

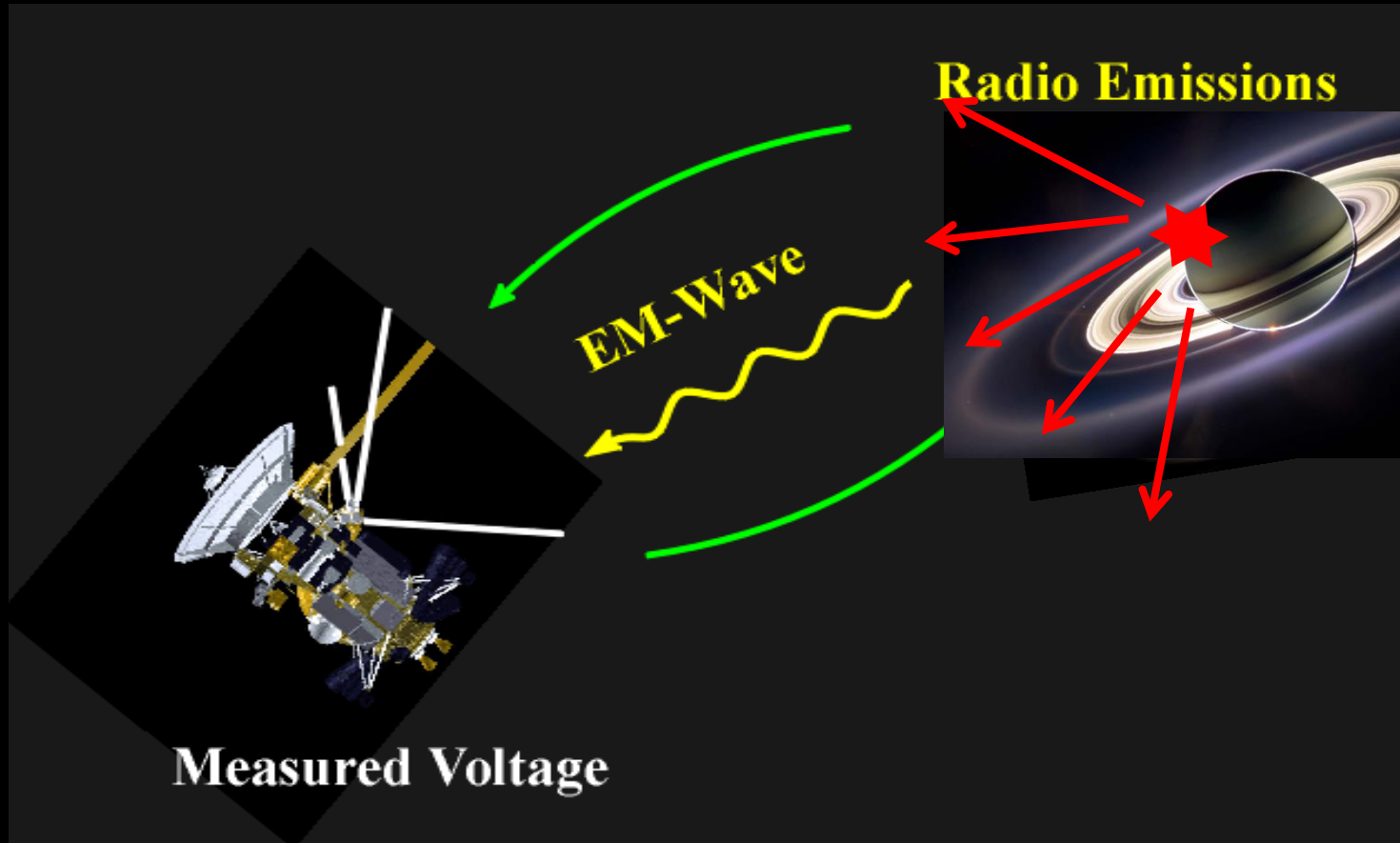
Calibration of spacecraft antennas Kalibration von Raumsonden-Antennen

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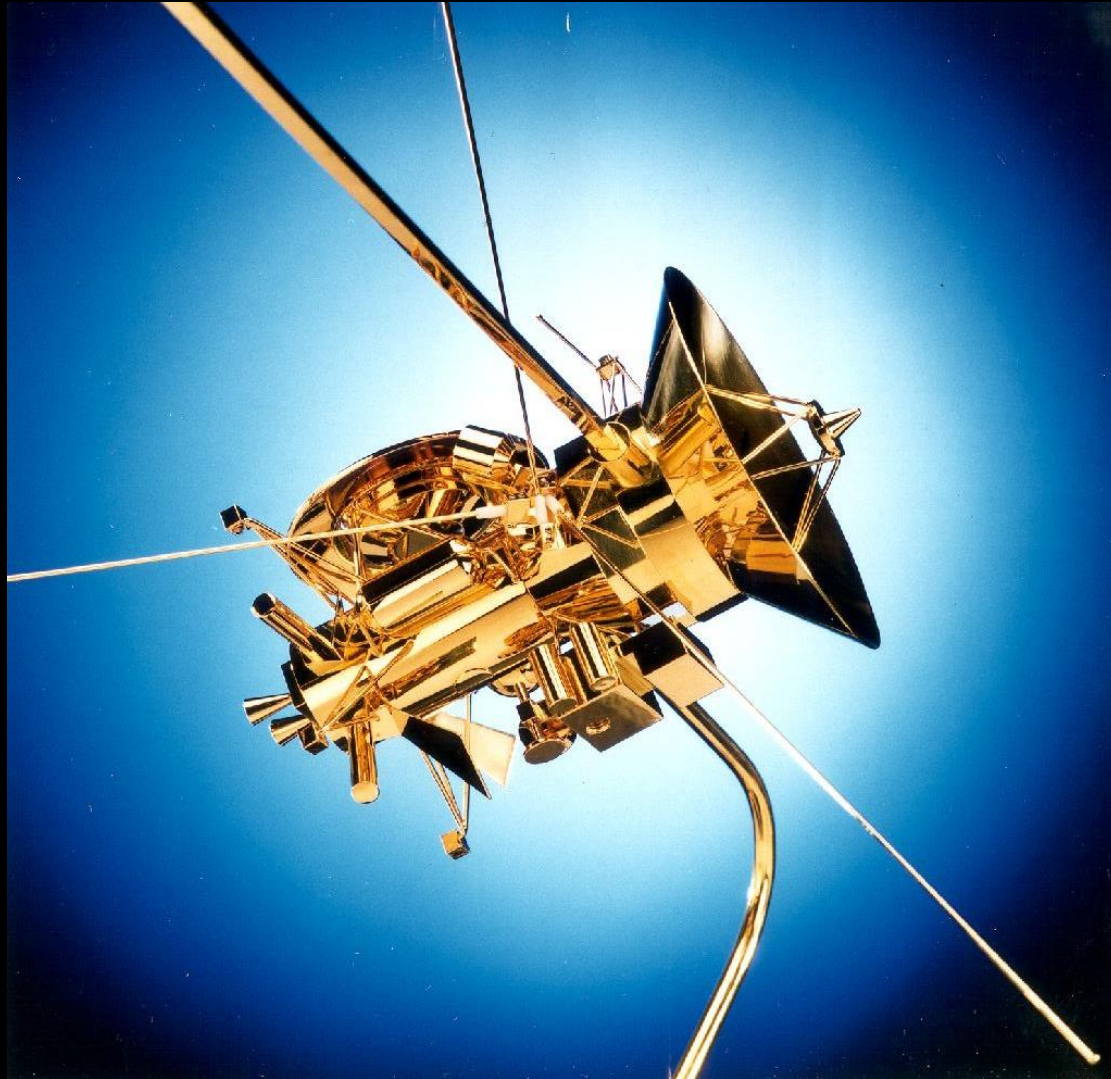
Direction Finding

Determination of the 4 Stokes parameters and direction of incidence (angles theta, phi)



Cassini rheometry model

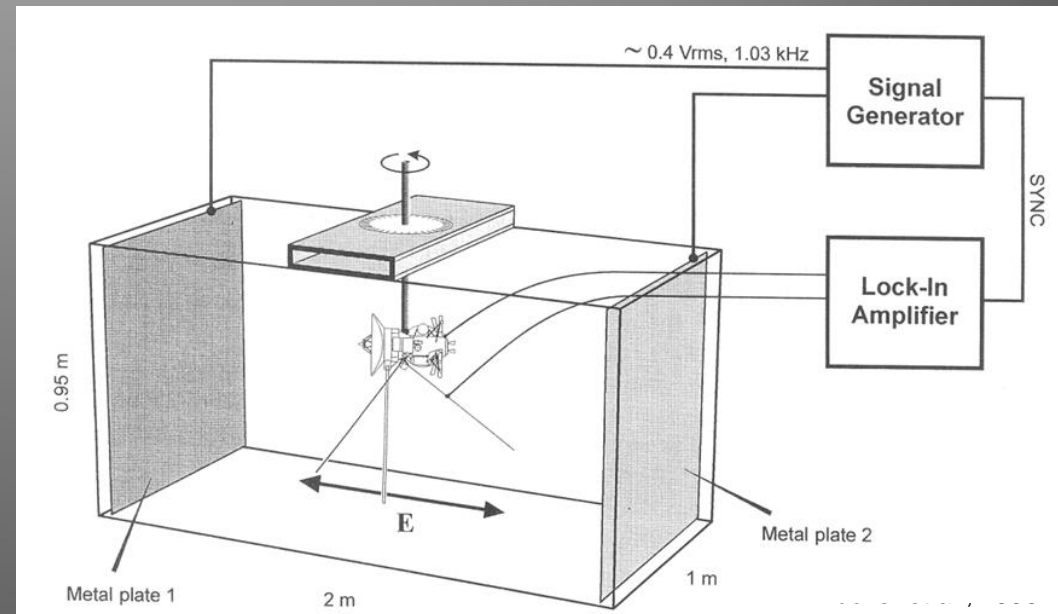
(scale 1:30)



Rheometry:

„Electrolytic“ water tank,
metal plates under voltage and water form a
capacitor providing a homogeneous electric
field.

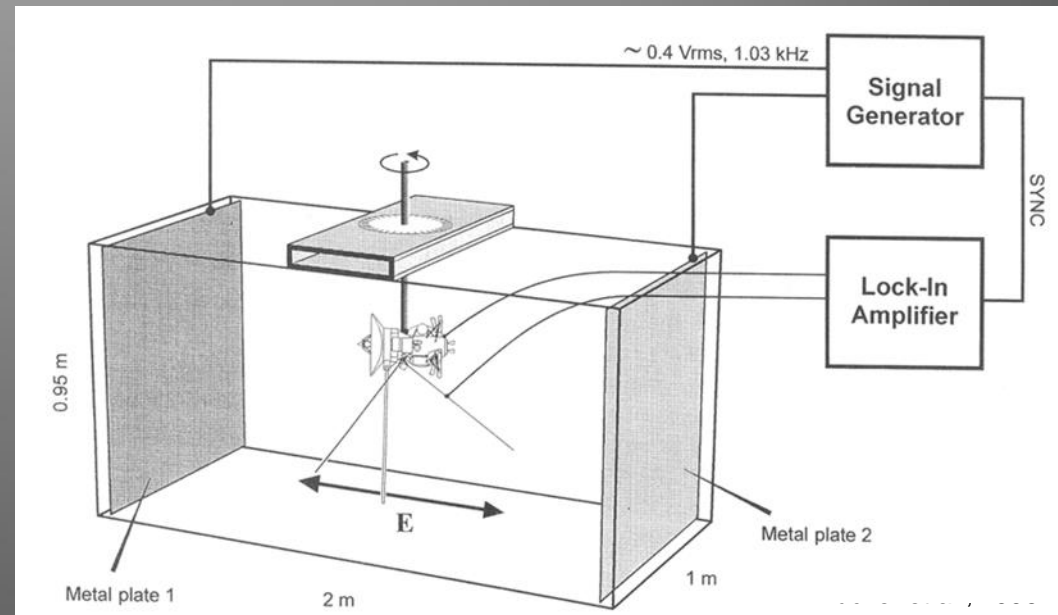
The antennas are connected
to a „lock-in“-amplifier
acting as high-sensitive
voltage instrument.



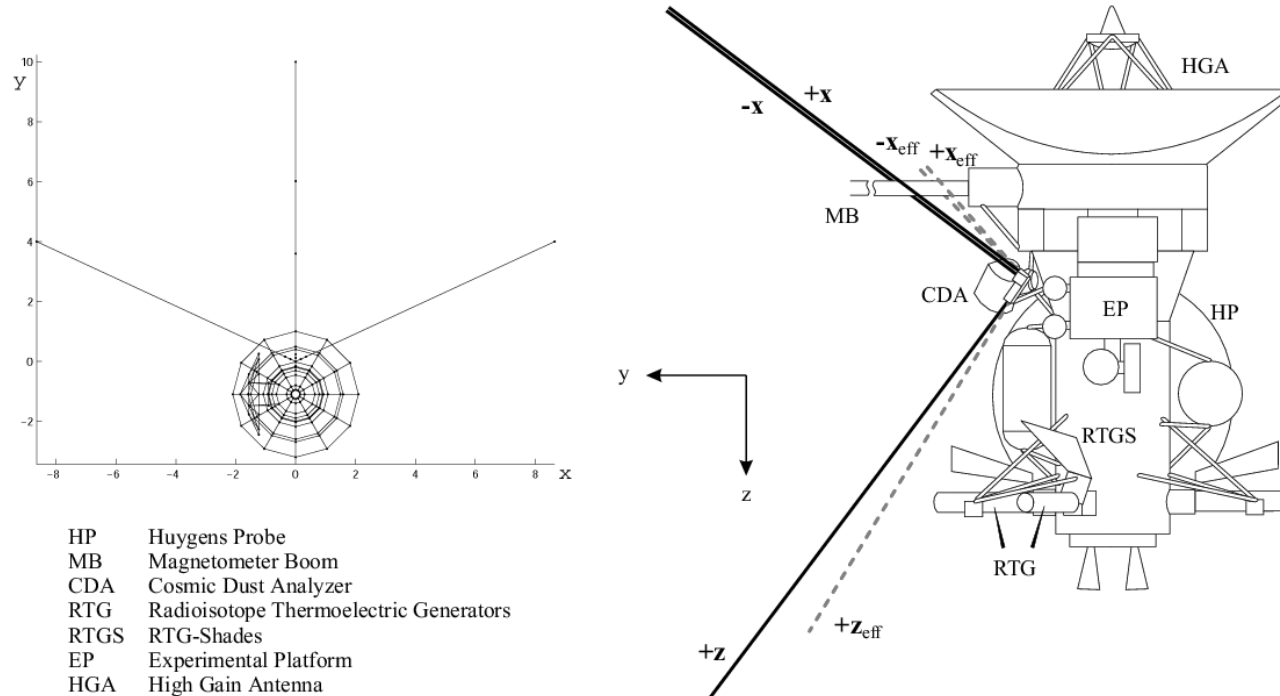
Exact scale model with spacecraft antennas (1:30).

Measurement of induced voltage in dependence of orientation of model relative to electric field.

Determination of effective antennen vectors and effective antenna lengths.



Results:



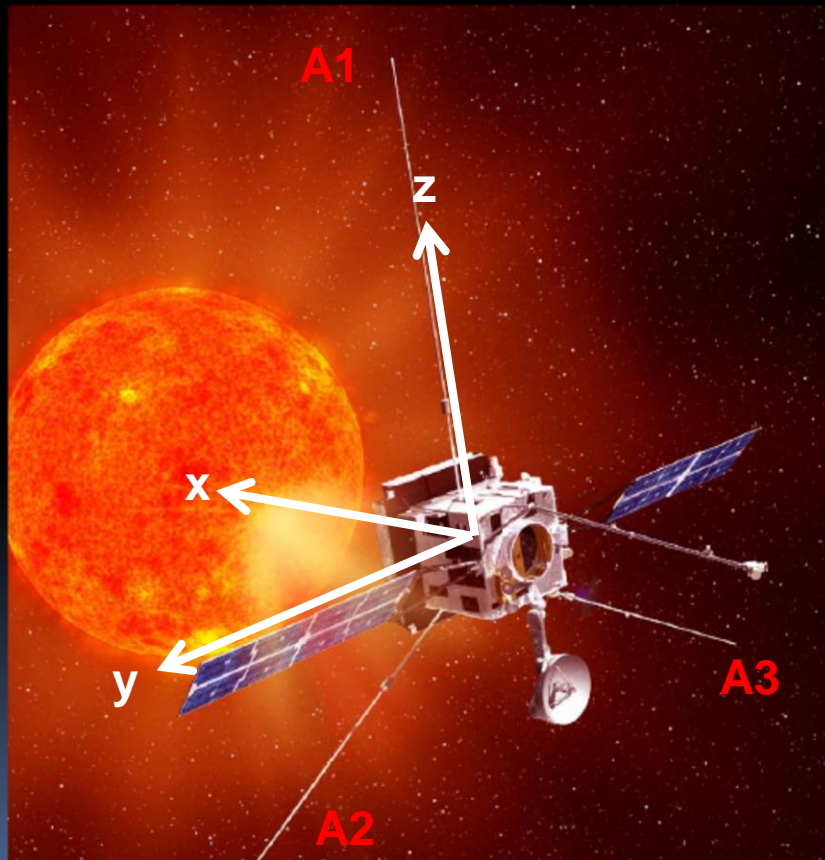
These results have been confirmed by „inflight calibration“ at Jupiter !

Antenna Mode	Physical antennas		Rheometry h_{eff} -HP on		Rheometry h_{eff} -HP off		ASAP new HP on		ASAP new HP off		In flight cal. HP on	
	ϑ	φ	ϑ	φ	ϑ	φ	ϑ	φ	ϑ	φ	ϑ	φ
w (+z)	37.0	90.0	31.4	91.2	30.8	92.9	29.6	89.5	28.4	91.7	-	-
u (+x)	107.5	24.8	107.9	16.5	107.6	16.3	106.4	16.0	106.2	15.3	108.3	16.4
v (-x)	107.5	155.2	107.3	162.7	106.4	163.5	106.6	164.2	105.7	165.6	108.5	163.8

Methods of antenna calibrations:

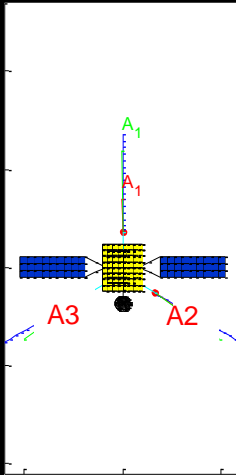
- a) Rheometry measurements
- b) Inflight calibration
- c) Wiregrid/patchgrid calculations
- d) Anechoic chamber measurements

Solar Orbiter



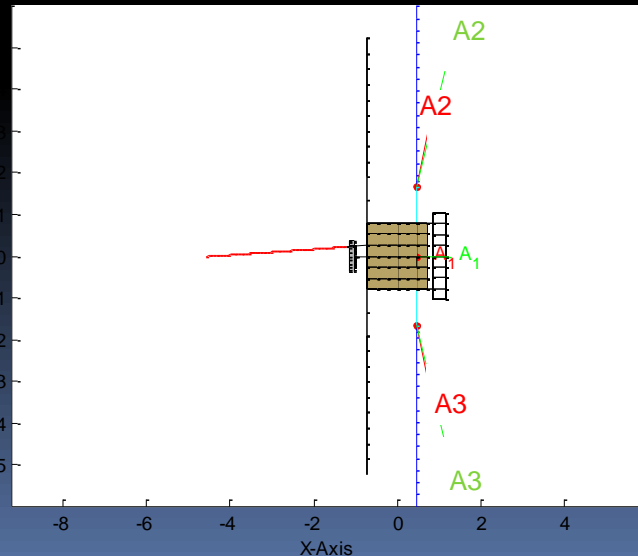
- **Wiregrid modeling** comprises spacecraft hull, heat shield, solar panels, high gain antenna, boom, three (coplanar) antennas.
- wire radius 2 mm
- antenna radius 7.5 mm

	Length/m	Theta/°	Phi/°
A1	5	90	0
A2	5	90	-120
A3	5	90	120



Wire-grid quasi-static calculation

- $f=300$ kHz
- Calculation of current distribution for wire-grid using ASAP and CONCEPT II

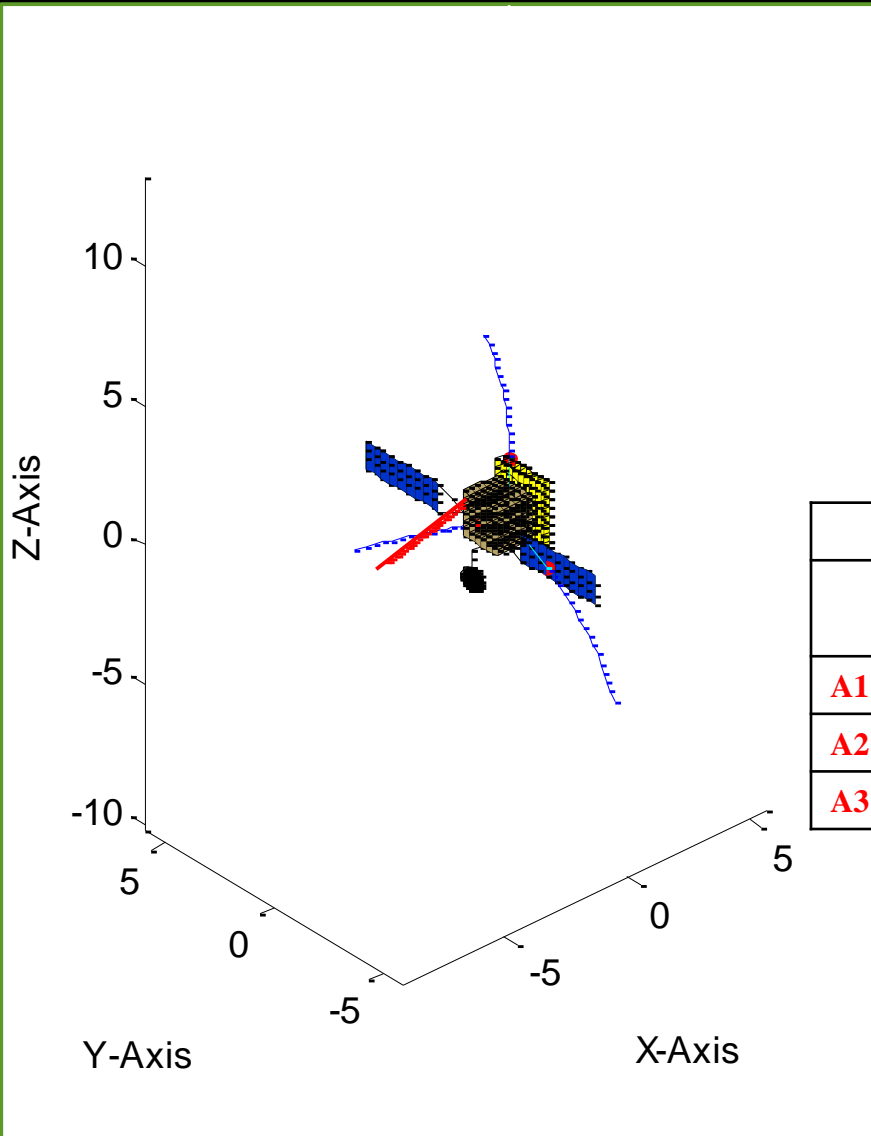


$$\vec{h}_{eff} = \frac{1}{I_a} \int \vec{J}(\vec{r}') e^{j\vec{k} \cdot \vec{r}'} dV'$$

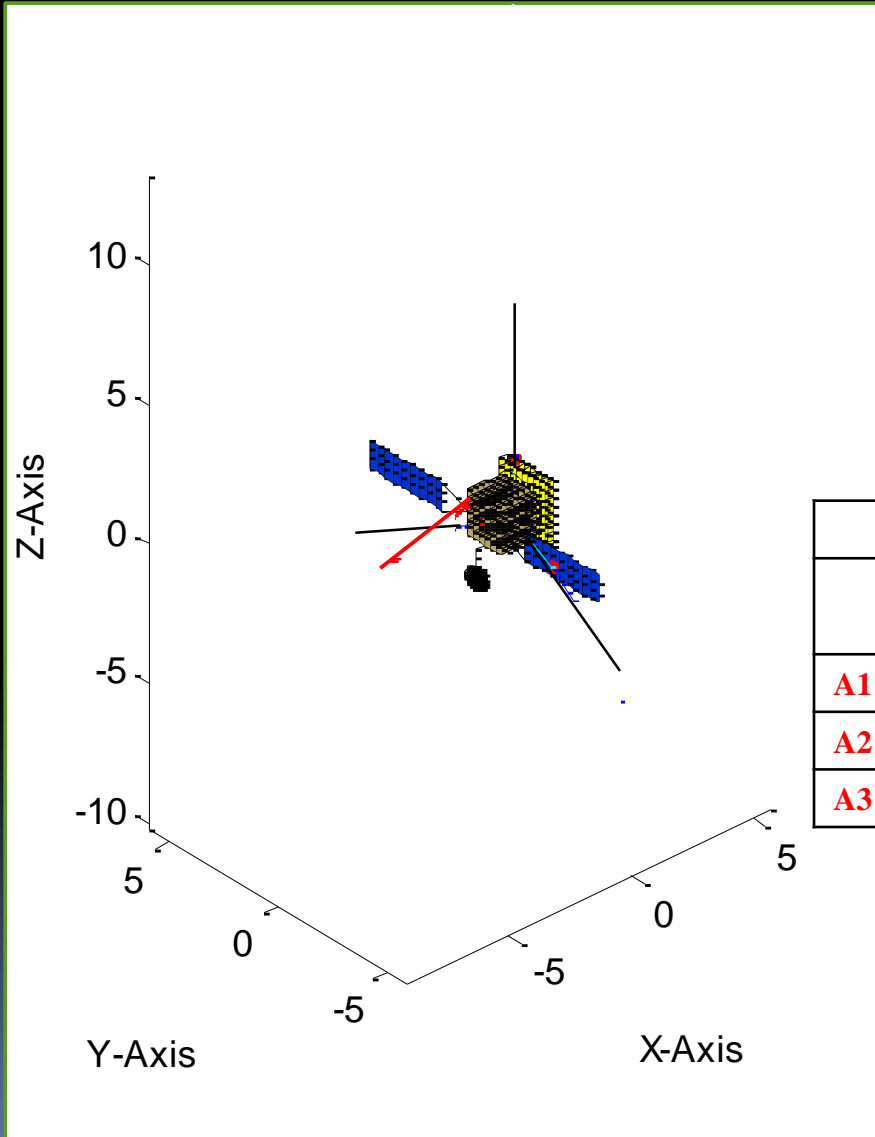
- h_{eff} ... effective antenna vector
- I_a ... port current driving the antenna
- J ... surface current density
- V' ... volume containing all surface currents

Thermal bending

- Simulation : tip offset of 1 m.



	Open feeds			Base cap. 70pF		
	Length/ m	Theta/°	Phi/°	Length/ m	Theta/°	Phi/°
A1	4.14	84.0	0.0	1.69	84.9	0.0
A2	4.05	83.2	-125.9	1.65	84.1	-125.6
A3	4.06	83.2	125.8	1.65	84.1	125.2



Thermal bending

- Simulation : tip offset of 1 m.

	Open feeds			Base cap. 70pF		
	Length/ m	Theta/°	Phi/°	Length/ m	Theta/°	Phi/°
A1	4.22	79.7	0.0	1.72	81.3	0.0
A2	4.16	79.9	-125.7	1.68	80.4	-125.4
A3	4.15	78.9	125.6	1.68	80.4	125.3

CONCEPT II

Calculation without bending !

Conclusions

Radio data analysis, direction finding (determination of Stokes parameters and direction of incidence) crucially depend on the knowledge of radio antennas reception properties.



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Wire-/patch grid, h_{eff} with increasing imaginary part

Anechoic chamber

Inflight calibration