Report on the tests at 30 GHz

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The measurements were done in the night October 9/10, 95 with the Filter 3 with a bandwidth of 80 MHz around 30.001 GHz; additionally data with a band with of 2 GHz centered at 29.3 GHz were recorded. After these measurements a thermal calibration was done by O. Lochner for both bands, the protocol is given in the appendix. For the evaluation the results of both thermal calibrations were combined (see below). This report is mainly based on the narrow band data, the broad band data were inspected for systematic differences.

To derive the instrumental gain curve the antenna should be properly focussed and the extinction/absorption should be known. The axial focus, expected to be independent of elevation, was measured about once per hour, the lateral focus was investigated systematically with elevation. Figures 1 a/b give the results. The lateral focus (focus 1) in Fig. 1 a shows an elevation dependence, which has a similar slope as the measurements of Feb. 17, 95 at 43 GHz, indicated by the smooth line, but it has a significant offset. The axial focus in Fig 1 b (only night time measurements) seems to show an elevation dependence, but this may be mimiced by normal time dependent focus variations.

Similarly to the quoted 43 GHz measurements a differential lateral focus change results in an elevation error. (Note: the automatic focus correction for homology needs an adequate pointing correction. If this correction is not fully correct, the remaining error will show up as pointing error. Since this is a systematic and repeatable error, it will be compensated by the set of observed [shammed] pointing constants.)

In Table 1 the observed mean pointing errors are given as function of OFC1:

Table 1

OFC1	-20	-10	0	10	20
NULE ["]	-7.9	-2.9	1.7	5.1	8.3

This function is about identical for 30 and 43 GHz, see internal report of Altenhoff and Schmidt [1995]. The implications of these pointing errors should be discussed in more detail.

Extinction/absorption measurements are done at longer wavelengths e.g. with the Moon, which is more extended than the antenna beam with all near sidelobes. A change of the surface accuracy with elevation will change the power, which comes into the main beam and into the near sidelobes; but the sum of both is constant. So measurements of the lunar center as function of elevation are only dependent on extinction. At shorter wavelengths sky dips are used to monitor extinction, which suffer from the fact that their results depend on several model assumption. We have tried to compare both methods.

The Moon was systematically observed from its rise to fall with crossscans. For analysis of the lunar emission usually either the total flux density or the intensity at the center of the moon is used. Here the intensity at the moon's center is used, defined as the average of the central values of the RA and DEC subscans. In Fig. 2 all lunar data are shown with a logarithmic scale for the intensity and an air mass (sec z) scale for elevation. The results are:

tau = 0.075	("opacity" in the usual definition)
Ta (extraterr) = 204 K	(antenna temperature of Moon's center)

It should be noted that a constant decrease of intensity (about 3% in 12 hours),

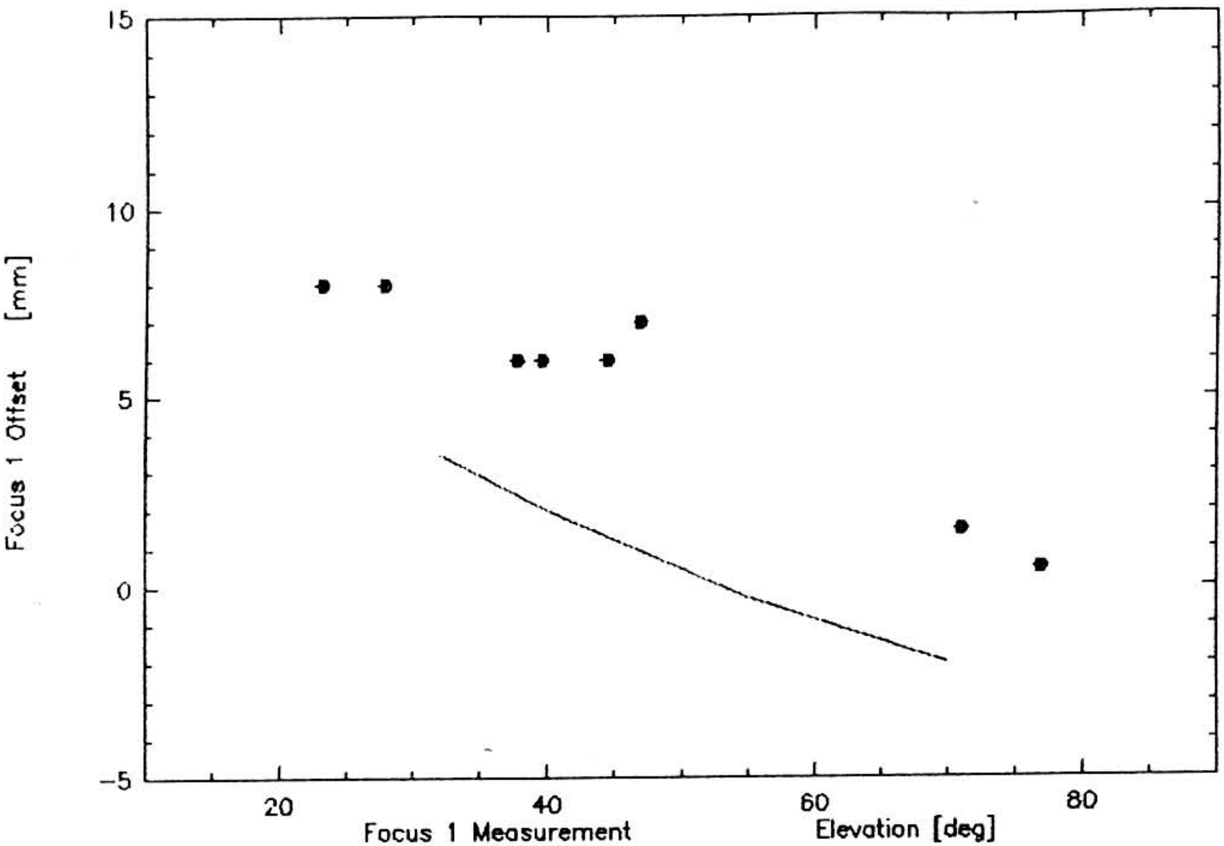

Figure 1 a

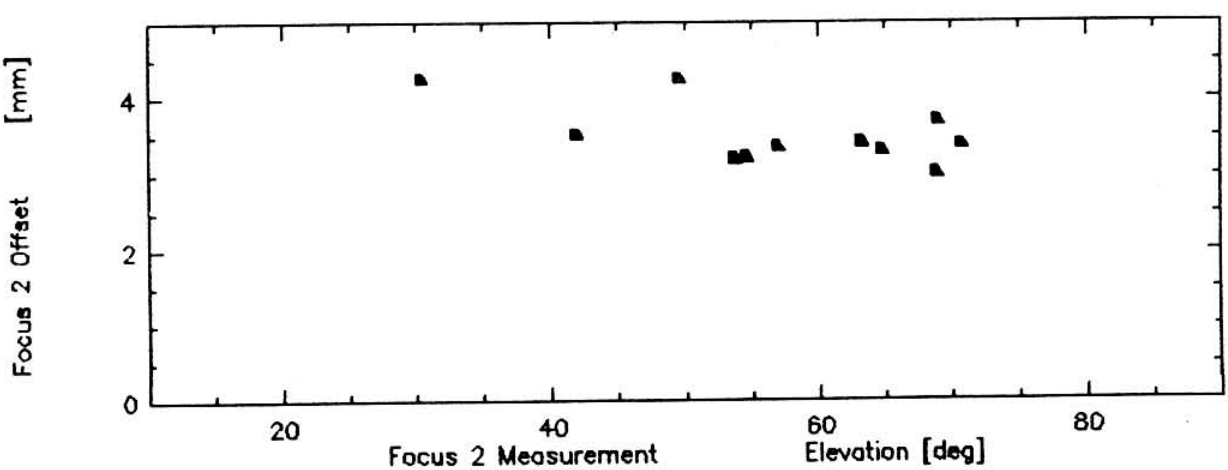

Figure 1 b

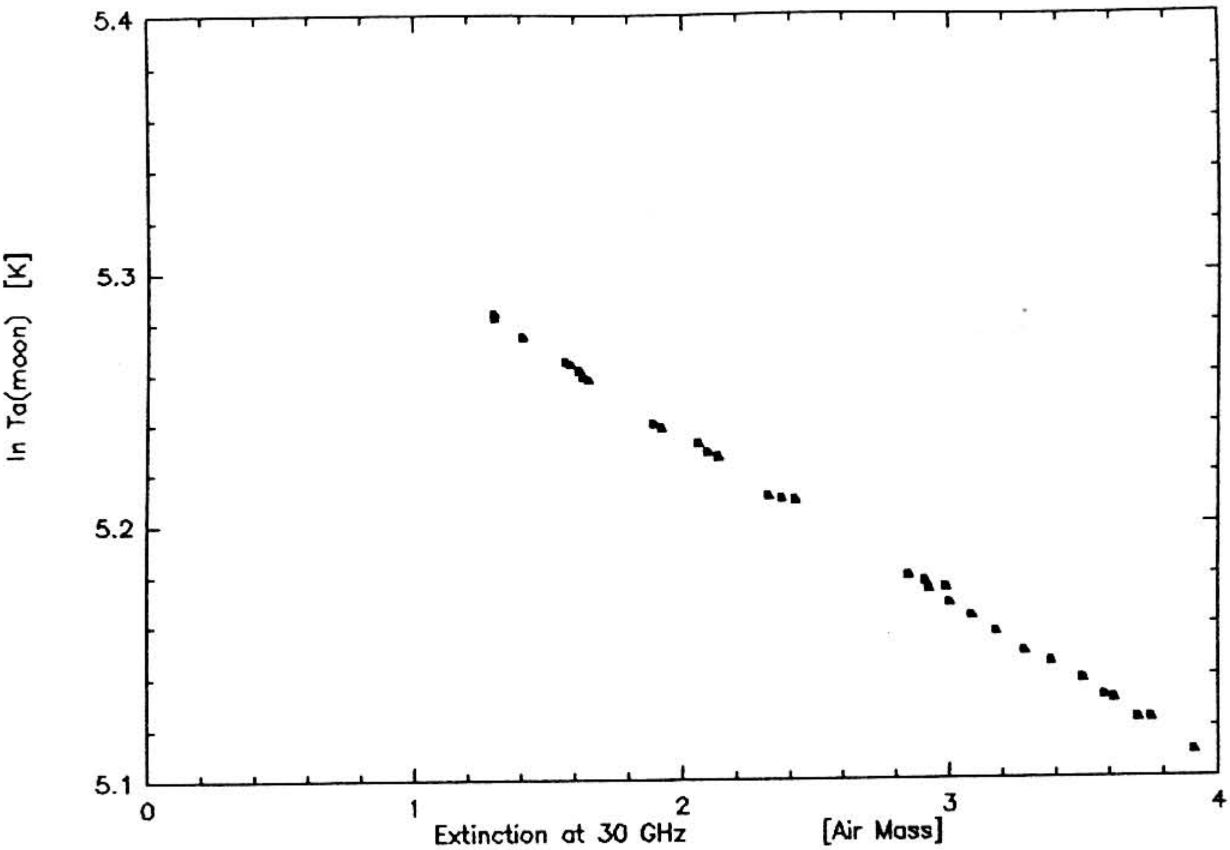

Figure 2

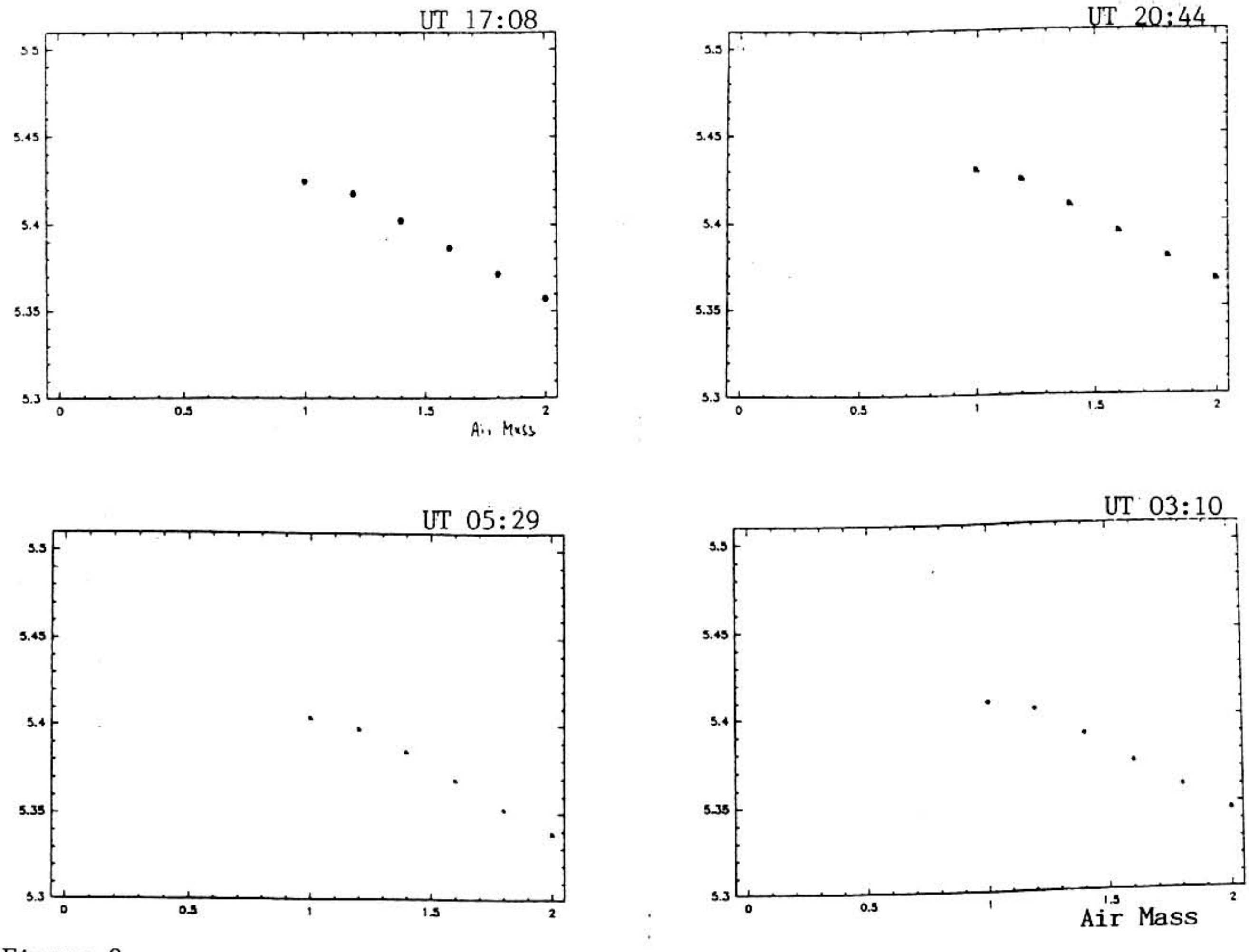

Figure 3

related to the lunar phase change, has been removed for Fig. 2; this removal does not affect the average slope, i.e. the derived opacity.

Extinction measurements with the moon are probably the most accurate method, but they are time consuming and they can be falsified by changing meteorological conditions. In contrast the opacity determination by measuring the atmospheric emission is very quick, but it has some fundamental drawbacks. The atmosphere is in the very near field of the telescope and it may weight emission elements in the line of sight differently, depending on the distance. In addition the atmospheric emission can be confused by scattering by condensed water and by stray radiation of objects near the telescope (in the extreme near field).

For better comparability all 4 sky dips were observed at Azm 180 deg and from air mass 2 (elevation 30 deg) in 5 steps of -0.2 air masses to the zenith. The results are plotted in Fig. 3. In all sky dips the measurements seem well correlated, except for the values at the zenith, where the emission is stronger than expected. While at other elevations the telescope itself shields off the stray radiation of the near hills, at zenith the "montains" are in line of sight to the RX feed. Surpressing the falsified value at zenith we derive the following opacities:

Date	UT	tau	meteorological values at the telescope pressure	Temperature	rel. humidity
Oct. 9	17 08	0.066	984.5	17.3	87.8
	20 44	0.065	983.6	13.0	96.8
Oct. 10	03 10	0.063	983.6	10.9	97.0
	05 29	0.066	984.1	9.9	96.9

Obviously, the opacity stayed fairly constant over the night. The results agree very well with the lunar observations. Note tnat the local weather data do not correlate well with the opacity. Provided good weather conditions and looking to the south, sky dips will give reliable results at mm-wavelength at the 100m telescope.

For a point like source the elevation dependence is caused by the extinction and the instrumental gain curve (deterioration of the surface accuracy with distance from the elevation, for which the surface was optimized).

For the derivation of the antenna efficiency and the instrumental gain curve a point source with known flux density has to be measuered precisely in antenna temperatures. To establish the antenna temperatures, a thermal calibration was done independently for narrow band at 30 GHz and broad band around 31 GHz. From measurements of the Moon and of NGC7027 in both bands it was found that the derived intensities differed by 7 %, while the calibration factors differed by 10 %. For the final evaluation the mean calibration was used (see addition in appendix).
As calibration source NGC7027 was used, to which a size and time correction had to be applied (Ott et al. 1994): the predicted flux density for 30 GHz in 1990.77 is 5.27 Jy, converted to 1995.77 it reduces to 5.12 Jy; with their size correction of 0.97 the expected flux density is Sv = 4.96 Jy.

The result is shown in Fig.4; the left ordinate is in antenna temperatures, on the other aperture efficencies. The derived antenna efficiency for elevation of 38 deg. is about 28.5 %, which seems rather high. The upper curve in Fig. 4 gives the antenna efficency, corrected for attenuation (at elevation 38 deg eta(a) = 31.7 %). (Corresponding values with W3OH result in about 27 and 29 %, respectively.)

The observed half power beam widths (HPW) can give a clou on the effective illumination of the dish. In Fig. 5 the scan by scan averaged HPWs are shown. The average beam width near elevation 40 deg. is approximately 29.9 arcsec. As for higher frequencies the HPWs are a function of elevation, from the point of optimization they decrease to higher elevations; the function to lower elevations is not well defined in the present accuracy. In Table 2 the HPWs and and efficiencies are compared to other PF receiving systems.

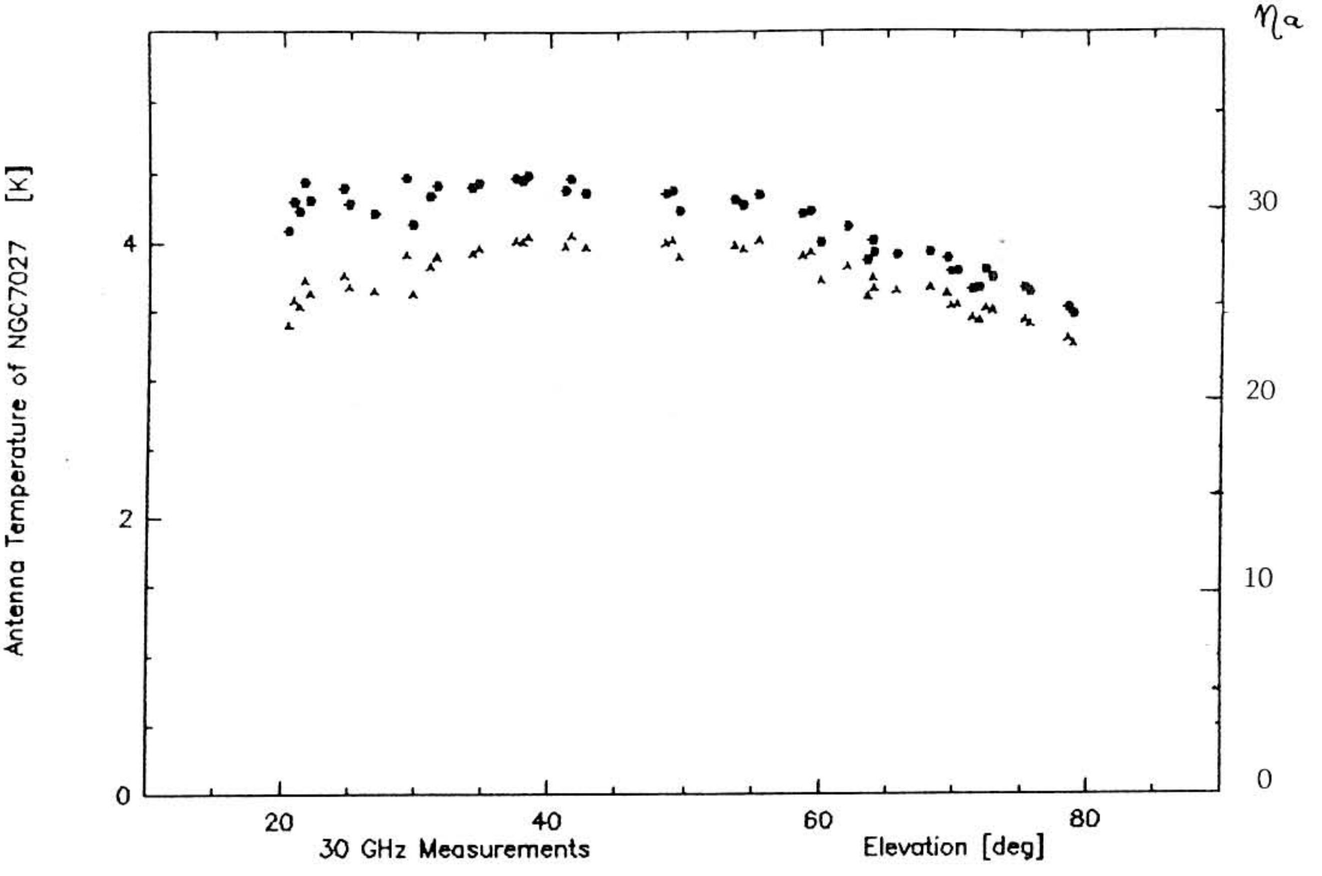

Figure 4

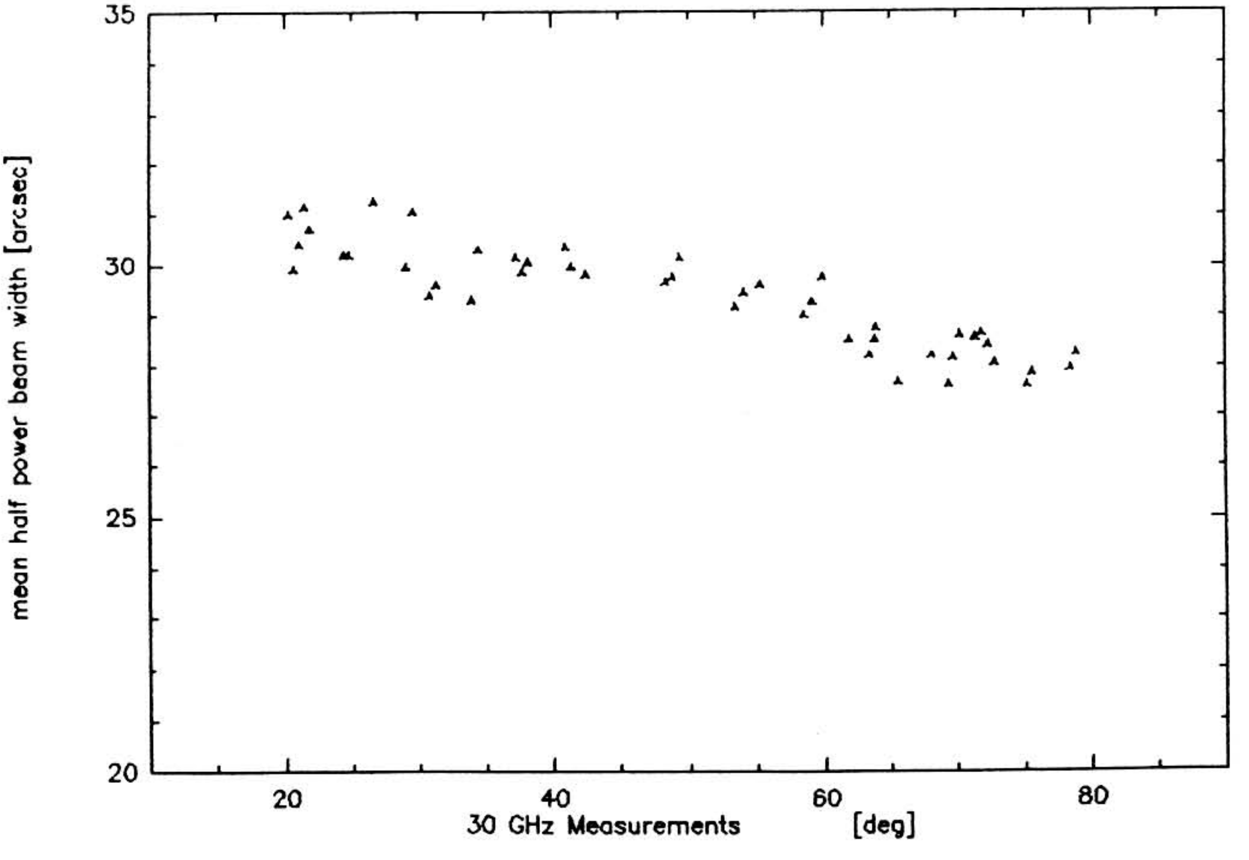

Figure 5

Table 2. Derived antenna parameters.

Frequency GHz	HPW ["]	HPW/lam ["]	Ant.eff. [%]	Illum. % diam	Ant.eff/(Illum.)**2 [%] normalized
4.875	156.	25.35	0.47	1.00	0.47
15.	60.	30.0	0.35	0.85	0.48
23.	43.	33.0	0.240	0.76	0.42
30.	29.9	29.9	0.317	0.85	0.44
43.	24.4	35.0	0.158	0.72	0.30

Obviously the high efficiency at 30 GHz is partially explained by the wider illumination; the data in Table 2 are not homogeneous, for more accurate comparisons they have to be updated.

Another argument for the correct order of magnitude of the antenna efficiency comes from the lunar observations. The extrarerrestrial value of the lunar antenna temperature (see above) was 204 K, the expected brightness temperature according to Kuzmin and Salomonovich (1966) is about 278 K near full moon. This gives a sort of beam efficency of 73%, which is rather low for such an extended source. This argument would ask for an even higher antenna efficiency.

The accuracy of the thermal calibration is not known. The difference between both sets of thermal calibration may be used as indicator. Possibbly also the annular decrease of the flux density may be overestimated.

During the measurements it was noticed that the second Azm-sub scan showed oscillations, which were dependent on elevation. This is illustrated in Fig. 6.

References:

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A.D. Kuzmin, A.E. Salomonovich, 1966,Radioastronomical Methods of Antenna Measurements, Academic Press, NY

M. Ott, A. Witzel, A.Quirrenbach, T.P.Krichbaum, K.J.Standke, C.J.Schalinski, C.A. Hummel [1994], An upddated list of radio flux density calibrators, A&A 284, 331

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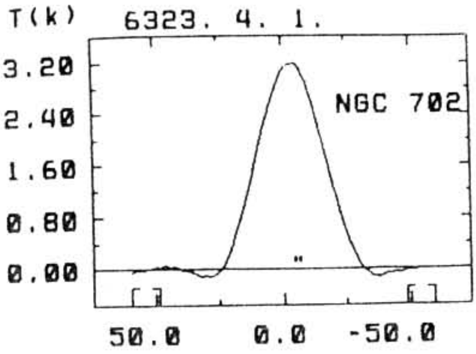
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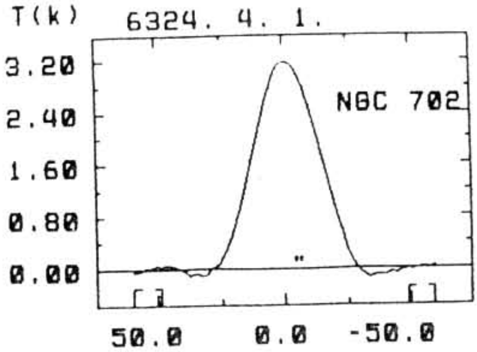
3.20
2.40
1.60
0.80
0.00
NGC 702
50.0
0.0
-50.0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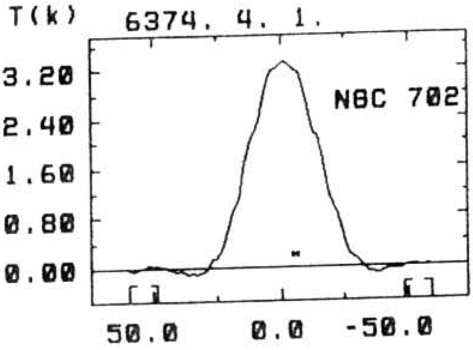
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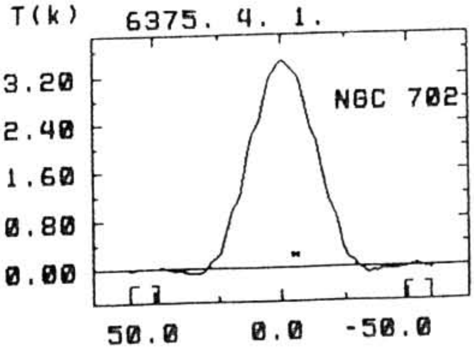
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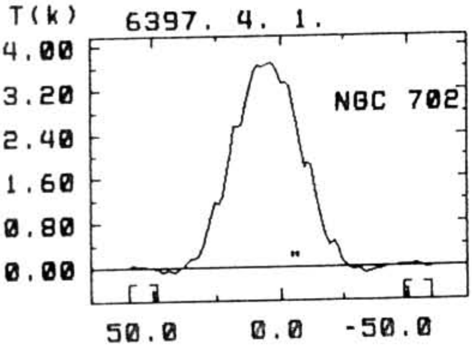
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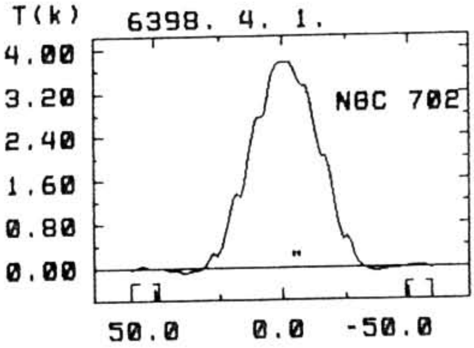
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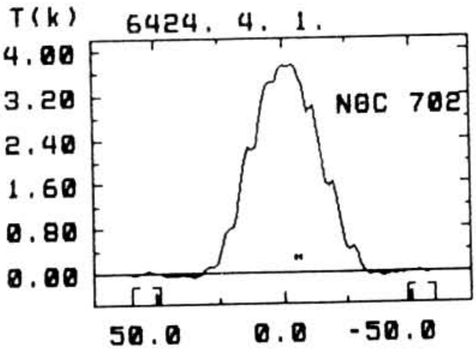
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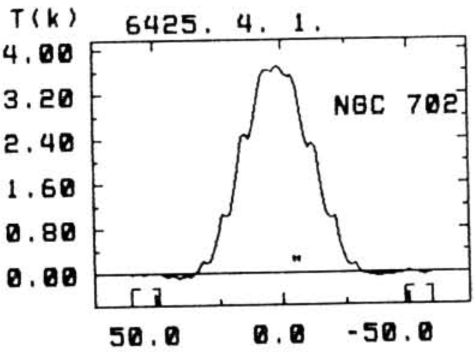
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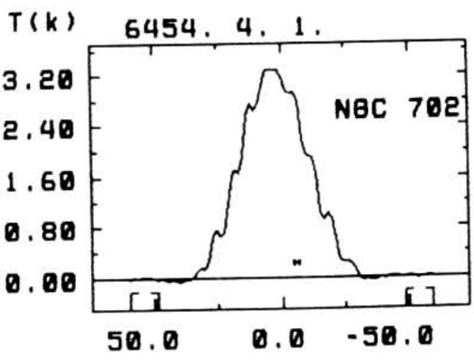
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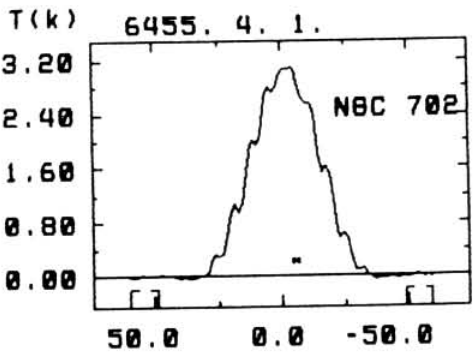
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NGC 702
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-50.0

Systemgruppe Effelsberg
Otmar G. Lochner

10-10-1995

Eichbericht: 1cm PFK

Frequnzbereiche: 28.30 GHz bis 30.30 GHz BB
29.96 GHz bis 30.04 GHz SB

T_E	115 K BB
T_E	103 K SB
T_{Cal}	8.4 K BB
T_{Cal}	9.3 K SB

Geeicht wurde am Morgen des 10- 10- 95 nach den Messungen von Herrn Altenhoff.

OGL

Revised calibration values:

T_{cal}	8.68 K BB
T_{cal}	9.00 K SB

With these calib. factors signal in both channels are about equal.

26.10.95