(Preliminary!) ABCD2T double-sided module at KEK

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KEK

Abstract

Although preliminary at this stage, the double-sided ABCD2T module with the barrel kapton hybrid showed:

1. Threshold matching was <3 mV after trimming,
2. Gain was 55 mV/fC at 2 fC in average,
3. Noise was 1454 $\pm$ 37 e at 2 fC, and
4. No apparent instability was observed.

I. Introduction

A double-sided barrel module has been assembled with the barrel Kapton hybrid [1], staffed with 12 ABCD2T chips [2]. The module construction was done in the default fashion. No special patch work was applied. Digital (DGND) and Analog (AGND) grounds were connected with wire-bonds on the "stiching pads" between the chips. There was no extra DGND-AGND connection otherwise. The module was placed in an aluminium enclosure, called “H8 testbox”, and connected to the Melbourne support card, as shown in the photograph.

The support card was connected to the MuSTARD daq VME setup [3]. Data were taken with the sctdaq program [4].

The operation conditions of the module were

1. Detector bias voltage: 100 V
2. FE bias current: 267 µA
3. FE shaper current: 30 µA
4. Vcc: 3.50 V (with an external series regulator power supply)
5. Vdd: 4.00 V (with an external series regulator power supply).

Data taking modes of the chips were

1. Edge detection ON
2. Compression of "01X".

The data compression of "01X" means that the pattern of hits of three time bins are such that there is no hit in the one previous clock timing of the calibration strobe, a hit in the strobe timing, and no care in the one afterward. This compression mode counts less events where the noise rate is more than 50%, which is equivalent as differentiation.

The "trimming" of the Trim DAC was done at a charge injection of 2 fC such that the threshold would be 200 mV.

II. Results

A. Threshold scan at a charge injection of 2 fC

The result of the scan is shown in the first 2 pages of the figures. The 1st is of the 6 chips in the topside hybrid. The 2nd is of the 6 chips in the bottom side hybrid. The data points of the threshold scan was fitted, channel by channel, with the error function (i.e., integral of the Gaussian). The contents of the 1st and 2nd pages are

1. Left-top: Channel vs. threshold. The content is shown in colour. Median thresholds, i.e., the mean of the error function, are plotted on the figure (filled circles)
2. Left-middle: Channel vs. Sigma of the error function (filled circles) fitted and its errors
3. Left-bottom: Channel vs. chi-squares of the fit
4. Right 6 figures: Threshold vs. Number of events of each 6 chips, overlaid all channels

The matching of the median thresholds was 2.7 mV and 2.8 mV in one sigma of the distribution in the top and the bottom 6 chips, respectively.

B. Gain and noise

Multiple of threshold scan were performed for the charge injection from 2 and 8 fC with a step of 0.5 fC. The range of the charge injection was set according to two recommendations: Since parasitic capacitance affects the amount of charge injected, low charge injection points, e.g., below 2 fC, is advised not to use. In order to count the non-linearity of the amplifier, it is also recommended to include the high charge points.

1. First 2 pages: plots of charge injection vs. median threshold, so-called “response curve”. The second order polynomial was fitted to the data in order to derive the small signal gain, i.e., the derivative of the response curve at the threshold.
2. Second 2 pages: plots of charge injection vs. noise sigma in the unit of mV (i.e., output noise) of the 6 chips in the top and the bottom hybrids,
3. Third 2 pages: plots of charge injection vs. small signal gain[1], in mV/fC, of 6 chips,
4. Fourth 2 pages: plots of charge injection vs. noise sigma in the unit of fC (i.e., Input noise) of top and bottom 6 chips

The gain decreased as a result of amplifier nonlinearity. At 2 fC the gain was about 55 mV/fC. The input noise at 2 fC was slightly above 1400 e. The offset from the response curve, i.e., the intercepts of the polynomial at 0 fC was about 80 mV. The gain and noise are summarized in the table of chip characteristics.

1. As of 1999/11/24, a bug in the gain calculation was found in the stan_fitrc.cpp program. The gain, and resulting input noise, in this note are after the fix of the bug.

C. Noise scan

A threshold scan without charge injection, called “noise scan”, is useful in order to evaluate two aspects:

1. stability of the electronics, and
2. offset of the electronics, the noise pedestal.

The 11th to 13th figures are the results of the noise scan of 10k triggers per threshold. The figures in a page are

1. Top-left: Channels vs. Thresholds of the 6 chips in the top hybrid, with contents shown in colour
2. Top-right: projection of content toward the threshold, in log scale, of the 6 chips in the top hybrid
3. Bottom-left and -right: the same figures of the 6 chips in the bottom hybrid

The 11th page is with a trimming at 2 fC being 200 mV. The 12th and 13th are with a trimming at 0 fC being 100 mV. The 11th and 12th are with the detector bias voltage of 100 V, and the 13th with no bias voltage. Because of the gain difference in the chips, the noise pedestal had chip-pattern structure as seen in the distribution of channel vs. threshold when trimmed at 2 fC. Once trimmed at 0 fC, the pattern went away at noise pedestal.

The noise pedestal of the trimming at 2 fC was about 105 mV. There was about 20 mV shift in the offset estimated from the response curve. The shifts of chips are summarized in the table of chip characteristics.

Plausible explanations of the shift are

1. The response curve would be more linear in low threshold than expected from the polynomial
2. The residual parasitic capacitance would have caused to reduce the charges

From the offset of about 105 mV and the threshold of 200 mV of 2 fC, the threshold of 1fC would be expected around 150 mV. The noise occupancy at 1 fC (150 mV) was <1 events out of 10^4 triggers, i.e., $<10^{-4}$.

In the scatter and projection plots, there are minor structures which were caused by a few channels deviated largely. There was no apparent common-mode type structure, even with the detector bias voltage being off, although there might be a hint at 20 mV below the noise pedestal.

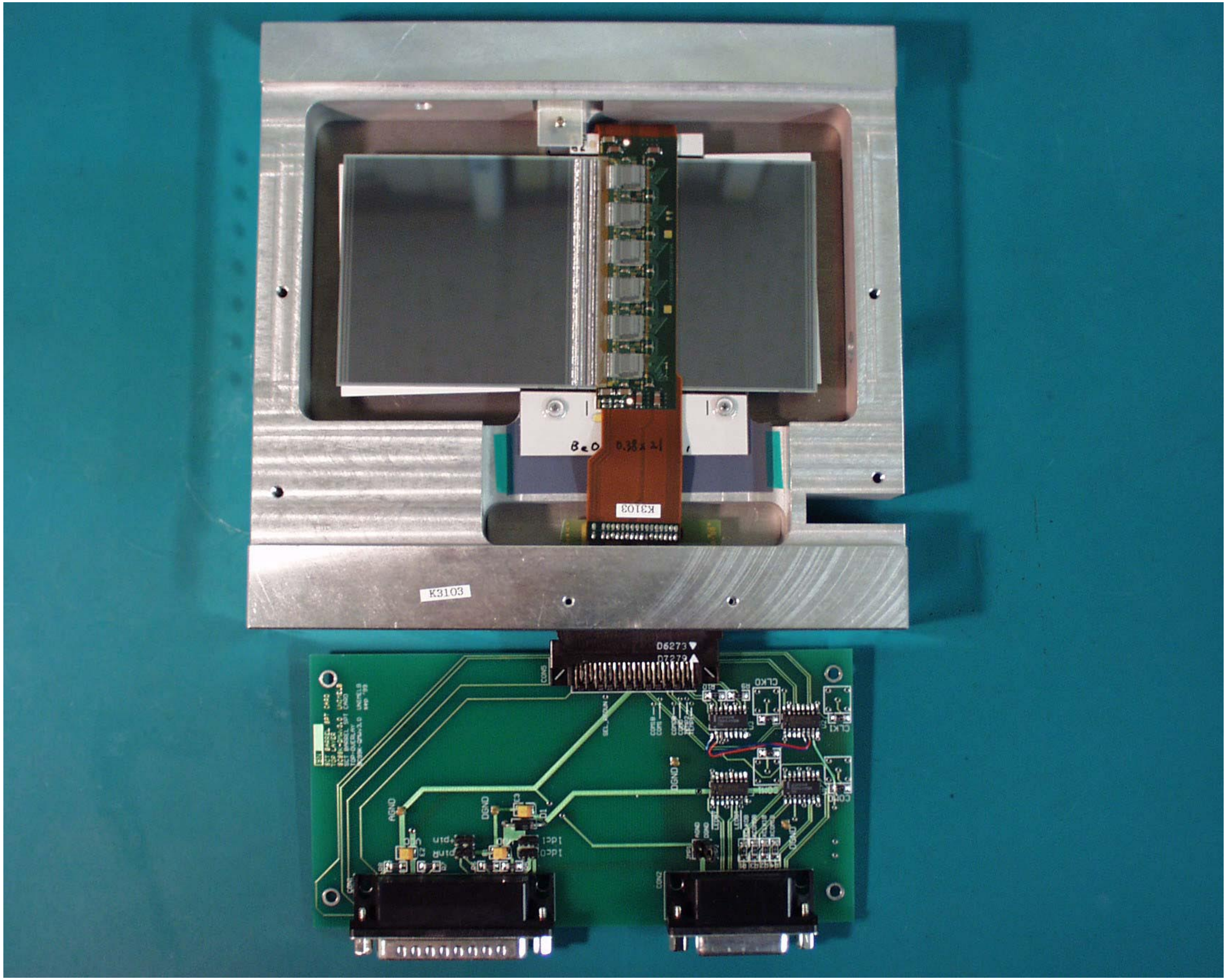
III. Conclusion

Although preliminary, the double-sided ABCD2T module with the barrel kapton hybrid showed:

1. Threshold matching was <3 mV after trimming,
2. Gain was 55 mV/fC at 2 fC in average of chips,
3. Noise was1454 $\pm$ 37 e at 2 fC, and
4. No apparent instability was observed.

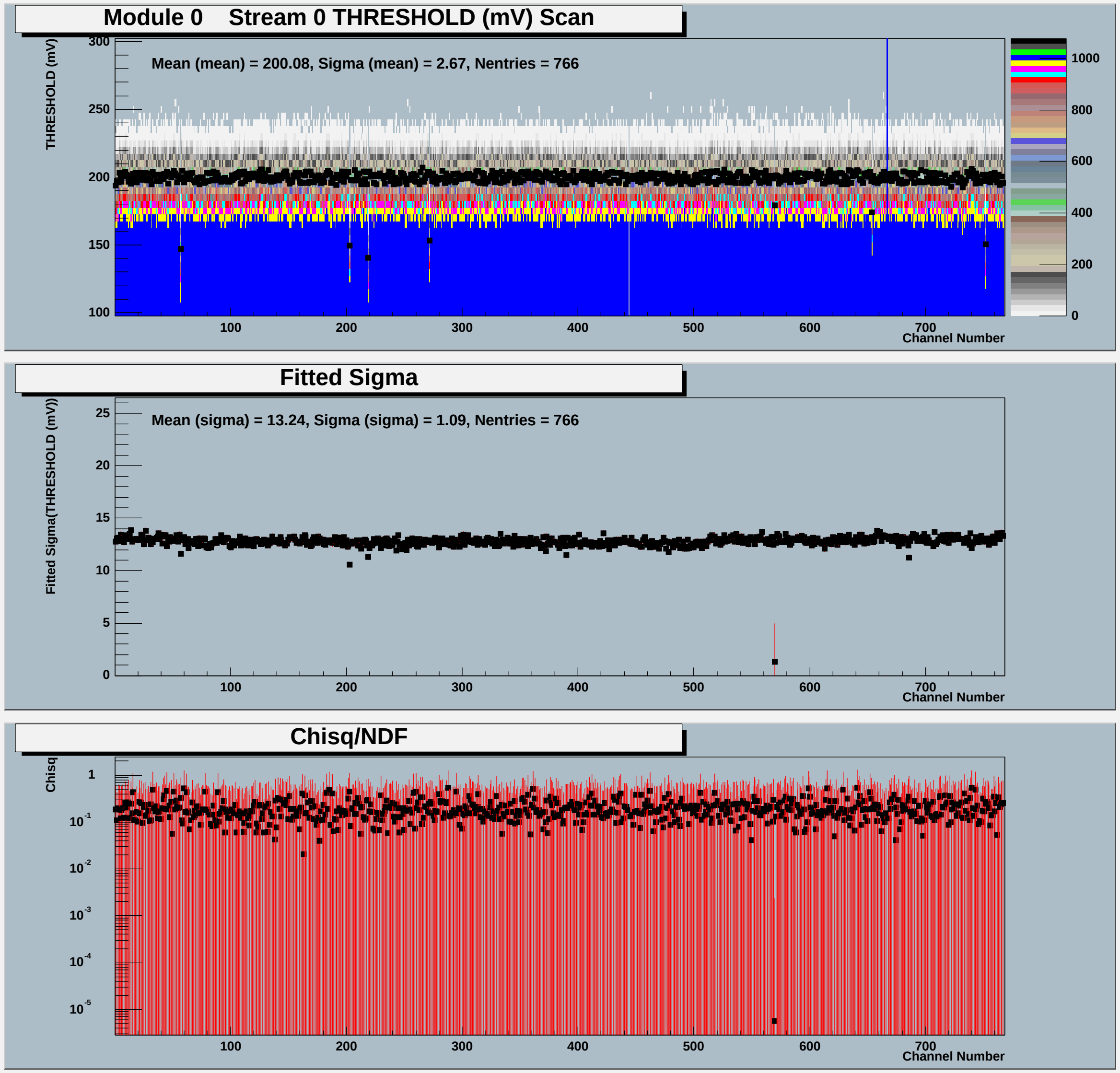
IV. References

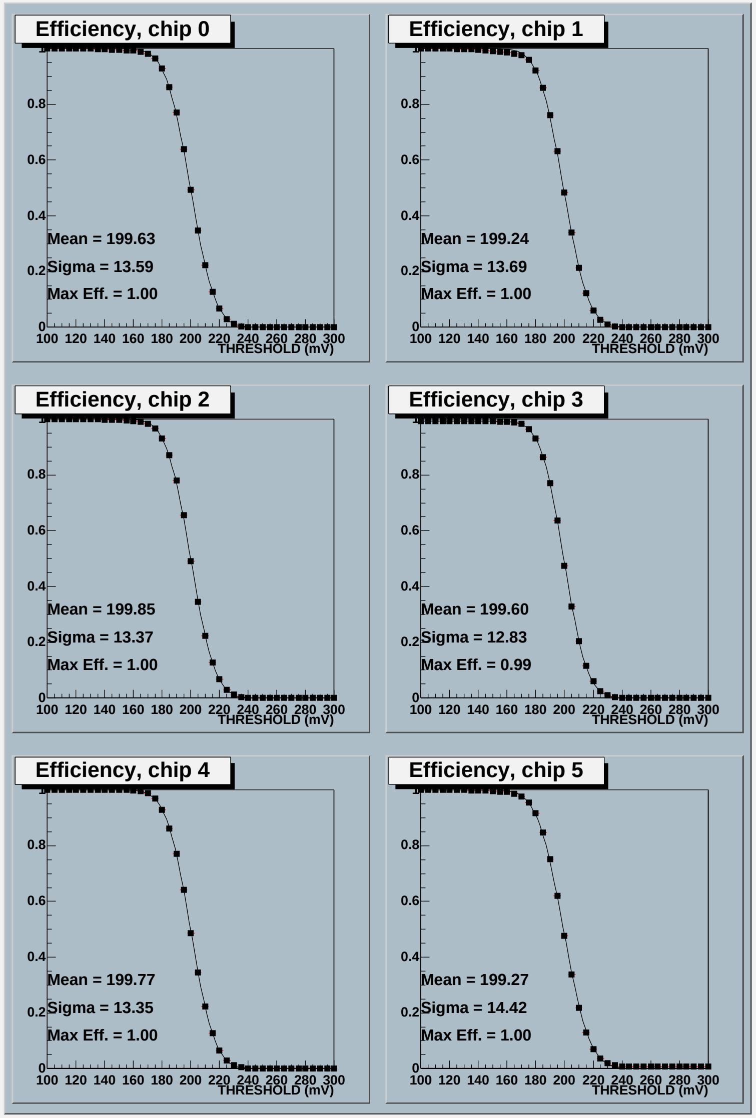
[1] T. Kondo et al., Barrel Kapton hybrid
[2] W. Dabrowski et al., ABCD specification, V2.1
[3] M. Morrissey et al., MuSTARD VME modules
[4] G. Moorhead, P. W. Phillips et al., sctdaq


K3103
D6273
CLK0
AGND
DGND

ATLAS SCT Module Test

Run 238 Scan 4 Module 0 Stream 0 Scan type: THRESHOLD (mV)





ATLAS SCT Module Test

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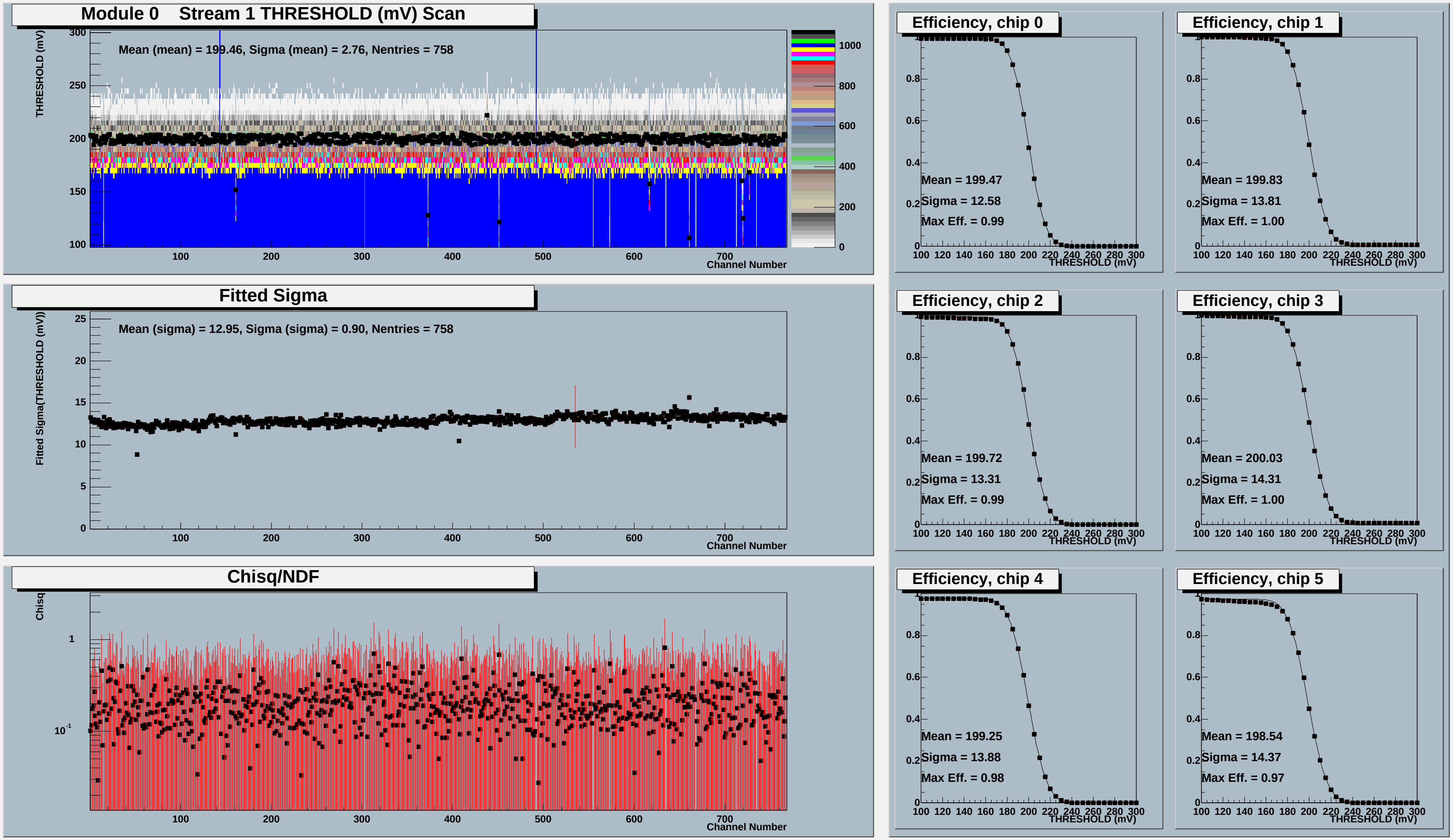

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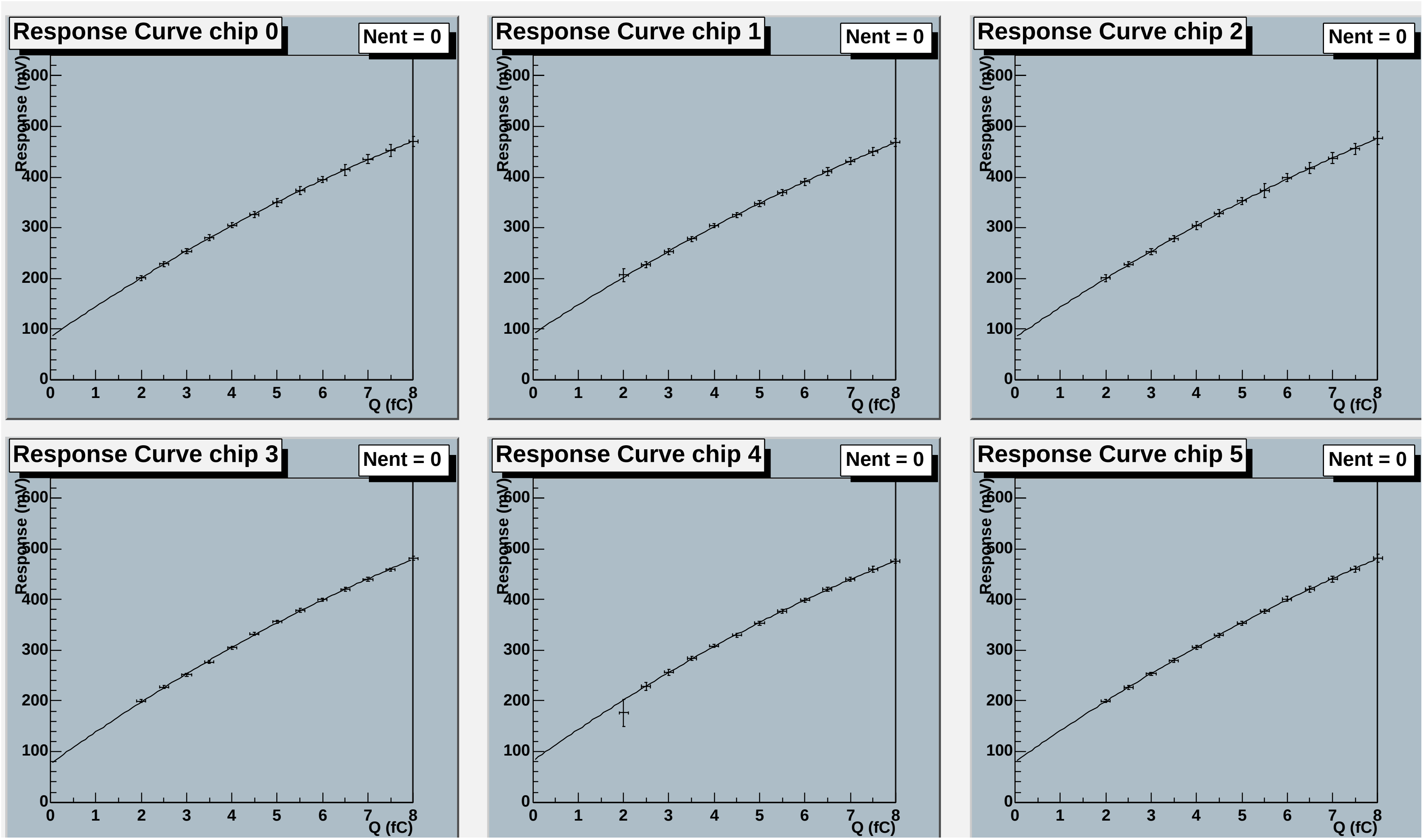

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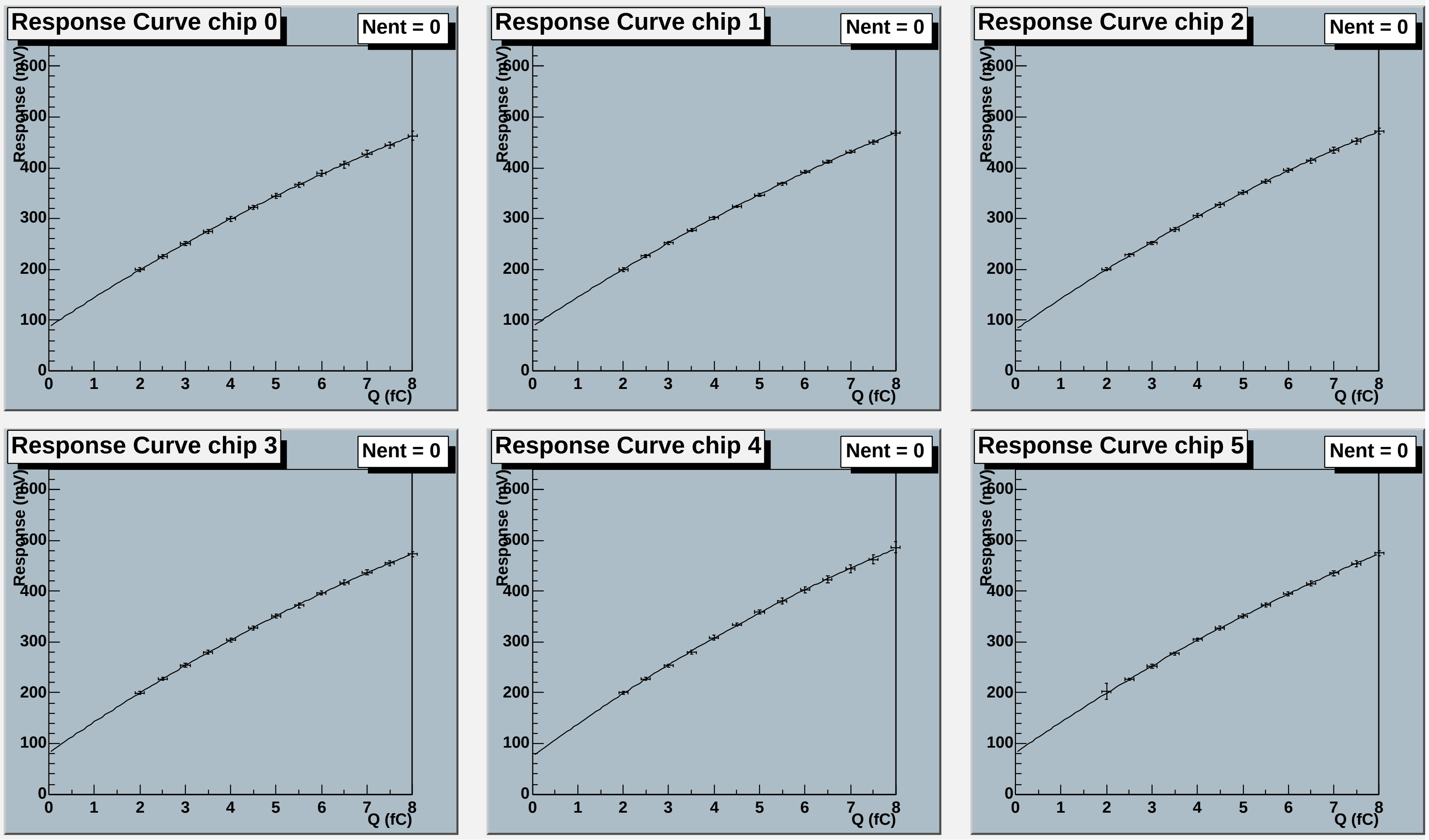
Response Curve chip 1
Nent = 0
Response Curve chip 2
Nent = 0
Response Curve chip 3
Nent = 0
Response Curve chip 4
Nent = 0
Response Curve chip 5
Nent = 0
Response (mV)
Q (fC)
0
100
200
300
400
500
600
0
1
2
3
4
5
6
7
8

strc238_4_0_1



Response Curve chip 0
Nent = 0
Response Curve chip 1
Nent = 0
Response Curve chip 2
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Response Curve chip 3
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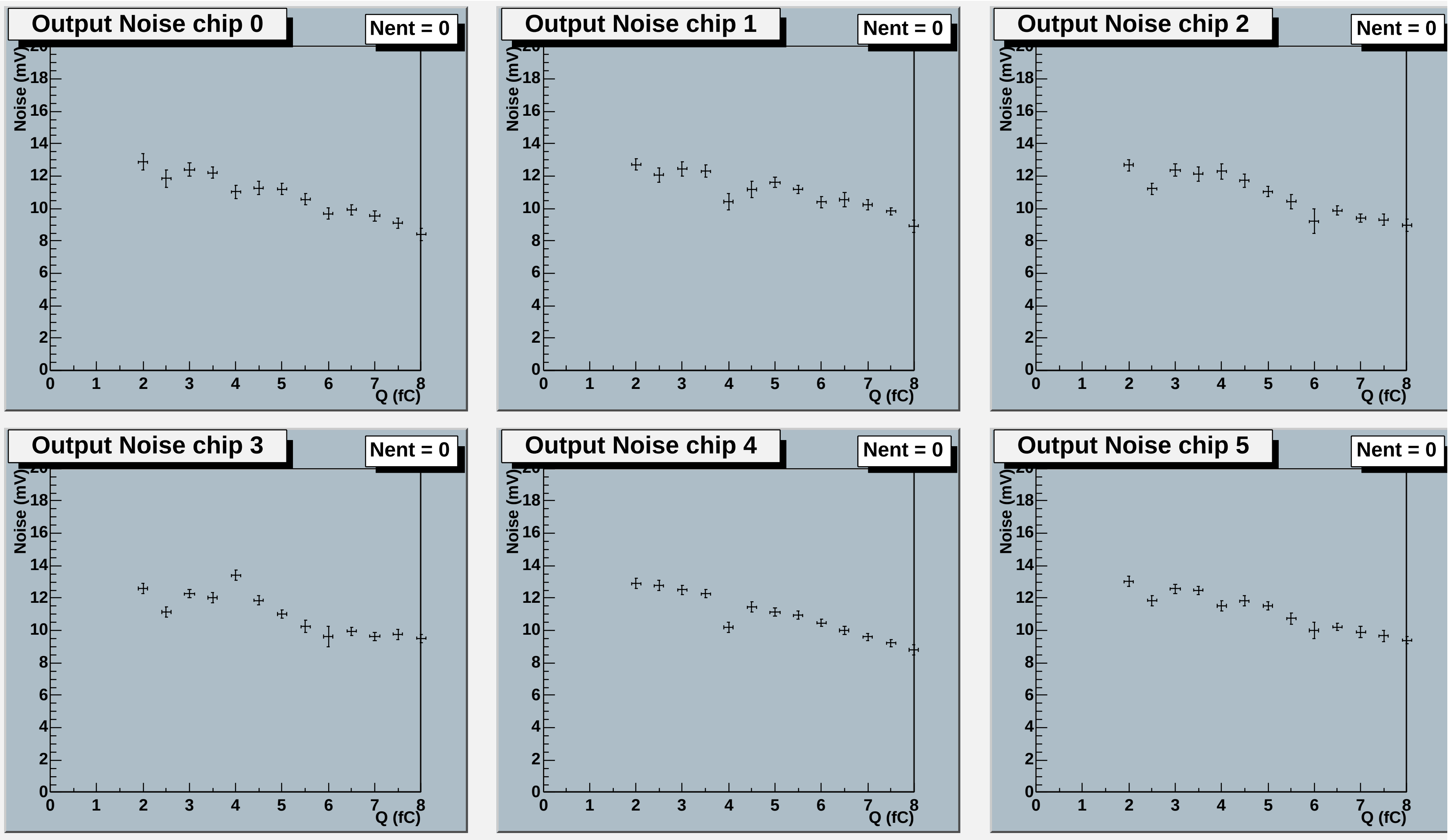
Response Curve chip 4
Nent = 0
Response Curve chip 5
Nent = 0
Response (mV)
Q (fC)

strc238_4_0_0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Output Noise chip 2
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Output Noise chip 3
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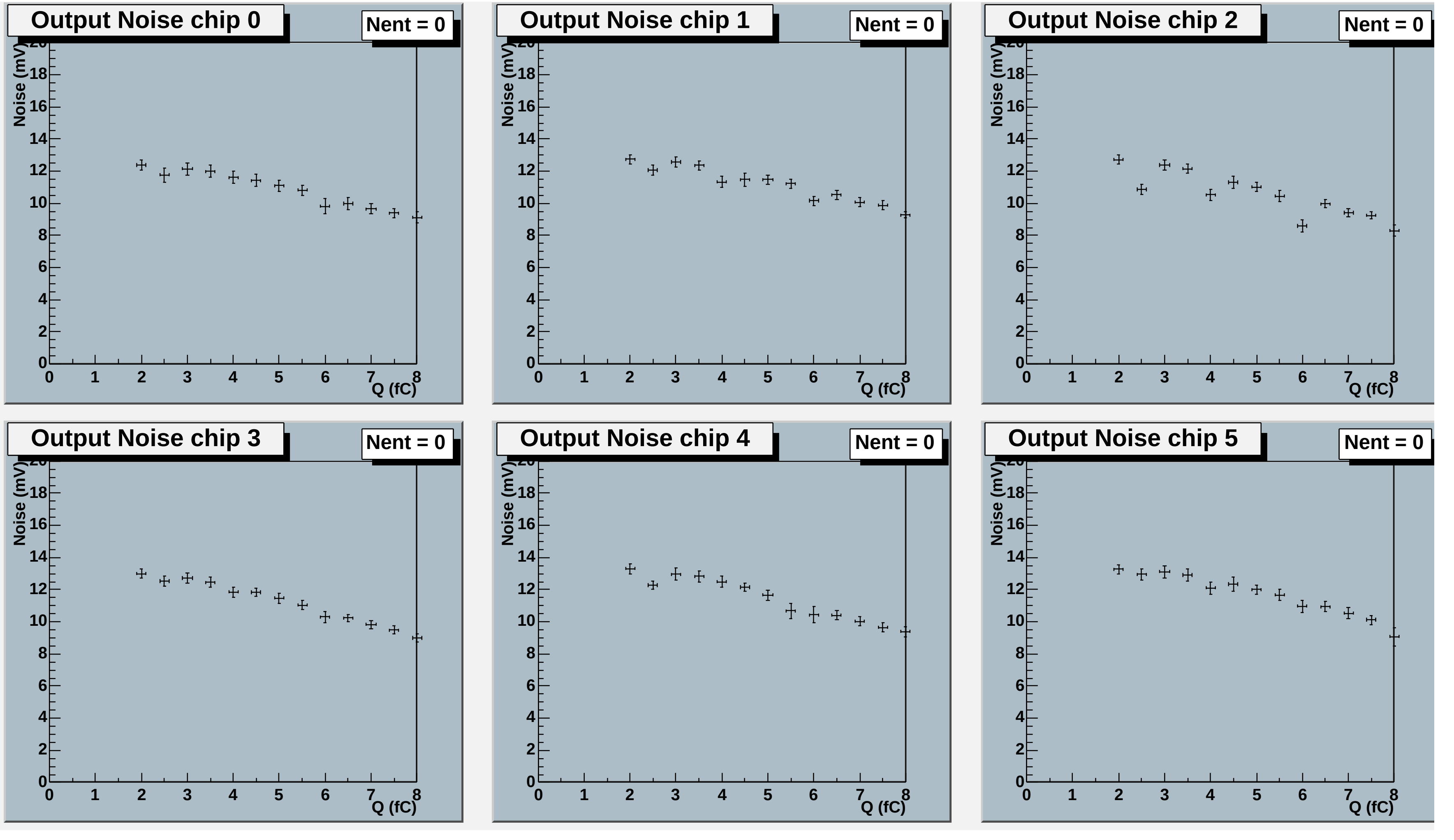
Output Noise chip 4
Nent = 0
Output Noise chip 5
Nent = 0
Noise (mV)
Q (fC)

strc238_4_0_1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Q (fC)
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Noise (mV)
Q (fC)
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Noise (mV)
Q (fC)
Output Noise chip 3
Nent = 0
Noise (mV)
Q (fC)
Output Noise chip 4
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Noise (mV)
Q (fC)
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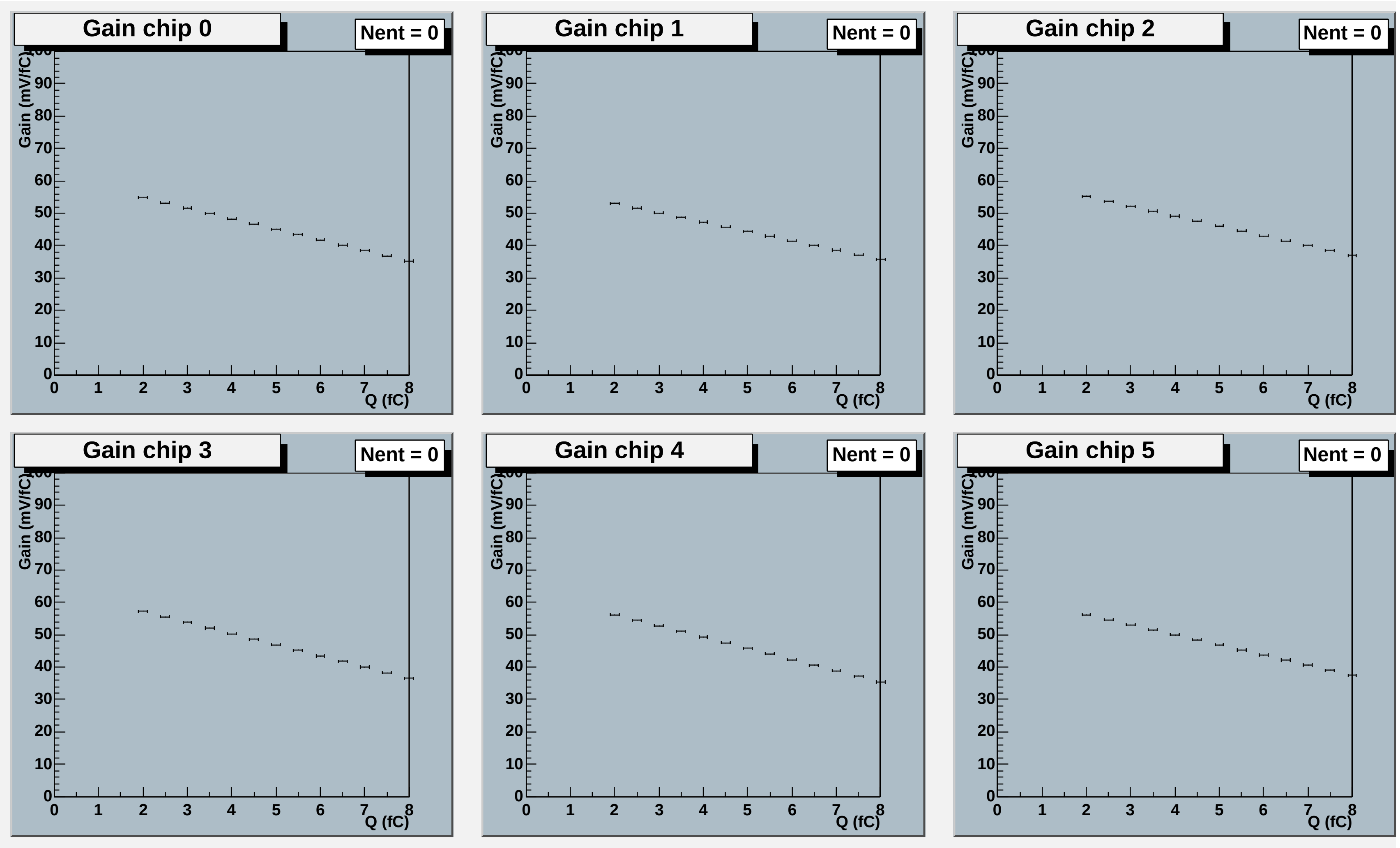
Noise (mV)
Q (fC)

strc238_4_0_0



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Gain chip 2
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Gain chip 3
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Gain chip 4
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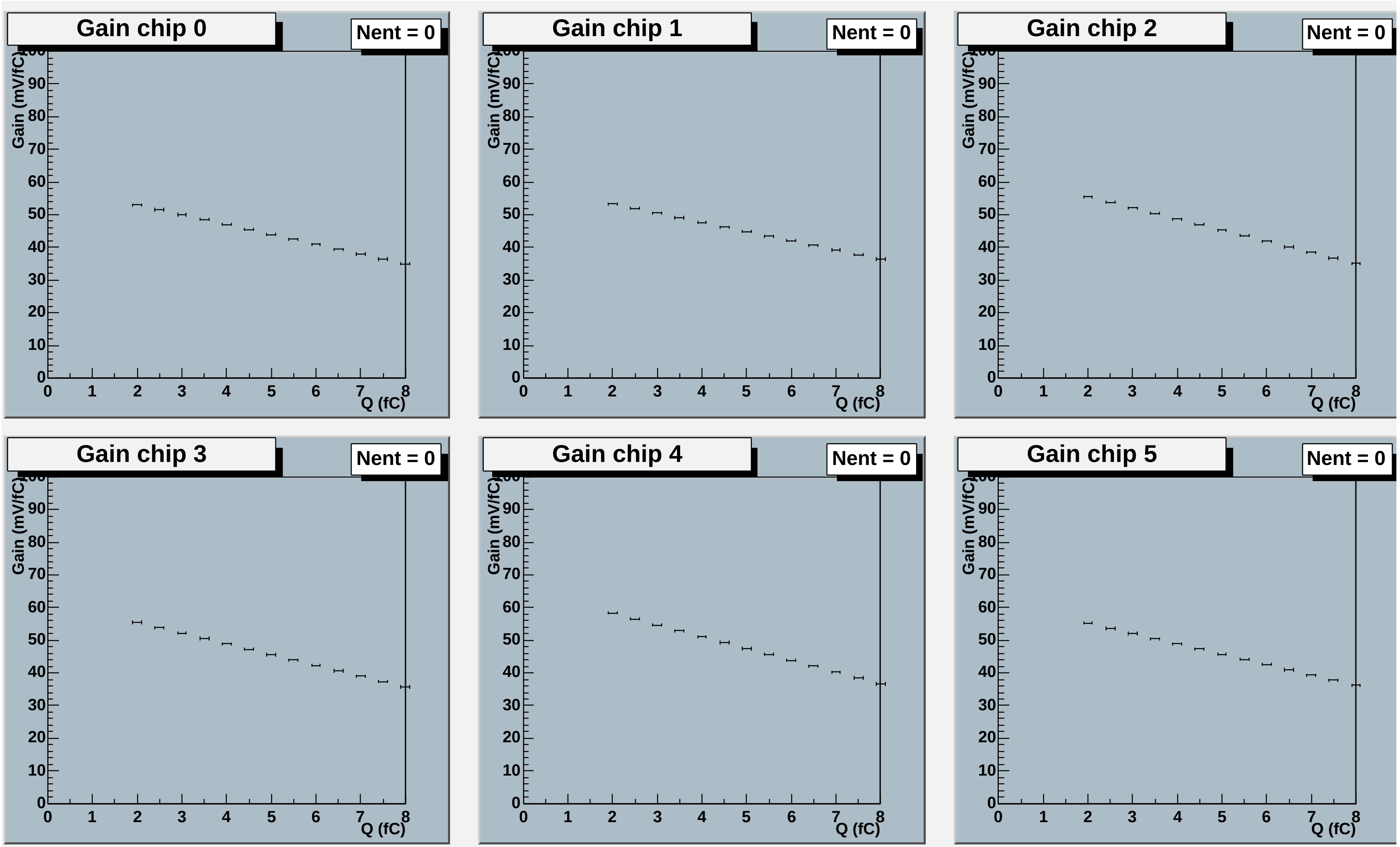
Gain chip 5
Nent = 0
Gain (mV/fC)
Q (fC)

strc238_4_0_1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Gain chip 2
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Gain chip 3
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Gain chip 4
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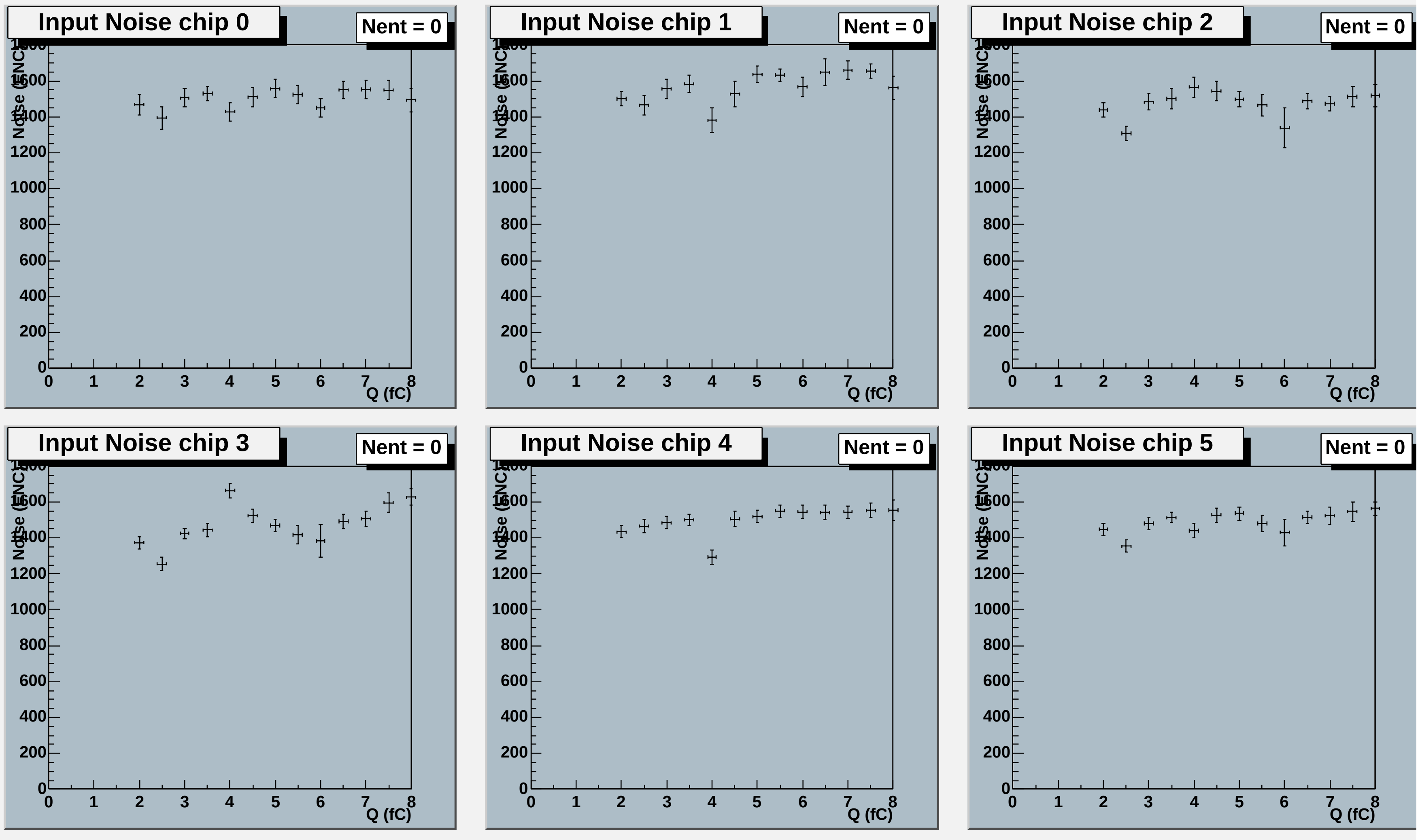
Gain chip 5
Nent = 0
Gain (mV/fC)
Q (fC)

strc238_4_0_0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Input Noise chip 1
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Input Noise chip 2
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Input Noise chip 3
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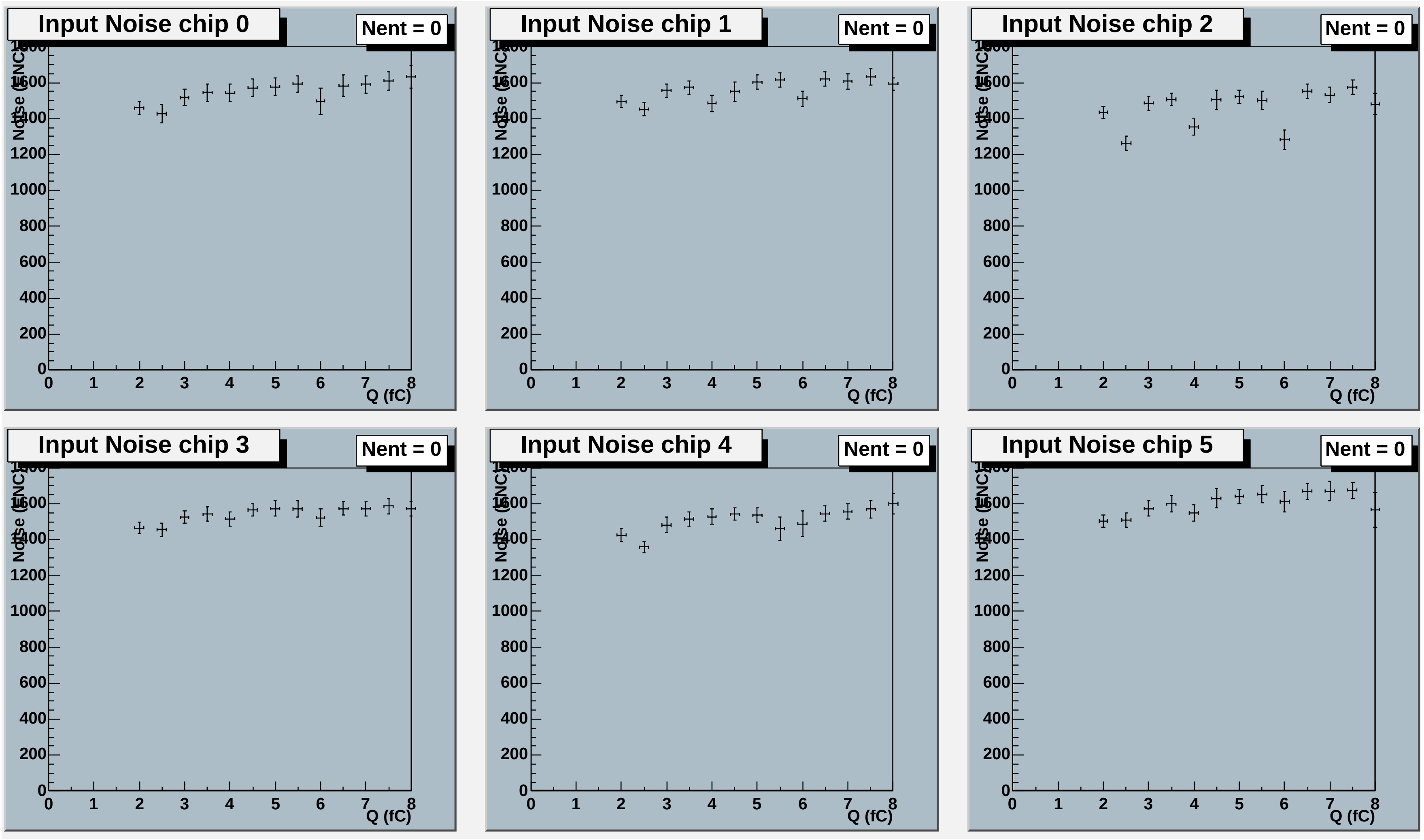
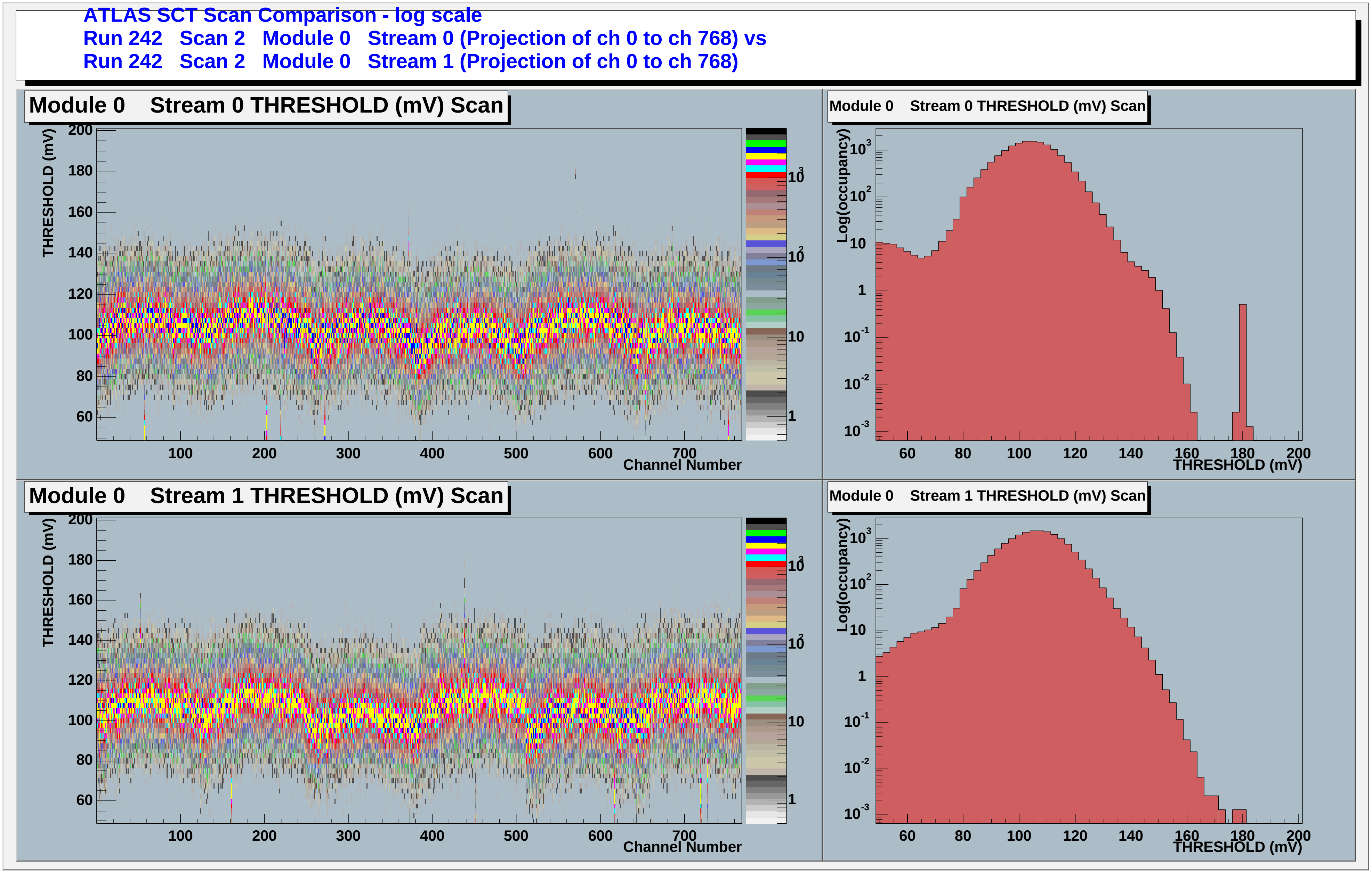
Input Noise chip 4
Nent = 0
Input Noise chip 5
Nent = 0
Noise (ENC)
Q (fC)

strc238_4_0_1

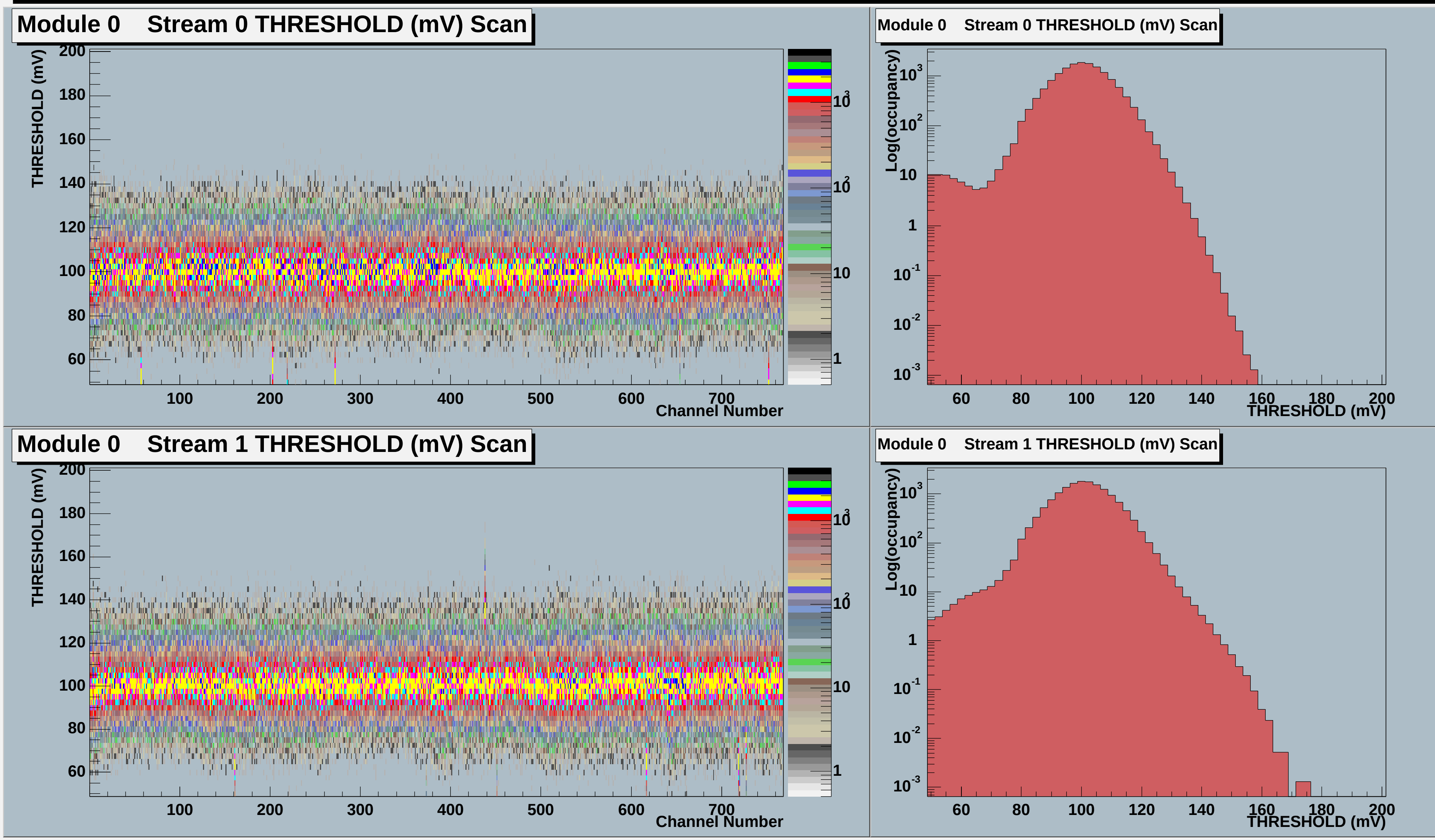

Input Noise chip 0
Nent = 0
Input Noise chip 1
Nent = 0
Input Noise chip 2
Nent = 0
Input Noise chip 3
Nent = 0
Input Noise chip 4
Nent = 0
Input Noise chip 5
Nent = 0
Noise (ENC)
Q (fC)


ATLAS SCT Scan Comparison - log scale
Run 242 Scan 2 Module 0 Stream 0 (Projection of ch 0 to ch 768) vs
Run 242 Scan 2 Module 0 Stream 1 (Projection of ch 0 to ch 768)
Module 0 Stream 0 THRESHOLD (mV) Scan
THRESHOLD (mV)
Channel Number
Module 0 Stream 0 THRESHOLD (mV) Scan
Log(occupancy)
THRESHOLD (mV)
Module 0 Stream 1 THRESHOLD (mV) Scan
THRESHOLD (mV)
Channel Number
Module 0 Stream 1 THRESHOLD (mV) Scan
Log(occupancy)
THRESHOLD (mV)

ATLAS SCT Scan Comparison - log scale

Run 251 Scan 1 Module 0 Stream 0 (Projection of ch 0 to ch 768) vs

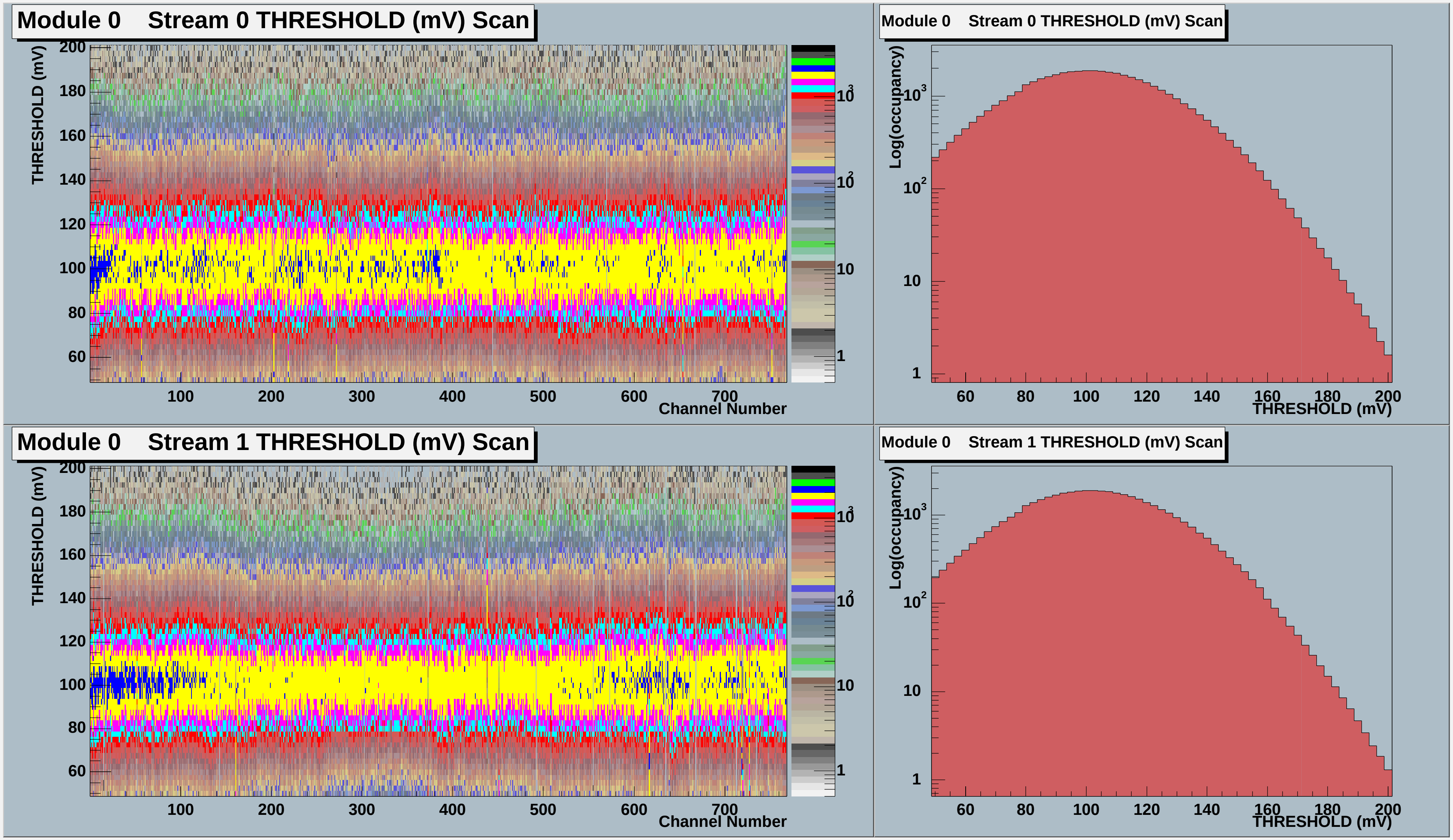
Run 251 Scan 1 Module 0 Stream 1 (Projection of ch 0 to ch 768)



ATLAS SCT Scan Comparison - log scale

Run 251 Scan 2 Module 0 Stream 0 (Projection of ch 0 to ch 768) vs

Run 251 Scan 2 Module 0 Stream 1 (Projection of ch 0 to ch 768)



Chip characteristics

	Wafer probing							Module							
Chip#	Chip address	ndead	dead ch.	non-trim	gain [mV/fC]	offset [mV]	qfactor	Dead	Non-trim	Gain module	Gain-Diff	Offset-module	Offset-Diff	Noise [e]	Noise error
0	M00	0		1	59.4	-16.4	7.0	0		54.8	-4.5	-19.1	-2.6	1468.6	57.8
1	S01	0		1	56.5	-2.7	7.4	0		53.0	-3.6	-15.8	-13.1	1501.1	40.7
2	S02	0		1	61.1	-18.3	5.4	0		55.2	-5.9	-17.2	1.1	1438.2	39.2
3	S03	1	60	1	63.0	-13.5	5.5	1		57.2	-5.8	-21.6	-8.1	1374.7	34.5
4	S04	1	58	2	62.0	-15.5	7.9	0		56.2	-5.8	-22.1	-6.6	1433.1	34.1
5	E05	1	27	2	60.1	-16.8	5.7	0		56.2	-3.9	-20.2	-3.4	1448.5	34.5
6	M08	0		1	57.6	-5.8	6.4	1		53.0	-4.6	-18.7	-12.9	1459.1	38.3
7	S09	2	15, 33	2	59.9	-7.3	6.0	0		53.3	-6.6	-19.7	-12.4	1493.9	34.2
8	S10	1	47	3	60.2	-2.9	5.7	1		55.5	-4.7	-16.6	-13.7	1434.0	33.4
9	S11	2	67, 108	3	60.5	-18.3	7.1	0		55.5	-5.1	-25.4	-7.1	1465.3	31.2
10	S12	1	43	4	61.4	-10.5	6.4	3		58.3	-3.1	-26.2	-15.7	1426.2	34.5
11	E13	0		6	58.2	-5.7	7.0	3		55.2	-3.0	-24.0	-18.3	1502.4	32.9
Sum		9		27				9	32	<55.3>				<1454>	<37>