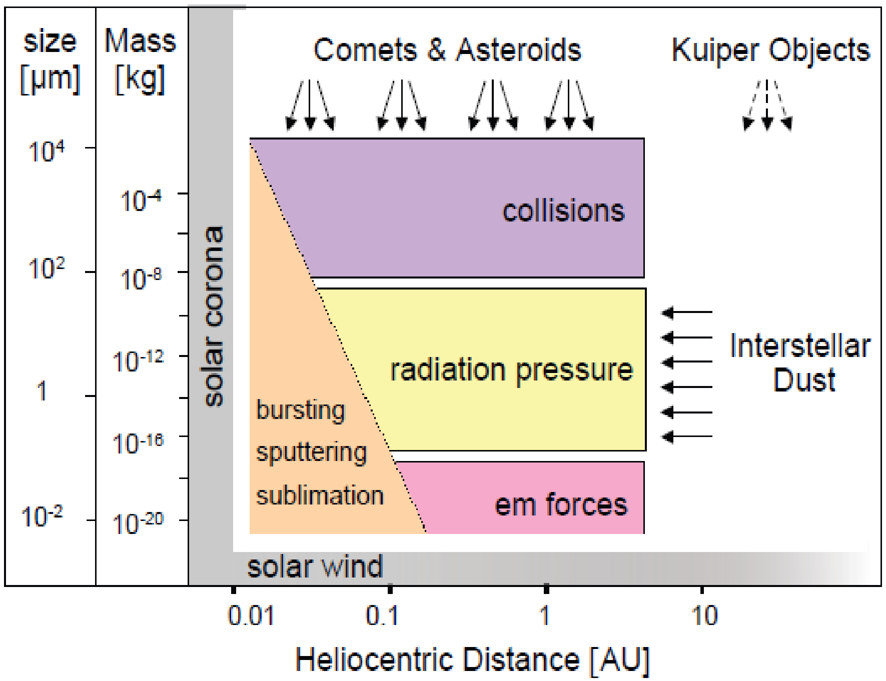
Heliospheric dust detection by S/WAVES

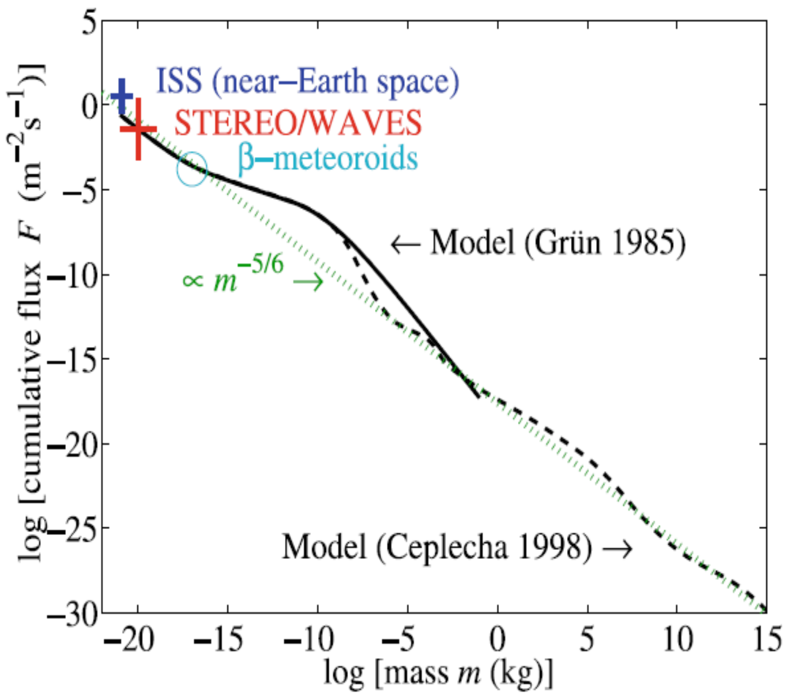
A. Zaslavsky

Harvard-Smithsonian Center For Astrophysics

LUNAR Meeting - Boulder

Dust grains in the interplanetary medium





<u>Sources :</u>

- **Planets, comets, asteroids**
- **Interstellar medium**

<u>Sinks :</u>

- **Fragmentation to small size**
- **Sublimation**

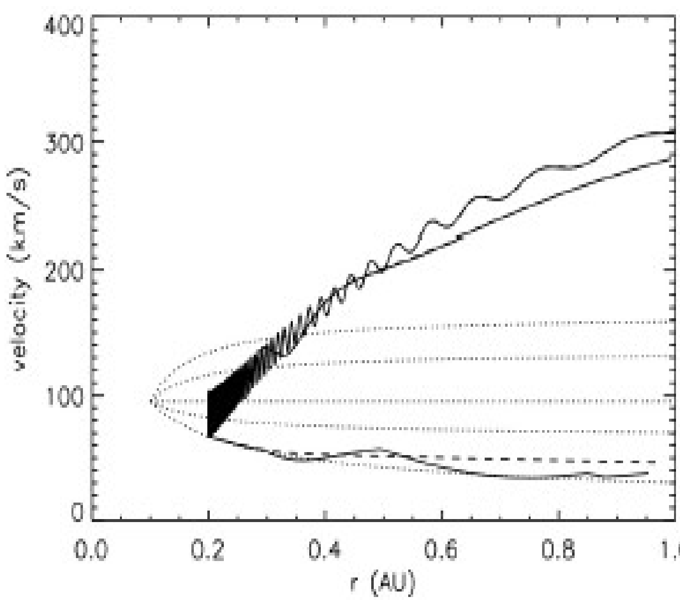
<u>Mass Flux essentially controlled by fragmentation : F ~ m^-5/6</u>

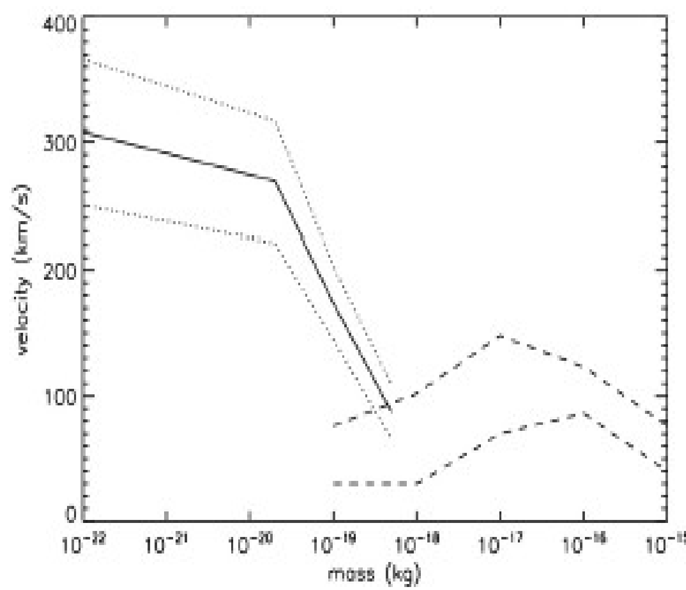
Dust dynamics in the IP medium

$$\frac{d\mathbf{v}}{dt} = \frac{Q}{mc}(\mathbf{v} - \mathbf{V}) \times \mathbf{B} - \frac{GM_{\odot}}{r^2}\hat{\mathbf{e}}_r + \mathbf{F}_{\mathrm{PR}}$$

Radiation pressure : <u>Fpr/Fg ratio proportional to 1/size</u>

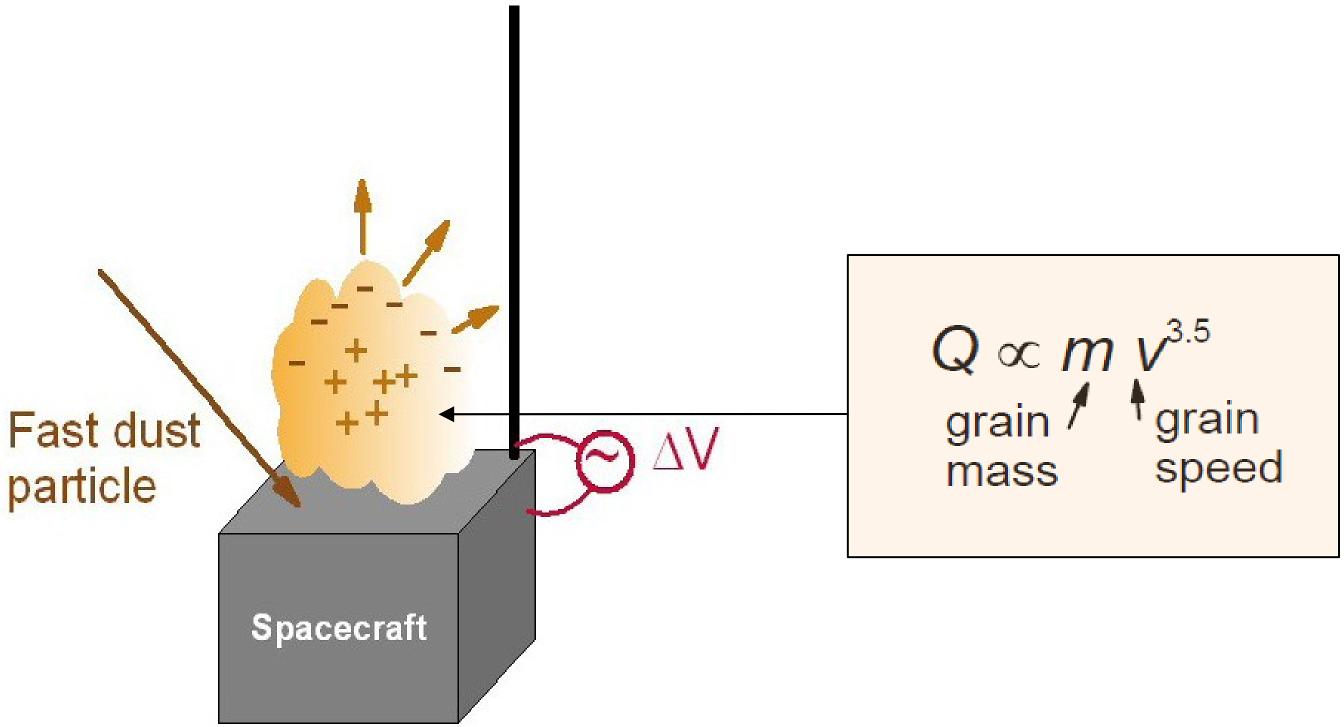
Charge of bodies in the interplanetary medium : <u>Q/m ratio proportional to 1/size^2</u>





Small grains streaming at high velocities at 1 A.U.

Basics of dust detection with a radio antenna

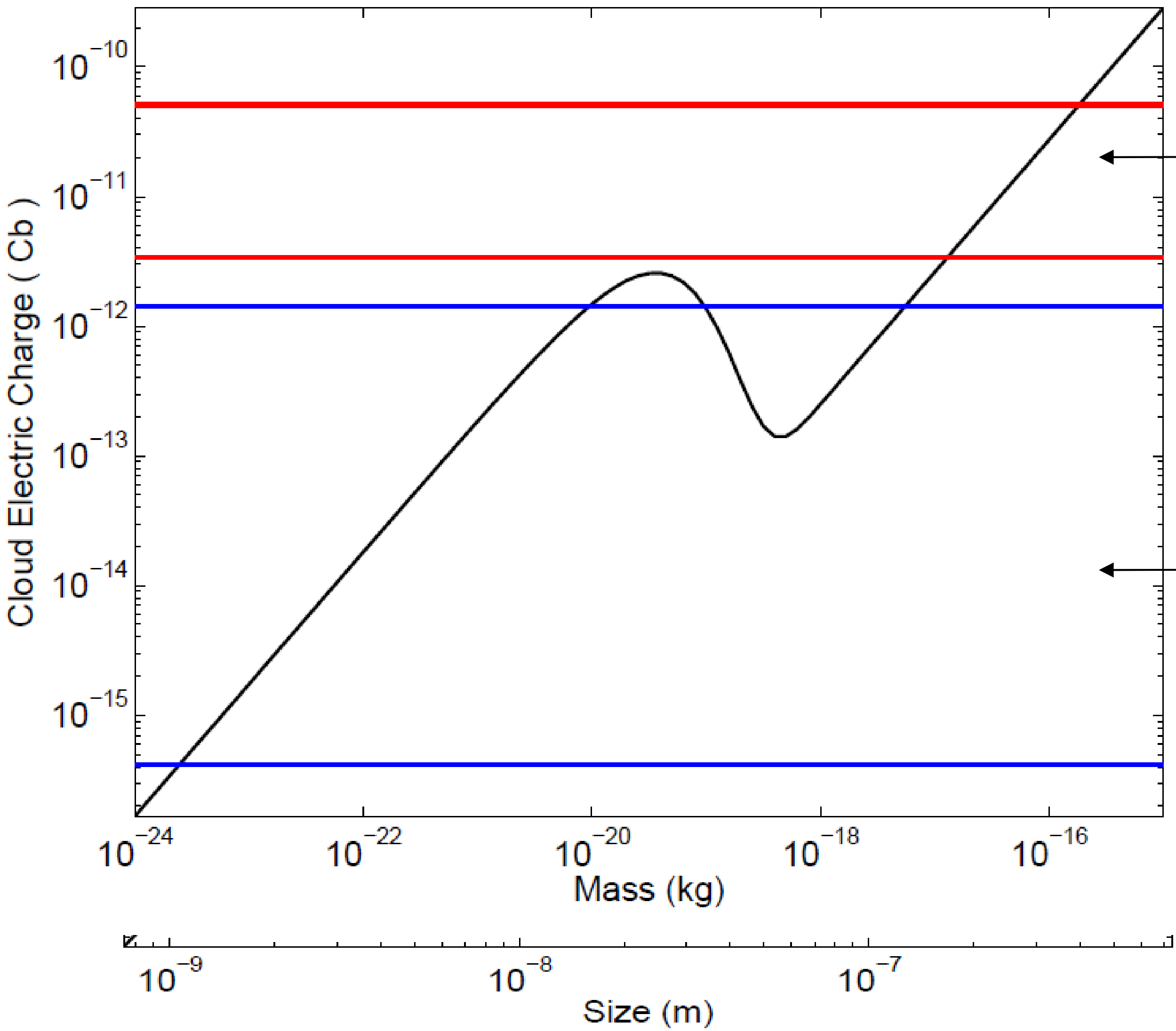


<u>Electric signal measured is essentially a function of the charge Q of the plasma cloud</u>

- Recollection of the cloud's electrons by the SC surface : $\delta V_1 \sim -Q/C$

- Direct detection of the electric charge
(if the impact is close enough to an antenna) $\delta V_2 \sim (k_B T/e) R_2/L$ **(?)**

Electric charge in the plasma cloud



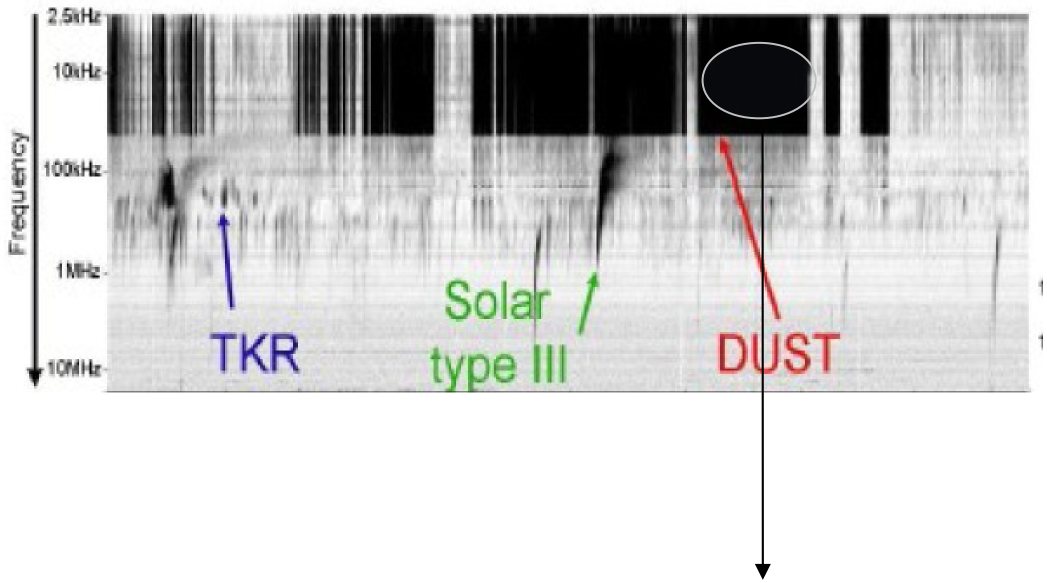
$$\delta V_1 \sim -Q/C$$

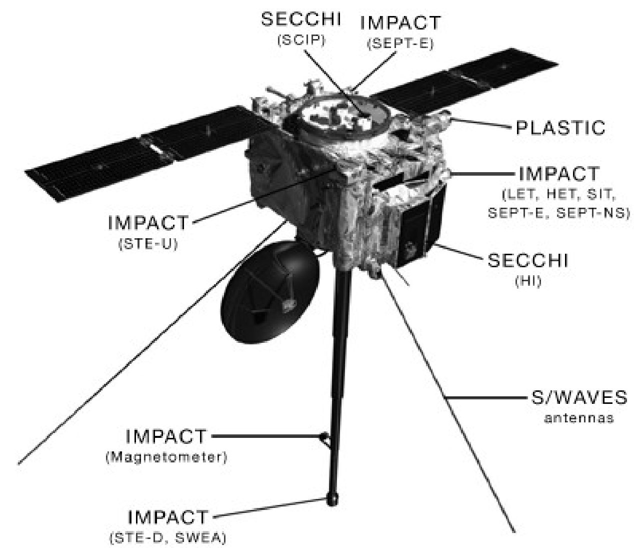
Particle size ~ 0.3 μm

$$\delta V_2 \sim (k_B T/e) R_2/L$$

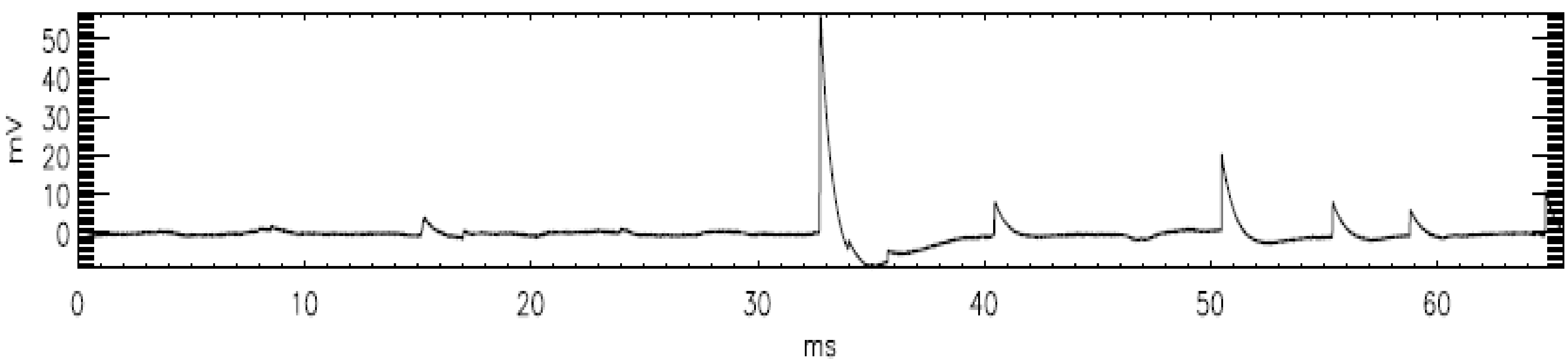
Particle size ~ 1-10 nm

Electric signals detected by the S/WAVES instrument



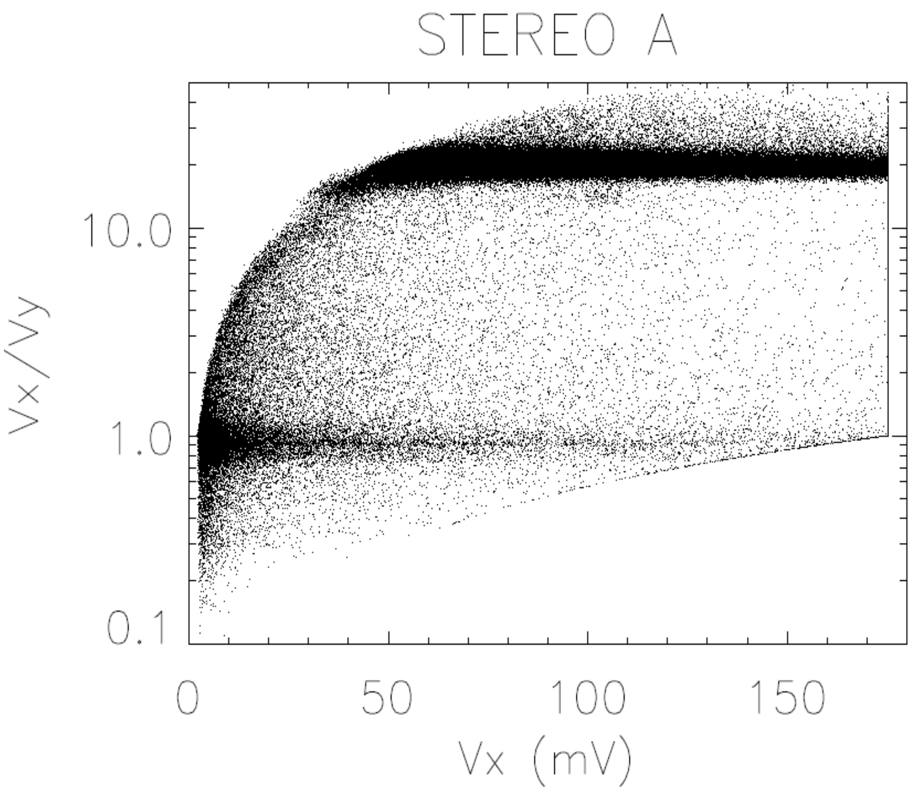


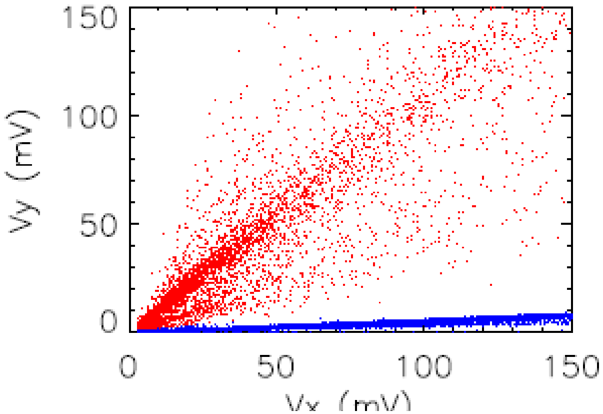
STEREO A – X Monopole – Jan 01, 2009 : Wave-form

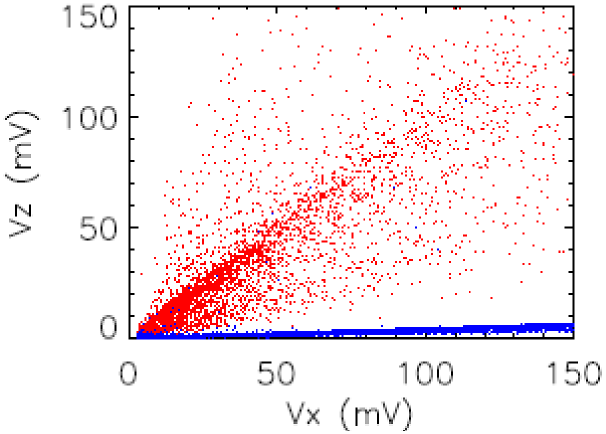


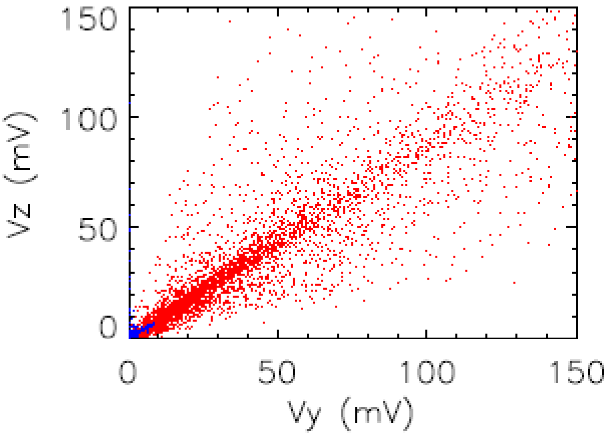
Observations of impacts with a short rise time, and large amplitude (some → 175 mV)

Correlations between antenna signals





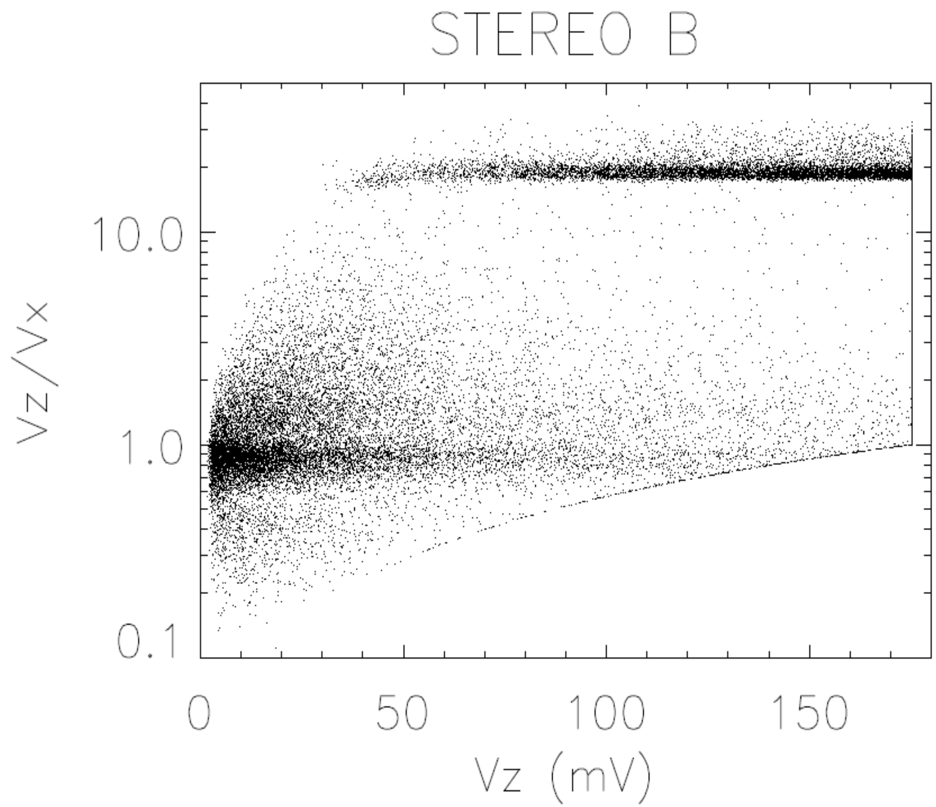


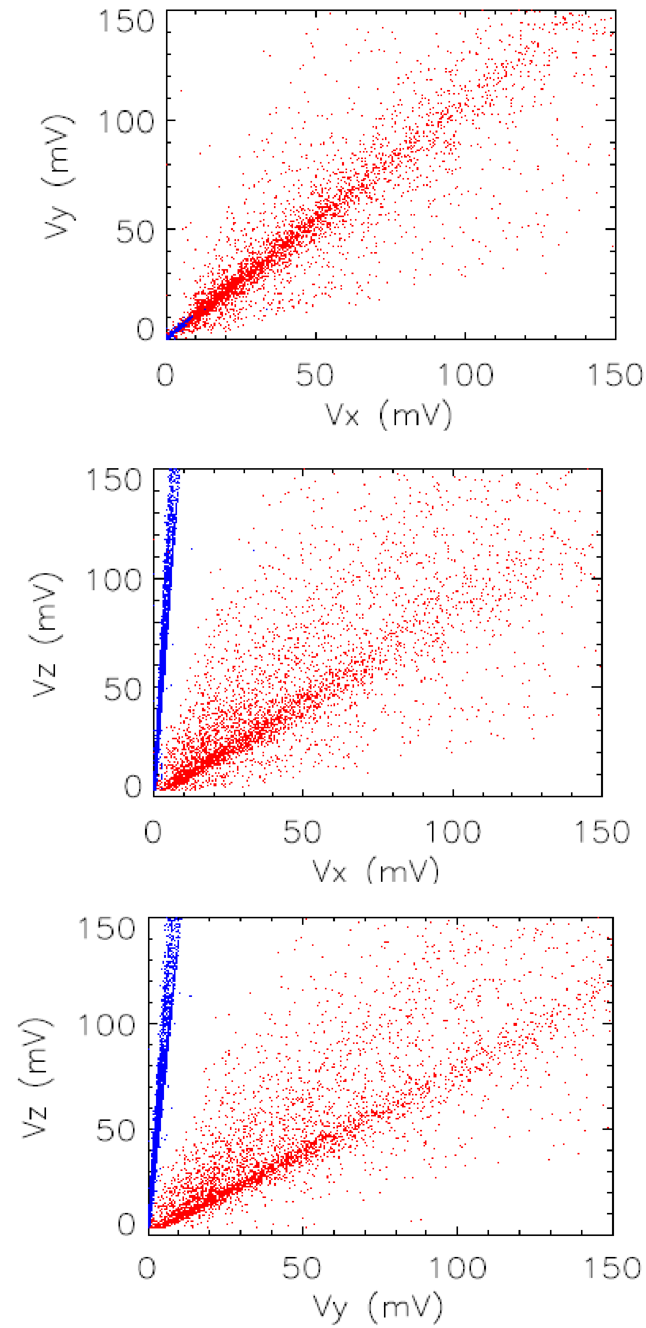


Single and Triple hits

- **N 3hits ~ 5000**
- **N 1hit ~ 150 000**

Correlations between antenna signals

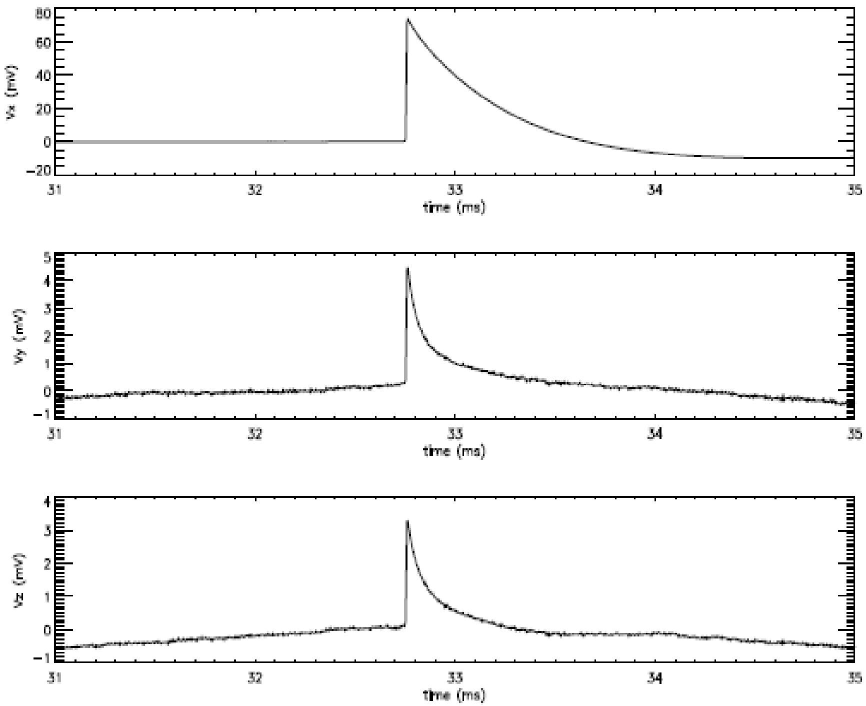


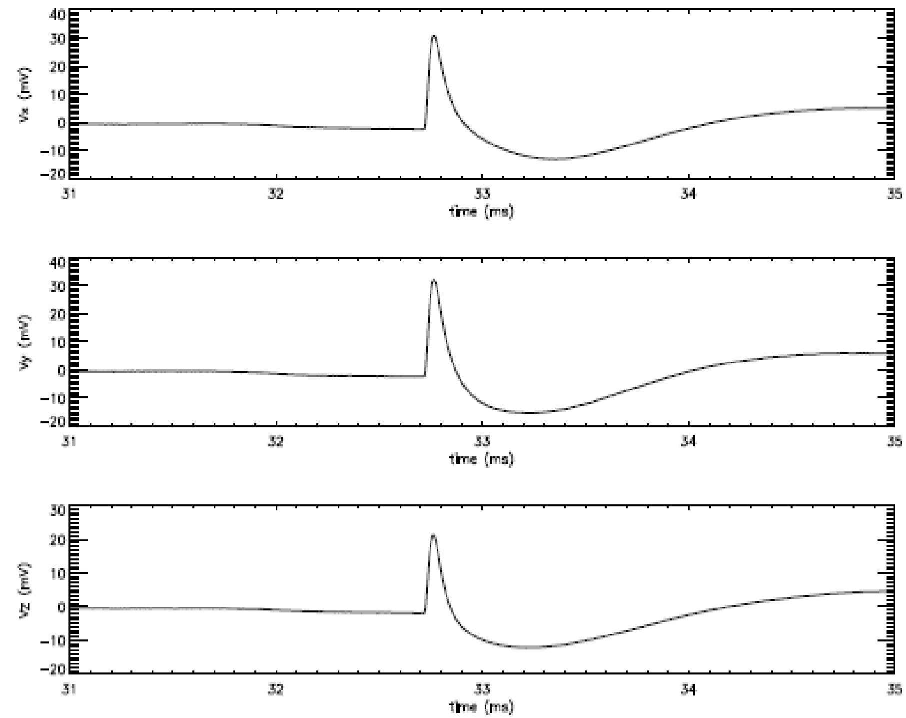


Single and triple hits

- **N 3hits ~ 5000**
- **N 1hit ~ 40 000**

Typical signals detected for the Single/Triple impacts





Single antenna impact :

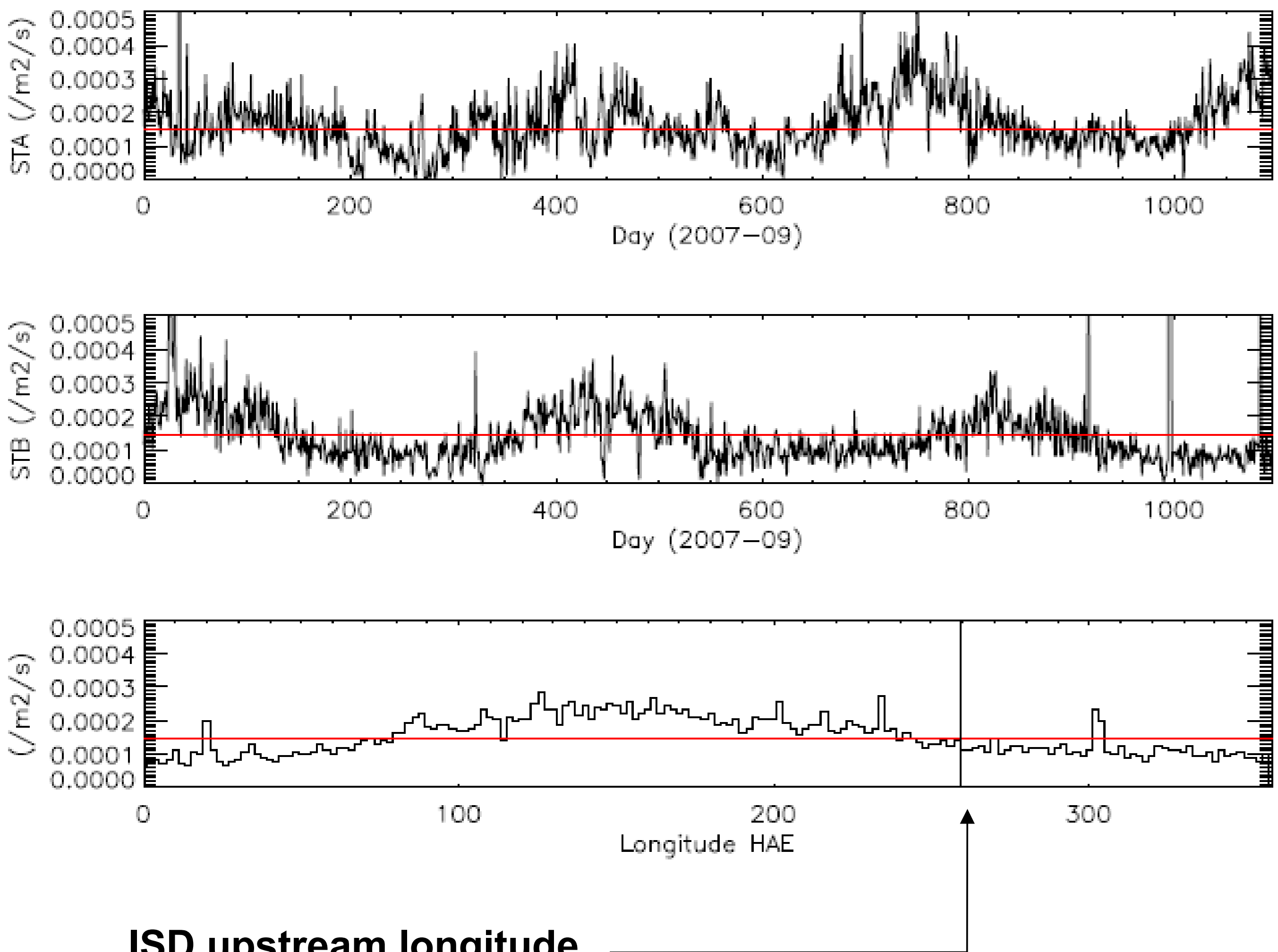
- Vy ~ Vz (STA)
- Vy,z ~ Vx * 5% (STA)
- Rise time : Tr ~ 10 microseconds
- Decay time : Td ~ 1 ms

Triple antenna impact :

- Vx ~ Vy ~ Vz

- Rise time : Tr ~ 70 microseconds
- Decay time : Td ~ 110 microseconds

0.2 – 0.5 μm sized grains flux at 1 AU



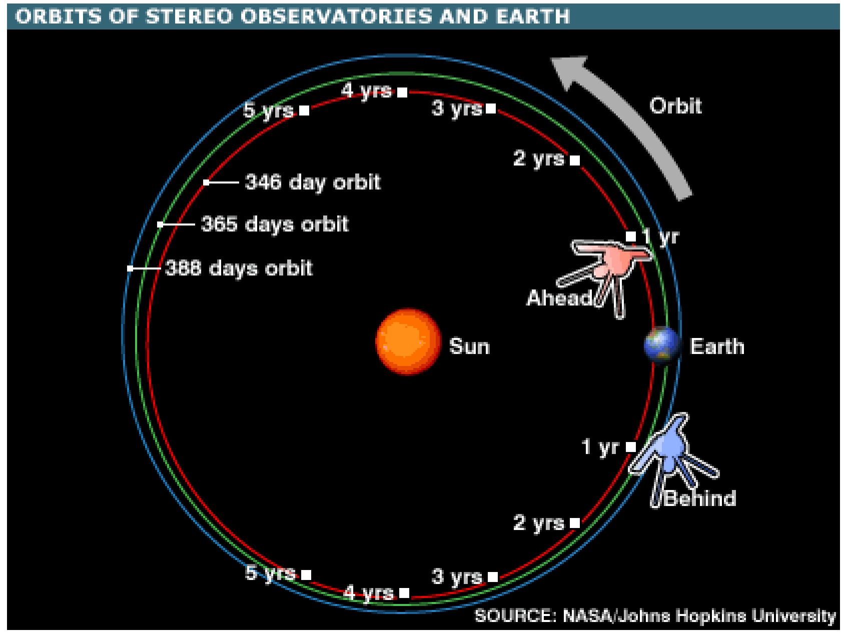
ISD upstream longitude

Modulation allows to determine the respective fluxes of solar and interstellar dust

0.2 – 0.5 μm sized grains flux at 1 AU

F = n * (V+Visd)

ISD

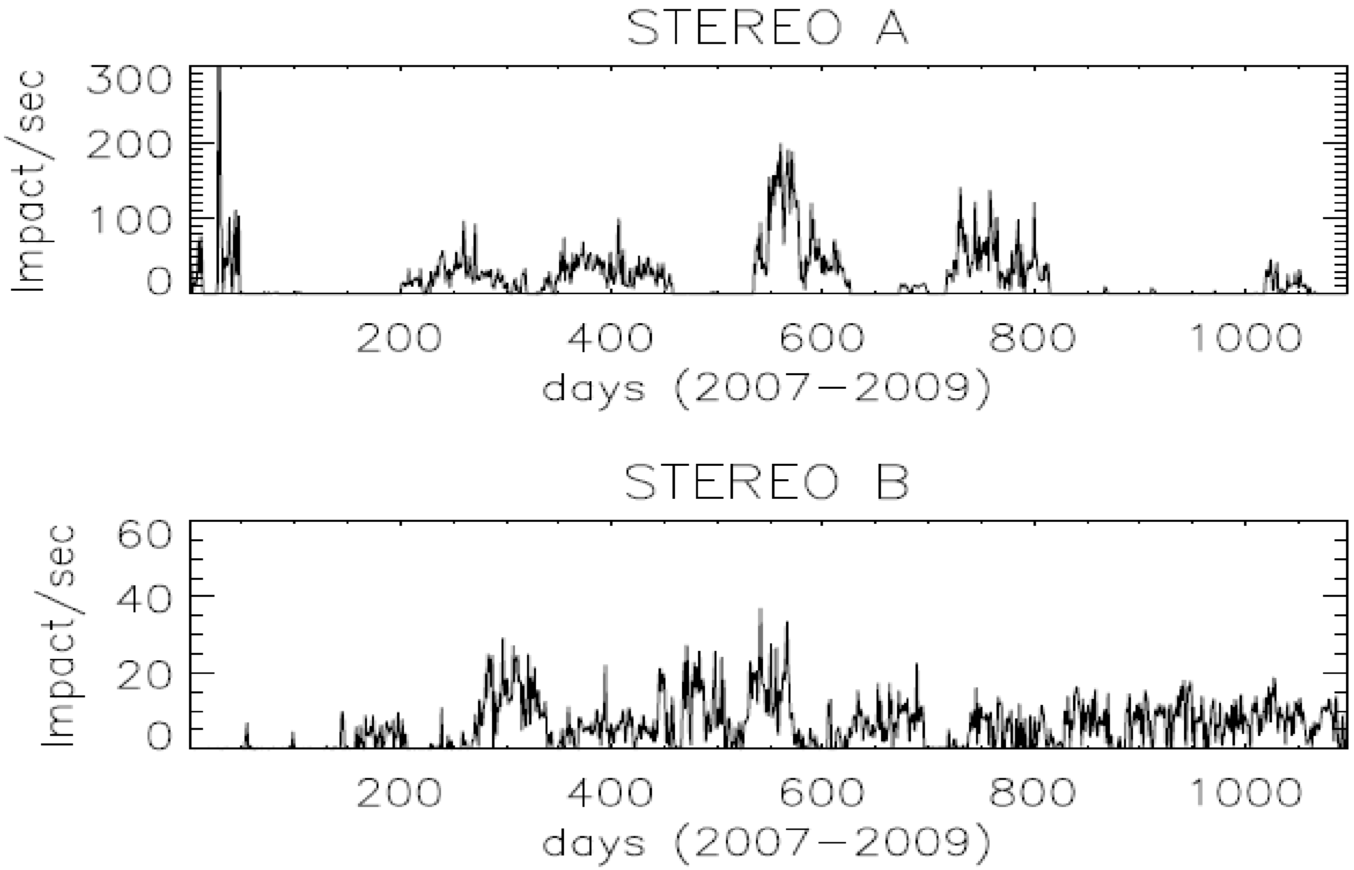


F = n * (V-Visd)

$$F = F_0 + F_{ISD} \times |1 - (V_{SC}/V_{ISD}) sin(\theta - \theta_0)|$$

F0 ~ 1e-4 /m²/s – Fisd ~ 1e-4 /m²/s – Vsc/Visd ~ 1 – Theta ~ 255 °

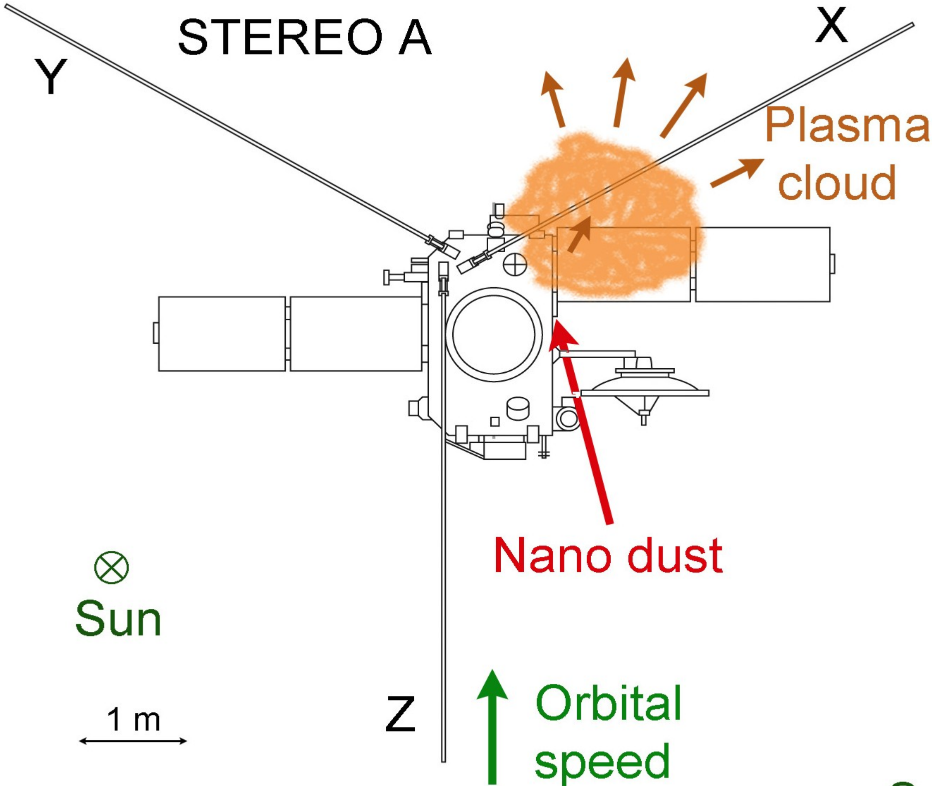
10-20 nm sized grains flux at 1 AU

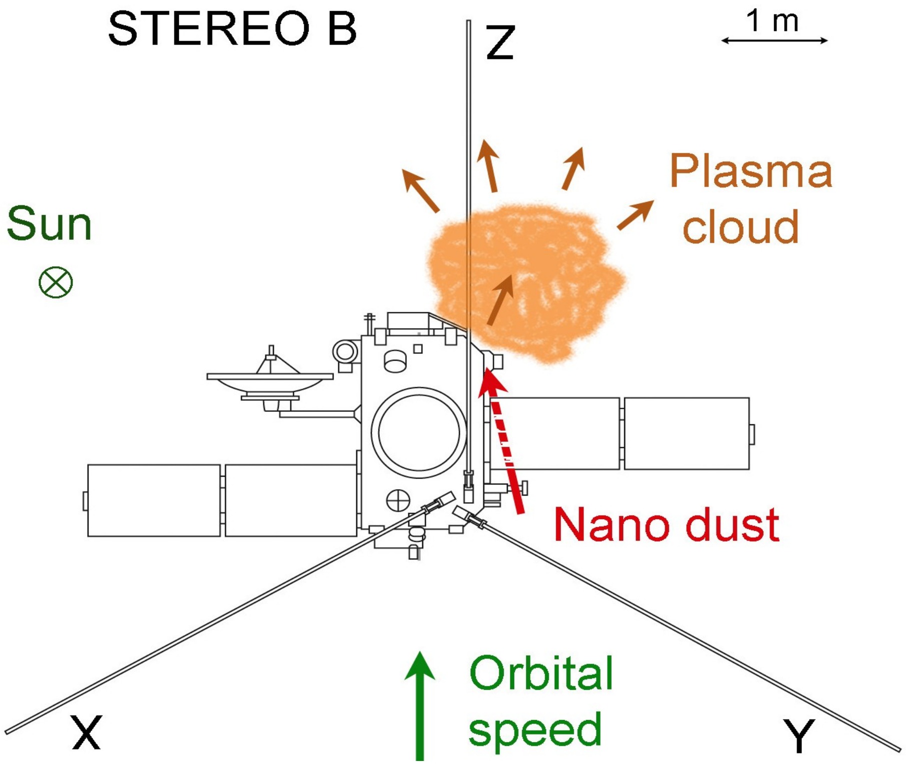


How reliable are these measurements ?

What is the influence of the antennas orientation in the detection of the nano-dusts (producing the single hits) ?

Nanodust velocity vector direction ?



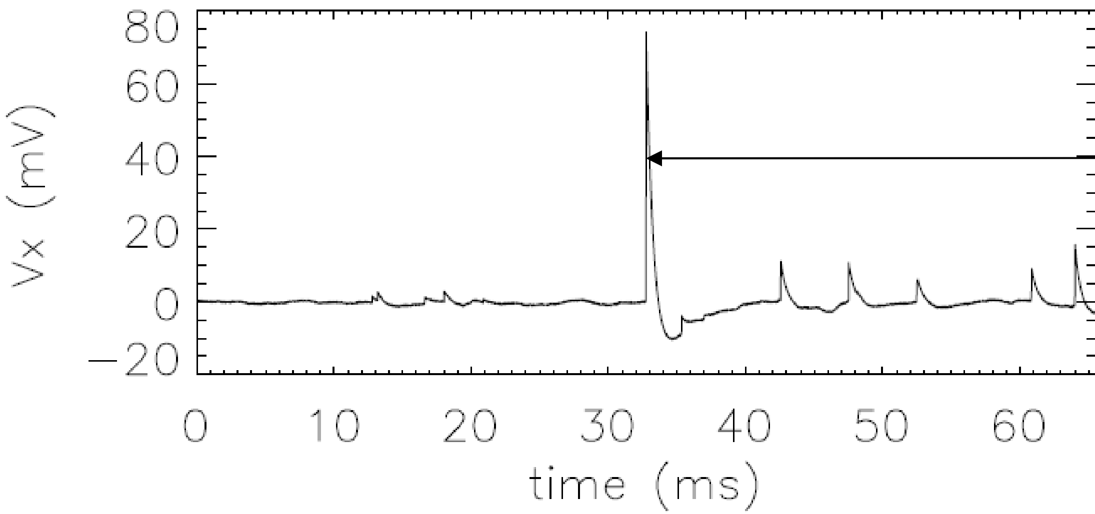


Nano dust velocity vector :

radial + prograde component ?

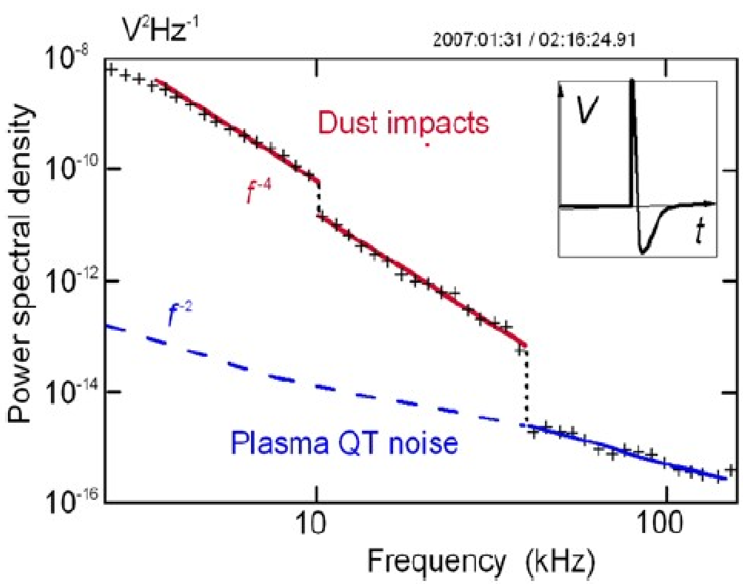
In agreement with numerical calculations

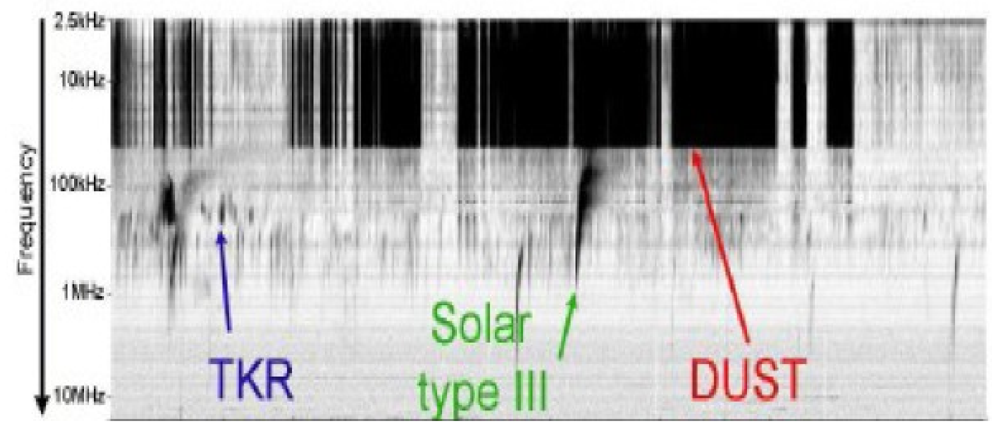
Perturbation of radio observations below 100 kHz



Rise time ~ 10 µs

=> f ~ f^-4 until ~ 100 kHz





Conclusions

• It is possible to use antennas as fast dust detectors with accurate results in the ~0.3μm size range.

• The results in the ~10nm range need some calibration effort

• **High velocity dust would be observed by radio antennas installed on the Moon**

=> simple geometry (compared to spacecraft based observation) would enable the study of the poorly known nano-dust population

=> can perturbate radio measurements at very low frequencies