S/WAVES Status Report

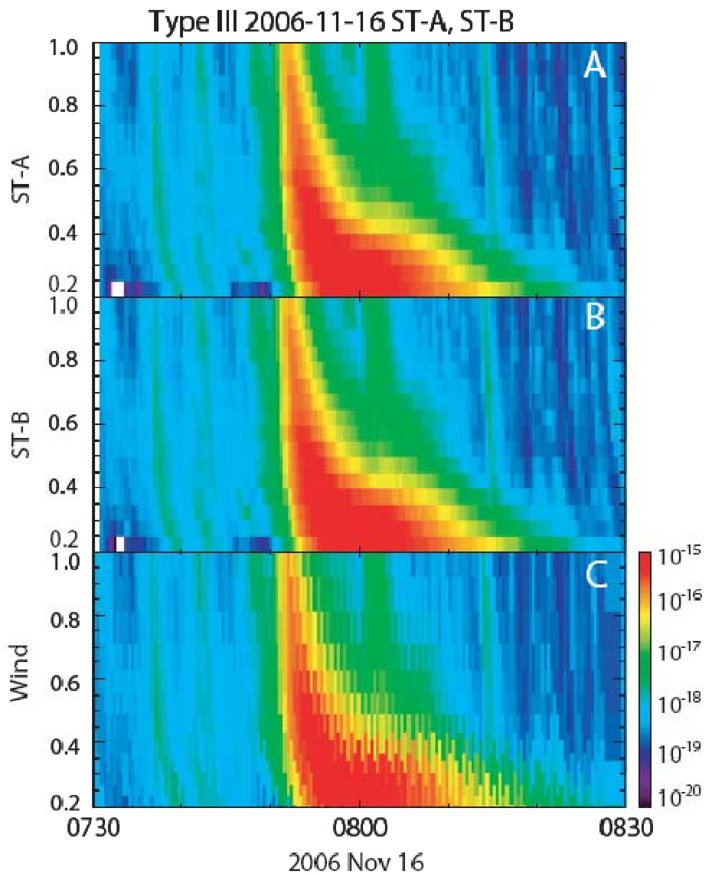
STEREO / WAVES

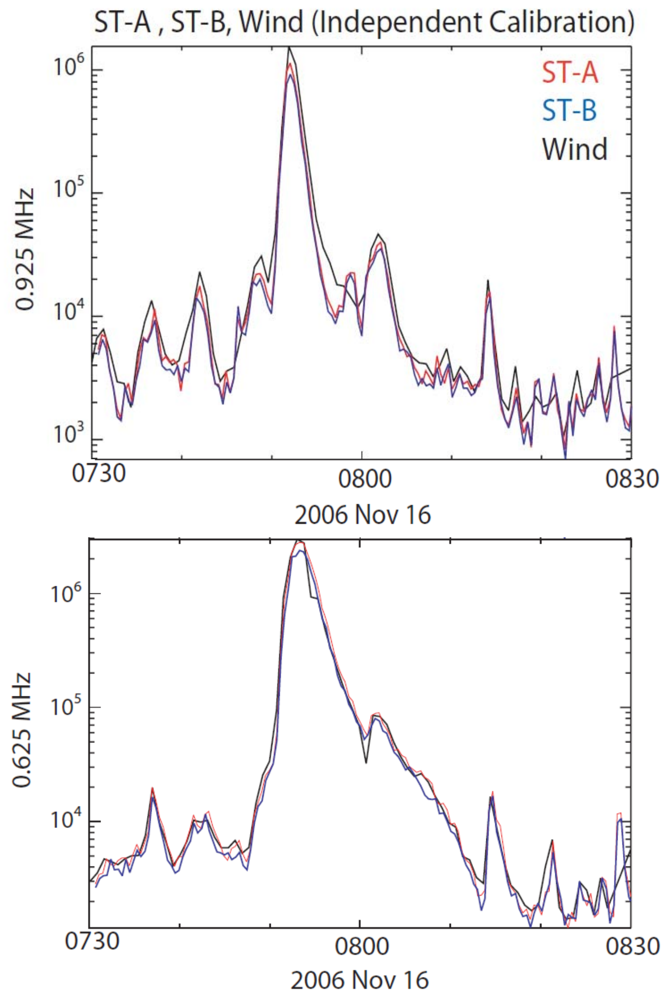
- S/WAVES instrument status
- Science status
  - Tracking of radio events
  - Radio beaming pattern
  - Magnetospheric physics
  - *In situ* micro-physics
  - Dust

S/WAVES instrument status

- Both instruments continue to function nominally
- We continue to see lots of “dust”
- B instrument: one inexplicable reset since launch
- A instrument:
  - ✧ Inexplicable resets:
    - 3 since launch (2.5 years)
    - 3 in the last two months
  - ✧ Increasing number of TDS errors
- New flight software is being prepared to provide increased diagnostic information

Calibration

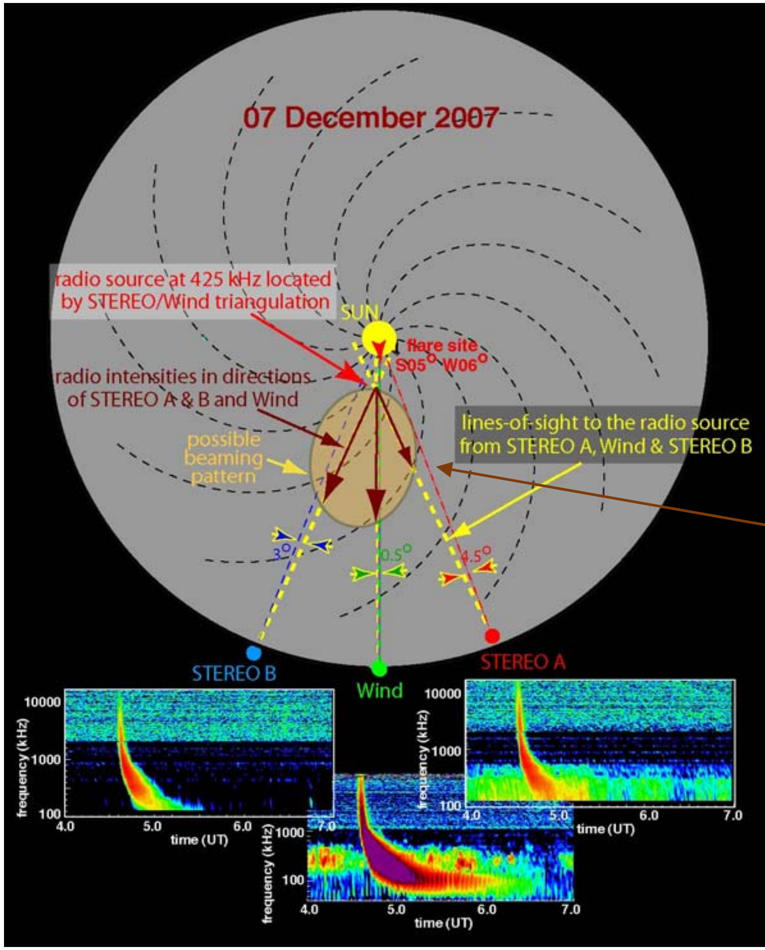




Eastwood et al., 2009

	Calibration with Galaxy Eastwood et al., 2009	Calibration with shot noise Zouganelis et al., 2009	Laboratory measurements Bale et al., 2007
Monopole (pF)	~60 to 80	~60 to 70	67
Dipole (pF)	~30 to 40	~30 to 35	~33

Type III radio source locations by STEREO/WIND triangulation



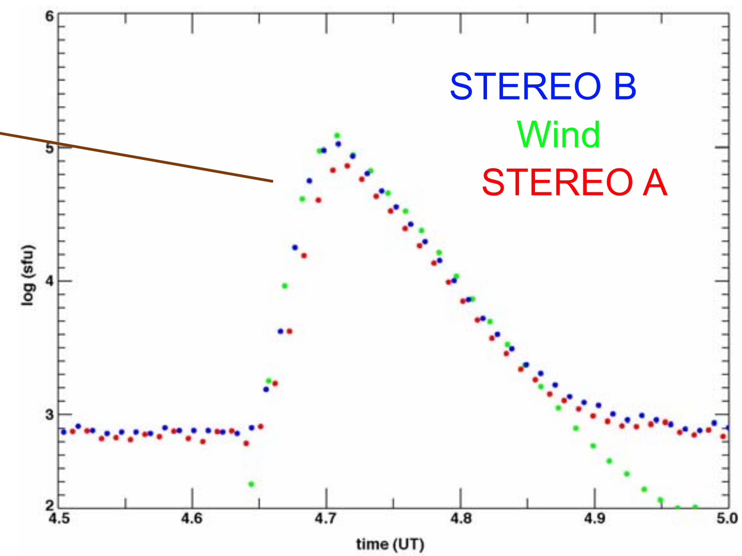
Dynamic spectra showing a type III radio burst simultaneously observed by STEREO A & B and by Wind on 7 Dec. 2007

Reiner et al., submitted to Solar Physics

Radiation beaming pattern for individual type III radio bursts

- need at least 3 independent measurements at different longitudes to quantify the type III beaming pattern--since the radiation beaming pattern is a curved surface

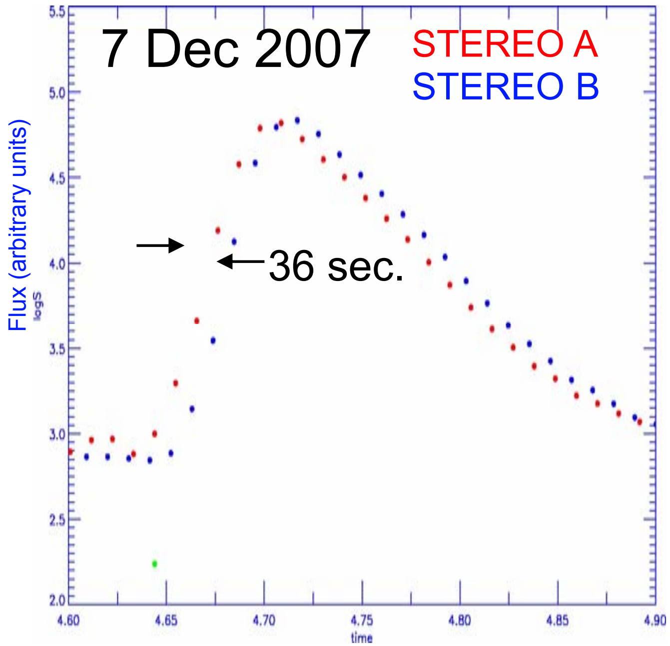
- wider the s/c angular separations sample more of the beaming pattern



Results obtained for this burst indicate a wide beaming pattern with maximum directed along the tangent to the Parker spiral at the source location

Reiner et al. --- Goddard

Radiation propagation times



The difference in the radiation arrival times at Stereo A and B is about 36 sec, which corresponds to a distance difference of ~0.07 AU.

- the measured distance difference between the source and STEREO A and B gives ~0.05 AU, which corresponds to 25 sec.

These differences may be due to propagation effects.

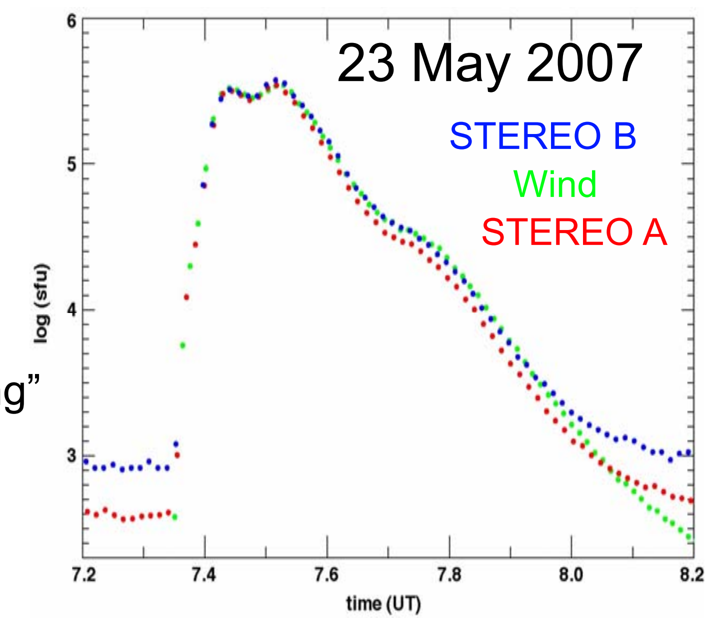
- there are some difficulties in measuring these time differences due to differences in the bursts profiles caused by directivity effects.
- measurements for more bursts and at different frequencies are in progress.

Directivity effects of burst profiles

For this burst the type III profile for STEREO B is essentially identical to Wind, but the STEREO A profile is clearly different. These profile differences already occurred for a STEREO separation of only 7 degrees.

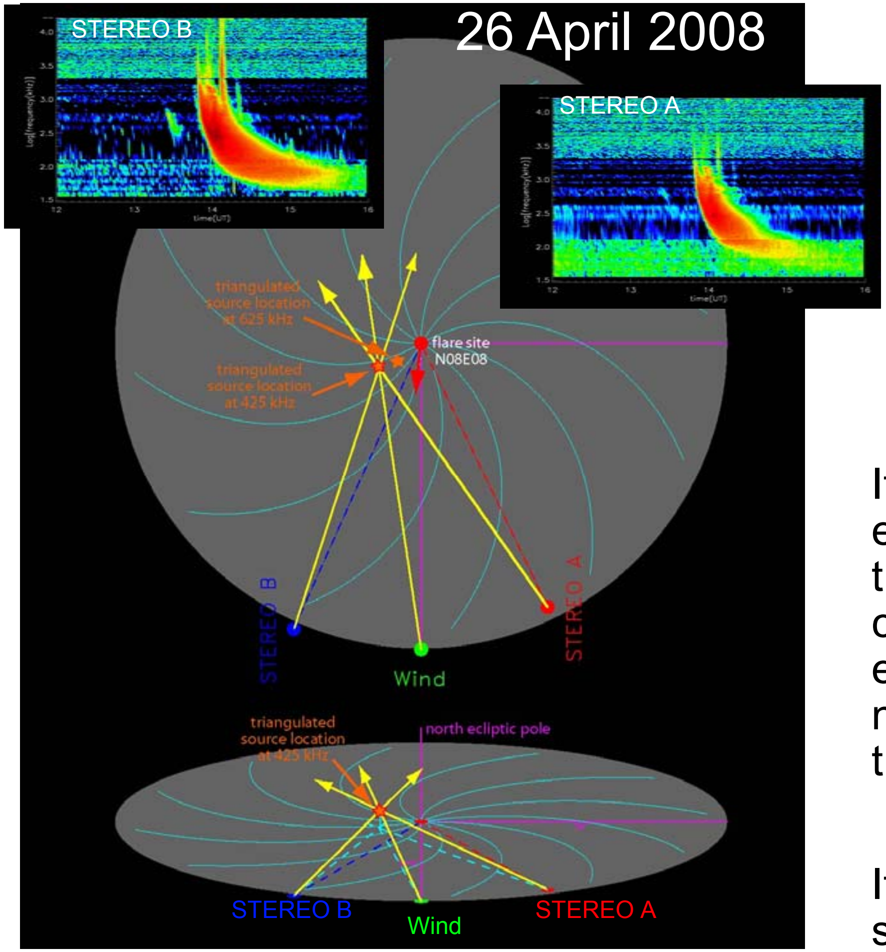
These differences are likely due to each spacecraft "seeing" slightly different aspects of large type III source regions

More bursts are being studied at different longitudinal separations and for different source locations



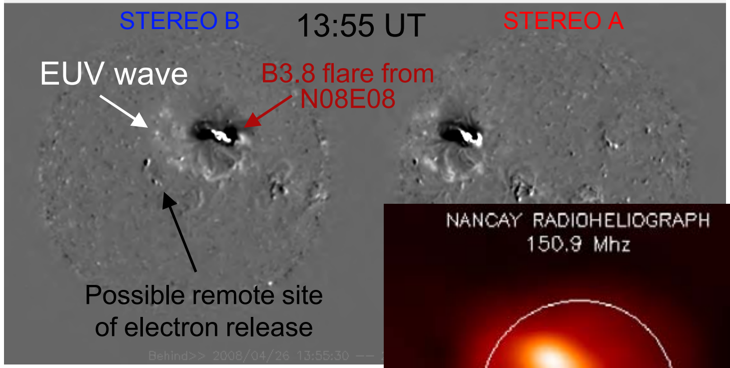
Relationship of the origin of type III bursts to solar features

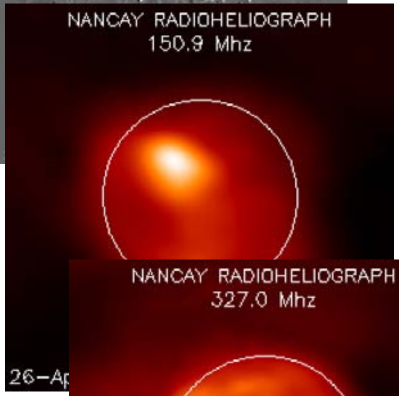
Reiner et al. --- Goddard

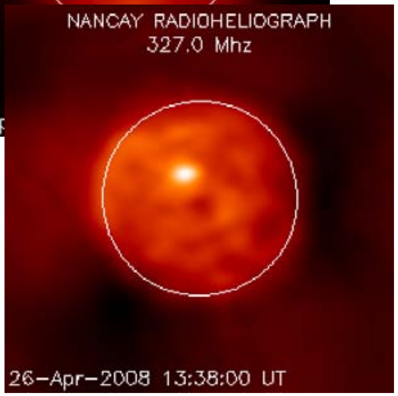


For this type III burst, the triangulated radio source locations clearly indicate a solar origin of the electron beam along a Parker spiral from about E40º, while the flare occurred in the active region at about E08º. The radio source is also located well north of the ecliptic plane.

Work in progress - Possible interpretations







It is possible that the burst electrons were released at the flare site but were channeled along a flux tube extending eastward and northward, as suggested by the Nançay RadioHeliograph

It is also possible that the EUV surface wave triggered the release of electrons at a remote site

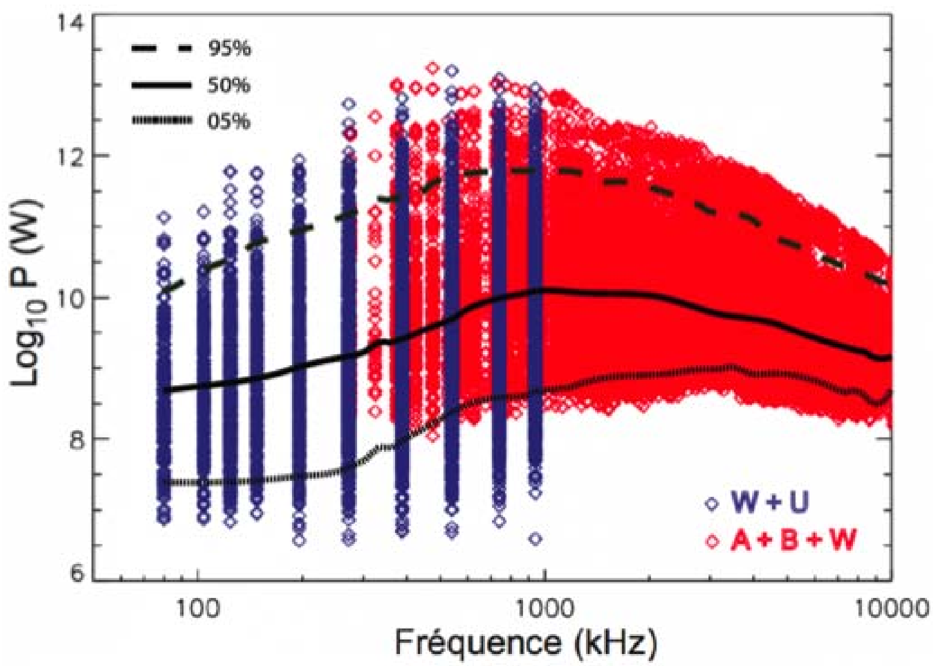
Since we don't have a height-time plot for STEREO A, we can't yet estimate the height of the corresponding CME at the onset time of the type III burst

Radio flux deconvoluted from beam pattern

STEREO → higher frequencies, closer to Sun

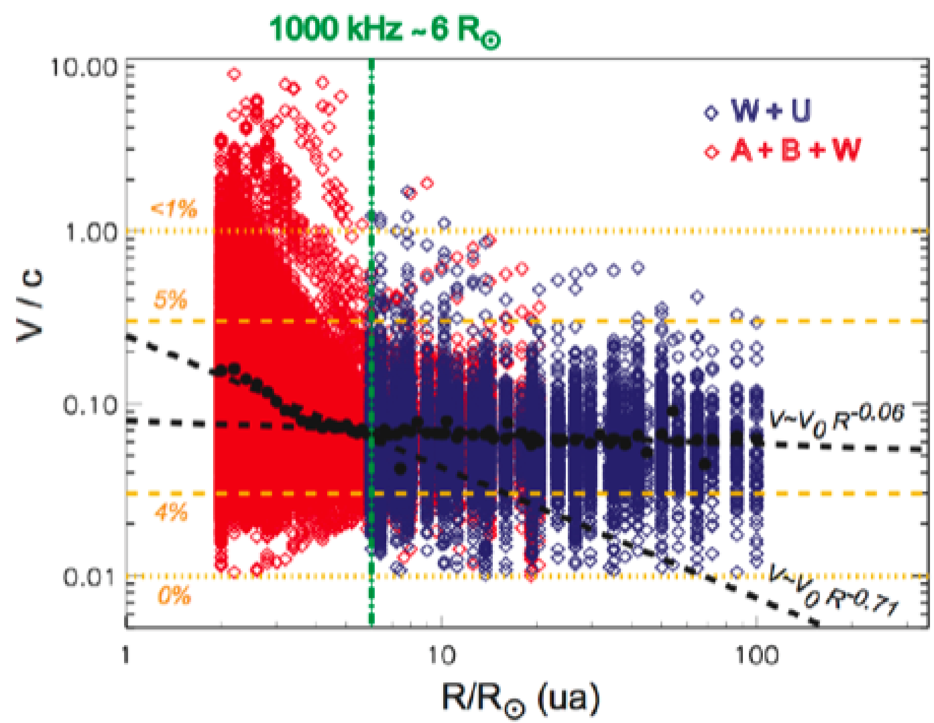
Radio spectrum

Total radiated power



Velocity of e⁻ beams

Deceleration



Blue: ULYSSES-WIND

Red: STEREO-WIND

Bonnin et al., 2009

Daily variations of Auroral Kilometric Radiation observed by STEREO/WAVES

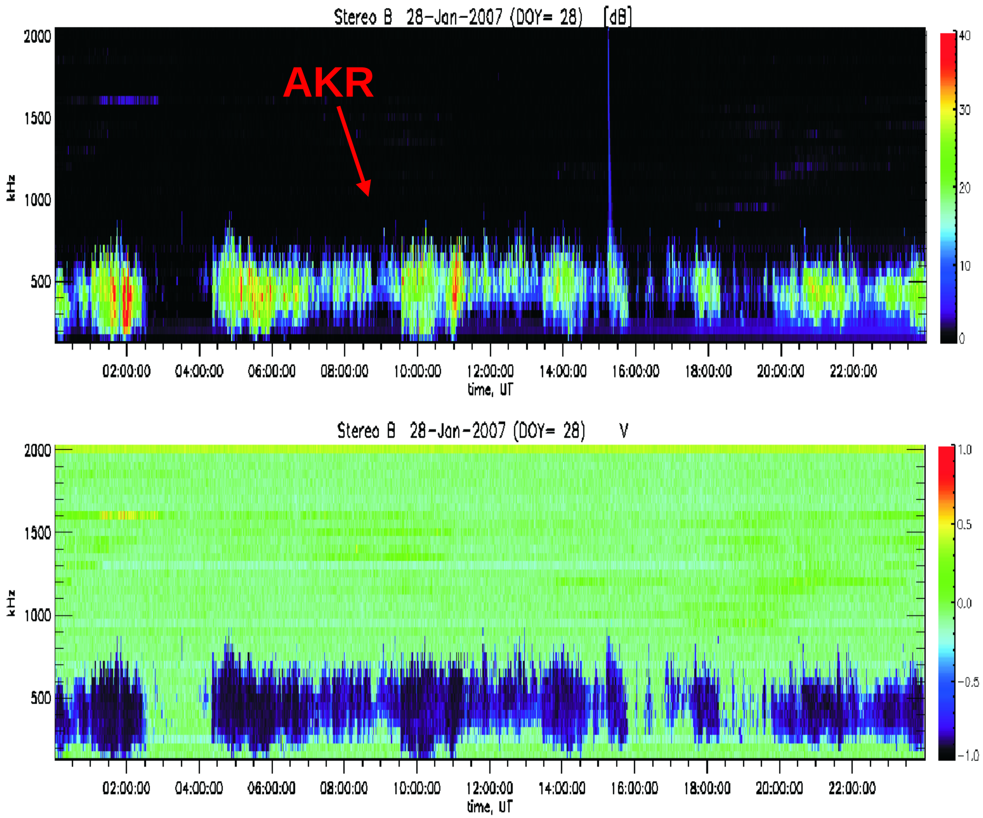


Fig. 1. AKR emission (top panel) and parameter of circular polarization (bottom panel, blue indicates RH polarization) observed by STEREO-B.

- Auroral Kilometric Radiation (AKR) is a strongly variable emission generated in the Earth's magnetosphere;
- frequency range 20 kHz -1000kHz
- generation mechanism - Cyclotron Maser Instability;

- The analyzed data record covers a period between January 23, 2007 and May 1, 2007 when STEREO-B provided the best quality quasi-continuous observations of AKR.

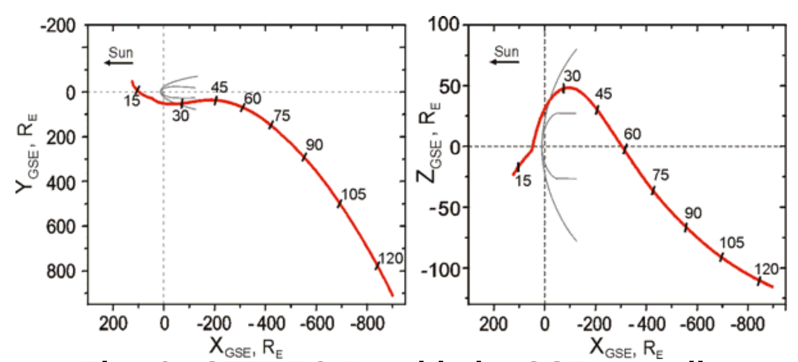


Fig. 2. STEREO-B orbit in GSE coordinates. Ticks indicate the day of year, 2007.

Panchenko et al., submitted to GRL

Auroral Kilometric Radiation: Results

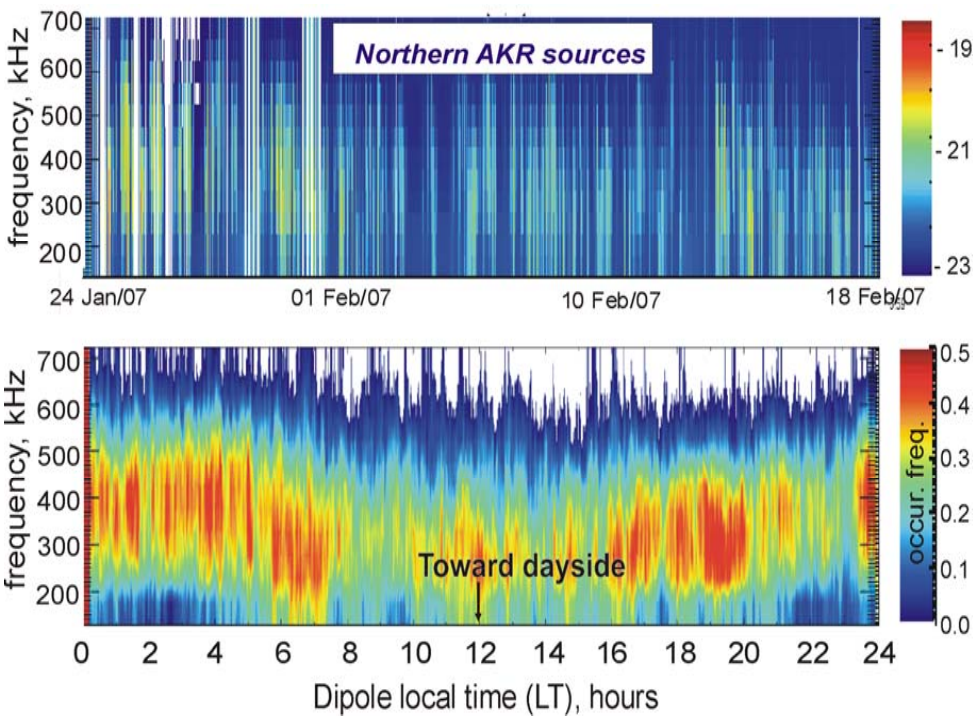


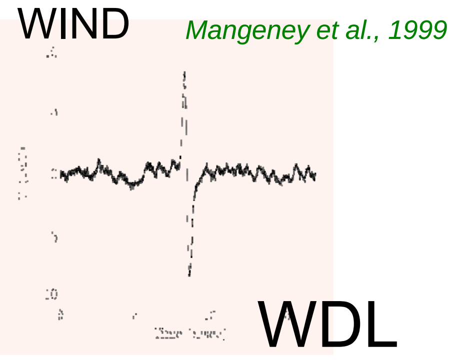
Fig. 3. AKR emission (top panel) and normalized occurrence frequency of the AKR emitted from the Northern hemispheres as functions of local time of the axis of the magnetic dipole (bottom panel) .

Paper Panchenko et al. "Daily variations of Auroral Kilometric Radiation observed by STEREO" has been submitted to GRL

Panchenko et al., submitted to GRL

- Daily variations of AKR are considered.
- It has been found that:
  - the intensities of the AKR are modulated with a period of ~24 hours.
  - the occurrence frequency of the AKR is strongly dependent on the orientation of the rotating oblique magnetic dipole of the Earth relative to the Sun.
  - AKR occurs more often and emits in a broader frequency range when the axis of the terrestrial magnetic dipole in the given hemisphere is oriented toward the nightside.
- We suggest that this effect is connected with diurnal changes of the ambient plasma density in the auroral region, caused by the varying solar illumination of the auroral ionosphere.
- The detected daily variations of the AKR occurrence frequency and the emission frequency range look very similar to those observed on the annual (seasonal variations) and solar activity cycle time scales.

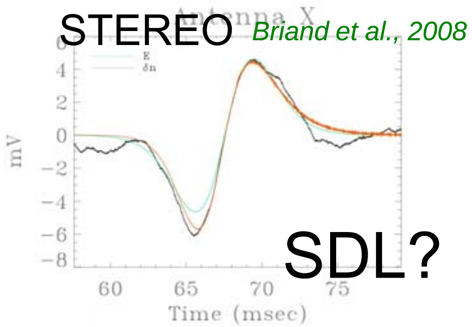
In situ micro-physics: TDS studies



- **Waveform snapshots: WIND/WAVES: 15 ms**

  S/WAVES: 130 ms

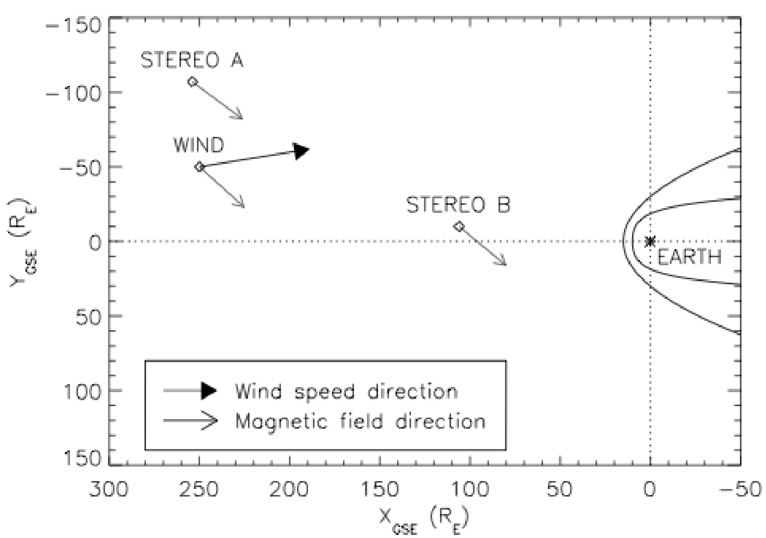
- **Several studies** *(Minnesota, Berkeley, Boulder, Meudon, Sydney)***:**
  - **Wave coupling**
  - **SGT**
  - **Solitary waves**
  - **Eigenmodes**



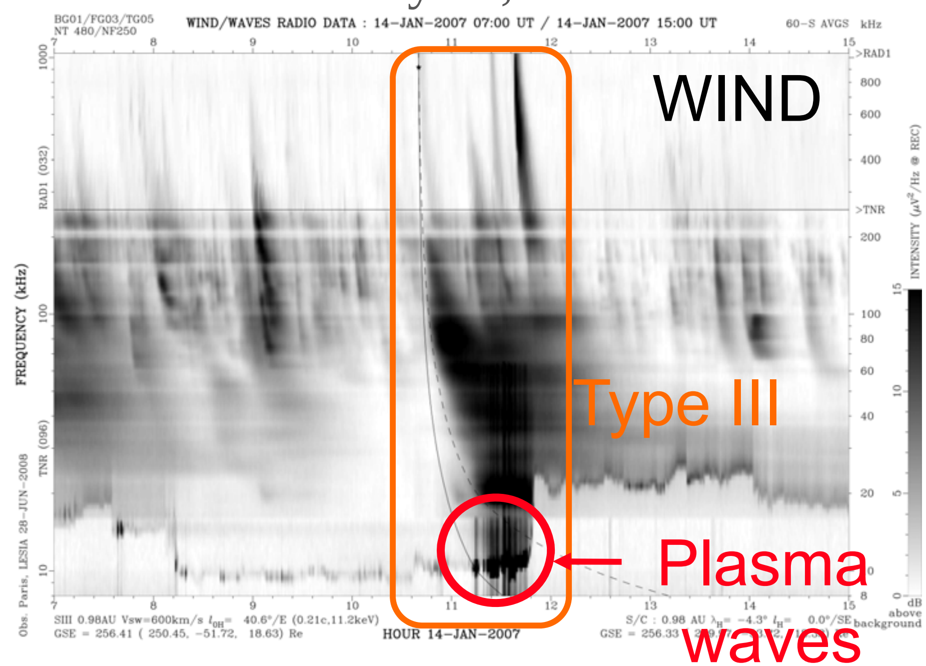
- **Direct access to basic plasma radiation mechanisms and fundamental plasma physics processes**

SWAVES/TDS electric waveforms associated to a type III

Simultaneous observation of Type III radio emissions and In situ Langmuir waves (WIND + STEREO)



January 14, 2007



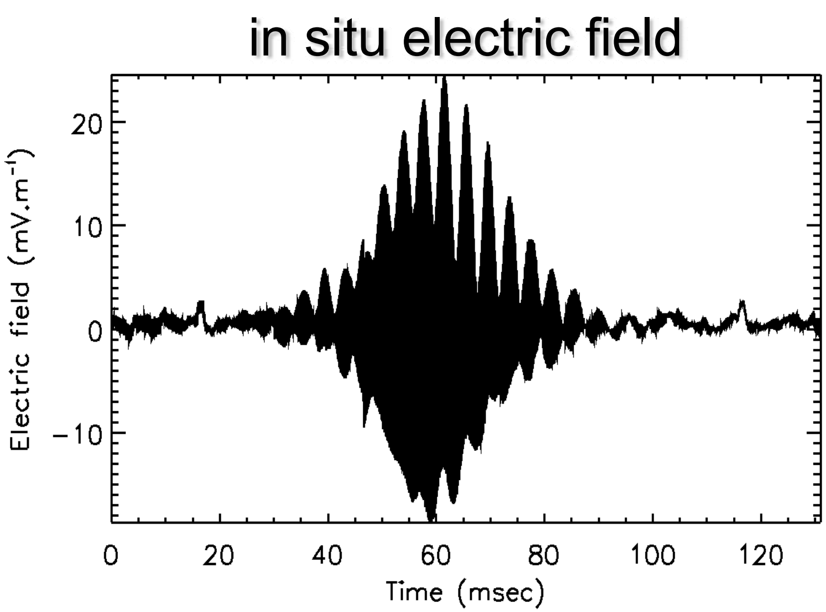
Two approaches:

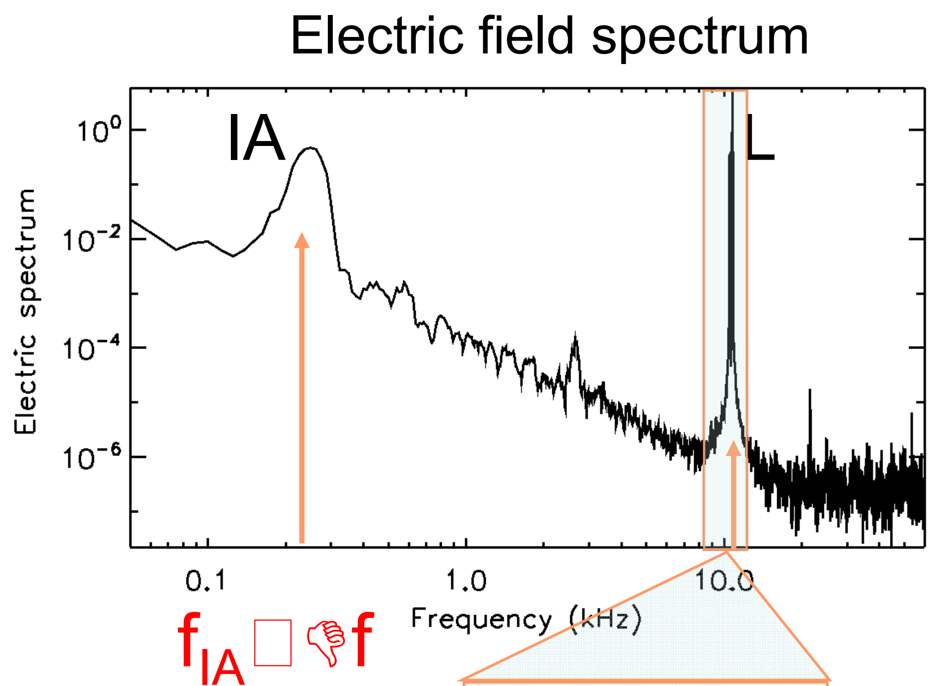
Wave coupling signature

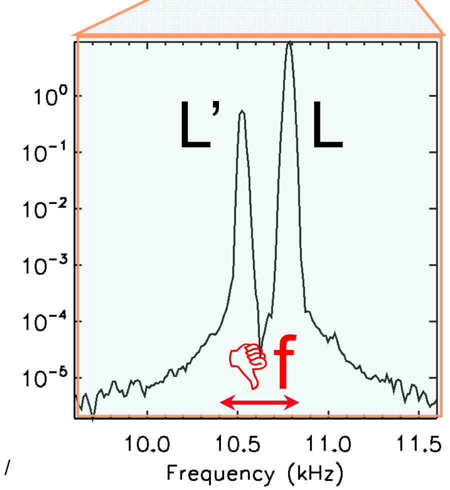
Eigenmodes of density cavities

Several TDS events

SWAVES/TDS electric waveforms associated to a type III





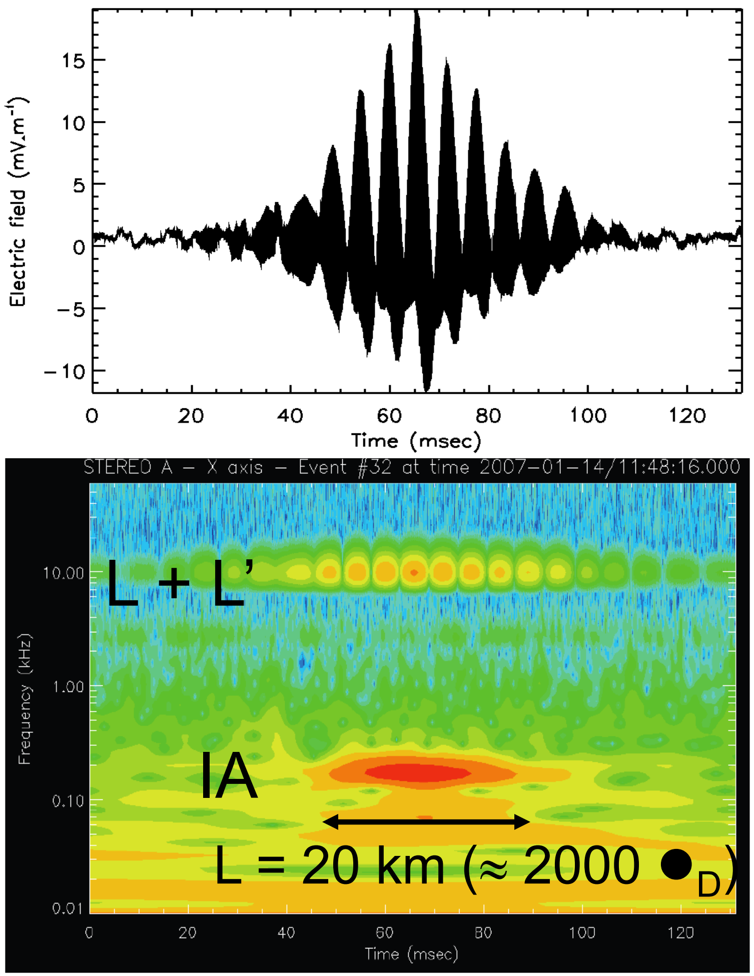


Wave coupling signature
L -> L' + IA

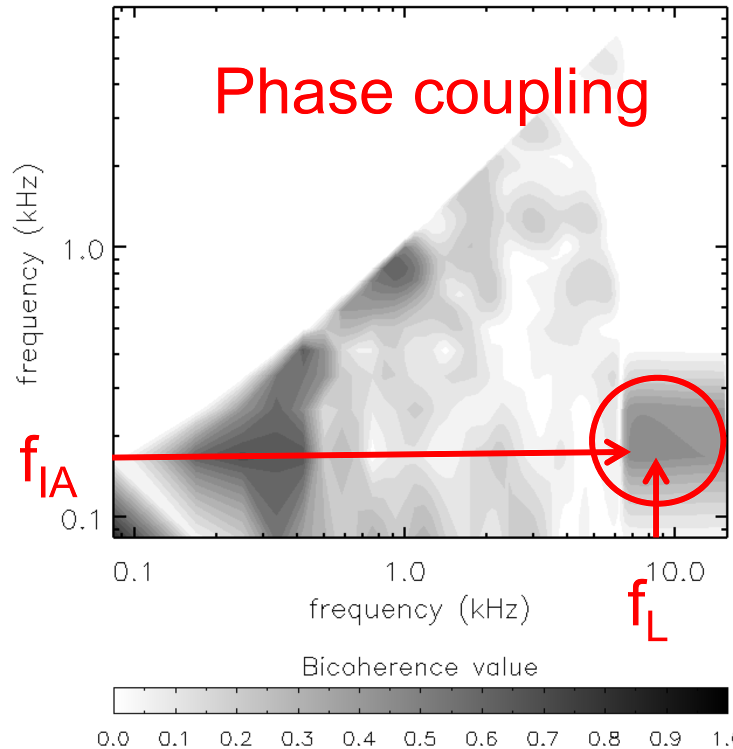
Henri et al., JGR (in press)

SWAVES/TDS electric waveforms associated to a type III

Wavelet analysis



Bicoherence analysis



Henri et al., JGR (in press)

Langmuir waves as eigenmodes of density cavities

- Langmuir waves may be interpreted as Eigenmodes of pre-existing solar wind density cavities

- Zakharov equation (E field response to density variation) (Zakharov, 1972)

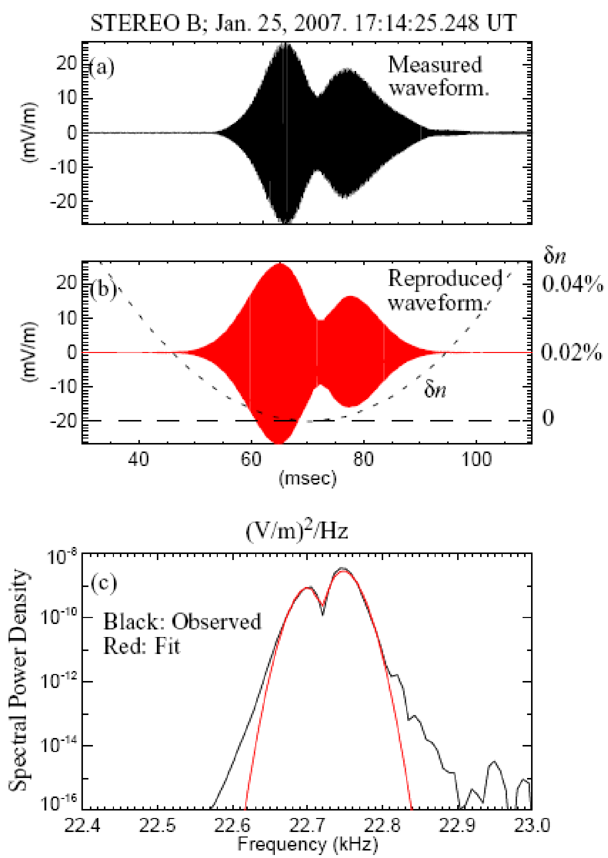
- Assume parabolic density wells

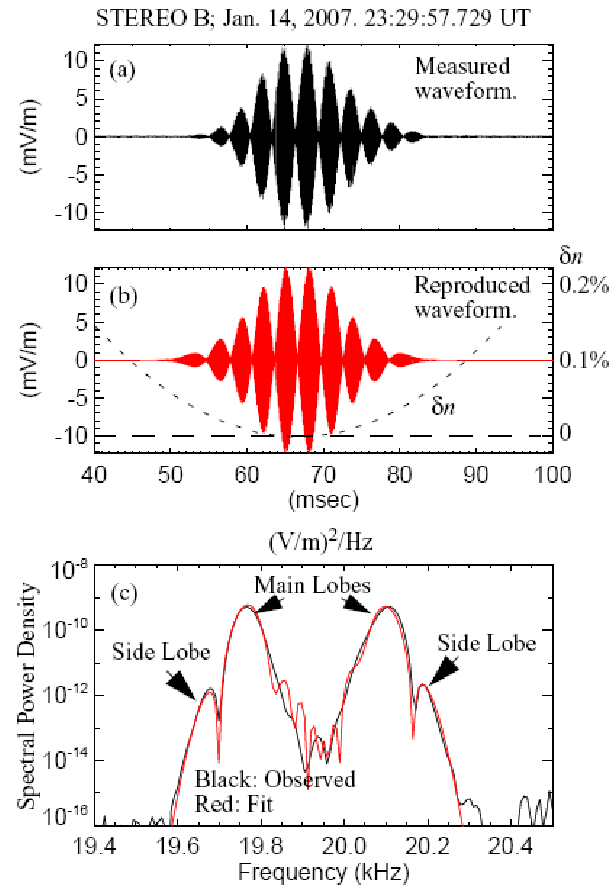
- **Eigenmode solutions** (Hermite-Gauss functions)

Ergun, Malaspina et al. (PRL, 2008)

Langmuir waves as eigenmodes of density cavities

Observed Langmuir waves interpreted as Eigenmodes of pre-existing solar wind density cavities





Implies cavities of 0.02% – 4% depth

Ergun, Malaspina et al. (PRL, 2008)

Dust detection with S/WAVES

- Very frequent. Extensive analyses *(Goetz, Kaiser, StCyr)*
- Signal produced by plasma cloud generated by dust impact on spacecraft
- Detection requires large value of mass or speed

- S/WAVES sees:

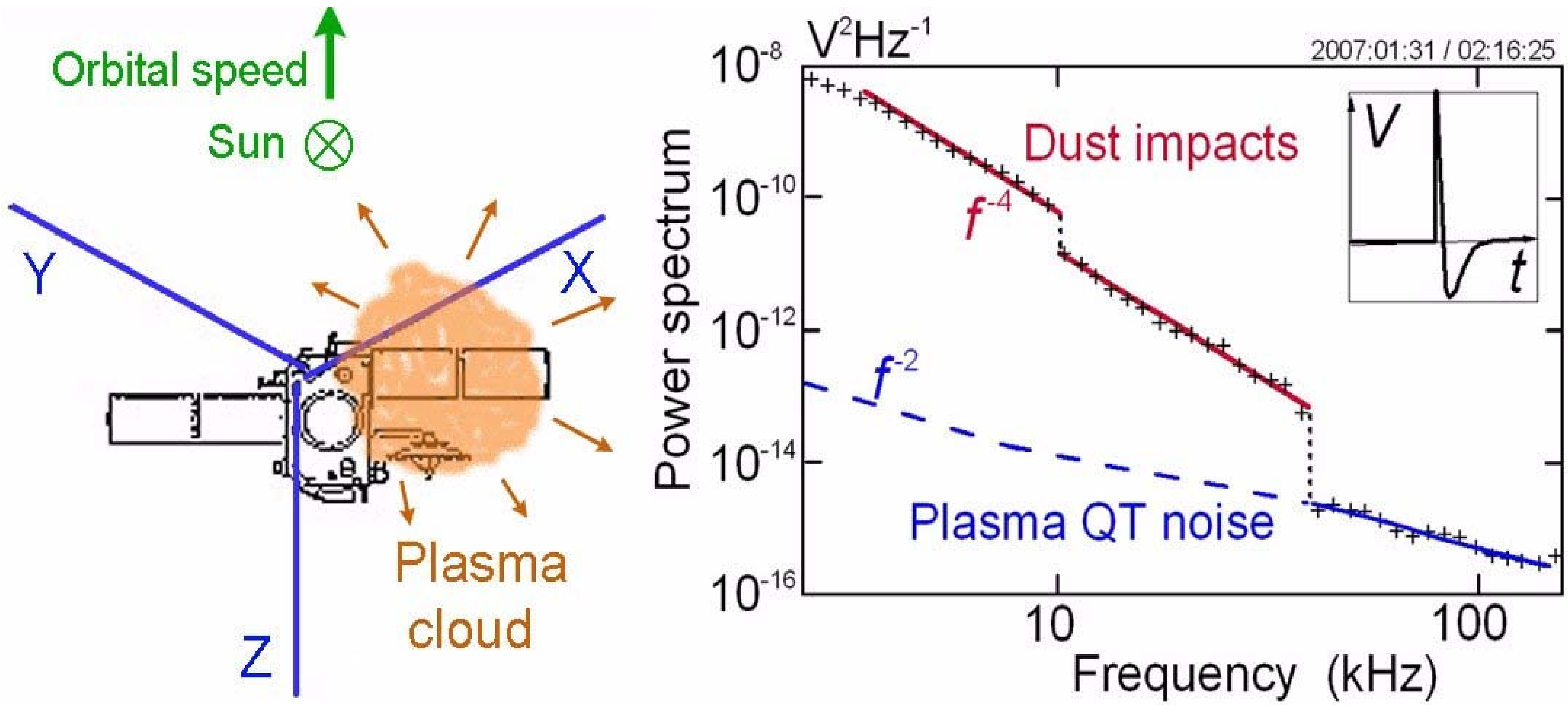
1) Nanoparticles impacting the S/C at about the solar wind speed (because large q/m)

2) Large (micron size) grains impacting at moderate speeds (flux smaller by 4 orders of magnitude)

1. Nanoparticles (<10 nanometers) impacts (~ solar wind speed) produce:

- frequent voltage pulses in S/WAVES TDS receiver saturating only 1 antenna boom

- f^{-4} power spectra (LFR receiver) on the same antenna boom



Meyer-Vernet et al., 2008

2. Large dust grains (> micron) impacts (a few tens km/s) produce simultaneously:

- rare voltage pulses in S/WAVES TDS receiver, which saturate the 3 antenna booms

- ejecta from the sunward ITO coating, which perturb SECCHI instruments

St Cyr et al., 2008, 2009

Science prospects: 90° and beyond

- Access to 360° radiation pattern
  - WIND/WAVES radio data essential
- Radio and white light “orthogonal”:
  - Radio sees head front events best
  - White light sees limb events best
- Relevance of HI observations

Websites, lists

- General
  http://www.lesia.obspm.fr/plasma/STEREO.html
  http://swaves.gsfc.nasa.gov/
- Data access
  http://stereo-ssc.nascom.nasa.gov/data.shtml
  TMLib can be downloaded from web
  http://cdpp.cesr.fr
  http://secchirh.obspm.fr
- Distribution lists
  swaves@listserv.gsfc.nasa.gov
  swaves@sympa.obspm.fr
- Secure website and forum
  https://sympa.obspm.fr/wws/info/swaves