Anomalous chips & large oscillation modules – beamtest experience

Gareth Moorhead
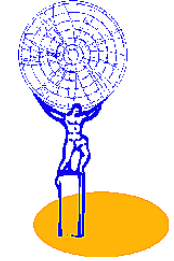
with

Jose Enrique Garcia & Sergio Gonzalez
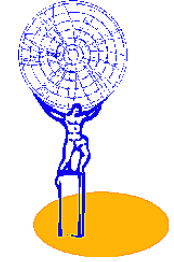
and results from

Paul Dervan

CERN, SCT Week, 22-26 September 2003

Program

- The barrel testbeam program in 2003 was part of an investigation into various anomalously behaved modules and chips that have appeared during production:

    - Large gain-spread chips
    - Negative offset chips
    - Large oscillation, or "wiggly s-curve" modules

- Modules were beamtested in May, then some were irradiated at the PS in June (either P1A or P1B), annealed, front end currents re-optimised ("current matrix"), then beamtested again in September

Modules & chips

| Module	Anomaly	Testbeam May	Irradiation	Testbeam September
20220170200010	Large offset, chip S03	Yes	No	Yes
20220170200447	Large gain spread, chips S02 & S03	Yes	Yes, P1B 25/6-9/7 60% fluence (?)	Yes
20220040200041	Large gain spread, chip S02	No	Yes, P1A 19/5-2/6	Not working – no data
20220040200018	Large oscillations (wiggly s-curves) on back side	Yes	Yes, P1B 25/6-9/7 60% fluence (?)	Yes
20220380200006 (scand006)	Large oscillations (wiggly s-curves) on back side	No	Yes, P1A 19/5-2/6	Yes
20220130000002 (Geneva endcap)	None	No	Yes, P1B 25/6-9/7 60% fluence (?)	Yes

Fluences

- **There is some question about the fluence reached in the second irradiation, P1B, 25 June – 9 July.**

- **After the P1B irradiation chip gains are high and noise low:**

Average gains at 2fC: before/after irradiation

Unirr.

P1B

P1A
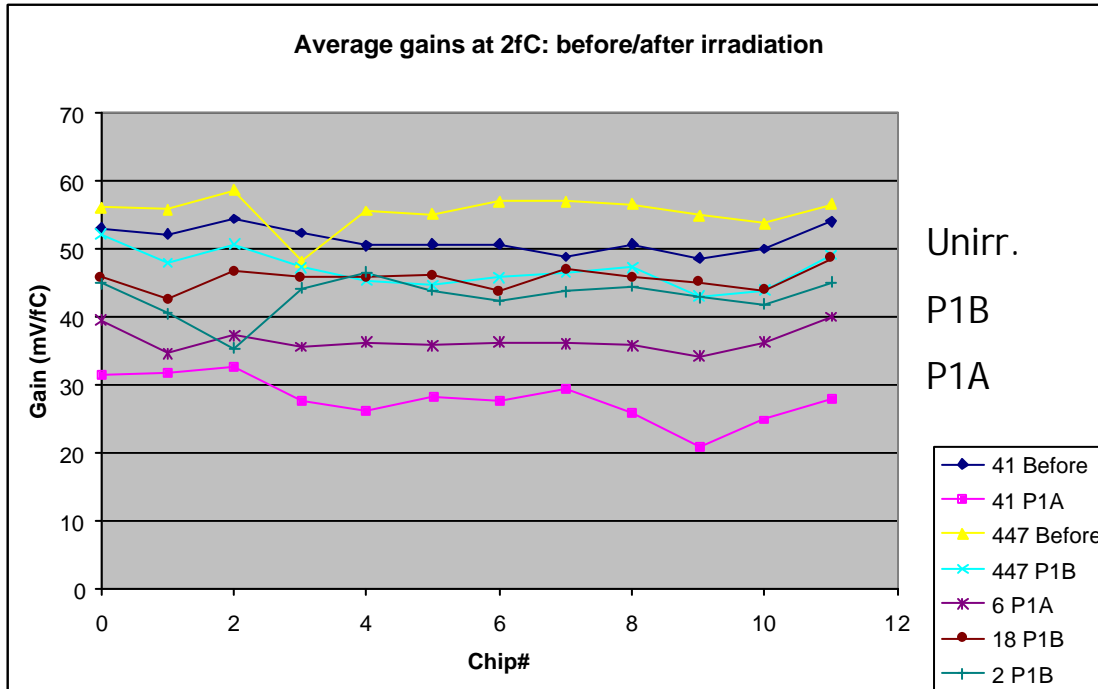
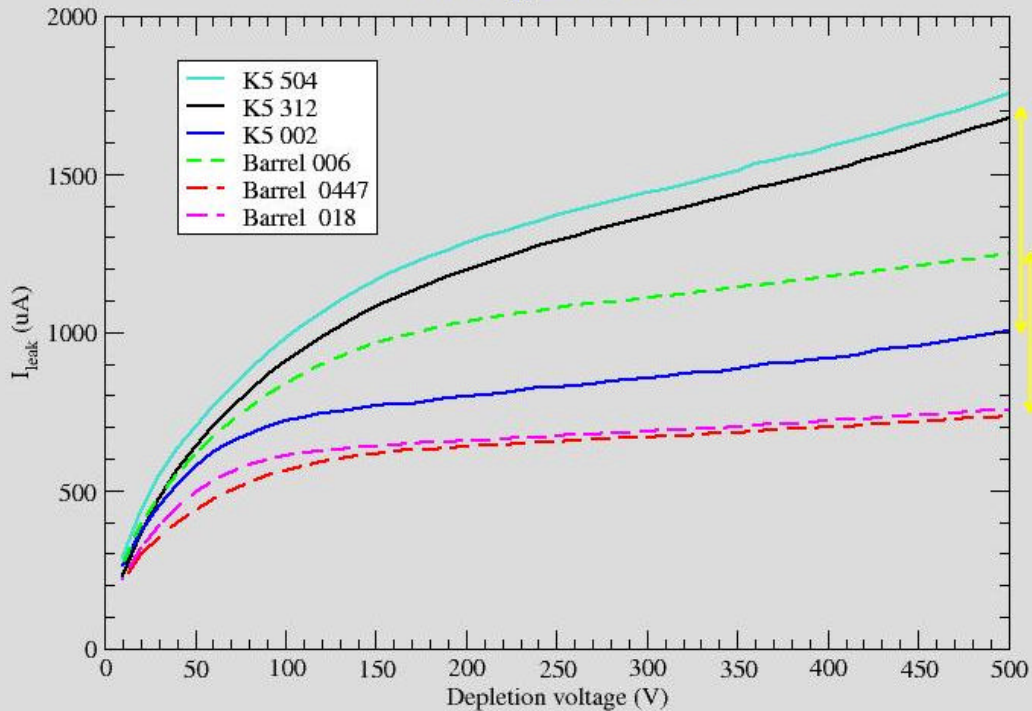| Ave.	gain	noise
0041 Un.	51	
0447 Un.	55	
0447 P1B	46	1831
0018 P1B	46	1649
0002 P1B	43	1939
0006 P1A	36	1990
0041 P1A	30	2213
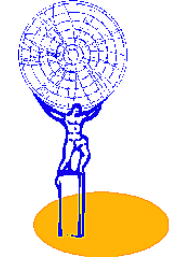
Fluences..

- In the testbeam setup, Mariane measured the IV curves of all modules, with LV off, all reading the same hybrid T = -13C
  >>> *no normalisation required for comparison*

IV curve of irradiated modules
LV off, T_{hyb} = - 13°C, TB set-up

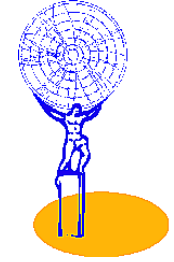Ratio P1B / other irradiations consistently around **0.6** for both barrels and endcaps separately
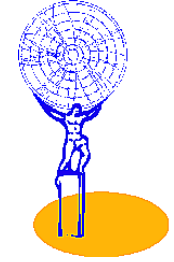
Program II

- **For whatever reason, it looks like we have a systematic radiation study:**

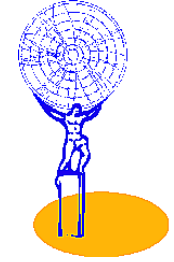| Fluence	0	~60% ?	100%
Large gain spread	yes	yes	yes
Negative offset	yes	no	no
Wiggly s-curve	yes	yes	yes

Note: option to irradiate 0010, negative offset module, before the end of 2003

Large gain-spread chips

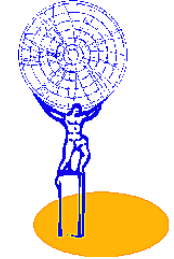0041 chip S02 before/after P1A

0447 chip S02,S03 before/after P1B

Large gain spread – 0041 chip S02

Irradiation P1A

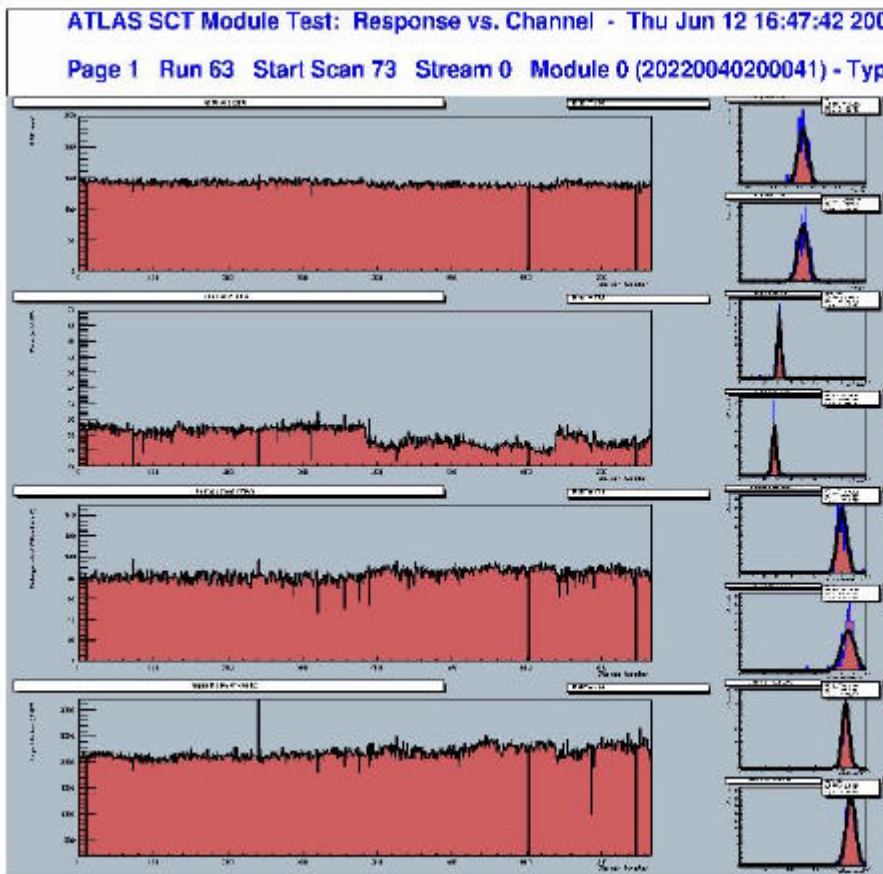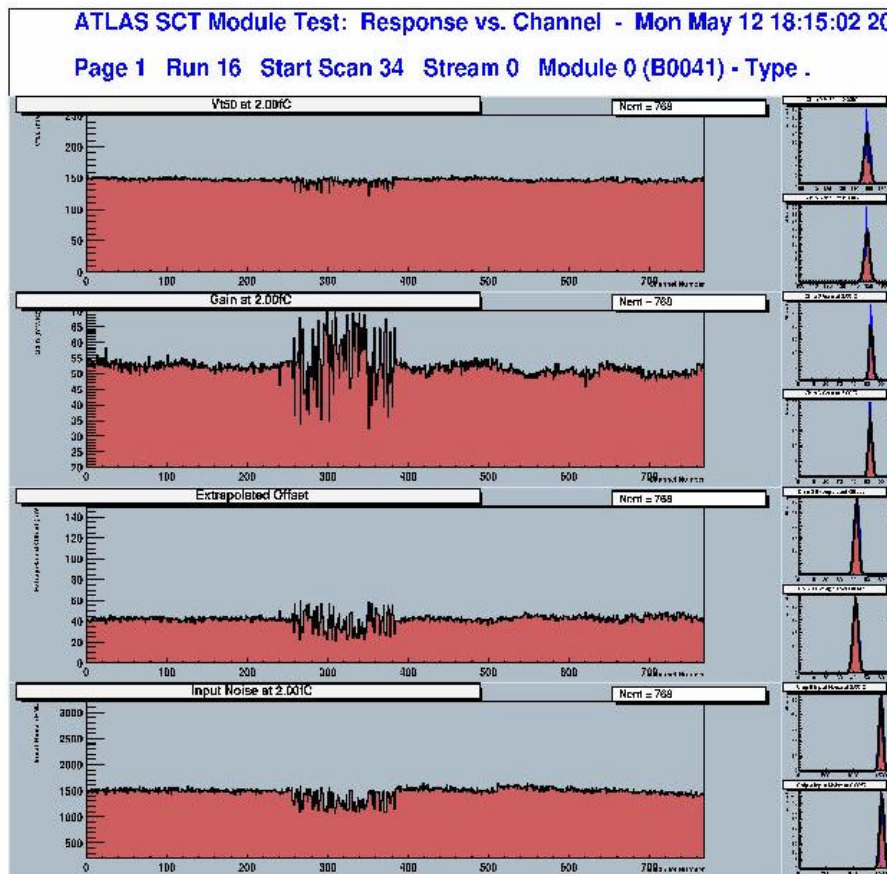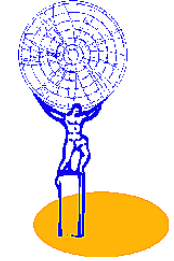| Chip	Before		After		
	Gain	RMS	Gain	RMS	Ish
0	53.0	1.3	31.5	2.0	
1	52.1	1.1	31.8	1.5	
2	54.4	8.9	32.5	1.5	32.0
3	52.3	1.4	27.6	1.6	
4	50.4	1.2	26.2	1.4	
5	50.7	1.5	28.3	1.9	
6	50.6	1.2	27.7	1.4	
7	48.9	1.1	29.6	1.8	
8	50.8	1.0	25.9	1.6	
9	48.5	1.3	20.9	1.3	
10	49.9	1.3	24.9	1.5	
11	54.0	1.1	27.9	2.2	

Large gain spread – 0041 chip S02

Before

After P1A (full fluence)&
current matrix, Ish=32; freezer

Large gain spread – 0447 chips S02,S03

Irradiation P1B - ~60% fluence?

Chip	Before Gain	RMS	After Gain	RMS	Ish
0	56.1	1.4	52.1	2.4	
1	55.7	1.2	47.8	2.0	
2	58.7	2.8	50.6	3.3	32.0
3	48.1	8.9	47.3	2.1	25.6
4	55.5	1.0	45.4	1.7	
5	55.1	1.4	44.7	1.8	
6	57.0	1.3	45.9	2.2	
7	57.0	1.3	46.5	2.0	
8	56.6	1.2	47.2	1.7	
9	55.0	1.3	43.1	1.8	
10	53.7	1.3	44.0	2.3	
11	56.6	1.1	49.0	1.8	

Large gain spread – 0447 chips S02,S03

Before   After P1B (~60% fluence ?)
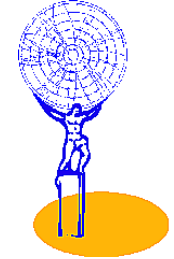

2003

Negative offset chip – 0010 Chip S03

Not irradiated – information from H8

Module was used as an anchor in May/June and September

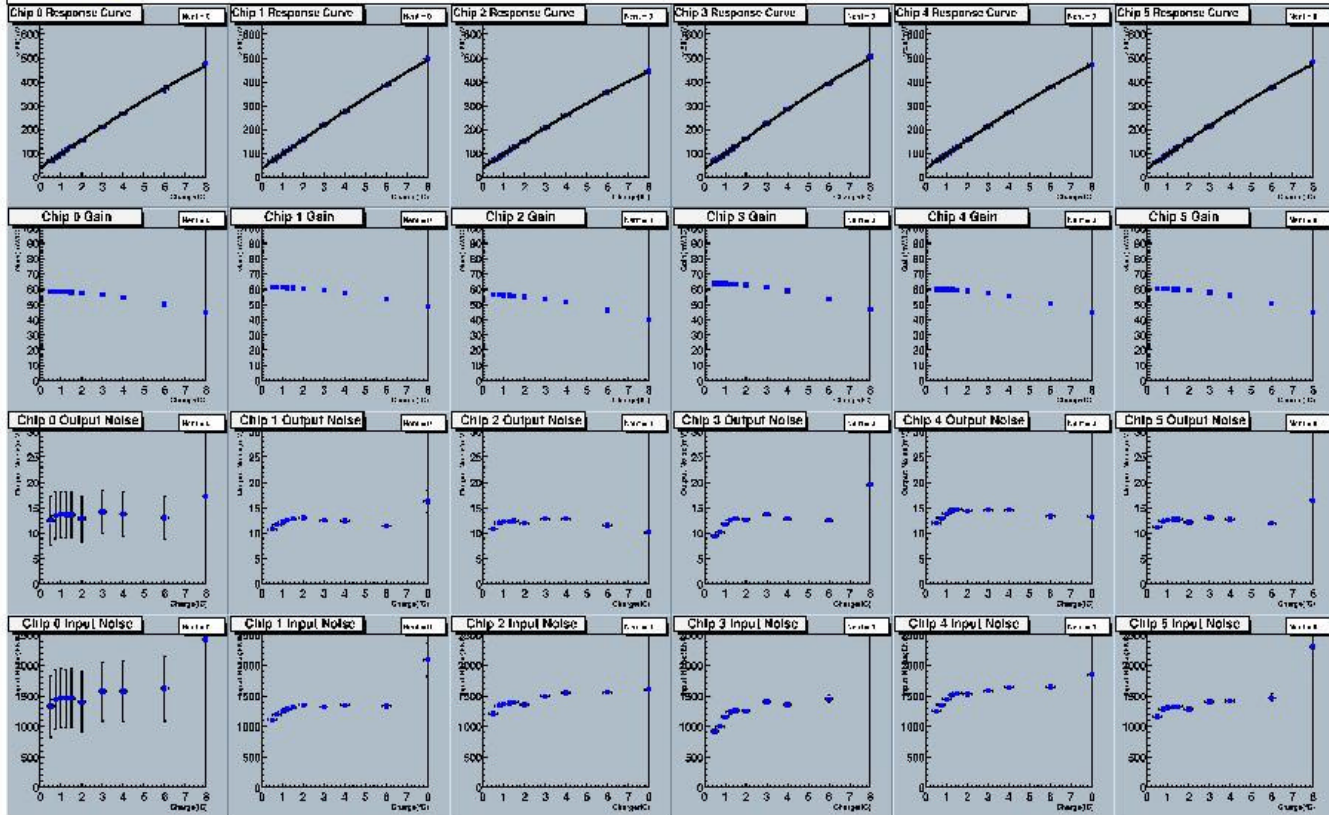Several threshold scans last weekend – not yet analysed

Some online information

Negative offset chip – 0010 Chip S03
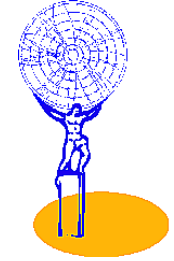

ATLAS SCT Module Test: Response Curve - Wed Sep 03 18:12:56 2003 - CERN H8 - Module 20220170200010mDa
Page 2 Run 52 Start Scan 4 Module 0 Stream 0 - Type .

Not obvious in standard response curve...

Negative offset chip – 0010 Chip S03
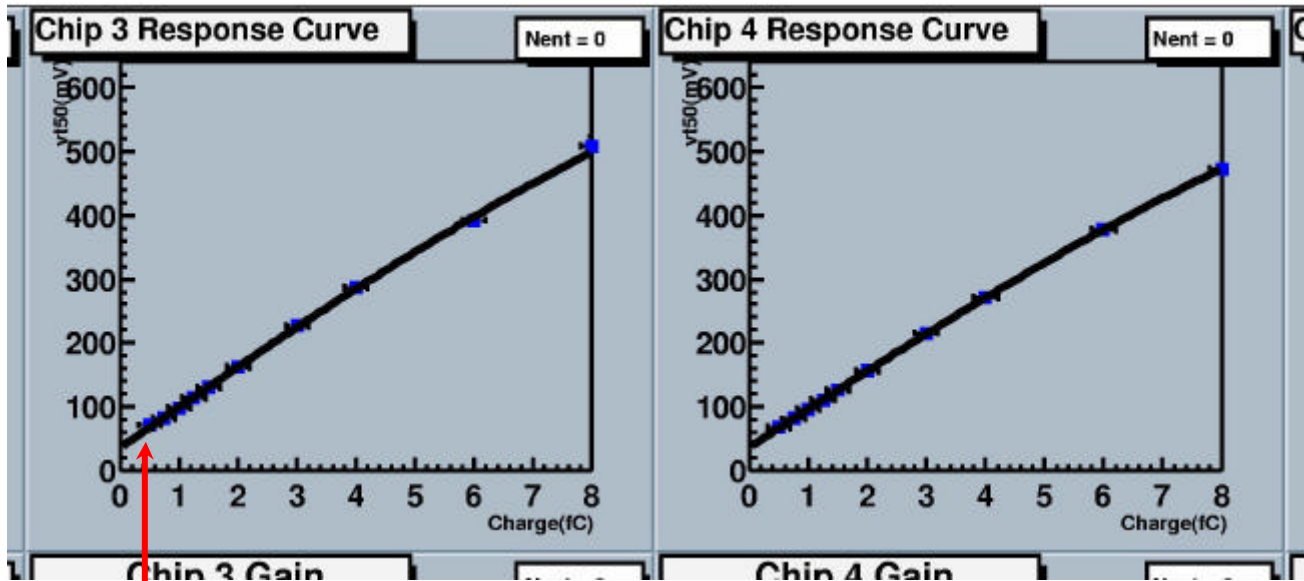
Slight upturn below 1fC
compared to others

Negative offset chip - 0010 Chip S03

Negative offset chip

S-curves

3.0fC

0.5fC

0fC
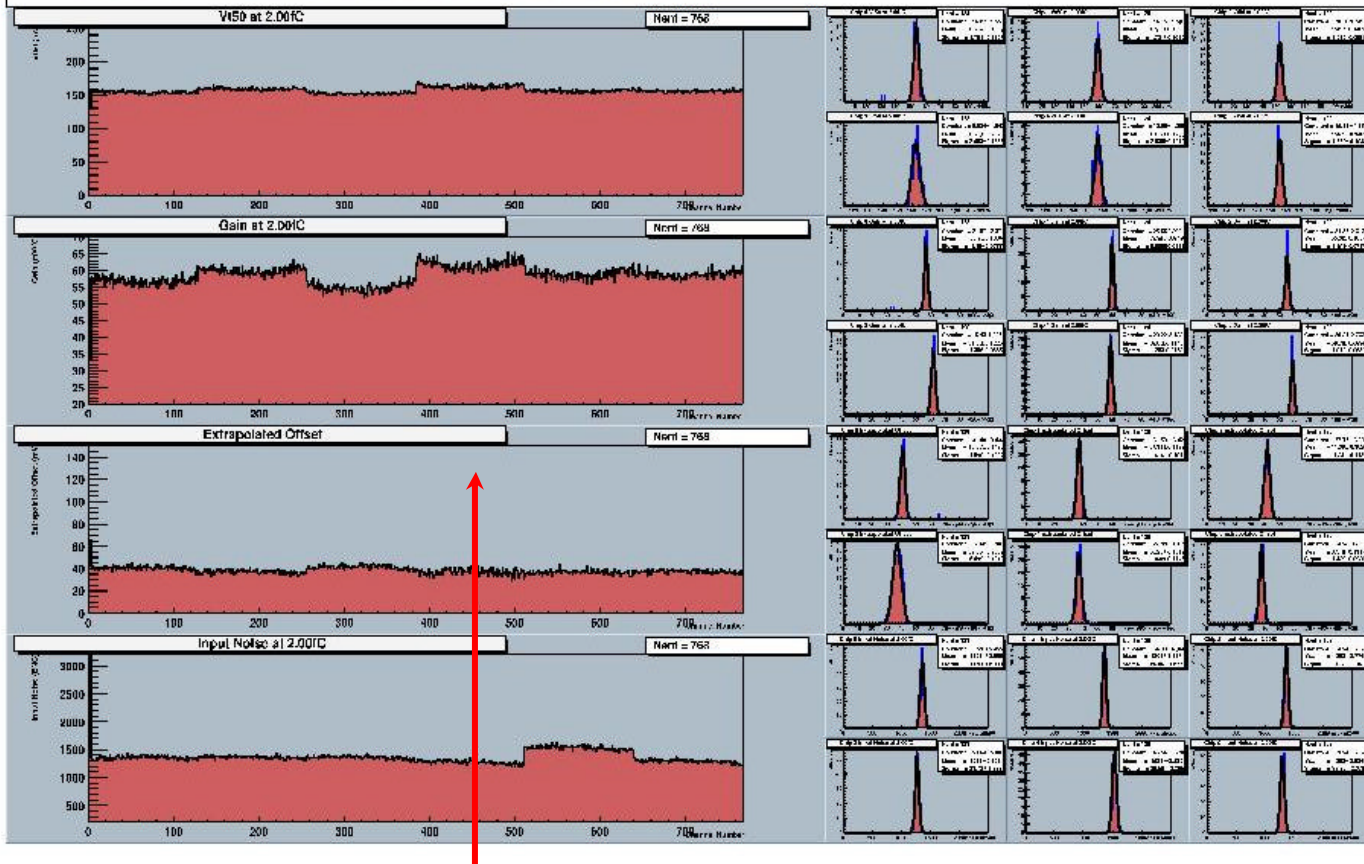
Module 0010 – Beam Efficiency vs Qthr

The negative offset chip is one of ~2 in the beam on link 0:

Efficiency vs Threshold, Module 0010
(Online - estimates only)

G.F.Moorhead   SCT Testbeam Chip Studies September 2003
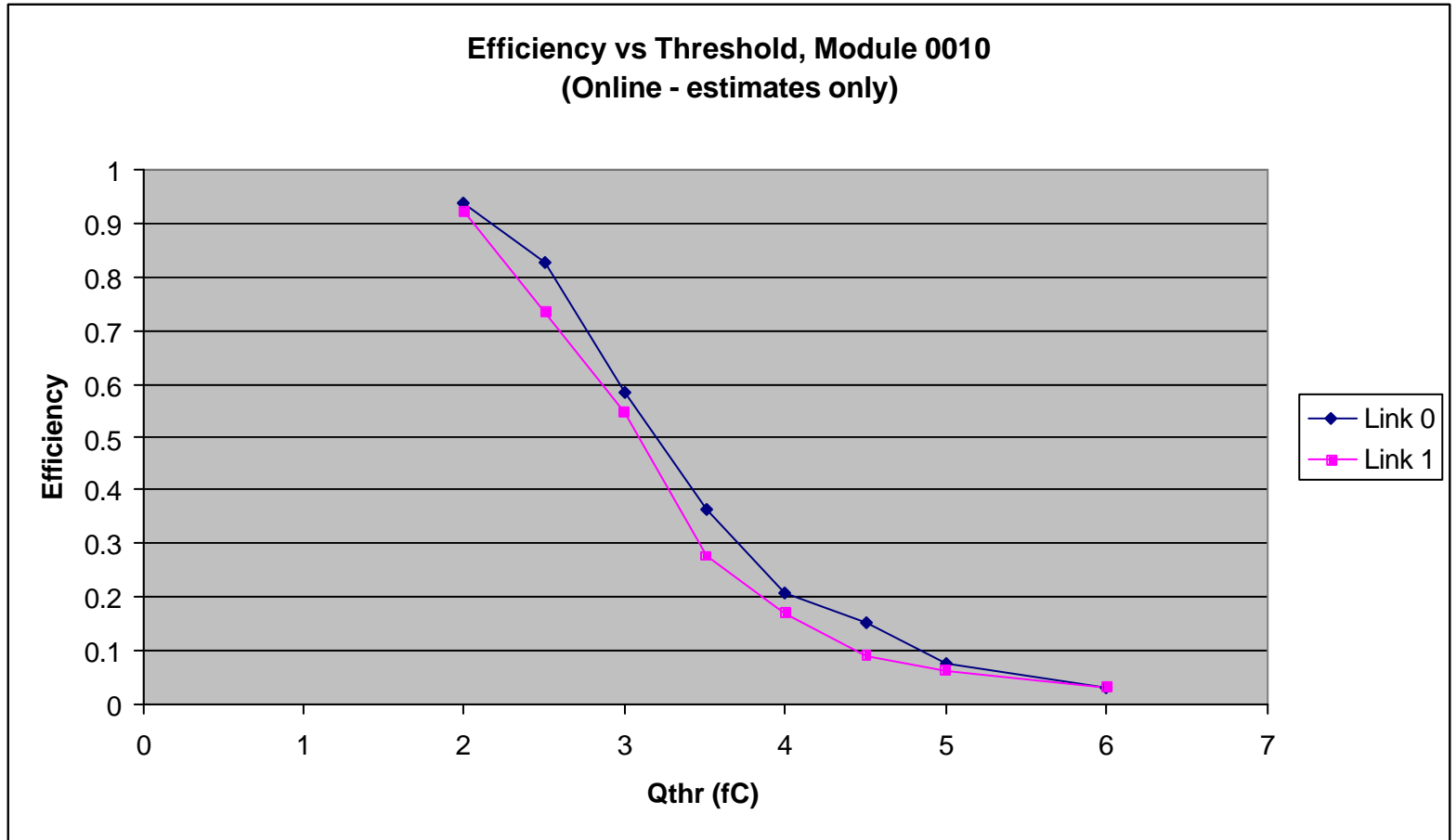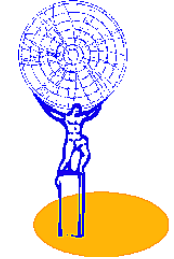
Module 0010 – Beam profile at Qthr = 3.5fC
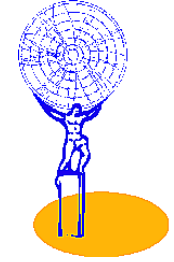
Online
hit map
at 3.5fC
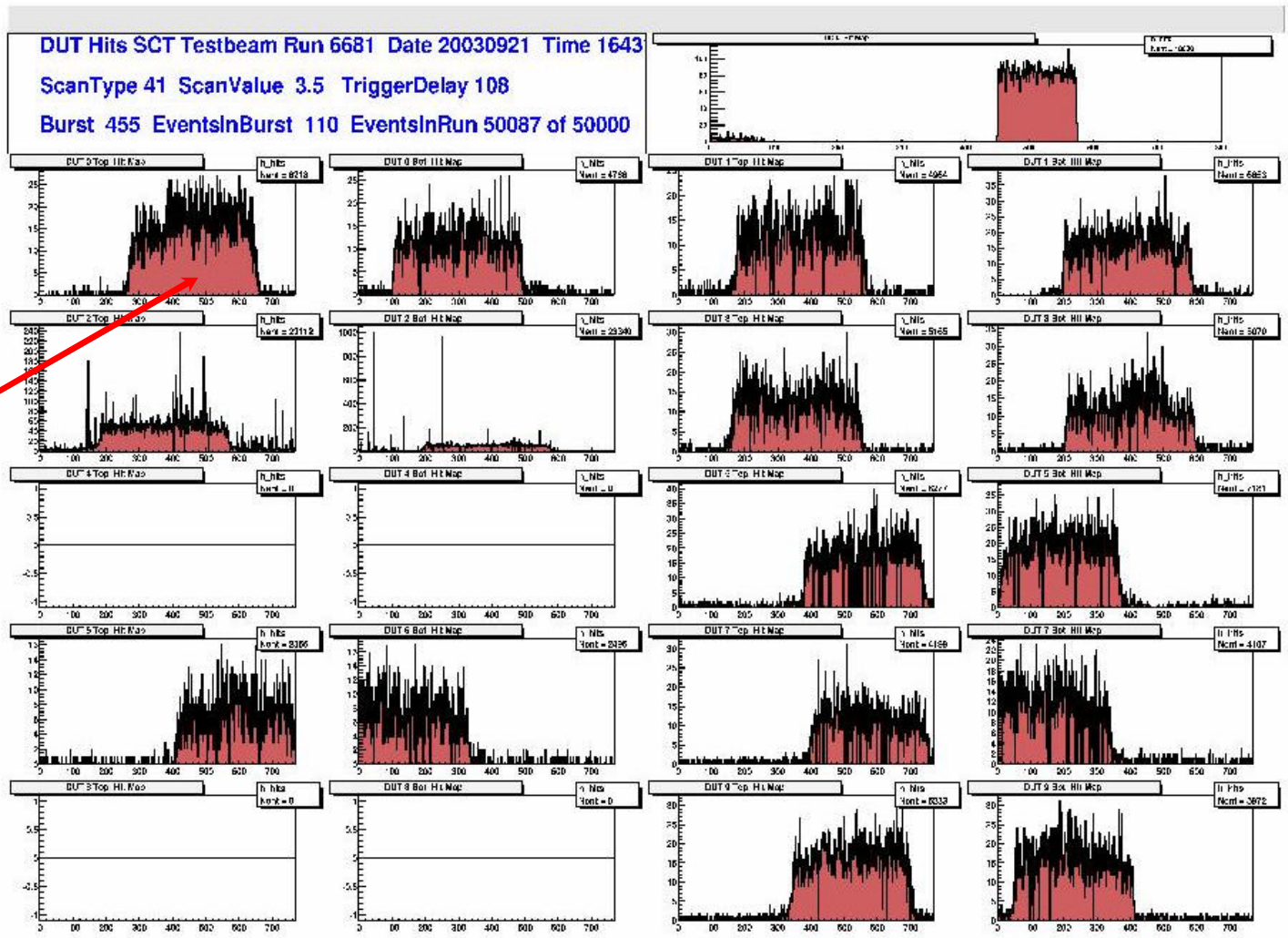
Steepest part
of S-curve:
should stand
out clearly if
excess gain

Large oscillation / wiggly s-curve modules

Large oscillation module – Scand0006

Front & back NO s-curves *before P1A*
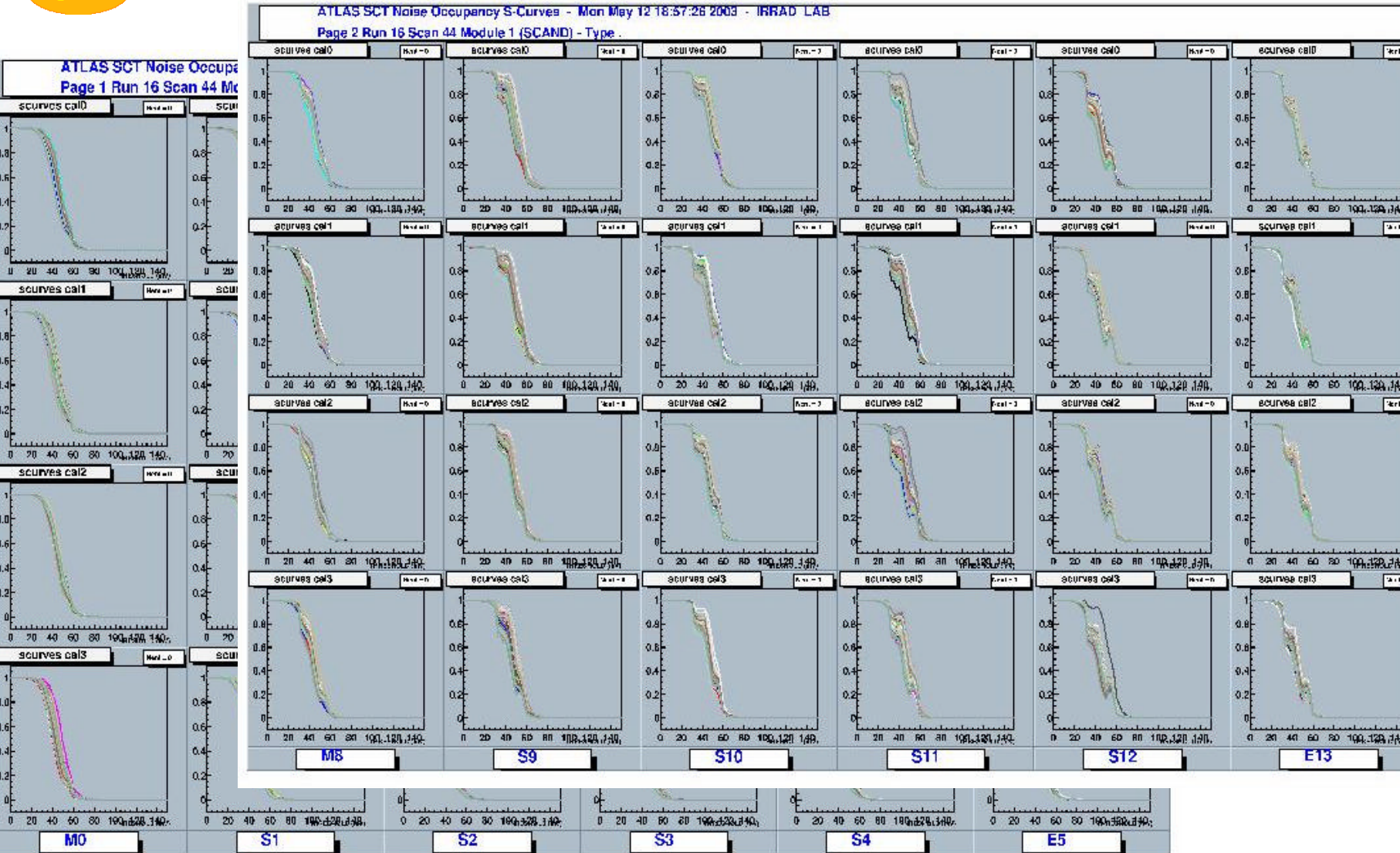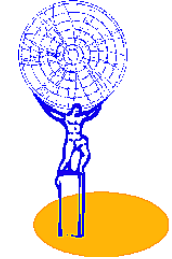
Large oscillation module – Scand0006

Front & back NO s-curves *after P1A (full irradiation dose)*

Large oscillation module – 0018

Front NO s-curves *before P1B*
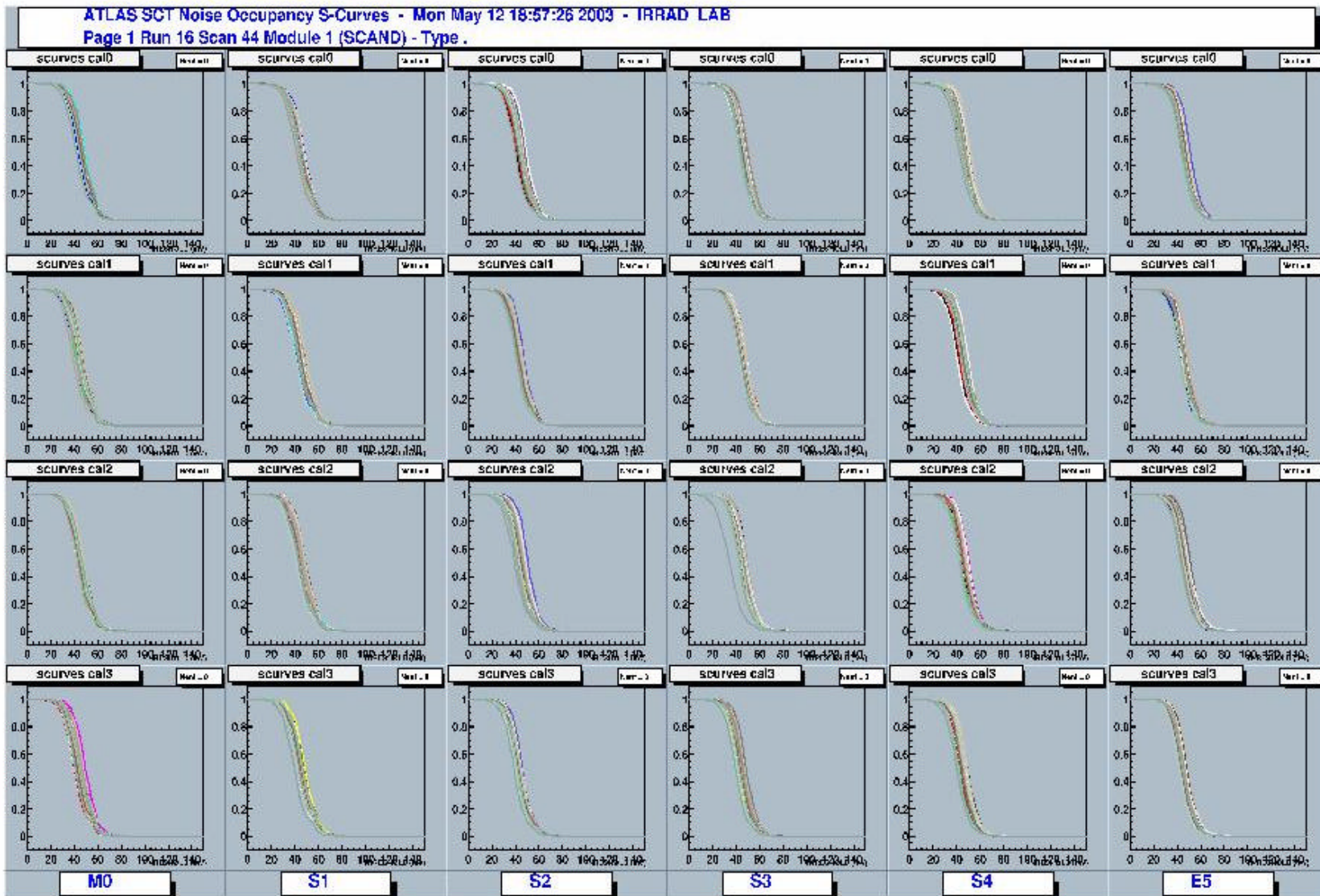
Large oscillation module – 0018

Back-side NO s-curves *before P1B*
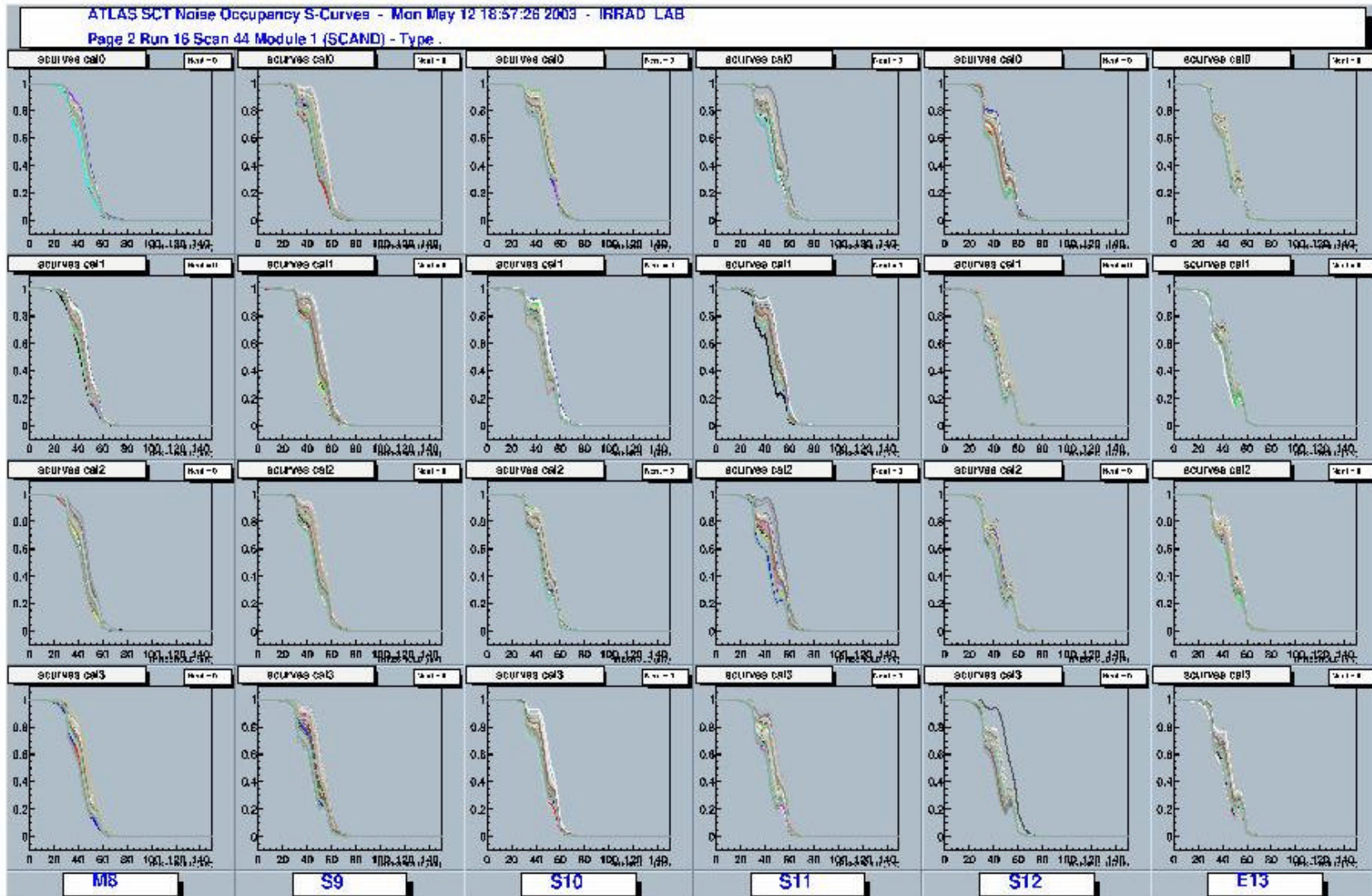
Large oscillation module – 0018

Front NO s-curves **after P1B, ~60% fluence ?**

ATLAS SCT Noise Occupancy S-Curves - Mon Aug 18 18:45:04 2003 - IRRAD LAB
Page 1 Run 73 Scan 73 Module 0 (20220380200006) - Type .
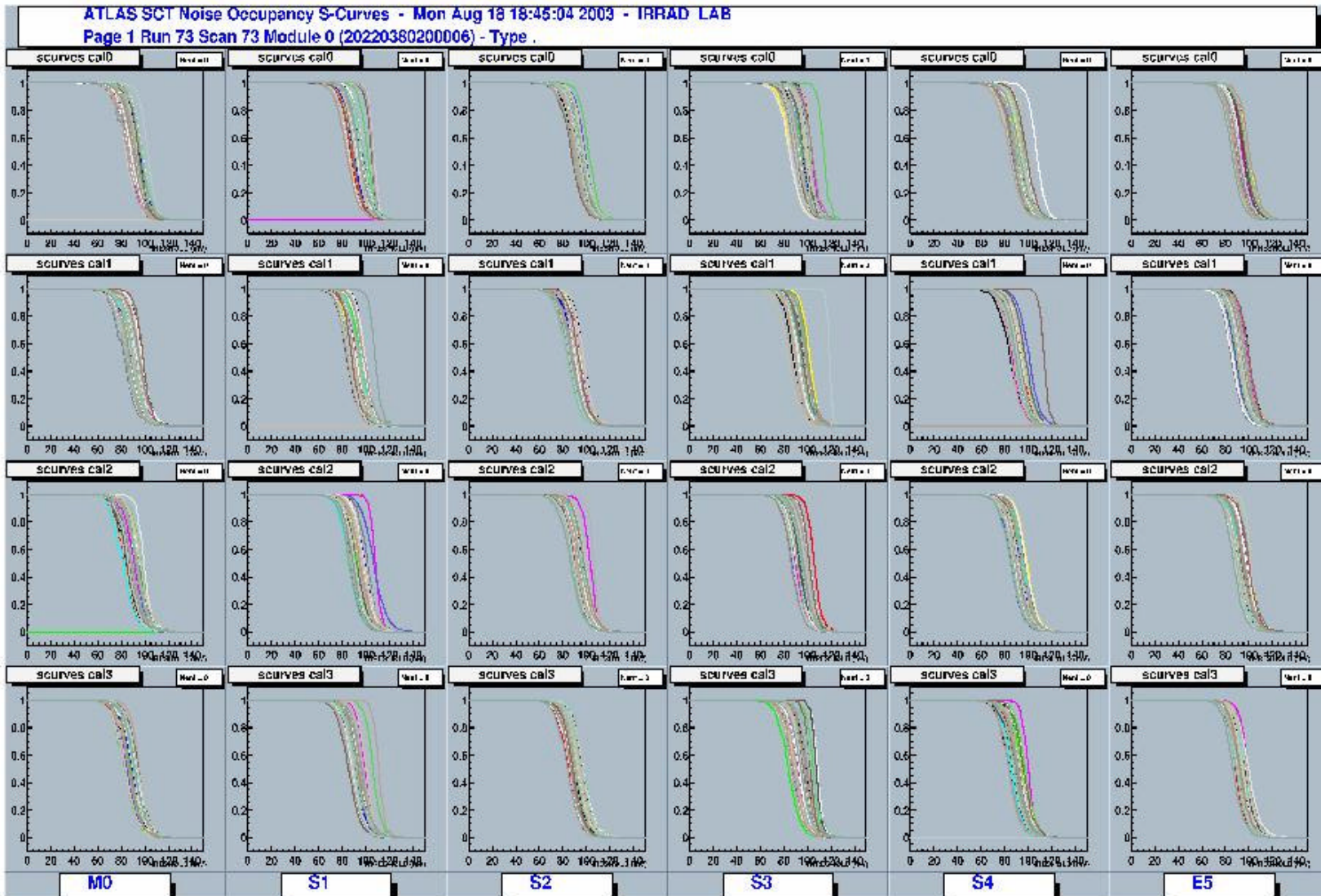
Large oscillation module – 0018

Back NO s-curves *after P1B, ~60% fluence ?*
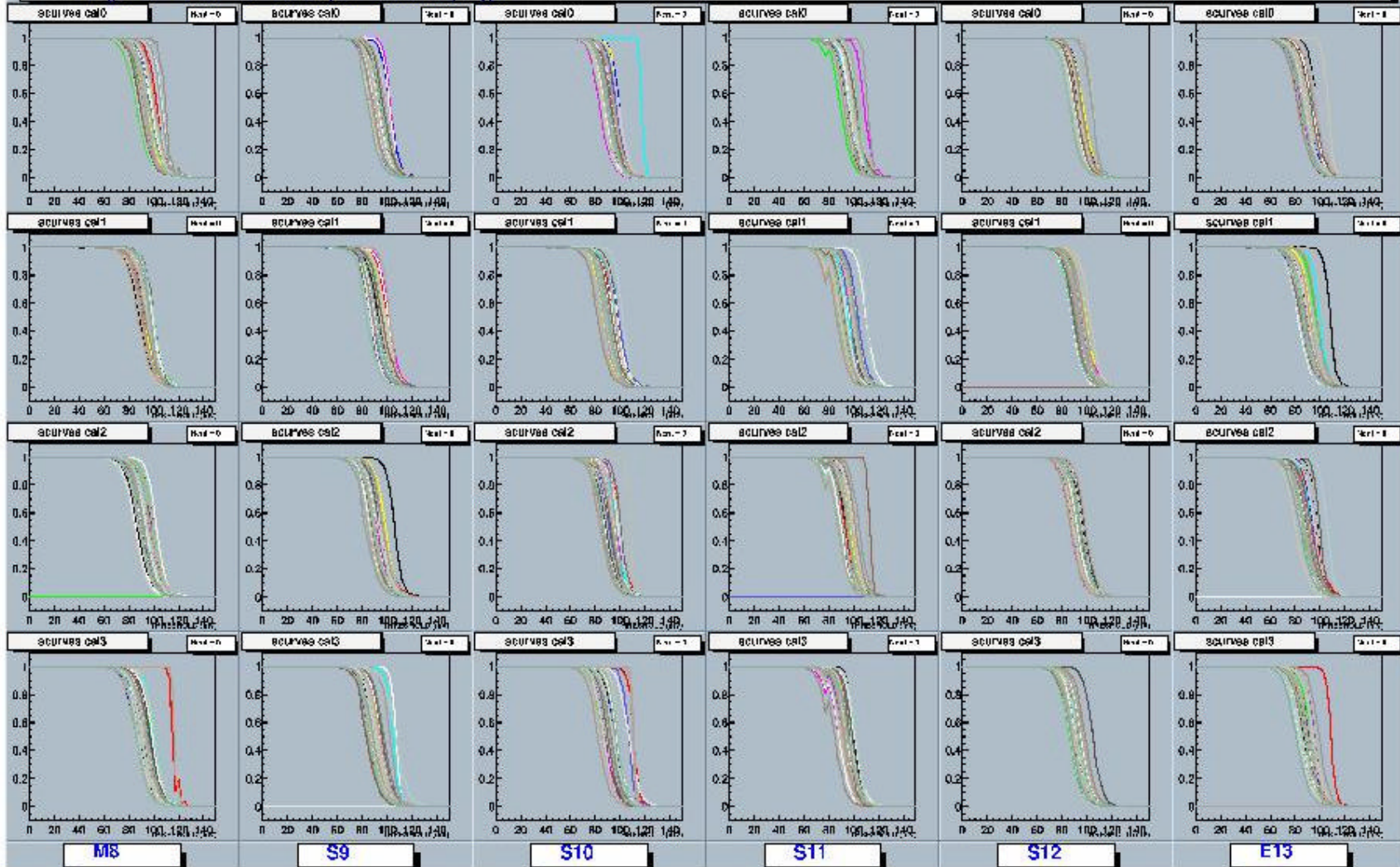
IFIC - Instituto de Física Corpuscular

September 03 beamtest results for Large Oscillation Modules (0006**, 0018*) and Large Gain Spread module (0447*)

Sergio Gonzalez Sevilla, Jose Enrique Garcia Navarro

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Outline

- <u>Large Oscillation module 0018*</u>
    - ➢ chip by chip analysis comparative before/after irradiation
    - ➢ s-curves post-irradiation
    - ➢ efficiency an NO versus corrected threshold for different bias voltages after irradiation

- <u>Large Oscillation module 0006**</u>
    - ➢ chip by chip analysis afer irradiation
    - ➢ s-curves post-irradiation

- <u>Large Gain Spread module 0447*</u>
    - ➢ chip by chip analysis comparative before/after irradiation
    - ➢ s-curves post-irradiation
    - ➢ efficiency an NO versus corrected threshold for chip S3 before and after irradiation

- Conclusions

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$C_{cal} = 1.027$

Large Oscillation barrel module 2022040200018*

- Results @1fC corrected threshold.
- Detectors bias voltage:
  - ➢ pre-irradiation: 200V (runs 6268, 6280)
  - ➢ post-irradiation: 400V (runs 6379, 6463)
- Results of pre-irradiated module with synchronous 25 ns beam (no TDC cut).
- Masked channels divided in [hardware mask] + (offline mask).
- Chips with less than 500 events have not been analysed.

Results pre-irradiation (May03)

| | LINK 0 | | | | | | LINK 1 | | | | | |
	M0	S1	S2	S3	S4	E5	M8	S9	S10	S11	S12	E13
Eff		99.3	99.4	99.2					99.8	99.0	99.6	
NO		8.9×10^{-6}	1.1×10^{-5}	1.3×10^{-5}					3.3×10^{-6}	2.9×10^{-6}	4.5×10^{-6}	
Q_{med}		3.5	3.5	3.4					3.4	3.4	3.5	
Events		3588	4850	777					1076	5151	3184	
Masked Ch.		[0] +(0)	[0] +(0)	[0] +(0)					[0] +(0)	[0] +(0)	[0] +(0)	

Results post-irradiation (Sep03)

| | LINK 0 | | | | | | LINK 1 | | | | | |
	M0	S1	S2	S3	S4	E5	M8	S9	S10	S11	S12	E13
Eff	99.8	99.9	99.8	99.8					99.8	99.7	99.9	99.7
NO	3.4×10^{-4}	9.4×10^{-4}	9.8×10^{-4}	1.8×10^{-3}					5.6×10^{-4}	1.4×10^{-3}	5.6×10^{-4}	2.8×10^{-4}
Q_{med}	3.4	3.3	3.2	3.6					3.2	3.3	3.2	3.3
Events	2376	2662	2784	1979					2545	2189	2933	1935
Masked Ch.	[0] + (0)	[1] + (0)	[0] + (0)	[4] + (0)					[2] + (0)	[6] + (0)	[2] + (0)	[1] + (0)

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Large Oscillation barrel module 20220040200018*

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Large Oscillation barrel module 20220040200018*

Efficiency and noise occupancy as function of the corrected threshold for module 0018* link 0 (left) and link 1 (right) for different detector bias voltages. The dark markers correspond to efficiency measurements, being the red line the noise occupancy.

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$C_{cal} = 1.076$

Large Oscillation barrel module 20220380200006**

- Results @1fC corrected threshold.
- Detectors bias voltage:
  - Post-irradiation: 400V (runs 6378, 6462)
- Masked channels divided in [hardware mask] + (offline mask).
- Chips with less than 500 events have not been analysed.

Results post-irradiation (Sep03)
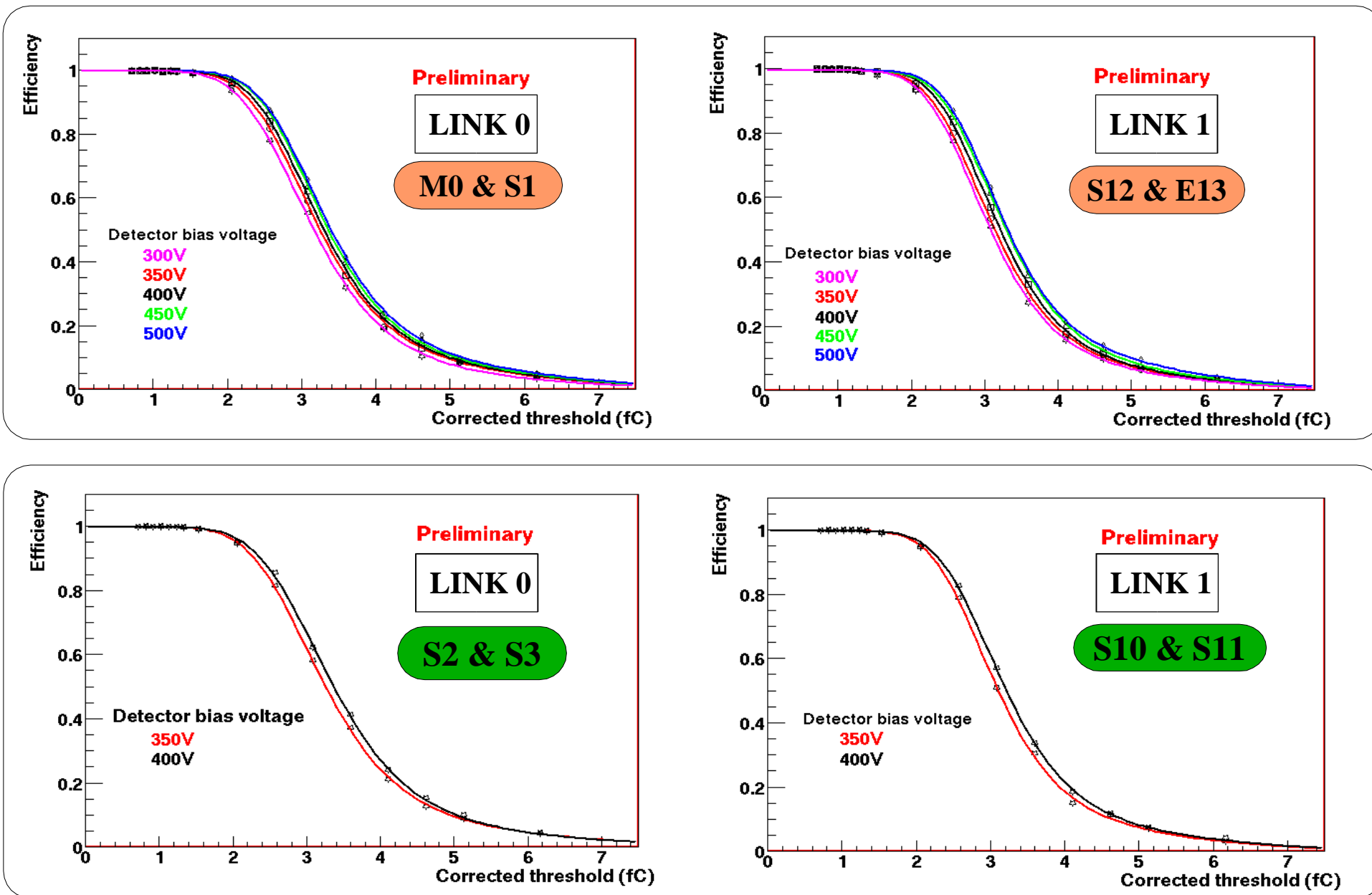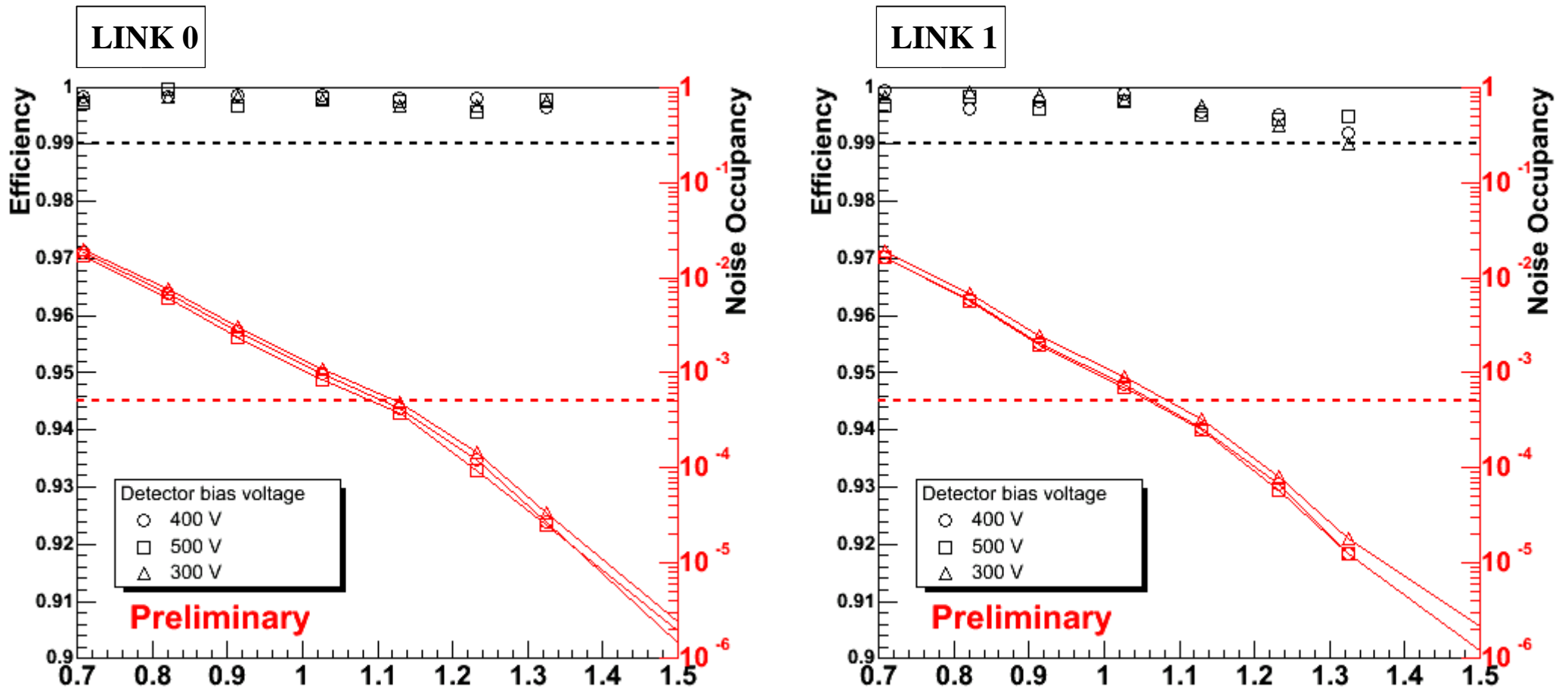
	M0	S1	S2	S3	S4	E5	M8	S9	S10	S11	S12	E13
Eff	99.8	99.9	99.7	99.5					99.8	99.8	99.9	99.8
NO	4.1×10^{-3}	8.8×10^{-3}	5.4×10^{-3}	8.3×10^{-3}					5.7×10^{-3}	1.1×10^{-2}	3.4×10^{-3}	2.4×10^{-4}
Q_{med}	3.0	3.3	3.1	3.1					2.8	3.0	3.0	2.9
Events	2921	2249	3374	1807					2269	2669	2744	2491
Masked ch.	[2] + (0)	[2] + (1)	[0] + (0)	[0] + (1)					[0] + (0)	[2] + (1)	[1] + (0)	[2] + (0)

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Large Oscillation barrel module 20220380200006**

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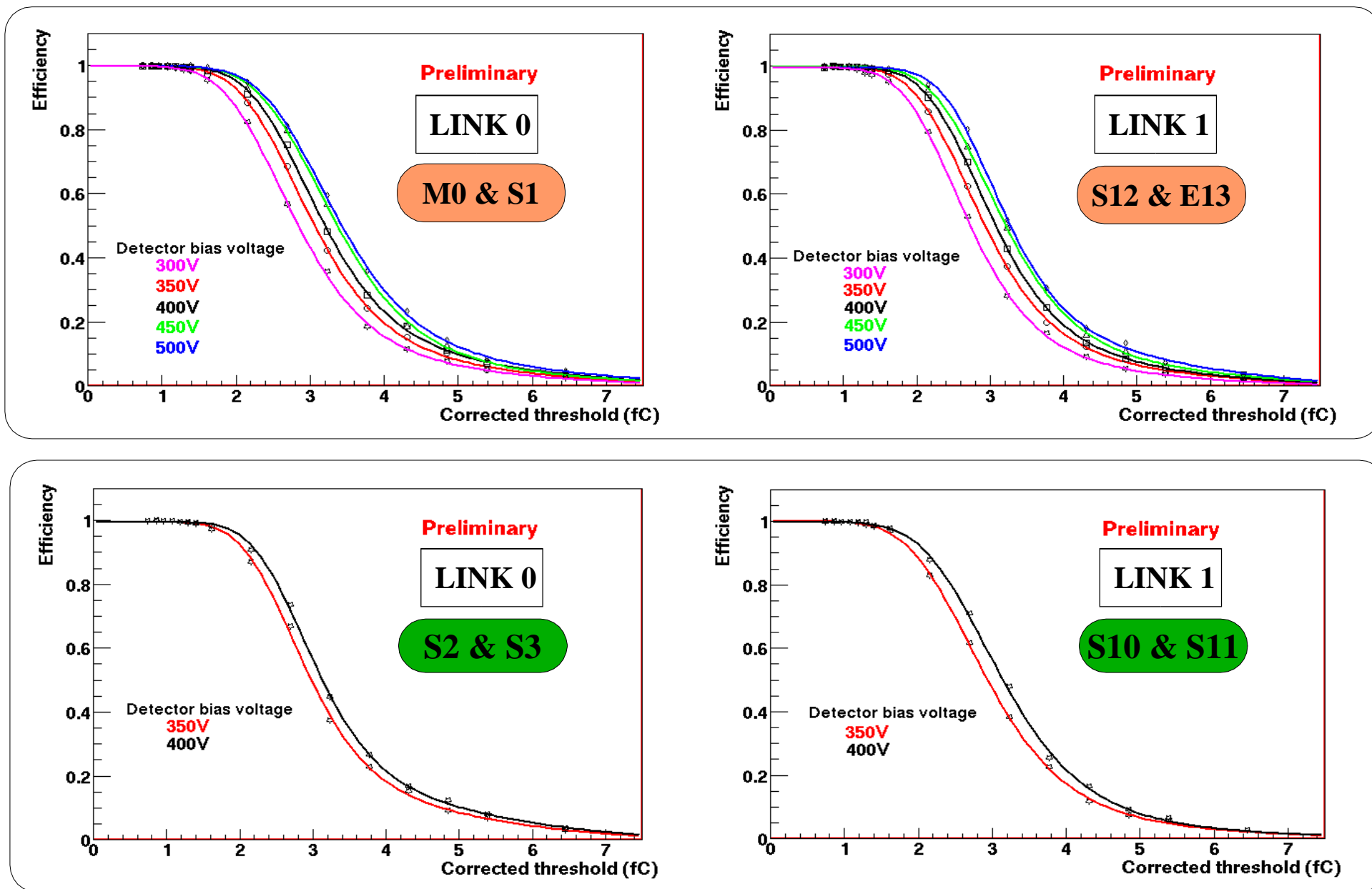
$C_{cal} = 1.089$

Large Gain Spread barrel module 20220040200447*

- Results @1fC corrected threshold.
- Detectors bias voltage:
  - pre-irradiation: 200V (runs 6267, 6279)
  - post-irradiation: 400V (runs 6378, 6462)
- Results of pre-irradiated module with synchronous 25 ns beam (no TDC cut).
- Masked channels divided in [hardware mask] + (offline mask).
- Chips with less than 500 events have not been analysed.
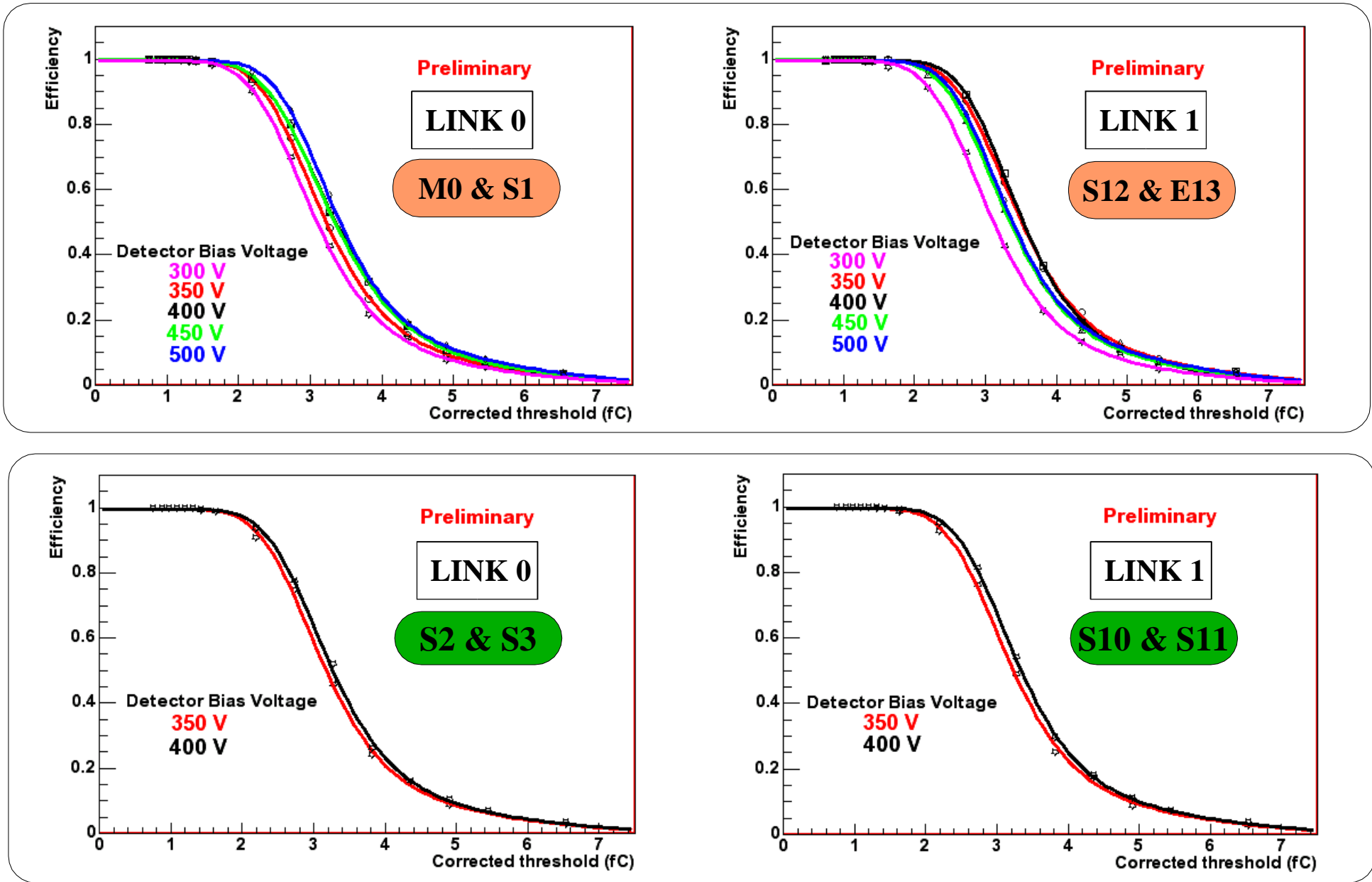
Large Gain Spread chip: **S3**

Results pre-irradiation (May03)

	LINK 0						LINK 1					
	M0	S1	S2	S3	S4	E5	M8	S9	S10	S11	S12	E13
Eff			99.8	99.5	99.4			99.3	99.5			
NO			4.5×10^{-6}	3.4×10^{-6}	1.9×10^{-5}			1.9×10^{-4}	1.1×10^{-4}			
Q_{med}			3.4	3.4	3.3			3.1	3.1			
Events			3292	7420	1988			2699	7076			
Masked ch.			[0] + (0)	[0] + (0)	[0] + (0)			[0] + (128)	[0] + (0)			

Results post-irradiation (Sep03)

	M0	S1	S2	S3	S4	E5	M8	S9	S10	S11	S12	E13
Eff	99.8	99.9	99.8	99.8					99.9	99.8	99.7	99.8
NO	1.2×10^{-3}	2.8×10^{-3}	2.1×10^{-3}	2.7×10^{-3}					4.8×10^{-3}	5.3×10^{-3}	2.8×10^{-2}	3.8×10^{-2}
Q_{med}	3.4	3.4	3.3	3.4					3.4	3.4	3.54	3.63
Events	2960	2500	3046	2002					2263	2867	2956	2532
Masked ch.	[1] + (0)	[1] + (0)	[4] + (0)	[1] + (0)					[1] + (2)	[0] + (0)	[2] + (3)	[1] + (2)

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Large Gain Spread barrel module 20220040200447*

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Large Gain Spread barrel module 20220040200447*
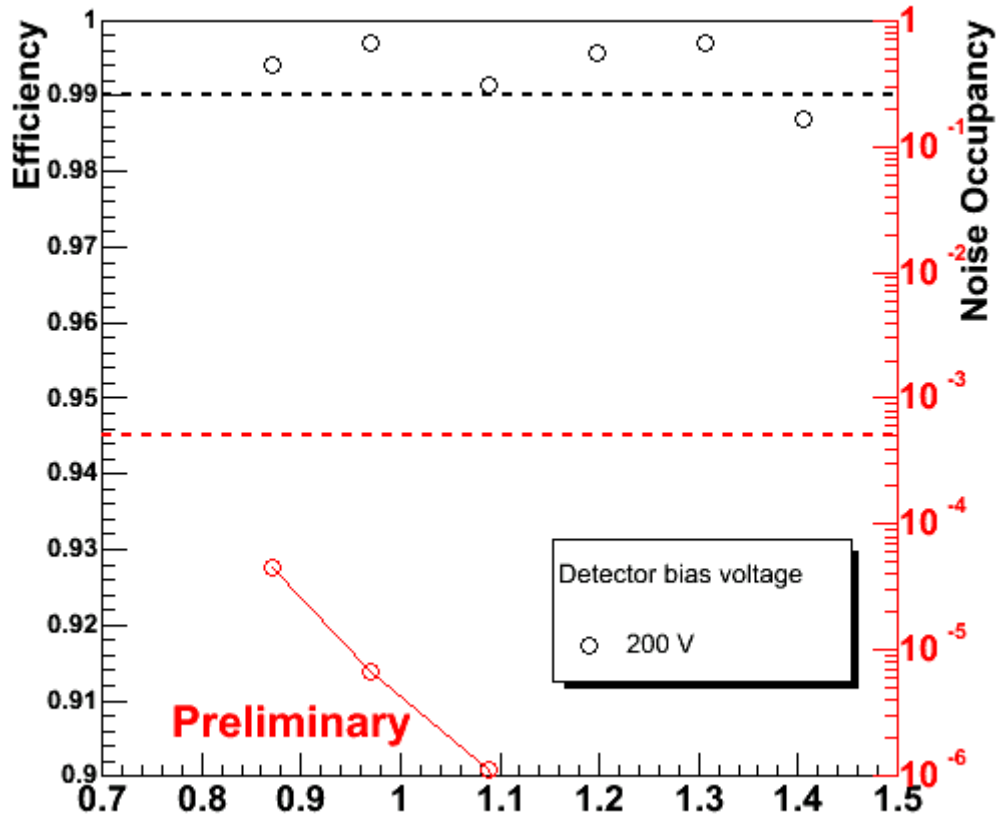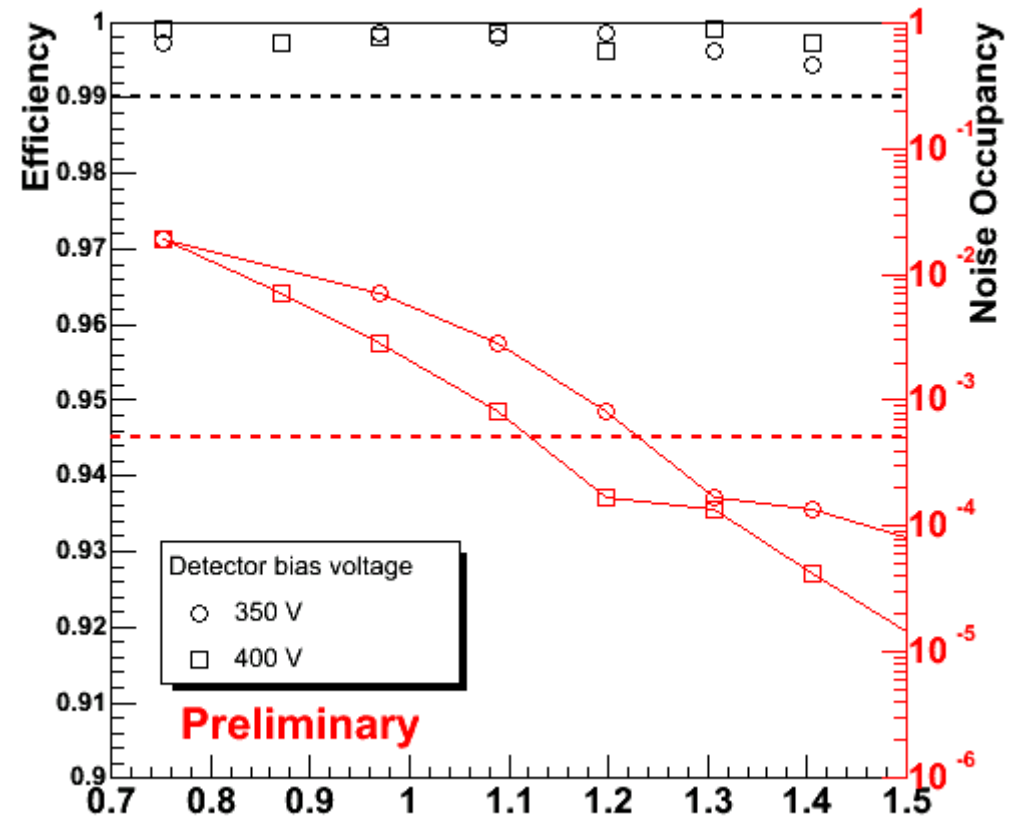
Efficiency and noise occupancy as function of the corrected threshold for chip S3 of barrel module 0047 before and after the irradiation. The dark markers correspond to efficiency measurements, being the red line the noise occupancy.

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Conclusions

- No oscillation beahaviour observed after irradiation (no s-curves shape distortion).

- I go to sleep ..