TITLE:

SUMMARY OF THE EBB 30GHz OMT MEASURED PERFORMANCES

DOC. TYPE: TECHNICAL NOTE

PROJECT REF.: PL-LFI-PST-TN-015 **PAGE:** I of IV, 6

ISSUE/REV.: 1.0 **DATE:** March 2001

Prepared by	F. VILLA LFI Project System Team	Date: Signature:	09/03/01 [signature]
Checked by	M. BERSANELLI LFI Instrument Scientist	Date: Signature:	09/03/01 [signature]
Agreed by	C. BUTLER LFI Program Manager	Date: Signature:	09/03/01 [signature]
Approved by	N. MANDOLESI LFI Principal Investigator	Date: Signature:	09/03/01 [signature]

DISTRIBUTION LIST

Recipient	Company / Institute	E-mail address	Sent
N. Mandolesi	ITESRE / CNR – Bologna	mandolesi@tesre.bo.cnr.it	Yes
R.C. Butler	ITESRE / CNR – Bologna	butler@tesre.bo.cnr.it	Yes
M. Bersanelli	Univ. di Milano – Milano	marco@ifctr.mi.cnr.it	Yes
A. Mennella	IFC / CNR – Milano	daniele@ifctr.mi.cnr.it	Yes
A. Simonetto	IFP / CNR – Milano	simonetto@ifp.mi.cnr.it	Yes
C. Sozzi	IFP / CNR – Milano	sozzi@ifp.mi.cnr.it	Yes
E. Alippi	LABEN – Vimodrone	ealippi@webmail.laben.it	Yes
P. Guzzi	LABEN – Vimodrone	pguzzi@webmail.laben.it	Yes
G. Tofani	CAISMI / CNR – Firenze	tofani@arcetri.astro.it	Yes
R. Nesti	Oss. Di Arcetri – Firenze	nesti@arcetri.astro.it	Yes
A. Wilkinson	JBO – Manchester	aw@jb.man.ac.uk	Yes
C. Castelli	University of Birmingham	cmc@star.sr.bham.ac.uk	Yes
F. Winder	JBO – Manchester	fwinder@jb.man.ac.uk	Yes
LFI SPCC	LFI Project Control C/o ITESRE/CNR – Bologna	lfispcc@tesre.bo.cnr.it	Yes

CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
1.0	March 2001	All	First Issue of the Document	

TABLE OF CONTENTS

1 Introduction and Scope

1.1 Scope

The scope of this technical note is to report briefly the results of the test campaign on the OMT EBB model for LFI at 30 GHz. Since the performances are degraded with respect the specifications, the impact on the overall system temperature and sensitivity has been evaluated using the LFI Microsoft Excel Spreadsheet 6.0.

1.2 Introduction

The OMT is an asymmetric configuration (with a septum inside) and the dimensions are satisfying the maximum allocated envelope foreseen for the FM. A stepped twist (built in a separate block for this prototype), which is connected to the Main Arm, assures the compatibility between the OMT output waveguides and the EBB 30 GHz FEM interface.

The Measurements have been done on 23rd of February 2001 and 26th of February 2001 at IFP / CNR (Istituto di Fisica del Plasma – Milano) and have been performed at room temperature (300K). The results of the measurement campaign show that the OMT works with degraded performance both for the Return Loss and the Insertion Loss, with respect to the specifications[1].
Several measurements have been performed with the aim to disentangle the measurement uncertainties from the OMT performance.
During the test campaign, performed with an "*ABmillimeter*" VNA, some criticalities have been identified:

- Successive measurements need to be taken within 20 minutes to preserve the stability (both in phase and amplitude) of the VNA.
- Flanges could contribute to the insertion loss at a significant level[2]
- Typical uncertainty on the insertion loss is 0.2 dB.
- The circular to rectangular transition for both insertion loss and return loss tests introduces resonances.
- Precise insertion loss measurements require two OMT's, not available for the EBB tests.
- As shown in the Chapter 2, the insertion loss measurement set-up requires a commercial twist and a rectangular to circular waveguide transition to be used; the measured losses comprise both the OMT losses and the twist and transition ones. A rough estimation of the insertion loss of the twist and the transition is available (approximately 0.1 dB each).

[1] The specifications require a return loss better (or equal) than –20dB between 27 and 33 GHz and an insertion loss better than 0.15 dB over the same frequency range, at 20K. At 300K no specification are set. However, at room temperature an insertion loss better than 0.5 dB is needed.
[2] It is under study the possibility to require for the QM and FM alignment pins even for the rectangular flanges.

2 Measurement Set–up

The measurements have been done with a VNA. The four scattering parameters have been measured. TRL calibration has been applied. In order to eliminate the resonances, a sliding–short/sliding–load calibration has been used for additional Return Loss measurements. The calibration has been applied at the directional coupler ports: thus all the items written in italic font on the following lists constitute the Device Under Test.

The chain for the Main Arm measurements is composed of (from the input port to the output):

- Directional coupler
- *Commercial twist*
- *Rectangular to Circular waveguide transition*
- *OMT Main Arm + stepped twist*
- Directional coupler

The chain for the Side Arm measurements is composed of (from the input port to the output)

- Directional coupler
- *Rectangular to circular waveguide transition*
- *OMT Side Arm*
- Directional Coupler

3 Return Loss

A summary of the return loss measurement results is reported in Fig. 1. The resonances have been experimentally removed by testing the OMT with the corrugated horn attached in front instead of the circular to rectangular transition.

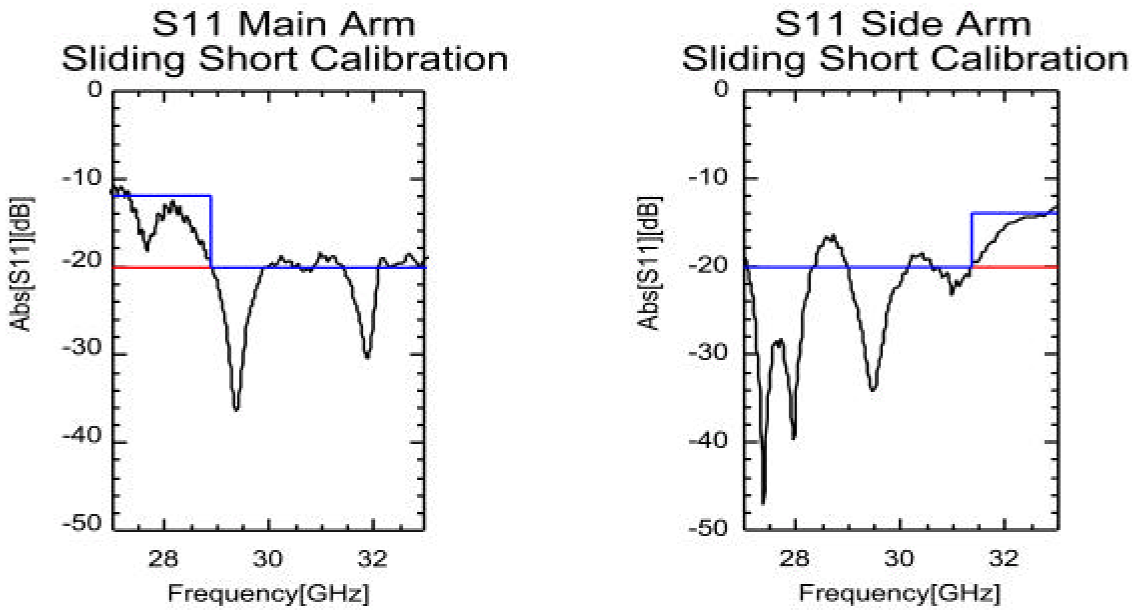

Fig. 1: *Return Loss measurements. The red line is representing the specification value. The blue line define the effective bandwidth in which the Return Loss is near the specification (29 – 33 GHz for the Main Arm; 27 - 31.5 GHz for the Side Arm)*

3.1 Main Arm Return Loss

The Return Loss shows a degradation at low frequencies, in the worst case, at –10 dB. The effect is a reduction of the bandwidth, which can be quantified in an effective frequency range within specification from 29 GHz to 33 GHz (13% of band assuming 30 GHz as a unchanged centre frequency).

3.2 Side Arm Return Loss

The Return Loss shows a degradation at high frequencies, in the worst case, at a level of –15dB. The effect is a reduction in the bandwidth, which can be quantified in an effective frequency range from 27 GHz to 31.5 GHz almost inside specification (conservatively because of the non–dramatic return loss degradation). This means a bandwidth of 15%, referred to 30 GHz as the unchanged centre frequency.

3.3 Impact of the Return Loss on the sensitivity

The minimum detectable signal is proportional to the inverse root of the bandwidth:

$$\Delta T/T \propto \frac{1}{\sqrt{\Delta u}}$$

For the main and side arm the bandwidth is 4 GHz and 4.5 GHz respectively (6 GHz required).

$$\frac{\left(\Delta T/T\right)_{spec}}{\left(\Delta T/T\right)_{MainArm}} = \sqrt{\frac{(\Delta u)_{MainArm}}{(\Delta u)_{spec}}} = \sqrt{\frac{4}{6}} = 0.82$$

$$\frac{\left(\Delta T/T\right)_{spec}}{\left(\Delta T/T\right)_{SideArm}} = \sqrt{\frac{(\Delta u)_{SideArm}}{(\Delta u)_{Spec}}} = \sqrt{\frac{4.5}{6}} = 0.87$$

Then, the effect of the limited bandwidth is to degrade the sensitivity by a factor of 18% for the Main Arm and 13% for the Side Arm. These should be considered as upper limits because the return loss is degraded by –10dB maximum.

4 Insertion Loss

The resonances have been artificially removed on the insertion loss curves (see for instance the holes on the left panel of Fig. 2).

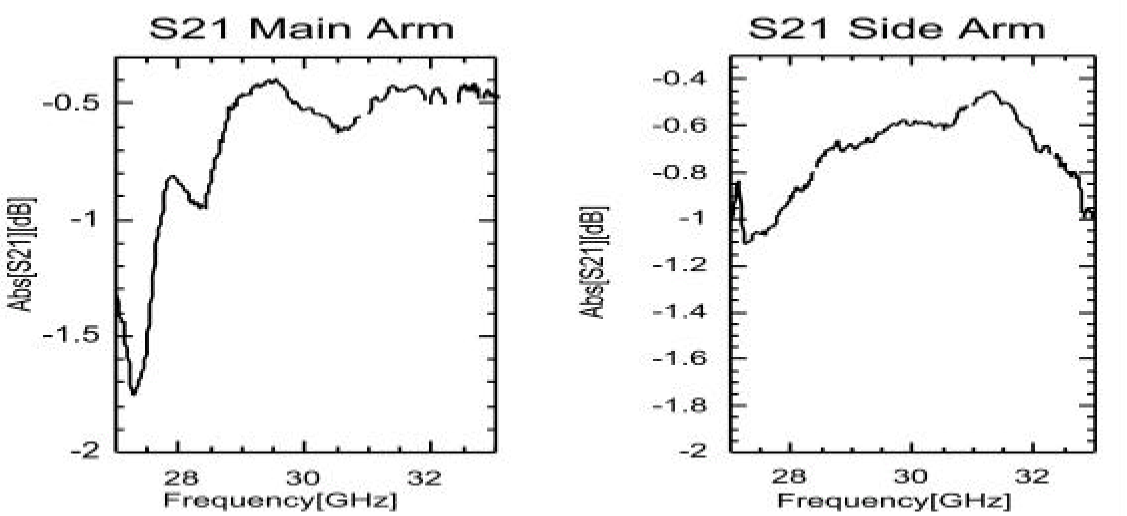

***Fig. 2:** OMT Insertion Loss measurements.*

4.1 Main Arm Insertion Loss

The commercial twist, the rectangular to circular waveguide transition, the OMT Main Arm (including the stepped twist) contribute to the Insertion Loss that has been measured and reported on the left panel of Fig. 2. However the total expected contribution of the commercial twist and of the transition is expected to be about 0.2 dB (0.1dB each).

4.2 Side Arm Insertion Loss

The transition and the OMT Side Arm contribute to the Insertion loss. The transition is expected to have an insertion loss of about 0.1 dB.

4.3 Impact of the Insertion Loss on the Noise

The impact of the insertion loss on the noise performance of the 30GHz RCA can be evaluated using the LFI Microsoft Excel Spreadsheet Version 6.0.
The OMT insertion loss at 20K has been varied from 0.15 dB (specification) to 2.0 dB. The system noise temperature Tsys has been obtained, ranging between ~11K and ~28K (see the spreadsheet for detailed information). In the following tables the results from the spreadsheet are shown.
The correlation between the Tsys and the OMT insertion loss has been reported in Fig. 4.

Tphys(K)	22	Tphys(K)	22	Tphys(K)	22
L(feed) - dB	0.1	L(feed) - dB	0.1	L(feed) - dB	0.1
L(OMT) -dB	0.15	L(OMT) -dB	0.2	L(OMT) -dB	0.5
T(feed+OMT) - K	**1.3036**	***T(feed+OMT) - K***	**1.5734**	***T(feed+OMT) - K***	**3.2594**
Tnoise(FE) - K	8.6000	Tnoise(FE) - K	8.6000	Tnoise(FE) - K	8.6000
T(FE) - K	**9.1096**	***T(FE) - K***	**9.2151**	***T(FE) - K***	**9.8741**
G(FE) dB	35.0000	G(FE) dB	35.0000	G(FE) dB	35.0000
L(WGs) - dB	2.0000	L(WGs) - dB	2.0000	L(WGs) - dB	2.0000
Teff - K	70.0000	Teff - K	70.0000	Teff - K	70.0000
T(WGs)- K	**0.0137**	***T(WGs)- K***	**0.0139**	***T(WGs)- K***	**0.0149**
Tnoise(BE) - K	350.0000	Tnoise(BE) - K	350.0000	Tnoise(BE) - K	350.0000
T(BE) - K	**0.1858**	***T(BE) - K***	**0.1880**	***T(BE) - K***	**0.2014**
Tsys - K	**10.6127**	**Tsys - K**	**10.9903**	**Tsys - K**	**13.3498**

Tphys(K)	22	Tphys(K)	22	Tphys(K)	22
L(feed) - dB	0.1	L(feed) - dB	0.1	L(feed) - dB	0.1
L(OMT) -dB	1	L(OMT) -dB	1.5	L(OMT) -dB	2
T(feed+OMT) - K	**6.3415**	***T(feed+OMT) - K***	**9.7997**	***T(feed+OMT) - K***	**13.6798**
Tnoise(FE) - K	8.6000	Tnoise(FE) - K	8.6000	Tnoise(FE) - K	8.6000
T(FE) - K	**11.0789**	***T(FE) - K***	**12.4308**	***T(FE) - K***	**13.9476**
G(FE) dB	35.0000	G(FE) dB	35.0000	G(FE) dB	35.0000
L(WGs) - dB	2.0000	L(WGs) - dB	2.0000	L(WGs) - dB	2.0000
Teff - K	70.0000	Teff - K	70.0000	Teff - K	70.0000
T(WGs)- K	**0.0167**	***T(WGs)- K***	**0.0187**	***T(WGs)- K***	**0.0210**
Tnoise(BE) - K	350.0000	Tnoise(BE) - K	350.0000	Tnoise(BE) - K	350.0000
T(BE) - K	**0.2260**	***T(BE) - K***	**0.2536**	***T(BE) - K***	**0.2845**
Tsys - K	**17.6631**	**Tsys - K**	**22.5027**	**Tsys - K**	**27.9329**

Fig. 3: *Results of the LFI Spreadsheet 6.0 regarding the impact of the OMT insertion loss on the system noise temperature. The values reported in boldface have been calculated by the spreadsheet.*

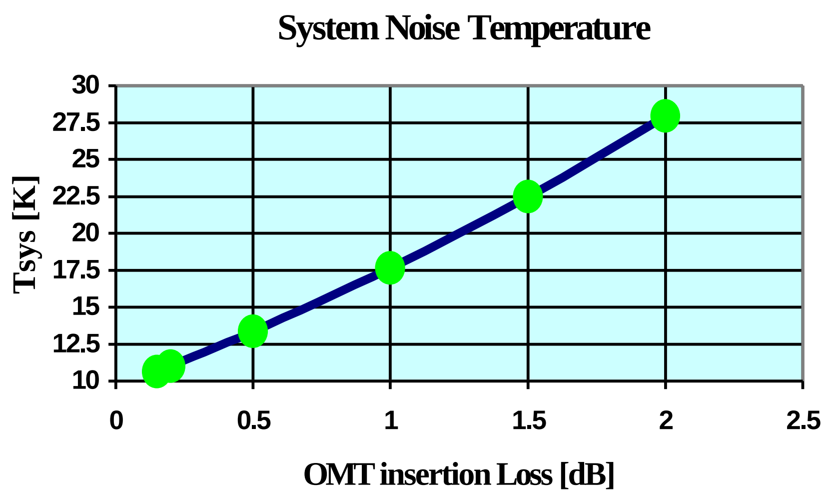

Fig. 4: *Correlation between the System noise temperature and the OMT insertion loss, based on data carried out from the LFI spreadsheet 6.0*

5 Conclusions

The actual EBB OMT is not satisfying the specifications. Causes could be identified as the non – perfect planarity of the septum inside the OMT, the low accuracy of the manufacturing of the stepped twist connected to the Main Arm, and the non perfect coupling between the OMT and the twist.
The OMT has not been measured at cryogenic temperatures (20K) and its performances could be tested for example by testing the RCA assembly with the HORN and the OMT and with the HORN and the Circular to Rectangular transition.