Latest VGOS Receiver Developments from Yebes Observatory

J. A. López-Pérez, C. Albo-Castaño, R. Amils-Samalot, M. Bautista-Durán, F. J. Beltrán-Martínez, M. Díez-González, J. D. Gallego-Puyol, P. García-Carreño, A. García-Castellano, A. García-Merino, O. García-Pérez, G. Gómez-Molina, J. González-García, I. López-Fernández, I. Malo-Gómez, A. Martínez-Parra, F. Muñoz-Mozos, M. Patino-Esteban, F. Tercero-Martínez

Abstract The receivers' laboratory at Yebes Observatory has recently built the corresponding VGOS receivers for the Matera (ASI, Italy), HartRAO (SARAO, South Africa), and Songkhla (NARIT, Thailand) stations. Each receiver is equipped with the latest developments of QRFH antennas, 30 dB cryogenic couplers, balanced LNAs, CDMS, and equalized phasecal spectrum of tones. In particular, the CDMS for Matera is implemented through a fiber optic link. The results of these receiver developments are presented here.

Keywords VGOS, VLBI, receiver.

1 Introduction

Yebes Observatory has an extensive experience of more than 35 years in the development of receivers for radioastronomy and geodetic VLBI, and it was designated a Technology Development Center (TDC) for the IVS in 2015.

Throughout 2022 and 2023, the Yebes laboratories constructed VGOS receivers for the Matera, HartRAO, and Songkhla stations. At the end of 2023, the Songkhla receiver was dispatched to Thailand. The HartRAO receiver was installed in February 2024, followed by the installation of the Matera receiver in April 2024.

Each receiver was equipped with the latest developments in Yebes labs, which were introduced in [1]. These developments are:

- Improved QRFH antennas with better matching,
- 30 dB cryogenic couplers, more reliable than COTS units, which are not developed for cryogenic temperatures,
- Balanced LNAs with improved input matching and gain flatness,
- New CDMS with improved noise and stability. In particular, the CDMS for Matera is implemented with a 5 MHz fiber optic transceiver,
- New PhaseCal AU with new pulse generator, variable attenuators, and equalizer to flatten envelope of tones.

A picture of the three receivers in the laboratory is shown in Figure 1. From left to right, the two racks containing fiber optic receivers, backends, and time and frequency distribution systems for Matera are visible, followed by the Matera and HartRAO equipment on their respective trolleys and the Songkhla frontend.

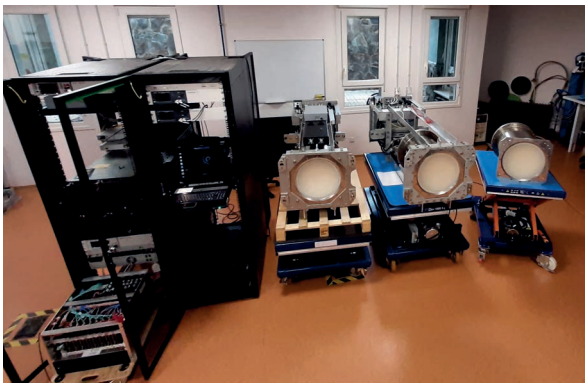

Fig. 1 The three VGOS receivers in Yebes labs.

The results of these VGOS receiver developments are presented below.

Observatorio de Yebes - RAEGE, IGN-Spain

2 NARIT-Songkhla VGOS Receiver

In this case, only the frontend inside the dewar was developed in Yebes, as NARIT plans to take over the responsibility of the remaining room-temperature modules.

Figure 2 shows the internal view of this receiver, where the QRFH, 30 dB couplers, and balanced LNAs can be seen attached to the cold stage of the dewar.

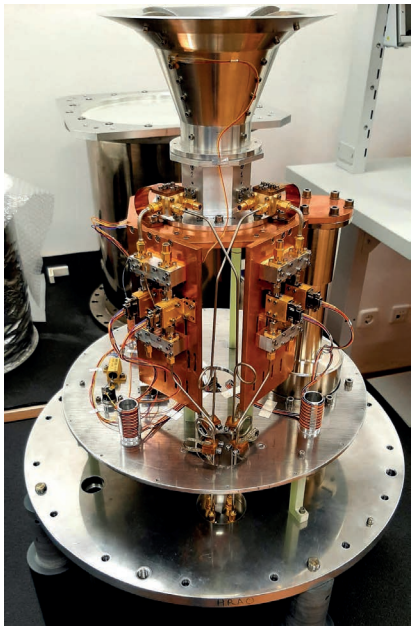

Fig. 2 NARIT-Songkhla VGOS receiver frontend.

3 HartRAO VGOS Receiver

The complete VGOS frontend and analog receiver chain for HartRAO was developed at Yebes Observatory. Neither the DBBC3 nor the Mark 6 were in the scope of the supply. Additionally, HartRAO provided some COTS equipment like the RF-over-fiber optic links for analog signal transportation from the receiver to the backend room.

Figure 3 shows the Spanish and South African team involved in the installation and start-up of the HartRAO VGOS receiver.

4 Matera VGOS Receiver

Similarly, the complete VGOS frontend and analog receiver chain for Matera was developed at Yebes Observatory. This time both the DBBC3 and the Mark 6 were in the scope of the supply, which a Yebes contractor (OHB Digital Connect, GmbH) provided.

Additionally, all the required COTS equipment like the RF-over-fiber optic links, distributors, counters, and switches were provided by OHB too.

Figure 4 shows the Yebes team involved in the installation and start-up of the Matera VGOS receiver.

Fig. 3 Team involved in the HartRAO VGOS receiver installation.

Fig. 4 Yebes team during the Matera VGOS receiver installation.

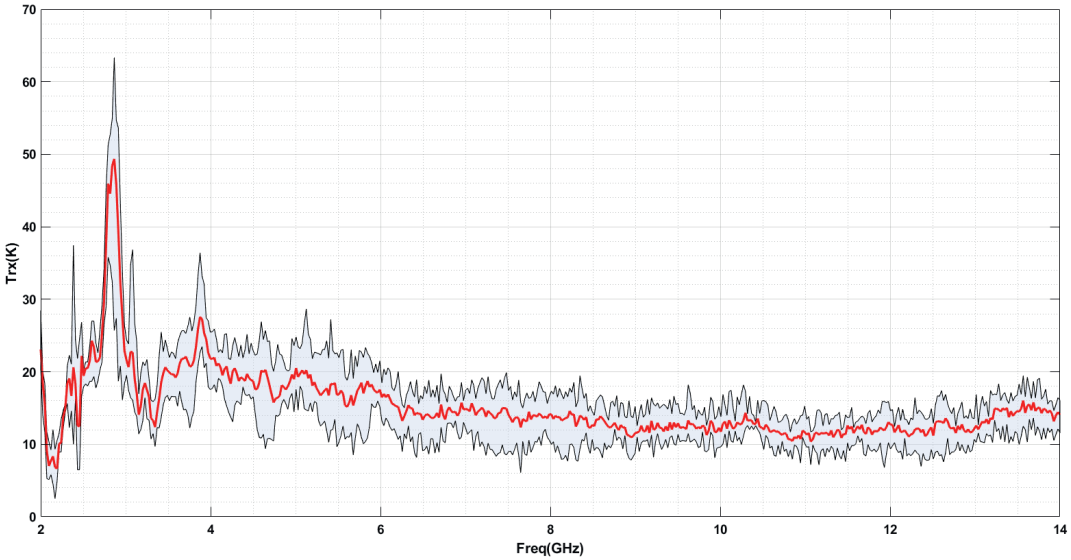

Fig. 5 Receiver noise temperature in the H-pol channel.

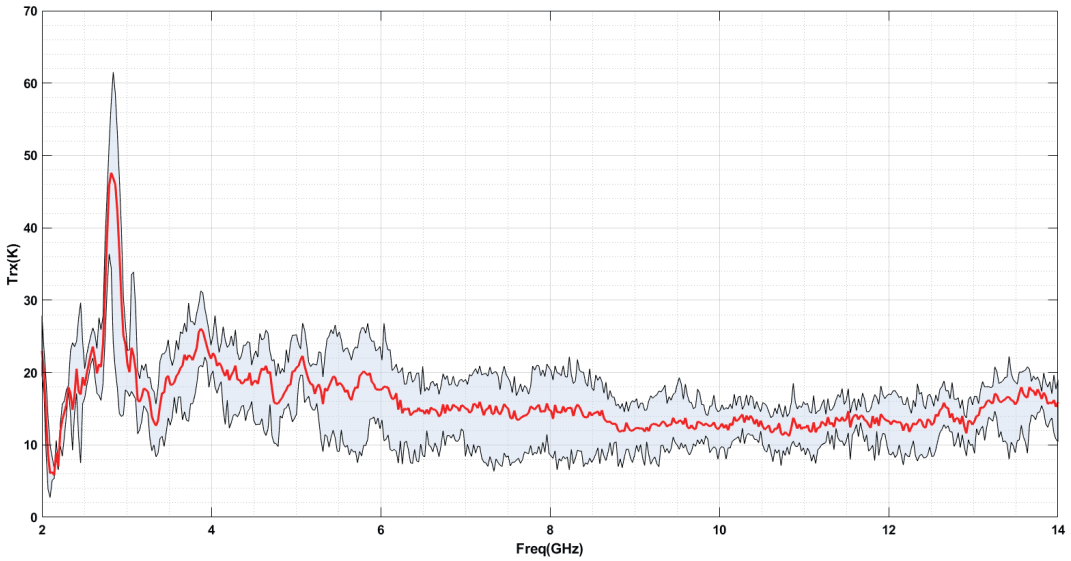

Fig. 6 Receiver noise temperature in the V-pol channel.

5 Laboratory Measurements

The receivers were fully characterized in Yebes labs before shipment. A key parameter is the receiver noise temperature. Figures 5 and 6 show the measured receiver noise temperatures for the Santa Maria, Hart-RAO, Matera, and Songkhla receivers in horizontal and vertical polarization, respectively. The red line in each figure represents the averaged receiver noise for those receivers.

Noise peaks at 2.9 and 3.8 GHz can be seen systematically in all feeds. The main hypothesis is that they are caused by internal dewar resonances. Tests to confirm it are pending.

Nevertheless, the receiver noise temperature is well below 30 Kelvin under the whole range 3–14 GHz, except at 3.8 GHz.

6 Conclusions and Future Work

Yebes Observatory has successfully built three VGOS receivers for the Matera, HartRAO, and Songkhla stations and carried out the installation of two of them (Matera and HartRAO) with support from the stations' staff.

On the one side, the receiver for Songkhla is stored and waiting for the remaining room-temperature modules to be developed by NARIT. After that, they will be integrated in the corresponding trolley.

On the other side, the receivers for HartRAO and Matera are installed. System tests were performed onsite with good results for both receivers. Scheduling of fringe tests with the RAEGE Yebes radiotelescope is pending.

Concerning the future works related to VGOS, it has to be mentioned that the first NMA VGOS receiver will be returned to Yebes labs for an upgrade with balanced LNAs and 30 dB cryogenic couplers.

Additionally, Yebes labs started a line of development on HTS filters. Several HTS filters have been successfully built:

- A 4–12-GHz band-pass filter,
- A 9.4-GHz notch filter for SLR radar mitigation,
- A 2.95-GHz notch filter for the Santa Maria space debris radar mitigation. This development has allowed RAEGE Santa Maria to join the VGOS core network,
- New HTS filter topologies under development.

References

1. J. A. López-Pérez et al., "Description of RAEGE Yebes VGOS Receiver Upgrades", In K. L. Armstrong, D. Behrend, and K. D. Baver, editors, International VLBI Service for Geodesy and Astrometry 2022 General Meeting Proceedings, NASA/CP-20220018789, 2023.