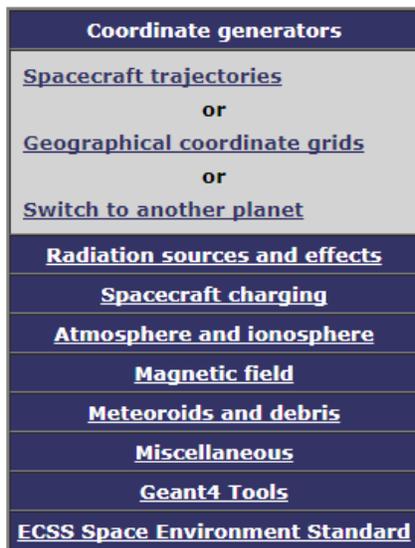


# Instructions for SPENVIS

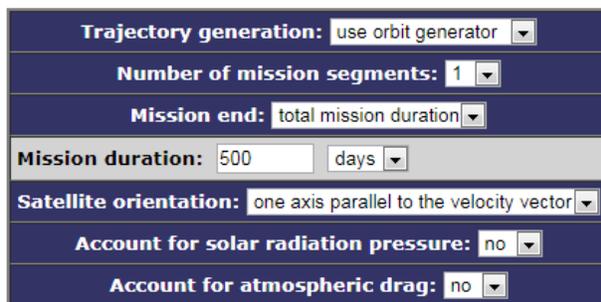
This will step you through getting set up and using the SPENVIS simulation for testing shields for a trip to Mars.

The website for Spenvis is <https://www.spenvis.oma.be/intro.php> You will need to register, it is free and educator friendly.

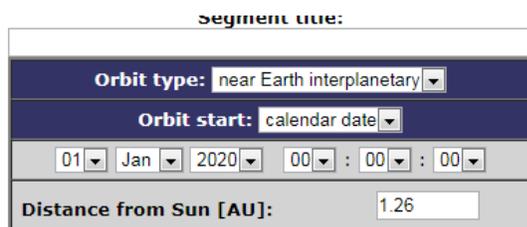
After logging in you will see a menu for different inputs to the simulation



Under “Spacecraft Trajectories” I set



And after hitting “next”



Then hit “next” and then “run”.

This will create a trajectory file for your simulation, and you will be able to check it before you hit “up” to return to the main menu.

<b>Ion range:</b> H to Ni
<b>GCR model at 1 AU:</b> ISO 15390
ISO-15390 standard model
solar activity data: user defined
solar cycle number: even
12-month average ssn at minimum: 9.6
12-month average ssn at maximum: 110.6
reversal moment (decimal year): 2014.5
12-month average ssn at epoch: 110.0
12-month average ssn at epoch - lag: 95.0
<b>Magnetic shielding: no</b>

Then in “Radiation sources and effects” select “Galactic cosmic ray fluxes”. Solar particle radiation is usually lower energy and shielding against it is easier, creating a shield to protect against cosmic rays is more difficult, so that is what my project had students focused on.

Then hit “run” to create a radiation flux file that your simulation will use. Once again you can look at your outputs before hitting “up” (twice) to get back to the menu.

I did not use any of the other features of the simulation, but certainly feel free to explore and experiment.

The set up

<b>Coordinate generators</b>
<b>Radiation sources and effects</b>
<b>Spacecraft charging</b>
<b>Atmosphere and ionosphere</b>
<b>Magnetic field</b>
<b>Meteoroids and debris</b>
<b>Miscellaneous</b>
<b>Geant4 Tools</b>
<b>General models</b>
<a href="#">Multi-Layered Shielding Simulation (MULASSIS)</a>
<a href="#">Geant4 Radiation Analysis for Space (GRAS)</a>
<a href="#">Geant4-based Microdosimetry Analysis Tool (GEMAT)</a>
<a href="#">Sector Shielding Analysis Tool (SSAT)</a>
<b>Planet specific models</b>
<a href="#">Magnetocosmics</a>
<a href="#">Planetocosmics</a>
<b>Common settings</b>
<a href="#">Definition of source particles</a>
<a href="#">User defined materials</a>
<a href="#">Geometry definition tool</a>
<b>ECSS Space Environment Standard</b>

rest of the simulation is and run in “Geant4 Tools”.

<b>User defined materials (20)</b>	
carbon_(graphite) (C)	Del
iron (Fe)	Del
G4_ADIPOSE_TISSUE_ICRP (*N.A.*)	Del
G4_AIR (*N.A.*)	Del
tungsten (W)	Del
lead (Pb)	Del
G4_BONE_COMPACT_ICRU (*N.A.*)	Del
G4_MUSCLE_WITH_SUCROSE (*N.A.*)	Del
G4_Al (Al)	Del
uranium (U)	Del
G4_POLYETHYLENE ((C2-H4)-N)	Del
G4_CONCRETE (*N.A.*)	Del
G4_WATER (H2-O)	Del
tin (Sn)	Del
Boron_Nitride (B-N)	Del
Brass (Cu6-Zn4)	Del
Boric_Acid (H3-B-O3)	Del
G4_POLYPROPYLENE (C3-H6)	Del
G4_Cu (Cu)	Del
G4-Ta (Ta)	Del
<b>Adding new material</b>	
Source:	NIST pure elements
Material:	Tantalum
Chemical formula:	Ta
Density [g cm <sup>-3</sup> ]:	16.654
Add	

Reset Save >>

Your simulation can only use up to 20 different materials at a time. These are set in “User defined materials”. To use other materials you need to first “delete” a material from the list and then select a new material (or you can define your own).

I used the “Multi-Layered Shielding Simulation (MULASSIS)” simulation, mostly because of the features it had.

Status	Settings	Remarks
defined	<a href="#">Source particle macro</a>	GCR, ion, <a href="#">GPS macro file</a>
defined	<a href="#">Geometry</a>	Sphere, 14 layers
defined	<a href="#">Analysis parameters</a>	Total ionizing dose
Advanced settings		
defined	<a href="#">Material definition</a>	20 material defined
defined	<a href="#">Cuts-in-range</a>	No cuts-in-range

[Create macro](#)

Source particle type and spectrum	
Environment:	Mission based <input type="button" value="v"/> GCR particles <input type="button" value="v"/>
Number of primary particles to simulate:	10,000,000 <input type="button" value="v"/> <small>Warning: Particle track visualisation will be disabled!</small>
Incident particle type:	ion <input type="button" value="v"/>
Ion definition	
Atomic number:	1 <input type="button" value="v"/>
Isotope:	H1 <input type="button" value="v"/>
Incident energy spectrum	
Mission average spectrum	
<input type="button" value="v"/> Don't use	energy biasing
Angular distribution	
The angular distribution is omnidirectional.	

[Reset](#) [Create GPS macro](#)

This sets the what radiation hits the shield, you want to use “Mission based” with “GCR particles” as the environment.

When I tested my student’s shields I did two simulations, one with protons (Atomic number = 1 and Isotope = H1), and one with alpha particles (Atomic number = 2 and Isotope = He4).

The “Geometry” part of MULASSIS is where you define the thickness and order of your shield layers.

Geometry: User defined			
Shape: sphere		Number of layers: 14	
Layer number	Material	Thickness (unit)	Visualisation colour
Layer 1	Vacuum	0.1 mm	white
Layer 2	Vacuum	0.07 mm	white
Layer 3	Vacuum	0.06 mm	white
Layer 4	Vacuum	0.1 mm	white
Layer 5	Vacuum	0.1 mm	white
Layer 6	Vacuum	0.1 mm	white
Layer 7	Vacuum	0.2 mm	white
Layer 8	tungsten	0.05 m	white
Layer 9	carbon_(graphite)	3.2 m	white
Layer 10	lead	0.4 m	white
Layer 11	G4_AIR	5.65 m	white
Layer 12	G4_ADIPOSE_TISSUE_ICRP	.05 m	white
Layer 13	G4_MUSCLE_WITH_SUCROSE	.3 m	white
Layer 14	G4_BONE_COMPACT_ICRU	.2 m	white

The inner 3 layers (12, 13, and 14) represent the astronauts, the air represents their living space, and then the tungsten, carbon, and lead are the shield that is being tested.

Under “Analysis parameters” you want to select total ionizing dose, Grays (Gy), and all layers.

Analysis type: Total ionizing dose	
Energy deposition / TID	
Output units: Gy	
Select layers for energy deposition/total ionising dose analysis:	
1 <input checked="" type="checkbox"/>	2 <input checked="" type="checkbox"/>
3 <input checked="" type="checkbox"/>	4 <input checked="" type="checkbox"/>
5 <input checked="" type="checkbox"/>	6 <input checked="" type="checkbox"/>
7 <input checked="" type="checkbox"/>	8 <input checked="" type="checkbox"/>
9 <input checked="" type="checkbox"/>	10 <input checked="" type="checkbox"/>
11 <input checked="" type="checkbox"/>	12 <input checked="" type="checkbox"/>
13 <input checked="" type="checkbox"/>	14 <input checked="" type="checkbox"/>

Layer	Thickness cm	Density g/cm3	Dose Gy	Error Gy
1	1.00000e-2	1.00000e-25	6.57226e-2	5.07860e-3
2	7.00000e-3	1.00000e-25	6.24039e-2	3.76586e-3
3	6.00000e-3	1.00000e-25	6.25233e-2	3.79178e-3
4	1.00000e-2	1.00000e-25	6.26924e-2	3.83063e-3
5	1.00000e-2	1.00000e-25	6.29479e-2	3.89389e-3
6	1.00000e-2	1.00000e-25	6.32834e-2	3.98493e-3
7	2.00000e-2	1.00000e-25	6.42799e-2	4.28912e-3
8	5.00000e+0	1.93000e+1	4.20874e-2	1.53229e-3
9	3.20000e+2	2.25000e+0	1.62660e-2	7.03529e-4
10	4.00000e+1	1.13000e+1	1.22512e-4	4.30382e-5
11	5.65000e+2	1.20479e-3	1.74555e-4	6.10778e-5
12	5.00000e+0	9.50000e-1	3.26498e-4	1.83591e-4
13	3.00000e+1	1.11000e+0	6.36362e-5	6.34038e-5
14	2.00000e+1	1.85000e+0	5.65828e-4	5.65828e-4

Then you click on “Create Macro” and “Run”. It takes a few minutes, but when it finishes you can look at the output. Just click on the little blue html button after the “Output file for the

multilayered analysis tool” and you will get this...

Then you add up the dose for layers 12, 13, and 14 and that will be the total dose in Grays.

