COLLEGE OF ENGINEERING

Nuclear Science and Engineering

Solar Particle Events

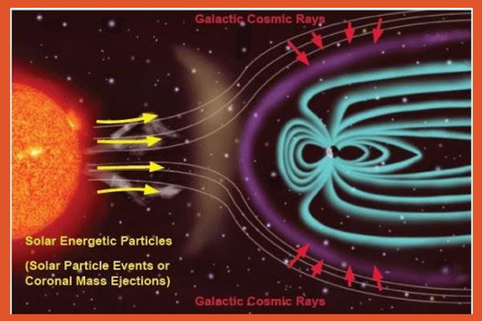
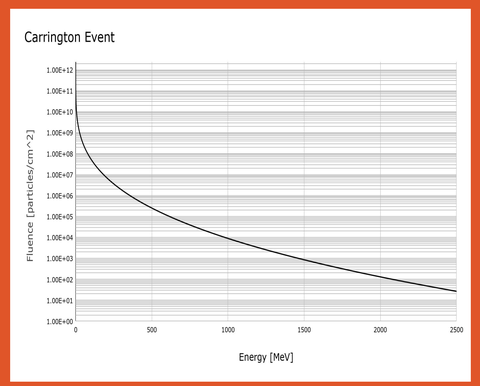


Image courtesy of NASA, hosted by https://www.curtisswrightds.com/content/images/sources-of-space-radiation.JPG

- Coronal Mass Ejections produce up to 10^{11} protons per cm^2 with energies ranging from .01 to 2500 MeV. This translates to .2 to 85% the speed of light.
- Energies above 30 MeV penetrate outer shielding.
- Can last several hours to up to 3 days
- Occur on a rough average of 7 events per year
- Carrington Event is the largest recorded Solar Particle Event



Oregon State University

Solar Particle Event Shielding

Team: Brockway Elmore II, Yusuf Alyaqoub, Michael Sussman, Tyler Law, Chase Griffin

Project Objective: Using only materials found on a modern variant of the Skylab Space Station during a mission to Mars, create a temporary shelter that will protect astronauts during a Solar Particle Event (SPE).

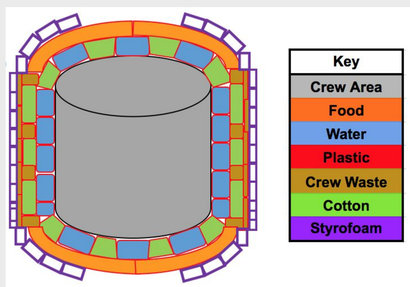
Project Motivation: Before utilizing our temporary shielding, astronauts on interplanetary missions could receive potentially fatal doses of radiation.

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.flickr.com%2Fphotos%2Fnasa2explore%2F10840900533&psig=AOvVaw2dp73hrLty1t808_Lrix_q&ust=1588709727900000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCOj9i4yDm-kCFQAAAAAdAAAAABAD

Shielding Description

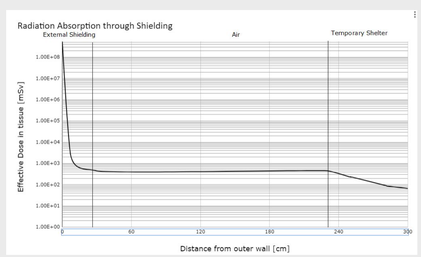
The design concepts are limited to available resources, such as food, water and waste.

The design is centered around the crew quarters as it will provide the most room for the astronauts if a SPE lasts for longer than a few hours.



Shielding Effectiveness

- Individual simulation data was compiled utilizing NASA code OLTARIS, for the expected materials found on board during interplanetary missions.
- Simulation data shows that astronauts could reduce their radiation doses to 13% compared to having no shielding except for the outer hull. (50 vs 450 mSv)



Acute and Chronic Radiation Effects

- Acute Radiation Syndrome (ARS) is when a body receives a high dose of radiation in a short period of time.
- Chronic Radiation Syndrome is when a body receives a continuous amount of radiation over a longer period of time. Effects may show up months to years after doses received.
- Astronauts will be in space for an extended period of time, causing them to receive higher amounts of radiation from space.
- Solar Particle Events have a chance of releasing high amounts of radiation particles that would cause harm to the astronauts during their mission.
- Chronic radiation exposure can lead to cancer, eye cataracts and skin burns.
- Human ability to react to space radiation varies which makes the effect that astronauts could face in during and after the mission to Mars uncertain.
- Studies show that there is a significant difference between radiosensitivity of female and male astronauts that must be taken into account.

Hellweg, C. E., & Baumstark-Khan, C. (2007). Getting ready for the manned mission to Mars: the astronauts' risk from space radiation. *Naturwissenschaften*, *94*(7), 517-526.

Tabulation of Documented Radiation Effects

Chronic dose[a]	***Observed Impact***
~0.1 Sv	First evidence of increased cancer risk as late effect from protracted radiation
2–4 Sv/year	Chronic radiation syndrome with complex clinical symptoms
Acute Single Dose[b]	***Observed Impact***
<0.2 Gy	No obvious direct clinical effects
~0.25 Gy	First evidence of increased cancer risk as late effect
>0.5 Gy	Nausea, vomiting
3–5 Gy	***Hematopoietic syndrome***: internal bleeding, fatigue, bacterial infections, and fever.
5–12 Gy	***Gastrointestinal syndrome***: nausea, vomiting, diarrhea, dehydration, electrolytic imbalance, loss of digestion ability, bleeding ulcers
>20 Gy	***Central nervous system syndrome***: loss of coordination, confusion, coma, convulsions, shock, and the symptoms of the blood forming organ and gastrointestinal tract syndromes
Acute Single Dose	***Observed Impact***
< 0.5 Gy	No early death anticipated
3–5 Gy	Death rate for this syndrome peaks at 30 days, but continues out to 60 days. Death occurs from sepsis; Roughly 50% of exposed population dies without medical intervention
5–12 Gy	Deaths from this syndrome occur between 3 and 10 days post exposure. Death occurs from sepsis. Above 7 Gy 100% lethality
>20 Gy	No survivors expected, death is rapid

[a]Chronic dose effects are reported in Sv
[b]Acute high doses are reported in Gy (not weighted by organ risk or particle type).