Yebes CX-band receiver

February 8th, 2022

EVN TOG meeting

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& Yebes Team

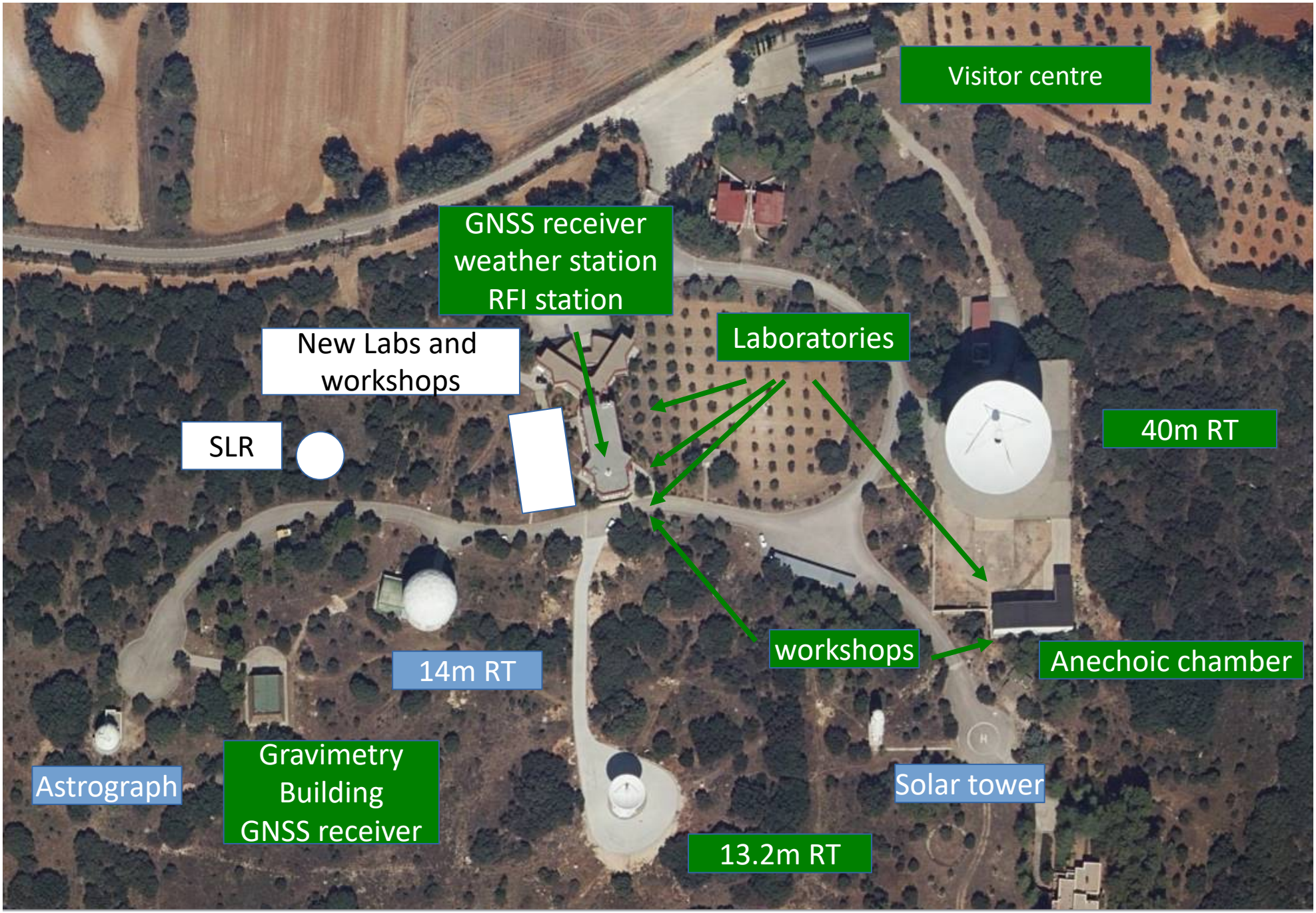
Presentation overview

- Short description of Yebes Observatory
- Motivation for a new receiver
- CX-band receiver description
- Receiver characterisation
- VLBI fringe test with the EVN

Yebes Observatory: a unique scientific and technical infrastructure

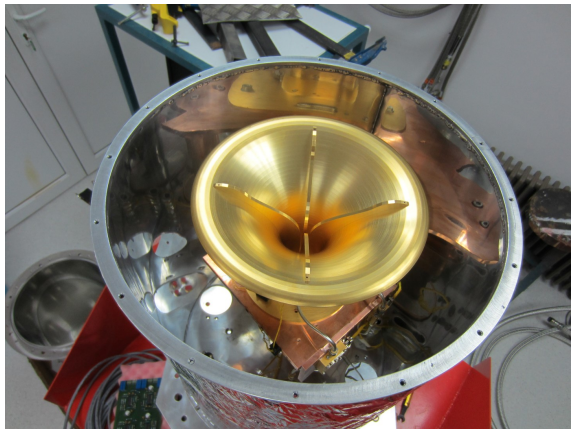
- One of the seven astronomy and astrophysics infrastructures in Spain
- The only one in Castilla La Mancha autonomous region

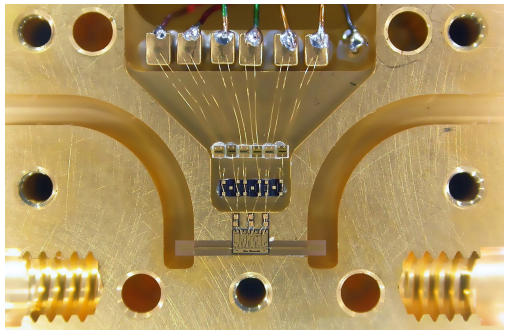
Yebes Observatory: facilities and instruments

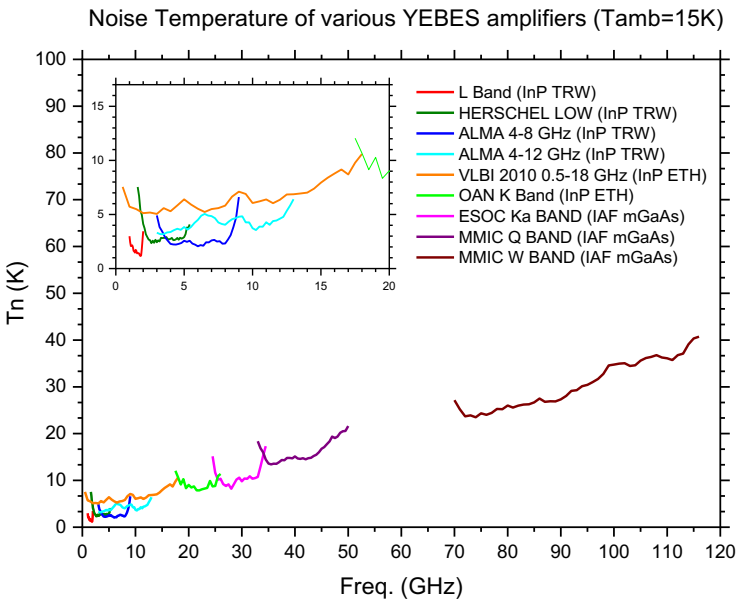


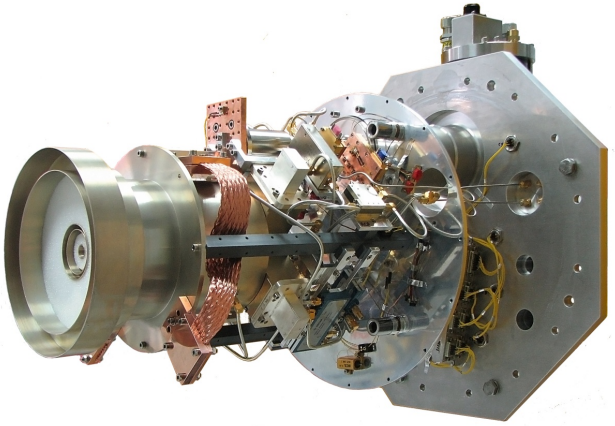
Yebes Observatory: a unique scientific and technical infrastructure

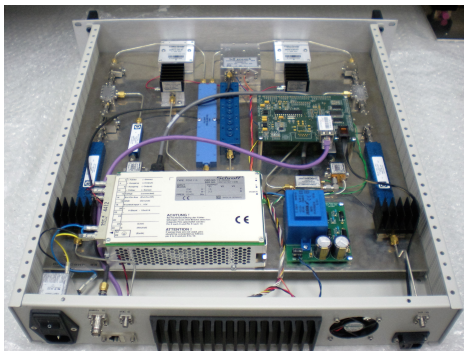
- 35 years experience in radio astronomy technology
- End-to-end complete RA receivers development: design, implementation, characterisation, installation and commissioning
- International collaborations: IRAM (Pico Veleta 30m, Noema), ESA (Herschel-HIFI, Ka-band), ESO (ALMA), NASA (8-36 GHz VLBI receiver), NARIT, ESRON, IVS, EU-VGOS, NMA, FGI, HartRAO, Matera, Ventspils, GSI, SKA, etc.



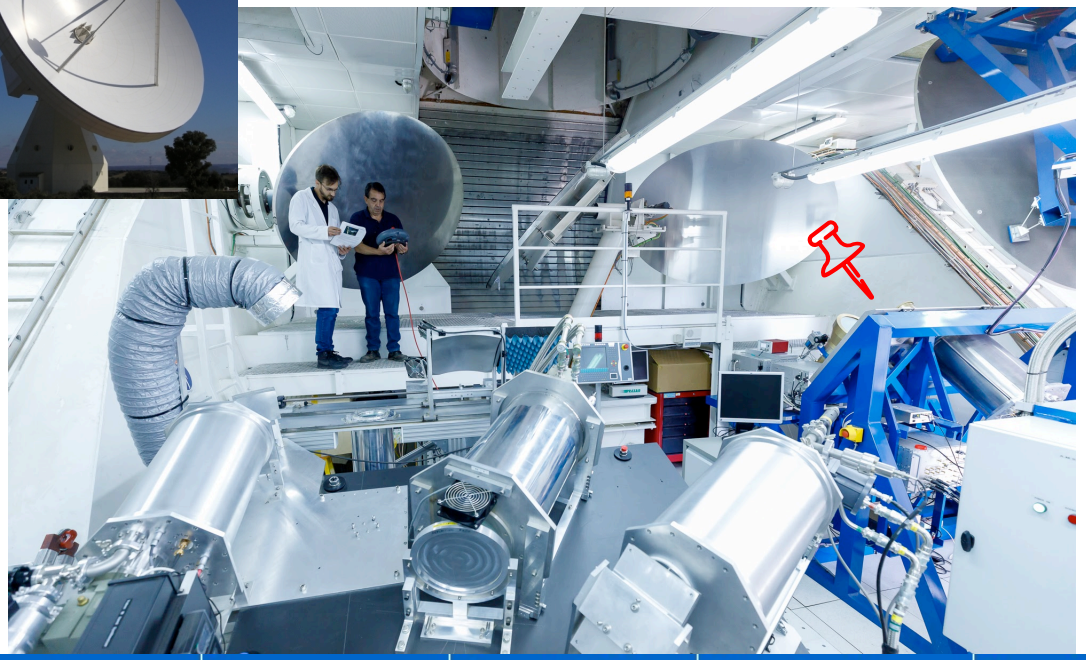


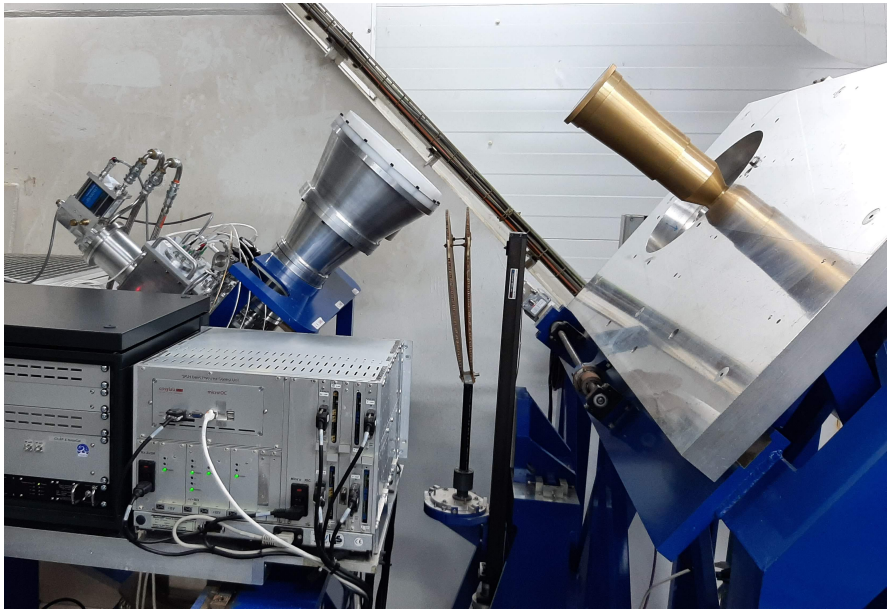






Yebes Observatory: 40-m radio telescope





Receiver	Frequency range (GHz)	Bandwidth	Polarization	Trec (K)
S band	2.2 - 2.4	170 MHz	RCP/LCP	50
C band 1	4.6 - 5.1	500 MHz	RCP/LCP	10
C band 2	5.9 - 6.9	500 MHz	RCP/LCP	10
X band	8.1 - 8.6	500 MHz	RCP/LCP	10
K band	20 - 25	2.5 GHz	RCP/LCP	30
Q band	32 - 50	18 GHz	H/V	40
W band	72 - 90	18 GHz	H/V	80

New CX band receiver
4.5 - 9 GHz
b/w 500 MHz (DBBC2)
b/w 4 GHz (DBBC3)
Dual circ pol: RCP/LCP
Trec ~ 12K (feed @ 300K)
Noise diode, 80 Hz
Phase calibration every MHz

Motivation for a new receiver

- Adapt the EVN to the scientific challenges of the next decade, to work in collaboration with the next generation of telescopes (SKA, ELT, CTA, etc.).

- Based on the EVN Vision document, EVN CBD prioritised the development of **broad-band EVN antenna/receiver systems that are compatible with SKA1-MID:** C/X/U:
  - SKA Band5a,b: 4.6-8.5 GHz & 8.3-15.3 GHz, with 5 GHz instantaneous b/w

- Low-noise receivers with large instantaneous bandwidths:
  - quadruple the sensitivity of the EVN observations.
  - carry out complete spectral and polarization studies of radio sources.

- **Technological challenges:** Increase of the observable bandwidth without degrading the noise characteristics and thus the sensitivity of the receiver, and in parallel, without compromising the purity of its polarization response.

- The new Yebes CX band receiver meets these requirements and becomes one of the most sensitive receivers currently in use in the EVN in this frequency range.

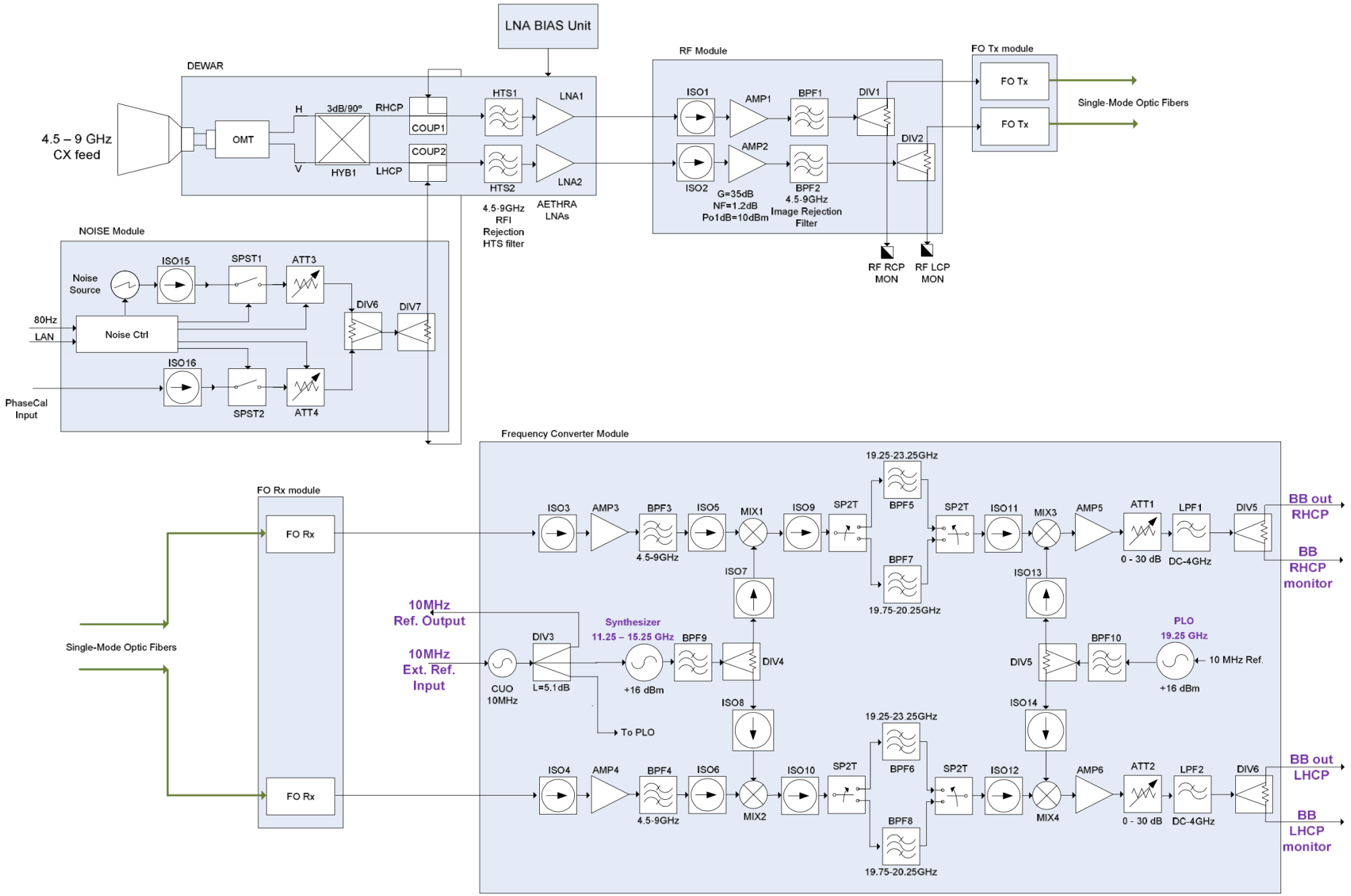
- This project is part of a more ambitious program that includes the development of an even broader receiver that will cover the 4 to 18 GHz frequency range. The program to update the infrastructures of the radio telescopes at the Yebes Observatory (YNART) is co-funded with **ERDF 2014-2020 funds, granted by the former Spanish Ministry of Economy and Competitiveness**.

European Union

European Regional Development Fund - ERDF

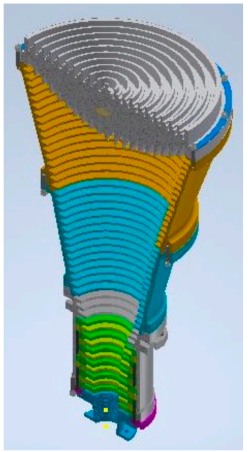
"A way of making Europe"

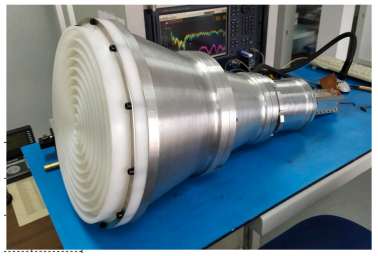
CX-band receiver description: block diagram

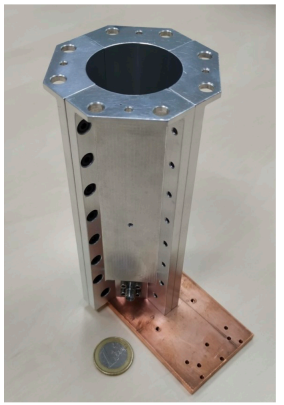


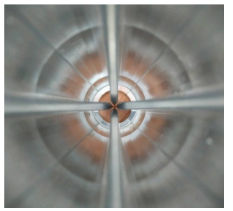
CX-band receiver description

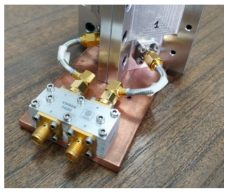
phase-corrected corrugated feed horn @ 300K



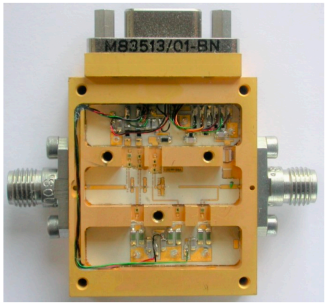




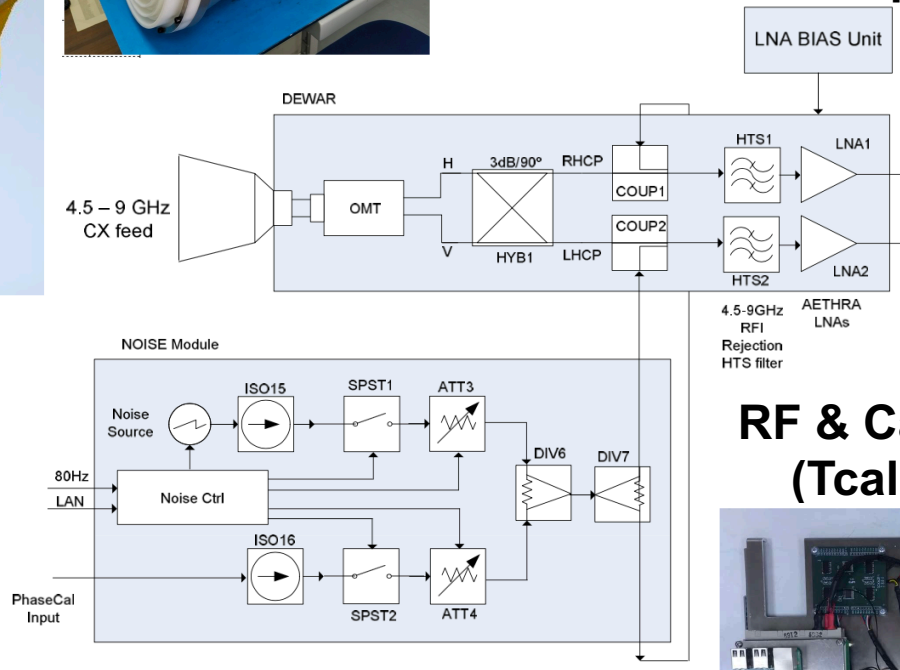




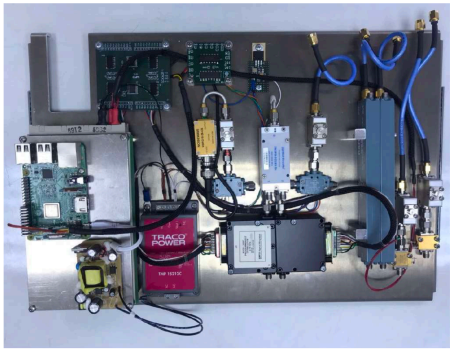
Cryo LNA HEMT InP



Cryo OMT + 3dB/90º hybrid for circ pol

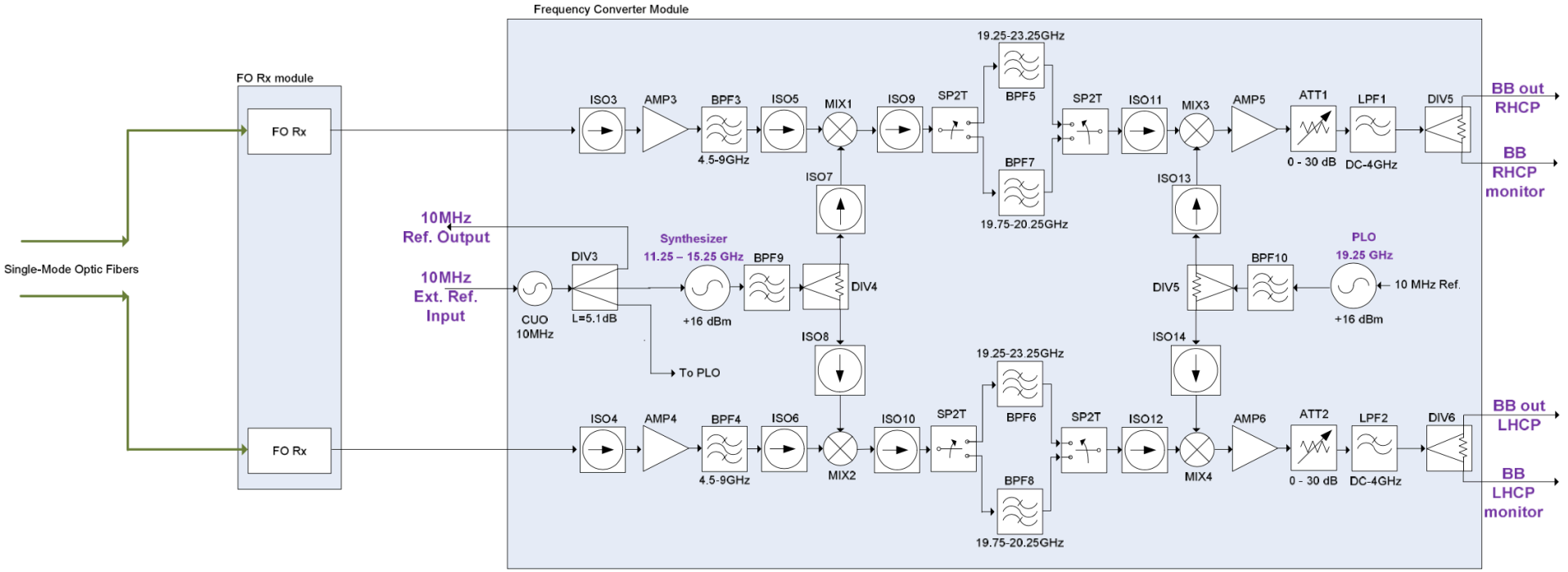


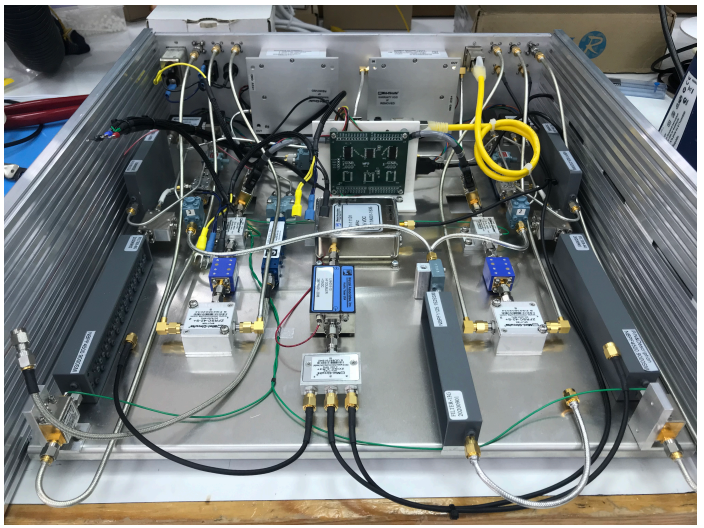
RF & Cal module (Tcal + Pcal)



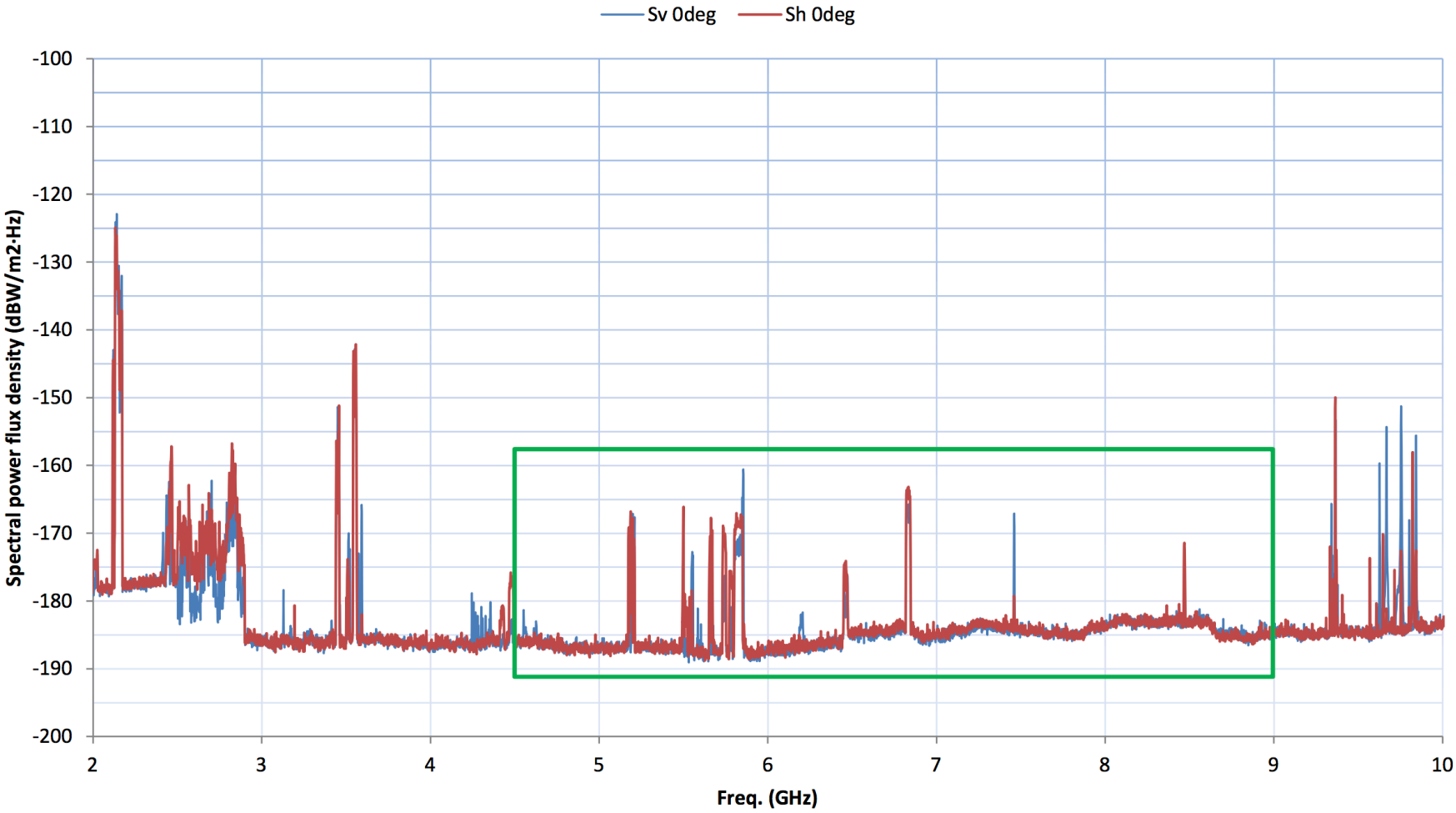
RF-over-fiber link

Frequency converter module



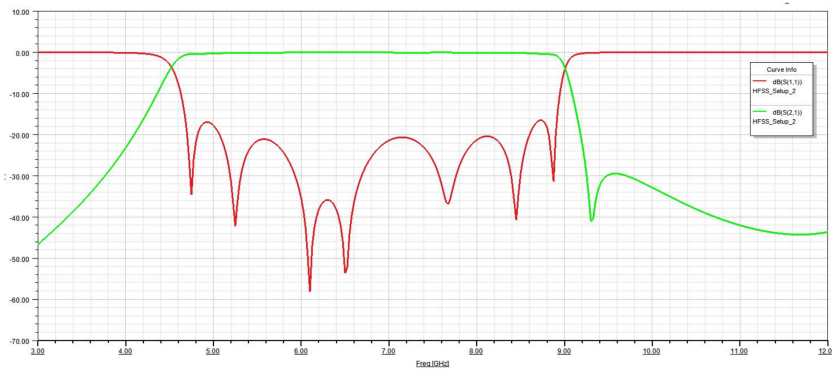


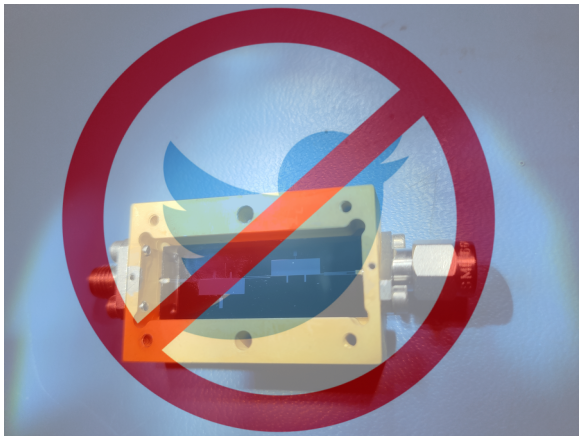
RFI environment at 0º Elev.



CX-band receiver characterisation: RFI

HTS filter

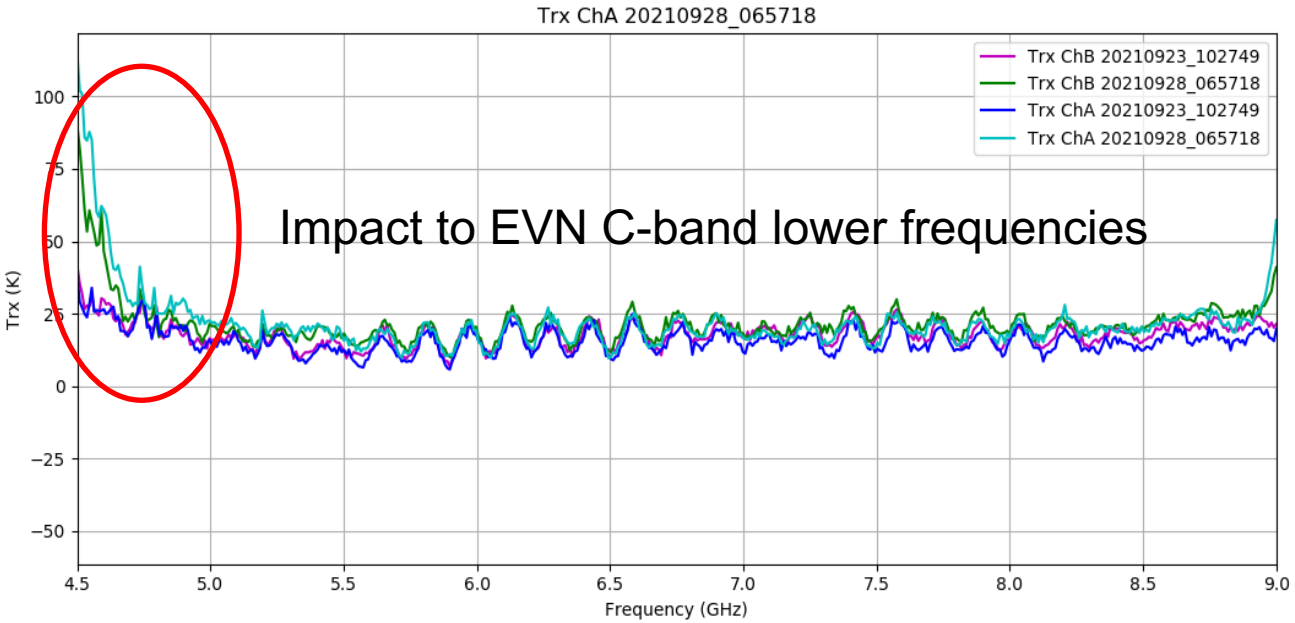




- Trec laboratory measurements with and without High Temperature Superconductor filters (HTS)

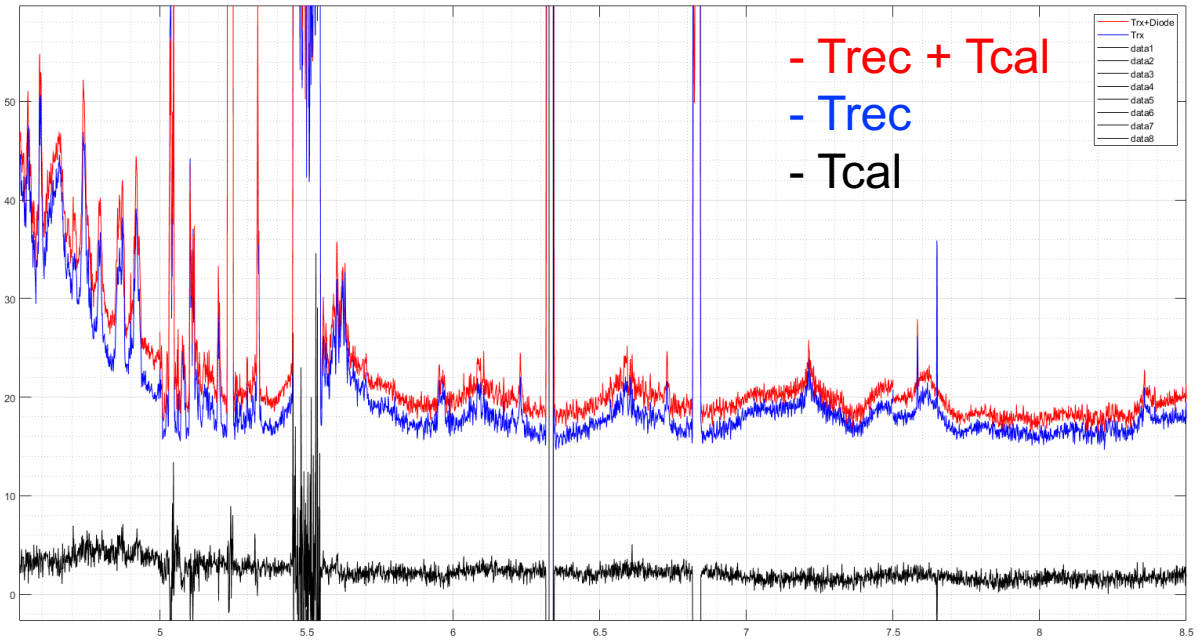
→ decided to remove the filters

- Problem identified and easy to solve in new design

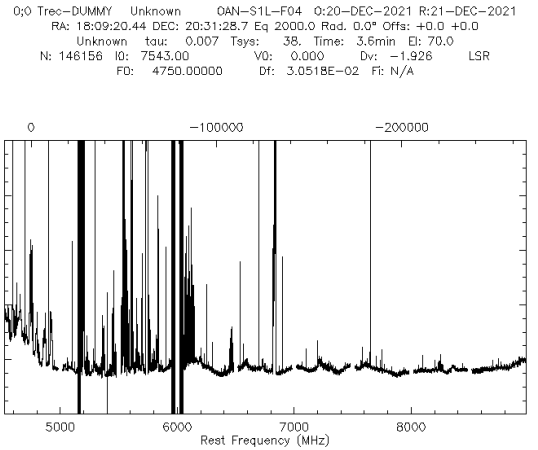


CX-band receiver characterisation: Tcal + Trec

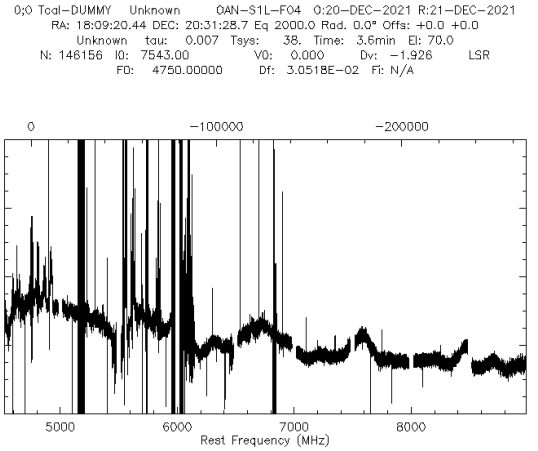
- Trec and Tcal mesurements at the antenna: sky (cold) + ambient load (hot) –LCP-



Trec & Tcal with spectrum analyser at downconverter output



Trec

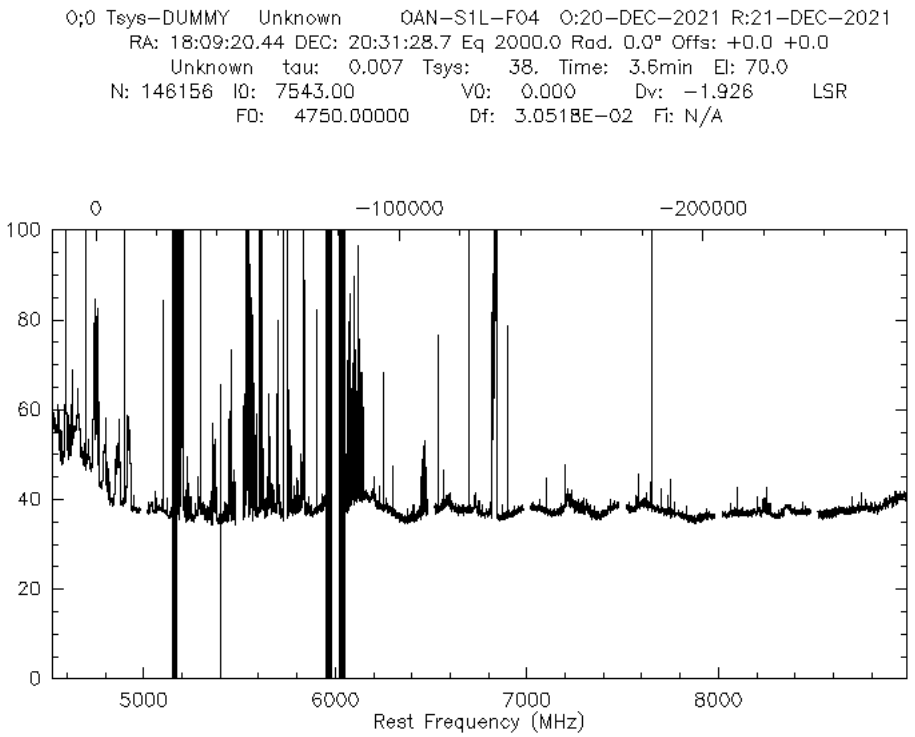


Tcal

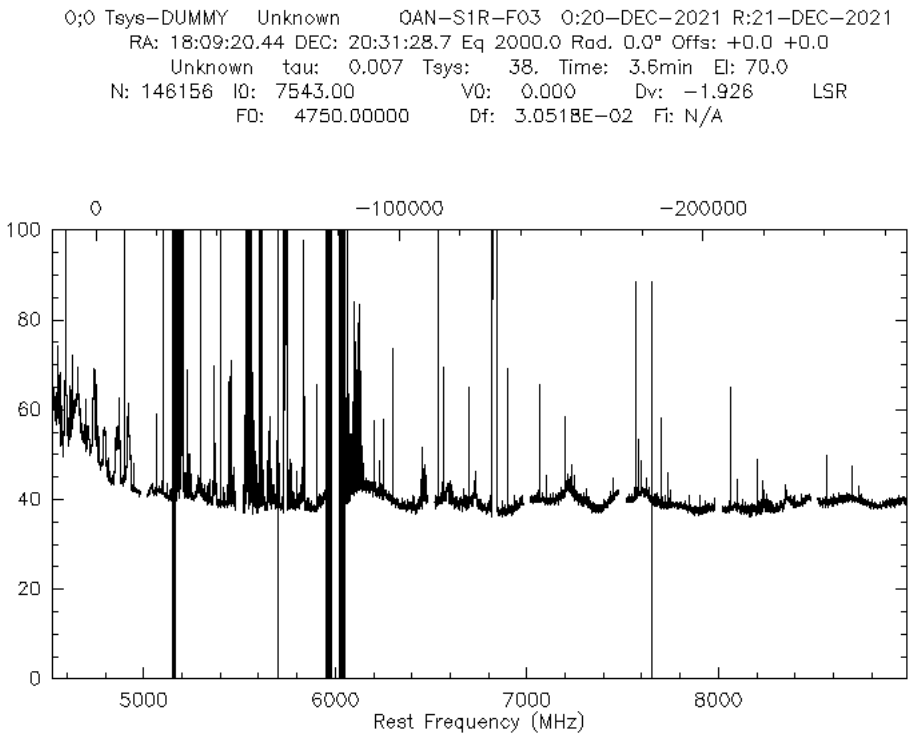
Trec & Tcal with FFTS spectrometers at end of signal chain

CX-band receiver characterisation: Tsys

- Tsys measurements at the antenna with FFTS: sky (cold) + ambient load (hot)



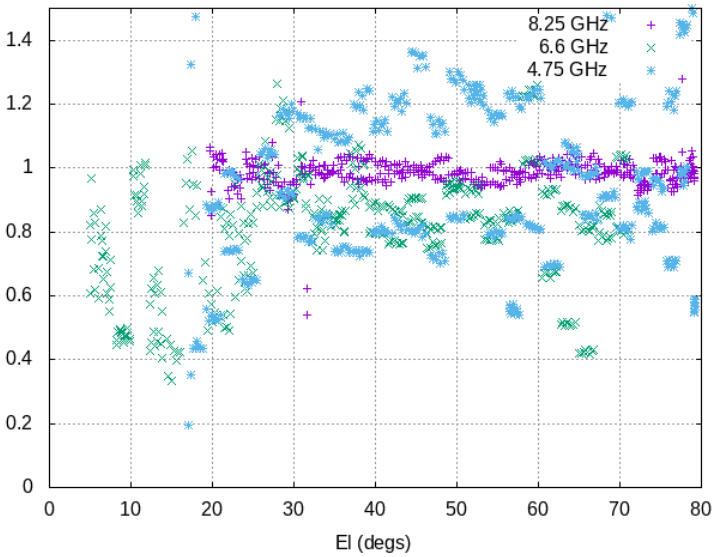
LCP



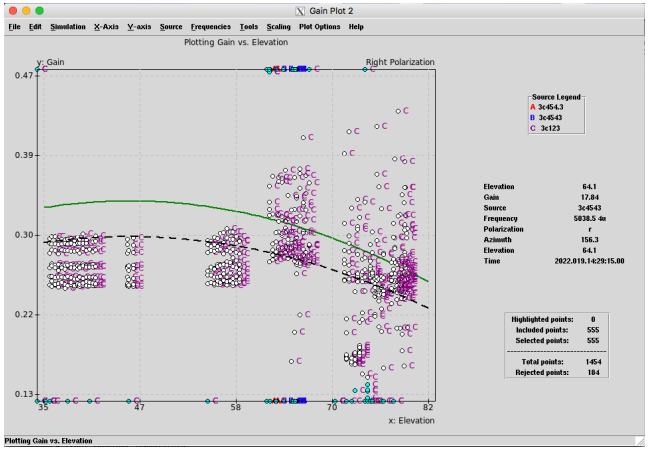
RCP

CX-band receiver characterisation: gain and efficiency

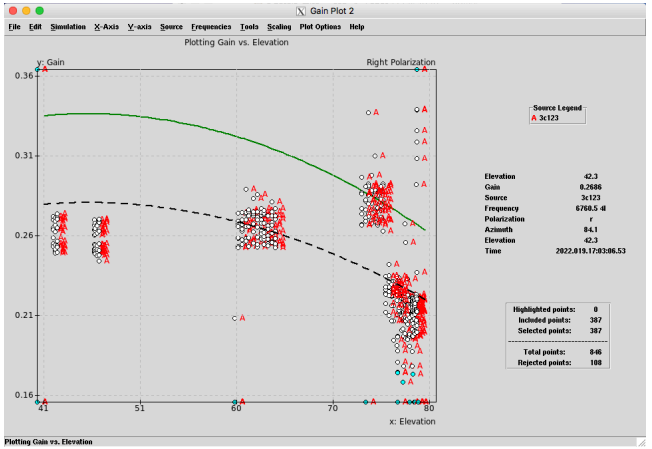
- Gain and efficiency measurements: FFTS and FS onoffs with 3C123



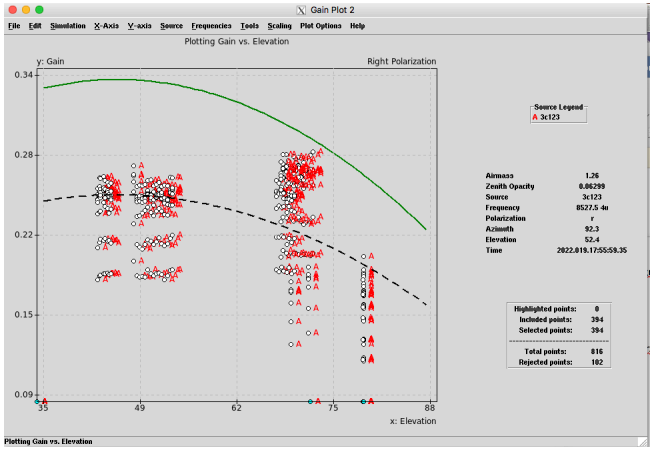
Freq(GHz)	λ(mm)	θ_{HPBW} (")	Pol	DPFU(K/Jy)	η_A	SEFD(Jy)
4.8	63.2	371.3	RCP	0.30	0.66	178
			LCP	0.32	0.70	156
6.7	45.0	264.8	RCP	0.28	0.62	165
			LCP	0.32	0.70	156
8.2	36.4	213.8	RCP	0.25	0.55	172
			LCP	0.26	0.57	169



C-band



M-band

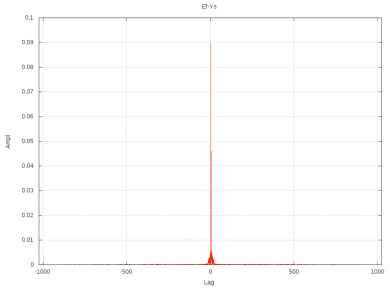


X-band

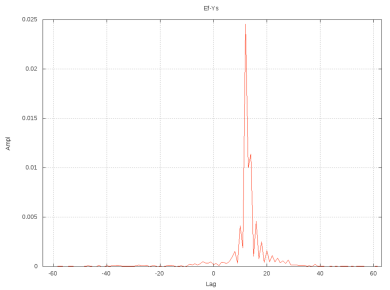
- Coordinated by EVN TOG chairman, Uwe Bach.
- Organised by JIVE, expname ft043: 2048 Mbps, 16 BBC channels, 32 MHz filters, 2-bit sampling, 3 frequency setups.
- Participating stations apart from Yebes: Effelsberg, Medicina, Westerbork, Noto and Onsala85 radio telescopes → **Many thanks to all!**

Effelsberg to Yebes fringes

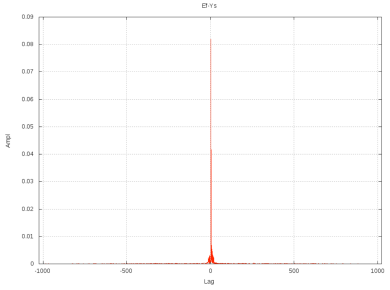
C-band



M-band: linear to circular!



X-band



Yebes autocorrelations: C, M and X-band

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Instituto Geográfico Nacional

CENTRO NACIONAL DE INFORMACIÓN GEOGRÁFICA

Well done Yebes team!

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Stay tuned for our new 4-18 GHz receiver

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