Preliminary Results From an Automated Charging Event Identification Program for LEO Spacecraft

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Outline

- Charging Events Definition
- Previous work
- Algorithm Description
- Preliminary Results
- Summary

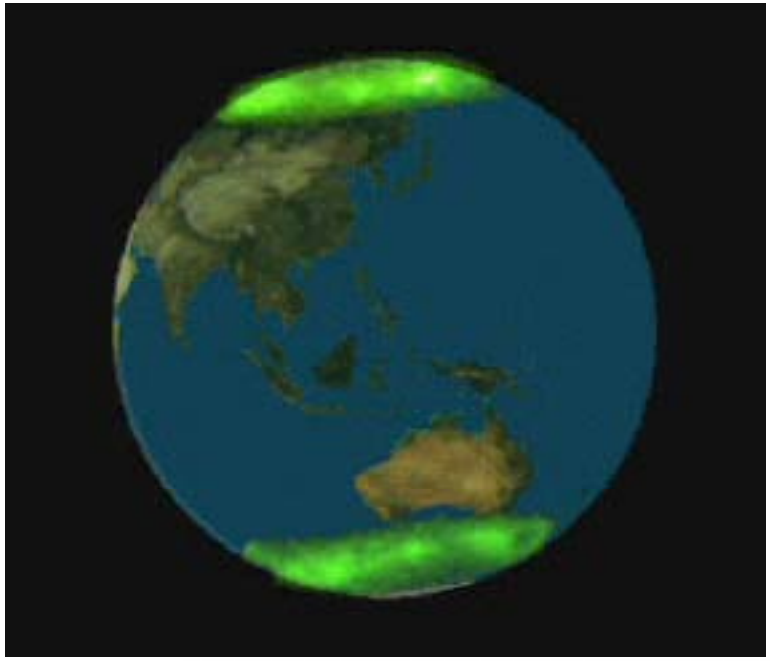
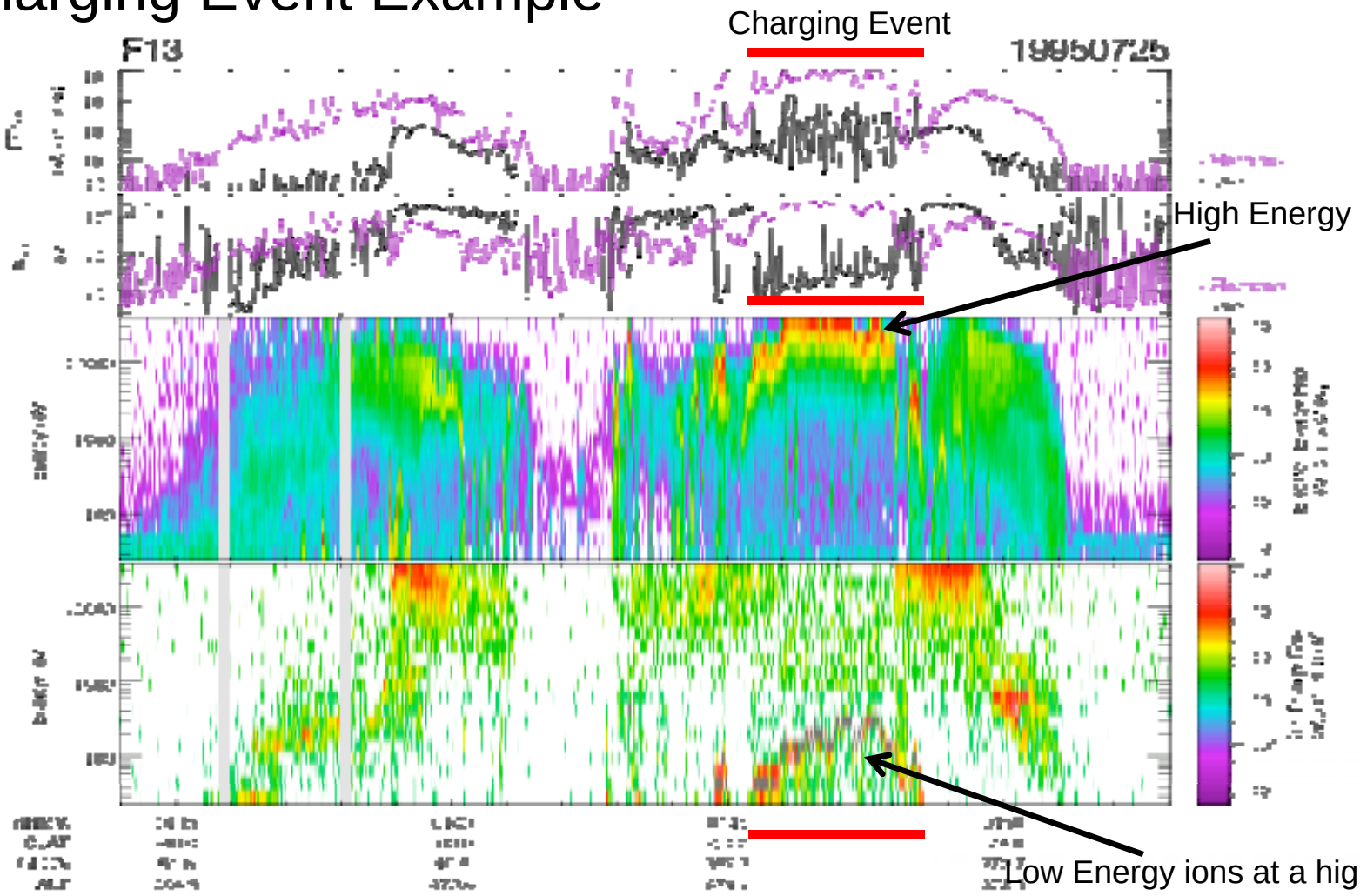


Figure shows auroral light emissions as observed by NASA POLAR Satellite on22 October 2001. Charging events on LEO satellites occur during passage through the auroral oval region.
Image courtesy of NASA.

Charging Event Example



- Strong Charging event 0145 to 0148.

Previous Work

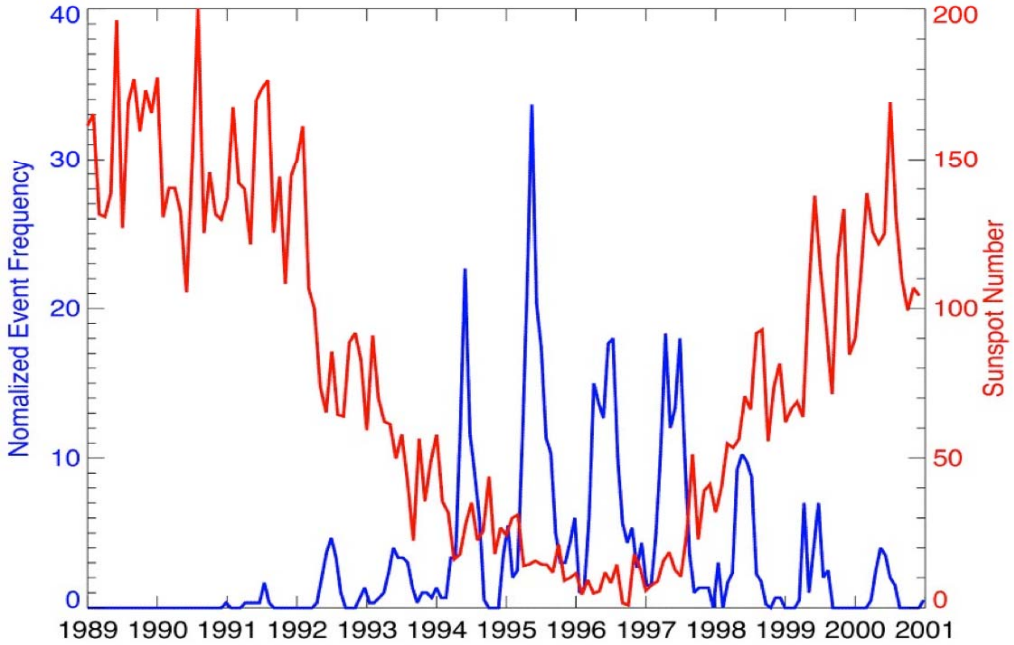
- Surface charging events are capable of producing spacecraft anomalies:
  - *May 5, 1995: DMSP F13 microwave imager experienced microprocessor lockup [Anderson and Koons, 1996]*

- Study by *Gussenhoven et al. [1985]* showed DMSP F6 and F7charged to -100V under the following conditions:
  - *spacecraft is in darkness*
  - *plasma density is less than 104 cm-3*
  - *high integral number flux (> 108 electrons cm-2 s-1 sr-1) of high energy (> 14 keV) electrons.*

- Over 1.5 year during solar minimum period DMSP F10, F12, F13 spacecraft experienced 704 charging events [Anderson, 1998]

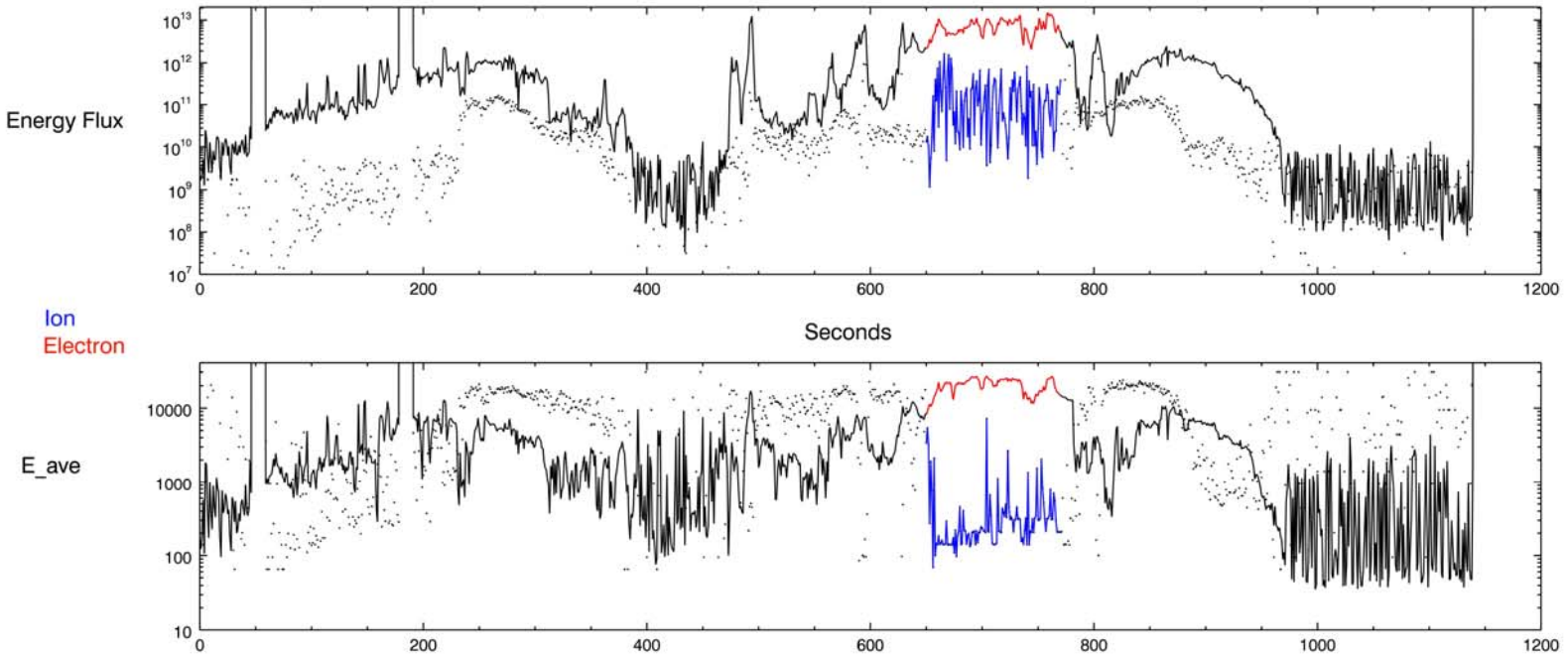
Previous Work cont.

- Solar cycle variations in charging events has been observed and shown in figure. [Anderson, 2005]
  - *Figure shows normalized charging event frequency utilizing DMSP F8-F14 spacecraft data.*
  - *Frequency determined by summing the number of charging events in 25-day bins and dividing by the number of spacecraft monitored during the binned period.*

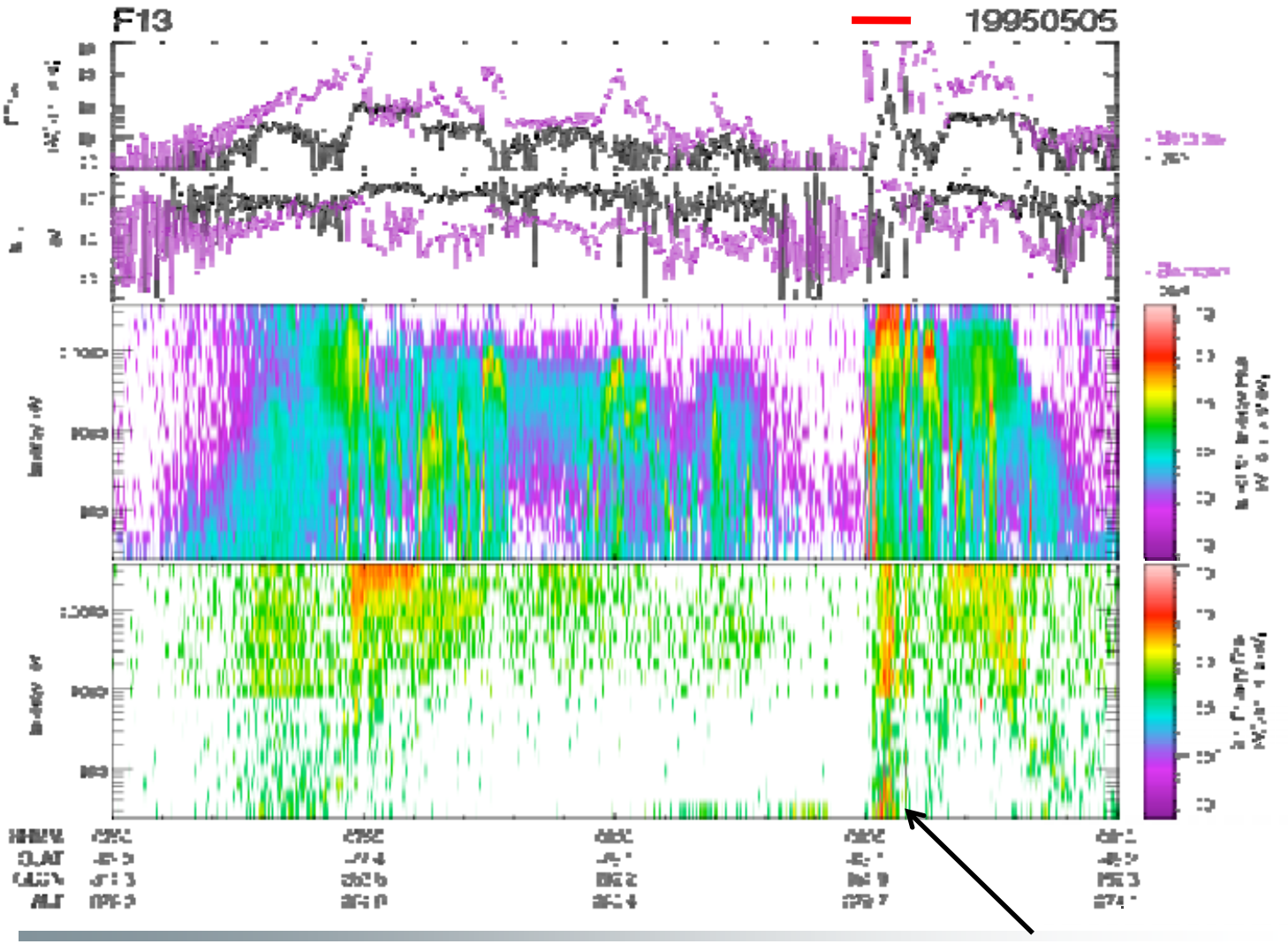


Algorithm Description

- Charging event characterized by high flux of low energy ions and high energy e^-
- Algorithm Criteria:
  - *Apply 10 sec running average smoothing to E_{ave} and Energy Flux*
  - *Filter for Ion Energy Flux greater than 10^9 eV/(cm^2 s sr)*
  - *Difference between electron and ion energies greater than 7 keV*
    - $(E_e - E_i) > 7$ kev for more than 3.0 sec
  - *Ion Density, Ni, less than 600 cm^{-3}*

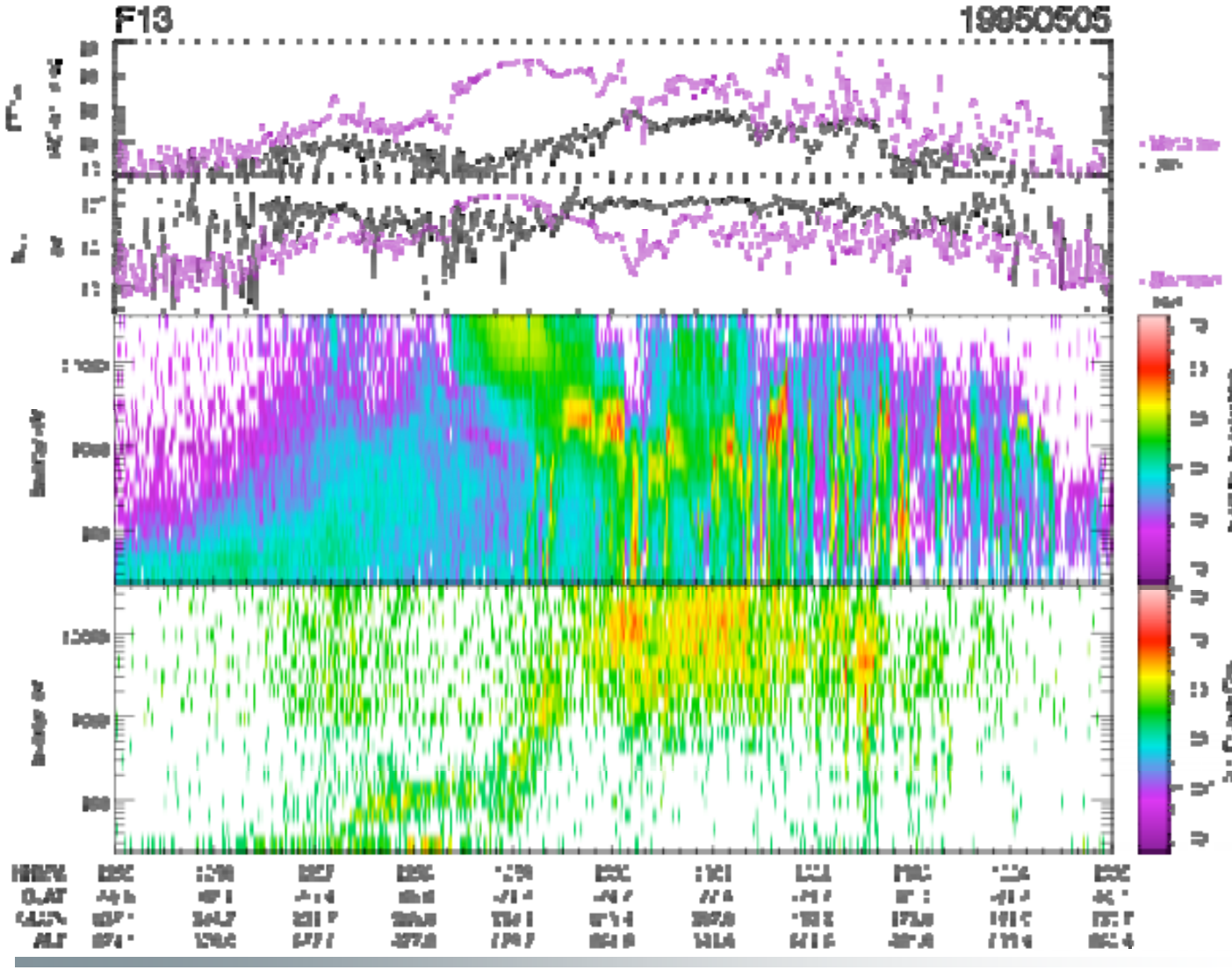


Event Identification: May 5, 1995 DMSP F13



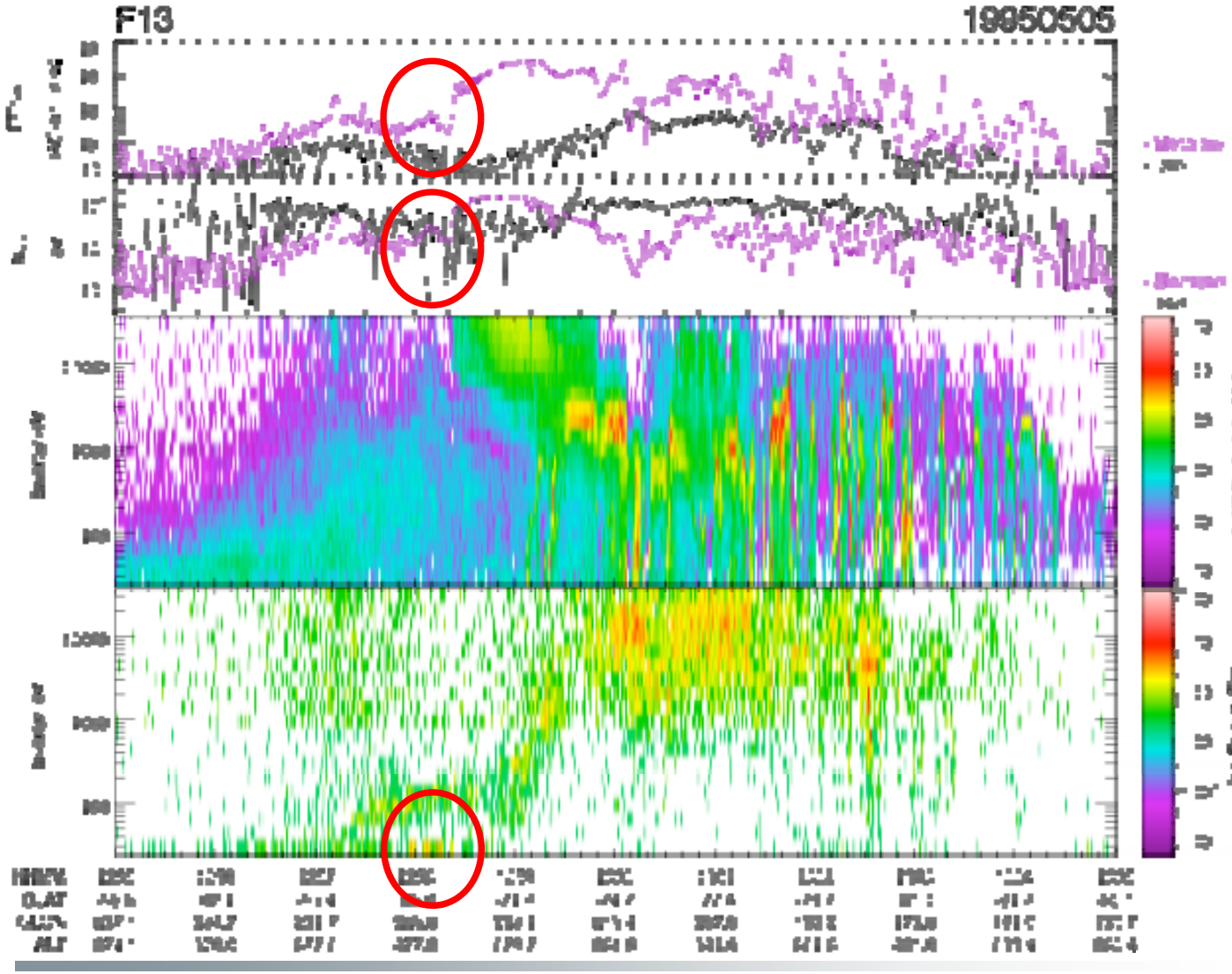
- Clearly visible event near 0805
- Identified by algorithm.
- “Hook” feature not easily discerned.

Event Identification cont.



- At first glance, no charging event is discerned.
- Filter algorithm identifies feature near 1258.

Event Identification cont.



- At first glance, no charging event is discerned.
- Filter algorithm identifies feature near 1258.
- Possible weak event visible.
- Important to use smoothed data!

Statistics for May 5, 1995 DMSP F13

SSJ Filter Only	Event Post Ni Filter	Visual Confirmation	Event Type
Event Time		Event/No Event	
0428	Yes	Event	Moderate
0530	No	No Event	
0619	No	No Event	
0712	No	No Event	
0805	Yes	Event	Moderate
1007	No	No Event	
1258	Yes	Event	Weak*
1439	Yes	No Event	
1940	Yes	Event	Moderate
1955	Yes	Event	Weak
2047	No	No Event	
2122	Yes	Event	Weak

- 12 possible events identified using SSJ data only.
- Inclusion of SSIES Ni reduces events to 7.
- Large variability in event ID by visual inspection.
- Visual confirmation for 85% of cases.
- Anderson identified 13 events
  - All but 1 event correspond to SSJ Filter
  - Anderson identified events visually

Charging events for DMSP F13 May 1995

	Anderson Statistics	SSJ5 criteria only	SSJ5 + N_i
May 1-10	15	87	31
May 11-20	5	29	4
May 21-31	8	46	21

- Total Events identified visually by Anderson in previous study: 28
- Total Events identified SSJ5+Ni filter: 56
- SSJ5 criteria identifies a significantly larger number of possible charging events but proportional to Anderson statistics.
- SSJ5+Ni often identifies additional events to Anderson study.

Charging Event Statistics for May 2010

	DMSP F16 Events	DMSP F17 Events	DMSP F18 Events
May 1-10	0	0	12
May 11-20	0	0	5
May 21-31	22	2	10

- DMSP F18 issues with with Ni data does not prevent use in study.
- Larger number of events observed by the F16, F18 satellites as expected because of orbit (dawn-dusk).
- 2010 occurs during relatively quiet geomagnetic period.

Summary

- Previously, charging events have been identified by manual inspection which is a labor intensive activity and can events ID can vary depending on personnel.
- New algorithm allows identification of events to be automated.
- Based on May 1995 data, algorithm identifies additional number of events compared to previous study.
- Number of events observed during May of this year occurred primarily on DMSP F16 and F18 satellites.

References:

Anderson, P., Proceedings of the 6th Spacecraft Charging Conference. p.55-59, 1998.

Anderson, P., Presentation at 9th Spacecraft Charging Conference, 2005.

Gussenhoven, M., D. Hardy, F. Rich, W. Burke, H. Yeh, *J. Geophys. Res.*, *90*, 11000, 1985.

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