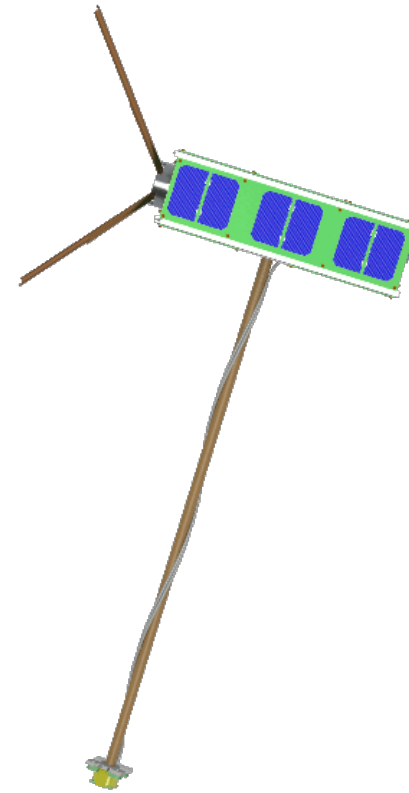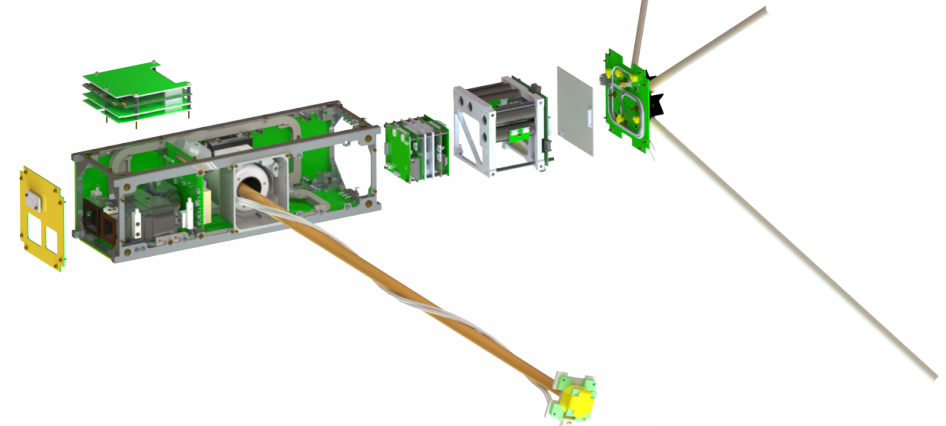# Electron Losses and Fields Investigation

Lydia Bingley, Project Manager
Vassilis Angelopoulos, Principal Investigator
Ryan Caron, Chief Engineer

August 07, 2016
Logan, Utah

- **Introduction**

- **Science Mission**

- **Primary Payload**

- **Additional Instruments**

- **Summary**

- What 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 into the Earth's atmosphere.

Image Credit: http://www.nasa.gov/topics/solarsystem/sunearthsystem/main/Helio-facts.html

- **Approach**: ELFIN will measure, for the first time, if the angle and energy distribution of precipitating electrons bear the characteristic signature of scattering by Electromagnetic Ion Cyclotron (EMIC) waves
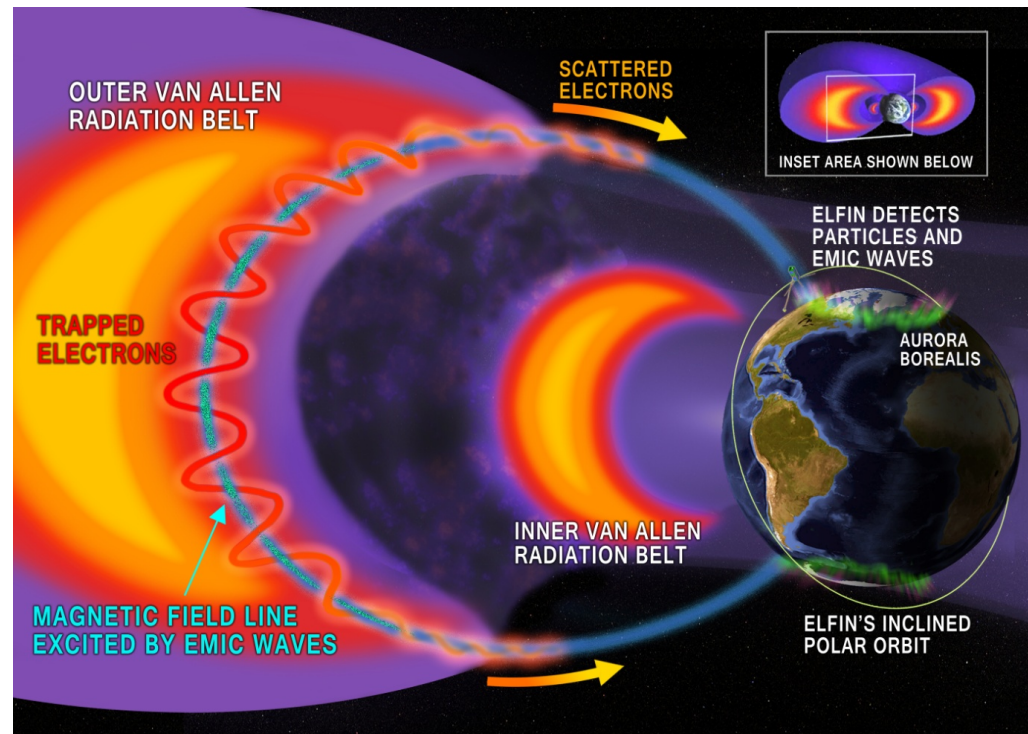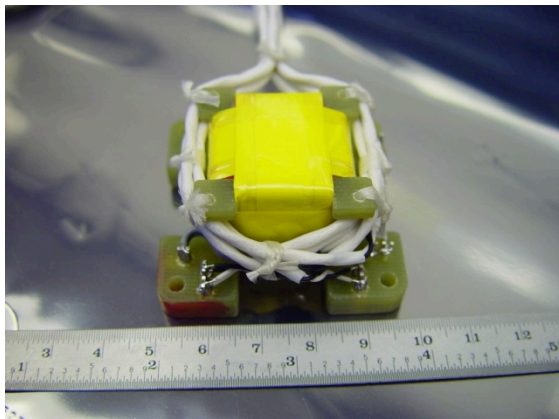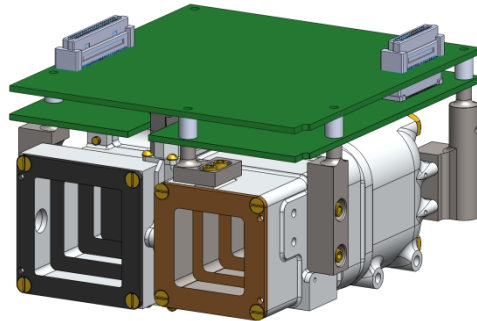
- **Substantial Flight Heritage**:
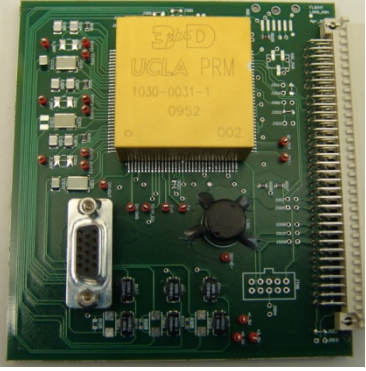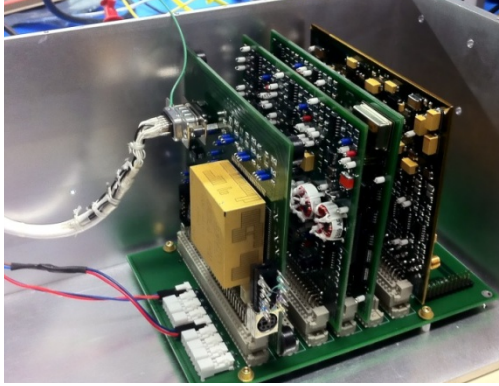
Space Technology 5 (ST5)

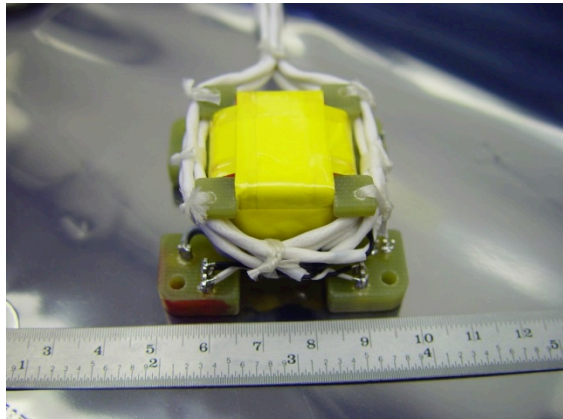Demonstration and Science Experiments (DSX)
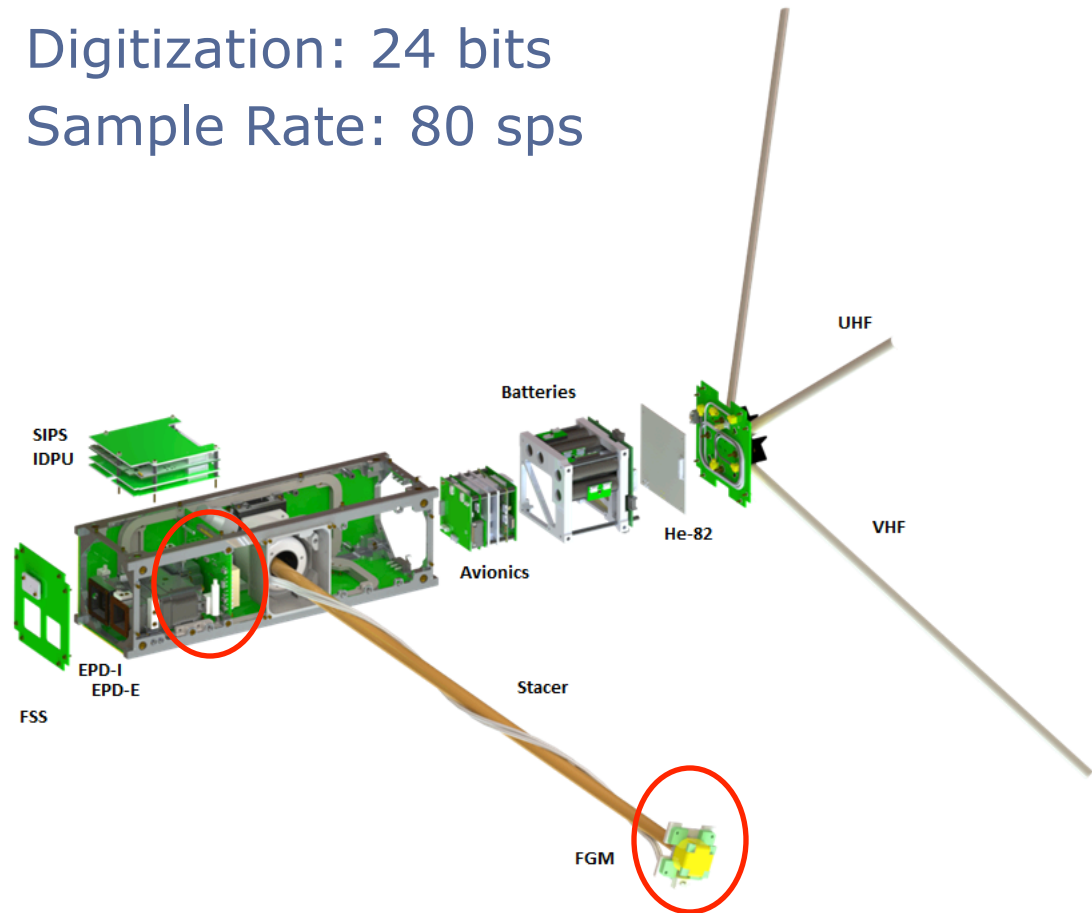

InSight

ELFIN – Lomonosov (ELFIN-L)

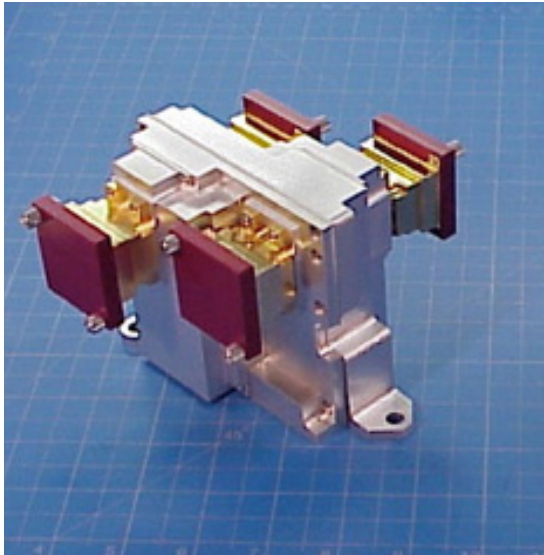**FGM Electronics**
Volume: 90mm x 90mm x 25 mm
Mass: 100 g

FGM Sensor
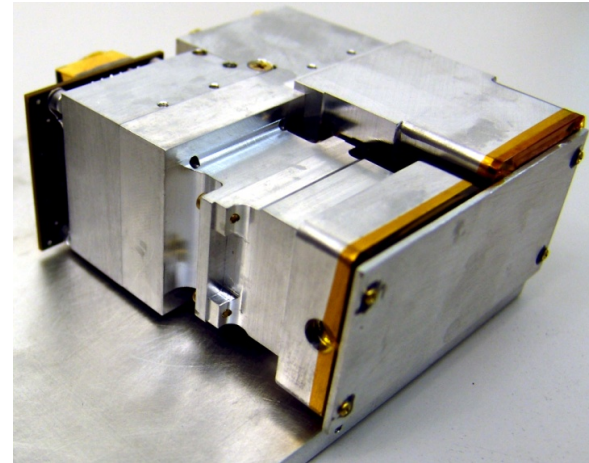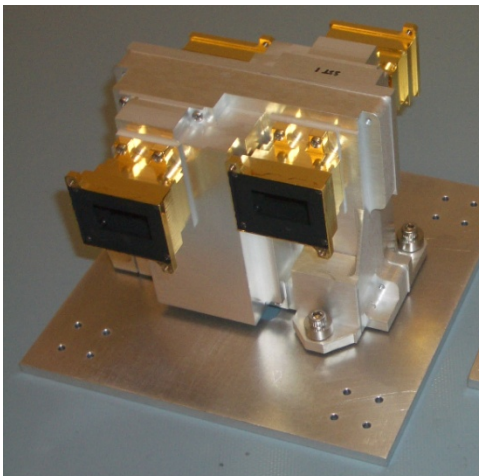Volume: 48mm x 48mm x 25mm
Mass: 58 g

- Dynamic Range: ±55,000 nT
- Resolution: 6.5 pT
- Noise Resolution: 0.2 nT/√Hz
- Digitization: 24 bits
- Sample Rate: 80 sps

SIPS
IDPU

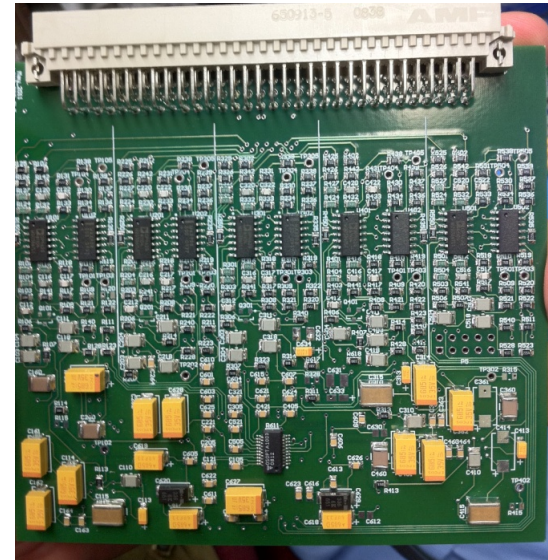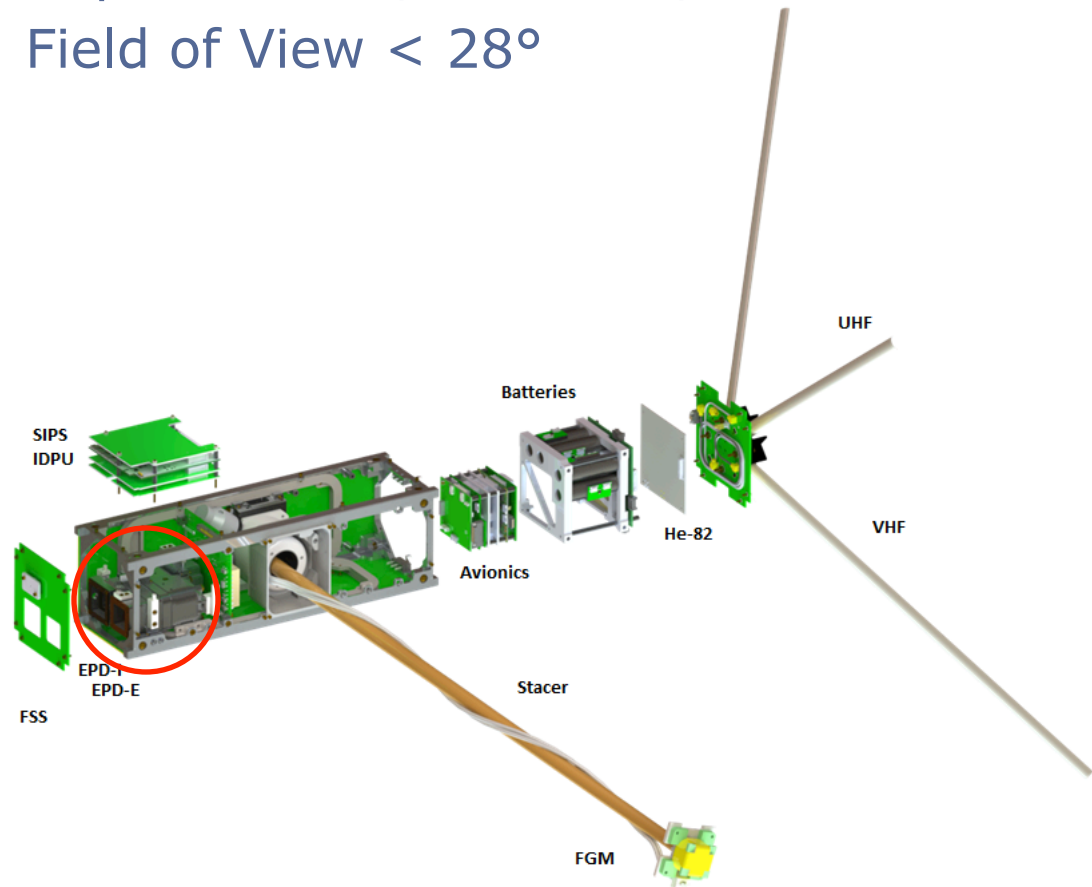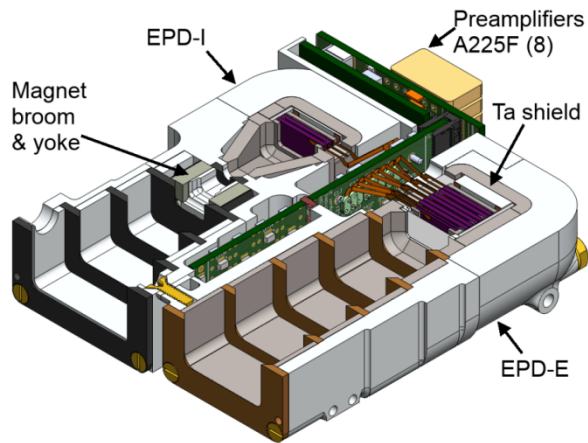Batteries

UHF

EPD-I
EPD-E

He-82

Avionics
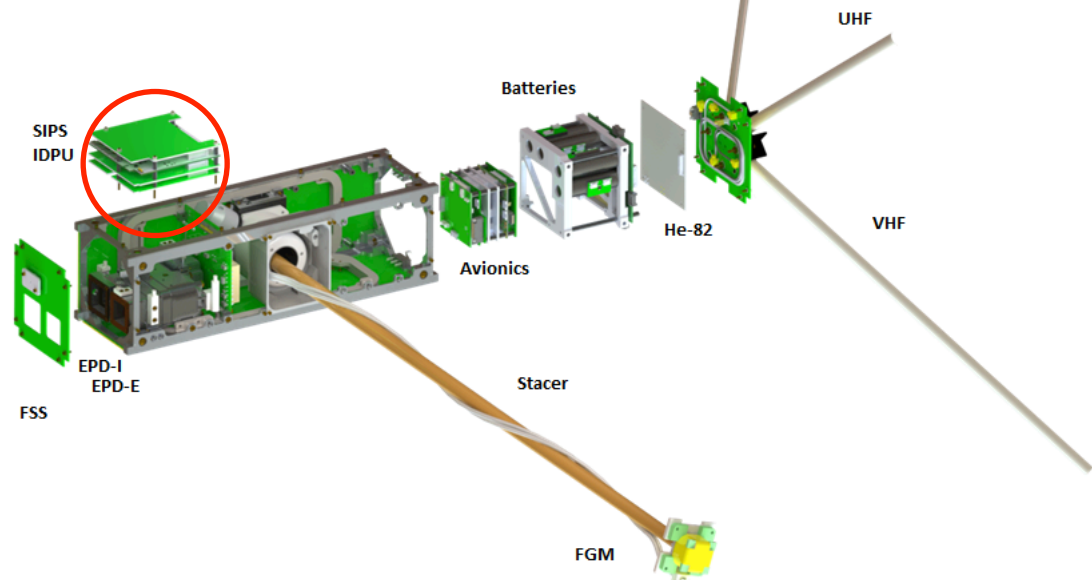
VHF
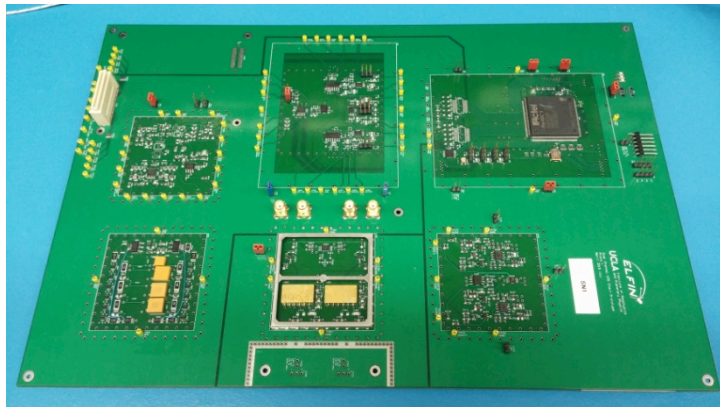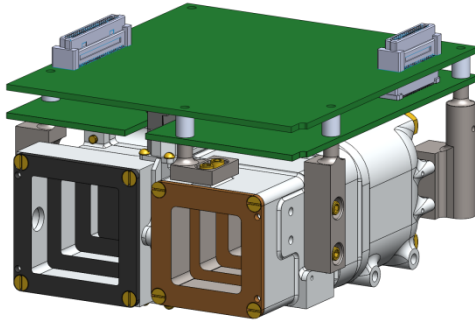
FSS

Stacer

FGM

ELFIN – L Energetic Particle Detector

THEMIS – Solid State Telescope

- EPD-E: 50 keV – 4 MeV
- EPD-I: 50 keV – 300 keV
- Capable of 10,000 to 50,000 counts/s
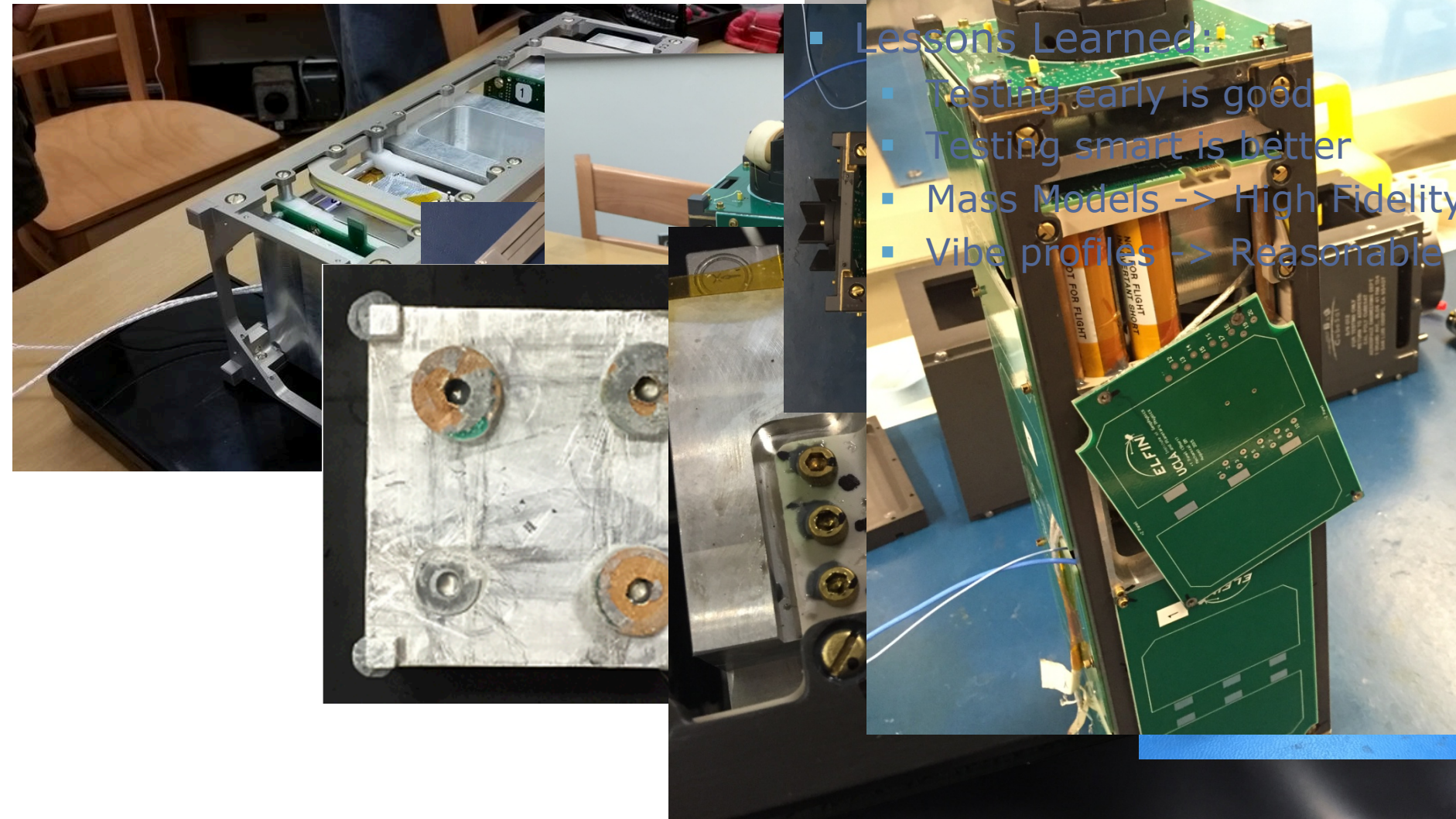- Field of View < 28°
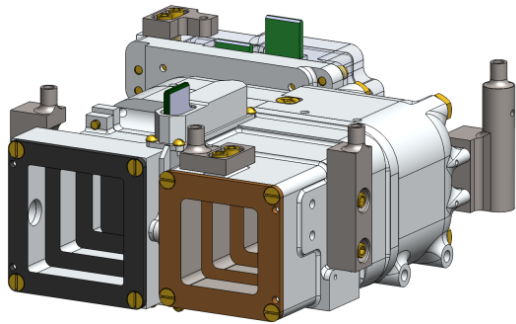
- Old analog circuitry replaced to save acreage
- EPD – Digital 1: 5 ADCs, 1 FPGA
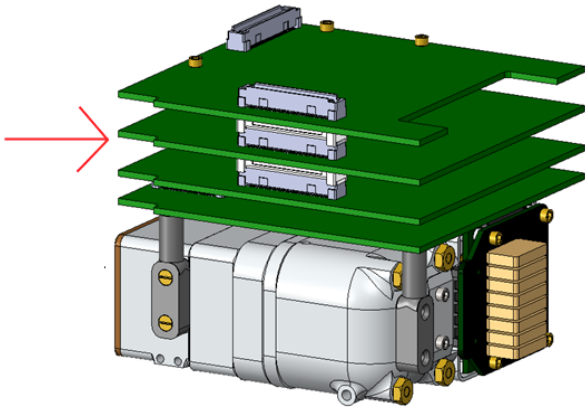- EPD – Digital 2: 3 ADCs, 1 FPGA

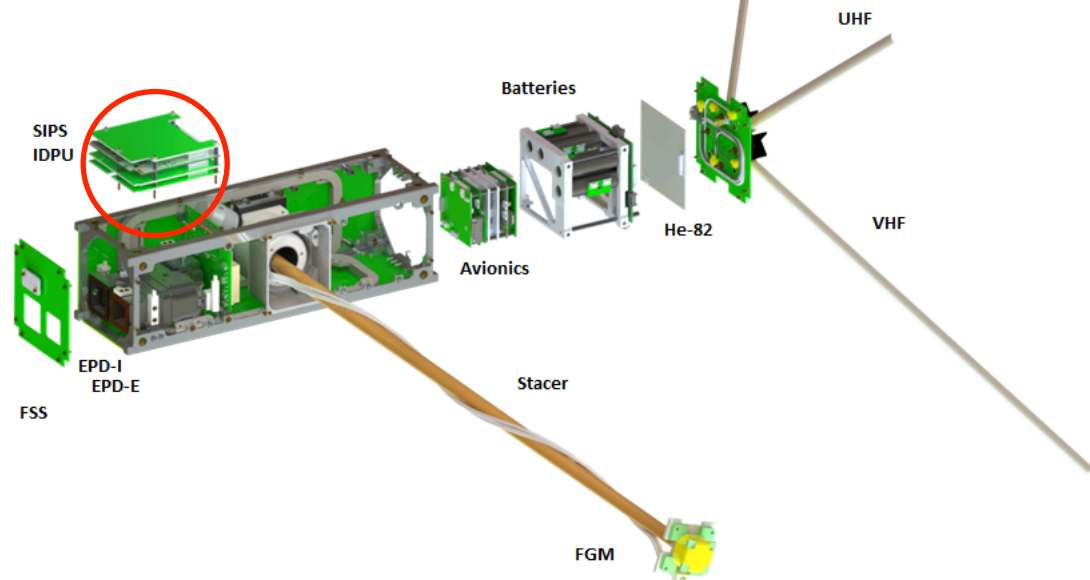- Vibration Testing

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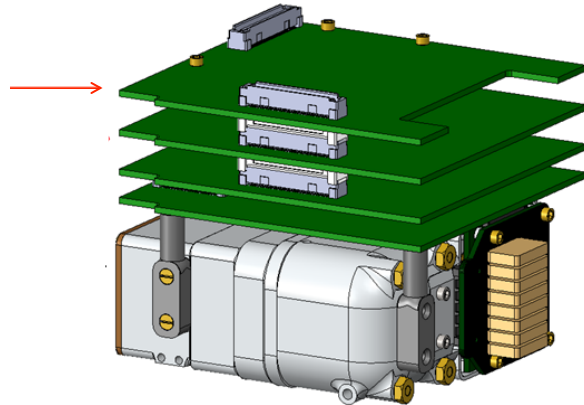 - Vibe profiles -> Reasonable

Instrument Data Processing Unit

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

SIPS
IDPU

Batteries

EPD-I
EPD-E

Avionics

FSS

Stacer

He-82

UHF

VHF

FGM

Switching Instrument Power Supply

- Provides regulated, switched, monitored power to EPD and FGM
- Provides regulated, unswitched power to IDPU
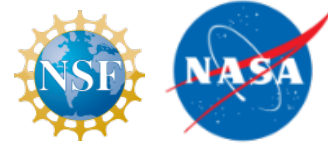- Provides latch up protection to EPD ADCs
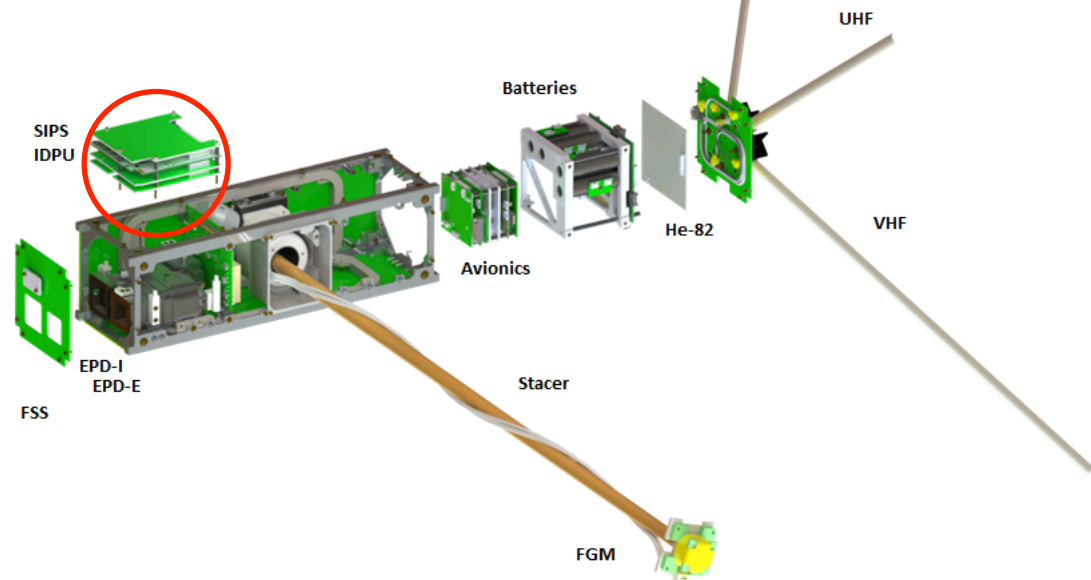
- ELFIN is developing two instruments capable of performing large scale science on a CubeSat platform
- ELFIN-L on orbit now, starting to receive results
- FGM – significant flight heritage
- EPD – newer design and implementation
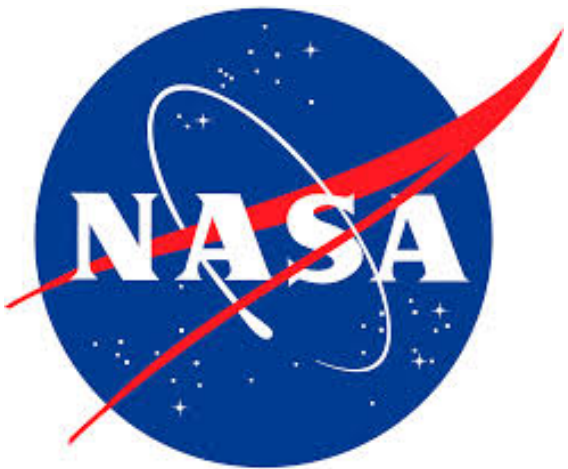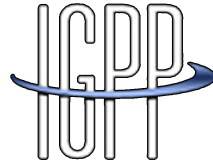- ELFIN ready for launch in late 2017
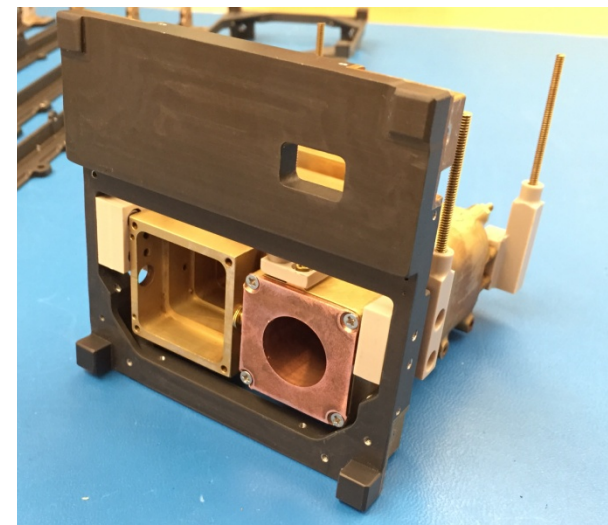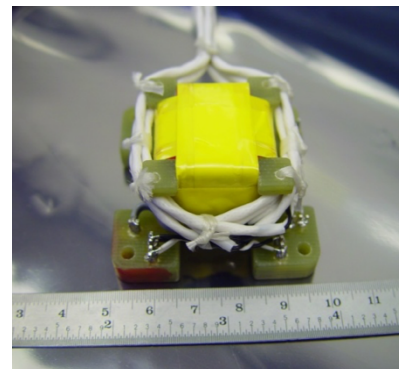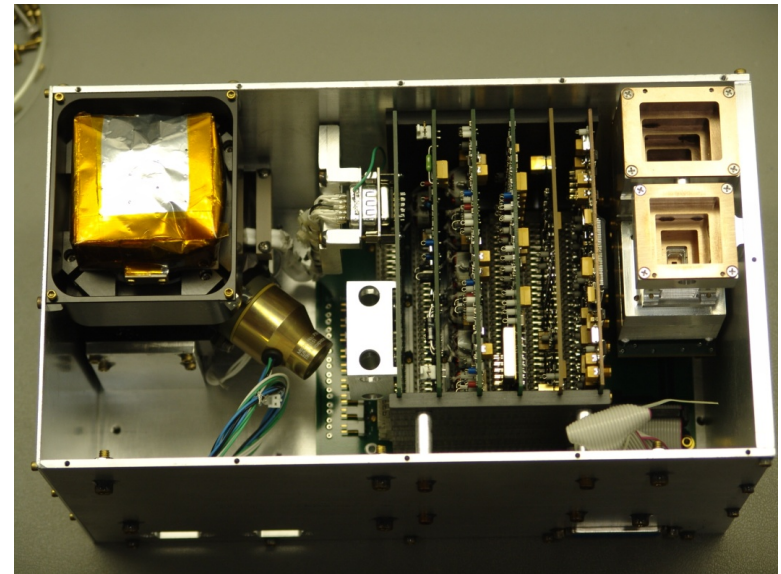
ACKNOWLEDGEMENTS

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

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

- ELFINs 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
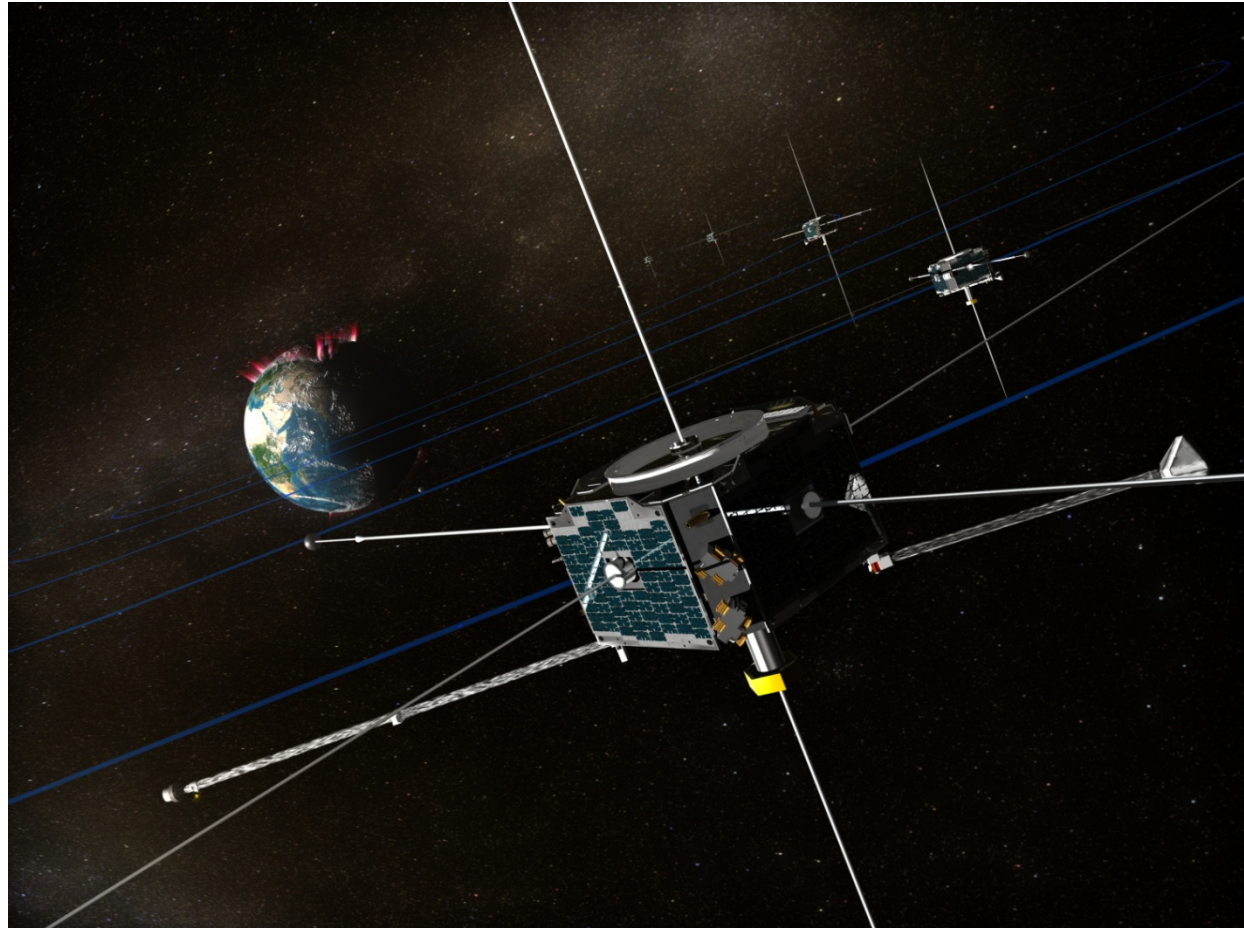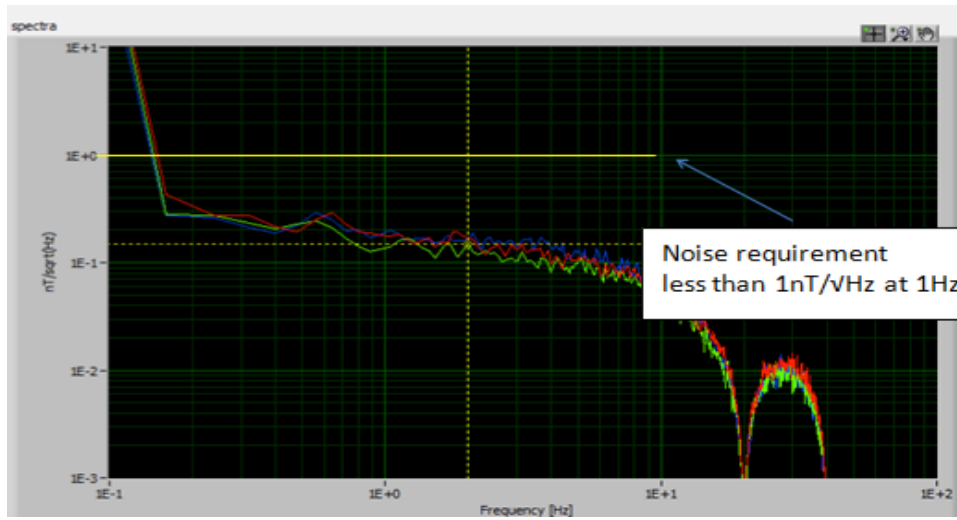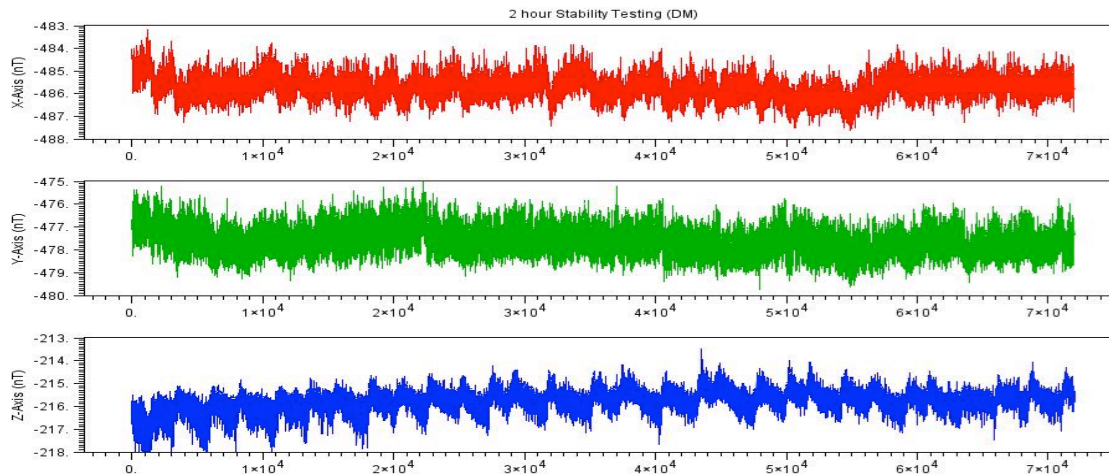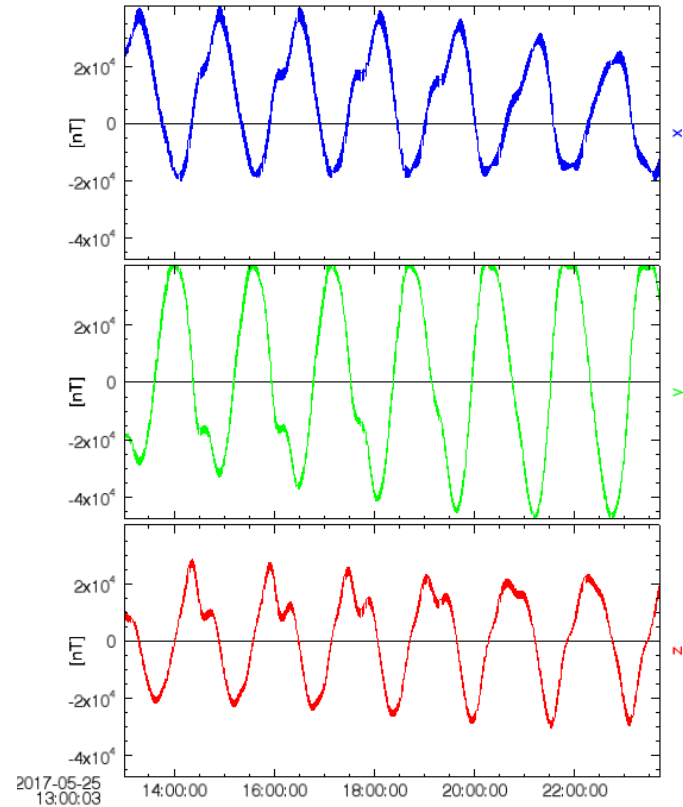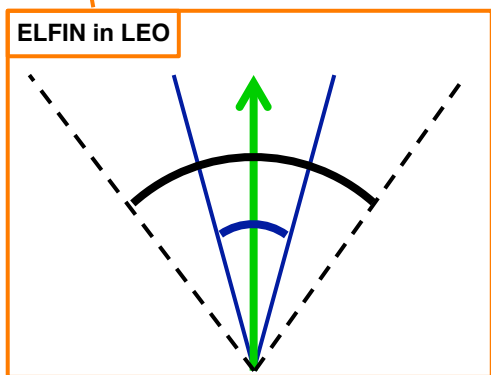

Image Credit: NASA

ELFIN FGM Noise Results

ELFIN-L FGM Results
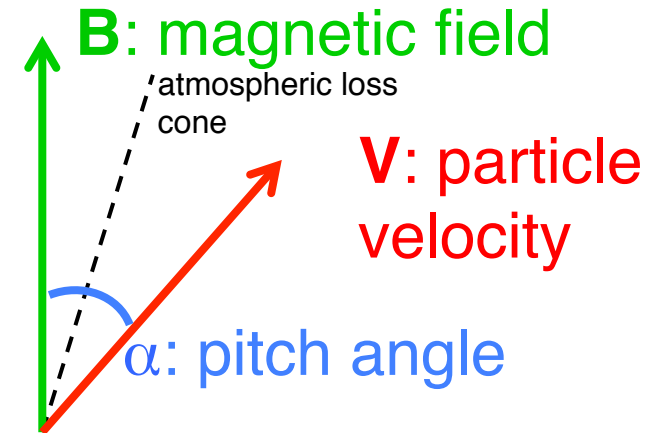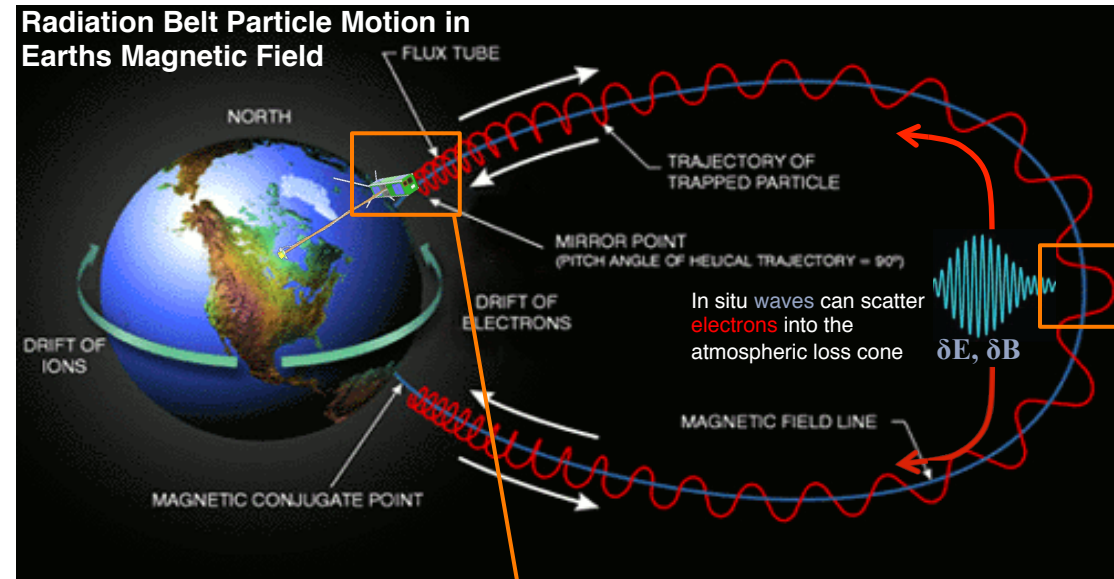

ELFIN FGM Stability Test Results
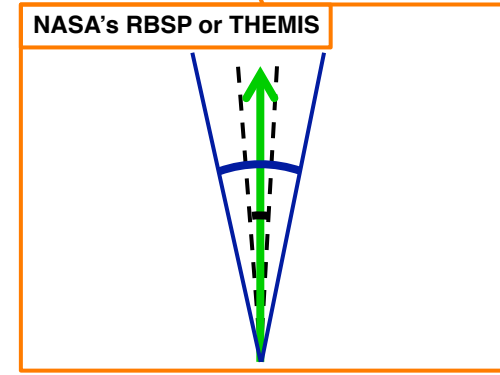
To determine the dominant loss mechanism of relativistic electrons by precipitation, namely if electromagnetic ion cyclotron (EMIC) waves or other processes are the dominant scattering mechanism.

Radiation Belt Particle Motion in Earths Magnetic Field

B: magnetic field

atmospheric loss cone

V: particle velocity

α: pitch angle

ELFIN in LEO

ELFIN FoV: ~22°

$$\theta_{LC} > \theta_{FoV}$$

NASA's RBSP or THEMIS

Instrument FoV: typically ~20°

$$\theta_{LC} < \theta_{FoV}$$