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Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
INAF ISTITUTO NAZIONALE DI ASTROFISICA

Enhancing VLBI capabilities: recent achievements and future upgrades of the INAF radio telescopes

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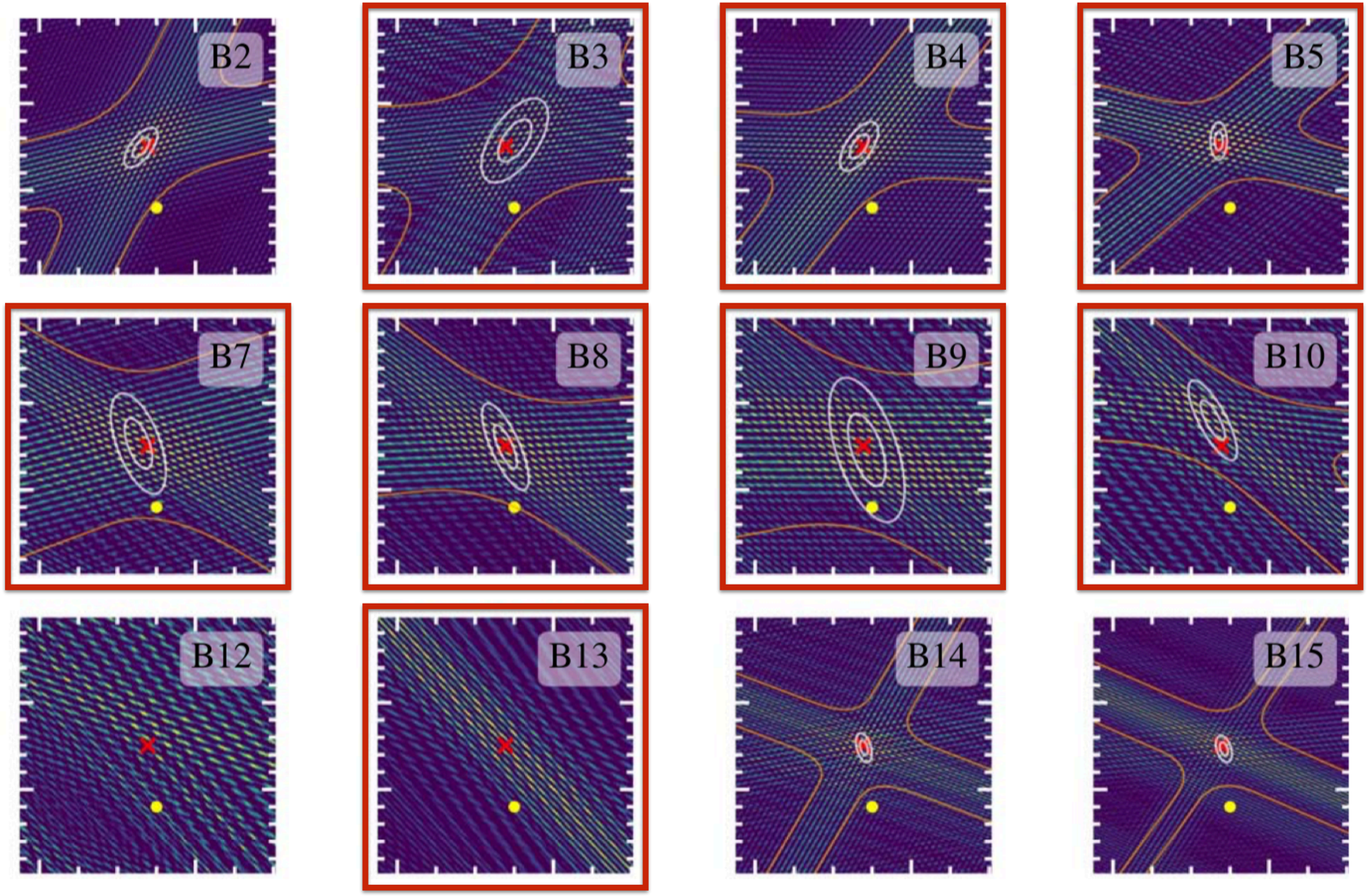
Pinpointing REpeating ChIme Sources with EVN dishes, FRB 20201124A (Nimmo et al. 2022)

Mc, Nt, Sr

Table 2
Interferometric Burst Properties

Burst	Effective No. of Baselines[h]
Epoch 1	
B1	10
B2	10
B3	6
B4	6
B5	6
B6	15
B7	6
B8	6
B9	6
B10	6
B11	15
B12	15
B13	6



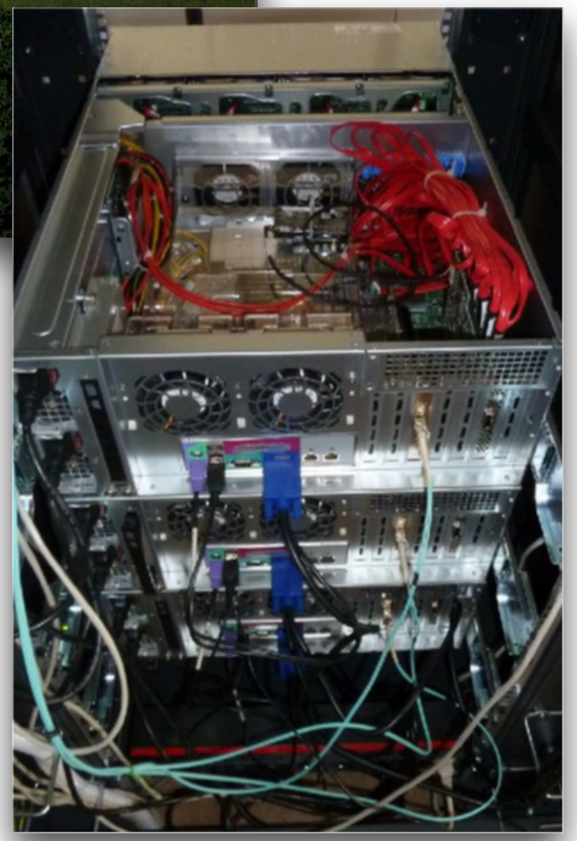
Sardinia, 64m

Medicina, 32m

Noto, 32m

INAF collecting area: 4825 m2

VLBA collecting area: 4909 m2



Bologna, DiFX correlator

INAF telescope tables

Table 1. INAF radio telescopes.

Location	Code	Size	Year	Latitude	Longitude	Elevation	Operating receivers
Medicina	Mc	32 m	1983	44° 31′ 15″ N	11° 38′ 49″ E	25 m	L, S, C, C+, X, K
Noto	Nt	32 m	1988	36° 52′ 34″ N	14° 59′ 21″ E	78 m	P, L, C+, K
Sardinia	Sr	64 m	2011	39° 29′ 34″ N	9° 14′ 42″ E	600 m	L, S, C, C+, X, K

Table 2. INAF VLBI baseline length and sensitivity.

		Sensitivity (mJy min^{-1} Gbps^{-1})		
Baseline	Length (km)	L-band	C+-band	K-band
Mc-Nt	893	5.9	7.8	6.1
Mc-Sr	592	1.8	1.7	2.5
Nt-Sr	580	1.8	1.9	2.7

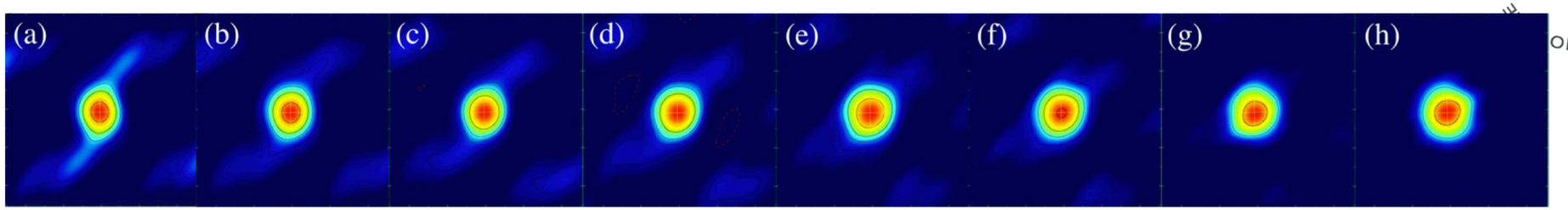
From Eating VLBI review (Giovannini et al. 2023)

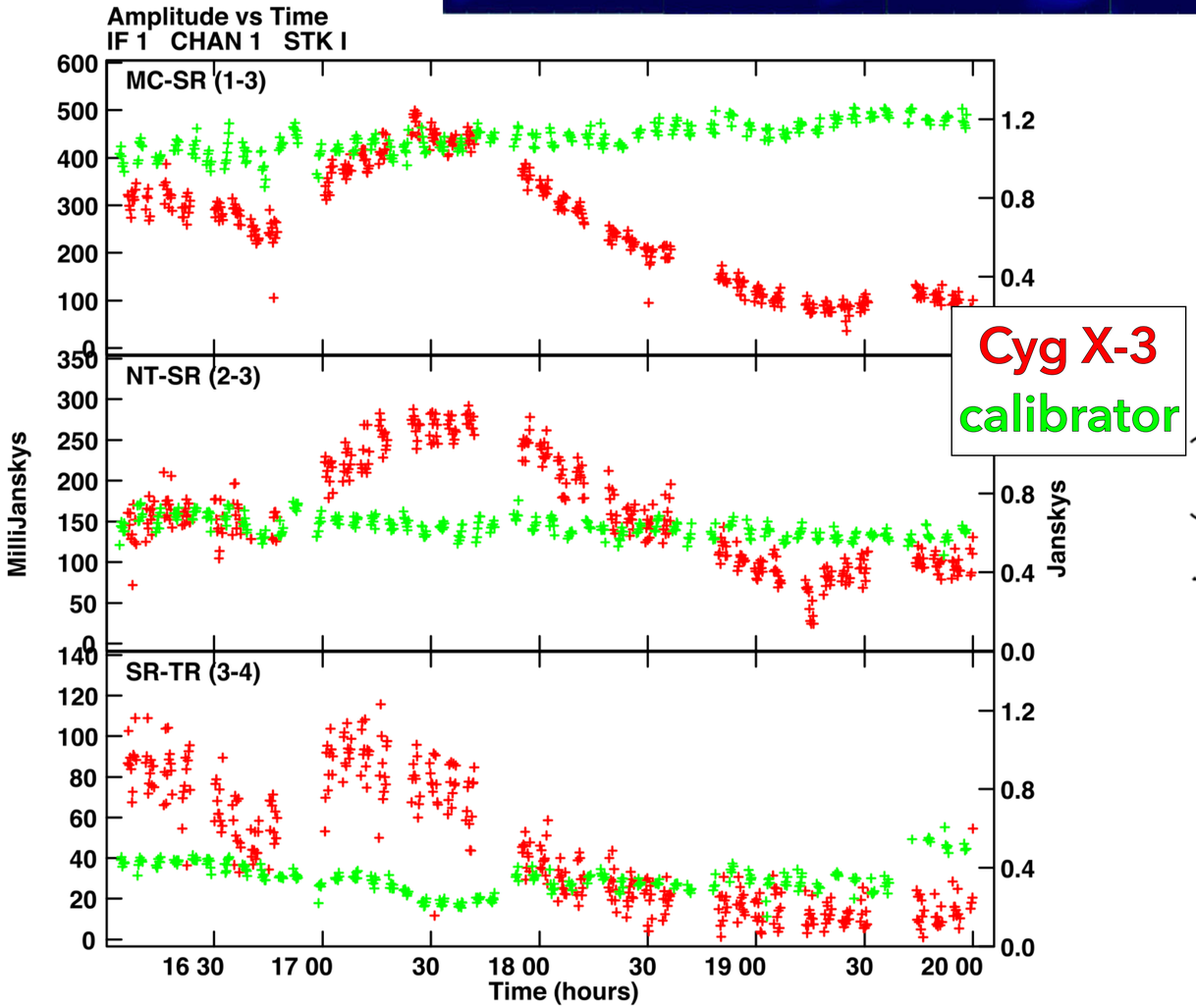
INAF radio telescopes - activities

- ~70 days yr are devoted to EVN observations
- other commitments:
  - single dish observations
  - maintenance and development
  - IVS observations for geodesy (Mc, Nt), ASI support for space (Sardinia)
- other VLBI observations
  - RadioAstron, PRECISE (now EVN-lite)
  - East Asia To Italy: Nearly Global VLBI
  - PI-led, self-organised projects

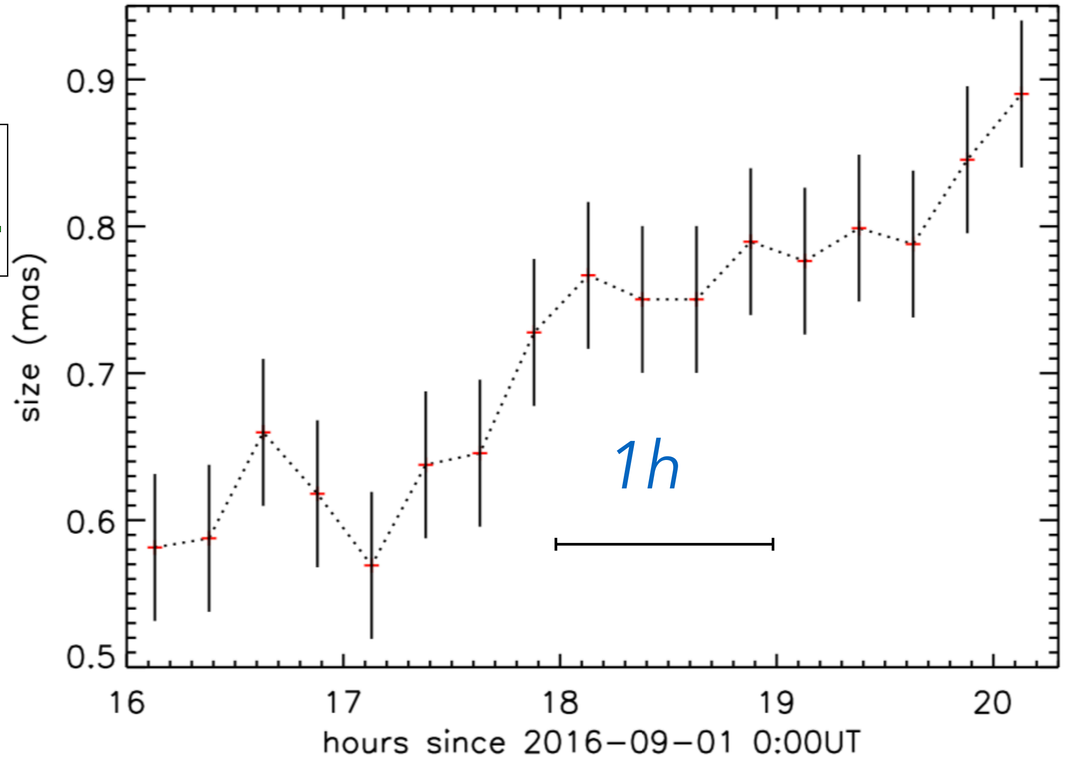
Cyg X-3

Egron et al. 2017, first Italian VLBI paper (+Ys/On/Tr)

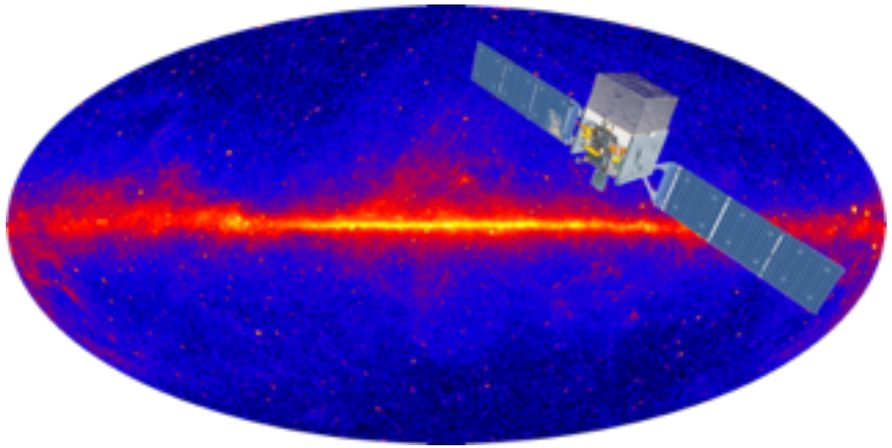




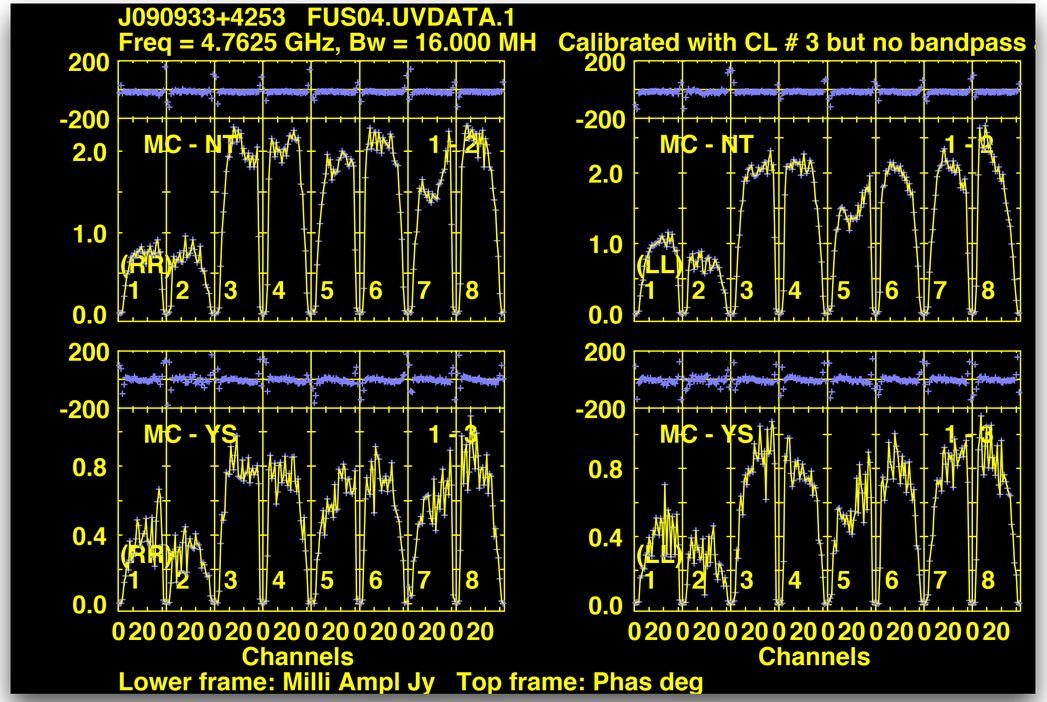
Cyg X-3
calibrator



VLBI observations of γ-ray unidentified sources



- ~30% of sources in Fermi-LAT catalogues have no clear counterparts (~10^3 sources north of -20deg)
- some empty fields, some just too many arcsec-scale candidates (especially at low fluxes)
- filter out the intruders with VLBI!
- potentially on massive scales
- 5 GHz, baseline sensitivity of 10 mJy, 3-5 mas astrometry
- stations: Mc, Nt, Ys, Tr, Ir



Upgrades

1. High-frequency: compact triple band receivers on Mc/Nt/Sr
2. Mid-frequency: broadband receivers on Mc/Nt

Upgrade #1

- “Enhancement of the SRT for the study of the Universe at high radio frequencies” (scientific coordinator Federica Govoni, ~20 M€)
- 9 WPs, including WP4 “Simultaneous microwave compact triple-band (**CTR**) receiving system for the three Italian radio telescopes (18-26; 35-50; 85-116 GHz)”
- Receiver specifications by INAF, design and construction by KASI
- CTR’s delivered and currently being installed on INAF telescopes

Current status

- Sardinia: CTR in position on the telescope, initial tests carried out (8/2024)
- Medicina: installation of active surface system starting this month (9/2024) and new sub-reflector surface
- Noto: active surface available but new sub-reflector required - several major upgrades on the antenna ongoing

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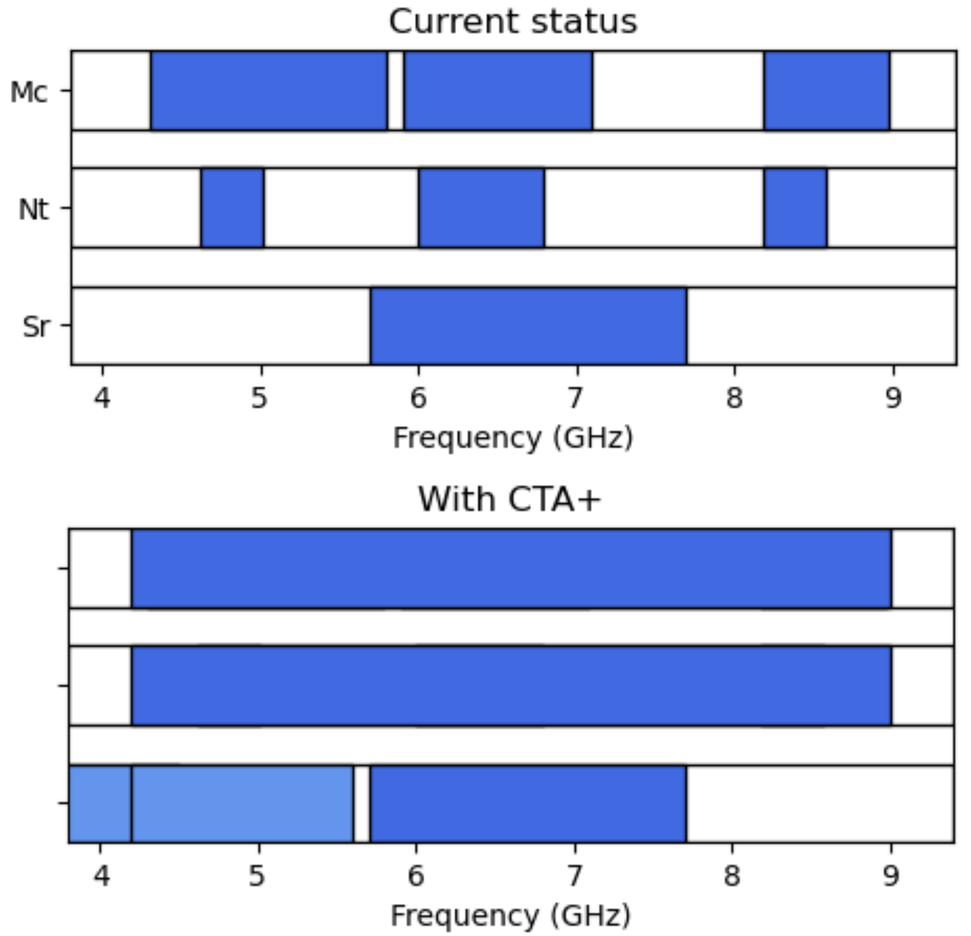
Further upgrades: "CTA+"

- 70M€ INAF-led project to improve Cherenkov Telescope Array Observatory
  - and supporting MWL instrumentation
- VLBI key for transient physics
- Complements "PON" at lower frequency: ~1M€ for Medicina&Noto broadband (4-9 GHz) receivers
- Delivery: end 2025



Outlook

- Multimessenger context
  - Gravitational wave astrophysics (Ligo-Virgo, Einstein Telescope): need screening of candidates to select primary targets to follow up with full-sized VLBI arrays
  - Neutrino astrophysics (IceCube, KM3NeT): large number of potential source types/counterparts, monitoring projects
- compact objects & other transients (VRO-LSST; CTAO; etc); gravitational lenses

…stay tuned!