Blocking of the antenna beam by the chopper wheel

16-May-2013

Juan Peñalver

The chopper wheel is a facility used for observations in beam switching mode. The chopper wheel should not block the beam when the observations are not in beam switching mode. Nevertheless a small blocking is produced at some antenna elevations, as presented in this document, conclusion from the skytip and calibration scans analyzed. Measurements were carried out during the TT on 7-May-2013.

The effect of this blocking is small, being more significant at low frequencies than at high frequencies, what is normal considering that at higher frequencies the beam is narrower. As a consequence of the blocking the system temperature measured is higher, what could impact in the calculated opacity of the calibration scans. At 47^{o} elevation the increasing of Tsys measured has been 3.8 K in band E0 and 20.5 K in band E2. The blocking seems to have a small effect, probably negligible, in the parameters obtained from the skytips.

For bolometer observations (MAMBO, GISMO, NIKA) the chopper wheel is placed in its upper position. In those cases the chopper wheel must be left vertical to avoid any blocking of the beam travelling from M3 to the vertex.

Positions of the chopper wheel

The chopper wheel is used dynamically when rotating for pointing scans in beam switching mode, with four phases produced, two ON source and two OFF source approximately at 85". The ON/OFF phases last 40 % of the time, being the other 60% blanking time.

When the chopper wheel is stop is left in the default horizontal position as shown in Photo 1 to carry out heterodyne observations (EMIR, HERA, HEMT).

The chopper wheel could be left in vertical position as shown in Photo 2, but this position is never used for observation. This position is used in two of the four phases in beam switching mode.

The copper wheel is in upper position as shown in Photo 3 to permit the rotation of M4 necessary for bolometer observations (MAMBO, GISMO, NIKA).

Chopper wheel in the default horizontal position

With the chopper wheel in the default horizontal position, as shown in Photo 1, the beam from the heterodyne receiver is reflected in mirror 4 (M4), then in mirror 3 (M3) to go to the vertex, to the subreflector (M2) and to the antenna main reflector (M1).

With the chopper wheel placed in the default horizontal position it must permit the complete reflection of the beam from M4 to M3 and must not block the beam when going from M3 to the vertex.

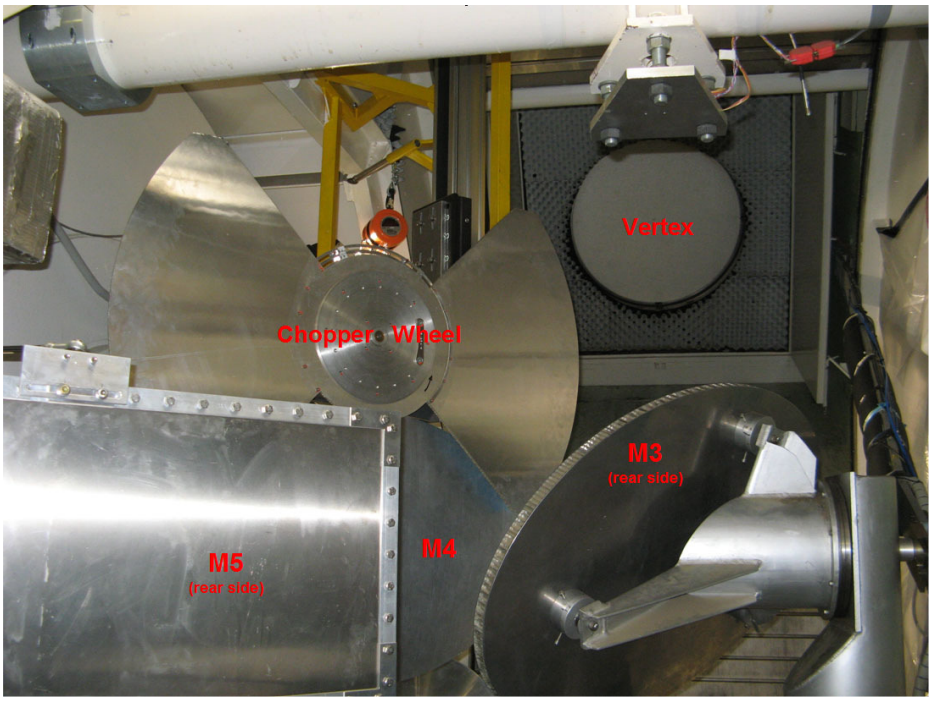

Photo 1

In many antenna skytips it has been observed that some points are above the fit line for airmass 1.3 and 1.5 as shown in Figure 1.

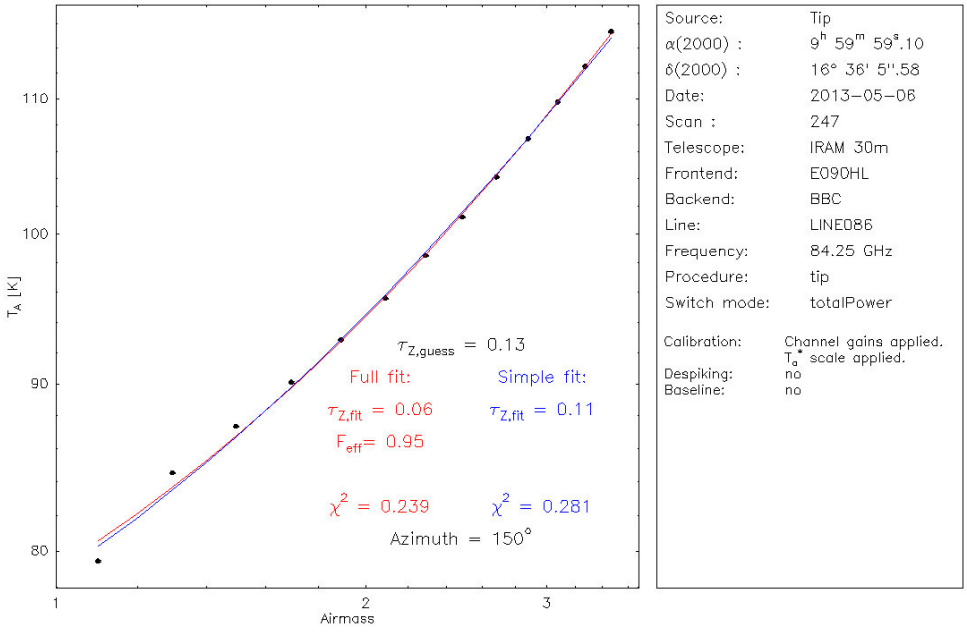

Figure 1

With the chopper wheel in its vertical position, as shown in Photo 2, the skytips don't show this anomaly as seen in Figure 2, but in this position Tsys pick up some extra hot temperature as described later. The pointing is also different. So, is not an alternative neither for observations nor for skytips.

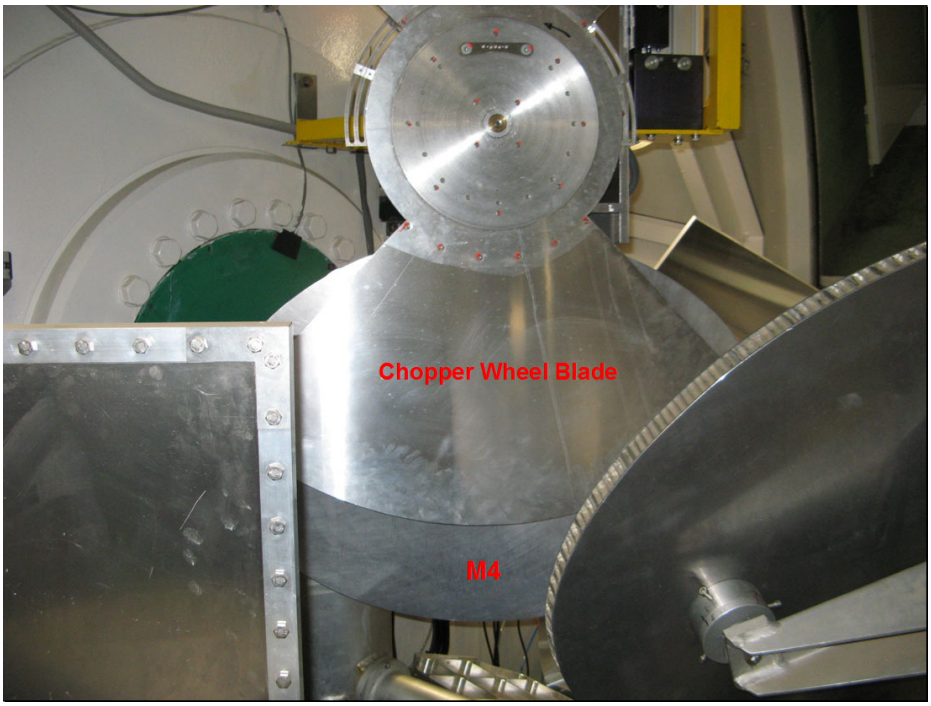

Photo 2

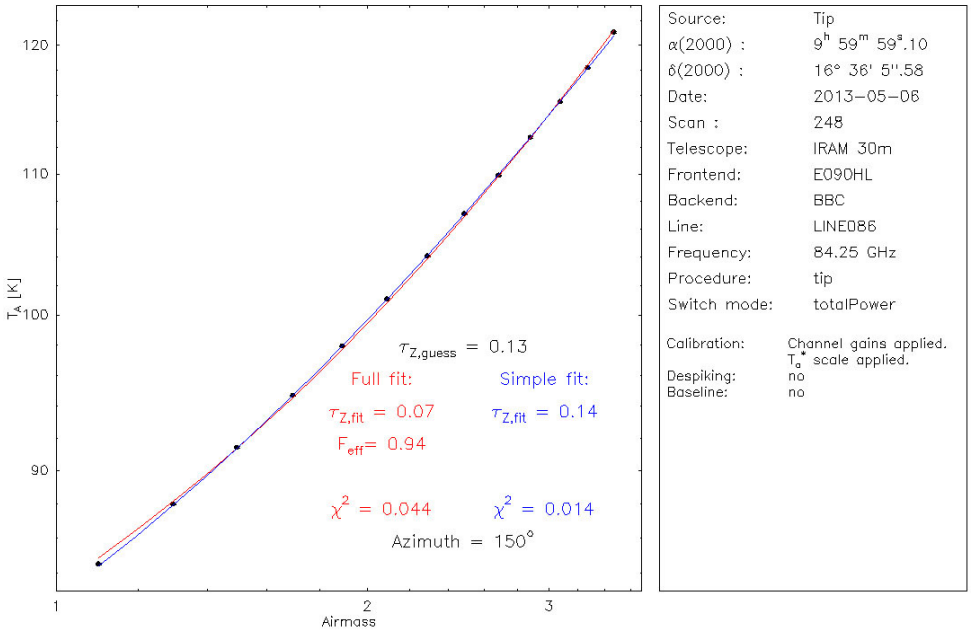

Figure 2

Figure 3 shows a skytip fit where the points at airmass 1.3 and 1.5 are not included in the fit, in that way is easier to identify the antenna elevations where some blocking of the chopper wheel is present. Because the fit is OK with the remaining points, we can conclude that at least at antenna elevations higher than 65° and lower than 36° the beam is free of chopper wheel blocking.

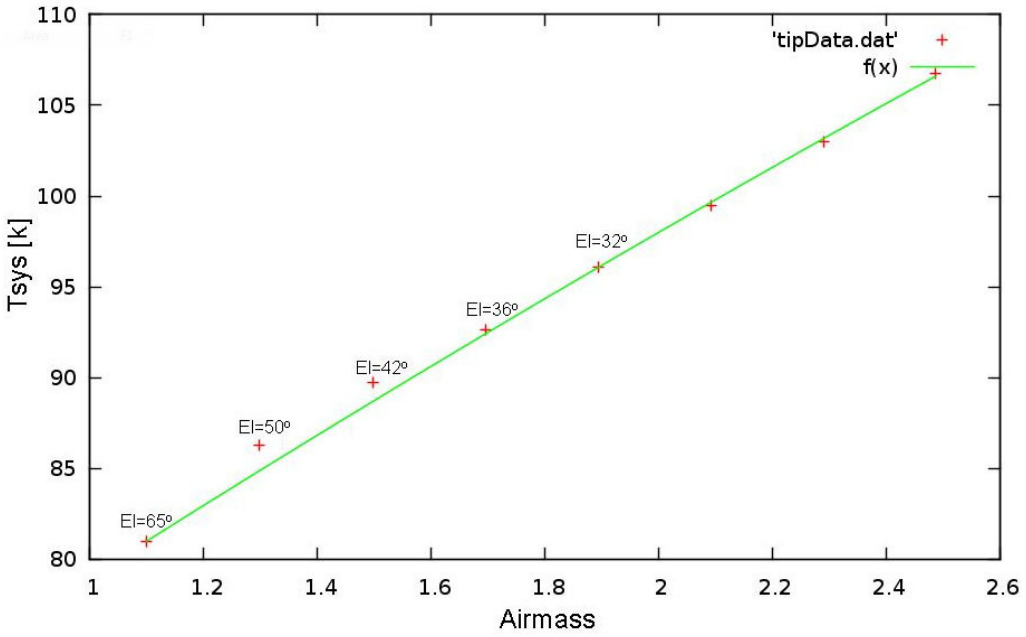

Figure 3

Several calibration scans have been performed with the chopper wheel in its default horizontal position (with blocking) and with the chopper wheel in its upper position (without blocking) to quantify typical contributions of the chopper wheel blocking to the system temperature Tsys in the elevation range of blocking. A total of twelve calibration scans have been done in four series of three, for each series the chopper wheel remains alternatively in its default horizontal position or its upper position. The antenna elevation range was between 47.3° and 46.2°. The resume of these measurements, showing Tsys, is in Table 1.

	Rx band	E0HL	E0HU	E0VL	E0VU	E2HL	E2HU	E2VL	E2VS	
	frequency	84.3	100.3	84.3	100.3	215.8	231.8	215.8	231.8	
scan	elevat.	Tsys	Tsys	Tsys	Tsys	Tsys	Tsys	Tsys	Tsys	
278	47.3	104.02	123.91	107.07	123.43	403.05	448.38	457.51	607.27	chopper in default position
279	47.3	104.12	124.08	107.18	123.61	406.68	452.98	461.18	612.56	
280	47.2	104.29	124.34	107.42	123.88	409.32	455.50	463.92	615.53	
281	47.0	100.05	120.35	103.18	119.84	390.11	433.10	441.78	586.89	chopper up
282	47.0	99.46	119.42	102.59	119.03	378.45	420.31	429.46	569.49	
283	46.9	99.14	118.86	102.18	118.37	371.44	411.65	421.34	559.47	
284	46.7	102.29	121.22	105.24	120.62	369.10	408.11	419.46	555.86	chopper in default position
285	46.6	102.19	121.11	105.14	120.44	368.51	407.18	418.14	554.68	
286	46.5	102.17	121.08	105.15	120.41	368.06	406.88	418.94	555.26	
287	46.4	98.62	118.12	101.81	117.72	359.14	396.70	407.83	540.63	chopper up
288	46.3	98.77	118.28	101.95	117.78	361.24	399.20	410.64	544.57	
289	46.2	98.78	118.32	101.88	117.89	361.55	399.86	411.43	545.76	
ΔTsys(def.-up)		**4.04**	**3.73**	**3.94**	**3.63**	**17.13**	**19.70**	**19.45**	**25.72**	

Table 1

The conclusion is that the increasing of Tsys at an antenna elevation of approximately 47º is 3.8 K ± 0.2 K in the band E0 and 20.5 K ± 3.7 K in the band E2.

This chopper wheel blocking effect seems less prominent in the band E2 as shown in Figure 4. But giving percentages figures of ΔTsys / Tsys for the band E0 results in 4.1% and for the band E2 in 4.5 %.

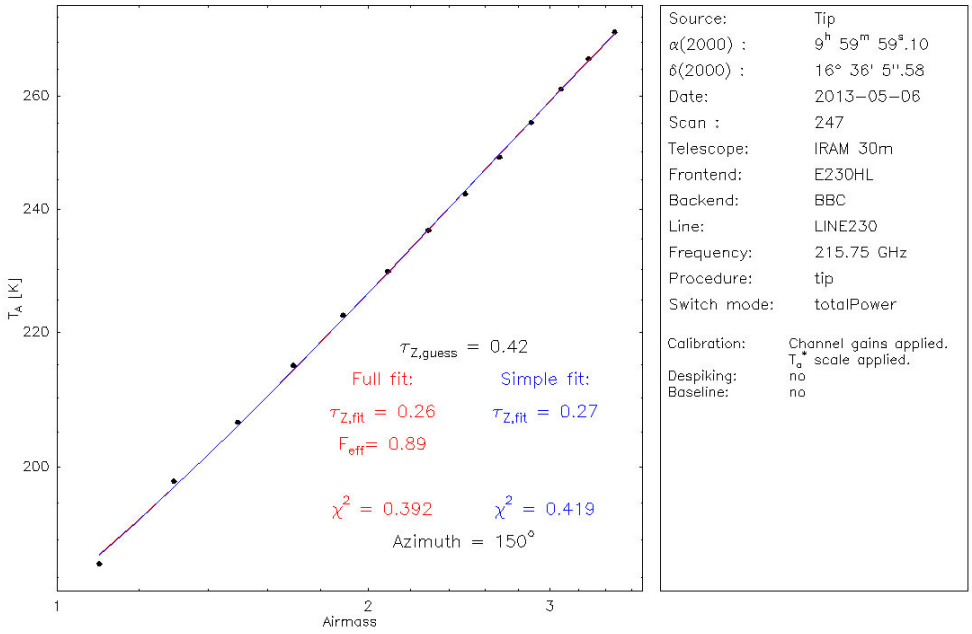

Figure 4

The fit improves concerning the blocking when the chopper wheel is moved to its vertical position as shown in Figure 5.

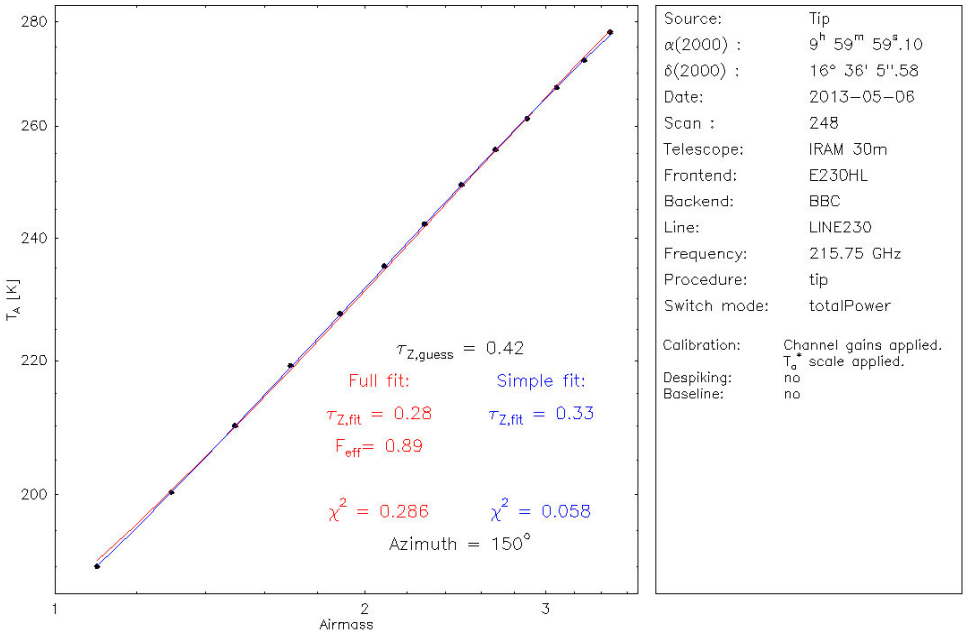

Figure 5

The results obtained for the forward efficiency Feff and the opacity tau are quite similar when the skytip fit is done manually with/without the airmass points partially blocking the beam. Table 2 shows these results for the manual analysis of the skytip in Figure 1.

Scan 247. Case of the Figure 1	Feff	tau
including all the airmass points	0.9506 ± 0.0017	0.0698 ± 0.0009
removing the airmass points 1.3, 1.5 and 1.7	0.9553 ± 0.0011	0.0717 ± 0.0005

Table 2

Chopper wheel in vertical position

The chopper wheel in vertical position is used exclusively for two of the four phases in beam switching observing mode. The chopper wheel in vertical position has the disposition shown in Photo 2, with the mirror M4 not completely covered. As a consequence of the not complete covering of M4 some hot temperature is collected from the receiver cabin and the system temperature Tsys is higher with the chopper wheel in vertical position than in horizontal position.

Figure 6 shows two consecutive skytips done in band E0 with the chopper wheel in horizontal position (red points) and in vertical position (green points). Tsys with the chopper wheel in vertical position is about 5 – 6 K higher than in horizontal position. Figure 7 is a similar plot but for skytips in the band E2, in this case the temperature difference is about 8 – 12 K.

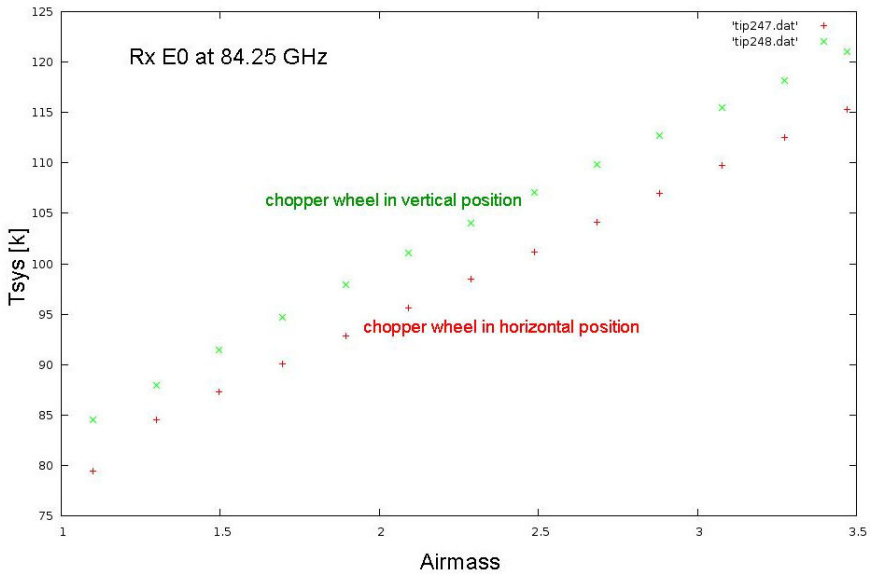

Figure 6

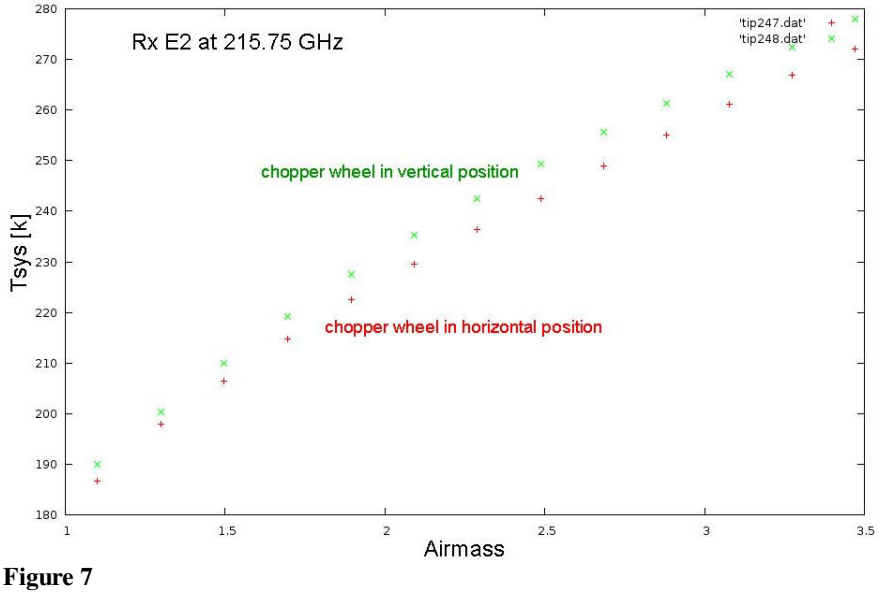

Figure 7

Chopper wheel in upper position

The chopper wheel is placed in the upper position, as shown in Photo 3, to permit the rotation of mirror M4 looking to the bolometers area. In the upper position the chopper wheel can not be left completely horizontal, but a bit inclined as shown in Photo 3. In that position, near horizontal, the chopper wheel also blocks the beam at higher elevations from M3 to the vertex as shows the skytip of Figure 8 for the point corresponding to the airmass 1.1 (elevation 65^{o}). If the chopper wheel in its upper position is placed vertical then doesn't block the beam as shown in Figure 9.

Conclusion is that special care has to be taken when moving the chopper wheel to its upper position. It must be left in vertical disposition to avoid blocking!

Photo 3

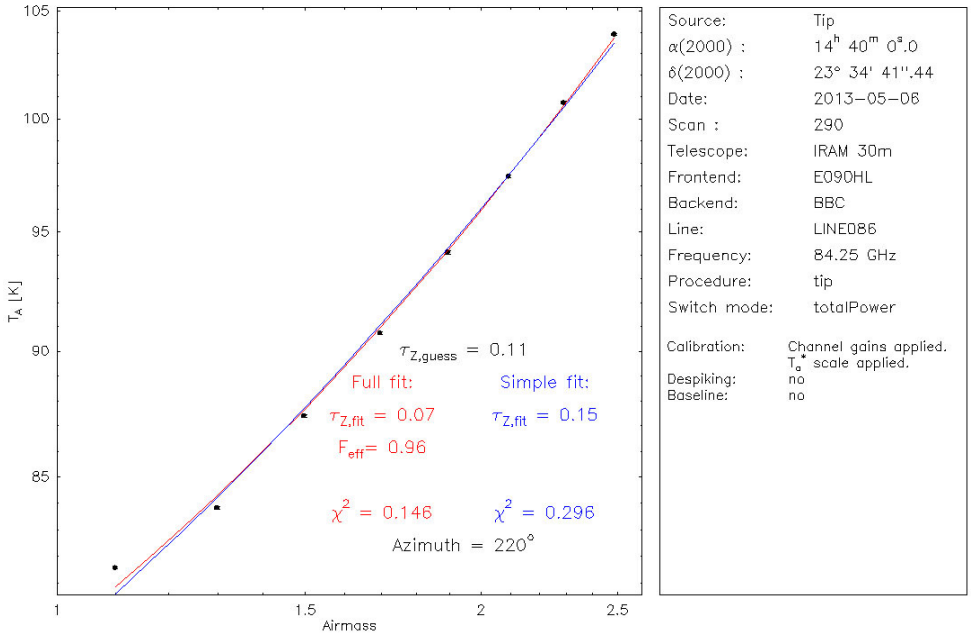

Figure 8

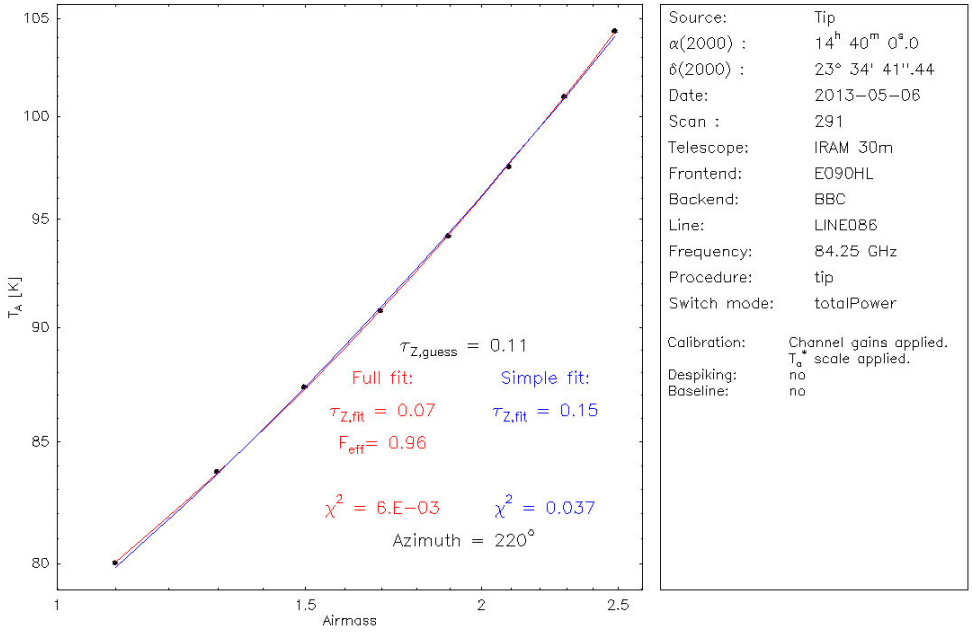
105
100
95
90
85
80
T_A [K]
1
1.5
2
2.5
Airmass
$\tau_{Z,guess}$ = 0.11
Full fit:
Simple fit:
$\tau_{Z,fit}$ = 0.07
$\tau_{Z,fit}$ = 0.15
F_{eff}= 0.96
χ^2 = 6.E-03
χ^2 = 0.037
Azimuth = 220°
Source: Tip
α(2000) : 14h 40m 0s.0
δ(2000) : 23° 34' 41".44
Date: 2013-05-06
Scan : 291
Telescope: IRAM 30m
Frontend: E090HL
Backend: BBC
Line: LINE086
Frequency: 84.25 GHz
Procedure: tip
Switch mode: totalPower
Calibration: Channel gains applied. T_a^* scale applied.
Despiking: no
Baseline: no

Figure 9