SEE Test Report V3.0

Heavy ion SEE test of SMTR28515T from Interpoint

Anthony B. Sanders[1], Hak S. Kim[2], Anthony M. Phan[2]

[1] NASA GSFC
[2] MEI Technologies

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I. Introduction

This study was undertaken to determine the single event destructive and transient susceptibility of the SMRT28515T, Single DC/DC Converters, for transient interruptions in the output signal and for destructive events induced by exposing it to a heavy ion beam for transient interruptions in the output signal and for destructive events induced by exposing it to a heavy ion beam at the Lawrence Berkeley Nuclear Laboratory (LBNL). Utilizing the Berkeley Accelerator Space Effects Facility (BASEF) and 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 investigation of radiation susceptibility of transient events and destructive events for Crane Interpoint. This work was in conjunction with the NASA Electronics Parts and Packaging (NEPP) Program. NEPP is a HQ sponsored program that seeks to find new developments that will benefit NASA.

II. Devices Tested

The sample size of Device Under Test (DUT) for testing is one. Each device was exposed to the radiation beam and the results will be compared for verification. For the SMRT28515T, the test samples code markings for DUT2 is SN-0102 with DC-0824. The device is packaged in a 14-pin lead metal can package. The device was prepped for test by delidding. The SMRT Series™ of DC/DC converters offers up to 35watts of power in a radiation tolerant design. The low profile SMRT converters are manufactured in Interpoint’s fully certified and qualified MIL-STD-1772 production facility and packaged in hermetically sealed steel cases. They are ideal for use in programs requiring high reliability, small size, and high levels of radiation hardening assurance.

The SMRT converters are switching regulators which use a two-phase, phase shifted flyback design with a nominal switching frequency of 300 kHz. Close regulation is maintained with advanced constant frequency pulse width modulation design techniques. The SMRT’s feed-forward compensation and discontinuous topologies provide high levels (80 dB peak) of input-to-output ripple rejection. Two independent feedback loops are used to regulate the dual and triple outputs; one feedback loop regulates the two-phased single output. Each set of outputs is electrically isolated from the other and from the input. This product configuration eliminates cross regulation effects between output sets.

III. Test Facility

Facility: Berkeley Accelerator Space Effects Facility, 10 & 16 MeV/u beams

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

Flux: 2.48×10^2 to 2.20×10^5 particles/cm^2/s.

Fluence: For destructive events, all tests will be run to 1×10^7 p/cm^2 or until destructive events occurred

For non destructive events, all tests will be run to 1×10^7 p/cm^2 or until a sufficient (>100) number of transient events occurred.

The ions and LET values 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} = +/-15V

See Figure 2 for detailed conditions

	Vsupply (V)	Isupply (A)	Vin (V)	Loading %
DUT 2	+15/-15	.486	28V	30
DUT 2	+15/-15	.637	21V	30
DUT 2	+15/-15	.397	35V	30
DUT 2	+15/-15	.818	28V	50
DUT 2	+15/-15	1.09	21V	50
DUT 2	+15/-15	.655	35V	50

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. Current is higher at TAMU than LBNL because of the use of a shorter cable at this facility.

Table 1, shows the test conditions where tests were conducted for an input nominal voltage of 28V, 21V, and 35V with 30% & 50% loading. Figure 2, shows the test schematic circuit of the SMRT28515T and Figure 3, shows the internal circuitry of the converter exposed for ion beams at LBNL and TAMU.

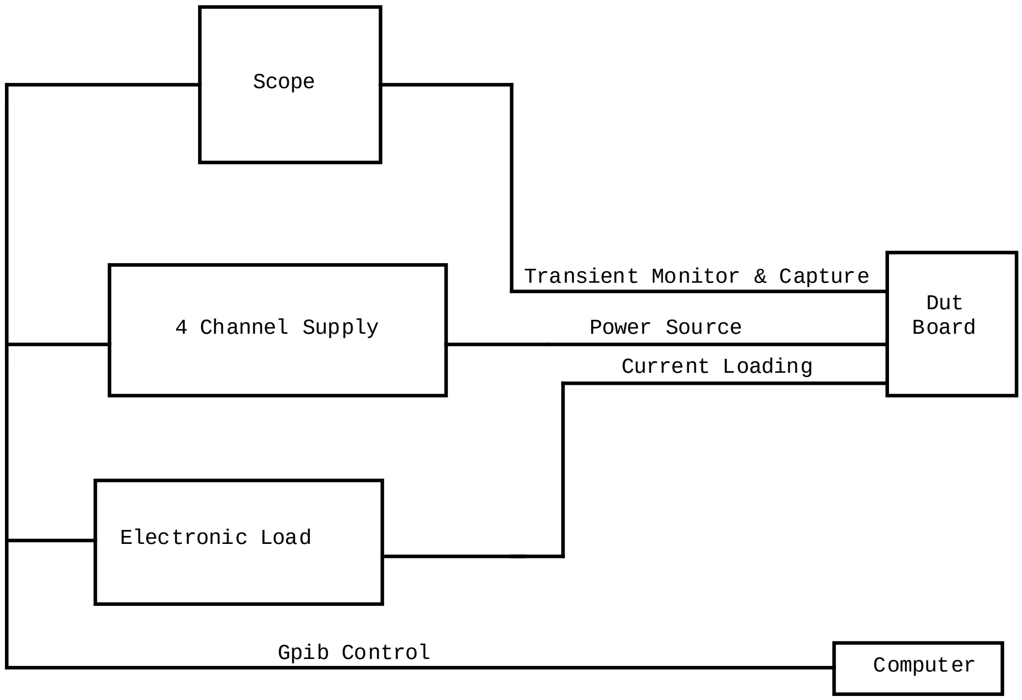

Figure 1. Overall Block Diagram for the testing of the SMRT28515T

VI. Test Performance

- Destructive test at high LET (>86.3 MeVcm^2/mg) on 1 part up to a fluence of 10^7 #/cm^2.
- SET test on 1 part for at least 2 LET values (starting from lowest LET) for each device output and each condition described in Table 1.

SMRT28515T DC/DC CONVERTERS

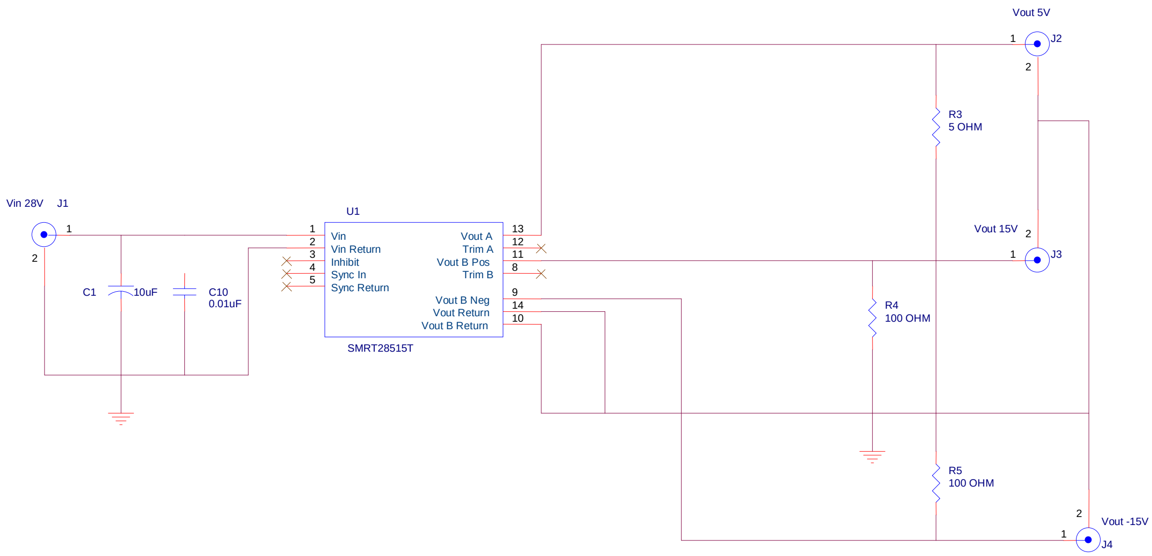

Figure 2. Overall Block Diagram for the testing of the SMRT28515T

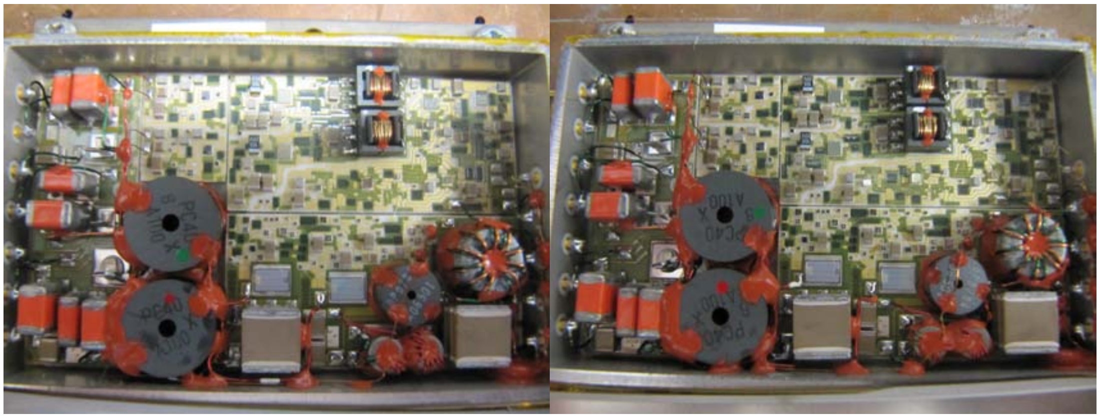

Figure 3. SMRT28515T internal circuitry exposed to ion beam at LBNL

VII. Test Results

Detailed test results are shown in Table 2 below. The device was exposed from a fluence of 2.02 x 10^4 to 1.02 x 10^7 particles/cm2 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 86.3 MeV-cm^2/mg at normal angle of incidence. A possible destructive event was observed for the SMRT28515T where current went up to 2A; possible gate rupture. In addition 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 600ns for worse case width duration. Charts 1 & 2 show the worse case transients and Chart 3 shows the SET cross sections observed. Runs 51-70 were taken at TAMU, all others were at LBNL. The tests were run with an input of 28V, 21V, & 35V at 30% & 50% loading conditions. In general most SETs were small; therefore this device is suitable for space applications.

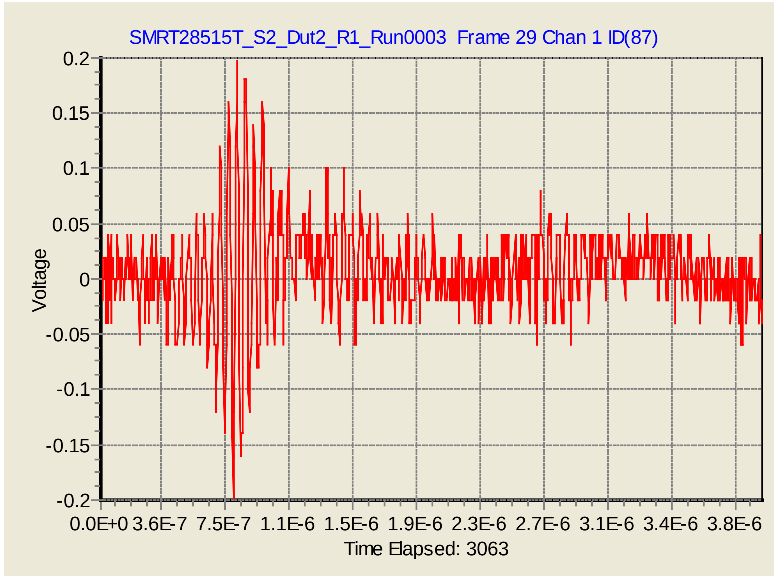

Chart 1. Typical Worse Peak Transient of approx +/-200mV and 500ns

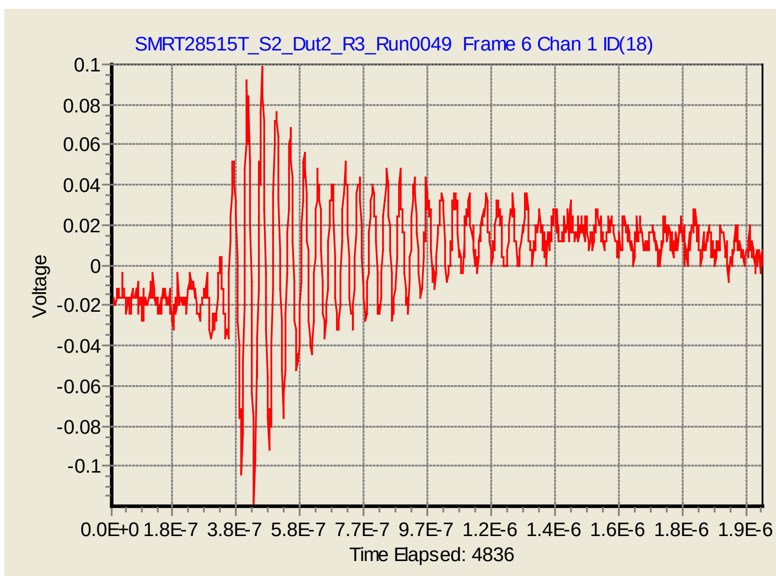

Chart 2. Typical Worse Width Transient of approx +/-100mV and 600ns

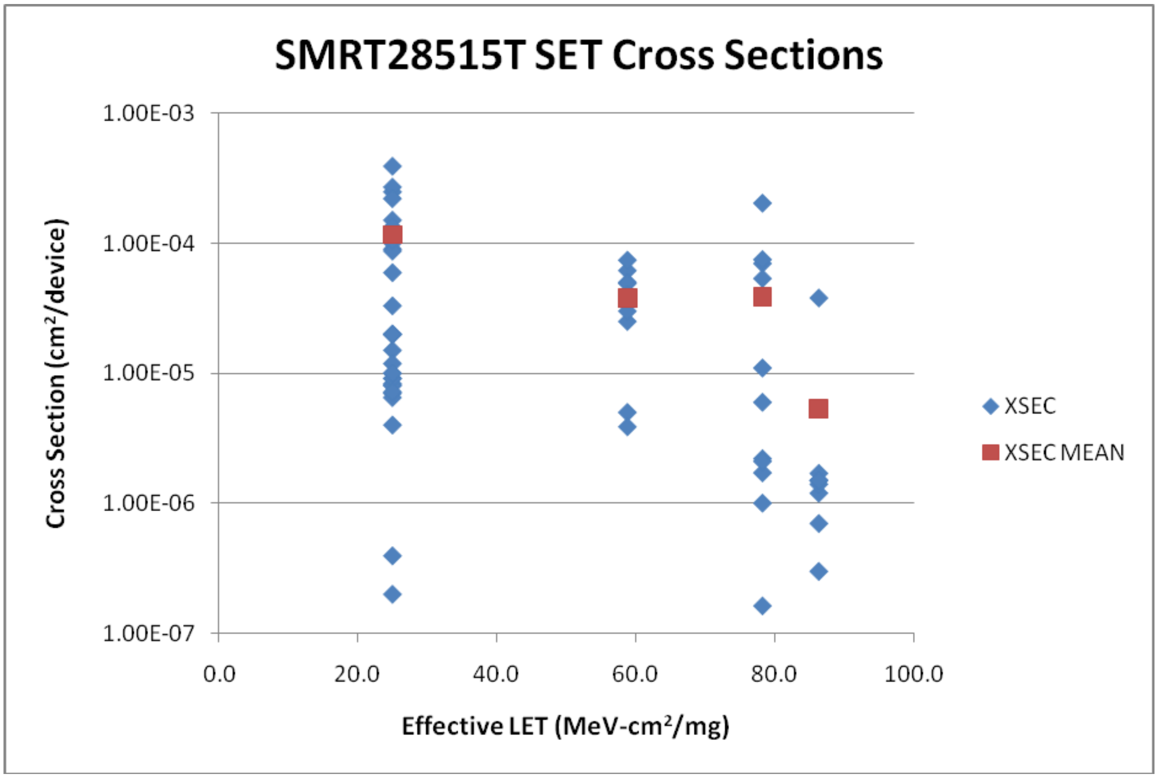

Chart 3. SMRT28515T SET Cross Sections

Table 2: SMRT28515T Data Collected at LBNL & TAMU

Run#	Serial #	DC	Region	Voltage	Trig	Current(A)	Load(A)	Ion	Energy	LET	LET(eff)	angle	Flux	Fluence$_{eff}$	SET	SEL	σ_{seu}
1	0102	0824	1	28	14.75	0.486	0.15	Xe-10	1232	58.78	58.8	0	2.00E+03	2.60E+05	15	0	6.15E-05
2	0102	0824	1	28	14.75	0.486	0.15	Xe-10	1232	58.78	58.8	0	1.98E+03	1.00E+06	24	0	2.50E-05
3	0102	0824	1	28	13.5	0.486	0.15	Xe-10	1232	58.78	58.8	0	9.05E+04	1.00E+06	73	0	7.40E-05
4	0102	0824	1	28	13.5	0.486	0.15	Xe-10	1232	58.78	58.8	0	1.75E+03	1.00E+06	49	0	5.00E-05
5	0102	0824	1	21	13.5	0.637	0.15	Xe-10	1232	58.78	58.8	0	1.71E+03	1.00E+06	37	0	3.80E-05
6	0102	0824	1	21	13.5	0.637	0.15	Xe-10	1232	58.78	58.8	0	1.65E+03	1.00E+06	48	0	4.90E-05
7	0102	0824	1	35	13.5	0.391	0.15	Xe-10	1232	58.78	58.8	0	1.53E+03	1.00E+05	2	0	3.00E-05
8	0102	0824	1	35	13.5	0.391	0.15	Xe-10	1232	58.78	58.8	0	1.67E+03	1.00E+06	39	0	4.00E-05
9	0102	0824	1	28	13.5	0.486	0.15	Xe-10	1232	58.78	58.8	0	1.68E+04	1.00E+06	3	0	5.00E-06
10	0102	0824	1	28	13.5	0.486	0.15	Xe-10	1232	58.78	58.8	0	1.62E+04	3.87E+06	14	0	3.88E-06
11	0102	0824	1	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	2.16E+05	1.01E+07	3	0	3.95E-07
12	0102	0824	1	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	2.20E+05	1.01E+07	53	0	8.29E-06
13	0102	0824	1	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	9.85E+02	1.12E+05	0	0	0.00E+00
14	0102	0824	1	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	1.91E+05	1.00E+07	57	0	8.10E-06
15	0102	0824	1	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	1.99E+05	1.12E+06	7	0	8.04E-06
16	0102	0824	1	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	2.14E+05	6.56E+05	4	0	9.15E-06
17	0102	0824	1	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	1.44E+03	5.00E+05	1	0	4.00E-06
18	0102	0824	2	28	14.85	0.671	0.15	Kr-16	1230	25	25.0	0	9.55E+02	1.00E+05	8	0	9.00E-05
19	0102	0824	2	21	14.85	0.671	0.15	Kr-16	1230	25	25.0	0	9.92E+02	1.00E+06	12	0	1.50E-05
20	0102	0824	2	21	14.85	0.671	0.15	Kr-16	1230	25	25.0	0	9.98E+02	1.00E+05	12	0	1.30E-04
21	0102	0824	2	35	14.85	0.412	0.15	Kr-16	1230	25	25.0	0	9.19E+02	1.00E+05	11	0	1.20E-04
22	0102	0824	2	35	14.85	0.412	0.15	Kr-16	1230	25	25.0	0	9.83E+02	1.00E+05	11	0	1.20E-04
23	0102	0824	2	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	9.49E+02	1.00E+05	14	0	1.50E-04

24	0102	0824	3	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	1.04E+03	1.00E+05	1	0	2.00E-05
25	0102	0824	3	28	14.85	0.512	0.15	Kr-16	1230	25	25.0	0	1.07E+03	1.00E+05	1	0	9.34E+01
26	0102	0824	3	21	14.85	0.671	0.15	Kr-16	1230	25	25.0	0	1.08E+03	1.00E+05	1	0	2.00E-05
27	0102	0824	3	21	14.85	0.671	0.15	Kr-16	1230	25	25.0	0	2.50E+03	1.02E+05	0	0	0.00E+00
28	0102	0824	3	35	14.85	0.412	0.15	Kr-16	1230	25	25.0	0	2.44E+03	1.02E+05	0	0	0.00E+00
29	0102	0824	3	35	14.85	0.412	0.15	Kr-16	1230	25	25.0	0	1.77E+05	1.01E+07	61	0	9.10E-06
30	0102	0824	1	28	14.85	0.818	0.3	Kr-16	1230	25	25.0	0	9.38E+02	1.00E+07	1	0	2.00E-07
31	0102	0824	1	28	14.85	0.818	0.3	Kr-16	1230	25	25.0	0	1.40E+04	1.00E+06	8	0	1.00E-05
32	0102	0824	1	21	14.85	1.09	0.3	Kr-16	1230	25	25.0	0	1.37E+04	1.00E+06	29	0	3.30E-05
33	0102	0824	1	21	14.85	1.09	0.3	Kr-16	1230	25	25.0	0	2.31E+03	3.88E+05	21	0	5.93E-05
34	0102	0824	1	21	14.85	1.09	0.3	Kr-16	1230	25	25.0	0	3.66E+02	2.02E+04	4	0	2.48E-04
35	0102	0824	1	35	14.85	0.655	0.3	Kr-16	1230	25	25.0	0	1.30E+03	1.97E+05	0	0	0.00E+00
36	0102	0824	1	35	14.85	0.655	0.3	Kr-16	1230	25	25.0	0	1.64E+04	1.01E+06	11	0	1.19E-05
37	0102	0824	2	28	14.85	0.817	0.3	Kr-16	1230	25	25.0	0	1.69E+04	1.00E+06	66	0	1.00E-04
38	0102	0824	2	28	14.85	0.817	0.3	Kr-16	1230	25	25.0	0	1.72E+03	1.81E+05	23	0	1.33E-04
39	0102	0824	2	21	14.85	1.09	0.3	Kr-16	1230	25	25.0	0	1.65E+03	1.74E+05	45	0	2.70E-04
40	0102	0824	2	21	14.85	1.09	0.3	Kr-16	1230	25	25.0	0	5.94E+02	7.18E+04	16	0	3.90E-04
41	0102	0824	2	35	14.85	0.655	0.3	Kr-16	1230	25	25.0	0	5.89E+02	6.91E+04	5	0	8.68E-05
42	0102	0824	2	35	14.85	0.512	0.3	Kr-16	1230	25	25.0	0	2.04E+03	1.23E+05	12	0	1.06E-04
43	0102	0824	3	28	14.85	0.816	0.3	Kr-16	1230	25	25.0	0	2.04E+03	1.01E+05	1	0	1.98E-05
44	0102	0824	3	28	14.85	0.816	0.3	Kr-16	1230	25	25.0	0	1.48E+04	1.00E+06	9	0	1.00E-05
45	0102	0824	3	35	14.85	0.655	0.3	Kr-16	1230	25	25.0	0	1.46E+04	1.00E+06	6	0	7.00E-06
46	0102	0824	3	35	14.85	0.655	0.3	Kr-16	1230	25	25.0	0	1.26E+03	1.00E+05	1	0	2.00E-05
47	0102	0824	3	35	14.85	0.655	0.3	Kr-16	1230	25	25.0	0	2.06E+05	1.02E+07	47	0	6.50E-06
48	0102	0824	3	21	14.85	1.09	0.3	Kr-16	1230	25	25.0	0	2.07E+05	5.15E+06	25	0	7.18E-06
49	0102	0824	3	21	14.85	0.512	0.3	Kr-16	1230	25	25.0	0	1.00E+03	1.00E+05	19	0	2.20E-04
50	0102	0824	3	21	14.85	0.512	0.3	Kr-16	1230	25	25.0	0	2.48E+02	2.02E+04	11	0	1.14E-03
51	0102	0824	3	28	14.85	0.564	0.271	Ta-15	1967	78.2	78.2	0	1.27E+04	1.00E+06	63	0	6.98E-05
52	0102	0824	3	28	14.85	0.564	0.271	Ta-15	1967	78.2	78.2	0	1.17E+04	1.00E+06	62	0	7.48E-05
53	0102	0824	3	21	14.85	0.739	0.271	Ta-15	1967	78.2	78.2	0	9.56E+03	5.22E+05	63	0	2.03E-04
54	0102	0824	3	35	14.85	0.453	0.271	Ta-15	1967	78.2	78.2	0	9.62E+03	1.00E+06	10	0	1.10E-05
55	0102	0824	3	28	14.85	0.765	0.421	Ta-15	1967	78.2	78.2	0	8.92E+03	1.00E+06	5	0	5.98E-06
56	0102	0824	3	21	14.85	1.276	0.421	Ta-15	1967	78.2	78.2	0	9.82E+03	9.96E+05	0	0	1.00E-06
57	0102	0824	3	35	14.85	0.764	0.421	Ta-15	1967	78.2	78.2	0	1.05E+04	5.83E+05	0	0	1.72E-06
58	0102	0824	3	35	14.85	0.764	0.421	Ta-15	1967	78.2	78.2	0	8.90E+04	6.14E+06	0	0	1.63E-07
59	0102	0824	3	28	14.9	1.04	0.421	Ta-15	1967	78.2	78.2	0	8.62E+04	9.97E+06	20	0	2.21E-06
60	0102	0824	3	21	14.9	1.54	0.3	Ta-15	1967	78.2	78.2	0	8.23E+04	9.97E+06	20	0	2.11E-06
61	0102	0824	3	35	14.9	0.809	0.3	Ta-15	1967	78.2	78.2	0	9.02E+04	4.62E+06	67	0	5.34E-05
62	0102	0824	1	28	14.9	0.639	0.271	Au-15	2127	86.3	86.3	0	5.00E+04	2.77E+06	64	0	3.79E-05
63	0102	0824	1	21	14.85	0.9	0.271	Au-15	2127	86.3	86.3	0	4.99E+04	9.99E+06	14	0	1.50E-06
64	0102	0824	1	35	14.85	0.492	0.271	Au-15	2127	86.3	86.3	0	4.86E+04	1.00E+07	9	0	1.20E-06
65	0102	0824	2	35	14.85	0.492	0.271	Au-15	2127	86.3	86.3	0	4.82E+04	9.99E+06	12	0	1.40E-06
66	0102	0824	2	28	14.85	0.638	0.271	Au-15	2127	86.3	86.3	0	4.69E+04	1.00E+07	6	0	7.00E-07
67	0102	0824	2	21	14.85	0.915	0.271	Au-15	2127	86.3	86.3	0	4.57E+04	1.00E+07	11	0	1.50E-06
68	0102	0824	3	21	14.85	0.915	0.271	Au-15	2127	86.3	86.3	0	3.96E+04	1.00E+07	15	0	1.70E-06
69	0102	0824	3	28	14.85	0.642	0.271	Au-15	2127	86.3	86.3	0	3.87E+04	7.31E+06	5	0	1.50E-06
70	0102	0824	3	35	14.85	0.523	0.271	Au-15	2127	86.3	86.3	0	3.91E+04	1.00E+07	2	1	3.00E-07