

SEE Test Report V4.0  
Heavy ion SEE test of SMSA2812D from Interpoint  
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## I. Introduction

This study was undertaken to determine the single event destructive and transient susceptibility of the SMSA2812D, Dual DC/DC Converters, for transient interruptions in the output signal and for destructive events induced by exposing it to a heavy ion beam at the Radiation Effects Facility at the Cyclotron Institute located on the campus of Texas A&M University (TAMU). This test was performed for the potential use in electronic circuitry for the Magnetospheric Multiscale (MMS) project. MMS is one of the missions of the Solar Terrestrial Probes (STP) Program of NASA's Science Mission Directorate Heliophysics Division. MMS comprises of four identically instrumented spacecraft that will use Earth's magnetosphere as a laboratory to study the microphysics of three fundamental plasma processes: magnetic reconnection, energetic particle acceleration, and turbulence. These processes occur in all astrophysical plasma systems but can be studied in situ only in our solar system and most efficiently only in Earth's magnetosphere, where they control the dynamics of the geospace environment and play an important role in the processes known as space weather.

## II. Devices Tested

The sample size of Device Under Test (DUT) for testing was two. Each device was exposed to the radiation beam and the results will be compared for verification. For the SMSA2812D, the test samples code markings for DUT1 were SN-0830 & DUT2 SN-0832 with DC-0733 on both. The device is packaged in an 8-pin lead metal can package. The device was prepped for test by delidding. The SMSA series of high frequency DC/DC converters are low power devices that provide up to 5 watts output power over the full military temperature range of -55C to +125C with up to 76% efficiency. Their small size, light weight, and hermetically sealed metal packages make them ideal for use in space, military, aerospace and other high reliability applications.

The SMSA converters are switching regulators that use a flyback converter design with constant switching frequency of 500kHz. They are regulated, isolated units using a pulse width modulated topology and built as high reliability thick-film hybrids. Isolation between input and output circuits is provided with a transformer in the forward power loop and an optical link in the feedback control loop. Excellent input line transient response. Negative output regulation is maintained by tightly coupled magnetic. Predictable current limit is accomplished by direct monitoring of the output load current, which results in a constant current output above the overload point. Internal input and output filters eliminate the need for external capacitors.

### III. Test Facility

**Facility:** Texas A&M Cyclotron Radiation Effects Facility, 15 MeV/u beams

**Flux:**  $5.65 \times 10^2$  to  $6.49 \times 10^5$  particles/cm<sup>2</sup>/s.

**Fluence:** For destructive events, all tests were ran to  $1 \times 10^7$  p/cm<sup>2</sup> or until destructive events occurred

For non destructive events, all tests were ran to  $1 \times 10^7$  p/cm<sup>2</sup> or until a sufficient (>100) number of transient events occurred.

The ions and LET values planned for these tests were Kr, Xe, Ta, & Au.

### IV. Test Conditions and Error Modes

**Test Temperature:** Room Temperature

**Bias conditions**  $V_{in} = 28V$ ,  $V_{out} = +/-12V$

See Figure 2 for detailed conditions

	<b>Vsupply (V)</b>	<b>Isupply (mA)</b>	<b>Vin (V)</b>	<b>Loading %</b>
DUT 1	+12/-12	33	28V	0
DUT 2	+12/-12	33	28V	0
DUT 1	+12/-12	95	28V	30
DUT 2	+12/-12	94	28V	30
DUT 1	+12/-12	135	28V	50
DUT 2	+12/-12	135	28V	50
DUT 1	+12/-12	175	28V	70
DUT 2	+12/-12	175	28V	70
DUT 1	+12/-12	236	28V	100
DUT 2	+12/-12	303	28V	100

Table 1: Test conditions

**PARAMETERS OF INTEREST:** Power supply currents, output voltage

**SEE Conditions:** SEL, SEGR, SET

## V. Test Methods

The block diagram, as shown in Figure 1, for the DC-DC Converters contains a power supply for +/- input voltages, an electronic load, a DUT board for the test circuitry and devices, a computer for GPIB control of measurement equipment, and a digital scope to capture any output anomalies, and after the desired voltage input is applied, each of the two device outputs will display on the digital scope, which is set to trigger on voltages that are above or below a predetermined threshold (set to 250 mV). Each device output was tested one after each other.

Table 1, shows the test conditions where tests were conducted for an input nominal voltage of 28V and also with worse case conditions of 21V and 35V with no load, 30%, 50%, 70%, and 100% loading. Figure 2, shows the test schematic circuit of the SMSA2812D and Figure 3, shows the device and test board mounted at the beam at TAMU.

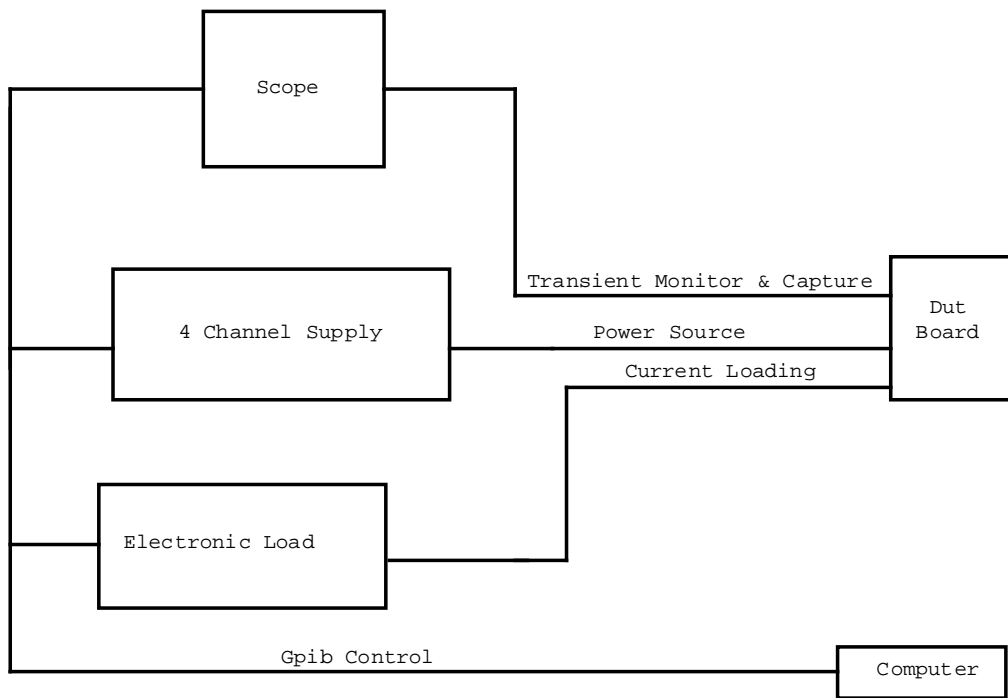


Figure 1. Overall Block Diagram for the testing of the SMSA2812D

## VI. Test Performance

- Destructive test at high LET ( $\geq 78.2 \text{ MeVcm}^2/\text{mg}$ ) on 2 parts and one part at LET ( $\geq 86.3 \text{ MeVcm}^2/\text{mg}$ ) up to a fluence of  $10^7 \text{ \#/cm}^2$ .
- SET test on 2 parts for 2 LET values for each device output and each condition described in Table 1.

## SMSA2812D DC-DC Converter Schematic Diagram

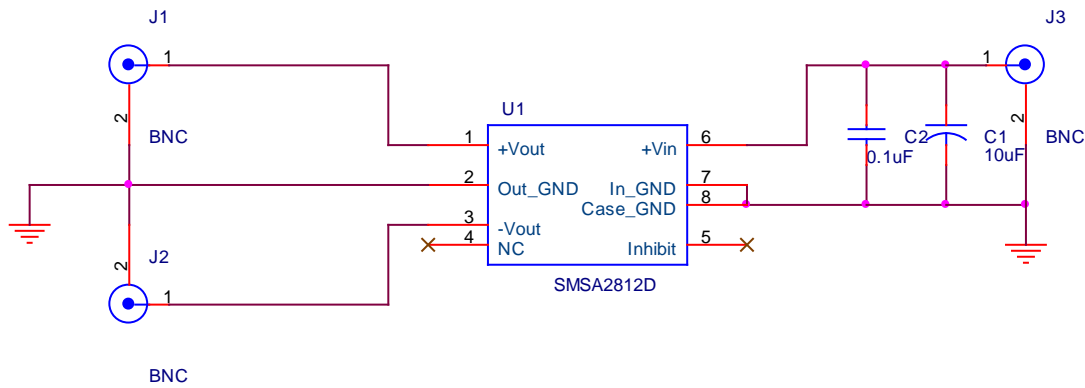


Figure 2. SMSA2812D Test Schematic Circuit

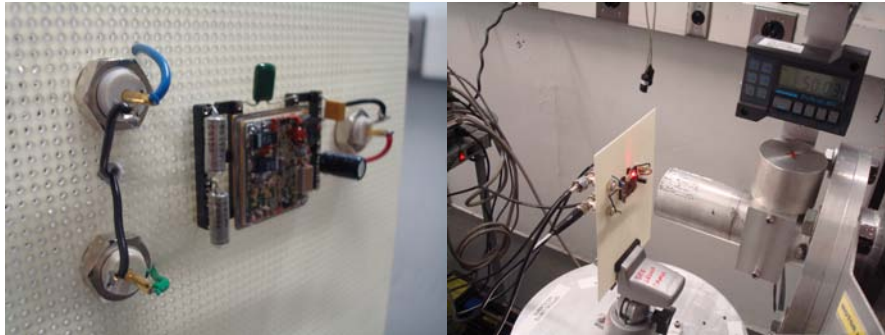


Figure 3. SMSA2812D under test at TAMU

## VII. Test Results

Detailed test results are shown in Table 2 below. The devices were exposed from a fluence of  $9.93 \times 10^4$  to  $1.02 \times 10^7$  particles/cm<sup>2</sup> of the Krypton, Xenon, Tantalum, and Gold ion beams. Observations for destructive and non-destructive events were for energies up to the maximum LET of 53.1 MeV-cm<sup>2</sup>/mg at normal angle of incidence and up to a maximum LET of 86.3 MeV-cm<sup>2</sup>/mg at an angle of 45 degrees. There were no destructive events observed for the SMSA2812D, but the device was sensitive to SETs and did experience transient events that can be mitigated with using the appropriate LC filtering circuitry in conjunction with this DC-DC converter, with the worse case occurring around 300mV of peak spikes and 700us for worse case width duration. Charts 1 & 2 show the worse case transients and Chart 3 shows the SET cross sections observed. The tests were run with an input of 28V at no load, 30%, 50%, 70, and 100% loading conditions with a few additional runs at 21V, & 35V inputs for statistics. In general most SETs were small; therefore this device is suitable for space applications.

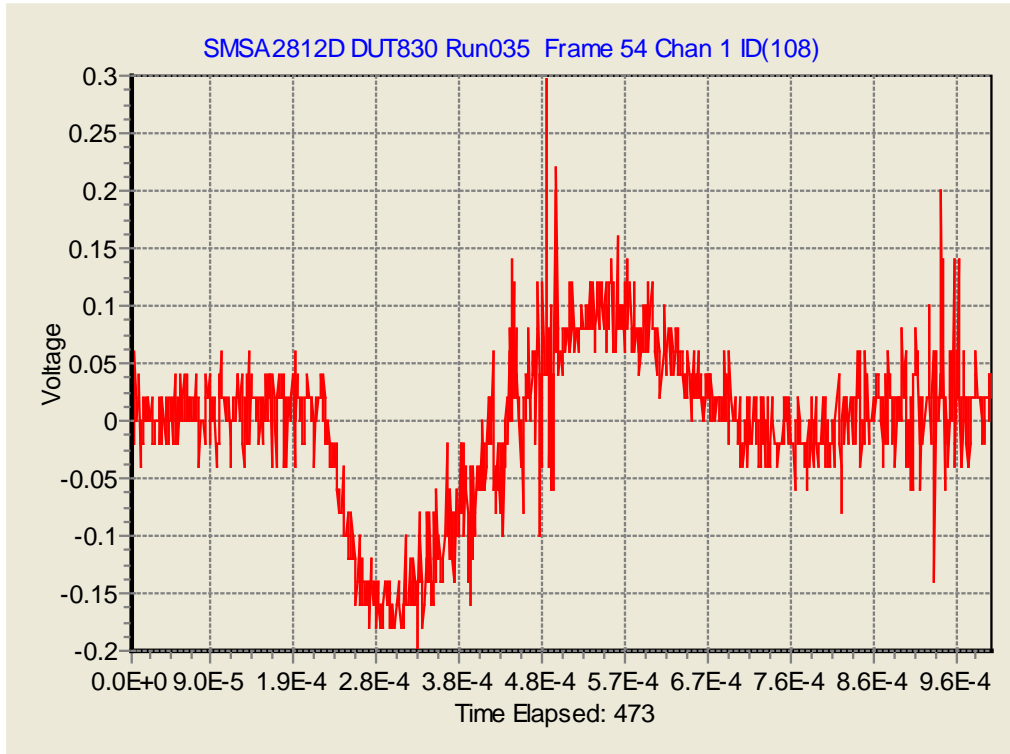


Chart 1. Typical Positive Transient of approx +300mV and 700us

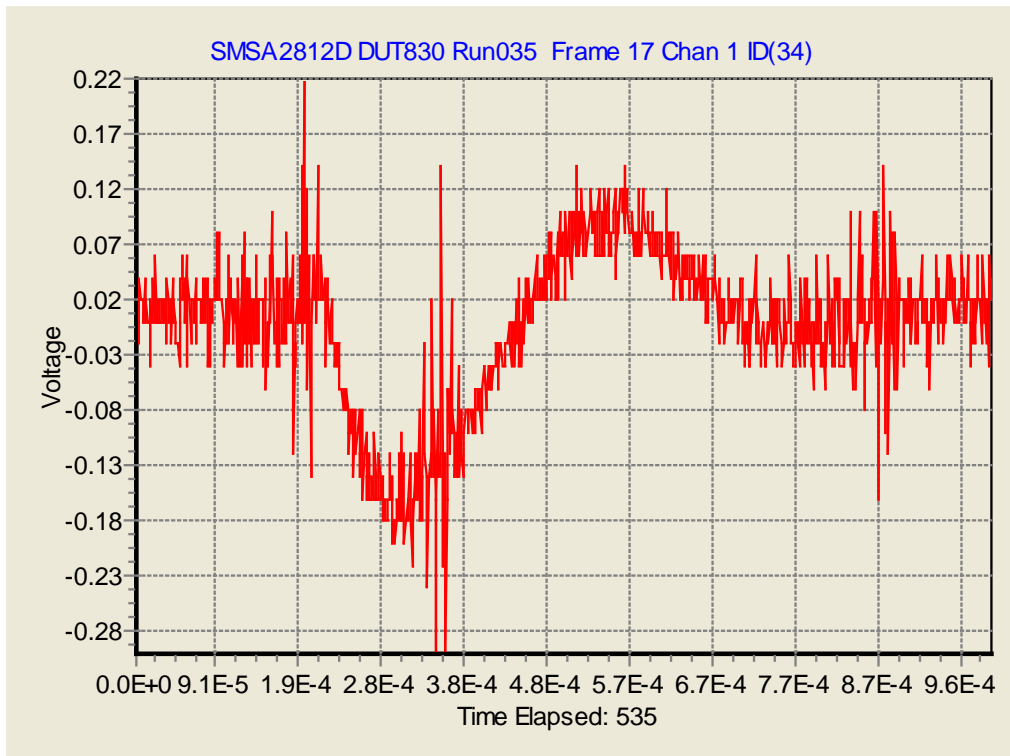


Chart 2. Typical Negative Transient of approx -300mV and 700us

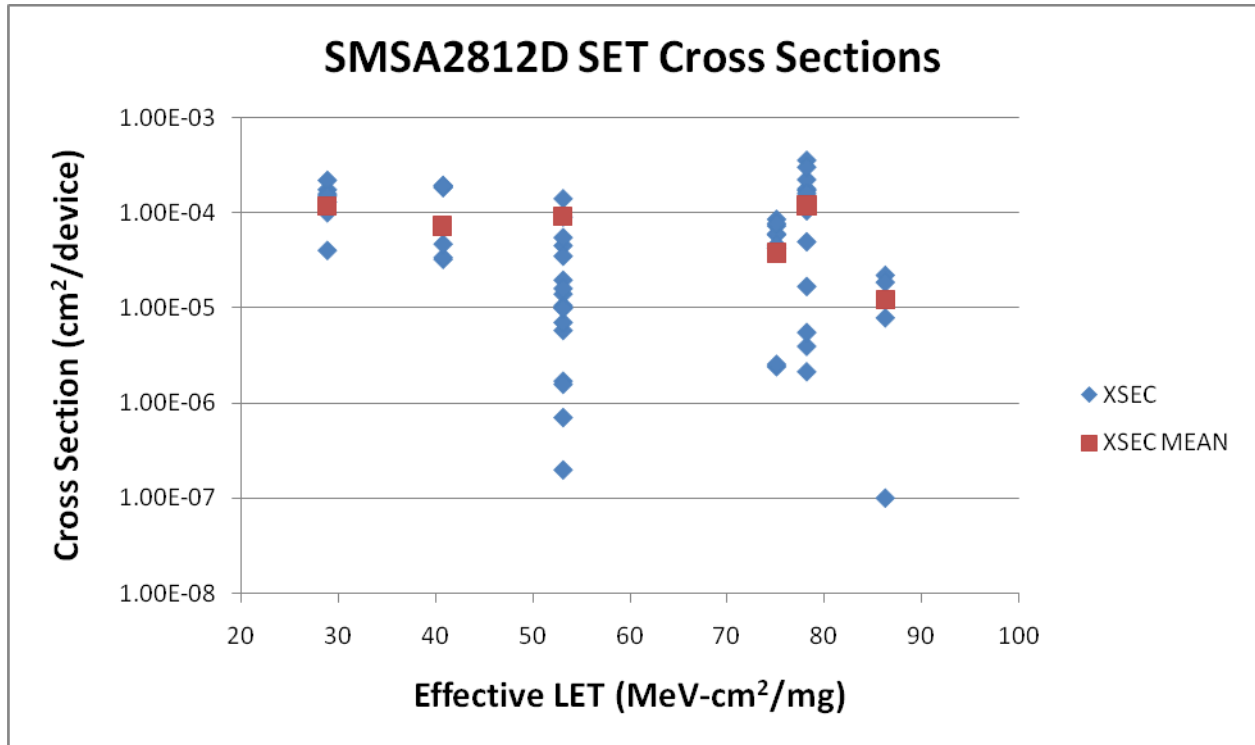


Chart 3. SMSA2812D SET Cross Sections

Table 2: SMSA2812D Data Collected at TAMU

Run#	Voltage	Trig	Current(A)	Load(A)	Ion	LET	LET(eff)	angle	Flux	Fluence <sub>eff</sub>	SET	$\sigma_{\text{seu}}$
17	28	11.75	0.095	0.055	Xe-15	53.1	53.1	0	1.28E+05	9.97E+06	0	0.00E+00
18	28	11.75	0.095	0.055	Xe-15	53.1	53.1	0	1.34E+05	9.94E+06	6	7.04E-07
19	28	11.75	0.095	0.055	Xe-15	53.1	53.1	0	1.05E+04	4.02E+06	0	0.00E+00
20	28	11.75	0.095	0.055	Xe-15	53.1	53.1	0	4.81E+05	1.00E+07	17	1.70E-06
21	28	11.75	0.095	0.055	Xe-15	53.1	53.1	0	5.13E+05	1.02E+07	16	1.57E-06
22	28	11.75	0.095	0.055	Xe-15	53.1	53.1	0	5.09E+05	1.01E+07	2	1.98E-07
23	28	11.75	0.095	0.055	Xe-15	53.1	75.1	45	5.17E+05	9.95E+06	23	2.41E-06
24	28	11.75	0.095	0.055	Xe-15	53.1	75.1	45	5.03E+05	1.02E+07	22	2.55E-06
25	28	11.75	0.135	0.1	Xe-15	53.1	75.1	45	5.17E+05	9.90E+06	57	4.46E-05
26	28	11.75	0.135	0.1	Xe-15	53.1	75.1	45	1.09E+04	1.00E+06	58	5.90E-05
27	28	11.75	0.135	0.1	Xe-15	53.1	75.1	45	1.02E+04	1.00E+06	72	7.30E-05
28	28	11.75	0.135	0.1	Xe-15	53.1	75.1	45	1.06E+04	1.00E+06	60	6.00E-05
29	28	11.75	0.135	0.1	Xe-15	53.1	53.1	0	1.04E+04	1.00E+06	14	1.40E-05
30	28	11.75	0.135	0.1	Xe-15	53.1	53.1	0	1.02E+00	1.02E+06	20	1.96E-05
31	28	11.75	0.094	0.055	Xe-15	53.1	53.1	0	5.22E+05	1.02E+07	0	0.00E+00
32	28	11.75	0.094	0.055	Xe-15	53.1	53.1	0	5.31E+05	1.02E+07	0	0.00E+00
33	28	11.75	0.094	0.055	Xe-15	53.1	53.1	0	5.31E+05	1.02E+07	38	1.06E-05
34	28	11.75	0.094	0.055	Xe-15	53.1	53.1	0	1.07E+05	1.00E+07	55	5.80E-06
35	28	11.75	0.094	0.055	Xe-15	53.1	75.1	45	9.85E+04	5.84E+06	148	4.25E-05
36	28	11.75	0.094	0.055	Xe-15	53.1	75.1	45	1.14E+04	1.05E+06	44	4.21E-05
37	28	11.75	0.133	0.1	Xe-15	53.1	75.1	45	1.12E+04	1.00E+06	46	4.60E-05
38	28	11.75	0.133	0.1	Xe-15	53.1	75.1	45	1.27E+04	1.23E+06	101	8.56E-05
39	28	11.75	0.133	0.1	Xe-15	53.1	75.1	45	1.09E+04	1.00E+06	76	7.70E-05
40	28	11.75	0.133	0.1	Xe-15	53.1	53.1	0	9.50E+03	9.97E+05	7	7.02E-06

41	28	11.75	0.133	0.1	Xe-15	53.1	53.1	0	1.05E+04	9.96E+05	45	4.52E-05
42	28	11.75	0.094	0.055	Kr-15	28.8	28.8	0	5.00E+04	9.85E+05	0	0.00E+00
43	28	11.75	0.094	0.055	Kr-15	28.8	28.8	0	5.82E+05	9.71E+06	1	1.03E-07
44	28	11.75	0.133	0.1	Kr-15	28.8	28.8	0	6.42E+05	9.88E+06	27	3.85E-06
45	28	11.75	0.133	0.1	Kr-15	28.8	28.8	0	6.46E+05	1.02E+07	10	9.81E-07
46	28	11.75	0.133	0.1	Kr-15	28.8	40.7	45	6.49E+05	1.00E+07	45	3.25E-05
47	28	11.75	0.133	0.1	Kr-15	28.8	40.7	45	1.38E+04	1.00E+06	33	3.40E-05
48	28	11.75	0.133	0.1	Kr-15	28.8	40.7	45	1.43E+04	1.00E+06	46	4.70E-05
49	28	11.7	0.175	0.14	Kr-15	28.8	40.7	45	1.38E+04	7.75E+05	116	1.85E-04
50	28	11.7	0.175	0.14	Kr-15	28.8	40.7	45	1.35E+04	6.96E+05	101	1.87E-04
51	28	11.75	0.0335	0	Kr-15	28.8	40.7	45	1.36E+04	8.38E+05	130	1.95E-04
52	28	11.75	0.0335	0	Kr-15	28.8	28.8	0	1.33E+04	8.57E+05	105	1.61E-04
53	28	11.75	0.094	0.055	Kr-15	28.8	28.8	0	1.33E+04	1.75E+06	0	0.00E+00
54	28	11.75	0.0335	0	Kr-15	28.8	40.7	45	1.31E+04	8.29E+05	112	1.92E-04
55	28	11.75	0.094	0.055	Kr-15	28.8	40.7	45	1.27E+04	1.63E+06	0	0.00E+00
56	28	11.75	0.135	0.1	Kr-15	28.8	28.8	0	1.20E+04	1.30E+06	3	2.31E-06
57	28	11.75	0.094	0.055	Kr-15	28.8	28.8	0	5.65E+02	1.23E+06	0	0.00E+00
58	28	11.75	0.133	0.1	Kr-15	28.8	28.8	0	1.13E+04	1.00E+06	4	4.00E-06
59	28	11.75	0.175	0.14	Kr-15	28.8	28.8	0	1.15E+04	7.59E+05	102	1.75E-04
60	28	11.75	0.236	0.2	Kr-15	28.8	28.8	0	1.49E+03	1.01E+05	16	1.58E-04
61	28	11.75	0.0335	0	Kr-15	28.8	28.8	0	1.45E+03	1.00E+05	10	1.00E-04
62	28	11.75	0.094	0.055	Kr-15	28.8	28.8	0	1.45E+03	9.99E+04	0	0.00E+00
63	28	11.75	0.135	0.1	Kr-15	28.8	28.8	0	1.44E+03	9.93E+04	4	4.03E-05
64	28	11.7	0.175	0.14	Kr-15	28.8	28.8	0	1.36E+03	1.00E+05	21	2.20E-04
65	28	11.7	0.175	0.14	Kr-15	28.8	28.8	0	1.39E+03	1.00E+05	13	1.30E-04
66	28	11.7	0.236	0.2	Kr-15	28.8	28.8	0	1.43E+03	1.00E+05	15	1.50E-04
67	21	11.75	0.082	0.055	Xe-15	53.1	53.1	0	1.44E+03	1.00E+05	0	0.00E+00
68	35	11.75	0.0335	0.2	Xe-15	53.1	53.1	0	1.42E+03	9.95E+04	1	1.01E-05
69	35	11.75	0.0335	0.2	Xe-15	53.1	53.1	0	1.09E+04	1.01E+05	1	9.90E-06
70	28	11.75	0.0335	0.2	Xe-15	53.1	53.1	0	1.17E+04	9.99E+05	0	0.00E+00
71	35	11.75	0.0335	0.2	Xe-15	53.1	53.1	0	1.18E+04	6.10E+05	72	1.41E-04
72	21	11.75	0.082	0.055	Xe-15	53.1	53.1	0	1.15E+04	1.00E+06	0	0.00E+00
73	35	11.75	0.112	0.1	Xe-15	53.1	53.1	0	1.15E+04	9.98E+05	0	0.00E+00
74	35	11.75	0.113	0.1	Xe-15	53.1	53.1	0	1.18E+04	1.00E+06	16	1.60E-05
75	28	11.7	0.149	0.14	Xe-15	53.1	53.1	0	1.17E+04	9.98E+05	35	3.51E-05
76	28	11.7	0.194	0.2	Xe-15	53.1	53.1	0	1.21E+04	9.95E+05	84	9.05E-05
77	28	11.7	0.303	0.2	Xe-15	53.1	53.1	0	1.20E+04	1.00E+06	53	5.50E-05
78	28	11.75	0.096	0.055	Ta-15	78.2	78.2	0	2.21E+04	9.81E+05	42	1.05E-04
79	21	11.75	0.113	0.055	Ta-15	78.2	78.2	0	3.04E+04	1.01E+06	13	1.68E-05
80	35	11.75	0.085	0.055	Ta-15	78.2	78.2	0	2.86E+04	1.01E+06	45	1.14E-04
81	28	11.75	0.138	0.1	Ta-15	78.2	78.2	0	2.60E+04	3.91E+05	20	1.72E-04
82	28	11.75	0.138	0.1	Ta-15	78.2	78.2	0	4.45E+03	5.06E+05	1	3.95E-06
83	35	11.75	0.116	0.1	Ta-15	78.2	78.2	0	4.19E+03	4.32E+05	0	0.00E+00
84	21	11.75	0.172	0.1	Ta-15	78.2	78.2	0	4.97E+03	5.43E+05	2	5.53E-06
85	28	11.75	0.096	0.055	Ta-15	78.2	78.2	0	4.36E+03	4.69E+05	0	2.13E-06
86	28	11.75	0.096	0.055	Ta-15	78.2	78.2	0	1.22E+04	3.80E+05	18	1.79E-04
87	35	11.75	0.084	0.055	Ta-15	78.2	78.2	0	1.07E+04	2.95E+05	17	2.24E-04
88	21	11.75	0.113	0.055	Ta-15	78.2	78.2	0	6.03E+03	6.04E+05	12	4.97E-05
89	28	11.75	0.136	0.1	Ta-15	78.2	78.2	0	5.34E+03	2.76E+05	18	1.59E-04
90	21	11.75	0.171	0.1	Ta-15	78.2	78.2	0	6.72E+03	3.08E+05	37	3.57E-04
91	35	11.75	0.115	0.1	Ta-15	78.2	78.2	0	8.24E+03	4.20E+05	36	3.02E-04
92	28	11.75	0.096	0.055	Au-15	86.3	86.3	0	3.85E+04	9.99E+06	0	1.00E-07
93	28	11.75	0.135	0.1	Au-15	86.3	86.3	0	4.34E+04	5.98E+06	46	7.86E-06
94	28	11.75	0.175	0.138	Au-15	86.3	86.3	0	4.30E+04	4.71E+06	80	2.21E-05
95	28	11.75	0.242	0.205	Au-15	86.3	86.3	0	4.80E+04	5.86E+06	72	1.86E-05