Please complete and submit this ATLAS Standard Form to ATLAS RHA Coordinator (ARC), at least 2 weeks after the date of the test.

1. General information:

1.1	Date of the test:	03/15/2002
1.2	Pre-selection, or Qualification ? (specify)	Qualification
1.3	Name of the ATLAS (or other) System:	MUON CSC
1.4	Name of the board in the System:	ASM 1
1.5	Person responsible for the test:	Anand Kandasamy
1.6	Institute:	BNL
1.7	Email:	anand@bnl.gov
1.8	Person responsible for RHA of the Board:	Anand Kandasamy
1.9	Institute:	BNL
1.10	Email:	anand@bnl.gov

2. Component:

2.1	Name:	**ASM 1 (IC71 and BAV99ZX)**
2.2	Part Number:	**ASM 1**
2.3	Type (see section 10.1):	Linear Devices
2.4	Function (see section 10.1):	Front-End Charge Amplification/Shaping
2.5	Main specification of the component: MUON CSC Preamp/Shaper	
2.6	Design (specify: COTS/ASIC):	ASIC
2.7	Design center (if known):	BNL
Manufacturer:		
2.8	Name of the manufacturer:	Hewlett Packard (IC71), Zetex (BAV99)
2.9	Address of the manufacturer (if known):	
2.10	Phone of the manufacturer (if known):	
2.11	Email of the manufacturer (if known):	
2.12	Web URL of the manufacturer (if known):	
Sampling:		
2.13	Number of tested components (irradiated):	6
2.14	Number of reference components (un-irradiated):	1
Batch origin:		
2.15	Batch origin (Homogeneous/Unknown):	Homogeneous
2.16	Manufacturing date code (for homogeneous batch):	T17E-AT (MOSIS)
2.17	Manufacturing line code (for homogeneous batch):	
Technology:		
2.18	Name of the technology (if known):	HP AMOS14TB
2.19	Technology (CMOS/BiCMOS/Bipolar/AsGa/Other):	CMOS
2.20	Minimum geometry (μm) :	0.5
Package:		
2.21	Type:	QFP (IC71) and SOT-23 (BAV99)
2.22	Part number:	
2.23	Number of pin:	100 (IC71) and 3 (BAV99)
2.24	Ceramic ? Plastic ? hybrid ? (specify)	Plastic

3. Radiation:

3.1	Name of the radiation facility:	BNL GIF
3.2	Address of the radiation facility:	Brookhaven National Laboratory
3.3	Radiation source (see 12.2) :	Cobalt 60
3.4	Radiation type (see 12.2) :	Gamma
3.5	Radiation energy:	1.173meV and 1.332MeV
3.6	Dose rate (Gray/s) :	0.055 Gy/s and 0.0277 Gy/s
3.7	Total dose after last step (Gray) :	16700 Gy
3.8	NIEL (if any) after last step (1 MeV eq. n/cm2) :	
3.9	Dosimetry / Calibration method:	

4. Radiation test method (see 12.3): (put an "X" to designate your answer. Specify in 4.10 if necessary)

4.1	Extended TID test method for pre-selection of CMOS devices?	
4.2	Simplified TID test method for pre-selection of CMOS devices?	X
4.3	Extended TID test method for pre-selection of bipolar devices?	
4.4	Simplified TID test method for pre-selection of bipolar devices?	
4.5	Extended TID test method for qualification of CMOS batches?	
4.6	Simplified TID test method for qualification of CMOS batches?	
4.7	Extended TID test method for qualification of bipolar or BiCMOS batches?	
4.8	Simplified TID test method for qualification of bipolar or BiCMOS batches?	
4.9	Other TID test method?	
4.10	Which other TID test method (specify) ?	

5. Total dose: (if the irradiation is made in one single step, answer to question 5.1 and 5.2 only)

5.1	Total number of irradiation steps:	6
5.2	TID (Gray) after step 1:	900
5.3	TID (Gray) after step 2 (if more than one step):	2500
5.4	TID (Gray) after step 3 (if more than two steps):	5000
5.5	TID (Gray) after step 4 (if more than three steps):	7500
5.6	TID (Gray) after step 5 (if more than four steps):	10000
5.7	TID (Gray) after step 6 (if more than five steps):	16700

6. Simulation of Low Dose Rate Effects (see 12.4):

Bipolar devices only:		
6.1	Did you perform irradiation at elevated temperature to simulate low dose rate effects (Y/N) ?	
6.2	If "yes" to Q.6.1, how much irradiation pre-tests did you perform to determine the worst case temperature?	
6.3	If "yes" to Q.6.1, what is the worst temperature determined from pre-tests (^{o}C)?	
6.4	If "no" to Q.6.1, which safety factor do you use to represent low dose rate effects?	
CMOS and BiCMOS only:		
6.5	Did you perform post-irradiation aging to simulate low dose rate effects (Y/N) ?	N
6.6	If "no" to Q.6.5, which safety factor do you use to represent low dose rate effects?	5

7. Thermal and voltage stresses:

During irradiation:		
7.1	Temperature (°C) ?	25
7.2	Supply voltage (Y/N) ?	Y
7.3	If "yes" to 7.2, value of supply voltage:	3.3V
7.4	AC operation (Y/N) ?	N
7.5	If "yes" to 7.4, which AC operation?	
7.6	If "yes" to 7.4, which frequency?	
During post irradiation annealing:		
7.7	Did you perform post-irradiation annealing (Y/N) ?	N
7.8	If "yes" to 7.7, annealing temperature (°C) ?	
7.9	If "yes" to 7.7, duration?	
7.10	If "yes" to 7.7, supply voltage (Y/N) ?	
7.11	If "yes" to 7.7 and 7.10, which supply voltage?	
7.12	If "yes" to 7.7, AC operation (Y/N) ?	
7.13	If "yes" to 7.7 and 7.12, which AC operation?	
7.14	If "yes" to 7.7 and 7.12, which AC frequency?	
During post irradiation accelerated aging:		
7.15	Did you perform post-irradiation ageing (Y/N) ?	N
7.16	If "yes" to 7.15, aging temperature (°C) ?	
7.17	If "yes" to 7.15, duration?	
7.18	If "yes" to 7.15, supply voltage (Y/N) ?	
7.19	If "yes" to 7.15 and 7.18, which supply voltage?	
7.20	If "yes" to 7.15, AC operation (Y/N) ?	
7.21	If "yes" to 7.15 and 7.20, which AC operation?	
7.22	If "yes" to 7.15 and 7.20, which AC frequency?	

8. Electrical measurement:

During irradiation:		
8.1	Did you perform on-line measurement (Y/N) ?	N
8.2	If "yes" to 8.1, at which temperature (°C) ?	
8.3	If "yes" to 8.1, describe on-beam operation and measurements:	
After irradiation:		
8.4	Did you perform electrical measurements just after irradiation (Y/N) ?	Y
8.5	Duration between irradiation and electrical measurement?	5 min
8.6	Temperature during electrical measurement (°C) ?	25
After annealing:		
8.7	Did you perform electrical measurements after annealing (Y/N) ?	
8.8	Duration between annealing and electrical measurement?	
8.9	Temperature during electrical measurements?	

8. Electrical measurement (cont.):

After accelerated aging:		
8.10	Did you perform electrical measurements after aging (Y/N) ?	N
8.11	Duration between aging and electrical measurement?	
8.12	Temperature during electrical measurement (°C) ?	

Description of off-line measurements (after irradiation; after annealing or after aging):

9. Rejection criteria:

	Measured parameter	Rejection Criteria
9.1	Gain	Outside 10% limits
9.2	Shaping Time	Outside 10% limits
9.3	Noise	Outside 10% limits
9.4		
9.5		

10. Results:

	10.1	10.2	10.3	10.4	10.5	10.6
	Serial number of the device under test	Max. applied total dose (Gy)	Failure dose (Gy) if any failure during irradiation	Failure during annealing (Y/N)?	Failure during ageing (Y/N)?	Failure mechanism (if any): for component "dead" or out of specification, give explanations and numbers
1	BD14	16700				
2	BD18	16700				
3	BD15	16700				
4	BD23	16700				
5	BD22	16700				
6	BD16	16700				
7						
8						
9						
10						
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20						

11. Comments

Use the space below to comment test results, or to report them if the above-dedicated space is inappropriate for you.
See Attached Report

12. Guidelines

12.1 Type and Function

Type	Function
Analogue device	ADC; Analogue memory; Analogue multiplexor; DAC; LVDS driver; LVDS receiver; Modulator/Demodulator; Voltage/Frequency converter
Data transmission Component	Receiver; Transceiver; Transmitter
Front-end electronic device	Drift Time Measurement; Multiple functions; Readout memory
Linear device	Amplifier; Comparator; Operational amplifier; Voltage reference;
Memory	SRAM
Microprocessor or peripheral	Microcontroller; Microprocessor
Optoelectronic component	Laser; Light emitting diode – LED; PIN diode; VCSEL
Power device	DC-DC converter; Power transistor; Voltage regulator
Programmable device	EEPROM; FPGA; Lookup table; Programmable delay
Passive component	Capacitor
Interfaces/Communication	LVDS; Switch
Mixed A/D device	Multiple functions
Logic gates	NOR, NAND, etc.

12.2 Radiation source and type

Source of radiation	Type of radiation
Accelerator	Electron, proton, spallation neutron
Am-241	Ions (fission products)
Cf-252	Ions (fission products)
Co-60	Photon gamma 1.173 MeV and 1.332 MeV
Cs-137	Photon gamma 0.662 MeV
Cyclotron	Proton, ion (specify), spallation neutron
Reactor	Neutron
Tandem accelerator	Protons, ions
Van-de-Graaf	Electron
X-Ray generator	Photon X

12.3 Radiation test methods:

see ATLAS Policy on Radiation Tolerant Electronics rev. 2, pp. 20-26
http://atlas.web.cern.ch/Atlas/GROUPS/FRONTEND/WWW/RAD/RadWebPage/ATLASPolicy/APRTE_rev2_250800.pdf

12.4 Low dose rate effects:

see ATLAS Policy on Radiation Tolerant Electronics rev. 2, pp. 11
http://atlas.web.cern.ch/Atlas/GROUPS/FRONTEND/WWW/RAD/RadWebPage/ATLASPolicy/APRTE_rev2_250800.pdf

BROOKHAVEN NATIONAL LABORATORY	**US ATLAS** **MUON SPECTROMETER** **CATHODE STRIP CHAMBER**	
Anand Kandasamy anand@bnl.gov	Total Ionizing Dose Test Report For CSC Front-end Electronics	4/9/2002

1. Overview:

Total Ionizing Dose (TID) tests were conducted on major components for the Cathode Strip Chamber front-end electronics. This test was targeted towards the analog circuitry that performs charge amplification, shaping and Electro-Static-Discharge (ESD) protection. The analog charge amplification and shaping circuit identified as IC71 is a custom ASIC developed at Brookhaven National Laboratory and fabricated in 0.5 μm CMOS technology. The ESD protection devices used for the front-end amplifiers are commercial of the shelf (COTS) components manufactured by ZETEX (BAV99ZX)

2. Ionizing Radiation Levels in CSC.

Worst case Simulated Radiation Levels (SRL) and Radiation Tolerance Criteria (RTC) for the CSC is given below. This data is obtained from the ATLAS Radiation Tolerance Criteria documents and extraction tools.

Qualification/Pre-selection:

Zmin (cm)	Zmax (cm)	Rmin (cm)	Rmax (cm)	SRLtid (Gy/10 years)	RTCtid (Gy/10 years)
760	770	80	90	362	12700

RTCtid = SRLtid * SFsim * SFldr * SFlot
SFsim = 3.5 (Simulation)
SFldr = 5 (Low Dose Rate)
SFlot = 2 (Lot Variation)

For production qualification the SFlot factor decreases to 1 and hence the RTC decreases to 6350 Gy/10 years.

3. TID Radiation Test Setup

A total of 6 test devices and 1 reference device was screened and used for the test. The test devices were obtained from a homogenous lot. Simplified TID test method for pre-selection of CMOS devices were followed. The devices were not subjected to post-irradiation aging to simulate low dose rate effects. The devices were biased under their normal operating condition and at room temperature. The devices were also not subjected to post-irradiation annealing and post-irradiation ageing. Devices parameters were measured in-between radiation steps and returned back for radiation within an hour.

Electronics gain, shaping time, Equivalent Noise charge, input & output dc levels and current consumption of the devices were monitored and the rejection criteria for the devices were formulated as any failed channel or degradation of one or more parameters beyond the 10% level.

Initial dose of 90 KRad was applied at 20KRad/HR and subsequent doses were applied at 10KRad/Hr. Measurements were conducted at 0KRad, 90KRad, 250KRad, 500KRad, 750 KRad, 1000KRad and 1670 KRad intervals.

4. Test Results

A total of 150 front-end channels were irradiated and none of them exhibited failures or exceeded the rejection criteria. The worst case degradation observed is outlined in the table below.

Parameter	% Change from Pre-Radiation Measurement
Charge Gain	0.44%
Shaping Time	1.79%
ENC	7.43%
Device Current	1.39%

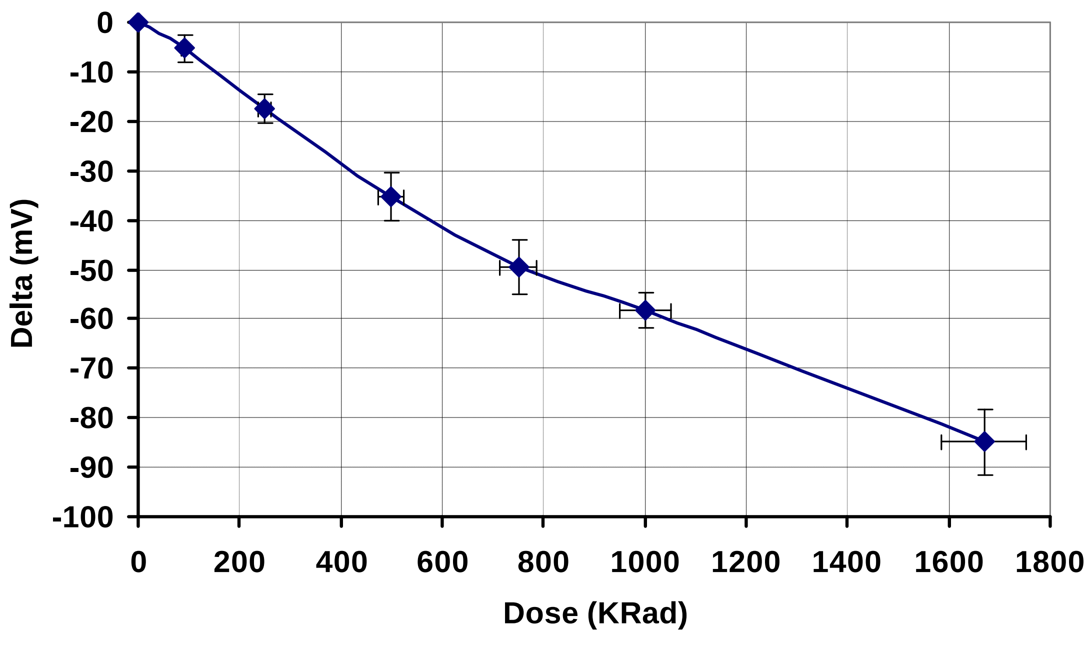

Figure 1. Input DC Shift

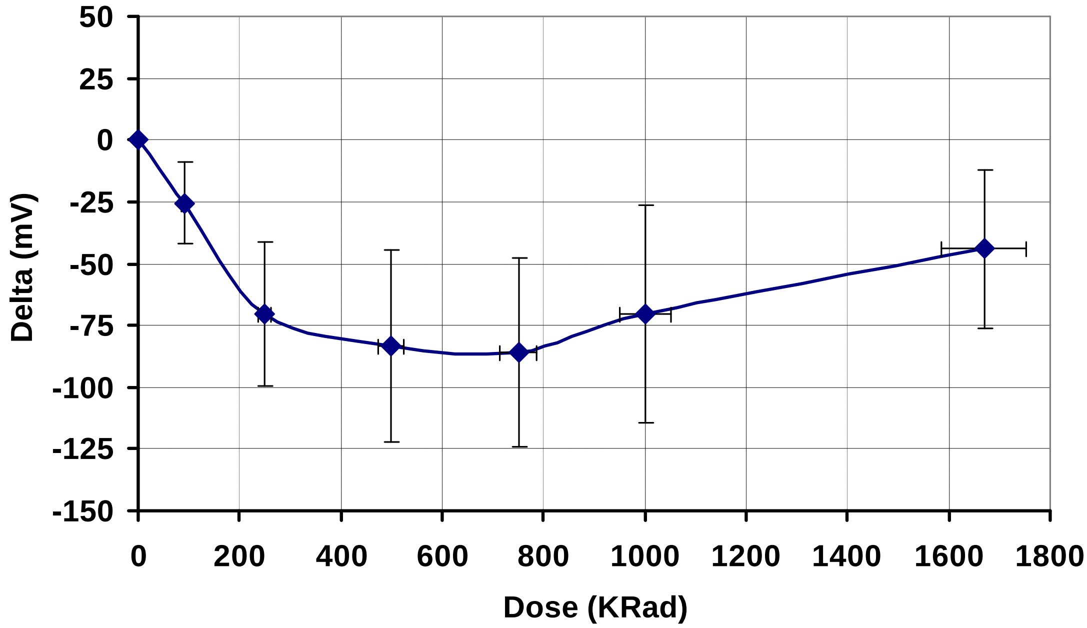

Figure 2. Output DC Shift

This change in output DC level is of less significance to the system design as the front-end stage is AC coupled to the readout stage and the overall gain change of the front-end system remains within the rejection criteria.

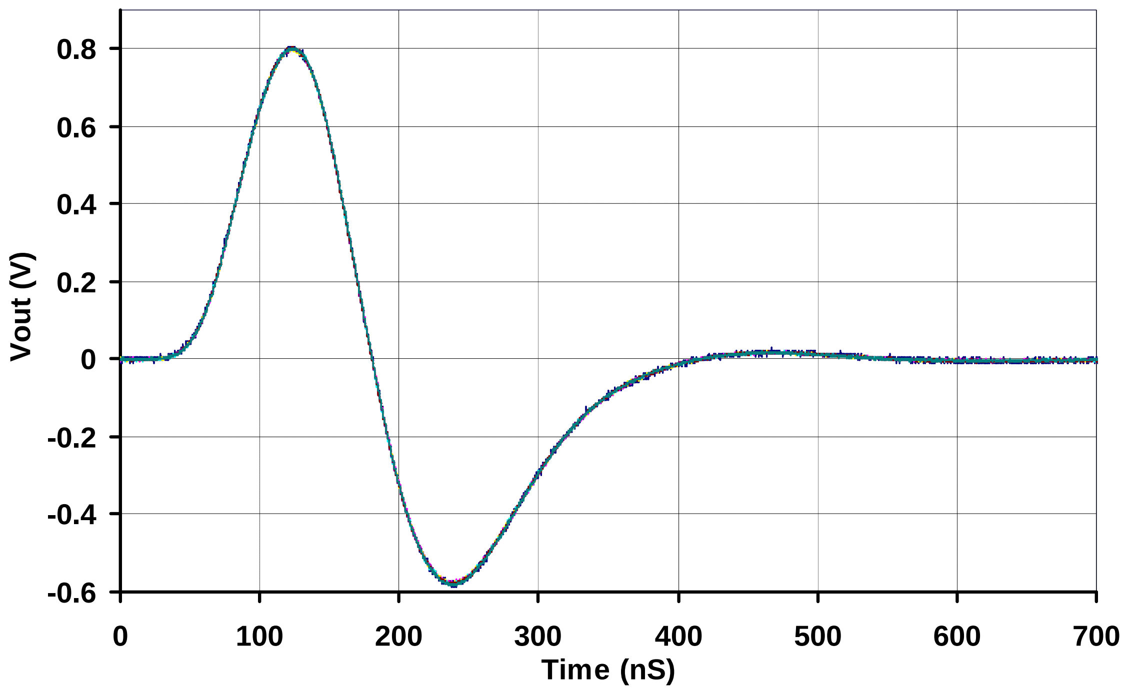

Figure 3 Board 15 super-imposed output Waveforms

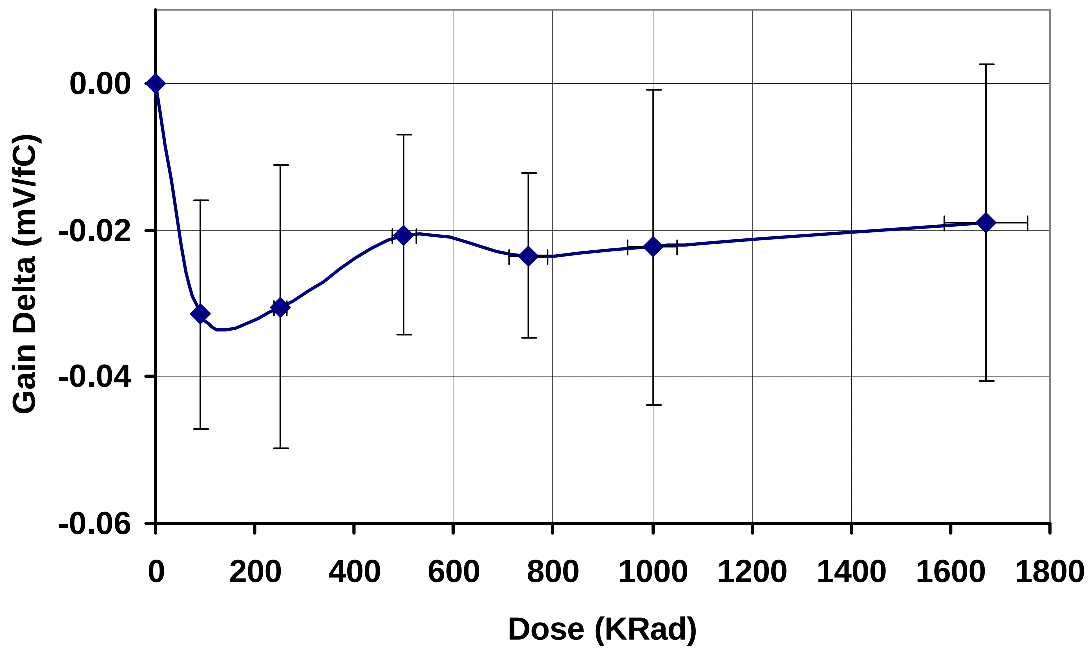

Figure 4. Charge Gain

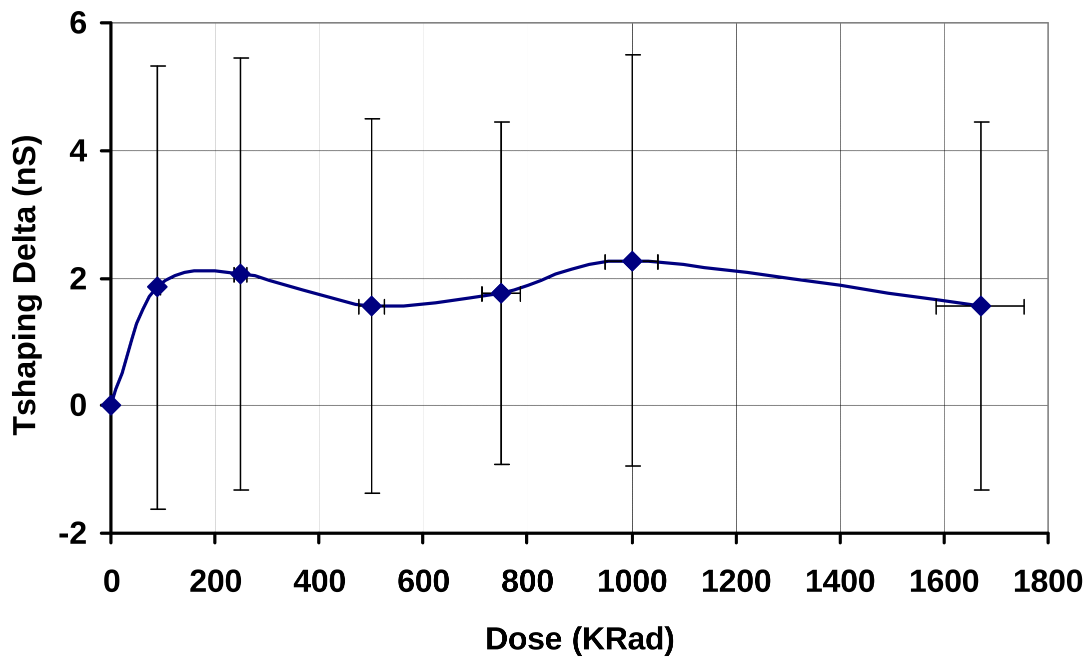

Figure 5. Shaping Time

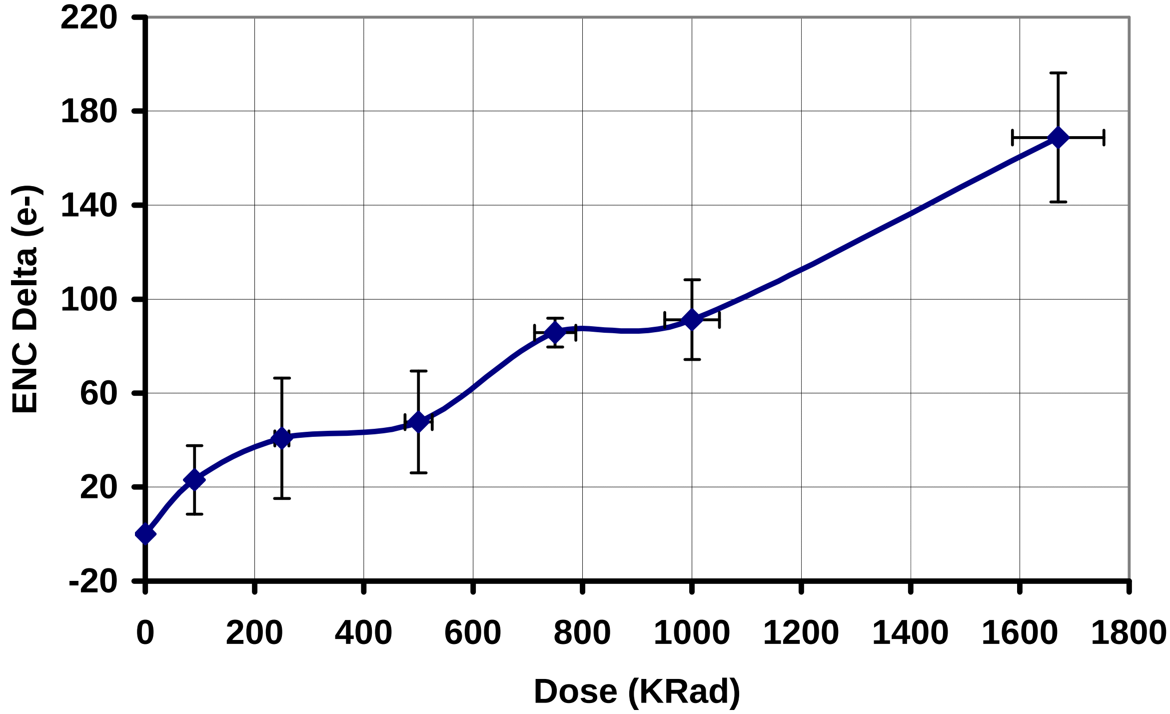

Figure 6. ENC Delta (r.m.s. electrons) @ 47pF Cdetector

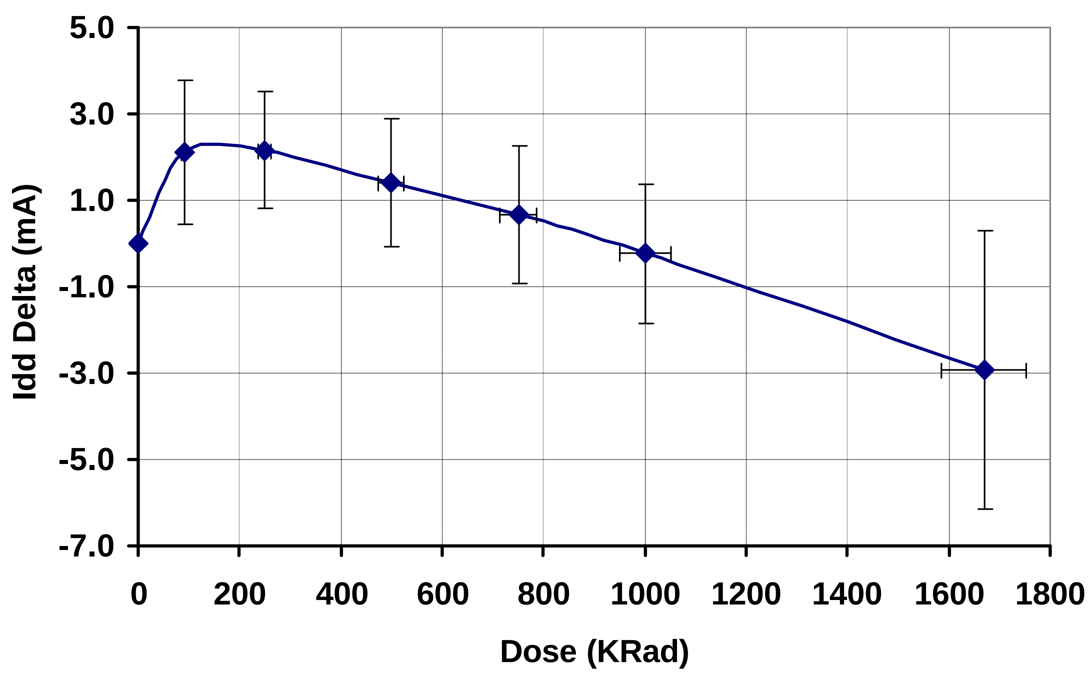

Figure 7. Device Current Consumption

The X-error bars in the above figures illustrates the probable error in total ionizing dose (5%) and the Y-error bars illustrate the standard deviation of the parameter.

5. Conclusion:

Both the front-end electronics components for the CSC namely IC71 Preamp/Shaper and the ESD diode BAV99ZX were irradiated well above the Radiation tolerance criteria (1270 KRad). The degradation of the front-end electronics module due to ionizing dose is well within the acceptable range for the CSC electronics requirement.