VLBI

The role of the italian radio astronomical facilities in the national and international scientific framework

Tiziana Venturi
INAF, Istituto di Radioastronomia

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Type: INAF Infrastructure
Primary RSN4
Secondary RSN1, RSN2, RSN3, RSN5

Duration: 1980 ⟹ indefinite

VLBI as a national and international radio astronomical facility

Management and scientific impact of the three Italian antennas used in ***VLBI mode***, i.e. individual antennas observing the same source simultaenously with signal correlation either a-posteriori or in real time (e-VLBI)

Roughly 120 full days/year

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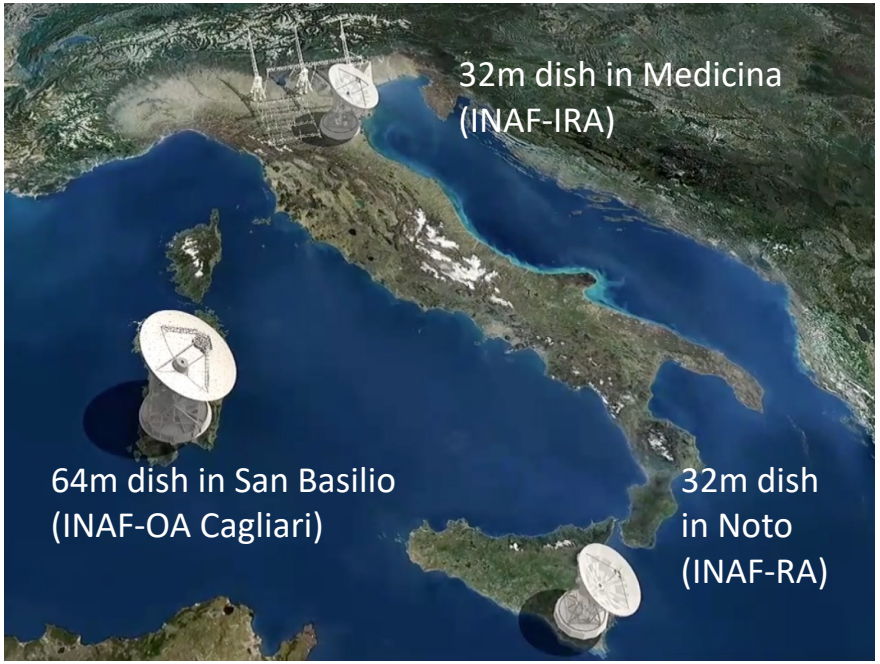


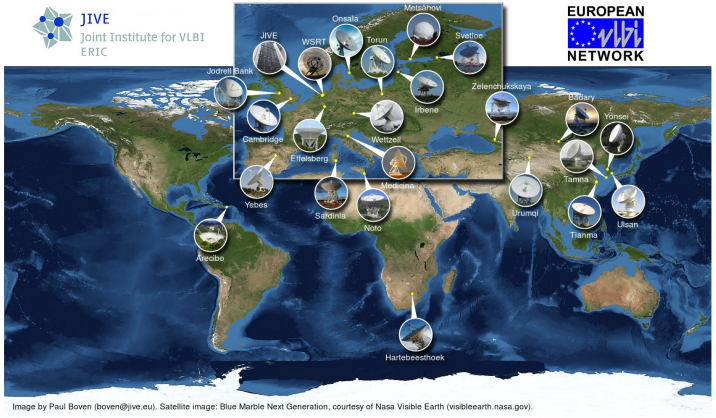
Central coordination by **INAF, UTG-II**

INAF-IRA manages the two 32m dishes in Medicina and Noto and the software correlator
INAF-OA Cagliari manages the 64m dish SRT

Antennas operating in the frequency range 300 MHz-22 GHz, soon up to 116 GHz

The sites, individual observatories, hardware and software technological developments and respective fundings presented in the ‘’schede’’: IRA MC, IRA NT, SRT, PON-SRT

European VLBI Network



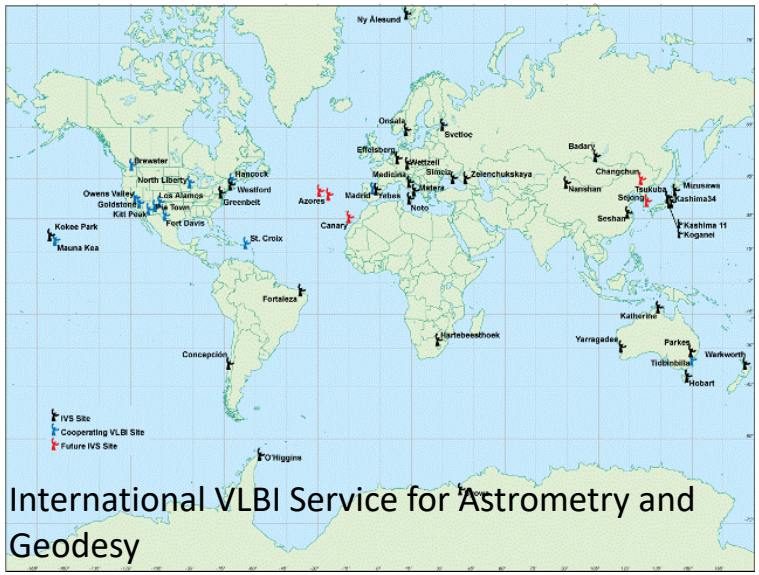
East Asia VLBI Netwok

The EAVN can be flexibly operated using subarrays to support diverse science projects. The coloured circles show telescopes affiliated with each subarray. The small coloured dots above each telescope name indicate their available frequency bands. Note that only four common frequency bands (6.7, 8.4, 22 and 43 GHz) of the EAVN are marked here, but some individual telescopes have broader frequency coverage (see details in Table 2). Credit: Tamna 21 m and Yonsei 21 m, KASI; Sejong 22 m, NGII; KASI/KJCC and Ulsan 21 m, KASI; Mizusawa 20 m, VERA; Takahagi 32 m and Hitachi 32 m, Ibaraki University; Kashima 34 m, NICT; Ogasawara 20 m, VERA; Nobeyama 45 m, Nobeyama Radio Observatory; Usuda 64 m, JAXA; Gifu 11 m, Gifu University; Ishigakijima 20 m and Iriki 20 m, VERA; Yamaguchi 32 m, Yamaguchi University; FAST 500 m, NAOC; Kunming 40 m, SHAO/DFX, Sheshan 25 m, Tianma 65 m, Miyun 50 m and Nanshan 26 m, CVN; background map, NASA.

eVLBI (data transfer to the correlator through fiber link connection) is a **SKA pathfinder**

International VLBI Networks which may include the INAF facilities (open sky)

mas to μas angular resolutions from 1.4 GHz to 100 GHz with μJy/b sensitivity



International VLBI Service for Astrometry and Geodesy

Formal participation (MoU or Consortium Agreements):

- EVN
- KVN
- IVS

Coordinated scientific observing sessions

Observing time allocated through:

- INAF TAC (~ 1/3 of the proposals asks for VLBI observations)
- EVN PC

TEAM

Management, Operations and Science

INAF Structure	Personnel	Type of personnel
IRA (Bo, Med, Noto)	38	Tecnici, Tecnologi, Ricercatori (scienza e UTG-II), Amministrazione
OA Brera	1	Ricercatori (scienza e UTG-II)
OA Arcetri	1	Ricercatori (scienza e UTG-II)
OA Cagliari	8	Tecnici, Tecnologi, Ricercatori (scienza e UTG-II)
OA Catania	1	Ricercatori (scienza e UTG-II)

INAF Associates	Personnel	Type of personnel
IRA – in quiescenza	1	Tecnologo
Politecnico Milano	1	Ricercatrice

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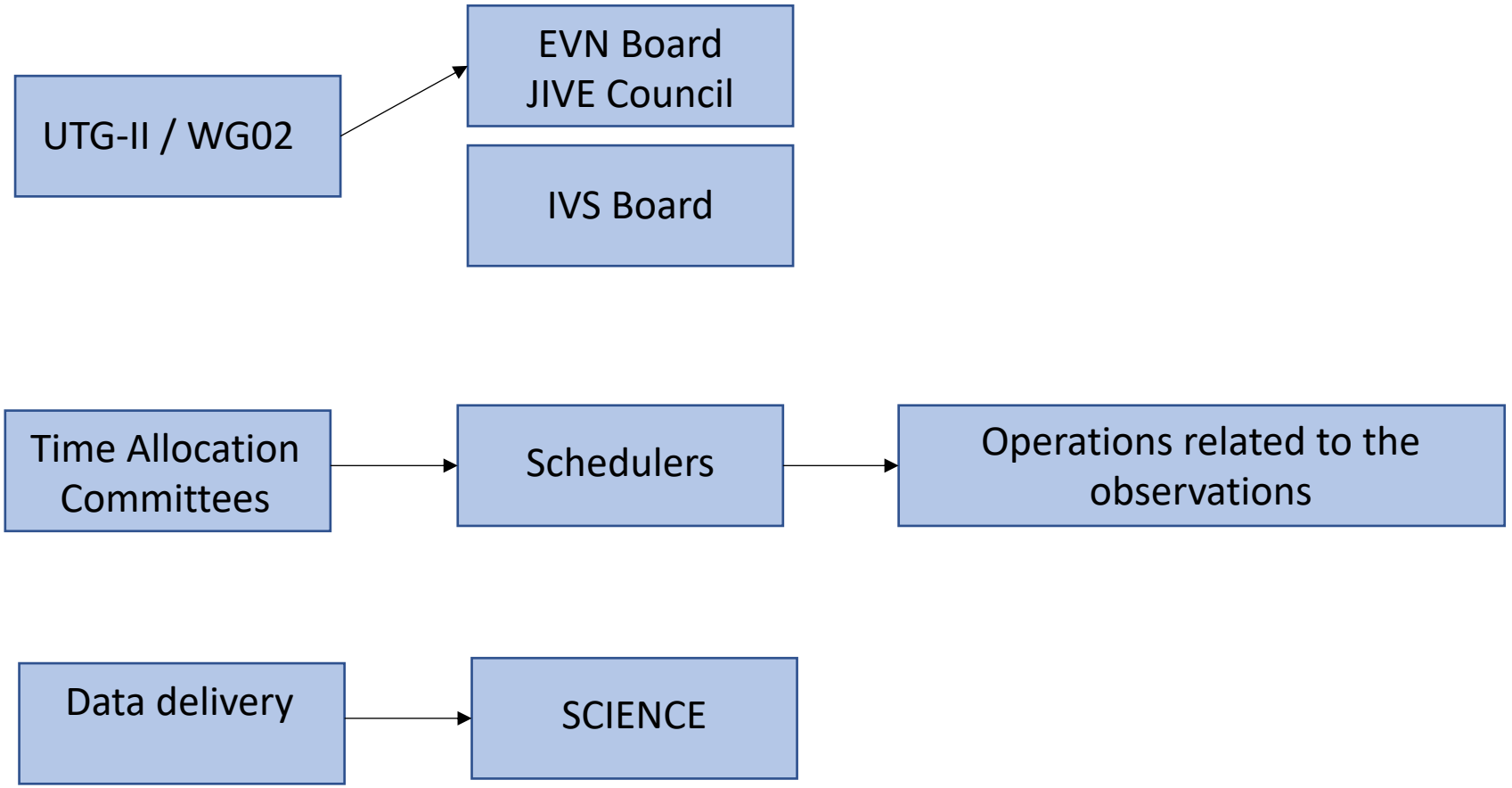
Most personnel is TI

TEAM

Management, Operations and Science



FINANCIAL RESOURCES. I. Technological development

The technological developments for VLBI are part of a strategic roadmap agreed within the EVN to maximize the scientific output of the network
VLBI20-30: a scientific roadmap for the European VLBI Network, arXiv:2007.02347

VLBI has been given considerable support by the DS over the past few years, after the PON-SRT project was approved. Details are given in different *schede* (Mc, NT, SRT, PON), as they are major upgrades which improve the performances of the antennas not just for VLBI

- Capabilities up to 116 GHz with the new triband receiver K/Q/W on all antennas
- DBBC3 at all stations to support higher recording bitrates (up to 32 Gbps)
- Other upgrades (i.e. antenna servosystem in Mc and Nt, and more)

Ongoing

~ 8 Meuro from 2018 to date: partly from PON-SRT partly from the PTA2018-21 allocation to SRT and VLBI (MUR)

FINANCIAL RESOURCES. II. VLBI Operations

- Participation in JIVE
- Optical fiber link connection
- Software correlator
- Investment in recording supports (disks/flexbuff)
- Developments to facilitate the users' access
- Regular maintenance

These are accounted for in the *scheda* VLBI and are estimated to amount to ~ 10 MEuro in the period 2005-2030 from the sources: FP5-FARADAY, FP6-RadioNet, FP6-EXPReS, FP7-RadioNet (2 projects), FP7-NEXPReS, H2020-RadioNet, H2020-ORP, KASI, FFO, Fondi MUR

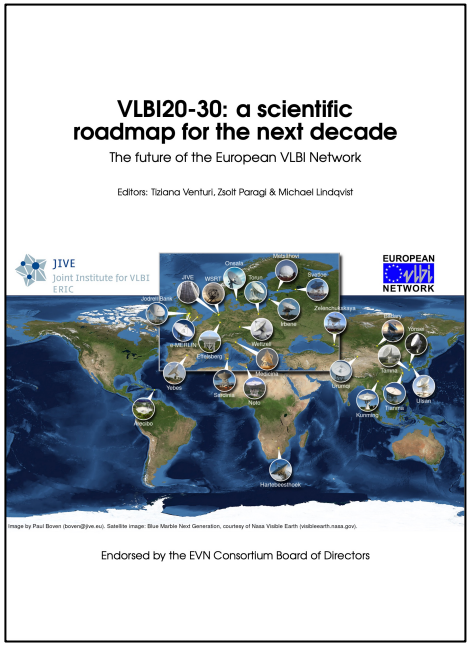
Running costs: ~ 400 kEuro/yr + FTE of dedicated personnel

SCIENCE WITH VLBI AND INAF/ITALIAN LEADERSHIP

1985: First meeting of the EVN Consortium

Italy among the founding members of the EVN, in the early ‘80s
Now part of JIV ERIC

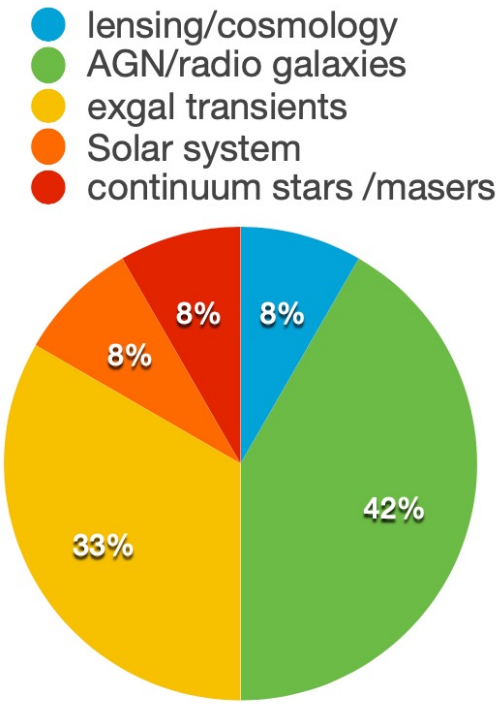
INAF is presently chairing the main international boards (EVN CBD, EVN PC, JIVE Council)



INAF led the VLBI scientific roadmap for 2020-2030 and Italy contributed to all science chapters:

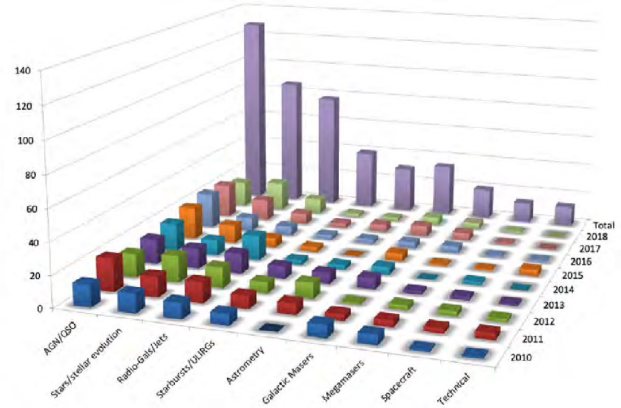
- Cosmology
- Galaxy Evolution
- Inner regions of AGN
- Transients
- Stellar evolution
- Milky Way
- SETI
- Terrestrial and Celestial Reference Frames

SCIENCE WITH VLBI AND INAF/ITALIAN LEADERSHIP

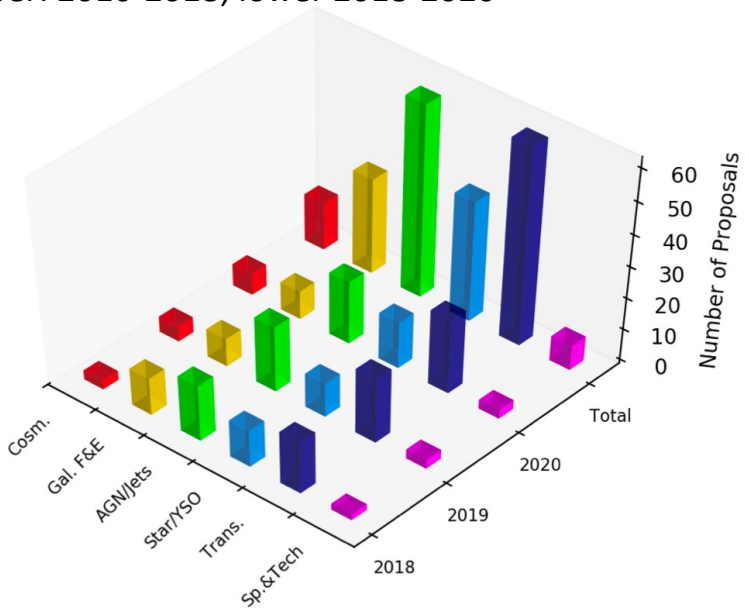


Typical trend in EVN Call for Proposals

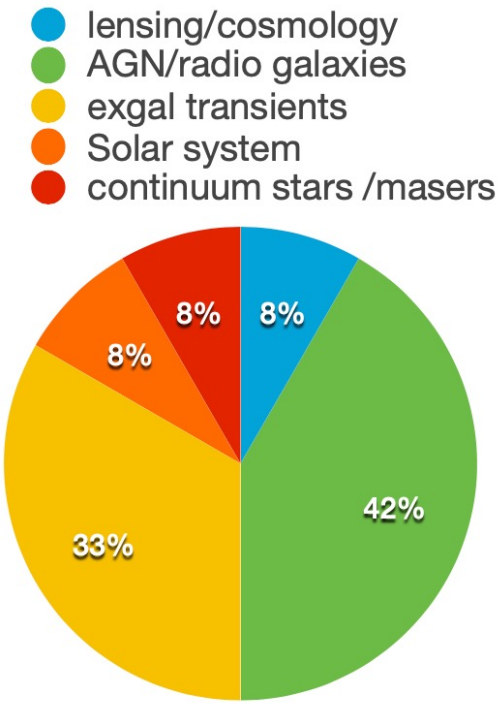
AGN, radio galaxies, extragalactic transients are the science categories where VLBI is mainly used, but note the much broader science range



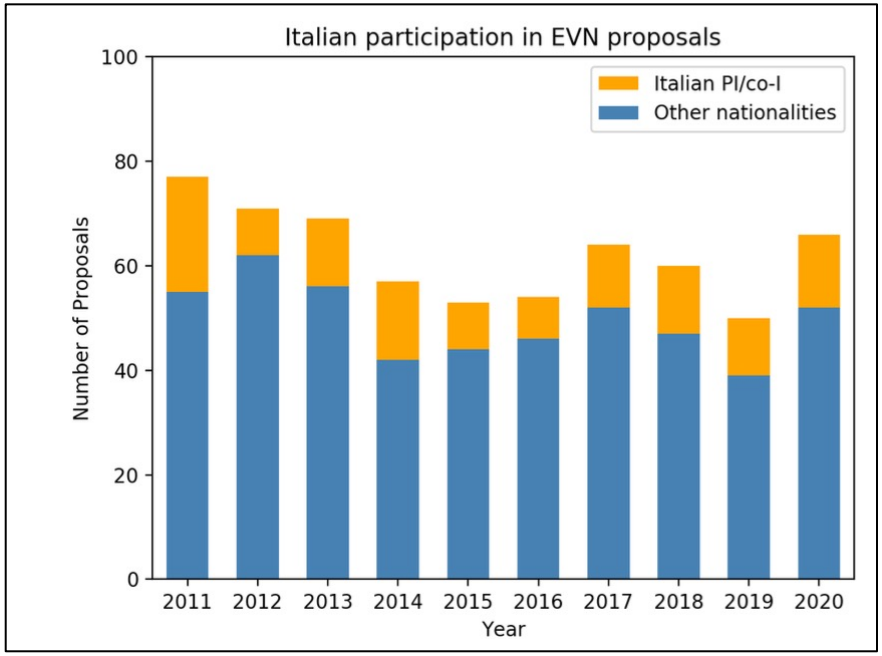
Number of proposal for scientific topic.
Upper: 2010-2018; lower 2018-2020



SCIENCE WITH VLBI AND INAF/ITALIAN LEADERSHIP



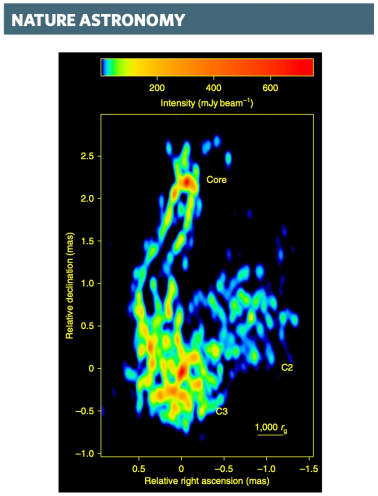
Typical trend in Call for Proposals



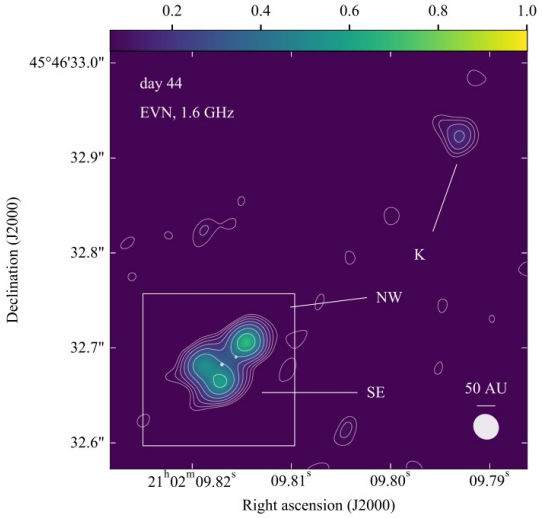
AGN, radio galaxies, extragalactic transients are the science categories where VLBI is mainly used, but note the much broader science range

AGN, extragalactic transients, stellar masers and megamasers are areas with strong Italian leadership recognised internationally

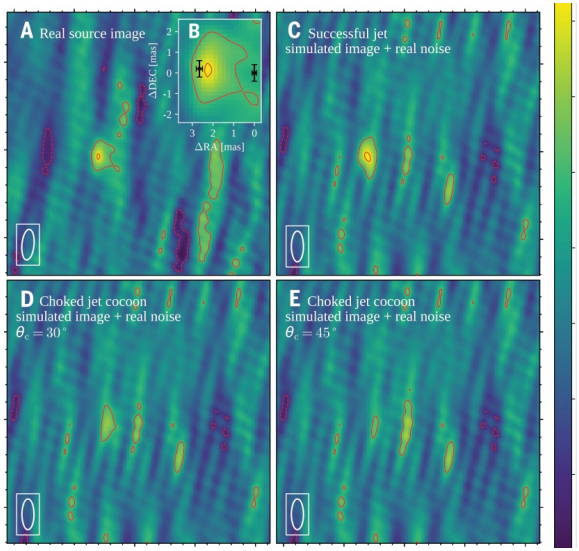
SCIENCE WITH VLBI AND INAF/ITALIAN LEADERSHIP



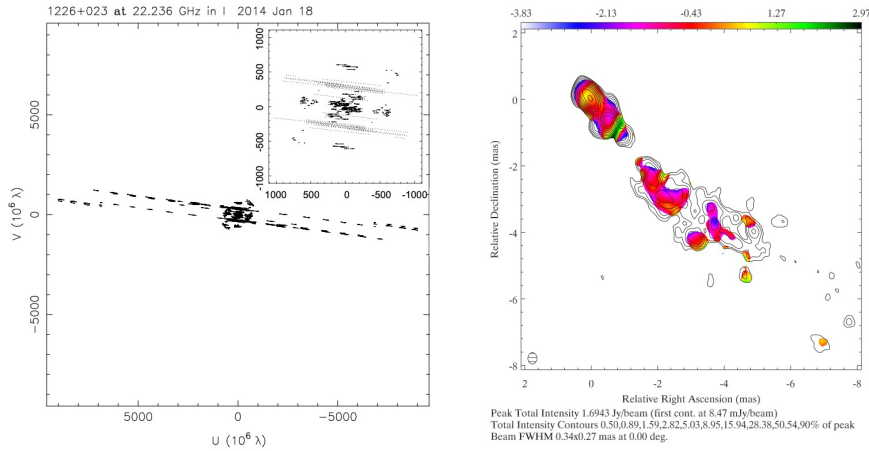
3C84 -22 GHZ with Space VLBI
Giovannini et al. 2018



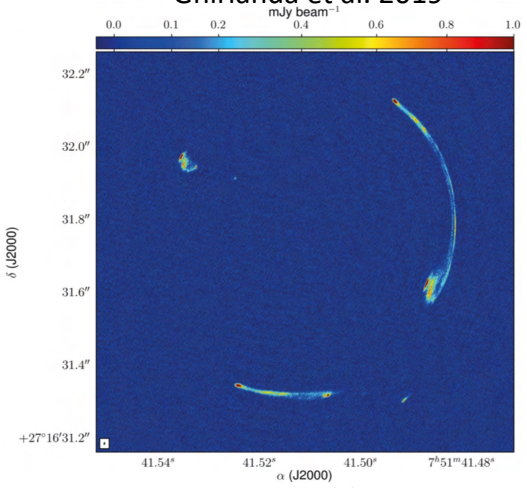
V407Cyg – first symbiotic star with gamma detection– Giroletti et al. 2020



Radio emission from GW170817
Ghirlanda et al. 2019

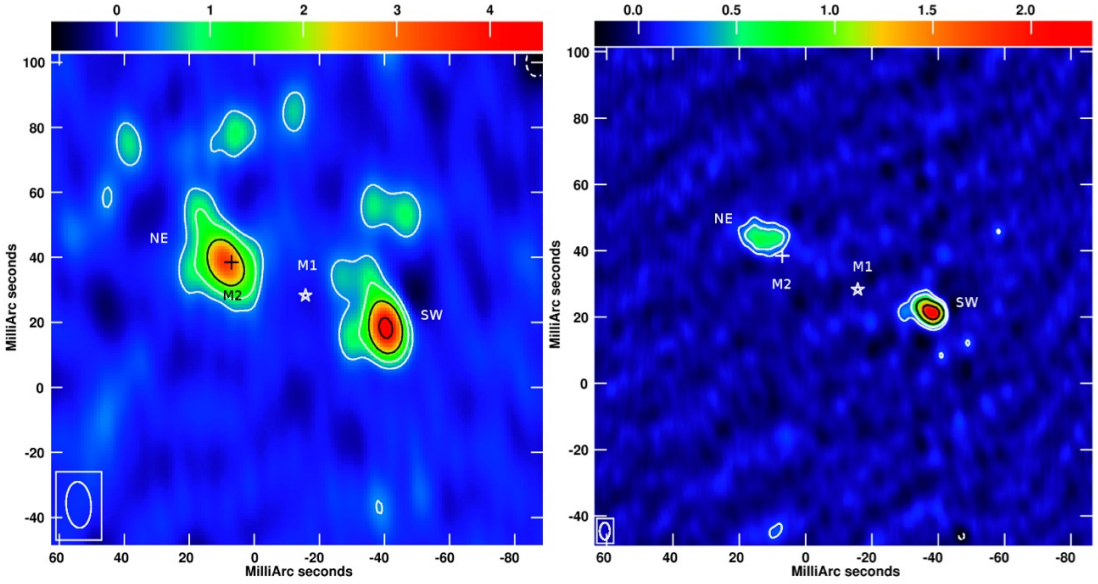


Magnetic fields in radio jets with Space VLBI – Bruni et al. 2019

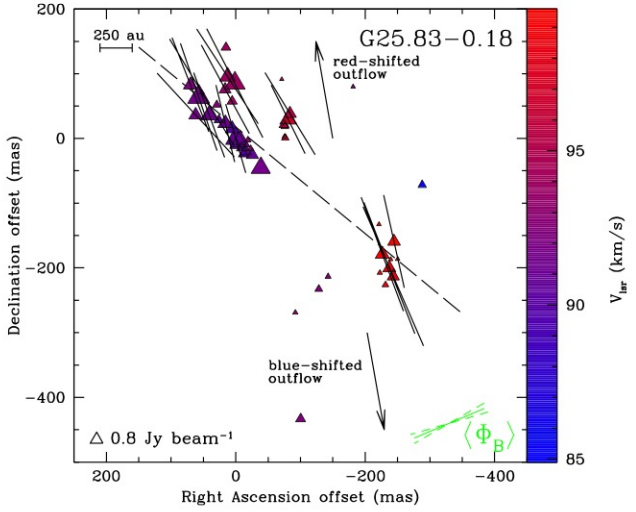


Gravitational lensing
Spingola et al. 2018

SCIENCE WITH VLBI AND INAF/ITALIAN LEADERSHIP



Extragalactic megamasers
Castangia et al. 2019



Magnetic fields in stellar masers
Surcis et al. 2019

VLBI for Geodesy and Metrology

Geodetic VLBI:

- determines the Earth orientation parameters,
- defines and realizes the International Celestial Reference Frame
- contributes to the definition of the International Terrestrial Reference Frame.
- It is used to study the changing Earth, by investigating its geodynamics, atmosphere, gravitational field.

A coherent optical fiber link connects the Italian National Metrology Institute to the Medicina and Matera stations, disseminating a highly stable and accurate frequency reference signal to the VLBI antennas. **Common-clock experiment**s have been carried out in the last few years.

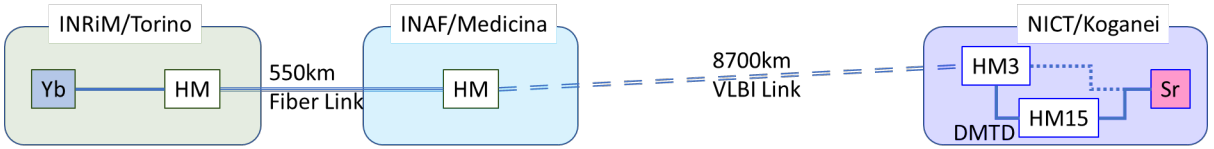
Delivering the same frequency to distant telescopes

INRIM
National
Metrology Inst.

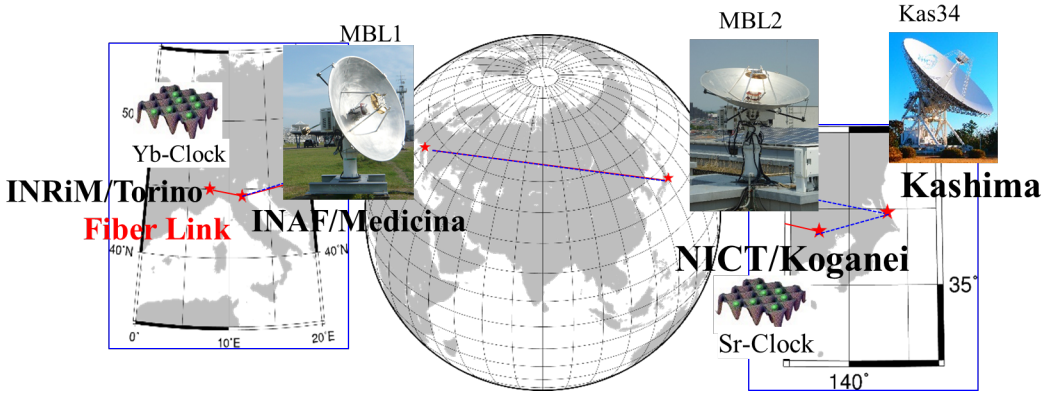
Medicina Radio Observatory
(National Inst. Astrophysics)

Matera Space Geodesy Centre
(Italian Space Agency)

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA



Broadband geodetic VLBI has proved to be a tool for **optical clock comparison over intercontinental distance**, using transportable antennas. Medicina has been involved in Italy-Japan experiments also thanks to the optical link to INRiM.



ISSUES

Funds

- The best practice would be to ensure ordinary maintenance to all the VLBI antennas - Regular funds are necessary – Essential to keep the VLBI allocation from MUR

Personnel

- A number of staff members (operators, engineers, technicians) will retire VERY SOON – Mandatory to ensure that they are replaced timely
- Difficulties in recruiting technicians, engineers and scientists

Users

- Need to increase the national awareness of the scientific potentials of VLBI. Important to broaden the users' community – Action on UTG-II/WG02