Type III Solar Radio Burst Directivity : Wind/Stereo observations

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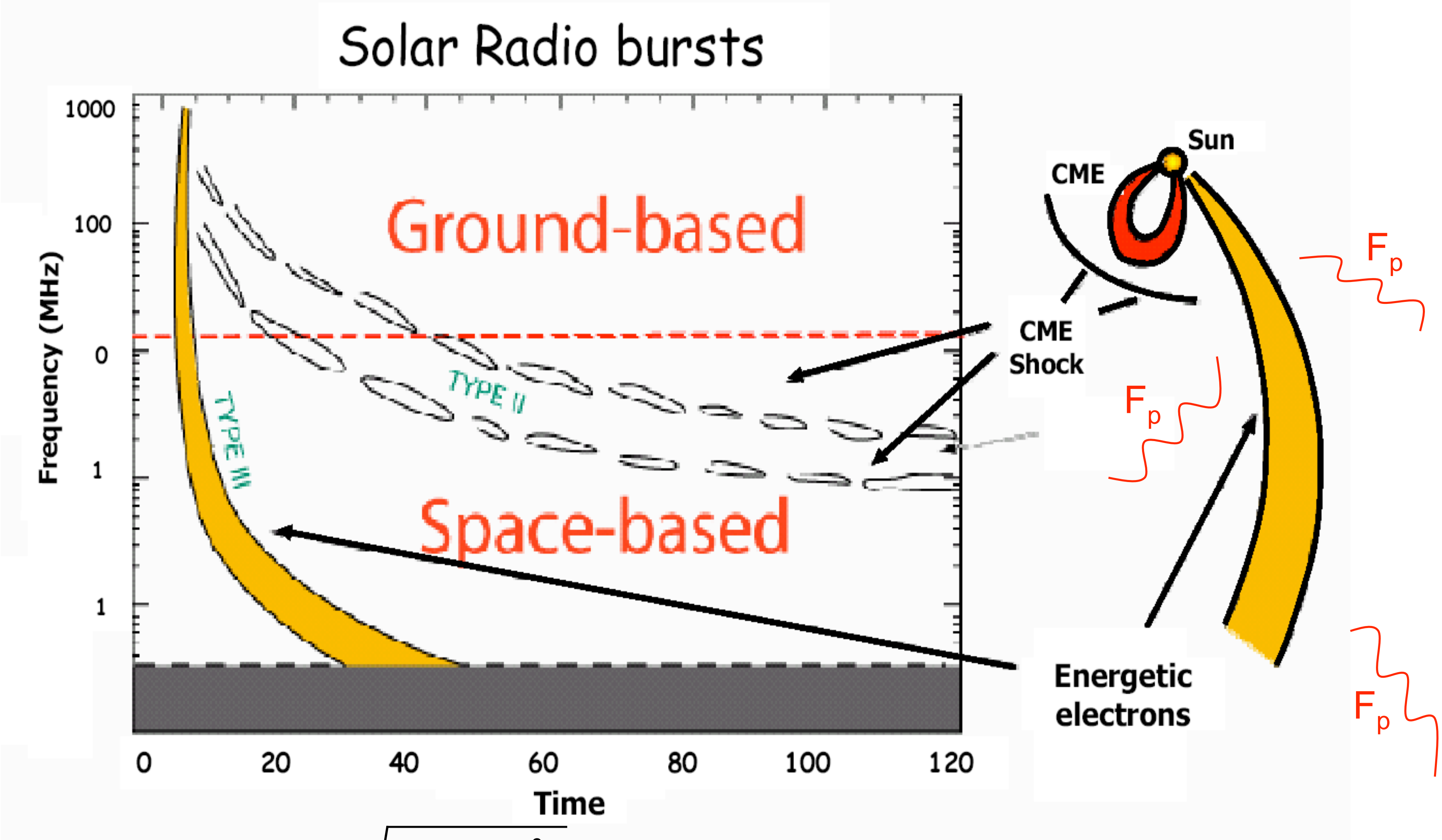
Outline

1. Type III solar radio bursts
2. S/Waves HFR calibration
3. Observations
4. Radiation pattern
5. Radio Energy
6. Summary

Type III Solar Radio Burst

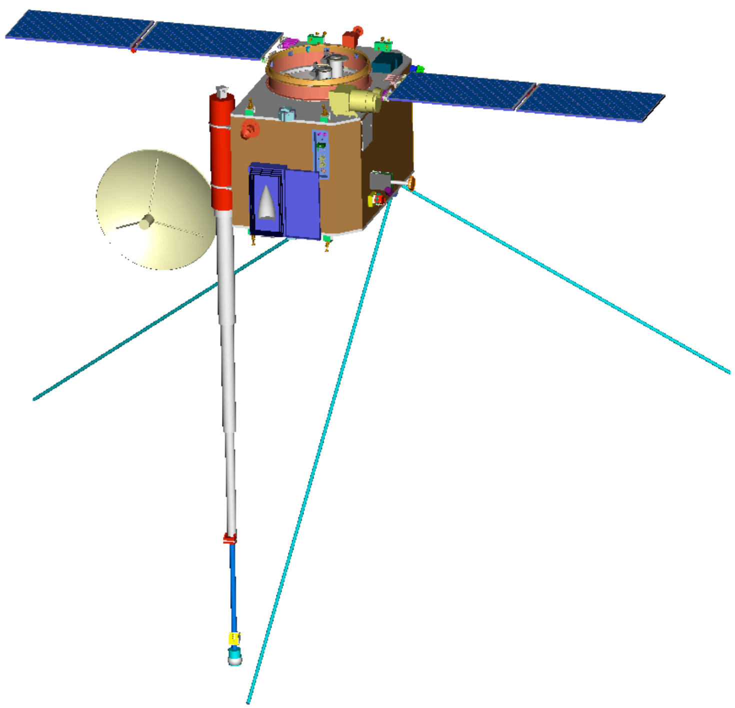


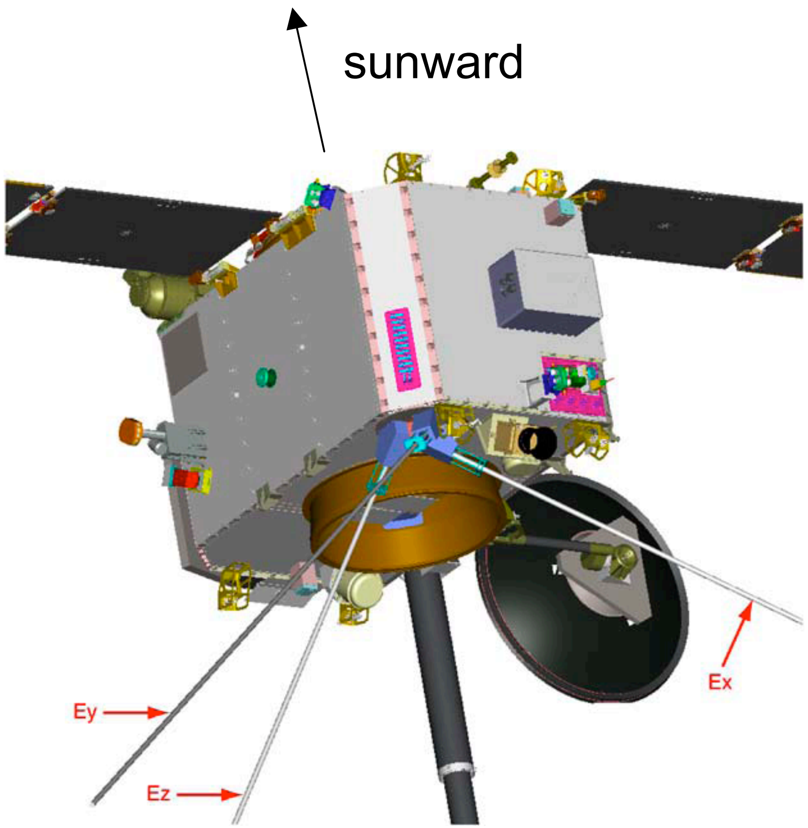
$$F_p(\text{kHz}) = 9\sqrt{N_e(\text{cm}^{-3})}$$

$$\rightarrow F_p \propto 1/\text{R}$$

Radio emission at Fp (Fundamental)
And/or 2Fp (Harmonic)

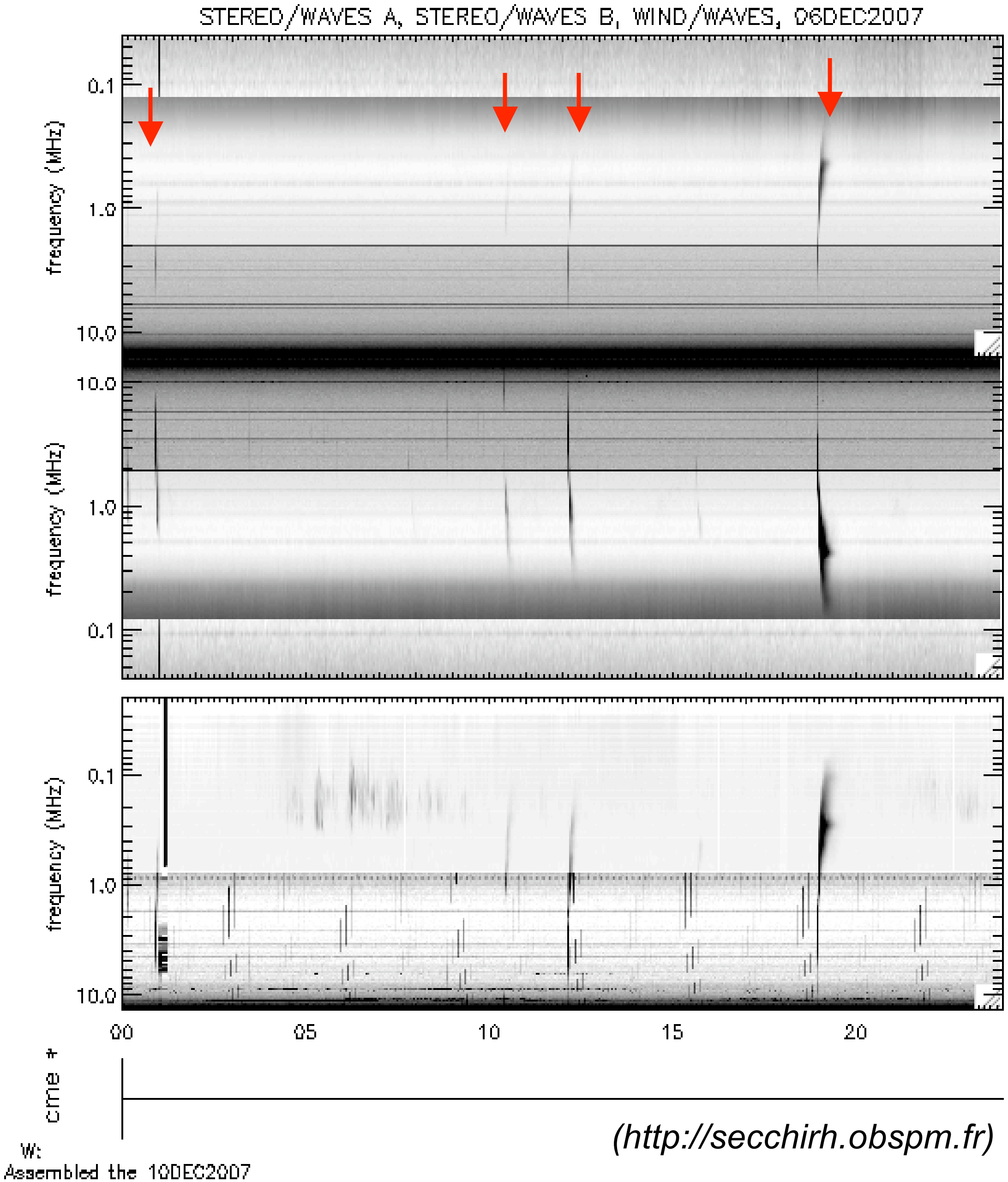
The S/Waves instrument





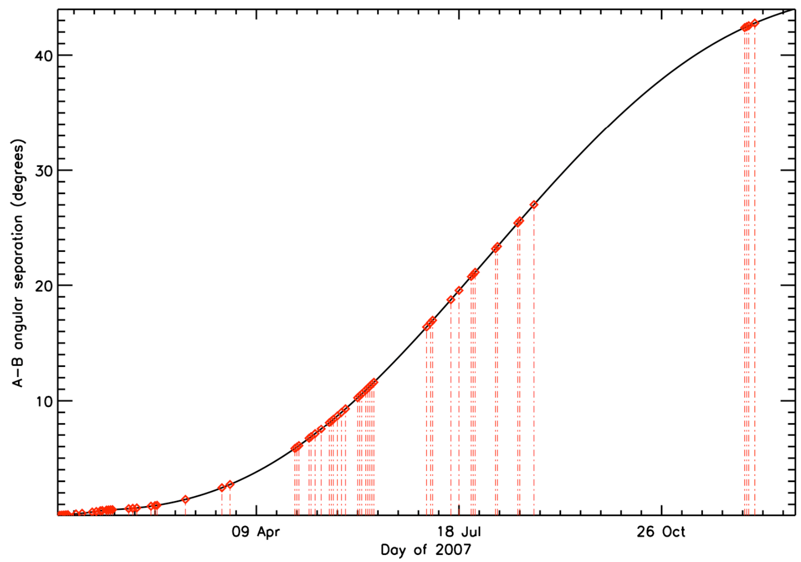
- **Fixed Frequency Receiver (FFR)** : 30 or 32 MHz
- **High Frequency Receivers (HFR1 and HFR2)** 125-16025 kHz
- **Low Frequency Receiver (LFR)** : 2-160 kHz

Observations



(http://secchirh.obspm.fr)

- **~120 type III bursts simultaneously observed by STEREO A, B and Wind spacecraft during 2007.**
- **Separation angle A with B ~ 0° to 40°**

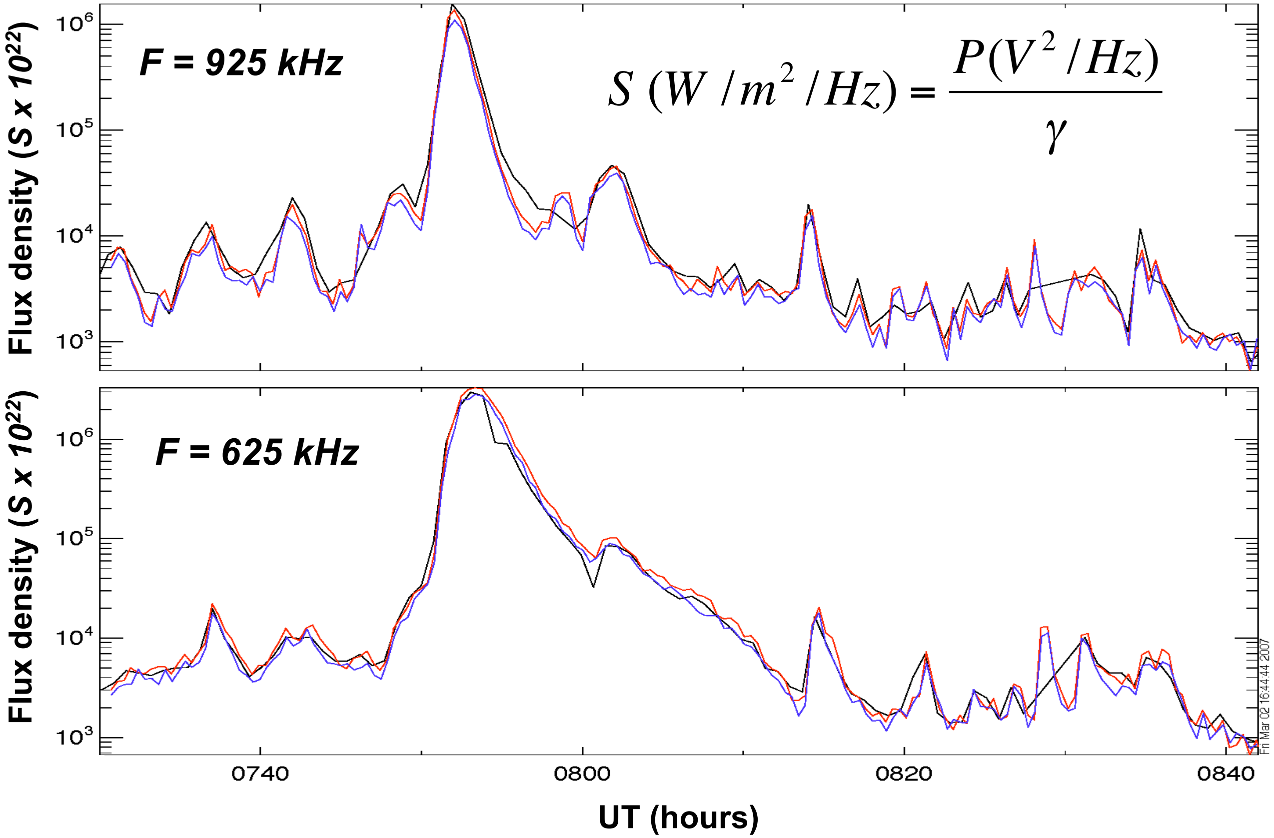


Some very quiet periods

Comparison with Wind/WAVES data

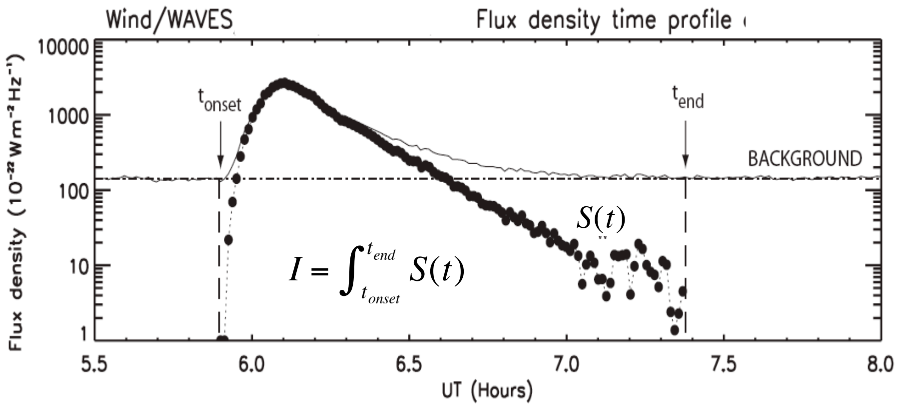
At the beginning of 2007 ➔ Wind, Stereo A & B at the Earth ➔ $S_W \approx S_A \approx S_B$

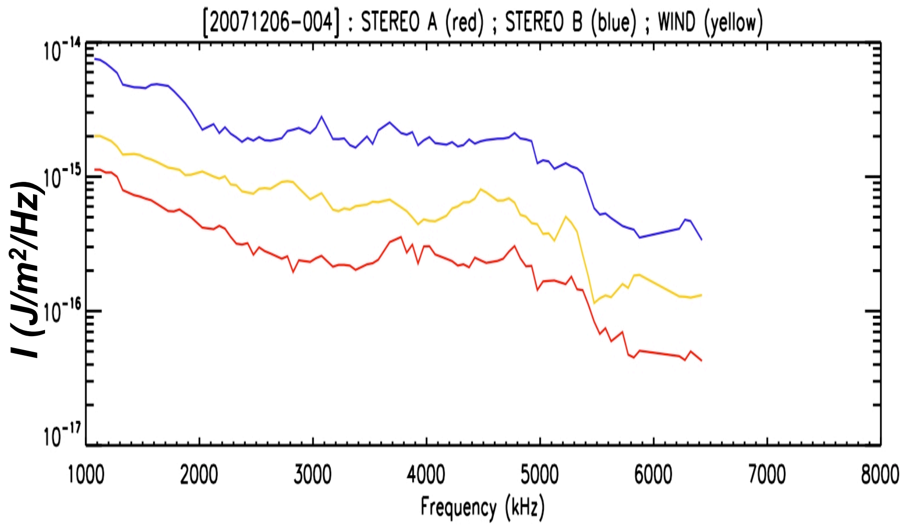
Stereo A (Red), Stereo B (Blue), Wind (Black), 925kHz and 625kHz. Independent Calibrations



No significant intensity variation until July 2008

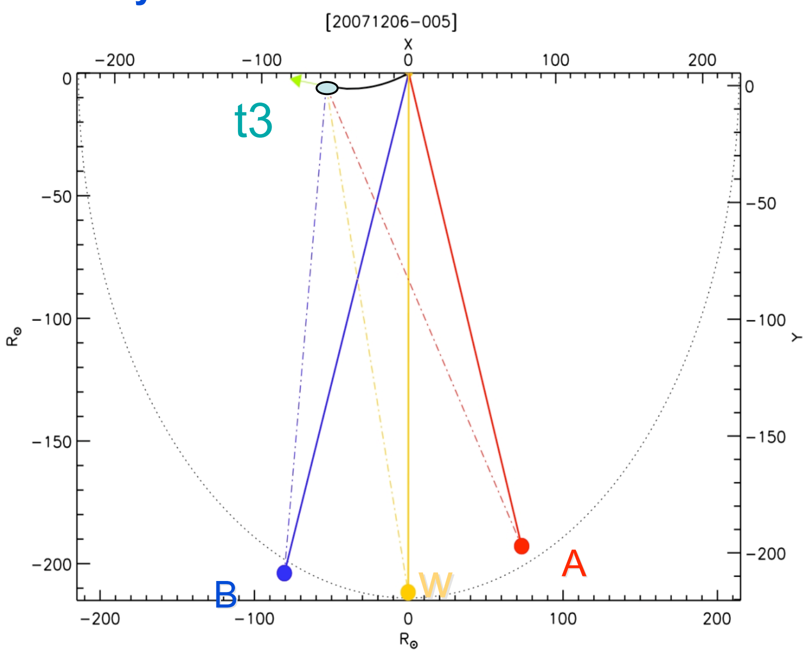
Directivity evidence

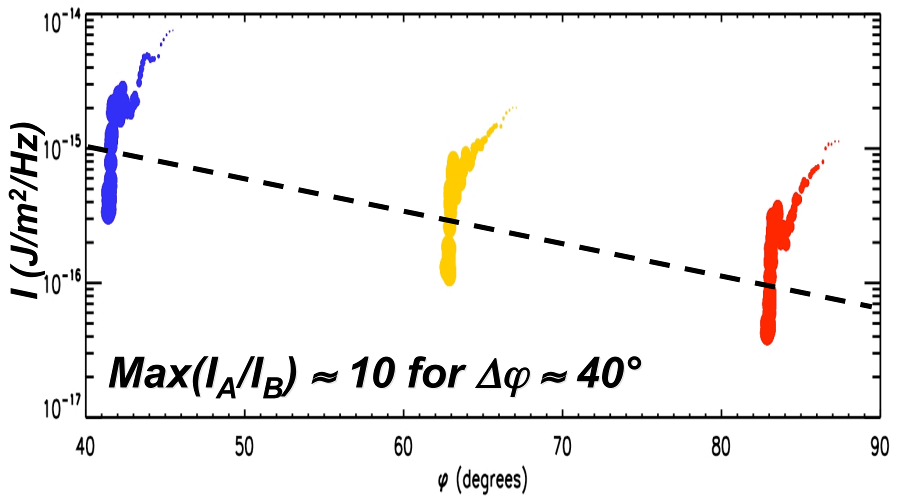




Type III source position determination :

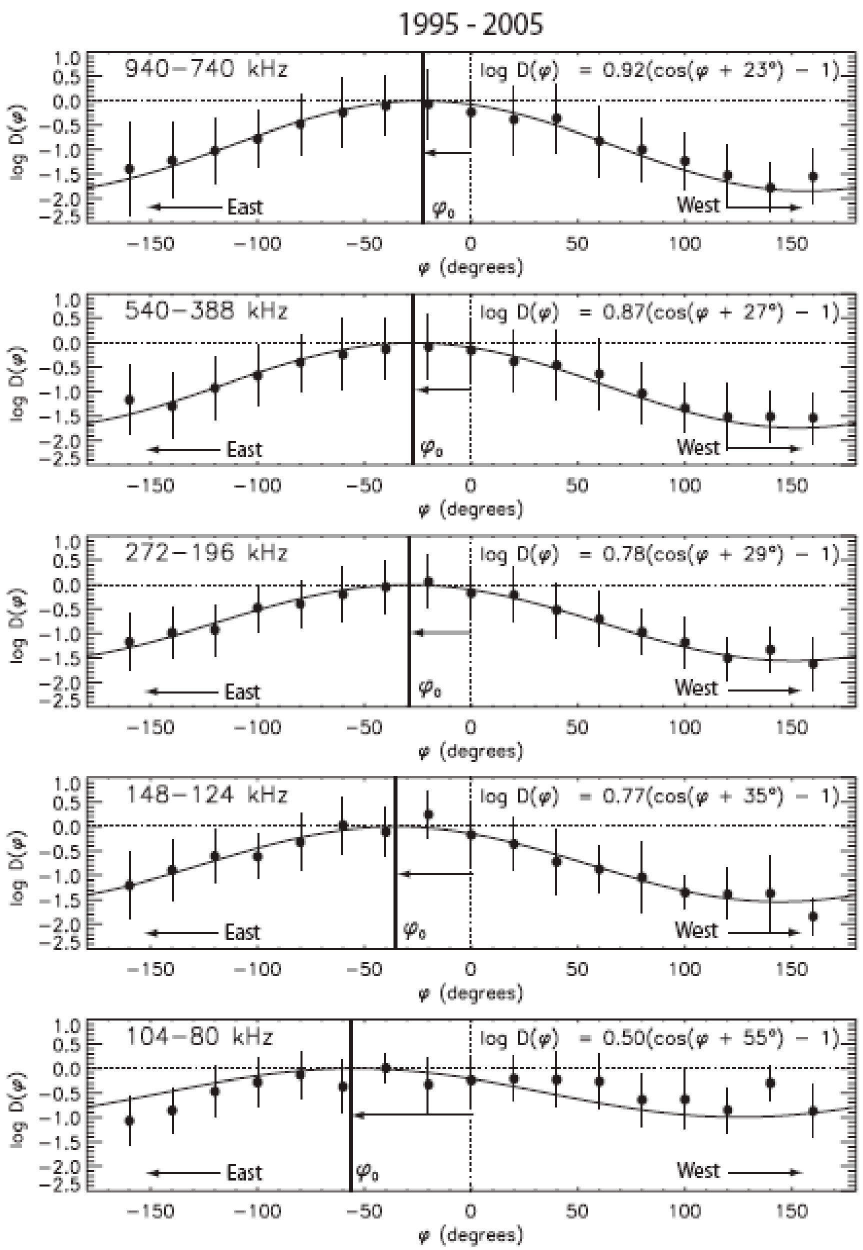
1. **Associated active region (flares,Nancay)**
2. **Spiral-like open magnetic field line**
3. **Density model**





Need more statistics and larger angular separation between spacecraft to perform accurate radiation diagram determination.

Radiation Diagram



Type III directivity study below ~ 1MHz using Wind/Ulysses observations during full solar cycle 23.

(Bonnin et al. , A&A, Accepted)

Longitudinal diagram :

- **Eastern shift of diagram axis :**
  - **$\varphi_0 \sim -23°$ at f ~ 800 kHz**
  - **$\varphi_0 \sim -55°$ at f ~ 100 kHz**

- **Large diagram aperture :**
  - **$\Delta\varphi_2 \sim 96°$ at f ~800 kHz**
  - **$\Delta\varphi_2 \sim 124°$ at f ~100 kHz**

Latitudinal diagram :

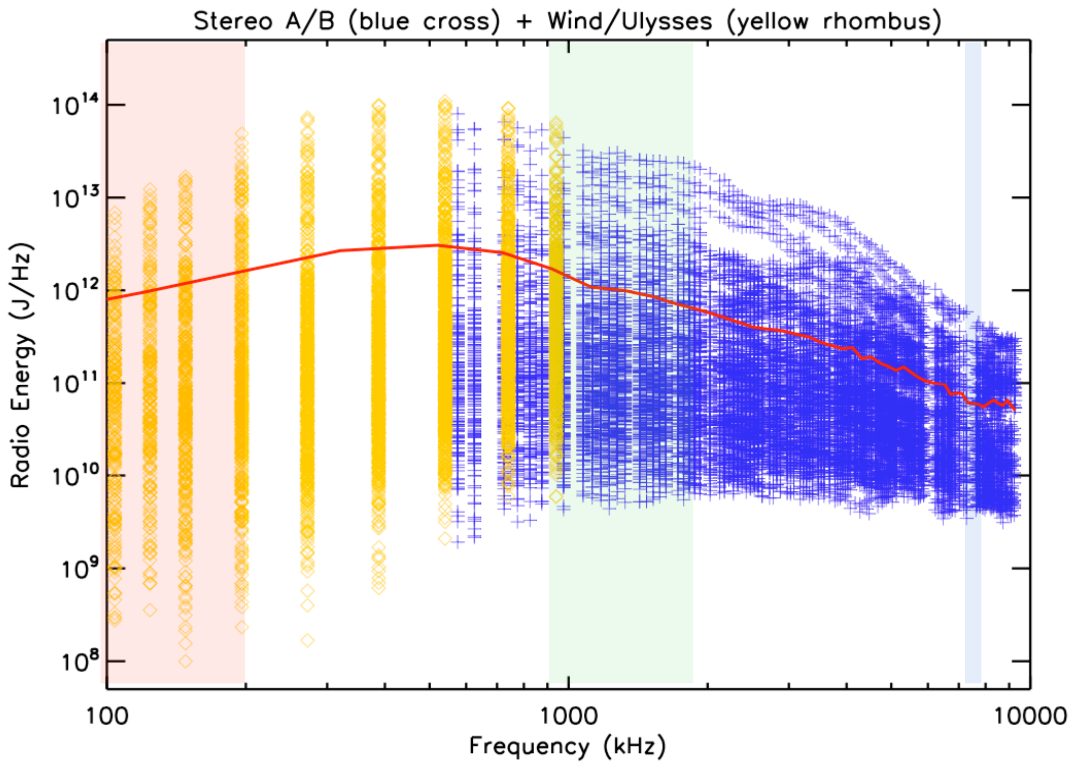
- **No correlation with longitudinal directivity.**
- **Weak directivity effects.**

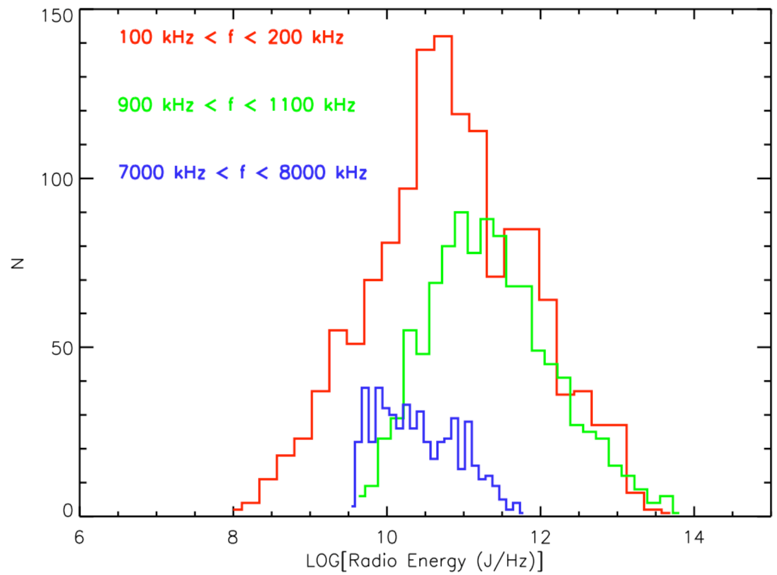
Radio Energy

$$E_R(f) = \int_{4\pi} E(f)\,d\Omega \quad \text{with} \quad E(f) = \frac{1}{D(\varphi,\theta)} \int_{t_{onset}}^{t_{end}} S(t,f,\varphi,\theta)\,d^2\,dt$$

Correction from diagram contribution

Total energy corrected from distance to the source





Using $D(\varphi,\theta)$ (Bonnin et al.) *Extrapolation*

- Energy Peak (?)
- Dispersion in energy when frequency decreases (?)

BUT …

- !! Fundamental + Harmonic
- !! Radio energy losses by propagation effects

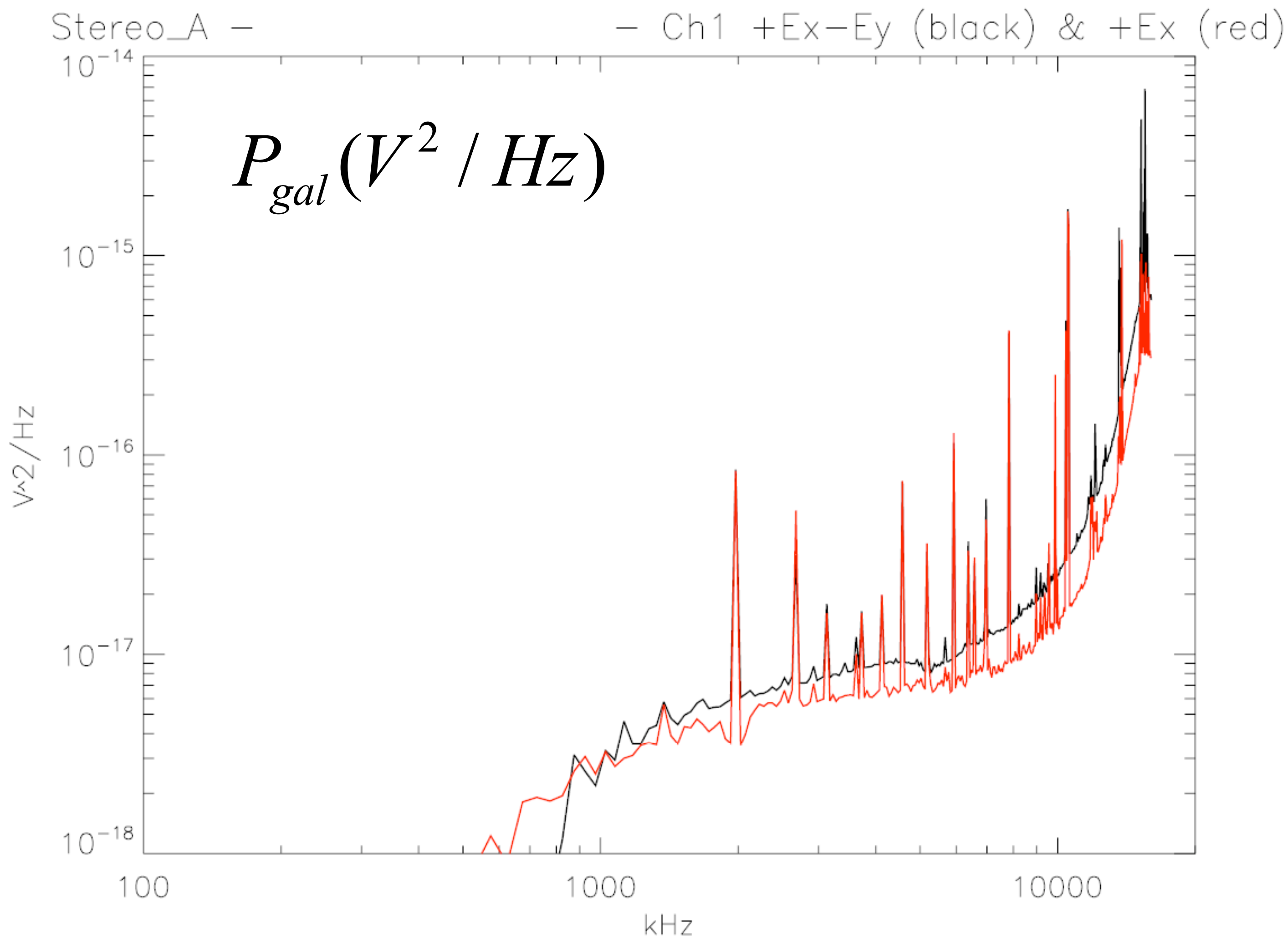
Summary

- S/WAVES HFR data in good agreement with well calibrated WIND/Waves data.
- We begin to observe directivity effects but …
  - Need more statistics and larger angular separation between spacecraft to get Radiation diagram.
- However using diagram extrapolation, we are able to extract preliminary values of type III radio energy.
  - Energy Peak
  - Energy dispersion with frequency

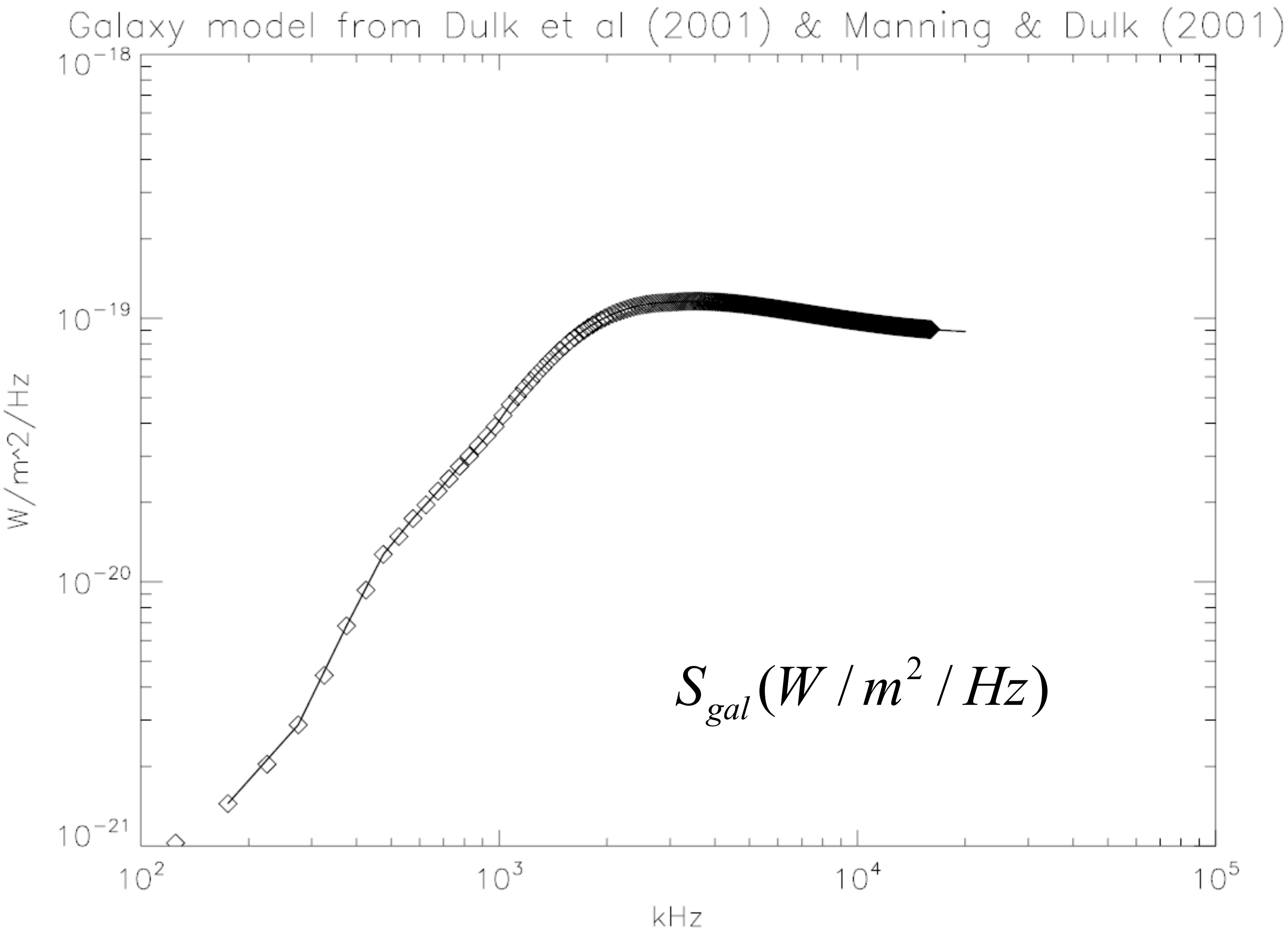
Thank you

Calibration of High Frequency Receivers (HF1 & HF2)

Receiver background + shot noise removed → Galaxy (+ antenna resonance)



Galaxy model



Calibration

$$S_{galaxy}(W/m^2/Hz) = \frac{P_{galaxy}(V^2/Hz)}{\boxed{Z_0 L_{eff}^2 \left(\frac{c_a}{c_a + c_b}\right)^2}}$$

Antenna gain γ