SINGLE EVENT EFFECTS
TEST REPORT

Test Type:	Heavy ion
Test facility:	REF, TAMU, College station, Tx, USA
Test Date:	August 2013, June 2014, November 2014
Part Type:	STP24NF10
Part Description:	N-channel 100V - 0.0055Ω - 26A - TO-220 Low gate charge STripFET™ II Power MOSFET
Part Manufacturer:	STMicroelectronics

ESA contract n° 4000105495/12/NL/SFe dated 27/2/2012

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DOCUMENTATION CHANGE NOTICE

Issue	Date	Page	Change Item	
01	03/06/2016	All	Original issue	
02	09/08/2016		Addition of Table 3 and Figure 10 on SEB Vds thresholds as a function of ion species and deposited charge.	

<u>Contributors to this work:</u>

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SEE TEST REPORT

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1 Glossary

DUT: Device under test.

Fluence (of particle radiation incident on a surface): The total amount of particle radiant energy incident on a surface in a given period of time, divided by the area of the surface.
In this document, Fluence is expressed in ions per cm2.

Flux: The time rate of flow of particle radiant energy incident on a surface, divided by the area of that surface.
In this document, Flux is expressed in ions per cm2*s.

Single-Event Effect (SEE): Any measurable or observable change in state or performance of a microelectronic device, component, subsystem, or system (digital or analog) resulting from a single energetic particle strike.
Single-event effects include single-event upset (SEU), multiple-bit upset (MBU), multiple-cell upset (MCU), single-event functional interrupt (SEFI), single-event latch-up (SEL), single-event gate rupture (SEGR), single-event burnout (SEB).

Single-Event Gate rupture (power mosfet) (SEGR): An event in which a single energetic-particle strike results in a breakdown and subsequent conducting path through the gate oxide of a MOSFET.

Sijngle-Event Burnout (SEB): An event in which a single energetic-particle strike induces a localized high-current state in a device, resulting in a catastrophic failure. SEB can be destructive and the use ofa protection limiting current resistor in serie with the drain supply allows for getting non destructive SEB during testing.

Error cross-section: the number of errors per unit fluence. For device error cross-section, the dimensions are cm2 per device. For bit error cross-section, the dimensions are cm2 per bit.

Tilt angle: tilt angle, rotation axis of the DUT board is perpendicular to the beam axis; roll angle, board rotation axis is parallel to the beam axis
Weibull fit: $F(x) = A (1- \exp\{-[(x-x_0)/W]^s\})$ with:

x = effective LET in MeV/(mg/cm^2);
$F(x)$ = SEE cross-section in cm^2;
A = limiting or plateau cross-section;
x_0 = onset parameter, such that $F(x) = 0$ for $x < x_0$;
W = width parameter;
s = a dimensionless exponent.

Error bars: error bars are computed using a confidence level of 95% and a beam flux uncertainty of +/-10% as recommended by Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100.

2 Introduction

This report presents the results of Heavy Ions test program carried out on STP24NF10 part type from STMicroelectronics. STP24NF10 samples were used for heavy ions testing at REF, TAMU, College station, Tx, USA.
This work was performed for ESA under ESA contract n° 4000105495/12/NL/SFe dated 27/2/2012.

3 Applicable and Reference Documents

3.1 Applicable Documents

AD-1. Hirex proposal « Test Methods, Requirements, and Guidelines for Evaluation of Radiation Sensitivity of Analog to Digital Converters (ADC), Digital to Analog Converters (DAC) and Vertical Power MOSFETs» HRX/PRO/3624 Issue 01 /2011/10/12.
AD-2. STP24NF10, STMicroelectronics datasheet, August 2006 Rev 7.

3.2 Reference Documents

RD-1. Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100.

4 DEVICE INFORMATION

4.1 Device description

STP24NF10 is an N-channel 100V - 0.0055Ω - 26A - TO-220
Low gate charge STripFET™ II Power MOSFET.

Part type:	STP24NF10
Manufacturer:	STMicroelectronics
Manufacturer lot number:	-
Datecode:	-
Package:	TO-220
Top marking:	P24NF10 640EB V3 CHN 130 logo e3
Die dimensions:	2064µ x 2625µ

4.2 Sample identification

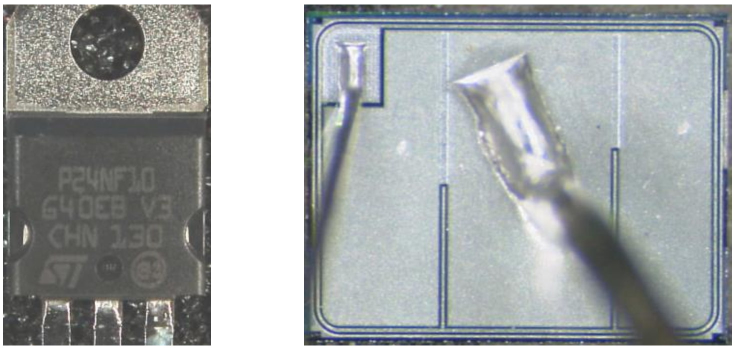


Photo 1 – Device top view Photo 2 – Die full view

Figure 1: STP24NF10 device identification

4.3 Die microsection

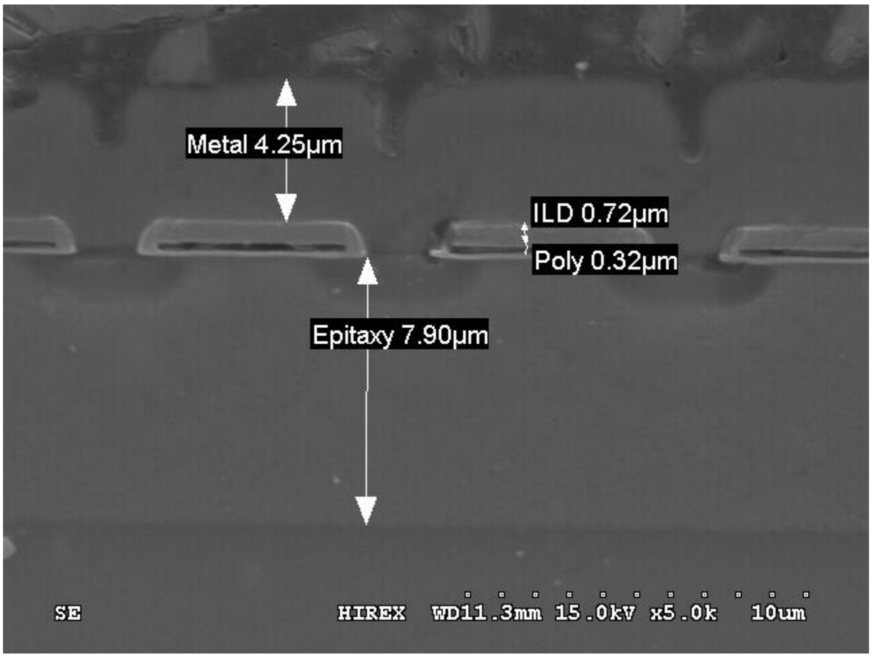


Figure 2 -STP24NF10 die microsection

4.4 Sample preparation

Samples are opened by chemical etching.

5 TAMU Facility (REF)

Test at the cyclotron accelerator was performed at Texas A & M in College Station - TX- USA.
This facility includes a special beam line dedicated to irradiation studies of semiconductor components and devices. Testing may be conducted in either 30" diameter vacuum chamber or with in-air positioning system . Both provide precise positioning in x, y, and z as well as rotations up to 60 degrees. Positioning and dosimetry are carried out by custom-made SEUSS software.

In Air Station

The in-air station is located at the end of dedicated beam-line. The station consists of a rotating platform and a removable target mounting fixture. The target positioning assembly allows the motion of the target in four directions: X, Y, Z and Theta. X and Y are the horizontal and the vertical axis in the target plane, respectively. The Z-axis is in the direction of the beam-line, with theta being the clockwise and counter-clockwise rotation about the y-axis. Target position verification is provided by the means of a CCD camera aligned with the beam path and a narrow laser beam that crosses the beam path at the center of the target chamber. The size of the exposed area is controlled by the aperture defined by a pair of remotely adjustable horizontal and vertical slits.

Vacuum Station

Vacuum station has an inside diameter of 30inch and a height 30inch.Pumping time to an operating pressure in the low 10 -4 Torr range is approximately ten minutes and the chamber vents to gaseous nitrogen in two and half minutes. Target positioning system allows X, Y, Z and Theta moving. Like for in air station, the position is checked with the means of a CCD camera.

Ion Beam

Various ion beams are available for the Radiation Effects Facility. These beams provide for a wide scope of LET with high energies for deep part penetration. Time for beam species changes will vary, but with species that have the same energy per nucleon change times is about one half hour.
Beams can be delivered with a high degree of uniformity over a 1.8" x 1.8" cross sectional area for measurements inside the vacuum chamber and 1" diameter circular cross sectional area for the in-air station. Uniformity is achieved by means of magnetic defocusing.
A degrader foil system makes it possible to set the desired beam LET value at a particular depth inside the target without changing the beam or rotating the target. The beam energy is reduced by means of a degrader system with foils having a suitable thickness and orientation with respect to the incident beam. Each foil can be inserted, withdrawn, and rotated remotely through use of computer controls.
The intensity of any beam is easily regulated over a broad range spanning several orders of magnitude in a matter of seconds. This can be done by the operator on duty at the users request.
The target exposure system is fully automated. Exposure can be set for a certain time, total accumulated fluence, or can be manually stopped at any time.

Beam Quality control

The beam uniformity and flux are determined using an array of five detectors. Each detector is made up with a plastic scintillator coupled to photo-multiplier tubes. Four of the detectors are fixed in position and set up to measure beam particle counting rates continuously at four characteristic points 1.64 inches (4.71 mm) away from the beam axis. The fifth scintillator can be optionally put in to measure the beam particle counting rate right at the beam axis. The sensitive area of each detector is defined by a 0.1 cm^2 aperture, while the intrinsic efficiency is 100% for all practical purposes. The beam uniformity parameter (ranging from 0 to 100%), the axial gain (%), and the beam flux (in particles/cm^2/s) are determined by the control software based on the detector counting rates. The results are displayed and updated once every second.

Dosimetry

The current TAMU Cyclotron dosimetry system and procedures were used.

Figure 3 shows the TAMU facility different beam lines. K500 (88”) cyclotron is used to inject beam in Radiation Effects Facility (REF) cave.

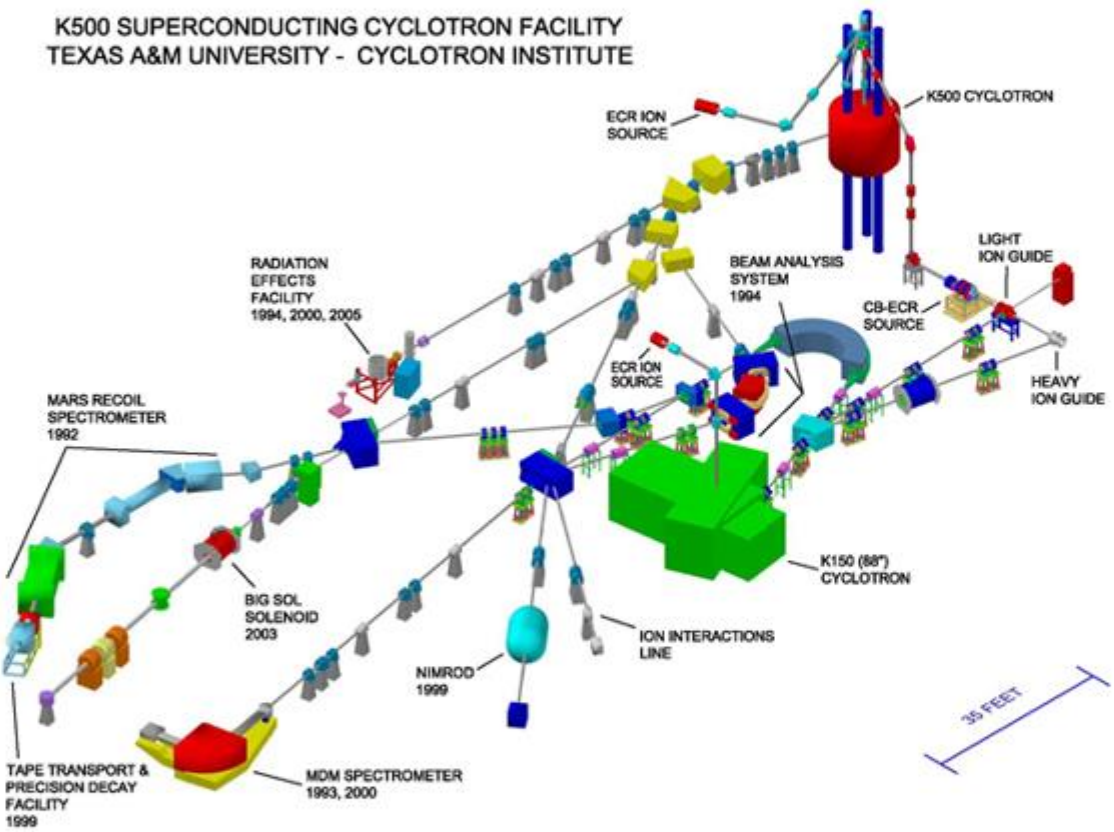


Figure 3 – TAMU facility beam lines (http://cyclotron.tamu.edu/facilities.html)

6 Test Set-up

The test set-up is composed of 4 main parts as shown in the following Figure 4 :

- DUTs board
- Set of Agilent Source Monitor Units (HP4142)
- V5 ASERT test board mounted with a 400 Msps digitizer
- A laptop running a Graphical User Interface

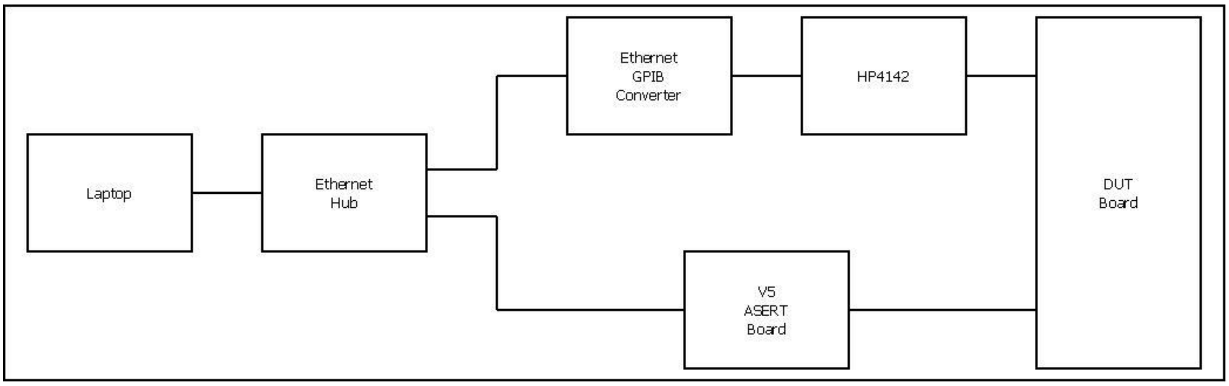


Figure 4 - Test set-up block diagram

6.1 DUTs board:

The DUTs board can hold up to 16 DUTs (2 rows by 8 columns). Each row (or line) as detailed on the Figure 5 is supplied by a set of 2 SMUs (Source Monitor Units) supplying drain and gate supplies. A drain sense is outputted from each line. A relay system allows the dynamic selection of:

- The DUT
- The bias included on the input and output conditioning systems

Input and output conditioning systems as well as DUTs are integrated on daughter boards plugged on the DUTs board.

The 2 lines are fully independent allowing the irradiation of 2 DUTs close by at the same time.

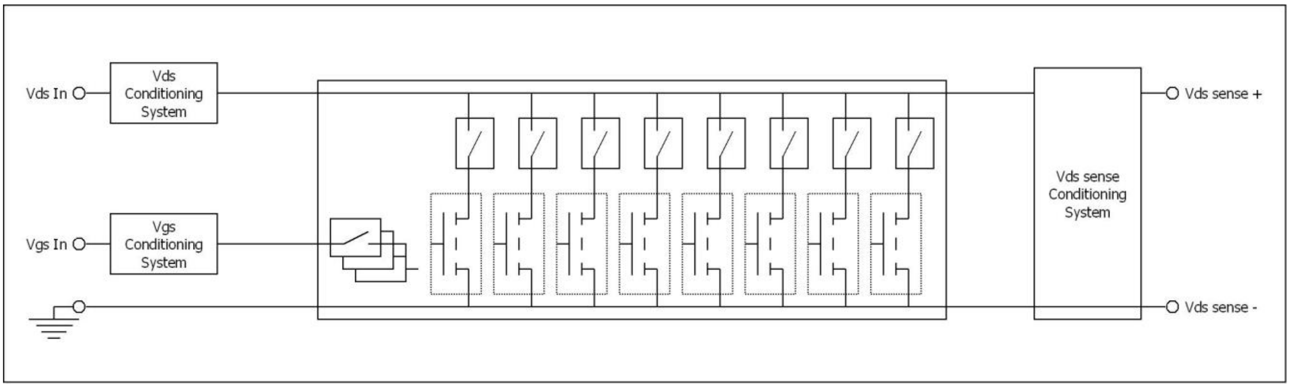


Figure 5 - DUTs board - One line schematic

The used bias is detailed on the following Figure 6.

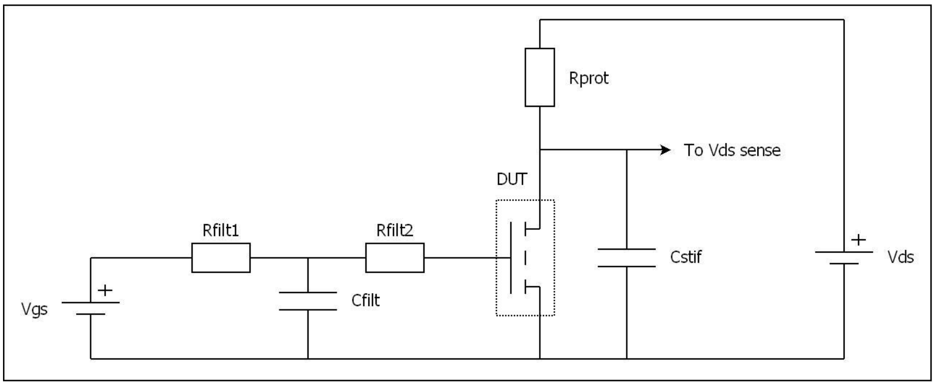


Figure 6 - Bias schematic

6.2 Agilent set of Source Monitor Units

The sourcing and monitoring of the DUT’s drain and gate supplies (voltages and currents) are performed using a set of Agilent SMUs (Source Monitor Units) HP4142 featuring the following ranges:

- For the gate: HP41421B: 40µV - 100 V / 20 fA - 100 mA
- For the drain: HP41423A: 2 mV - 1000 V / 2 pA - 2 mA

This set of SMUs is controlled remotely by the Graphical User Interface through an Ethernet/GPIB converter.

6.3 V5 ASERT test board

The V5 ASERT test board is used to:

- Monitor the bias through the relay system.
- Digitize (using a 400Msps digitizer) the drain sense signal. The digitizer is configured to trig on level voltage of both channels (lines). For each test conditions, high and low thresholds are set. All events higher than the high threshold or lower than the low threshold trig the digitizer and data are plotted and recorded on the computer.

6.4 Graphical User Interface

The GUI running on the computer mainly allows the:

- Selection of the DUT
- Control of the bias
- Choice of test conditions
- Monitoring of the SMUs
- Display of currents graphs
- Management of the test sequence

6.5 Test sequence

The basic sequence used to test was the following:

- Pre run test: Initial gate stress
- Pre run test: On / Off test
- Run test: Start off test
- Run test:: exposition
  Run test: Stop off test
- Post run test: Post gate stress (PIGS)

The On / Off test is performed at the beginning of each run before the irradiation. This test is used to verify the functionality of the device.
The Off test is the test achieved during the irradiation.
Gate Stress test is carried out at the beginning and at the end of the each run. This test is used to verify the integrity of the gate. For a selected drain voltage, a voltage cycle (between the upper and lower absolute maximum ratings) is applied on the gate.

7 SEE Test Results

7.1 Ions selection

The selection of the different ions and energies was performed in compliance with the following requirements:

> Each device type shall be tested with at least four ion types. Two of the ion types shall have an atomic number 25 < Z < 37 (group 1). The two other ion types shall have an atomic number 45 < Z < 55 (group 2). One of the ion type belonging of each group shall be tested for at least three energies: worst-case energy (corresponding to maximum deposited charge in sensitive volume), one energy that satisfies ion range requirements of Table 2, and a high-energy (≥40 MeV/u). The calculation of the worst case energy shall be detailed in the test plan. The second ion type of each group shall be tested at one energy such as the mean LET in EPI layer is similar to mean LET in EPI corresponding to one of the selected energies with the first ion.

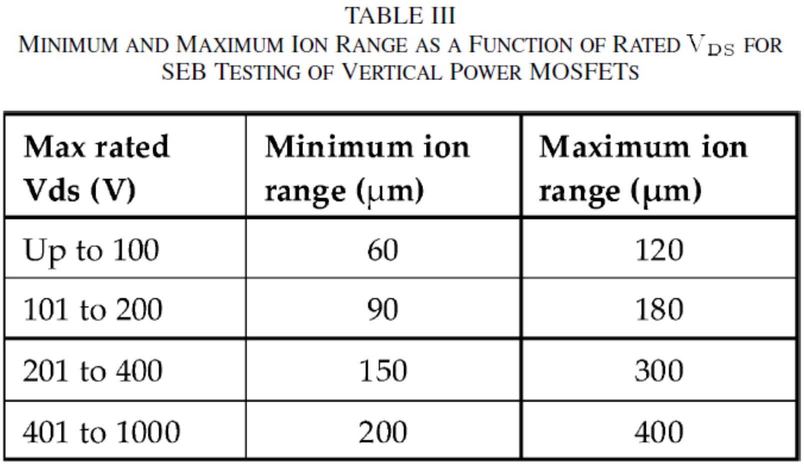


TABLE III
MINIMUM AND MAXIMUM ION RANGE AS A FUNCTION OF RATED V_{DS} FOR SEB TESTING OF VERTICAL POWER MOSFETS

Max rated Vds (V)	Minimum ion range (μm)	Maximum ion range (μm)
Up to 100	60	120
101 to 200	90	180
201 to 400	150	300
401 to 1000	200	400

(Table III Charge Collection in Power MOSFETs for SEB Characterisation—Evidence of Energy Effects, V. Ferlet-Cavrois *et al., IEEE TNS, VOL. 57, NO. 6, DECEMBER 2010)*

Table 1 – Ion range requirements

Copper and Kryptons ions, Cu (Z=29), Kr (Z=36), have been selected for the group 1 while Silver and Xenon, Ag(Z=47), Xe (Z=54) have been selected for the group 2.
SRIM 2013 was used to compute the critical charge deposited,energy deposited, the average LET value.
A dead layer equivalent to 5µm of Aluminum (noted 4(1) in detailed run results in Table 4) was used during the first test campaign (y13w35), a sandwich of 4.25 µm of Aluminum, 0.7 µm of inter layer dielectric (ILD) and 0.3 µm of gate polysilicon noted 5(2) in detailed run results in Table 4. Epitaxy depth was set to 8µm according to the die microsection results (see § 4.3
The different ion beams selected are detailed in Table 2 where R correspond to the silicon surface level below the dead layer. TAMU interface is based on SRIM 2005 computations and then some minor differences have been observed with SRIM 2013 computations. Table 2 identifies also the beam selected during the three different test slots.

SRIM 2013 computation						TAMU beam selection						
Ion	Q	R	LET at R	E at R	Mean_LET	Cocktail	Energy	degrader	Eff. LET	y13w353	y14w26	y14w48
	pC	µm	MeV/ (mg/cm²)	MeV	MeV/ (mg/cm²)		MeV		MeV/ (mg/cm²)			
Kr_wc	3.3652	32	40.76	238.8	40.8	**15MeV**	**239**	**yes**	**40.4**	y	y	
Kr	2.591	106	30.99	855.7	31.42	**15MeV**	**856**	**yes**				
Kr	2.3709	132	28.44	1034.8	28.75	**15MeV**	**1034**	**no**	**27.8**	y		
Kr high	1.2406	568	15	2999.7	15.04	**40MeV**	**2996**	**no**	**14.6**	y	y	y
Cu	2.5902	40	30.6	262.6	31.41	**15MeV**	**263**	**yes**	**29.2**		y	
Xe_wc	5.7057	44	69.15	539.7	69.18	**15MeV**	**540**	**yes**	**62**			y
Xe	4.7098	108	56.51	1475.9	57.11	**25MeV**	**1476**	**yes**				
Xe	4.5983	116	55.17	1579.6	55.75	**25MeV**	**1581**	**yes**	**50.8**	y		
Ag	4.7109	54	56.31	604.7	57.12	**15MeV**	**605**	**yes**	**51**			y

Table 2 – Ion beam setting

7.2 Run tests

All tests were performed in air and at room temperature.
Resistor protection was set to 10kOms.
The detailed list of runs performed at TAMU during the three test campains is provided in Table 4.
One or two samples can be tested at the same time with same or different test biasing conditions

Figure 1 shows Example of the data recorded for each dut under test and each test run.
In this figure, one can observe the initial get stress followed by on/off condition then under off condition, beam is started until the desired fluence, then when run is stopped, a post gate stress is performed.
Actual final beam fluence value is listed in Table 4 while in this figure the computed flux is based on the recorded data from one scintillator only instead of the four scintillator detectors used by the accelerator interface.
Please note that Igs current plot can exhibit a scale factor (1e-8 in the present case)
The recorded sebs are identified by a blue triangle which are detected using 0.93 V threshold value (15 tester LSBs, 1 LSB=62mV)
All data recorded for the different runs and duts are provided in a companion document ref. HRX/SEE/474-appendix issue1.

Figure 8 and Figure 9 show the cumul of the non destructive SEBs for 2 different runs.

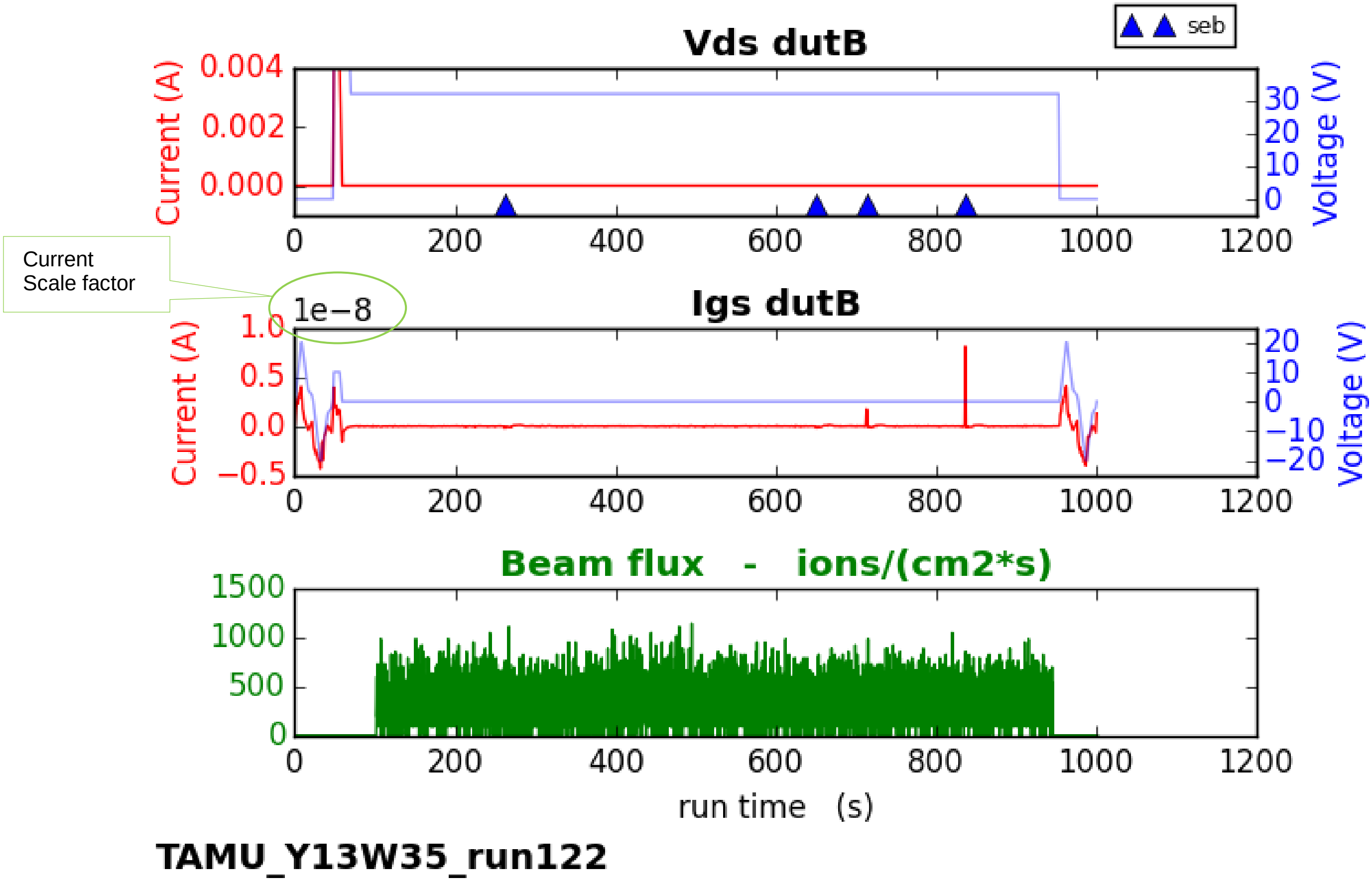
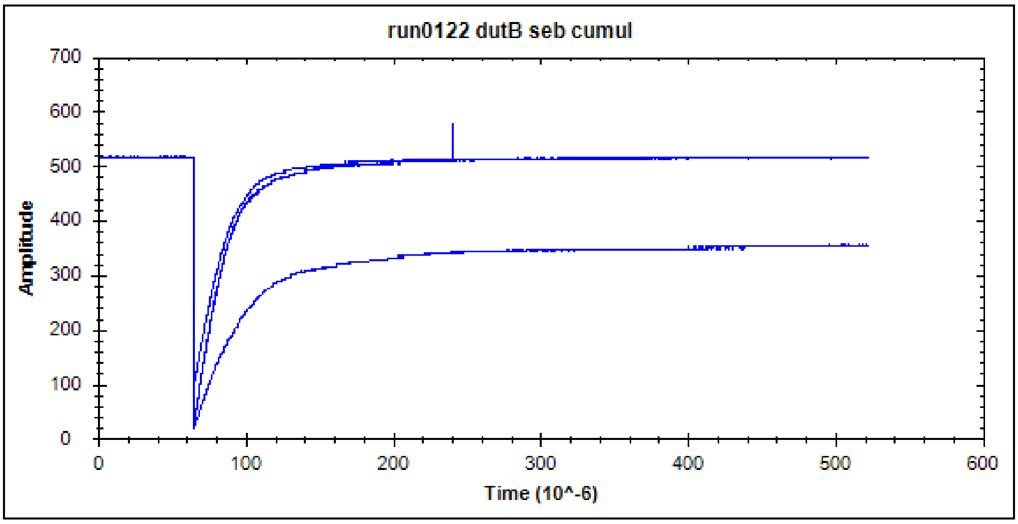
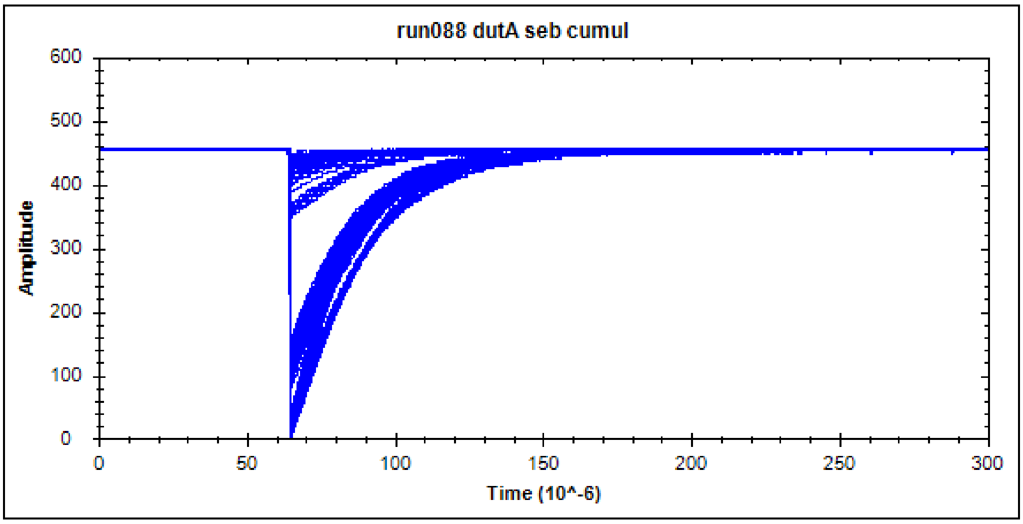


Figure 7 – Example of the data recorded for each dut under test and each test run.



Amplitude is measured in tester LSBs (1 LSB correspond to 62mV)

Figure 8 – SEBs recorded during y13w35 run0122 (see Figure 7)



Amplitude is measured in tester LSBs (1 LSB correspond to 62mV)

Figure 9 – SEBs recorded during y13w35 run088 (1042 SEBs)

7.3 Discussion

During first test campaign, samples delidding operation was not optimum (preopening subcontracted outside Hirex) and not all samples under test were under nominal conditions. For the two other campaigns, all deliding tasks were performed at Hirex site with a better control.

SEB VDS voltage threshold is clearly different between the 2 groups, above or equal to 28V for Group 1 while below or equal to 25V for group 1 (apart from some results of the first test campaign) as shown in Table 3 and Figure 10.

Ion group	Ion	Ion, LET	Computed charge in critical volume Q (pC)	Test slot	SEB threshold (V)
Group 1	Kr High energy	Kr, 14.6	1.24	y13w35	around 32
		Kr, 14.6	1.24	y14w26	between 28 and 30
	Kr_wc	kr, 40.4	3.37	y13w35	between 27.5 and 28.5
	Kr	Kr, 27.8	2.37	y13w35	between 30 and 35
	Cu	Cu, 29.2	2.59	y14w26	around 31
Group 2	Xe_wc	Xe, 62.1	5.71	y14w26	between 24 and 25
		Xe, 62.1	5.71	y14w48	between 23 and 24
	Xe	Xe, 50.8	4.60	y13w35	Above 27.5 on 2 samples around 25 on 1 sample
		Xe, 51.9	4.71	y14w26	between 23 and 24
	Ag	Ag, 50.9	4.71	y14w26	between 23 and 24
		Ag, 50.9	4.71	y14w48	around 24

Table 3 – SEB Vds thresholds as a function of ion species and deposited charges

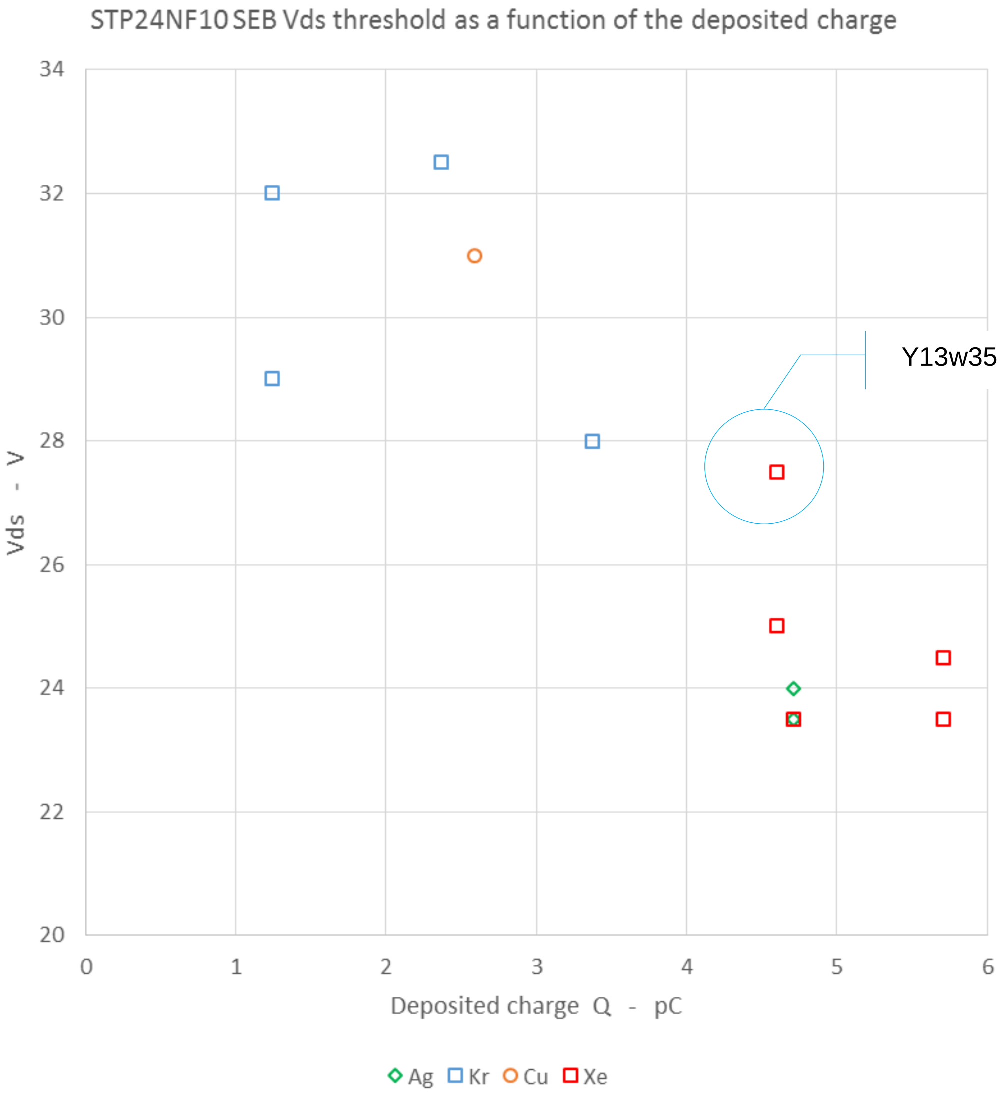


Figure 10 – STP24NF10, SEB Vds threshold as a function of the deposited charge

test campaign	medium	run_number	Facility_run_number	DUT_board	dut_part_id	Selected_beam cocktail MeV/u	Ion	LET	roll	tilt	Al_thickness(mil)	Number_of_layers(file)	Beam_energy(MeV)	Eff._LET(MeVcm2/mg)	Eff._range(um)	Eff._fluence(ions/cm2)	Dose(rad)	run_duration live_time	Aver._flux(ions/(cm2s))	VgsA	vdsA	seb	VgsB	vdsB	seb	SEGR	comment
y13w35	air	2	35	MOS2	12, 13	15	Kr	40	0	0	3.611	4 (1)	239	40.4	30.8	3.00E+05	194	462.483	649	0	25	0	0	25	0	√	
y13w35	air	3	36	MOS2	12, 13	15	Kr	40	0	0	3.611	4 (1)	239	40.4	30.8	3.50E+04	22.7	45.5167	769	0	30	38	37	30	39	√	
y13w35	air	5	37	MOS2	12, 13	15	Kr	40	0	0	3.611	4 (1)	239	40.4	30.8	3.00E+05	195	343.417	875	0	27.5	0	0	27.5	0	√	
y13w35	air	7	38	MOS2	12, 13	15	Kr	40	0	0	3.611	4 (1)	239	40.4	30.8	3.00E+05	194	560.117	535	0	28.5	4	0	28.5	4	√	
y13w35	air	8	39	MOS2	12, 13	15	Kr	40	0	0	3.611	4 (1)	239	40.4	30.8	2.57E+04	16.7	365.65	70.4	0	33	232	0	33	260	√	1 measure at 1µA on Igs dutA
y13w35	air	10	40	MOS5	18, 19	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	2.60E+04	11.6	305.933	85	0	33	3	0	33	3	√	
y13w35	air	11	41	MOS5	18, 19	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	1.84E+04	8.19	218.367	84.2	0	37	6	0	37	9	√	
y13w35	air	12	42	MOS5	18, 19	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	1.95E+04	8.67	230.683	84.4	0	41	52	0	41	38	√	
y13w35	air	13	43	MOS5	18, 19	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	1.90E+05	84.5	255.633	742	0	41	288	0	41	37	√	ids dutA increase to 12µA
y13w35	air	14	44	MOS5	18, 19	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	1.99E+05	88.5	355.517	559	0	37	4	0	37	0	√	ids dutA is 74µA
y13w35	air	21	46	MOS6	20,21	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	3.00E+05	134	655.567	458	0	28.5	0	0	28.5	0	√	
y13w35	air	22	47	MOS6	20, 21	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	3.00E+05	134	706.683	425	0	30	2	0	30	0	√	
y13w35	air	23	48	MOS6	20, 21	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	1.03E+05	45.8	237.317	433	0	35	1	0	35	7	√	increase of both dutA and dutB Ids ; Noise (trigs) on vdsB
y13w35	air	27	50	MOS3	15	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	3.00E+05	134	545.817	549	0	-	-	0	30	13	√	
y13w35	air	28	51	MOS3	15	15	Kr	40	0	0	0	4 (1)	1034	27.8	134.4	5.20E+04	23.2	93.4833	556	0	-	-	0	35	1	√	1 seb together with ids dutB degradation: dutB dead
y13w35	air	87	107	MOS6	20, 21	24.8	Xe	50.8	0	0	4.373	4 (1)	1581	50.8	125.5	3.00E+05	244	877.05	342	0	27.5	0	0	27.5	0	√	
y13w35	air	88	108	MOS6	20, 21	24.8	Xe	50.8	0	0	4.373	4 (1)	1581	50.8	125.5	3.00E+05	244	988.167	304	0	30	1042	0	30	28	√	
y13w35	air	89	109	MOS6	20, 21	24.8	Xe	50.8	0	0	4.373	4 (1)	1581	50.8	125.5	3.00E+05	244	719.283	417	0	28.9	172	0	31.1	362	1	dutB fail post gate stress
y13w35	air	90	110	MOS7	22, 23	24.8	Xe	50.8	0	0	4.373	4 (1)	1581	50.8	125.5	3.00E+05	244	842.233	356	0	25	1	0	25	1	√	2 small events
y13w35	air	118	131	MOS7	22, 23	40	Kr	14.6	0	0	0	4 (1)	3000	14.6	585.7	3.00E+05	70.3	707.833	424	0	34	5	0	0	-	√	tuning Vds 30 to 34
y13w35	air	122	135	MOS8	24, 25	40	Kr	14.6	0	0	0	4 (1)	3000	14.6	585.7	3.00E+05	70.3	842.533	356	0	0	-	0	32	4	√	
y14w26	air	17	14	A	B	40	Kr		0	0	0	5 (2)	3000	14.6	585.5	1.00E+06	234	946.833	1060	0	-	-	0	30	44	√	
y14w26	air	18	15	A	B	40	Kr		0	0	0	5 (2)	3000	14.6	585.5	3.02E+05	70.7	295.333	1020	0	-	-	0	28	1	√	
y14w26	air	19	16	B	A&B	40	Kr		0	0	0	5 (2)	3000	14.6	585.5	3.01E+05	70.5	277.833	1080	0	28	0	0	28	4	√	

test campaign	medium	run_number	Facility_run_number	DUT_board	dut_part_id	Selected_beam cocktail MeV/u	Ion	LET	roll	tilt	Al_thickness(mil)	Number_of_layers(file)	Beam_energy(MeV)	Eff._LET(MeVcm2/mg)	Eff._range(um)	Eff._fluence(ions/cm2)	Dose(rad)	run_duration live_time	Aver._flux(ions/(cm2s))	VgsA	vdsA	seb	VgsB	vdsB	seb	SEGR	comment
y14w26	air	20	17	B	A&B	40	Kr		0	0	0	5 (2)	3000	14.6	585.5	1.00E+06	234	962.083	1040	0	30	32	0	30	47	√	
y14w26	air	21	18	C	A&B	40	Kr		0	0	0	5 (2)	3000	14.6	585.5	5.00E+05	117	537.2	931	0	30	94	0	30	25	√	partly open
y14w26	air	22	19	C	A&B	40	Kr		0	0	0	5 (2)	3000	14.6	585.5	3.03E+05	71	338.667	896	0	28	12	0	28	3	√	partly open
y14w26	air	23	20	C	A&B	40	Kr		0	0	0	5 (2)	3000	14.6	585.5	3.00E+05	70.1	378.667	791	0	27	2	0	27	0	√	partly open
y14w26	air	76	69	A	A&B	15	Cu		0	0	3.369	5 (2)	263	29.2	39.3	301000	141	99.4167	3030	0	28	0	0	28	0	√	
y14w26	air	77	70	A	A&B	15	Cu		0	0	3.369	5 (2)	263	29.2	39.3	301000	141	106.417	2820	0	30	0	0	30	2	√	
y14w26	air	78	71	A	B	15	Cu		0	0	3.369	5 (2)	263	29.2	39.3	300000	140	116.233	2580	0	32	0	0	32	183	√	
y14w26	air	83	75	C	A&B	15	Cu		0	0	3.369	5 (2)	263	29.2	39.3	301000	141	104.35	2880	0	30	4	0	30	0	√	
y14w26	air	84	76	C	A&B	15	Cu		0	0	3.369	5 (2)	263	29.2	39.3	301000	141	98.4167	3050	0	31	33	0	31	5	√	
y14w26	air	85	77	C	A&B	15	Cu		0	0	3.369	5 (2)	263	29.2	39.3	300000	140	94.05	3190	0	30	4	0	30	0	√	
y14w26	air	134	124	E	A&B	15	Xe		0	0	0	6 (3)	1504	51.6	119.1	3.00E+05	248	129.033	2330	0	15	0	0	15	0	√	wrong layer
y14w26	air	136	125	E	A&B	15	Xe		0	0	2.588	5 (2)	540	62.1	45.7	2.99E+05	298	146.7	2040	0	15	0	0	15	0	√	
y14w26	air	137	126	E	A&B	15	Xe		0	0	2.588	5 (2)	540	62.1	45.7	3.00E+05	298	134.033	2240	0	20	0	0	20	0	√	
y14w26	air	138	127	E	A&B	15	Xe		0	0	2.588	5 (2)	540	62.1	45.7	1.69E+05	168	77.35	2190	0	25	75	0	25	86	√	
y14w26	air	139	128	E	A&B	15	Xe		0	0	2.588	5 (2)	540	62.1	45.7	3.01E+05	300	130.283	2310	0	22	0	0	22	0	√	
y14w26	air	140	129	E	A&B	15	Xe		0	0	2.588	5 (2)	540	62.1	45.7	3.00E+05	299	122.55	2450	0	23	0	0	23	0	√	
y14w26	air	142	131	E	A&B	15	Xe		0	0	2.588	5 (2)	540	62.1	45.7	3.00E+05	299	525.6	571	0	24	163	0	24	92	√	
y14w26	air	144	133	E	A&B	15	Xe		0	0	2.588	5 (2)	540	62.1	45.7	8.40E+04	83.6	554.95	151	0	25	267	0	25	259	√	
y14w26	air	145	134	F	A&B	15	Xe		0	0	2.588	5 (2)	540	62.1	45.7	3.01E+05	299	390.217	770	0	23	0	0	23	0	√	
y14w26	air	146	135	F	A&B	15	Xe		0	0	2.588	5 (2)	540	62.1	45.7	3.00E+05	298	296.3	1010	0	24	174	0	24	0	√	a lot of small events
y14w26	air	167	156	E	A&B	15	Ag		0	0	1.037	5 (2)	991	45.5	89.9	3.00E+05	218	259.067	1160	0	25	3	0	25	1	√	wrong energy
y14w26	air	168	157	E	A&B	15	Ag		0	0	2.241	5 (2)	605	50.9	55.4	3.00E+05	244	253.817	1180	0	25	124	0	25	250	√	
y14w26	air	169	158	E	A&B	15	Ag		0	0	2.241	5 (2)	605	50.9	55.4	3.00E+05	244	257.967	1160	0	23	0	0	24	0	√	
y14w26	air	170	159	E	A&B	15	Ag		0	0	2.241	5 (2)	605	50.9	55.4	3.00E+05	244	217.15	1380	0	24	0	0	24.5	6	√	
y14w26	air	171	160	E	A&B	15	Ag		0	0	2.241	5 (2)	605	50.9	55.4	3.00E+05	245	231.95	1290	0	24	4	0	24	0	√	
y14w26	air	172	161	E	A&B	15	Ag		0	0	2.241	5 (2)	605	50.9	55.4	3.00E+05	244	240.417	1250	0	25	357	0	25	0	√	
y14w26	air	173	162	E	A&B	15	Ag		0	0	2.241	5 (2)	605	50.9	55.4	3.00E+05	244	244.133	1230	0	24.5	79	0	26	141	√	
y14w26	air	199	186	E	A&B	24.8	Xe		0	0	4.672	5 (2)	1477	51.9	116.8	3.01E+05	250	286.217	1050	0	23	0	0	23	0	√	
y14w26	air	200	187	E	A&B	24.8	Xe		0	0	4.672	5 (2)	1477	51.9	116.8	3.00E+05	249	284.333	1060	0	24	2	0	24	0	√	

test campaign	medium	run_number	Facility_run_number	DUT_board	dut_part_id	Selected_beam cocktail MeV/u	Ion	LET	roll	tilt	Al_thickness(mil)	Number_of_layers(file)	Beam_energy(MeV)	Eff._LET(MeVcm2/mg)	Eff._range(um)	Eff._fluence(ions/cm2)	Dose(rad)	run_duration live_time	Aver._flux(ions/(cm2s))	VgsA	vdsA	seb	VgsB	vdsB	seb	SEGR	comment
y14w26	air	201	188	E	A&B	24.8	Xe		0	0	4.672	5 (2)	1477	51.9	116.8	3.00E+05	249	293.267	1020	0	25	17	0	25	8	√	
y14w26	air	202	189	E	A&B	24.8	Xe		0	0	4.672	5 (2)	1477	51.9	116.8	3.00E+05	249	306.217	980	0	26	386	0	26	243	√	
y14w26	air	203	190	F	A&B	24.8	Xe		0	0	4.672	5 (2)	1477	51.9	116.8	3.00E+05	250	314.767	954	0	23	0	0	23	0	√	
y14w26	air	204	191	F	A&B	24.8	Xe		0	0	4.672	5 (2)	1477	51.9	116.8	3.00E+05	249	365.75	821	0	24	2	0	24	0	√	
y14w26	air	205	192	F	A&B	24.8	Xe		0	0	4.672	5 (2)	1477	51.9	116.8	3.00E+05	249	306.667	978	0	25	63	0	25	2	√	
y14w26	air	206	193	F	A&B	24.8	Xe		0	0	4.672	5 (2)	1477	51.9	116.8	3.00E+05	249	344.9	870	0	25	71	0	26	9	√	
y14w26	air	207	194	F	A&B	24.8	Xe		0	0	4.672	5 (2)	1477	51.9	116.8	3.00E+05	249	328.917	912	0	25	82	0	27	235	√	
y14w48	air	56	88	2A	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	1.52E+05	151	187.767	809		25	59	-	-	-	√	-
y14w48	air	57	89	2A	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	3.00E+05	299	434.267	691		20	0	-	-	-	√	-
y14w48	air	58	90	2A	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	3.00E+05	299	380.35	789		22	0	-	-	-	√	-
y14w48	air	60	91	2A	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	3.00E+05	298	412.717	727		24	1	-	-	-	√	-
y14w48	air	61	92	2B	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	1.49E+05	148	190.7	782		24	22	-	-	-	√	-
y14w48	air	62	93	2B	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	3.00E+05	299	390.45	769		23	0	-	-	-	√	-
y14w48	air	63	94	2C	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	3.00E+05	299	461.967	650		23	0	-	-	-	√	-
y14w48	air	64	95	2C	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	1.83E+05	182	290.4	631		24	26	-	-	-	√	-
y14w48	air	65	96	2C	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	3.00E+05	299	475.683	632		22	0	-	-	-	√	-
y14w48	air	66	97	2C	up	15	Xe		0	0	2.373	5 (2)	540	62.1	45.7	3.00E+05	299	474.433	633		21	0	-	-	-	√	-
y14w48	air	96	126	D	up	15	Ag		0	0	2.027	5 (2)	605	50.9	55.4	2.43E+04	19.8	18.9667	1280		25	56	-	-	-	√	-
y14w48	air	97	127	D	up	15	Ag		0	0	2.027	5 (2)	605	50.9	55.4	3.00E+05	244	253.867	1180		22	0	-	-	-	√	-
y14w48	air	98	128	D	up	15	Ag		0	0	2.027	5 (2)	605	50.9	55.4	3.00E+05	245	259.3	1160		24	21	-	-	-	√	-
y14w48	air	99	129	G	up	15	Ag		0	0	2.027	5 (2)	605	50.9	55.4	3.00E+05	244	199.283	1500		24	0	-	-	-	√	-
y14w48	air	100	130	G	up	15	Ag		0	0	2.027	5 (2)	605	50.9	55.4	3.00E+05	244	241.183	1240		25	169	-	-	-	√	-

Table 4 – REF, August 2013 (y13w35), June 2014 (y14w26) and November 2014 (y14w48), STP24NF10, run table