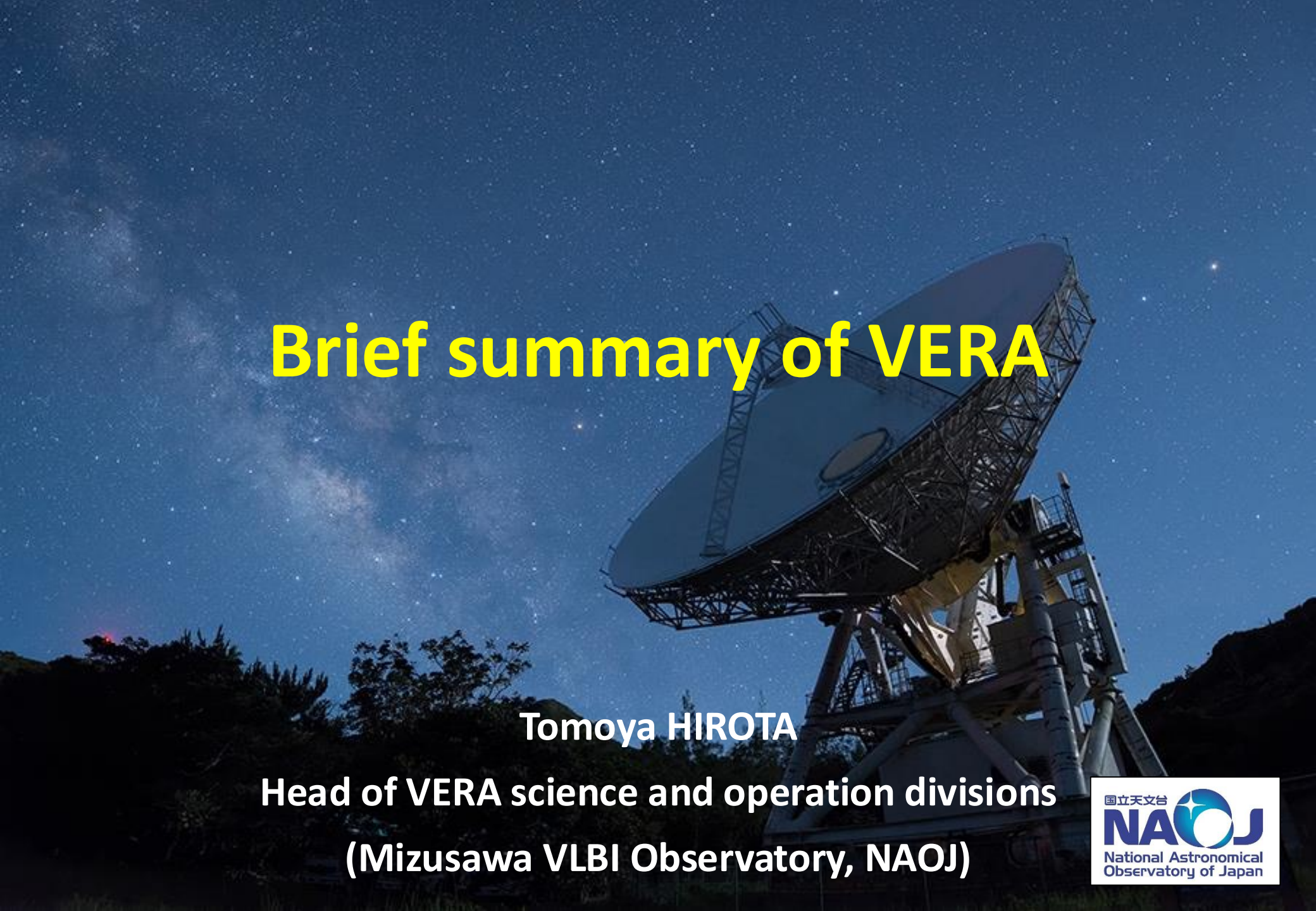


Brief summary of VERA

Tomoya HIROTA

Head of VERA science and operation divisions

(Mizusawa VLBI Observatory, NAOJ)

国立天文台 NAOJ National Astronomical Observatory of Japan

History of Mizusawa VLBI Observatory

1899 Established as

International Latitude Observatory

aimed to measure Earth Rotation

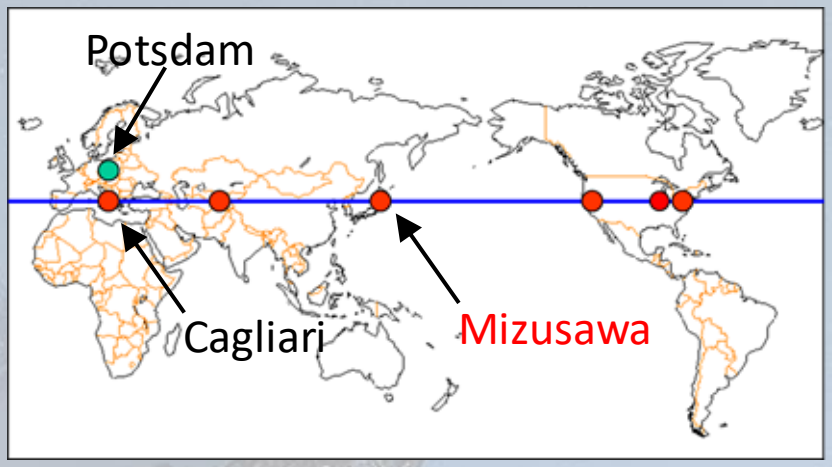
1988 Reorganized as NAOJ, together with Tokyo Astronomical Observatory of University of Tokyo, and a part of Solar Radio Research lab at Nagoya University

2002 Construction of VERA 4 stations

2007 First parallax results (Orion, S269)

2014 KaVA (KVN and VERA array) open use

2018 EAVN (East Asian VLBI Network) open use

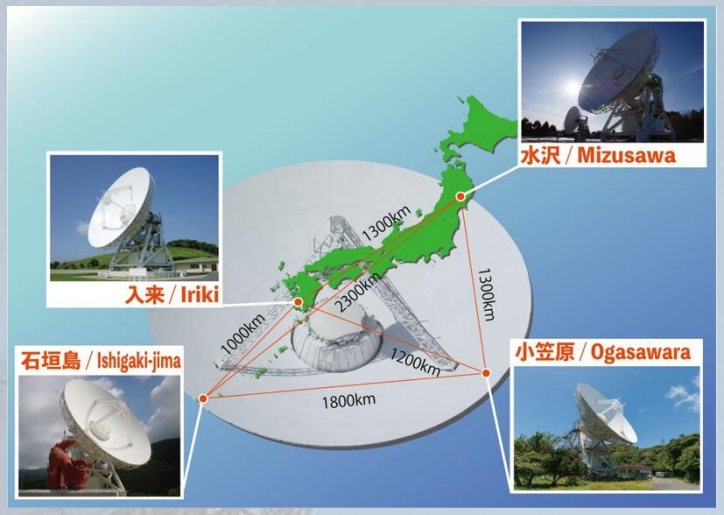


Location of ILO observatories along 39d08' N

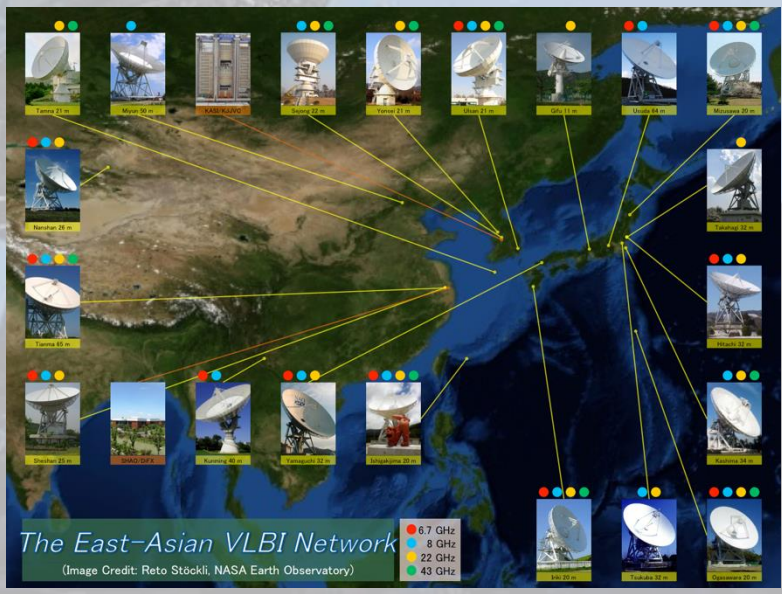
Old observatory building of ILO in Mizusawa (since 1899)

Current projects in Mizusawa VLBI Observatory

- **VERA: VLBI Exploration of Radio Astrometry**
- JVN: Japanese VLBI Network
  (collaboration with Japanese universities)
- KaVA: KVN and VERA Array
- EAVN: East Asian VLBI Network
- EHT: Event Horizon Telescope
- BURSTT: Bustling Universe Radio Survey Telescope in Taiwan (remote station in OGA)
- SKA: Square Kilometre Array (pathfinder)



VERA array configuration

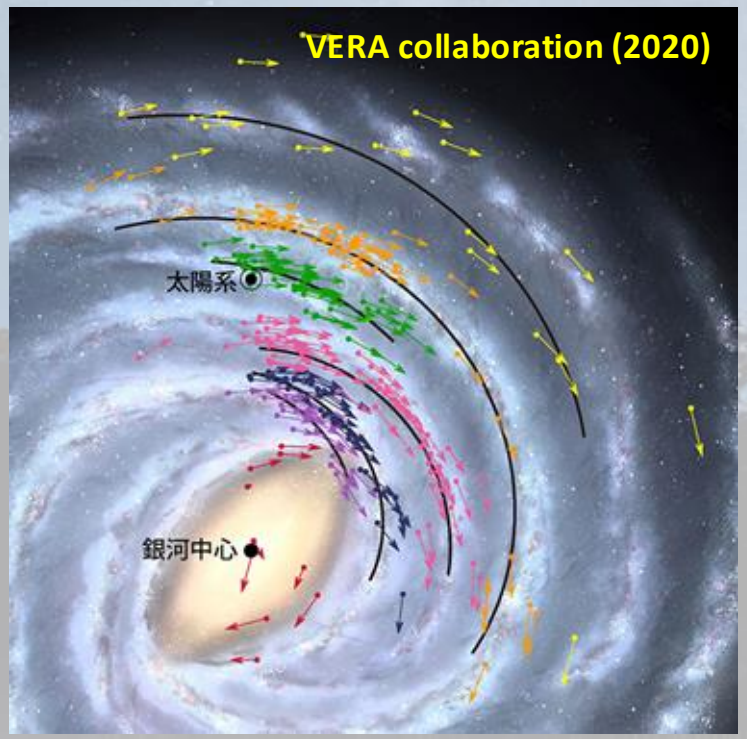


VERA, JVN, , KaVA, and EAVN

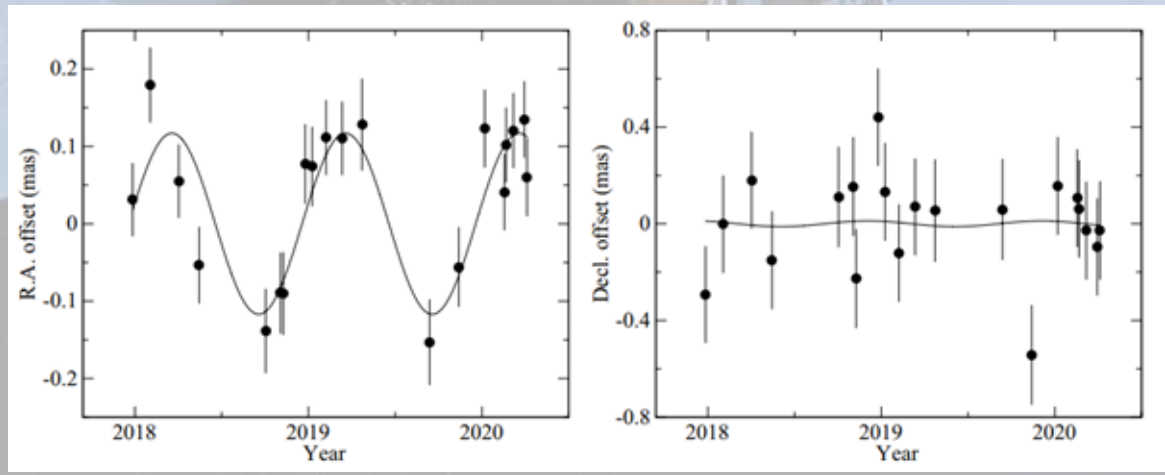
VERA as a VLBI astrometry project

- Maser parallaxes combined with VLBA (Bessel) and EVN projects

	Reid+(2009)	Honma+(2012)	Reid+(2014)	Reid+(2019)	VERA+(2020)
N_src	18	52	103	200	224 (99 from VERA)
R0 (kpc)	8.4 (+/- 0.6)	8.05 (+/- 0.45)	8.34 (+/- 0.16)	8.15 (+/- 0.15)	7.92 (+/- 0.16)
Θ0 (km/s)	247 (+/- 16)	238 (+/- 14)	240 (+/- 8)	236 (+/-7)	227 (+-/-8)



- Direct measurements of Sgr A* parallax: 117+/-17 mas (Oyama et al. 2024)

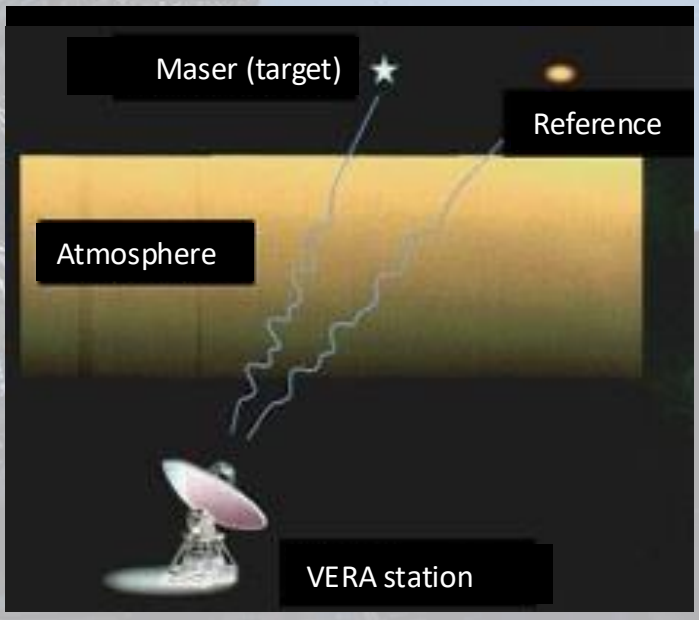


Parallax in RA (left) and Decl (right) (Oyama et al. 2024)

VERA observing frequency

- Four 20-m antennas with dual-beam system
  - Mainly dedicated for VLBI astrometry at K and Q bands (VERA collaboration et al. 2020, Honma et al. 2025)

Band	Polarization	Station	Note
K	Dual Single (2-beam)	All	K/Q simultaneous mode with additional optics
Q	Dual Single (2-beam)	All	
C	Single	IRK,OGA,ISG	
S/X	Single	MIZ	Only for geodesy
C/X/Ku	Dual	MIZ	Under development
W	Single	MIZ,ISG	Under development
L	Single	MIZ,ISG	Developed for test



Dual-beam observation system and its concept to calibrate atmospheric phase fluctuation

In-house/outsourced developments of digital backends, recorders, correlators

- Nominal recording mode
  - 1 Gbps (various digital filter modes): employed for EAVN common-use programs
  - 2, 4, 8, 12 Gbps (2 Gbps*N ch): mainly for VERA internal use

- **New wide-band system: OCTAD (Oyama et al. 2024)**
  - Input: 4 ch, 0-26 GHz
  - DBBC: 2-32 ch, 8-4096 MHz
  - Output: 32 Gbps (max)
  - Recording rate: 16 Gbps

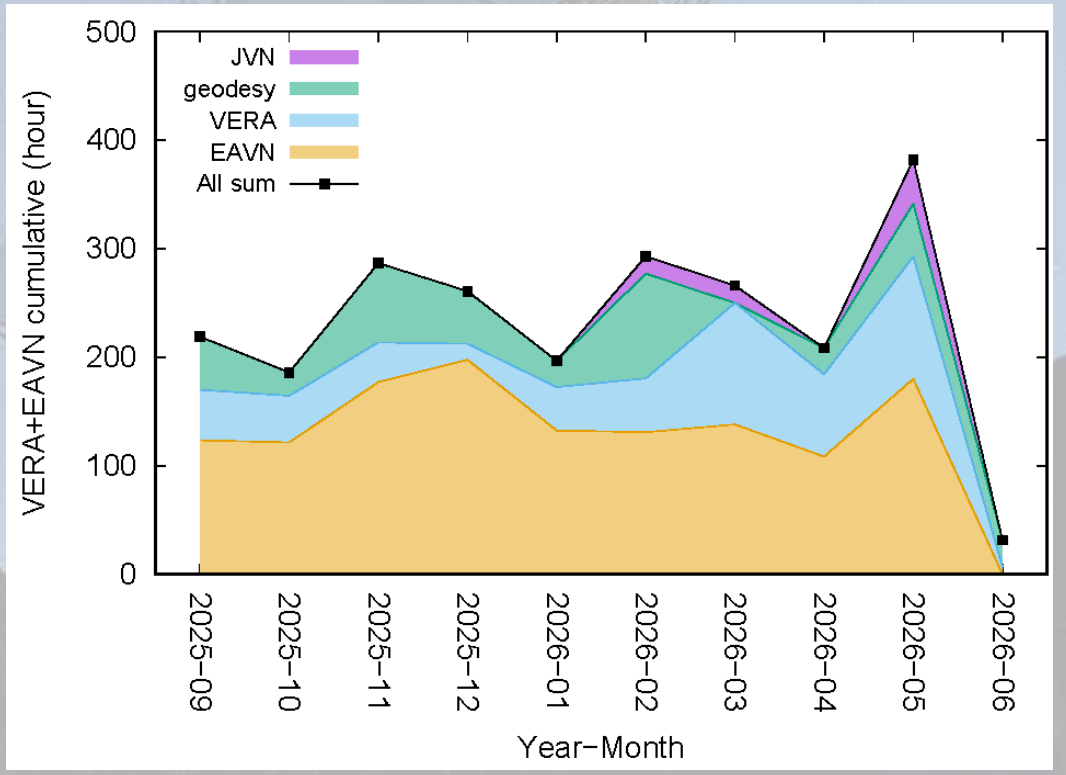
- CPU/GPU software correlators
  - Mizusawa correlation center since 2015
  - 30 servers for CPU/GPU correlators
  - 8 Playback systems and Raid boxes

Mizusawa correlation center

Operation mode

- VERA Large-scale COllaborative Program (VLCOP) since 2022
  - In-kind contribution to array operation by user community, including PI projects and EAVN common-use programs, to secure their own machine time with VERA (VLBI, single-dish, developments/commissioning of new instruments)

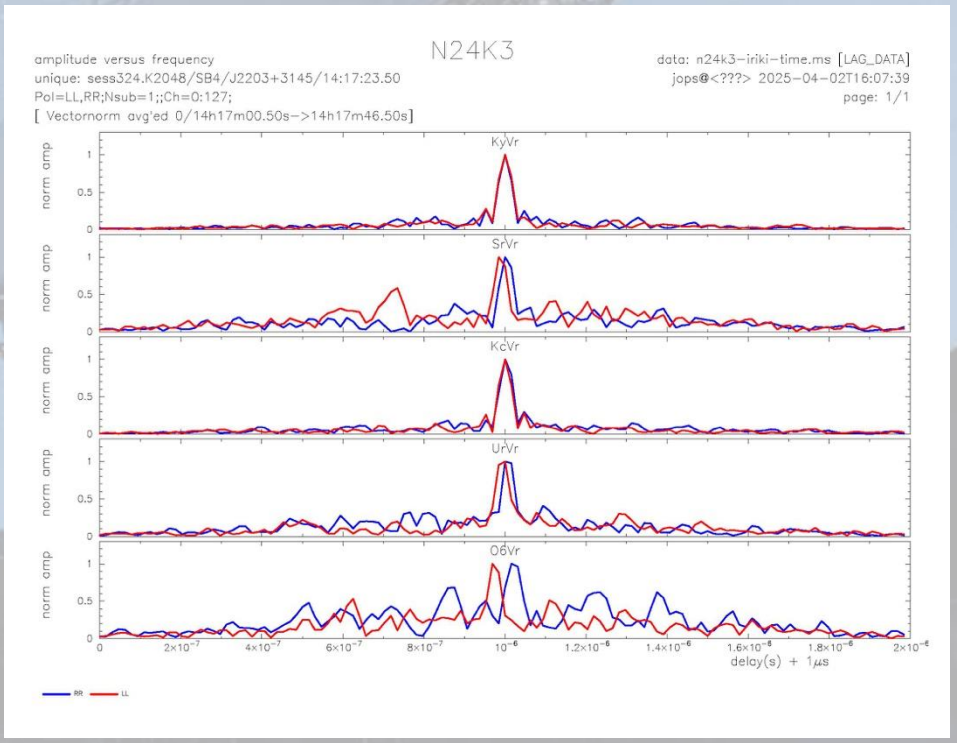
- 2025-2026 season
  - 2331 hours for VLBI (1310 hrs for EAVN, 1021 hrs for others)
  - 1146 hours (sum of 4 stations) for Single-dish/developments
  - Maintenance from June to August



Monthly VLBI observation details in 2025-2026 season

Participation to EVN

- Experience with EVN stations
  - C-band test observations in early 2010s
  - EATING VLBI and part of EAVN in 2010s-2020s (Italy, Spain)
  - **Fringe-test in Nov. 2024: 2Gbps, K-band, dual-pol (32 MHz*8ch*2pol)**
- Issues to be considered
  - Compatibility of recording modes
  - Securing storage capacity
  - Data transfer speed
- Preparing the next global VLBI session for future collaboration



Fringes between VERA IRK and EVN stations