

SPace

ENVironment

Iinformation

Ssystem

SPENVIS

SPENVIS

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SPENVIS Laboratory Work:

1 Summary:

- Characterise the space environment
- Give rough estimates of worst possible cases and critical phases
- Study specific electronic equipment for errors and degradation – give recommendations
- Study solar panel degradation

2 Define the Mission

- Mission objectives/type
- Orbit selection for mission type

3 Illustrate the orbit

- Using the SPENVIS plotting tools, or downloading the SPENVIS ephemeris file, plot the orbit in a variety of forms (world map, time-series of parameters, 3D plot)
- Determine if the representative orbit is adequate to evaluate the environment.

4 Describe the space environment

4.1 Describe the different phases of the orbit

- Describe the space environment during the different phases
- Describe the space environment effects during the different phases
- Give characteristic values of many physical parameters
- Which interaction is the most significant during the mission?

4.2 Where is the radiation environment the strongest?

- Which are the critical phases of the mission?
- Describe the composition of particles in the radiation flux
-

5 Compute the different environmental fluxes

- Trapped proton and Electron fluxes
- Solar particle fluxes (short and long term)
- Galactic cosmic ray fluxes
- Effects of geomagnetic shielding

6 Compute the different environmental effects

6.1 How thick must the cover glass for the Azur 3G28 solar cells be to ensure the power at the mission end is 95% of the beginning of mission power?

6.2 How long will the memory device function if its Total Ionising Dose Sensitivity is 25 krad(Si)?

- Assume the device is mounted behind the front face of a shielded box with thickness 2 mm Al.
- How thick must the shielding be to permit the memory device to function during the entire mission. Include reasonable margins.

6.3 Single Event Effects

6.3.1 **LET –spectra: Determine the differential LET spectra, i.e. the particle flux $f(LET)$ as a function of LET for a shielding thickness of 1 g/cm².**

6.3.2 **Device Cross Section**

- Determine the device cross section for a certain electronics chip by fitting a Weibull function to the data with the help of MATLAB.
- Estimate the sensitive volume dimensions for the devices using their cross sections and assuming a device layer thickness of 5 microns.

6.3.3 **Device SEU rates:**

- Using the Weibull fit in SPENVIS from 6.3.2, calculate the SEU rates for the devices
- Using the SPENVIS data fit functionality, calculate the SEU rate for the SMJ329C50GFAM66 device.
- Use MATLAB to calculate the SEU rate for each electronic device using the following formula:

$$\frac{dU}{dt} = \int_0^{2\pi} \int_0^{\pi} \sin \theta \int_0^{\infty} \sigma(LET, \theta, \phi) \cdot \sum_{Z=1}^{92} h(LET) d(LET) d\theta d\phi$$

- Determine if the components are also susceptible to proton-nuclear SEE and comment about expected changes to SEU rate (Hint: try “PROFIT” cross section method).

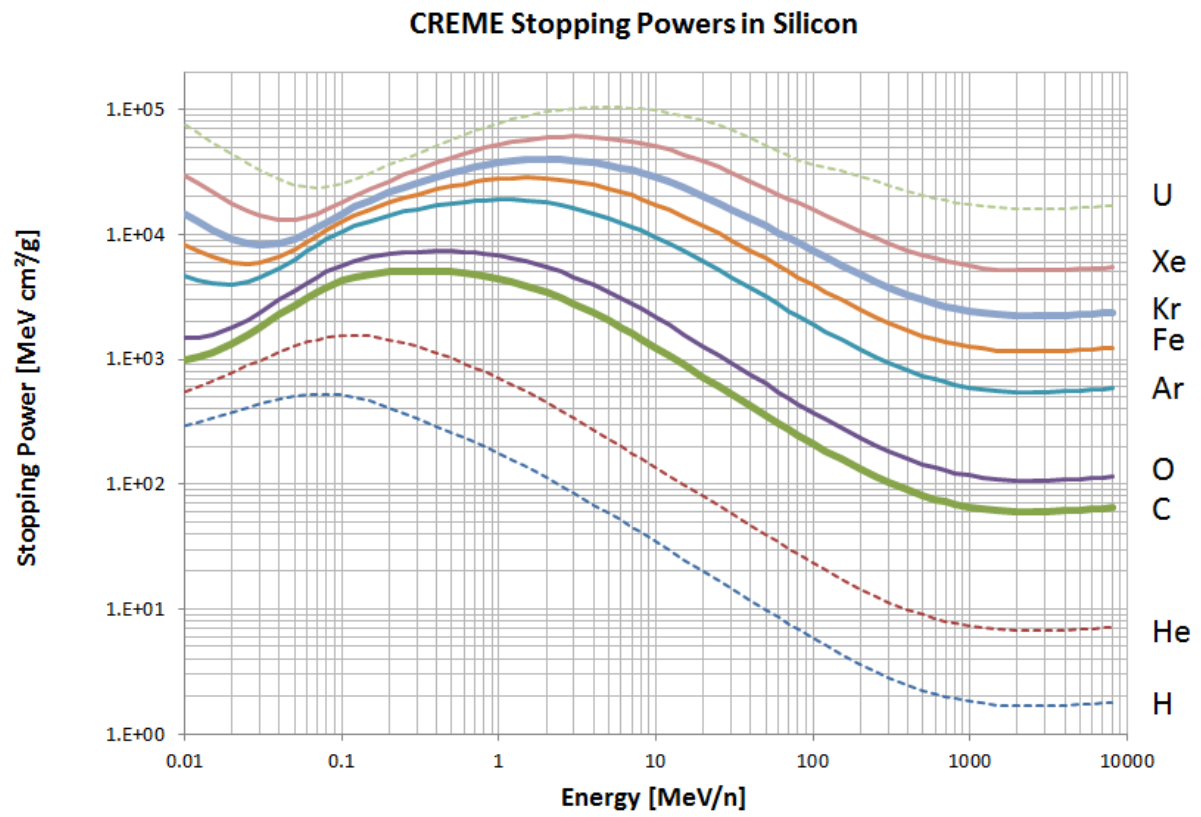
7 Conclusions:

- Is there a danger for the spacecraft or its equipment?
- What are your recommendations?
- Is the performance degradation in accordance with the mission duration and requirements?
- If not, propose design changes that could mitigate the radiation effects.
- What Radiation Design margin should be chosen for the mission? Analyse sources of uncertainty and error. Is the RDM feasible and realistic?

8 SPENVIS Report

- Hand in at the latest <TBD>
- 1, 2 or 3 students per group, with a common report
- Write as a full report (including abstract); at most 20 pages
- Write as if it were a serious report to be submitted to a customer for a formal Preliminary Design Review.
- Hand in a printed report.

9 Appendix: Stopping Power Table



Energy [MeV/n]	Stopping Power [MeV cm ² /g]								
	H	He	C	O	Ar	Fe	Kr	Xe	U
0.01	2.92E+02	5.45E+02	9.98E+02	1.47E+03	4.65E+03	8.31E+03	1.45E+04	2.95E+04	7.52E+04
0.012	3.13E+02	5.98E+02	1.04E+03	1.49E+03	4.29E+03	7.41E+03	1.27E+04	2.56E+04	6.53E+04
0.015	3.41E+02	6.73E+02	1.13E+03	1.57E+03	4.02E+03	6.59E+03	1.09E+04	2.16E+04	5.49E+04
0.02	3.80E+02	7.88E+02	1.34E+03	1.80E+03	3.97E+03	5.97E+03	9.27E+03	1.76E+04	4.39E+04
0.025	4.12E+02	8.92E+02	1.57E+03	2.08E+03	4.17E+03	5.84E+03	8.53E+03	1.53E+04	3.71E+04
0.03	4.39E+02	9.86E+02	1.81E+03	2.38E+03	4.51E+03	5.99E+03	8.26E+03	1.40E+04	3.25E+04
0.04	4.78E+02	1.15E+03	2.28E+03	2.99E+03	5.38E+03	6.70E+03	8.50E+03	1.29E+04	2.73E+04
0.05	5.04E+02	1.27E+03	2.73E+03	3.57E+03	6.34E+03	7.67E+03	9.28E+03	1.30E+04	2.48E+04
0.06	5.19E+02	1.37E+03	3.13E+03	4.11E+03	7.30E+03	8.74E+03	1.03E+04	1.36E+04	2.38E+04
0.07	5.26E+02	1.44E+03	3.48E+03	4.58E+03	8.22E+03	9.80E+03	1.14E+04	1.46E+04	2.37E+04
0.08	5.26E+02	1.49E+03	3.77E+03	5.00E+03	9.05E+03	1.08E+04	1.25E+04	1.56E+04	2.41E+04
0.1	5.16E+02	1.55E+03	4.23E+03	5.65E+03	1.05E+04	1.26E+04	1.46E+04	1.79E+04	2.57E+04
0.12	4.97E+02	1.56E+03	4.54E+03	6.11E+03	1.16E+04	1.42E+04	1.65E+04	2.00E+04	2.77E+04
0.15	4.63E+02	1.53E+03	4.82E+03	6.56E+03	1.29E+04	1.60E+04	1.87E+04	2.29E+04	3.09E+04
0.2	4.10E+02	1.44E+03	5.03E+03	6.94E+03	1.43E+04	1.81E+04	2.16E+04	2.68E+04	3.59E+04
0.25	3.69E+02	1.35E+03	5.09E+03	7.13E+03	1.52E+04	1.96E+04	2.38E+04	3.00E+04	4.03E+04
0.3	3.37E+02	1.27E+03	5.11E+03	7.23E+03	1.59E+04	2.09E+04	2.57E+04	3.27E+04	4.44E+04
0.4	2.91E+02	1.13E+03	5.07E+03	7.31E+03	1.70E+04	2.28E+04	2.87E+04	3.73E+04	5.15E+04
0.5	2.59E+02	1.02E+03	4.99E+03	7.30E+03	1.77E+04	2.43E+04	3.10E+04	4.10E+04	5.77E+04
0.6	2.35E+02	9.34E+02	4.88E+03	7.24E+03	1.82E+04	2.54E+04	3.29E+04	4.42E+04	6.30E+04
0.7	2.16E+02	8.62E+02	4.77E+03	7.15E+03	1.86E+04	2.63E+04	3.44E+04	4.68E+04	6.75E+04
0.8	2.00E+02	8.01E+02	4.65E+03	7.03E+03	1.88E+04	2.69E+04	3.56E+04	4.89E+04	7.15E+04
1	1.76E+02	7.05E+02	4.40E+03	6.77E+03	1.90E+04	2.77E+04	3.74E+04	5.23E+04	7.81E+04
1.2	1.58E+02	6.31E+02	4.17E+03	6.49E+03	1.89E+04	2.82E+04	3.85E+04	5.48E+04	8.32E+04
1.5	1.37E+02	5.47E+02	3.85E+03	6.09E+03	1.87E+04	2.84E+04	3.95E+04	5.73E+04	8.89E+04
2	1.13E+02	4.50E+02	3.41E+03	5.49E+03	1.79E+04	2.80E+04	4.00E+04	5.97E+04	9.53E+04
2.5	9.71E+01	3.85E+02	3.06E+03	4.99E+03	1.71E+04	2.73E+04	3.98E+04	6.06E+04	9.91E+04
3	8.52E+01	3.37E+02	2.77E+03	4.58E+03	1.62E+04	2.65E+04	3.92E+04	6.09E+04	1.02E+05
4	6.87E+01	2.70E+02	2.33E+03	3.92E+03	1.47E+04	2.48E+04	3.76E+04	6.02E+04	1.04E+05
5	5.89E+01	2.31E+02	2.03E+03	3.45E+03	1.35E+04	2.32E+04	3.59E+04	5.89E+04	1.04E+05
6	5.13E+01	2.01E+02	1.79E+03	3.08E+03	1.24E+04	2.17E+04	3.42E+04	5.72E+04	1.04E+05
7	4.56E+01	1.78E+02	1.61E+03	2.78E+03	1.15E+04	2.05E+04	3.27E+04	5.55E+04	1.03E+05
8	4.11E+01	1.60E+02	1.46E+03	2.53E+03	1.07E+04	1.93E+04	3.12E+04	5.38E+04	1.01E+05
10	3.45E+01	1.35E+02	1.23E+03	2.16E+03	9.47E+03	1.74E+04	2.86E+04	5.06E+04	9.81E+04
12	2.99E+01	1.17E+02	1.07E+03	1.88E+03	8.49E+03	1.58E+04	2.64E+04	4.76E+04	9.47E+04
15	2.51E+01	9.89E+01	9.00E+02	1.59E+03	7.36E+03	1.39E+04	2.37E+04	4.37E+04	8.96E+04
20	2.01E+01	8.01E+01	7.21E+02	1.27E+03	6.05E+03	1.17E+04	2.03E+04	3.85E+04	8.19E+04
25	1.70E+01	6.78E+01	6.08E+02	1.08E+03	5.17E+03	1.01E+04	1.78E+04	3.44E+04	7.52E+04
30	1.47E+01	5.88E+01	5.29E+02	9.37E+02	4.54E+03	8.97E+03	1.59E+04	3.11E+04	6.93E+04
40	1.17E+01	4.69E+01	4.23E+02	7.50E+02	3.70E+03	7.41E+03	1.33E+04	2.63E+04	5.96E+04
50	9.85E+00	3.94E+01	3.55E+02	6.31E+02	3.15E+03	6.38E+03	1.16E+04	2.32E+04	5.22E+04
60	8.56E+00	3.43E+01	3.09E+02	5.49E+02	2.75E+03	5.62E+03	1.04E+04	2.10E+04	4.66E+04
70	7.61E+00	3.05E+01	2.75E+02	4.88E+02	2.45E+03	5.04E+03	9.37E+03	1.93E+04	4.25E+04

80	6.88E+00	2.76E+01	2.48E+02	4.41E+02	2.22E+03	4.58E+03	8.58E+03	1.80E+04	3.97E+04
100	5.84E+00	2.34E+01	2.11E+02	3.75E+02	1.89E+03	3.92E+03	7.39E+03	1.59E+04	3.65E+04
120	5.12E+00	2.05E+01	1.85E+02	3.29E+02	1.66E+03	3.46E+03	6.55E+03	1.43E+04	3.47E+04
150	4.39E+00	1.76E+01	1.58E+02	2.82E+02	1.43E+03	2.97E+03	5.67E+03	1.25E+04	3.24E+04
200	3.63E+00	1.45E+01	1.31E+02	2.33E+02	1.19E+03	2.48E+03	4.74E+03	1.06E+04	2.91E+04
250	3.17E+00	1.27E+01	1.15E+02	2.04E+02	1.04E+03	2.17E+03	4.16E+03	9.38E+03	2.66E+04
300	2.86E+00	1.15E+01	1.03E+02	1.84E+02	9.36E+02	1.96E+03	3.77E+03	8.53E+03	2.48E+04
400	2.47E+00	9.90E+00	8.93E+01	1.59E+02	8.10E+02	1.70E+03	3.27E+03	7.45E+03	2.22E+04
500	2.24E+00	8.98E+00	8.10E+01	1.44E+02	7.35E+02	1.54E+03	2.98E+03	6.80E+03	2.06E+04
600	2.09E+00	8.38E+00	7.57E+01	1.35E+02	6.87E+02	1.44E+03	2.78E+03	6.37E+03	1.95E+04
700	1.99E+00	7.97E+00	7.20E+01	1.28E+02	6.53E+02	1.37E+03	2.65E+03	6.08E+03	1.87E+04
800	1.92E+00	7.68E+00	6.93E+01	1.23E+02	6.29E+02	1.32E+03	2.56E+03	5.86E+03	1.81E+04
1000	1.82E+00	7.28E+00	6.57E+01	1.17E+02	5.97E+02	1.25E+03	2.43E+03	5.57E+03	1.73E+04
1200	1.76E+00	7.04E+00	6.35E+01	1.13E+02	5.77E+02	1.21E+03	2.35E+03	5.39E+03	1.68E+04
1500	1.71E+00	6.84E+00	6.17E+01	1.10E+02	5.61E+02	1.18E+03	2.28E+03	5.24E+03	1.64E+04
2000	1.67E+00	6.70E+00	6.05E+01	1.08E+02	5.50E+02	1.16E+03	2.24E+03	5.14E+03	1.61E+04
2500	1.67E+00	6.67E+00	6.03E+01	1.07E+02	5.47E+02	1.15E+03	2.23E+03	5.12E+03	1.60E+04
3000	1.67E+00	6.69E+00	6.04E+01	1.08E+02	5.49E+02	1.15E+03	2.23E+03	5.13E+03	1.60E+04
4000	1.69E+00	6.77E+00	6.11E+01	1.09E+02	5.55E+02	1.17E+03	2.26E+03	5.19E+03	1.62E+04
5000	1.72E+00	6.87E+00	6.20E+01	1.10E+02	5.63E+02	1.18E+03	2.29E+03	5.26E+03	1.64E+04
6000	1.74E+00	6.97E+00	6.29E+01	1.12E+02	5.71E+02	1.20E+03	2.32E+03	5.33E+03	1.66E+04
7000	1.76E+00	7.06E+00	6.37E+01	1.13E+02	5.78E+02	1.21E+03	2.35E+03	5.39E+03	1.68E+04
8000	1.78E+00	7.14E+00	6.44E+01	1.15E+02	5.85E+02	1.23E+03	2.38E+03	5.45E+03	1.70E+04