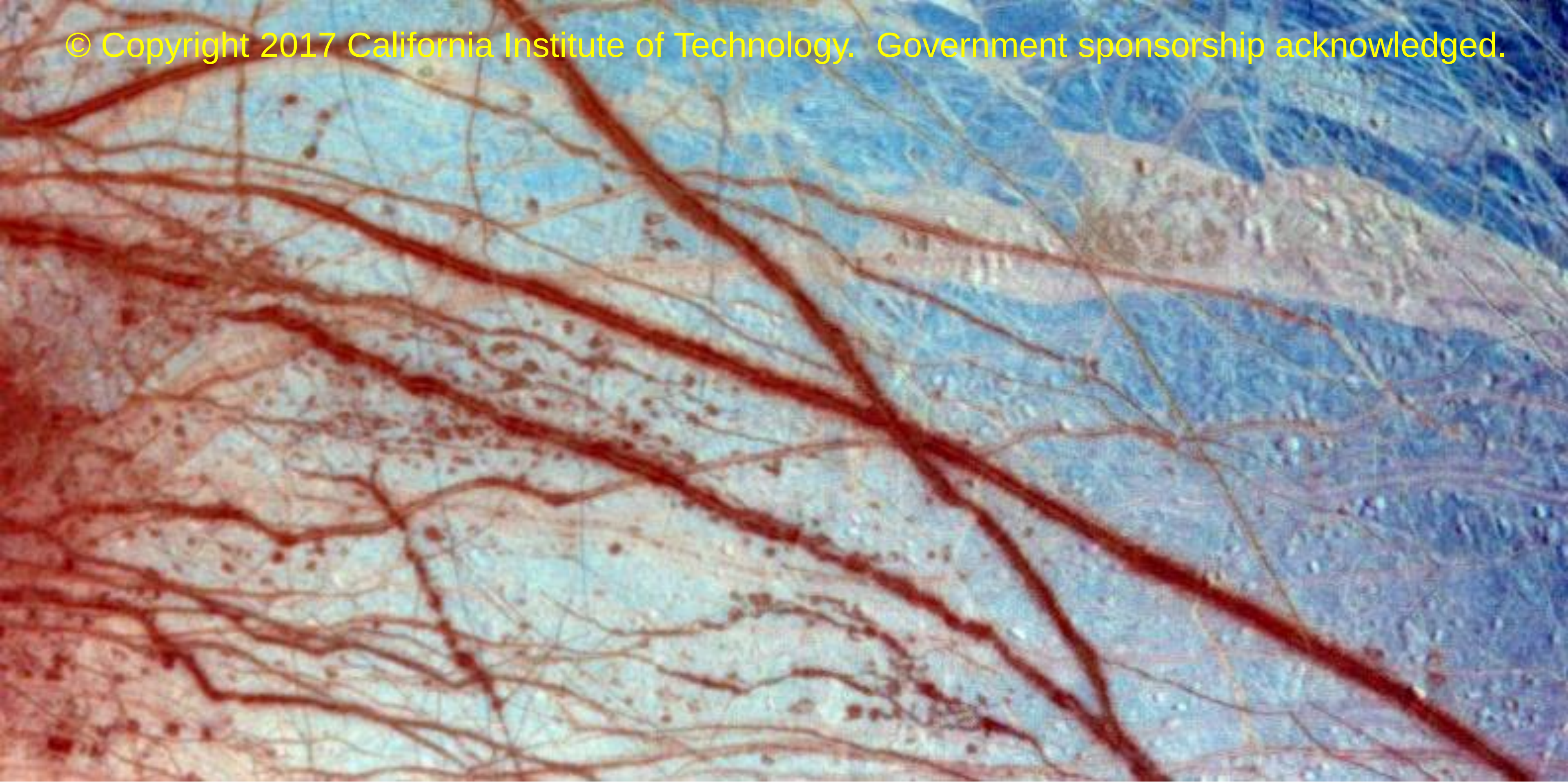

Europa Lander Mission Concept - Radiation Environment Definition and Initial Shielding Design

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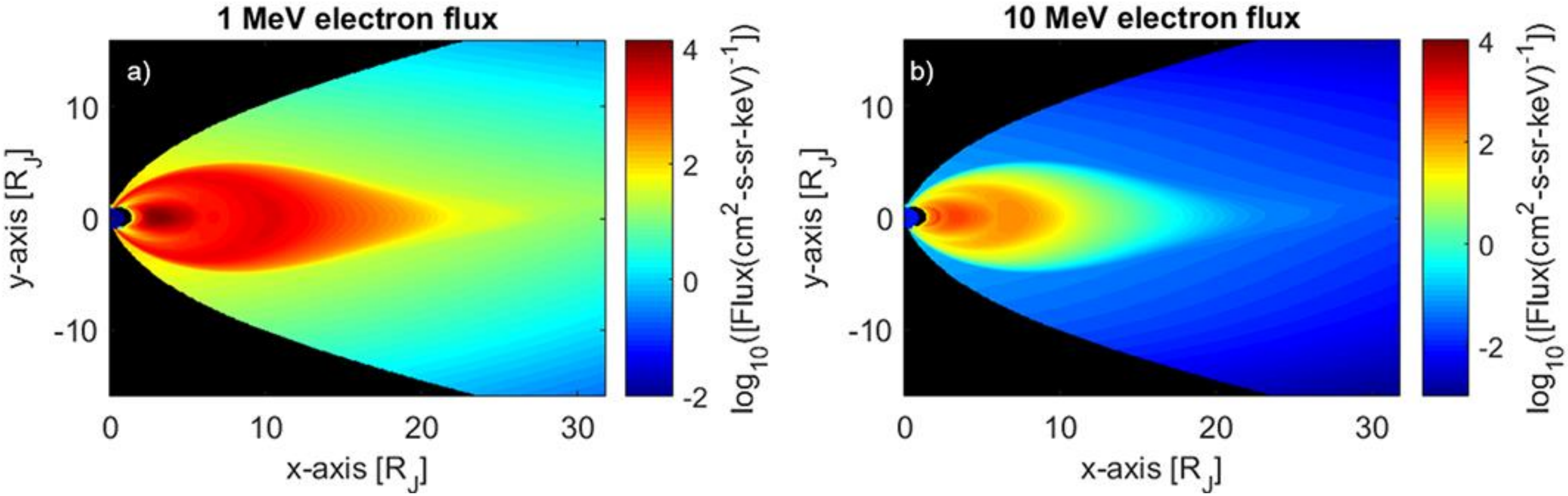
Introduction

- Radiation damage to electronic components presents a high risk for space missions.
- The energetic particles can cause damage to components, compromising their functionality.
- Missions flying in high radiation environments require substantial shielding to reduce the radiation to a tolerable level.
- Harsh radiation environment at Jupiter – Europa is located in the heart of the trapped particles

Electron Environment around Jupiter

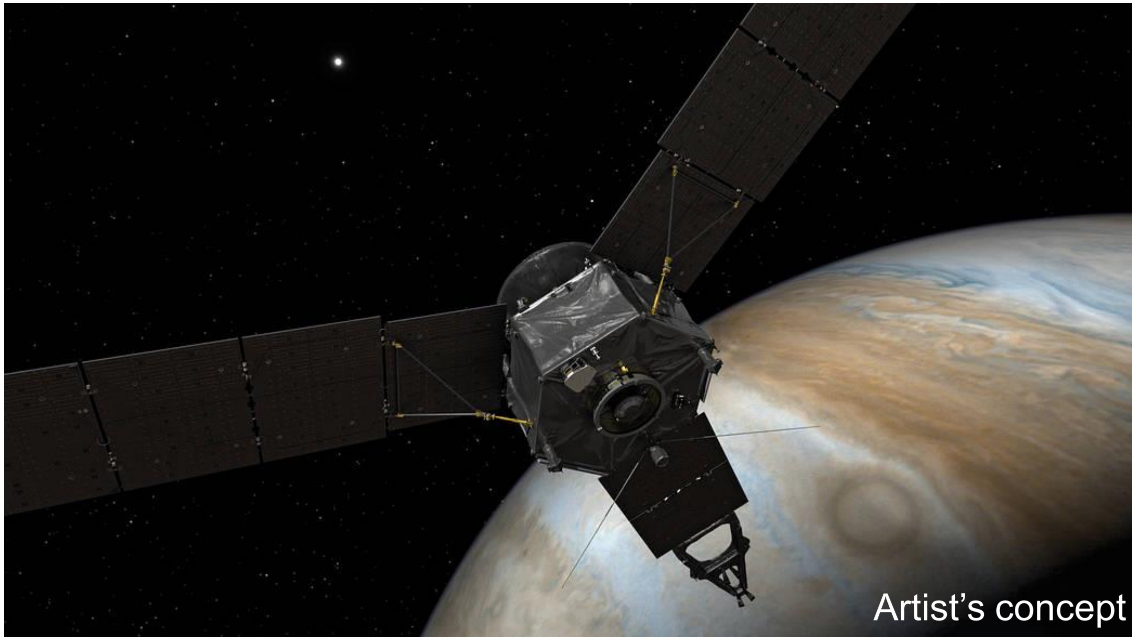
- Europa orbit ~9.5 Rj

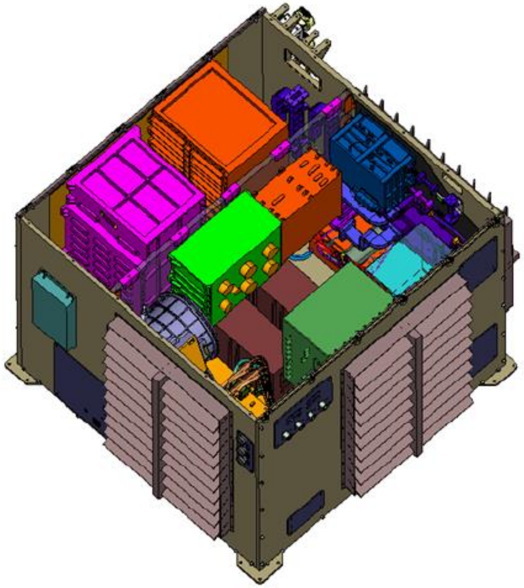


Example previous mission with radiation vault

Juno Spacecraft – Radiation Vault

- About 1 cm thick titanium (1 m x 1 m size)
- Mass of ~18 kg each panel (whole vault ~200 kg)

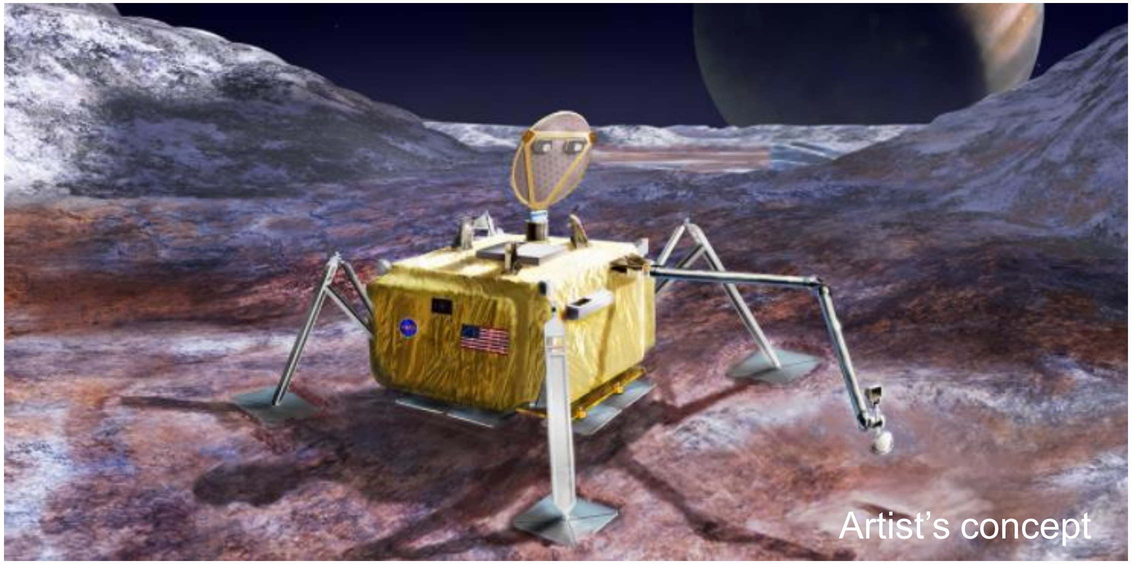




Europa Lander Mission Concept

Science Description

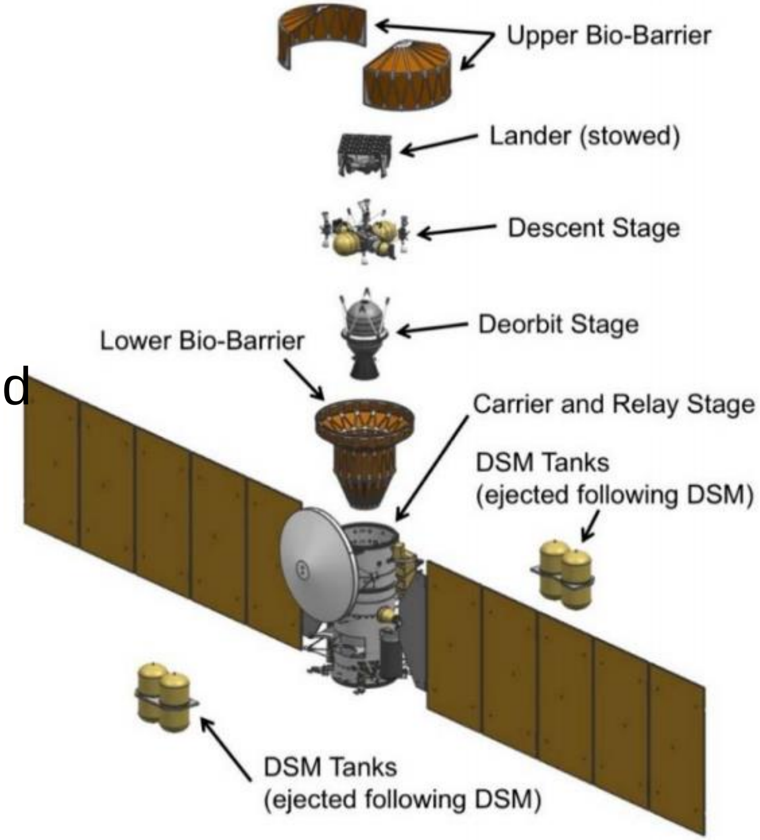
- To place a robotic prove on the surface of Europa
- Science Goals
  - Search for evidence of life in Europa
  - Assess the current habitability of Europa using in-situ techniques
  - Characterize surface and subsurface properties.



Europa Lander Mission Concept

Mission design and engineering

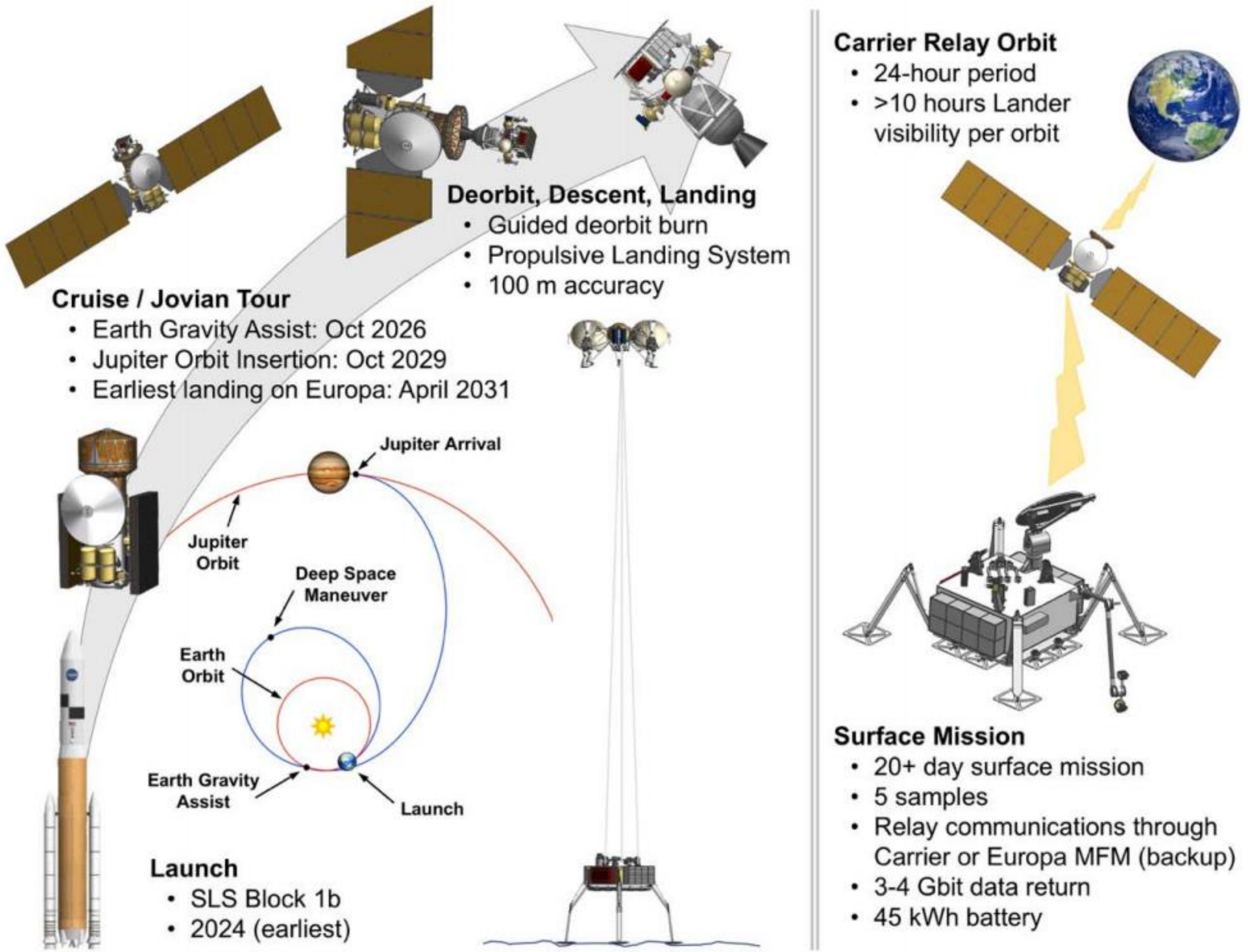
- Possible SLS launch ~2024 – 5 year cruise to Jupiter Orbit Insertion (JOI)
- 42.5 kg scientific instrument payload allocation
- Baseline surface lifetime of 20+ days
- Expected TID to 150 krad (Si). All electronics within the vault must be rated to 300 krad (radiation design factor of two,RDF = 2).



Artist's concept

Europa Lander Mission Concept

Cruise and stages of the mission profile

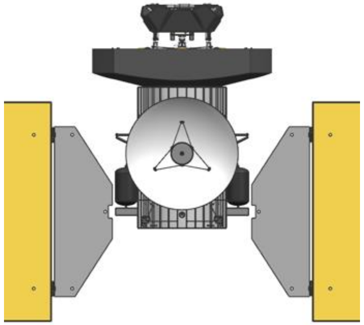


Artist's concept

Mission Concept segments studied

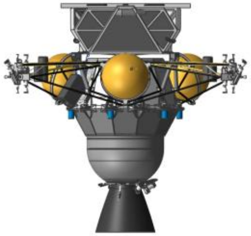
Post Jupiter Insertion

- The dose to a given piece of hardware is determined by summing the doses it sees during each mission segment in the hardware configuration in which it resides during that mission segment.



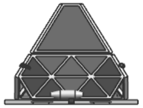
Cruise Vehicle at Jupiter, post-JOI (CVJ)

Dose from JOI to DOV separation.



Deorbit Vehicle (DOV) (aka, the Lander Stack)

Dose for 48 hrs prior to landing



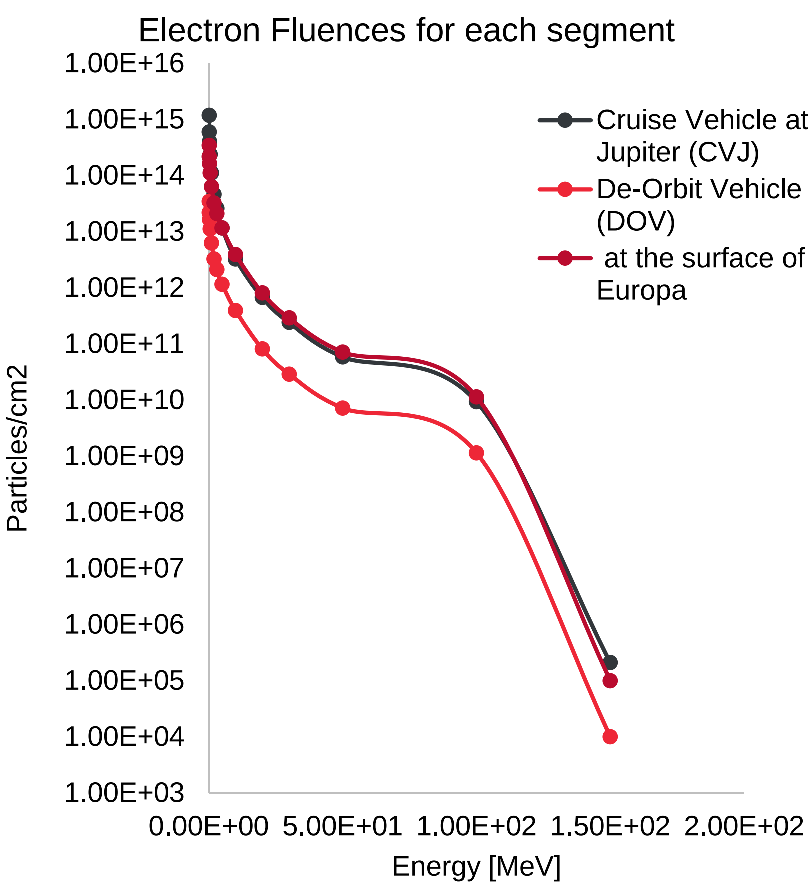
Lander

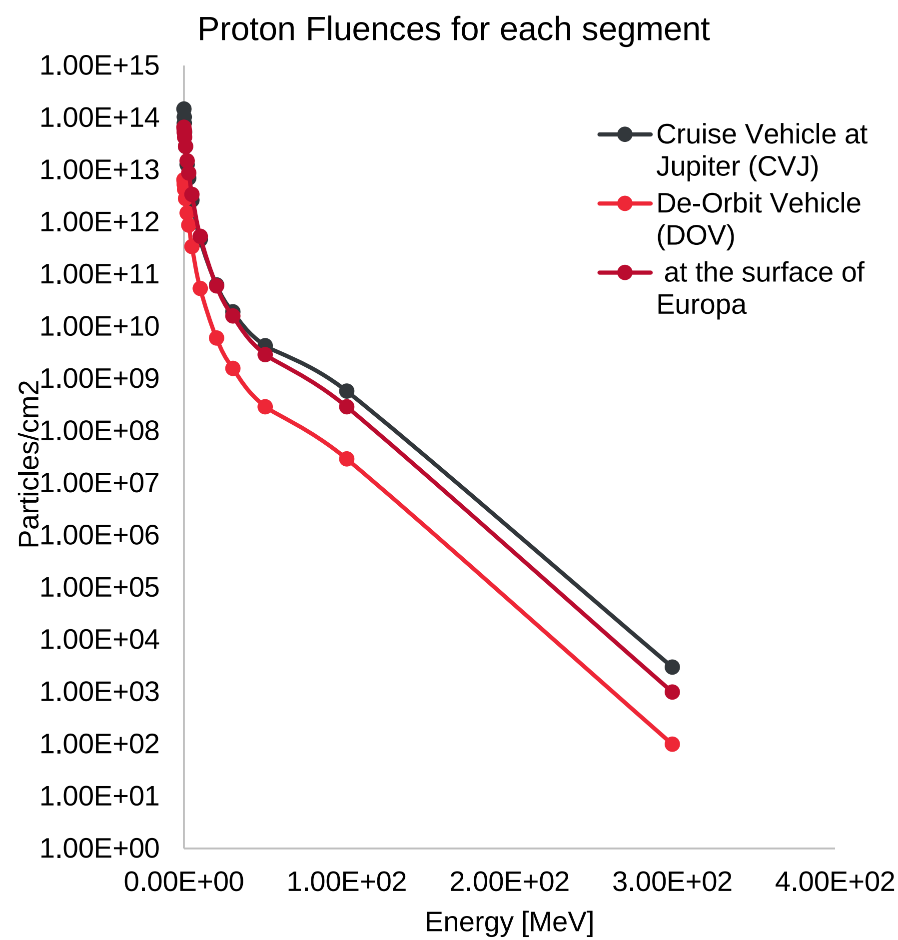
On the surface (modeled it on an ice sheet)

Artist's concept

Radiation Environments for each segment

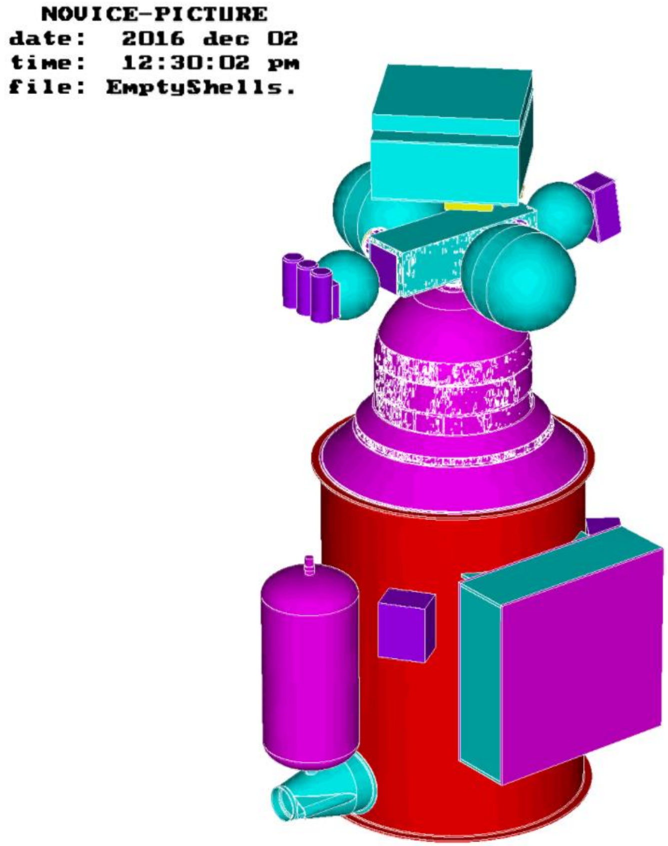
Using JPL model – GIRE2p



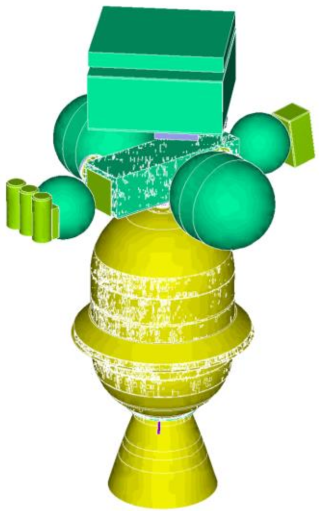


Models imported to Radiation analysis tool

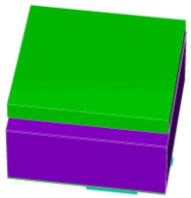
NOVICE Transport Code



Cruise Vehicle at Jupiter, post-JOI (CVJ)



Deorbit Vehicle (DOV) (aka, the Lander Stack)



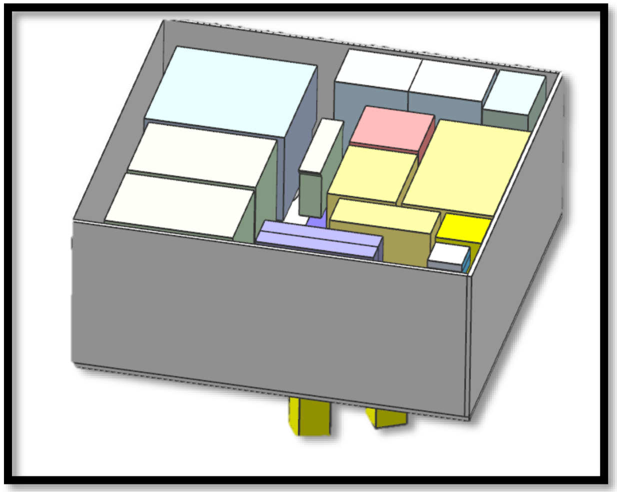
Lander

On the surface (modeled it with an ice sheet on “top”)

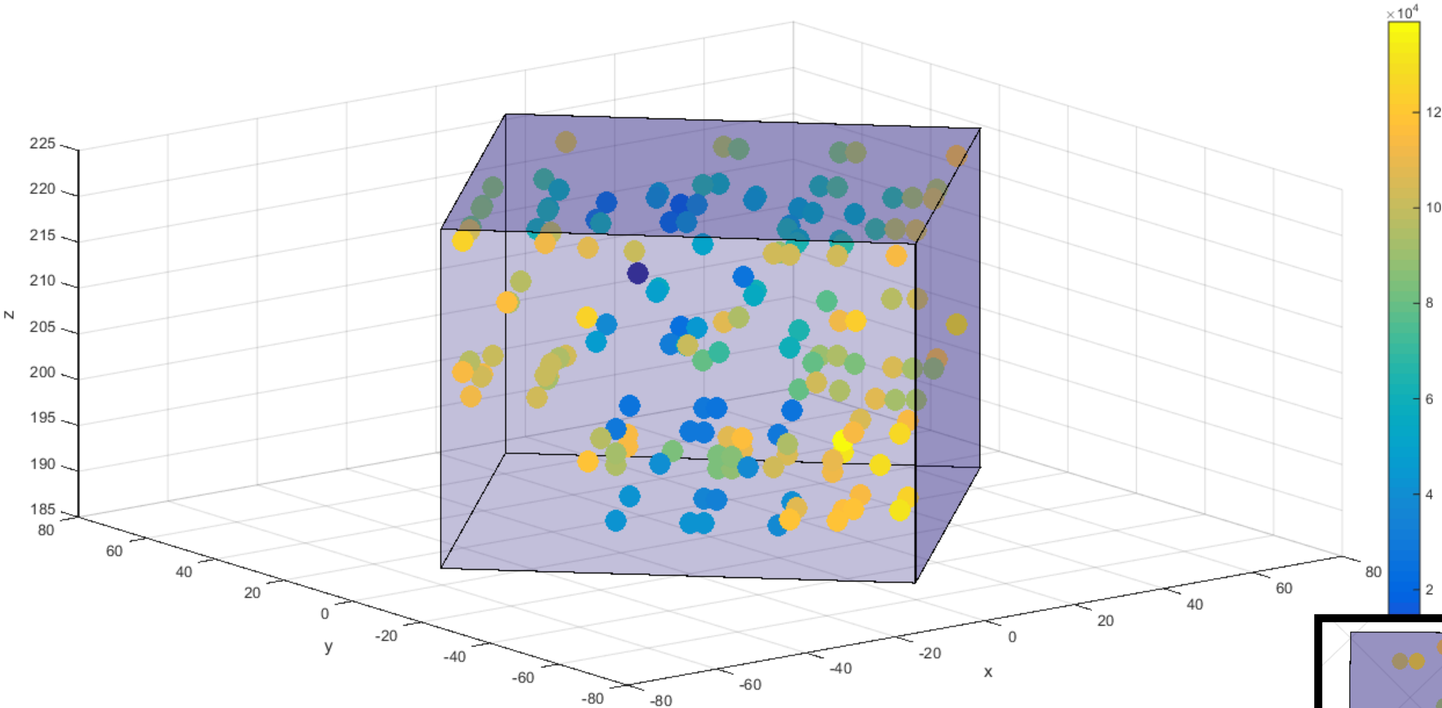
Total Ionizing dose (TID) simulations

methodology

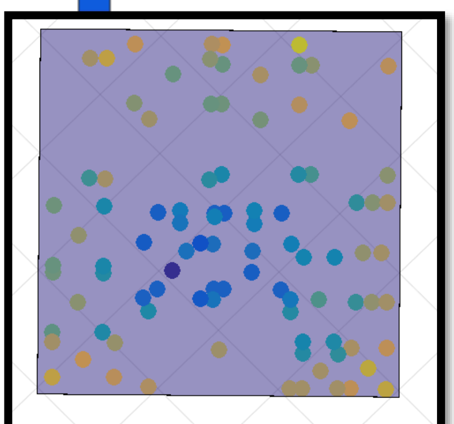
- Detector points were located inside the vault's electronic boxes. (8 corners and 1 center point)
- Bottom and side panels were modified (by mass equivalent method)
- Top panel unchanged, the thickness is not uniform.



3D view of the "detector points" inside electronic boxes



Top view of "iso-dose contours"

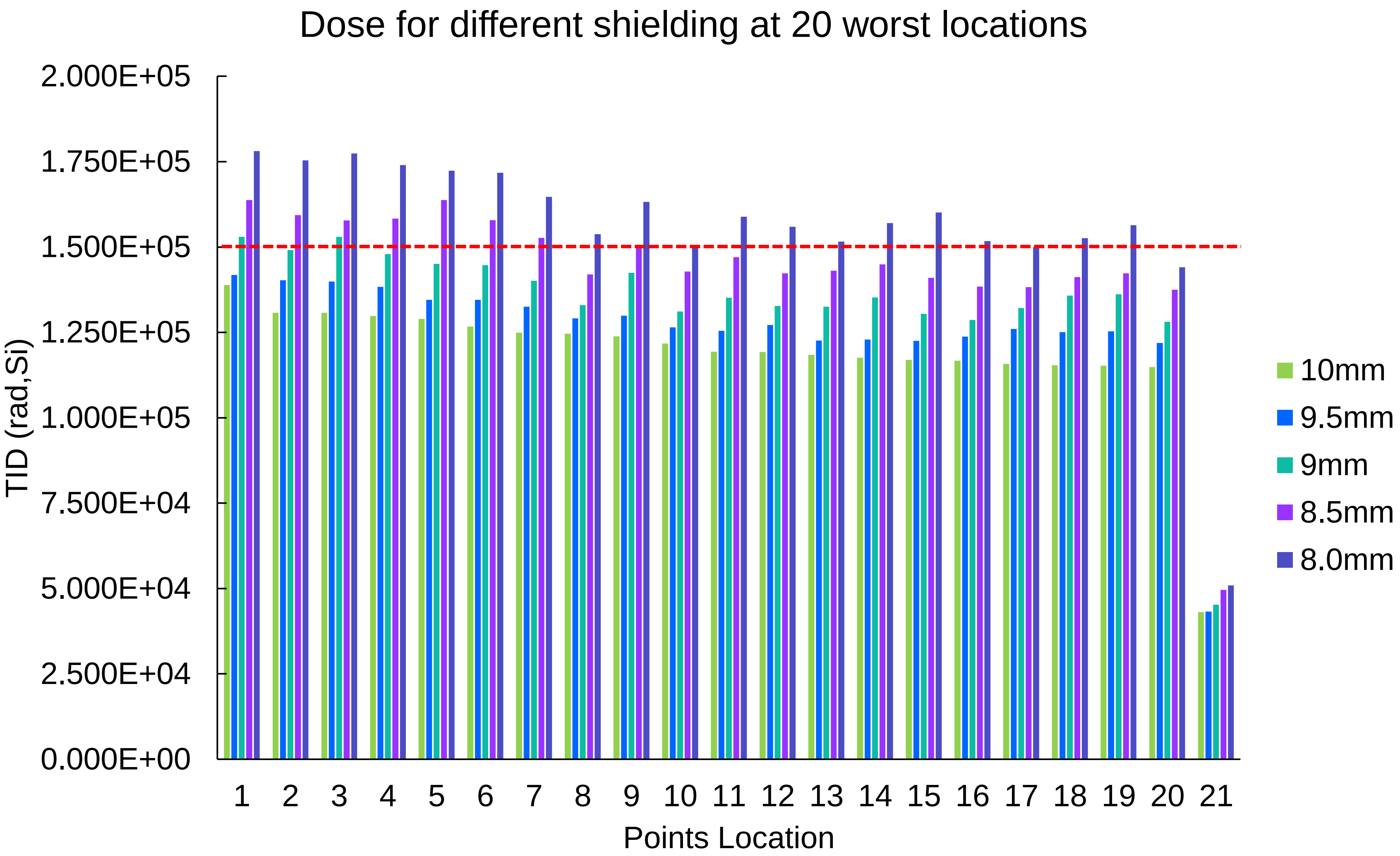


TID Summary table

For the 20 worst points and for the radio inside the vault

Location Name	Dose: 10 mm (rad, Si)	Dose: 9.5 mm (rad, Si)	Dose: 9 mm (rad, Si)	Dose: 8.5 mm (rad, Si)	Dose: 8 mm (rad, Si)
GAN SSPA1 C	1.39E+05	1.418E+05	1.53E+05	1.64E+05	1.78E+05
GAN SSPA1 C	1.31E+05	1.403E+05	1.49E+05	1.59E+05	1.75E+05
SAMPLECAM C	1.31E+05	1.399E+05	1.53E+05	1.58E+05	1.77E+05
SAMPLECAM CT	1.30E+05	1.383E+05	1.48E+05	1.58E+05	1.74E+05
COMPUTE1 C	1.29E+05	1.346E+05	1.45E+05	1.64E+05	1.72E+05
SAMPLECAM C	1.27E+05	1.345E+05	1.45E+05	1.58E+05	1.72E+05
SAMPLECAM C	1.25E+05	1.325E+05	1.40E+05	1.53E+05	1.65E+05
MTR CTRL C	1.25E+05	1.291E+05	1.33E+05	1.42E+05	1.54E+05
PYROPWR C	1.24E+05	1.299E+05	1.42E+05	1.50E+05	1.63E+05
COMPUTE1 C	1.22E+05	1.265E+05	1.31E+05	1.43E+05	1.50E+05
SAMPLECAM C	1.19E+05	1.255E+05	1.35E+05	1.47E+05	1.59E+05
RAMAN C	1.19E+05	1.272E+05	1.33E+05	1.42E+05	1.56E+05
RAMAN C	1.18E+05	1.226E+05	1.32E+05	1.43E+05	1.52E+05
PLD GCMS C	1.18E+05	1.229E+05	1.35E+05	1.45E+05	1.57E+05
RAMAN C	1.17E+05	1.226E+05	1.30E+05	1.41E+05	1.60E+05
GAN SSPA1 C	1.17E+05	1.238E+05	1.29E+05	1.38E+05	1.52E+05
MTR CTRL CTR	1.16E+05	1.260E+05	1.32E+05	1.38E+05	1.50E+05
SAMPLECAM C	1.15E+05	1.251E+05	1.36E+05	1.41E+05	1.53E+05
GEOPHONE C	1.15E+05	1.254E+05	1.36E+05	1.42E+05	1.56E+05
COMPUTE1 CTR	1.15E+05	1.219E+05	1.28E+05	1.37E+05	1.44E+05
FRADIO2 C	4.31E+04	4.322E+04	4.53E+04	4.96E+04	5.09E+04

Summary of worst points TID



Conclusions and Future work

- Dose estimates presented suggest that a wall thickness of ~8.5 mm is sufficient.
- Mass reduction of ~8 kg from the baseline mass estimate with 10 mm thick walls.

- Additional re-configuration is under process. Future shielding analyses are needed
- Spot shielding or modification can be made to specific electronic boxes if needed

Wall Thickness (mm)	Vault Walls Mass (kg)	# Boxes exceeding 150 krad
10.00	72.71	0
9.50	70.09	0
9.00	67.46	2
8.50	64.83	3
8.00	62.21	7

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