Irradiation at the LBNL Co60 Source facility

- Motivation
- Goal
- Setup
- Preliminary results

Motivation

Excess Idd current in the ABCD3TA observed after
proton irradiation at the PS and high dose rate X-Ray irradiation
caused by ionization effects in the silicon oxide

Evidence of annealing (short and long term) after irradiation
The operation of the chips is not effected by the excess Idd current

Correlation studies between PS and X-Ray irradiation results show
a smaller excess Idd current possibly due to the lower dose rate of the PS

Need to study the effects of much lower dose rate irradiation and if
annealing during irradiation would help mitigating the excess Idd current

Goal

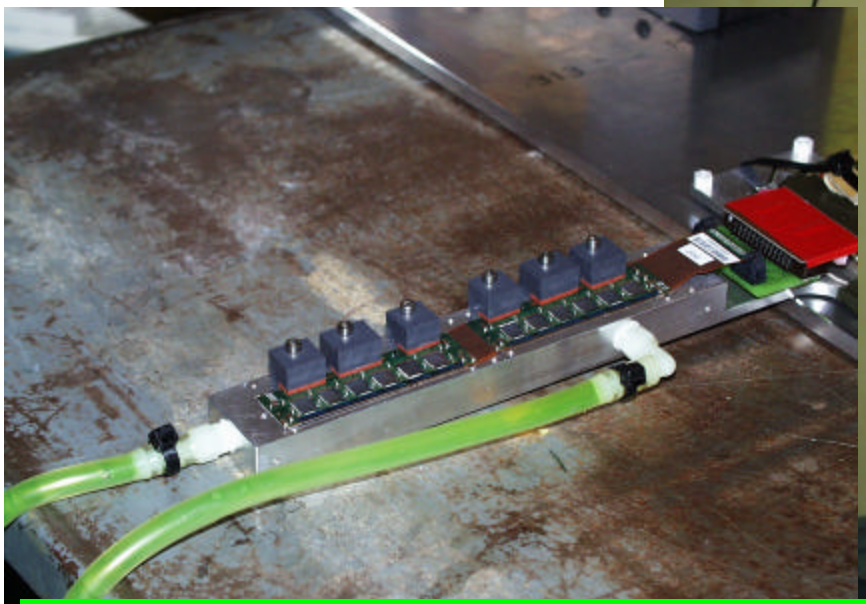
- Expose chips up to 10 Mrad and dose rate of the order of 1-2 Rad/sec
- Irradiate 12 ABCD3TA on hybrid from the same wafer/lot used for PS and X-Ray tests (substantial variation observed)
- Gamma source Co60 is appropriate to study effects caused by ionization and for low dose rate
  1.17-1.3 MeV gamma, half life 5.27 y, 5.6 Krad/hr at 35 cm)
- Monitor values and performance of the chips during irradiation
- Continue to monitor values (Idd) and performance of the chips during long term annealing
- Correlate Co60 results with PS and X-Ray results

LBNL-Co60 Hybrid

Z34685 wafer 3, 5, 8	chip 5, 0, 6
Z34685A wafer 12, 20	chip 7, 1
Z36459A wafer 3, 4, 5, 6	chip 2, 3, 4, 9
Z38850 wafer 12, 15, 18	chip 10, 8, 11

Setup

- The Co60 source is inside the white cylinder, at 30 cm.
- Hybrid placed in close contact on aluminum base (for cooling)
- Temperature of chiller 16^0C
- Extender cable to shield support card



http://www-atlas.lbl.gov/strips/hybrids/irradiation/cobalt/setup.html

Setup

Hybrid's base is held in front of source on hybrid holder inside an aluminum/lead box (16x16 cm^2) (thickness of aluminum is 0.8mm, lead 2.6mm) to stop low energy photons (10-200 KeV)

Approx. distance from the source is 35 cm.
The predicted dose rate is ~ 5.6×10^3 Rad/hr at 35 cm.
We measured radiation dose on TLD's placed around hybrid exposed for 60 seconds
The dose rate is ~1.3 Rad/sec (with error to be determined).

Test log from 12/13/01 to 2/17/02

Dec 13, 2001: Irradiation test starts.
Dose rate ~ 1.3 Rad/sec.
Initial temperature of chiller 18^0 C.
Idd is 490 mA

Dec 19: Temperature of chiller lowered to 15^0 C (dose 0.6 Mrad).

Dec 21: Chips are now automatically clocked and triggered with 100-hour longterm RUN's.
Idd, Icc and temperature are measured every 5 minutes.

Dec 25: Idd = 570 mA, Dose = 1.3 MRad

Jan 2, 2002: Idd = 700 mA, Dose = 1.77 MRad
Problem with readout appeared due probably to condensation discovered later.

Jan 7: Idd is around 770 mA at 2.7 Mrad.
Hybrid disconnected and brought back to lab for inspection and test.
A few pads and bonds (on hybrid) were damaged by condensation preventing last chips to be readout.
During this period hybrid temperature range from room to 20^0 C

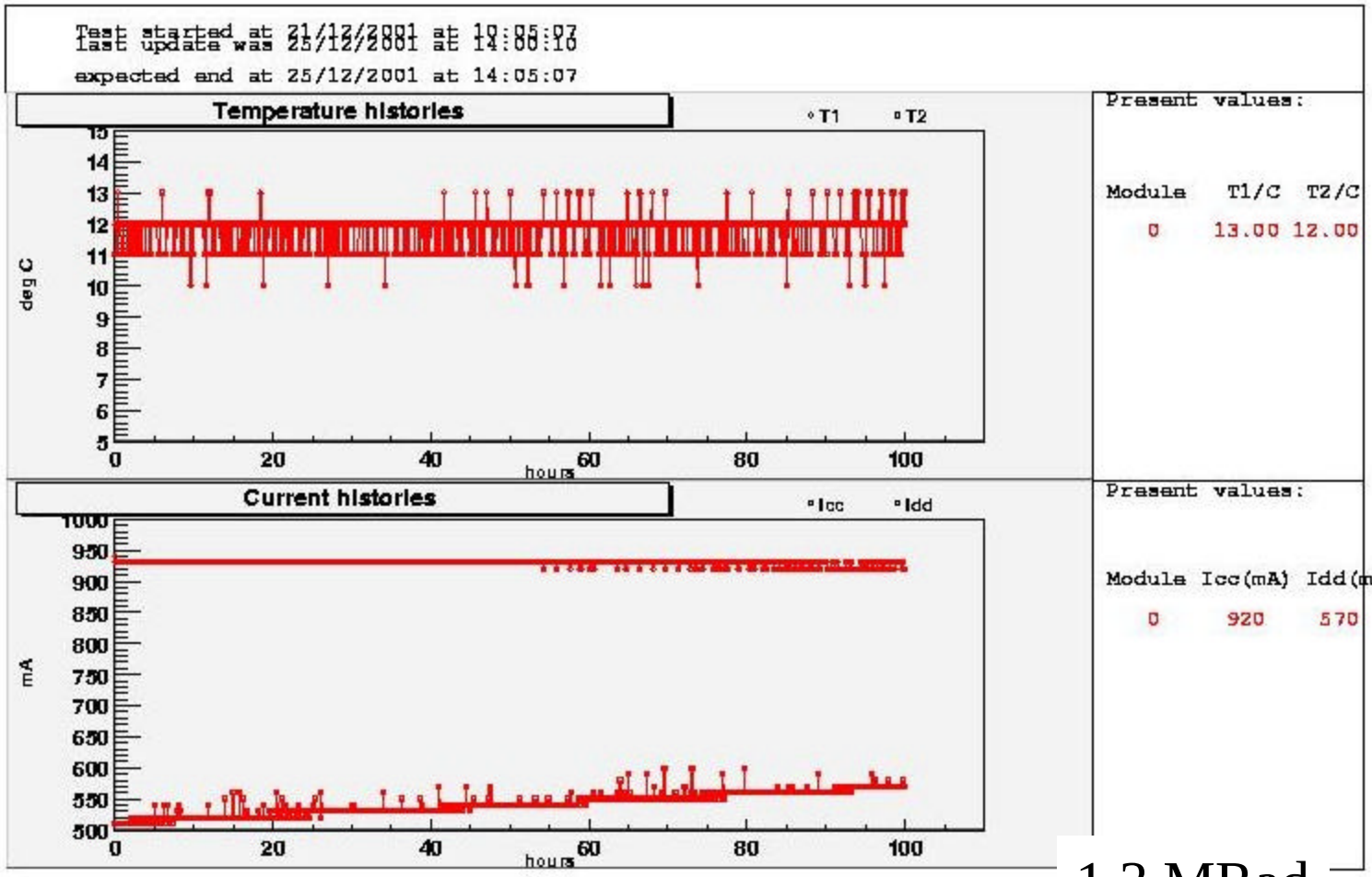
Jan 9: Irradiation resumed. Hybrid is fixed and all chips are fully functional again.
Also installed dry-air system and temperature of chiller set to 16^0 C.
After the shutdown (55 hours) Idd is around 720.

Occasionally we have 1-2 hours shutdown due to other groups using the same source.
Hybrid is kept at chiller temperature (16- 18^0 C) during the longer periods and chips are not running (nor irradiated).
We also do 10-20 min occasional accesses to change dry air gas bottle (program still runs but not irradiation).
Not noticeable difference is found in Idd.

Feb 17: Idd is now at 870 mA. Accumulated dose is 7 Mrad . 1502 hours of irradiation.

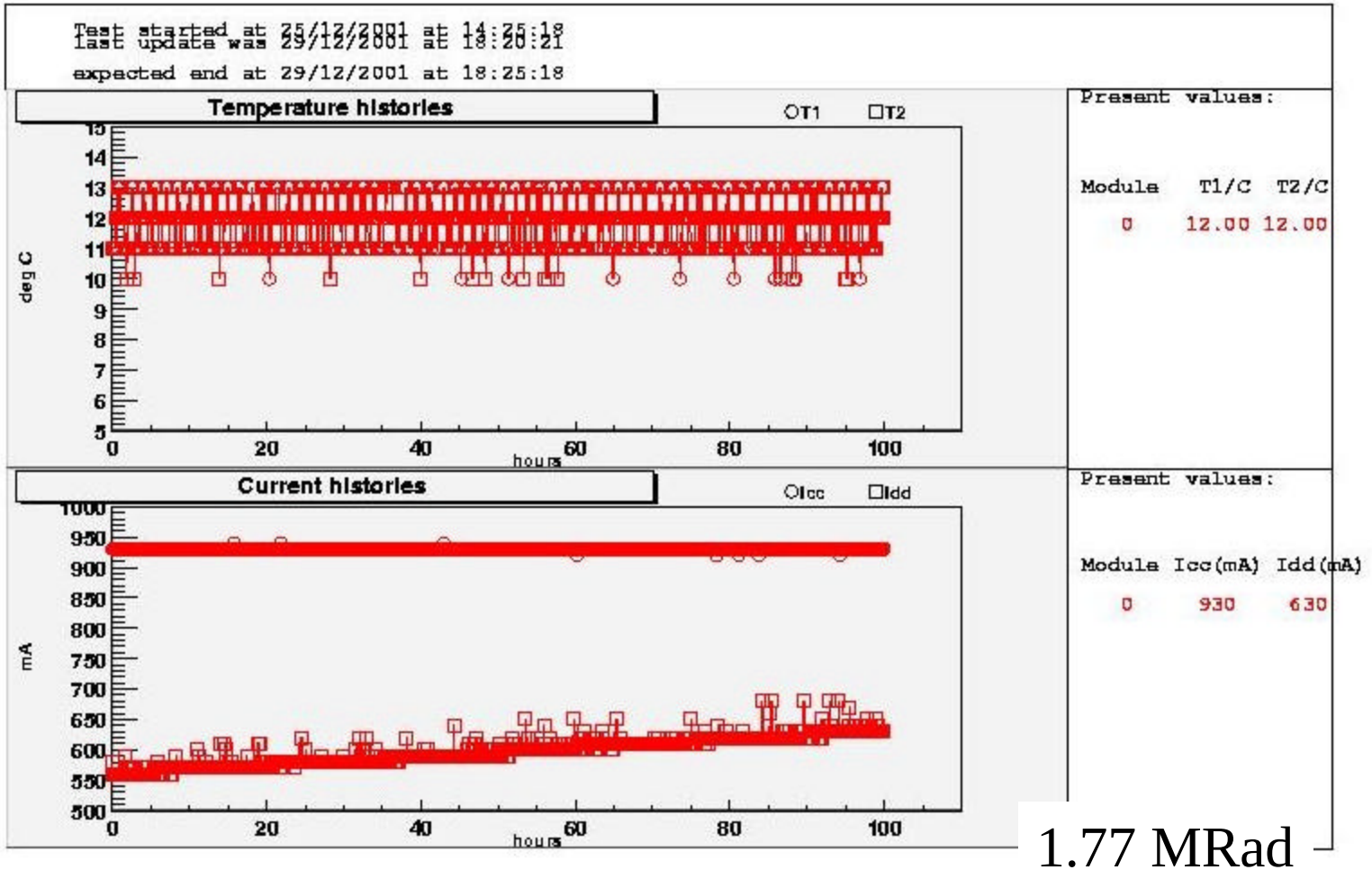
http://www-atlas.lbl.gov/strips/hybrids/irradiation/cobalt/results.html

100-Hour RUN (XMAS)



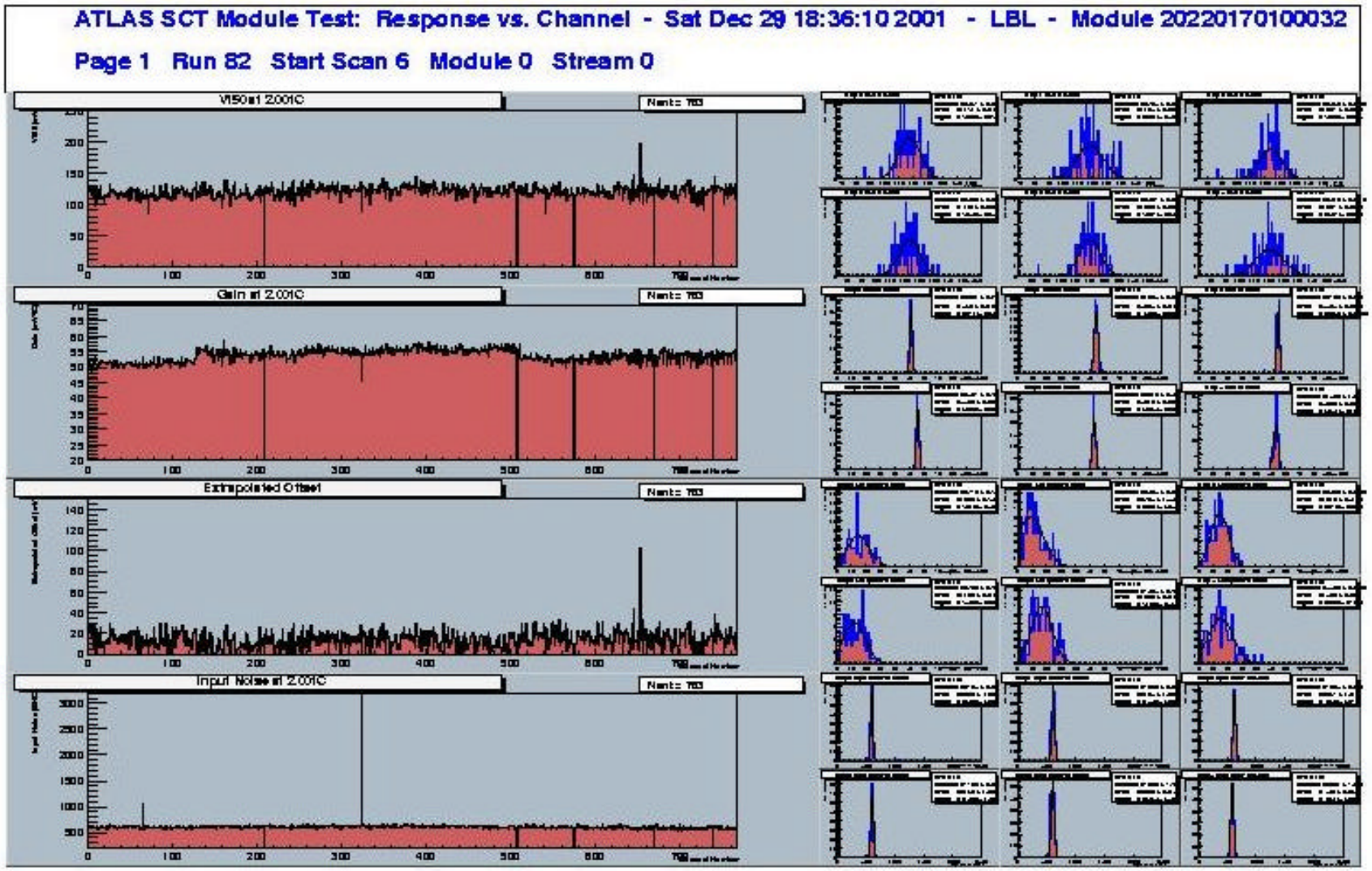
1.3 MRad

100-Hour RUN

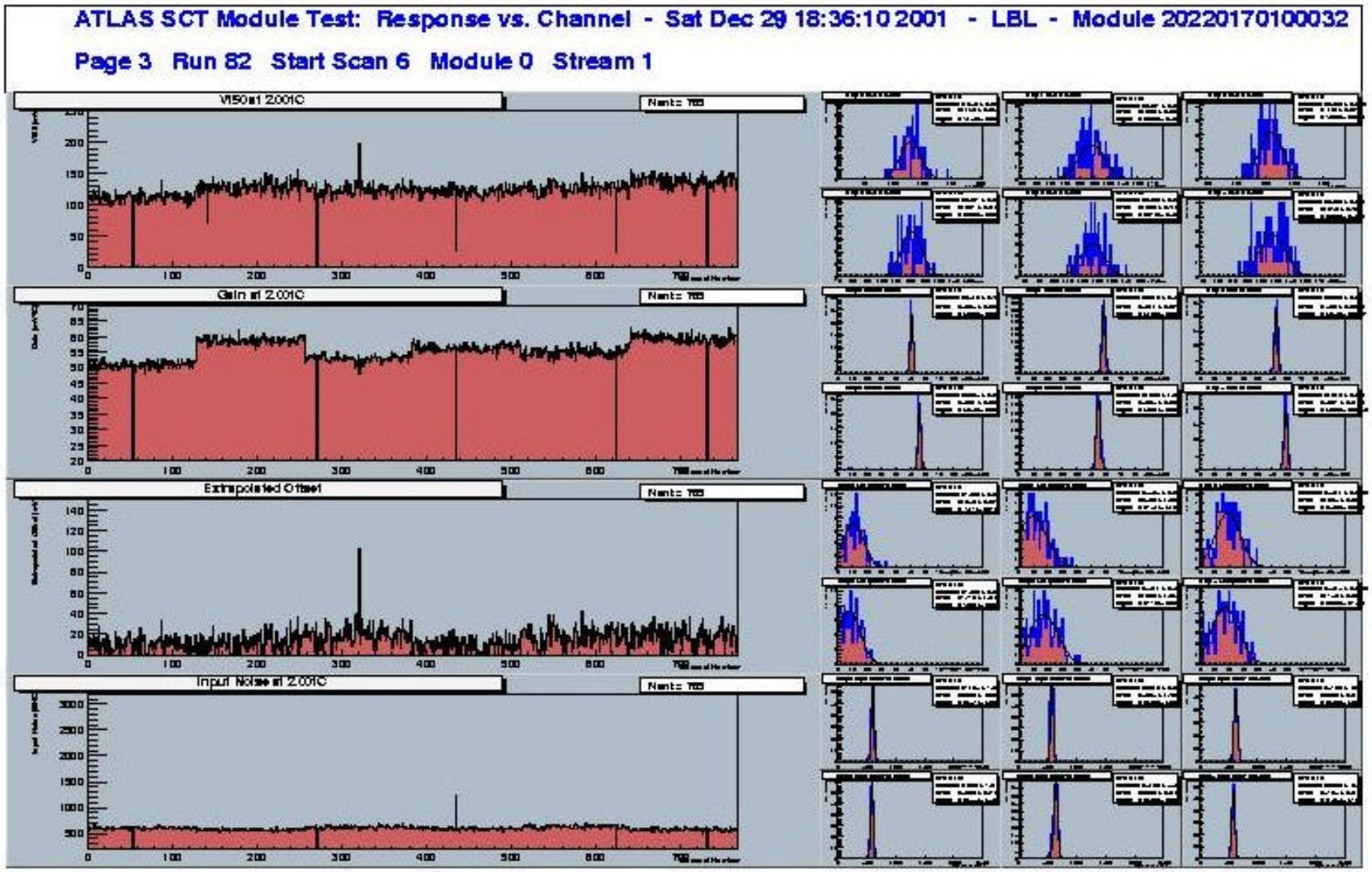


1.77 MRad

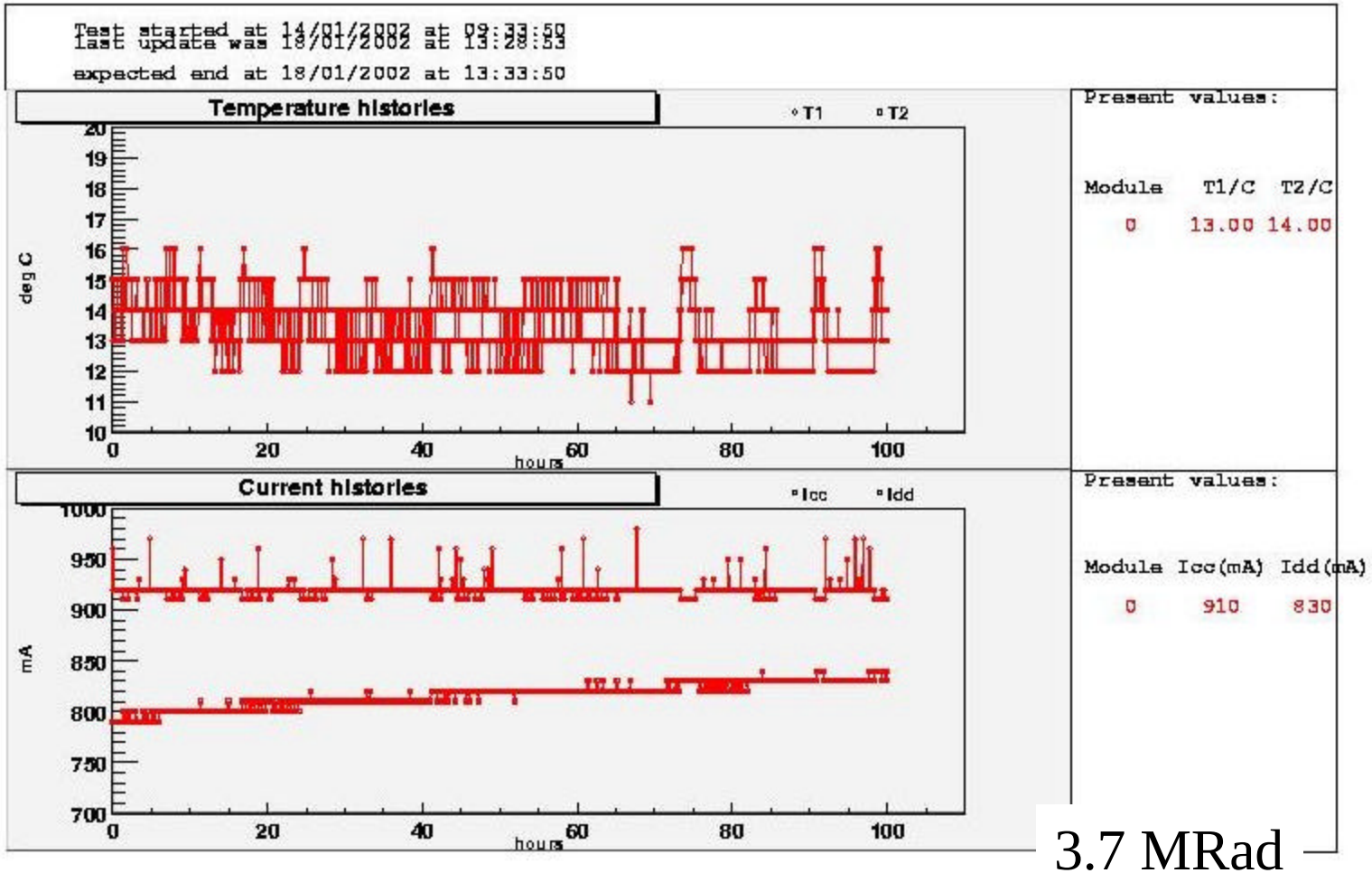
Chips Response



Chips Response

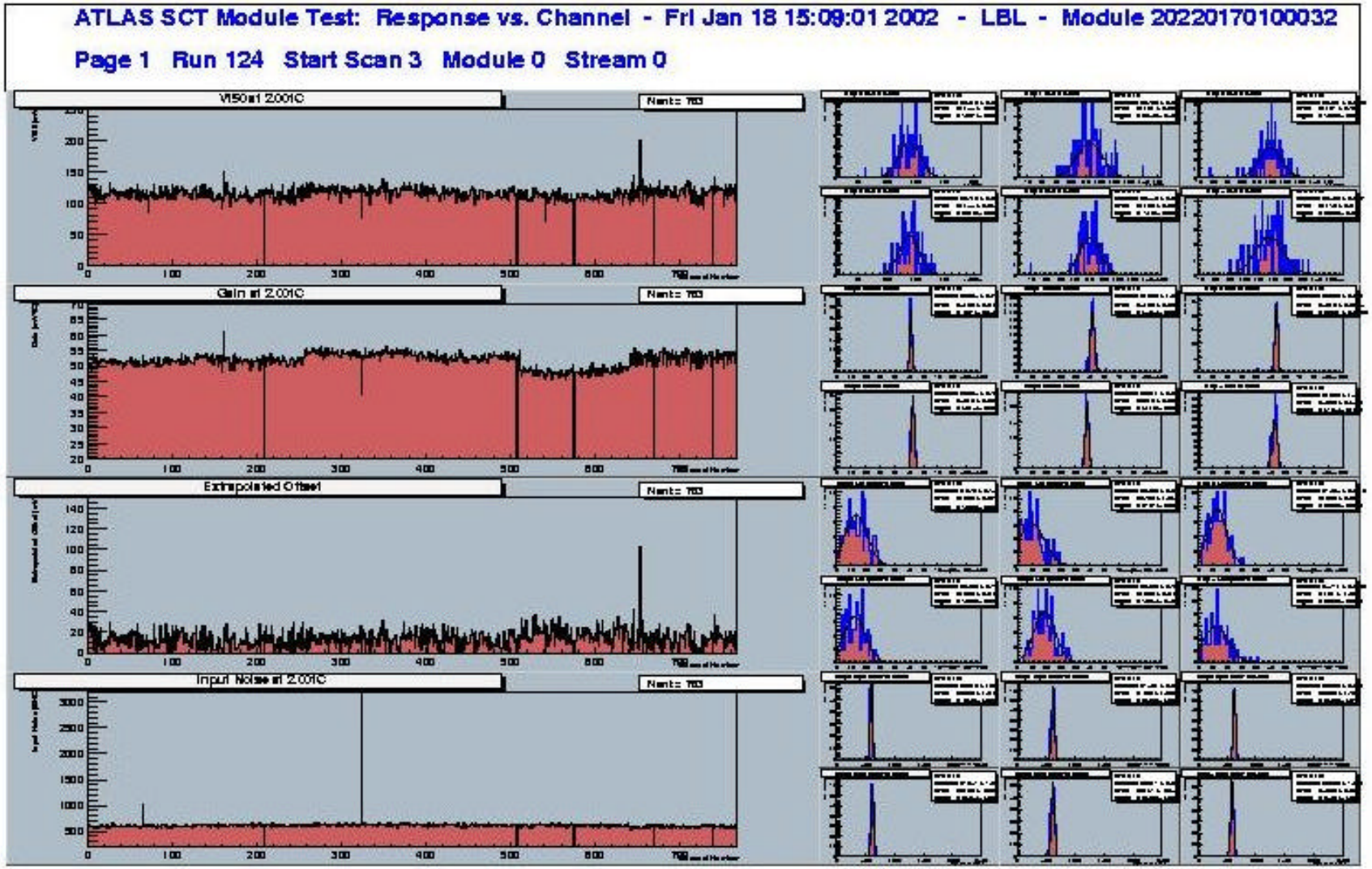


100-Hour RUN

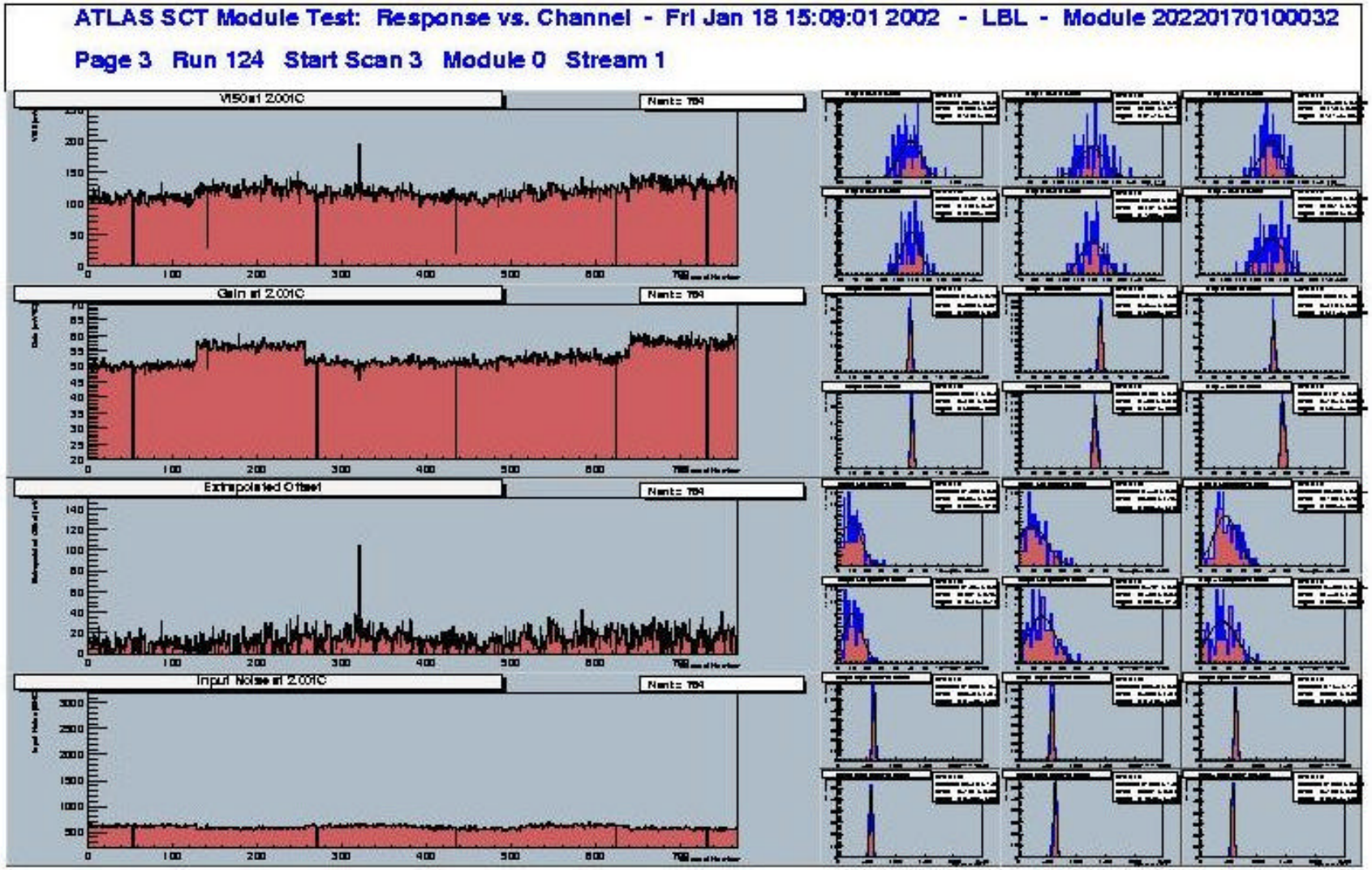


3.7 MRad

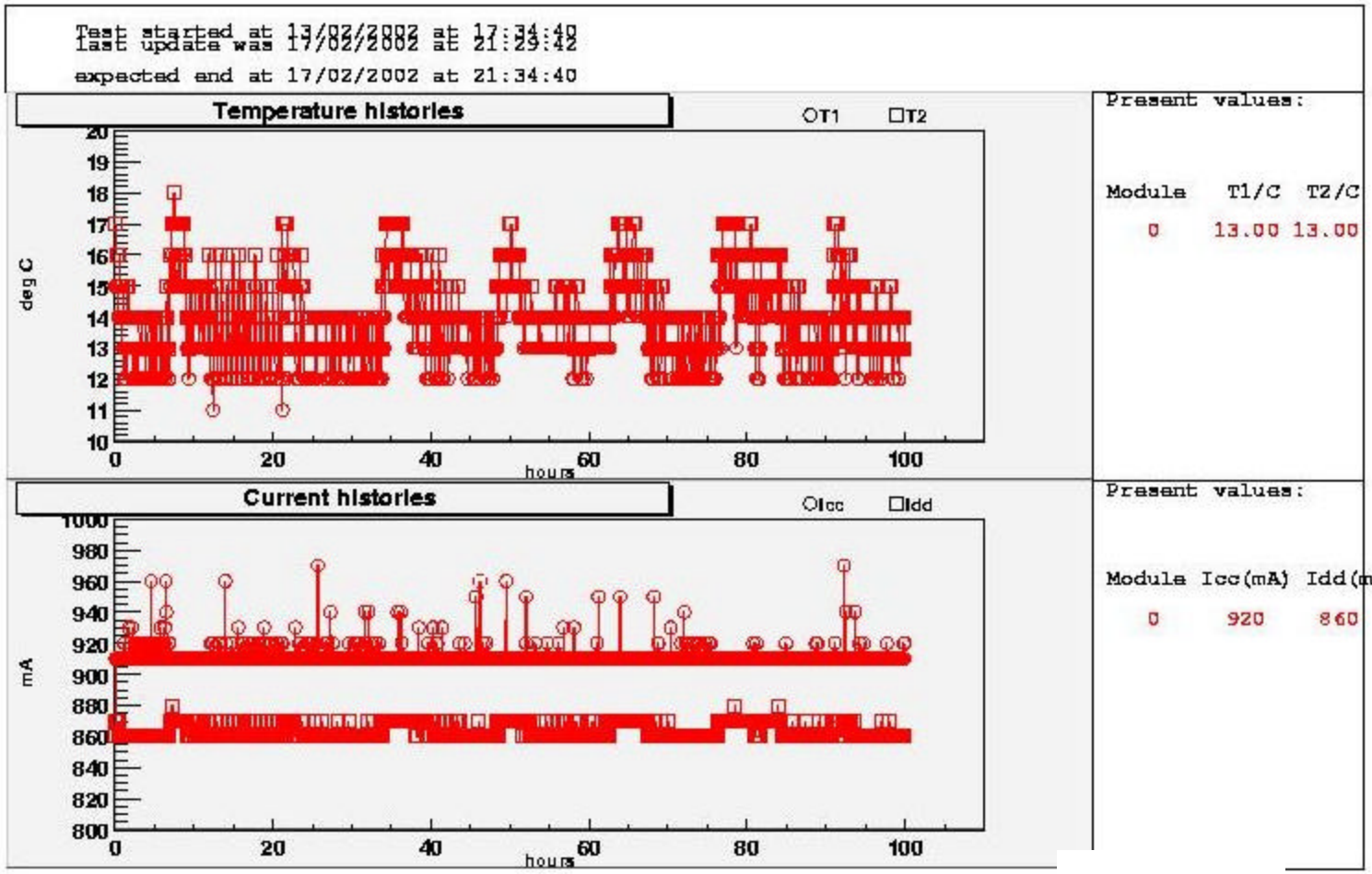
Chips Response



Chips Response

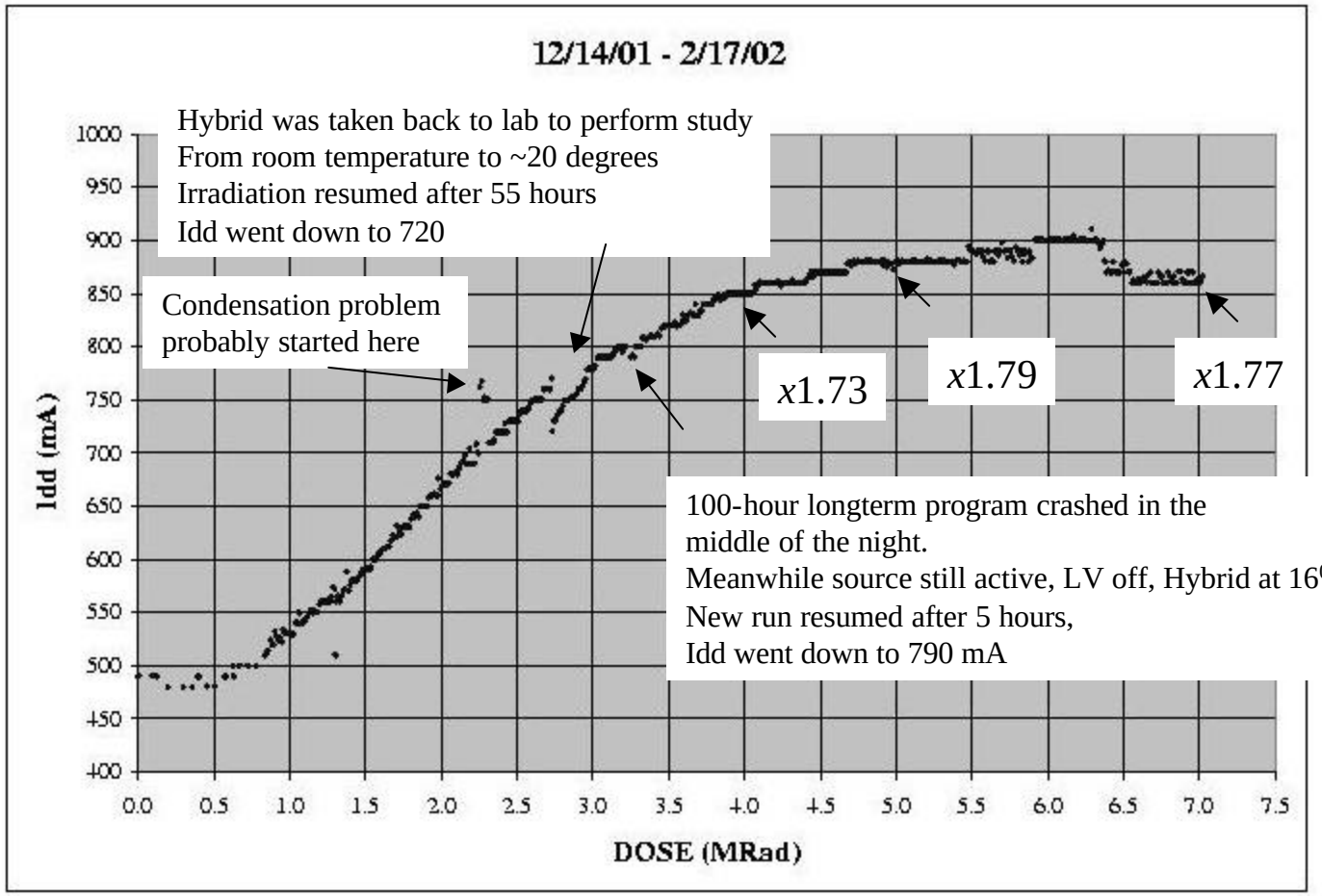


Most Recent 100-H RUN



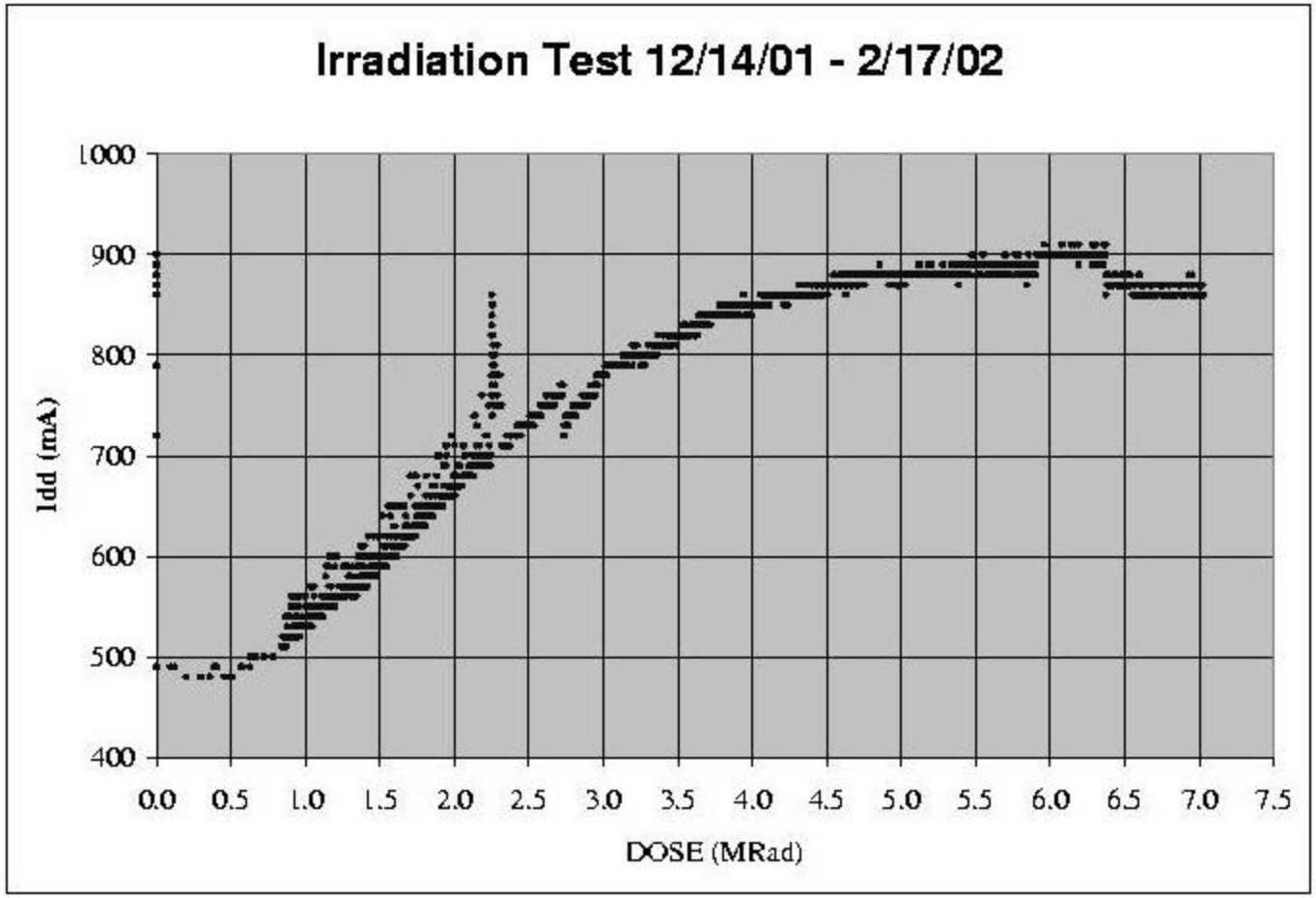
7 MRad

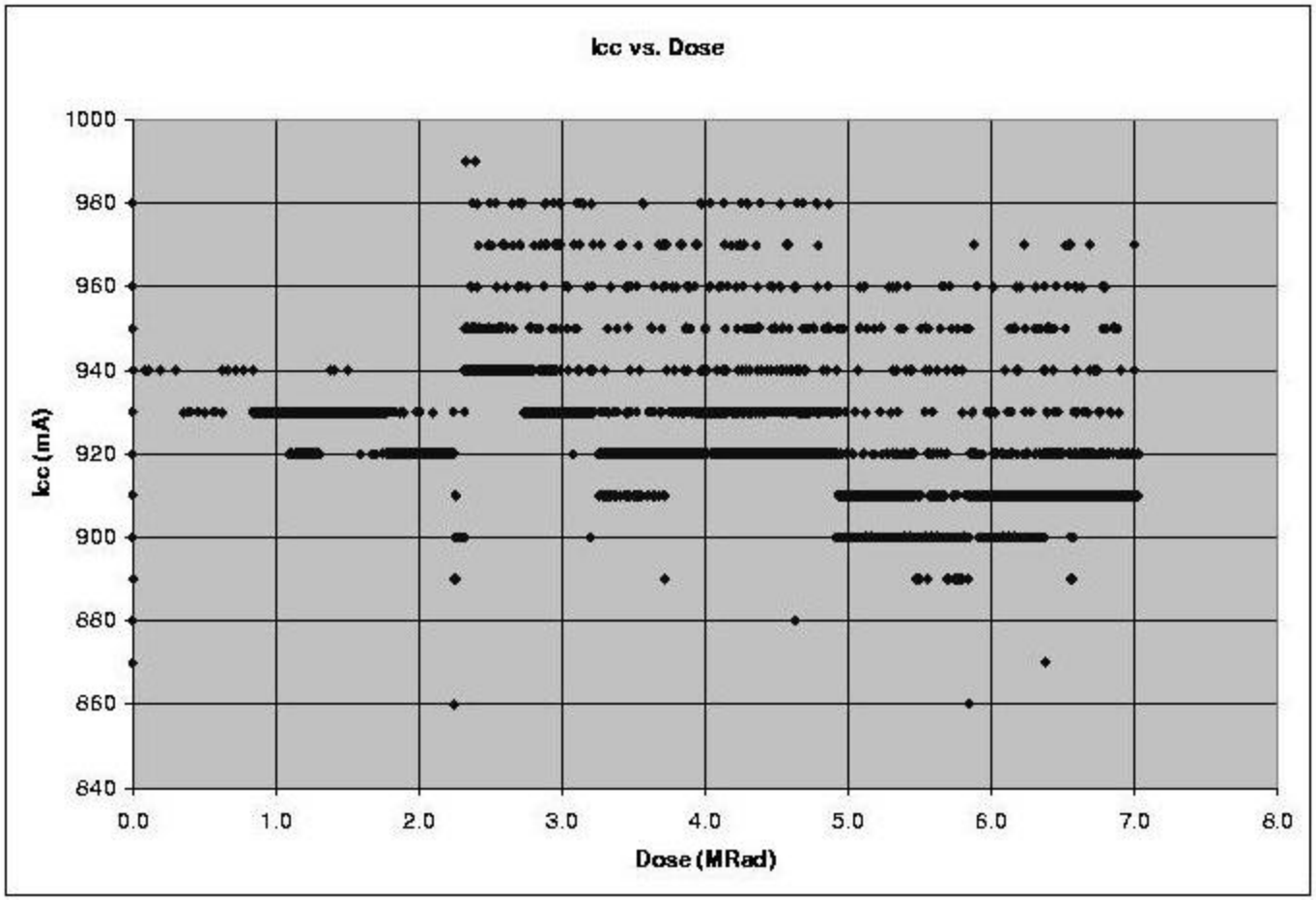
Idd vs Dose



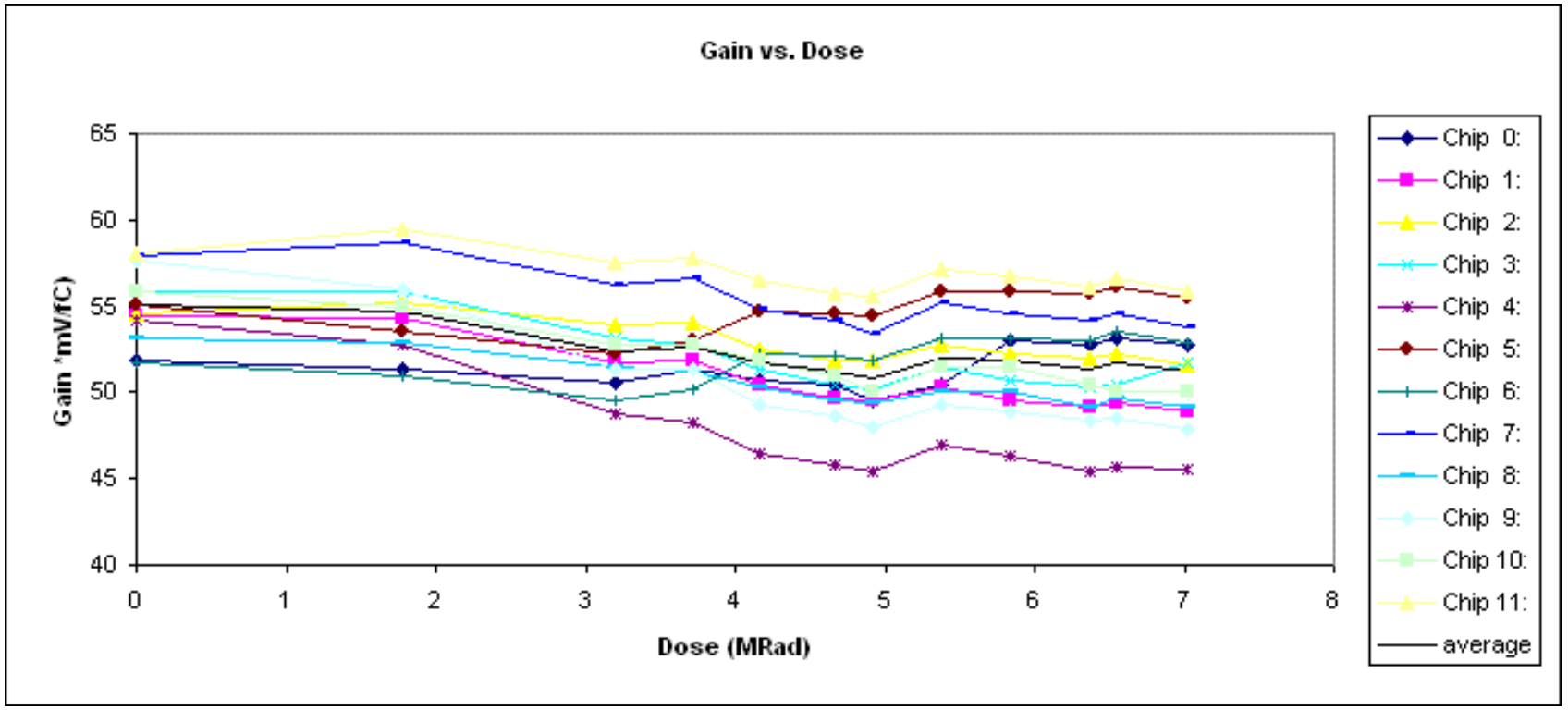
Started to show saturation at ~ 4 Mrad (Idd is *x*1.73 higher)
At 6 Mrad Idd=900 mA (*x*1.84)
At 6.37 Mrad (2/11/02) Idd=880 mA and at 6.5 Mrad (2/17/02) Idd=860-870 mA

Idd vs Dose (total)

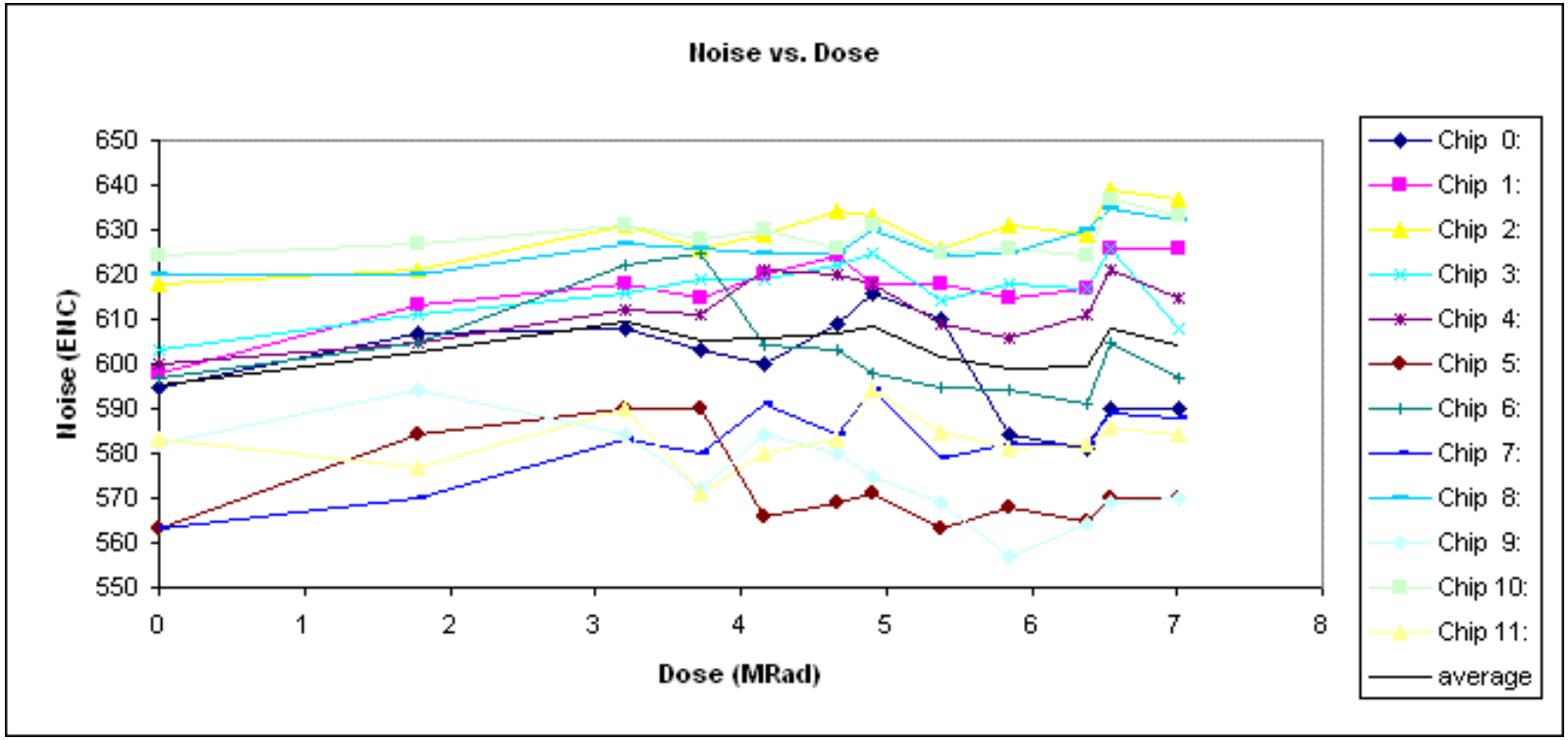



Icc vs. Dose
Icc (mA)
1000
980
960
940
920
900
880
860
840
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Dose (MRad)

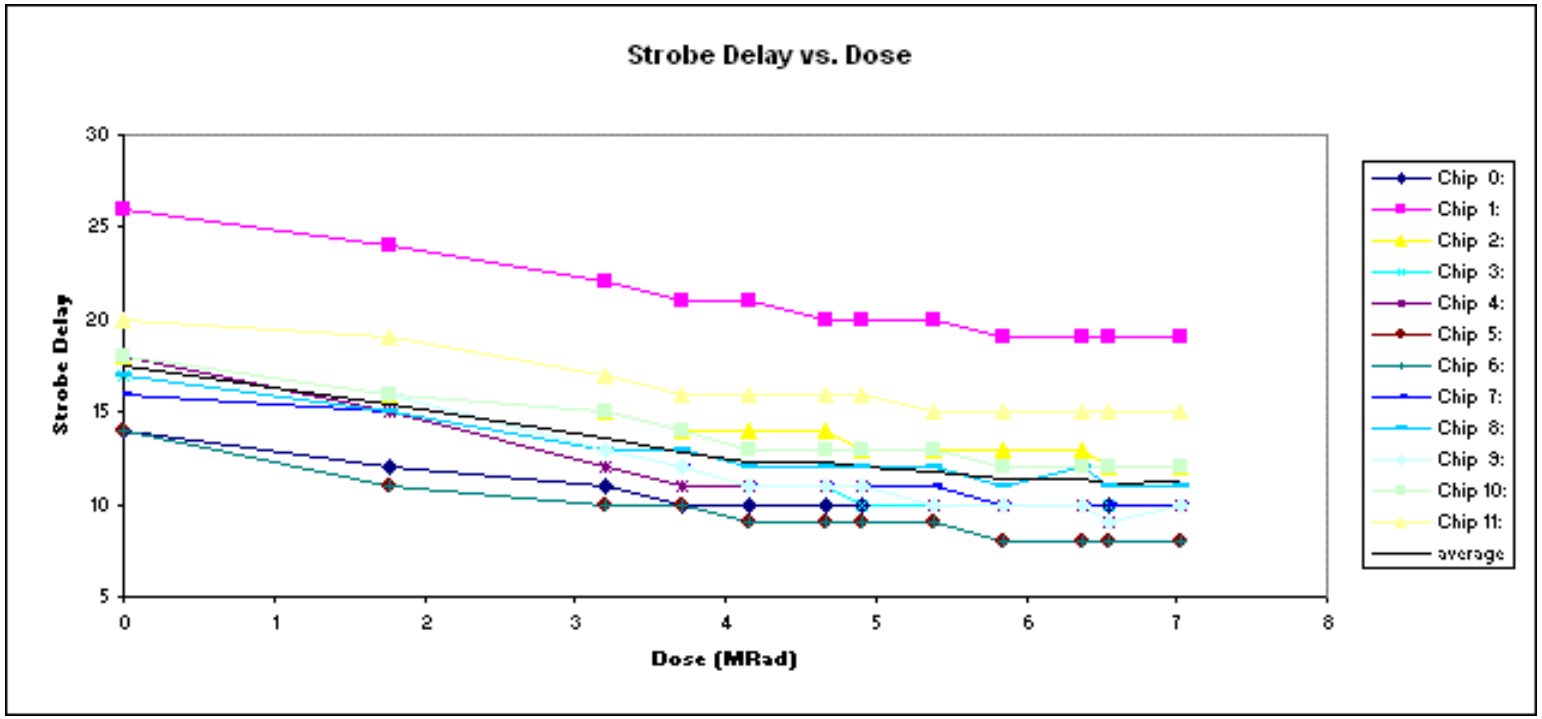
gain


Gain vs. Dose
Gain 'mV/fC)
65
60
55
50
45
40
0
1
2
3
4
5
6
7
8
Dose (MRad)
Chip 0:
Chip 1:
Chip 2:
Chip 3:
Chip 4:
Chip 5:
Chip 6:
Chip 7:
Chip 8:
Chip 9:
Chip 10:
Chip 11:
average

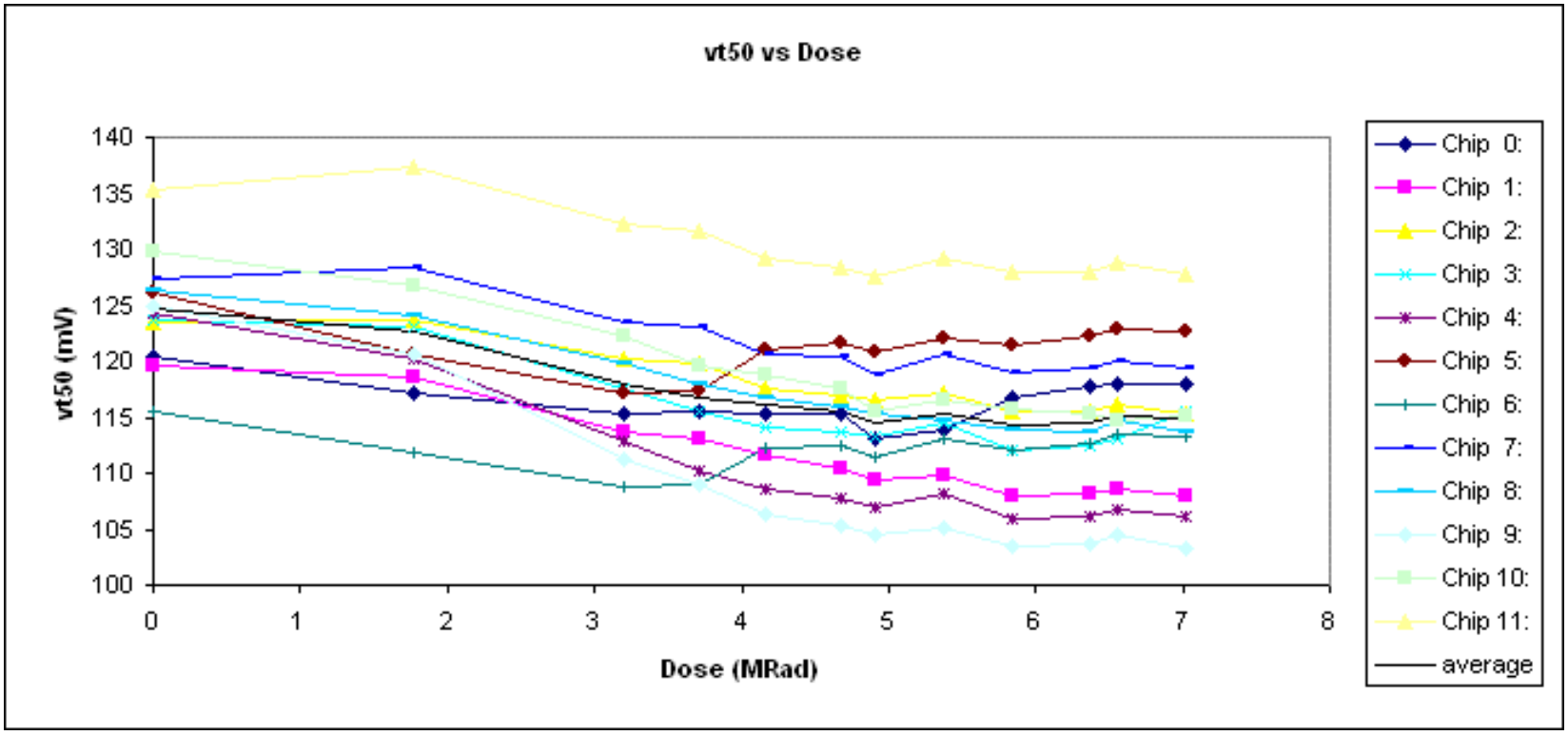
noise


Noise vs. Dose
Noise (ENC)
650
640
630
620
610
600
590
580
570
560
550
0
1
2
3
4
5
6
7
8
Dose (MRad)
Chip 0:
Chip 1:
Chip 2:
Chip 3:
Chip 4:
Chip 5:
Chip 6:
Chip 7:
Chip 8:
Chip 9:
Chip 10:
Chip 11:
average

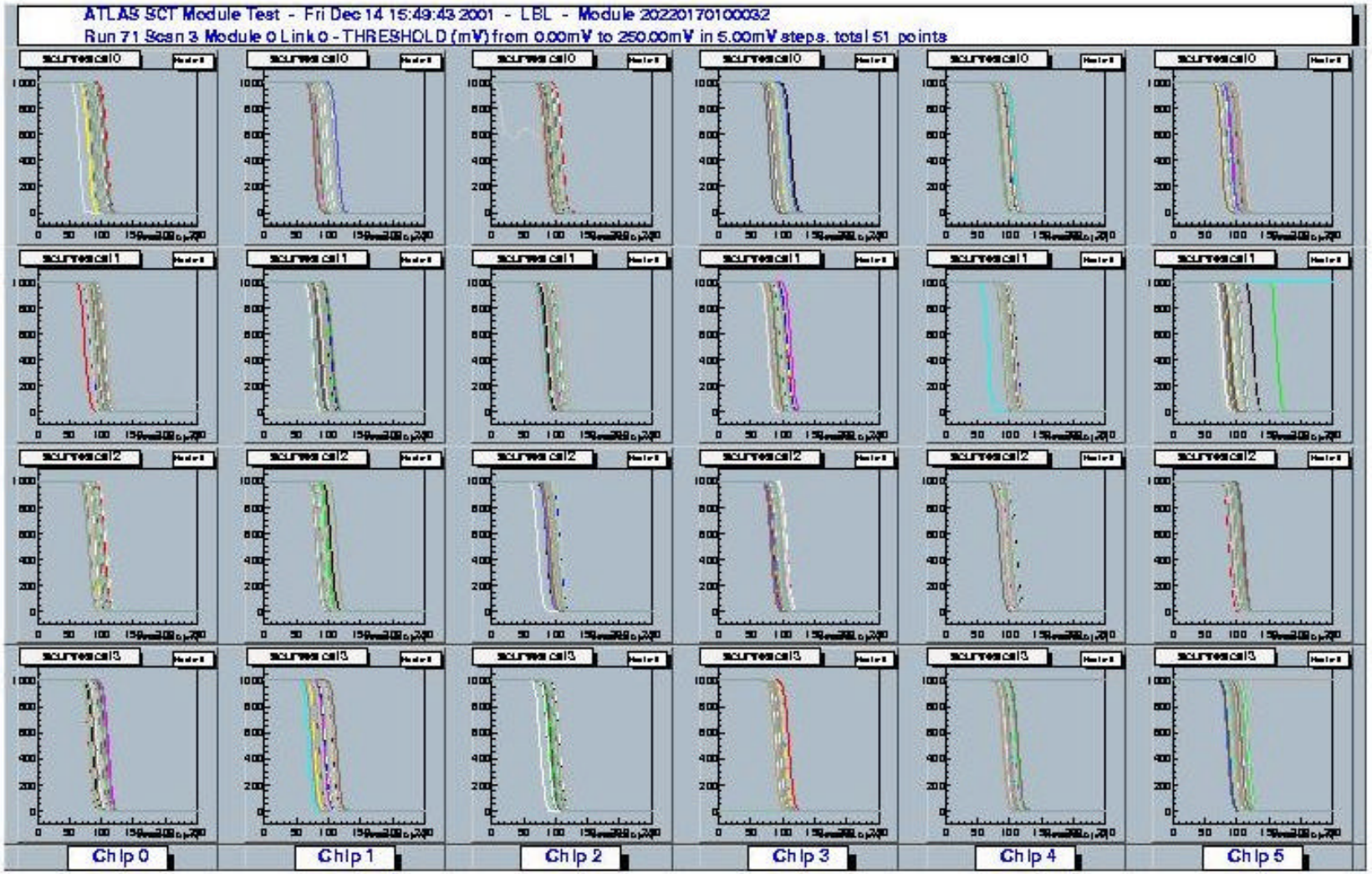
Strobe delay



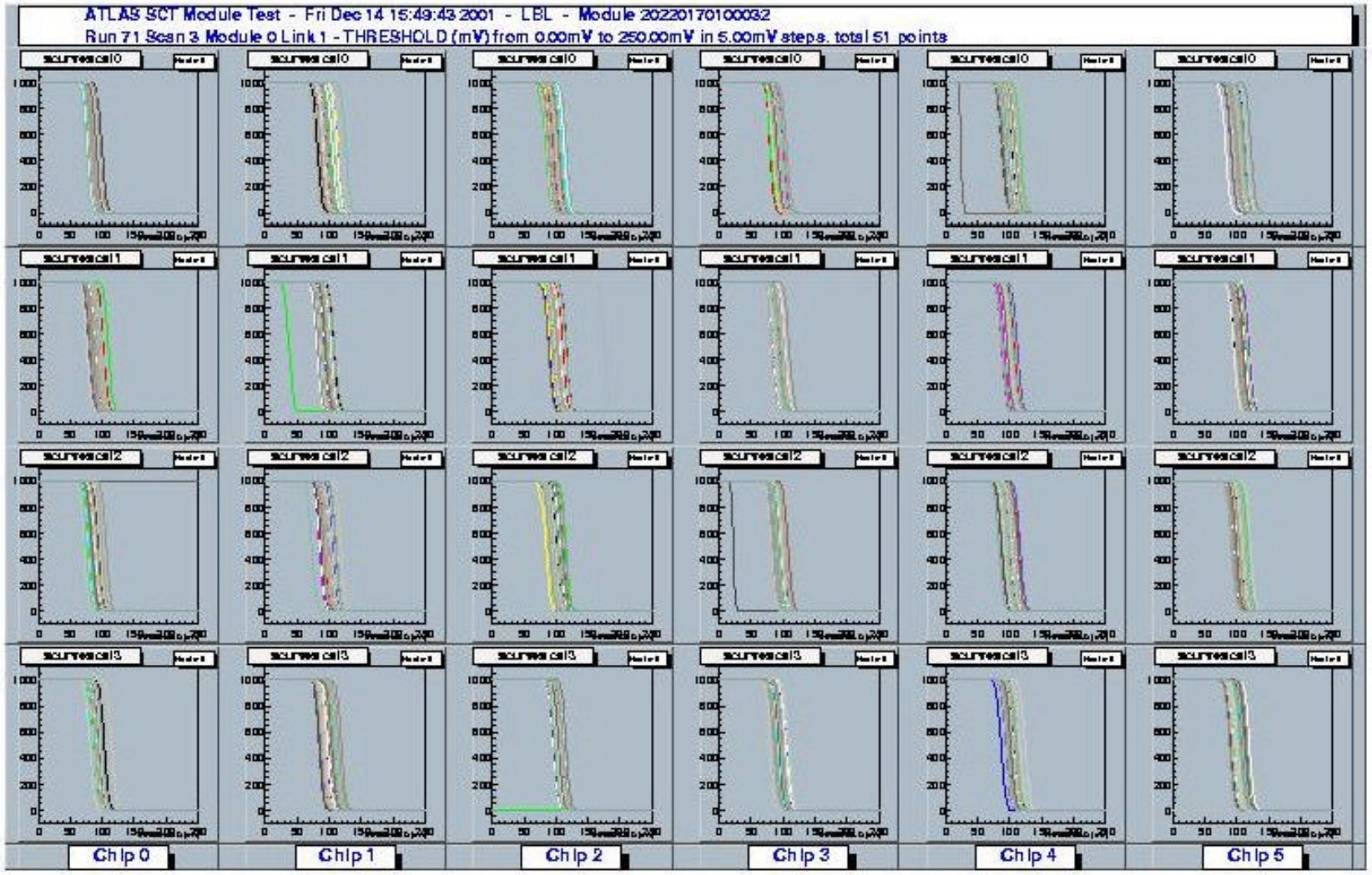
vt50


vt50 vs Dose
vt50 (mV)
140
135
130
125
120
115
110
105
100
0
1
2
3
4
5
6
7
8
Dose (MRad)
Chip 0:
Chip 1:
Chip 2:
Chip 3:
Chip 4:
Chip 5:
Chip 6:
Chip 7:
Chip 8:
Chip 9:
Chip 10:
Chip 11:
average

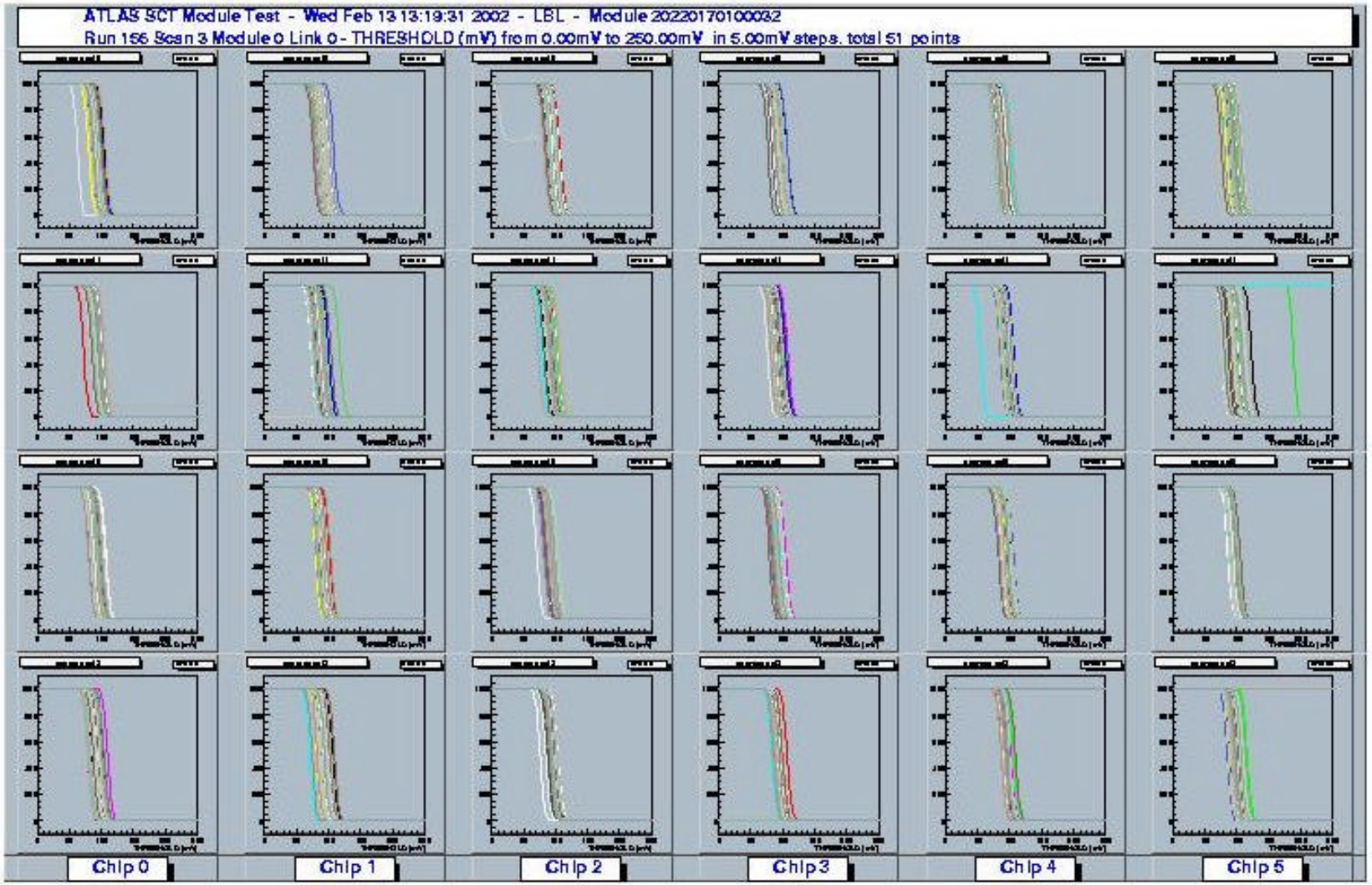
S-Curves Dec 14



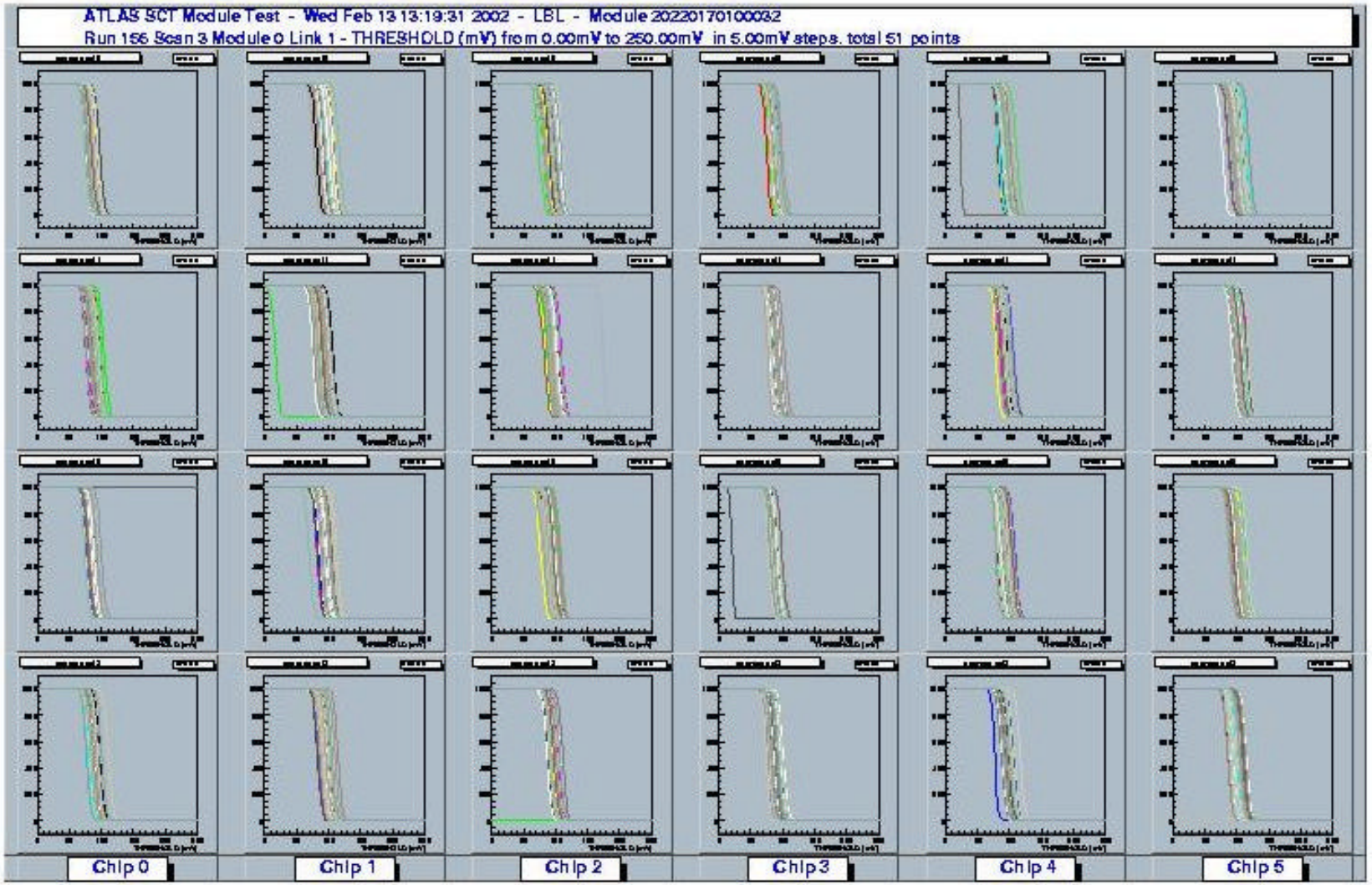
S-Curves Dec 14



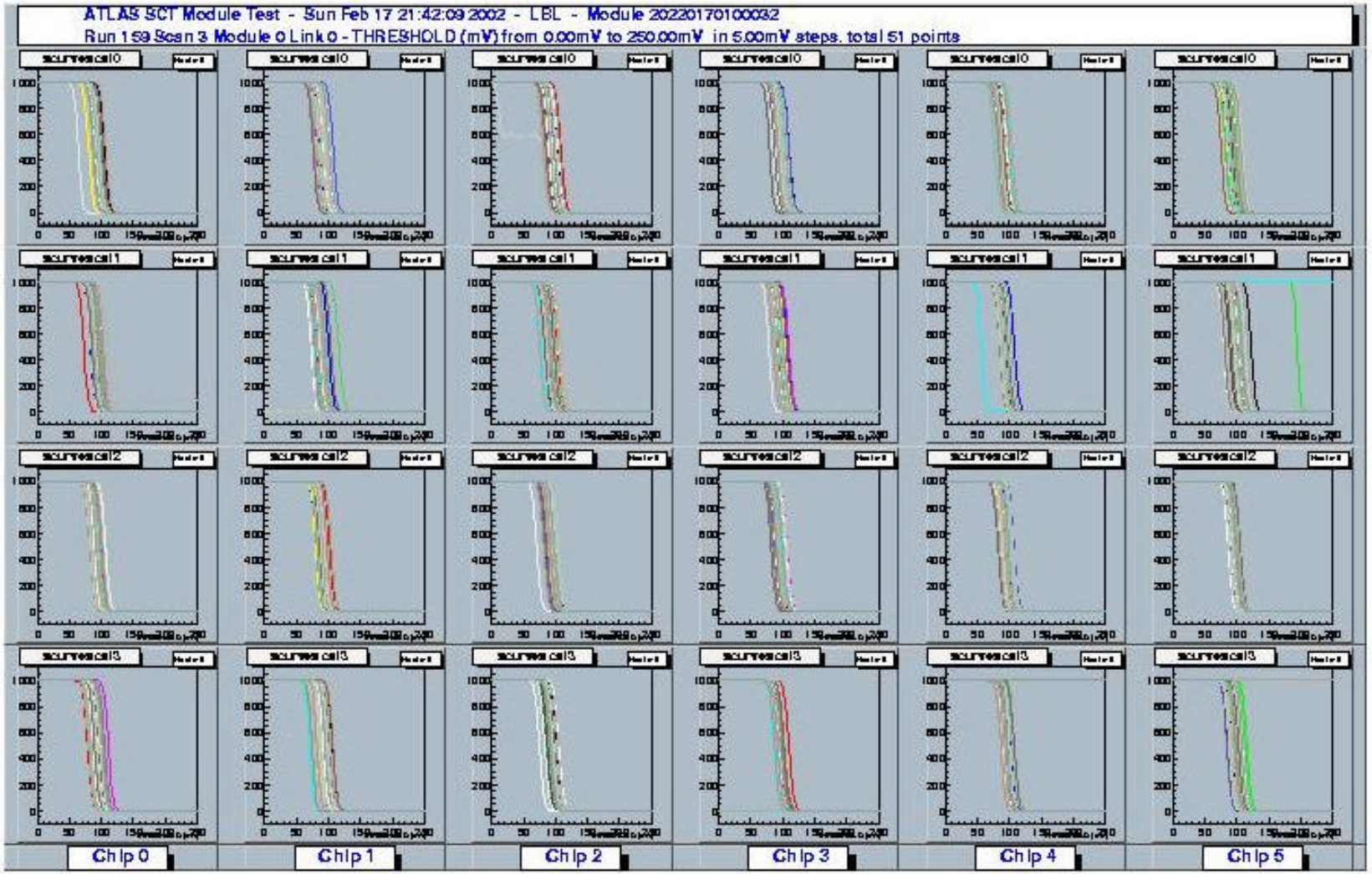
S-Curves Feb 13



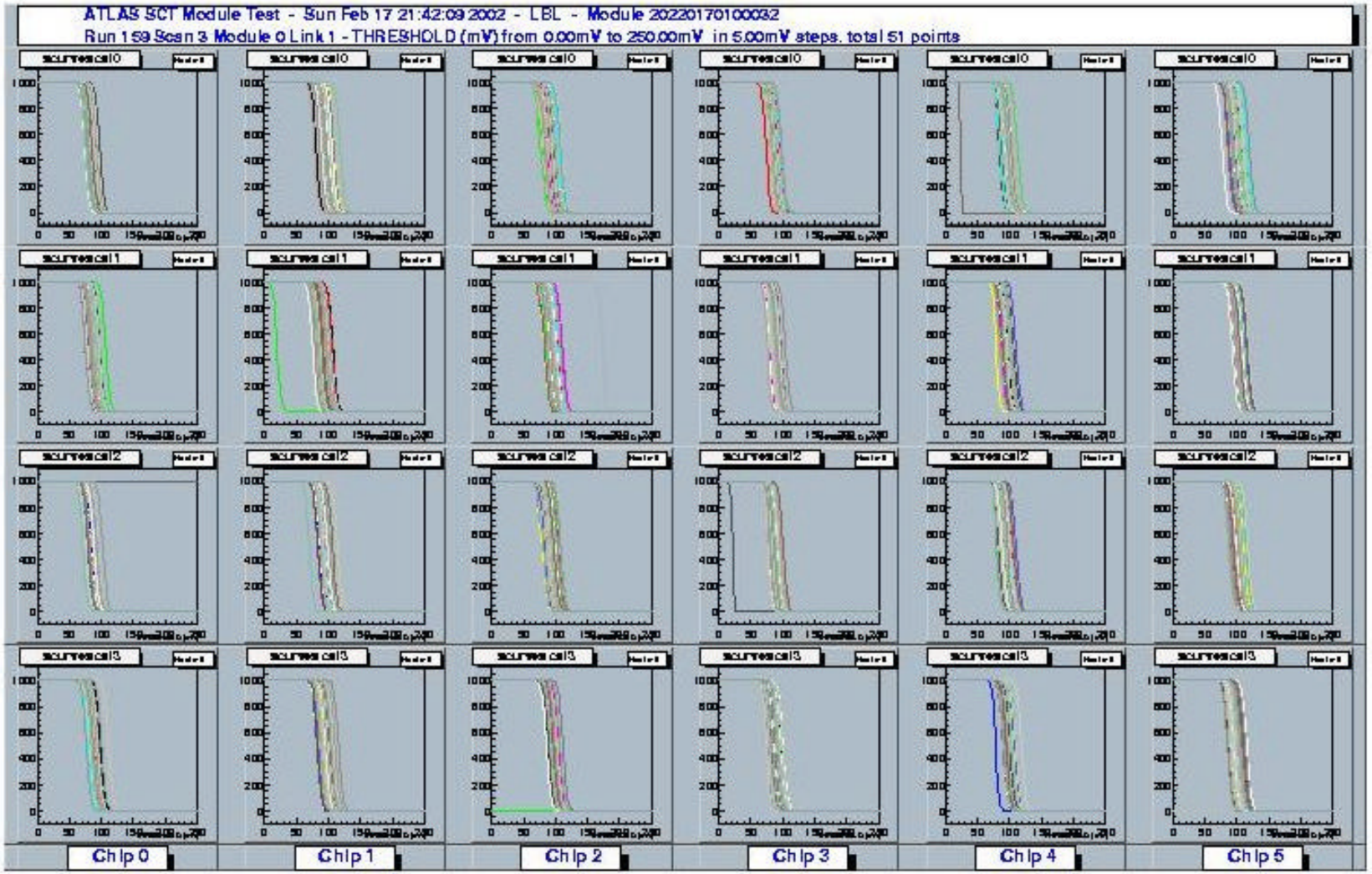
S-Curves Feb 13



S-Curves Feb 17



S-Curves Feb 17

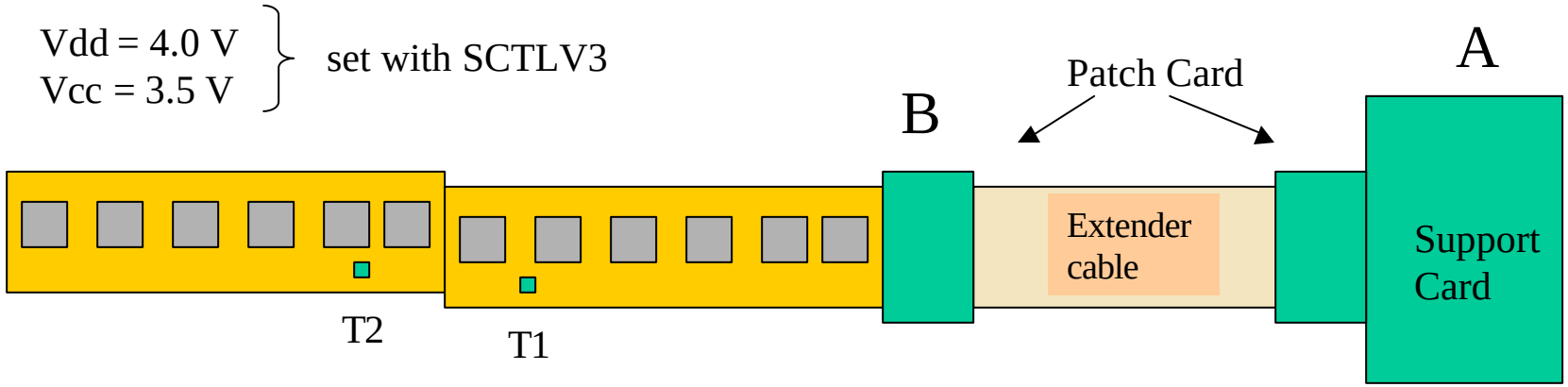


Statistics

Dec 14, 2001
%DEFECTS
#name channel value
%PARTBONDED 65 1035.59
%DEAD 209
%NOISY 324 5325.04
%DEAD 507
%STUCK 575
%STUCK 669
%STUCK 739
%STUCK 822
%DEAD 1039
%PARTBONDED 1202 842.78
%DEAD 1499
#11 defects found

Feb 17, 2002
%DEFECTS
#name channel value
%PARTBONDED 65 1043.64
%DEAD 209
%NOISY 324 5318.76
%DEAD 507
%STUCK 575
%STUCK 669
%STUCK 739
%STUCK 822
%DEAD 1039
%DEAD 1499
#10 defects found

Voltage checks



Vdd (A) = 4.01 V
Vdd (B) = 3.92 V
Vcc (A) = 3.49 V

Vdd drop across hybrid => 3.92 – 3.905 V (chip0-5)
3.902- 3.896 V (chip6-11)

External Power Supply(same voltage drop between A and B (100 mV) and across hybrid
T1, T2 ((chiller 16^0C) 13.18 – 13.46 kOhm
14.22 – 14.39 kOhm (on hybrid)
15.06 – 15.21 kOhm (on support card)

SCTLV3, 80 μA supplied to $T_{1,2}$ => temperature shown typically lower by a few degrees (voltage drop and $T_{1,2}$ connected to digital ground)

DV (T1,A) = 50 mV
DV (Vdd) = 100 mV

Work in Progress

- Measure more accurately radiation dose
- Reach 10 Mrad (0.8 Mrad/week -> 4 more weeks)
- Annealing (long term) with same monitoring
- Comparison with PS and X-Ray post-irr and after annealing
- Results regularly updated on the web and completed mid-April