Single Event Effect Testing of the Texas Instruments' MAX4595 Single-Channel Analog Switch

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Introduction

The Texas Instruments' (TI) MAX4595 was tested for single event latch-up (SEL) response at the Texas A&M University Cyclotron Facility (TAMU) on 26 October 2014. The device was exercised in varied load conditions to replicate its intended application with concerns about destructive effects on the commercial device.

Devices Tested

MAX4595 Background

The MAX4595 is a single-pole single-throw (SPST) analog switch that is designed to operate from 2 V to 5.5 V. This device can handle both digital and analog signals, and signals up to V+ can be transmitted in either direction.

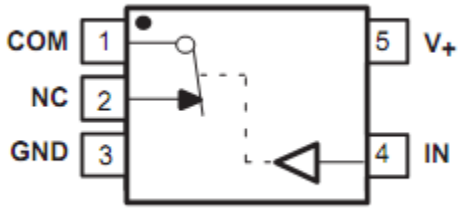


Figure 1: Pin out.

Device Under Test (DUT) Preparation

Three devices were tested in an application specific switching condition. Table 1 lists the pertinent DUT information.

Table 1. MAX4595 Test Information

Part Number:	MAX4595
Manufacturer:	TI
Additional Case Markings:	6SB
Quantity Tested:	3
Part Function:	SPST
Part Technology:	CMOS (B8)
Package Style:	SOT-23
REAG Identification	14-077

De-encapsulation of the part required acid etching the package away from the die. The size of the DUTs was small. For reasonable handling after acid etch and to avoid post etching soldering the devices were mounted onto daughter cards. The first etching revealed that the die was under

the lead-forms from a top down package perspective. A hole was then drilled into the daughter card and acid etch was successfully completed on the three devices that were tested. The die with daughter card through this process can be seen in Figure 2. This setup constrained the angles at which we were able to test the device at TAMU.

Die Information

A. Dimensions:	31 X 30 mils
B. Passivation:	Si_3N_4/SiO_2 (Silicon nitride/ Silicon dioxide)
C. Interconnect:	Al/0.5%Cu with Ti/TiN Barrier
D. Backside Metallization:	None
E. Minimum Metal Width:	0.8 microns (as drawn)
F. Minimum Metal Spacing:	0.8 microns (as drawn)
G. Bondpad Dimensions:	5 mil. Sq.
H. Isolation Dielectric:	SiO_2
I. Die Separation Method:	Wafer Saw

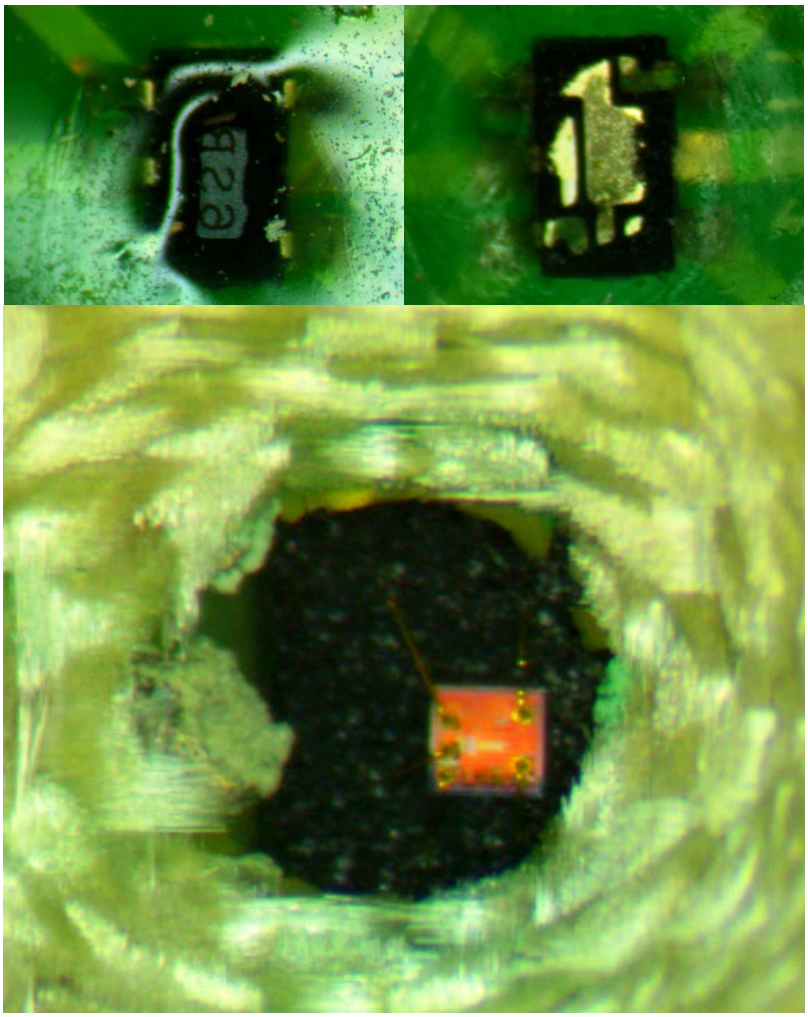


Figure 2: MAX4595 die test prep

The schematic for the switching circuit is shown in Figure 3, however resistance was added in parallel to give different loads on the three devices. Each part had its own power supply, but shared a crystal for clocking all at the same frequency with a 50% duty cycle. The picture of this board with the daughter card in its socket is shown in Figure 4.

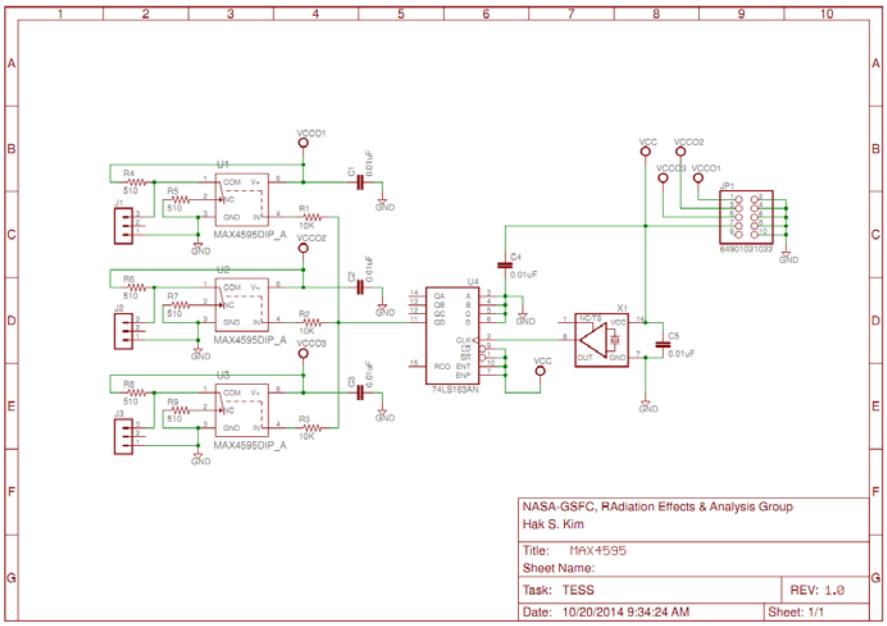


Figure 3: Test board schematic

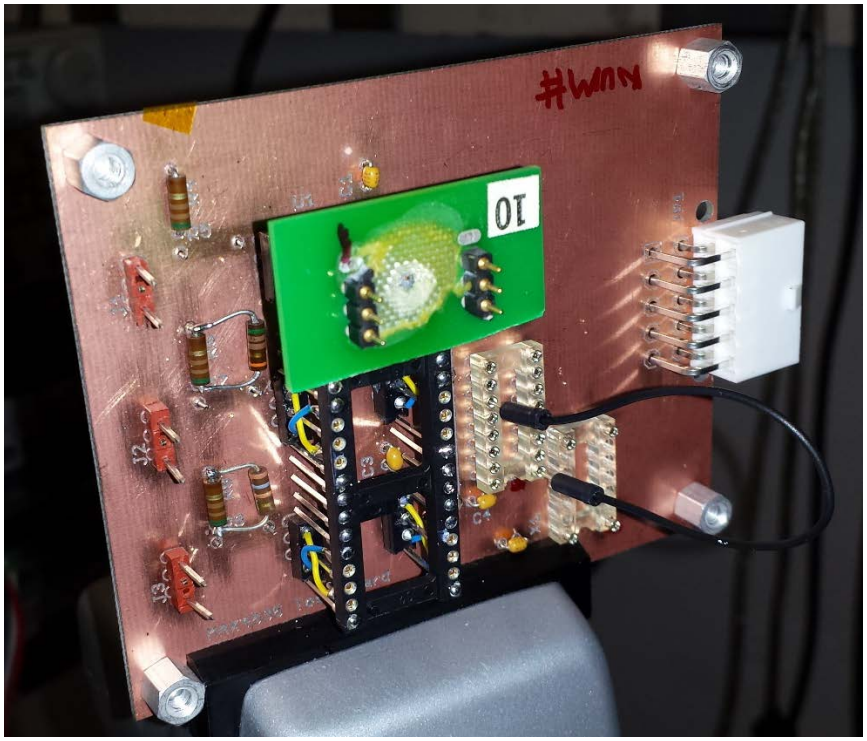


Figure 4: Test board for MAX4595.

Test Method

Test Description

Temperature: Room temperature, >70C (Latch test)
Test Voltages: 3.3V, 5V, 6V

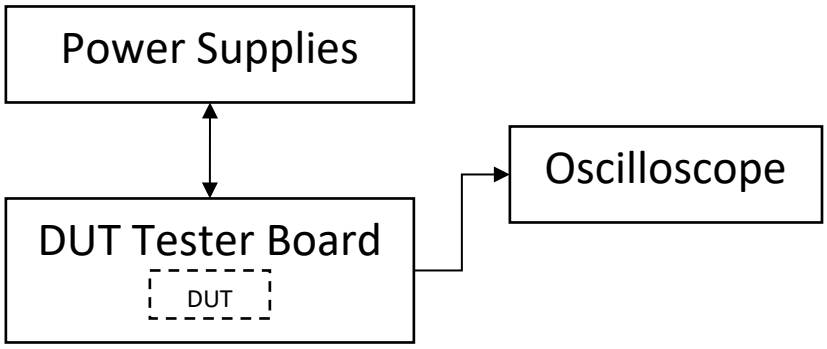


Figure 5: Block diagram of test setup where the dashed line represents the components exposed to the heavy-ion beam and/or laser.

Testing of the TI MAX4595 involved positioning the daughter card and circuit card in the beam line at TAMU, Figure 6a and 6b show the device in the beam aligned. Only one device at a time was in the beam while running. Thermal paste can be seen on the front of the die where a thermistor was placed to monitor device temperature.

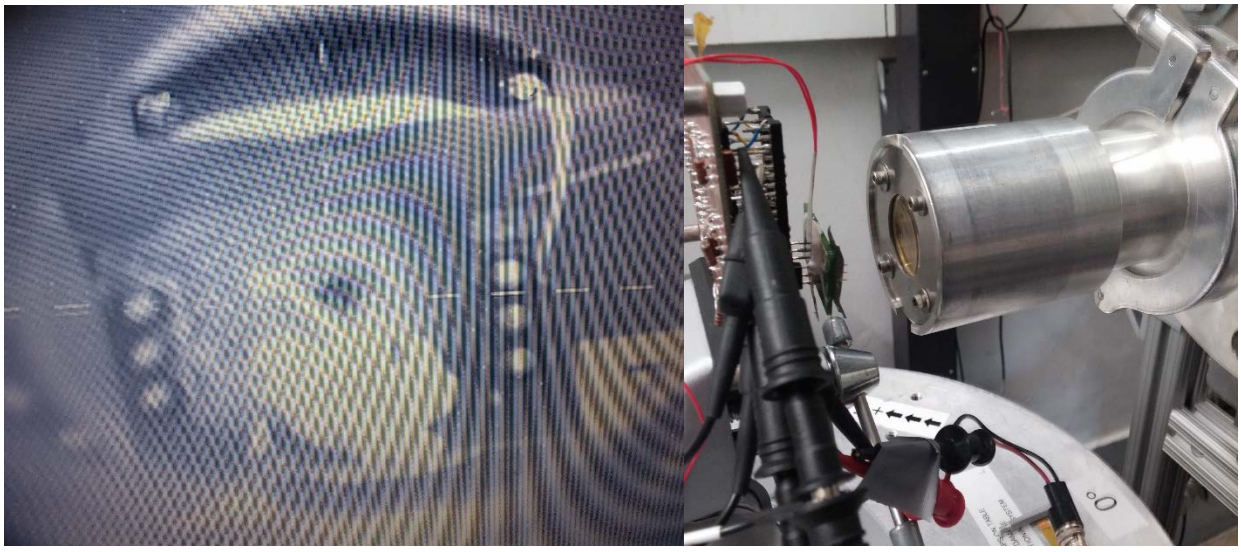


Figure 6a and 6b: Photo of MAX4595 in the beam line.

Test Facility

Texas A&M University Cyclotron Facility (TAMU) was used to bombard the device with the following ions at the 15 MeV/amu tune.

Table 3:

Ion	LET (MeV-cm2/mg)*	Range (um)*
Kr	27.8	134
Xe	51.5	119.7
Au	85.4	118.1

*at 30mm air-gap

Flux: The range was chosen from 10^2 to 10^4 ions/cm^2/s which gave stable beams

Fluence: SEL irradiations were continued until either latch-up was observed or a fluence of 10^7 ions/cm^2/s was reached. SEL was assumed to occur if a current twice the magnitude of the stand-by current was observed during irradiation.

Results

At first changes in that pulse width were monitored for deviations, and later a dc supply was given to a single part to capture transient waveforms with an oscilloscope trigger.

Destructive Single Event Effects

There were no destructive single event effects capture during the testing.

Single Event Transient (SET) Response

During single event testing, an added interest of transients arose due to the parts' response and not recording latch up. Removing the clock and feeding a DC voltage to the part to hold the switch high resulted in obtaining transients of the following form: negative going as shown in Figure 7.

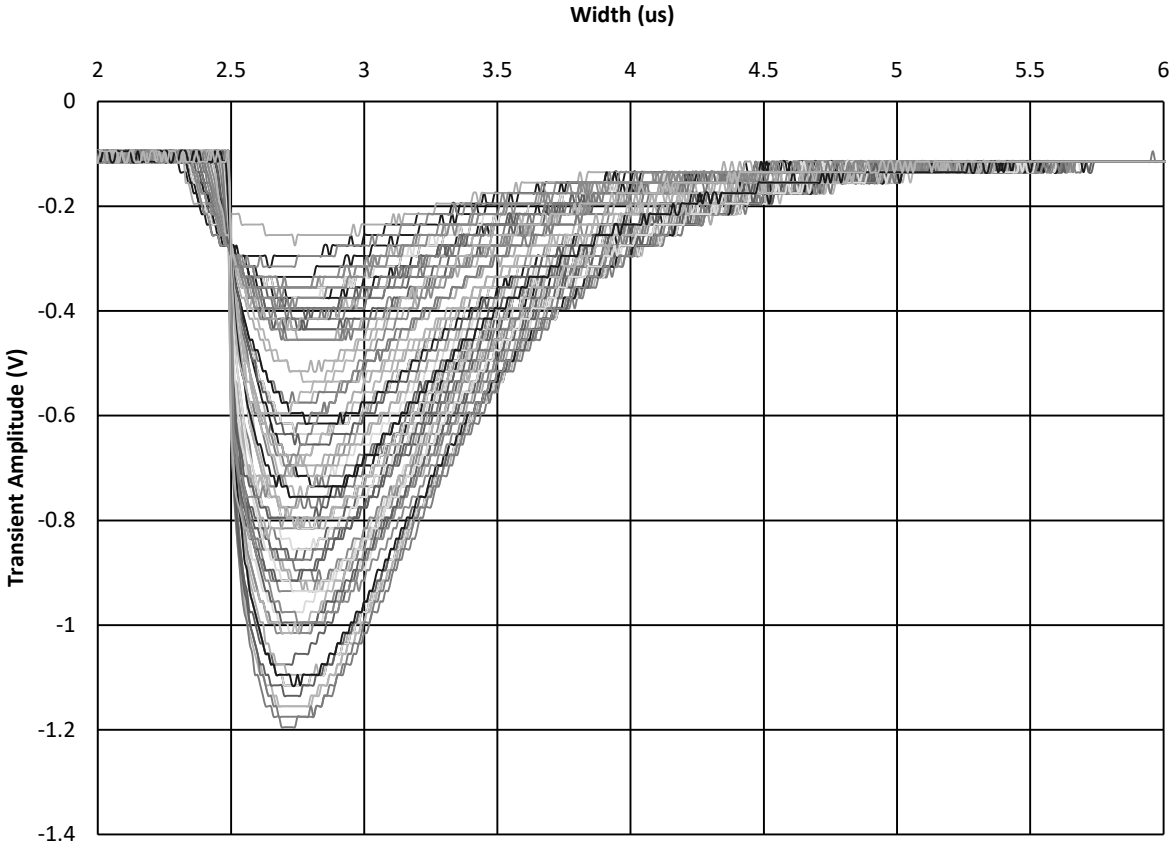


Figure 7: SET captures for one run of the MAX4595

The typical transient that was captured was around 2.5us long and -750mV in amplitude. The Figure 8 below shows all of the transients captured with histograms and the probability density function of the dataset in contour lines.

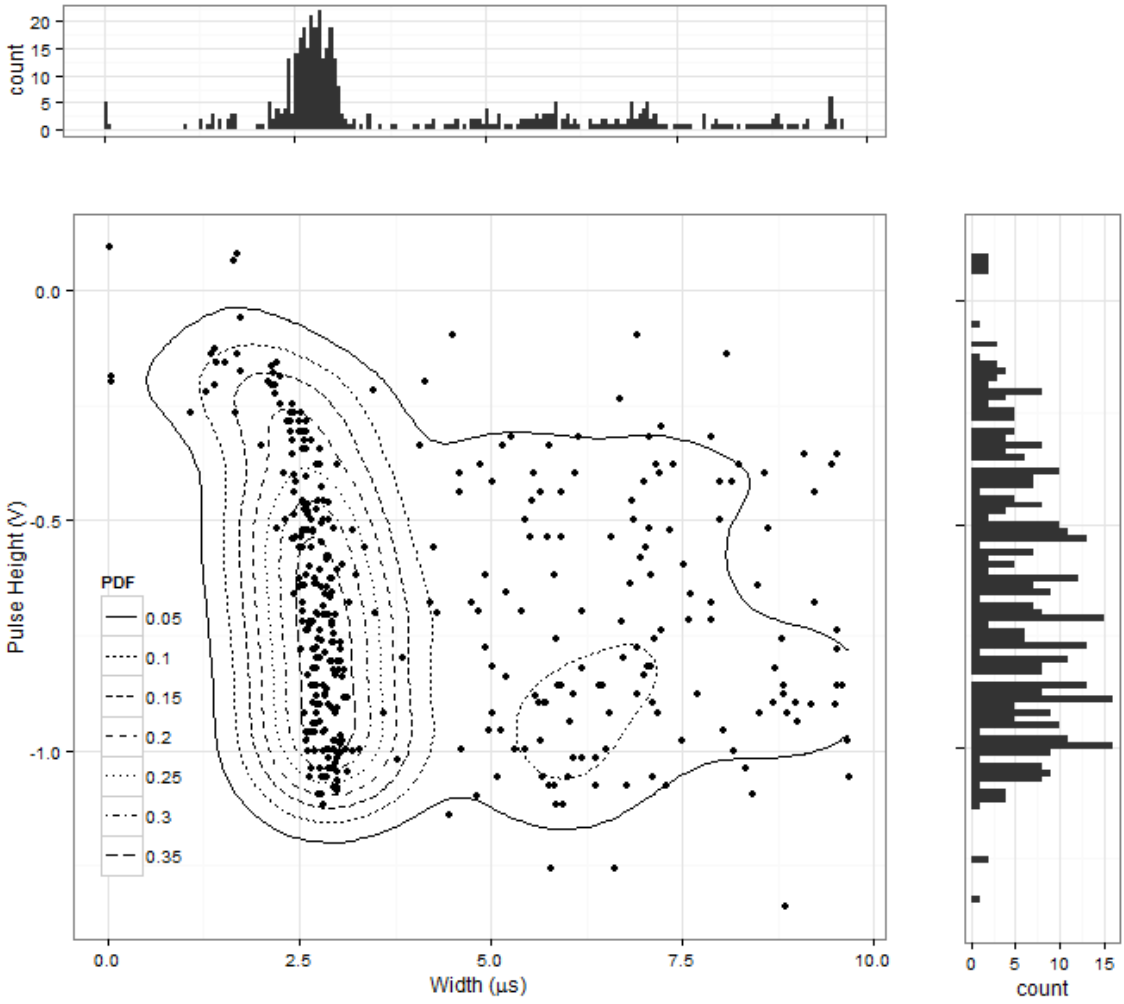


Figure 8: All recorded transients shown with histograms for pulse width and pulse height as well as contour lines for the probability density function of the dataset

Conclusions

The functionality of the MAX4595 was retained through all testing and no destructive single event effects were recorded for the LET tested at both room and elevated temperatures. The transients that were captured were at worst 10us long and had negative going amplitudes of less than 1.5V if these types of transients do not disrupt the parts intended application it may be considered for applications exposed to heavy ions. Degradation testing of the device due to Total Ionizing Dose was not explored and these results do not qualify as a lot specific test.

References

http://www.ti.com/lit/ds/symlink/max4595.pdf

Run Log

Slit_width_/_Roll_angle	Slit_height_/_Unused	Al_degrader_number	Degrader_angle	Target_material	Al_thickness(mil)	Number_of_layers(file)	DUT_location
-120.537_deg	0.100_in	-0.000_steps	0.000_deg	silicon	0	3_(30_mm_air)	In-air

Run #	Selected_beam	Beam_ energy (MeV/amu)	Beam_ energy (MeV)	Nominal_LET (MeVcm²/mg)	Nominal_ range (um)	Eff._LET (MeVcm²/mg)	Eff._range (um)	Eff._fluence (ions/cm²)	Dose (rad)	Live_ time (s)	Aver._flux (ions/(cm2s))	Aver._ flux_error (%)	Overall_ uniformity (%)	Overall Central _shift (%)	Calibration _factor	DUT_X_ coordinate	DUT_Y_ coordinate	DUT_Z _coordinate	DUT_tilt_angle	Detector_bias (V)
1	15.0_MeV/u__Kr	12.3	1032	27.8	134	32.1	116	3.01E+06	1.55E+03	108.283	3.21E+04	0.085	93	5	1.06634	0.094_in	1.518_in	-8.062_cm	30.000_deg	371_350_360_361_311
2	15.0_MeV/u__Kr	12.3	1032	27.8	134	32.1	116	2.99E+06	1.54E+03	183.933	1.88E+04	0.085	84	12	1.06543	0.094_in	1.518_in	-8.062_cm	30.000_deg	371_350_360_361_311
3	15.0_MeV/u__Kr	12.3	1032	27.8	134	27.8	134	3.00E+06	1.34E+03	136.7	2.19E+04	0.091	90	6	1.14751	-0.659_in	1.522_in	-7.628_cm	0.000_deg	371_350_360_361_311
4	15.0_MeV/u__Kr	12.3	1032	27.8	134	27.8	134	3.00E+06	1.34E+03	146.883	2.04E+04	0.091	91	6	1.09856	-0.659_in	1.522_in	-7.628_cm	0.000_deg	371_350_360_361_311
5	15.0_MeV/u__Kr	12.3	1032	27.8	134	27.8	134	3.01E+06	1.34E+03	114.75	2.62E+04	0.091	92	5	1.07103	-0.684_in	2.417_in	-7.825_cm	0.000_deg	371_350_360_361_311
6	15.0_MeV/u__Kr	12.3	1032	27.8	134	27.8	134	3.00E+06	1.34E+03	115.333	2.60E+04	0.091	93	5	1.02806	-0.684_in	2.417_in	-7.825_cm	0.000_deg	371_350_360_361_311
7	15.0_MeV/u__Kr	12.3	1032	27.8	134	29.6	125.9	3.00E+06	1.43E+03	96.4833	3.31E+04	0.088	95	3	1.05135	-0.172_in	2.407_in	-8.013_cm	20.000_deg	371_350_360_361_311
8	15.0_MeV/u__Kr	12.3	1032	27.8	134	29.6	125.9	3.00E+06	1.42E+03	178.733	1.79E+04	0.088	91	7	1.07097	-0.172_in	2.407_in	-8.013_cm	20.000_deg	371_350_360_361_311
9	15.0_MeV/u__Kr	12.3	1032	27.8	134	32.1	116	3.00E+06	1.55E+03	122.117	2.84E+04	0.085	93	4	1.0966	0.094_in	3.246_in	-8.062_cm	30.000_deg	371_350_360_361_311
10	15.0_MeV/u__Kr	12.3	1032	27.8	134	32.1	116	3.01E+06	1.55E+03	107.05	3.24E+04	0.085	91	6	1.10062	0.094_in	3.246_in	-8.062_cm	30.000_deg	371_350_360_361_311
11	15.0_MeV/u__Kr	12.3	1032	27.8	134	27.8	134	3.00E+06	1.34E+03	114.8	2.61E+04	0.091	93	5	1.1623	-0.634_in	3.267_in	-7.628_cm	0.000_deg	371_350_360_361_311
12	15.0_MeV/u__Kr	12.3	1032	27.8	134	27.8	134	3.00E+06	1.34E+03	111.483	2.69E+04	0.091	92	5	1.15587	-0.634_in	3.267_in	-7.628_cm	0.000_deg	371_350_360_361_311
13	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.00E+06	2.48E+03	115.717	2.60E+04	0.091	90	7	1.12119	-0.634_in	3.267_in	-7.628_cm	0.000_deg	341_301_341_321_271
14	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.01E+06	2.48E+03	157.683	1.91E+04	0.091	89	8	1.01996	-0.634_in	3.267_in	-7.628_cm	0.000_deg	341_301_341_321_271
15	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	54.8	112.5	3.00E+06	2.64E+03	136.217	2.35E+04	0.088	93	4	1.30716	-0.172_in	3.246_in	-8.013_cm	20.000_deg	341_301_341_321_271
16	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	54.8	112.5	3.00E+06	2.63E+03	153.583	2.08E+04	0.089	88	8	1.25185	-0.172_in	3.246_in	-8.013_cm	20.000_deg	341_301_341_321_271
17	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	59.5	103.7	3.01E+06	2.86E+03	124.267	2.79E+04	0.085	88	9	1.13873	0.094_in	3.246_in	-8.062_cm	30.000_deg	341_301_341_321_271
18	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	59.5	103.7	2.99E+06	2.85E+03	174.2	1.98E+04	0.085	81	14	1.03051	0.094_in	3.246_in	-8.062_cm	30.000_deg	341_301_341_321_271
19	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.00E+06	2.47E+03	136.5	2.19E+04	0.091	87	9	1.02075	-0.684_in	2.417_in	-7.825_cm	0.000_deg	341_301_341_321_271
20	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.00E+06	2.47E+03	200.167	1.50E+04	0.091	92	5	1.00127	-0.684_in	2.417_in	-7.825_cm	0.000_deg	341_301_341_321_271
21	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.00E+06	2.47E+03	207.433	1.45E+04	0.091	94	4	0.978141	-0.684_in	2.417_in	-7.825_cm	0.000_deg	341_301_341_321_271
22	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.00E+06	2.48E+03	119.083	2.52E+04	0.091	81	15	0.96354	-0.684_in	2.417_in	-7.825_cm	0.000_deg	341_301_341_321_271
23	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.00E+06	2.47E+03	186.25	1.61E+04	0.091	90	6	1.06967	-0.684_in	2.417_in	-7.825_cm	0.000_deg	341_301_341_321_271
24	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.01E+06	2.48E+03	169.2	1.78E+04	0.091	83	14	1.24671	-0.684_in	2.417_in	-7.825_cm	0.000_deg	341_301_341_321_271
25	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.00E+06	2.48E+03	253.05	1.19E+04	0.091	81	17	1.10463	-0.684_in	2.417_in	-7.825_cm	0.000_deg	341_301_341_321_271
26	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.01E+06	2.48E+03	155.033	1.94E+04	0.091	89	7	1.20069	-0.634_in	3.267_in	-7.628_cm	0.000_deg	341_301_341_321_271
27	15.0_MeV/u__Xe	11.7	1512	51.5	119.7	51.5	119.7	3.00E+06	2.47E+03	242.25	1.24E+04	0.091	82	14	1.28085	-0.634_in	3.267_in	-7.628_cm	0.000_deg	341_301_341_321_271
28	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	1.01E+06	1.38E+03	37.2	2.72E+04	0.16	96	3	1.04751	-0.634_in	3.267_in	-7.628_cm	0.000_deg	330_298_338_320_280

Run #	Selected_beam	Beam_ energy (MeV/amu)	Beam_ energy (MeV)	Nominal_LET ($MeVcm^2/mg$)	Nominal_ range (um)	Eff._LET ($MeVcm^2/mg$)	Eff._range (um)	Eff._fluence ($ions/cm^2$)	Dose (rad)	Live_ time (s)	Aver._flux (ions/(cm2s))	Aver._ flux_error (%)	Overall_ uniformity (%)	Overall Central _shift (%)	Calibration _factor	DUT_X_ coordinate	DUT_Y_ coordinate	DUT_Z _coordinate	DUT_tilt_angle	Detector_bias (V)
29	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	3.01E+06	4.12E+03	112.817	2.67E+04	0.091	96	2	1.04996	-0.634_in	3.267_in	-7.628_cm	0.000_deg	330_298_338_320_280
30	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	3.00E+06	4.11E+03	116.967	2.57E+04	0.091	95	3	1.04539	-0.634_in	3.267_in	-7.628_cm	0.000_deg	330_298_338_320_280
31	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	2.99E+06	4.10E+03	115.617	2.59E+04	0.091	95	3	1.05756	-0.634_in	3.267_in	-7.628_cm	0.000_deg	330_298_338_320_280
32	15.0_MeV/u__Au	11.4	2247	85.4	118.1	90.9	111	3.00E+06	4.38E+03	123.75	2.58E+04	0.088	94	4	1.06971	-0.172_in	3.246_in	-8.013_cm	20.000_deg	330_298_338_320_280
33	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	3.00E+06	4.10E+03	131.383	2.28E+04	0.091	93	5	1.03499	-0.634_in	3.267_in	-7.628_cm	0.000_deg	330_298_338_320_280
34	15.0_MeV/u__Au	11.4	2247	85.4	118.1	98.6	102.3	2.99E+06	4.73E+03	167.967	2.06E+04	0.085	93	5	1.04718	0.094_in	1.518_in	-8.062_cm	30.000_deg	330_298_338_320_280
35	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	1.00E+05	1.37E+02	228.467	4.38E+02	0.5	90	8	1.05391	-0.684_in	1.522_in	-7.628_cm	0.000_deg	330_298_338_320_280
36	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	1.27E+05	1.73E+02	274.033	4.62E+02	0.44	91	7	1.05391	-0.684_in	1.522_in	-7.628_cm	0.000_deg	330_298_338_320_280
37	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	4.09E+04	5.60E+01	87.45	4.68E+02	0.78	89	8	1.05391	-0.684_in	1.522_in	-7.628_cm	0.000_deg	330_298_338_320_280
38	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	2.47E+04	3.38E+01	49.75	4.97E+02	1	91	6	1.05391	-0.684_in	1.522_in	-7.628_cm	0.000_deg	330_298_338_320_280
39	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	1.00E+05	1.37E+02	199.517	5.02E+02	0.5	90	7	1.05391	-0.684_in	1.522_in	-7.628_cm	0.000_deg	330_298_338_320_280
40	15.0_MeV/u__Au	11.4	2247	85.4	118.1	85.4	118.1	1.47E+05	2.01E+02	249.967	5.87E+02	0.41	91	7	1.05391	-0.684_in	1.522_in	-7.628_cm	0.000_deg	330_298_338_320_280
41	15.0_MeV/u__Au	11.4	2247	85.4	118.1	90.9	111	1.90E+05	2.76E+02	321.017	6.29E+02	0.35	91	7	1.05391	-0.172_in	1.522_in	-8.013_cm	20.000_deg	330_298_338_320_280
42	15.0_MeV/u__Au	11.4	2247	85.4	118.1	90.9	111	6.06E+03	8.83E+00	10.9333	5.90E+02	2	91	5	1.05391	-0.172_in	1.522_in	-8.013_cm	20.000_deg	330_298_338_320_280
43	15.0_MeV/u__Au	11.4	2247	85.4	118.1	90.9	111	1.44E+05	2.10E+02	321.167	4.77E+02	0.4	94	4	1.05391	-0.172_in	1.522_in	-8.013_cm	20.000_deg	330_298_338_320_280
44	15.0_MeV/u__Au	11.4	2247	85.4	118.1	90.9	111	1.41E+05	2.05E+02	298.35	5.02E+02	0.41	92	5	1.05391	-0.172_in	1.522_in	-8.013_cm	20.000_deg	330_298_338_320_280