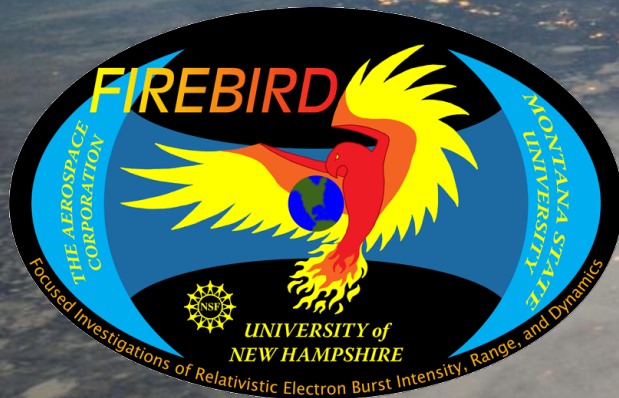


FIREBIRD

One Mission; Two launches;
Two pairs of CubeSats separated by fourteen months;
Performance enhancements derived from on-orbit
experience



4/23/2015

2015 CubeSat Developers' Workshop

Matthew
Handley

Dr. Dave
Klumpar



Microbursts

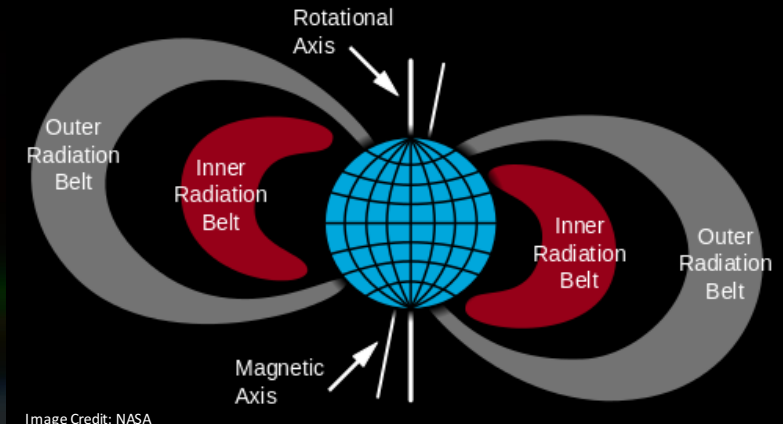
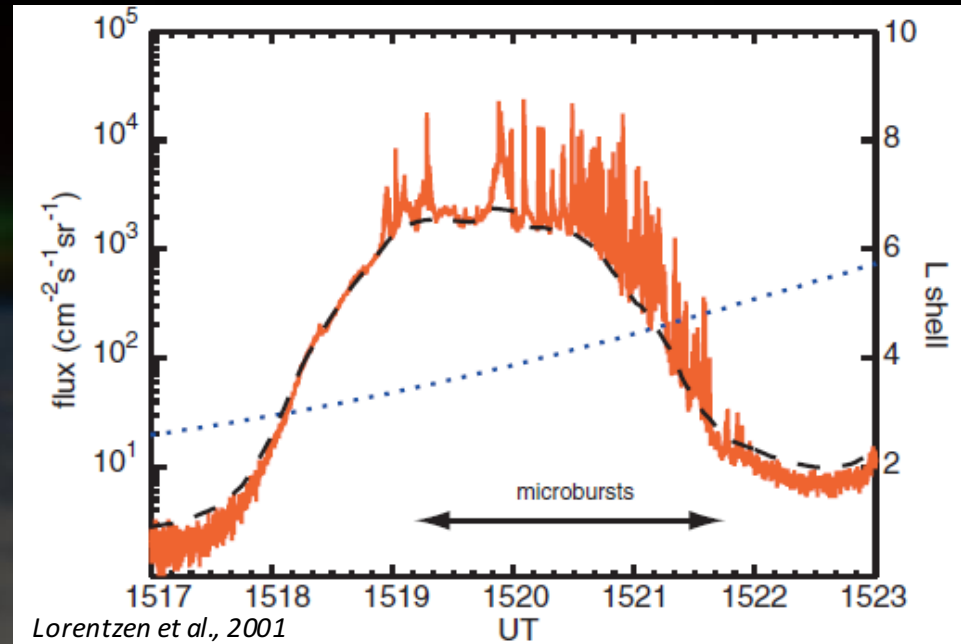


Image Credit: NASA

- Localized region of precipitating electrons in Earth's Radiation Belts
- Occur on short (<0.2s) timescale

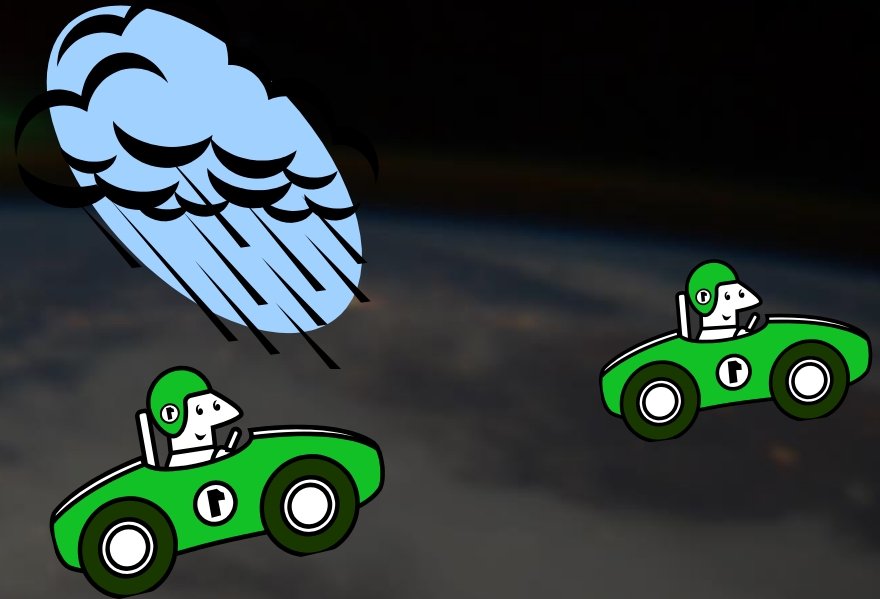




Science Objectives



- What is the spatial scale size of an individual burst?
- What is the energy dependence of an individual burst?
- How much total electron loss do bursts produce globally?
- Driving Through a rainstorm

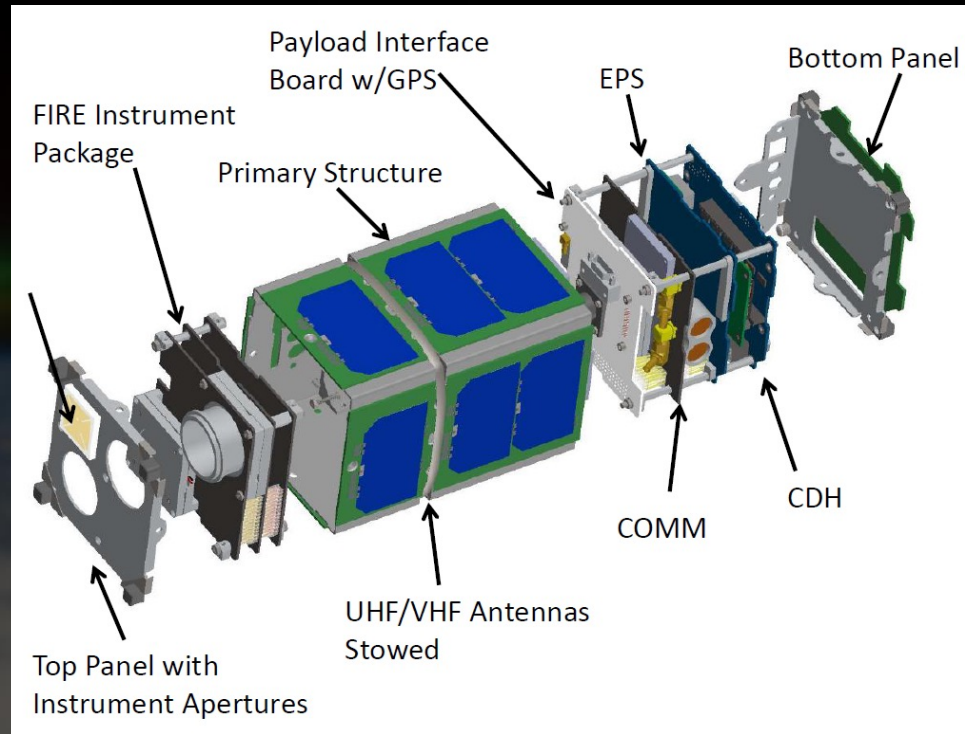




Design



- Two 1.5U CubeSats
- FIRE Payload – University of New Hampshire
- BIRD Bus – MSU
- Passive Magnetic Stabilization
- UHF 19.2kbaud Downlink





FIREBIRD-I



- FU1 & FU2 Launched Dec. 2013 with ELaNa II (GEMSat/NROL-39)
- Low inclination orbit
- FU2 Operational for 6 weeks after launch
- FU1 Operational March – June '14
- Power System failure on both units
- No Microbursts Observed



Image Credit: CalPoly





FIREBIRD-II



- Identical FIRE Payloads
- Complete redesign of power system
- New solar panels and experiment
- Misc. software improvements
- FU3 & FU4 Launched Jan. 2015 with ELaNa X (SMAP)
- High Inclination Polar Orbit
- Fully operational from launch to present
- Hundreds of Microbursts observed!

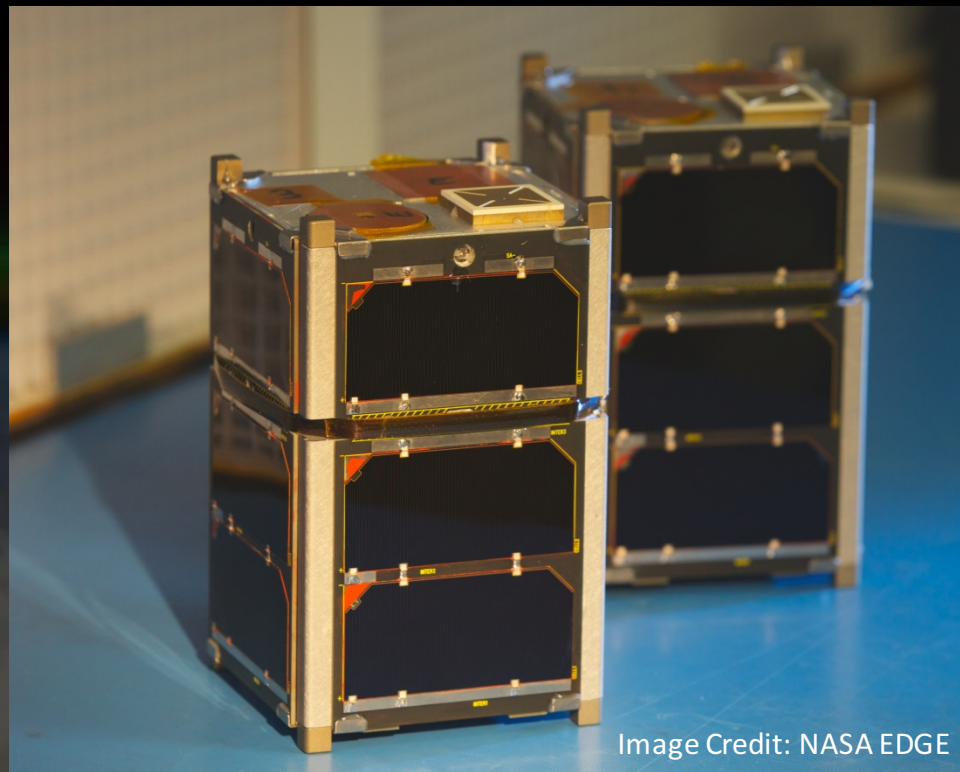
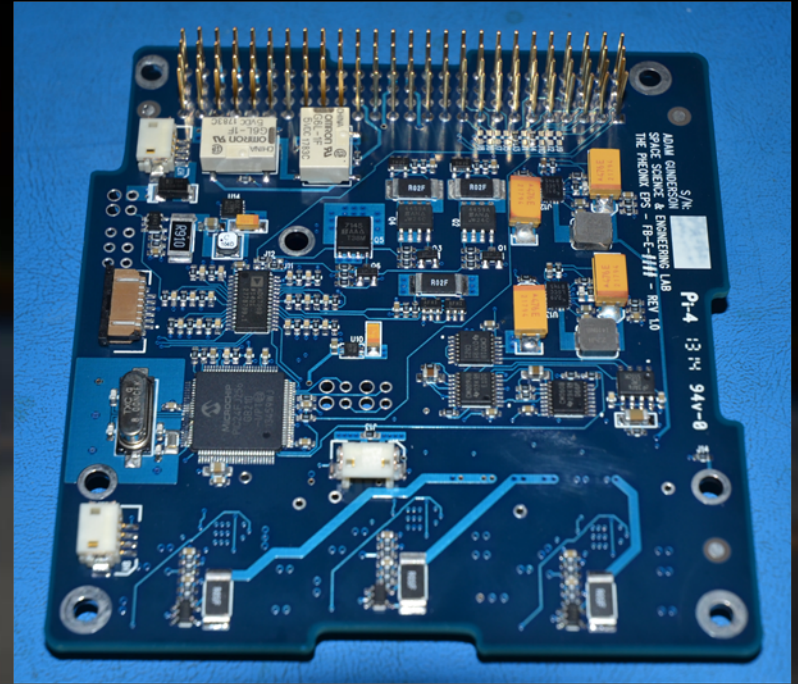


Image Credit: NASA EDGE

Phoenix Power System

- KISS
- New Direct Energy Transfer (DET) EPS board
- 12 hr satellite reboot via HW watchdog Implemented using discrete logic ICs
- Counter warns CDH to save state
- No shunt, no PPT, excess power to cells



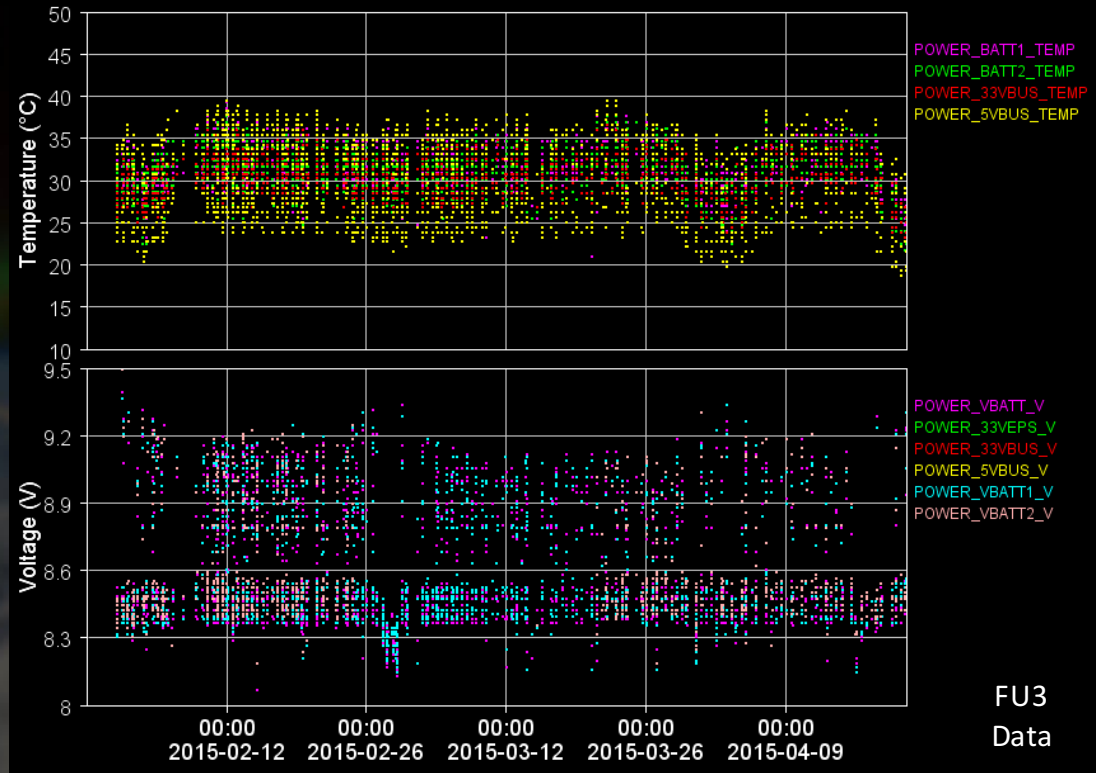
SSEL-Designed "Phoenix" Electrical Power System



Phoenix Performance



- Full sun from launch until Apr. 19, 2015
- ~20 minute eclipses by May 1, 2015
- Battery OV Protection working as intended
- Similar profiles to previous SSEL DET satellite (HRBE)



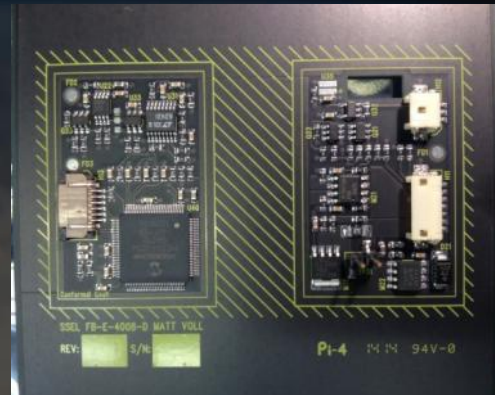


FISCE



FIREBIRD IMM Solar Cell Experiment

- All FB-II solar panels assembled by Vanguard Space Technologies
- 37% efficient cells
- I-V Curves measured on experimental THINS assembly
 - Monitor degradation in space environment



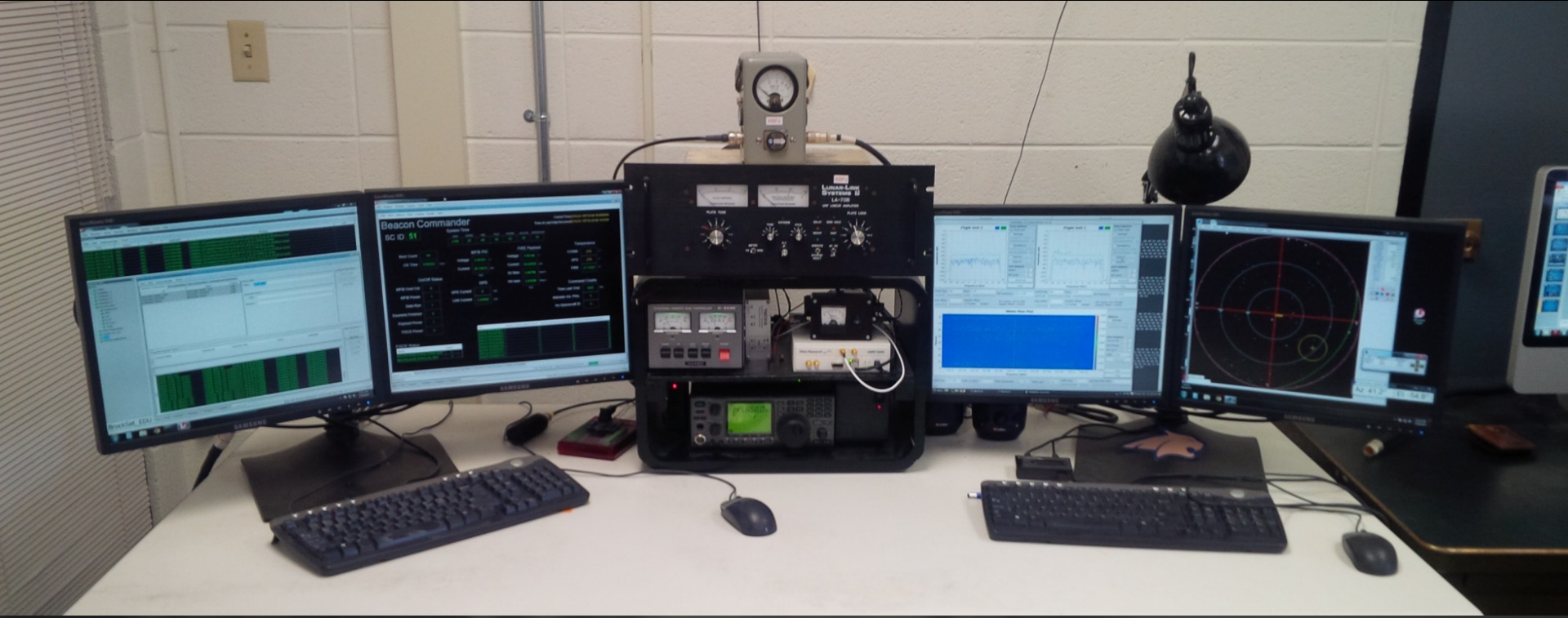
FISCE circuit on back of panel



Calibration at MSU



Ground Ops





Secondary Ground Station



- COSMIAC Research Center at University of New Mexico
- Gave us remote access to control their station
- Integrated with our ground station software
- Working out RF noise issues
- Improve dual-satellite operations efficiency



COSMIAC Ground Station – Credit: COSMIAC

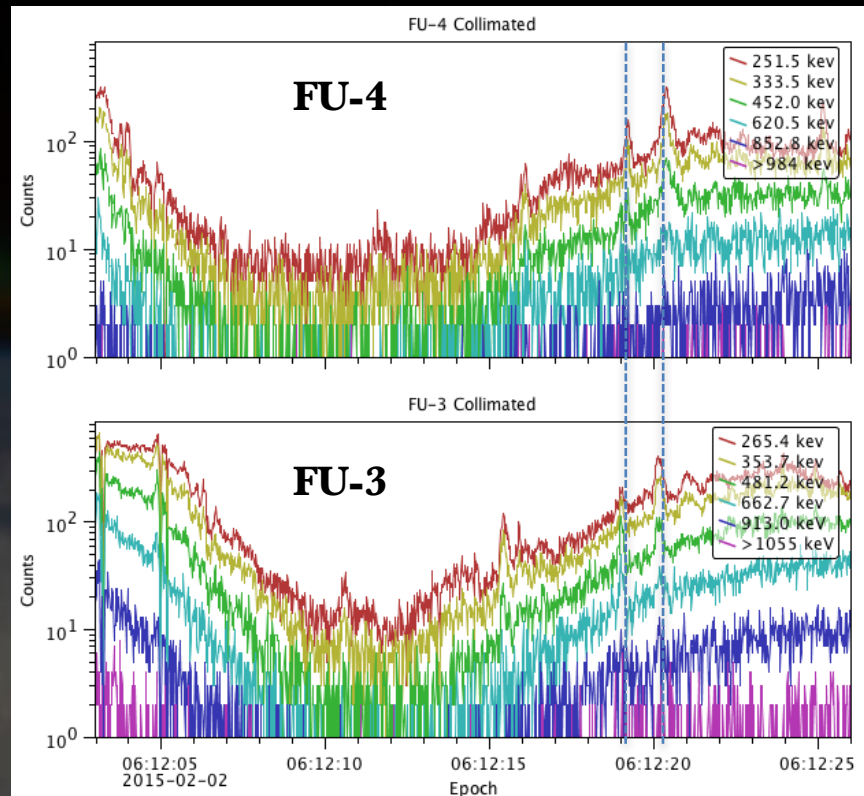
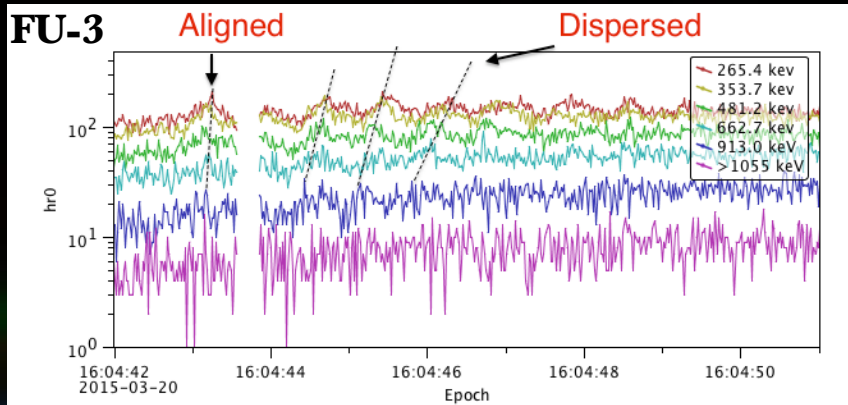


Data Processing



- 60 MB of raw data downlinked to date
 - Millions of data points
- Two payload data campaigns to date
- Data Integrity
 - Know your data path and KISS

Payload Data



- Multi-bounce dispersion feature observed three days after 2015 Saint Patrick's Day Storm (above)
- Early data (small inter-spacecraft separation) filled with electron microbursts (right)



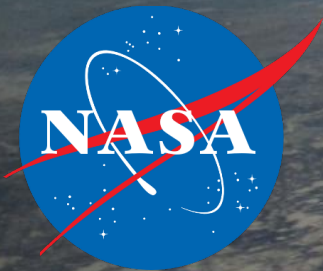
Conclusion



- Over-complicated power system lead to problems on FB-I
 - KISS!
- Direct energy transfer works well on FB-II
- Many Microburst observed and downlinked
- New solar panels providing plenty of excess power

Full Mission Success declared: Significant Microburst activity has been observed via paired satellites at relative separations at ~10 km and beyond

Acknowledgements





Questions?



Thank You!

<http://ssel.montana.edu>

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