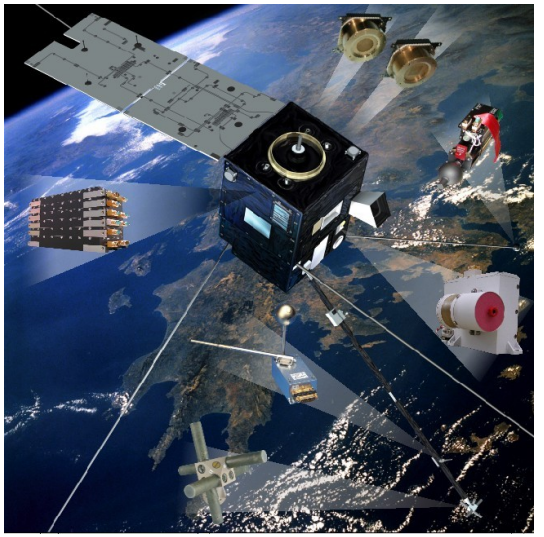
Overview of Line Radiation observed by DEMETER



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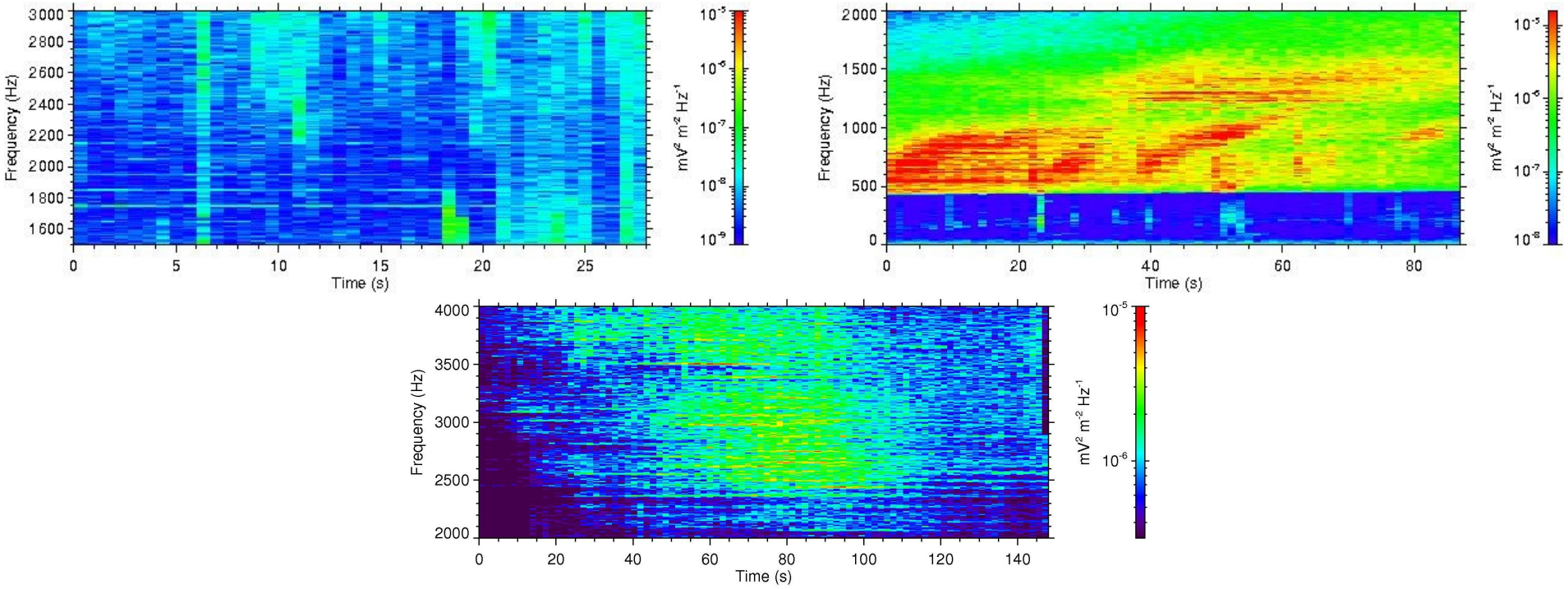
Outline

- Introduction
- Classification of events
- Power Line Harmonic Radiation (PLHR)
- ElectroMagnetic Harmonic ELF Emissions
- Magnetospheric Line Radiation (MLR)
- Summary

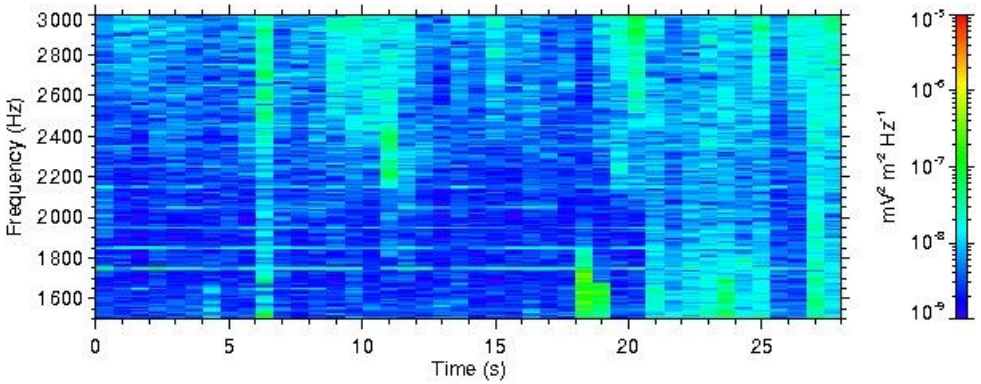
Introduction

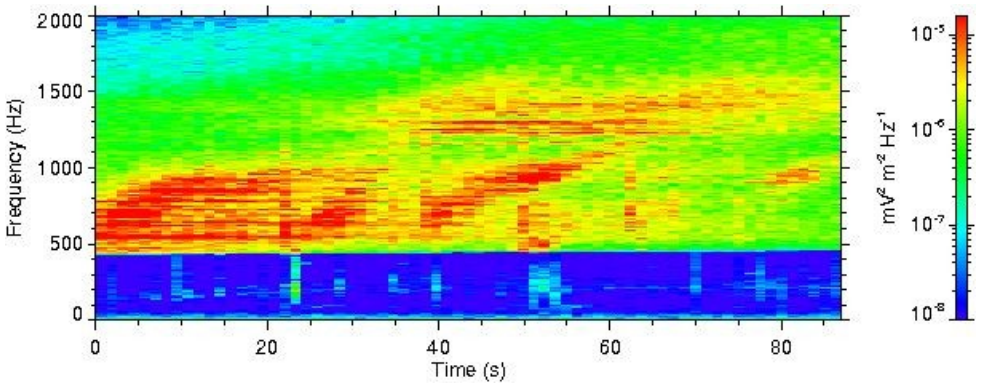
- electromagnetic waves that, when represented in the form of frequency-time spectrogram, consist of several nearly equidistant and almost horizontal intense lines
- reported both in ground and low-altitude satellite data

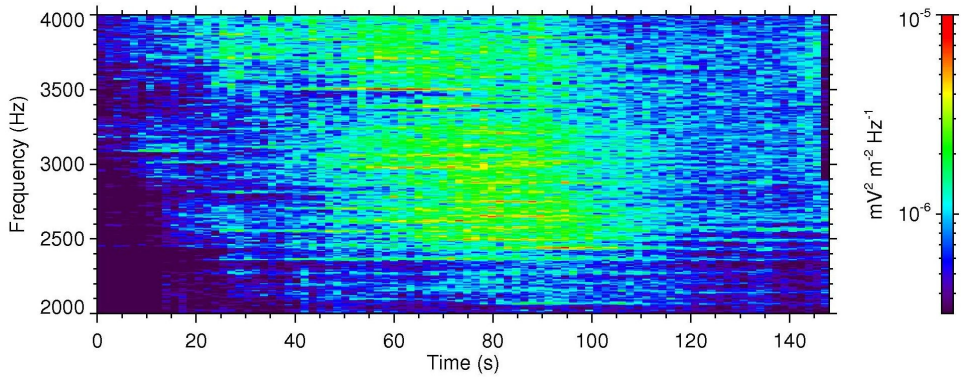
- DEMETER spacecraft (altitude 700 km, Sun-synchronous orbit 10:30/22:30 LT)
  - Survey VLF (up to 20 kHz): spectrum of 1 electric and 1 magnetic (~19.53 Hz, ~ 2 s)
  - Burst VLF (up to 20 kHz): waveform of 1 electric and 1 magnetic field component
  - Burst ELF (up to 1250 Hz): waveforms of 3 electric and 3 magnetic field components
- identification of events both by an automatic procedure and visual inspection of the data



Classification of Events







1. PLHR

- Frequency spacing 50/100 or 60/120 Hz
- Generated by electric power systems on the ground

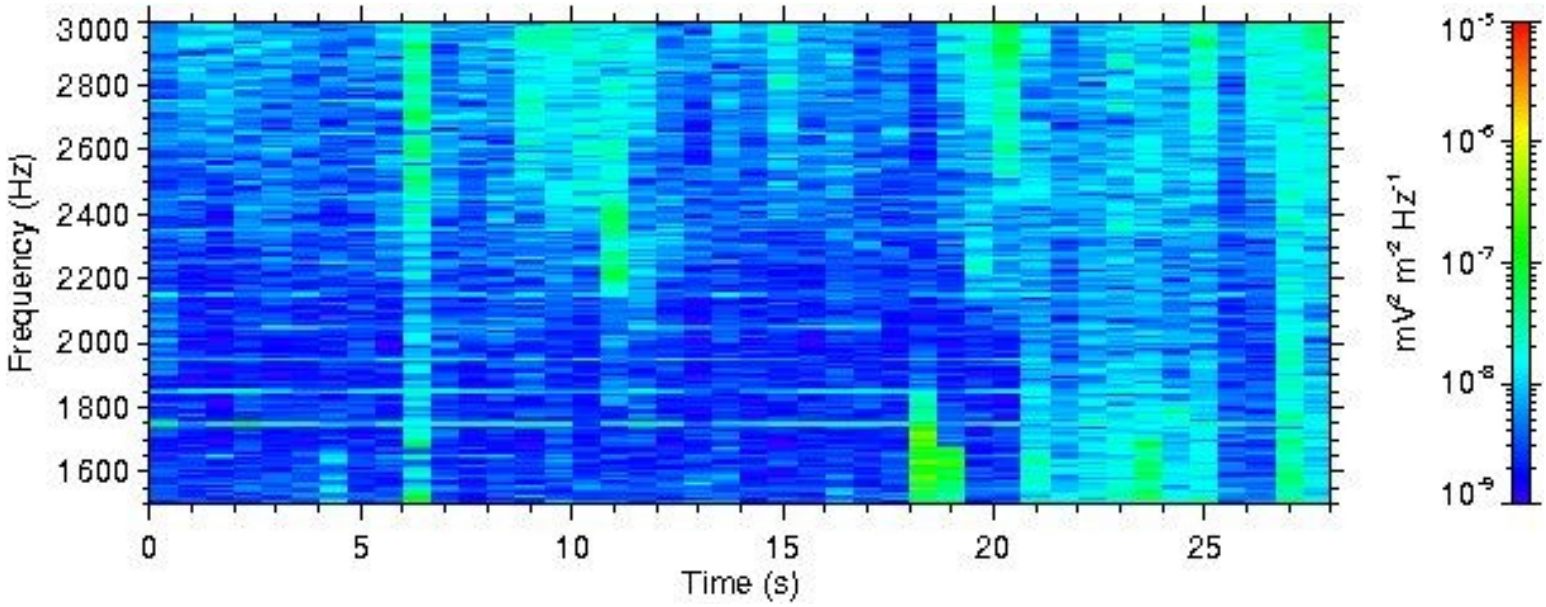
2. EM Harmonic ELF Emissions

- Close to the geomagnetic equator during disturbed periods
- Generated by instabilities of ion distribution functions at frequencies below f_{lh}
- Equatorial noise propagating down to the low altitudes

3. MLR

- At larger frequencies and latitudes
- Origin still unclear

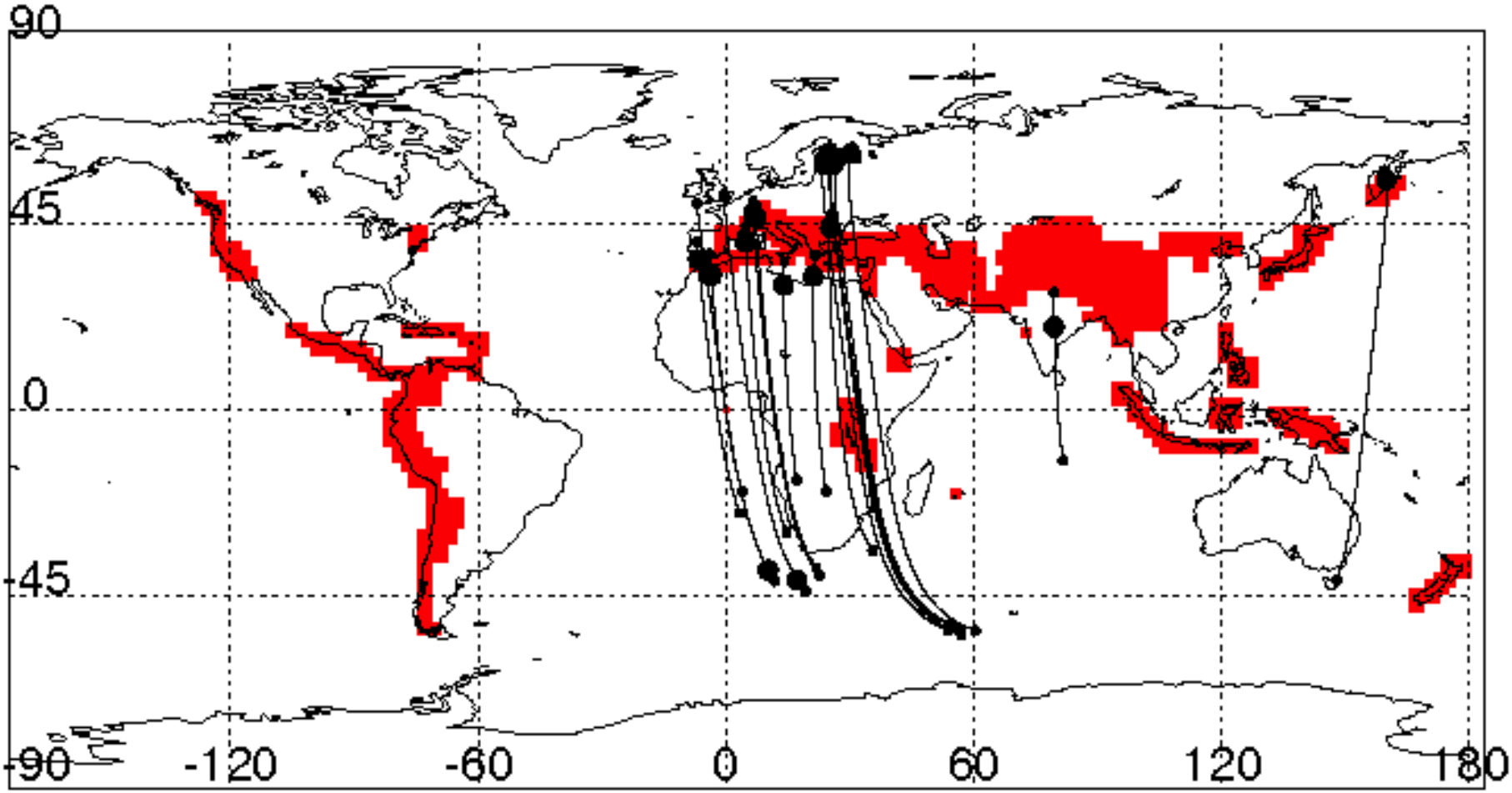
Power Line Harmonic Radiation (PLHR)



~100 events in VLF range, Burst mode
(waveform of 1 electric & 1 magnetic comp.)

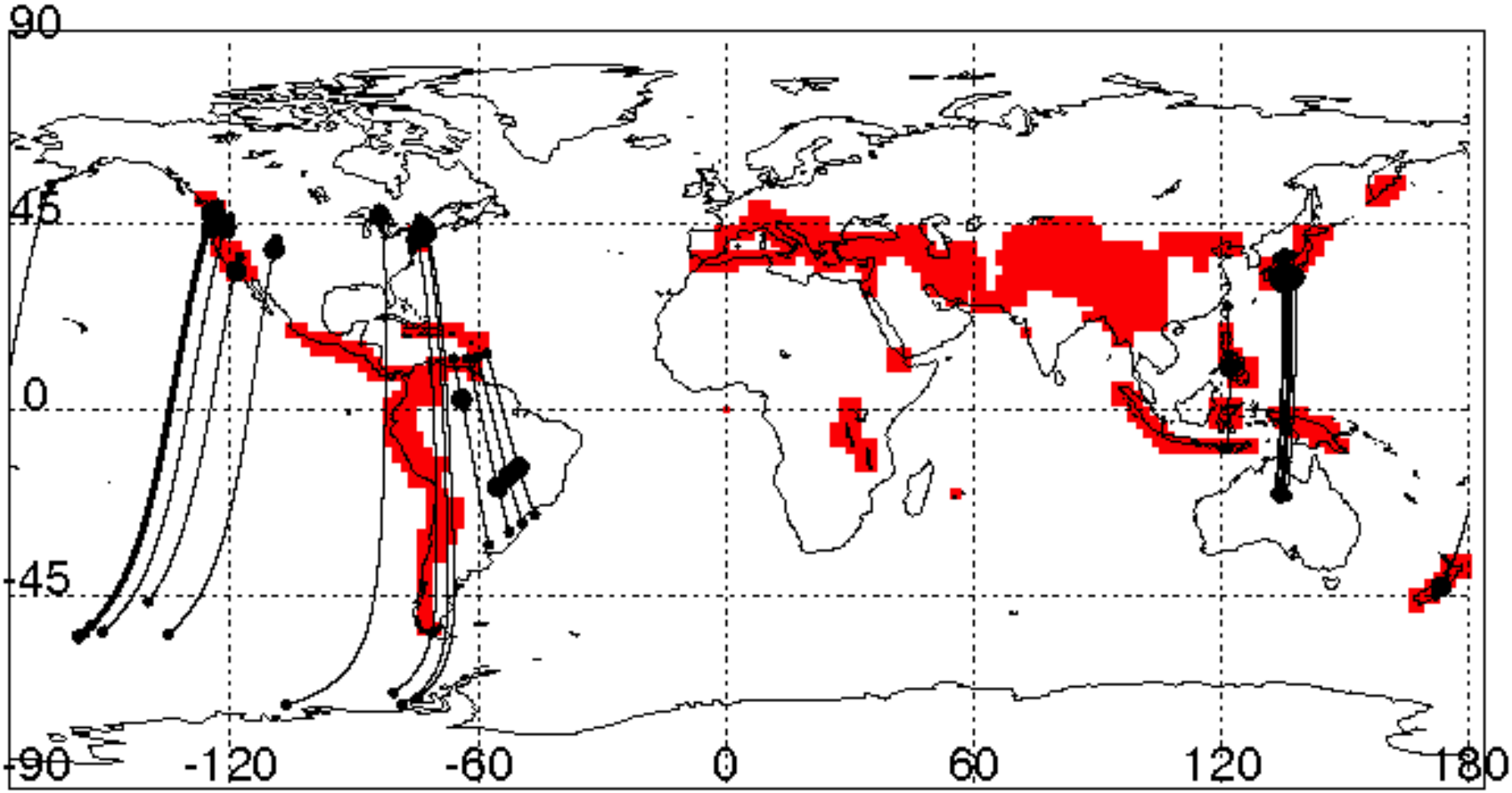
Nemec et al., JGR, 111, A04308, doi: 10.1029/2005JA011480, 2006.
Nemec et al., JGR, 113, A08317, doi: 10.1029/2008JA013184, 2008.

PLHR events with spacing 50/100 Hz

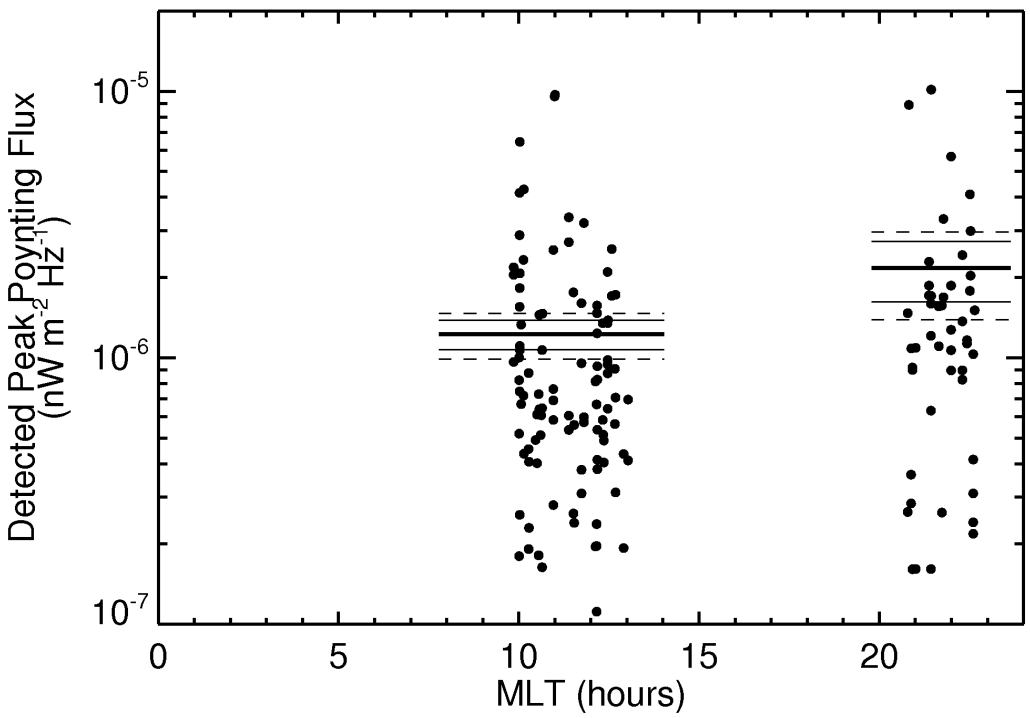


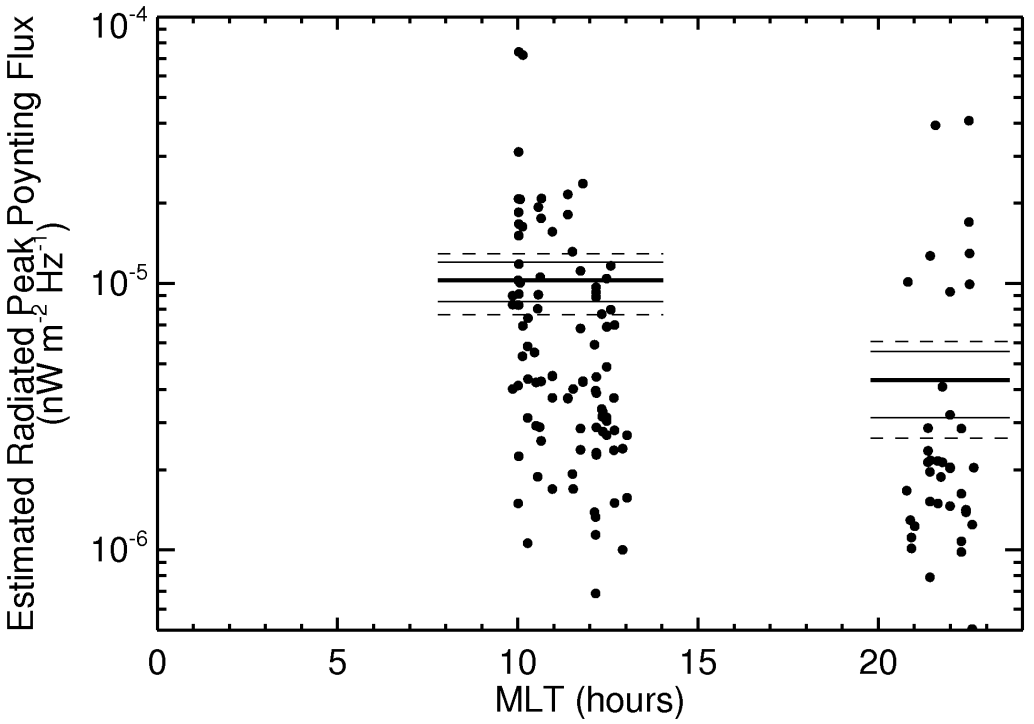
- Geographic locations of the events (large points)
- Projections of the magnetic field lines (lines)
- Footprints of the points of observation (small points)
- Areas with permanently active Burst mode (red)

PLHR events with spacing 60/120 Hz



Power vs. MLT





(left) detected peak Poynting flux of individual lines

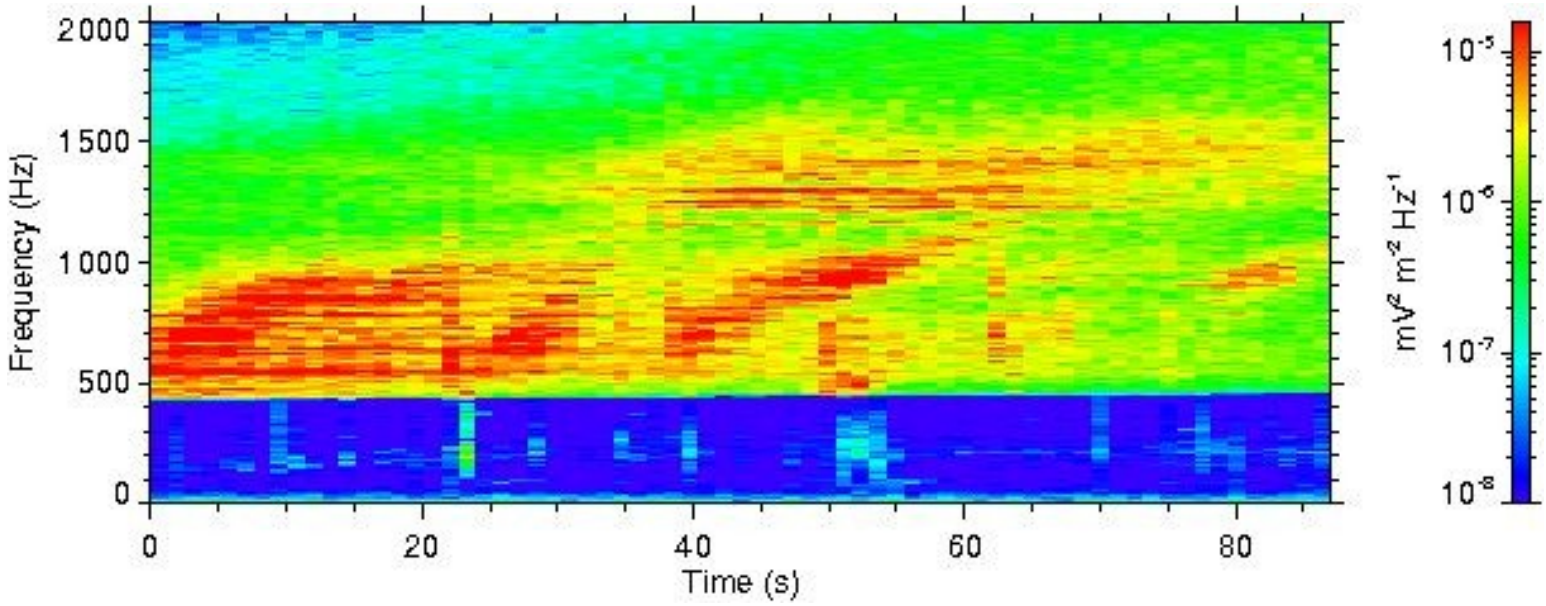
(right) estimated radiated peak Poynting flux of individual lines on the ground

Detected peak Poynting flux slightly lower during the day.

Estimated radiated peak Poynting flux on the ground larger during the day.

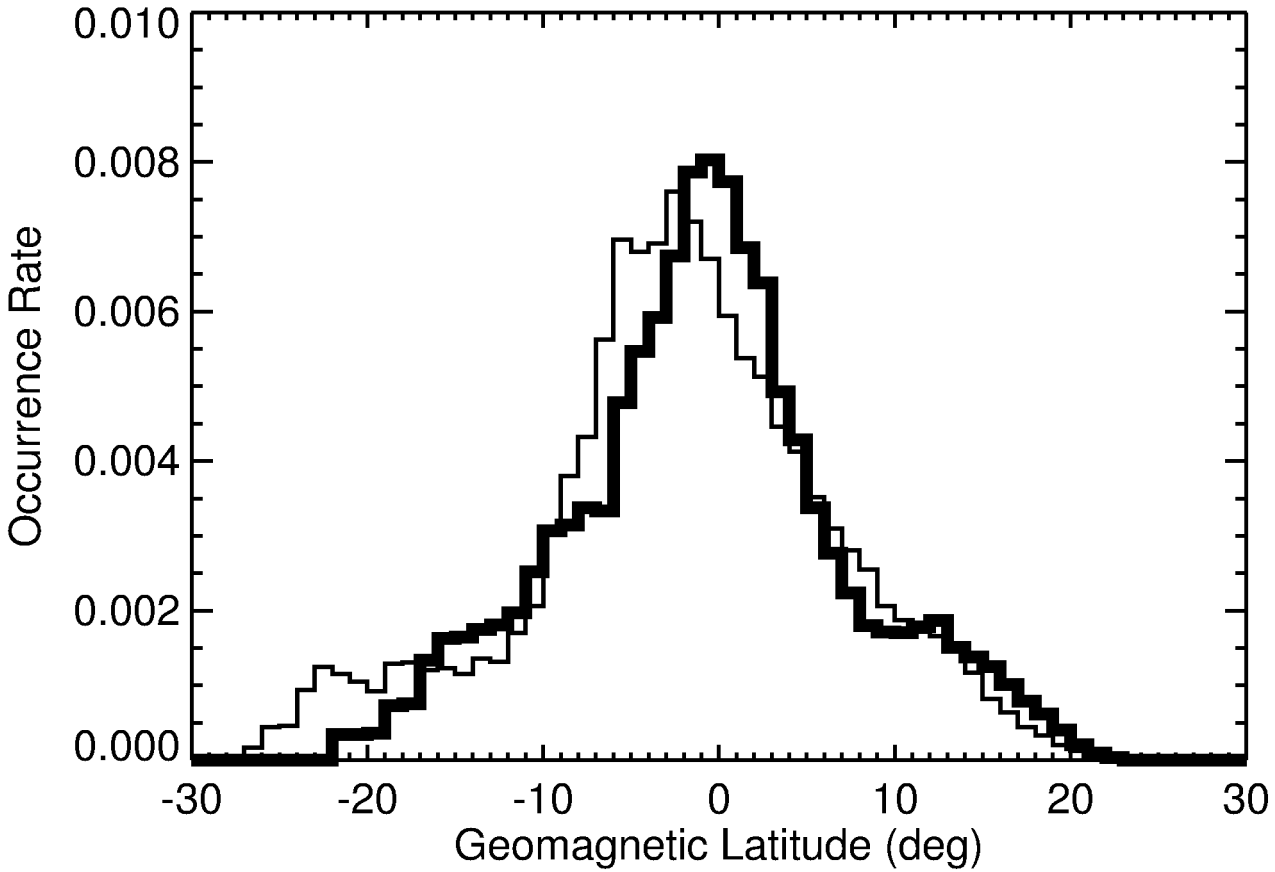
More events observed during the day than during the night.

EM Harmonic ELF Emissions



~50 events in ELF range, Burst mode
(waveforms of 3 electric & 3 magnetic comp.)

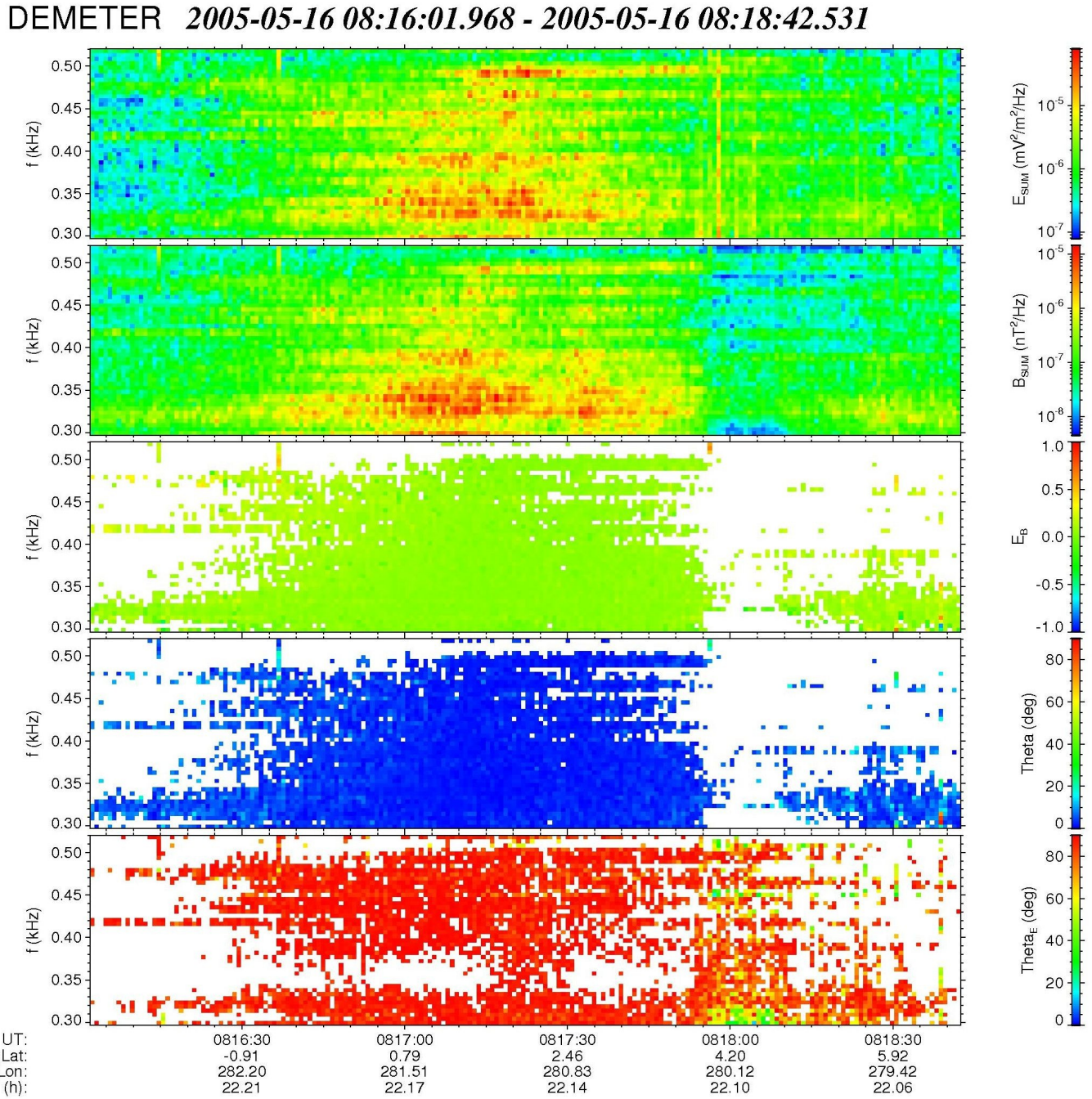
Occurrence Rate vs. λ_m



thin: distribution obtained for the dipole equator

thick: distribution obtain for the min-B equator

Example of Wave Analysis (1/2)



PSD of electric field fluctuations

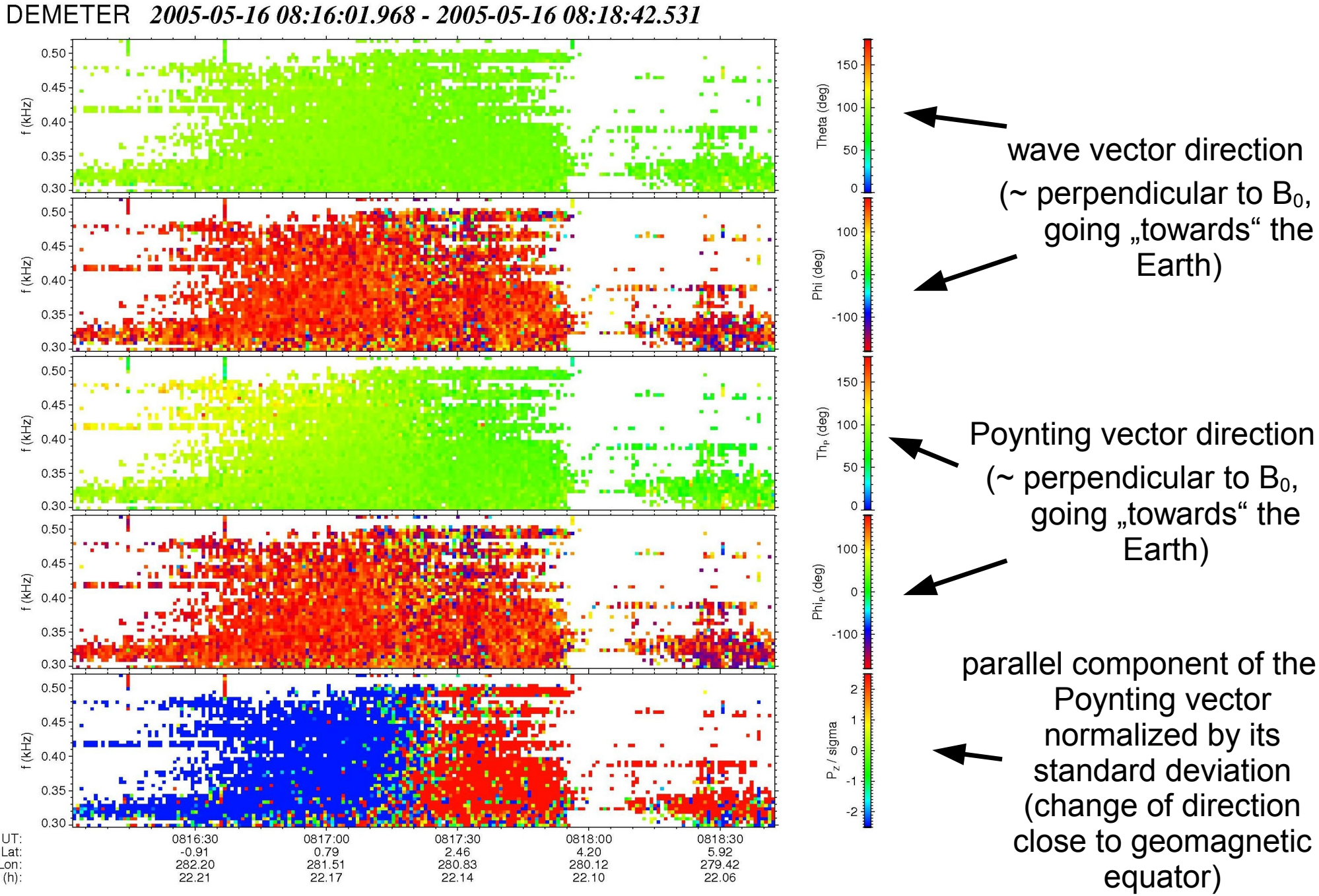
PSD of magnetic field fluctuations

ellipticity (=> linearly polarized)

direction of the major polarization axis of magnetic field (=> along B_0)

direction of the major polarization axis of electric field (=> perpendicular to B_0)

Example of Wave Analysis (2/2)

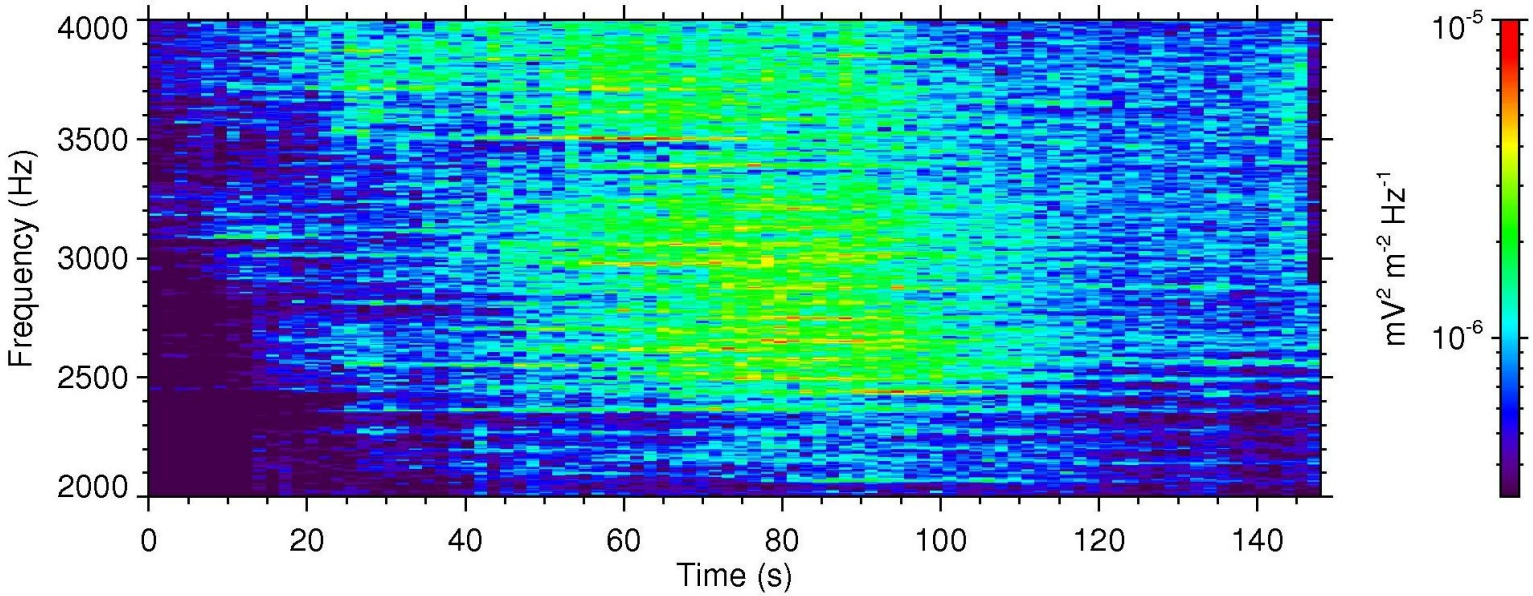


wave vector direction (~ perpendicular to B_0, going „towards“ the Earth)

Poynting vector direction (~ perpendicular to B_0, going „towards“ the Earth)

parallel component of the Poynting vector normalized by its standard deviation (change of direction close to geomagnetic equator)

Magnetospheric Line Radiation (MLR)

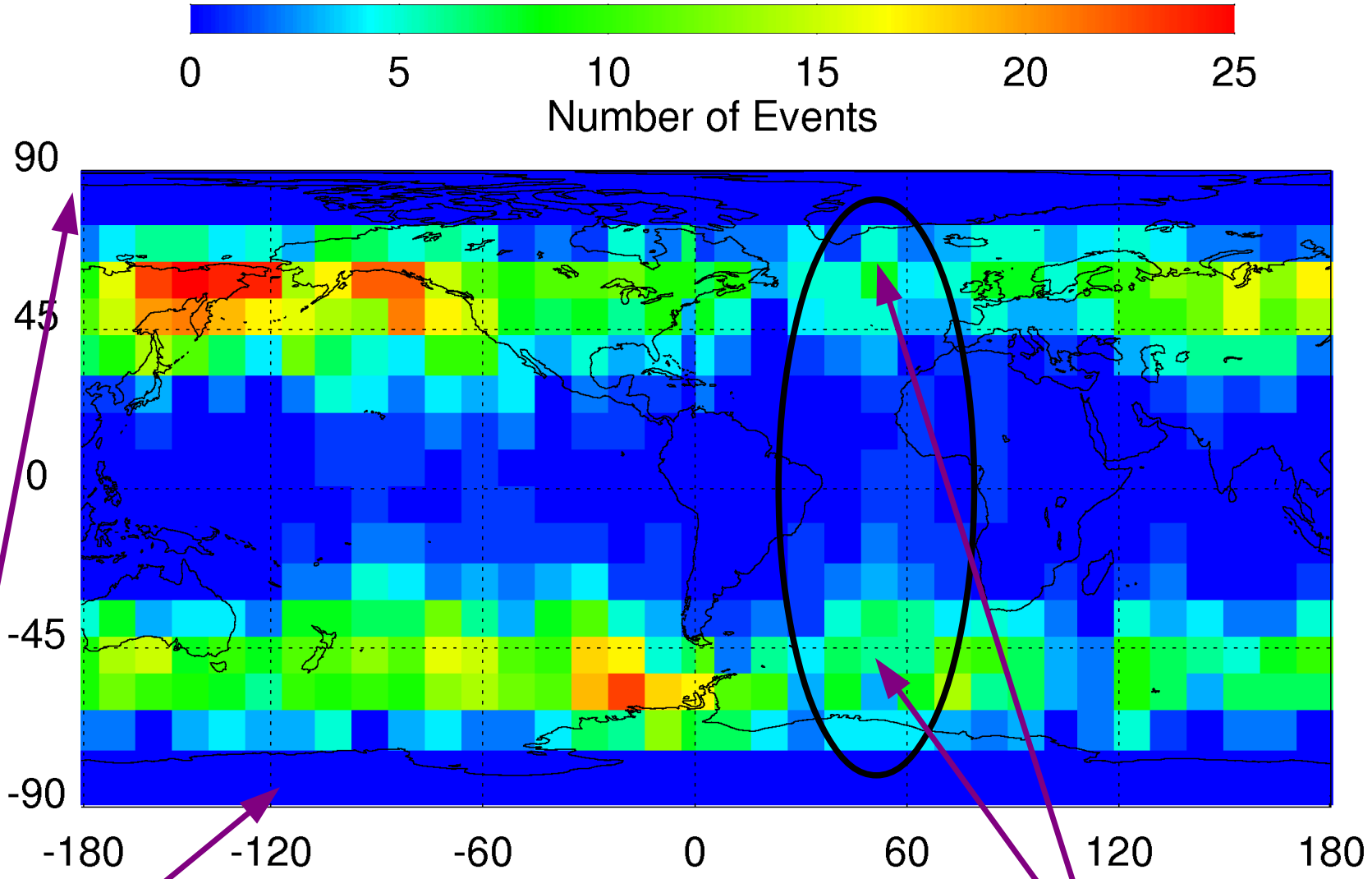


>500 events in VLF range, Survey mode
(spectrum of 1 electric & 1 magnetic field component)

Nemec et al., JGR, 114, A05203, doi: 10.1029/2008JA014016, 2009.

Map of Occurrence

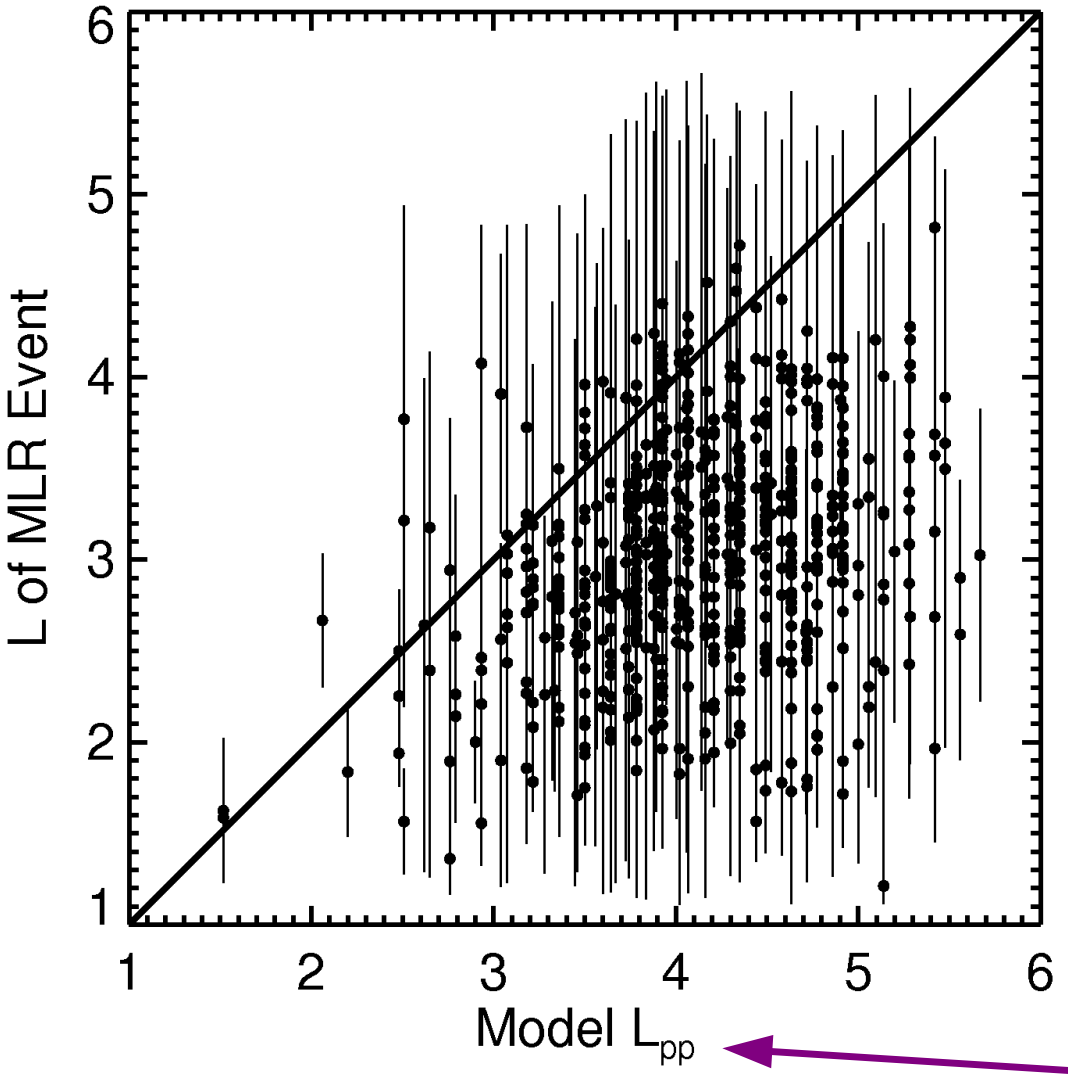
in geomagnetic coordinates



DEMETER does not measure at $\lambda_m > 65°$

? less events above the Atlantic Ocean ?

Inside / Outside Plasmasphere



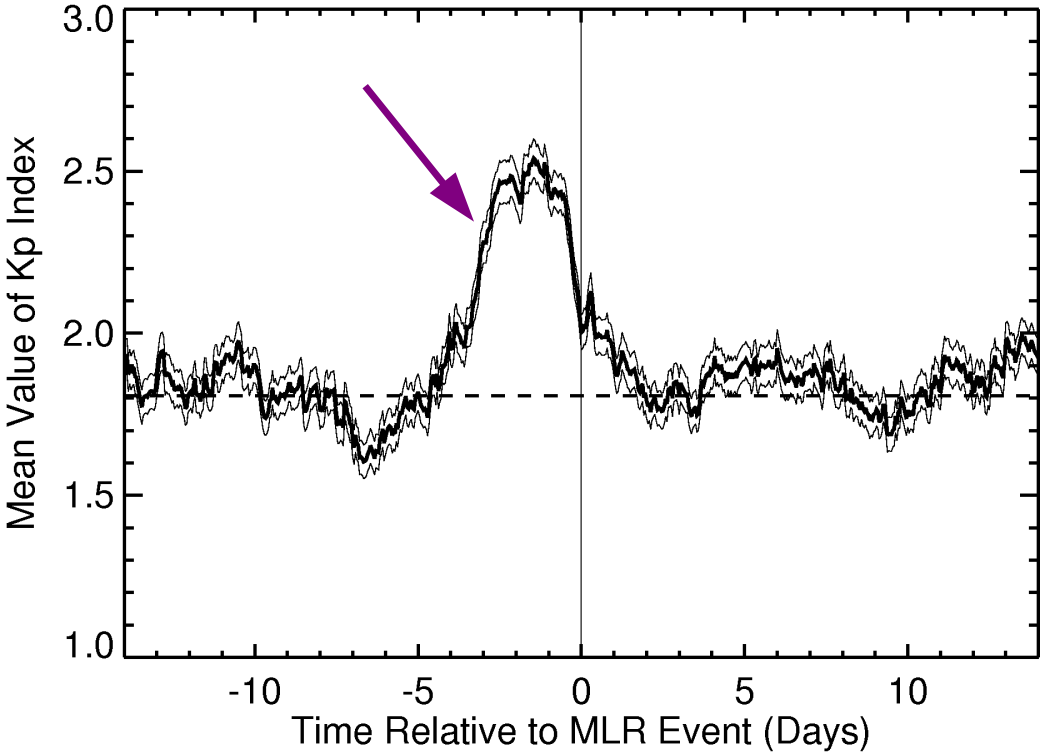
(points)
central positions of
the observed MLR events

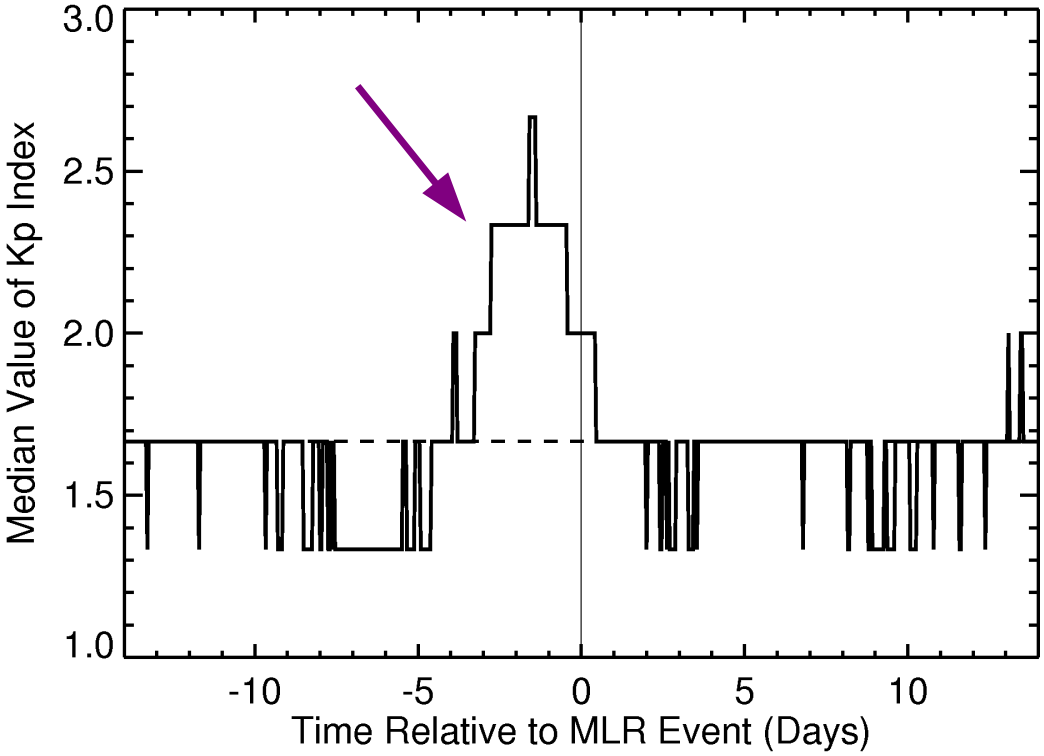
(lines)
dimensions of the MLR events

mostly inside the plasmasphere
(some events may stretch beyond?)

model location
of the plasmapause
(Moldwin et al., 2002)

Most Favorable Conditions: Kp





Superposed epoch analysis

(left) mean value *(thick line)* and standard deviation of the mean *(thin lines)*

(right) median value

Summary

- **PLHR** (Power Line Harmonic Radiation)
  - frequency spacing between indiviudal lines corresponds to the frequency of the electric system below the observation point (or in the conjugate region)
  - intensity of events is lower during the day; can be explained by taking into account the efficiency of coupling of EM waves through the ionosphere

- **EM Harmonic ELF Emissions**
  - confined to the equatorial region
  - coming from larger radial distances
  - most likely “equatorial noise” emissions that propagate to DEMETER altitudes (L ~ 1.1)

- **MLR** (Magnetospheric Line Radiation)
  - less events above the Atlantic Ocean (related to the South-Atlantic anomally?)
  - observed after or during the periods of increased geomagnetic activity
  - origin still unclear