Effelsberg Radio Observatory 2017–2018 Biennial Report

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Abstract The 100-m radio telescope of the Max-Planck-Institut für Radioastronomie (MPIfR) is one of the largest fully steerable single-dish radio telescopes in the world and a unique high-frequency radio telescope in Europe. The telescope can be used to observe radio emissions from celestial objects in a wavelength range from 90 cm (300 MHz) down to 3.5 mm (90 GHz).

1 General Information

The Effelsberg radio telescope was inaugurated in 1971 and was (for almost 30 years) the largest fully steerable single-dish radio telescope in the world. It is situated in a protected valley near Bad Münstereifel (about 40 km southwest of Bonn) and operated by the Max-Planck-Institut für Radioastronomie (MPIfR) on behalf of the Max-Planck-Society (MPG). To this day, it is the largest radio telescope in Europe and is mostly used for astronomical observations.

This extremely versatile and flexible instrument can be used to observe radio emissions from celestial objects in a wavelength range from about 1 m (corresponding to a frequency of 300 MHz) down to 3.5 mm (90 GHz). The combination of the high surface accuracy of the reflector (the mean deviation from the ideal parabolic form is $\sim$0.5 mm rms) and the construction principle of 'homologous distortion' (i.e., the reflector in any tilted position has a parabolic shape with a well-defined, but shifted, focal point) enables very sensitive observations to be made at high frequencies (i.e., $\nu > 10$ GHz).

The wide variety of observations with the 100-m radio telescope is made possible by the good angular resolution, the high sensitivity, and a large number of receivers which are located either in the primary or in the secondary focus. Together with a number of distinct backends dedicated to different observing modes, this provides excellent observing conditions for spectroscopic observations (atomic and molecular transitions in a wide frequency range), high time-resolution (pulsar observations), mapping of extended areas of the sky, and participation in a number of interferometric networks (e.g., IVS, mm-VLBI, EVN, and Global VLBI).

Table 1 Telescope properties.

Name	Effelsberg
Coordinates	6:53:01.0 E,+50:31:29.4 N
Mount	azimuthal
Telescope type	Gregorian (receivers in primary and secondary focus)
Diameter of main reflector	100 m
Focal length of prime focus	30 m
Focal length of secondary focus	387.7 m
Surface accuracy	0.55 mm rms
Slew rates	Azi: 25 deg/min, Elv: 16 deg/min
Receivers for Geodetic observations	3.6 cm/13 cm secondary-focus (coaxial)
T_{sys} (3.6 cm/13 cm)	25 K, 200 K
Sensitivity (3.6 cm/13 cm)	1.4 K/Jy, 0.5 K/Jy
HPBW (3.6 cm/13 cm)	81 arcsec, 350 arcsec
Tracking accuracy	$\sim$ 2 arcsec

Max-Planck-Institut für Radioastronomie, Bonn, Germany

Effelsberg Network Station

IVS 2017+2018 Biennial Report

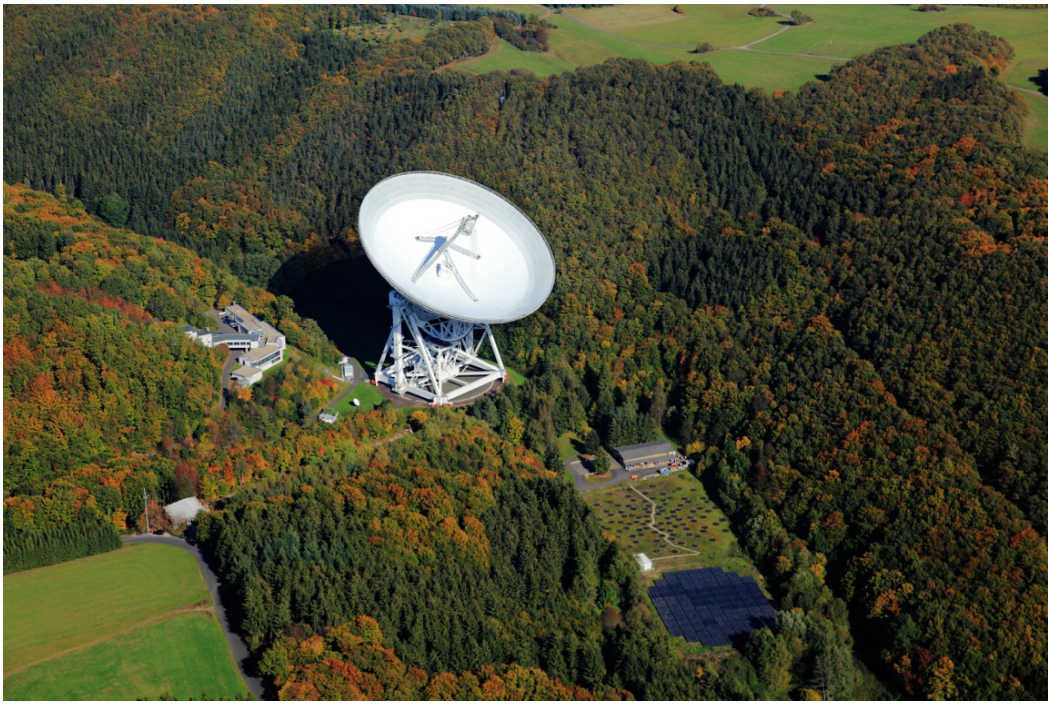

Fig. 1 Aerial image of the Effelsberg radio observatory. Shown are the 100-m Effelsberg antenna and the institute's building (left of the antenna). Effelsberg hosts also a station of the European Low Frequency Array (LOFAR), seen in the lower part of the picture.

2 Staff

The staff at Effelsberg consists of about 40 people, including telescope operators; technical personnel for receivers, electronics, and mechanics; scientists; and administrative personnel. Involved in IVS activities are, beside the telescope operators, **Dr. Alexander Kraus** as station manager and scheduler for the 100-m Effelsberg telescope, and **Dr. Uwe Bach** as support scientist and VLBI friend. Two of the telescope operators, **Marcus Keseberg** and **Peter Vogt**, are also involved in the preparation of schedules and disk management and shipping.

3 Activities during the Past Years

Effelsberg has participated regularly in the EUROPE IVS sessions since 1991. In 2017 and 2018, the experiments T2116, T2124, T2127, and T2128 were observed. About 30% of the observing time of the Effelsberg antenna is used for VLBI observations. Most of them are astronomical observations for the European VLBI Network (EVN), High Sensitivity Array (HSA), Global MM VLBI Array (GMVA) or other global networks, but also geodetic VLBI observations within the IVS are performed. Since 2011, the Russian Astro Space Center has been operating a 10-m space radio antenna on board the satellite SPEKTR-R (RadioAstron) to perform VLBI observations. Effelsberg was highly involved in the ground-based support of this mission for the last seven years, but the mission has now come to an end, as the satellite is no longer operational.

In 2017, two longer periods of downtime were caused by maintenance of the azimuth rail and roll bearings of the azimuth wheels. The maintenance of the azimuth rail was planned, as it suffered from a crack in the rail which goes back to 2009. A provisional repair worked well, but the foundation suffered over the years and proper welding became necessary. The azimuth track was repaired from April 5 – May 11, 2017 and caused operational restrictions. Only a small number of observations could be performed in a limited azimuth range. After May 11, the observatory

started with normal operation again. Two of the roll bearings of the azimuth wheels broke in July, and more was unexpected in September 2017. Both times an external company was needed to help with the repair. Because the tool that is provided by the company was available, the repairs could be performed within a few days and did not cause much down time. The Effelsberg workshop has now bought its own tool for future repairs, so that repairs can be done independently and at any time. The bearings are about 30 years old and in total we have 64 (two for each of the 32 wheels). The bearings are checked regularly for degradation now.

In March 2018 a new Q-band receiver was installed in the secondary focus. It is a two-horn system and provides a tunable frequency range of 33 to 50 GHz with an IF bandwidth of 4 GHz. Commissioning of the receiver is finished and the system performance is very good. It provides an SEFD two times better than the old receiver ranging from about 100 Jy at 33 GHz to 150 Jy at 50 GHz. In Autumn 2018 a fringe test was organized between Effelsberg, KVN, Tian Ma (Shanghai), and Yebes to test the new Q-band receivers at Effelsberg and Tian Ma. Good fringes were found between all stations and proved that the new receivers work well. The new Q-band receiver at Effelsberg is now officially available for science observations.

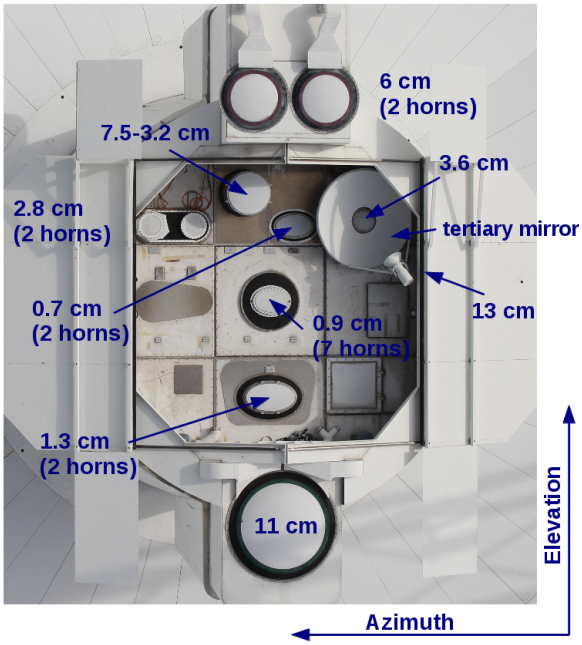

Fig. 2 Picture of the secondary focus cabin with several astronomical receivers, e.g. the new Q-band with two horns and the geodetic SX system with the 3.6-cm horn and the tertiary mirror for the 13-cm horn.

4 Current Status

Effelsberg uses the DBBC2, Fila10G, and a Mark 6 recorder for all EVN, global, RadioAstron, and geodetic VLBI observations. The Mark 6 recorders provide 390 TB of storage capacity and most of the recorded data is e-transferred to the correlators in Bonn, at the ASC in Moscow, and JIVE. In addition there are two NRAO RDBEs and a Mark 5C recorder that are used for observations with the VLBA, HSA, and GMVA. Mark 5 diskpacks to Socorro are still being shipped. Both VLBI backends and their recorders are controlled by the Field System (current release FS-9.13.1). The observatory is connected via a 10 GE optical fiber to the e-VLBI network and can do real time e-VLBI observations (performed about monthly within the EVN) and e-transfers.

5 Future Plans

The VLBA is planning an upgrade to Mark 6 recorders in 2019 to allow 4-Gbps recordings and therefore also Effelsberg—as an HSA station—will change the recording of the RDBE data from Mark 5C to Mark 6 during the next month as well. Because there are two Mark 6 recorders, switching between the use of the Mark 6 as a recorder for disk module shipment and the use as a Flexbuff should not be a problem.

Effelsberg has bought a new maser from T4 Science. The new maser is currently commissioned and monitored against the old maser. Once the new housing and infrastructure to distribute the timing signals within the institute are being finished, the new maser will become the standard time and frequency reference for Effelsberg. The new maser was necessary, because the previous (much older) backup maser broke down in 2017.