SSC15-P-38

The FIREBIRD Instrument for Relativistic Electrons: Enabling Technologies for a Fast High-Sensitivity, Low-Power Space Weather Radiation Payload

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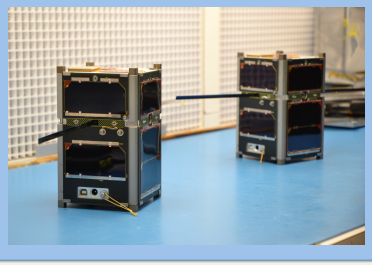
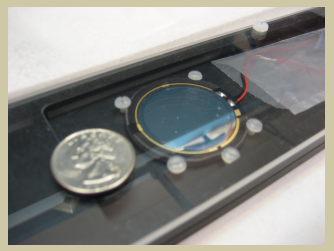
What is FIREBIRD?

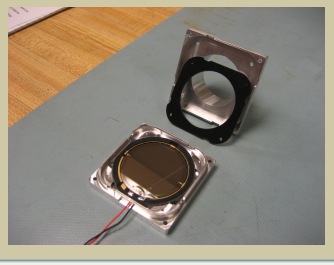
FIREBIRD (Focused Investigations of Relativistic Burst Intensity, Range and Dynamics) is an NSF funded CubeSat specifically designed to study electron microbursts. Microbursts are short-lived (~100ms) bursts of electron precipitation from the Earth's radiation belts to the atmosphere. Each FIREBIRD mission (launched December 2013, and January 2015, respectively) consisted of a pair of CubeSats which slowly separated over the course of the mission to measure bursts at a variety of spatial scale sizes.



Left: 2 FIREBIRD spacecraft fully assembled with antenna deployed. The top 1/3 of the spacecraft contains FIRE (the instrument, built at UNH) while the bottom 2/3 is BIRD, built by MSU.

FIRE Instrument



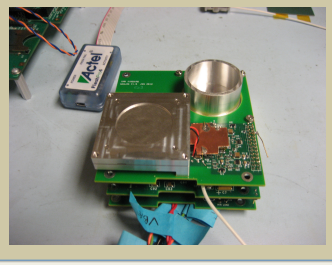


FIRE uses a pair of 1500um thick solid state silicon detectors on each spacecraft. These detectors are identical, with the exception of a collimator that surrounds one detector to change the geometric factor and acceptance angle. These detectors were acquired as surplus from a NOAA mission.

An additional enabling technology for FIRE was the DAPPER, an Aerospace developed chip for NASA's MMS mission which handles both detectors simultaneously in a low-noise and low-power environment.

Top Left: Single solid state detector with quarter for scale.
Bottom Left: one of FIREBIRD's solid state detectors being integrated into it's light-tight doghouse. The active area of the detector is then covered by an aluminum foil that also screens out low-energy particles.

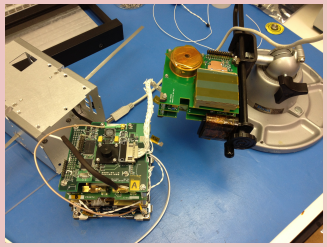
Right: FIRE Engineering model for testing. Surface detector and collimated detectors (hr1, and hr0 respectively) are shown. The DAPPER lies underneath the small electronics shield. Top board is analog board, the middle one is the digital board, and the bottom one is the power board, responsible for generating the 250V the detectors require.



FIRE/BIRD Interface

The sole instrument on FIREBIRD is FIRE (FIREBIRD Instrument for Relativistic Electrons). This is connected to BIRD (Bus in support of Radiation Detection) through a single interface cable (pictured below). This was done for testing and design simplicity with the instrument and spacecraft teams being located across the country from one another.

Right: FIRE/BIRD interface. BIRD is at left next to a skeletonized structure. FIRE is at right with the single interface cable connecting the two. Both FIRE detectors are covered by lab dust covers to prevent damage during testing that were removed prior to integration into the p-pod.



Digital Interface

In addition to being the interface between FIRE and BIRD, the digital board is also responsible for converting the pulse widths produced by the DAPPER into counts in the defined energy bins at the appropriate timing (200 keV to >1 MeV at 18.75ms time resolution). These values are customizable which aids in calibration.

Left: FIRE digital board, the middle board in the FIRE instrument stack.

Calibration and Flight

Calibration consisted of both bench-top testing with beta and gamma sources (at left), running at the highest energy resolution possible (~10 keV). This was used to set the digital fence-posts that defined the 6 energy channels from 200 keV to 1 MeV used in flight. At right is an example of on-orbit measurements from Flight Unit 3 during the St. Patrick's day storm in 2015. Both detectors measure microbursts across a large energy range and the different geometric factors both ensure sufficient counts and mitigate saturation issues.