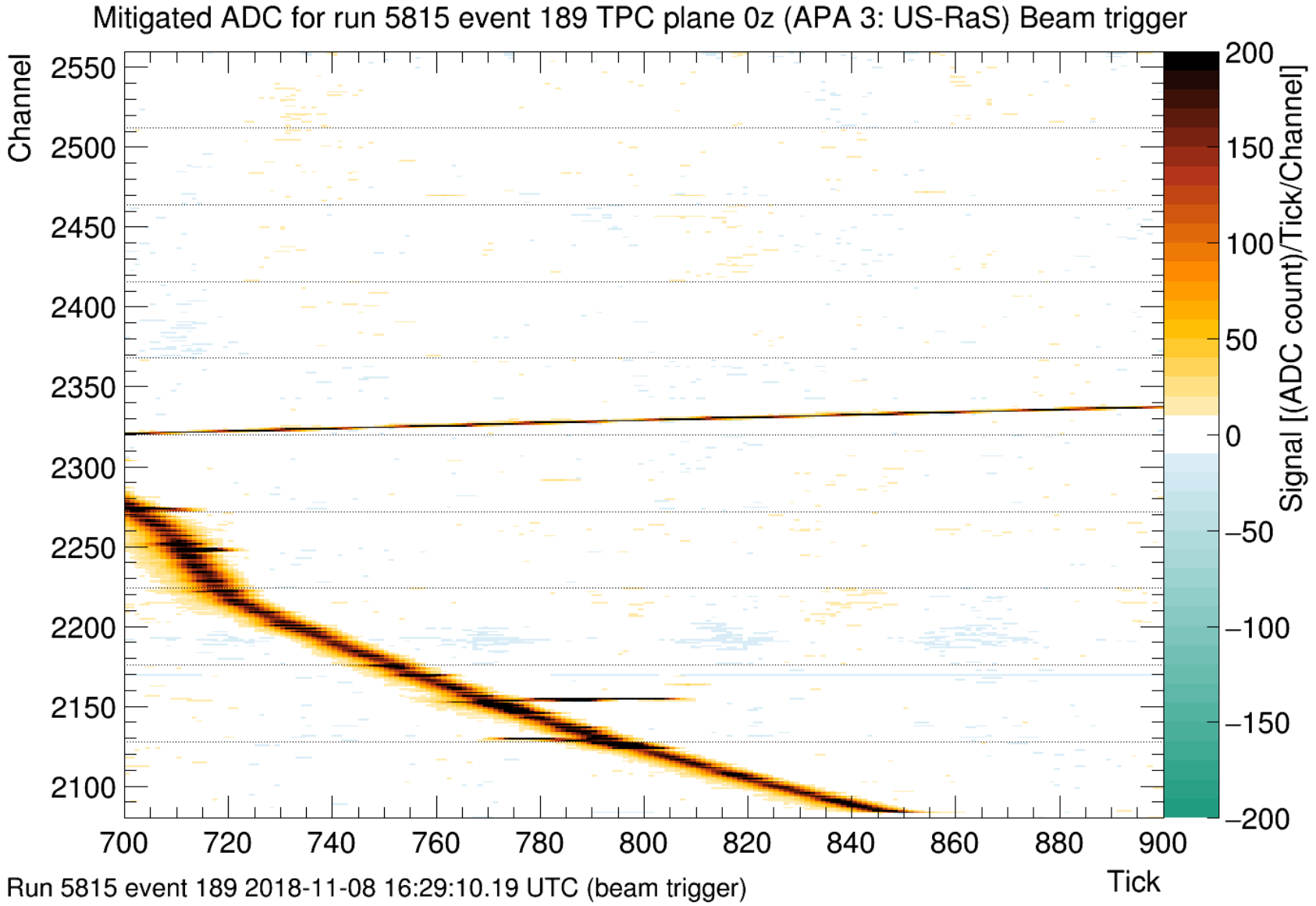
0.9993, 2


Mitigated ADC for run 5815 event 189 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
700
720
740
760
780
800
820
840
860
880
900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 189 2018-11-08 16:29:10.19 UTC (beam trigger)

0.9993, 1

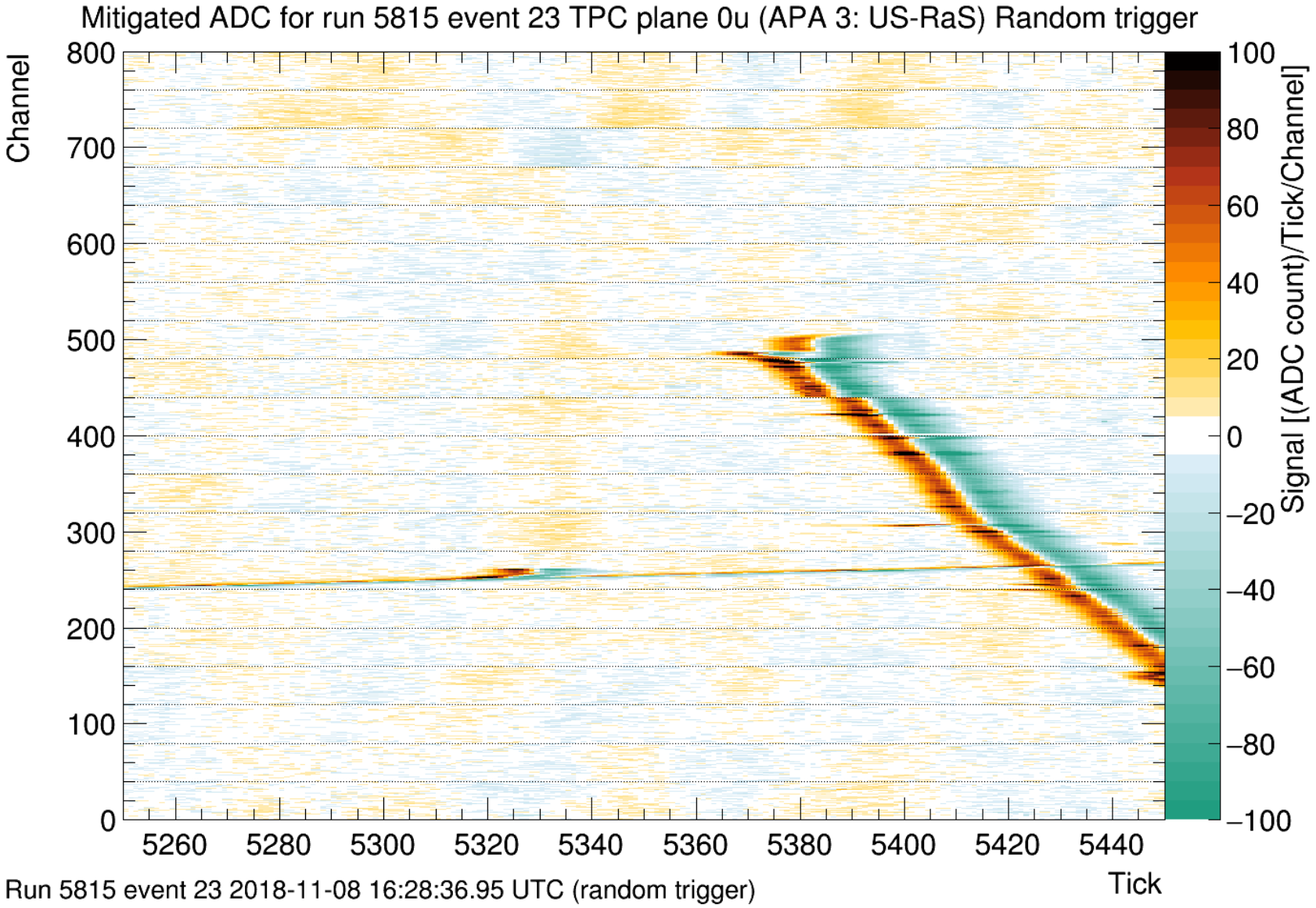

Mitigated ADC for run 5815 event 189 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
700
720
740
760
780
800
820
840
860
880
900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 189 2018-11-08 16:29:10.19 UTC (beam trigger)

0.9993, 0

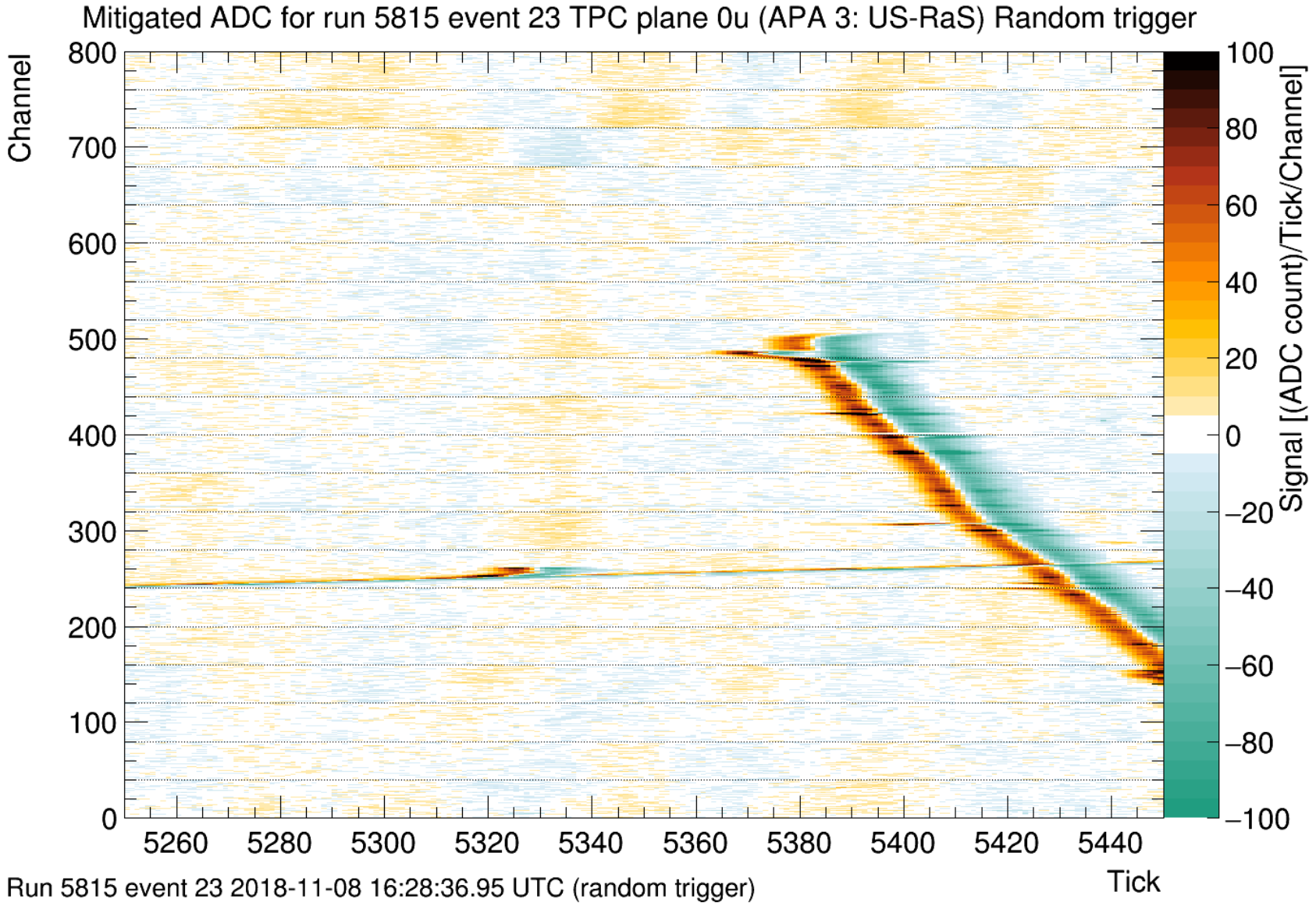

Mitigated ADC for run 5815 event 189 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
700
720
740
760
780
800
820
840
860
880
900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5815 event 189 2018-11-08 16:29:10.19 UTC (beam trigger)

Event 23 u5250-5450

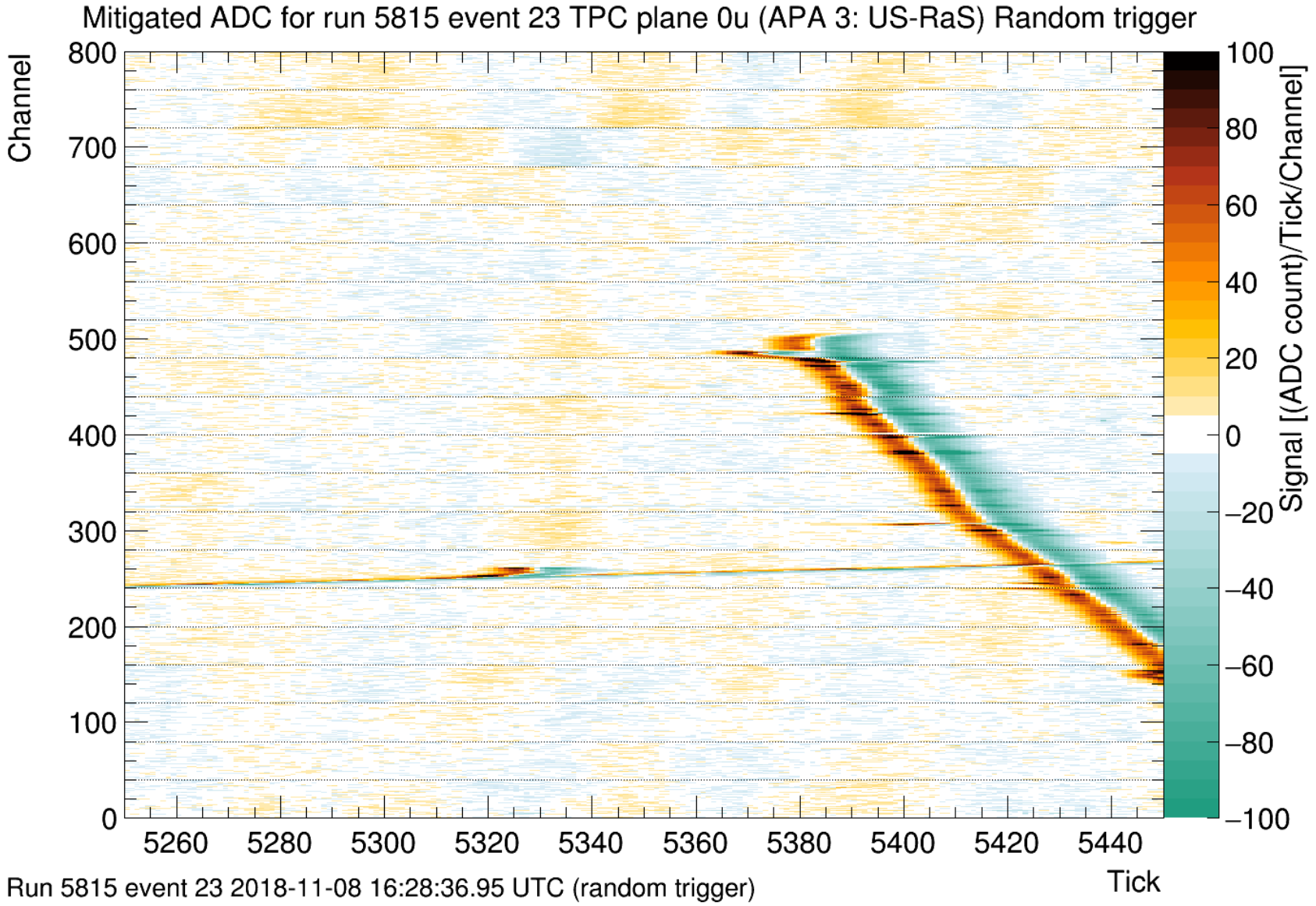
1.0, 0 (no correction)



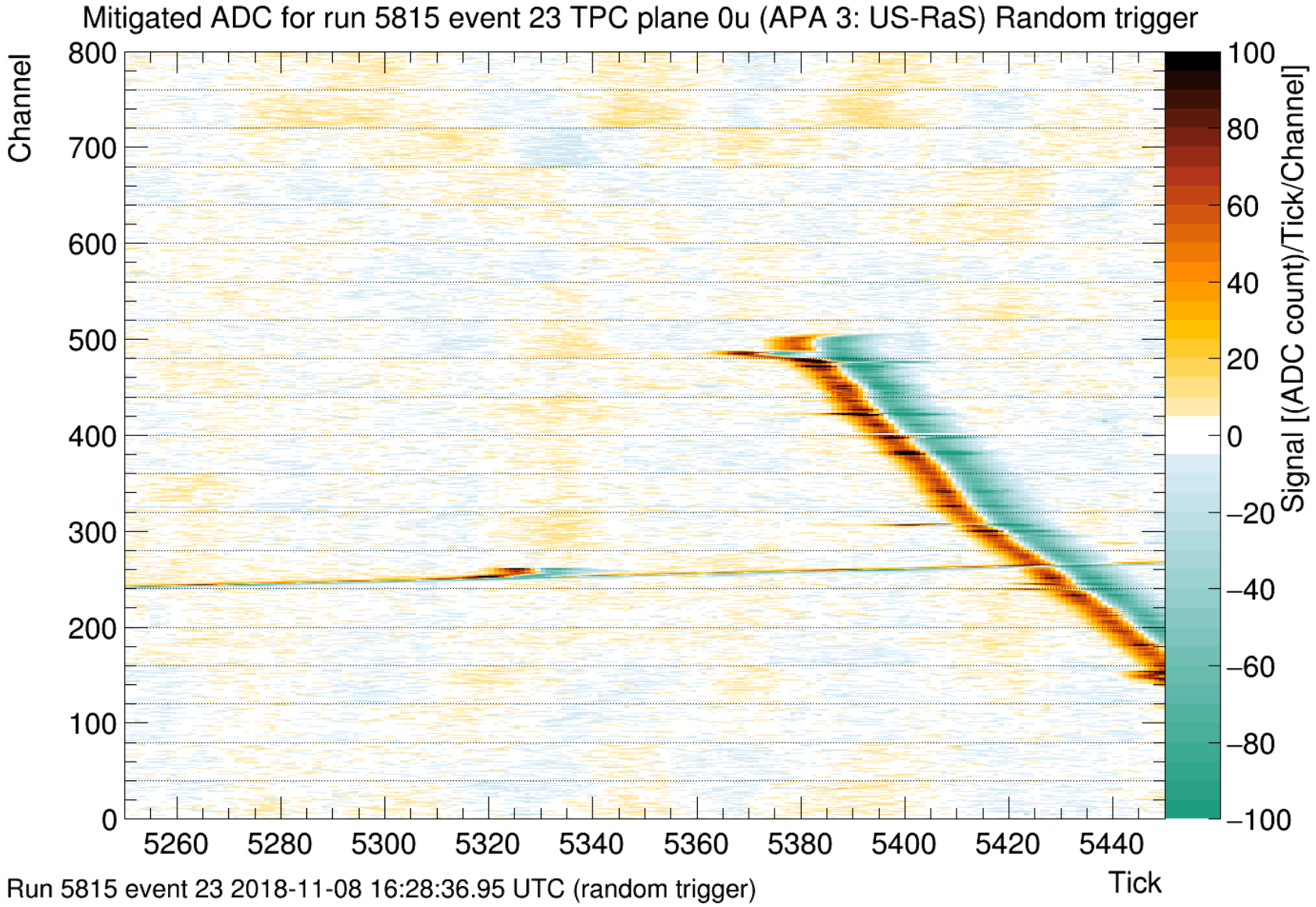
0.9995, 3 (Dec 2018 correction)



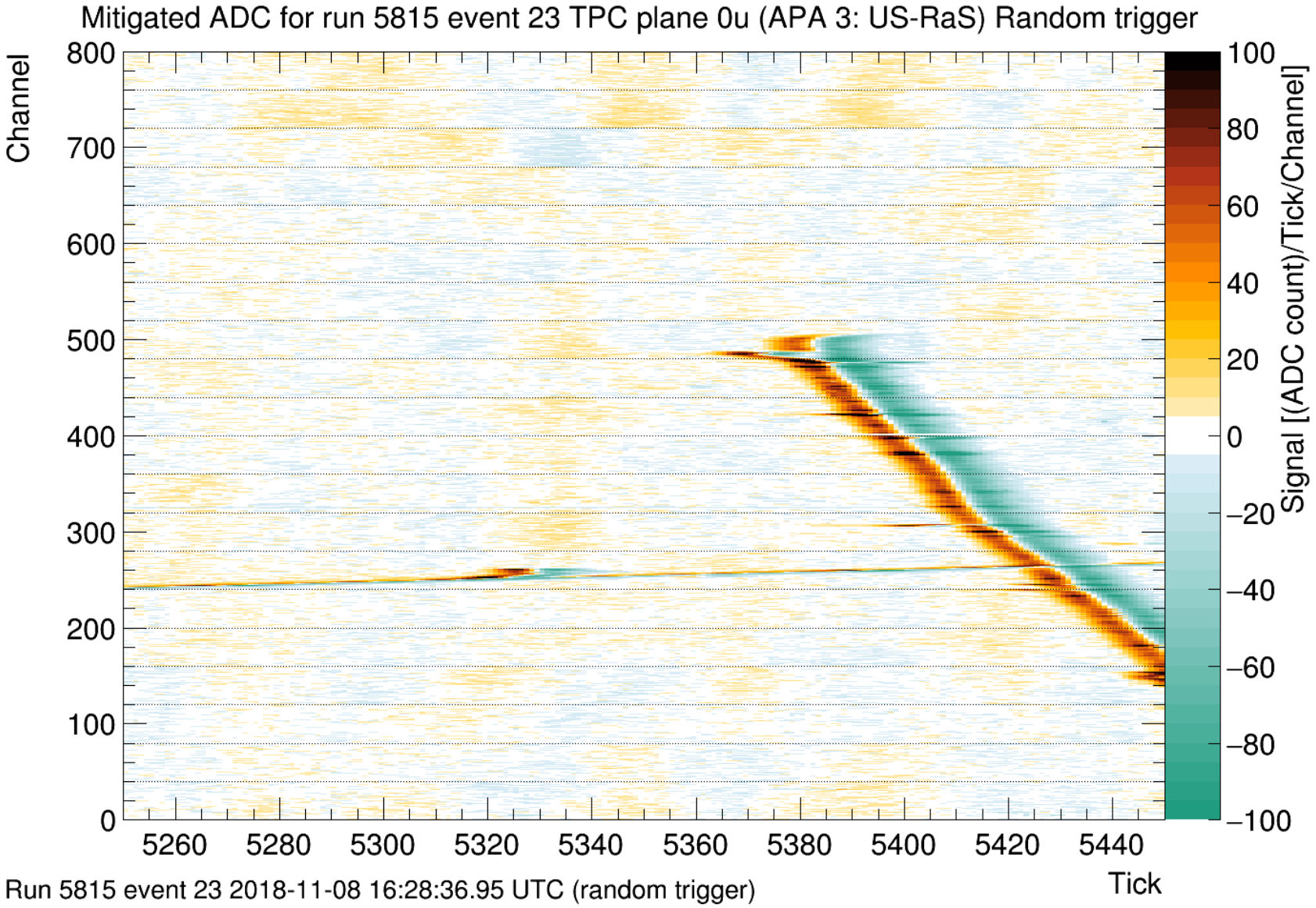
0.9993, 3


Mitigated ADC for run 5815 event 23 TPC plane 0u (APA 3: US-RaS) Random trigger
Channel
800
700
600
500
400
300
200
100
0
5260
5280
5300
5320
5340
5360
5380
5400
5420
5440
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

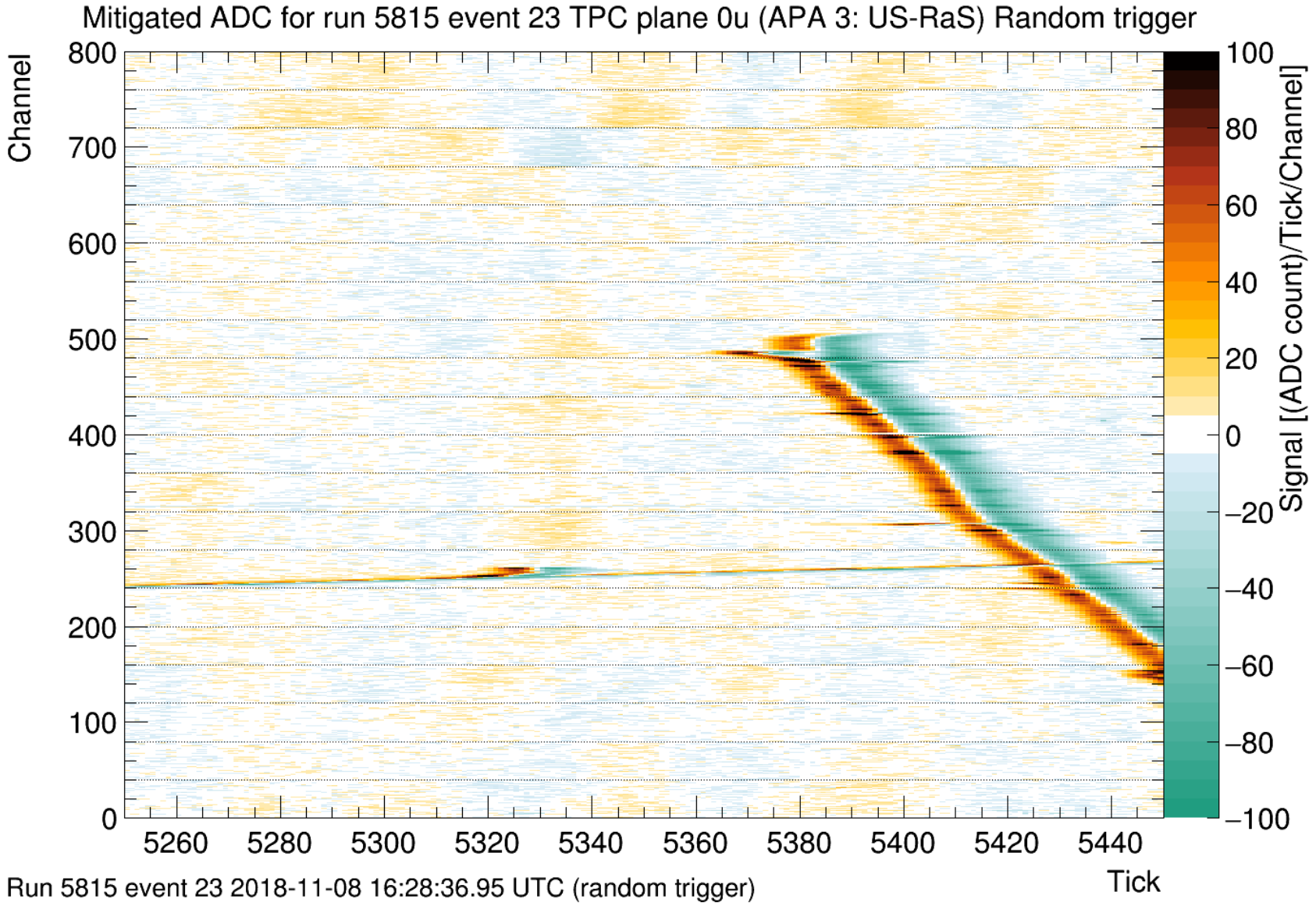
0.9993, 2


Mitigated ADC for run 5815 event 23 TPC plane 0u (APA 3: US-RaS) Random trigger
Channel
800
700
600
500
400
300
200
100
0
5260
5280
5300
5320
5340
5360
5380
5400
5420
5440
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

0.9993, 1

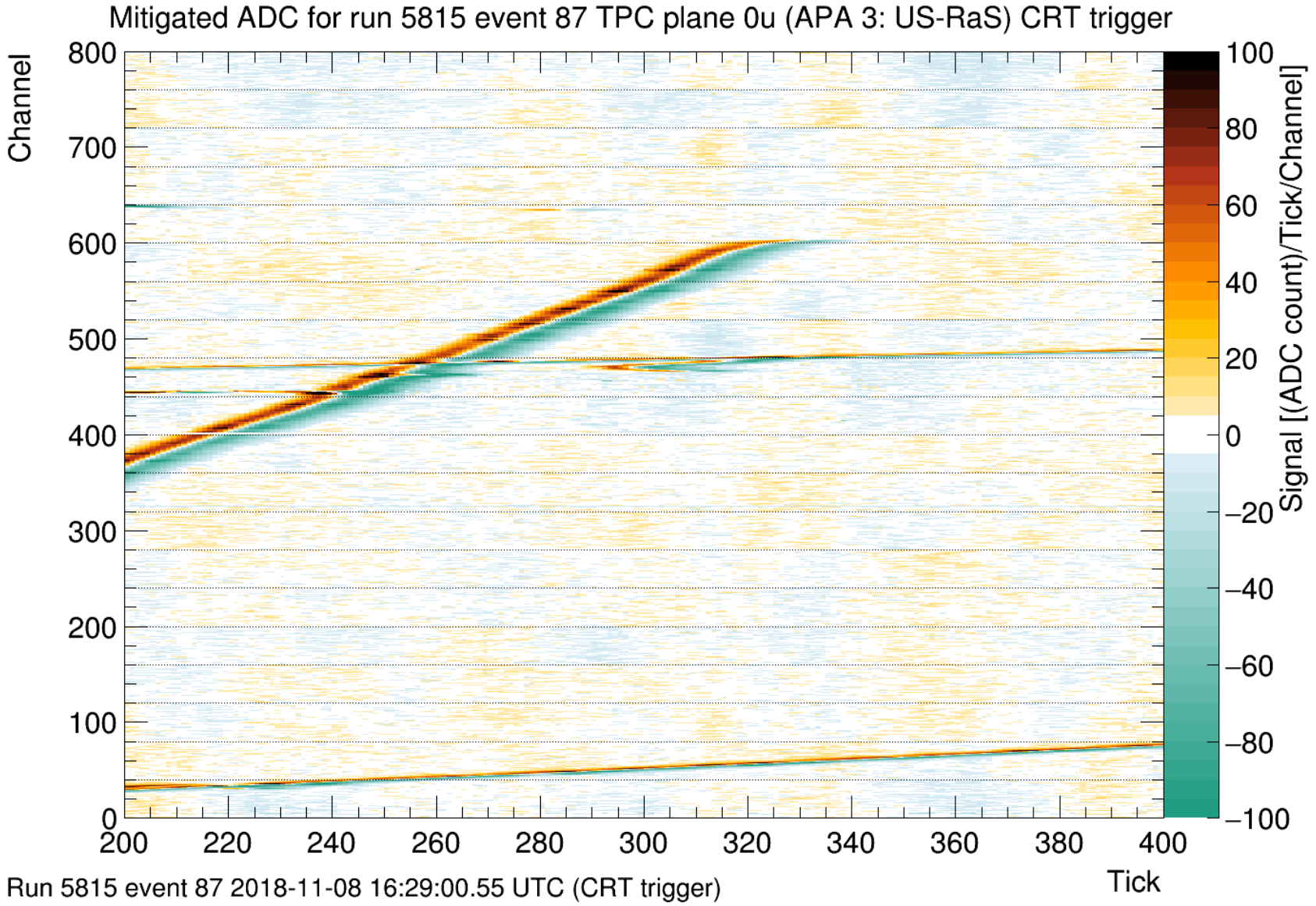

Mitigated ADC for run 5815 event 23 TPC plane 0u (APA 3: US-RaS) Random trigger
Channel
800
700
600
500
400
300
200
100
0
5260
5280
5300
5320
5340
5360
5380
5400
5420
5440
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

0.9993, 0

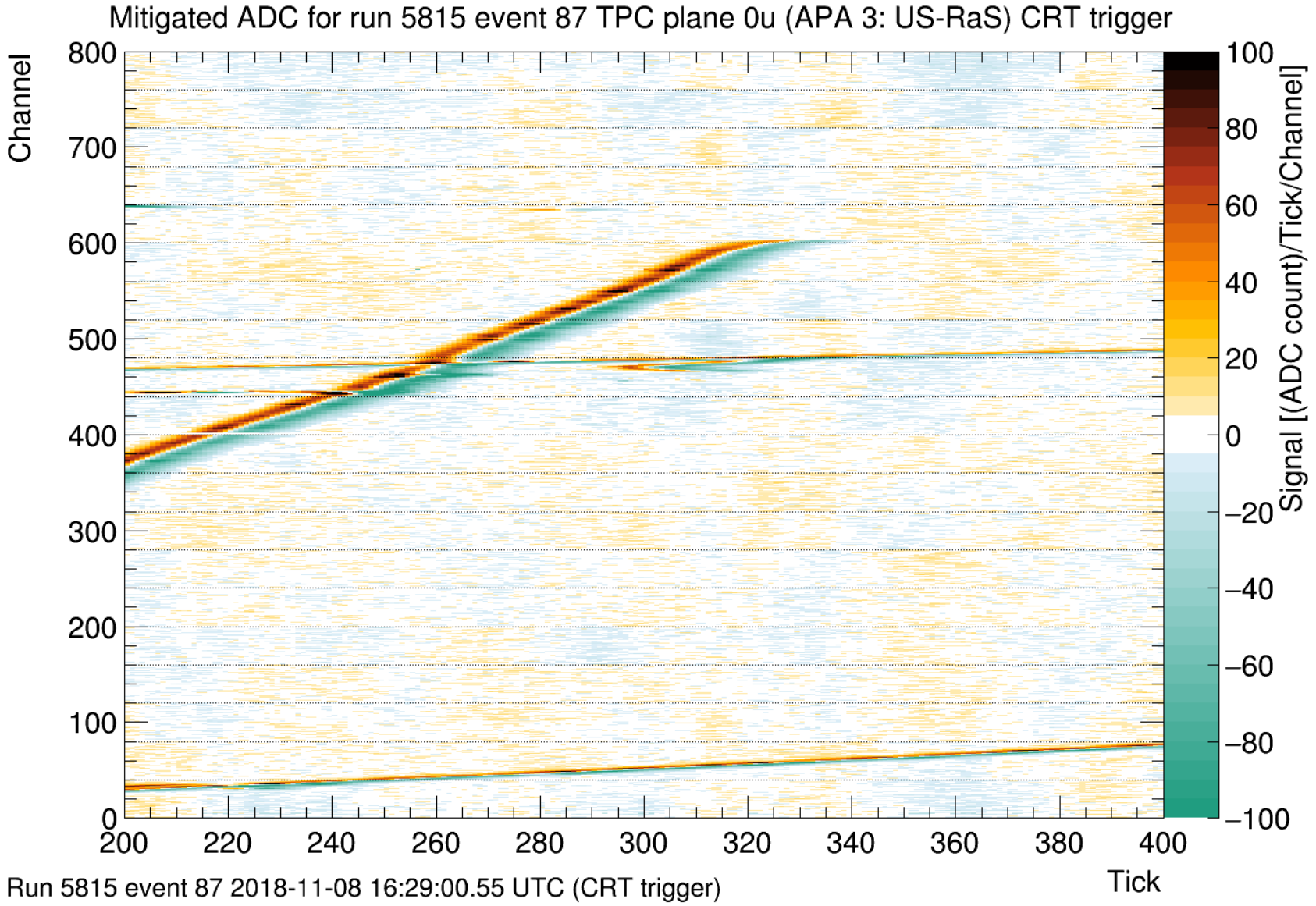

Mitigated ADC for run 5815 event 23 TPC plane 0u (APA 3: US-RaS) Random trigger
Channel
800
700
600
500
400
300
200
100
0
5260
5280
5300
5320
5340
5360
5380
5400
5420
5440
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

Event 87 u200-400

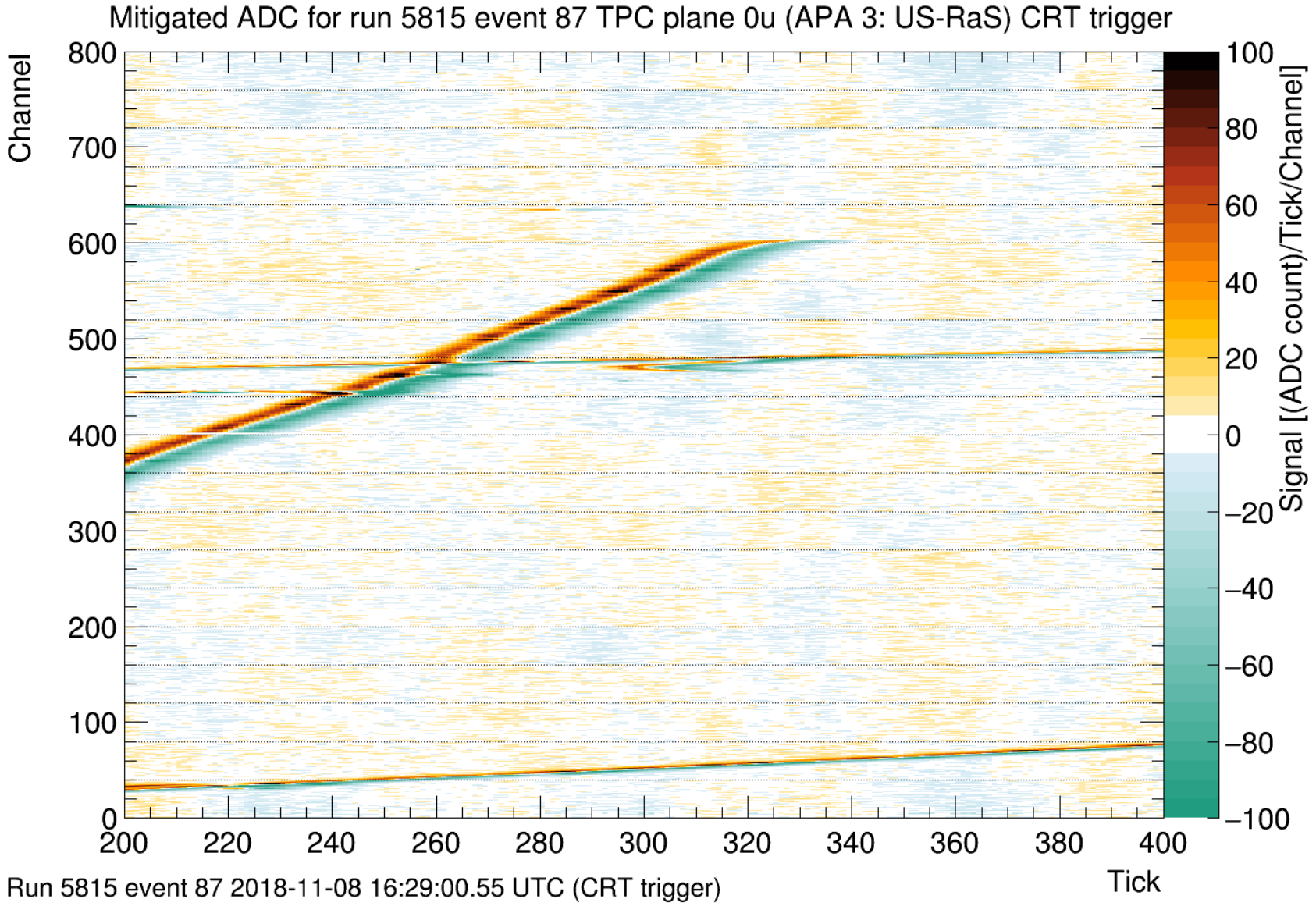
1.0, 0 (no correction)



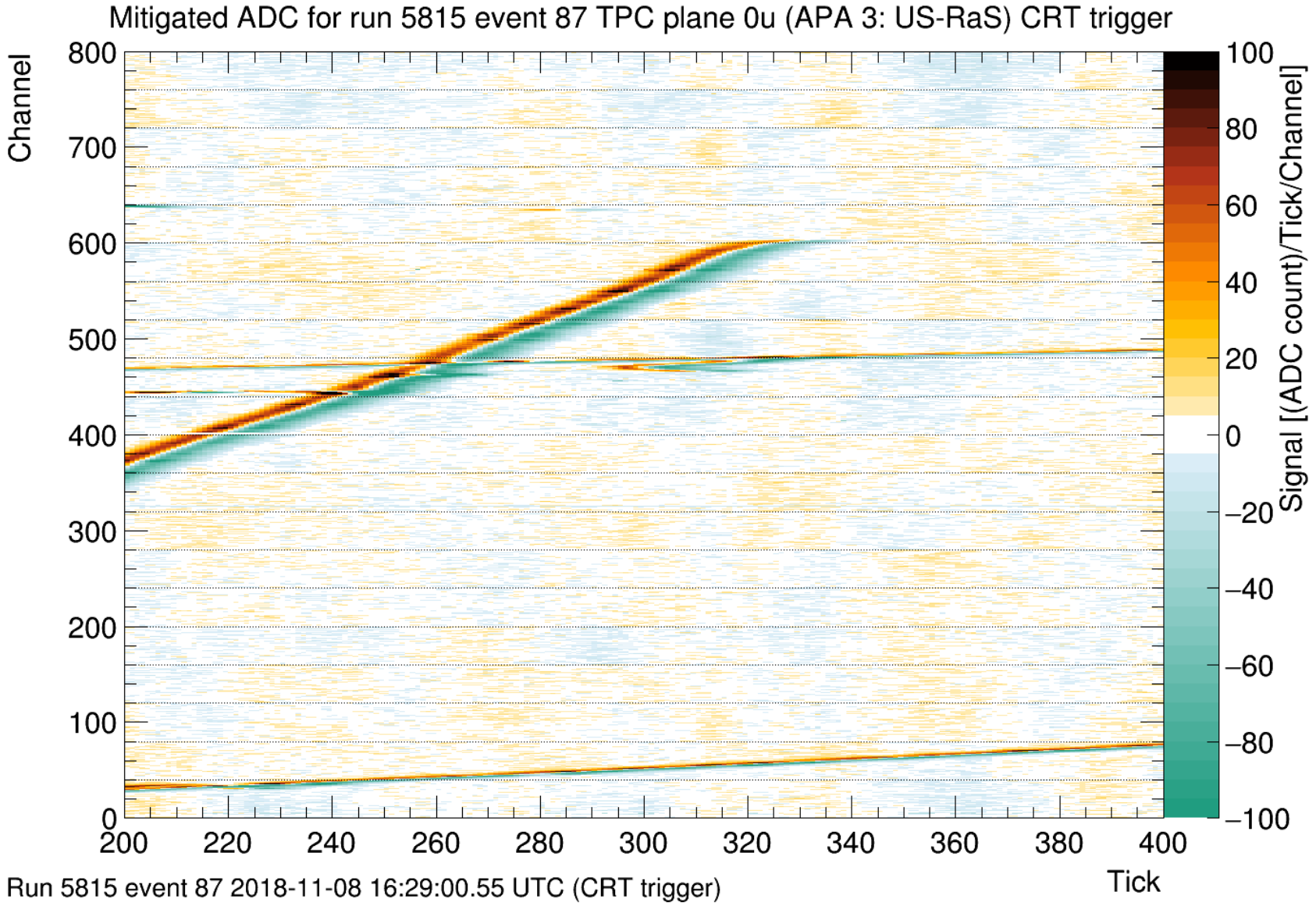
0.9995, 3 (Dec 2018 correction)



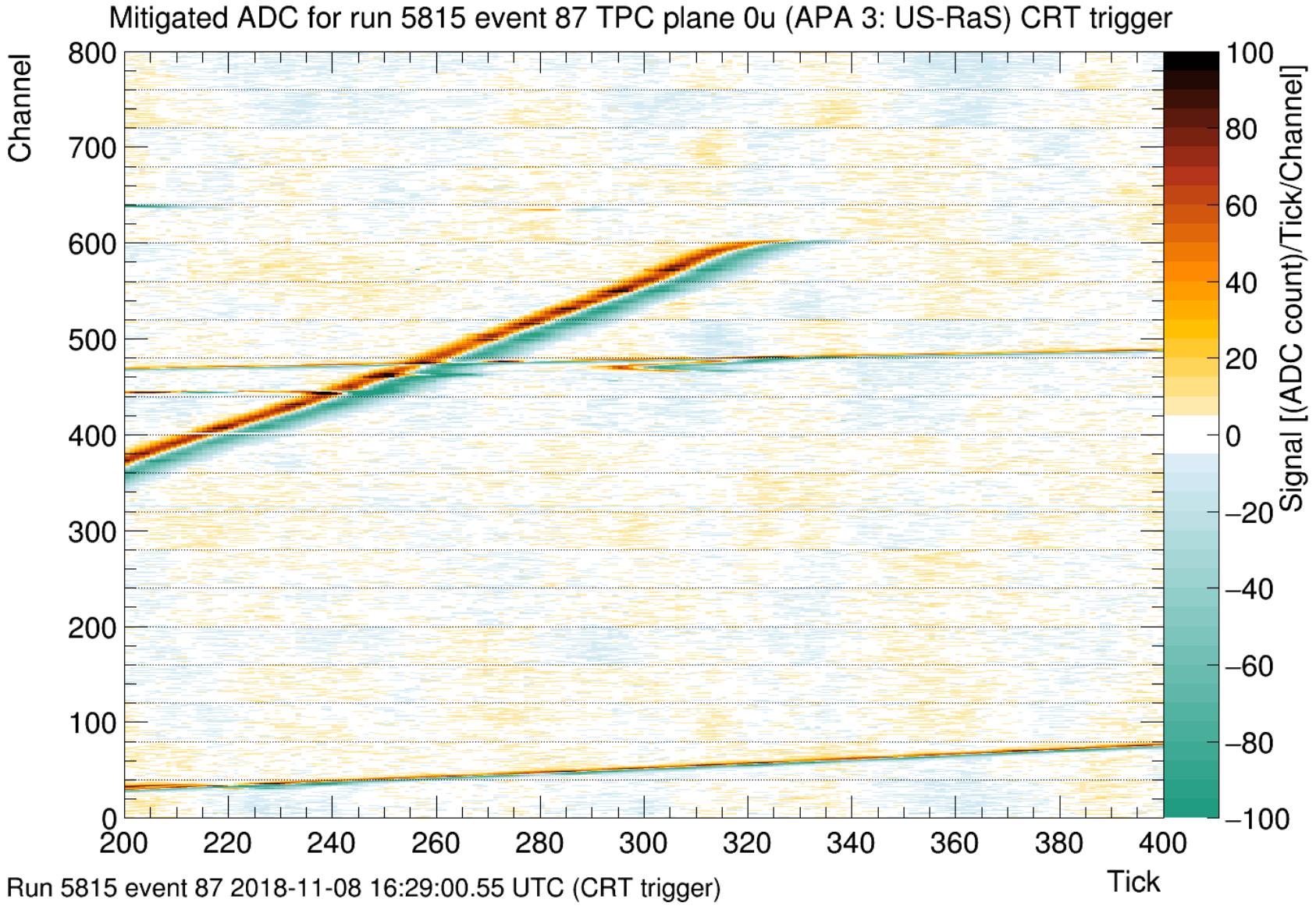
0.9993, 3


Mitigated ADC for run 5815 event 87 TPC plane 0u (APA 3: US-RaS) CRT trigger
Channel
800
700
600
500
400
300
200
100
0
200
220
240
260
280
300
320
340
360
380
400
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 87 2018-11-08 16:29:00.55 UTC (CRT trigger)

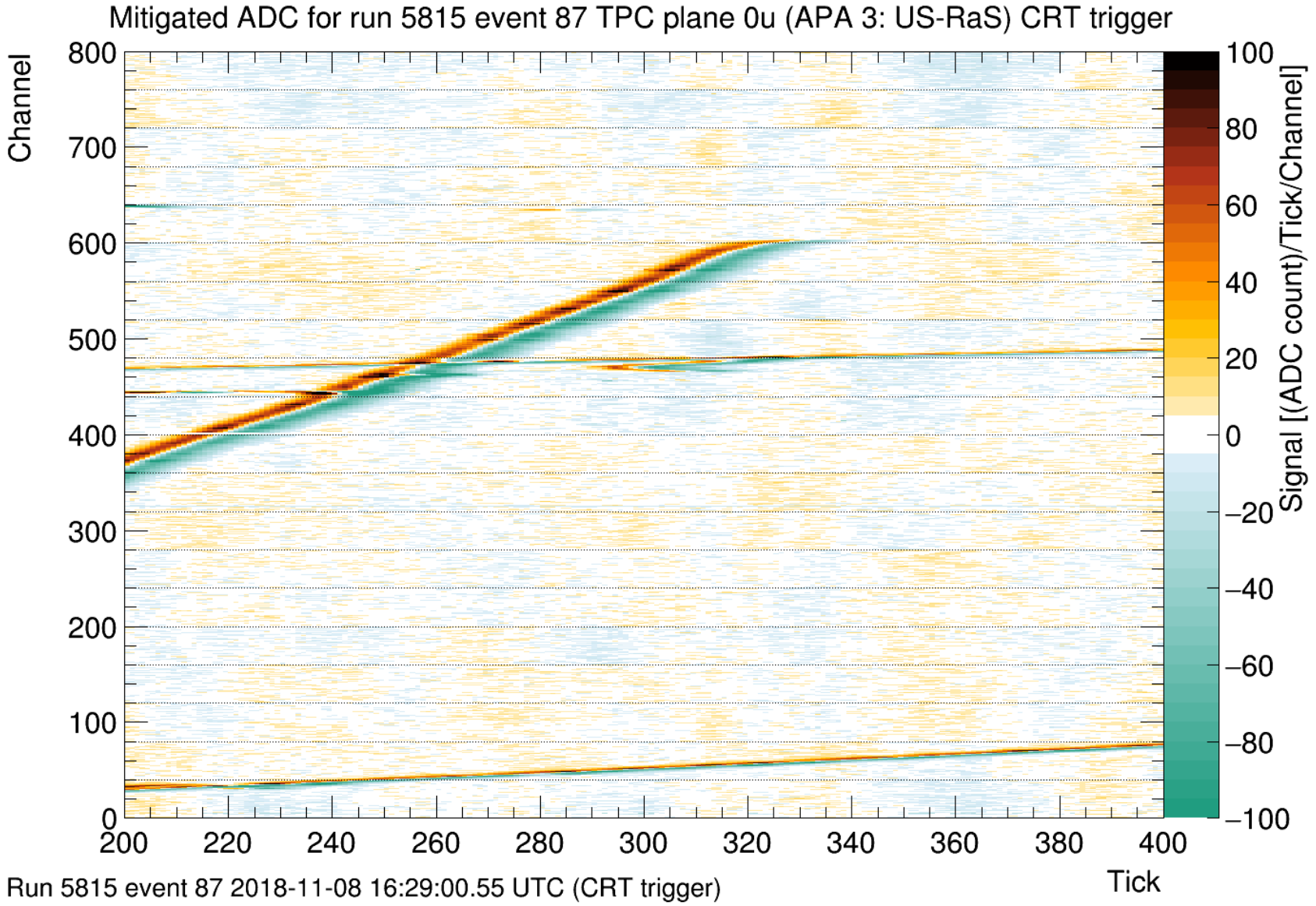
0.9993, 2


Mitigated ADC for run 5815 event 87 TPC plane 0u (APA 3: US-RaS) CRT trigger
Channel
800
700
600
500
400
300
200
100
0
200
220
240
260
280
300
320
340
360
380
400
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 87 2018-11-08 16:29:00.55 UTC (CRT trigger)

0.9993, 1

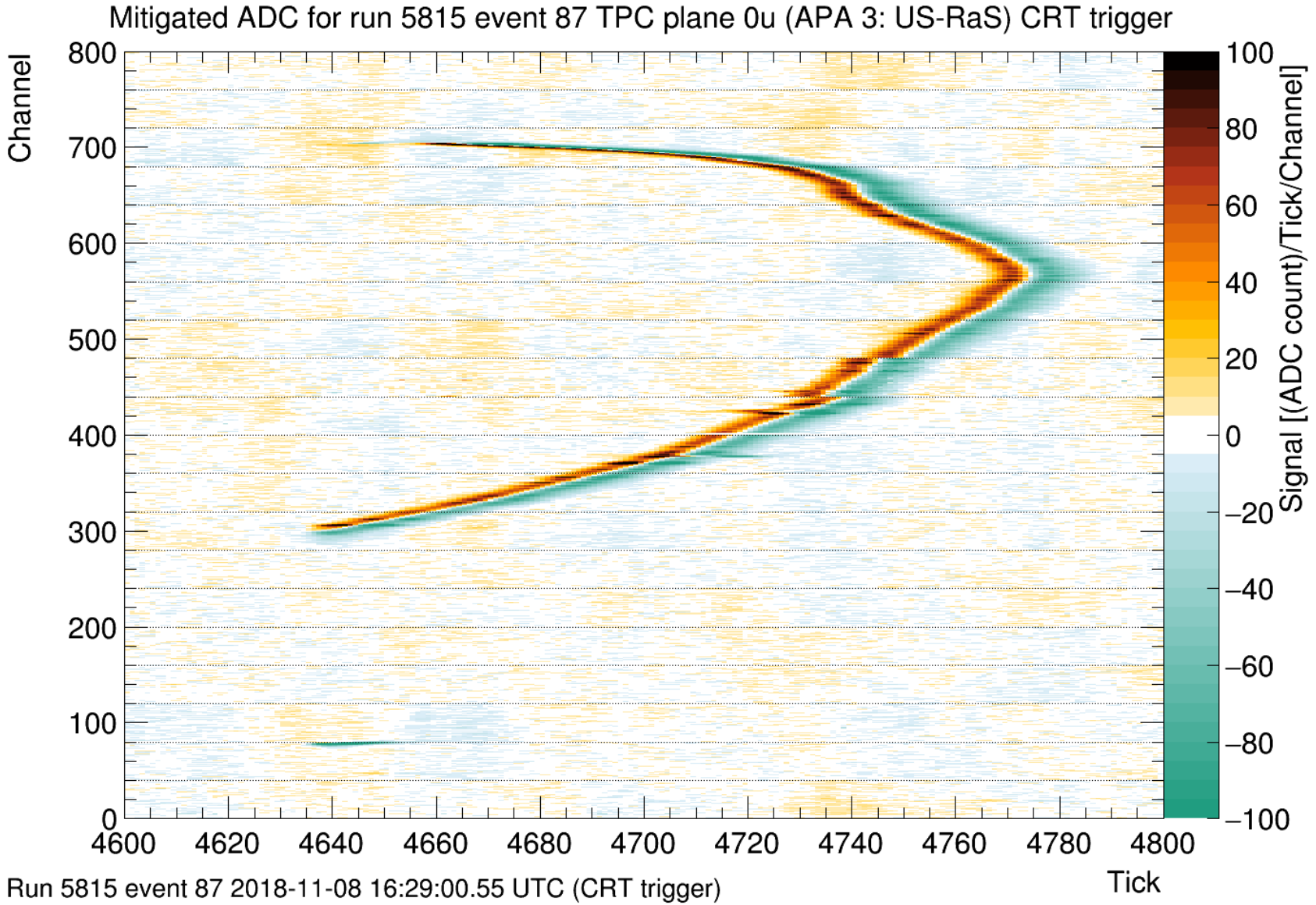

Mitigated ADC for run 5815 event 87 TPC plane 0u (APA 3: US-RaS) CRT trigger
Channel
800
700
600
500
400
300
200
100
0
200
220
240
260
280
300
320
340
360
380
400
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 87 2018-11-08 16:29:00.55 UTC (CRT trigger)

0.9993, 0

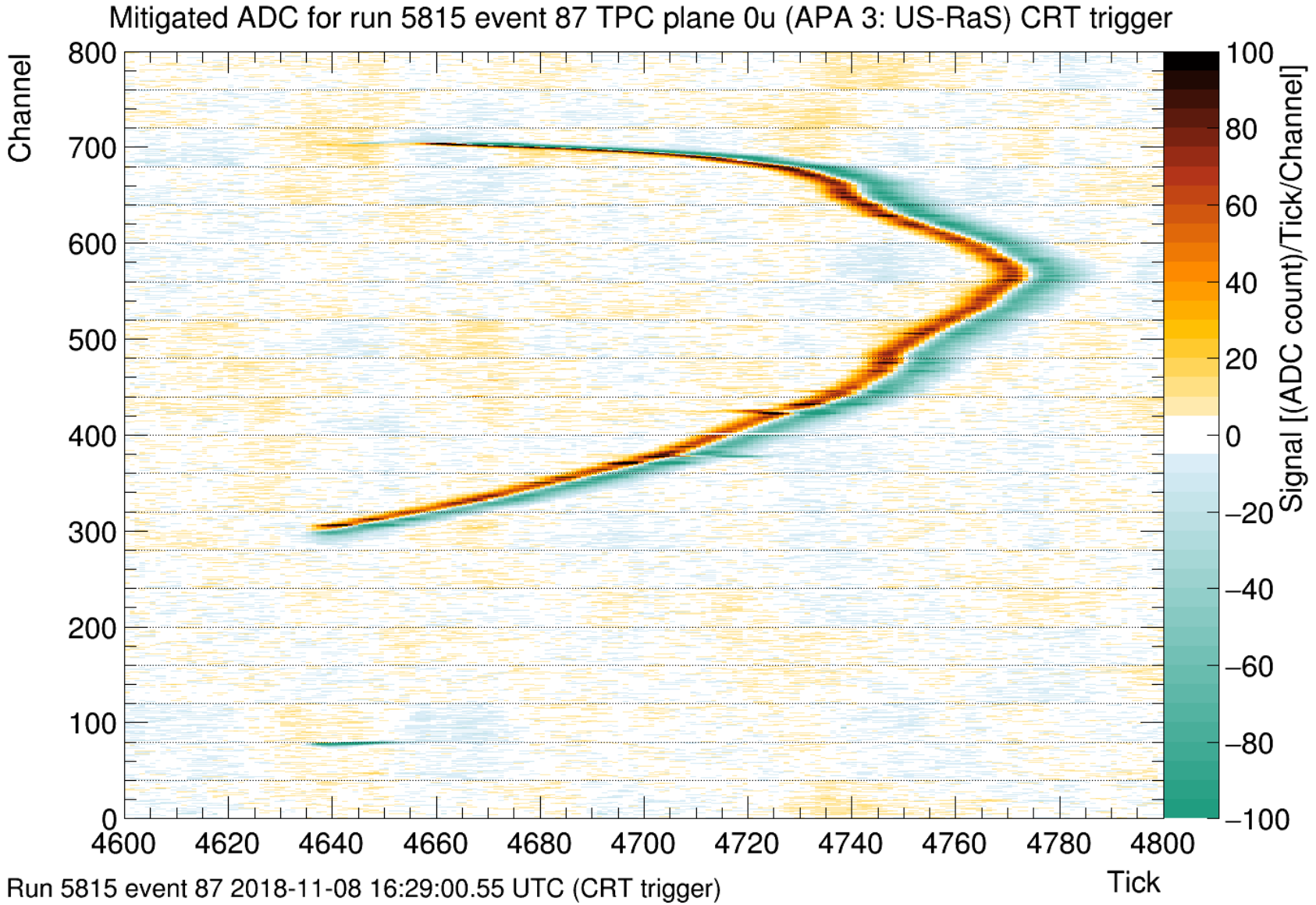

Mitigated ADC for run 5815 event 87 TPC plane 0u (APA 3: US-RaS) CRT trigger
Channel
800
700
600
500
400
300
200
100
0
200
220
240
260
280
300
320
340
360
380
400
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 87 2018-11-08 16:29:00.55 UTC (CRT trigger)

Event u

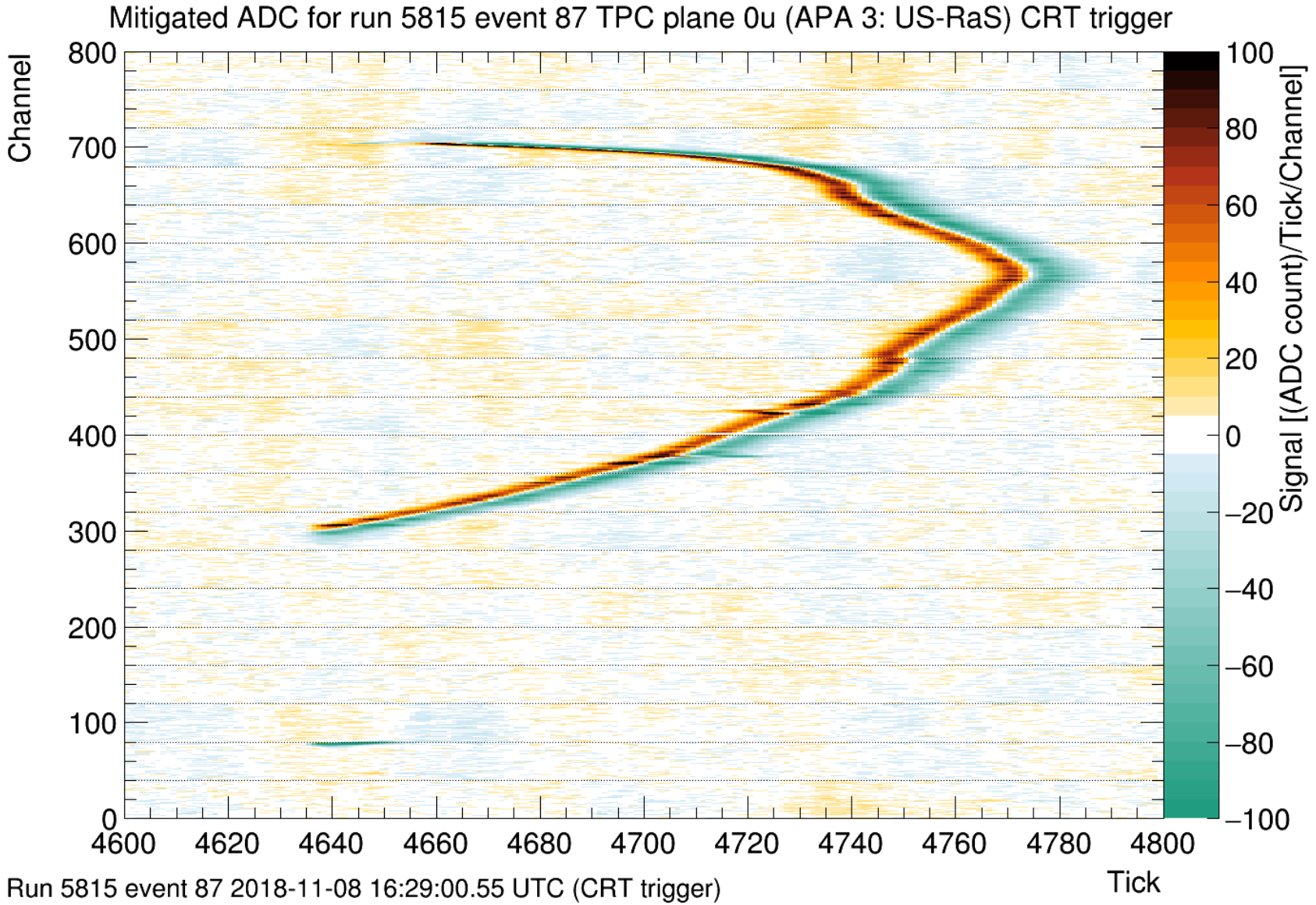
1.0, 0 (no correction)



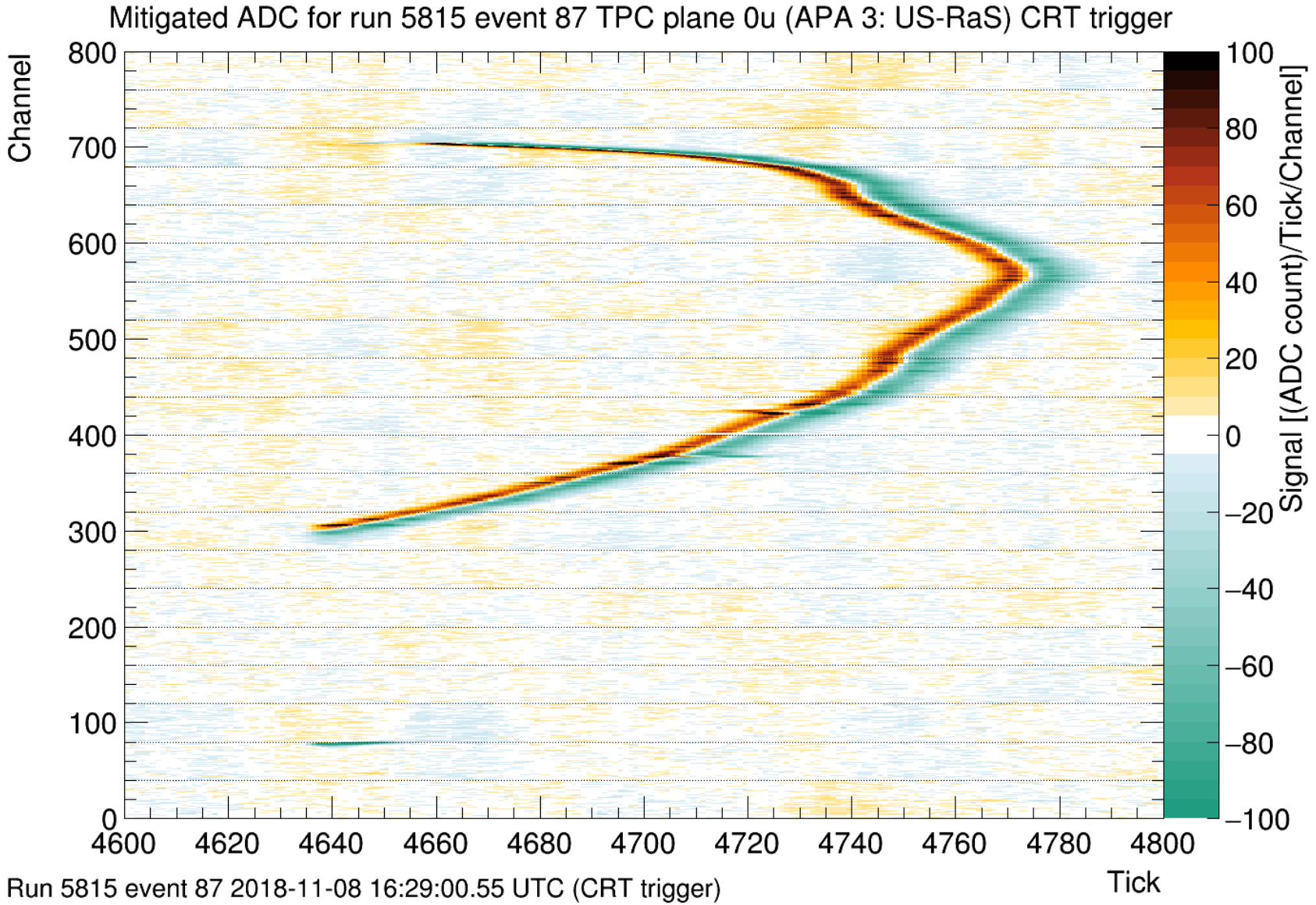
0.9995, 3 (Dec 2018 correction)



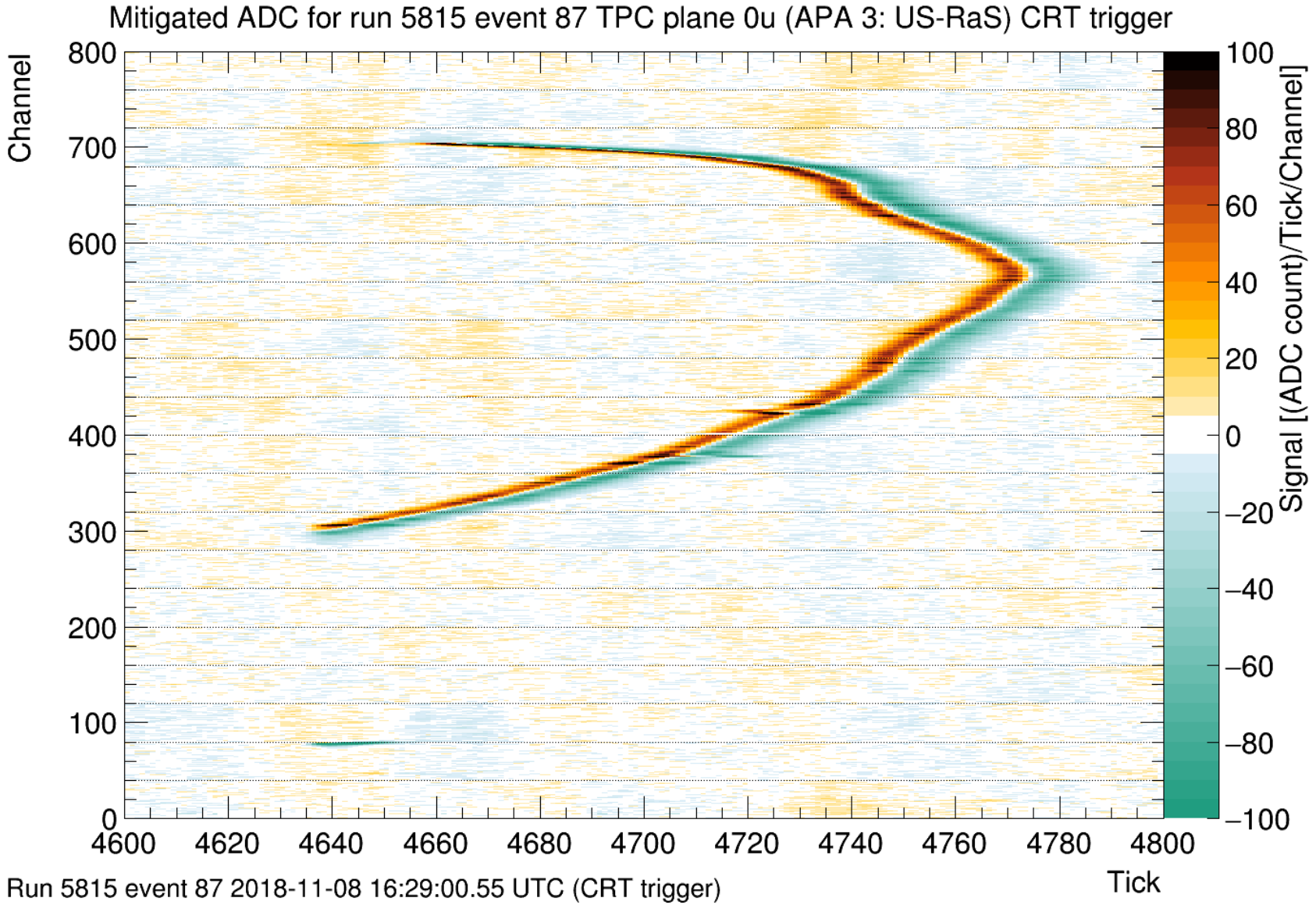
0.9993, 3


Mitigated ADC for run 5815 event 87 TPC plane 0u (APA 3: US-RaS) CRT trigger
Channel
800
700
600
500
400
300
200
100
0
4600
4620
4640
4660
4680
4700
4720
4740
4760
4780
4800
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 87 2018-11-08 16:29:00.55 UTC (CRT trigger)

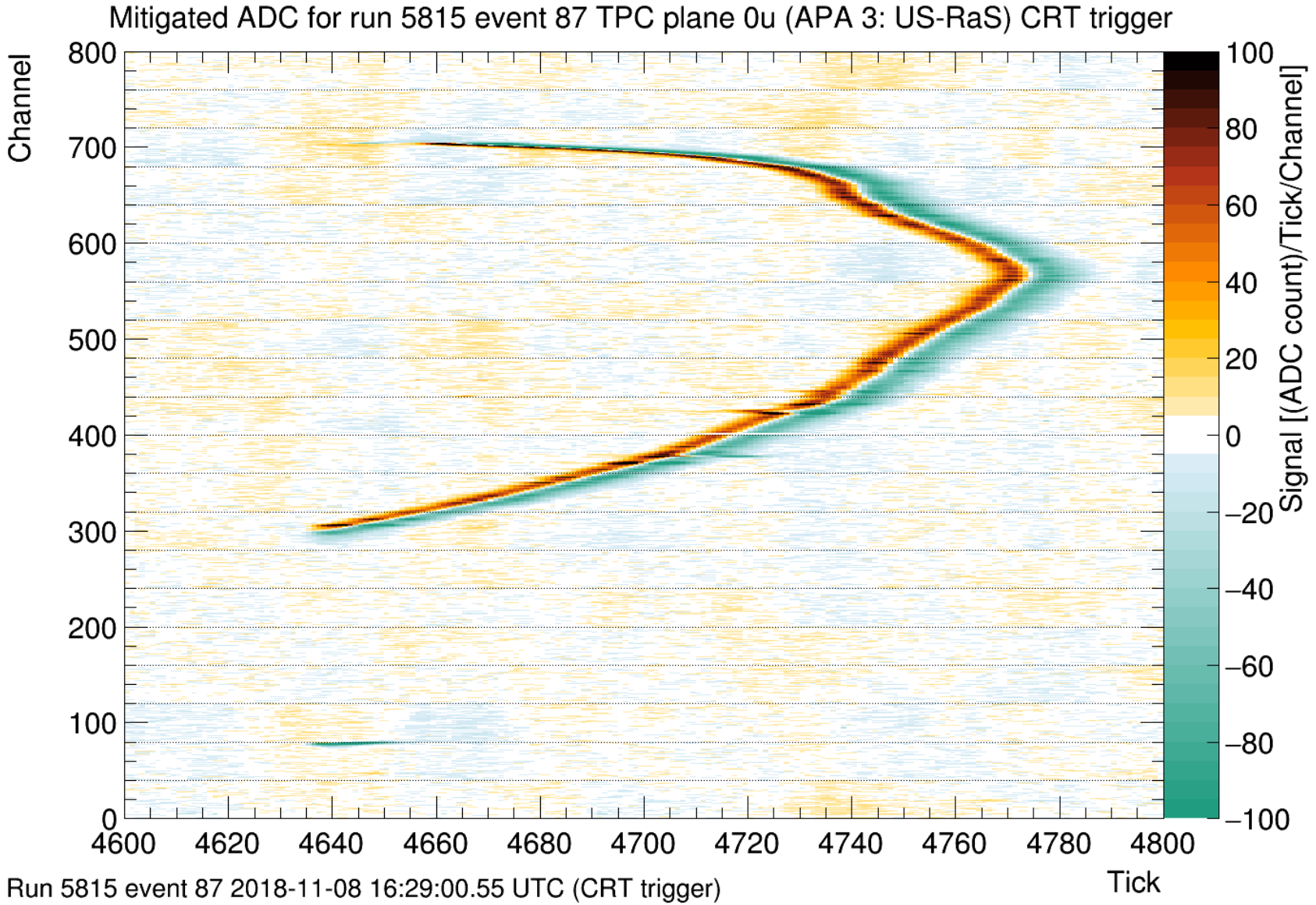
0.9993, 2


Mitigated ADC for run 5815 event 87 TPC plane 0u (APA 3: US-RaS) CRT trigger
Channel
800
700
600
500
400
300
200
100
0
4600
4620
4640
4660
4680
4700
4720
4740
4760
4780
4800
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 87 2018-11-08 16:29:00.55 UTC (CRT trigger)

0.9993, 1

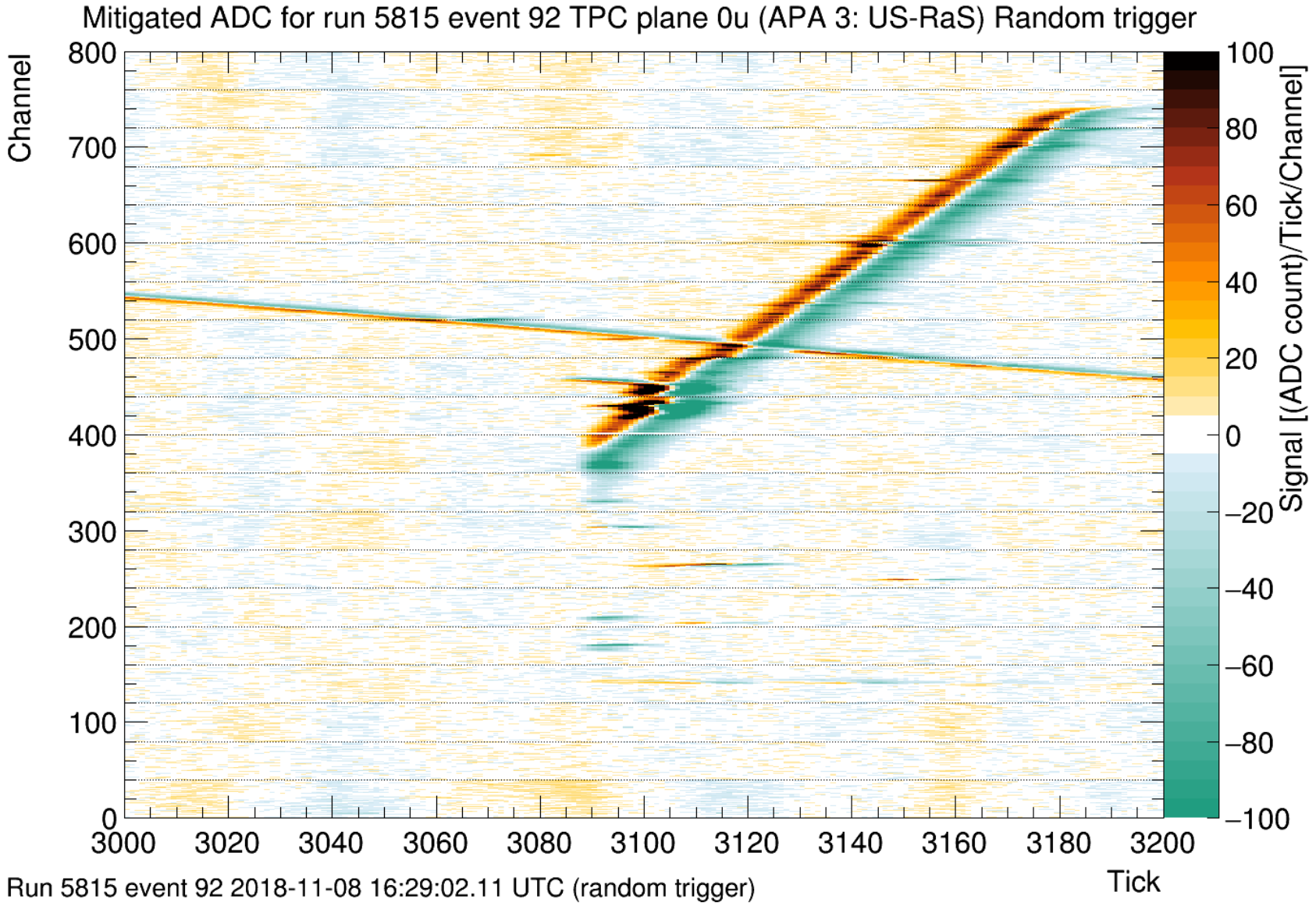

Mitigated ADC for run 5815 event 87 TPC plane 0u (APA 3: US-RaS) CRT trigger
Channel
800
700
600
500
400
300
200
100
0
4600
4620
4640
4660
4680
4700
4720
4740
4760
4780
4800
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 87 2018-11-08 16:29:00.55 UTC (CRT trigger)

0.9993, 0

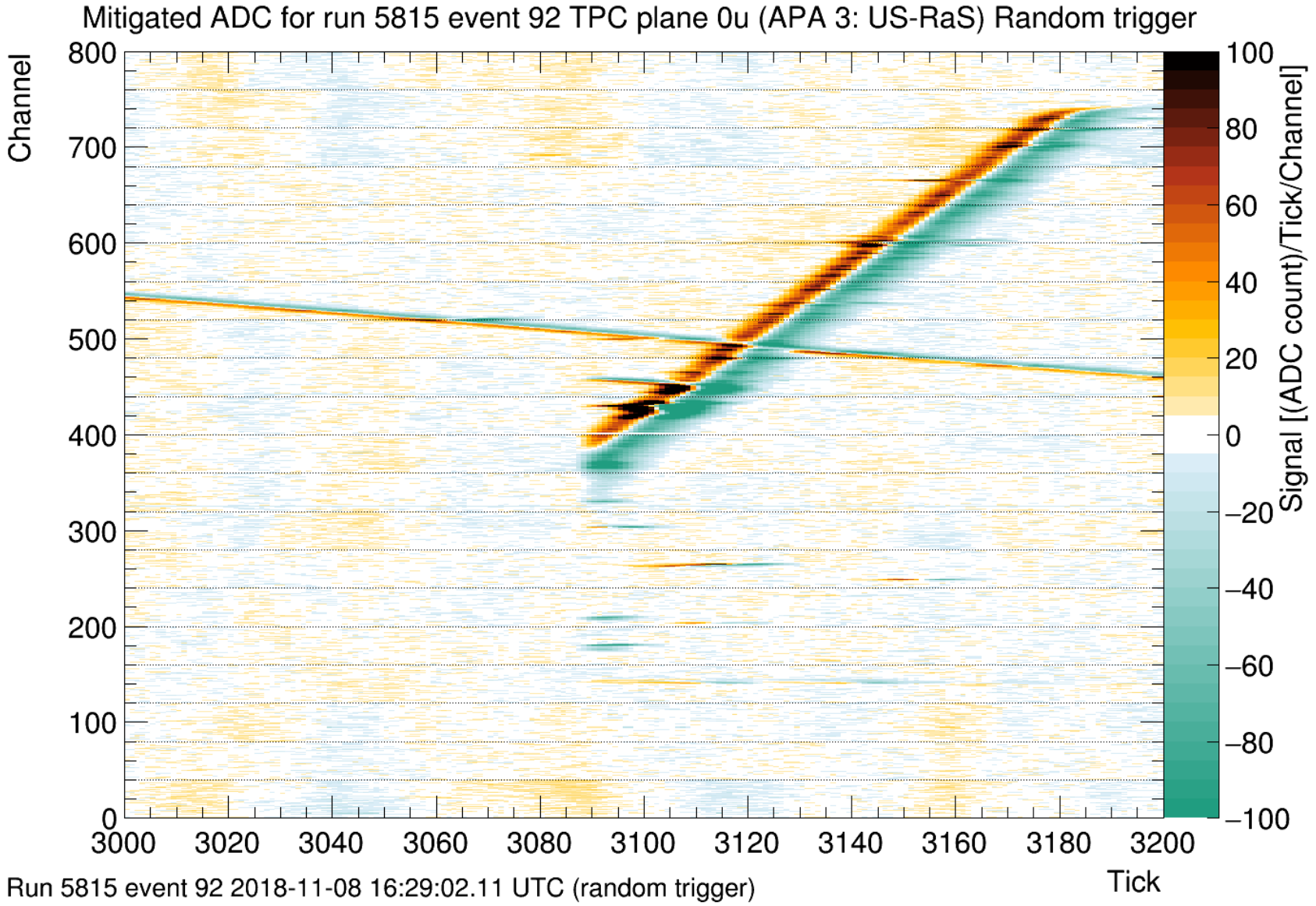

Mitigated ADC for run 5815 event 87 TPC plane 0u (APA 3: US-RaS) CRT trigger
Channel
800
700
600
500
400
300
200
100
0
4600
4620
4640
4660
4680
4700
4720
4740
4760
4780
4800
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 87 2018-11-08 16:29:00.55 UTC (CRT trigger)

Event 92 u3000-3200

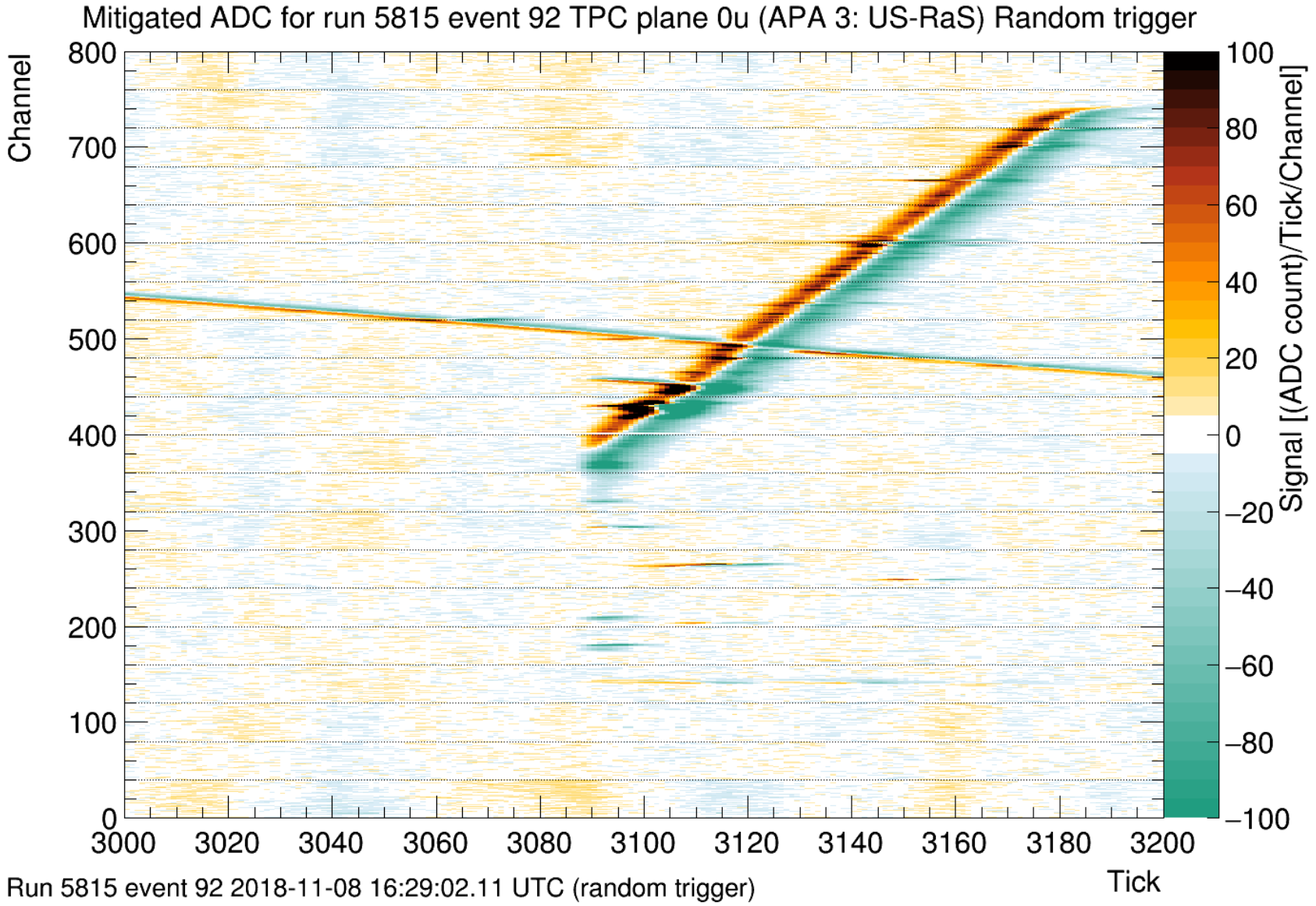
1.0, 0 (no correction)



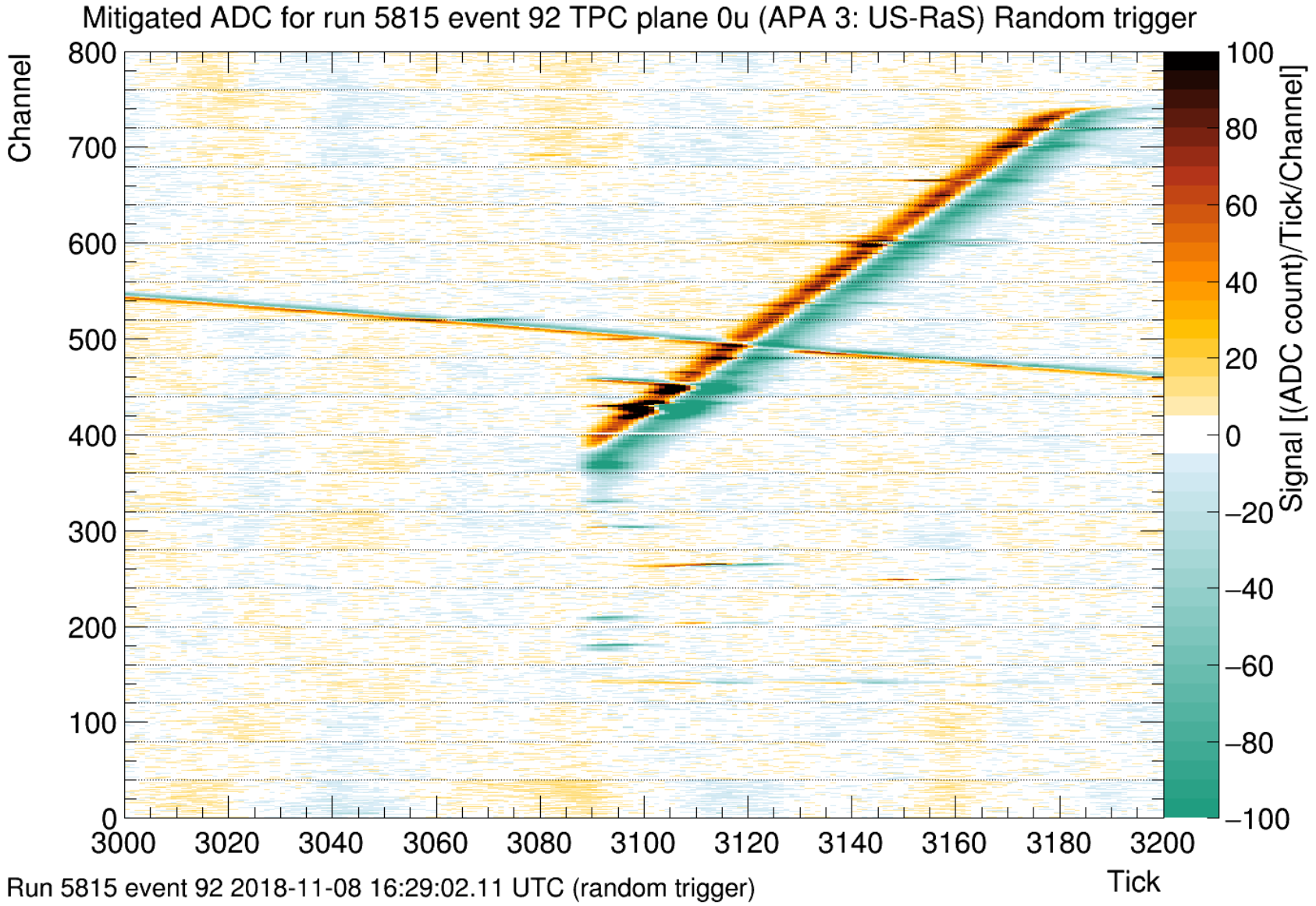
0.9995, 3 (Dec 2018 correction)



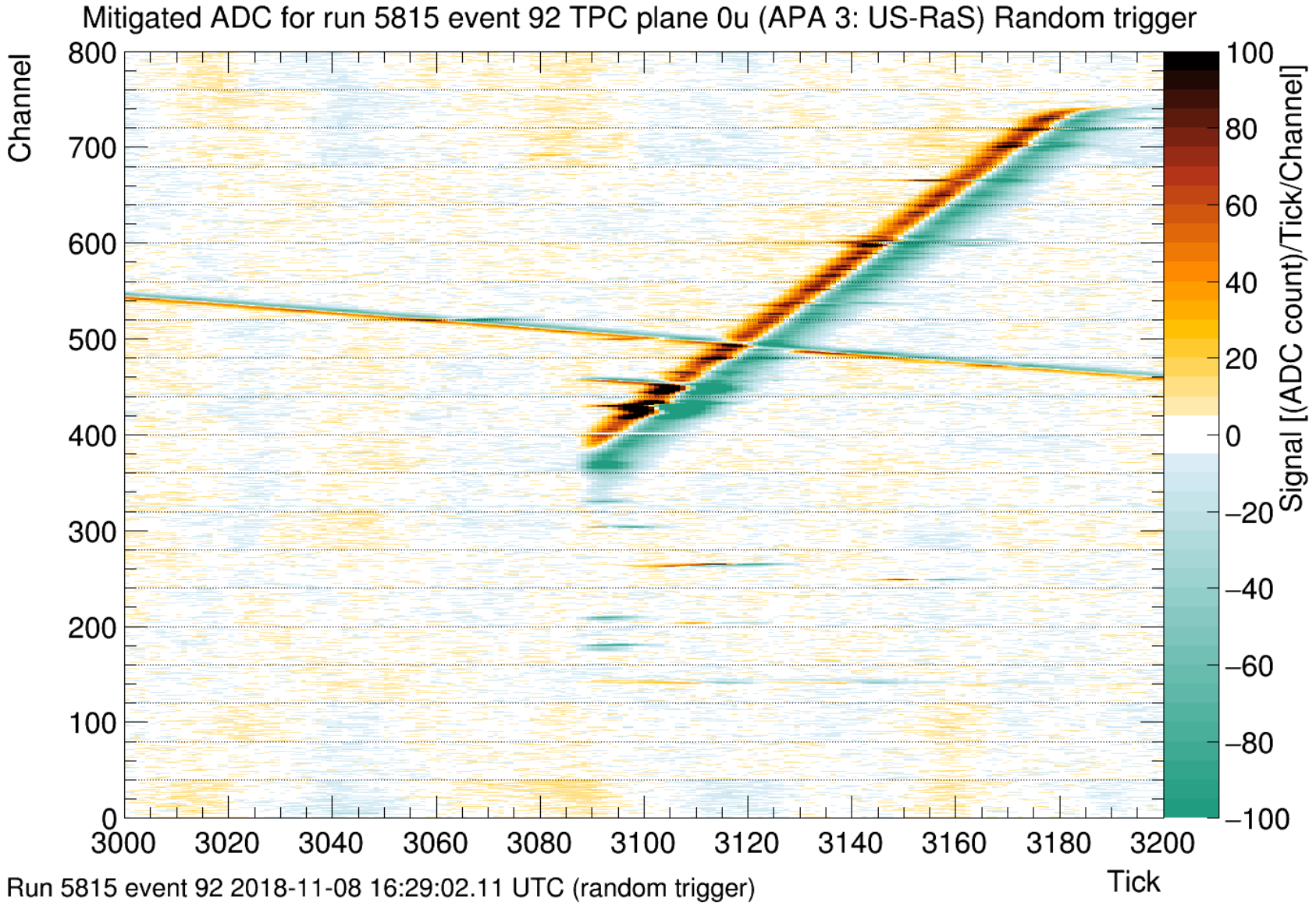
0.9993, 3


Mitigated ADC for run 5815 event 92 TPC plane 0u (APA 3: US-RaS) Random trigger
Channel
800
700
600
500
400
300
200
100
0
3000
3020
3040
3060
3080
3100
3120
3140
3160
3180
3200
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 92 2018-11-08 16:29:02.11 UTC (random trigger)

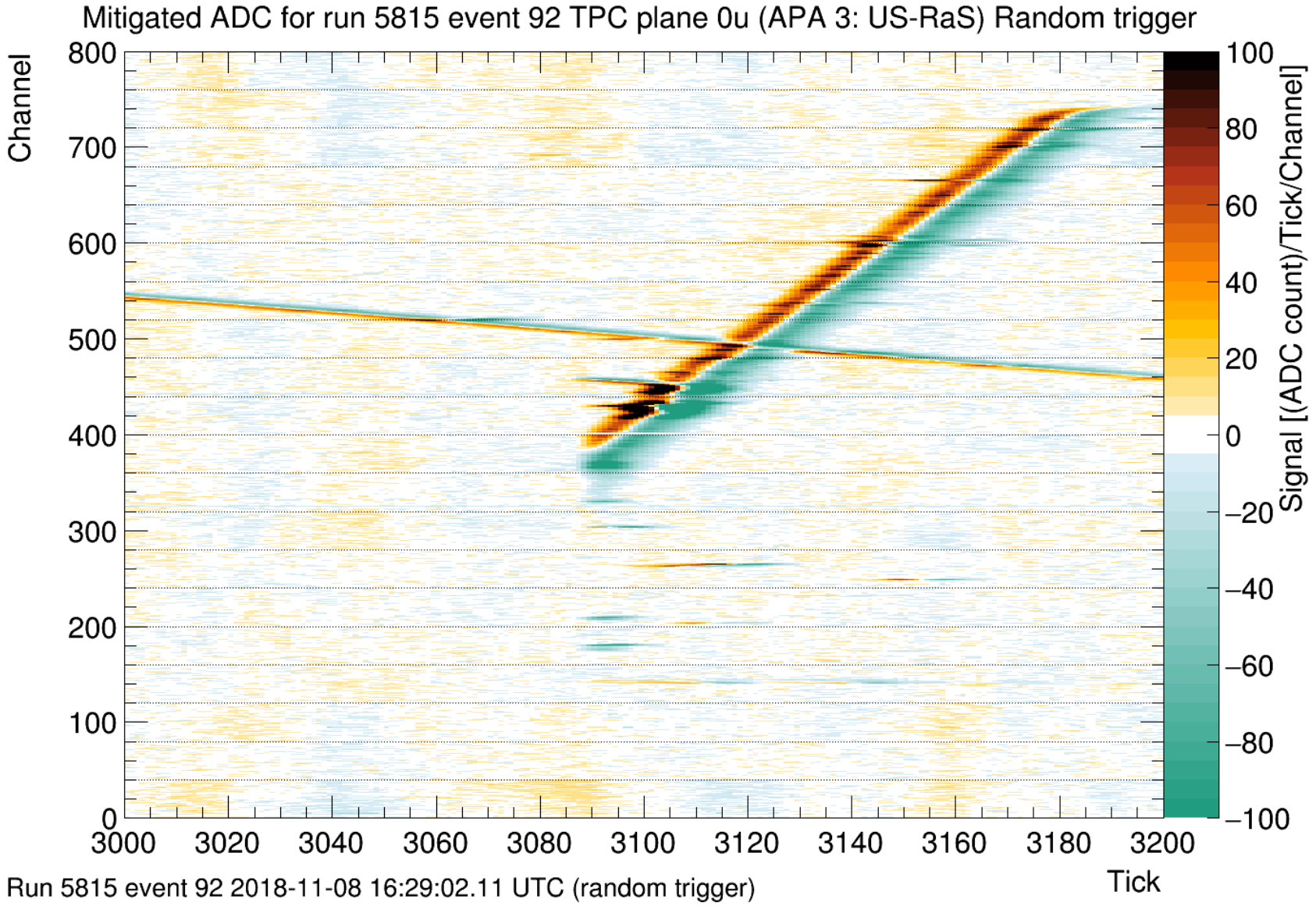
0.9993, 2


Mitigated ADC for run 5815 event 92 TPC plane 0u (APA 3: US-RaS) Random trigger
Channel
800
700
600
500
400
300
200
100
0
3000
3020
3040
3060
3080
3100
3120
3140
3160
3180
3200
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 92 2018-11-08 16:29:02.11 UTC (random trigger)

0.9993, 1

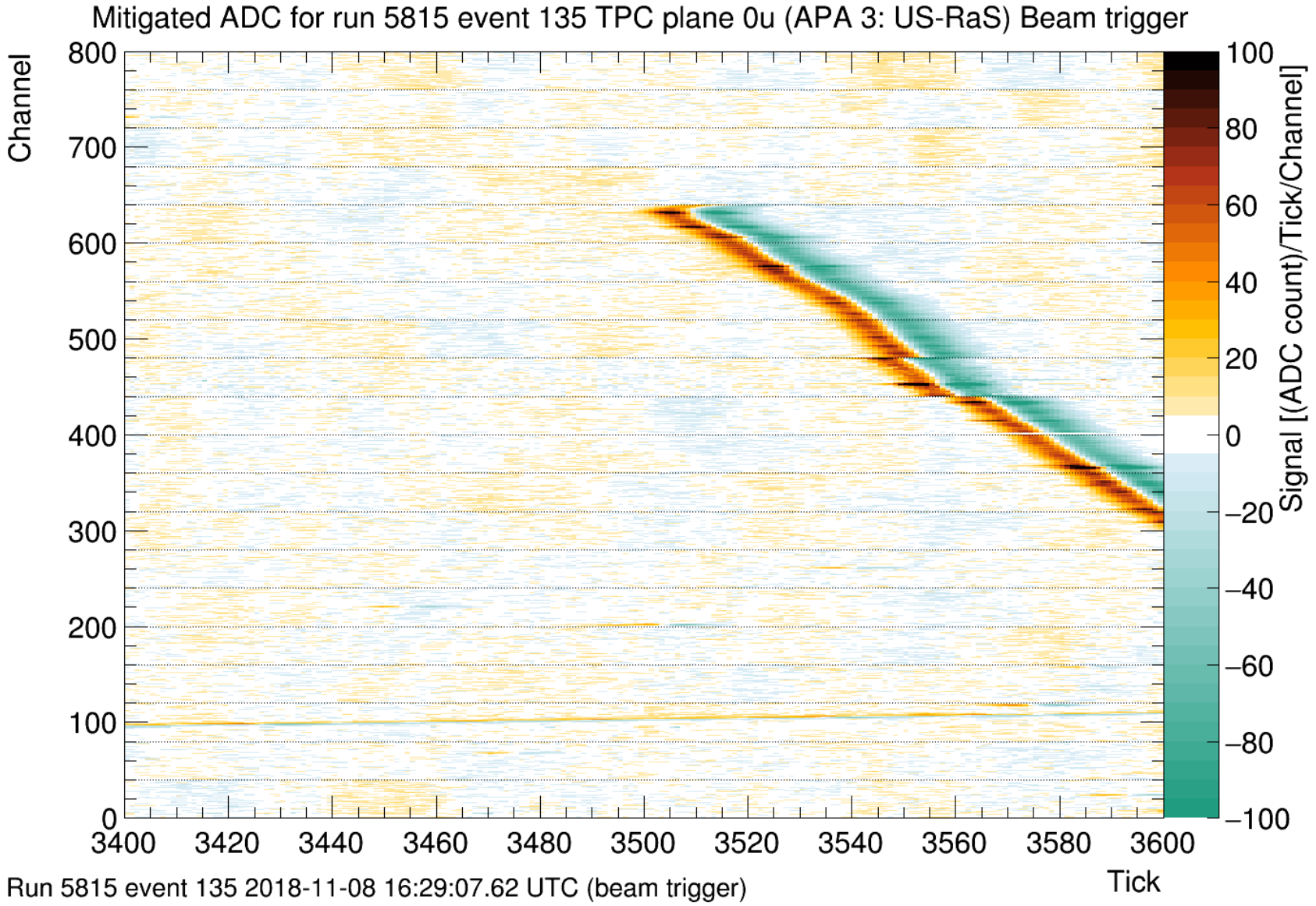

Mitigated ADC for run 5815 event 92 TPC plane 0u (APA 3: US-RaS) Random trigger
Channel
800
700
600
500
400
300
200
100
0
3000
3020
3040
3060
3080
3100
3120
3140
3160
3180
3200
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 92 2018-11-08 16:29:02.11 UTC (random trigger)

0.9993, 0

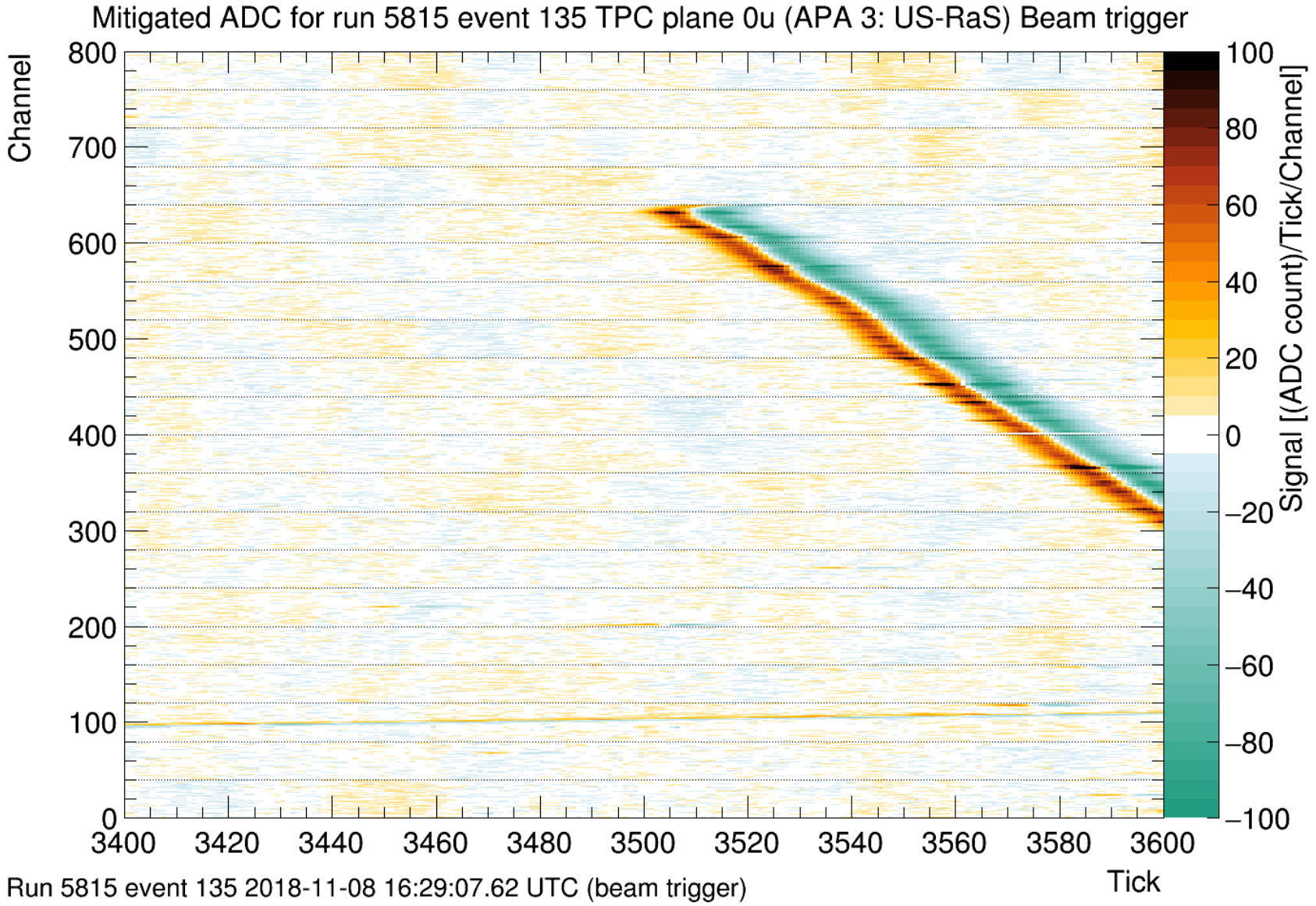

Mitigated ADC for run 5815 event 92 TPC plane 0u (APA 3: US-RaS) Random trigger
Channel
800
700
600
500
400
300
200
100
0
3000
3020
3040
3060
3080
3100
3120
3140
3160
3180
3200
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 92 2018-11-08 16:29:02.11 UTC (random trigger)

Event 135 u3400-3600

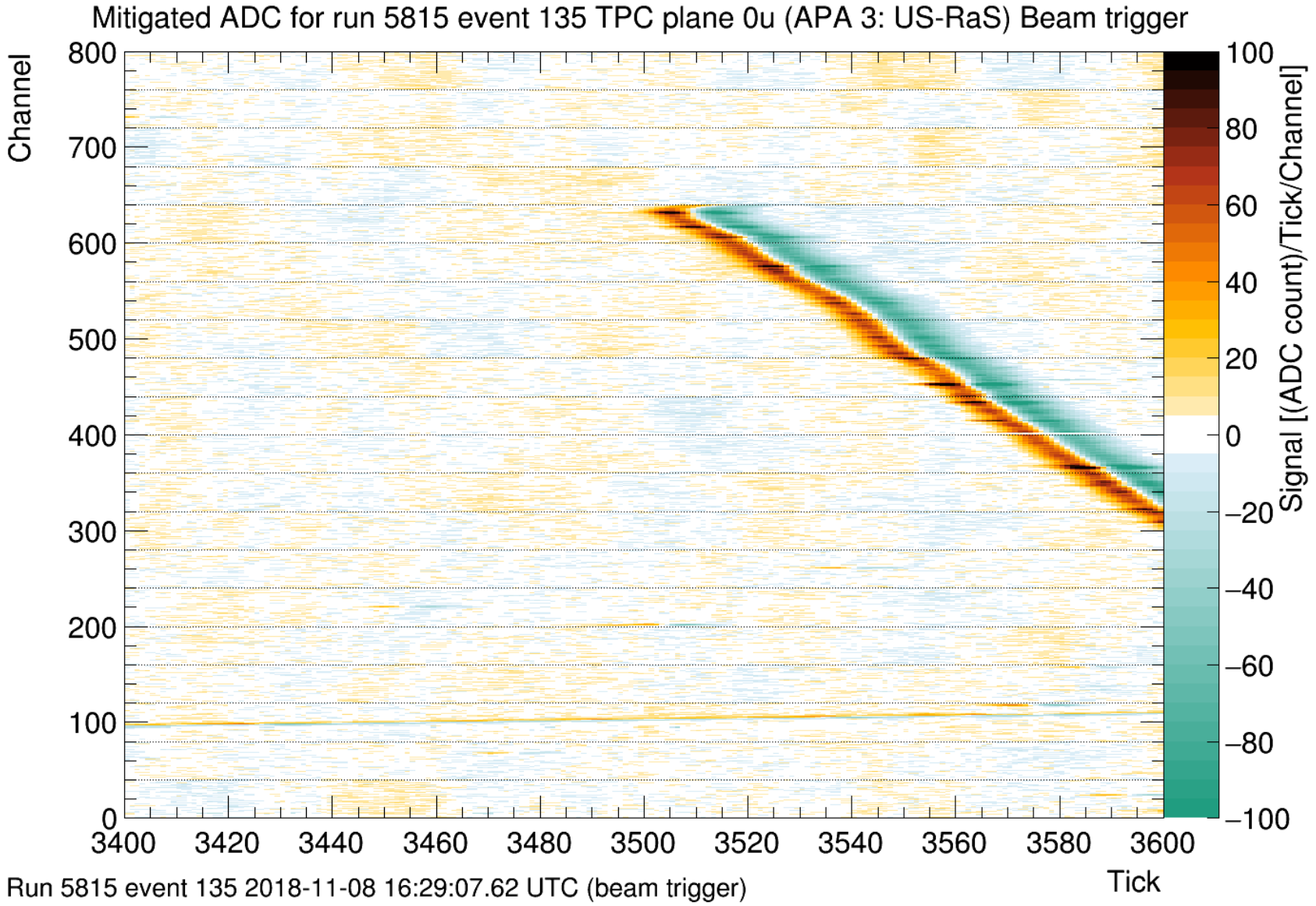
1.0, 0 (no correction)



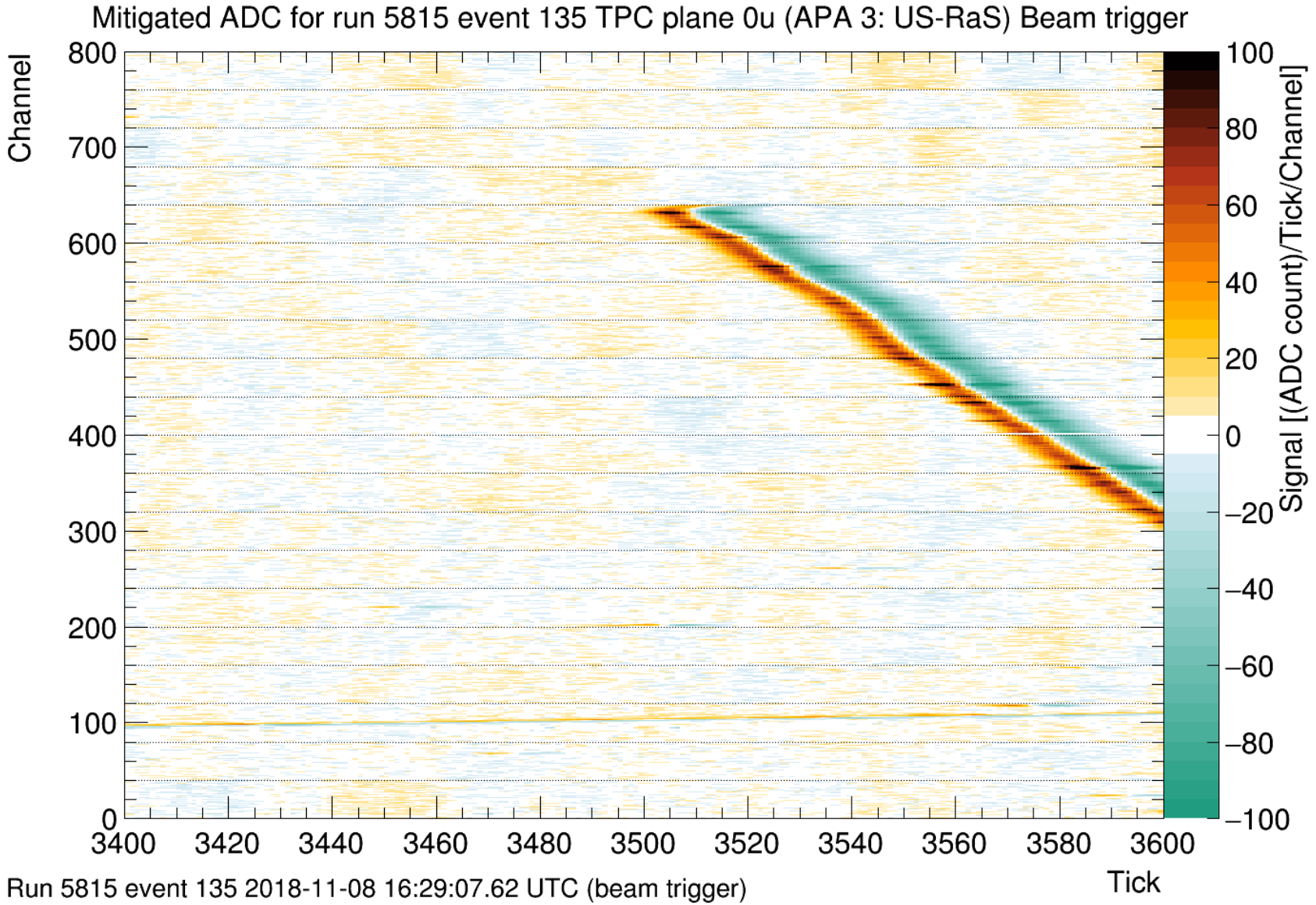
0.9995, 3 (Dec 2018 correction)



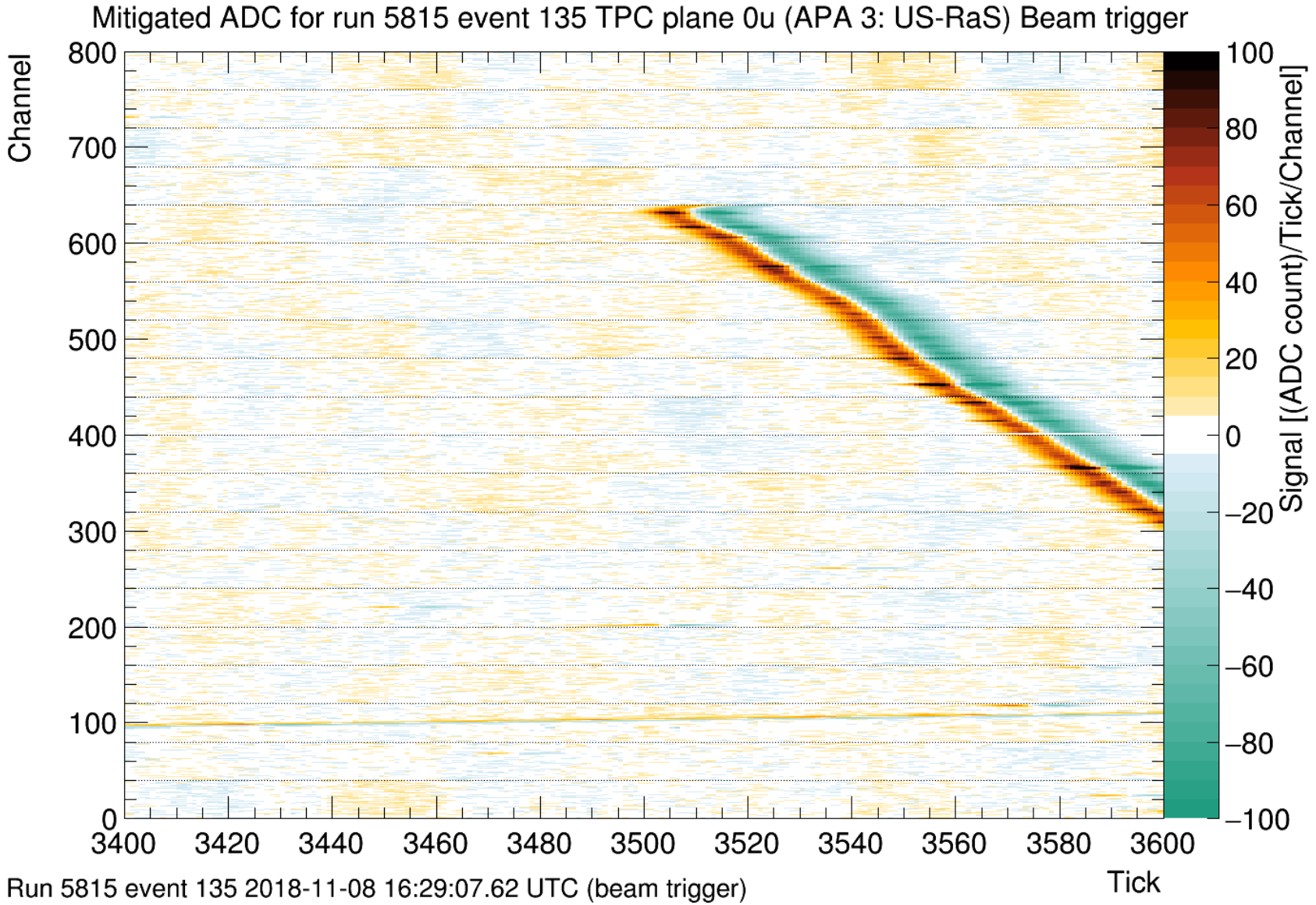
0.9993, 3


Mitigated ADC for run 5815 event 135 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
3400
3420
3440
3460
3480
3500
3520
3540
3560
3580
3600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 135 2018-11-08 16:29:07.62 UTC (beam trigger)

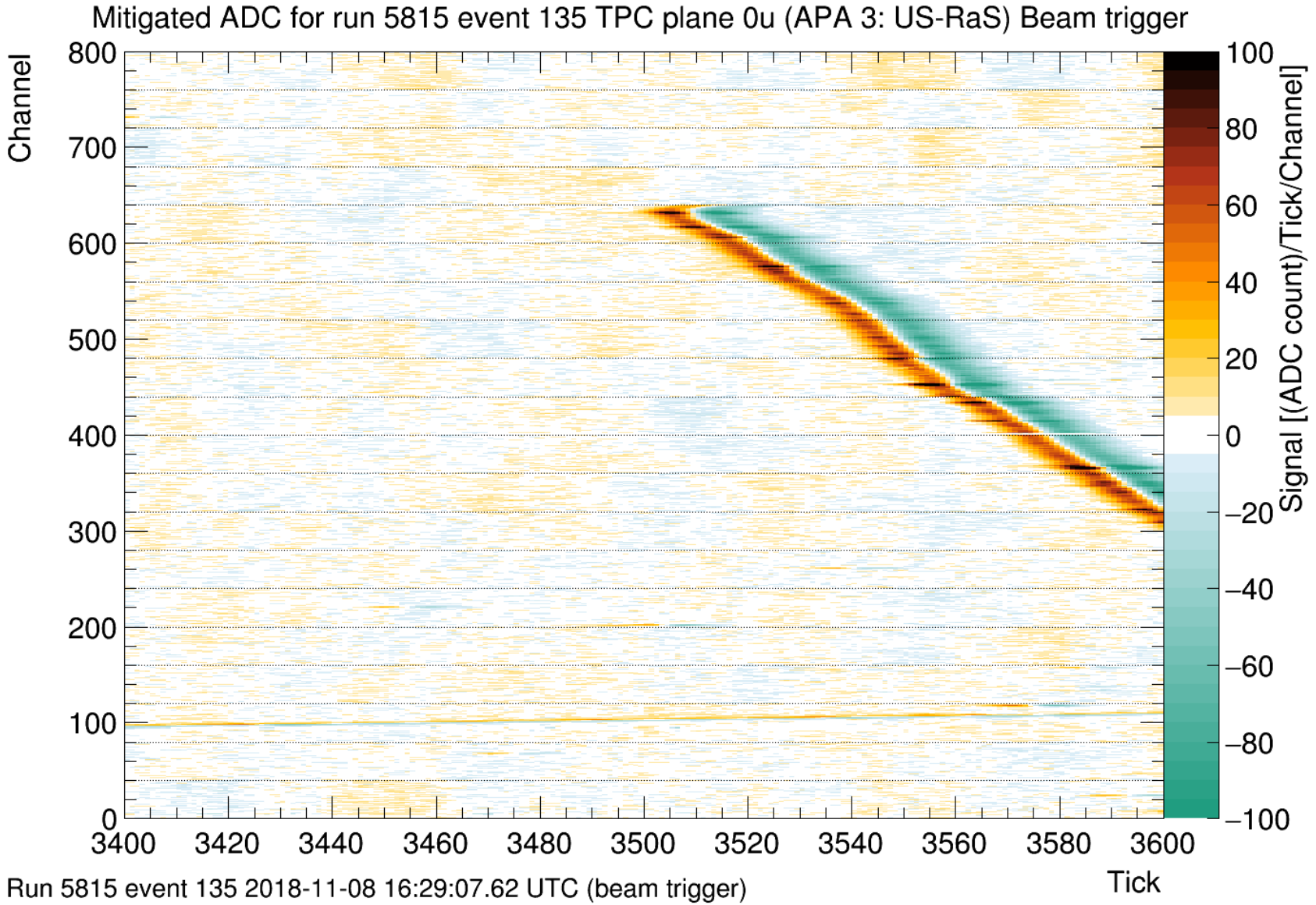
0.9993, 2


Mitigated ADC for run 5815 event 135 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
3400
3420
3440
3460
3480
3500
3520
3540
3560
3580
3600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 135 2018-11-08 16:29:07.62 UTC (beam trigger)

0.9993, 1

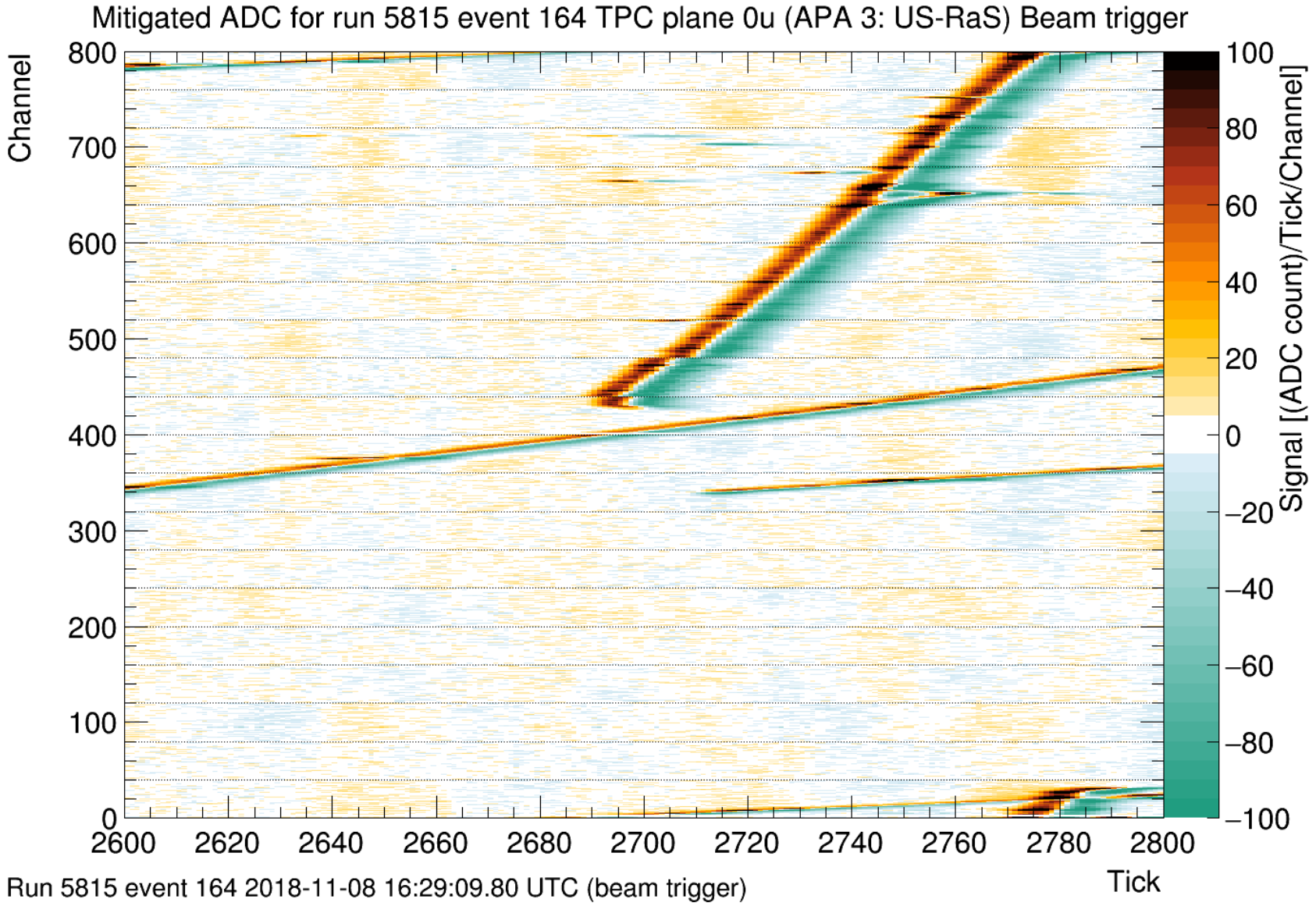

Mitigated ADC for run 5815 event 135 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
3400
3420
3440
3460
3480
3500
3520
3540
3560
3580
3600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 135 2018-11-08 16:29:07.62 UTC (beam trigger)

0.9993, 0

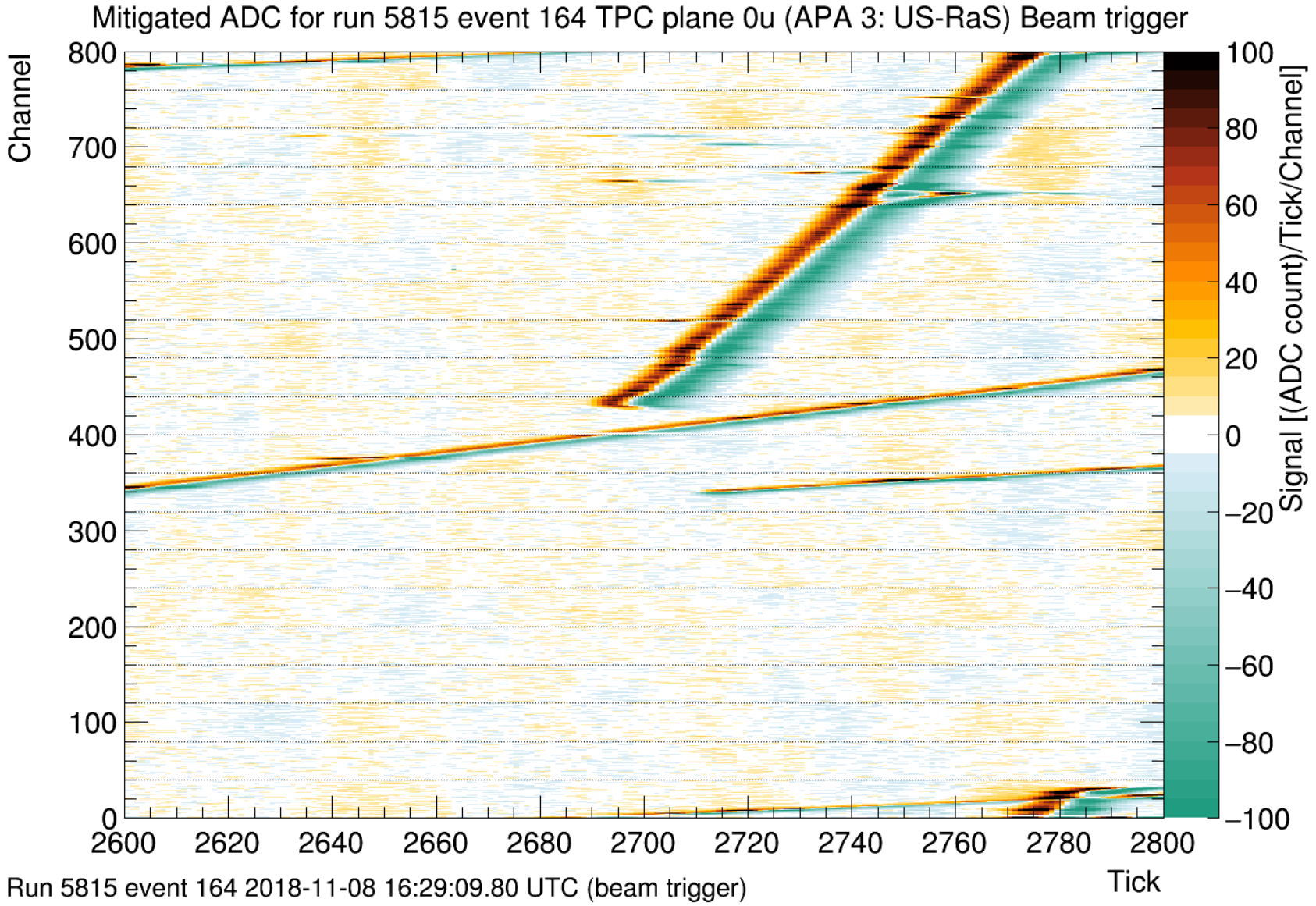

Mitigated ADC for run 5815 event 135 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
3400
3420
3440
3460
3480
3500
3520
3540
3560
3580
3600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 135 2018-11-08 16:29:07.62 UTC (beam trigger)

Event 164 u2600-2800

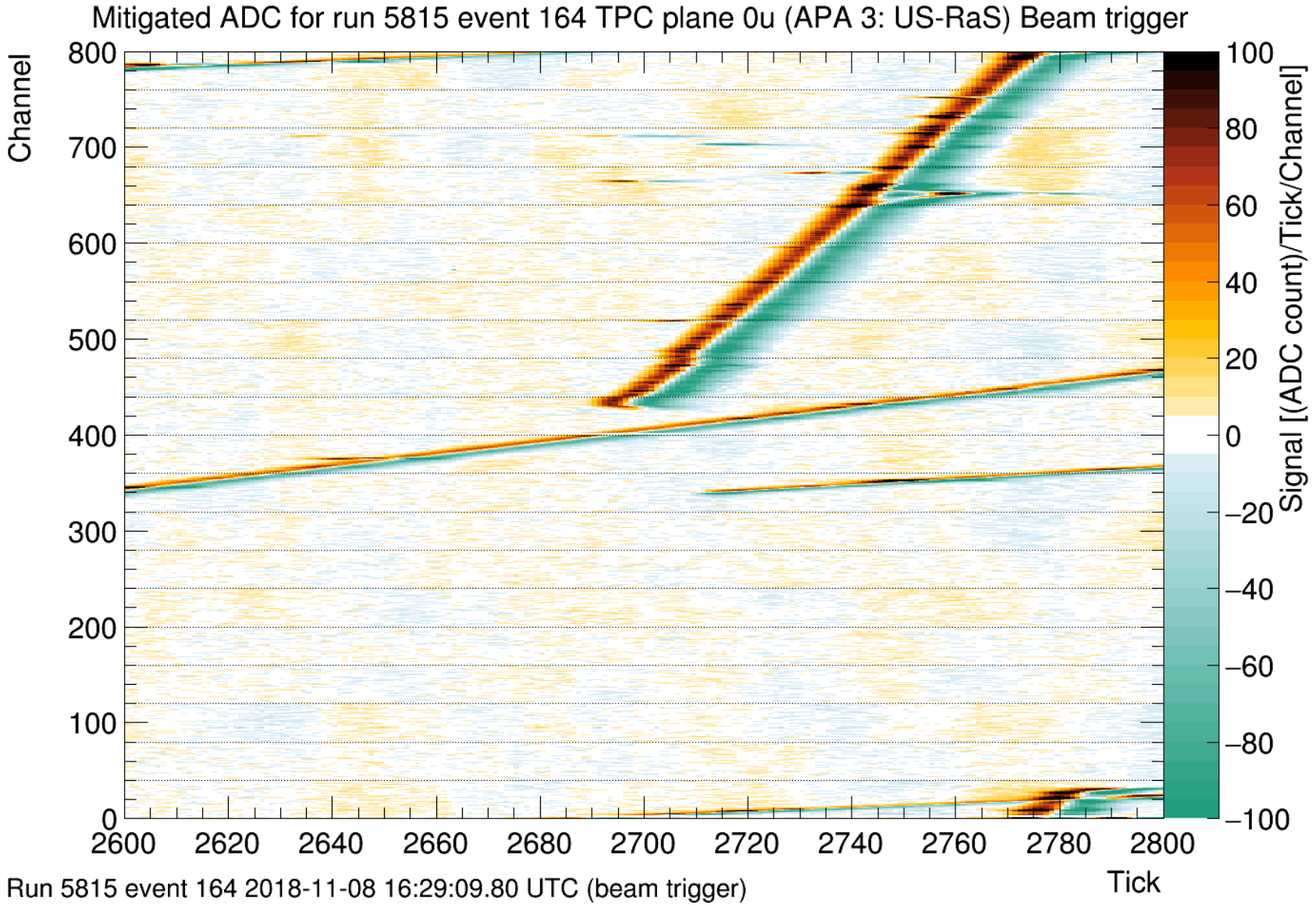
1.0, 0 (no correction)



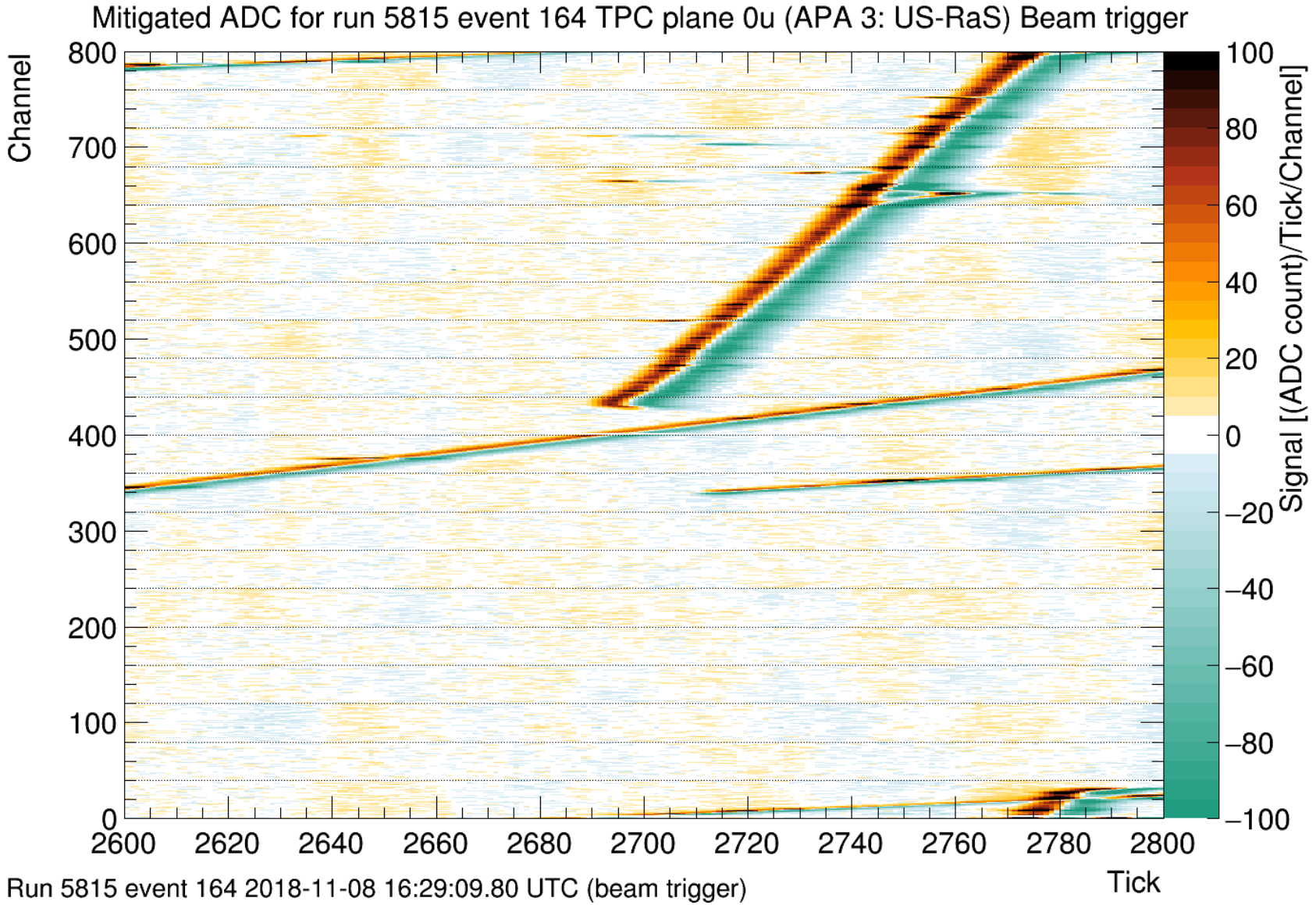
0.9995, 3 (Dec 2018 correction)



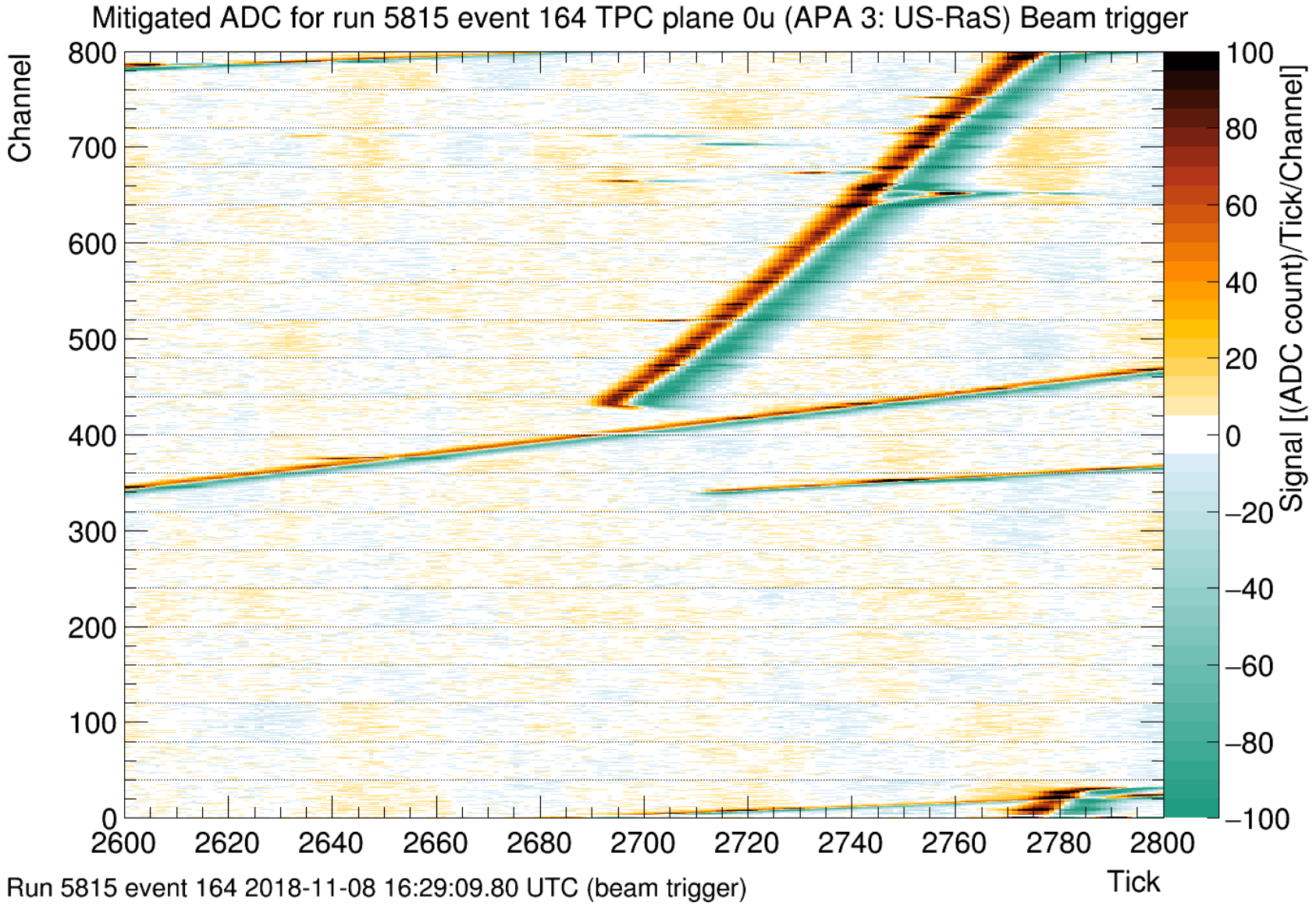
0.9993, 3


Mitigated ADC for run 5815 event 164 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

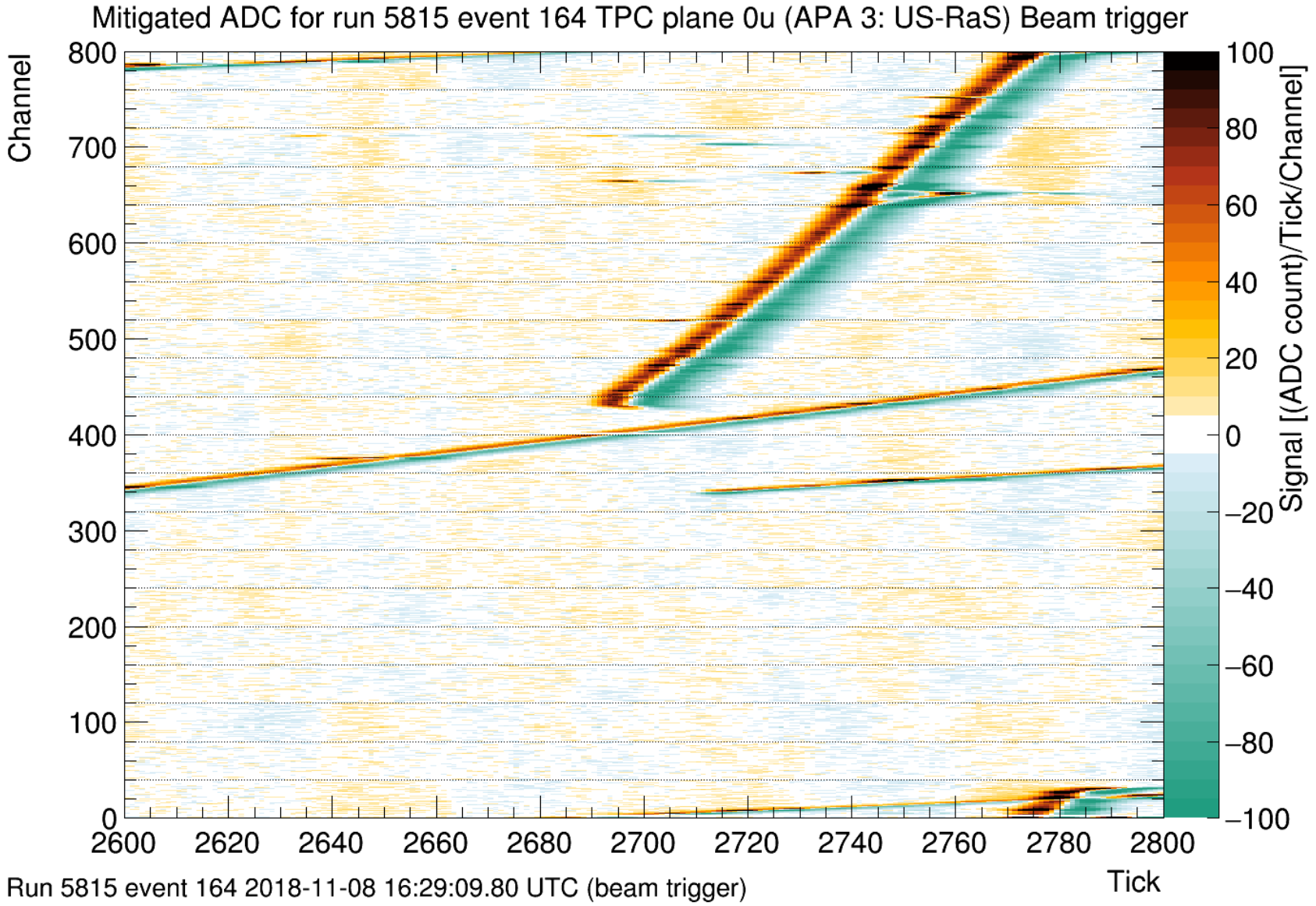
0.9993, 2


Mitigated ADC for run 5815 event 164 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

0.9993, 1

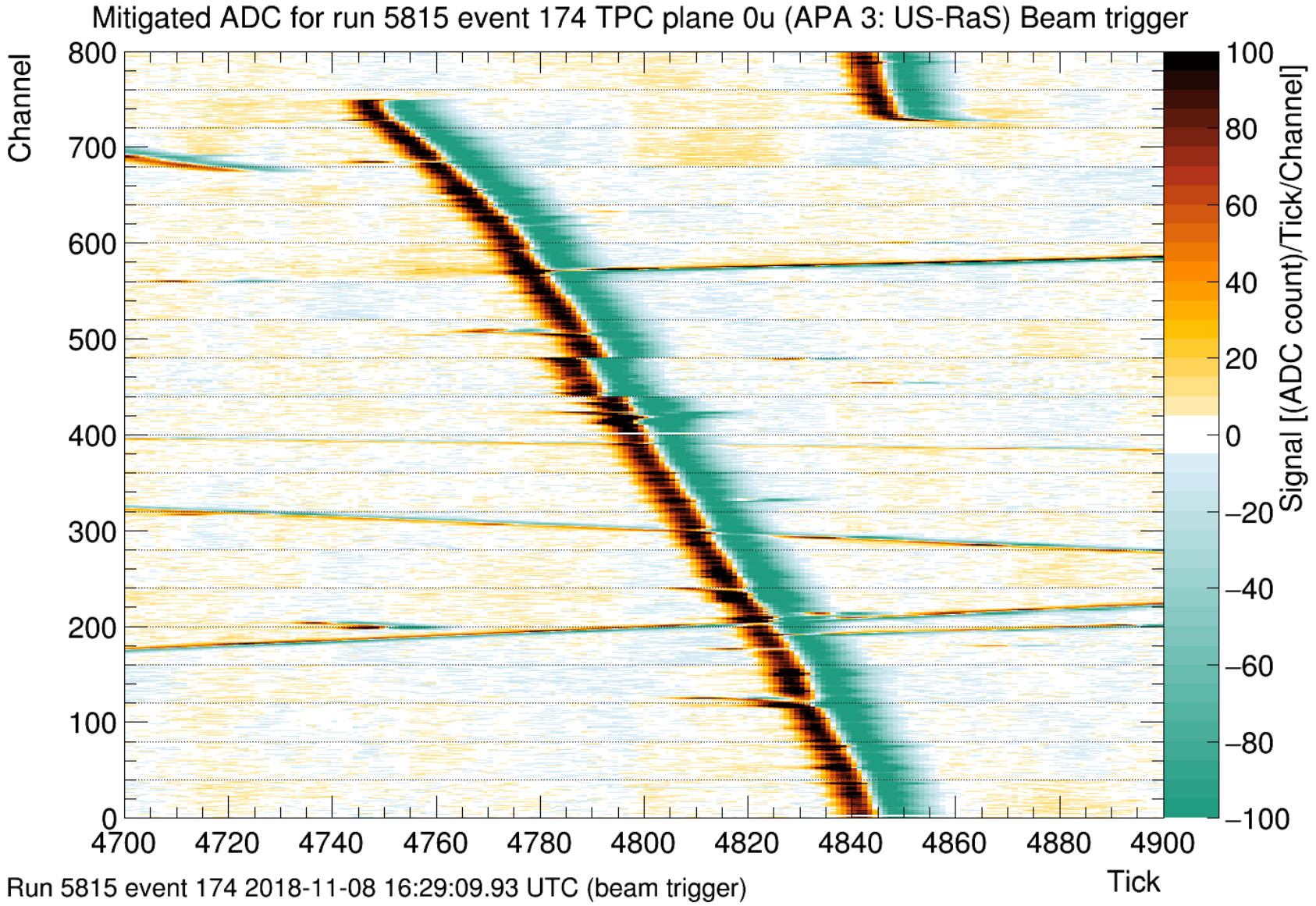

Mitigated ADC for run 5815 event 164 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

0.9993, 0

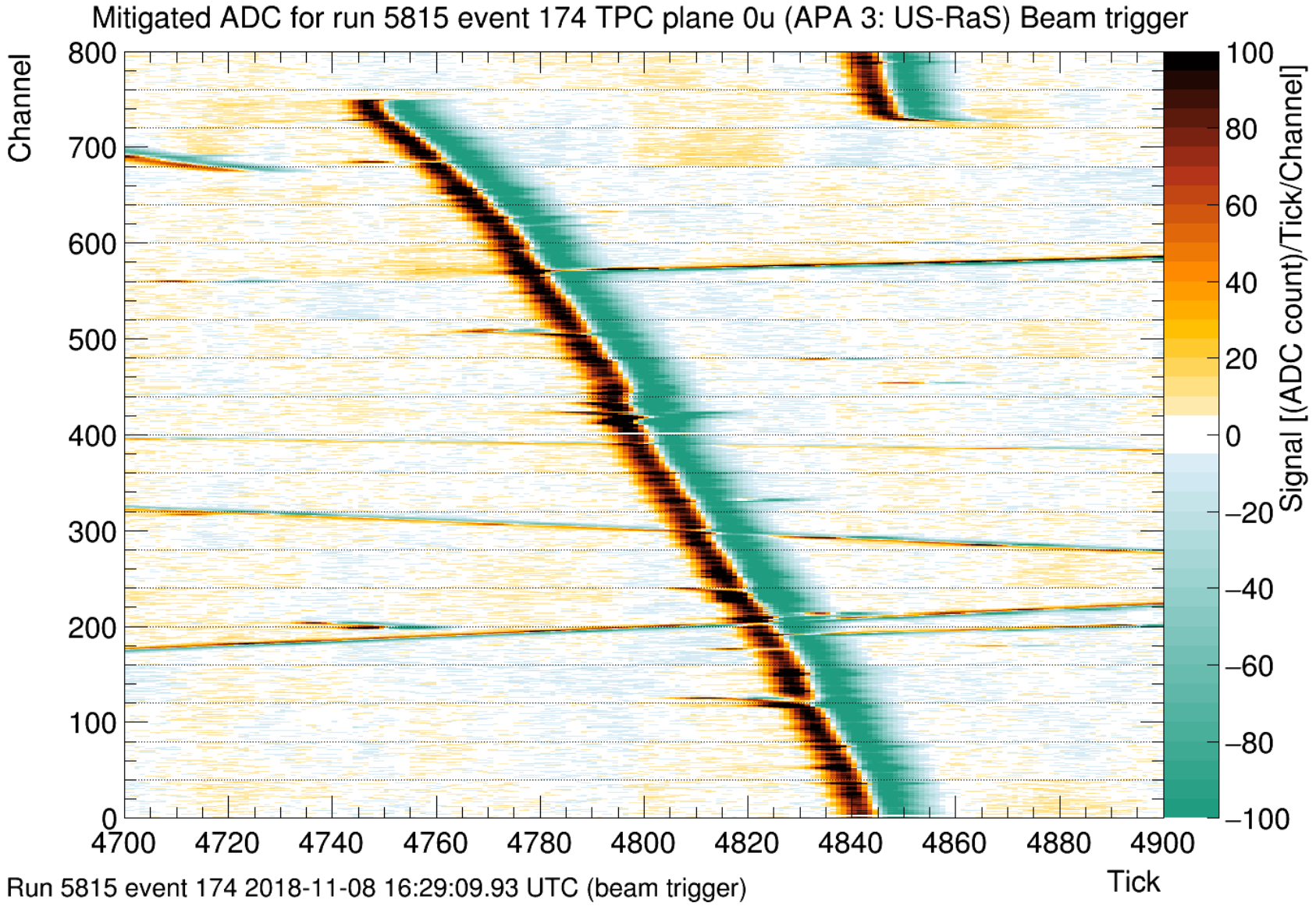

Mitigated ADC for run 5815 event 164 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 164 2018-11-08 16:29:09.80 UTC (beam trigger)

Event 174 u4700-4900

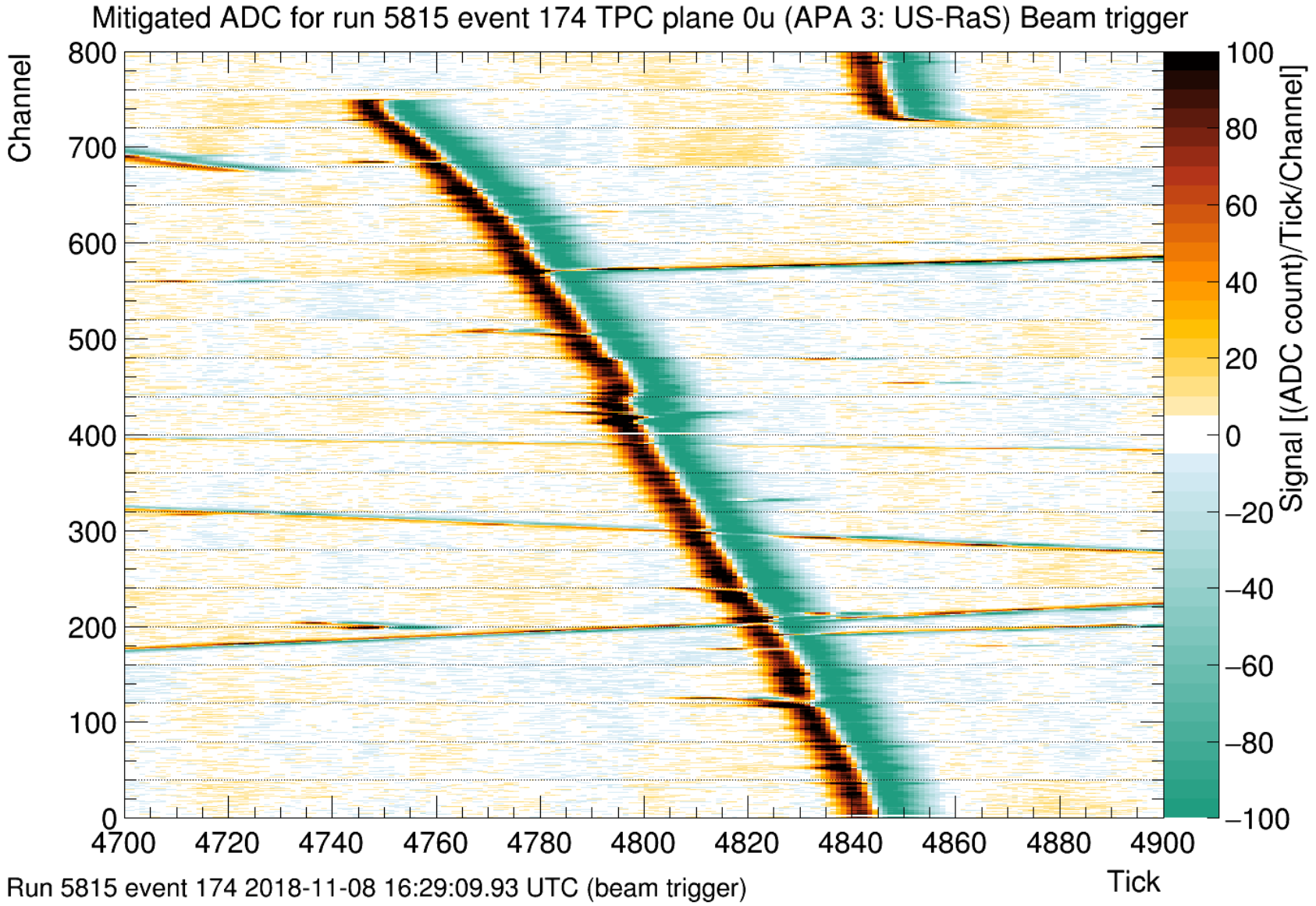
1.0, 0 (no correction)



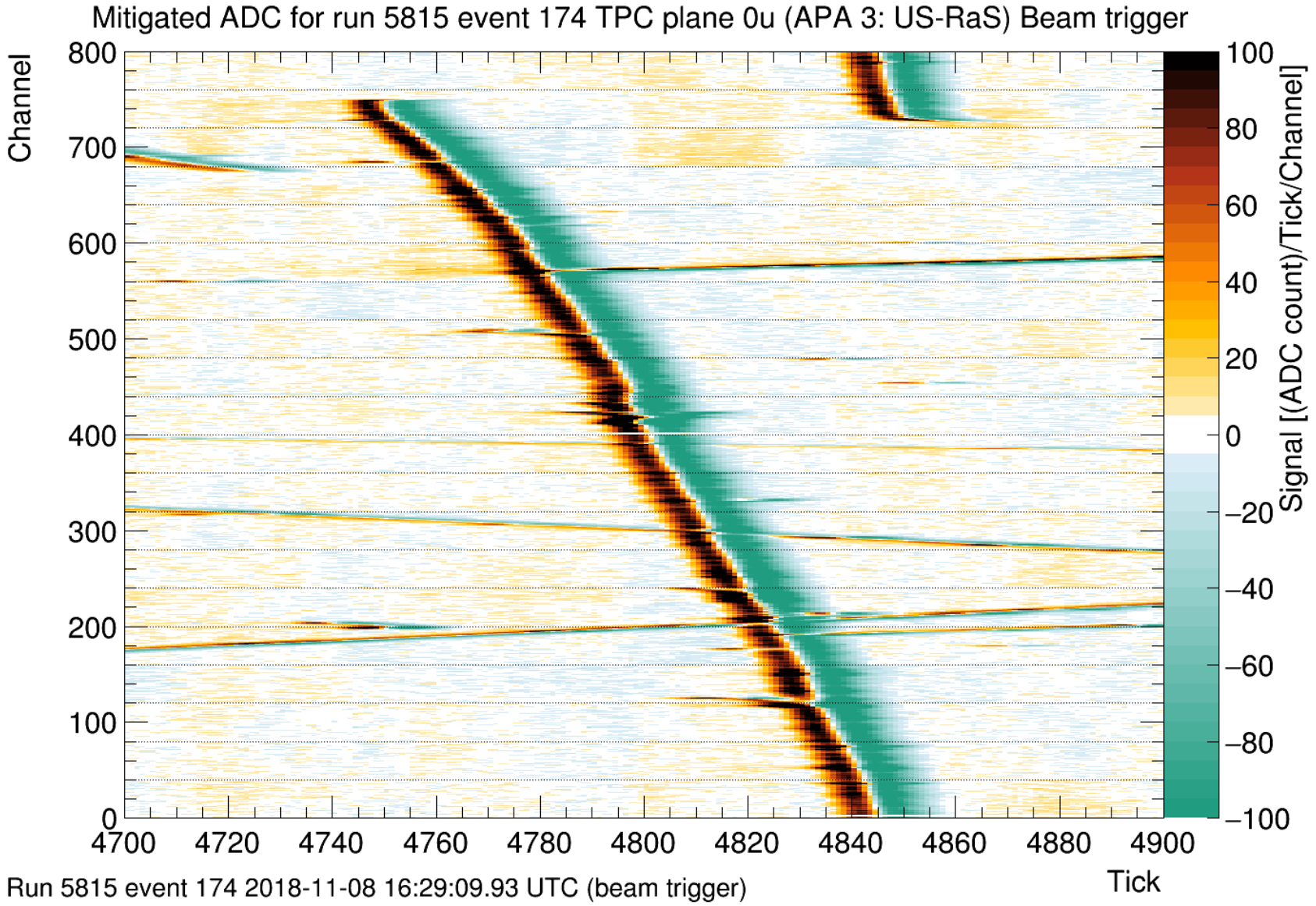
0.9995, 3 (Dec 2018 correction)



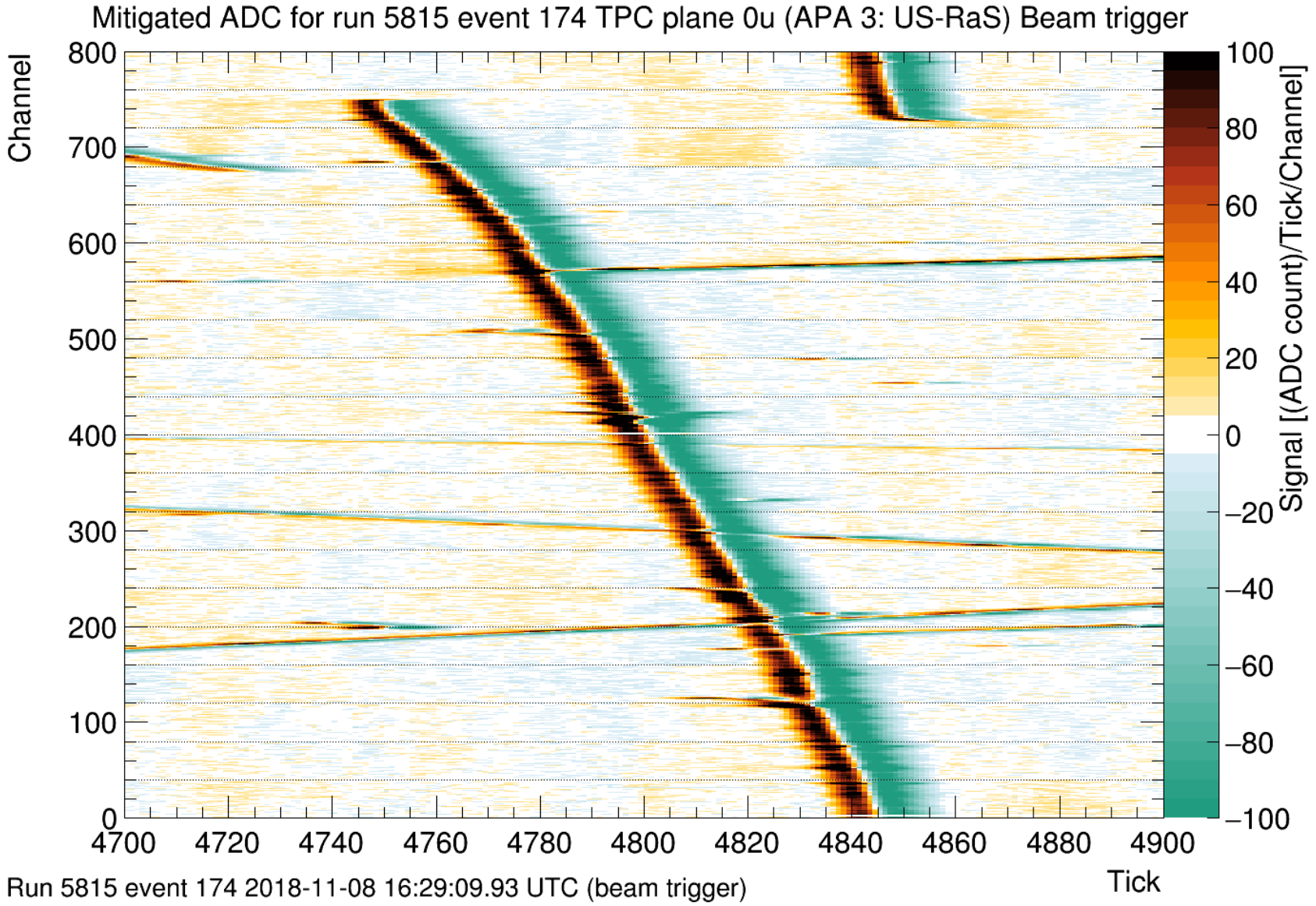
0.9993, 3


Mitigated ADC for run 5815 event 174 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 174 2018-11-08 16:29:09.93 UTC (beam trigger)

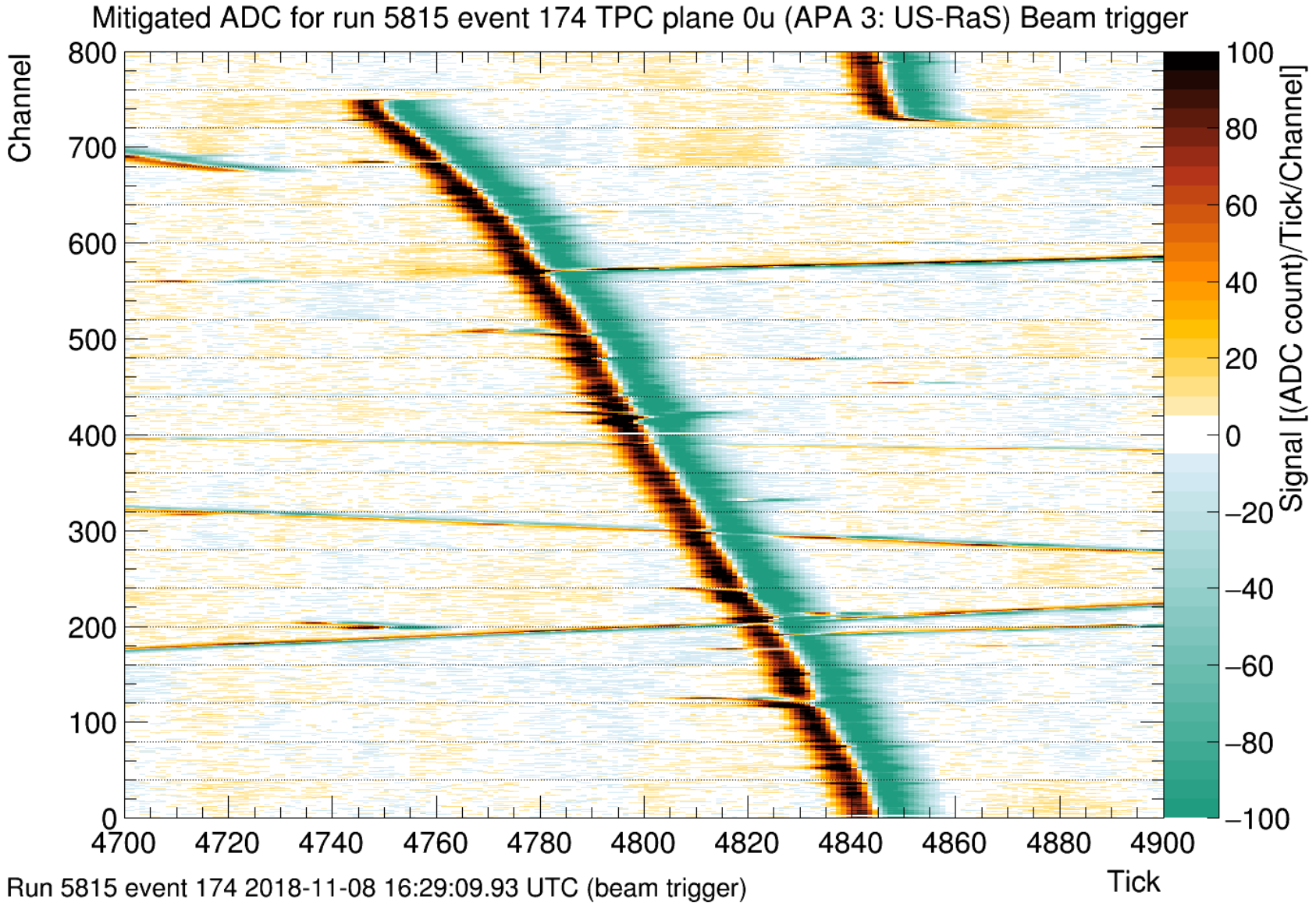
0.9993, 2


Mitigated ADC for run 5815 event 174 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 174 2018-11-08 16:29:09.93 UTC (beam trigger)

0.9993, 1

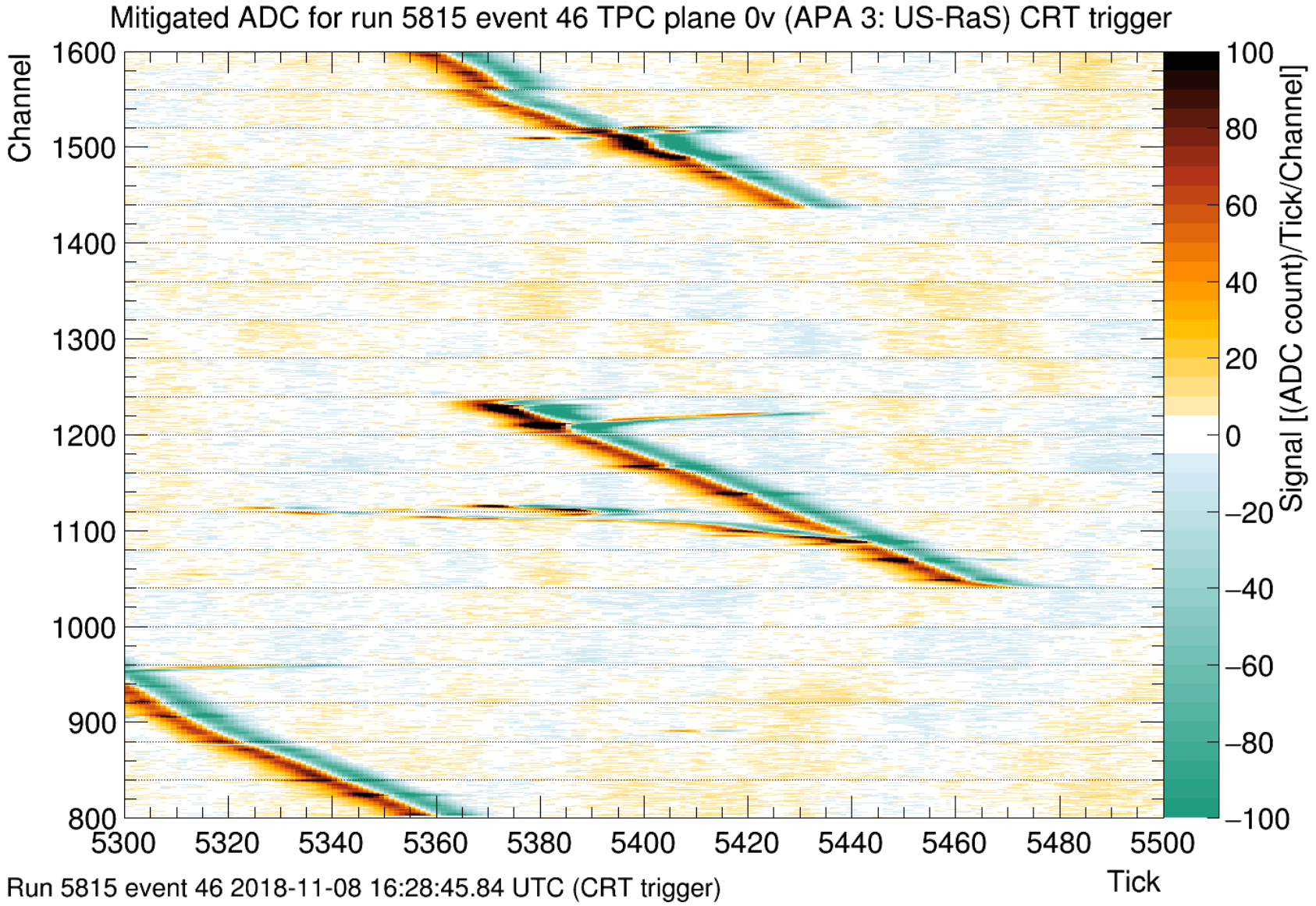

Mitigated ADC for run 5815 event 174 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 174 2018-11-08 16:29:09.93 UTC (beam trigger)

0.9993, 0

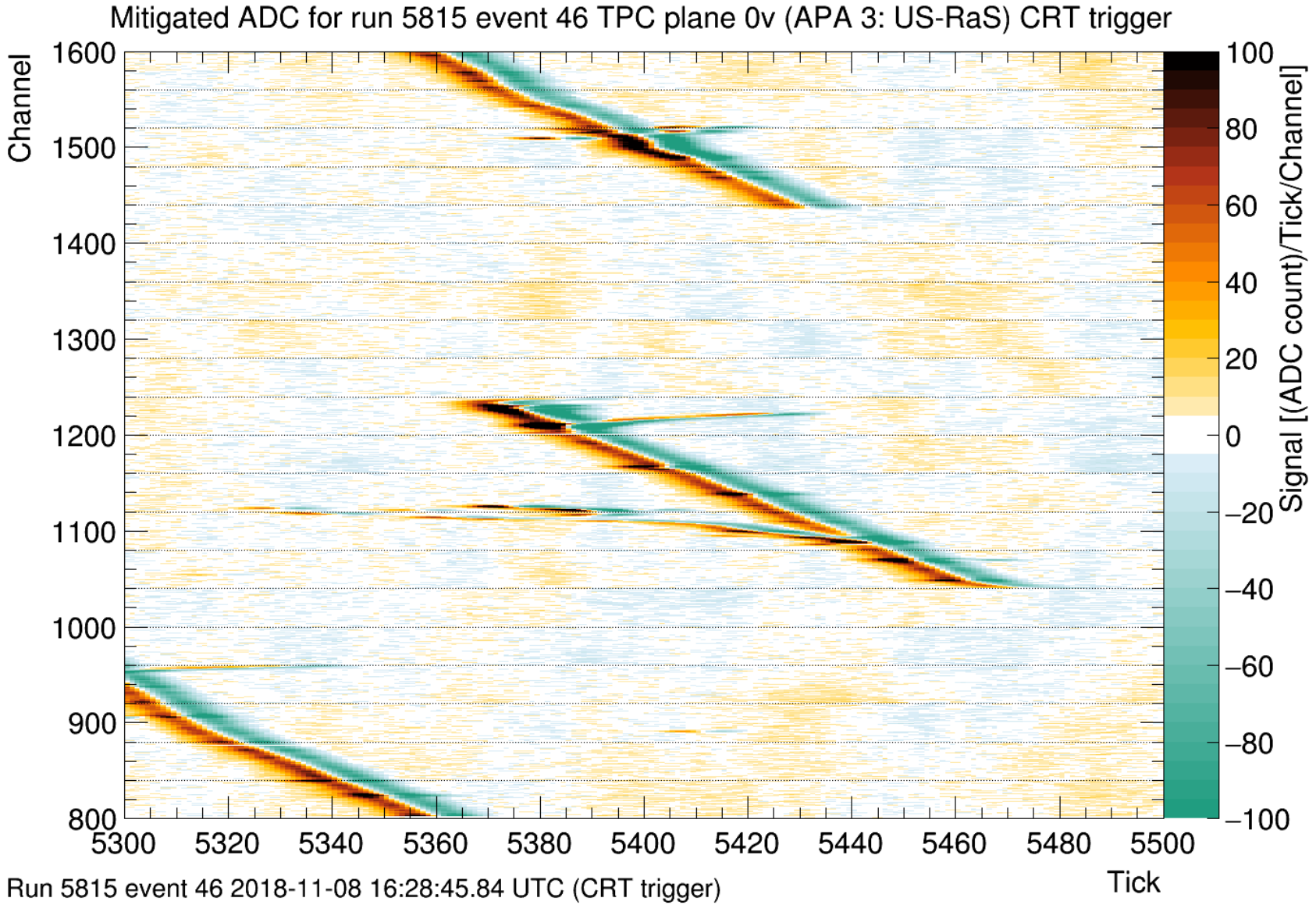

Mitigated ADC for run 5815 event 174 TPC plane 0u (APA 3: US-RaS) Beam trigger
Channel
800
700
600
500
400
300
200
100
0
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 174 2018-11-08 16:29:09.93 UTC (beam trigger)

Event 46 v5300-5500

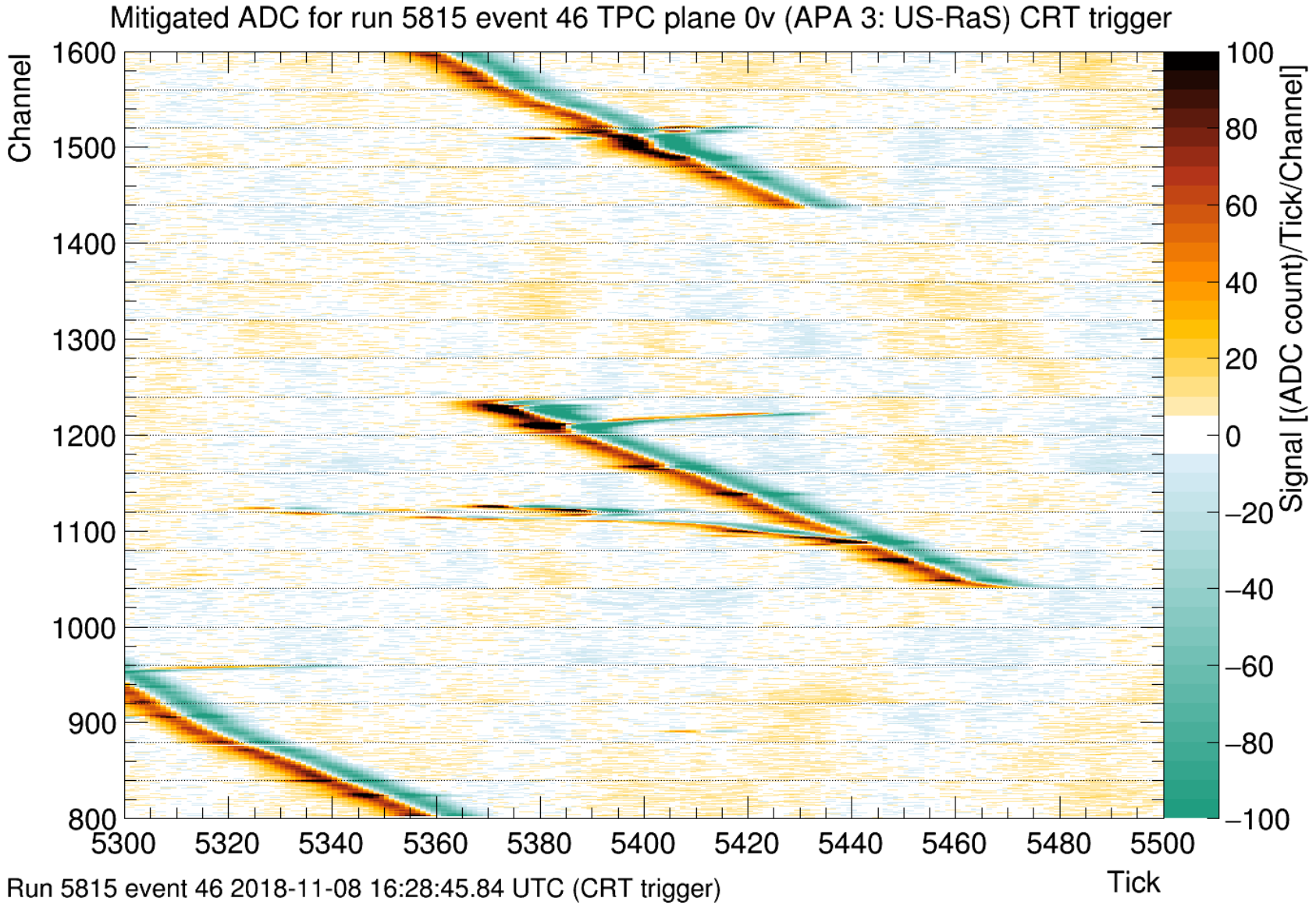
1.0, 0 (no correction)



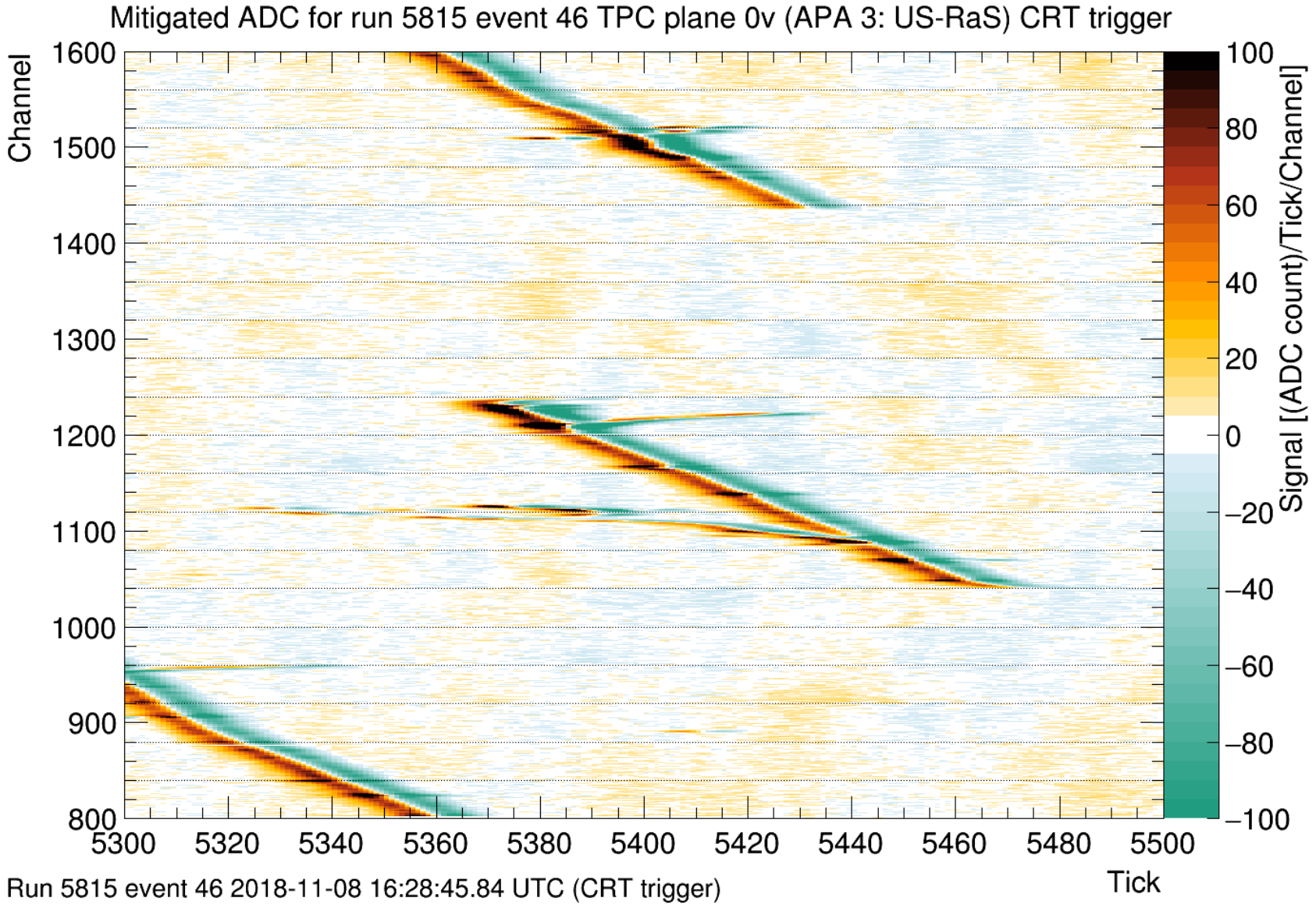
0.9995, 3 (Dec 2018 correction)



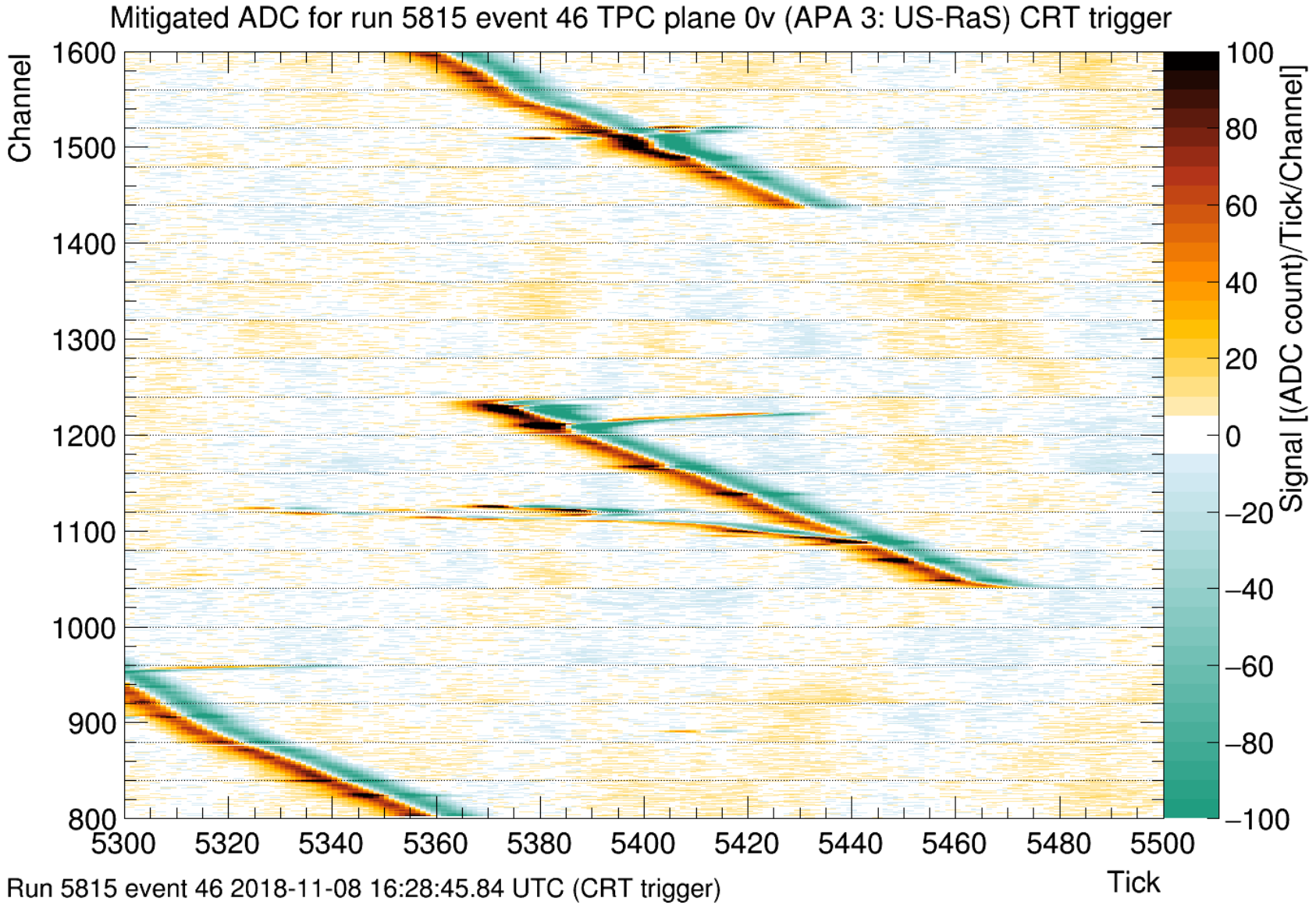
0.9993, 3


Mitigated ADC for run 5815 event 46 TPC plane 0v (APA 3: US-RaS) CRT trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
5300
5320
5340
5360
5380
5400
5420
5440
5460
5480
5500
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 46 2018-11-08 16:28:45.84 UTC (CRT trigger)

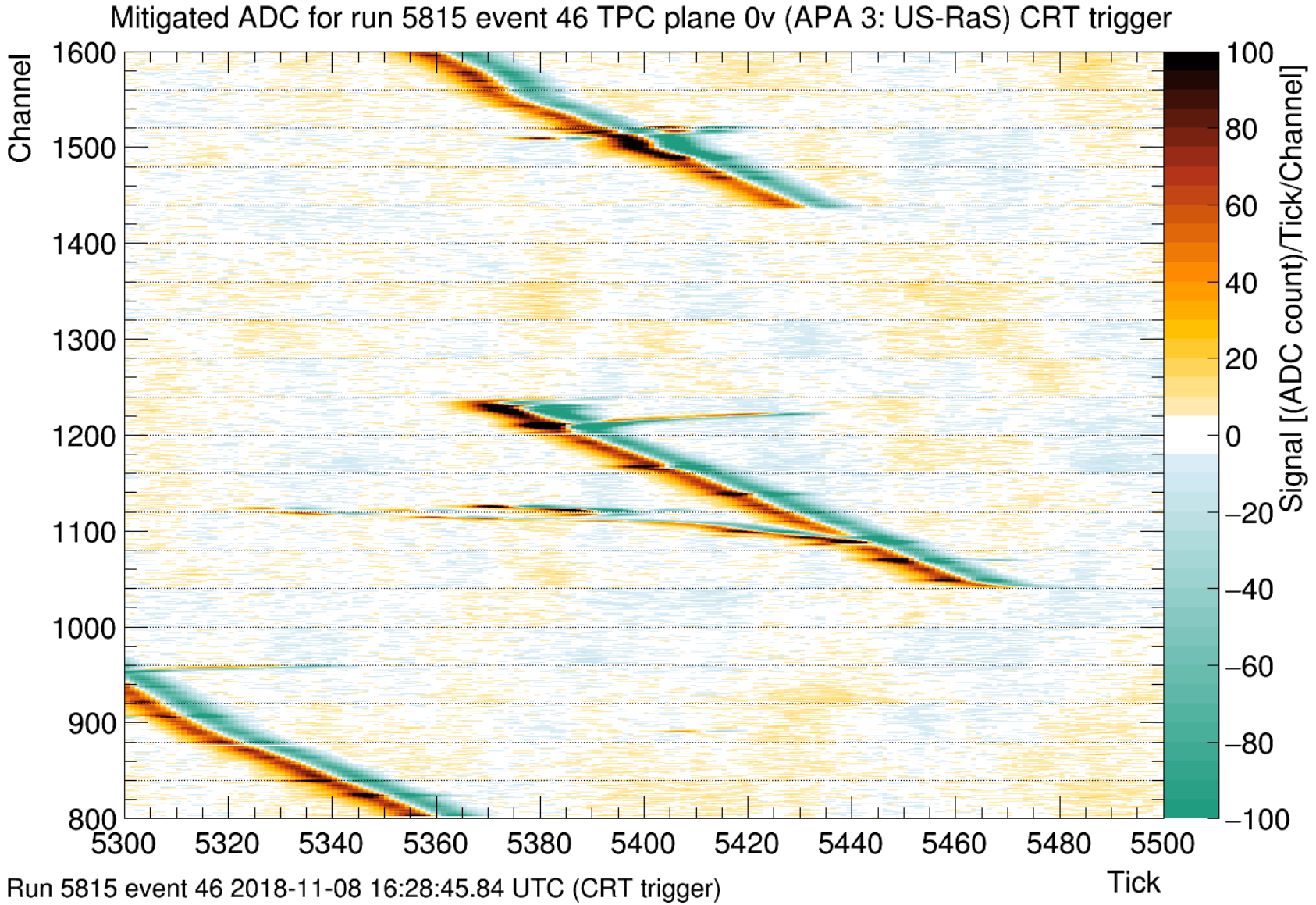
0.9993, 2


Mitigated ADC for run 5815 event 46 TPC plane 0v (APA 3: US-RaS) CRT trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
5300
5320
5340
5360
5380
5400
5420
5440
5460
5480
5500
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 46 2018-11-08 16:28:45.84 UTC (CRT trigger)

0.9993, 1

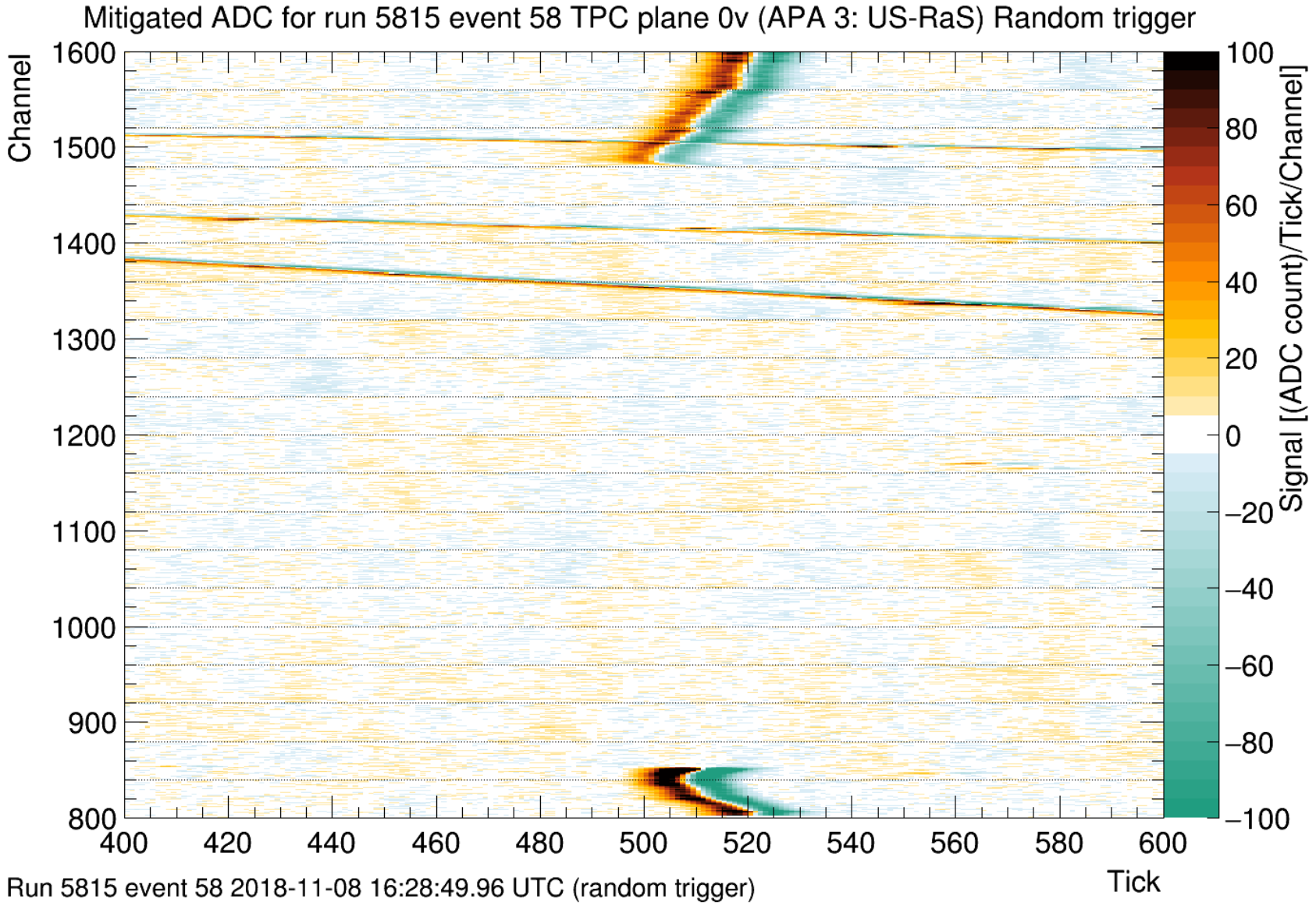

Mitigated ADC for run 5815 event 46 TPC plane 0v (APA 3: US-RaS) CRT trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
5300
5320
5340
5360
5380
5400
5420
5440
5460
5480
5500
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 46 2018-11-08 16:28:45.84 UTC (CRT trigger)

0.9993, 0

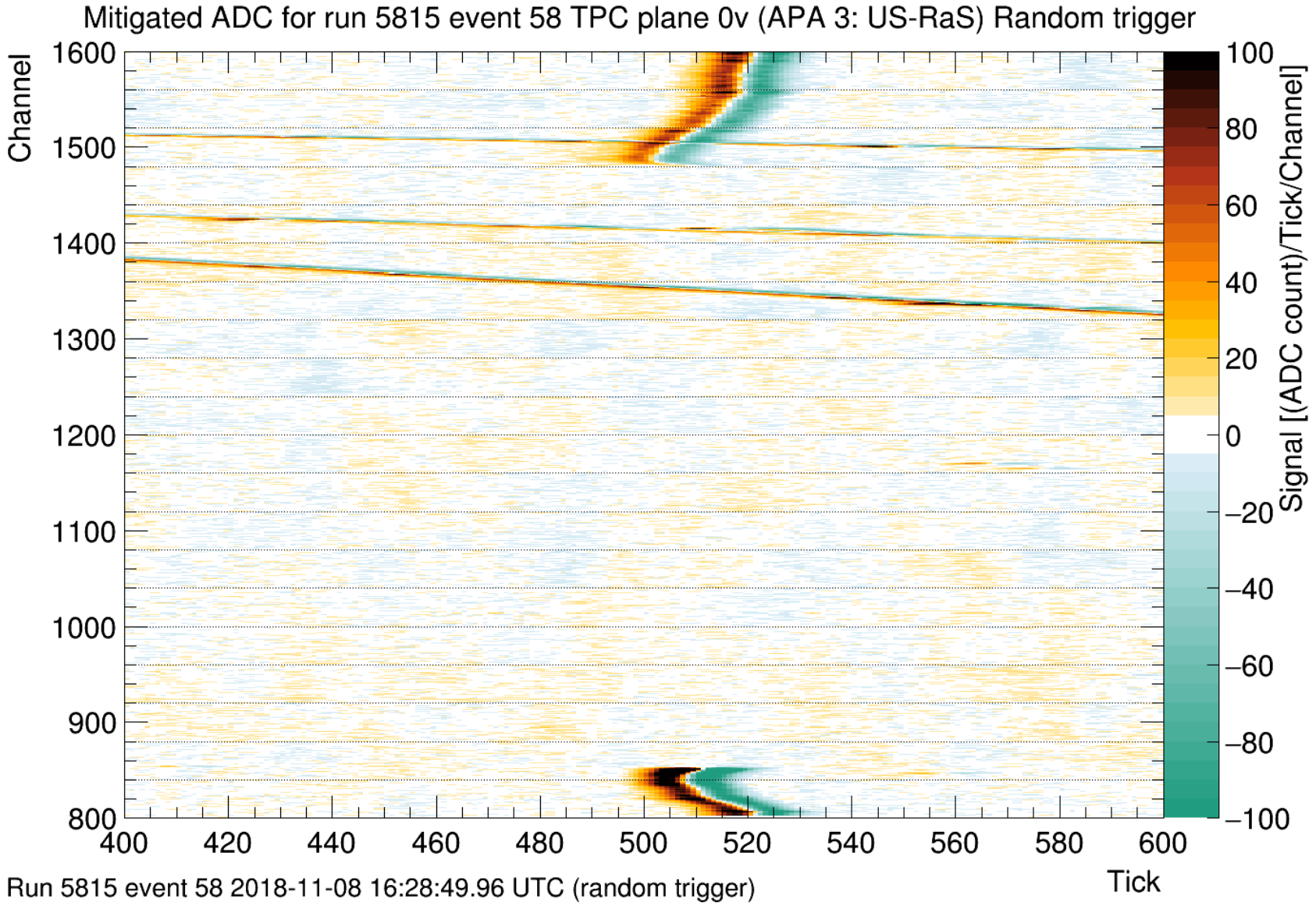

Mitigated ADC for run 5815 event 46 TPC plane 0v (APA 3: US-RaS) CRT trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
5300
5320
5340
5360
5380
5400
5420
5440
5460
5480
5500
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 46 2018-11-08 16:28:45.84 UTC (CRT trigger)

Event 58 v400-600

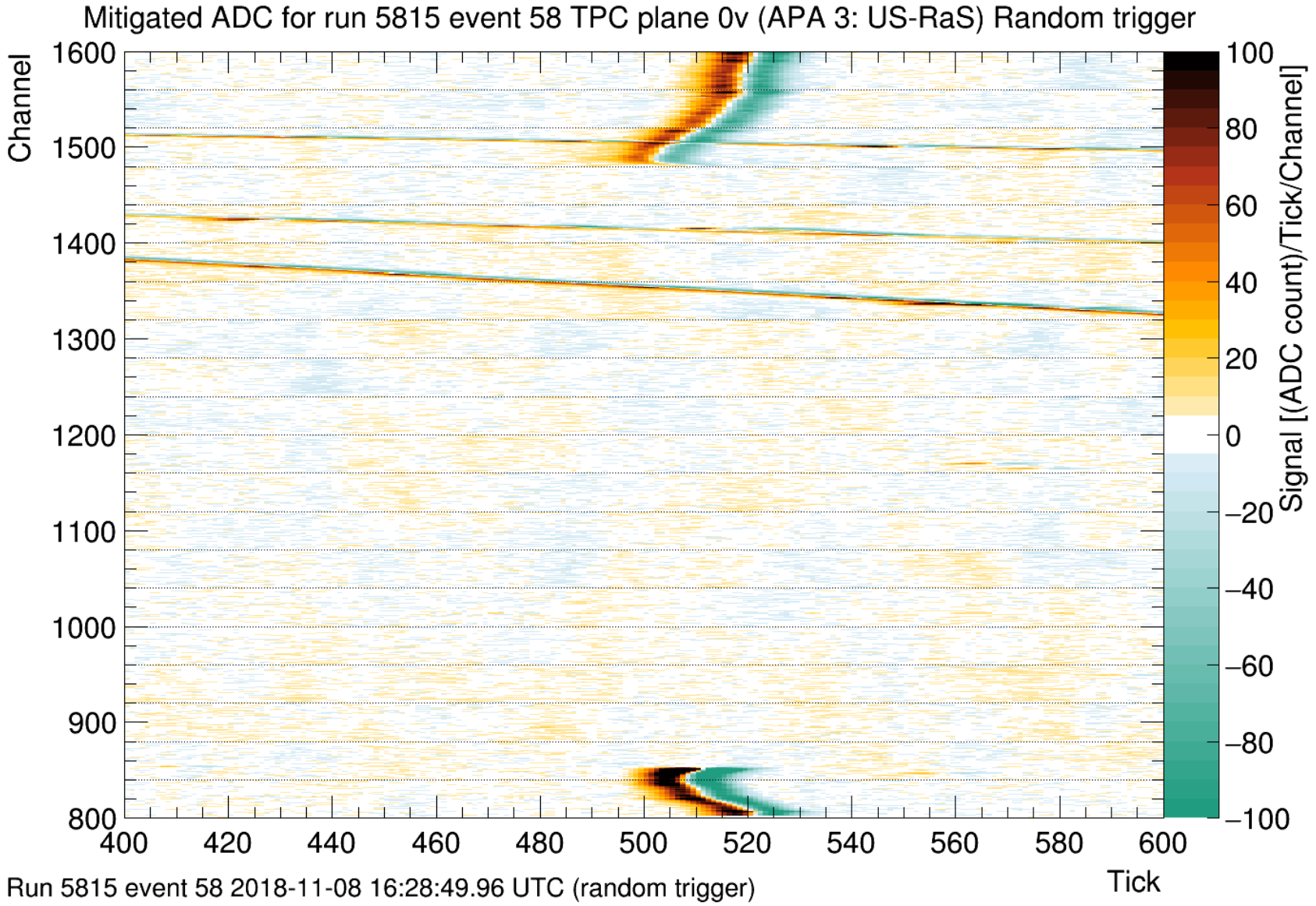
1.0, 0 (no correction)



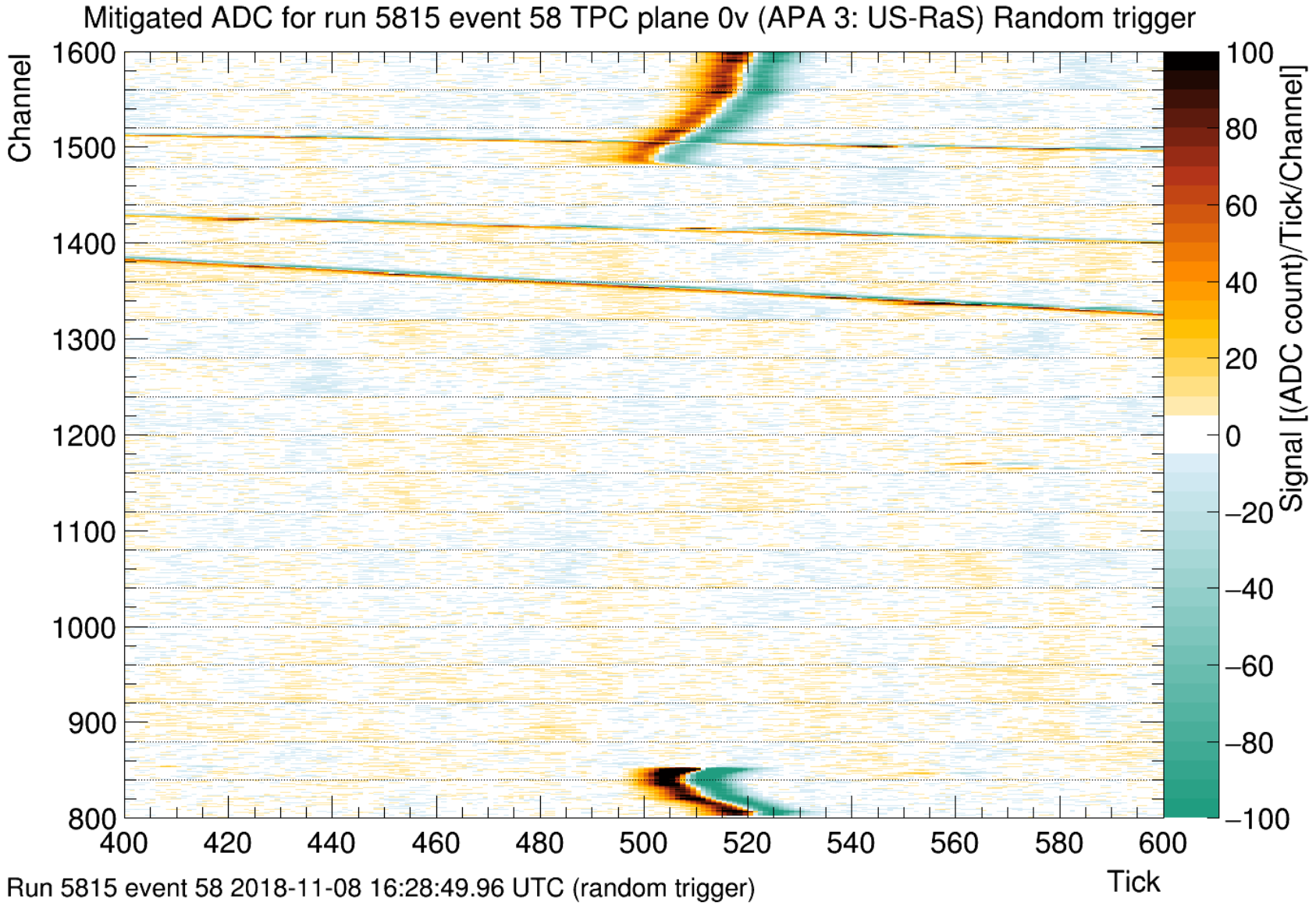
0.9995, 3 (Dec 2018 correction)



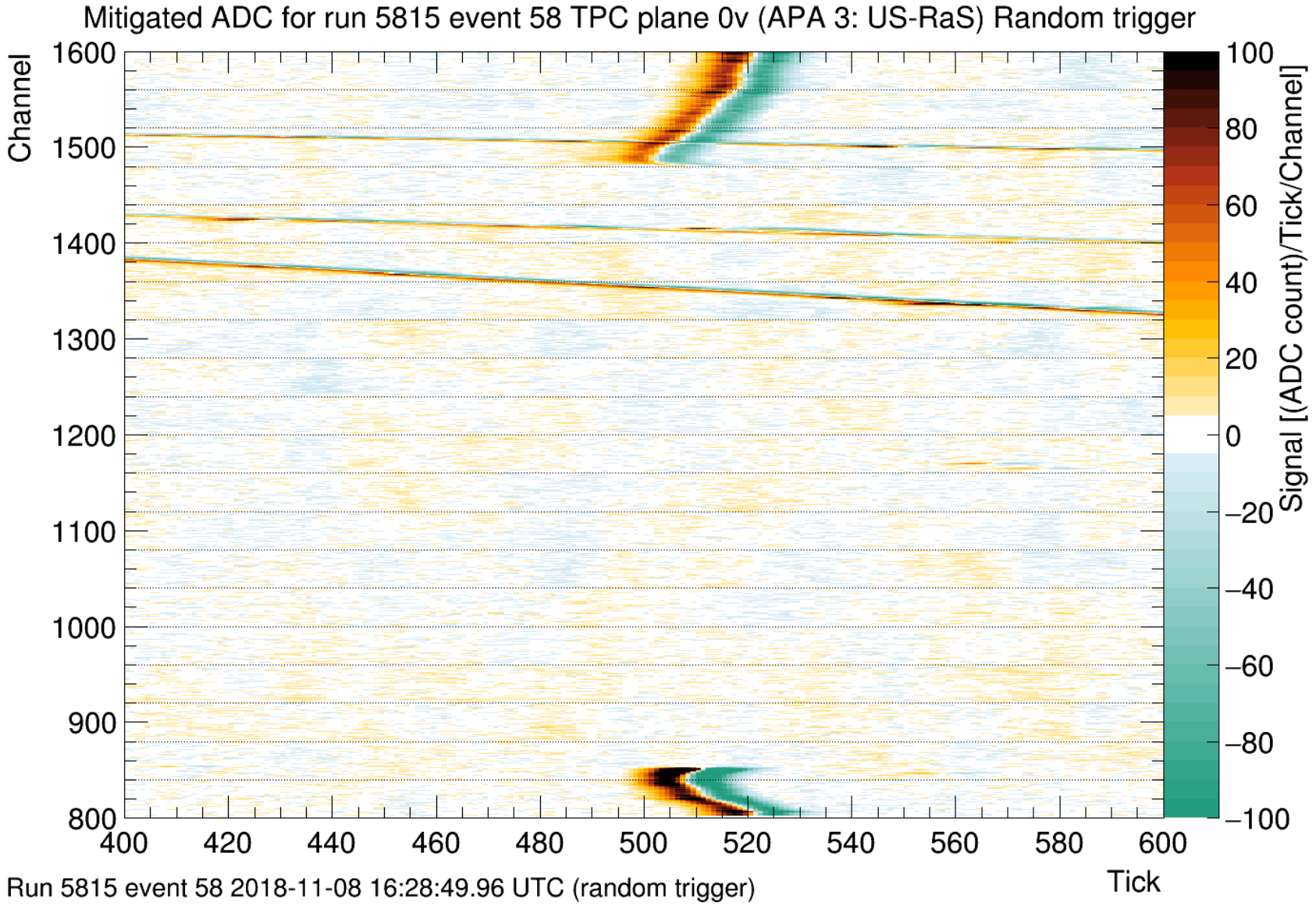
0.9993, 3


Mitigated ADC for run 5815 event 58 TPC plane 0v (APA 3: US-RaS) Random trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
400
420
440
460
480
500
520
540
560
580
600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 58 2018-11-08 16:28:49.96 UTC (random trigger)

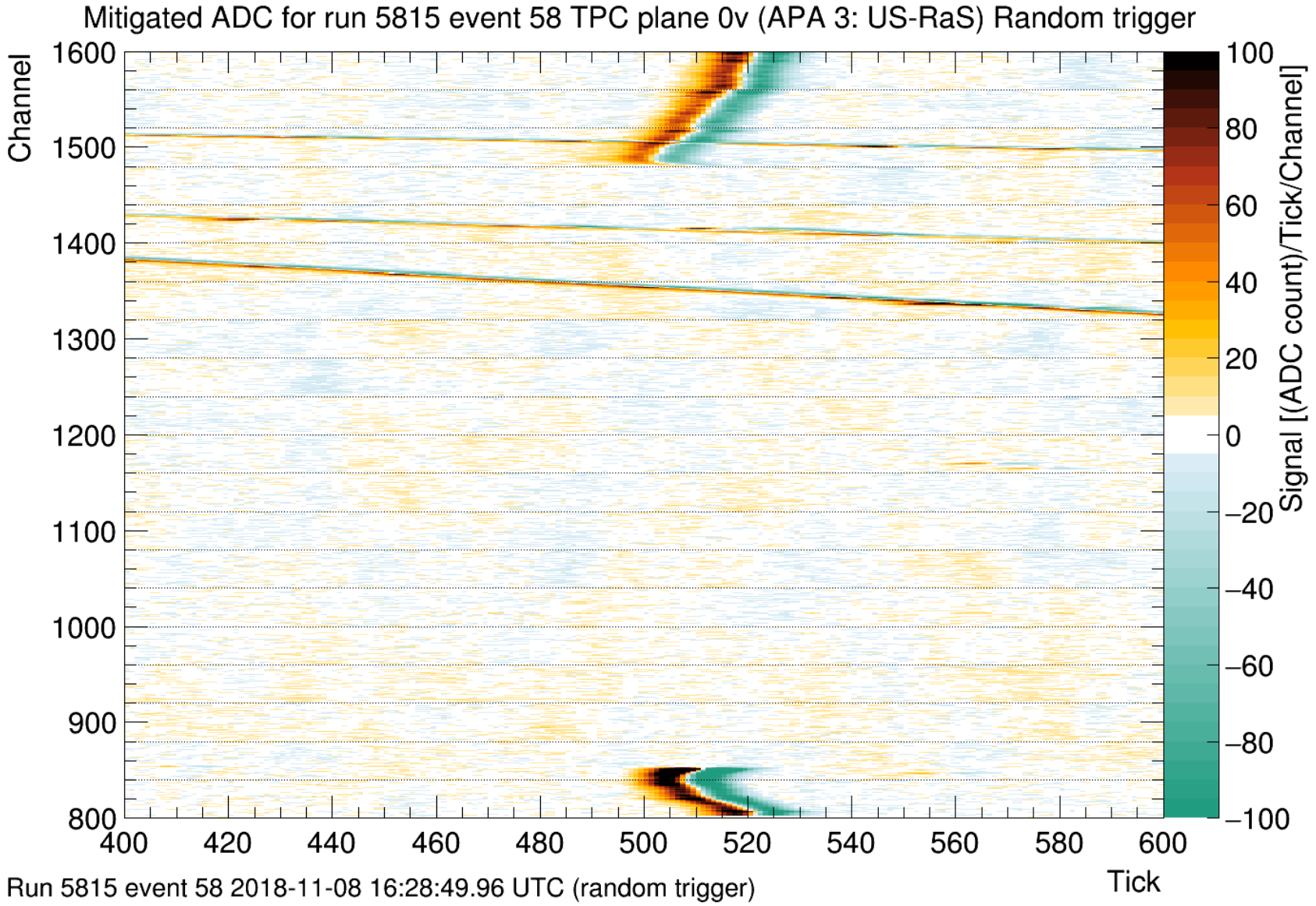
0.9993, 2


Mitigated ADC for run 5815 event 58 TPC plane 0v (APA 3: US-RaS) Random trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
400
420
440
460
480
500
520
540
560
580
600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 58 2018-11-08 16:28:49.96 UTC (random trigger)

0.9993, 1

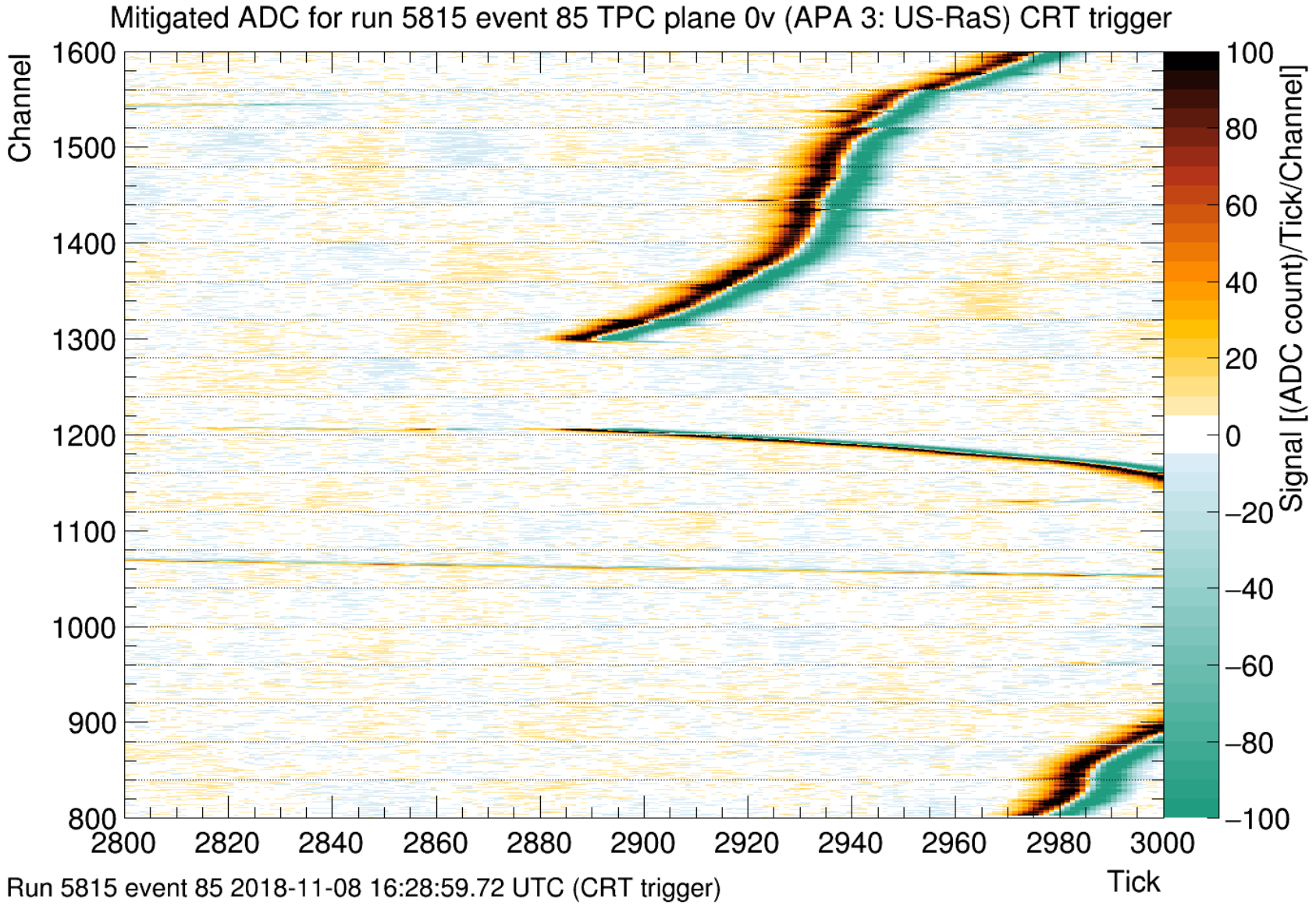

Mitigated ADC for run 5815 event 58 TPC plane 0v (APA 3: US-RaS) Random trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
400
420
440
460
480
500
520
540
560
580
600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 58 2018-11-08 16:28:49.96 UTC (random trigger)

0.9993, 0

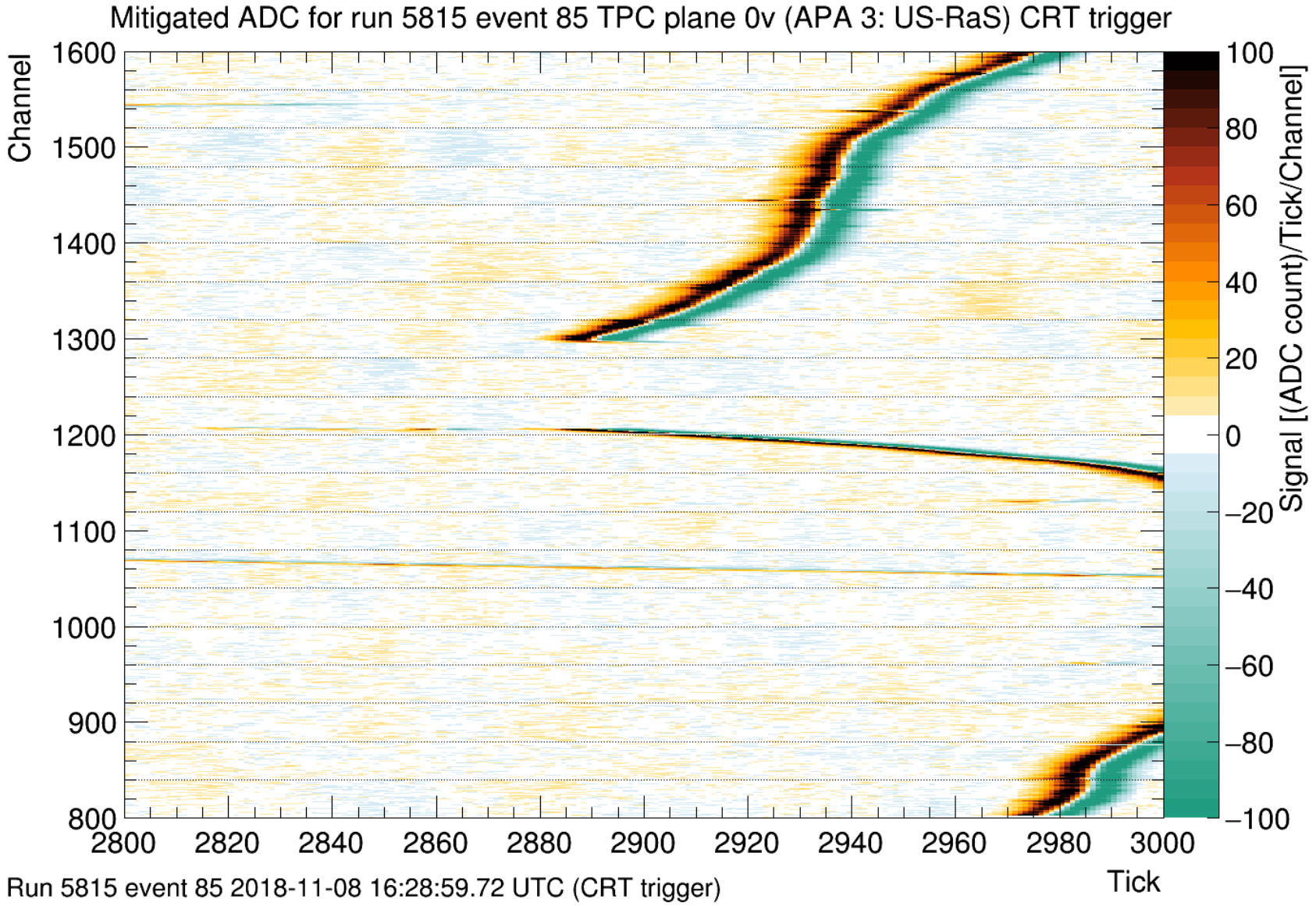

Mitigated ADC for run 5815 event 58 TPC plane 0v (APA 3: US-RaS) Random trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
400
420
440
460
480
500
520
540
560
580
600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 58 2018-11-08 16:28:49.96 UTC (random trigger)

Event 85 v2800-3000

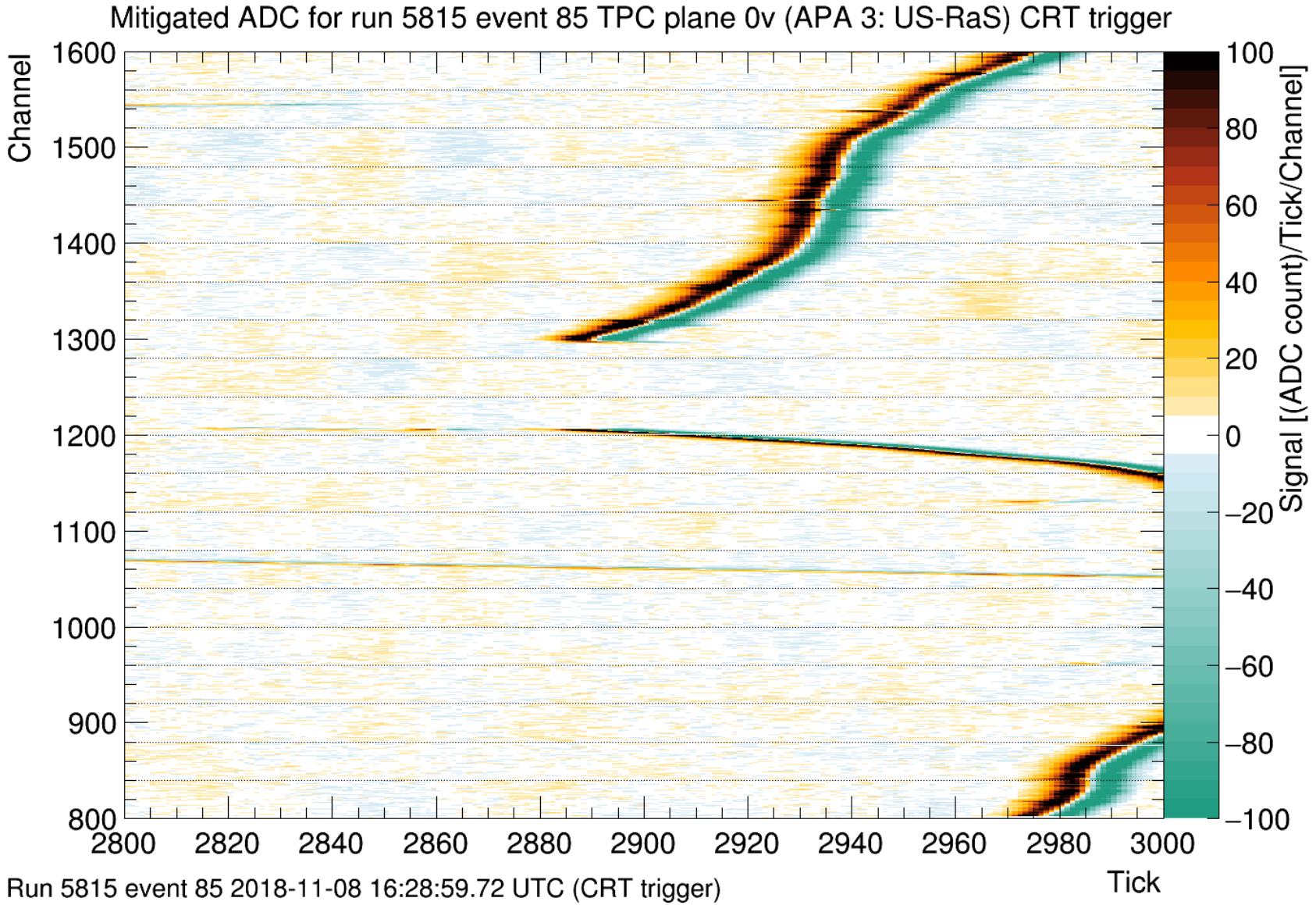
1.0, 0 (no correction)



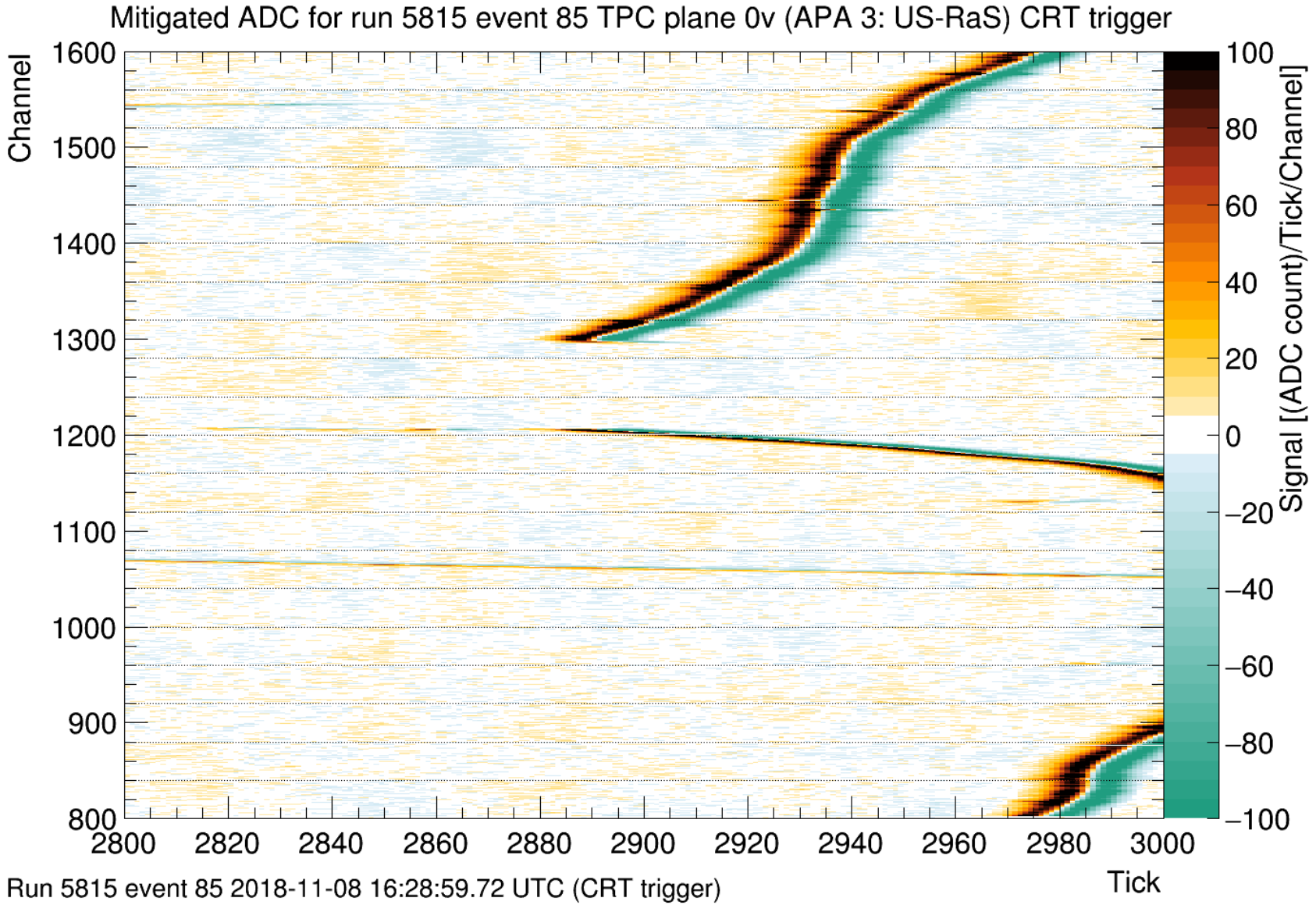
0.9995, 3 (Dec 2018 correction)



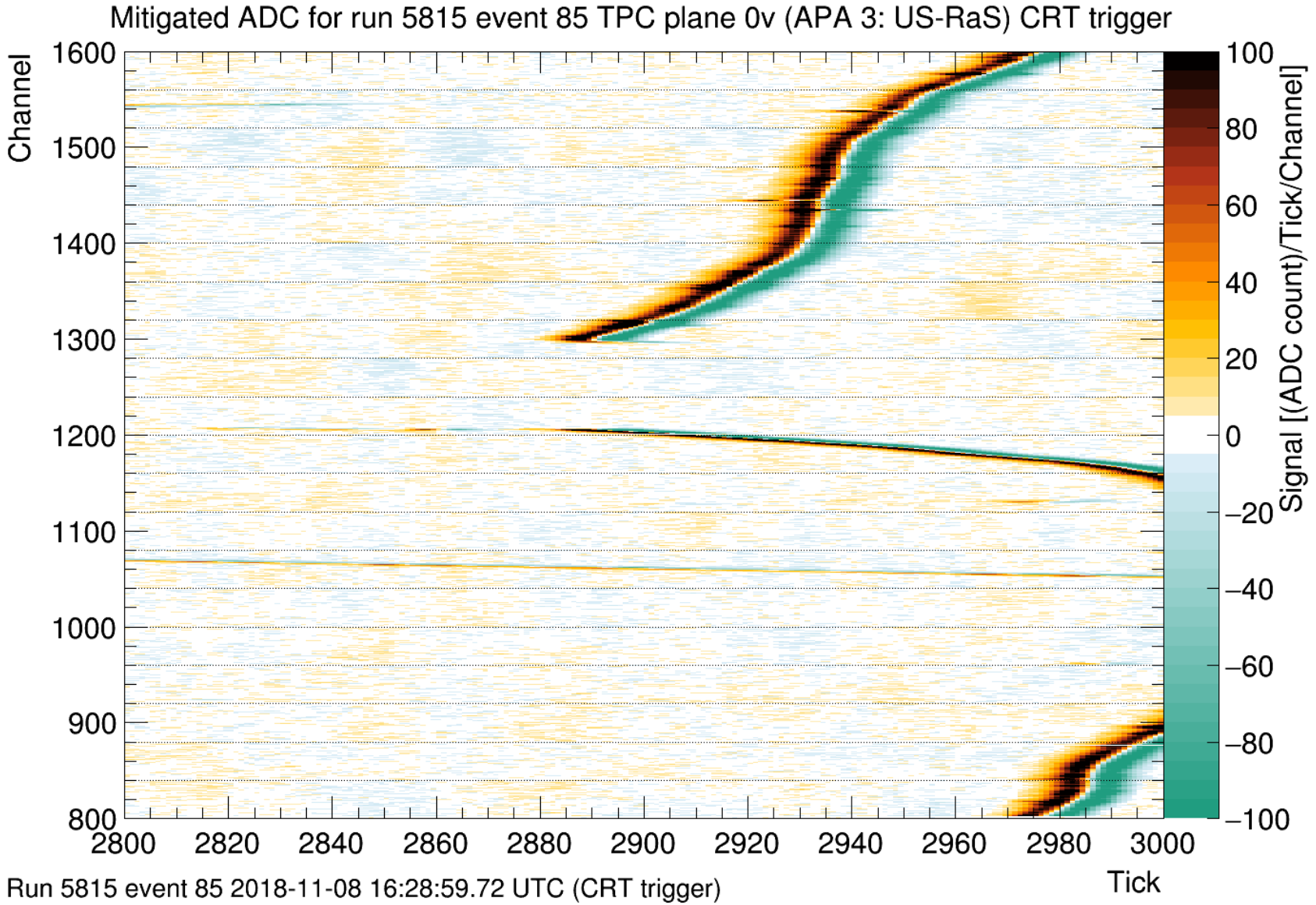
0.9993, 3


Mitigated ADC for run 5815 event 85 TPC plane 0v (APA 3: US-RaS) CRT trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
2800
2820
2840
2860
2880
2900
2920
2940
2960
2980
3000
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 85 2018-11-08 16:28:59.72 UTC (CRT trigger)

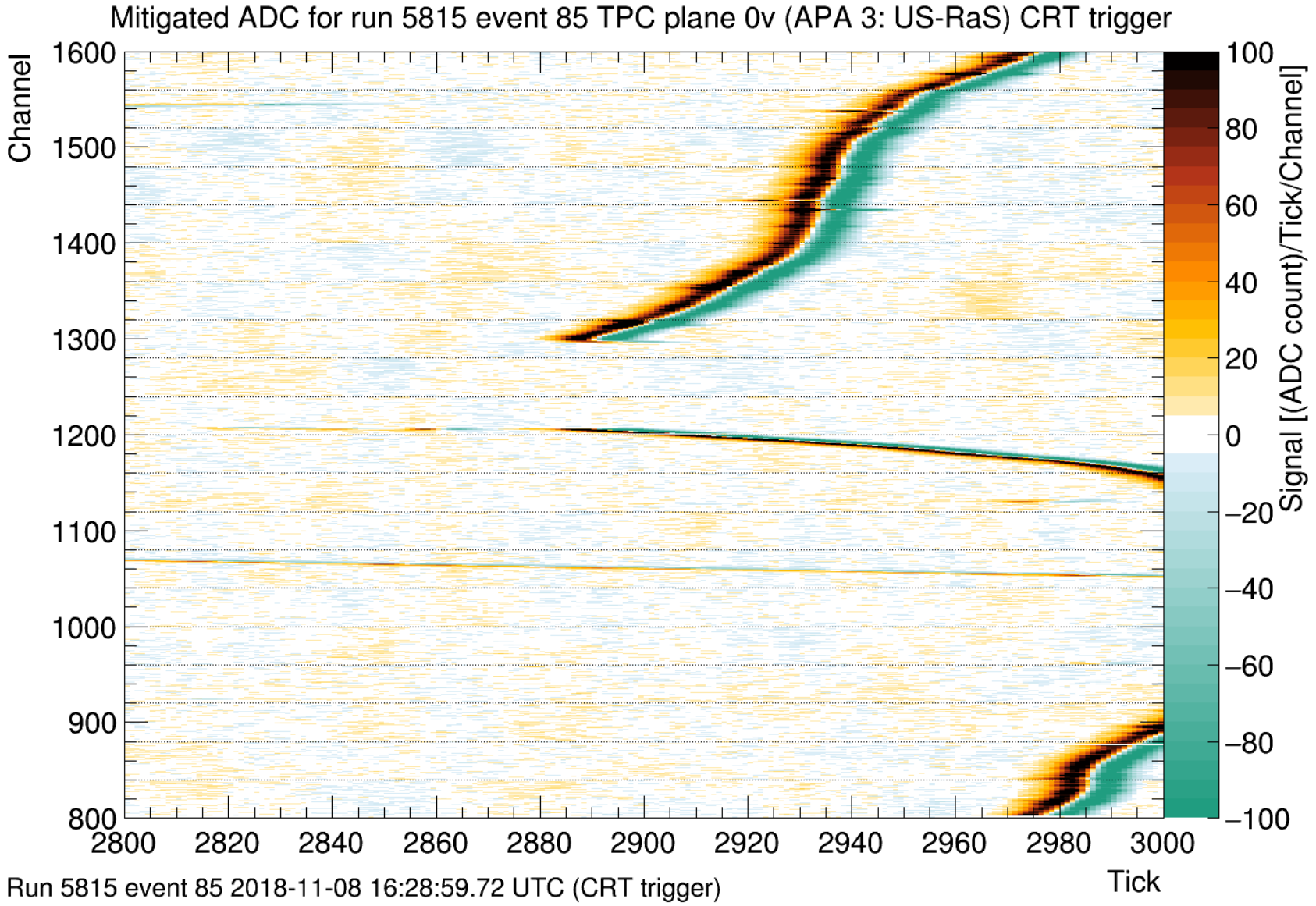
0.9993, 2


Mitigated ADC for run 5815 event 85 TPC plane 0v (APA 3: US-RaS) CRT trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
2800
2820
2840
2860
2880
2900
2920
2940
2960
2980
3000
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 85 2018-11-08 16:28:59.72 UTC (CRT trigger)

0.9993, 1

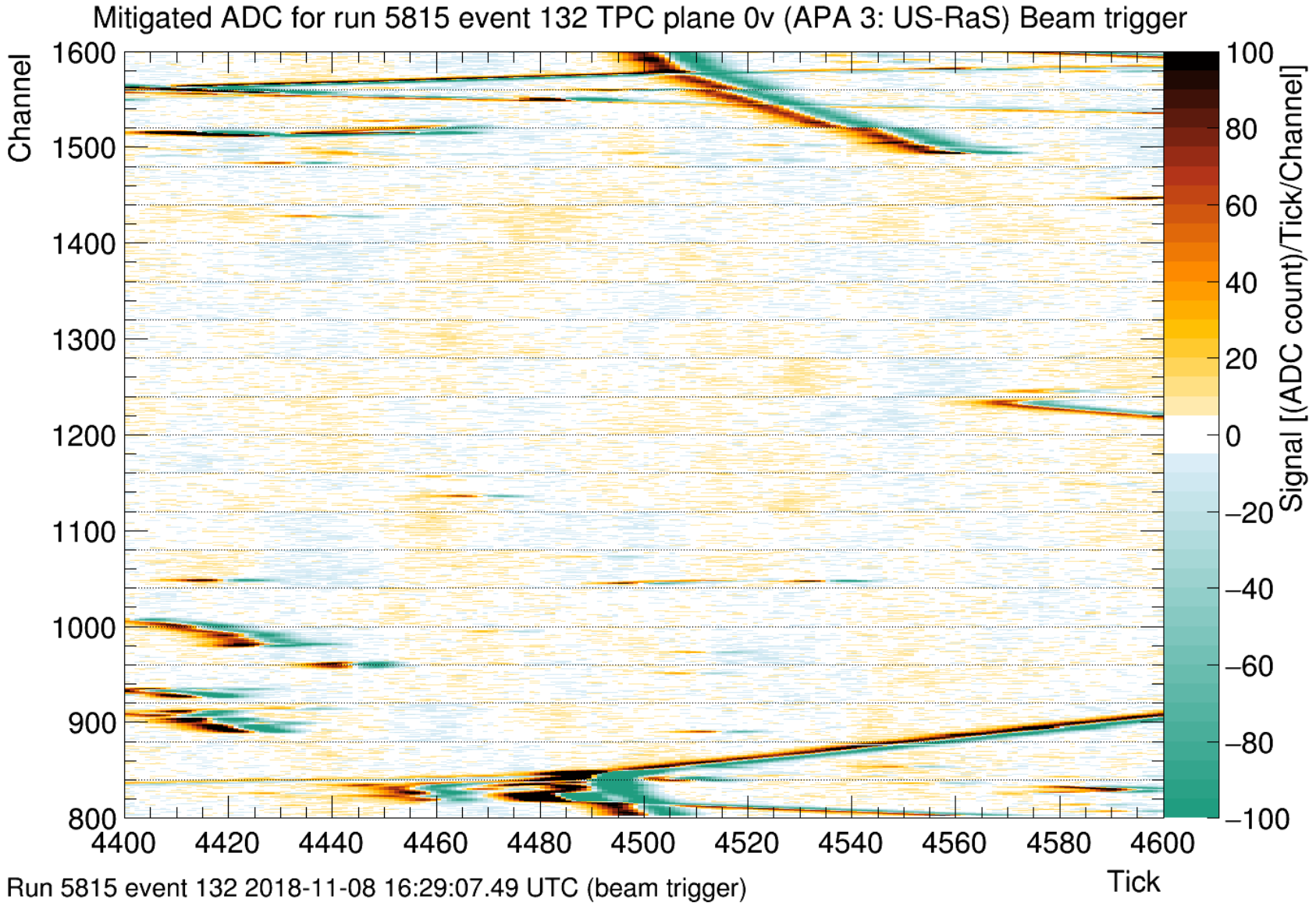

Mitigated ADC for run 5815 event 85 TPC plane 0v (APA 3: US-RaS) CRT trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
2800
2820
2840
2860
2880
2900
2920
2940
2960
2980
3000
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 85 2018-11-08 16:28:59.72 UTC (CRT trigger)

0.9993, 0

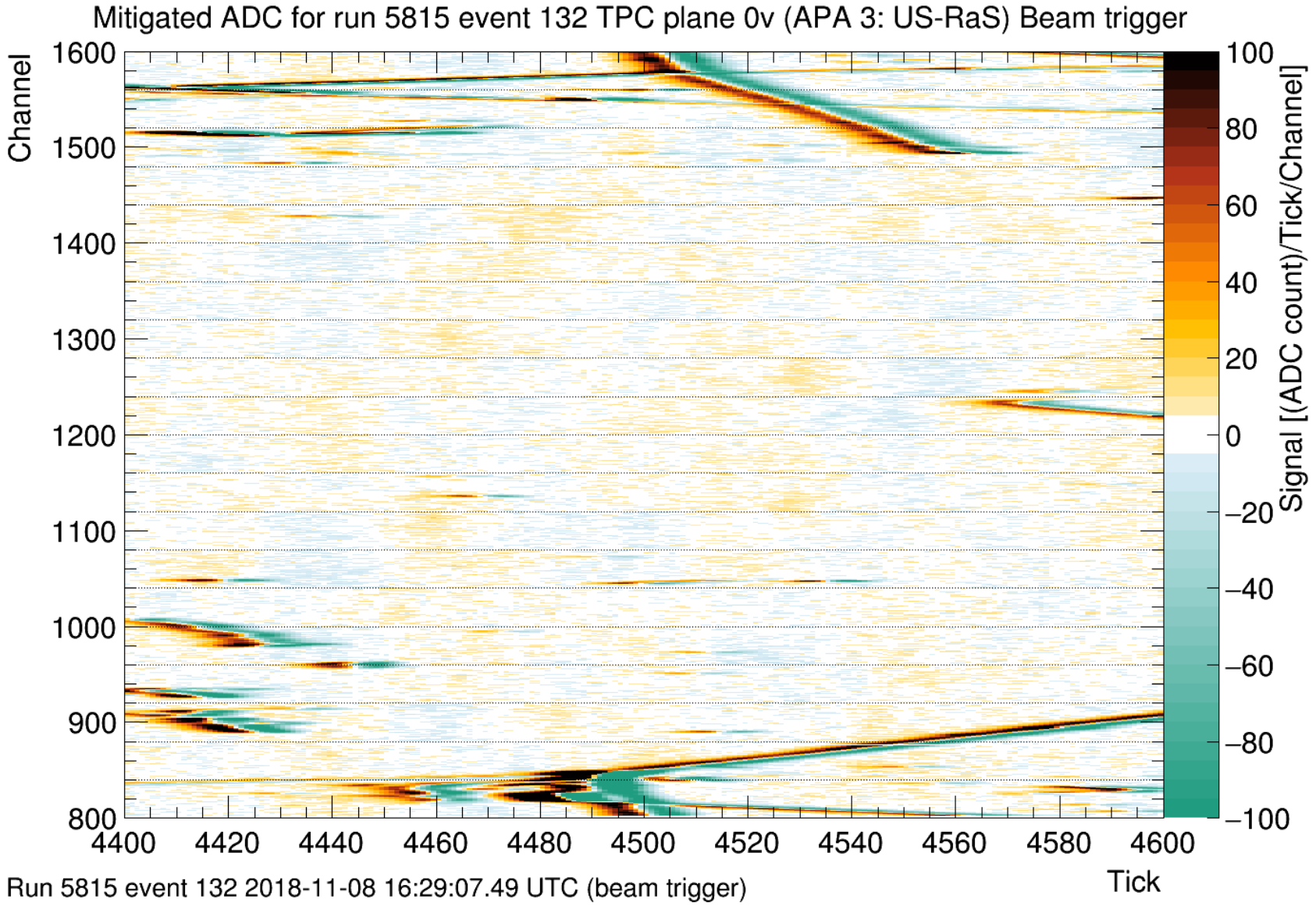

Mitigated ADC for run 5815 event 85 TPC plane 0v (APA 3: US-RaS) CRT trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
2800
2820
2840
2860
2880
2900
2920
2940
2960
2980
3000
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 85 2018-11-08 16:28:59.72 UTC (CRT trigger)

Event 132 v4400-4600

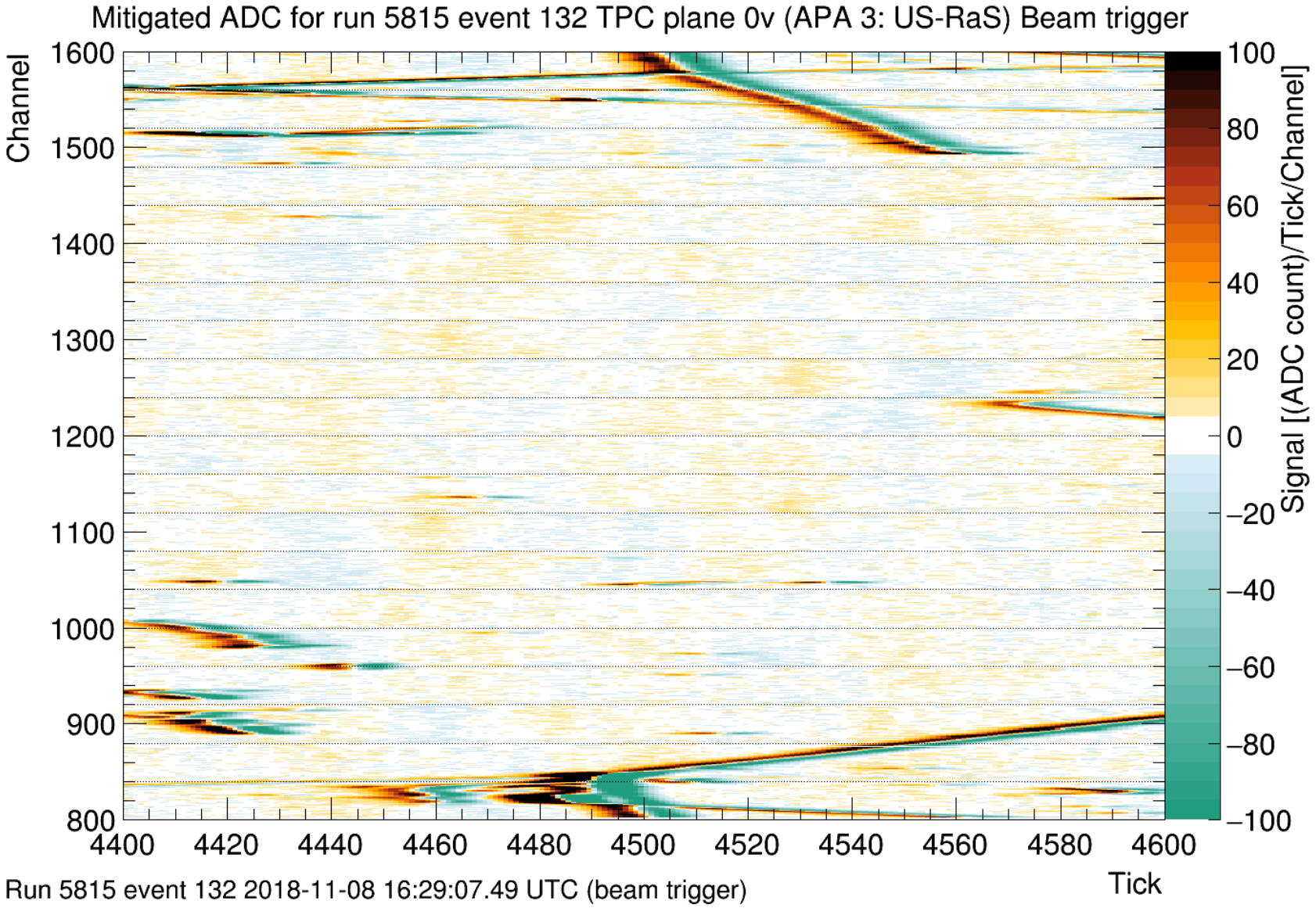
1.0, 0 (no correction)



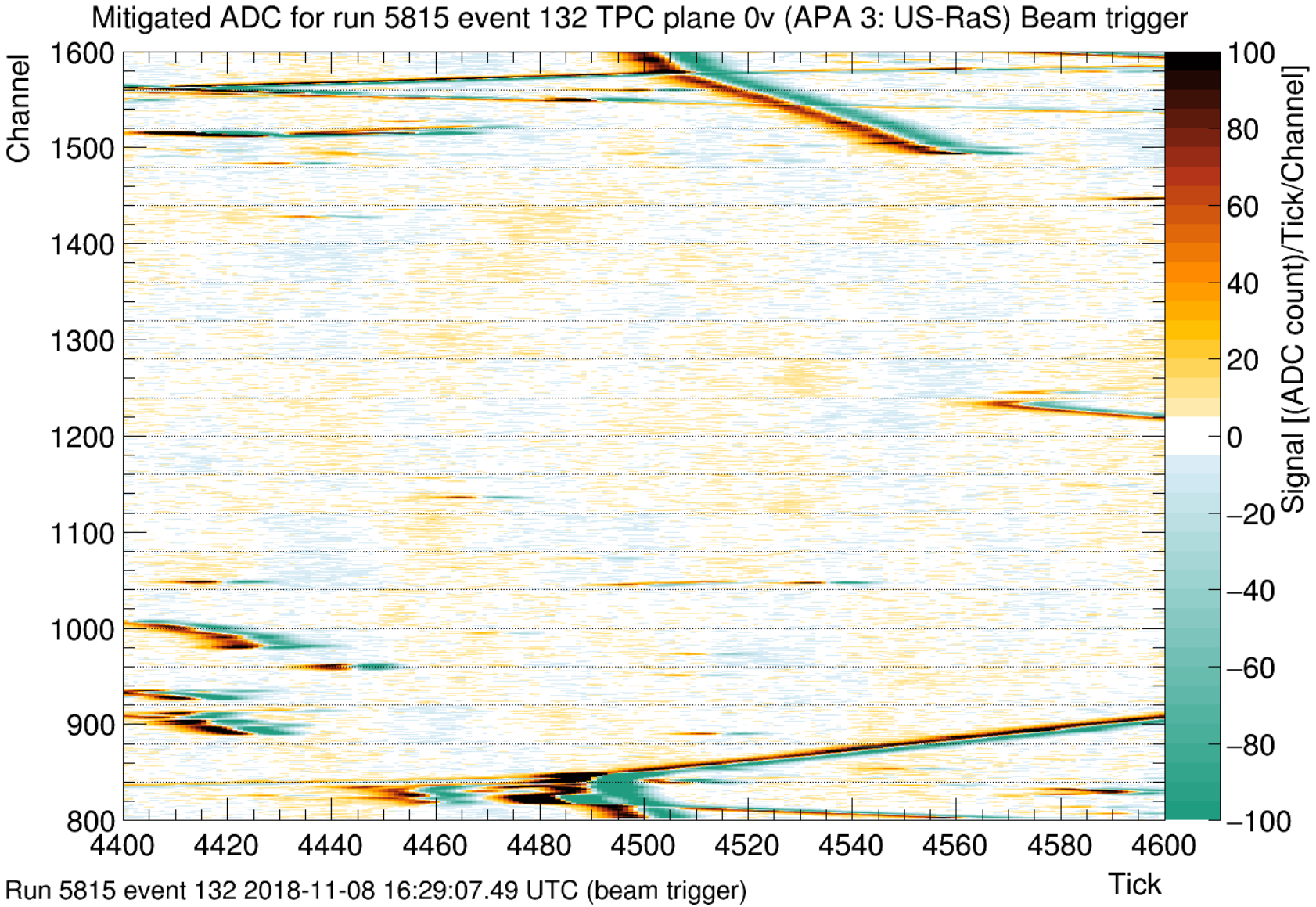
0.9995, 3 (Dec 2018 correction)



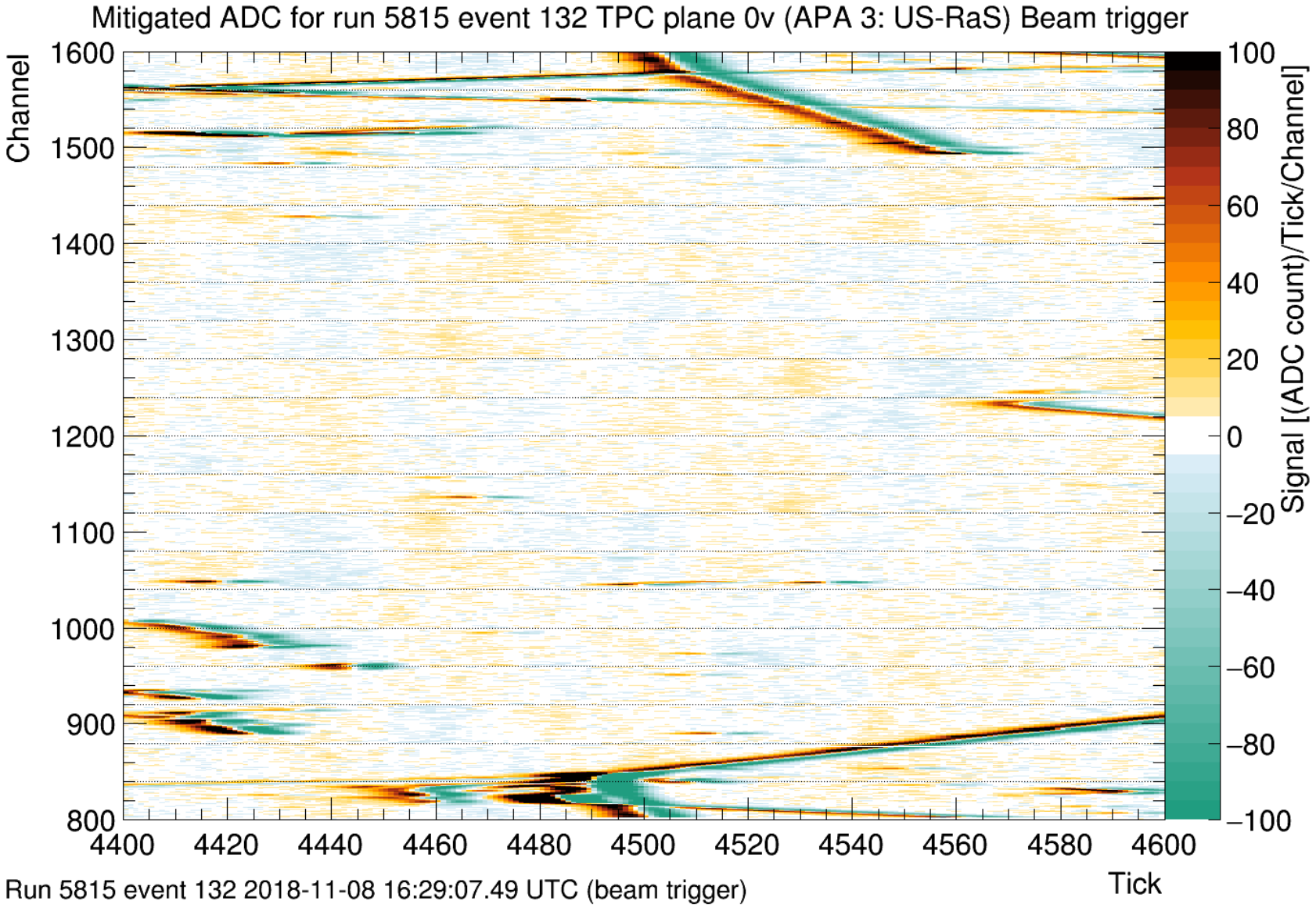
0.9993, 3


Mitigated ADC for run 5815 event 132 TPC plane 0v (APA 3: US-RaS) Beam trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
4400
4420
4440
4460
4480
4500
4520
4540
4560
4580
4600
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 132 2018-11-08 16:29:07.49 UTC (beam trigger)

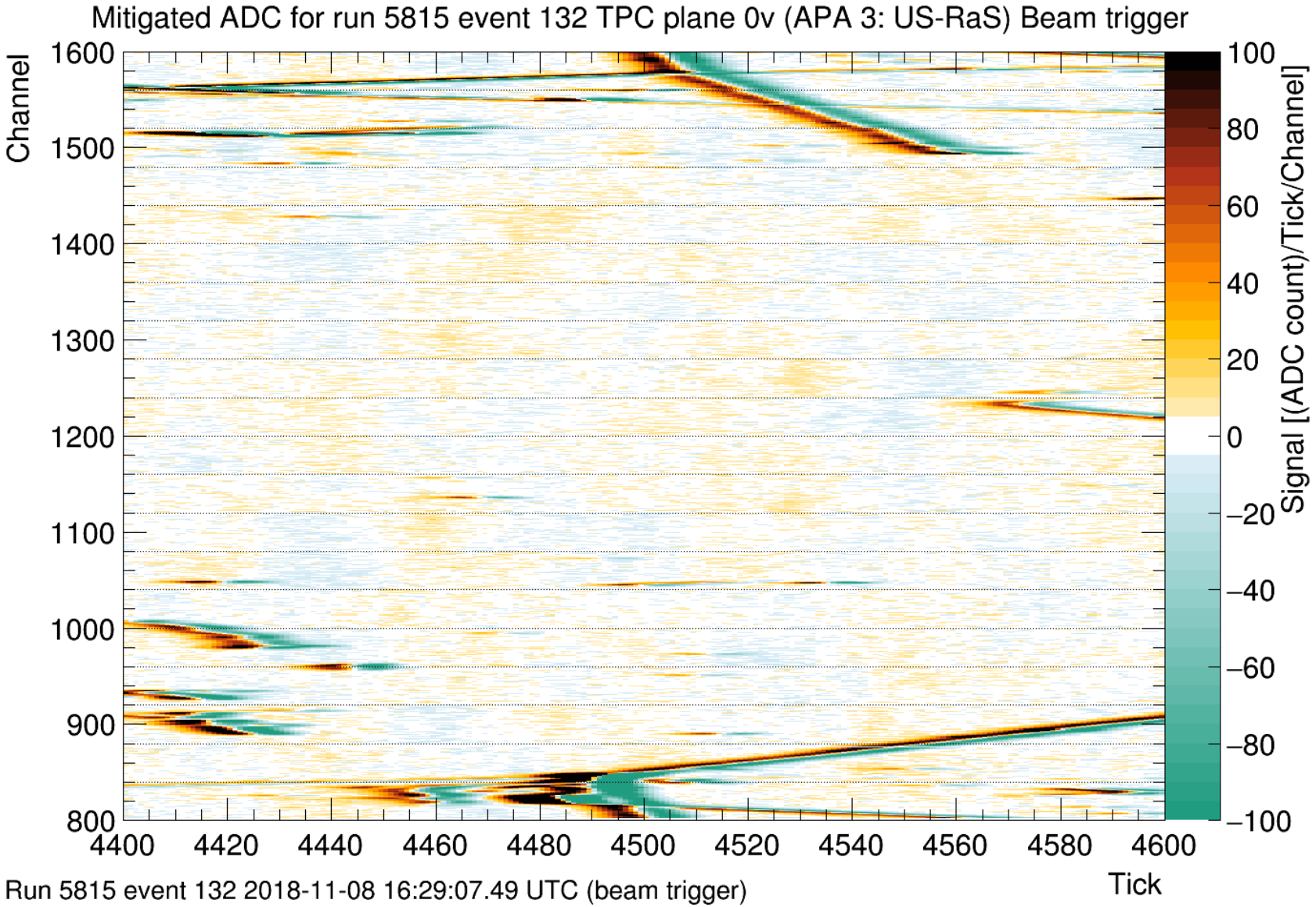
0.9993, 2


Mitigated ADC for run 5815 event 132 TPC plane 0v (APA 3: US-RaS) Beam trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
4400
4420
4440
4460
4480
4500
4520
4540
4560
4580
4600
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 132 2018-11-08 16:29:07.49 UTC (beam trigger)

0.9993, 1

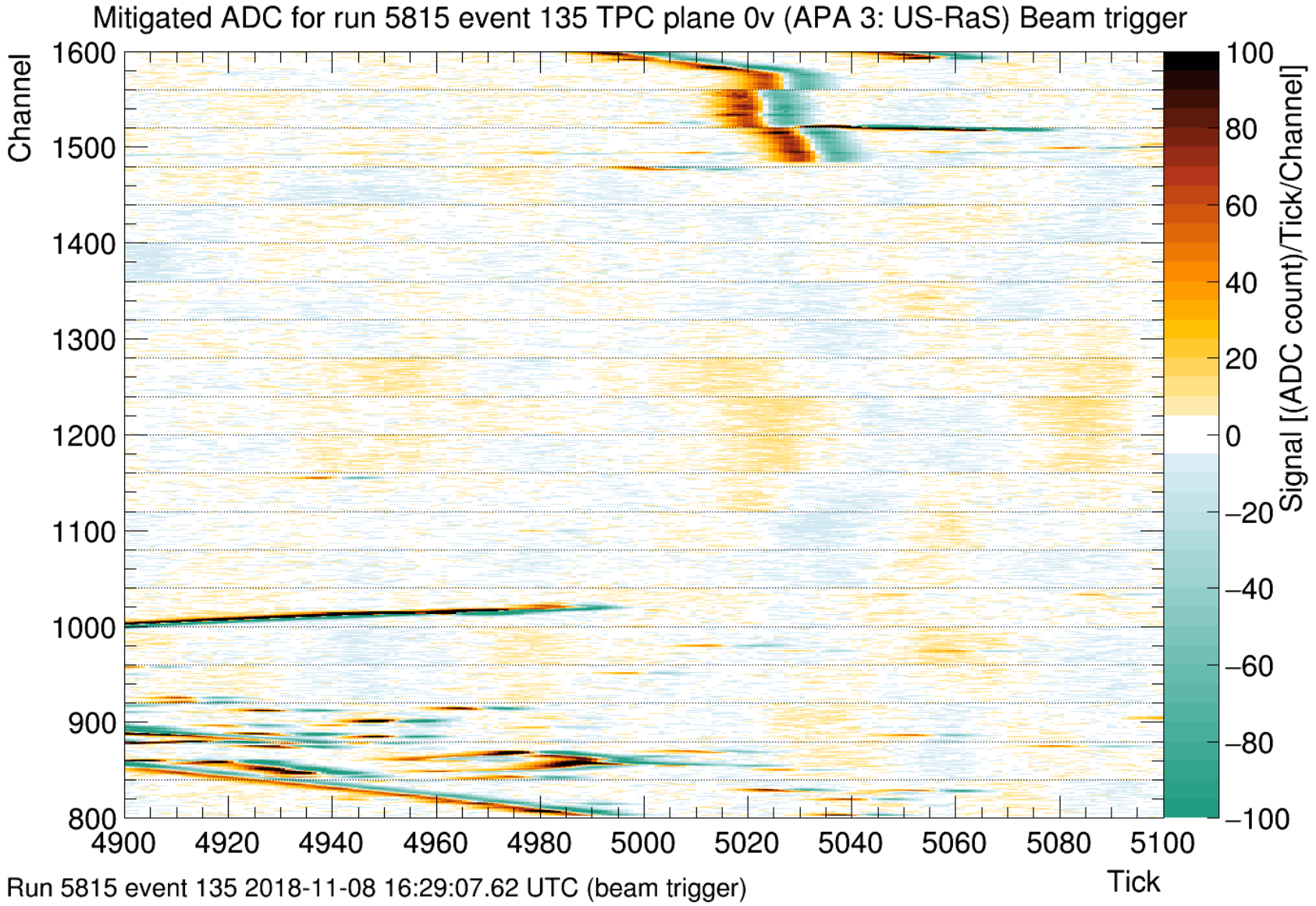

Mitigated ADC for run 5815 event 132 TPC plane 0v (APA 3: US-RaS) Beam trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
4400
4420
4440
4460
4480
4500
4520
4540
4560
4580
4600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 132 2018-11-08 16:29:07.49 UTC (beam trigger)

0.9993, 0

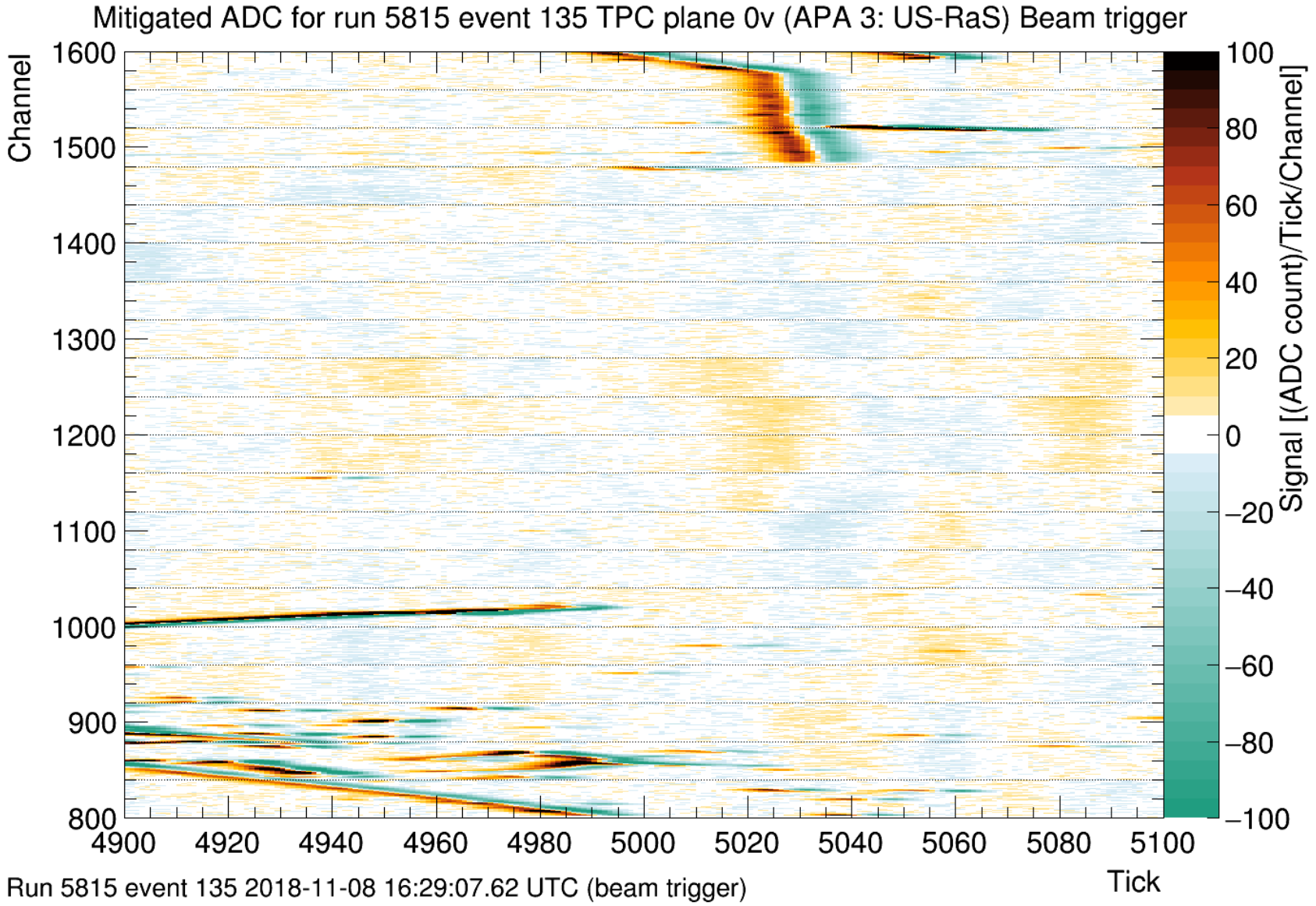

Mitigated ADC for run 5815 event 132 TPC plane 0v (APA 3: US-RaS) Beam trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
4400
4420
4440
4460
4480
4500
4520
4540
4560
4580
4600
Tick
100
80
60
40
20
0
−20
−40
−60
−80
−100
Signal [(ADC count)/Tick/Channel]
Run 5815 event 132 2018-11-08 16:29:07.49 UTC (beam trigger)

Event 135 u4900-5100

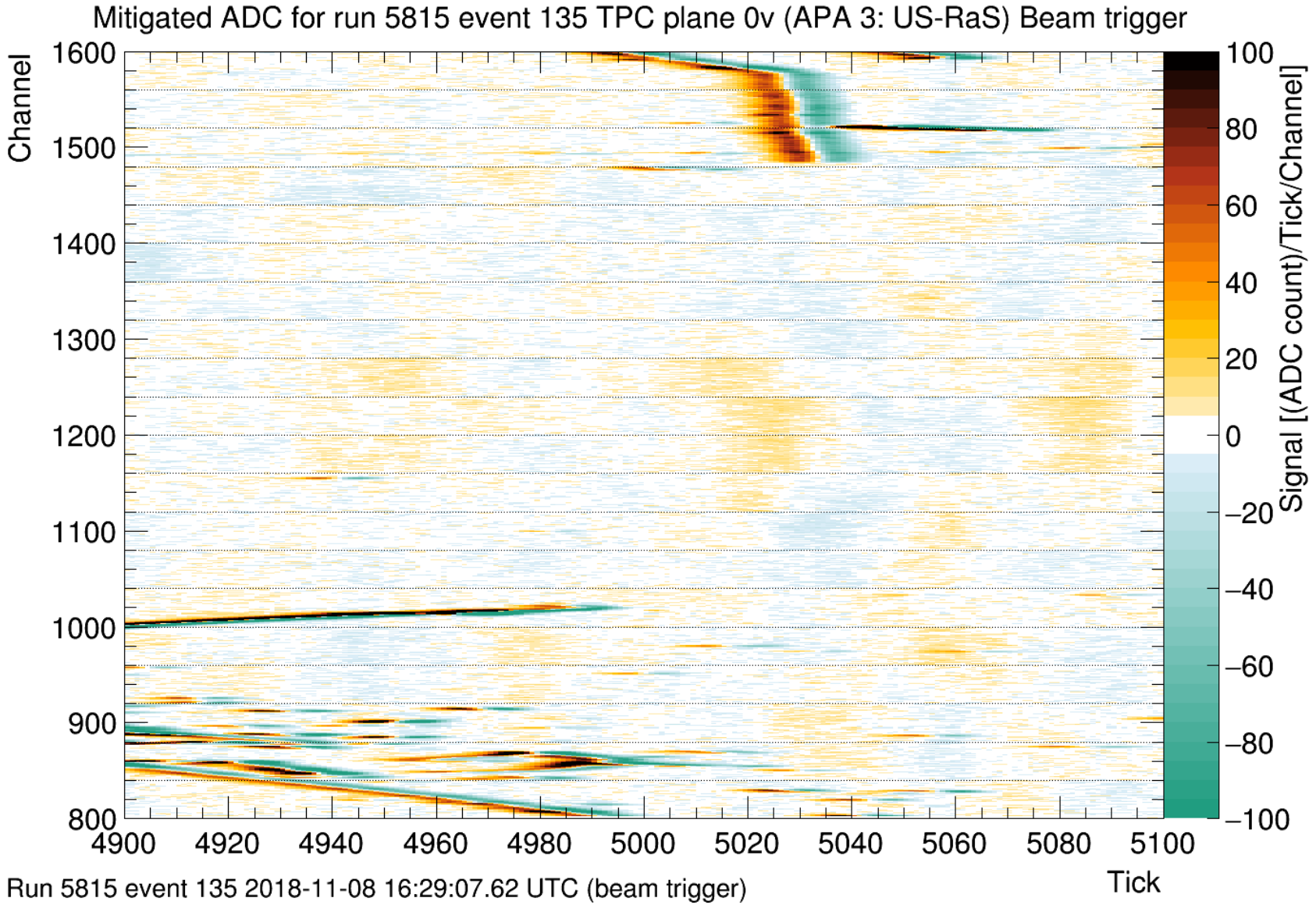
1.0, 0 (no correction)



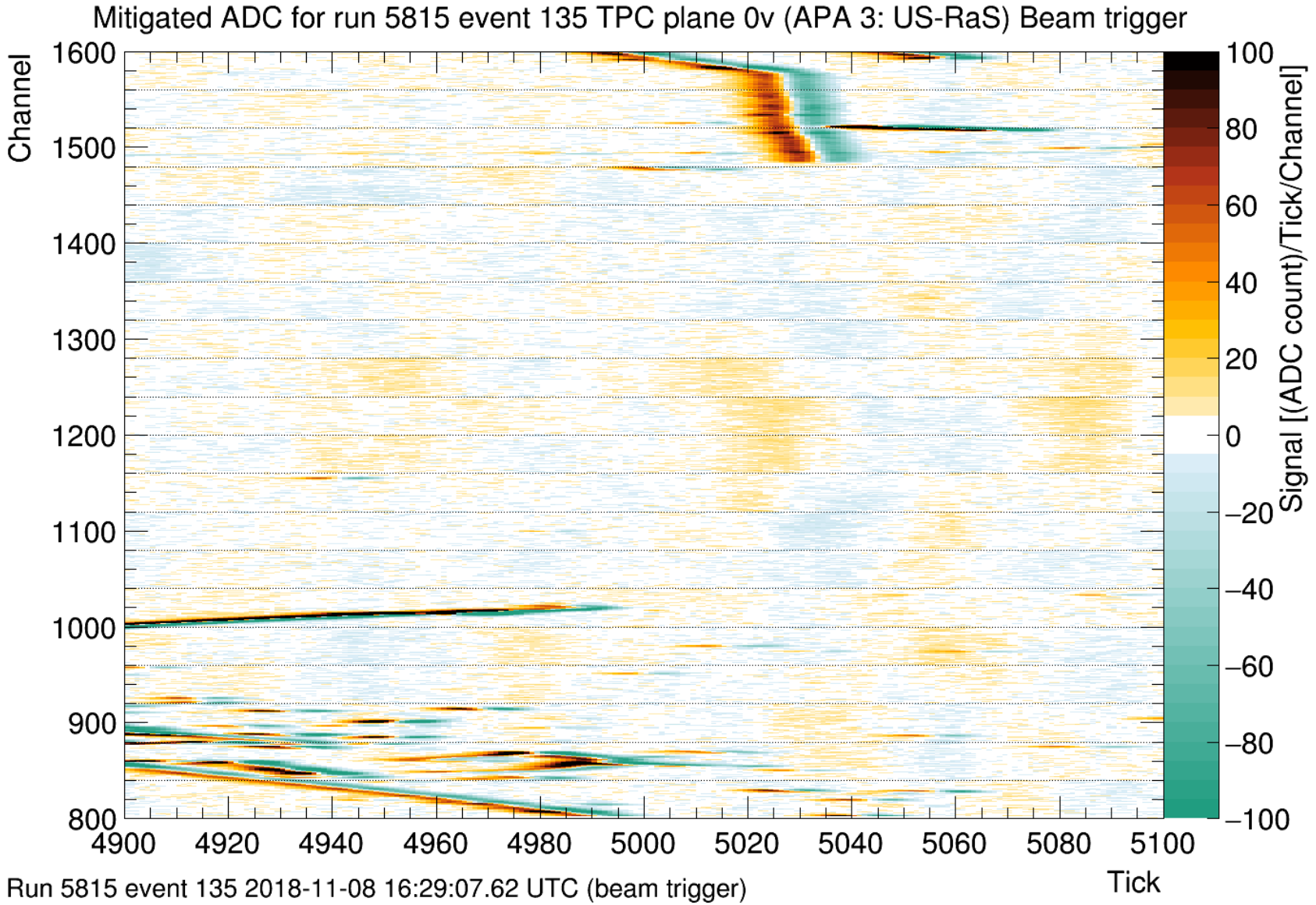
0.9995, 3 (Dec 2018 correction)



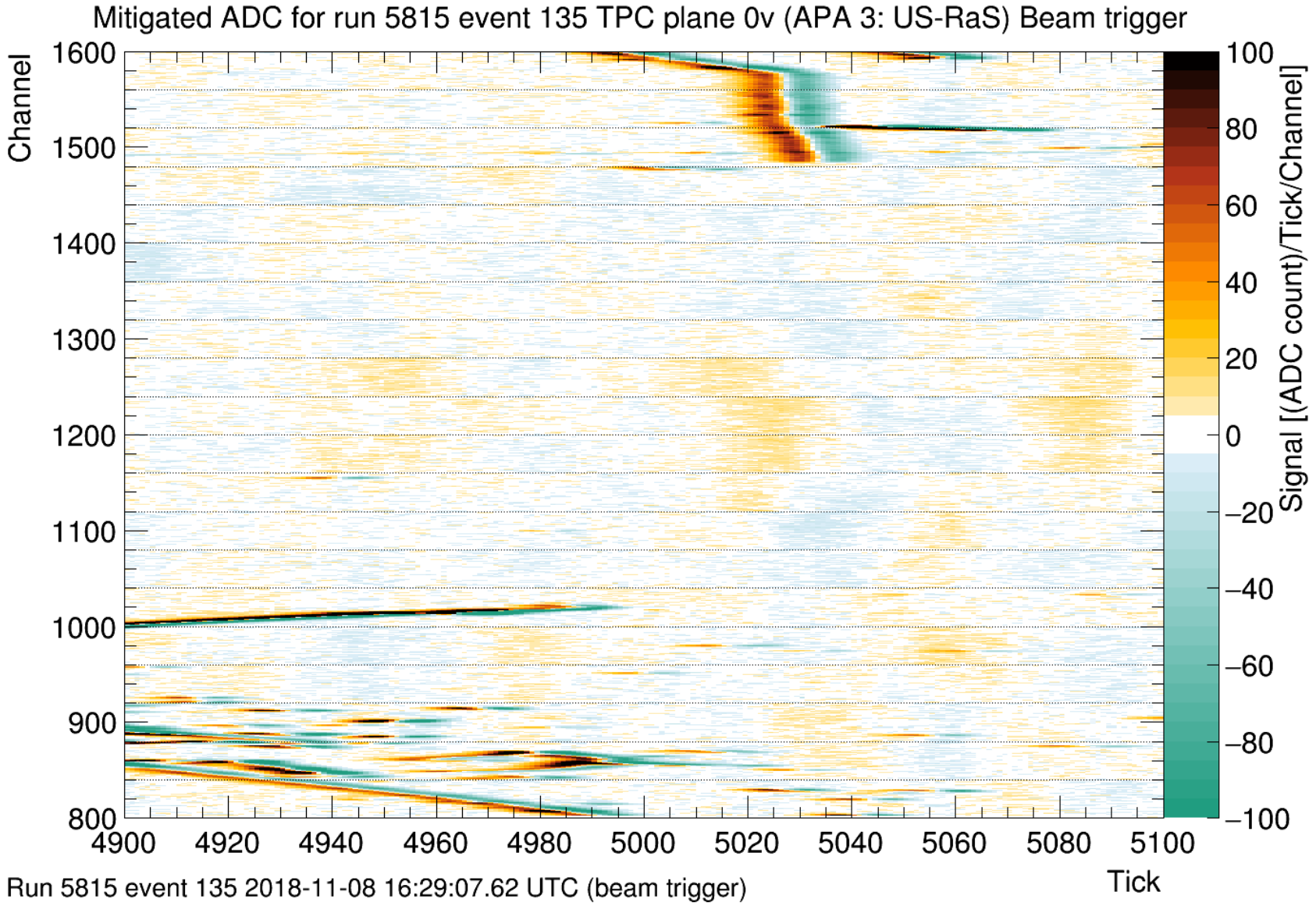
0.9993, 3


Mitigated ADC for run 5815 event 135 TPC plane 0v (APA 3: US-RaS) Beam trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
4900
4920
4940
4960
4980
5000
5020
5040
5060
5080
5100
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 135 2018-11-08 16:29:07.62 UTC (beam trigger)

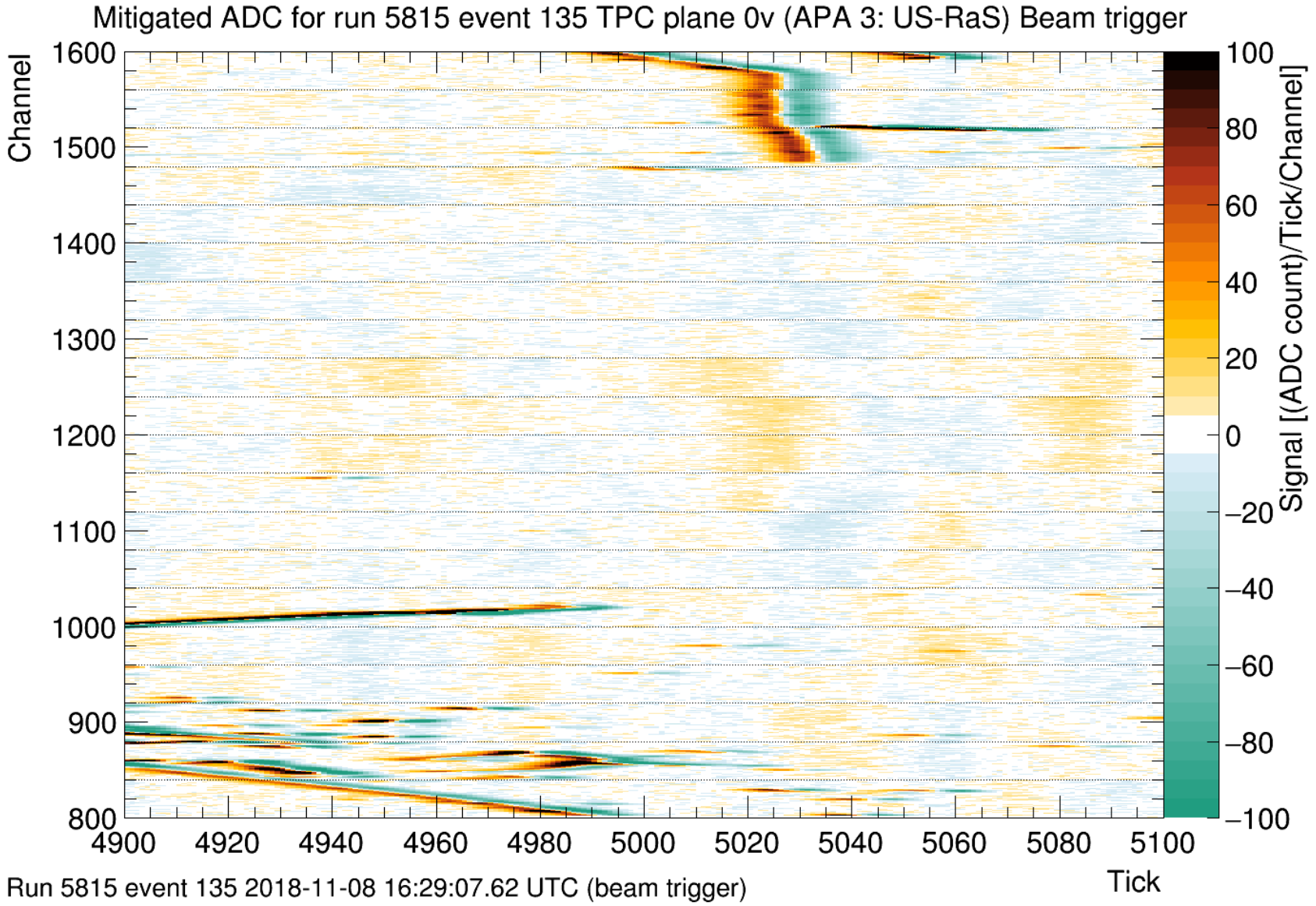
0.9993, 2


Mitigated ADC for run 5815 event 135 TPC plane 0v (APA 3: US-RaS) Beam trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
4900
4920
4940
4960
4980
5000
5020
5040
5060
5080
5100
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 135 2018-11-08 16:29:07.62 UTC (beam trigger)

0.9993, 1


Mitigated ADC for run 5815 event 135 TPC plane 0v (APA 3: US-RaS) Beam trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
4900
4920
4940
4960
4980
5000
5020
5040
5060
5080
5100
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 135 2018-11-08 16:29:07.62 UTC (beam trigger)

0.9993, 0


Mitigated ADC for run 5815 event 135 TPC plane 0v (APA 3: US-RaS) Beam trigger
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
4900
4920
4940
4960
4980
5000
5020
5040
5060
5080
5100
Tick
Signal [(ADC count)/Tick/Channel]
100
80
60
40
20
0
−20
−40
−60
−80
−100
Run 5815 event 135 2018-11-08 16:29:07.62 UTC (beam trigger)

Another run

Previous plots all for the same run 5815

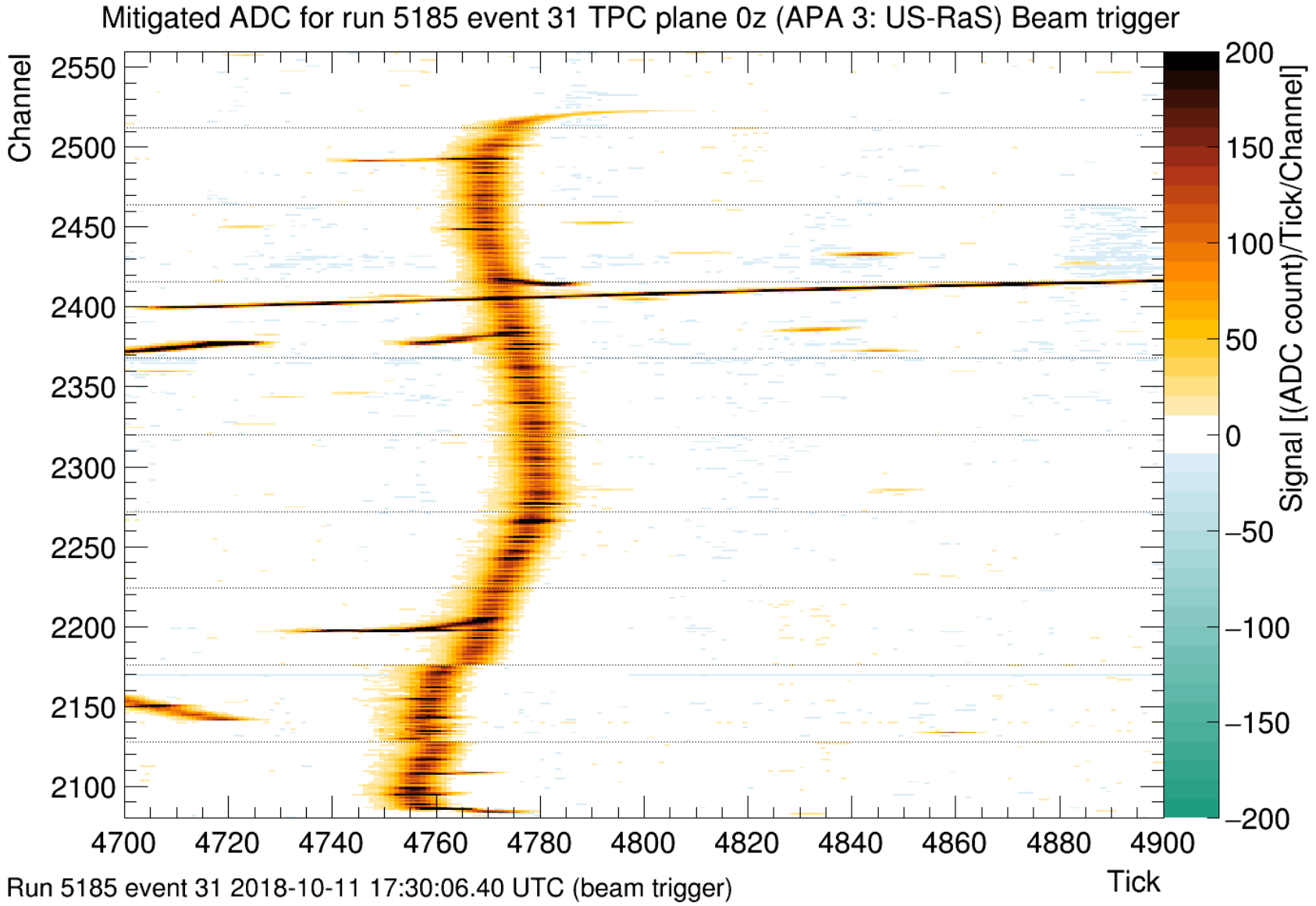
- Late in beam data taking: November 8
  - Last beam run was Nov 11 (GRL)
- Events used here were taken at about the same time (see plots)

Look at another run: 5185

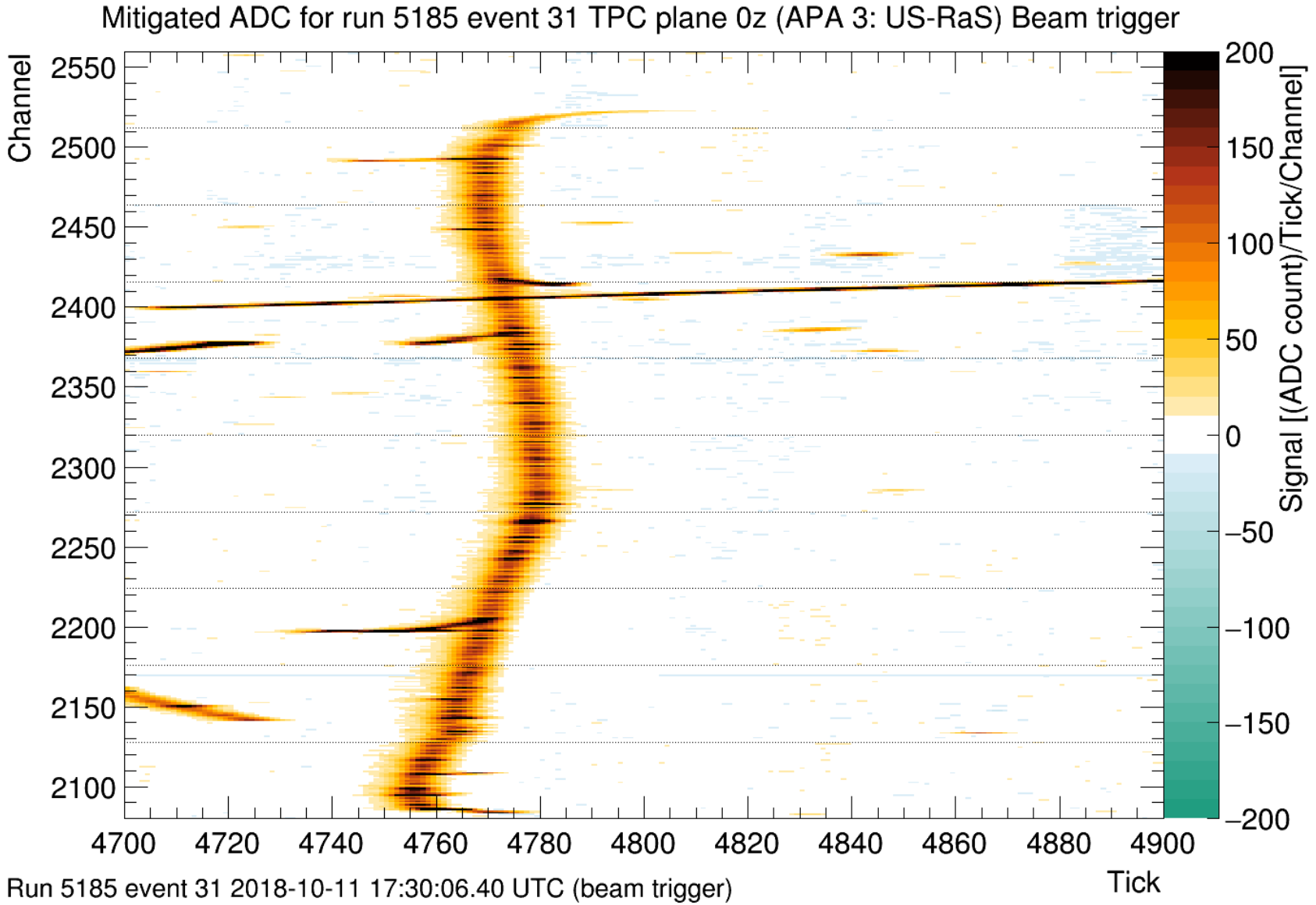
- Taken early, shortly after the change in the amplifier baseline
- Event displays for this run follow

Event 31 z4700-4900

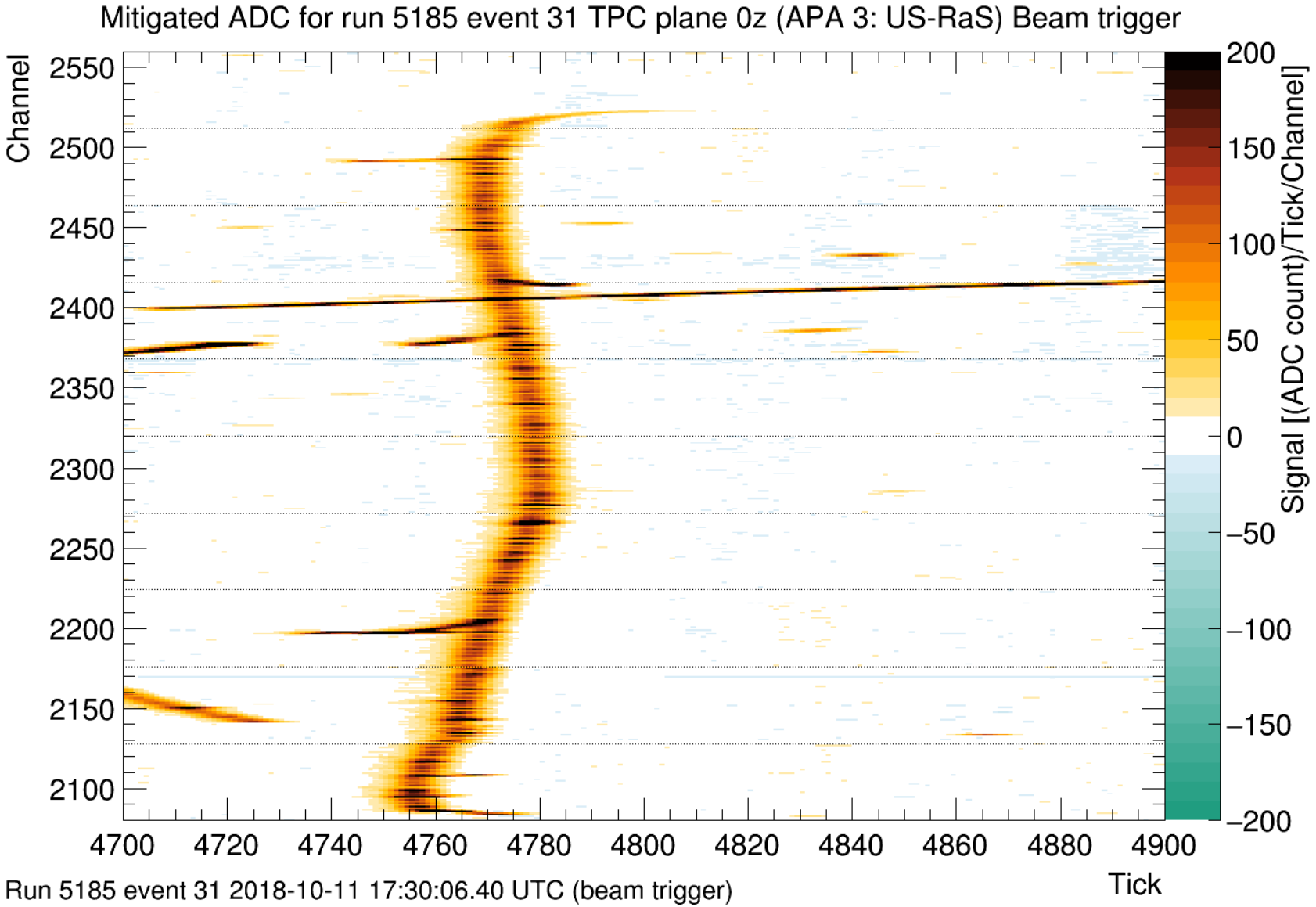
1.0, 0 (no correction)



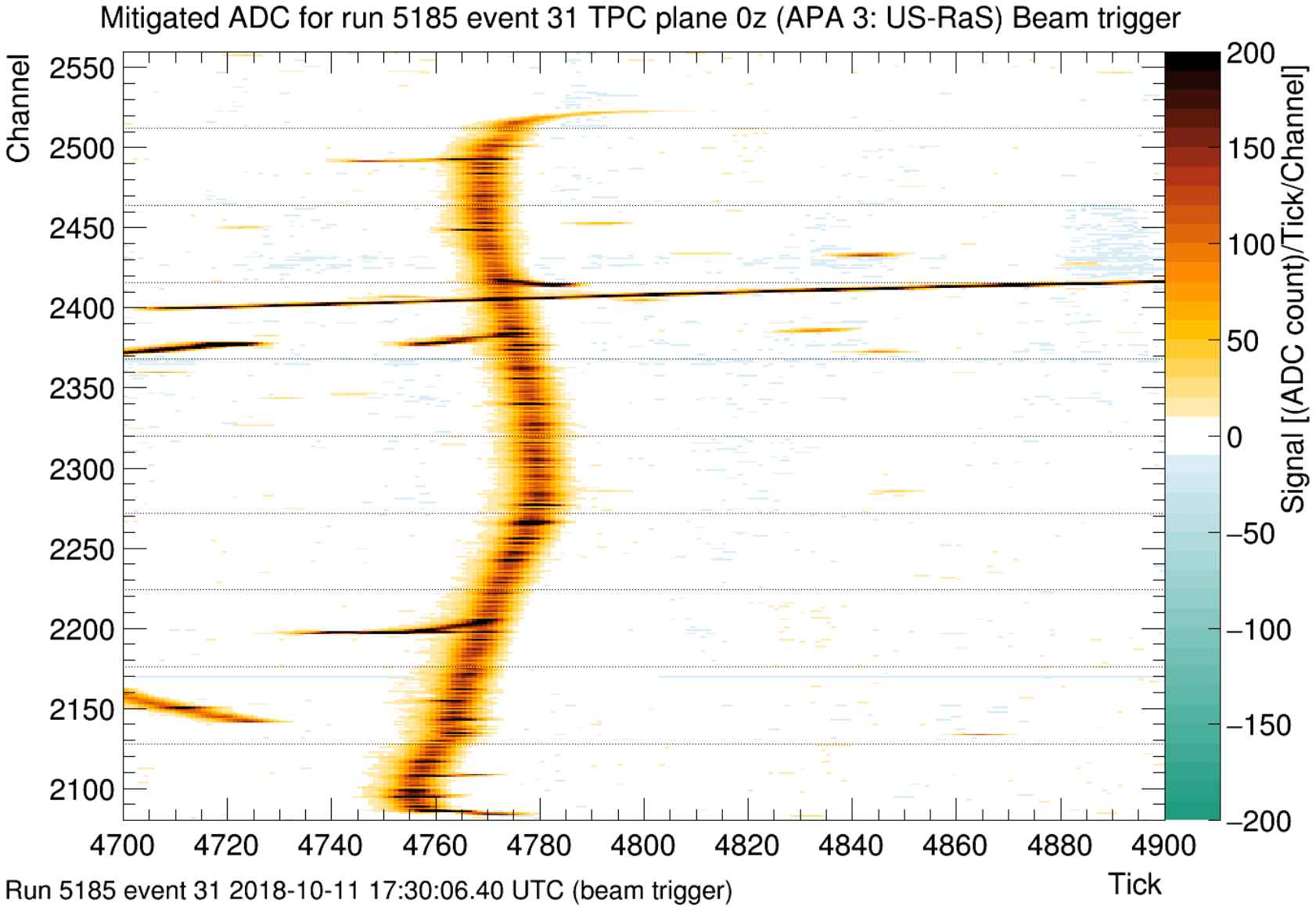
0.9995, 3 (Dec 2018 correction)



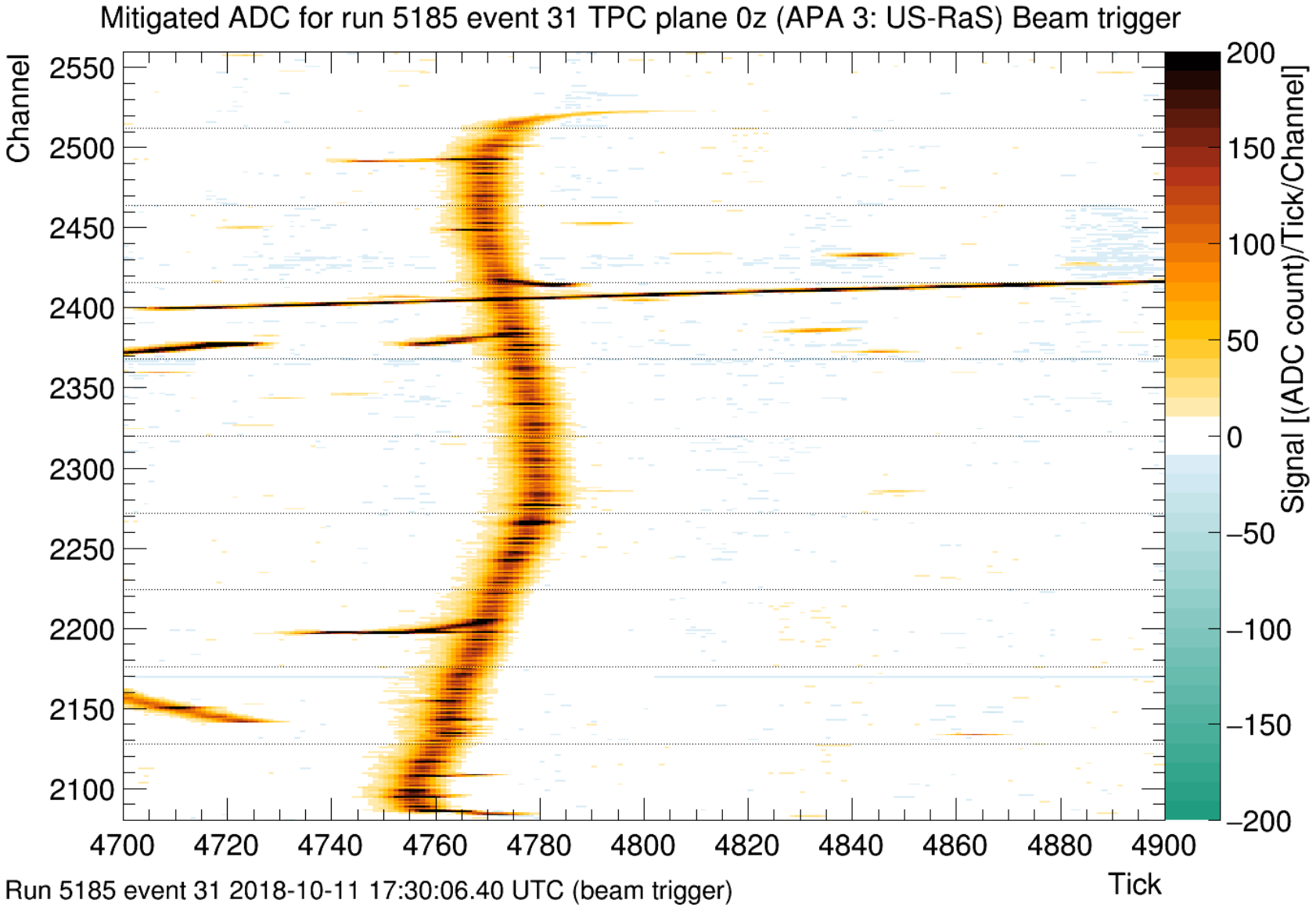
0.9993, 3


Mitigated ADC for run 5185 event 31 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 31 2018-10-11 17:30:06.40 UTC (beam trigger)

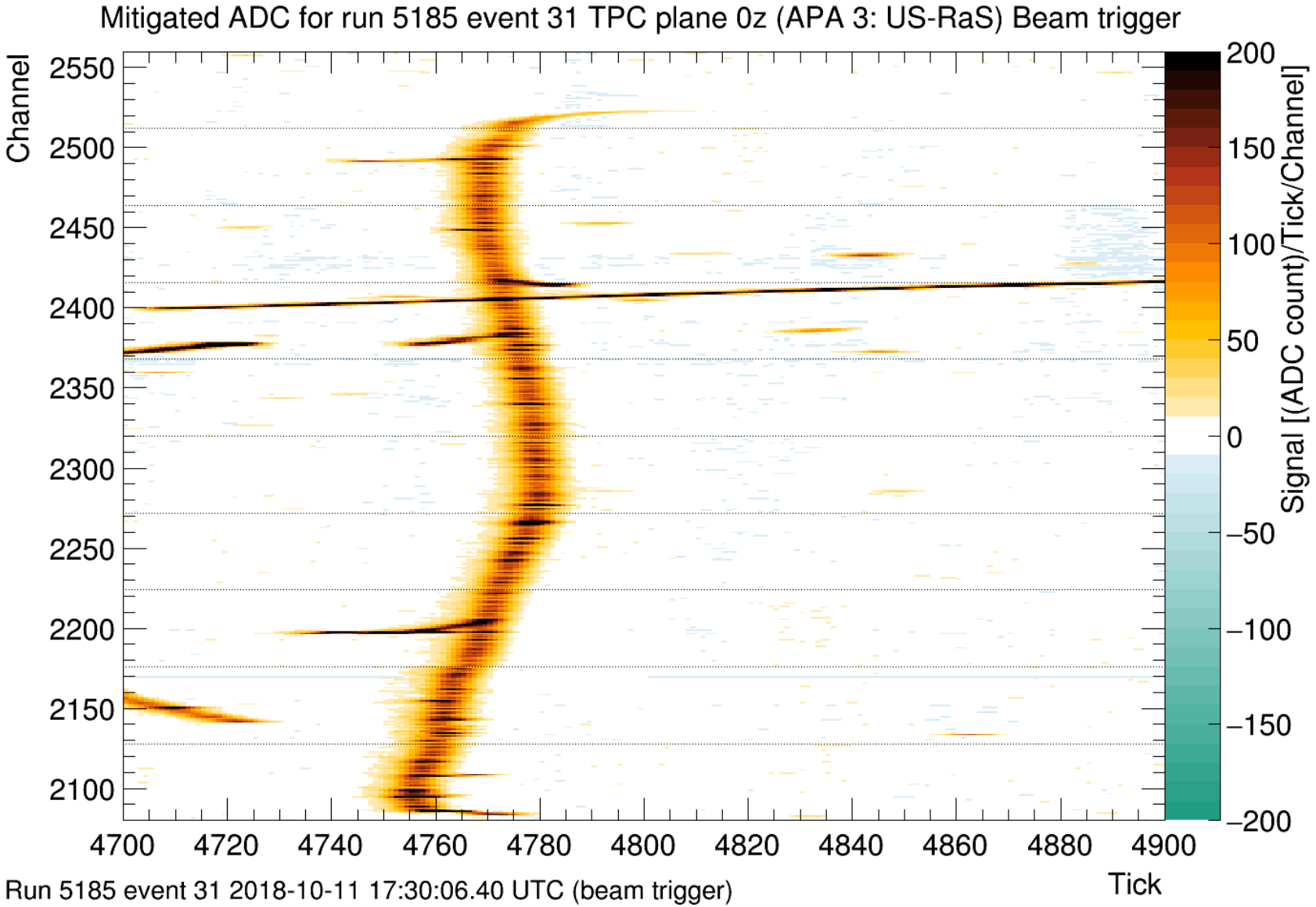
0.9993, 2


Mitigated ADC for run 5185 event 31 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 31 2018-10-11 17:30:06.40 UTC (beam trigger)

0.9993, 1

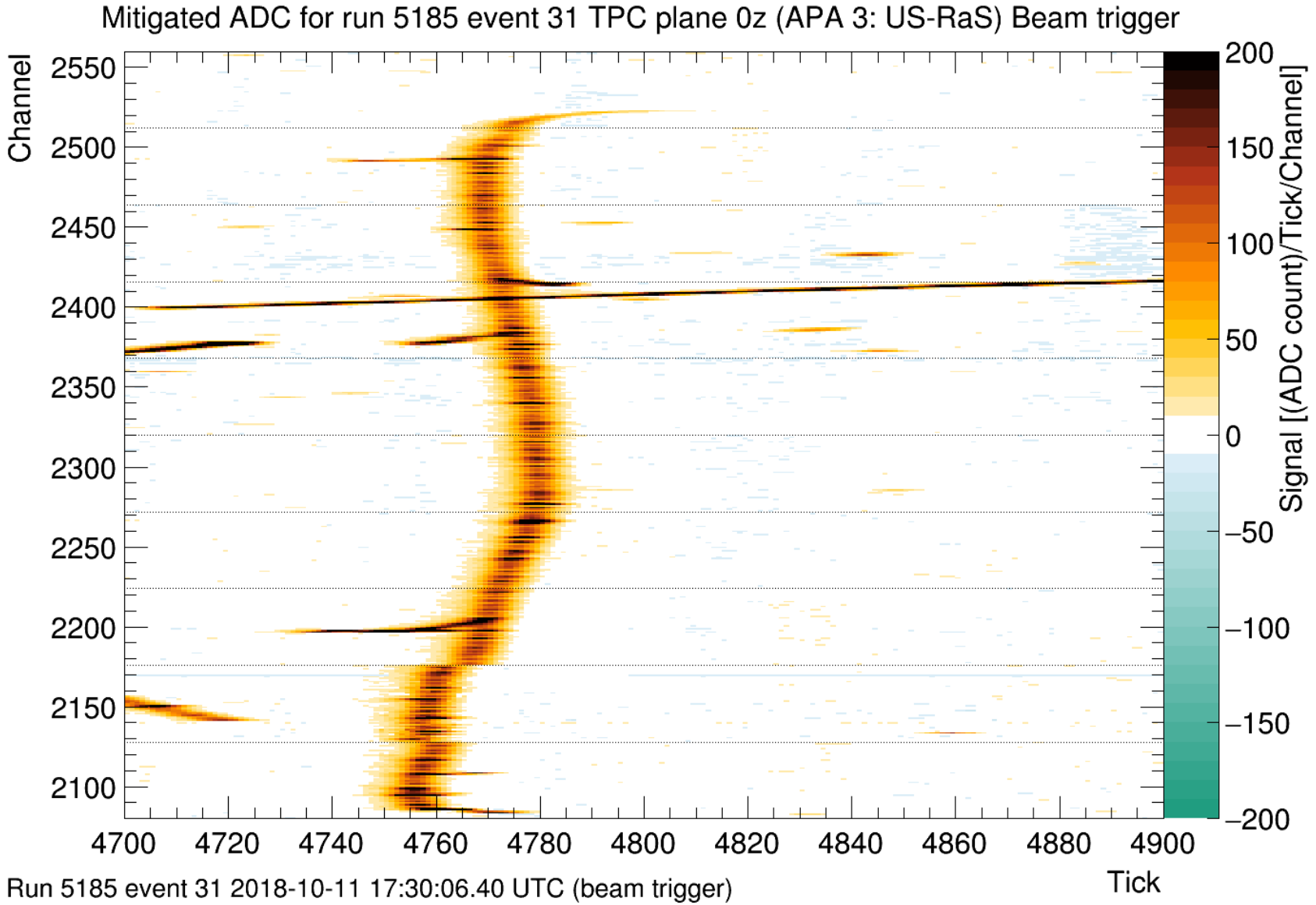

Mitigated ADC for run 5185 event 31 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 31 2018-10-11 17:30:06.40 UTC (beam trigger)

0.9993, 0

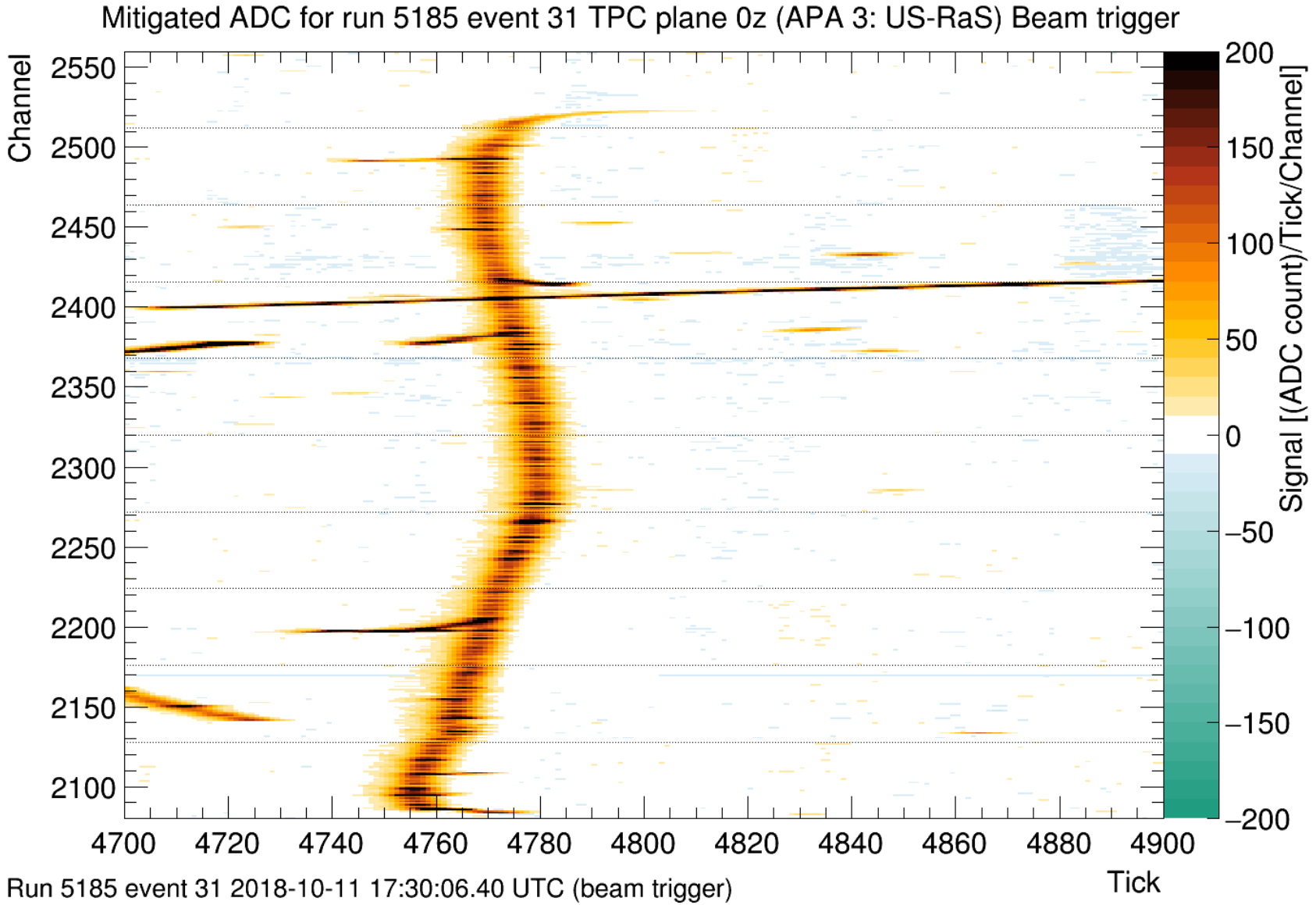

Mitigated ADC for run 5185 event 31 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 31 2018-10-11 17:30:06.40 UTC (beam trigger)

Event 31 z4700-4900

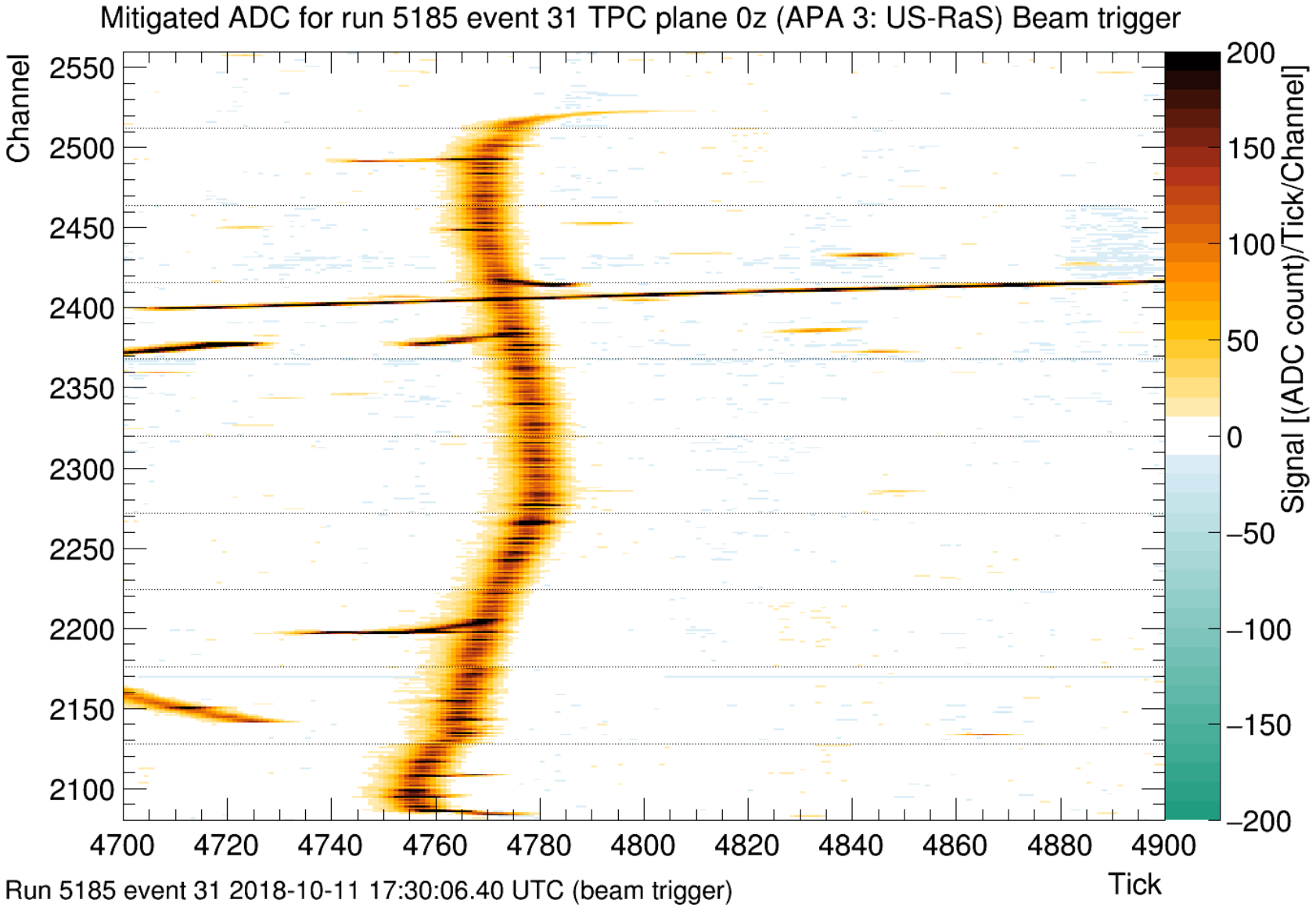
1.0, 0 (no correction)



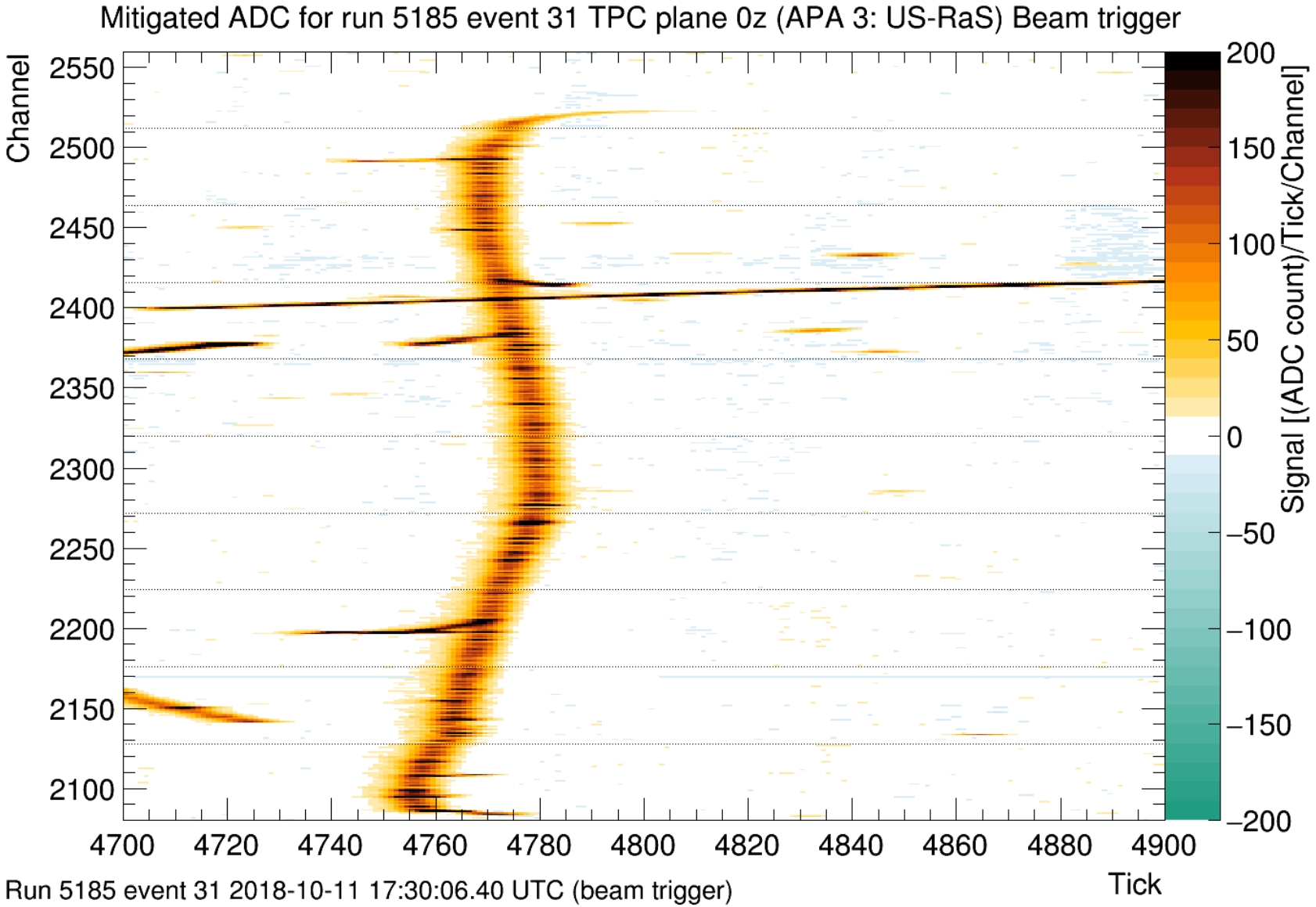
0.9995, 3 (Dec 2018 correction)



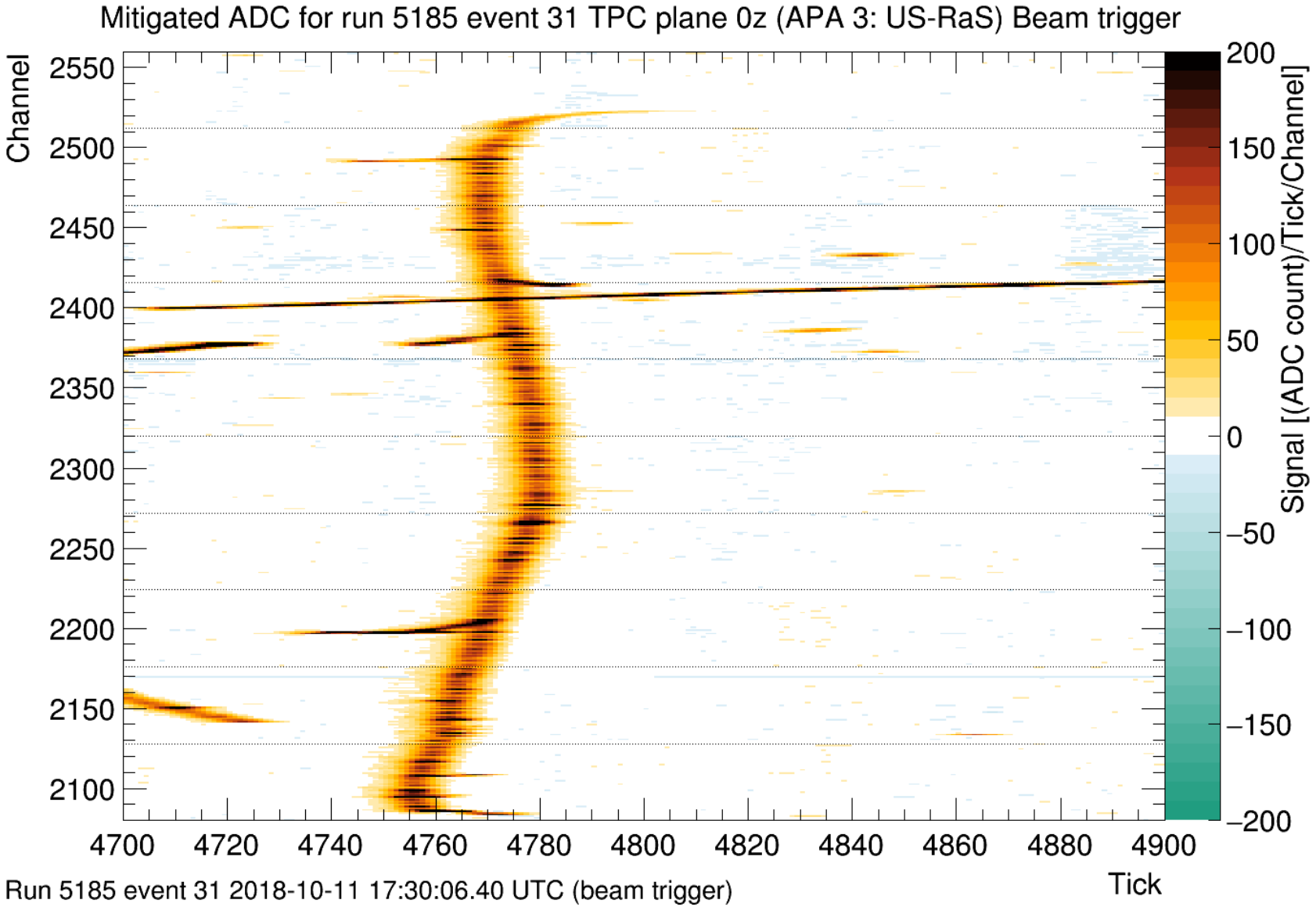
0.9993, 3


Mitigated ADC for run 5185 event 31 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 31 2018-10-11 17:30:06.40 UTC (beam trigger)

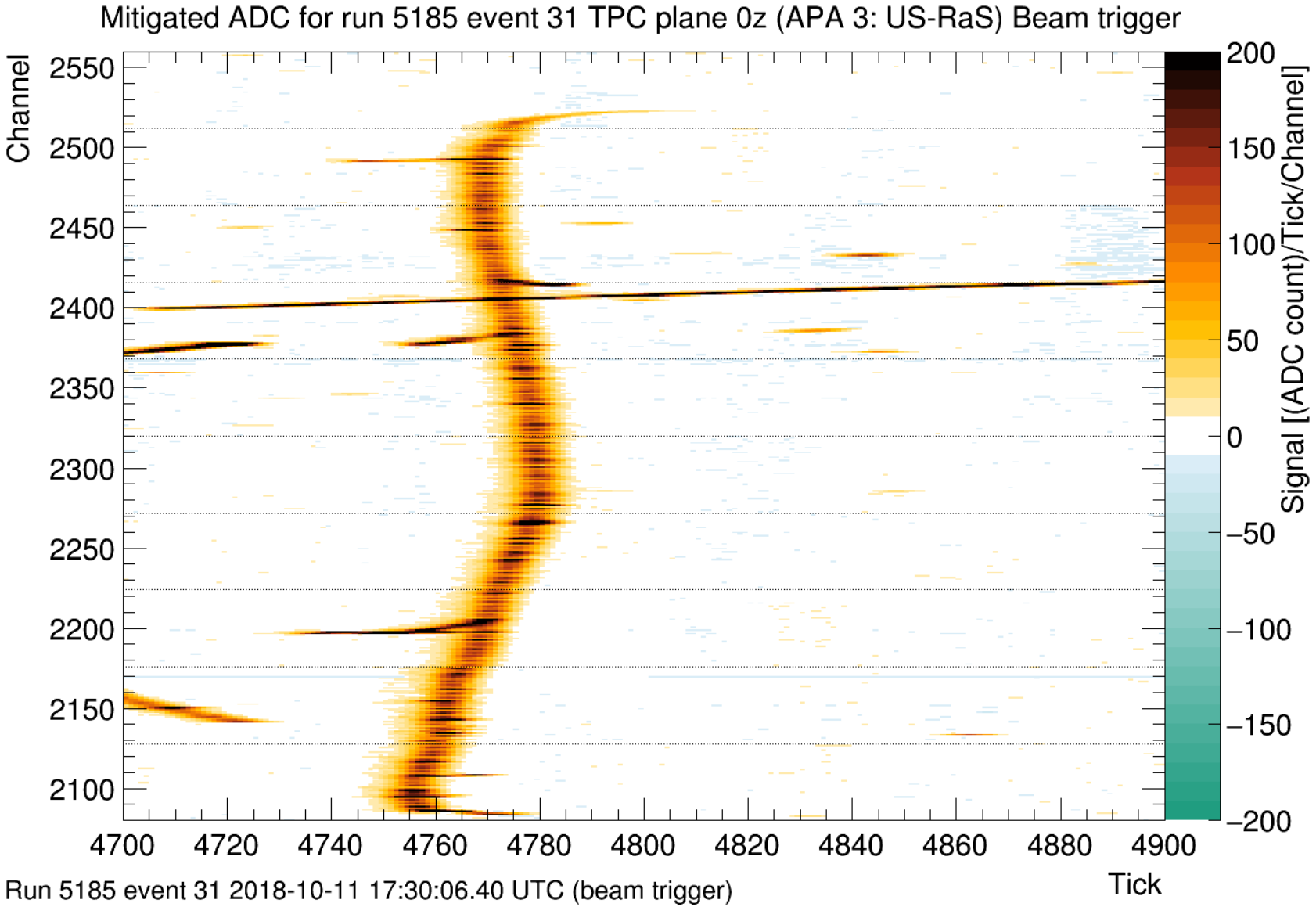
0.9993, 2


Mitigated ADC for run 5185 event 31 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
Signal [(ADC count)/Tick/Channel]
200
150
100
50
0
−50
−100
−150
−200
Run 5185 event 31 2018-10-11 17:30:06.40 UTC (beam trigger)

0.9993, 1

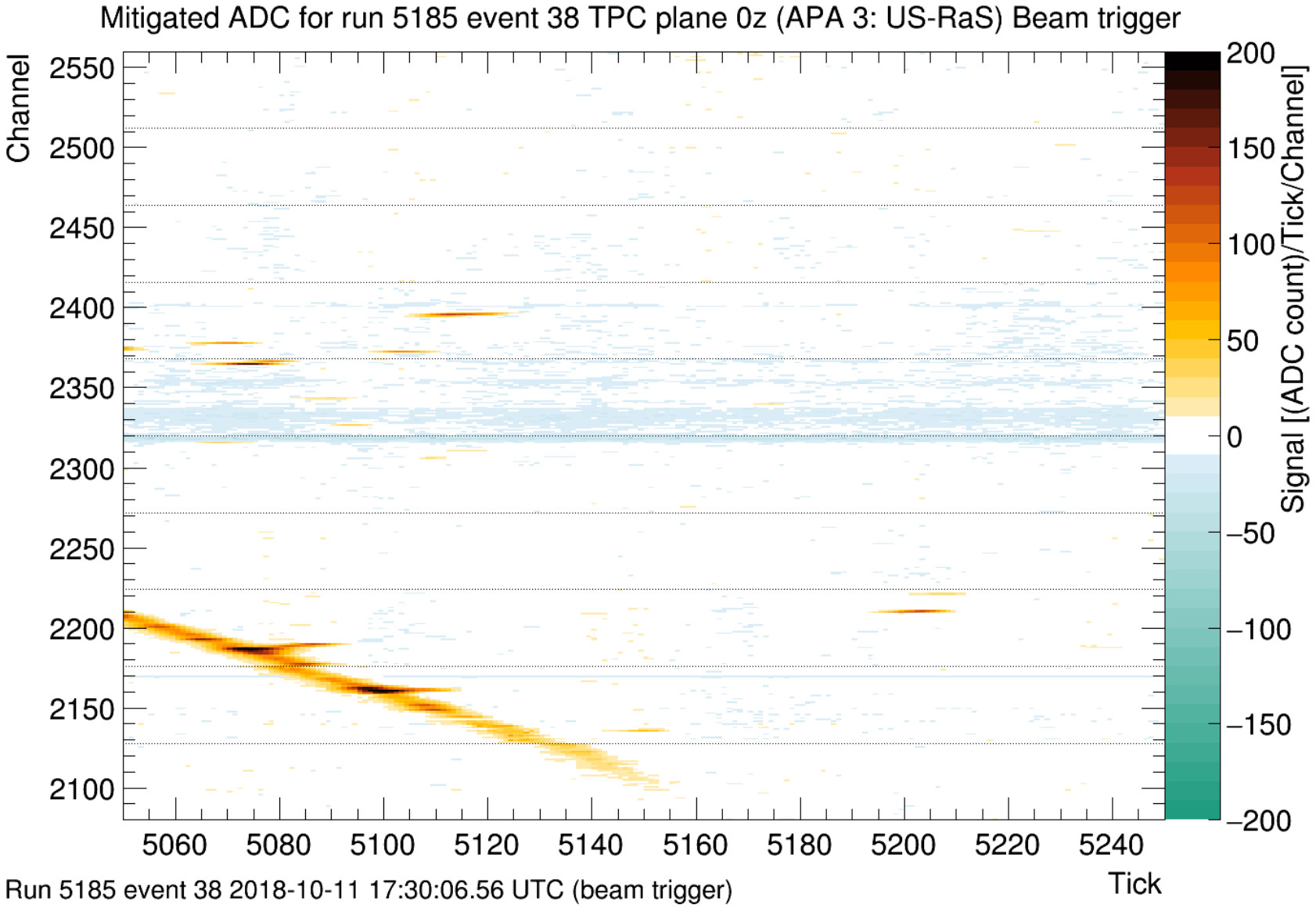

Mitigated ADC for run 5185 event 31 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 31 2018-10-11 17:30:06.40 UTC (beam trigger)

0.9993, 0

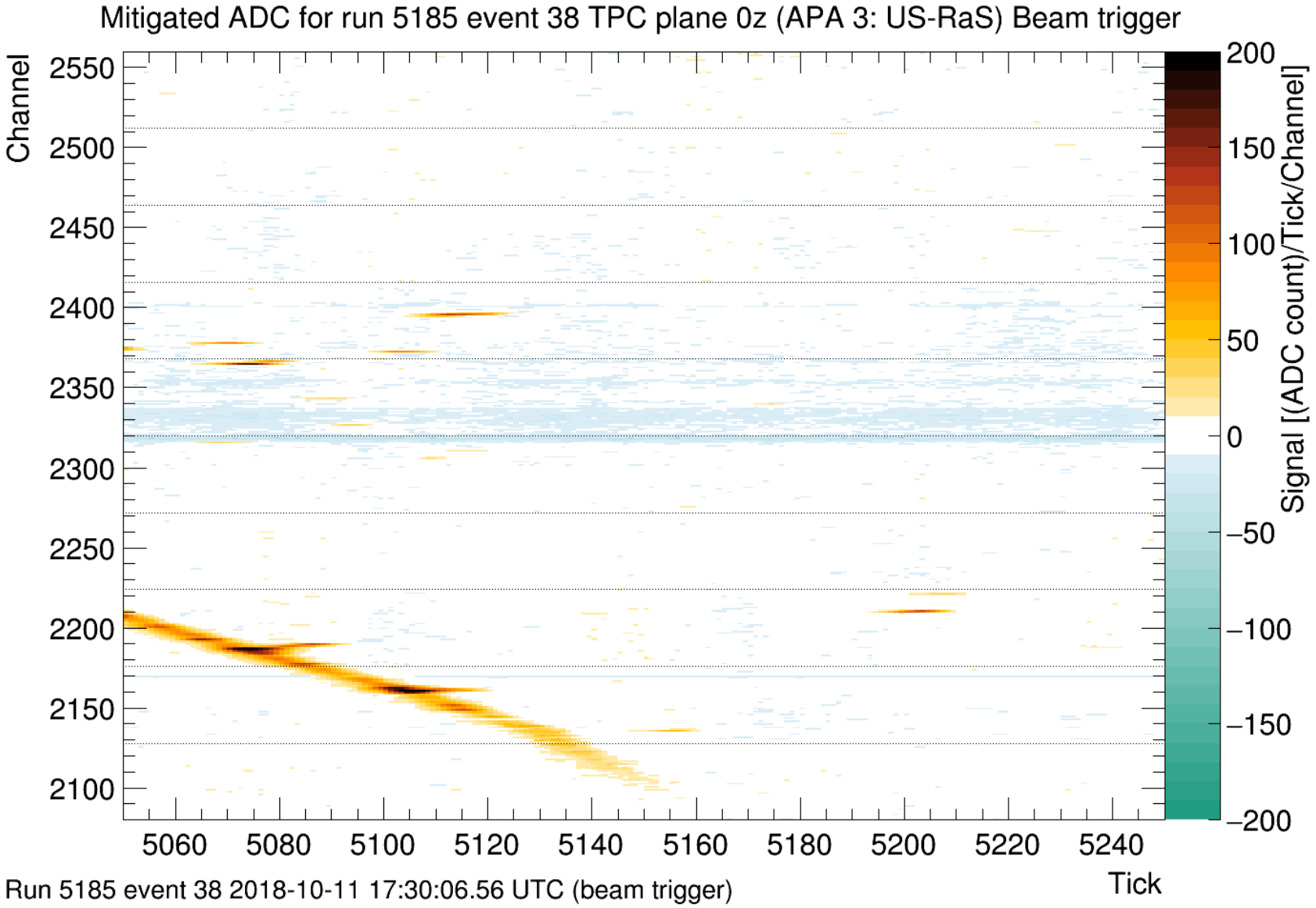

Mitigated ADC for run 5185 event 31 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
4700
4720
4740
4760
4780
4800
4820
4840
4860
4880
4900
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 31 2018-10-11 17:30:06.40 UTC (beam trigger)

Event 38 z5050-5250

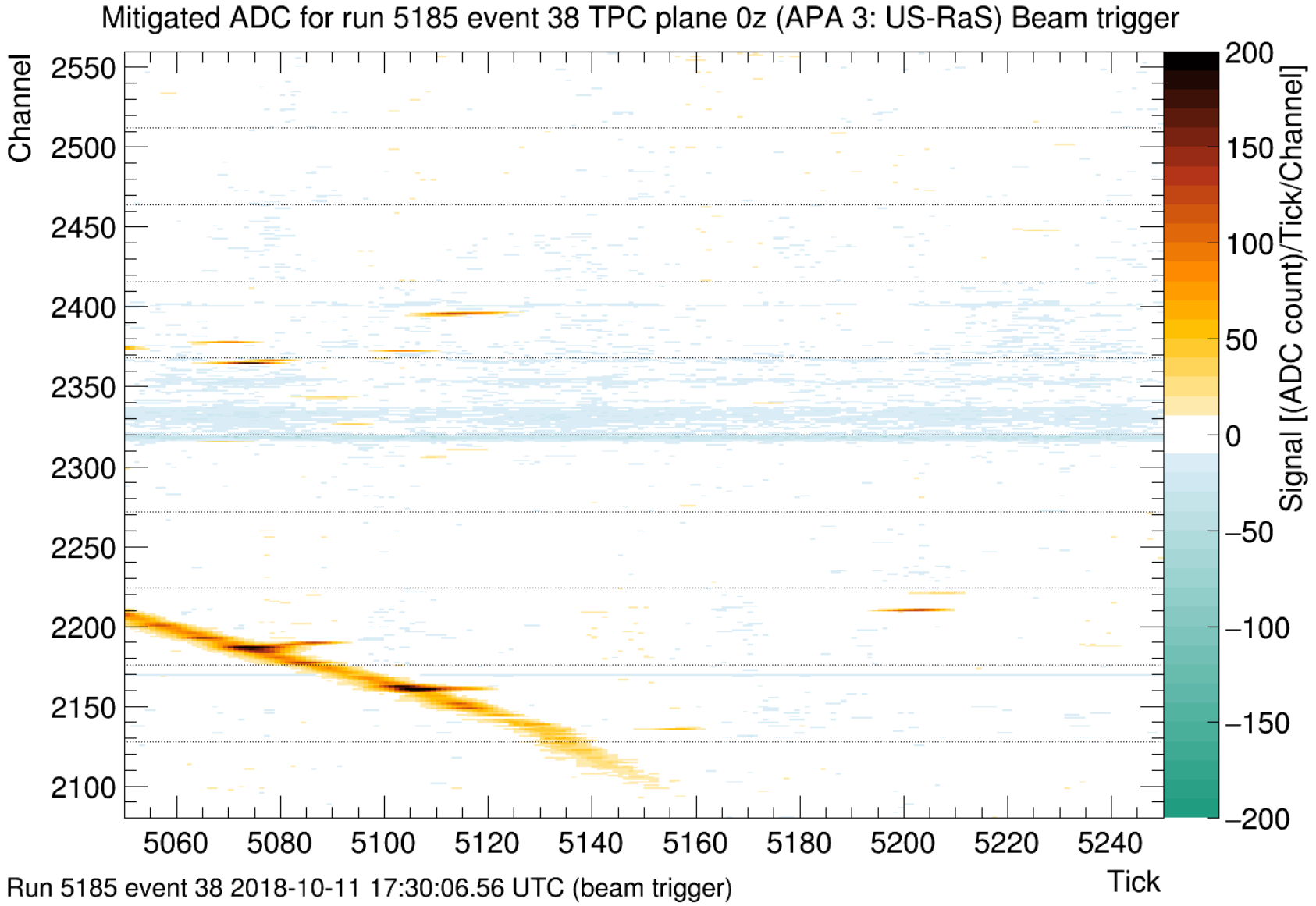
1.0, 0 (no correction)



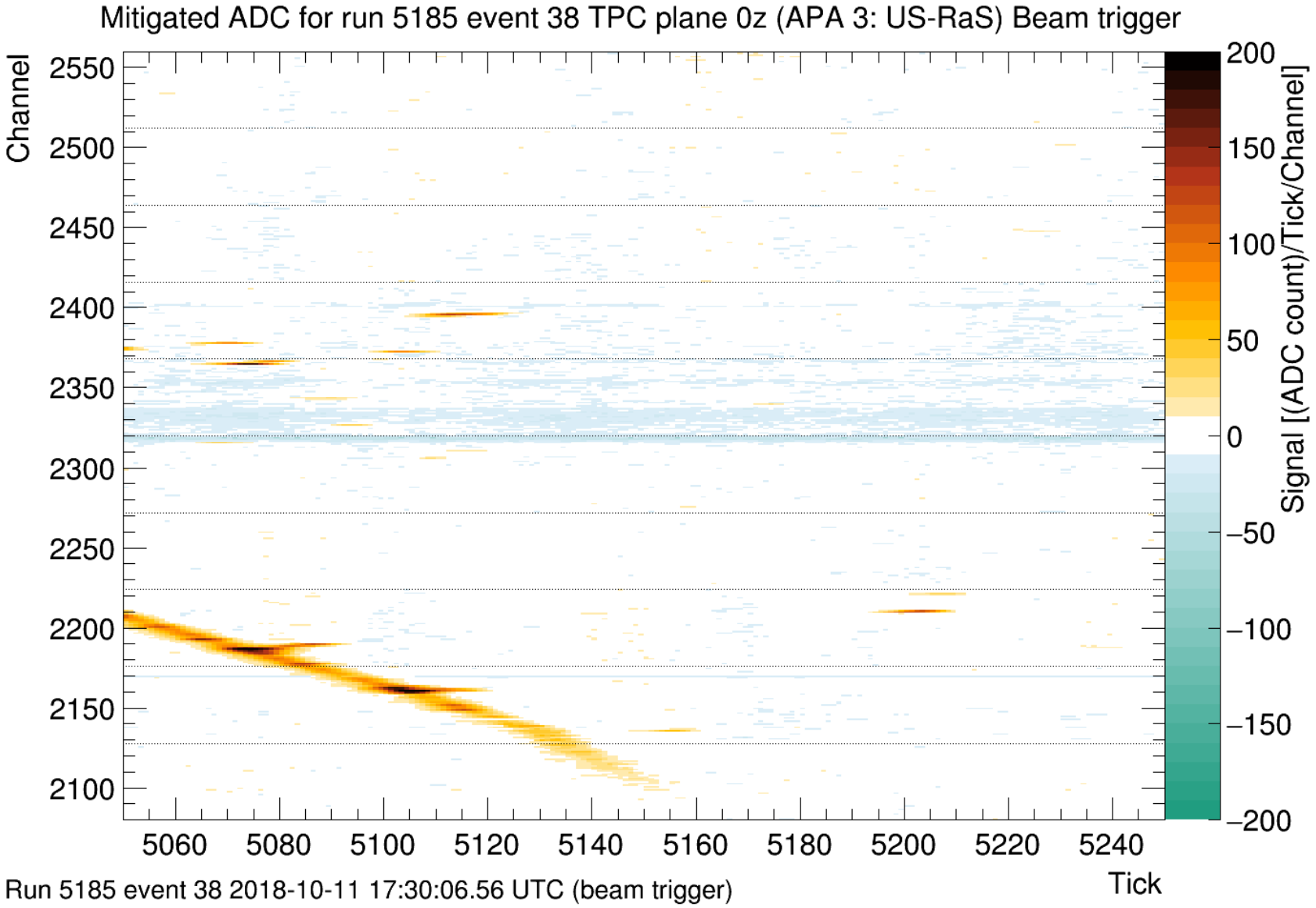
0.9995, 3 (Dec 2018 correction)



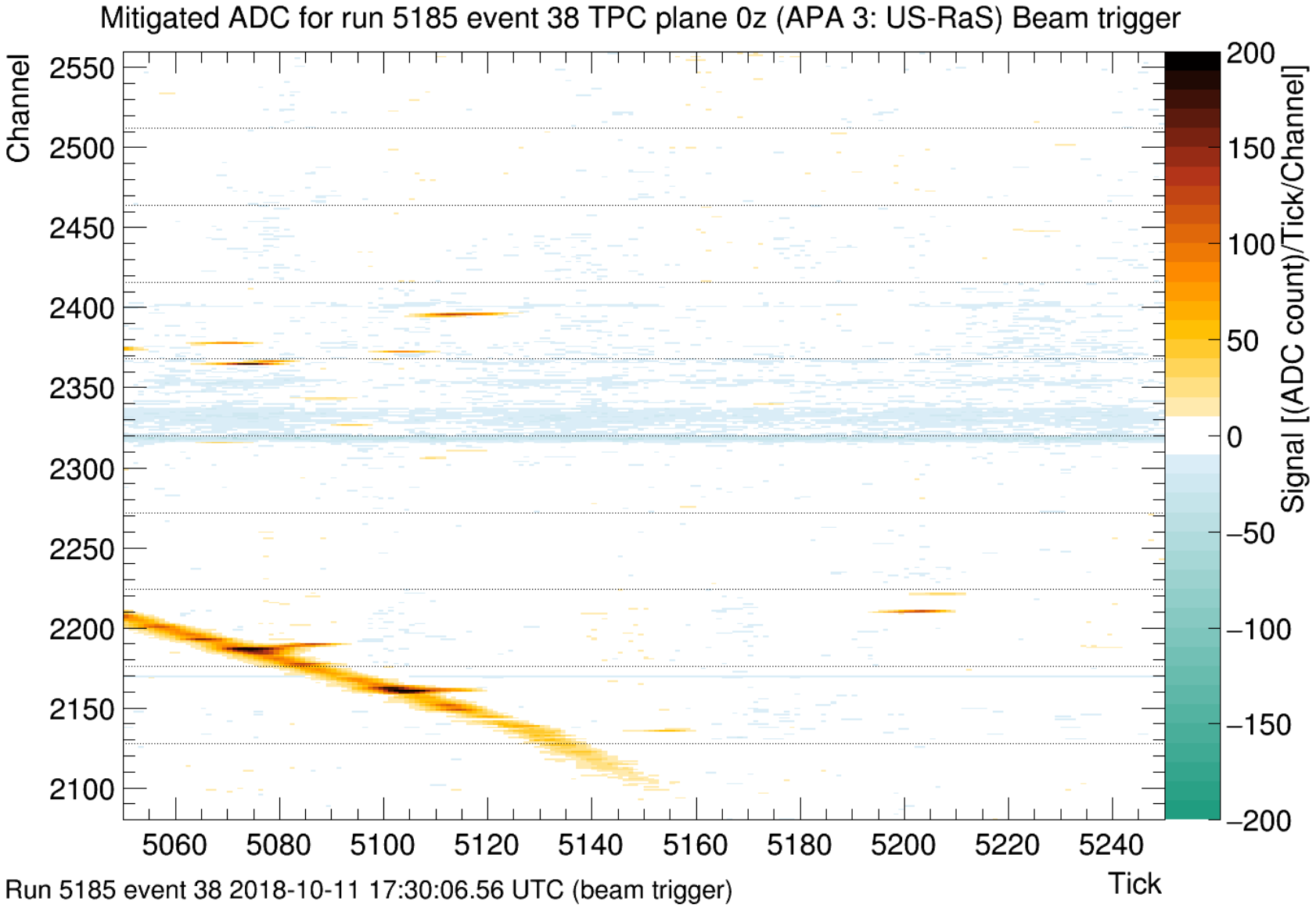
0.9993, 3


Mitigated ADC for run 5185 event 38 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5060
5080
5100
5120
5140
5160
5180
5200
5220
5240
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 38 2018-10-11 17:30:06.56 UTC (beam trigger)

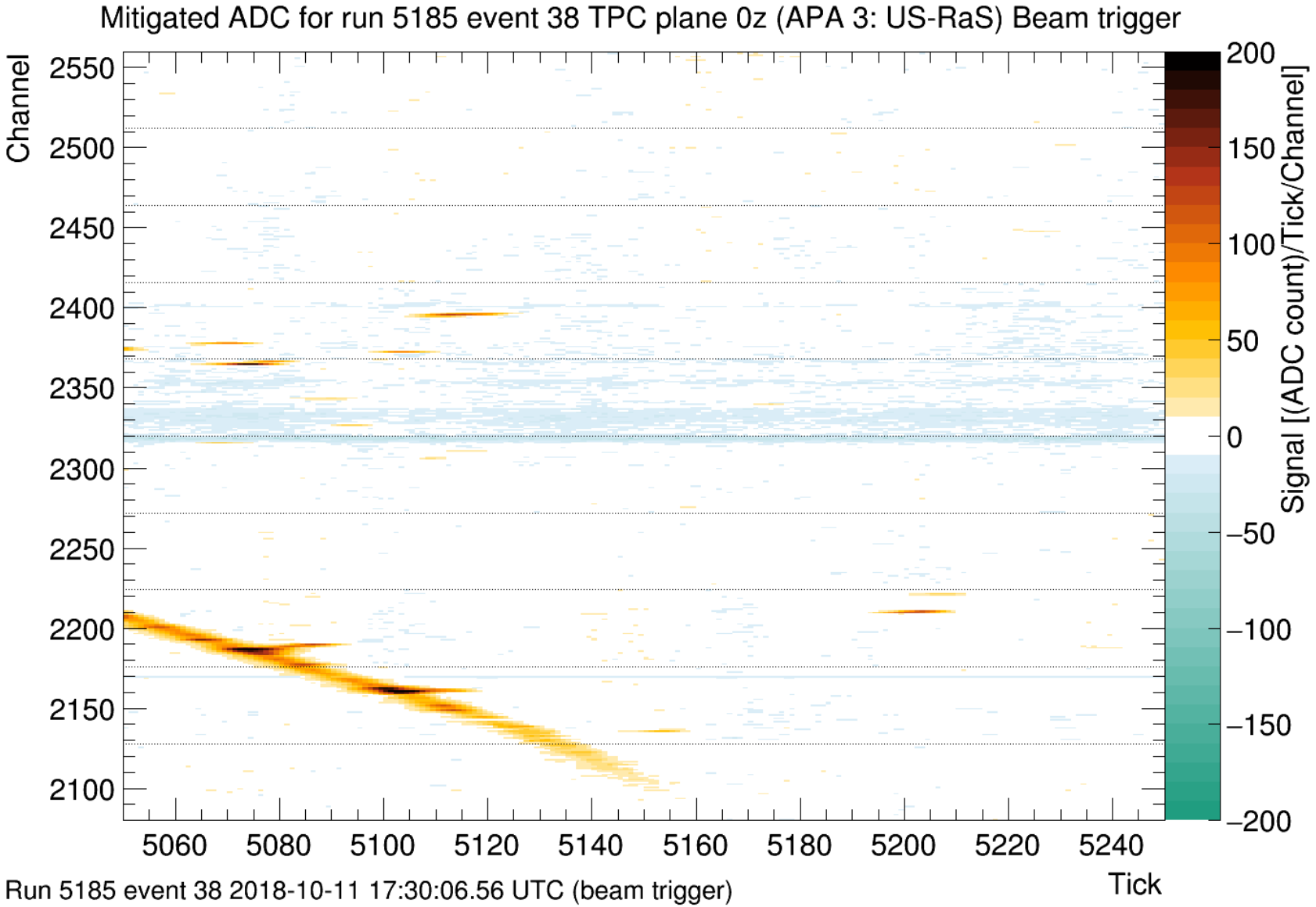
0.9993, 2


Mitigated ADC for run 5185 event 38 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5060
5080
5100
5120
5140
5160
5180
5200
5220
5240
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 38 2018-10-11 17:30:06.56 UTC (beam trigger)

0.9993, 1

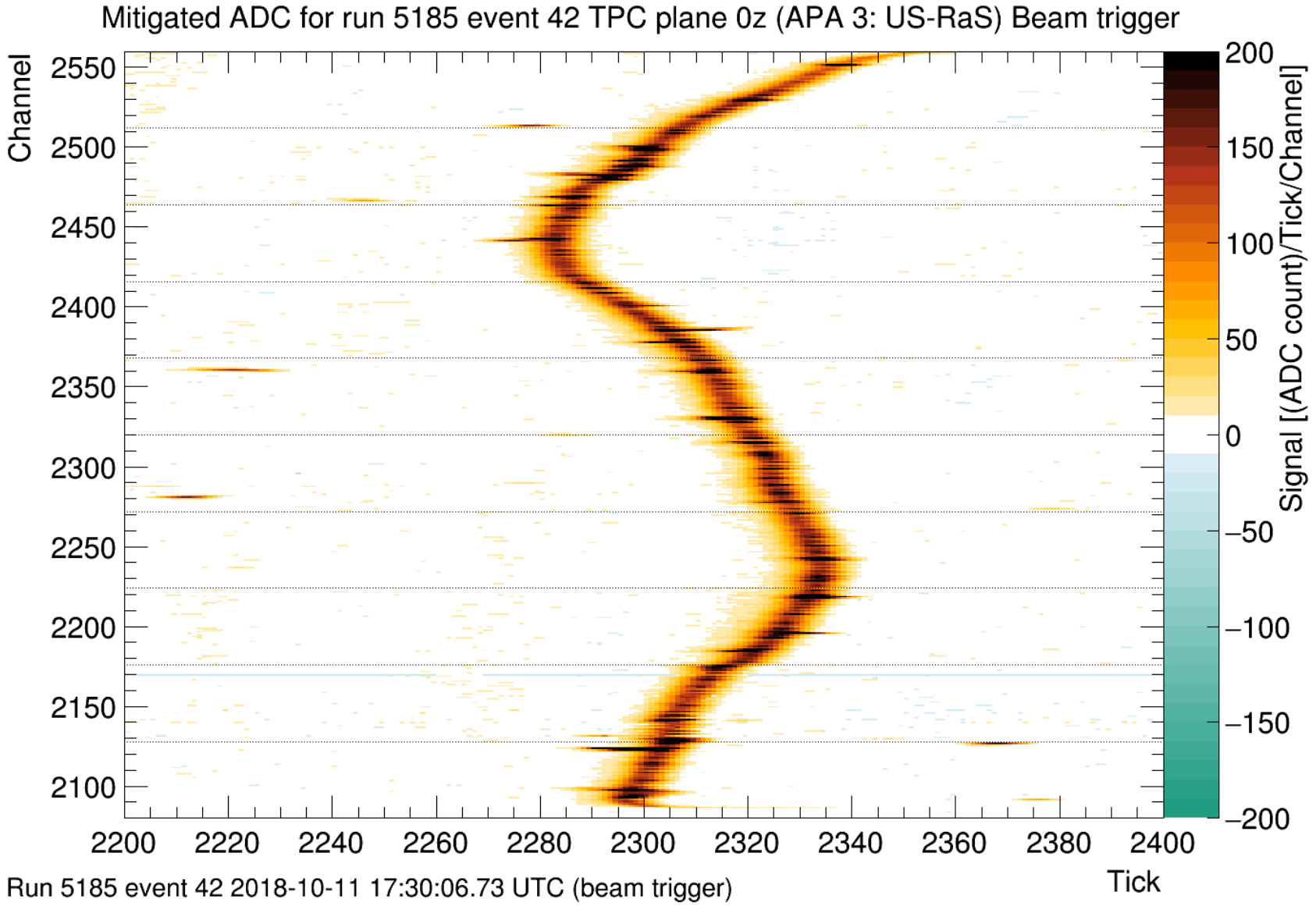

Mitigated ADC for run 5185 event 38 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5060
5080
5100
5120
5140
5160
5180
5200
5220
5240
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 38 2018-10-11 17:30:06.56 UTC (beam trigger)

0.9993, 0

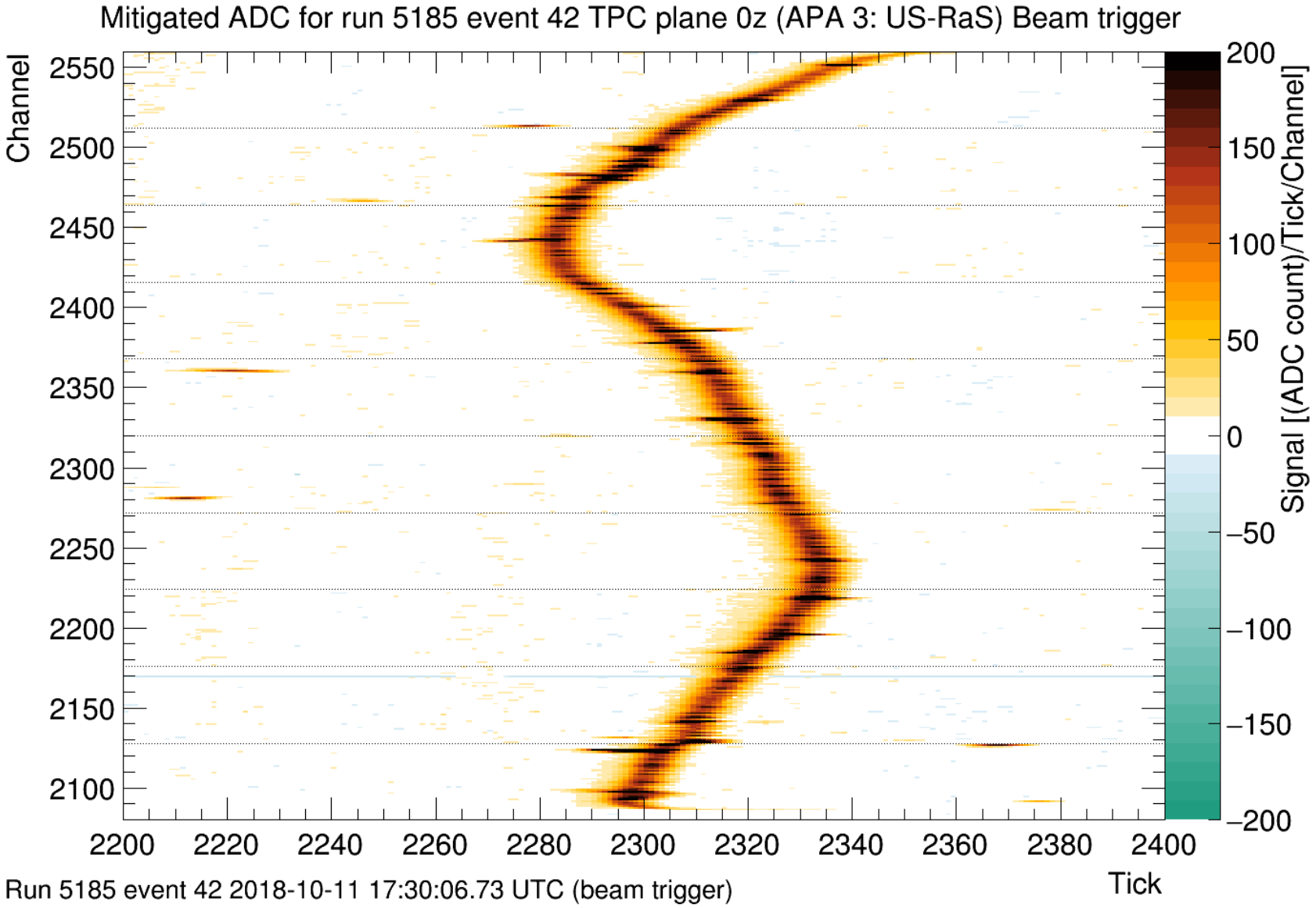

Mitigated ADC for run 5185 event 38 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5060
5080
5100
5120
5140
5160
5180
5200
5220
5240
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 38 2018-10-11 17:30:06.56 UTC (beam trigger)

Event 42: z2200-2400

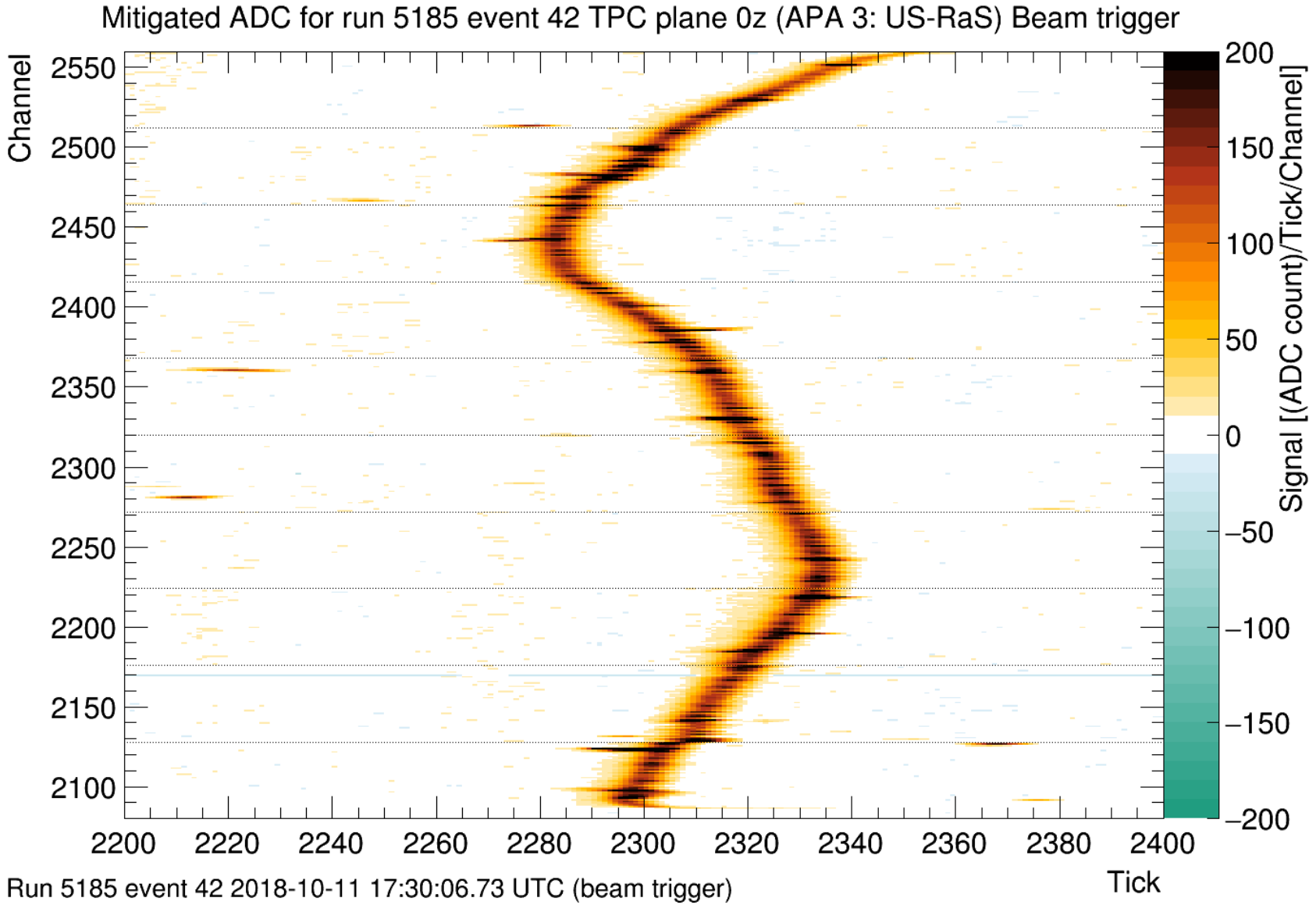
1.0, 0 (no correction)



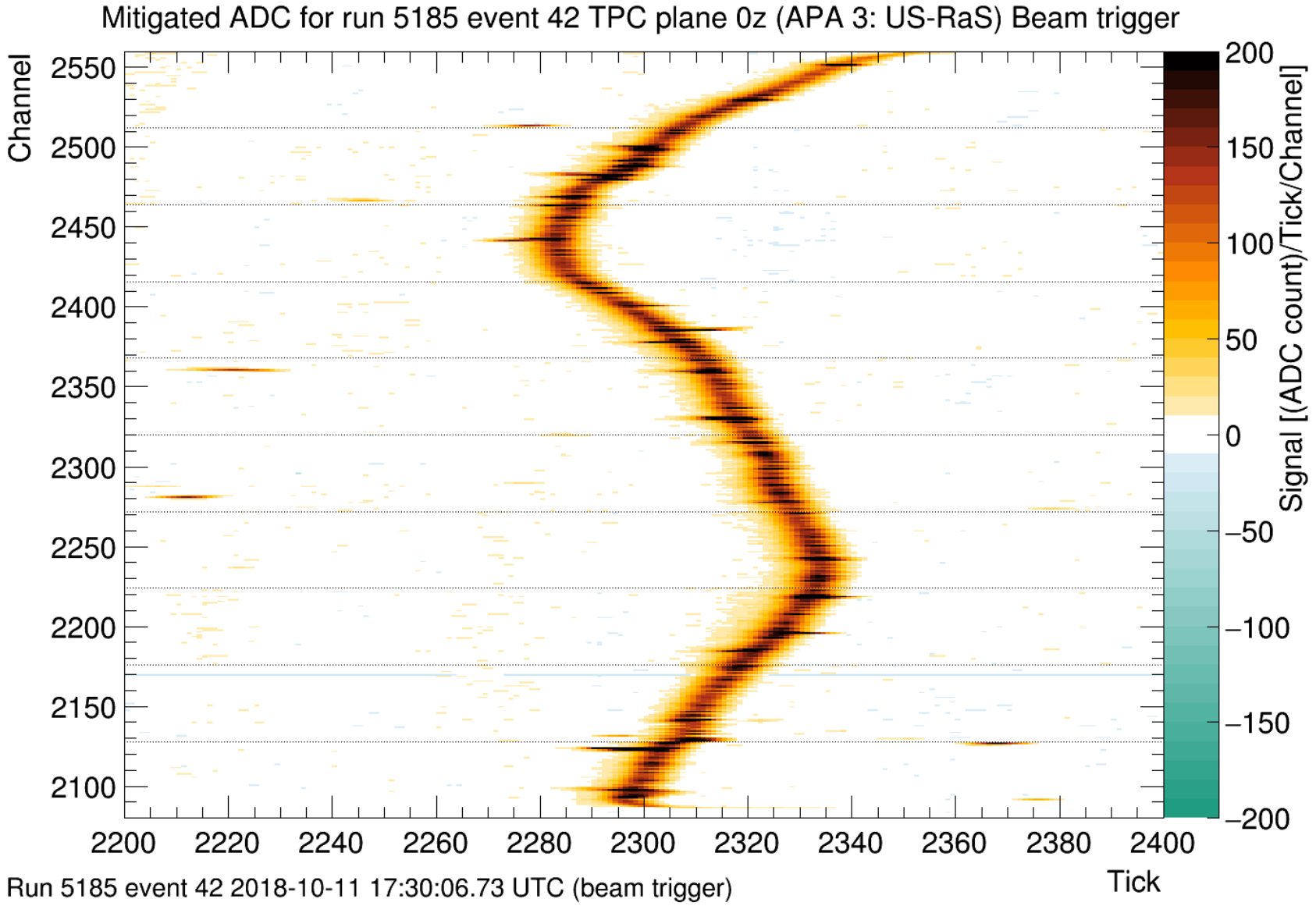
0.9995, 3 (Dec 2018 correction)



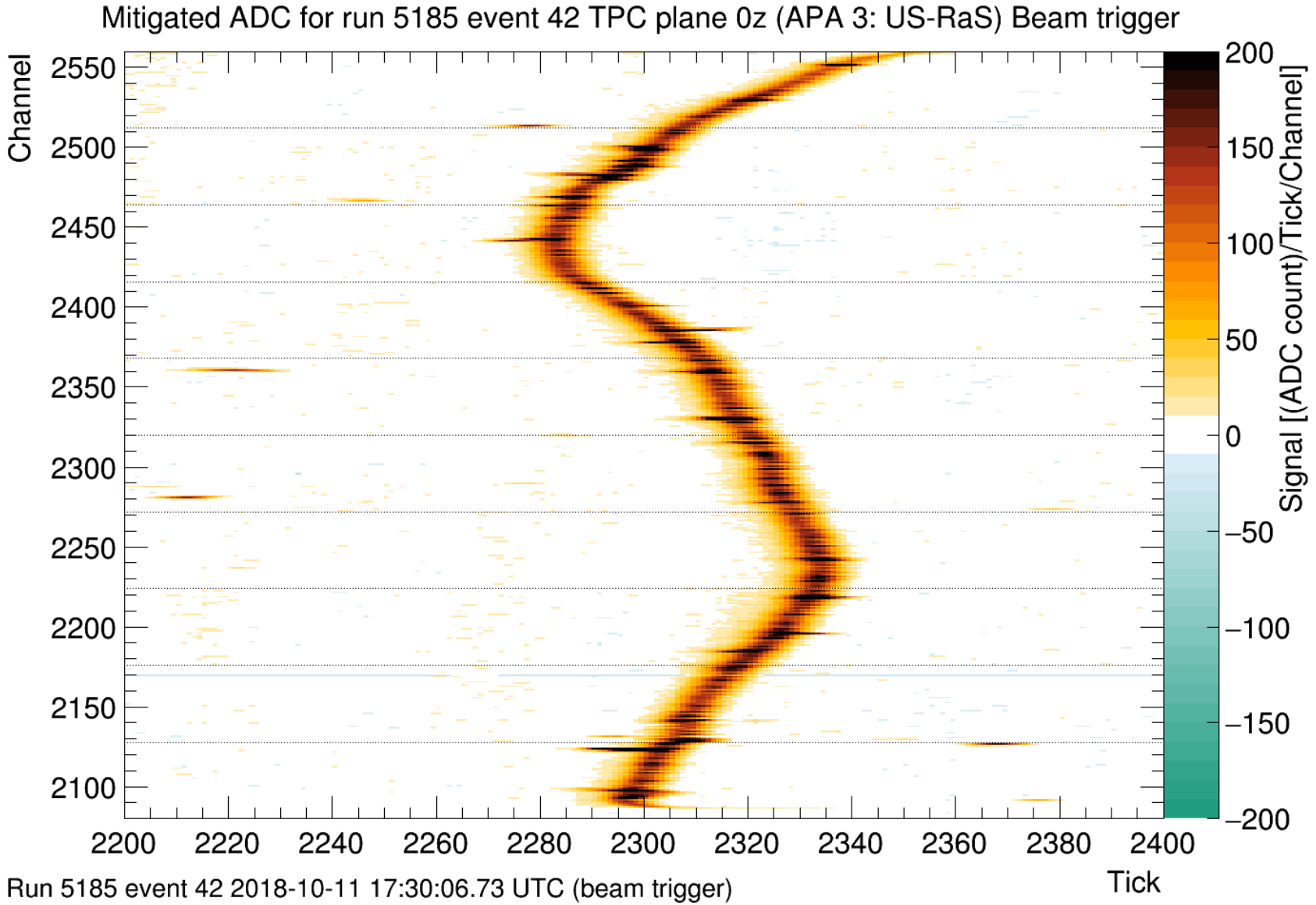
0.9993, 3


Mitigated ADC for run 5185 event 42 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2200
2220
2240
2260
2280
2300
2320
2340
2360
2380
2400
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 42 2018-10-11 17:30:06.73 UTC (beam trigger)

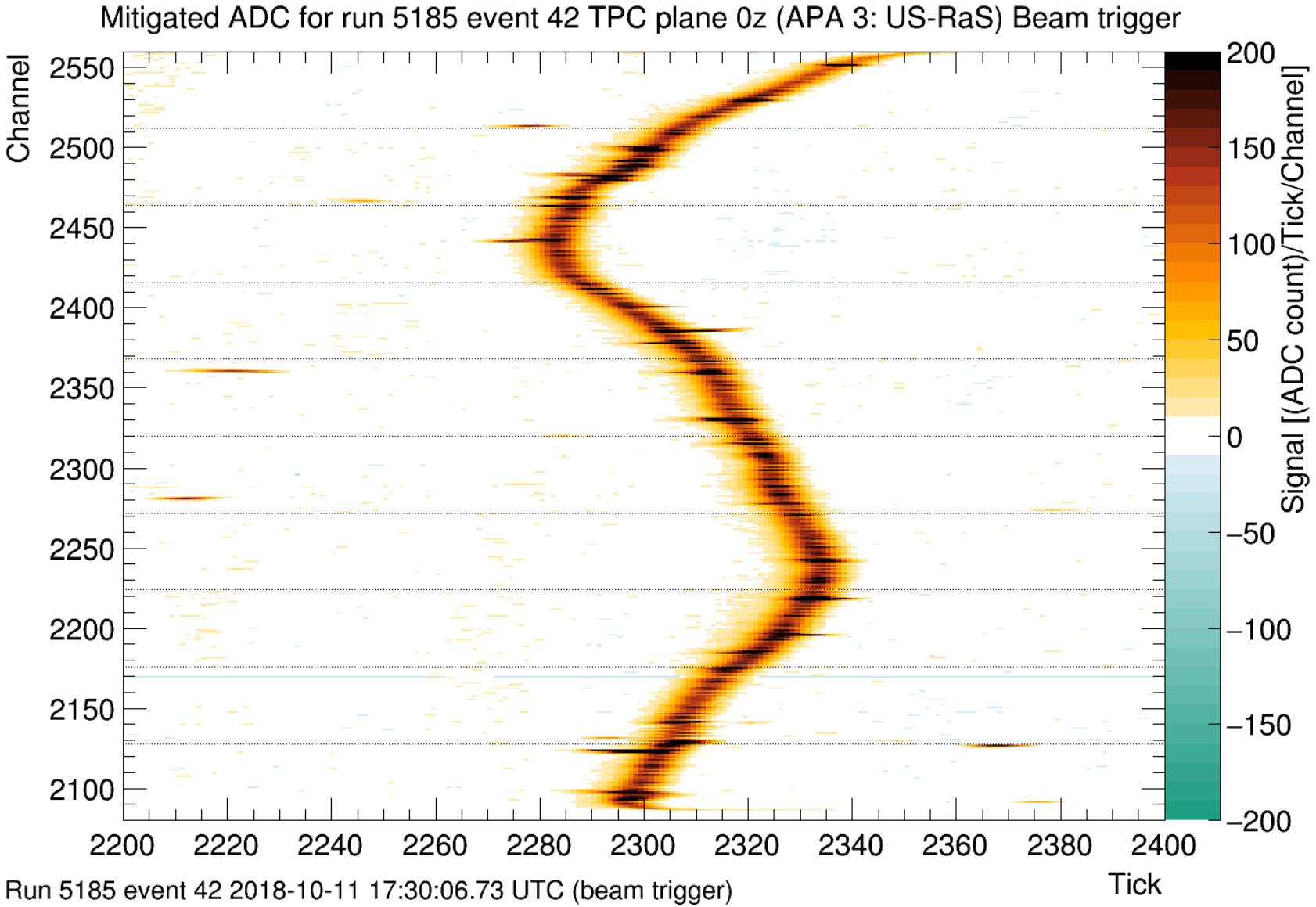
0.9993, 2


Mitigated ADC for run 5185 event 42 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2200
2220
2240
2260
2280
2300
2320
2340
2360
2380
2400
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 42 2018-10-11 17:30:06.73 UTC (beam trigger)

0.9993, 1

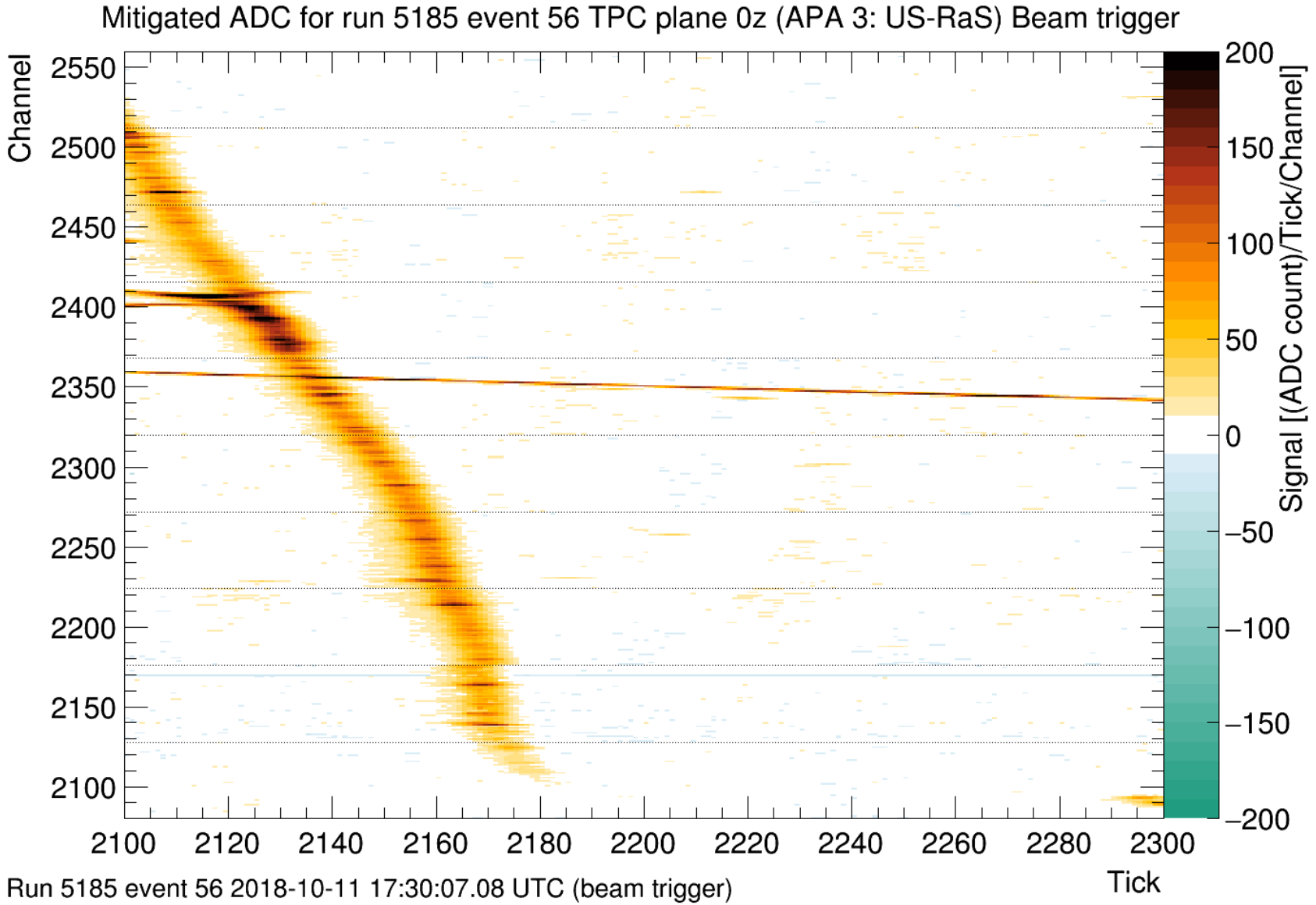

Mitigated ADC for run 5185 event 42 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2200
2220
2240
2260
2280
2300
2320
2340
2360
2380
2400
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 42 2018-10-11 17:30:06.73 UTC (beam trigger)

0.9993, 0

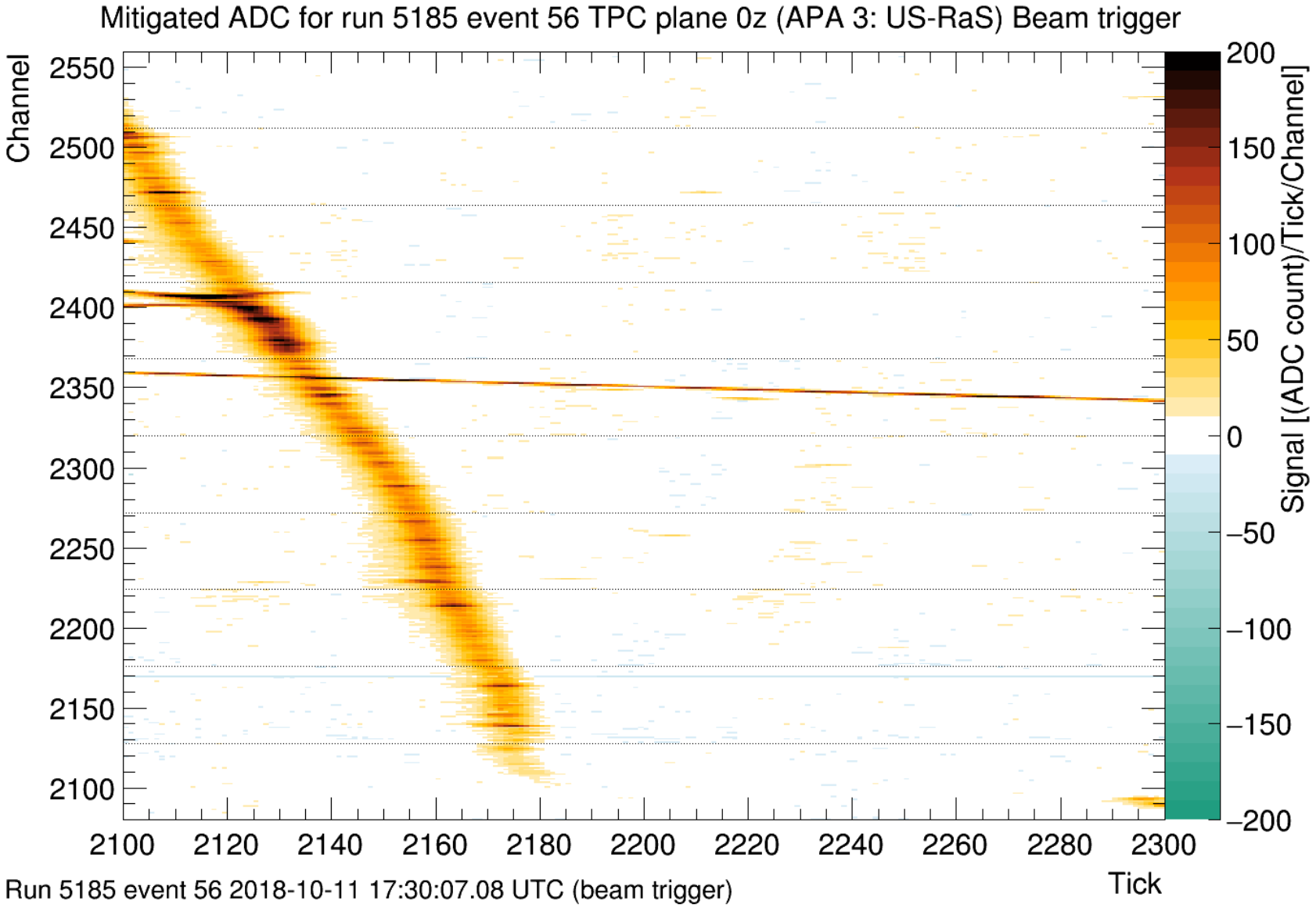

Mitigated ADC for run 5185 event 42 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2200
2220
2240
2260
2280
2300
2320
2340
2360
2380
2400
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 42 2018-10-11 17:30:06.73 UTC (beam trigger)

Event 56 z2100-2300

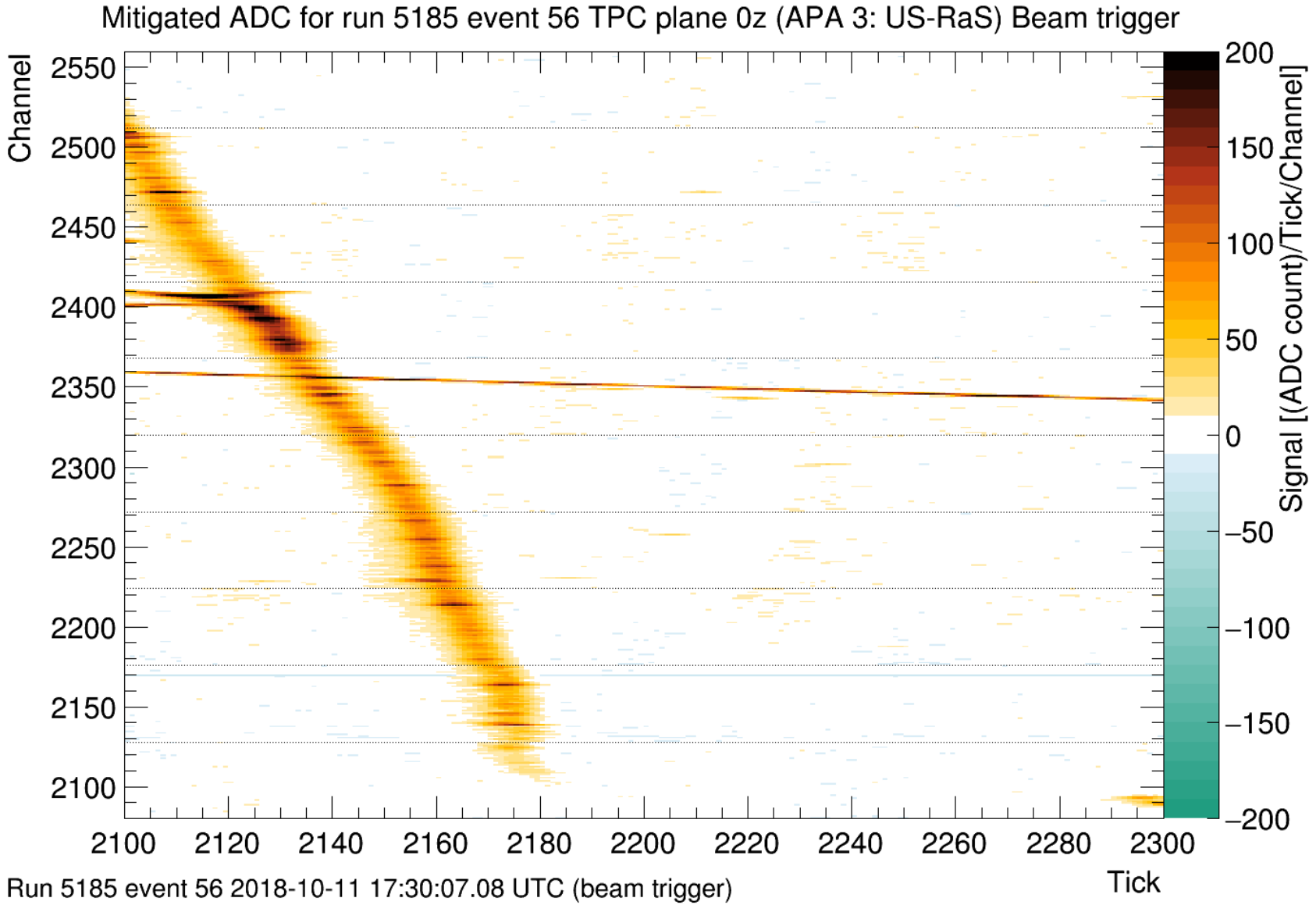
1.0, 0 (no correction)



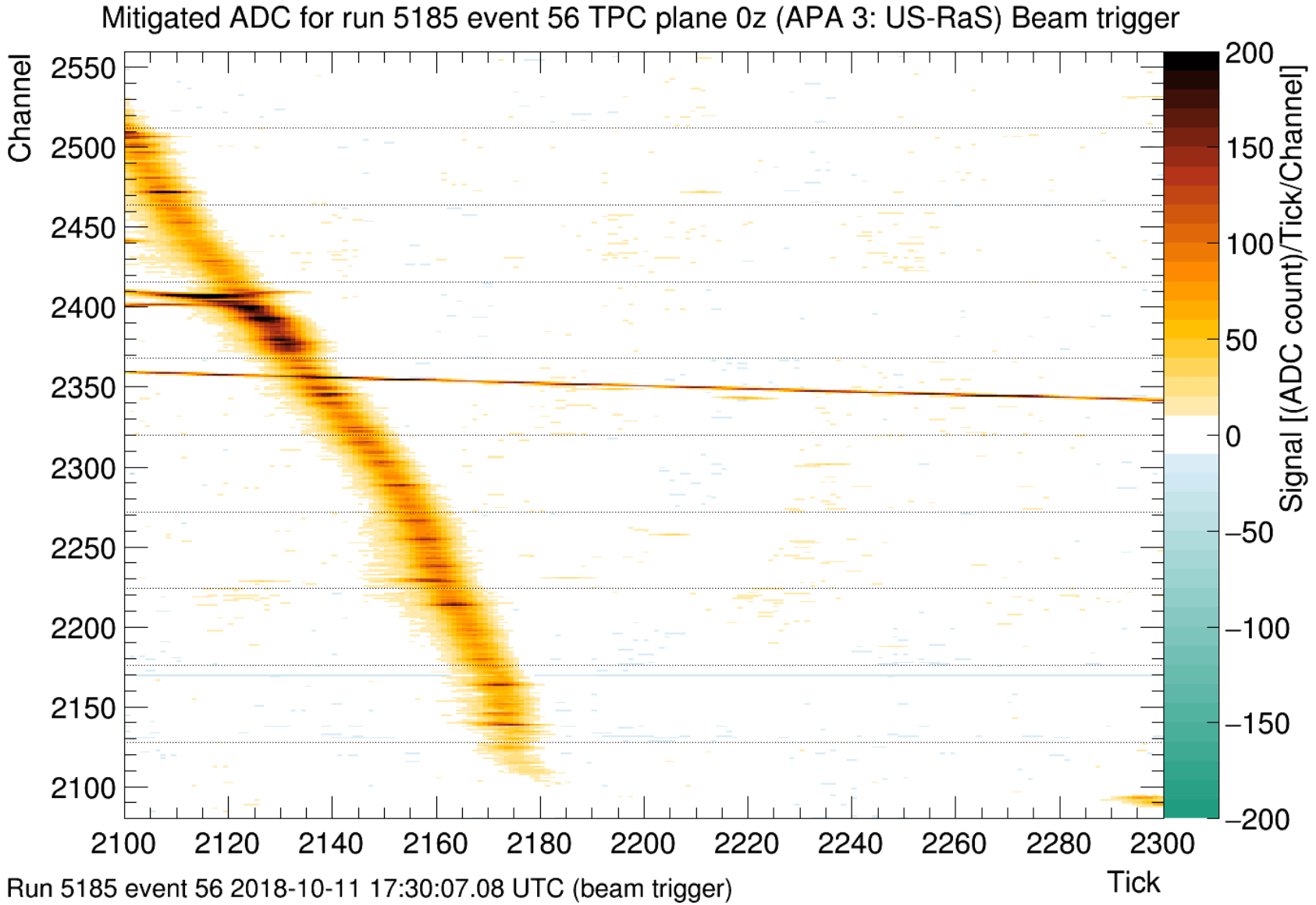
0.9995, 3 (Dec 2018 correction)



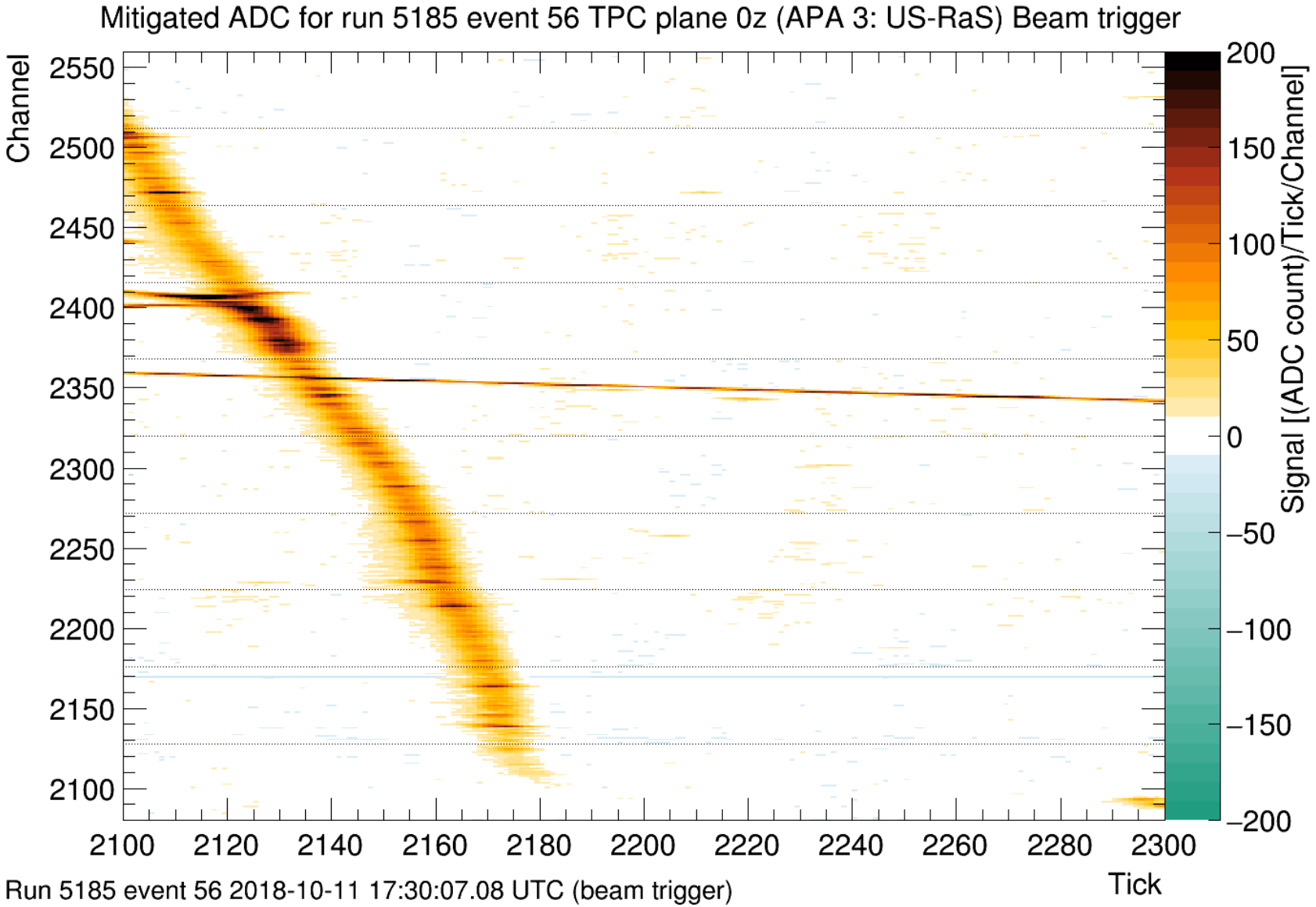
0.9993, 3


Mitigated ADC for run 5185 event 56 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2100
2120
2140
2160
2180
2200
2220
2240
2260
2280
2300
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 56 2018-10-11 17:30:07.08 UTC (beam trigger)

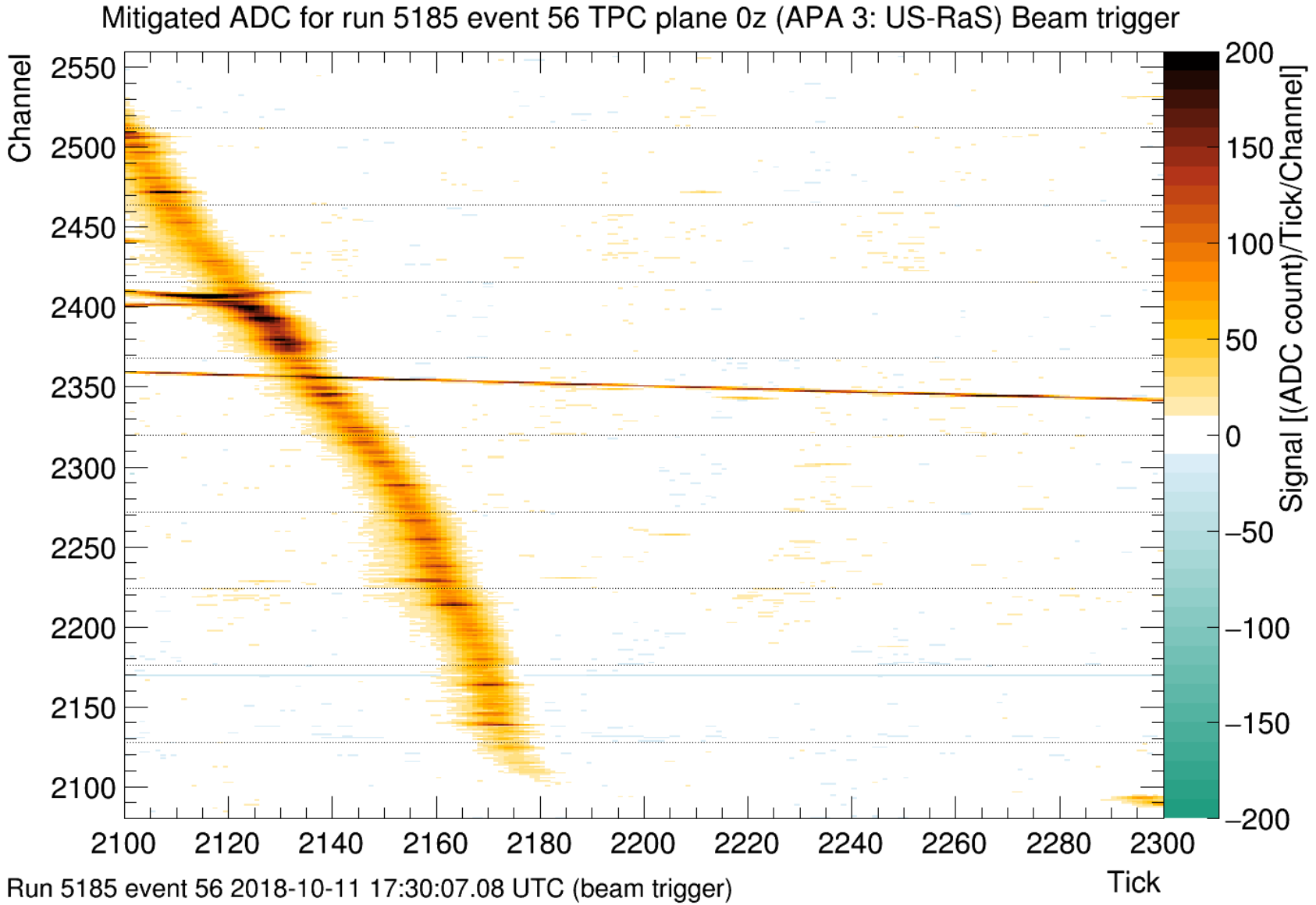
0.9993, 2


Mitigated ADC for run 5185 event 56 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2100
2120
2140
2160
2180
2200
2220
2240
2260
2280
2300
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 56 2018-10-11 17:30:07.08 UTC (beam trigger)

0.9993, 1

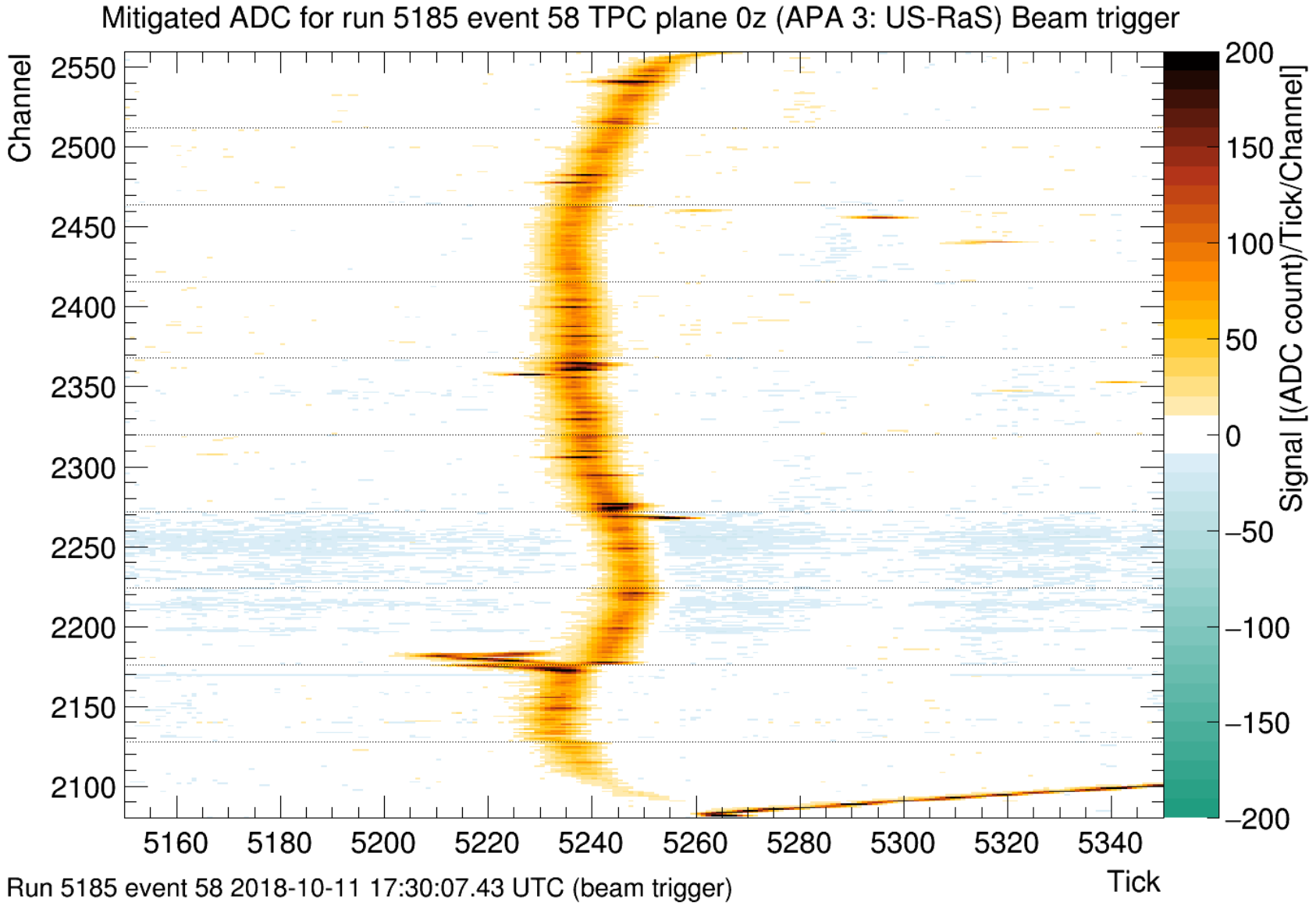

Mitigated ADC for run 5185 event 56 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2100
2120
2140
2160
2180
2200
2220
2240
2260
2280
2300
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 56 2018-10-11 17:30:07.08 UTC (beam trigger)

0.9993, 0

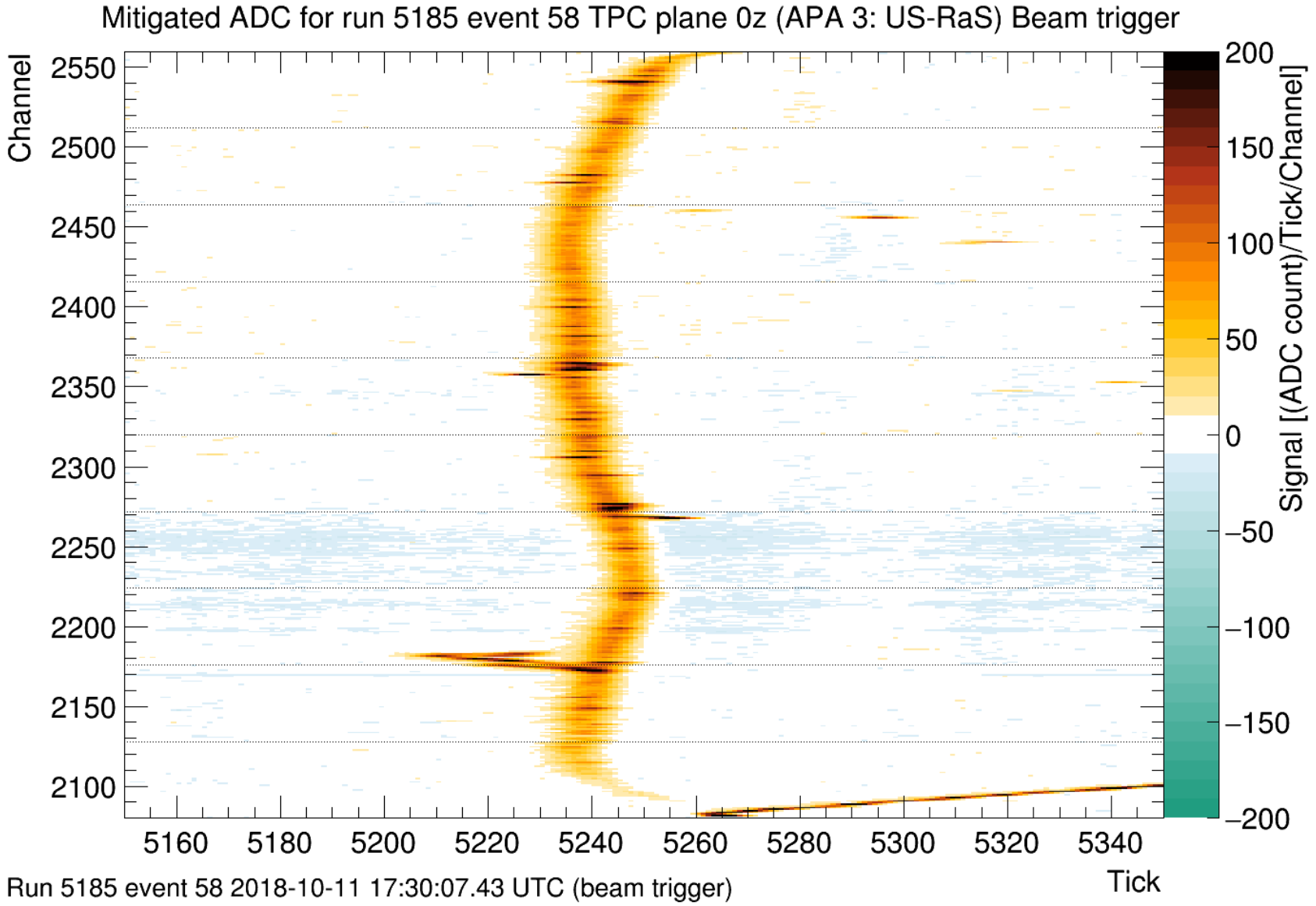

Mitigated ADC for run 5185 event 56 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
2100
2120
2140
2160
2180
2200
2220
2240
2260
2280
2300
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 56 2018-10-11 17:30:07.08 UTC (beam trigger)

Event 58 z5150-5350

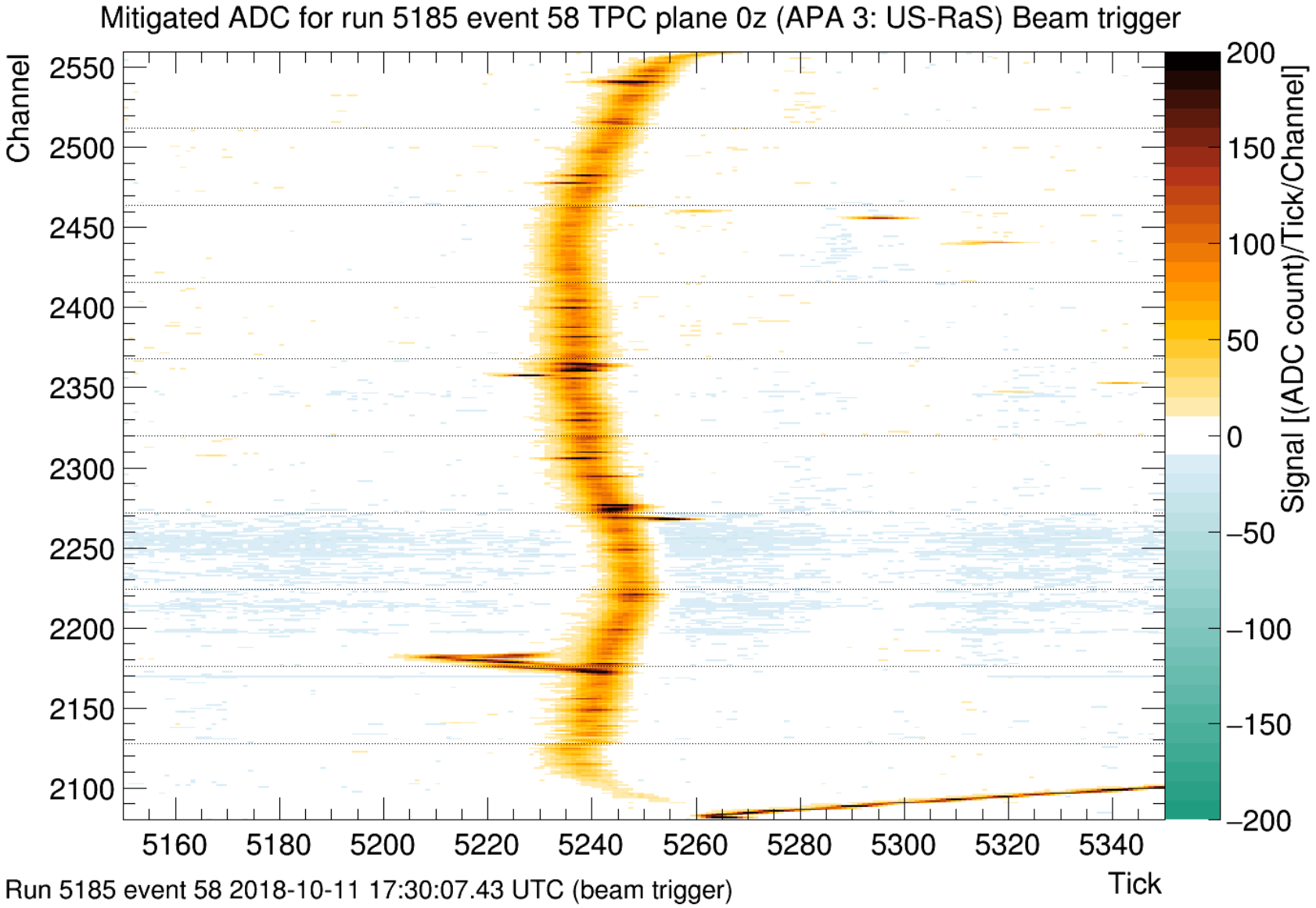
1.0, 0 (no correction)



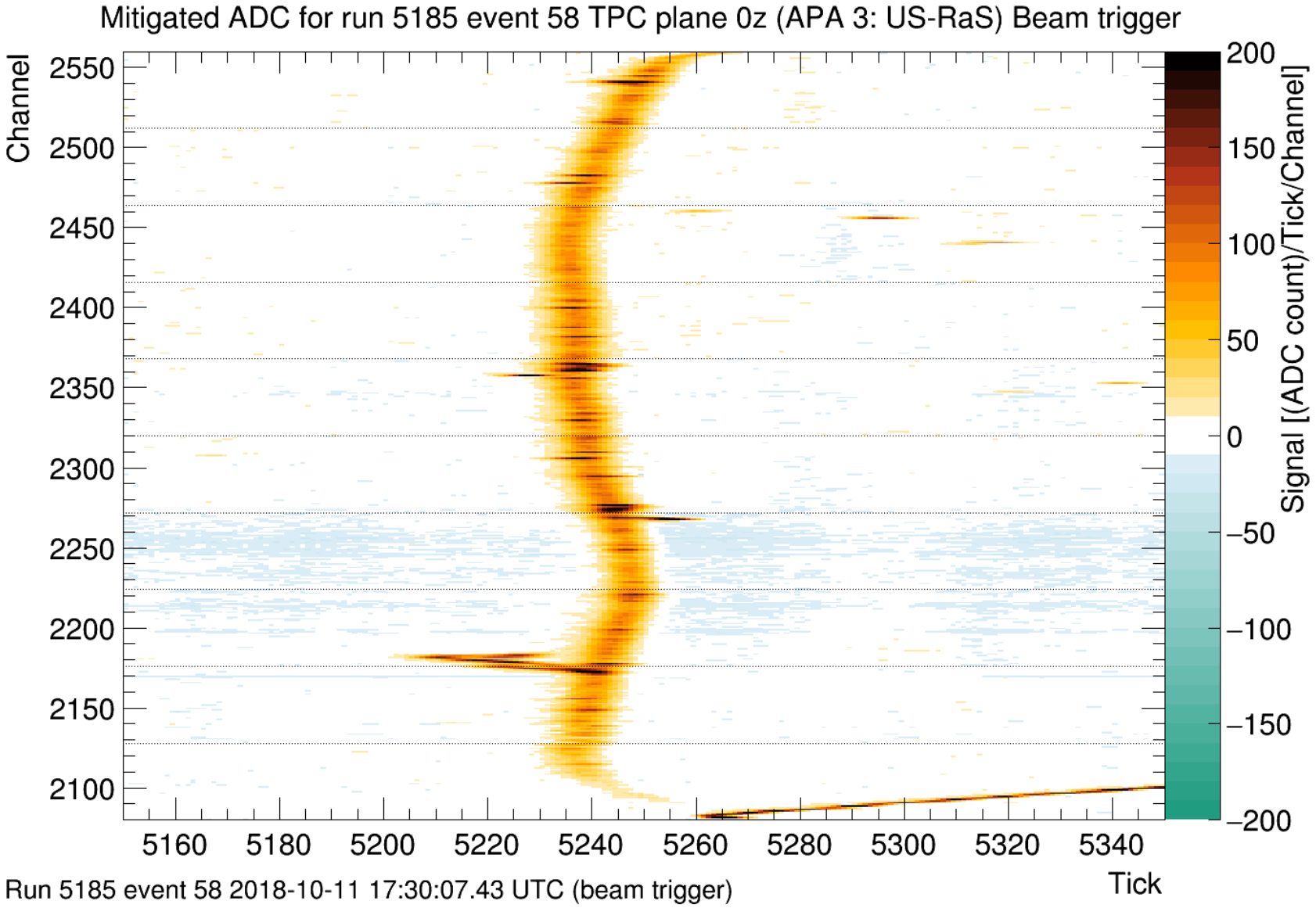
0.9995, 3 (Dec 2018 correction)



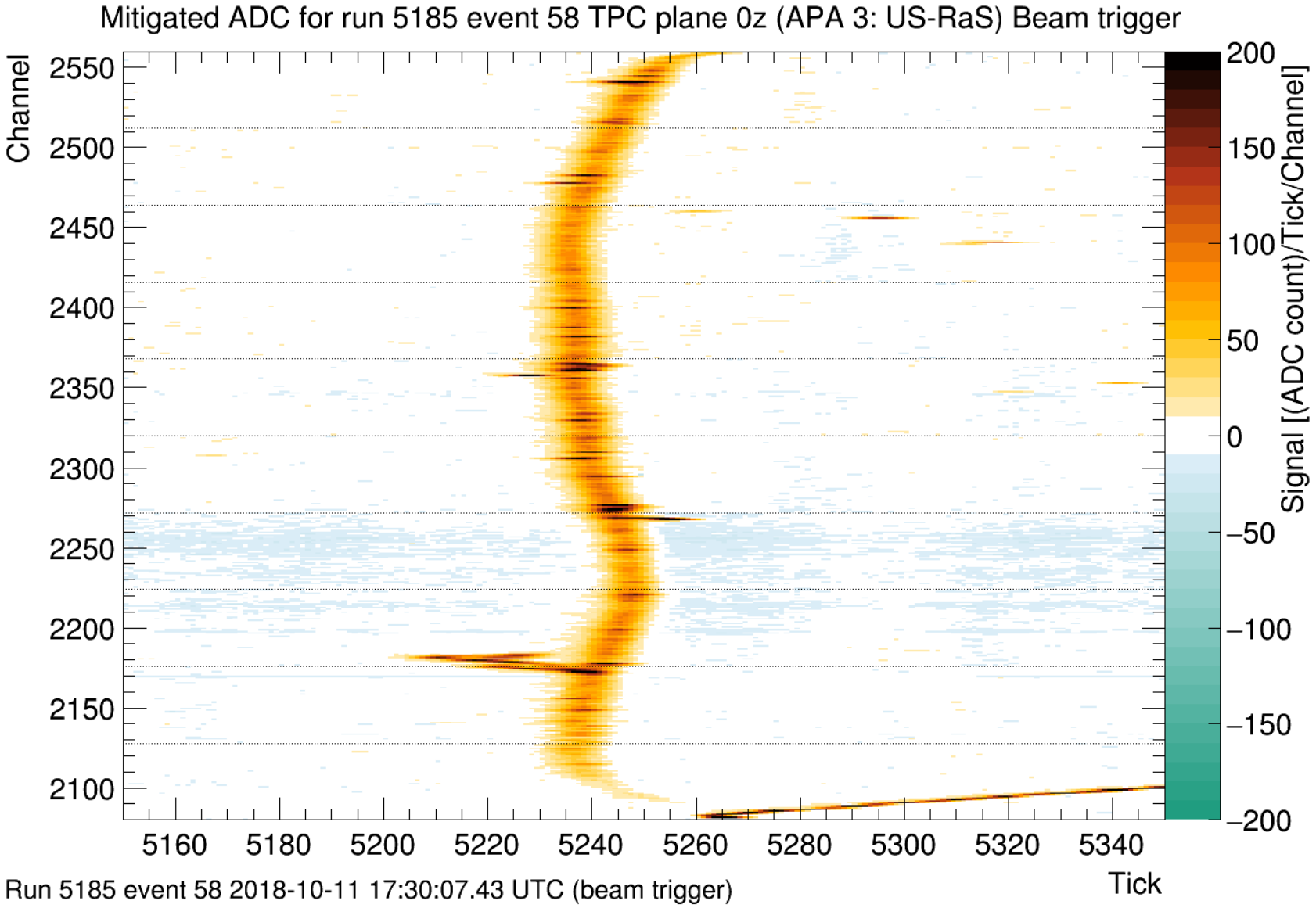
0.9993, 3


Mitigated ADC for run 5185 event 58 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5160
5180
5200
5220
5240
5260
5280
5300
5320
5340
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 58 2018-10-11 17:30:07.43 UTC (beam trigger)

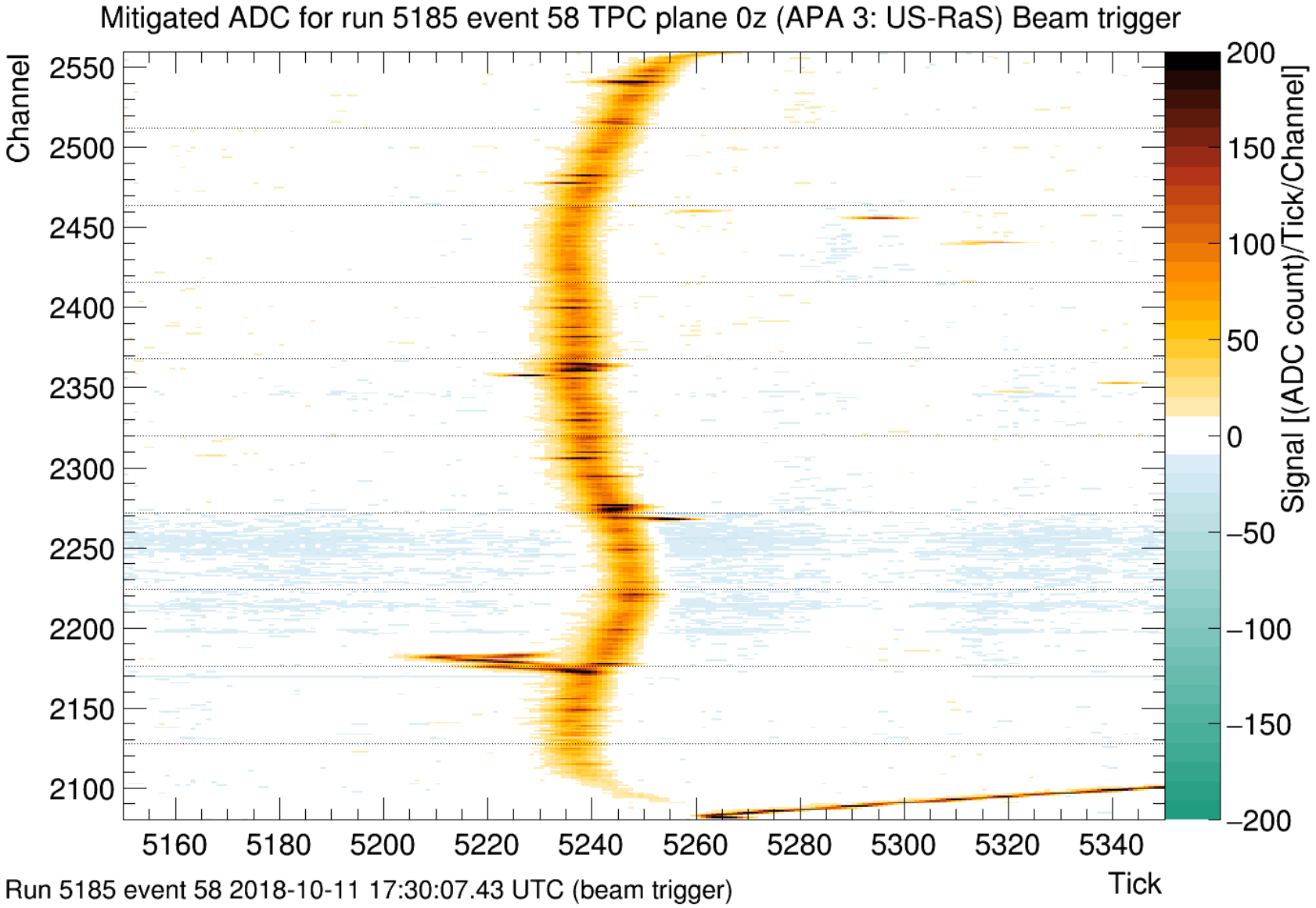
0.9993, 2


Mitigated ADC for run 5185 event 58 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5160
5180
5200
5220
5240
5260
5280
5300
5320
5340
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 58 2018-10-11 17:30:07.43 UTC (beam trigger)

0.9993, 1

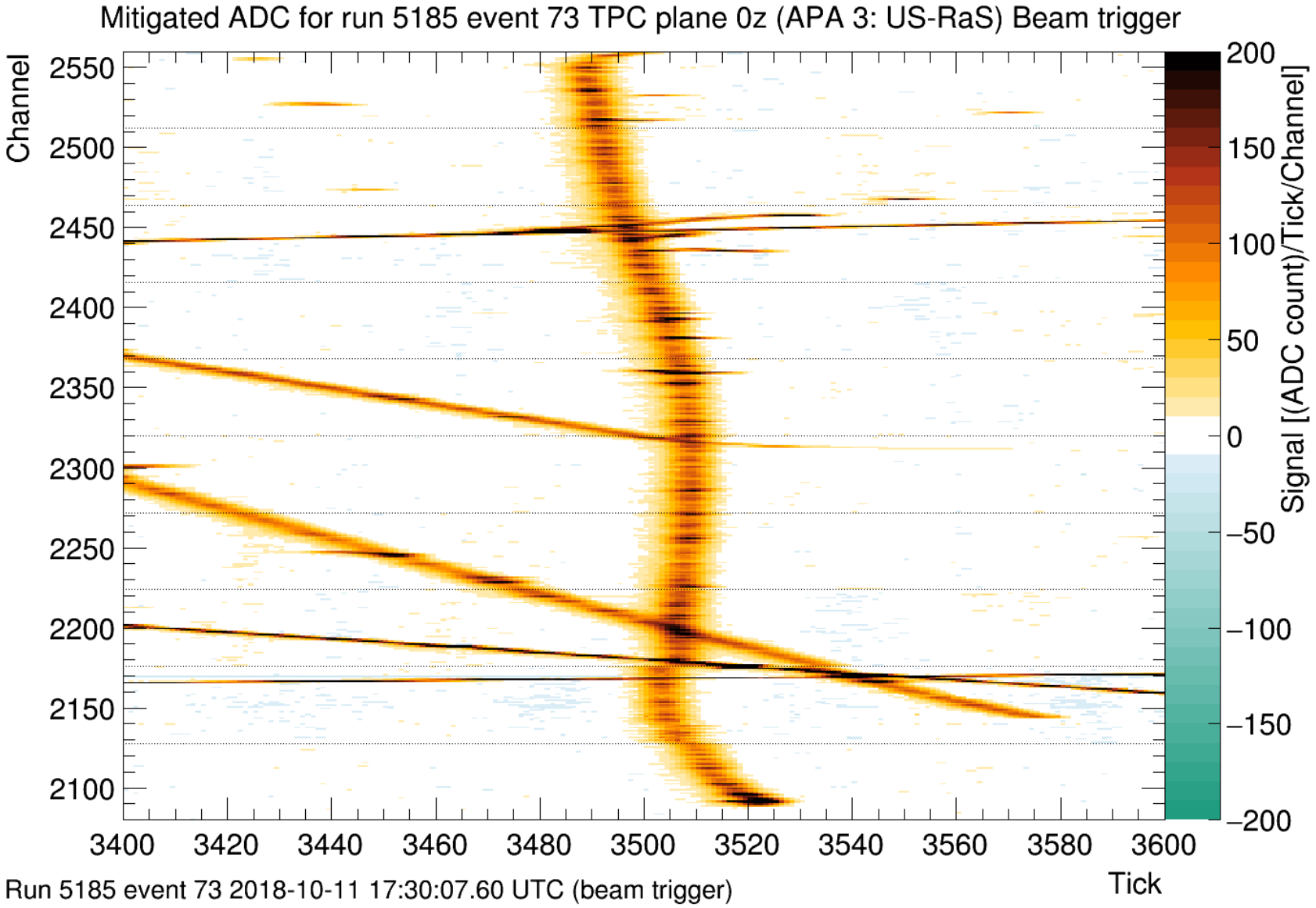

Mitigated ADC for run 5185 event 58 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5160
5180
5200
5220
5240
5260
5280
5300
5320
5340
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 58 2018-10-11 17:30:07.43 UTC (beam trigger)

0.9993, 0

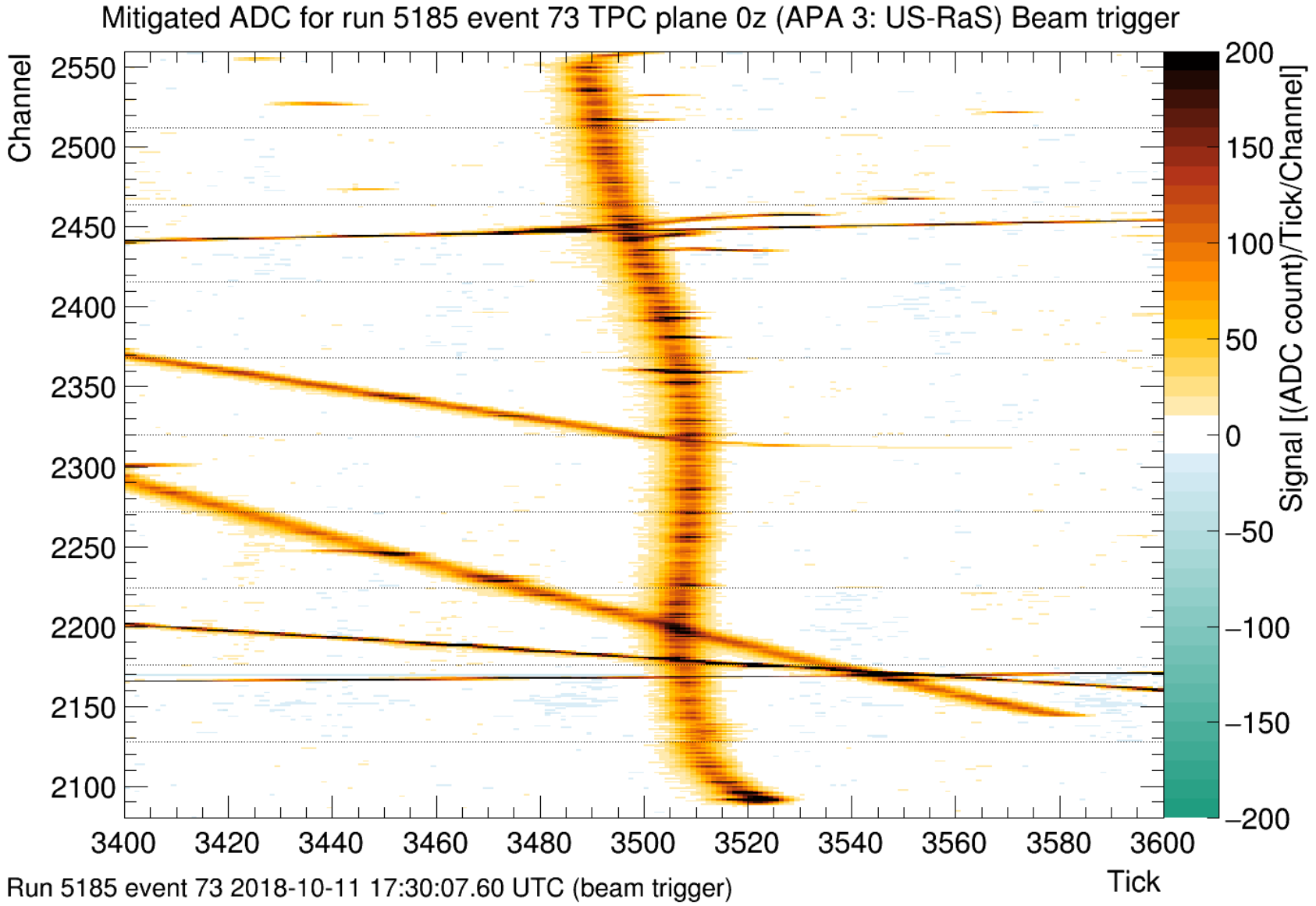

Mitigated ADC for run 5185 event 58 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
5160
5180
5200
5220
5240
5260
5280
5300
5320
5340
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 58 2018-10-11 17:30:07.43 UTC (beam trigger)

Event 73 z3400-3600

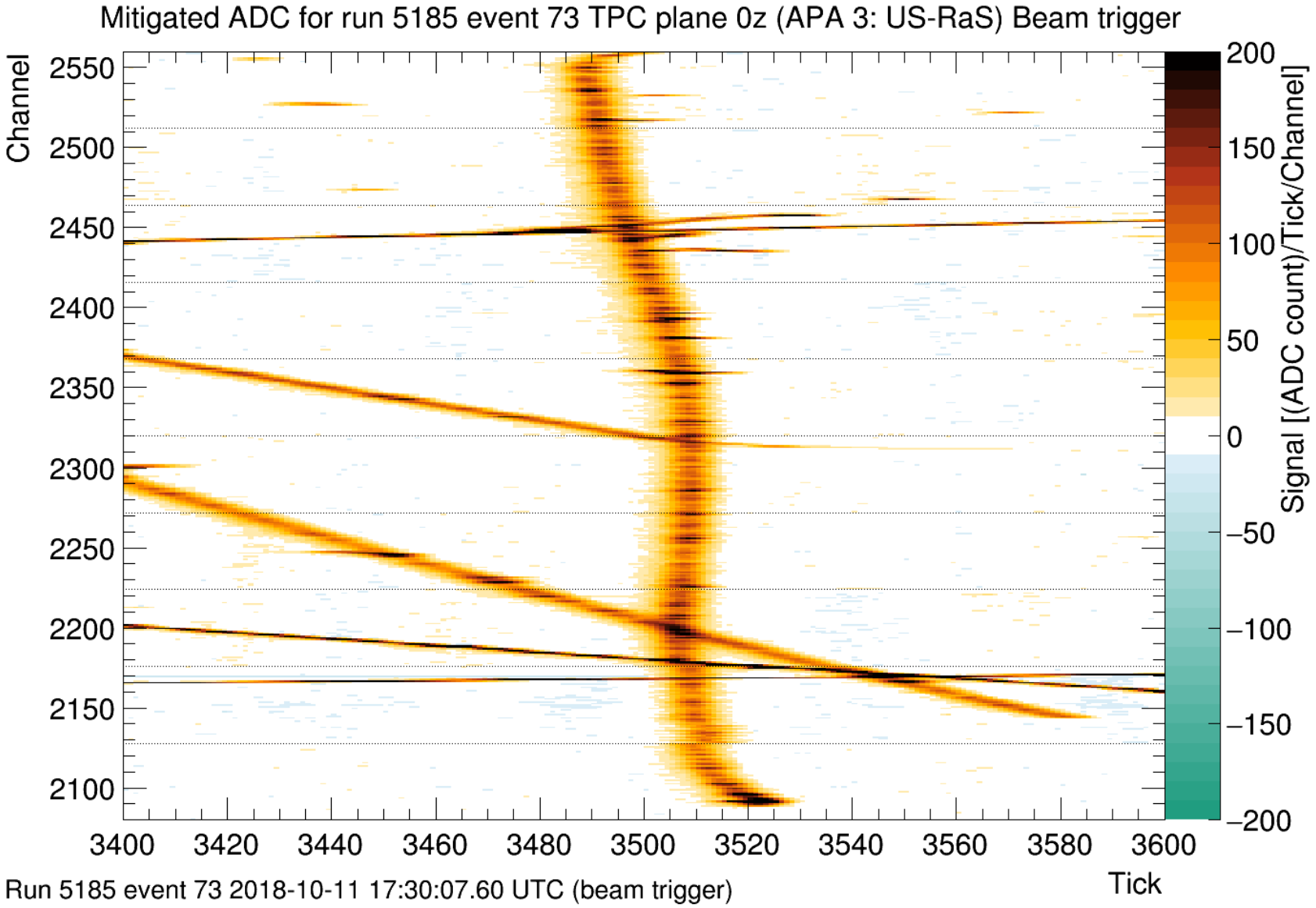
1.0, 0 (no correction)



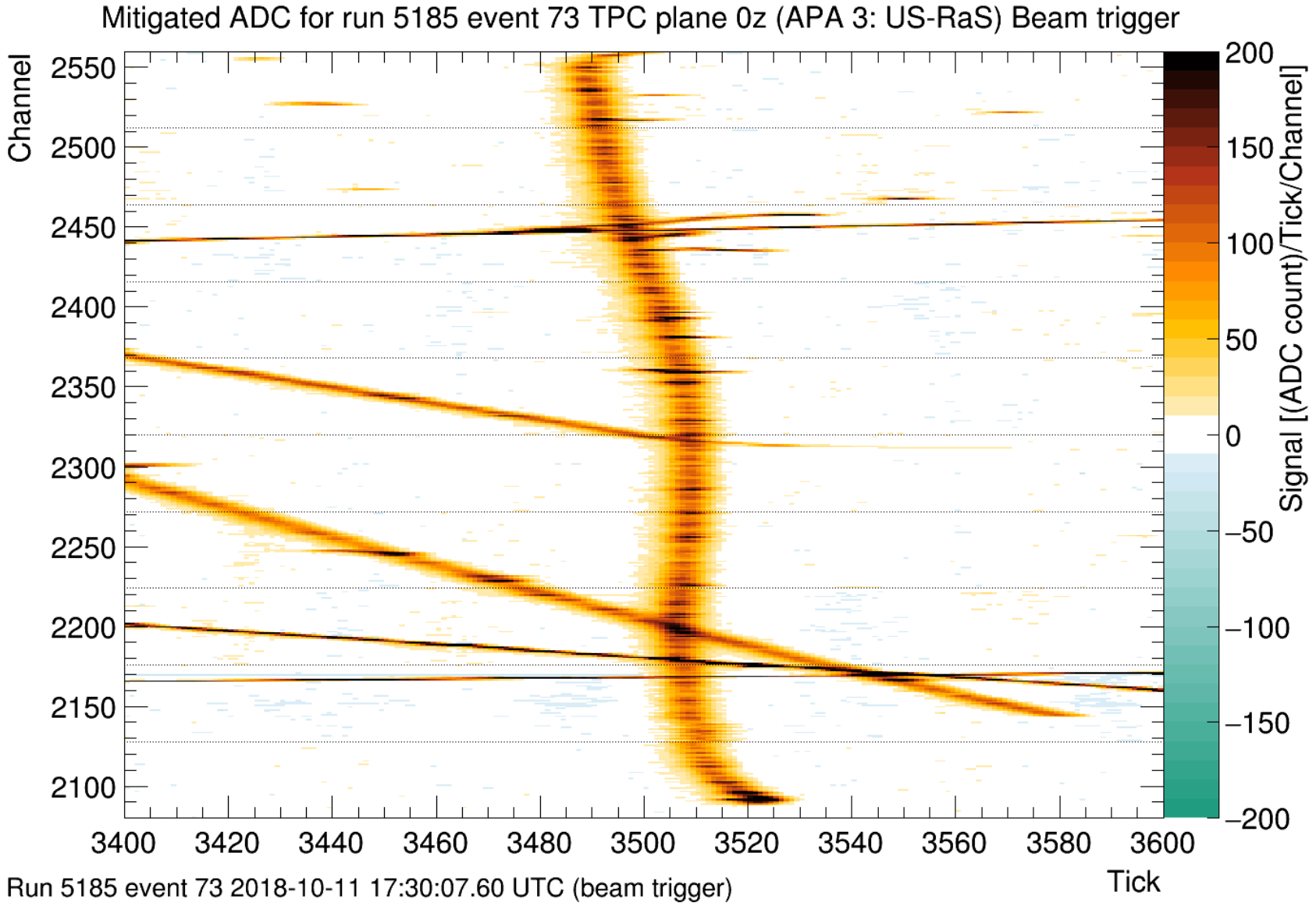
0.9995, 3 (Dec 2018 correction)



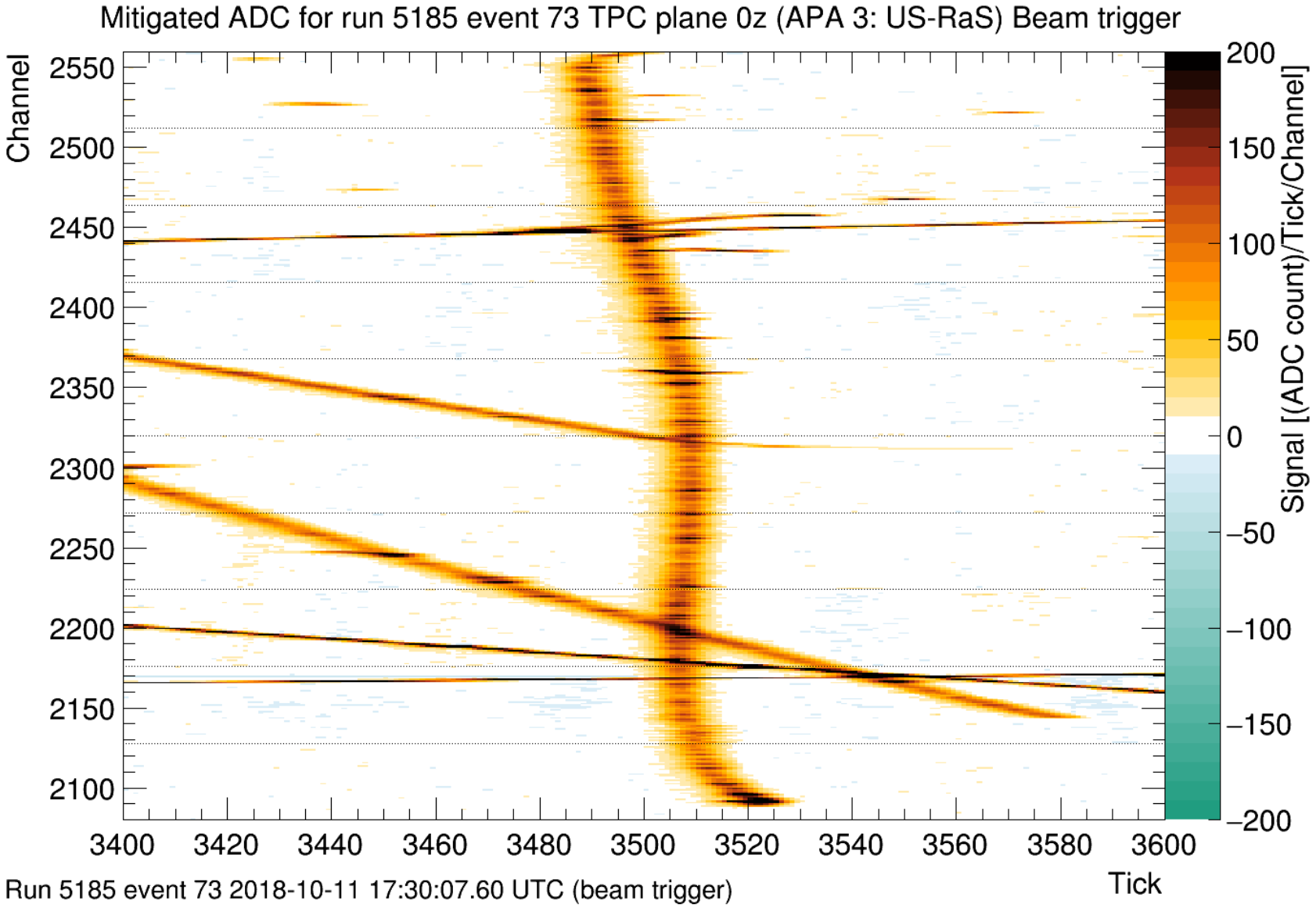
0.9993, 3


Mitigated ADC for run 5185 event 73 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
3400
3420
3440
3460
3480
3500
3520
3540
3560
3580
3600
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 73 2018-10-11 17:30:07.60 UTC (beam trigger)

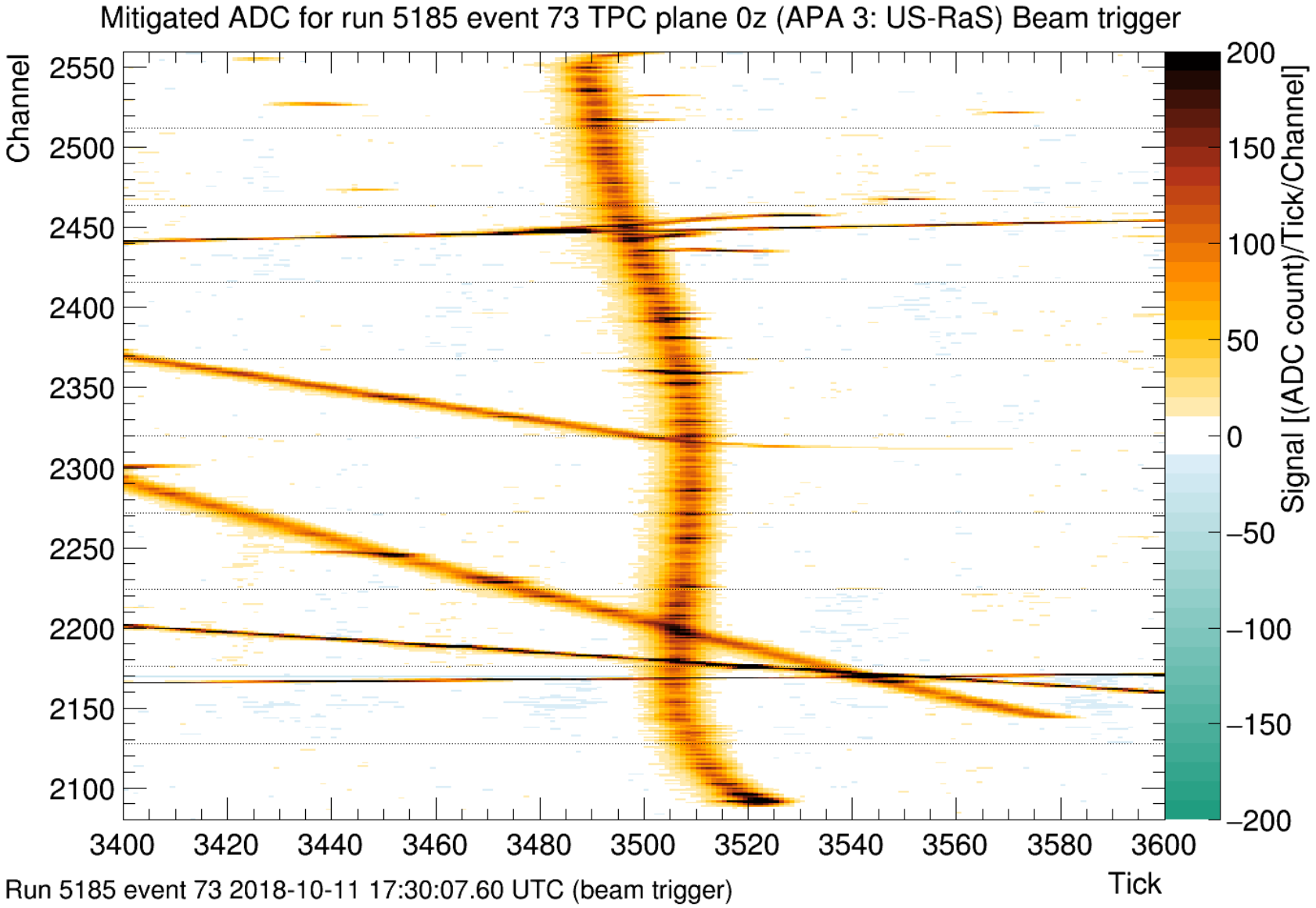
0.9993, 2


Mitigated ADC for run 5185 event 73 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
3400
3420
3440
3460
3480
3500
3520
3540
3560
3580
3600
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 73 2018-10-11 17:30:07.60 UTC (beam trigger)

0.9993, 1


Mitigated ADC for run 5185 event 73 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
3400
3420
3440
3460
3480
3500
3520
3540
3560
3580
3600
Tick
Signal [(ADC count)/Tick/Channel]
200
150
100
50
0
−50
−100
−150
−200
Run 5185 event 73 2018-10-11 17:30:07.60 UTC (beam trigger)

0.9993, 0


Mitigated ADC for run 5185 event 73 TPC plane 0z (APA 3: US-RaS) Beam trigger
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
3400
3420
3440
3460
3480
3500
3520
3540
3560
3580
3600
Tick
200
150
100
50
0
−50
−100
−150
−200
Signal [(ADC count)/Tick/Channel]
Run 5185 event 73 2018-10-11 17:30:07.60 UTC (beam trigger)

Comments/conclusions

Without correction

- FEMB 302 is off by 5-10 ticks
- All other FEMBs look fine (only APA 3z, u, v shown here)

Old (Dec 2018) correction

- Much better but still often off by 1-2 ticks

Offset was varied using the pulser-derived rate factor of 0.9993

- Offset of 1.0 looks good and usually best
- 2.0 is sometimes similar or marginally better
- 0.0, 3.0 almost always look significantly worse
- Pulser rate factor looks good, most likely better than the old factor

Propose new default for FEMB 302 timing mitigation

- Rate factor 0.9993, offset 1.0. OK?
- In dunetpc v08_13_02

Stability

- Rate seen to be stable to much higher precision with pulser data
- Two runs here that bracket most of the beam data are consistent

Extras

Timing ratios (from last week)

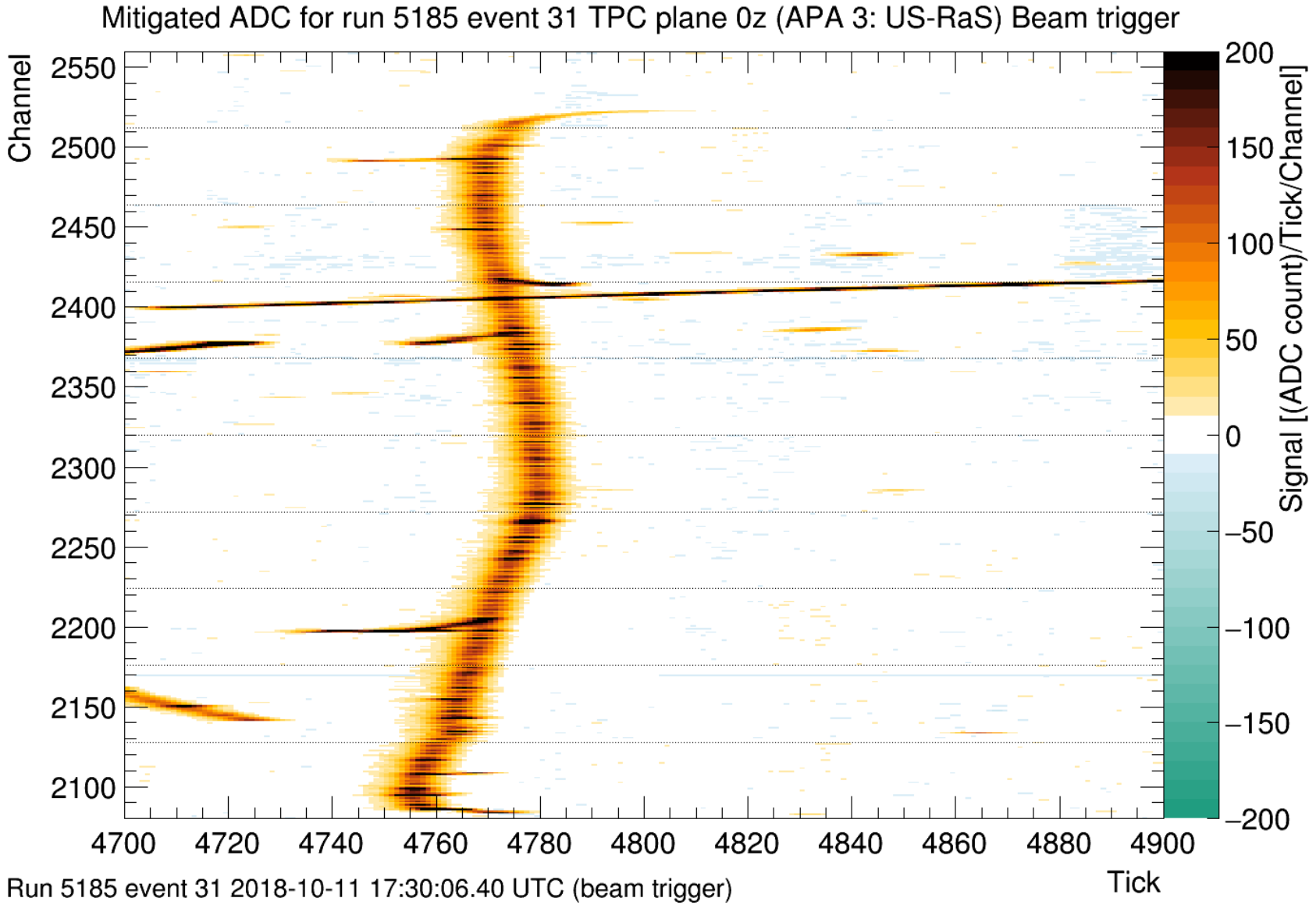
Timing ratio evaluated with pulser data

- Look at peak of tickmod distribution in each event
- Plot this vs. timing clock
- Results are shown in table
- Ratio changes with time
  - Not important for reco
  - Important for pulser analysis
- Plots showing effect follow

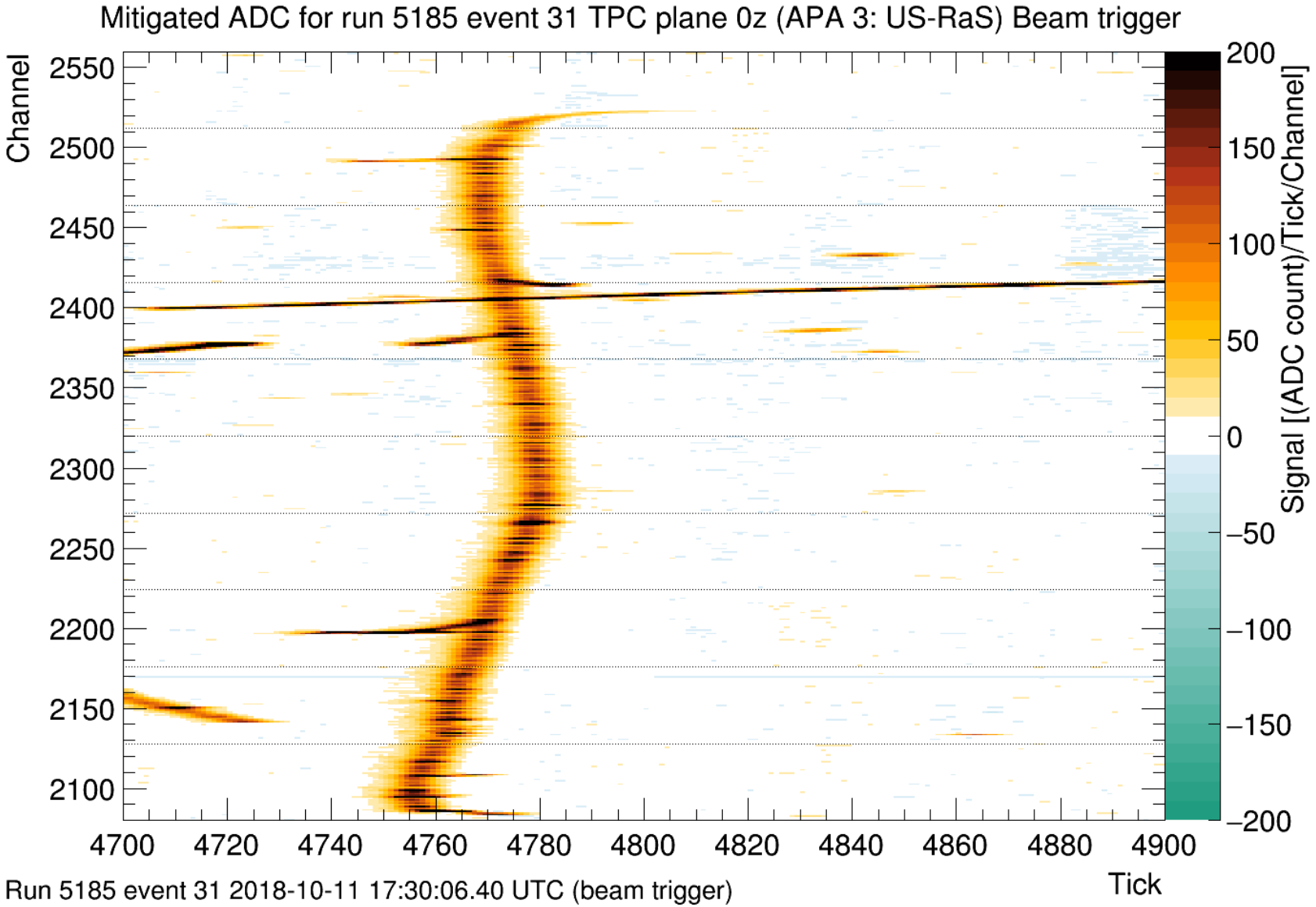
Run	**Timing ratio**
Event display	0.9995
5954	0.9992875
5531 (5526, 5540)	0.9992961
6036	0.9992927
6690	0.9992930

Following shows the new correction tool gives the expected behavior

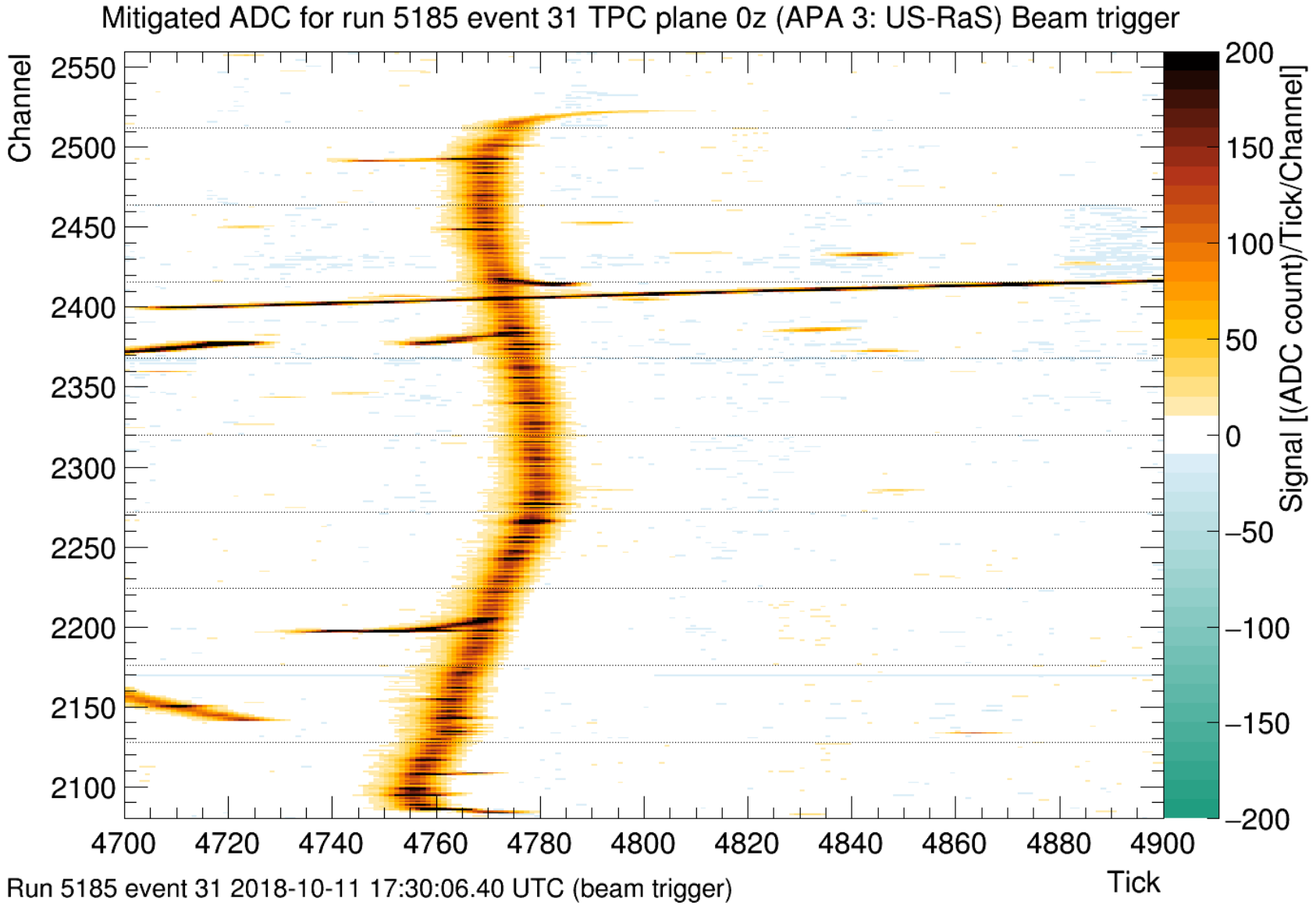
Old reco (Dec 2018 correction)



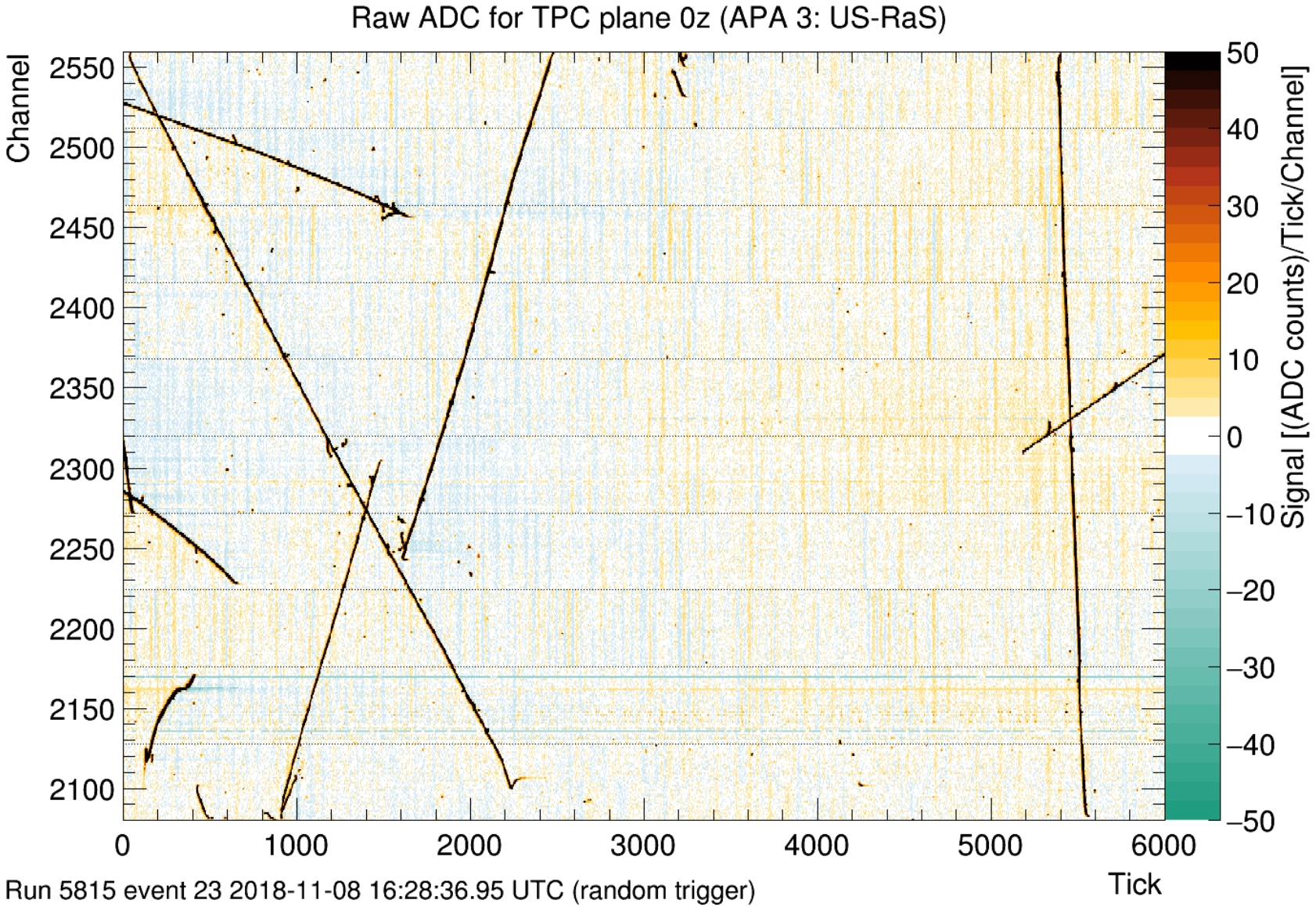
New reco (Mar 2019 correction)

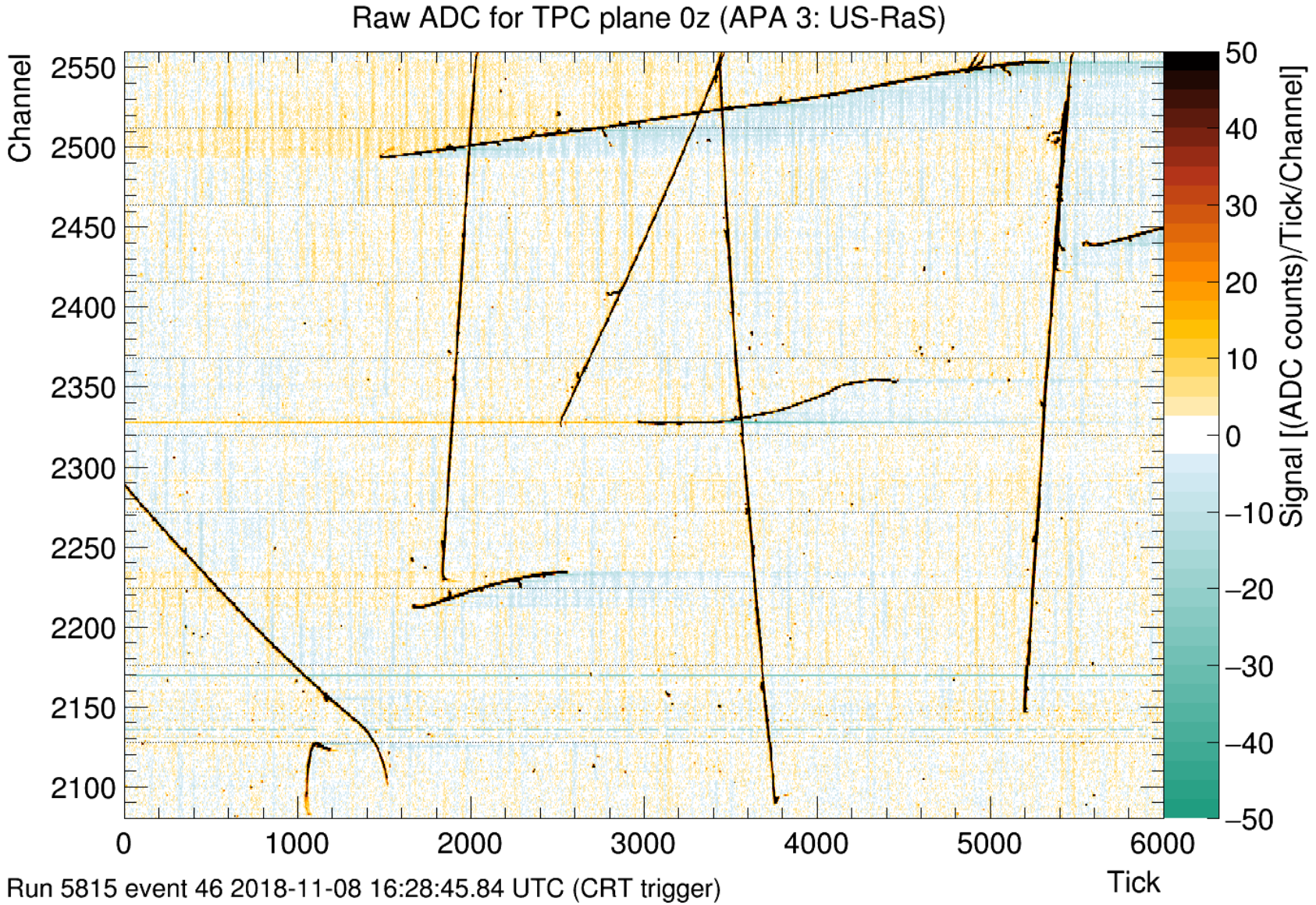


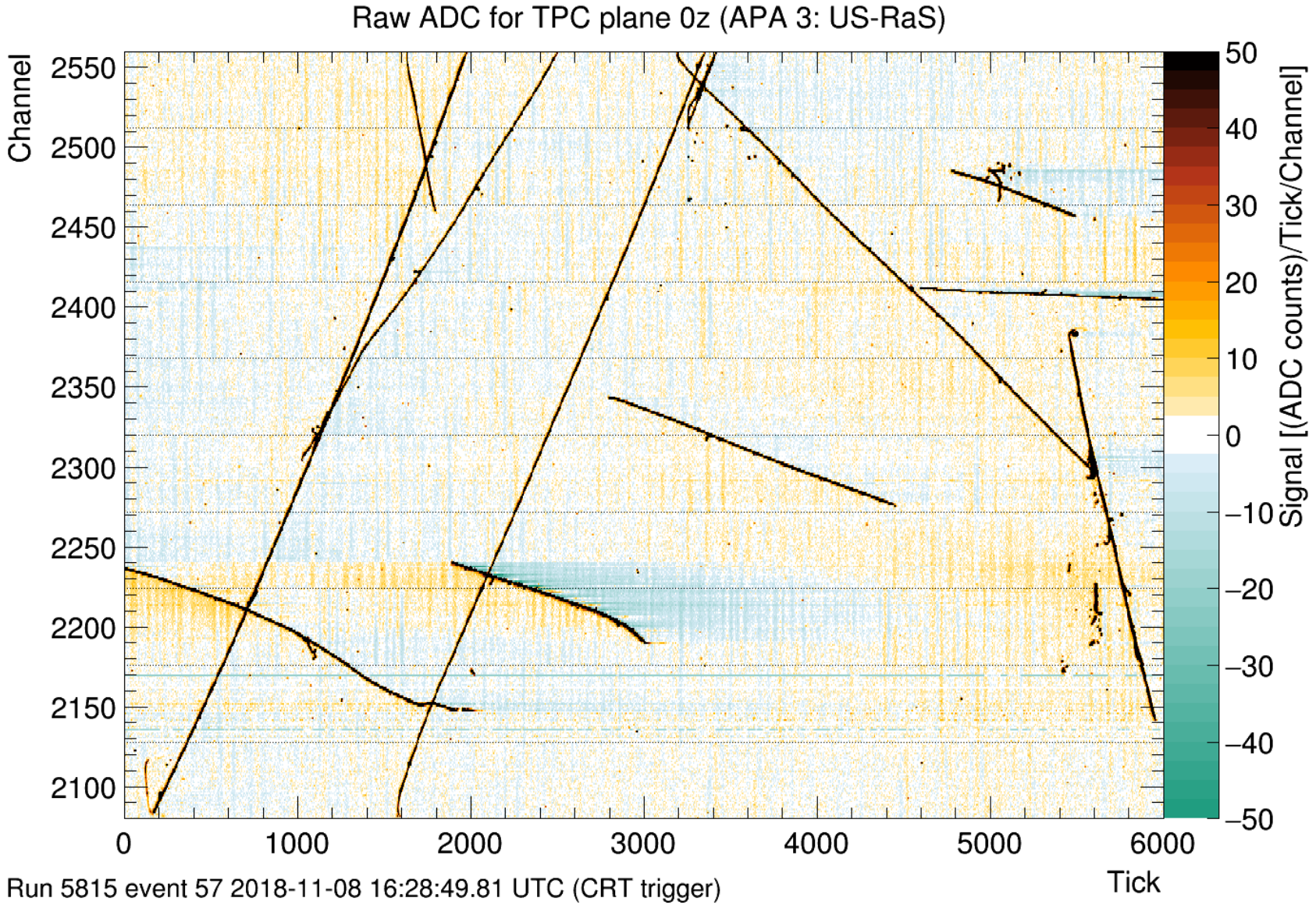
(0.9993, 1) from study here

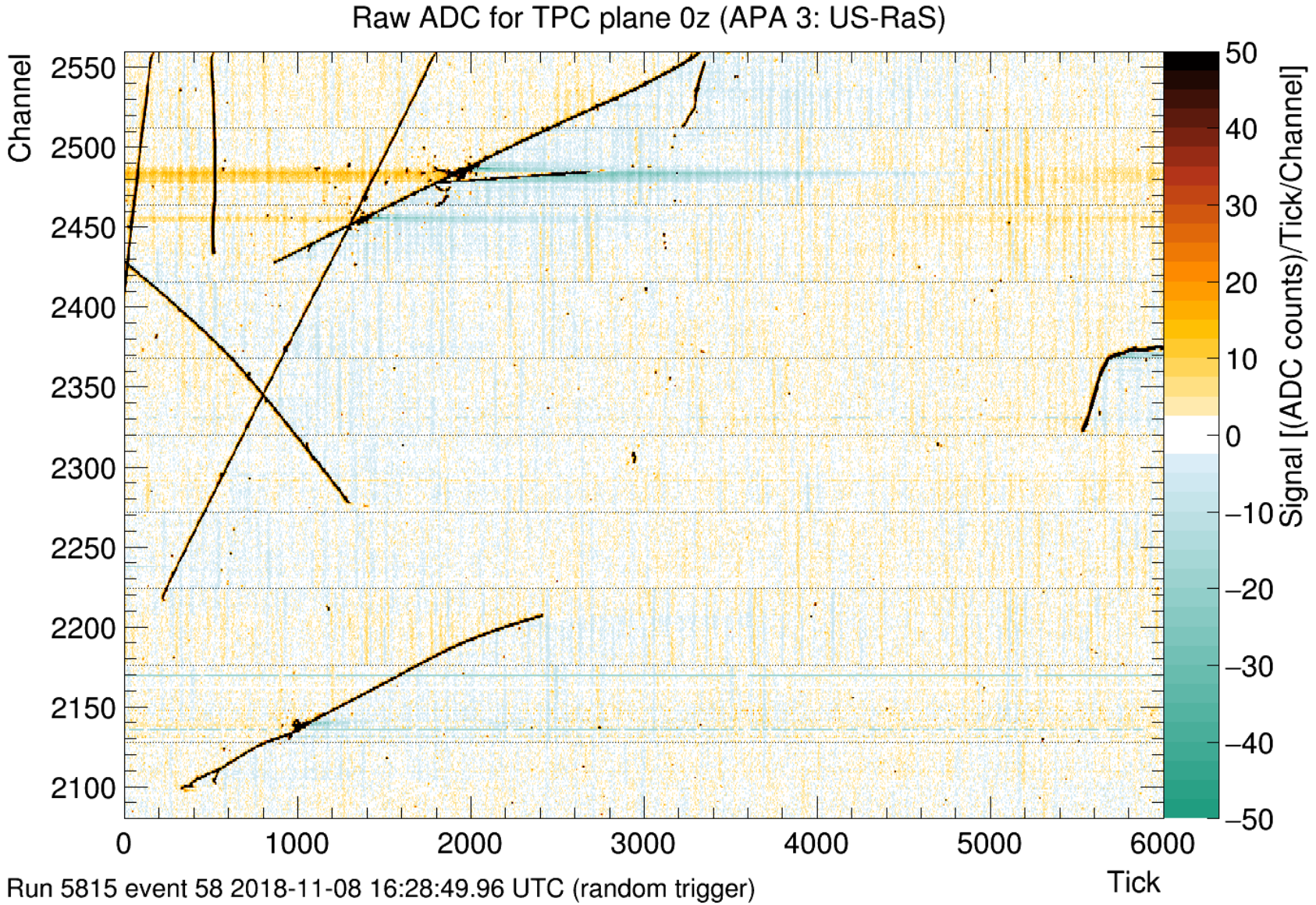


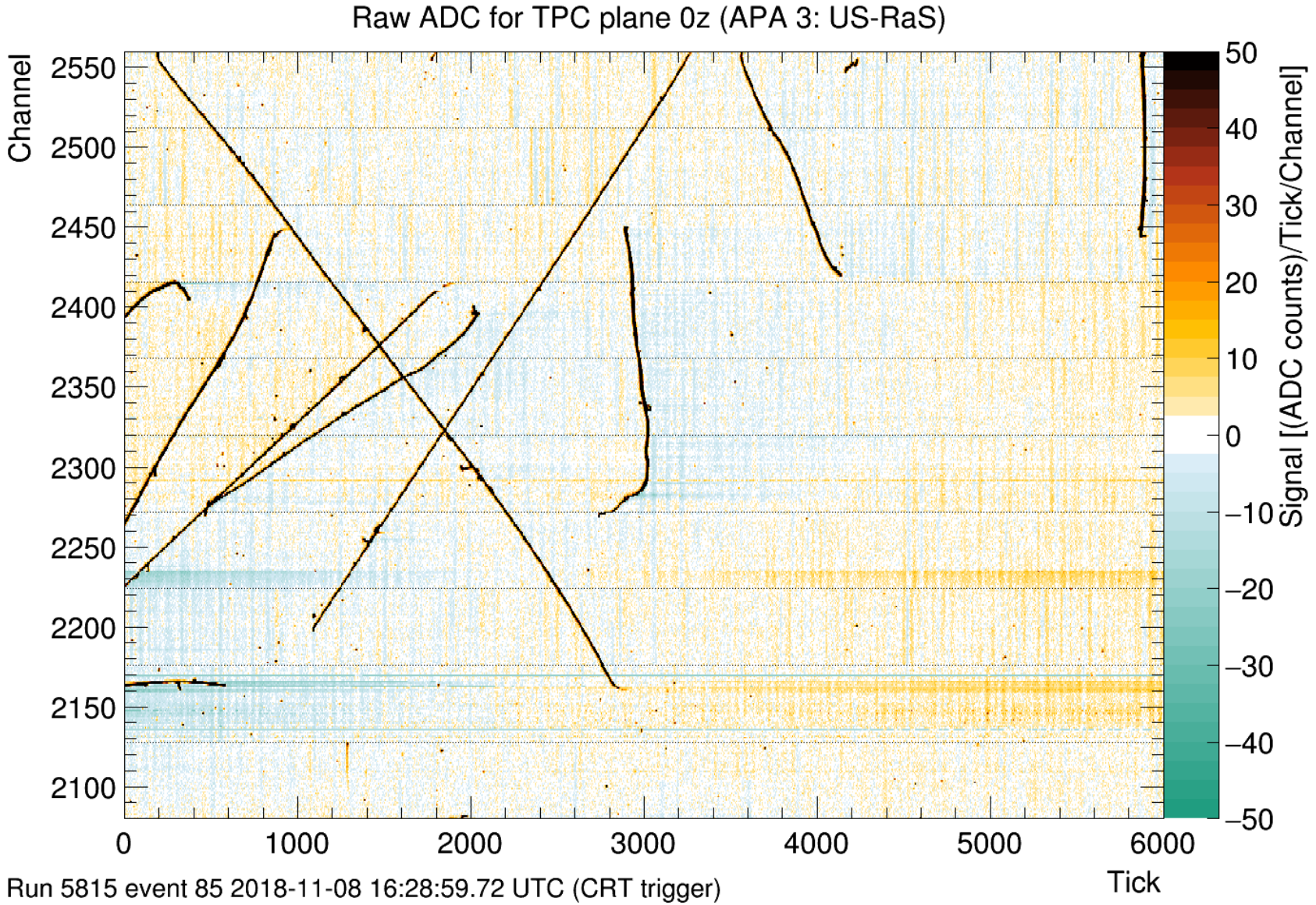
Following are example event displays used to select the tracks used here

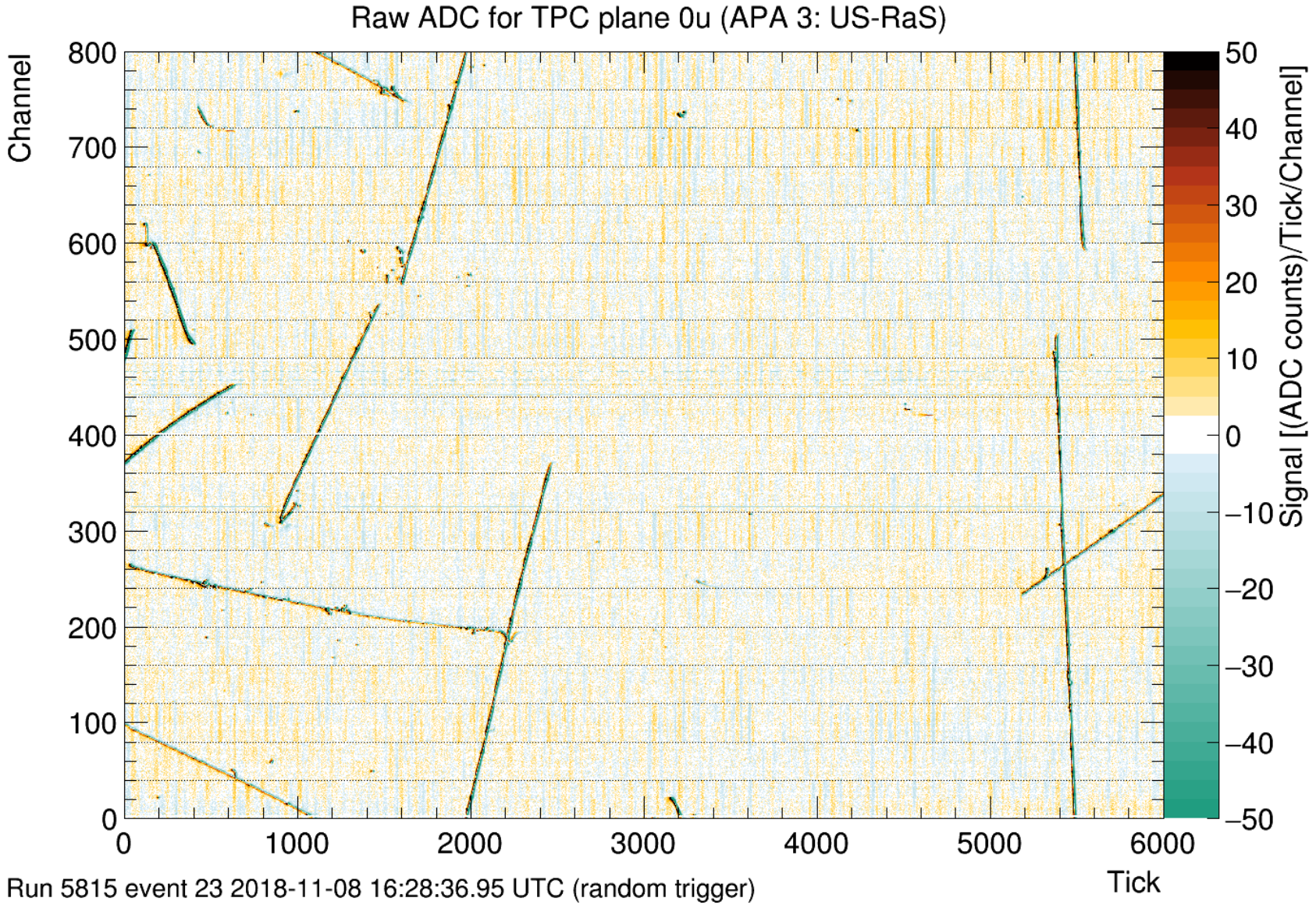

Raw ADC for TPC plane 0z (APA 3: US-RaS)
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

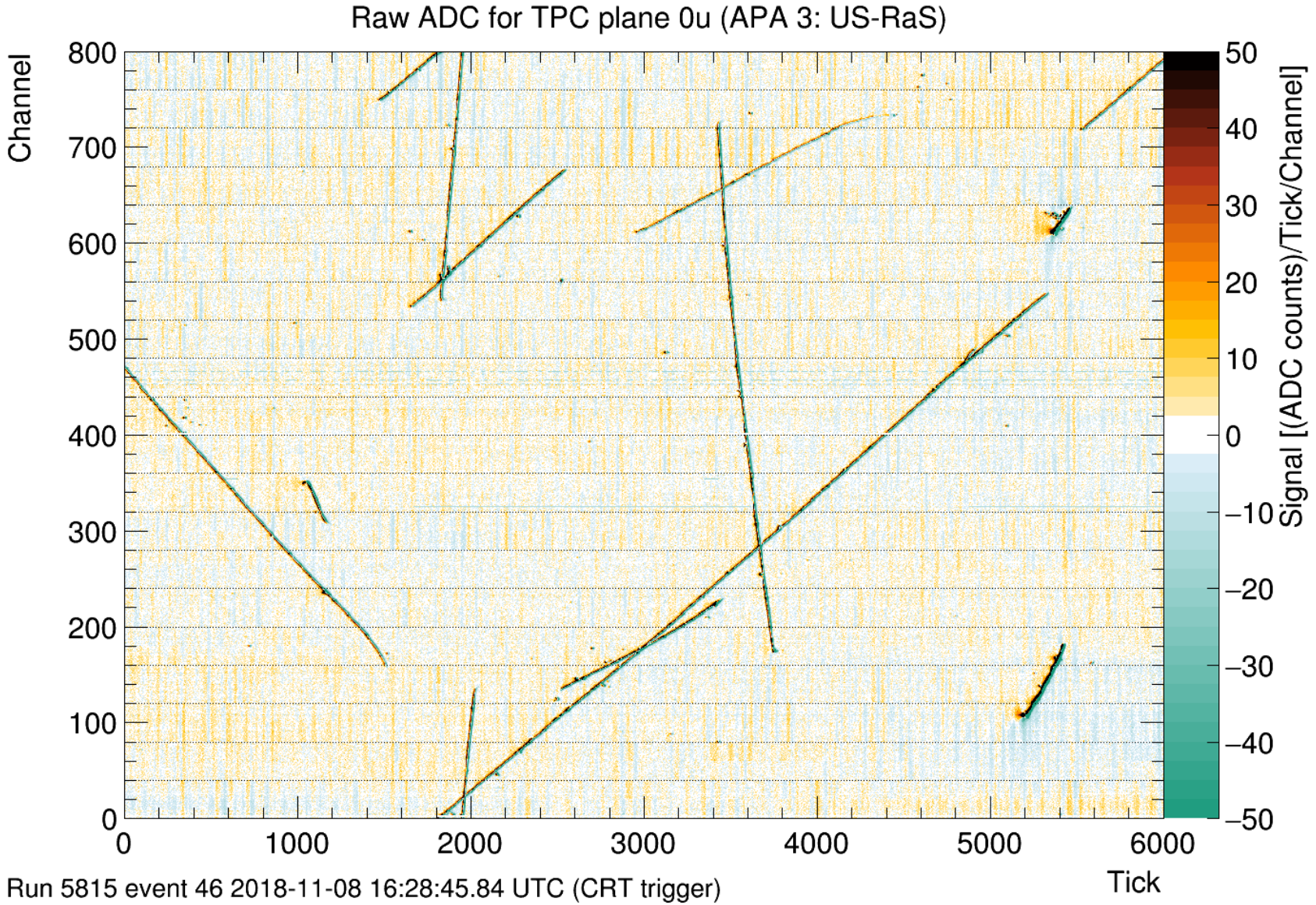

Raw ADC for TPC plane 0z (APA 3: US-RaS)
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 46 2018-11-08 16:28:45.84 UTC (CRT trigger)

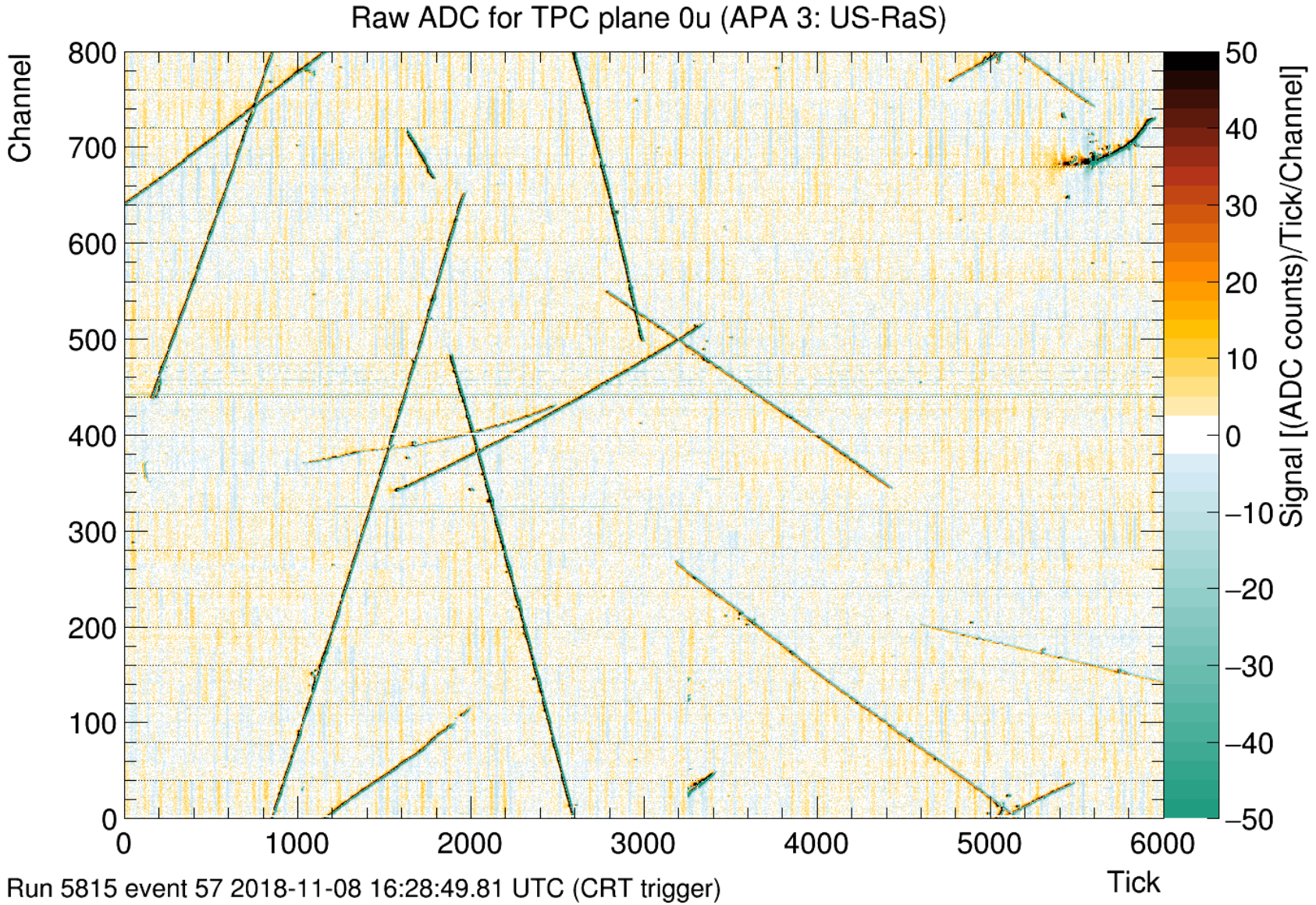

Raw ADC for TPC plane 0z (APA 3: US-RaS)
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 57 2018-11-08 16:28:49.81 UTC (CRT trigger)

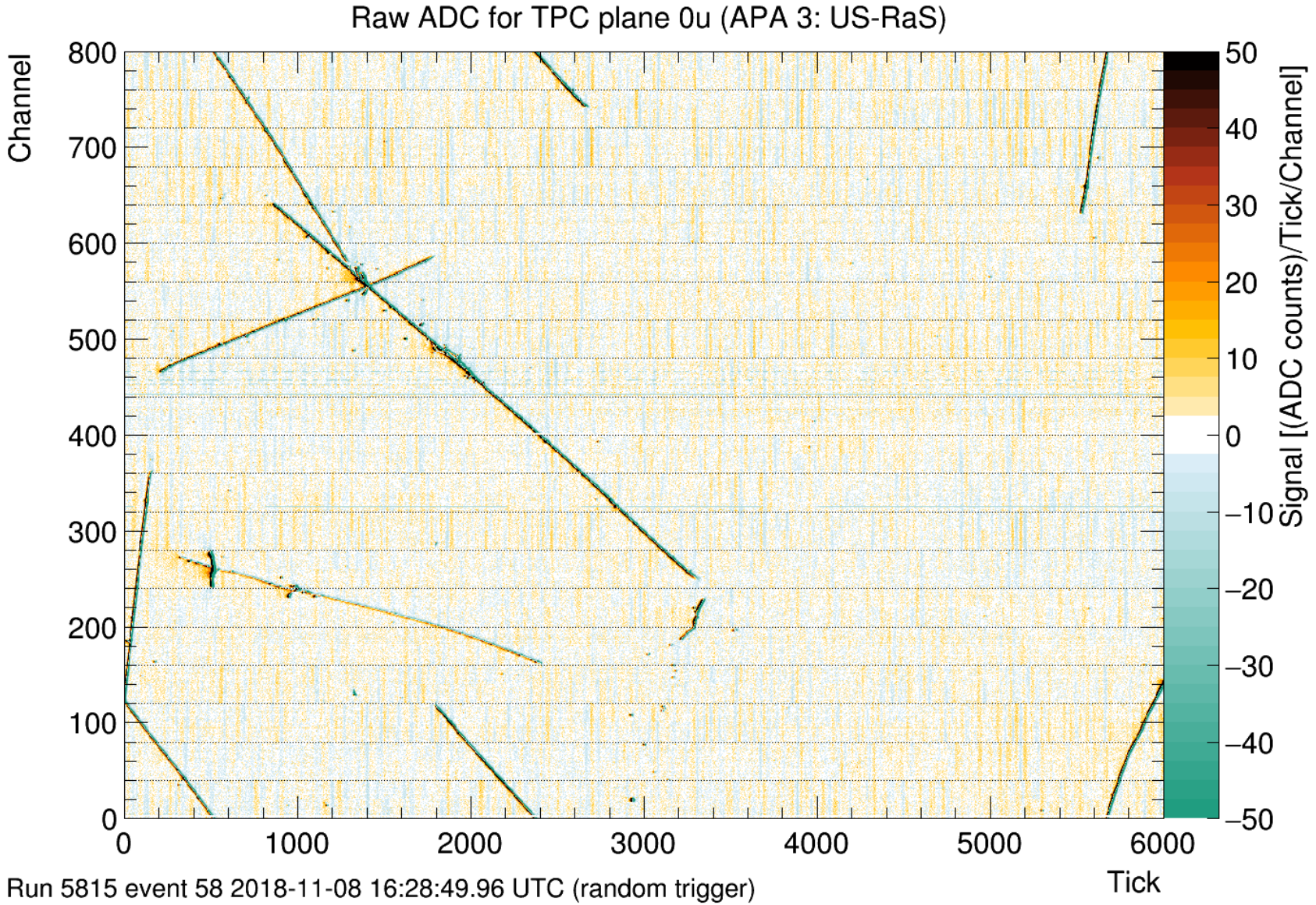

Raw ADC for TPC plane 0z (APA 3: US-RaS)
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 58 2018-11-08 16:28:49.96 UTC (random trigger)

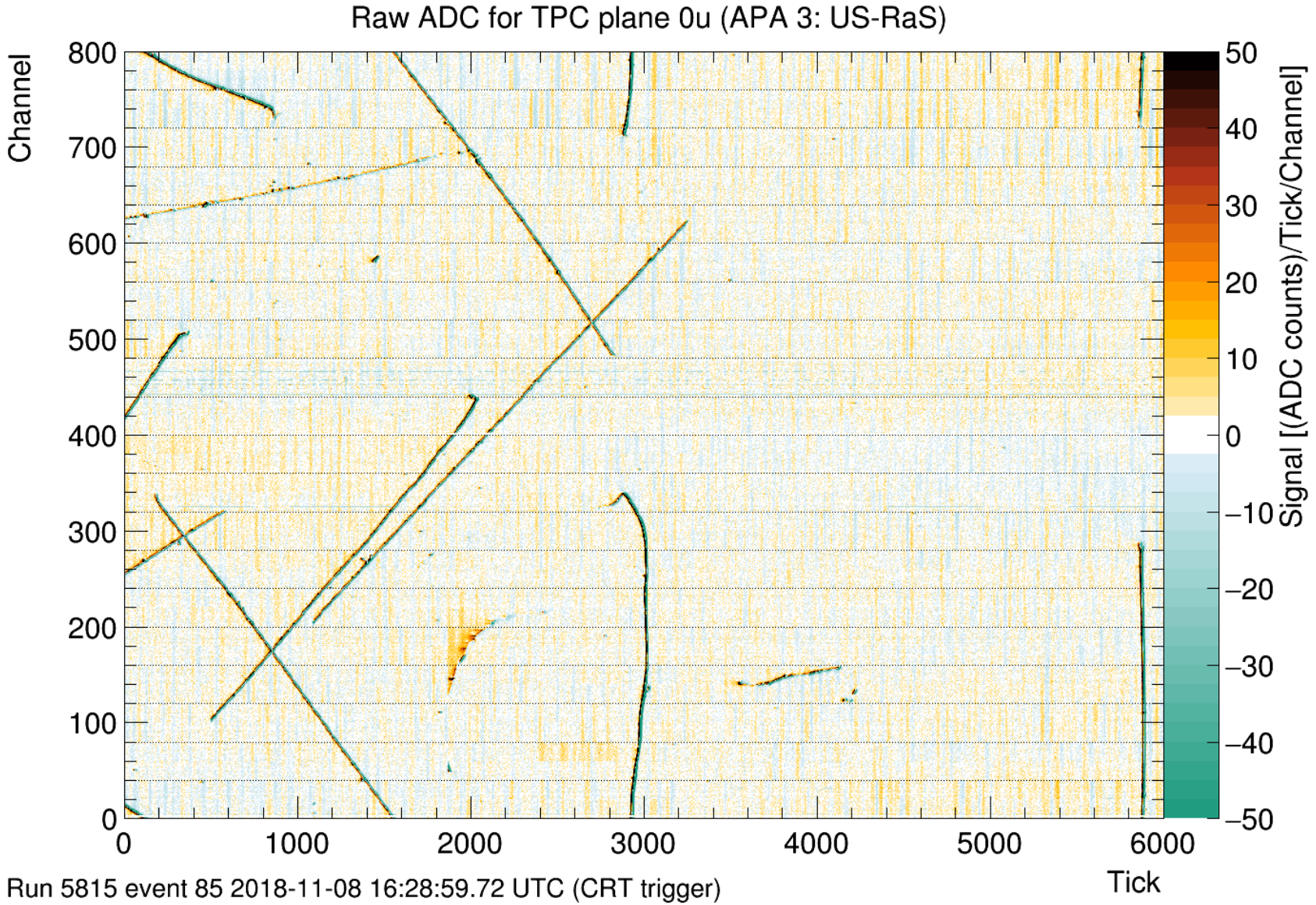

Raw ADC for TPC plane 0z (APA 3: US-RaS)
Channel
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 85 2018-11-08 16:28:59.72 UTC (CRT trigger)

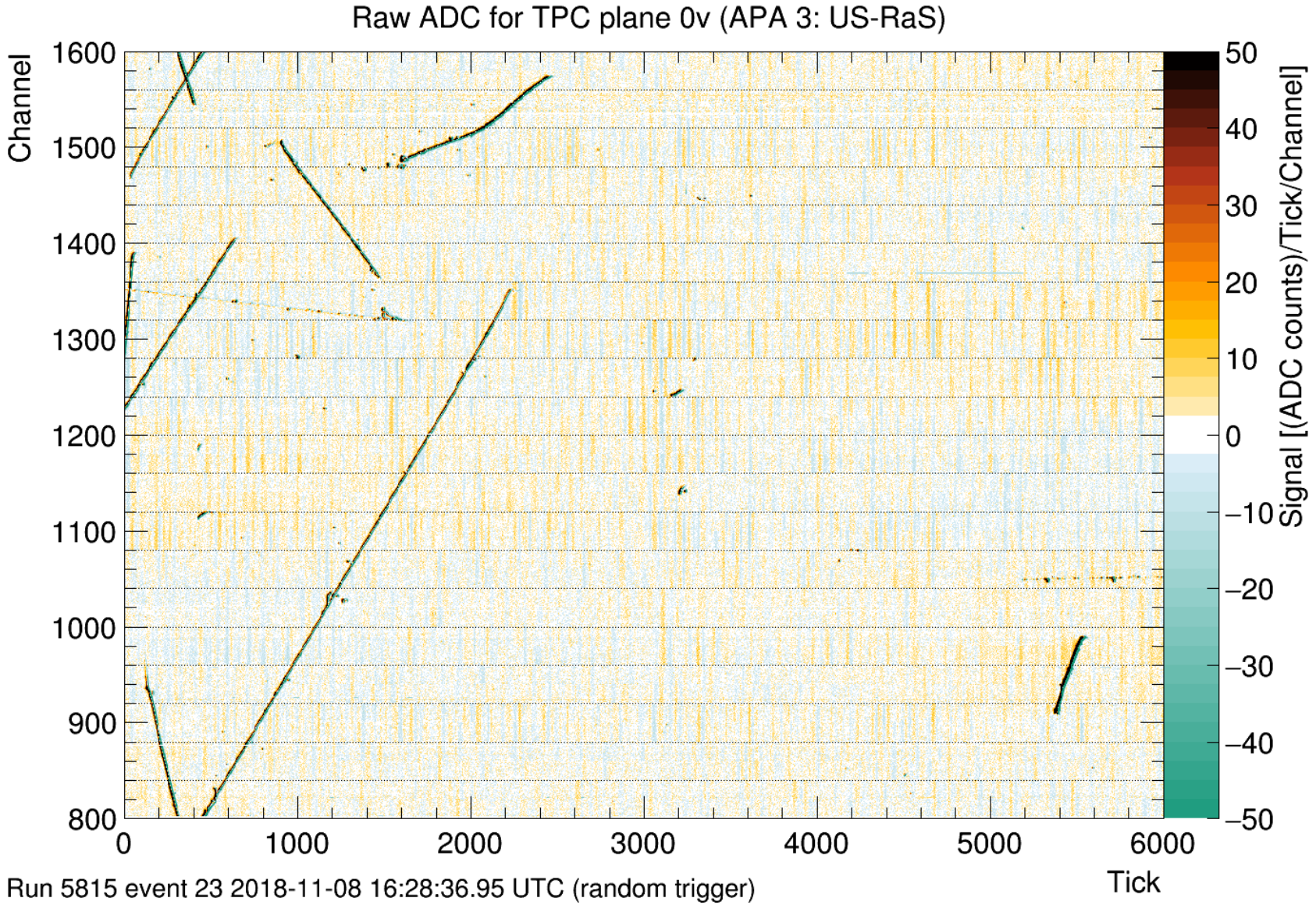

Raw ADC for TPC plane 0u (APA 3: US-RaS)
Channel
800
700
600
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)

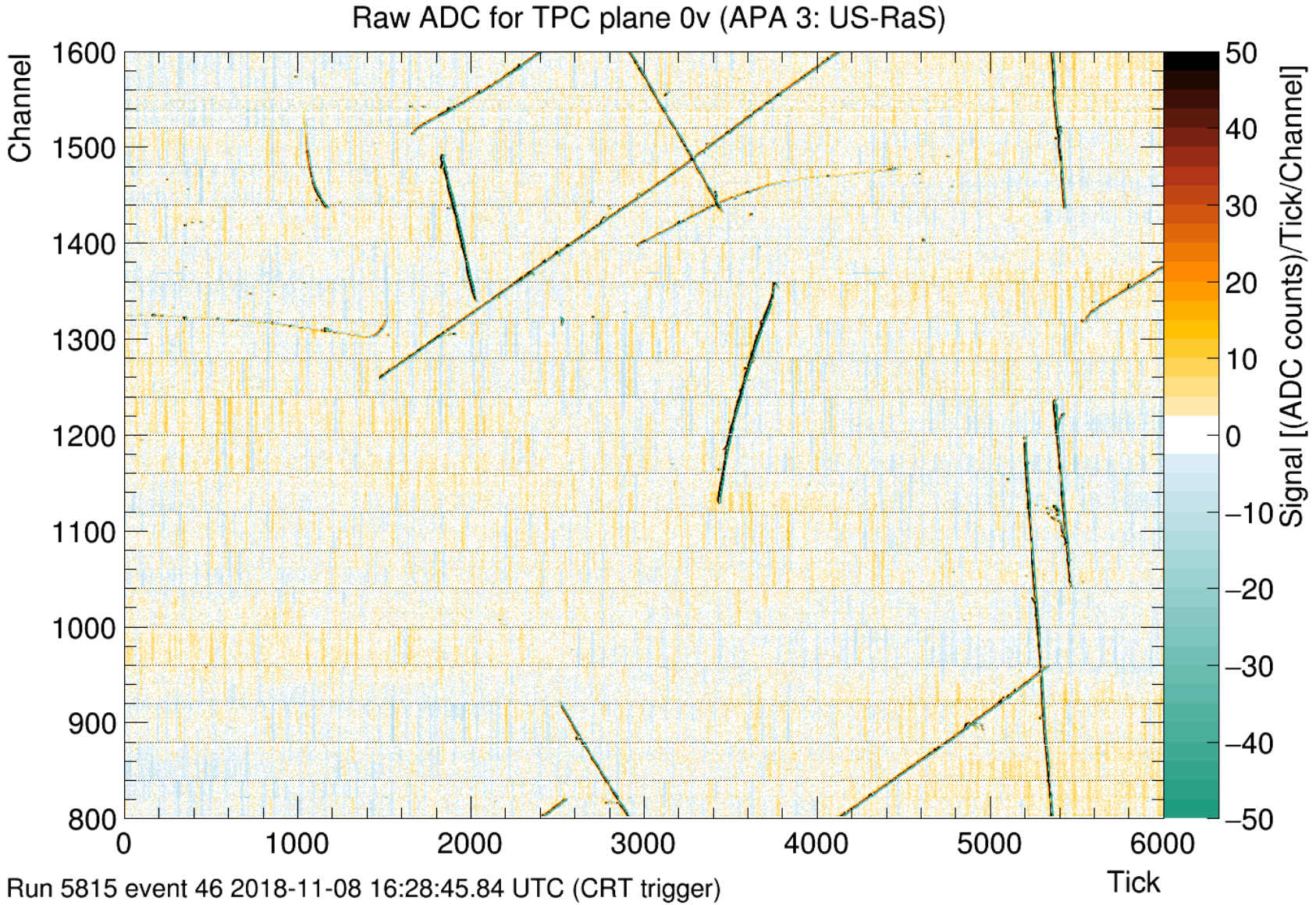

Raw ADC for TPC plane 0u (APA 3: US-RaS)
Channel
800
700
600
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 46 2018-11-08 16:28:45.84 UTC (CRT trigger)

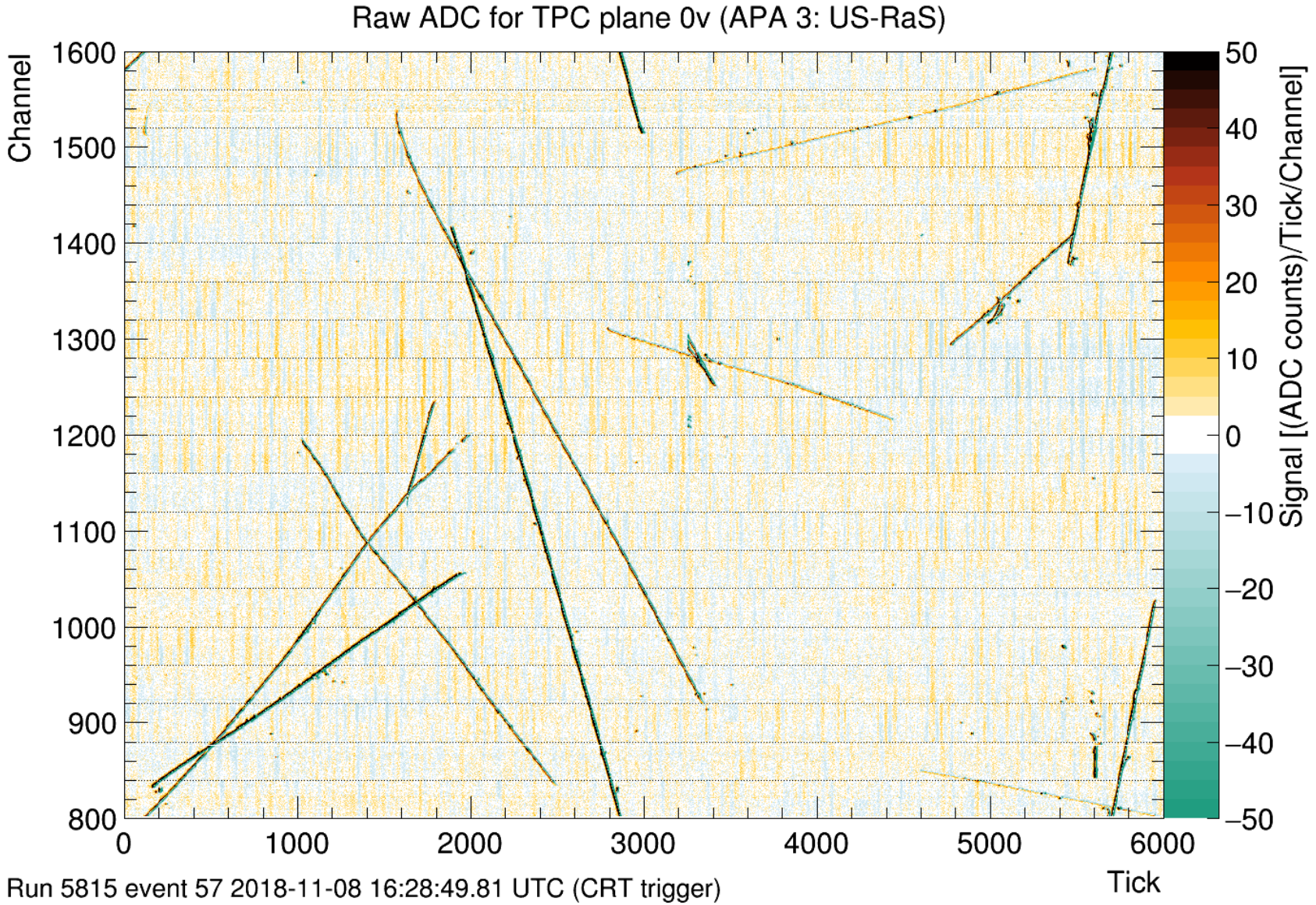

Raw ADC for TPC plane 0u (APA 3: US-RaS)
Channel
800
700
600
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 57 2018-11-08 16:28:49.81 UTC (CRT trigger)

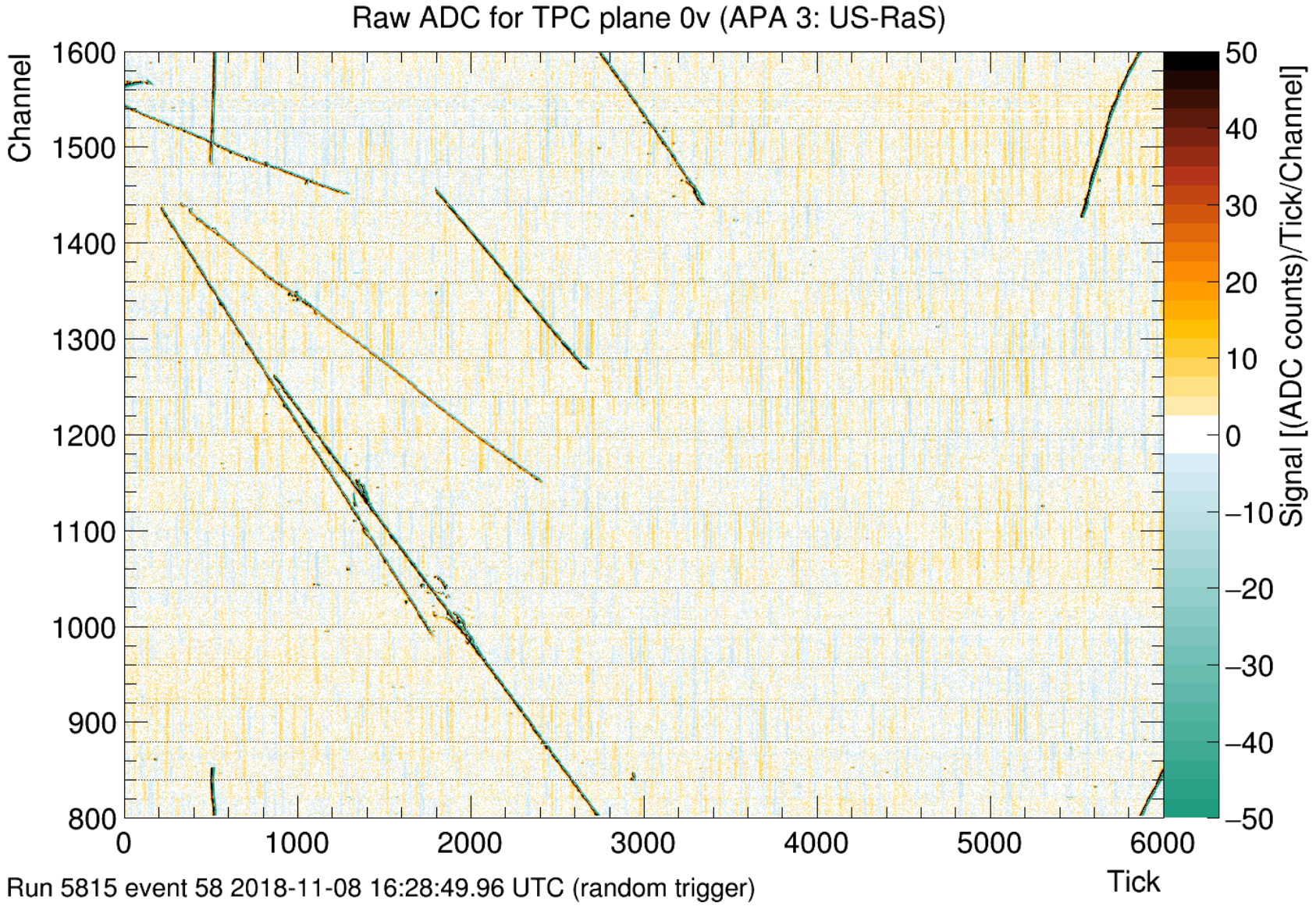

Raw ADC for TPC plane 0u (APA 3: US-RaS)
Channel
800
700
600
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 58 2018-11-08 16:28:49.96 UTC (random trigger)

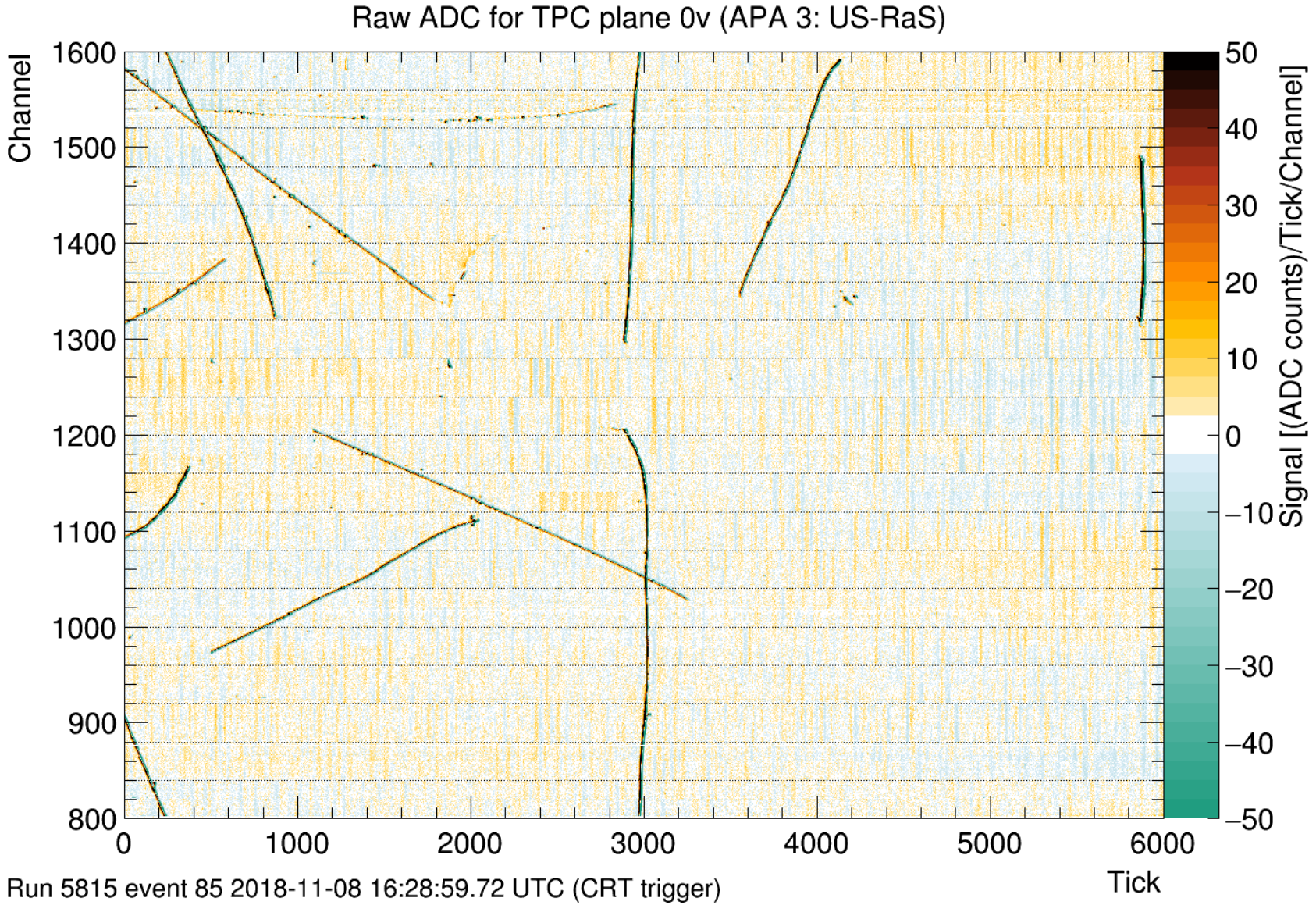

Raw ADC for TPC plane 0u (APA 3: US-RaS)
Channel
800
700
600
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 85 2018-11-08 16:28:59.72 UTC (CRT trigger)


Raw ADC for TPC plane 0v (APA 3: US-RaS)
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 23 2018-11-08 16:28:36.95 UTC (random trigger)


Raw ADC for TPC plane 0v (APA 3: US-RaS)
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 46 2018-11-08 16:28:45.84 UTC (CRT trigger)


Raw ADC for TPC plane 0v (APA 3: US-RaS)
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 57 2018-11-08 16:28:49.81 UTC (CRT trigger)


Raw ADC for TPC plane 0v (APA 3: US-RaS)
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 58 2018-11-08 16:28:49.96 UTC (random trigger)


Raw ADC for TPC plane 0v (APA 3: US-RaS)
Channel
1600
1500
1400
1300
1200
1100
1000
900
800
0
1000
2000
3000
4000
5000
6000
Tick
50
40
30
20
10
0
−10
−20
−30
−40
−50
Signal [(ADC counts)/Tick/Channel]
Run 5815 event 85 2018-11-08 16:28:59.72 UTC (CRT trigger)