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Dangers of X-Ray Computed Tomography on Radiation Sensitive Mission Components

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Outline

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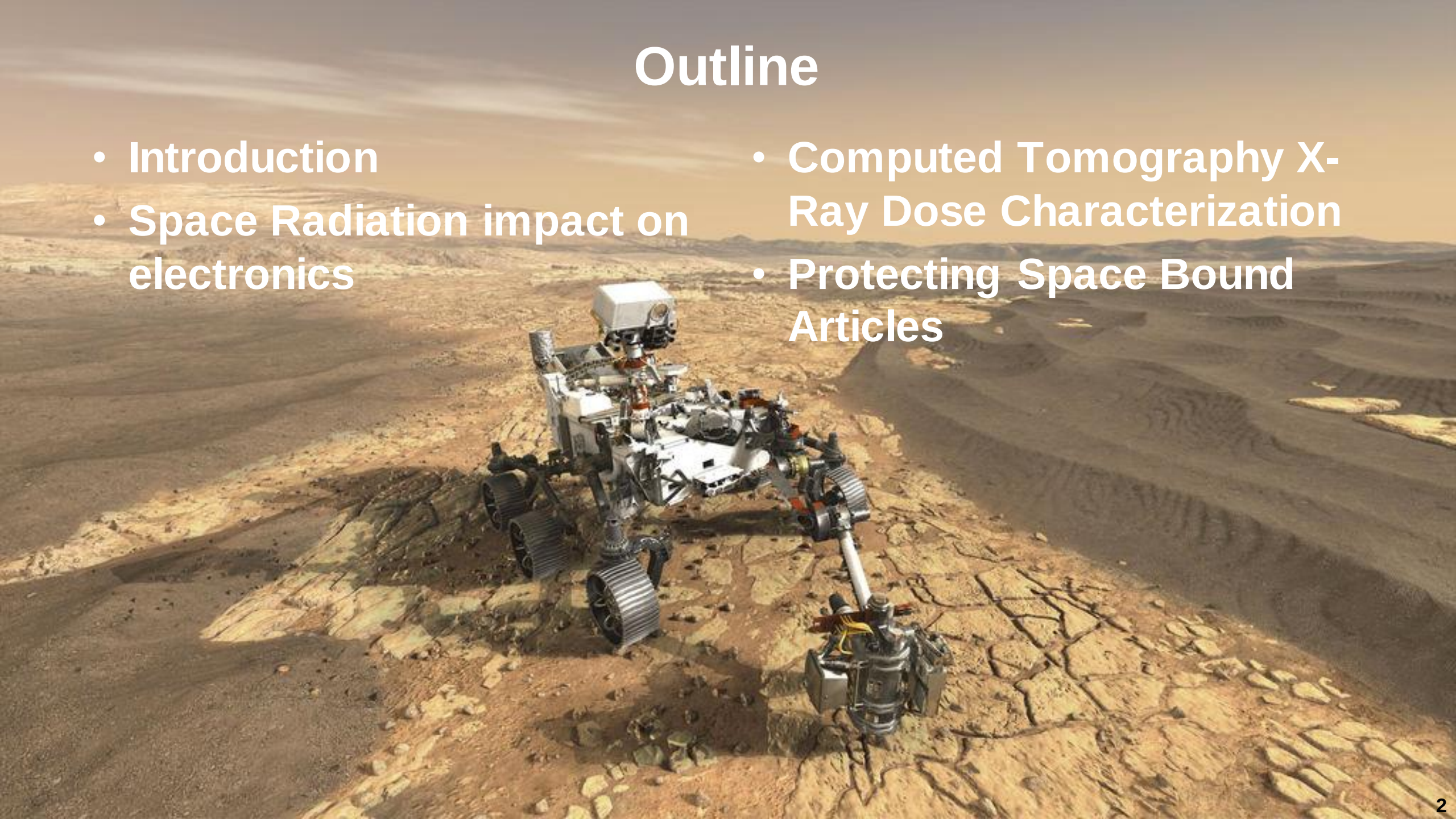
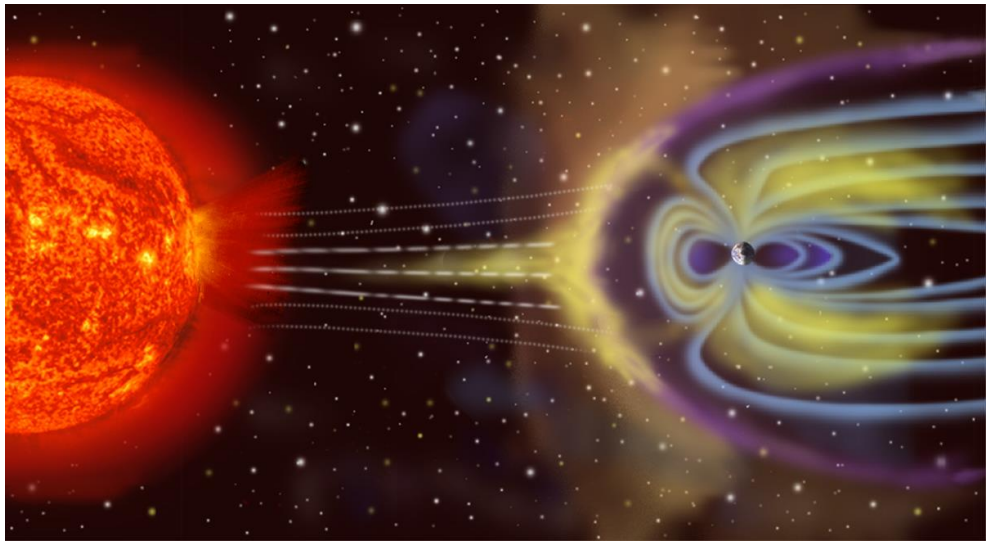
- Protecting Space Bound Articles



Introduction

- **Materials & components have varying tolerances to ionizing radiation.**
- **Components are carefully selected and verified to meet mission Total Ionizing Dose (TID) requirements (among other concerns).**
- **Component TID budget can be consumed prior to launch.**
- **Today we will touch on concerns related to CT X-Ray, which may be prescribed in screening or troubleshooting.**

Space Radiation Impact on Electronics

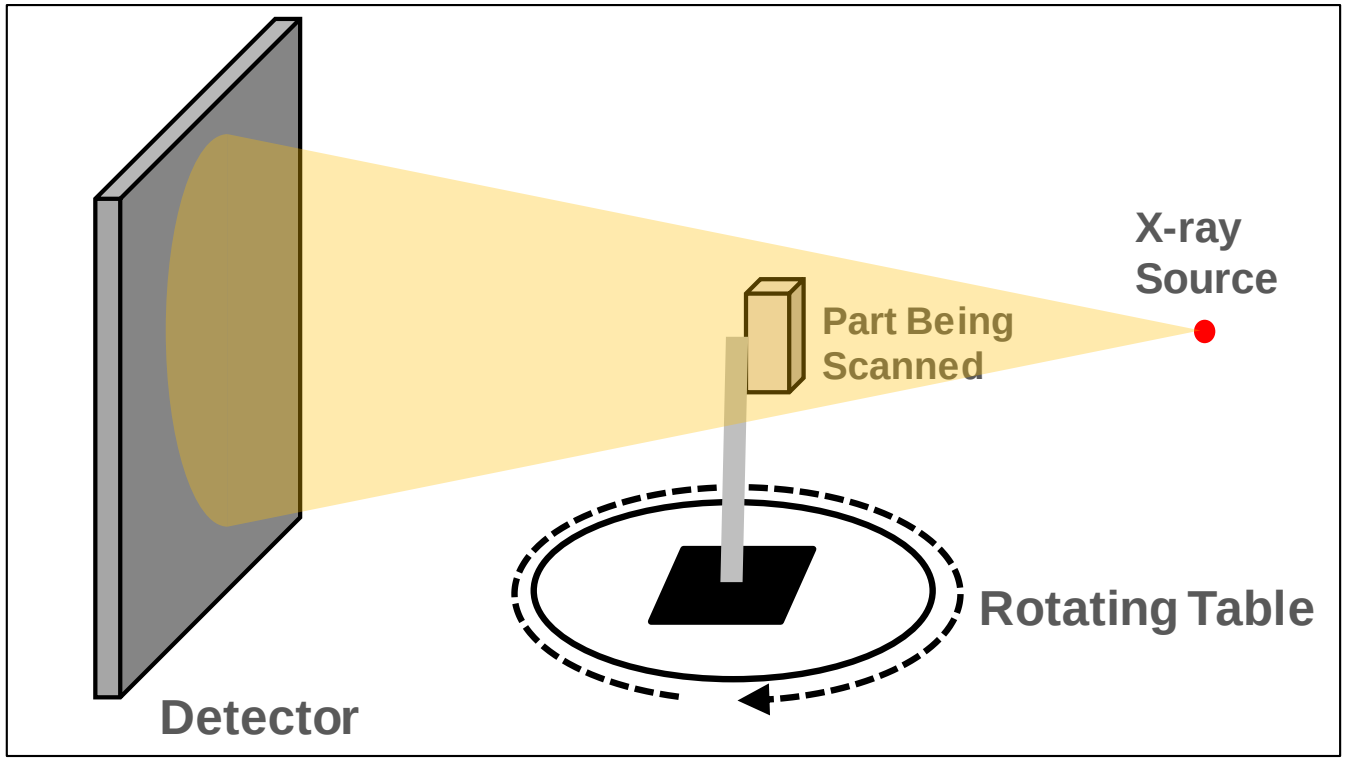


- **Single Event Effects (SEE)**
  - **Typically soft error, non destructive**
  - **Can induce destructive latchup (SEL)**
  - **Rebooting typically recovers**

- **Total Ionizing Dose (TID)**
  - **Long term or cumulative exposure to ionizing radiation causes latent or permanent device damage which can go un-noticed.**
  - **Components typically tested by lot to characterize TID degradation.**
  - **<u>Computed Tomography X-ray is an ionizing radiation!</u>**

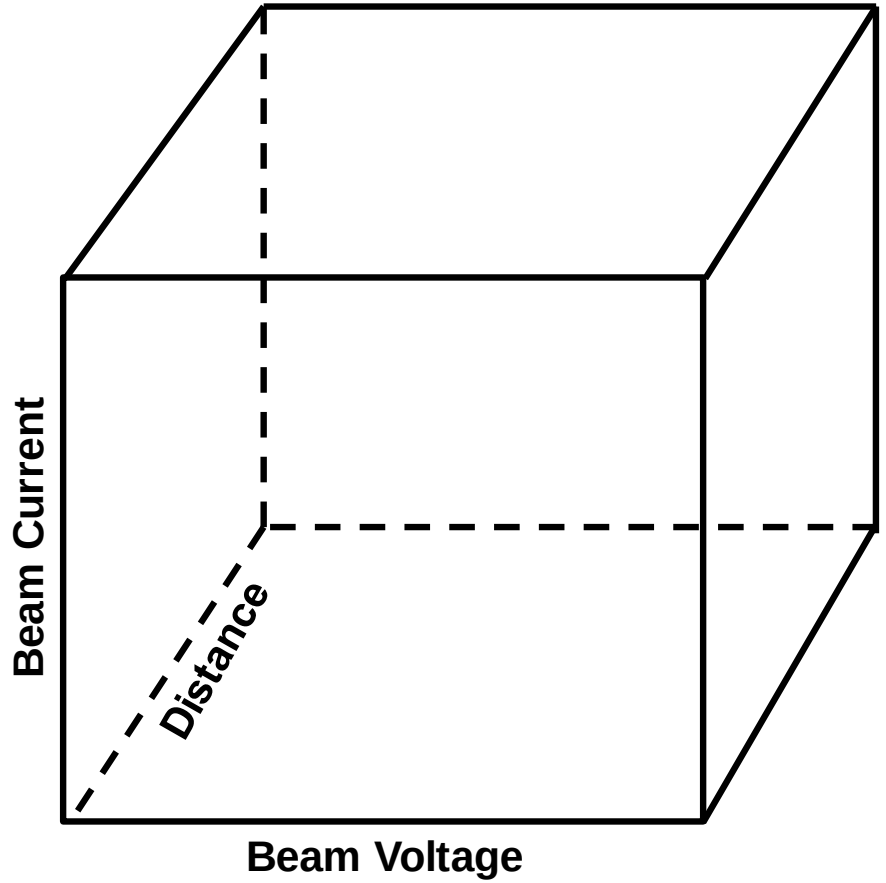
Computed Tomography X-Ray

- ***<u>Ionizing X-ray radiation applied to sample</u>***
- ***Duration can vary from 30 minutes to 10's of hours***
- ***Accelerating voltage, beam current, source to sample distance, duration are key factors***



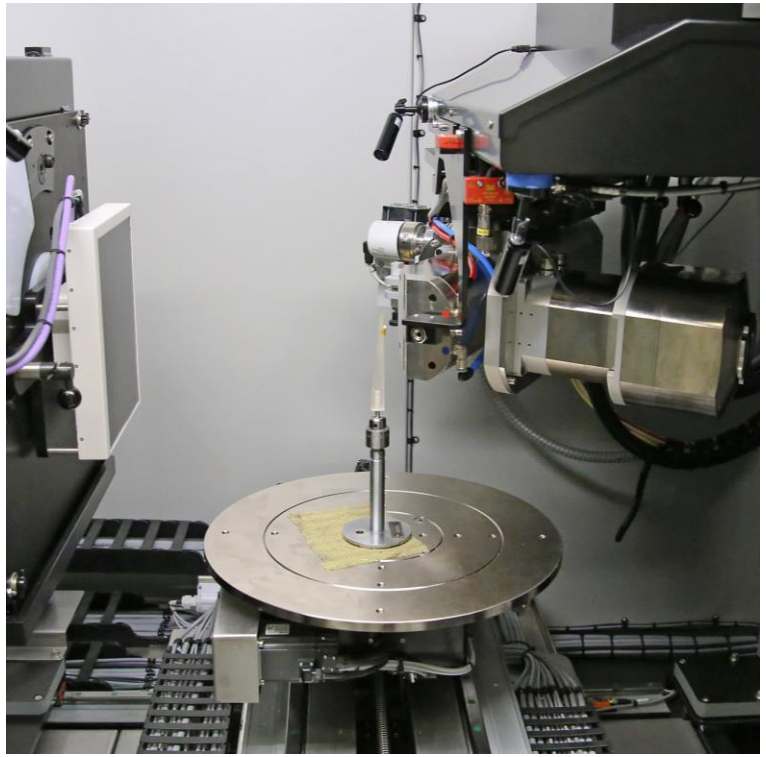
Computed Tomography X-Ray Dose Characterization

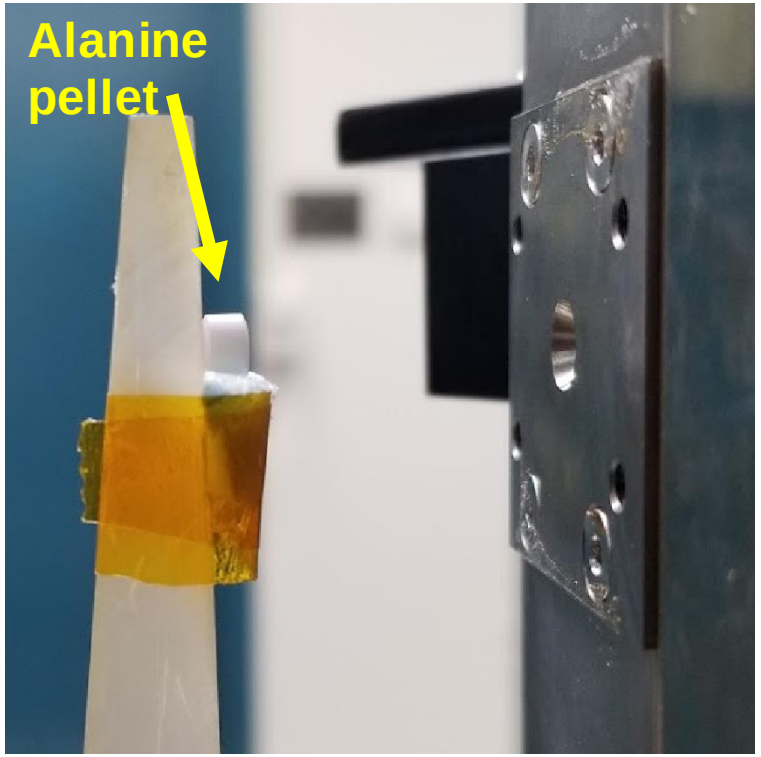
- **Experiment designed to expose alanine pellets under varying conditions:**
  - **6 Beam Voltages (50-450kV)**
  - **7 Beam Currents (up to 3mA)**
  - **3 Distances from X-Ray source**
  - **2 Different X-Ray sources**
  - **29 total exposures**

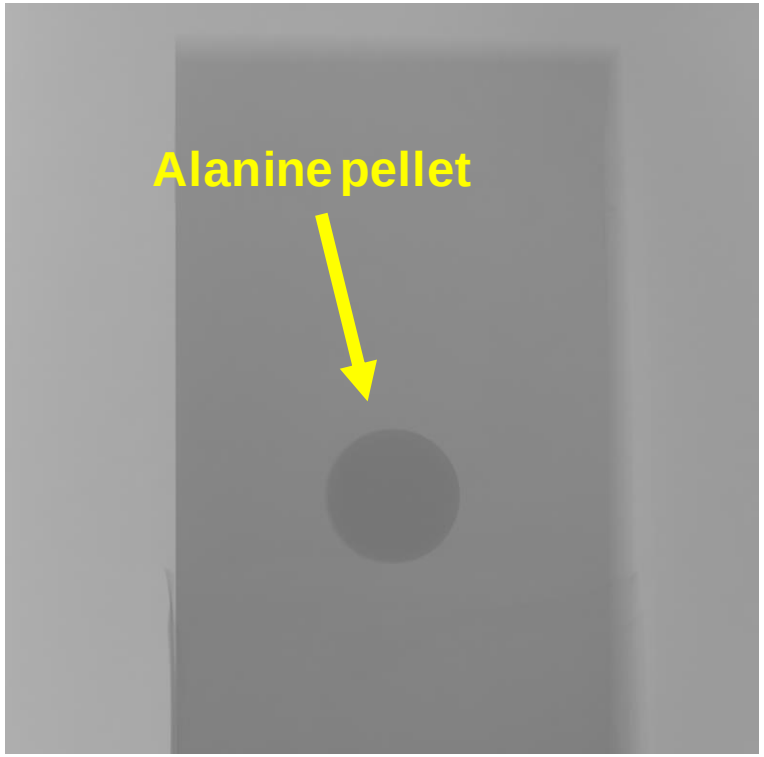


Computed Tomography X-Ray Dose Characterization

- Experiment dosing example in 225kV configuration

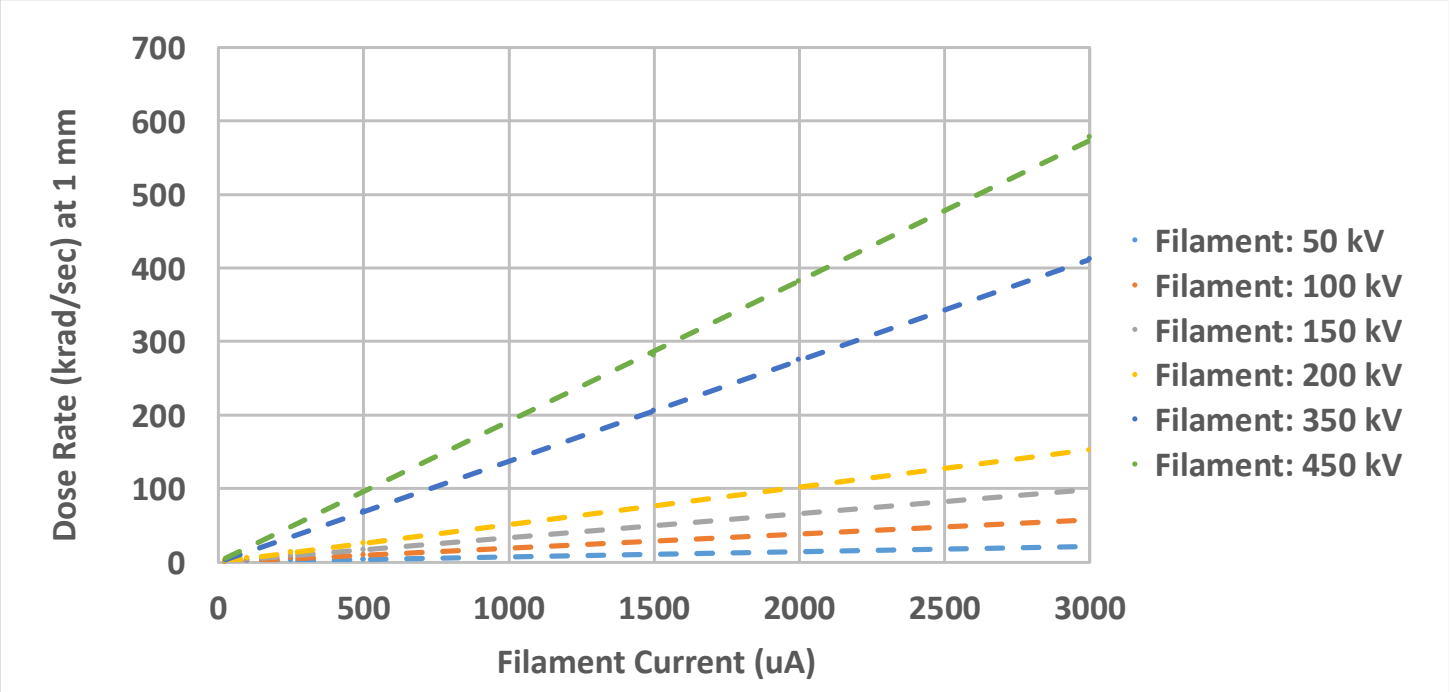






Computed Tomography X-Ray Dose Curves

- **Sample distance has inverse square effect on total dose I=1/(D^2)**
  - **I: radiation intensity**
  - **D: distance**
- **Given varying distances, lines are calculated using E/T=m(C)**
  - **E/T: exposure over time**
  - **m: slope**
  - **C: beam current**



Protecting Space Bound Articles

JPL **CT X-ray Radiation Safety Form**

Date:	9/12/19	
Manufacturer:	Confidential	
IBAT#:	Confidential	Optional
JPL IR #:	Confidential	Optional
Part #:	Confidential	

Is or could the part become flight?	Yes
Is there concern about a potentially destructive radiation dose?	Yes
If yes what is the approved radiation dose limit for this part?	100 Krad
Is the part JCI / ESD sensitive?	Yes
If yes to what voltage is it sensitive to (50V, 250V, etc)?	50V
What is the minimum feature size to be visualized?	10 micron
What are the part X,Y,Z dimensions ?	10cm x 5cm x 10mm
What materials is the part made of and what are their approximate thicknesses?	Al

Describe any special handling instructions below:

Radiation Exposure Details

Source	Xrayworks 225
KV	160
uA	165
Distance (mm)	50
Time (hours)	2.00
Dose (Krad)	**17.4**

The hardware submitted for CT scanning can safely sustain the estimated radiation dose

	Approved (Yes/No)	Date
3X M&P:	Yes	13-Sep
5X Rad Effects:	Yes	13-Sep
COGE:	Yes	13-Sep
MAM:	Yes	13-Sep

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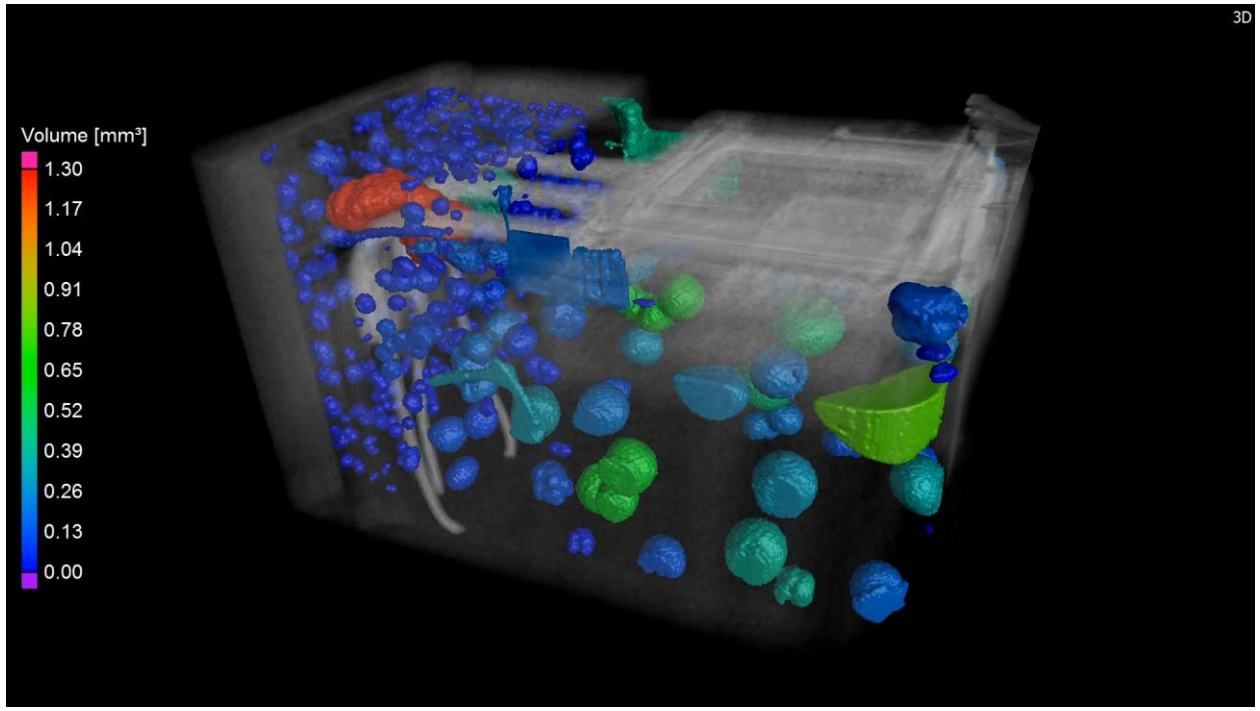
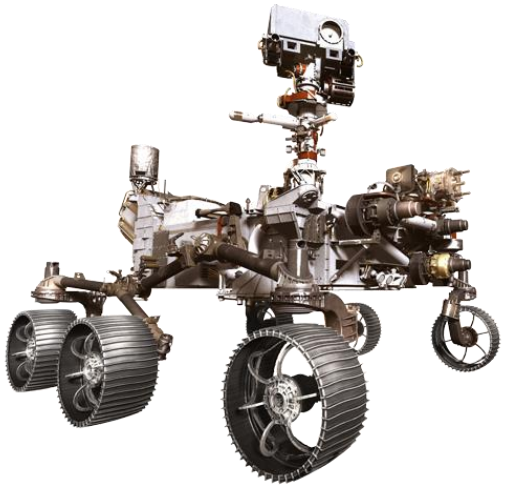
1. **Gather hardware key facts**
   - **Is it or could it become a flight-qualified article?**
   - **Is there concern about potentially destructive radiation doses?**
   - **If yes, what is the radiation dose limit for the device?**
   - **Dimensions, component list, material list.**

Protecting Space Bound Articles



2. Establish sample dependent parameters to generate dose estimate.
   - Sample distance, kV, beam current, scan time.
3. Gain written approval from stakeholders to proceed.
4. Capture & analyze CT data, document actual parameters & estimated dosage.
5. Review results with project adding insight to anomaly investigation.

Summary



- **Well intentioned troubleshooting steps can consume TID budget and reduce lifetime prior to launch.**
- **It's strongly recommend to consider TID budget & CT X-Ray contributions prior to CT scanning flight electronics & materials.**
- **Safeguarding hardware via a documented process is suggested to avoid escapes during high pressure or emergency situations.**