



Focused Investigations of Relativistic Electron Burst Intensity, Range, and Dynamics (**FIREBIRD**)



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Overview

- Overall premise
- Mission concept
- Mission science
- FIREBIRD observations
- Three scientific questions FIREBIRD will answer



Overall premise

- This is a science mission
 - Short term: order of months (think of as an extended sounding rocket)
 - Data amount set by science we are going after
- Students will be intimately involved and educated in the process of accomplishing a science mission
 - It will not be enough to teach students, the mission needs to go forward to the best of our ability in the time allotted
- This is a simple experiment to be done in a really short timeline ~3 years, funding to end of mission
- Exciting and challenging mission, big bang for the buck
 - Good chance of success



Mission concept

- Fly two 1.5kg (1.5u) cubesat spacecraft to assess the spatial scale and spatial temporal ambiguity of magnetospheric microbursts
 - 1) What is the spatial scale size of an individual burst?
 - 2) What is the energy dependence of an individual burst?
 - 3) How much total electron loss do bursts produce globally?



Mission concept

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 - 3) How much total electron loss do bursts produce globally?
- **Current and planned measurements alone cannot answer these questions, it takes low altitude multi-point measurements**
 - Time is right for these questions to be answered with RBSP et al coming down the pipe rapidly



Microbursts

- Microbursts are short (~ 100 ms) bursts of precipitation
- Initial work started in the 1960s from balloon measurements
- Studied sporadically since then (e.g. Aerospace and others)
- Primary form of electron loss on the dayside?



Effects

- Microbursts capable of losing large numbers of electrons
- Possible to empty pre-storm electron belt in a day [O'Brien, 2003]
- Need to understand temporal/spatial structure
- Recovery is on the timescale of a day
- Microbursts continue into recovery phase
- Part of balance between acceleration and loss



SAMPEX observations

> 1 MeV electrons

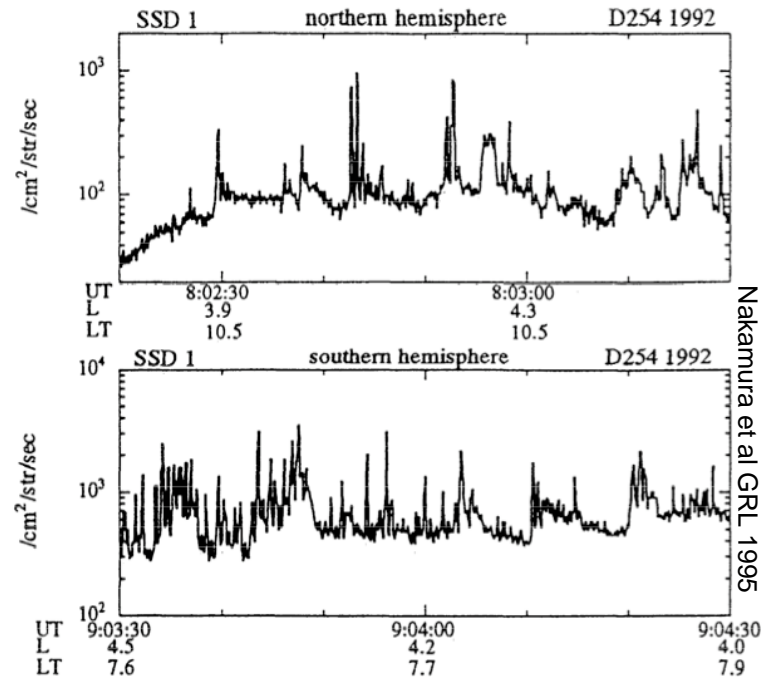
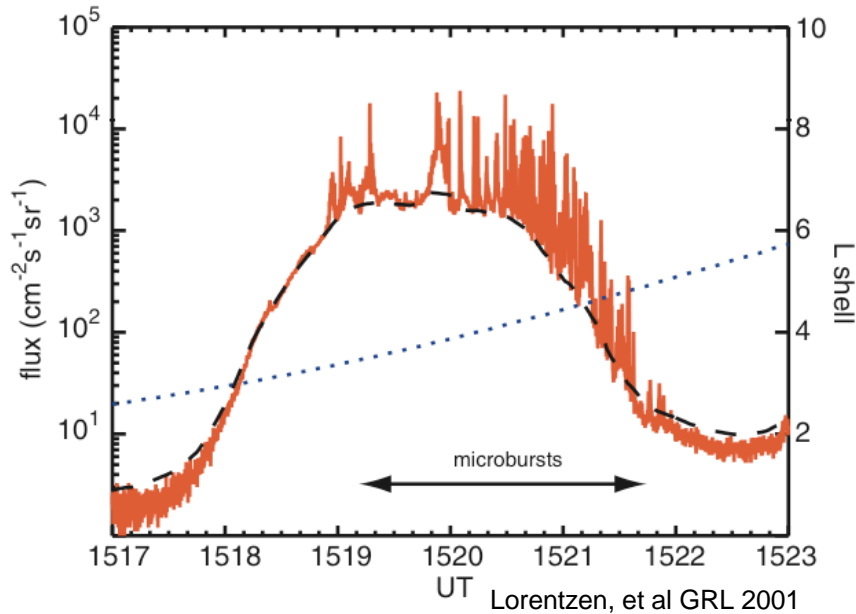
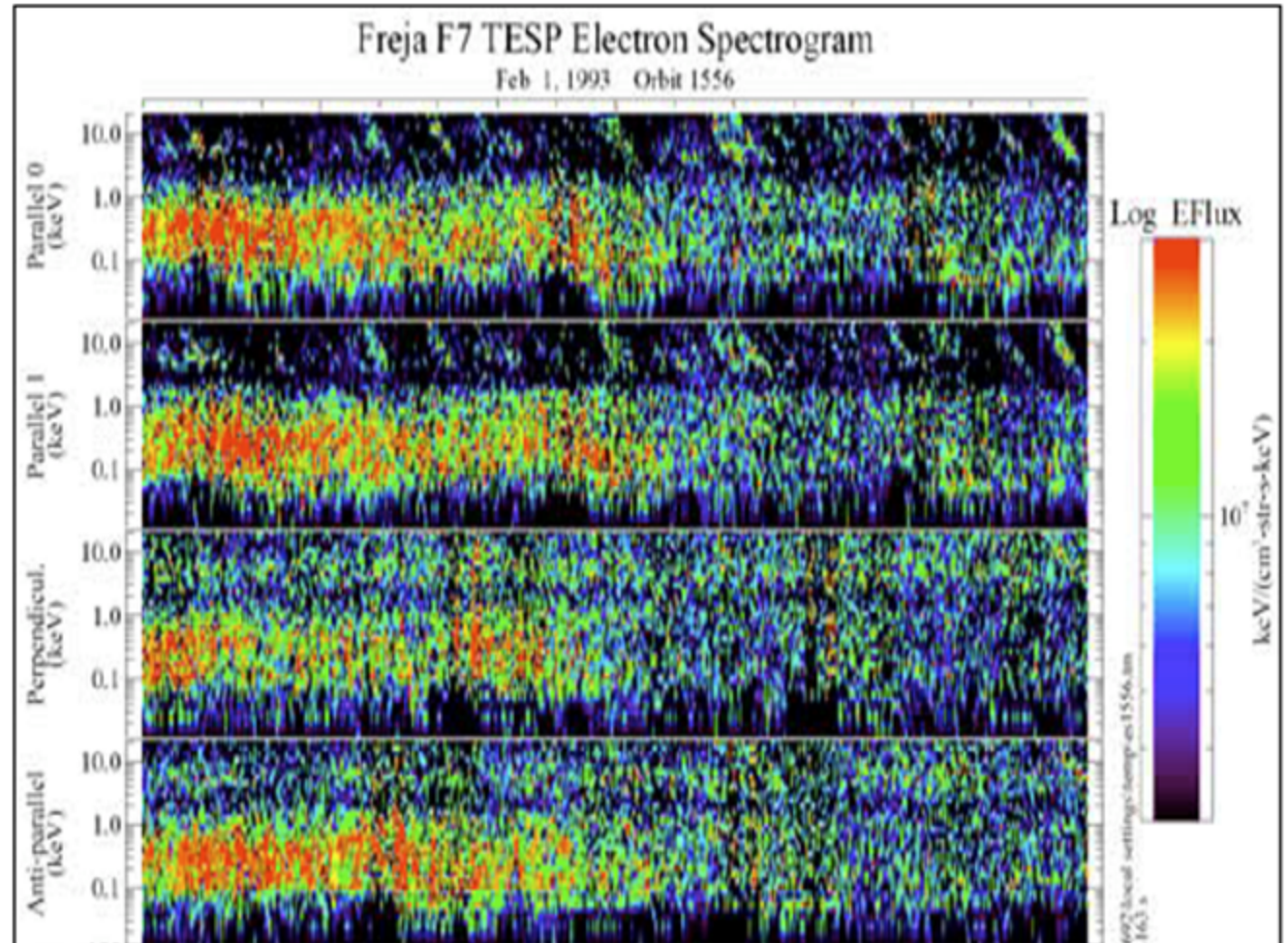


Figure 3. A plot of microbursts which occurred during two consecutive orbits on Day 254, 1992.



Freja observations

- Similar events are common in the Freja dataset
- Frequency/intensity associated with geomagnetic activity

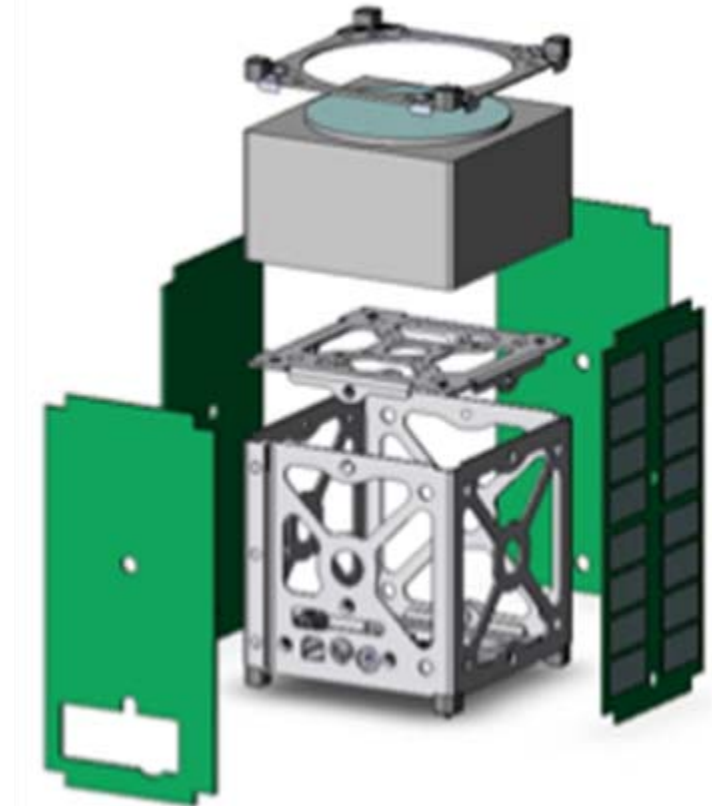


Courtesy Jim Clemmons



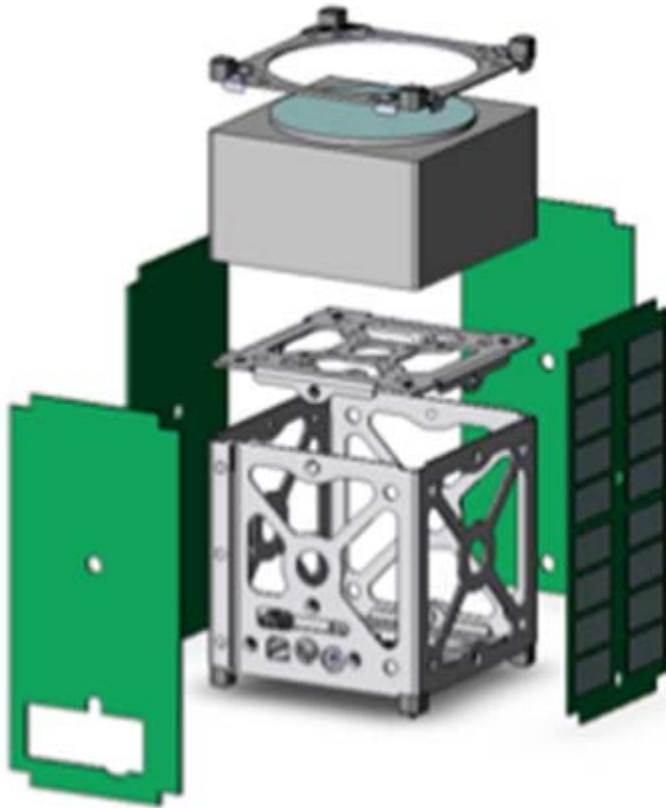
FIREBIRD observations

- Two identical 10x10x15cm cubesats
- Passive magnetic attitude control
- Large GF omni solid state detector – one per s/c
- Uncontrolled separation over the 120 day prime mission to allow sampling across many spatial scales
 - About 3 cm/s separation





FIREBIRD



BU sensor module (1/2U)
Spence/Larsen/Students
w/ Aerospace Expertise
Blake

MSU spacecraft (1U)
Klumpar/Springer/Students

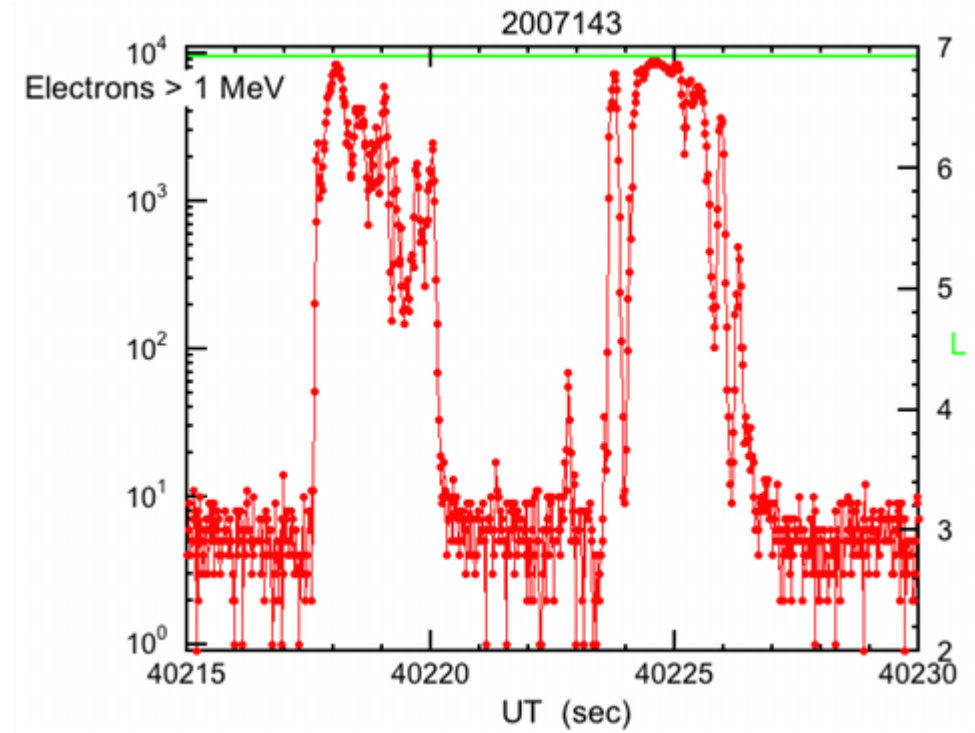


- 1) What is the spatial scale size of an individual burst?
 - Better insight into causes
 - Better insight into total radiation belt loss due to microbursts



Microburst region size scale

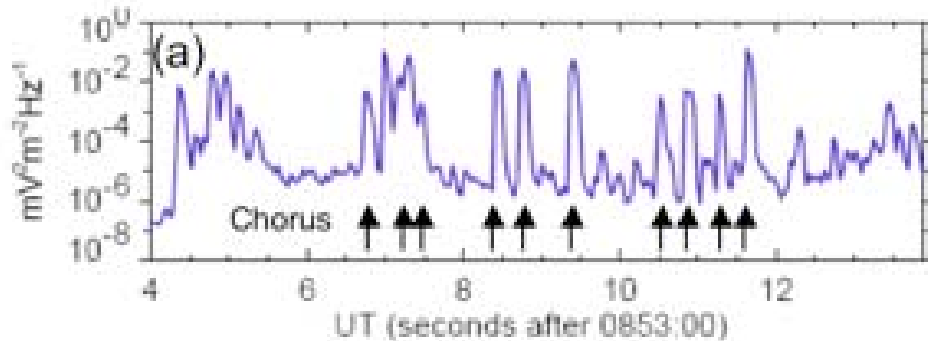
- Microbursts are in discrete “packets”
- FIREBIRD will help resolve spatio/temporal ambiguity and determine the size of the microburst region as the spacecraft drift apart



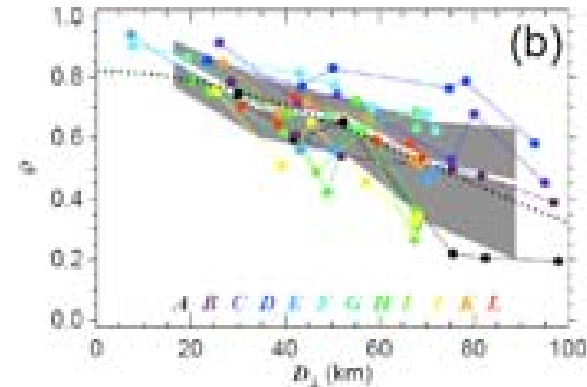


Chorus and microburst decorrelation length

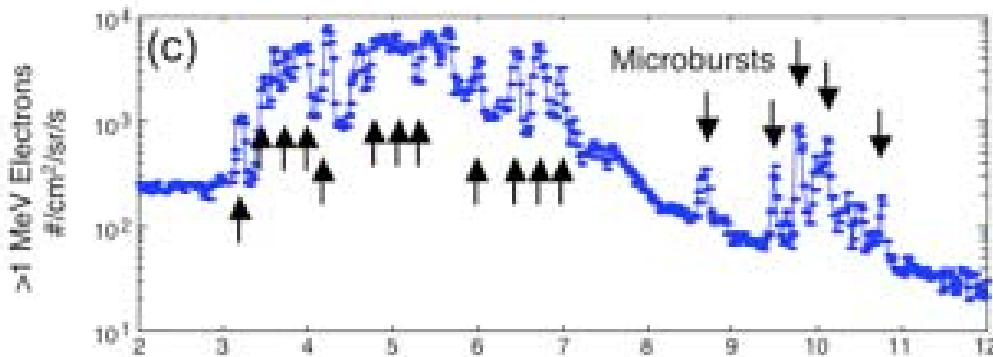
Cluster 4



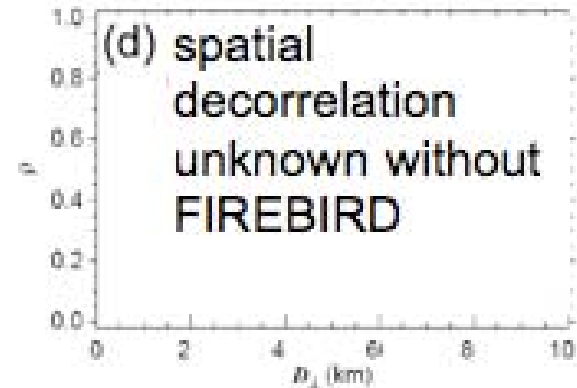
From Santolik et al., 2004, Figs 4(b) and 6(b)



Chorus properties



After Lorentzen, 2001, Plate 3(b) Seconds after 12 Sep 1996 03:33



Microburst properties

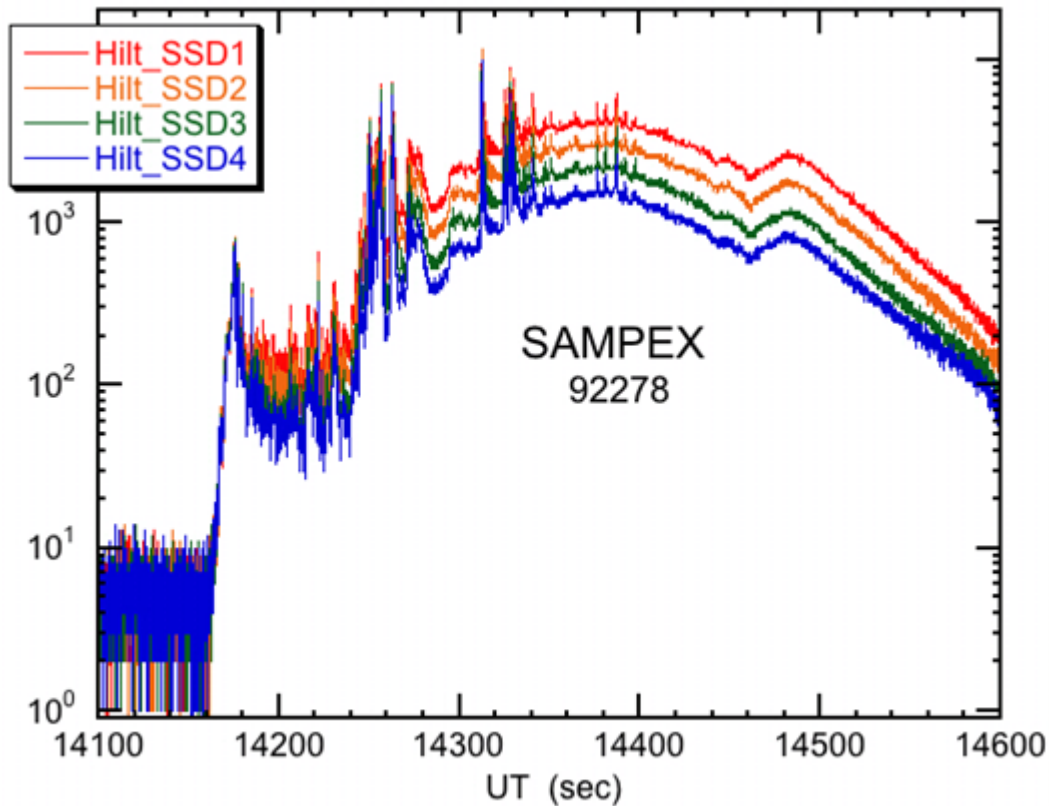


2) What is the energy dependence of an individual burst?

- Better insight into causes
- Better insight into total radiation belt loss due to microbursts
- What resonance conditions are occurring?



Microburst energy coherence

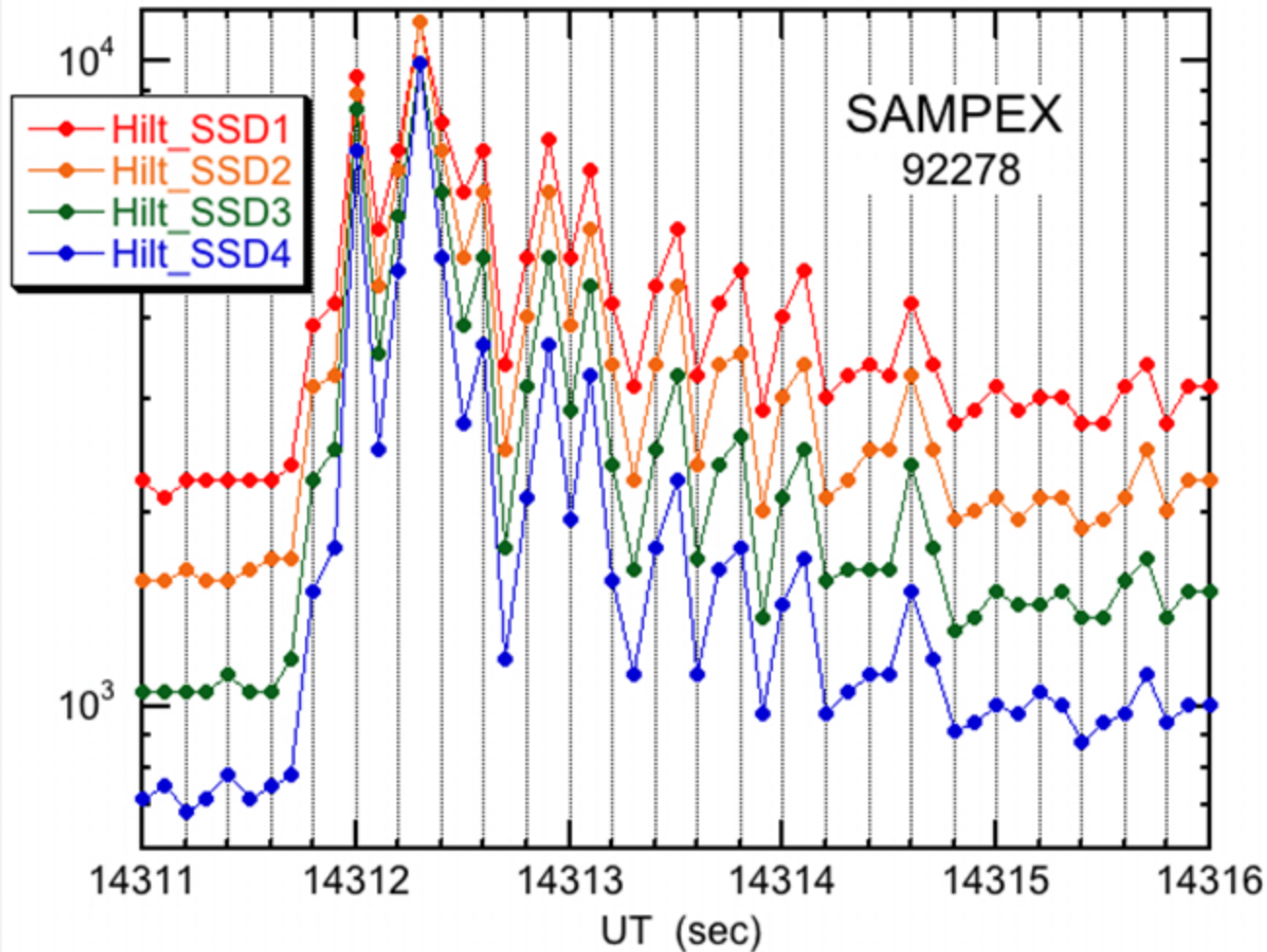


- At MeV energies there is a high level of energy coherence



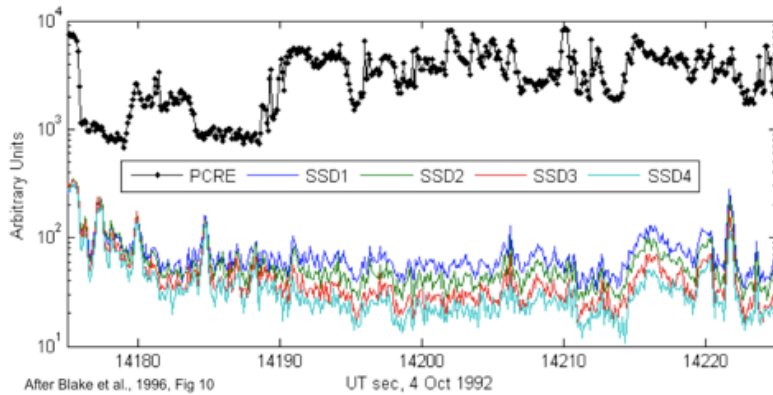
Microburst energy coherence

Zoom in





Microburst energy coherence

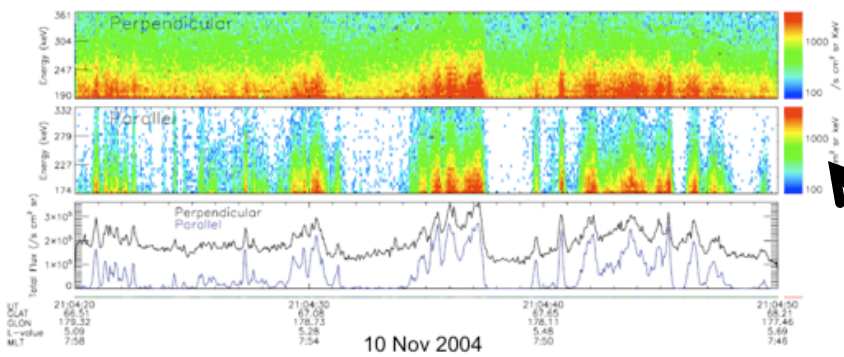
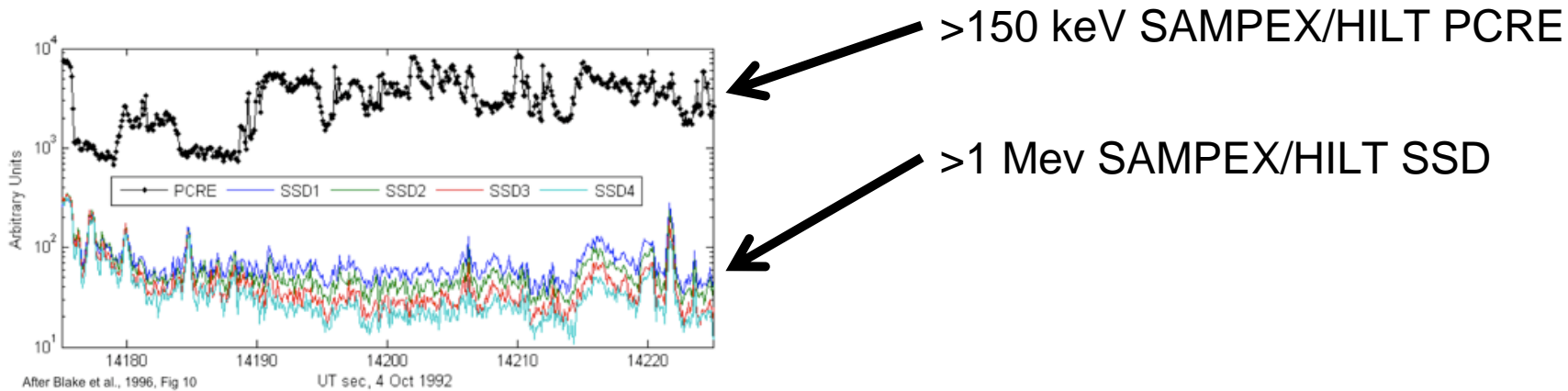


>150 keV SAMPEX/HILT PCRE

>1 Mev SAMPEX/HILT SSD



Microburst energy coherence

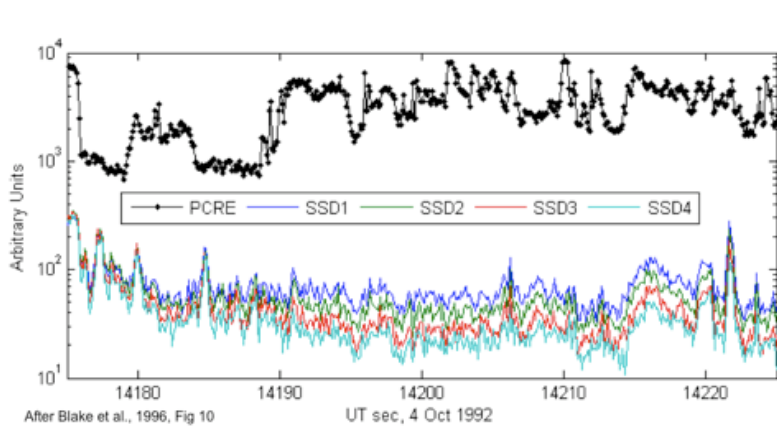


but there is coherence between 170-360 keV

Figure 2 The top panel shows an example of the lack of one-to-one correspondence between microbursts observed in the >150 keV (PCRE) channel and in the >1 MeV (SSD) channels on SAMPEX/HILT. The bottom panels show strong microburst correlation across the ~170-~360 keV range from STSAT-1.



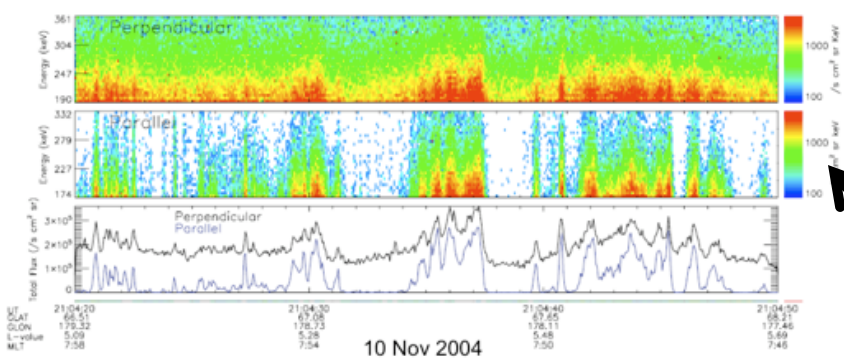
Microburst energy coherence



>150 keV SAMPEX/HILT PCRE

>1 MeV SAMPEX/HILT SSD

Somewhere between
150 keV and 1 MeV
energy coherence is
broken...



but there is coherence
between 170-360 keV

Figure 2 The top panel shows an example of the lack of one-to-one correspondence between microbursts observed in the >150 keV (PCRE) channel and in the >1 MeV (SSD) channels on SAMPEX/HILT. The bottom panels show strong microburst correlation across the ~170~360 keV range from STSAT-1.



Microburst energy coherence

- The FIREBIRD instrument provides enough counts for a high time resolution measurement with reasonable statistics
 - $\sim 350 \text{ cm}^2 \text{ sr}$
 - Measurements between 5-100 ms programmable depending on final TM, ground stations, and current separation
- 3 on-orbit programmable integral energy channels between $>200 \text{ keV}$ and $>800+ \text{ keV}$
 - Find the decorrelation “length” in the energy spectra

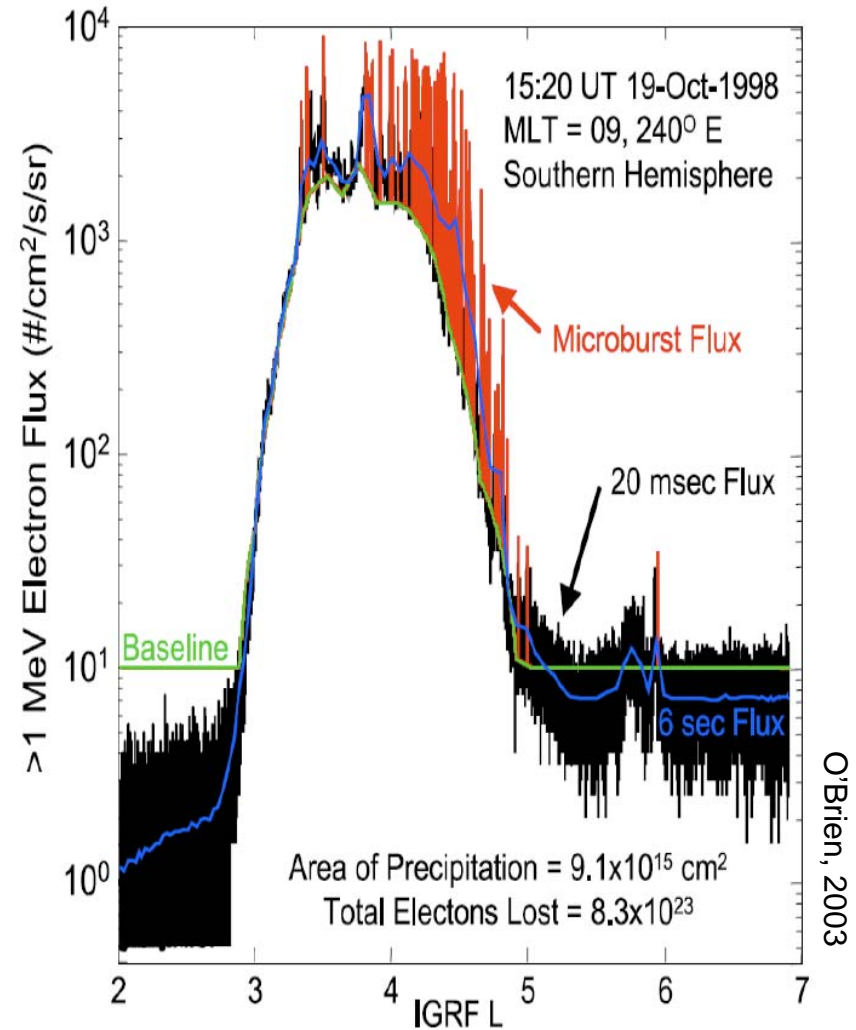


- 3) How much total electron loss do bursts produce globally?
- How important are microbursts in the system as a whole?
 - Better insight into total radiation belt loss due to microbursts



Electrons lost in microbursts

- Work by O'Brien (2003)
 - Calculate total number lost by integrating over time and space (with some basic assumptions)
- FIREBIRD contribution: by bringing in objectives 1 and 2 along with concurrent measurements, probability models, etc this can be further addressed





Summary

- In summary we are excited about this science
- We feel this is one of the viable options for cubesats in space weather
- It will certainly be exciting to see what science cubesats are built, flown, and what science is done