

Results from the beamtest and lab measurements of ABCD2T and CAFE/ABC modules at KEK

Y. Unno

Physics, KEK

for many other contributors to the beamtest

- **Dec99 beamtest at KEK (T450)**
- **Calibrations**
- **Threshold scans**
- **Bias voltage dependence of median charge**
- **Experience gained**
- **Summary**

Dec99 beamtest at KEK (T450)

- **Execution: Dec 10-21, 1999**

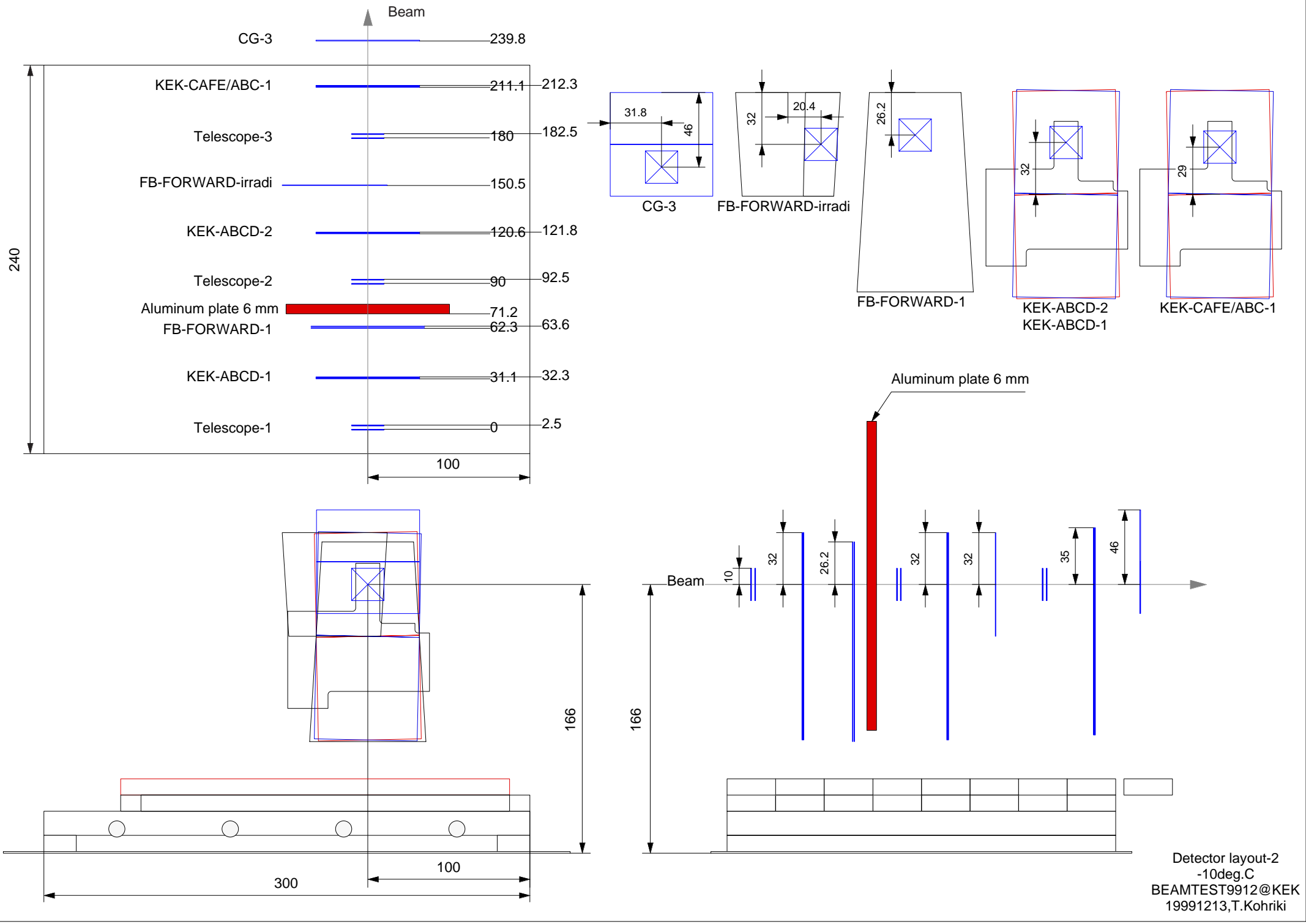
- π^2 beamline in the 12 GeV PS at KEK, 4 GeV/c π^-
- Participants:
 - Domestic = Y. Unno, Y. Ikegami, T. Kohriki, +6~9 students
 - Abroad = G. Moorhead, K. Runge, J. Ludwig, Z. Dorazel
- Photo's out of the beamtest

- **DUT's: 5 modules**

- Module 0: KEK-ABCD#1, 285 μm , trimmed at 2 fC to 200 mV
- Module 1: FR-ABCD, 285 μm , trimmed at 2 fC to 200 mV
- Module 2: KEK-ABCD#2, 325 μm , not trimmed
- Module 3: FR-irrad det-ABCD, 285 μm , trimmed?
- Module 4: KEK-CAFE, 285 μm
- Module 5: CG3, anchor

- **Run conditions:**

- Edge detection=ON, Mode=Any hits
- 2cm x 2cm triggered region with 3 planes of scintillator
- Two temperatures: +10, and -10 $^{\circ}\text{C}$
 - +10 $^{\circ}\text{C}$ = Mod0, Mod1, Anchor
 - 10 $^{\circ}\text{C}$ = All





Modules setup

- **Three telescope planes + Anchor**

- Two DUT's between telescopes or anchor
- Separation: 30 mm each
- Sequence:

Telescope1

Mod0.....KEK-ABCD#1

Mod1.....Freiburg-ABCD

- (6 mm Al plate)

Telescope2

Mod2.....KEK-ABCD#2

Mod3.....Freiburg-irradiated detector

Telescope3

Mod4.....KEK-CAFE/ABC

Anchor (CG3)

- No shielding between the DUTs
- 6 mm Aluminum plate was forgotten to be removed

- **Setup drawings**

- Setup of -10 °C
- Setup of +10 °C

Run quality

- **Telescopes**

- Hit maps
- Pulse heights
- Number of hits

- Not incorporated in the current analysis yet

- **DUTs**

- Hit maps
- Correlation plots with anchor
- Number of hits
- Link0 = Top side 6 chips
- Link1 = Bottom side 6 chips

- Typical example at 1.4 fC threshold

- **Correlation with anchor**

- Hit positions
- Deviations from anchor position
- Efficiencies derivation in this analysis

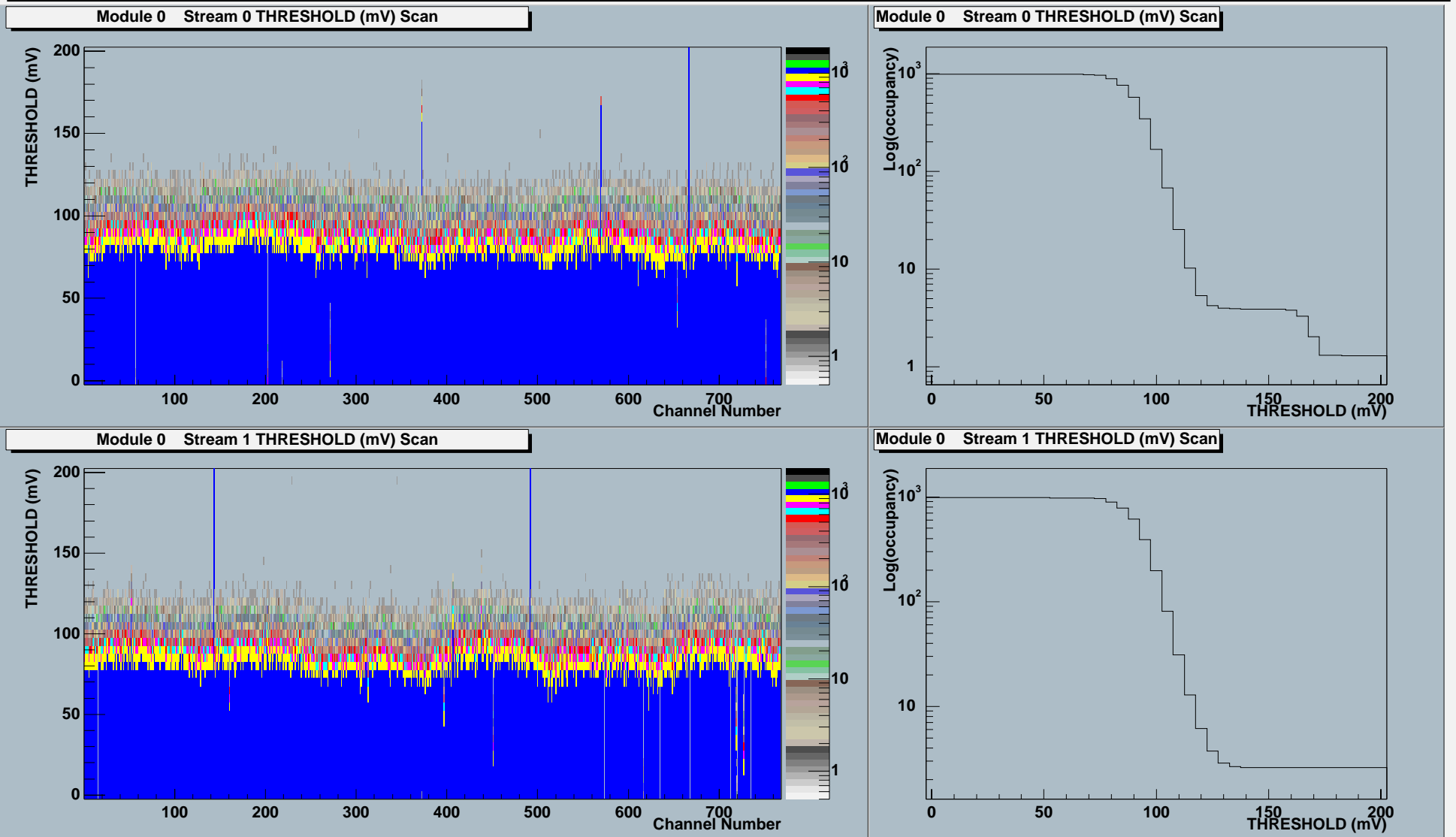
Module stability

- **Pedestal noise of Modules 0, 1, 2, 4**
 - Out of in-situ calibration runs
 - Null charge injection
 - Detector bias 100V
 - Edge detection = OFF
 - Mode = X1X
 - Beam ~ middle 2 chips, ch 256 - 511

ATLAS SCT Scan Comparison - log scale

Run 1115 Scan 1 Module 0 Stream 0 (Projection of ch 0 to ch 768) vs

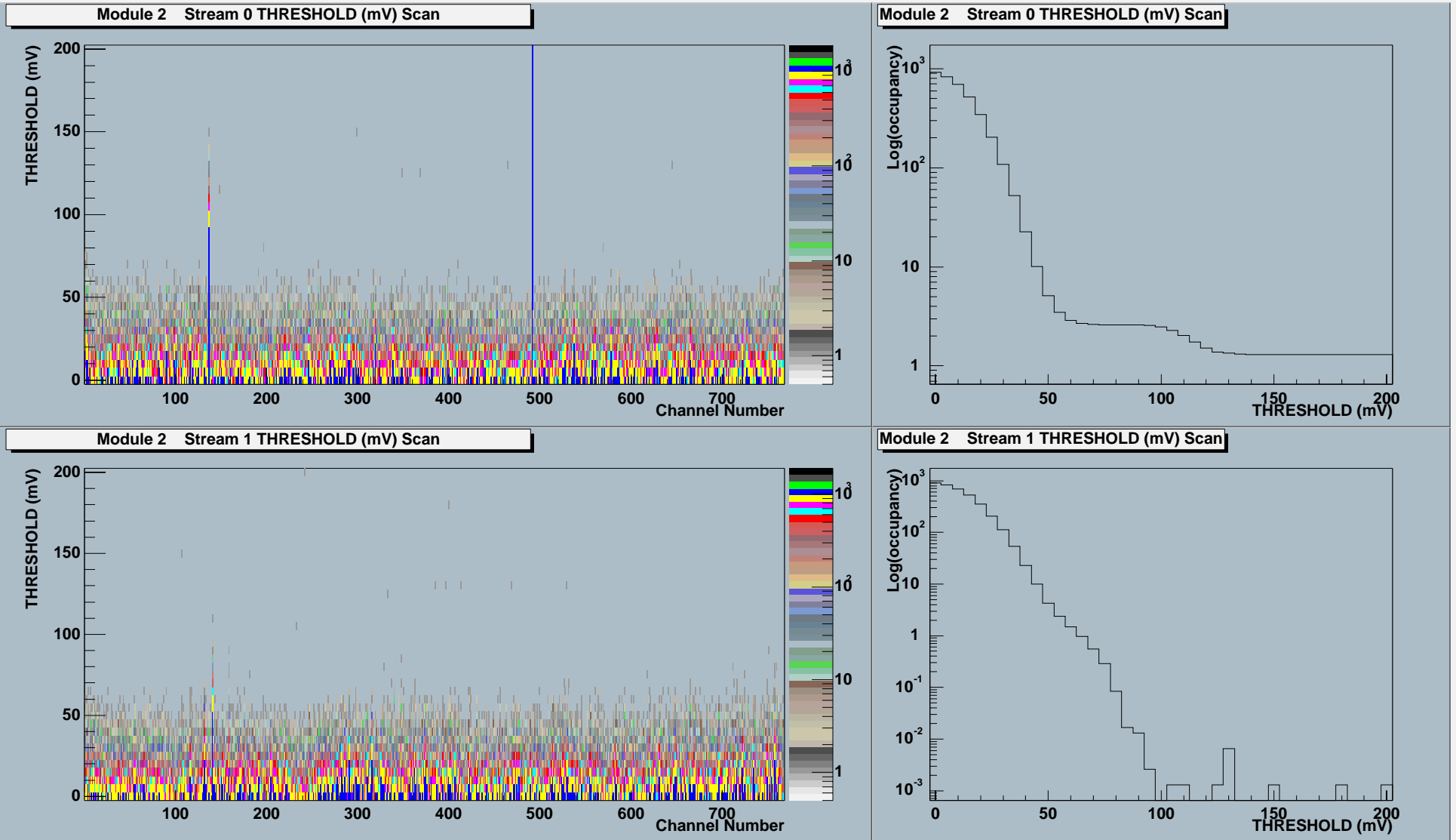
Run 1115 Scan 1 Module 0 Stream 1 (Projection of ch 0 to ch 768)



ATLAS SCT Scan Comparison - log scale

Run 1115 Scan 1 Module 2 Stream 0 (Projection of ch 0 to ch 768) vs

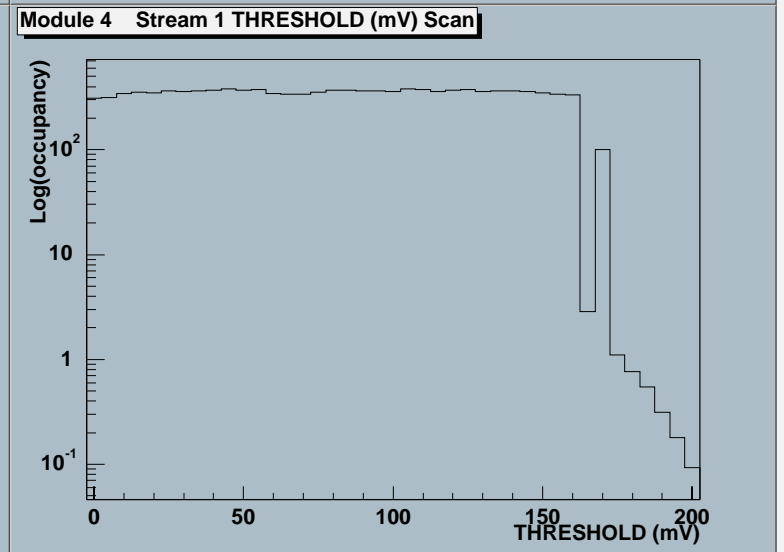
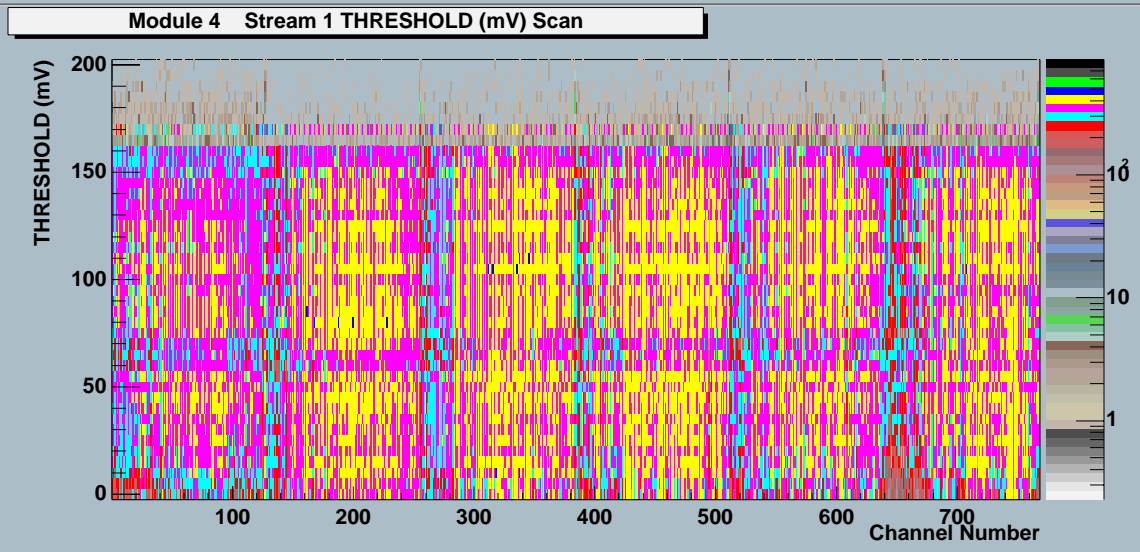
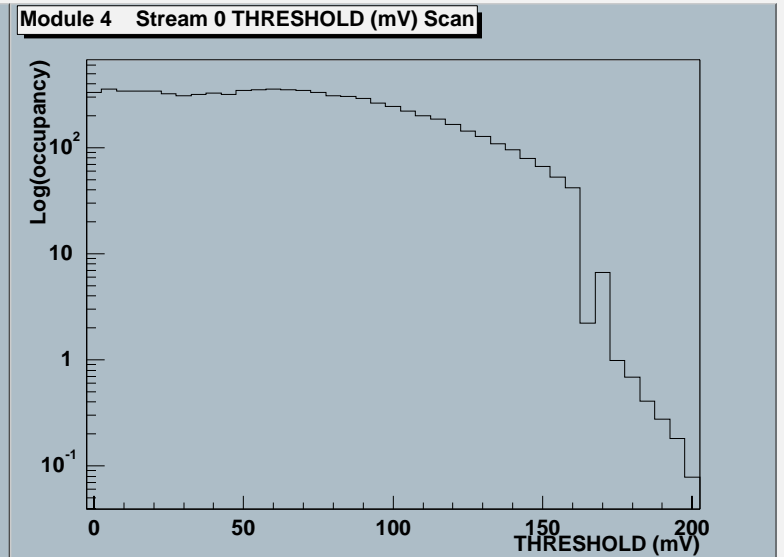
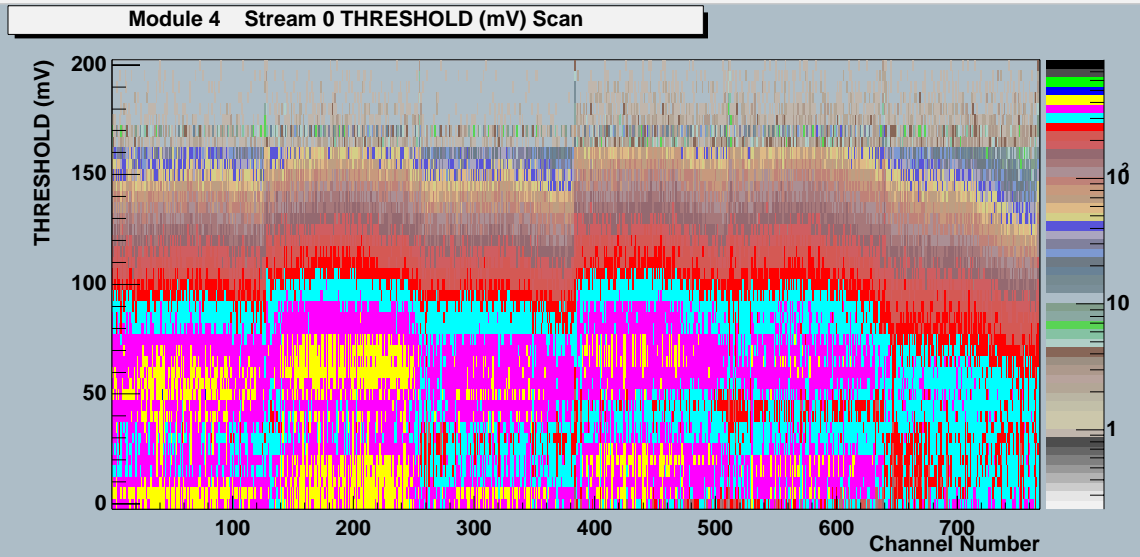
Run 1115 Scan 1 Module 2 Stream 1 (Projection of ch 0 to ch 768)



ATLAS SCT Scan Comparison - log scale

Run 1115 Scan 1 Module 4 Stream 0 (Projection of ch 0 to ch 768) vs

Run 1115 Scan 1 Module 4 Stream 1 (Projection of ch 0 to ch 768)



Module stability - continued

- **Mod0 - KEK-ABCD#1**

- Trimmed: 200 mV = 2 fC
 - Gain ~ 50 mV/fC, then pedestal ~ 100 mV
- Top: 2 deads + 1 noisy channels in the beam region
- Bottom: 2 deads + 1 sick + 1 noisy in the beam region

- **Mod1 - Freiburg ABCD**

- See the report by Freiburg

- **Mod2 - KEK-ABCD#2**

- Not trimmed
 - chip3 (0-5) of top side, ~50 mV/trim step (normally ~5mV/step)
 - did not find a way to incorporate both good and sick trim chips
- Top: 1 noisy channels in the beam region
- Bottom: none?

- **Mod4 - KEK-CAFE/ABC**

- Unstable upto 160 or 170 mV (0.6~0.7 fC)
 - Hybrid: unstable upto 100 mV (~0.3 fC)

In-situ calibration

- **Notes**

- Not reflected into the analysis yet
- Bias 100V (Irrad 350V)

- **Set of results**

- 1. Typical threshold scan s-plots, top and bottom sides
- 2. Response curves, gains, noises
- 3. List of summaries

- Mod0(KEK-ABCD#1)

- Mod1(FR-ABCD)

- Mod2(KEK-ABCD#2)

- Mod3(FR-irrad)

- Mod4(KEK-CAFE)

- KEK-CAFE calibration at Fuji

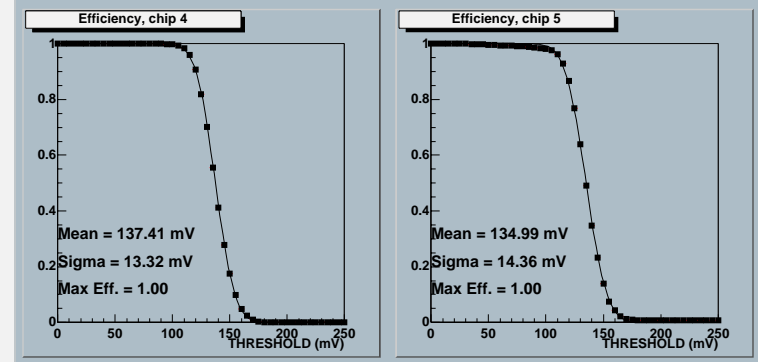
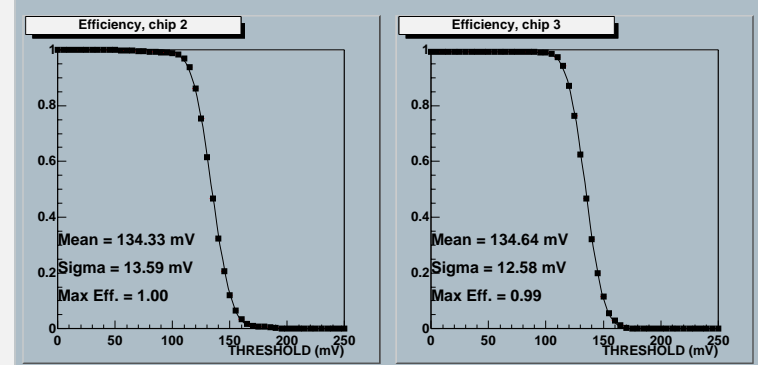
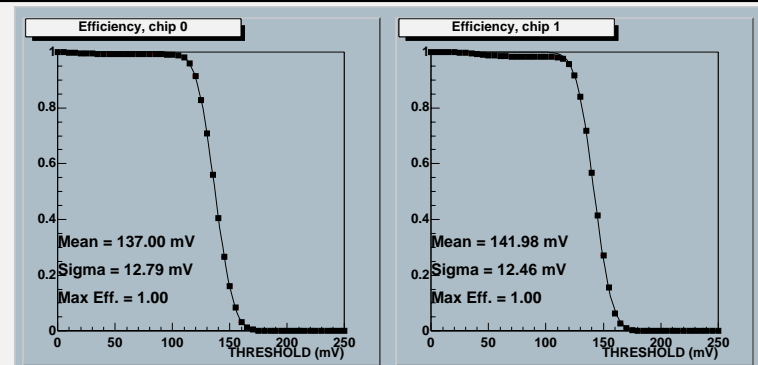
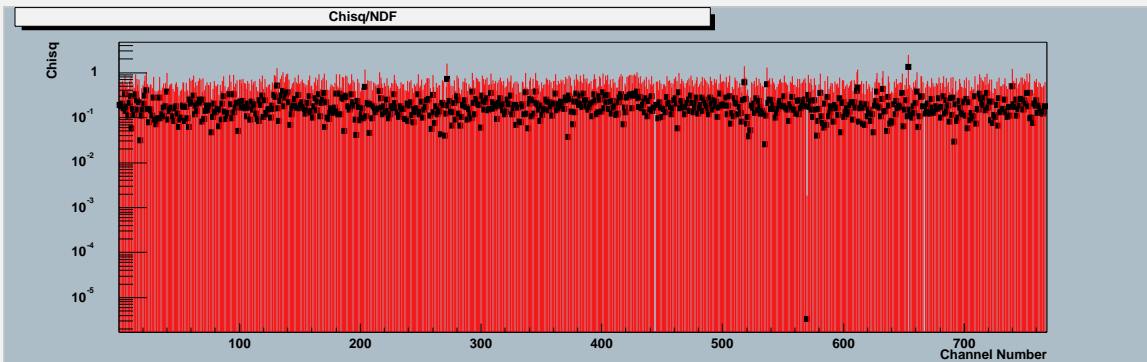
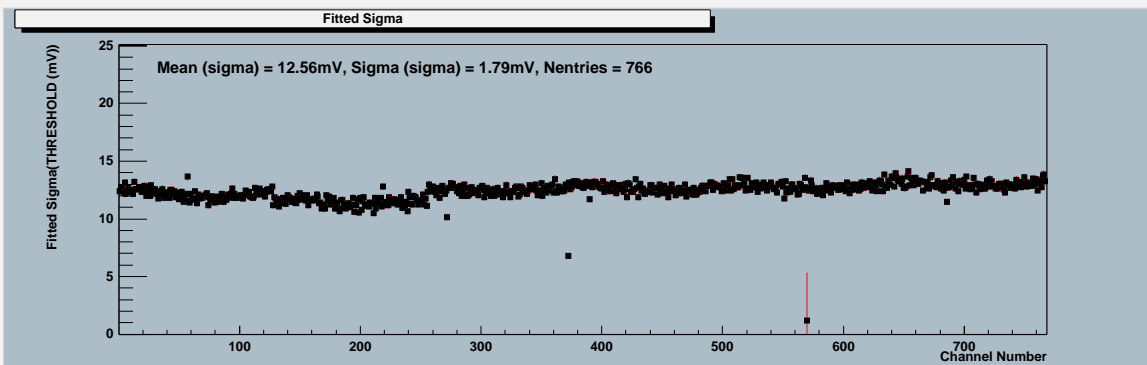
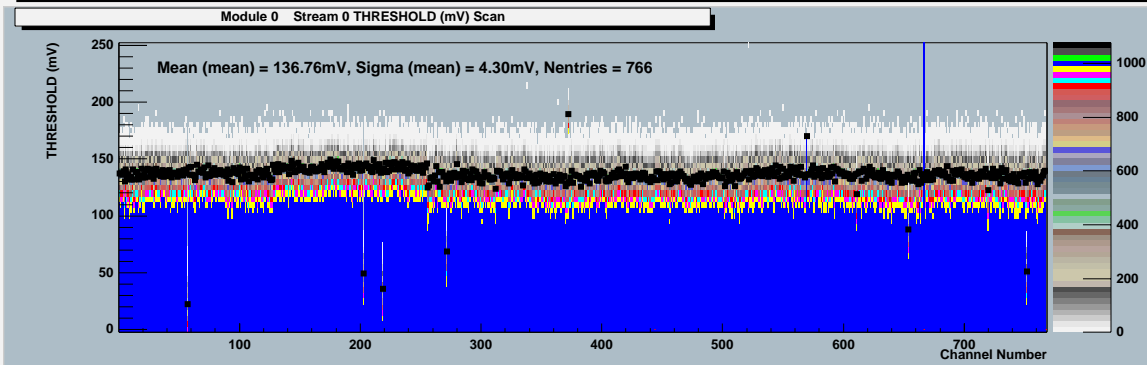
- Module (Bias 150V)

- Hybrid

```
#run scan q ABCD2T in beam at -10 deg.C
#1115 1 0.00
#1115 2 0.60
#1115 3 0.80
#1115 4 1.00
#1115 5 1.20
#1115 6 1.40
#1115 7 1.50
#1115 8 1.60
#1115 9 1.80
1115 10 2.00
1115 11 2.20
1115 12 2.50
1115 13 3.00
1115 14 3.50
1115 15 4.00
1115 16 4.50
1115 17 5.00
1115 18 5.50
1115 19 6.00
1115 20 6.50
1115 21 7.00
1115 22 7.50
1115 23 8.00
```

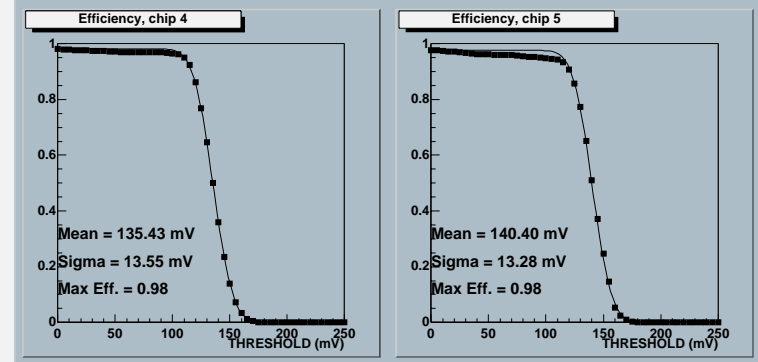
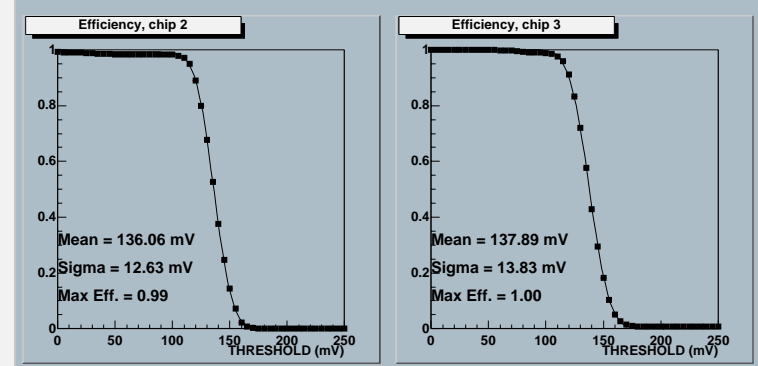
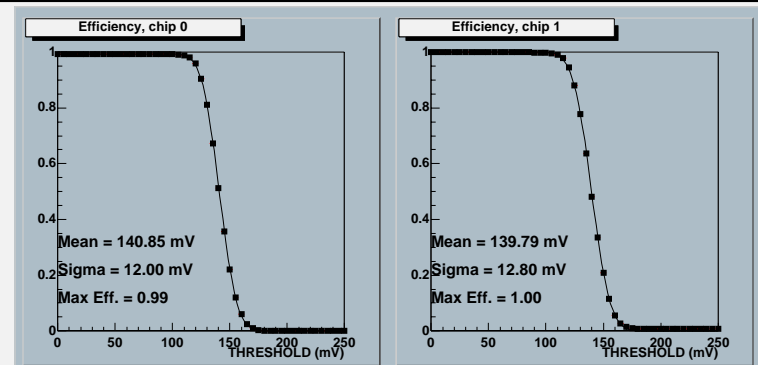
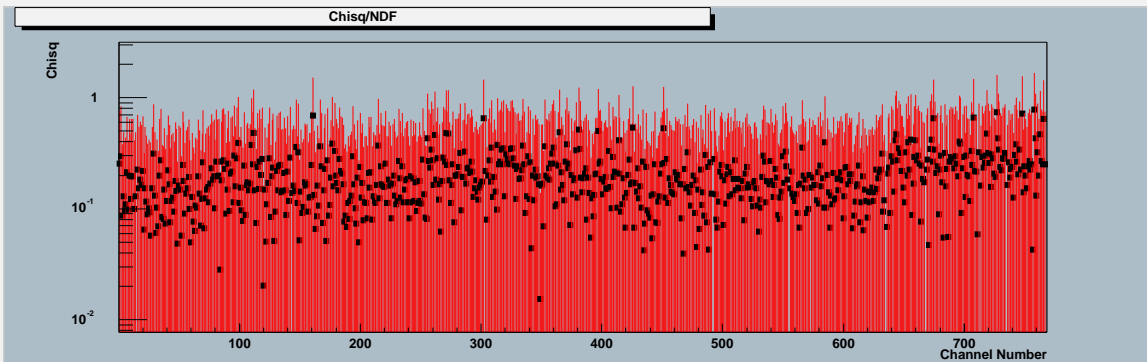
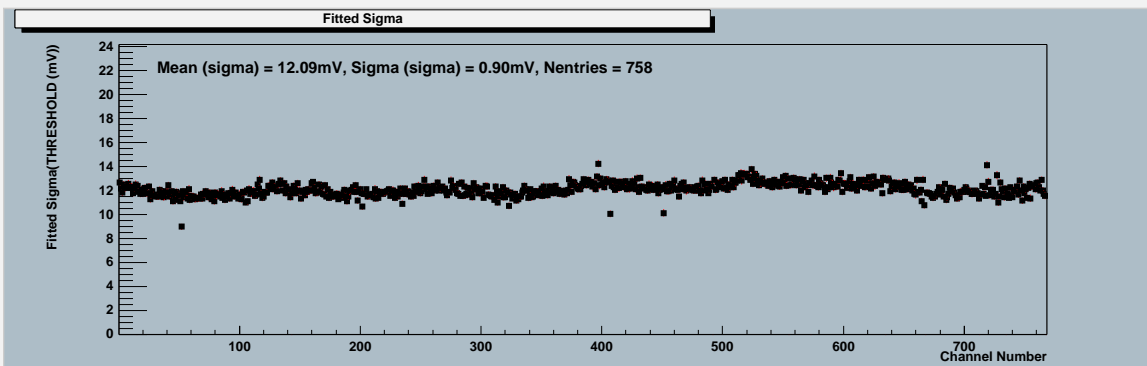
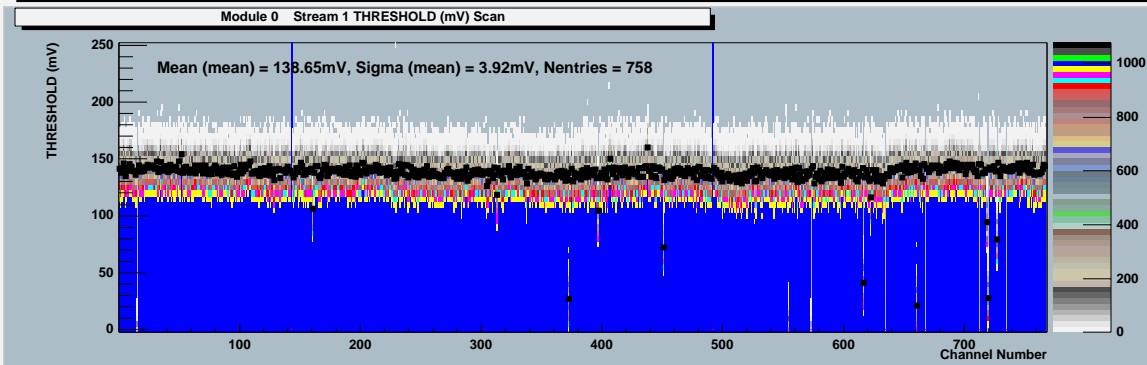
ATLAS SCT Module Test

Run 1115 Scan 4 Module 0 Stream 0 Scan type: THRESHOLD (mV)



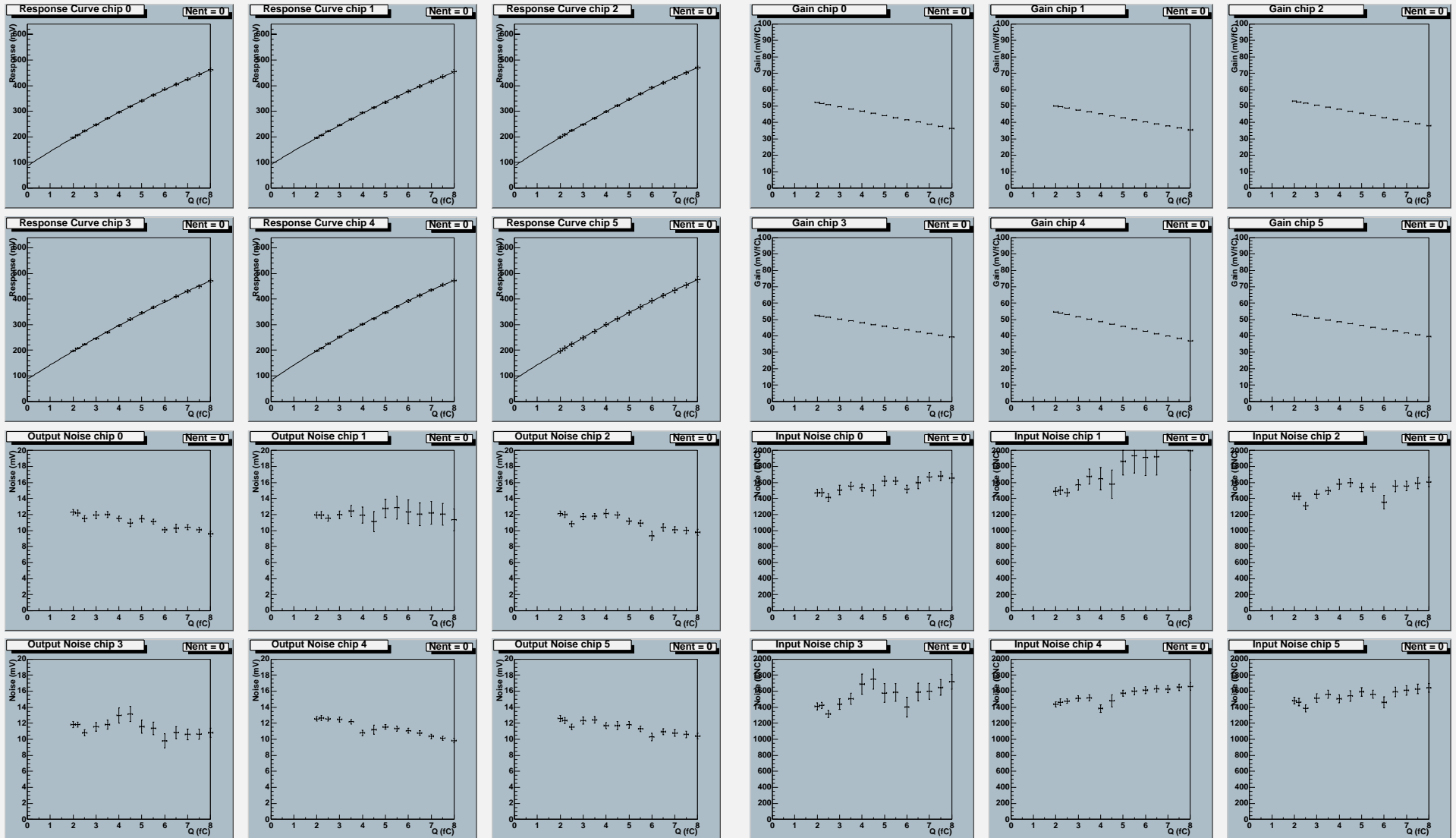
ATLAS SCT Module Test

Run 1115 Scan 4 Module 0 Stream 1 Scan type: THRESHOLD (mV)



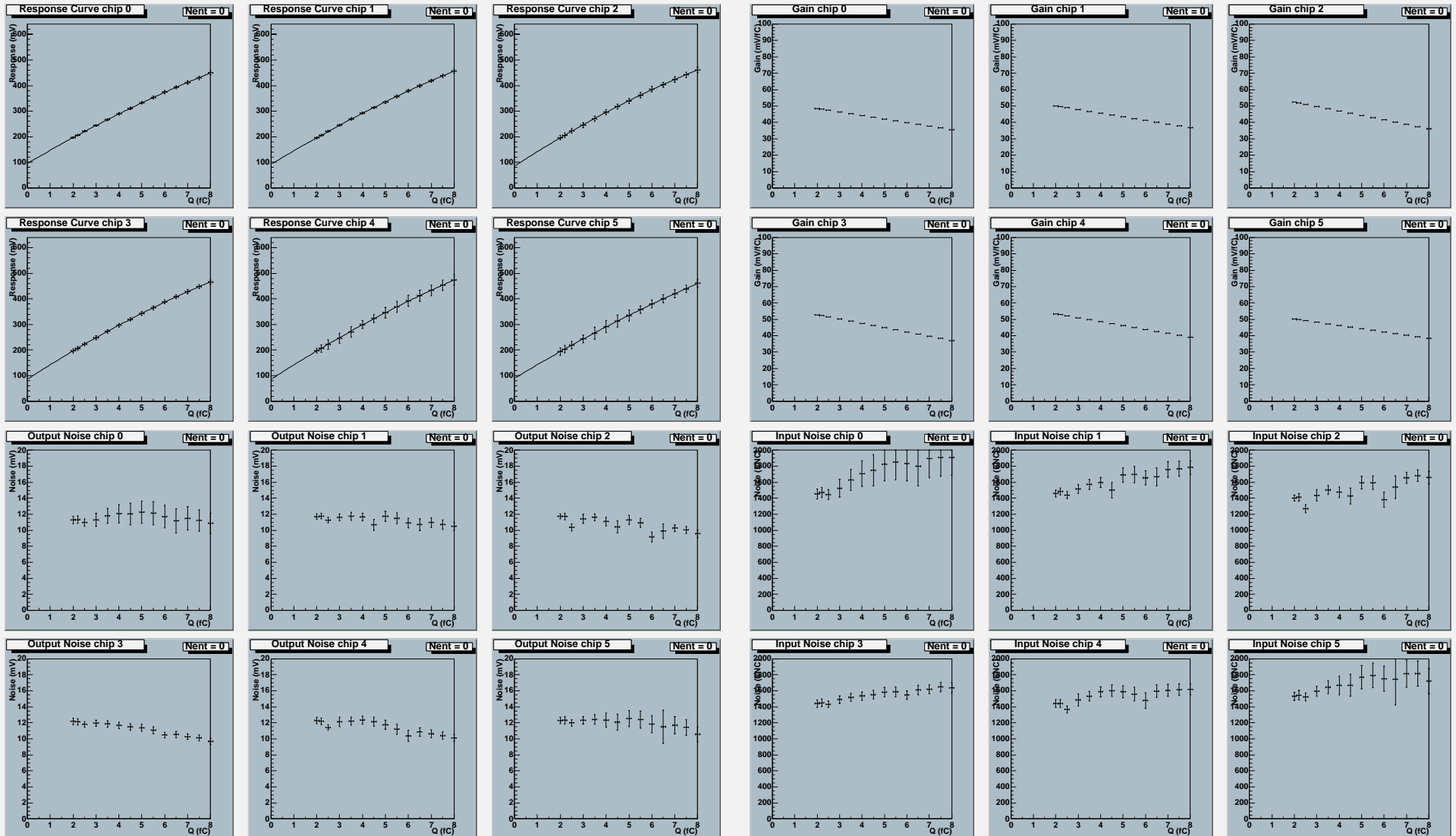
ATLAS SCT Module Response Curve - ABCD2T - 2nd-order Polynomial fit

Run 1115 Scans 10 - 23 Charges 2.00 - 8.00 fC Module 0 Stream 0



ATLAS SCT Module Response Curve - ABCD2T - 2nd-order Polynomial fit

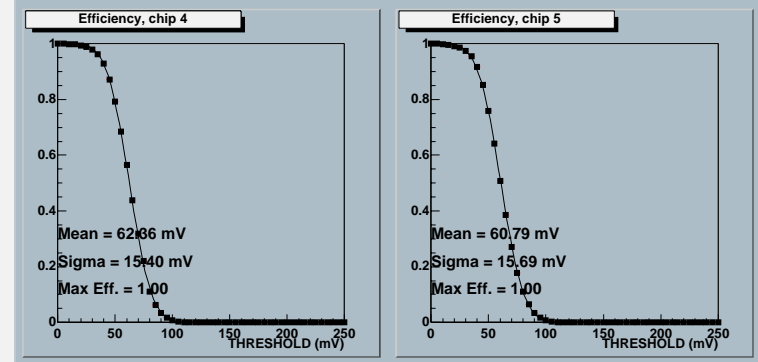
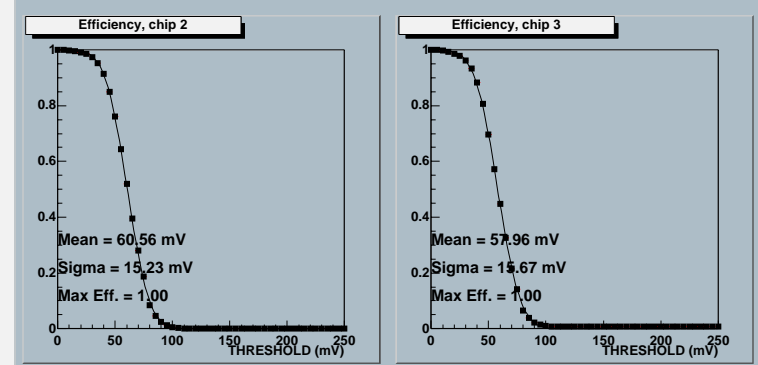
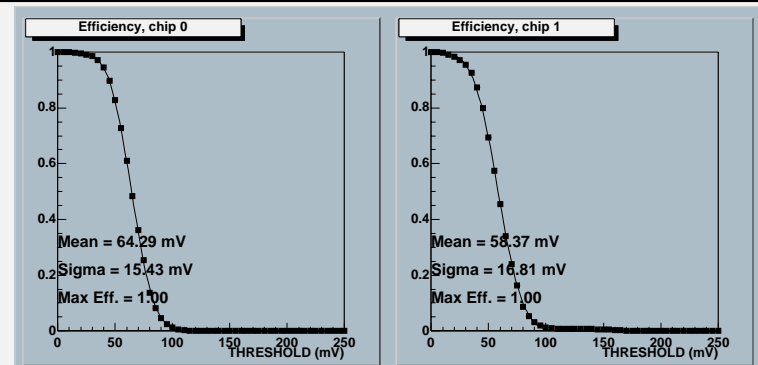
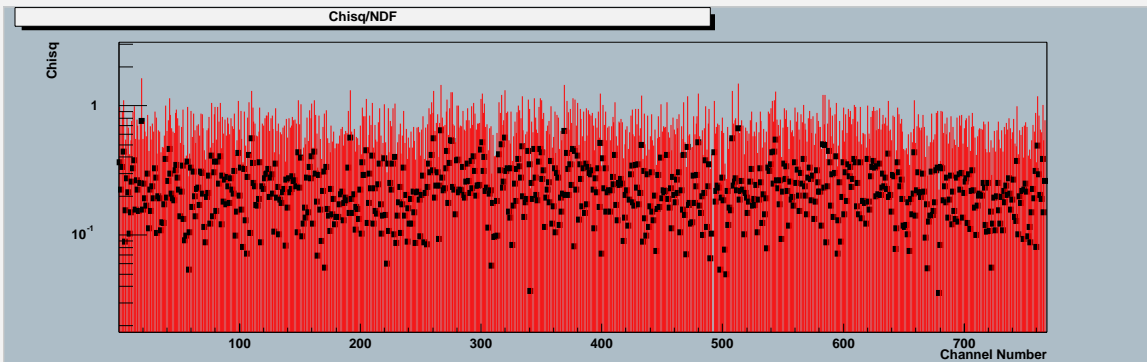
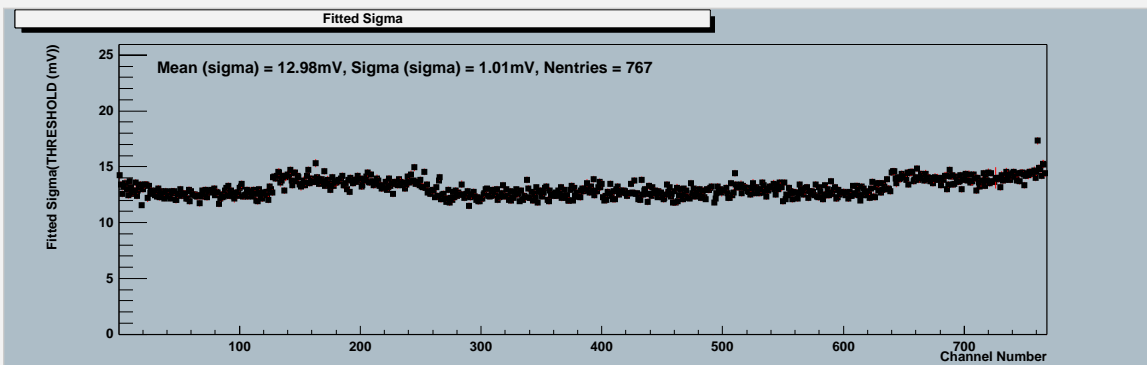
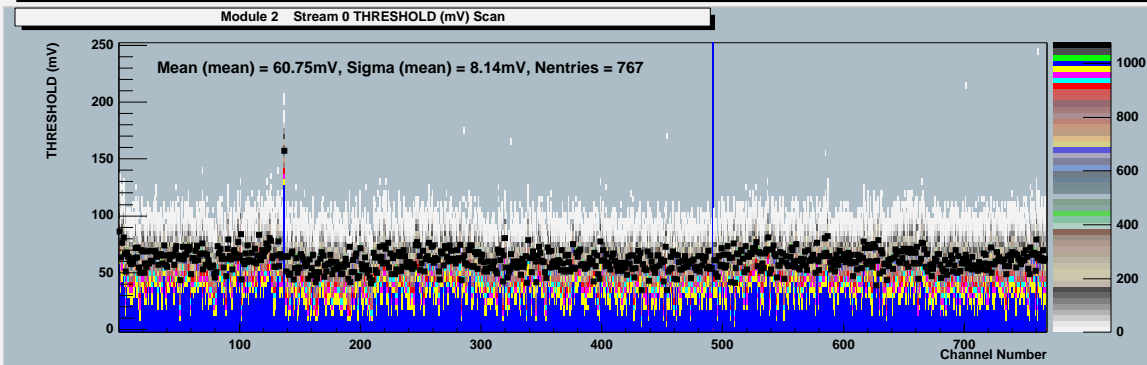
Run 1115 Scans 10 - 23 Charges 2.00 - 8.00 fC Module 0 Stream 1



```
#run scan q ABCD2T in beam at -10 deg.C
#1115 1 0.00
#1115 2 0.60
#1115 3 0.80
#1115 4 1.00
#1115 5 1.20
#1115 6 1.40
#1115 7 1.50
#1115 8 1.60
#1115 9 1.80
1115 10 2.00
1115 11 2.20
1115 12 2.50
1115 13 3.00
1115 14 3.50
1115 15 4.00
1115 16 4.50
1115 17 5.00
1115 18 5.50
1115 19 6.00
1115 20 6.50
1115 21 7.00
1115 22 7.50
1115 23 8.00
```

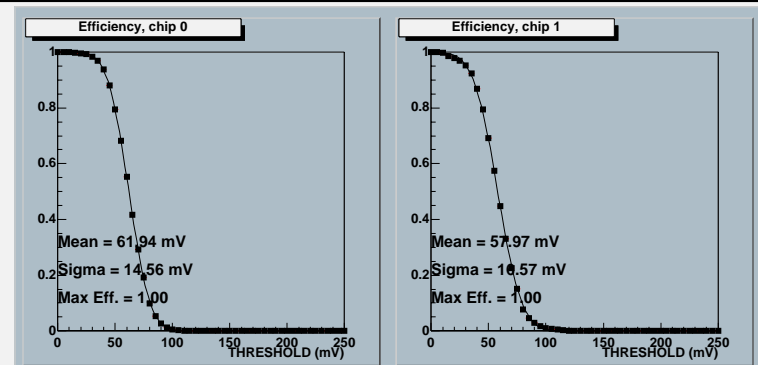
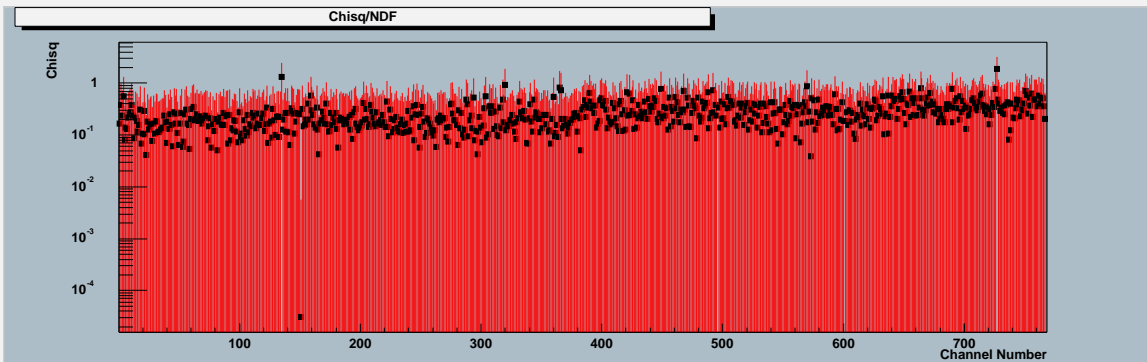
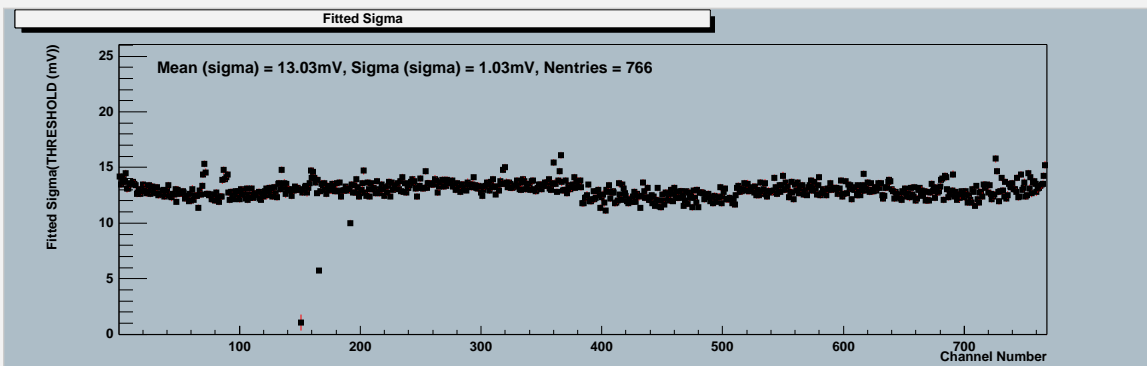
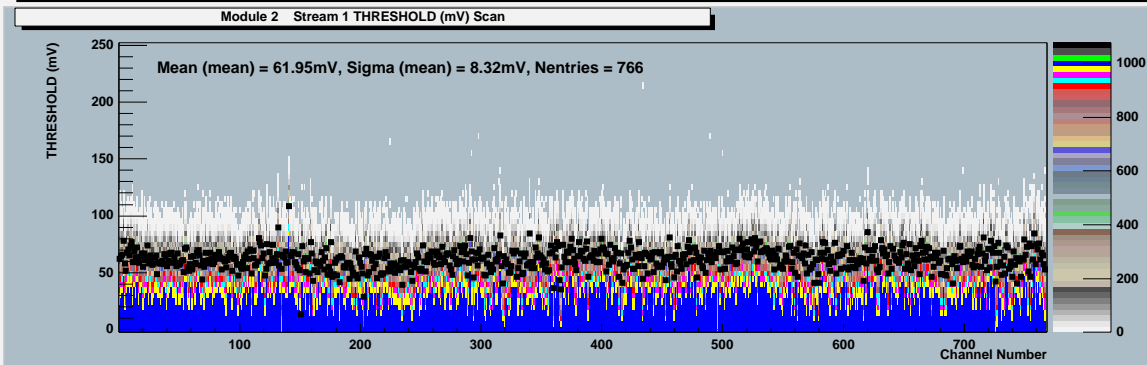
ATLAS SCT Module Test

Run 1115 Scan 4 Module 2 Stream 0 Scan type: THRESHOLD (mV)



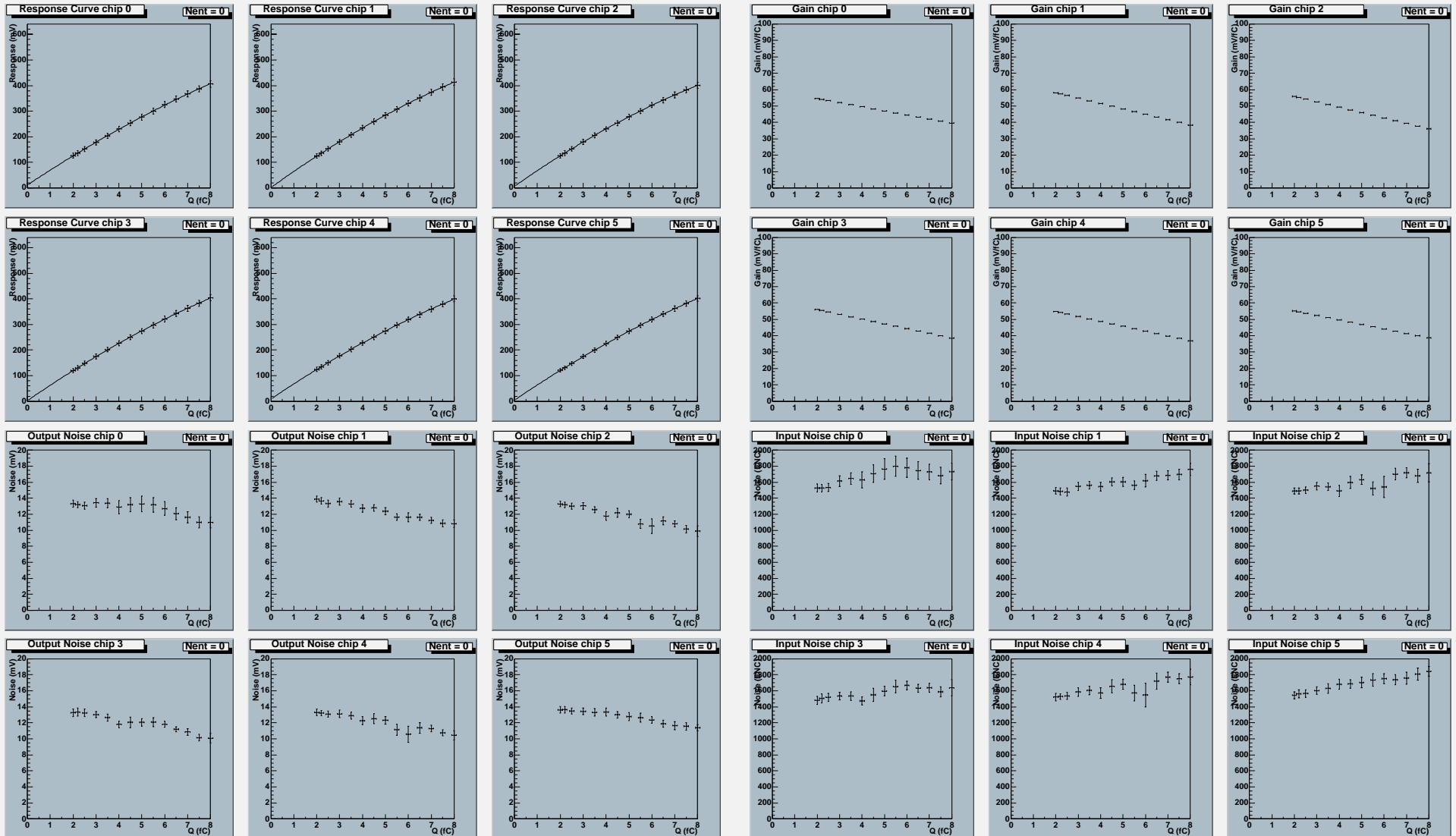
ATLAS SCT Module Test

Run 1115 Scan 4 Module 2 Stream 1 Scan type: THRESHOLD (mV)



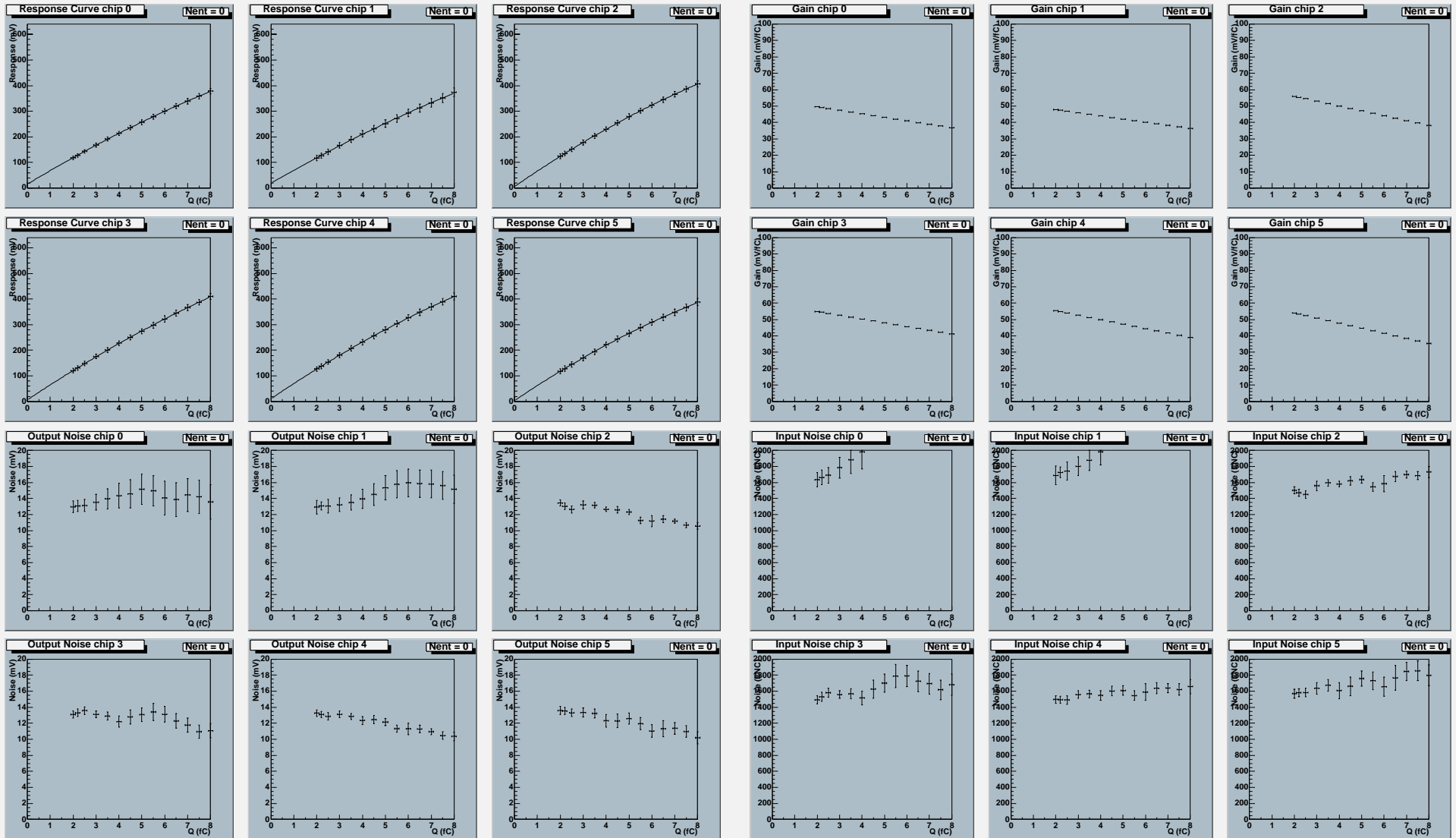
ATLAS SCT Module Response Curve - ABCD2T - 2nd-order Polynomial fit

Run 1115 Scans 10 - 23 Charges 2.00 - 8.00 fC Module 2 Stream 0



ATLAS SCT Module Response Curve - ABCD2T - 2nd-order Polynomial fit

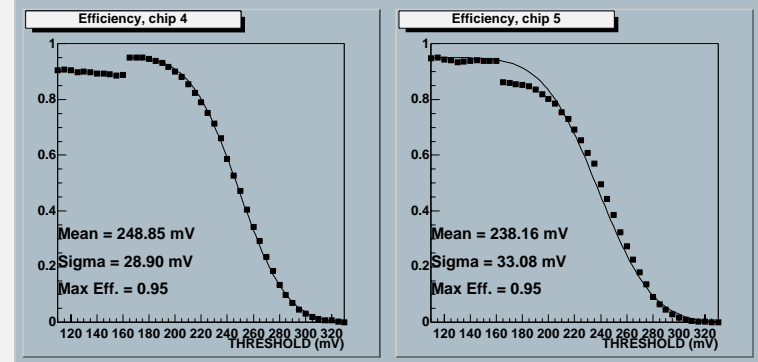
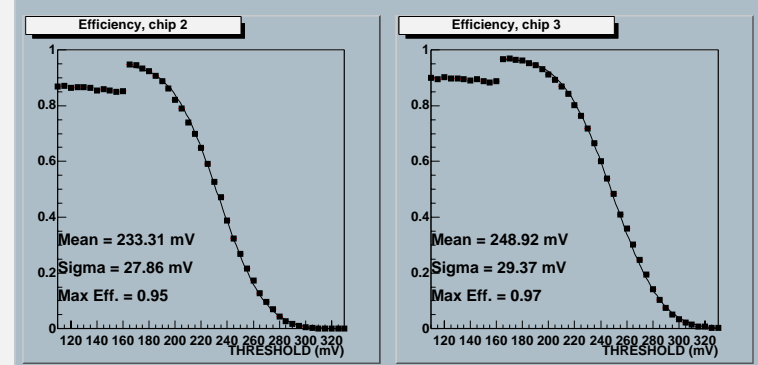
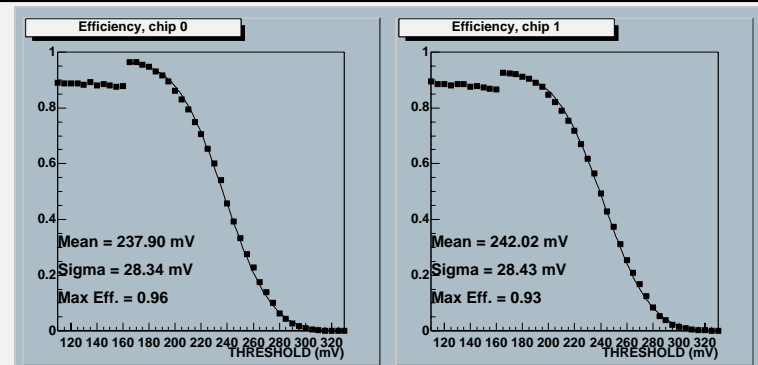
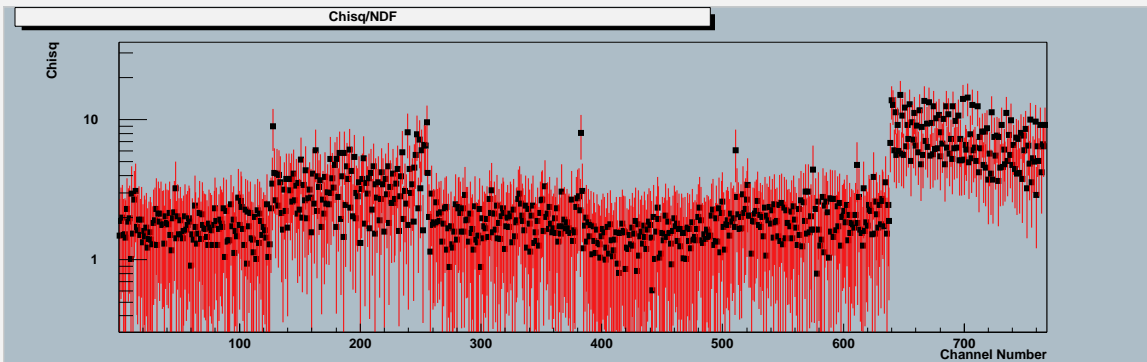
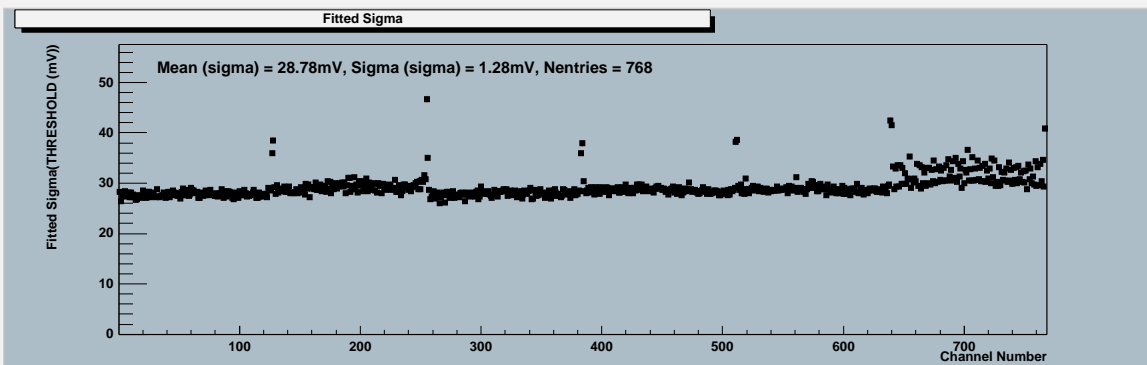
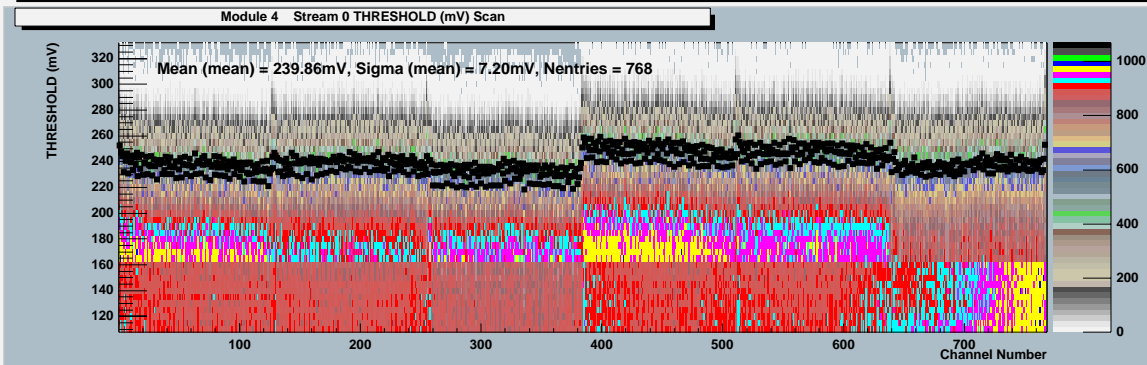
Run 1115 Scans 10 - 23 Charges 2.00 - 8.00 fC Module 2 Stream 1




```
#run scan q CAFE/ABC module in beam at -10 deg.C
#1116 1 0.000
1116 2 0.625
1116 3 0.9375
1116 4 1.25
1116 5 1.5625
1116 6 1.875
1116 7 2.1875
1116 8 2.50
1116 9 2.8125
1116 10 3.125
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1116 14 4.375
1116 15 4.6875
1116 16 5.00
```

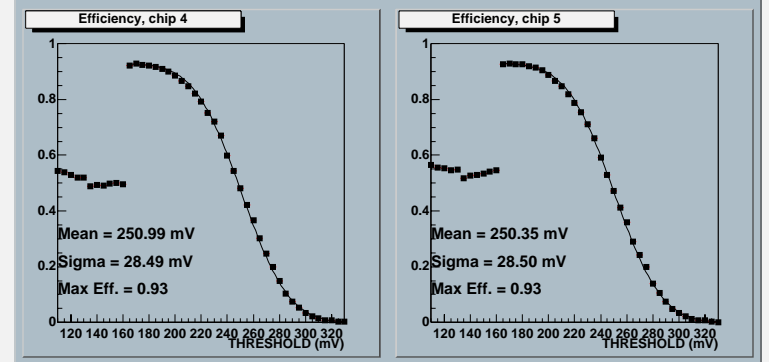
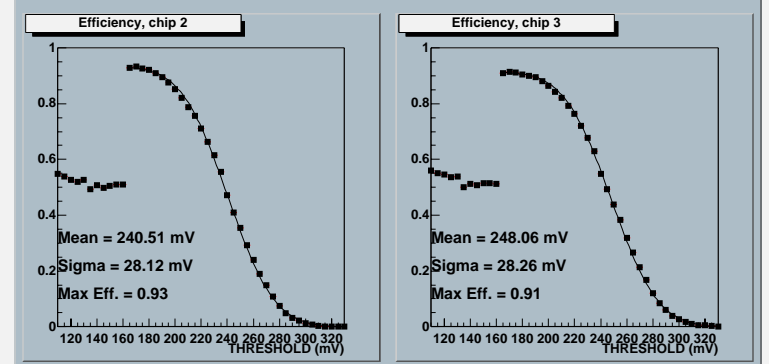
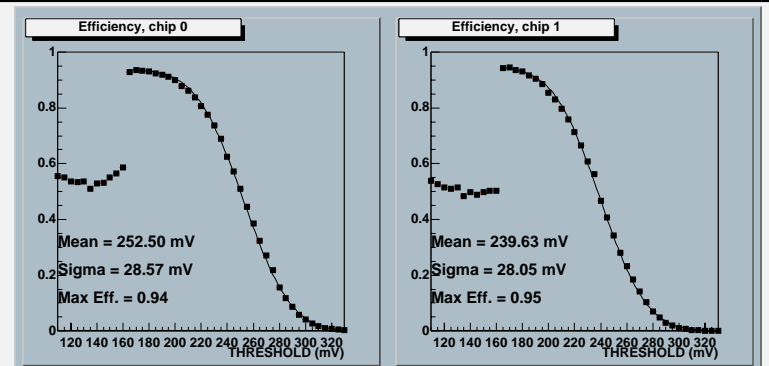
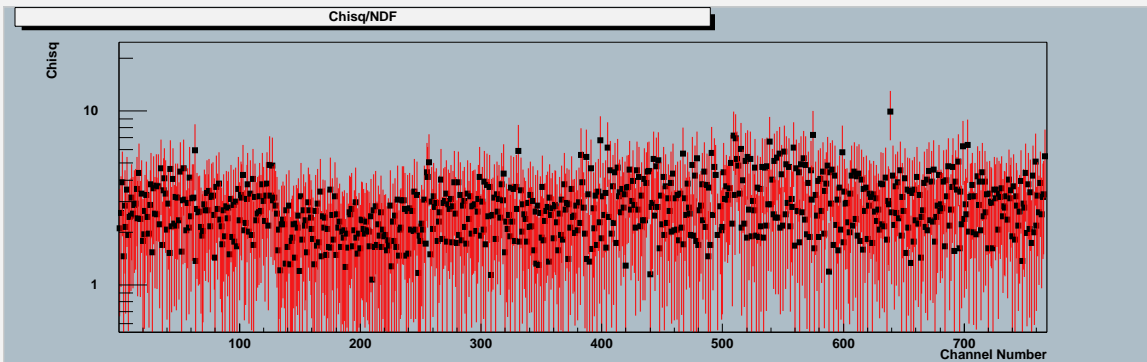
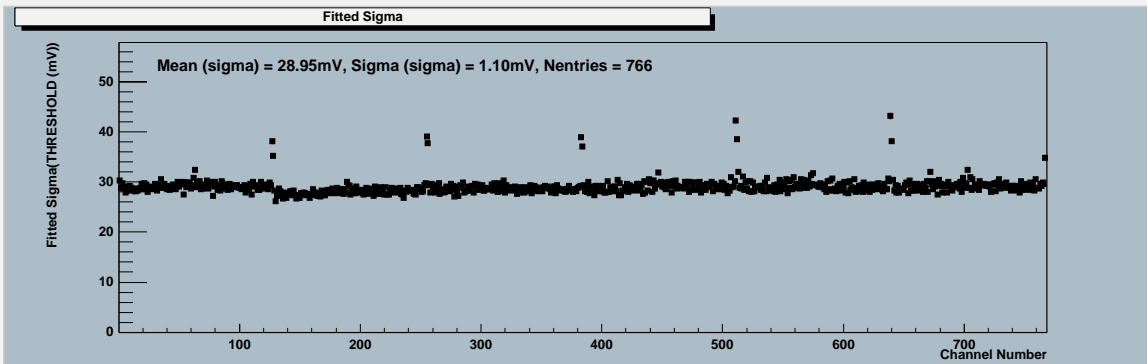
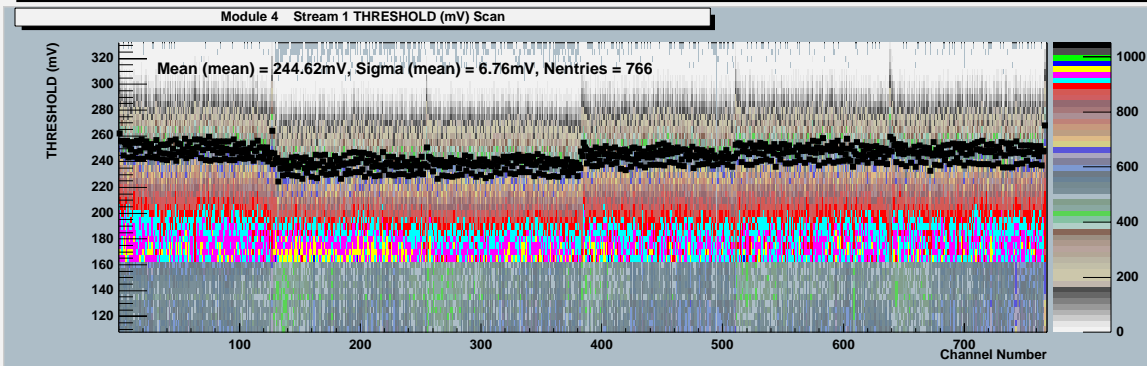
ATLAS SCT Module Test

Run 1116 Scan 4 Module 4 Stream 0 Scan type: THRESHOLD (mV)

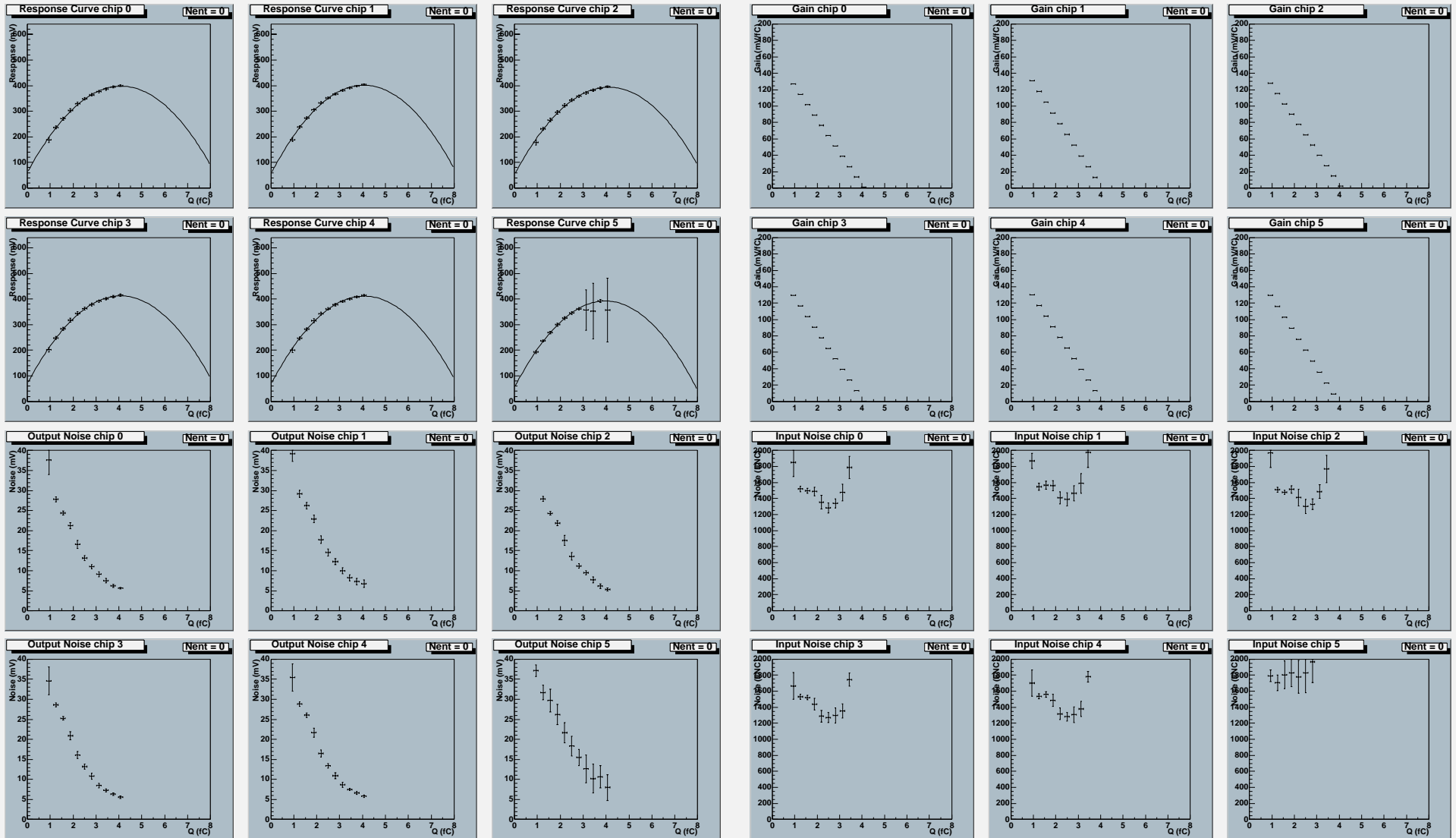


ATLAS SCT Module Test

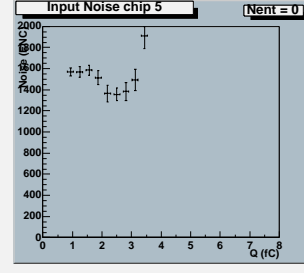
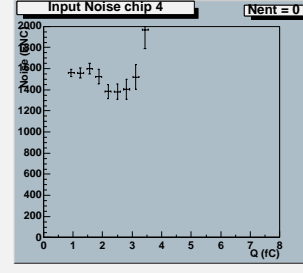
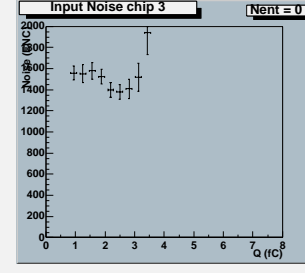
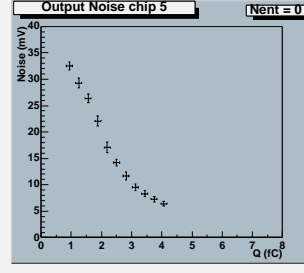
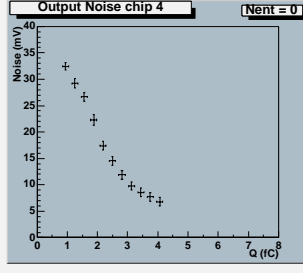
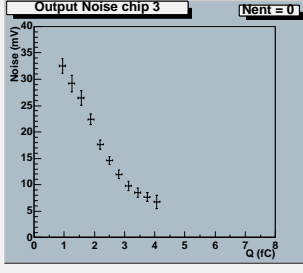
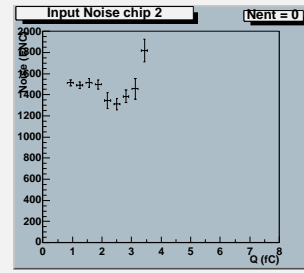
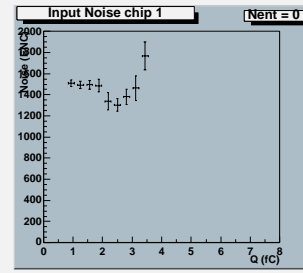
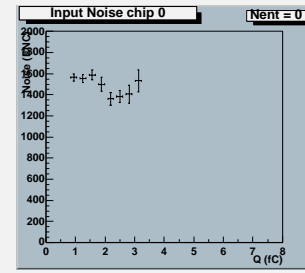
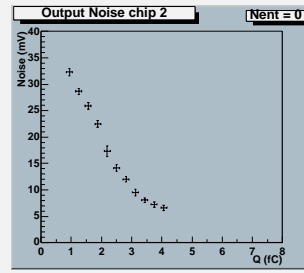
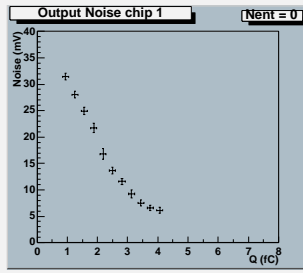
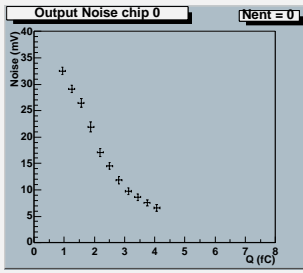
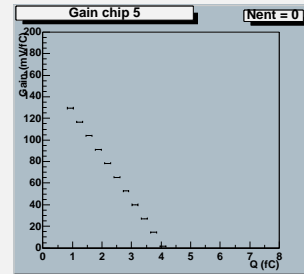
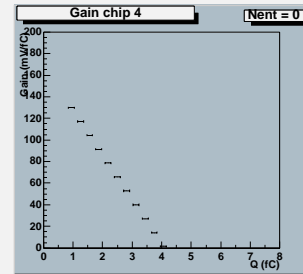
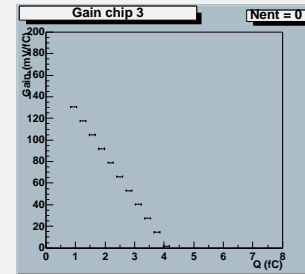
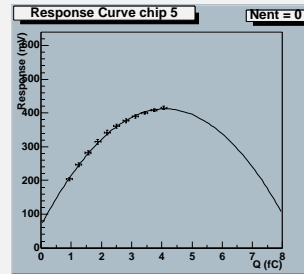
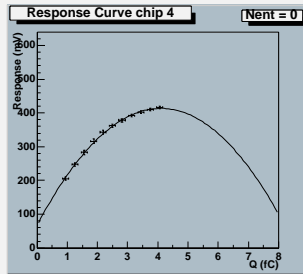
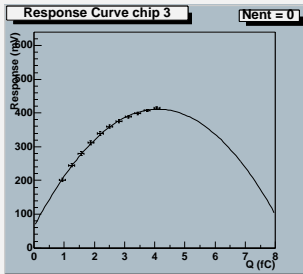
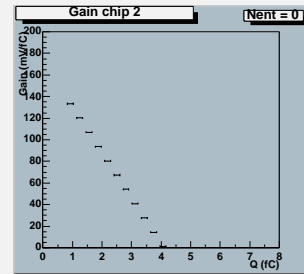
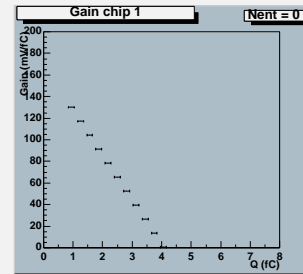
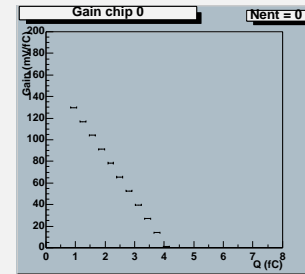
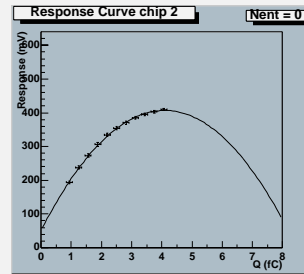
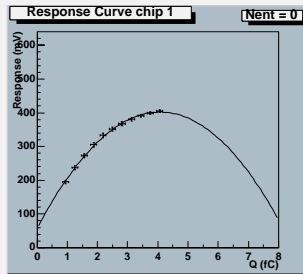
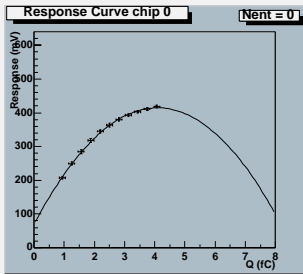
Run 1116 Scan 4 Module 4 Stream 1 Scan type: THRESHOLD (mV)



ATLAS SCT Module Response Curve - ABC/CAFE (CAFE $Q \cdot ABCD$ V_{th}) - 2nd-order Polynomial fit
Run 1116 Scans 3 - 13 Charges 0.94 - 4.06 fC Module 4 Stream 0



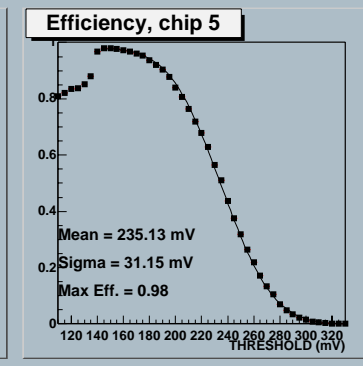
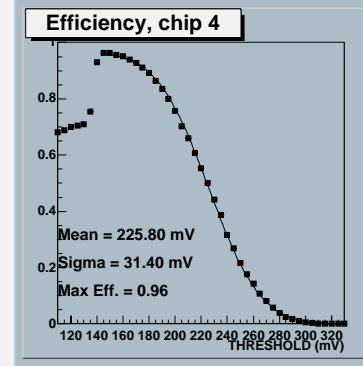
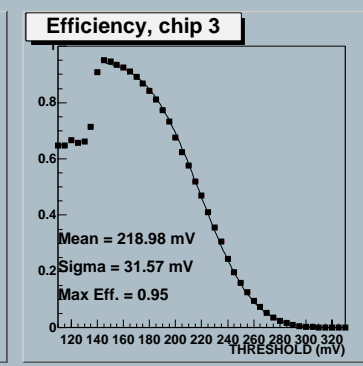
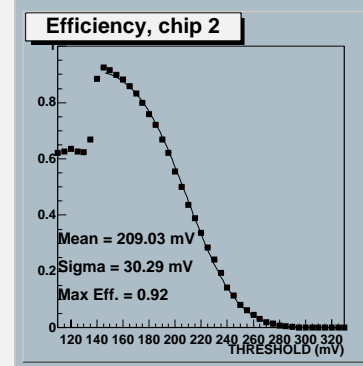
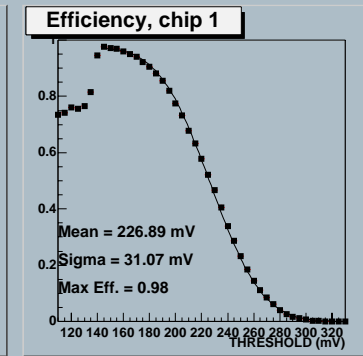
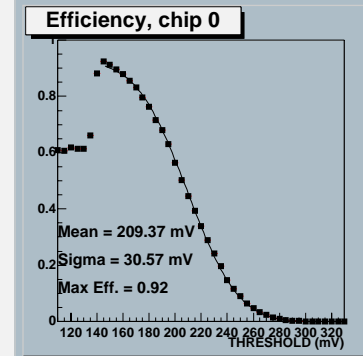
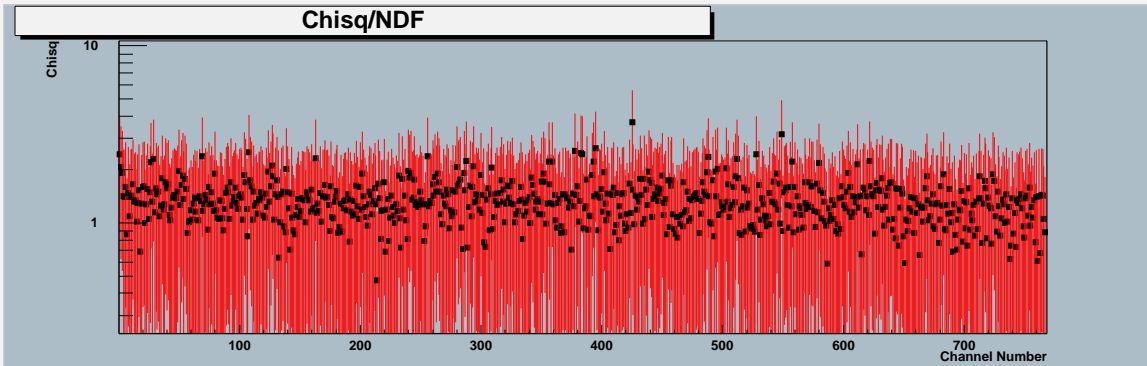
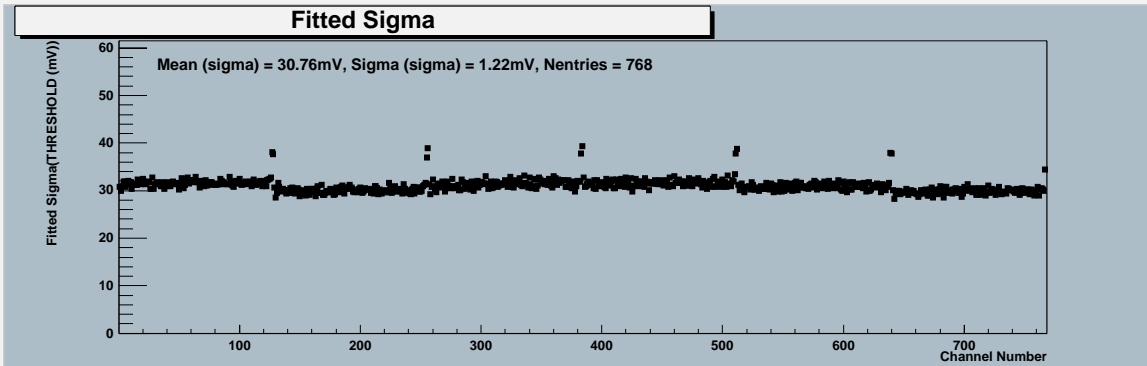
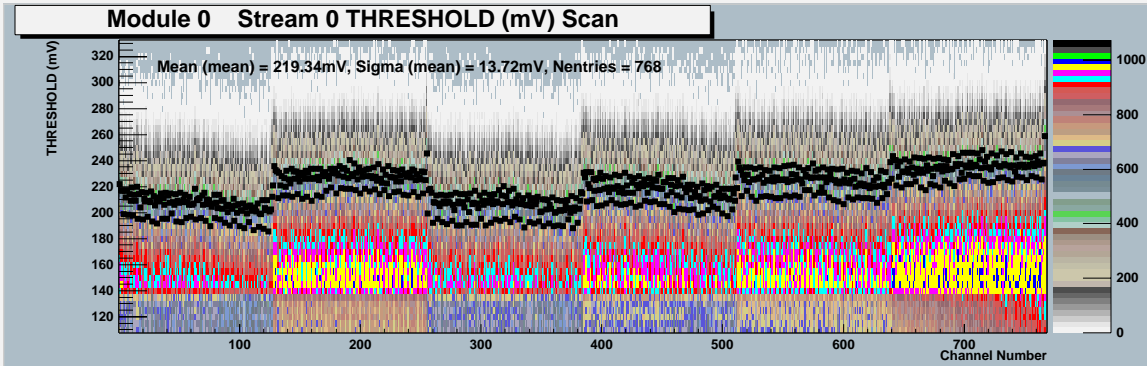
ATLAS SCT Module Response Curve - ABC/CAFE (CAFE $Q \cdot ABCD$ V_{th}) - 2nd-order Polynomial fit
Run 1116 Scans 3 - 13 Charges 0.94 - 4.06 fC Module 4 Stream 1



```
#run scan q CAFE/ABC
#101 1 0.625
101 2 0.9375
101 3 1.25
101 4 1.5625
101 5 1.875
101 6 2.1875
101 7 2.50
101 8 2.8125
101 9 3.125
101 10 3.4375
101 11 3.75
101 12 4.0625
#101 13 4.375
#101 14 4.6875
#101 15 5.00
```

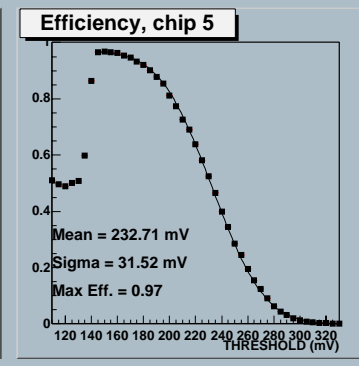
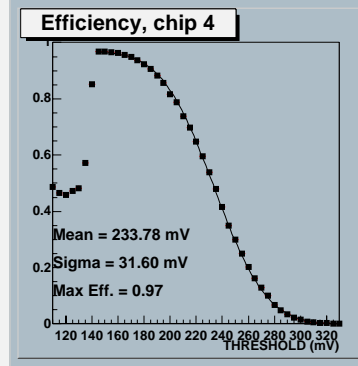
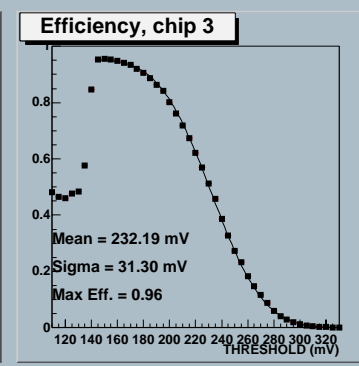
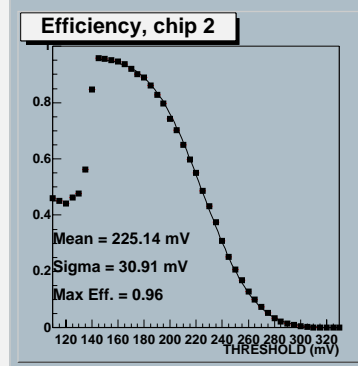
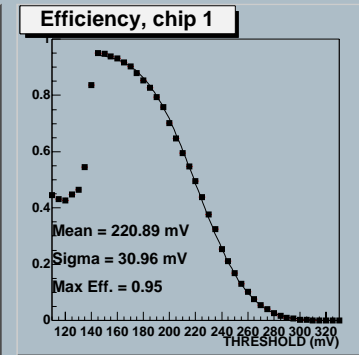
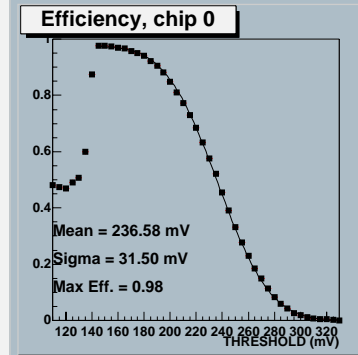
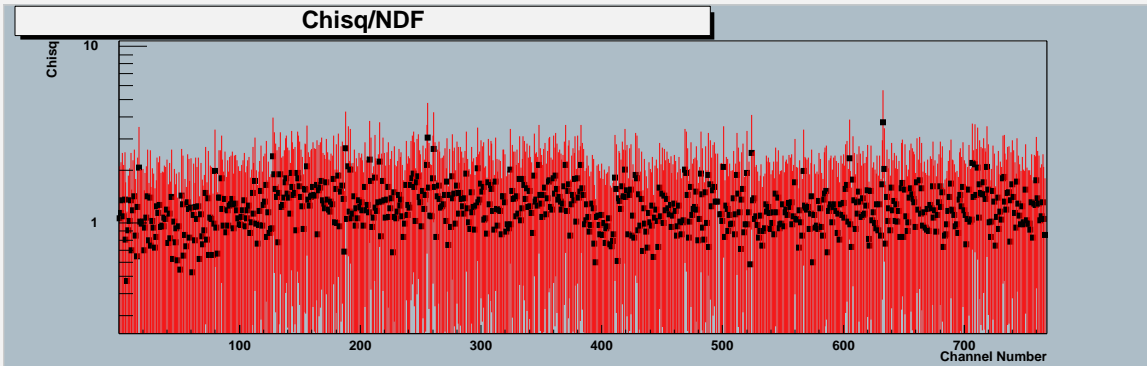
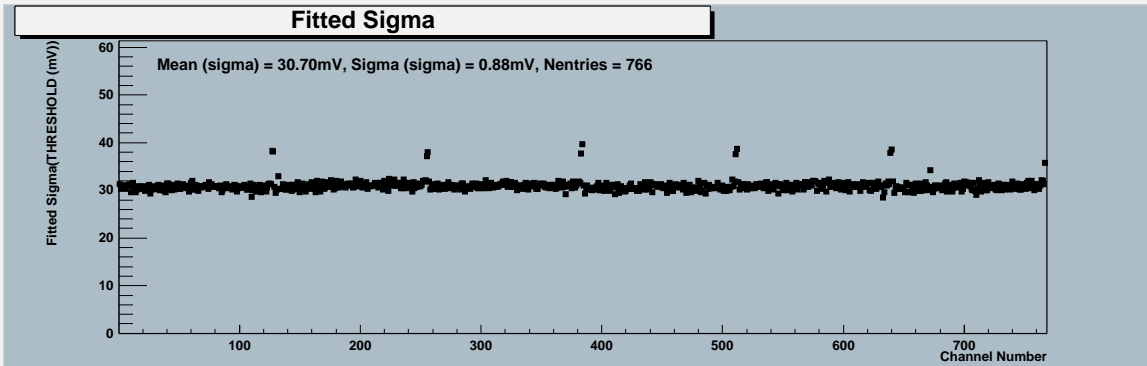
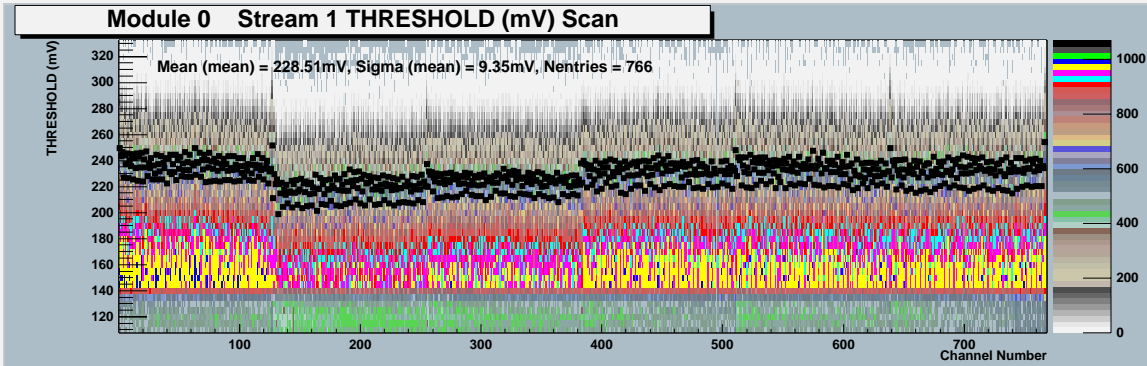
ATLAS SCT Module Test

Run 101 Scan 3 Module 0 Stream 0 Scan type: THRESHOLD (mV)



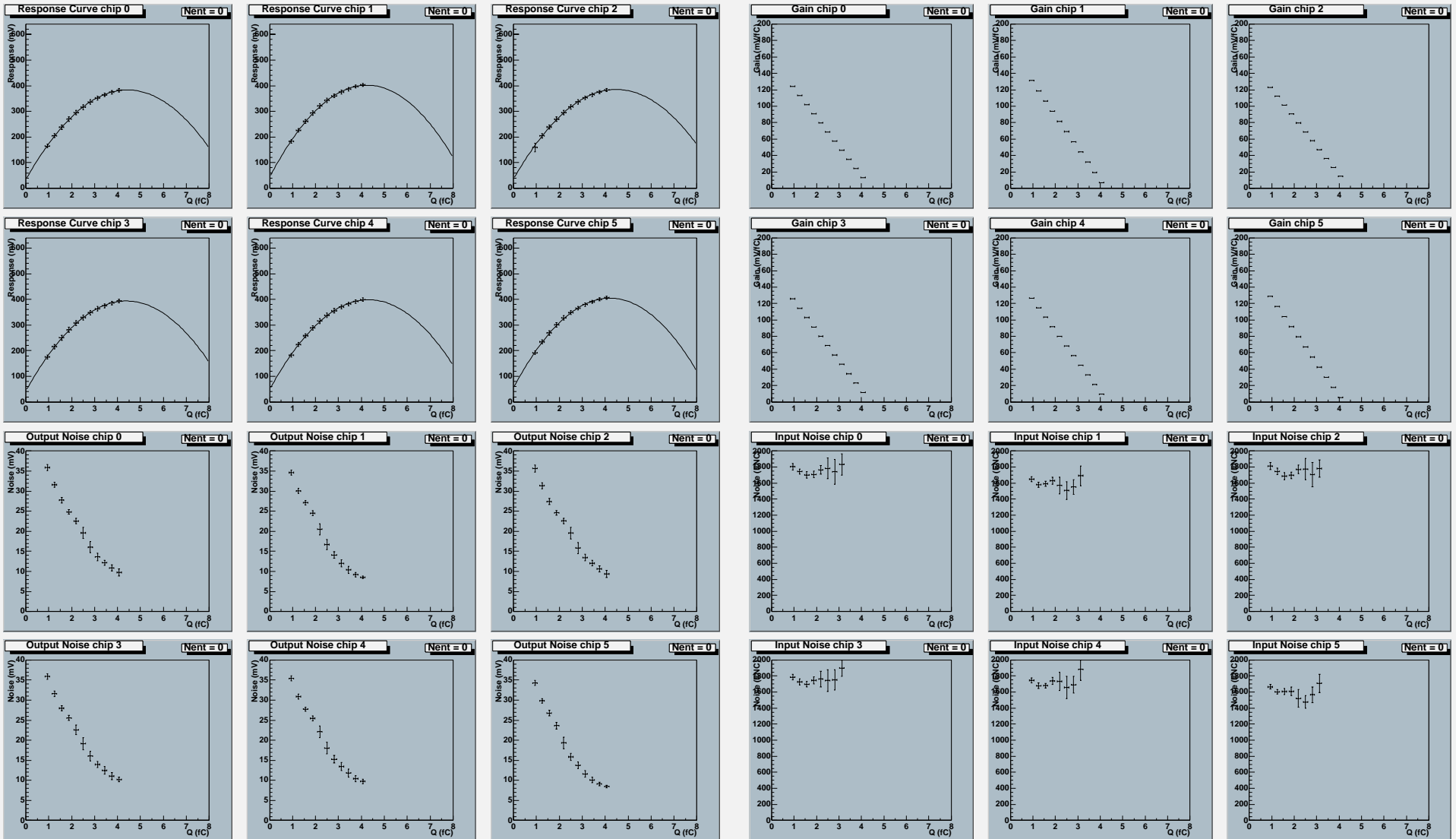
ATLAS SCT Module Test

Run 101 Scan 3 Module 0 Stream 1 Scan type: THRESHOLD (mV)



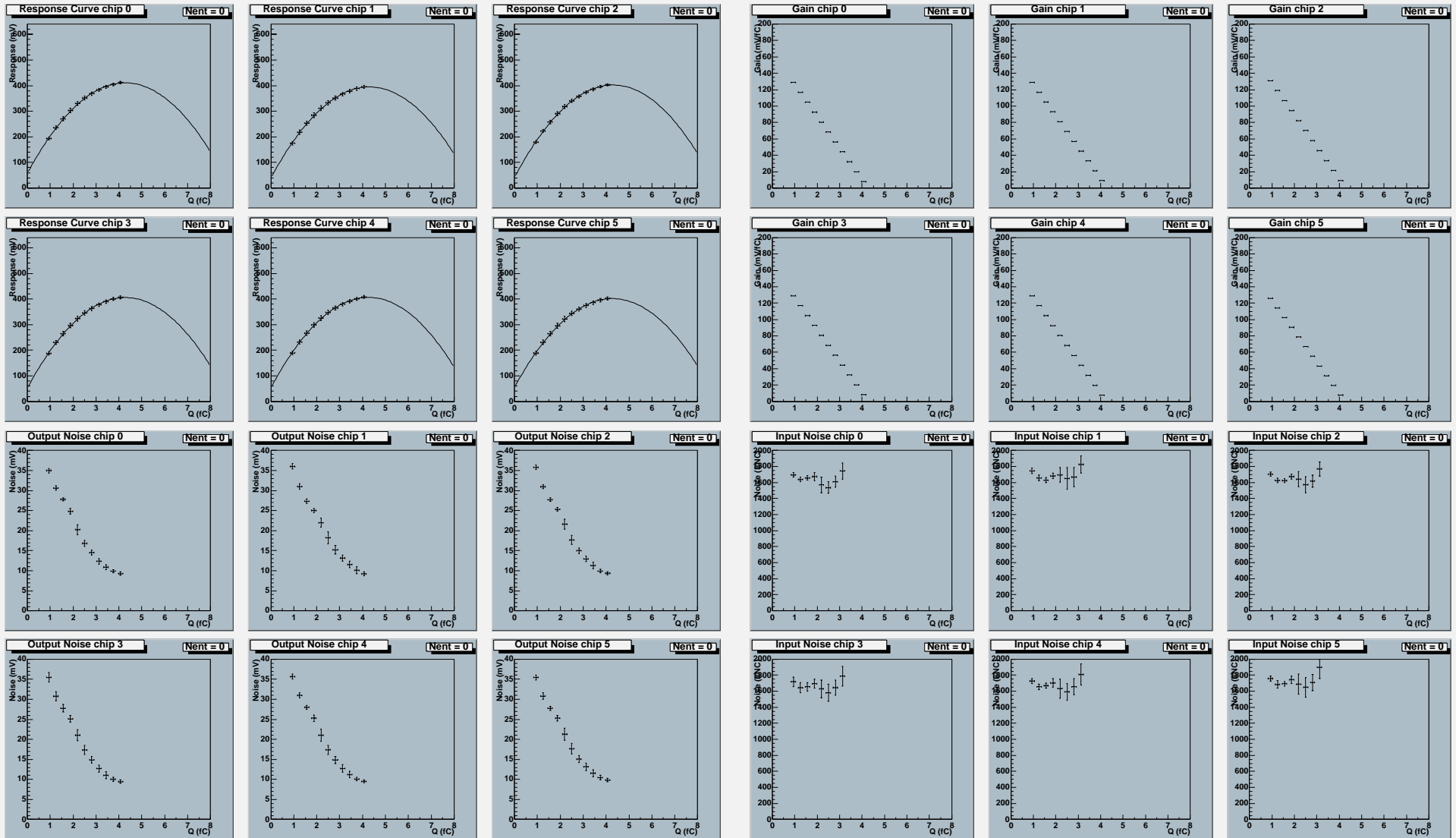
ATLAS SCT Module Response Curve - ABC/CAFE (CAFE $Q \cdot ABCD$ V_{th}) - 2nd-order Polynomial fit

Run 101 Scans 2 - 12 Charges 0.94 - 4.06 fC Module 0 Stream 0



ATLAS SCT Module Response Curve - ABC/CAFE (CAFE $Q \cdot ABCD$ V_{th}) - 2nd-order Polynomial fit

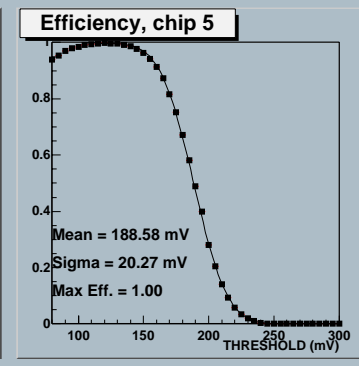
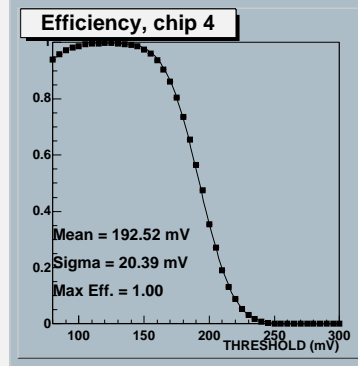
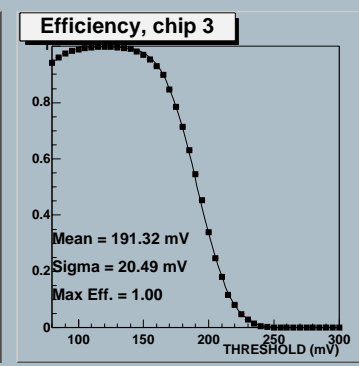
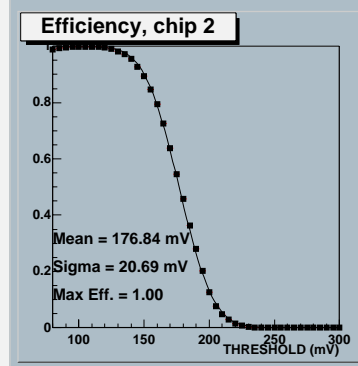
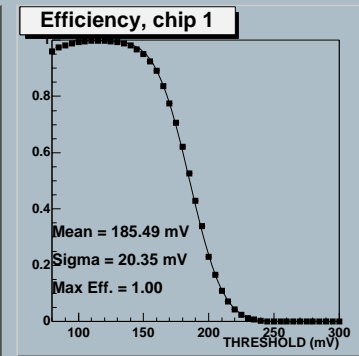
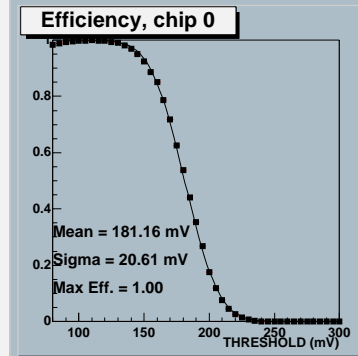
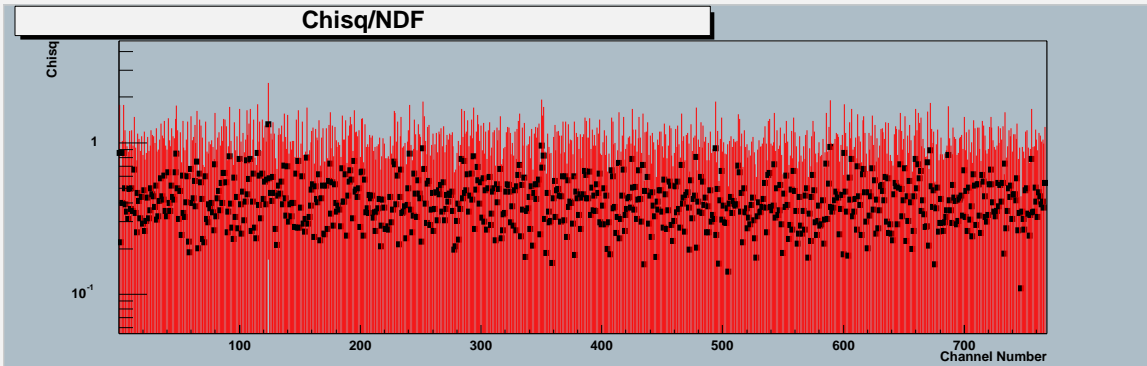
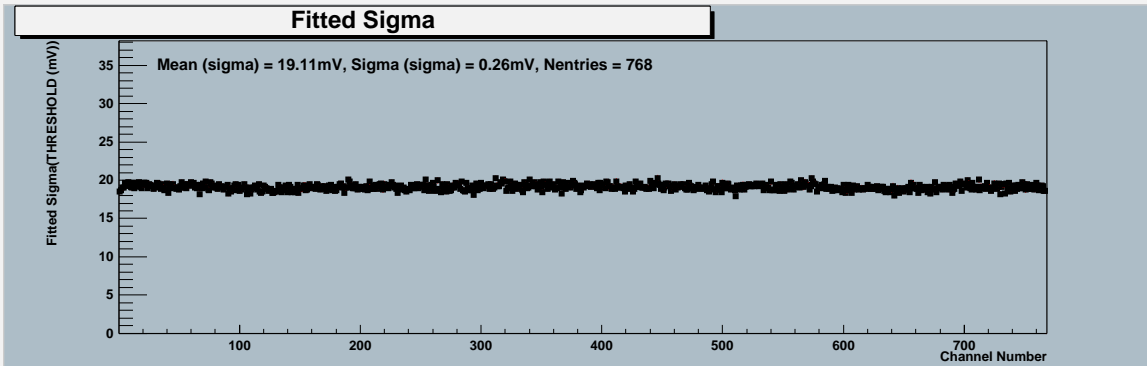
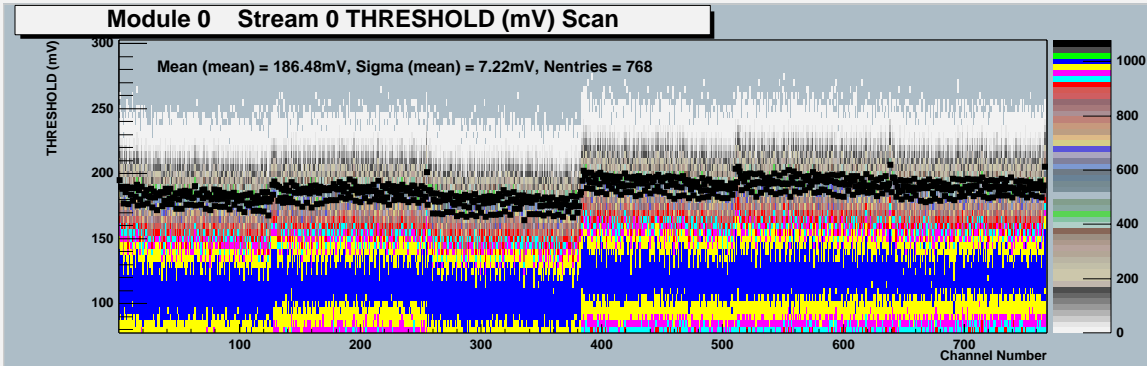
Run 101 Scans 2 - 12 Charges 0.94 - 4.06 fC Module 0 Stream 1



```
#run scan q CAFE/ABC hybrid at Fuji
41 1 0.625
41 2 0.9375
41 3 1.25
41 4 1.5625
41 5 1.875
41 6 2.1875
41 7 2.50
41 8 2.8125
41 9 3.125
41 10 3.4375
41 11 3.75
41 12 4.0625
#41 13 4.375
#41 14 4.6875
#41 15 5.00
```

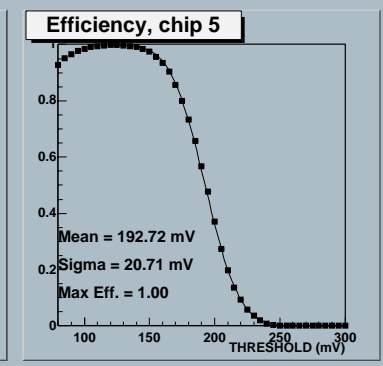
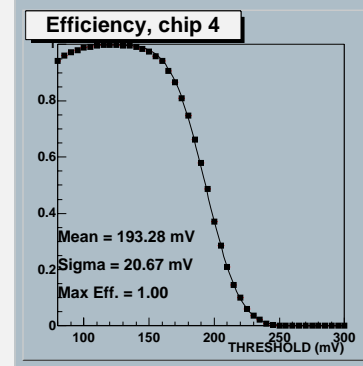
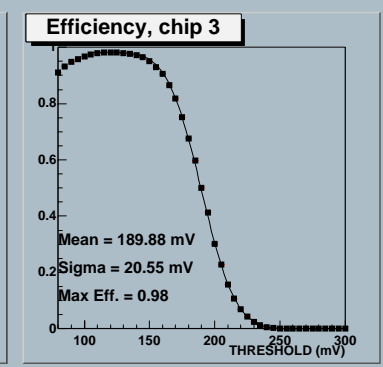
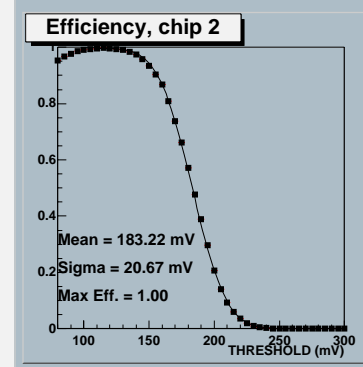
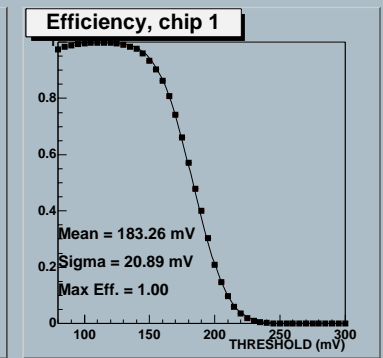
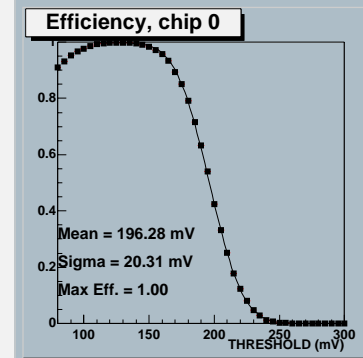
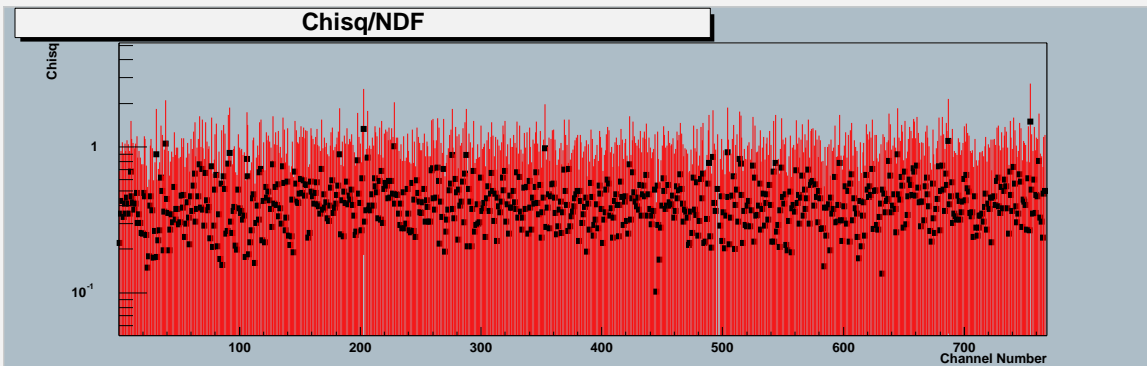
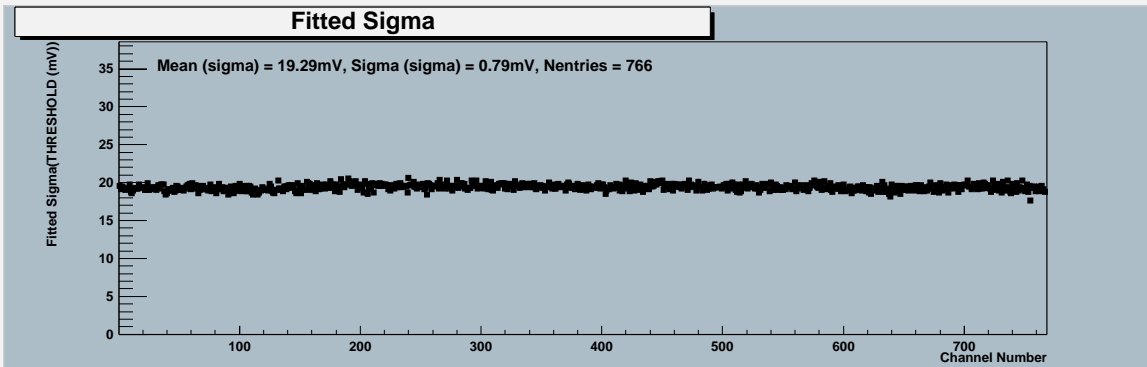
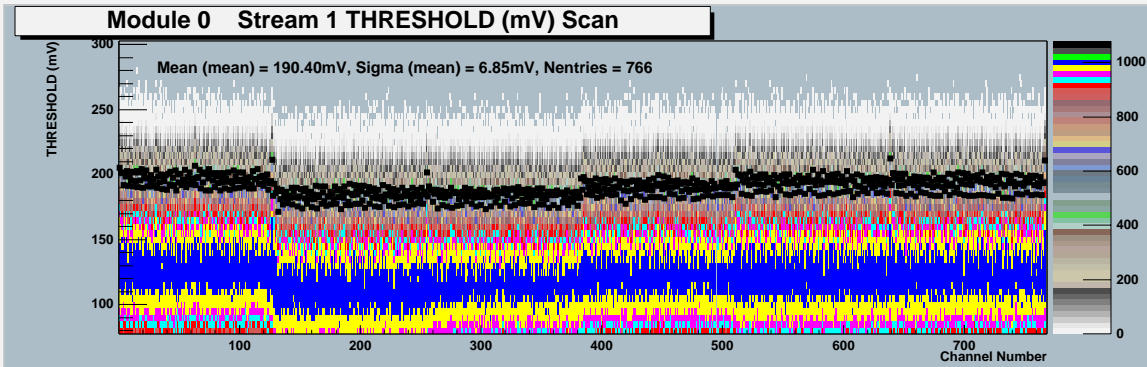
ATLAS SCT Module Test

Run 41 Scan 2 Module 0 Stream 0 Scan type: THRESHOLD (mV)



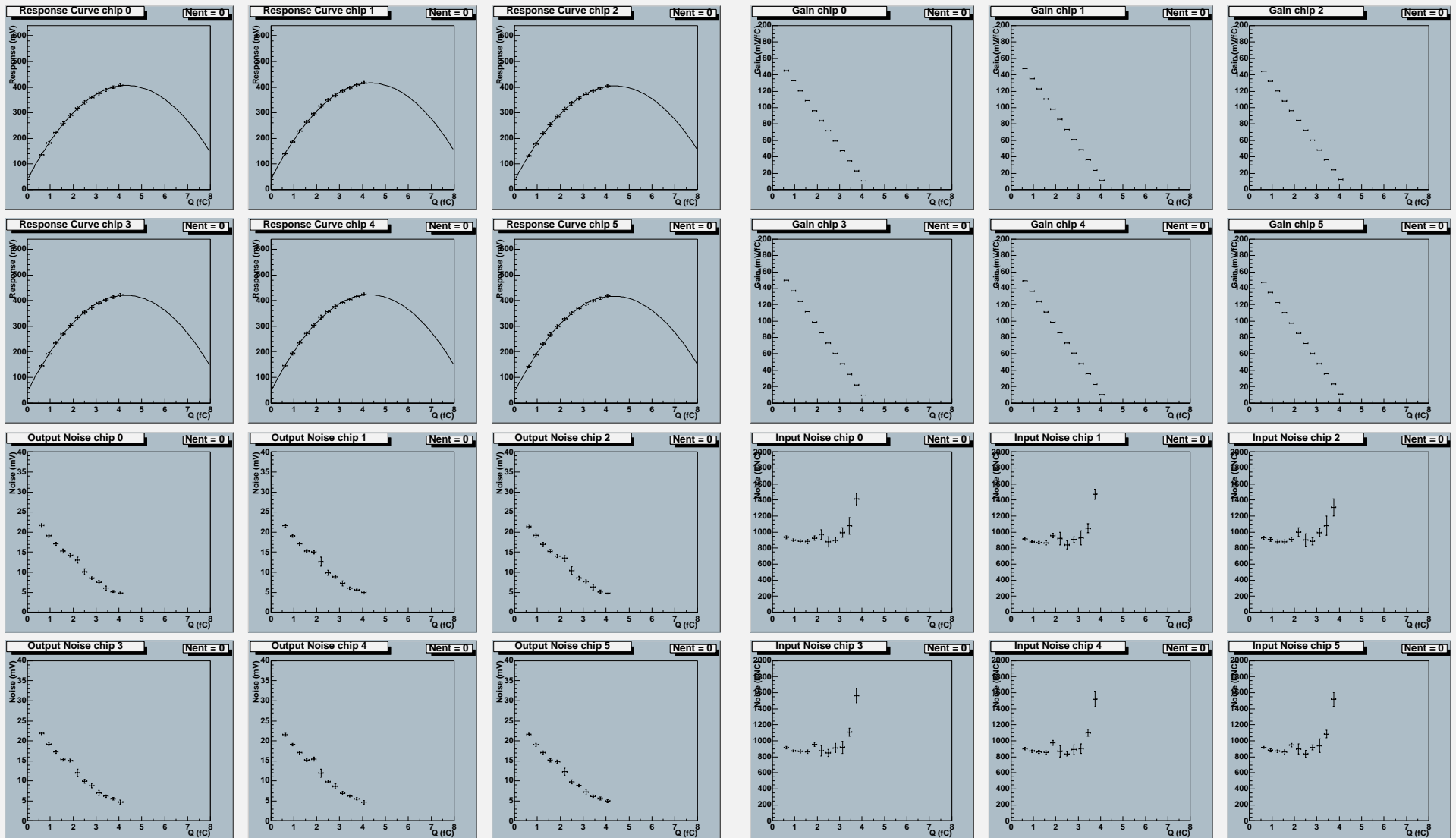
ATLAS SCT Module Test

Run 41 Scan 2 Module 0 Stream 1 Scan type: THRESHOLD (mV)



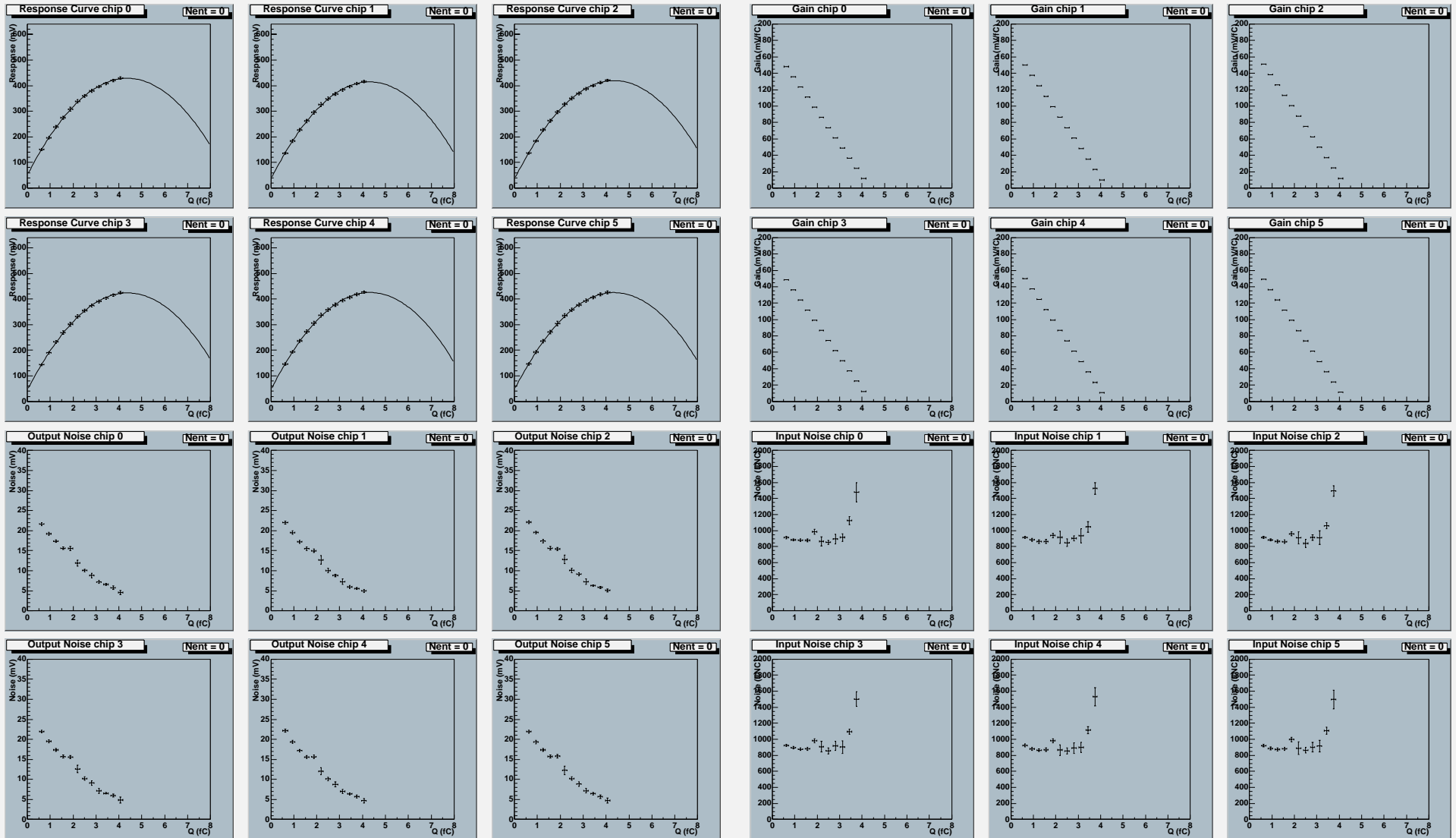
ATLAS SCT Module Response Curve - ABC/CAFE (CAFE $Q \cdot ABCD V_{th}$) - 2nd-order Polynomial fit

Run 41 Scans 1 - 12 Charges 0.63 - 4.06 fC Module 0 Stream 0



ATLAS SCT Module Response Curve - ABC/CAFE (CAFE $Q \cdot ABCD$ V_{th}) - 2nd-order Polynomial fit

Run 41 Scans 1 - 12 Charges 0.63 - 4.06 fC Module 0 Stream 1

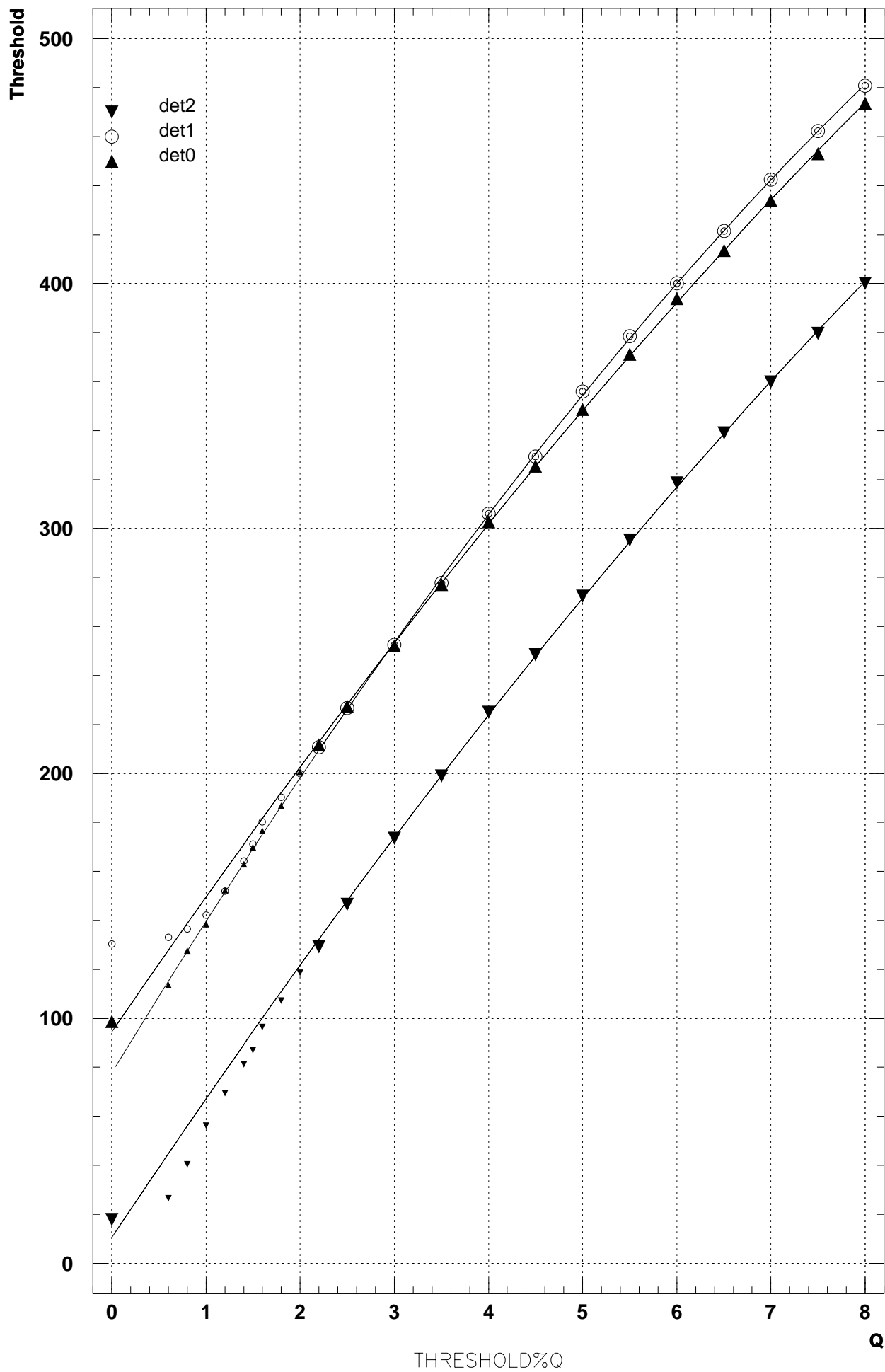


Calibrations

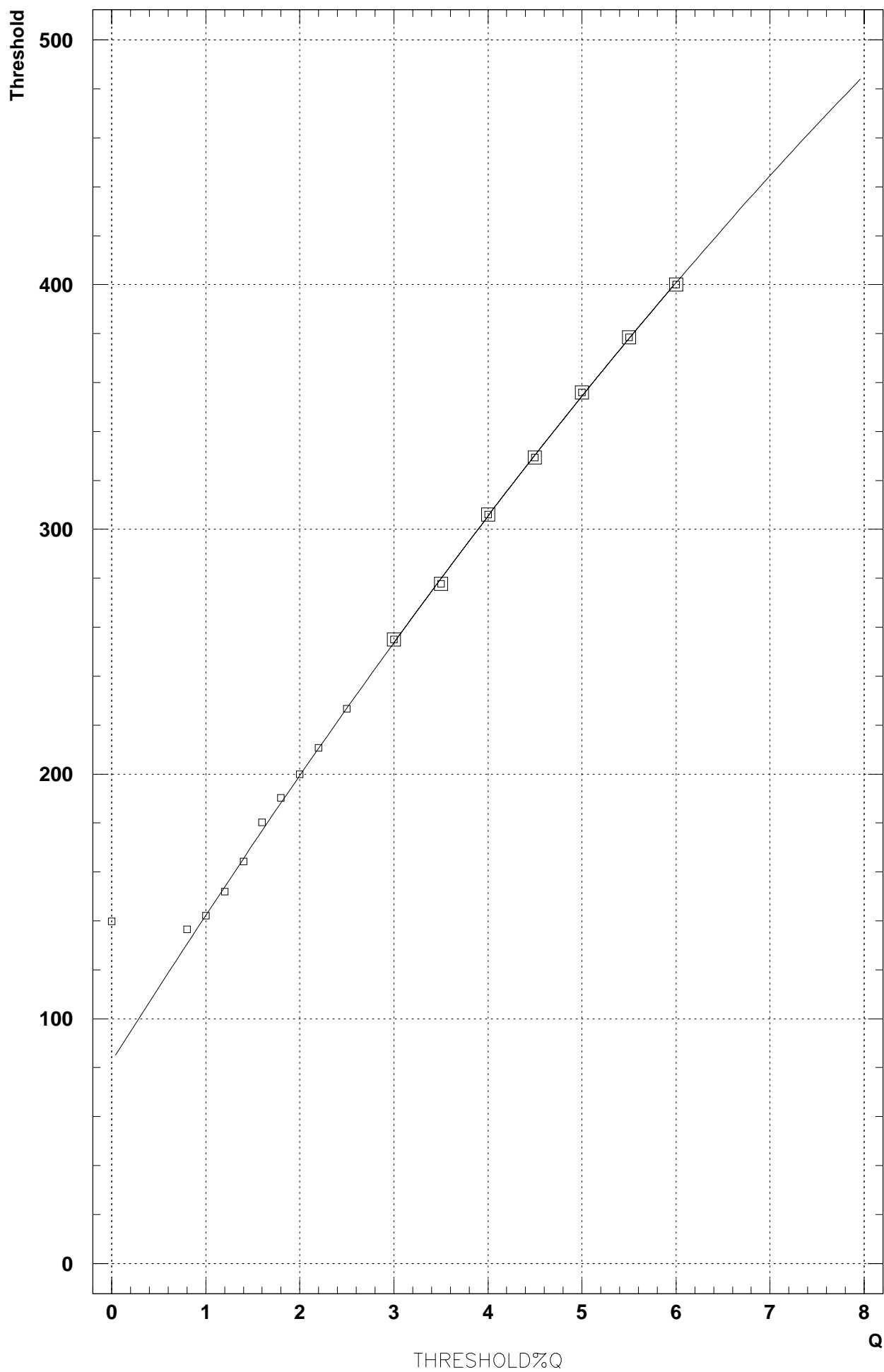
- **Summary**

- Lab calibration runs: Bias 150V (irrad 350V)
 - Scan points were fed into the thresholds of beamtest
- Later, fitted to a response curve and charge values are corrected
 - Scan points with larger markers were those used for the fit
- Det4(Mod4):
 - Threshold in (ABCD) mV
 - 640 (ABCD)mV~680 (CAFE)mV
 - open square (nominal scale)
 - filled square (KEK internal)
- Nominal charge scale: IDAR~300 μA = 10 fC
 - KEK internal scale: IDAR~300 μA ~ 7 fC

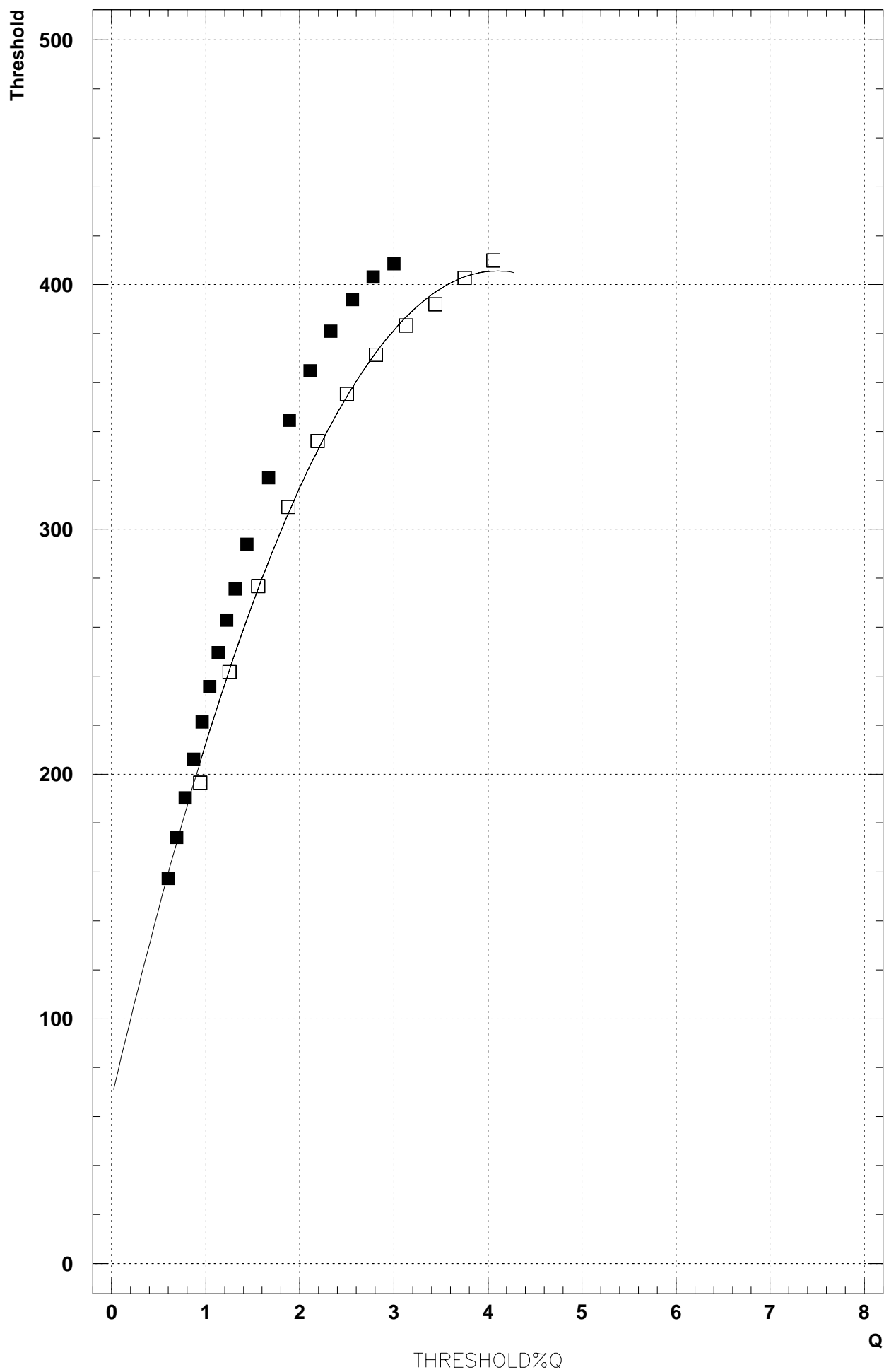
det0,det1,det2



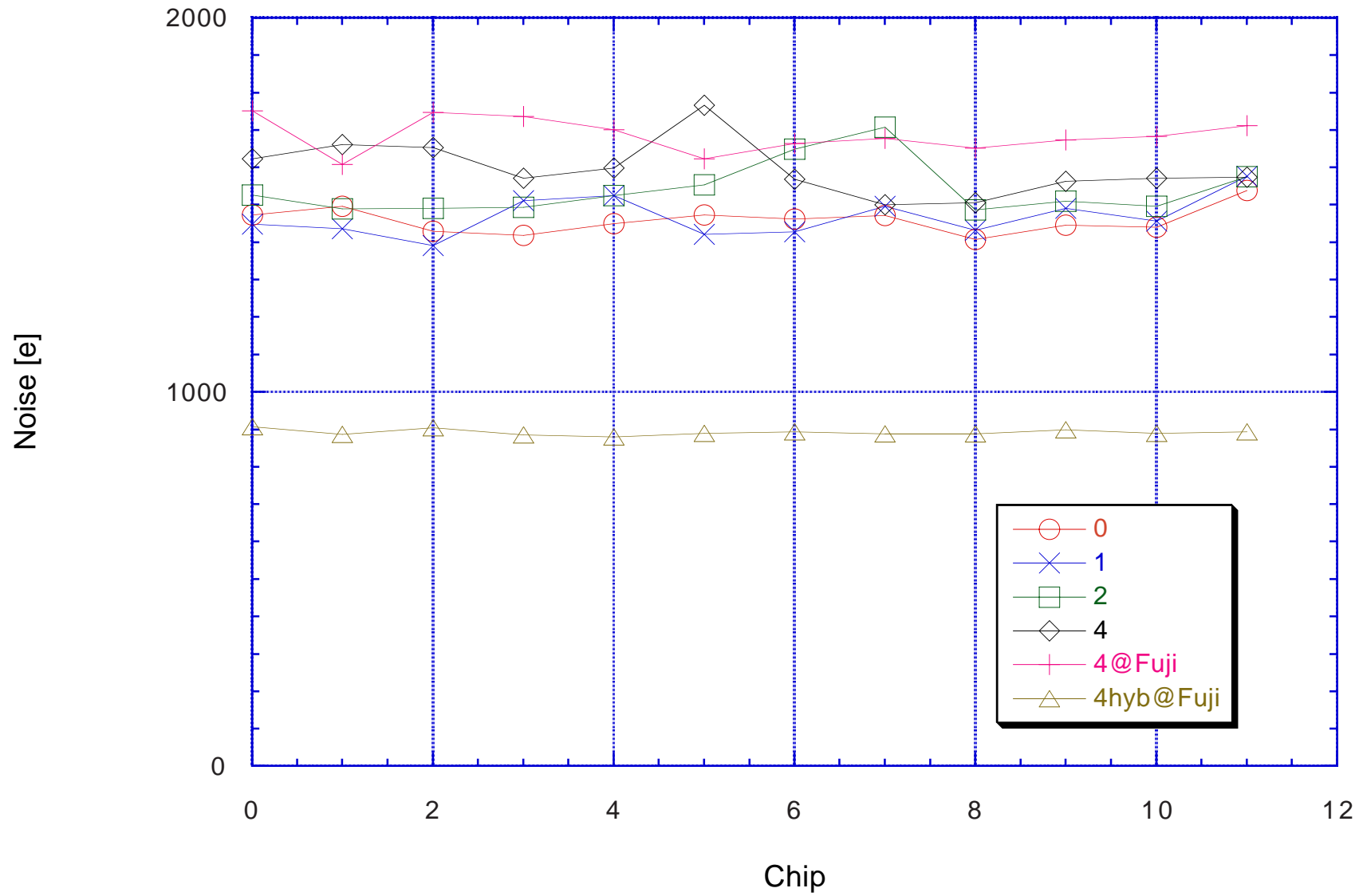
det3



det4



Noise000131.txt



Calibration - Summary of noises

- Module	Calibration	Noise [e]
-		
- Mod0 - KEK-ABCD#1	in-situ	~1460
- Mod1 - Freiburg ABCD	in-situ	~1470
- Mod2 - KEK-ABCD#2	in-situ	~1515(1680) ^a
- Mod4 - KEK CAFE/ABC	in-situ	~1600
-	Module@Fuji	~1690
-	Hybrid@Fuji	~890

- Notes:

^aChip6,7 in () were noiser than the rest

^aChip3 was too large trim step

- No particular characteristics in wafer probed data

CAFE/ABC in nominal charge scale, IDAR ~300 μ A=10fC

In-situ: -10 °C environment air cooled

@Fuji: +20 °C environment air cooled

Threshold scans

- **In beam**

- Scan points: typically, 0.8, 1.0, ..., 2.2, 2.5, 3.0, ..., 8.0 fC
- Bias voltages of 60, 80, 100, 120, 140, 160, 180, 200 V
- 5k events per point, several points in 10k or more

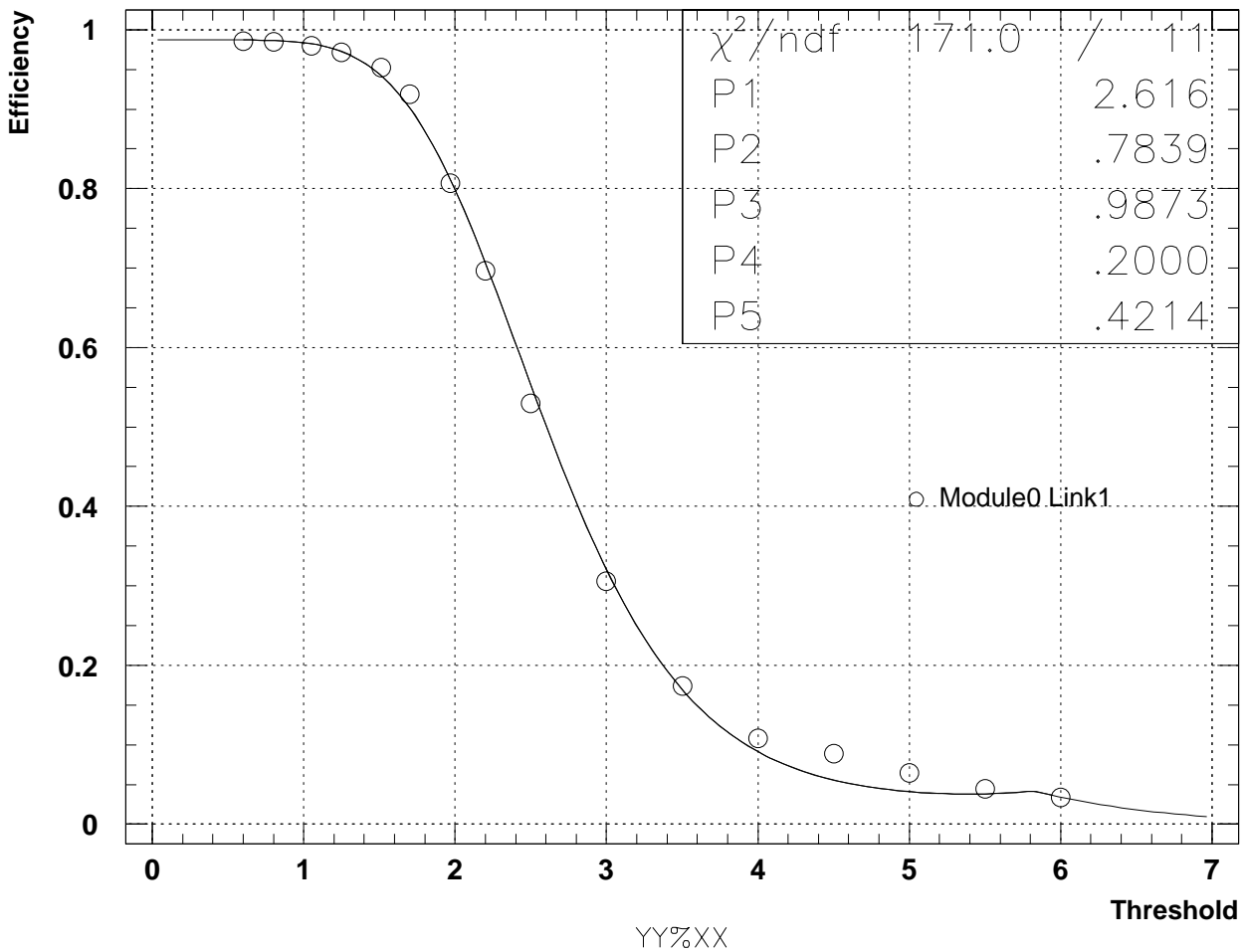
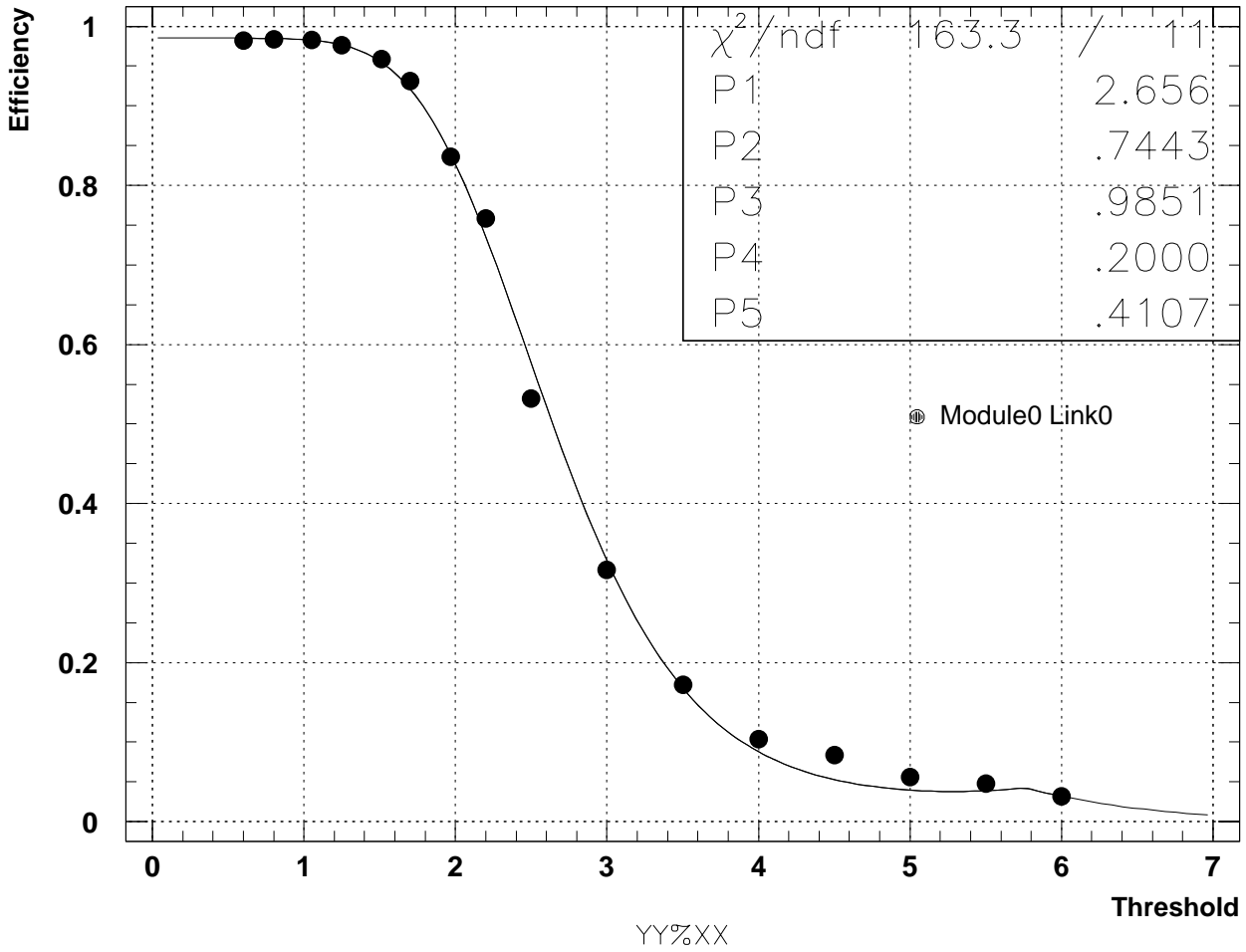
- low threshold points being re-calibrated after the calibration curve fit

- **Efficiency**

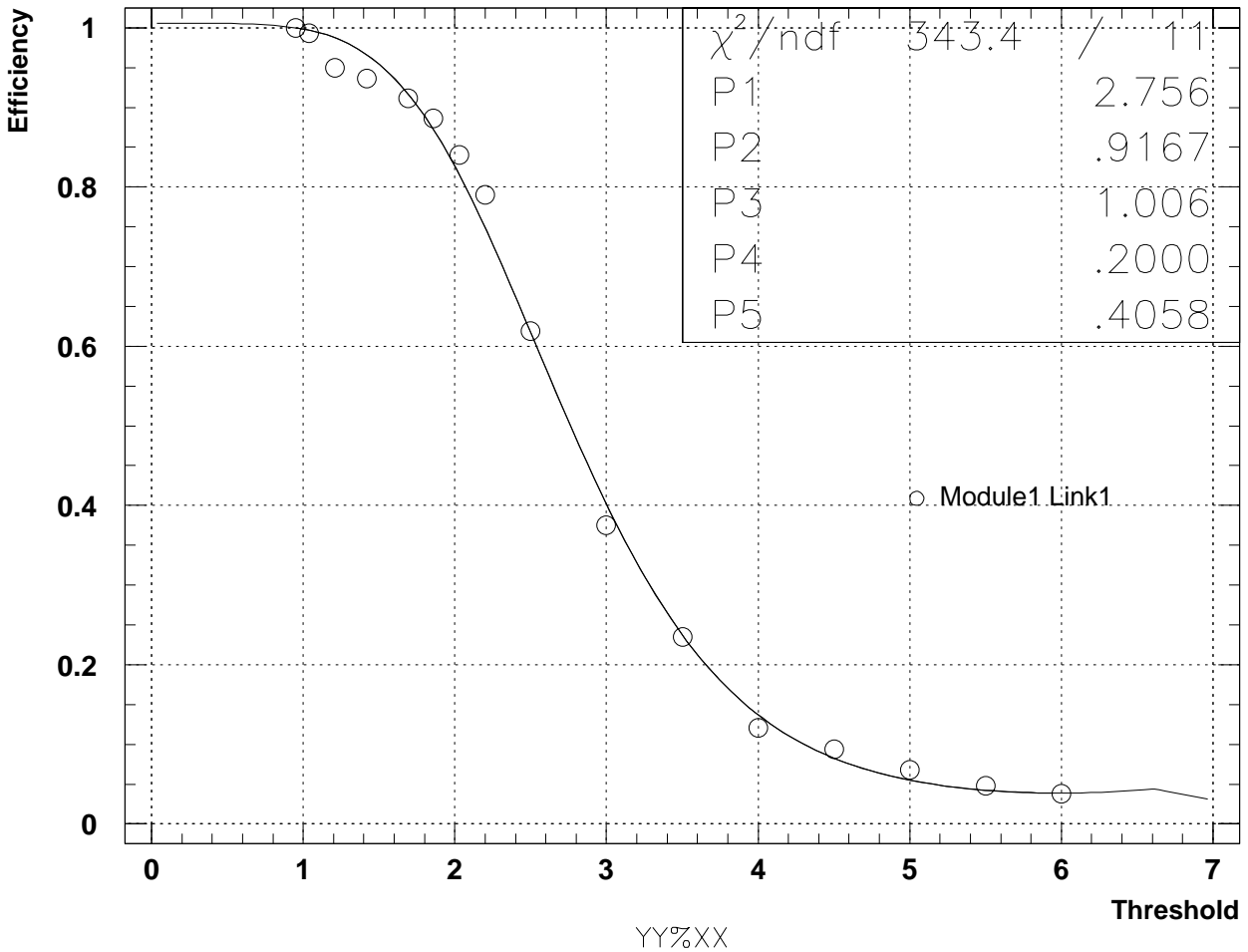
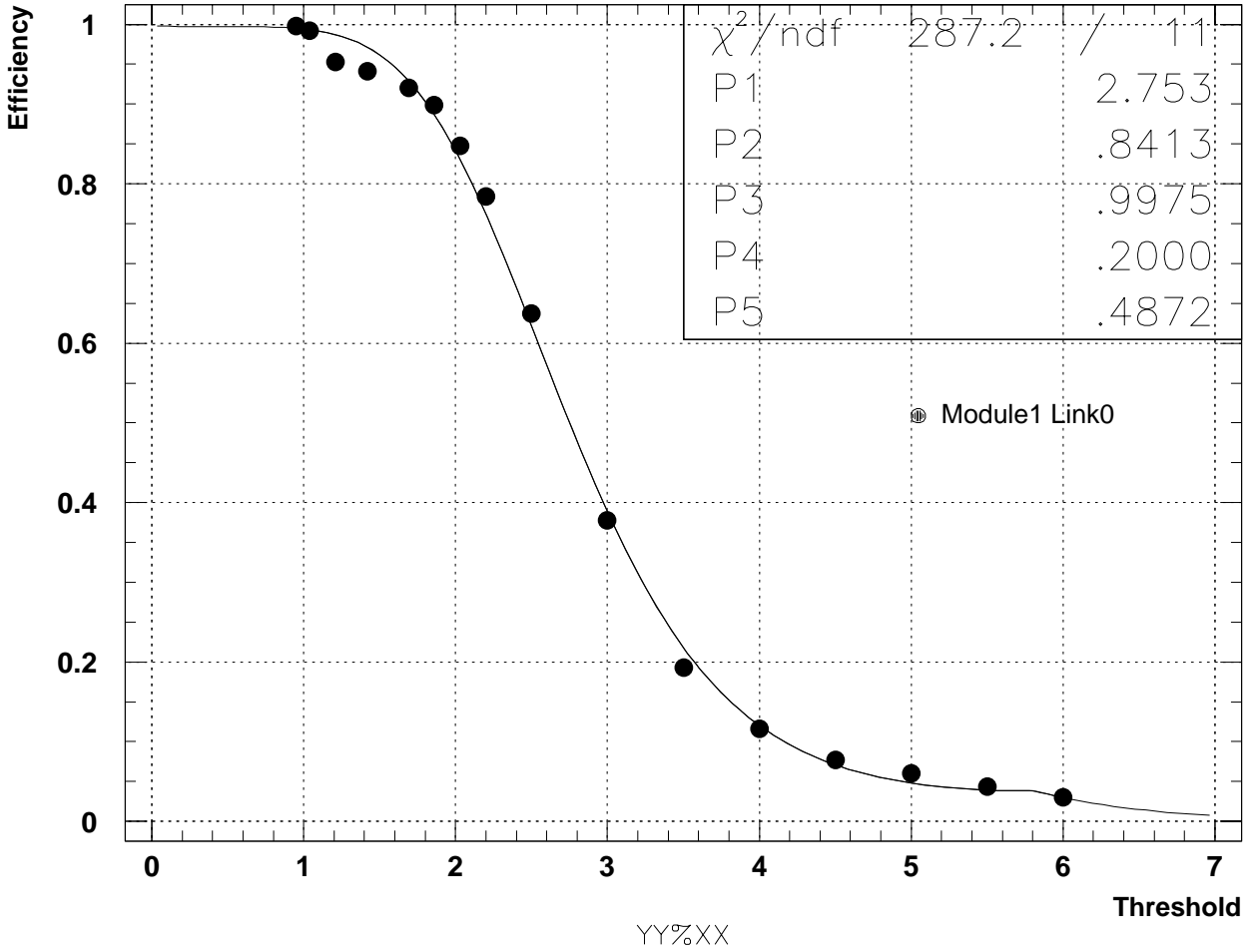
- Only correlation with anchor
- Rather wide window (but multiplicity was mostly single)
- In future, of course, with a track defined by telescope planes

- Fit to a modified Error function
 - Median charge = p1
 - Saturation = p3

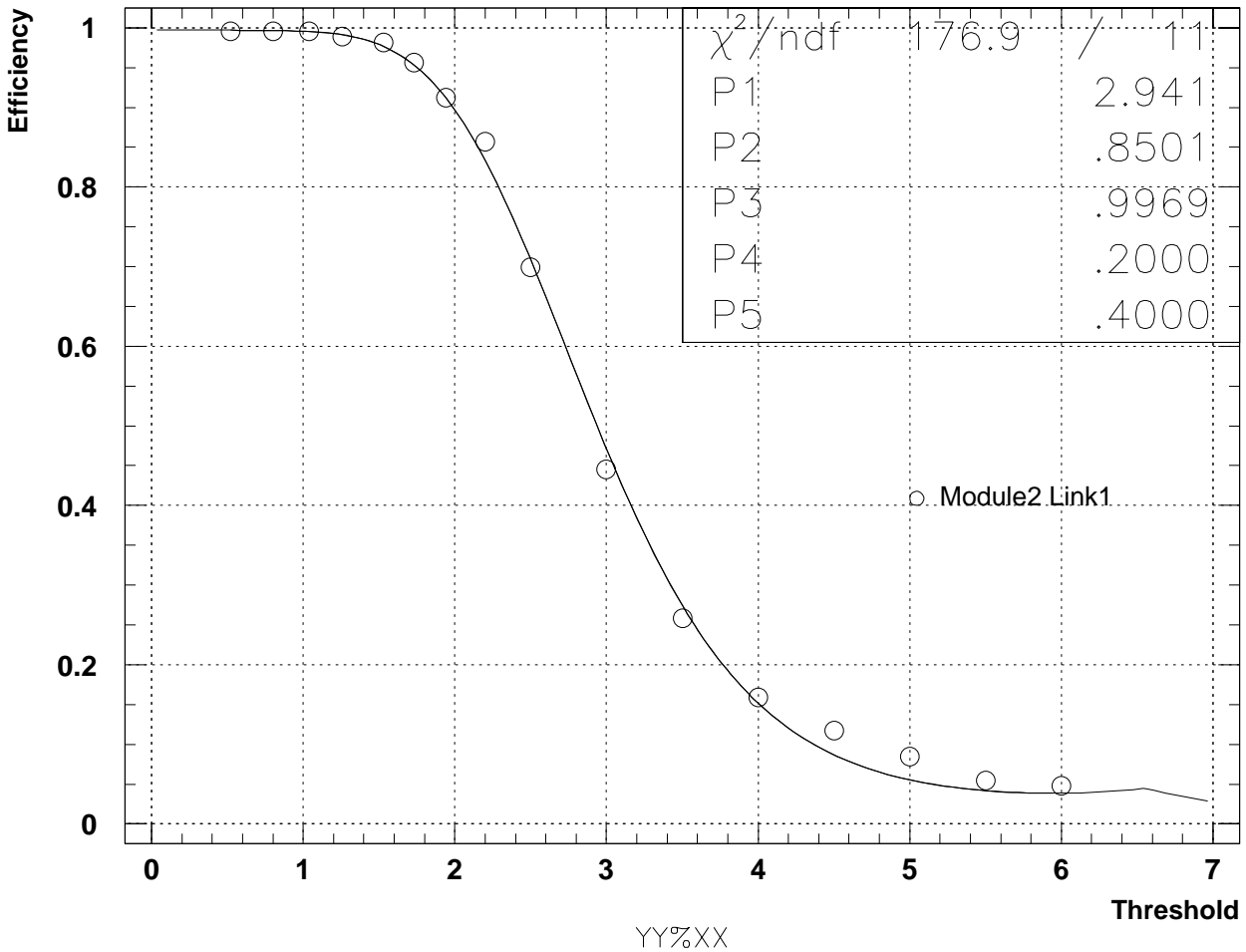
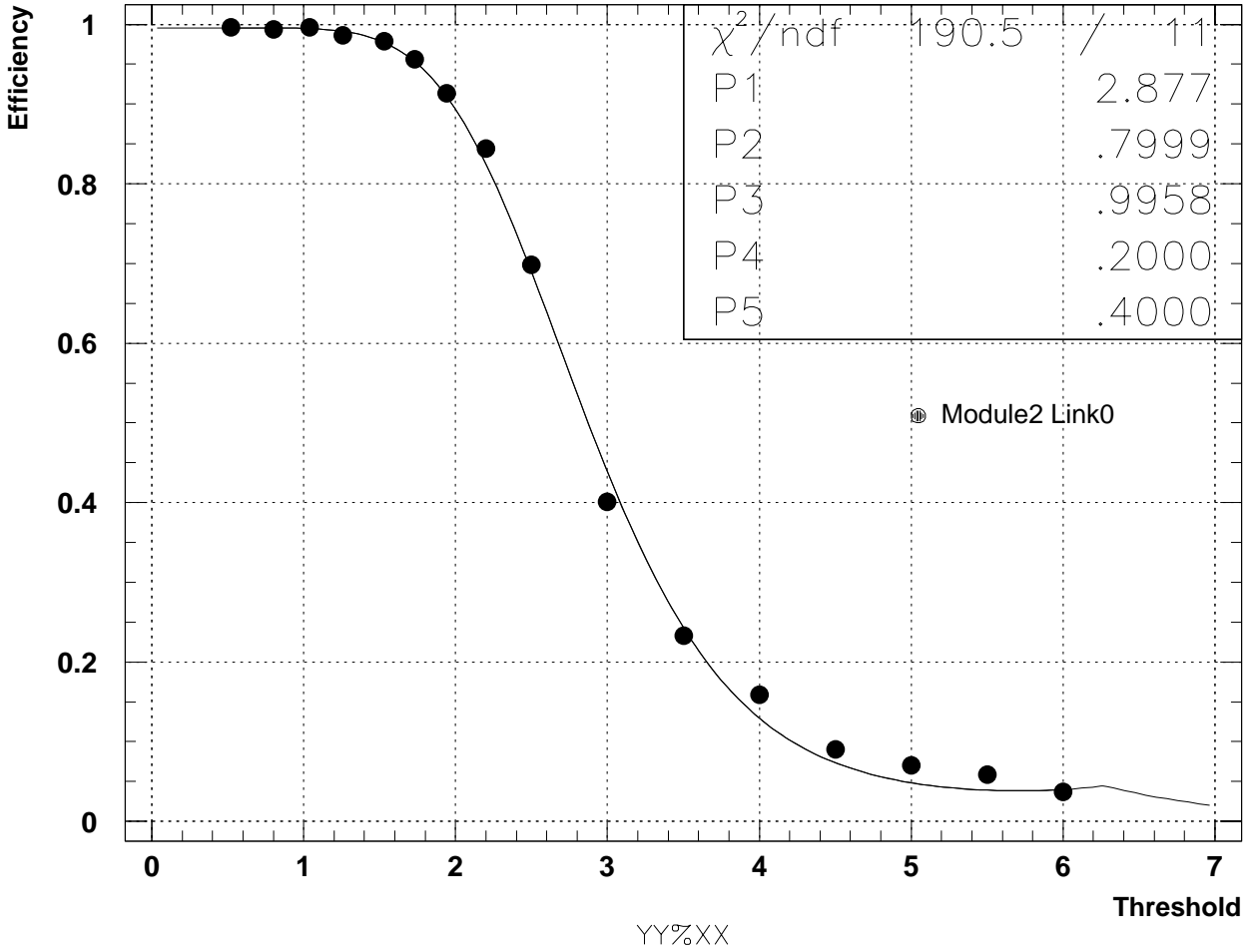
tbscan80v.dat2



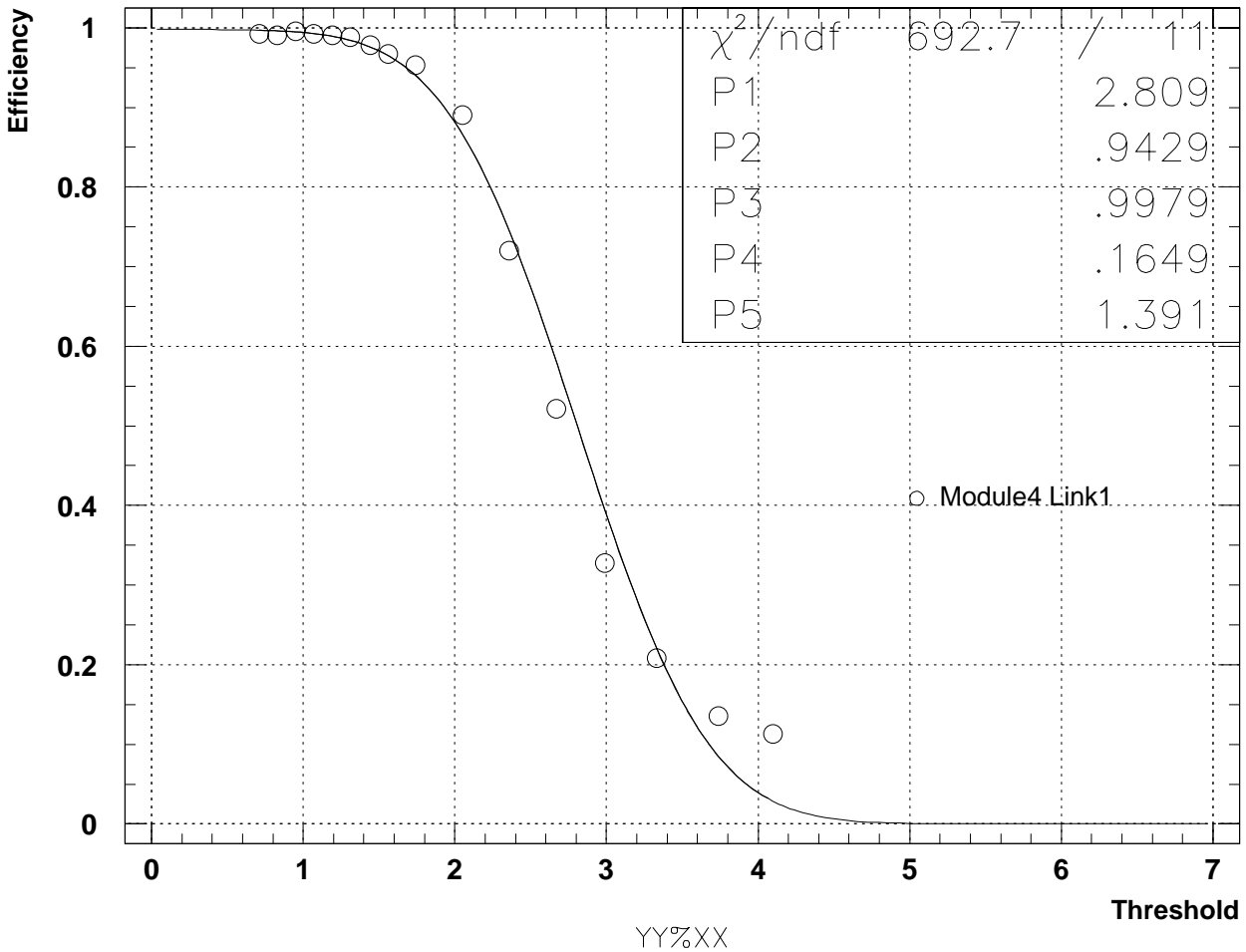
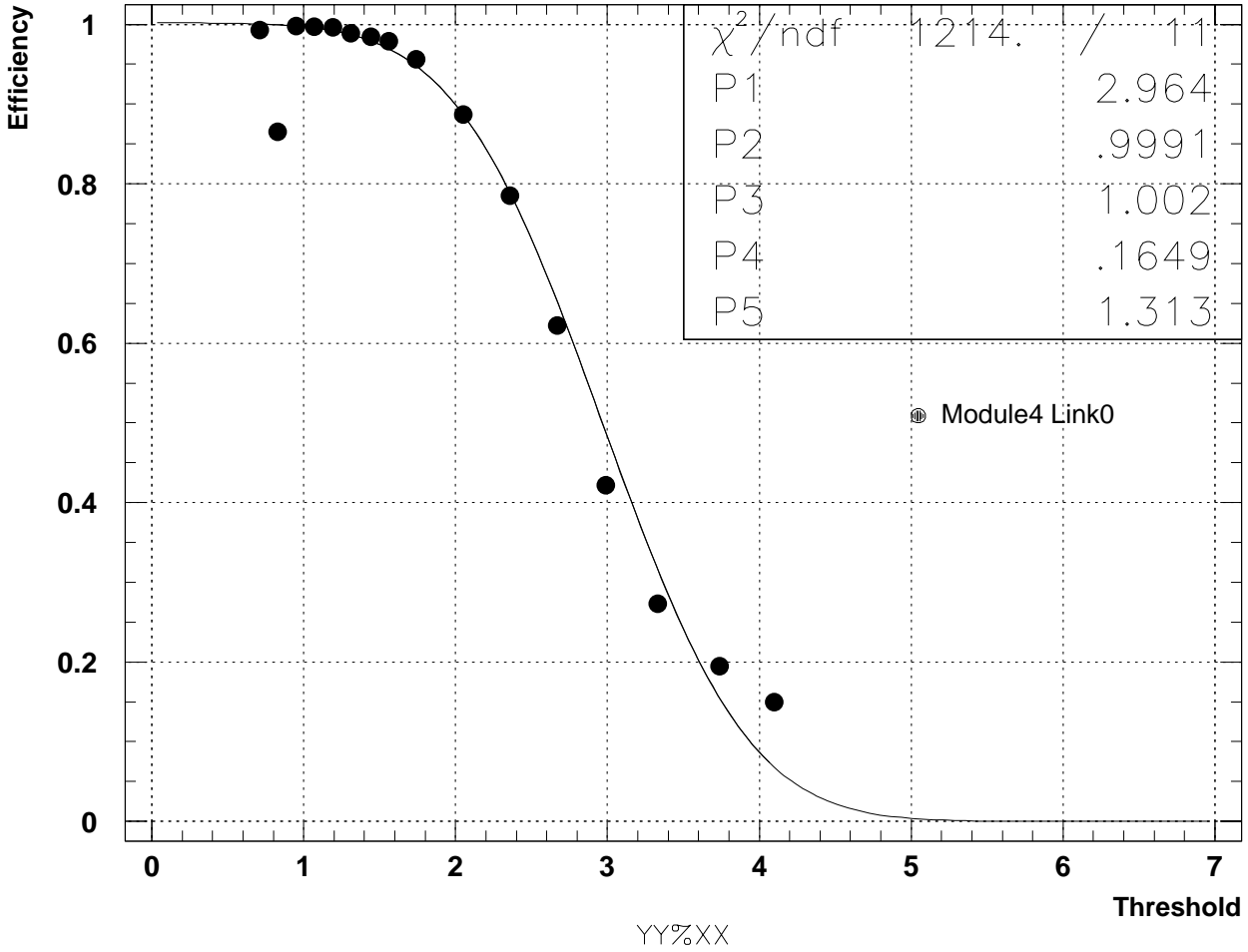
tbscan80v.dat2



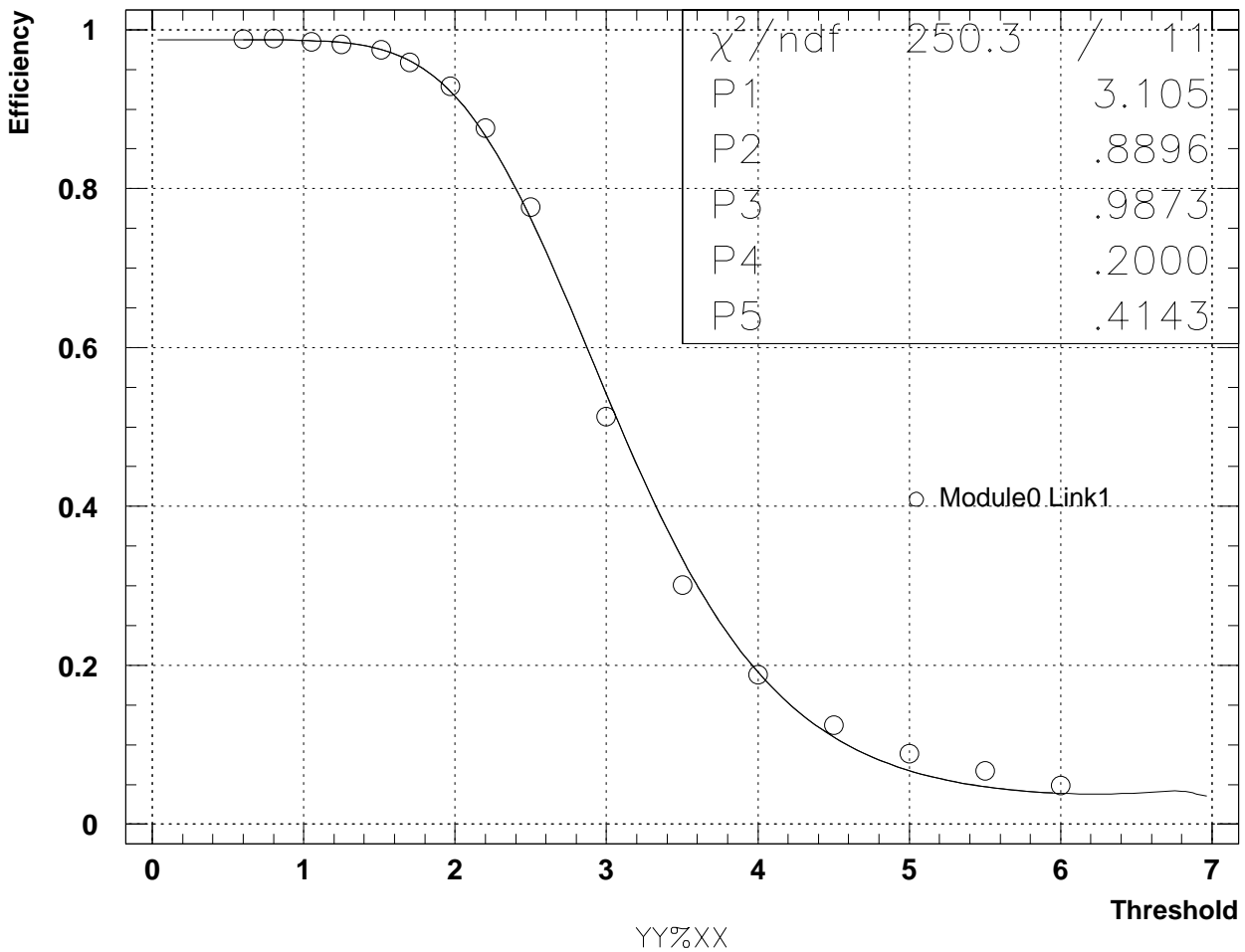
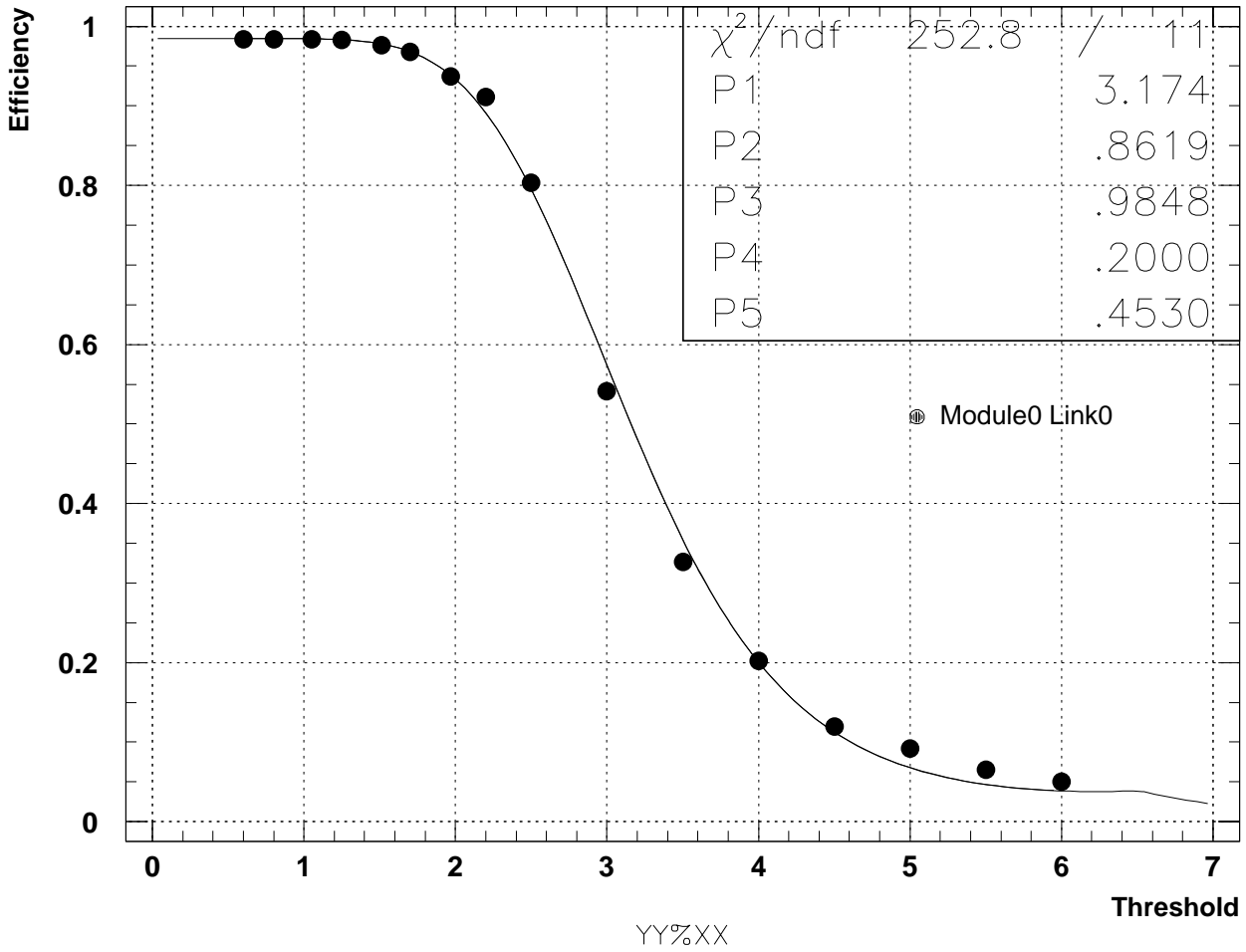
tbscan80v.dat2



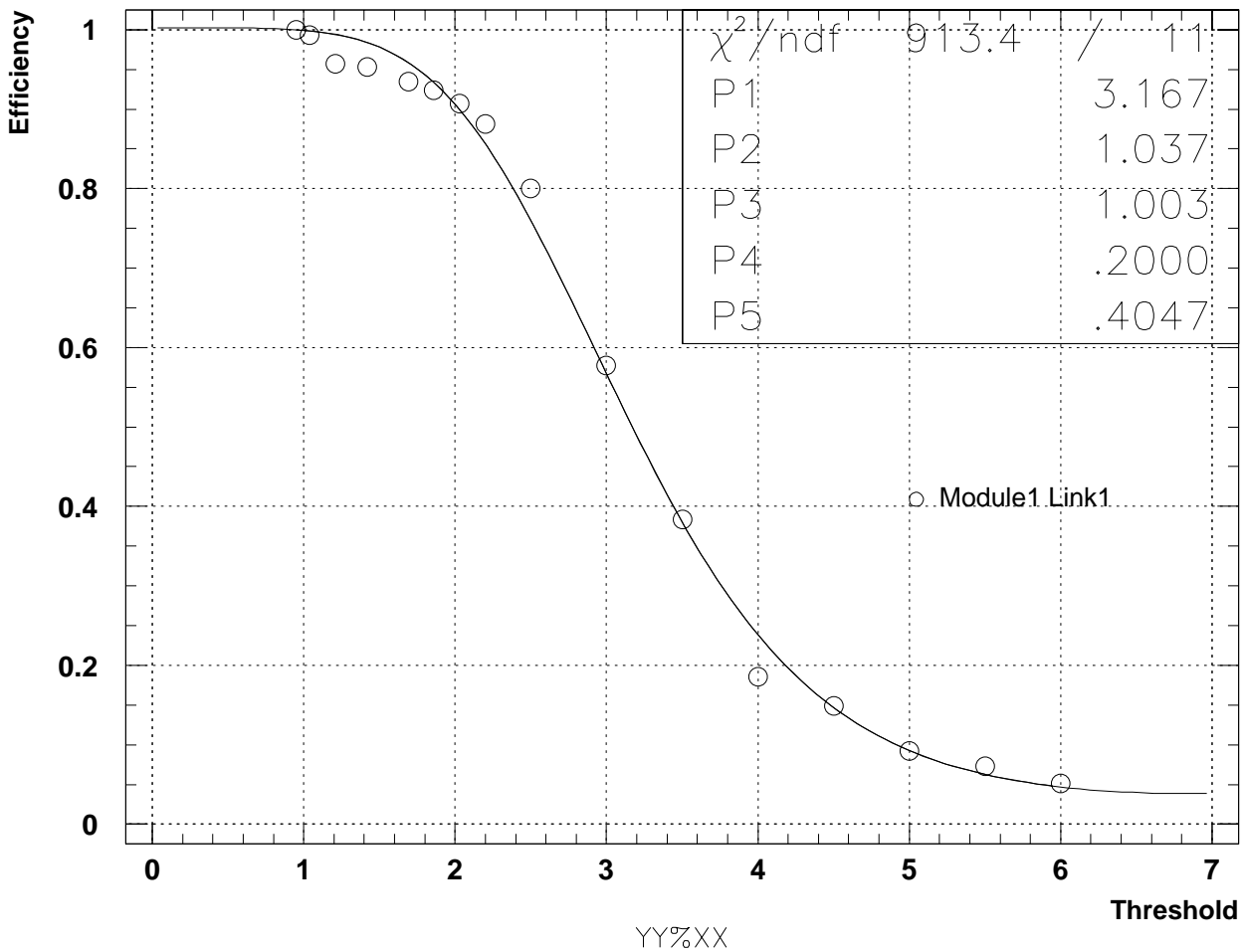
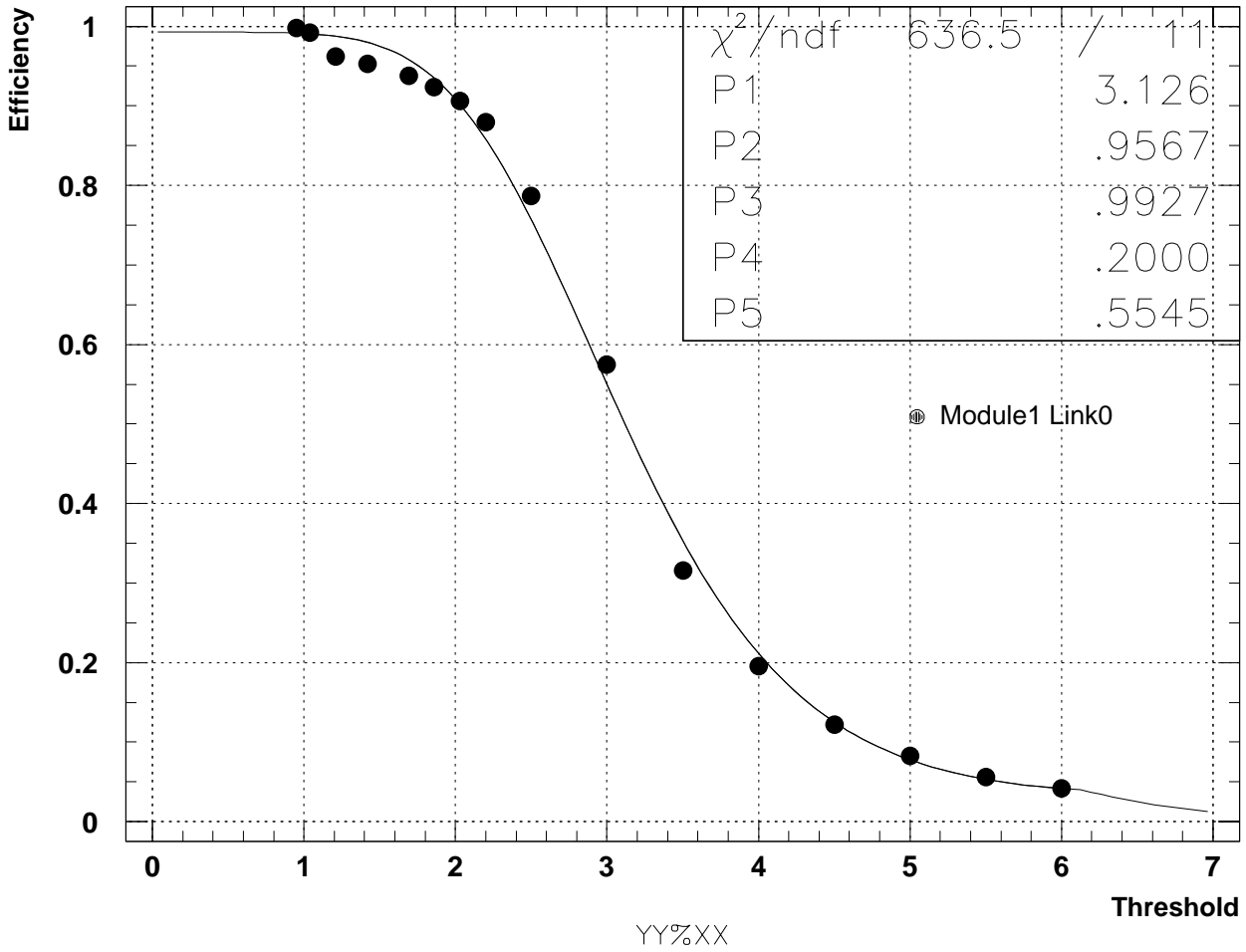
tbscan80v.dat2



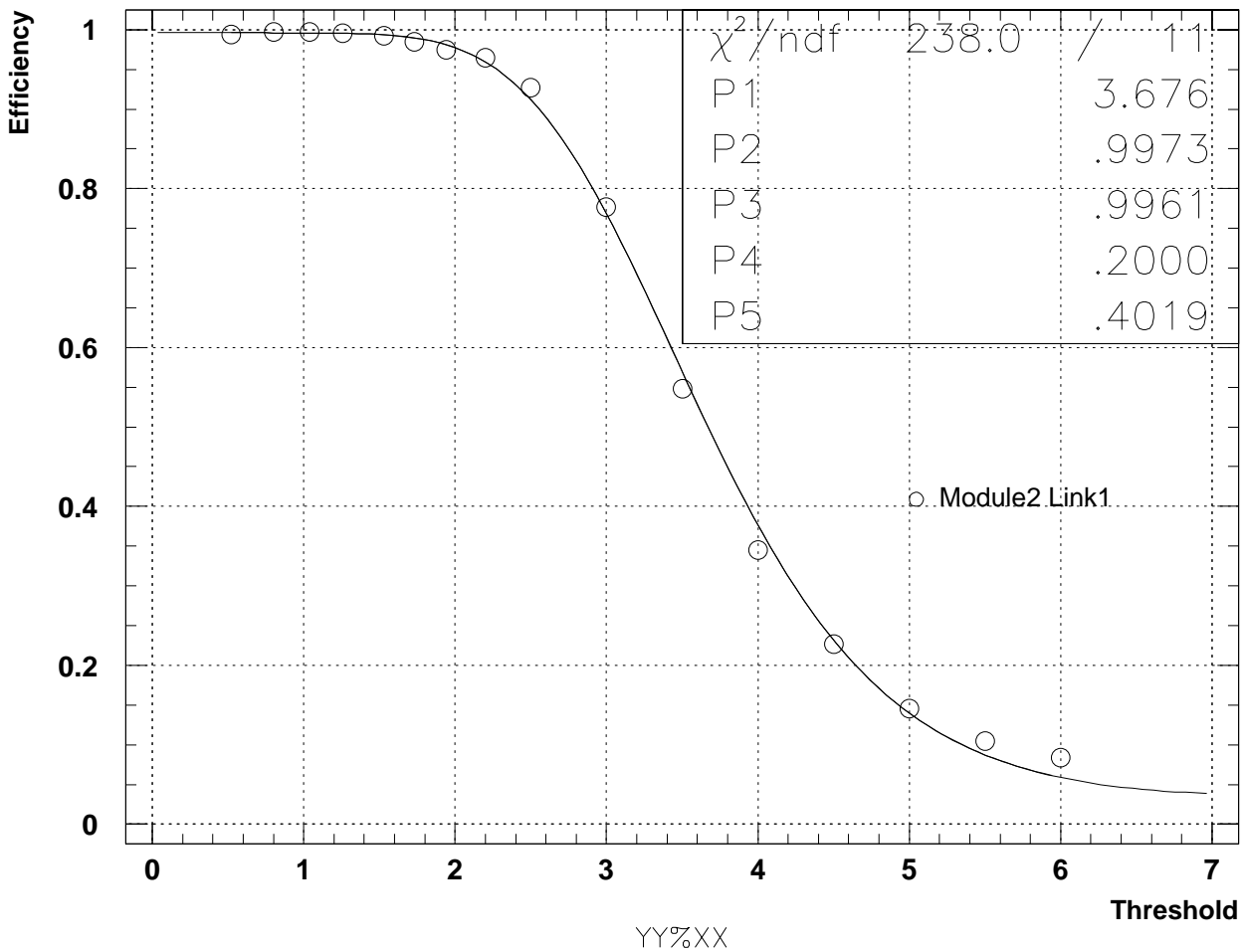
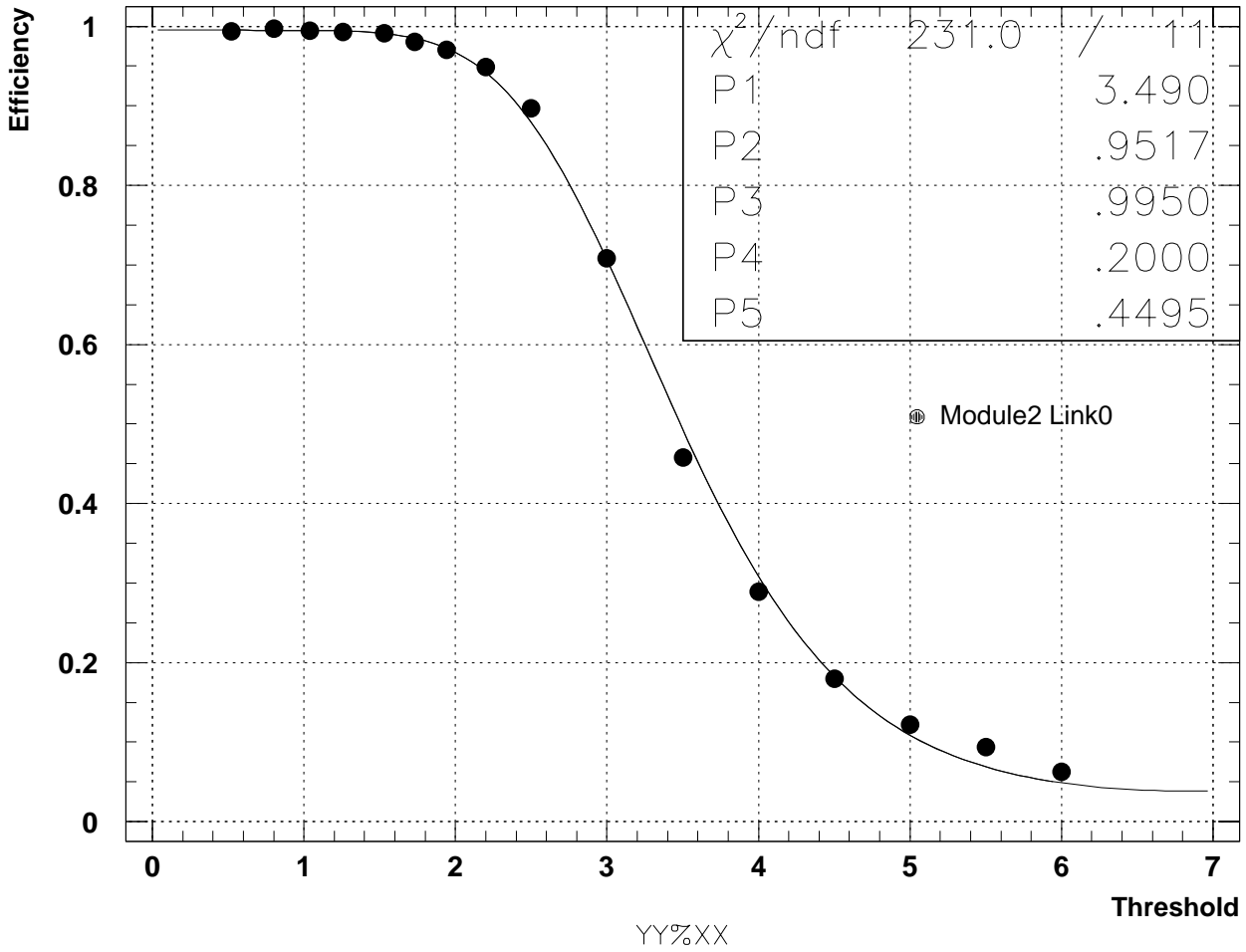
tbscan120v.dat2



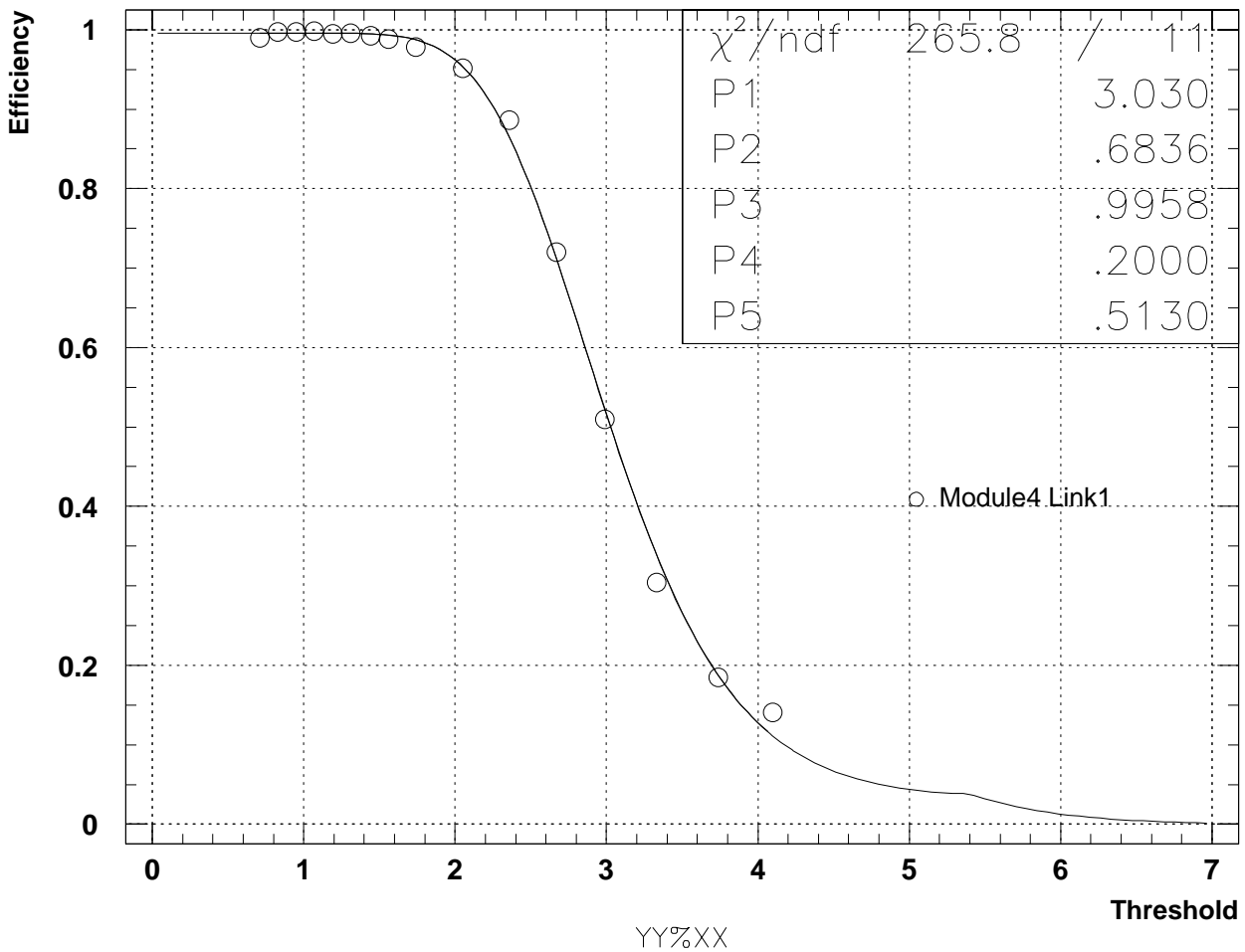
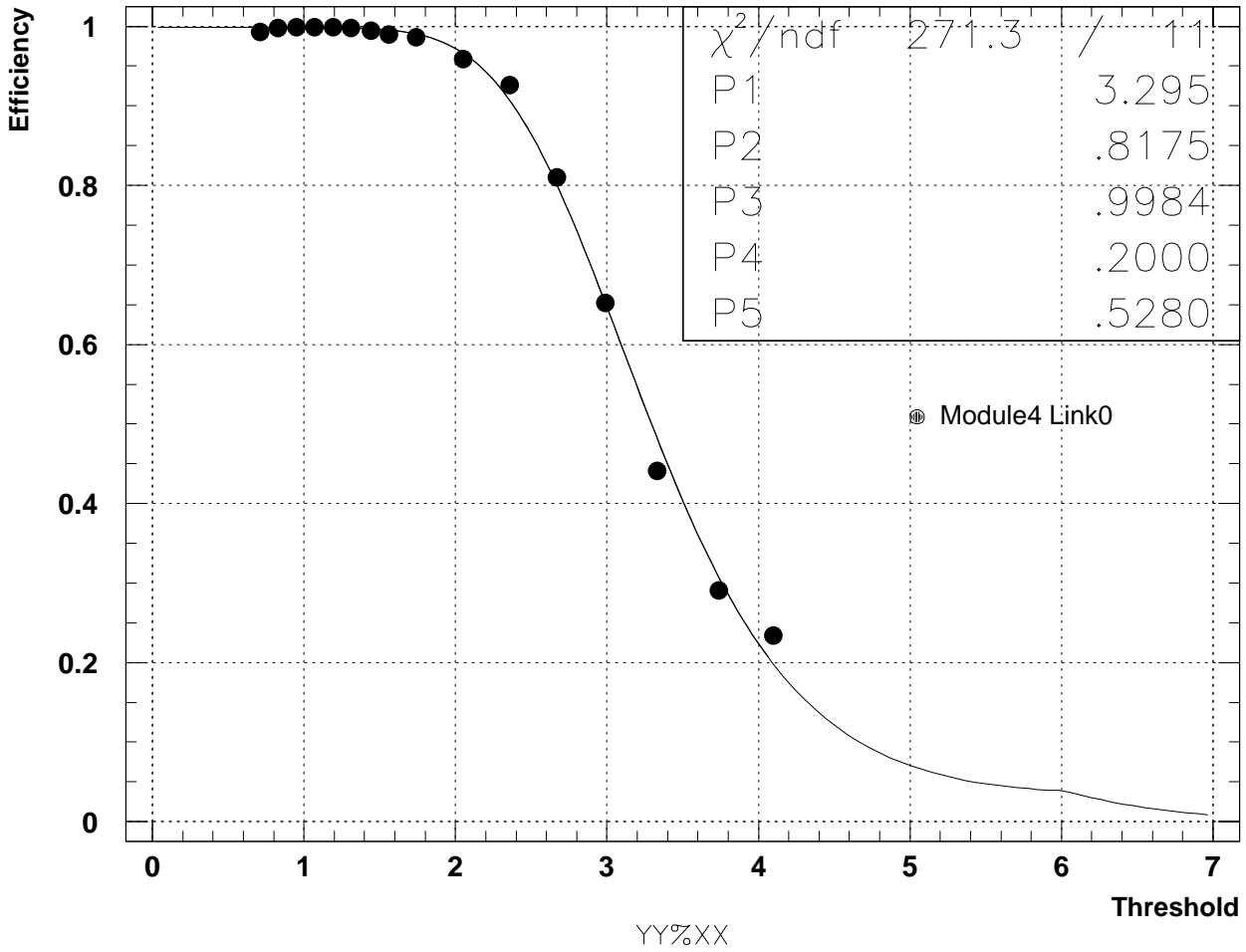
tbscan120v.dat2



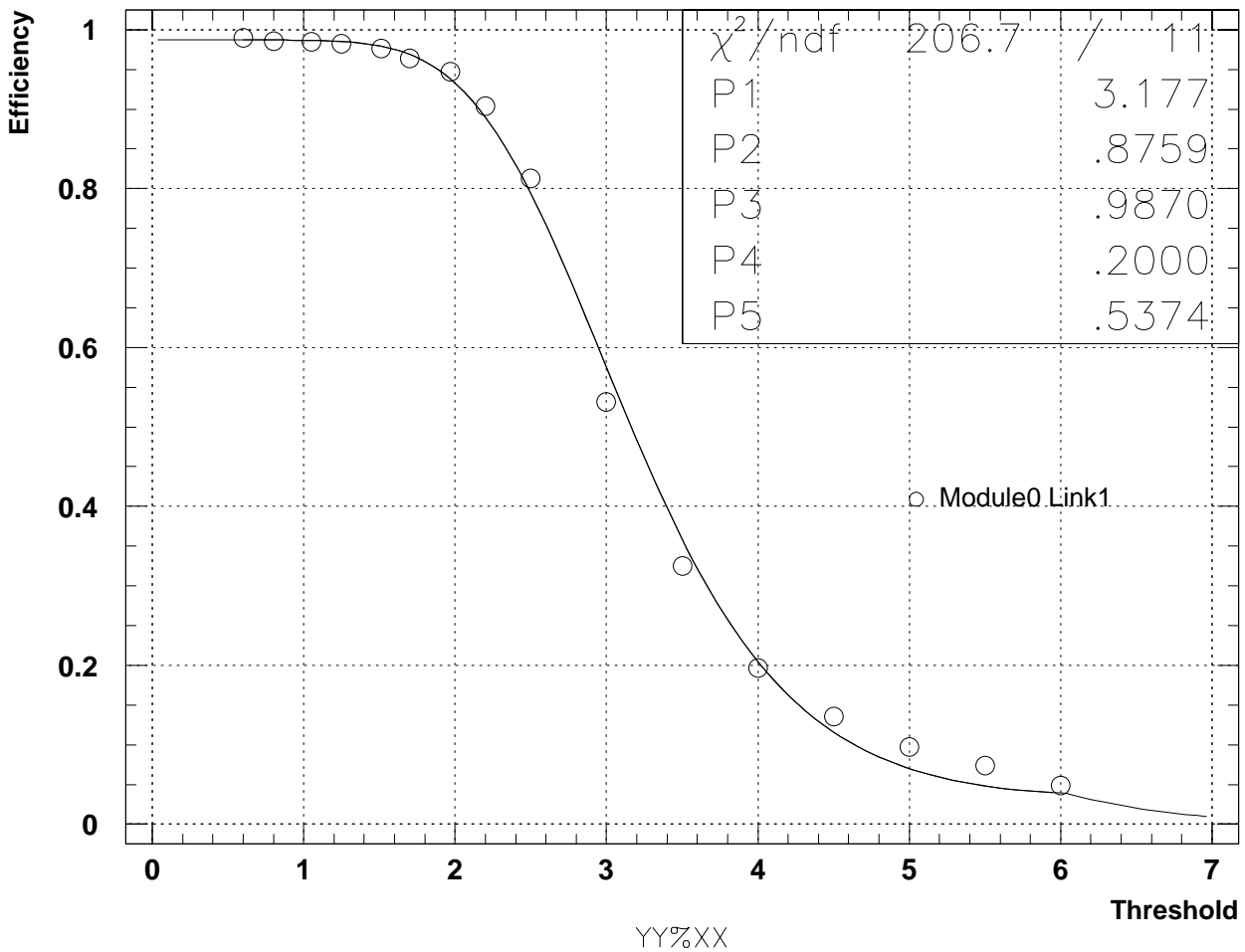
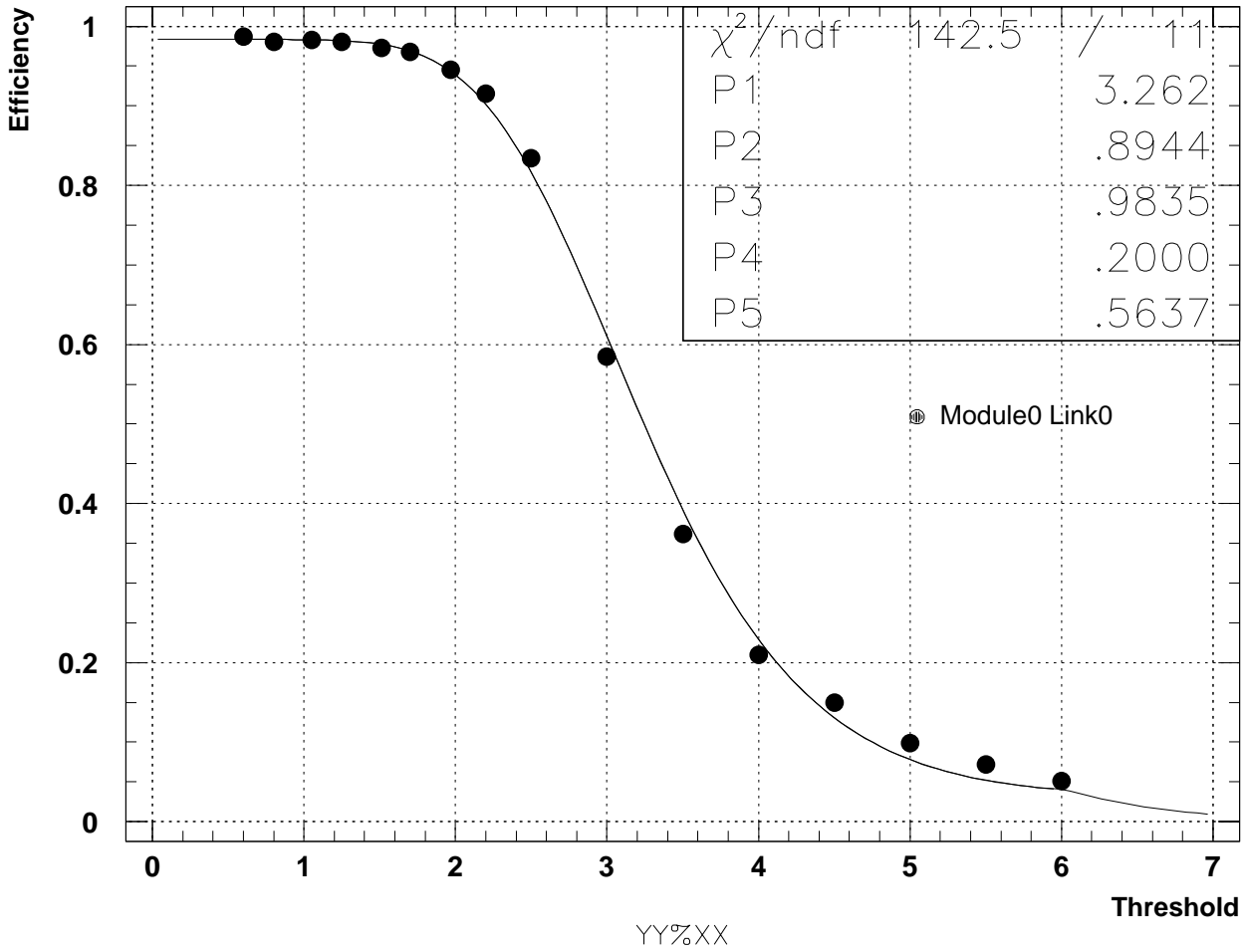
tbscan120v.dat2



tbscan120v.dat2



tbscan140v.dat2



Saturation

- **Mod0**

- ~98.5%
- 4 insensitive channels?/256 ~ 1.5% geometrical acceptance loss

- **Mod1**

- Many non-trimmed channels
- See the report by Freiburg

- **Mod2**

- ~99.5%
- 1 insensitive channel?

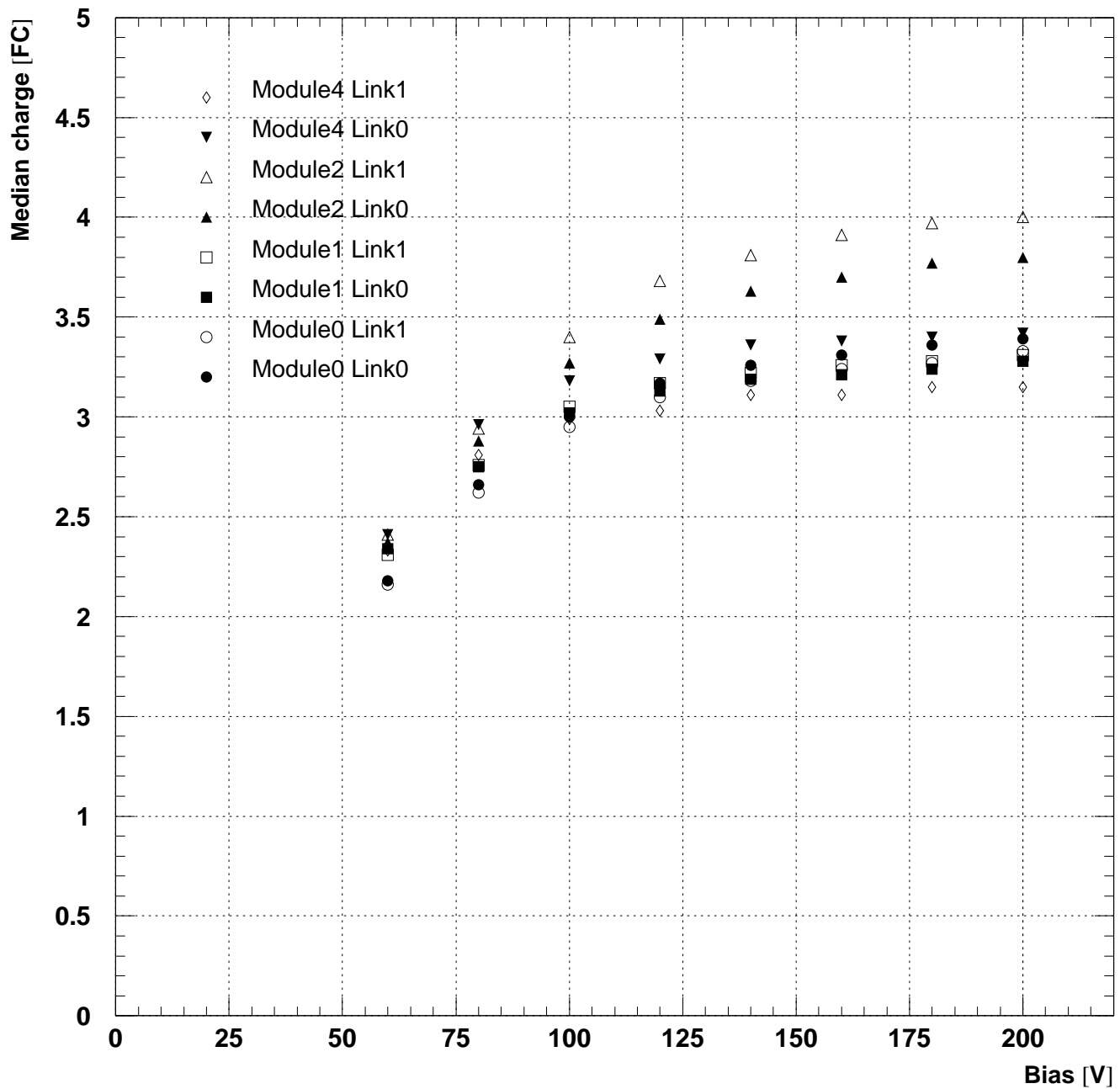
- **Mod4**

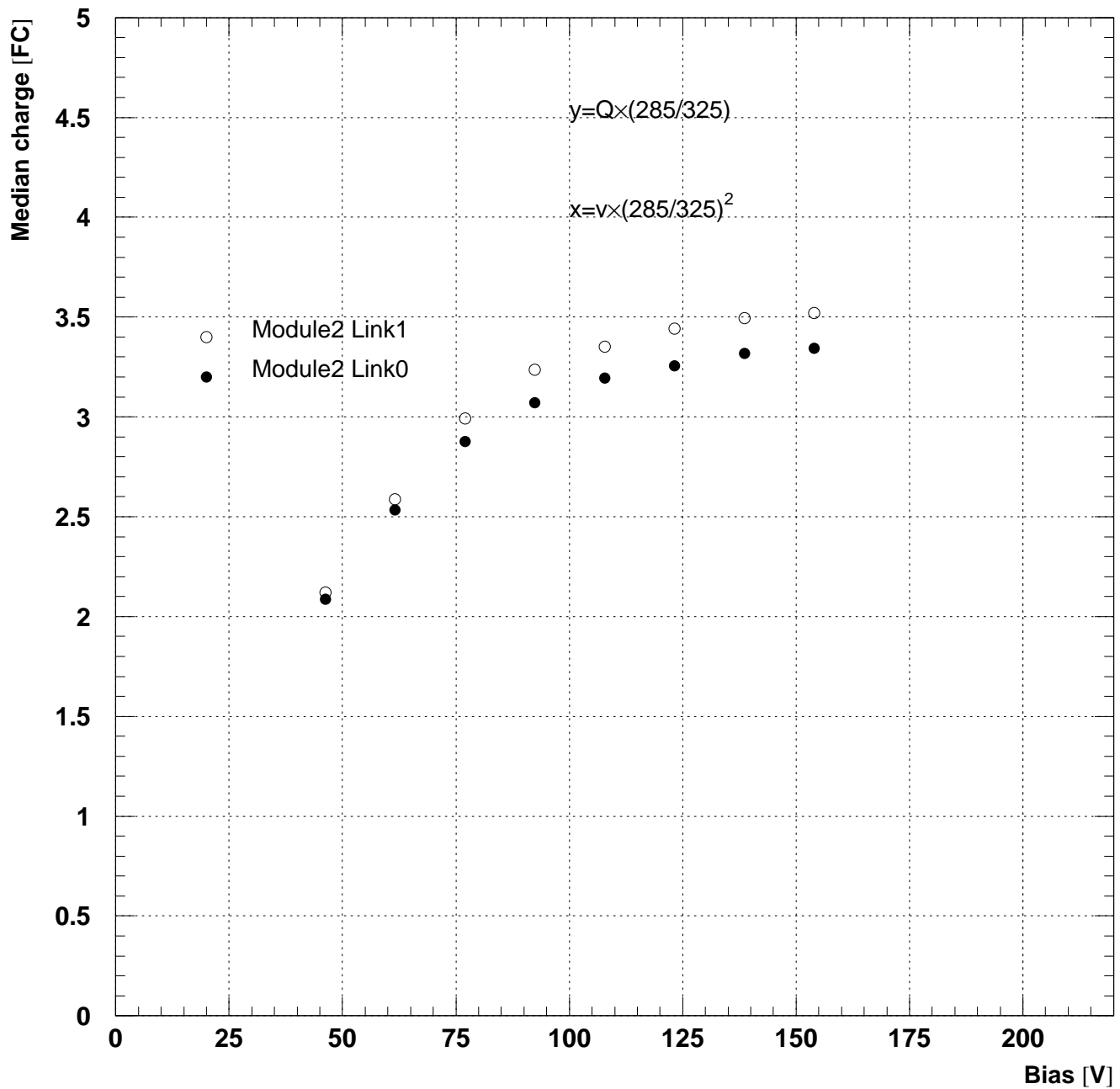
- ~99.7%
- None?

Better understanding - future with telescopes

Bias voltage dependence of median charges

- **Charges of 50% efficiency derived from the fits**
 - All 285 μm detector modules saturate at about 3.3 fC
 - 325 μm detector at about 3.8 fC, see renormalization
 - Saturation above 120 V
 - Required $\sim 50\text{V}$ overdepletion to get full charge
 - CAFE/ABC nominal charge scale seems correct
- **Mod2(325 μm) renormalization to thickness 285 μm**
 - Bias voltage \propto (Depletion thickness)²
 - Collected charge \propto Depletion thickness
 -
 - Bias voltage (285 μ) = (285 μ /325 μ)² * Bias voltage(325 μ)
factor = 0.77
 - Median charge (285 μ) = (285 μ /325 μ) * Median charge (325 μ)
factor = 0.88
 - Saturation at about 3.4 fC at $\sim 130\text{ V}$





Experience gained

- **ABCD modules**

- No trouble
- “Power-on reset” seems working

- **CAFE/ABC module**

- No power-on reset, reset with command

CAFE chips ~ 1/4 current

ABC chips ~ 2 current

- ABC chip “Latch-up” often

“Latch-up” =

- ABC chip drops into “un-listen to command” mode
- ABC chip draws more current
- Only reset with Vdd OFF-ON

Sort of randomly in chips (1 or 2 chips)

Associated with electrical shocks

- Cooling box power on-on (in lab observation)
- Bias voltage change (in beam)
- No particular events (in beam)

Summary

- **Dec 99 beamtest at KEK was carried out successfully**
 - with a new PC-based SCTDAQ
 - 4 ABCD2T and 1 CAFE/ABC modules
- **Gained experience on operation of the modules**
 - ABCD2T without trouble
 - CAFE/ABC experienced “latch-up” problem
- **Reasonable behaviours of median charges**
 - Saturation above 120 V
 - Saturation at 3.3 fC for 285 μm thickness
- **ASIC/hybrid/Module performance (Preliminary)**
 - ABCD2T
 - Same performance in lab and beam, noise (module)~ 1450 e
 - CAFE/ABC
 - Nominal charge scale seems correct
 - Instability - <0.3 fC (hybrid), <0.7 fC (module)?
 - Noise
 - 900 e (no detector, +20 °C)
 - 1550 e (module, -10 °C), 1680 e (module, +20 °C)