# SpinSat

## A Comprehensive and Flexible Approach to Lunar- and Mars- relevant Science & Technology Development Activities

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*https://www.nasa.gov/ames-studies-current/spinsat/*

# Problem Statement


## Human Health and Environmental Control & Life Support System (ECLSS):

Radiation exposure incurred during space exploration is one of the greatest threats to an astronaut's health. There is insufficient knowledge of the health effects of space radiation and the space radiation environment to provide recommendations on crew exposure limits and design requirements for long-duration missions.

## Space Science & Technology:

SMD/Biological & Physical Sciences, PSD/Astrobiology, and the Exploration Systems Development Mission Directorate communities need access to combined deep-space radiation and relevant gravity ranges

**National Academies** "...The research opportunities that are envisioned to exist within cis-lunar space are expected to be severely limited in volume and frequency. This sets an interesting conundrum where some critical research cannot be met with the current deep space platforms, yet they would richly inform human exploration beyond LEO during the Artemis missions."

**NASA needs access to deep space radiation environments, those regions above the Van Allen Belts.**
https://www.nasa.gov/directorates/esdmd/hhp/space-radiation/

# SpinSat Can Provide "Environments" to Help Answer Many BPS & ESDMD Questions

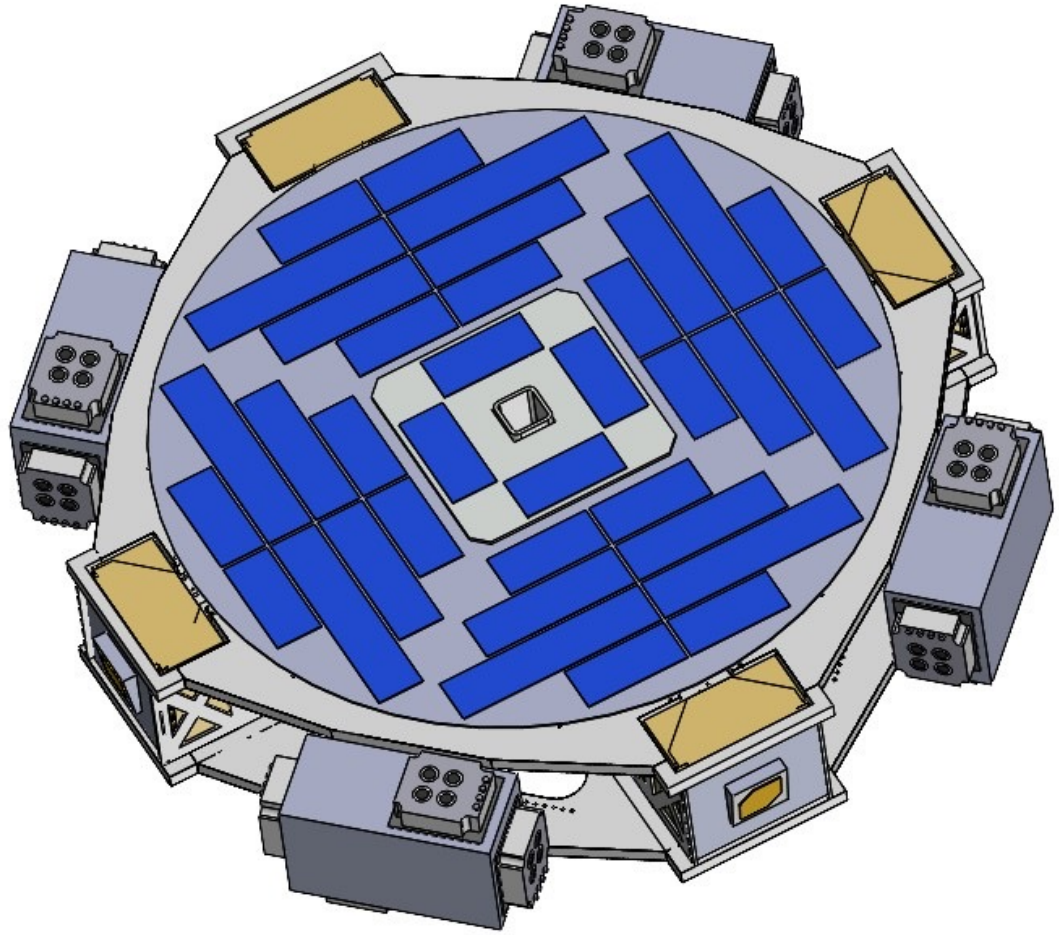
Humans will encounter multiple environments in space that require in-situ characterization for risk mitigation

## Risk Ratings and Dispositions per Design Reference Mission (DRM) Category

| DRM Categories | Mission Type and Duration | Long-Term Health | |
|---|---|---|---|
| | | L X C | *Risk Disposition |
| Low Earth Orbit | Short (<30 days) | 3x1 | Accepted |
| | Long (30 days - 1 year) | 3x2 | Requires Characterization |
| Low Earth Orbit | Short (<30 days) | 3x1 | Accepted |
| | Long (30 days - 1 year) | 3x2 | Requires Characterization |
| Lunar Orbital + Surface | Short (<30 days) | 3x1 | Accepted |
| | Long (30 days - 1 year) | 3x2 | Requires Characterization |
| Mars | Preparatory (<1 year) | 3x3 | Requires Mitigation |
| | Mars Planetary (730 - 1224 days) | 3x3 | Requires Mitigation |

# SpinSat Addresses PI Needs

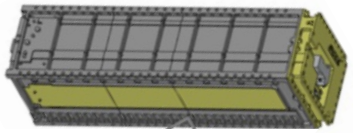
- A highly cost-effective standardized secondary-compatible Class D plug-n-play platform
- Utilizes standard open source U-form factors for experiments
- Allows PI to focus on the experiments and not the spacecraft
- Offers increased flight opportunities for experiments needing the combined gravity and radiation effects from near-0 to Earth g, with deep space, lunar, or Mars radiation environments



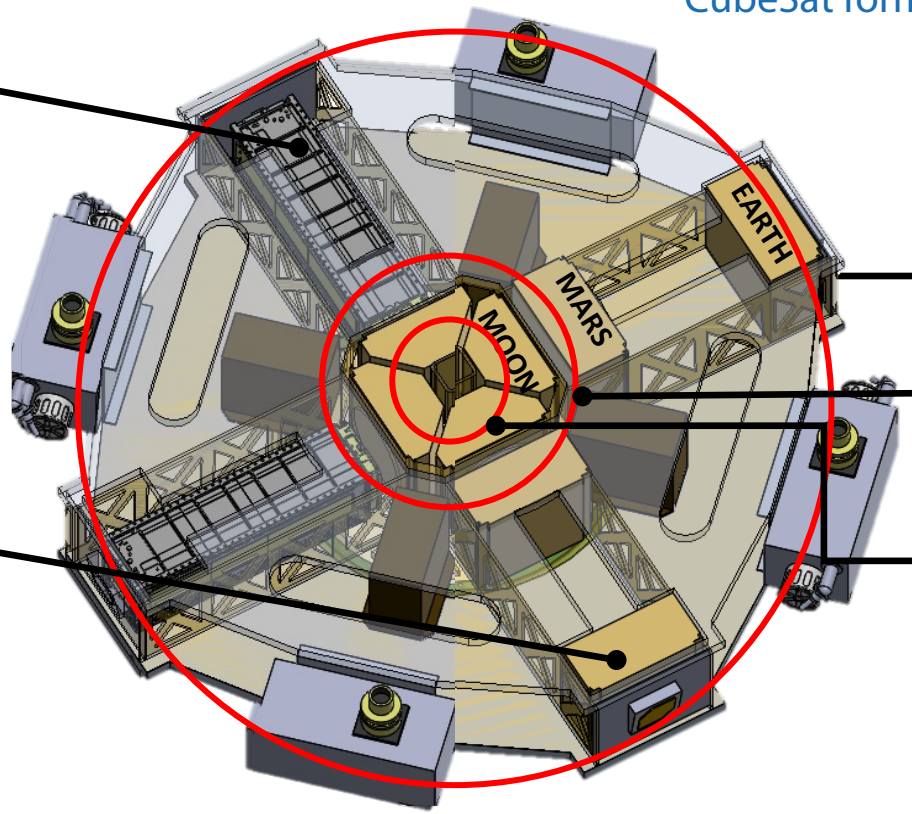
# SpinSat Provides Alternate "Gravity Fields"

Experiments are packaged into CubeSat form factors (U)

Placement of a 1x4U Radial Payload



Placement of a 2x2U Payload




Earth g
Ø 1.35m

Martian g
Ø 0.45m

Lunar g
Ø 0.225m

**Top View** – Upper Deck and Solar Panels Removed

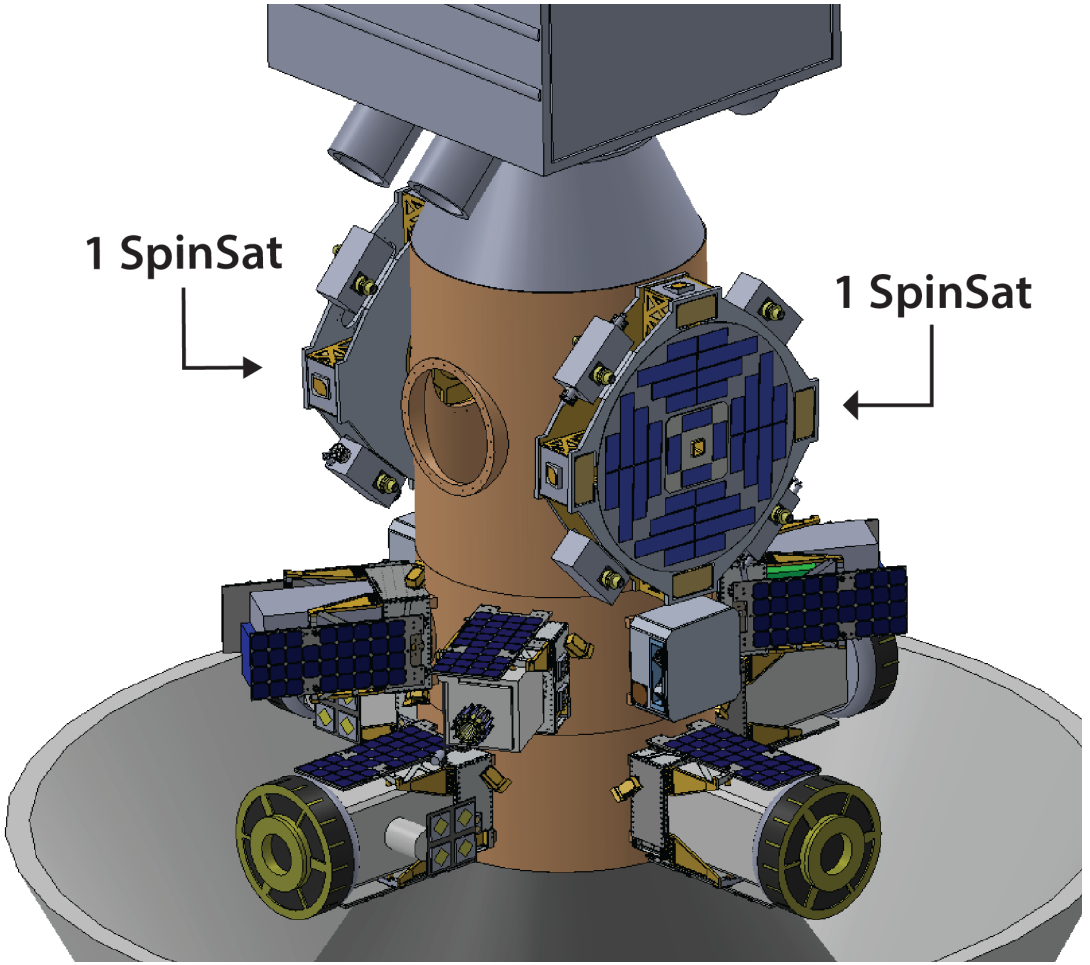
# SpinSat can Satisfy a Large Range of Objectives

| | |
|---|---|
| **O-1** | Simultaneous long duration exposure to deep space radiation environment over a range of (0 -> 1g) gravities simultaneously, including 1g control |
| **O-2** | **Low cost per experiment**<br>Many experiments can be hosted on the platform<br>Allows for multiple copies of experiments / enhanced statistical significance |
| **O-3** | Allow for **frequent access** to space:<br>O-3a: LV Agnostic<br>O-3b: Orbit agnostic |
| **O-4** | Interfaces consist of the highly familiar "**Cubesat" interfaces** based on the "U" format<br>Other configurations are achievable and not a priori precluded.<br>PI focus on the experiment, not the s/c. |
| **O-5** | **Easy integration**/ payload access<br>Stretch: Permit "just-in time" loads for biology prior to launch |
| **O-6** | Addition of regolith simulant allows for simulation of **lunar and Mars radiation** environments |

# Launch Vehicle Accommodation is Easy

SpinSat can be:

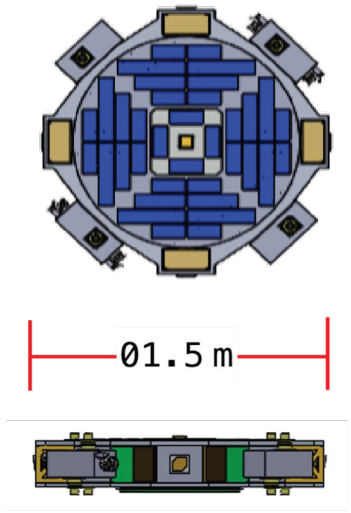
- Launched on a variety of launch vehicles into almost any orbit
- Mounted as an ESPA-port secondary payload
- Cost effective




*Two SpinSats each on their own port*

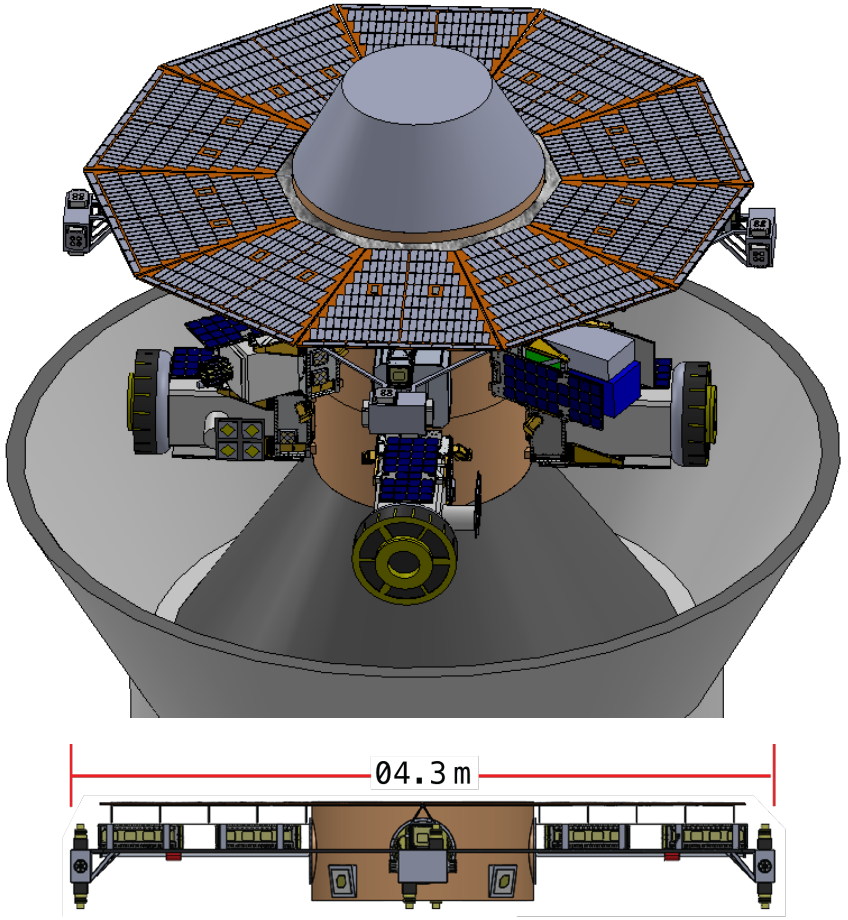
# SpinSat Comes in Two Different Sizes

## 1.5m ESPA port mounted




- 1.5m diameter
- Accommodate >48 “U” of science
- Approx. 330 kg spacecraft
- Approx 300 W of available power

## 4.3m ESPA In-line stack

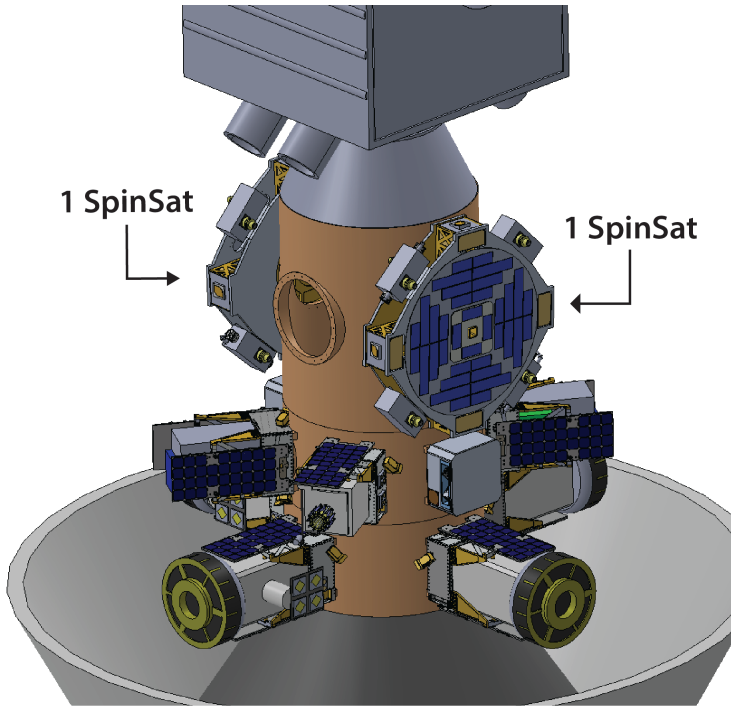



- 4.3m diameter
- Accommodate >300 “U” of science
- Approx. 1,000 kg spacecraft ✯
- Approx 4,000 W of available power

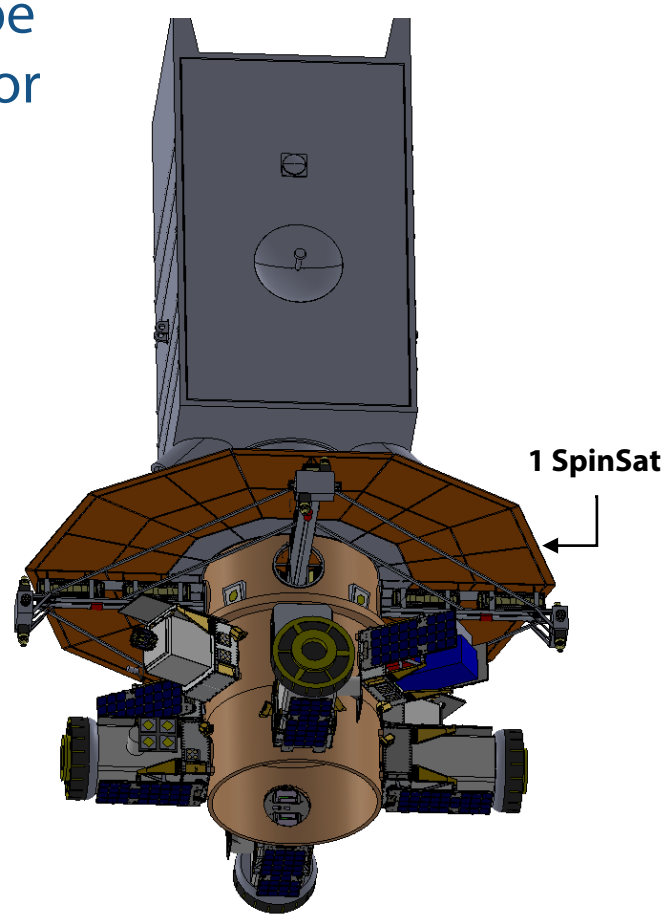
✯ includes 50% contingency

# SpinSat Can be Mounted Port or In-Line

SpinSat has flexible LV accommodations: experiments can be mounted axially, radially, or azimuthally w.r.t. the spin axis for both approaches

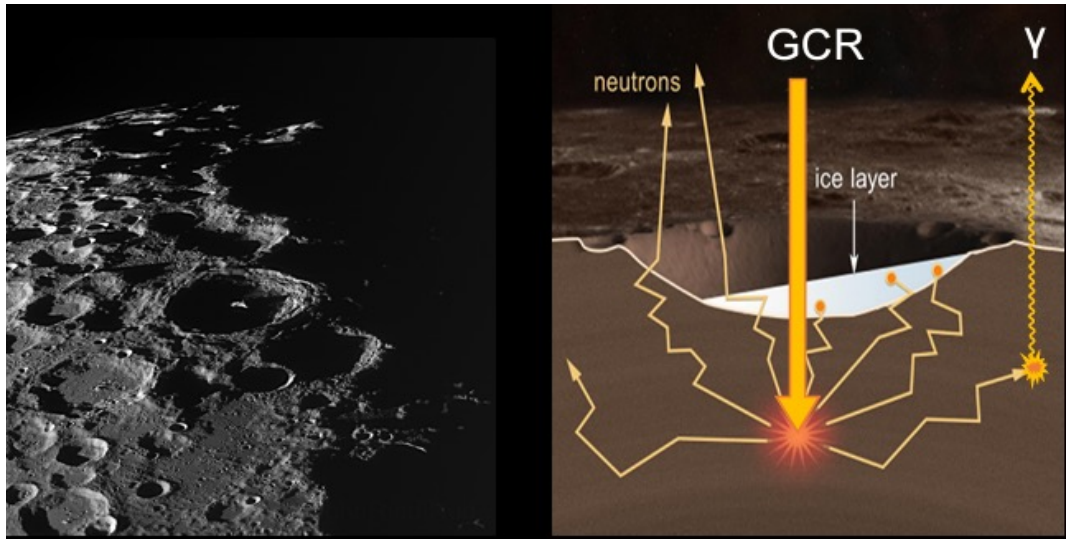



1.5m ESPA Port Mounted

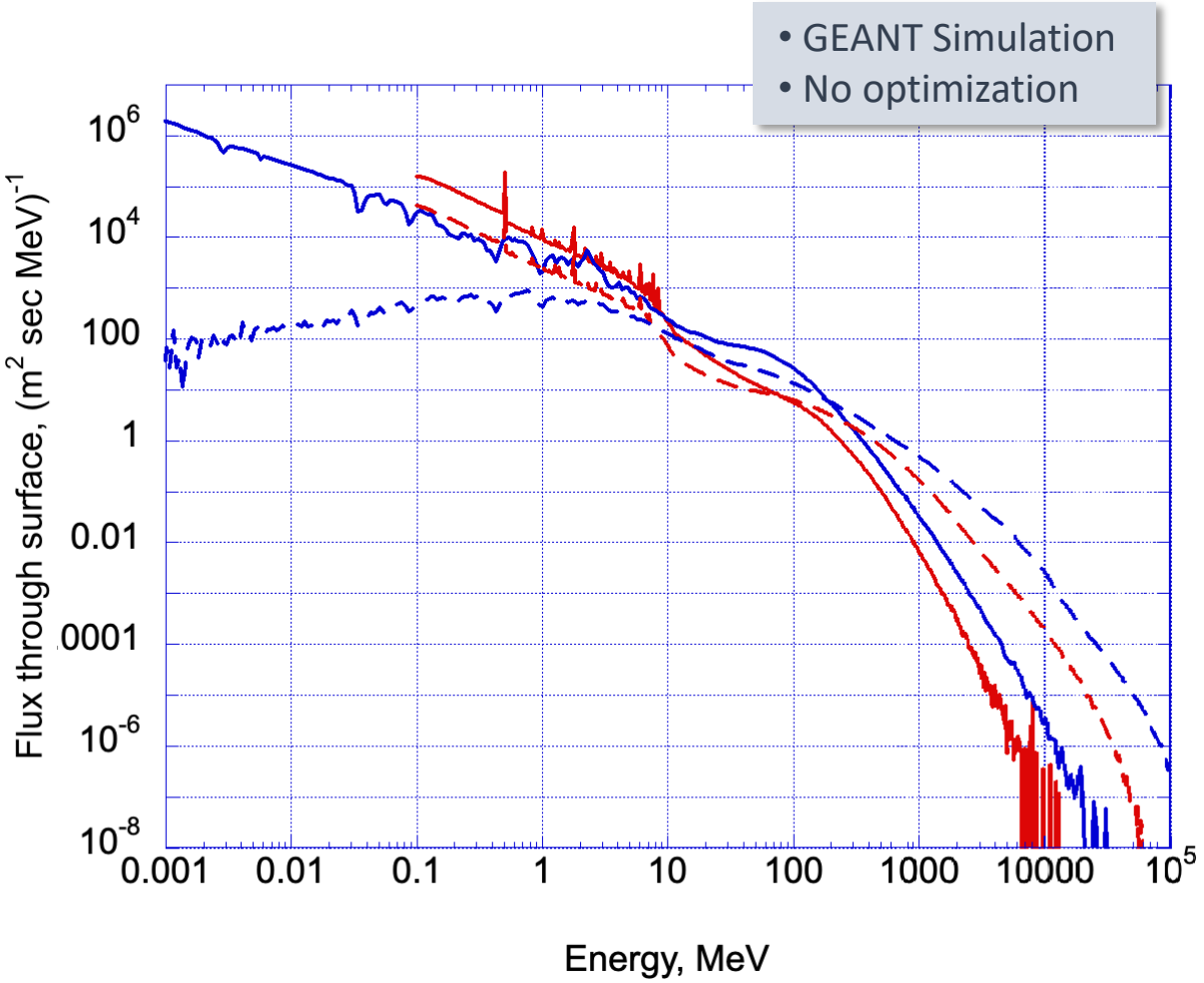



4.3m ESPA In-line Stack

# SpinSat can Simulate Lunar Environment

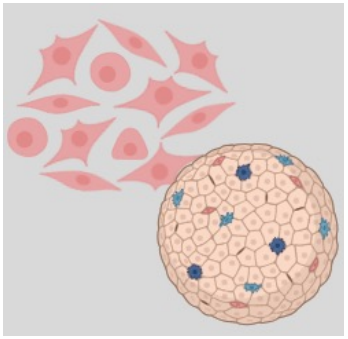



- **Fast neutrons cause direct cellular damage and also produce ionizing radiation**
- Lunar surface radiation environment can be approximated by including lunar regolith simulant surrounding the experiment
- Simulation of ferroan anorthosite (FAN) bombarded isotropically by GCRs, tabulated all particles except neutrinos coming out of the block



# Science Opportunities

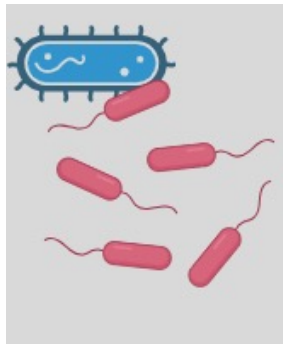
## Human Cells



- Stem cells
- Neurons/glia
- Intestinal cells
- Cancer cells

## Model Organisms

### Multicellular
- C. Elegans
- Tardigrades



### Bacteria
- Microbiome
- E. coli
- B. subtilis

### Yeast
- S. Cerevisiae
- S. Pombe
- Saccharomyces

### Plant
- Microalgea
- Cyanobacteria
- Arabidosis

## Synthetic Biology

## Investigational Focus

- Central Nervous System
- Cancer
- Bone and Muscle Health
- Pathogenesis and Wound Healing
- Microbiomics
- Pharmacologics
- Food Sources
- Environmental Control and Life Support

Assessment : DNA damage | Protein damage | Cell membrane damage | Mitochondrial damage | Germination | Growth | Tropisms | 2° metabolite production

# Take Aways


- There is insufficient knowledge of the health effects of space radiation and the space radiation environment to provide recommendations on crew exposure limits and design requirements for long-duration missions
- Current capabilities for providing the Biological & Physical Sciences (BPS) and Exploration Systems Development Mission Directorate (ESDMD) communities access to combined deep-space radiation and gravity ranges are limited
- Provides a platform for astrobiology experiments (PSD)
- SpinSat can provide environments to help answer many ESDMD, BPS, & PSD questions:
  - *Launched on a variety of launch vehicles into almost any orbit*
  - *Mount as an ESPA-port secondary payload*
  - *Provide at least 48 'U' worth of experiments per SpinSat*
  - *Configured for multiple SpinSats on a single launch*
  - *Cost effective*

# BACKUP

# Example Science Experiments


- Determine cellular sensitivities to deep space and lunar radiation environments
- Measure changes in cellular morphology, viability, metabolism
- Evaluate effects on DNA integrity and its maintenance/repair
- Understand the role and importance of oxidative stress
- Evaluate synthetic biology-enabled production of anti-oxidants (nutrients/proteins) under deep space and lunar surface conditions
- Study changes in the genome
- Study targeted changes in the transcriptome
- Study targeted changes in the proteome
- Study targeted changes in the metabolome
- Understand changes in pharmacological efficacy, specificity
- Study plant germination, growth, tropisms, 2° metabolite production, and produced food quality
- Characterize the effects of plant-microbe interactions

# BPS 2023 Decadal Linkages

## Adapting to Space

1. KSQ #1: How does the space environment influence biological mechanisms required for organisms to survive the transitions to and from space, and thrive while off Earth?
2. KSQ #3: How does the space environment alter interactions between organisms?

## Probing Phenomena Hidden by Gravity or Terrestrial Limitations

1. KSQ #1: What are the mechanisms by which organisms sense and respond to physical properties of surroundings, and to applied mechanical forces including gravitational force?

## Living and Traveling in Space

1. KSQ #1: What are the important multi-generational effects of the space environment on growth, development, and reproduction?

*SpinSat can directly address the #1 science question in each of the three themes*