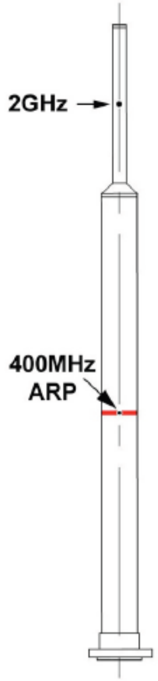
DORIS Ground Antenna Characterization

A. Auriol, F. Boldo, C.Jayles, C. Tourain,

Antenna Phase Center position

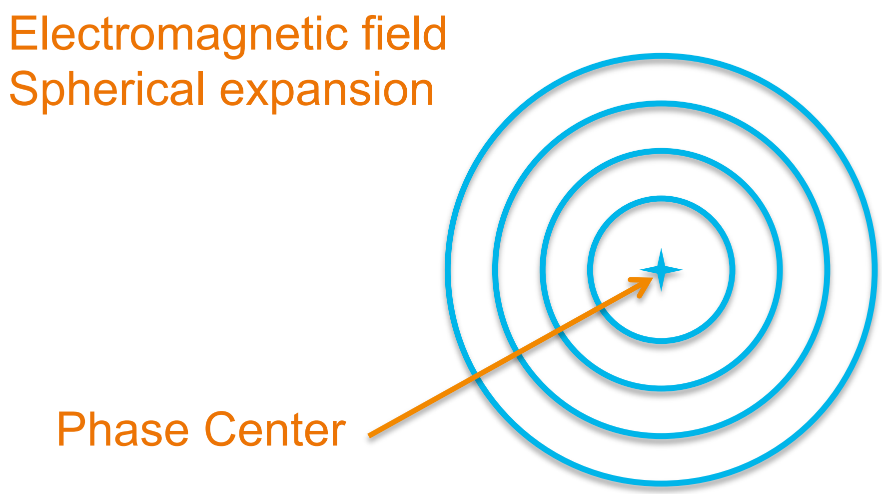
- ✦ DORIS system measures the distance between 2 points:
  - » the ground antenna phase center
  - » the onboard antenna phase center

- ✦ Difficulties on ground:
  - » determine the antenna phase center position in its own frame
    - No physical existence
    - Position function of signal incidence
    - Impact of environment on antenna radiation pattern*
  - » Tie the antenna phase center to terrestrial reference frame



PHASE CENTER DEFINITION (1)

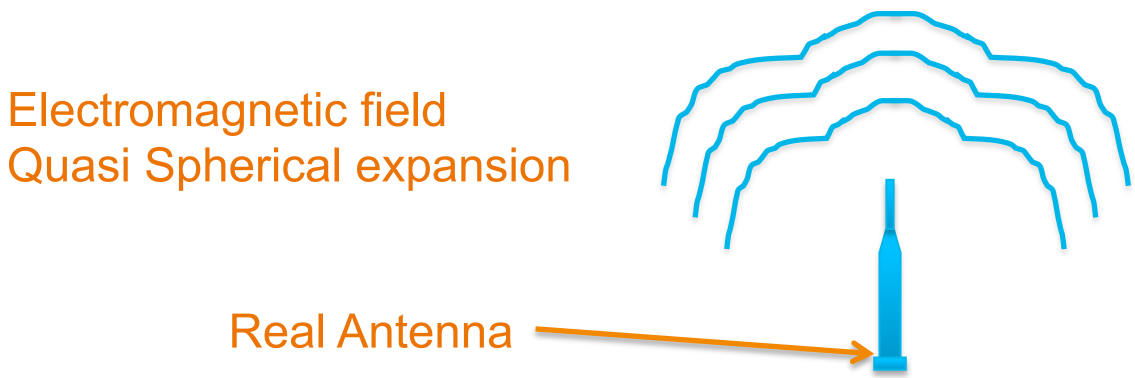
- The Antenna phase center is
  - a virtual point
  - theoretically defined as the center of the iso-phase sphere



- But …

PHASE CENTER DEFINITION (2)

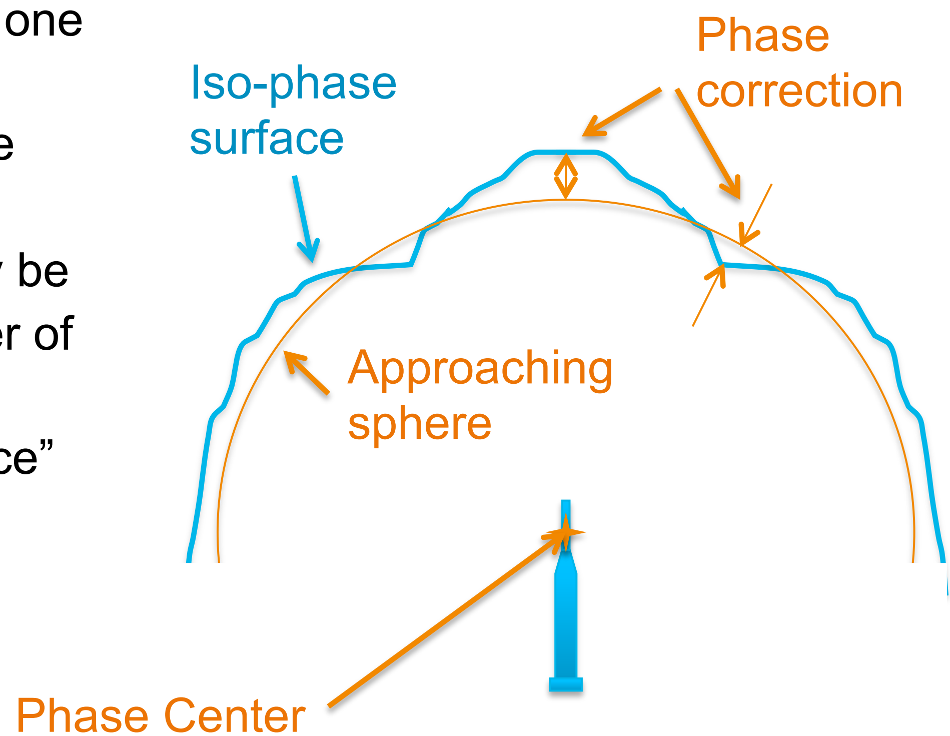
- The real iso-phase surface of the Antenna is
  - not a sphere
  - but a kind of potato



- But …

PHASE CENTER DEFINITION (3)

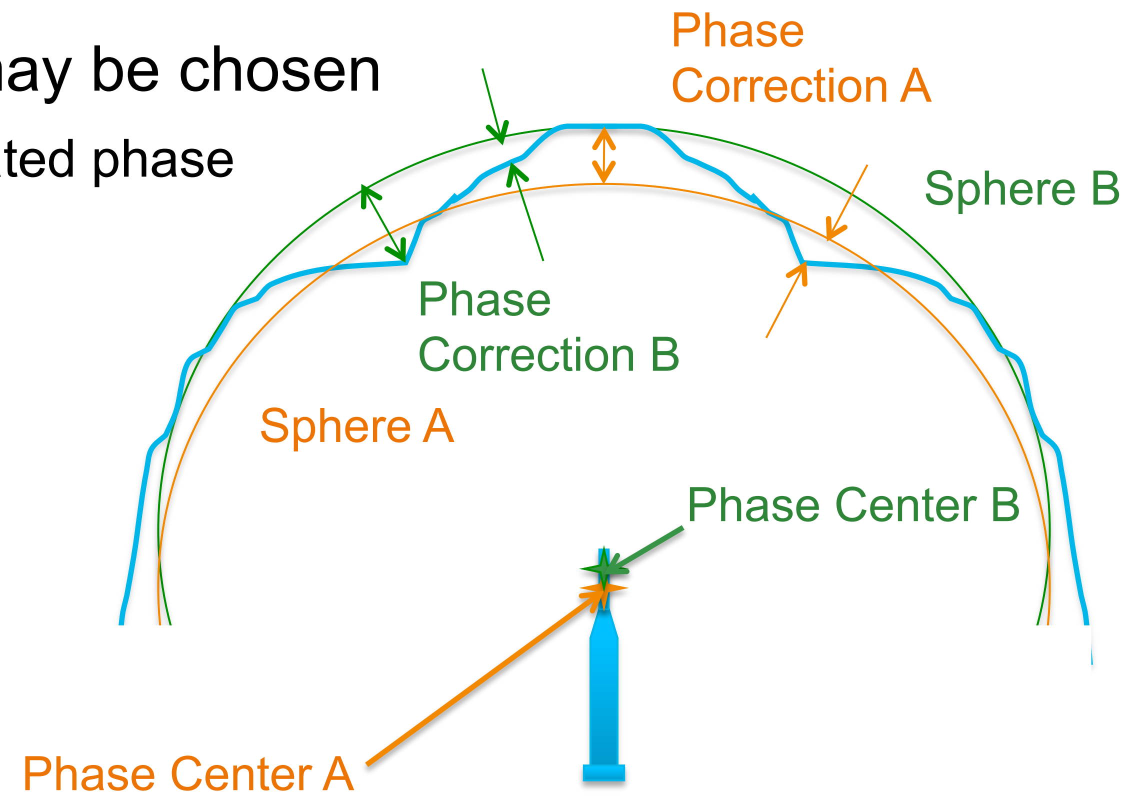
- The potato surface may be approached by a sphere
  - which is generally the closest one of the potato surface
  - at least in a defined part of the useful coverage
  - The center of this sphere may be considered as the phase center of the antenna
  - for each direction, the “distance” between the potato and the sphere defines the “phase correction” associated to the phase center



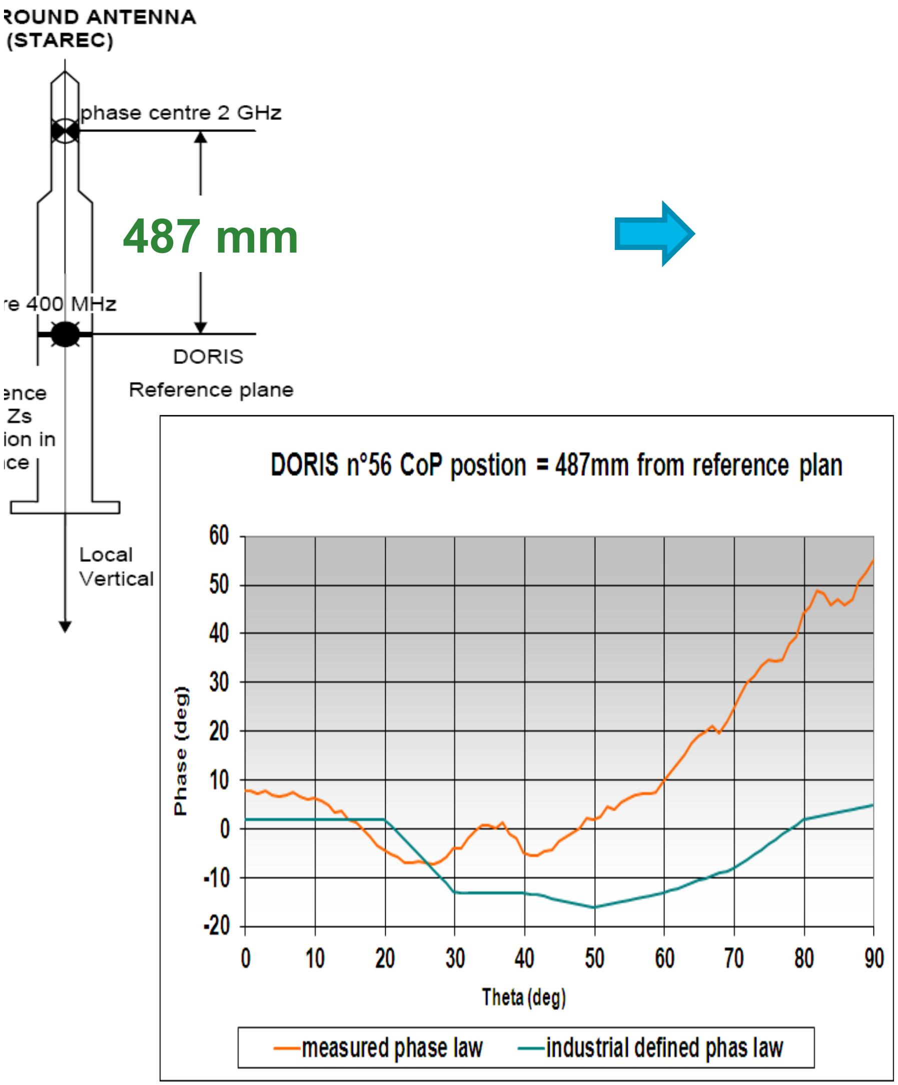
- But …

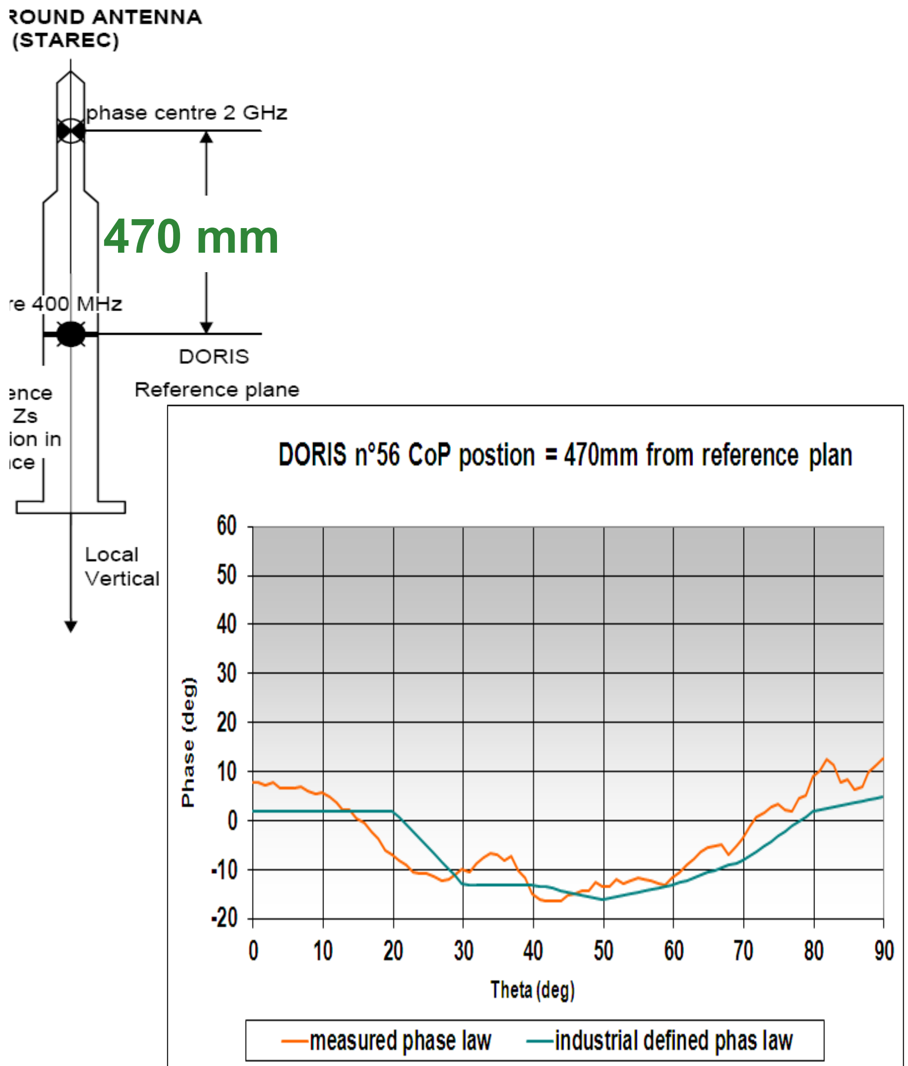
PHASE CENTER DEFINITION (4)

- different spheres may be chosen
  - With different associated phase centers
  - and dedicated phase corrections



Example : For the same antenna, We can give 2 phase center positions associated with 2 phase laws :

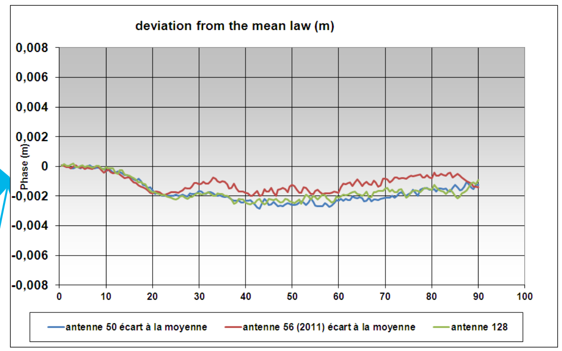


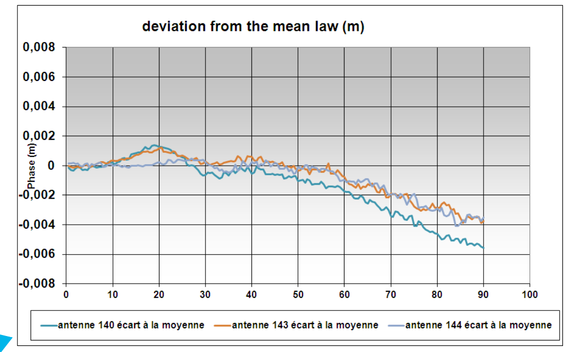


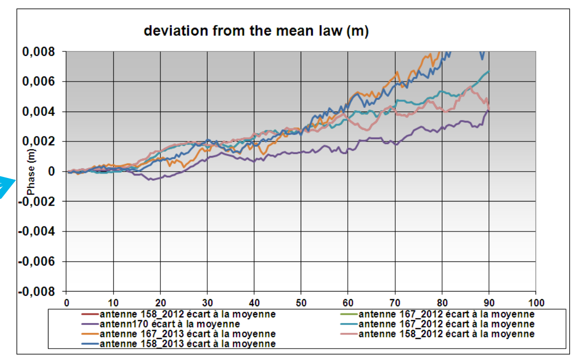
Antenna dispersion

- **Antennas characterized at CNES compact antenna test range (CATR)**
- **In parallel, a set of antennas dismantled**
  - ✦ **Distance between 2GHz radiating element bottom and mounting flange (TCMA)**

Batch	Antenna	TCMA (mm)
Starec	26	715
	50	715
	56	716
Juin 2000	61	710,5
Dec 2000 (64 80 82 85-> 134)	88	712
	90	712
	103	712
	118	713
	127	715
	128	
2006 (135-> 156)	140	
	143	
	144	
	149	714,5
	156	720
2012 (157 -> 170)	158	
	167	
	170	713







- Distance corresponding to the mean law provided via antex files : 716mm
- Dispersion wrt this distance : -6mm /+4mm for old antennas (SN < 171)
- **Future antennas : distance guaranted at 716 ±1mm (from SN 171)**

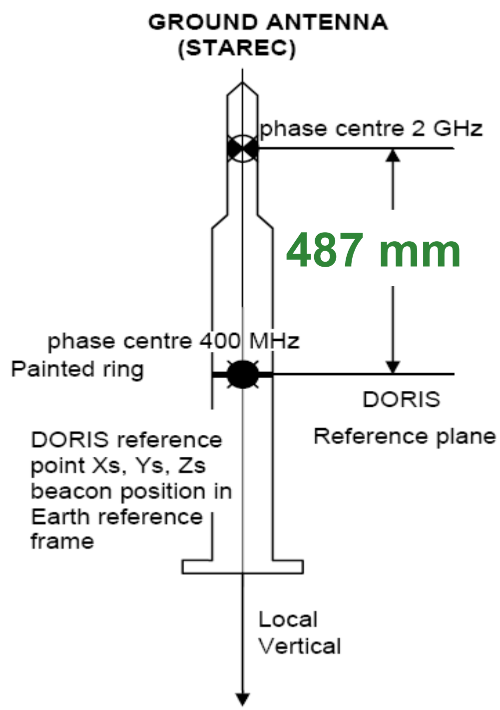
DORIS cnes

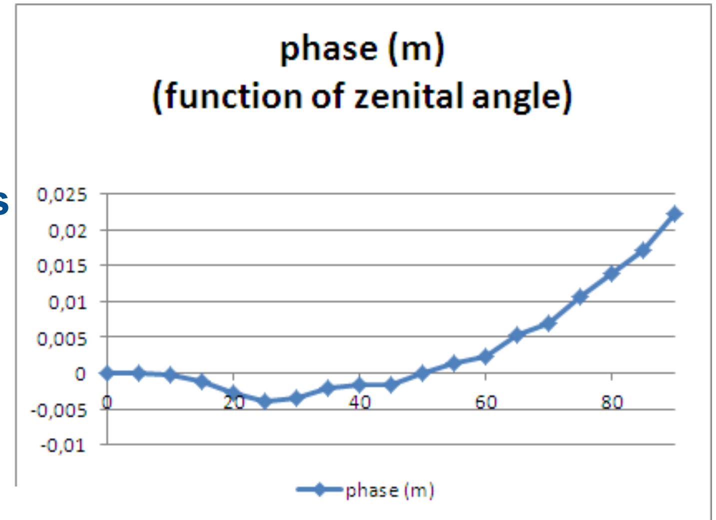
DORIS “Starec” Antenna Characterization provided

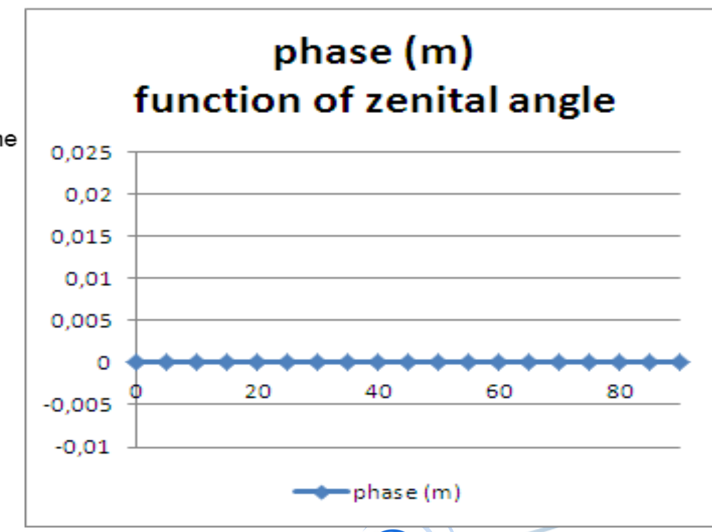
- **2GHz :**
  - » **Phase center : 487 mm above the reference plan**

  This figure is now ensured at manufacturing process level (reproducibility) : +/- 1mm

  - » **2Ghz Phase law**







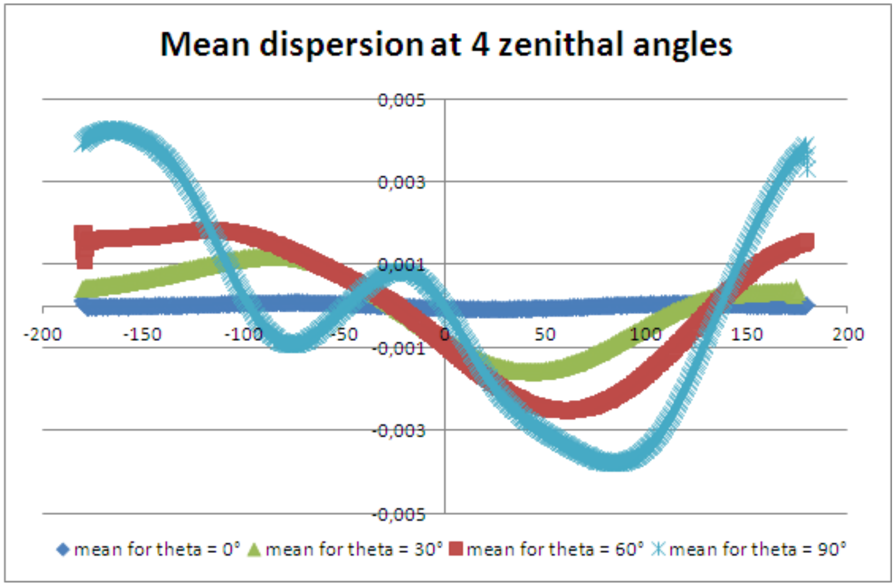
- **400 MHz : no change**
  - » Phase center: 0 mm above the reference plan
  - » 400Mhz Phase law

Characterizations provided via antex files

Analysis of dispersion w.r.t. azimuth angle

- Specific analysis performed at CATR
  - On 3 antennas
  - for 4 different zenithal angles
- => **Impact of dispersion :**
  - **Law θ values (close to zenith) :**
    impact on the up component
    small dispersion => small impact on up
  - **High θ values (low elevation) :**
    impact on the N/E component
    greater dispersion (±3,7mm at 85°)
    => greater impact

standard passes max impact : ±3mm



θ	Max dispersion
0°	0 mm
30°	±1,4mm
60°	±2,15mm
85° (interpolation)	±3,7mm
90°	±4 mm

- **This dispersion includes:**
  - **True Azimuthal RF dispersion**
  - **Perpendicularity / Coaxiality defaults of Antenna axis w.r.t. Mounting flange**
  - **Centering default of radiating elements**
  - **CATR eventual default, rotation axis perpendicularity**

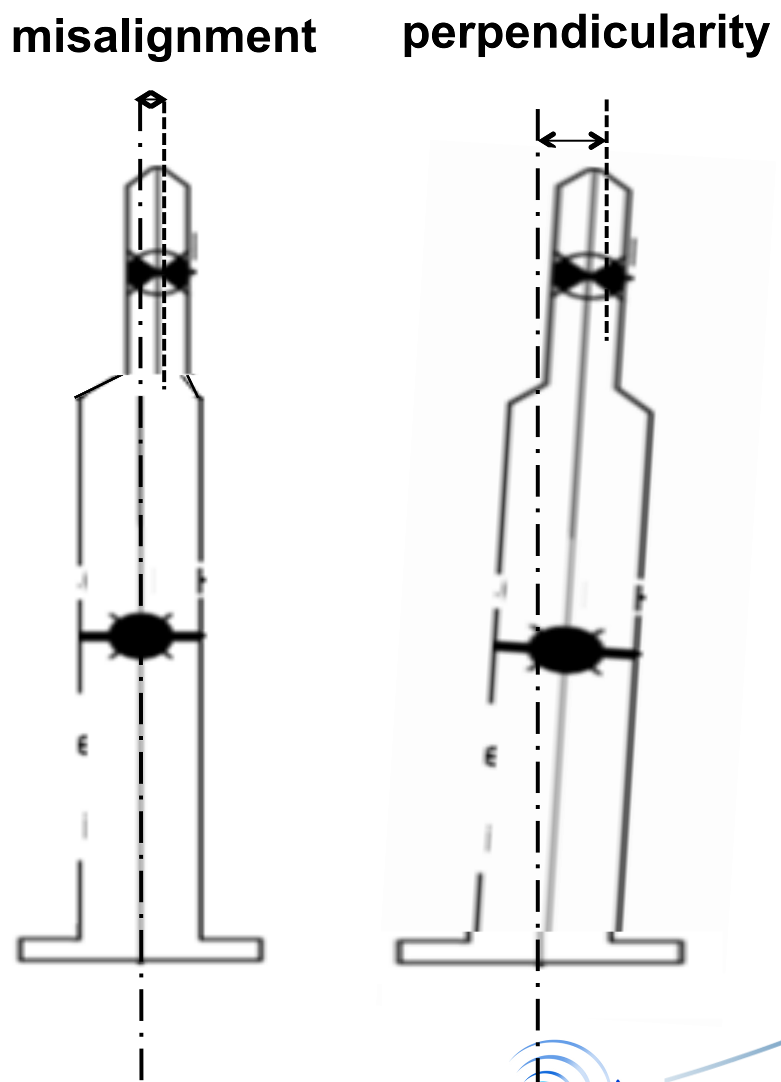
DORIS cnes

Antenna axis eventual defaults

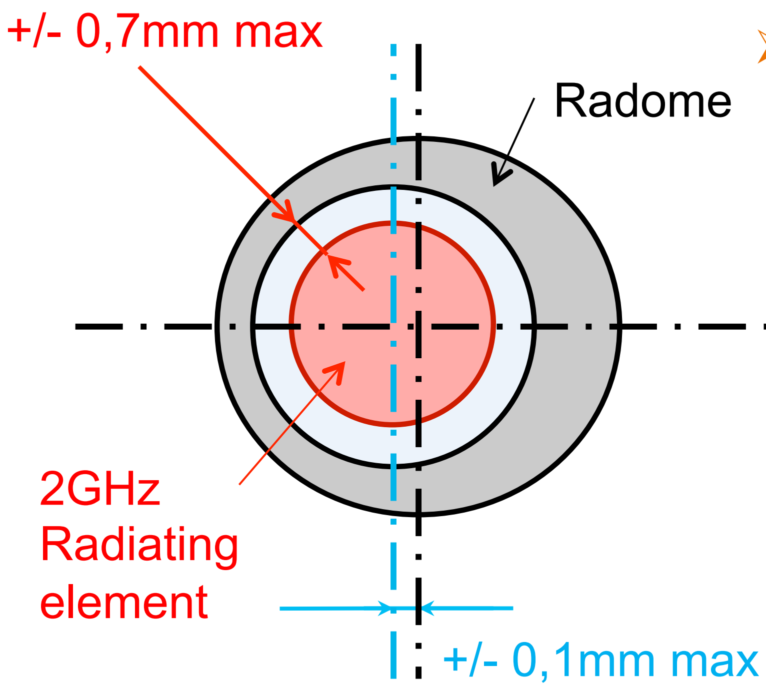
- Alignment / perpendicularity
  - Now controlled by manufacturer on a machine tool w.r.t. mounting flange (plane&axis)
  - Error due to non perpendicularity or misalignment :
    < ±0,5mm at antenna extremity

=> error in the horizontal plane

≈ ±0,5mm of 2GHz phase center position N/E



Centering default of 2GHz radiating elements



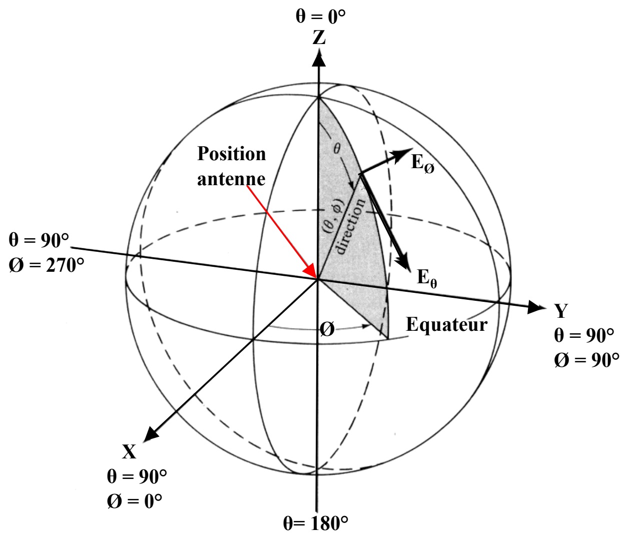
- Perpendicularity of the radome external skin axis is controlled by the manufacturer with respect to mounting flange
- Remaining internal / external discrepancies
  - Irregularity of radome thickness
  - clearance between radiating elements and radome

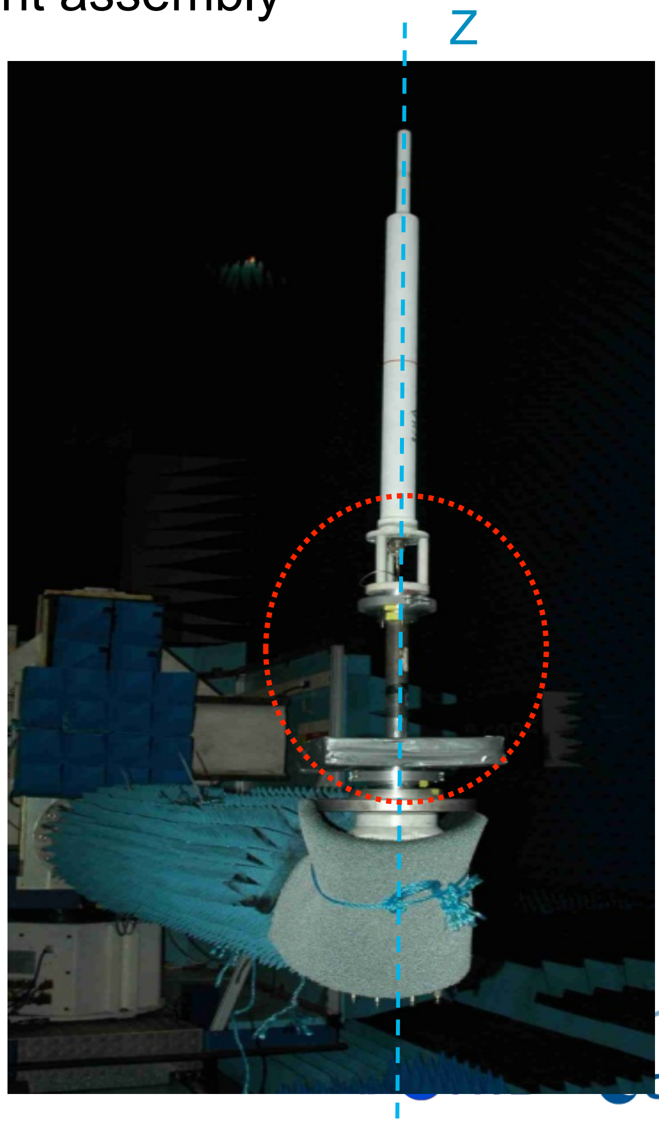
Discrepancy between internal axis and radome external surface	± 0,1mm
Gap between radiating element and internal radome surface	± 0,7mm
total	**± 0,8mm N/E**

Antenna perpendicularity default in CATR

Perpendicularity default due to measurement assembly

- ✦Antenna aligned on Z axis of measurement device
- ✦Antenna is set on measurement device thank to mechanic interface
  - » Perpendicularity is not totally perfect
  - » Default assumed : **± 1 mm** at 2GHz height (887mm)





Analysis of dispersion w.r.t. azimuth angle
Conclusion

- The worst impact of azimuthal dispersion would be ±3mm in horizontal plane (N/E), assuming the dispersion is totally due to antenna
  - But ±1mm is probably due to CATR measurement assembly

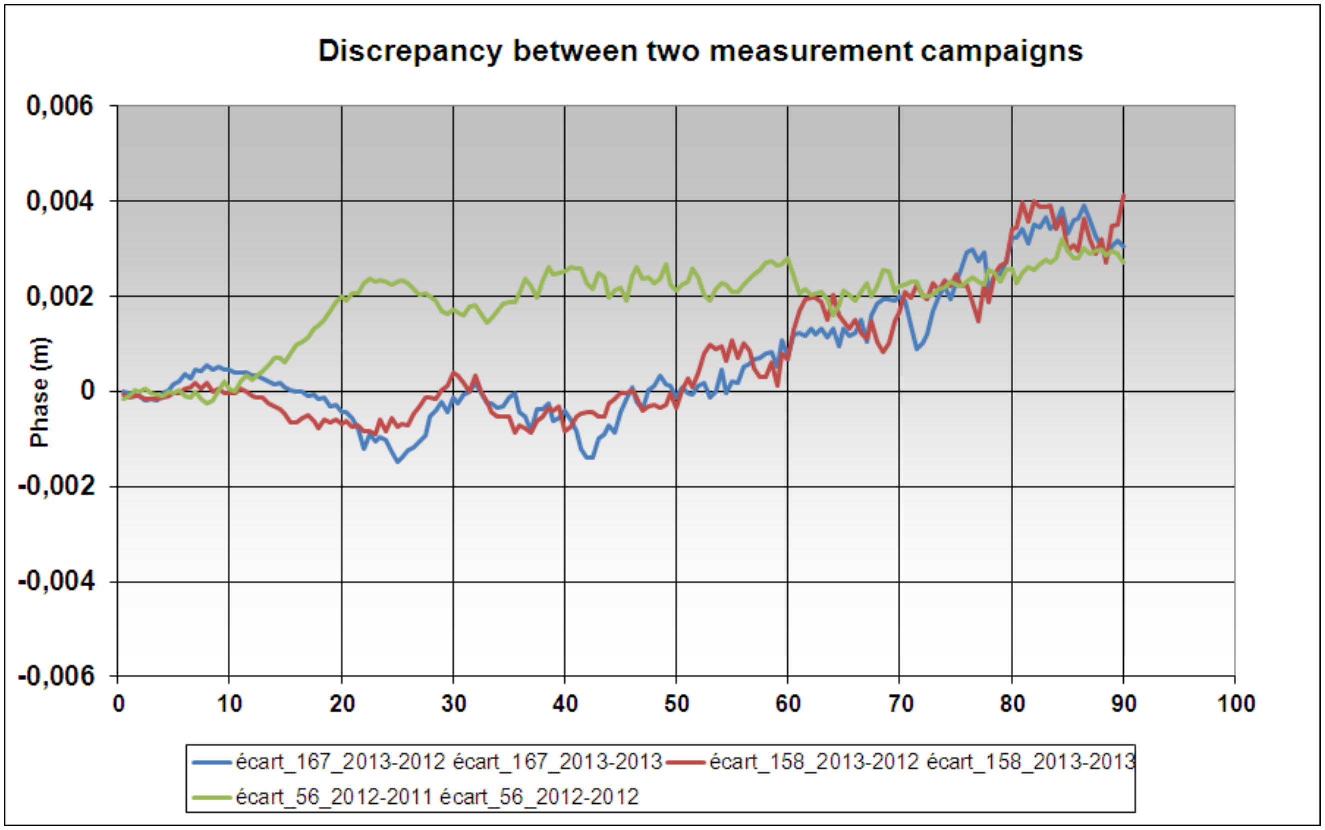
- This allows to establish the following azimuth error budget

Antenna Azimuth error budget	
Error source	**N/E impact**
Total observed	**±3 mm**
CATR assembly	**±1 mm**
=> Total antenna	**±2 mm**
Perpendicularity	**±0,5 mm**
Centering	**±0,8 mm**
=> Azimuth phase pattern variation	**±0,7 mm**

- We assume the DORIS STAREC antenna is non azimuth dependent
  - Not really a surprise, STAREC antenna is helicoidal, it has a revolution symmetry by conception

CATR measurement error

- To get an estimation of this error :
  - Some antennas characterized twice at CATR at 3 different epochs
  - Measurement discrepancy observed : 4 mm max



⇒ We assume a **CATR measurement noise error** of **± 2mm (up)**

DORIS Ground antenna error budget

Error source	up	plan (N/E)
Antennas variability (2GHz phase center position) before consolidation with manufacturer (SN < 171)	+4/-6 mm	
Antennas variability (2GHz phase center position) after consolidation with the manufacturer (From SN 171)	±1 mm	
Antenna characterization error (BCMA)	±2 mm	
Azimuthal dispersion (including RF, perpendicularity, centering)	0mm	± 2mm
Total antenna alone		
SN < 171	+6/-8 mm max 5,4 mm rms	± 2 mm max 0,7 mm rms
From SN 171	**± 3 mm max** 1 mm rms	**± 2 mm max** 0,7 mm rms
Antenna environment impact	TBD	TBD

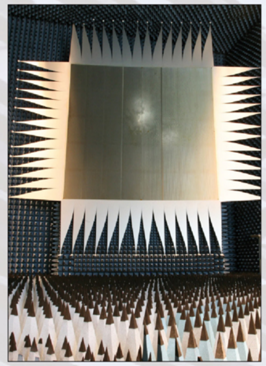
Backup slides

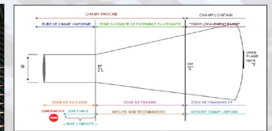
BASE COMPACTE DE MESURES D'ANTENNES

Objectifs : Connaître et maîtriser le rayonnement des antennes seules et sur structures

Chambre anéchoïque faradisée :
22 m x 12,5 m x 12 m

Simuler la distance satellite sol

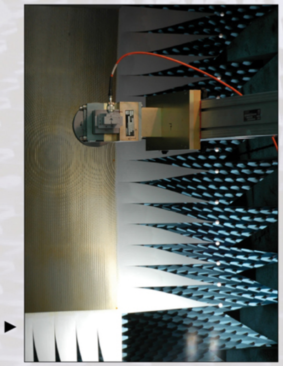


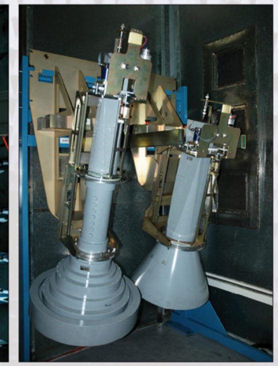


◄ **Réflecteur parabolique :**
5,3 m x 5,6 m, 48 tonnes.
- Focale : 13 m.
- Etat de surface : 25 µm RMS,
- Zone tranquille maximale de 4 m x 4 m x 4 m.

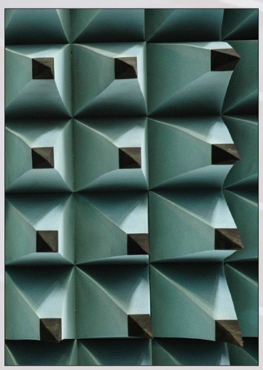
15 sources primaires ► de 0,4 à 200 GHz.

Simuler la liaison bord sol





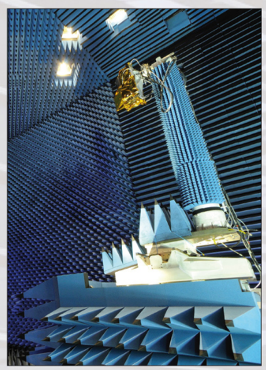
Isoler l'antenne dans l'espace



◄ **Absorbants :** -70 dB de réflectivité typique à 8 GHz.

Positionneur : 7 degrés ► de liberté en rotation et translation.
Capacité : 350 Kg maximum.

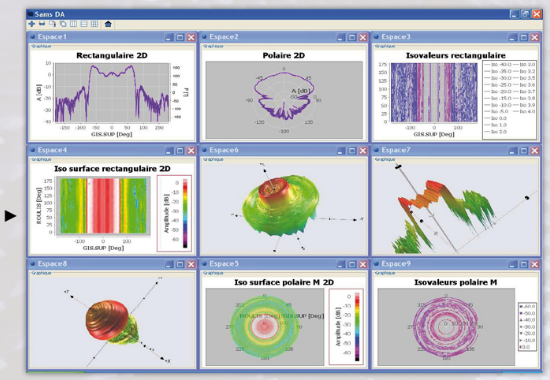
Positionner l'antenne dans l'espace



◄ Diagramme de rayonnement, directivité, gain, localisation centre de phase, temps de propagation de groupe. Performances système, surface équivalente radar.

Instrumentation : analyseurs ► de réseau Agilent et ABmillimètre, logiciels CNES/SILICOM d'acquisition et post-traitement.

Réaliser les mesures avec précision



cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

DORIS cnes