

Solar Cruiser Total Ionizing Dose

Anthony M. DeStefano
NASA, MSFC, EV44

May 3, 2021

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1 Executive Summary

2 Mission Trajectory

The nominal Solar Cruiser location is beyond the Sun-Earth L1 point, called sub-L1, roughly 0.984 AU from the Sun. The sub-L1 location is in interplanetary space with no shielding from any planetary bodies and is exposed to the solar wind. The nominal mission length is 2 years.

3 Materials

The representative material for the Reaction Control Device (RCD) of Solar Cruiser is 150 μ m of Kapton. Using data from NIST¹, the composition of Kapton is shown in Table 1, where the density of Kapton is 1.42 g/cm³.

Table 1: Composition of Kapton.

Atomic #	Fraction by Weight	Weight (amu)	Fraction by Number	Stoichiometry
1	0.026362	1.008	0.25639	10
6	0.691133	12.011	0.56412	22
7	0.073270	14.007	0.05128	2
8	0.209235	15.999	0.12821	5

4 Dose-Depth in Kapton

The SRIM (Stopping and Range of Ions in Solids) software is used to compute the dose in thin materials with no prior shielding. The SRIM software package contains TRIM (the Transport of Ions in Matter), with a screenshot of the setup used in this analysis shown in Figure 1.

The dose deposited in Kapton depends on the energy of the incident protons. As the energy increases, the depth of the deposited dose increases. In Figure 2, the colored solid curves show the percentiles of dose deposited less than a particular depth, as a function of energy for normally incident protons. For example, the purple curve shows the depth vs. energy at which 95% of the dose is deposited. From Figure 2, it is clear that the dose is not deposited uniformly. Thicknesses between the green and blue curves, 45% of the dose is deposited, as well as between the green and purple curves. Therefore, 90% of the dose is deposited between the blue and purple curves. In general, the depth vs. energy profile has a double-power-law shape

$$D(E) = \left(\frac{E}{a}\right)^b + \left(\frac{E}{c}\right)^d, \quad (1)$$

where a is the low-energy scale, c is the high-energy scale, and b & d are the indices for each scale, respectively. As the percentile increases, the values for the energy

¹<https://physics.nist.gov/cgi-bin/Star/compos.pl?matno=179>

TRIM Setup Window

TRIM (Setup Window)

Read Me ?

TRIM Demo ?

Restore Last TRIM Data ?

ION DATA ?

Symbol: PT, Name of Element: H, Atomic Number: 1, Mass (amu): 1.008, Energy (keV): 7.50E+03, Angle of Incidence: 0

TARGET DATA ?

Target Layers

Add New Layer ?

Layer Name	Width	Density (g/cm3)	Compound	Corr	Gas
X Kapton	1500000 Ang	1.42	1		

Input Elements to Layer

Add New Element to Layer

Compound Dictionary

Symbol	Name	Atomic Number	Weight (amu)	Atom Stoich or %	Damage (eV) Disp	Latt	Surf
X PT H	Hydrogen	1	1.008	10	25.6	10	3 2
X PT C	Carbon	6	12.01	22	56.4	28	3 7.4
X PT N	Nitrogen	7	14.00	2	05.1	28	3 2
X PT O	Oxygen	8	15.99	5	12.8	28	3 2

Special Parameters

Name of Calculation: H (10) into Layer 1

Stopping Power Version: SRIM-2008

AutoSave at Ion #: 10000

Total Number of Ions: 99999

Random Number Seed:

Plotting Window Depths: Min: 0, Max: 1500000

Output Disk Files

Resume saved TRIM calc. ?

Save Input & Run TRIM

Clear All

Calculate Quick Range Table

Main Menu

Problem Solving

Quit

Figure 1: Example of TRIM setup.

scales a and c decreases. For a list of parameter fits, see Table 4 in Appendix A. Observing that $b < d$, the Kapton material is more effective at stopping lower energy protons ($< \sim 100$ keV) than higher energy protons.

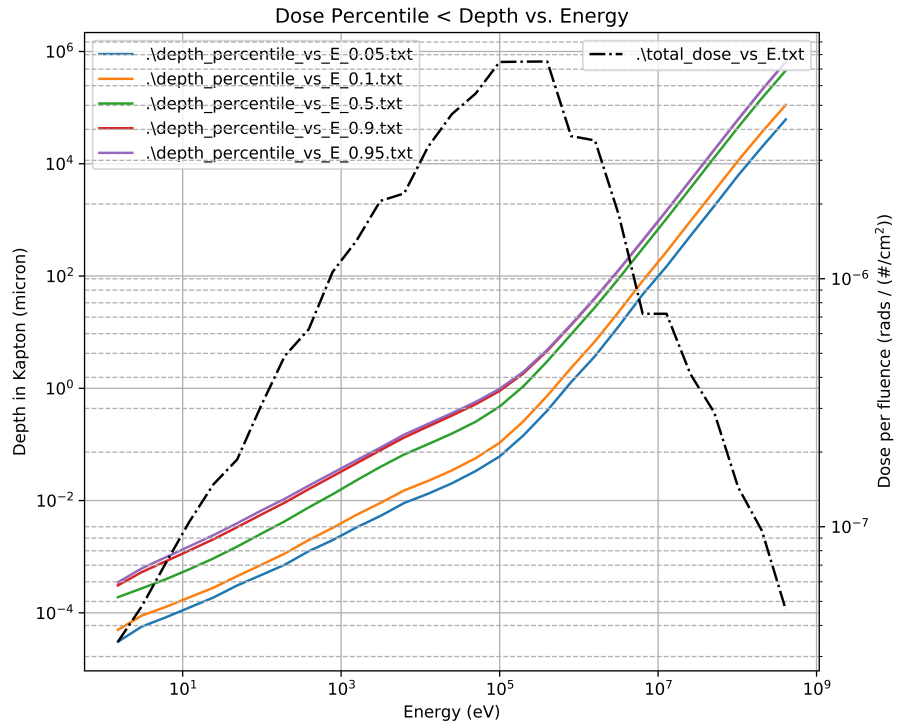


Figure 2: Left axis: Depth in Kapton vs. energy for various dose-depth percentiles. Right axis: Dose per fluence vs. energy.

The dotted-dashed curve in Figure 2 shows the total dose deposited per fluence as a function of energy. Basically, this curve can be thought of as the dose cross-section of Kapton for normally incident protons. One way to find the total dose for a given energy spectrum, one could convolute the dose cross-section with the differential energy spectrum, taking into account the depth percentile for a particular thickness of Kapton material. However, a more direct method to find the total dose is used in the following sections.

5 Natural Environment

The natural environments for the RCD of Solar Cruiser are separated into a mid-energy component (solar energetic particles, Section 5.1) and a low-energy component (background solar wind, Section 5.2). The high-energy component (galactic cosmic rays, $> \text{GeV}$) are omitted because of the thin materials studied in this analysis. In general, for an isotropic proton environment with energies greater than $\sim 6.5 \text{ MeV}$ (see Equation (1)), the particles do not deposit a significant amount of energy in $150\mu\text{m}$ Kapton (i.e., the Bragg peak has not been reached yet).

5.1 Solar Particle Events

The solar particle event (SPE) environment for interplanetary space is derived following the same procedure as outlined in the Cross-Program Design Specification for Natural Environments (DSNE) Section 3.3.1 (see the technical notes at the end of the section). A 2-year trajectory is defined in interplanetary space at the sub-L1 location of 0.984 AU in SPENVIS² under the Coordinate generators tab. Once this is set, the SPE fluence is computed under the Solar particle mission fluences. The following parameters are set:

- Solar particle model: ESP-PSYCHIC (worst event fluence)
- Ion range: H to H
- Prediction period: override
- Prediction period [years]: 2.0
- Offset in solar cycle: override
- Offset from solar maximum [years]: 0
- Confidence level [%]: 95.0

Table 2 shows the down-selected energy bins that match DSNE Table 3.3.1.10.2-1. In terms of fluence $> 100 \text{ keV}$, the 2-year SPE environment shown in Table 2 is only 6% greater than the unshielded SPE environment is DSNE Table 3.3.1.10.2-1, despite the fluence duration doubling. This is why it is important to run the ESP-PSYCHIC model for the required mission length and not multiply Table 3.3.1.10.2-1 by the number of years. Otherwise, a large overestimate occurs.

²<https://www.spenvis.oma.be/>

Table 2: ESP-PSYCHIC worst event fluence of protons for 2 years during solar maximum at 0.984 AU. The energy center = $\sqrt{\text{bin left edge} \times \text{bin right edge}}$.

Energy Center (keV)	Bin Flux (#/cm ²)	Bin Width (keV)	Bin Left Edge (keV)
1.58E+02	2.08E+11	1.50E+02	1.00E+02
3.54E+02	1.00E+11	2.50E+02	2.50E+02
7.07E+02	6.83E+10	5.00E+02	5.00E+02
1.41E+03	4.65E+10	1.00E+03	1.00E+03
2.65E+03	2.74E+10	1.50E+03	2.00E+03
4.18E+03	1.46E+10	1.50E+03	3.50E+03
5.96E+03	1.51E+10	2.10E+03	5.00E+03
7.54E+03	4.83E+09	9.00E+02	7.10E+03
8.49E+03	4.23E+09	1.00E+03	8.00E+03
9.49E+03	3.38E+09	1.00E+03	9.00E+03
1.26E+04	1.07E+10	6.00E+03	1.00E+04
1.70E+04	1.88E+09	2.00E+03	1.60E+04
1.90E+04	1.52E+09	2.00E+03	1.80E+04
2.24E+04	3.50E+09	5.00E+03	2.00E+04
2.96E+04	3.77E+09	1.00E+04	2.50E+04
3.74E+04	1.83E+09	5.00E+03	3.50E+04
4.24E+04	1.02E+09	5.00E+03	4.00E+04
4.74E+04	1.15E+09	5.00E+03	4.50E+04
5.96E+04	2.35E+09	2.10E+04	5.00E+04
7.54E+04	5.35E+08	9.00E+03	7.10E+04
8.49E+04	4.18E+08	1.00E+04	8.00E+04
9.49E+04	2.59E+08	1.00E+04	9.00E+04
1.26E+05	6.29E+08	6.00E+04	1.00E+05
1.70E+05	7.92E+07	2.00E+04	1.60E+05
1.90E+05	5.44E+07	2.00E+04	1.80E+05
2.24E+05	7.92E+07	5.00E+04	2.00E+05
3.16E+05	7.33E+07	1.50E+05	2.50E+05
4.47E+05	1.27E+07	1.00E+05	4.00E+05

5.2 Low-Energy Solar Wind

To compute the low-energy solar wind plasma contribution of the environment (assumed at 1 AU), the L2-CPE V1.3 software package was used. The proton fluence was computed with the setup shown in Figure 3. Other percentiles that are automatically calculated are 5%, 50%, 95%, and the maximum, mean, and minimum fluxes for each energy bin (see Listing 1 in Appendix B). Table 3 shows the reduced data in the same format as Table 2. The 95% is used in accordance with DSNE (see the technical notes at the end of Section 3.3.1). The sunward facing flux is used and assumed isotropically as worst-case.

Particle Flux Calculation

Species Selection: Proton

Geospace Region: Solar Wind (Max-IMP8)

Flux Direction: All Directions

Energy Bin Scaling: Logarithmic

Min. Energy in Flux Spectrum (keV): 0.10000E-02
(Min = 0.001; Max = 10000.0)

Max. Energy in Flux Spectrum (keV): 10000.
(Min = 0.001; Max = 10000.0)

Number of Energy Interval Bins: 28
(Min = 1; Max = 50)

Random Number Seed: 15739
(Min = 100; Max = 100000)

Number of Monte Carlo Runs: 100
(Min = 2; Max = 1000)

☒ Kappa-distribution
☐ Maxwellian-distribution

Flux Percentile: 67

Buttons: Run, Close, Help, Plot, View Data, Save Inputs, Load Inputs, Reset Inputs, Exit L2-CPE

Figure 3: Screen shot of the setup used in computing the low-energy proton flux environment in L2-CPE.

Table 3: The 95% sunward solar wind environment from L2-CPE for 2 years.

Energy Center (keV)	Bin Flux (#/cm ²)	Bin Width (keV)	Bin Left Edge (keV)
1.34E-03	4.97E+09	8.00E-04	1.00E-03
2.40E-03	8.36E+09	1.40E-03	1.80E-03
4.23E-03	1.38E+10	2.40E-03	3.20E-03
7.48E-03	2.24E+10	4.40E-03	5.60E-03
1.33E-02	3.50E+10	7.80E-03	1.00E-02
2.37E-02	5.29E+10	1.38E-02	1.78E-02
4.21E-02	7.66E+10	2.46E-02	3.16E-02
7.50E-02	1.05E+11	4.38E-02	5.62E-02
1.33E-01	1.37E+11	7.78E-02	1.00E-01
2.37E-01	1.64E+11	1.38E-01	1.78E-01
4.22E-01	1.86E+11	2.46E-01	3.16E-01
7.50E-01	1.94E+11	4.38E-01	5.62E-01
1.33E+00	1.88E+11	7.78E-01	1.00E+00
2.37E+00	1.68E+11	1.38E+00	1.78E+00
4.22E+00	1.40E+11	2.46E+00	3.16E+00
7.50E+00	1.10E+11	4.38E+00	5.62E+00
1.33E+01	8.21E+10	7.78E+00	1.00E+01
2.37E+01	5.75E+10	1.38E+01	1.78E+01
4.22E+01	3.91E+10	2.46E+01	3.16E+01
7.50E+01	2.56E+10	4.38E+01	5.62E+01
1.33E+02	1.65E+10	7.78E+01	1.00E+02
2.37E+02	1.04E+10	1.38E+02	1.78E+02
4.22E+02	6.43E+09	2.46E+02	3.16E+02
7.50E+02	3.91E+09	4.38E+02	5.62E+02
1.33E+03	2.35E+09	7.78E+02	1.00E+03
2.37E+03	1.43E+09	1.38E+03	1.78E+03
4.22E+03	8.50E+08	2.46E+03	3.16E+03
7.50E+03	5.05E+08	4.38E+03	5.62E+03

6 Total Ionizing Dose

6.1 Solar Particle Events

6.2 Low-Energy Solar Wind

7 Results

A Dose Percentile-Depth vs. Energy Parameters Fits

Table 4: Parameter fits to Equation (1) for various dose percentiles using normally incident protons.

Percentile/100	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>
0.05	8.445E+00	6.539E-01	4.543E+03	1.785E+00
0.10	4.414E+00	6.654E-01	3.267E+03	1.786E+00
0.15	2.923E+00	6.729E-01	2.682E+03	1.787E+00
0.20	2.171E+00	6.793E-01	2.339E+03	1.788E+00
0.25	1.723E+00	6.845E-01	2.109E+03	1.789E+00
0.30	1.429E+00	6.894E-01	1.947E+03	1.790E+00
0.35	1.216E+00	6.937E-01	1.826E+03	1.792E+00
0.40	1.057E+00	6.976E-01	1.732E+03	1.793E+00
0.45	9.332E-01	7.013E-01	1.658E+03	1.794E+00
0.50	8.296E-01	7.043E-01	1.598E+03	1.795E+00
0.55	7.407E-01	7.067E-01	1.549E+03	1.796E+00
0.60	6.660E-01	7.089E-01	1.510E+03	1.798E+00
0.65	6.006E-01	7.109E-01	1.479E+03	1.799E+00
0.70	5.423E-01	7.128E-01	1.456E+03	1.800E+00
0.75	4.868E-01	7.140E-01	1.438E+03	1.801E+00
0.80	4.309E-01	7.141E-01	1.423E+03	1.802E+00
0.85	3.744E-01	7.131E-01	1.412E+03	1.803E+00
0.90	3.140E-01	7.104E-01	1.402E+03	1.804E+00
0.95	2.441E-01	7.046E-01	1.396E+03	1.804E+00
0.99	1.554E-01	6.904E-01	1.393E+03	1.805E+00
0.999	9.998E-02	6.752E-01	1.394E+03	1.807E+00
0.9999	7.282E-02	6.638E-01	1.385E+03	1.806E+00

B Raw L2-CPE output of the Interplanetary Proton Environment

Listing 1: The sunward facing flux (worst-case) during solar maximum from IMP8 using L2-CPE.

```

1                                     - FLUX SUMMARY -
2 L2-CPE V1.3                      Kappa-distribution
3 Cartesian (LRAD) Algorithm
4
5
6 Phenomenological Region => Solar Wind at SolMax (IMP-8)
7
8
9
10 Species => Protons
11
12 Positive X direction flux calculated.
13
14 Minimum Energy = 0.0010 keV
15 Maximum Energy = 10000.0000 keV
16
17 Number of Energy Bins = 28
18
19 50% Total Flux = 0.6109E+03 (#/cm^2/sec)
20 95% Total Flux = 0.2986E+05 (#/cm^2/sec)
21 5% Total Flux = 0.6493E+01 (#/cm^2/sec)
22 67% Total Flux = 0.1896E+04 (#/cm^2/sec)
23 Maximum Total Flux = 0.5679E+07 (#/cm^2/sec)
24 Minimum Total Flux = 0.1387E-02 (#/cm^2/sec)
25 Mean Total Flux = 0.7319E+04 (#/cm^2/sec)
26 Std. Dev. Total Flux = 0.4616E+05 (#/cm^2/sec)
27
28
29 Differential Energy Flux Table (#/cm^2/sec/keV)
30
31 E1(keV) E2(keV) 50% 95% 5% 67%
32 Maximum Minimum Mean Std. Dev.
33 0.0010 0.0018 0.4228E+04 0.1013E+06 0.8432E+02 0.1078E+05 0.4149E
34 +08 0.2333E-01 0.2406E+05 0.1700E+06
35 0.0018 0.0032 0.3944E+04 0.9578E+05 0.7729E+02 0.1009E+05 0.3867E
36 +08 0.2121E-01 0.2272E+05 0.1597E+06
37 0.0032 0.0056 0.3597E+04 0.8902E+05 0.6892E+02 0.9277E+04 0.3526E
38 +08 0.1871E-01 0.2109E+05 0.1472E+06
39 0.0056 0.0100 0.3200E+04 0.8097E+05 0.5914E+02 0.8297E+04 0.3125E
40 +08 0.1588E-01 0.1914E+05 0.1324E+06
41 0.0100 0.0178 0.2742E+04 0.7134E+05 0.4856E+02 0.7171E+04 0.2671E
42 +08 0.1282E-01 0.1688E+05 0.1155E+06
43 0.0178 0.0316 0.2252E+04 0.6065E+05 0.3763E+02 0.5959E+04 0.2182E
44 +08 0.9715E-02 0.1437E+05 0.9709E+05
45 0.0316 0.0562 0.1746E+04 0.4935E+05 0.2715E+02 0.4692E+04 0.1685E
46 +08 0.6801E-02 0.1173E+05 0.7806E+05
47 0.0562 0.1000 0.1268E+04 0.3808E+05 0.1798E+02 0.3485E+04 0.1216E
48 +08 0.4322E-02 0.9100E+04 0.5960E+05
49 0.1000 0.1778 0.8508E+03 0.2786E+05 0.1078E+02 0.2404E+04 0.8108E
50 +07 0.2350E-02 0.6656E+04 0.4296E+05
51 0.1778 0.3162 0.5214E+03 0.1882E+05 0.5686E+01 0.1526E+04 0.4940E
52 +07 0.1078E-02 0.4558E+04 0.2909E+05
53 0.3162 0.5623 0.2876E+03 0.1200E+05 0.2641E+01 0.8831E+03 0.2727E
54 +07 0.4226E-03 0.2905E+04 0.1846E+05
55 0.5623 1.0000 0.1428E+03 0.7016E+04 0.1063E+01 0.4634E+03 0.1357E
56 +07 0.1060E-03 0.1717E+04 0.1096E+05

```

44	1.0000	1.7783	0.6332E+02	0.3824E+04	0.3668E+00	0.2177E+03	0.6088E
	+06	0.2191E-04	0.9409E+03	0.6094E+04			
45	1.7783	3.1623	0.2496E+02	0.1928E+04	0.1092E+00	0.9264E+02	0.2900E
	+06	0.3786E-05	0.4789E+03	0.3183E+04			
46	3.1623	5.6234	0.8762E+01	0.9028E+03	0.2810E-01	0.3574E+02	0.1467E
	+06	0.5546E-06	0.2276E+03	0.1569E+04			
47	5.6234	10.0000	0.2794E+01	0.3977E+03	0.6305E-02	0.1251E+02	0.7069E
	+05	0.7017E-07	0.1018E+03	0.7351E+03			
48	10.0000	17.7828	0.8167E+00	0.1673E+03	0.1265E-02	0.4048E+01	0.3331E
	+05	0.7825E-08	0.4326E+02	0.3295E+03			
49	17.7828	31.6228	0.2200E+00	0.6582E+02	0.2297E-03	0.1225E+01	0.1518E
	+05	0.7849E-09	0.1764E+02	0.1422E+03			
50	31.6228	56.2341	0.5576E-01	0.2516E+02	0.3830E-04	0.3482E+00	0.6881E
	+04	0.7220E-10	0.6967E+01	0.5949E+02			
51	56.2341	100.0000	0.1341E-01	0.9267E+01	0.5868E-05	0.9401E-01	0.2985E
	+04	0.6195E-11	0.2690E+01	0.2427E+02			
52	100.0000	177.8279	0.3090E-02	0.3361E+01	0.8546E-06	0.2441E-01	0.1249E
	+04	0.5030E-12	0.1023E+01	0.9707E+01			
53	177.8279	316.2278	0.6874E-03	0.1191E+01	0.1201E-06	0.6135E-02	0.5097E
	+03	0.3913E-13	0.3849E+00	0.3827E+01			
54	316.2278	562.3413	0.1495E-03	0.4141E+00	0.1598E-07	0.1510E-02	0.2056E
	+03	0.2944E-14	0.1441E+00	0.1493E+01			
55	562.3413	1000.0000	0.3152E-04	0.1416E+00	0.2079E-08	0.3623E-03	0.8160E
	+02	0.2159E-15	0.5386E-01	0.5782E+00			
56	1000.0000	1778.2794	0.6590E-05	0.4795E-01	0.2656E-09	0.8677E-04	0.3197E
	+02	0.1552E-16	0.2013E-01	0.2229E+00			
57	1778.2794	3162.2776	0.1354E-05	0.1634E-01	0.3325E-10	0.2047E-04	0.1240E
	+02	0.1100E-17	0.7536E-02	0.8573E-01			
58	3162.2776	5623.4131	0.2765E-06	0.5473E-02	0.4064E-11	0.4813E-05	0.4777E
	+01	0.6855E-19	0.2829E-02	0.3294E-01			
59	5623.4131	10000.0000	0.5583E-07	0.1828E-02	0.4980E-12	0.1122E-05	0.1829E
	+01	0.3413E-20	0.1066E-02	0.1266E-01			
60							
61							
62							
63							
64							
	Particle Flux per Energy Bin Table (#/cm ² /sec)						
	E1 (keV)	E2 (keV)	50%	95%	5%	67%	
	Maximum	Minimum	Mean	Std. Dev.			
65	0.0010	0.0018	0.3291E+01	0.7883E+02	0.6563E-01	0.8387E+01	0.3229E
	+05	0.1815E-04	0.1873E+02	0.1323E+03			
66	0.0018	0.0032	0.5458E+01	0.1326E+03	0.1070E+00	0.1397E+02	0.5352E
	+05	0.2935E-04	0.3145E+02	0.2211E+03			
67	0.0032	0.0056	0.8853E+01	0.2191E+03	0.1696E+00	0.2283E+02	0.8678E
	+05	0.4606E-04	0.5190E+02	0.3623E+03			
68	0.0056	0.0100	0.1400E+02	0.3544E+03	0.2588E+00	0.3631E+02	0.1368E
	+06	0.6950E-04	0.8375E+02	0.5794E+03			
69	0.0100	0.0178	0.2134E+02	0.5552E+03	0.3779E+00	0.5581E+02	0.2079E
	+06	0.9978E-04	0.1314E+03	0.8989E+03			
70	0.0178	0.0316	0.3117E+02	0.8393E+03	0.5209E+00	0.8248E+02	0.3019E
	+06	0.1345E-03	0.1989E+03	0.1344E+04			
71	0.0316	0.0562	0.4296E+02	0.1215E+04	0.6682E+00	0.1155E+03	0.4147E
	+06	0.1674E-03	0.2887E+03	0.1921E+04			
72	0.0562	0.1000	0.5549E+02	0.1666E+04	0.7870E+00	0.1525E+03	0.5322E
	+06	0.1891E-03	0.3983E+03	0.2608E+04			
73	0.1000	0.1778	0.6622E+02	0.2169E+04	0.8392E+00	0.1871E+03	0.6310E
	+06	0.1829E-03	0.5180E+03	0.3343E+04			

74	0.1778	0.3162	0.7216E+02	0.2605E+04	0.7869E+00	0.2113E+03	0.6837E
	+06	0.1492E-03	0.6308E+03	0.4026E+04			
75	0.3162	0.5623	0.7079E+02	0.2952E+04	0.6500E+00	0.2173E+03	0.6712E
	+06	0.1040E-03	0.7149E+03	0.4543E+04			
76	0.5623	1.0000	0.6250E+02	0.3071E+04	0.4650E+00	0.2028E+03	0.5941E
	+06	0.4638E-04	0.7516E+03	0.4797E+04			
77	1.0000	1.7783	0.4928E+02	0.2976E+04	0.2854E+00	0.1694E+03	0.4738E
	+06	0.1705E-04	0.7323E+03	0.4743E+04			
78	1.7783	3.1623	0.3454E+02	0.2669E+04	0.1511E+00	0.1282E+03	0.4014E
	+06	0.5240E-05	0.6628E+03	0.4405E+04			
79	3.1623	5.6234	0.2156E+02	0.2222E+04	0.6916E-01	0.8797E+02	0.3611E
	+06	0.1365E-05	0.5602E+03	0.3862E+04			
80	5.6234	10.0000	0.1223E+02	0.1741E+04	0.2760E-01	0.5475E+02	0.3094E
	+06	0.3071E-06	0.4456E+03	0.3217E+04			
81	10.0000	17.7828	0.6356E+01	0.1302E+04	0.9842E-02	0.3150E+02	0.2593E
	+06	0.6090E-07	0.3367E+03	0.2564E+04			
82	17.7828	31.6228	0.3045E+01	0.9110E+03	0.3178E-02	0.1696E+02	0.2101E
	+06	0.1086E-07	0.2441E+03	0.1968E+04			
83	31.6228	56.2341	0.1372E+01	0.6192E+03	0.9425E-03	0.8571E+01	0.1693E
	+06	0.1777E-08	0.1715E+03	0.1464E+04			
84	56.2341	100.0000	0.5868E+00	0.4056E+03	0.2568E-03	0.4114E+01	0.1306E
	+06	0.2711E-09	0.1177E+03	0.1062E+04			
85	100.0000	177.8279	0.2405E+00	0.2616E+03	0.6651E-04	0.1900E+01	0.9719E
	+05	0.3915E-10	0.7958E+02	0.7555E+03			
86	177.8279	316.2278	0.9513E-01	0.1649E+03	0.1662E-04	0.8491E+00	0.7055E
	+05	0.5415E-11	0.5327E+02	0.5296E+03			
87	316.2278	562.3413	0.3678E-01	0.1019E+03	0.3933E-05	0.3717E+00	0.5061E
	+05	0.7245E-12	0.3547E+02	0.3674E+03			
88	562.3413	1000.0000	0.1380E-01	0.6197E+02	0.9101E-06	0.1586E+00	0.3571E
	+05	0.9447E-13	0.2357E+02	0.2531E+03			
89	1000.0000	1778.2794	0.5129E-02	0.3732E+02	0.2067E-06	0.6753E-01	0.2488E
	+05	0.1208E-13	0.1567E+02	0.1735E+03			
90	1778.2794	3162.2776	0.1874E-02	0.2261E+02	0.4601E-07	0.2833E-01	0.1717E
	+05	0.1522E-14	0.1043E+02	0.1186E+03			
91	3162.2776	5623.4131	0.6804E-03	0.1347E+02	0.1000E-07	0.1185E-01	0.1176E
	+05	0.1687E-15	0.6963E+01	0.8106E+02			
92	5623.4131	10000.0000	0.2443E-03	0.8000E+01	0.2180E-08	0.4910E-02	0.8007E
	+04	0.1494E-16	0.4665E+01	0.5541E+02			
93							
94	TOTALS:		0.5836E+03	0.2937E+05	0.6244E+01	0.1811E+04	0.6977E
	+07	0.1260E-02	0.7319E+04	0.5040E+05			