In-flight antenna calibration for Direction-Finding with STEREO/Waves

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Direction-Finding with STEREO/Waves

- STEREO/Waves: 3 antennas, 2 channels
- DF data samples: DF0, DF1 and DF2
  - DF0: 2 antennas [1 instantaneous measurement]
    (2 auto+1 complex cross = 4 measurements)
  - DF1: 3 antennas [2 successive measurements with antenna switching]
    (3 auto+2 complex cross = 7 measurements)
  - DF2: 3 antenna [3 successive measurements with antenna switching]
    (3 auto+3 complex cross = 9 measurements) → Full information
- DF = computing instantaneous source parameters
  S, Q, U, V, θ, φ (and possibly γ, source size) : 6 (7) unknowns
  - *available:* instantaneous analytical DF inversions for unresolved sources (or γ>5°)
    with DF0 or DF1 or DF2 measurements.
  - DF inversion with γ as an output in preparation.

STEREO/Waves VS Cassini/RPWS/HFR

- Cassini/RPWS/HFR: DF0 and DF1 but no DF2

- Cassini: main source of noise: 8 bits data coding (~20 dB noise !)
- STEREO: 12 bits data coding. Noise = 1/16 of Cassini.

- DF accuracy on Cassini:
  - only direction (1 probe)
  - 1° on directions, 10% on polarization degrees and 1db on flux
    IF: SNR>30dB and angular selection β>20°
    (with $\beta \equiv$ elevation over the antenna planes)

- Excepted accuracy on STEREO: at least identical.
  - with digitalization noise 16 times lower.
  - complete data set on DF2 mode.
  - position (stereo observation)
  - extended sources: enough measurements to obtain typical size of the radio source.

In-Flight Antenna System Calibration

- In-Flight Antenna calibration necessary to do accurate DF:

  - *calibration of direction and relative length:*
    Short dipole approximation:
    DF inversions are supposing that the antenna is a electric dipole.
    ok if L≪λ (f<1.5 MHz).

    calibration is the determination of the effective electrical dipole equivalent to the monopole+satellite system.

    Reference radio source with known properties (AKR ? SURA ?).
    SURA calibration : f~8-9MHz (not good for short dipole approximation)
    Calibration at f<1.5 MHz is only possible with AKR, but only if distance STEREO/Earth > 120 R_E

  - *absolute antenna gain calibration:*

    Reference radio source (Galactic background ? SURA ? Sun (with joint observations)?)

    antenna/base capacitance and absolute effective length must be evaluated through in-flight calibration for absolute flux measurements [necessary for multi S/C analysis]

    (accuracy depending on the accuracy of the determination of the reference source.)

DF before in-flight antenna calibration ?

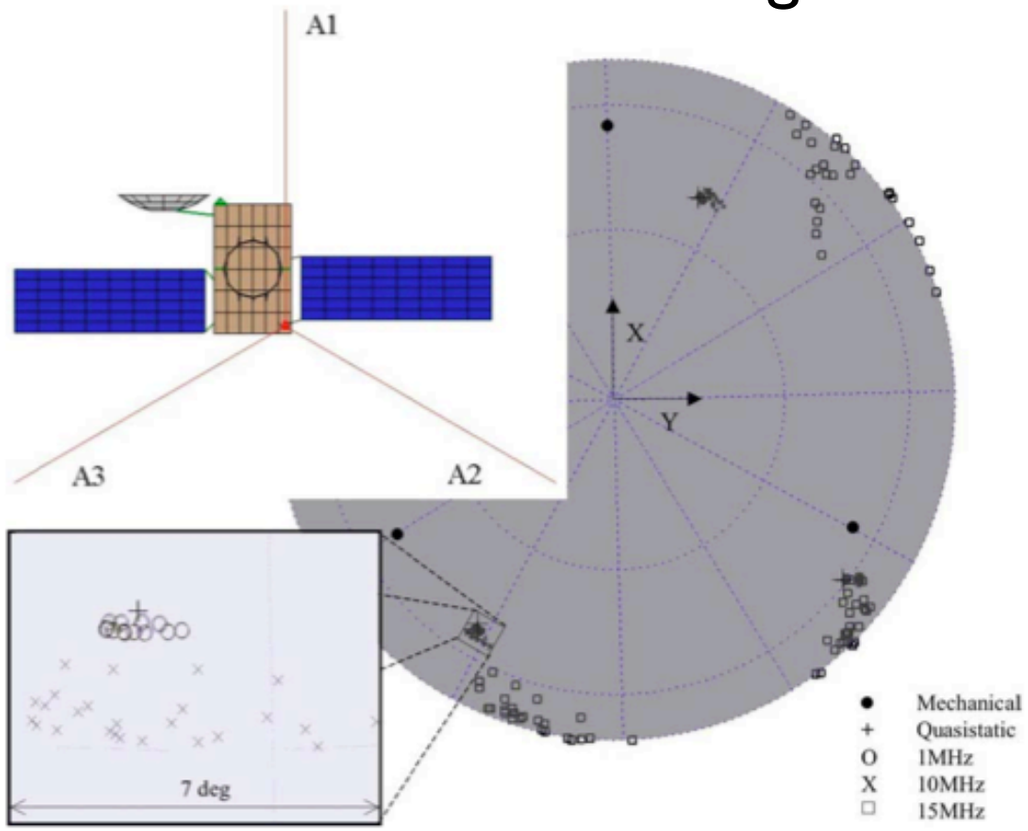
- Use antenna calibration obtained through wire-grid simulation [Rucker et al.]

- on Cassini : $\Delta\theta$ = ~7-8° from physical to calibrated
  effective antenna length ratio: +20%

- Rucker et al. *Adv. Space Res.* 2005: $\Delta\theta$ for STEREO/Waves antenna as computed through wire-grid simulation is ~10-30° !

In-flight calibration is necessary !!! but S/C rolls @ >120 R_E needed !

STEREO/Waves antenna wire-grid simulation



Cassini/RPWS/HFR antennas

	u Antenna	*v* Antenna	*w* Antenna
	Physical directions		
h/h_w	1.0	1.0	1.0
θ	107.5°	107.5°	37.0°
φ	24.8°	155.2°	90°
	wire-grid simulation (ASAP)		
h/h_w	-	-	-
θ	106.4°	106.6°	29.6°
φ	16.0°	164.2°	89.5°
	In-Flight Antenna Calibration		
h/h_w	1.21	1.19	1.0
θ	107.9°	107.6°	29.3°
φ	17.6°	164.4°	90.9°