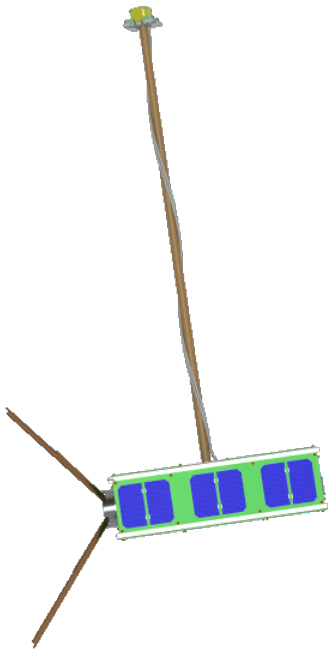
ELFIN

An Update on UCLA's Electron Losses and Fields Investigation

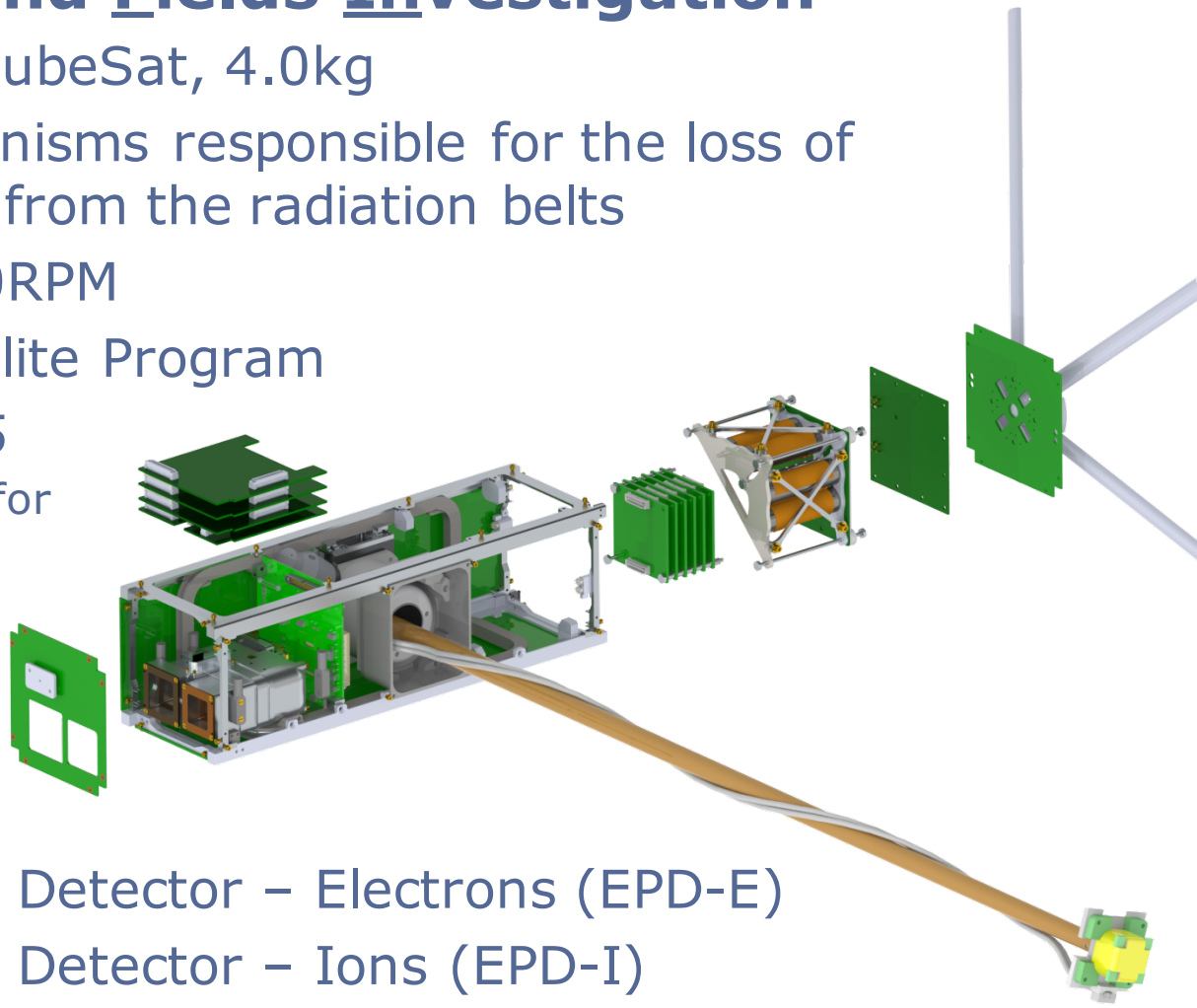


2014 CubeSat Developers Workshop

Mission Overview

Electron Losses and Fields Investigation

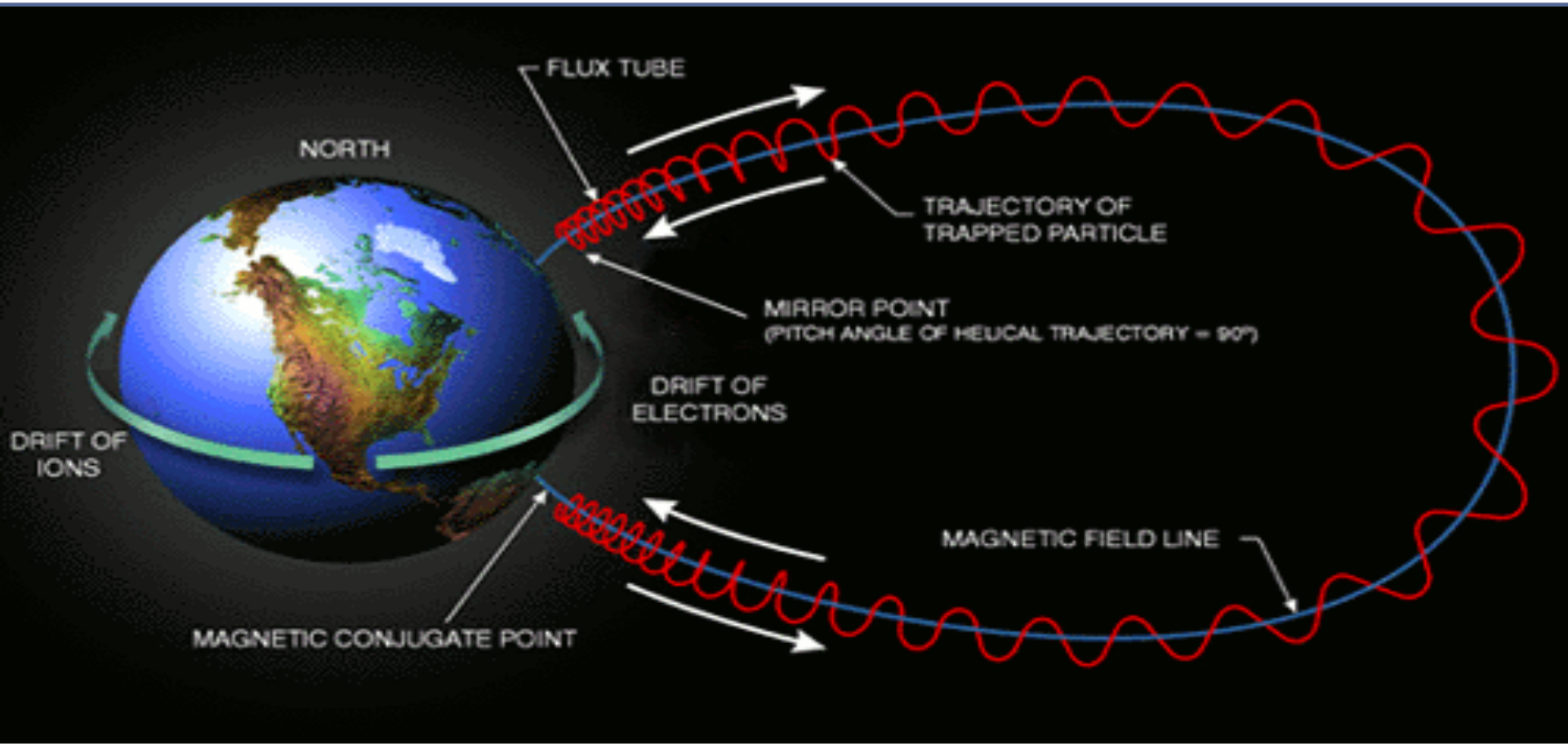
- 3U Space Weather CubeSat, 4.0kg
- Exploring the mechanisms responsible for the loss of relativistic electrons from the radiation belts
- Spin Stabilized @ 20RPM
- University Nanosatellite Program
- Selected for CLSI #5
  - Ranked 3rd out of 16 for a 2015 – 2017 launch



Instruments:

- Energetic Particle Detector – Electrons (EPD-E)
- Energetic Particle Detector – Ions (EPD-I)
- Fluxgate Magnetometer (FGM) on 75cm stacer boom

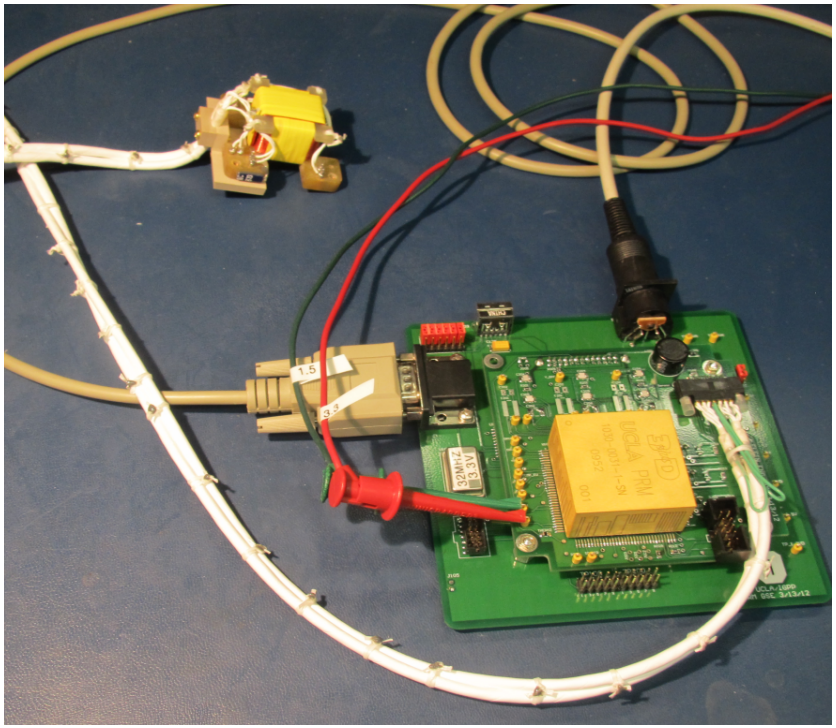
Science Overview

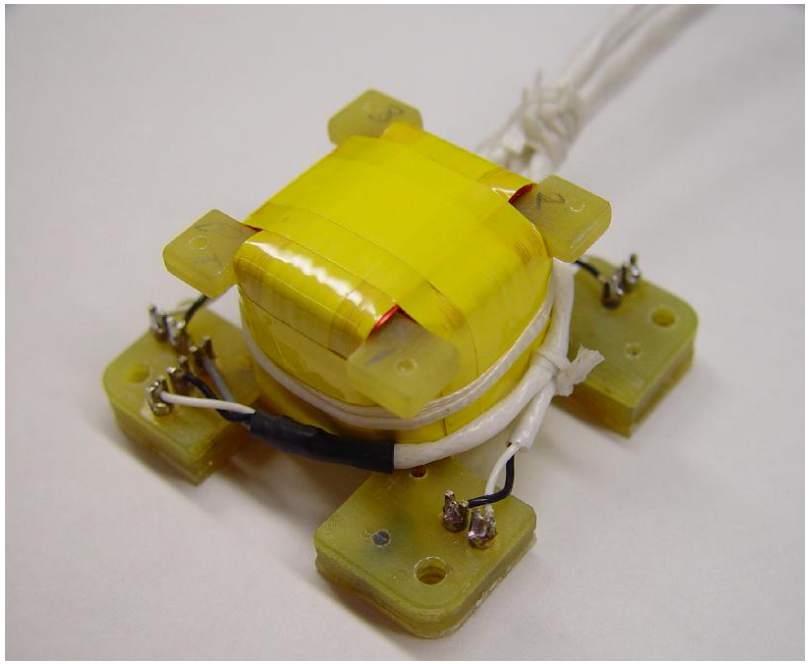


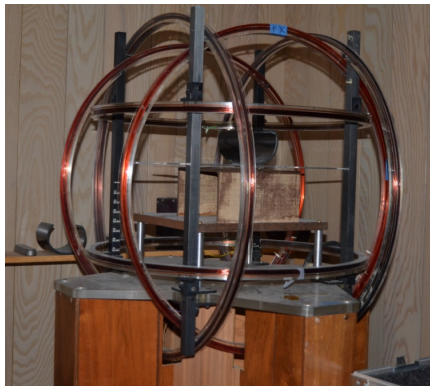
- Orbital Requirements:
  - Inclination must exceed 65°
  - > 400 km perigee
  - < 2500 km apogee
- 3 month minimum duration
  - Required time to have a high probability of seeing a geomagnetic storm

FLUXGATE MAGNETOMETER

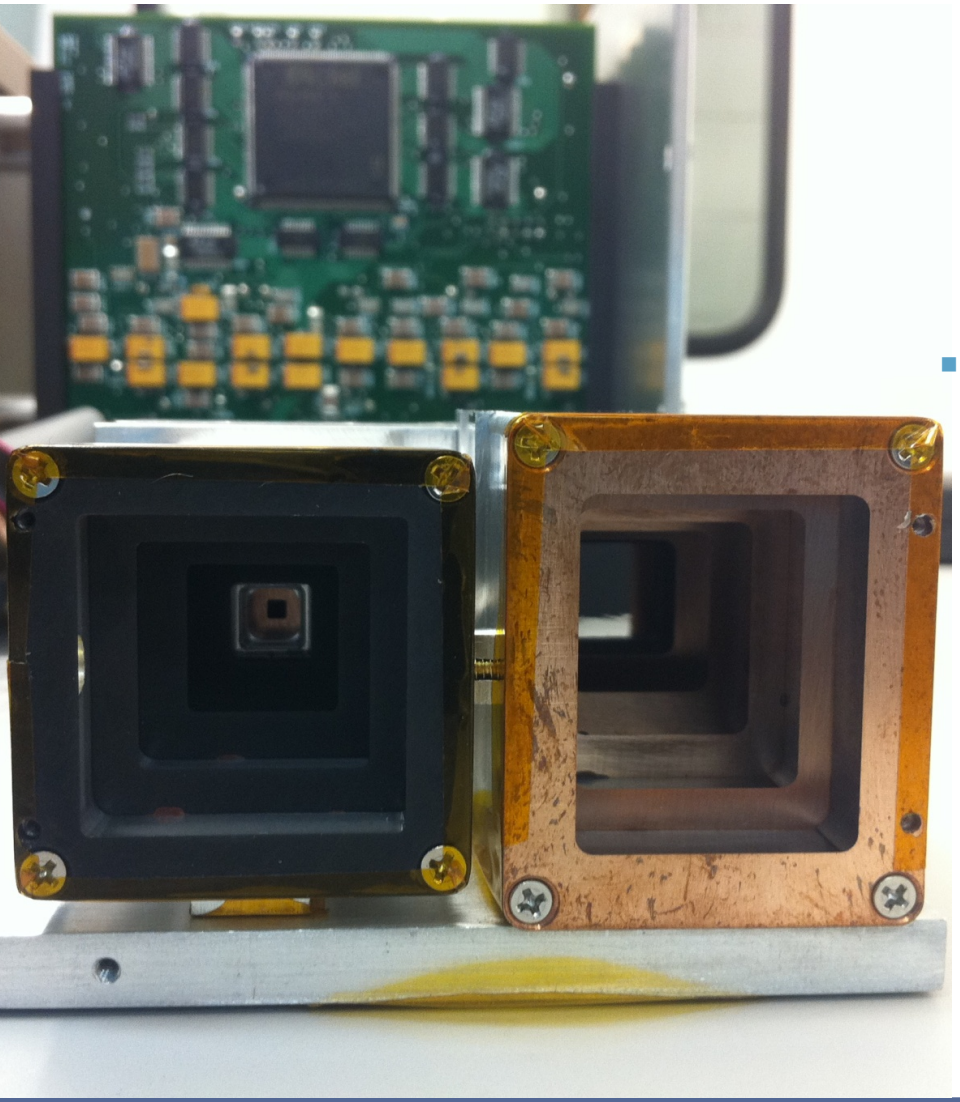
- Performance Characteristics:
  - Measure the magnitude of the Earth's magnetic field to a resolution of 0.1nT
  - Measure the full 50,000nT range of the Earth's magnetic field
  - Have an offset stability of less than 1nT per 10,000s





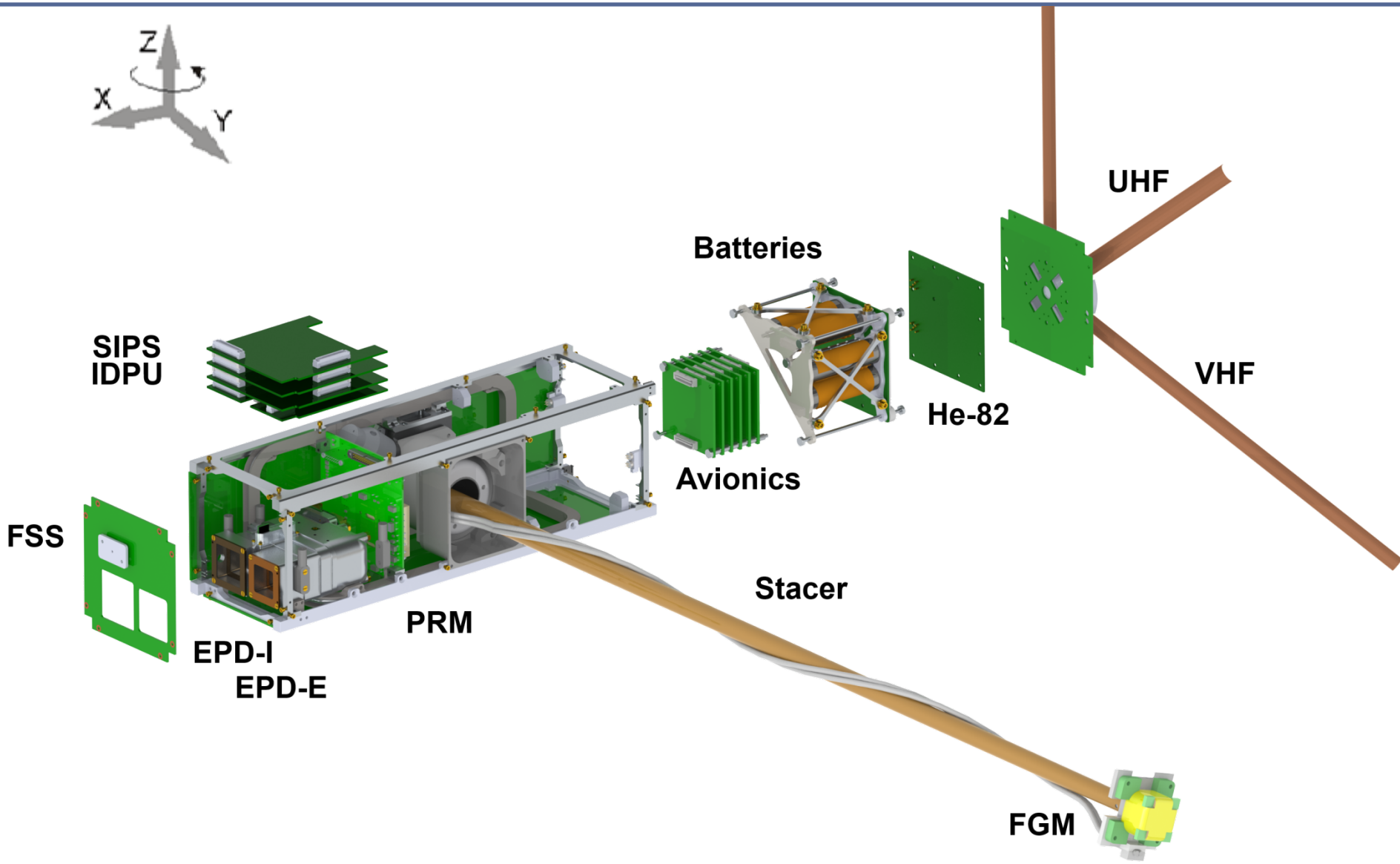


Energetic Particle Detectors



- **Capabilities:**
  - Measure incident energies to a resolution of $\Delta E/E \leq 50\%$
  - Have ≥ 16 pitch angles per revolution, which translates to each sector lasting < 187ms at 20RPM
  - Have a field of view < 28°
- **Each detector will measure a different energy range**
  - Ion side EPD (EPD-I): 50keV - 300keV ions (protons)
  - Electron side EPD (EPD-E): 50keV - 4.5MeV electrons
- **Shielding**
  - 3mm of tantalum w/ 9mm aluminum ~750g
  - Reject side penetrating particles
    - <1% of measured
    - Coincidence logic reduces this to <0.01%

Exploded View



Atypical CubeSat Characteristics

- **20RPM Spinner**
  - Only a handful of spinners exist, most slower, few faster
  - Some CubeSats are inadvertent spinners (or tumblers)
  - Maintained with torquer coils
- **Payload Requirements**
  - Tight magnetic cleanliness requirements enforced by FGM
  - Electrical cleanliness requirements enforced by EPD
- **Mission Longevity**
  - Science based on geomagnetic storms, which are infrequent
  - Need a long mission life to guarantee science data
- **Moderate instrument data volume (~4.5 MiB/day)**
  - 4 downlinks/day (2 ground stations)
  - 19.2kbps on amateur bands

Consequences of Spinning

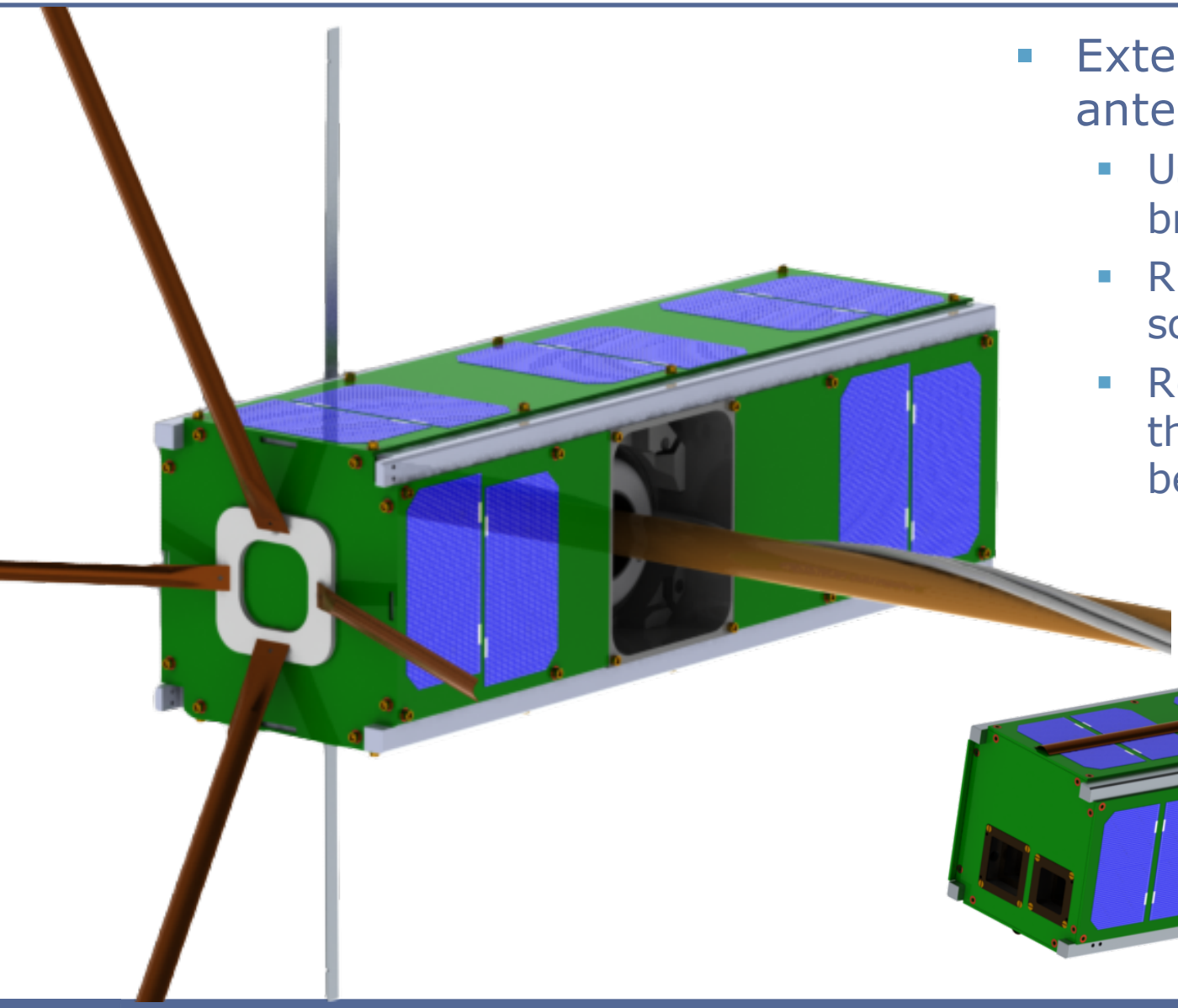
- **Electrical Power Subsystem**
  - Reduced power generation (2.4W AAOAP)
  - Dynamic power over a revolution
- **Attitude Determination & Control Subsystem**
  - Little/no COTS; Spinning on purpose is rare & usually avoided
  - High-efficiency torquer coils
  - Nutation & damping modeling
  - Sensor skewing
- **Communications**
  - No nadir tracking: omni-directionality is key
  - Spin fading

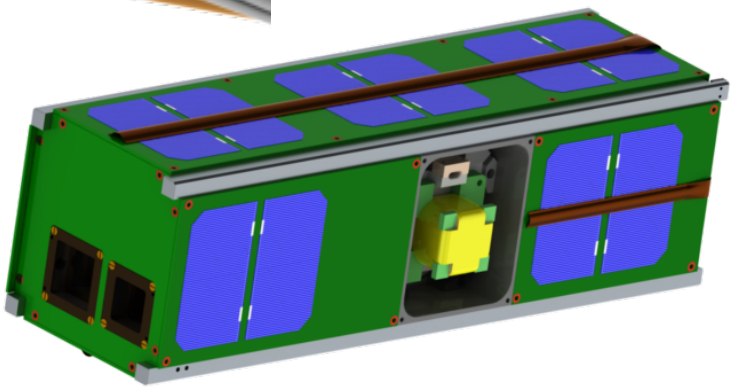
Major Changes Since Last Year's Conference

- **Antennas Stored in the Tuna Can**
  - Based off CubeSat Rev-13 bonus volume
- **Simplified Antenna Configuration**
  - Extensive simulations have showed that there is an optimal, more omni-directional antenna configuration
- **Settled on UTJ Solar Cells**
  - Extensive trade study between UTJs and TASCs
  - EPS incompatibilities led us to select UTJs

2013 Antenna Mounting

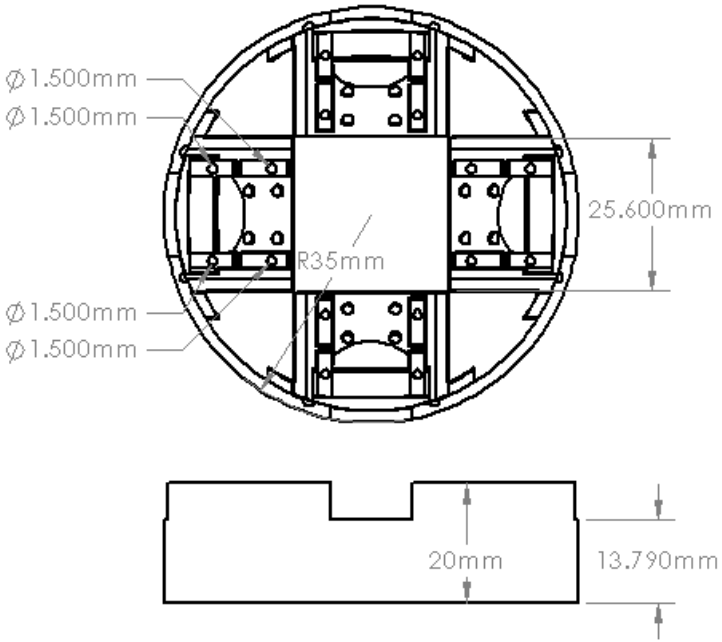
- Externally mounted antennas
  - Used weak phosphor bronze springs
  - Risk of recontacting solar panels
  - Required cutting into the spacecraft for bend radius

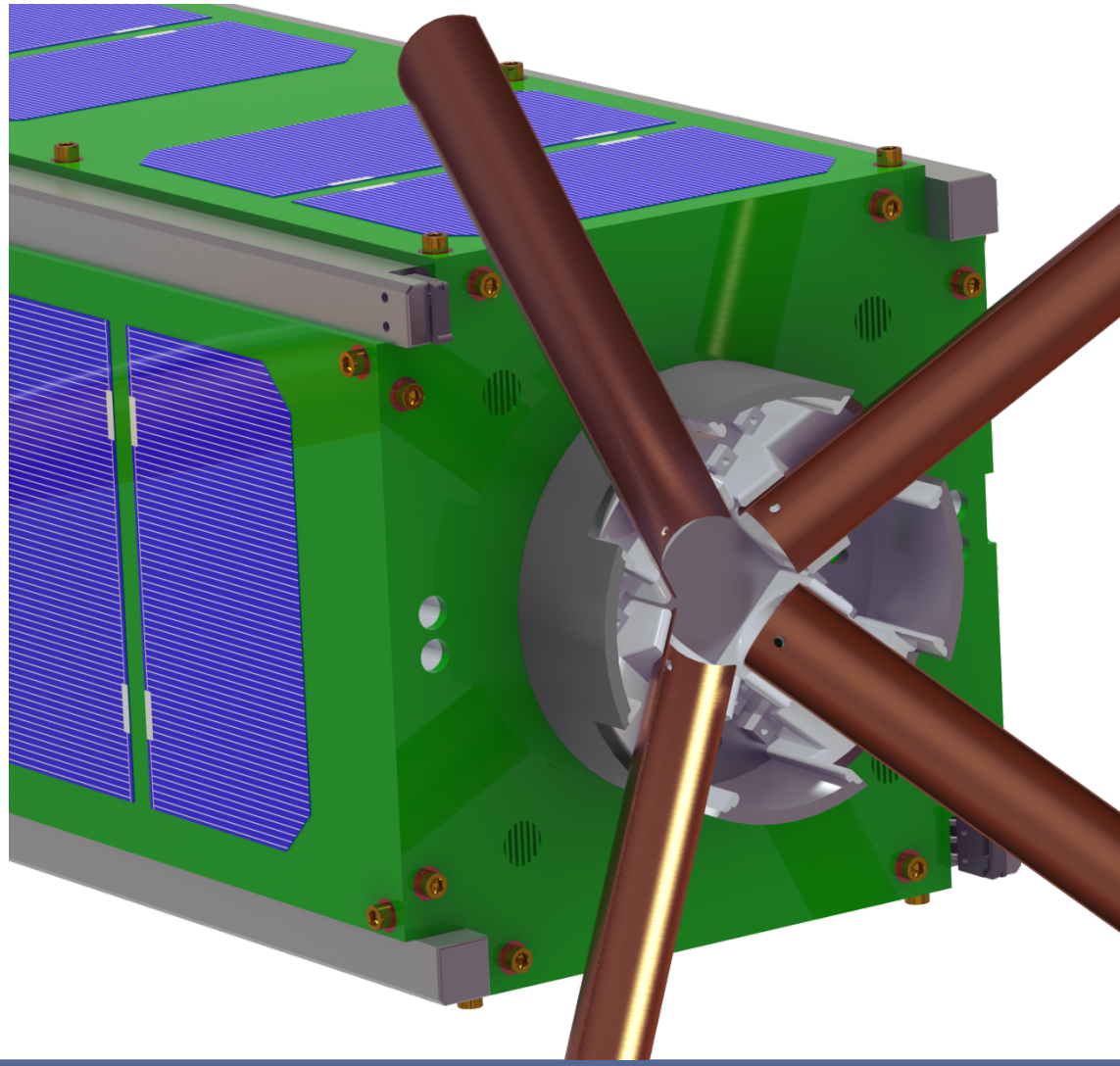




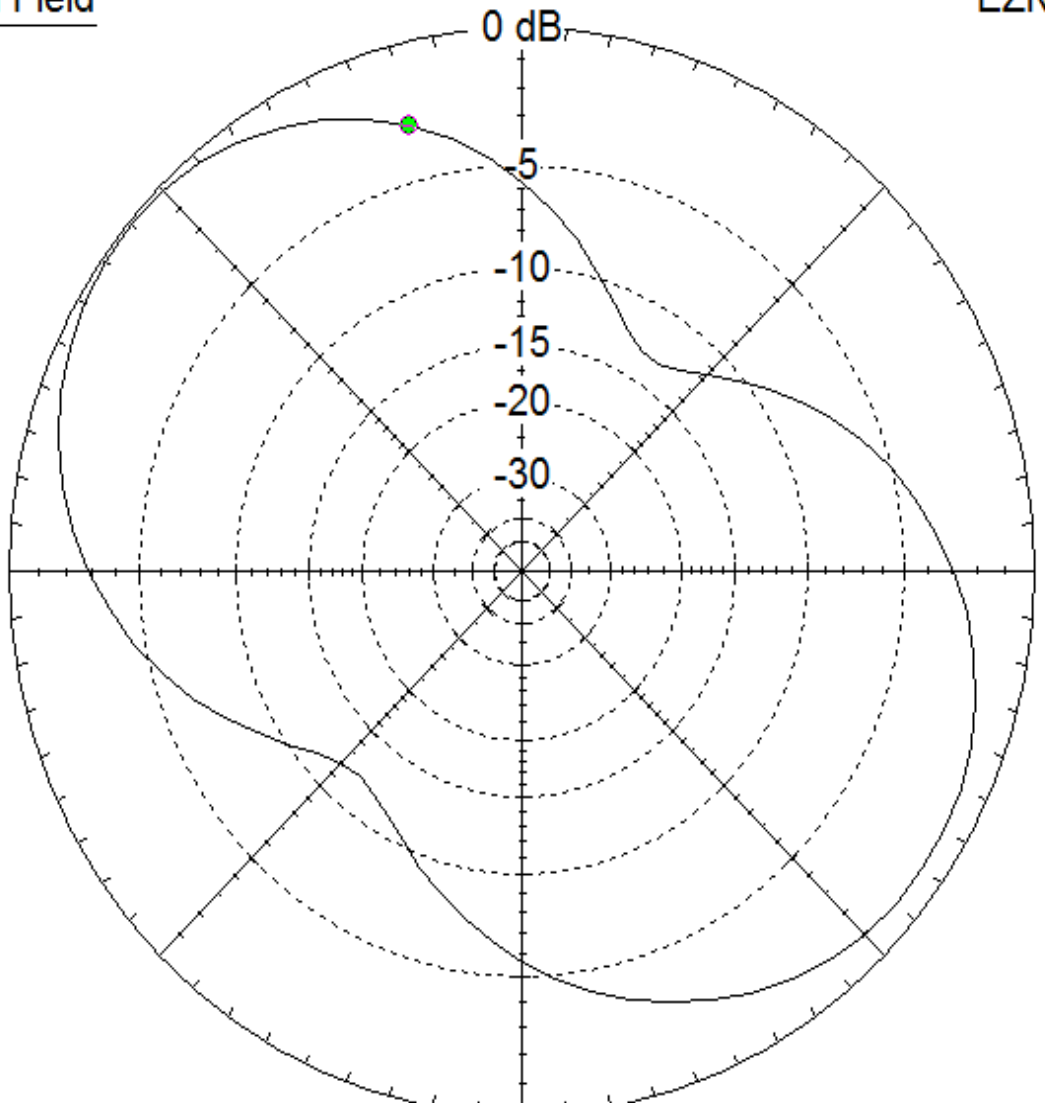
2014 Antenna Mounting: Tuna Can

- Moved antennas to new tuna can volume
- Clocked 45 degrees out of plane and 30 degrees out of body axis

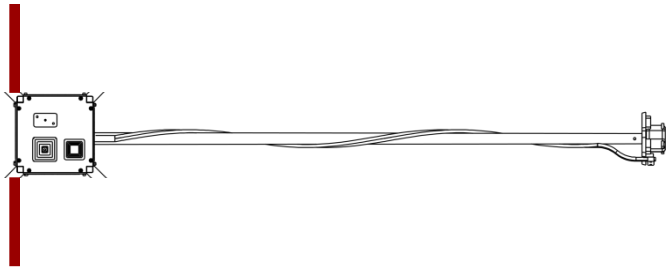


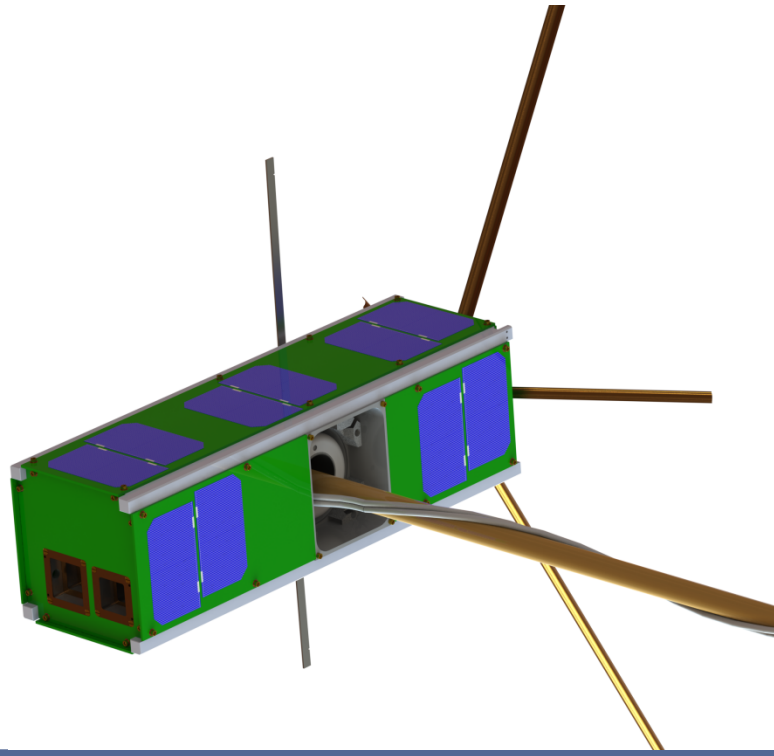


2013 Antenna Configuration

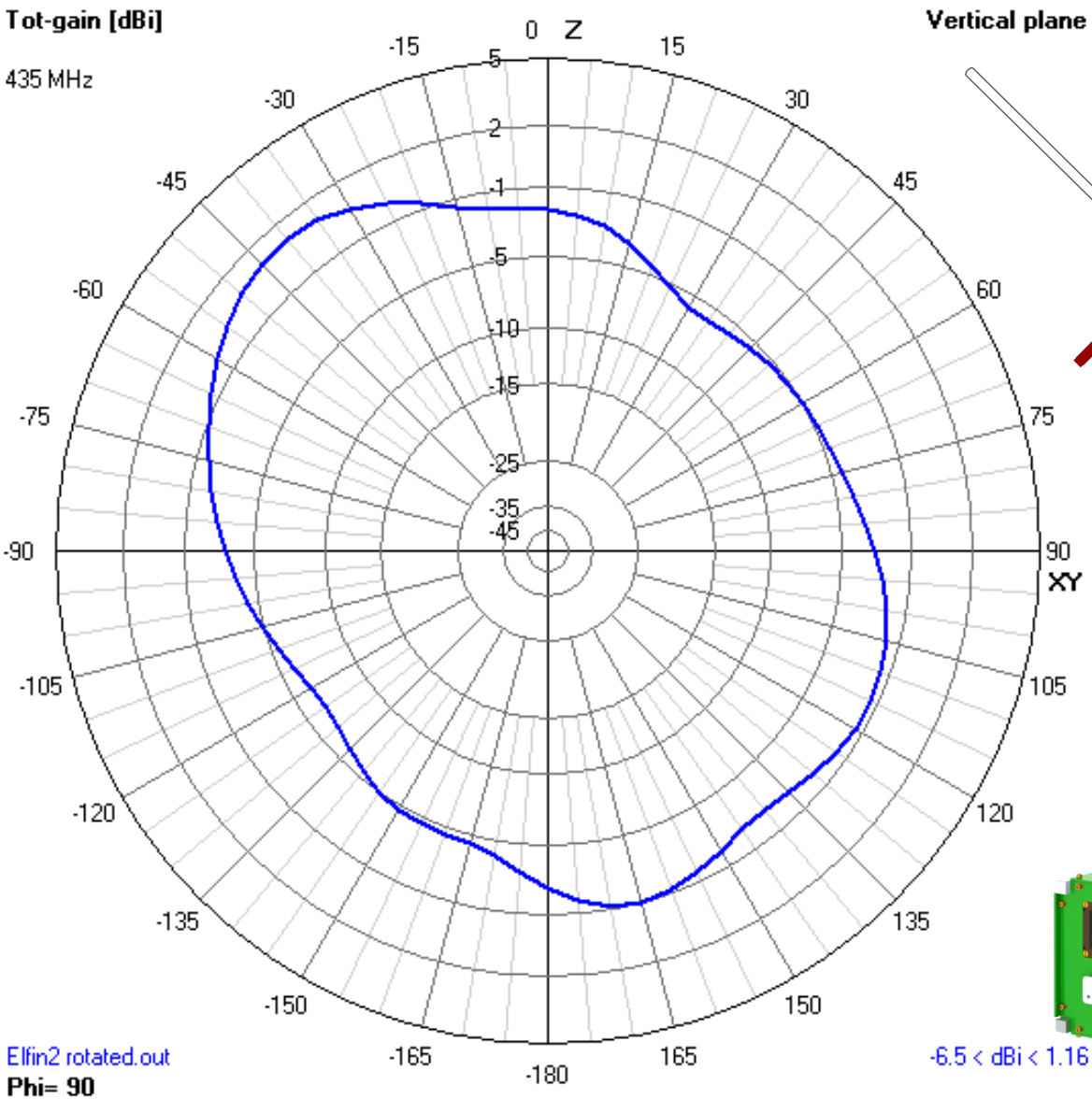


EZNEC

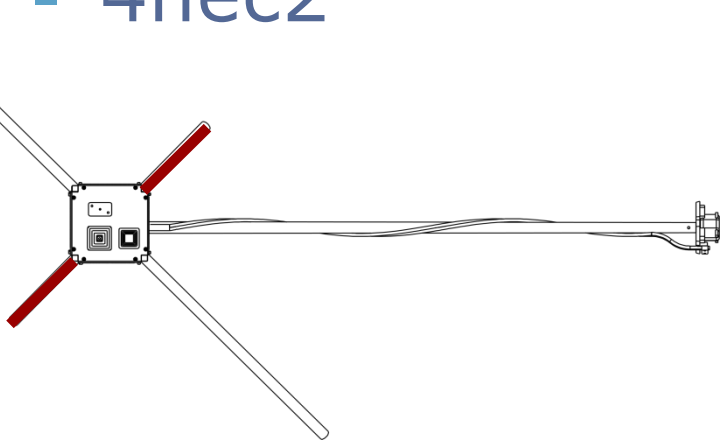


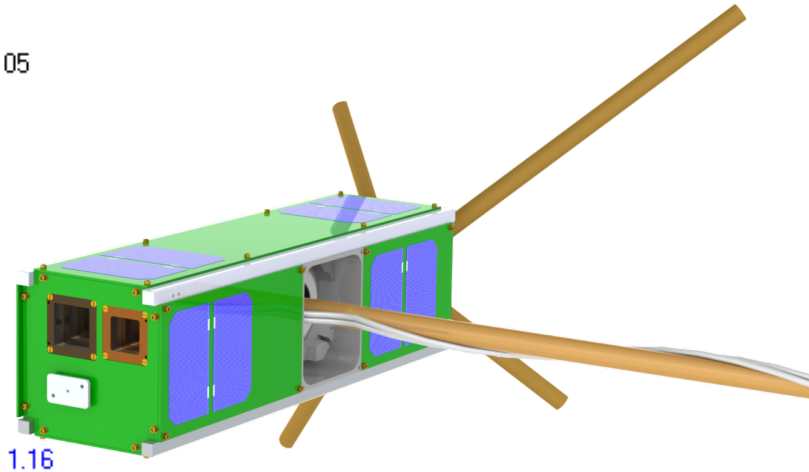


2014 Antenna Configuration

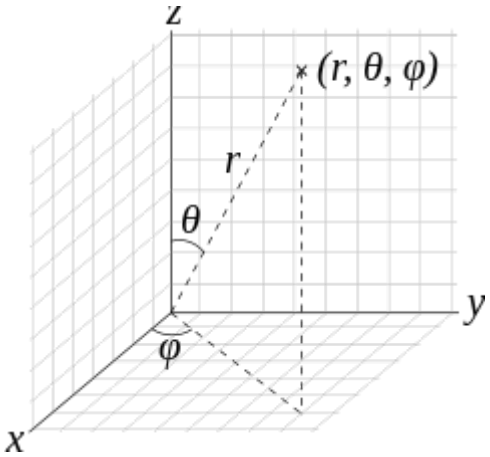


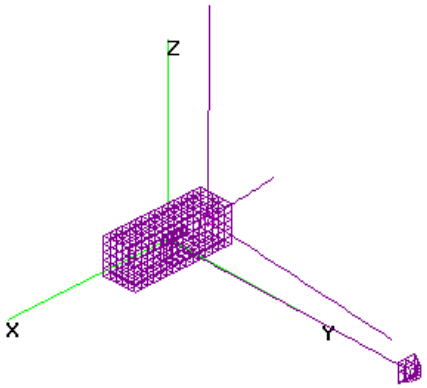
- 4nec2

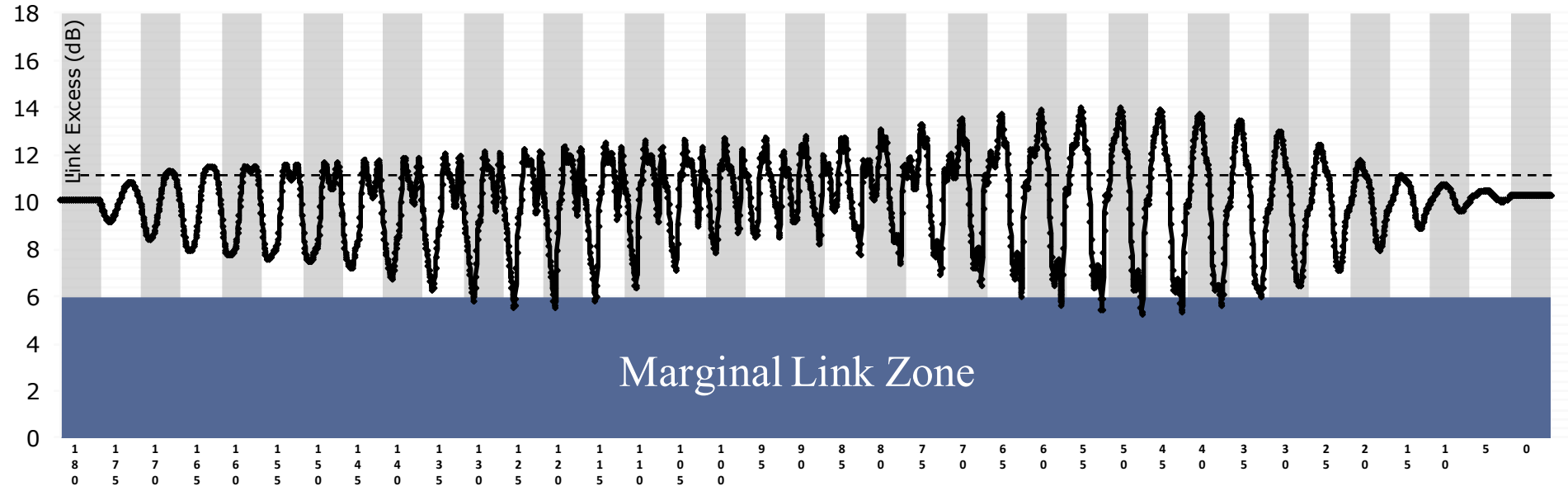




Link Excess During Spin







UTJ vs TASC Trade Study

- **Advantages in using TASC**
  - More power BOL (better packing factor)
  - Better theoretical magnetic cleanliness
  - Dramatically cheaper compared to larger cells
- **Not quite suitable for our mission:**
  - Higher string voltage, incompatible with current EPS
  - Higher current-matching burden (120 pairs vs 10 pairs)
  - Very complicated wiring pattern required
  - Short natural cell lifespan
    - Can be extended with aftermarket coverglass and encapsulent
- **Selected:** SpectroLab UTJs

ACKNOWLEDGEMENTS

Thank you to all of our sponsors, stakeholders, mentors, reviewers and contributors

David Hinkley @ The Aerospace Corporation

Shaun Murphy @ Northrop Grumman

Katharine Gamble @ UT Austin

Jim White WD0E @ Colorado Satellite Services

Mark Spencer WA8SME @ ARRL

Tony Monteiro AA2TX & Bob Davis KF4KSS @ AMSAT-NA

Questions?