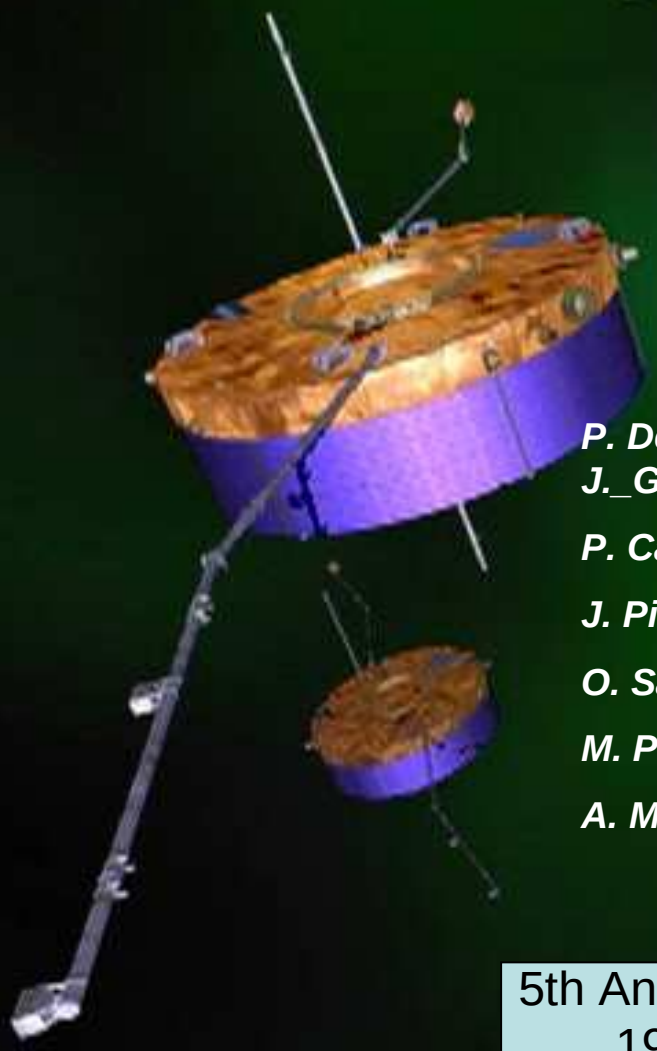
Non Thermal Continuum radiation observed from the Cluster fleet



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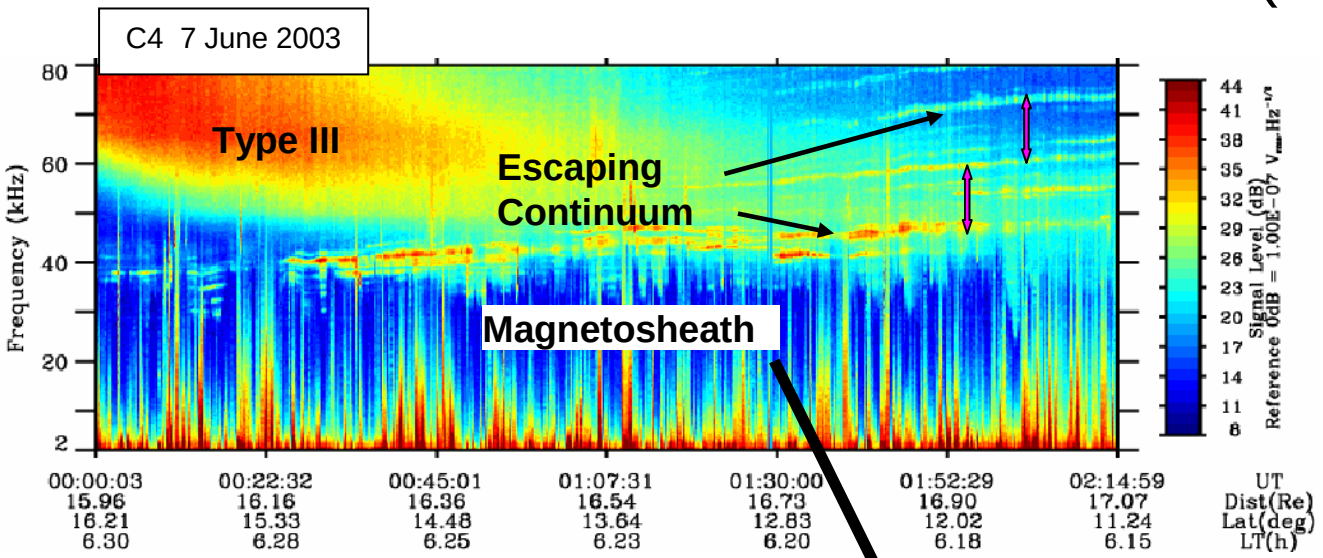
5th Anniversary of Cluster in Space
19-23 September, ESTEC

NTC observed from the Cluster fleet

1. Generalities
2. Advances with Cluster observations
   - Ray path from multipoint observatory
   - Sources
3. Summary and perspectives

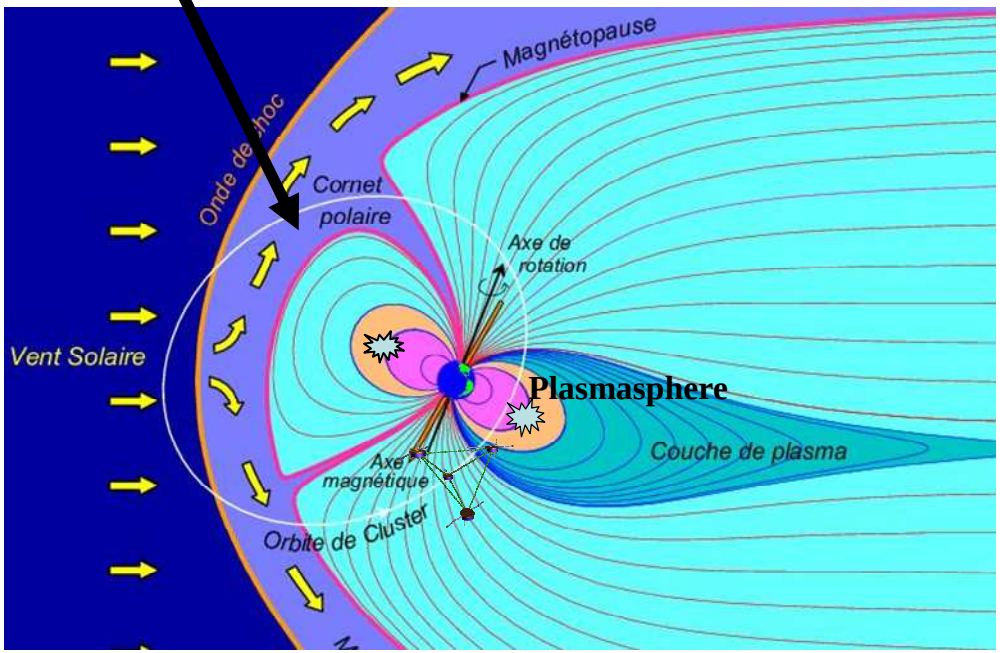
1.1 What is Non Thermal Continuum (NTC)?



NTC and Type III:

~ 10^{-16} V^2 M^{-2} Hz^{-1}

$\Delta F \sim F_{ce}$ at source



NTC radiations are:

- weak, long lasting, narrow band, EM emissions
- observed (since 1970s), in almost all regions of magnetosphere, they can escape in the interplanetary medium

1.2 What is the source of NTC?

General scheme of NTC generation:

This happens at the plasmapause boundary layer

Models

Radio window at grad (Ne)
Jones, 1982

N.L. processes
• coalescence with LF waves
Melrose, 1981
• decay of Bernstein waves
Rönmark, 1985

NTC formation is largely not understood. How to explain:

Duration of emissions?

Spectral characteristics (narrow bands, harmonic structures)?

Wave intensity?

Beaming properties?

1.3 Current studies

Sources

Several generation models
Few observations

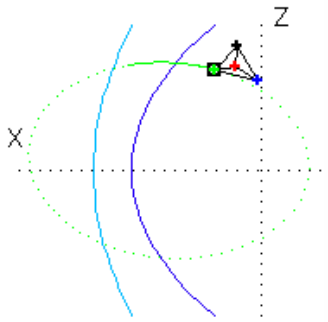
Link to be understood

Remote Observations

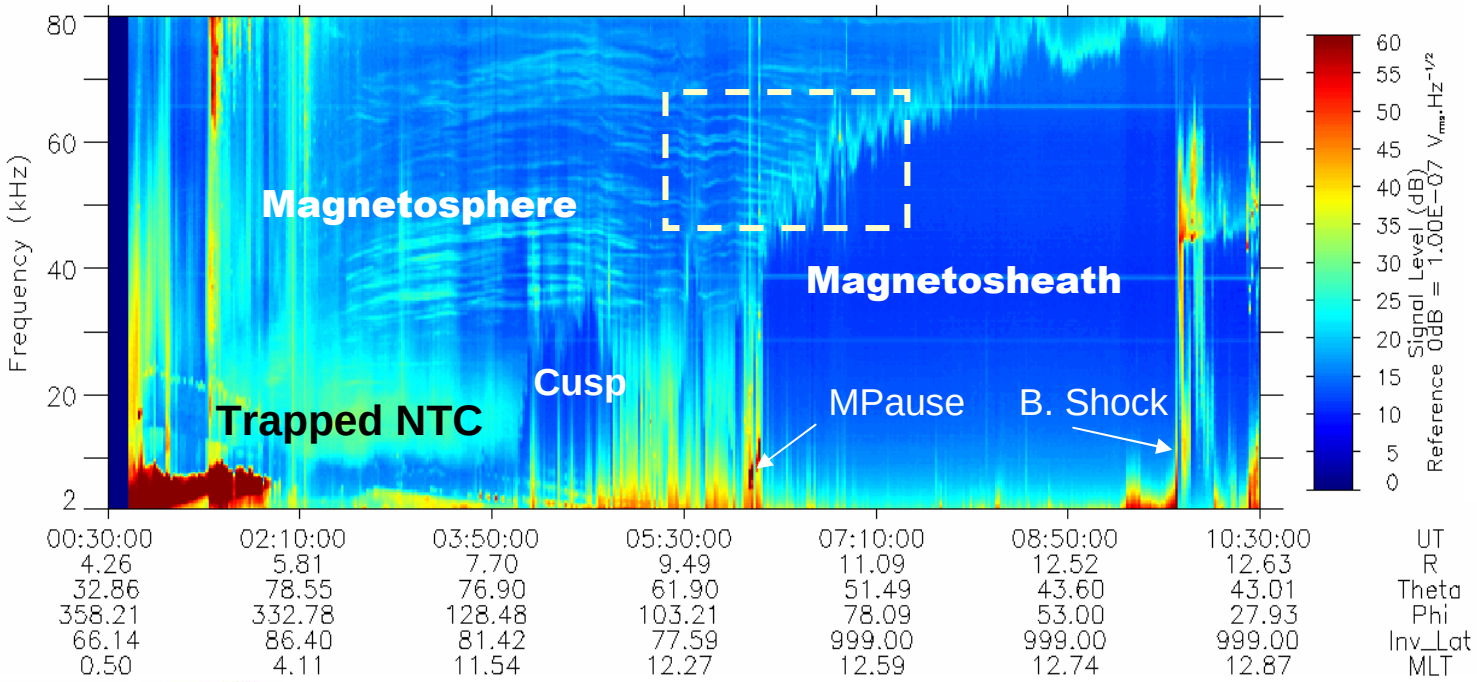
Increasing data set:
Injun 5, Hawkeye, ISEE, GEOS, DE1, Polar, Geotail, IMAGE, Cluster

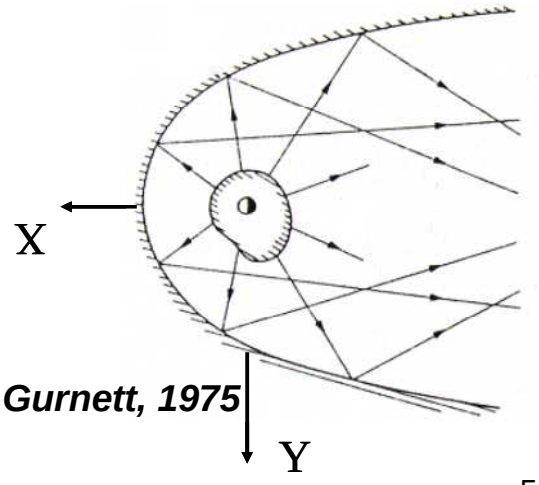
Various behaviors

1.4 How does NTC propagate?



26/02/2001





Gurnett, 1975

- NTC radiation emerges from sources at PPause boundary layer. It is beaming predominantly near equatorial plane.
- The lower frequency band is trapped inside the magnetospheric cavity, bouncing between MPause(/cusp) and Plasmapause

2. Advances with Cluster observations

- Ray path from multipoint observatory
  2 examples

- Sources

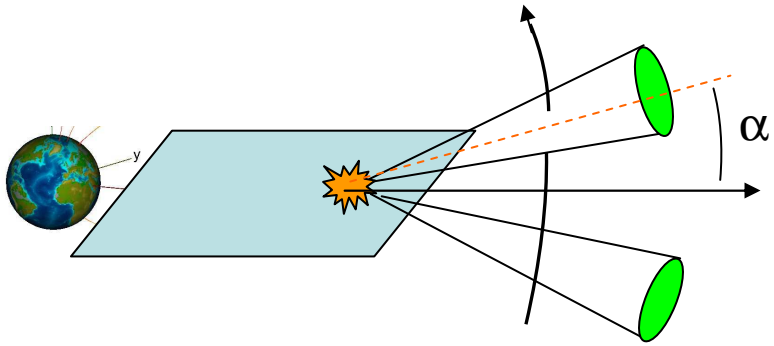
Example 1: Beaming properties

Test of Jones theory

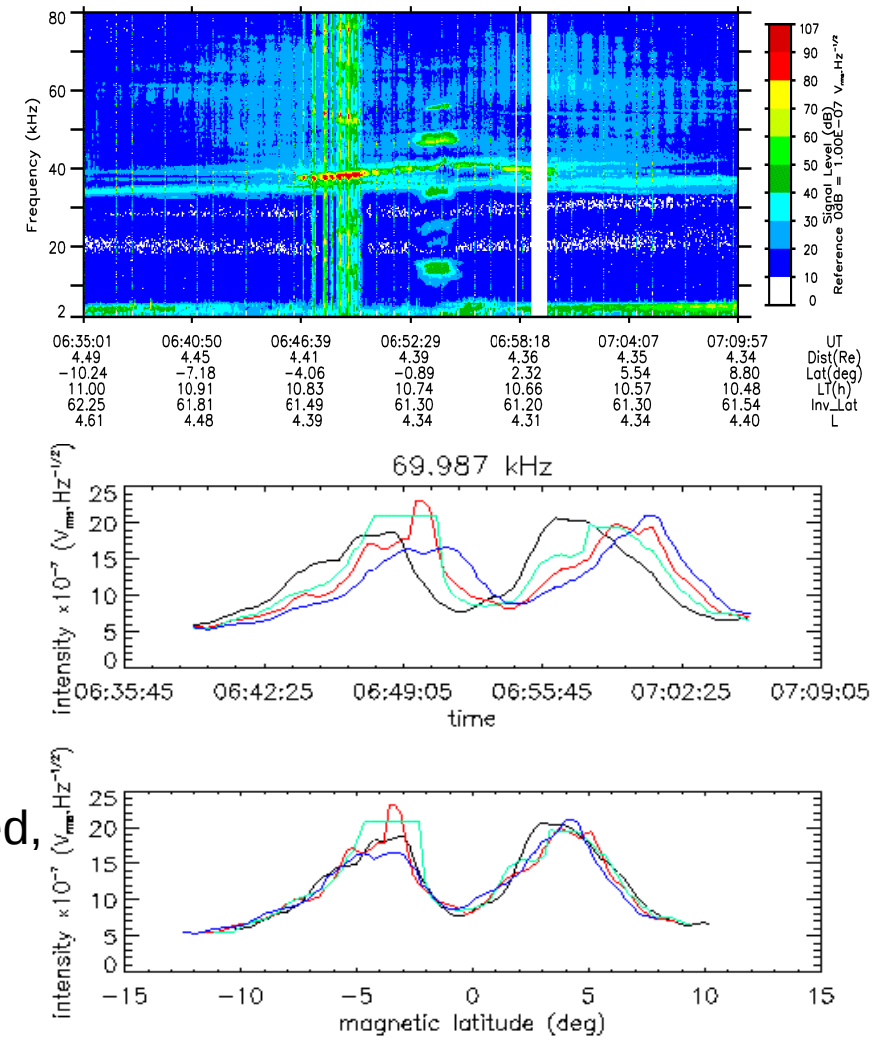
(ES to EM conversion)

2 narrow beams, symetric / equator

$$\alpha = \arctan(f_{ce}/f_{pe})^{1/2}$$

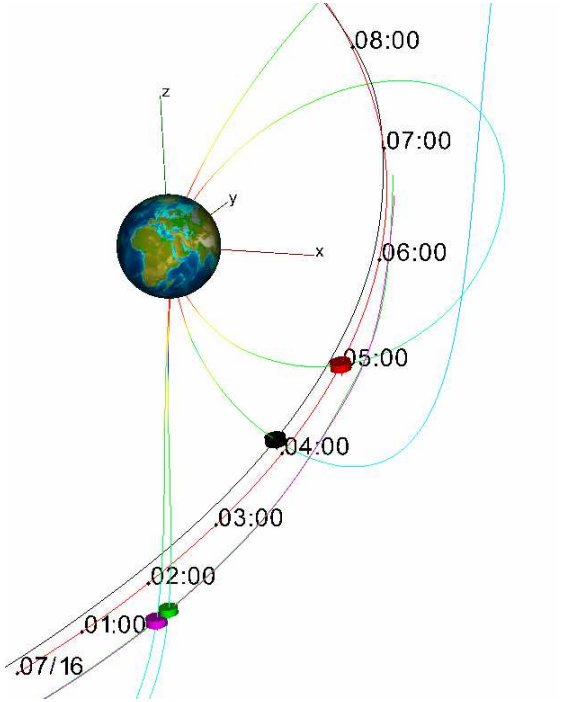


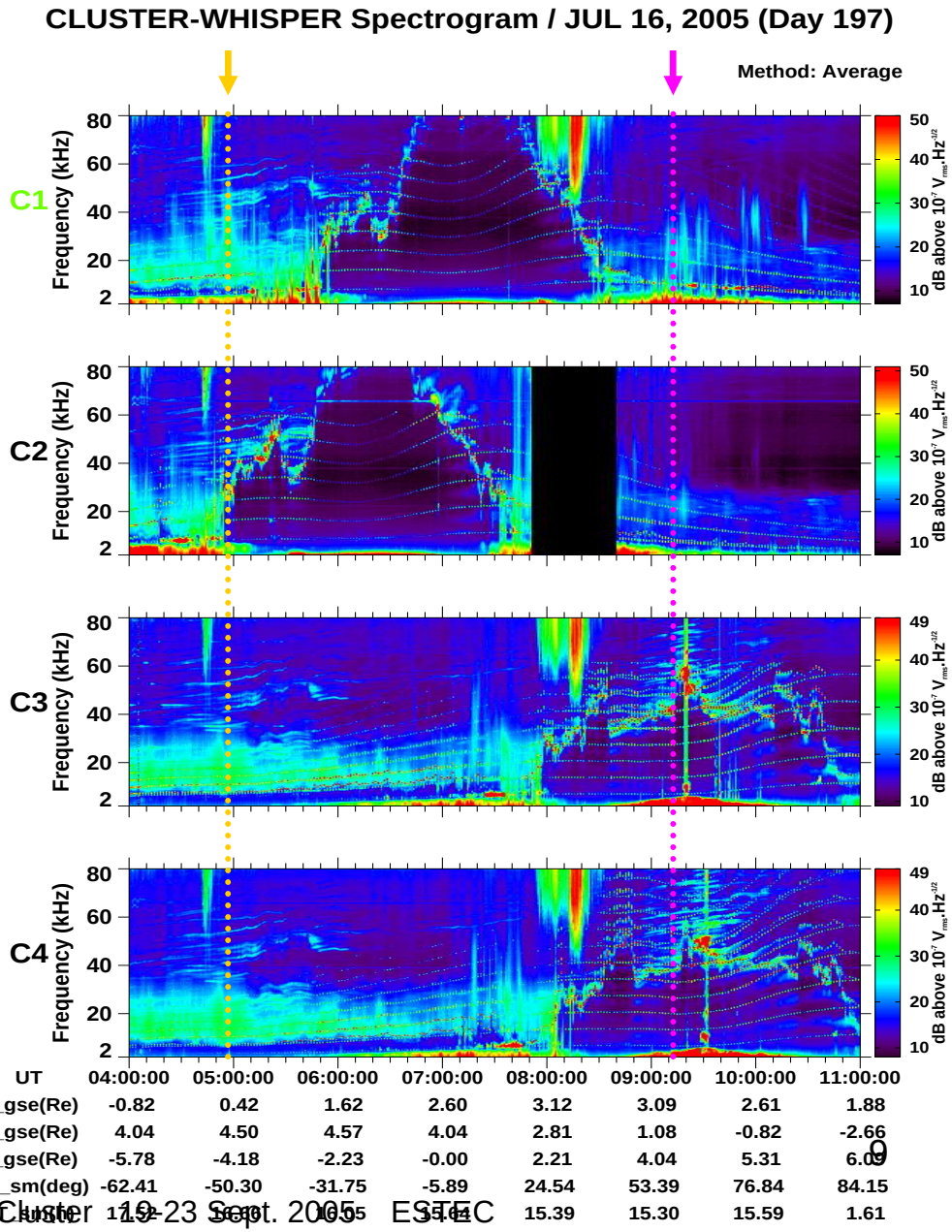
26/09/03 Separation ~ 250 km



- No definitive conclusion has been reached, concerning the validity of Jones theory
- Cluster orbit does not cross a beam pair issued from the same source

Example 2: Observation of narrow band emissions



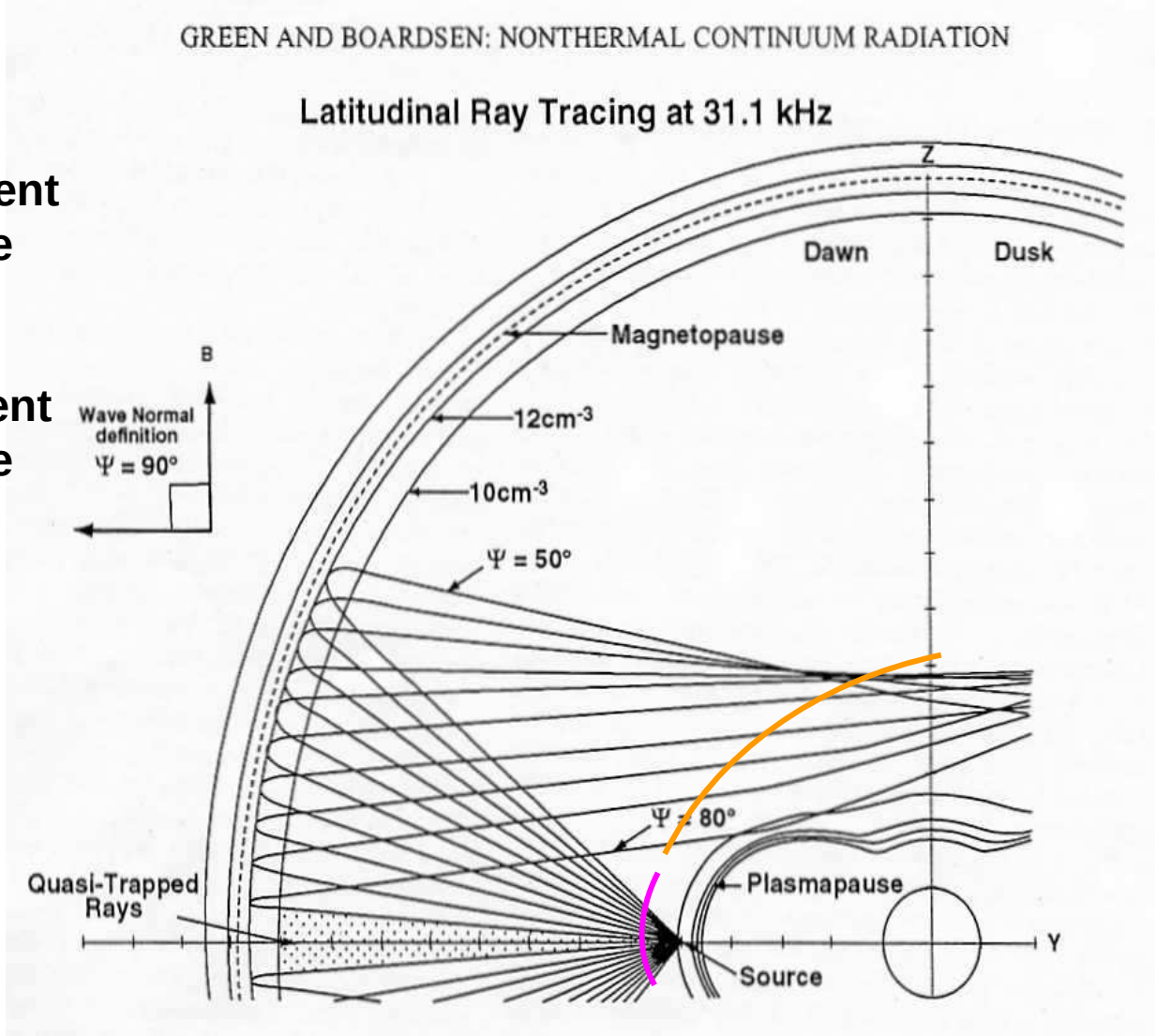


Far from equator, the four SC see exactly the same emission

Only part of the constellation is illuminated near the equator

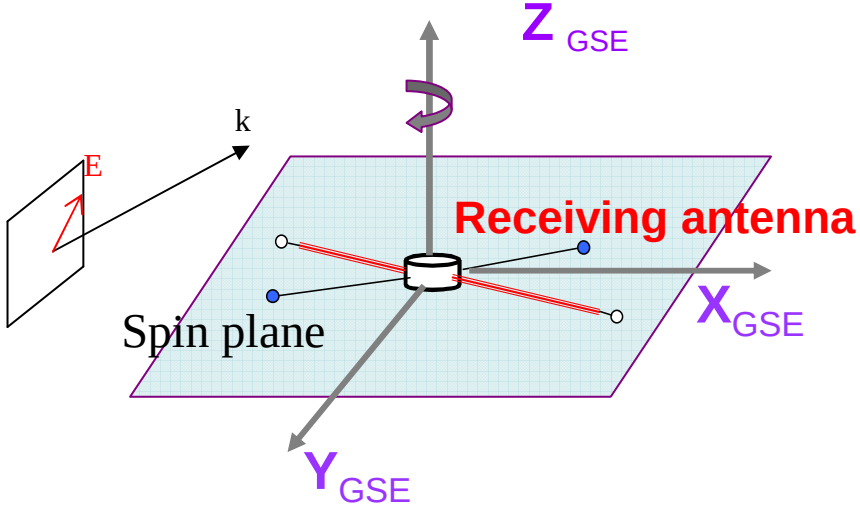
Interpretation

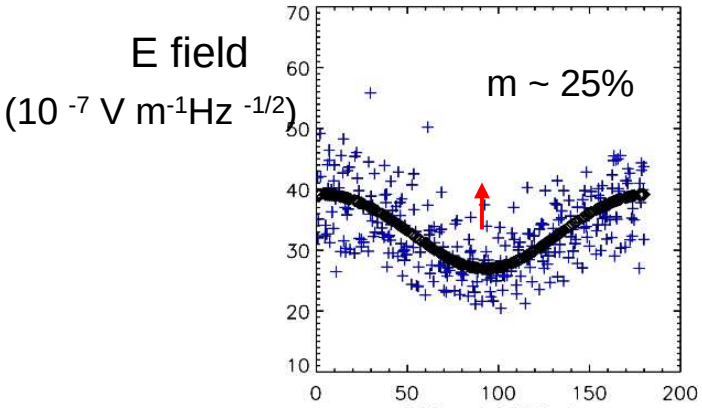
- **A small orbit element is illuminated by the direct path**
- **A large orbit element is illuminated by the reflected radiation**



Meridian plane

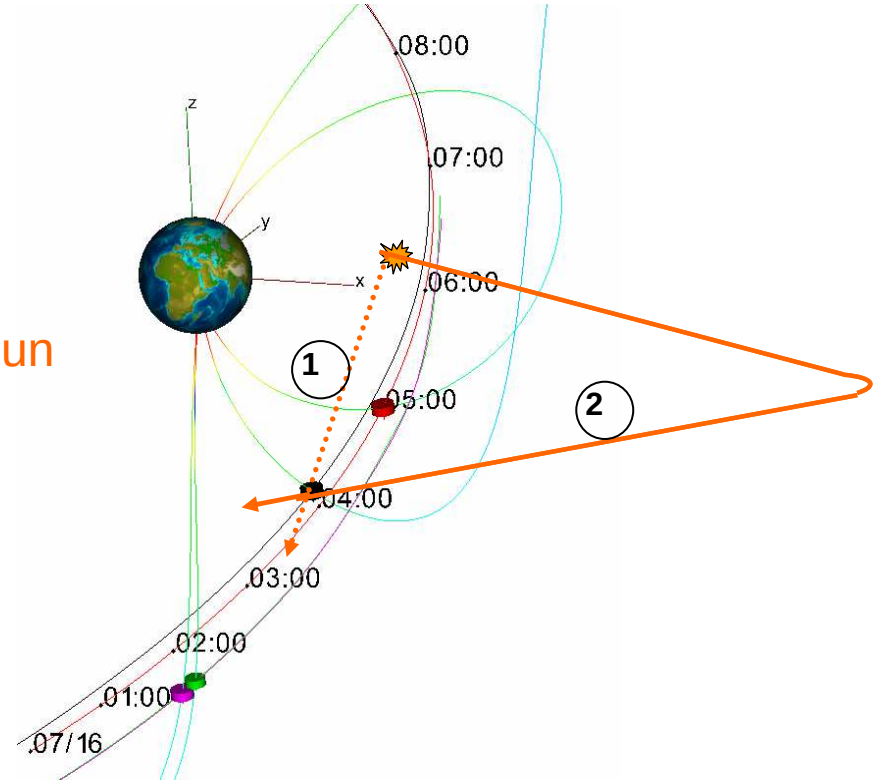
Spin modulation as a clue to ray path orientation





Phase angle (0-180°)

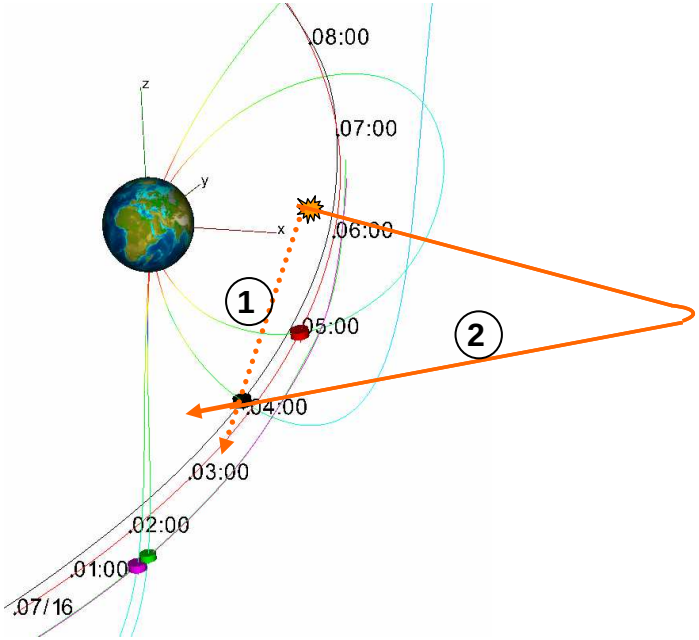
Sun



The spin modulation gives an estimation of the inclination of the ray wrt the spin plane

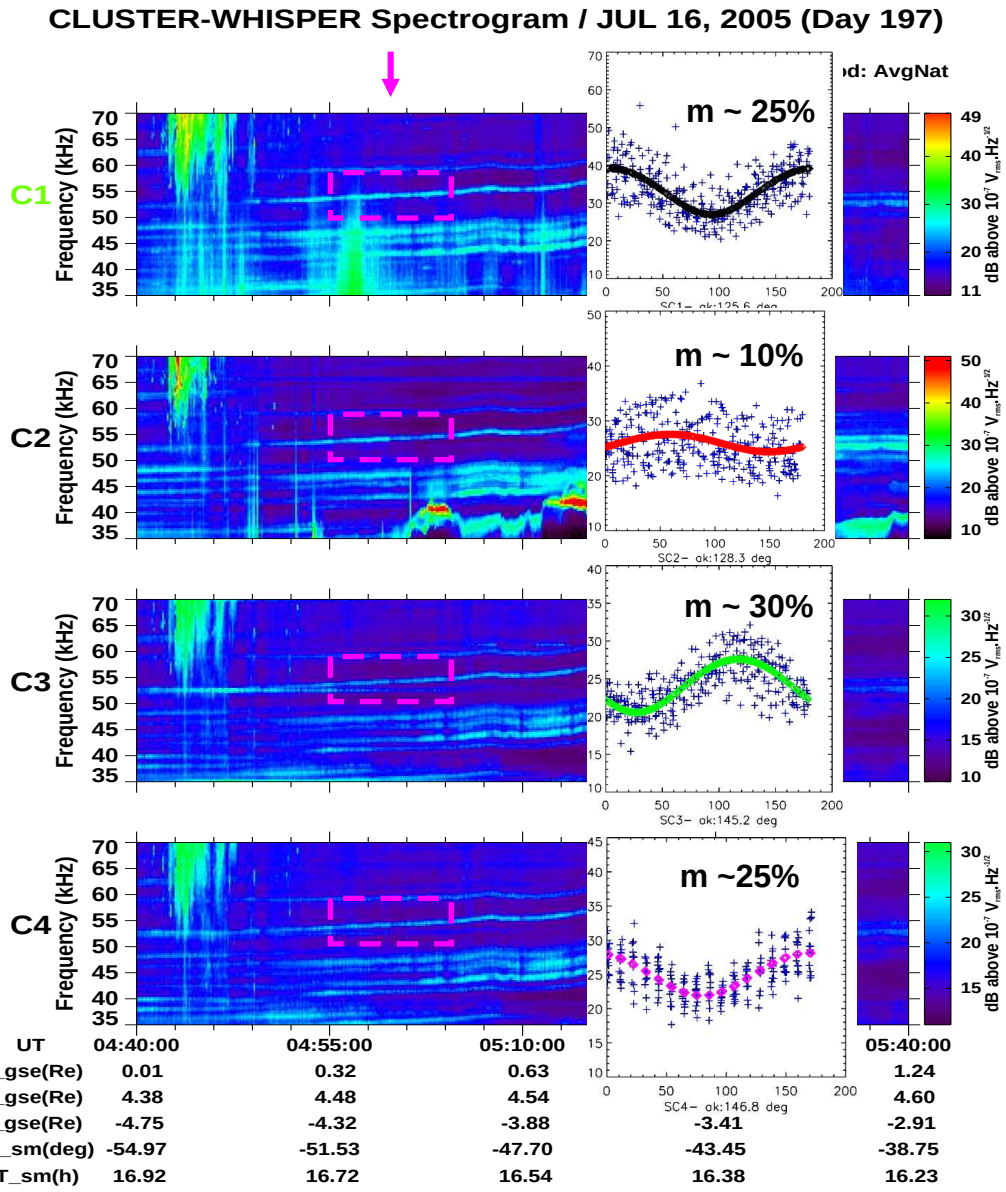
It allows to find out if the ray reaches the observatory directly (1) or after a reflection (2)

Compared spin modulations

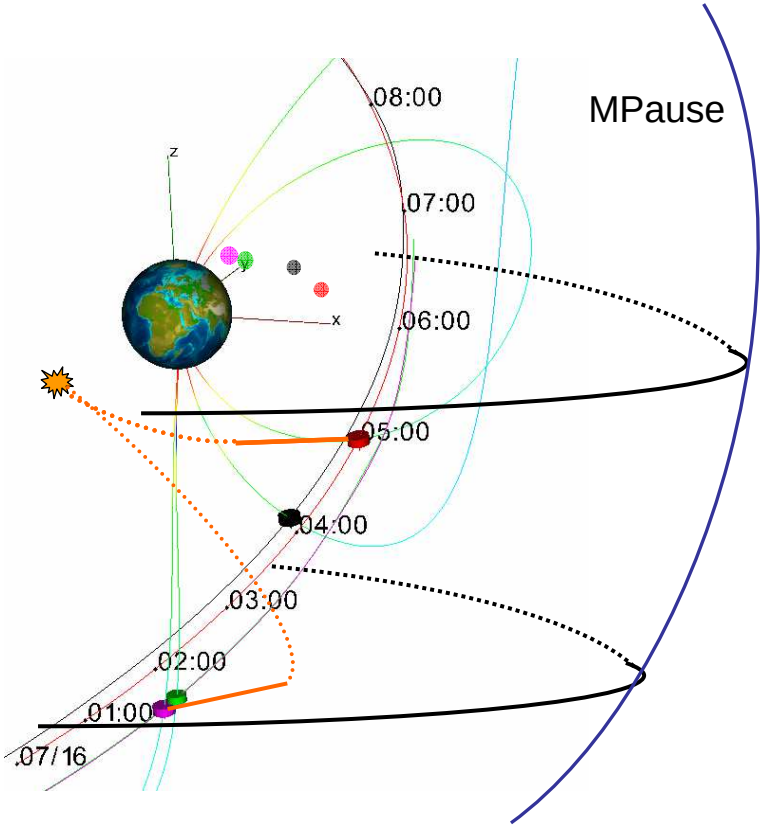


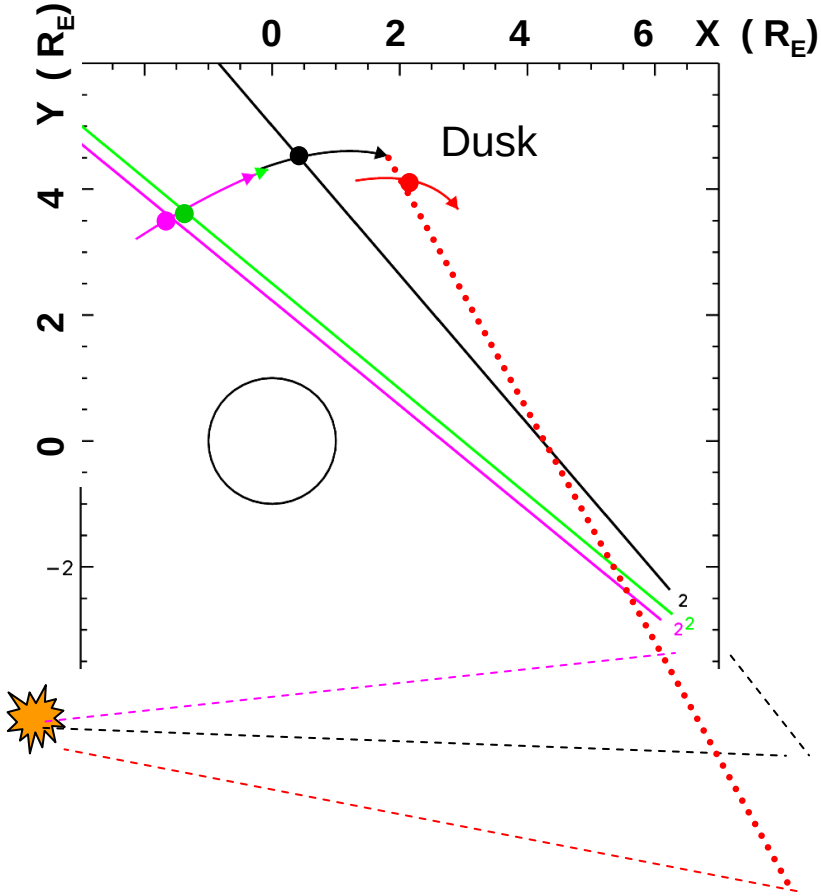
Modulation values indicate that beams have been reflected

Directivity angles complete the information



Triangulation points toward high X value, it is compatible with the proposed scenario



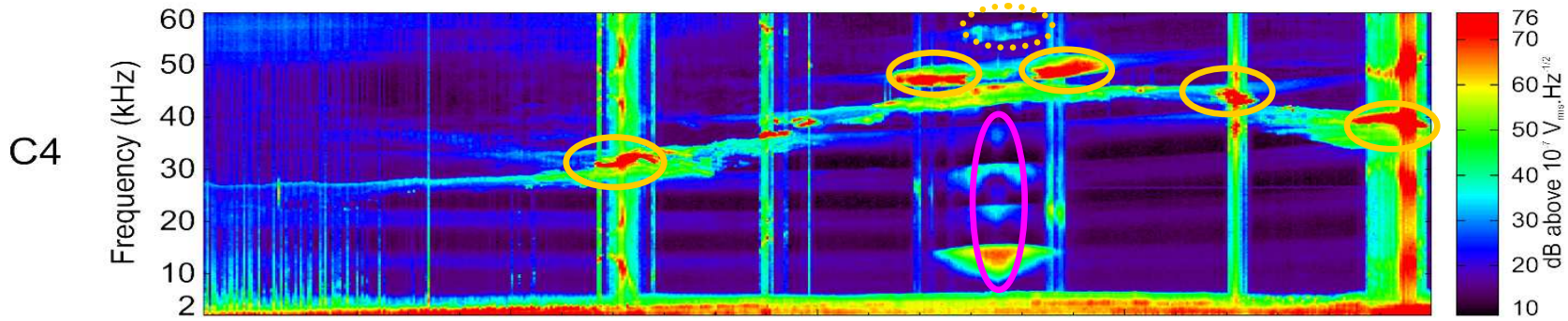


- Conclusion: the origin of beams observed in the dusk sector is probably a source placed in the dawn sector

2. Advances with Cluster observations

- Ray path from multipoint observatory
- Sources

NTC Sources: Which candidate Electrostatic Emissions ?



UT	11:45:00	12:00:00	12:15:00	12:30:00	12:45:00
R(Re)	4.87	4.70	4.55	4.45	4.38
Lat_gsm(deg)	-22.20	-14.95	-7.18	1.03	9.60
LT_gsm(h)	10.79	10.90	11.00	11.10	11.20
L	5.52	4.95	4.62	4.53	4.69

- ***Equatorial n+1/2?***

Too far from density gradient (inside plasmasphere)

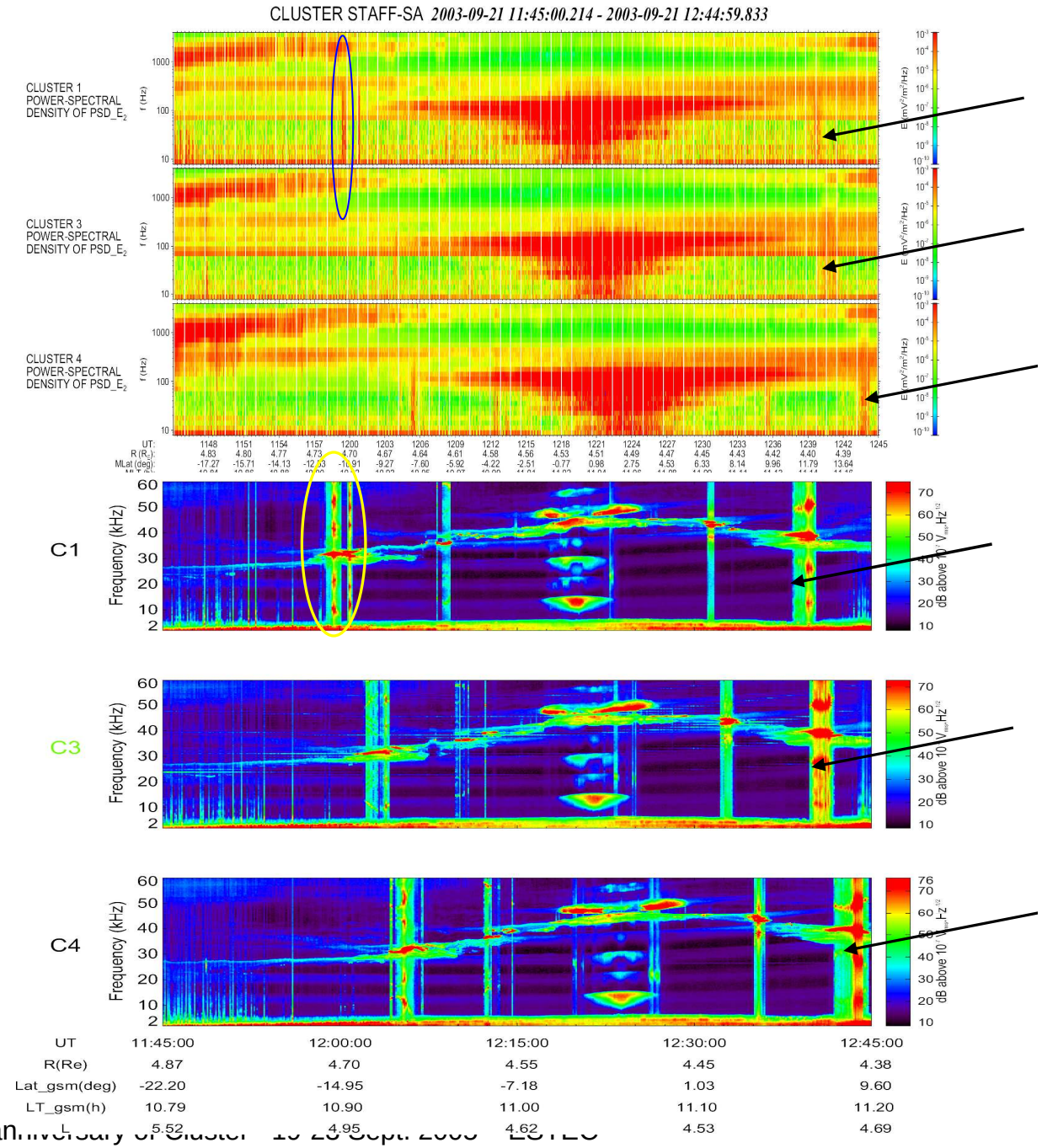
- ***Intense (saturating) emissions at PPause density gradient ?***

Observed just above Fp (in the band Fp - Fq), close to equator

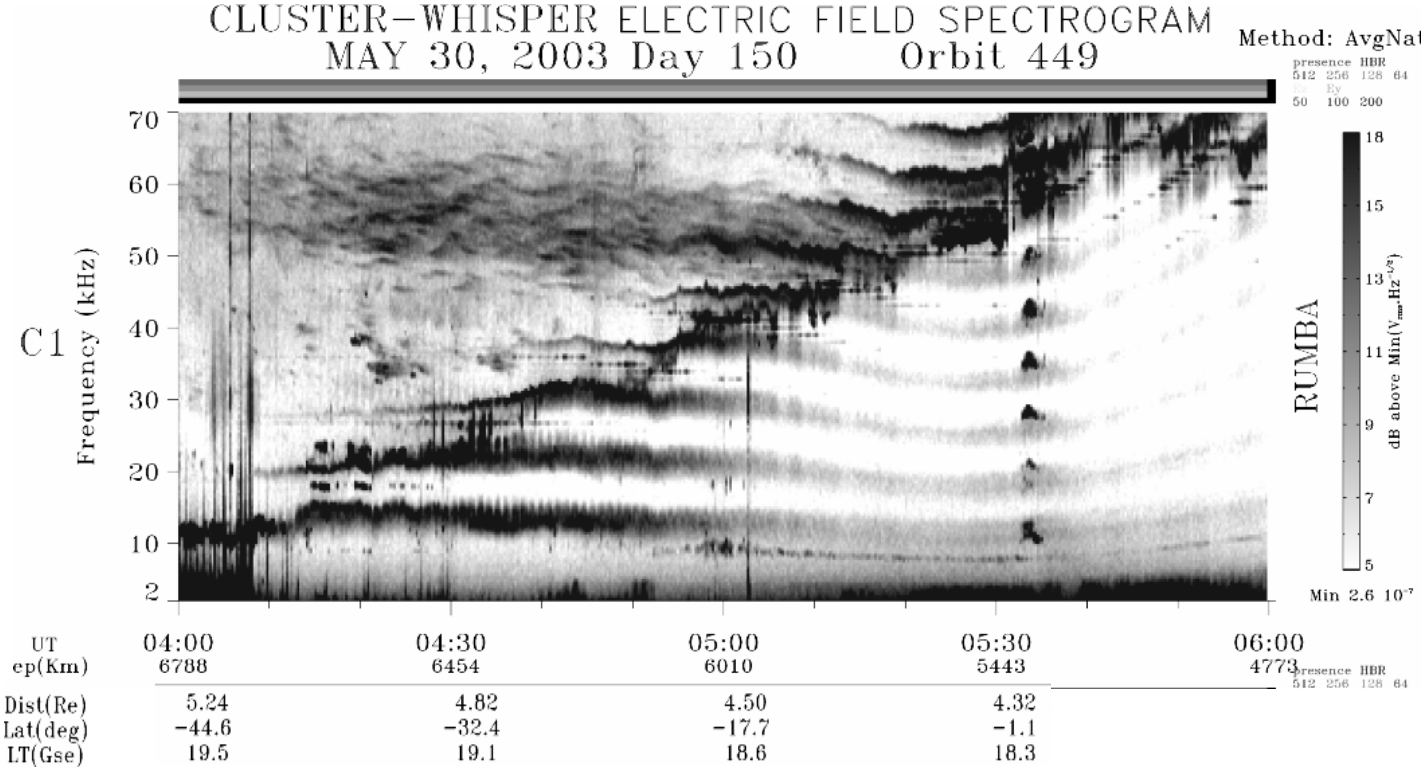
Good candidates for the main forms of NTC

NTC Sources

- Intense ES emissions at plasmapause surface are often associated with LF broadband emissions
- More analysis is needed to interpret these observations

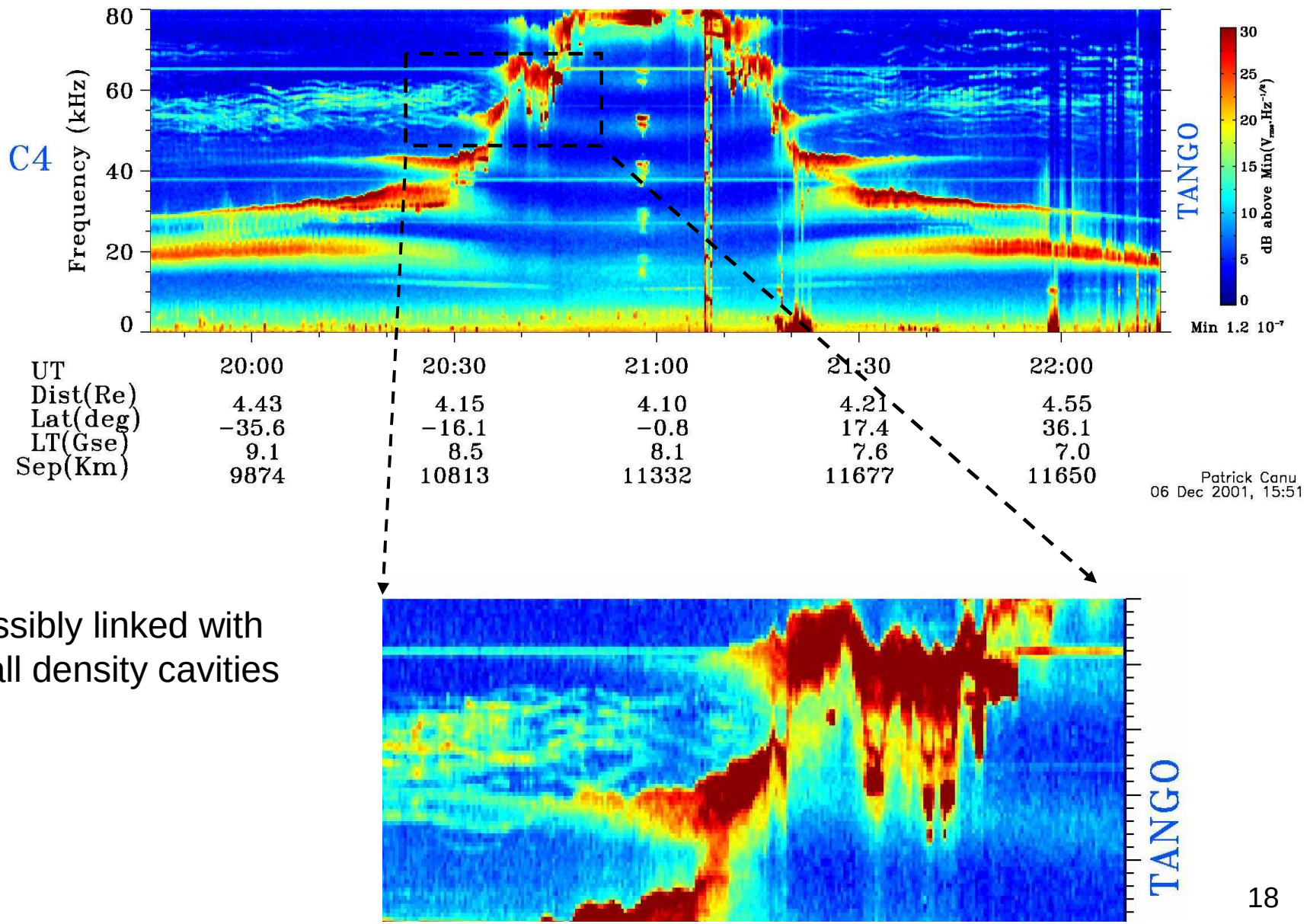


Role of Bernstein waves



Several examples show convincing evidence of a link between ES emission at local Fqs (Bernstein mode) and simultaneously observed NTC

Canu et al., 2005

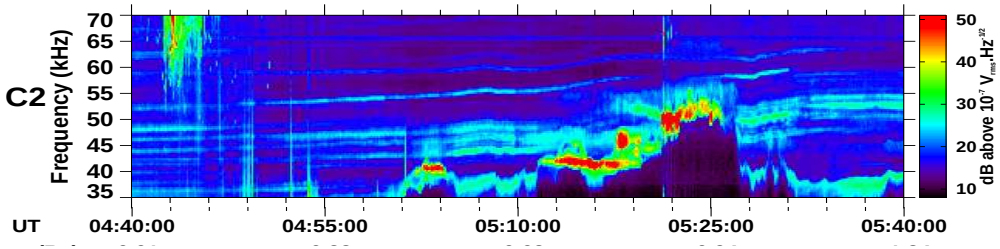


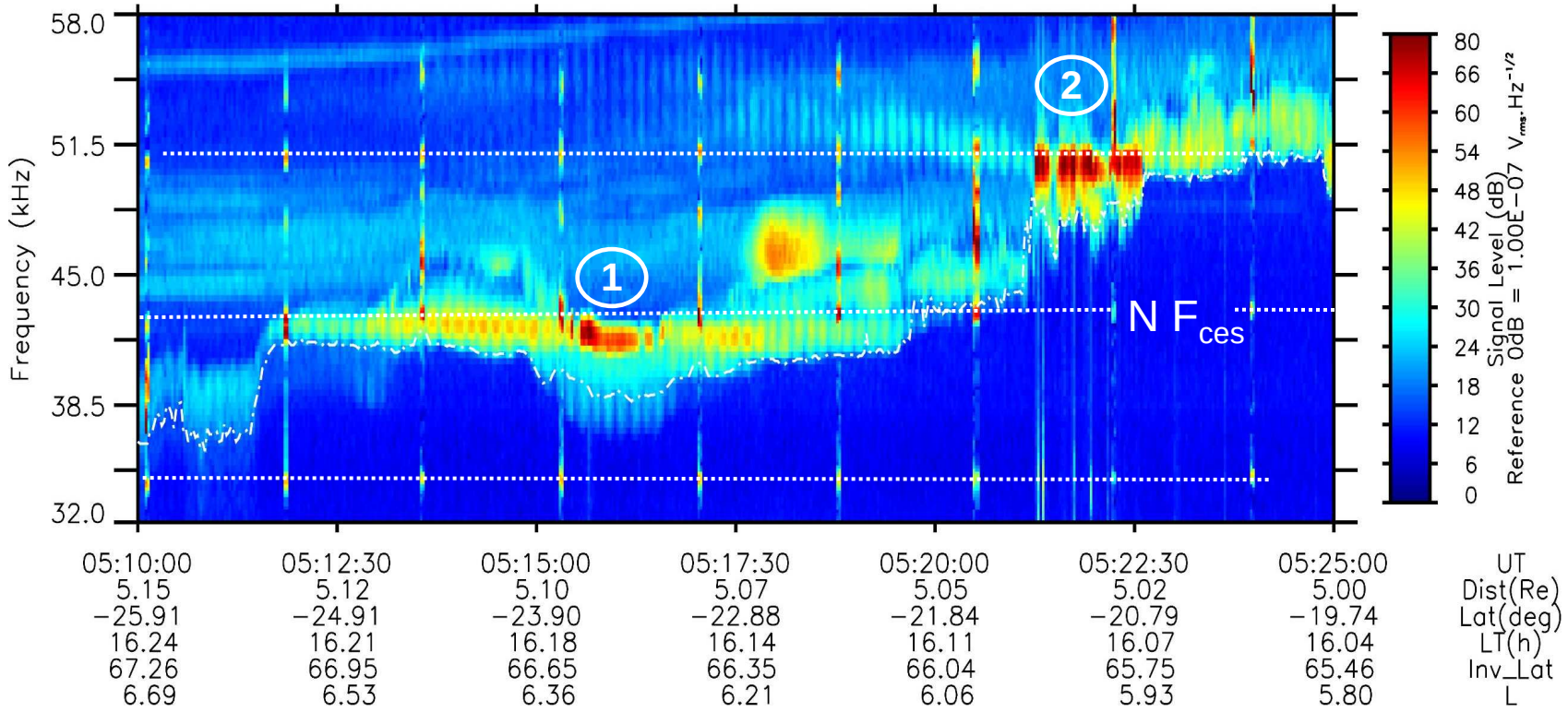
Possibly linked with small density cavities

NTC observed at sources

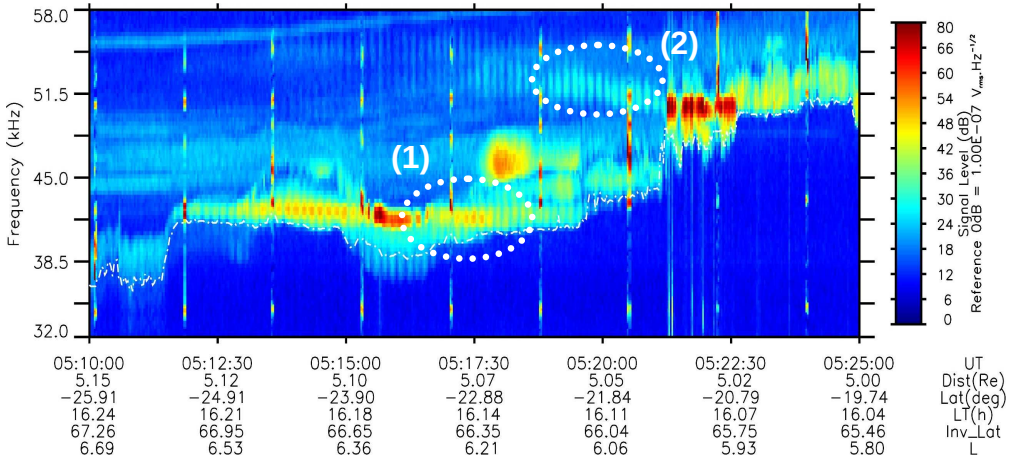
More from the 16 July 2005 event

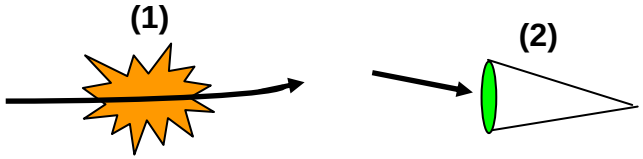
EM emissions near density cavities



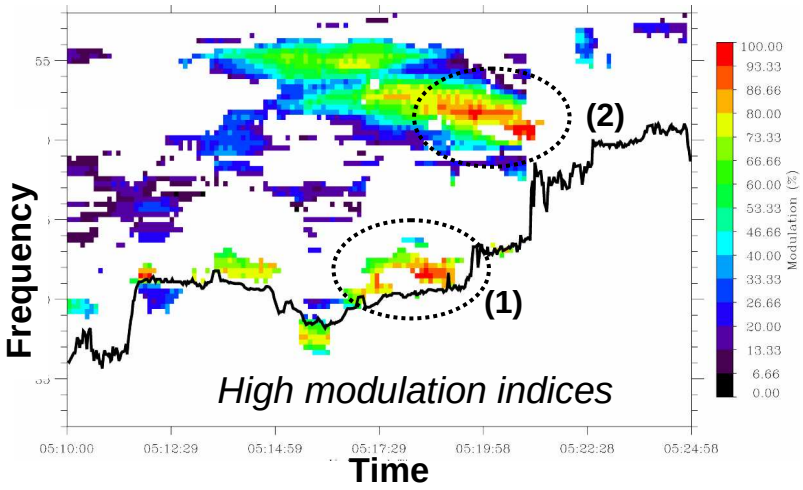


Analysis of directivity properties

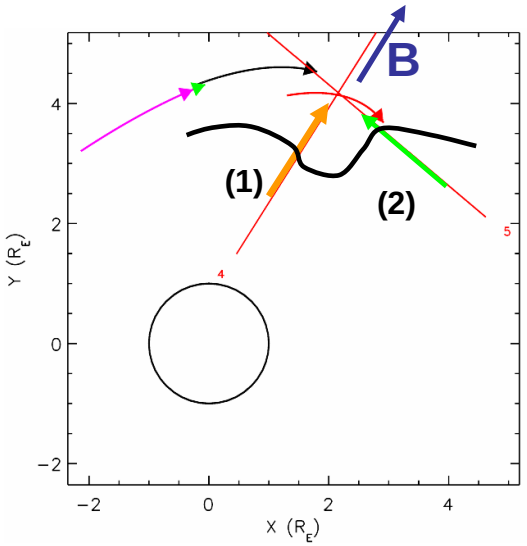


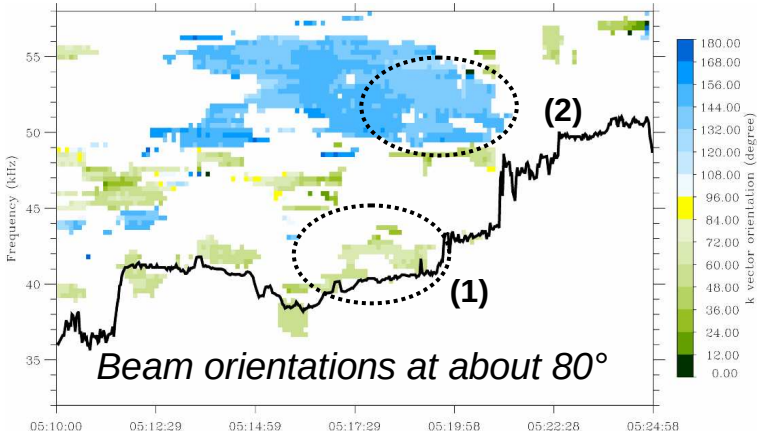


Study in the spin plane (parallel to XY GSE)

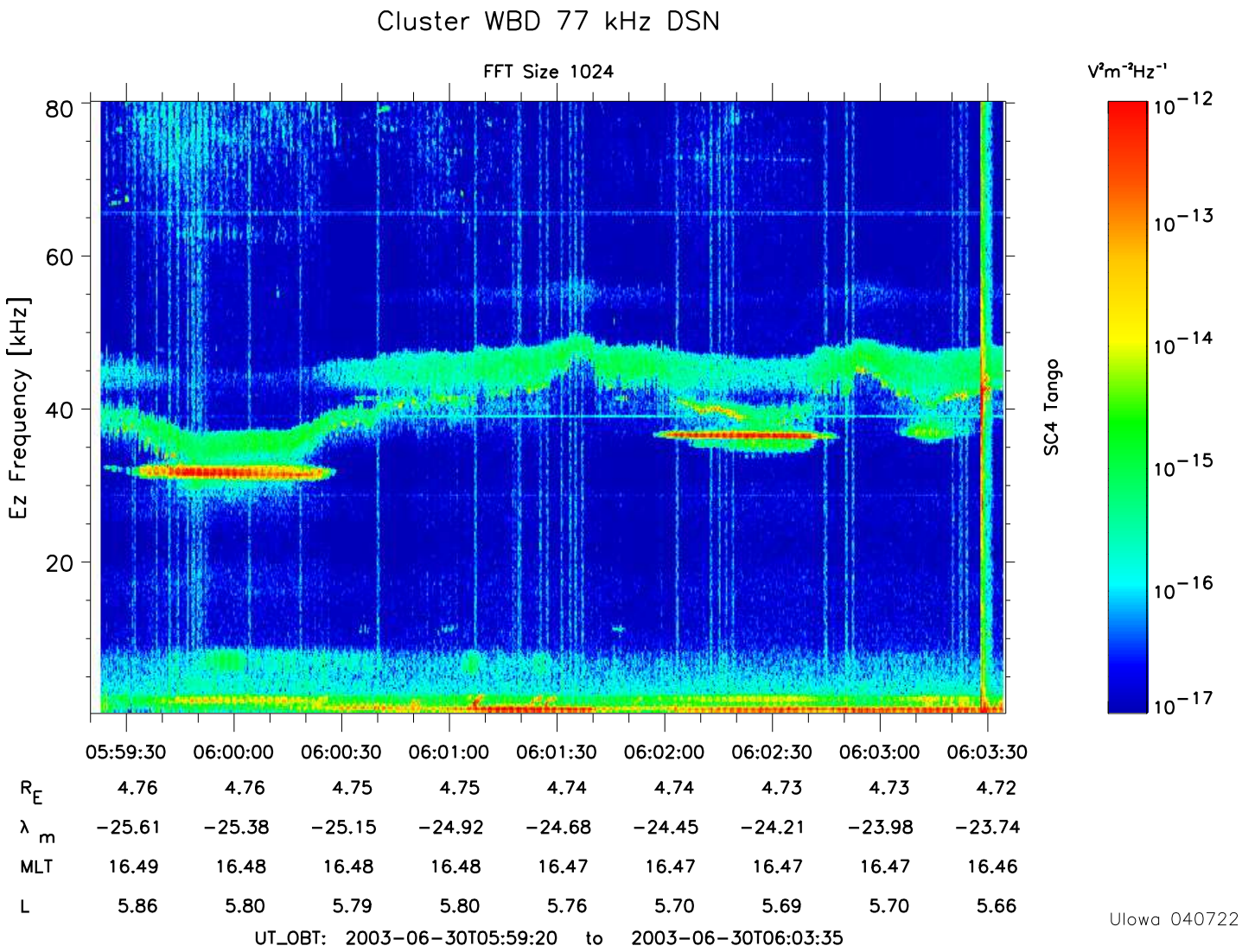


Ripples in the PPause boundary (rays aligned with density gradient) could explain different beam orientations

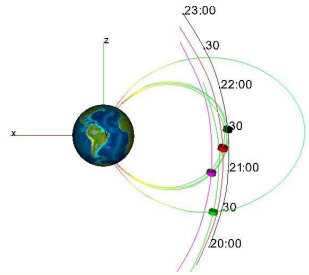




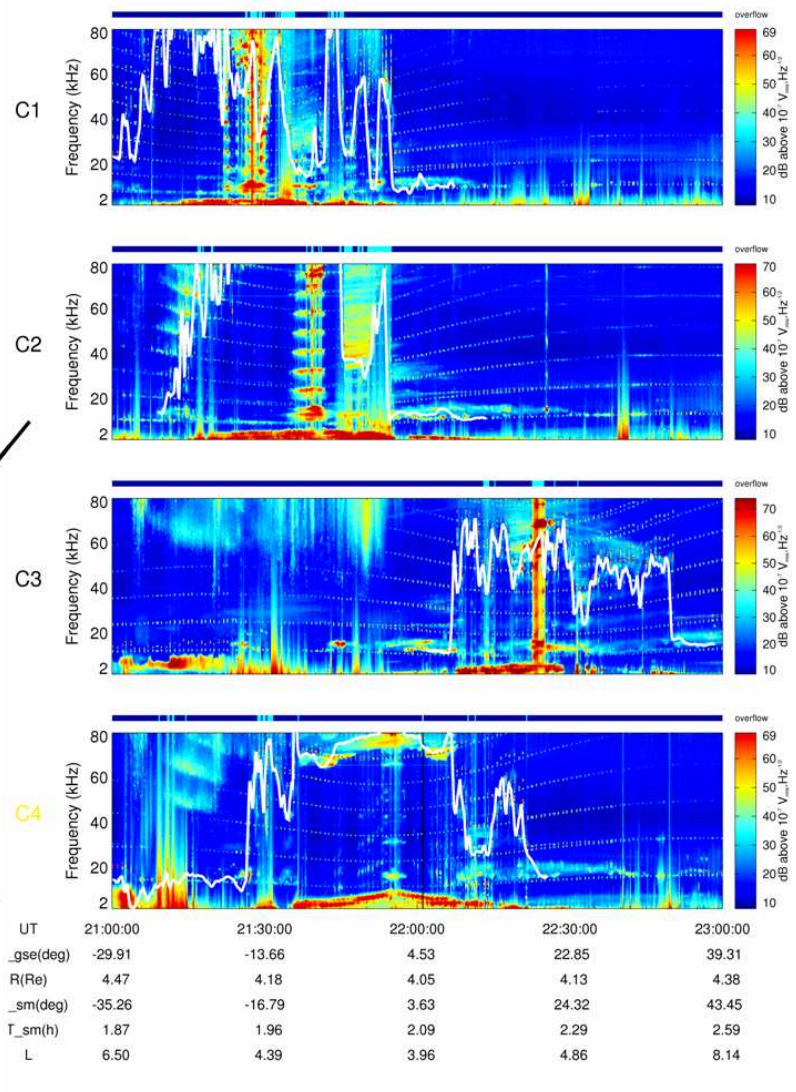
WBD instrument offers a good time/frequency resolution of 'micro' sources

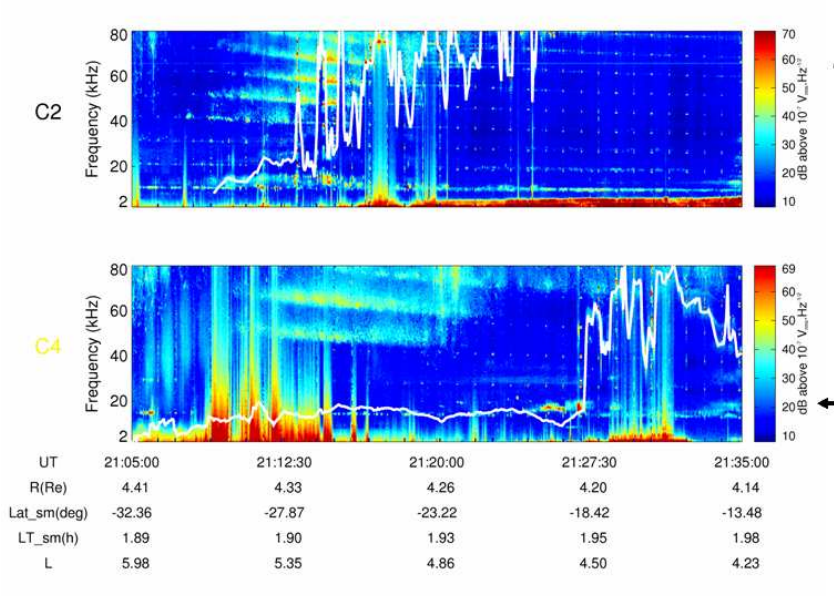


Other large scale findings



- Simultaneous observations of harmonic ‘large band’ NTC structures
- Different spectral characteristics when viewed from different SC
- Local sources (off equator) are illuminating short orbit elements





5. Summary and conclusion

- Various types of ES emissions observed in the Ppause boundary layer

  (a) Intense emissions in F_{pe} - F_q band

  (b) 'Micro' sources, in density holes, some at n F_{ce}

- Two main types of structured EM radiations observed in magnetosphere:

  (a) multiple narrow spectral lines, radiating over a long range, having undergone one reflection at Msheath in many cases

  (b) 'harmonic wide bands', structured according to local magnetic field conditions.

Both forms could result from many small size sources. Respective source spatial distribution might be different.

- Challenging question: how to conciliate numerous, micro sources, with well established beams of large aperture ?

Perspectives

Close analysis of ES sources (PEACE, WBD, WHISPER) plus simulation, toward a better understanding of source behavior (stability, power)