Effelsberg Radio Observatory 2014 Annual Report

Uwe Bach, Alex Kraus

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 (IVS, mm-VLBI, EVN, and Global VLBI etc.).

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	0.55mm 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 2014 Annual Report

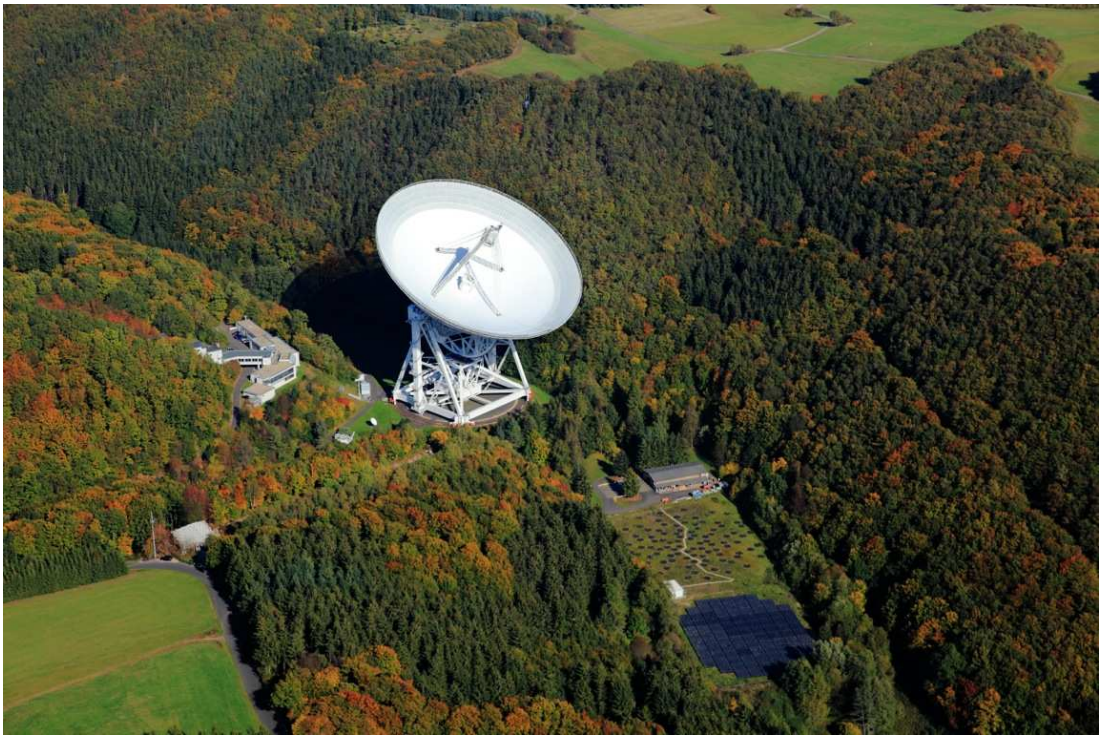

Fig. 1 Aerial image of the Effelsberg radio observatory. Shown are the 100-m Effelsberg antenna and the institute's building (left of the antenna). Effelsberg hosts also a station of the European Low Frequency Array (LOFAR), seen in the lower part of the picture.

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, **Dr. Uwe Bach** as support scientist and VLBI friend, and **Thomas Georgi** for VLBI support.

3 Activities during the Past Year

Effelsberg has participated regularly in the EUROPE IVS sessions since 1991. In 2014, the experiments EUR129 and EUR132 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 is highly involved in the ground based support of this mission, and 262 of a total of 455 VLBI observations in 2014 were connected to RadioAstron observations.

To reduce the gain elevation dependence for secondary focus observations, the 6.5-m diameter subreflector of the Effelsberg antenna consists of 96 individual panels with actuators. The panels are adjusted for each elevation via a look-up table based on the finite element model that describes the gravitational deformations of the main dish. To further improve the look-up table, a holography technique which can produce low resolution maps of the wavefront-errors in an antenna surface using astronomical observations was tested at Effelsberg. This "out-of-focus (OOF)" holography requires — in contrast to traditional holography measurements — only several focused and out of focus

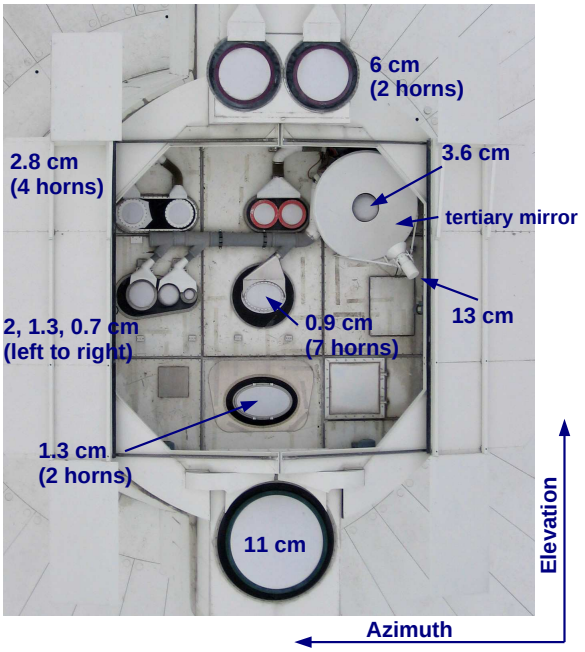

Fig. 2 Picture of the secondary focus cabin with several astronomical receivers, e.g. the new K-band with two horns and the geodetic SX system with the 3.6-cm horn and the tertiary mirror for the 13-cm horn.

images of a compact source at a good signal to noise ratio. The study is still in progress, but some promising measurements were obtained and were reported at the EVN Symposium (Bach U., 2014, PoS (12th EVN Symposium) 036, in press).

A new K-band receiver (18 to 26 GHz) was installed in the secondary focus in 2014 (see Figure 2). The commissioning is in progress, and first VLBI fringes were obtained in the second EVN Session in June 2014. The system will soon replace the old K-band VLBI receiver.

4 Current Status

Effelsberg uses the DBBC2 and a Mark 5B+ recorder for all EVN, global, and geodetic VLBI observations. In addition there are two NRAO RDBEs and a Mark 5C recorder that are used for observations with the VLBA, HSA, and GMVA. Both VLBI backends and their recorders are controlled by the Field System (current release FS-9.11.6). The observatory is connected via a 10 GE optical fiber to the e-VLBI network and can do real time e-VLBI observations and e-transfer of data to Bonn and JIVE.

5 Future Plans

Upgrades for several receiving systems are planned for 2015. A new C-band system (4-8/9.3 GHz) for wideband observations has been constructed and will be installed in the secondary focus within the next month. The installation of a new Q-band receiver (38 to 50 GHz) is planned for autumn 2015. The new receivers will provide wideband IF signals of 2.5 GHz and 4 GHz bandwidth which can be used with the next generation of digital VLBI backends and recorders (e.g. DBBC3 and Mark 6) to record data at recording rates of up to 32 Gbps.

Two Mark 6 recorders are currently tested in the lab in Bonn and will be installed in Effelsberg soon. The installation of a DBBC3 is planned for summer 2015. It is planned to replace the shipment of modules for all EVN observations to JIVE by e-transfers via the e-VLBI network using a Mark 6 recorder in raid mode.