Detection of Communication Errors from ADC Curves

and first Hybrid5.0.09 results

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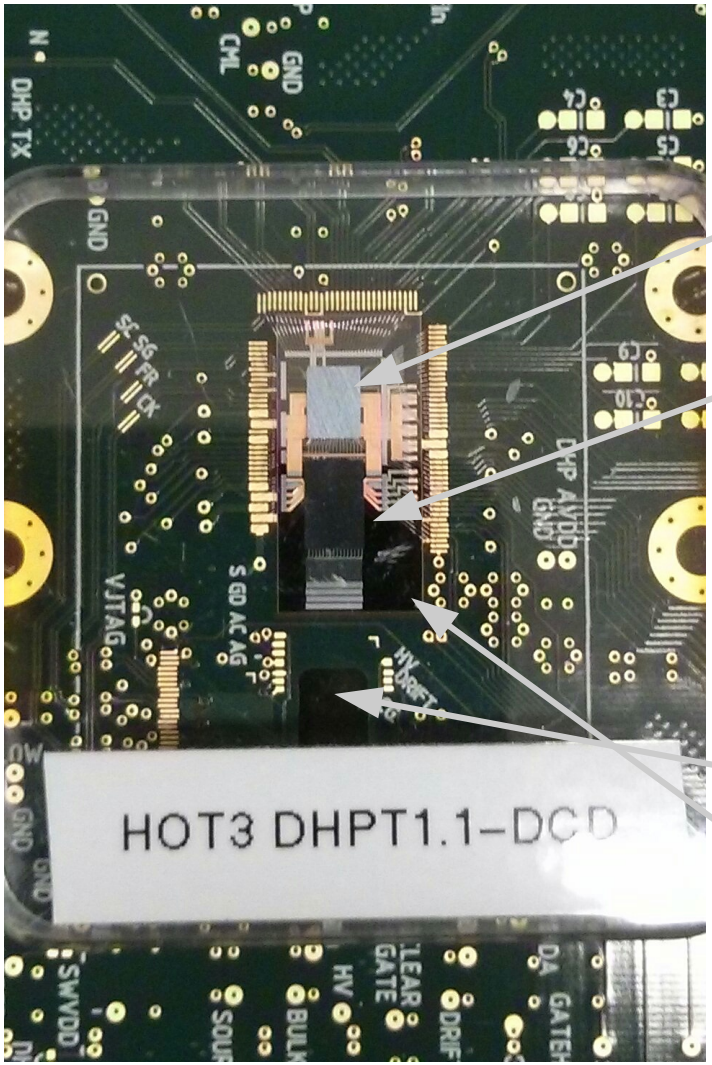
Hybrid5.0.09



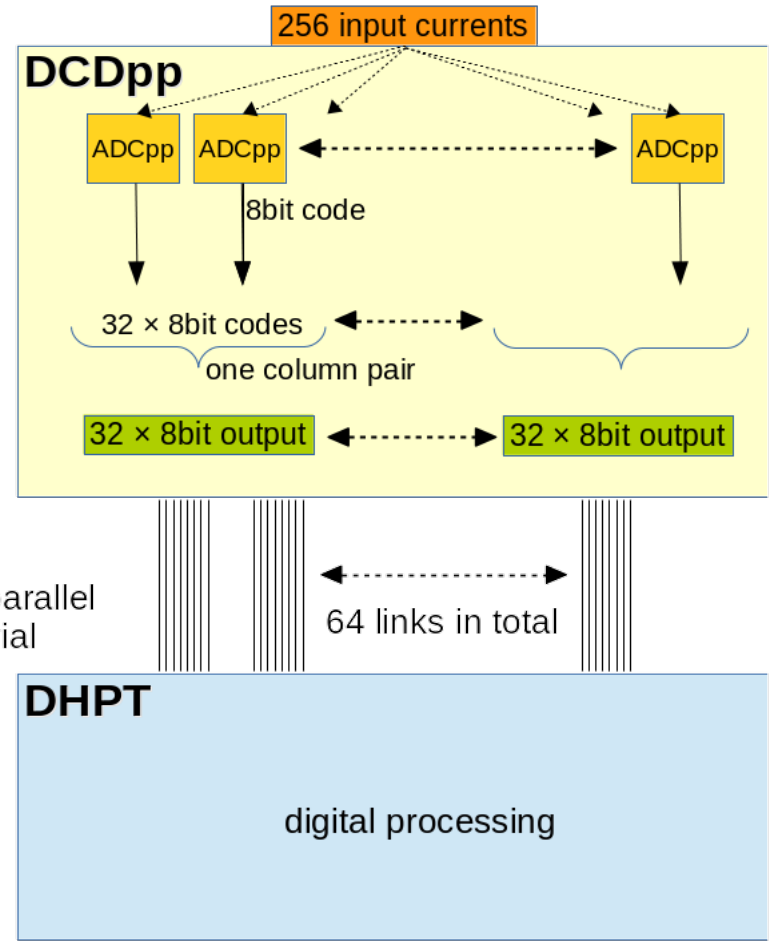
DHPT1.1

DCDpp

no matrix attached

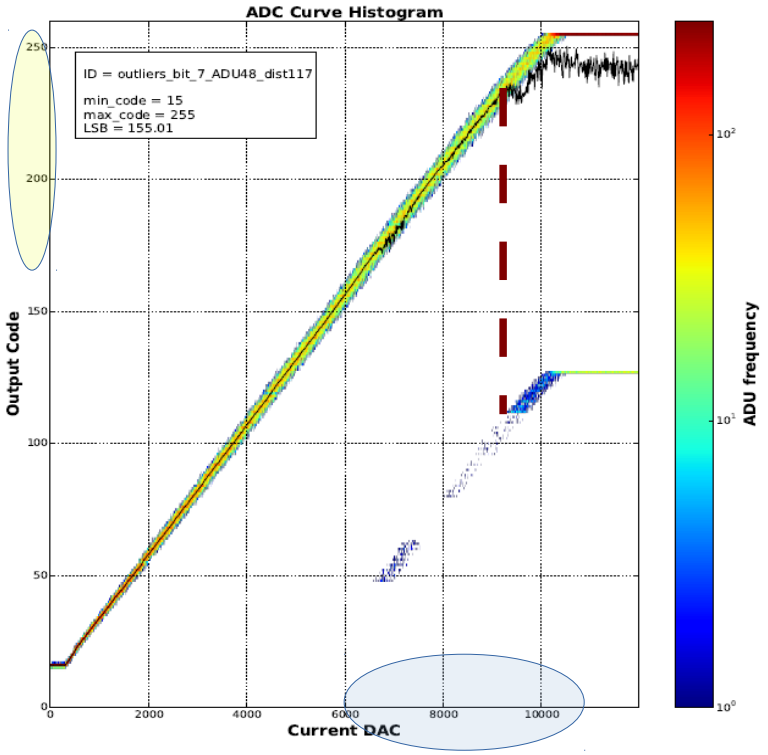
wirebond adapter
(ASICs-PCB connection)

DCD - DHP communication



Toggling bits in ADC curves

ADC curve (channel 0 some pair)



:- Example ADC curve at optimized DCD Settings.

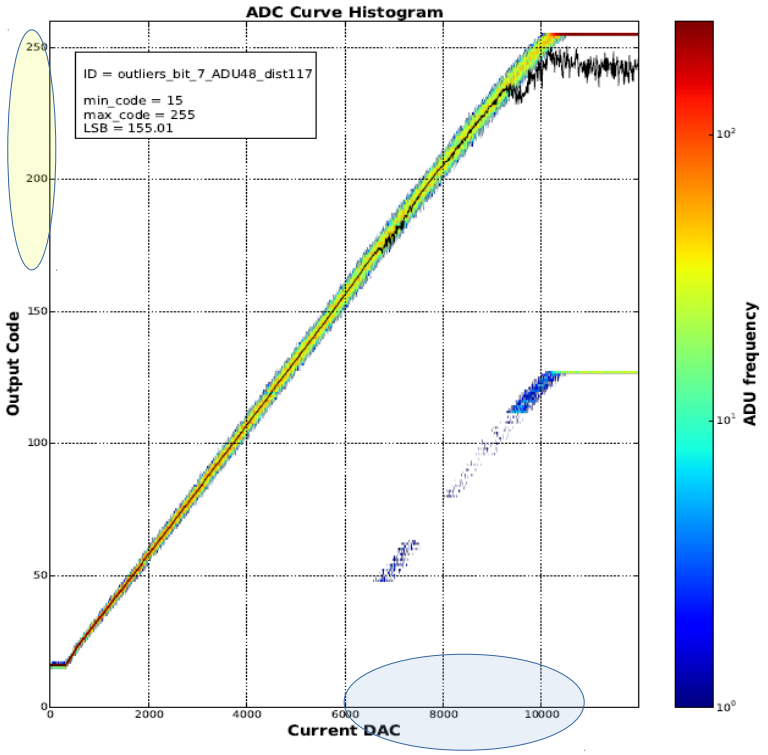
:- Input currents in blue circle should yield Output codes in yellow circle.

:- In reality: some fraction of readings, the output codes is shifted by 2^7=128.

:- The reason: toggling of most significant bit (MSB)

A model for toggling

ADC curve (channel 0 some pair)



Transmission of code 250 in channel 0:

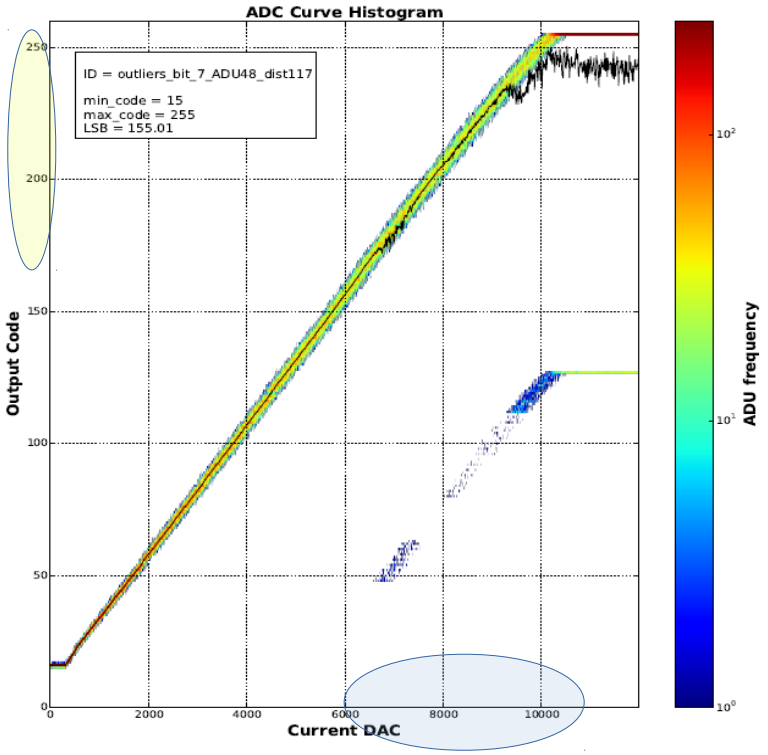
	Ch 30	Ch 31	Ch 0	….
Bit 0 (LSB)	?	?	0	
Bit 1	?	?	1	
Bit 2	?	?	0	
Bit 3	?	?	1	
Bit 4	?	?	1	
Bit 5	?	?	1	
Bit 6	?	?	1	
Bit 7 (MSB)	1	1	0	

Channel1 sends pedestal with MSB set.

8bit encoding for 250.

A model for toggling

ADC curve (channel 0 some pair)



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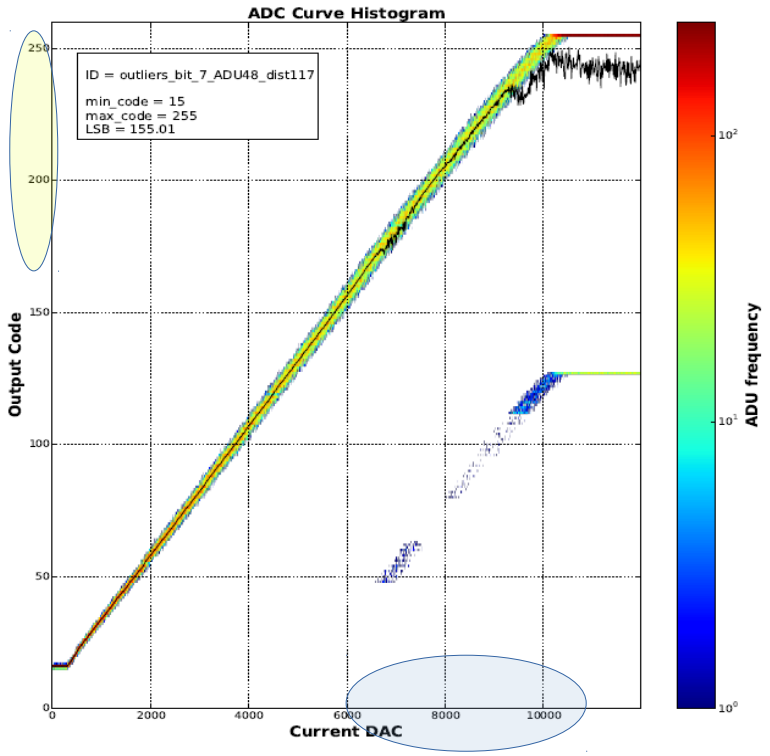
Bit 6	?	?	1	
Bit 7 (MSB)	1	1	**1**	

For some readings the MSB toggles to 1.

A model for toggling

ADC curve (channel 0 some pair)



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Bit 6	?	?	1	
Bit 7 (MSB)	1	1	**1**	

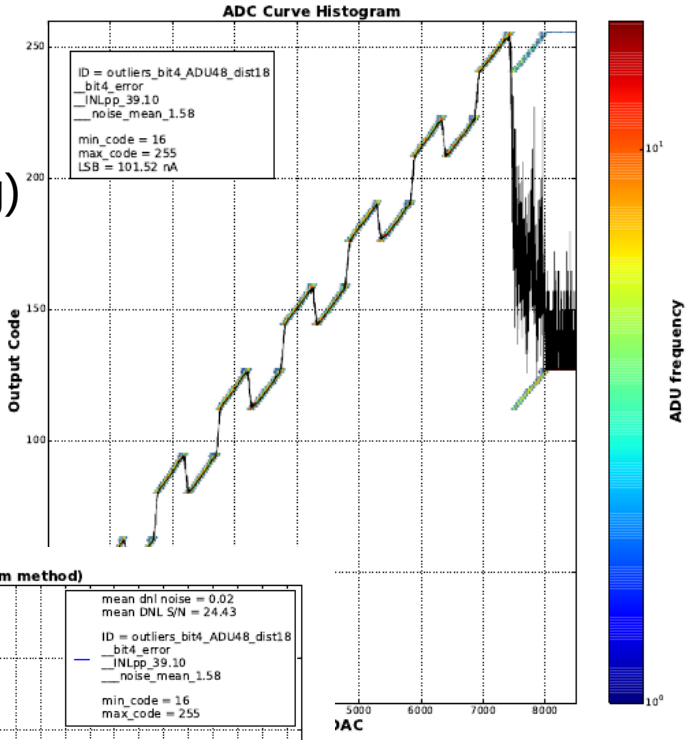
→ In general: toggling can happen for all bits (0-7)
→ toggling probability depends on previous bit value.
→ toggling probability depends on transitions on neighbor bits (cross talk)

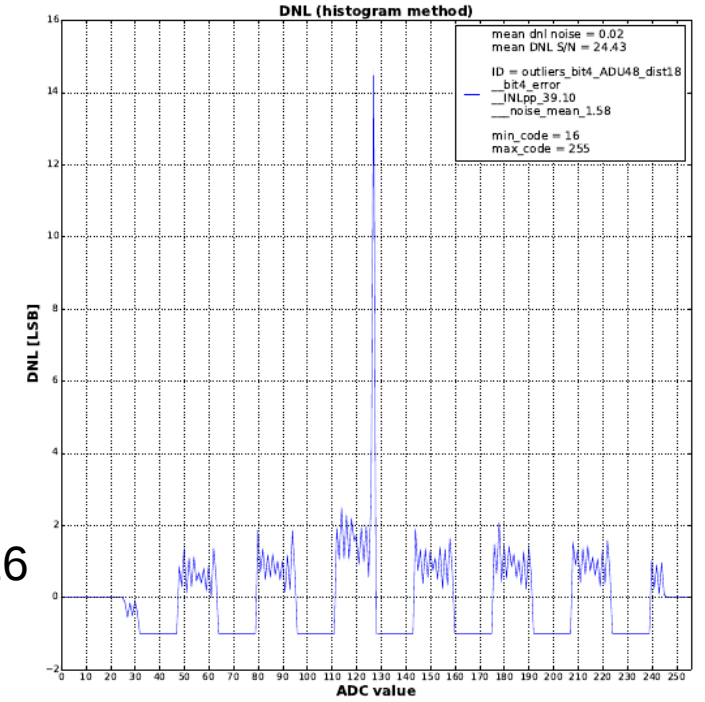
For some readings the MSB toggles to 1.

Bit Error Recognition – DNL Method

- bit errors appear as negative valleys in DNL curve
- width of valley determined by affected bit n as 2^n
- count number of valleys with widths 2^i, i = 0,...,7
- define thresholds for number of valleys

bit4 stuck
(+ bit7 toggling)



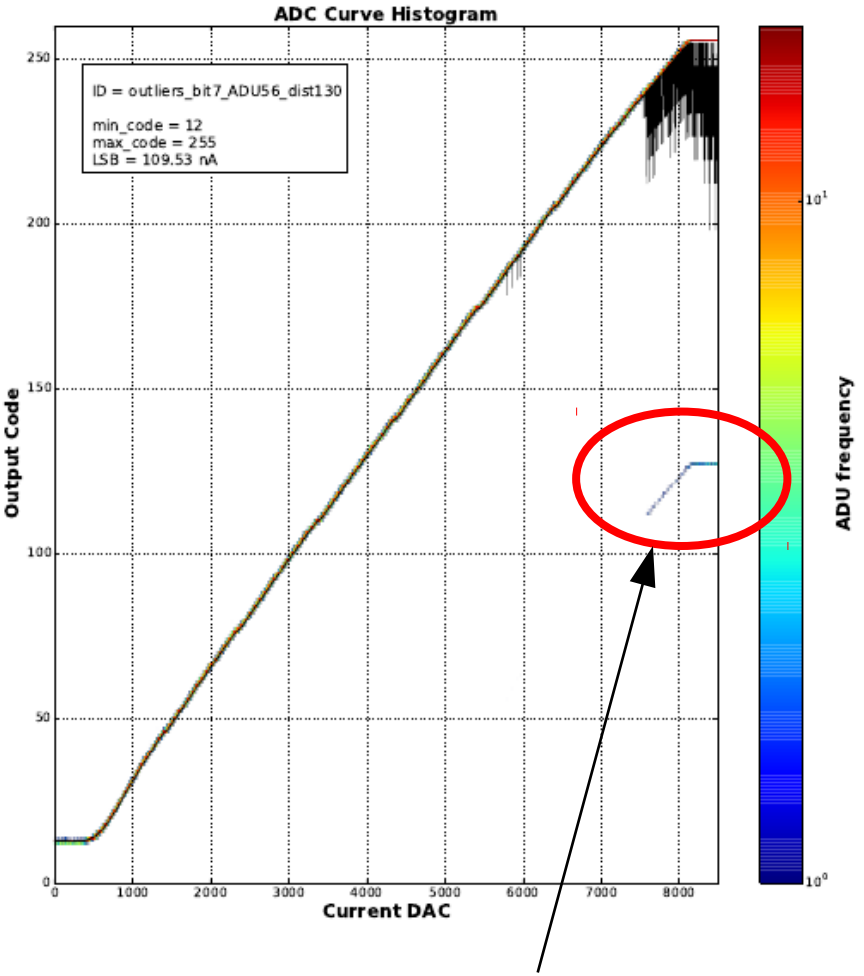


valleys with width 16

Bit Error Recognition – Outliers

- check if there are ADU readings off of ADC curve
- per DAC define ADU code with max number of readings as curve reference
- check distances to all other ADU code readings for this DAC
- if distance = 2^i, i = 3,...,7 found within a certain margin

  → toggling bit i

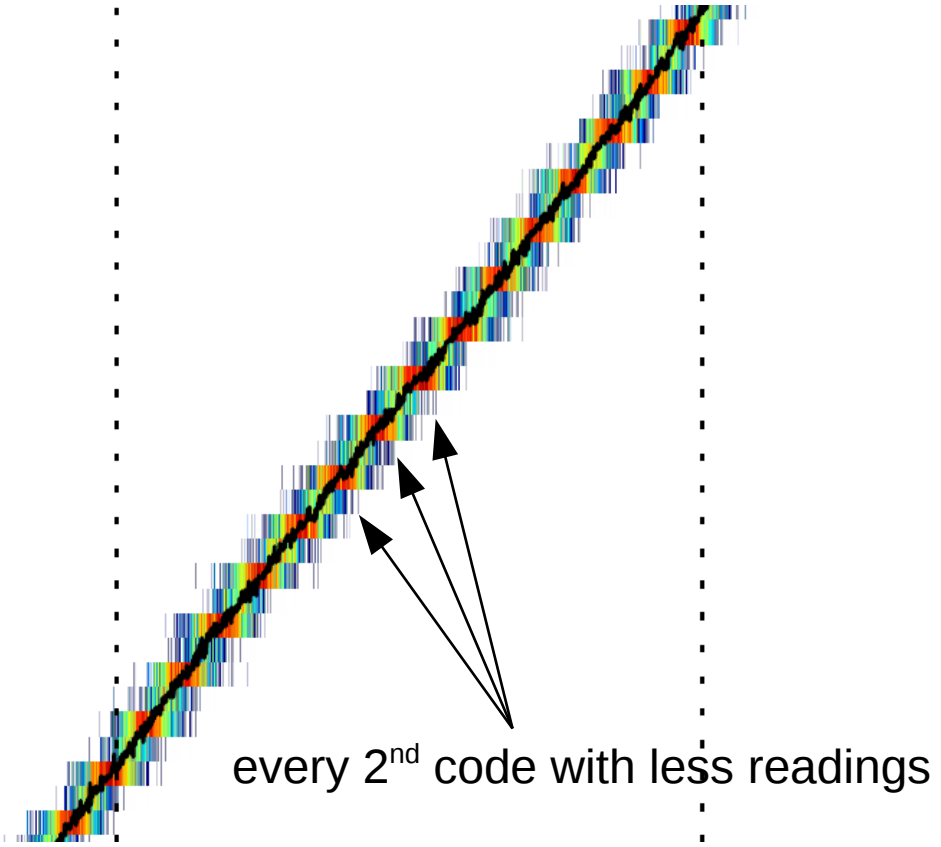


toggling bit7 (MSB)

Bit Error Recognition – Bit0

- bit0 (LSB) error specific
- count occurances of even and odd ADU codes
- compute ration even/odd
- if ratio > 2 or ratio < 0.5

  → bit0 (LSB) error



Results from H5.0.09 with DHPT1.1

All Channel Scan Statistic

good channels	181
channels with bit error	74*
channels with comparator error	1**
channels with dynamic range error	0
median LSB	131.94 nA/ADU

* includes miss-identified bit3 errors (see later)
** comparator errors without concurrent bit error

settings:

IPSource: 90
IPSource2: 95
IFBPBias: 90

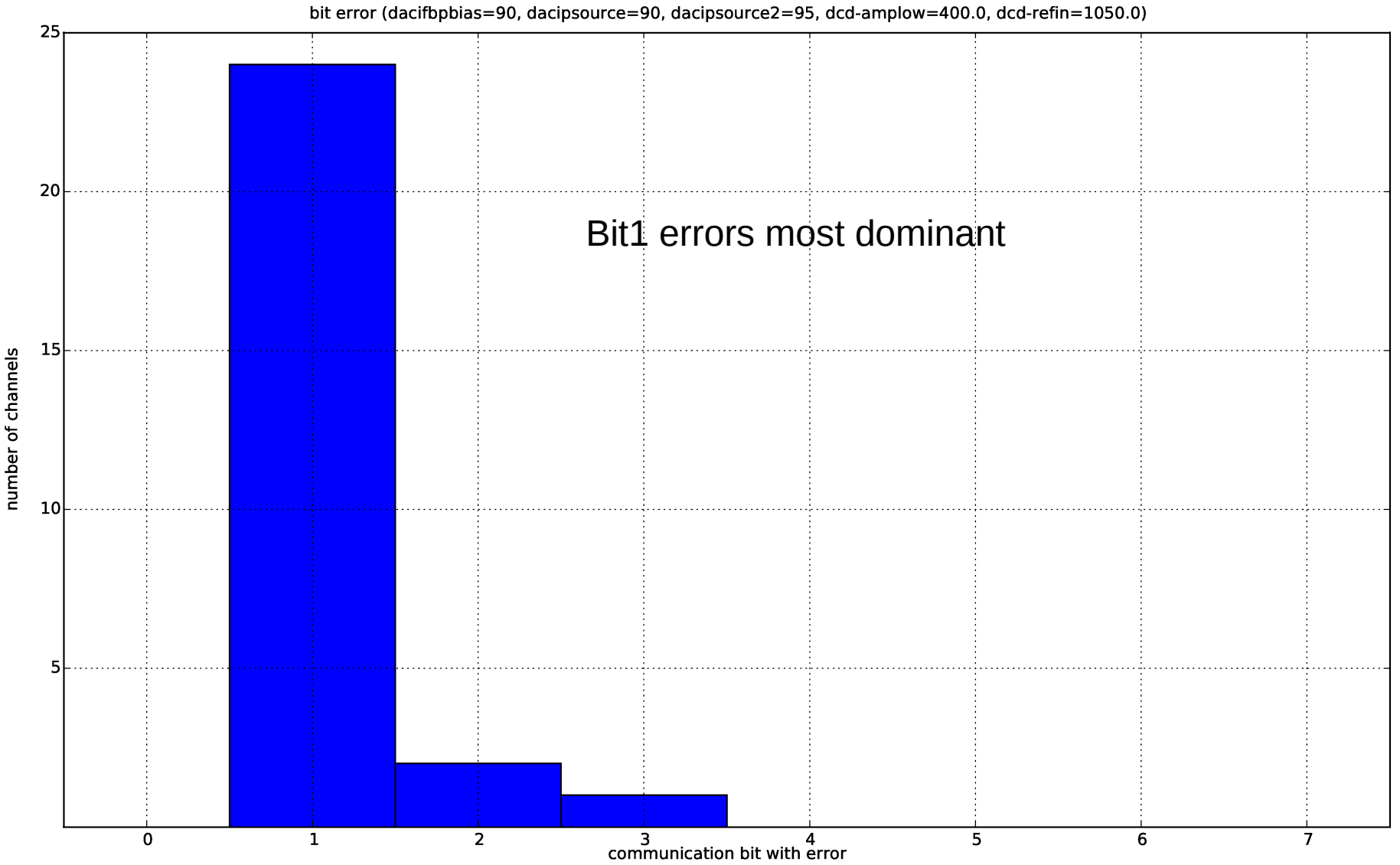
RefIn: 1050 mV
Amplow: 400 mV

En30 ON, En60 OFF, HighGain OFF
GCK: 76.23 MHz

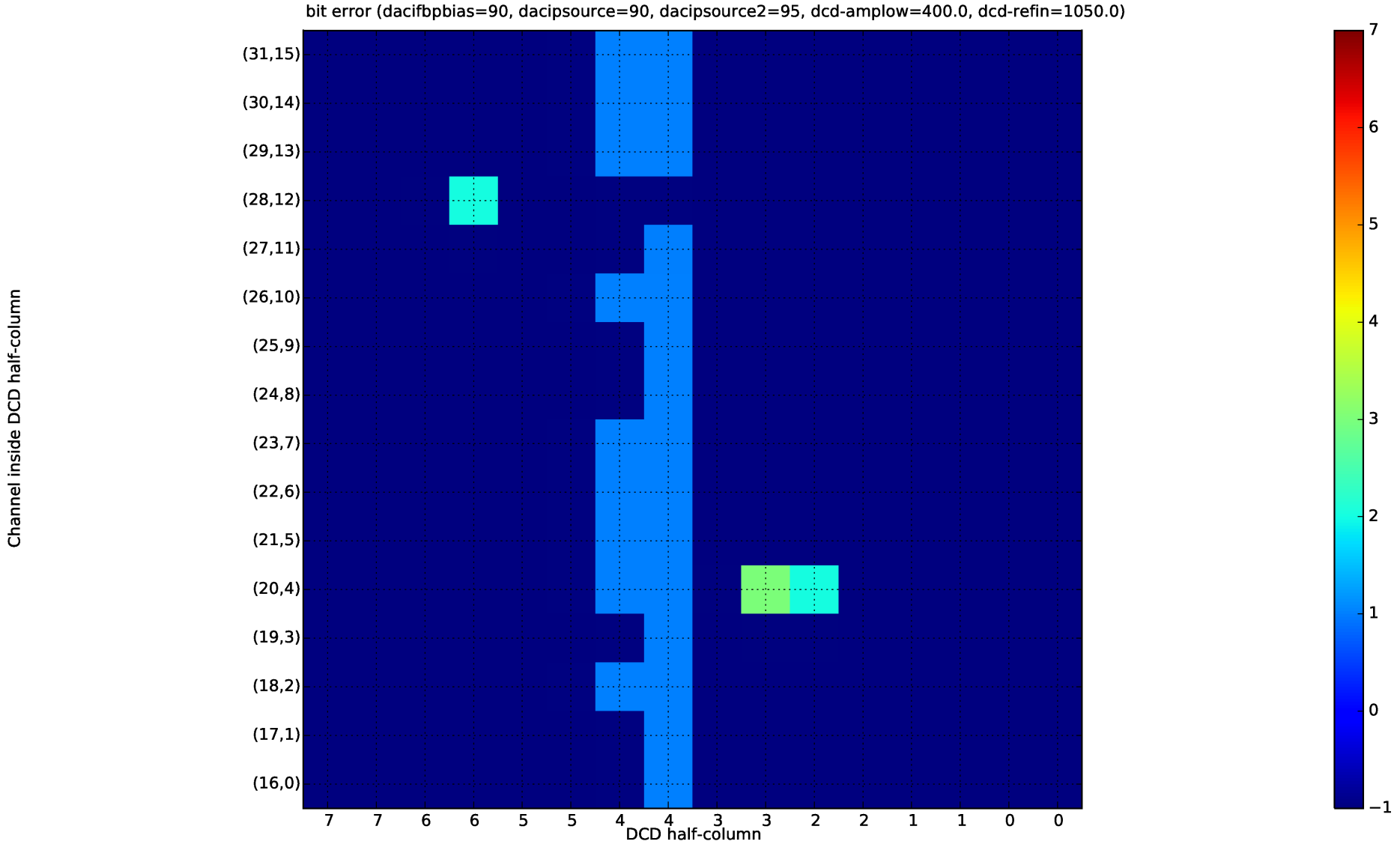
DHPT_Core: 1300 mV
DHPT_IO: 1900 mV

DCD_DVDD: 1900 mV

Bit Error Distribution (DNL test)



Bit Error Map (DNL test)

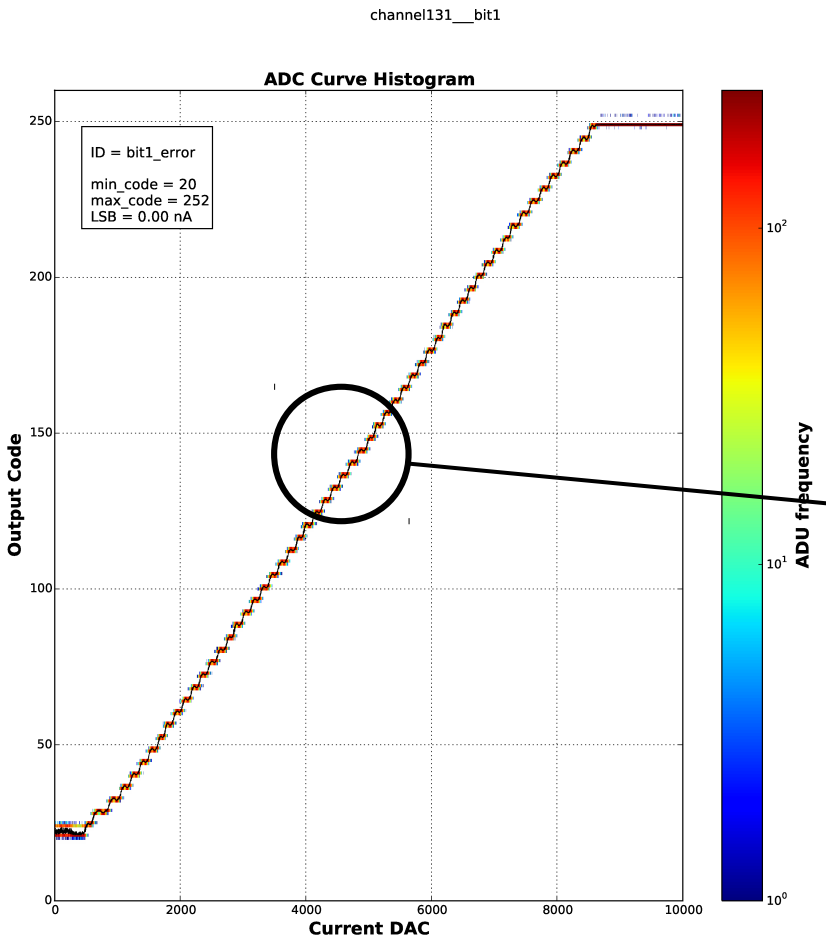


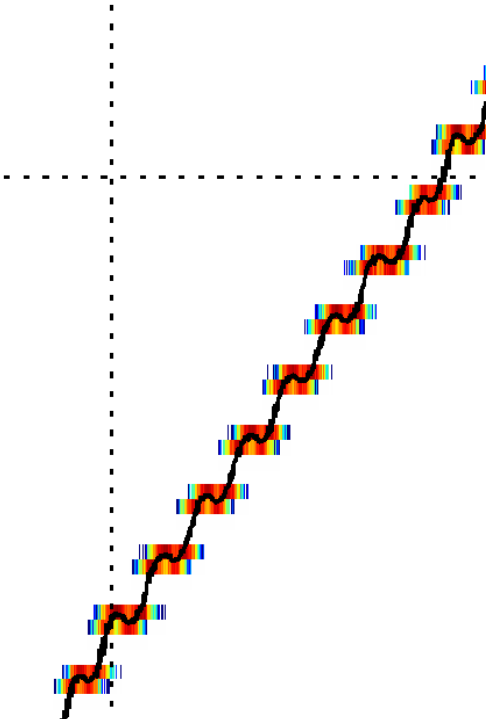
:- bit1 errors occur only for ADC channels all in column pair 4

:- Problem search boiled down to very few components.

Bit1 Errors

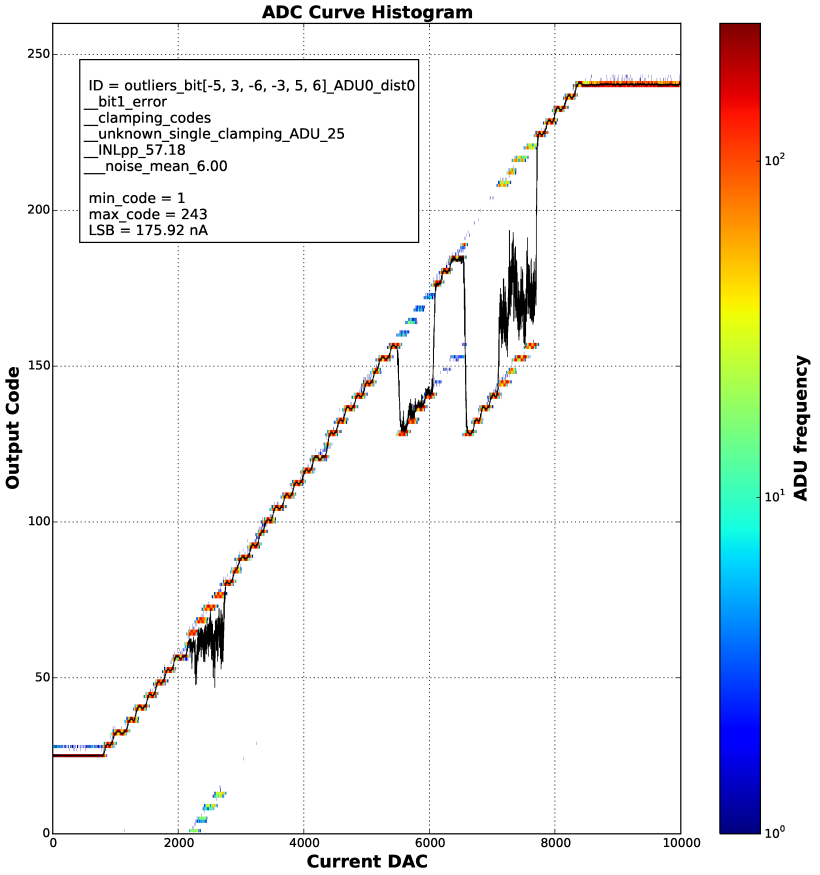
:- Bit1 errors hardly visible from averaged data (mean code vs. input current)
:- robust detection needs access to 2d binned data.



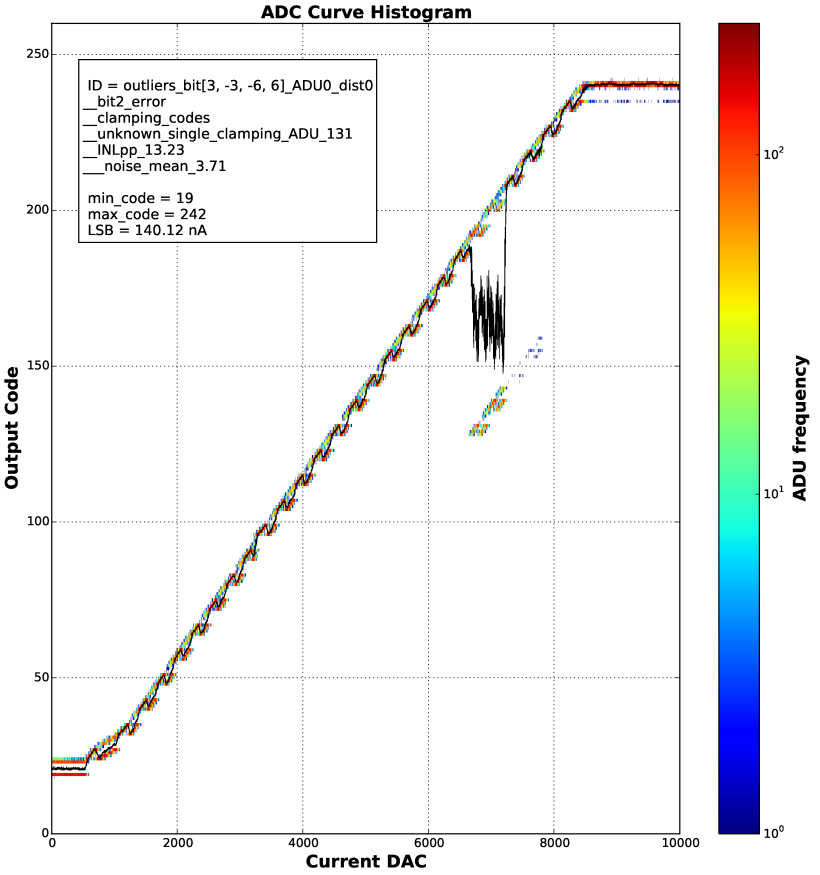


Two examples of very bad cases (problems in multiple bits)

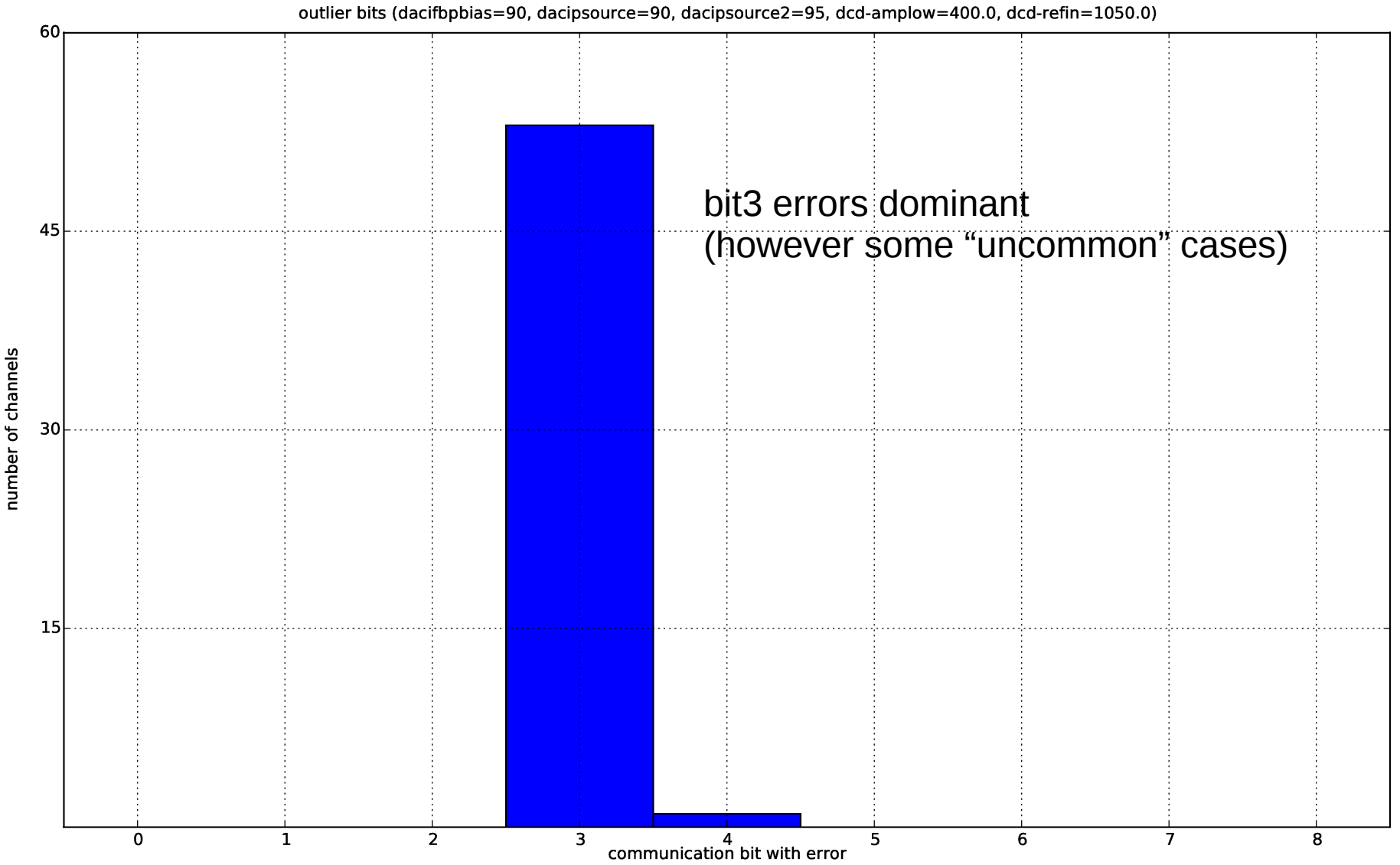
el148___outliers_bit[-5, 3, -6, -3, 5, 6]_ADU0_dist0___bit1___clamping_codes___unknown_single_clamping_ADU_25___INLpp_57.18___noise_mear



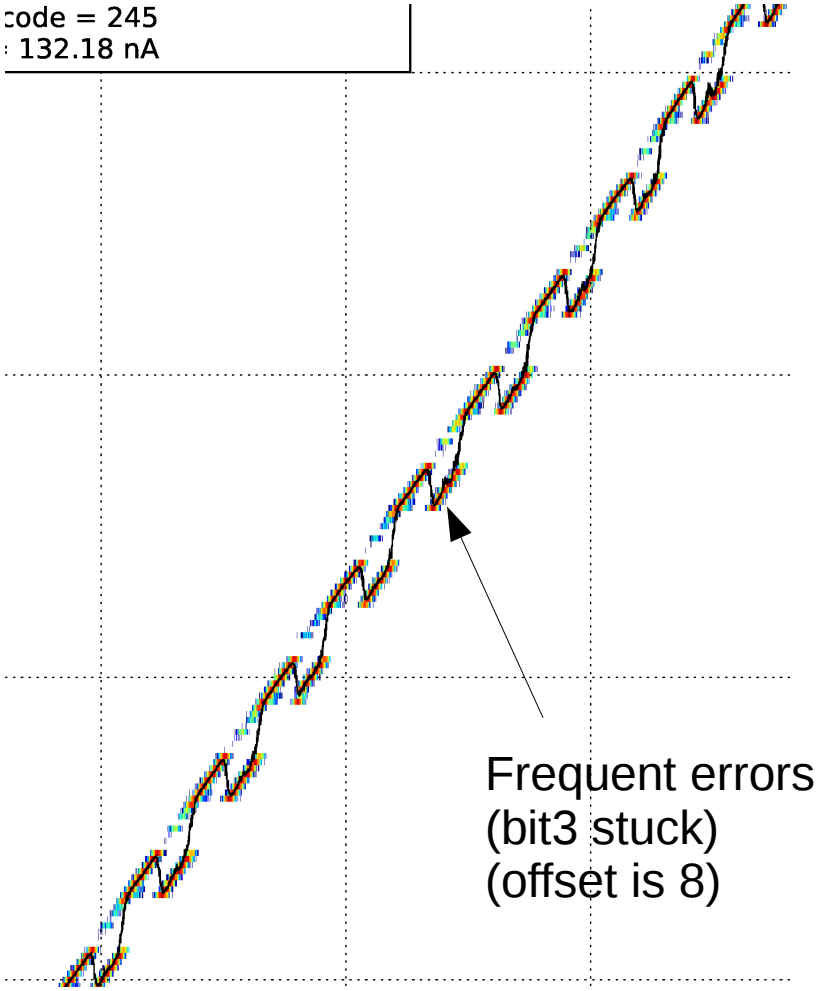
nnel084___outliers_bit[3, -3, -6, 6]_ADU0_dist0___bit2___clamping_codes___unknown_single_clamping_ADU_131___INLpp_13.23___noise_mean_3

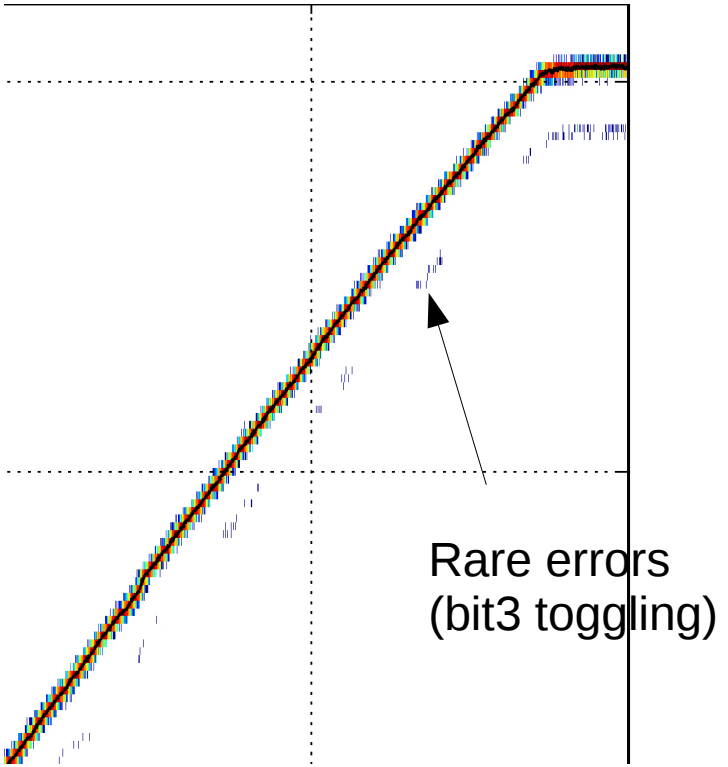


Bit Error Distribution (outliers test)

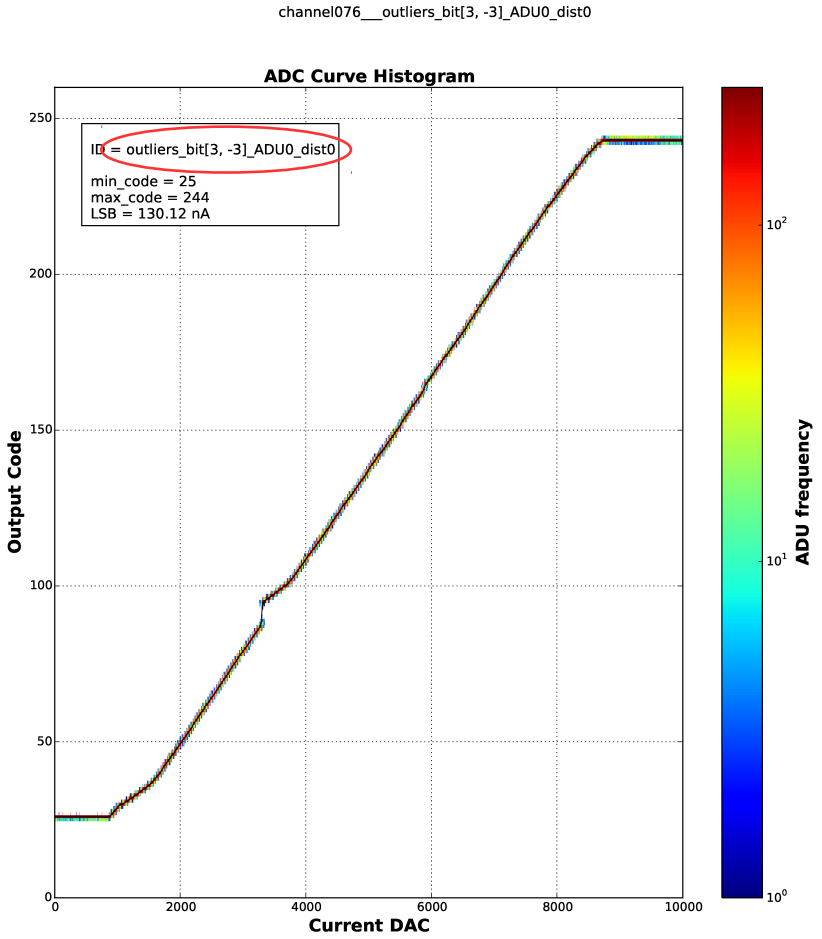


Real Bit3 Errors

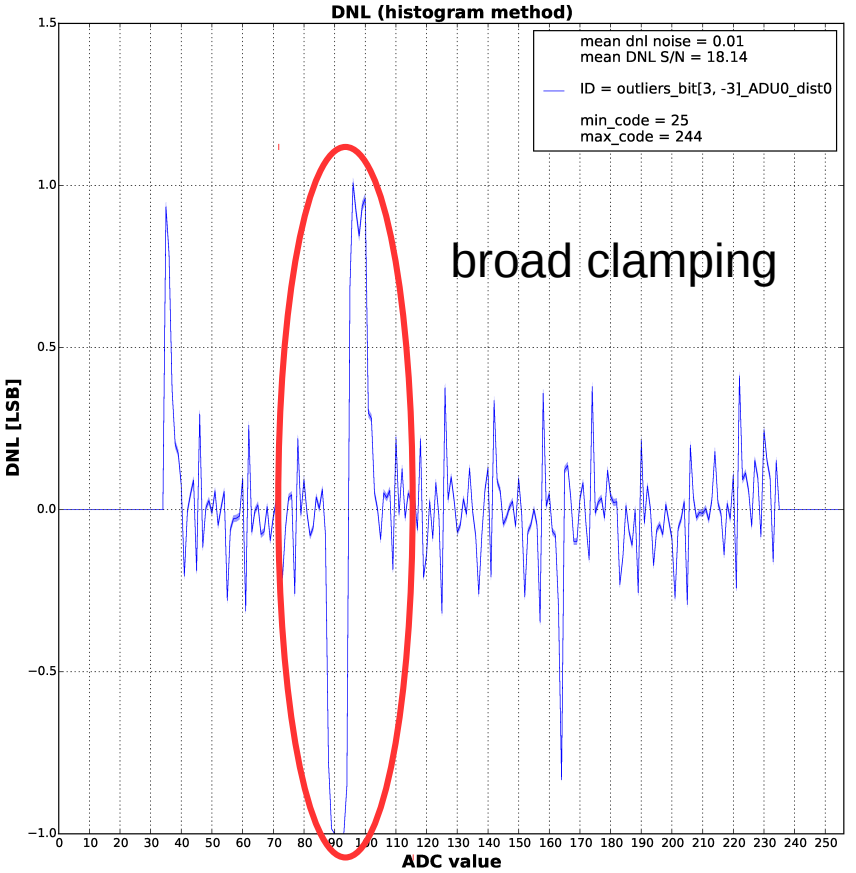




miss-identified Bit3 Errors/ Broad Clamping

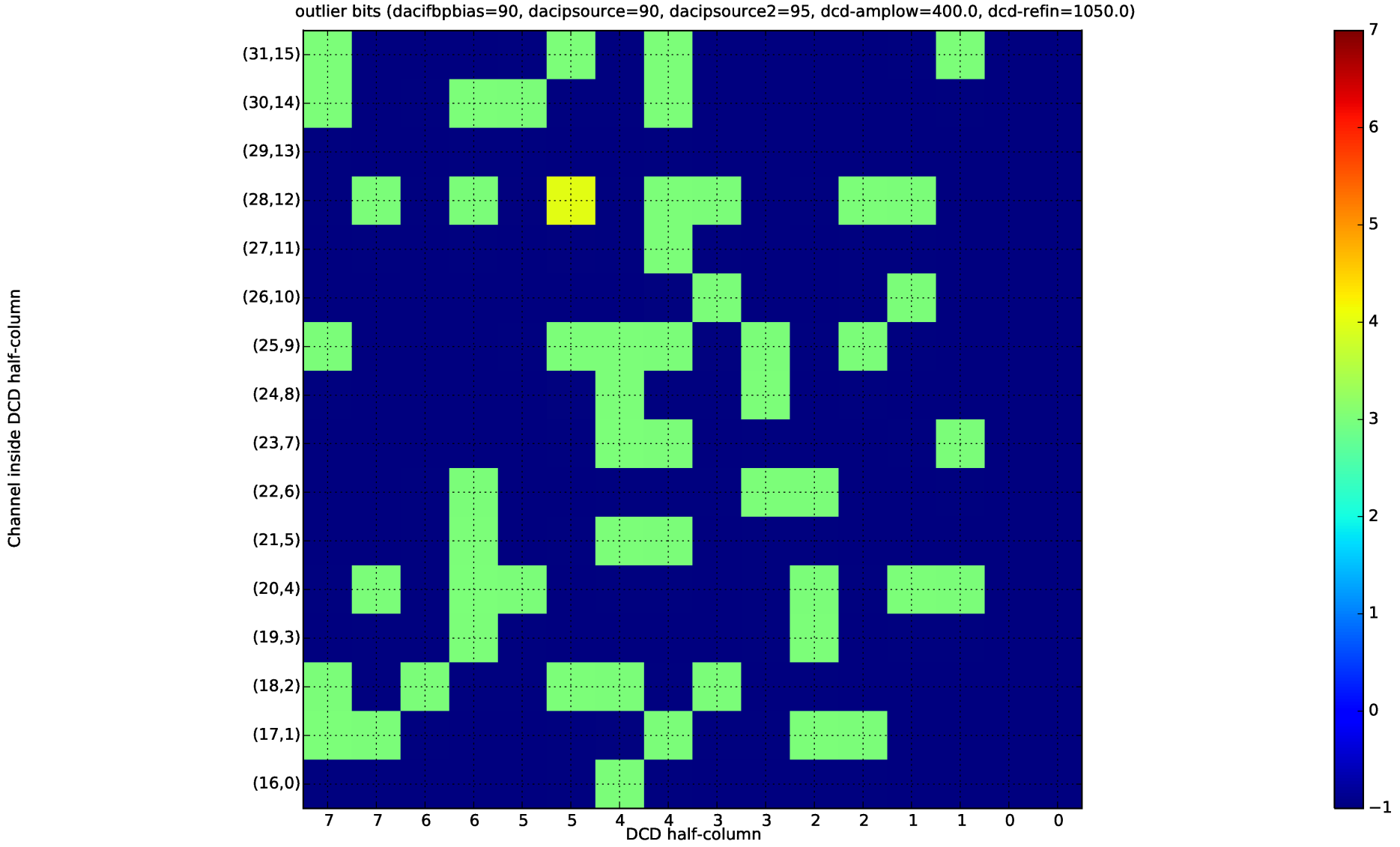


typically miss-identified as bit3 error



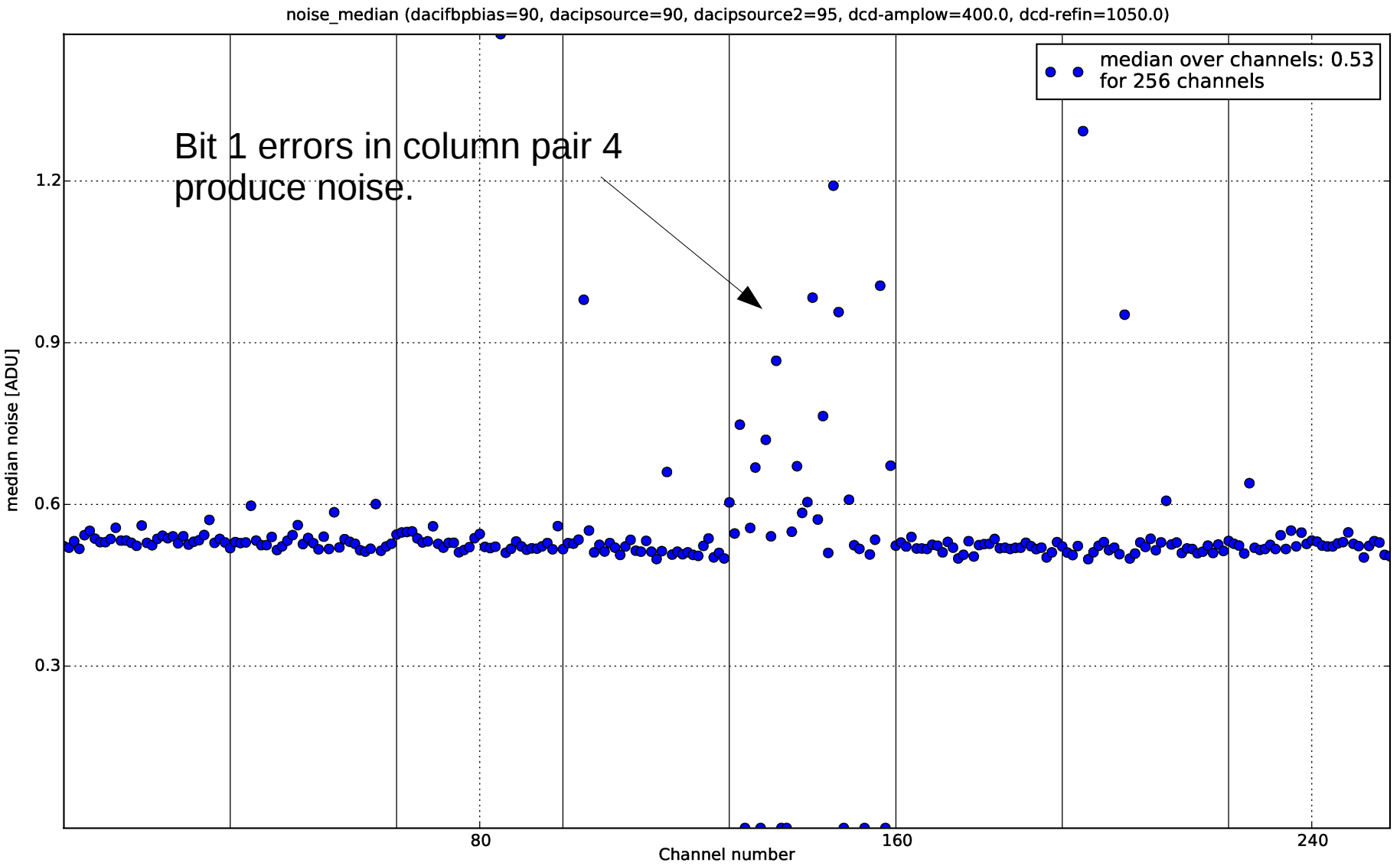
probably ADC problem
similar to clamping codes

Bit Error Map (outliers test)



:- bit3 errors happen in all column pairs 1-7; not 0

Median Noise vs Channel



Summary

- Robust method implemented to detect errors in DCD-DHPT communication.
- Method gives detailed info about errors:
  - Which bit line causes trouble?
  - How frequently does it happen (severity)?
  - Can detect cross talk between lines.
- Code already in use to study new Hybrid 5 boards.
  - Also applicably to big PXD9 pilots.
- Summary data for different systems collected in online repo.