SIMULATIONS OF AN INSTRUMENTAL EFFECT ON WIND OBSERVATIONS

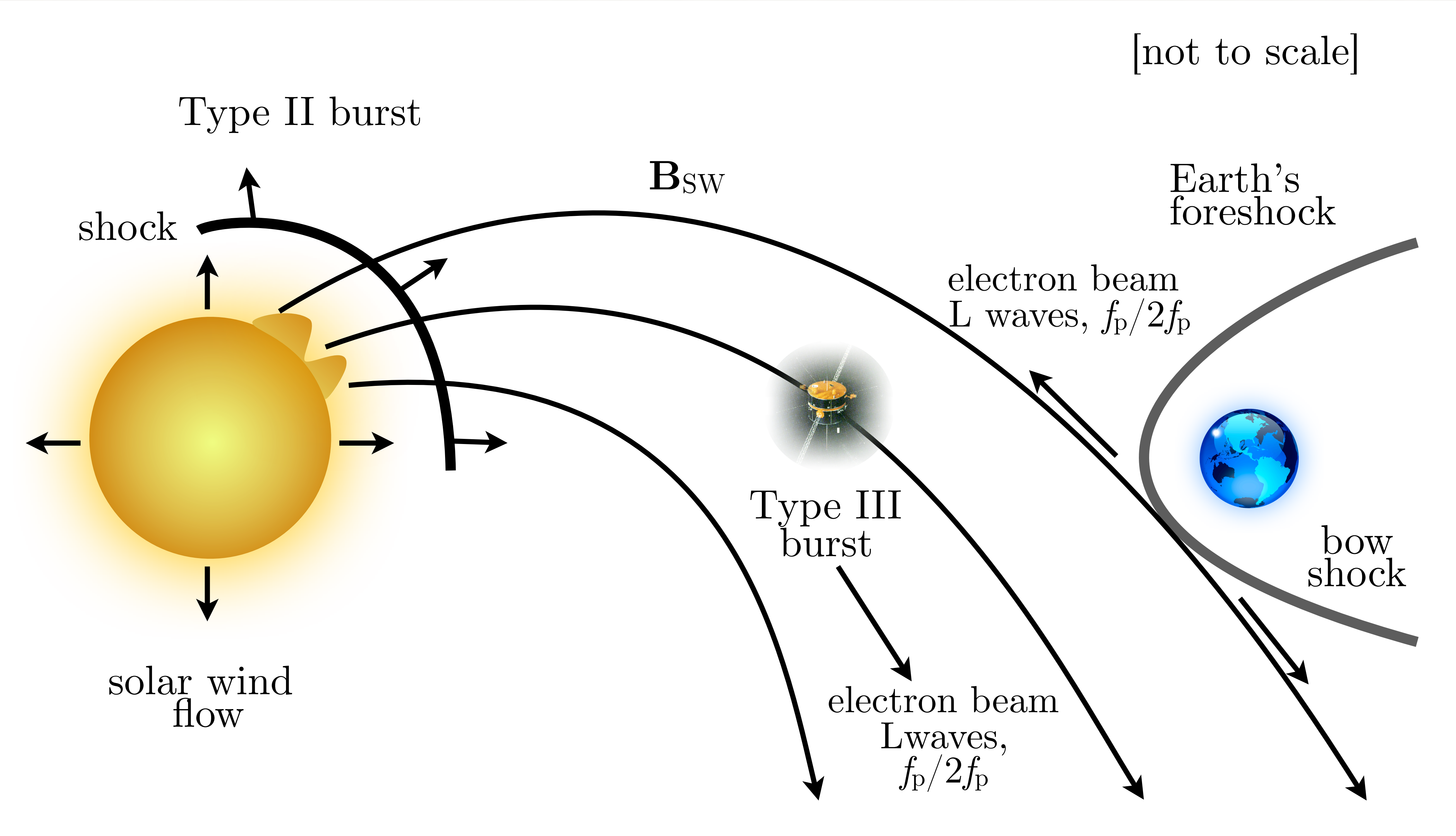
Sonja VIDOJEVIC[1], Arnaud ZASLAVSKY[2], Milan MAKSIMOVIC[2], Olga ATANACKOVIC[3], Milan DRAZIC[3]

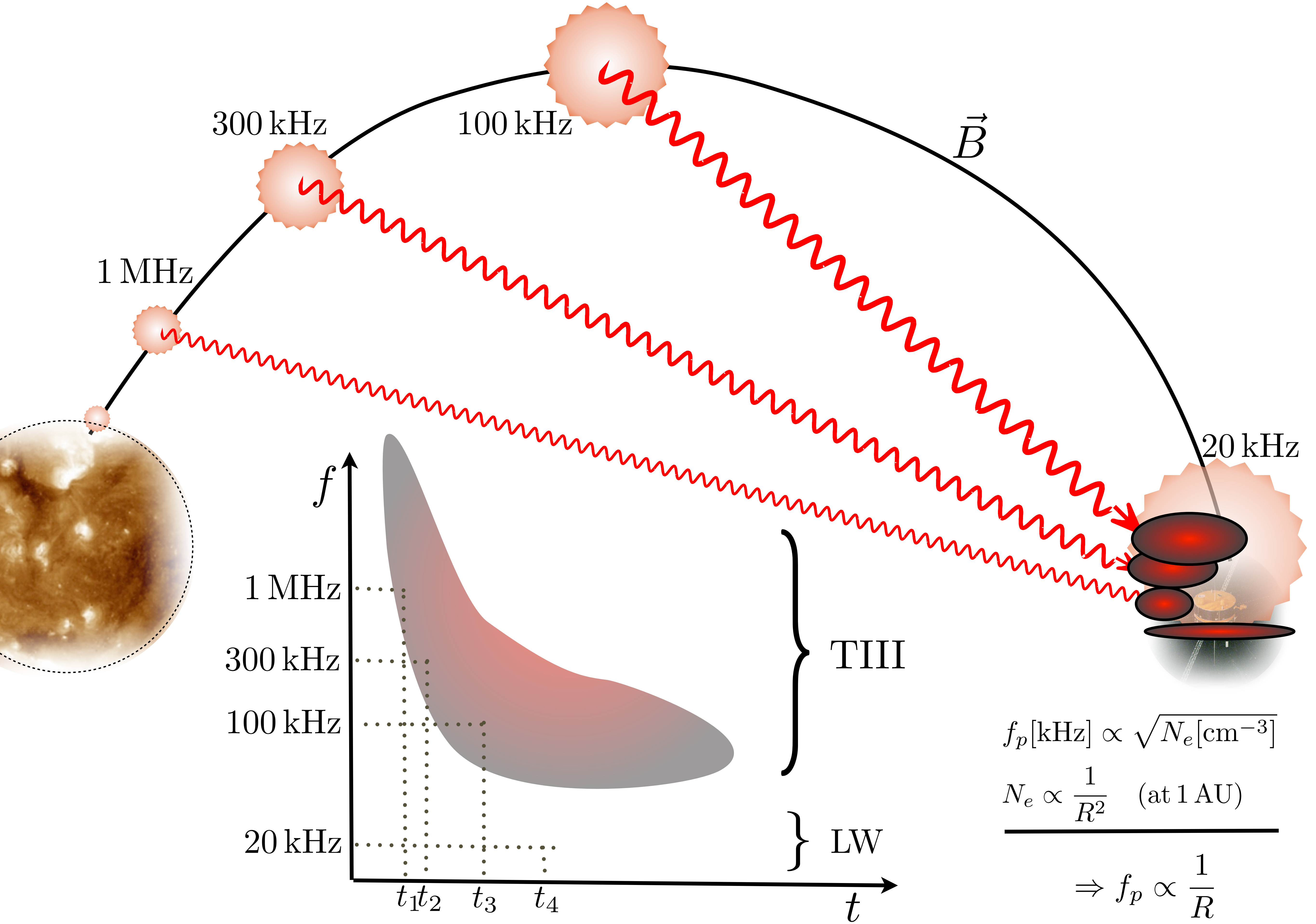
[1]IHIS techno-experts, Belgrade, Serbia
[2]Observatoire de Paris, France
[3]Faculty of Mathematics, Belgrade, Serbia

E-mails: sonja@matf.bg.ac.rs, arnaud.zaslavsky@obspm.fr, milan.maksimovic@obspm.fr, olga@matf.bg.ac.rs, mdrazic@matf.bg.ac.rs

IX Bulgarian-Serbian Astronomical Conference: Astroinformatics, 1-4 July, 2014, Sofia, Bulgaria

Beam - LW - T III


[not to scale]
Type II burst
shock
$\mathbf{B}_{\mathrm{SW}}$
Earth's foreshock
electron beam
L waves, $f_p/2f_p$
Type III burst
bow shock
solar wind flow
electron beam
Lwaves,
$f_p/2f_p$



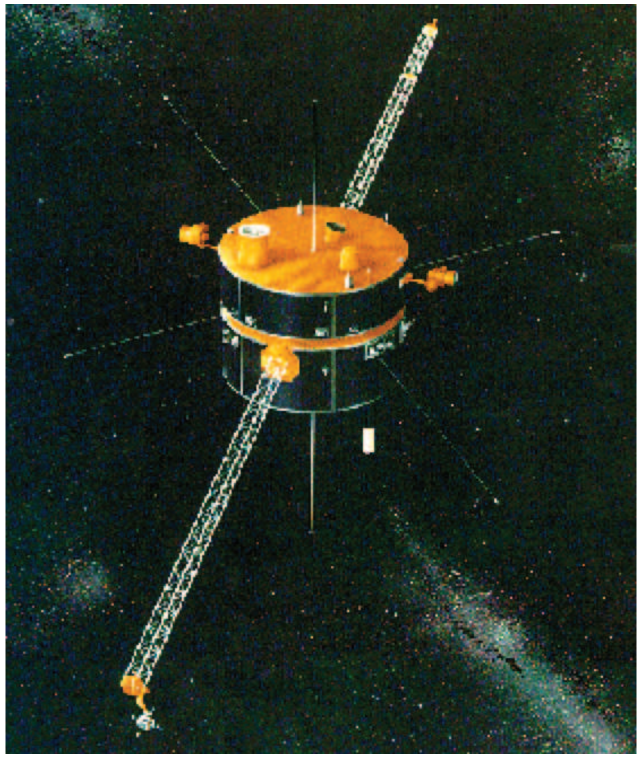
300 kHz
100 kHz
$\vec{B}$
1 MHz
20 kHz
f
1 MHz
300 kHz
100 kHz
20 kHz
TIII
LW
t_1 t_2 t_3 t_4
t
$f_p[\mathrm{kHz}] \propto \sqrt{N_e[\mathrm{cm}^{-3}]}$
$N_e \propto \frac{1}{R^2}$ (at 1 AU)
$\Rightarrow f_p \propto \frac{1}{R}$

Data Set

WIND spacecraft

- Langmuir waves – TNR[a]
- Type III bursts – RAD1, RAD2[b]
- Electron beam – 3DP[c]
- (Magnetic field – MFI[d])
- (Solar wind velocity – SWE[e])

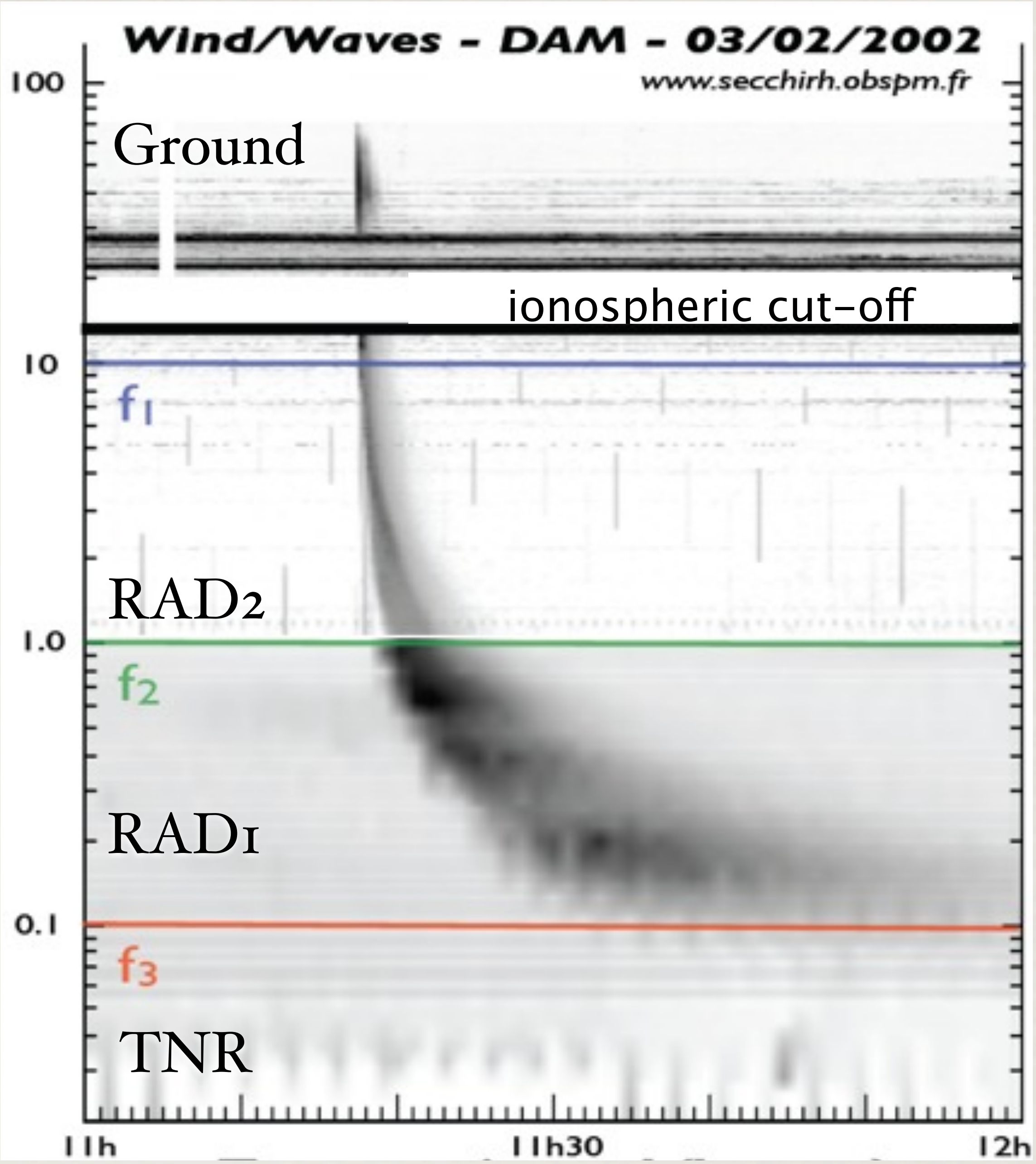
[a] Bougeret et al, 1995
[b] Bougeret et al, 1995
[c] Lin et al, 1995
[d] Lepping et al, 1995
[e] Ogilvie et al, 1995



- TDS data from STEREO S/Waves experiment[1]

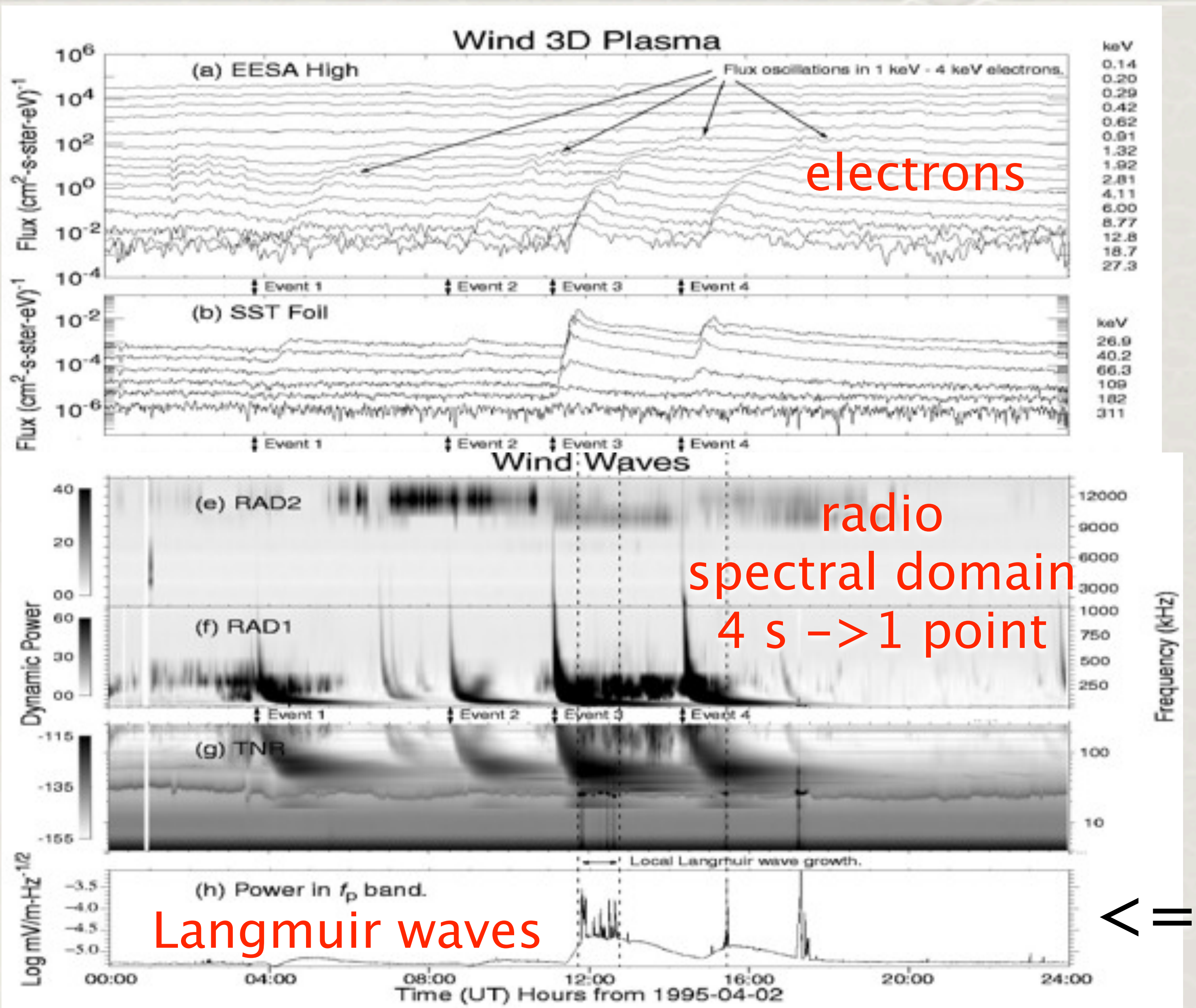
[1] Bougeret et al, 2008

What we see

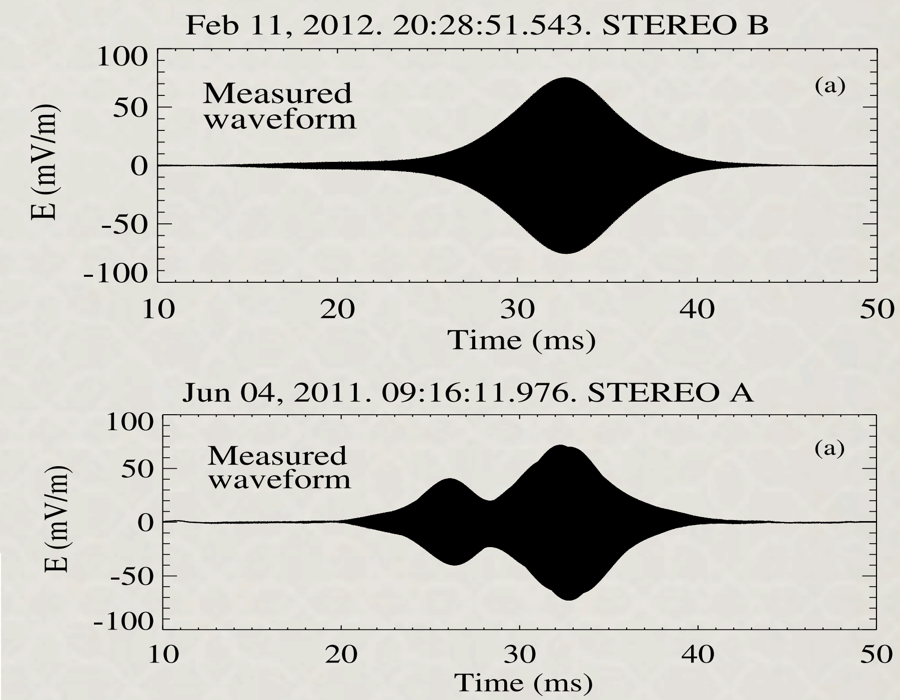


- Short (sec → hrs) & very intense (→10^{-14} $Wm^{-2}Hz^{-1}$) radio emissions;
- Emission frequencies decrease rapidly (GHz → kHz);
- Emission at fundamental f_p or at harmonic of f_p;
- Often associated with solar flares;
- Associated with the propagation of electrons supra-thermal (c/10 → c/3);

e⁻ Beam - LW - T III



Ergun et al, 1998 (Wind)



LW wave packets (TDS)

temporal waveform

~ 60 per day,

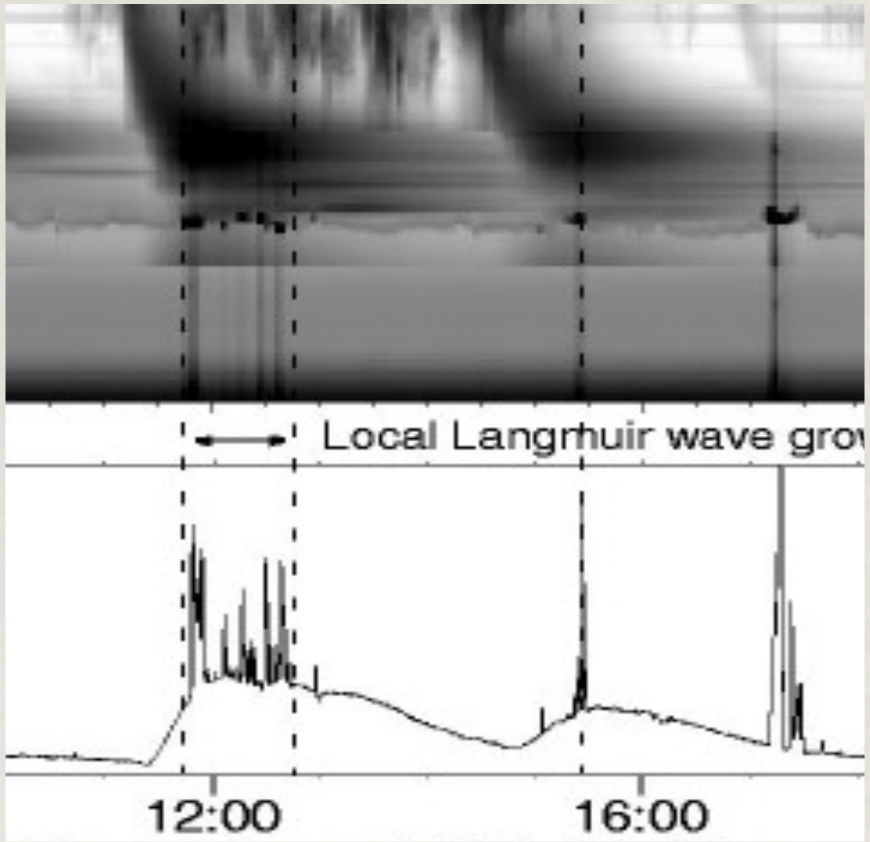
telemetry limitation!

<=
$$P_{LW}(t) = \frac{1}{(\Gamma L_{\mathrm{eff}})^2} \int_{f_1}^{f_2} S(f,t)\,\mathrm{d}f,$$

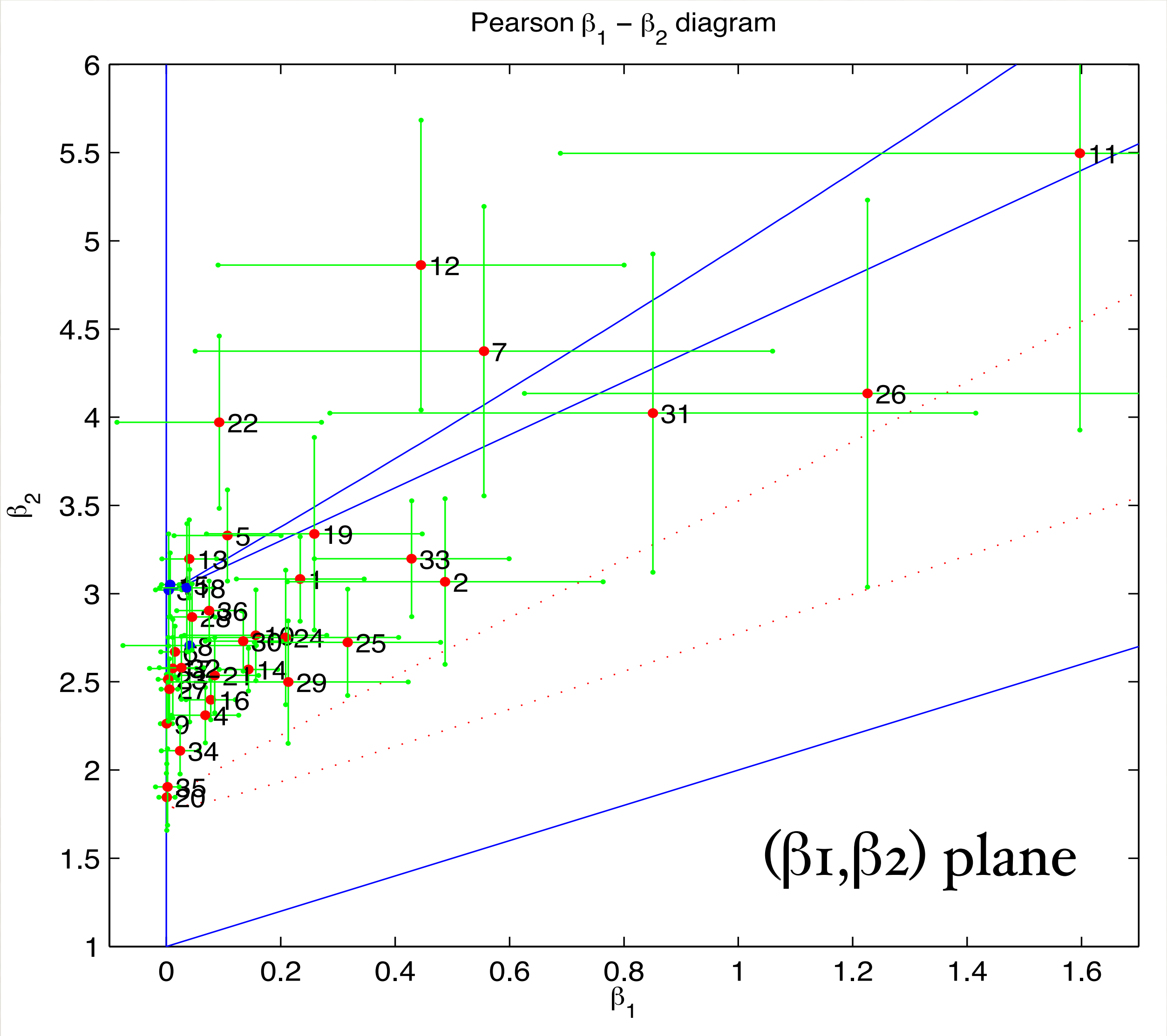
$f_1 < f_p < f_2$

LW in Spectral Domain

36 events:
beam + LW + T III



=>



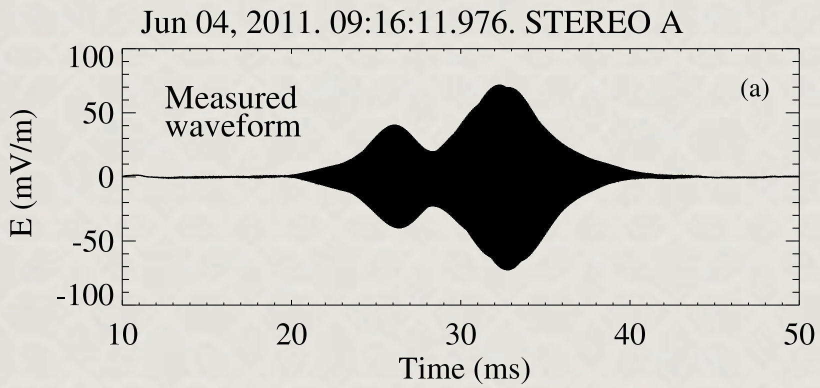
LW distribution in spectral domain is Pearson type I !

... what about the LW distribution in Temporal domain?

TNR & TDS limitations

NOT ENOUGH TELEMETRY!

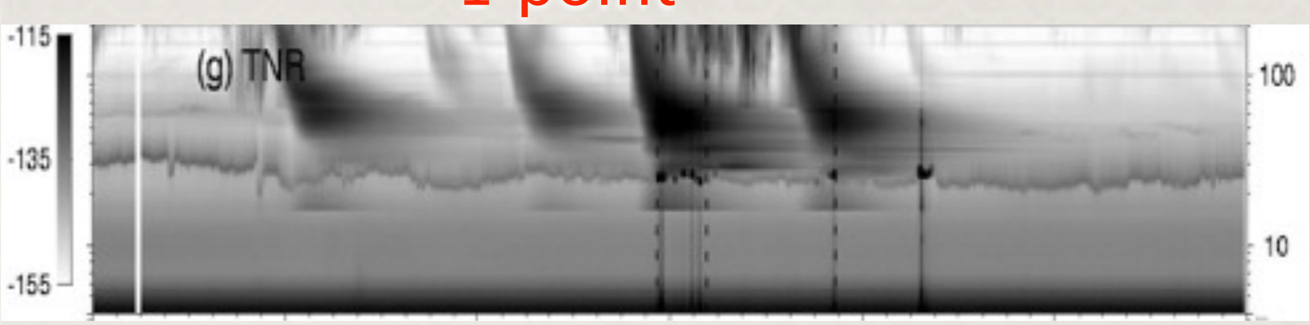
TNR: 4 s of data in temporal domain => 1 point in spectral domain



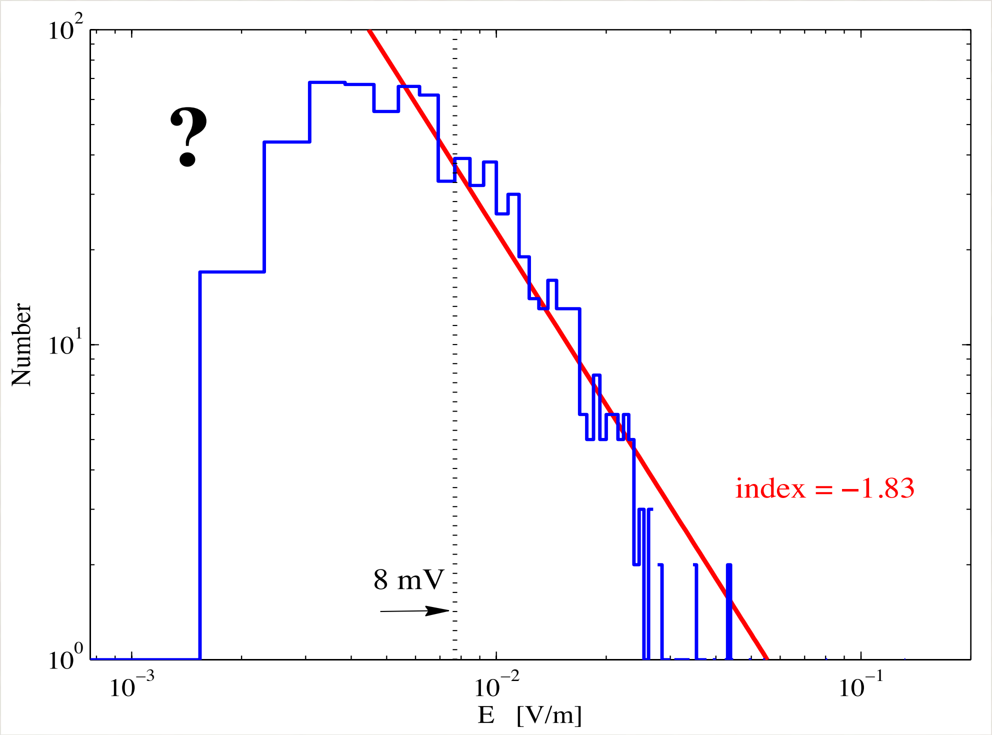
4s

⇓

1 point



TDS: selection criteria - max amplitude => amplitude distribution at lower values unknown



LW Distribution in Temporal Domain?

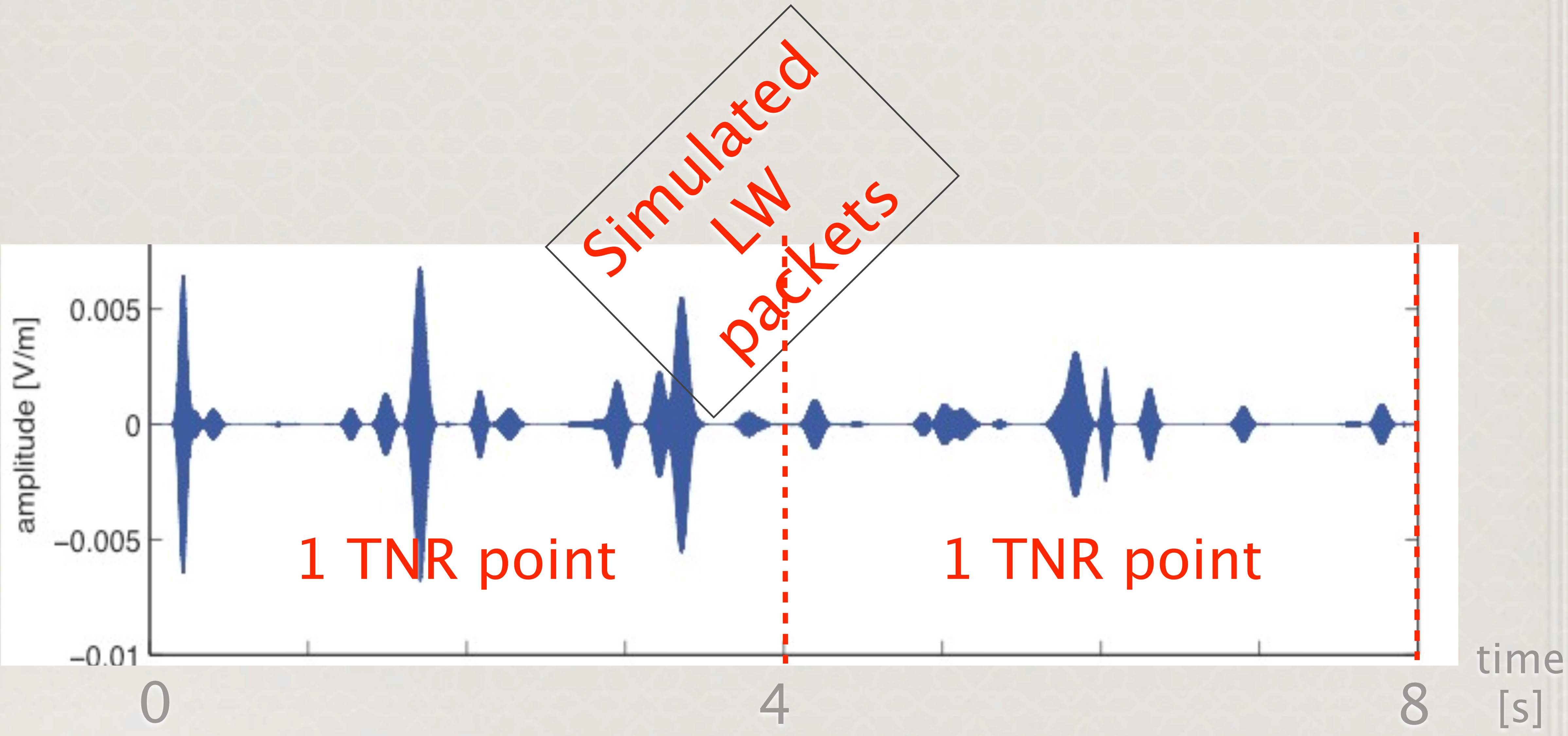
1) How many LW packets in 1 second we have?
λ = 0.1, 1, 5, or 10?
2) What is distribution of LW amplitudes?
Normal, Pearson or power-law?

GOALS:

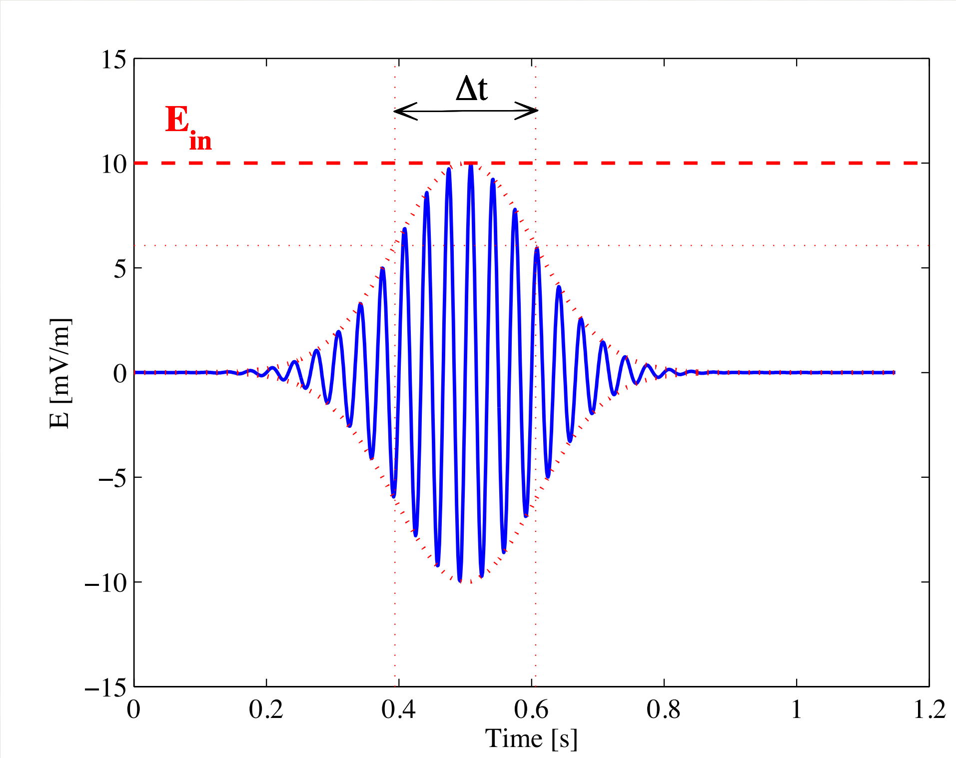
1) to estimate number of LW packets per second (λ)

2) to find distribution of LW amplitudes?

Numerical Simulations



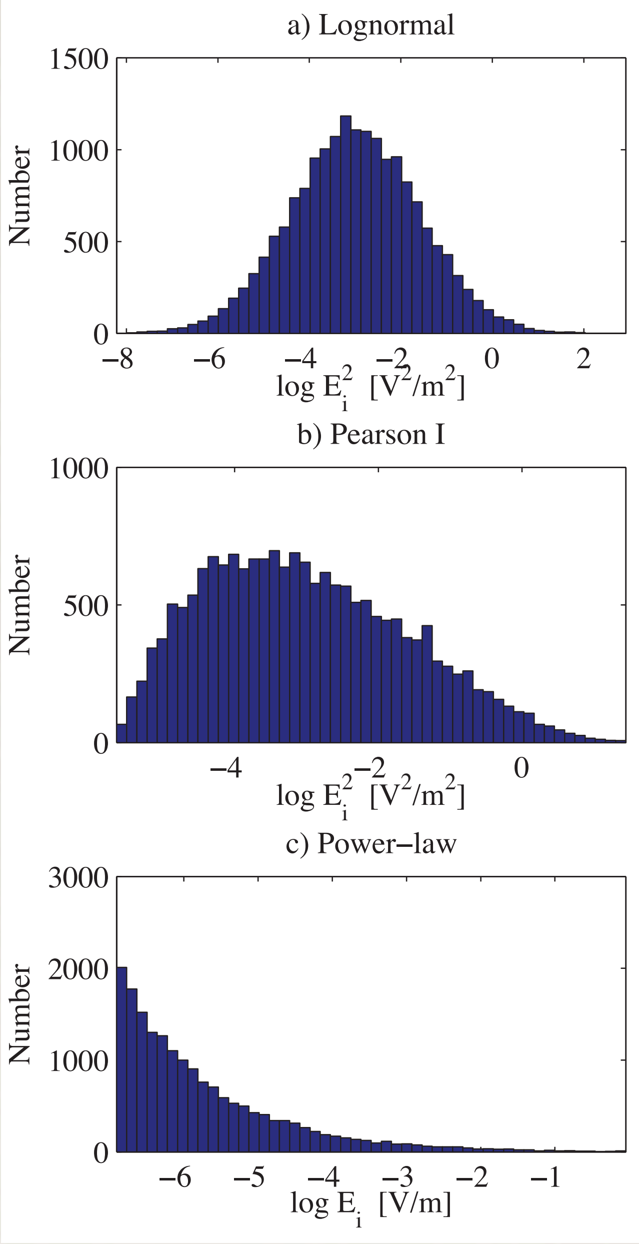
LW packet



Input distributions:
1) amplitudes
2) starting time
3) duration
4) frequency
5) phase

$$E(t) = \sum_{i=1}^{N} E_i e^{-(t-t_{0i})^2/2\Delta t_i^2} \cos\left(2\pi f_{pi} t + \varphi_i\right)$$

LW amplitude distribution

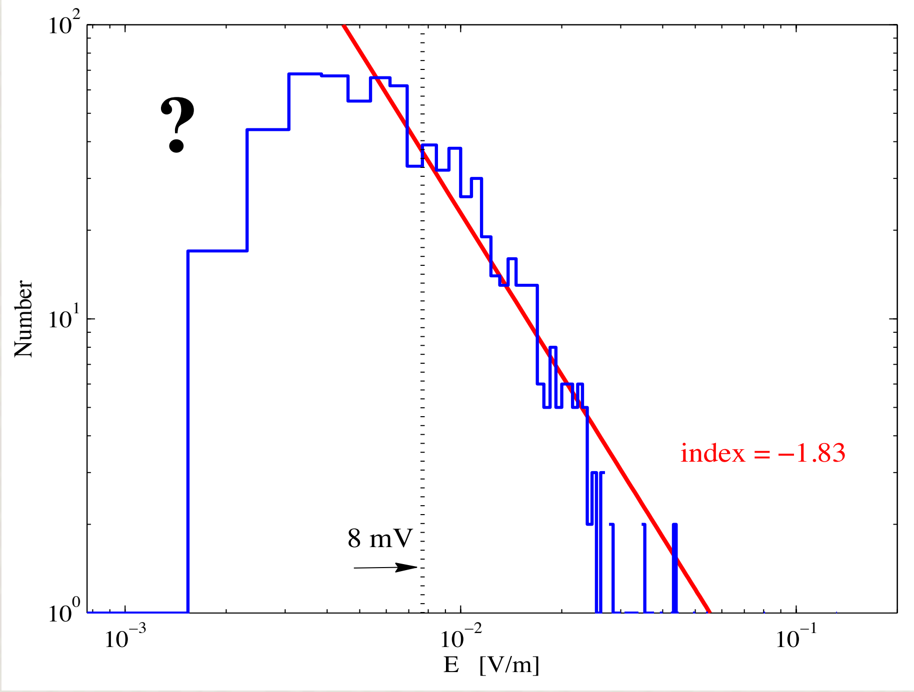


$$\mathcal{N}(\log E_i^2 | m, \sigma^2)$$

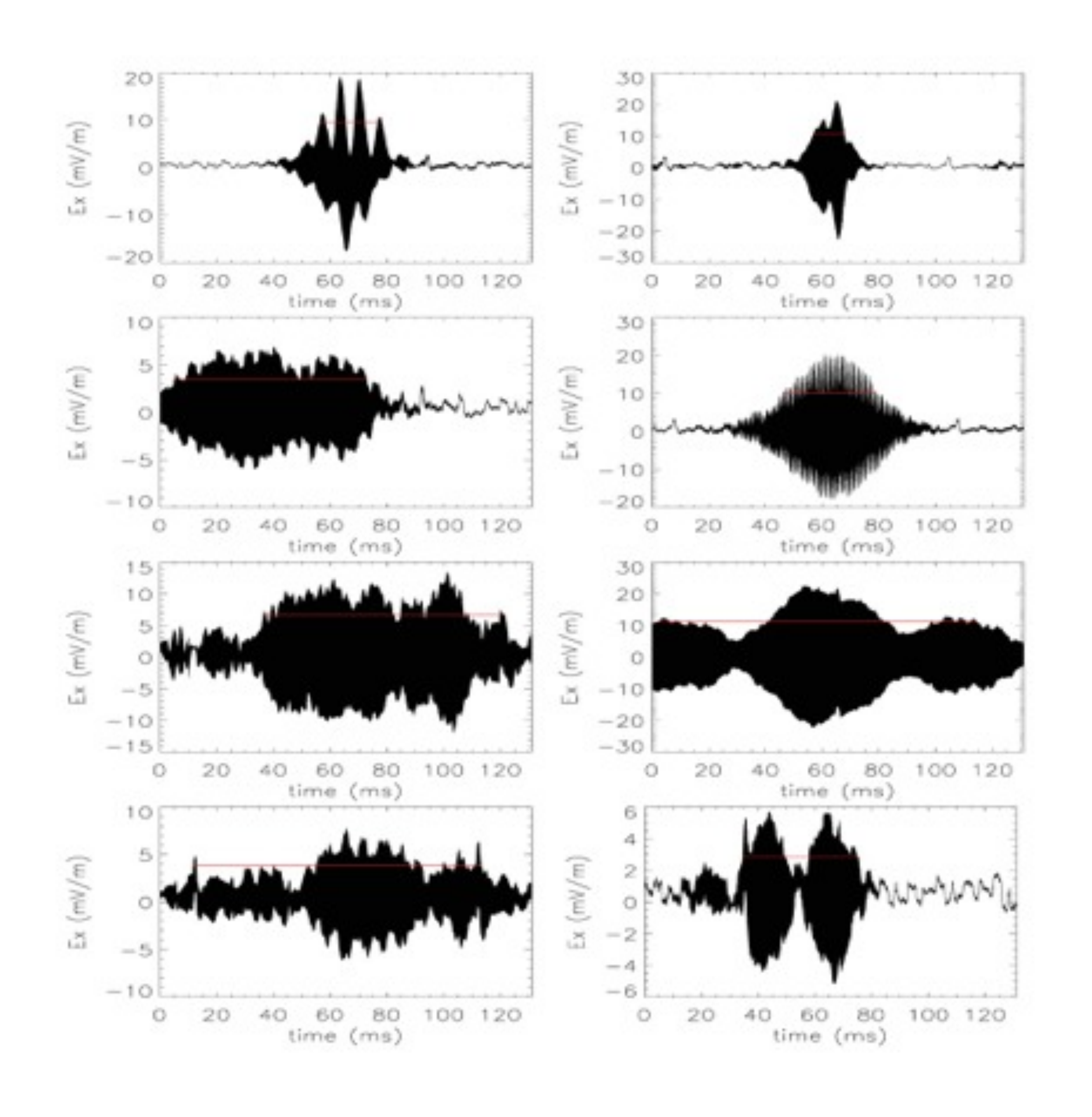
$$\mathcal{P}^I(\log E_i^2 | m, \sigma^2, \mathrm{sk}, \mathrm{kur})$$

$$\mathcal{P}_{\mathcal{L}}(E_i | \beta)$$

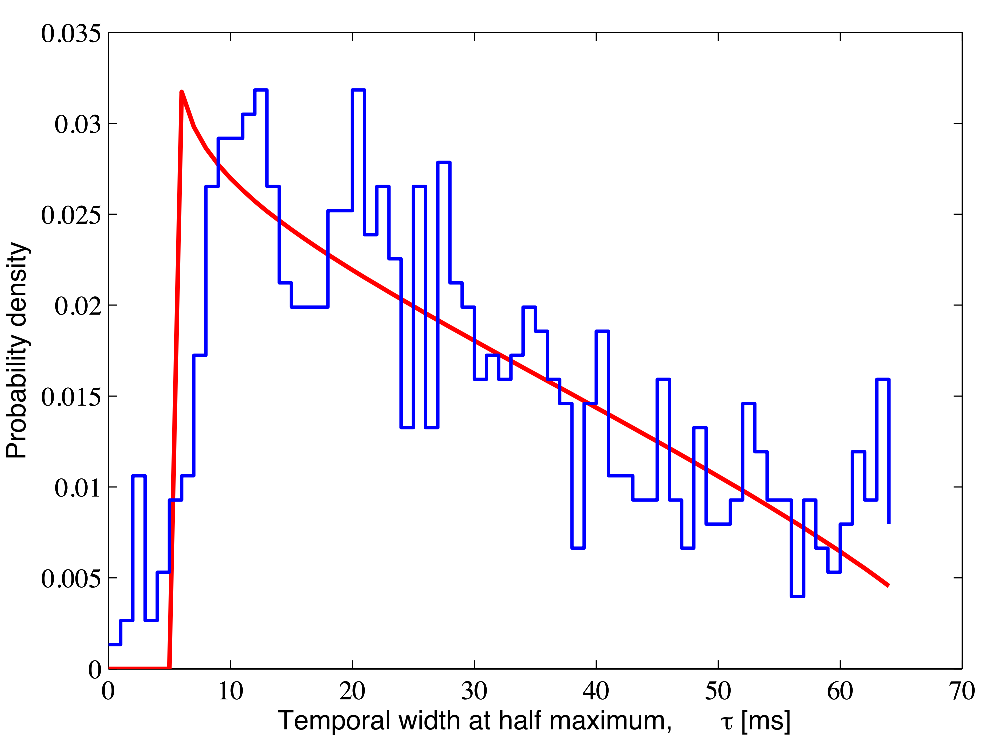
STEREO data



Temporal Width



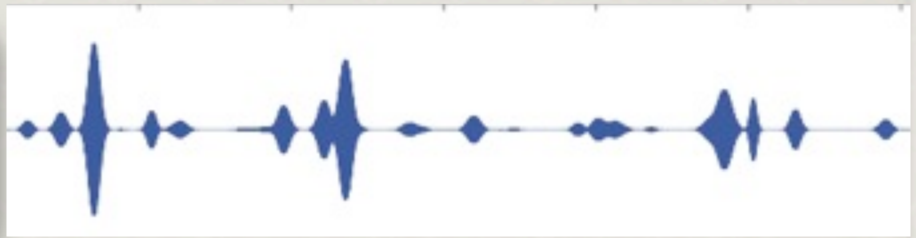
STEREO data



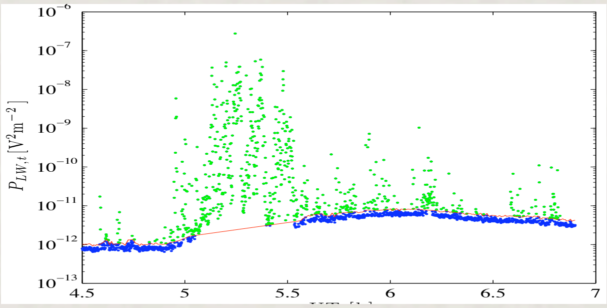
$$\mathcal{P}^I(\log E_i^2 | m, \sigma^2, \mathrm{sk}, \mathrm{kur})$$

Simulation Procedure

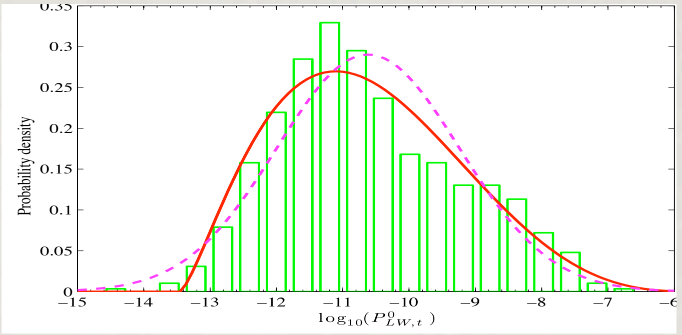
1. 36 periods of 30 min of input data



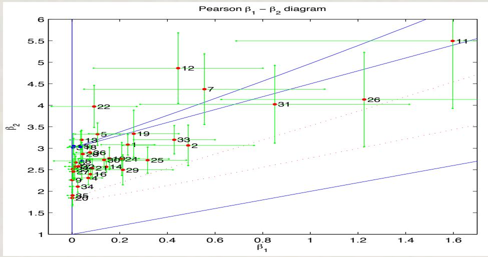
2. 4 s integration time + wavelet-like trans. (the same as at WIND/TNR)



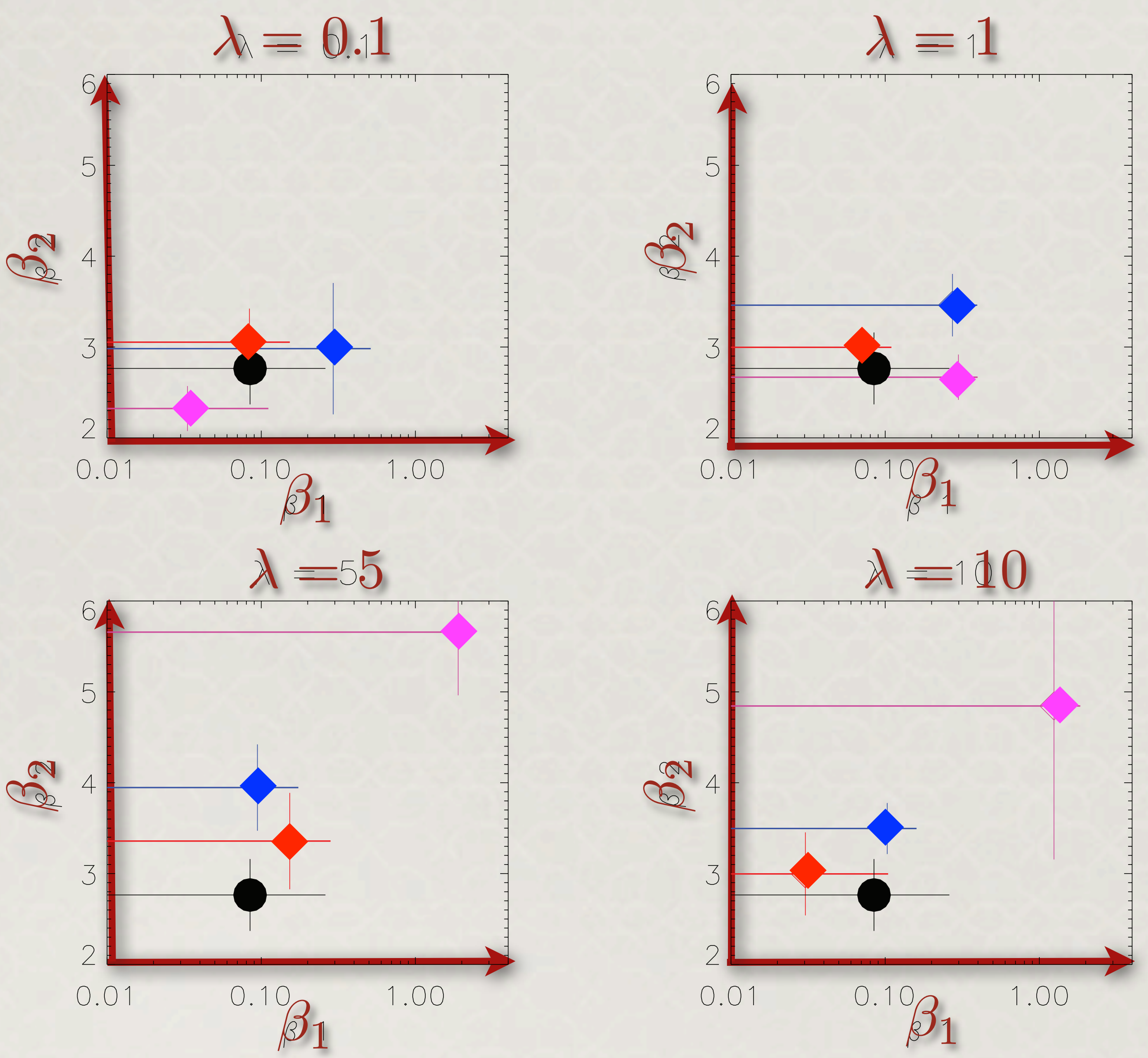
3. From simulated data => LW power => fit with Pearson distributions



4. Calculate β_1, β_2 => medians 36 β_1, β_2



Simulations & Observations Comparison



Medians of β_1, β_2

OBSERVATIONS:

- 36 Wind events

SIMULATIONS (ampl. distr.):

- Normal
- Pearson I
- Power law

Conclusions

1. The shape of the input distributions is rather Pearson I or normal than a power law;
2. The average of parameter λ (number of Langmuir wave packets in 1 s) over 30 min is comprised between 0.1 and 1;
3. The input Langmuir wave packet amplitudes are about $5 \times 10^{-3} \mathrm{V\,m^{-1}}$.