The morphology and characteristics of Equatorial Magnetosonic Waves in the Terrestrial Inner Magnetosphere

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Introduction

Equatorial noise

- Electromagnetic fluctuations observed in the frequency range $\Omega_p < \omega < \omega_{LH}$
- Distances in the range L=3-5
- The waves were elliptically polarised
- *k-vector* almost perpendicular to B_0 – confined to a few degrees equatorial region
- ΔB directed parallel to the external magnetic field.
- Complex frequency structure, dominant oscillations at ion gyroharmonics
- Finer substructure characterised by frequencies $\Omega_p/8$ and $\Omega_p/2$.

- Occurrence coincident with peaks in the energy spectra of 90° pitch angle protons (ring-like ion distributions)

The dispersion obtained was characterised by multiple branches at frequencies $\omega = n\Omega_p$, reducing to the cold plasma dispersion $\omega \sim k_{perp} V_A$ as ring density -> zero.

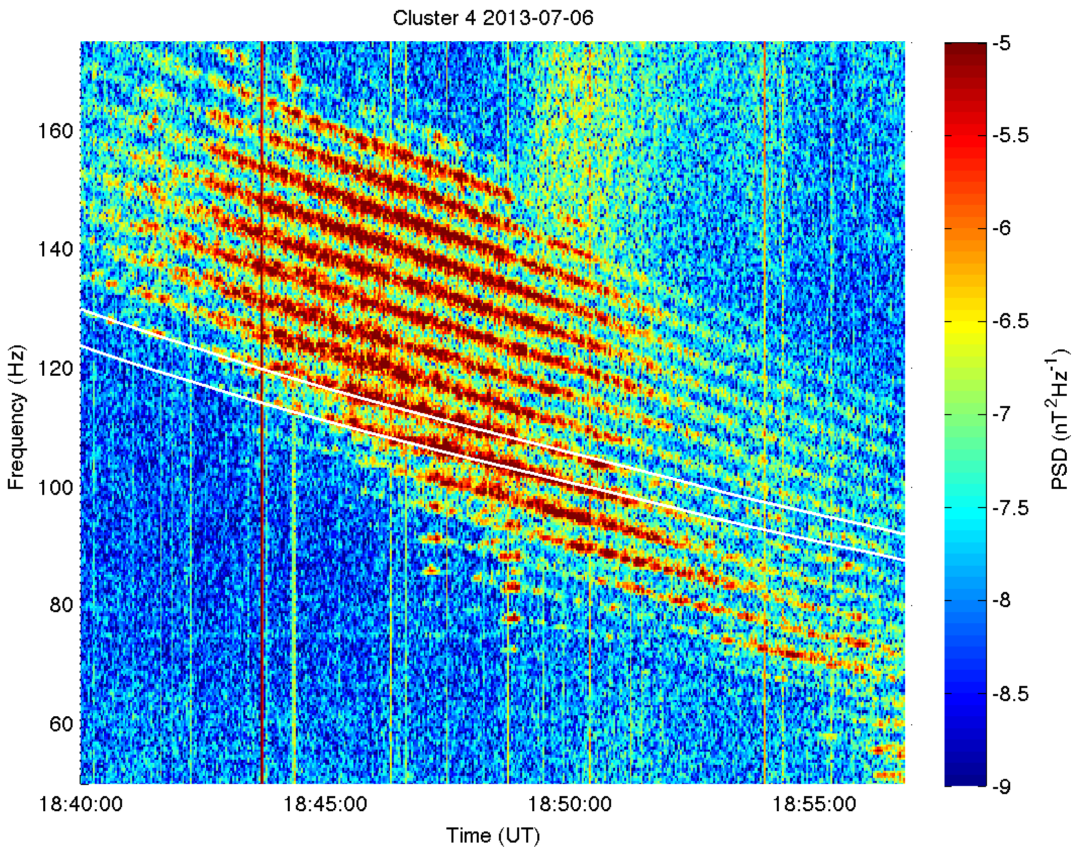
Data Source

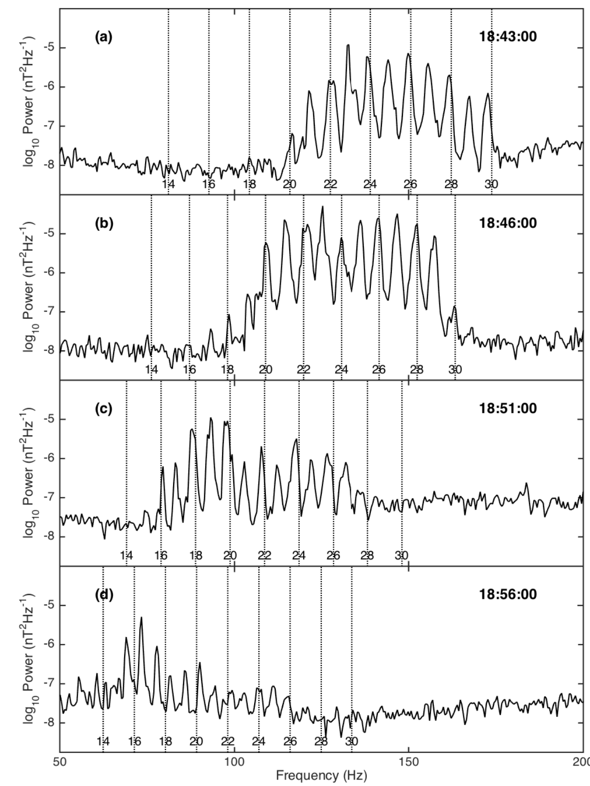
This study uses data from STAFF-SC magnetometer.

To study higher frequencies limited to burst science mode (BM1)

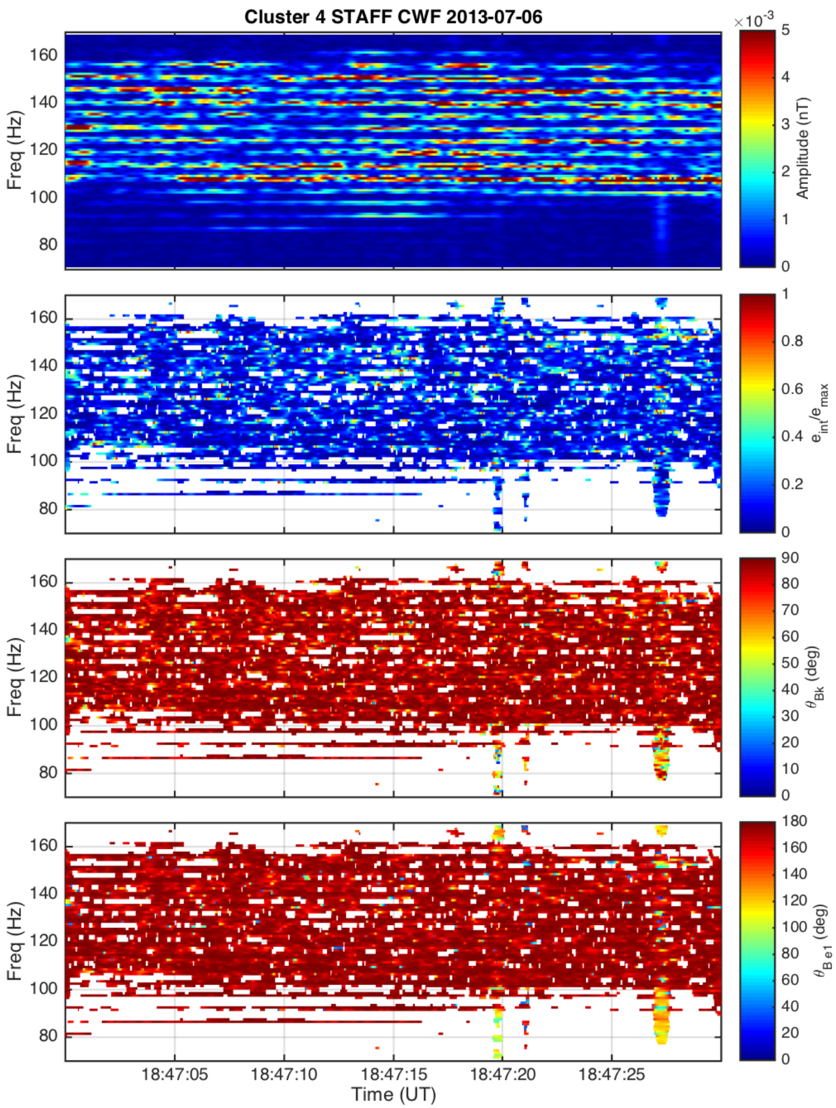
Sampling 450Hz, 180Hz filter

Frequency Spectrum





Propagation Properties



Wave amplitudes

Banded structure

Ellipticity

Ratio intermediate to maximum eigenvalues

Typically eint/emax < 0.1

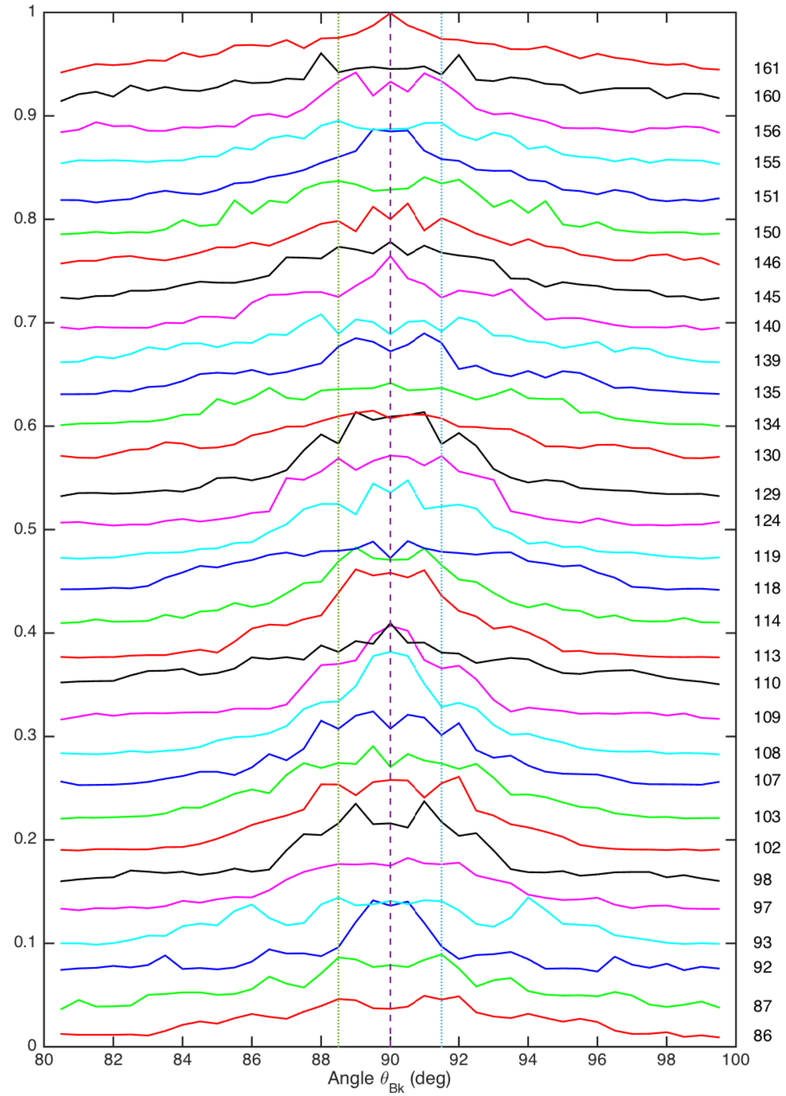
K-vector direction wrt external magnetic field

Almost perpendicular

Maximum eigenvector direction

Parallel to external field – compressive wave

K-vector distribution



Distribution of wave vector directions

For a 20 second period

- minimal frequency change

Use wavelet frequency decomposition

- Each frequency has ~9000 k-vector

Histogram of values shows peak

- 88-92 degrees (resolution 0.5 deg)

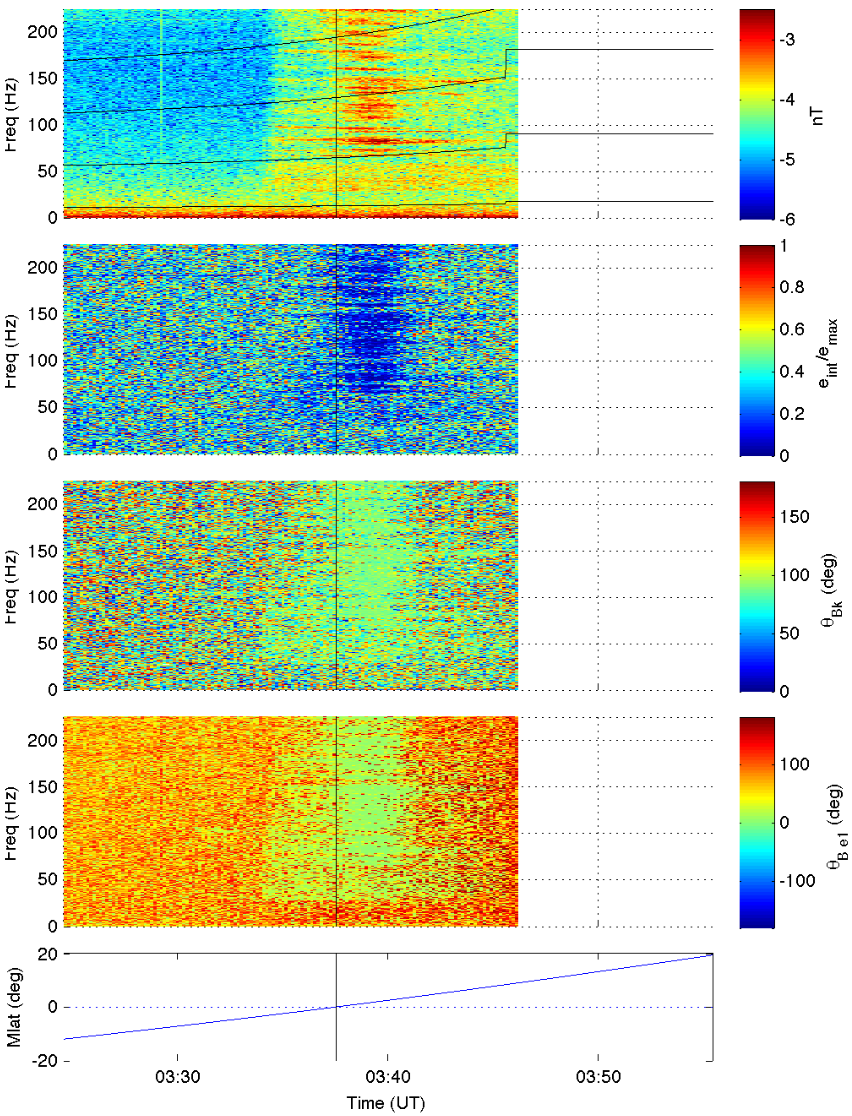
Two basic distributions

- Peak either side of 90 degrees
- Single peak at 90 degrees

Evidence for two generation mechanisms,

- one for $\theta_{Bk} < 90$,
- another for $\theta_{Bk} = 90$ [Chen 2015]

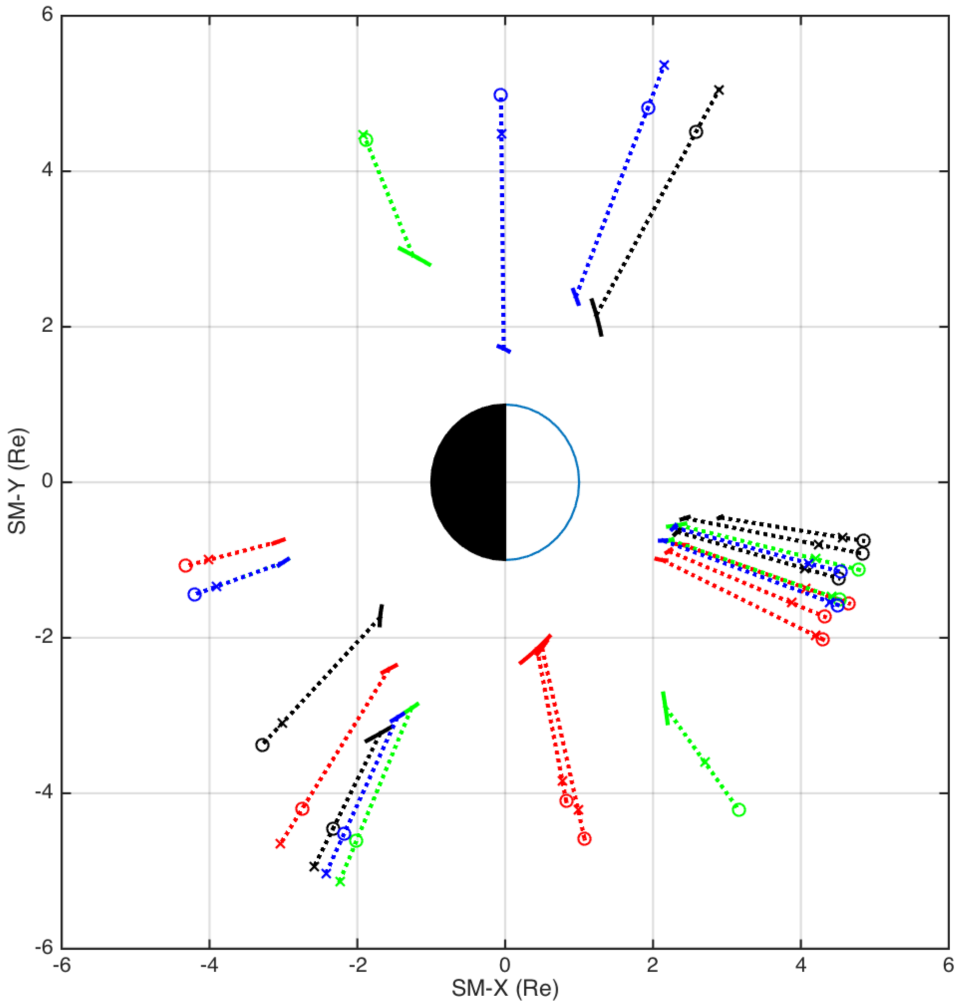
Pillar - spectrum



Pillar type emissions usually consist of

- Well defined set of bands
- Frequencies are unrelated to the local background magnetic field.
- Observed in the frequency range $n\Omega_p$ where $1 < n < 5$
- Some instances $n > 15$ (see left)
- Typically observed North of the magnetic equator
- All magnetic local times
- Inside plasmapause, $2 < L < 3.5$

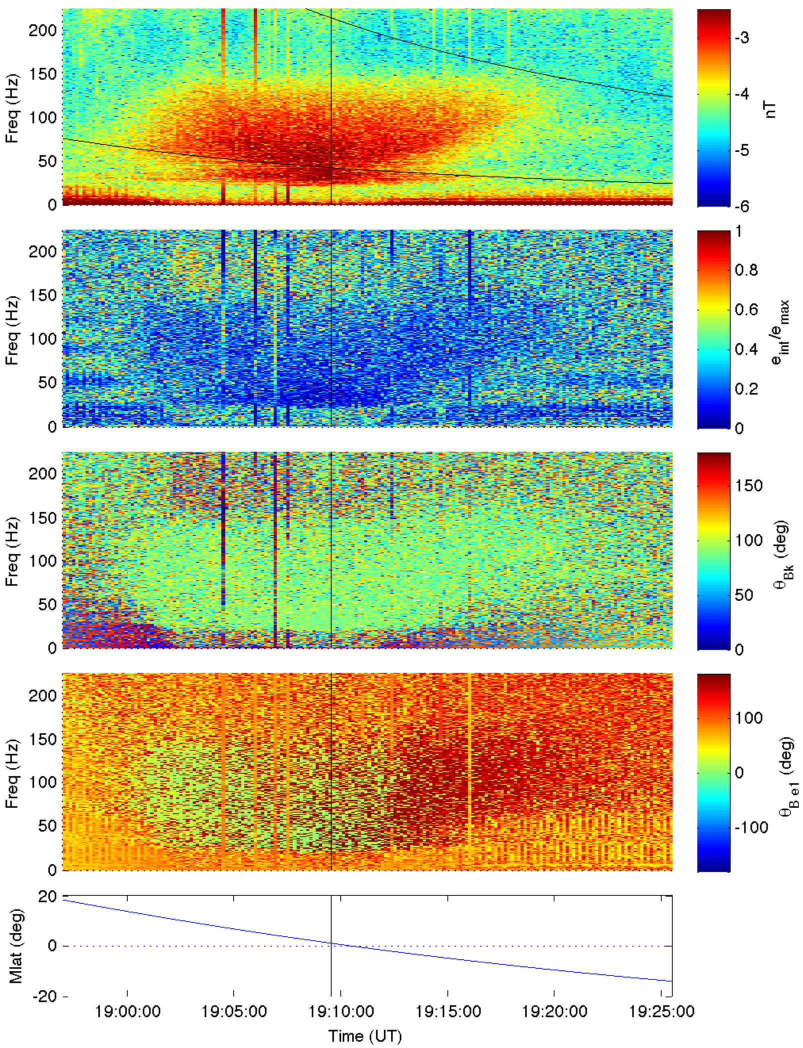
Pillar - Location

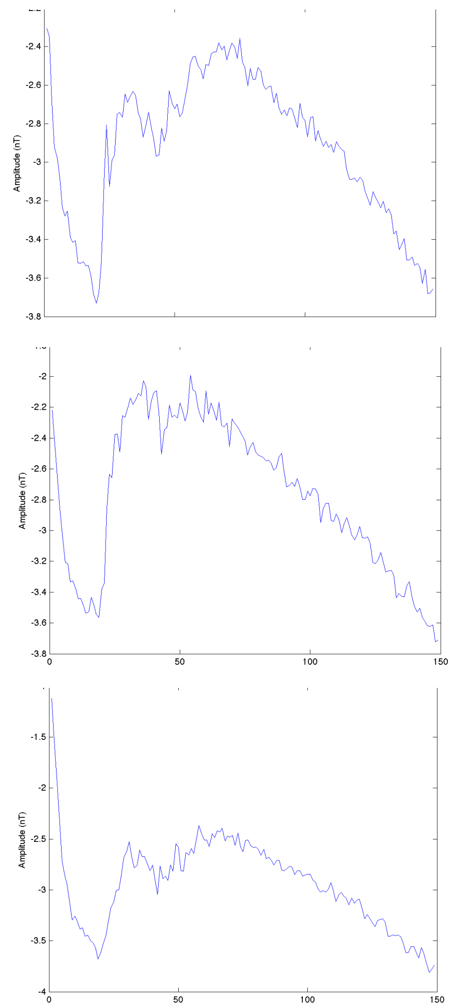


Distribution of locations when 'pillar type' emissions were observed during burst data periods in the SM X-Y plane

- Solid lines indicate periods when emissions were observed
- Colour (black, red, green, blue) indicates satellite C1, C2, C3, or C4
- Model plasmapause location calculated using model of Liu and Liu (2014) based on Dst (crosses) and AE (circles)

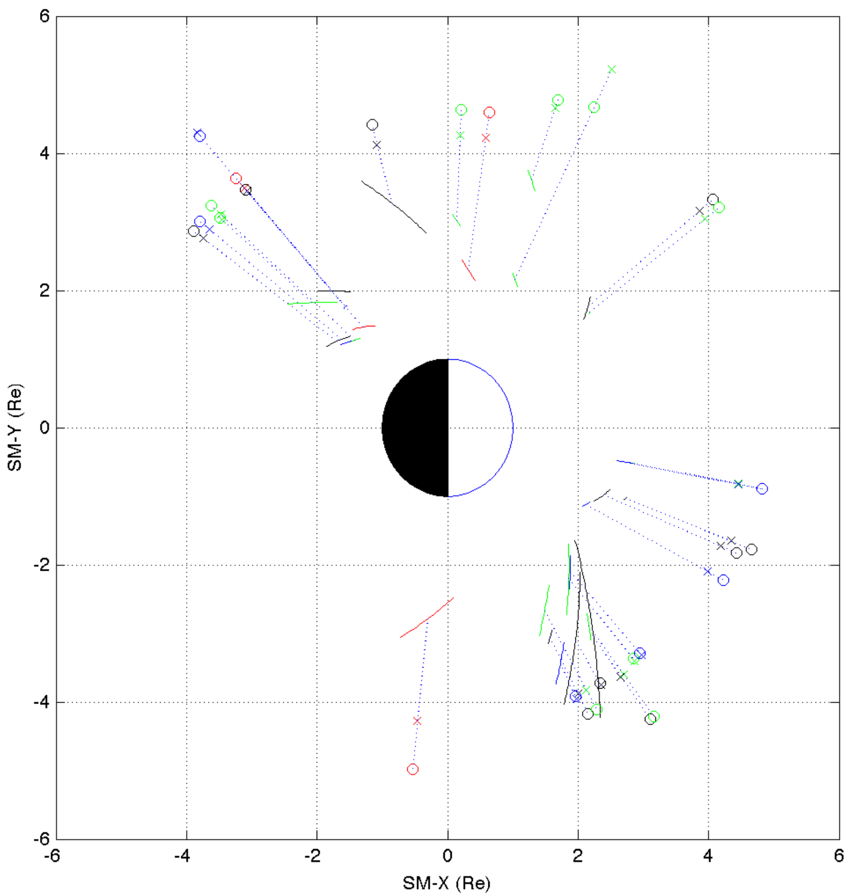
Funnel Properties





- Not all observations of magnetosonic waves show a clear frequency structure.
- An example of a 'funnel shaped' emission
- Does not appear to possess any clear discrete emission lines.
- The individual spectra on the right confirm this.

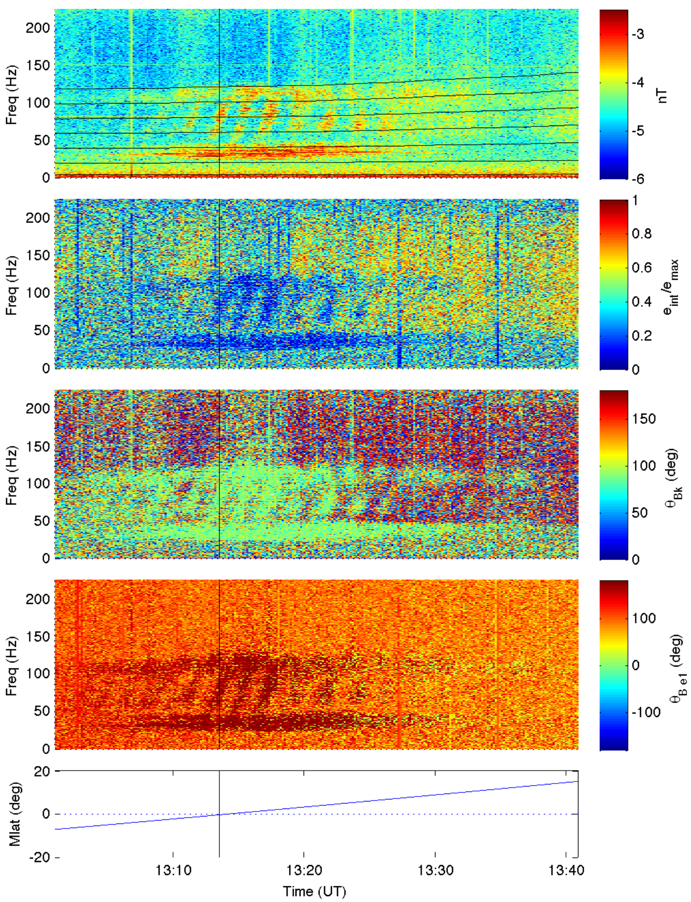
Funnel Location



As can be seen from the figure, these emissions were observed

- From 03-18 MLT
- Inside the model plasmapause.

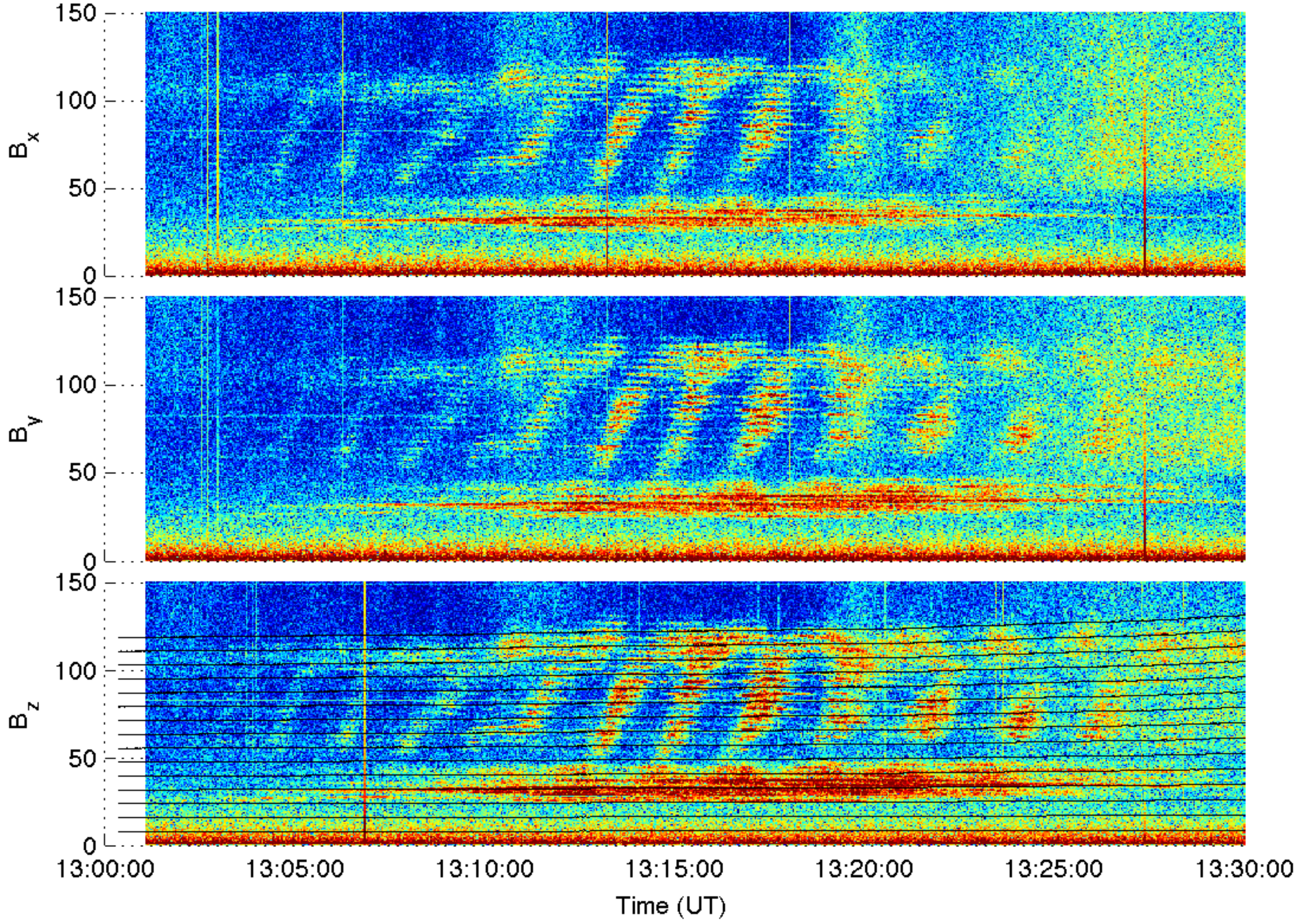
Rising Tone Spectrum



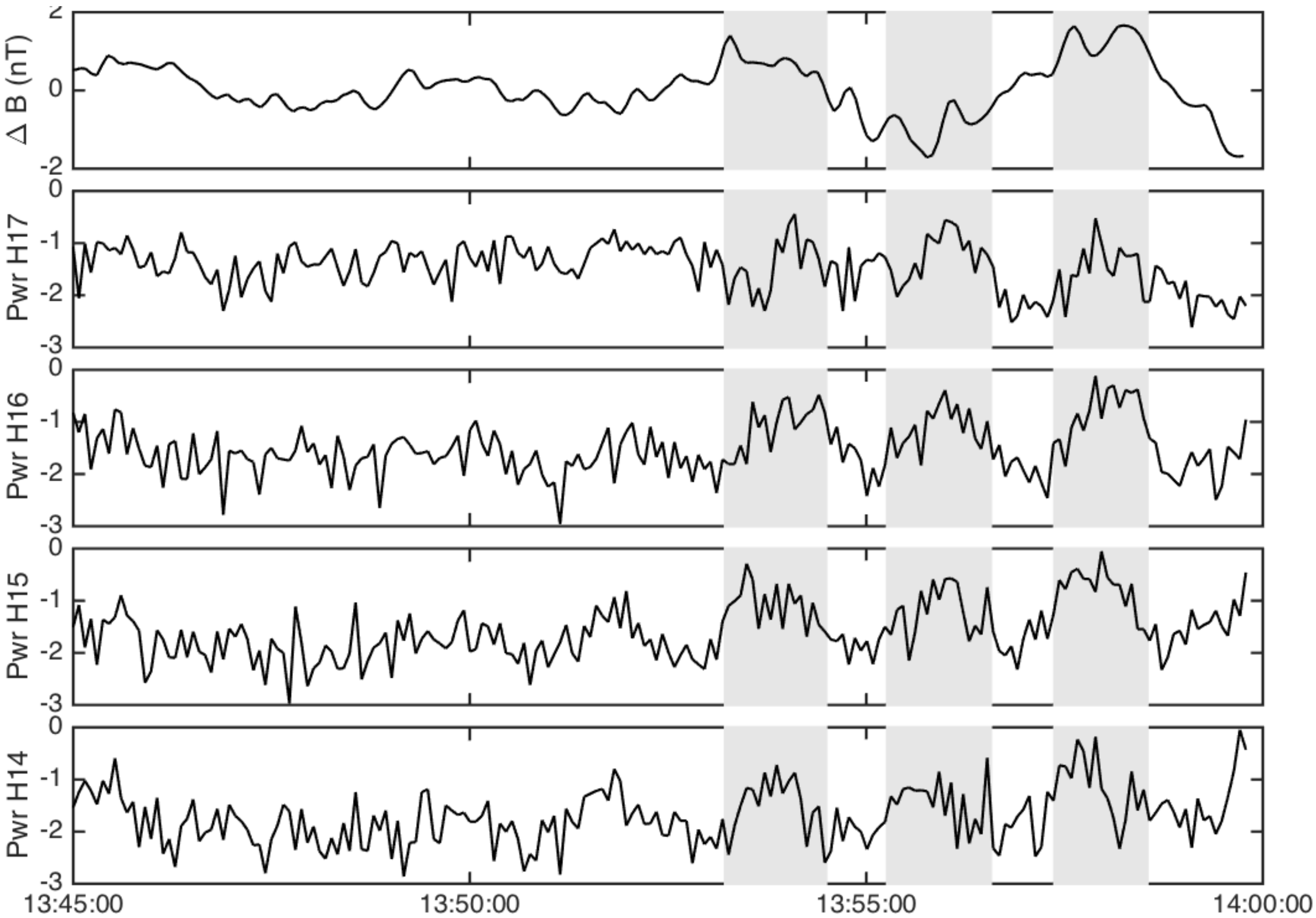
Rising tone magnetosonic waves

- First reported Fu 2014 (VAP), Boardsen, 2014 (THEMIS), Nemec 2015 (Cluster)
- Periodic occurrence, typically 1-2 minutes
- Emission frequencies coincident with gyroharmonic frequencies
- Usually accompanied by other magnetosonic emissions above or below periodic emissions

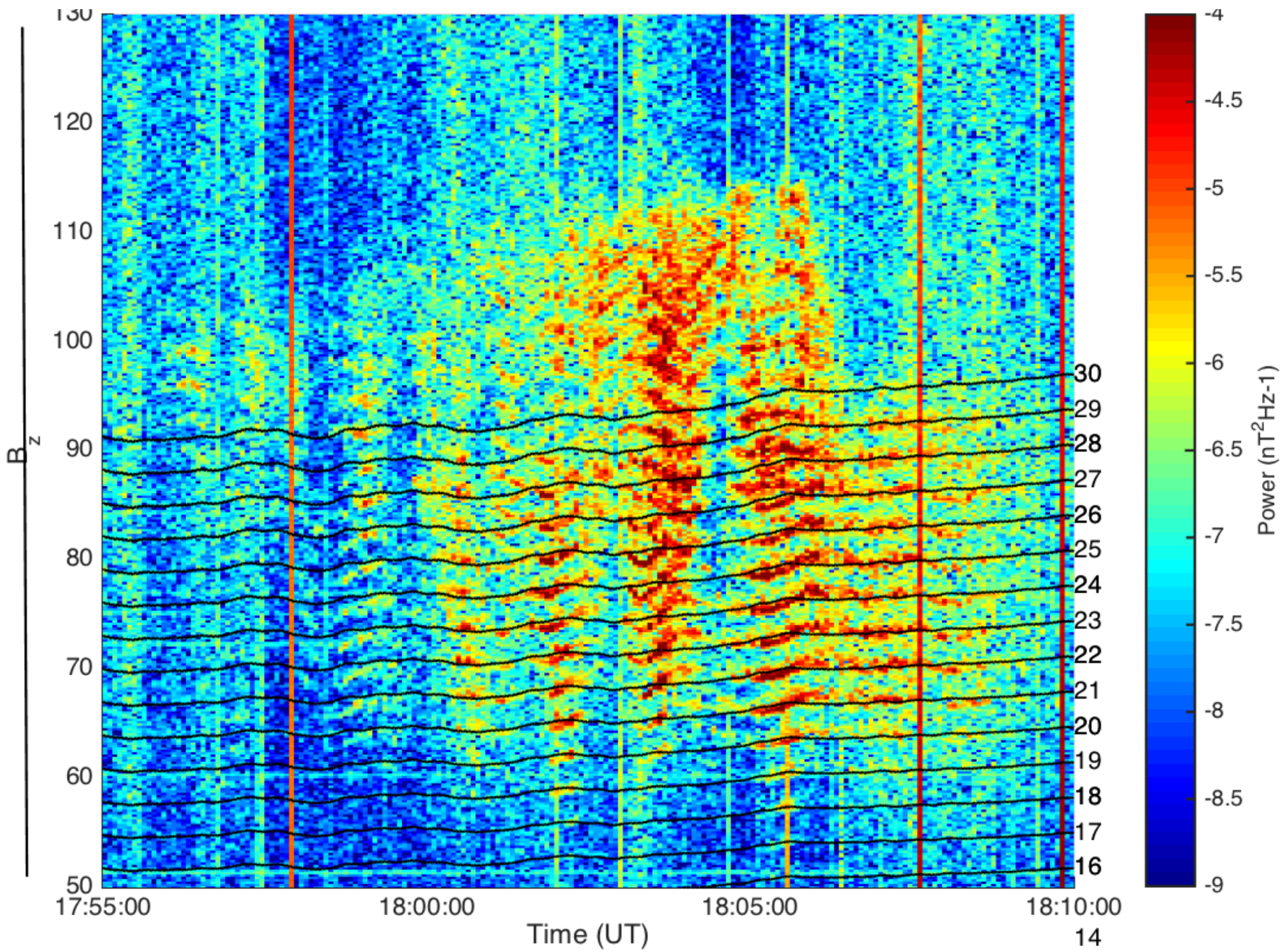
Rising Tone Spectrum



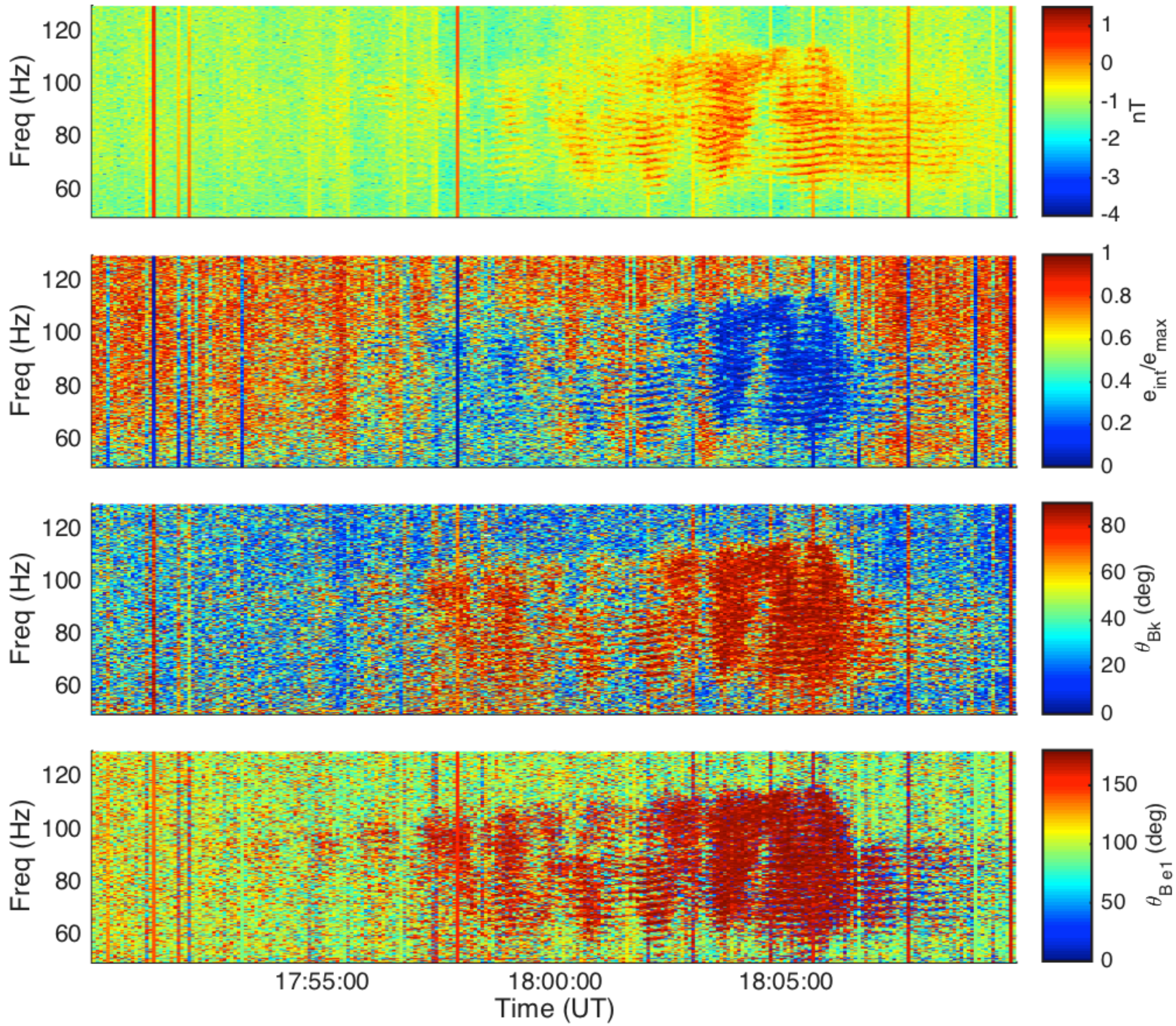
Rising Tone v Magnetic Field



Non-Time Continuous



Properties



Freq (Hz)
120
100
80
60
1
0
-1
-2
-3
-4
nT
Freq (Hz)
1
0.8
0.6
0.4
0.2
0
e_int/e_max
Freq (Hz)
80
60
40
20
0
θ_Bk (deg)
Freq (Hz)
150
100
50
0
θ_B e1 (deg)
17:55:00
18:00:00
18:05:00
Time (UT)

Summary

Shown various examples of Equatorial Magnetosonic Wave emissions

Banded emissions

- Track proton gyrofrequency emissions
- Propagation almost perpendicular to eternal field
- Evidence for propagation exactly perpendicular (different generation mechanism)

Funnel shaped emissions

- No Frequency structure

Rising tone emissions

- Occurrence related to low frequency magnetic field oscillations

Non time continuous emissions

- Sometimes emissions follow gyrofrequencies
- Other times emissions show frequency changes independent of local field

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