Tracker commissioning plans

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MICE CM40
26th October 2014

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Content

- Focus on electronics and commissioning needs
- QA recently completed
- Issues for commissioning – ISIS RF integration, consideration of efficiencies, alignment (M Uchida)
- November plans
- Step IV commissioning
- Not everything has equal importance

Cryostats and associated

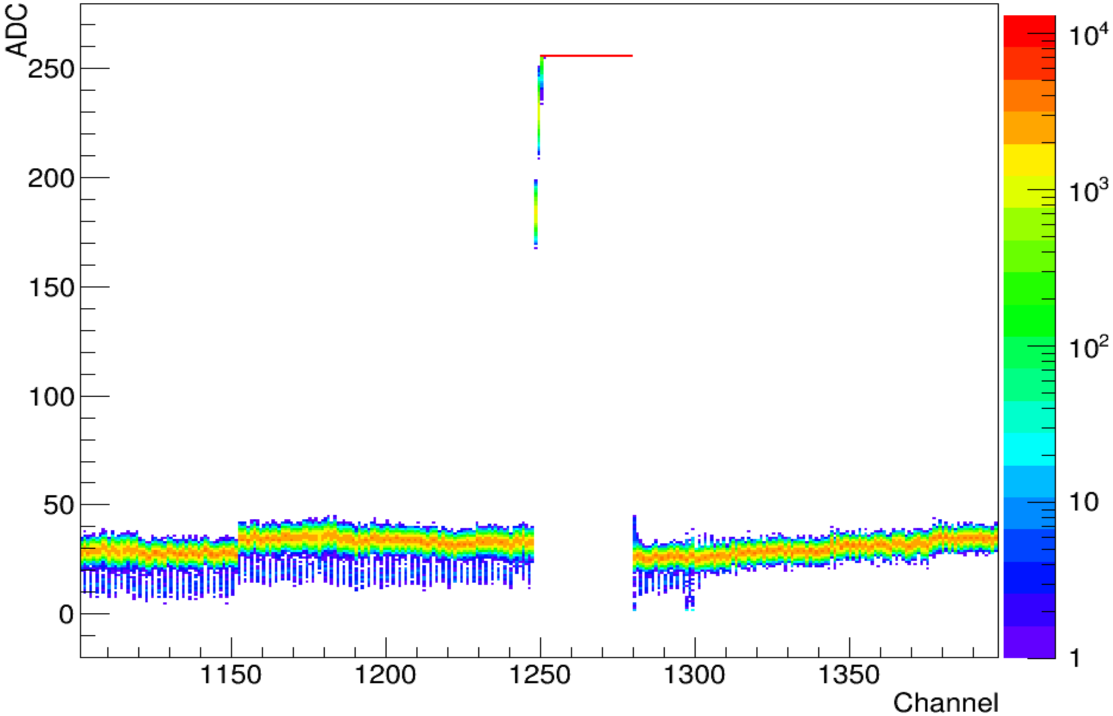
- Cold heads and compressors serviced
- Vacuum pumps checked
- One failed PSU – returned to vendor, spare purchased
- C MacWaters managing and installing into hall – hall infrastructure helium lines, vacuum, downstream racks, C&M/DAQ fibers, BNC etc.

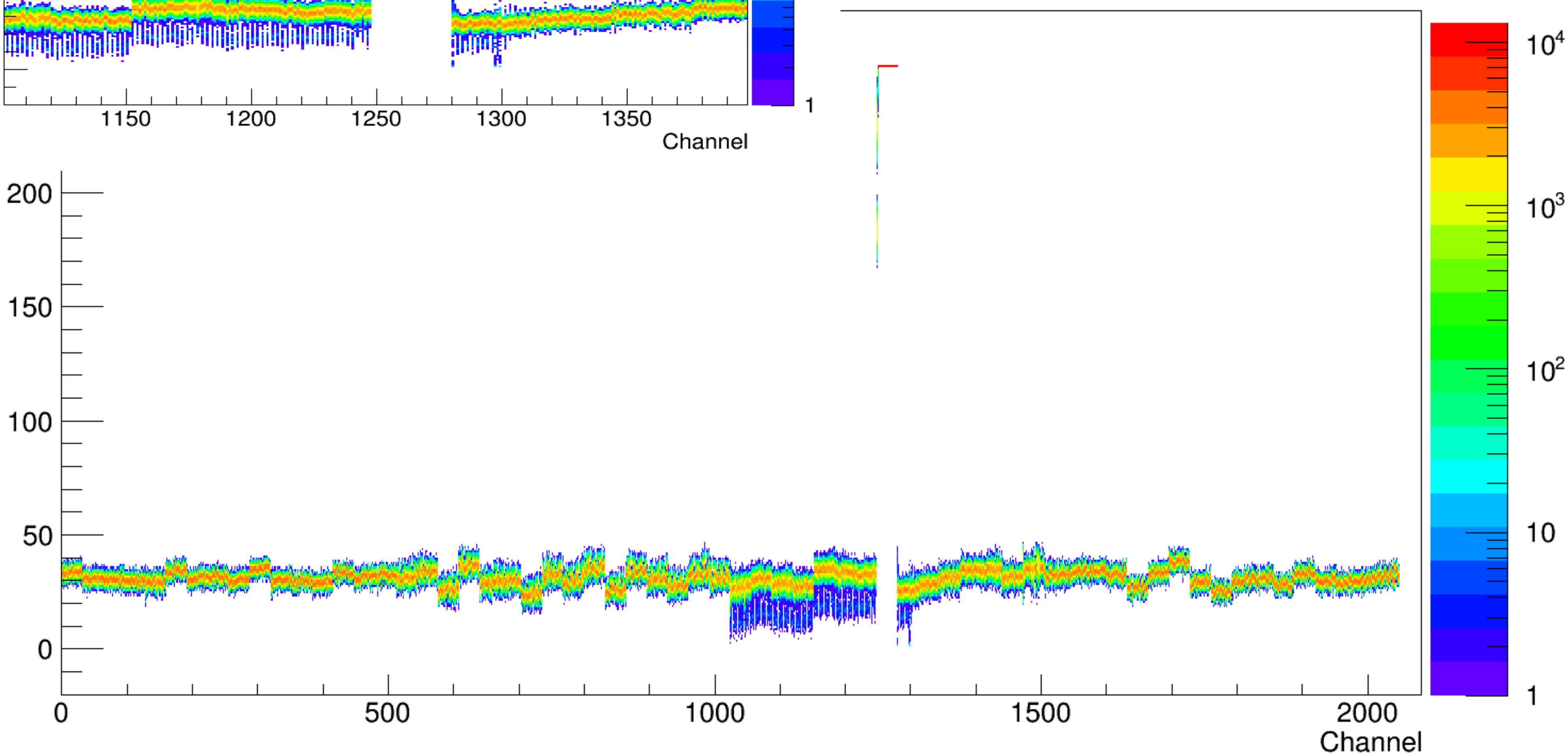
QA of existing electronics

- 8/30 – 9/13
- QA setup using fast-DAQ and internal triggering of AFES – no external pulser or RF period generator
- 16 AFE boards (front end electronics – lots of spares) currently in use rotating on cryostat 3
- All currently used LVDS cables (data cables, very difficult to replace)
- All currently used VLSB boards (VME buffers, almost impossible to replace)

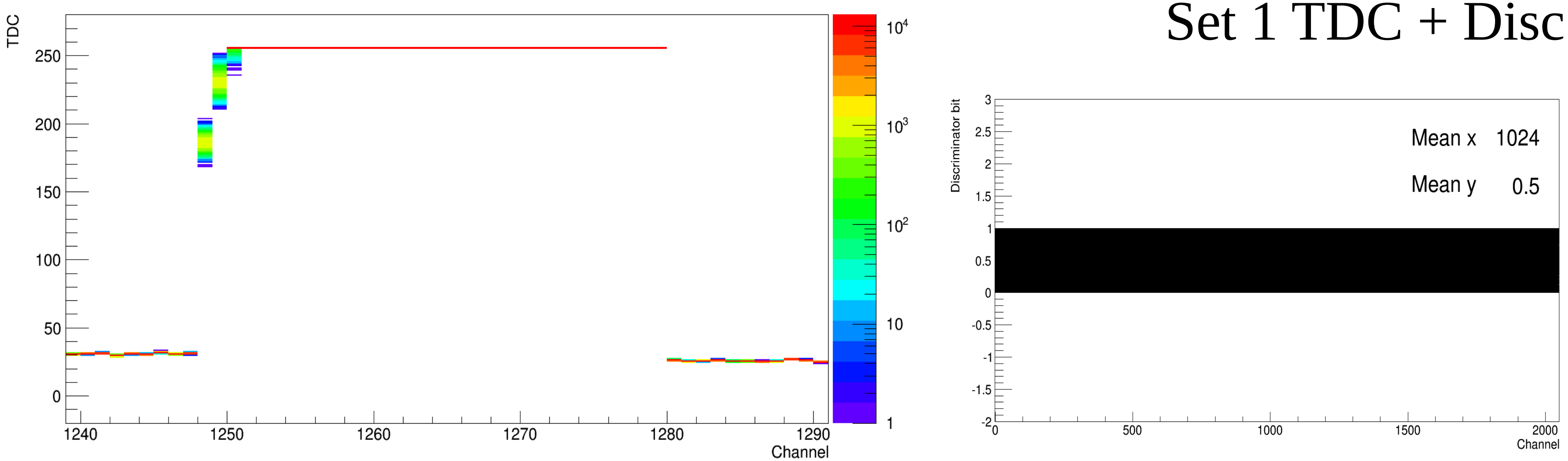
Set 1 ADC

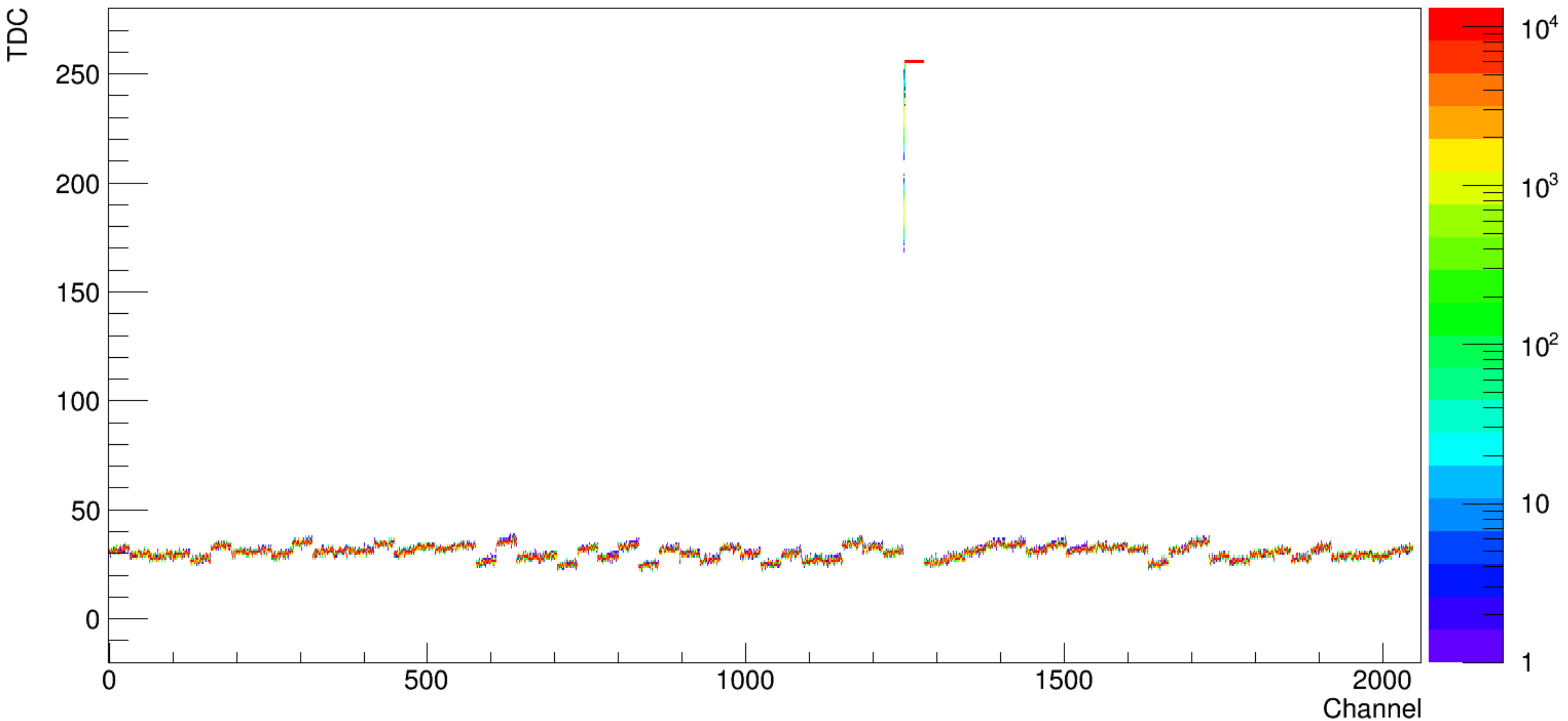
Observe base ADC, TDC and discriminator values for odd behavior – chip problems are usually digital



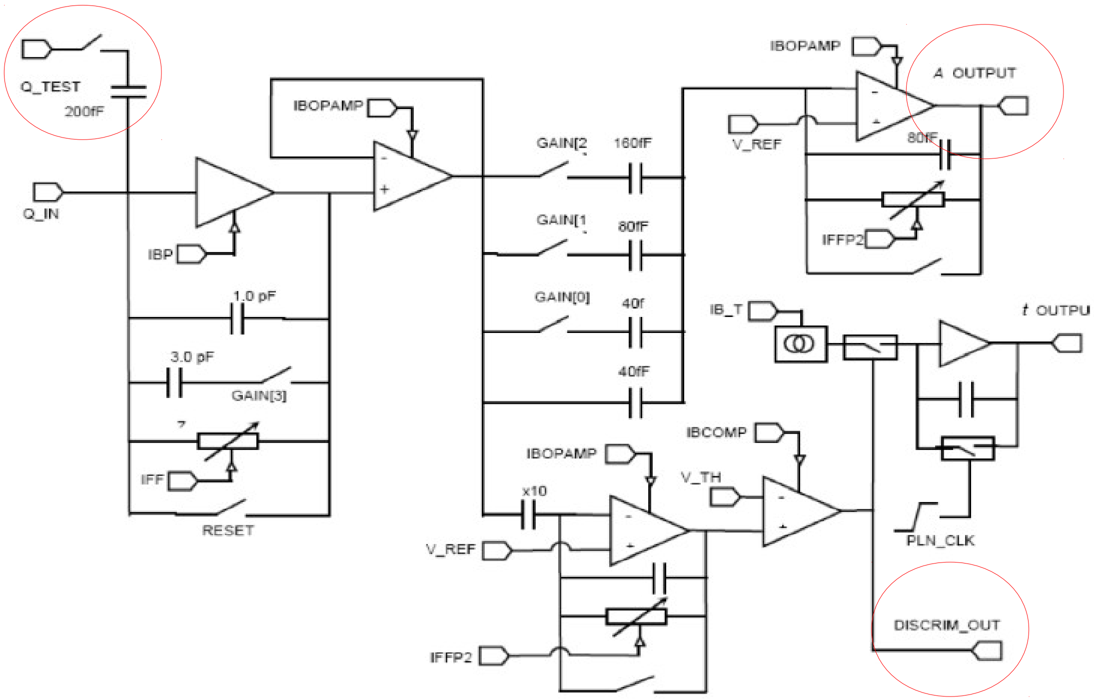


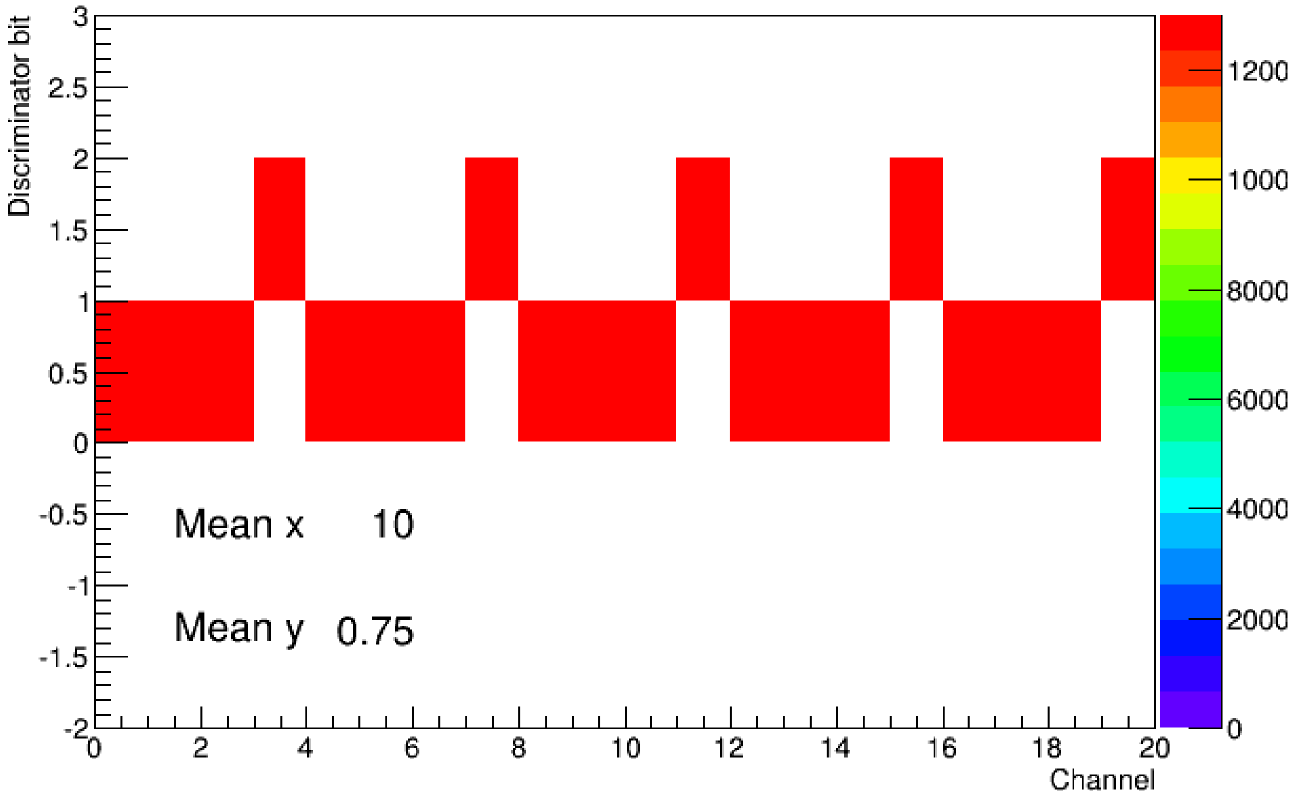
Set 1 TDC + Disc





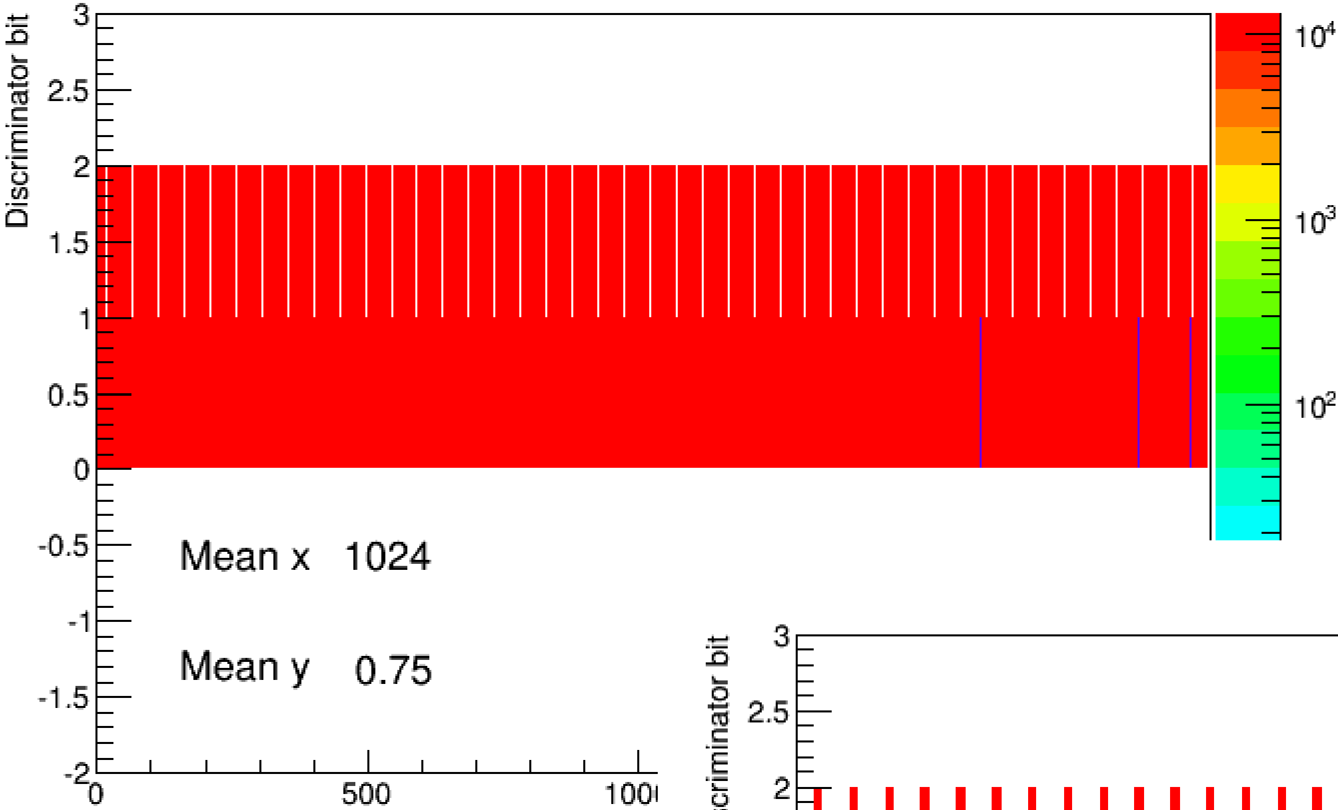
Set 1 Discriminator InjMap1



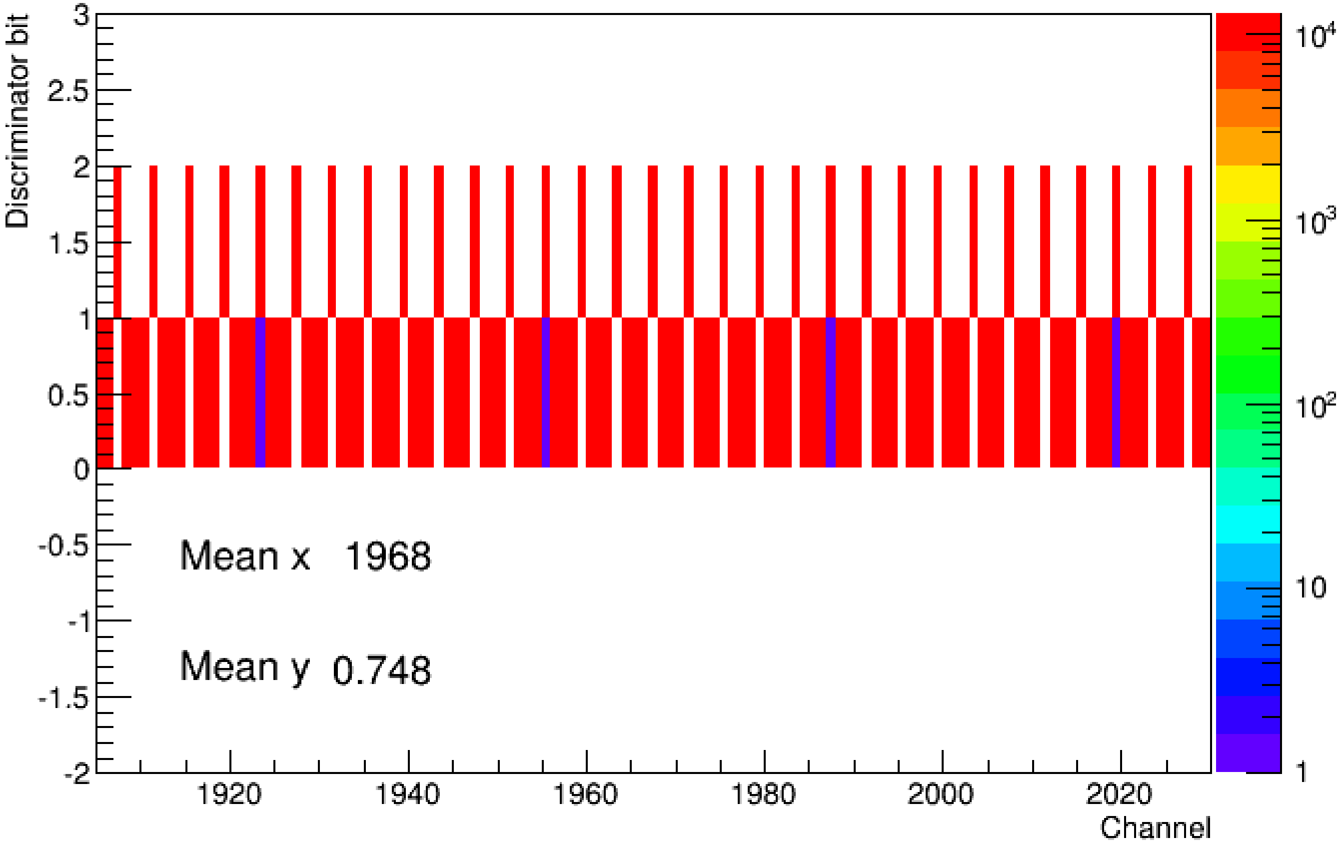


- Charge artificially injected into each channel tao test discriminator (also trigger timing etc.)
- Based on 32 channel chip
- Did not inject in all channels simultaneously given cross-talk, inject in groups of 4

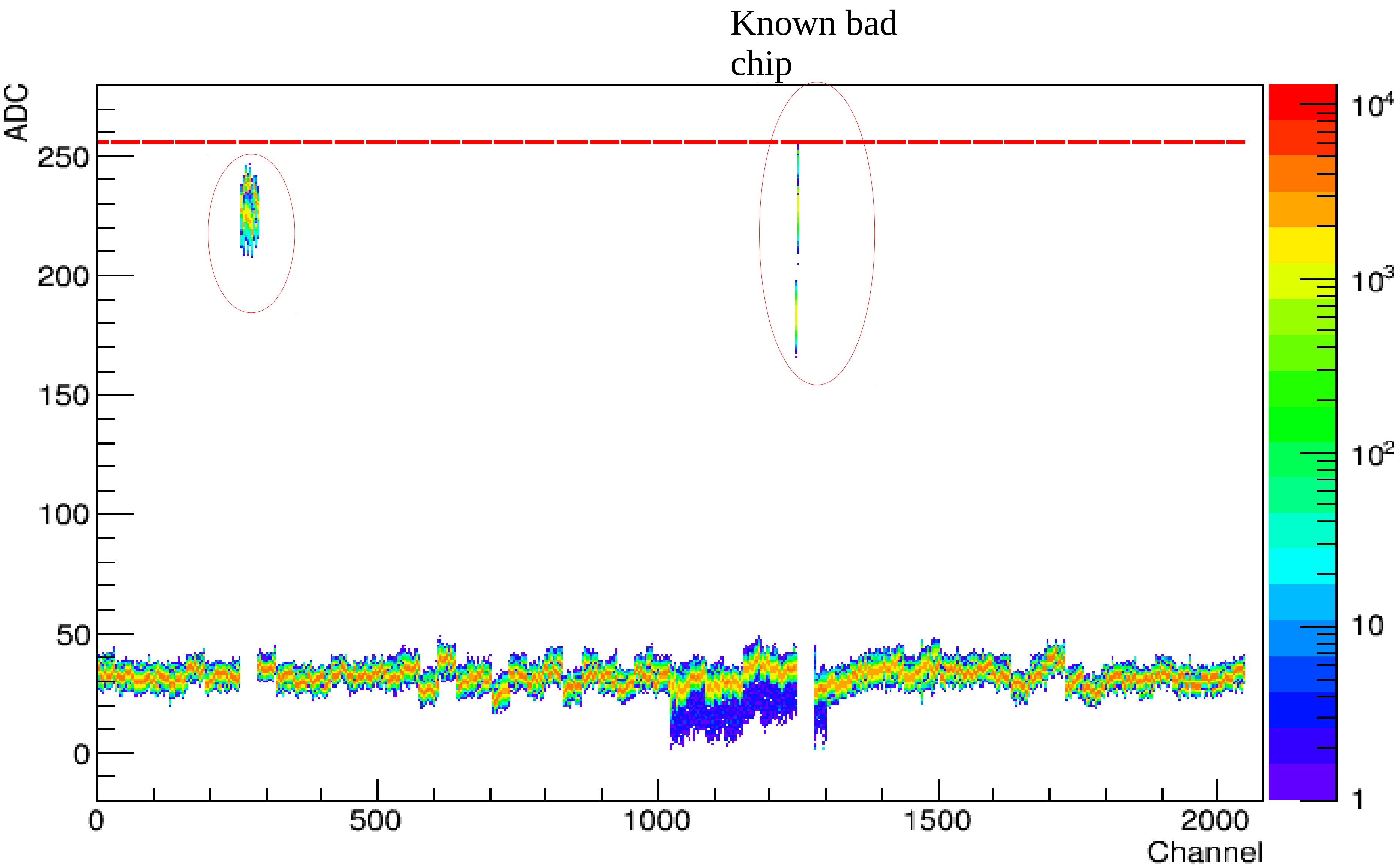
Set 1 Discriminator InjMap1



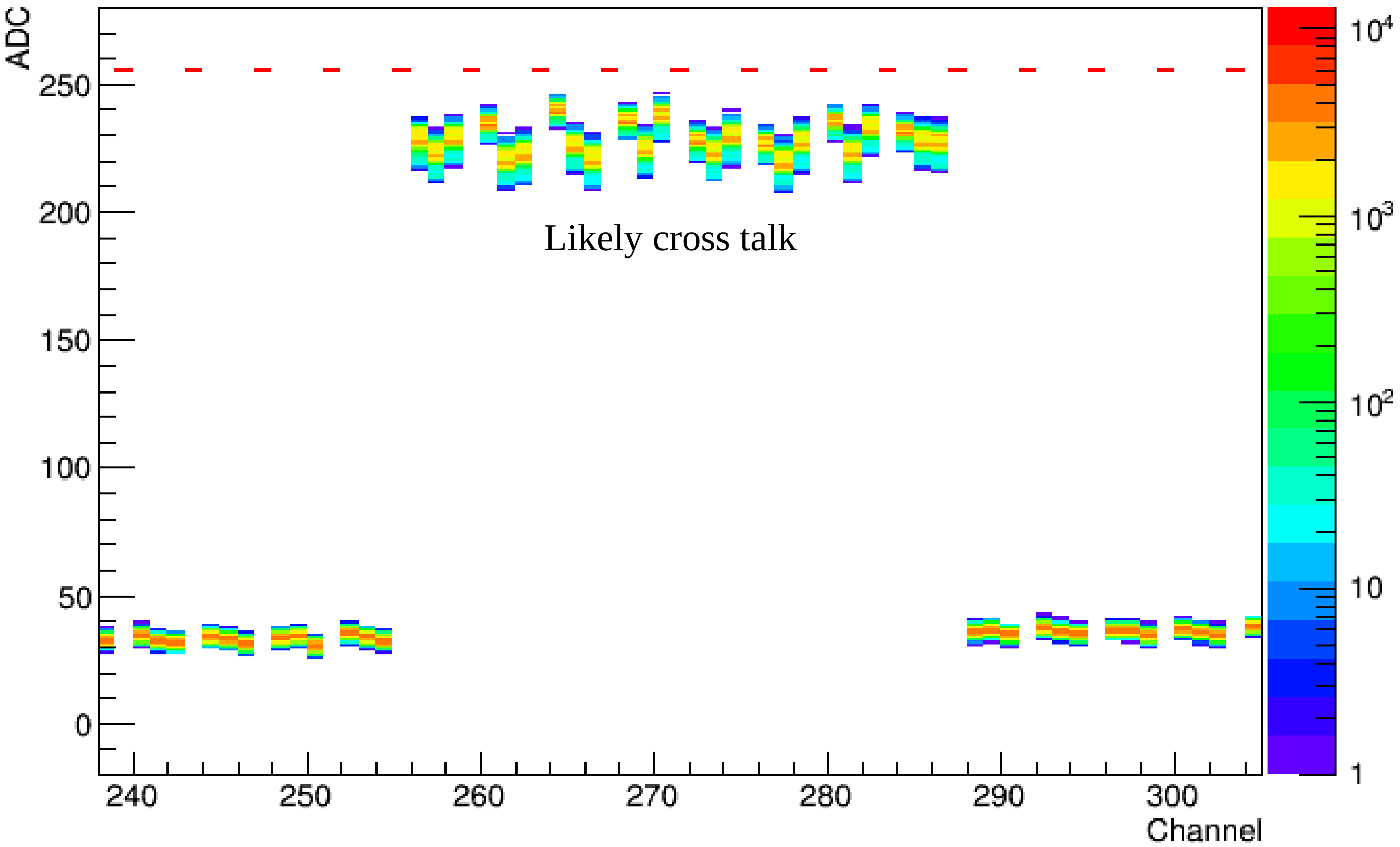
- Discriminators for first set of four
- Some occasional discriminator non-firing (injection good from ADC)

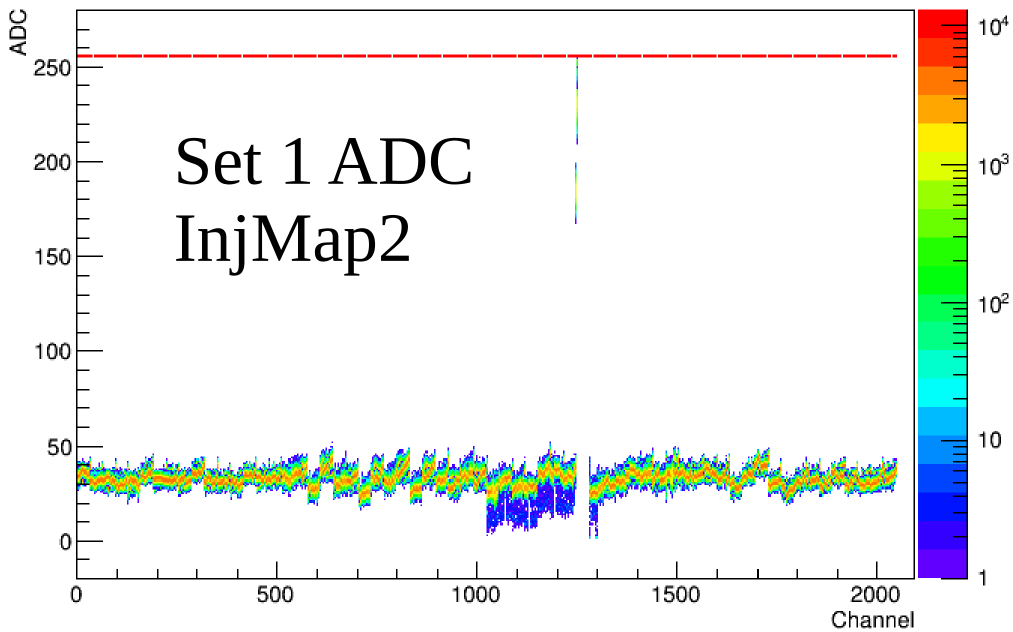


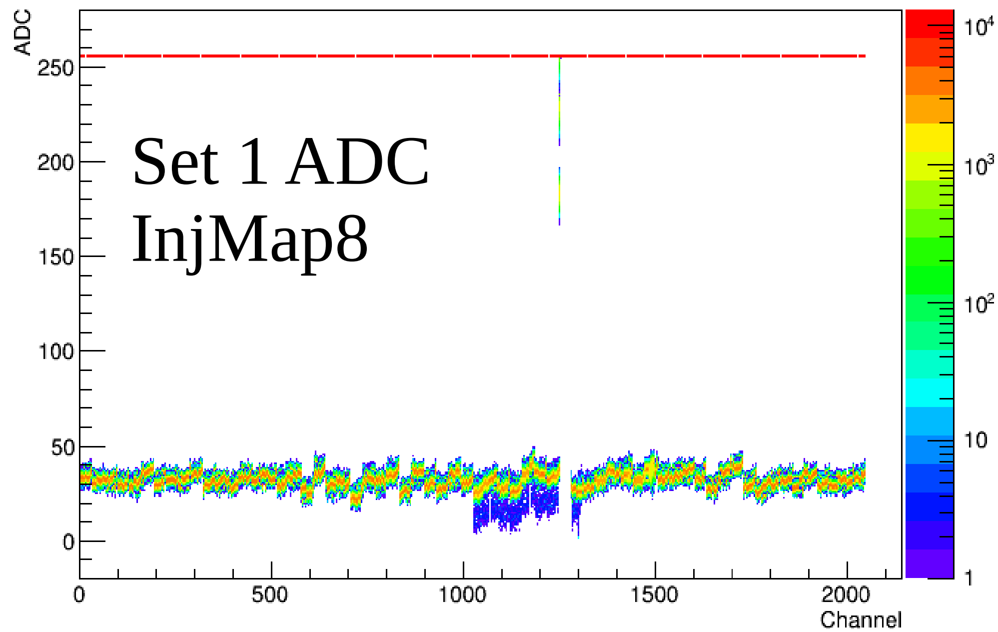
Set 1 ADC
InjMap1

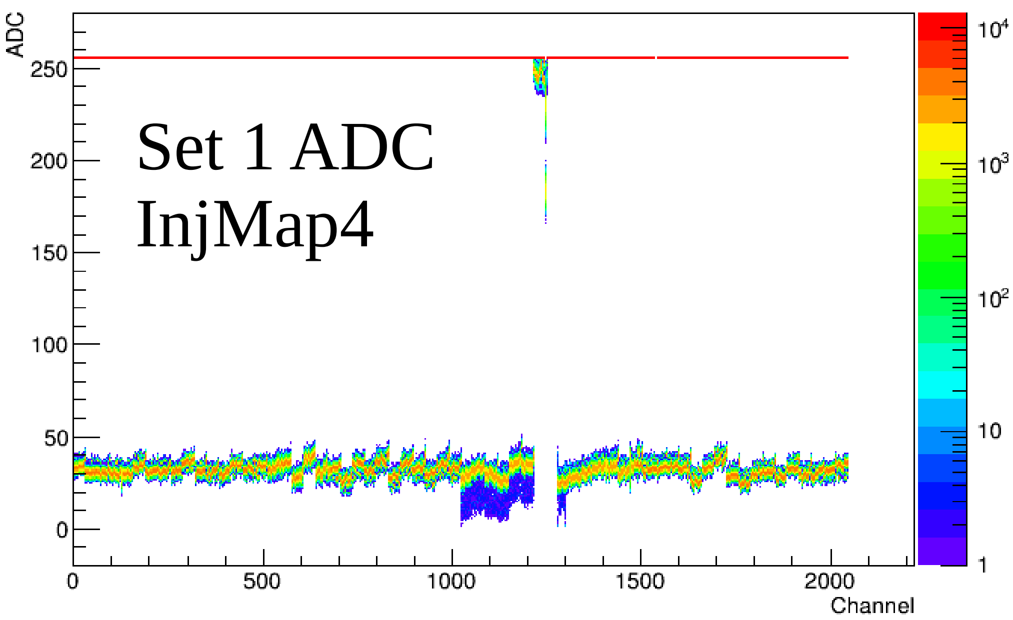


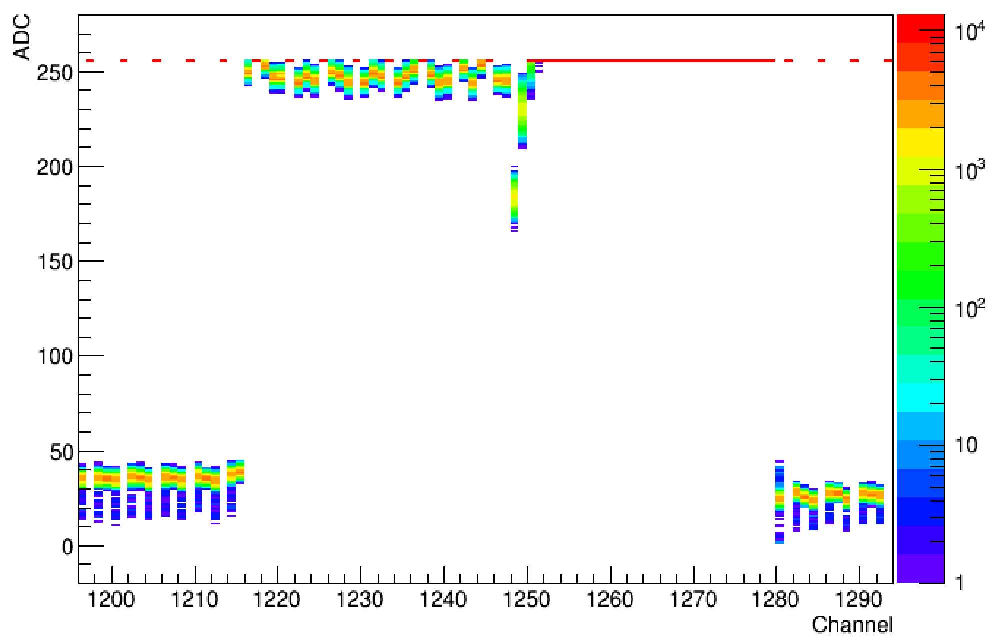
Set 1 ADC
InjMap1





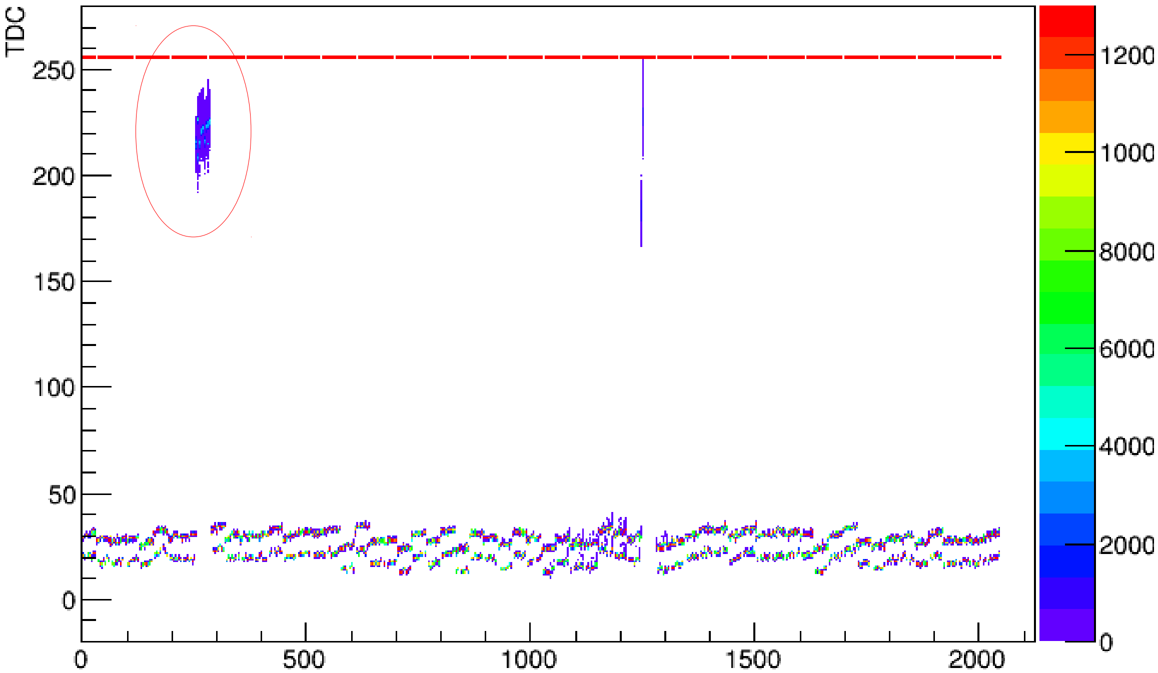


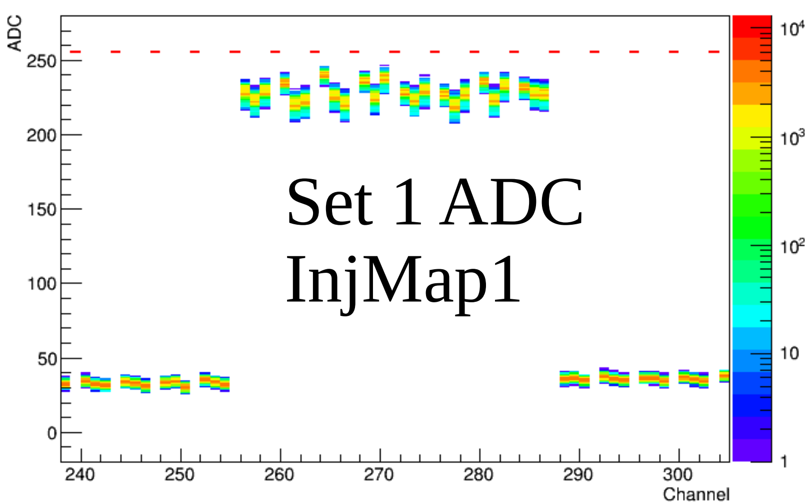




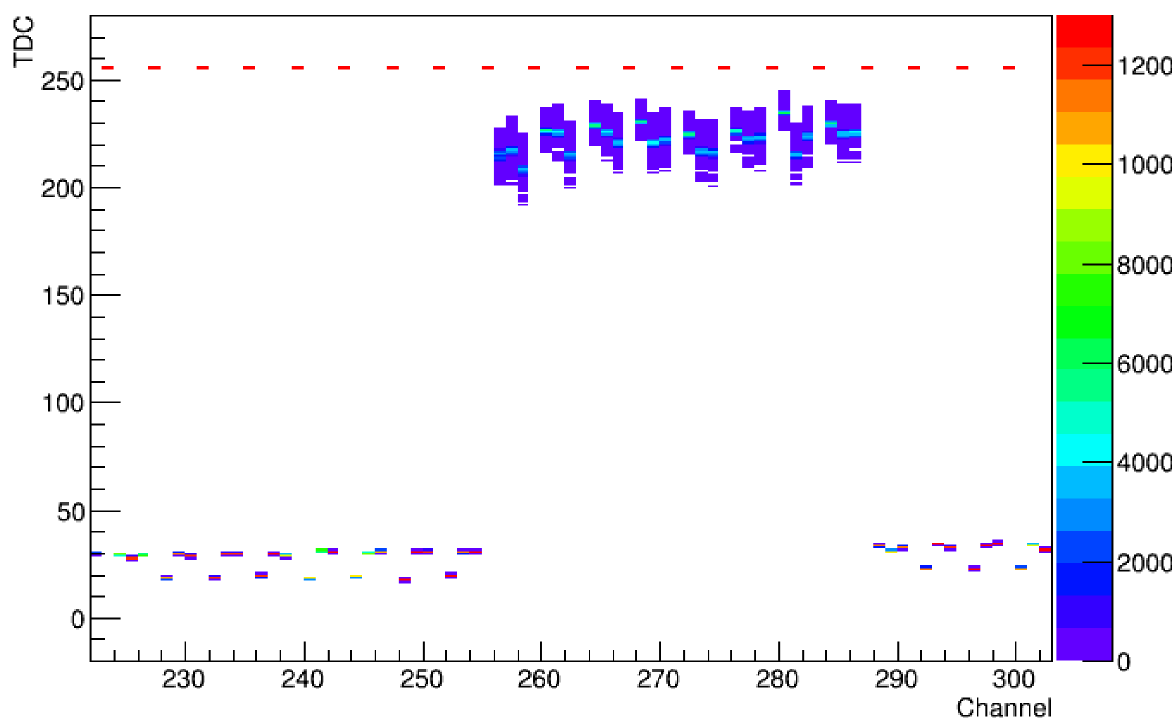
More probable cross talk for this set of channel injection

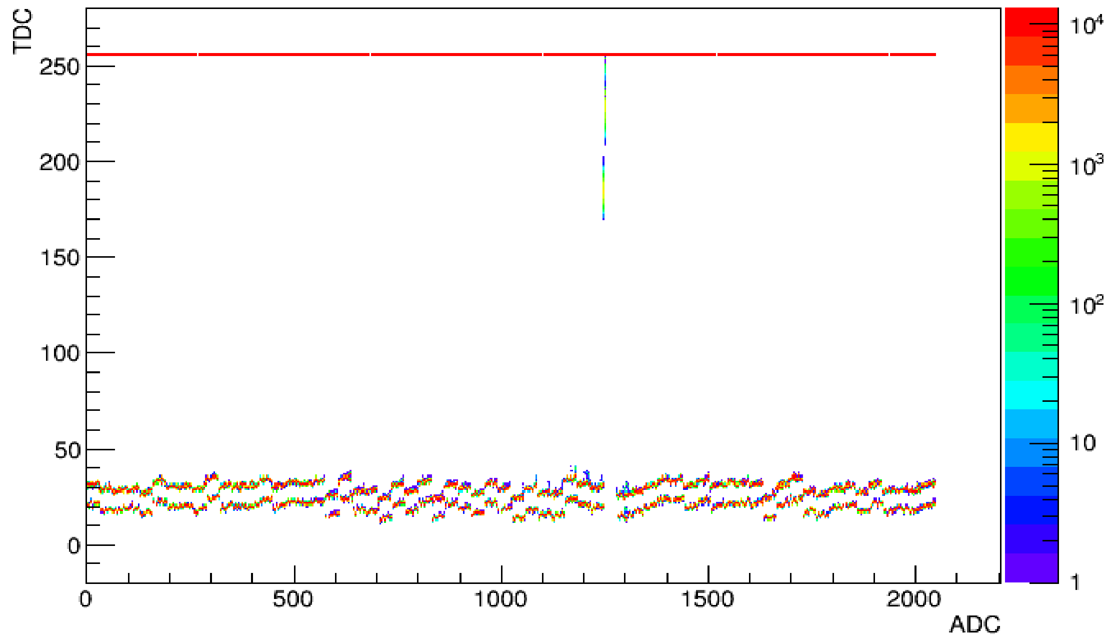
Set 1 TDC
InjMap1
Time circuit on





Set 1 ADC
InjMap1

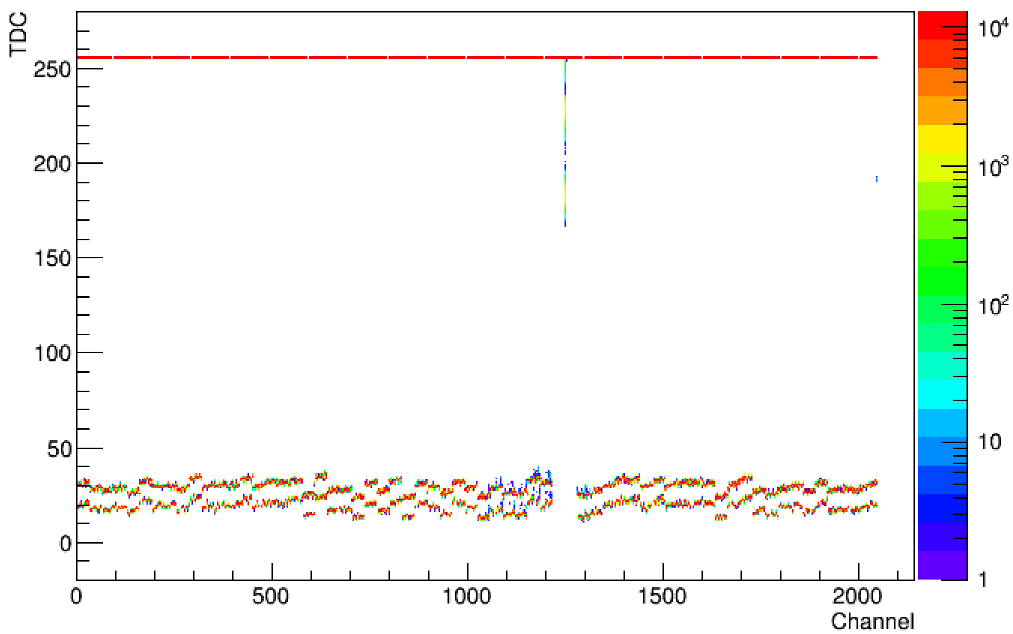




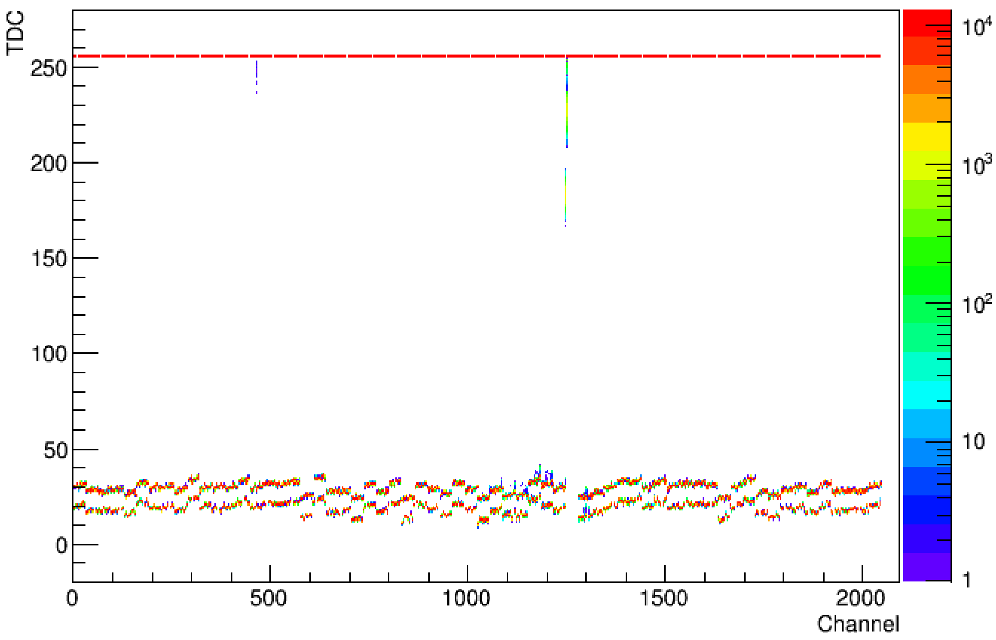
Set 1 TDC InjMap2 Time circuit on

Observed “inverse” cross talk in likely current drain in TDCs from current source – could be calibrated out

Set 1 TDC InjMap4 Time circuit on



Set 1 TDC InjMap8 Time circuit on



QA Summary

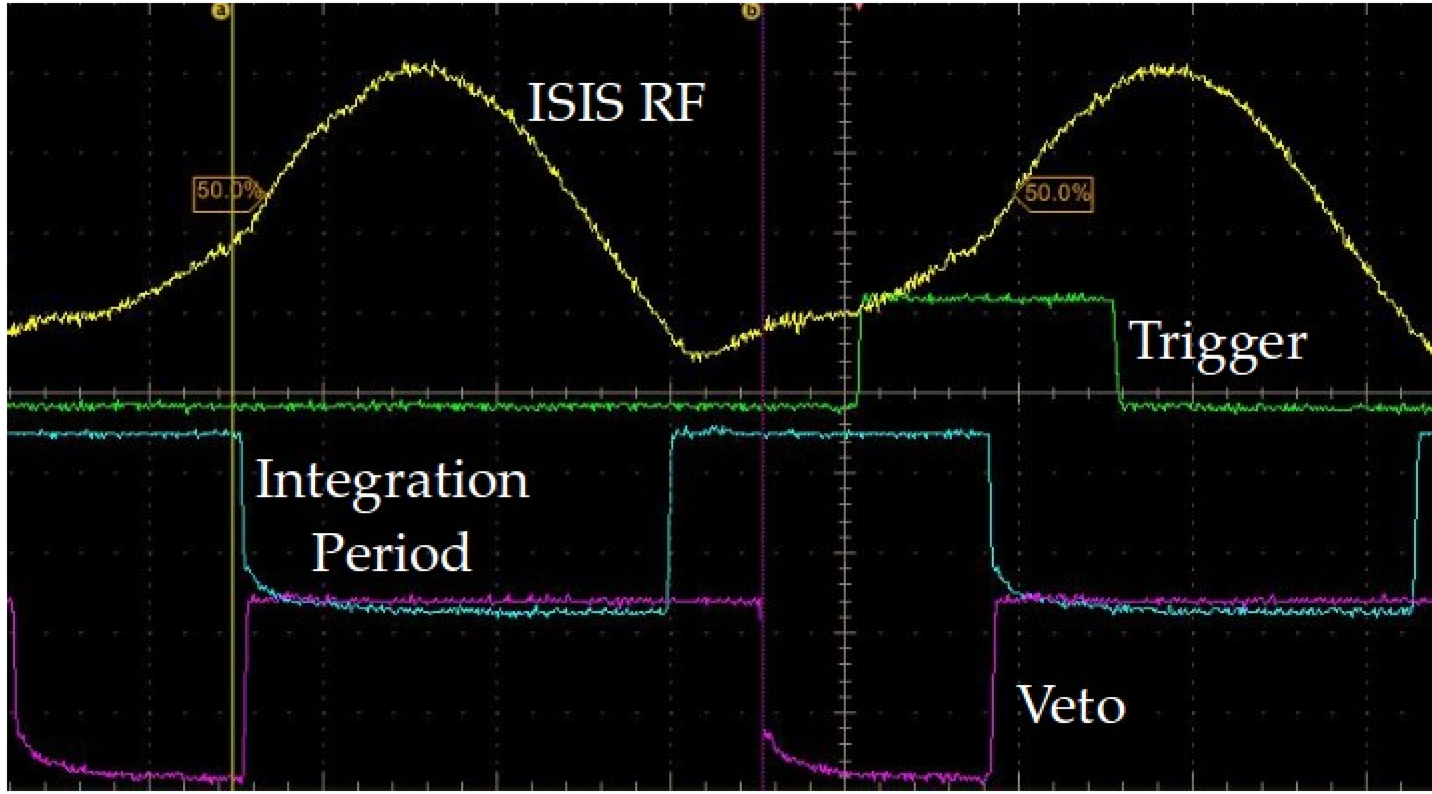
- 3 boards with complete dead/malfunctioning chips
- Up to 4 more boards with semi-functioning chips eg. Cross talk.
- Cross talk may not be so much of an issue using real signal injection, and should in any case be dealt with by reconstruction – low level noise issue
- One known dead LVDS cable out of 64 – spares available but limited
- All bias circuits were confirmed. Heater circuits unavailable without cold system
- VLSBs functional except for one known board with single dead bit on event number input – 50% spares
- VME controller failed on final run – probably the fiber

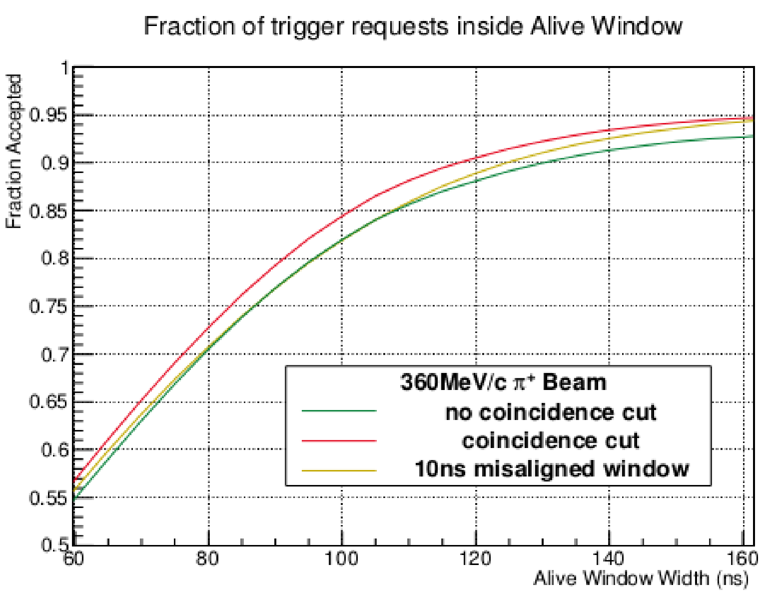
Next

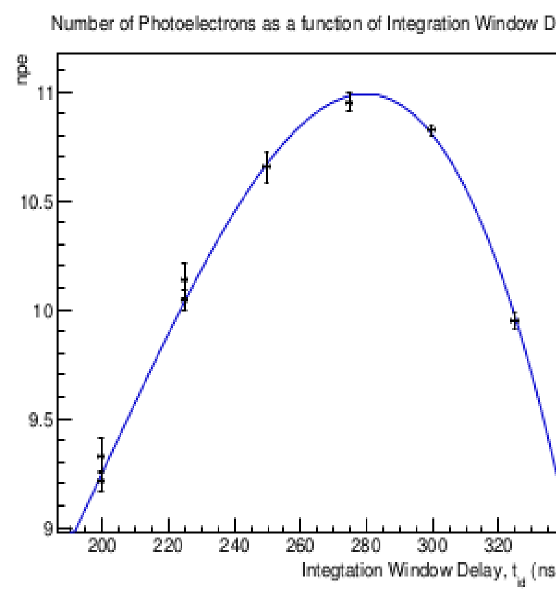
- Modify, upload firmware on new set of spares (4 + 16 taken from D0)
- Verify spare set
- Replace boards with dead chips
- Firmware updates and replacements can take place during installation in November
- Second round of QA depending on time

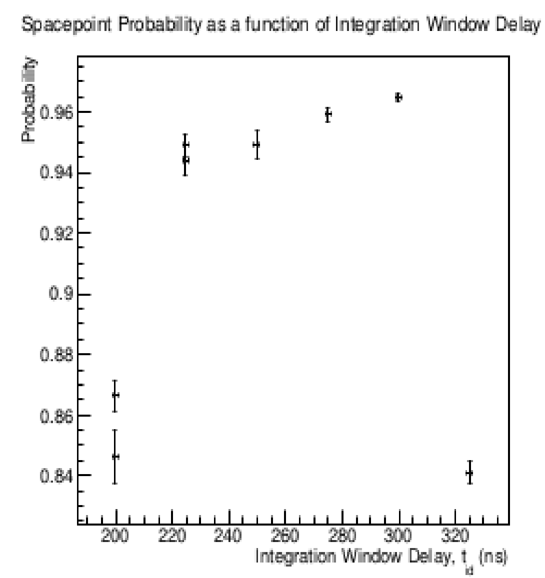
ISIS RF Timing

- Periodic dead-time due to pipelining
- Need to alive VLPC integration with particle arrival
- RF buckets asynchronous – input ISIS RF into AFEs
- Two periods to optimize – integration period (to retrieve all the light) and alive period – to ensure triggers correspond to captured light
- Proven in single station test, but not to required precision (10^4 triggers?)









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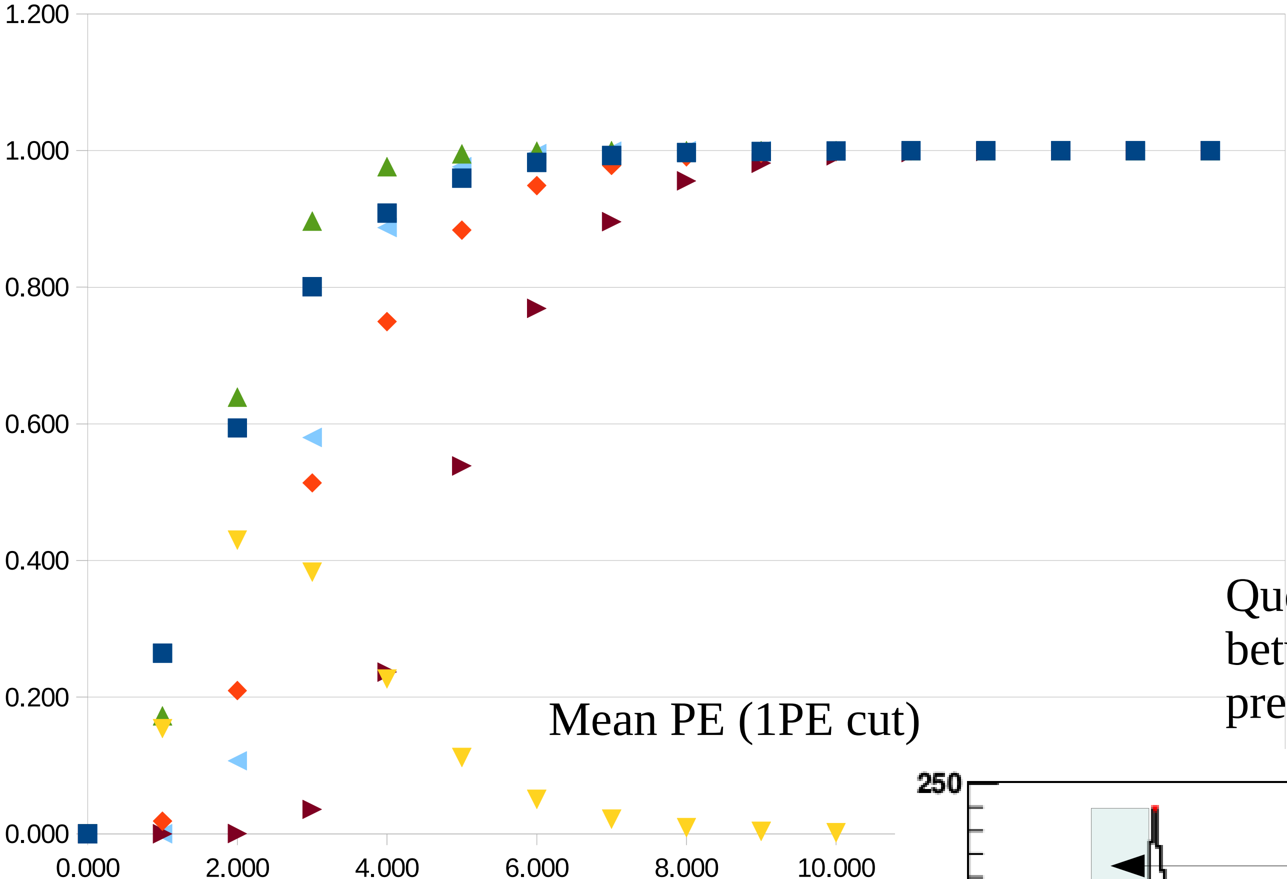
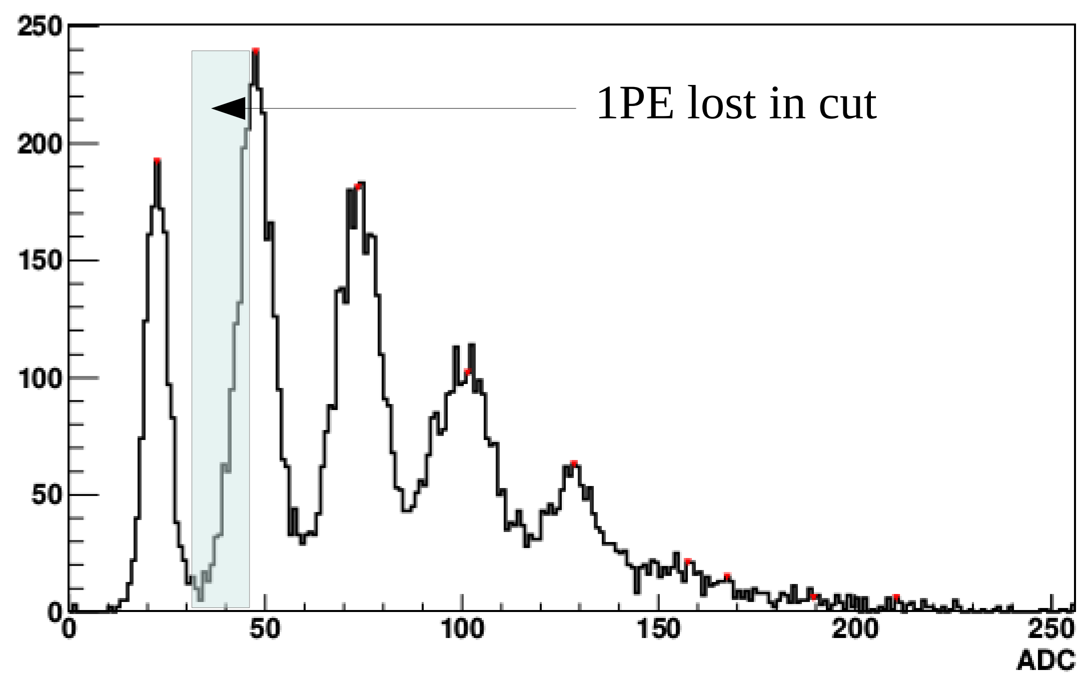
Efficiency

- Inefficiencies are monitored by reconstruction and analysis cuts, and compensated for by longer running
- Issue is correlation between efficiency and parameters of interest – P_T, P_Z
- Aside from needing to run longer, not a first order problem
- Mostly everything shown is from a toy MC/statistical calculation

- First consider uniform efficiency and statistical behavior of efficiency



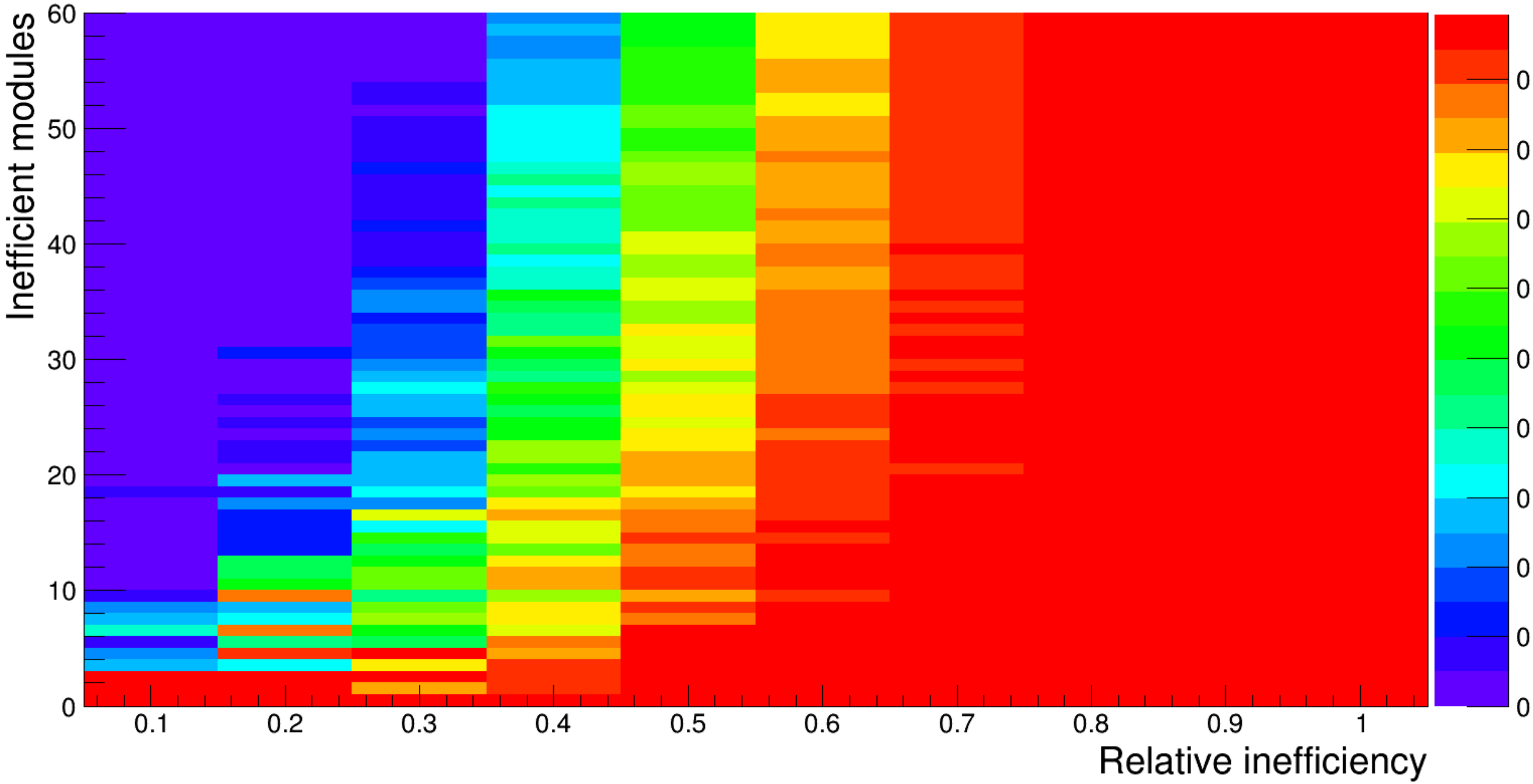
Questions persist around tension between cosmic, single station and predicted efficiencies



- Assumes binomial hit efficiency (OK)
- Poisson light yield (Not OK) - Saying “10PE mean light yield gives 99.9% plane efficiency” is not correct
- Re-treat as binomial problem with high k,n,p?
- Re-evaluate linear ADC-PE conversion to accommodate gain dispersion? Dispersion is an issue when cut is made at mean ADC of 1PE peak

- Next consider non-uniform efficiency and statistical behavior of efficiency

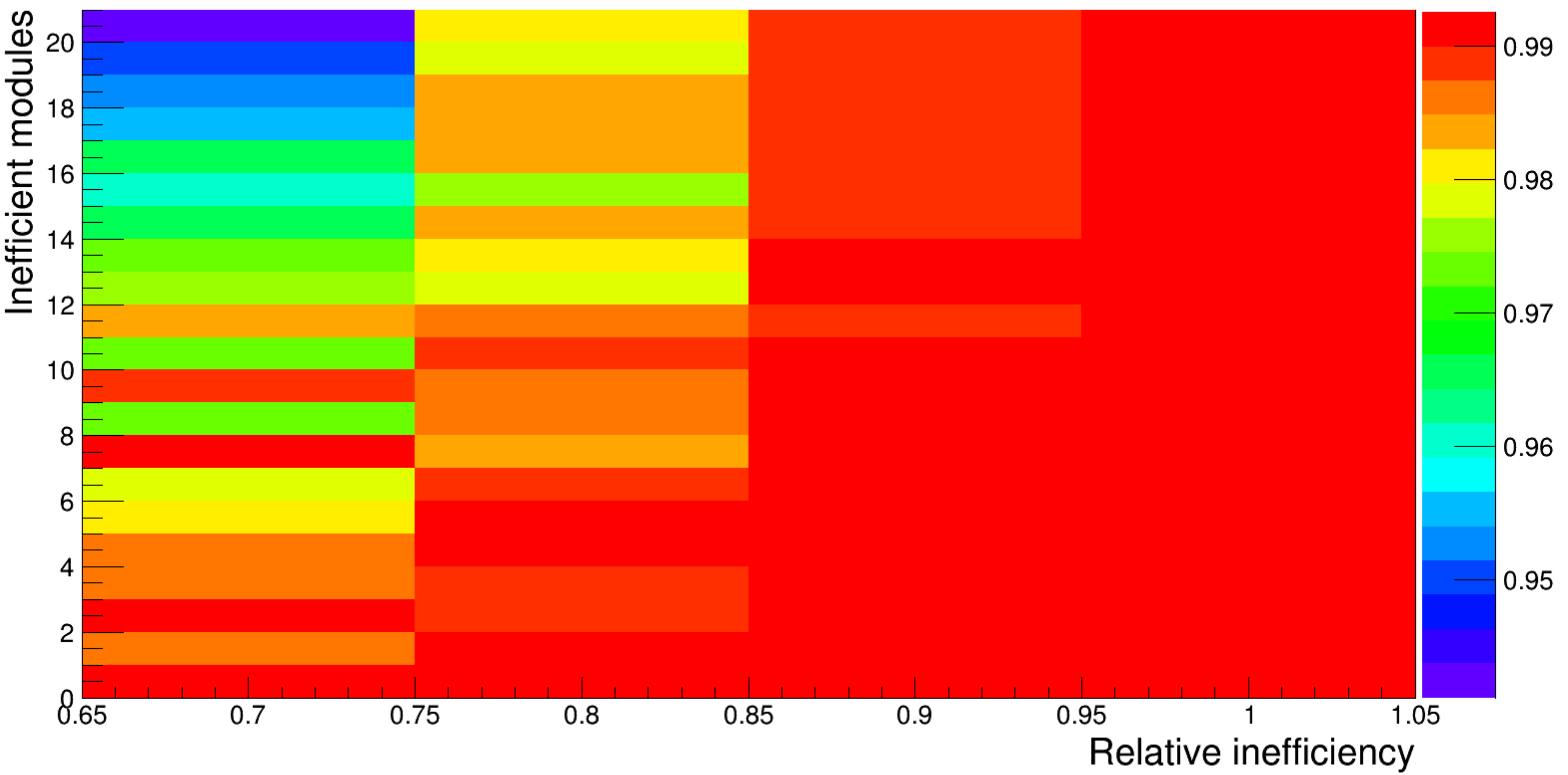
Efficiency of 5 triplet tracks with N modules at X efficiency



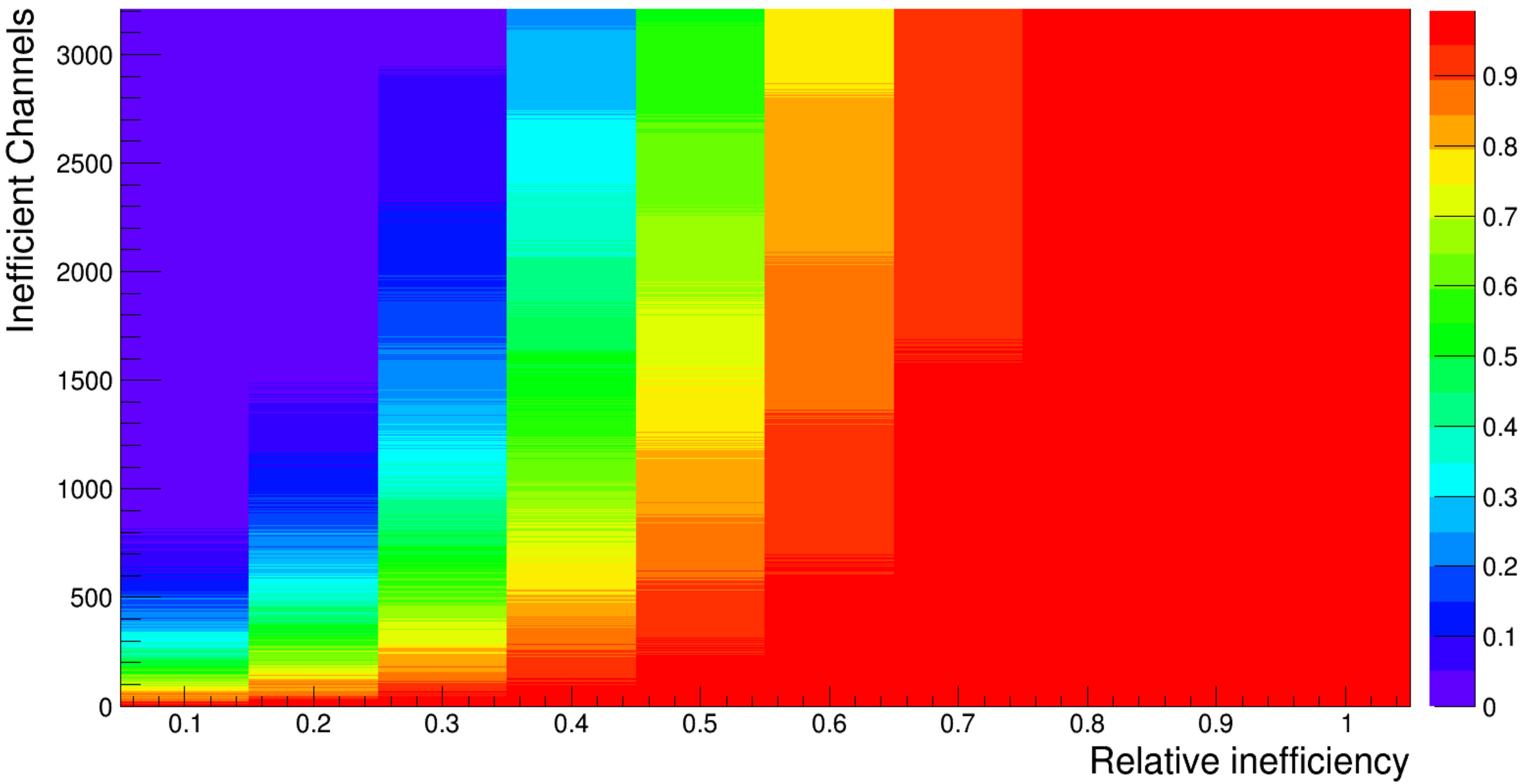
Can tolerate:

- Fewer than 10 modules at 90%
- Fewer than 5 modules at 80%
- Maybe 1 module below 70%

5 triplet track efficiency



Efficiency of 5 triplet tracks with N channels at X efficiency

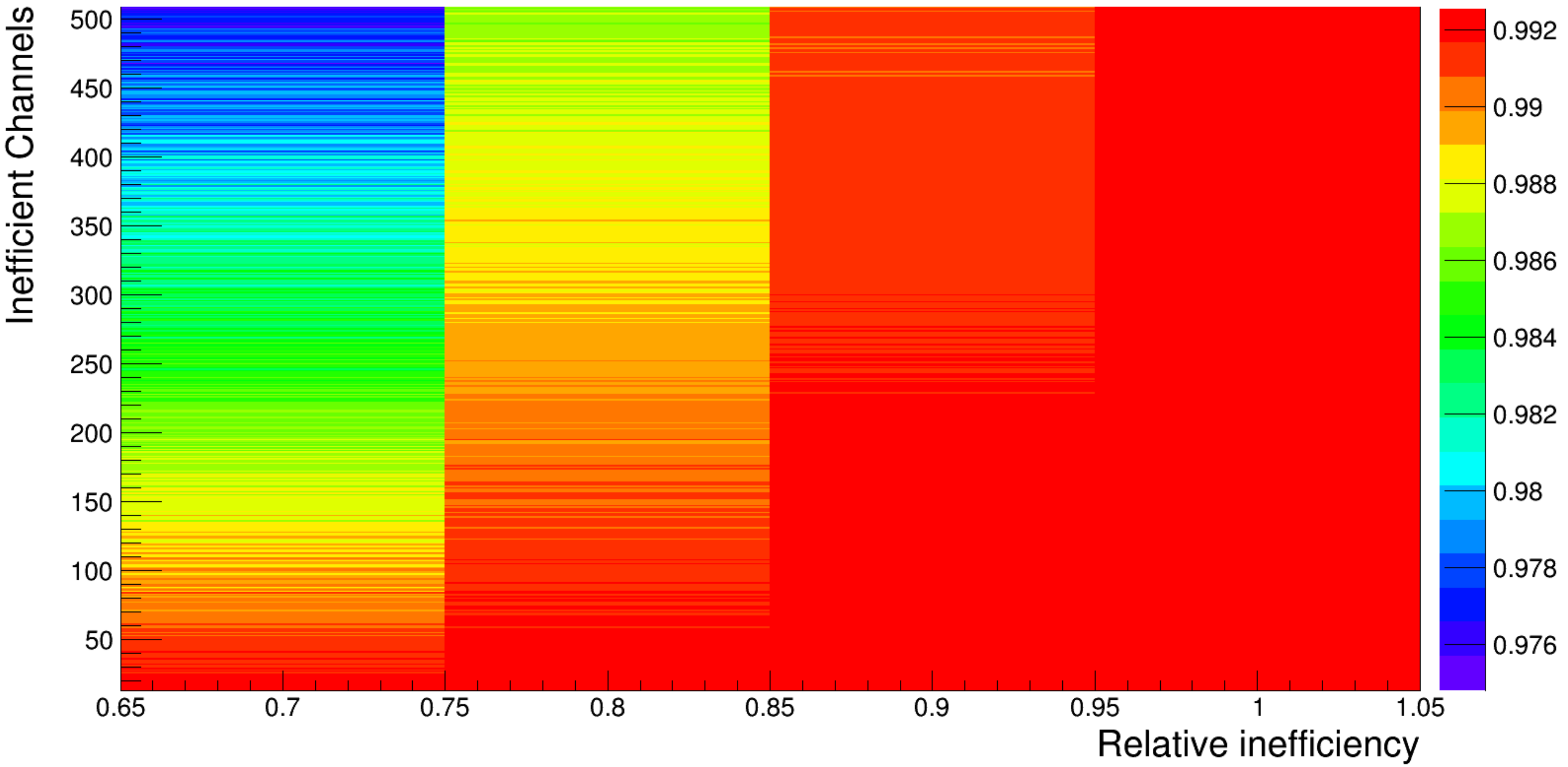


Can tolerate:

- Fewer than 800 channels at 90%
- Fewer than 200 channels at 80%
- Fewer than 100 channels at 70%

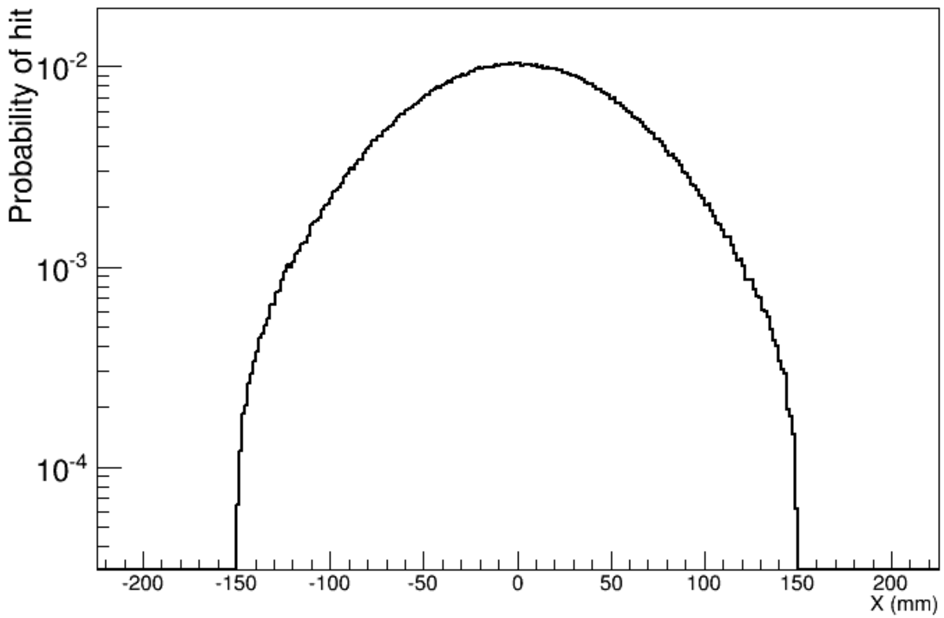
But, without correlations to desired observables, could just take more data

5 triplet track efficiency

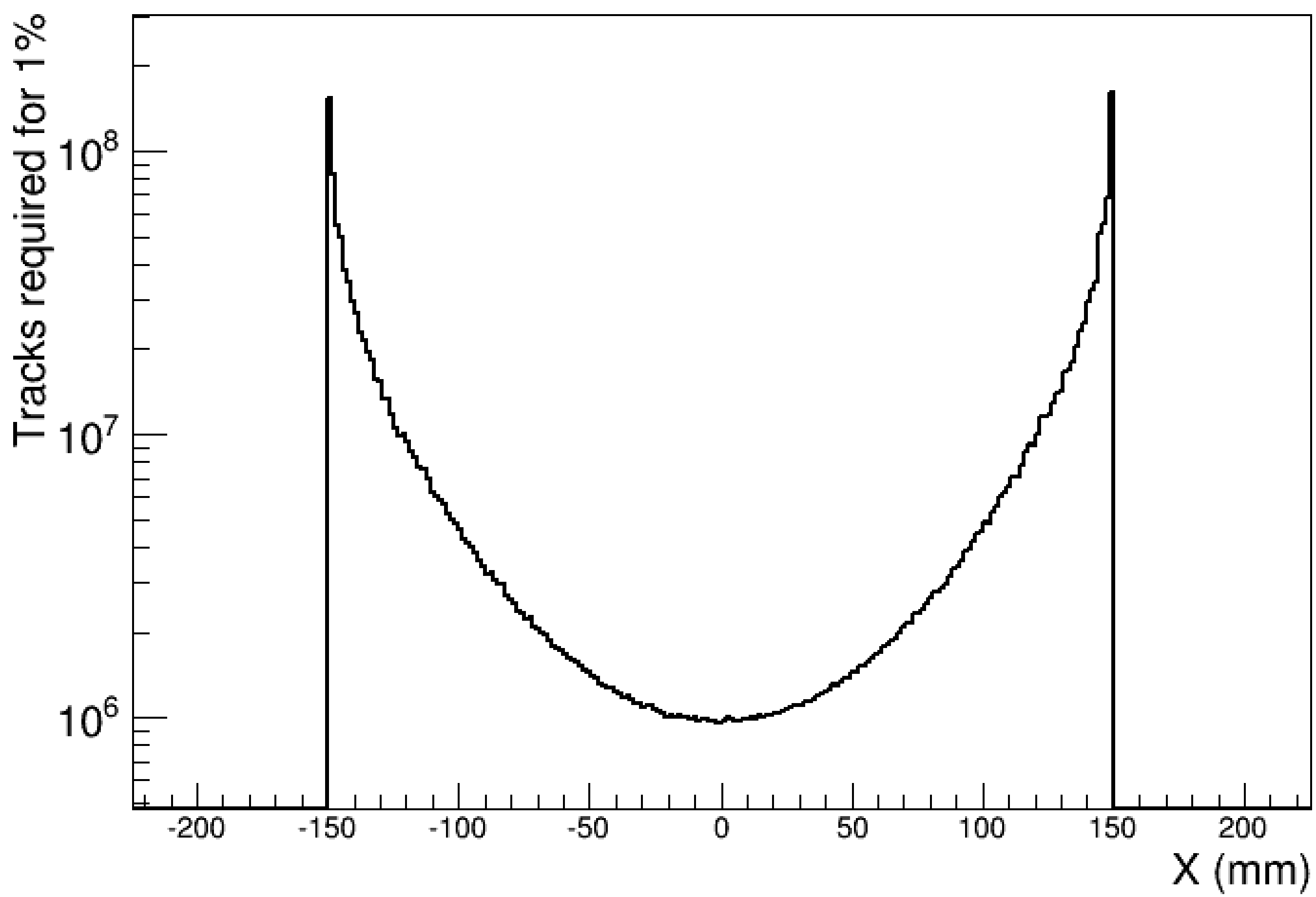


Feature	Risk	Measurable
Scintillating fibre		No
Mirror		No
Scintillating/internal waveguide connection		No
Internal waveguide		No
Internal/external waveguide connection		No
External waveguide		In progress
External/cassette connection		No
VLPC		Yes
VLPC bias		Yes - combined
VLPC temperature		Yes - combined

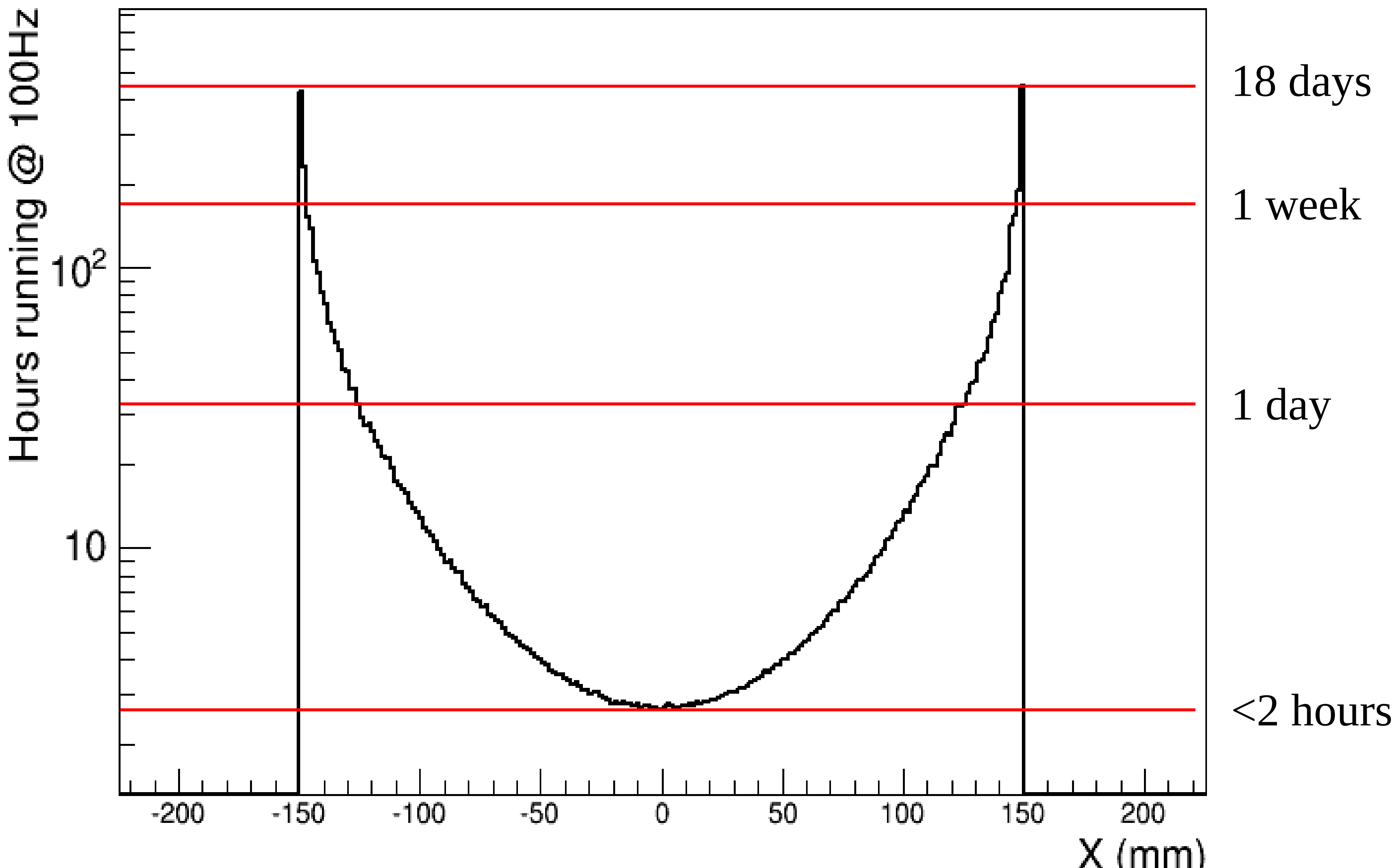
- Efficiency = fibre x mirror x internal connection x internal waveguide x external connection x external waveguide x cassette connection x VLPC
- Provided we have installed the best available equipment, the efficiency of each sub-system is irrelevant
- Need to know the combined efficiency - BEAM



- Based on a 10mm emittance, 333mm beta function, probability of hit in a given channel varies by 100
- Assume 10^4 hits / channel for precision on efficiency of each channel
- Total required triggers for desired precision in each channel:



Time requirements



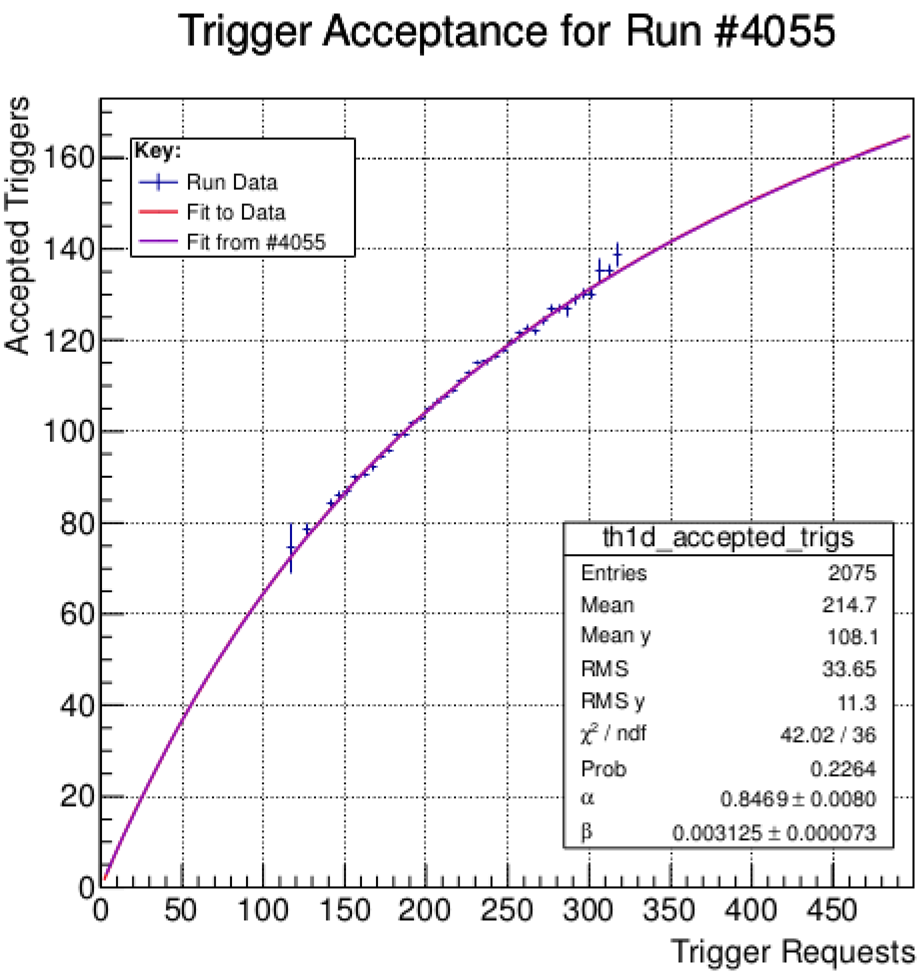
- Hit efficiency – binomial error with high p means very few events for 1%, but really need 0.1% or 0.05% - 1000 to 4000 hits
- Hit requirement based on PE cut, which is convolution of statistical distributions – not even Poisson, but also high λ
- Assumes a lot about beam shape and size at extremities

LED and beyond

- Illuminate all channels with LED and measure mean light yield (scaled to LED location)
- Normalize to MIP mean PE from beam in central channels with minimal statistics – MIP/LED ratio gives all information except on scintillator degradation
- Use efficiency map to re-simulate performance and emittance resolution
- First need to fully test and understand internal LED vs. known external LED

Other Step IV considerations

- 5.7 microsecond digitization time impacts on number of accepted triggers
- Essentially irreducible
- Timing information employed in commissioning likely available for global reconstruction
- Temperature and bias (efficiency) stable over time
- Time and discriminator settings may require regular checks/recalibration – a few hours each time
- Zero suppression will be enabled



What information is needed?

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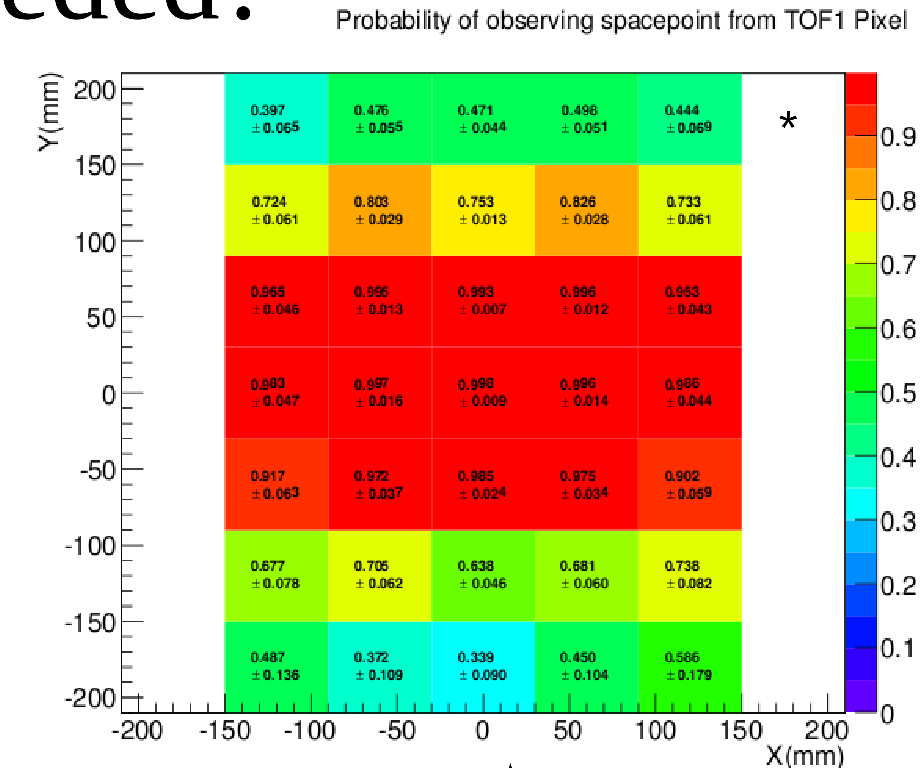


Figure 11: Space-point finding [obscured]ncy for each pixel in TOF1

- Full understanding of pedestal and gain values and distributions, including dispersion
- Points/trigger (veto period) LY/point or TDC (int. period)
- Large statistics measurement of hit efficiency and MIP light yield, necessitating LED + beam
- Expectation of solenoid acceptance in each mode / TOF1 acceptance

Step I

Table 3 The characterised Step I beams

	Beam ε_N	Beam p_z	$\langle p_z \rangle$ (MeV/c)	σ_{p_z} (MeV/c)	ε_x (π mm-rad)	α_x	β_x (m)	ε_y (π mm-rad)	α_y	β_y (m)
μ^-	3	140	171.58 ± 2.39	22.81 ± 0.32	2.28 ± 0.12	0.50 ± 0.01	1.49 ± 0.09	0.95 ± 0.05	-0.55 ± 0.28	3.62 ± 0.18
		200	223.24 ± 2.72	24.02 ± 0.29	1.74 ± 0.09	0.49 ± 0.01	1.69 ± 0.10	0.78 ± 0.04	-0.50 ± 0.25	3.71 ± 0.19
		240	260.55 ± 3.24	24.49 ± 0.30	1.49 ± 0.08	0.49 ± 0.01	1.80 ± 0.10	0.75 ± 0.04	-0.41 ± 0.21	3.65 ± 0.18
	6	140	176.43 ± 2.27	22.83 ± 0.29	2.17 ± 0.12	0.52 ± 0.01	1.57 ± 0.09	0.96 ± 0.05	-0.54 ± 0.28	3.64 ± 0.18
		200	232.22 ± 2.51	23.62 ± 0.26	1.53 ± 0.08	0.55 ± 0.01	1.85 ± 0.10	0.78 ± 0.04	-0.51 ± 0.26	3.80 ± 0.19
		240	270.96 ± 3.65	24.53 ± 0.33	1.51 ± 0.08	0.48 ± 0.01	1.80 ± 0.10	0.73 ± 0.04	-0.39 ± 0.20	3.51 ± 0.18
	10	140	183.46 ± 2.35	22.75 ± 0.29	2.01 ± 0.11	0.53 ± 0.01	1.62 ± 0.09	0.92 ± 0.05	-0.56 ± 0.29	3.68 ± 0.18
		200	247.23 ± 3.56	24.20 ± 0.35	1.23 ± 0.07	0.59 ± 0.01	2.22 ± 0.13	0.75 ± 0.04	-0.52 ± 0.27	3.81 ± 0.19
		240	281.89 ± 3.65	25.28 ± 0.33	1.65 ± 0.09	0.56 ± 0.01	1.82 ± 0.10	0.64 ± 0.03	-0.39 ± 0.20	3.40 ± 0.17
μ^+	3	200	222.69 ± 2.40	26.49 ± 0.29	1.98 ± 0.11	0.49 ± 0.01	1.58 ± 0.09	0.83 ± 0.04	-0.40 ± 0.20	3.44 ± 0.17
		240	257.97 ± 2.83	26.37 ± 0.29	1.59 ± 0.08	0.57 ± 0.01	1.87 ± 0.11	0.76 ± 0.04	-0.31 ± 0.16	3.40 ± 0.17
	6	140	176.45 ± 1.98	24.36 ± 0.27	2.32 ± 0.12	0.45 ± 0.01	1.50 ± 0.09	0.95 ± 0.05	-0.48 ± 0.25	3.59 ± 0.18
		200	229.16 ± 2.36	25.87 ± 0.27	1.91 ± 0.10	0.50 ± 0.01	1.61 ± 0.09	0.81 ± 0.04	-0.38 ± 0.19	3.42 ± 0.17
		240	267.65 ± 2.85	25.79 ± 0.28	1.69 ± 0.09	0.54 ± 0.01	1.76 ± 0.10	0.76 ± 0.04	-0.26 ± 0.14	3.23 ± 0.16
	10	140	182.42 ± 2.05	23.87 ± 0.27	2.16 ± 0.12	0.47 ± 0.01	1.56 ± 0.09	0.92 ± 0.05	-0.48 ± 0.24	3.59 ± 0.18
		200	243.39 ± 2.65	26.77 ± 0.29	1.66 ± 0.09	0.51 ± 0.01	1.78 ± 0.10	0.78 ± 0.04	-0.38 ± 0.19	3.37 ± 0.17
		240	274.77 ± 2.94	24.79 ± 0.27	1.78 ± 0.09	0.51 ± 0.01	1.65 ± 0.09	0.76 ± 0.04	-0.22 ± 0.11	3.07 ± 0.15

*Defocusing?

What tools are needed?

- ADC plotting of beam and LED with full peak finding and dispersion measurements – not in MAUS (separate calibration code using stream-lined DAQ) options:

  1) Add to MAUS (plotting only) 2) Add DATE unpacking to calibration 3) Use calibration DAQ with MLCR trigger

- Online/offline reconstruction to compare tracks in tracker to triggers, correlate to expected acceptance of TOF trigger, which should be calculated
- EO thesis plots into online rec

1) Raw ADC/TDC for all electronics channels on each tracker - gives information about chip status and zero suppression – pure monitoring (no cabling or calibration)

2) Calibrated to PE for all electronics channels - gives information on VLPC performance (requires calibration)

3) PE for each fiber-channel - gives information on fiber performance

4) Hits / plane, space points / station - gives information about cabling, reconstruction efficiency

5) Same as a fraction of trigger requests and accepted triggers - gives information on timing of RF window; hits as a function of time within veto period/ points within spill gate as well. Part of this is the differing acceptance between TOF1 and the solenoid on a momentum/field basis. Calculate and then divide space-point-non-rec by it? Easier for a shifter to see a deviation from 1 than 0.03 or whatever.

6) Event displays: x-y by station & the circle swirly-line plots Adam uses. Need to randomly select events or something.

November

- Installation of all compressor/cryostats. Cool-down of cryostats – full test of vacuum and cryo systems. Can only run upstream – 1 Weiner PSU being repaired, awaiting spare
- Upload firmware onto spares taken from D0
- Integrate/debug with controls and DAQ infrastructure as changed since the last test two years ago (new machines, DATE version, FPGA trigger)
- Calibrate
- Use cassette top LED with TOF trigger LED to time in, using ISIS RF
- Connect waveguides (possibly in PRY positions) and repeat with internal LEDs

Tracker commissioning runs

• Readout commissioning – no beam, random and LED triggering to iron out VME based trigger logic – 2 days

• Calibration – no beam runs with LED varying bias, discriminator and TDCs (latter not Step 4 essential) – 4 days (bias) + 4 days (discriminators) + 4 days (timing) = 12 days

• Timing commissioning – starting with LED and moving to beam to ensure integration and veto period align with arrival of particles – 5 days

• Fiber efficiency – 1 hour LED, 2 hours beam

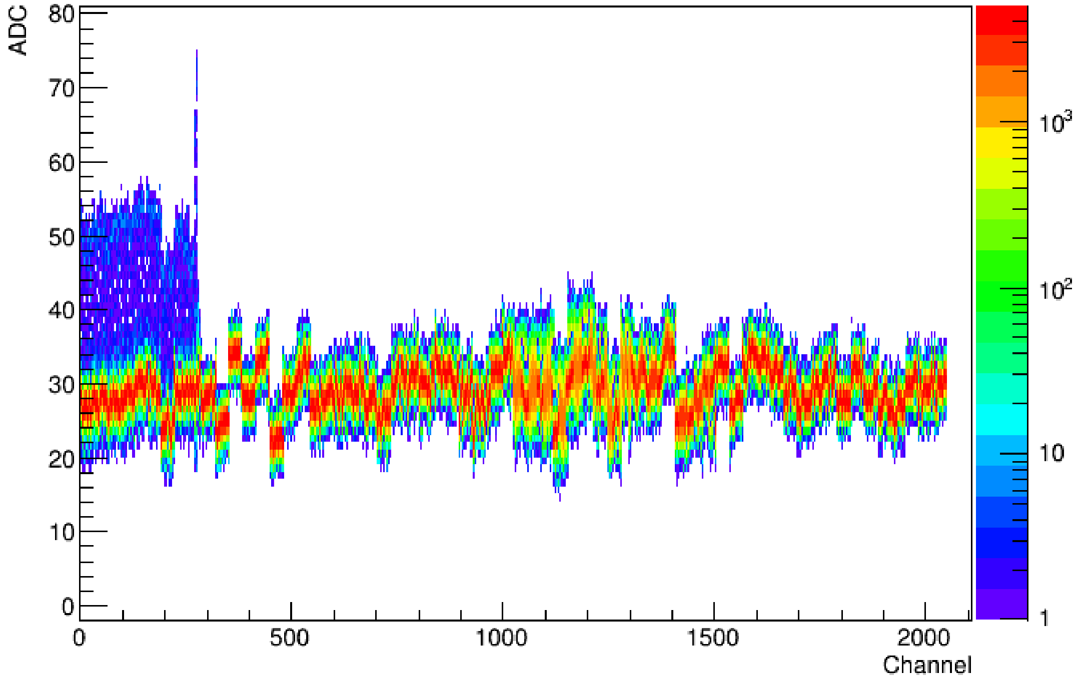
• Alignment checks – no field straight tracks (~25% transmission) to reconstruct actual alignment of tracker in reference frame – 1-5 days depending on previous commissioning

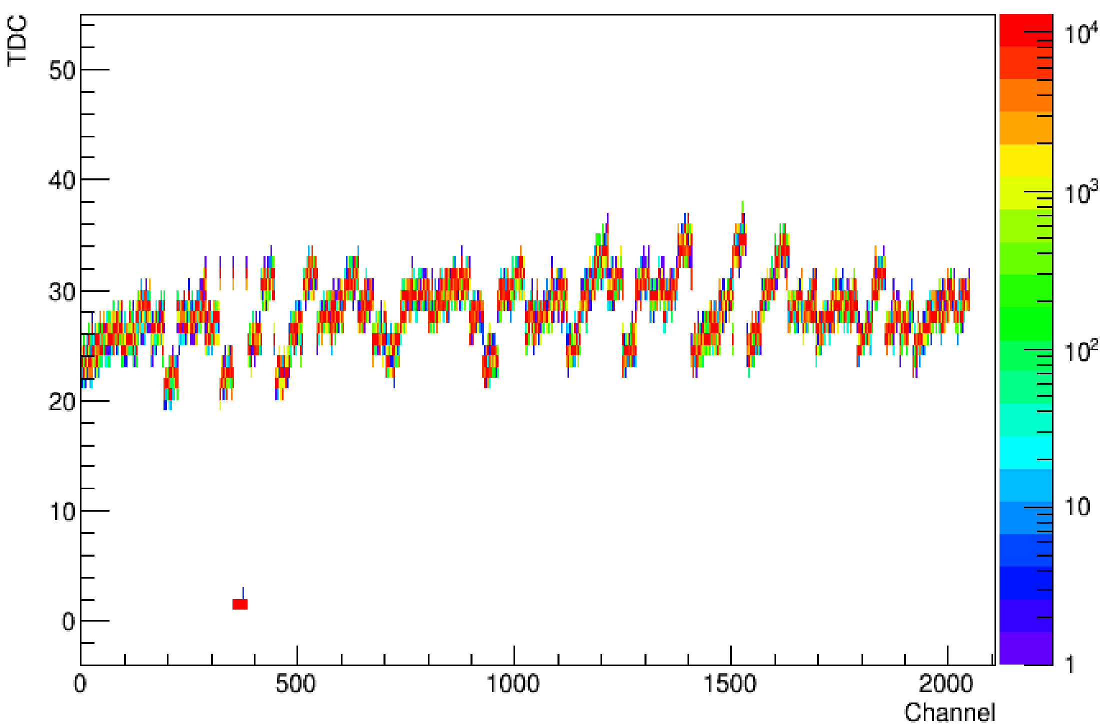
Tracker commissioning runs

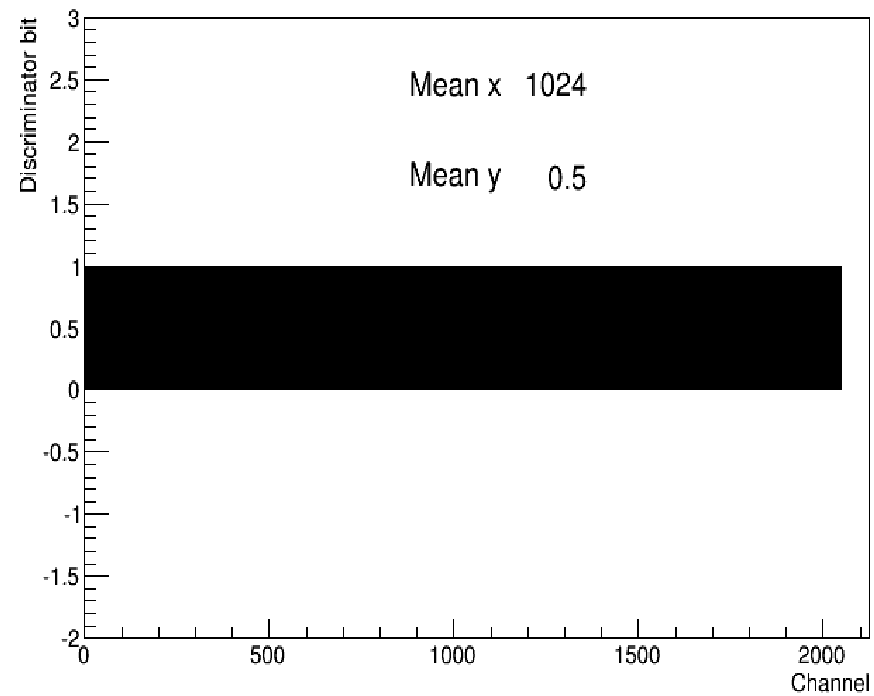
- Three weeks, without beam
- Two weeks, with beam
- Total commissioning time alone is not enough – need time between commissioning and real running to analyze data, make adjustments, etc.
- Run 1: 15/4/15 – 24/4/15?
- Run 2: 2/6/15 – 23/6/15?
- Tracker should get unrestrained (by other detectors) time at the beginning of the commissioning period

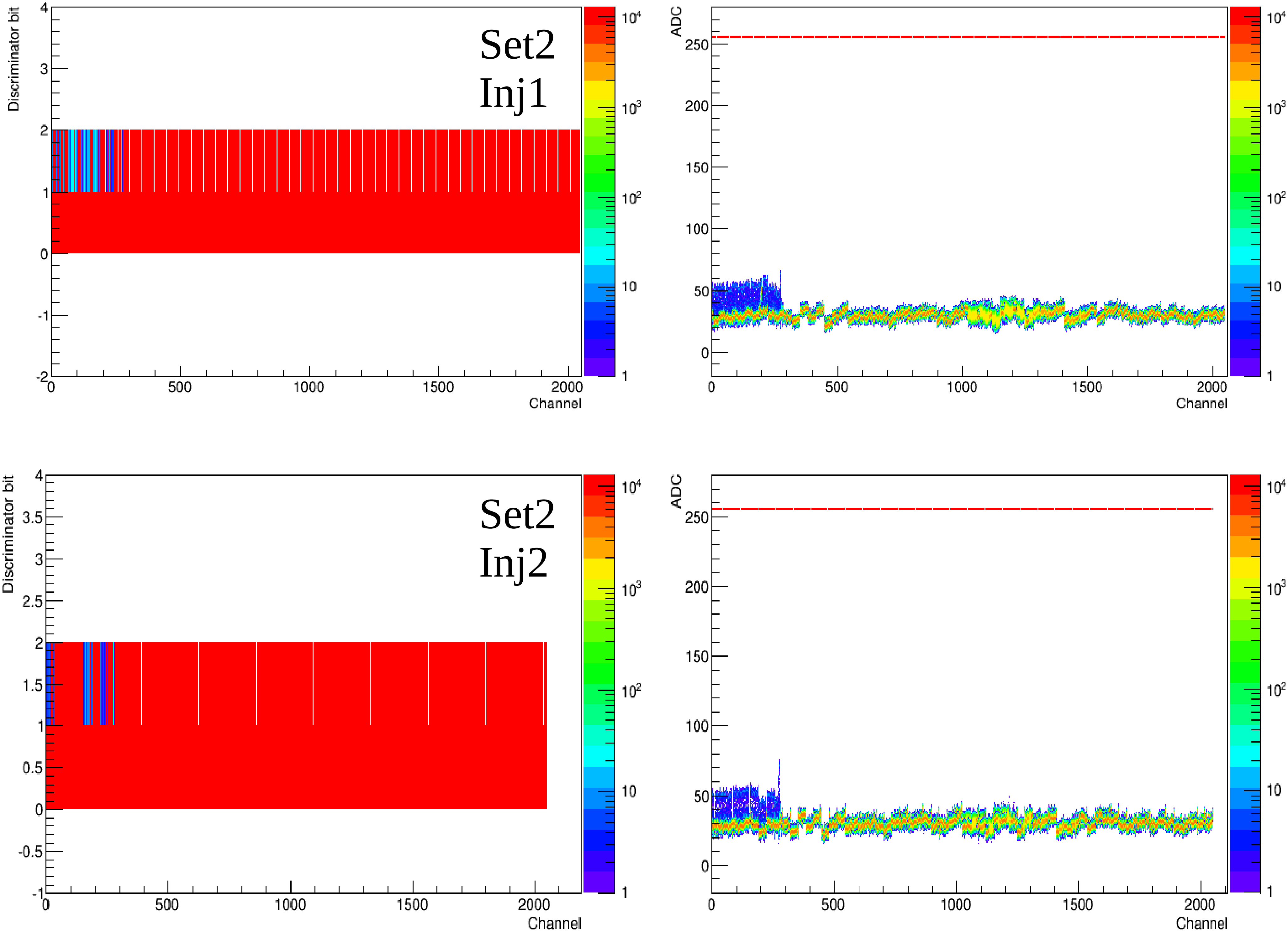
Backups

Set 2 Reference

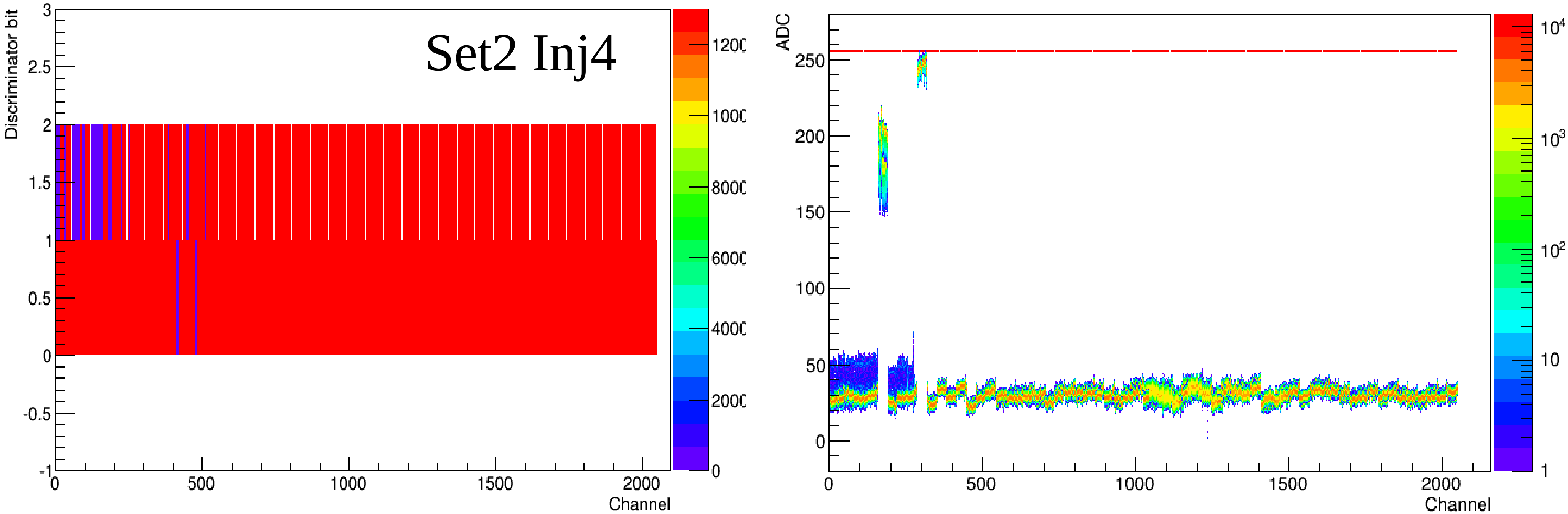


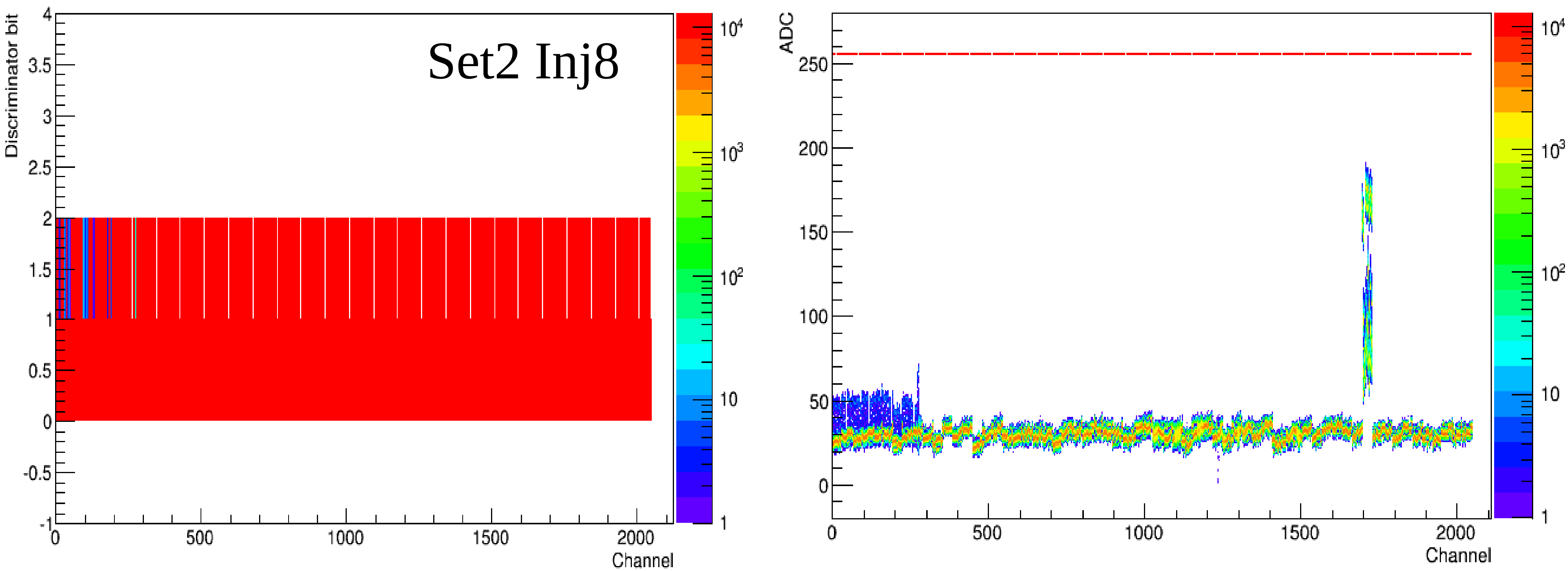


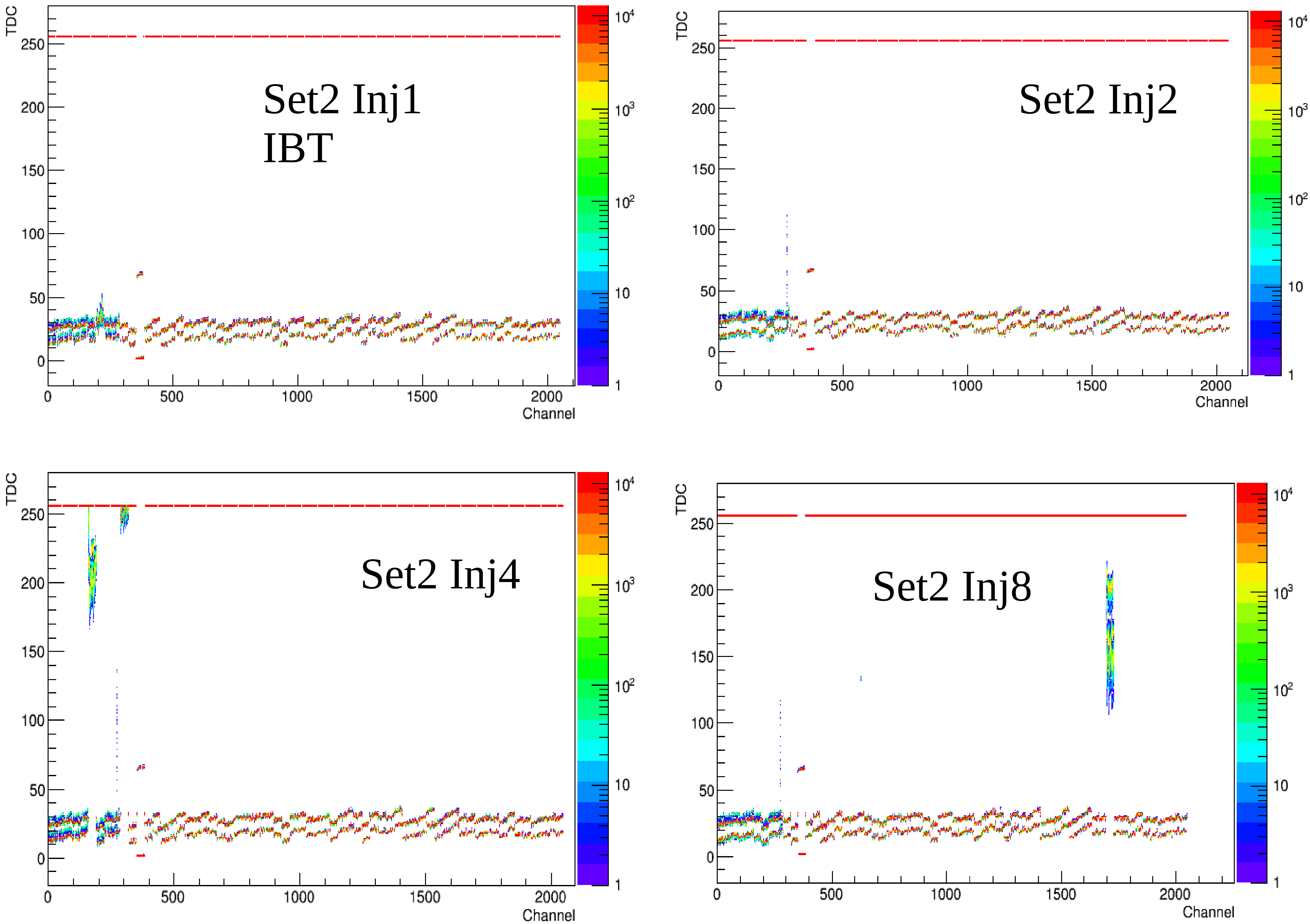




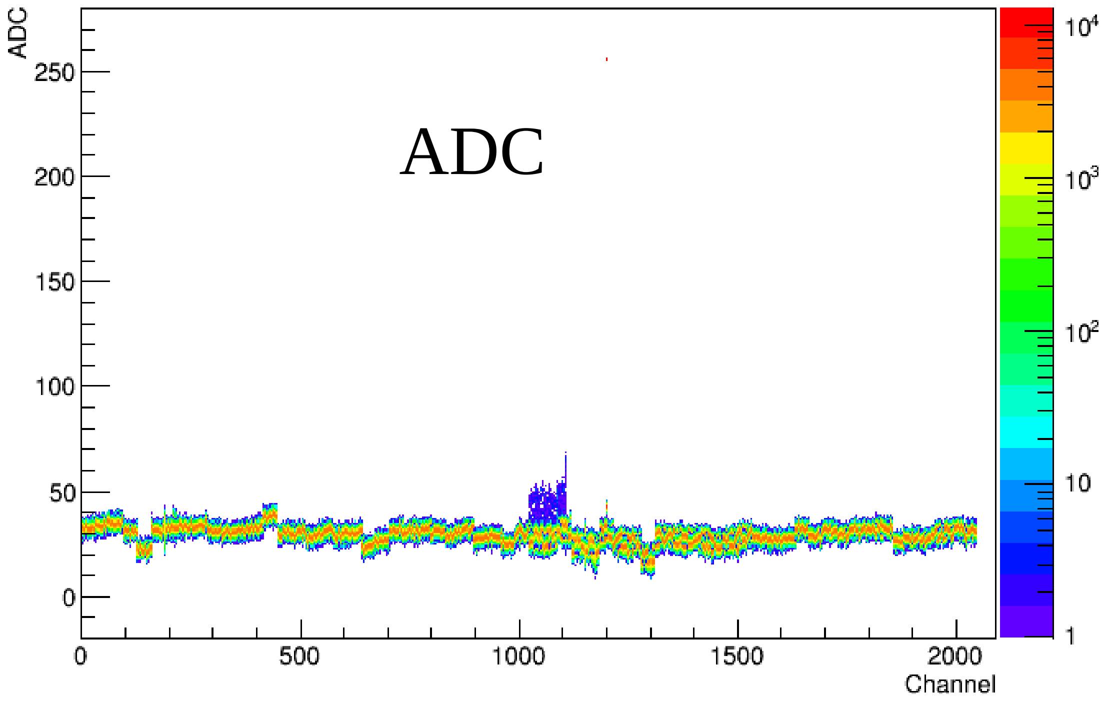
Set2
Inj1
Discriminator bit
ADC
Channel
Set2
Inj2
Discriminator bit
ADC
Channel

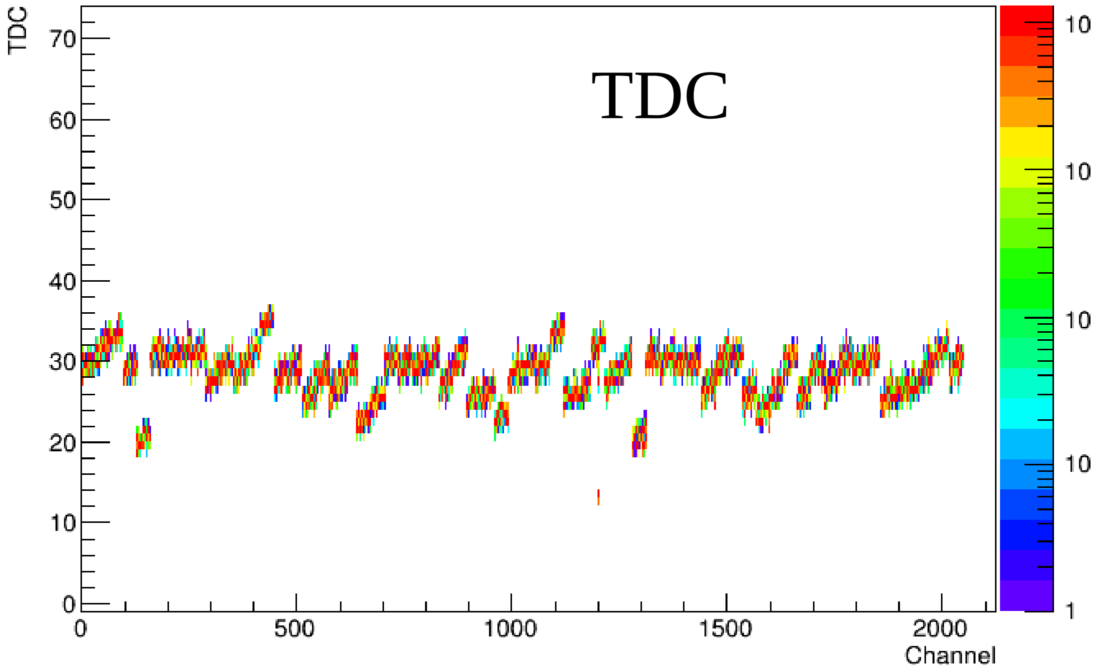

Set2 Inj4
Discriminator bit
Channel
ADC
Channel

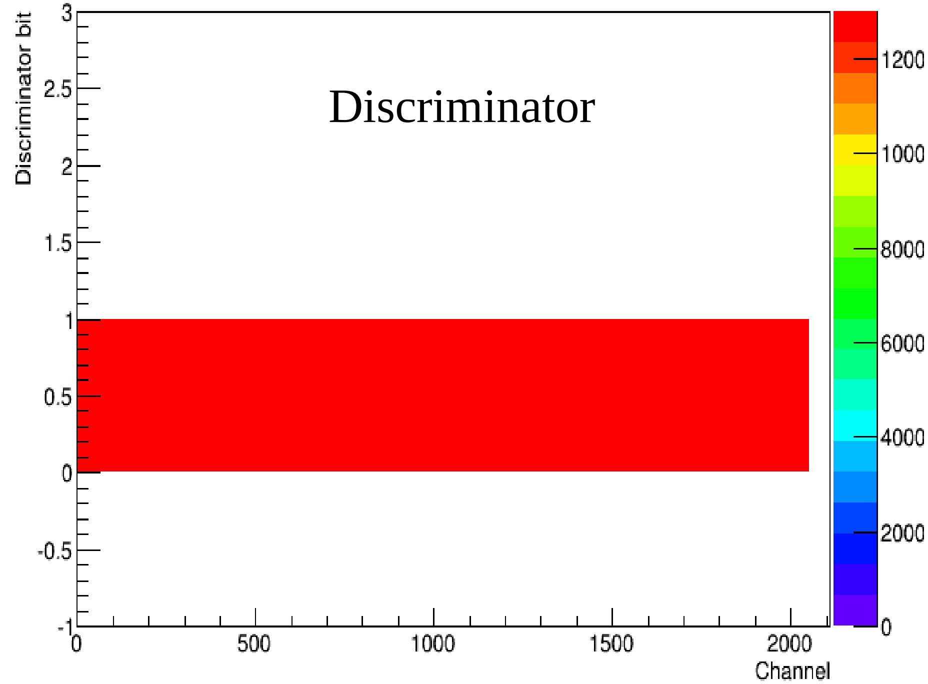

Set2 Inj8
Discriminator bit
Channel
ADC
Channel


Set2 Inj1
IBT
Set2 Inj2
Set2 Inj4
Set2 Inj8
TDC
Channel

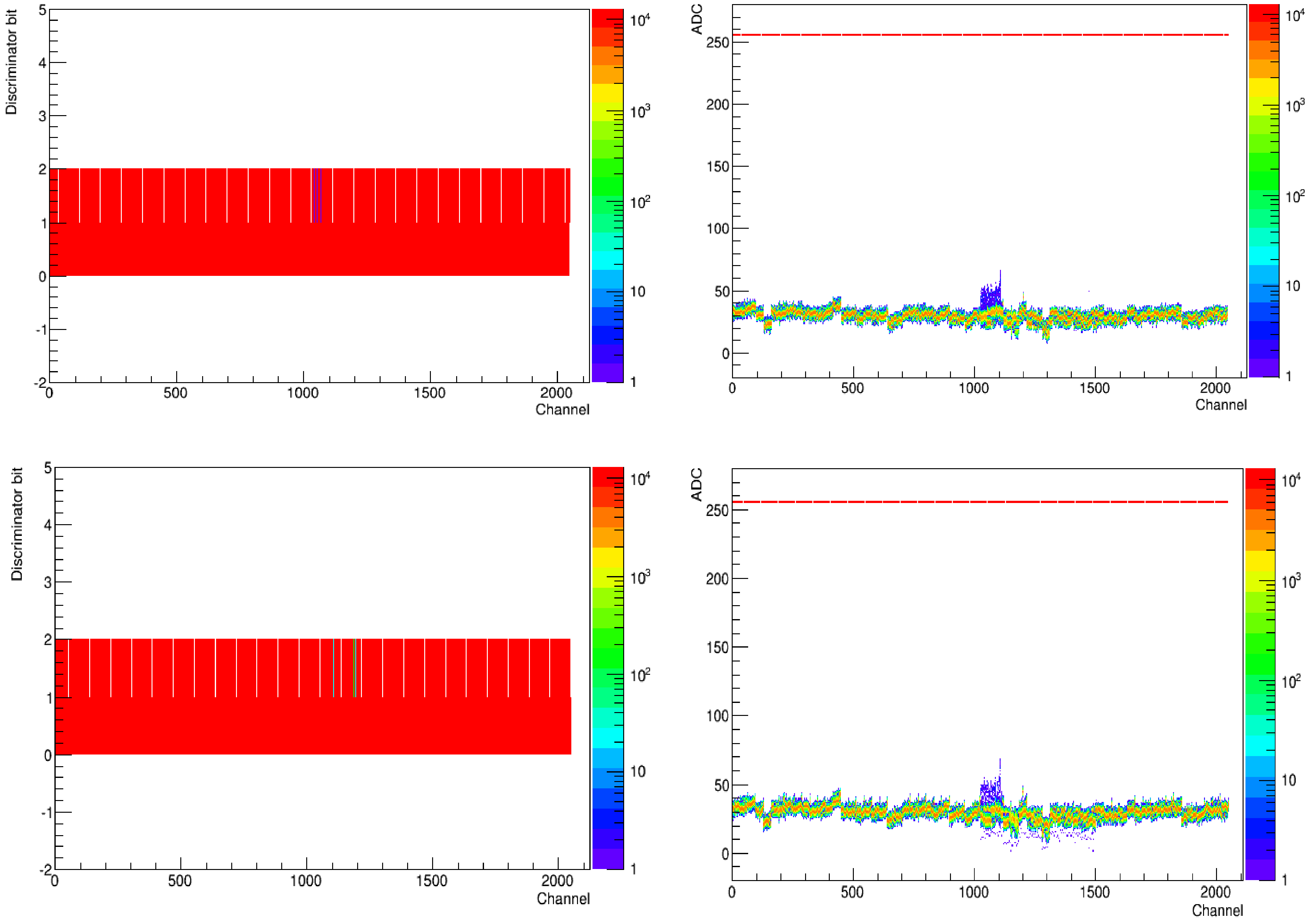
Set 3
Reference



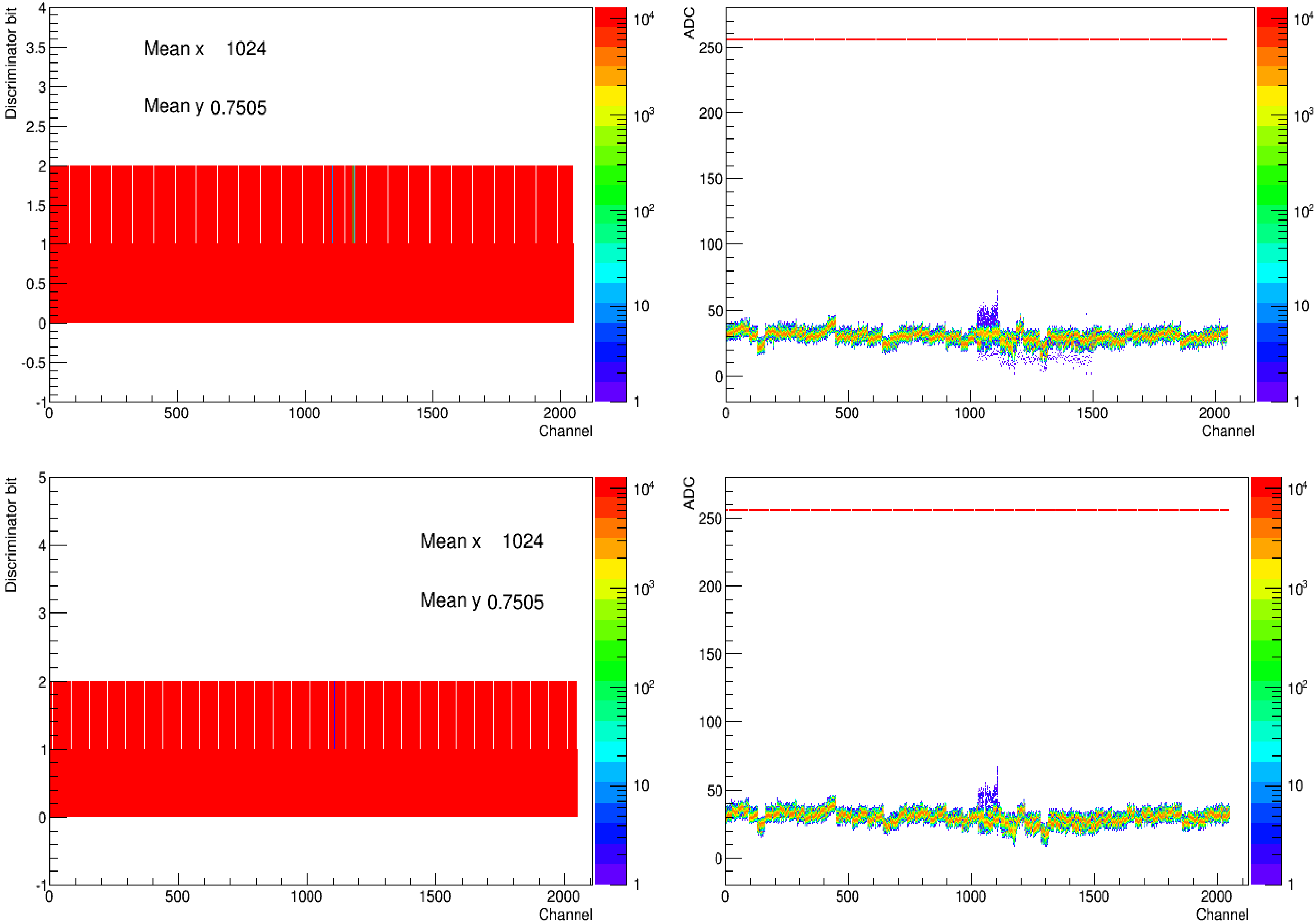




Set 3 Inj1+2

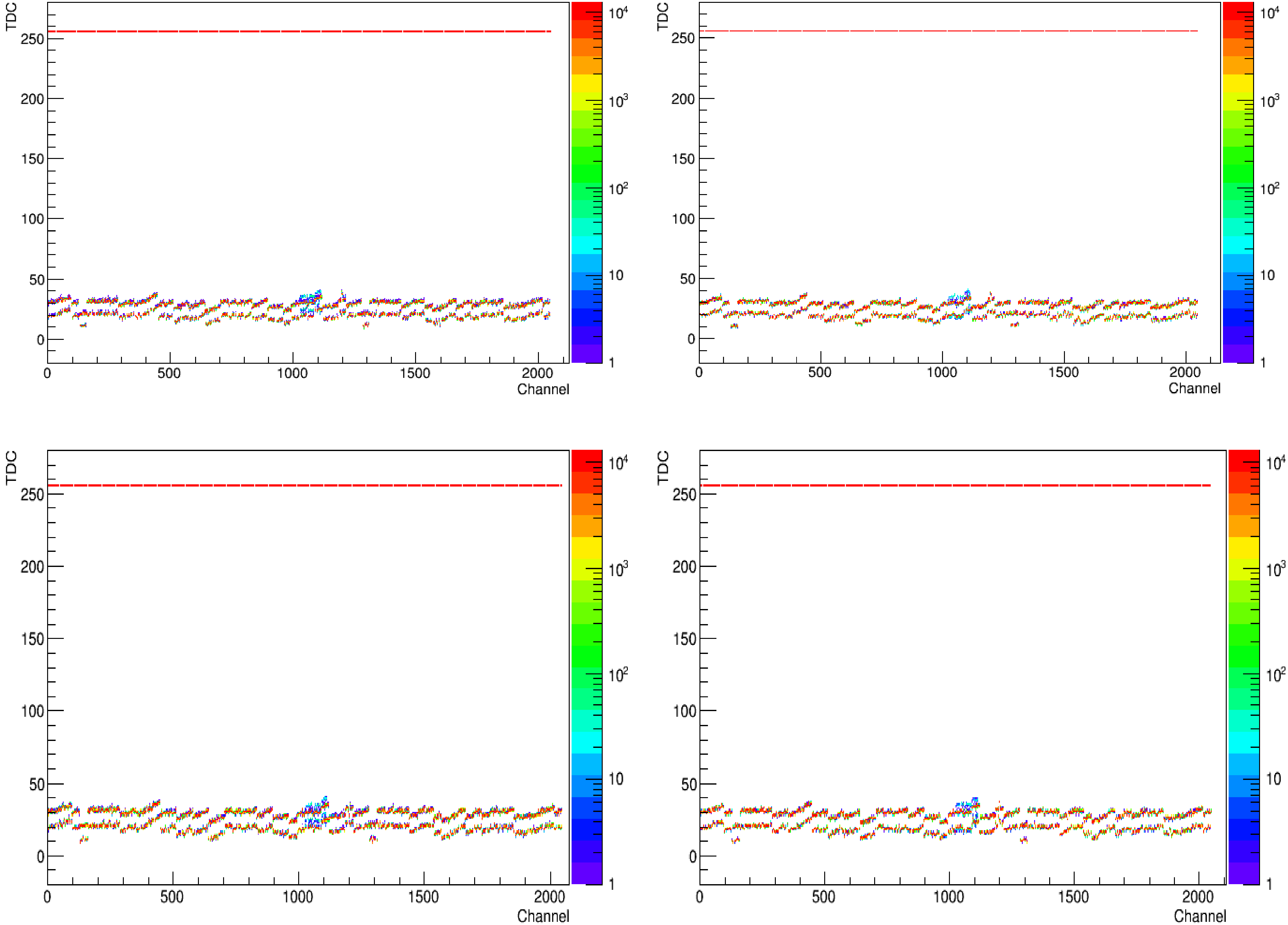

Discriminator bit
Channel
ADC
Channel
Discriminator bit
Channel
ADC
Channel

Set 3 Inj4+8

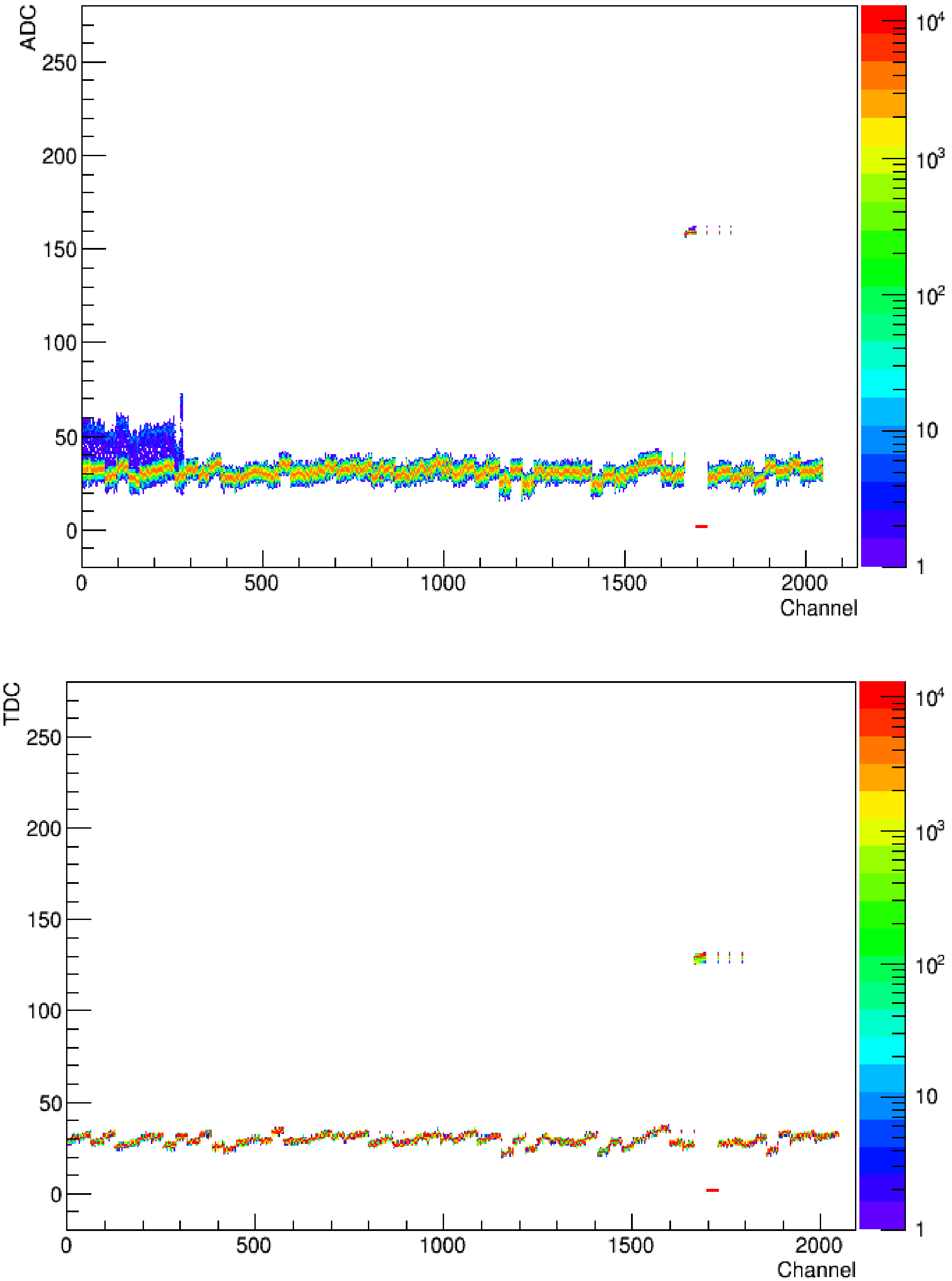


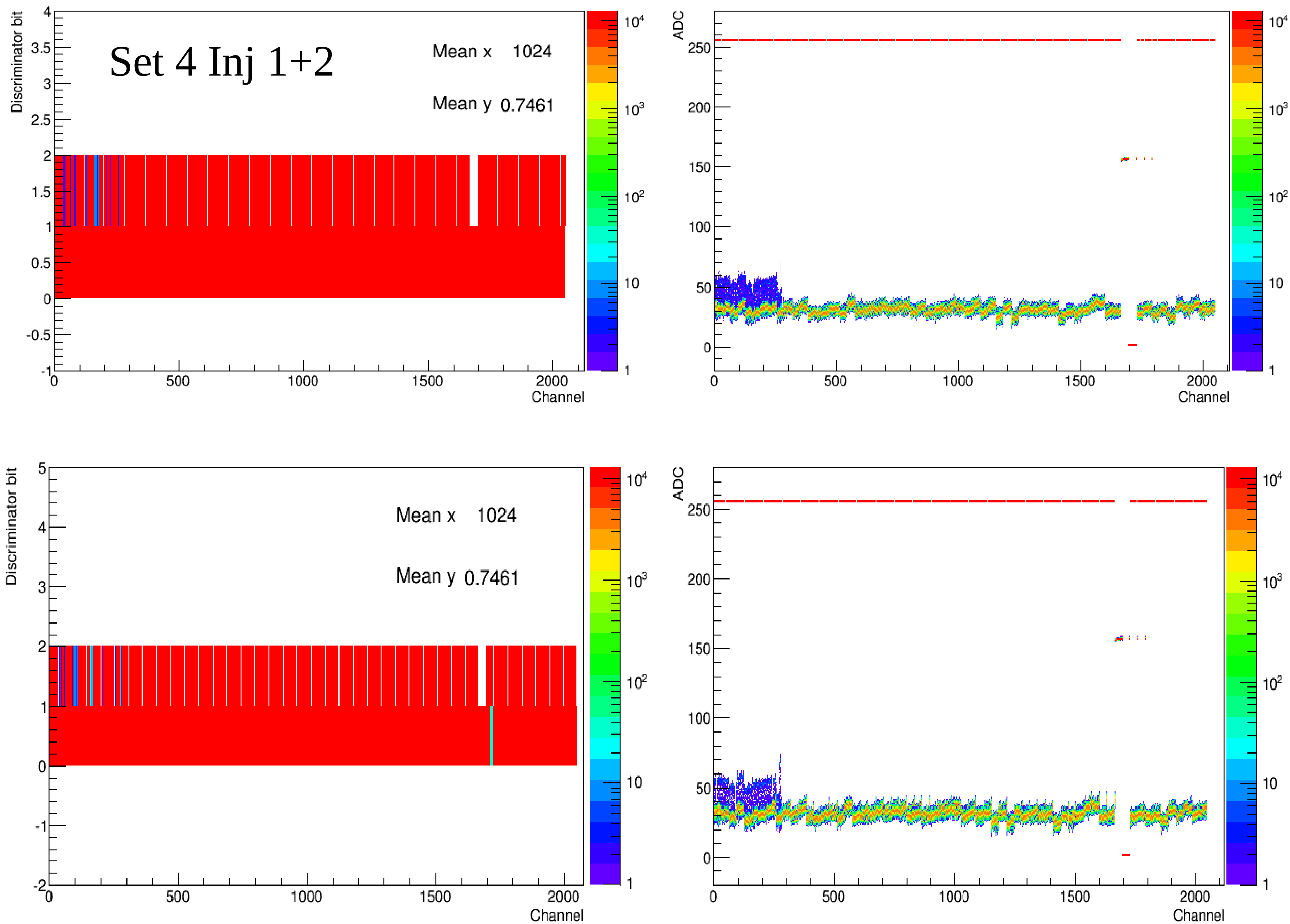
Mean x 1024
Mean y 0.7505
Discriminator bit
Channel
ADC
Channel
Mean x 1024
Mean y 0.7505
Discriminator bit
Channel
ADC
Channel

Set 3 IBT

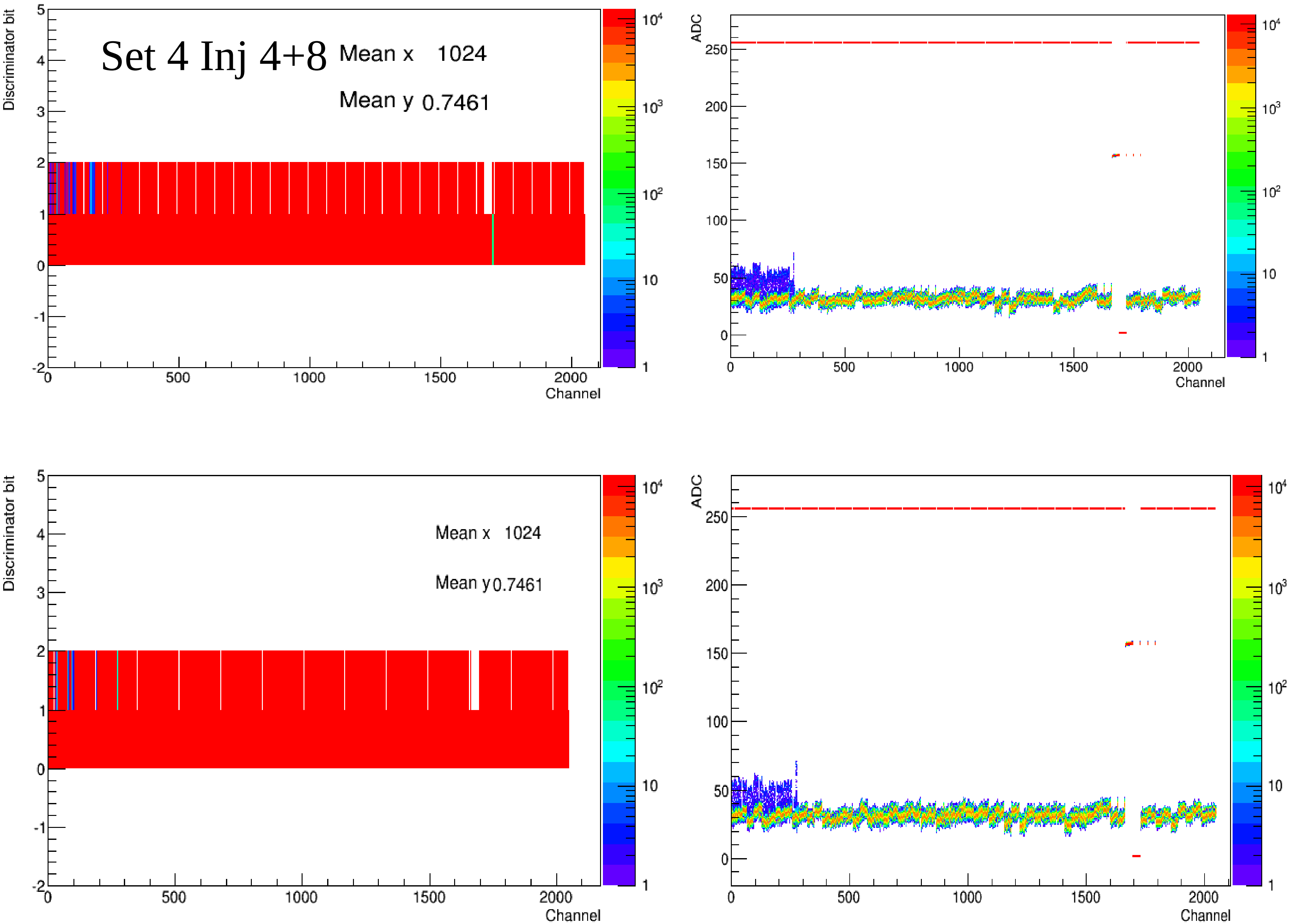

TDC
Channel
0
50
100
150
200
250
500
1000
1500
2000
1
10
10^2
10^3
10^4

Set 4 Reference



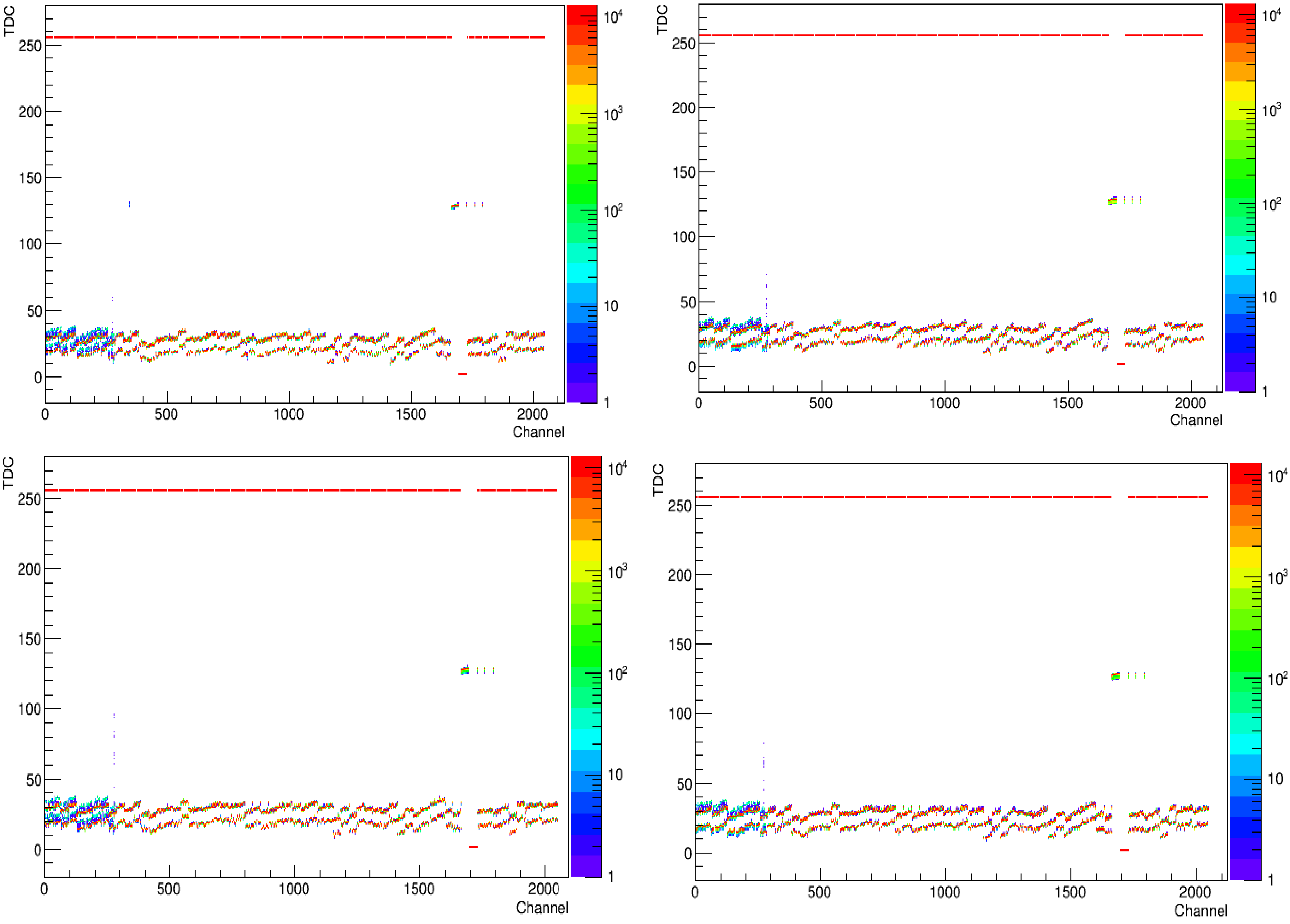


Set 4 Inj 1+2
Mean x 1024
Mean y 0.7461
Discriminator bit
Channel
ADC
Channel
Mean x 1024
Mean y 0.7461
Discriminator bit
Channel
ADC
Channel



Set 4 Inj 4+8
Mean x 1024
Mean y 0.7461
Discriminator bit
Channel
ADC
Channel
Mean x 1024
Mean y 0.7461
Discriminator bit
Channel
ADC
Channel

Set 4 IBT


TDC
Channel
0
50
100
150
200
250
500
1000
1500
2000
1
10
10^2
10^3
10^4