Report on the Solar Drift Scans done at ISU

J.Köppen
Observatoire Astronomique, Strasbourg,
International Space University, Illkirch

Overview:

During the commissioning time of the ESA-Dresden radio telescope at ISU and the Personal Assignments of the Masters students from Jan. to April 2007, several partial and full drift scans across the Sun were obtained. The successful and more complete ones are listed below, along with the essential data and the results of the quantitative analysis:

Date	Telescope	HPBW deg	Source dBµV	Backgrd dBµV	Antenna Temp.	Solar Temp.
7 Feb., 13:00	ESA-Dresden	2.7	45.7	42.85	--	--
12 Feb., 10:38	ESA-Dresden	3.5	46.4	42.0	219	9260
14 Feb., 13:17	ESA-Dresden	3.5	45.7	42.7	180	7610
14 Feb., 14:35	ESA-Dresden	3.5	46.5	43.1	210	8880
19 Feb., 15:53	ESA-Dresden	(3.5)**	45.1*	42.0	171*	7230*
19 Feb., 14:35	ESA-Dresden	(3.5)**	45.0*	42.3	195*	8240*
21 Feb.	Repair of LNB arm					
27 Feb., 10:56	ESA-Dresden	1.8	50.2	41.8	(1050)	(12200)
16 Mar., 12:40	ESA-Dresden	1.9	49.8*	41.8	(870)*	(11000)*
16 Mar., 13:25	ESA-Dresden	1.5	49.8*	41.8	(810)*	(6400)*
29 Mar., 16:21	ESA-Dresden	1.5	50.1	41.8	(930)	(7400)
24 Apr.	Inverted mounting of ESA-Dresden dish					
24 Apr., 10:10	Small, SatFinder	2.5	64.6*	62.4	195*	4370*
24 Apr., 18:36	ESA-Dresden	1.5	50.2	42.0	990	7980
26 Apr., 15:00	ESA-Dresden	1.5	50.0	41.7	1035	8460
30 Apr., 10:10	Small, SatFinder	3.2	65.3	62.2	285	10450
30 Apr., 11:15	ESA-Dresden	1.8***	50.2	42.0	1050	12190***
4 June, 17:11	ESA-Dresden	1.4	48.6	40.3	975	6846
XX Apr., 11:15	ESA-Dresden	1.8	50.2	42.0	1050	12190

All observations are done on 12500 MHz, except the one on Feb.7th which was done on 11250 MHz.
* These observations missed the true maximum.
** the antenna pattern is rather asymmetric. Hence, it is difficult to give a reliable value for the HPBW.
*** if one had used a HPBW of 1.5°, the solar temperature would have been 8460 K; but this would have been unacceptable to match the observed scan profile. This indicates that the measurement of the HPBW is rather crucial.

Values in parentheses are estimated based on previous flux calibrations.

For comparison, we also performed scans with a smaller antenna, a 60 by 70 cm offset dish, positioned manually, but using the AMA receiver and computer to record the data.

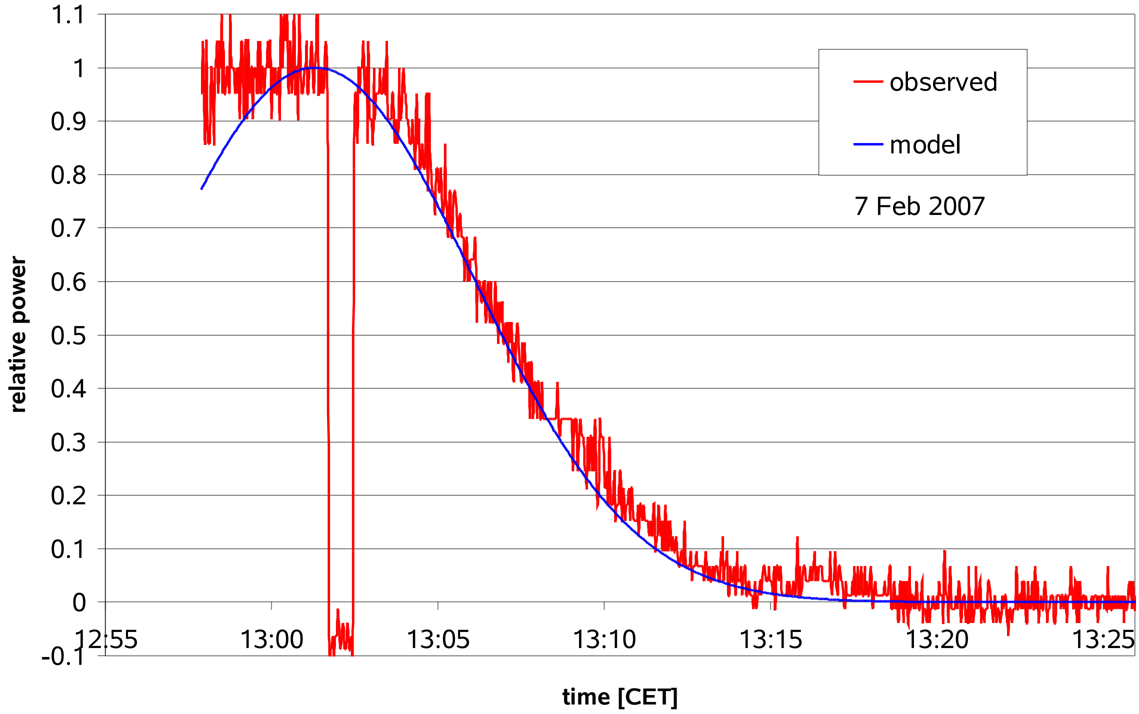
In the period before the repair of the LNB arm on 21 Feb. the 1.2m antenna showed a beam much broader than expected, and the solar signal was much lower (only about 3 dB above background) than seen in the prototype (about 8 dB above background). Nonetheless, values for the solar temperature were in reasonable agreement with the expected value of about 10000 K. This demonstrates that even if the dish is badly focused, as the result of wind damage or perhaps some mishandling, it can produce useful and meaningful results. However, it had been noticed that the antenna pattern deviates from a nice symmetrical shape, and thus there would be uncertainties how to measure the HPBW which is crucial to deduce the solar temperature.

To obtain meaningful data, a flux calibration must be executed by observing the ground, which is an emitter of thermal radiation of about 300 K. Also, the current angular diameter of the Sun must be applied, rather than the simple estimate of 0.5°. Furthermore, the angular motion of the sun across the sky must be corrected from the knowledge of the current solar declination, instead of the mean value of 0.25°/min.

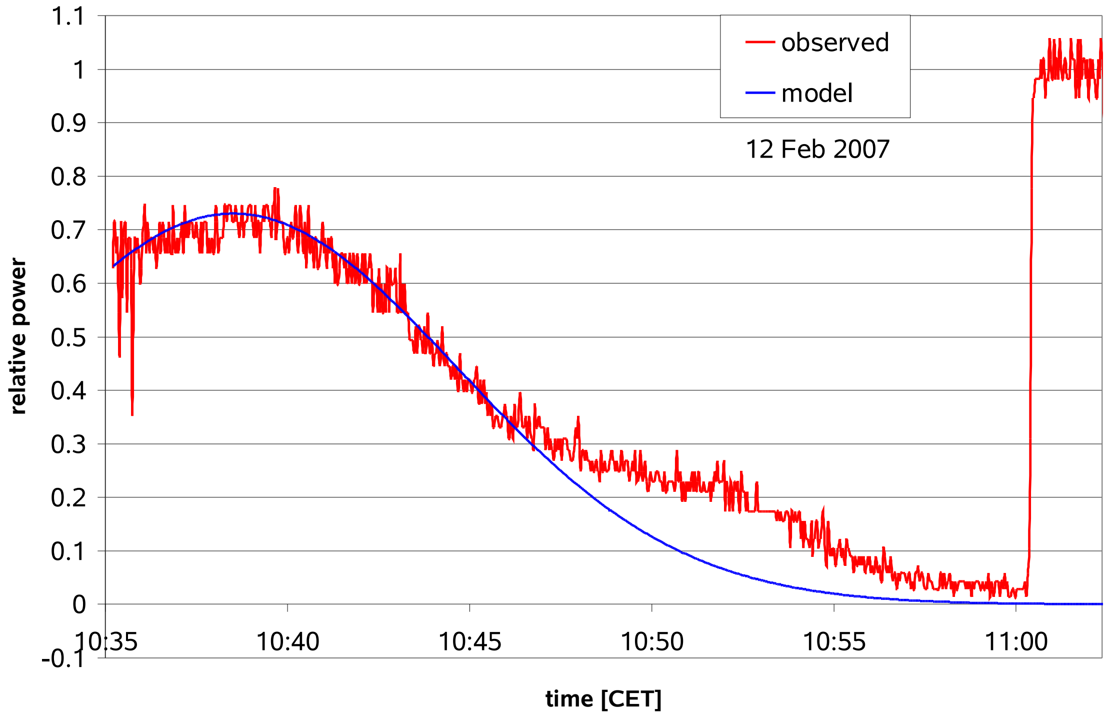
The individual scans:

In the following, we present the individual data and discuss some of the peculiarities encountered.

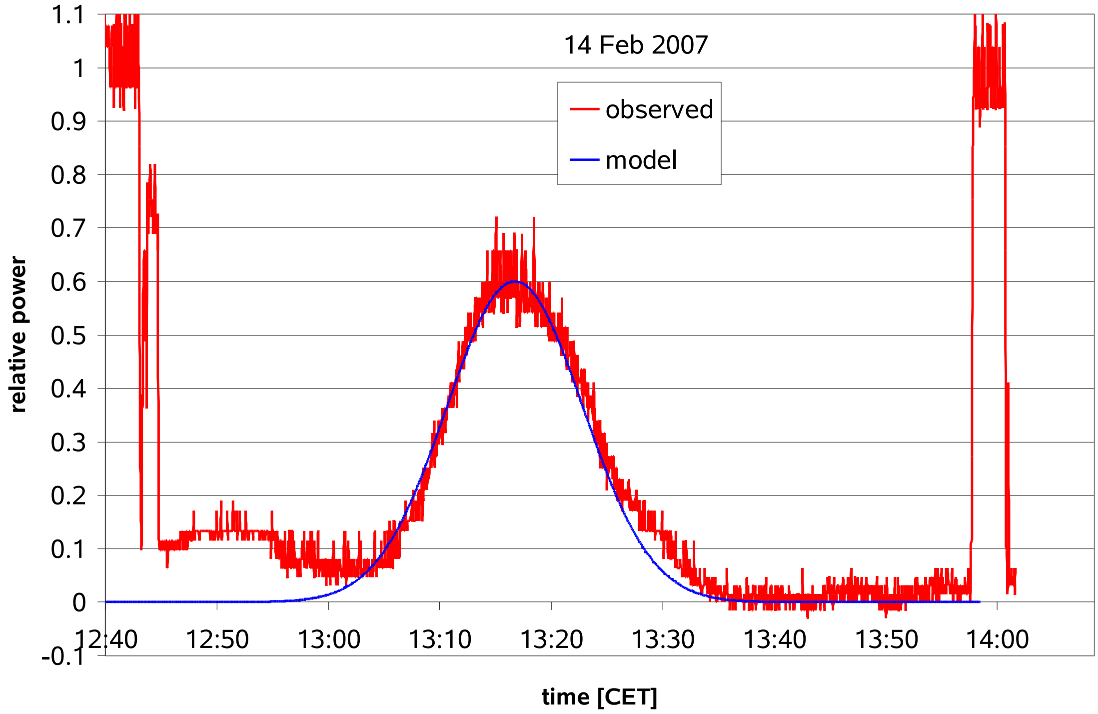
The first drift scan was done on 7 Feb., without a flux calibration. At 13:02 the telescope was moved to an empty position in the sky. Note that at 13:08 the tracing exhibits a strange feature when the receiver level passed +44 dBµV. Such behaviour was often noted; perhaps this is a slight fault in the receiver's ADC which digitizes the measured signal. It does not present any real problem.



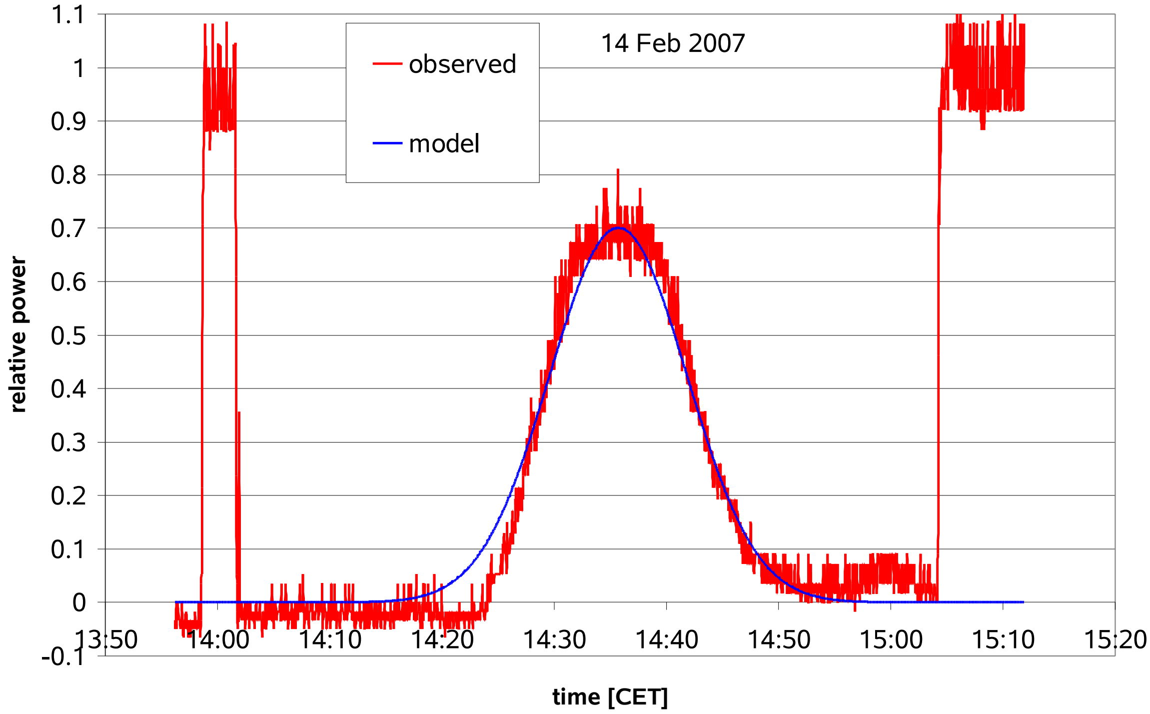
The first scan with flux calibration was done on 12 Feb. One notes a jump in level at 10:44 as well as a stretch of constant level at 10:54, when it passed +43 dBµV. Also, the profile shows a rather conspicuous 'hump' after 10:47.



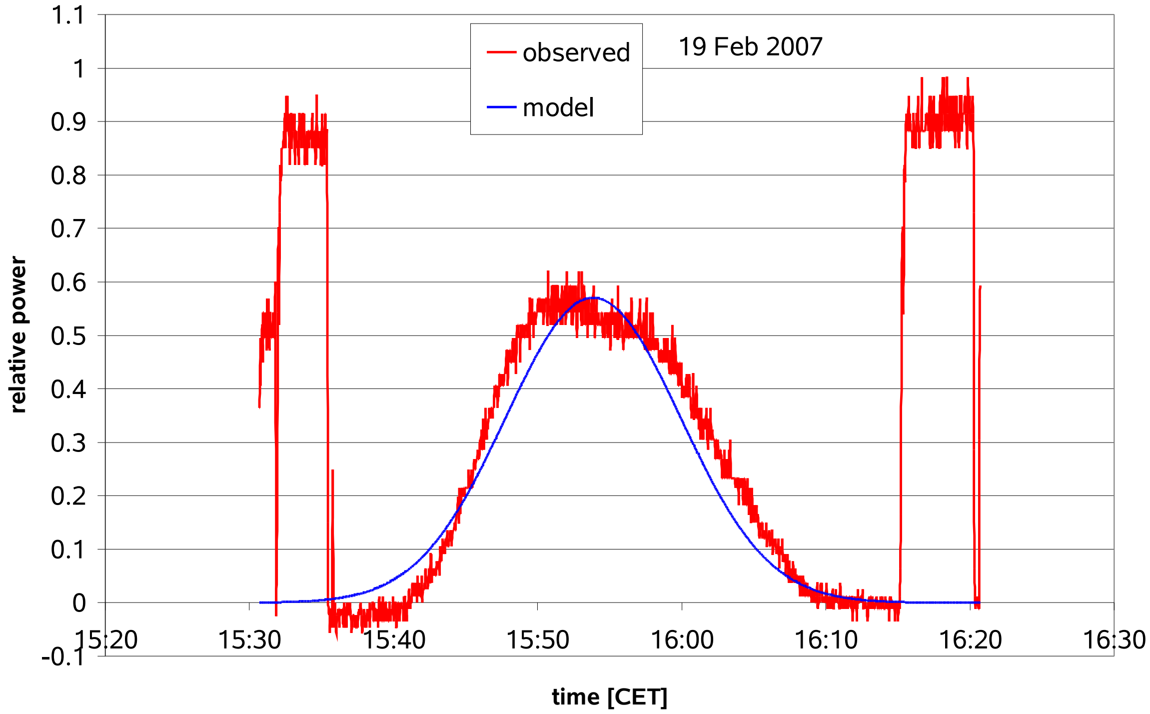
On 14 Feb. we obtained the first full drift scans, after some trials. All runs were flux calibrated. Again; a 'hump' in the lower part of the profile is apparent. One also notes that the level 'gets stuck' around 12:50, 13:09, and 13:30: the value of +43.5dBµV occurs very often.

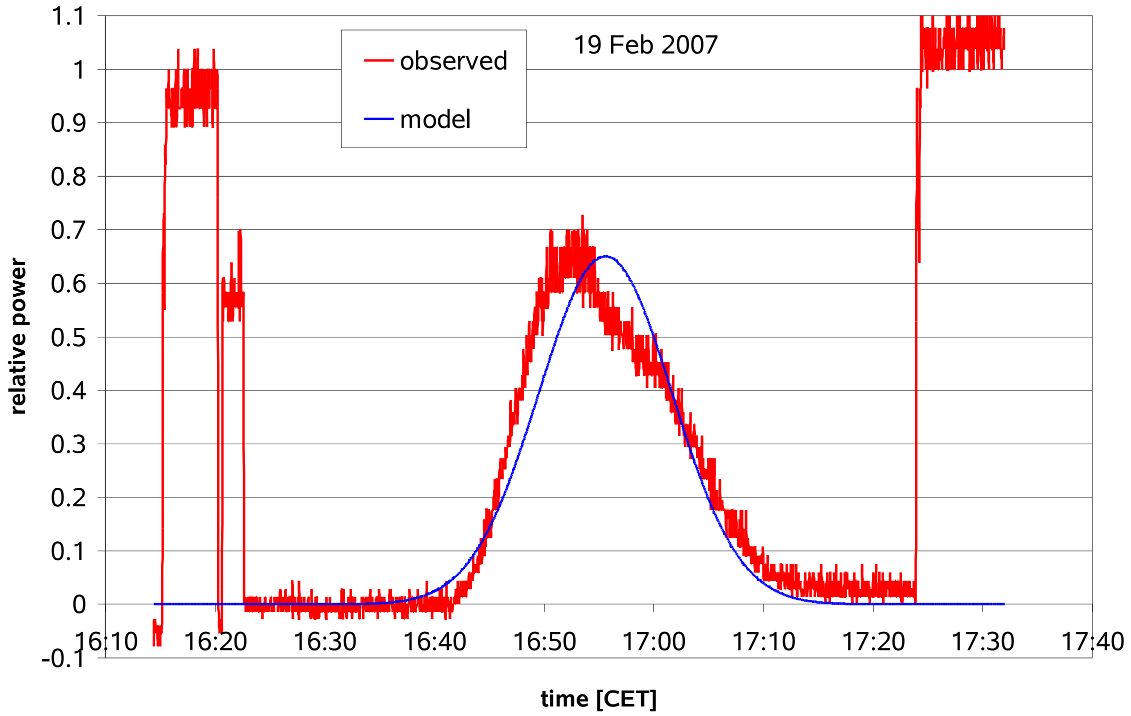


The full scan immediately following was more symmetrical, but the profile showed a rather broad top and steep shoulders. Some variations of the background and calibration levels were noted, and had been taken into account in an earlier interpretation, but here we assume for simplicity average values for the background and calibration levels.

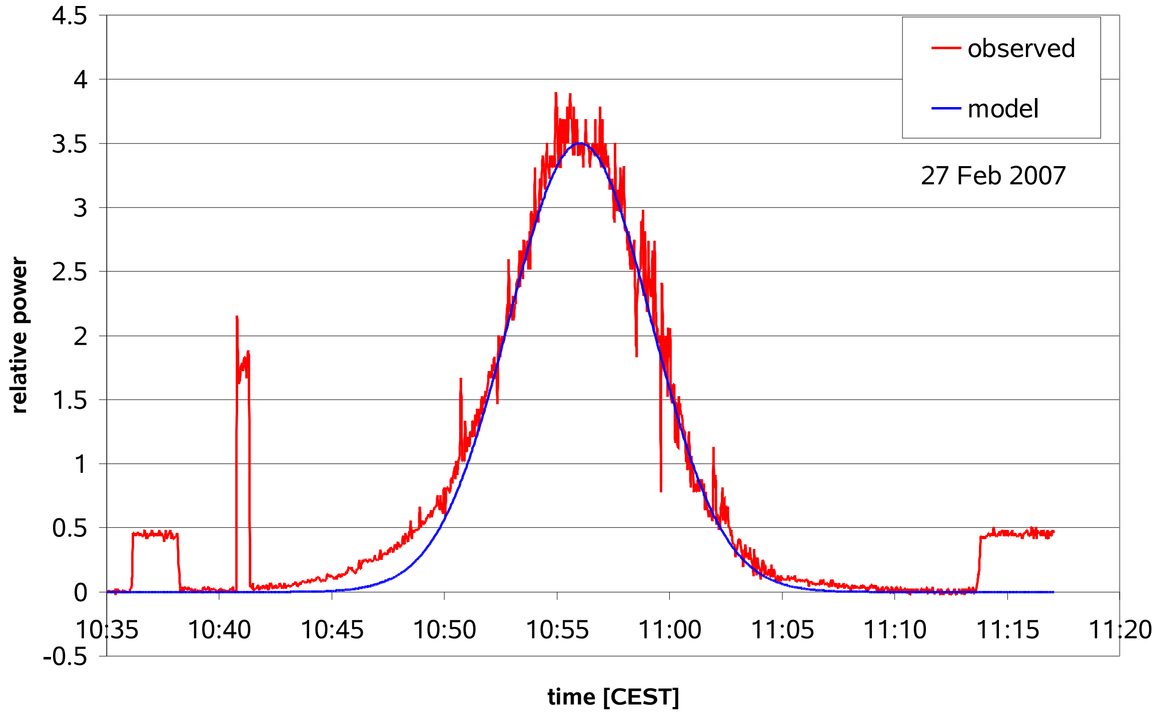


The following two scans were obtained by Aravind Saini Saini on 19 Feb. They are rather similar to the scans of 14 Feb., but show what seems to be a two-component structure of the profile, which results in a rather broad top but steep shoulders. Since the telescope is not moved during a scan, the variation of the structure can only be attributed to differences in the position at which the Sun must have traversed the antenna beam. At this time, the telescope still had its LNB arm bent slightly and thus was out of focus. It seems reasonable to surmise that the structured profile and its variations reflect the defocused antenna pattern which was sampled by the different scans. Funny structures at 15:45 and 16:04 appear when the level passes over +43.6 dBµV; the same occurs at 16:45 and 17:06.

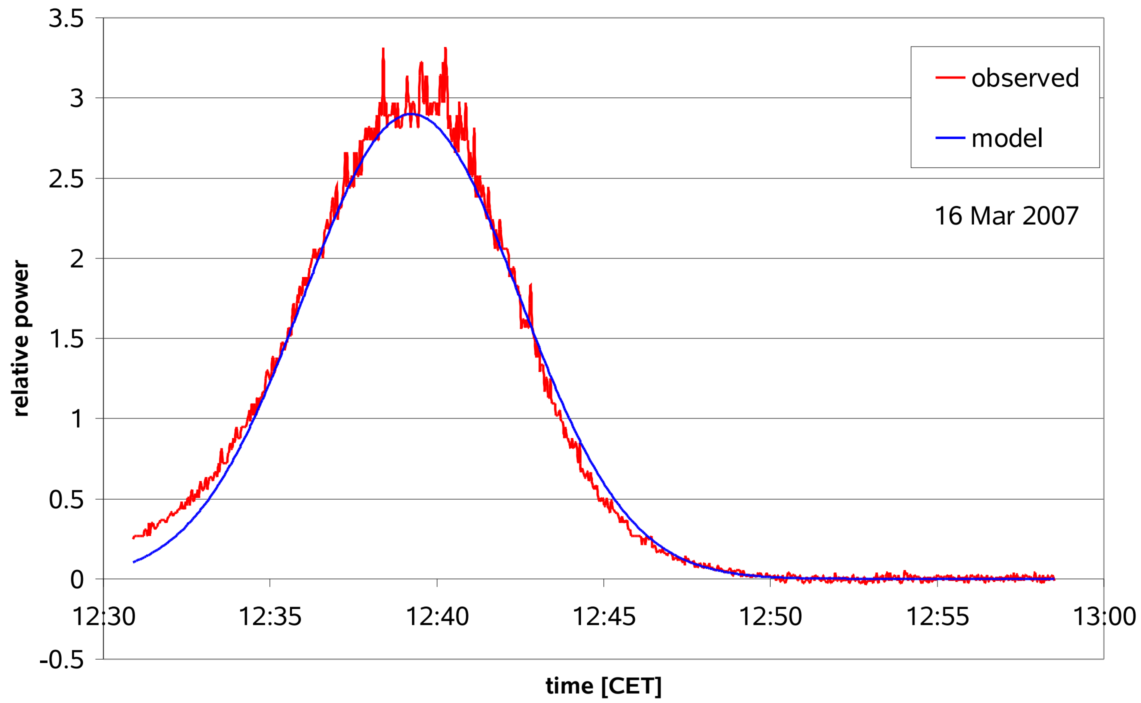


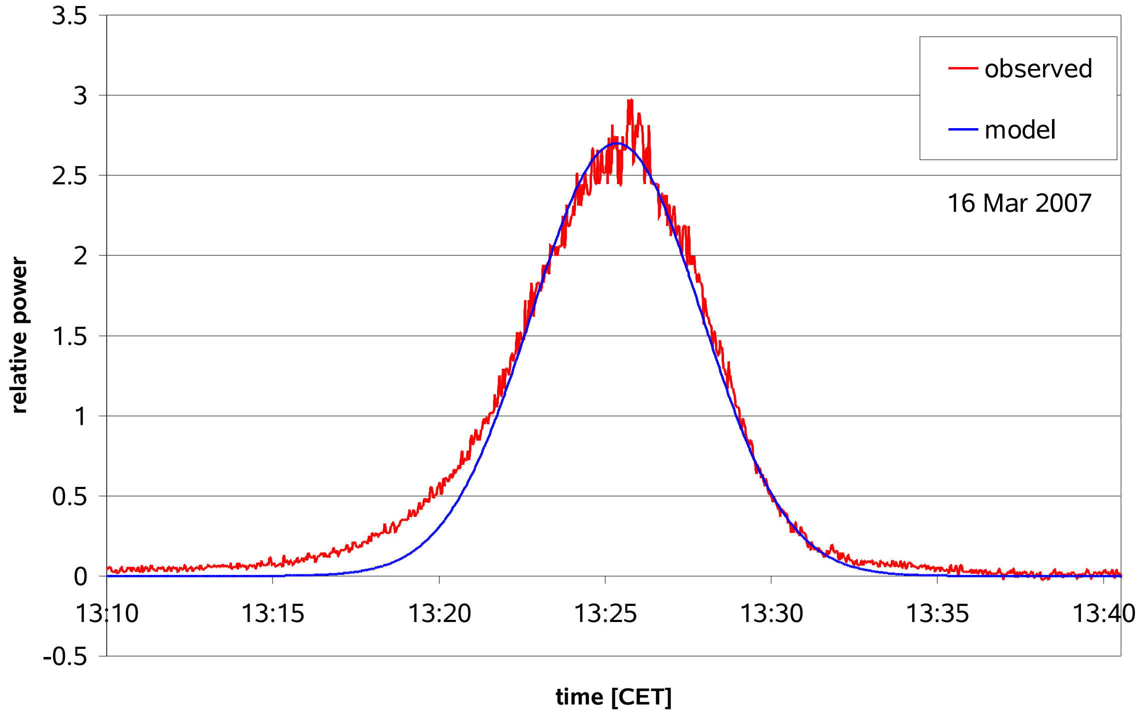


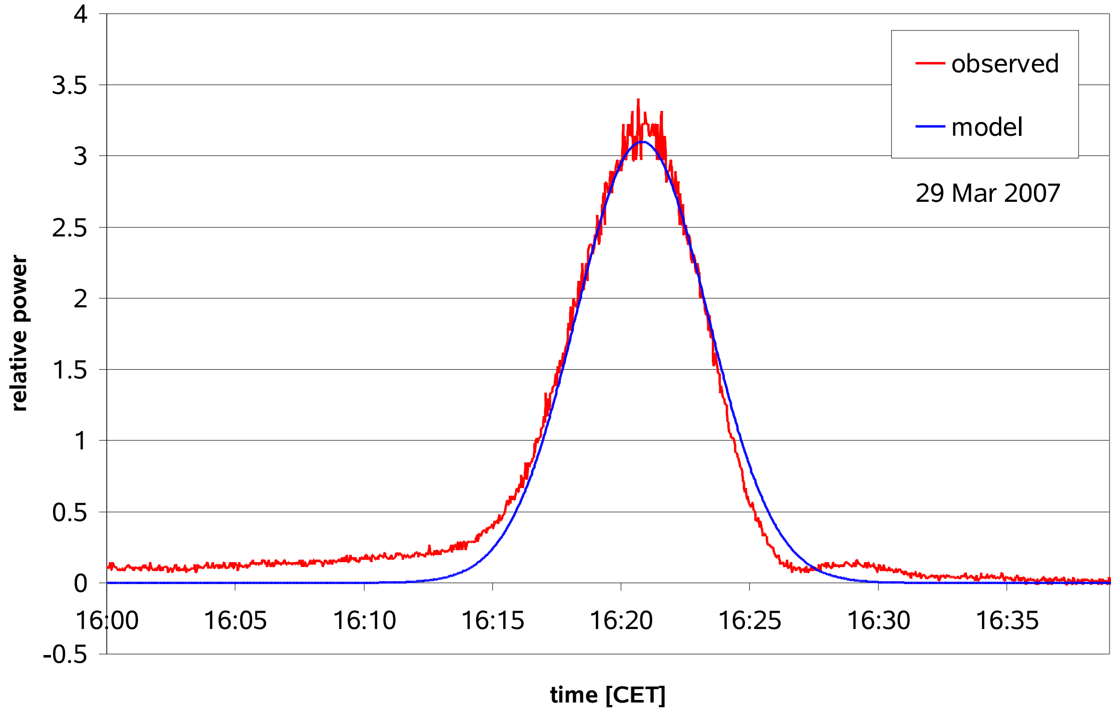
Some days later, the LNB arm was straightened, and the first solar scan with the repaired antenna on 27 Feb. showed the narrower beam and the higher signal at maximum. This scan, however, is not flux calibrated, because the antenna could no longer be pointed towards the ground. Since it appears that both the background and the calibration are rather stable, we take the flux calibration from later scans. The overall shape of the profile is symmetrical and rather closely matches that of a Gaussian.



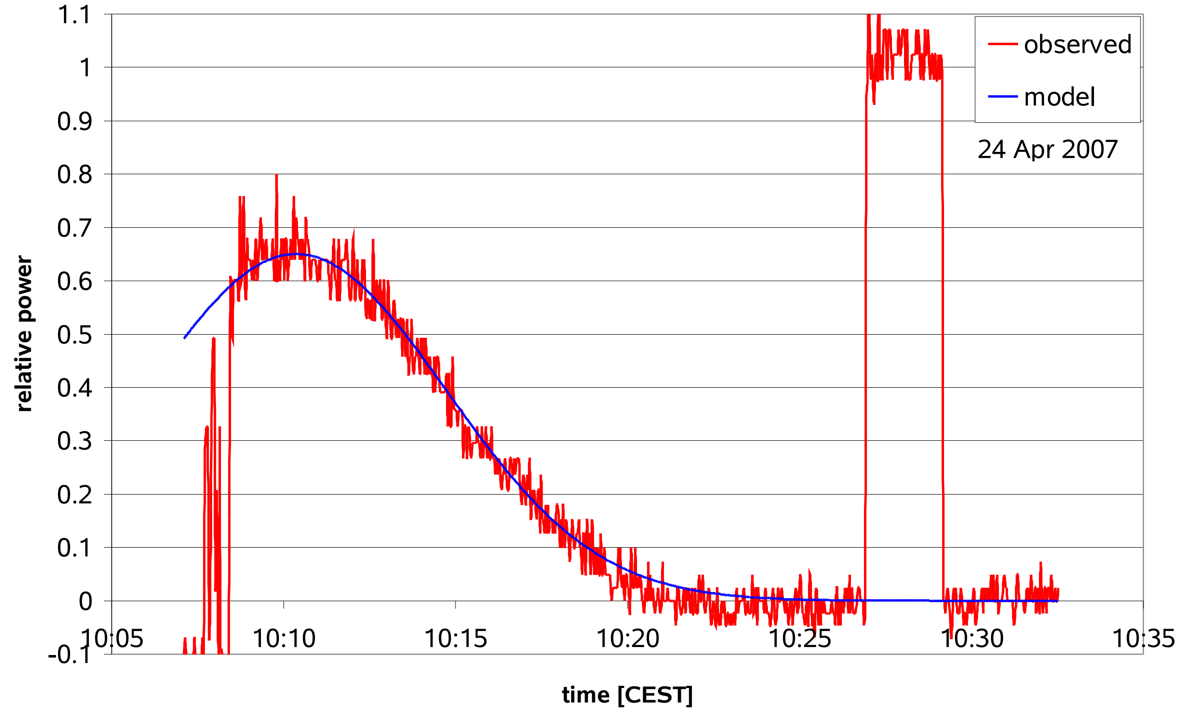
A number of uncalibrated scan were done by Marc Cornwall on 16 and 29 March. Again, we apply the flux calibration from later scans. In all three profiles one notes the symmetry and the absence of any features at low level. However, it is remarkable that the Western (i.e. the outgoing) side seems steeper than the Eastern side, which is also seen in the data of 27 Feb. Furthermore, it is apparent that the Sun did not pass through the exact centre of the beam in all scans, but this does not affect the shape of the profile.



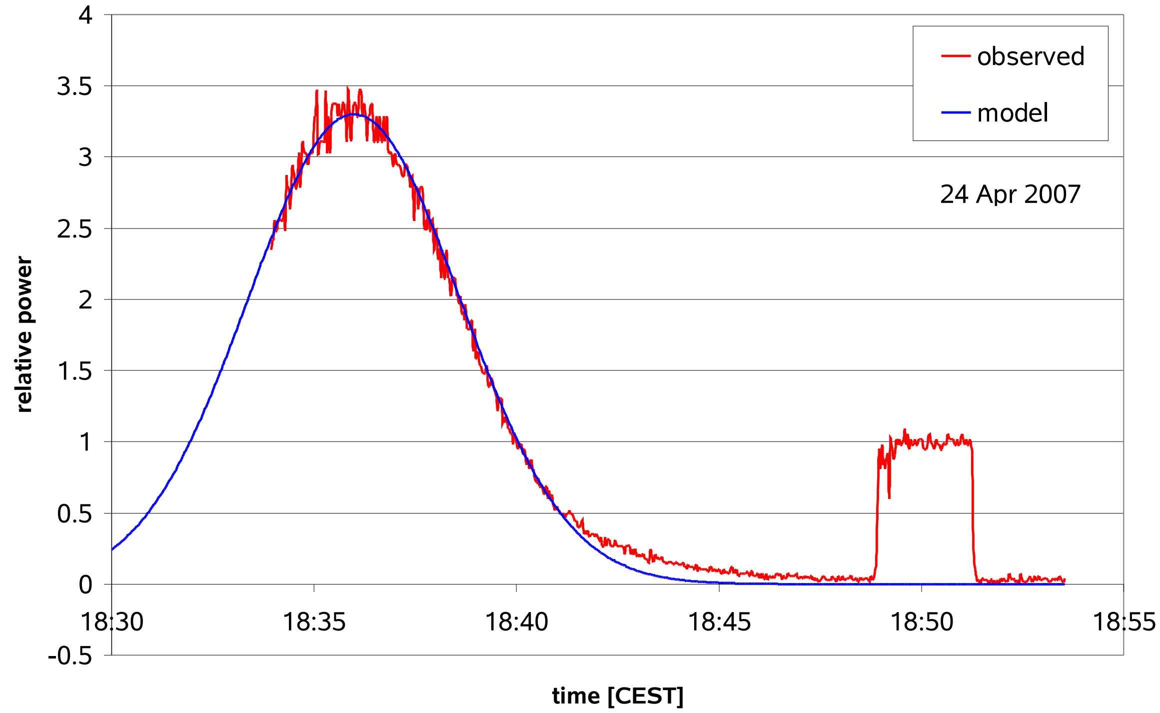




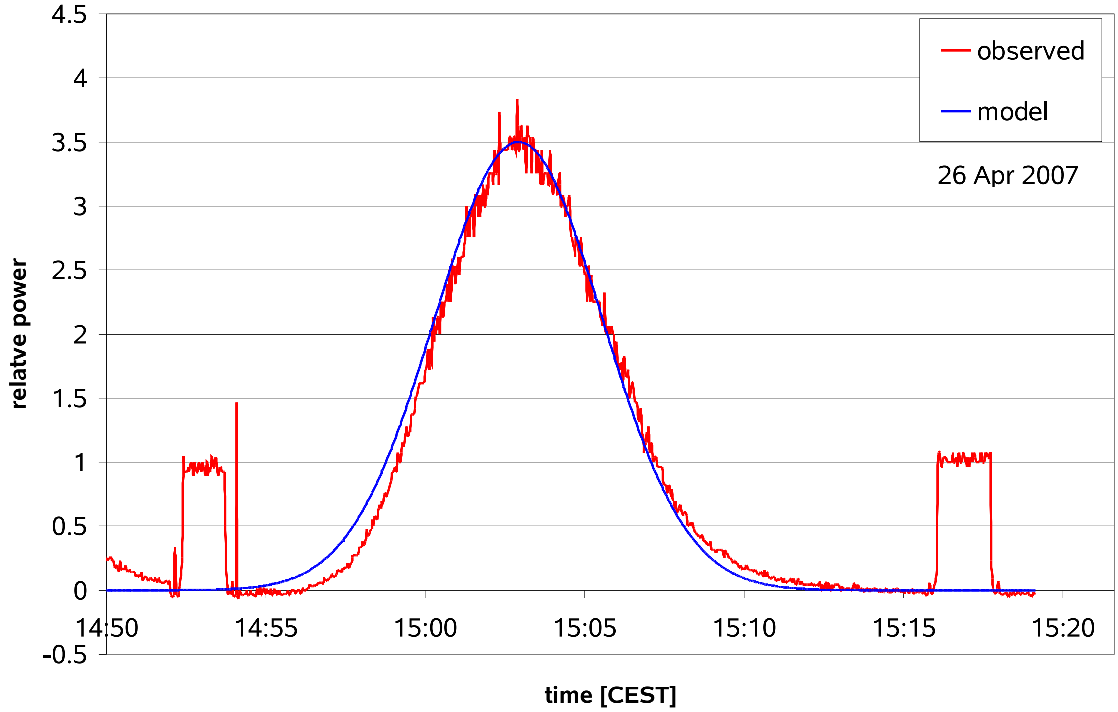
On 24 April, the antenna was mounted upside-down, so that the offset dish which normally points upwards now cana gain be pointed towards the ground for flux calibration. For comparison, we also made a drift scan with the smaller, 60 cm dish and a SatelliteFinder between the LNB and the AMA receiver. A near-Gaussian profile was obtained, but as a later scan showed, the Sun did not pass through the centre of the antenna beam.



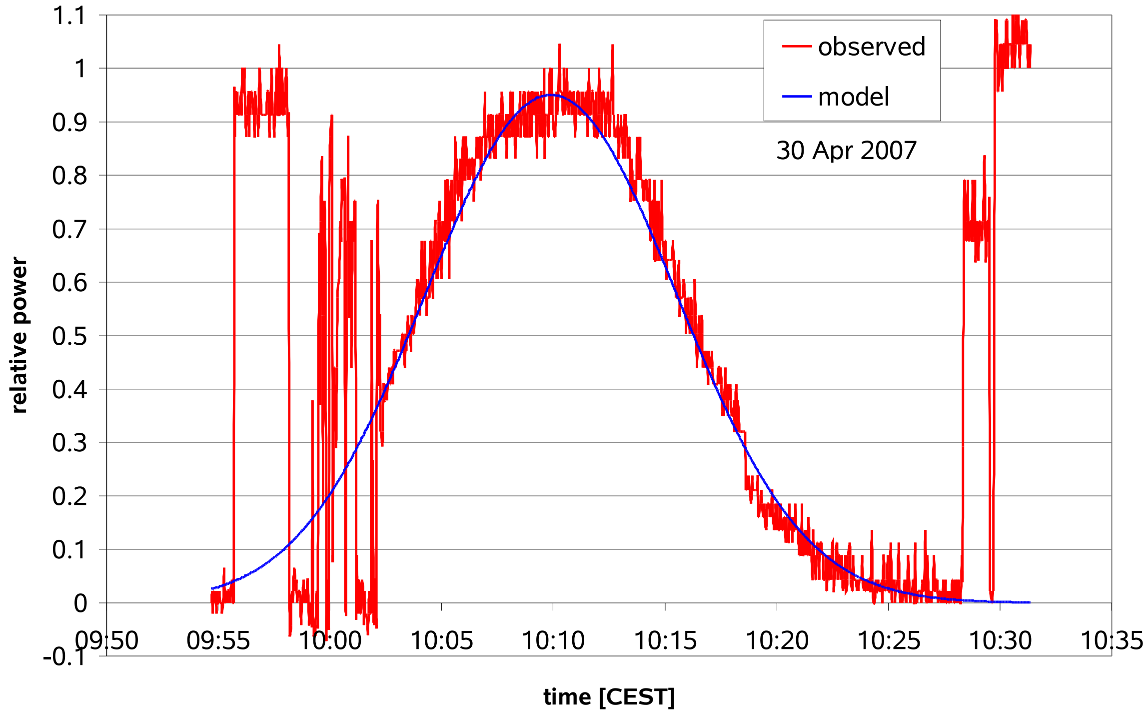
The drift scan done with the ESA-Dresden telescope also showed a neat near-Gaussian profile, and with the flux calibration possible, the data could be quantitatively analyzed.



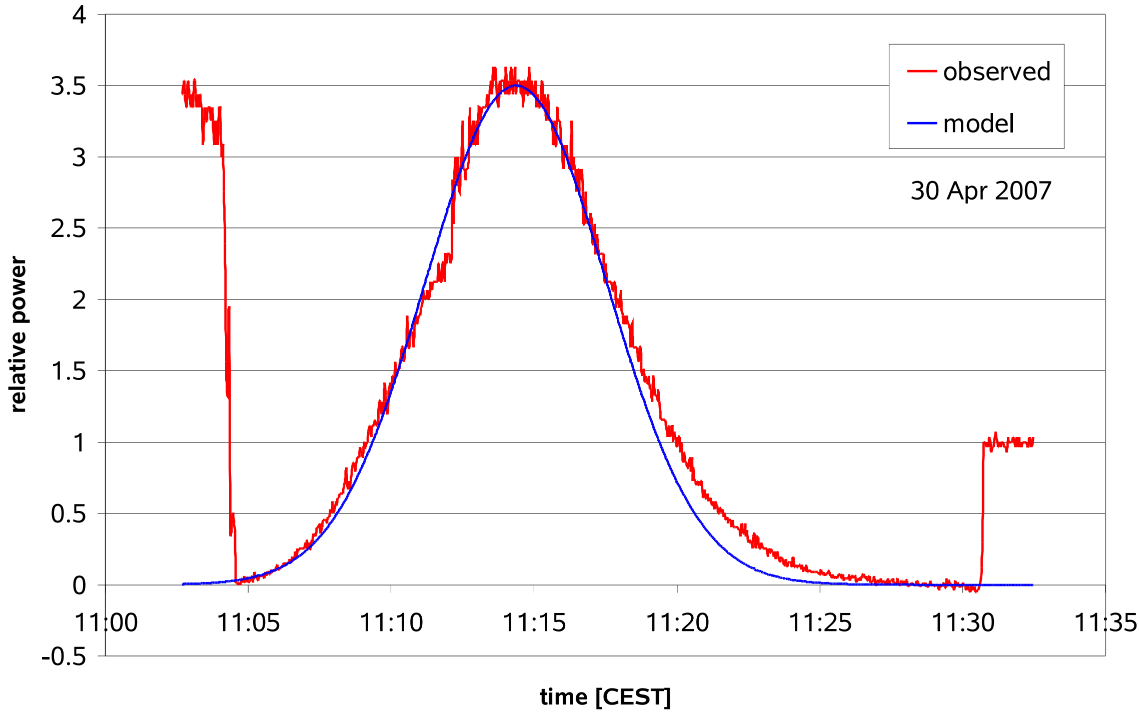
A successful full solar scan on 26 April gave evidence of a slight asymmetry of the profile, but this time it is the Eastern side which is steeper, as one should expect from an inverted mounting of the antenna dish. We can conclude that there remains a slight asymmetry of the antenna pattern, perhaps caused by the slight indent at the dish rim, which is the only optically striking result of the antenna's falls in autumn.



A scan with the small dish on 30 April showed a higher maximum signal – with the small dish we use an improvised method to adjust and maintain the elevation – thus the resulting solar temperature is close to 10000 K. The strong fluctuations around 10:00 are the record of the search for the maximum signal, before fixing the antenna's position. At 10:18 a jump in the signal is present, from +63.5 to 63.1 dBµV. There was no change of the antenna's position, for example by a gust of wind that could have caused this drop of the signal.

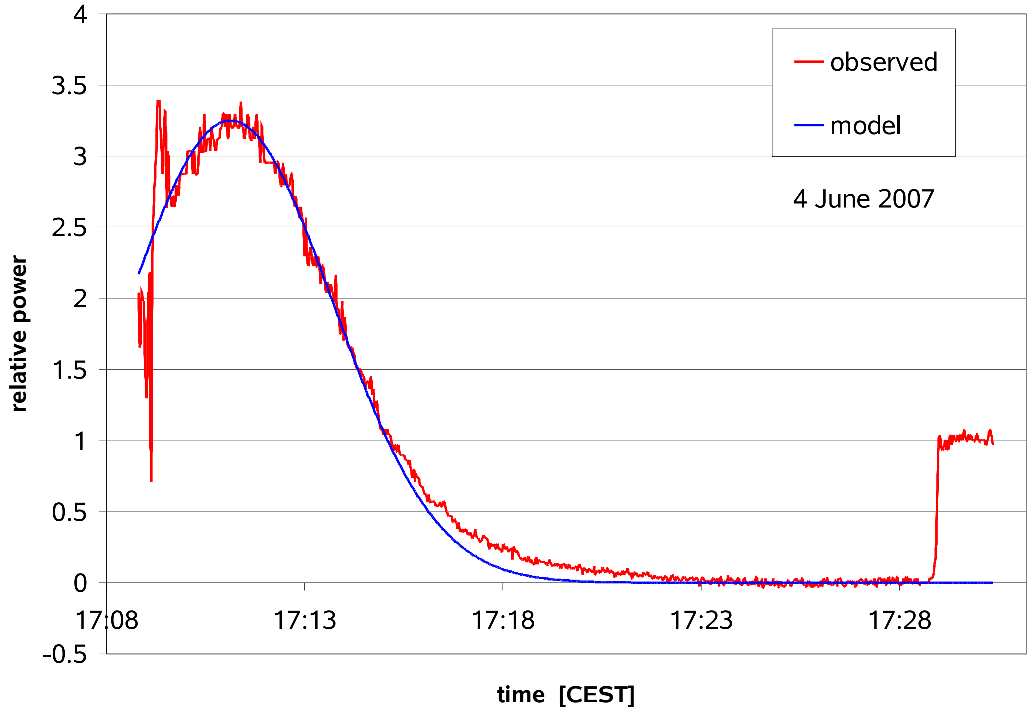


Several attempts for a full scan were done with the ESA-Dresden telescope. However, often the Sun did not pass through the beam's centre and thus the scan had to be abandoned. It was frequently noted that a slight repositioning, by a short click on the 'UP' or 'DOWN' button resulted in a significant increase of the signal, but without any change in the elevation. Since the azimuth and elevation are displayed only in full degrees, the real positions may well deviate from the indicated value by at least 0.5°. Therefore, setting the antenna to the expected position for the solar transit does not prevent the Sun from passing at least 0.5° away from the centre of the antenna beam. With an HPBW of 1.8° (the value found for our instrument) an offset of 0.5° means a signal reduced to 80 % of the maximum! In the best attempt, shown below, one notes a jump upward at 11:12: The telescope had been set to capture the 11:15 transit, but by that time it had become apparent that the profile would not reach the expected maximum height, and a single click on the 'UP' button resulted in the signal going up from +48.8 to +49.5 dBµV, which is an increase of almost 20% in linear power.



During these and other observations, we frequently noticed that the position indications had jumped by 1° – sometimes even 2° – without that any change of position had been executed. Evidently, the sensors of the position indicators were subject to some slight drift, and the rounded value of the angle had flipped by one digit.

We must conclude that for an antenna beam as narrow as 1.8° the accuracy and stability of the positioning system is critically close to its technical limits. Attempting full scans of the Sun can thus be a most frustrating experience, prevent to obtain data sufficiently reliable to warrant a quantitative analysis, and might cause disappointment to students.



After a one-month pause, on June, 4th another scan was made. It showed lower values for the background and the solar signal, but with the same difference. The antenna HPBW is back to a low value of 1.4°.

Further observations are planned to study the stability of these values and trace the origin of any systematic variations.