

SLS Booster Radiation Environment

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1 Executive Summary

The purpose of the following update is to provide the Booster element with a low-altitude 50 km radiation environment. The SLS-SPEC-159 Cross-Program Design Specification for Natural Environments (DSNE) includes a 20 km and 200 km radiation environment, however the Booster element will only be achieving altitudes less than roughly 50 km. The updated 50 km radiation environment is derived following similar procedures as the generation of the 200 km radiation environment, as outlined in Section 3.2.13 of the DSNE. Specifically, tables for the linear energy transfer (LET), differential flux, and integral flux are given for the 50 km environment (see Tables [2](#), [3](#), and [4](#)) and compared with DSNE Tables 3.2.13-1 – 3.2.13-3.

2 Reproducing DSNE 200 km Tables using CREME96

The 200 km LET (Linear Energy Transfer) and particle flux environments SLS-SPEC-159 Cross-Program Design Specification for Natural Environments (DSNE) were obtained using the Cosmic Ray Effects on Microelectronics 96 (CREME96¹). In this section, DSNE Tables 3.2.13-1 – 3 are reproduced using the technical notes provided in the DSNE.

For the LET and flux, the GTRN routine is run using the following options:

- 1.C.a. & 1.C.b. 200 km circular orbit
- 1.C.c. 51.6 degrees orbit inclination
- 1.C.g. Effective L-shell range: $2.4 \leq L \leq 2.55$
- 2. Stormy magnetic weather conditions

2.1 Linear Energy Transfer (LET)

To compute the LET, the LETSPEC routine is used setting the following parameters:

- 2. and 3. $Z = 1$ to 92
- 4. particles > 0.1 MeV/nuc
- 5. Silicon target material

Integral LET due to solar particle events (SPEs) and galactic cosmic rays (GCRs) are both computed as shown in Figure 1. Agreement in both the SPE and GCR integral LET spectra show that the CREME96 inputs were interpreted correctly. The SPE LET integral flux includes a factor of 2x on the CREME96 output to match what is in DSNE.

¹<https://creme.isde.vanderbilt.edu/>

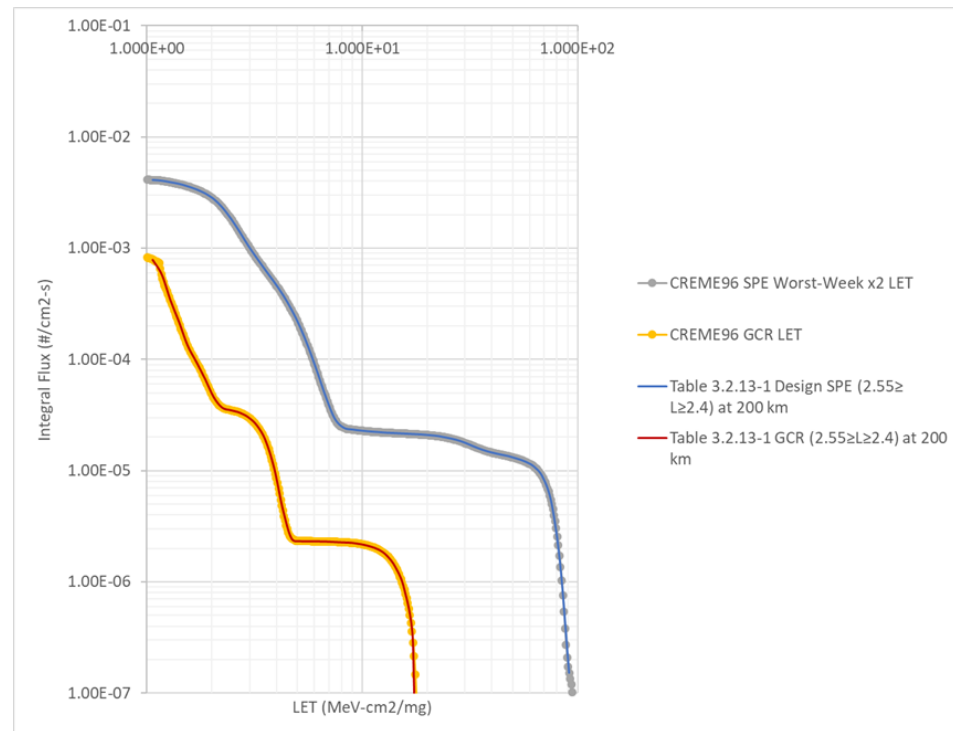


Figure 1: Output generated from CREME96 LETSPEC are plotted against DSNE Table 3.2.13-1 for SPEs and GCRs.

2.2 Differential Flux

The differential flux for both SPEs and GCRs are computed using the FLUX routine with the following options set:

SPE

- 1. and 2. $Z = 1$ to 92
- 2.a. CREME96
- 3.b. Worst Week
- 4. Inside Earth's Magnetosphere

GCR

- 1. and 2. $Z = 1$ to 92
- 2.a. CREME96
- 3.b. Solar Minimum (Cosmic-Ray Maximum)
- 4. Inside Earth's Magnetosphere

The differential flux output from CREME96 is plotted against Table 3.2.13-2 in Figure 2 and shows perfect agreement. Note that there is a factor of 2x on the SPEs from CREME96 to DSNE. According to the technical notes in DSNE, "The x2 multiplier of the 1989 event is needed to simulate a 'worst case' SPE exposure at the high 97% probability level..."

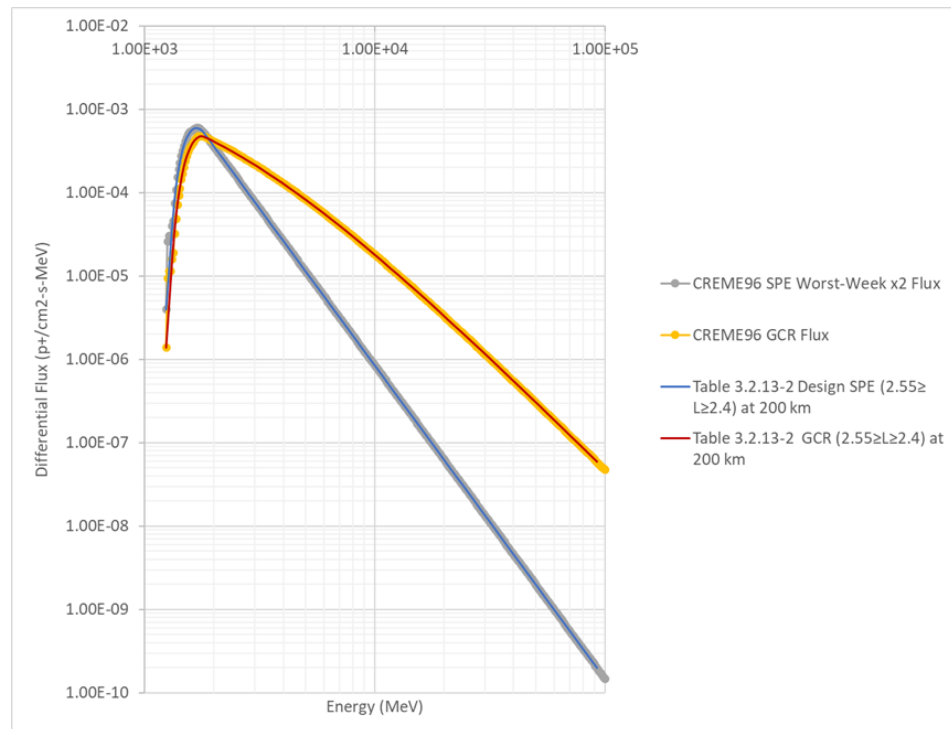


Figure 2: Output generated from CREME96 FLUX are plotted against DSNE Table 3.2.13-2 for SPEs and GCRs.

2.3 Integral Flux

The integral flux for both the SPEs and GRCs are derived from the differential flux output. Since the flux spectra have power-law-like features, the best way to approximate the differential flux is to interpolate using a power-law fit between data points (x_i, y_i) , i.e.

$$y(x) = y_i \left(\frac{x}{x_i} \right)^{b_i}, \text{ for } x_i \leq x \leq x_{i+1}, \quad (1)$$

where

$$b_i = \frac{\log(y_{i+1}/y_i)}{\log(x_{i+1}/x_i)}. \quad (2)$$

The integral flux ($> x$) can then be computed by integrating from some x to infinity

$$Y(> x) = \int_x^\infty dx' y(x'). \quad (3)$$

Inserting Equation (1) for $y(x)$, the integral flux becomes

$$Y(> x_n) = \sum_{i=n}^{N-1} \frac{y_i x_i}{b_i + 1} \left[\left(\frac{x_{i+1}}{x_i} \right)^{b_i+1} - 1 \right]. \quad (4)$$

Applying Equation (4) to the differential fluxes shown in Section 2.2, the integral fluxes are derived and compared with DSNE Table 3.2.13-3 in Figure 3. The comparison again shows perfect agreement and also give merit to the power-law interpolation method outlined above.

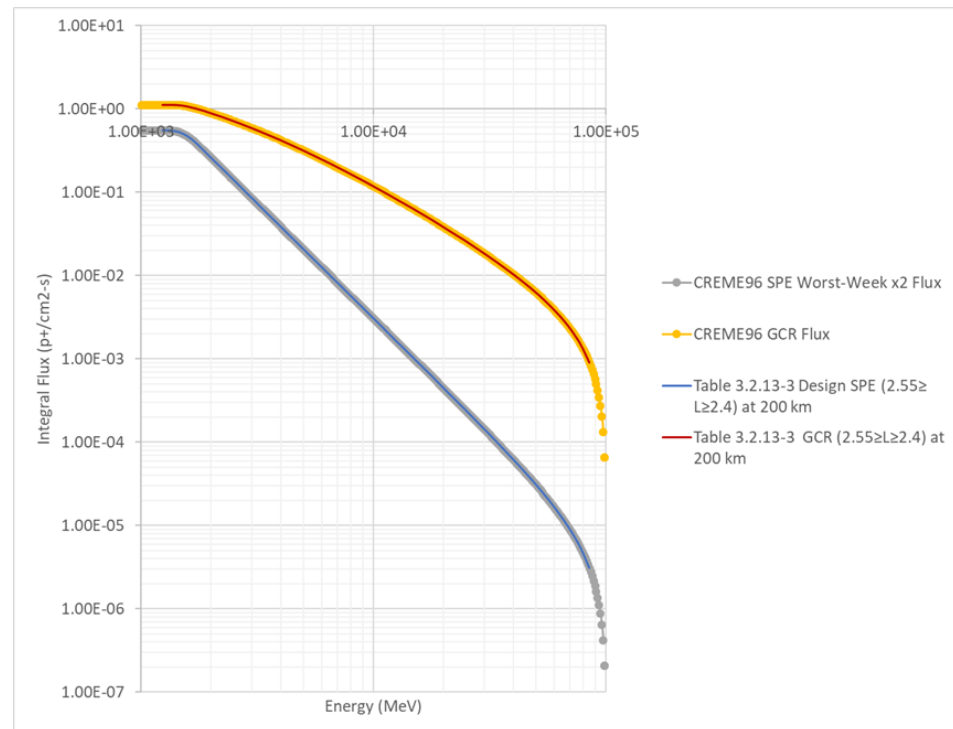


Figure 3: Output generated from CREME96 FLUX and converted to integral fluxes using Equation (4) are plotted against DSNE Table 3.2.13-3 for SPEs and GCRs.

3 Updated 50 km Environment

In this section, the methods used to derive the DSNE tables for the 200 km environments will be used to compute the new 50 km environments. The assumptions that went into the parameters used for the 50 km environments are discussed in Section 3.1. Following in Section 4, the integral LET spectra, differential fluxes, and integral fluxes generated for the 50 km environments are compared to the DSNE 200 km environments.

3.1 Assumptions

Information about the 3-DOF DAC-1 BOLE separation was given by Patrick Montgomery on 2/2/2021. The trajectory was optimized to produce maximum loads, so a lower separation altitude is achieved. There also was no dispersion in launch azimuth. The specific data provided is as follows:

3.1.1 BOLE Separation Location

- Altitude (ft): 1.47769768×10^5 to 1.56331111×10^5 (or 45.04 km to 47.65 km)
- Geodetic Latitude (deg): 28.63679 to 28.63769
- Longitude (deg): 279.844269 to 279.892322
- Inclination (deg): 28.48989 to 28.49106

3.1.2 LC-39b Location

In order to include dispersion in launch azimuth, the downrange distance is computed assuming a launch location from KSC launch complex 39b.

- Geodetic Latitude (deg): 28.627623
- Longitude (deg): 279.378890.

3.1.3 Downrange Distance and Initial Bearing

Given the latitude and longitude (ϕ , λ) of the starting and ending location, a downrange distance can be computed² using

$$D = 2r_E \arcsin(\sqrt{a}), \quad (5)$$

where $r_E = 6371$ km (Earth's radius), and

$$a = \sin^2(\Delta\phi/2) + \cos\phi_1 \cos\phi_2 \sin^2(\Delta\lambda/2), \quad (6)$$

for $\Delta\phi = \phi_1 - \phi_2$ and $\Delta\lambda = \lambda_1 - \lambda_2$.

²E.g., see <https://www.movable-type.co.uk/scripts/latlong.html>

The initial bearing from the launch point can also be calculated using

$$\tan \theta_{i(1,2)} = \frac{\sin \Delta \lambda \cos \phi_2}{\cos \phi_1 \sin \phi_2 - \sin \phi_1 \cos \phi_2 \cos \Delta \lambda}. \quad (7)$$

Therefore, from the initial separation data, the bearing and downrange distance is the following:

- **Nominal bearing** (deg, from N CCW): -88.48 to -88.71 (i.e., almost strictly due East)
- **Downrange distance** (km): 45.4 to 50.1 .

The range of valid bearings from KSC LC-39b are -35° to -120° , where the worst-case³ would be -35° (most northerly direction), giving an orbital inclination of 57° .

3.1.4 Magnetic Epoch and L-Shell

A magnetic epoch must be selected in order to convert geodetic latitude and longitude to magnetic latitude and longitude. The magnetic latitude and separation altitude are used to compute the L-shell. In DSNE, it is implicitly assumed that the magnetic epoch is 1980, driven by the assumptions built into CREME96. However, a magnetic epoch of 2020 is also used in the analysis for the lower bound⁴ on the L-shell.

The L-shell can be computed by

$$L = \frac{1 + \frac{h}{R_E}}{\cos(\phi_{\text{geomagnetic}})}, \quad (8)$$

where h is the spacecraft altitude, $R_E = 6371$ km, and $\phi_{\text{geomagnetic}}$ is the geomagnetic latitude.

If a most-northerly(southerly) launch azimuth case is assumed, the magnetic latitude for different magnetic epochs is given in Table 1.

Table 1: The magnetic latitudes at BOLE separation for magnetic epochs of 1980 & 2020 and bounding cases for launch azimuths (65° to -30°).

	1980 epoch	2020 epoch
Most-northerly	39.83°	38.14°
Most-southerly	39.23°	37.54°

L-Shell Sensitivity: The L-shell sensitivity, or dL , is affected by magnetic epoch, launch azimuth, and separation altitude, summarized below:

³Worst-case in terms of a larger L-shell value, giving less magnetic field protection from space radiation.

⁴Currently, the magnetic south pole (near the geographic north pole) has been migrating towards the Asian continent, hence putting KSC at a lower L-shell over several decades.

- Magnetic epoch: Magnetic latitude difference of 1.69° ($dL \approx 0.08$ or 72% of total dL)
- Launch azimuth: Magnetic latitude difference of 0.60° ($dL \approx 0.03$ or 27% of total dL)
- Altitude at separation: Altitude difference of 5 km ($dL \approx 0.0013$ or 1% of total dL)

Therefore, the choice of magnetic epoch drives the range of the L-shell compared to the launch azimuth range and range in separation altitude.

3.1.5 L-Shell Range

Given the analysis in Section 3.1.4, the L-shell range used in deriving the new 50 km environments is:

- From 1.60174 (most southerly launch azimuth, 2020 magnetic epoch, and separation altitude of 45 km)
- To 1.70896 (most northerly launch azimuth, 1980 magnetic epoch, and separation altitude of 50 km).

The difference from using a separation altitude of 47.65 km vs. 50 km changes the L-shell value only in the last two significant figures.

3.2 GTRN, FLUX, and LETSPEC Options for 50 km Environments

The options used in the GTRN routine for the 50 km environments (as a best guess worst-case) are as follows:

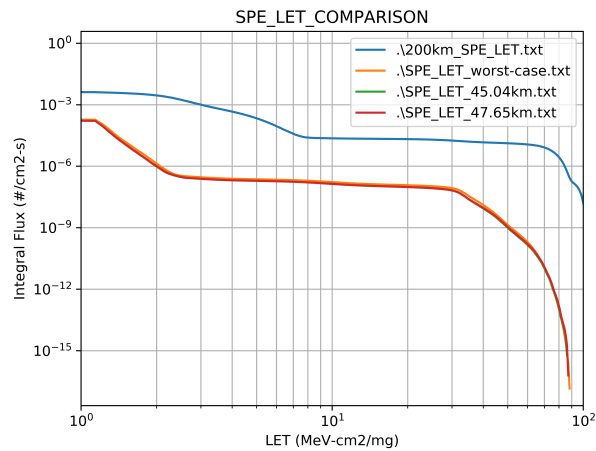
- 1.C.a. & 1.C.b. 50 km circular orbit
- 1.C.c. 57 degrees orbit inclination
- 1.C.g. Effective L-shell range: $1.60174 \leq L \leq 1.70896$
- 2. Stormy magnetic weather conditions.

Options for the FLUX and LETSPEC routines are the same as in Sections 2.2 and 2.1, respectively.

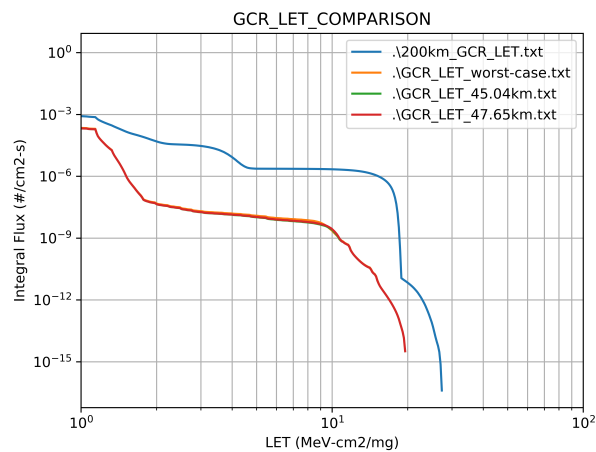
4 Comparison of 50 km and 200 km Environments

4.1 Linear Energy Transfer (LET)

The high resolution tables for the SPE and GCR LET spectra are given in Appendix B, Listings 5 and 6. For a lower resolution table (that would conform to what is in DSNE), see Table 2.



(a) Comparing different SPE LET BOLE environments with 200 km DSNE environment.



(b) Comparing different GCR LET BOLE environments with 200 km DSNE environment.

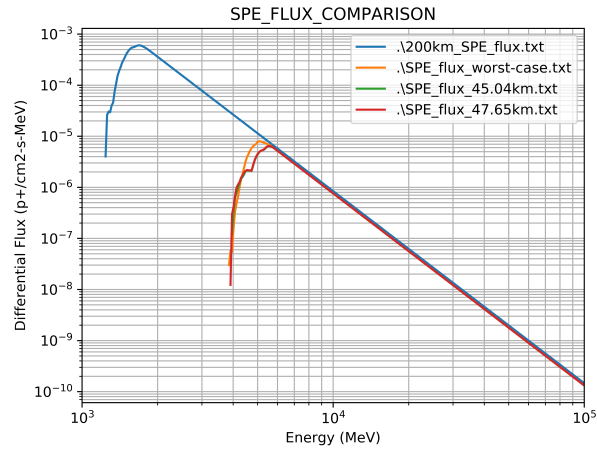
Figure 4: Comparison of integral LET fluxes between 50 km and 200 km environments.

Table 2: 50 km Integral LET Flux as Shown in Figure 4, worst-case lines.

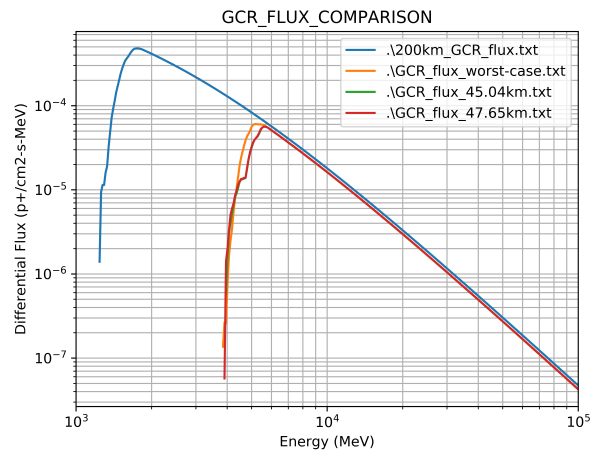
LET (MeV-cm ² /mg)	Design SPE Integral Flux (#/cm ² -s)	GCR Integral Flux (#/cm ² -s)
1.00E+00	1.86E-04	2.23E-04
1.10E+00	1.84E-04	2.04E-04
1.20E+00	1.24E-04	5.81E-05
1.31E+00	5.31E-05	2.04E-05
1.44E+00	2.19E-05	3.32E-06
1.58E+00	1.01E-05	4.63E-07
1.73E+00	4.73E-06	1.21E-07
1.89E+00	2.19E-06	5.80E-08
2.07E+00	9.77E-07	4.33E-08
2.27E+00	4.92E-07	3.53E-08
2.49E+00	3.46E-07	3.04E-08
2.73E+00	3.11E-07	2.44E-08
2.99E+00	2.90E-07	2.03E-08
3.27E+00	2.71E-07	1.82E-08
3.58E+00	2.56E-07	1.71E-08
3.92E+00	2.45E-07	1.58E-08
4.30E+00	2.38E-07	1.47E-08
4.71E+00	2.32E-07	1.33E-08
5.16E+00	2.27E-07	1.16E-08
5.65E+00	2.22E-07	1.00E-08
6.19E+00	2.17E-07	9.19E-09
6.78E+00	2.10E-07	8.47E-09
7.43E+00	2.03E-07	7.90E-09
8.14E+00	1.93E-07	7.17E-09
8.91E+00	1.82E-07	5.79E-09
9.76E+00	1.71E-07	2.92E-09
1.07E+01	1.59E-07	9.12E-10
1.17E+01	1.49E-07	3.93E-10
1.28E+01	1.40E-07	8.18E-11
1.41E+01	1.34E-07	3.83E-11
1.54E+01	1.29E-07	5.54E-12
1.69E+01	1.25E-07	1.04E-12
1.85E+01	1.21E-07	1.10E-13
2.02E+01	1.17E-07	0.00E+00
2.22E+01	1.13E-07	0.00E+00
2.43E+01	1.07E-07	0.00E+00
2.66E+01	1.00E-07	0.00E+00
2.91E+01	9.00E-08	0.00E+00
3.19E+01	6.84E-08	0.00E+00
3.50E+01	3.58E-08	0.00E+00
3.83E+01	1.79E-08	0.00E+00
4.20E+01	8.48E-09	0.00E+00
4.60E+01	3.46E-09	0.00E+00
5.04E+01	1.27E-09	0.00E+00
5.52E+01	5.07E-10	0.00E+00
6.04E+01	1.82E-10	0.00E+00
6.62E+01	4.21E-11	0.00E+00
7.25E+01	4.54E-12	0.00E+00
7.94E+01	1.54E-13	0.00E+00
8.70E+01	2.84E-16	0.00E+00

4.2 Differential Flux

High resolution tables shown in Appendix B in Listings 3 and 4. The low resolution data is shown in Table 3.



(a) Comparing different differential SPE flux BOLE environments with 200 km DSNE environment.



(b) Comparing different differential GCR flux BOLE environments with 200 km DSNE environment.

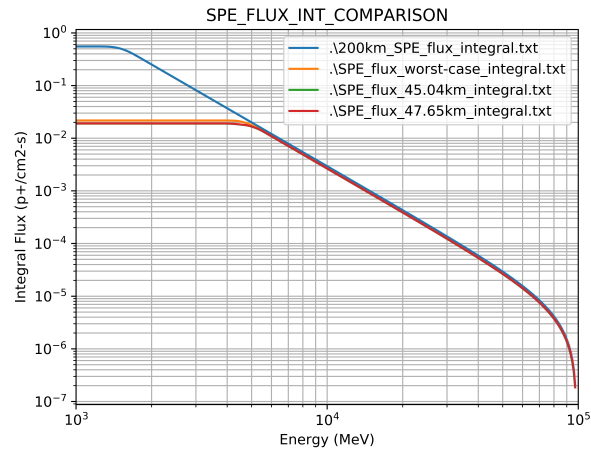
Figure 5: Comparison of differential fluxes between 50 km and 200 km environments.

Table 3: 50 km Differential Flux as Shown in Figure 5, worst-case lines.

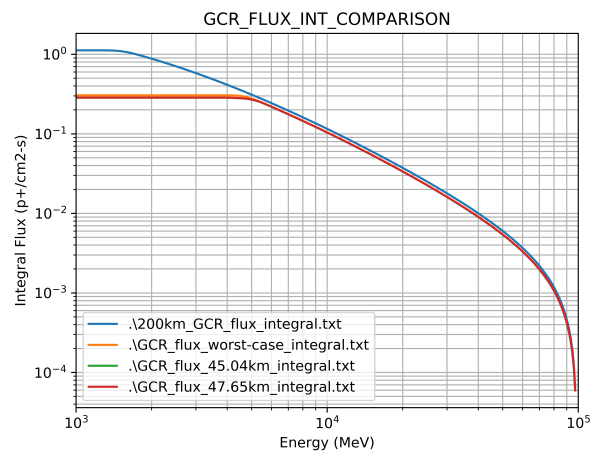
Energy (MeV)	Design SPE	GCR
	Differential Flux (p+/cm ² -s-MeV)	Differential Flux (p+/cm ² -s-MeV)
3.90E+03	5.50E-08	2.56E-07
4.17E+03	5.99E-07	3.17E-06
4.45E+03	2.77E-06	1.66E-05
4.75E+03	6.00E-06	4.01E-05
5.08E+03	7.97E-06	5.95E-05
5.42E+03	7.19E-06	6.00E-05
5.79E+03	5.92E-06	5.50E-05
6.19E+03	4.63E-06	4.78E-05
6.61E+03	3.61E-06	4.14E-05
7.06E+03	2.82E-06	3.58E-05
7.55E+03	2.20E-06	3.09E-05
8.06E+03	1.72E-06	2.66E-05
8.61E+03	1.34E-06	2.29E-05
9.20E+03	1.04E-06	1.97E-05
9.83E+03	8.15E-07	1.68E-05
1.05E+04	6.35E-07	1.44E-05
1.12E+04	4.96E-07	1.23E-05
1.20E+04	3.87E-07	1.05E-05
1.28E+04	3.02E-07	8.96E-06
1.37E+04	2.35E-07	7.62E-06
1.46E+04	1.84E-07	6.48E-06
1.56E+04	1.43E-07	5.50E-06
1.67E+04	1.12E-07	4.67E-06
1.78E+04	8.72E-08	3.95E-06
1.90E+04	6.80E-08	3.35E-06
2.03E+04	5.31E-08	2.83E-06
2.17E+04	4.14E-08	2.39E-06
2.32E+04	3.23E-08	2.02E-06
2.48E+04	2.52E-08	1.70E-06
2.64E+04	1.97E-08	1.44E-06
2.82E+04	1.53E-08	1.21E-06
3.02E+04	1.20E-08	1.02E-06
3.22E+04	9.34E-09	8.57E-07
3.44E+04	7.29E-09	7.21E-07
3.68E+04	5.69E-09	6.06E-07
3.93E+04	4.44E-09	5.09E-07
4.20E+04	3.46E-09	4.27E-07
4.48E+04	2.70E-09	3.59E-07
4.79E+04	2.11E-09	3.01E-07
5.12E+04	1.64E-09	2.52E-07
5.47E+04	1.28E-09	2.12E-07
5.84E+04	1.00E-09	1.77E-07
6.24E+04	7.80E-10	1.48E-07
6.66E+04	6.09E-10	1.24E-07
7.12E+04	4.75E-10	1.04E-07
7.60E+04	3.71E-10	8.71E-08
8.12E+04	2.89E-10	7.29E-08
8.68E+04	2.26E-10	6.10E-08
9.27E+04	1.76E-10	5.10E-08
9.90E+04	1.37E-10	4.27E-08

4.3 Integral Flux

High resolution tables are omitted from the appendix since they can be derived from Listings 3 and 4 by applying Equation (4). The low resolution data is shown in Table 4.



(a) Comparing different integral SPE flux BOLE environments with 200 km DSNE environment.



(b) Comparing different integral GCR flux BOLE environments with 200 km DSNE environment.

Figure 6: Comparison of integral fluxes between 50 km and 200 km environments.

Table 4: 50 km Integral Flux as Shown in Figure 6, worst-case lines.

Energy (MeV)	Design SPE	GCR
	Integral Flux (p+/cm ² -s)	Integral Flux (p+/cm ² -s)
3.50E+03	2.17E-02	3.05E-01
3.74E+03	2.17E-02	3.05E-01
4.00E+03	2.16E-02	3.04E-01
4.28E+03	2.14E-02	3.03E-01
4.58E+03	2.04E-02	2.97E-01
4.90E+03	1.84E-02	2.83E-01
5.24E+03	1.57E-02	2.63E-01
5.61E+03	1.31E-02	2.41E-01
6.00E+03	1.09E-02	2.20E-01
6.42E+03	9.04E-03	2.00E-01
6.87E+03	7.50E-03	1.82E-01
7.34E+03	6.23E-03	1.65E-01
7.86E+03	5.17E-03	1.50E-01
8.40E+03	4.29E-03	1.36E-01
8.99E+03	3.56E-03	1.23E-01
9.61E+03	2.96E-03	1.11E-01
1.03E+04	2.46E-03	9.98E-02
1.10E+04	2.04E-03	8.99E-02
1.18E+04	1.69E-03	8.09E-02
1.26E+04	1.40E-03	7.27E-02
1.35E+04	1.16E-03	6.53E-02
1.44E+04	9.66E-04	5.85E-02
1.54E+04	8.01E-04	5.24E-02
1.65E+04	6.64E-04	4.68E-02
1.76E+04	5.51E-04	4.18E-02
1.89E+04	4.56E-04	3.73E-02
2.02E+04	3.78E-04	3.32E-02
2.16E+04	3.13E-04	2.95E-02
2.31E+04	2.59E-04	2.62E-02
2.47E+04	2.14E-04	2.32E-02
2.64E+04	1.77E-04	2.05E-02
2.83E+04	1.46E-04	1.81E-02
3.02E+04	1.21E-04	1.59E-02
3.23E+04	9.93E-05	1.40E-02
3.46E+04	8.17E-05	1.22E-02
3.70E+04	6.70E-05	1.07E-02
3.96E+04	5.48E-05	9.26E-03
4.23E+04	4.47E-05	8.00E-03
4.53E+04	3.63E-05	6.88E-03
4.84E+04	2.93E-05	5.87E-03
5.18E+04	2.35E-05	4.97E-03
5.54E+04	1.87E-05	4.17E-03
5.93E+04	1.47E-05	3.45E-03
6.34E+04	1.14E-05	2.80E-03
6.78E+04	8.67E-06	2.23E-03
7.26E+04	6.39E-06	1.72E-03
7.76E+04	4.49E-06	1.26E-03
8.30E+04	2.91E-06	8.53E-04
8.88E+04	1.60E-06	4.89E-04
9.50E+04	5.14E-07	1.63E-04

5 Results

In general, both the SPE and GCR fluxes⁵ were reduced by flying in an altitude of 50 km vs. 200 km, which is to be expected. The peak SPE and GCR fluxes shifted from 1.7×10^3 MeV to 5.1×10^3 MeV (see Figure 5). The shifted peak is due to the lower L-shell the 50 km environment is in. This lower L-shell blocks particles of lower rigidity, and hence filters out the lower energy particles.

The overall integral SPE flux reduced by a factor of 25x whereas the overall integral GCR flux reduced by a factor of 3.7x (see Figure 6). Since the SPE energy spectrum occurs at much lower energies compared to the GCRs, it is expected that more of the SPEs would be shielded by the Earth's magnetic field compared to the GCRs.

At 1 LET (MeV-cm²/mg), the SPE LET flux reduced by a factor of 22x while the GCR LET flux reduced by a factor of 3.7x. However, at 10 LET (MeV-cm²/mg), the SPE LET flux reduced by a factor of 137x and the GCR LET flux reduced by a factor of 965x. Therefore, it is clear to see that the 50 km environments are much more benign compared with the 200 km environments that are in DSNE.

⁵Differences in fluxes due to heavy ions were not studied in this analysis.

A Raw CREME96 Output for Integral LET

Listing 1: 50 km worst case SPE integral LET.

```

1  14 Booster_50km_worst_case_worst_week.LET.LET 210
2      5
3  %Created by CREME96:LETSPEC_DRIVER Version 210 on 20210318 at 121049.0
4  %ZMIN = 1 ZMAX = 92 LETMIN = 1.00E+00 LETMAX = 1.10E+05 MeV-cm2/g LBINS =
5      1002
6  %EMINCUT = 1.00E-01 MeV/nuc
7  %TARGET MATERIAL = SILICON
8  %Input File to LETSPEC_DRIVER: Booster_50km_worst_case_worst_week.flx
9  %Created by CREME96:FLUX_DRIVER Version 210 on 20210318 at 120824.4
10 %ZMIN = 1 ZMAX = 92
11 %MODE = 2 WORST-WEEK SOLAR ENERGETIC PARTICLE MODEL
12 %TRANS = 1 INSIDE MAGNETOSPHERE/NO TRAPPED FLUXES
13 %INPUT GEOMAGNETIC TRANSMISSION FILE: Booster_50km_worst_case.gt1
14 %Created by CREME96:GTRANS_DRIVER Version 210 on 20210318 at 120634.3
15 %Incl = 57.000 deg Apo = 0.5000E+02 Peri = 0.5000E+02 km 0.00 0.00
16 %STORM = 1 IPRECALC = 0 Grid Epoch = 1980.0 L Bin: 0.1602E+01 0.1709E+01
17 %Relative dwell time = 0.3899E-01
18 1.0000E+00 1.1000E+05 1002 1 92 SILICON 210
19      5
20 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00
21 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00
22 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00
23 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00
24 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00 8.7670E+00
25 8.7670E+00 8.7670E+00 8.7670E+00 8.6588E+00 7.2476E+00 5.0224E+00
26 3.4655E+00 2.4476E+00 1.7633E+00 1.2896E+00 9.5834E-01 7.2363E-01
27 5.5640E-01 4.3677E-01 3.5093E-01 2.8938E-01 2.4530E-01 2.1384E-01
28 1.9143E-01 1.7550E-01 1.6431E-01 1.5645E-01 1.5097E-01 1.4719E-01
29 1.4460E-01 1.4283E-01 1.4164E-01 1.4126E-01 1.4126E-01 1.4126E-01
30 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
31 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
32 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
33 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
34 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
35 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
36 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
37 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
38 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
39 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
40 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
41 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
42 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
43 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
44 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01 1.4126E-01
45 1.4126E-01 1.2918E-01 9.4673E-02 8.9177E-02 8.6825E-02 8.5462E-02
46 8.4605E-02 8.4038E-02 8.3652E-02 8.3385E-02 8.3197E-02 8.3064E-02
47 8.2969E-02 8.2901E-02 8.2852E-02 8.2817E-02 8.2792E-02 8.2774E-02
48 8.2762E-02 8.2753E-02 8.2747E-02 8.2742E-02 8.2739E-02 8.2737E-02

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49	8.2736E-02	8.2735E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
50	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
51	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
52	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
53	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
54	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
55	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
56	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
57	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
58	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
59	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
60	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
61	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
62	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
63	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
64	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
65	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
66	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
67	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
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71	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
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73	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
74	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02
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76	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2734E-02	8.2469E-02
77	8.2060E-02	8.1944E-02	8.1891E-02	8.1859E-02	8.1837E-02	8.1825E-02
78	8.1818E-02	8.1814E-02	8.1812E-02	8.1810E-02	8.1809E-02	8.1808E-02
79	8.1808E-02	8.1808E-02	8.1807E-02	8.1807E-02	8.1807E-02	8.1807E-02
80	8.1807E-02	8.1807E-02	8.1807E-02	8.1807E-02	8.1807E-02	8.1807E-02
81	8.1807E-02	8.1807E-02	8.1675E-02	8.1584E-02	8.1545E-02	8.1522E-02
82	8.1510E-02	8.1504E-02	8.1502E-02	8.1501E-02	8.1500E-02	8.1500E-02
83	8.1500E-02	8.1499E-02	8.1499E-02	8.1499E-02	8.1499E-02	8.1499E-02
84	8.1499E-02	8.1499E-02	8.1499E-02	8.1499E-02	8.1499E-02	8.1499E-02
85	8.1499E-02	8.0548E-02	7.9603E-02	7.9199E-02	7.8994E-02	7.8910E-02
86	7.8880E-02	7.8866E-02	7.8857E-02	7.8852E-02	7.8848E-02	7.8845E-02
87	7.8843E-02	7.8841E-02	7.8840E-02	7.8840E-02	7.8839E-02	7.8839E-02
88	7.8839E-02	7.8838E-02	7.8838E-02	7.8838E-02	7.8838E-02	7.8838E-02
89	7.8838E-02	7.8838E-02	7.8838E-02	7.8838E-02	7.8838E-02	7.8838E-02
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91	7.8838E-02	7.8838E-02	7.8838E-02	7.8809E-02	7.8552E-02	7.8455E-02
92	7.8421E-02	7.8409E-02	7.8403E-02	7.8400E-02	7.8398E-02	7.8396E-02
93	7.8395E-02	7.8395E-02	7.8394E-02	7.8394E-02	7.8393E-02	7.8393E-02
94	7.8393E-02	7.8393E-02	7.8380E-02	7.8362E-02	7.8357E-02	7.8355E-02
95	7.8354E-02	7.8354E-02	7.8353E-02	7.8353E-02	7.8353E-02	7.8353E-02
96	7.8353E-02	7.8353E-02	7.8353E-02	7.8353E-02	7.8353E-02	7.8230E-02
97	7.7990E-02	7.7912E-02	7.7888E-02	7.7880E-02	7.7876E-02	7.7874E-02
98	7.7872E-02	7.7871E-02	7.7870E-02	7.7869E-02	7.7869E-02	7.7868E-02
99	7.7868E-02	7.7853E-02	7.7829E-02	7.7816E-02	7.7809E-02	7.7806E-02
100	7.7805E-02	7.7804E-02	7.7804E-02	7.7804E-02	7.7804E-02	7.7804E-02
101	7.7804E-02	7.7804E-02	7.7433E-02	7.6982E-02	7.6736E-02	7.6571E-02
102	7.6440E-02	7.6326E-02	7.6224E-02	7.6134E-02	7.6061E-02	7.6004E-02
103	7.5964E-02	7.5939E-02	7.5922E-02	7.5912E-02	7.5905E-02	7.5901E-02
104	7.5898E-02	7.5896E-02	7.5895E-02	7.5895E-02	7.5894E-02	7.5894E-02
105	7.5894E-02	7.5826E-02	7.5681E-02	7.5575E-02	7.5479E-02	7.5395E-02

106	7.5324E-02	7.5267E-02	7.5224E-02	7.5193E-02	7.5171E-02	7.5156E-02
107	7.5146E-02	7.5139E-02	7.5135E-02	7.5132E-02	7.5131E-02	7.5130E-02
108	7.5129E-02	7.5128E-02	7.5128E-02	7.5128E-02	7.5125E-02	7.5123E-02
109	7.5121E-02	7.5118E-02	7.5116E-02	7.5114E-02	7.5112E-02	7.5109E-02
110	7.5107E-02	7.5105E-02	7.5103E-02	7.5102E-02	7.5100E-02	7.5099E-02
111	7.5098E-02	7.5097E-02	7.5097E-02	7.5096E-02	7.5049E-02	7.4980E-02
112	7.4925E-02	7.4868E-02	7.4811E-02	7.4753E-02	7.4698E-02	7.4650E-02
113	7.4609E-02	7.4573E-02	7.4547E-02	7.4527E-02	7.4514E-02	7.4504E-02
114	7.4498E-02	7.4494E-02	7.4488E-02	7.4452E-02	7.4426E-02	7.4405E-02
115	7.4386E-02	7.4368E-02	7.4350E-02	7.4333E-02	7.4316E-02	7.4297E-02
116	7.4281E-02	7.4267E-02	7.4256E-02	7.4246E-02	7.4238E-02	7.4231E-02
117	7.4110E-02	7.4003E-02	7.3923E-02	7.3850E-02	7.3781E-02	7.3713E-02
118	7.3647E-02	7.3552E-02	7.3455E-02	7.3375E-02	7.3306E-02	7.3245E-02
119	7.3191E-02	7.3135E-02	6.6072E-02	5.9826E-02	5.5118E-02	5.0818E-02
120	4.6701E-02	4.2619E-02	3.8613E-02	3.4629E-02	3.0929E-02	2.7468E-02
121	2.4462E-02	2.1742E-02	1.9317E-02	1.7011E-02	1.5046E-02	1.3411E-02
122	1.1980E-02	1.0776E-02	9.7150E-03	8.7951E-03	7.9590E-03	7.2269E-03
123	6.5527E-03	5.9520E-03	5.4094E-03	4.9002E-03	4.4319E-03	4.0129E-03
124	3.6408E-03	3.2998E-03	2.9949E-03	2.7185E-03	2.4663E-03	2.2407E-03
125	2.0328E-03	1.8509E-03	1.6857E-03	1.5346E-03	1.3879E-03	1.2588E-03
126	1.1432E-03	1.0304E-03	9.3110E-04	8.4657E-04	7.6001E-04	6.8865E-04
127	6.2005E-04	5.5765E-04	5.0500E-04	4.5297E-04	4.1192E-04	3.7017E-04
128	3.3817E-04	3.0529E-04	2.8087E-04	2.5620E-04	2.3620E-04	2.1727E-04
129	2.0111E-04	1.8786E-04	1.7530E-04	1.6594E-04	1.5731E-04	1.5117E-04
130	1.4608E-04	1.4163E-04	1.3832E-04	1.3536E-04	1.3292E-04	1.3094E-04
131	1.2925E-04	1.2785E-04	1.2653E-04	1.2526E-04	1.2403E-04	1.2289E-04
132	1.2168E-04	1.2053E-04	1.1939E-04	1.1830E-04	1.1723E-04	1.1619E-04
133	1.1517E-04	1.1417E-04	1.1316E-04	1.1218E-04	1.1125E-04	1.1032E-04
134	1.0943E-04	1.0856E-04	1.0771E-04	1.0688E-04	1.0609E-04	1.0530E-04
135	1.0456E-04	1.0383E-04	1.0313E-04	1.0246E-04	1.0180E-04	1.0117E-04
136	1.0058E-04	9.9993E-05	9.9430E-05	9.8906E-05	9.8386E-05	9.7900E-05
137	9.7427E-05	9.6990E-05	9.6563E-05	9.6147E-05	9.5758E-05	9.5388E-05
138	9.5035E-05	9.4705E-05	9.4394E-05	9.4053E-05	9.3744E-05	9.3444E-05
139	9.3176E-05	9.2915E-05	9.2662E-05	9.2421E-05	9.2132E-05	9.1869E-05
140	9.1632E-05	9.1391E-05	9.1160E-05	9.0933E-05	9.0684E-05	9.0422E-05
141	9.0177E-05	8.9944E-05	8.9707E-05	8.9473E-05	8.9232E-05	8.8956E-05
142	8.8698E-05	8.8442E-05	8.8182E-05	8.7919E-05	8.7651E-05	8.7374E-05
143	8.7093E-05	8.6816E-05	8.6524E-05	8.6233E-05	8.5932E-05	8.5618E-05
144	8.5301E-05	8.4980E-05	8.4651E-05	8.4312E-05	8.3965E-05	8.3613E-05
145	8.3252E-05	8.2881E-05	8.2501E-05	8.2109E-05	8.1707E-05	8.1297E-05
146	8.0870E-05	8.0443E-05	8.0006E-05	7.9546E-05	7.9080E-05	7.8614E-05
147	7.8126E-05	7.7633E-05	7.7125E-05	7.6610E-05	7.6088E-05	7.5550E-05
148	7.5026E-05	7.4442E-05	7.3906E-05	7.3329E-05	7.2751E-05	7.2186E-05
149	7.1590E-05	7.0998E-05	7.0401E-05	6.9804E-05	6.9198E-05	6.8606E-05
150	6.7998E-05	6.7408E-05	6.6797E-05	6.6203E-05	6.5600E-05	6.5015E-05
151	6.4434E-05	6.3851E-05	6.3287E-05	6.2705E-05	6.2166E-05	6.1609E-05
152	6.1087E-05	6.0571E-05	6.0076E-05	5.9582E-05	5.9099E-05	5.8623E-05
153	5.8165E-05	5.7724E-05	5.7286E-05	5.6878E-05	5.6482E-05	5.6094E-05
154	5.5732E-05	5.5381E-05	5.5032E-05	5.4705E-05	5.4393E-05	5.4072E-05
155	5.3773E-05	5.3498E-05	5.3215E-05	5.2945E-05	5.2697E-05	5.2449E-05
156	5.2200E-05	5.1963E-05	5.1736E-05	5.1510E-05	5.1285E-05	5.1070E-05
157	5.0865E-05	5.0657E-05	5.0454E-05	5.0252E-05	5.0054E-05	4.9859E-05
158	4.9660E-05	4.9465E-05	4.9268E-05	4.9078E-05	4.8879E-05	4.8687E-05
159	4.8492E-05	4.8296E-05	4.8099E-05	4.7896E-05	4.7698E-05	4.7491E-05
160	4.7287E-05	4.7074E-05	4.6866E-05	4.6650E-05	4.6433E-05	4.6209E-05
161	4.5986E-05	4.5754E-05	4.5521E-05	4.5279E-05	4.5033E-05	4.4790E-05
162	4.4526E-05	4.4272E-05	4.4009E-05	4.3728E-05	4.3456E-05	4.3163E-05

163	4.2868E-05	4.2565E-05	4.2248E-05	4.1930E-05	4.1593E-05	4.1251E-05
164	4.0889E-05	4.0522E-05	4.0127E-05	3.9725E-05	3.9300E-05	3.8849E-05
165	3.8385E-05	3.7883E-05	3.7338E-05	3.6766E-05	3.6143E-05	3.5462E-05
166	3.4710E-05	3.3877E-05	3.2939E-05	3.1894E-05	3.0714E-05	2.9367E-05
167	2.7785E-05	2.6077E-05	2.4452E-05	2.2530E-05	2.0724E-05	1.9222E-05
168	1.7459E-05	1.5816E-05	1.4462E-05	1.3234E-05	1.2120E-05	1.1064E-05
169	1.0145E-05	9.3097E-06	8.4972E-06	7.8152E-06	7.1313E-06	6.5247E-06
170	5.9796E-06	5.4063E-06	4.9334E-06	4.4973E-06	4.0625E-06	3.6770E-06
171	3.3394E-06	3.0241E-06	2.6962E-06	2.4284E-06	2.1778E-06	1.9302E-06
172	1.7127E-06	1.5214E-06	1.3352E-06	1.1853E-06	1.0429E-06	9.1569E-07
173	8.0629E-07	7.0320E-07	6.2233E-07	5.4443E-07	4.8160E-07	4.2546E-07
174	3.8013E-07	3.3721E-07	3.0119E-07	2.6745E-07	2.3910E-07	2.1320E-07
175	1.8975E-07	1.6741E-07	1.4873E-07	1.3168E-07	1.1610E-07	1.0063E-07
176	8.8020E-08	7.6375E-08	6.5344E-08	5.6031E-08	4.7504E-08	3.9560E-08
177	3.2889E-08	2.6677E-08	2.1913E-08	1.7512E-08	1.3889E-08	1.0977E-08
178	8.4935E-09	6.3543E-09	4.7338E-09	3.5154E-09	2.5674E-09	1.8406E-09
179	1.2957E-09	8.8832E-10	5.9195E-10	3.9170E-10	2.5237E-10	1.6007E-10
180	1.0003E-10	5.8494E-11	3.3128E-11	1.8683E-11	9.8686E-12	4.9447E-12
181	2.3797E-12	9.4333E-13	2.8423E-13	8.5922E-14	5.6218E-15	0.0000E+00
182	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
183	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
184	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Listing 2: 50 km worst case GCR integral LET.

1	14	Booster_50km_worst_case_GCR_LET.LET	210
2	5		
3	%Created by CREME96:LETSPEC_DRIVER Version 210 on 20210318 at 121114.4		
4	%ZMIN = 1 ZMAX = 92 LETMIN = 1.00E+00 LETMAX = 1.10E+05 MeV-cm2/g LBINS = 1002		
5	%EMINCUT = 1.00E-01 MeV/nuc		
6	%TARGET MATERIAL = SILICON		
7	%Input File to LETSPEC_DRIVER: Booster_50km_worst_case_GCR.flx		
8	%Created by CREME96:FLUX_DRIVER Version 210 on 20210318 at 120916.8		
9	%ZMIN = 1 ZMAX = 92		
10	%MODE = 0 SOLAR-QUIET MODE: YEAR = 1977.0000		
11	%TRANS = 1 INSIDE MAGNETOSPHERE/NO TRAPPED FLUXES		
12	%INPUT GEOMAGNETIC TRANSMISSION FILE: Booster_50km_worst_case.gt1		
13	%Created by CREME96:GTRANS_DRIVER Version 210 on 20210318 at 120634.3		
14	%Incl = 57.000 deg Apo = 0.5000E+02 Peri = 0.5000E+02 km 0.00 0.00		
15	0.00		
16	%STORM = 1 IPRECALC = 0 Grid Epoch = 1980.0 L Bin: 0.1602E+01 0.1709E+01		
17	%Relative dwell time = 0.3899E-01		
18	1.0000E+00 1.1000E+05 1002 1 92 SILICON	210	
19	5		
20	2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02		
21	2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02		
22	2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02		
23	2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02		
24	2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02 2.8661E+02		
25	2.8661E+02 2.8661E+02 2.8661E+02 2.8539E+02 2.6622E+02 2.2927E+02		
26	1.9682E+02 1.7051E+02 1.4895E+02 1.3099E+02 1.1600E+02 1.0342E+02		
27	9.2864E+01 8.3998E+01 7.6557E+01 7.0328E+01 6.5128E+01 6.0810E+01		
28	5.7231E+01 5.4271E+01 5.1850E+01 4.9870E+01 4.8261E+01 4.6965E+01		

29	4.5923E+01	4.5092E+01	4.4437E+01	4.4204E+01	4.4204E+01	4.4204E+01
30	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
31	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
32	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
33	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
34	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
35	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
36	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
37	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
38	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
39	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
40	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
41	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
42	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
43	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
44	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01	4.4204E+01
45	4.4204E+01	3.9349E+01	2.4113E+01	1.9282E+01	1.6192E+01	1.3903E+01
46	1.2119E+01	1.0689E+01	9.5213E+00	8.5617E+00	7.7656E+00	7.1042E+00
47	6.5536E+00	6.0950E+00	5.7132E+00	5.3960E+00	5.1331E+00	4.9154E+00
48	4.7368E+00	4.5899E+00	4.4703E+00	4.3731E+00	4.2947E+00	4.2315E+00
49	4.1812E+00	4.1413E+00	4.1131E+00	4.1094E+00	4.1094E+00	4.1094E+00
50	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00
51	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00
52	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00
53	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00
54	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00
55	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00
56	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.1094E+00	4.0868E+00
57	3.9981E+00	3.9651E+00	3.9502E+00	3.9400E+00	3.9321E+00	3.9257E+00
58	3.9204E+00	3.9161E+00	3.9125E+00	3.9095E+00	3.9070E+00	3.9049E+00
59	3.9031E+00	3.9016E+00	3.9004E+00	3.8994E+00	3.8985E+00	3.8978E+00
60	3.8973E+00	3.8968E+00	3.8964E+00	3.8961E+00	3.8959E+00	3.8957E+00
61	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00
62	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00
63	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00
64	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00	3.8955E+00
65	3.8955E+00	3.8639E+00	3.8203E+00	3.8073E+00	3.8002E+00	3.7949E+00
66	3.7909E+00	3.7877E+00	3.7851E+00	3.7830E+00	3.7813E+00	3.7799E+00
67	3.7788E+00	3.7778E+00	3.7771E+00	3.7764E+00	3.7759E+00	3.7755E+00
68	3.7752E+00	3.7749E+00	3.7747E+00	3.7746E+00	3.7744E+00	3.7743E+00
69	3.7742E+00	3.7742E+00	3.7741E+00	3.7741E+00	3.7741E+00	3.7741E+00
70	3.7741E+00	3.7741E+00	3.7741E+00	3.7741E+00	3.7741E+00	3.7741E+00
71	3.7741E+00	3.7741E+00	3.7741E+00	3.7637E+00	3.6140E+00	3.5579E+00
72	3.5342E+00	3.5180E+00	3.5058E+00	3.4964E+00	3.4889E+00	3.4830E+00
73	3.4783E+00	3.4744E+00	3.4713E+00	3.4688E+00	3.4668E+00	3.4651E+00
74	3.4638E+00	3.4628E+00	3.4619E+00	3.4612E+00	3.4607E+00	3.4603E+00
75	3.4600E+00	3.4597E+00	3.4595E+00	3.4594E+00	3.4593E+00	3.4593E+00
76	3.4593E+00	3.4593E+00	3.4593E+00	3.4593E+00	3.4593E+00	3.2203E+00
77	2.8705E+00	2.7546E+00	2.6760E+00	2.6170E+00	2.5706E+00	2.5332E+00
78	2.5027E+00	2.4776E+00	2.4567E+00	2.4394E+00	2.4250E+00	2.4129E+00
79	2.4029E+00	2.3947E+00	2.3878E+00	2.3821E+00	2.3775E+00	2.3737E+00
80	2.3706E+00	2.3681E+00	2.3660E+00	2.3644E+00	2.3631E+00	2.3621E+00
81	2.3615E+00	2.3615E+00	2.2488E+00	2.1926E+00	2.1674E+00	2.1498E+00
82	2.1366E+00	2.1263E+00	2.1181E+00	2.1115E+00	2.1061E+00	2.1017E+00
83	2.0981E+00	2.0952E+00	2.0928E+00	2.0908E+00	2.0892E+00	2.0879E+00
84	2.0869E+00	2.0860E+00	2.0854E+00	2.0848E+00	2.0844E+00	2.0841E+00
85	2.0838E+00	1.7358E+00	1.4824E+00	1.3799E+00	1.3074E+00	1.2517E+00

86	1.2075E+00	1.1715E+00	1.1419E+00	1.1173E+00	1.0968E+00	1.0797E+00
87	1.0653E+00	1.0533E+00	1.0433E+00	1.0349E+00	1.0279E+00	1.0221E+00
88	1.0174E+00	1.0135E+00	1.0102E+00	1.0040E+00	9.9240E-01	9.8806E-01
89	9.8518E-01	9.8301E-01	9.8179E-01	9.8115E-01	9.8064E-01	9.8023E-01
90	9.7991E-01	9.7964E-01	9.7943E-01	9.7926E-01	9.7912E-01	9.7901E-01
91	9.7892E-01	9.7885E-01	9.7879E-01	9.6966E-01	8.9850E-01	8.7446E-01
92	8.6055E-01	8.5041E-01	8.4256E-01	8.3631E-01	8.3122E-01	8.2705E-01
93	8.2360E-01	8.2074E-01	8.1836E-01	8.1638E-01	8.1473E-01	8.1337E-01
94	8.1223E-01	8.1130E-01	8.0152E-01	7.8985E-01	7.8606E-01	7.8351E-01
95	7.8160E-01	7.8011E-01	7.7893E-01	7.7799E-01	7.7724E-01	7.7672E-01
96	7.7630E-01	7.7596E-01	7.7568E-01	7.7545E-01	7.7527E-01	7.2686E-01
97	6.5148E-01	6.2706E-01	6.1054E-01	5.9807E-01	5.8821E-01	5.8025E-01
98	5.7372E-01	5.6831E-01	5.6380E-01	5.6005E-01	5.5692E-01	5.5430E-01
99	5.5211E-01	5.3951E-01	5.2587E-01	5.2080E-01	5.1720E-01	5.1442E-01
100	5.1221E-01	5.1044E-01	5.0900E-01	5.0783E-01	5.0687E-01	5.0609E-01
101	5.0552E-01	5.0515E-01	4.4929E-01	4.0869E-01	3.9203E-01	3.8012E-01
102	3.7095E-01	3.6360E-01	3.5759E-01	3.5263E-01	3.4849E-01	3.4502E-01
103	3.4211E-01	3.3966E-01	3.3503E-01	3.3155E-01	3.2949E-01	3.2787E-01
104	3.2656E-01	3.2548E-01	3.2461E-01	3.2389E-01	3.2330E-01	3.2283E-01
105	3.2244E-01	3.1423E-01	3.0349E-01	2.9981E-01	2.9731E-01	2.9542E-01
106	2.9392E-01	2.9271E-01	2.9171E-01	2.9089E-01	2.9020E-01	2.8944E-01
107	2.8553E-01	2.8388E-01	2.8296E-01	2.8228E-01	2.8175E-01	2.8133E-01
108	2.8098E-01	2.8071E-01	2.8048E-01	2.7965E-01	2.7148E-01	2.6815E-01
109	2.6673E-01	2.6576E-01	2.6504E-01	2.6448E-01	2.6404E-01	2.6368E-01
110	2.6339E-01	2.5968E-01	2.5605E-01	2.5481E-01	2.5398E-01	2.5335E-01
111	2.5287E-01	2.5249E-01	2.5219E-01	2.5195E-01	2.4251E-01	2.3481E-01
112	2.3183E-01	2.2973E-01	2.2814E-01	2.2688E-01	2.2586E-01	2.2504E-01
113	2.2389E-01	2.2087E-01	2.1965E-01	2.1888E-01	2.1829E-01	2.1782E-01
114	2.1744E-01	2.1713E-01	2.1607E-01	2.0763E-01	2.0449E-01	2.0308E-01
115	2.0209E-01	2.0134E-01	2.0075E-01	2.0029E-01	1.9873E-01	1.9451E-01
116	1.9308E-01	1.9232E-01	1.9176E-01	1.9132E-01	1.9098E-01	1.9069E-01
117	1.8253E-01	1.7820E-01	1.7652E-01	1.7537E-01	1.7450E-01	1.7382E-01
118	1.7327E-01	1.6849E-01	1.6441E-01	1.6292E-01	1.6191E-01	1.6112E-01
119	1.6050E-01	1.5990E-01	1.0200E-01	7.1024E-02	5.8245E-02	4.9141E-02
120	4.2063E-02	3.6345E-02	3.1534E-02	2.7227E-02	2.3830E-02	2.1016E-02
121	1.8653E-02	1.6671E-02	1.4989E-02	1.0747E-02	8.1834E-03	6.5796E-03
122	5.3094E-03	4.2770E-03	3.4361E-03	2.7119E-03	2.1141E-03	1.6343E-03
123	1.2418E-03	9.2050E-04	6.8675E-04	5.4543E-04	4.3932E-04	3.6649E-04
124	3.0737E-04	2.5851E-04	2.1786E-04	1.8049E-04	1.5148E-04	1.2832E-04
125	1.0951E-04	9.4137E-05	7.7866E-05	6.1212E-05	5.6402E-05	5.3490E-05
126	5.1199E-05	4.9292E-05	4.7168E-05	4.5647E-05	4.4563E-05	4.3688E-05
127	4.2964E-05	3.9581E-05	3.6727E-05	3.5505E-05	3.4789E-05	3.4235E-05
128	3.3348E-05	3.2498E-05	3.2033E-05	3.1689E-05	3.1414E-05	2.9872E-05
129	2.8358E-05	2.7739E-05	2.7352E-05	2.7061E-05	2.6280E-05	2.5760E-05
130	2.5476E-05	2.5267E-05	2.4733E-05	2.2647E-05	2.1762E-05	2.1322E-05
131	2.1006E-05	2.0489E-05	1.9952E-05	1.9678E-05	1.9479E-05	1.9141E-05
132	1.7937E-05	1.7409E-05	1.7130E-05	1.6922E-05	1.6589E-05	1.6339E-05
133	1.6188E-05	1.6071E-05	1.5666E-05	1.5146E-05	1.4938E-05	1.4805E-05
134	1.4673E-05	1.4531E-05	1.4442E-05	1.4377E-05	1.4247E-05	1.4010E-05
135	1.3909E-05	1.3846E-05	1.3752E-05	1.3617E-05	1.3553E-05	1.3510E-05
136	1.3295E-05	1.3017E-05	1.2913E-05	1.2849E-05	1.2712E-05	1.2613E-05
137	1.2559E-05	1.2480E-05	1.2172E-05	1.2029E-05	1.1957E-05	1.1874E-05
138	1.1782E-05	1.1731E-05	1.1676E-05	1.1325E-05	1.1135E-05	1.1047E-05
139	1.0953E-05	1.0849E-05	1.0791E-05	1.0685E-05	1.0250E-05	1.0033E-05
140	9.9275E-06	9.7919E-06	9.6924E-06	9.6317E-06	9.4749E-06	9.2804E-06
141	9.1916E-06	9.1194E-06	9.0359E-06	8.9867E-06	8.8208E-06	8.3278E-06
142	8.1115E-06	7.9960E-06	7.8830E-06	7.8098E-06	7.7280E-06	7.5600E-06

143	7.4740E-06	7.4142E-06	7.3458E-06	7.3031E-06	7.2293E-06	7.0996E-06
144	7.0417E-06	6.9993E-06	6.9615E-06	6.9361E-06	6.8131E-06	6.7114E-06
145	6.6653E-06	6.6147E-06	6.5817E-06	6.5268E-06	6.4118E-06	6.3598E-06
146	6.3122E-06	6.2693E-06	6.2311E-06	6.1073E-06	6.0360E-06	5.9746E-06
147	5.9043E-06	5.8480E-06	5.7389E-06	5.6537E-06	5.5687E-06	5.4795E-06
148	5.3708E-06	5.1914E-06	5.0327E-06	4.8480E-06	4.6761E-06	4.4471E-06
149	4.1695E-06	3.8914E-06	3.6085E-06	3.3238E-06	2.9966E-06	2.6674E-06
150	2.3640E-06	2.1037E-06	1.8731E-06	1.5971E-06	1.3868E-06	1.1986E-06
151	1.0439E-06	8.9469E-07	7.2660E-07	6.4722E-07	5.8162E-07	5.3835E-07
152	4.7452E-07	4.3710E-07	4.0548E-07	3.8076E-07	3.0398E-07	2.0661E-07
153	1.6181E-07	1.3200E-07	1.1147E-07	9.5485E-08	8.2435E-08	7.1695E-08
154	6.2787E-08	5.5373E-08	4.9204E-08	4.4103E-08	3.9974E-08	3.6548E-08
155	3.3793E-08	3.1530E-08	2.9803E-08	2.4768E-08	1.8889E-08	1.5880E-08
156	1.4122E-08	1.1337E-08	7.2386E-09	5.0405E-09	3.7350E-09	2.9959E-09
157	2.4477E-09	2.0091E-09	1.6465E-09	1.3454E-09	1.0939E-09	8.8428E-10
158	7.0953E-10	5.6435E-10	4.4382E-10	3.4416E-10	2.6199E-10	1.9456E-10
159	1.3949E-10	9.4711E-11	5.8598E-11	3.6624E-11	2.2632E-11	1.1388E-11
160	2.5699E-12	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
161	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
162	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
163	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
164	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
165	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
166	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
167	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
168	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
169	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
170	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
171	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
172	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
173	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
174	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
175	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
176	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
177	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
178	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
179	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
180	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
181	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
182	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
183	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
184	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

B Processed CREME96 Flux and LET Data

Listing 3: SPE differential flux in units of $p^+/cm^2\text{-s-MeV}$ as a function of energy in MeV. Note, values with zero flux are omitted.

1	3849.5909565252637	3.003865231656417e-08
2	3903.0902315631893	5.701865002559331e-08
3	3957.3330070046322	5.4135924606659315e-08
4	4012.3296155662606	1.5648147343824614e-07
5	4068.090533562524	3.308474055348483e-07
6	4124.626382901348	4.825486315913922e-07

7 4181.947933107477 6.506866704115179e-07
8 4240.06610337394 9.99654782372272e-07
9 4298.991964642105 1.4062774027117063e-06
10 4358.736741710519 1.7963878120638725e-06
11 4419.311815373194 2.387786345916844e-06
12 4480.7287245874595 3.209953709731907e-06
13 4542.999168672099 3.911659844837724e-06
14 4606.1350095358775 4.507054484546061e-06
15 4670.148273937197 5.210771238950175e-06
16 4735.051155774997 5.852410122519354e-06
17 4800.856018411652 6.386732201041906e-06
18 4867.575397027993 6.6739994332861565e-06
19 4935.2220010112105 7.087181699086287e-06
20 5003.808716375796 7.696399346470418e-06
21 5073.348608218278 7.972608172574033e-06
22 5143.8549232059095 7.900477205247612e-06
23 5215.341092100118 7.746916156340143e-06
24 5287.820732314845 7.507652459842744e-06
25 5361.307650510617 7.3189055732150686e-06
26 5435.815845224494 7.167355143605897e-06
27 5511.359509536735 6.929599411582222e-06
28 5587.953033774356 6.7207463319715725e-06
29 5665.61100825243 6.411864942270624e-06
30 5744.348226053355 6.099716296209942e-06
31 5824.17968584476 5.82325614269404e-06
32 5905.12059473669 5.5287004154934615e-06
33 5987.186371178312 5.248973005617826e-06
34 6070.392647895075 4.983319930830273e-06
35 6154.755274866495 4.731238536306228e-06
36 6240.290322345519 4.4919748398088295e-06
37 6327.014083919647 4.264774859101216e-06
38 6414.943079614811 4.049135939358812e-06
39 6504.0940590421615 3.8443040983447585e-06
40 6594.484004588822 3.649776681234478e-06
41 6686.130134652754 3.4650510332033982e-06
42 6779.049906922799 3.2898758268392316e-06
43 6873.261021704094 3.123497079905116e-06
44 6968.78142528991 2.9654121375764774e-06
45 7065.629313380139 2.815369672441029e-06
46 7163.823134547507 2.673118357086483e-06
47 7263.381593751727 2.5379042092759784e-06
48 7364.3236559027355 2.409450768855999e-06
49 7466.6685494731955 2.2875821066379437e-06
50 7570.435770161459 2.1718709660209245e-06
51 7675.645084605177 2.0619906213689676e-06
52 7782.316534146764 1.9576897452697866e-06
53 7890.470438651029 1.8586667448286364e-06
54 8000.127400375862 1.7646451598920011e-06
55 8111.308307896872 1.6753736630475935e-06
56 8224.034340086333 1.5906260596243552e-06
57 8338.326970147675 1.510176154951228e-06
58 8454.207969705787 1.4337977543571528e-06
59 8571.69941295444 1.3612646631710717e-06
60 8690.823680861058 1.2924009522043833e-06
61 8811.603465430217 1.227030692268487e-06
62 8934.061774026108 1.1649528214335527e-06
63 9058.221933755356 1.1060416759934368e-06

64	9184.107595910458	1.0500710612770813e-06
65	9311.742740475276	9.969655790607993e-07
66	9441.151680692832	9.465241674147615e-07
67	9572.359067696898	8.986462953740531e-07
68	9705.38989520764	8.532062992325305e-07
69	9840.269504292832	8.100282498015922e-07
70	9977.023588194927	7.690618815987813e-07
71	10115.67819722552	7.301563981767254e-07
72	10256.25974372752	6.932364013117382e-07
73	10398.795007106608	6.581510945564472e-07
74	10543.311138932282	6.248753451696242e-07
75	10689.835668110107	5.932583567038965e-07
76	10838.396506125651	5.632498636768069e-07
77	10989.021952361272	5.347493351234403e-07
78	11141.740699487027	5.077065055613392e-07
79	11296.581838926179	4.820208440255892e-07
80	11453.574866396988	4.5764208503373235e-07
81	11612.749687531192	4.344948303620828e-07
82	11774.13662357091	4.1250368178695415e-07
83	11937.766417144358	3.91643506567118e-07
84	12103.670238122208	3.718389064788879e-07
85	12271.879689554951	3.5303961603980655e-07
86	12442.426813693159	3.351702370261879e-07
87	12615.344098091025	3.1820563669680296e-07
88	12790.664481795127	3.021206823104232e-07
89	12968.42136161878	2.868399756433625e-07
90	13148.64859850402	2.7233838395439196e-07
91	13331.380523971564	2.585405090198256e-07
92	13516.651946660839	2.4547399685501494e-07
93	13704.498158960478	2.3305590941390522e-07
94	13894.954943731389	2.212686537776363e-07
95	14088.058581122814	2.1007453083436514e-07
96	14283.84585548357	1.9944840784286302e-07
97	14482.354062368882	1.893601255136555e-07
98	14683.62101564501	1.797820378313909e-07
99	14887.685054692352	1.7068649878071776e-07
100	15094.58505170861	1.6205340216865303e-07
101	15304.360419113784	1.5385510197984509e-07
102	15517.051117057608	1.460740052954339e-07
103	15732.69766103181	1.386849793741907e-07
104	15951.341129587669	1.3166791802313255e-07
105	16173.023172161324	1.2500774159752218e-07
106	16397.78601700733	1.1868434390437663e-07
107	16625.67247924299	1.126826452989587e-07
108	16856.725969003943	1.0698253958828538e-07
109	17090.99049971364	1.0156894712761944e-07
110	17328.510696467205	9.643181482046941e-08
111	17569.33180453234	9.155354974797518e-08
112	17813.499697967836	8.692409881364525e-08
113	18061.060888362415	8.252586909861956e-08
114	18312.06253369443	7.835132078052943e-08
115	18566.552447315302	7.438788748876055e-08
116	18824.579107057205	7.062551612682142e-08
117	19086.191664467897	6.705415359822054e-08
118	19351.43995417332	6.366123353234357e-08
119	19620.374503370906	6.044172938094475e-08
120	19893.04654145421	5.7383074773409726e-08

121	20169.508009771867	5.448024316149275e-08
122	20449.81157152182	5.172569472282523e-08
123	20734.01062178298	4.9109376360915644e-08
124	21022.159297686794	4.66237482533954e-08
125	21314.31248872947	4.4266297126141615e-08
126	21610.525847228237	4.2026969882662816e-08
127	21910.85579892224	3.990073997471324e-08
128	22215.35955372141	3.788258085404716e-08
129	22524.095116604058	3.5967465972418824e-08
130	22837.121298666603	3.4147855507459615e-08
131	23154.497728326147	3.2418722910923793e-08
132	23476.284862679473	3.078006818281136e-08
133	23802.54399901916	2.9221838226630822e-08
134	24133.337286510483	2.774403304238218e-08
135	24468.727738029847	2.63416260818197e-08
136	24808.7792421685	2.500883681446076e-08
137	25153.55657540231	2.3743654621007082e-08
138	25503.125414431415	2.254256091768663e-08
139	25857.552348690613	2.1402288448139683e-08
140	26216.904893034392	2.031982128341878e-08
141	26581.251500597446	1.9291892167164202e-08
142	26950.661575834725	1.8315987825253066e-08
143	27325.205487741892	1.738959498356251e-08
144	27704.954583260303	1.6509949040557367e-08
145	28089.981200867736	1.5674788049527057e-08
146	28480.35868435799	1.4881850063760995e-08
147	28876.161396812553	1.412912446396088e-08
148	29277.46473476558	1.341434930341613e-08
149	29684.345142566675	1.2735765290240733e-08
150	30096.880126942287	1.2091613132548684e-08
151	30515.148271760496	1.147988221104168e-08
152	30939.22925299995	1.089931588658285e-08
153	31369.203853927873	1.0347903546100205e-08
154	31805.153980487972	9.824388546306001e-09
155	32247.162676903234	9.327514252214239e-09
156	32695.31414149451	8.855772699351196e-09
157	33149.693742719995	8.407655923243148e-09
158	33610.38803543657	7.982409941653234e-09
159	34077.484777388156	7.57852679010773e-09
160	34551.072945922184	7.195252486369775e-09
161	35031.24275493945	6.831330393377933e-09
162	35518.08567207842	6.485755201483056e-09
163	36011.6944361395	6.1577729284482815e-09
164	36512.16307475026	5.846126937212175e-09
165	37019.58692227738	5.550565900362447e-09
166	37534.06263798633	5.269581853425376e-09
167	38055.688224454505	5.003174796400961e-09
168	38584.56304623956	4.750088092227767e-09
169	39120.78784880712	4.509819086081219e-09
170	39664.4647777224	4.281613795724457e-09
171	40215.69739810724	4.064969566332905e-09
172	40774.590714368904	3.859383743081989e-09
173	41341.25119020179	3.6641023437348477e-09
174	41915.78676886829	3.4788740408791935e-09
175	42498.30689376034	3.302944852278165e-09
176	43088.92252924794	3.135812123107188e-09
177	43687.74618181609	2.9772245259539754e-09

178	44294.89192149689	2.8266794059939524e-09
179	44910.475403598066	2.6836741084025447e-09
180	45534.61389073484	2.5479573057674655e-09
181	46167.42627516664	2.419001210522912e-09
182	46809.03310144558	2.2966298934802825e-09
183	47459.55658937835	2.180466363521146e-09
184	48119.12065730856	2.0701587622683014e-09
185	48787.85094572127	1.965430629568232e-09
186	49465.87484117702	1.8660306380086507e-09
187	50153.321500576916	1.7716320619535848e-09
188	50850.321875766596	1.6820087067319752e-09
189	51557.0087384804	1.5969343776727636e-09
190	52273.51670563398	1.5161577473636629e-09
191	52999.982264966595	1.4394526211336143e-09
192	53736.54380104148	1.3666430697940175e-09
193	54483.34162160639	1.2975028986738132e-09
194	55240.51798432056	1.2318813113256297e-09
195	56008.217123854134	1.1695772458196368e-09
196	56786.58527936256	1.110414772967234e-09
197	57575.770722344656	1.0542430963210483e-09
198	58375.92378488591	1.0009114194337081e-09
199	59187.19688829625	9.502689458578405e-10
200	60009.744572143805	9.022151446285312e-10
201	60843.72352369419	8.565740865571786e-10
202	61689.2926077569	8.132452406788682e-10
203	62546.61289694847	7.721029432874563e-10
204	63415.84770237424	7.33046663418028e-10
205	64297.16260473853	6.959758701056684e-10
206	65190.72548588514	6.607648996442341e-10
207	66096.70656077818	6.273383538100387e-10
208	67015.27840992535	5.955957016381674e-10
209	67946.61601225386	5.654866776461627e-10
210	68890.89677844117	5.368856181278813e-10
211	69848.30058471099	5.097171248596367e-10
212	70819.00980709694	4.839309323589717e-10
213	71803.20935618442	4.594516424022001e-10
214	72801.08671233321	4.362038567656356e-10
215	73812.83196139157	4.141373099668209e-10
216	74838.63783090533	3.932017365232985e-10
217	75878.69972683015	3.7329660547015355e-10
218	76933.21577075552	3.544219168073861e-10
219	78002.38683764367	3.365022723113099e-10
220	79086.41659409564	3.194874064994676e-10
221	80185.5115371464	3.033270538894017e-10
222	81299.88103360188	2.879709489986548e-10
223	82429.73735991989	2.7339395908599813e-10
224	83575.29574264813	2.5957095141020305e-10
225	84736.77439942134	2.464441206664435e-10
226	85914.39458053098	2.3397828101699917e-10
227	87108.38061106988	2.221432731723957e-10
228	88318.95993366533	2.1090642456903572e-10
229	89546.36315180332	2.0023757591744478e-10
230	90790.82407375761	1.9010908120227129e-10
231	92052.5797571265	1.8049329440816366e-10
232	93331.8705539914	1.7136256951977028e-10
233	94628.94015670012	1.6269428706998533e-10
234	95944.03564428937	1.5446331431758006e-10

235	97277.40752954928	1.4665205834369441e-10
236	98629.30980674532	1.3923287313297675e-10
237	100000.0	1.3220324541130424e-10

Listing 4: GCR differential flux in units of $p^+/\text{cm}^2\text{-s-MeV}$ as a function of energy in MeV. Note, values with zero flux are omitted.

1	3849.5909565252637	1.3643308576009754e-07
2	3903.0902315631893	2.657410393818534e-07
3	3957.3330070046322	2.5886723465579897e-07
4	4012.3296155662606	7.67654448089973e-07
5	4068.090533562524	1.664792778990303e-06
6	4124.626382901348	2.4904033283537008e-06
7	4181.947933107477	3.4440651942774185e-06
8	4240.06610337394	5.425530512749573e-06
9	4298.991964642105	7.825707300092175e-06
10	4358.736741710519	1.024837789083448e-05
11	4419.311815373194	1.3963751026675913e-05
12	4480.7287245874595	1.924037004764533e-05
13	4542.999168672099	2.4028157251716173e-05
14	4606.1350095358775	2.837235157310014e-05
15	4670.148273937197	3.360875820810361e-05
16	4735.051155774997	3.867300556569035e-05
17	4800.856018411652	4.3233341461641295e-05
18	4867.575397027993	4.6275659787377646e-05
19	4935.2220010112105	5.033082758463135e-05
20	5003.808716375796	5.597312799047862e-05
21	5073.348608218278	5.937107460460135e-05
22	5143.8549232059095	6.0240667451115e-05
23	5215.341092100118	6.047314530748064e-05
24	5287.820732314845	5.9991853312950683e-05
25	5361.307650510617	5.986241969562279e-05
26	5435.815845224494	5.999813649825787e-05
27	5511.359509536735	5.933211885569683e-05
28	5587.953033774356	5.888224278770278e-05
29	5665.61100825243	5.747732255301742e-05
30	5744.348226053355	5.593919878981985e-05
31	5824.17968584476	5.463103960886506e-05
32	5905.12059473669	5.305396009676299e-05
33	5987.186371178312	5.151709297062686e-05
34	6070.392647895075	5.002043823045668e-05
35	6154.755274866495	4.856273923919102e-05
36	6240.290322345519	4.7142739359768434e-05
37	6327.014083919647	4.576169522925036e-05
38	6414.943079614811	4.4415836936452495e-05
39	6504.0940590421615	4.310516448137483e-05
40	6594.484004588822	4.183093450107881e-05
41	6686.130134652754	4.0589377084380126e-05
42	6779.049906922799	3.938174886834021e-05
43	6873.261021704094	3.820679321589763e-05
44	6968.78142528991	3.706325348999094e-05
45	7065.629313380139	3.5952386327681594e-05
46	7163.823134547507	3.487042181778527e-05
47	7263.381593751727	3.3818616597363405e-05
48	7364.3236559027355	3.279571402935457e-05
49	7466.6685494731955	3.180171411375876e-05
50	7570.435770161459	3.08341035764531e-05

51	7675.645084605177	2.9895395691560468e-05
52	7782.316534146764	2.898182054789656e-05
53	7890.470438651029	2.8093378145461365e-05
54	8000.127400375862	2.7231325121316324e-05
55	8111.308307896872	2.639314820133857e-05
56	8224.034340086333	2.557759074846666e-05
57	8338.326970147675	2.4787166036823466e-05
58	8454.207969705787	2.4018104155224687e-05
59	8571.69941295444	2.3271661740731752e-05
60	8690.823680861058	2.2546582156283226e-05
61	8811.603465430217	2.1842865401879117e-05
62	8934.061774026108	2.1159254840457973e-05
63	9058.221933755356	2.049575047201981e-05
64	9184.107595910458	1.985235229656462e-05
65	9311.742740475276	1.922654703996953e-05
66	9441.151680692832	1.8619591339295987e-05
67	9572.359067696898	1.8031485194543977e-05
68	9705.38989520764	1.7459715331590633e-05
69	9840.269504292832	1.690428175043596e-05
70	9977.023588194927	1.6366441088141386e-05
71	10115.67819722552	1.584493670764548e-05
72	10256.25974372752	1.5338511971886805e-05
73	10398.795007106608	1.4847166880865364e-05
74	10543.311138932282	1.4370901434581149e-05
75	10689.835668110107	1.3908458995972731e-05
76	10838.396506125651	1.3461096202101544e-05
77	10989.021952361272	1.3026299778844718e-05
78	11141.740699487027	1.2605326363263685e-05
79	11296.581838926179	1.219754763682773e-05
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81	11612.749687531192	1.1418181331325175e-05
82	11774.13662357091	1.104646808855243e-05
83	11937.766417144358	1.0686190243038754e-05
84	12103.670238122208	1.0337096467371856e-05
85	12271.879689554951	9.998809770433306e-06
86	12442.426813693159	9.671078824810819e-06
87	12615.344098091025	9.353526639385963e-06
88	12790.664481795127	9.04590188674645e-06
89	12968.42136161878	8.747827575773851e-06
90	13148.64859850402	8.459303706468164e-06
91	13331.380523971564	8.179701960298672e-06
92	13516.651946660839	7.909022337265375e-06
93	13704.498158960478	7.6467621825437e-06
94	13894.954943731389	7.392921496133644e-06
95	14088.058581122814	7.147123286916779e-06
96	14283.84585548357	6.909116227480816e-06
97	14482.354062368882	6.678774654119613e-06
98	14683.62101564501	6.455721575714737e-06
99	14887.685054692352	6.239831328560047e-06
100	15094.58505170861	6.030852585243254e-06
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102	15517.051117057608	5.632875627886499e-06
103	15732.69766103181	5.443374759021963e-06
104	15951.341129587669	5.260157075464606e-06
105	16173.023172161324	5.082719922389854e-06
106	16397.78601700733	4.911188963503851e-06
107	16625.67247924299	4.7451872076881674e-06

108 16856.725969003943 4.584463327530513e-06
109 17090.99049971364 4.429142986737034e-06
110 17328.510696467205 4.278849194189298e-06
111 17569.33180453234 4.133456286181163e-06
112 17813.499697967836 3.992838599006483e-06
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114 18312.06253369443 3.72542623233292e-06
115 18566.552447315302 3.5982545617156054e-06
116 18824.579107057205 3.475229793401029e-06
117 19086.191664467897 3.3563519273891913e-06
118 19351.43995417332 3.2413696362678047e-06
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122 20449.81157152182 2.8185112650946185e-06
123 20734.01062178298 2.7213732202456228e-06
124 21022.159297686794 2.627628095462503e-06
125 21314.31248872947 2.5368988996268295e-06
126 21610.525847228237 2.4493112964447464e-06
127 21910.85579892224 2.3646139585039653e-06
128 22215.35955372141 2.282806885804487e-06
129 22524.095116604058 2.203638750934024e-06
130 22837.121298666603 2.1272352175987205e-06
131 23154.497728326147 2.0534706220924323e-06
132 23476.284862679473 1.9820936370028724e-06
133 23802.54399901916 1.9131042623300404e-06
134 24133.337286510483 1.8465024980739369e-06
135 24468.727738029847 1.782162680528418e-06
136 24808.7792421685 1.7200848096934836e-06
137 25153.55657540231 1.6600175581568465e-06
138 25503.125414431415 1.6020865896246508e-06
139 25857.552348690613 1.5460405766846088e-06
140 26216.904893034392 1.4920051830428647e-06
141 26581.251500597446 1.4397290812871303e-06
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149 29684.345142566675 1.080921501135333e-06
150 30096.880126942287 1.0428076990619815e-06
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152 30939.22925299995 9.704756698057301e-07
153 31369.203853927873 9.36182044399144e-07
154 31805.153980487972 9.03082224200922e-07
155 32247.162676903234 8.711259437286066e-07
156 32695.31414149451 8.402755038703548e-07
157 33149.693742719995 8.105057718849379e-07
158 33610.38803543657 7.817664822898986e-07
159 34077.484777388156 7.540199359733934e-07
160 34551.072945922184 7.272535665648084e-07
161 35031.24275493945 7.014171085816859e-07
162 35518.08567207842 6.764728629121829e-07
163 36011.6944361395 6.524082631856852e-07
164 36512.16307475026 6.291981766609637e-07

165 37019.58692227738 6.06779771484947e-07
166 37534.06263798633 5.851530476576349e-07
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173 41341.25119020179 4.536208464371374e-07
174 41915.78676886829 4.3738509560338537e-07
175 42498.30689376034 4.2171483144727944e-07
176 43088.92252924794 4.0661005396881976e-07
177 43687.74618181609 3.9202049768554875e-07
178 44294.89192149689 3.7795872896808086e-07
179 44910.475403598066 3.643996150751873e-07
180 45534.61389073484 3.51305456895025e-07
181 46167.42627516664 3.386888207982084e-07
182 46809.03310144558 3.265120076728944e-07
183 47459.55658937835 3.1477501751908296e-07
184 48119.12065730856 3.034527175955453e-07
185 48787.85094572127 2.925199751610528e-07
186 49465.87484117702 2.8198935658621985e-07
187 50153.321500576916 2.718357291298176e-07
188 50850.321875766596 2.6203396005061746e-07
189 51557.0087384804 2.5258404934861936e-07
190 52273.51670563398 2.4347343065320894e-07
191 52999.982264966595 2.346895375937719e-07
192 53736.54380104148 2.2620723742907946e-07
193 54483.34162160639 2.1803909652974601e-07
194 55240.51798432056 2.1015998215454281e-07
195 56008.217123854134 2.025573279328555e-07
196 56786.58527936256 1.952311338646841e-07
197 57575.770722344656 1.8816883357941426e-07
198 58375.92378488591 1.813578607064316e-07
199 59187.19688829625 1.7479821524573608e-07
200 60009.744572143805 1.6846476445609906e-07
201 60843.72352369419 1.623575083375205e-07
202 61689.2926077569 1.5647644689000042e-07
203 62546.61289694847 1.5079644737231008e-07
204 63415.84770237424 1.4533007615506384e-07
205 64297.16260473853 1.4005220049703298e-07
206 65190.72548588514 1.3497538676883187e-07
207 66096.70656077818 1.3006193585861744e-07
208 67015.27840992535 1.2534326369292556e-07
209 67946.61601225386 1.2078795434522035e-07
210 68890.89677844117 1.1639726445256327e-07
211 69848.30058471099 1.1216491082964711e-07
212 70819.00980709694 1.0808461029116468e-07
213 71803.20935618442 1.0415133628887026e-07
214 72801.08671233321 1.0036131891157953e-07
215 73812.83196139157 9.670701833692389e-08
216 74838.63783090533 9.3184664653719e-08
217 75878.69972683015 8.978923131371917e-08
218 76933.21577075552 8.651694840574003e-08
219 78002.38683764367 8.336404601859732e-08
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221 80185.5115371464 7.739376333971527e-08

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222 81299.88103360188 7.457009986266877e-08
223 82429.73735991989 7.184948062466e-08
224 83575.29574264813 6.92256224403818e-08
225 84736.77439942134 6.669852530983417e-08
226 85914.39458053098 6.426190604770994e-08
227 87108.38061106988 6.191450801694764e-08
228 88318.95993366533 5.965130466930156e-08
229 89546.36315180332 5.747103936771024e-08
230 90790.82407375761 5.5369942200989384e-08
231 92052.5797571265 5.334424325795469e-08
232 93331.8705539914 5.139394253860614e-08
233 94628.94015670012 4.951275685763657e-08
234 95944.03564428937 4.7700686215045986e-08
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236 98629.30980674532 4.42725803114488e-08
237 100000.0 4.2654031776319334e-08
```

Listing 5: SPE integral LET flux in units of $\#/\text{cm}^2\text{-s}$ as a function of LET in units of $\text{MeV}\text{-cm}^2/\text{mg}$. Note, values with zero LET are omitted.

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1 0.001 0.022033874235217372
2 0.001011664140702465 0.022033874235217372
3 0.0010234643335832573 0.022033874235217372
4 0.0010354021655741273 0.022033874235217372
5 0.0010474792421170211 0.022033874235217372
6 0.0010596971873799857 0.022033874235217372
7 0.0010720576444755924 0.022033874235217372
8 0.0010845622756819092 0.022033874235217372
9 0.0010972127626660488 0.022033874235217372
10 0.0011100108067103262 0.022033874235217372
11 0.0011229581289410524 0.022033874235217372
12 0.0011360564705599977 0.022033874235217372
13 0.0011493075930785557 0.022033874235217372
14 0.0011627132785546356 0.022033874235217372
15 0.0011762753298323217 0.022033874235217372
16 0.0011899955707843244 0.022033874235217372
17 0.0012038758465572632 0.022033874235217372
18 0.0012179180238198067 0.022033874235217372
19 0.0012321239910137091 0.022033874235217372
20 0.001246495658607776 0.022033874235217372
21 0.0012610349593547893 0.022033874235217372
22 0.001275743848551431 0.022033874235217372
23 0.0012906243043012394 0.022033874235217372
24 0.0013056783277806303 0.022033874235217372
25 0.001320907943508023 0.022033874235217372
26 0.0013363151996161047 0.022033874235217372
27 0.0013519021681272698 0.022033874235217372
28 0.001367670945232274 0.022033874235217372
29 0.001383623651572137 0.022033874235217372
30 0.0013997624325233328 0.022033874235217372
31 0.00141608945848631 0.022033874235217372
32 0.0014326069251773721 0.022033874235217372
33 0.0014493170539239672 0.022033874235217372
34 0.0014662220919634185 0.022033874235217372
35 0.0014833243127451428 0.022033874235217372
36 0.0015006260162363897 0.022033874235217372
37 0.001518129529231551 0.022033874235217372
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38	0.001535837205665075	0.022033874235217372
39	0.0015537514269280332	0.022033874235217372
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41	0.001590209168714935	0.022033874235217372
42	0.0016087575922051761	0.022033874235217372
43	0.0016275223671168165	0.022033874235217372
44	0.0016465060170032762	0.022033874235217372
45	0.001665711094853058	0.022033874235217372
46	0.0016851401834330816	0.021761937975122637
47	0.001704795895636023	0.018215205532925906
48	0.0017246808748317068	0.012622667954711501
49	0.0017447977952225946	0.008709751472812343
50	0.0017651493622034221	0.006151489743141102
51	0.0017857383127250295	0.004431656260859906
52	0.0018065674156624372	0.003241118308855518
53	0.0018276394721872128	0.0024085711229129936
54	0.0018489573161441836	0.0018186805535337456
55	0.0018705238144325418	0.0013983857219658888
56	0.001892341867391395	0.0010977227386467312
57	0.0019144144091898141	0.0008819832879394129
58	0.0019367444082214306	0.0007272912656766515
59	0.001959334867503638	0.000616506142340461
60	0.001982188825081447	0.0005374385384349131
61	0.0020053093544360506	0.00048111606534135523
62	0.002028699564898163	0.0004410796085640069
63	0.002052362602066165	0.00041295607112907113
64	0.0020763016482291423	0.0003932017365232985
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66	0.0021250206827226575	0.0003699288181455053
67	0.0021498072229615833	0.0003634194381672673
68	0.0021748828768933834	0.00035897094296978414
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70	0.0022259150542213247	0.00035502510259687536
71	0.0022518784406054975	0.00035502510259687536
72	0.002278144667581568	0.00035502510259687536
73	0.00230471726752481	0.00035502510259687536
74	0.0023315998140126205	0.00035502510259687536
75	0.0023587959223051055	0.00035502510259687536
76	0.002386309249831274	0.00035502510259687536
77	0.0024141434966808996	0.00035502510259687536
78	0.0024423024061021267	0.00035502510259687536
79	0.0024707897650048717	0.00035502510259687536
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82	0.002558261073364433	0.00035502510259687536
83	0.0025881009904777956	0.00035502510259687536
84	0.002618288964582918	0.00035502510259687536
85	0.002648829055465525	0.00035502510259687536
86	0.002679725370265253	0.00035502510259687536
87	0.0027109820640279928	0.00035502510259687536
88	0.002742603340264675	0.00035502510259687536
89	0.002774593451516573	0.00035502510259687536
90	0.002806956699927201	0.00035502510259687536
91	0.0028396974378208793	0.00035502510259687536
92	0.002872820068288052	0.00035502510259687536
93	0.00290632904577743	0.00035502510259687536
94	0.002940228876695039	0.00035502510259687536

95	0.0029745241200102614	0.00035502510259687536
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103	0.0032636858273332567	0.00035502510259687536
104	0.0033017539180319132	0.00035502510259687536
105	0.0033402660402967535	0.00035502510259687536
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112	0.0036227265380472462	0.00035502510259687536
113	0.0036649825301135843	0.00035502510259687536
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115	0.0037509789027769798	0.00035502510259687536
116	0.003794730848470949	0.00035502510259687536
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124	0.004163627117824889	0.00035502510259687536
125	0.004212192250359799	0.00035502510259687536
126	0.004261323853433829	0.00035502510259687536
127	0.0043110285344390535	0.00035502510259687536
128	0.0043613129778370925	0.00035502510259687536
129	0.004412183946058071	0.00035502510259687536
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797 10.207975939847703 1.6487078246039234e-07
798 10.327043207497463 1.6340051709851233e-07
799 10.447499292510166 1.619403048331238e-07
800 10.569360394246903 1.604750660194895e-07
801 10.692642901020456 1.590575794141898e-07
802 10.81736339229917 1.5759485387467838e-07
803 10.943538640936659 1.5624019912245045e-07
804 11.071185615427403 1.5484030543601084e-07
805 11.200321482188851 1.5352837634387178e-07
806 11.330963607869938 1.5223152689646988e-07
807 11.463129561686664 1.5098745620564834e-07
808 11.596837117784759 1.4974589878894965e-07
809 11.732104257630164 1.4853198738760254e-07
810 11.868949172427172 1.4733566890511553e-07
811 12.007390265564764 1.4618458935684026e-07
812 12.147446155091716 1.4507623546865377e-07
813 12.289135676220319 1.439754214028359e-07
814 12.432477883859455 1.429500055607042e-07
815 12.577492055177073 1.4195474900804696e-07
816 12.724197692192789 1.4097959864837268e-07
817 12.872614524400527 1.4006979341589307e-07
818 13.022762511421726 1.3918763419876505e-07
819 13.17466184568973 1.3831050152988278e-07
820 13.328332955165248 1.374886608917037e-07
821 13.48379650608362 1.367045193653677e-07
822 13.64107340573398 1.3589775837192583e-07
823 13.80018480527111 1.3514628940918717e-07
824 13.961152102559806 1.344551390253974e-07
825 14.123996945052603 1.3374388244862465e-07
826 14.288741232700877 1.330652984354493e-07
827 14.455407120900208 1.3244200645297706e-07
828 14.624017023469827 1.3181871447050485e-07
829 14.794593615666818 1.3119290921390977e-07
830 14.96715983723574 1.3059726324678913e-07
831 15.141738895493535 1.3002675002089723e-07
832 15.318354268450587 1.294587500691282e-07
833 15.497029707967993 1.2889326339148202e-07
834 15.677789242952008 1.2835290945506459e-07
835 15.860657182585387 1.2783768825987587e-07

836 16.045658119596652 1.2731492724231852e-07
837 16.23281693356727 1.2680473259537555e-07
838 16.422158794277752 1.2629705122255543e-07
839 16.613709165092455 1.257994229462268e-07
840 16.80749380638392 1.253093344922668e-07
841 17.003538778997388 1.248091929418153e-07
842 17.20187044775543 1.243191044878553e-07
843 17.40251548500365 1.2382398948564954e-07
844 17.605500874197553 1.2334646740230388e-07
845 17.810853913531556 1.2284632585185238e-07
846 18.018602219610067 1.2236377722026103e-07
847 18.228773731161343 1.21873688766301e-07
848 18.441396712794997 1.2138108703821812e-07
849 18.656499758803008 1.2088597203601237e-07
850 18.874111797005227 1.2037577738906937e-07
851 19.09426209263954 1.1987814911274077e-07
852 19.316980252297824 1.193579013693063e-07
853 19.542296227907357 1.1884519344824044e-07
854 19.77024032075895 1.1830986606006873e-07
855 20.00084318558183 1.177871050425114e-07
856 20.234135834666382 1.1724423783197109e-07
857 20.47014964203476 1.1669885734730789e-07
858 20.708916347659958 1.161358839437846e-07
859 20.950468061734632 1.1557542381438418e-07
860 21.194837268989197 1.1499234421787792e-07
861 21.442056833060573 1.1440675134724878e-07
862 21.692160000911635 1.1379853900951379e-07
863 21.945180407302644 1.1318027357528732e-07
864 22.201152079314436 1.1256954796342947e-07
865 22.460109440924374 1.119060435949913e-07
866 22.722087317636074 1.1126767196778185e-07
867 22.987120941162665 1.1060668087346657e-07
868 23.255245954165005 1.0990045084493957e-07
869 23.526498415044813 1.0921684028351844e-07
870 23.800914802794203 1.08480450965517e-07
871 24.07853202190137 1.0773903509926979e-07
872 24.359387407313676 1.0697751304003964e-07
873 24.643518729458428 1.0618080514308926e-07
874 24.930964199322656 1.0538158397201601e-07
875 25.221762473591717 1.0453461059260821e-07
876 25.51595265984783 1.0367507084258605e-07
877 25.813574321829726 1.0276526561010644e-07
878 26.114667484753074 1.0184289400701249e-07
879 26.419272640693364 1.008501507284781e-07
880 26.72743075403119 9.983981453108364e-08
881 27.03918326696159 9.87716730288631e-08
882 27.354572105067156 9.76381863994479e-08
883 27.67363968295643 9.647202720643536e-08
884 27.996428909967744 9.521036359675371e-08
885 28.322983195940157 9.384062919978855e-08
886 28.653346457051203 9.240303640150587e-08
887 28.98756312172272 9.083726662295671e-08
888 29.325678136596064 8.9125726945281e-08
889 29.667736972576513 8.723574480488137e-08
890 30.01378563094842 8.514218746052914e-08
891 30.363870649561413 8.278473633327535e-08
892 30.718039109089332 8.015836487487429e-08

893	31.076338639361627	7.719270140988551e-08
894	31.43881742576858	7.380732116637716e-08
895	31.80552421574184	6.983132150399392e-08
896	32.176508325309904	6.553864930212883e-08
897	32.55181964573041	6.145457885246209e-08
898	32.93150865019946	5.662406598830243e-08
899	33.31562640063982	5.20850929223959e-08
900	33.70422455456763	4.831015518984240e-08
901	34.09735537203964	4.3879252911219357e-08
902	34.49507172268105	3.974994352734093e-08
903	34.89742709279601	3.634697036497247e-08
904	35.30447559256046	3.326066974208586e-08
905	35.71627196329881	3.046088236920663e-08
906	36.132871584846214	2.7806864895453975e-08
907	36.55433048299595	2.5497165976534762e-08
908	36.98070533703408	2.3397828101699918e-08
909	37.41205348736163	2.1355792876866552e-08
910	37.848432943206355	1.964173992506796e-08
911	38.28990239042371	1.7922911752435913e-08
912	38.73652119938933	1.639835966950186e-08
913	39.18834943298302	1.5028373945124422e-08
914	39.64544785466667	1.3587513890482e-08
915	40.10787793665582	1.2398986557775909e-08
916	40.57570186818625	1.1302947712791501e-08
917	41.04898256387803	1.0210176124166826e-08
918	41.52778367219612	9.241308949799736e-09
919	42.01216958401021	8.392827605918205e-09
920	42.50220544125391	7.600392274976714e-09
921	42.99795714568576	6.7762896900870405e-09
922	43.49949136775167	6.1032348799819626e-09
923	44.00687555555078	5.473408384790282e-09
924	44.520177943906575	4.8511217119672155e-09
925	45.03946756354306	4.3044845902425905e-09
926	45.564814250368414	3.823695250537209e-09
927	46.09628865486638	3.355723608858473e-09
928	46.63396225159816	2.978983817839985e-09
929	47.17790734881422	2.6210935827430363e-09
930	47.72819709817873	2.30137998157251e-09
931	48.284905504606854	2.0264277925303313e-09
932	48.848107436217795	1.767334363203474e-09
933	49.41787863440305	1.5640858848868288e-09
934	49.994295724012055	1.368301830715113e-09
935	50.57743622365756	1.2103928175750753e-09
936	51.167378556140235	1.0692976083170507e-09
937	51.76420205899543	9.553708923272704e-10
938	52.36798699516236	8.475011669736113e-10
939	52.978814563778776	7.569730330677678e-10
940	53.59676691110058	6.721751641620721e-10
941	54.22192714154886	6.009238427786557e-10
942	54.85437932888667	5.358300429962751e-10
943	55.494208527525174	4.768937648149306e-10
944	56.14150078396226	4.207472209099738e-10
945	56.79634314835393	3.7379926029472797e-10
946	57.458823686221784	3.3094793649976317e-10
947	58.129031490295986	2.9179112566542e-10
948	58.80705669249692	2.5291077498459267e-10
949	59.492990476056015	2.2121838829517887e-10

950	60.18692508777912	1.9195131113433634e-10
951	60.8889538504518	1.6422738428493717e-10
952	61.59917117538935	1.4082126237863177e-10
953	62.31767257513429	1.1939057393290363e-10
954	63.044554676300784	9.942512430080976e-11
955	63.779915232569515	8.265907262713176e-11
956	64.52385313783347	6.704661377585193e-11
957	65.27646843949832	5.5073375854490504e-11
958	66.03786235193662	4.401245643973157e-11
959	66.80813727009975	3.4906864292566905e-11
960	67.58739678328776	2.7588210046764125e-11
961	68.37574568908134	2.1346493762611925e-11
962	69.17329000743486	1.5970097758964496e-11
963	69.98013699493397	1.189733704285069e-11
964	70.79639515922064	8.835163851543647e-12
965	71.62217427358507	6.452579983061148e-12
966	72.45758539172876	4.625932350557899e-12
967	73.30274086269873	3.256449281005036e-12
968	74.15775434599756	2.232591668829508e-12
969	75.02274082686823	1.4877326170339824e-12
970	75.89781663175737	9.844494739288976e-13
971	76.78309944396004	6.342749903891648e-13
972	77.67870831944572	4.022997888480945e-13
973	78.58476370286961	2.514028105108696e-13
974	79.50138744376981	1.470114565432651e-13
975	80.42870281295511	8.325974514249813e-14
976	81.36683451908213	4.6955500437614483e-14
977	82.31590872542702	2.4802497008972987e-14
978	83.27605306685165	1.242738655536436e-14
979	84.24739666696932	5.980838430198105e-15
980	85.23007015550937	2.3708468783286874e-15
981	86.22420568588417	7.143479039438615e-16
982	87.22993695296257	2.1594553918539376e-16
983	88.24739921104906	1.4129124463960878e-17

Listing 6: GCR integral LET flux in units of $\#/\text{cm}^2\text{-s}$ as a function of LET in units of $\text{MeV-cm}^2/\text{mg}$. Note, values with zero LET are omitted.

1	0.001	0.36016474817814825
2	0.001011664140702465	0.36016474817814825
3	0.0010234643335832573	0.36016474817814825
4	0.0010354021655741273	0.36016474817814825
5	0.0010474792421170211	0.36016474817814825
6	0.0010596971873799857	0.36016474817814825
7	0.0010720576444755924	0.36016474817814825
8	0.0010845622756819092	0.36016474817814825
9	0.0010972127626660488	0.36016474817814825
10	0.0011100108067103262	0.36016474817814825
11	0.0011229581289410524	0.36016474817814825
12	0.0011360564705599977	0.36016474817814825
13	0.0011493075930785557	0.36016474817814825
14	0.0011627132785546356	0.36016474817814825
15	0.0011762753298323217	0.36016474817814825
16	0.0011899955707843244	0.36016474817814825
17	0.0012038758465572632	0.36016474817814825
18	0.0012179180238198067	0.36016474817814825
19	0.0012321239910137091	0.36016474817814825

20	0.001246495658607776	0.36016474817814825
21	0.0012610349593547893	0.36016474817814825
22	0.001275743848551431	0.36016474817814825
23	0.0012906243043012394	0.36016474817814825
24	0.0013056783277806303	0.36016474817814825
25	0.001320907943508023	0.36016474817814825
26	0.0013363151996161047	0.36016474817814825
27	0.0013519021681272698	0.36016474817814825
28	0.001367670945232274	0.36016474817814825
29	0.001383623651572137	0.36016474817814825
30	0.0013997624325233328	0.36016474817814825
31	0.00141608945848631	0.36016474817814825
32	0.0014326069251773721	0.36016474817814825
33	0.0014493170539239672	0.36016474817814825
34	0.0014662220919634185	0.36016474817814825
35	0.0014833243127451428	0.36016474817814825
36	0.0015006260162363897	0.36016474817814825
37	0.001518129529231551	0.36016474817814825
38	0.001535837205665075	0.36016474817814825
39	0.0015537514269280332	0.36016474817814825
40	0.0015718746021883782	0.36016474817814825
41	0.001590209168714935	0.36016474817814825
42	0.0016087575922051761	0.36016474817814825
43	0.0016275223671168165	0.36016474817814825
44	0.0016465060170032762	0.36016474817814825
45	0.001665711094853058	0.36016474817814825
46	0.0016851401834330816	0.3586316509631964
47	0.001704795895636023	0.33454191849546994
48	0.0017246808748317068	0.2881091790754128
49	0.0017447977952225946	0.24733130643181722
50	0.0017651493622034221	0.21426918534543823
51	0.0017857383127250295	0.18717609030087987
52	0.0018065674156624372	0.16460688867749082
53	0.0018276394721872128	0.1457698991265664
54	0.0018489573161441836	0.12996140489370256
55	0.0018705238144325418	0.11669634407318502
56	0.001892341867391395	0.10555499988649418
57	0.0019144144091898141	0.09620436351234952
58	0.0019367444082214306	0.0883767712566652
59	0.001959334867503638	0.08184225853719841
60	0.001982188825081447	0.07641609970591813
61	0.0020053093544360506	0.07191859566303899
62	0.002028699564898163	0.06819894996118867
63	0.002052362602066165	0.06515663163545231
64	0.0020763016482291423	0.06266849025380919
65	0.0021005199227948474	0.06064656122195881
66	0.0021250206827226575	0.05901795959033786
67	0.0021498072229615833	0.05770854377232163
68	0.0021748828768933834	0.05666427837426838
69	0.0022002510167808504	0.05584118109902785
70	0.0022259150542213247	0.055548384663713285
71	0.0022518784406054975	0.055548384663713285
72	0.002278144667581568	0.055548384663713285
73	0.00230471726752481	0.055548384663713285
74	0.0023315998140126205	0.055548384663713285
75	0.0023587959223051055	0.055548384663713285
76	0.002386309249831274	0.055548384663713285

77	0.0024141434966808996	0.055548384663713285
78	0.0024423024061021267	0.055548384663713285
79	0.0024707897650048717	0.055548384663713285
80	0.002499609404470099	0.055548384663713285
81	0.0025287652002650442	0.055548384663713285
82	0.002558261073364433	0.055548384663713285
83	0.0025881009904777956	0.055548384663713285
84	0.002618288964582918	0.055548384663713285
85	0.002648829055465525	0.055548384663713285
86	0.002679725370265253	0.055548384663713285
87	0.0027109820640279928	0.055548384663713285
88	0.002742603340264675	0.055548384663713285
89	0.002774593451516573	0.055548384663713285
90	0.002806956699927201	0.055548384663713285
91	0.0028396974378208793	0.055548384663713285
92	0.002872820068288052	0.055548384663713285
93	0.00290632904577743	0.055548384663713285
94	0.002940228876695039	0.055548384663713285
95	0.0029745241200102614	0.055548384663713285
96	0.0030092193878689375	0.055548384663713285
97	0.003044319346213627	0.055548384663713285
98	0.0030798287154111	0.055548384663713285
99	0.0031157522708871476	0.055548384663713285
100	0.0031520948437688007	0.055548384663713285
101	0.0031888613215340354	0.055548384663713285
102	0.003226056648669057	0.055548384663713285
103	0.0032636858273332567	0.055548384663713285
104	0.0033017539180319132	0.055548384663713285
105	0.0033402660402967535	0.055548384663713285
106	0.003379227373374441	0.055548384663713285
107	0.003418643156923102	0.055548384663713285
108	0.003458518691716974	0.055548384663713285
109	0.003498859340359266	0.055548384663713285
110	0.003539670528003351	0.055548384663713285
111	0.0035809577430823514	0.055548384663713285
112	0.0036227265380472462	0.055548384663713285
113	0.0036649825301135843	0.055548384663713285
114	0.0037077314020169064	0.055548384663713285
115	0.0037509789027769798	0.055548384663713285
116	0.003794730848470949	0.055548384663713285
117	0.003838993123015499	0.055548384663713285
118	0.003883771678958149	0.055548384663713285
119	0.003929072538277766	0.055548384663713285
120	0.003974901793194431	0.055548384663713285
121	0.004021265606988731	0.055548384663713285
122	0.004068170214830633	0.055548384663713285
123	0.004115621924617995	0.055548384663713285
124	0.004163627117824889	0.055548384663713285
125	0.004212192250359799	0.055548384663713285
126	0.004261323853433829	0.055548384663713285
127	0.0043110285344390535	0.055548384663713285
128	0.0043613129778370925	0.055548384663713285
129	0.004412183946058071	0.055548384663713285
130	0.004463648280410051	0.055548384663713285
131	0.004515712901999071	0.055548384663713285
132	0.004568384812659926	0.055548384663713285
133	0.004621671095897797	0.055548384663713285

134	0.004675578917840865	0.055548384663713285
135	0.00473011552820404	0.055548384663713285
136	0.0047852882612639275	0.055548384663713285
137	0.004841104536845166	0.055548384663713285
138	0.00489757186131827	0.055548384663713285
139	0.0049546978286091215	0.055548384663713285
140	0.005012490121220217	0.055548384663713285
141	0.005070956511263847	0.055548384663713285
142	0.00513010486150731	0.055548384663713285
143	0.005189943126430332	0.055548384663713285
144	0.005250479353294807	0.055548384663713285
145	0.005311721683227026	0.055548384663713285
146	0.0053736783523125236	0.055548384663713285
147	0.005436357692703687	0.055548384663713285
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149	0.005563918203083193	0.055548384663713285
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822 13.64107340573398 4.59275713213599e-11
823 13.80018480527111 4.246553621710395e-11
824 13.961152102559806 3.962176654707447e-11
825 14.123996945052603 3.745155434197464e-11
826 14.288741232700877 3.1124386737644796e-11
827 14.455407120900208 2.373661745346304e-11
828 14.624017023469827 1.9955396535602367e-11
829 14.794593615666818 1.7746228581598024e-11
830 14.96715983723574 1.4246494365498993e-11
831 15.141738895493535 9.09629303291003e-12
832 15.318354268450587 6.33407910816774e-12
833 15.497029707967993 4.693539424463151e-12
834 15.677789242952008 3.764758972355865e-12
835 15.860657182585387 3.0758705352766946e-12
836 16.045658119596652 2.5247095201309013e-12
837 16.23281693356727 2.069052921654238e-12
838 16.422158794277752 1.690679502455883e-12
839 16.613709165092455 1.3746352815047498e-12
840 16.80749380638392 1.1112190206865528e-12
841 17.003538778997388 8.916216942006264e-13
842 17.20187044775543 7.0918312562136e-13
843 17.40251548500365 5.577206606064888e-13
844 17.605500874197553 4.3248421106378524e-13
845 17.810853913531556 3.2922634372559596e-13
846 18.018602219610067 2.4449130667297207e-13
847 18.228773731161343 1.752883036996961e-13
848 18.441396712794997 1.1901735272565715e-13
849 18.656499758803008 7.363641852602188e-14
850 18.874111797005227 4.6023075738029035e-14
851 19.09426209263954 2.844020997441768e-14
852 19.316980252297824 1.4310582855632226e-14
853 19.542296227907357 3.229431584184164e-15

```

C Python Conversion Scripts

Listing 7: Python routine to plot processed raw CREME96 output.

```

1 import sys
2 import numpy as np
3 from numpy import vectorize # https://stackoverflow.com/questions/8036878/
   function-of-numpy-array-with-if-statement
4 import matplotlib.pyplot as plt
5
6 # python .\plot.CREME96.py 4 FLUX SPE.FLUX.COMPARISON .\200km.SPE_flux.txt .\
   SPE_flux_worst-case.txt .\SPE_flux_45.04km.txt .\SPE_flux_47.65km.txt
7 # python .\plot.CREME96.py 4 FLUX GCR.FLUX.COMPARISON .\200km.GCR_flux.txt .\
   GCR_flux_worst-case.txt .\GCR_flux_45.04km.txt .\GCR_flux_47.65km.txt
8 # python .\plot.CREME96.py 8 FLUX FLUX.COMPARISON .\200km.SPE_flux.txt .\
   SPE_flux_worst-case.txt .\SPE_flux_45.04km.txt .\SPE_flux_47.65km.txt
   .\200km.GCR_flux.txt .\GCR_flux_worst-case.txt .\GCR_flux_45.04km.txt .\
   GCR_flux_47.65km.txt

```

```

9
10 # python .\plot.CREME96.py 4 LET SPE.LET.COMPARISON .\200km.SPE.LET.txt .\
    SPE.LET_worst-case.txt .\SPE.LET.45.04km.txt .\SPE.LET.47.65km.txt
11 # python .\plot.CREME96.py 4 LET GCR.LET.COMPARISON .\200km.GCR.LET.txt .\
    GCR.LET_worst-case.txt .\GCR.LET.45.04km.txt .\GCR.LET.47.65km.txt
12 # python .\plot.CREME96.py 8 LET LET.COMPARISON .\200km.SPE.LET.txt .\
    SPE.LET_worst-case.txt .\SPE.LET.45.04km.txt .\SPE.LET.47.65km.txt .\200
    km.GCR.LET.txt .\GCR.LET_worst-case.txt .\GCR.LET.45.04km.txt .\
    GCR.LET.47.65km.txt
13
14 # python .\plot.CREME96.py 4 FLUX.INT SPE.FLUX.INT.COMPARISON .\200
    km_SPE_flux_integral.txt .\SPE_flux_worst-case_integral.txt .\SPE_flux_45
    .04km_integral.txt .\SPE_flux_47.65km_integral.txt
15 # python .\plot.CREME96.py 4 FLUX.INT GCR.FLUX.INT.COMPARISON .\200
    km_GCR_flux_integral.txt .\GCR_flux_worst-case_integral.txt .\GCR_flux_45
    .04km_integral.txt .\GCR_flux_47.65km_integral.txt
16 # python .\plot.CREME96.py 8 FLUX.INT FLUX.INT.COMPARISON .\200
    km_SPE_flux_integral.txt .\SPE_flux_worst-case_integral.txt .\SPE_flux_45
    .04km_integral.txt .\SPE_flux_47.65km_integral.txt .\200
    km_GCR_flux_integral.txt .\GCR_flux_worst-case_integral.txt .\GCR_flux_45
    .04km_integral.txt .\GCR_flux_47.65km_integral.txt
17
18 Nfiles = int(sys.argv[1])
19 plotType = sys.argv[2] # options are [FLUX, FLUX.INT, LET]
20 plotTitle = sys.argv[3]
21
22 xLabel = ''
23 yLabel = ''
24
25 xmin = 0.0
26 xmax = 1.0
27
28 # convert from CREAM96 units to DSNE units
29 if plotType == 'FLUX':
30     xLabel = 'Energy_(MeV)'
31     yLabel = 'Differential_Flux_(p+/cm2-s-MeV)'
32     xmin = 1.E3
33     xmax = 1.E5
34
35 if plotType == 'FLUX.INT':
36     xLabel = 'Energy_(MeV)'
37     yLabel = 'Integral_Flux_(p+/cm2-s)'
38     xmin = 1.E3
39     xmax = 1.E5
40
41 if plotType == 'LET':
42     xLabel = 'LET_(MeV-cm2/mg)'
43     yLabel = 'Integral_Flux_(#/cm2-s)'
44     xmin = 1.E0
45     xmax = 1.E2
46
47
48 for i in range(0, Nfiles):
49
50     filename = sys.argv[4 + i]
51
52     x,y = np.loadtxt(filename, unpack=True)

```

```

53     data_masked = np.ma.masked_where(y == 0.0, y)
54
55     #print(data_masked)
56
57     #print(np.shape(E), np.shape(data))
58
59     plt.loglog(x, data_masked, label=filename)
60     plt.grid(b=True, which='both') # https://stackoverflow.com/questions/9127434/how-to-create-major-and-minor-gridlines-with-different-linestyles-in-python
61
62     # # plt.xscale('symlog')
63     # # plt.yscale('symlog')
64
65     plt.title(plotTitle)
66     plt.xlabel(xLabel)
67     plt.ylabel(yLabel)
68     plt.xlim(xmin, xmax)
69     plt.legend()
70     plt.savefig(plotTitle + ".png", dpi=800)
71     plt.show()

```

Listing 8: Python routine to read raw CREME96 output and save as processed output.

```

1  import sys
2  import numpy as np
3  from numpy import vectorize # https://stackoverflow.com/questions/8036878/function-of-numpy-array-with-if-statement
4  import matplotlib.pyplot as plt
5
6  # python .\read_CREME96.flx.py 1 1 SPE_FLUX .\3_2_13_200km_SPE_worst_week.flx
7  # python .\read_CREME96.flx.py 1 1 GCR_FLUX .\3_2_13_200km_GCR.flx 12 > 200
8  # python .\read_CREME96.flx.py 1 1 SPE_LET .\3_2_13_200km_SPE_worst_week_with_heavies.LET.let 17 > 200km_SPE_LET.txt
9  # python .\read_CREME96.flx.py 1 1 GCR_LET .\3_2_13_200km_GCR_with_heavies.LET.let 17 > 200km_GCR_LET.txt
10
11 # python .\read_CREME96.flx.py 3 0 SPE_FLUX .\Booster_45_04km_SPE_worst_week.flx 12 .\Booster_47_65km_SPE_worst_week.flx 12 .\3_2_13_200km_SPE_worst_week.flx 12
12 # python .\read_CREME96.flx.py 3 0 GCR_FLUX .\Booster_45_04km_GCR.flx 12 .\Booster_47_65km_GCR.flx 12 .\3_2_13_200km_GCR.flx 12
13
14 ### 3/18/2021
15
16 # python .\read_CREME96.flx.py 1 1 SPE_FLUX .\Booster_50km_worst_case_SPE_worst_week.flx 12 > SPE_flux_worst-case.txt
17 # python .\read_CREME96.flx.py 1 1 GCR_FLUX .\Booster_50km_worst_case_GCR.flx 12 > GCR_flux_worst-case.txt
18 # python .\read_CREME96.flx.py 1 1 SPE_LET .\Booster_50km_worst_case_SPE_worst_week.LET.let 17 > SPE_LET_worst-case.txt
19 # python .\read_CREME96.flx.py 1 1 GCR_LET .\Booster_50km_worst_case_GCR_LET.let 17 > GCR_LET_worst-case.txt
20

```

```

21 # python .\read_CREME96.flx.py 4 0 SPE_FLUX .\
    Booster_50km_worst_case_SPE_worst_week.flx 12 .\3
    _2_13_200km_SPE_worst_week.flx 12 .\Booster_45_04km_SPE_worst_week.flx 12
    .\Booster_47_65km_SPE_worst_week.flx 12
22 # python .\read_CREME96.flx.py 4 0 GCR_FLUX .\Booster_50km_worst_case_GCR.flx
    12 .\3_2_13_200km_GCR.flx 12 .\Booster_45_04km_GCR.flx 12 .\
    Booster_47_65km_GCR.flx 12
23 # python .\read_CREME96.flx.py 4 0 SPE_LET .\
    Booster_50km_worst_case_SPE_worst_week.LET.let 17 .\3
    _2_13_200km_SPE_worst_week_with_heavies.LET.let 17
    Booster_47_65km_SPE_worst_week.LET.let 17
    Booster_45_04km_SPE_worst_week.LET.let 17
24 # python .\read_CREME96.flx.py 4 0 GCR_LET .\Booster_50km_worst_case_GCR.LET.
    let 17 .\3_2_13_200km_GCR_with_heavies.LET.let 17 Booster_47_65km_GCR.LET
    .let 17 Booster_45_04km_GCR.LET.let 17

25
26 Nfiles = int(sys.argv[1])
27 toPrint = int(sys.argv[2])
28 plotType = sys.argv[3] # options are [SPE_FLUX, GCR_FLUX, SPE_LET, GCR_LET]
29
30 xScale = 1.
31 yScale = 1.
32
33 xLabel = ''
34 yLabel = ''
35
36 # convert from CREAM96 units to DSNE units
37 if plotType == 'SPE_FLUX':
38     xScale = 1. # MeV
39     yScale = 4.*np.pi/100.**2 * 2. # convert from p+/m2-s-sr-MeV to p+/cm2
    -s-MeV (2x)
40     xLabel = 'Energy_(MeV)'
41     yLabel = 'Differential_Flux_(p+/cm2-s-MeV)_(2x)'
42
43 if plotType == 'GCR_FLUX':
44     xScale == 1. # MeV
45     yScale = 4.*np.pi/100.**2 # convert from p+/m2-s-sr-MeV to p+/cm2-s-
    MeV
46     xLabel = 'Energy_(MeV)'
47     yLabel = 'Differential_Flux_(p+/cm2-s-MeV)'
48
49 if plotType == 'SPE_LET':
50     xScale = 1.E-3 # MeV-cm2/g to MeV-cm2/mg
51     yScale = 4.*np.pi/100.**2 * 2. # convert from #/m2-s-sr to #/cm2-s (x2
    )
52     xLabel = 'LET_(MeV-cm2/mg)'
53     yLabel = 'Integral_Flux_(#/cm2-s)_(x2)'
54
55 if plotType == 'GCR_LET':
56     xScale = 1.E-3 # MeV-cm2/g to MeV-cm2/mg
57     yScale = 4.*np.pi/100.**2 # convert from #/m2-s-sr to #/cm2-s
58     xLabel = 'LET_(MeV-cm2/mg)'
59     yLabel = 'Integral_Flux_(#/cm2-s)'
60
61
62 for i in range(0, Nfiles):
63

```

```

64     filename = sys.argv[4 + i*2]
65     Nheader = int(sys.argv[5 + i*2])
66
67     line = np.loadtxt(filename, skiprows = Nheader-2, max_rows = 1,
68                        usecols = (0,1,2))
69
70     Emin = line[0]
71     Emax = line[1]
72     N.E = int(line[2])
73
74     E = np.logspace(np.log10(Emin), np.log10(Emax), N.E) * xScale
75
76     #print(Emin, Emax, N.E)
77
78     data = np.loadtxt(filename, skiprows = Nheader, max_rows = int(N.E/6))
79
80     data = data.flatten() * yScale
81
82
83     data_masked = np.ma.masked_where(data == 0.0, data)
84
85     #print(data_masked)
86
87     #print(np.shape(E), np.shape(data))
88     if toPrint == 1:
89         for i in range(0,N.E):
90             print(E[i], data[i])
91
92     if toPrint == 0:
93         plt.loglog(E, data_masked, label=filename)
94         plt.grid(b=True, which='both') # https://stackoverflow.com/
95         questions/9127434/how-to-create-major-and-minor-gridlines-with-different-
96         linestyles-in-python
97     # # plt.xscale('symlog')
98     # # plt.yscale('symlog')
99     if toPrint == 0:
100         plt.xlabel(xLabel)
101         plt.ylabel(yLabel)
102         plt.legend()
103         plt.show()

```

Listing 9: Python routine to read processed CREME96 differential flux output and save as processed integral flux output.

```

1  import sys
2  import numpy as np
3  import matplotlib.pyplot as plt
4
5  # python .\convert_differential_to_integral_flux.py .\200km-SPE_flux.txt > 200
6  km-SPE_flux_integral.txt
7  # python .\convert_differential_to_integral_flux.py .\SPE_flux_worst-case.txt
8  > SPE_flux_worst-case_integral.txt
9  # python .\convert_differential_to_integral_flux.py .\SPE_flux_45.04km.txt >
10 SPE_flux_45.04km_integral.txt
11 # python .\convert_differential_to_integral_flux.py .\SPE_flux_47.65km.txt >
12 SPE_flux_47.65km_integral.txt
13

```

```

10 # python .\convert_differential_to_integral_flux.py .\200km-GCR_flux.txt > 200
    km-GCR_flux_integral.txt
11 # python .\convert_differential_to_integral_flux.py .\GCR_flux_worst-case.txt
    > GCR_flux_worst-case_integral.txt
12 # python .\convert_differential_to_integral_flux.py .\GCR_flux_45.04km.txt >
    GCR_flux_45.04km_integral.txt
13 # python .\convert_differential_to_integral_flux.py .\GCR_flux_47.65km.txt >
    GCR_flux_47.65km_integral.txt
14
15 filename = sys.argv[1]
16
17 x,y = np.loadtxt(filename, unpack=True)
18
19 N = x.shape[0]
20
21 yint = np.zeros(N-1)
22
23 for i in range(0, N-1):
24     if y[i] > 0. and y[i+1] > 0:
25         bi = np.log(y[i+1] / y[i]) / np.log(x[i+1] / x[i])
26
27         yint[i] = y[i] * x[i] / (bi + 1.) * ((x[i+1] / x[i])** (bi +
    1.) - 1.)
28
29         if i > 0:
30             yint[i] = yint[i] + yint[i-1]
31
32 yint = yint[-1] - yint # to make an integral flux > x, not < x
33
34 for i in range(0, N-1):
35     print(x[i], yint[i])

```

Listing 10: Python routine to sample data at a different resolution with logarithmically spaced abscissa.

```

1 import sys
2 import numpy as np
3 from numpy import vectorize # https://stackoverflow.com/questions/8036878/
    function-of-numpy-array-with-if-statement
4 import matplotlib.pyplot as plt
5
6
7 # python .\convert_lower_res_data.py SPE_LET_worst-case.txt 1. 87. 50 >
    SPE_LET_low-res.txt
8 # python .\convert_lower_res_data.py GCR_LET_worst-case.txt 1. 87. 50 >
    GCR_LET_low-res.txt
9
10 # python .\convert_lower_res_data.py SPE_flux_worst-case.txt 3900. 1.E5 50 >
    SPE_flux_low-res.txt
11 # python .\convert_lower_res_data.py GCR_flux_worst-case.txt 3900. 1.E5 50 >
    GCR_flux_low-res.txt
12
13 # python .\convert_lower_res_data.py SPE_flux_worst-case_integral.txt 3500.
    9.5E4 50 > SPE_flux_integral_low-res.txt
14 # python .\convert_lower_res_data.py GCR_flux_worst-case_integral.txt 3500.
    9.5E4 50 > GCR_flux_integral_low-res.txt
15

```



```
16 def y_power_law(x0, x1, y0, y1, x):
17     return y0 * (x/x0)**(np.log(y1/y0) / np.log(x1/x0))
18
19
20 def get_y(x_vec, y_vec, x):
21     i = 0
22
23     while i < x_vec.size and x > x_vec[i]:
24         i = i + 1
25
26     i = i - 1
27     if i < 0 or i > x_vec.size - 2:
28         return 0.
29     else:
30         return y_power_law(x_vec[i], x_vec[i+1], y_vec[i], y_vec[i+1],
31                             x)
32
33 vget_y = vectorize(get_y)
34
35 filename = sys.argv[1]
36 xmin = float(sys.argv[2])
37 xmax = float(sys.argv[3])
38 Nx = int(sys.argv[4])
39
40
41 x_data, y_data = np.loadtxt(filename, unpack=True)
42
43 x_low_res = np.logspace(np.log10(xmin), np.log10(xmax), Nx)
44
45 #y_low_res = vget_y(x_data, y_data, x_low_res)
46
47 for i in range(0, Nx):
48     y_low_res = get_y(x_data, y_data, x_low_res[i])
49     print(x_low_res[i], y_low_res)
```