

Yebes Observatory Station Report

Torun TOG meeting 13-14 December 2023

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1 General status

The 40-m radio telescope is undergoing a major upgrade since July 2023, to install a new sub-reflector. This upgrade is preventing our participation in all EVN observations during the second semester. It is planned to be operational by January 2024.

2 VLBI Equipment

Following is the description of the equipment used to support the EVN observations:

- DBBC2 backend:
 - 4 CoMo boards (Unica4).
 - 4 ADB2.
 - 4 Core2.
 - Internal Fila10G.
 - Software available:
 - DDC:
 - v105_1 (June 10 2015). This firmware is used with channel bandwidth narrower than 4 MHz.
 - v107 (beta 4) (June 7 2019). This firmware is used with 4 MHz channel bandwidth or wider.
 - PFB (mode not regularly used):
 - v16_2 (October 13 2017).
 - Fila10G:
 - fila10g_v4_1 (reported as 2.8.0, October 20 2017).

- DBBC3 backend:
 - DBBC3-6L-6H.
 - Internal Fila10G.
 - Software available:
 - DDC:
 - v126U (June 23rd 2022). This firmware provides 16 BBCs with up to 128 MHz bandwidth.
 - v126E (October 25th 2022). This firmware provides 8 BBCs with up to 128 MHz bandwidth, but flatter bandpass.
- Flexbuffs: there are 3 units at the observatory dedicated to observation recording, and one devoted to correlation tasks:
 - flexastro:
 - 36 disks of 10TB capacity. Total capacity of 360TB
 - Software version: jive5ab : 2.9.0 : 64bit : dev : flexastro
 - flexbuff: underwent major upgrade during 2023 to replace aging HDDs by 16 TB units (Seagate part number ST16000NM001G-2KK103)
 - 36 disks of 16TB capacity. Total capacity of 576TB
 - Software version: jive5ab : 2.9.0 : 64bit : dev : flexbuff
 - flexcosmos:
 - 36 disks of 10TB capacity. Total capacity of 360TB
 - Software version: jive5ab : 2.9.0 : 64bit : dev : flexcosmos
 - flexcorr (correlation tasks):
 - 36 disks of 4TB capacity. Total capacity of 144TB
 - Software version: jive5ab : 2.9.0 : 64bit : dev : flexcorr
 - Two additional units (360 TB each) located at JIVE.
- Harrobox running Debian Jessie (8.2) acting as a proxy between the FS and the DBBC to allow concurrent connections to DBBC2. JIVE correlator uses this feature to control the flow of data from the Fila10G when doing eVLBI. This host is in the public LAN but allows connections from the private LAN.
- Spare DBBC2 backend is on lend to RAEGSMAR station to support EVN observations.
- Two H-masers at Yebes and two GPS receivers to keep the maser clocks synchronised. The masers are regularly checked by the manufacturer.

3 Field System

We run three Field System computers:

- RT40m: FS version 9.13.2 on Debian 7.11 Wheezy, kernel 3.2.0-6-686-pae
- RT13.2m: FS version 10.1.0 on Debian Jessie 10, kernel 4.19.0-19-amd64.
- A test computer which can be connected to any of the non-used backends. Debian Buster and FS 10.

4 EVN observations

Below are the metrics for the participation of the Yebes 40-m radio telescope in the EVN observations in 2023, since the report at the last TOG meeting:

EVN session 2023-1: participated in a total of 16 observations (plus one CL calibration run, and a second one cancelled due to bad weather).

C-band: performed 10/10 successful observations. For observations eo019b and em170a we started recording late (first 2 scans lost) due to delays in system configuration.

X-band: performed 6/6 successful observations.

EVN session 2023-2: participated in a total of 19 observations (plus 4 CL calibration runs).

C-band: performed 12/13 successful observations, ea067 affected by an initial equipment misconfiguration (first 8h of 10h lost). Part of the session affected by rain.

K-band: performed 2/3 successful observations. Fringes not found for gm082, problem under investigation. Stormy weather impacted during the whole K-band session.

X-band: performed 3/3 successful observations. Observation eh042b slightly affected by M3 mirror and servo failures (scans no0002-no0008 lost).

EVN session 2023-3: Yebes 40-m could not participate in any of the EVN observations since July.

EVN e-VLBI: during the first half of the year, Yebes 40-m participated in 4 C-band e-VLBI sessions (ea065k, ew034, en011d and ew031c). All observations were successful except for the ew031c run (27/06) which was affected by an amplification problem at the CX receiver (scans no0001, 0004, 0103-0112, 0237-0242 lost to perform Y-factor measurements).

EVN ToO: Yebes 40-m participated in 2 observations in X- and C-band for the rg013 project and one observation in K-band for the ra006 project. All observations were successful except for rg013d (C-band), where the recording of scans no0059 to no0093 was affected by a parallel test performed with the DBBC3, which saturated the Ethernet switch, causing almost 80% data loss during this period.

Summary: 50 observations performed out of 50 scheduled for Yebes 40-m during the first semester of 2023. Yebes 40-m has not been able to participate in 35 observations so far scheduled during the second semester.

5 Storage

Since the last TOG meeting, no storage purchases have been made for the EVN.

6 Spares

One Mark5B+ system together with some old DBBC2 pieces are available at the station.

7 Internet connection

Internet connectivity is provided by RedIRIS, the Spanish National Research and Education Network (NREN). In January 2023, new network elements were installed at the observatory and the upgrade to a 100 Gbps link was completed. This outside 100 Gbps connection is available to the correlator and the VLBI traffic for e-transfer can be routed through aggregated 10 Gbps uplinks to take advantage of the higher bandwidth. Currently, the observatory supports disk recording (flexbuff) and e-VLBI with maximum data rates of 8 Gbps each.

8 40-m radio telescope upgrades

The RT40m is undergoing several upgrades to improve its performance in terms of frequency coverage, gain and phase stability, and observing efficiency. Since the summer, the sub-reflector has been upgraded to support a wobbler system to allow fast and more efficient on-off spectroscopic observations by reducing the movement of the primary dish (Figure 1). This major installation (Figure 2) has impacted our support of the IVS, GMVA and EVN observations during the second half of 2023. The system is currently being commissioned and is expected to be operational by January 2024.

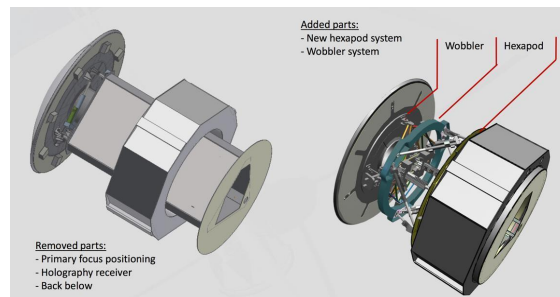


Figure 1: Wobbler system for RT40 (left: previous configuration, right: wobbler configuration with new hexapod to support load increase)



Figure 2: Details of wobbler installation

With the recent development of a dichroic mirror for Q- and K-band transmission and W-band reflection (up to 116 GHz), the observatory has acquired the capability for simultaneous VLBI observations in K/Q/W bands for application to the Frequency Phase Transfer technique. Our 40m would be the first radio telescope in Europe to support this capability. To test the performance of the recently installed DBBC3-6L-6H backend to support tri-band dual polarisation observations, we have participated in recent Network Monitoring Experiments (NMEs) using both the DBBC2 and the DBBC3 in piggyback mode. Results from the JIVE correlator are awaited. Meanwhile, several fringe tests have been carried out with the KVN to test tri-band K-Q-W simultaneous reception, also awaiting correlator results.

Two new receivers under development are expected to see first light in the first quarter of 2024. These receivers, the ASTROREC K-band linear polarisation receiver covering the 18-32 GHz range and a wideband CX linear polarisation receiver covering the 4-18 GHz range, will significantly enhance our support to the EVN. Meanwhile, the CX receiver (4.6-9 GHz) is undergoing troubleshooting, as it experienced an amplification problem during the last e-VLBI observation supported in June 2023.

9 News about Yebes Observatory

Yebes has just installed a new DifX software correlator to support the VGOS observing programme, which will help reduce the correlation backlog and alleviate storage constraints, to allow more frequent VGOS observations. The RAEGE software correlator is currently in the commissioning phase. The correlator consists of (Figure 3):

- 4 computational nodes totalling 128 CPU cores.
- 24 storage servers that make up a single virtual storage unit with a BeeGFS distributed file system. Data availability is ensured with a RAID6 storage scheme. Total storage capacity is 1920 TB.
- Infiniband network for the internal connectivity, with three network elements (switches) compatible with 200 Gbps Infiniband technology.
- The hardware is installed with dedicated climate control.



Figure 3: Cabinets with the RAEGE correlator equipment

Recently, the Yebes Observatory has also acquired another space geodetic technique, a Satellite Laser Ranging station, which saw first light in May 2023 (Figure 4). The station has a 70m diameter telescope with a laser package installed in piggy-back configuration for SLR observations, and another laser in Coudé focus for space debris studies.



Figure 4: Yebes YLARA Satellite Laser Ranging station

10 Staff

The VLBI group consists of the following members:

- VLBI Scientific Support: Victor Pérez (IVS/VGOS), Cristina García-Miró (EVN/GMVA).
- VLBI Technical Staff: Javier González (VLBI technical friend), Felipe Paredes (scholarship, instrumentation), Francisco Beltrán (software development). There is also a team of operators and engineers who support the operation and the various maintenance activities.

- Yebes Schedulers: Belén Tercero, Nuria Marcelino.

Yebes VLBI group - astrovlbi@oan.es (schedules, observations, data transfer, antenna calibration, antabfs files, etc.)

Yebes VLBI technical group – vlbitech@oan.es (backends, firmware, etc.)