BioSentinel – ISS mission

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HUMAN EXPLORATION

NASA's Path to Mars

EARTH RELIANT

MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS

Mastering fundamentals aboard the International Space Station

U.S. companies provide access to low-Earth orbit

PROVING GROUND

MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS

Expanding capabilities by visiting an asteroid redirected to a lunar distant retrograde orbit

The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft

MARS READY

MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS

Developing planetary independence by exploring Mars, its moons and other deep space destinations

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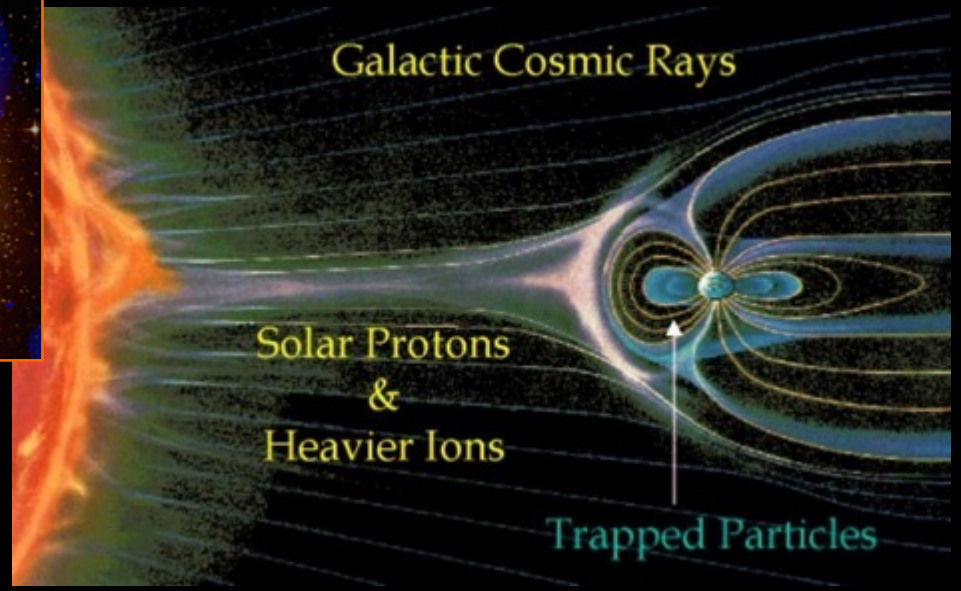
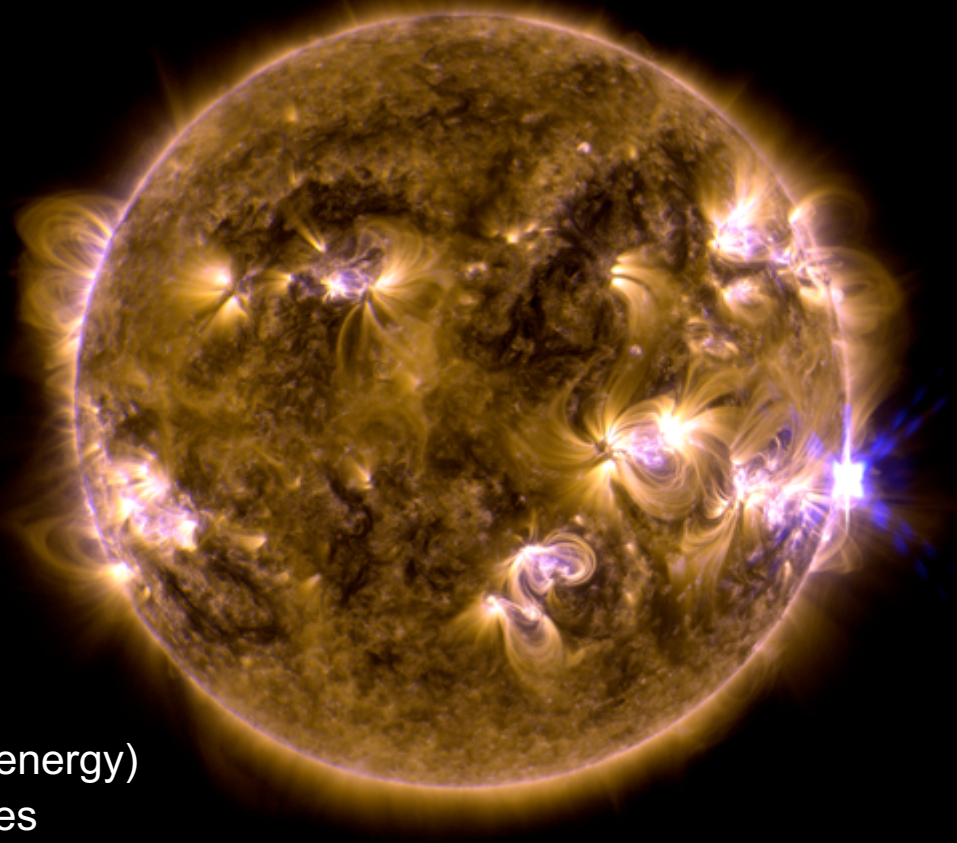
Interplanetary space radiation: GCRs and SPEs

What type of radiation are we going to encounter beyond low Earth orbit (LEO)?



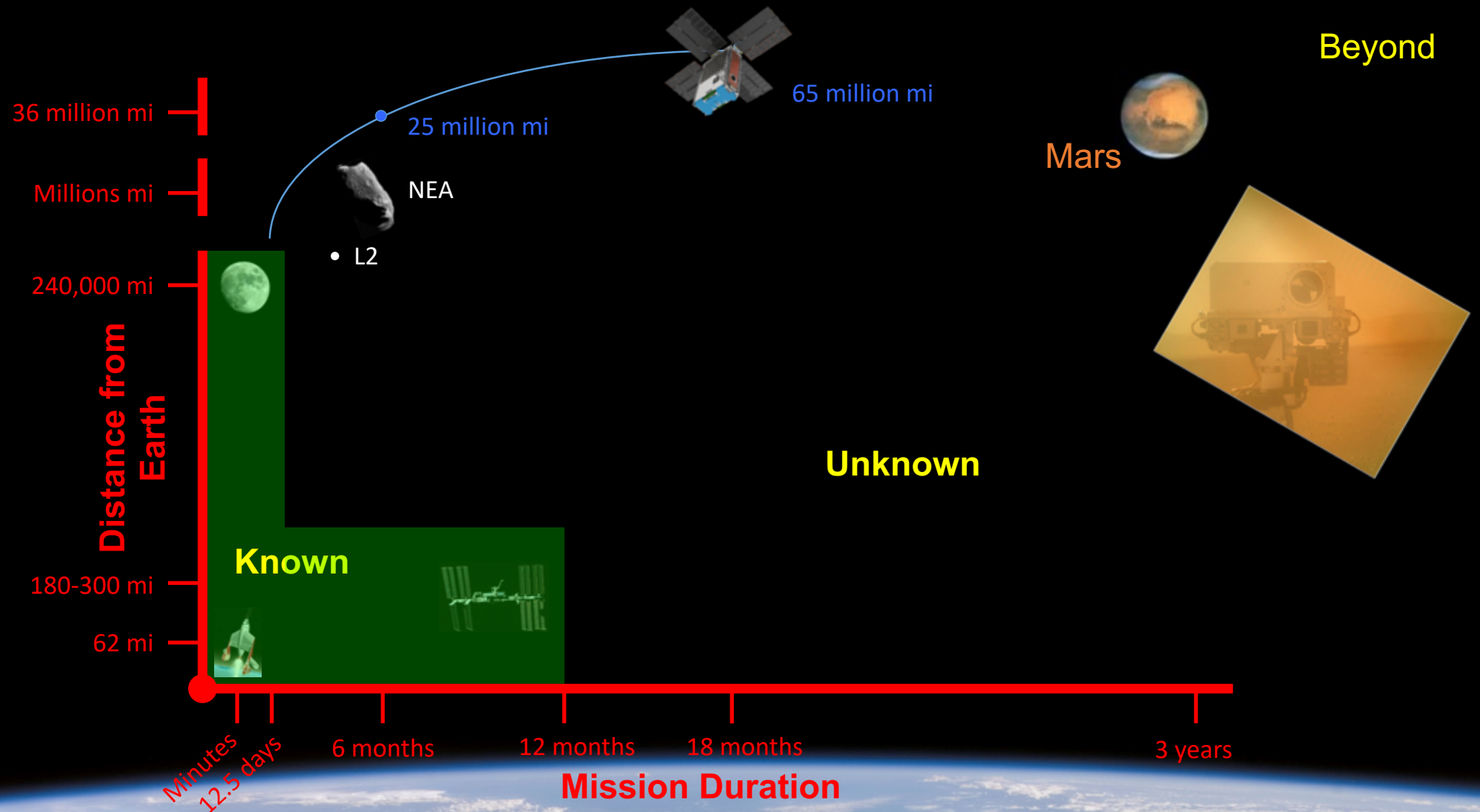


- Interplanetary, modulated by the 11-year solar cycle
- SPEs: sporadic, transient (mins to days); high proton flux (low-medium energy)
- GCRs: high-energy protons and highly charged, energetic heavy particles
- GCRs not effectively shielded; can break up into lighter, more penetrating pieces

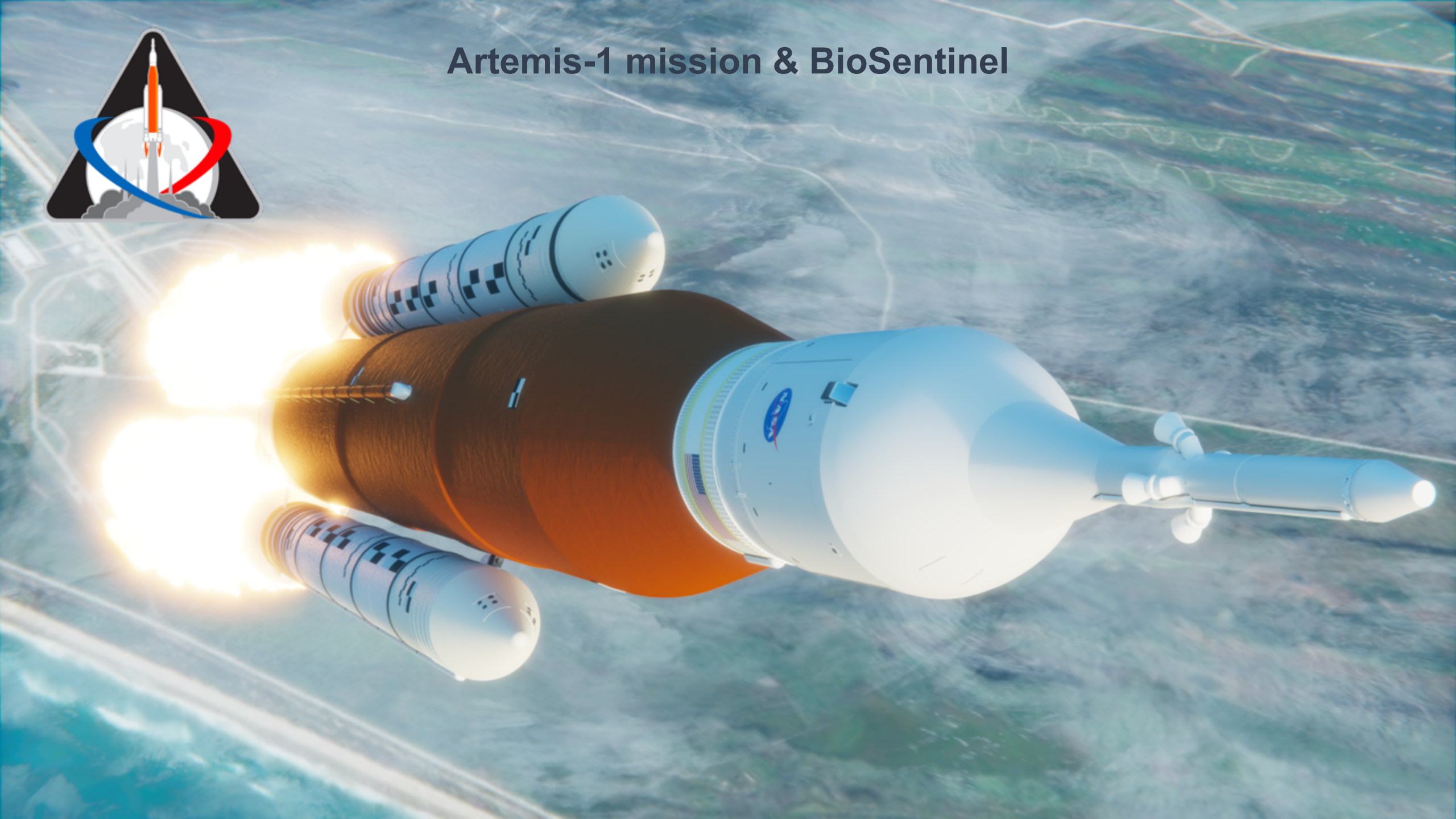
Challenges: SPEs – unpredictable; large doses in short time

GCRs – biology effects poorly understood (but most hazardous)

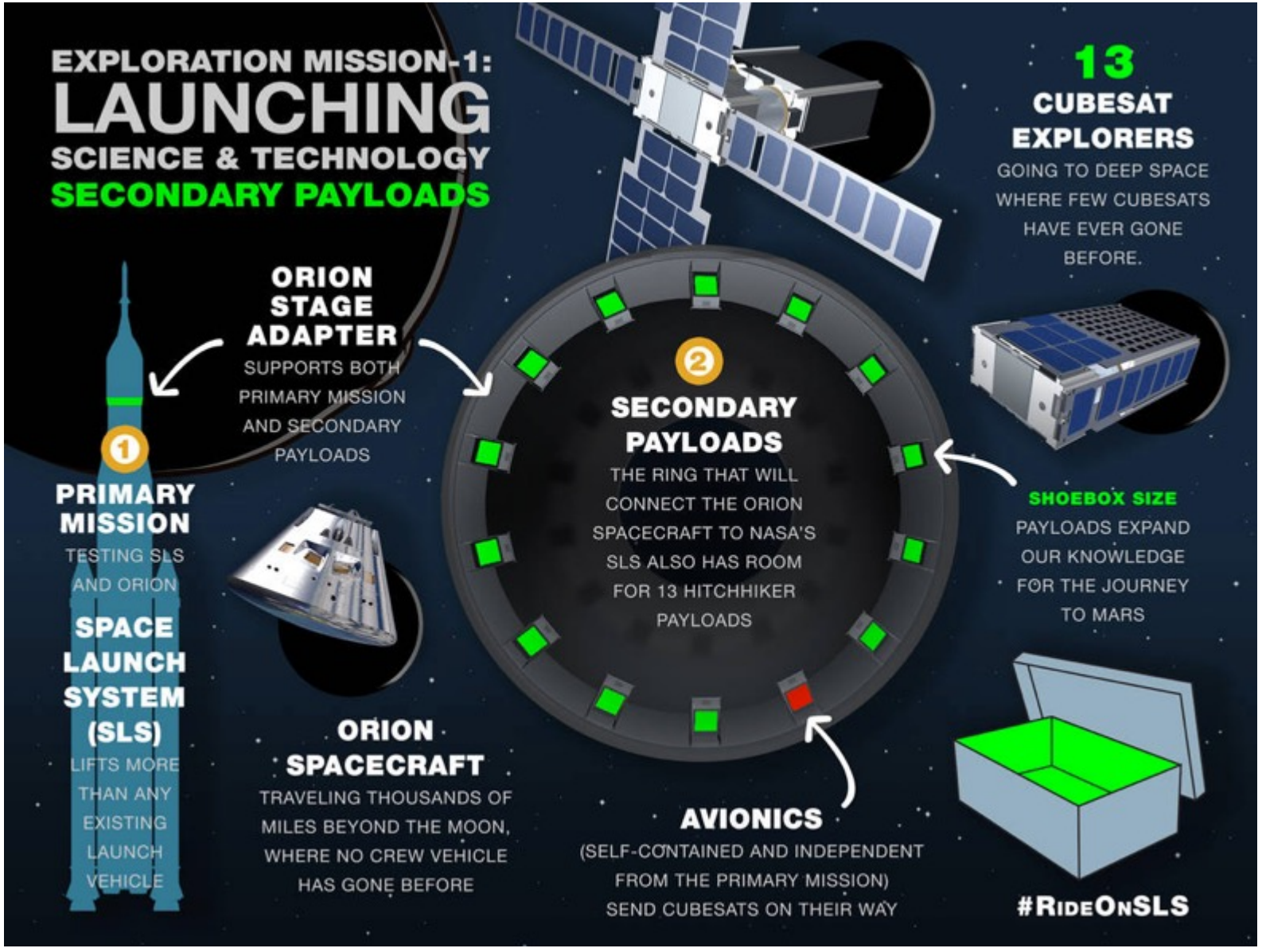
The limits of life in space – as we know it – is 12.5 days on a lunar round trip or 1.2 years in LEO. As we send people further into space, we can use model organisms and/or biosensors to understand the biological risks and how they can be addressed

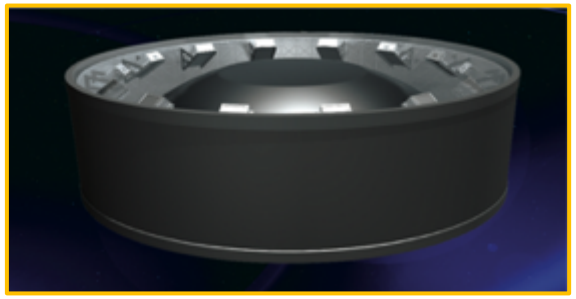


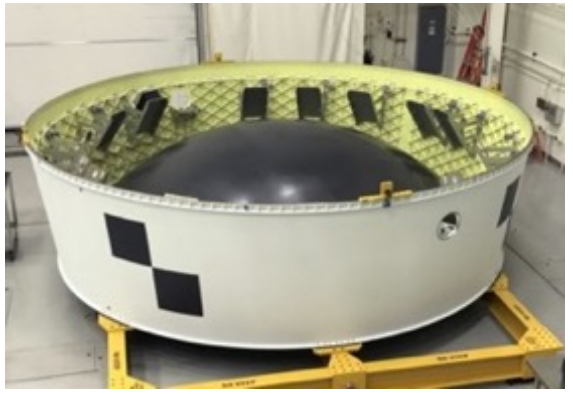
Artemis-1 mission & BioSentinel



Artemis-1: secondary payloads (6U CubeSats)







BioSentinel mission: the 1st interplanetary bio satellite

Main objective: develop a tool with autonomous life support technologies to study the biological effects of the space radiation environment at different orbits

- First biological study beyond low Earth orbit (LEO) in 50 years
  - First CubeSat to combine biological studies with autonomous capability & physical dosimetry beyond LEO
  - Secondary payload in SLS ARTEMIS-1 (launch in FY22)
  - Far beyond the protection of Earth's magnetosphere (~0.3 AU from Earth at 6 months; ~40 million km)
  - BioSentinel will allow to compare different radiation and gravitational environments (deep space, ISS, Moon…)

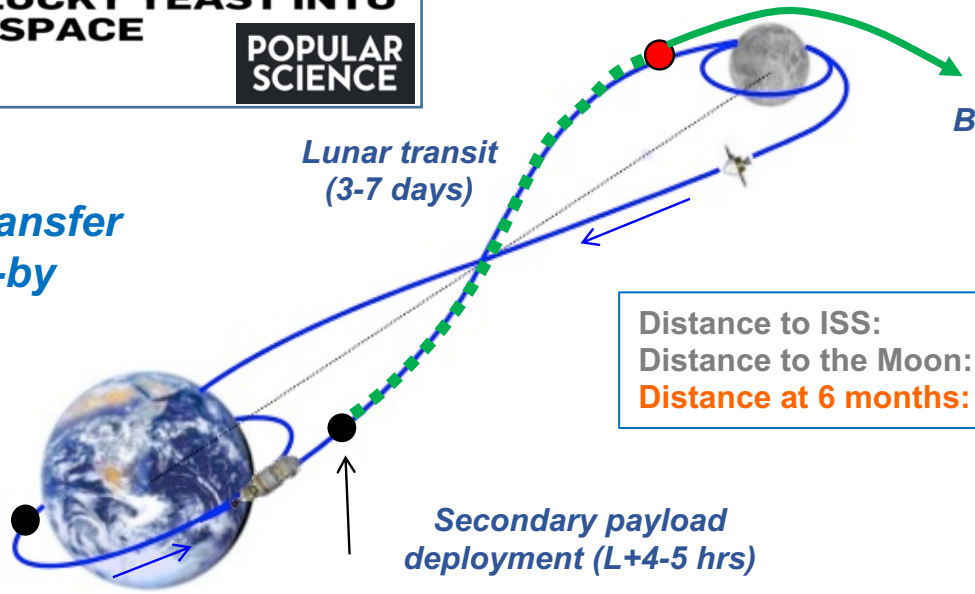
SPACE

NASA IS SENDING SOME LUCKY YEAST INTO RADIATION-FILLED DEEP SPACE

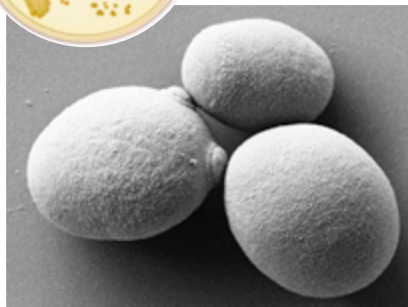
WHERE NO YEAST HAS GONE BEFORE

By Shannon Stirone May 15, 2015

POPULAR SCIENCE



Distance to ISS:	~ 350 km
Distance to the Moon:	~385,000 km
Distance at 6 months:	~40'000,000 km



What is BioSentinel?

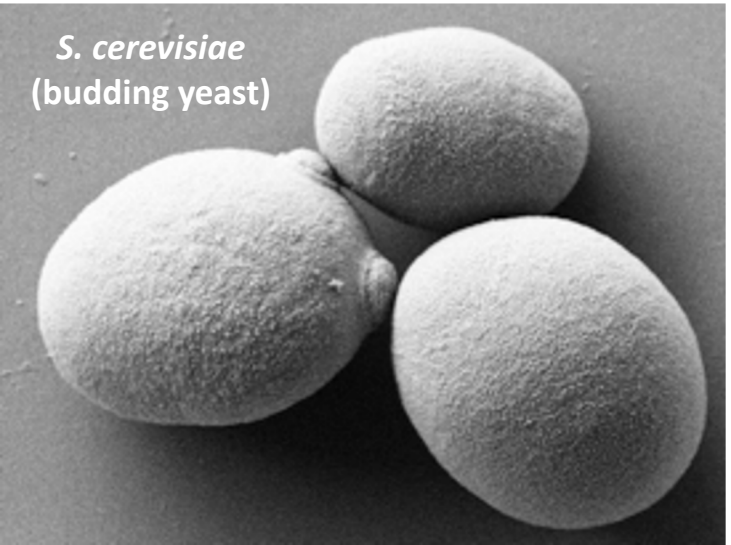
BioSentinel is a yeast radiation biosensor that will measure the DNA damage response caused by space radiation, and will provide a tool to study the true biological effects of the space environment at different orbits.

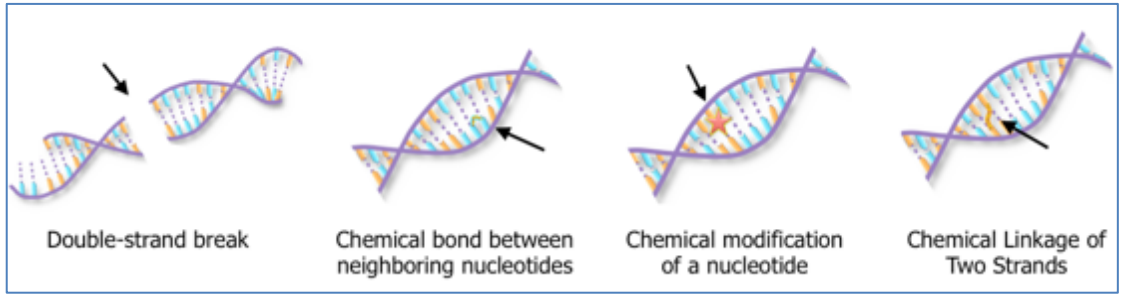
Why?

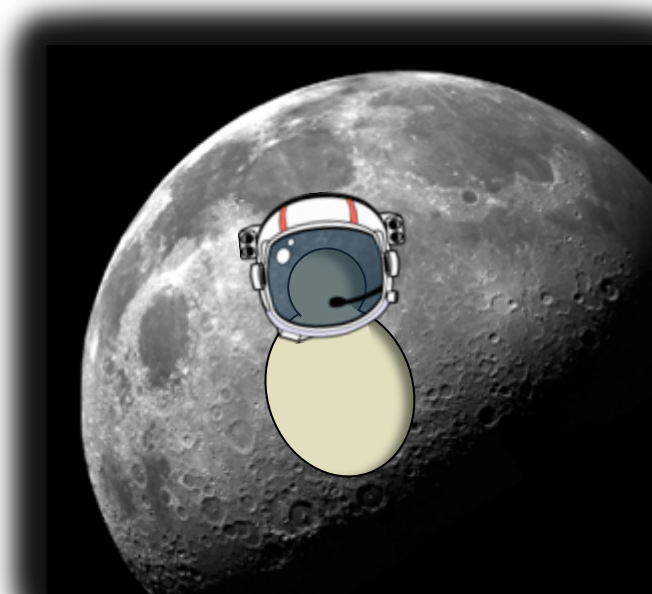
Space radiation environment's unique spectrum cannot be duplicated on Earth. It includes high-energy particles, is omnidirectional, continuous, and of low flux.

How?

Lab-engineered *S. cerevisiae* cells will sense & repair direct (and indirect) damage to their DNA. Yeast cells will remain dormant until rehydrated and grown using a microfluidic and optical detection system.







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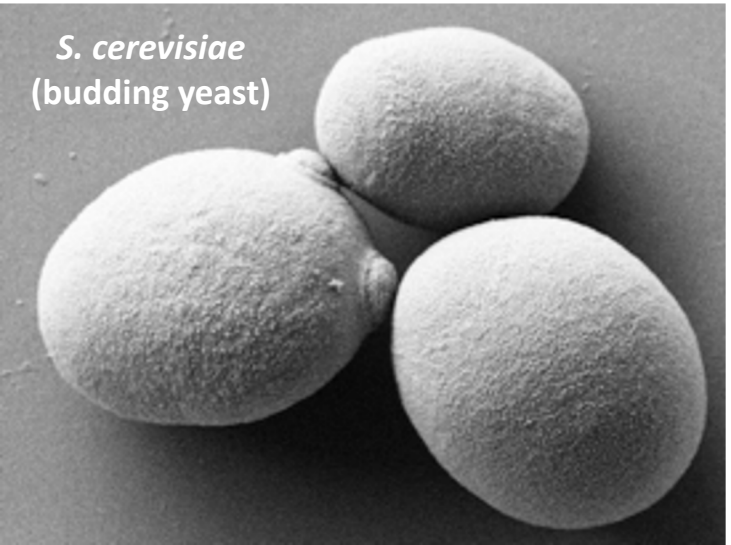
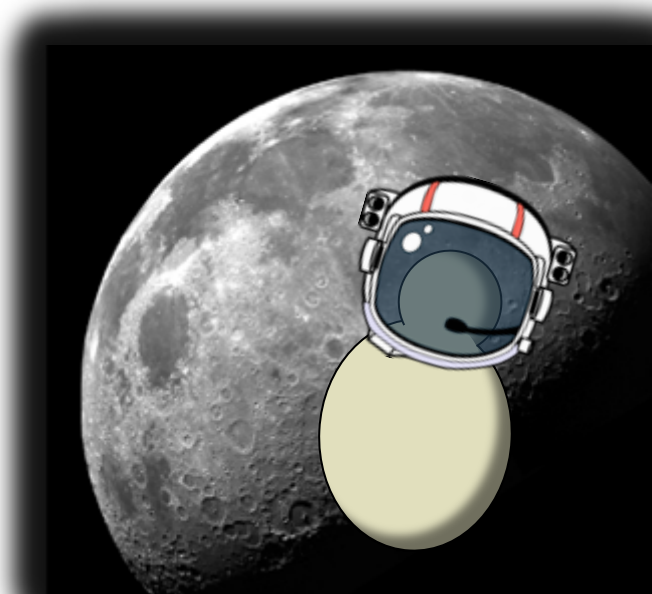


Why budding yeast?

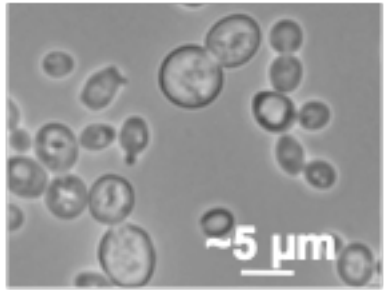
It is a eukaryote; easy genetic & physical manipulation; assay availability; flight heritage; ability to be stored in dormant state

While it is a simple model organism, yeast cells are the best for the job given the limitations & constraints of spaceflight

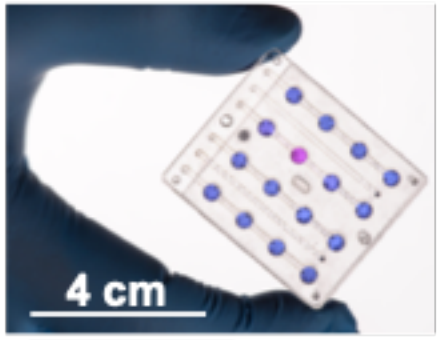


BioSentinel: a 6U nanosatellite for deep space

Budding yeast

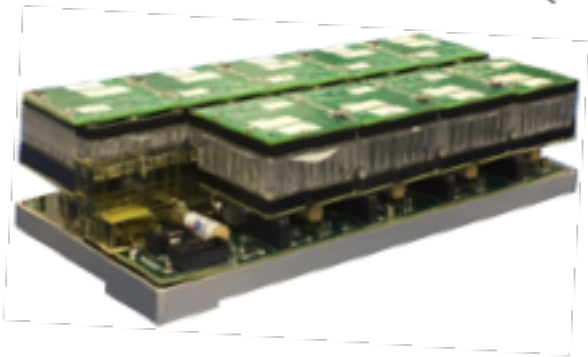


16-well fluidic card (x18)

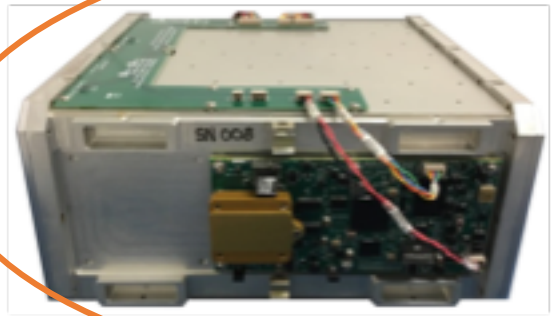


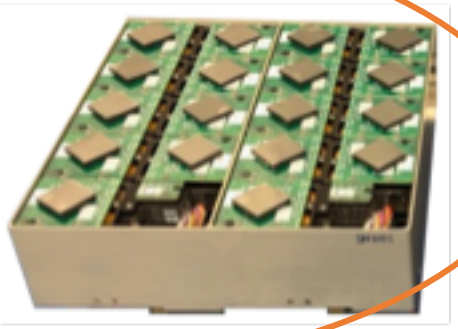
Card stack

9-card fluidic manifold (x2)

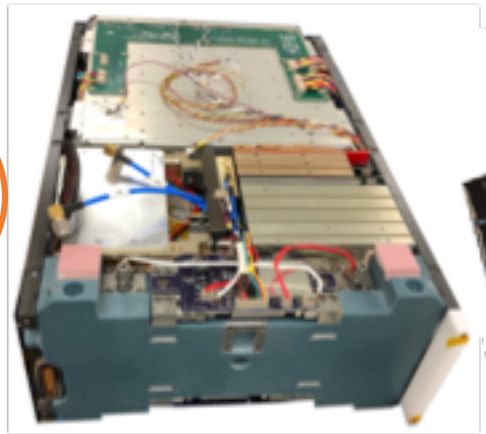


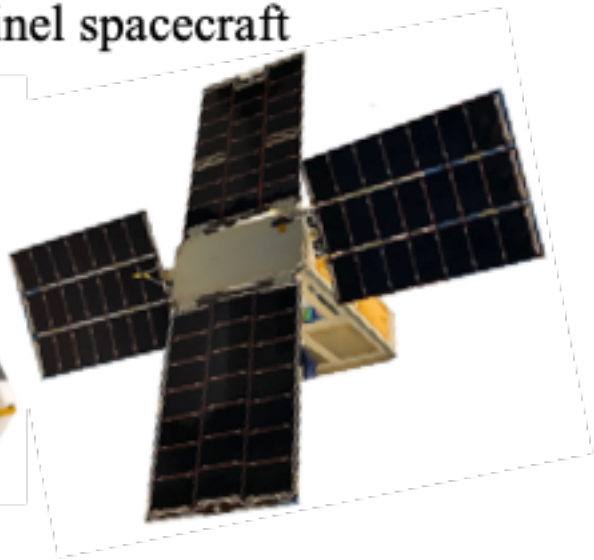
4U BioSensor payload





6U BioSentinel spacecraft

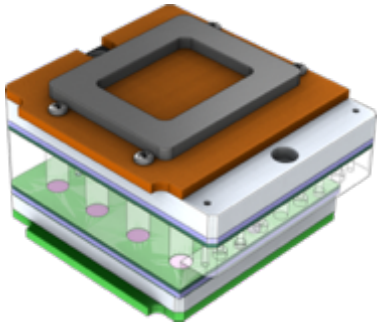


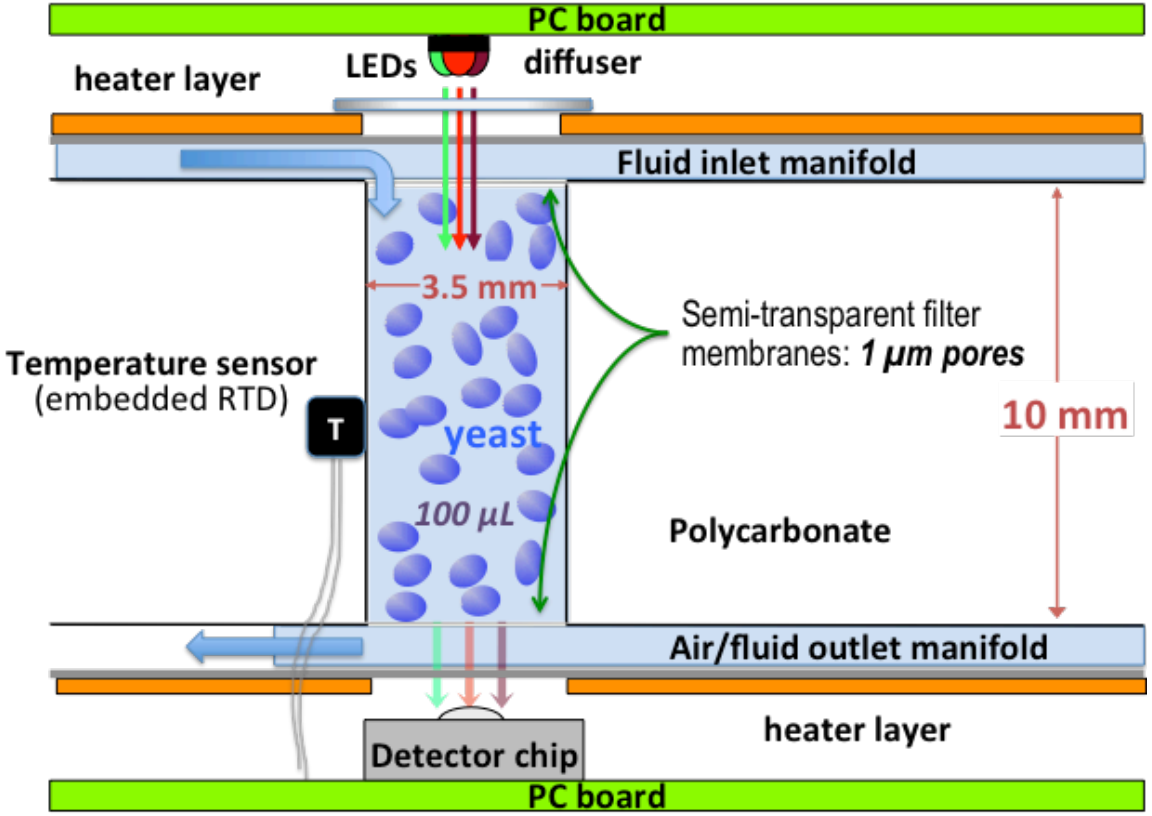


ISS

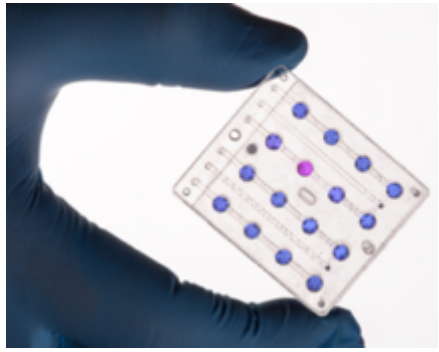
BioSentinel: microfluidics card

Microfluidic card (x18)

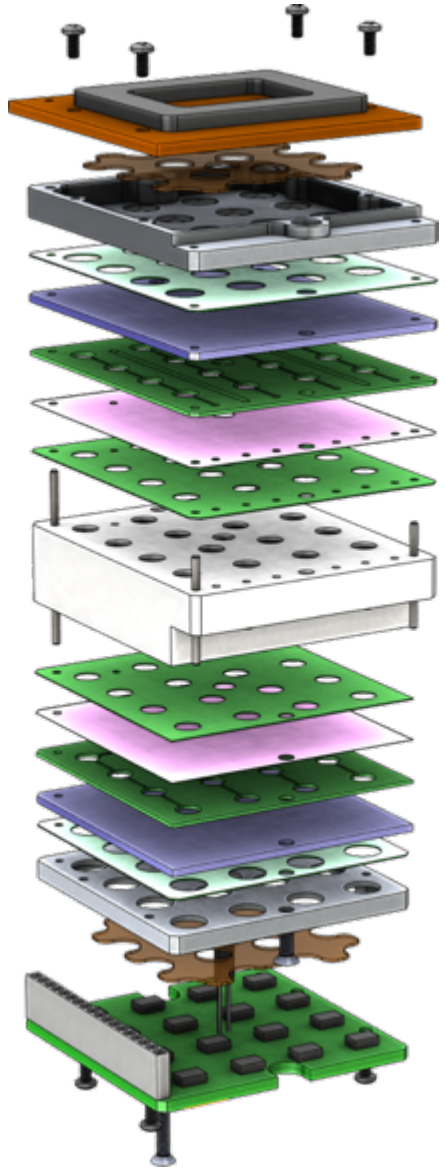




3-LED emitter



Photodiode detector array



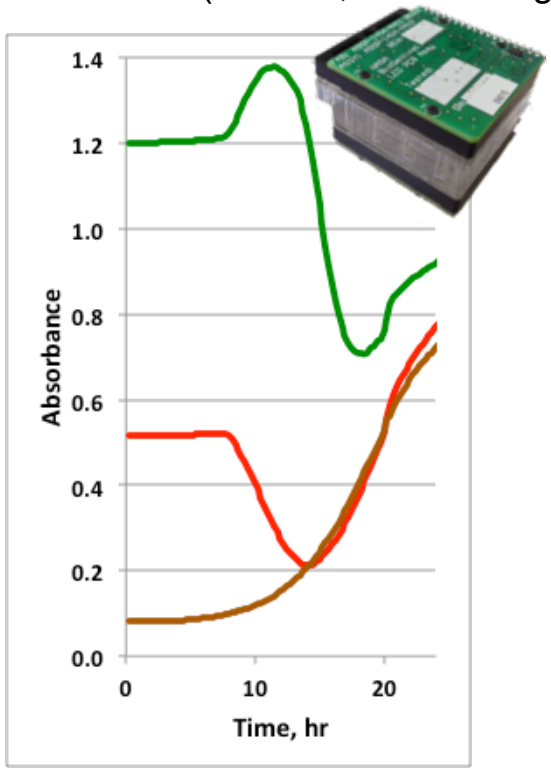
BioSentinel: optical detection system

Dedicated 3-color optical system at each well to track growth *via* optical density and cell metabolic activity *via* dye color changes

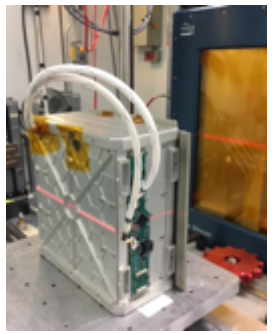
LEDs: 570 nm (green, measures pink)

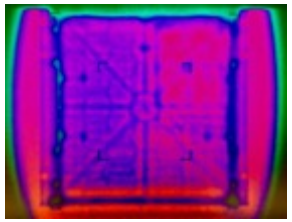
630 nm (red, measures blue)

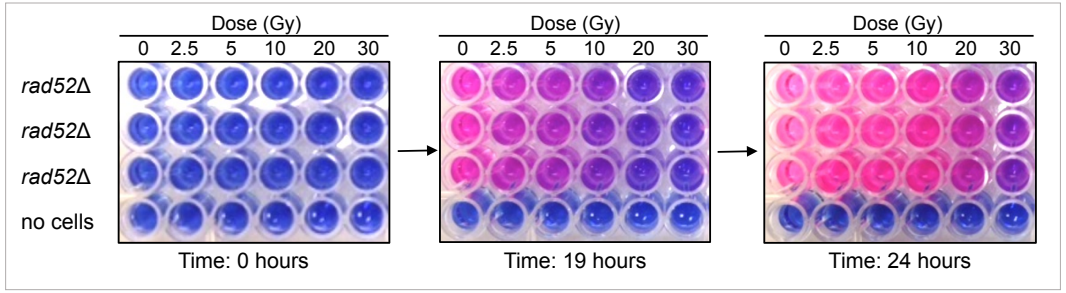
850 nm (infrared, measures growth)



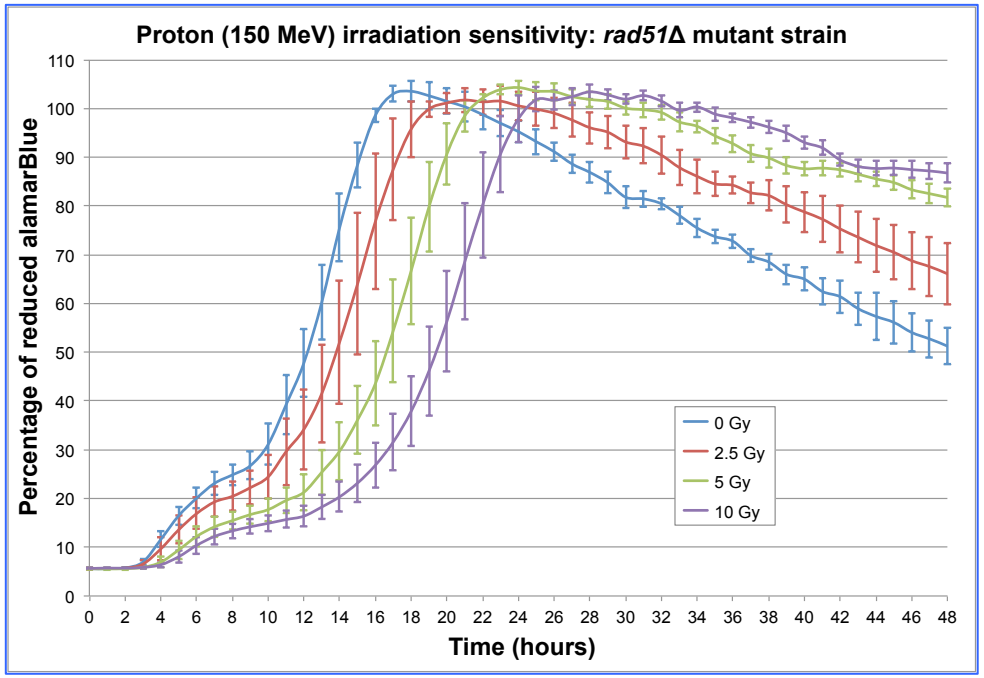
Yeast growth with flight-like optical unit







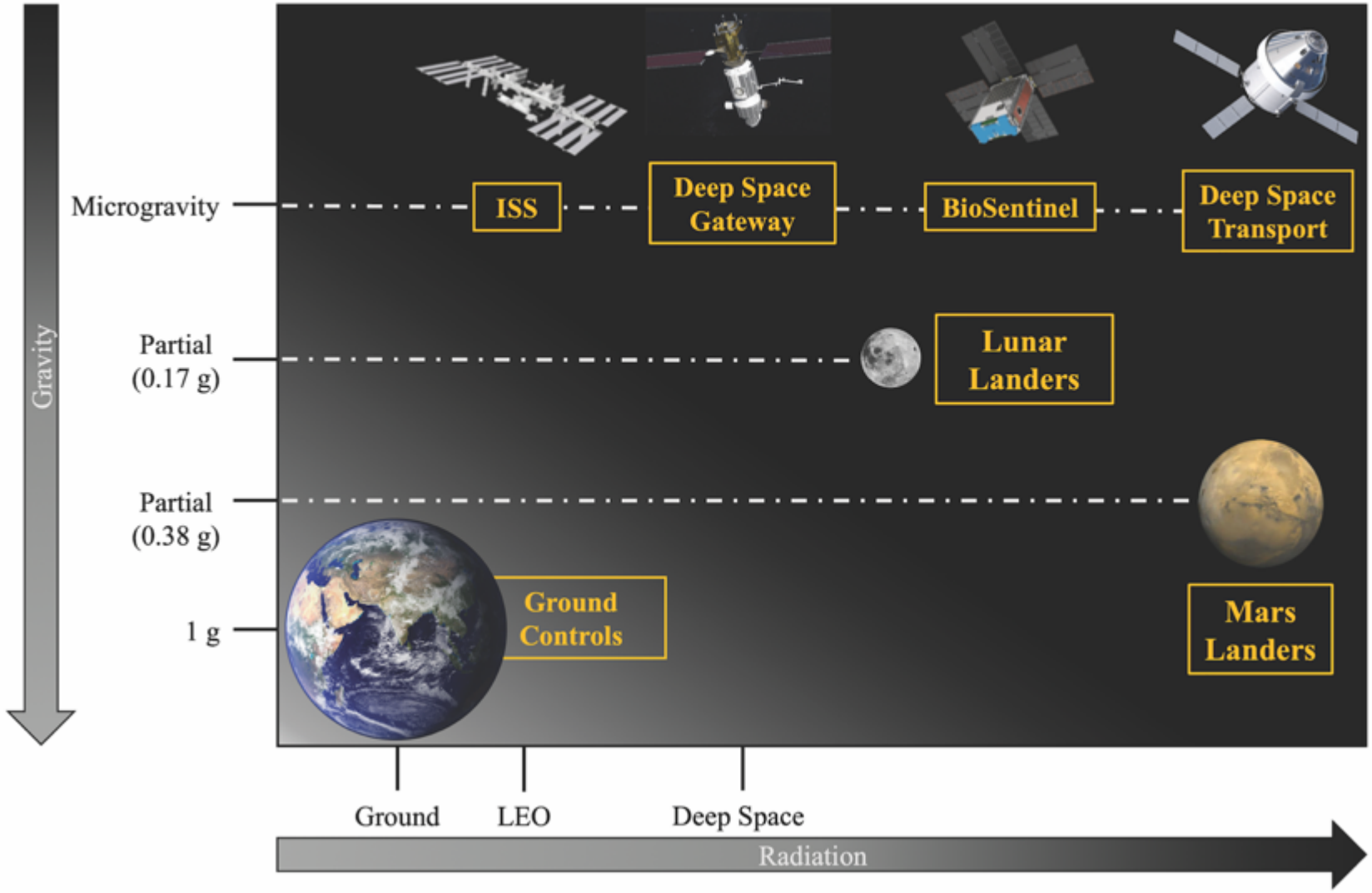
alamarBlue turns pink when cells are metabolically active



HR repair defective cells show sensitivity to ionizing radiation

BioSentinel: future & ongoing objectives

A flexible design that can (and will be) used on different space platforms




Thank you!
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