20-m Radiotelescope at Wettzell

R. Kilger

Abstract

This report summarizes some general information of the 20-m radio telescope, the main design and technical criteria and introduces the working staff of the antenna. Additionally it gives an overview of the VLBI observing activities through the present lifetime of the antenna.

1. General Information

The 20-m radio telescope in Wettzell was designed in the years 1980/81 as a project of the former "Sonderforschungsbereich 78 Satellitengeodsie", hosted at the Technical University Munich; the antenna was constructed in 1982/83 in cooperation with the German companies MAN/VERTEX (VERTEX is former KRUPP). The telescope is an essential part of the Fundamental Station Wettzell, which is operated by the Bundesamt für Kartographie und Geodäsie (BKG) together with the Forschungseinrichtung Satellitengeodäsie (FESG) of the Technical University of Munich (Figure 1).

Figure 1. The 20m-radiotelescope and its operation building at Wettzell.

The antenna was designed for geodetic applications and is dedicated 100% to geodetic VLBI observations. It is a "turning head" antenna with a cassegrain geometry; azimuth-, elevation- and boresight-axis intersect to the highest, technically possible precision within one single point, which is the reference point of the antenna.

2. Main Design and Technical Criteria

Geometry of the antenna:		
- General Concept:	"Turning Head", Cassegrain geometry with coaxial adjusted main- and sub-reflector.	
- Main reflector:	Mathematical rotational paraboloid, diameter	$20m$
	orthogonal aperture area	$314.2m^2$
	focal length	$9.0m$
- Subreflector:	Mathematical rotational hyperboloid, fixed mounted, diameter	$2,7m$
Kinematic Data of the antenna:		
- Azimuth axis	angle of movement	$\pm 270°$ from South
	velocity	$\pm \ 3°/sec$
	acceleration	$\pm 1.5°/sec^2$
- Elevation axis	angle of movement	$0 \ldots 90°$
	velocity	$\pm 1.5°/sec$
	acceleration	$\pm 1.5°/sec^2$
Surface Tolerances:		
- total error of main reflector		$\pm 0.35mm$ rms
- total error of sub reflector		$\pm 0.02mm$ rms

Further Instrumentation:

- Feedhorn

In 1983 the 20-m radio telscope in Wettzell had been equipped with a dual frequency S/X-band feedhorn of JPL design used for the big 64m-telescopes of DSN, modified to the actual geometry of our 20-m antenna in Wettzell. This feedhorn had been operated more than 12 years with great success until R&D observations enlarged the IF frequency span for geodetic VLBI observations:

X-band from 360 to 720 MHz and
S-band from 85 to 125 MHz.

Since July 1996 Wettzell operates with a new feedhorn manufactured by VERTEX, which was designed according to the enlarged IF frequency span. Due to the fact that Wettzell is a station nearly exclusively dedicated to geodetic VLBI observations, it has implemented only this feedhorn and cannot observe different frequencies in the radio spectrum.

- Receiver

Wettzell started its VLBI observations with an uncooled S-X-receiver with parametric amplifiers on loan from Goddard Space Flight Center. These were used until 1986 and then were replaced by a helium cooled S/X receiver in Haystack standard design for geodetic application. To have the first preamplifiers in S/X-band as close to the feedhorn as possible and to improve the accessibility of the helium cooled dewar the dewar is mounted directly at the output of the X-band waveguide.

- Data Aquisition

Wettzell has a standard VLBI data aquisition terminal with:

- Standard IF Distributor including IF3 module,
- Mark IV Formatter,
- Mark III Decoder,
- 16 Videoconverters upgraded to Mark IV,
- Delay Calibrator (antenna + ground unit)
- TTY Distributor,
- 5 MHz Distributor,
- A rack mounted oscilloscope to monitor phasecal signal permanently and
- Power supply units.

• Tape Units

Wettzell has two Honeywell tape recorder units (Model 96); both have been upgraded for thin tape usage by MPIfR. One unit is still Mark IIIA standard, one unit has been upgraded to Mark IV standard by Haystack Observatory. All operations are done in Mark IV standard since Feb 26, 1999.

• K4

The 20-m radio telescope in Wettzell has a long history of VLBI observations with Japan; they were partly recorded in Mark III, partly in K4 recording technique. Here the data are recorded on D1 cassettes instead of magnetic inch tapes. Presently Wettzell has on loan from CRL, Koganei:

- VLBI Interface Unit DFC 2100 and
- Digital Instrumentation Recorder DIR 1000.

It is planned to purchase these units in the near future.

• Field System

Wettzell runs its VLBI observations presently - May 1999 - with Field System, version 9.3.25.

The Japanese K4 equipment can be operated by a K4 version of Field System, version 9.3.120. This K4 version was developed and installed in Wettzell by Ed Himwich.

• Additional Equipment

A measuring system to determine the relative height of the reference point of the antenna (intersection of Az-, El- and boresight-axis) and the ground is installed inside the 20-m radio telescope. An Invar wire is spanned closely from the reference point of the antenna to the ground; the relative height is taken by an inductive sensor. Since May 1999 the data “relheight” are logged in all log files in “postob” in every observed scan.

Additionally as an integral part of the 20-m telescope a water vapour radiometer is operated; it was designed and built at the ETH-Zrich (Switzerland) by Beat Brki.

• Overall Performance of the Antenna

The overall performance of the antenna can be demonstrated with the three characteristic values:

- System Temperature, TSYS (K),
- Overall Antenna Efficiency, ETA (-) and
- System Equivalent Flux Density, SEFD (K).

All values are a function of
- observed frequency,
- elevation angle,
- weather conditions.

The diagrams show these three values for X/S-band and the expected design values over the IF frequency (MHz); the values were observed at elevation 60° and fine weather conditions (Fig. 2, 3).

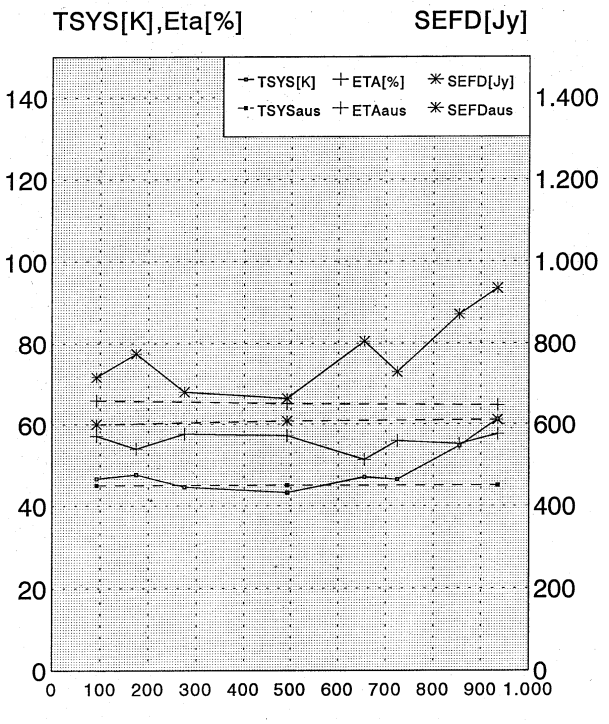

Figure 2. Antenna parameters for X-band at Wettzell.

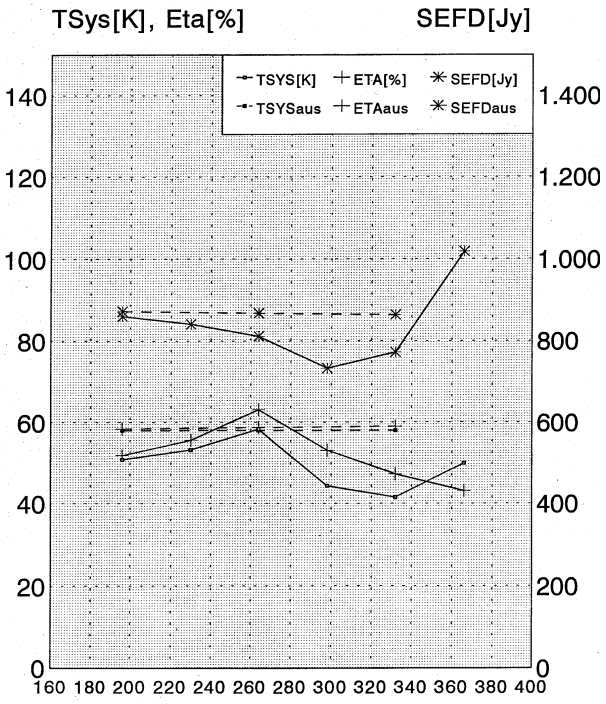

Figure 3. Antenna parameters for S-band at Wettzell.

3. VLBI Observing Activities

The 20-m radio telescope in Wettzell is dedicated 100% to geodetic VLBI-observations; all observations are made in X/S-band only. The observations started in late 1983. A summary of all VLBI observations from 1983 until 1998 is given in Table 1.

Since the beginning NEOS-A is a project with very high priority at Wettzell. In the early days this session had still the synonym POLARIS and partner telescopes were Westford, (old) Fort Davis and Richmond (Florida). This session has the aim to determine with the highest possible precision the coordinates of the rotational pole of the Earth X (marcsec), Y (marcsec) and ΔUT1 (μsec), as well as the coefficients of nutation and precession. This is the aim of CORE as well; therefore NEOS-A will be integrated into CORE as CORE-2. Meanwhile Wettzell comes close to one thousand NEOS-A sessions and is the telescope with the highest number of performed

observations within the NEOS-A project. Wettzell started from its very beginning in April 1984 together with Westford, now with Green Bank, the INTENSIVE sessions. The interferometer is an East-West baseline with about one Earth radius long baseline, being very sensitive to changes in $\Delta\ UT1 - UTC$. The session gains from the fact, that both INTENSIVE antennas participate in NEOS-A as well. Therefore the coordinates of the two telescopes and of the observed quasars do not need to be determined by observations; they can be interpolated from NEOS-A sessions. INTENSIVE observations are done every weekday.

Wettzell was part of the observing program IRIS-S from the beginning, a monthly VLBI session including Hartebeesthoek; it is also part of the network EUROPE since its start in 1988.

Additionally Wettzell was involved in the CDP-program of Goddard Space Flight Center (POLAR, X-ASIA, X-ATL, N.ATL, E.ATL (later EUROPE), GLOBAL, R&D, ...).

To some extent Wettzell participates in EVN or special X/S-sessions of MPIfR or astronomical VLBI sessions of universities, whenever there was a possibility.

In near future Wettzell will take part in CORE-2 and CORE-3 within CORE.

Wettzell has often a Japanese K4 data recording system on loan controlled by a K4 Field System since 1999; Wettzell performed with Japanese partners

- special VLBI time transfer sessions,
- additional $\Delta UT1 - UTC$ observations to support parallel $\Delta UT1 - UTC$ measurements with Westford-Greenbank or
- just to support a better geodetic link between European and Asian VLBI stations.

4. Technical Staff of Wettzell

Wettzell benefits from the knowledge and experience of the team:

Bauernfeind, Erhard	mechanical engineer	TU-Munich	100%
Bielmeier, Ewald	electro technician	TU-Munich	100%
Kilger, Richard	mechanical engineer	TU-Munich	100%
Kronschnabl, Gerhard	electronic engineer	BKG	100%
Schatz, Raimund	software engineer	TU-Munich	100%
Schwarz, Walter	electronic engineer	BKG	100%
Zeitlhfler, Reinhard	electronic engineer	TU-Munich	100%
Zernecke, Rudolf	geodetic engineer	TU-Munich	100%

The staff performs

- all the VLBI observations, sometimes assisted by trained students,
- the service of the whole hardware (mechanical, electric/electronical) and software,
- upgrade of the observing system,
- looking for technical problems and bugs and trying to fix them.

Table 1. Summary of VLBI-Sessions observed at the 20m-Radiotelescope Wettzell 1983-1998

<table>
<tr><th>Observations</th><th>1983</th><th>1984</th><th>1985</th><th>1986</th><th>1987</th><th>1988</th><th>1989</th><th>1990</th><th>1991</th><th>1992</th><th>1993</th><th>1994</th><th>1995</th><th>1996</th><th>1997</th><th>1998</th><th>Σ(1998)</th></tr>
<tr><td>IRIS-A, NEOS-A+B</td><td>3</td><td>67</td><td>72</td><td>72</td><td>72</td><td>73</td><td>73</td><td>73</td><td>59</td><td>48</td><td>60</td><td>62</td><td>52</td><td>53</td><td>52</td><td>45</td><td>936</td></tr>
<tr><td>Intensive Δ(UT1)</td><td>-</td><td>73</td><td>211</td><td>276</td><td>281</td><td>282</td><td>287</td><td>287</td><td>292</td><td>236</td><td>281</td><td>225</td><td>287</td><td>200</td><td>277</td><td>247</td><td>3742</td></tr>
<tr><td>IRIS-S</td><td>-</td><td>-</td><td>-</td><td>4</td><td>5</td><td>3</td><td>3</td><td>12</td><td>12</td><td>12</td><td>12</td><td>12</td><td>12</td><td>12</td><td>12</td><td>10</td><td>121</td></tr>
<tr><td>EUROPE</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>5</td><td>2</td><td>4</td><td>3</td><td>5</td><td>4</td><td>6</td><td>6</td><td>6</td><td>6</td><td>5</td><td>52</td></tr>
<tr><td>NASA-Geodesy</td><td>-</td><td>2</td><td>12</td><td>12</td><td>12</td><td>5</td><td>1</td><td>-</td><td>21</td><td>22</td><td>15</td><td>23</td><td>15</td><td>33</td><td>5</td><td>6</td><td>184</td></tr>
<tr><td>NASA-Astrometry</td><td>-</td><td>-</td><td>-</td><td>-</td><td>2</td><td>2</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>2</td><td>-</td><td>8</td><td>3</td><td>17</td></tr>
<tr><td>USNO</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td><td>11</td><td>6</td><td>14</td><td>4</td><td>4</td><td>-</td><td>-</td><td>40</td></tr>
<tr><td>Uni, MPIfR</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>3</td><td>5</td><td>-</td><td>2</td><td>2</td><td>3</td><td>5</td><td>2</td><td>4</td><td>26</td></tr>
<tr><td>Mobile Campaigns</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>10</td><td>-</td><td>4</td><td>21</td><td>4</td><td>4</td><td>-</td><td>-</td><td>-</td><td>-</td><td>43</td></tr>
<tr><td>1 . . . 8 h Measurements</td><td>-</td><td>16</td><td>13</td><td>25</td><td>27</td><td>1</td><td>19</td><td>23</td><td>22</td><td>1</td><td>1</td><td>2</td><td>6</td><td>10</td><td>1</td><td>-</td><td>167</td></tr>
<tr><td>Other 24 h|Mk2</td><td>-</td><td>-</td><td>1|-</td><td>-|-</td><td>1|-</td><td>7|3</td><td>18|3</td><td>3|4</td><td>9|1</td><td>13|-</td><td>-|-</td><td>2|-</td><td>-|-</td><td>2|-</td><td>-</td><td>-</td><td>56|11</td></tr>
<tr><td>Wettzell staff [h]</td><td>344</td><td>2640</td><td>3688</td><td>3908</td><td>4032</td><td>3976</td><td>3408</td><td>3976</td><td>3842</td><td>2921</td><td>2703</td><td>3468</td><td>2957</td><td>3140</td><td>2701</td><td>2203</td><td>49.907</td></tr>
<tr><td>Students [h]</td><td>-</td><td>-</td><td>-</td><td>192</td><td>224</td><td>56</td><td>1140</td><td>56</td><td>443</td><td>1690</td><td>1365</td><td>808</td><td>390</td><td>504</td><td>214</td><td>175</td><td>7.457</td></tr>
<tr><td>Total Obs. [h]</td><td>344</td><td>2640</td><td>3688</td><td>4100</td><td>4256</td><td>4032</td><td>4548</td><td>4232</td><td>4285</td><td>4611</td><td>4068</td><td>4276</td><td>3347</td><td>3644</td><td>2915</td><td>2378</td><td>57.564</td></tr>
</table>