STEREO/WAVES

Interplanetary Radio Burst Tracker

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Science Working Group Teleconf

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Status

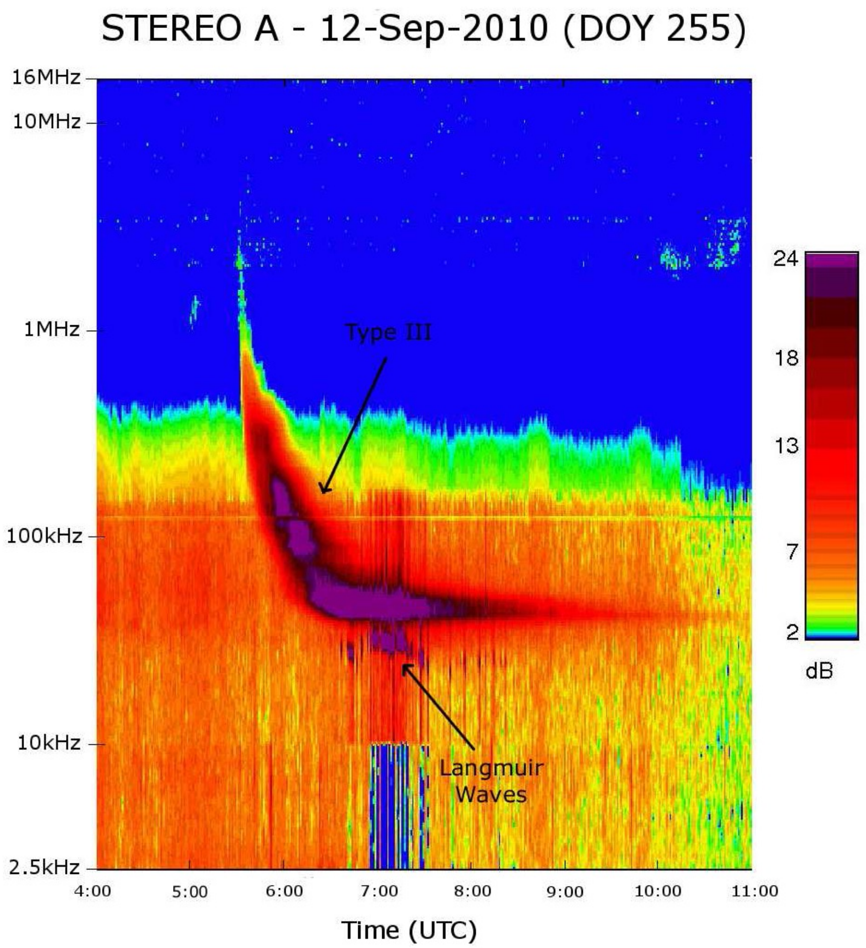
- Both A & B receivers continue to function nominally
  - No unexpected resets or anomalies
  - No trend changes in HK parameters

- Operations continue to go well
  - Commands go up
  - Telemetry comes down
  - Associated data products are produced and made available
  - Special situations are handled
  - Mission Ops is taking good care of us

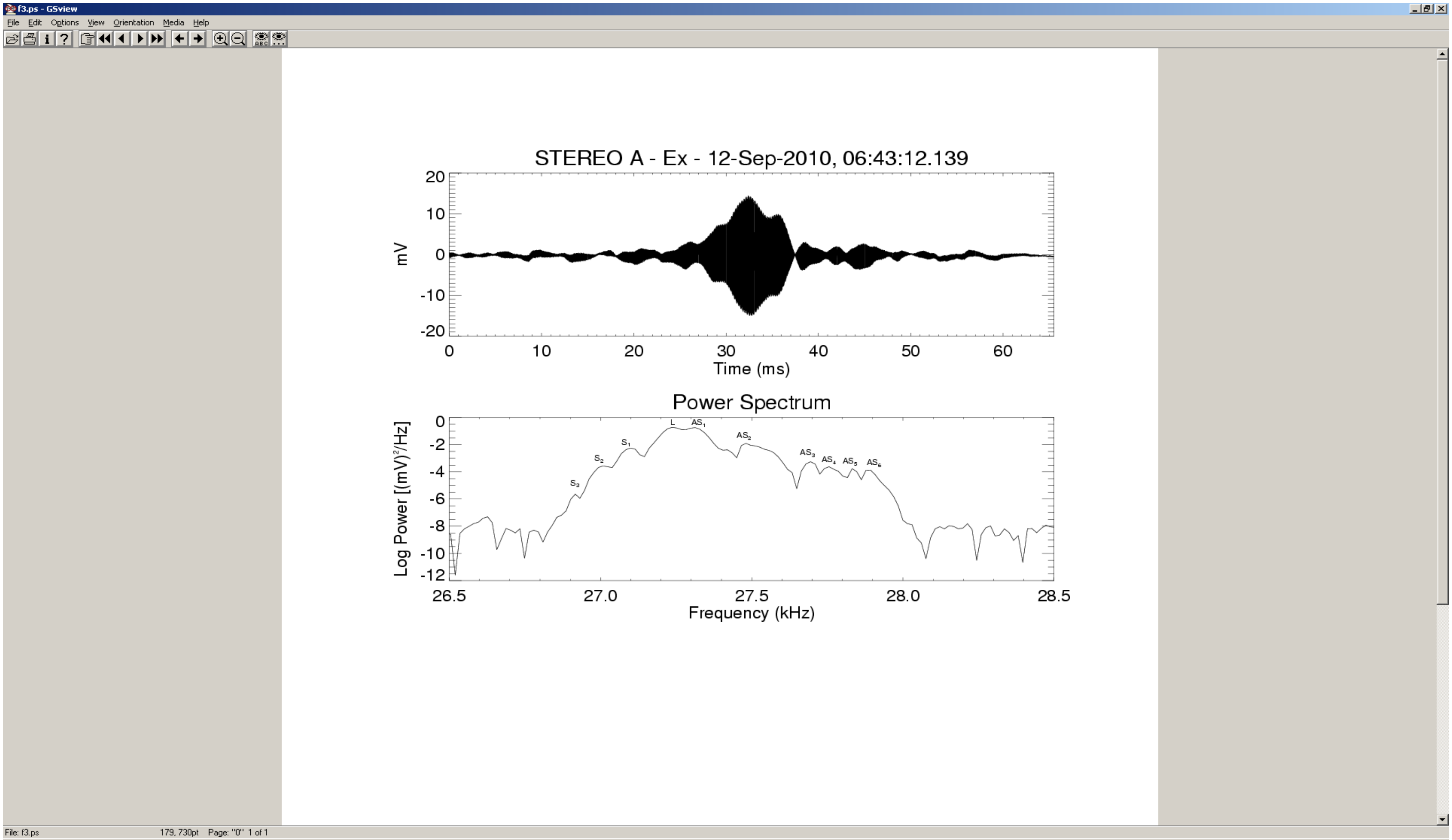
STEREO/WAVES Science, selected topics

- *In situ* wave analyses
  - Langmuir wave statistics
  - Size and amplitude distributions of Langmuir eigenmodes in the solar wind
  - Observations of ion-bulk waves using the TDS
- Dust
  - Evaluation/comparison of different detection algorithms
  - Very accurate, separate measurements of:
    - Nano dust; - Beta-meteroids; - interstellar dust.
- Radio emissions
  - a new time-of-flight algorithm to locate the primary radiation source
  - Statistical study of type III bursts
  - Direction and size of type III bursts using the singular value decomposition (SVD) method
  - Type II from 2009 May 5 backside eruption; Occulted event of 2010 Nov 3
  - Measurement of Interplanetary type III storms
  - Large amplitude transmitter- and lightning-associated whistler waves in the Earth’s inner plasmasphere at L<2
  - Terrestrial and Jovian auroral activity in response to a CME
- Theory and modelling
  - STEREO constraints on AKR models (sources and beaming)
  - Investigation of non-linear wave-wave interactions using in situ waves asociated with type III and type II radio bursts
  - Beam-plasma interaction in strongly inhomogeneous plasmas
  - Type II data–theory comparisons

Dynamic spectrum



Typical TDS event and its Structured spectrum (Stokes and anti-Stokes modes)



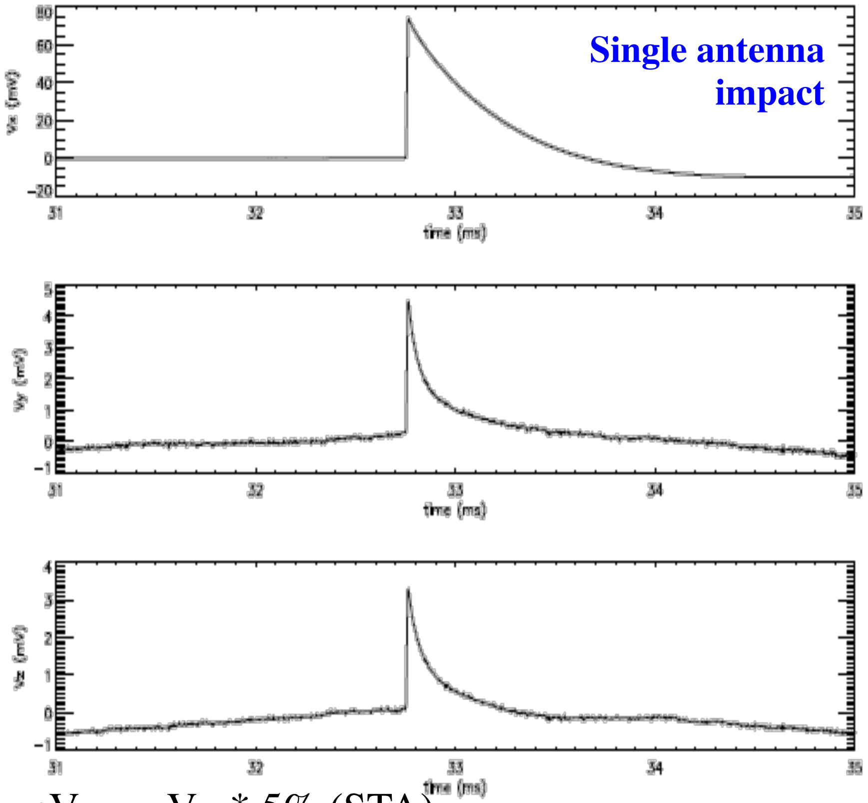
Type III burst waveform summary

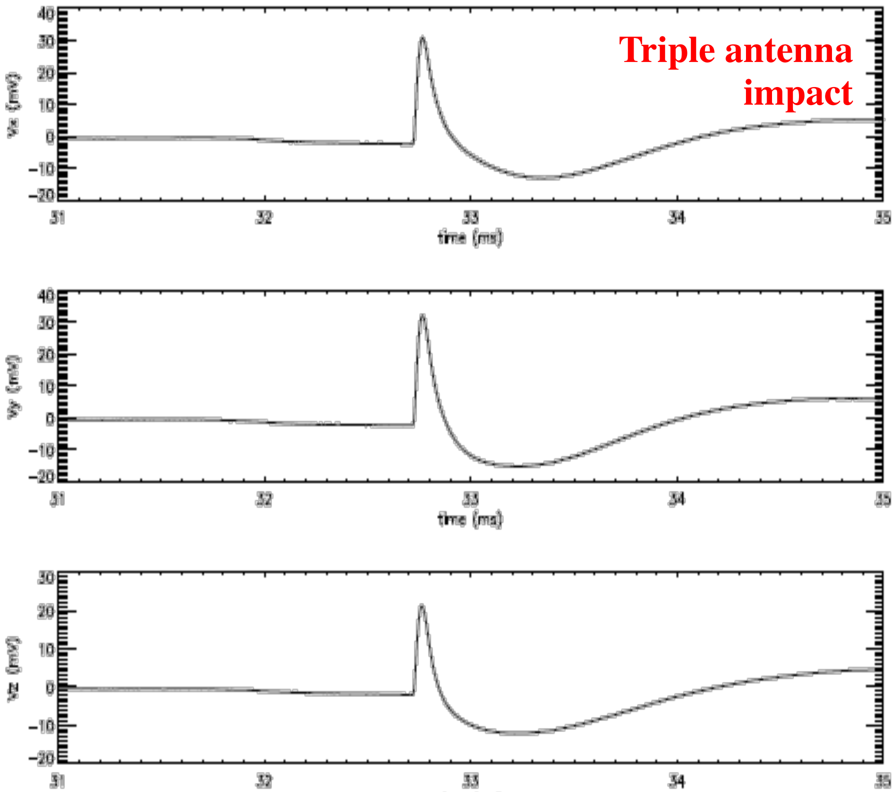
Highly modulated waveforms with very complex sideband structures with Stokes as well anti-Stokes spectral peaks,

The peak WL/neTe = 3 × 10^−4 − 1.2 × 10^ − 3 is well above the modulational instability thrshold of broad Langmuir wavepackets in a weakly magnetized plasma of » 2.2 × 10^−6

- The filtered waveforms correlate with waves at several other low frequencies
- The peak values of the low frequency ion-sound fluctuations correlate well with the peak values of Langmuir waves
- Often the waveforms show the characteristics of envelope solitons by being very intense short duration coherent field structures with spatial scales of the order of a few hundred Debye lengths

Two types of Dust impact signals

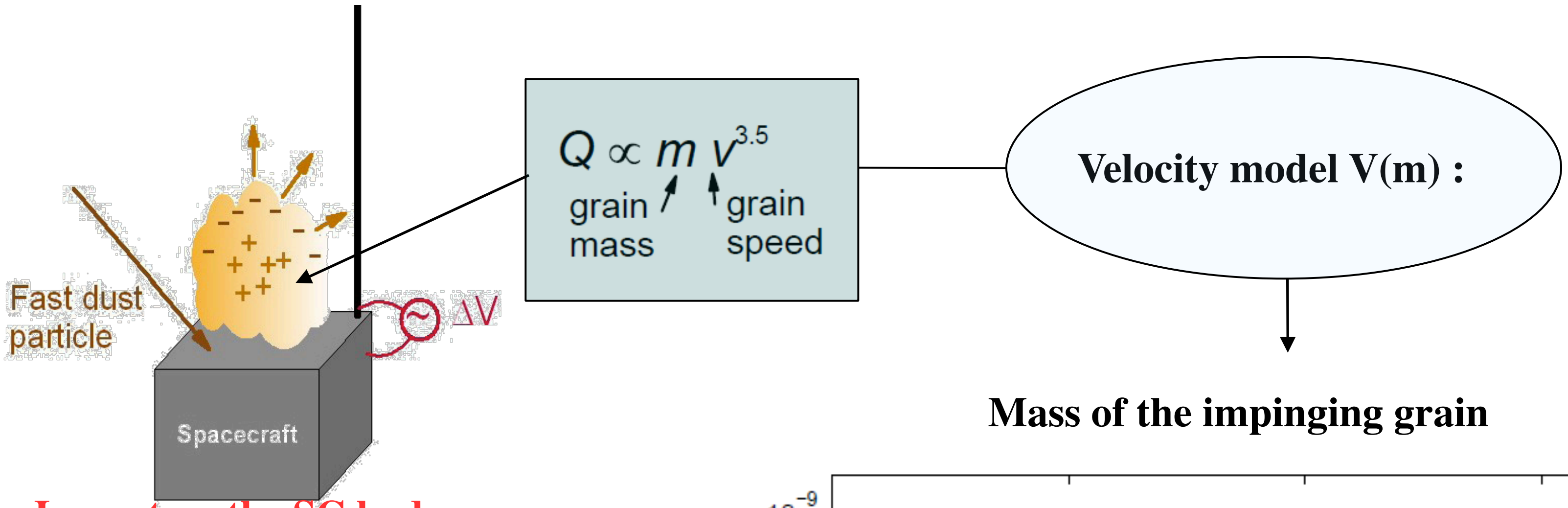




- Vy,z ~ Vx * 5% (STA)
- Rise time : Tr ~ 10 microseconds
- Decay time : Td ~ 1 ms (antenna discharge)

- Vx ~ Vy ~ Vz (Same on every antenna)
- Rise time : Tr ~ 70 microseconds
- Decay time : Td ~ 110 microseconds

Mass / Voltage Calibration



$$Q \propto m\, v^{3.5}$$

grain mass

grain speed

Velocity model V(m) :

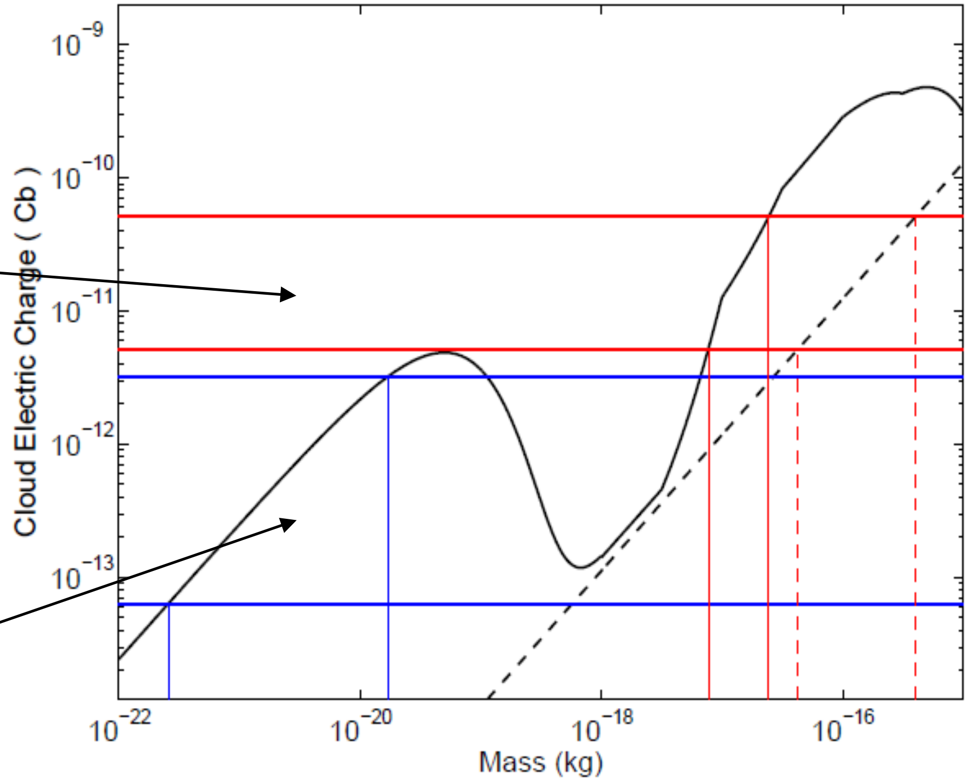
Mass of the impinging grain

Impact on the SC body
V ~ Q / C

Mass ~ 1e-17 / 1e-15
Size ~ 0.1 – 0.3 μm

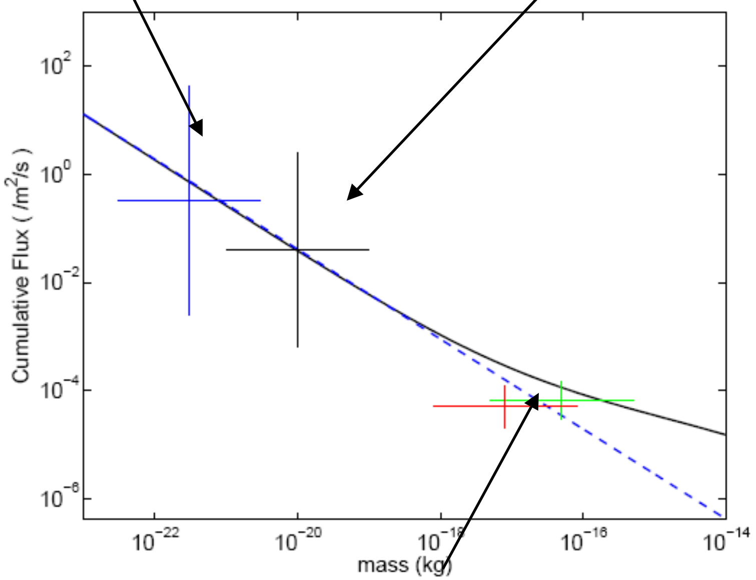
Impact close to an antenna :
V ~ 20 * Q / C

Mass ~ 1e-22 / 1e-20
Size ~ 5-10 nm



Summary of Dust impact results

- STEREO Results for dust fluxes at 1 AU
- Solid line compares with model [Grun et al, 1985]
- Implications for ROLSS
- 3 500m x 1m Kapton = 1500 m^2
- Order 10^3 dust impacts per second



WAVES TDS (1 antenna hit)
[Zaslavsky et al, in prep]

WAVES LFR
[Meyer-Vernet et al, 2009]

S/WAVES TDS (Beta and ISD)
(3 antenna hit)
[Zaslavsky et al, in prep.]

Direction finding and propagation effects

– Direction finding technique from a single spacecraft works “as promised“

- However:

  - triangulations combining the direction findings from 3 spacecraft (WIND, STEREO-A, -B) often give inconsistent results

  - it points to a “scattered“ source very different from the “primary“ source

- A new algorithm based on the difference of the radio emission arrival times at 3 spacecraft does not have this drawback

  - it gives access to the primary source localization

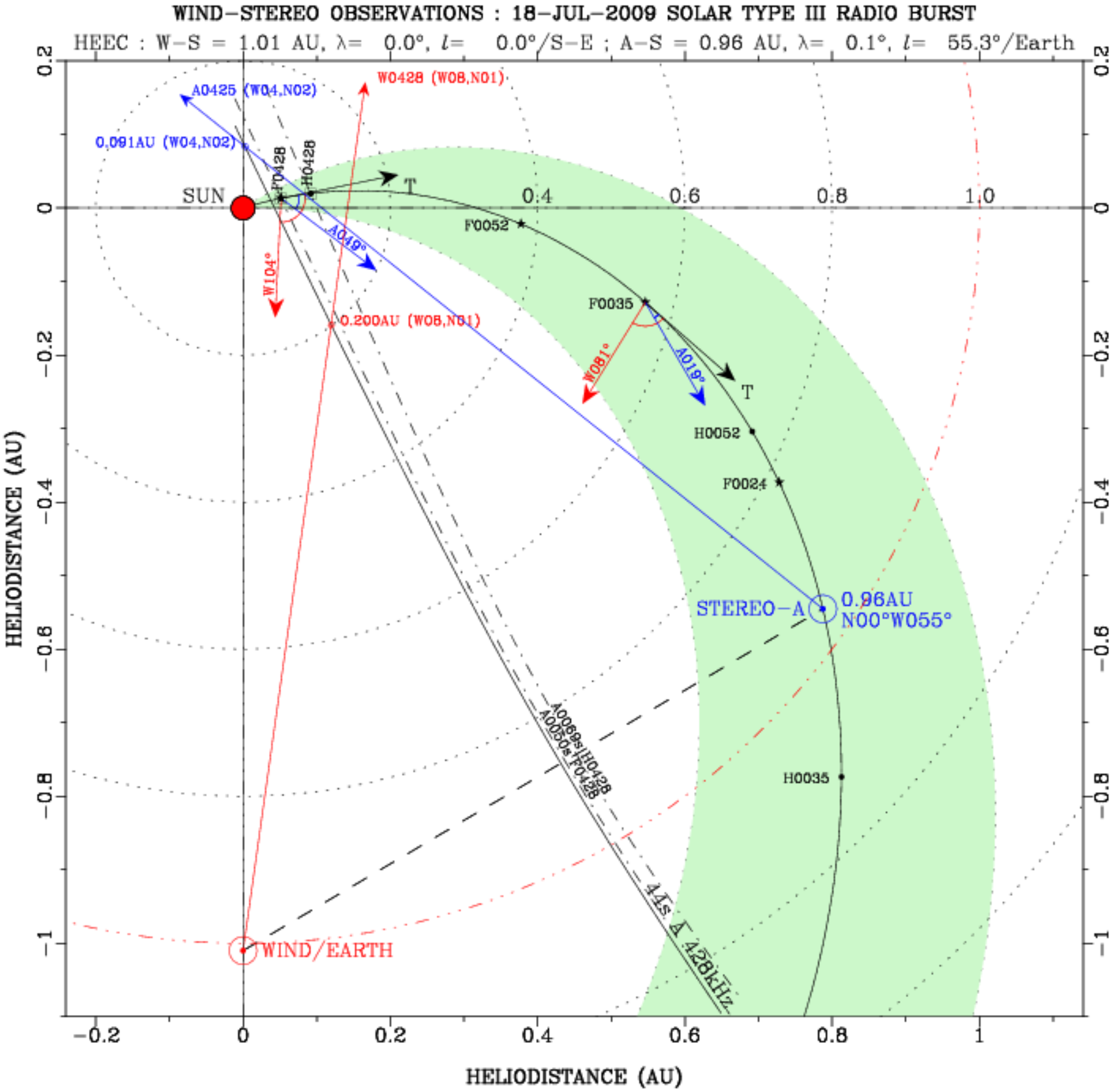
  - then, source positions (using time-of-flight) are compatible with expected radiation levels

  - comparison with direction finding yields information on scattering effects

- This new method works particularly well for type III events whose trajectory can be inferred (flare-associated, or in situ Langmuir waves-associated).

-The method is being extended to type II radio emissions.

Direction finding and propagation effects



Radio Tracking of CME/Shocks from STEREO & Wind: alternate perspective

Two ways to (independently) track CME/shocks using radio observations:

1. Frequency tracking:

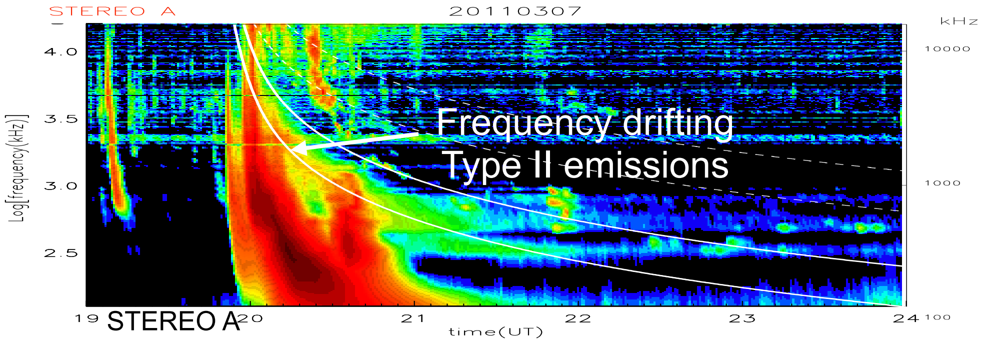
   Makes use of the fact that a propagating CME/shock generates radio emissions at lower frequencies as the shock moves farther from the Sun, due to the $1/R^2$ fall off of the IP plasma density.

2. Direct tracking of a radio source at a CME/shock using 2 or 3 – s/c triangulation:

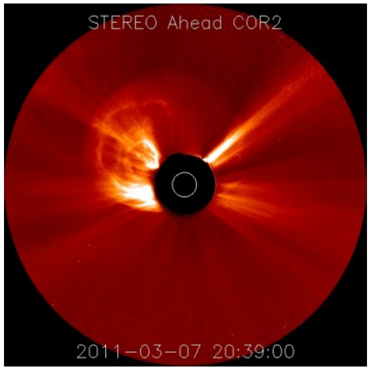
   Uses direction-finding analyses from spacecraft with large angular separations.

We illustrated both methods using STEREO and Wind radio observations

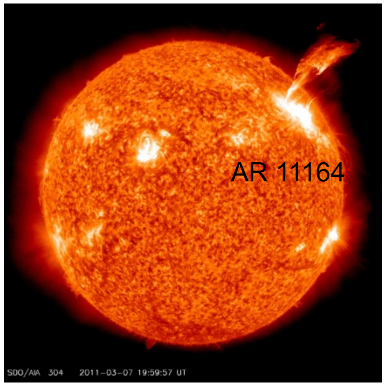
STEREO/Wind Radio Observations of the March 7-8, 2011 CME



Estimated CME speed 2200 km/s
deceleration ~ -25 m/s^2

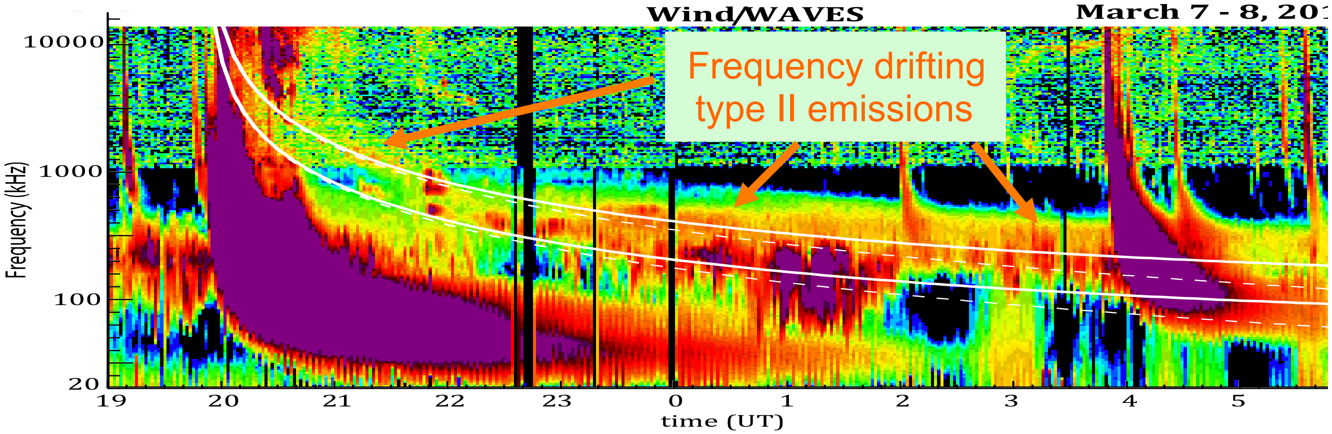


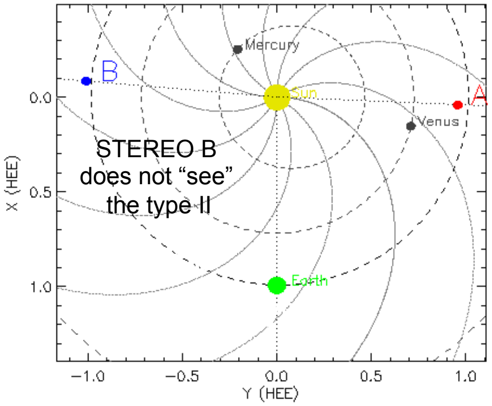
SDO/AIA prominence
eruption 19:29UT



The beginning of this radio event (high-frequency part) is well observed by STEREO A

The Wind/WAVES (near Earth) tracks the weak (type II) radio emissions from the CME/shock through the IPM





STEREO B
does not "see"
the type II

Radio emissions are generated at the fundamental (F) and harmonic (H) of the plasma frequency at the shock front: $f_p(kHz) = 9\ sqrt(n(cm^{-3}))$

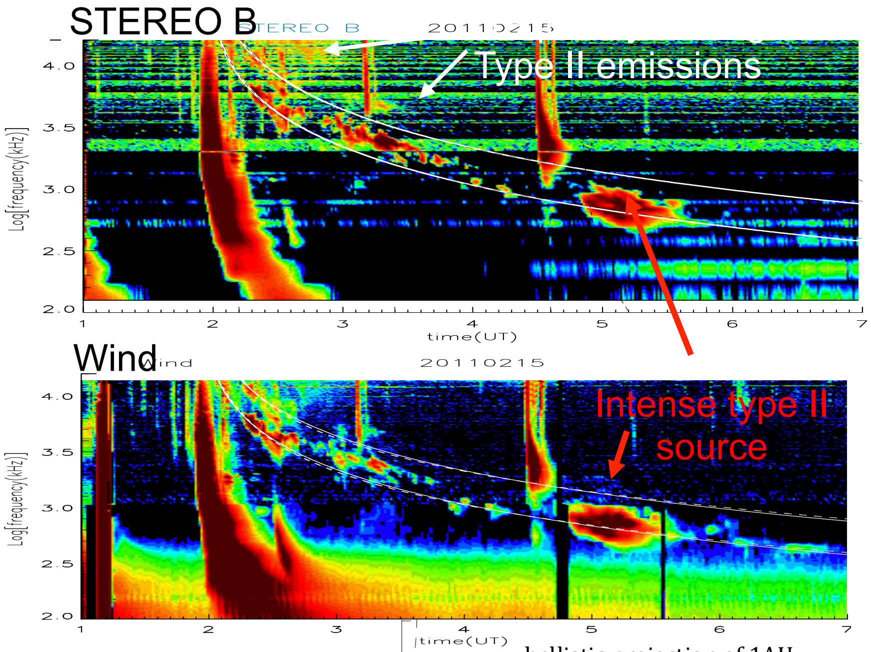
- The white curves, which provide a good fit to the frequency drift of the type II radio emissions, correspond to a shock with v_0 = 2200 km/s and a = -35 m/s^2 propagating through the IPM, with plasma density falling off as 1/R^2

- The observed frequency drift of the radio emissions implies rapid deceleration of this CME/shock; dashed curves = no deceleration

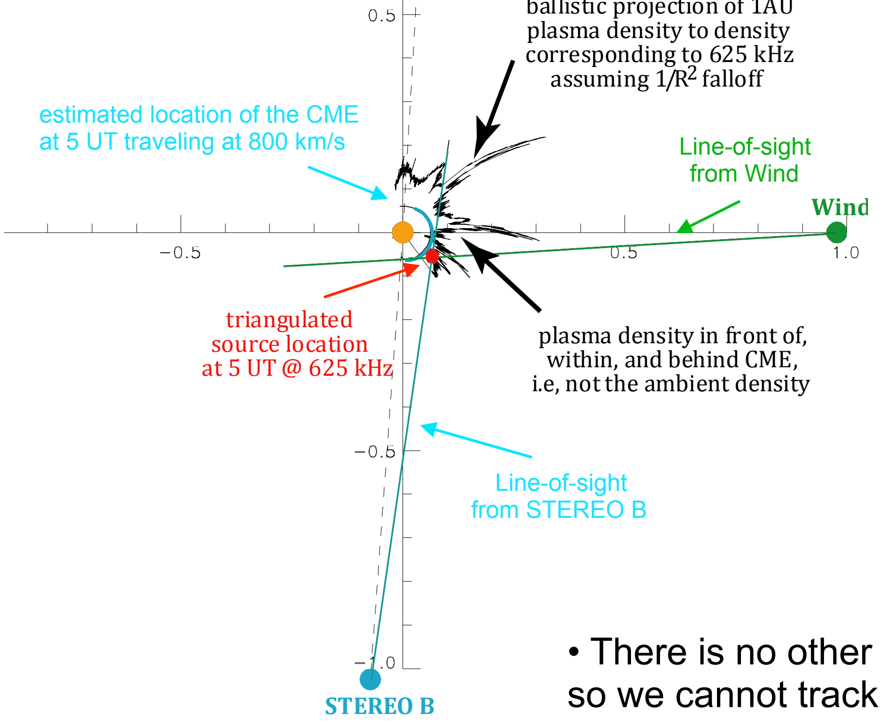
- A difficulty for this event is that its northern propagation direction may indicate that s/c in the ecliptic plane observe only the flank of the shock - therefore hard to pin down the shock kinematics from shock speed and transit times to STEREO A & Wind

- Since the STEREOs do not observe radio emissions below 1MHz, we cannot triangulate the radio source locations for this event

Type II radio source located by triangulation between STEREO B and Wind on February 15, 2011 at a frequency of 625 kHz



At this time the CME is entering HI 1



ballistic projection of 1AU plasma density to density corresponding to 625 kHz assuming $1/R^2$ falloff

estimated location of the CME at 5 UT traveling at 800 km/s

Line-of-sight from Wind

triangulated source location at 5 UT @ 625 kHz

plasma density in front of, within, and behind CME, i.e, not the ambient density

Line-of-sight from STEREO B

- The radio source location is about 0.04 AU beyond the estimated CME location from the height-time observations; this may correspond to the actual stand-off distance between the shock and the driver CME and/or it may be partly due to scattering of the radio emissions in propagating to the s/c.

- Ideally the radio source should lie somewhere on the 625 kHz iso-frequency contour. However, we don't know the ambient density in the region of the CME, and therefore of the radio source, but we should be able to obtain this information from the plasma parameters measured at STEREO B

- There is no other intense radio source below 625 kHz, so we cannot track this event farther out in the IPM