Electron Losses and Fields Investigation

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at is ELFIN?
3U+ CubeSat
Space Weather Mission
Developed at UCLA in collaboration with the Aerospace Corporation
Sponsored jointly by NASA/NSF
Team of UCLA staff and students from all disciplines
Builds upon experience from past space weather missions (ELFIN-L, THEMIS)
Problem: Space weather is not well understood and current models lack accurate storm prediction.

Goal: Increase understanding of relativistic electron loss from the radiation belts to the Earth’s atmosphere.

Image Credit: http://www.nasa.gov/topics/solarsystem/
**Approach:** ELFIN will measure, for the first time, if the angle and energy distribution of precipitating electrons show the characteristic signature of scattering by electromagnetic Ion Cyclotron (EMIC) waves.
Substantial Flight Heritage:

- Space Technology 5 (ST5)
- Demonstration and Science Experiments (DSX)
- InSight
- ELFIN – Lomonosov (ELFIN-L)
**PRIMARY PAYLOAD - FGM**

- **FGM Electronics**
  - Size: 90mm x 90mm x 25 mm
  - Mass: 100 g

- **FGM Sensor**
  - Size: 48mm x 48mm x 25mm
  - Dynamic Range: ±55,000 nT
  - Resolution: 6.5 pT
  - Noise Resolution: 0.2 nT/√Hz
  - Digitization: 24 bits
  - Sample Rate: 80 sps
Primary Payload - EPD

S - Solid State Telescope

ELFIN – L Energetic Particle Detector
**Primary Payload - EPD**

- **EPD-E**: 50 keV – 4 MeV
- **EPD-I**: 50 keV – 300 keV
- Capable of 10,000 to 50,000 counts/s
- Field of View < 28°
Primary Payload - EPD

- Old analog circuitry replaced to save acreage
- EPD - Digital 1: 5 ADCs, 1 FPGA
- EPD - Digital 2: 3 ADCs, 1 FPGA
Vibration Testing

Lessons Learned:
- Testing early is good
- Testing smart is better
- Mass Models -> High Fidelity
- Vibe profiles -> Reasonable
**Additional Instruments**

**Instrument Data Processing Unit**

- Generates magnetic sectoring
- Performs lossless compression of instrument data
- Fast and Slow survey data products
ADDITIONAL INSTRUMENTS

Switching Instrument Power Supply

- Provides regulated, switched, monitored power to EPD and FGM
- Provides regulated, unswitched power to IDPU
- Provides latch up protection to EPD ADCs
FIN is developing two instruments capable of performing large scale science on a CubeSat platform.
FIN-L on orbit now, starting to receive results.
SM – significant flight heritage.
D – newer design and implementation.
FIN ready for launch in late 2017.
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FINs science mission is complementary to larger NASA missions (THEMIS, MMS, DSX, etc)

Conjunctions with equatorial spacecraft will reveal the full significance of wave-particle dynamics in the magnetosphere
ELFIN FGM Noise Results

Noise requirement less than 1nT/VHz at 1Hz

ELFIN FGM Stability Test Results

ELFIN-L FGM Results
Determine the dominant loss mechanism of relativistic electrons precipitation, namely if electromagnetic ion cyclotron (EMIC) or other processes are the dominant scattering mechanism.

\[ V: \text{particle velocity} \]
\[ B: \text{magnetic field} \]
\[ \alpha: \text{pitch angle} \]

ELFIN FoV: \( \sim 22^\circ \)

\[ L_C > \theta_{\text{FoV}} \]

In situ waves can scatter electrons into the atmospheric loss cone

\[ \delta E, \delta B \]

\[ \theta_L C < \theta_{\text{FoV}} \]

NASA's RBSP or THEMIS Instrument FoV: typically \( \sim 20^\circ \)