Low-Power Multi-Aspect Space Radiation Detector System

National Aeronautics and Space Administration

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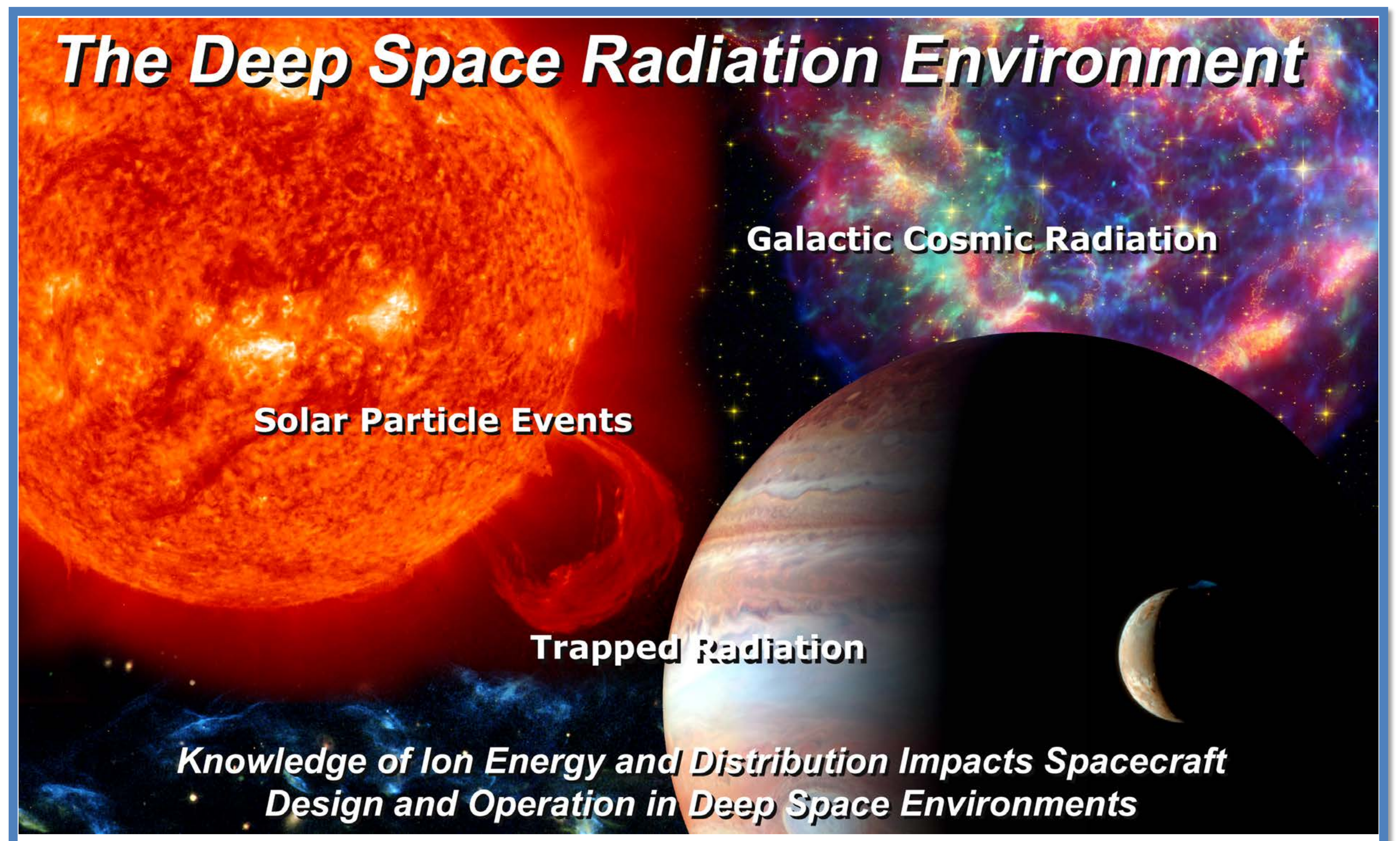
Abstract

The advanced space radiation detector development team at NASA Glenn Research Center (GRC) has the goal of developing unique, more compact radiation detectors that provide improved real-time data on space radiation. The team has performed studies of different detector designs using a variety of combinations of solid-state detectors, which allow higher sensitivity to radiation in a smaller package and operate at lower voltage than traditional detectors [1-3]. Integration of all of these detector technologies will result in an improved detector system in comparison to existing state-of-the-art (SOA) instruments for the detection and monitoring of the deep space radiation field.

The Deep Space Radiation Environment



Radiation Detector Issues for Exploration

- Improvements of existing models will impact spacecraft design and posturing during mission operations
- Deep space environments and outer planetary radiation belts need improved understanding for localized time and statistical variations of steady state and "storm" conditions
- Current radiation detector technology is limited in lifetime, precision, discrimination, and directional sensitivity for the mass, power, and volume requirements for future missions [4-7]

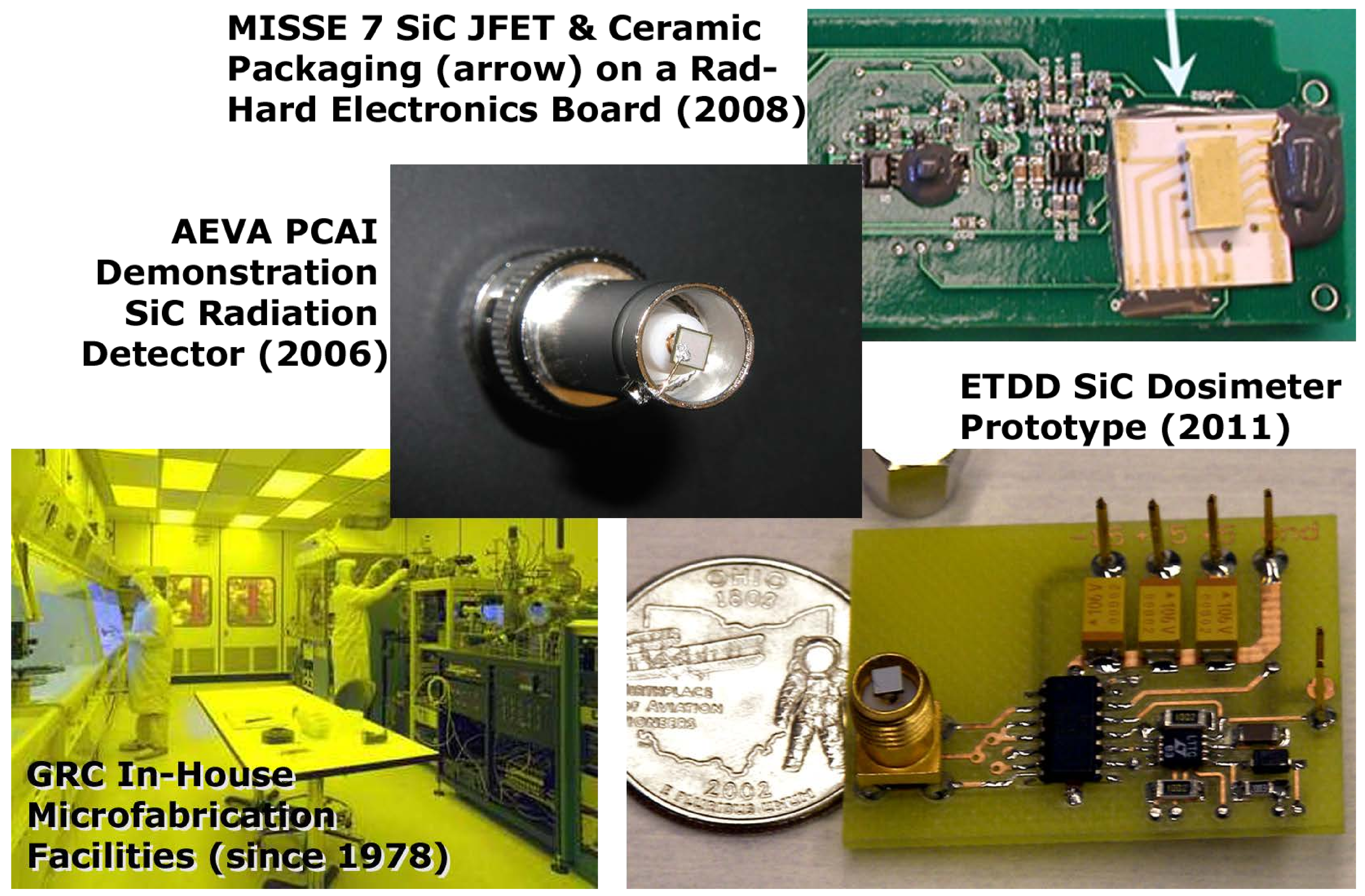
Challenges & Solutions

- Mapping of heavy ions > 200 MeV/amu
  - ✓ *Solution*: Integrated solid-state Cherenkov detector system with large area detectors
- High radiation flux rates for 10+ year missions
  - ✓ *Solution*: Precision rad-hard, thermally stable wide band gap detectors
- Low noise, multi-directional measurements at single locations
  - ✓ *Solution*: Compact, spherical detector system

Approach:

- Develop new robust, low power, thermally stable solid-state technologies as radiation detectors to improve lifetime, power and noise performance
- Demonstrate omni-directional measurements of radiation using novel integrating techniques
- Integrate multiple types of detectors and materials to expand energy range and sensitivity for lower mass, power and volume requirements

Advanced Radiation Detector Technology Research & Development at NASA GRC



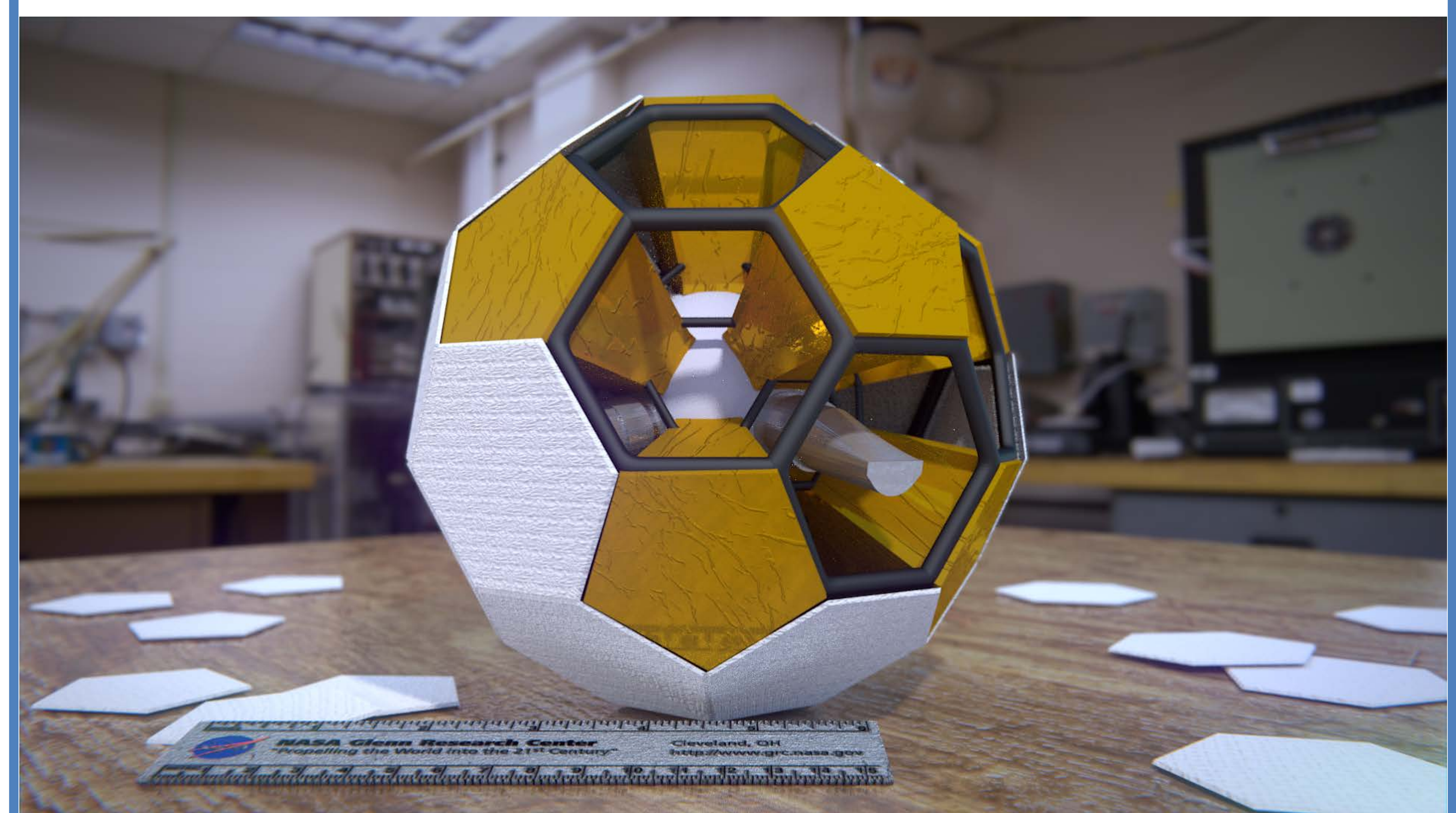
GRC Instrumentation Research Expertise & Capabilities for Space Radiation Environments

Application of GRC Expertise and Facilities in:

- Harsh Environment Thin Films
- Silicon Carbide (SiC) Devices & Harsh Environment Packaging
- Micro-Optics
- Radiation Shielding Materials

Research Objectives

Develop detector technologies to enable a low-power radiation detector system capable of monitoring a wide range of high energy heavy ions (HZE ions) over a spherical (4π) aspect area [8,9]



Design Concept for a Spherical Space Radiation Detector System (cables not shown for clarity)

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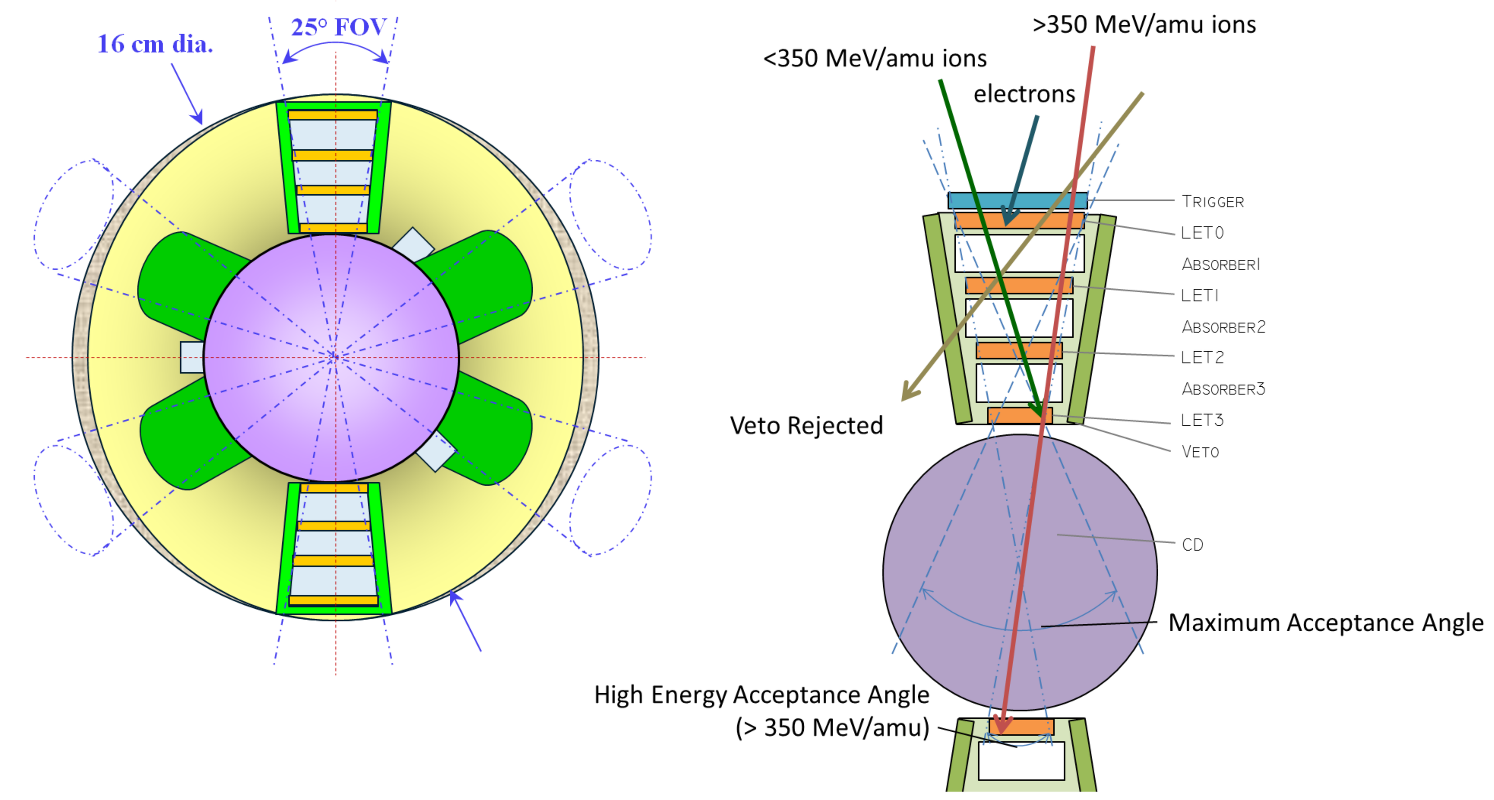
Concept System Design



A concept schematic drawing of a spherical detector system comprising a spherical Cherenkov detector, surrounded by various arrays of detector stacks is shown above. Potential improvements over state-of-the-art (SOA) are shown in the table below.

SIS CRM Metric	CRM SOA	Improvement Enablers	Detector System Expected Performance
Energy Range	140 MeV/amu	Integrated Detectors	1,000 MeV/amu
Energy Resolution	±30 keV	Low Noise Detectors	±25 keV
Angle Coverage	0.3 cm²-sr	Spherical Geometry	1 cm²-sr
Angle Resolution	±14°	Solid State Detectors; Spherical Geometry	±12°
Particle Species/Charge	Multiple in multiple detectors	Integrated Detectors	e – Fe
Miniaturization (Mass, Power, & Volume)	Defined by Detectors	Integrated Solid State Detectors	30% SOA

Enables:

- Improved temperature insensitivity to changes induced by transitions from sunlight into shadow (and vise-versa)
- Improved precision with lower mass, power and volume requirements
- Improved radiation discrimination and directional sensitivity
- Unique monitoring of radiation environment of high relevancy for planetary exploration from all directions of the celestial sphere

References:

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