## K-band Interference Measurements with the Yebes 40 m Radio Telescope

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## 1 Introduction

This report shows the results of new RFI measurements performed the  $12^{th}$  of January 2018 with the Yebes 40 meter radio telescope. The purpose of these measurements is to check the RFI environment in K-band after some actions carried out by Telefónica and Jefatura Provincial de Telecomunicación de Guadalajara to remove some of the RFI signals reported in a previous technical report ( $17^{th}$  of January, 2017, technical report IT-CDT 2017-2).

Yebes Observatory wants to thank the help provided by Telefónica and Jefatura Provincial de Telecomunicación de Guadalajara to improve the quality of the spectrum for radio astronomical observations.

The measured band in this report ranges from 21750 MHz to 24250 MHz (2.5 GHz bandwidth). The maximum allowed level of RFI in this band is regulated in *Disposición 4950 del BOE núm. 114 de 10 Mayo de 2014, Sec. I. Pág. 35904-35905.* 

This regulation sets a power flux intensity limit of -146.4 dB  $\left(\frac{W}{m}^2\right)$  for the 22.21-22.5 GHz band and -147 dB  $\left(\frac{W}{m}^2\right)$  for the 23.6-24 GHz band. Also the frequencies of 22200 and 23700 MHz with a bandwidth of 250 kHz have a power flux intensity limit of -162 and -161 dB  $\left(\frac{W}{m}^2\right)$  respectively in order to protect the spectral lines observed by astronomy. The remaining frequencies out of these ranges have a limit of -57 dB  $\left(\frac{W}{m}^2\right)$ .

The performed measurements were carried out at 5 degrees of elevation and 0-355 degrees of azimuth in 5 degrees steps.

In order to remove the background noise, an ON-OFF observation with 30 seconds integration time was performed for each in each azimuth direction. The ON-source scan was measured with the radio telescope pointing at every azimuth with 5 degree in elevation, while the OFF-source scan was carried out at the same azimuth but at 10 degree in elevation.

## 2 Detected interferences

In this section the detected interferences are shown in Figures 1-31, plotted in frequency range for x-axis and equivalent antenna temperature (Kelvin) for y-axis. Different azimuth angles for the same interference are plotted in different colors in the same graph. This is useful to check whether the same RFI signal reaches the radio telescope through different angles due to bounces.

Finally, Table 1 translates the equivalent antenna temperature (K) into power intensity flux dB  $\left(\frac{W^2}{m}\right)$  in order to check if these interferences comply with the regulation.



Figure 1: Interference detected at 22.011 GHz.



Figure 2: Interferences detected at 22.020 GHz.



Figure 3: Interferences detected at 22.019 and 22.026 GHz.



Figure 4: Interferences detected at 22.012 and 22.020 GHz.



Figure 5: Interference detected at 22.038 GHz.



Figure 6: Interference detected at 22.018 and 22.024 GHz.



Figure 7: Interference detected at 22.214 GHz (protected band).



Figure 8: Interference detected at 22.246 GHz (protected band).



Figure 9: Interference detected at 22.3025, 22.305 and 22.3085 GHz (restricted band).



Figure 10: Interferences detected at 22.3245 GHz (protected band).



Figure 11: Interferences detected at 22.325 GHz (protected band).



Figure 12: Interferences detected at 22.324 and 22.325 GHz (protected band).



Figure 13: Interference detected at 22.3235, 22.3245 and 22.3255 GHz (protected band).



Figure 14: Interference detected at 22.472 and 22.475 GHz (protected band).



Figure 15: Interference detected at 22.475 GHz (protected band).



Figure 16: Interference detected at 22.475 GHz (protected band).



Figure 17: Interference detected at 23.022 GHz.



Figure 18: Interference detected at 23.030 GHz.



Figure 19: Interference detected at 23.019 and 23.032 GHz.



Figure 20: Interference detected at 23.0325 GHz.



Figure 21: Interference detected at 23.0325 GHz.



Figure 22: Interference detected at 23.0335 GHz.



Figure 23: Interference detected at 23.0815 GHz.



Figure 24: Interference detected at 23.068 GHz.



Figure 25: Interference detected at 23.255 GHz.



Figure 26: Interferences detected at 23.333 GHz.



Figure 27: Interference detected at 23.333 GHz.



Figure 28: Interference detected at 23.333 GHz.



Figure 29: Interference detected at 23.480 GHz.



Figure 30: Interference detected at 23.717 GHz (protected band).



Figure 31: Interference detected at 23.883 GHz (protected band).



Figure 32: Interference detected at 24.100 GHz.

		DW		Orden	
Freq.	Azimuth		$S_{ML}$	CTE	Difference
(MHz)	(deg)	(MHZ	$(dB(W/m^2))$	1444/2003	(dB)
	( )	@3dB)		$(dB(W/m^2))$	
22011	0	3	-106,9	-57	-49,9
22020	100	25	-95,9	-57	-38,9
22026	315	6	-106,1	-57	-49,1
22023	95	20	-78,4	-57	-21,4
22019	345	4	-106,1	-57	-49,1
22038	135	50	-76,9	-57	-19,9
22018	245	2	-94,6	-57	-37,6
22024,5	0	1,4	-103,6	-57	-46,6
22214	345	2	-124,6	-146,4	21,8
22305	345	2	-114,5	-146,4	31,9
22246	300	24	-104,7	-146,4	41,7
22324,5	305	$0,\!6$	-103,7	-146,4	42,7
22472	0	0,5	-127,5	-146,4	18,9
22475	20	2	-101,5	-146,4	44,9
23019	135	4	-104,8	-57	-47,8
23022	15	12	-102,9	-57	-45,9
23032,5	0	4	-108,2	-57	-51,2
23030	90	22	-92,4	-57	-35,4
23032	20	4	-101,3	-57	-44,3
23033.5	310	1.5	-68.0	-57	-11
23081,5	10	2	-112,2	-57	-55,2
23068	10	6	-121,7	-57	-64,7
23255	285	24	-90,4	-57	-33,4
23333	315	2	-90,3	-57	-33,3
23480	0	2	-103,7	-57	-46,7
23717	310	4	-108	-147	39
23883	315	4	-119,5	-147	27,5
24100	315	95	-94,5	-57	-37,5

Table 1: Sumarizes the set of RFI signals detected, showing their frequency, bandwith at 3dB, main azimuth, flux power intensity measured, threshold limited by regulation and the difference between these two values (a positive value means that RFI signal level is higher that allowed by regulation.)

## 3 Conclusion

Several interferences are still present in the band of 21.75 to 24.25 GHz. Some of them have levels higher than the regulated ones (gray color in Table 1) and all of them are found within the radio astronomy band.

The remaining RFI signals are below their regulated threshold.

Comparing with the RFI signals detected in January 2017, it has to be mentioned that those located at 22.333, 22.481 and 22.488 GHz, within the radio astronomy band, have disappeared.