Auroral energy flow budget as a function of altitude: How does energy arrive from the magnetosphere?

Pekka Janhunen, FMI/Space/Helsinki
Annika Olsson, Unaffiliated (was:IRF/Uppsala)
Christopher Russell, UCLA/Los Angeles
Harri Laakso, ESA/ESTEC
Nikolai Tsyganenko, NASA/GSFC
Lars Blomberg, KTH/Stockholm

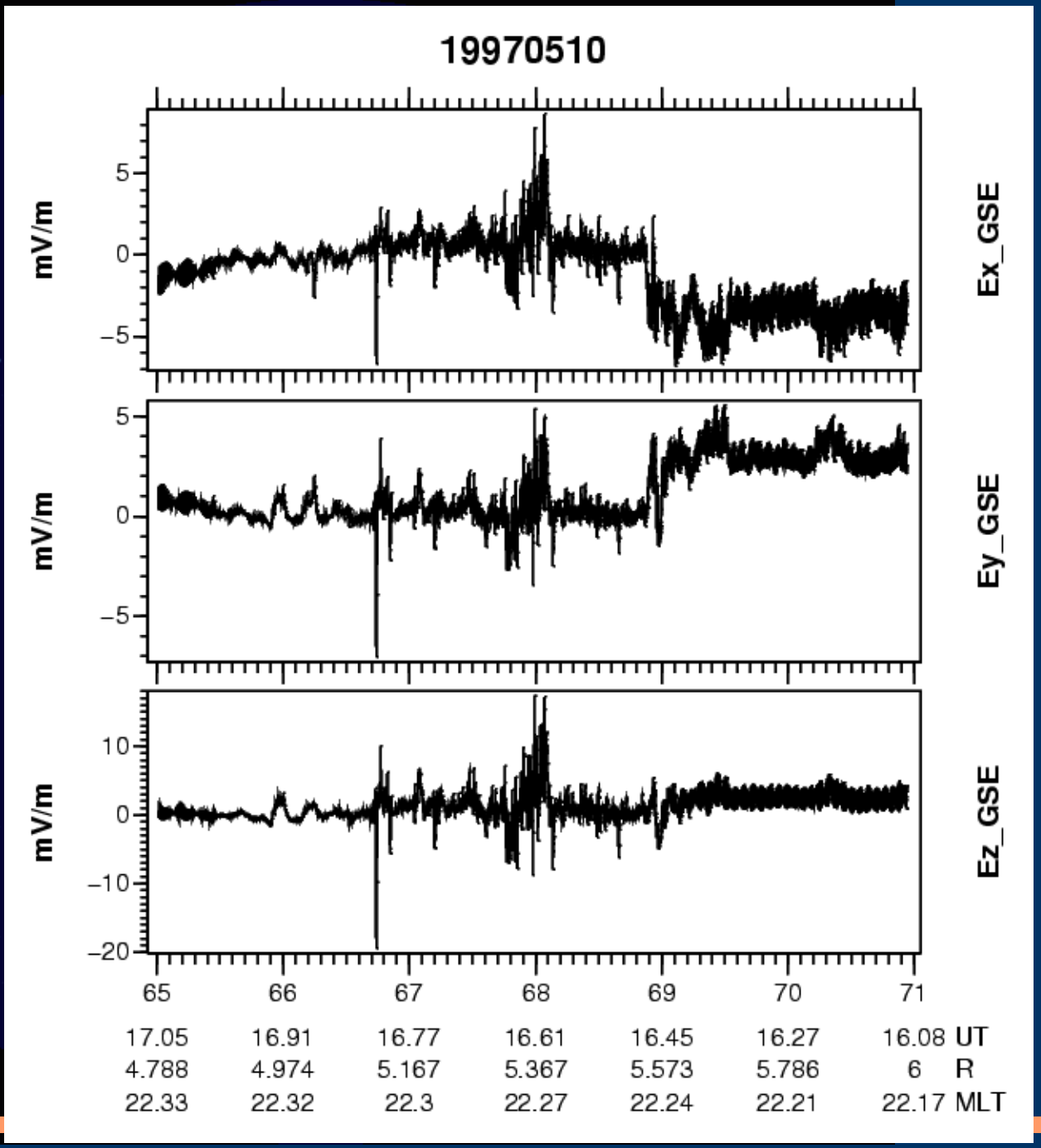
Acknowledgements: ***Andris Vaivads***

Plan of presentation

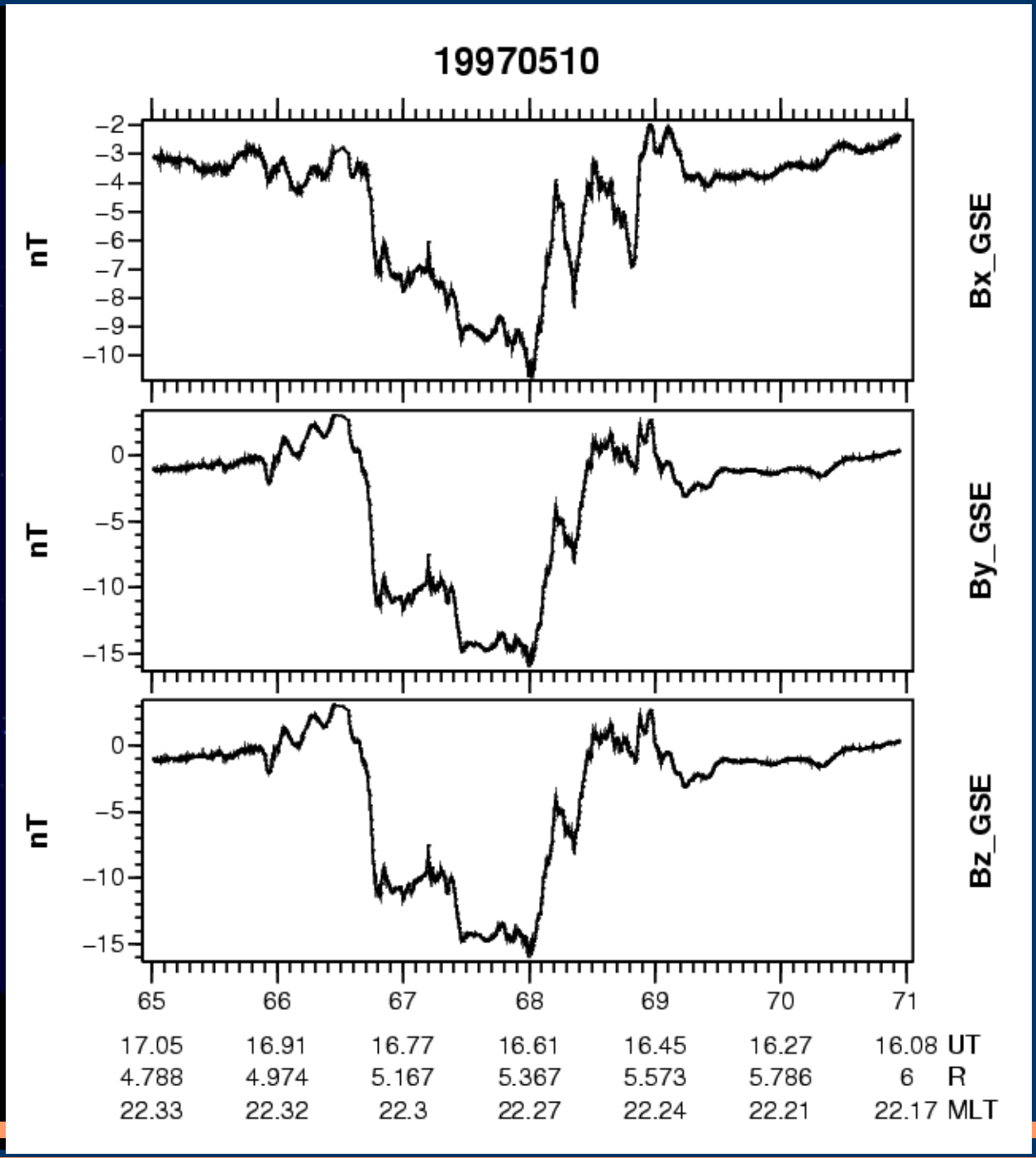
- Poynting flux as function of altitude
- Comprehensive statistical study using 5 years of Polar data (EFI + MFE)
- Locus of Alfvenic electron acceleration ("Alfven Resonosphere")
- Fraction of electron precipitation powered by Alfvenic acceleration

Example Polar EFI and MFE data:

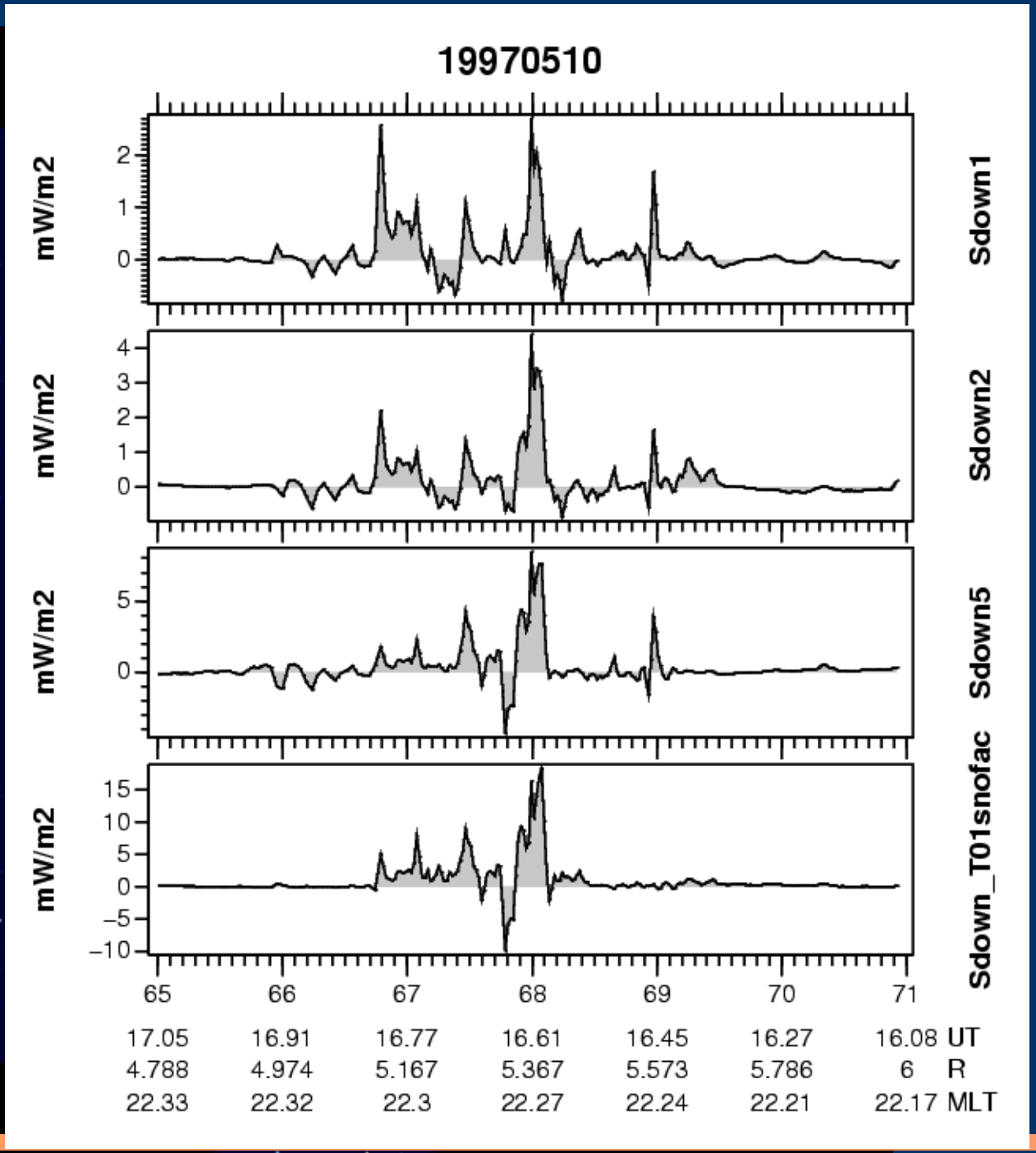
E-field



Polar B-field



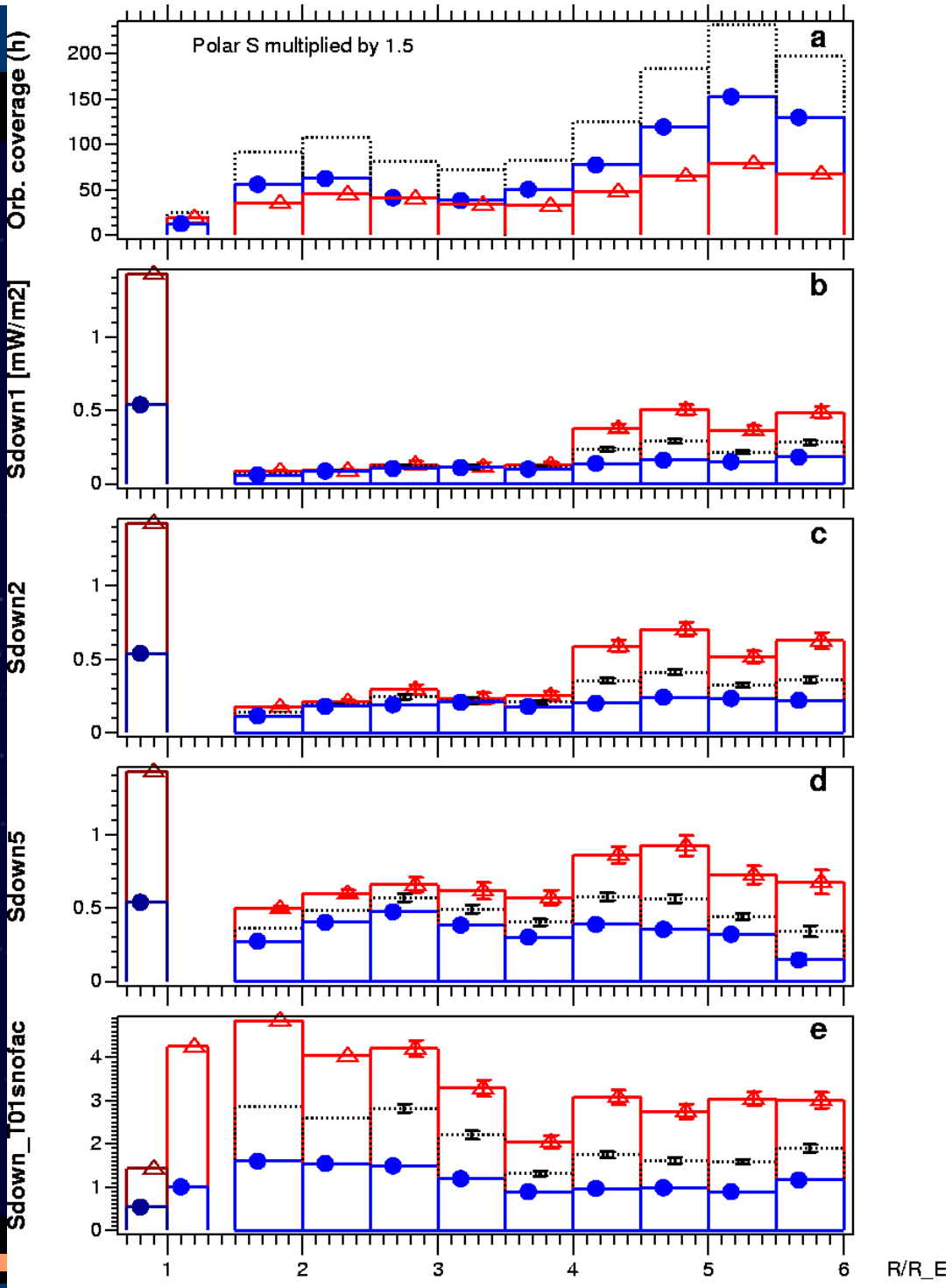
Poynting flux from Polar E-field and B-field



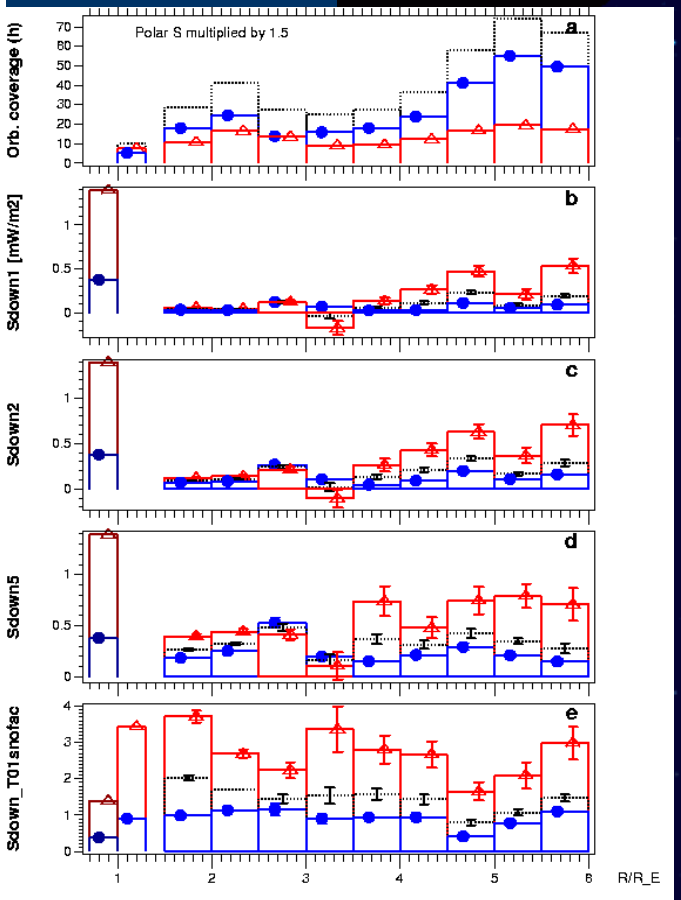
Basic statistical plot from Polar data

MLT 18-06, ILAT 65-74

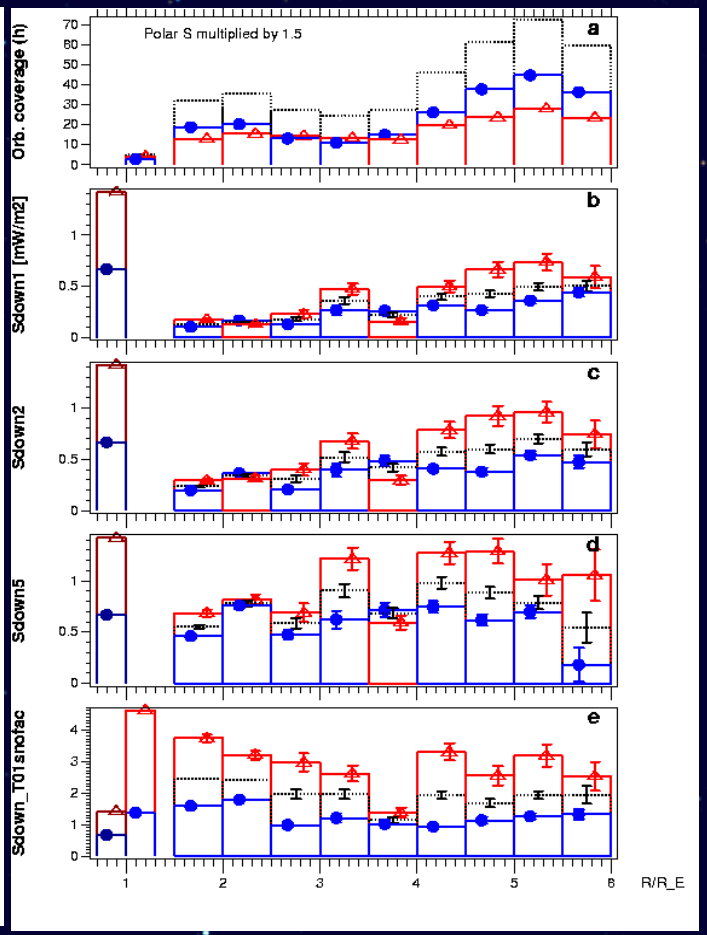
Kp>2 red, Kp 0-2 blue



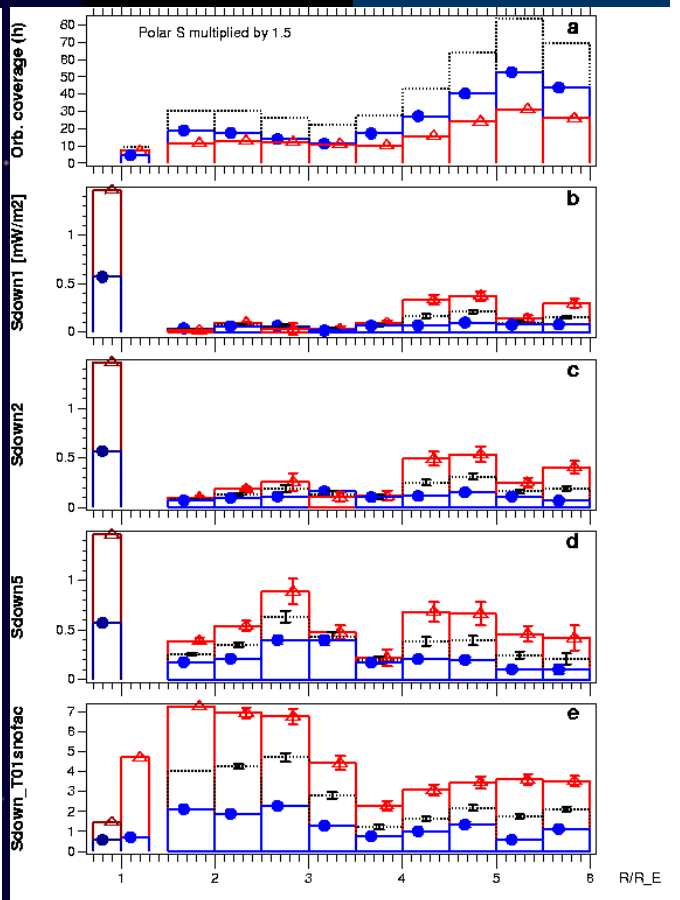
MLT-decomposed Polar statistics



MLT 18-22

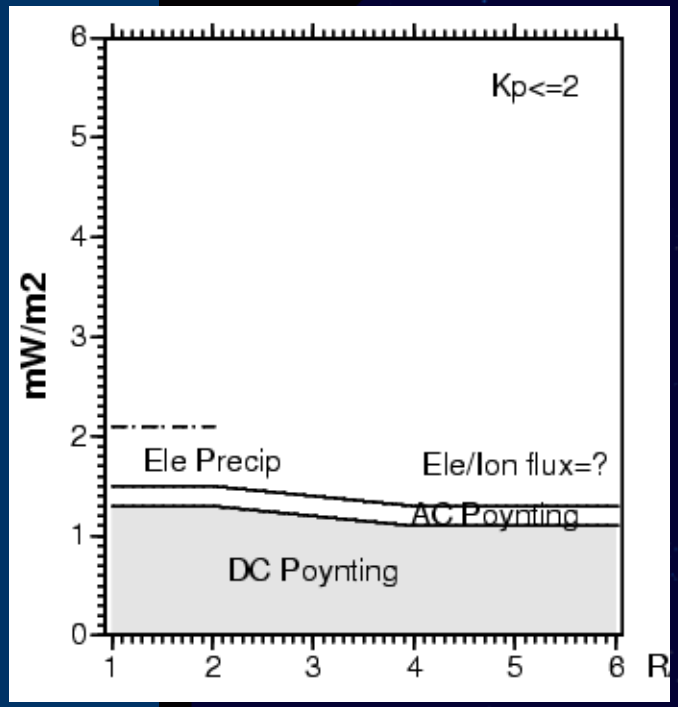


MLT 22-02

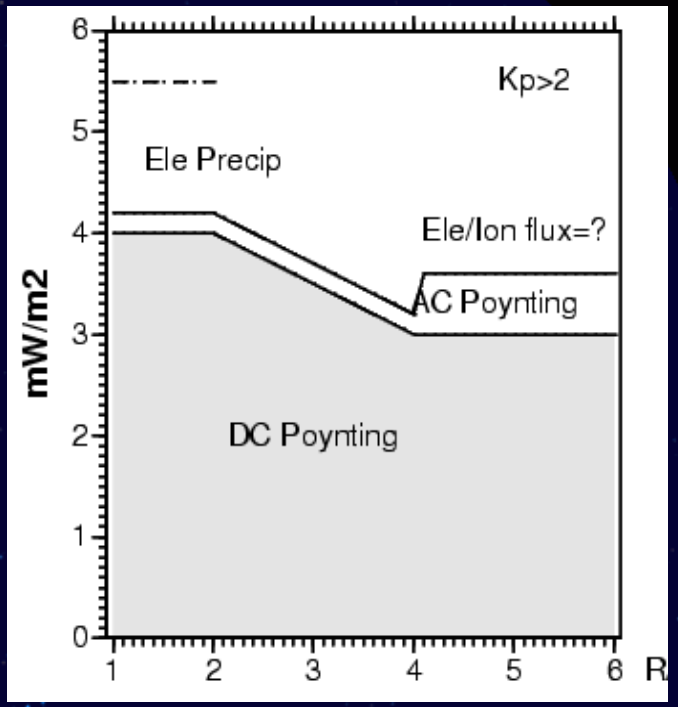


MLT 02-06

Auroral energy budget



Low Kp



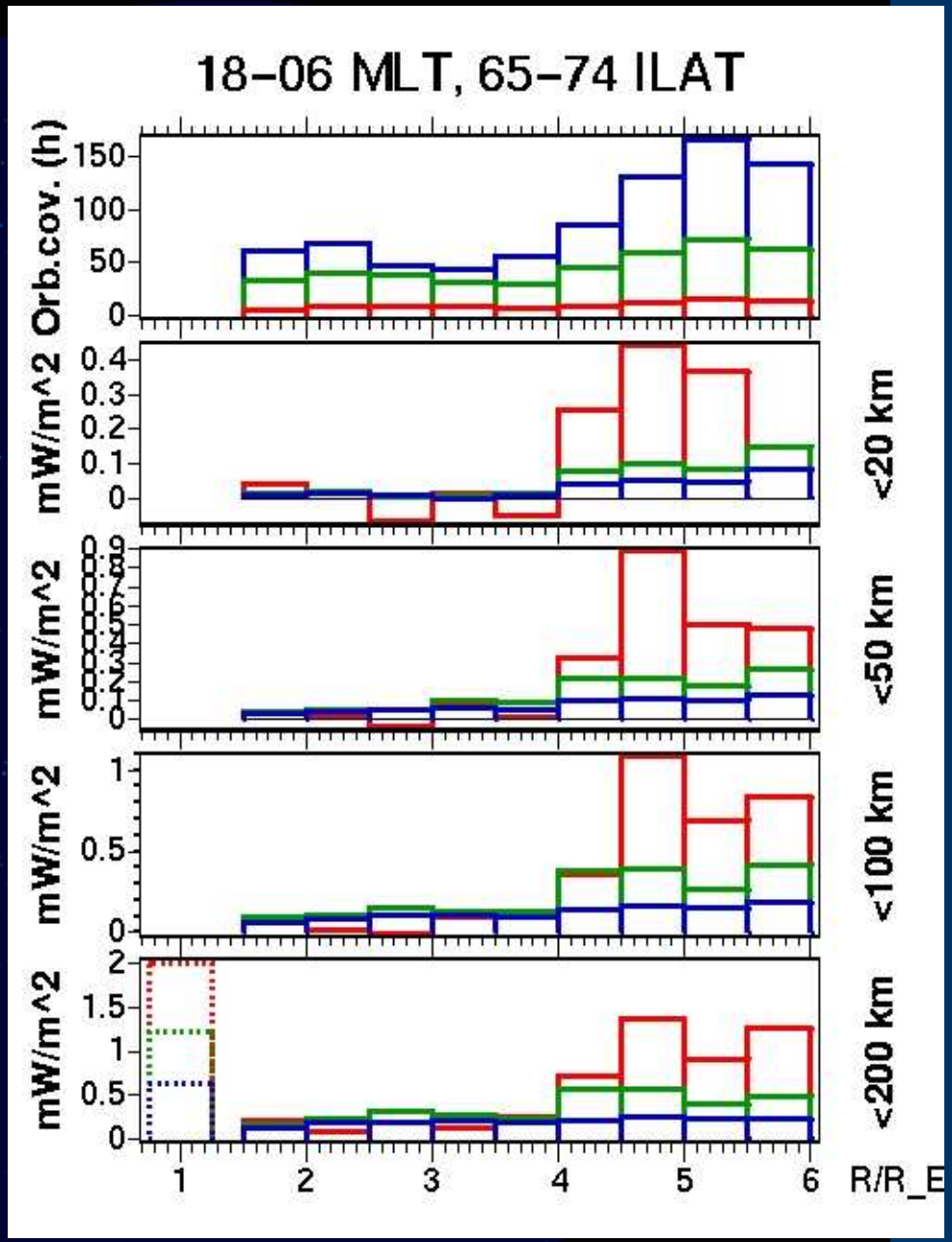
High Kp

- DC Poynting dominates
- AC small, but stepwise transition for Kp>2

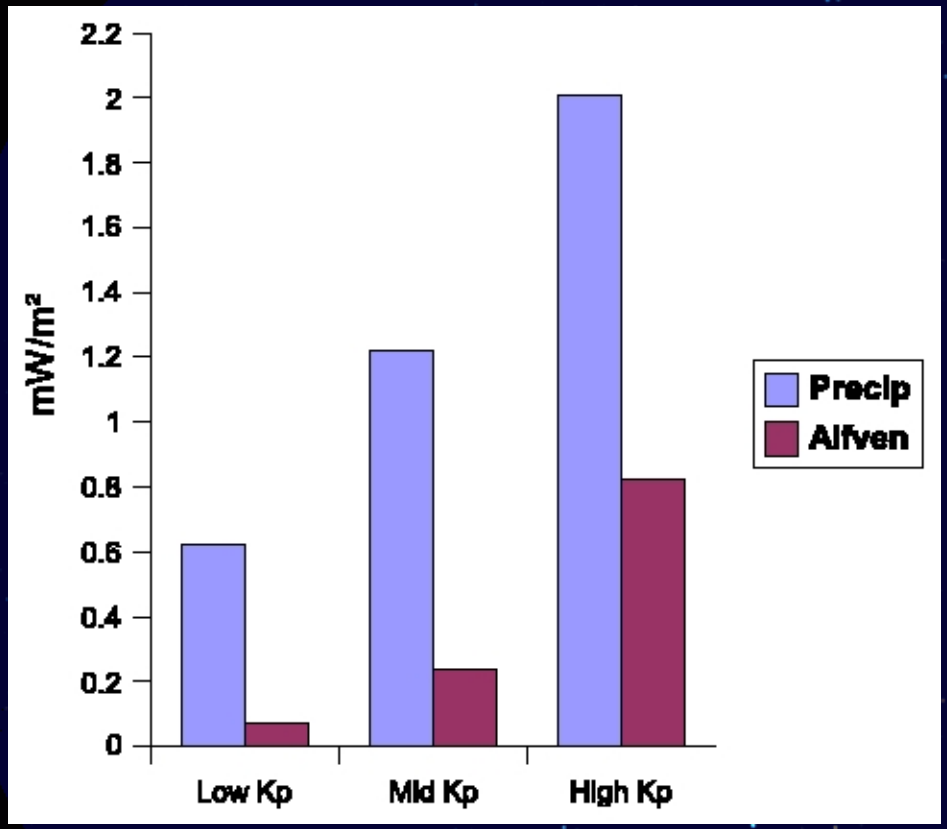
Same data;

only AC;

*3 Kp ranges (**blue**: 0-2, **green**: 2-4, **red**: >4)*

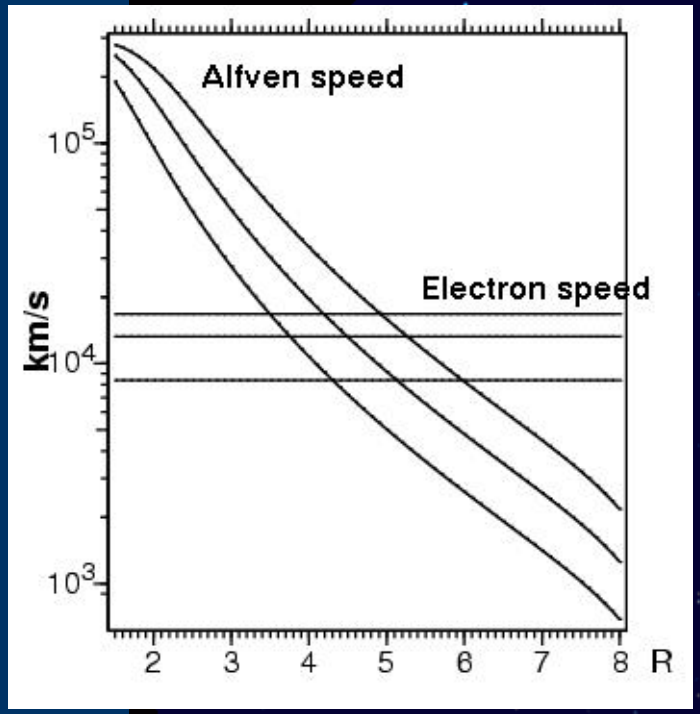


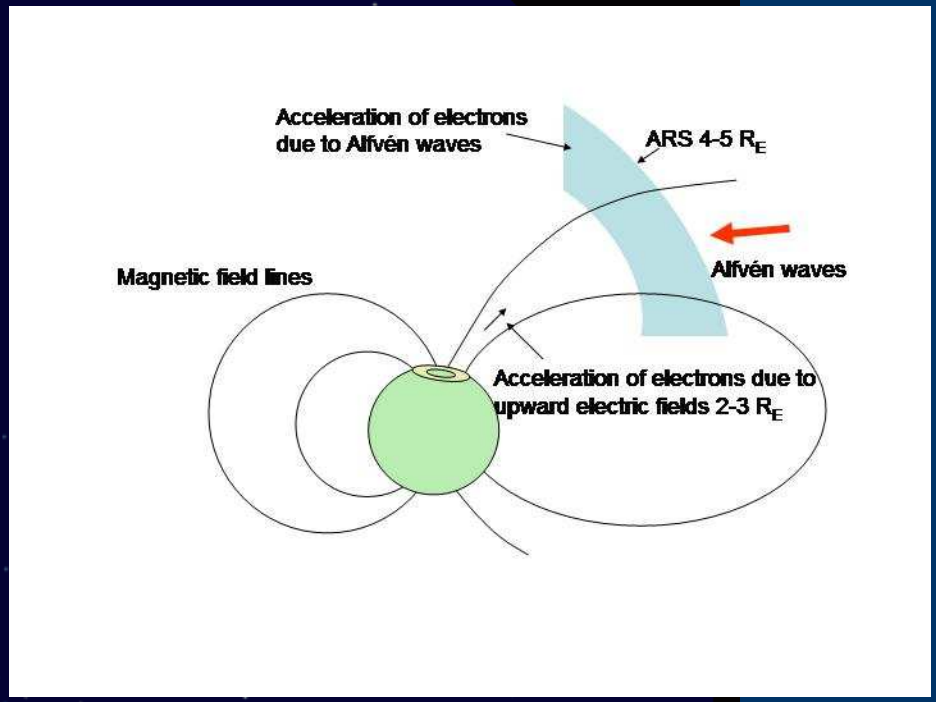
Electron precipitation energy budget



- AC Poynting sink at 4-5 R_E
- Compared to electron precipitation (Hardy)

The "Alfven Resonosphere"





- Alfven speed and electron thermal speed in **Landau resonance** at 4-5 R_E
- Natural explanation for "Alfven Resonosphere" and Poynting sink
- Independent support from dens. & E-field statistics

Conclusions

- 30% particle precipitation (mainly electron), 70% Joule heating
- Alfven waves (~100 km scale) responsible for 10-20-40% of electron precipitation for low-mid-high Kp, respectively
- Alfvenic electron acceleration occurs in the "Alfven Resonosphere" at 4-5 R_E (***not*** in the normal acceleration region)
- ARS explanation: Landau resonance

References

- **Janhunen,** P., A. Olsson, N.A. Tsyganenko, C.T. Russell, H. Laakso and L.G. Blomberg, Statistics of parallel Poynting vector in the auroral zone as a function of altitude using Polar EFI and MFE data and Astrid-2 EMMA data, ***Ann. Geophys.,*** in review, **2005**.
- **Olsson,** A., P. Janhunen, C.T. Russell and H. Laakso, Alfvenic electron acceleration in aurora occurs in global Alfven Resonosphere region, ***Phys. Rev. Lett.,*** submitted, **2005**.
- **Janhunen,** P., A. Olsson, J. Hanasz, C.T. Russell, H. Laakso and J.C. Samson, Different Alfven wave acceleration processes of electrons in substorms at 4-5 R_E and 2-3 R_E radial distance, ***Ann. Geophys.,*** 22, 2213-2227, **2004**.
- **Olsson,** A., P. Janhunen, J. Hanasz, M. Mogilevsky, S. Perraut and J.D. Menietti, Observational study of generation mechanism of substorm-associated low-frequency AKR emissions, ***Ann. Geophys.,*** 22, 3571-3582, **2004**.
- **Olsson,** A., P. Janhunen, T. Karlsson, N. Ivchenko and L.G. Blomberg, Statistics of Joule heating in the auroral zone and polar cap using Astrid-2 satellite Poynting flux, ***Ann. Geophys.,*** 22, 4133-4142, **2004**.
- **Janhunen,** P., A. Olsson and H. Laakso, Altitude dependence of plasma density in the auroral zone, ***Ann. Geophys.,*** 20, 1743-1750, **2002**.
- **Janhunen,** P., A. Olsson and H. Laakso, The occurrence frequency of auroral potential structures and electric fields as a function of altitude using Polar/EFI data, ***Ann. Geophys.,*** 22, 1233-1250, **2004**.
- ***These and more papers:*** **http://www.space.fmi.fi/~pjanhune/papers/**