Multi-frequency enabling at the stations of Medicina and Noto

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on behalf of:
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Towards high-performance mm-VLBI science operations with multi-band receivers (Bologna, October 28-31 2025)

Environment and setting

UNIONE EUROPEA
Fondo Sociale Europeo
Fondo Europeo di Sviluppo Regionale

Ministero dell'Istruzione, dell'Università e della Ricerca

PON RICERCA E INNOVAZIONE

INAF ISTITUTO NAZIONALE DI ASTROFISICA NATIONAL INSTITUTE FOR ASTROPHYSICS

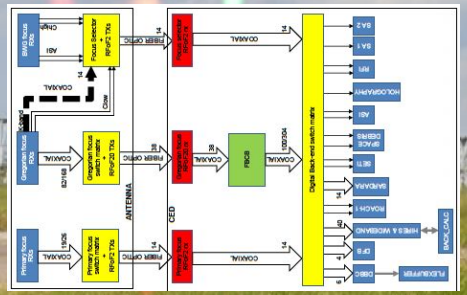
~18.7 M€

Enhancement of the SRT for the study of the Universe at high radio frequencies – PI: F. Govoni

WP4: Simultaneous mw CTR (K,Q,W-bands) receiving system for the three INAF radio telescopes – PI: P. Bolli

WP7: Integration – PI: A. Orlati

SRT IFD - Intermediate Frequency Distribution



Active Surface System for Medicina RT

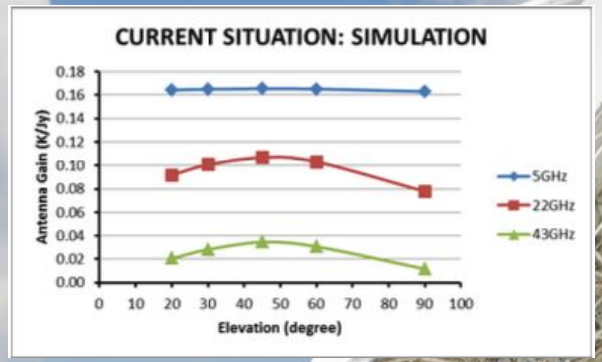
Medicina - Updates on CTR

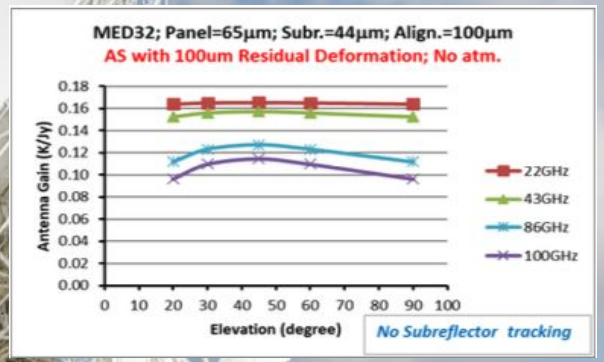
- Medicina CTR was assembled and tested in the lab.
  - Dew water over the vacuum window. **Solved**.
  - Receiver performance aligned with the FAT.
- CTR installed in antenna (July 25) and already under test.

Medicina - New Active Surface project and deployment

- Design, project and construction:
  - 240 new aluminum panels (60 μm)
  - a new secondary mirror (50 μm)
  - mechanics and servo system of 268 linear actuators.
  - software to calibrate and control the whole system (open loop)
- Deployment and installation
  - from October 2024 to May 2025

Medicina - Active Surface Commissioning

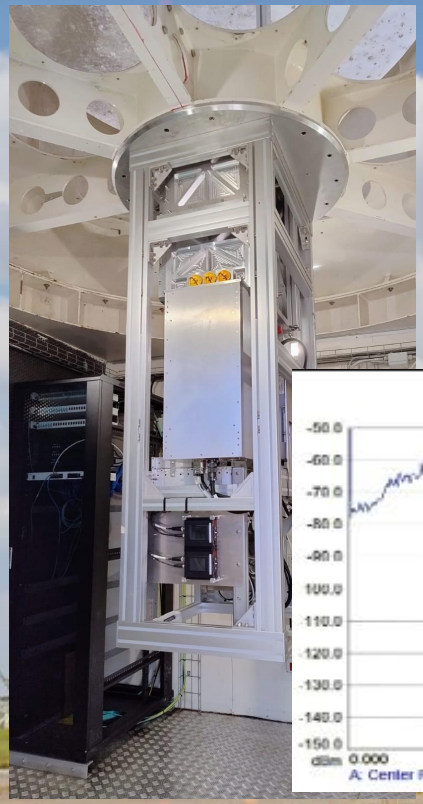




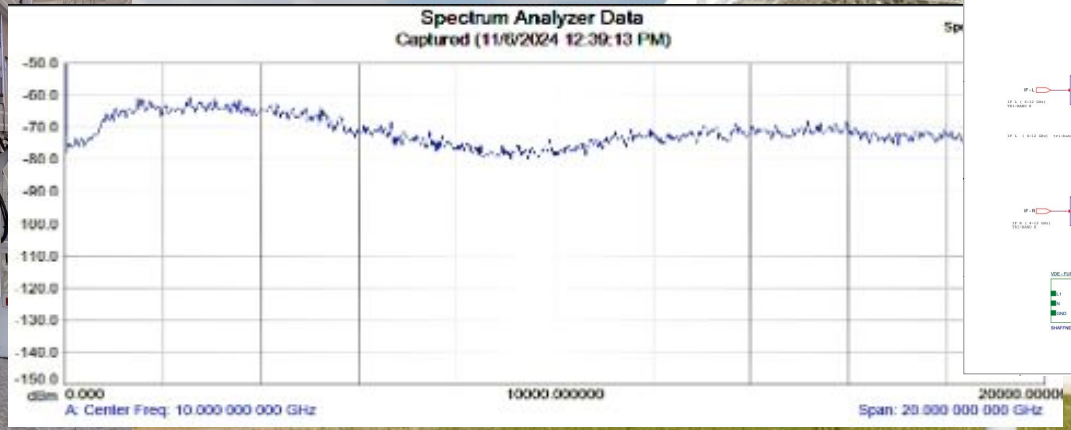
Photogrammetry overall alignment: 200-300 µm along the elevation range

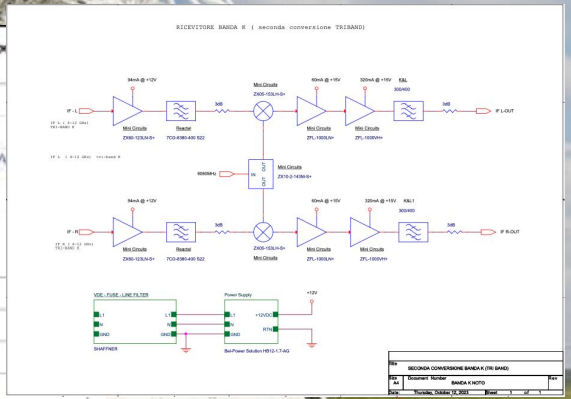
Commissioning will start late fall, preliminary results are very encouraging

Noto - Updates on CTR



- Receiver assembled and tested.
  - Gain hole in Q-band Channel B. Probable issue related to LNA and waveguides, need to open the dewar to fix.
  - Same condensation problema as Medicina CTR. **Solved**.
- Installed in Dec. 2024, ready for commissioning and first light. But a severe issue with driver of the servo system halted telescope operations.





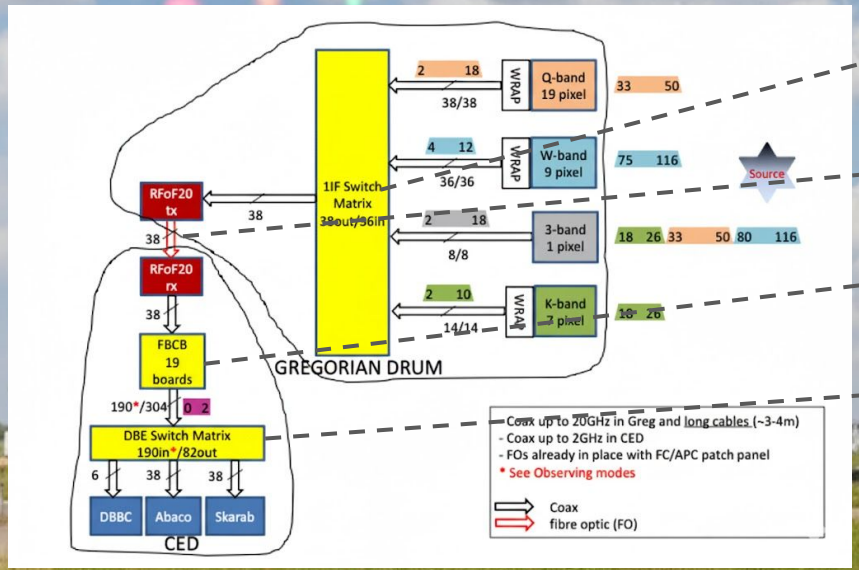
Noto - Updates on Station and Radio Telescope

- Station Refurbishment
  - Air cooling system
  - Power distribution
  - Time & Frequency - new H-maser
- Radio Telescope
  - Elevation rack
  - Azimuth rail
  - Replacement of mechanical parts of the Active Surface Actuators
  - Primary mirror repainting
  - New secondary mirror (50 μm), twin to the Medicina one

IF Distribution system (PON integration)

How can we effectively manage and transmit **very wide** Intermediate Frequency (IF) bandwidths (up to **16 GHz**) over l**ong distances** to **all** necessary backend processing systems?

19 feeds, 2 polarizations, 1 subband
7 feed, 2 polarizations, 2 subbands
2 feed, 2 polarizations, 8 subbands



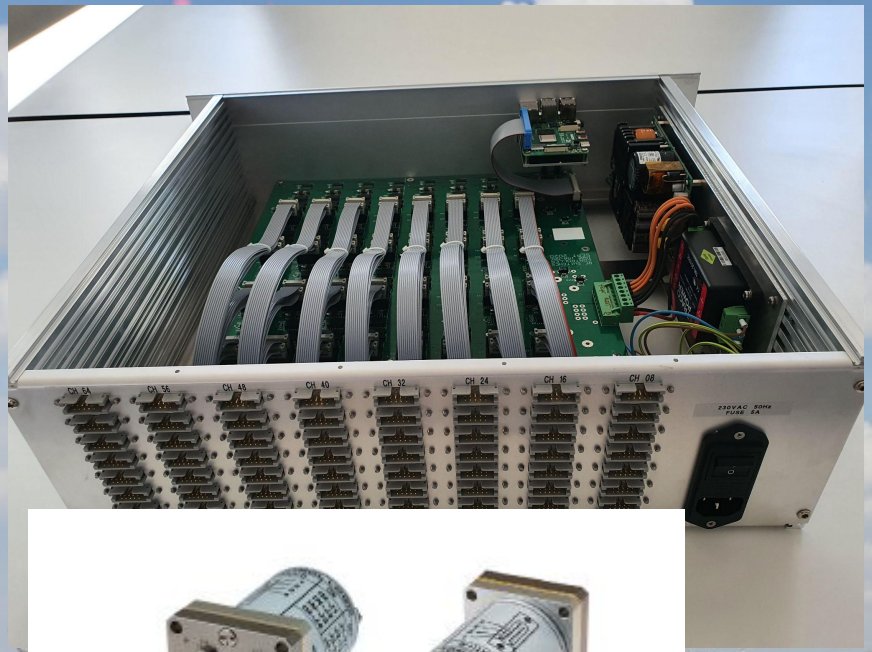
IF Switch Matrix (Receiver Selector). Coaxial - Coaxial

RF over fiber 20GHz. Coaxial - Fiber - Coaxial

Full Band Conversion/Continuum Board/Backend (FBCB)

Digital BackEnd Switch Matrix

(IFs) Switch matrix

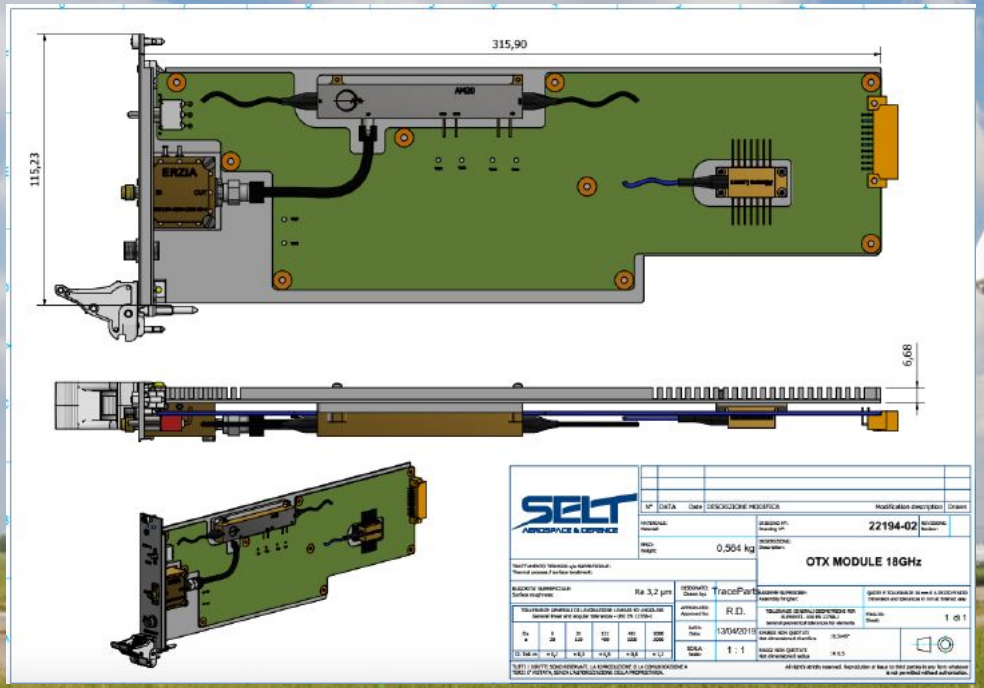


System designed, built tested and **delivered**

- Up to 64, 4 positions. Coaxial switches.
- Up to 26 GHz.
- Used to convey wide bandwidths IF signal to RF over Fiber Tx.
- Software to fully control the configuration.

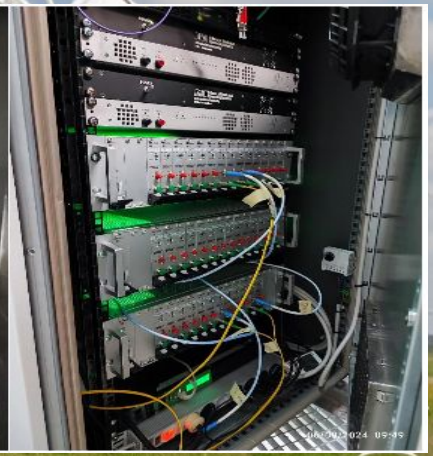
RF over Fiber 20 GHz

Delivered: acceptance certificate signed in November 2024

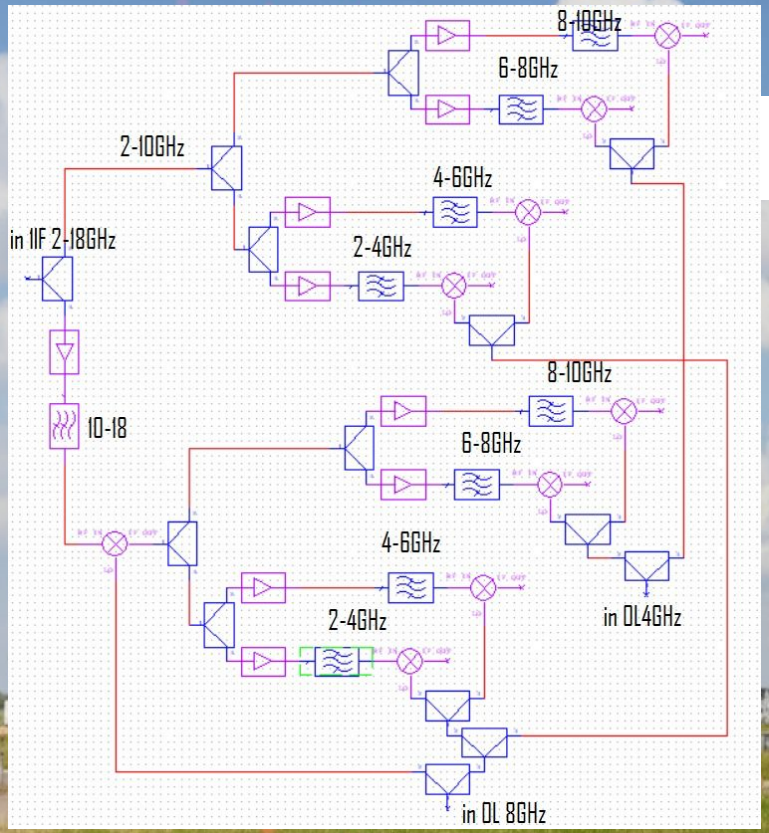


Specification:

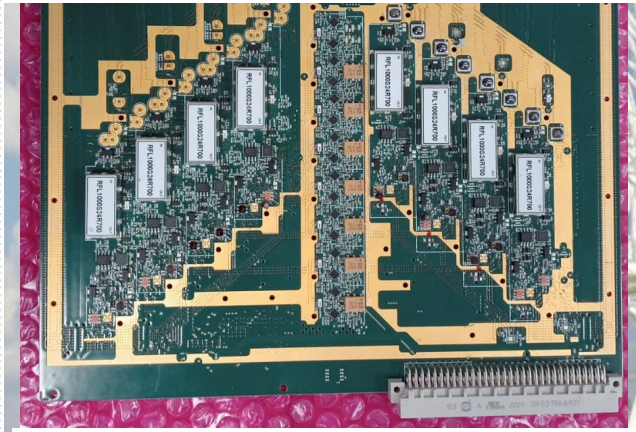
- RF bandwidth: 1-18 GHz
- Gain: 14 dB ± 2.5dB
- Noise figure: < 6 dB
- Input P1dB: > -11dBm



Full Band Conversion/Continuum Board/Backend (FBCB)



Verification of the second prototype is completed. A third one is about to be produced. Final delivery estimated in six months.



19 boards (SRT deployment)

- 38 inputs (2-18 GHz)
- 0.1-1.9 GHz subbands
- Polarimeter

DBE Switch Matrix

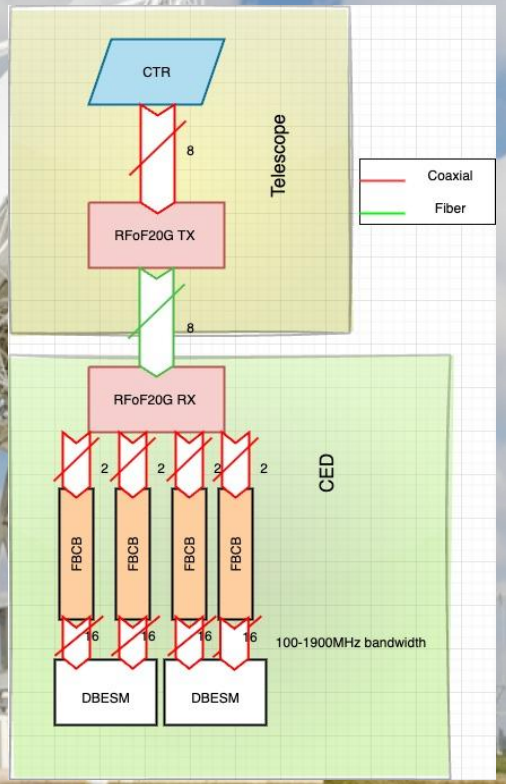
Boards are **delivered and tested**.
The first prototype has been installed at the SRT for PON commissioning purposes.

- Each board provides up to 10 channels to serve several backends.
- Antialiasing filters on boards.
- Switching, attenuation fully programmable with dedicated control software.
- Traditional receiver (non-FBCB) can be switched as well.

IF Distribution for Medicina and Noto

Medicina and Noto infrastructure is simpler but:

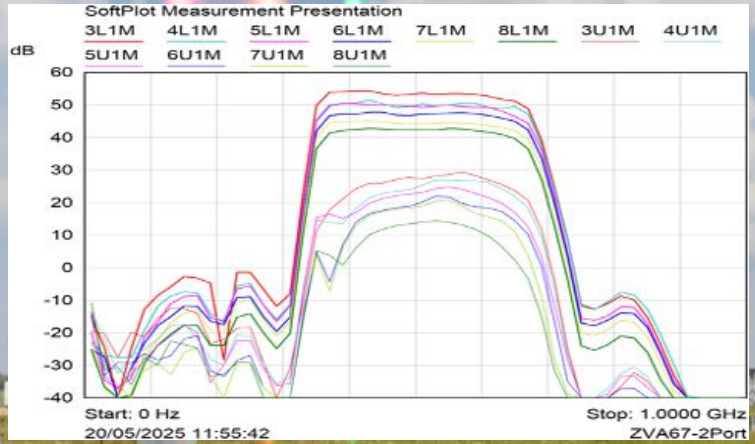
- The CTR is **8** IFs, **2-18 GHz** bandwidth.
- Several VLBI and single-dish backends available:
  - DBBC2 and DBBC3
  - SARDARA (Roach-based)
  - MUSKAS (Skarab-based, only in Noto)
  - XARCOS (only in Medicina)
  - Many piggyback applications



- RFoF link, review of the specifications and discussions with Industrial partners started
- FBCB board timeline is aligned with the IFD system for the SRT
- DBESM Boards: the contract for production should be signed soon (Nov 2025).

CTR commissioning: 8-channel image rejection converter

The Warm Section(WS) of a previous design, "Design of PHAROS2 Phased Array Feed"*, will be used to quickly enable high-frequency 3-band receiver measurements at the Medicina and Noto (and SRT) antennas



Limited but ready to use for commissioning:

- Useful input band from 3 to 8 GHz
- Bandwidth from 0.375 to 0.650 GHz
- Same Local Oscillator is distributed to all 8 channels

*NAVARRINI, et al. “Design of PHAROS2 Phased Array Feed,” 2018.

Preliminary results in Medicina

- To ensure a quick operational recovery, we focused all our efforts on system verification and restoring the previous configuration.
- Medicina is fully available, supporting all EVN and IVS VLBI experiments, and all Italian TAC projects.
- Although preliminary measurements have been taken, the results are currently too inconclusive to be presented.

Noto and Medicina Timeline for the CTR

Noto	Description	Start	End	Duration
1	**Telescope Refurbishment** (Structural and mechanical updates)	Mar 25	Apr 26	13 Months
2	**Receiver Installation & Vertex Cabling**	May 26	May 26	1 Month
3	**Active Surface Verification**	Jun 26	Jun 26	1 Month
4	**CTR Commissioning** (Testing and calibration)	Jul 26	Sep 26	3 Months
5	**Operations Readiness** (Final system handover and readiness for scientific use)	Oct 26	Oct 26	-
Medicina	**Description**	**Start**	**End**	**Duration**
1	**CTR Installation**	Oct 25	Oct 25	1 Month
2	**Active Surface Commissioning**	Nov 25	Dec 25	2 Months
3	**CTR Commissioning** (Testing and calibration)	Nov 25	Mar 26	5 Months
4	**Operations Readiness** (Final system handover and readiness for scientific use)	Apr 26	Apr 26	-


THANK YOU FOR THE ATTENTION