Preliminary Results of the SERSIO Sounding Rocket Mission

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ABSTRACT

While the auroral phenomena of ion up/outflows in the dayside cusp-cleft region are often recognized, the mechanism creating this drift is not. The SERSIO (Svalbard EISCAT Rocket Study of Ion Outflows) sounding rocket mission was designed to probe possible sources of this energy transfer, such as joule heating, wave-particle interactions, and ambipolar fields. SERSIO was launched January 22, 2004 at 8:57UT from Ny-Alesund, Svalbard, Norway into an event simultaneously observed by the EISCAT radars. It reached an apogee of 790 km. Multiple ground cameras confirmed soft electron precipitation over the length of the trajectory while the radars showed increased ion velocity above 500km and enhanced electron temperature and density. The extensive suite of observations indicates the event was exceptional due to its intensity and 2.5 hr duration. Unfortunately, an attitude control system malfunction compromised much of the in situ data. Particle energy and electric field wave frequency data are recoverable, however, and we are in the preliminary stages of data analysis. I intend to share our current efforts and results including a discussion of the role our in situ measurements of the thermal ion population will play in the larger effort with the EISCAT community. Also of interest is the broader behavior of our thermal detectors including an investigation of a possible instrument energy cutoff and our future avenues of research.

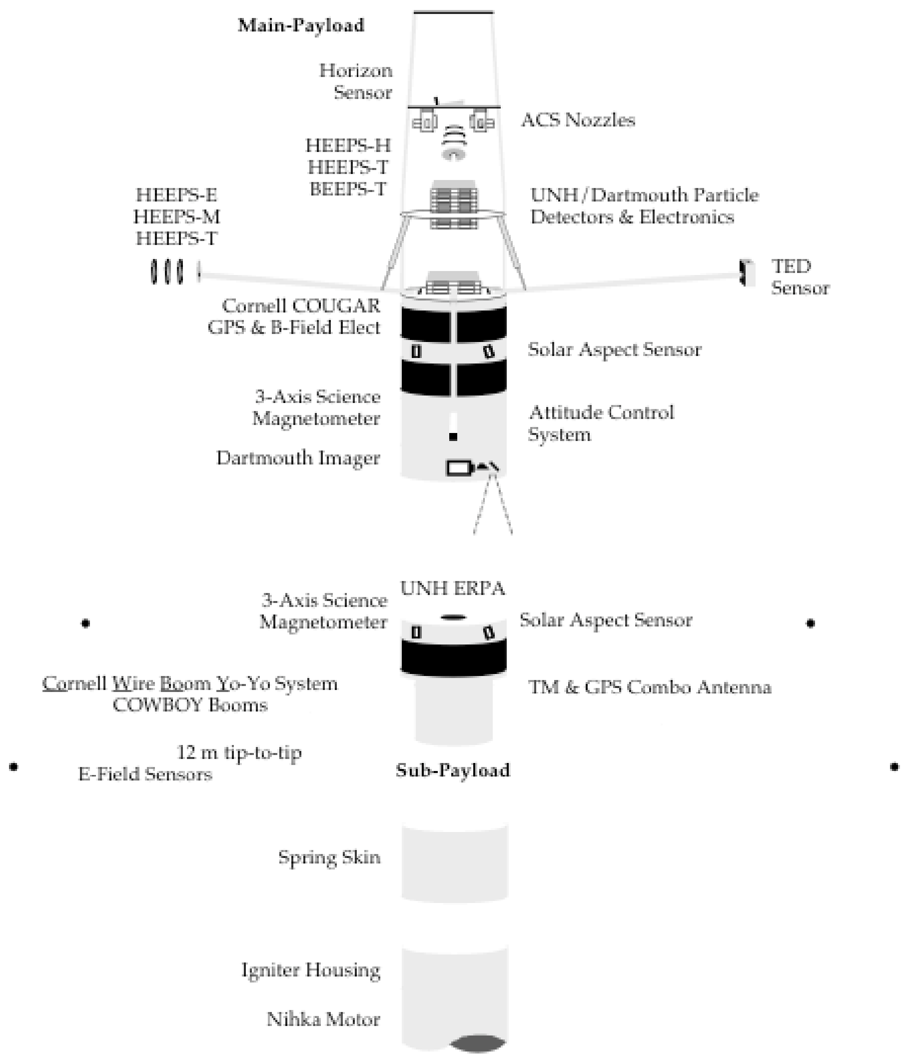


Figure 1b. SERSIO Final Configuration

(From SERSIO MRR document)

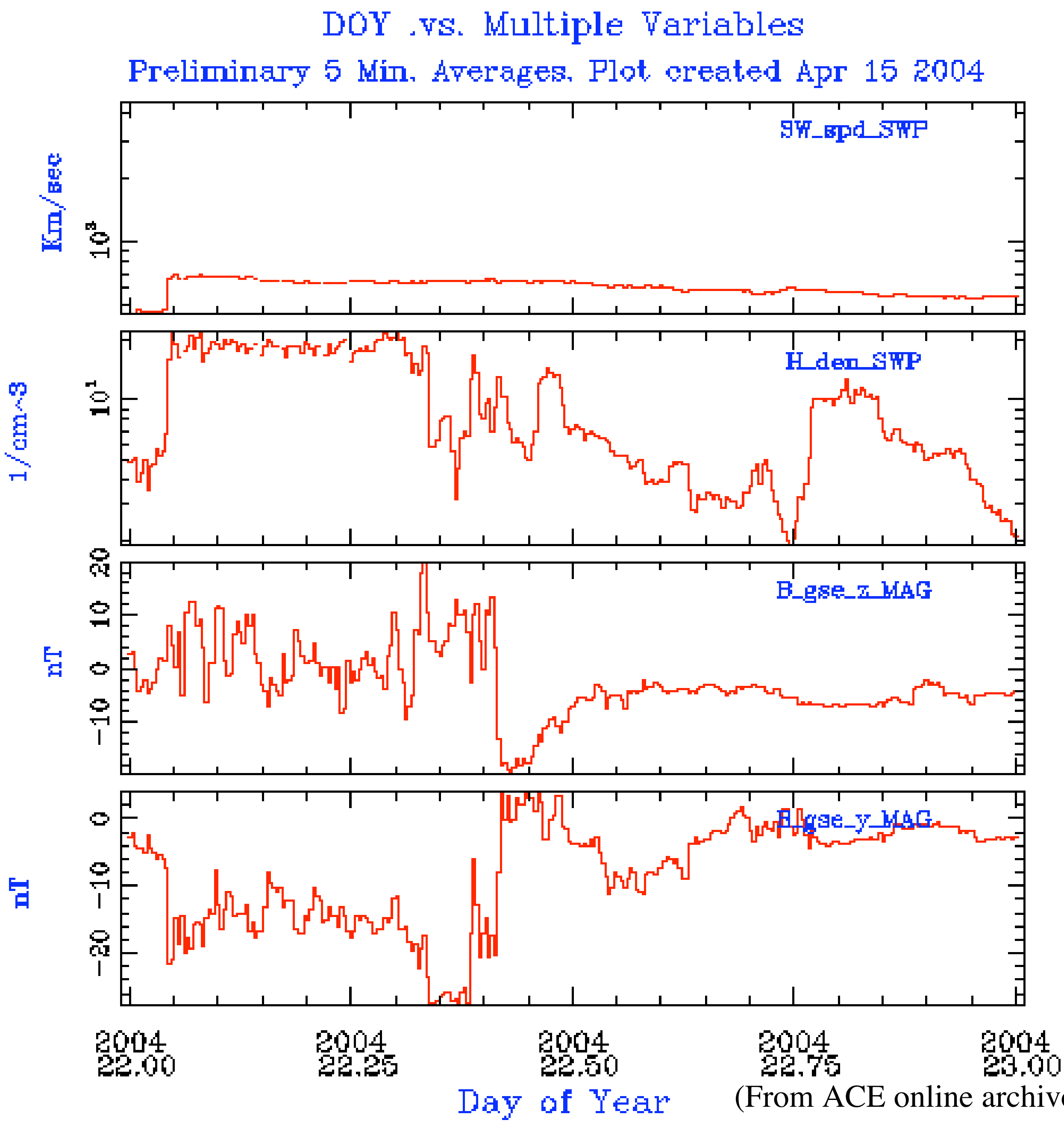
SUITE OF PAYLOAD INSTRUMENTS

HEEPS E – Electron detector (5-16000 eV)
HEEPS M – Mid-energy ion detector (7-800 eV)
HEEPS H- High-energy ion detector (200-8000 eV)
HEEPS THERMAL 1 – Thermal ion detector (0.1-20 eV)
HEEPS THERMAL 2 – Thermal ion detector (0.1-20 eV)
BEEPS – Thermal ion detector, mass separation (0.1-20 eV)
TED - Thermal ion detector (0.1-6 eV)
ERPA – Thermal electron detector (0-3 eV)
COWBOY- Electric field measurements (DC to 2 MHz)
Dartmouth Imager – Despun real-time auroral imaging
Magnetometer

ATTRIBUTES OF CONFIGURATION

•1 meter booms distance detectors from payload disturbance
•Thermal ion detector arrangement allows for 3D imaging
•Large (12 meter) electric field booms are ideal for measuring DC fields and low frequency plasma waves

1/22/04 EVENT



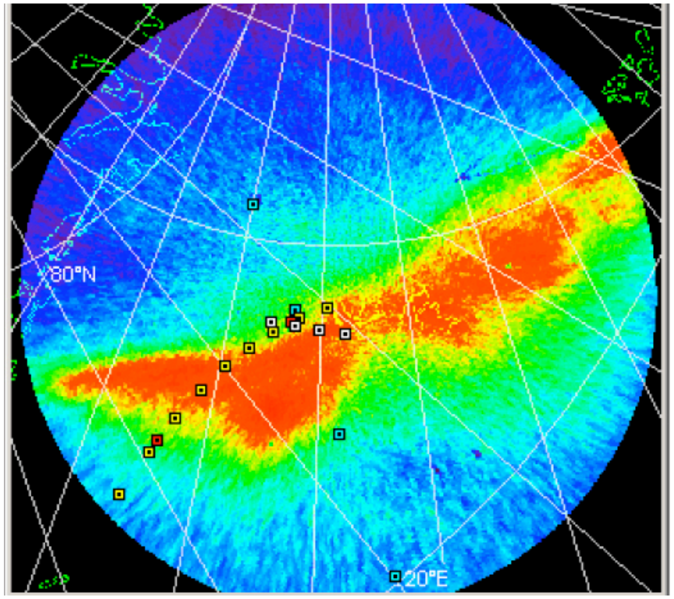
ACE SATELLITE

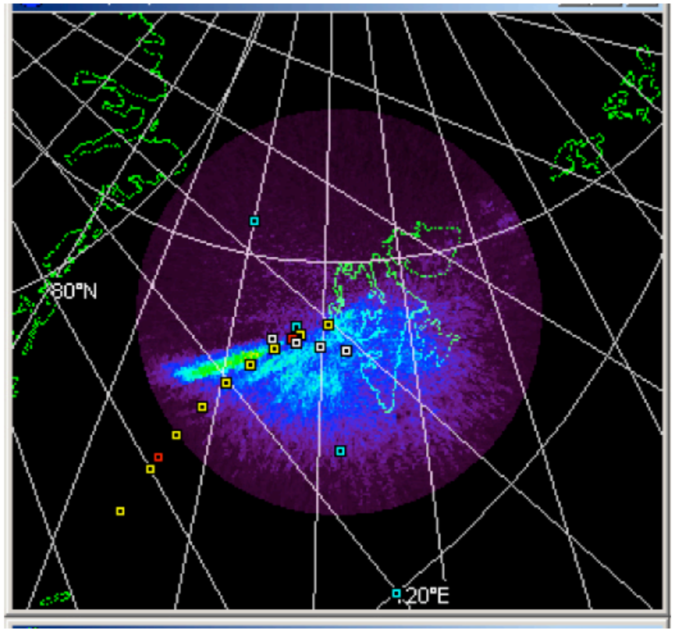
- Effects of CME evident at ~1 UT
- During timeframe of flight, IMF Bz > 0, By < 0
- Due to IMF configuration, auroral activity could be associated with lobe reconnection

(From ACE online archive, http://www.srl.caltech.edu/ACE/ASC/)

1/22/04 EVENT

ALL-SKY CAMERAS
- Multiple ground-based cameras confirmed soft electron precipitation
- Images were taken at 9:04 UT which corresponded with apogee
- Red was the soft 6300 A emission
- Green was the hard 5577 A emission





(From UiO Camera, Ny-Alesund, http://www.fys.uio.no/~kjellok/sersio/UiOallsky.html)

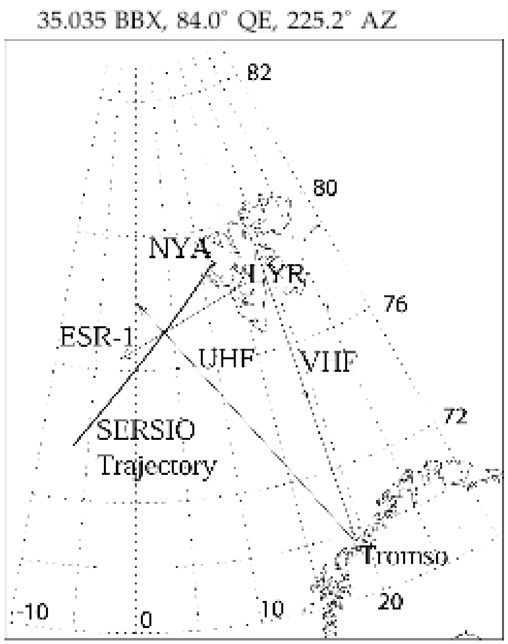
1/22/04 EVENT

EISCAT DATA

•Incoherent scatter radar located in Longyearbyen, Spitsbergen, Norway

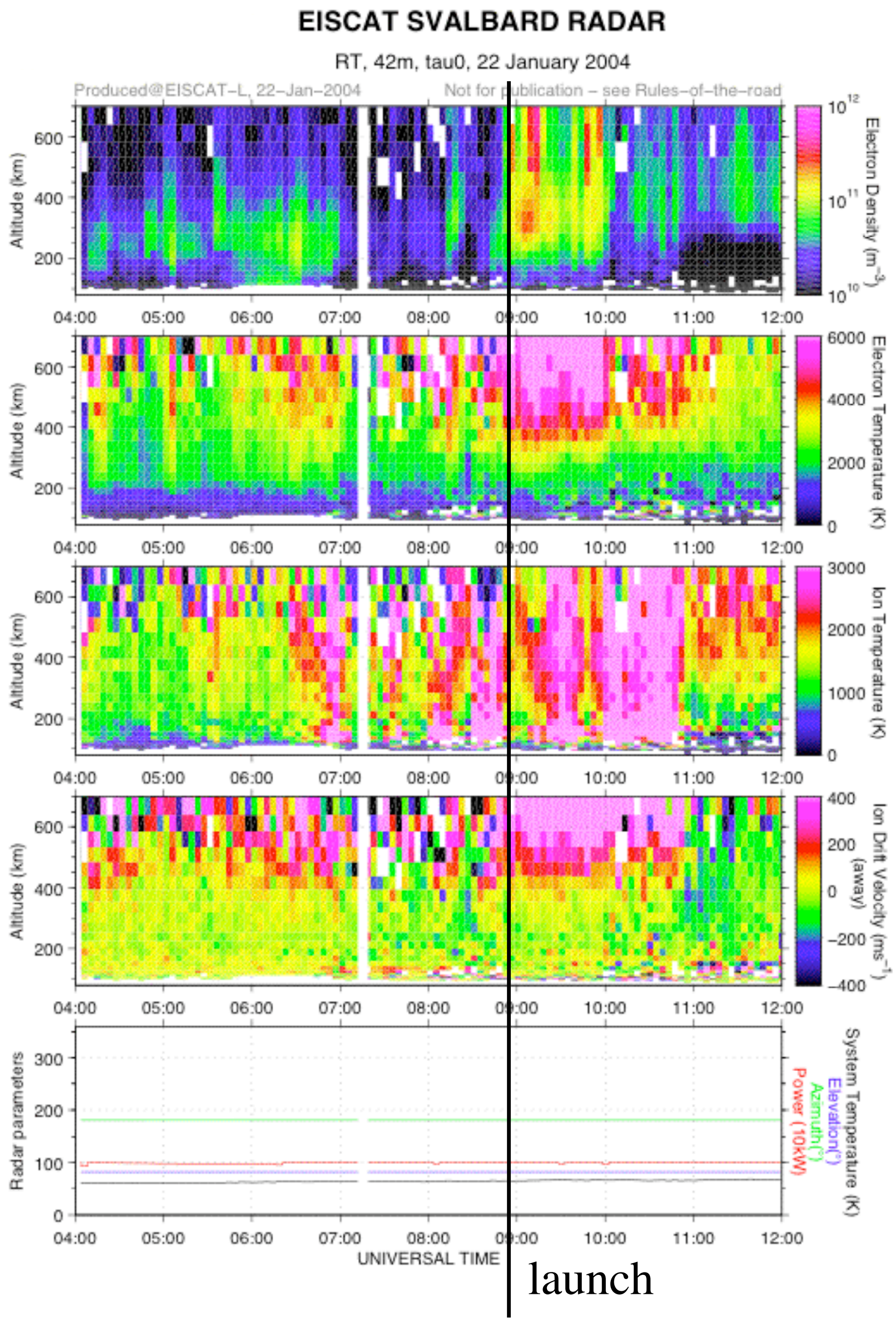
•Radar utilized to locate ion upflows (increased ion velocity over 500 km in conjunction with either enhanced ion or electron temperatures)

- •42 meter dish look direction was toward magnetic zenith
- •32 meter dish pointed toward anticipated apogee



(From SERSIO MRR document)

1/22/04 EVENT

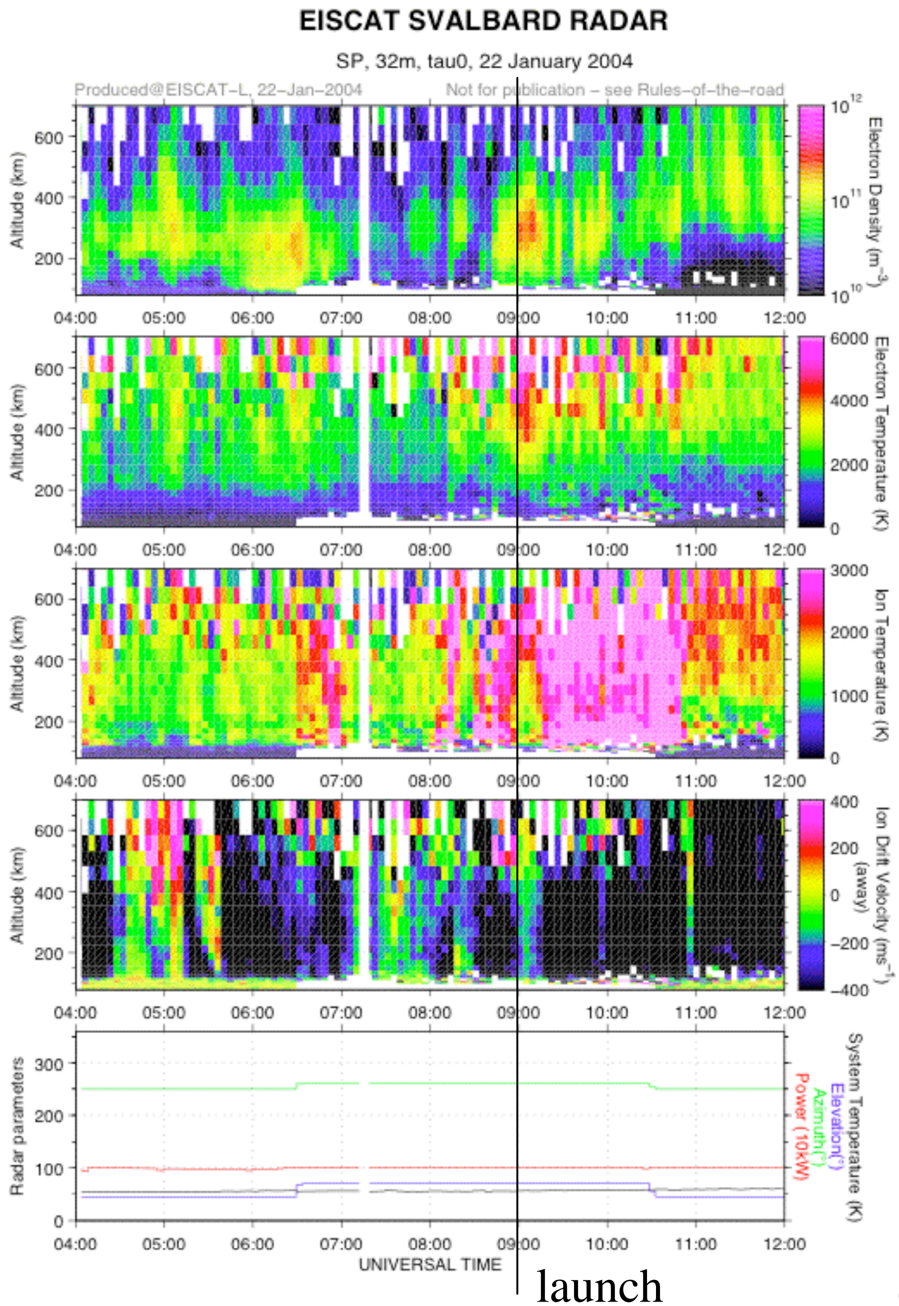


42 meter Plot

- This radar used to detect outward flows
- Look direction did not intersect trajectory - assumption that upflows seen in Longyearbyen were indicative of activity in the area in which we launched
- Note ion drift velocity ~9-11 UT; this is the upflow event we launched into
- ~15minutes of in situ data corresponds with period of increased electron temperature and density
- This period of flow evolves into an ion-heating event

(From http://www.fys.uio.no/~kjellok/sersio/eiscat.html)

1/22/04 EVENT

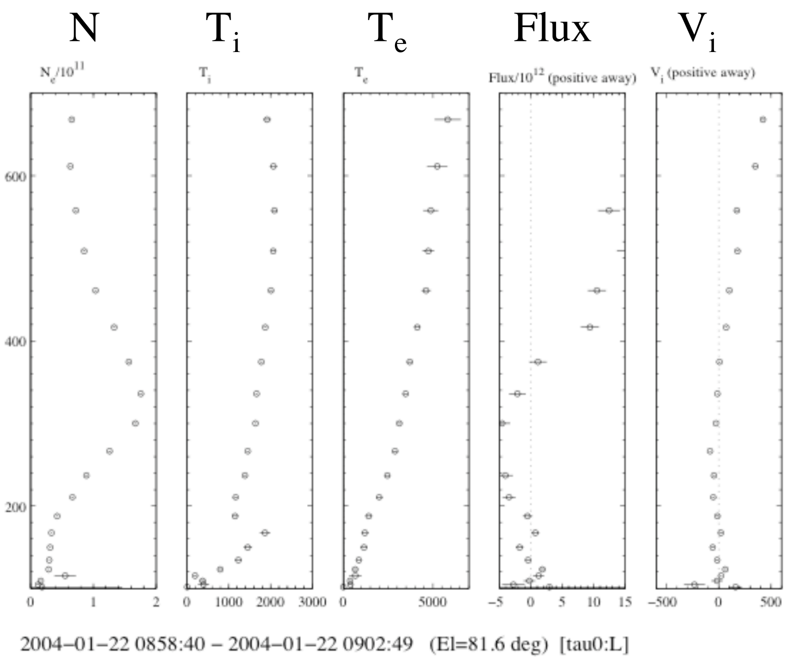


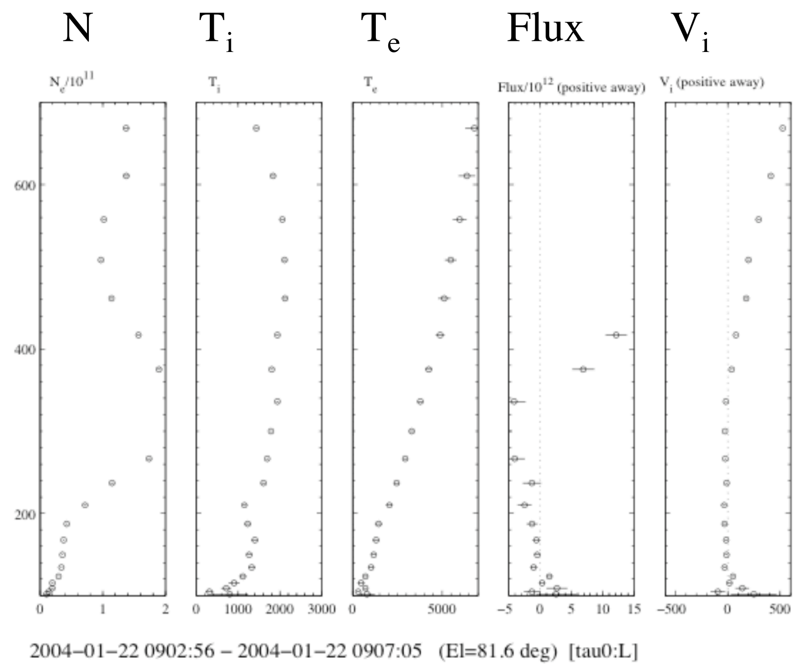
32 meter Plot

- Look direction of this radar gave information about ionospheric convective flows.
- Note the enhanced electron temperature and density and eventual increase in ion temperature

(From http://www.fys.uio.no/~kjellok/sersio/eiscat.html)

1/22/04 EVENT

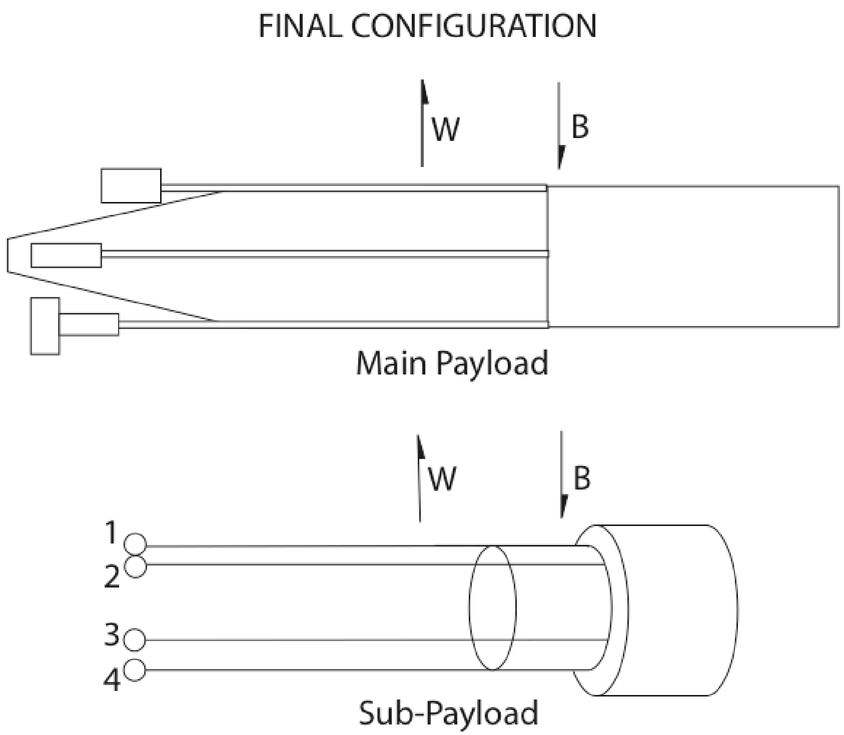




EISCAT Line Plots

- These plots are courtesy of Y. Ogawa
- Each panel represents 256 seconds accumulation of the 42 meter radar
- Time series matches acquisition of our in situ data
- At 600 km in altitude the radar measures 500 m/s upflowing ions and >5000 K electrons

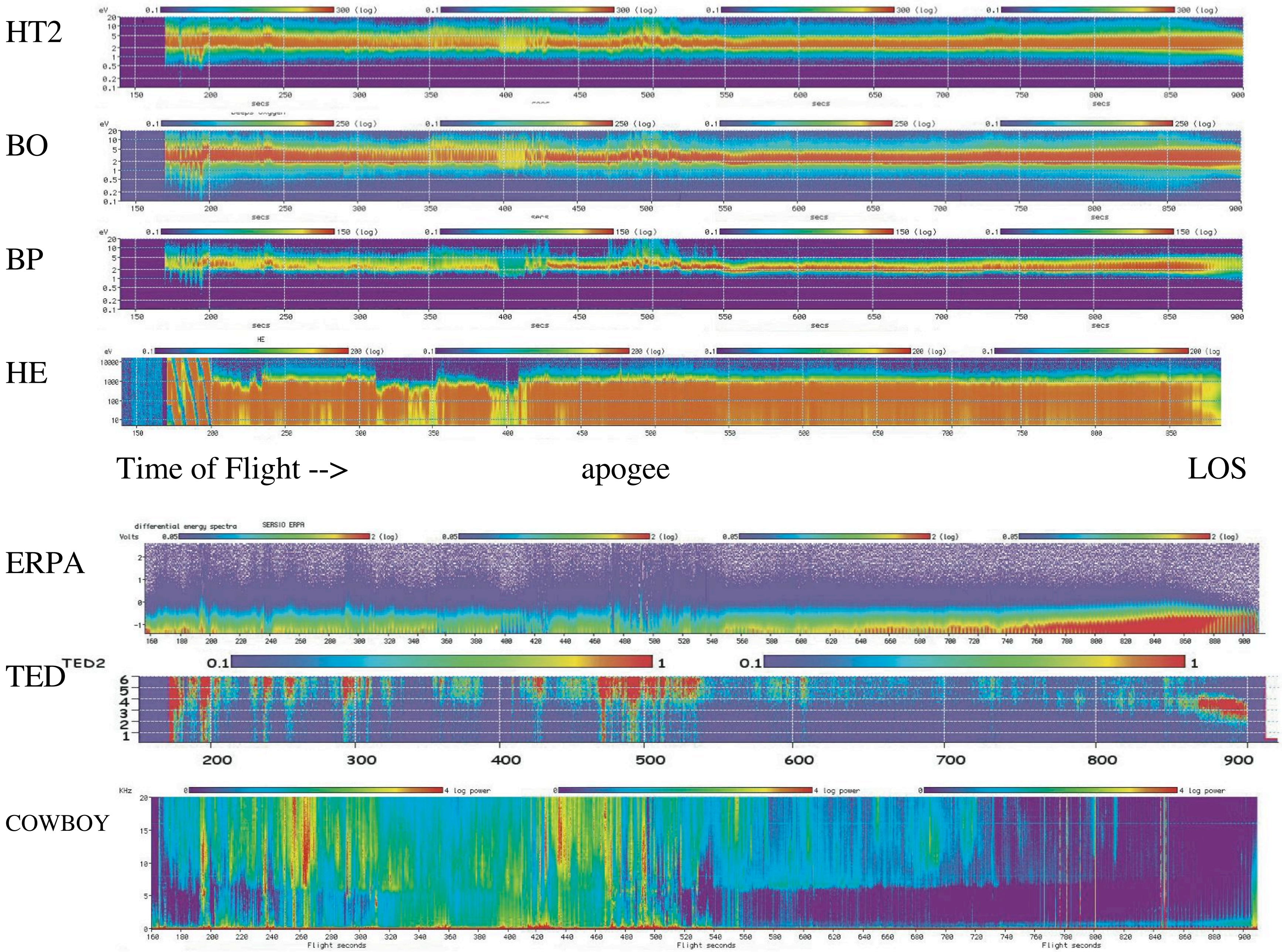
(From Ogawa, http://www.fys.uio.no/~kjellok/sersio/eiscat.html)



FLIGHT CONFIGURATION

- An ACS failure caused SERSIO not to achieve its proposed alignment with the Earth's magnetic field.
- The COWBOY went into a flat spin, with all the spheres grouped together – two of the four were touching.
- The Main payload also settled into a flat spin – the booms folded back up
- Our data was compromised. 3D imaging of the thermal ion detectors was lost, as was much directional information. Electric field sphere separation was a fraction of design. Incorrect spin axis caused the Dartmouth Imager to completely miss the aurora.
- We do have scalar information from the particle detectors like energy and temperature. There is some VLF data from COWBOY.

SERSIO In Situ Data



IN SITU DATA

•The ~2 eV cutoff in the thermal ion spectra indicated that the payload charged to about –2 V.

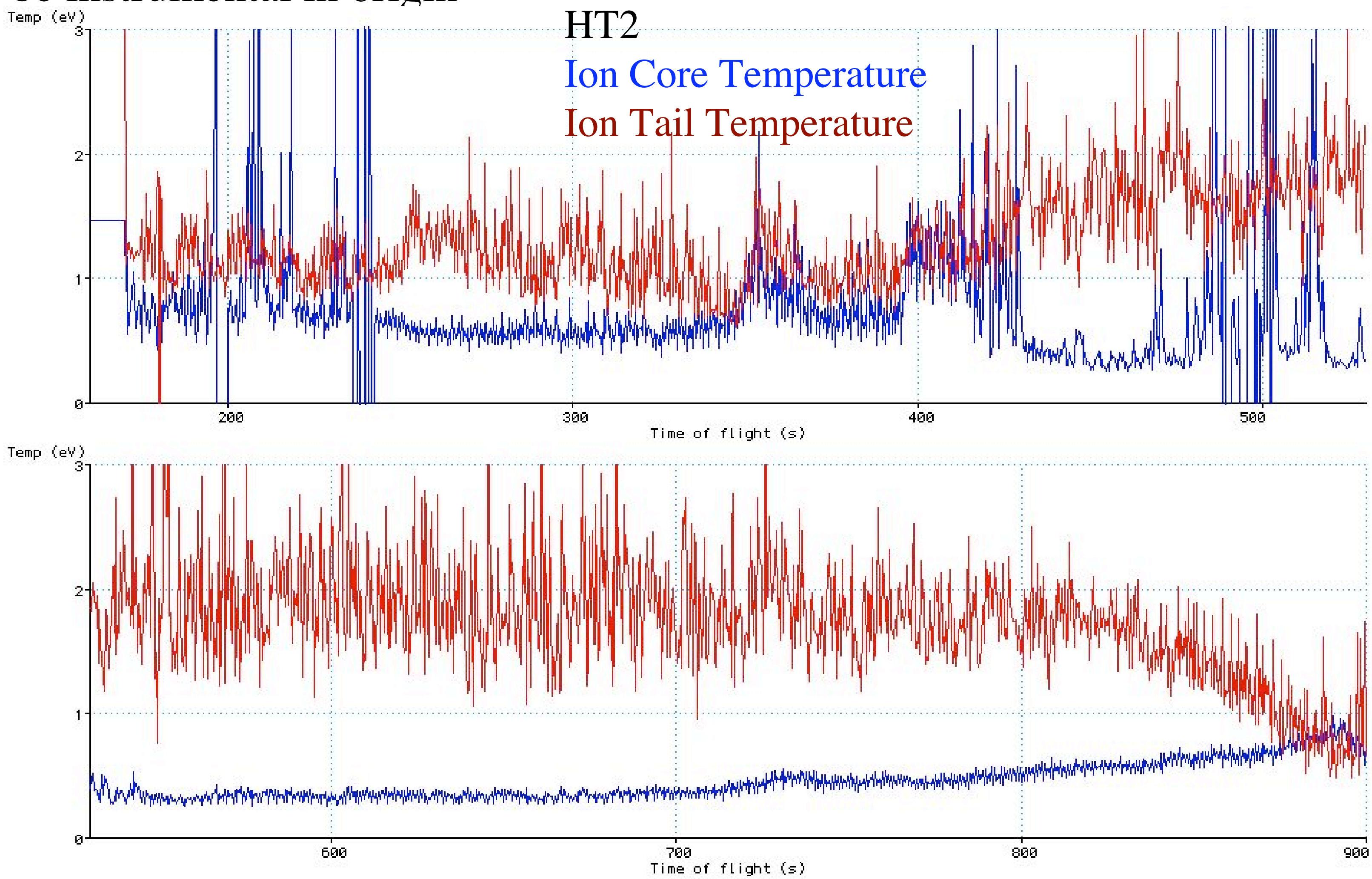
•Around 400 seconds in the flight there was a ~20 second interval of decreased count rate.

•HE detector's dropout preceded that seen in the thermal detectors.

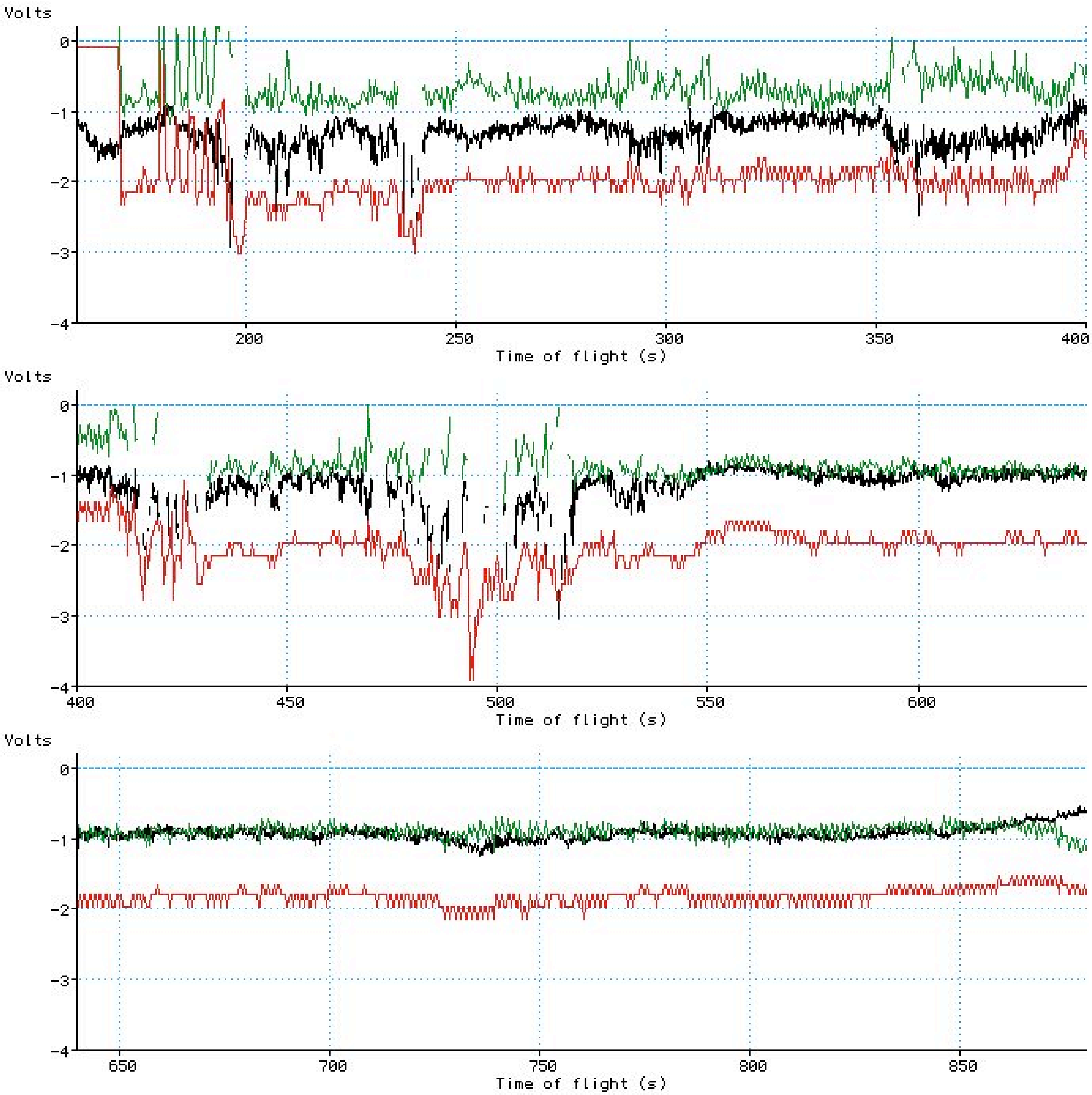
•Around 500 seconds there was heating of the thermal ion core and tail. There was also increased VLF activity at this time.

HT2 Temperature Plot

- At ~500 seconds the core and tail of thermal ion population experienced heating
- At ~400 seconds the core and tail plotlines merged – this behavior is suspected to be instrumental in origin



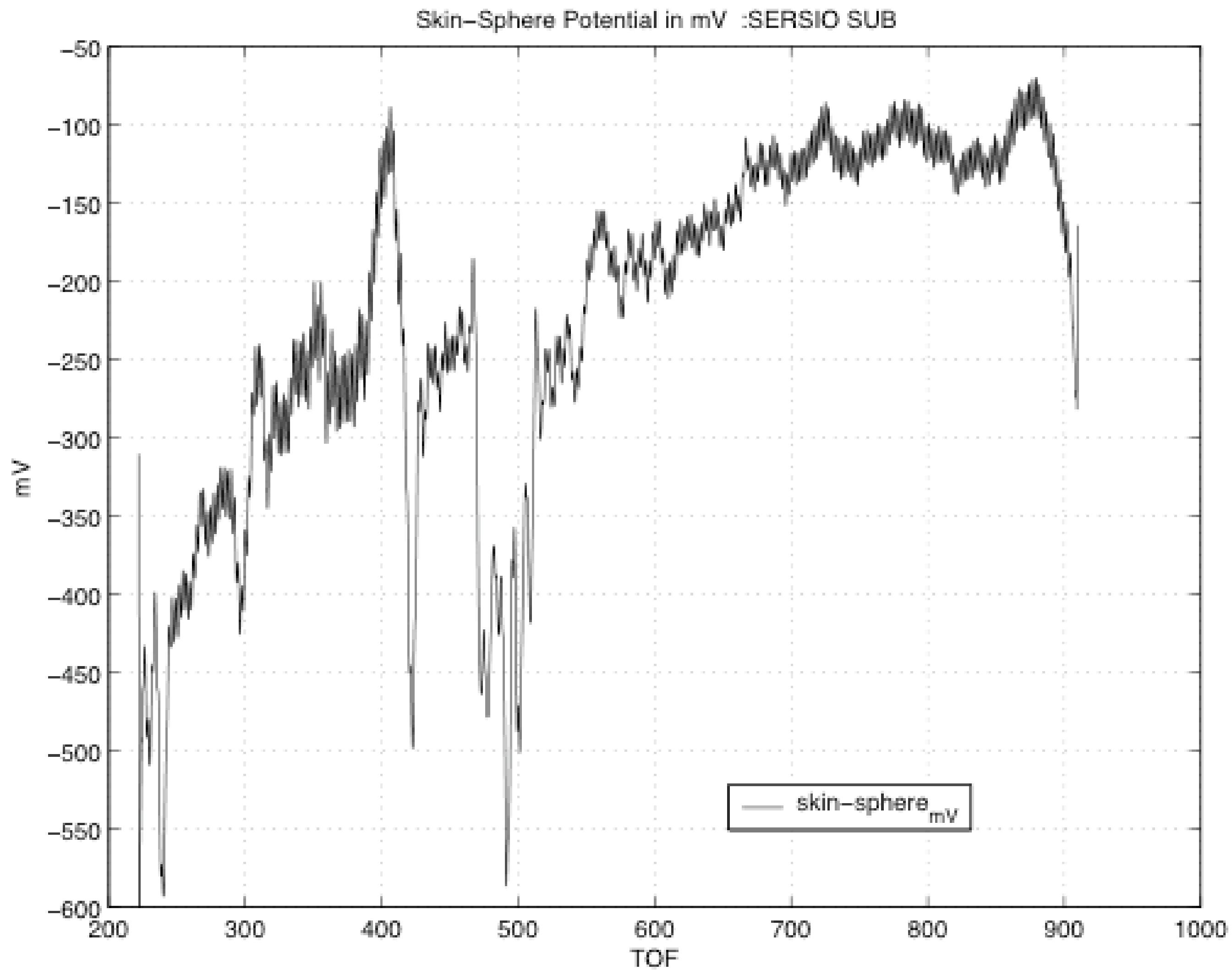
Potential vs. Time of Flight



Potential Plot

- The red plotline represents the payload potential we obtained from HT2 data
- Using ion temperatures from HT2 and electron temperatures from ERPA on the sub payload, we calculated the potential an ideal sphere would have – plotted in black.
- We infer the difference between these two potentials was an effective sphere to skin of the main payload – plotted in green.

The sub payload's sphere to skin potential



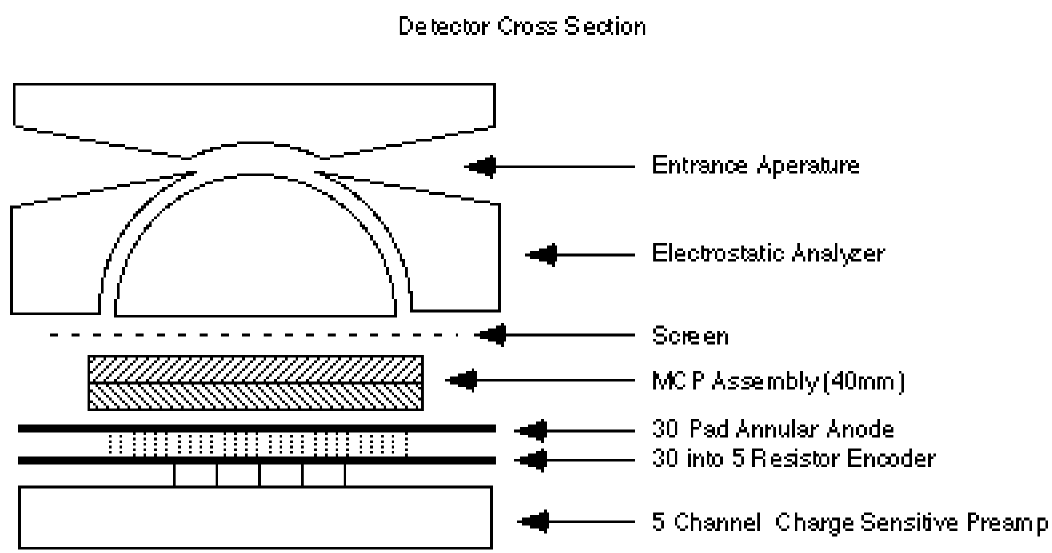
(courtesy of Eric Klatt)

Instrument Cutoff

•The 400 second dropout would have increased the payload potential, effectively lowering the observed energy cutoff.

•We however do not see the core of thermal ions at a lower energy.

•An instrument energy cutoff has been blamed for the loss of the core below ~1 V and would explain the merging of the core and tail temperatures in the previous plot



CONCLUSION

- The measured in situ electron and ion temperatures compare well with the EISCAT profiles
- Ion temperature shows tail enhancements invisible to EISCAT
- The spacecraft potential as measured by the thermal ion cutoff is consistent with a high electron, ion temperature environment.
- The spacecraft potential is not well measured by Vss
- In situ particle measurement under study in comparison with wealth of ground camera data.
- Indication of low energy instrument cutoff (~1 eV) motivates the design and fabrication of low energy calibration source.