An Update on UCLA's Electron Losses and Fields Investigation

2014 CubeSat Developers Workshop
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
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
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 $\geq 16$ pitch angles per revolution, which translates to each sector lasting $< 187$ms at 20RPM
  - Have a field of view $< 28^\circ$

- **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 $\sim 750$g
  - Reject side penetrating particles
    - $< 1\%$ of measured
    - Coincidence logic reduces this to $< 0.01\%$
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
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
- Externally mounted antennas
- Used weak phosphor bronze springs
- Risk of recontacting solar panels
- Required cutting into the spacecraft for bend radius
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

Elfin2 rotated.out
Phi= 90

-6.5 < dBi < 1.16

Competition Sensitive. Do Not Distribute.
Link Excess During Spin

Marginal Link Zone

Polar Angle $\theta$ (degrees)
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 encapsulant

Selected: SpectroLab UTJs
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Questions?