Los Alamos NATIONAL LABORATORY

The Experiment for Space Radiation Analysis: Probing the Earth's Radiation Belts using a CubeSat Platform

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ESRA PDR

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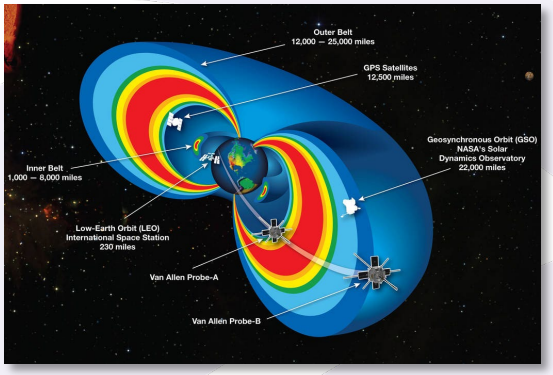
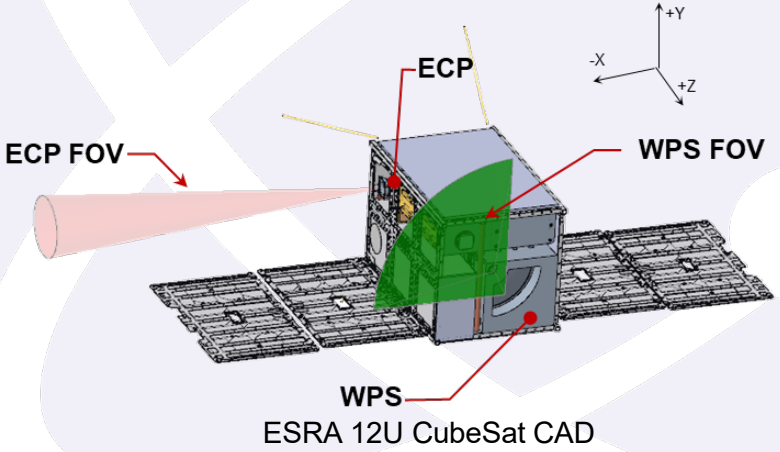
Mission Overview

- The Experiment for Space Radiation Analysis (ESRA) is a pathfinder for rapid Demonstration and Validation (DemVal) missions that LANL will fly on a 3 year cadence
- Primary goal is to provide TRL maturation (to TRL 6-8) and risk reduction for next generation systems
- ESRA will be one of the first CubeSats to operate in GTO
- Utilization of commercial spacecraft and ground station expertise allows for reduced risk and cost
  - Partnering with NanoAvionics for 12U bus
  - KSAT ground stations & services
- Enables LANL technical staff to focus on payload development
- Launch and integration provided by DoD Space Test Program (STP)



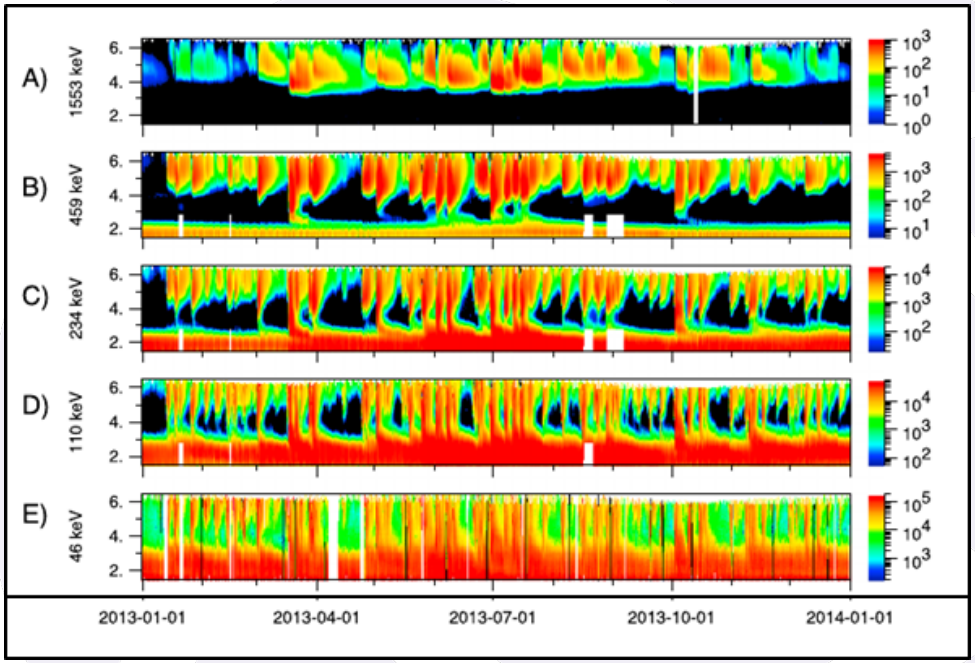
Earth's radiation belts illustrating the Van Allen Probe Mission in geostationary transfer orbit (GTO). Image courtesy of NASA



ESRA 12U CubeSat CAD

Mission Goals

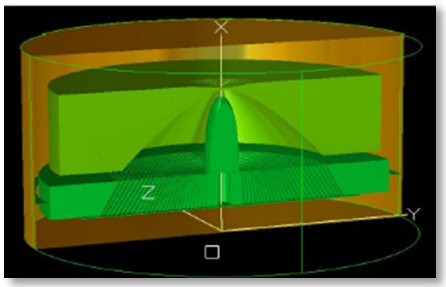
- Legacy space weather instruments provide a wealth of data but are resource intensive
  - Size, Weight, and Power - Cost (SWaP-C)
- Measurements of the local space environment are critical for anomaly resolution and addressing science questions
- A new generation of plasma and energetic particle sensors are being developed to provide the necessary data with lower SWaP-C
  - Wide-field-of-view Plasma Spectrometer (WPS)
  - Energetic Charged Particle (ECP) Telescope
- ESRA will achieve all mission requirements after six months
  - Bus shielding designed to last for 1 year based on the natural radiation environment
  - Payload anticipated to operate well beyond 1 year if the spacecraft can support
- After successfully demonstrating technology and providing risk reduction the payloads will contribute to scientific collection



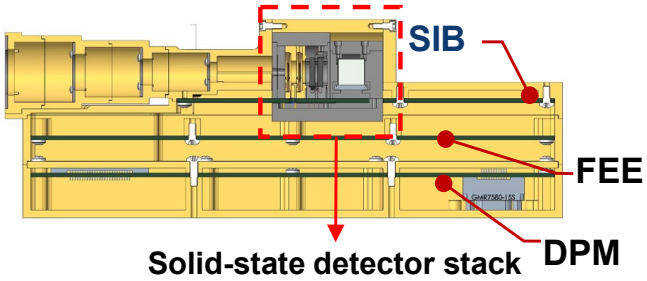
Reeves, G. D., et al. (2016), Energy-dependent dynamics of keV to MeV electrons in the inner zone, outer zone, and slot regions, J. Geophys. Res. Space Physics, 121, p. 397–412.

Sensor Payloads

Objective: On-orbit validation of the Wide-field-of-view Plasma Spectrometer (WPS) and Energetic Charged Particle (ECP) sensors' ability to measure proton and electron fluxes associated with the four major types of space environmental hazards: 1) total event dose; 2) single event effects; 3) deep dielectric charging; and 4) surface charging



Cross-section of full-size WPS CAD model



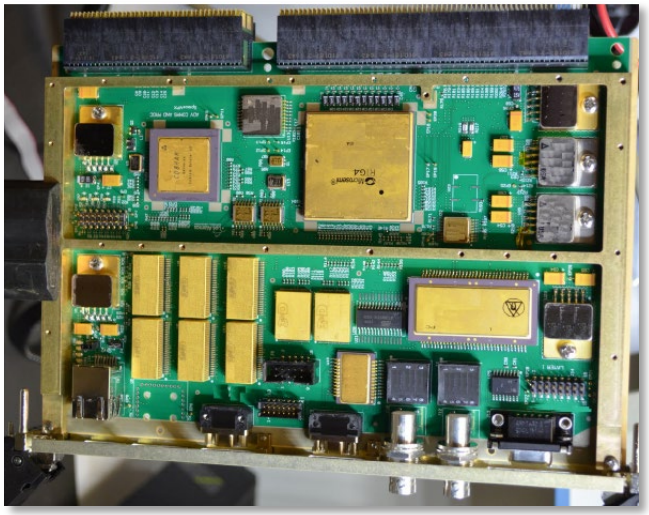
Cross-section of ECP telescope model

Description:

- The WPS will measure ions 0.1 – 35 keV/q
  - The WPS design is based on pin-hole camera concept, allowing for significantly increased field-of-view (FOV) compared to standard electrostatic analyzers
- The ECP telescopes will measure protons (p+): ≥100 keV – 500 MeV and electrons (e-): ≥100 keV – 20 MeV
  - CZT detectors allow for increased stopping power (shorter telescope with same energy range) when compared to standard silicon detectors
- Sensor performance can be compared against the previous AFRL Demonstration and Science Experiments (DSX), NASA Van Allen Probes, and GTOSat data sets
- WPS/ECP data will also be compared against the AE9/AP9 model

Critical Sub-System Payloads

Objective: Study and evaluate new technologies; Payload Processor, Distributed Processor Module (DPM), Flight Software (FSW) architecture, and High Voltage Power Supply (HVPS).



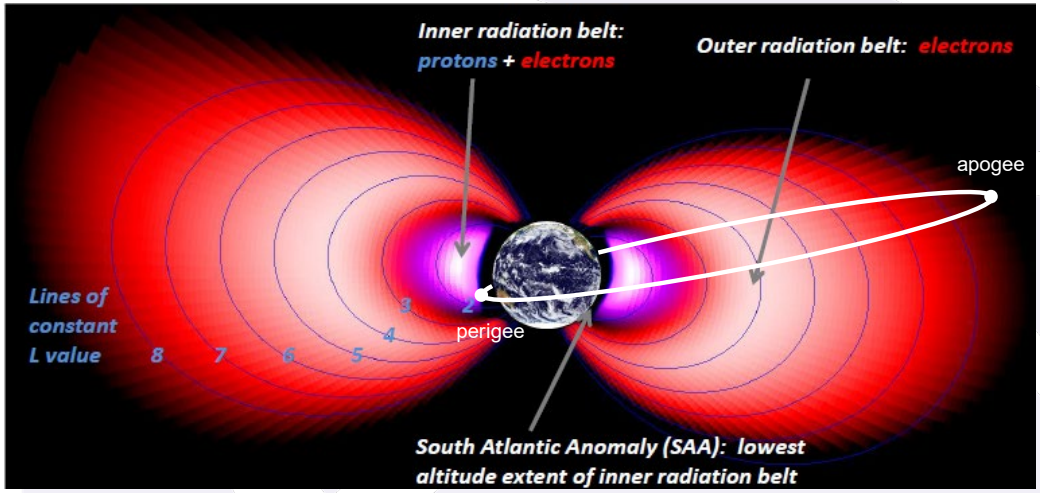
Payload Flight Processor evaluation board during bench top testing

Description:

- Provide technology maturation that can be evaluated for future LANL and NASA, missions
- Payload Processor (PP)
  - Employs a compact 3U Eurocard and open SpaceVPX architecture to reduce form factor while increasing performance
  - Will utilize quad-core LEON4 processor to provide lower cost, lower power, and high performance capability
- Distributed Processor Module (DPM) for “smart sensors”
  - Utilize low-power FPGAs, microcontrollers, and flash memory to provide C&DH at the sensor head location
  - Enables non-conventional layouts for sensor/instruments relative to central flight processors
- High Voltage Power System (HVPS)
  - Develop modular HVPS
  - VPX compliant form factor, standardize low voltage design, & plug in HV elements
- Flight Software (FSW)
  - Validate a generic and re-usable framework for future missions

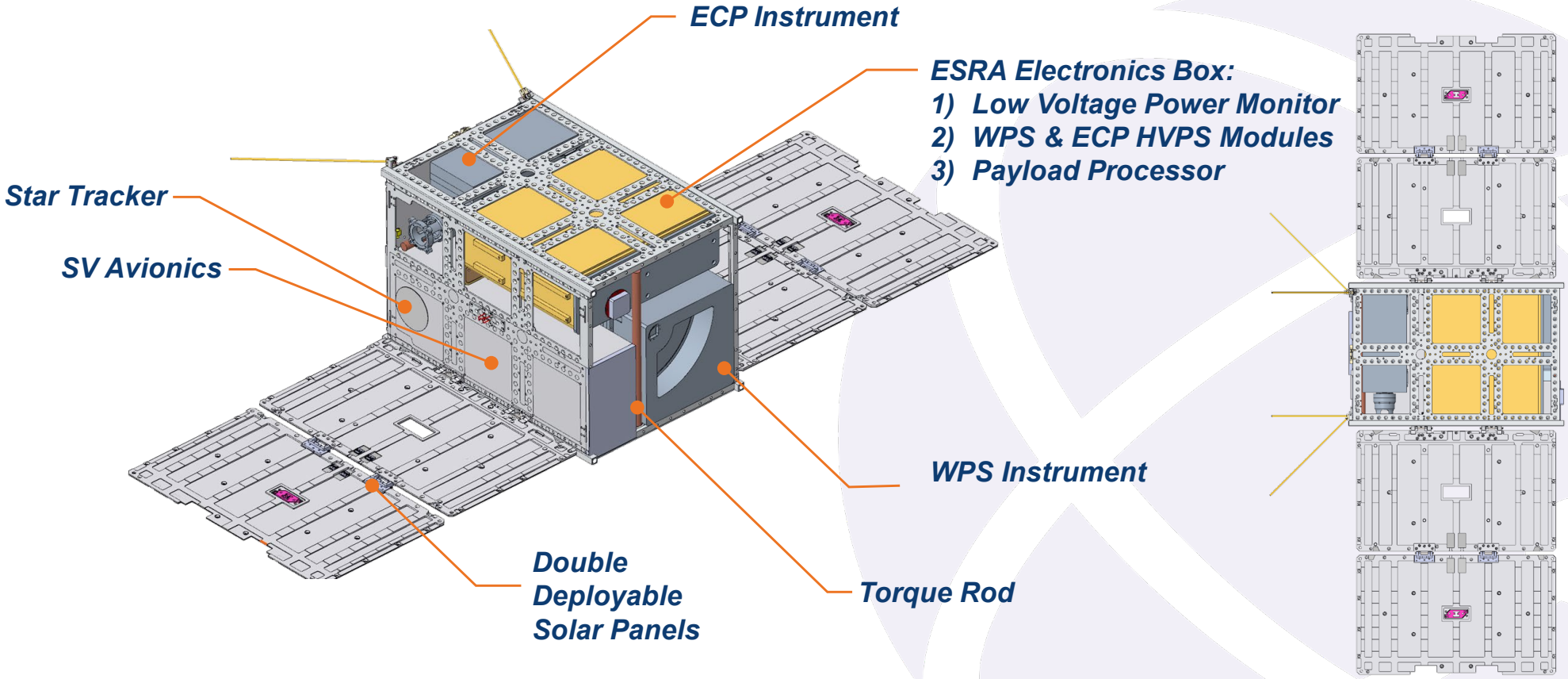
Mission CONOPS

- Requesting Geosynchronous Transfer Orbit (GTO) through STP
  - Perigee: ~200 km
  - Apogee: 36,000 km
  - Period: ~10 hrs
  - Inclination: 40 +/- 20 deg
- The low perigee is typical for SpaceX and ULA launch vehicles (185-200 km)
- Simultaneous WPS & ECP operation
- High-rate downlink (3.4 Mbps) at perigee (~2×/day)
- Nominal orientation during operations solar panels facing sun
  - WPS faces away from the Sun
  - ECP faces perpendicular to magnetic field lines

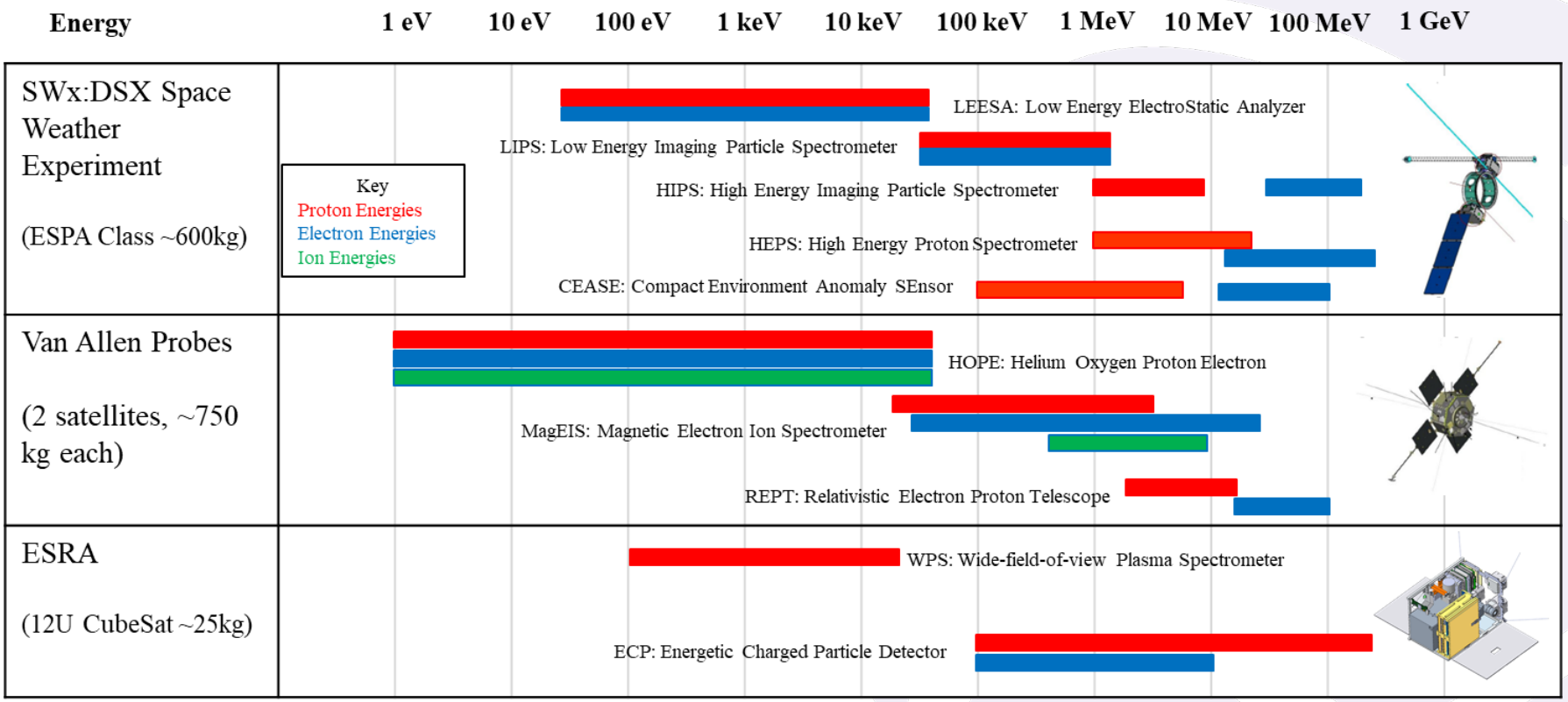


AE9/AP9/SPM: Radiation Belt and Space Plasma Specification Models

ESRA Space Vehicle Overview



Comparison to DSX and Van Allen Probes



Low SWaP ESRA Sensors cover similar Energy Range