Space Exposure Science on the ISS

A primer for new researchers

The International Space Station

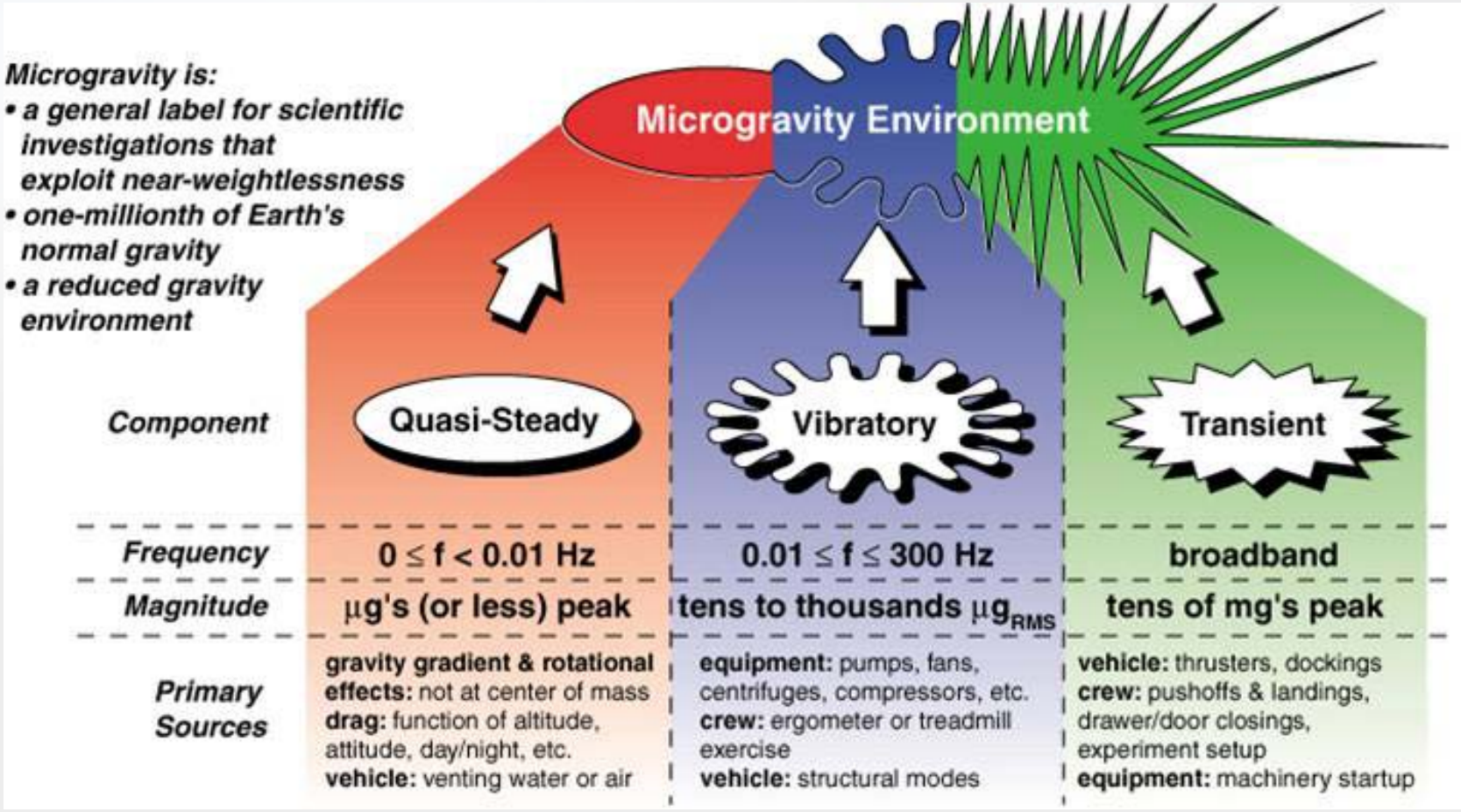
A Unique Platform for Science

- Crew tended
- Suitable for long-term studies

Critical Capabilities

- Microgravity
- Exposure to the thermosphere
- Observations at high altitude and velocity

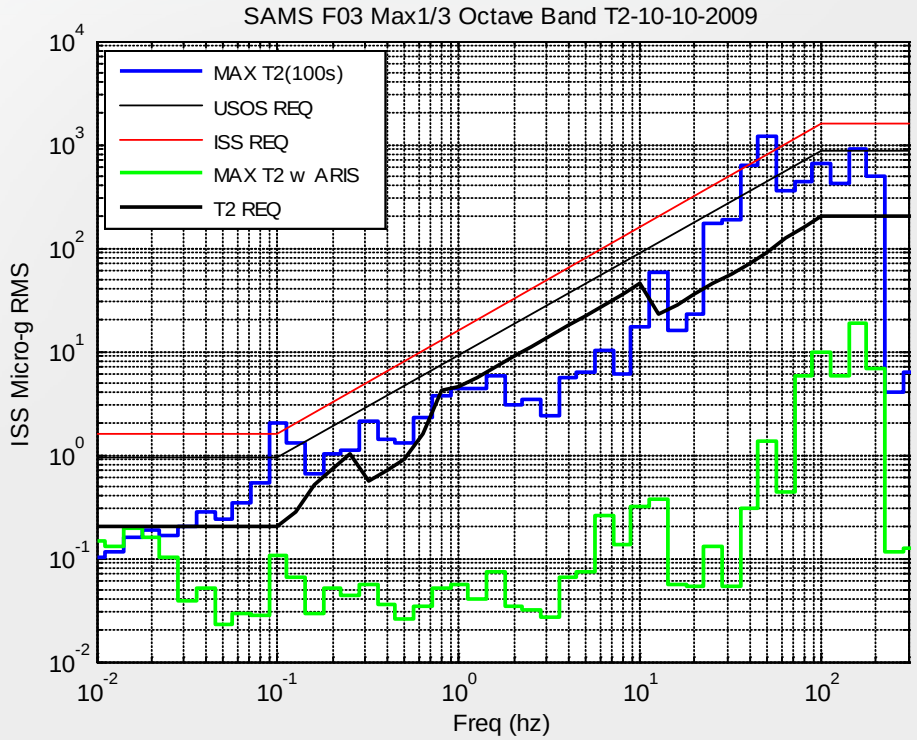
The Microgravity Environment

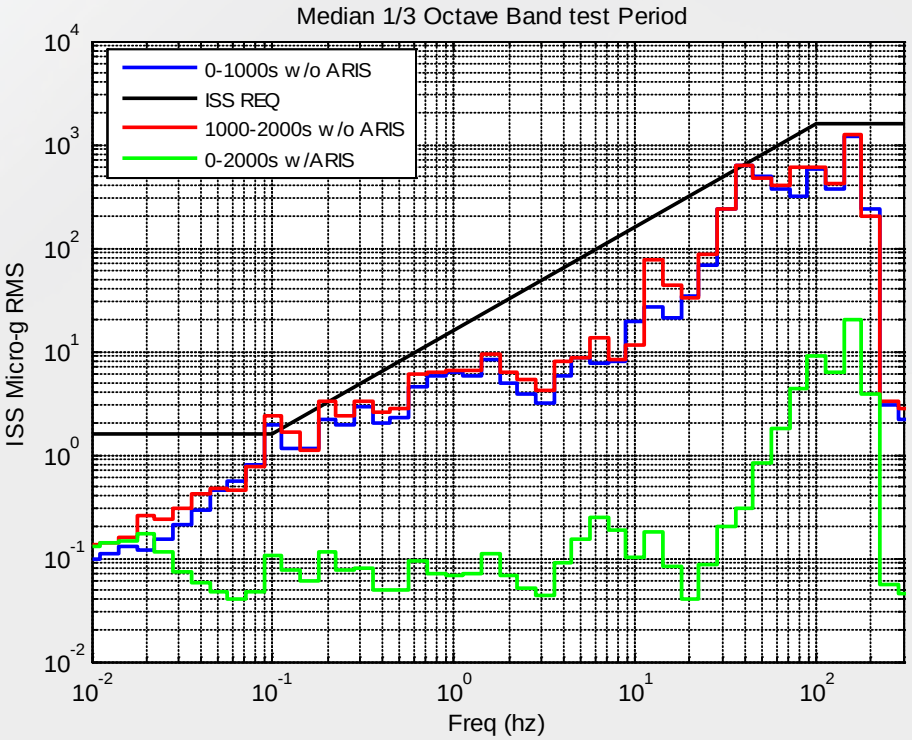


The Microgravity Environment

On-board sensors monitor perturbations to the microgravity state on the ISS.

Even without the Active Rack Isolation System, vibrations are typically within ISS requirements.



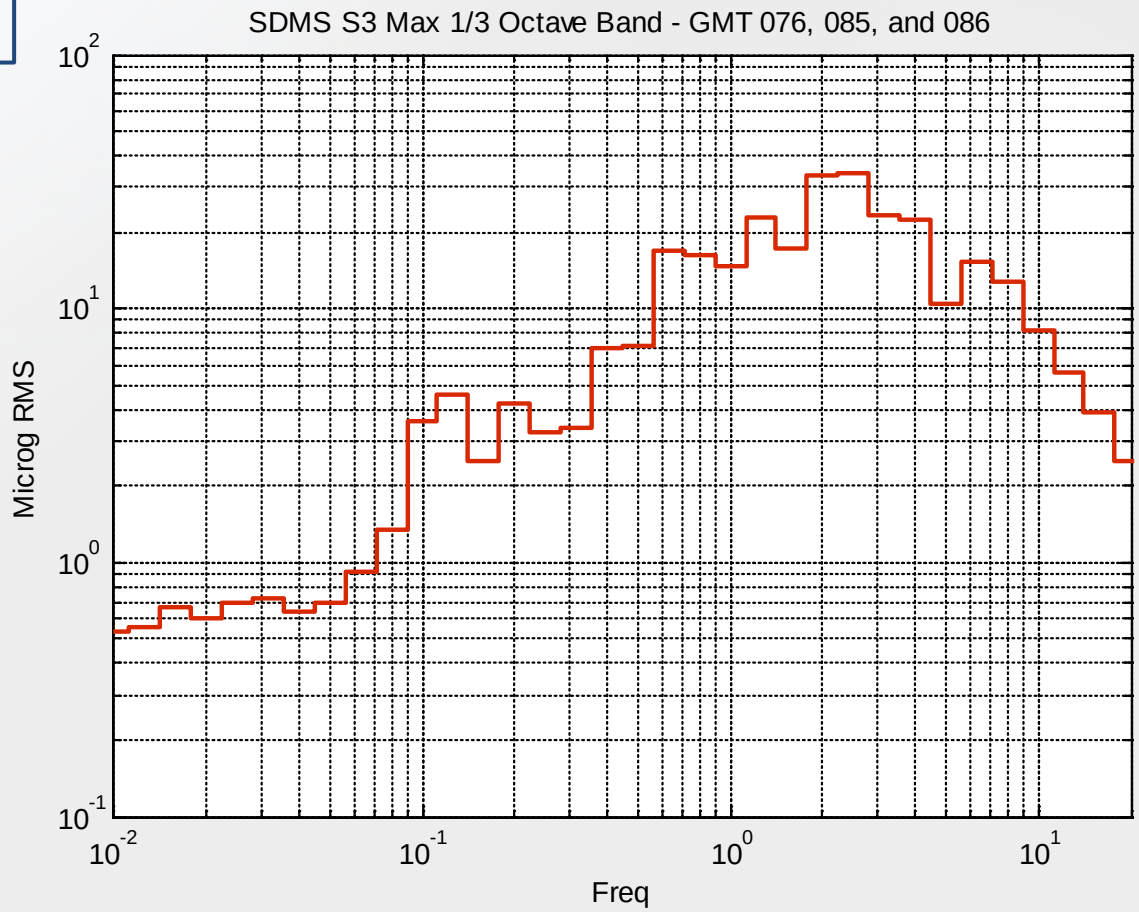


While the Station is at its most "quiet" during the eight hours of crew sleep, the Active Rack Isolation System can be effective even during crew exercise.

ISS Truss Vibratory Environment For External Payload Pointing Instrument

Data measured on ISS S3 truss

- ISS quiescent mode = No thruster firings, dockings, EVA, or robotics operations
- Typical response, not worst case
- Maximum per octave band
- Snapshot of 3 10-minute data takes
- All data taken on March 16, 26, and 27, Stbd SARJ Rotating, exercise, 3 crew.

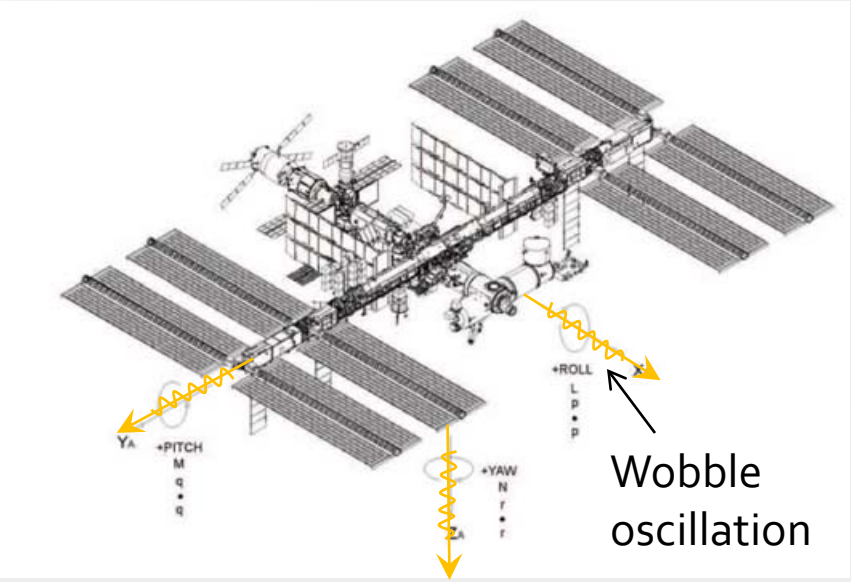


ULF-4 analysis concluded peak ELC rotations on the order of 0.03 degrees (quiescent mode)

Data provided by Boeing, June 2010

ISS Attitude Torque Equilibrium Attitude (TEA) & Wobble Oscillation Description

For Stage configurations (i.e.; no Orbiter or Orbiter sized vehicle docked on the ISS) in the foreseeable future, the predicted TEA ranges are:
Roll: -1.0 ~ +3.0 deg
Pitch: -7.0 ~ +2.0 deg
Yaw: -15 ~ +15 deg.

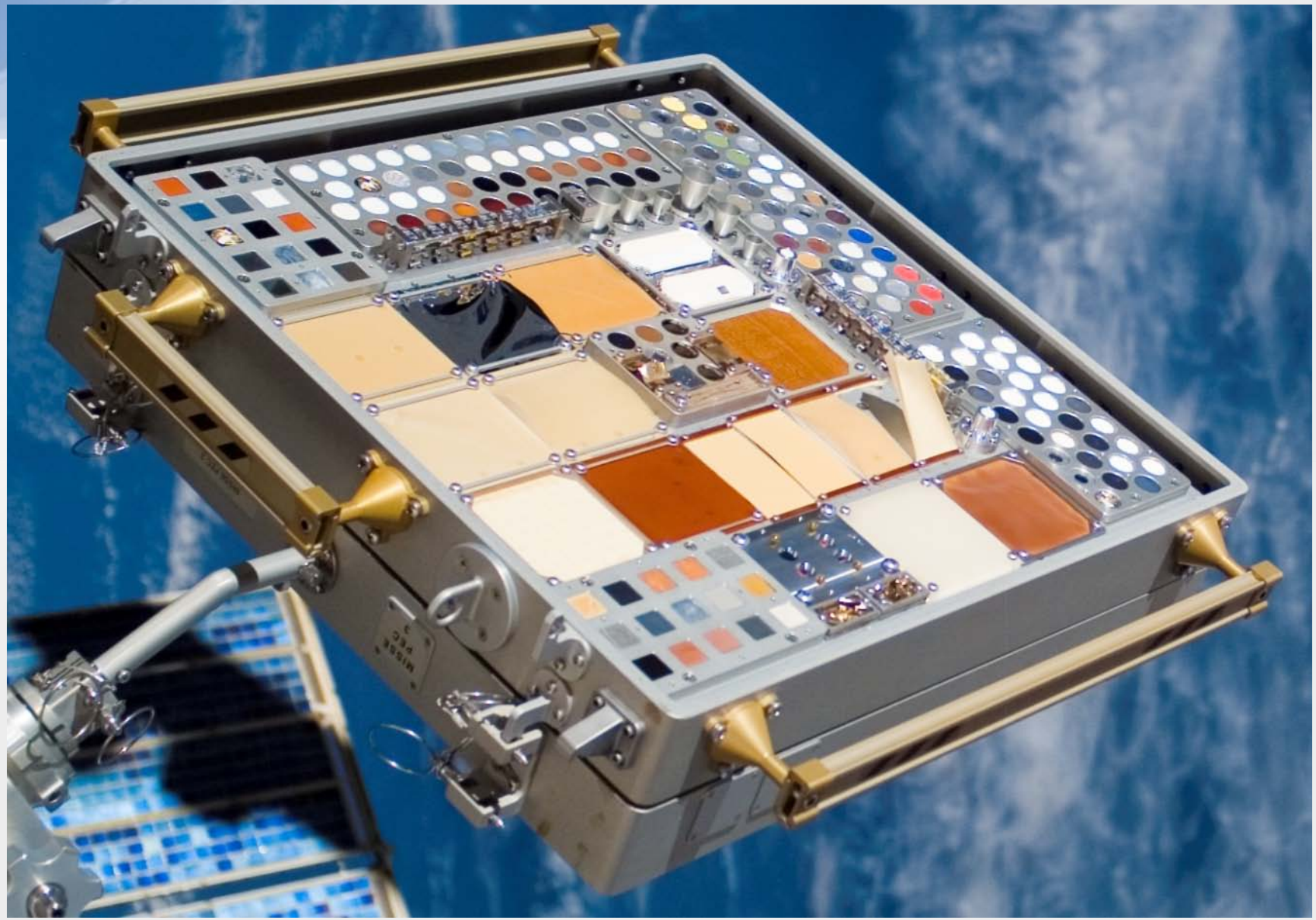


Momentum Manager Controller Peak to Peak Attitude Wobble Oscillation

Performance Descriptions	Peak to Peak Attitude Oscillations Per Orbit			Peak Attitude Variation from Steady-State Orbit-Average Attitude		
	Roll (X) (deg)	Pitch (Y) (deg)	Yaw (Z) (deg)	Roll (X) (deg)	Pitch (Y) (deg)	Yaw (Z) (deg)
Non-Micro-Gravity (Assembly Stages) Non-Propulsive (Momentum Manager) Attitude Control Performance Requirement	10.0	10.0	10.0	+/- 5	+/- 5	+/- 5
Micro-Gravity (Assembly Complete) Non-Propulsive (Momentum Manager) Attitude Control Performance Requirement	7.0	7.0	7.0	+/- 3.5	+/- 3.5	+/- 3.5
Typical Steady-State Performance of **Minimum** *CMG momentum oscillation* Momentum Manager Controller	1.6	1.6	2.0	+/- 0.8	+/- 0.8	+/- 1
Typical Steady-State Performance of **Minimum** *Attitude oscillation* Momentum Manager Controller	1.6	0.4	0.2	+/- 0.8	+/- 0.2	+/- 0.1
Typical Steady-State Performance of **Minimum** *CMG momentum & Attitude oscillation* **Blended** Momentum Manager Controller	1.6	0.7	1.2	+/- 0.8	+/- 0.35	+/- 0.6

Thermosphere Exposure

- Rarified gasses stratify by molecular diffusion
  - Oxygen, nitrogen, hydrogen, helium
  - Total density varies between 10^{-12} and 10^{-13} kg/m^3
- UV absorption heats resident molecules (1500-2500°C)
  - Energy lost by thermal radiation greater than heat transfer from gas contact
  - External ISS temperatures vary between -200°C (night/shadow) and 200°C (day)
- ISS resides in the F region of the ionosphere
  - Atomic oxygen dominant, flux of up to 4.4×10^{19} atoms/cm^3/day
  - Highest concentration of free electrons & ions: up to 106 e/cm^3



The Radiation Environment

- Average dose of 532 microSv/day (inside ISS)
- About 15% of the tissue damaging dose (effective dose) is from short-ranged neutrons and protons that were created within the spacecraft materials
- About 90% of the crewmember dose is due to particles that deposit less than 150 keV/micron
- External exposure only limited by structural shadowing and natural protection from Earth's magnetosphere

Opportunities on the ISS

- External remote sensing
  - HREP-RAIDS experiment measures limb electron and neutron density profiles, composition, and temperature of ionosphere
- External exposure platforms
  - MISSE experiments subject materials, films, coatings, etc. to vacuum, UV, ionizing radiation, thermal flux, atomic oxygen
  - Future technology testbeds will characterize operational parameters for new space systems (example: in-space propulsion, inflatable structures, ISS companion microsats)
- Internal dosimetry
  - CubeLab dosimeters measure internal radiation environment
- Deployable payloads from ISS cargo launches
  - Firefly will detect & characterize Terrestrial Gamma Ray flashes