Hybrid/Module Production Test Results

A. Ciocio - LBNL

Status – Hybrids

Hybrids Built	**200**
Hybrids Tested OK	**165**
Hybrids on HOLD	**27**
Hybrids PA bond DONE/PASS	**159**

• First 122 hybrids built and tested entirely at LBL then hybrid assembly and testing has moved to UCSC

• At UCSC
- Hybrid chip gluing and bonding and testing
- Hybrid Rework
- Burn-in
- PA bonding (some still at LBL)

• At LBL
- Some hybrid testing (burn-in and confirmation)
- Some PA bonding

All production modules built and tested at LBL

Defective Chips

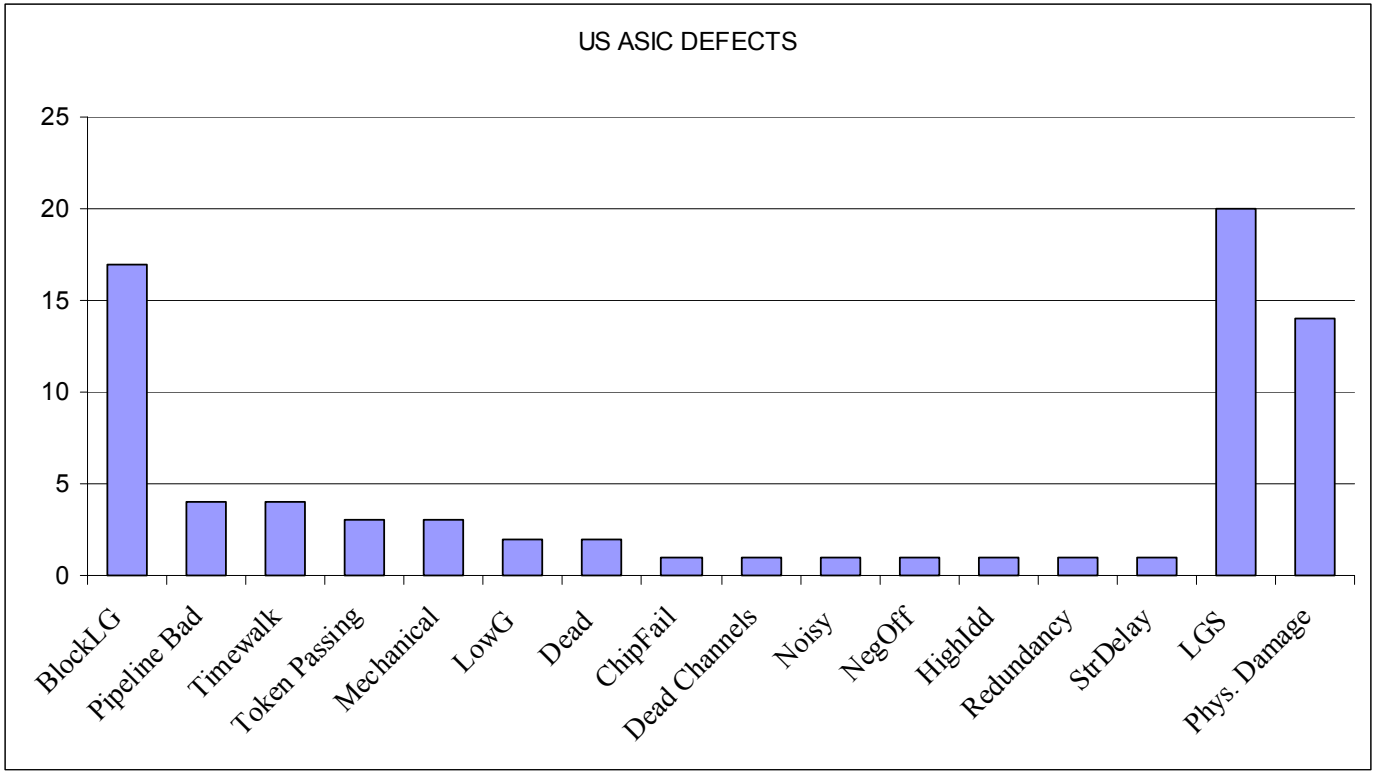
Hybrid Serial #	chip# on hybrid	lot/wafer	DEFECT	chip status
20220040200011	11	Z40859-W11	LGS	Replaced
20220040200013	6	Z40859-W02	Mechanical	Replaced
20220040200020	1	Z40859-W014	Token	Replaced
20220040200021	8	Z40859-W09	LGS	Replaced
20220040200021	7	Z40859-W09	BlockLG	HOLD
20220040200022	10	Z40859-W09	LowG	to rework
20220040200035	9	Z40859-W01	Mechanical	Replaced
20220040200035	6	Z40859-W01	TimeWalk	Replaced
20220040200039	10	Z40859-W04	Mechanical	Replaced
20220040200039	2	Z40859-W04	LGS	ok to use
20220040200039	6	Z40859-W04	LGS	ok to use
20220040200041	2	Z40802-W09	LGS	ok to use
20220040200046	9	Z40803-W02	LGS	ok to use
20220040200047	0	Z40862-W11	NegOff	to rework
20220040200048	9	Z40803-W02	LGS	ok to use
20220040200050	10	Z40862-W11	TimeWalk	to rework
20220040200052	7	Z40862-W09	LGS	ok to use
20220040200054	4	Z40803-W05	LGS	ok to use
20220040200056	6	Z40803-W05	Highldd	Replaced
20220040200057	9	Z40862-W09	LGS	ok to use
20220040200058	7	Z40803-W05	?	to rework
20220040200059	0	Z40803-W03	LowG	Replaced
20220040200064	0	Z40862-W02	Redundancy	to rework
20220040200068	1	Z40862-W02	LGS	ok to use
20220040200073	0	Z40803-W01	StrDelay	Replaced
20220040200098	6	Z41032-W13	BlockLG	HOLD
20220040200098	7	Z41032-W13	BlockLG	HOLD
20220040200099	0	Z41032-W13	BlockLG	HOLD
20220040200100	1	Z41032-W13	LGS	ok to use
20220040200100	7	Z41032-W13	BlockLG	HOLD
20220040200100	9	Z41032-W13	BlockLG	HOLD
20220040200107	8	Z41032-w12	BlockLG	HOLD
20220040200117	8	Z41032-w08	BlockLG	HOLD
20220040200119	0	Z41032-w08	Noisy	Replaced
20220040200122	10	Z41032-w09	LGS	ok to use
20220040200128	3	Z40615-w19	Dead	to rework
20220040200128	5	Z40615-w19	Timewalk	to rework
20220040200132	7	Z41032-w08	Dead	replaced

Hybrid Serial #	chip# on hybrid	lot/wafer	DEFECT	chip status
20220040200136	0	Z40803-W06	LGS	ok to use
20220040200137	9	Z40803-W06	LGS	ok to use
20220040200138	8	Z40803-W08	LGS	ok to use
20220040200141	0	Z40803-W08	LGS	ok to use
20220040200143	6	Z40920-W13	Token	Replaced
20220040200144	2	Z40920-W15	LGS	Replaced
20220040200145	1	Z40920-W15	BlockLG	HOLD
20220040200148	6	Z41032-w12	BlockLG	HOLD
20220040200155	8	Z40920-W10	BlockLG	HOLD
20220040200156	4	Z40920-W10	BlockLG	HOLD
20220040200158	11	Z40920-W10	BlockLG	HOLD
20220040200160	8	Z41032-W13	BlockLG	HOLD
20220040200161	0	Z41032-W13	LGS	ok to use
20220040200164	9	Z41032-w17	Pipeline Bad	Replaced
20220040200165	10	Z41032-w17	BlockLG	HOLD
20220040200165	8	Z41032-w17	BlockLG	HOLD
20220040200180	10	Z41032-w11	Pipeline Bad	Replaced
20220040200180	10	Z41032-w11	Dead Channels	Replaced
20220040200181	10	Z41032-w11	Physical Damage	HOLD
20220040200181	11	Z41032-w11	Physical Damage	HOLD
20220040200182	0	Z41032-w11	Physical Damage	Replaced
20220040200182	1	Z41032-w11	Physical Damage	Replaced
20220040200182	2	Z41032-w11	Physical Damage	Replaced
20220040200182	3	Z41032-w11	Physical Damage	Replaced
20220040200182	4	Z41032-w11	Physical Damage	Replaced
20220040200182	5	Z41032-w11	Physical Damage	Replaced
20220040200182	6	Z41032-w11	Physical Damage	Replaced
20220040200182	7	Z41032-w11	Physical Damage	Replaced
20220040200182	8	Z41032-w11	Physical Damage	Replaced
20220040200182	9	Z41032-w11	Physical Damage	Replaced
20220040200182	10	Z41032-w11	Physical Damage	Replaced
20220040200182	11	Z41032-w11	Physical Damage	Replaced
20220040200183	4	Z39693-W15	Pipeline Bad	Replaced
20220040200184	0	Z39693-w15	Pipeline Bad	Replaced
20220040200185	8	Z39693-W15	Timewalk	Replaced
20220040200186	10	Z41032-w11	Token	Replaced
20220040200189	9	Z41032-w07	BlockLG	HOLD
20220040200192	3	Z39693-w15	Token	Replaced
20220040200193	11	Z39693-w15	LGS	ok to use

Defective Chips

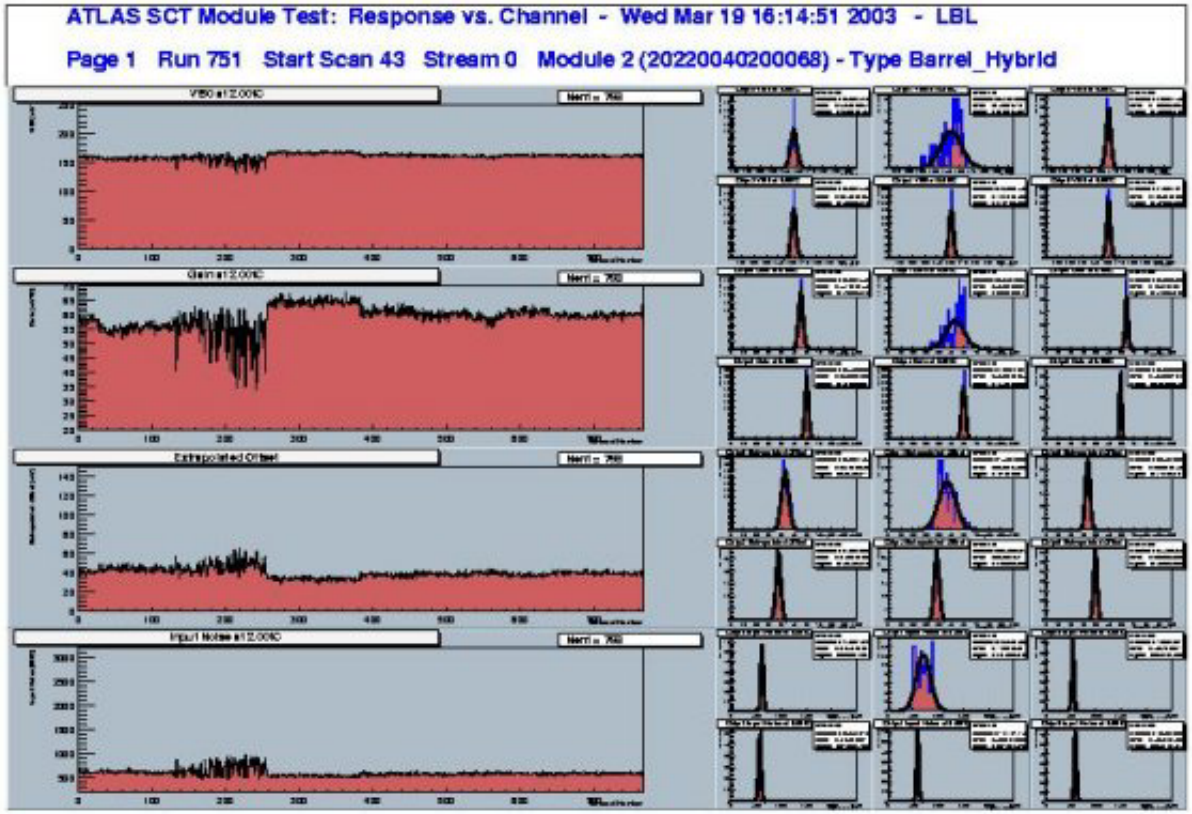
Chips Replaced	Hybrids on HOLD	Chips ok to use	to rework	Total
34	15	17	7	77

LGS	20 (<1%)
BlockLG	17
Physical	14
Pipeline	4
TW	4
Token	4
Mechanical	3
LowG	2
Dead	2
Dead Ch	1
Noisy	1
NegOffs	1
HighIdd	1
Redund	1
StrobeD	1
Other	1



LGS

A study of the Large Gain Spread (LGS) effect was conducted in numerous ASIC's to better understand the causes, effects, and possible solutions



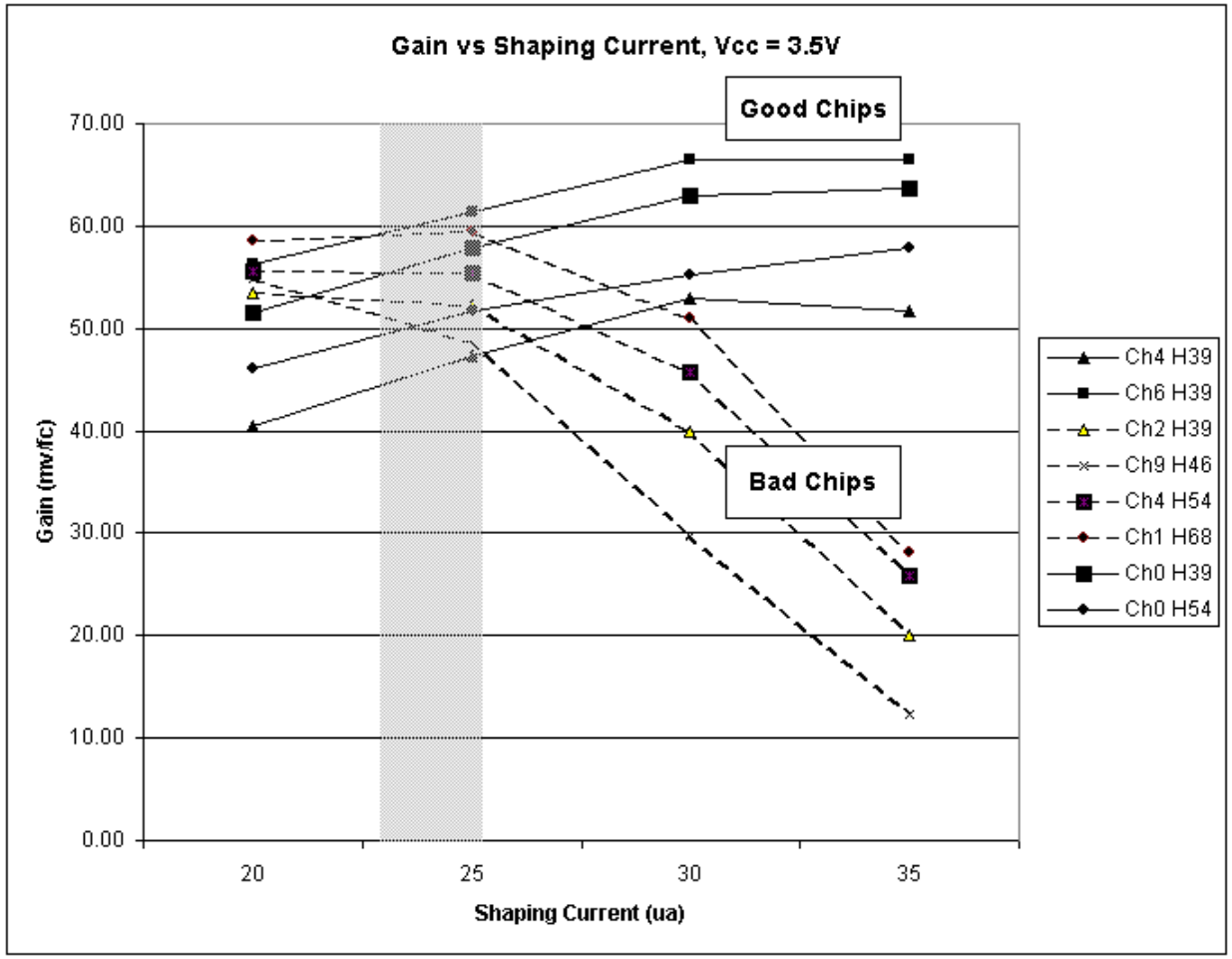
Areas of the Study

- ISh and Vcc
- Icc
- FE DAC's

LGS – Wafers

20220040200011	11	Z40859-W11	LGS
20220040200021	8	Z40859-W09	LGS
20220040200039	2	Z40859-W04	LGS
20220040200039	6	Z40859-W04	LGS
20220040200041	2	Z40802-W09	LGS
20220040200046	9	Z40803-W02	LGS
20220040200048	9	Z40803-W02	LGS
20220040200052	7	Z40862-W09	LGS
20220040200054	4	Z40803-W05	LGS
20220040200057	9	Z40862-W09	LGS
20220040200068	1	Z40862-W02	LGS
20220040200100	1	Z41032-W13	LGS
20220040200122	10	Z41032-w09	LGS
20220040200136	0	Z40803-W06	LGS
20220040200137	9	Z40803-W06	LGS
20220040200138	8	Z40803-W08	LGS
20220040200141	0	Z40803-W08	LGS
20220040200161	0	Z41032-W13	LGS
20220040200193	11	Z39693-w15	LGS

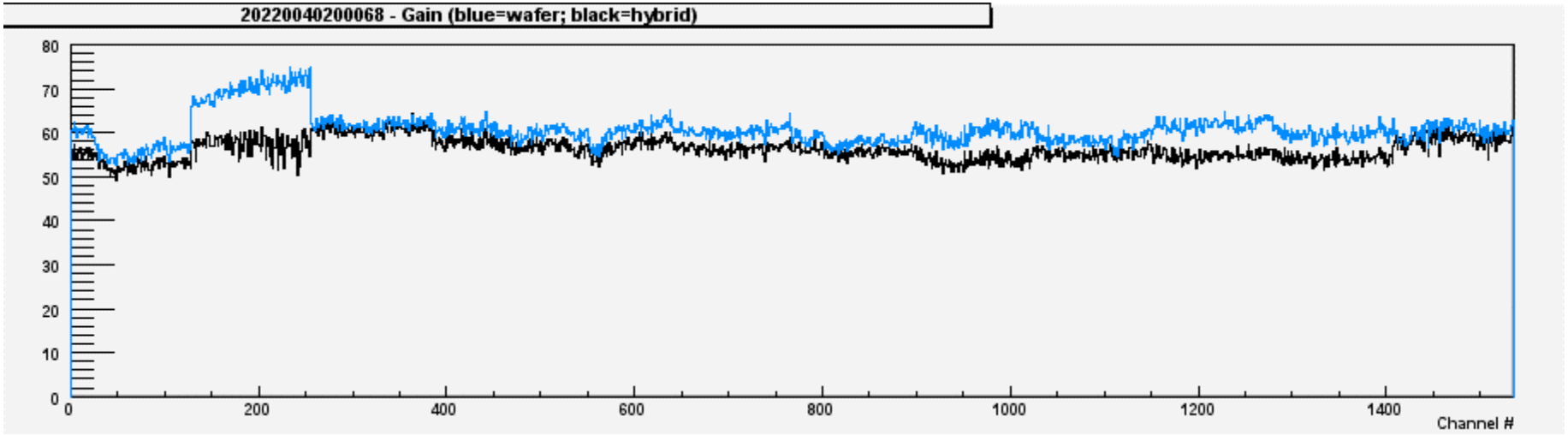
LGS - Ish/Vcc Study - Comparison for all Hybrids
Gain vs ISh



As a trend, in this data range, increasing the Shaping Current increases the Gain of the passable chips and decreases the gain of the LGS chips.

In a range between 22.5µA and 25µA, the gain of the LGS chips is within an acceptable range

LGS - Wafer/Hybrid Comparison



LGS - Icc Study

We looked at Icc (at the wafer level) for all the chips used so far in the US to verify a possible correlation with the LGS problem.

Having found that chips with LGS start to work normally mainly by lowering their Shaper current, and knowing that those chips have a strong dependence on the FE current, we are very likely facing a real defect for those chips in the distribution and regulation of the FE power that might cause an excessive current in the FE.

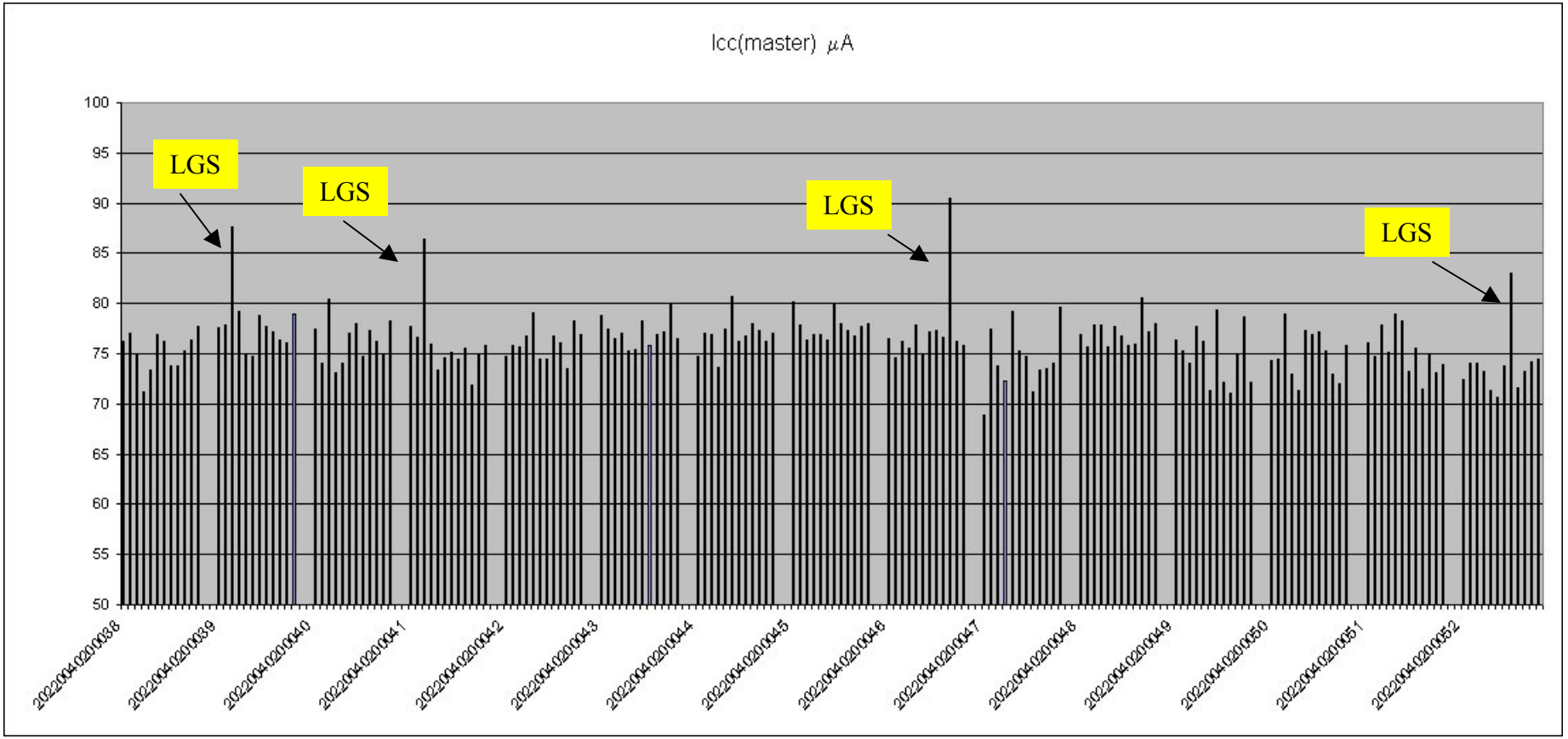
We found indeed a very strong correlation between high Icc and chips with LGS.

All our chips with LGS have much higher Icc (on the wafer).

http://www-atlas.lbl.gov/strips/modules/production/lgs-study/Icc/

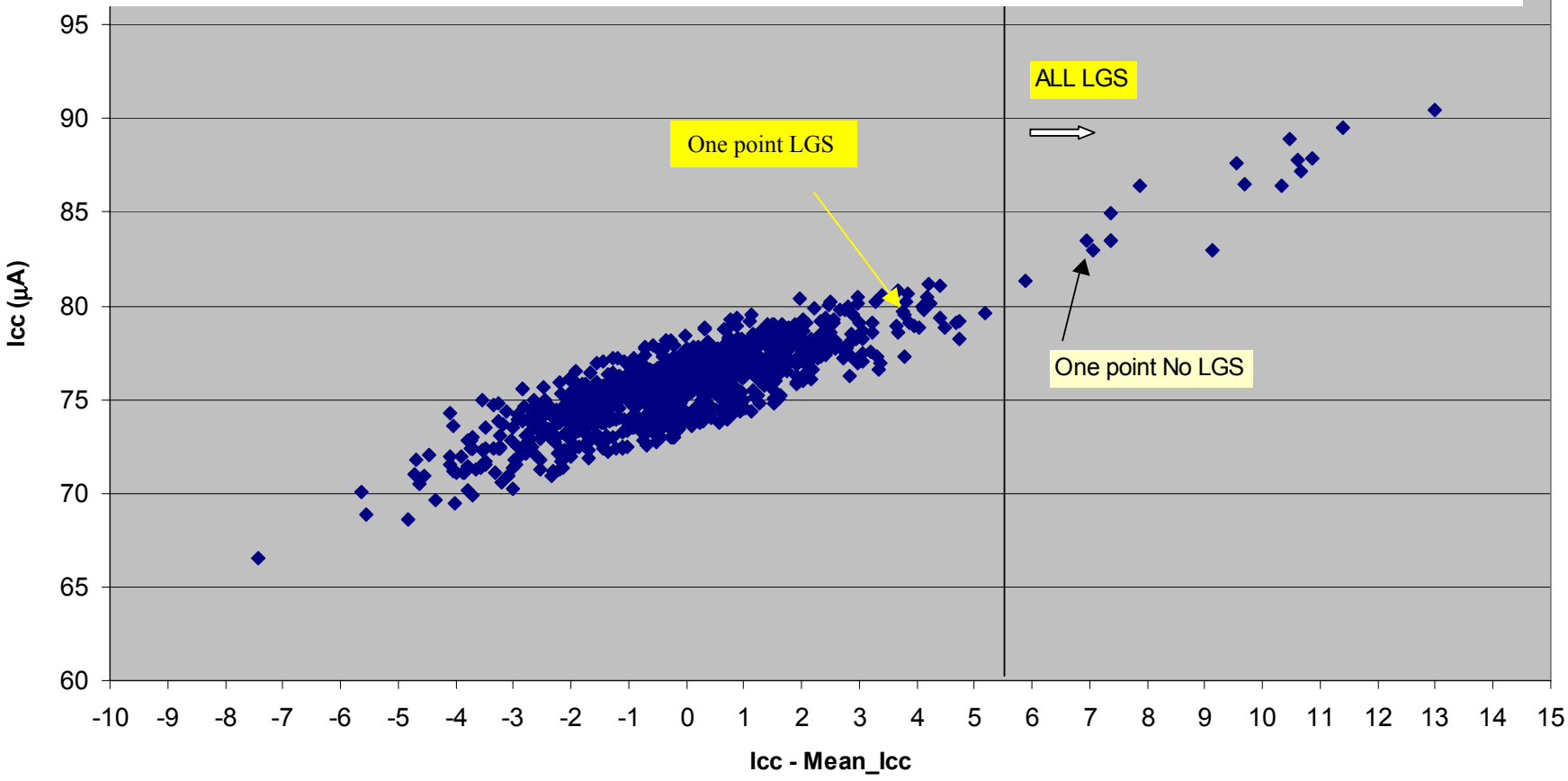
LGS - Icc Study – High Icc

Graph showing Icc of 15 hybrid. Chips that are known to have LGS show higher Icc
Similar graphs were produced for the 107 hybrids analyzed (1284 chips total)
17 chips were found having LGS (and higher Icc)

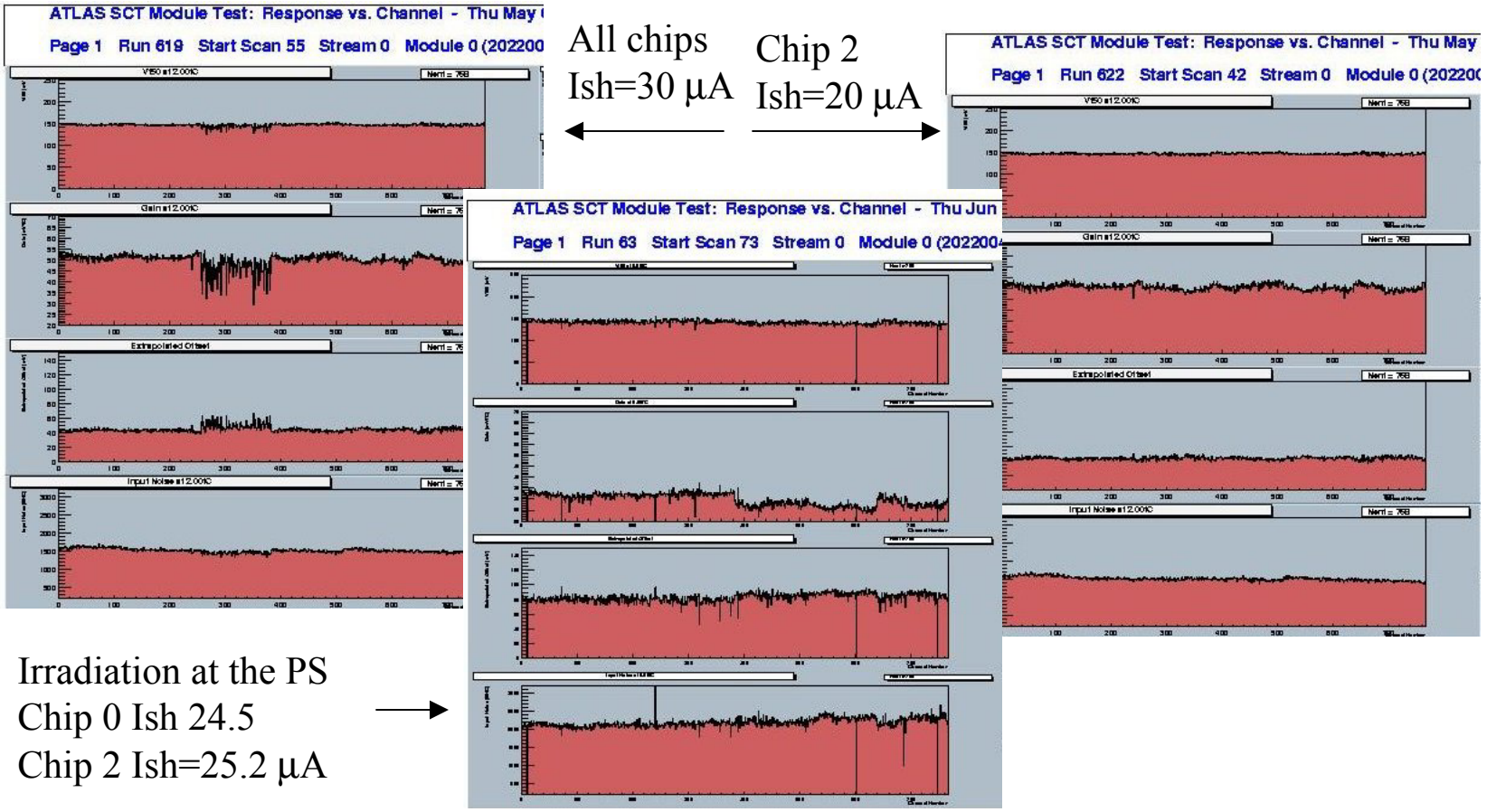


LGS - Icc Study – Icc vs (Icc-mean) Correlation

Scatter plot of Icc versus the deviation of Icc from the mean Icc for each wafer (or gelpak) each chip is coming from All but one of the 17 chips with LGS can be identified by cutting at 5.5 (deviation from the mean Icc). This method can be used for pre-selecting chips before they are mounted on hybrids

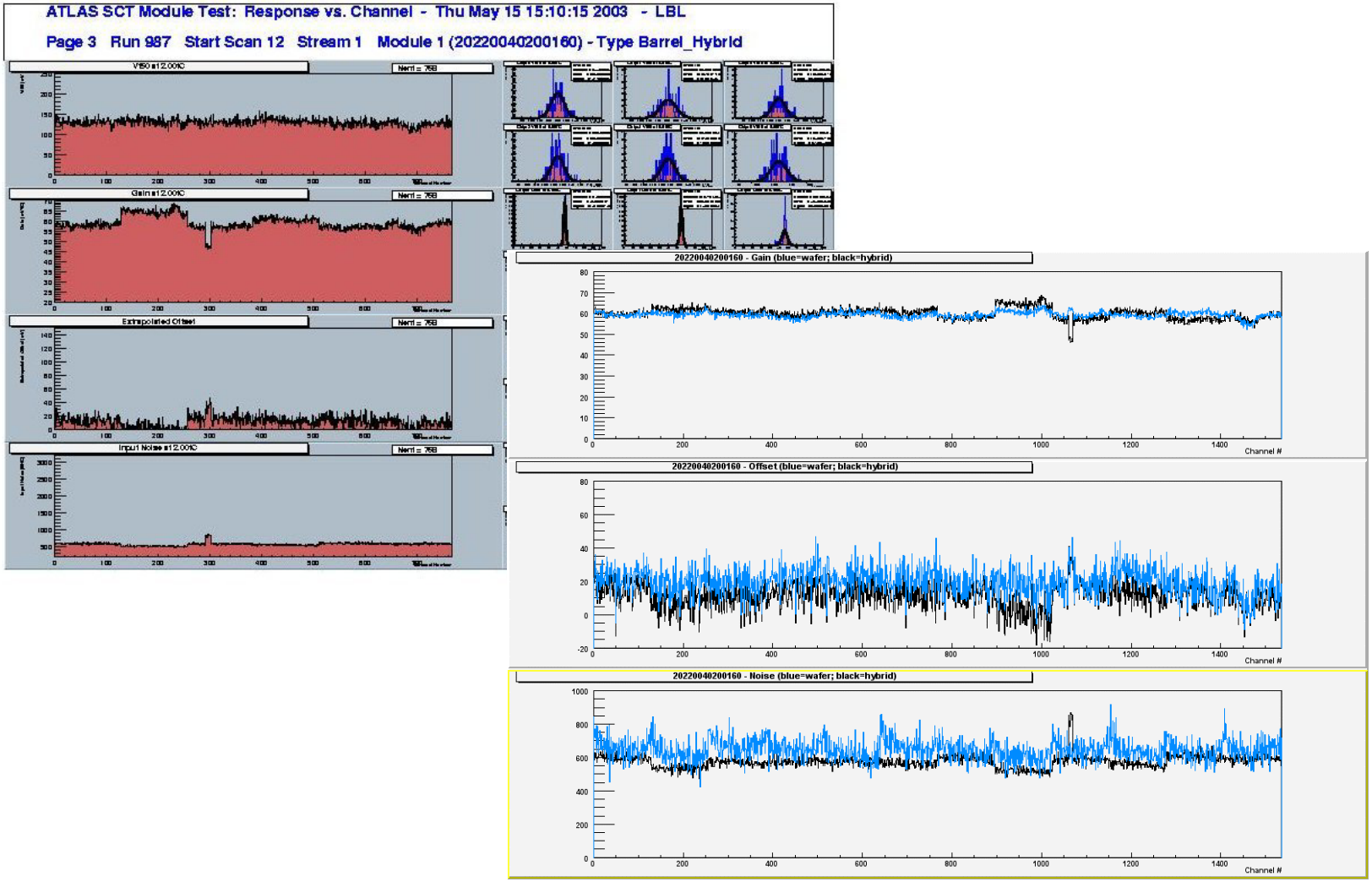


LGS – comparison before and after irradiation – Module 00041



LGS chips ok to use now (if gain/rms normal at Ish = 20µA)

Block Low Gain – Module 00160

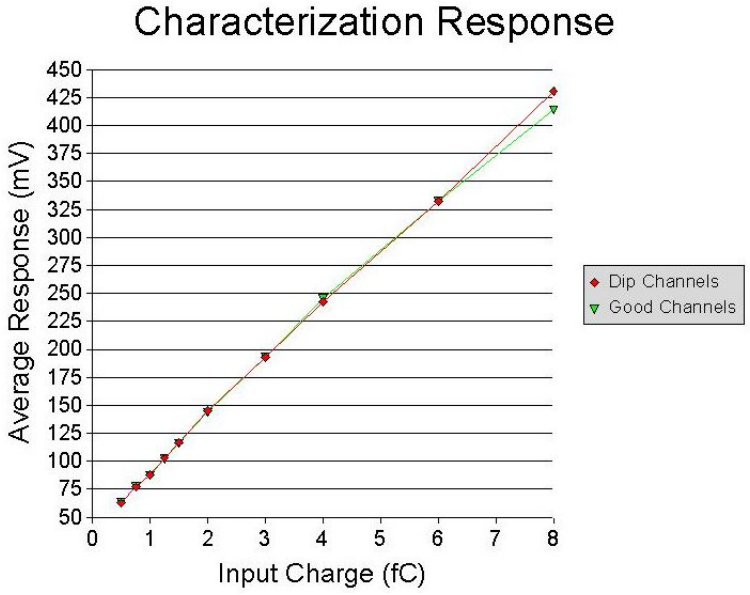


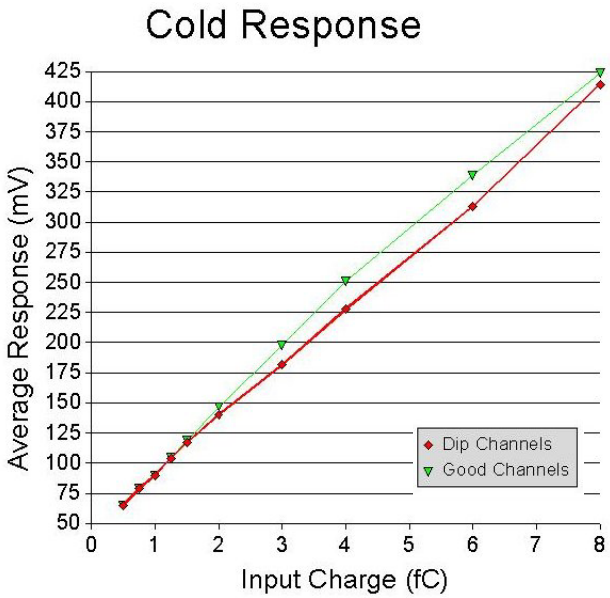
Block Low Gain – Module 00165

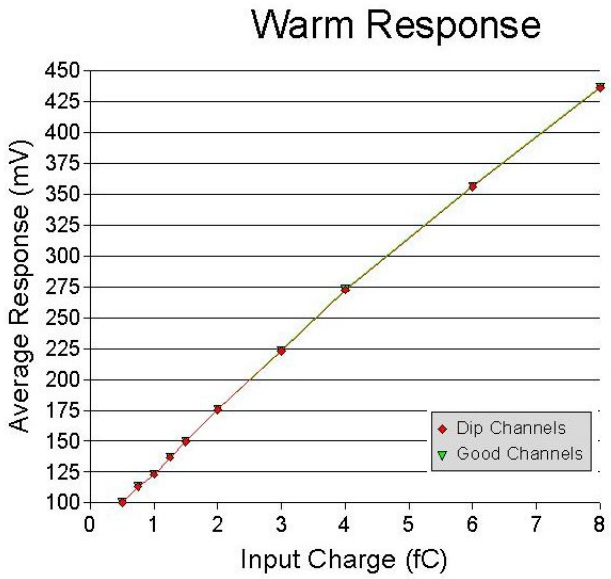
Response by selected channels (average) for a chip with blockLG

The red line in each plot is the average response of the blockLG channels and the green line is the average response of the rest of the channels on that chip, for each input charge used during the Response Curve test

The response of the blockLG channels starts to deviate from the others at around 2fC







Block Low Gain Summary

20220040200021	7	Z40859-W09	BlockLG
20220040200098	6	Z41032-W13	BlockLG
20220040200098	7	Z41032-W13	BlockLG
20220040200099	0	Z41032-W13	BlockLG
20220040200100	7	Z41032-W13	BlockLG
20220040200100	9	Z41032-W13	BlockLG
20220040200107	8	Z41032-w12	BlockLG
20220040200117	8	Z41032-w08	BlockLG
20220040200145	1	Z40920-W15	BlockLG
20220040200148	6	Z41032-w12	BlockLG
20220040200155	8	Z40920-W10	BlockLG
20220040200156	4	Z40920-W10	BlockLG
20220040200158	11	Z40920-W10	BlockLG
20220040200160	8	Z41032-W13	BlockLG
20220040200165	10	Z41032-w17	BlockLG
20220040200165	8	Z41032-w17	BlockLG
20220040200189	9	Z41032-w07	BlockLG

17 hybrids on HOLD

- Need to continue to investigate this defect in order to release/rework the many hybrids on hold
- Seem to appear less frequently now

Scurves Oscillation – first study

• Modules where tested in multiple combinations of active chips or using the trim to displace the threshold.
Oscillation disappears (or is significantly reduced)

- when switching activity is reduced by isolating every other chip
- or excluding only one chip in a particular case
- setting the shaper current much lower than the nominal value (ISH=20).
- trim every other channel thresholds (by 5 mV) namely changing the number of discriminator transitions at any given threshold

This indicates that this is a regenerative effect involving many channels and that the number of channels is more important than the geometric arrangement of the channels

• We introduced a method to quantify the oscillation (Abe's plot)

- We fit the region of low threshold (the first 10 points of the ln(occ) plot)
. which is significantly larger for most of the chips with large wiggles
- By looking at the mean square deviation of the fit
we can identify all but three cases of oscillation

• No oscillation was found at the hybrids level (except in two cases)

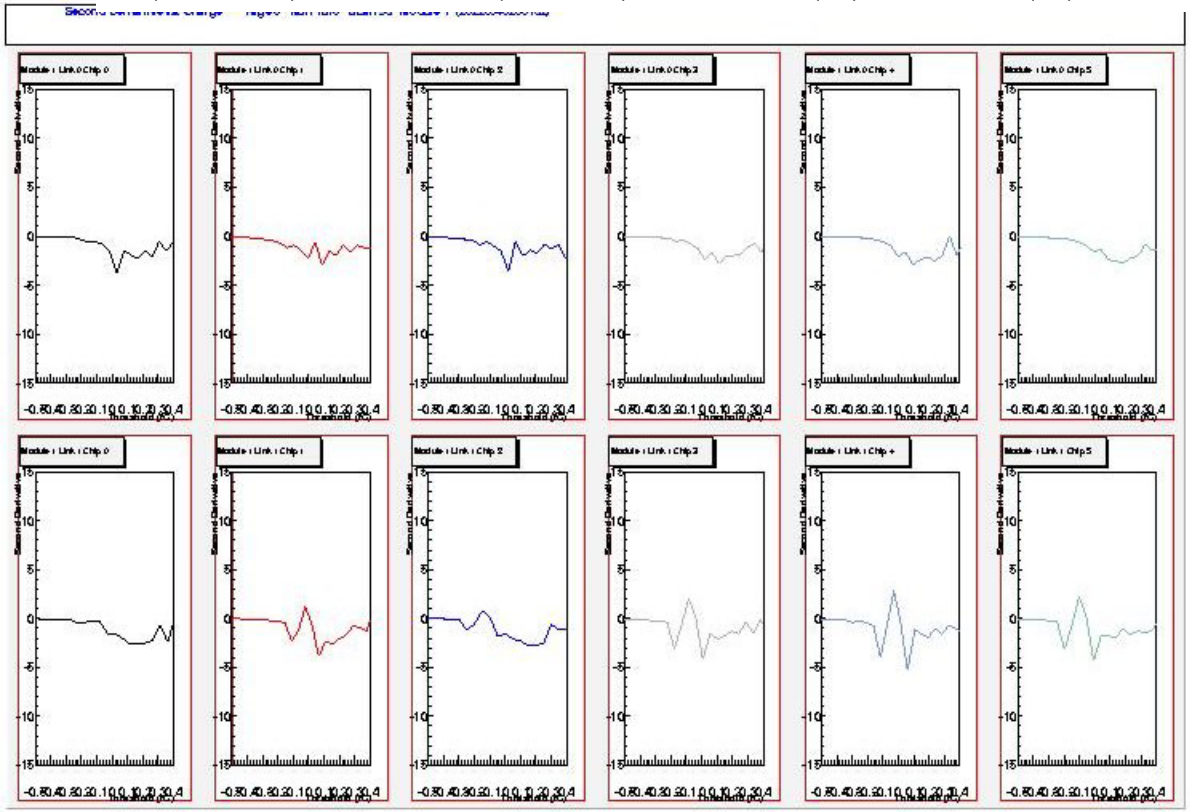
• The grounding scheme has been checked and we don't see evidence of pick up noise
(we also introduced noise filters cards)

• No correlation was found with hybrid Lot

Scurves Oscillation – 2nd derivative

To mathematically decide on when the module has oscillation, and to locate at what threshold the oscillation occurs, we calculate the 2nd derivative of the log(Occ) vs threshold

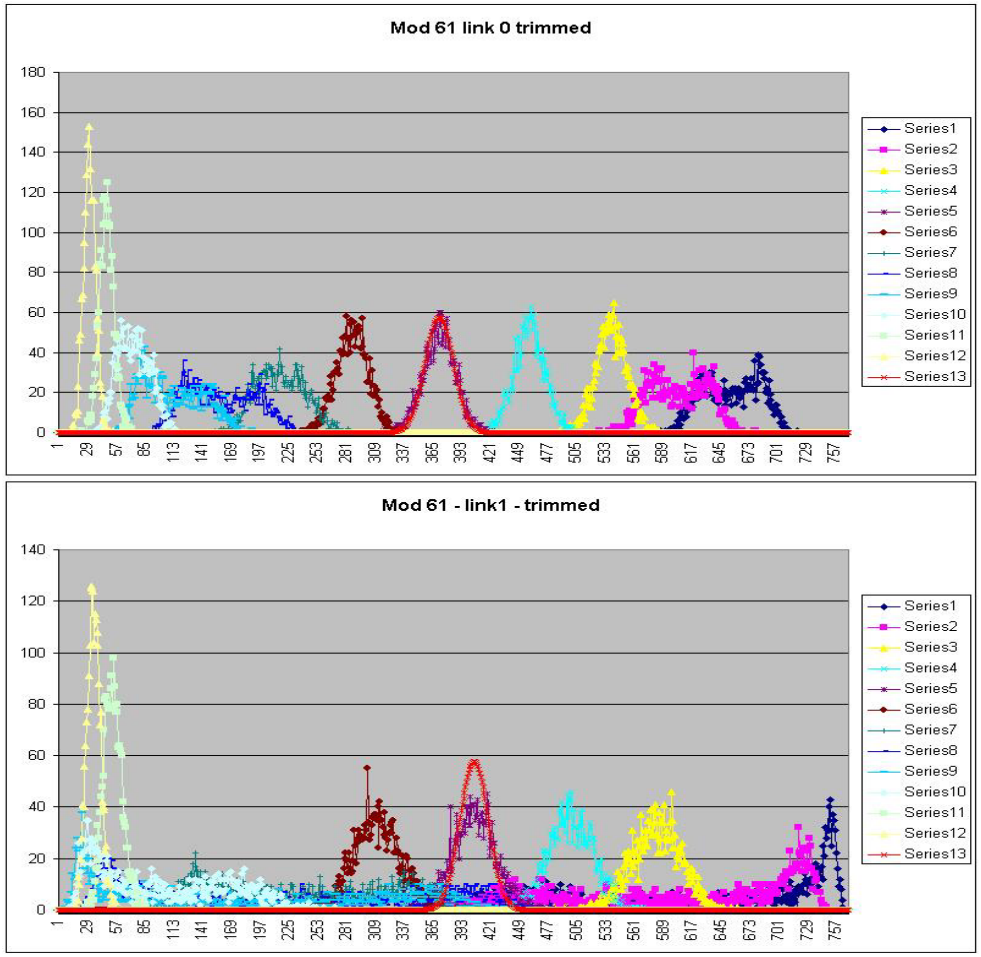
$$f(x+d1)/d1 + f(x-d2)/d2 - f(x)/d1 - f(x)/d2$$



This method works well up to 0.3 fC and above that statistics dominate the results

Scurves Oscillation – Residuals

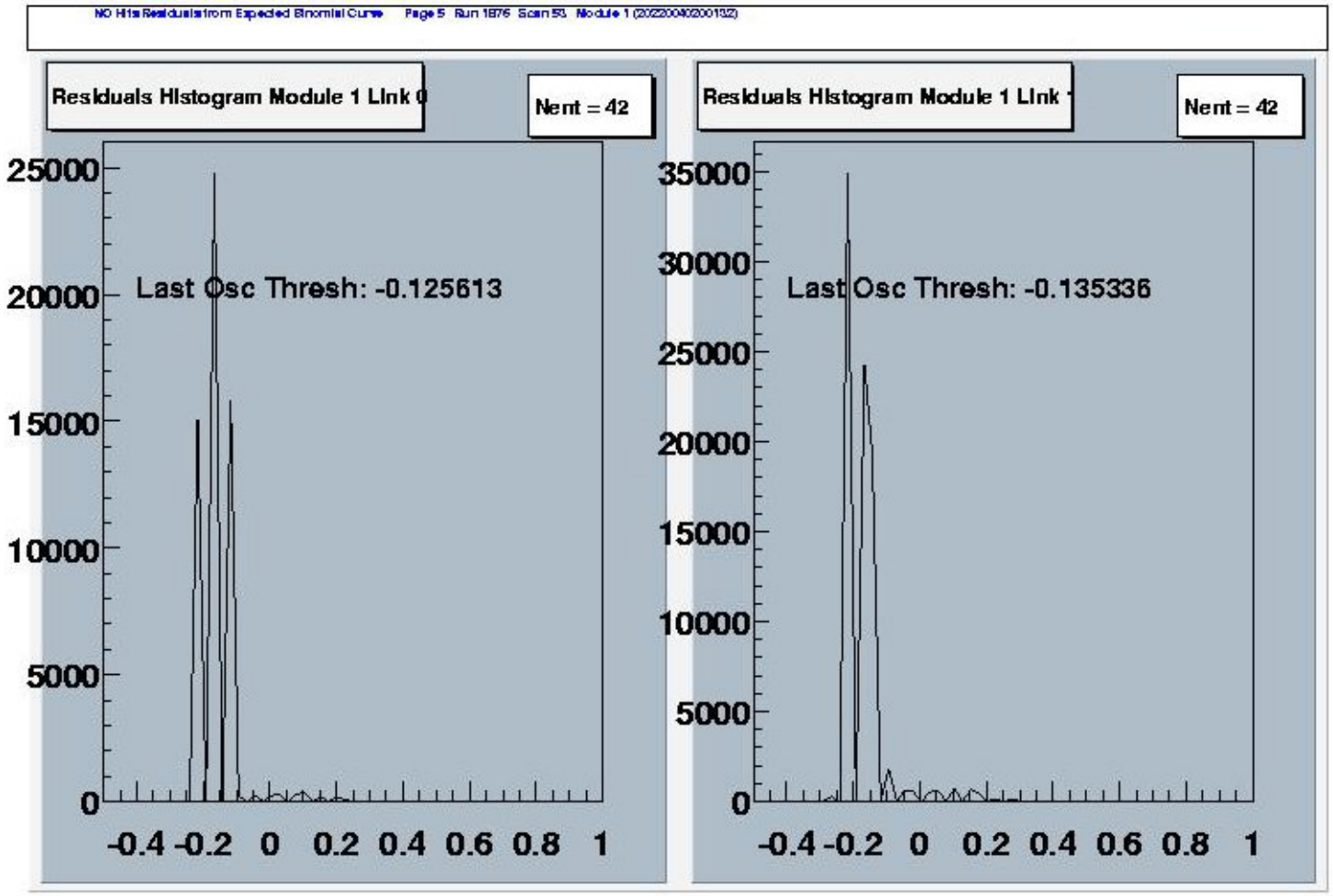
Using the hit distributions we calculate the residuals of the fit with a binomial distribution with the same average occupancy



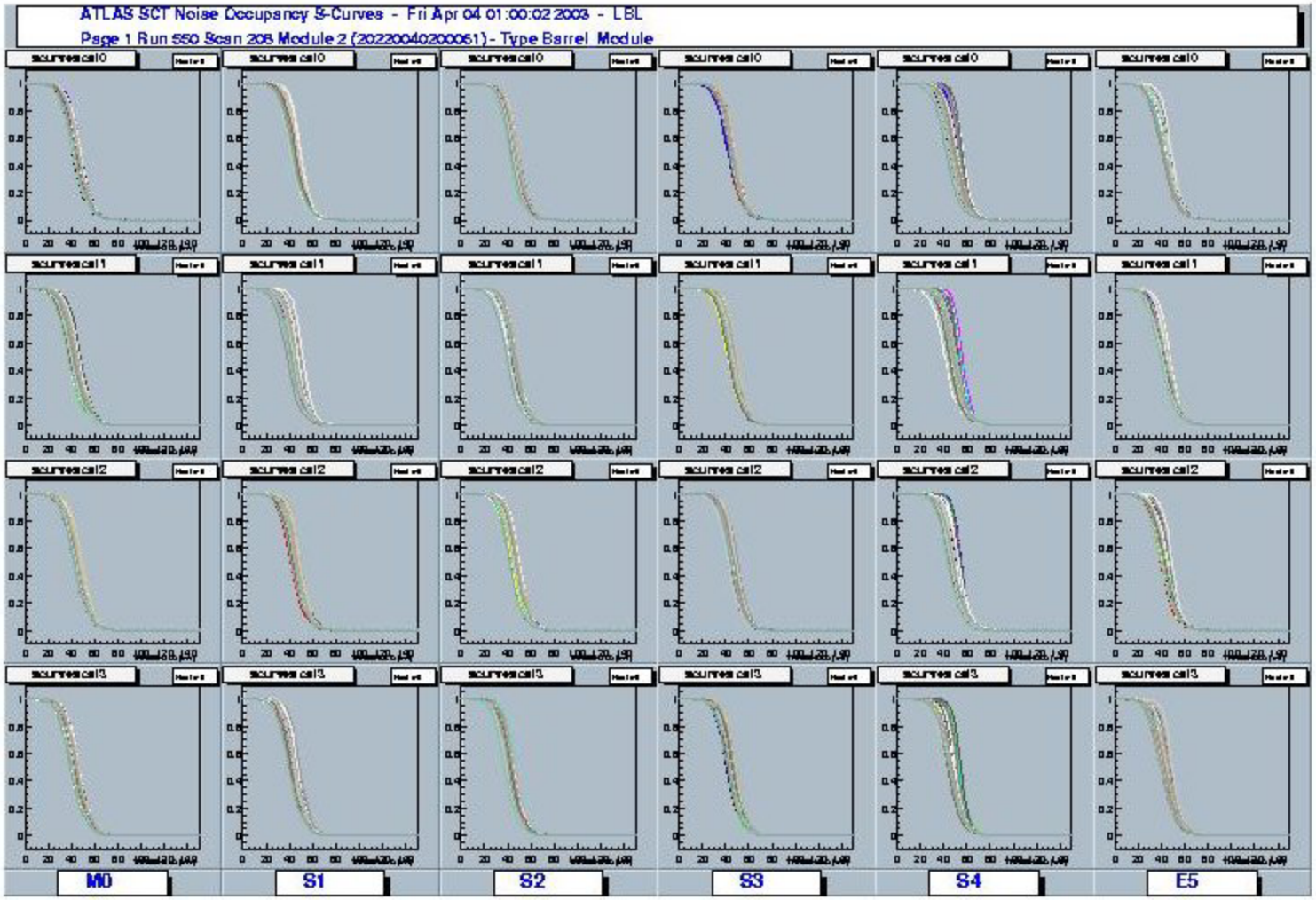
A calculated binomial curve is plotted for threshold = 45 mv.

Scurves Oscillation – Residuals

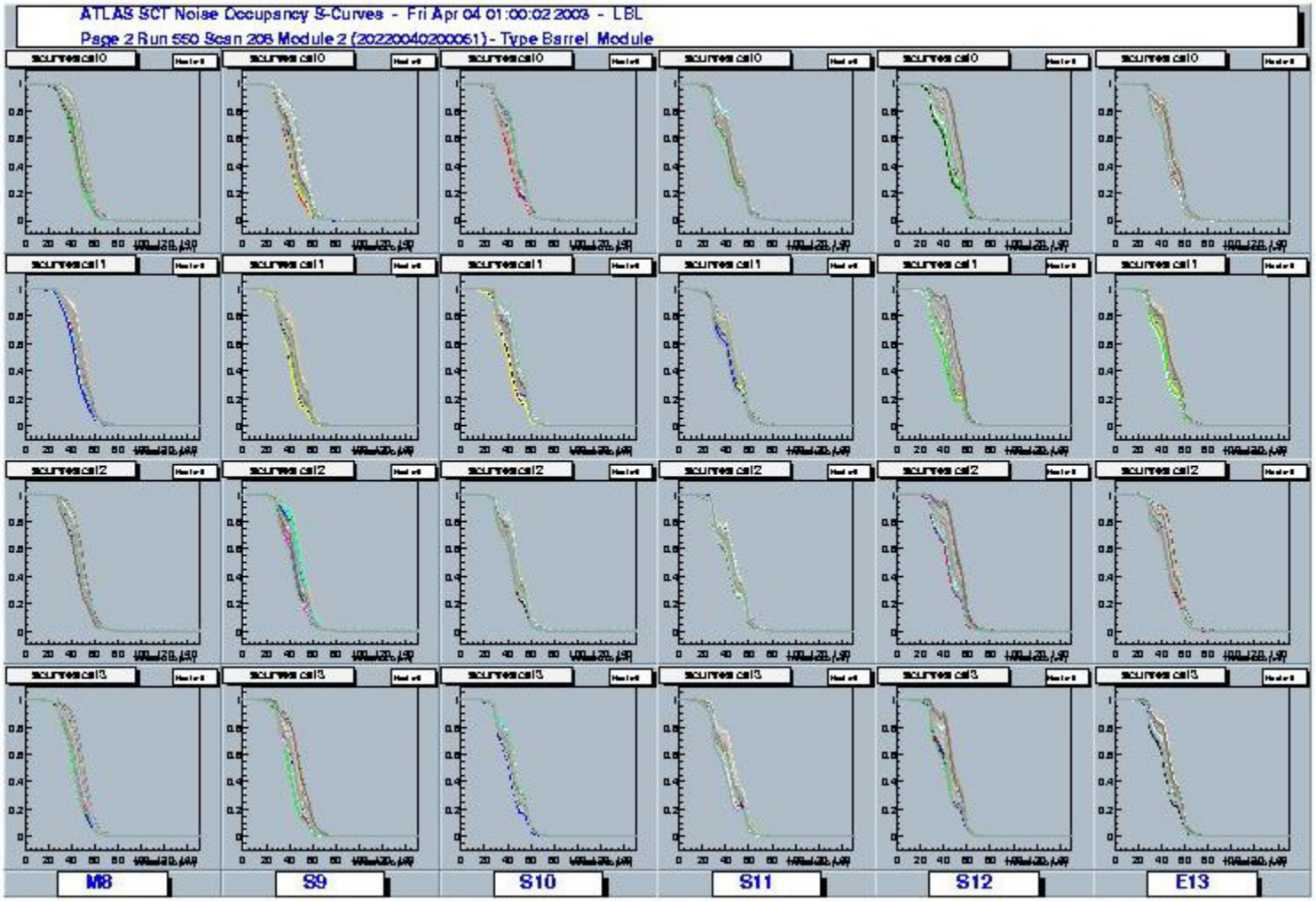
This method has been introduced locally in the Noise Occupancy test
And made available to be used by other group



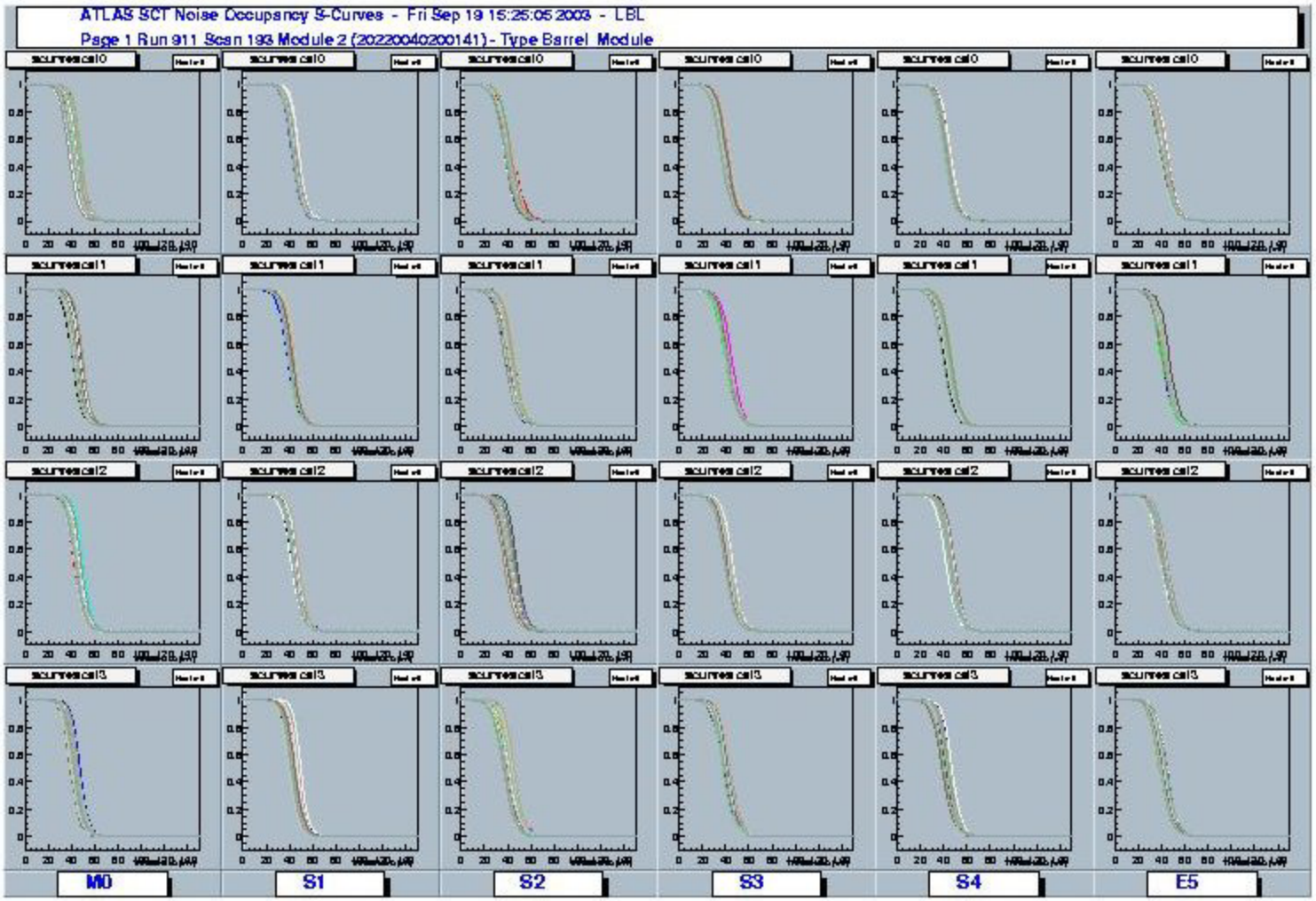
Scurves
Module 00061 - link 0



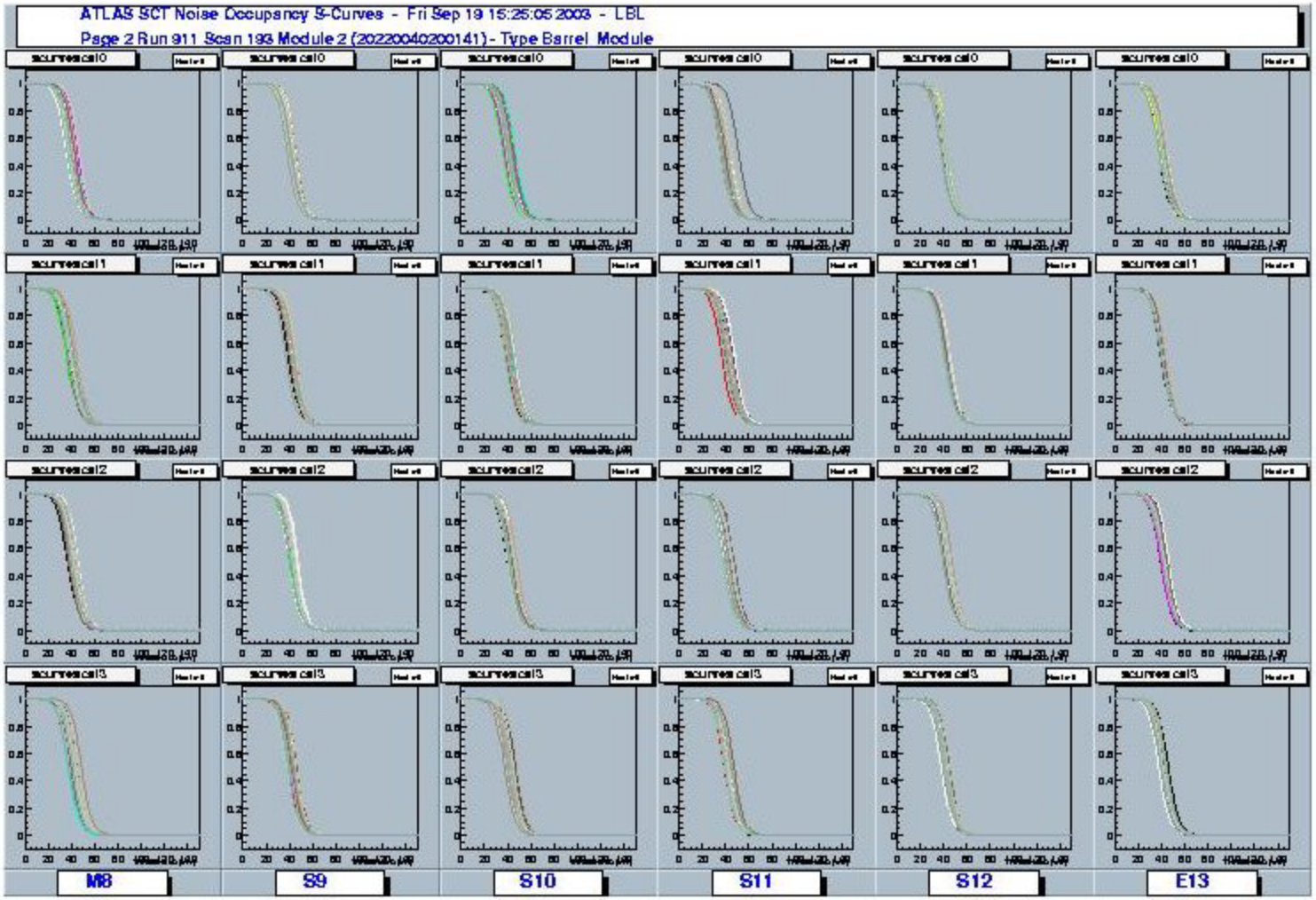
Scurves
Module 00061 - link 1



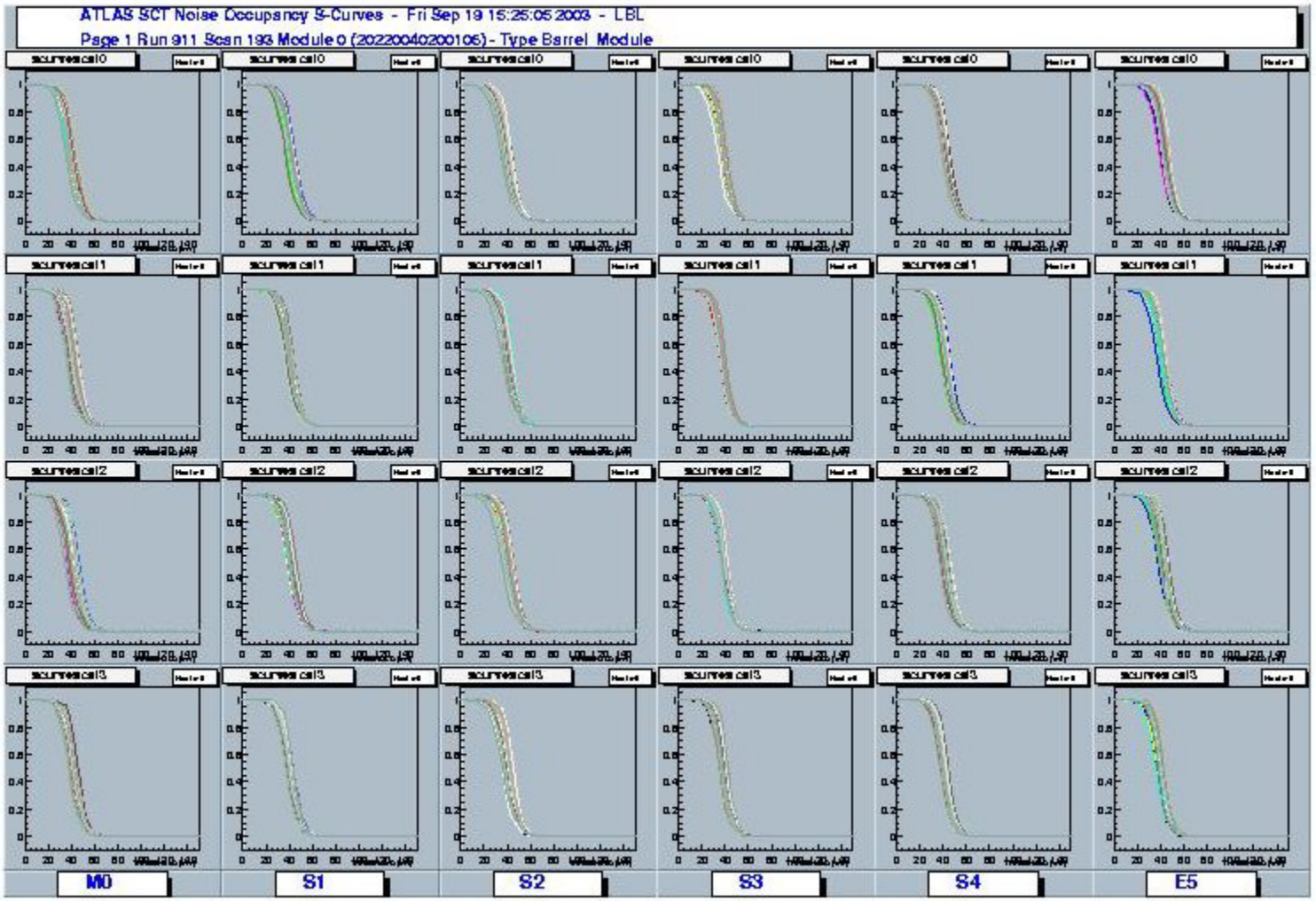
Scurves
Module 00141 - link 0



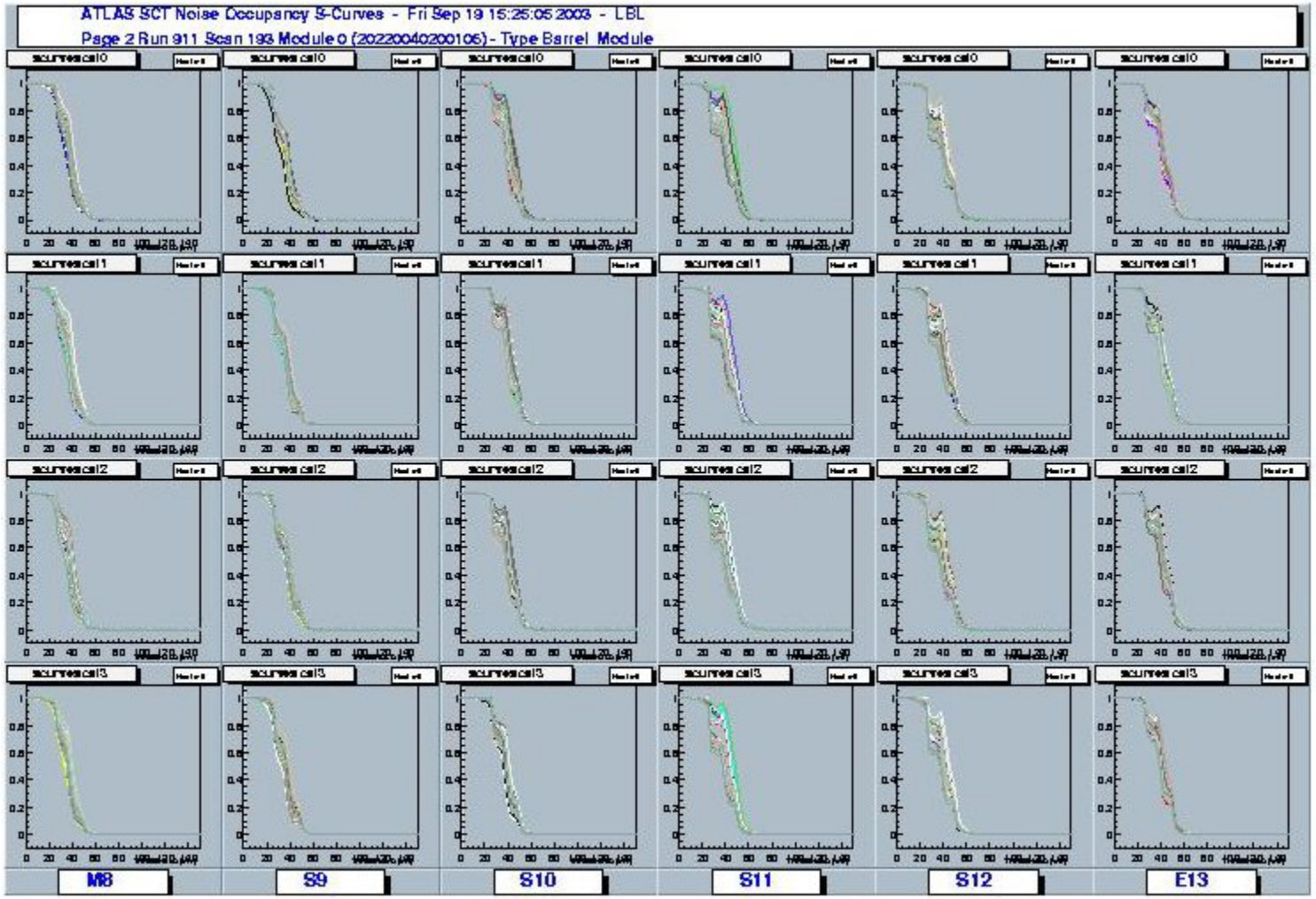
Scurves
Module 00141 - link 1



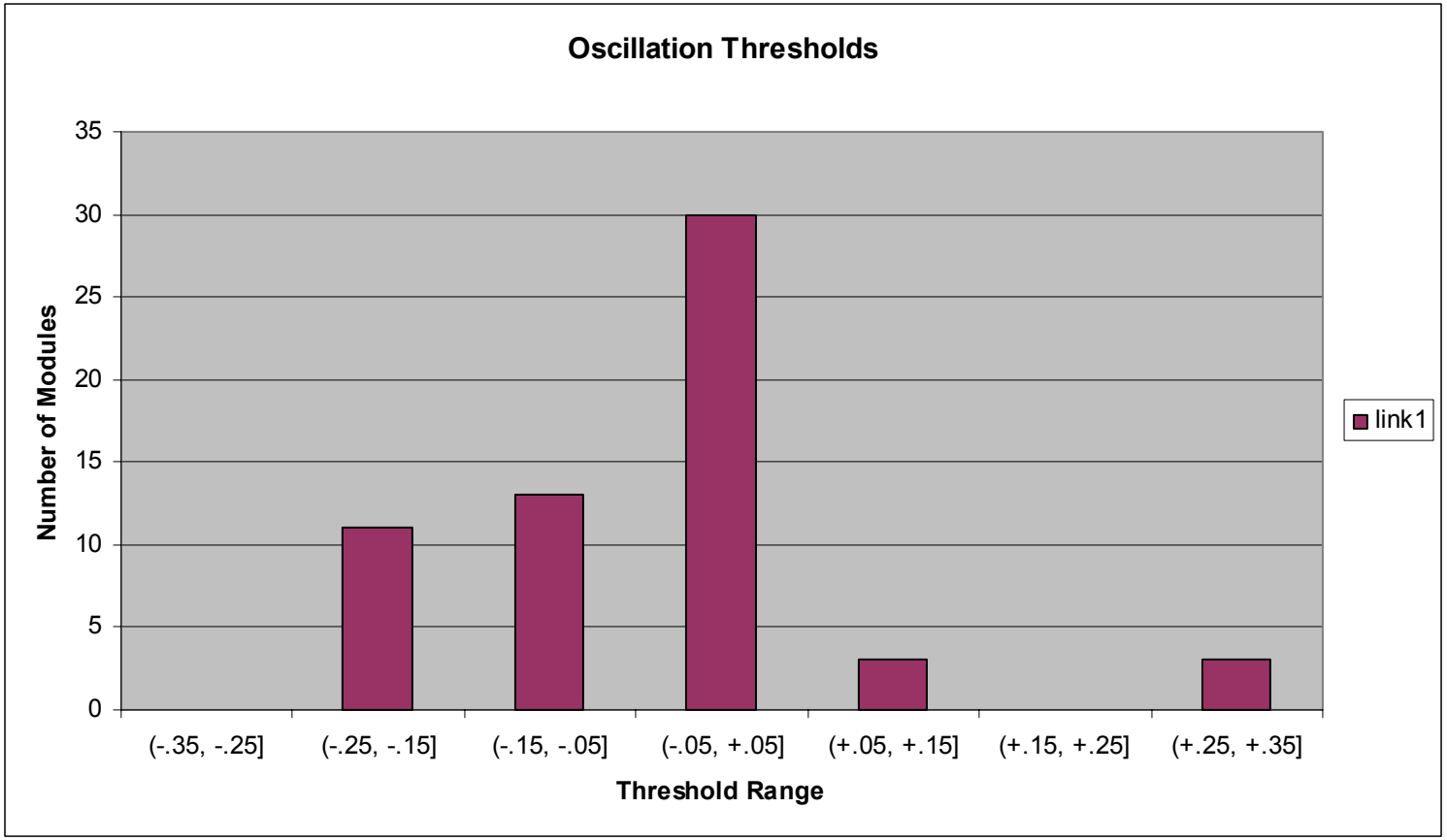
Scurves
Module 00106 - link 0



Scurves
Module 00106 - link 1



Scurves Oscillation – Threshold Range

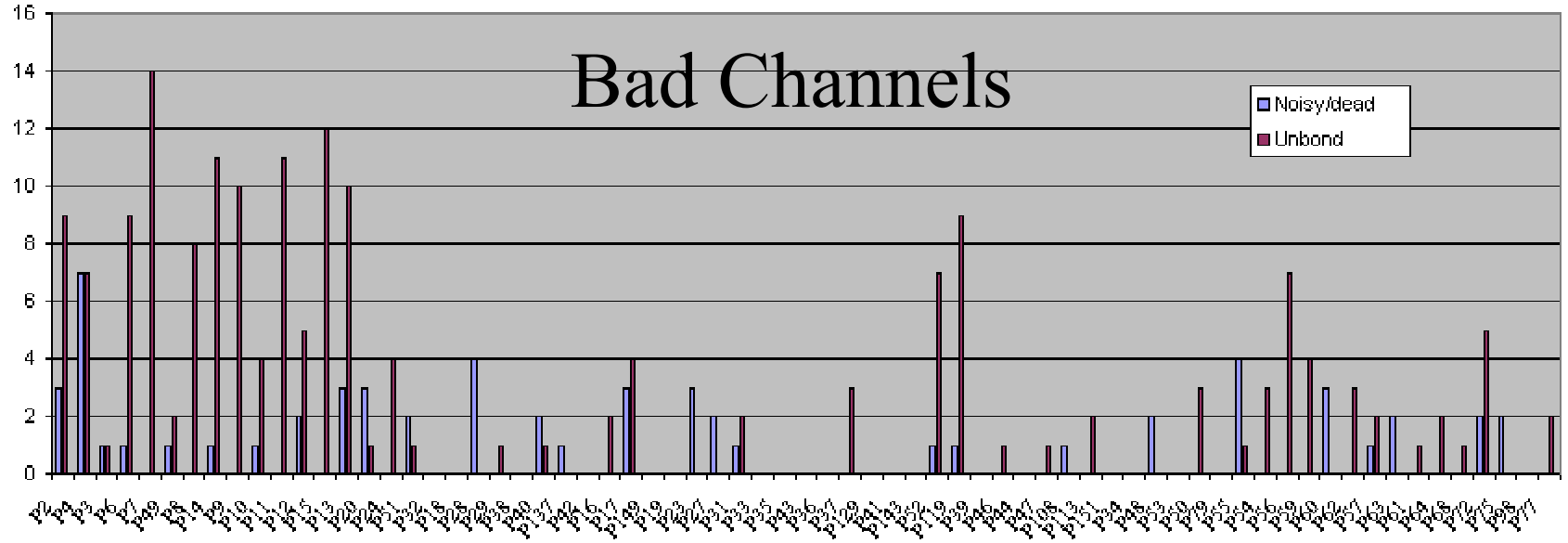


Oscillation Summary

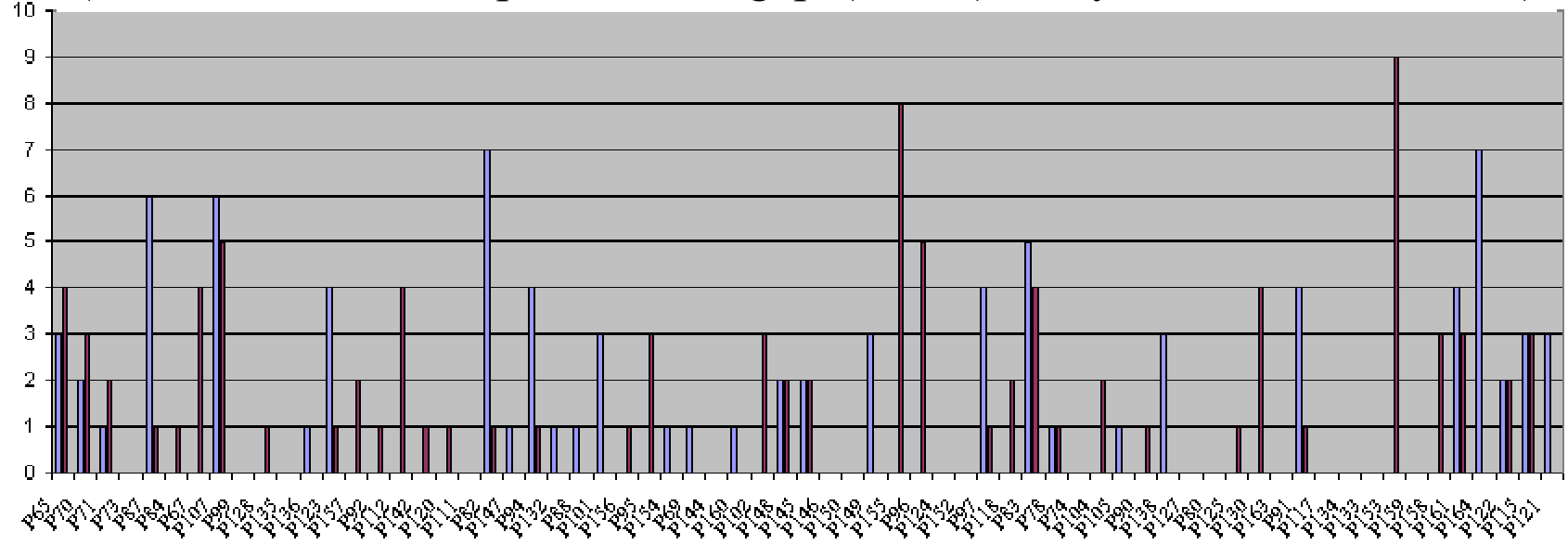
Of 142 modules tested – 128 LTT test done
62% have wiggles
17% only in negative
44% only on both pos/neg

Scurves taken from cold test
(except for modules that didn't go through LTT yet)

• Difference in the oscillation results for cold/warm
(cold is much worse – in same cases scurves at warm don't show oscillation while at cold yes)

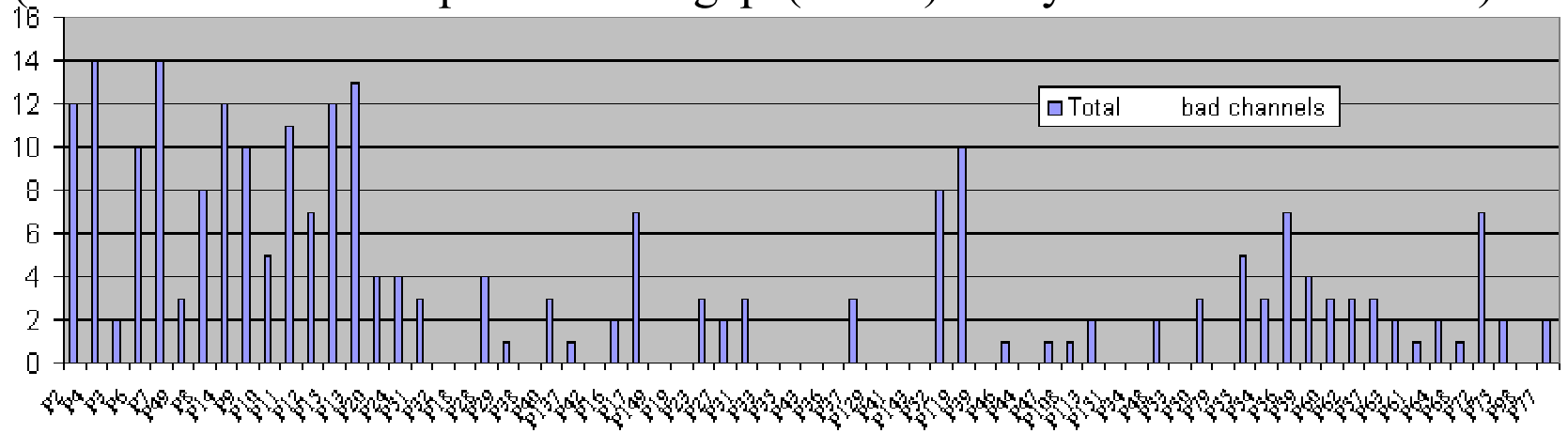


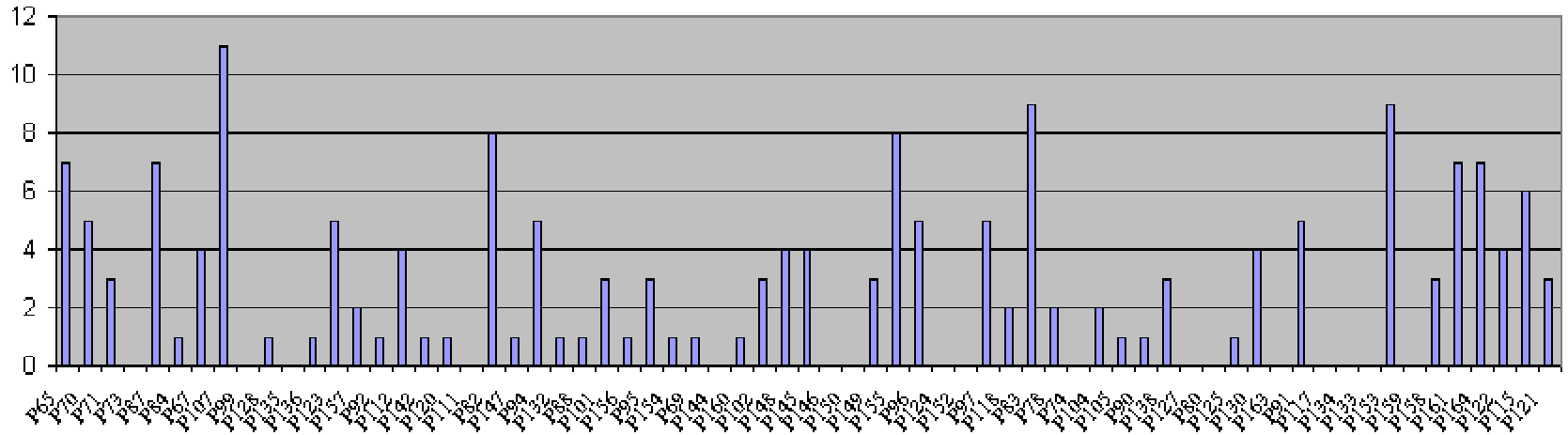
(all modules in these plots exist – gaps(zero's) really mean 0 bad channel)

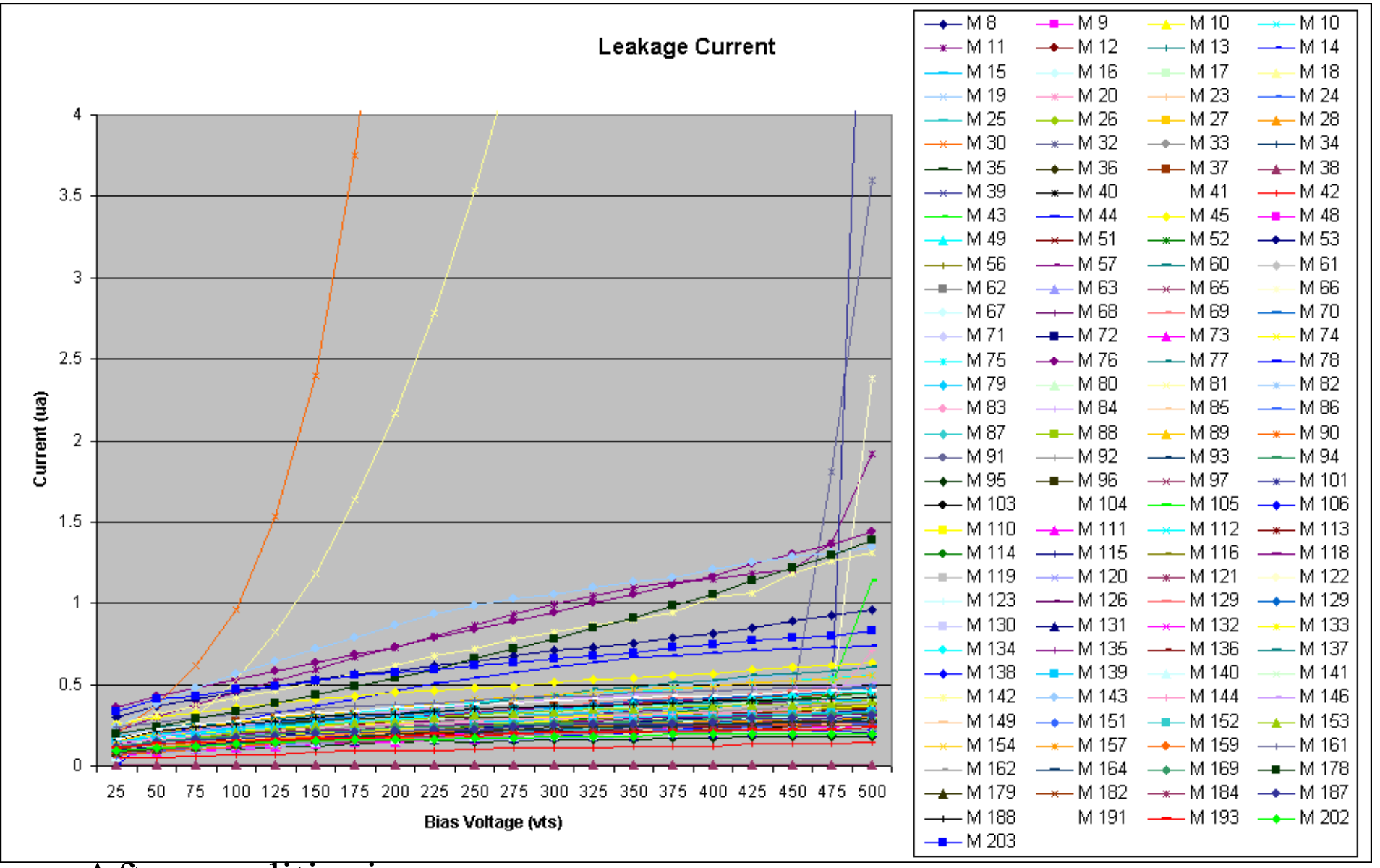


Bad Channels (Total)

(all modules in these plots exist – gaps(zero's) really mean 0 bad channel)



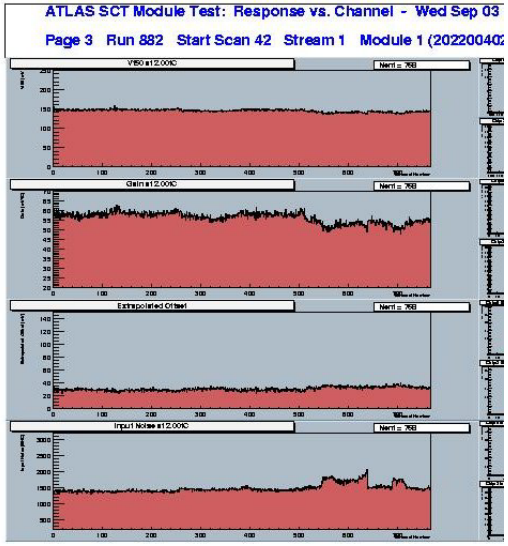


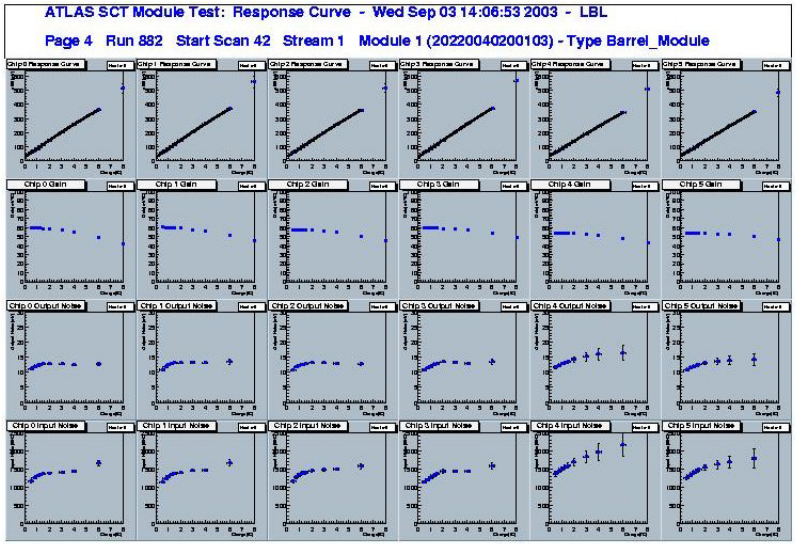


After conditioning

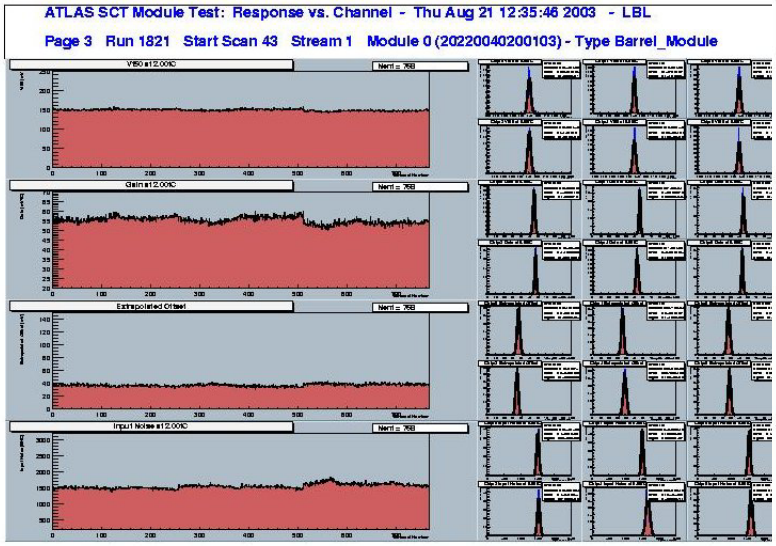
Module 103 defect at cold

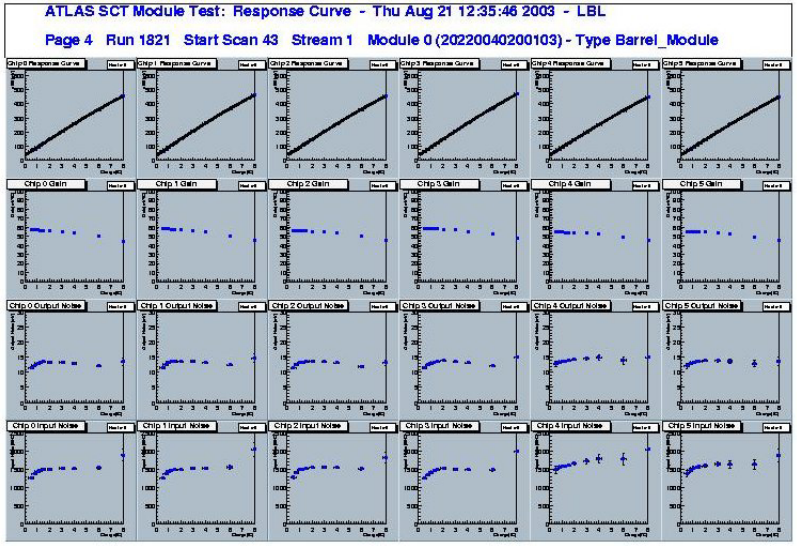
cold





roomT



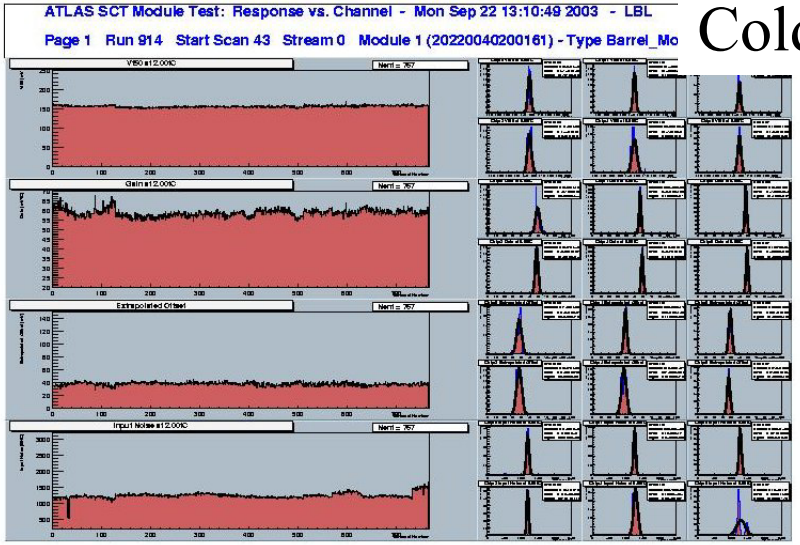


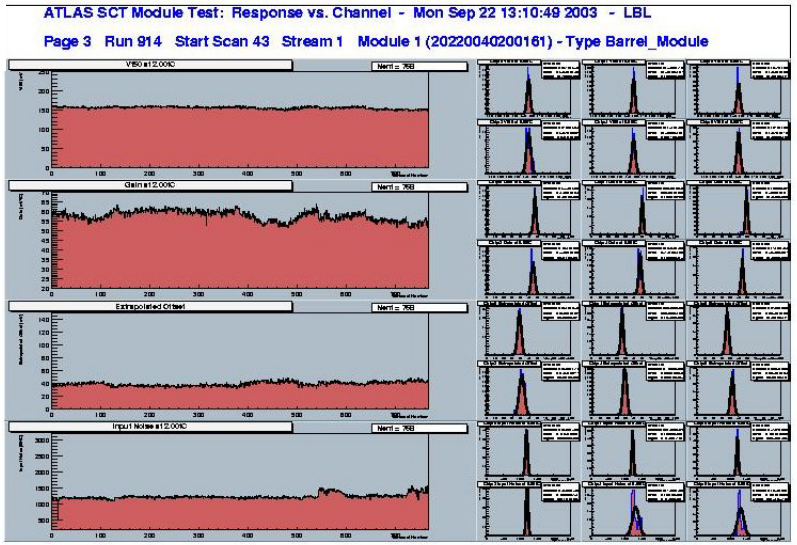
Module 161 defect at cold

link0

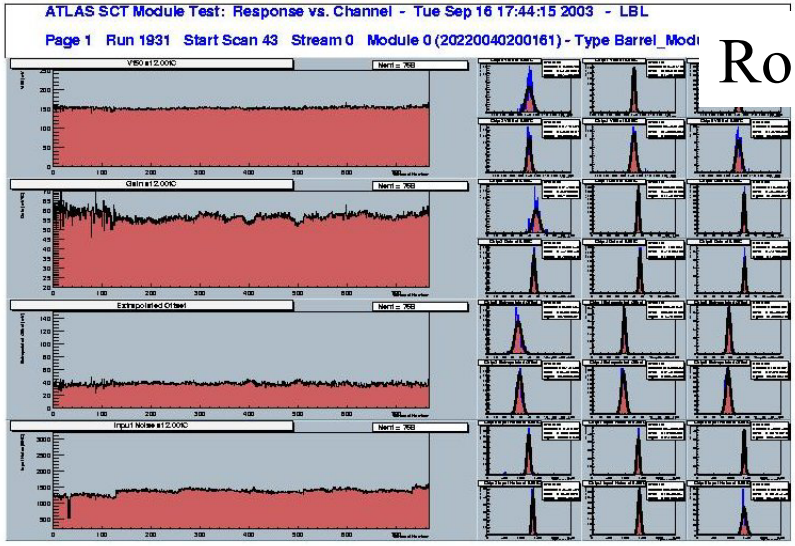
link1

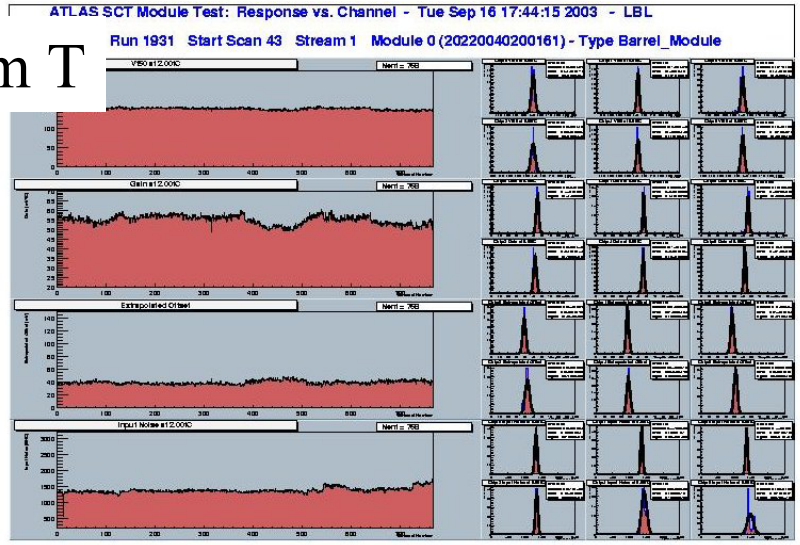
Cold





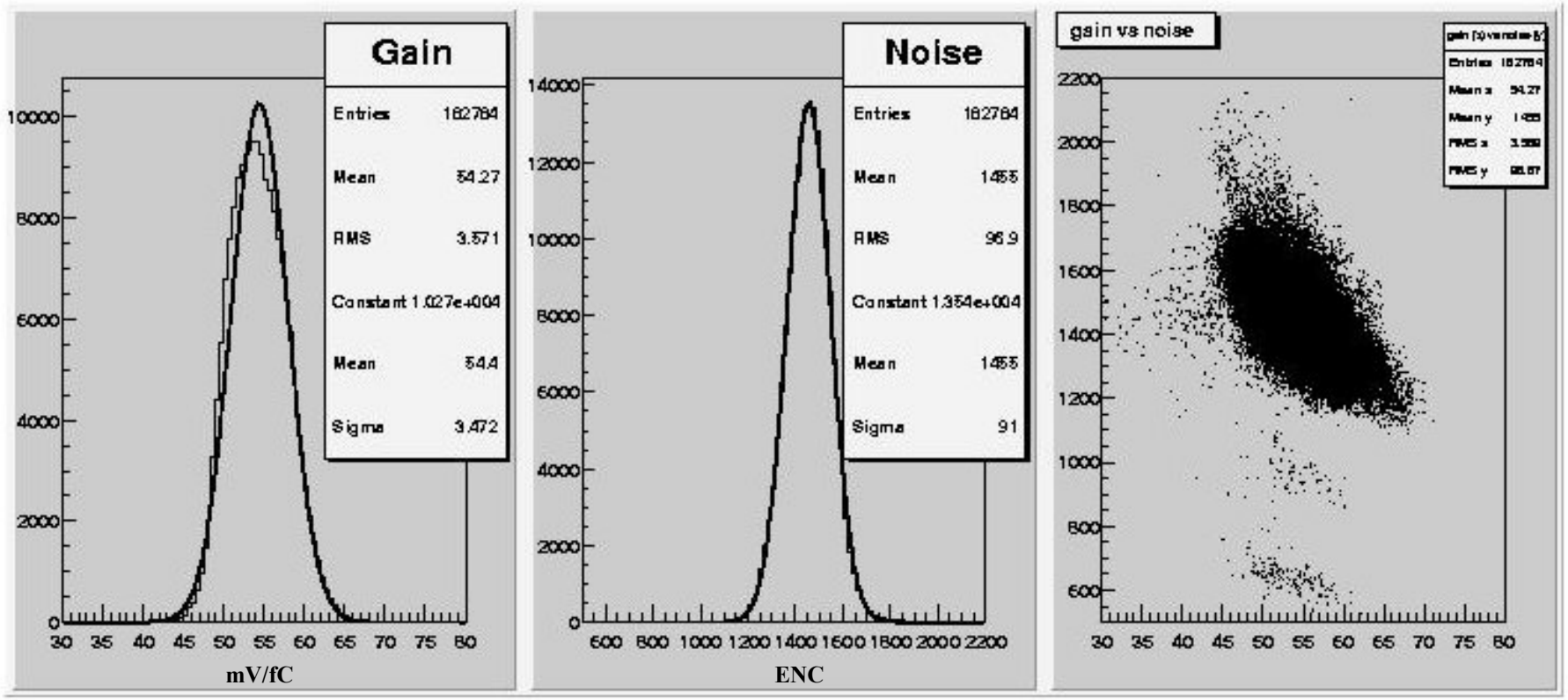
Room T





Gain vs NOISE

119 modules



Summary

The BM Production Testing in the US is going smoothly but with much time devoted to chip studies hopefully this activities will be reduced in the future

HYBRIDS

LGS ok to use after irradiation tests confirmed functionality with adjusted ISh
Block Low Gain ongoing analysis (need to be done soon to release the hybrids on hold)

MODULES

Oscillation study (software implementation) is completed
The Residuals methods shown to be reliable
Oscillation is found in ~61% of the modules
(or 17% neg thrsh 44% +/- thresh)
Mainly around a threshold range of +/- 0.5 fC
(very few residuals above the cut are at around 0.3fC max)

Hardware/DAQ

Mustard firmware upgrade necessary for better results in the Noise Occupancy scan
HV boards hardware failure (=> shortage of spares) but work better now after software fixes.