HERSCHEL / PLANCK

PLANCK RFQM test requirements for the 4 nominal horns

H-P-3-ASP-SP-0561

Product Code : 22000

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2.0	16-03-2004	Release for ITT	ESA
3	15-12-2004	**Update of test specification**	D. Dubruel
3	15-12-2004	Creation of Reference Document list (see section 1.2.2)	"
3	15-12-2004	Update of the horn selected for the RFQM (see section 3.2.1.)	"
3	15-12-2004	Update of horn location and orientation(see section 5.1)	"
3	15-12-2004	Update of table 5.1-3 in section 5.1	"
3			"
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3	15-12-2004	Update of section 3.2-1	"
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3	15-12-2004	Update of requirement SP-0180 in section 4.6	"
3	15-12-2004	Update of table 4.7.2 in section 4.7-2	"
3	15-12-2004	Update of table 4.7.2 in section 4.7-2	"
3	15-12-2004	Update of table 4.7.3 in section 4.7-3	"
3	15-12-2004	Update of requirement SP-0230 in section 5.1	"
3	15-12-2004	Update of requirement SP-0340 in section 7.1	"
3	15-12-2004	Update of requirement SP-0480 in section 7.4-1	"
3	15-12-2004	Update of requirement SP-0485 in section 7.4-1	"
3	15-12-2004	Update of requirement SP-0500 in section 7.4-2	"
3	15-12-2004	Update of requirement SP-0530 in section 7.4-3	"
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3	04-01-2005	Update of the horn selected for the RFQM (see section 3.2.1.)	D. Dubruel
3	04-01-2005	Update of horn location and orientation(see section 5.1)	"
3		Removal of requirement HP-SP-0250 (see section 5.1)	"
3		Removal of figure 5.1-3 (see section 5.1)	"
3		Update of table 5.1-2	"
3		Update of section 5.2.3	"
3		Update of requirement HP-SP-0480 (see section 7.4.1)	"
3		Update of requirement HP-SP-0485 (see section 7.4.1)	"
3		Update of requirement HP-SP-0500 (see section 7.4.2)	"
3		Update of requirement HP-SP-0500 (see section 7.4.3)	"
3		Update of requirement HP-SP-0540 (see section 7.4.3)	"
3		Update of appendix 5	"
3	15/02/05	Add on of definition of the 100 GHz additional test horn (see table 5.1-3	D. Dubruel

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Issue. Revision	DATE	§ : CHANGE RECORD	AUTHOR
3		Add on of section 5.2.4. : Additional test horn radiation pattern	"
3	21/09/05	Update of the definition of the HFI reference test horn, update of table 5.1-3.	D. Dubruel
3		Deletion of section 5.2.4. (information not available at the time of the release of this document)	
3		Update of appendix 5 with the definition of the mechanical interface of the RF modulator.	
3		Add of AD 9 and AD 10 reference	
3	23/09/05	Creation of section 8 : Detailed test sequence requirements	D. Dubruel
3		Section 7.4.5, update of Table 1-7 with the high resolution cut requirement of the the LFI horns @ 30 & 70 Ghz.	"
3	21/11/05	Removal of all reference of reference test horn. Creation of a separate document for the reference test horn.	D. Dubruel
3	5/12/*05	Implementation of section 1.4 Test objectives	D. Dubruel
		Creation of sections : 10 Success criteria 11 Organisation & responsibilities 12 Documentation	D. Dubruel

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1. INTRODUCTION

1.1 Purpose of this document

This document describes the requirements for the RF verification of the Planck Radio Frequency Qualification Model (RFQM). This documents contains only the requirements for the 4 nominals horns in the focal plane. The requirements for the reference test horns (at 70 GHz or RF modulator at 320 GHz) are not contained in this document.

1.2 Applicable and reference documents

1.2.1 Applicable documents

[AD1] Planck telescope optical and RF specification - H-P-3-ASP-SP-0274

[AD2] Radiometer allocated volume - PLA FPUIS 8000 A D 01

[AD3] Radiometer allocated volume - PLA FPUIS 8000 A E 02

[AD4] Planck interface SVM / PLM - PLSA180S000S A G 1

[AD5] Planck interface SVM / PLM - PLSA180S000S A G 2

[AD6] Planck interface SVM / PLM - PLSA180S000S A G 3

[AD7] Planck interface SVM / PLM - PLSA180S000S A G 4

[AD8] Planck interface SVM / PLM - PLSA180S000S A G 5

1.2.2 Reference document

[RD1] HFI detector data processing - H-P-3-ASP-TN-0559 - issue 3 - 13/12/2004

[RD2] "HFI focal plane unit layout : position and orientation of HFI horns and PSB orientation" - TN-PH-234-300275-IAS-issue 2-rev0 -15th Januray 2004

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1.3 Acronyms

AIT	Assembly Integration & Test
ASPI	Alcatel Space Industries
FPU	Focal Plane Unit
HFI	High Frequency Instrument
HP	Herschel-Planck.
I/F	Interface
LFI	Low Frequency Instrument
LOS	Line Of Sight
MGSE	Mechanical Ground Support Equipment
PLM	Payload Module
PR	Primary Reflector
PTR	Post Test Review
QM	Qualification Model
RF	Radio Frequency
RFQM	Radio Frequency Qualification Model.
S/C	Spacecraft
SR	Secondary Reflector
SRS	System Requirements Specification.
SVM	Spacecraft vehicle module
TFPU	Test Focal Plane Unit
TRR	Test Readiness Review
VSWR	Voltage Standing Wave Ration
W/G	Waveguides

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1.4 Test objectives.

The main test objective is to verify the RFQM Radio Frequency RF performances.

1.4.1 Test objectives of the horn mounted on the RF module.

The objectives of this elementary test is to verify that the electronic and the transition do not modify the original radiation pattern measured by the instrument teams. The second objective is also to correlate the measurement and the primary feed numerical model provided that the electronic and transition .do not modify the elementary patterns.

1.4.2 Main lobe measurement performance verification

The RFQM test shall provide all main lobe RF measurements. The objectives of the main lobe measurement test is to provide the input data so as to later on obtain the mainlobe flight performances.

1.4.3 Rejection performance verification toward Earth-Sun-Moon direction

The RFQM test shall provide the measurement of the radiation pattern levels toward the specified angular directions containing the Earth Sun an Moon .

For all other angular direction, the objectives of the RFQM test are to acquire all the RF measurement so as to perform later on the correlation with the numerical model.

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2. SPACECRAFT DESCRIPTION.

2.1 Axis System

Different axis systems are defined for the Planck spacecraft, the telescope, the FPU and the reflectors.

These co-ordinate systems are summarised in this paragraph. All co-ordinate systems defined below are right-handed Cartesian systems.

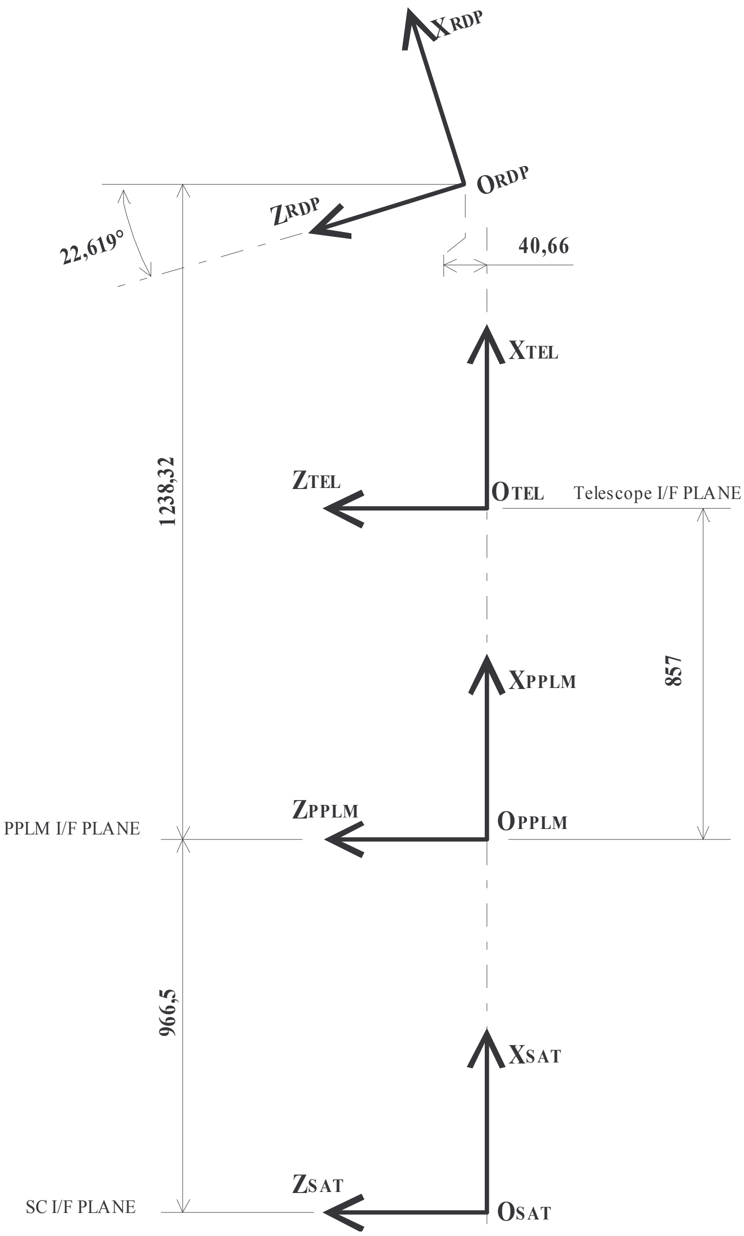

Figure 2.1-1 : main coordinate system (Rf-cut coordinate system not shown)

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Planck spacecraft axis system

The Planck spacecraft co-ordinate system (0_{sat}, X_{sat}, Y_{sat}, Z_{sat}) is defined as follows (see fig 2.1-1) :

- the origin 0_{sat} is at centre of the spacecraft to launcher interface,
- X_{sat} is the spin axis of the spacecraft with the sun nominally in –x direction,
- Z_{sat} axis is perpendicular to the X_{sat} axis and is contained in the symmetry plane of the telescope, with the positive direction on the concave side of the telescope.
- Y_{sat} complements the co-ordinate system.

Planck PLM axis system

The Planck PLM co-ordinate system (0_{PPLM} X_{PPLM}, Y_{PPLM} Z_{PPLM}) is a shifted telescope co-ordinate system and is defined as follows (see fig 2.1-1):

The Planck PLM axis system is expressed in the spacecraft (Sat) coordinate system as follows :

```
PPLM            coor_sys
(
  origin      : struct(x: 966.5  mm, y:0. mm, z:0. mm),
  x_axis      : struct(x:   1.000000000    , y:   0.000000000   ,z:   0.000000000),
  y_axis      : struct(x:   0.0000000000   ,y:    1.000000000   ,z:   0.000000000),
  z_axis      : struct(x:   0.0000000000   ,y:    0.000000000   ,z:   1.000000000)
  base        : ref(Sat)
)
```

Planck Telescope axis system

The Planck Telescope co-ordinate system (0_{Tel}, X_{Tel}, Y_{Tel}, Z_{Tel}) is a shifted spacecraft co-ordinate system and is defined as follows (see fig 2.1-1):

The Planck Telescope co-ordinate system is expressed in the PPLM coordinate system as follows :

- X_{Tel} is the spacecraft X_{sc} axis,
- Y_{Tel} is the spacecraft Y_{sc} axis,
- Z_{Tel} complements the co-ordinate system.

```
TEL             coor_sys
(
  origin      : struct(x: 857  mm, y:0. mm, z:0. mm),
```


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```
  x_axis      : struct(x:   1.000000000    , y:    0.000000000    ,z:   0.000000000),
  y_axis      : struct(x:   0.0000000000   ,y:     1.000000000    ,z:   0.000000000),
  z_axis      : struct(x:   0.0000000000   ,y:     0.000000000    ,z:   1.000000000)
  base        : ref(PPLM)
)
```


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Planck RF_cut axis system

The Planck RF_cut co-ordinate system (0_{RFcut}, X_{RFcut}, Y_{RFcut}, Z_{RFcut}) is defined as follows (see fig 2.1-5):

The Planck RF_cut co-ordinate system is expressed in the Planck Telescope (TEL) coordinate system as follows :

- X_{RFcut} is the spacecraft Z_{Tel} axis,
- Y_{RFcut} is the spacecraft -Y_{Tel} axis,
- Z_{RFcut} is the spacecraft X_{Tel} axis

```
RFcut                coor_sys
(
  origin       : struct(x: 1466  mm, y :0  mm, z : 0  mm),
  x_axis       : struct(x:   0,     y:      0,      z:   1    ),
  y_axis       : struct(x:   0,     y:     -1,      z:   0    ),
  z_axis       : struct(x:   1,     y:      0,      z:   0    ),
  base         : ref(TEL)
)
```

Planck Telescope Primary Reflector axis system

The Planck Telescope Primary Reflector co-ordinate system (0_{M1}, X_{M1}, Y_{M1}, Z_{M1}) system is defined as follows (see fig 2.1-4) :

- the origin 0_{M1} is at the vertex of the primary reflector,
- X_{M1} is along the minor axis of the ellipsoid, with positive direction toward the PR
- Z_{M1} is along the major axis of the ellipsoid, with positive direction on the concave side of the PR
- Y_{M1} complements the frame

The Planck telescope primary reflector axis system is expressed in the Planck Telescope (TEL) co-ordinate system as :

```
M1                coor_sys
(
  origin       : struct(x:   369.4600000    mm,y:   0.000000000    mm,z:  -109.6600000    mm),
  x_axis       : struct(x:  0.9883588600   ,y:   0.000000000   ,z:  -0.1521406400   ),
  y_axis       : struct(x:  0.0000000000   ,y:   1.000000000   ,z:   0.0000000000   ),
```


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```
  z_axis      : struct(x:   0.1521406400   ,y:    0.000000000   ,z:   0.9883588600   )
  base        : ref(TEL)
)
```


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Planck Telescope Secondary Reflector axis system

The Planck Telescope Secondary Reflector co-ordinate system (0_{M2}, X_{M2}, Y_{M2}, Z_{M2}) system is a local co-ordinate system and defined as follows (see fig 2.1-4) :

- the origin 0_{M2} is at the vertex of the vertex of the SR
- X_{M2} is along the minor axis of the ellipsoid with positive direction toward the PR
- Z_{M2} is along the major axis of the ellipsoid, with positive direction on the convex side of the SR
- Y_{M2} complements the frame

The Planck Telescope Secondary Reflector axis system is expressed in the Planck telescope primary reflector (M1) co ordinate system as :

```
M2              coor_sys
(
  origin        : struct(x:   -84.48 mm,y: 0. mm,z:    1180.298000     mm),
  x_axis        : struct(x:   0.9845031800   ,y:   0.0000000000   , z:   0.1753667300   ),
  y_axis        : struct(x:   0.0000000000   ,y:   1.0000000000   , z:   0.0000000000   ),
  z_axis        : struct(x:  -0.1753667300   ,y:   0.0000000000   , z:   0.9845031800   ),
 base           : ref(M1)
)
```

Planck Telescope Reference Detector Plane axis system

The Planck FPU co-ordinate system (0_{RDP}, X_{RDP}, Y_{RDP}, Z_{RDP}) is defined as follows (see fig 2.1-1 to 2.1-3):

- 0_{RDP} is the origin of the Focale plane reference frame
- Z_{RDP} is within the spacecraft X-Z plane, positive in the direction of the SR and tilted of 21.27° from X_{M2}
- X_{RDP} is perpendicular to the Z_{RDP} axis, within the spacecraft X-Z plane, positive in the direction of the primary reflector
- Y_{RDP} complements the co-ordinate system.

The Planck Telescope Reference Detector Plane axis system is expressed in the Planck telescope axis system (TEL).

```
coor_RDP_tel    coor_sys
(
  origin        : struct(x:381.32225 mm, y: 0. mm, z: 40.65760 mm),
  x_axis        : struct(x:   0.92308293,  y: 0.0000000000,   z:  0.38460097),
  y_axis        : struct(x:   0.00000000,  y: 1.0000000000,   z:  0.00000000),
```


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```
  z_axis        : struct(x:  -0.38460097,  y: 0.0000000000,   z: 0.92308293,),
  base          : ref(TEL)
)
```


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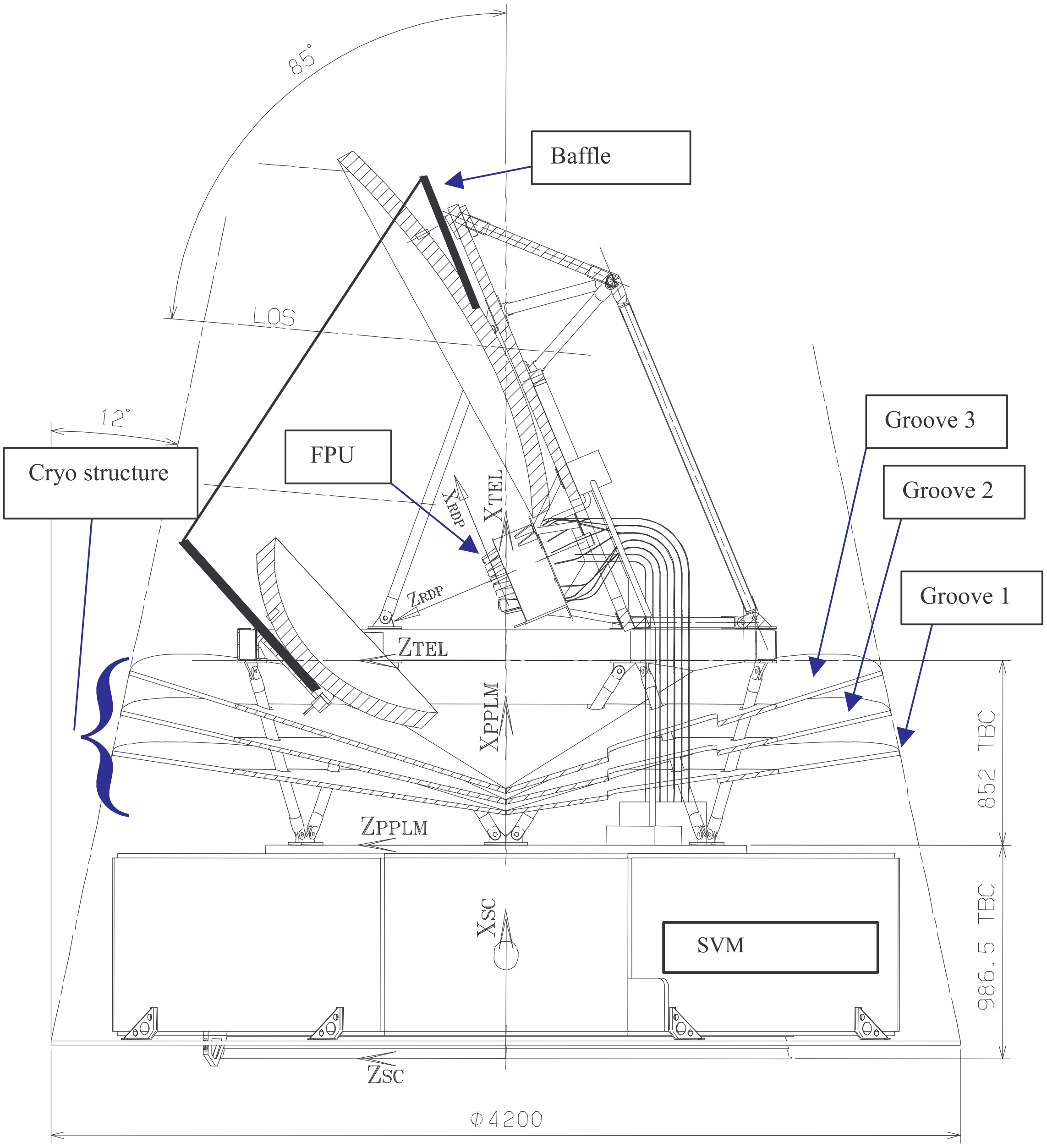

Figure 2.1-2 : Planck spacecraft axis system

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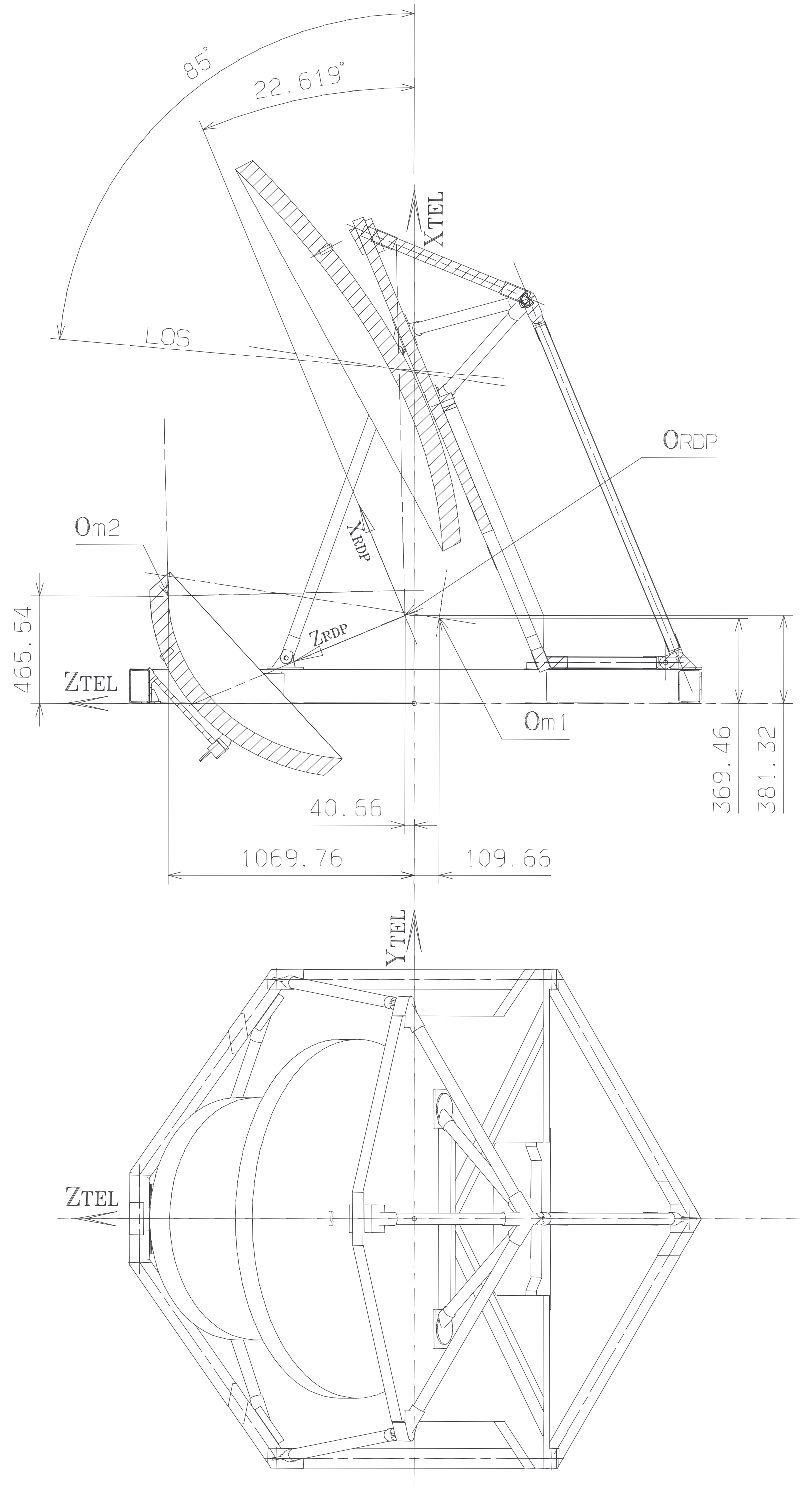

Figure 2.1-3 : Telescope, reflector and detector plane axis systems

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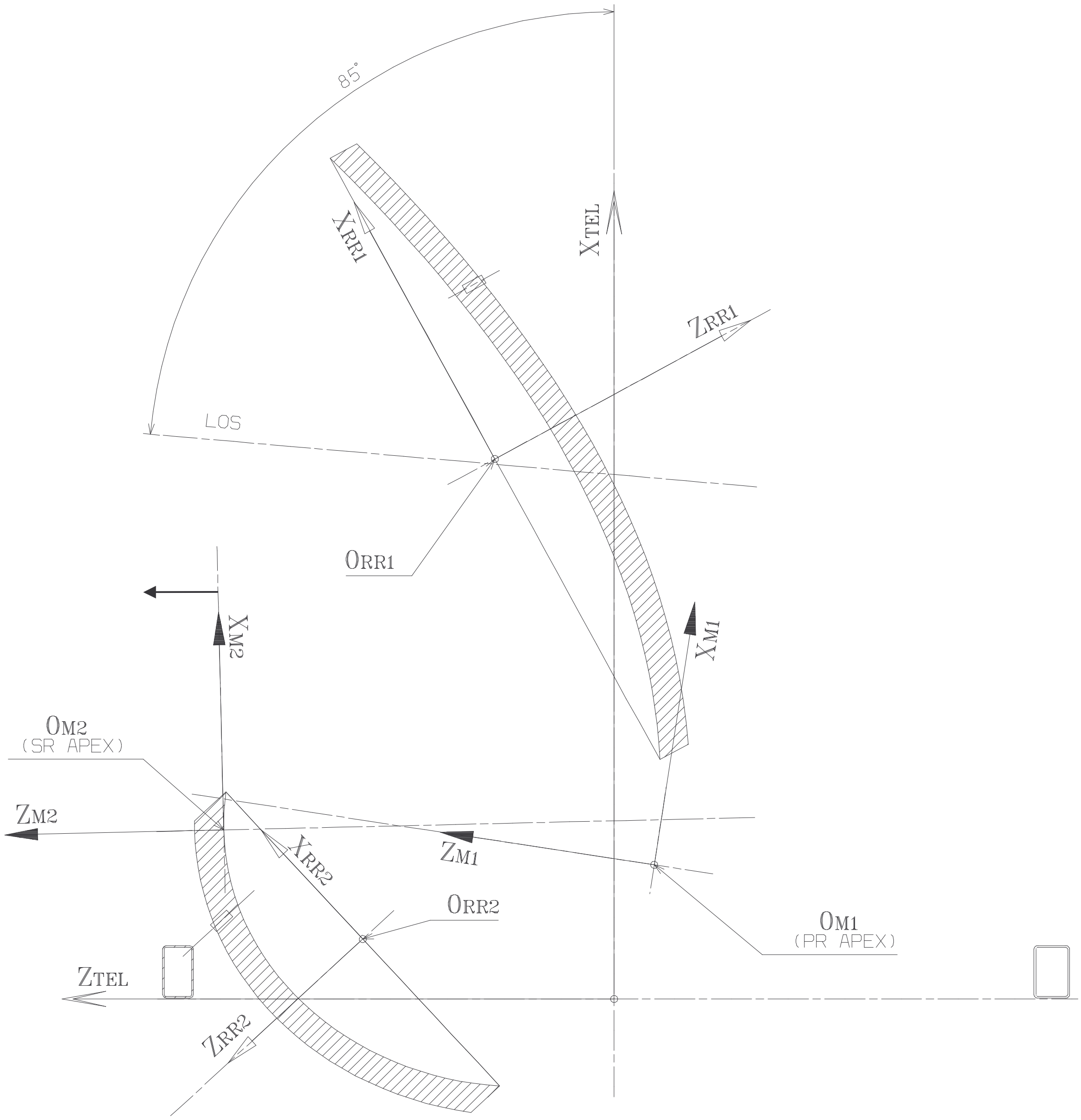

Figure 2.1-4 : Telescope and reflectors axis system

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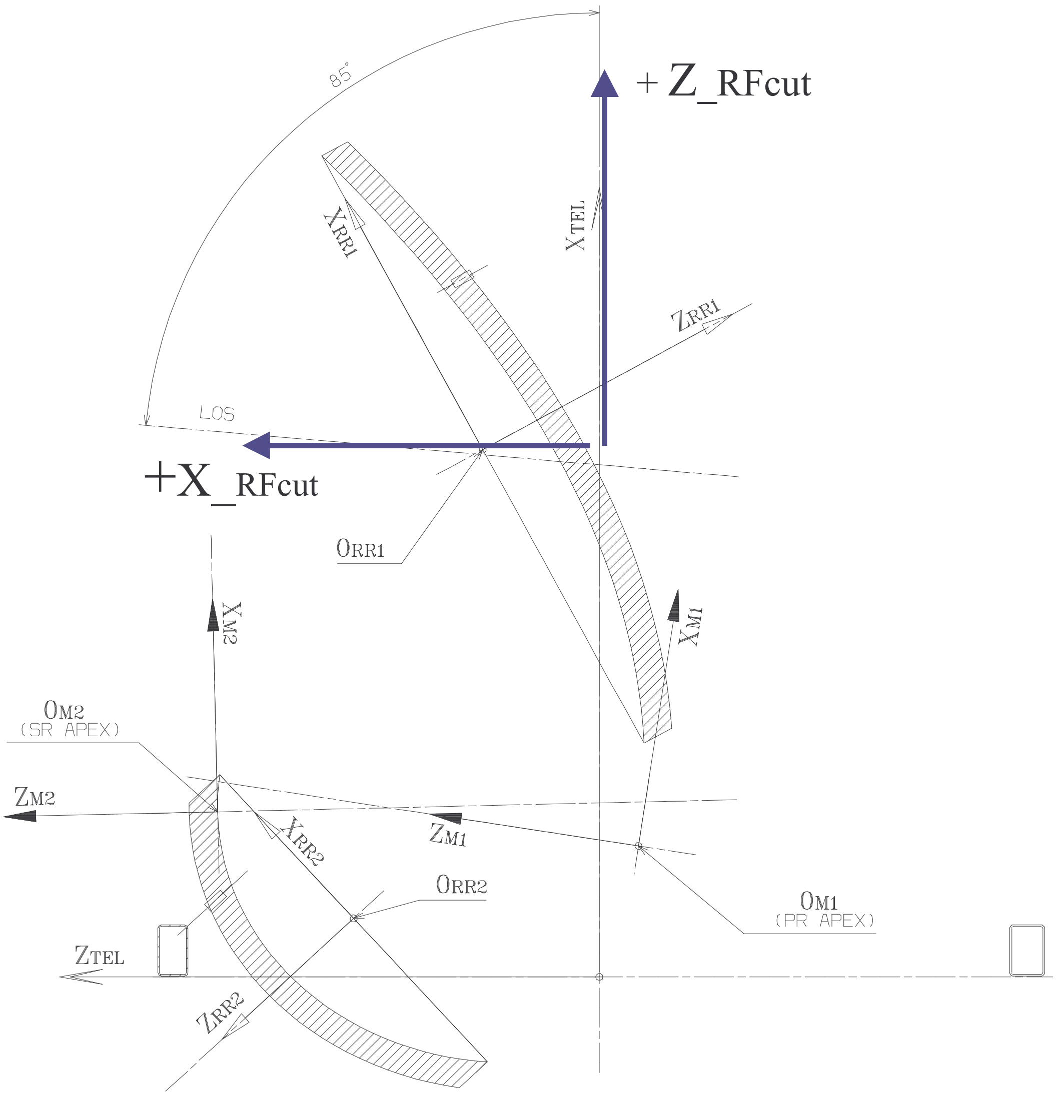

Figure 2.1-5 : Telescope and RF_cut axis system

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2.2 Description of the flight focal plane

The flight focal plane of the Planck Spacecraft is composed of two instruments the High Frequency Instrument (HFI) and the Low Frequency Instrument (LFI). These two instruments (arrays of detector) are mounted on an aluminium structure. The focal plane is hold by three bipods mounted on the primary reflector panel.

2.3 Description of the telescope

The Planck Telescope is designed as an off-axis tilted system offering the advantage of an unblocked aperture. The telescope LOS lies in the Z, X plane of the spacecraft co-ordinate system and is tilted at an angle of 85° with respect to the X spacecraft axis.

The telescope has an off axis 1.5 m diameter projected aperture.

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3. THE RADIO FREQUENCY QUALIFICATION MODEL

3.1 General description

The RFQM is composed of the following elements :

- QM telescope structure (hexagon frame, PR&SR panels)
- QM baffle
- QM V-groove N°3 only (N°3 is the upper V-groove; V-grooves N°1 and N°2 are not part of the RFQM)
- QM struts of the cryo-structure
- QM reflectors
- specific focal plane unit (see section 3.2)

The RFQM is presented in figure 3.1-1 & 3.1-2.

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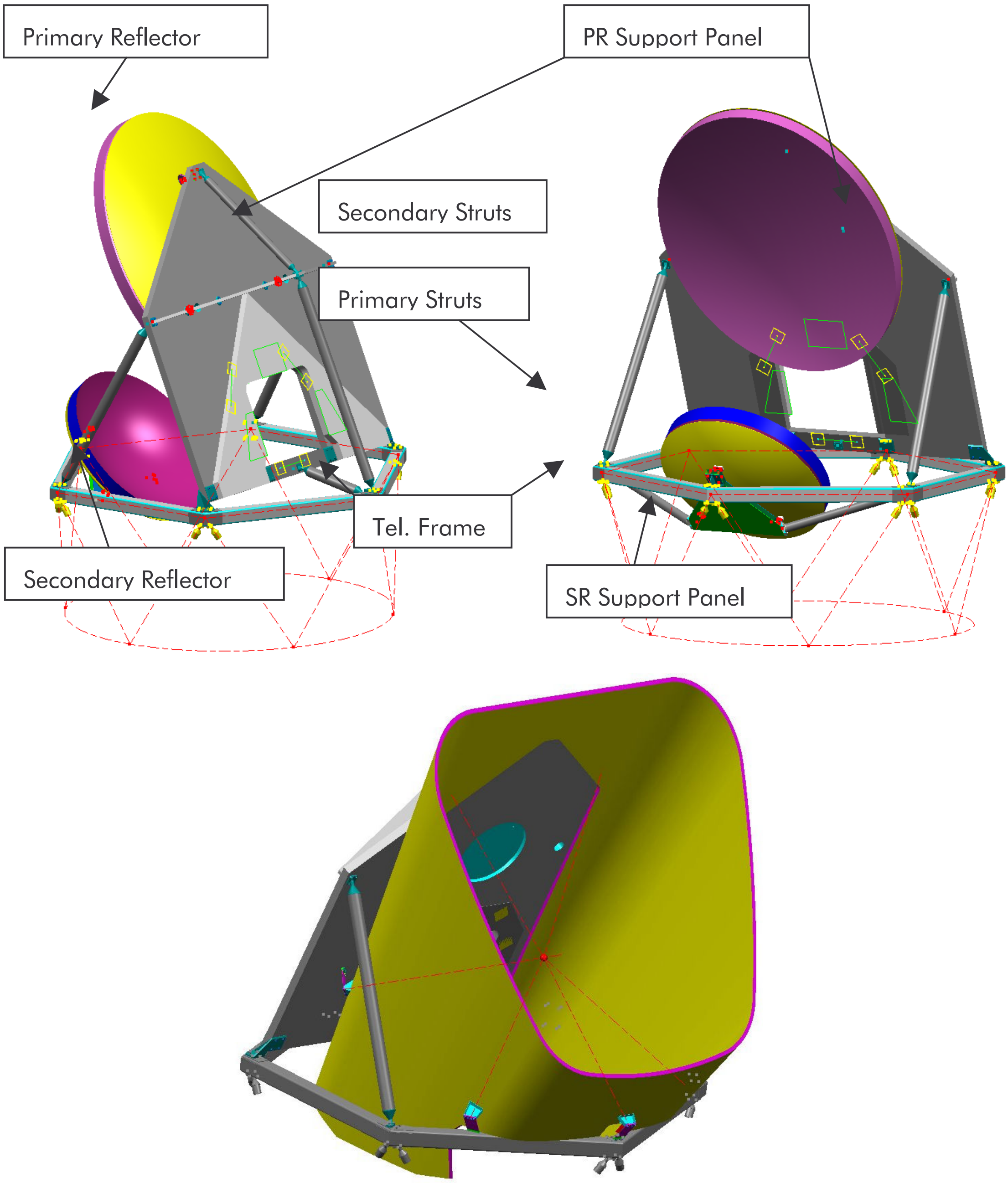

Figure 3.1-1: RFQM telescope and baffle (cryo structure & focal plane unit not shown).

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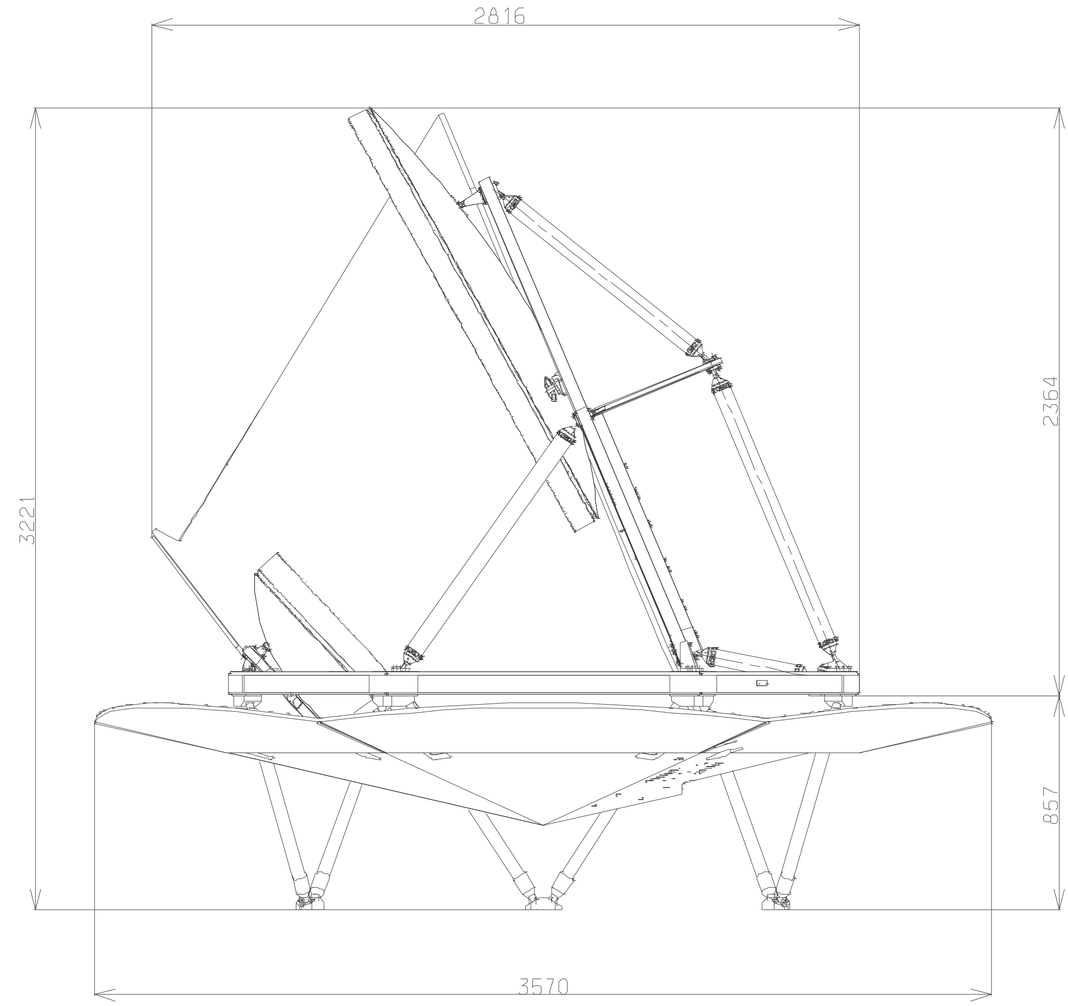

Figure 3.1-2: RFQM (focal plane unit not shown) overall dimensions in mm .

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3.2 RFQM focal plane unit

3.2.1 focal plane horn configuration

The RFQM test focal plane will be composed of :

- RF modules
- dedicated waveguide transitions between modules output and horns flange
- an external metallic envelop plate with holes around the horns
- dedicated mechanical structure
- the following horns :

-LFI-30-28
-LFI-70-23
-HFI-100-1
-HFI-353-6

HP-SP-0005

All feed horns shall be interfaced to a waveguide where only the TE11 mode can propagate. The Contractor shall design and manufacture if neccessary a waveguide transition to interface properly the 100, 353 GHz detector.

#

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3.2.2 Focal plane overall description

The overall focal plane configuration is composed of :

-set of three bipods

-shielding screen

-supporting structure

-waveguide to horn transition (W/G transition)

-horns

The horns are mounted on a W/G transition. This transition is mounted on a RF module. The RF module is then interfaced to the supporting structure.

All RF modules and supporting structure shall remain inside the shielding screen, only horns are passing through the front face of the shielding screeen via dedicated holes. On final, the test focal plane is interfaced to the RFQM thanks to the three bipods.

The test focal plane is displayed on the RFQM in figure 3.2-1 . The schematic of the focal plane configuration is provided in figure 3.2.2..

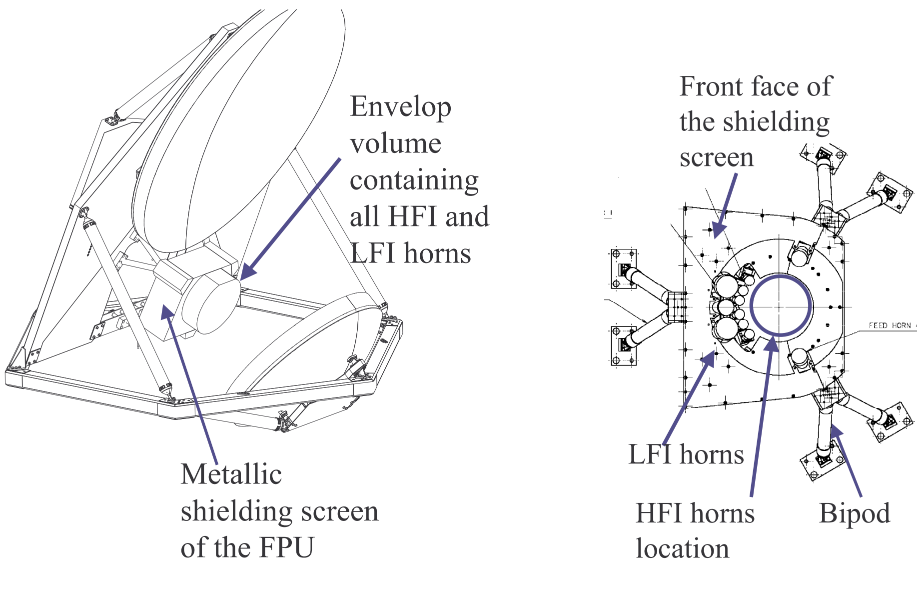

Figure 3.2-1 : test focal on the RFQM

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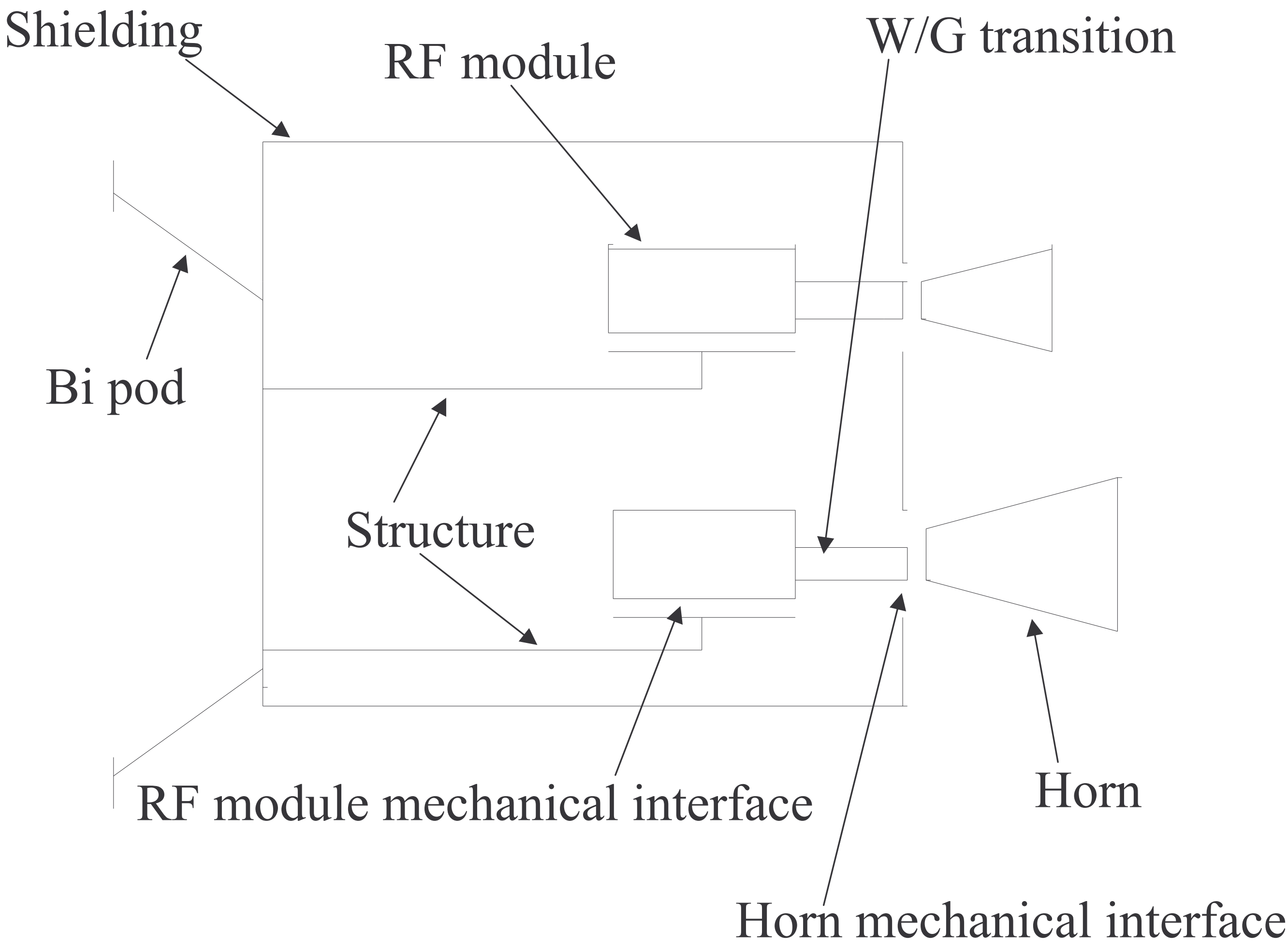

Figure 3.2-2 : overall focal plane configuration schematic (not fully populated)

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4. TEST FACILITY GENERAL REQUIREMENTS

4.1 General requirements

HP-SP-0010

The test facility shall be a Compact Antenna Test Range.

#

HP-SP-0020

The test faciltiy shall be equipped with at least a two axis positioner for the RFQM and one rotation stage for the range feed horn.

#

HP-SP-0030

The test facility shall be operated at frequencies from 30 GHz up to 353 GHz (see detailed frequency plan in section 7.1)

#

4.2 Environmental conditions

HP-SP-0040

All tests shall be carried out in ambient environment conditions, as defined below:

- Temperature: 22°C ± 5°C,
- Relative humidity: between 50% and 65%,
- Cleanliness conditions: Class 100.000

#

HP-SP-0050

The contractor shall record the room temperature (T) and the relative humidity (RH) with a one hour time step during the RF measurements. The contractor shall deliver the RH and T records.

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HP-SP-0060

The Cleanliness requirements shall correspond to an environment class 100 000 during all integration, alignment and RF test activities of the FPU and the RFQM.

#

HP-SP-0065

The Contractor shall minimize the contamination of the detector during RF test. The contractor shall implement a protective and RF transparent cover on the detectors which are not in operation. A all time, when the Planck reflectors are not used, they shall be protected by covers (furnished equipment with reflectors).

#

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4.3 CATR positioner pointing requirement

In this section different areas are defined. The angular areas are defined thanks to (θ,φ) angle as defined in the "Technical description of grasp8, TICRA February 2003". Anyhow the angle definition is provided in appendix 4.

HP-SP-0070

The contractor shall implement a positioner or a mechanical system allowing :

-to support the RFQM via the interface specified in HP-SP-0270

-to maintain the primary reflector of the telescope in the test zone during the rotation of the RFQM

#

4.3.1 Main lobes area

All the main lobes are located around the telescope line of sight within a cone of half cone angle of 5°. The line of sight is at 85° from the +Z_Rfcut axis and in the plane of symmetry (Plane (+X_RFcut, +Z_Rfcut)). The main lobes area and the line of sight are displayed in figure 4.3-1.

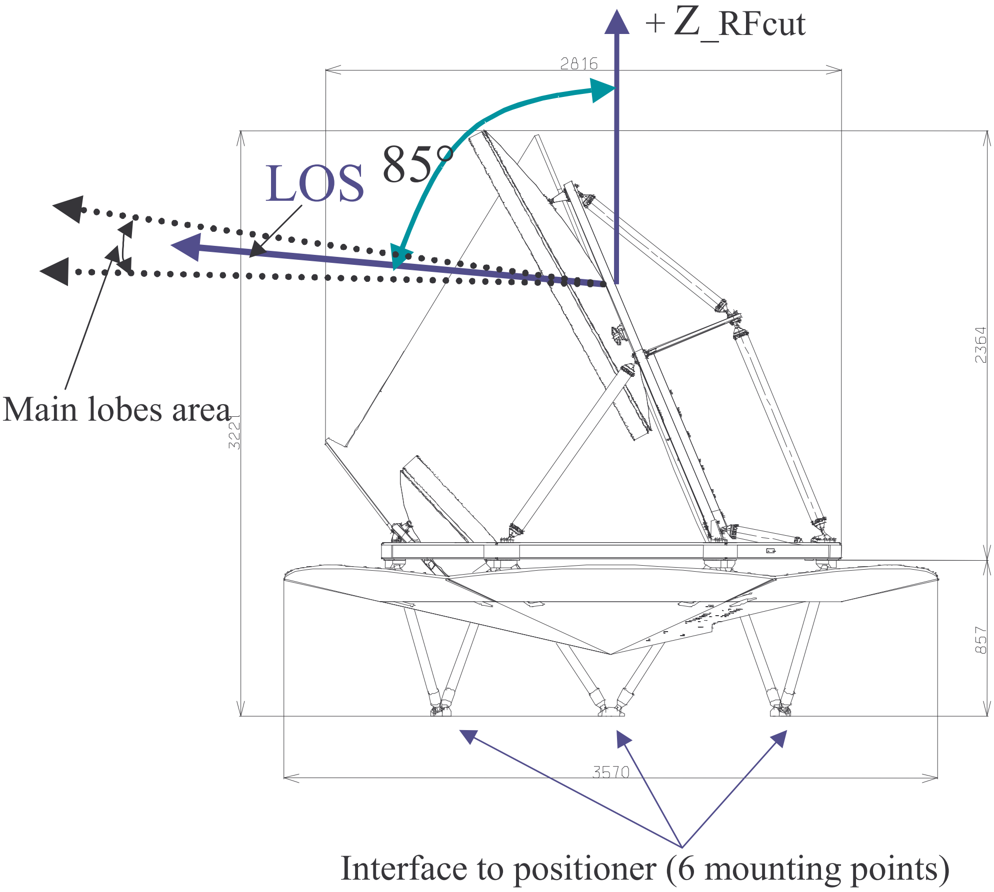

Figure 4.3-1 : line of sight orientation and main lobes area.

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HP-SP-0072

The positionner shall allow the pointing of the RFQM at +/-5° from the line of sight so as to measure all main lobes.

#

The precise locations of the main lobes to be measured are detailed in section 7.4.

4.3.2 Intermediate area

The intermediate area comprises the main lobe and the near in side lobe. This area is defined by all angular (θ , ϕ) values in the RF_cut coordinate system such that :

$70° \leq \theta \leq 100°$ and $-15° \leq \phi \leq 15°$

HP-SP-0075

The positionner shall allow the pointing of the RFQM for all angular values defining the intermediate area.

#

For each detector an intermediate area is defined. The detailed definition is provided in section 7.4.

4.3.3 Spill over area

The spill over lobe area is defined in the RF_cut coordinate system by all angular (θ , ϕ) values such that :

$0° \leq \theta \leq 120°$ and $0° \leq \phi \leq 95°$

and

$0° \leq \theta \leq 120°$ and $-95° \leq \phi \leq 0°$

The detailled RF measurement in cuts to be performed inside this area are defined in section 7.4.4.

HP-SP-0080

The contractor shall implement a positioner allowing the pointing of the RFQM inside the spill over area so as to perform RF measurement in cuts for θ varying while ϕ is constant.

#

4.3.4 Straylight area

The straylight area is defined in the RF_cut coordinate system by all angular (θ , ϕ) values such that :

$148° \leq \theta \leq 180°$ and $-10° \leq \phi \leq 10°$

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The detailled RF measurement in cuts to be performed inside this area are defined in section 7.4.

HP-SP-0090

The contractor shall implement a positioner allowing the pointing of the RFQM inside the straylight area so as to perform RF measurement in cuts for θ varying while ϕ is constant.

#

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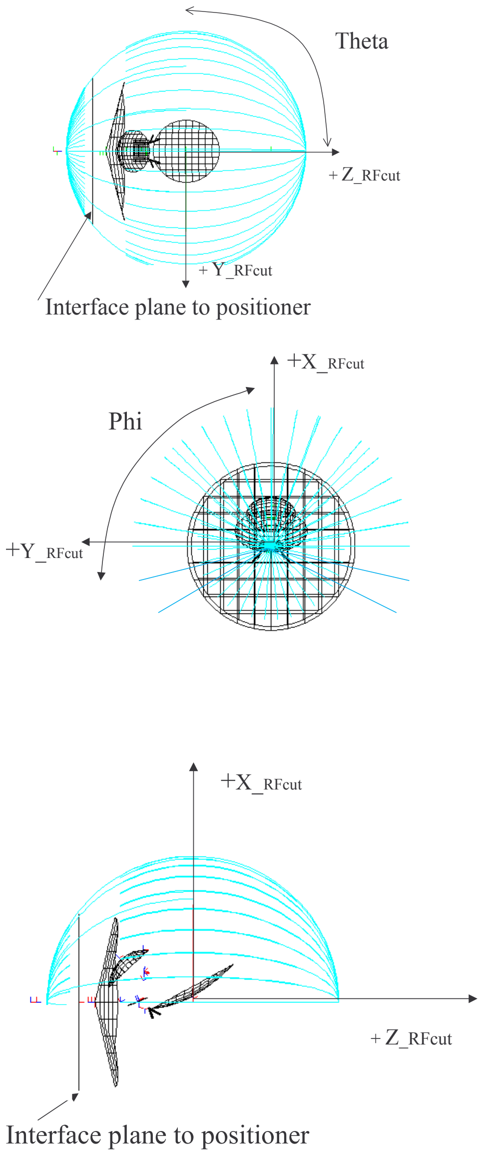

Figure 4.3-2 : example of RF cuts in the spill over zone (for information only)

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4.4 Compact antenna test range absolute and relative pointing accuracy requirements

The absolute angular accuracy is the maximum angular uncertainty around a selected direction with regard to the test facility reference. In other words, the positioner can be pointed in azimuth to an angle equal to (azimuth+/- absolute accuracy).

The relative angular accuracy is the known accuracy betwen two consecutive positions.

HP-SP-0120

The Contractor shall provide and verify the absolute and relative pointing accuracy of the test facility.

#

HP-SP-0140

The absolute pointing accuracy shall be better than 0.005°.

#

HP-SP-0150

The relative pointing accuracy shall be better than 0.0005°.

#

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4.5 RF module measurement facility RF requirements

HP-SP-0160

The RF modules integrated with the waveguide transition and the horn shall be measured in a dedicated test facility

#

HP-SP-0170

The amplitude measurement error for fully integrated RF module shall be lower than the values specified in the following table :

Levels below peak (dB)	max deviation (dB)
3	0.0045
10	0.05
20	0.2
30	0.45
40	0.8
50	1.25
60	1.8

#

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4.6 CATR measurement dynamic range requirements.

The following definition of the dynamic range is used to establish the requirements.

Definition : the RF dynamic range requirement is defined as the minimum amplitude (from peak) of the radiation pattern to be measured with a S/N ratio larger than 3 dB.

HP-SP-0180

For each solid angle area, the test facility shall provide a dynamic range better than the values displayed in table 4.6-1 :

Central frequency (GHz)	Dynamic Range (dB)
30	91
70	91
100	92
353	92

Table 4.6-1 : RF dynamic

#

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4.7 RF measurement accuracy

HP-SP-0190

The Contractor shall provide the error budget at all frequencies used for the test.

The Contractor shall provide the errror breakdown structure of the error budget and justify each elementary contributor.

The budget shall include as a minimum the following contributors :

-RF module error

-test facility error

-RF chain set up error.

#

4.7.1 RF accuracy for the main lobe measurement and near in side lobes.

HP-SP-0200

The amplitude measurement error shall be lower than the values specified in the following table for the main lobe area and the intermediate area measurement only. (*Note that these error bars have been calculated assuming a minimum dynamic range as specified in Table 4-1. The contractor shall detail the error budget attainable at their facilities.*)

Levels below co-polar peak (dB)	max deviation (dB)
0	0.0002
3	0.001
10	0.01
20	0.04
30	0.09
40	0.16
50	0.27
60	0.45

Table 4.7-1 : Measurement error for Co-polar and Cross-polar amplitude patterns

#

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4.7.2 RF accuracy for the spill over measurement

HP-SP-0210

The amplitude measurement accuracy (including RF module errror) shall be better than the values specified in the following table for the spill over lobe measurement.

#

F (GHz)	level below the peak (dB)	accuracy dB
30 GHz	54 ÷ 66	1
	67 ÷ 70	2
	71 ÷ 80	3
70 GHz	64 ÷ 66	1
	67 ÷ 70	2
	71 ÷ 80	3
100 GHz	60 ÷ 70	1
	70 ÷ 80	3
	80 ÷ 90	5
353 GHz	70 ÷ 80	1
	80 ÷ 90	3
	<90	5

Table 4.7-2 : RF accuracy for the spill over area

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4.7.3 RF accuracy for the straylight area.

HP-SP-0211

The amplitude measurement accuracy (including RF module errror) shall be better than the values specified in the following table for the straylight zone measurement.

#

Channel	dB level below the peak	accuracy dB
30 GHz	94	1
	96	2
	98	4
	100	6
	110	16
70 GHz	101	1
	104	3
	107	6
	110	9
	120	19
100 GHz	95	1
353 GHz	95	1

Table 4.7-3 : RF accuracy for the stray light area

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5. INTERFACE REQUIREMENTS

5.1 Mechanical and Radio-Frequency interfaces of the test focal plane.

As described in the SOW the test focal plane is composed of two parts. The first part of the delivery is procured by Alcatel (bipod, supporting structure and external shielding screen). The second part (RF modules and waveguide transitions to the horns) are designed and procured by the contractor.

The test focal plane unit is composed of a main frame and 3 bipods and shields as defined in [AD 2] and [AD 3].

The external geometry of these element is defined in [AD 2] and [AD 3] .

As explained in the statement of work the Contractor is only responsible of the design of the RF module on which is mounted the waveguide interface and horn. Anyhow the RF modules shall be designed in order to be accomodated in the same allowed volume. This sections reviews the requirement on the RF module and deliver the location information of the horn.

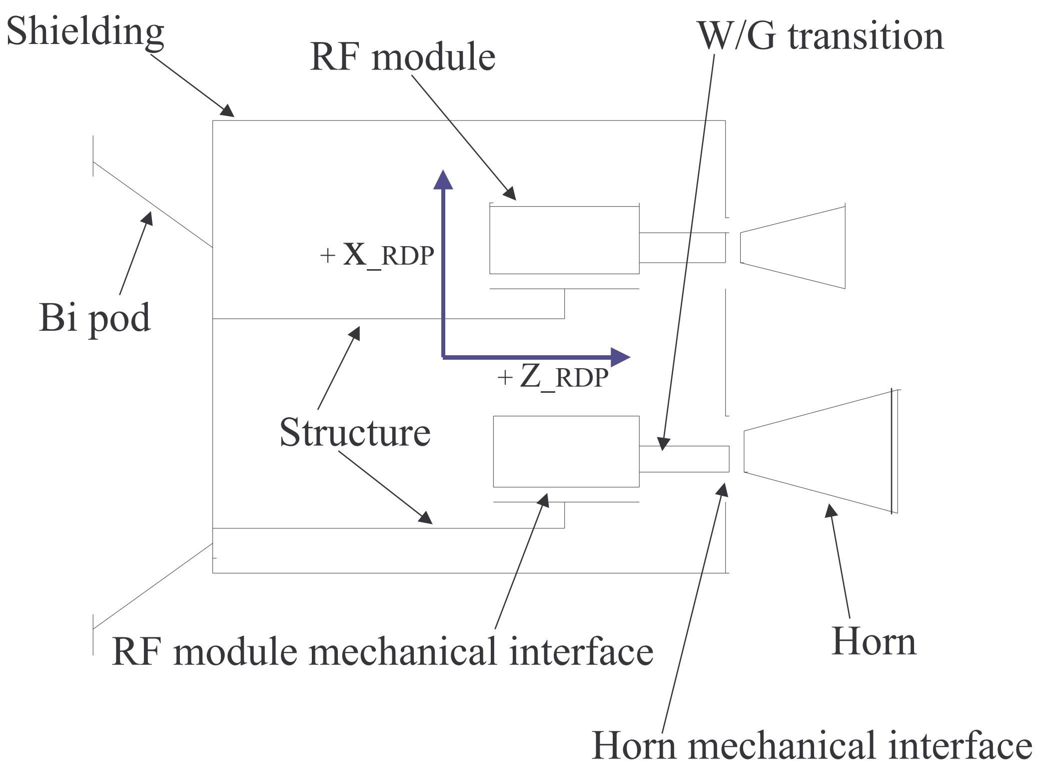

Figure 5.1-1: Schematic view of the test focal plane

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HP-SP-0212

The Contractor shall design a set of RF modules and RF transition with a RF output compatible with the horn flange mechanical interface defined in appendix 5.

#

HP-SP-0213

The Contractor shall implement on each RF module an optical system (cube + tooling ball (TBC)) and provide the location (position and orientation) of the horn mechanical interface and the mechanical interface of the RF module in the optical reference system within an accuracy better than +/-5µm (TBC).

#

HP-SP-0225

The contractor shall guarantee the position of the horn mechanical interface wrt the RF module mechanical interface including stability within 10 µm (TBC).

#

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Each horn delivered by Alcatel is referenced by two coordinate systems :

-a mechanical coordinate system (at the waveguide flange)

-a RF coordinate system (at the horn phase center)

There's only a translation between the mechanical coordinate system and the RF coordinate system.

The location of each RF coordinate system is defined for each detector in the RDP coordinate system so as to inform the contractor on the constraints on the design of each RF module.

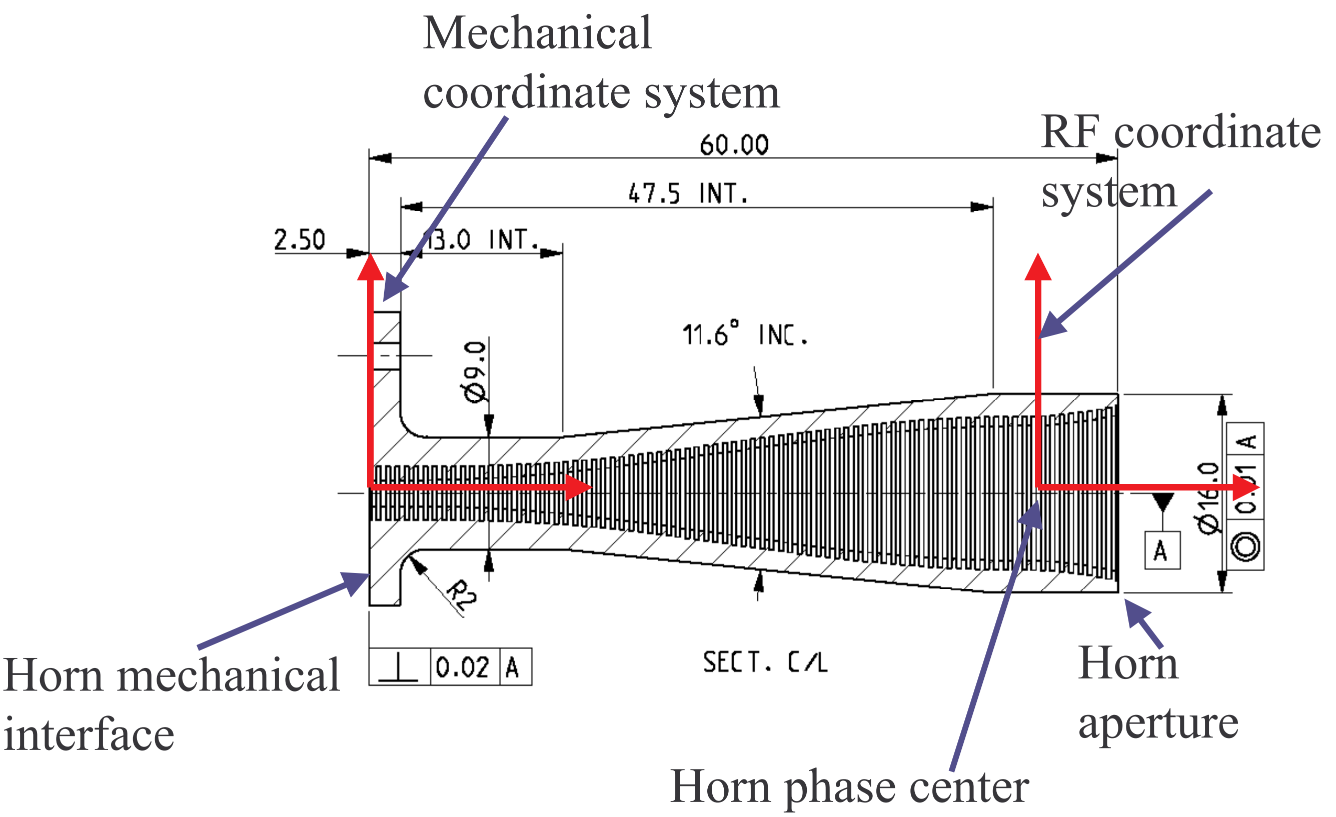

Figure 5.1-2 : example of RF and mechanical coordinate system (Nota Z_axis being along the horn axis of revolution).

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The RF coordinate of each horn are provided in the RDP coordinate system and are defined in the following table. Z_axis is the propagation axis (in transmission) of each horn. The polarization is aligned along X_axis and on Y_axis.

Detector	Xrdp (mm)	Yrdp (mm)	Zrdp (mm)
LFI-30-28	-136.950	-54.940	18.600
LFI-70-23	-76.380	69.370	14.540
HFI-100-1	-47.570	-32.966	14.847
HFI-353-6	0.450	27.045	7.897

	Normalised Xdet		
Detector	**/ Xrdp**	**/ Yrdp**	**/ Zrdp**
LFI-30-28	**0.91060136**	**0.31490145**	**-0.26766069**
LFI-70-23	**0.93637935**	**-0.29957394**	**-0.18289113**
HFI-100-1	**0.35297449**	**-0.93511528**	**0.03111960**
HFI-353-6	**0.99964681**	**0.02642420**	**0.00283200**

	Normalised Ydet		
Detector	**/ Xrdp**	**/ Yrdp**	**/ Zrdp**
LFI-30-28	**-0.33142608**	**0.94331456**	**-0.01773108**
LFI-70-23	**0.32031753**	**0.94239807**	**0.09634598**
HFI-100-1	**0.93072866**	**0.34752909**	**-0.11387580**
HFI-353-6	**-0.02654330**	**0.99799708**	**0.05742200**

	Normalised Zdet		
Detector	**/ Xrdp**	**/ Yrdp**	**/ Zrdp**
LFI-30-28	**0.24690468**	**0.10485568**	**0.96335007**
LFI-70-23	**0.14349350**	**-0.14879962**	**0.97840088**
HFI-100-1	**0.09567203**	**0.06915915**	**0.99300749**
HFI-353-6	**-0.00130900**	**-0.05747689**	**0.99834598**

Table 5.1-1 : Coordinate system definition of each RF coordinate system of each horn for the second set.

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HP-SP-0230

The Contractor shall implement all the RF modules in order to feed the corresponding horns with linear polarization aligned along the X_axis and Y_axis as defined in table 5.1.

#

For the telescope dual polarization measurement, at least three potential different configurations could be envisaged :

-implementation of an Ortho Mode Transducer.

-implementation of a 90° (+/-0.1°) twisted waveguide between the RF module and the horn, in addition to the rotation of the horn or the transition.

-rotation by 90° of the RF module and the horn.

HP-SP-0232

If the last option (rotation by 90° of the RF module & horn) is selected, the contractor shall guarantee an angular shift of 90° with an acuracy of +/-0.5 °. In addition the knowledge of the angular shift shall be known with an accuracy of +/-0.05°

#

The following table contains the reference of each detector as well as the translation between the RF and mechanical coordinate system. The detector reference is the reference of the CAD drawing provided in Appendix 5.

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detector ref	filename	Reference in the HFI focal plane	mechanical horn length (mm)	phase center (mm) from waveguide mechanical flange	phase center from horn aperture (mm)
100 GHz Front horn PQ100 F - 1A /1B	PQ100F-1x	100_1 & 100_4	60	58.800	1.2
353 GHz Front Horn PQ353F - 2A/2B/3A/3B	PQ353F-2x	all 353 GHz detector	53.212	51.712	1.5

Reference in the LFI focal plane	detector ref	mechanical horn length (mm)	phase center (mm) from waveguide mechanical flange	phase center from horn aperture (mm
LFI_30	LFI_30_(i)	156,12	143,73	12,39
LFI_70	LFI_70_(i)	61,5	59,14	2,36

Table 5.1-2 : Reference of each horn and relation between the RF and mechanical coordinate system.

HP-SP-0235

As a baseline, the contractor shall design the RF modules so as to allow the accomodation of all the RF modules inside the focal plane allowed volume (defined in [AD 2] and [AD 3]). The horns being located as described in table 5.1-1 & 5.1-2 & 5.1-3.

#

HP-SP-0245

The maximum mass of all the RF modules, waveguide transitions and feed horns composing the TFPU shall be lower than 28 kg, assuming of total mass of 1 kg (TBC) for all feed horns.

#

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5.2 RF characteristics of horns.

5.2.1 RFQM feed horn radiation patterns (30 GHz up to 353 GHz).

The RFQM feeds have the same corrugation definition as the flight ones except for the LFI 70 GHz.

HP-SP-0252

The Contractor shall consider as RF interface the predicted feeds radiation patterns provided in appendix 1 for the LFI feeds and in appendix 2 for the HFI feeds.

#

Nota : the phase center distances displayed in appendix 2 are different from the values provided in section 5.1. The reason is that a corrugation has been numerically added for computation reason only. The true distances for the phase centers wrt to the horn aperture or mechanical waveguide flange interface are contained in the table 5.1-4.

5.2.2 NIL

5.2.3 NIL

5.2.4 NIL.

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5.3 Test facility positioner mechanical interface

HP-SP-0260

The test facility design shall be compatible with the RFQM volume defined in figure 5.3-1

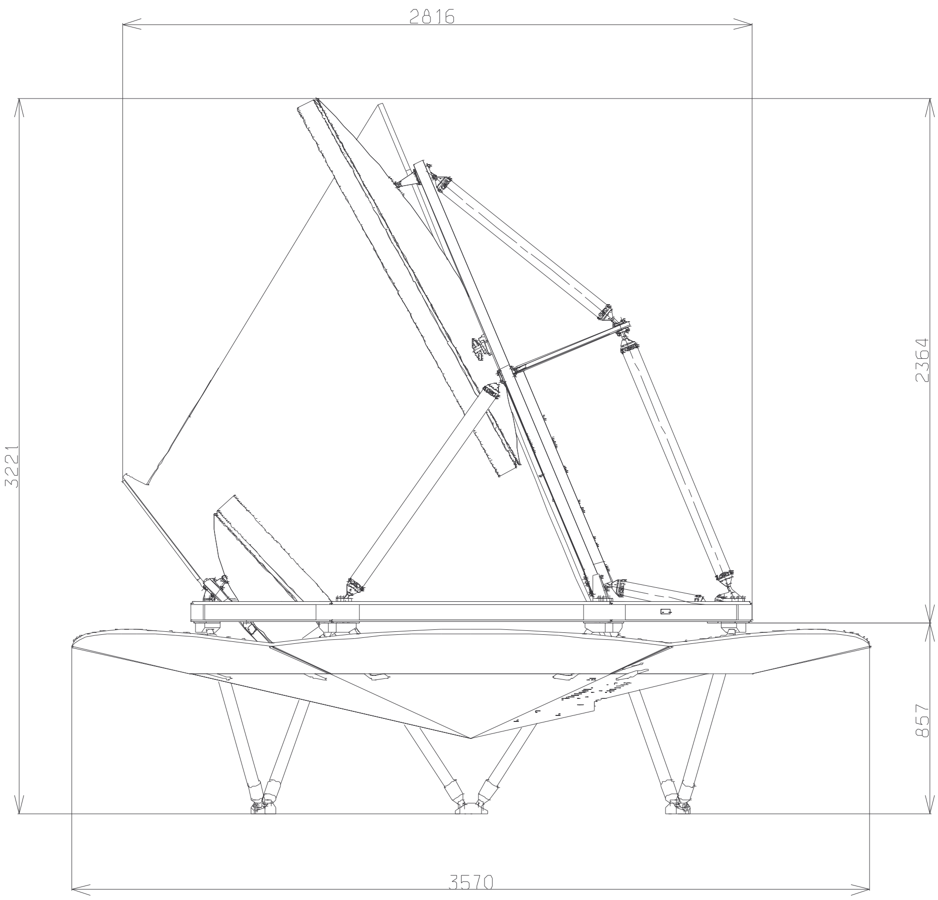

Figure 5.3-1 : RFQM (test focal plane not shown) overall dimensions in mm.

#

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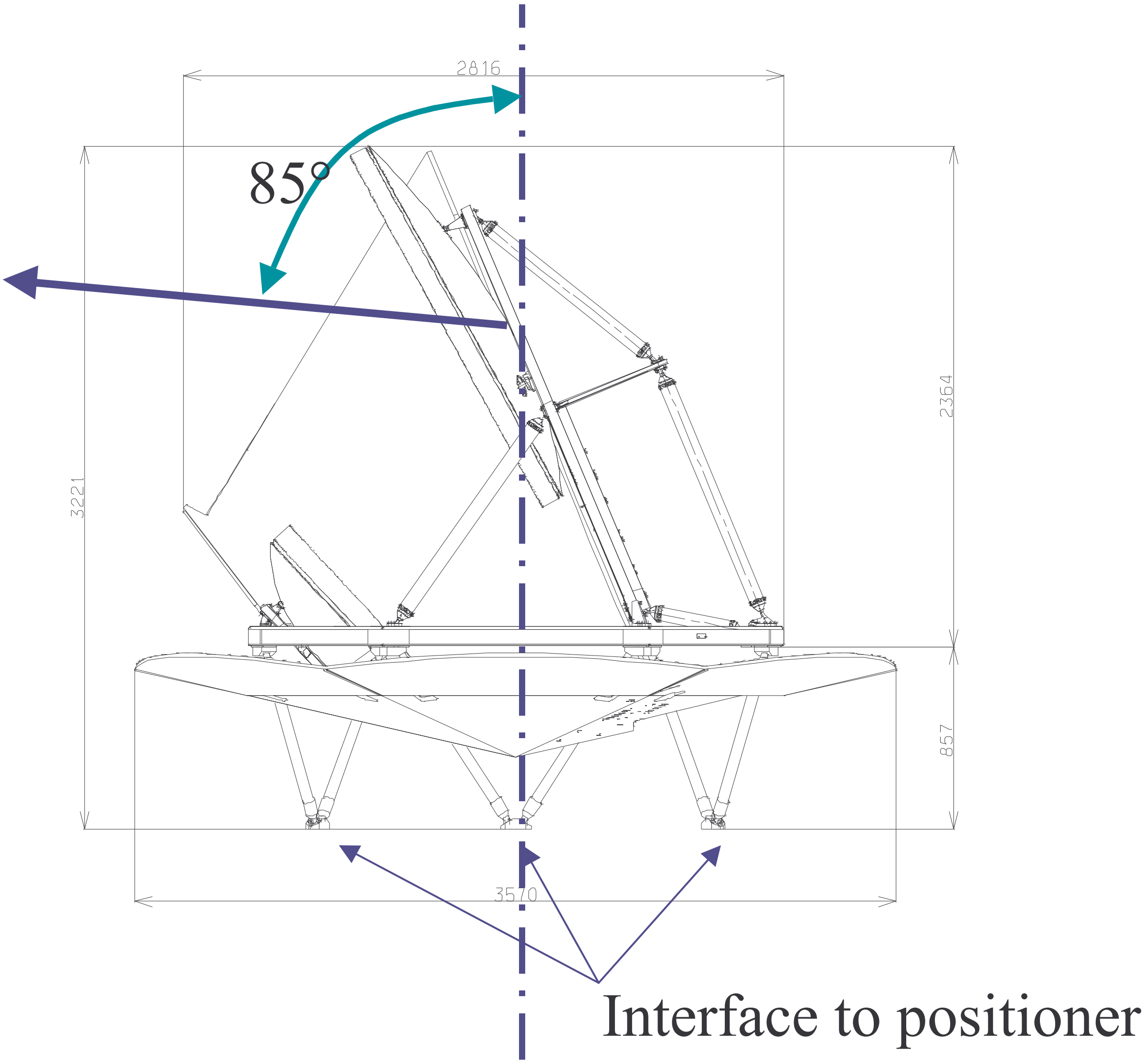

Figure 5.3-2 : line of sight orientation wrt the interface to positioner.

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The RFQM interface plane is defined as the lowest part of the struts passing through the grooves and interfacing the SVM. The strut interfaces are contained in a plane. The interfaces are shown in fig 5.3-3

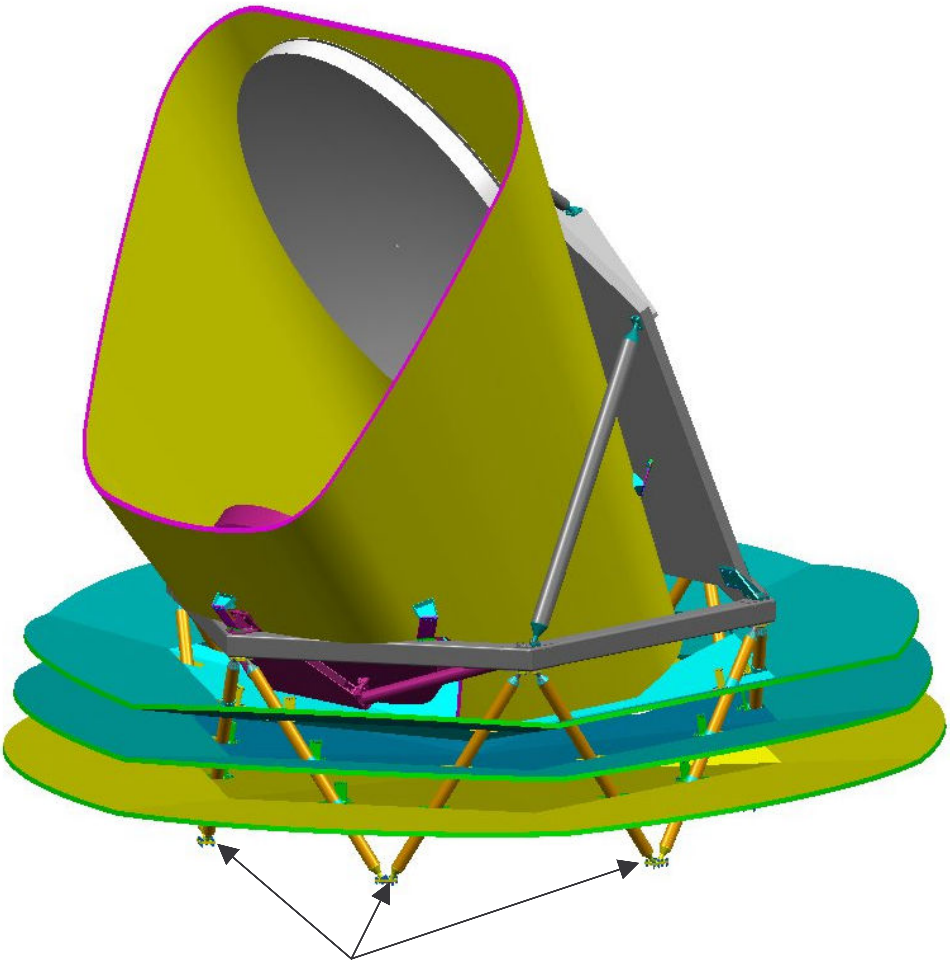

Figure 5.3-3 : RFQM interface to test facility positionner

HP-SP-0270

The test facility interface to RFQM shall be compatible with the Planck SVM/PLM interfaces described in [AD 4] [AD 5] [AD 6] [AD 7] [AD 8]

#

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HP-SP-0280

Each of 6 mounting areas composing the test facility interface to the RFQM shall have the following position accuracy (including stability) :

-in the interface plane : +/- 50 µm

-out of the interface plane : +/- 50 µm

In addition the location of the mounting areas shall be known with an accuracy of +/-5 µm.

#

HP-SP-0290

The test faicility positioner shall be able to support the RFQM which has the following mass breakdown structure

	Mass (kg) (tbc)
Baffle	40
Telescope	130
Cryo-struts + 3rd V-Groove	75
FPU support structure + shield	28
RF-modules, waveguide transitions and feed horns	28

table 5.3-1 : RFQM mass breakdown.

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6. ALIGNMENT REQUIREMENTS

6.1 CATR alignment

HP-SP-0320

The CATR Angle of Arrival shall be aligned with regard to the Z_axis of the Primary reflector (M1 or Global_Coor_arch) coordinate system using the primary reflector cube within a tolerance of +/-0.005°.

#

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7. RF TEST REQUIREMENTS

7.1 frequency plan

HP-SP-0340

The operating frequency of each horn shall be chosen inside a bandwidth of +/-10% around the central frequency of each channel. Anyhow, preference shall be given to the central frequency indicated. However, other frequencies within the allowed band may be selected if justified by:

- Equipment availability, e.g. transmit or receive modules
- Constraints such as atmospheric transmission and stability.

Central frequency (GHz)	lowest allowed test frequency (GHz)	highest allowed test frequency (GHz)	Comments
30	27	33	
70	63	77	
100	90	110	
353	317.7	388.3	

table 7.1-1 : frequency band for the RF measurements

#

7.2 polarisation orientation and measurement requirement

HP-SP-0350

The polarisation of the range feed horn shall be linear.

#

7.2.1 polarisation plane requirement

The orientation of the polarisation plane of the range feed horn is driven by the horn orientation in the focal plane.

HP-SP-0360

The polarisation plane orientation of the range feed horn shall be measured with an accuracy of +/- 0.1° wrt to the RFQM main coordinate system.

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#

7.2.2 polarisation measurement

HP-SP-0370

Polarisation measurements shall be delivered using the 3rd Ludwig polarisation convention.

The RF acquisition shall be performed for the two orthogonal polarizations. The Co-polarization being in the polarization plane.

#

7.3 feed horn test requirements.

As it is described in the statement of work, the focal plane of the RFQM is composed of a series of feed horns delivered by Alcatel. Those horns are mounted on a RF equipment designed by the contractor. Hence so as to confirm the RF properties of the feeds mounted on the RF equipment the contractor shall perform a set of RF tests at RF module level.

HP-SP-0390

The contractor shall characterize the radiation pattern of each feed mounted on the corresponding RF equipment or RF module.

The radiation pattern shall be measured in Co and Cross polarisations in the E-plane and the H-plane as well as in the plane at +/- 45°.

Each plane shall be measured from boresight up to 180° (with a step of 1°) .

The polarization shall be linear.

#

HP-SP-0400

The radiation pattern of each feed mounted on the RF equipment (or RF module) shall be measured at least in amplitude.

#

HP-SP-0410

The contractor shall explain any discrepancies higher than the RF module contribution to the overall RF budget (see HP-SP-0190) between the measurement and the provided feed radiation patterns.

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#

HP-SP-0420

The contractor shall test the feed at the same frequencies as the one used for the overall RFQM test (see frequency plan in section 7.1).

#

HP-SP-0430

The contractor shall measure the Voltage Wave Standing Ratio (VSWR) of each feed.

#

HP-SP-0440

The contractor shall perform pattern acquisition by rotating the feed around the predicted phase center (see section 5.1 for the phase center location).

#

In order to demonstrate there's no RF impact of the presence of the local environment of the horn an additionnal test is required as follows.

HP-SP-0450

The Contractor shall perform the RF measurement of the horn with a metallic plate (see figure 7.3-1) representing the front face of the focal plane allowed volume ([AD2]).

The plate being delivered by Alcatel.

The horn being located as defined in section 5.1 wrt to the RDP coordinate system (hence to the plate) .

#

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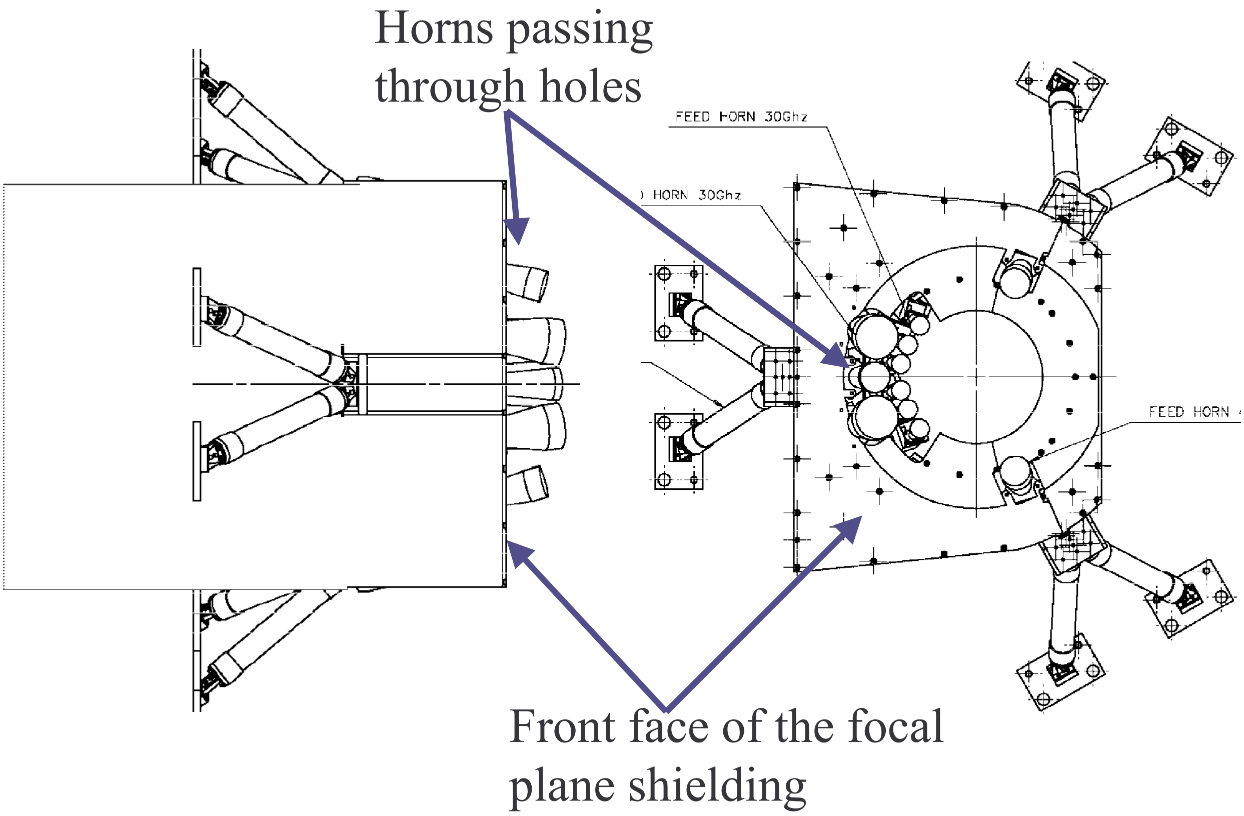

Figure 7.3-1 : font face of the focal plane shielding

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HP-SP-0460

The contractor shall provide for each measured pattern the directivity by integration

#

HP-SP-0470

The contractor shall convert each measured pattern in TICRA cut file compatible format see appendix 6 for the format.

#

7.4 RFQM test requirements.

The next section reviews all the test requirement for the main lobe , far out side lobe and straylight area.

7.4.1 main lobe measurement

This section defines the main lobe grid. Each grid is centered around the theoretical main lobe maximum.

HP-SP-0480

The acquisition grid for the main lobe RF measurement shall contain the maximum of each main lobe. The theoretical angular direction of each main lobe is defined in table 7-2.

	frequency (GHz)	theta (°)	phi (°)
LFI_30_28	30	88.8957	1.931
LFI 70 23	70	87.2024	-2.46
HFI_100_1	100	86.4852	1.1826
HFI_353_6	353	84.925	-0.82

Table 7.4-1: main lobe pointing direction in RF_cut coordinate axis.

#

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HP-SP-0485

The acquisition grid around each main lobe maximum shall be as defined in the table 7-3. The minimum number of point per line of the acquisition grid shall be at least as defined in table 7-3.

	frequency (GHz)	theta-min (°)	theta-max (°)	nb point
LFI_30_28	30	87.3957	90.3957	75
LFI 70 23	70	86.2024	88.2024	121
HFI_100_1	100	86	87	61
HFI_353_6	353	84.75	85.1	43

	frequency (GHz)	phi-min (°)	phi-max (°)	nb point
LFI_30_28	30	0.431	3.431	75
LFI 70 23	70	-3.47	-1.47	121
HFI_100_1	100	0.75	1.65	55
HFI_353_6	353	-1.02	-0.62	49

Table 7.4-2 : grid definition for the main lobe measurement

#

HP-SP-0490

The main lobe acquisition shall be performed for both copolar and crosspolar amplitude and phase. Phase radiation patterns measurements are required at least up to 353 GHz. Phase accuracy shall be less than 5deg (TBC).

#

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7.4.2 intermediate area measurements

The intermediate area is composed of the area comprising the main lobe and the firsts side lobes.

The intermediate area is centered around the direction (theta=85°, phi=0°).

HP-SP-0500

The RF measurement in the intermediate area shall be performed using the window as defined in the table 7-4-3.

	frequency (GHz)	theta range (°)	theta-min (°)	theta-max (°)	Step in theta (°)	nb point
LFI 30 28 (outer zone)	30	30	70	104	0.5	69
LFI 30 28 (central zone)	30	10	80	94	0.1	141
LFI 70 23 (outer zone)	70	20	75	95	0.2	101
LFI 70 23 (central zone)	70	10	80	90	0.1	101
HFI_100_1	100	20	75	95	0.15	134
HFI_353_6	353	15	77.5	92.5	0.1	151

	frequency (GHz)	phi range (°)	phi-min (°)	phi-max (°)	Step in phi (°)	nb point
LFI 30 28 (outer zone)	30	30	-18	18	0.5	73
LFI 30 28 (central zone)	30	10	-7	8	0.1	151
LFI 70 23 (outer zone)	70	30	-15	15	0.2	151
LFI 70 23 (central zone)	70	10	-5	5	0.1	101
HFI_100_1	100	25	-12.5	12.5	0.15	168
HFI_353_6	353	10	-5	5	0.1	101

Table 7.4-3 : RF acquisition window definition in the RF_cut coordinate system

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7.4.3 straylight zone measurements

HP-SP-0530

The straylight zone measurement is defined by a series of cuts of the radiation pattern. All cuts are defined in the table 7.4-4.

		frequency (GHz)	phi (°)	theta-min (°)	theta-max (°)	Step in theta (°)	nb point
2 cuts at 2 different phi	LFI 30_28	30	-140, 140	30	180	2	76
	LFI 70_23	70		30	180	2	76
	HFI_100_1	100		30	180	2	76
	HFI_353_6	353		30	180	2	76
5 cuts at 5 different phi	LFI 30_28	30	-45,-20 0 20,45	90	180	2	46
	LFI 70_23	70		90	180	2	46
	HFI_100_1	100		90	180	2	46
	HFI_353_6	353		90	180	2	46
2 cuts at 2 different phi	LFI 30_28	30	-80,80	70	180	2	56
	LFI 70_23	70		70	180	2	56
	HFI_100_1	100		70	180	2	56
	HFI_353_6	353		70	180	2	56

Table 7.4-4: straylight cut definition in the RF_cut coordinate system.

#

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7.4.4 spill over lobe zone measurements.

HP-SP-0540

The spill over zone area shall be measured in 19 cuts as defined in the table 7-6. The cuts are defined for constant phi value while theta is varying.

	frequency (GHz)	theta-min (°)	Theta-max (°)	step in theta (°)	nb point
LFI 30_28	30	0	120	5	24
LFI 70_23	70	0	120	5	24
HFI_100_1	100	0	120	2	61
HFI_353_6	353	0	120	2	61

	frequency (GHz)	phi-min (°)	Phi-max (°)	step in phi	nb_cut
LFI 30_28	30	-88.069	91.931	5	36
LFI 70_23	70	-92.46	87.54	5	36
HFI_100_1	100	-90	90	2	91
HFI_353_6	353	-90	90	2	91

Table 7.4-5: spill-over cut definition in the RF_cut coordinate system

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7.4.5 high resolution measurements.

HP-SP-0550

The following hihg resolution measurements shall be performed for constant phi value.

	frequency (GHz)	Phi (°)	theta-min (°)	Theta-max (°)	nb point
LFI 30 28	30	0	0	180	181 (spec) / 361 (goal)
		30	0	180	181 (spec) / 361 (goal)
		60	0	180	181 (spec) / 361 (goal)
		90	0	180	181 (spec) / 361 (goal)
		120	0	180	181 (spec) / 361 (goal)
		150	0	180	181 (spec) / 361 (goal)
LFI 70 23	70	0	0	180	181 (spec) / 361 (goal)
		30	0	180	181 (spec) / 361 (goal)
		60	0	180	181 (spec) / 361 (goal)
		90	0	180	181 (spec) / 361 (goal)
		120	0	180	181 (spec) / 361 (goal)
		150	0	180	181 (spec) / 361 (goal)
HFI	100, 353	-45	0	30	181
			40	70	181
			80	100	121

Table 7-7: high resolution cut definition in the RF_cut coordinate system

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8. TEST SEQUENCE DETAILED REQUIREMENTS

8.1 Elementary test sequence requirement at horn level.

All detailed test requirements are contained in section 7.3.

The contractor shall measure the horn mounted on the RF module with then without the FPU front plate.

The detailed test sequence is defined as follows.

For the horns mounted on the corresponding RF connection or RF module :

-30 GHz horn radiation pattern series of measurements

-70 GHz horn radiation pattern series of measurements

-100 Ghz horn radiation pattern series of measurements

-320 GHz horn radiation pattern series of measurements

The horns and RF module are mounted with a front metallic face representing the front FPU face.

In this configuration the test sequence is defined as follows :

-30 GHz horn radiation pattern series of measurements

-70 GHz horn radiation pattern series of measurements

-100 Ghz horn radiation pattern series of measurements

-320 GHz horn radiation pattern series of measurements

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8.2 RFQM detailed test sequence requirement.

8.2.1 Fisrt series of RF measurement.

The first series of measurement shall be performed in the following configuration :

-the FPU is composed at least of the 4 nominal RX RF module

-the CATR feed room is composed of the TX module for each frequency under test

The first series of RF measurement is the nominal **CATR RF test** for the 4 horns for the first polarization orientation.

The test shall be performed in the following order :

-main lobe then far out side lobe measurement at 30 GHz

-main lobe then far out side lobe measurement at 100 GHz.

-main lobe then far out side lobe measurement at 320 GHz

-main lobe then far out side lobe measurement at 70 GHz

8.2.2 Second series of RF measurement.

The second series of measurement shall be performed in the following configuration :

-the FPU is composed at least of the 4 nominal RX RF module rotated by 90°

-the CATR feed room is composed of the 90° rotated TX module for each frequency under test.

The second series of RF measurement is the nominal **CATR RF test** for the 4 horns for the second polarization orientation.

The test shall be performed in the following order :

-main lobe then far out side lobe measurement at 30 GHz

-main lobe then far out side lobe measurement at 100 GHz.

-main lobe then far out side lobe measurement at 320 GHz

-main lobe then far out side lobe measurement at 70 GHz

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9. POST PROCESSING OF THE DATA.

HP-SP-0560

The contractor shall provide all measured data as raw data and all processed data resulting from eventual error corrections.

#

HP-SP-0570

The contractor shall convert the measured, processed data into compatible electronic file format (TICRA format see appendix 6). In addition, the contractor shall provide the uncertainty boundary patterns per measurement.

#

HP-SP-0580

The contractor shall compute the directivity of each main lobe by pattern integration.

#

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10. SUCCESS CRITERIA

See section 4.3 for the area definition

10.1 Horn mounted on RF module test success criteria.

The elementary test so as to measure the radiation pattern of the horns mounted on the RF module is successful if all the required cuts have been performed within the test facility error budget.

The test is successful even if the measured pattern does not match with the one measured by the instruments.

10.2 Overall RFQM test success criteria

10.2.1 Main lobe area success criteria

The initial main lobe success criteria can be defined as a primary order correlation with the main lobe prediction.

At 30 GHz the measurement shall be directly comparable to the prediction down to at least 30 dB below the peak.

At all other frequencies the measurement should be comparable with the prediction associated with an interval error corresponding to the CATR error budget. The quiet zone impact being not removed in a first time. The CATR impact removal or deconvolution process is part of the measurement data analysis.

10.2.2 Intermediate area success criteria

The success criteria of the measurement in this area is the completion of all the required cut within the CATR error budget.

10.2.3 Spill over area success criteria

The success criteria of the measurement in this area is the completion of all the required cut within the CATR error budget.

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10.2.4 Straylight area success criteria

The success criteria in this area of the pattern is to measure the cut and to obtain the minimum measurable levels : at least a level equal to the required dynamic.

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11. ORGANISATION & RESPONSIBILITIES

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12. DOCUMENTATION

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Appendix 1 :

RF DEFINITION OF THE LFI DETECTORS

This appendix contains the RF characteristics of the horns. A french graphical interface has been used so as to display the results. Hence in order to ease the reading the following table provides the translation of all the term.

Fréquence	frequency
Directivité dans l'axe (dBi)	on axis directivity (dBi)
Taux d'onde stationnaire	VSWR
Centre de phase	phase center
Diametre du guide	input waveguide diameter.
distance infinie	infinite distance (ie far field)
Temps de calcul	CPU time
Nbdl	number of degree of freedom
Structure parfaitement conductrice	perfectly conductive structure.
plan E	E plane
plan H	H plane
plan 45 co-pol	45° co-polarization plane
plan 45 cross-pol	45° cross-polarization plane
puissance normalisée	normalized power (dBi)
balayage	angular direction (deg)

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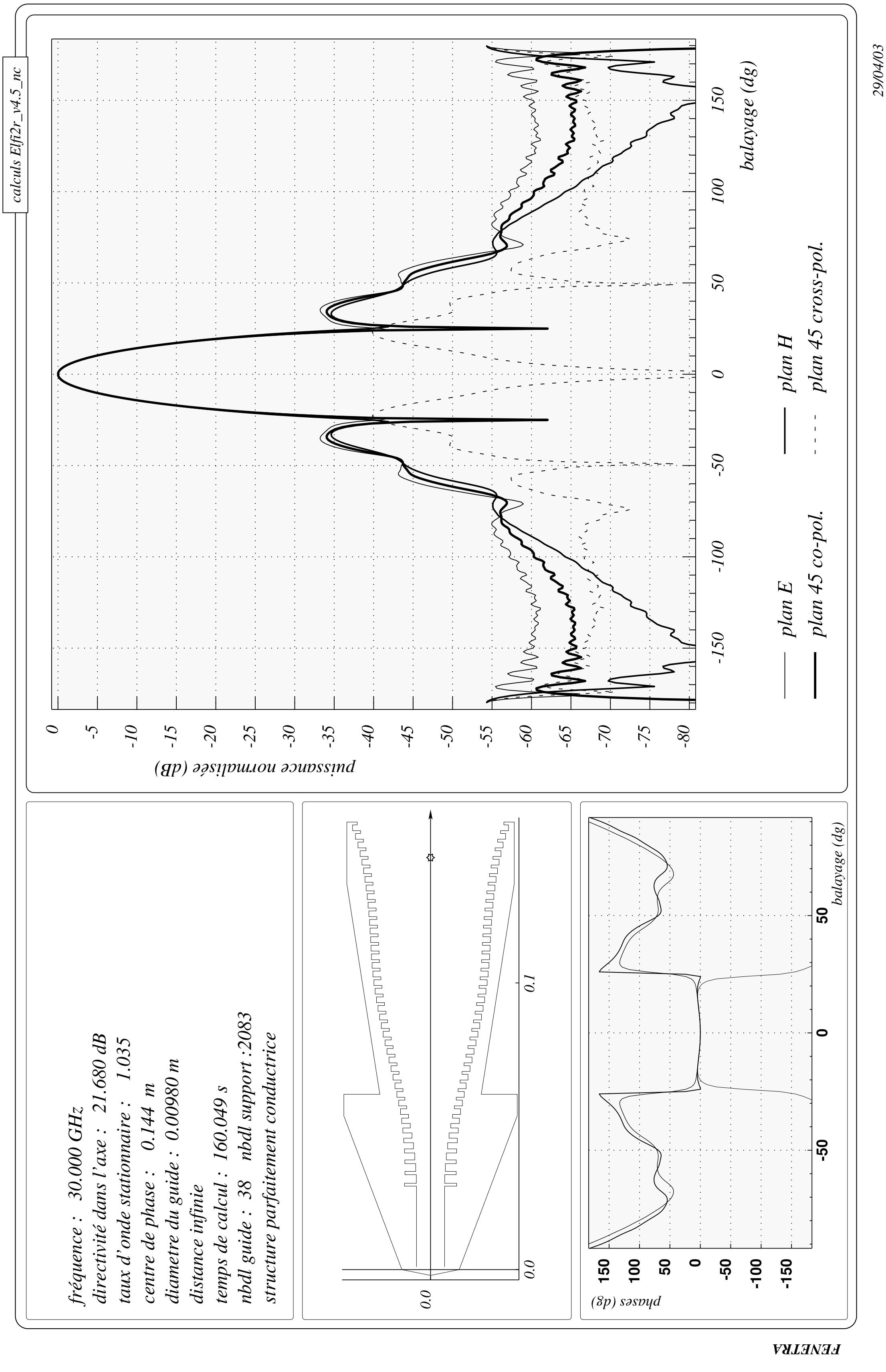

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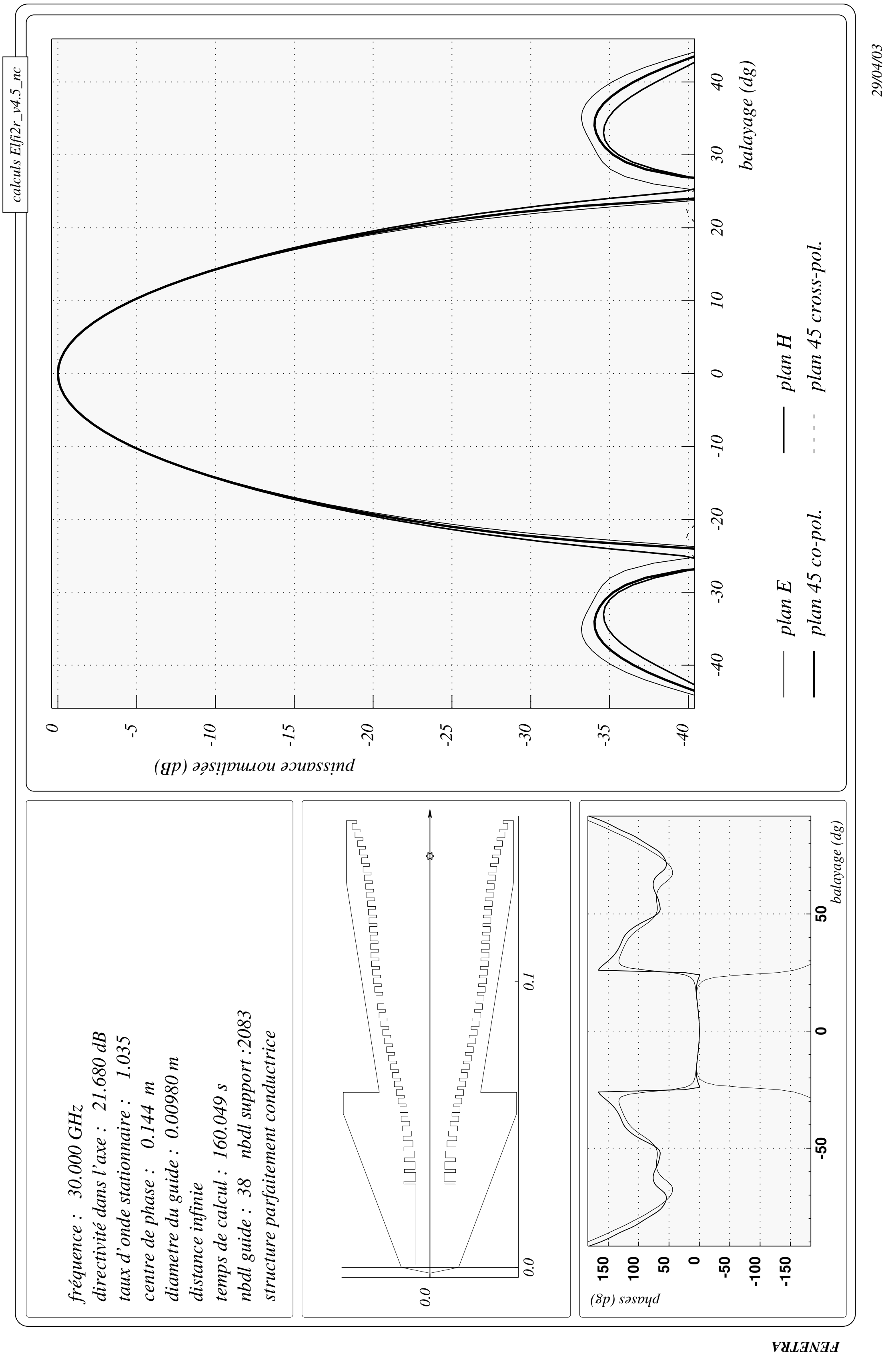

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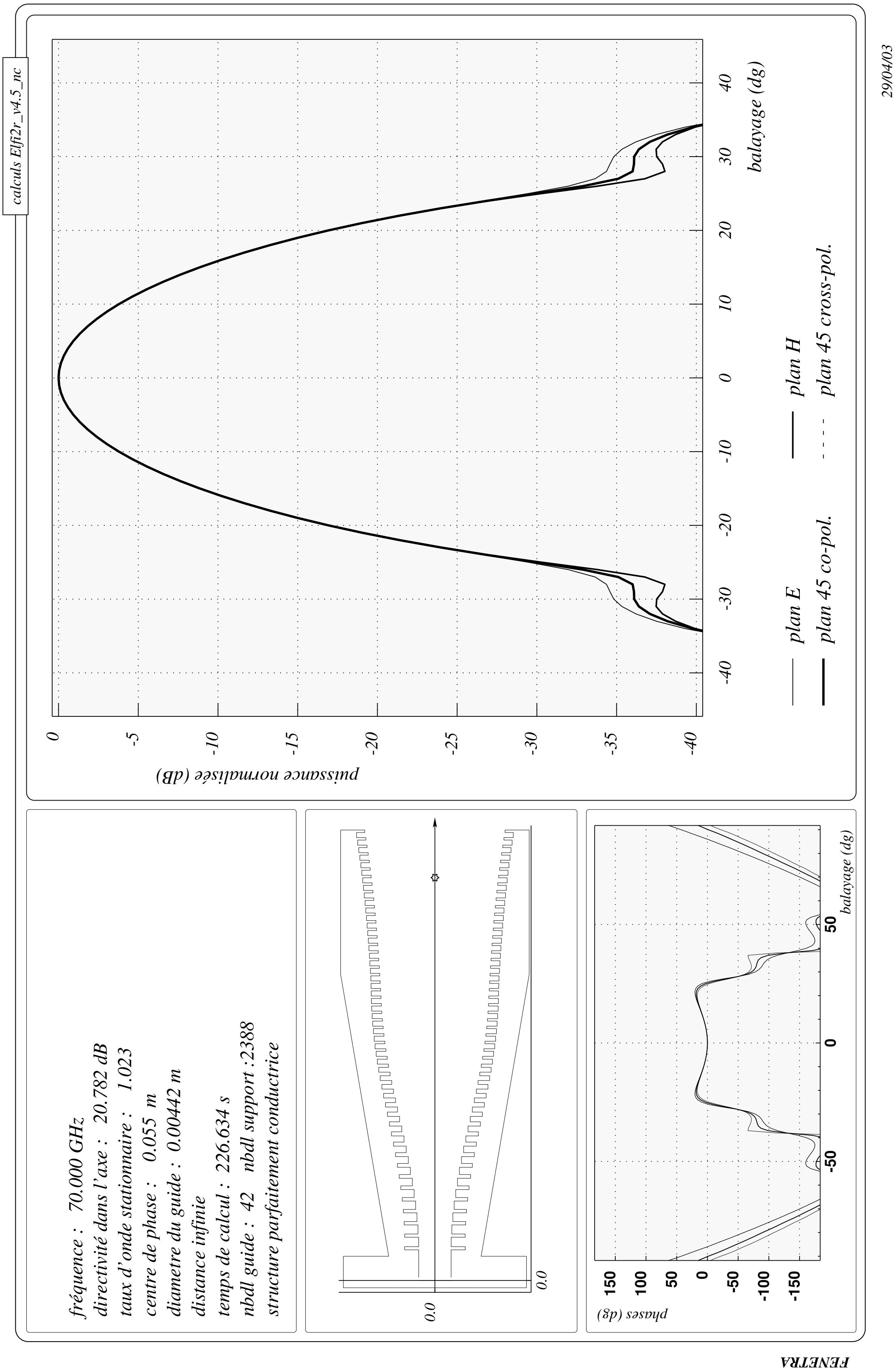

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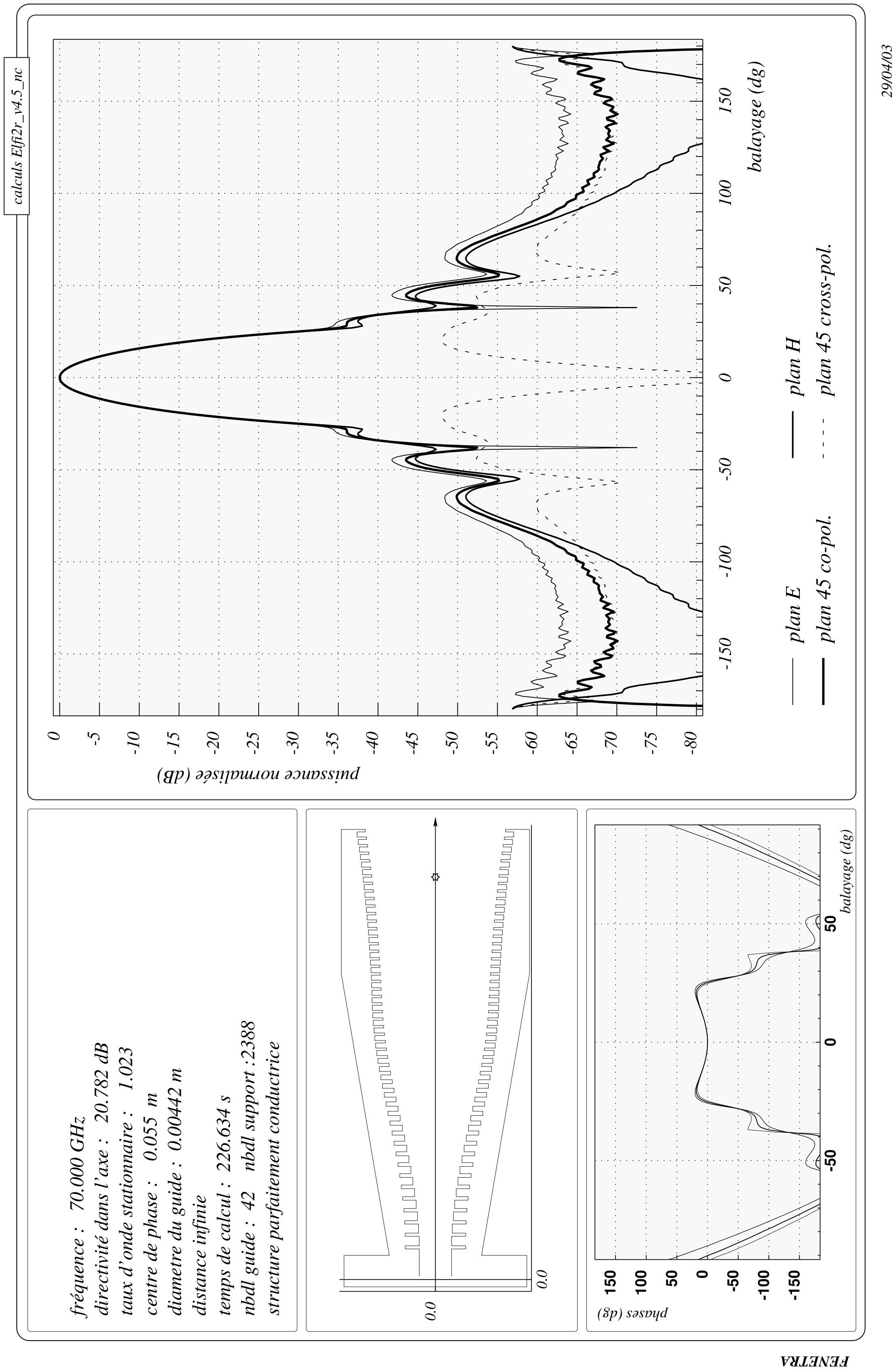

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Appendix 2 :

RF DEFINITION OF THE HFI DETECTORS

This appendix contains the RF characteristics of the horns. A french graphical interface has been used so as to display the results. Hence in order to ease the reading the following table provides the translation of all the term.

Fréquence	frequency
Directivité dans l'axe (dBi)	on axis directivity (dBi)
Taux d'onde stationnaire	VSWR
Centre de phase	phase center
Diametre du guide	input waveguide diameter.
distance infinie	infinite distance (ie far field)
Temps de calcul	CPU time
Nbdl	number of degree of freedom
Structure parfaitement conductrice	perfectly conductive structure.
plan E	E plane
plan H	H plane
plan 45 co-pol	45° co-polarization plane
plan 45 cross-pol	45° cross-polarization plane
puissance normalisée	normalized power (dBi)
balayage	angular direction (deg)

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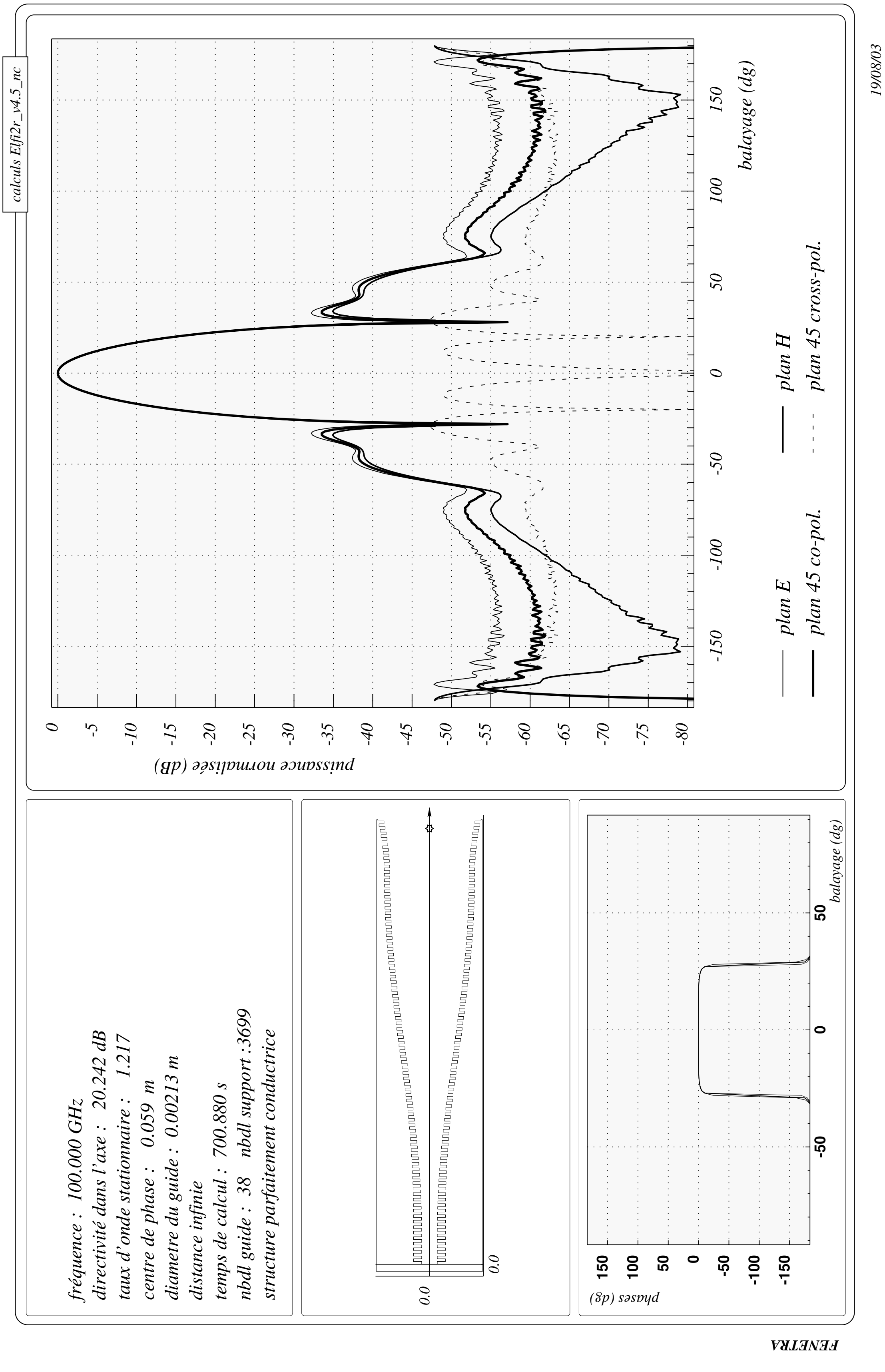

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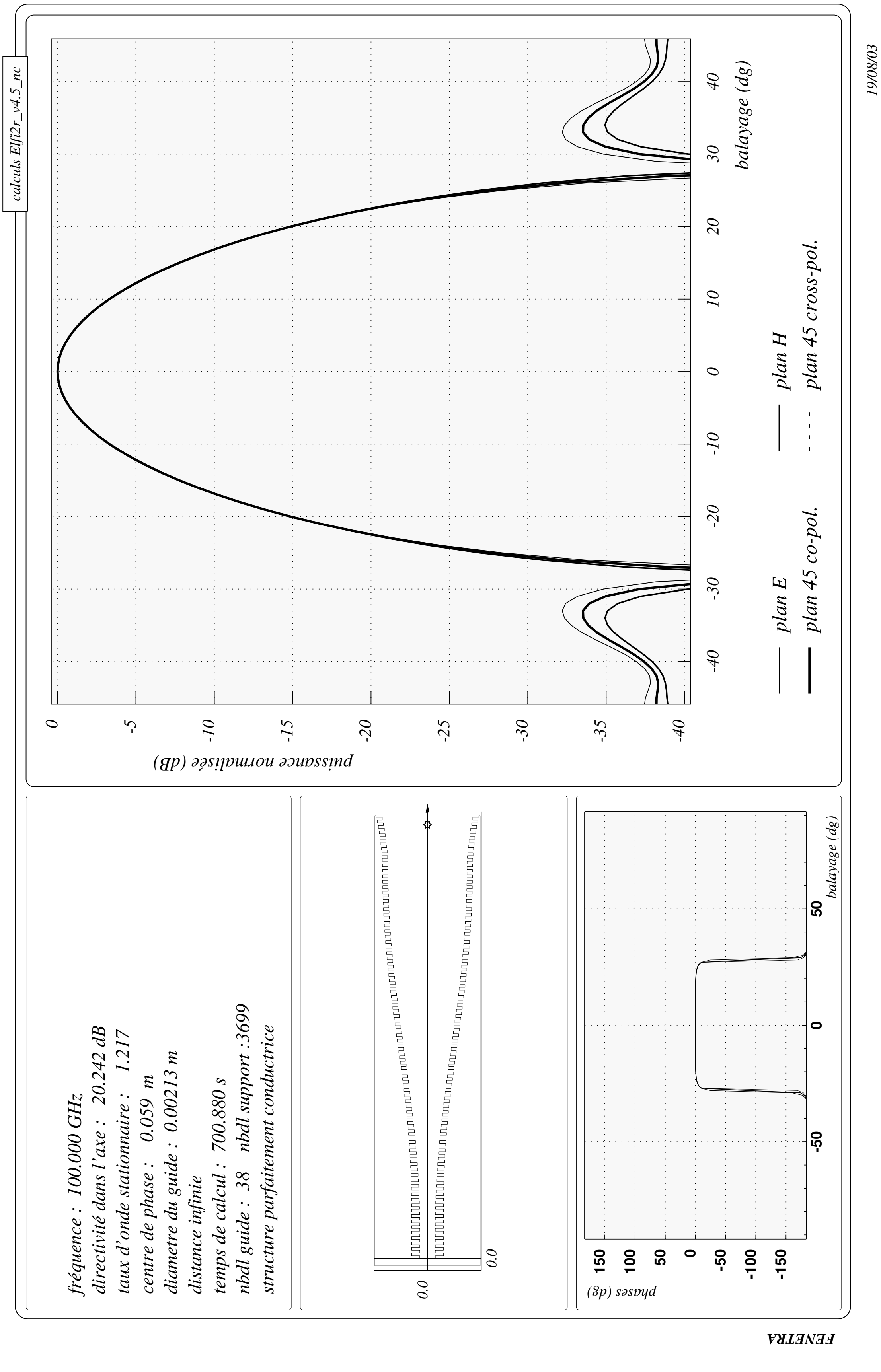

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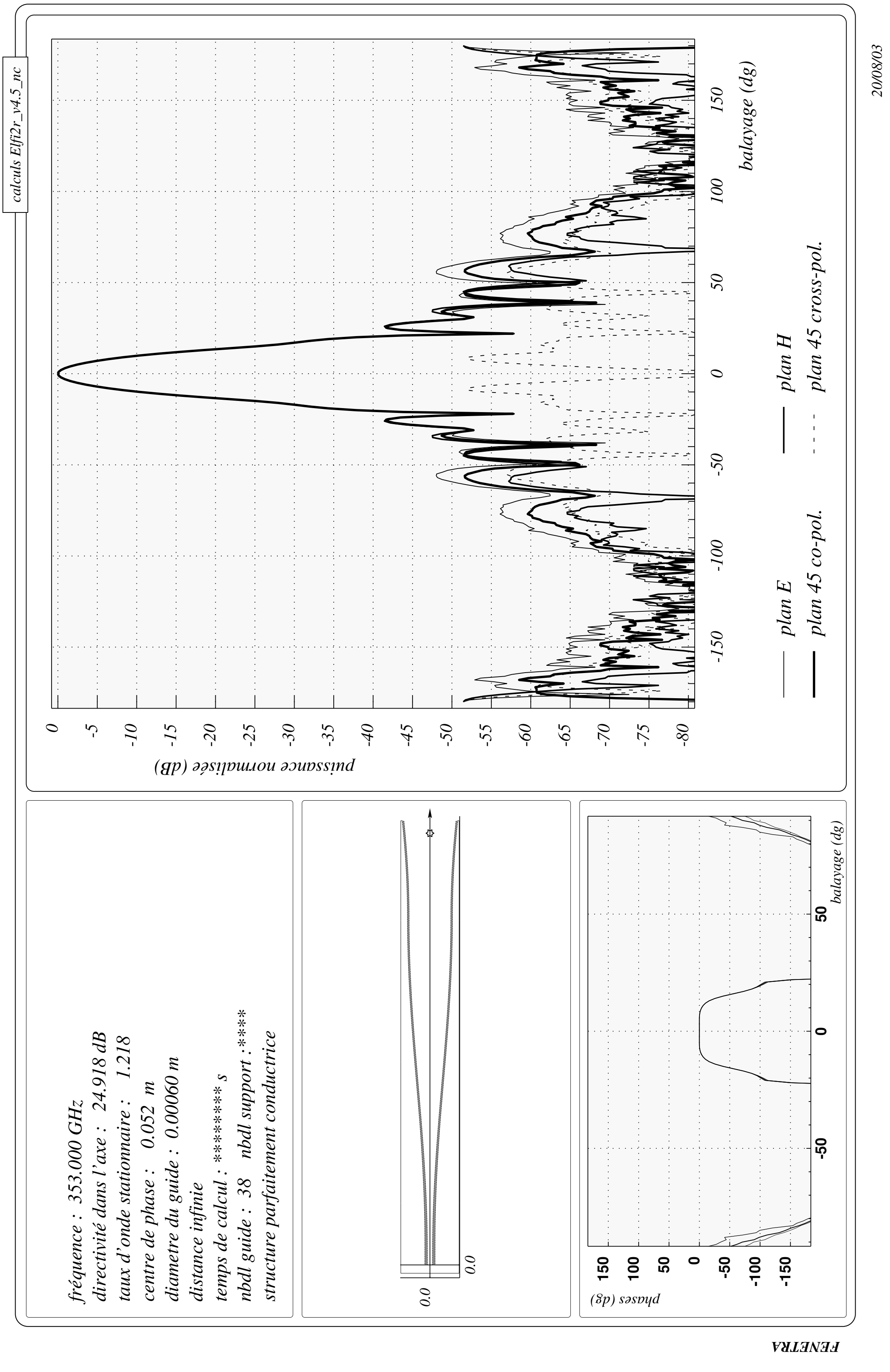

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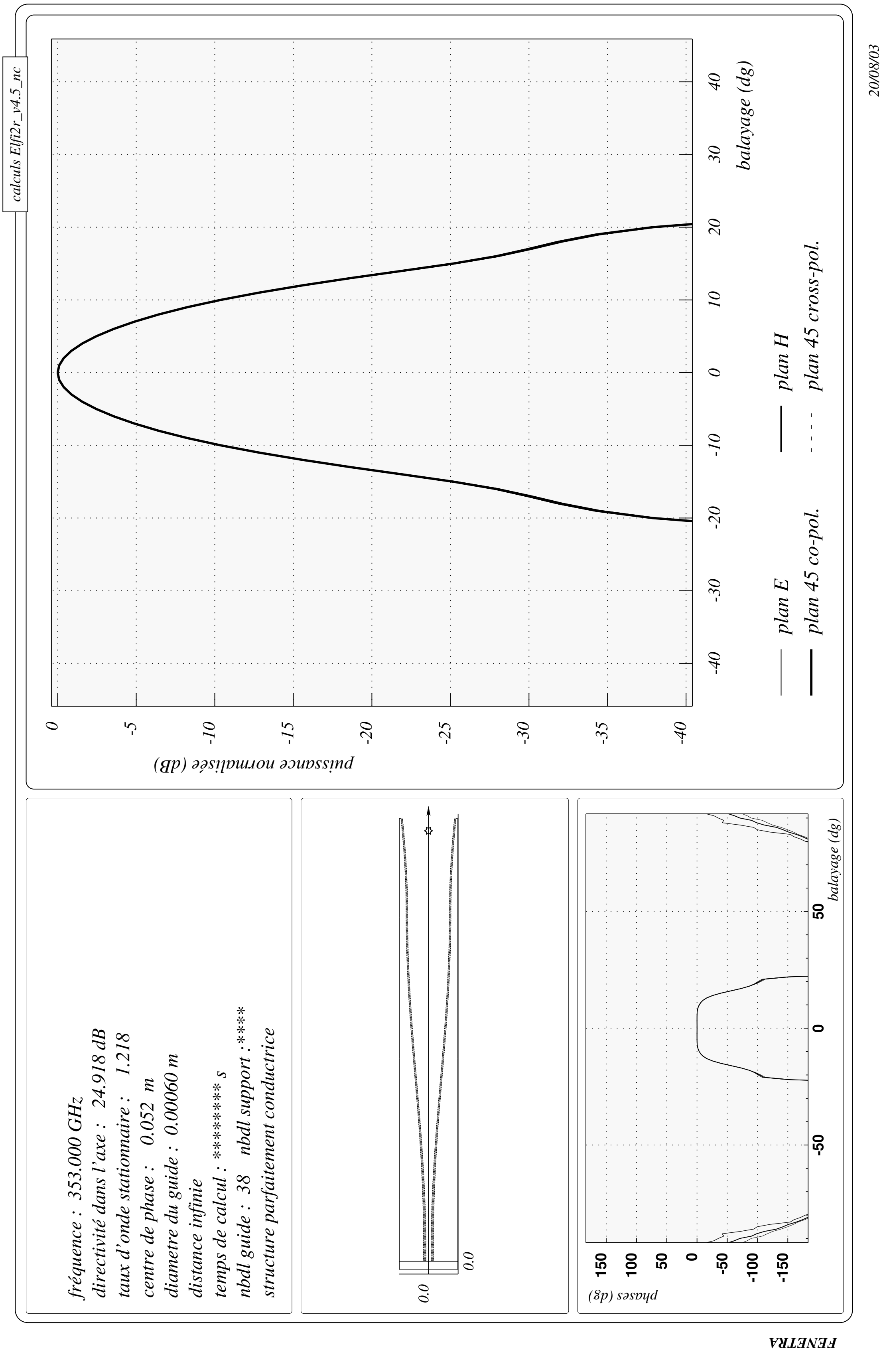

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APPENDIX 3 :

NIL

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APPENDIX 4 :

ANGLE CONVENTION

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The origin of a new coordinate system is given by the x-, y- and z-value in the reference coordinate system and three angles θ , φ and ψ in a spherical coordinate system. The latter definition is illustrated in Figure 2.1-1.

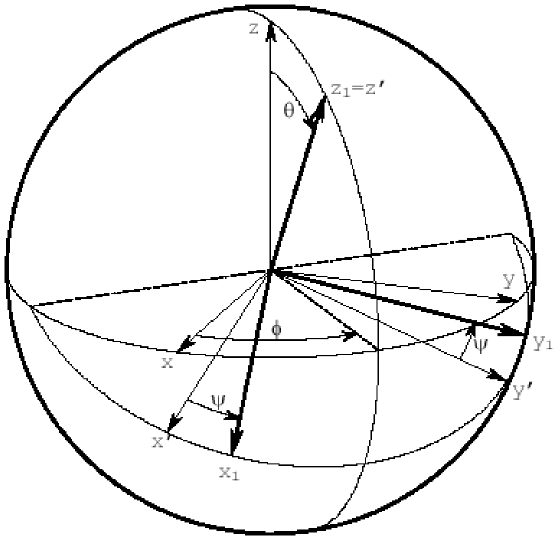

Figure ap-4-1: orientation of the new coordinate system (x_1 , y_1 , z_1) relative to (x , y , z) specified by the angles θ , φ and ψ (courtesy of TICRA)

The new coordinate system (x_1 , y_1 , z_1) is specified in the reference coordinate system (x , y , z). First, the z-axis is tilted the angle θ by rotating the (x , y , z) coordinate system around the line in the xy-plane orthogonal to the line making the angle φ with the x-axis (the dotted line in Figure ap-4-1). This process generates the coordinate system (x',y',z'). The (x_1 , y_1 , z_1)-coordinate system is then obtained by rotating the angle ψ around the z'-axis.

The unit vectors of the rotated coordinate systems are given by

$$\hat{x}_1 = \hat{\theta}\cos(\varphi - \psi) - \hat{\varphi}\sin(\varphi - \psi)$$

$$\hat{y}_1 = \hat{\theta}\sin(\varphi - \psi) + \hat{\varphi}\cos(\varphi - \psi)\,,$$

$$\hat{z}_1 = \hat{r}$$

where

$$\hat{\theta} = \hat{x}\cos\theta\cos\phi + \hat{y}\cos\theta\sin\phi - \hat{z}\sin\theta$$

$$\hat{\phi} = -\hat{x}\sin\phi + \hat{y}\cos\phi$$

$$\hat{r} = \hat{x}\sin\theta\cos\phi + \hat{y}\sin\theta\sin\phi + \hat{z}\cos\theta \quad .$$

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APPENDIX 5 :

CAD DRAWING OF THE HORNS INTERFACES

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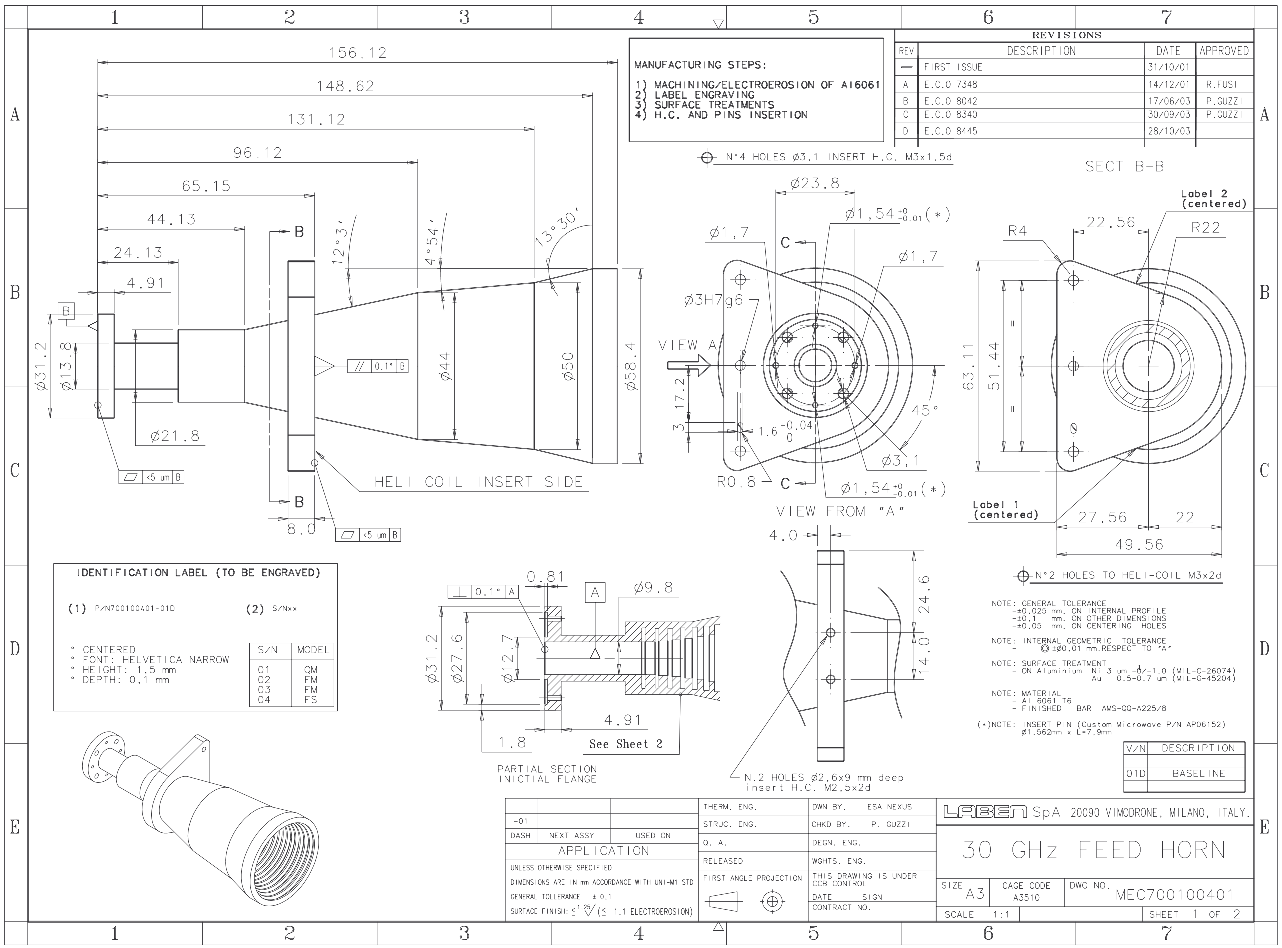

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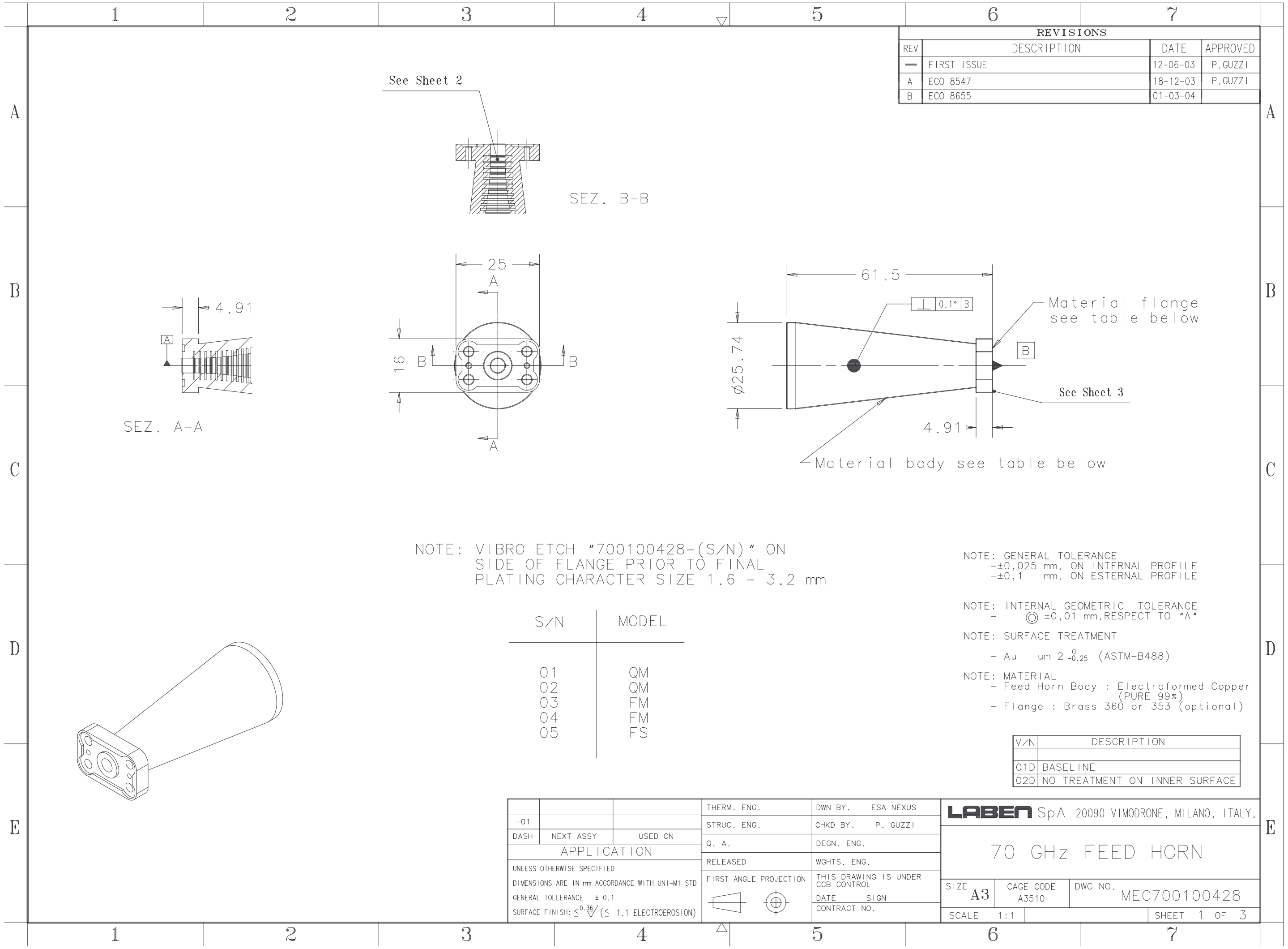

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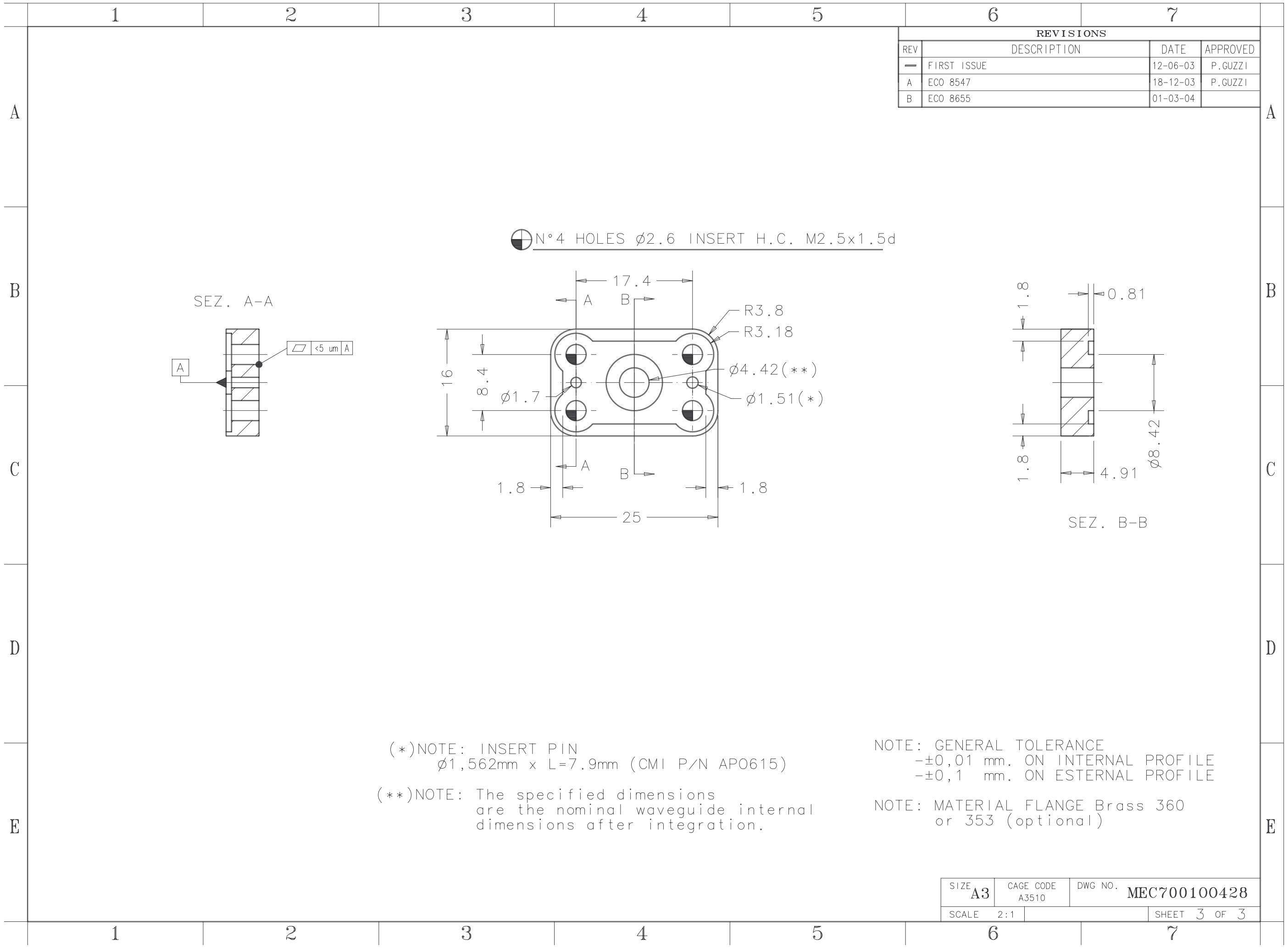

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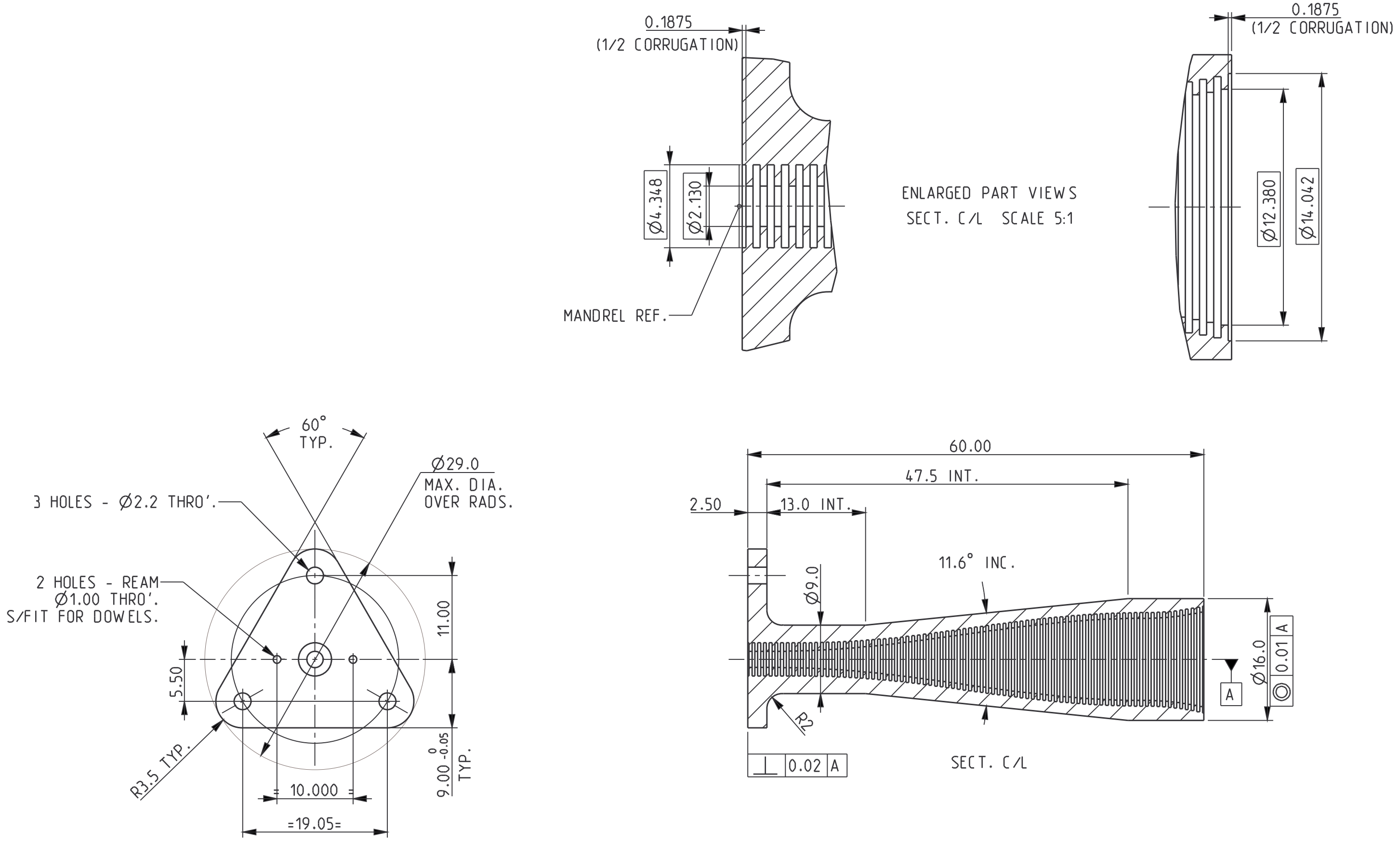

ALL DIMENSIONS IN mm
TOLERANCES
(UNLESS OTHERWISE STATED)
LINEAR
X.X = ±0.10
X.XX= ±0.02
X.XXX= ±0.005
ANGULAR
XX = ±1°
X.X = ±0°30'
X.XX= ±0°15'

NOTES
1) ESTIMATED WEIGHT = 0.042 Kg

Title	100GHz FRONT HORN PQ100F - 1A / 1B 4K PLATE
THIRD ANGLE PROJECTION, DIMENSIONS IN MM	CAD Scale 2:1/5:1
Tolerances	XYZ ±0.05mm ANG ±1°
Drawn by	C.A.B TK Ltd
Approved	Checked
Material	ELECTROFORMED COPPER
Finish	CLEAN, REMOVE BURRS AND SHARP EDGES - Au PLATE 1μ
Last Mod	
Date	02/05/2003 Sheet 1 OF 1 Sheet Size A3 Project PLANCK
Pro/E file	D:\Pro/E\PROUSERS\CARDIFF PLANCK\FRONT HORNS\100GHz PQ100F_1A Issue 1

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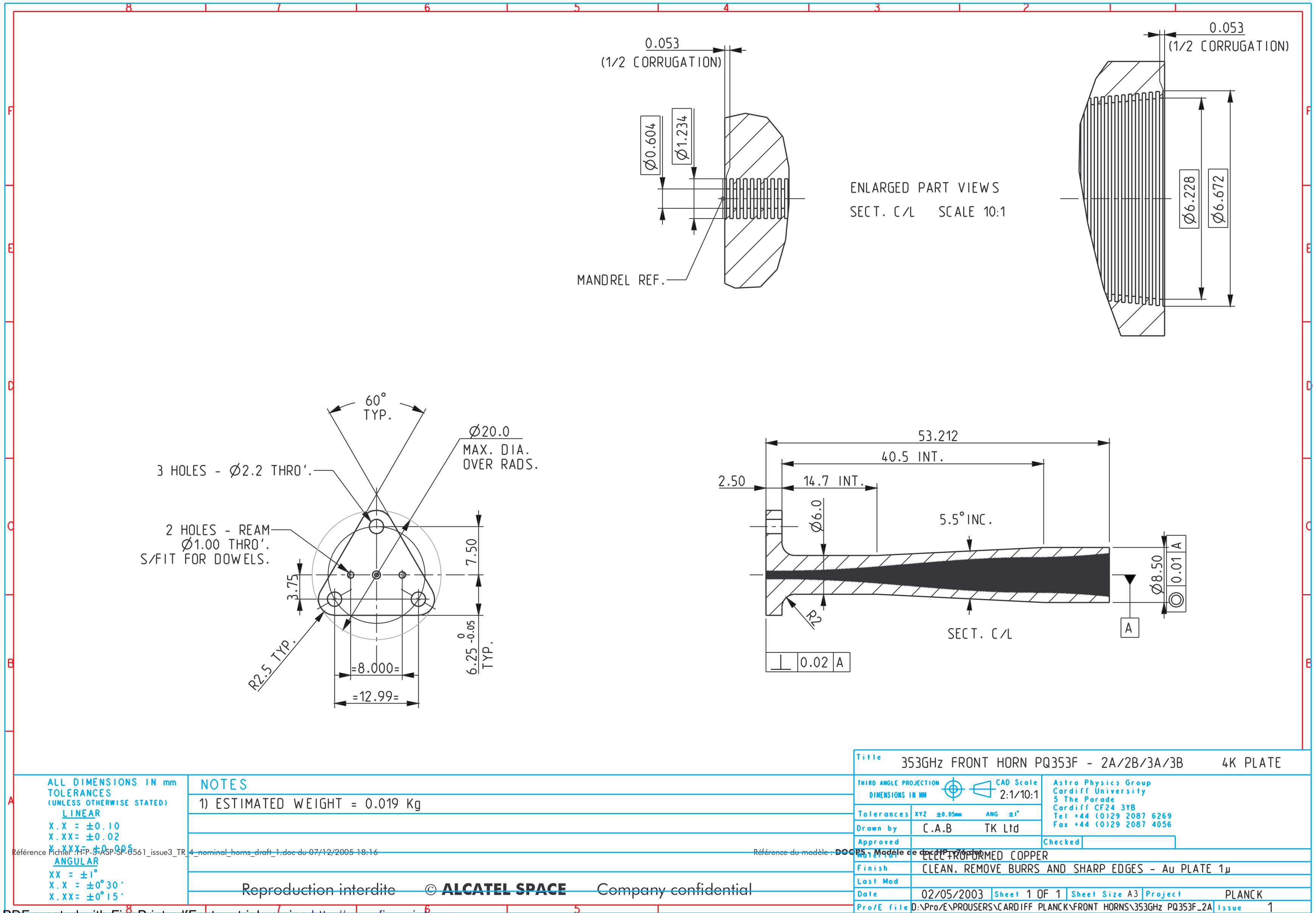

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The 320 GHz RF modulator mechanical interface is defined as follows :

The mechanical interface is defined as a plate and a set of holes.

The 26mm circular area is perpendicular to the Z_rdp axis and is located at z=-43,5 mm .

The circular surface is centered at the C point defined in the following table.

2 H7 holes of 2 mm diameter with a minimum depth of 2mm are centered at P1 and P2.

3 holes M2 x 2d, are centered at H1, H2 et H3

All the holes are along the Z_rdp direction.

	Xrdp (mm)	Yrdp (mm)	Zrdp (mm)
C	-17,861	-55,991	-43,5
	Xrdp (mm)	Yrdp (mm)	Zrdp (mm)
P1	-22,173	-54,705	-43,5
P2	-13,549	-57,277	-43,5
	Xrdp (mm)	Yrdp (mm)	Zrdp (mm)
H1	-15,717	-48,804	-43,5
H2	-25,157	-57,728	-43,5
H3	-12,709	-61,441	-43,5

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APPENDIX 6 :

TICRA FILE FORMAT.

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TICRA CUT FILE FORMAT

The file is generated by objects of the classes spherical_cut and plane_cut for storing field data in cuts. The file extension is .cut. The file can be either formatted or unformatted.

A cut consists of the records 1, 2 and 3 as described below. If more than one cut is contained in a file the records 1, 2 and 3 must be repeated for each cut.

Line no Contents Format

1 (TEXT(K), K=1,18) 18A4

TEXT - Alphanumeric identification label with up to 72 characters

2 SA, DA, NP, CA, ICOMP, ICON, NCOMP 2E18.10,I5,
E18.10,3I5

SA - Initial angle in degrees

DA - Angular step in degrees

NP - Number of points in cut

CA - Value in degrees of constant angle specifying cut

ICOMP - Polarisation components

=1 Etheta and Ephi components

=2 Right hand and left hand components (rhc and lhc)

=3 Linear co and cx components (Ludwig's third definition

=4 Major and minor axis of polarisation ellipse (see below)

=5 Etheta/Ephi and Ephi/Etheta

=6 rhc/lhc and lhc/rhc

=7 co/cx and cx/co

=8 major/minor and minor/major

=9 total power and sqrt(rhc/lhc)

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ICON - Specifies the type of cut, and depends on whether the cut is spherical or planar.

If the cut is spherical:

=1 A standard polar cut where phi is fixed and theta is increasing

=2 A conical cut where theta is fixed and phi is increasing

If the cut is planar:

=1 A radial cut where phi is fixed and rho is increasing

=2 A circular cut where rho is fixed and phi is increasing

NCOMP - Number of field components.

=2 The file contains two field components for each point as specified above.

=3 The file also contains the radial component. This is only possible for near fields.

If NCOMP=2:

3.2 (YA(I),YB(I), I=1,NP) 4E18.10

YA,YB - Complex arrays containing the two components of the field for the I'th data point. Angle = SA + DA*(I-1)

If NCOMP=3:

3.3 (YA(I),YB(I),YC(I), I=1,NP) 6E18.10

YA,YB,YC - Complex arrays containing the three components of the field for the I'th data point. The third component is always the r-component. Angle = SA + DA*(I-1)

-----end of data file-----

Remarks:

For ICOMP=4 YA and YB contains:

Real part of YA: major axis of polarisation ellipse

Imaginary part of YA: zero

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Real part of YB: minor axis of polarisation ellipse

Imaginary part of YA: zero

The values 5 to 8 of ICOMP give XPD fields corresponding to ICOMP=1 to 4.

For ICOMP=9 YA and YB contains

Real part of YA: total power of field

Imaginary part of YA: zero

YB: the complex square root of the ratio rhc/lhc

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TICRA UV grid FILE FORMAT

File format for field data in uv grid

This format is used for storing field values in a rectangular grid. Files of this type are generated by objects of the classes spherical_grid, plane_grid and cylindrical_grid, and the file extension is .grd. Data points may be located either on a sphere, a plane or on a cylinder. If the field points are located on a sphere the direction to a field point R is related to the polar angles theta and phi by

R = (sin(theta)*cos(phi), sin(theta)*sin(phi), cos(theta))

If the field points are located on a plane it is assumed that the plane is parallel to the xy-plane of the output coordinate system so that a point can be defined by its x and y coordinates.

If the field points are located on a cylinder the direction to a field point R is defined by

R = (rho*cos(phi), rho*sin(phi), z)

The field points are parameterised by two variables which are generally denoted X and Y and which run from XMIN to XMAX and from YMIN to YMAX, respectively. The file is organised so that X is varying faster than Y. The variables X and Y should be considered as general names for the actual variables which may e.g. be theta and phi for points on a sphere or any of the other options as specified by KGRID below.

The file format is:

Line	Contents	Format
1.1	(TEXT(K), K=1,18)	18A4

TEXT - Alphanumeric identification label with up to 72 characters. This line is repeated until a line containing ++++ as the first 4 characters is reached.

2 KTYPE I4 Specifies type of file format

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KTYPE =1 - standard format for 2D grid. For files used in GRASP8 this variable is always 1.

3 NSET, KCOMP, NCOMP, KGRID 4I4

NSET - Number of beams

KCOMP - Polarisation components

=1 Etheta and Ephi components (for KGRID = 1,4,5,6,7) or Erho and Ephi (for KGRID = 2,3)

=2 Right hand and left hand components (rhc and lhc)

=3 Linear co and cx components (Ludwig's third definition) (for KGRID = 1,4,5,6,7) or linear component along x and y (for KGRID = 2,3) or linear components along phi and z (for KGRID = 8)

=4 Major and minor axis of polarisation ellipse (see below)

=5 Etheta/Ephi and Ephi/Etheta (for KGRID = 1,4,5,6,7) or Erho/Ephi and Ephi/Erho (for KGRID = 2,3)

=6 rhc/lhc and lhc/rhc

=7 co/cx and cx/co (for KGRID = 1,4,5,6,7) or Ex/Ey and Ey/Ex (for KGRID = 2,3) or Ez/Ephi and Ephi/Ez (for KGRID = 8)

=8 major/minor and minor/major

=9 total power and sqrt(rhc/lhc)

NCOMP - Number of components.

=2 The file contains two field components for each point as specified above.

=3 The file also contains the radial component. This is only possible for near fields.

KGRID - Type of field grid

=1 uv-grid. Points on a sphere. (X,Y) = (u,v) where u and v are the two first coordinates of the unit vector to the field point. Hence, u and v are related to the spherical angles by

u = sin(theta)*cos(phi)

v = sin(theta)*sin(phi)

=2 rho-phi-grid. Points on a plane. (X,Y)=(rho,phi) where rho and phi are related to the x and y coordinates by

x = rho*cos(phi)

y = rho*sin(phi)

=3 xy-grid. Points on a plane. (X,Y)=(x,y). X and Y are identical to the xy-coordinates on the plane.

=4 Elevation over azimuth. Points on a sphere. (X,Y)=(Az.El), where Az and El define the direction R to the field point by

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R = (-sin(Az)*cos(El), sin(El), cos(Az)*cos(El))

=5 Elevation and azimuth. Points on a sphere. (X,Y)=(Az, El) where Az and El define the direction to the field point through the relations

Az = -theta*cos(phi)

El = theta*sin(phi)

=6 Azimuth over elevation. Points on a sphere. (X,Y)= (Az, El) where Az and El define the direction R to the field point by

R = (-sin(Az), cos(Az)*sin(El), cos(Az)*cos(El))

=7 theta-phi-grid. Points on a sphere. (X,Y)=(phi, theta), where theta and phi are the spherical angles of the direction to the field point

=8 phi-z-grid. Points on a cylinder. (X,Y) = (phi, z=, where phi is the polar angle and z the coordinate along the z-axis

4 (IX(I), IY(I), I=1, NSET) 2I4

IX,IY - Centre of beam No. I. See the following line for explanation. All the following lines are repeated NSET times

5 XS, YS, XE, YE 4E18.10 Limits of 2D grid. The grid points (X,Y) run through the values

X = XCEN + XS +DX*(I-1)

Y = YCEN + YS +DY*(J-1)

where

DX = (XE-XS)/(NX-1), DY = (YE-YS)/(NY-1)

and

XCEN = DX*IX, YCEN = DY*IY .

The number of grid values NX and NY and the range of the index I and J are defined in the following lines.

6 NX, NY, KLIMIT 3I4

NX - Number of columns

NY - Number of rows

KLIMIT - Specification of limits in a 2D grid

=0 Each row contains data for all NX columns.

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=1 The number of data points is defined in the following line.

The following lines 7 and 8 are repeated NY times (J=1,NY) for each beam

If KLIMIT = 1 line 7 is read

7 IS, IN 2I4

IS - Column number of first data point in row J

IN - Number of data points in row J

If KLIMIT = 0, IS and IN are always assumed to be 1 and NX, respectively.

If IN = 0 skip lines No. 8.2 and 8.3 and repeat from line No. 7. If IN > 0 continue at line No. 8.2 or 8.3 with IE = IS + IN - 1.

If NCOMP = 2:

8.2 (E1(I), E2(I)), I = IS, IE 4E18.10

E1,E2 - Complex field with two components, as defined by KCOMP.

If NCOMP = 3:

8.3 (E1(I), E2(I), E3(I)), I = IS, IE 6E18.10

E1,E2,E3 - Complex field with three components. The third component is the r-component for KGRID = 1,4,5,6,7, the z-component for KGRID = 2,3 or the rho-component for KGRID = 8.

-----end of data file-----

Remarks:

For KCOMP=4 E1 and E2 contain

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Real part of E1: major axis of polarisation ellipse

Imaginary part of E1: zero

Real part of E2: minor axis of polarisation ellipse

Imaginary part of E2: zero

The values 5 to 8 of KCOMP give XPD fields corresponding to KCOMP=1 to 4.

For KCOMP=9 E1 and E2 contains

Real part of E1: square root of the total power of the field

Imaginary part of E1: zero

E2: the complex square root of the ratio rhc/lhc

END OF DOCUMENT

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