Whistler-mode chorus waves in the dayside outer magnetosphere: PENGUIn/AGO and THEMIS conjugate observations

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Introduction

We investigate **dayside chorus waves**:

- Whistler-mode chorus waves *on the dayside* (06h<MLT<18h)
- It has been reported that they frequently appear under weak geomagnetic conditions as well as active conditions.
- They have been observed *over a wider range of magnetic latitudes* (extending at least 25° off the magnetic equator)

Comparison with nightside chorus

- Night-side chorus is observed mostly under disturbed geomagnetic conditions and generated *around the magnetic equator.*

Effects on the outer radiation belt

- Whistler-mode chorus waves play an important role in *acceleration* of electrons up to relativistic energies and *loss* of relativistic electrons into the atmosphere.

Motivations

- What controls the generation of whistler-mode chorus waves on the dayside? Why are they often generated even during quiet times?
  - ***Distortion of the dayside magnetospheric configuration*** [e.g., Tsurutani et al., 2009; Spasojevic and Inan, 2010]
    - Drift shell splitting and bifurcation
    - Small dB/ds effects
  - ***Modulation by ULF waves*** [e.g., Li et al., 2011]
  - ***Scattering followed by precipitation*** *(leading to electron anisotropy)* [e.g., Tao et al., 2011]
  - ***Sudden magnetospheric compression*** *(leading to electron anisotropy)* [e.g., Gail et al., 1990]
- Where in MLAT and L are dayside chorus waves preferably generated? Why?

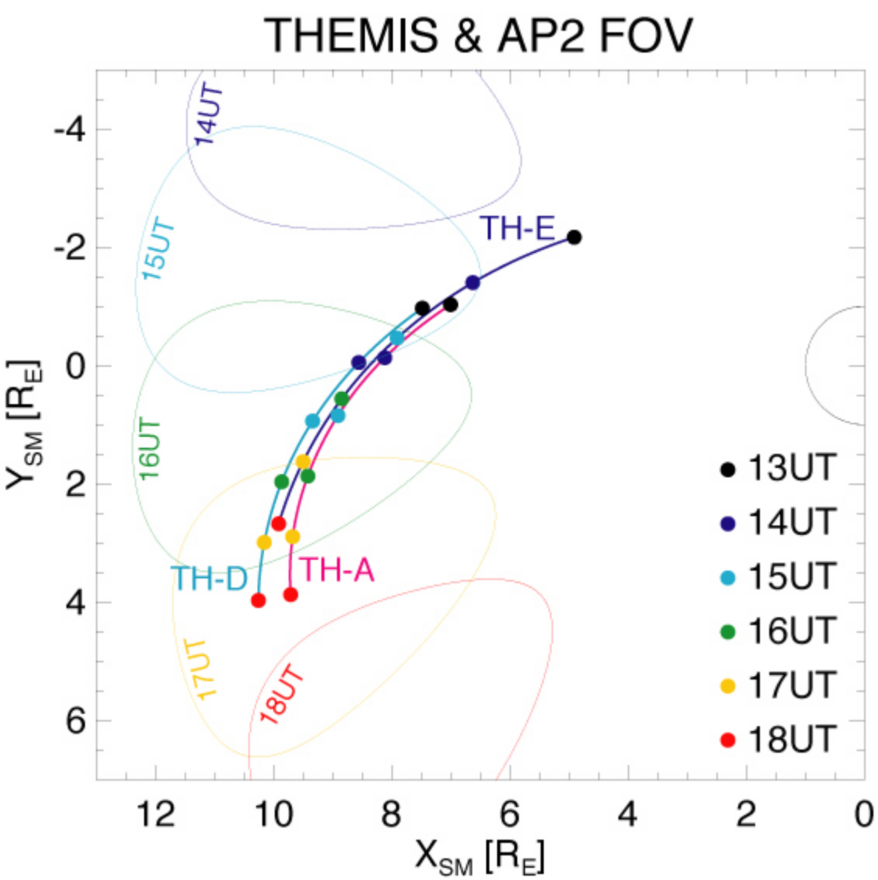
In this paper, we focus on quiet conditions.

- ✓ To understand why they are generated during quiet times as frequently as disturbed times.

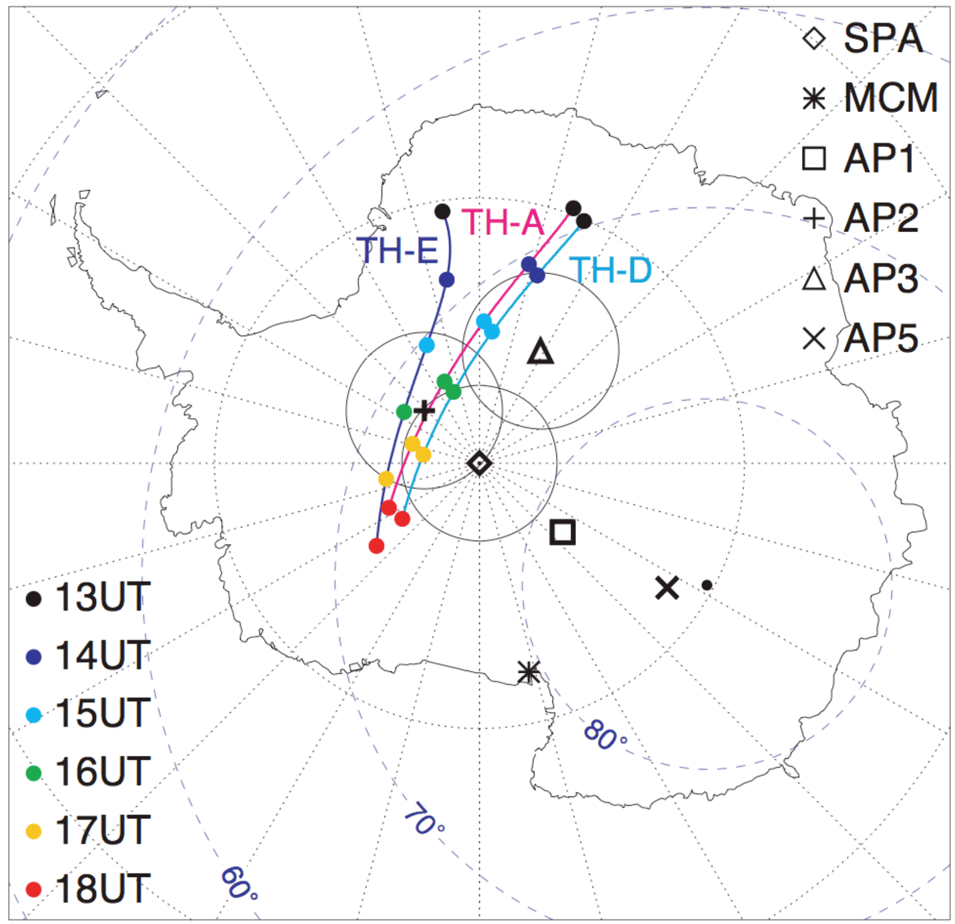
- ✓ **Dayside chorus waves can make an important contribution to generation and loss of outer radiation belt electrons under quiet conditions.**
  - During quiet times, chorus wave events occur on the dayside more frequently than on the night side.
  - The outer radiation belt is active even under quiet solar wind and/or geomagnetic conditions.

Case Study: 26 July 2008

- In-situ observations: THEMIS
  - Magnetic field (FGM), wave fields (SCM, EFW; providing >4 kHz sampling)
  - Electrons (ESA; providing <3s full distributions)
- Ground-based observations: PENGUIn/AGO in Antarctica
  - -69.8° to -86.7° CGM latitude at 100 km reference
  - ELF/VLF receivers

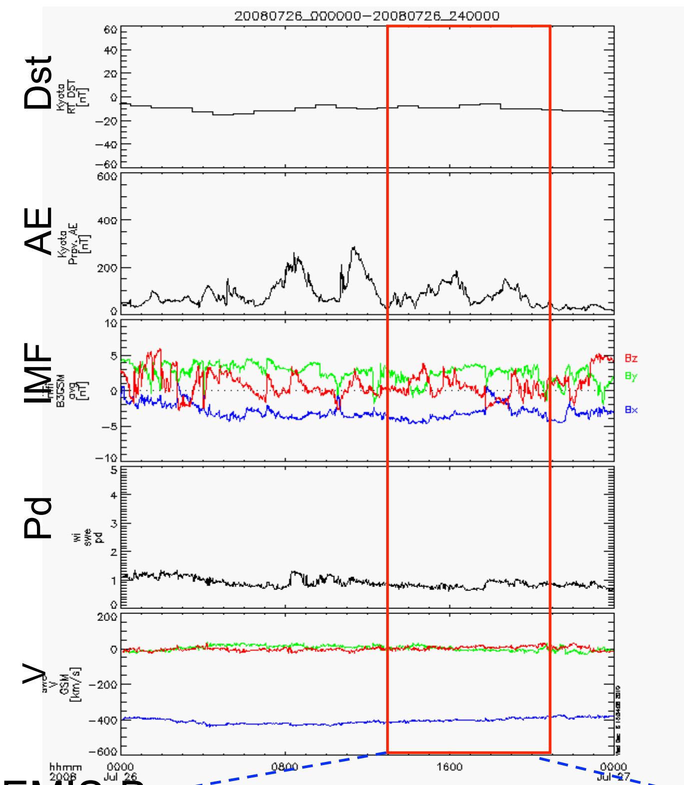


2008/07/26 1300UT - 1800UT

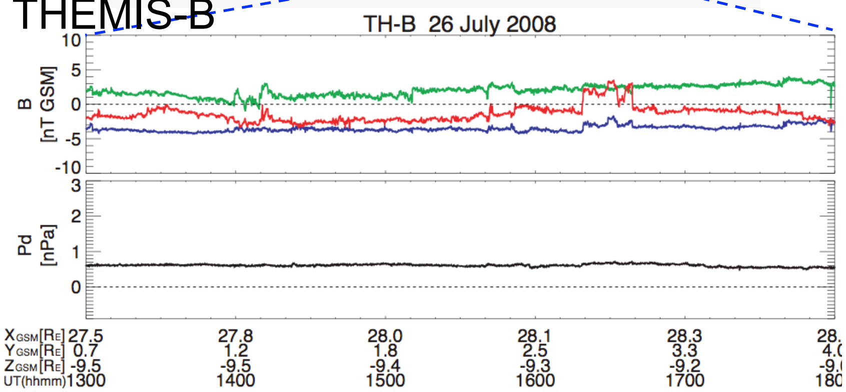


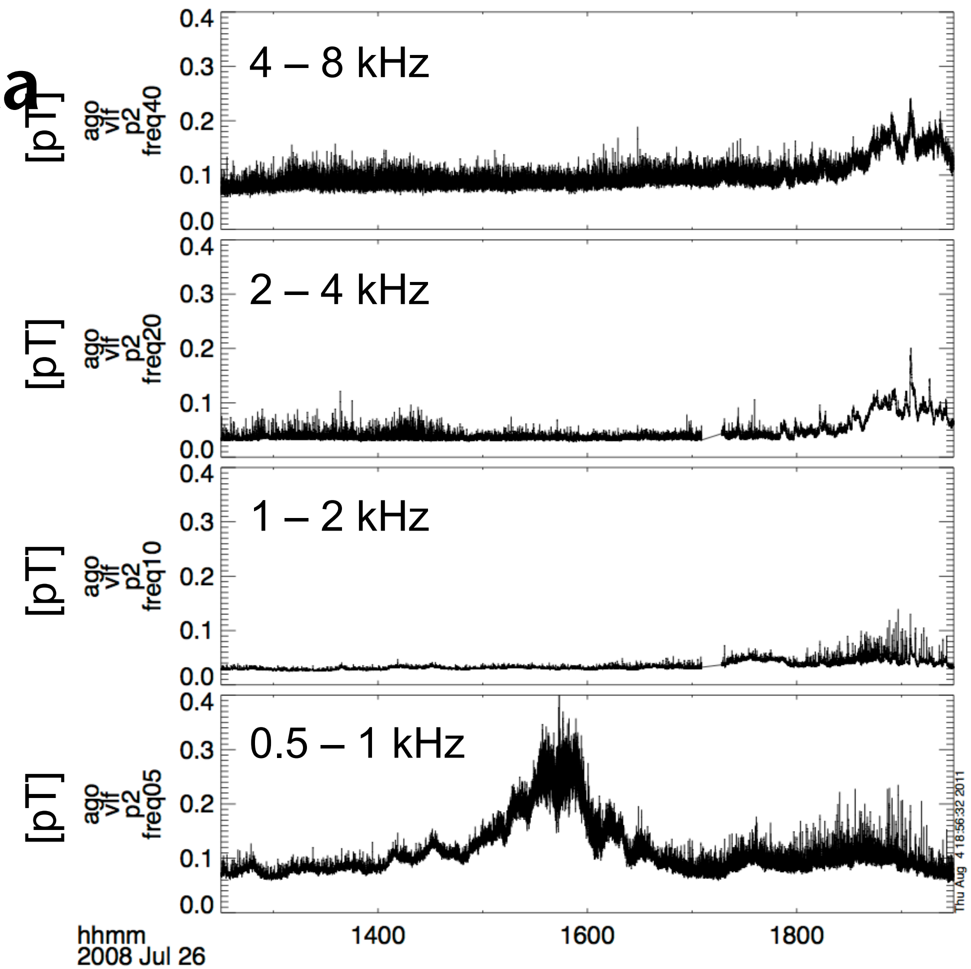
Solar wind & AGO VLF data

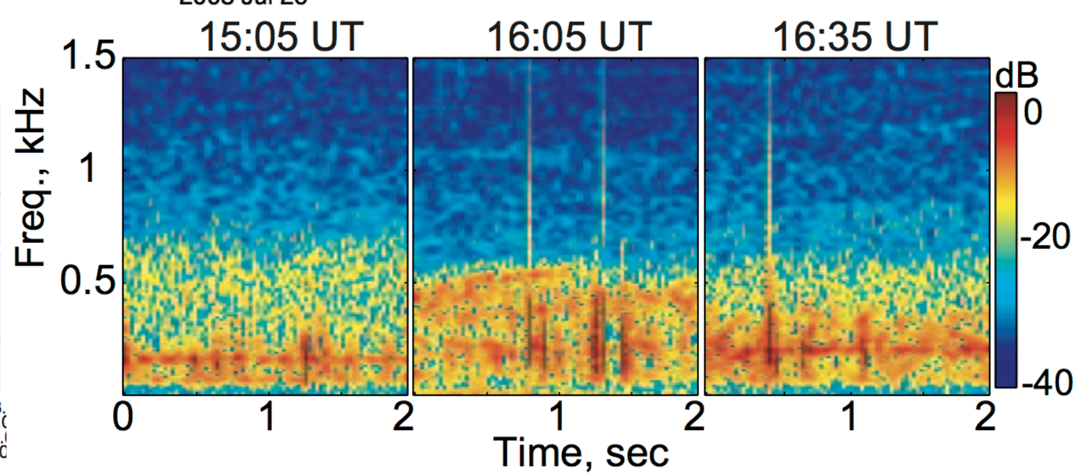
Dst, AE, and solar wind data (from Wind)



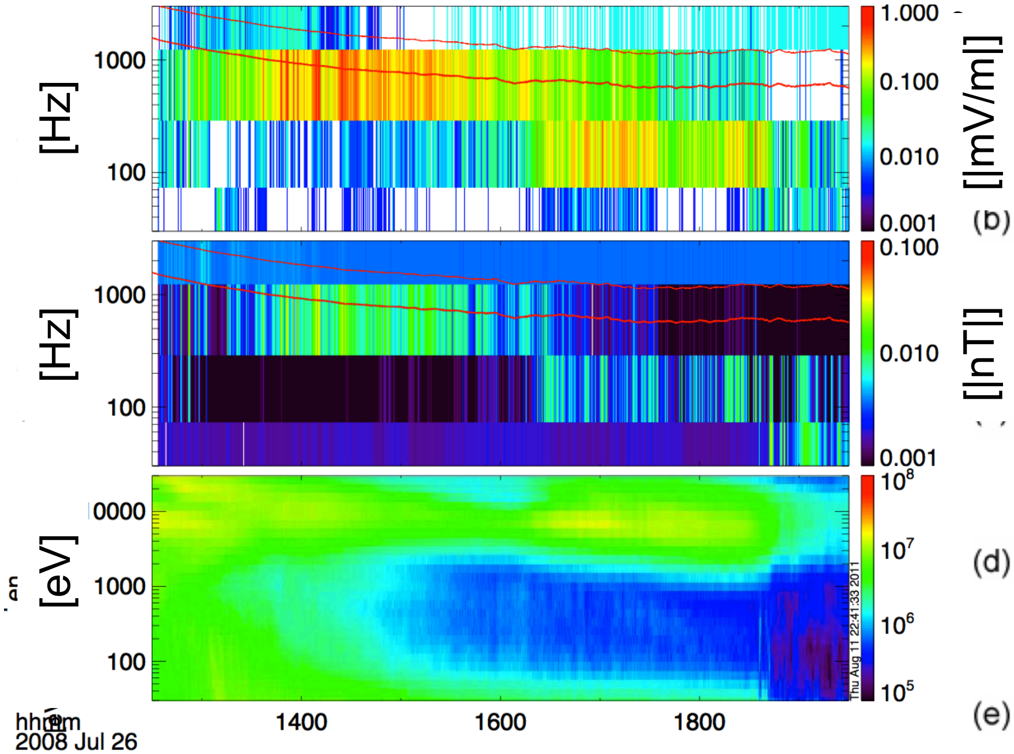
THEMIS-B

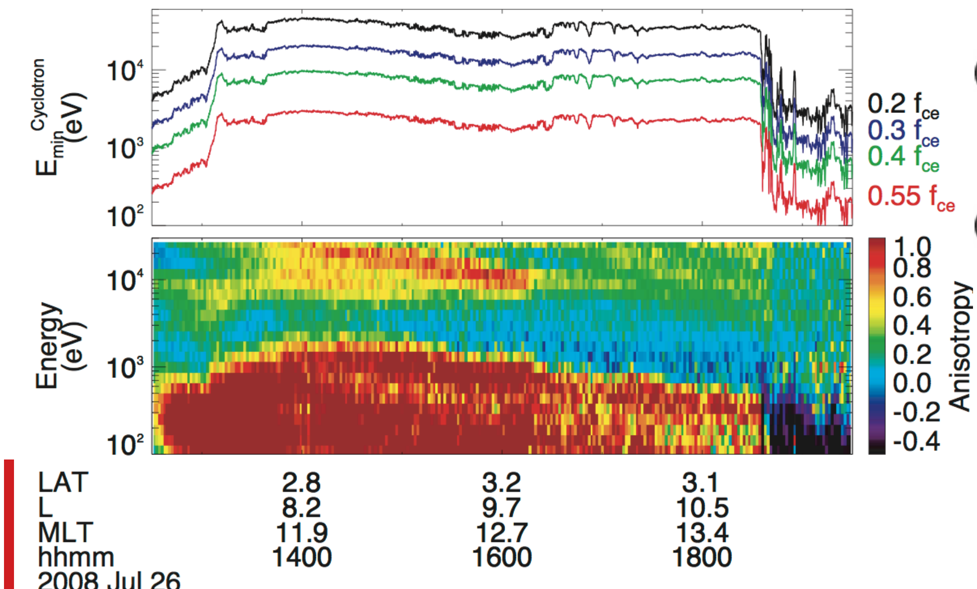


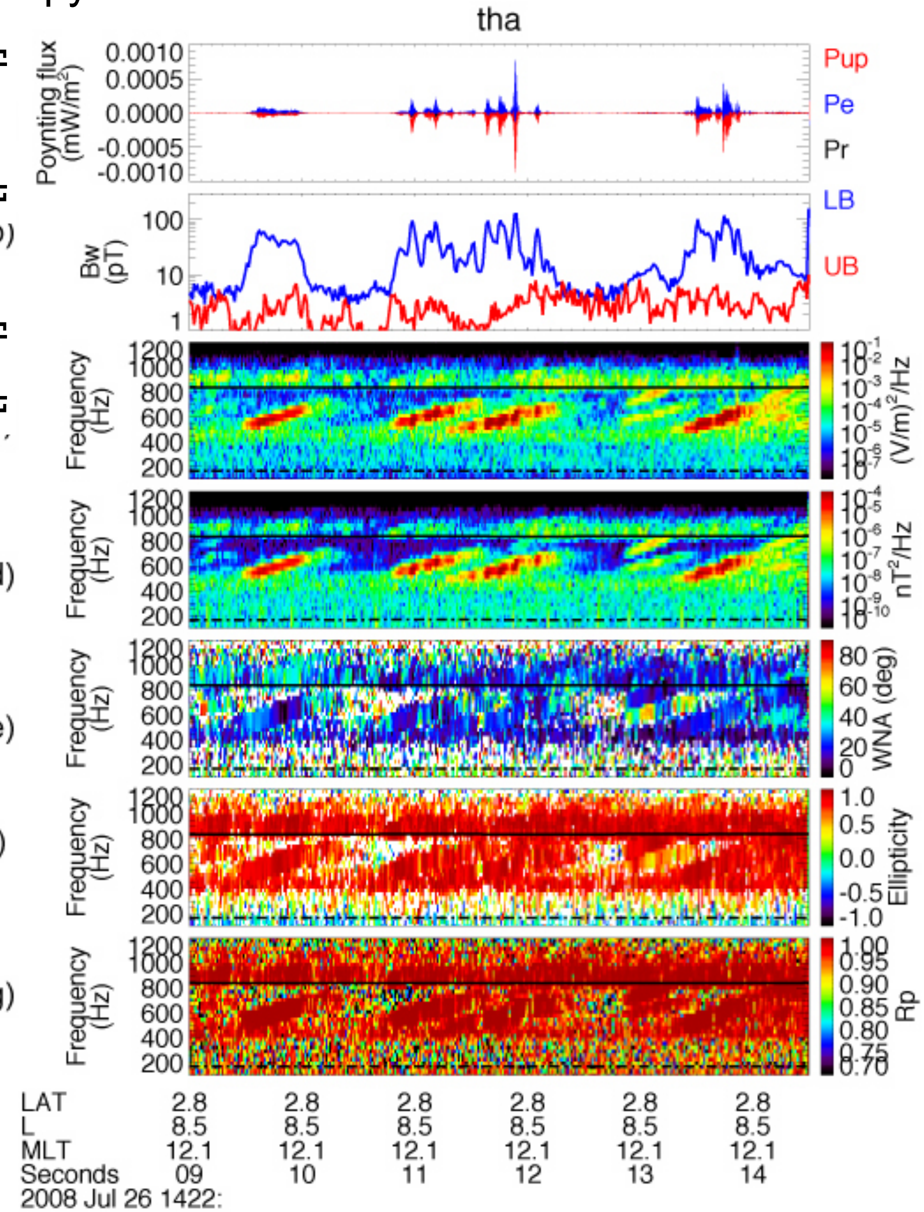




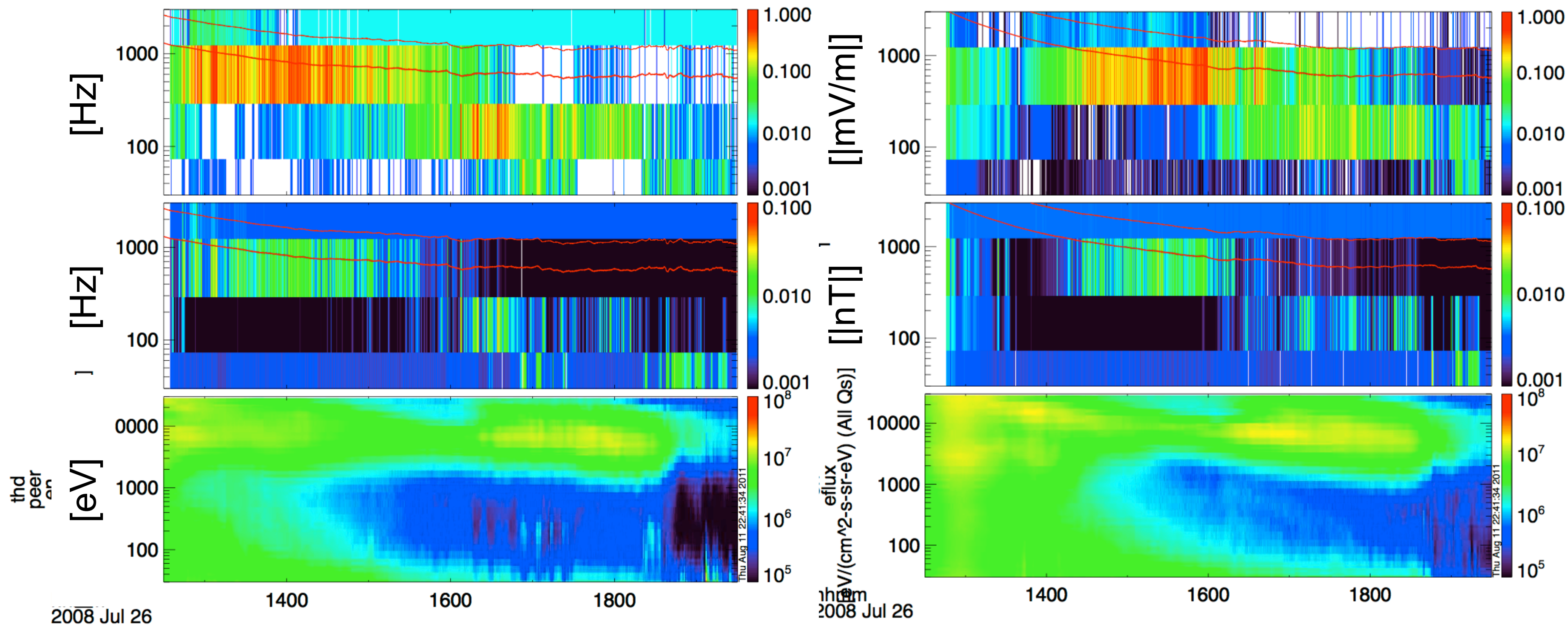
Filter bank data, e- flux, min resonant energy, anisotropy



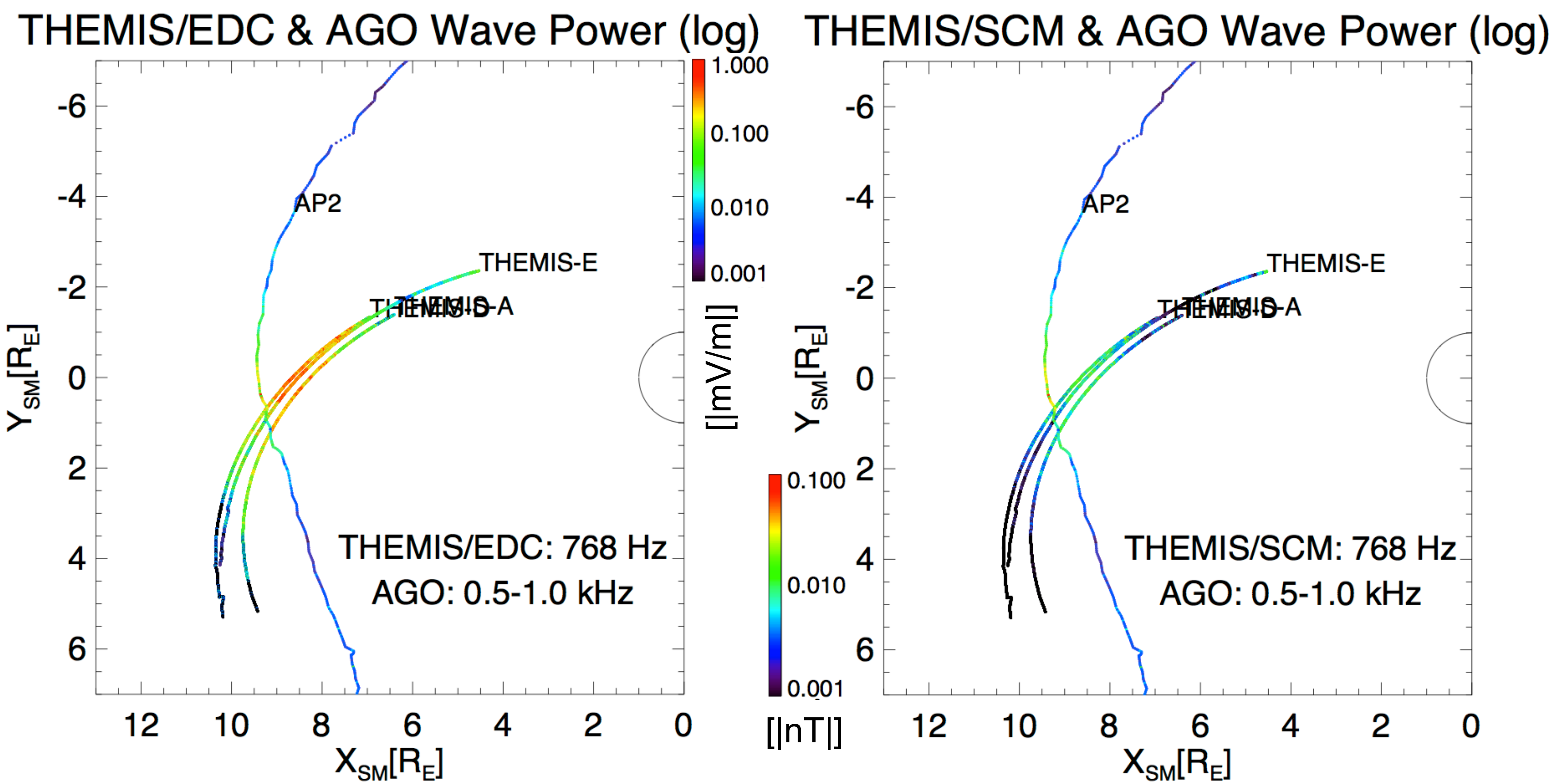




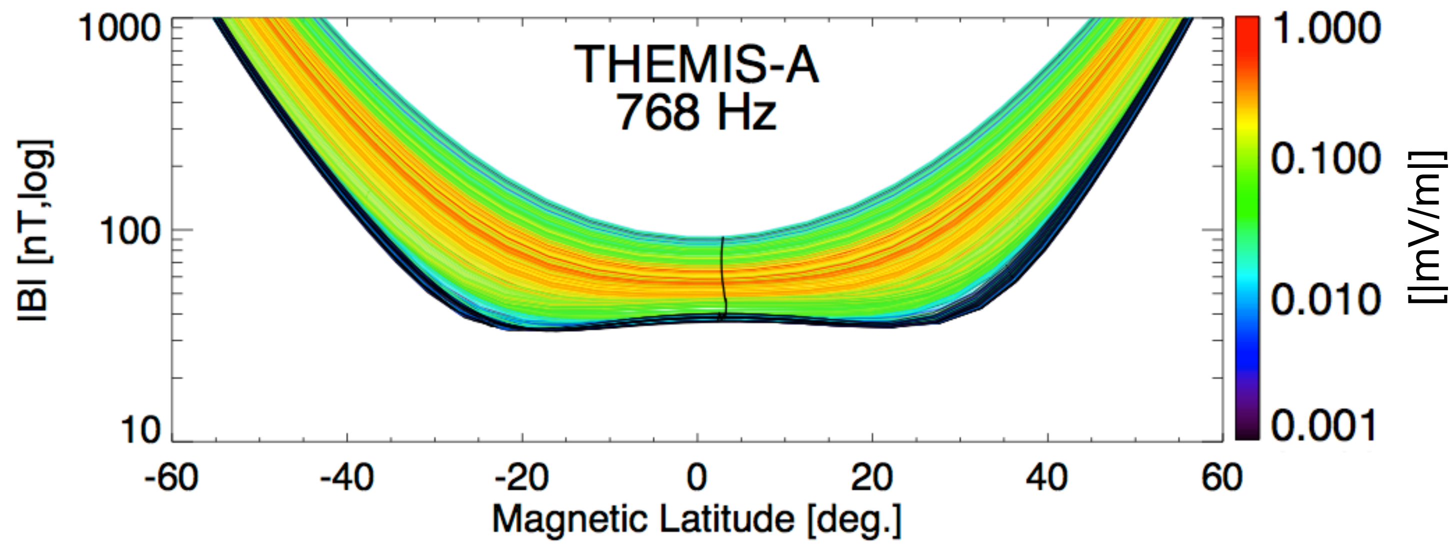
Filter bank data (EFI, SCM) and electron flux: THEMIS-D and THEMIS-E

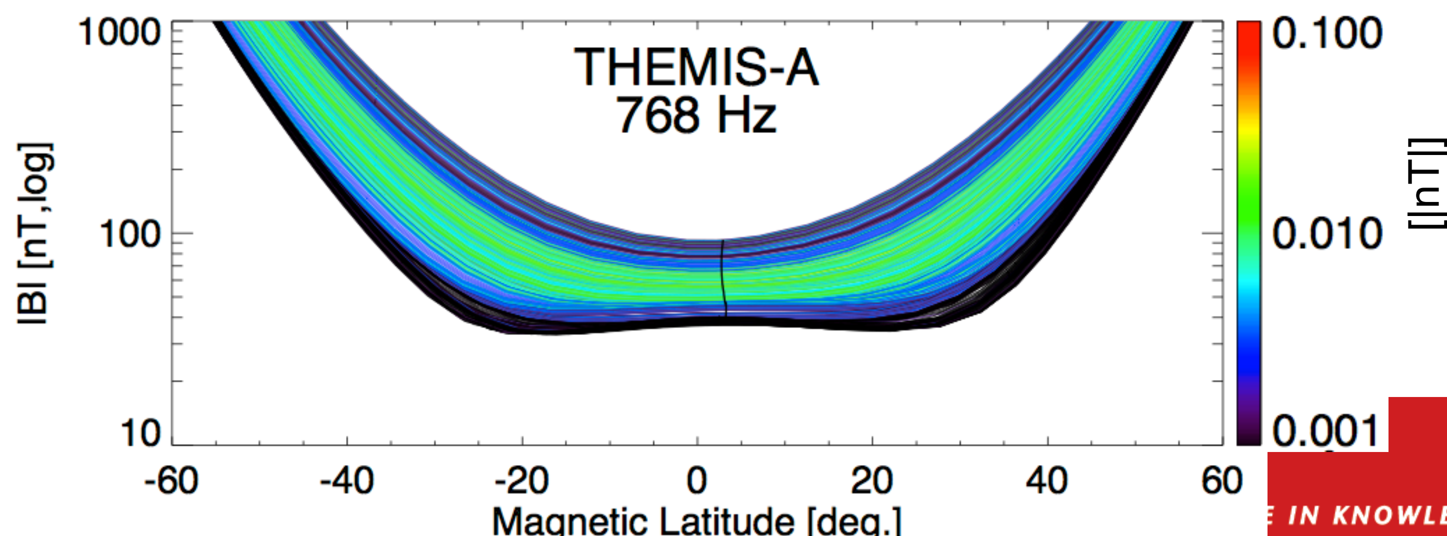


Spatial distributions of VLF wave intensification (mapped onto the magnetic equator using TS01)

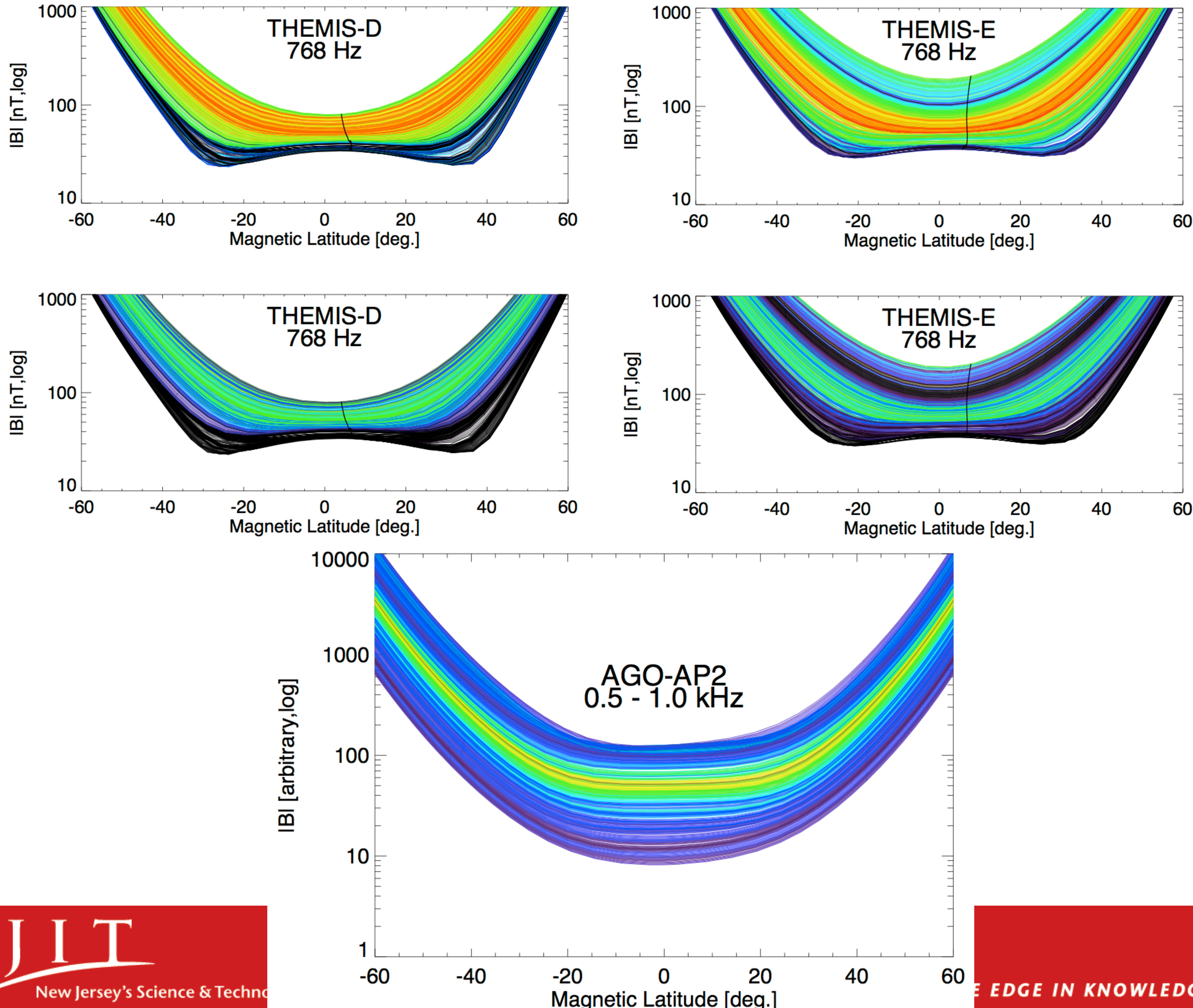


Magnetic field configuration (TS01)





NJIT New Jersey's ... IN KNOWLEDGE


THEMIS-D
768 Hz
IBI [nT,log]
Magnetic Latitude [deg.]
THEMIS-E
768 Hz
IBI [nT,log]
Magnetic Latitude [deg.]
THEMIS-D
768 Hz
IBI [nT,log]
Magnetic Latitude [deg.]
THEMIS-E
768 Hz
IBI [nT,log]
Magnetic Latitude [deg.]
AGO-AP2
0.5 - 1.0 kHz
IBI [arbitrary,log]
Magnetic Latitude [deg.]

Summary

On 26 July 2008, AGO in Antarctica and THEMIS were magnetically conjugated, when:

- Solar wind dynamic pressure was small and almost constant.
- VLF signals (0.5–1 kHz band) were enhanced at AGO AP2 and peaked around noon.
- Snapshots of power spectrograms indicate structureless chorus waves at ~0.5 kHz.
- THEMIS A, D, and E observed VLF wave intensification (0.3–1.2 kHz band) around noon in the outer magnetosphere.
- THEMIS A registered chorus waves with 0.5–0.7 kHz ~ 0.3–0.4 fce.
- Anisotropy is relatively higher above the estimated minimum resonant energy (~10 keV) than below it.

➢ Chorus waves were generated when field lines have small dB/ds with a wide range of magnetic latitude.

➢ Wave power was small when field lines have off-equatorial minimum B pockets.

Discussions

The conjugate observations showed:

- localized chorus intensification that persists for at least 1.5 hours under quiet conditions.

<u>What causes quiet-time localized chorus waves?</u>

✓ The distortion of the dayside magnetospheric configuration plays an important role. **Small dB/ds in a wide range of MLAT** (i.e., B uniform along B) seems responsible for the observed dayside chorus.

✓ A contribution from ULF waves is likely small.

<u>Possible mechanisms</u>

✓ Linear growth in a uniform (along B) field line. Resonant for a longer time?

✓ Non-linear growth due to long electron trapping?