

Natural Space Environment

Mod01a Exercise

Justin J. Likar

The Johns Hopkins University Applied Physics Laboratory (JHU / APL)

240-592-1090 | 240-583-9375

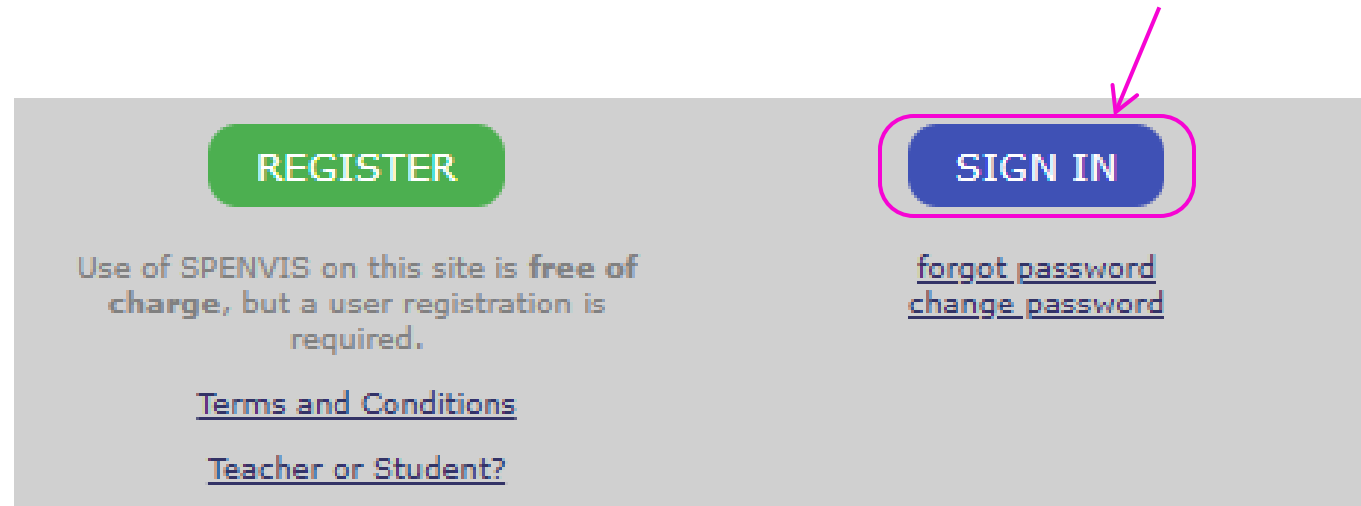
justin.likar@jhuapl.edu | jlikar1@jhu.edu

Purpose and objectives

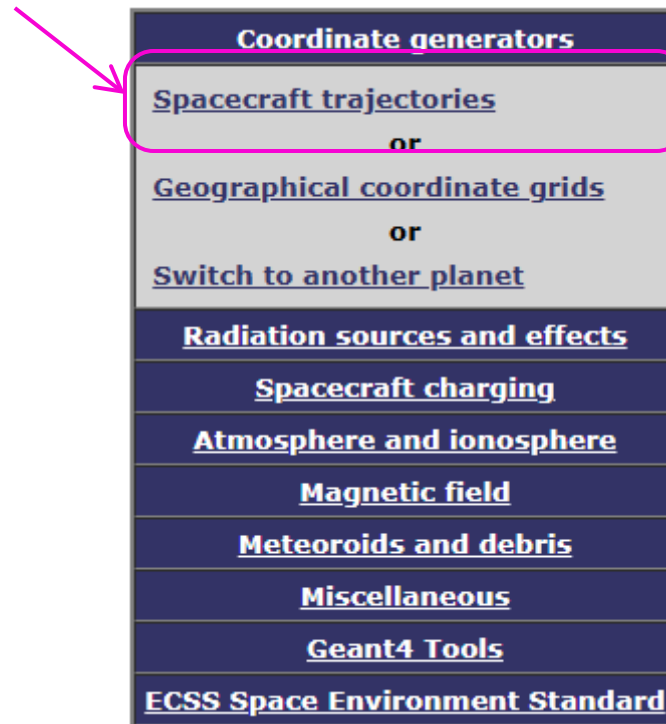
- Introduce the SPENVIS online tool kit
- Use SPENVIS to generate charged particle environments for several reference missions
 - Trapped particles
 - Solar Energetic Particles
 - Galactic Cosmic Rays
- Review resultant environments (compare & contrast)
 - Make observations
- Discuss how these environments will influence SEE test planning

Sign in to SPENVIS

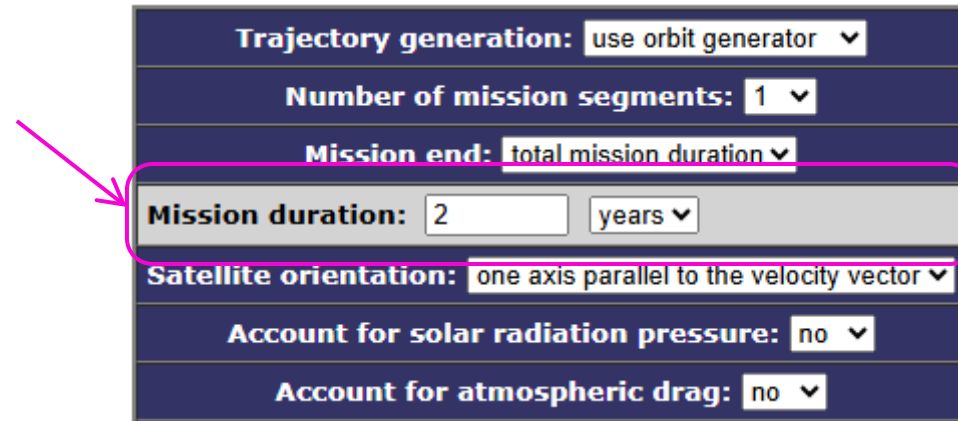
- <https://www.spervis.oma.be/>



Use the Coordinate Generator to create a trajectory



Use the Coordinate Generator to create a trajectory



The image shows a screenshot of a web-based interface for trajectory generation. The interface consists of several rows of controls. A pink arrow points to the 'Mission duration' field, which is highlighted with a pink rounded rectangle. The 'Mission duration' field contains the value '2' and a unit dropdown menu set to 'years'. Other fields include 'Trajectory generation' (set to 'use orbit generator'), 'Number of mission segments' (set to '1'), 'Mission end' (set to 'total mission duration'), 'Satellite orientation' (set to 'one axis parallel to the velocity vector'), 'Account for solar radiation pressure' (set to 'no'), and 'Account for atmospheric drag' (set to 'no').

Trajectory generation:	use orbit generator ▼
Number of mission segments:	1 ▼
Mission end:	total mission duration ▼
Mission duration:	2 years ▼
Satellite orientation:	one axis parallel to the velocity vector ▼
Account for solar radiation pressure:	no ▼
Account for atmospheric drag:	no ▼

Use the Coordinate Generator to create a trajectory

Segment title:
Starlink Mid Latitude

Orbit type: general

Orbit start: calendar date

01 Jan 2026 00 : 00 : 00

Representative trajectory duration [days]: 30

Altitude specification: perigee and apogee altitudes

Perigee altitude [km]: 530

Apogee altitude [km]: 530

Inclination [deg]: 53

R. asc. of asc. node [deg w.r.t. gamma50]: 0

Argument of perigee [deg]: 0

True anomaly [deg]: 0

Output resolution

1.	60.0	s below	20000.0	km
2.	240.0	s below	80000.0	km
3.	3600.0	s elsewhere		




Number of mission segments: 1










Segment 1: Starlink Mid Latitude


Orbit type: general
Orbit start: 1/1/2026 0:0:0
Trajectory duration: 30 day(s)

<< Back Run Combined Run

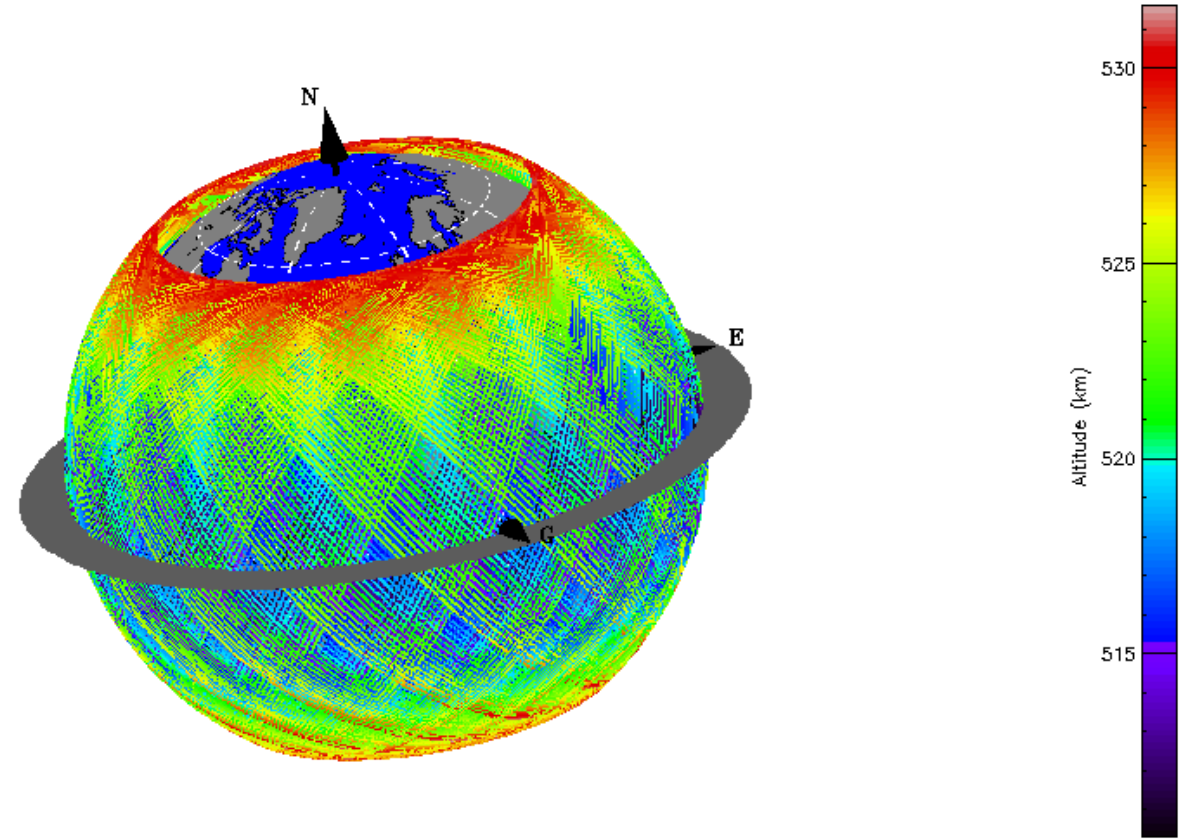
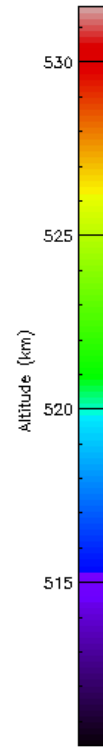
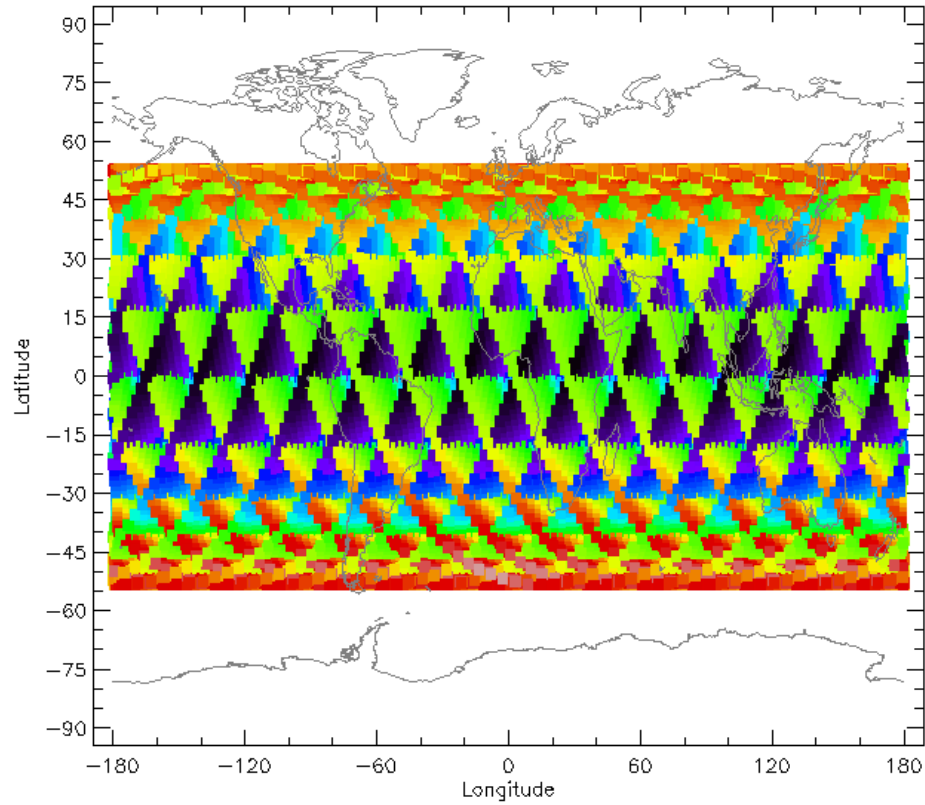
Explore the outputs

 **SPENVIS Project: A4RES**  
Orbit generator
Results


Tables	Plots
Report file Spacecraft coordinates  Attitude vectors 	
New plots	
<input type="checkbox"/> Orbit parameters as a function of time for mission segment 1 	
<input checked="" type="checkbox"/> World map  of the altitude  for mission segment 1  with linear  rainbow colour  scale	
<div>Plot as Portable Network Graphics (PNG) </div>	



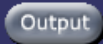

Explore the outputs



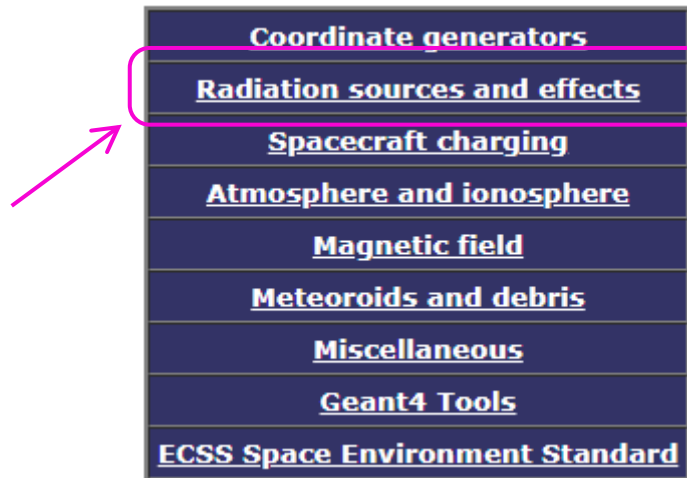
Modeling charged particle populations



SPENVIS Project: A4RES
Orbit generator
Results

1. Click UP and return to Main Menu
2. Click RADIATION SOURCES AND EFFECTS
3. Let's start with Trapped Particles



[Coordinate generators](#)

[Radiation sources and effects](#)

[Spacecraft charging](#)

[Atmosphere and ionosphere](#)

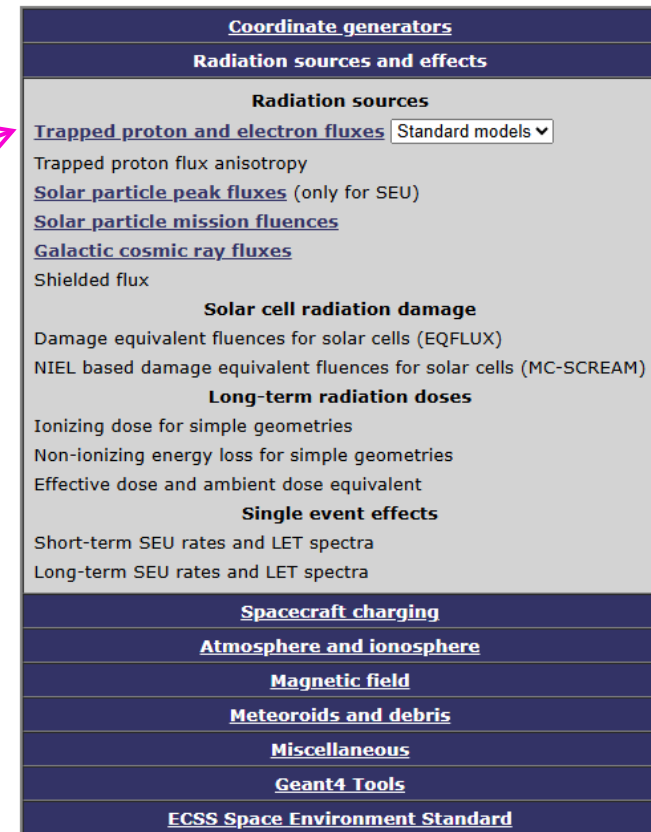
[Magnetic field](#)

[Meteoroids and debris](#)

[Miscellaneous](#)

[Geant4 Tools](#)

[ECSS Space Environment Standard](#)



[Coordinate generators](#)

[Radiation sources and effects](#)

Radiation sources

[Trapped proton and electron fluxes](#)

Trapped proton flux anisotropy

[Solar particle peak fluxes](#) (only for SEU)

[Solar particle mission fluences](#)

[Galactic cosmic ray fluxes](#)

Shielded flux

Solar cell radiation damage

Damage equivalent fluences for solar cells (EQFLUX)

NIEL based damage equivalent fluences for solar cells (MC-SCREAM)

Long-term radiation doses

Ionizing dose for simple geometries

Non-ionizing energy loss for simple geometries

Effective dose and ambient dose equivalent

Single event effects

Short-term SEU rates and LET spectra

Long-term SEU rates and LET spectra

[Spacecraft charging](#)

[Atmosphere and ionosphere](#)

[Magnetic field](#)

[Meteoroids and debris](#)



[Miscellaneous](#)

[Geant4 Tools](#)

[ECSS Space Environment Standard](#)

Run AP8 / AE8

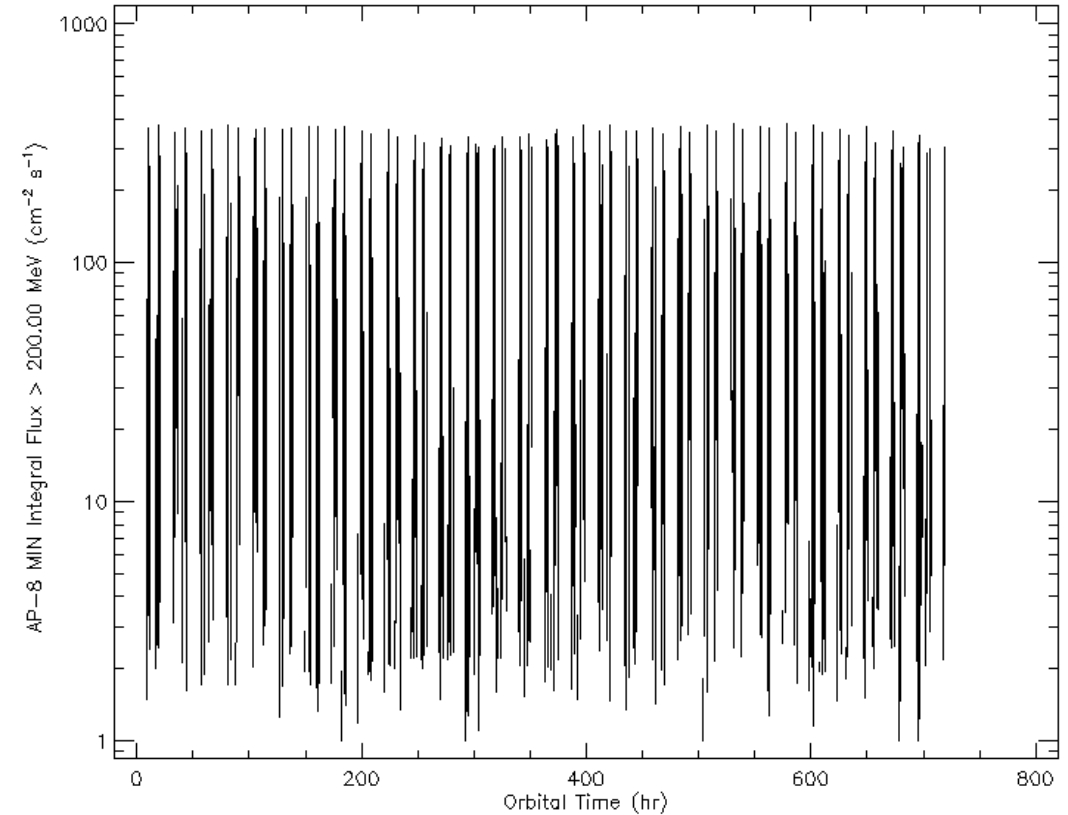
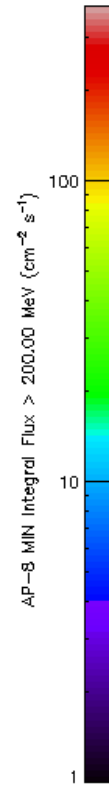
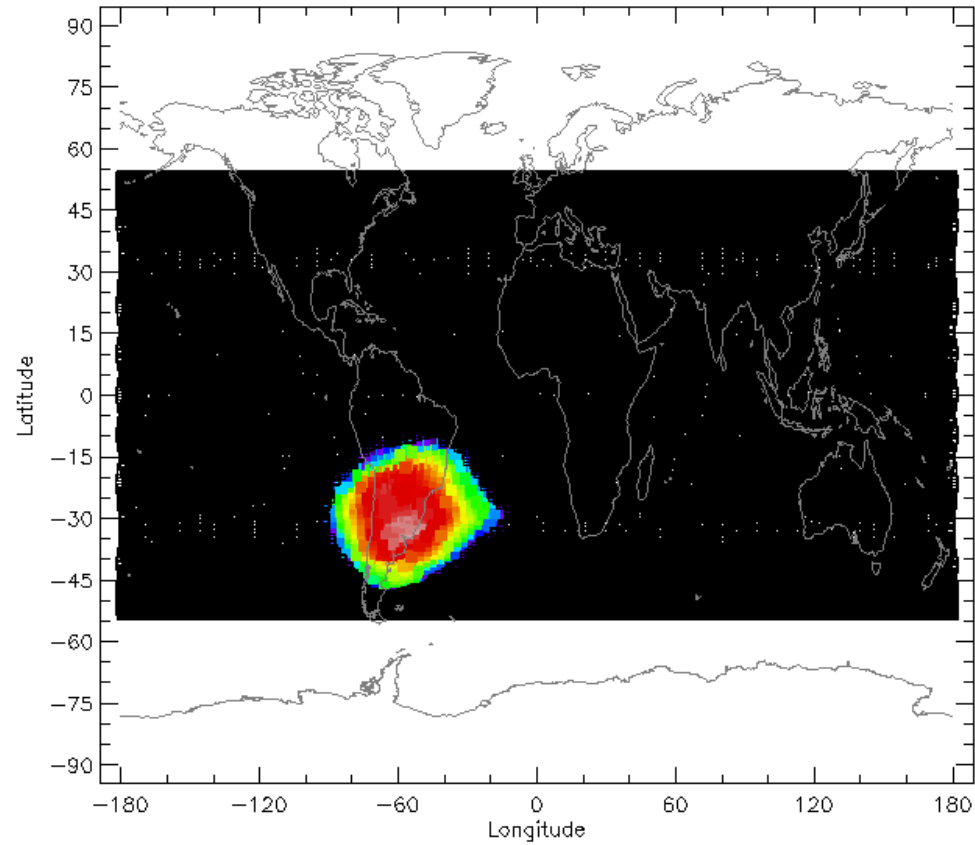
- SPENVIS includes options for Trapped Particles
 - IRENE (Ver. 1.50), SSREM, CRRESPRO, ...
- AP8 / AE8 is fast for illustrative purposes

Trapped radiation models	
Proton model: AP-8 ▼	Electron model : AE-8 ▼
Model version: solar minimum ▼	Model version: solar maximum ▼
Threshold flux for exposure(/cm2/s): 1.00	do not include ▼ local time variation
	Confidence level: 50.000% ▼
	Threshold flux for exposure(/cm2/s): 1.00
Model developed by:	Model developed by:
	


Explore the outputs

1. Generate a Proton spectra for this mission (flux vs. energy)
 - Review the Report file [[What sort of information is available here?](#)]
2. Generate a Time plot of proton flux >200 MeV for this mission
3. Generate a World map of proton flux >200 MeV for this mission
 - [[Why 200 MeV?](#)]
 - [[What sort of observations can you make?](#)]

Explore the outputs



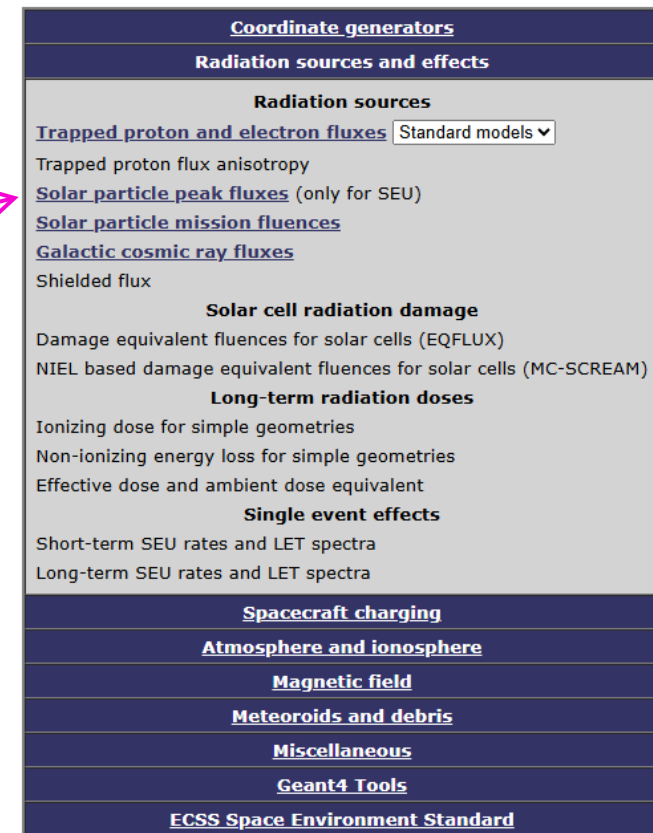
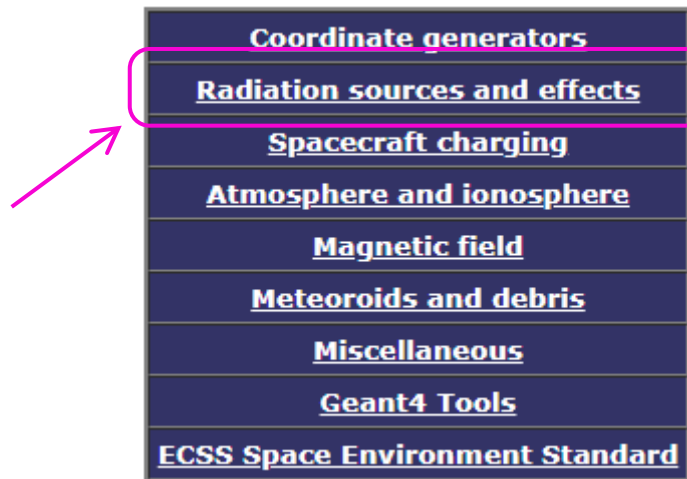
Modeling charged particle populations

A circular button with an upward-pointing arrow and the text "UP".

SPENVIS Project: A4RES
Orbit generator
Results

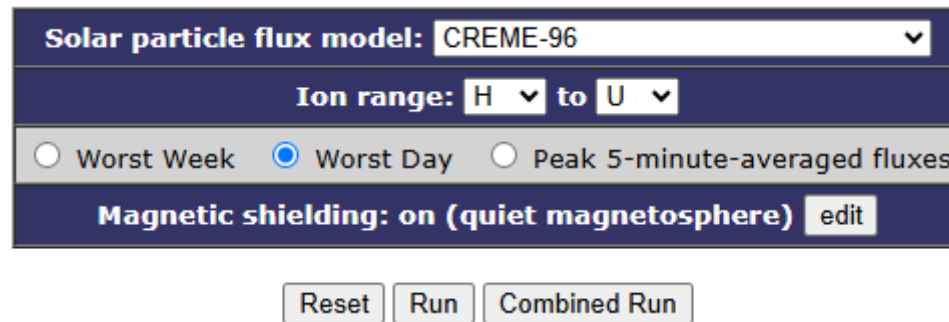
Output
Help

1. Click UP and return to Main Menu
2. Click RADIATION SOURCES AND EFFECTS
3. Let's add Solar particles



Run CREME-96 Worst Day (WD)

- Other options available (SAPPHIRE, CREME-86, ...)
- Why CREME-96?
 - Compatibility with SIRE-2, CREME-MC, ...
- Leave the Magnetic shielding as defaults



The screenshot shows a web-based configuration interface for the CREME-96 software. It features a dark blue header with white text. The first row contains a label 'Solar particle flux model:' followed by a dropdown menu set to 'CREME-96'. The second row is labeled 'Ion range:' and shows two dropdown menus, the first set to 'H' and the second to 'U', separated by the word 'to'. The third row contains three radio button options: 'Worst Week', 'Worst Day' (which is selected), and 'Peak 5-minute-averaged fluxes'. The fourth row is labeled 'Magnetic shielding: on (quiet magnetosphere)' and includes an 'edit' button. Below the configuration panel are three buttons: 'Reset', 'Run', and 'Combined Run'.

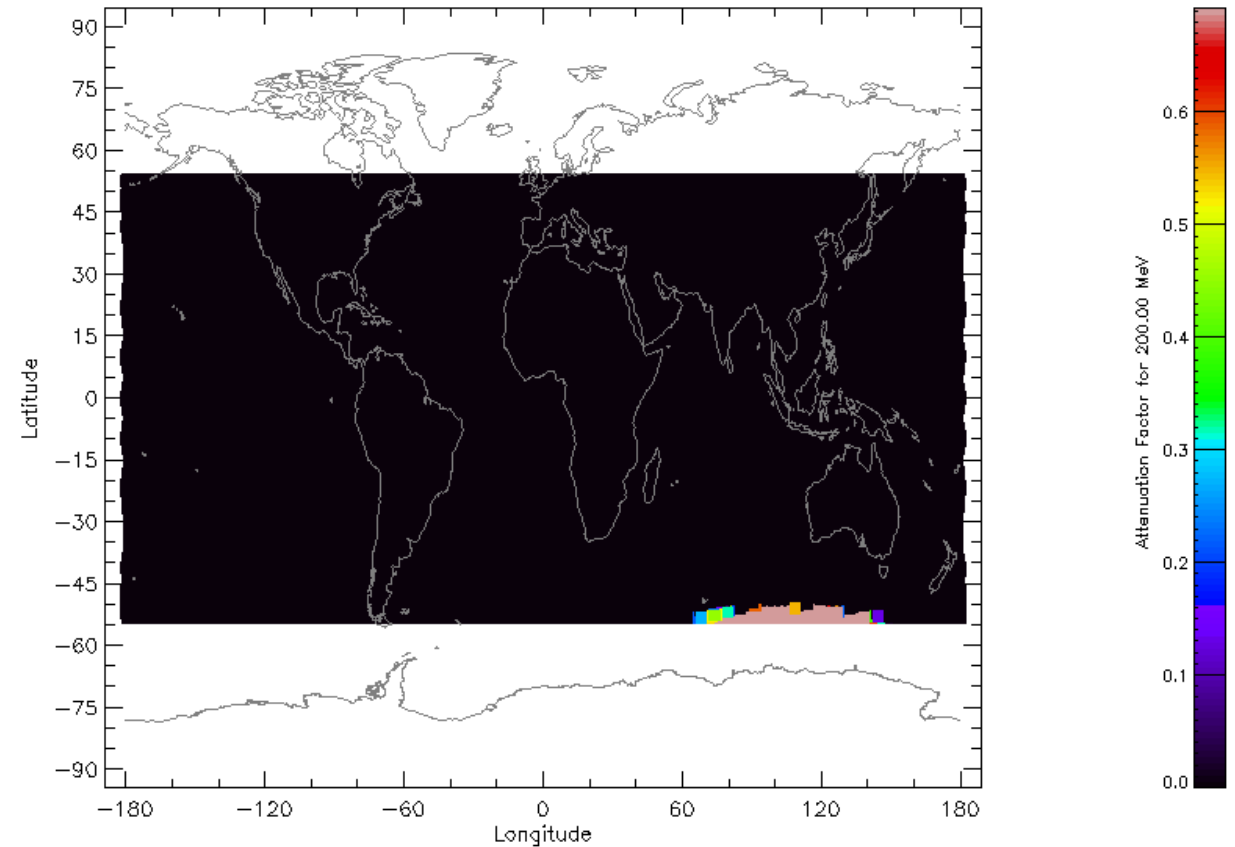
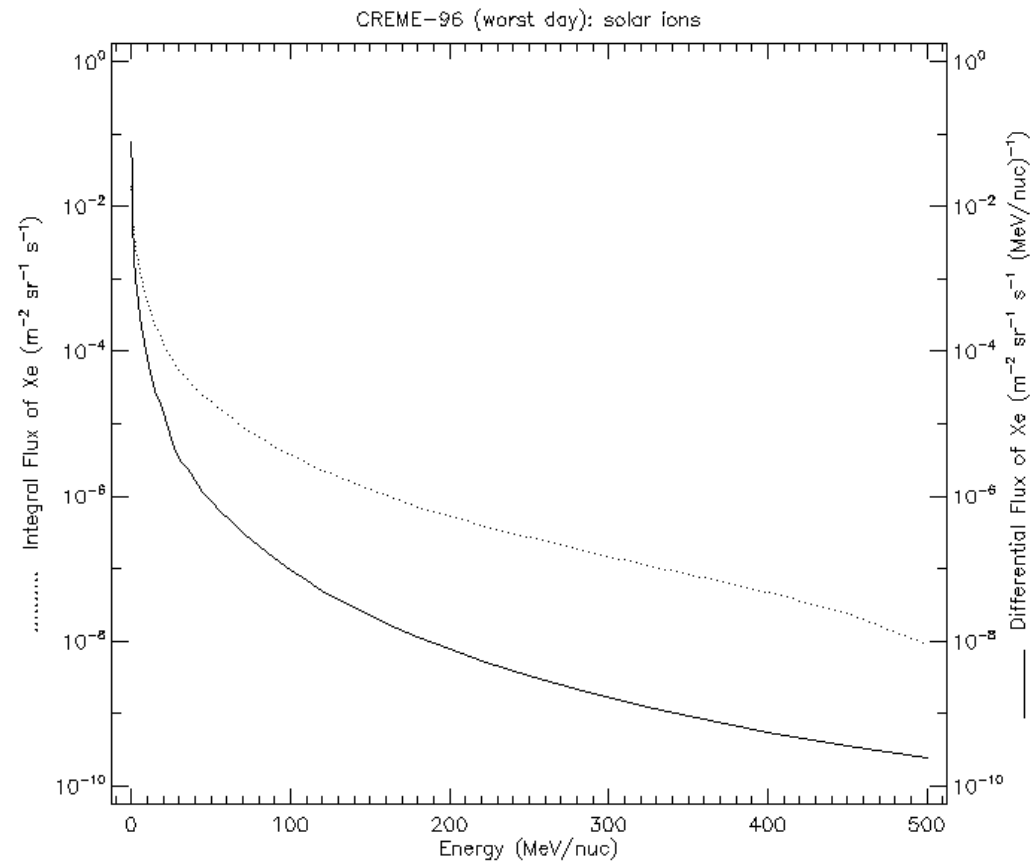
Solar particle flux model:	CREME-96
Ion range:	H to U
<input type="radio"/> Worst Week <input checked="" type="radio"/> Worst Day <input type="radio"/> Peak 5-minute-averaged fluxes	
Magnetic shielding: on (quiet magnetosphere) edit	

[Reset](#) [Run](#) [Combined Run](#)


Explore the outputs

1. Generate a Heavy Ion spectra for Xe ($Z=54$) for this mission (flux vs. energy)
2. Generate a World map of proton attenuation factor for >200 MeV for this mission
 - [Why 200 MeV?]
 - [What sort of observations can you make?]

Explore the outputs



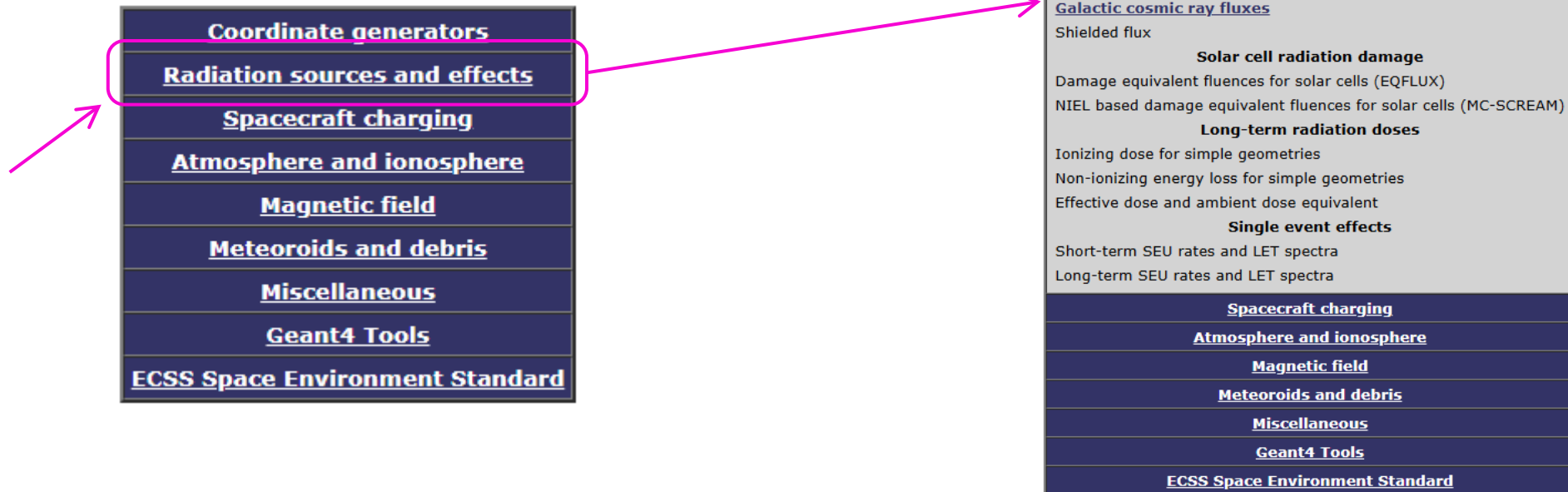
Modeling charged particle populations

A circular button with an upward-pointing arrow and the text "UP".

SPENVIS Project: A4RES
Orbit generator
Results

Output
Help

1. Click UP and return to Main Menu
2. Click RADIATION SOURCES AND EFFECTS
3. Let's add GCRs

The image shows a navigation menu on the left and a main content area on the right. The navigation menu has a pink box around "Radiation sources and effects" and a pink arrow pointing to it from the left. The main content area has a pink arrow pointing to it from the "Radiation sources and effects" menu item. The main content area is titled "Coordinate generators" and "Radiation sources and effects". It contains sections for "Radiation sources" (with a dropdown menu set to "Standard models"), "Solar cell radiation damage", "Long-term radiation doses", and "Single event effects".

Coordinate generators

Radiation sources and effects

Radiation sources

[Trapped proton and electron fluxes](#)

Trapped proton flux anisotropy

[Solar particle peak fluxes](#) (only for SEU)

[Solar particle mission fluences](#)

[Galactic cosmic ray fluxes](#)

Shielded flux

Solar cell radiation damage

Damage equivalent fluences for solar cells (EQFLUX)

NIEL based damage equivalent fluences for solar cells (MC-SCREAM)

Long-term radiation doses

Ionizing dose for simple geometries

Non-ionizing energy loss for simple geometries

Effective dose and ambient dose equivalent

Single event effects

Short-term SEU rates and LET spectra

Long-term SEU rates and LET spectra

Spacecraft charging

Atmosphere and ionosphere

Magnetic field

Meteoroids and debris

Miscellaneous

Geant4 Tools

ECSS Space Environment Standard

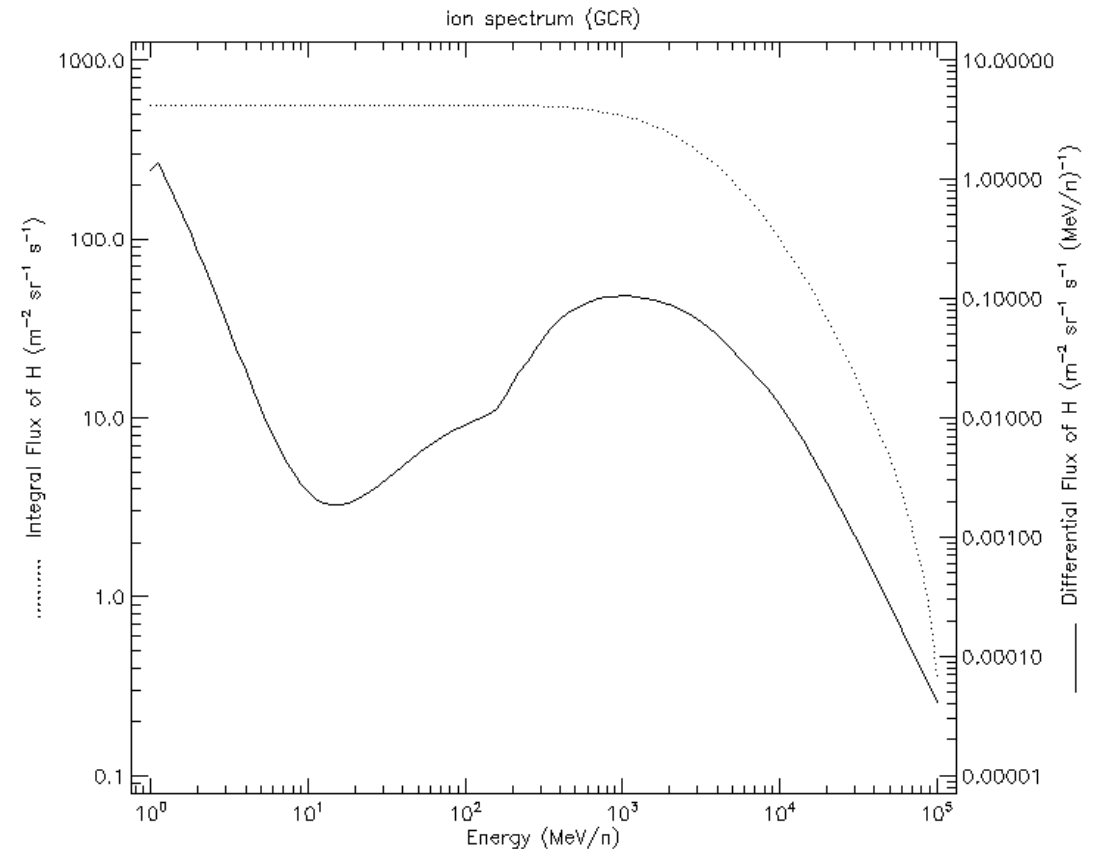
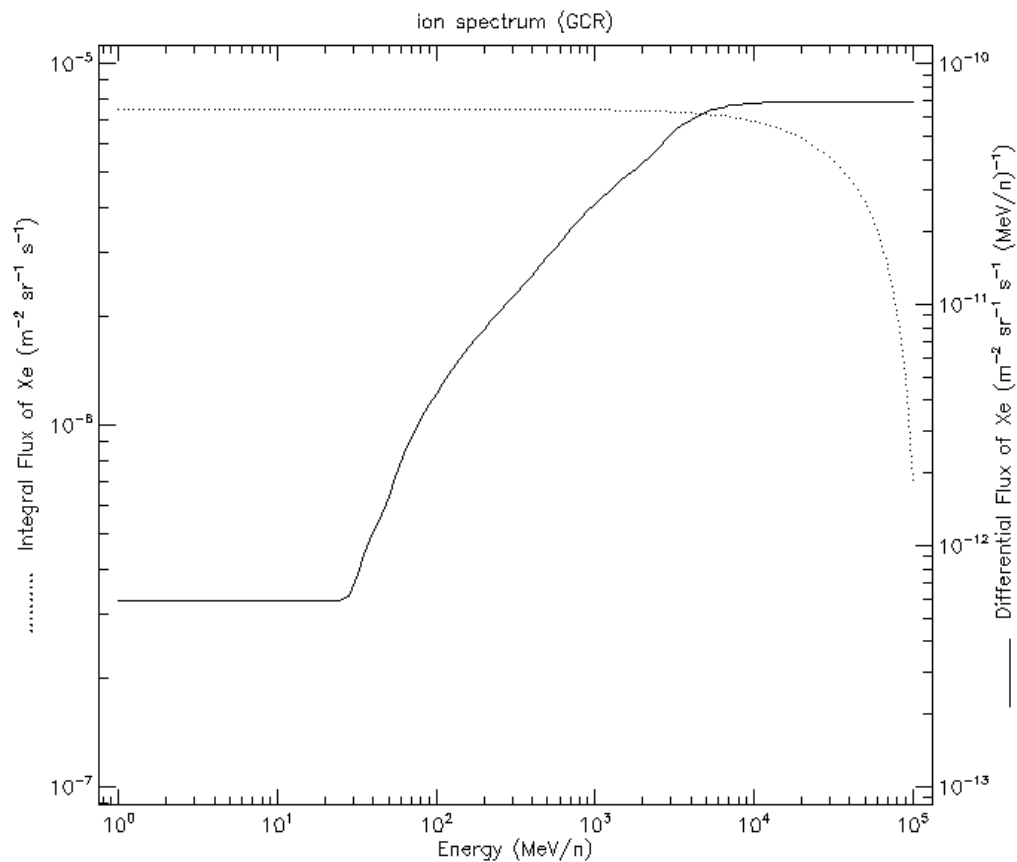
Run CREME-96

- Other options available (ISO 15390, CREME-86, Nymmik, ...)
- Why CREME-96?
 - Compatibility with SIRE-2, CREME-MC, ...
- Leave the Magnetic shielding as defaults

Ion range: H ▼ to U ▼
GCR model at 1 AU: CREME96 ▼
CREME-96 Sol. Min (1977)
Magnetic shielding: on (quiet magn.) edit

Explore the outputs

1. Generate a Heavy Ion spectra for Xe (Z=54) for this mission (flux vs. energy)
2. Generate a Heavy Ion spectra for protons (Z=1) for this mission (flux vs. energy)



Next steps ... on your own

- As of now we've generated charged particle environments for a notional mid latitude Starlink-like mission –
 - Trapped protons
 - SEP protons and ions
 - GCR protons and ions
- Repeat this process for a notional high latitude Starlink-like mission (see right)
 - Generate the same outputs and save so we can compare

Segment title:
Starlink High Latitude

Orbit type: general

Orbit start: calendar date

01 Jan 2026 00 : 00 : 00

Representative trajectory duration [days]: 30

Altitude specification: perigee and apogee altitudes

Perigee altitude [km]: 530

Apogee altitude [km]: 530

Inclination [deg]: 97.6

R. asc. of asc. node [deg w.r.t. gamma50]: 0

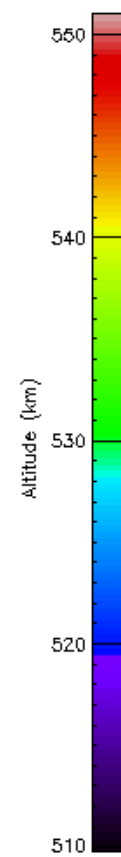
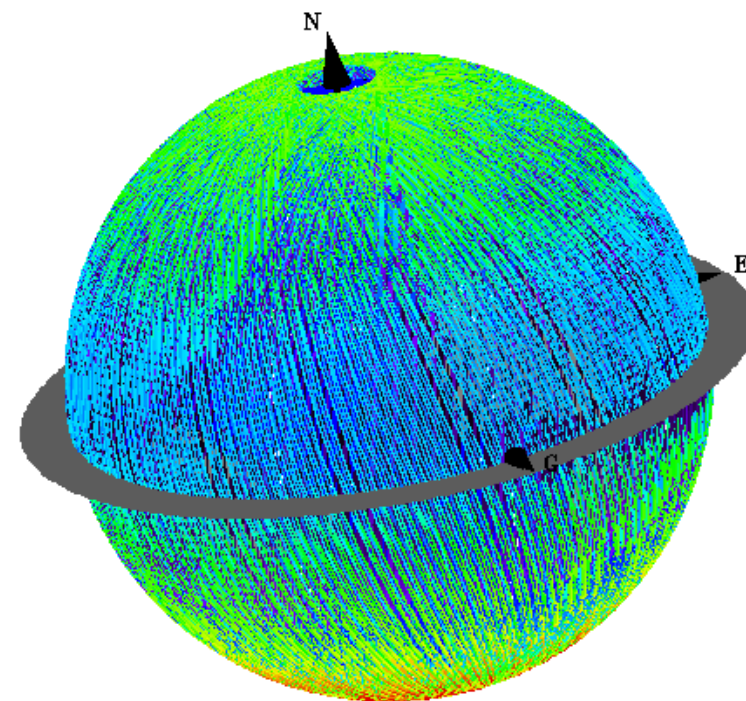
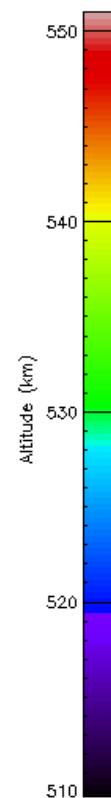
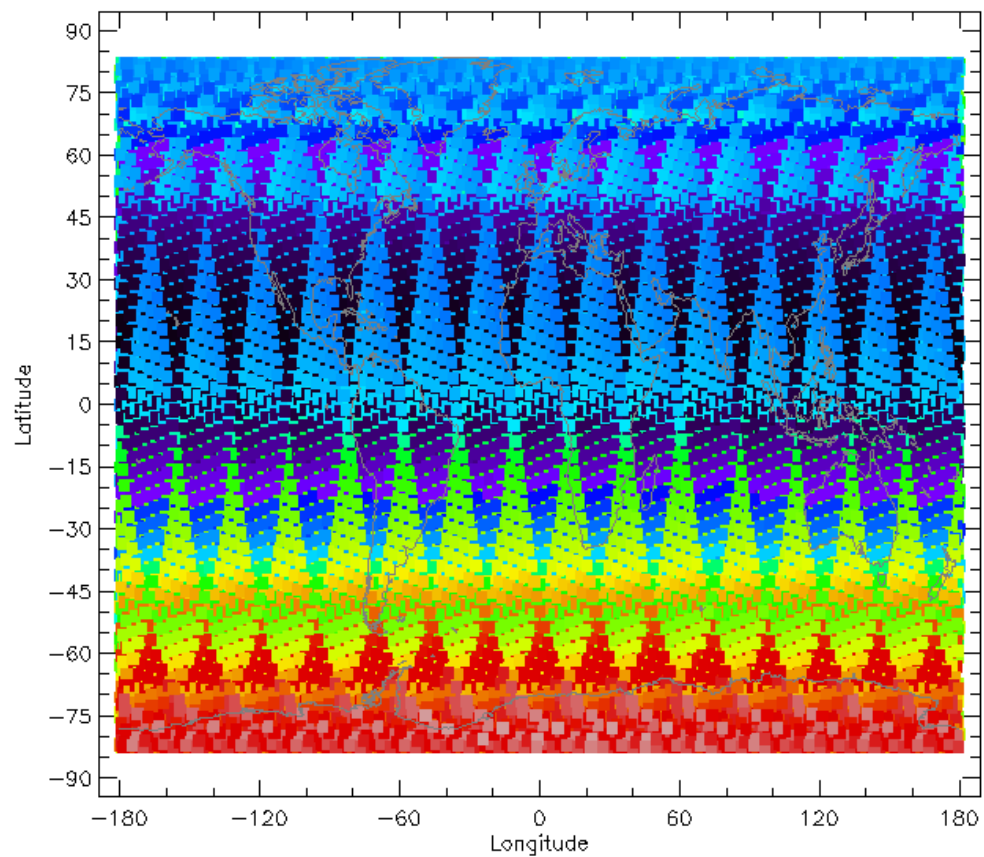
Argument of perigee [deg]: 0

True anomaly [deg]: 0

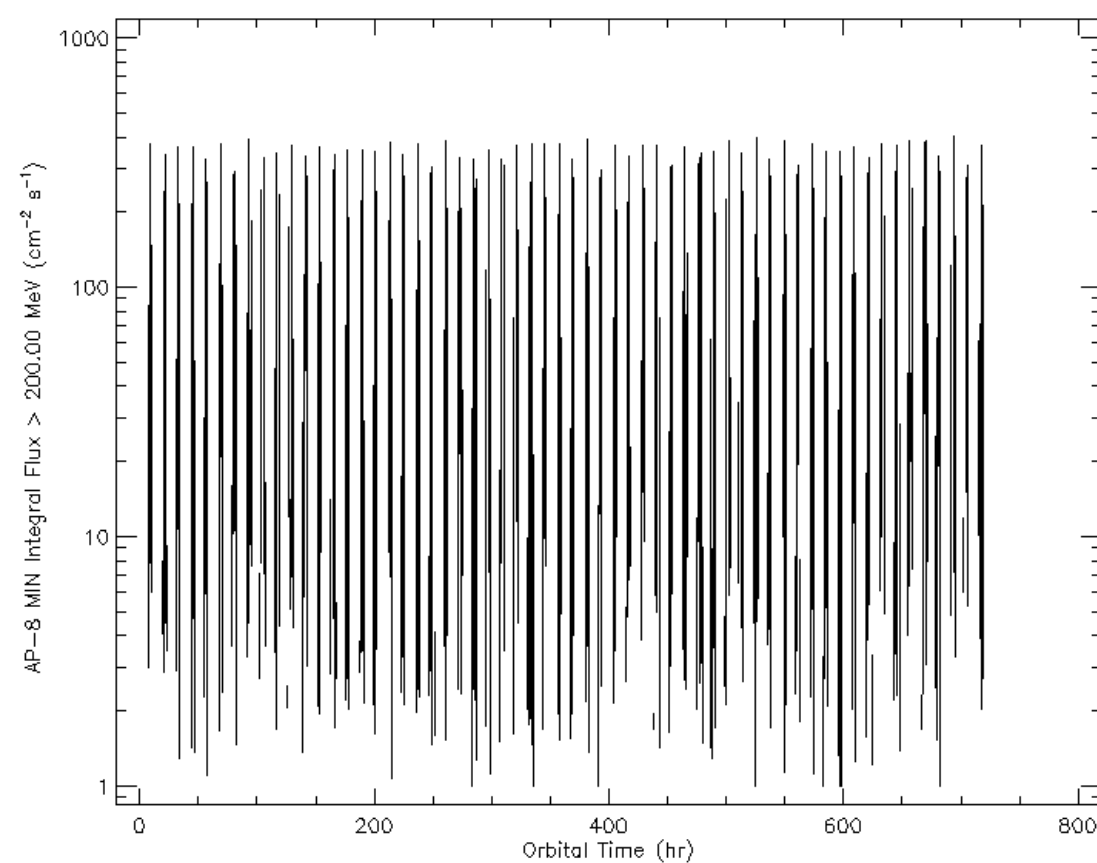
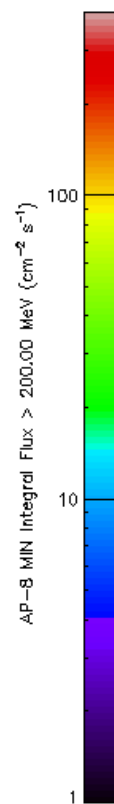
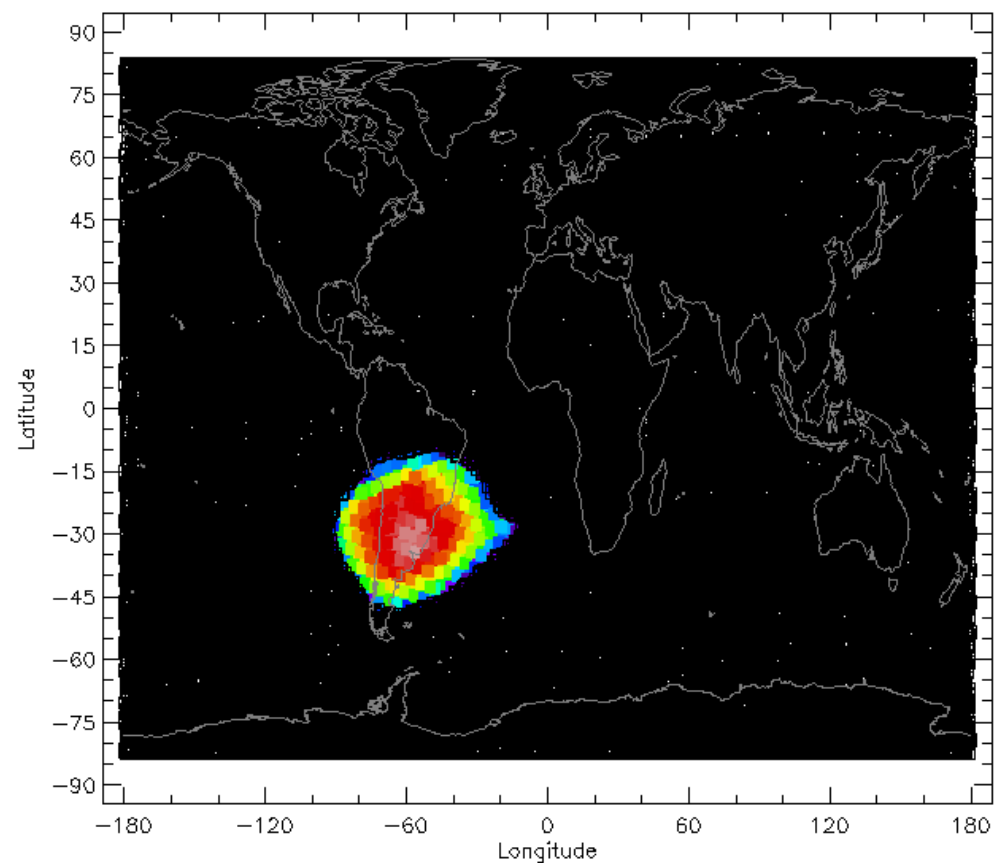
Output resolution

1.	60.0	s below	20000.0	km
2.	240.0	s below	80000.0	km
3.	3600.0	s elsewhere		

Trajectory

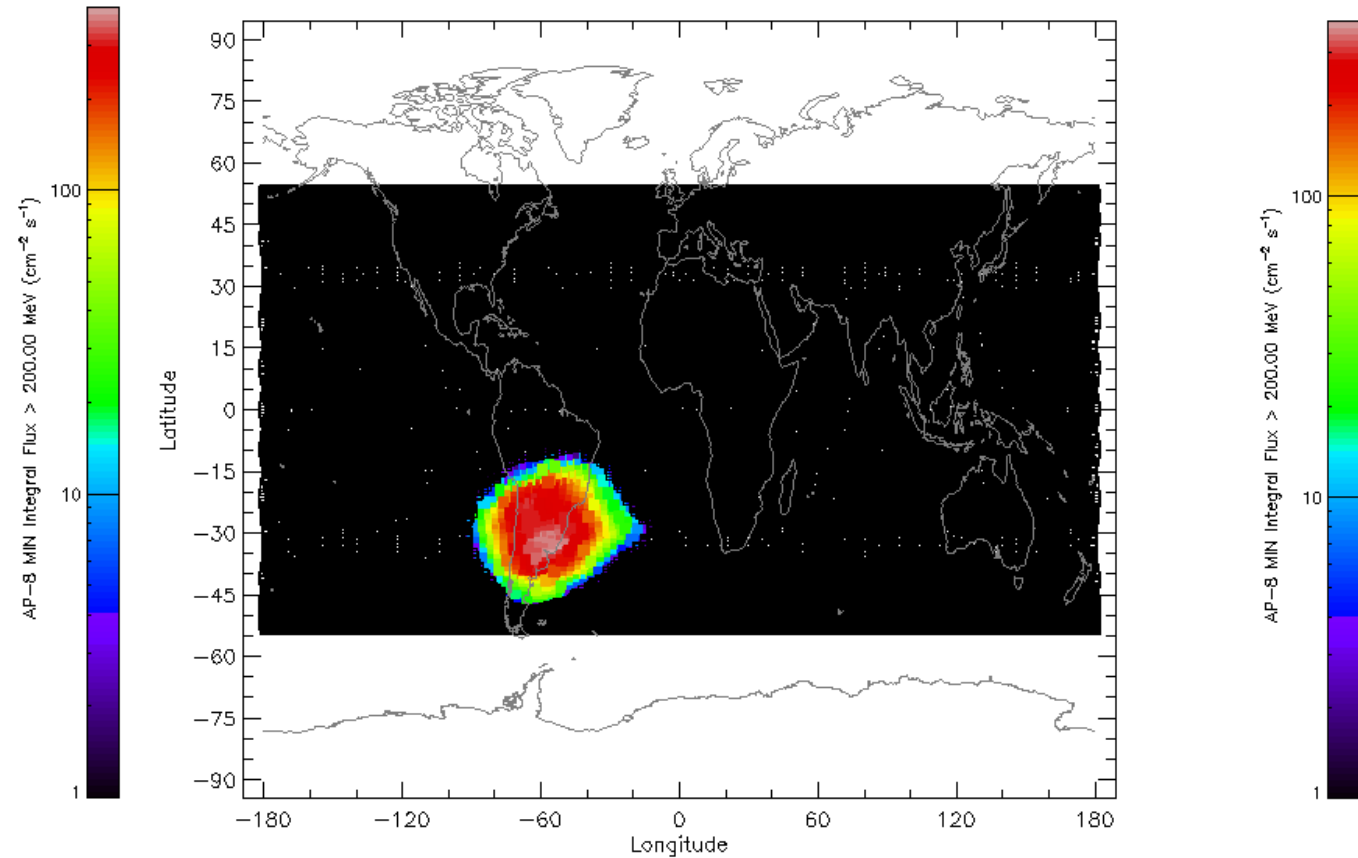
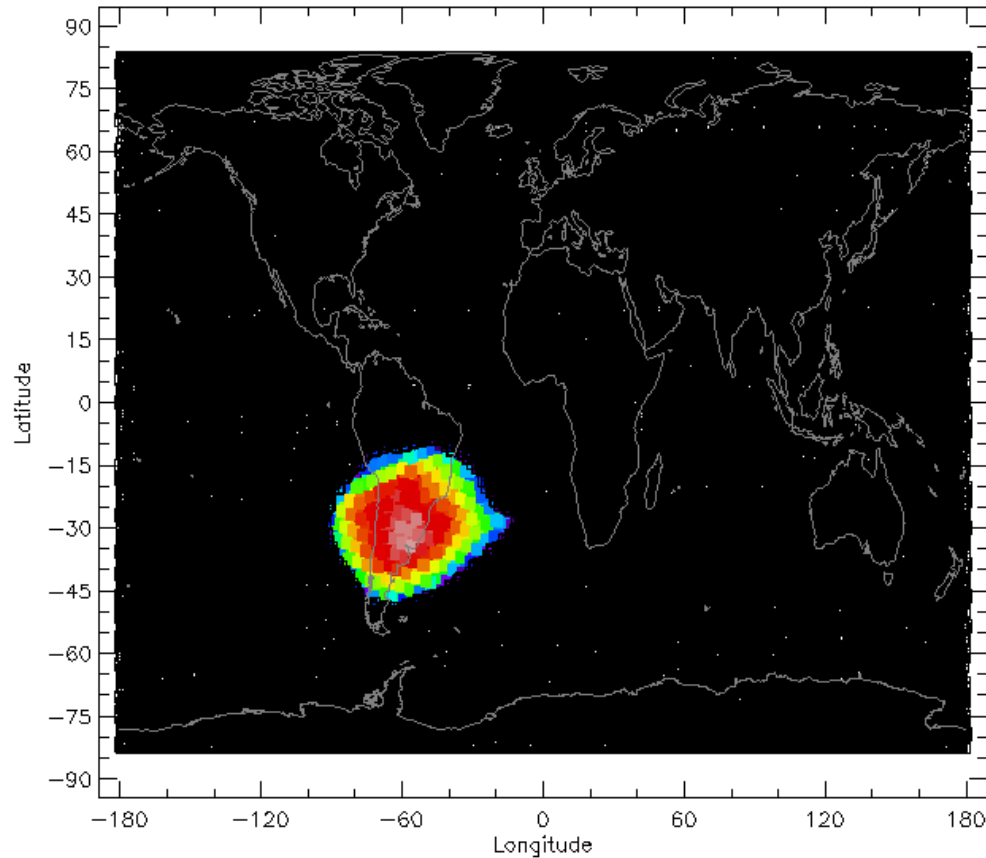


Trapped protons



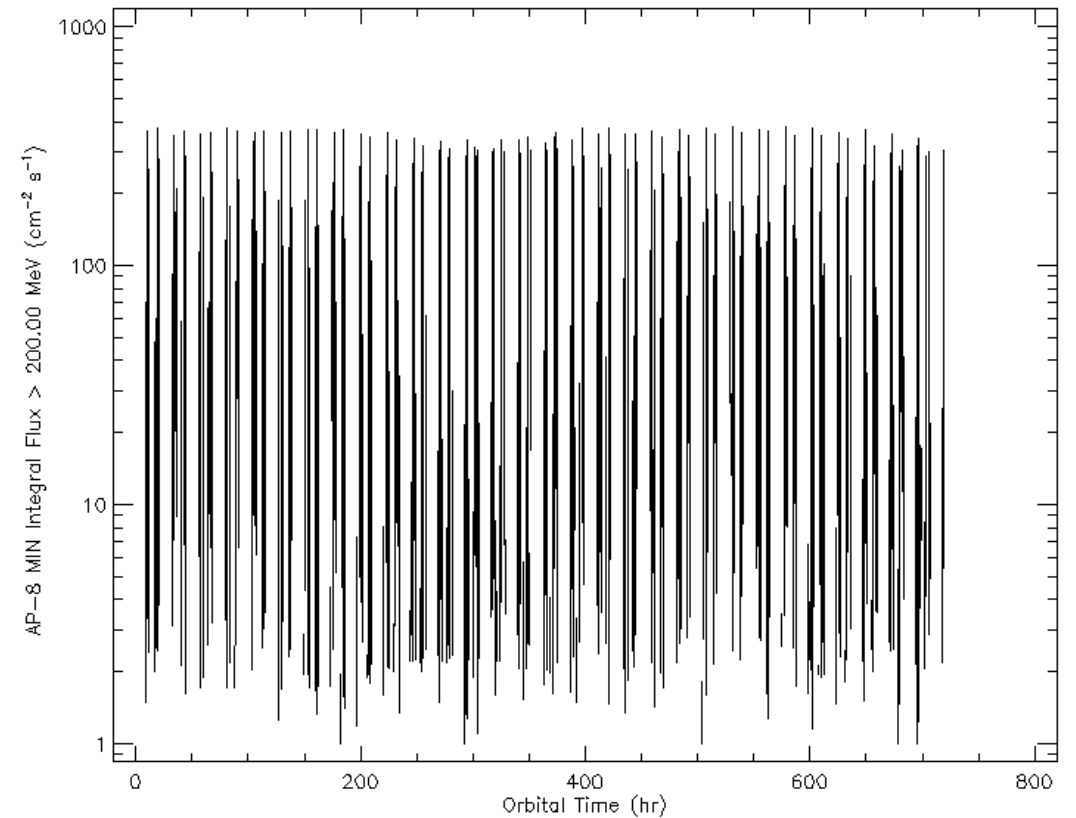
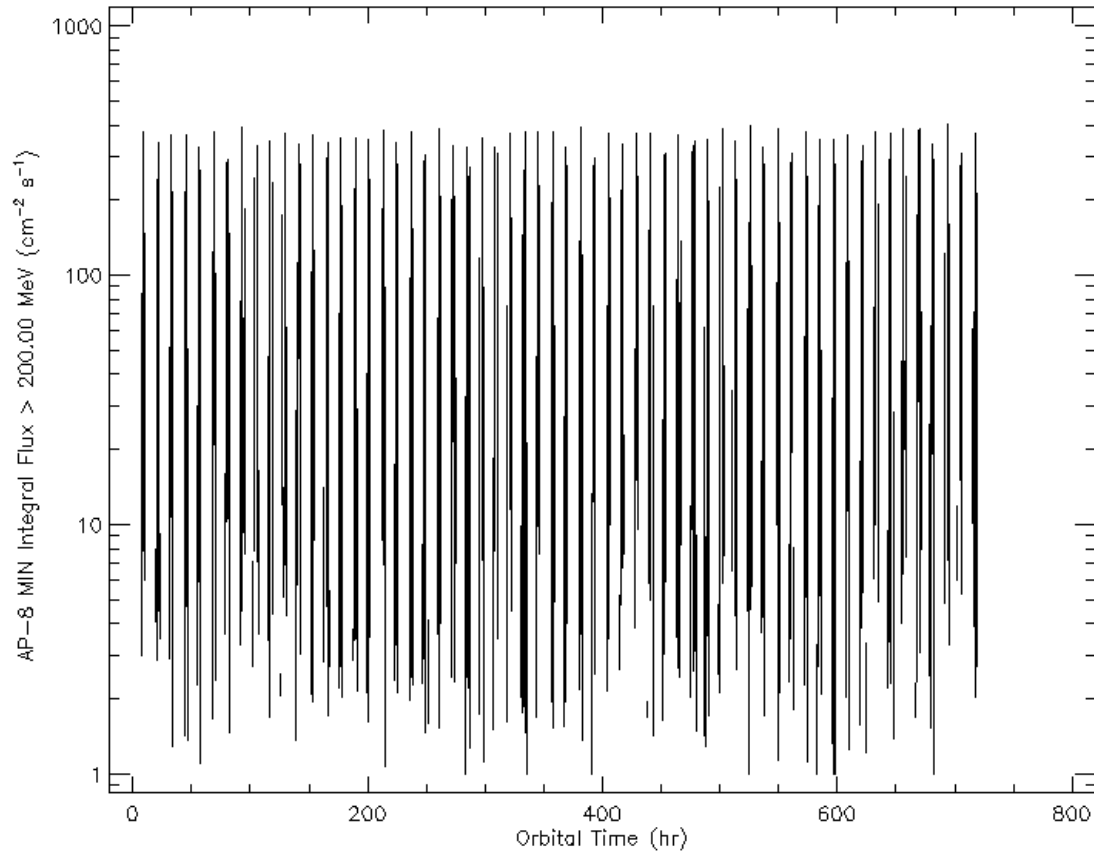
Comparisons (Trapped Protons)

- Make some observations about –
 - Mission / orbit average >200 MeV protons
 - Peak >200 MeV protons

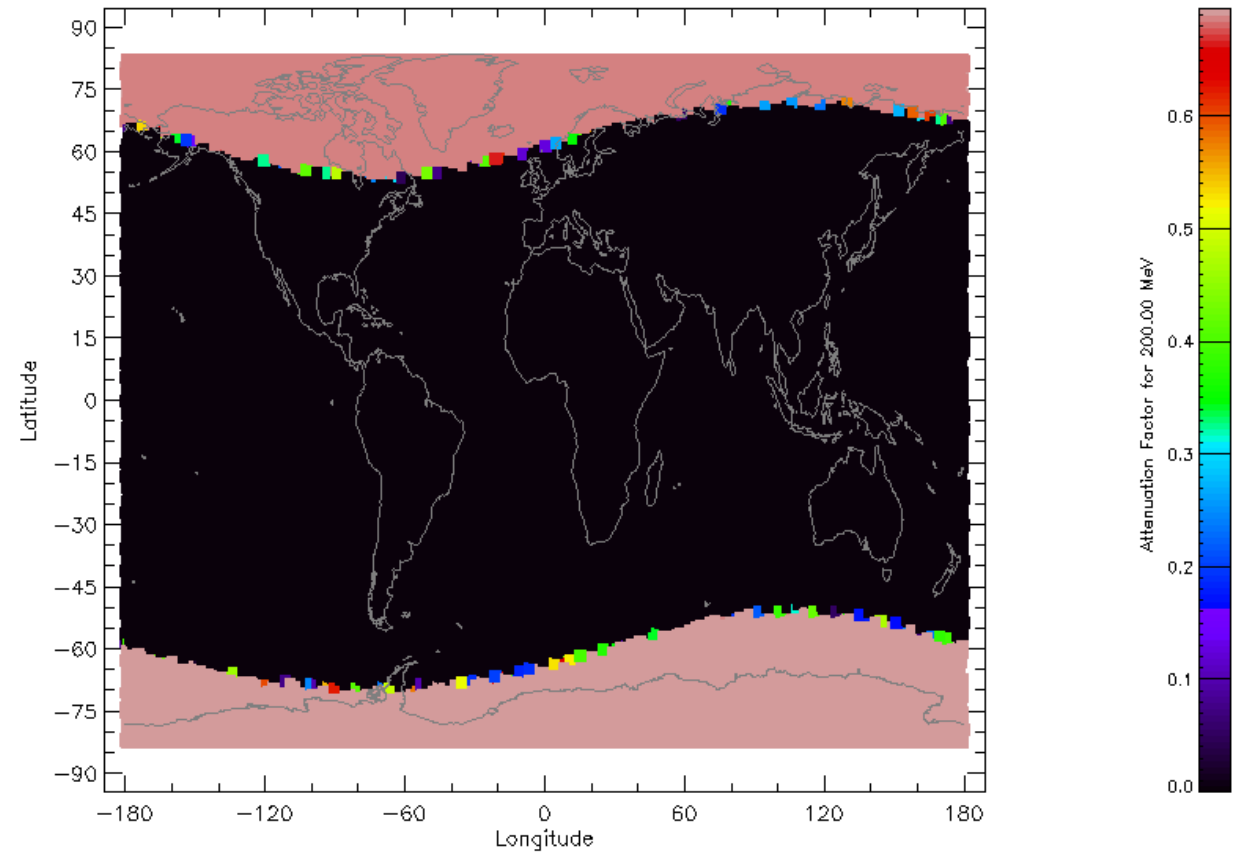
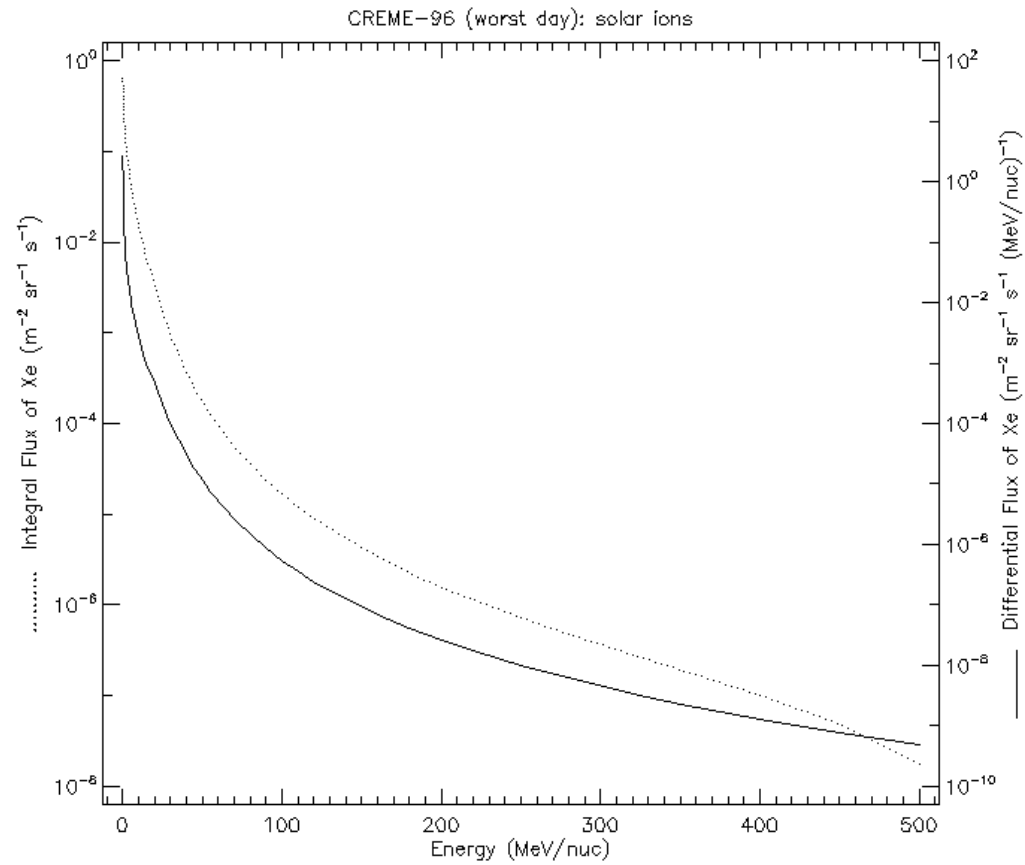


Comparisons (Trapped Protons)

- Make some observations about –
 - Mission / orbit average >200 MeV protons
 - Peak >200 MeV protons

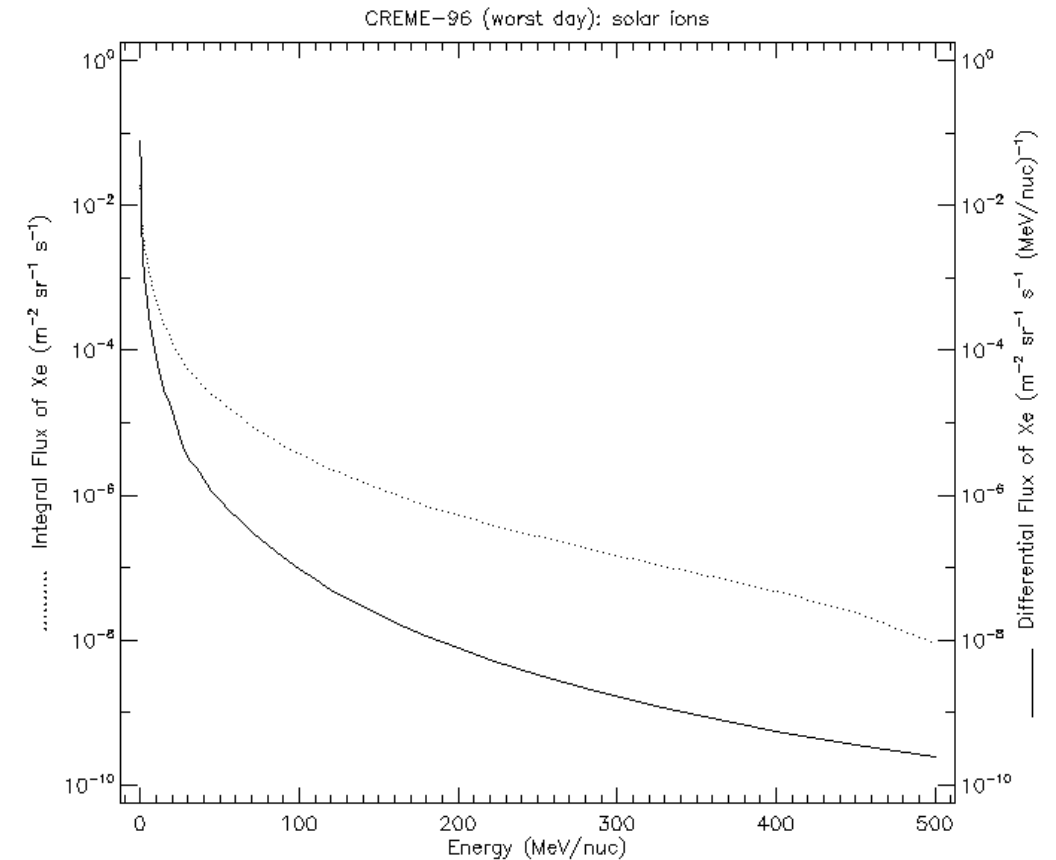
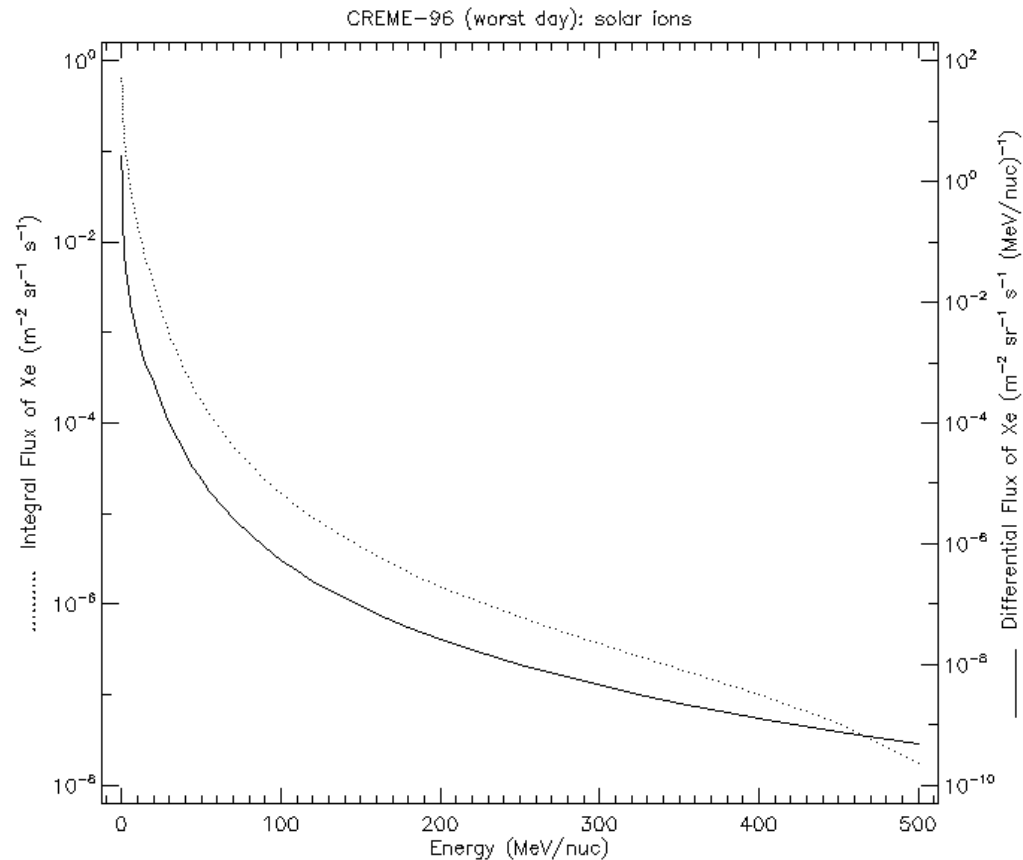


Worst Day



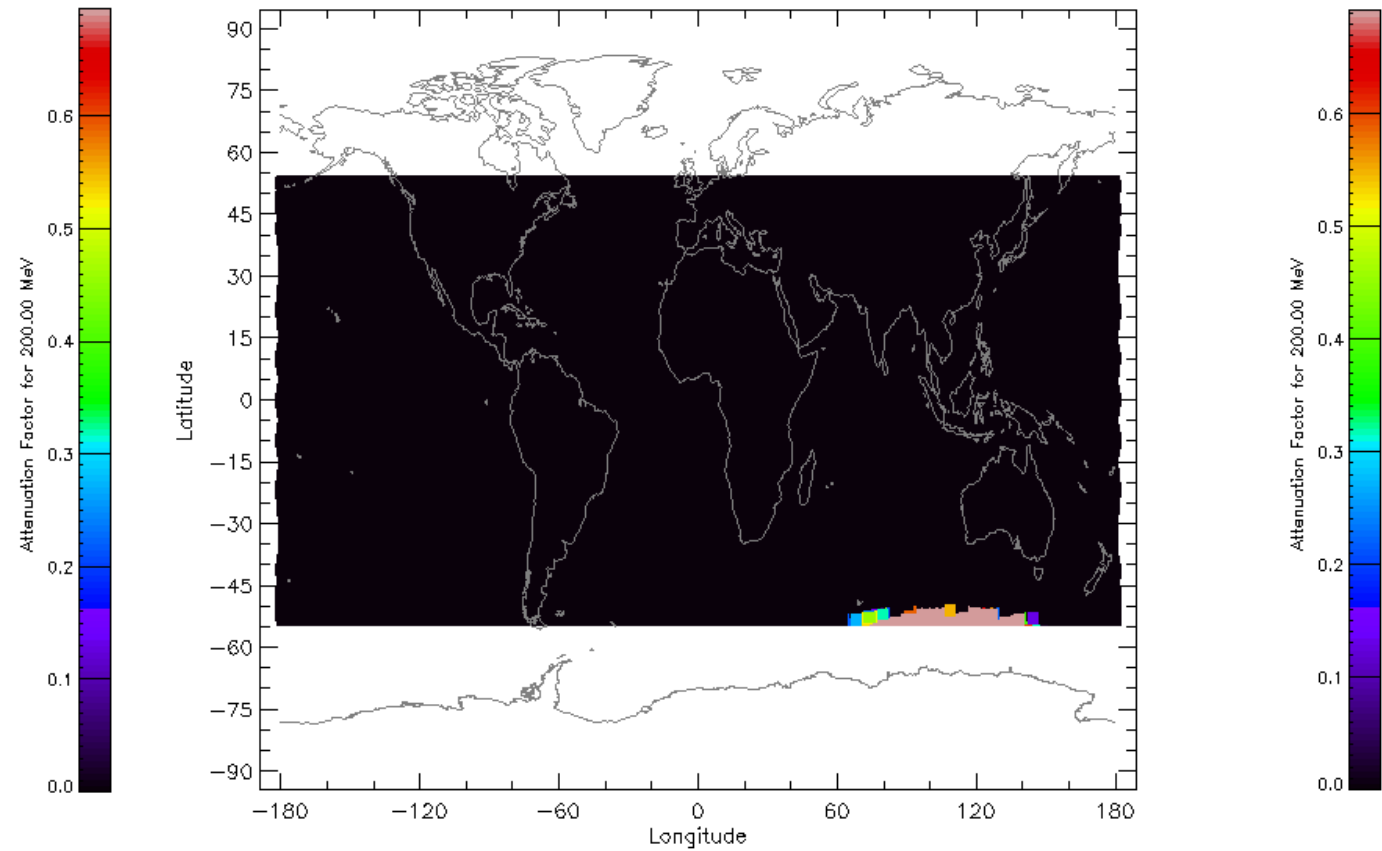
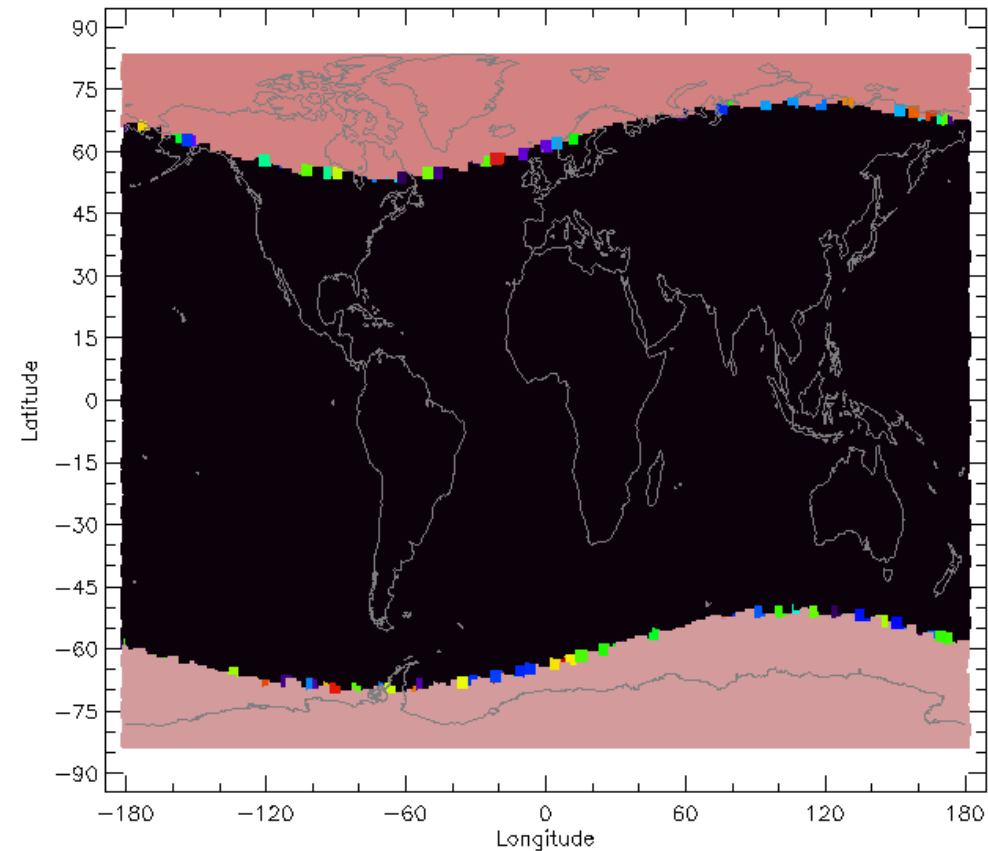
Comparisons (Worst Day)

- Make some observations about –
 - Fluxes and energies of Xe ions



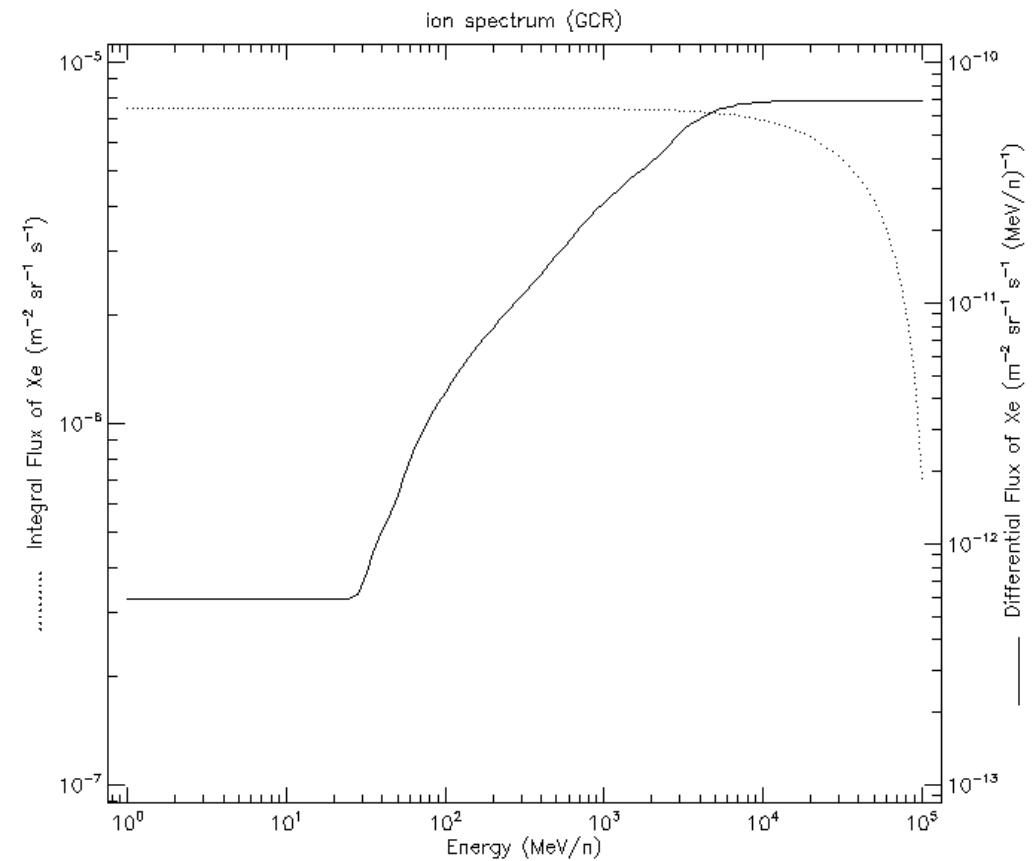
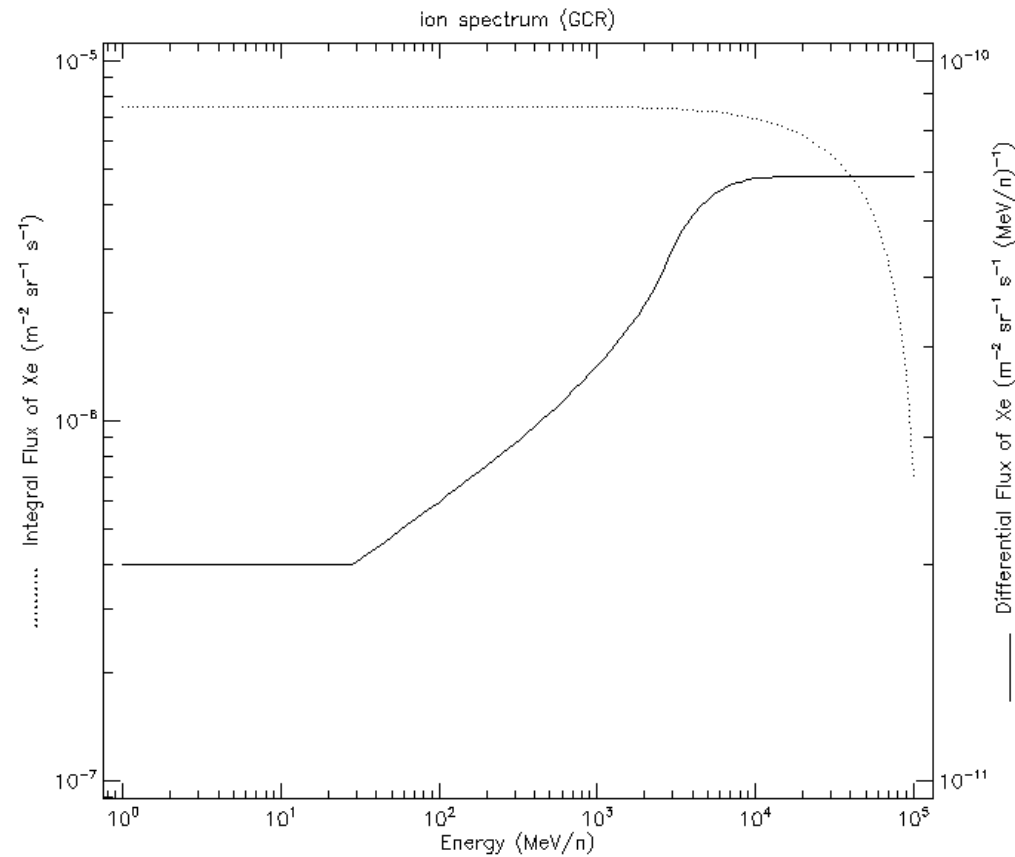
Comparisons (Worst Day)

- Make some observations about –
 - Access of >200 MeV protons
 - Is the mission susceptible in a WD environment?



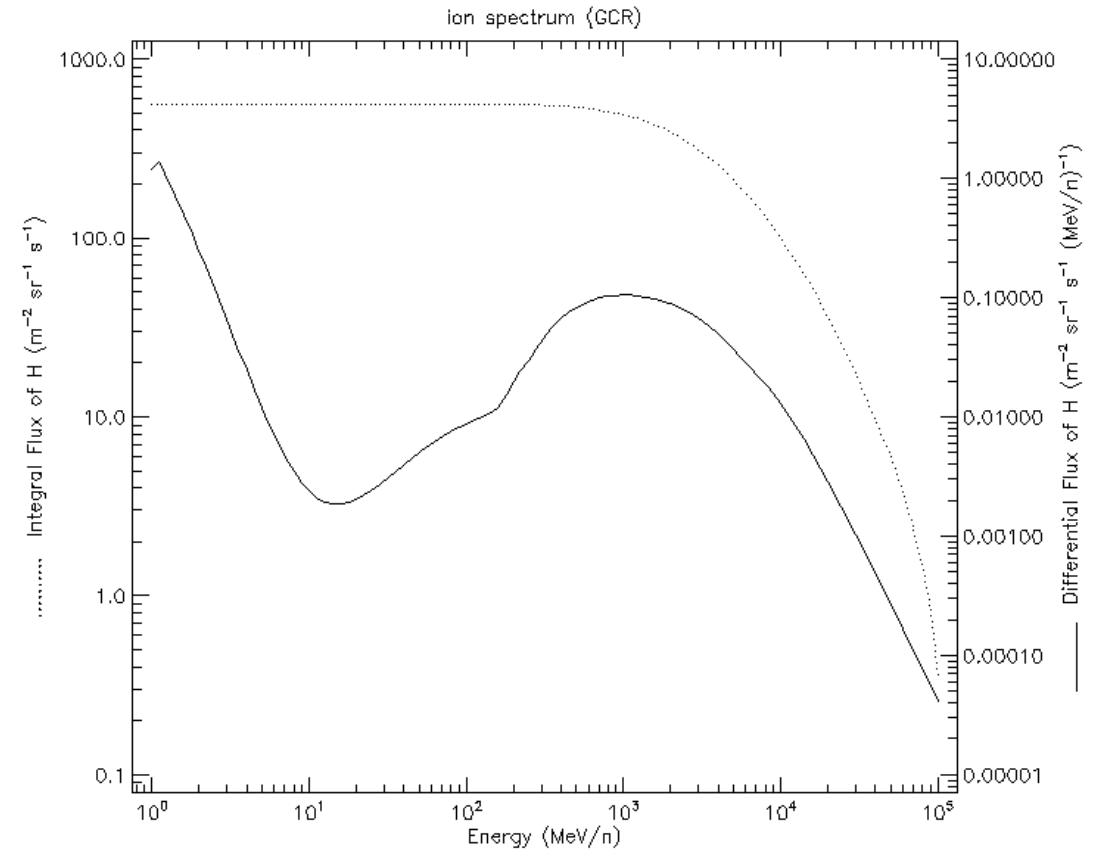
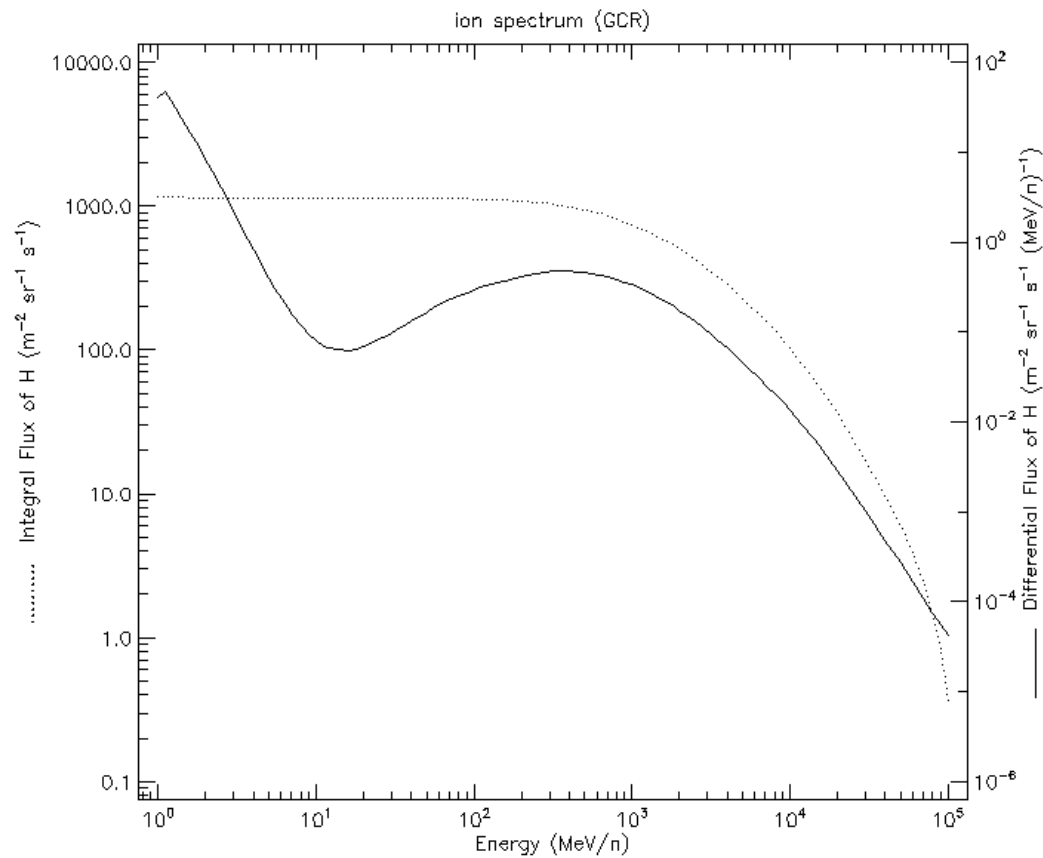
Comparisons (GCRs)

- Make some observations about –
 - Fluxes and energies of Xe ions



Comparisons (GCRs)

- Make some observations about –
 - Fluxes and energies of Xe ions



Discussion questions

- These are both LEO missions (same 530 km altitude)
 - But inclinations are quite different
- What are the major differences in –
 - SAA passage(s)?
 - Orbit averaged trapped protons?
 - Accessibility of SEP protons / ions?
 - Accessibility of GCR protons / ions?
- How might these environments (and differences therein) drive SEE test planning?
 - For a Class A (exquisite) mission?
 - For a Class D (risky) mission?
- How are these differences likely to impact error rates?
 - For a RT / RH device with onset LET of $>30 \text{ MeV-cm}^2/\text{mg}$
 - For a non-RT / RH device with onset LET $<1 \text{ MeV-cm}^2/\text{mg}$



JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Natural Space Environment

Mod01a Homework / Assignment

Justin J. Likar

The Johns Hopkins University Applied Physics Laboratory (JHU / APL)

240-592-1090 | 240-583-9375

justin.likar@jhuapl.edu | jlikar1@jhu.edu

Consider a different reference mission

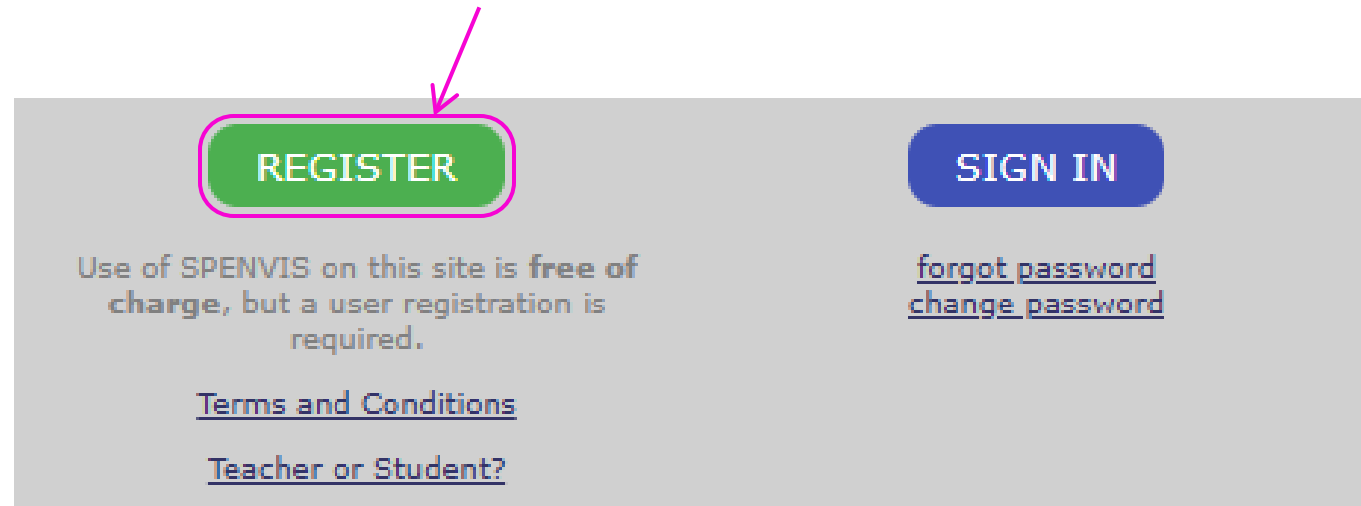
- Missions to GEO, L1 / L2, the lunar surface or cis-lunar space operate either entirely, or mostly, outside of the magnetosphere
- Use SPENVIS to define charged particle environments for such a mission (for ease of SPENVIS operations suggest GEO)
 - Trapped particles
 - Solar Energetic Particles
 - Galactic Cosmic Rays
- Compare / contrast with the reference missions we studied in class
- How might these environments (and differences therein) drive SEE test planning?
 - For a Class A (exquisite) mission?
 - For a Class D (risky) mission?
- How are these differences likely to impact error rates?
 - For a RT / RH device with onset LET of $>30 \text{ MeV-cm}^2/\text{mg}$
 - For a non-RT / RH device with onset LET $<1 \text{ MeV-cm}^2/\text{mg}$



JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Create an account

1. Navigate to <https://www.spenvis.oma.be/>
2. Click REGISTER



Create an account

1. Supply the requested registration information
2. Wait a few days



SPENVIS Registration

- The entries marked with * are mandatory.
- E-mail addresses should be linked to your affiliation, in particular hotmail, yahoo and similar accounts are not allowed.

Username*	<input type="text"/>
Email*	<input type="text"/>
Title*	--Select One-- ▼
First Name*	<input type="text"/>
Last Name*	<input type="text"/>
Phone Number	<input type="text"/>
Fax Number	<input type="text"/>
City*	<input type="text"/>
Affiliation*	<input type="text"/>
Affiliation Type*	--Select One-- ▼
Affiliation URL*	<input type="text"/>
Country*	--Select One-- ▼
Agreement*	<input type="checkbox"/> I have read and I fully accept the Terms and Conditions .

Next

Create an account

1. Once access is approved, sign in and navigate to your profile (icon below)

SPENVIS Project: A4RES
Project management

Output
Help

UP

Action: Edit settings

Project settings

Title	Module 1 demo
Abstract	No abstract.

Execute

© ESA

☆☆☆

User profile icon (circled in pink with two arrows pointing to it)

Other icons: Home, Settings, Help, etc.

Create an account

1. Set your Level to ADVANCED



My Account

- The entries marked with * are mandatory.

Username	likar
Email*	<input type="text" value="justin.likar@jhuapl.edu"/>
Password	<input type="password"/>
Verify Password	<input type="password"/>
Title*	<input type="text" value="Mr."/> ▼
First Name*	<input type="text" value="Justin"/>
Last Name*	<input type="text" value="Likar"/>
Phone Number	<input type="text" value="+00-1-267-664-0473"/>
Fax Number	<input type="text"/>
City*	<input type="text" value="Laurel, MD"/>
Affiliation*	<input type="text" value="Johns Hopkins APL"/>
Affiliation Type*	<input type="text" value="University/Institute"/> ▼
Affiliation URL*	<input type="text" value="https://www.jhuapl.edu/"/>
Country*	<input type="text" value="United States"/> ▼
Level*	<input type="text" value="Advanced"/> ▼

Update