National Aeronautics and Space Administration

NASA

An Overview of Small Satellite Activities at NASA's Glenn Research Center

Concha M. Reid
Space Science Project Office
NASA Glenn Research Center

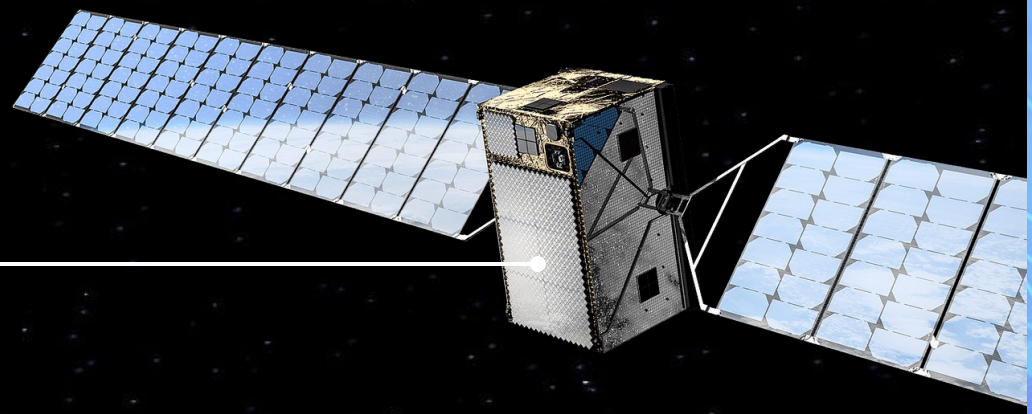
Small Satellite Conference, August 5-10, 2023

NASA GRC Small Satellite Efforts

Utilizing our unique capabilities and leveraging our partnerships to develop innovative technologies that enable new and exciting discoveries on Earth and In-Space

SmallSat Ka Operations User Terminal (SKOUT)

POC: Felix Miranda, felix.a.miranda@nasa.gov



Based on 5G Technology

Leverages Ka commercial timescale improvements at mass production costs

High-Rate Small Form Factor Payload

Fully integrated communications payload in a 1U form factor capable of providing up to Gbps data rates

Complete, Modular Communications Solution

Tiled architecture extensible from CubeSats to traditional large satellite user missions

Eliminates Mechanical Gimbal/Body Pointing

Electronically steered antenna provides near instantaneous pointing and tracking without disturbing spacecraft operations

Bringing 5G technology to Space

A Partnership Between NASA CESIUM

SBIR·STTR
America's Seed Fund™
POWERED BY NASA

Z8.02-1723 - Adapting 100G Optical Comm to Unique NASA Small Satellite DSM Applications

PI: Mark Storm , Fibertek, Inc. - Herndon, VA

NASA

NON-PROPRIETARY DATA

IDENTIFICATION AND SIGNIFICANCE OF INNOVATION

This SBIR will mature 100G optical transceiver and amplification technology to TRL 6 for GEO, lunar and Lagrange points using mature low-cost and low size, weight, and power (SWaP) technologies. We address specific performance with an emphasis on long mission duration and high reliability vs short LEO missions.

Our link budget in indicates that 100G-200G is feasible, small telescopes can support lunar, L1 and L2 ranges.

- Enable GEO-GEO intersatellite ling and GEO Lunar, and potentially L1 and L2 ranges direct to earth links.
- Ultra-low SWaP-C and can be expanded to Tbps with multiple modules.
- Enabler to expand NASA human spaceflight operations, telerobotic, HD video and SMD science for GEO, and Lunar missions.
- Enables NASA Heliophysics vision for affordable, sun-sensing SmallSat constellations at L1, L2 for space weather, astronaut safety missions
- Technical approach leverages terrestrial fibercom photonic integrated circuit (PIC) at low cost for space
- Ready for program insertion and available to the space FSO industry in 2025

TECHNICAL OBJECTIVES AND PROPOSED DELIVERABLES

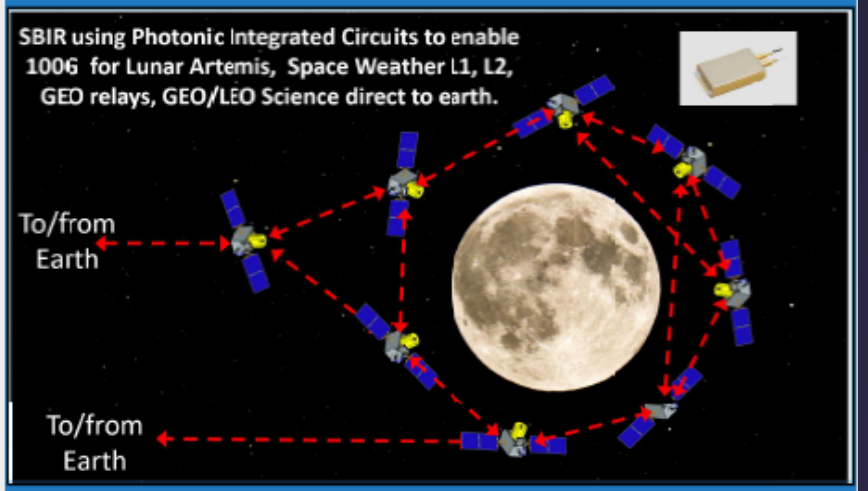
This SBIR proposes to develop a very low SWaP, (0.5 U) 100 G transceiver (TRX) card that supports GEO lunar and Lagrange laser communications to Earth and DSM optical inter-satellite links. During Phase I we conducted design and risk reduction activities that established feasibility to develop a TRL 6 prototype in Phase II.
The Phase 2 objectives of this SBIR include the following:

- Engineer a < 1 U CubeSat sized 100G transceiver ready for mission insertion.
- Demonstrates the unit meets unique to GEO, lunar and beyond practical free space links and support a link that tolerate: amplitude fluctuations, low dispersion, doppler shifting, and background noise.
- Demonstrate the unit meets radiation, vibration and thermal vacuum requirement for general aerospace industry use.
- Validate that short pulse 100G signals can be amplified to highpowers with minimal distortion and can support coherent communications

TRL

Estimated

IMAGE TITLE: Small Sat 100G for DSM



NASA APPLICATIONS

- Support Lunar Artemis human exploration missions
- NASA state-of-the-art mesh networked lasercom capability to support SCaN deployment of optical communications
- Deep Space & Heliophysics – Space weather, Sun studies out to L1, L2 at 100 Gbps
- Near Earth science missions – Increased data rate for SmallSat sensors
- Near Earth GEO and cis-lunar, lunar orbital, Lagrange Point L1, L2
- Future NASA SmallSat and CubeSat constellations with science missions that need optical coms to support high data rates including multispectral imaging sensors

NON-NASA APPLICATIONS

- DoD and U.S. Government for intelligence imagery. GEO, MEO, LEO
- CLPS commercial lunar payload services companies
- High data-rate, low-cost commercial optical communications from LEO/GEO satellites

FIRM CONTACTS

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WBG LET Charged Particle Telescope

POCs: John Wrbanek, john.d.wrbanek@nasa.gov; Susan Wrbanek, susan.y.wrbanek@nasa.gov

Phase I

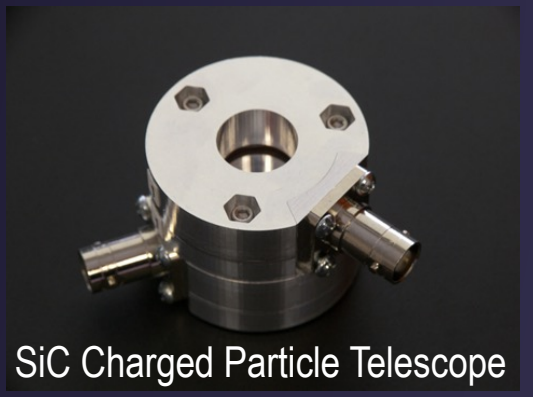
- Designed, fabricated, packaged and tested four LET detectors singly and configured as stacked pairs
- Improved performance and stable operation of the telescope design
- Phase I Telescope Specs:
  - Telescope Size: 4.375 cm dia. x 3.50 cm tall
  - Aperture Size: 200 mm^2
  - Geometric Factor: 0.5 $sr \cdot cm^2$
  - Field of View: 62°
  - Detector: HPSI 4H-SiC, 1000Å Pt/Ti (anode), 1000Å Ni/Ti (cathode)
  - Die Size: 1.778 cm x 1.778 cm square
  - Capacitance: 56.7 ± 1.5 pF

Phase II currently underway

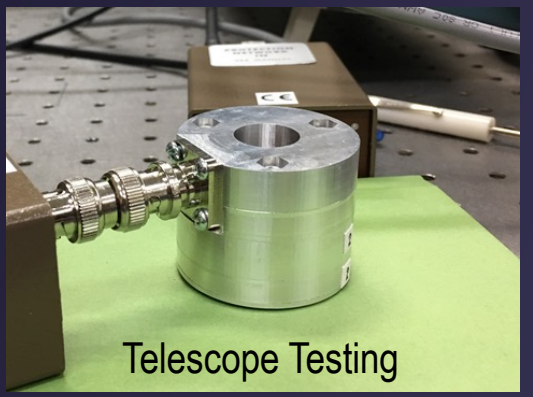
- Accommodate smaller connectors
- Measure a spectra

Future plans beyond Phase II

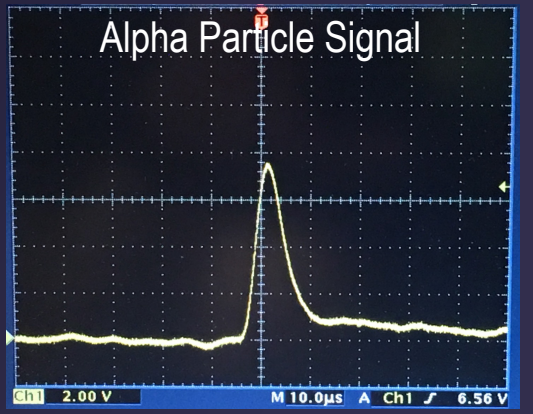
- Integration of charge amplifiers into the package
- Accelerator beam line tests



SiC Charged Particle Telescope

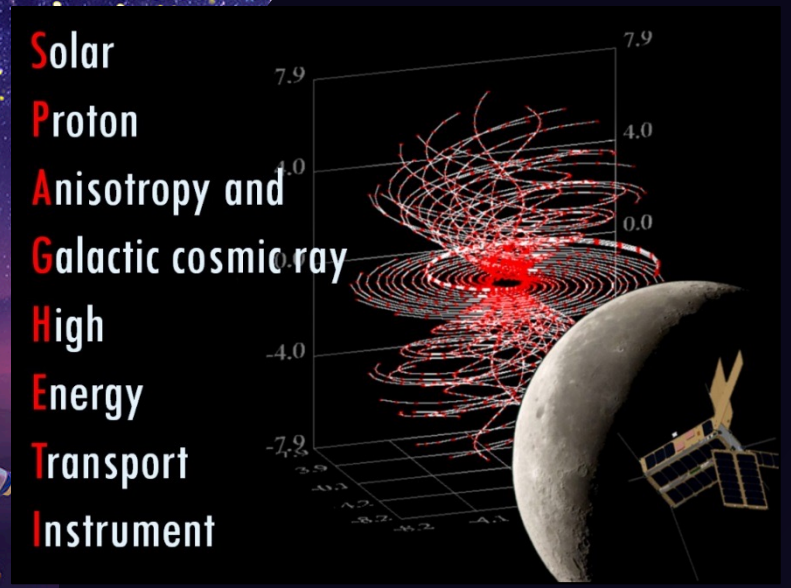


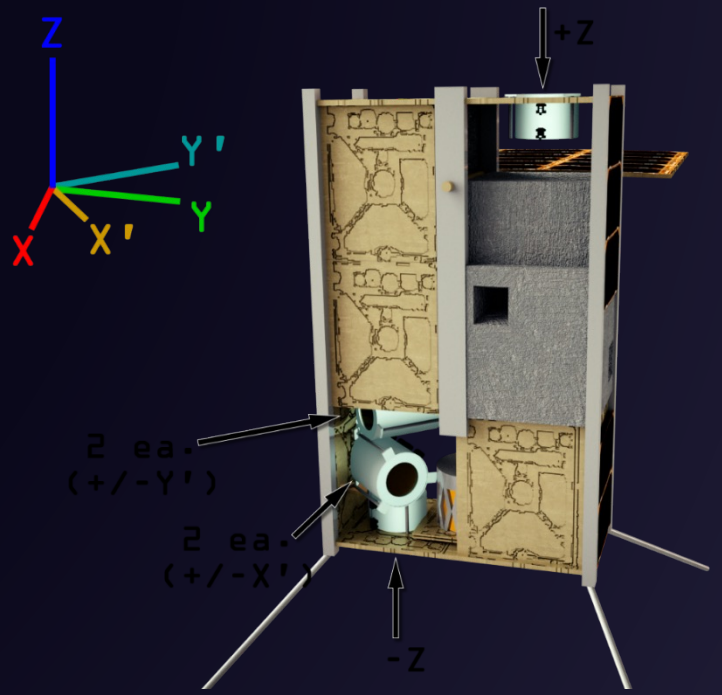
Telescope Testing

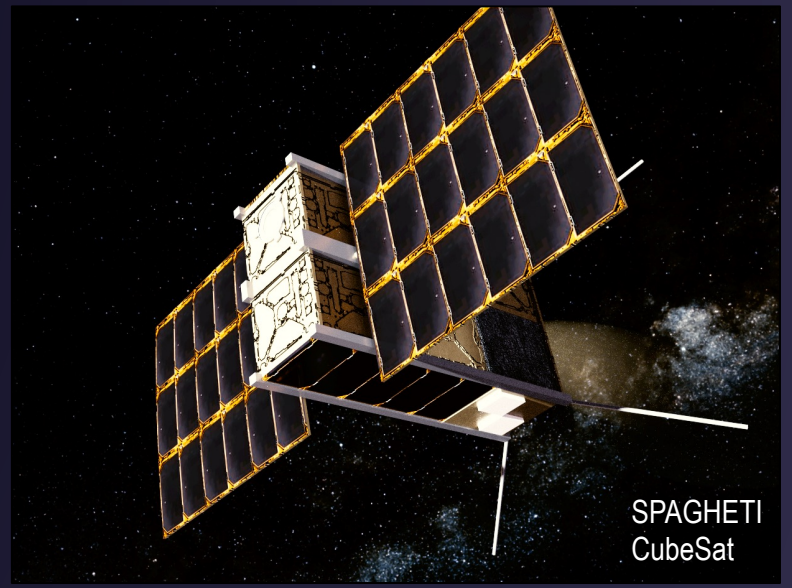


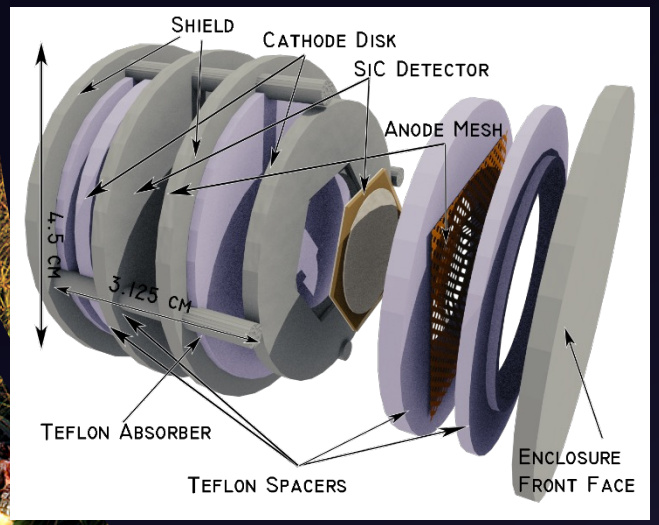
SPAGHETI: Deep-Space CubeSat Concept

POCs: John Wrbanek, john.d.wrbanek@nasa.gov; Susan Wrbanek, susan.y.wrbanek@nasa.gov









SiC LET Detector Stacks

Exploration of the transient variations in ion flux anisotropy in deep space and near the lunar surface

Features:

- 6 packages of SiC Linear Energy Transfer (LET) detector stacks, arranged to provide simultaneous multidirectional measurements
- Detector insensitivity to temperature changes will allow compact, low-power operation

NanoSonic Inc., NASA Ames Research Center, and NASA Glenn Research Center Technology Demonstration for Small Spacecraft

GRC POC: Susan Wrbanek, susan.y.wrbanek@nasa.gov

New lightweight composite structural and shielding material

- Developed by NanoSonic Inc. under a NASA Small Business Innovative Research (SBIR) contract

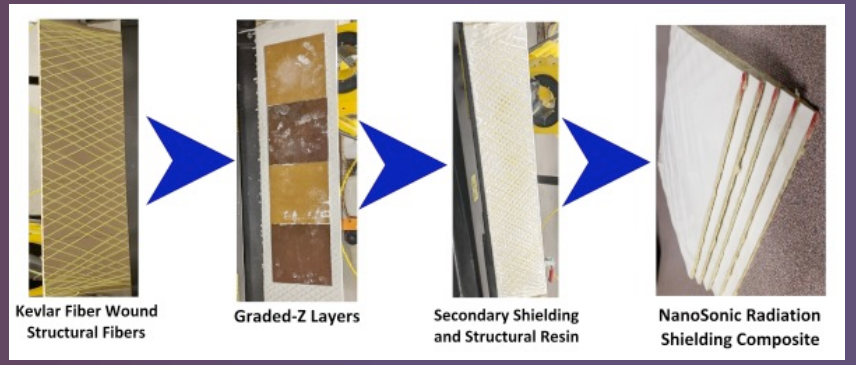
May offer increased mission lifetime and improved functionality for small satellites

- Protection of electronics from damage by space radiation

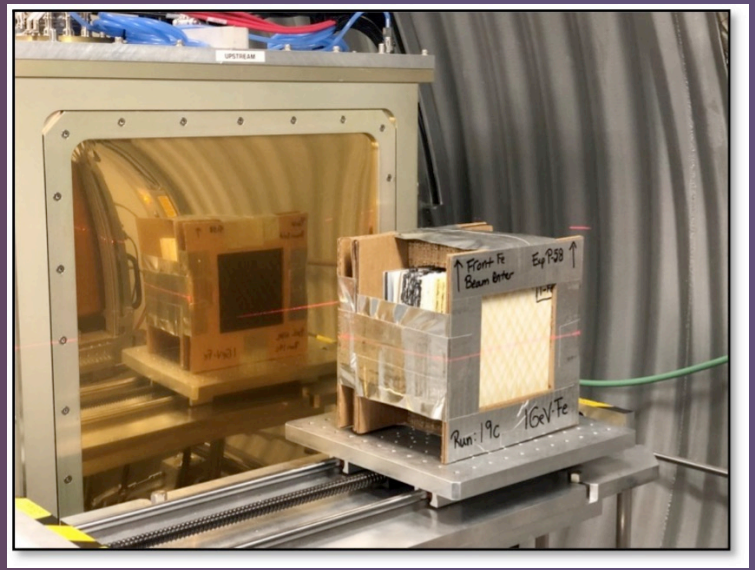
Planned for a CubeSat demonstration flight in Autumn 2024

- NanoSonic material development PI: Dr. Jennifer Lalli
- ARC CubeSat mission personnel: Ali Guarneros Luna, Avery Brock (Wyle Services LLC), Dr. Rudolphe De Rosee
- GRC COR and Science Demonstration PI: Susan Wrbanek

Applications: Commercial subsystems, Gateway, long missions to the Moon, Mars or Jupiter, and human missions



Material Development



Ground testing

Satellite Hosting Atmospheric and Littoral Ocean Water Sensors

POC: John Lekki, john.d.lekki@nasa.gov

Software Defined Hyperspectral Imaging System for large or small Earth Science and Planetary Science missions

Features:

- Small size
- Low power requirement
- Rapid deployment

Characterization of:

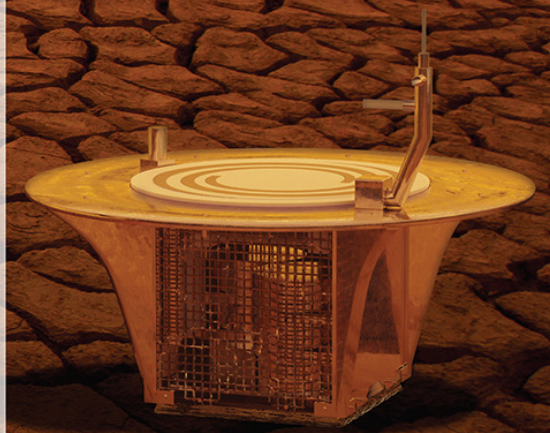
- Coastline water changes due to global warming
- Water/ice interfaces
- Atmospheric content and distribution (Earth and outer planets)
- Surface composition (Earth and outer planets)
- Ice content of planetary surfaces (Earth, outer planets, moons)

Platforms: Aircraft, UAVs, drones (Earth and outer planetary), high altitude balloons, CubeSats, small and large satellites

Long-lived In-situ Solar System Explorer (LLISSE)

National Aeronautics and Space Administration

- Small, long-duration lander for Venus
  - Designed to be an independent platform with all the needed subsystems (power, communication, sensors, ...)
- < 10 kg, < 20 cm/side at the base
- Operates for 60 days or more on Venus
- Enable compelling science by returning first ever temporal in-situ data
  - Meteorology (temp, pressure, radiance, wind speed and direction)
  - Atmospheric species abundances and variability
  - Future enhancements: seismometer, inclinometer, reaction chemistry analysis, accelerometer, camera system
- Will transmit measurements to a supporting orbiter to relay data to Earth



Principal Investigator: Tibor Kremic, tibor.kremic@nasa.gov, Program Manager: Nathan Funk, nathan.w.funk@nasa.gov

Future Concept: Compact Full-Field Ion Detector System (CFIDS)

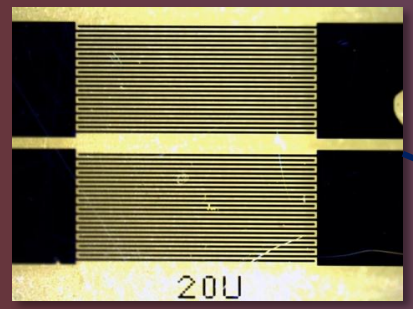
POCs: John Wrbanek, john.d.wrbanek@nasa.gov; Susan Wrbanek, susan.y.wrbanek@nasa.gov

Space radiation detector with spherical geometry

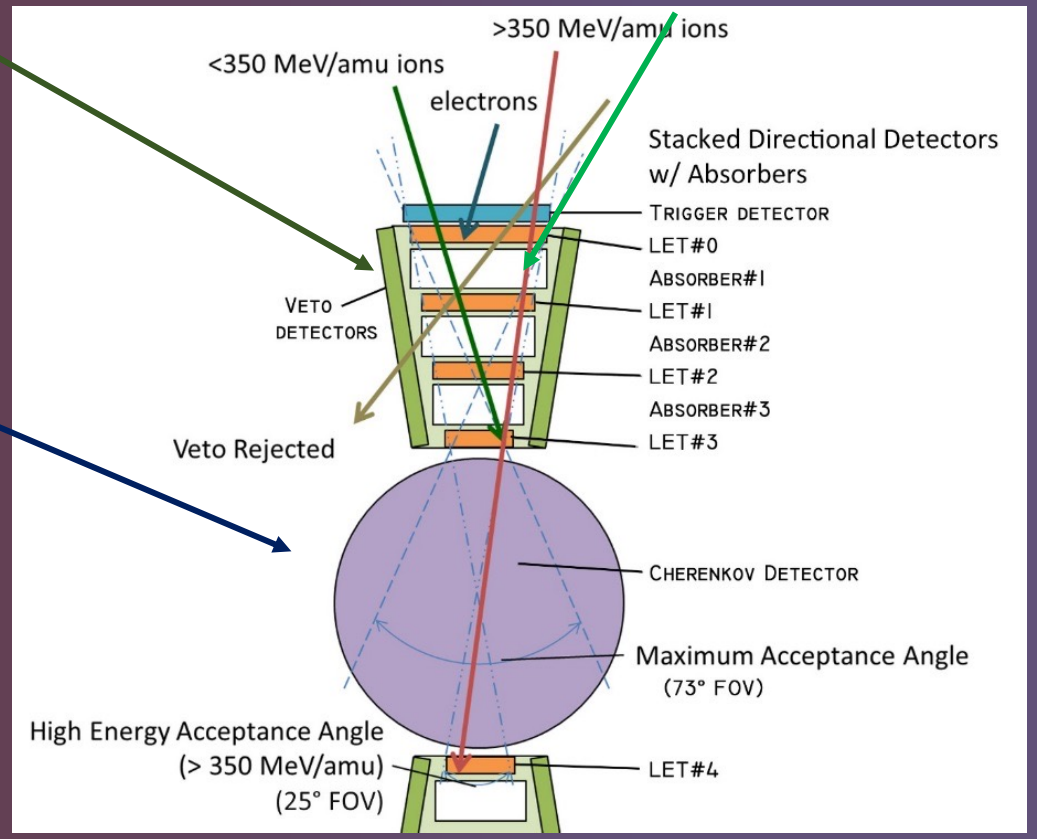
- Technology covered by U.S. Patents 7,872,750 and 8,159,669

Large Area SiC Diode for LET Detectors

GaP Diode for Solid-State Coincidence/Anticoincidence Detectors
(U.S. Pat. 10,429,521)



ZnO UV Sensor for Solid-State Cherenkov Detector
(U.S. Patent 10,054,691)



Wide Band Gap (WBG) detectors enable:

- Mapping of heavy ions > 100 MeV/amu
- High radiation flux rates for 10+ year missions
- Low noise, multi-directional measurements at single locations

NASA GRC Small Satellite Efforts

- Developing components, technologies, and systems
- Innovations to enable new science and exploration in harsh and unique environments
- Planetary Science and Earth Science Applications

Questions?

Concha M. Reid

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