ASDBLR Radiation & Rate Effects

Review of past measurements

Mitch Newcomer

ASDBLR *Rate effects* on analog power

→ In response to a question by Brig (~2004) about ASDBLR power requirements We monitored supply current vs trigger rate of an ASDBLR from 0 to 20MHz input of 20fC pulses. No change in current was observed.

→ An alternative approach was to look at current vs threshold setting.

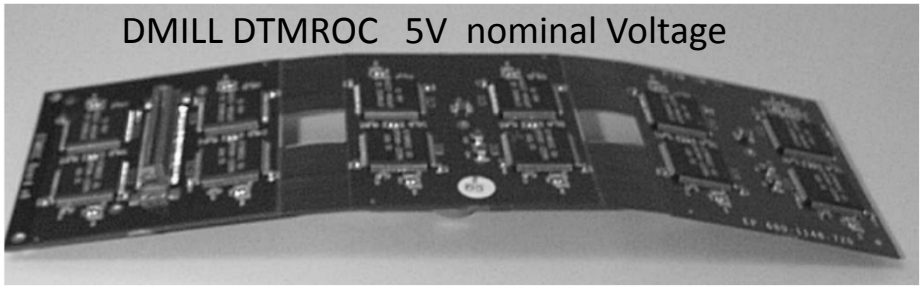
- TB3 board #24 +V = 2.8 -V = -2.8 with 2 ASDBLR00's

Threshold adjusted through zero with no change in current

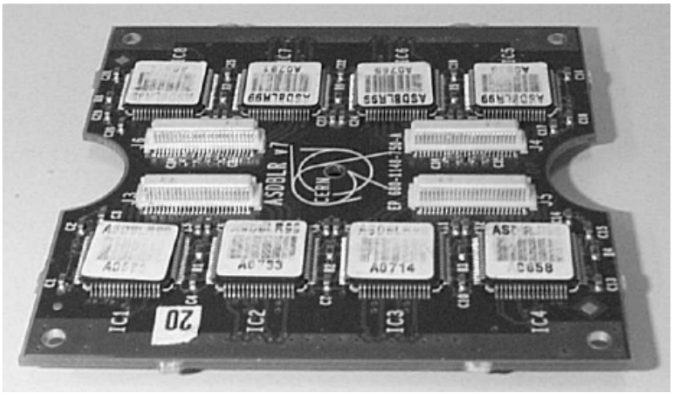
104.9mA negative supply

124.4mA Positive supply

Gamma Studies
3, 4, 7MRad



	I_{DD}	I_{CC}	I_{EE}
BEFORE	1.[illegible] A	1.58 A	1.41 A
AFTER	2.20 A	1.59 A	1.37 A



Gamma Irradiation Test
of the
TRT Electronics

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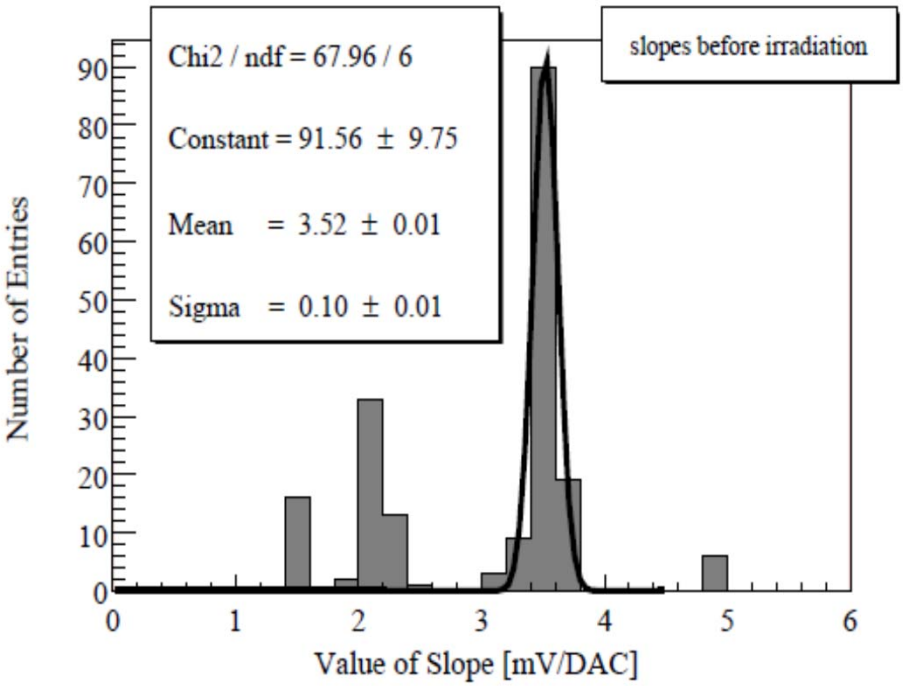
CERN

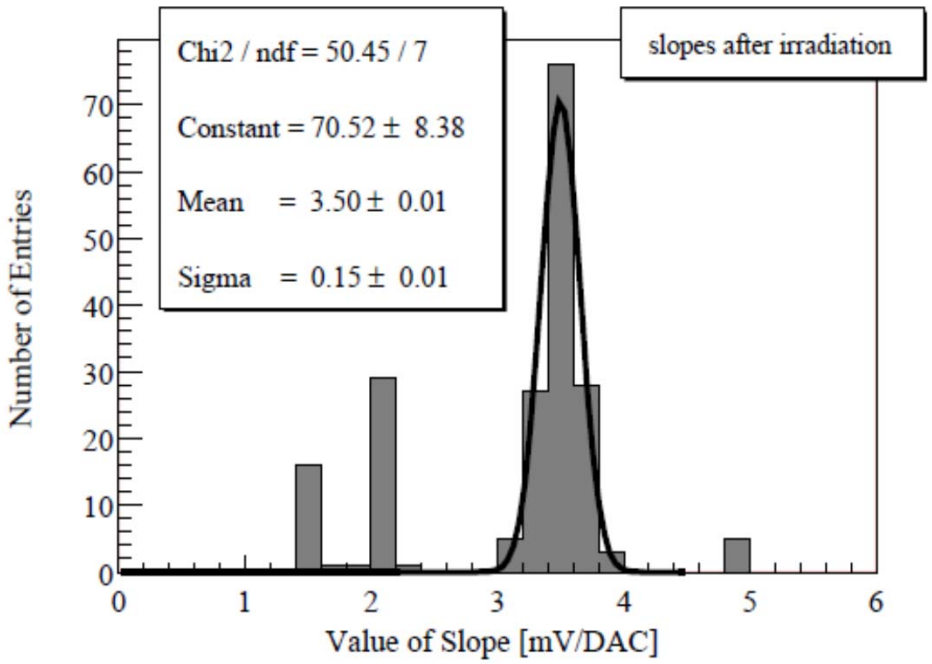
Abstract

The radiation tolerance of the TRT 01-version of the read-out electronics, i.e. DTMROC01 and ASDBLR01 chips, was evaluated by characterising a full flex board (12 DTMROC and 24 ASDBLR chips) before and after gamma irradiation.
The ASDBLR chips were exposed to three different doses, i.e. 3 Mrad, 4 Mrad and 7 Mrad the DTMROCs received 7 Mrad.
Some radiation induced changes are observed. The overall performance is however not significantly affected.

July 2002

Gamma Irradiation up to 7MRad





Histograms of the gain calculated from the external test pulse scans.

ASDBLR01 Neutron Exposure October 2001

- Nine ASDBLR01 chips were exposed to neutrons (3.5X1014N/cm2) at Prospero. Bare chip were characterized on the IMS test setup and sent to Prospero. Power was not applied. No channels or chips failed. →***The measured gain is lower by about 44%*** but the threshold deviations within each chip remain acceptable. It should be noted that the change in gain directly affects the threshold dispersion.
- **Power -**Only a small change in current draw is observed.

Average Supply Current before and after exposure

Supply	Pre Rad (mA)	Post Rad (mA)
+3V	65	64
-3V	-67	-64

LHC Qualification (from PRR documents)

- **Radiation Testing –**

A significant amount of radiation testing has been performed on ASDBLR circuits. Most has been performed with the ASDBLR99 although recently the ASDBLR01 design has been shown to be quite robust after being exposed to $3.5X10^{14}$ n/cm^2 at Prospero. We have seen three chip level failures on control lines with no input protection. In all three cases an internal short to the negative supply was the cause. The only component common to all three cases is the "polycap" capacitor. It would be useful to know if there has been a radiation hardness study done on it. The Cadence based library part generates a row of contacts just above a trench. We revised this cap for the 16pF of capacitance in the baseline restorer, but have not implemented the revised part anywhere else.

Summary of Radiation Testing for the '2002' PRR

Table 3 Summary of Radiation measurements with ASDBLR ASICS

ASDBTR Type	# chips	Power on	Date	Type Dose**	Comments
99	3		4/00	$5X10^{13}$ n	6 loose ASICS exposed without power at Prospero
	3		4/00	$1X10^{14}$ n	Test structures also exposed, NPN beta → 84 and 52
	6	x	10/00	$1X10^{14}$ p	Cern Test Beam 2 ASICS fail due to BLR Bias short
	8		'01	$1X10^{14}$ n	ASICS mounted on endcap boards exposed at Prospero.
	8		'01	$1X10^{14}$ n	No failing channels very little performance change.
	24	x	'01	3Mrad γ	ASICS mounted on endcap boards exposed at CEA Saclay. Very little change. No dead channels.
	6	x	5/01	5Mrad γ	6 ASICs mounted on 3 TB3 boards, one ASIC (5Mrad) fails due to control voltage short. CEA
	4	x	5/01	10Mrad γ	4 ASICs mounted on 2 TB3 boards, all channels remain functional. CEA
01	9		10/01	$3.5 X10^{14}$ n	9 loose ASICs exposed at Prospero No failing channels, beta → 22 Gain reduced by ~2

** n and p dose is in units of particles/cm^2

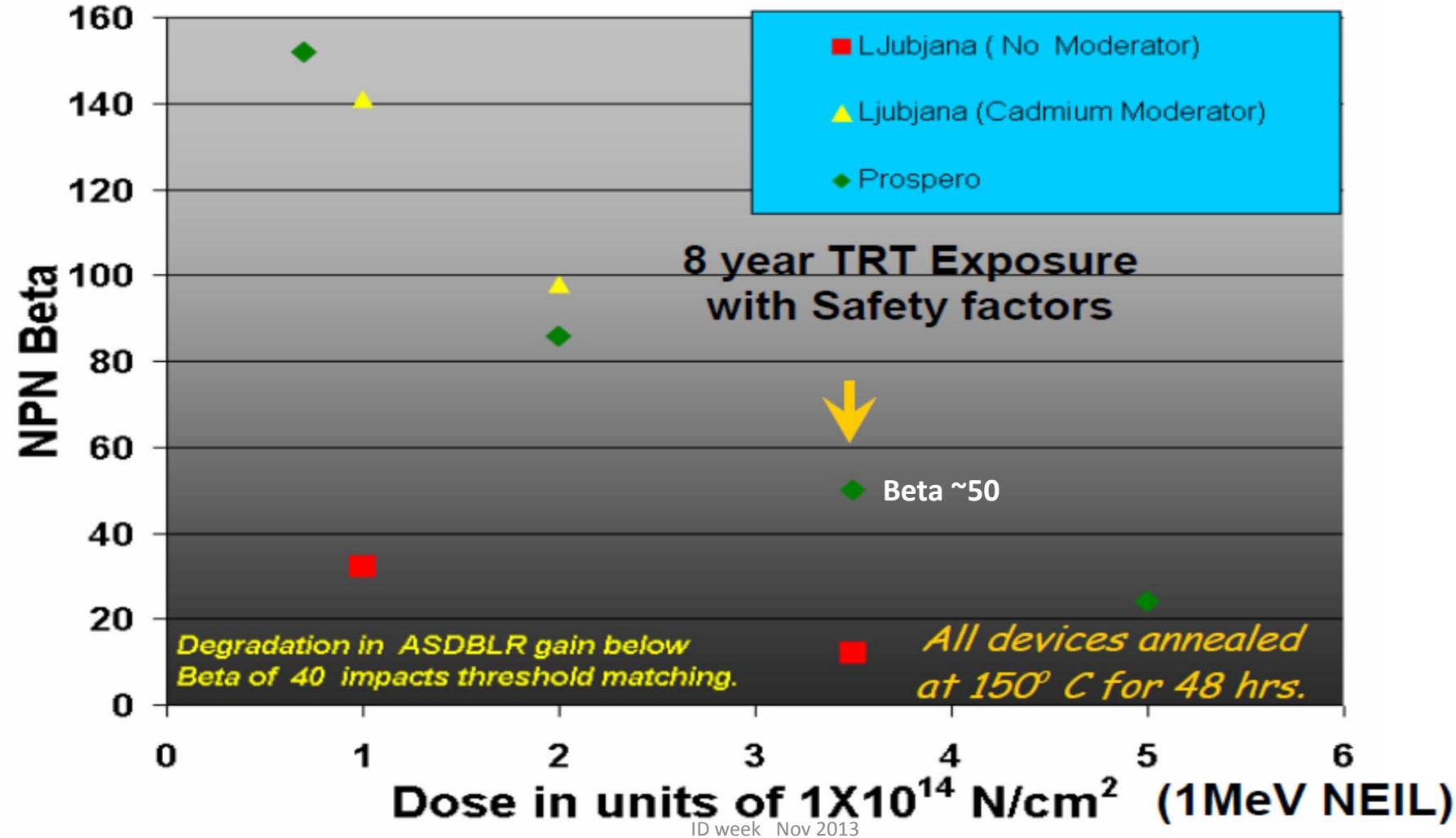
ASDBLR01 Neutron Exposure October 2001

- **Change in Gain -**The absolute threshold for a constant input charge is a sensitive function of gain. After exposure to neutrons, the mean value for the threshold for a fixed input demonstrates a significant change in gain for both the low and high thresholds.

Average Threshold for all exposed chips Pre and Post Irradiation

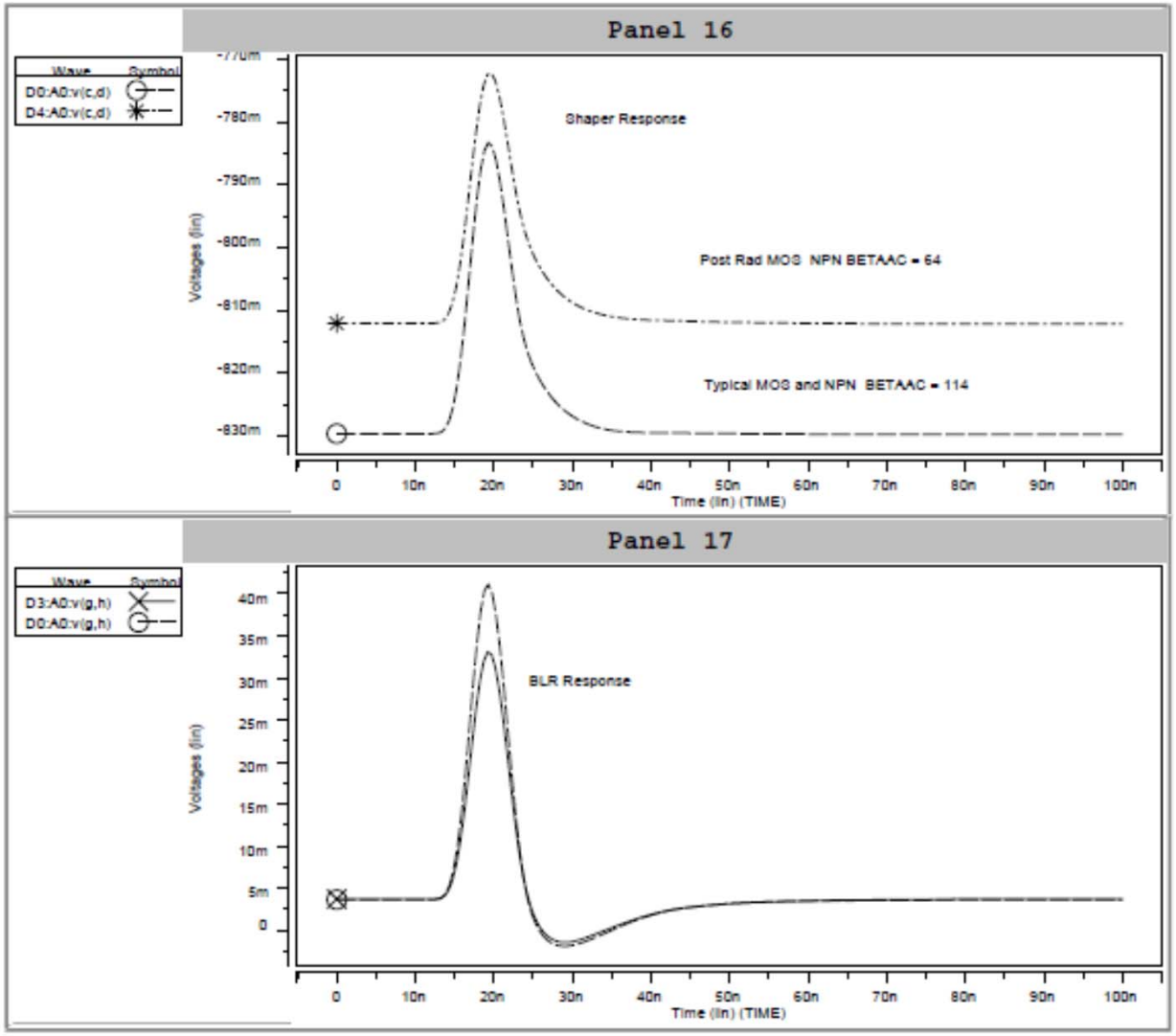
Comparator	Pre Rad (mV)	Post rad (mV)
Track (Low) 3fC	491	289
Tr (High) 30fC	352	220

DMILL NPN Neutron Gain Sensitivity



BLR amplitude

for beta = 114 and 64



Low Threshold Slope for several supply settings.

Slopes of 50 % Track Threshold Voltages for Power Supply Varied Voltages,

Slope (mv/fC)

	+ 2.7 V	+ 3.0 V	+ 3.3 V
- 2.7 V	49.5	62	
- 3.0 V	58	68.9	74.5
- 3.3 V		72.5	88

Intercept (mV)

+ 2.7 V	+ 3.0 V	+ 3.3 V
227	216	
248	269	294
	307	308

Ratio to Nominal +/-3V

- 2.7 V	0.72	0.90	
- 3.0 V	0.84	1.00	1.08
- 3.3 V		1.05	1.28

Measurements on several ASDBLR01 channels December 2004 FMN

Dose Rate Effects in DMILL technology

Ionizing radiation rates at LHC intensities are in the range of .01 -.02 Rads/s. In some technologies a dose rate sensitivity has been observed that manifests as an increase in sensitivity due for lower exposure rates. The SCT group examined dose rate sensitivity of the DMILL technology in the following IEEE paper in 2002:

Low Dose Rate Effects And Ionization Radiation Tolerance Of The Atlas Tracker Front-End Electronics

M. Ullán1,3, D. Dorfan1, T. Dubbs1, A. A. Grillo1, E. Spencer1, A. Seiden1, H. Spieler2, M. Gilchriese2, M. Lozano

- Their conclusion: The technology used in the fabrication has been found to be free from Low Dose Rate Effects which facilitates the studies of the radiation hardness of the chips.

Change in NPN base current vs Dose Rate.

For this experiment the transistors have been irradiated at a very wide range of dose rates and all of them up to a total dose of 1 Mrad(SiO2) in order to obtain data even for the very low dose rates in a reasonable period of time. The dose rates chosen cover a range of 4 full decades and the values are: 0.05, 0.28, 1.33, 31.1, 112, 575 rads(SiO2)/s.

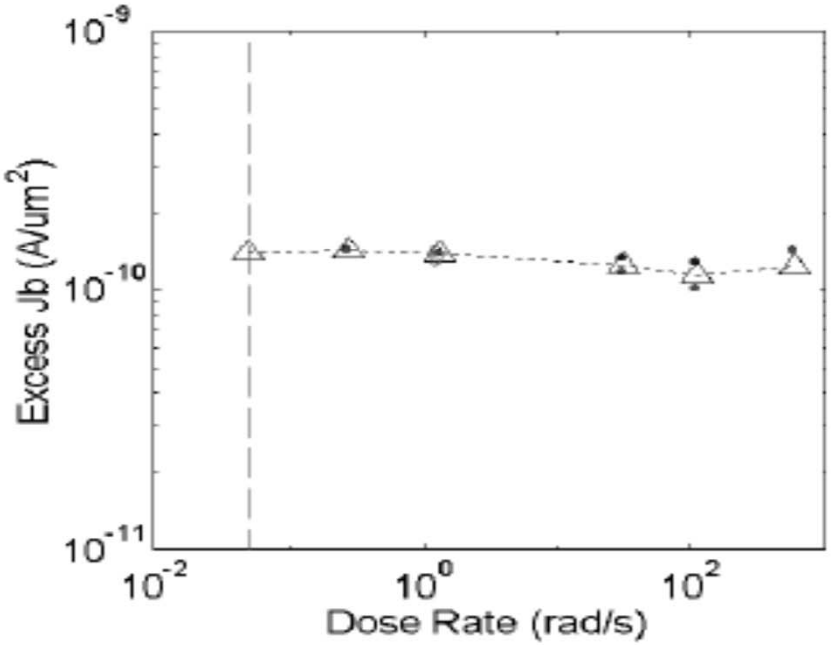


Figure 1: Excess base current density (ΔJb) versus dose rate for DMILL transistors from Experiment 0.

2005 Report on Prospero Neutron Exposure by **Ole Rhone** of Barrel and End cap boards

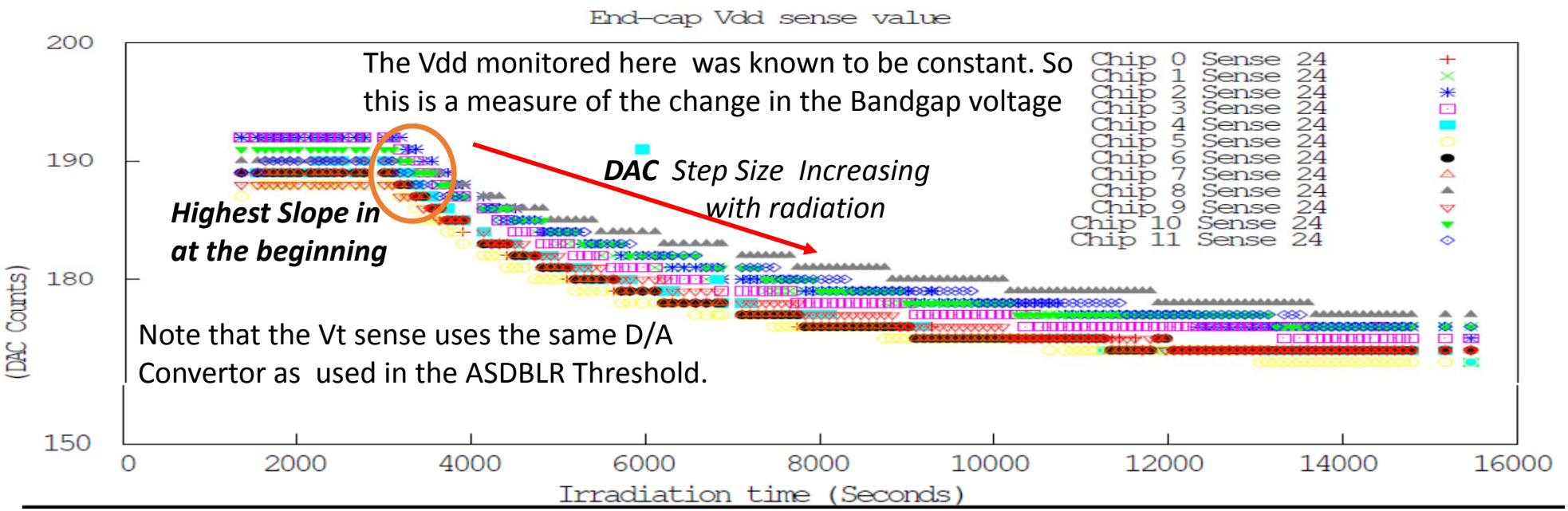
- http://trtsys.web.cern.ch/trtsys/prospero-jan-2005/index.html#rateana

Selected notes from Ole's Log.

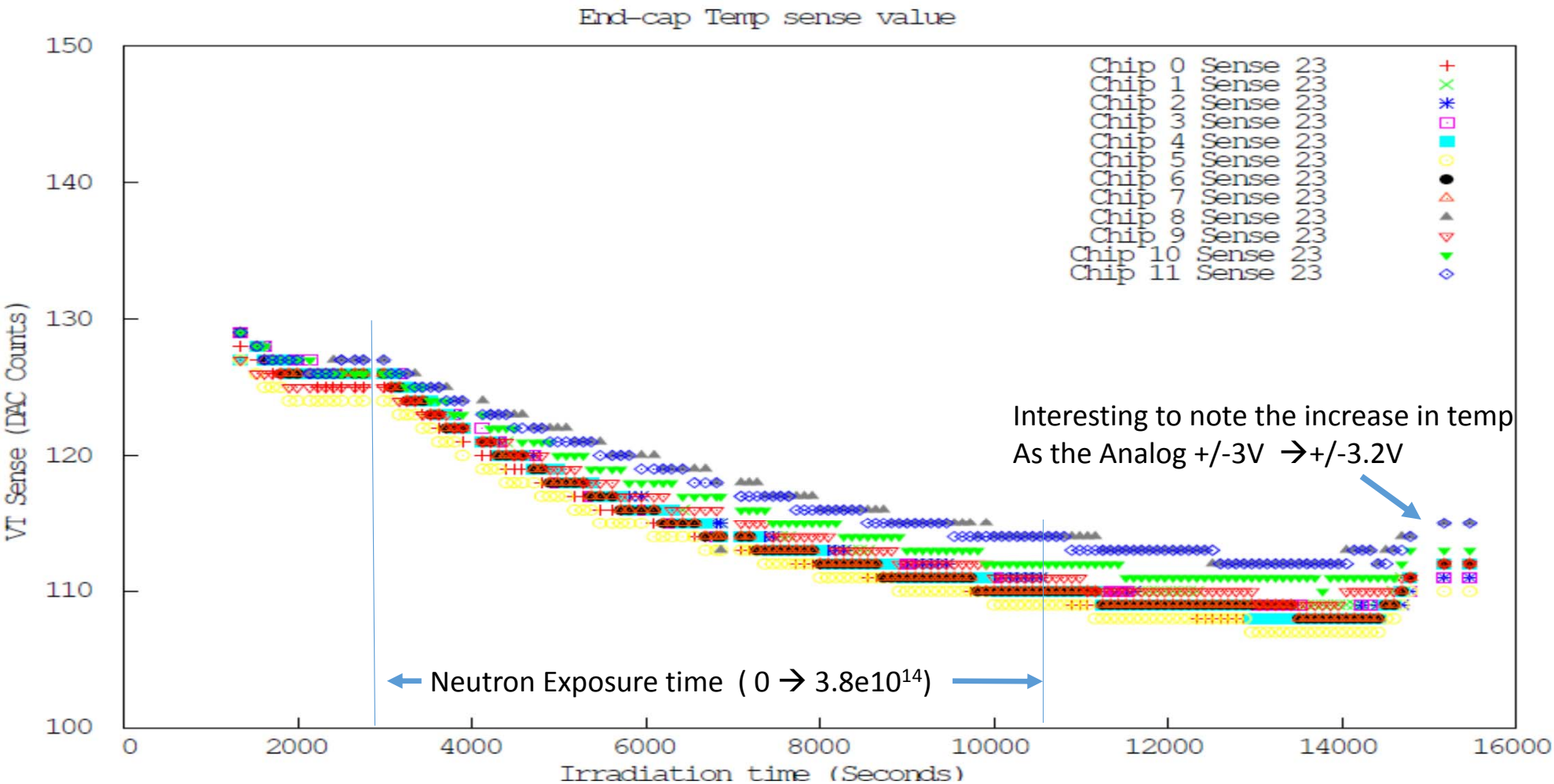
- Our run lasted for 10800 seconds, the total fluence was estimated to be about 3.85E14 n/cm2. The front-end boards were kept at constant operating voltage during the run. ***No significant changes to the current consumptions were observed.***
- After the irradiation run had ended, additional studies were done at elevated analog voltages (+/-3.1V and +/-3.2V).

The DTMROC Band-gap reference

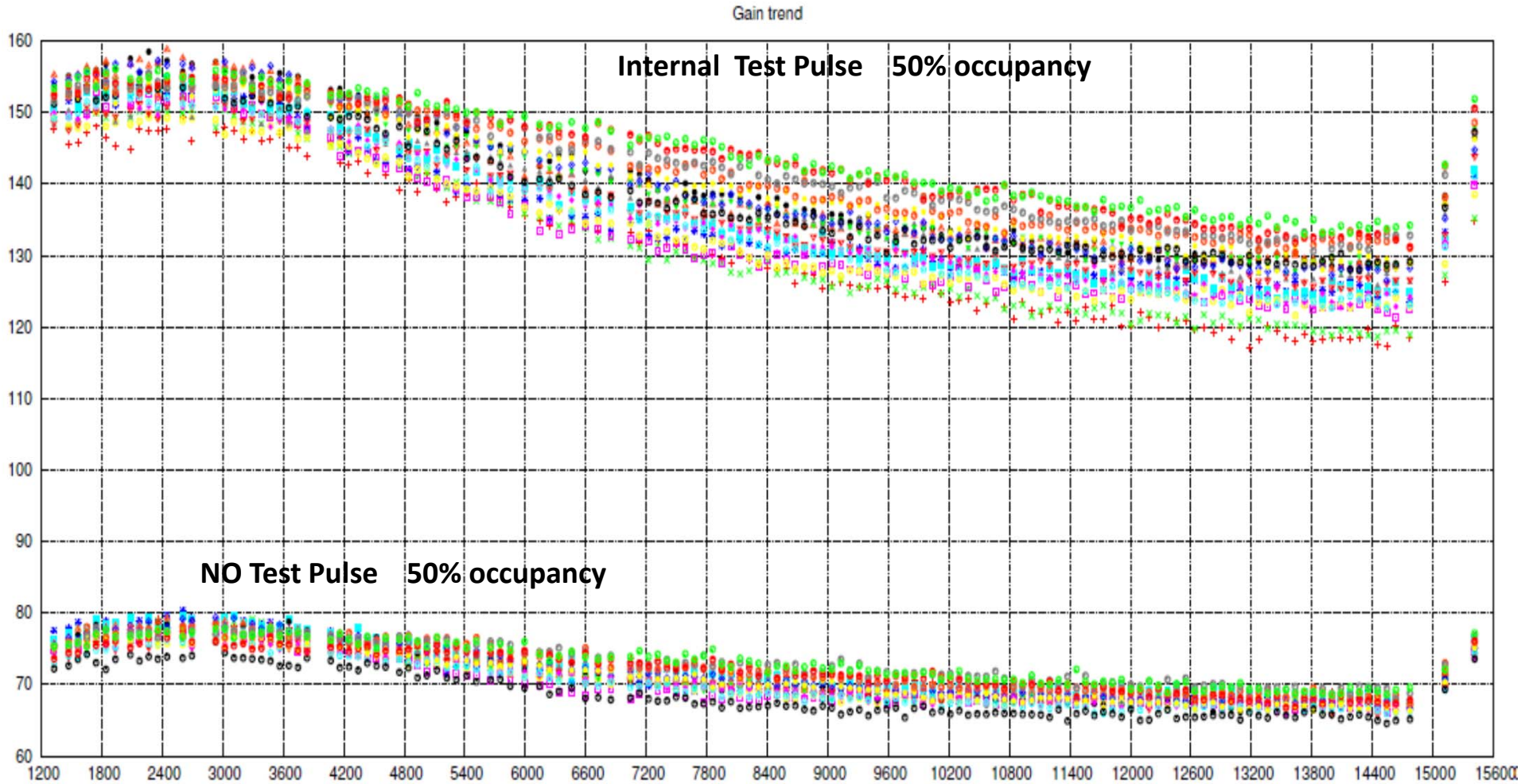
- The voltage output of the band-gap reference as implemented on the DTMROC is known to increase with irradiation. This is expected to affect all derived analog outputs (thresholds, test pulse and VT sense) proportionally. Keeping the DTMROC supply voltage constant during irradiation, the Vdd readback can be used to calibrate the band-gap reference. End-cap Vdd read-back vs irradiation time.



End Cap Temp sense vs time



Gain change


Gain trend
Internal Test Pulse 50% occupancy
NO Test Pulse 50% occupancy
160
150
140
130
120
110
100
90
80
70
60
1200
1800
2400
3000
3600
4200
4800
5400
6000
6600
7200
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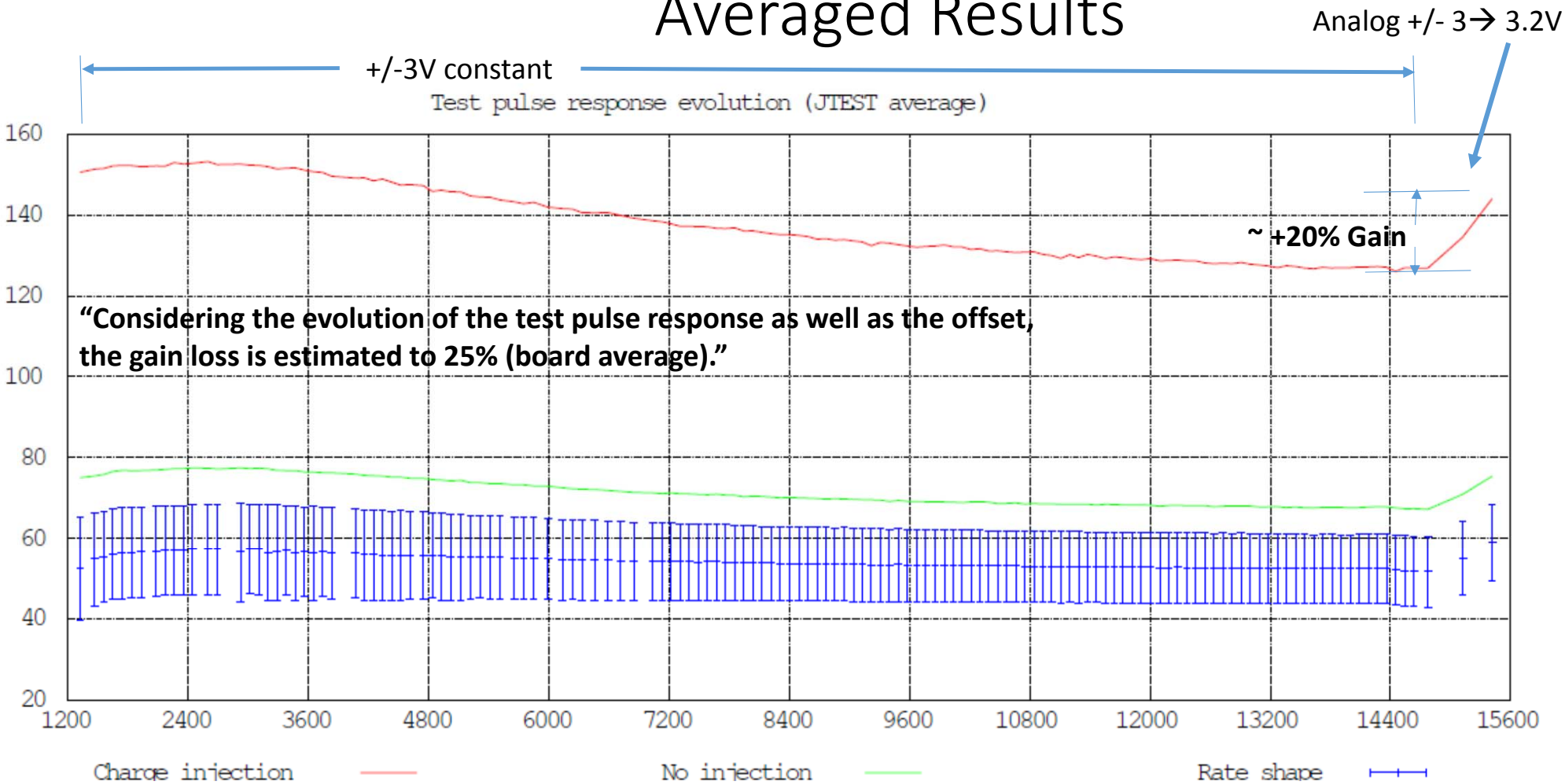
12000
12600
13200
13800
14400
15000

Averaged Results



Comment on the LHC Radiation Studies

- Supply current vs radiation and rate are constant
- The TRT exposure to date has been less than 1/10 of the smallest value examined for LHC qualifications.
- In measurements of (sense voltage) so far it doesn't appear that the bandgap has changed it's value. (This should be reconfirmed.)
- The change in gain observed by Ole is qualitatively consistent with the bench measurements that show a 28% gain increase as +/-3V → 3.3V. His work shows that this is likely a viable approach to extending the useful lifetime of the ASDBLR.

Low Dose Rate tests of the ASDBLR

Two TB4 boards with 2 each ASDBLR02 have been calibrated recently with a resurrected charge injector. Threshold measurement of both boards for several pulse amplitudes were made by Khilesh Mistry at Penn.

→ One board was sent to BNL for exposure to their CO60 source at low dose rate (80Rad/hr) with a target TID of 35KRad.

→One board remains at Penn as a calibration standard.

The several week exposure will be complete next week.