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:	04/10/2003
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 Kandasmy
1.6	Institute:	Brookhaven National Laboratory
1.7	Email:	anand@bnl.gov
1.8	Person responsible for RHA of the Board:	Anand Kandasmy
1.9	Institute:	Brookhaven National Laboratory
1.10	Email:	anand@bnl.gov

2. Component:

2.1	Name:	**IC71 (ASM1 CSC Preamp/Shaper)**
2.2	Part Number:	**IC71**
2.3	Type (see section 10.1):	Linear Devices
2.4	Function (see section 10.1):	Charge amplification & Shaping
2.5	Main specification of the component:	
2.6	Design (specify: COTS/ASIC):	CMOS ASIC
2.7	Design center (if known):	BNL
Manufacturer:		
2.8	Name of the manufacturer:	Agilent (HP)
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):	5
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
2.22	Part number:	IC71
2.23	Number of pin:	100 pin
2.24	Ceramic ? Plastic ? hybrid ? (specify)	Plastic

3. Radiation:

3.1	Name of the radiation facility:	Prospero
3.2	Address of the radiation facility:	France
3.3	Radiation source (see 10.2) :	Reactor
3.4	Radiation type (see 10.2) :	neutron
3.5	Radiation energy (MeV) :	0.75 MeV
3.6	Flux (1 MeV eq. n/cm^2 per second) :	0.8E14 n.cm^{-2}.h^{-1} (1MeV eq.)
3.7	Total fluence after last step (1 MeV eq. n/cm^2) :	7.0 E 13
3.8	Total dose (if any) after last step (Gray) :	
3.9	Dosimetry / Calibration method:	

4. Radiation test method (see 10.3):

4.1	ATLAS Standard NIEL Test Method?	Y
4.2	Other NIEL test method (specify)?	

5. Total fluence:

If several irradiation steps are applied on components placed at the same location, or if several components are placed at different locations during irradiation, give the value of the neutron fluence (1 MeV eq. n/cm2) reached after each step (or at each location). In case of only one irradiation step and one location, fill 5.1 only.

5.1	**5.2**	**5.3**	**5.4**	**5.5**
Step (location) # 1	Step (location) # 2	Step (location) # 3	Step (location) # 4	Step (location) # 5
7E13				

6. Electrical measurement:

During irradiation:

6.1	Did you perform on-line measurements (Y/N) ?	N
6.2	If "yes" to 6.1, describe on-beam measurements:	

After irradiation:

6.3	Did you perform electrical measurements after irradiation (Y/N) ?	Y
6.4	If yes to 6.3, how long time after the end of the irradiation (roughly) ?	7 Weeks

6.5 If "yes" to 6.3, describe post-irradiation measurements:
Measure circuit parameters charge gain, noise, shaping time and device current using automated test fixture

7. Rejection criteria:

	Measured electrical parameter	Rejection Criteria
7.1	Charge Gain, Shaping Time	> 10%
7.2	Noise	> 20%
7.3		
7.4		
7.5		

8. Results:

	8.1	8.2	8.3	8.4
	Serial number of the device under test	Max. applied fluence (see 10.4)	Failure fluence if any during irradiation (see 10.4)	Failure mechanism (if any): for component "dead" or out of specification, give explanations and numbers
1	1	7E13	N	
2	2	7E13	N	
3	3	7E13	N	
4	4	7E13	N	
5	5	7E13	N	
6				
7				
8				
9				
10				
11				
12				
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15				
16				
17				
18				
19				
20				

9. Comments

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

The devices are tolerant to NIEL radiation and their circuit parameter changes are well within the rejection criteria set.
See attached document.

10. Guidelines

10.1 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.

10.2 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

10.3 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

10.4 Maximum fluence and failure fluence:

Unit = 1 MeV equivalent n/cm^2.

	US ATLAS MUON SPECTROMETER CATHODE STRIP CHAMBER	
Anand Kandasamy anand@bnl.gov	NIEL Test Report For CSC Front-end Electronics	7/2/2003

1. Overview:

Non Ionizing Energy Loss (NIEL) tests were conducted on preamplifier/shaper integrated circuits for the Cathode Strip Chamber front-end electronics. This test was targeted towards the analog circuitry that performs charge amplification. 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

2. Non 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)	SRLniel (1 MeV eq n.cm^{-2}/10 years)	RTCniel (1 MeV eq n.cm^{-2}/10 years)
760	770	80	90	7.1×10^{12}	7.1×10^{13}

RTCniel = SRLniel * SFsim * SFldr * SFlot
SFsim = 5 (Simulation)
SFldr = 1 (Low Dose Rate)
SFlot = 2 (Lot Variation)

For production qualification the SFlot factor decreases to 1 and hence the RTC decreases to 3.55×10^{13} (1 MeV eq n.cm^{-2}/10 years).

3. NIEL Radiation Test Setup:

A total of 5 test devices and 1 reference device was screened and used for the test. The test devices were obtained from a homogenous lot. Simplified NIEL test method for pre-selection of CMOS devices was followed. The device pins were shorted together during the irradiation. The device parameters were measured prior to irradiation and upon receiving the devices back from the reactor.

Electronics gain, shaping time, Equivalent Noise charge, 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 for charge gain, shaping time and 20% level for noise. A total fluence of 7.0 7.0×10^{13} (1 MeV eq $n.cm^{-2}$) was delivered to the devices in a single step

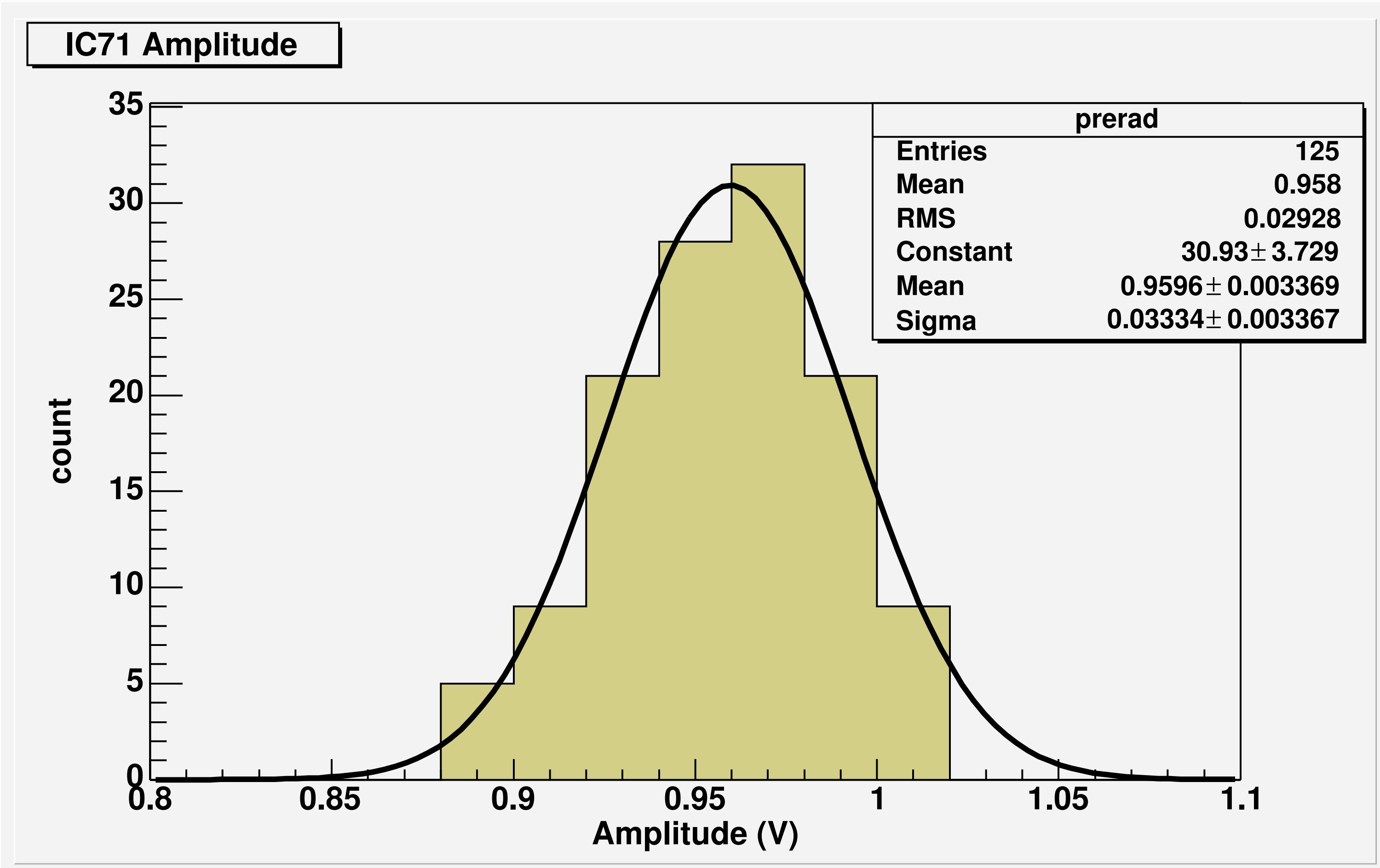
4. Test Results

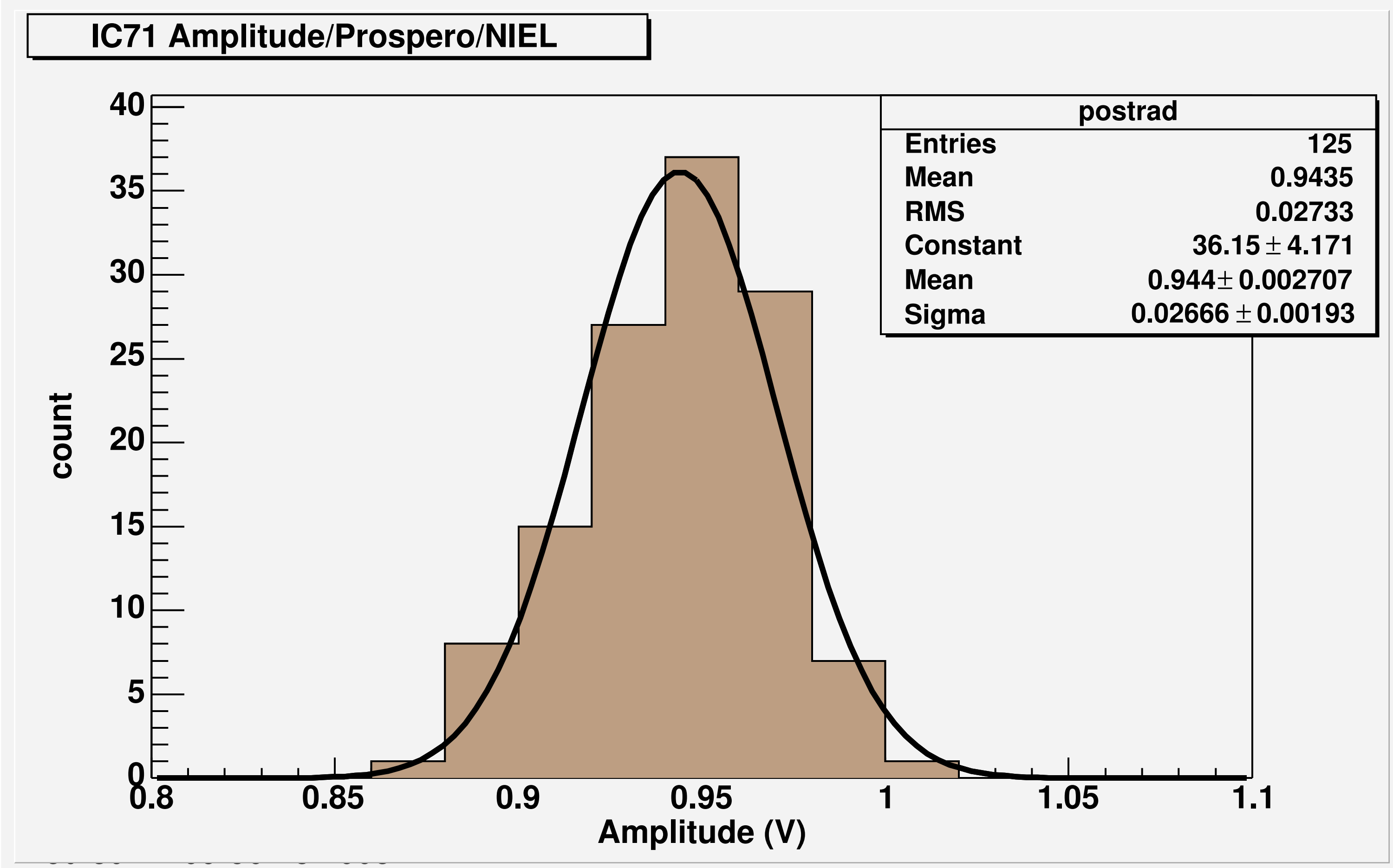
A total of 125 front-end channels were irradiated and none of them exhibited failures or exceeded the rejection criteria. The worst case degradation observed is outlined in the table below.

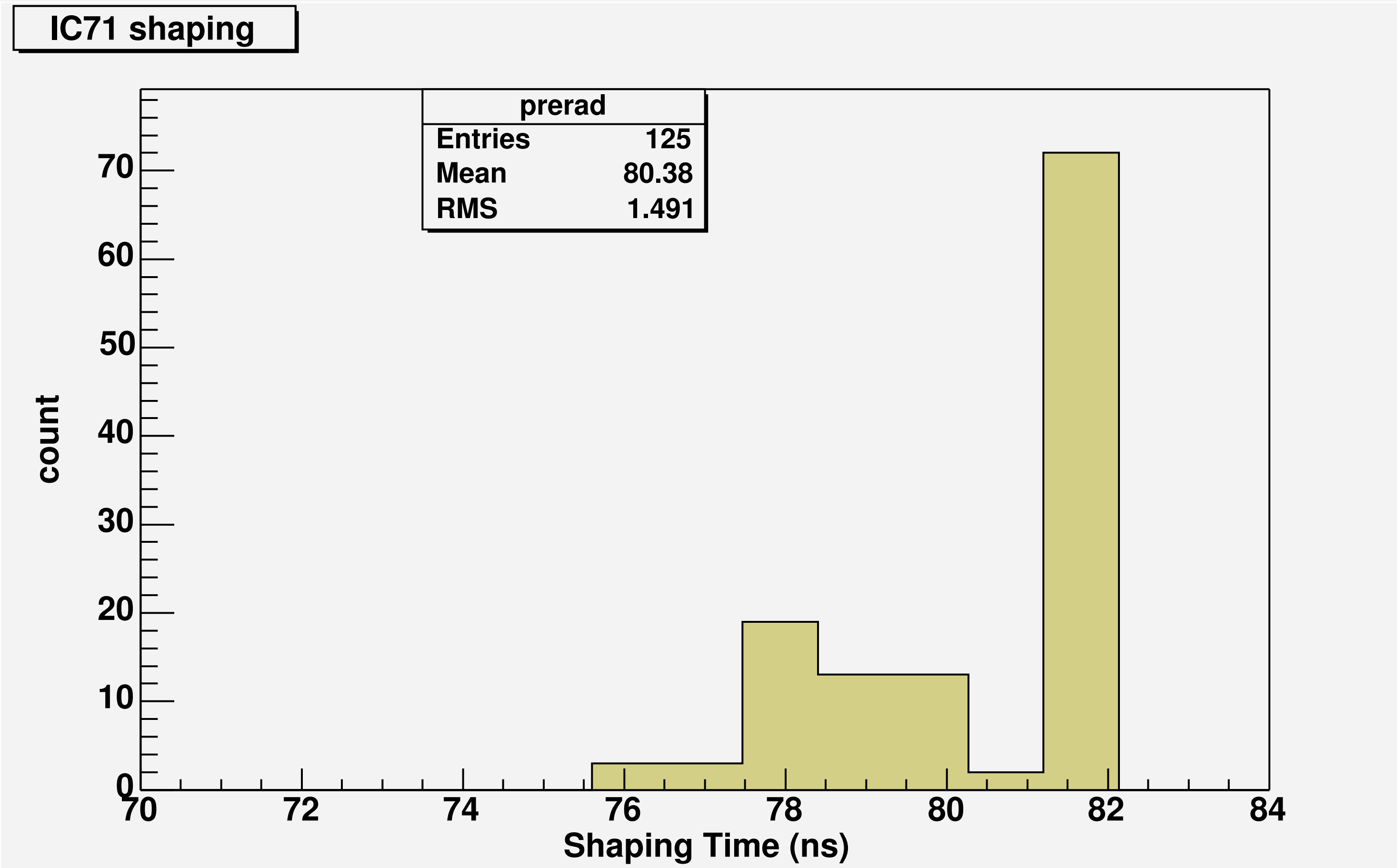
Parameter	% Change from Pre-Radiation Measurement
Charge Gain	1.5%
Shaping Time	2.9%
ENC	10.1%
Device Current	2%

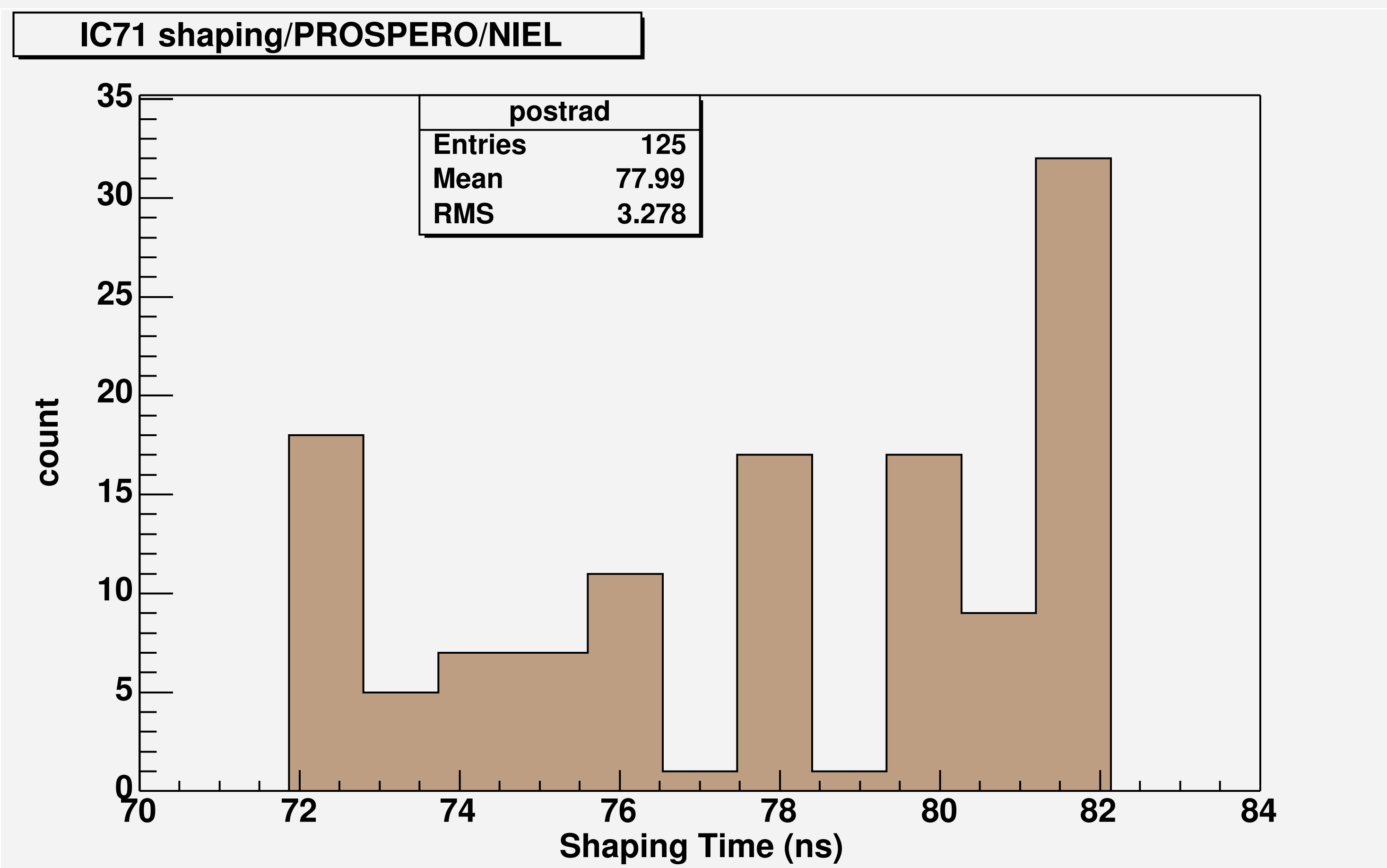
5. Conclusion:

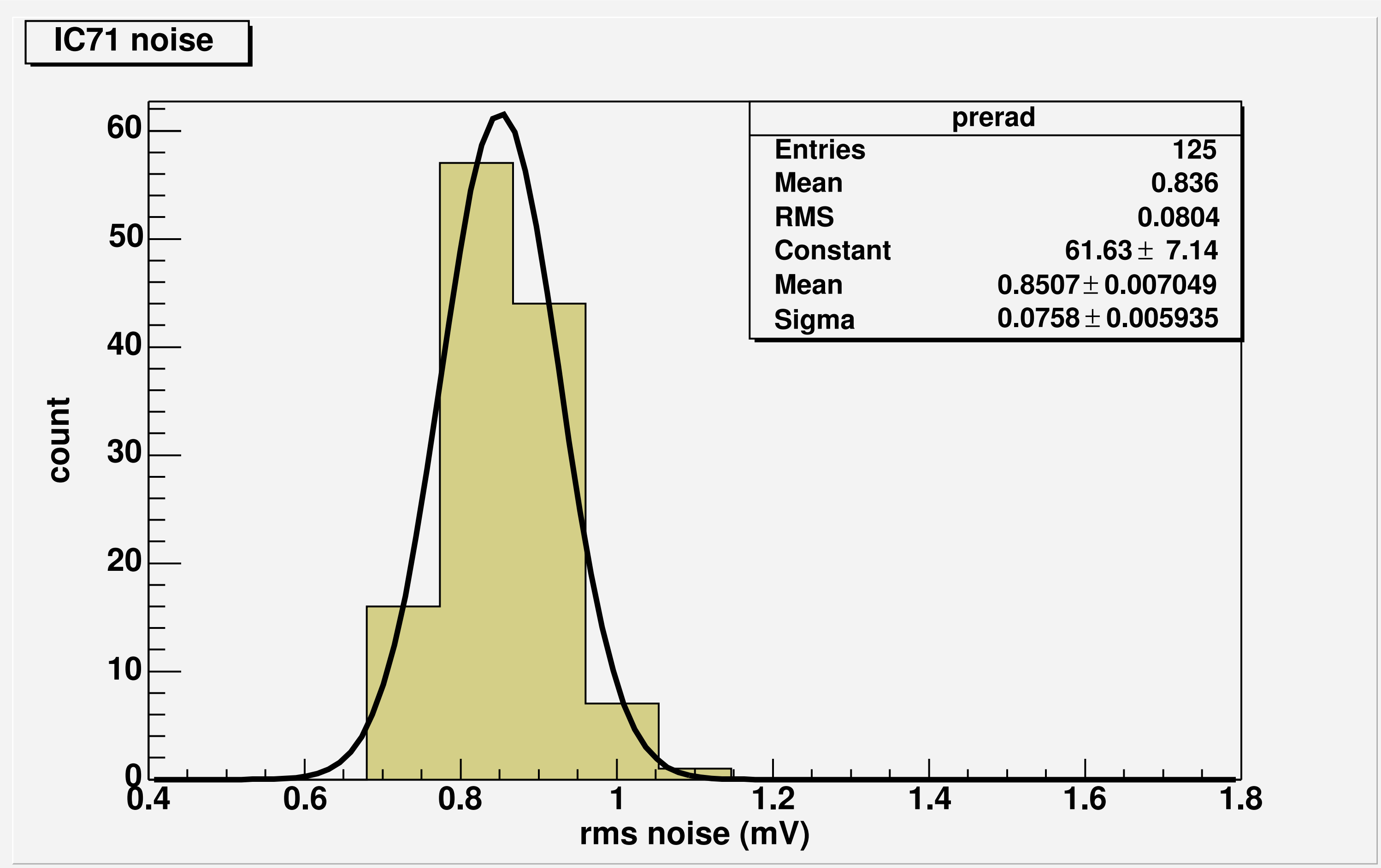
IC71 Preamp/Shaper was irradiated up to the Radiation tolerance criteria fluence. The degradation of the front-end electronics module due to NIEL radiation is well within the acceptable range for the CSC electronics requirement.

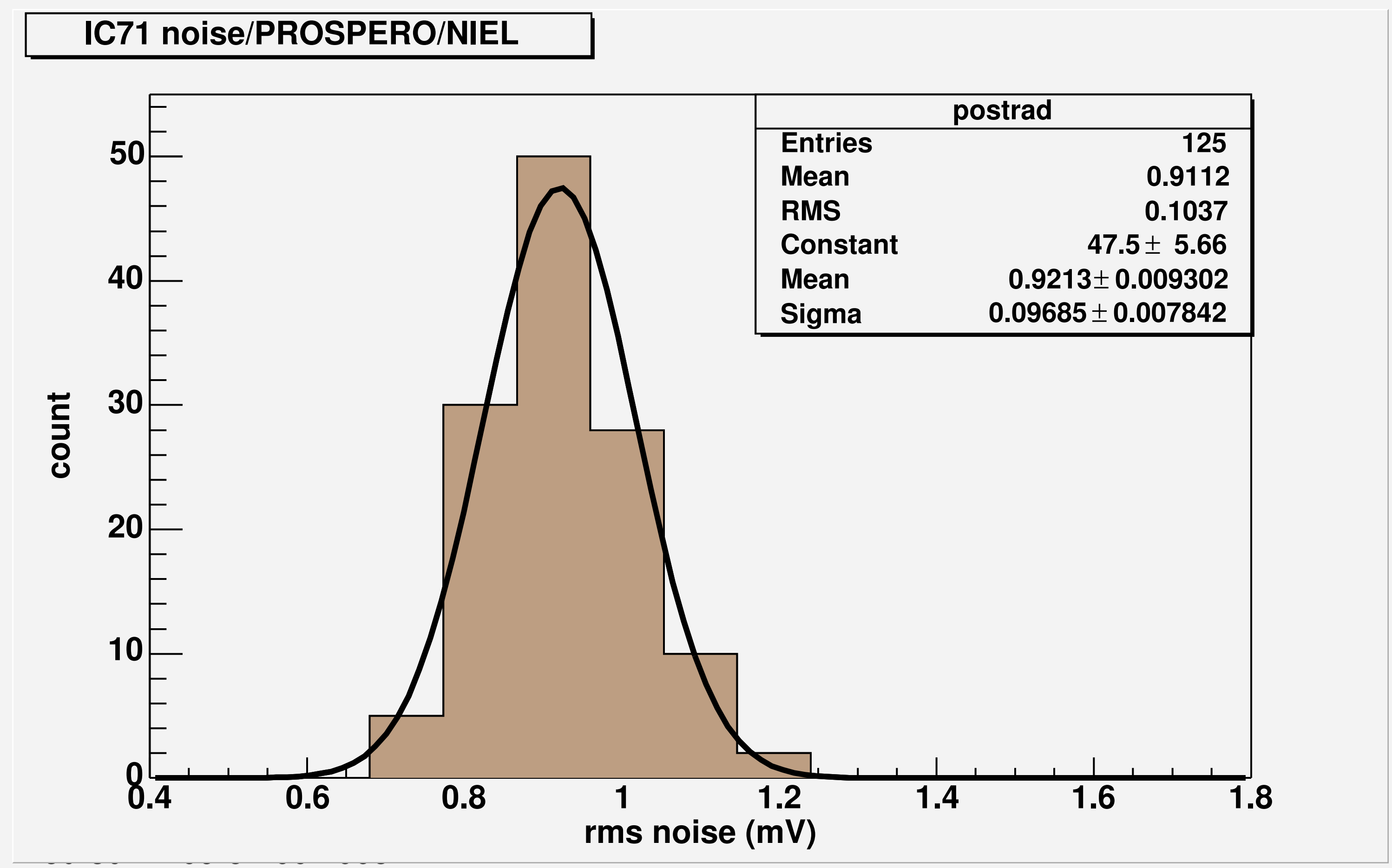

IC71 Amplitude
preRad
Entries 125
Mean 0.958
RMS 0.02928
Constant 30.93 ± 3.729
Mean 0.9596 ± 0.003369
Sigma 0.03334 ± 0.003367
count
Amplitude (V)
0 5 10 15 20 25 30 35
0.8 0.85 0.9 0.95 1 1.05 1.1

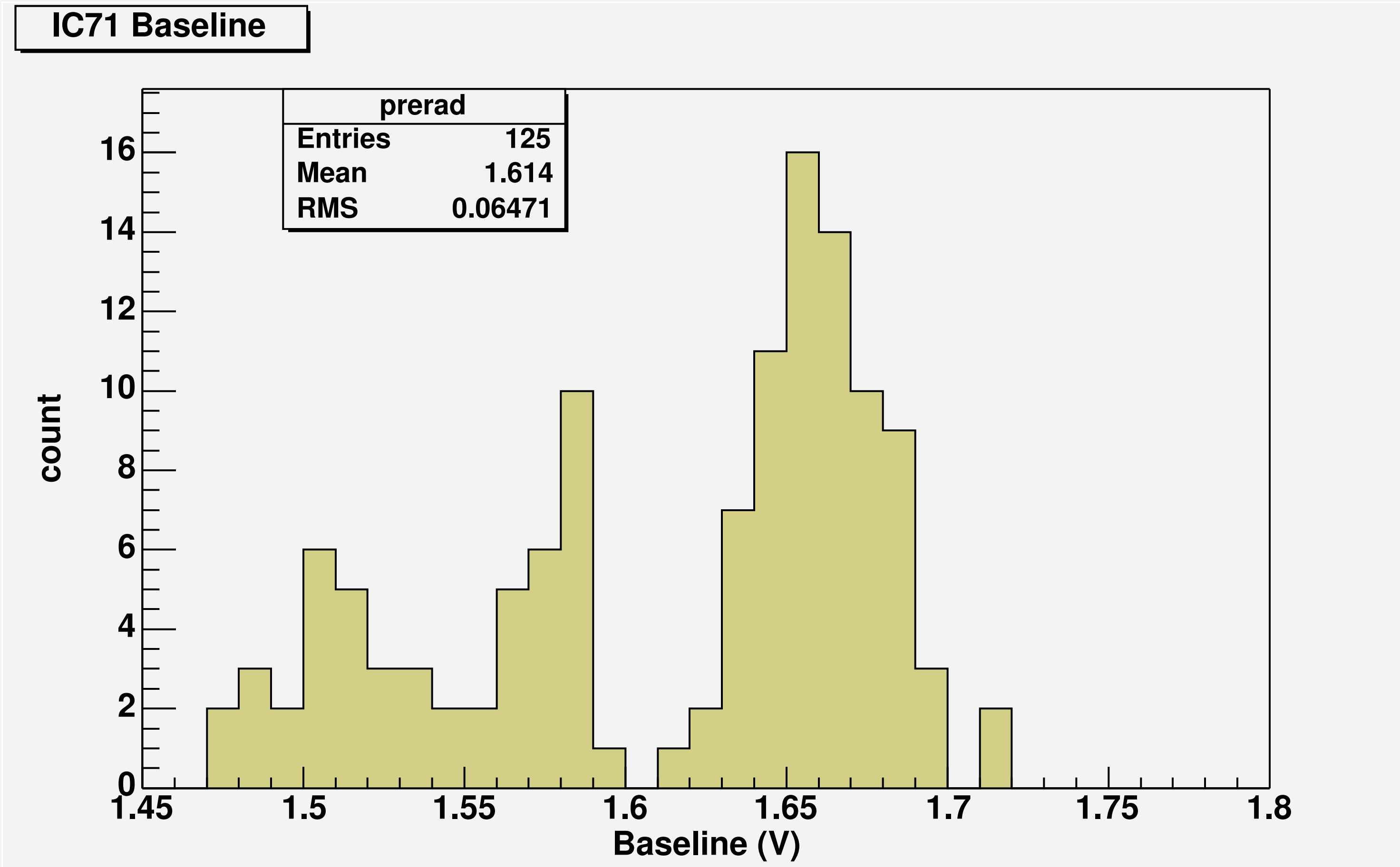

IC71 Amplitude/Prospero/NIEL
postrad
Entries 125
Mean 0.9435
RMS 0.02733
Constant 36.15 ± 4.171
Mean 0.944 ± 0.002707
Sigma 0.02666 ± 0.00193
count
Amplitude (V)
0 5 10 15 20 25 30 35 40
0.8 0.85 0.9 0.95 1 1.05 1.1

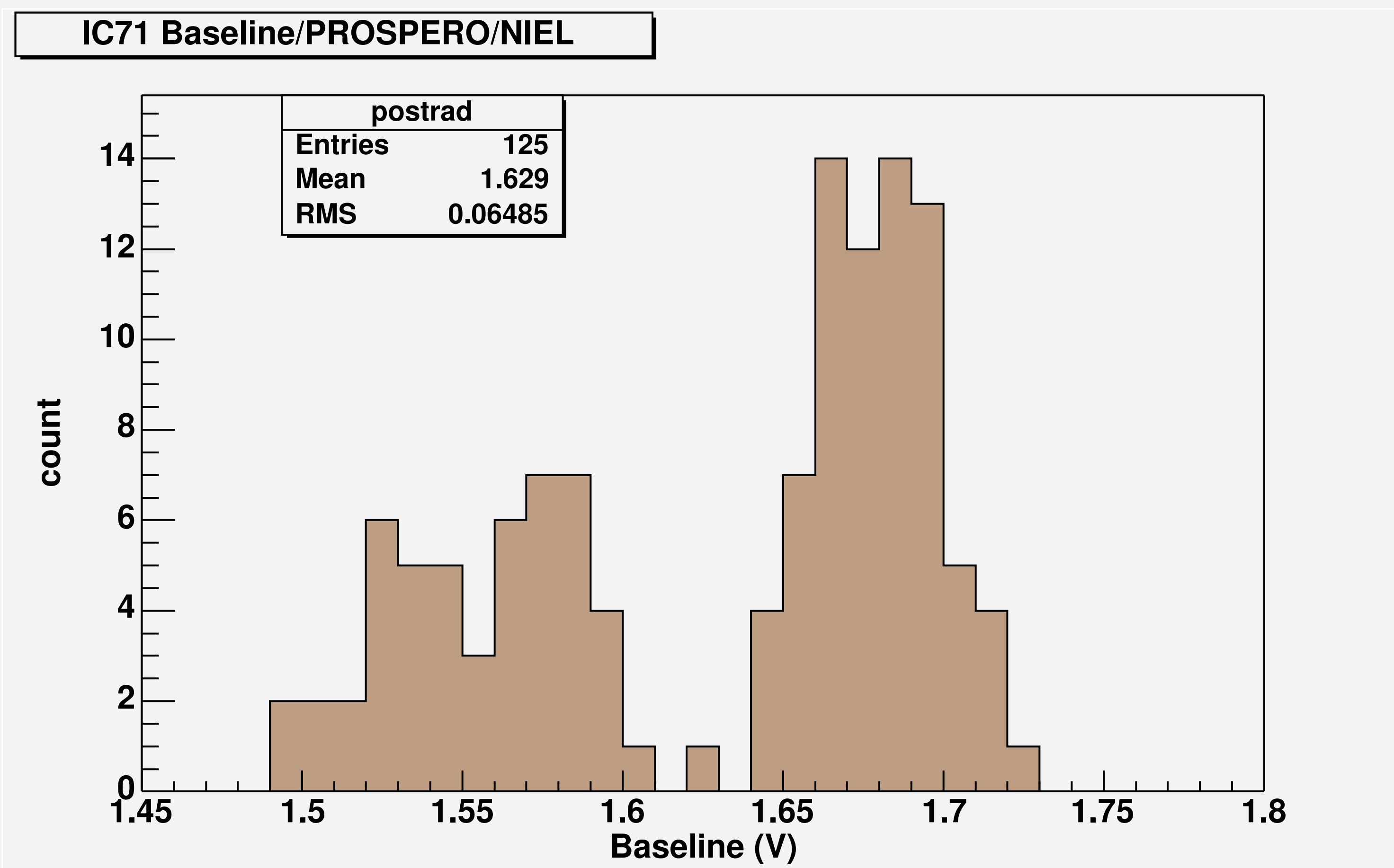

IC71 shaping
prerad
Entries 125
Mean 80.38
RMS 1.491
count
0
10
20
30
40
50
60
70
70
72
74
76
78
80
82
84
Shaping Time (ns)


IC71 shaping/PROSPERO/NIEL
postrad
Entries 125
Mean 77.99
RMS 3.278
count
0
5
10
15
20
25
30
35
70
72
74
76
78
80
82
84
Shaping Time (ns)


IC71 noise
preRad
Entries 125
Mean 0.836
RMS 0.0804
Constant 61.63 ± 7.14
Mean 0.8507 ± 0.007049
Sigma 0.0758 ± 0.005935
count
rms noise (mV)


IC71 noise/PROSPERO/NIEL
postrad
Entries 125
Mean 0.9112
RMS 0.1037
Constant 47.5 ± 5.66
Mean 0.9213 ± 0.009302
Sigma 0.09685 ± 0.007842
count
rms noise (mV)


IC71 Baseline
prerad
Entries 125
Mean 1.614
RMS 0.06471
count
0
2
4
6
8
10
12
14
16
1.45
1.5
1.55
1.6
1.65
1.7
1.75
1.8
Baseline (V)


IC71 Baseline/PROSPERO/NIEL
postrad
Entries 125
Mean 1.629
RMS 0.06485
count
0
2
4
6
8
10
12
14
1.45
1.5
1.55
1.6
1.65
1.7
1.75
1.8
Baseline (V)