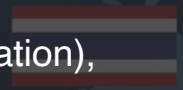
16th European VLBI Network Symposium and Users' Meeting
Session XVI: VLBI perspectives II – Chair: Zsolt Paragi
Sep 6, 2024 @CJD Bonn Castell, Germany

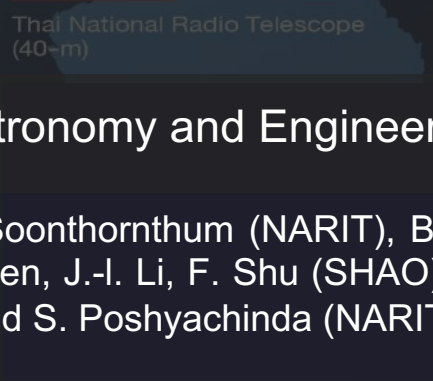
TNRO: A Beacon for Southeast Asia's VLBI Advancement and Role in Global VLBI Networks

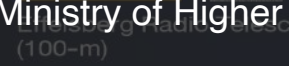
NARIT: National Astronomical Research Institute of Thailand (Public Organization), Ministry of Higher Education, Science, Research and Innovation, Thailand

Koichiro Sugiyama, Acting Manager of Center for Radio Astronomy and Engineering

Co-authors: N. Sakai, P. Jaroenjittichai, A. Leckngam, W. Rujopakarn, B. Soonthornthum (NARIT), B. H. Kramer, G. Wieching (MPIfR), P. de Vicente, J. A. Lopez perez (IGN), Z. Shen, J.-l. Li, F. Shu (SHAO), T. Hidayat (ITB), Z. Z. Abidin, J.-C. Algaba-Marcos (UM), P. N. Diep (VNSC), and S. Poshyachinda (NARIT)

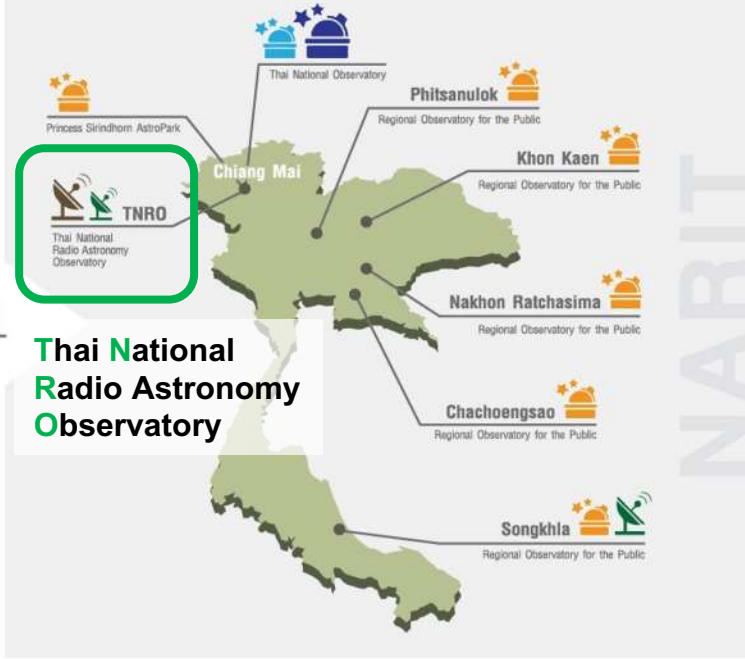






NARIT Infrastructure

Dr. Saran Poshyachinda | Assoc Prof. Boonrucksar Soonthornthum | Dr. Wiphu Rujopakarn | Dr. Busaba H. Kramer



⌀ 2.4 meters ⌀ 1 meters ⌀ 0.7 meters ⌀ 0.4 meters ⌀ 40 meters ⌀ 13 meters

Members of TNRO Project (project since 2017)

Directors Advisors Ex Project Leaders

S. Poshyachinda; W. Rujopakarn; B. Soonthornthum; B. H. Kramer; P. Jaroenjittichai; A. Leckngam

"Human Capacity & Technology Developments Through Radio Astronomy & Geodesy"

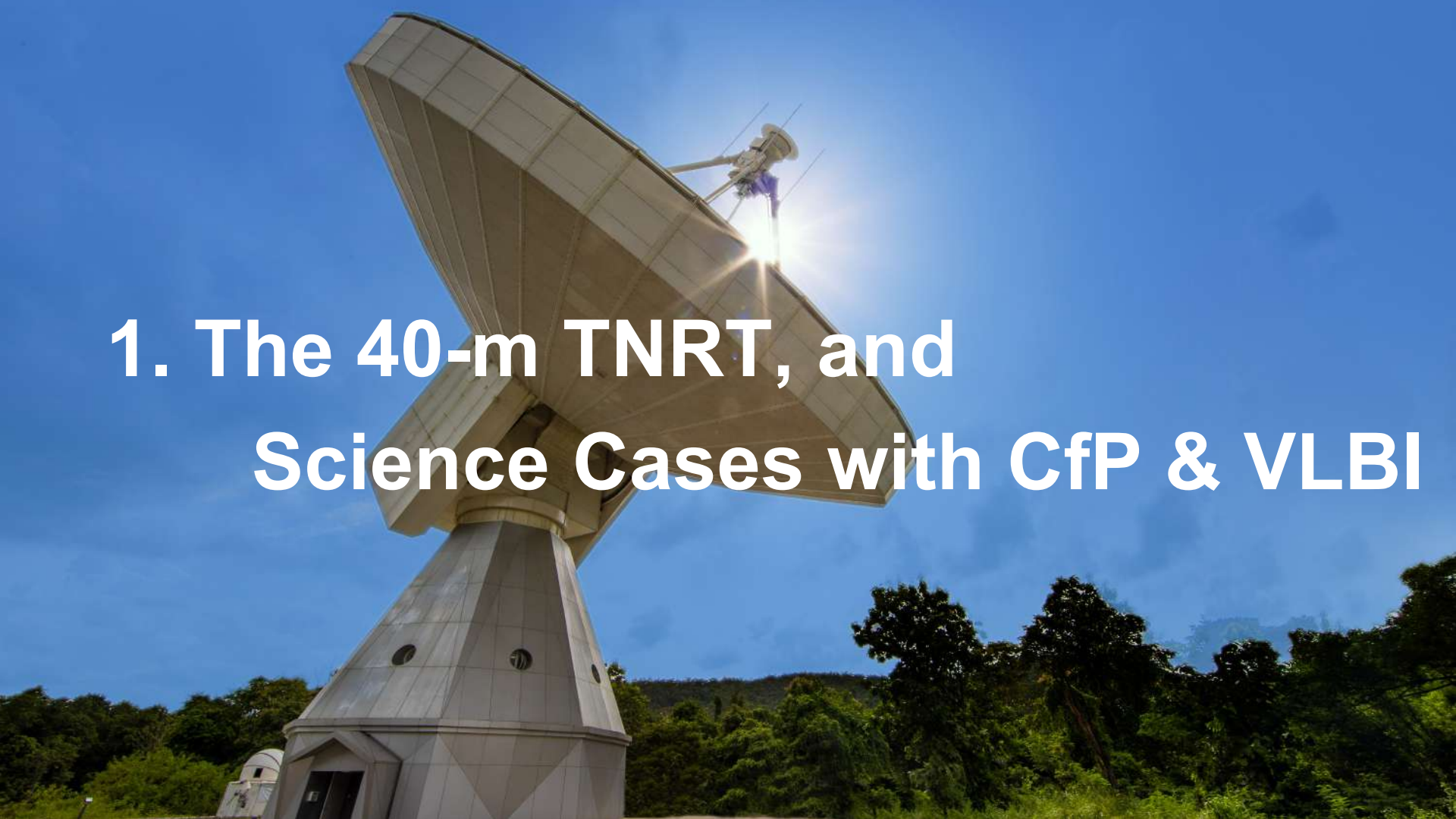
Speaker: KS

22 June 2023, Credit: นายศิวรุต พลอยแดง (ดราฟ), CAEP

*members who participate in this 16th EVN Symp.

Acknowledgement

- International Technical Advisory Committee (ITAC) members:
  - Hideyuki Kobayashi (Chair, NAOJ), Busaba H. Kramer (Secretariat, MPIfR/NARIT), Do-Young Byun (KASI), Francisco J. Colomer (JIVE, retired) ➔ Agnieszka Slowikowska (JIVE, new), Michael Garrett (JBCA), Yashwant Gupta (NCRA), Mareki Honma (NAOJ), Kee-Tae Kim (KASI), Jinling Li (SHAO), Zhiqiang Shen (SHAO), Tasso Tzioumis (CASS), Pablo de Vicente (IGN), & Gundolf Wieching (MPIfR).
- International Scientific Advisory Committee (ISAC) members:
  - Michael Bode (Chair, BIUST), Busaba H. Kramer (Secretariat, MPIfR/NARIT), Hideyuki Kobayashi (NAOJ), & Michael Kramer (MPIfR).
- Special thanks to Yebes Observatory, MPIfR, JBCA, and SHAO for constructing the TNRT and VGOS with its receivers developments!



1. The 40-m TNRT, and Science Cases with CfP & VLBI

Thai National Radio Astronomy Observatory

Thailand © NordNordWest in Wikipedia

- 40 km away toward NE from NARIT head quarters
- Site is a part of Huai Hong Khrai Royal Development Study Center
- Radio Quiet Zone: less RFI, & Relatively lower water vapor area

Image credit: P. Jaroenjittichai & TNRO/CROE members (NARIT)

The 40 m Thai National Radio Telescope (TNRT)

L-band
(1.0-1.8 GHz)

K-band
(18-26.5 GHz)

Gundolf
©LinkedIn

"Upgraded" version of IGN's Yebes 40-m Radio Telescope

With Prime-Focus Tetrapod Head Unit (THU)

0.3 – 115 GHz : **P/L/C/X/Ku/K/Q/W**-bands

150 um (rms) total surface accuracy

Beam size: 13.4 arcsec – 1.43 degree

Pointing: 2" (no wind), 6" (5 m/s wind)

Slew: AZ 3 deg/s, EL 1 deg/s

YEBES

White Paper for TNRT

Sciences with Thai National Radio Telescope

arXiv: arXiv:2210.04926 on 12 Oct 2022

Editors

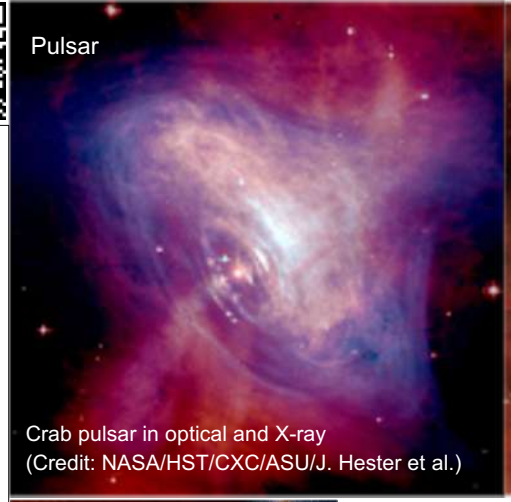
Jaroenjittichai, Phrudth [1,*], Sugiyama, Koichiro [1,2], Kramer, H. Busaba [3,1], and Soonthornthum, Boonrucksar [1]

Authors

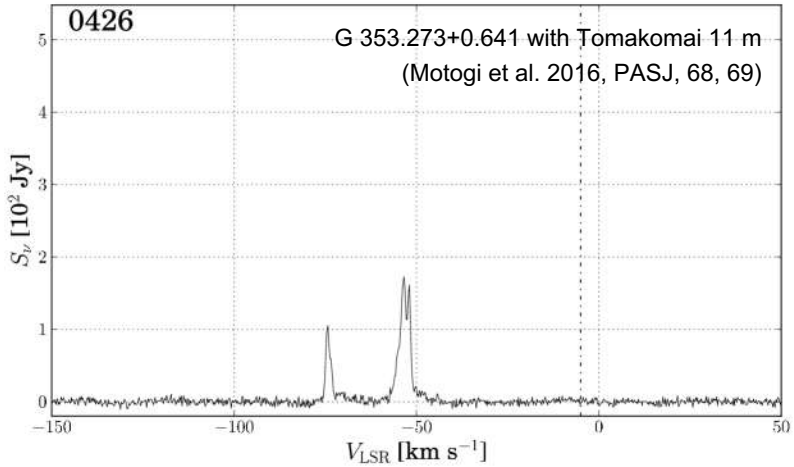
Akahori, Takuya [2,4], Asanok, Kitiyanee [1], Baan, Willem [5], Bran, Sherin Hassan[1,6], Breen, L. Shari [7], Cho, Se-Hyung [8], Chanapote, Thanapol [1], Dodson, Richard [9], Ellingsen, P. Simon [10], Etoka, Sandra[11], Gray, D. Malcolm[1,11], Green, A. James[12], Hada, Kazuhiro [13], Halson, Marcus[1], Hirota, Tomoya [2], Honma, Mareki [13], Imai, Hiroshi [14], Johnston, Simon [12], Kim, Kee-Tae [8], Kramer, Michael [3,11], Li, Di [15], Macatangay, Ronald[1], Menten, M. Karl [3], Minh, Young Chol [8], Mkrtichian, David [1], Pimpanuwat, Bannawit [11], Richards, M.S. Anita [11], Rioja, Maria [9,16,17], Rujopakarn, Wiphu [1,18], Sakai, Daisuke [13,1], Sakai, Nobuyuki [1,8], Samanso, Nattida[1], Sanpa-arsa, Siraprapa[1], Semenko, Eugene [1], Sunada, Kazuyoshi [13], Surapipith, Vanisa[1], Thoonsaengngam, Nattaporn[1], Voronkov, A. Maxim [12], Wongphecauxson, Jompoj [3], Yadav, Ram Kesh[1], Zhang, Bo [19], Zheng, Xing Wu[20] and Poshyachinda, Saran[1]

Pulsar / FRB / GW / SFR / Galaxy / AGN / ES / CP stars / Geodesy, & Forecasting system

[1] National Astronomical Research Institute of Thailand (Public Organization), 260 Moo 4, T. Donkaew, A. Maerim, Chiang Mai, 50180, Thailand
[2] Mizusawa VLBI Observatory, National Astronomical Observatory of Japan (NAOJ), Mitaka, Tokyo 181-8588, Japan
[3] Max Planck Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
[4] SKA Observatory, Jodrell Bank, Lower Withington, Macclesfield, Cheshire SK11 9FT, UK
[5] Netherlands Institute for Radio Astronomy ASTRON, 7991PD Dwingeloo, the Netherlands
[6] Environmental Science Research Center, Faculty of Science, Chiang Mai University, Chiang Mai, 50200, Thailand
[7] Sydney Institute for Astronomy (SIfA), School of Physics, University of Sydney, NSW 2006, Australia
[8] Korea Astronomy and Space Science Institute, 776 Daedeok-daero, Yuseong, Daejeon 34055, Republic of Korea
[9] International Centre for Radio Astronomy Research, M468, University of Western Australia, 35 Stirling Highwaym Perth 6009, Australia
[10] School of Natural Sciences, University of Tasmania, Private Bag 37, Hobart, Tasmania 7001, Australia
[11] Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, M13 9PL, UK
[12] Australia Telescope National Facility, CSIRO Space and Astronomy, PO Box 76, Epping NSW 1710, Australia
[13] Mizusawa VLBI Observatory, NAOJ, 2-12 Hoshigaoka, Mizusawa, Oshu, Iwate 023-0861, Japan
[14] Amanogawa Galaxy Astronomy Research Center, Graduate School of Science and Engineering, Kagoshima University, 1-21-35 Korimoto, Kagoshima 890-0065, Japan
[15] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China
[16] CSIRO Astronomy and Space Science, 26 Dick Perry Avenue, Kensington WA 6151, Australia
[17] Observatorio Astronómico Nacional, Alfonso XII, 3 y 5, 28014 Madrid, Spain
[18] Department of Physics, Faculty of Science, Chulalongkorn University, 254 Phyathai Road, Patumwan, Bangkok Thailand. 10330
[19] Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, China
[20] School of Astronomy and Space Sciences, Nanjing University, Nanjing 210093, China
*E-mail: phrudth@narit.or.th



Time-Domain Sciences with TNRT



High-cadence & Long-term Monitoring

【Pulsar】

by P. Jaroenjittichai, T. Akahori, R. Dodson, M. Rioja, J. Wongphecauxson, N. Intrarat, et al.

- Monitor known pulsars for unknown variability
- Monitor for known variable sources
- Multi-freq. astronomy for Giant Radio Pulse
- (Statistical parallax measurement)
- (Transverse vel. measurement toward Magnetar)

et al. …

Illustration of beamed pulsar ©Olena Shmahalo

【Fast Radio Burst】

by T. Akahori, P. Jaroenjittichai, S. Sanpa-arsa, et al.

- Polarized FRB High-precision Understanding by K-band Experiments with TNRT (PHUKET)
  - Long-term monitoring for linear pol. in K-band
  - Every month
  - Time-dependence of the pol. angle and the rotation measure

2nd repeating FRB with CHIME ©Danielle Futselaar

【Star Formation】

by K. Sugiyama, B.H. Kramer, M.D. Gray, J.A. Green, et al.

- Periodic & Bursting multi-species maser daily/Intraday flux/pol. monitor
- Address accretion mechanism
- Fundamental Maser physics

et al. …

Orion-KL Source-I ©ALMA (ESO/NAOJ/NRAO)

【Evolved Stars】

by S. Etoka, A.M.S. Richards, H. Imai, B. Pimpanuwat, M.D. Gray

- Distance by Phase-lag measure
- Find the shape / drive of winds
- Unveil episodic events
- Evolution of the Water Fountain
- SiO & stellar continuum detection

et al.

Artist's impression of water fountain ©Danielle Futselaar, artsource.nl.

【CP Stars】

by E. Semenko & D. Mkrtichian

- Unveil coherence in Optical & Radio
- Address CP Mag.
- Intraday monitor
- Flux, followed by multi-freq. & pol.

Artist's illustration of cataclysmic binary system ©M.Weiss/Center for Astrophysics | Harvard & Smithsonian

Unbiased / Deep Sky Survey

【Pulsar】

by P. Jaroenjittichai, J. Wongphecauxson, N. Intrarat, T. Akahori, et al.

- Blind / Piggyback search
- Address Emission physics
- (Statistical parallax measurement)

et al...

Artist's conception of ngVLA. Credit: Sophia Dagnello, NRAO/AUI/NSF

【Masers】

by K. Asanok, S. Breen, K. Sugiyama, N. Sakai, J.A. Green, et al.

- Northern survey for the Milky Way Galaxy
- Multi-species: OH, CH_3OH, H_2O, SiO, H_2CO, +
- Statistical discussion without any biases
  - How many sources present characteristic var.
  - How long last such var. phenomena
- Machine learning to clarify highly-prior areas

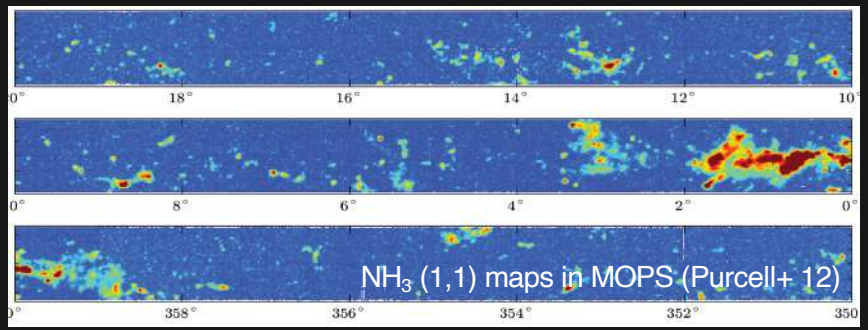
Artist's impression of the Sagittarius Stream. Credit: ESA

【Astrochemistry】

by T. Hirota, R.K. Yadav, B.H. Kramer, K. Sugiyama, et al.

- Northern survey of NH_3 for the Milky Way Galaxy
- Survey of long chains and aromatic molecules
  - Glycine (NH_2CH_2COOH), simplest amino acids
- Pilot survey for the next-gen.'s instruments
  - Synergy with ngALMA, SKA, ngVLA, etc.
- Long-integration by stacking all data in monitor
  - OH in L-, H_2CO / CH_3OH in C/Ku-, H_2O in K-bands

Credit: ALMA, NRAO



Call for Proposals: 40-m Thai National Radio Telescope, Cycle 0 (Resident Shared Risk Observing)

10 October 2023 to 30 November 2023
UTC timezone

Announced on 10th October 2023, 10 TST

Single-dish, Spectrometer in L-band: 1.63-1.67 GHz

Completed this season Jan-Jul 2024!

https://indico.narit.or.th/event/197/

Contact
tnrtprop@narit.or.th

TNRO / 40-m TNRT

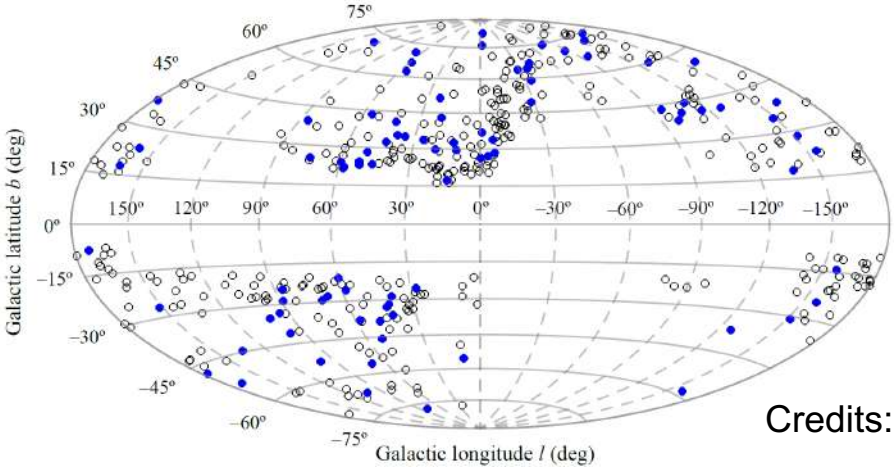
Photo 1-1: (Left) Chiang Mai, (Middle) Sketch of the TNRO site in Huai Hong Khrai Royal Development Study Centre, and (Right) the 40-m TNRT.

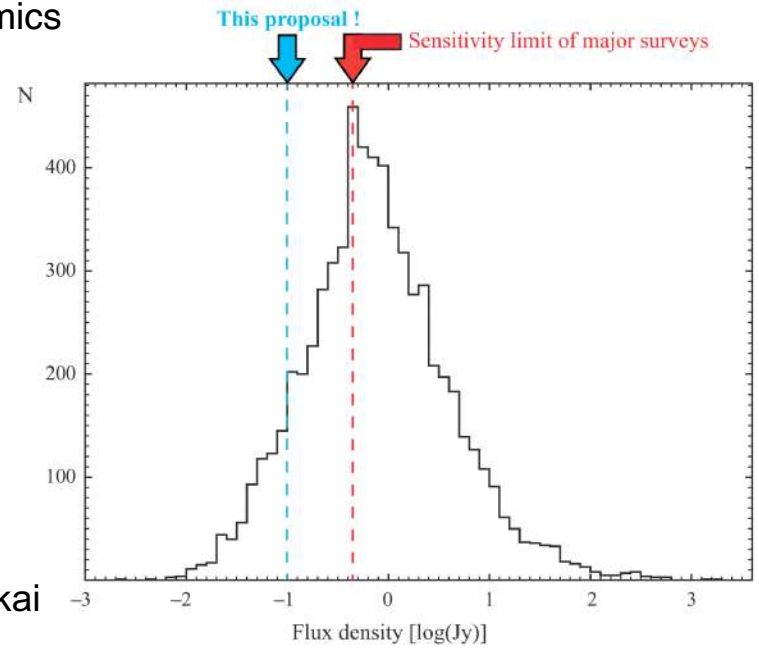
National Astronomical Research Institute of Thailand (NARIT, Public Organization) has established the Thai National Radio Astronomy Observatory (TNRO) in Huai Hong Khrai Royal Development Study Centre, Doi Saket District, Chiang Mai, in the northern part of Thailand 2018, which is 40 km away from NARIT headquarters in the North-East direction. This project was strongly motivated by the importance of the development by ourselves to achieve an empyreal goal of "*Capacity building through radio astronomy and geodesy*" via constructing national radio telescopes in Thailand. This construction has provided precious opportunities to develop engineering / technical / instrumental skills, its technology, unique sciences achieved with these telescopes, and essential experiences on the basis of collaboration with world-wide colleagues at the world-class facilities, as well as contribute to education via cultivating potential young astronomers, engineers, and geodesists. Given a radio quiet zone

Deep sky target survey of AGB OH masers at the Galactic off-plane

TNRT-CfP0_ID7: Nobuyuki Sakai, K. Sugiyama, Y. Wu, J.-H. Kim, H. Imai, A. Nakagawa

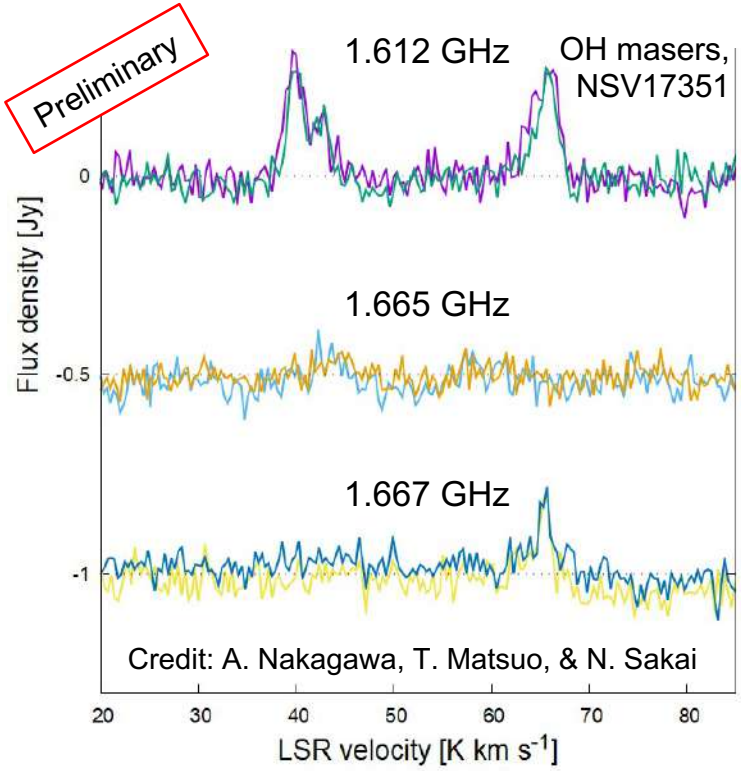
- Objectives: Statistical research of host AGBs & 3-D dynamics
- Target: > 400 sources (oxygen-rich AGB stars)
- Method: 1) Detection/Non-det.; 2) New radial vel. info





Credits: N. Sakai

Success of RSRO Style in Cycle 0: TNRT-CfP0_ID5 – Akiharu Nakagawa, et al.



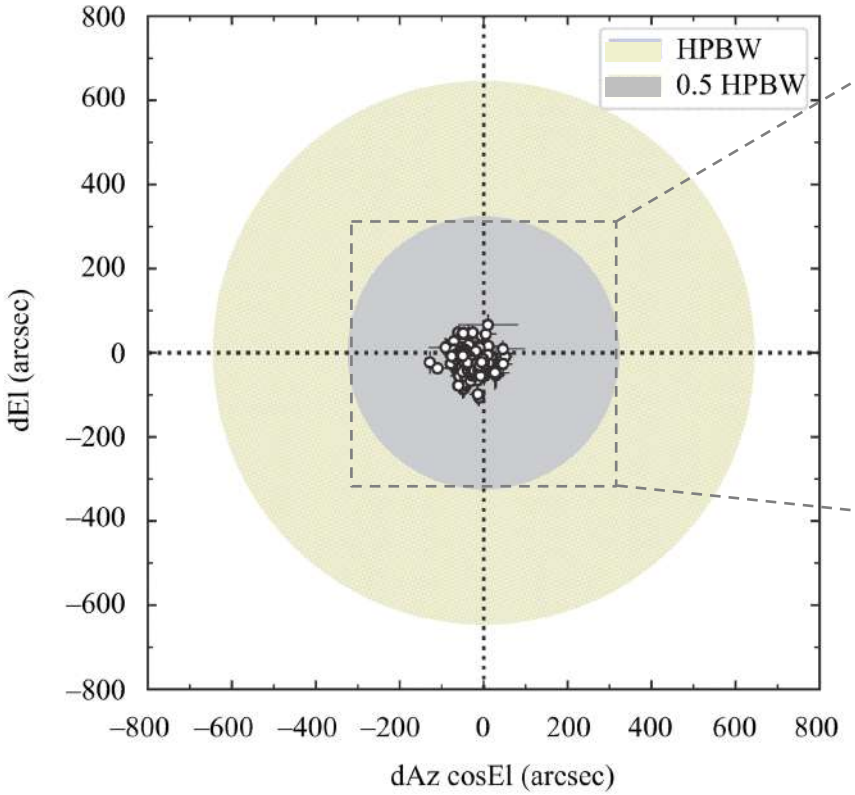
Detected with TNRT!!

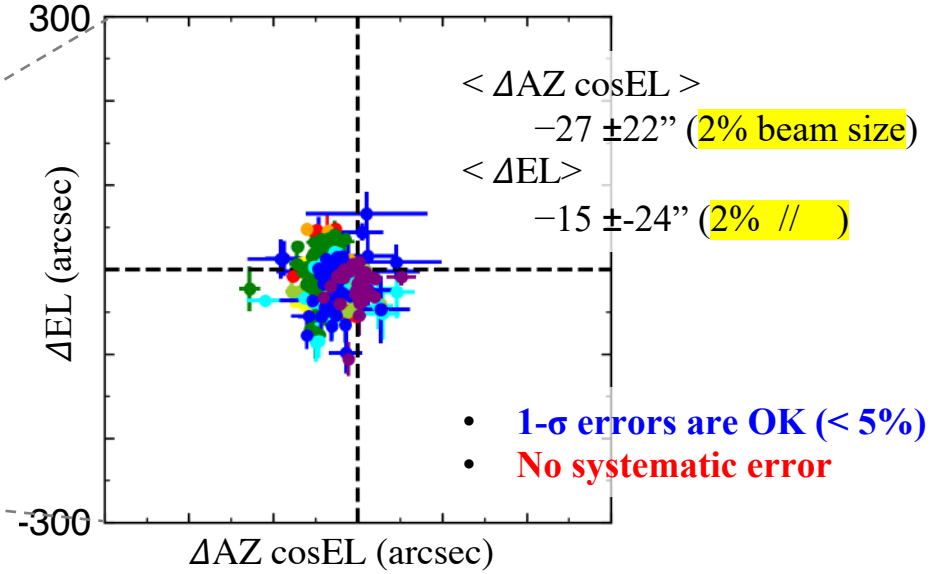
For the 1st time in the last 40 yrs,

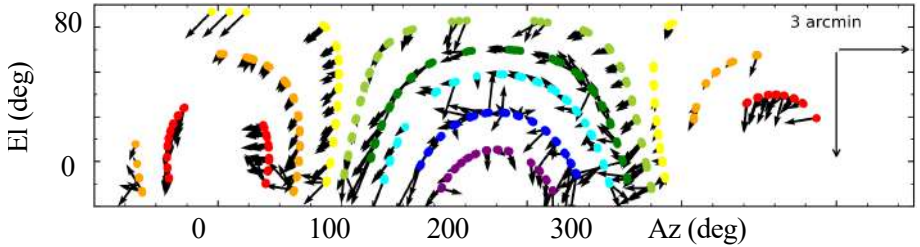
To validate mass transfer / acceleration

Slide Credit: Nobuyuki Sakai (NARIT)

Completed the L-band pointing, by Aug 28, 2024



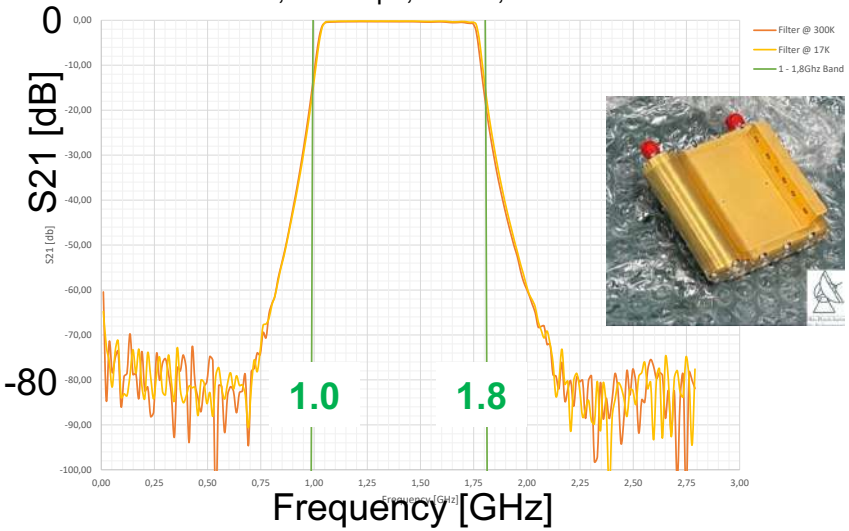




Upgraded the L-band receiver with MPIfR

- Gundolf Wieching, Christoph Kasemann, et al. in MPIfR have produced high-/low-pass filters for TNRT: 30 dB attenuate in 1.75-1.85 GHz, & 80 dB attenuate at max
  - Mitigate the RFI monster (1.805–1.845 GHz), & Cancel intermodulation due to RFI from out-band
- Completed installation in the mid-Nov 2023, with Christoph & Rafael (MPIfR)

Credit: Gundolf, Christoph, Rafeal, et al. in MPIfR



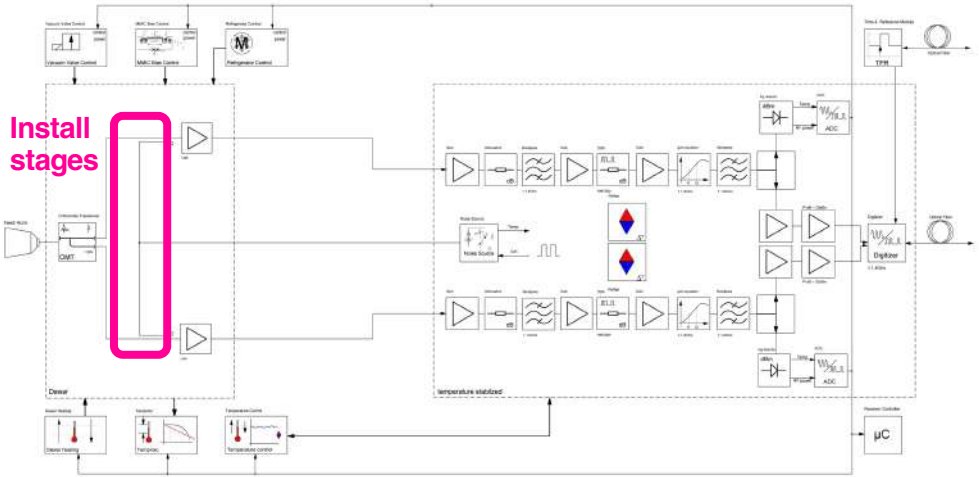
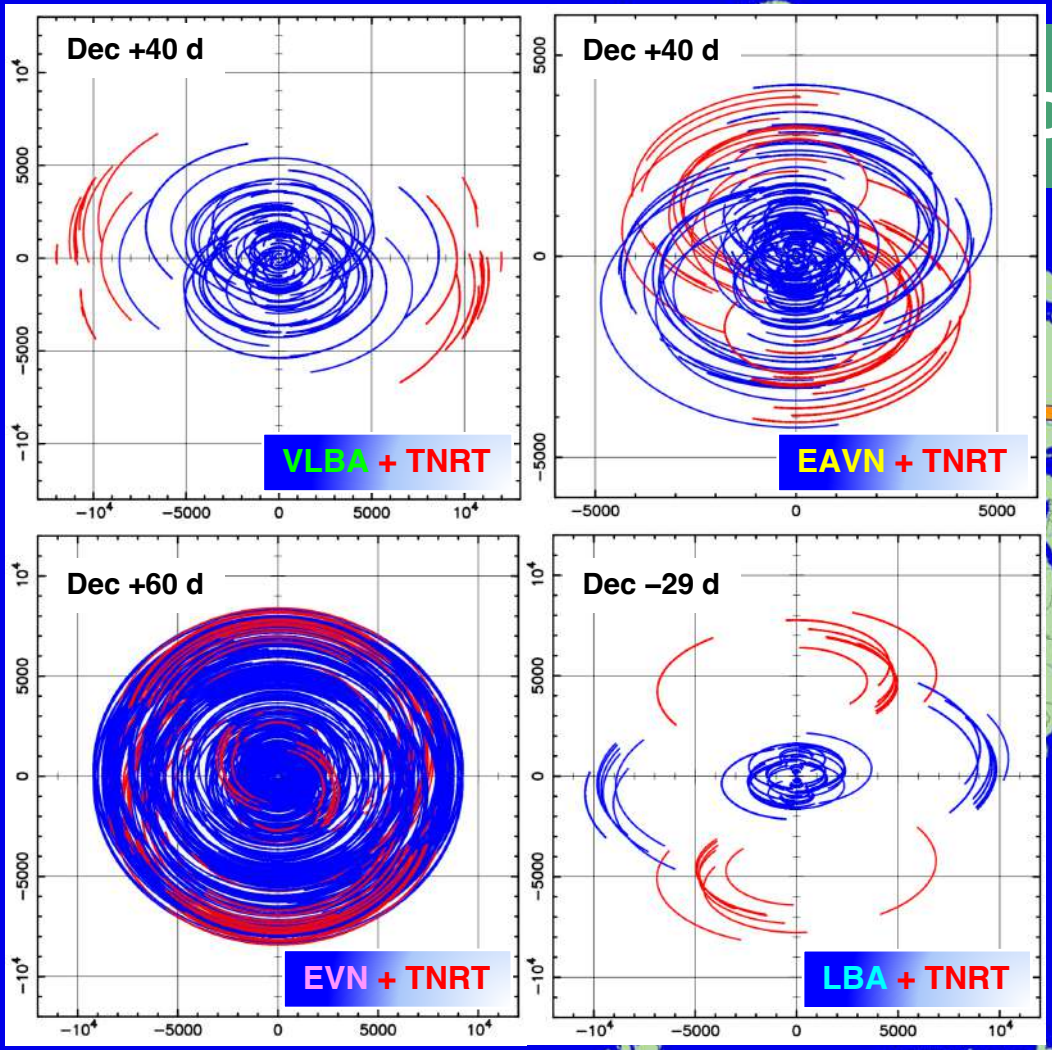


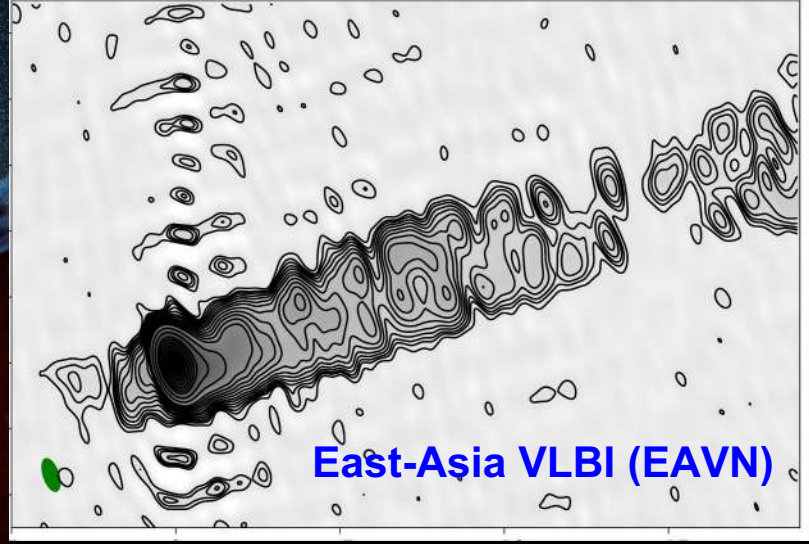
Diagram in the L-band receiver box ©Christoph Kasemann, MPIfR

World-wide Collaborations for VLBI

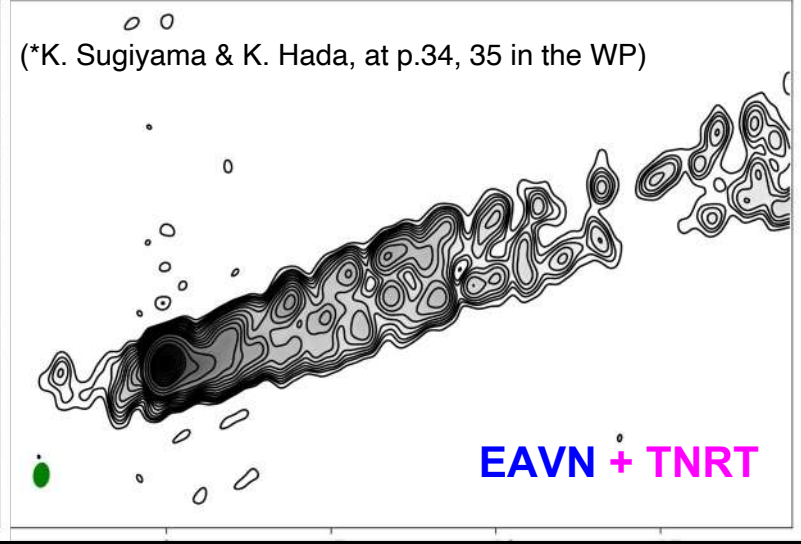
ons for VLBI


Dec +40 d
VLBA + TNRT
Dec +40 d
EAVN + TNRT
Dec +60 d
EVN + TNRT
Dec –29 d
LBA + TNRT

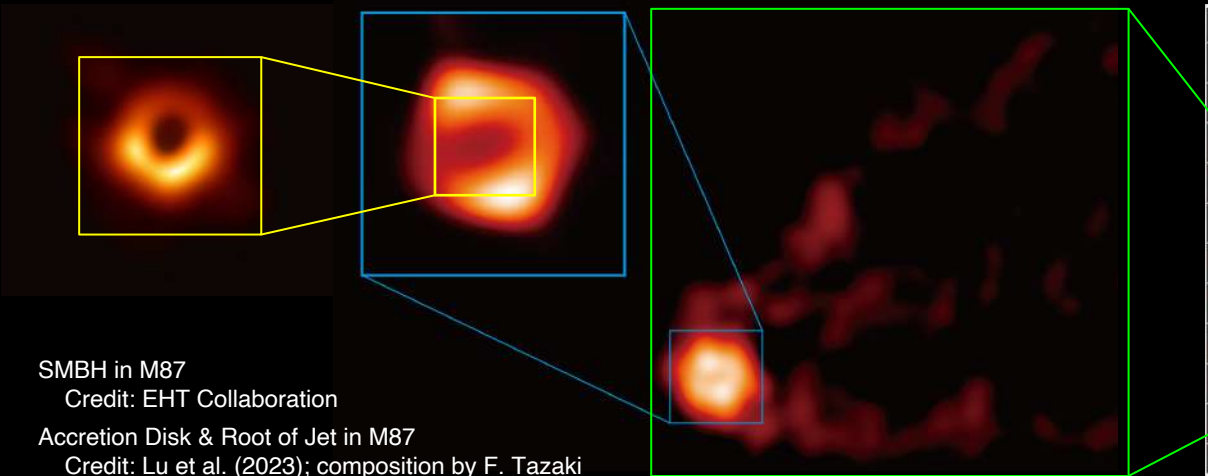

VLBA
EAVN
EVN
LBA
GMRT
TNRT
©NARIT, TNRO, RAOC
in K-band
Image credit of background world-map:
Illust AC



(*K. Sugiyama & K. Hada, at p.34, 35 in the WP)

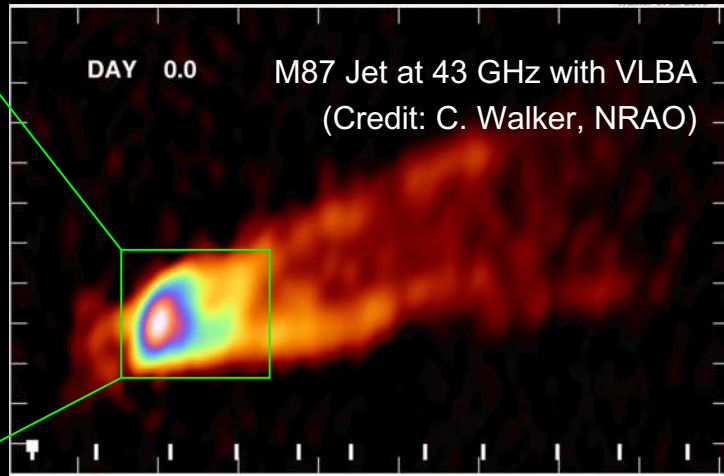


Simulated results of VLBI obs case towards Active Galactic Nucleus M87 at 22 GHz in K-band.



SMBH in M87
Credit: EHT Collaboration

Accretion Disk & Root of Jet in M87
Credit: Lu et al. (2023); composition by F. Tazaki



p.58-61 in the WP

EVN + TNRT: Baseline Lengths / Sensitivities & UV simulations

L-band

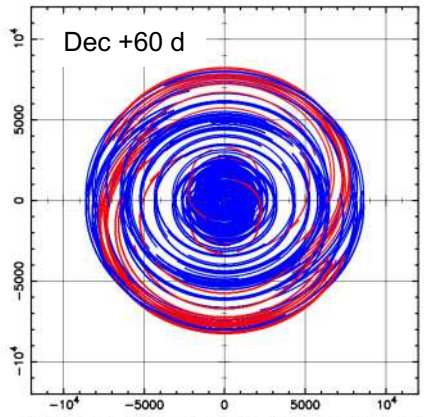
	Bd	Cm	Ef	Hh	Jd	Mc	Nt	On	Sr	Sv	T6	Tr	Ur	Wb	Zc	TNRT
B[illegible]		6139	5930	9833	6156	6087	6418	5272	6549	4282	2748	5200	1452	5786	4405	3620
C			510	8309	198	1205	2056	958	1573	2029	8392	1253	5957	455	3156	8250
E				8042	700	757	1644	832	1238	1804	8203	853	5652	267	2687	7935
Hn	4.2	3.0	1.0		8442	7453	6713	8525	7061	8697	10157	8108	8853	8239	7355	8388
Jd	1.9	1.4	0.4	1.4		1402	2248	1012	1757	2082	8418	1388	6028	600	3310	8334
Mc	7.8	5.7	1.9	6.1	2.7		894	1429	593	2140	8284	1078	5631	1002	2368	7777
Nt	8.0	5.8	1.9	6.2	2.8	11.7		2280	581	2809	8473	1818	5781	1891	2360	7697
On	5.2	3.8	1.2	4.0	1.8	7.6	7.8		1992	1080	7645	637	5119	602	2538	7561
Sr	2.4	1.8	0.6	1.9	0.8	3.5	3.6	2.3		2718	8652	1666	6030	1502	2697	8031
Sv	5.6	4.1	1.3	4.3	1.9	8.1	8.4	5.4	2.5		6759	1071	4127	1634	2015	6713
T6	1.8	1.3	0.4	1.4	0.6	2.7	2.8	1.8	0.8	1.9		7550	3245	8088	6579	2593
Tr	5.1	3.7	1.2	4.0	1.8	7.4	7.6	4.9	2.3	5.3	1.8		4875	800	1971	7261
Ur	5.1	3.7	1.2	4.0	1.8	7.4	7.6	4.9	2.3	5.3	1.8	4.9		5566	3586	2926
Wb	7.0	5.1	1.7	5.4	2.4	10.1	10.4	6.8	3.1	7.3	2.4	6.6	6.6		2727	7899
Zc	5.1	3.7	1.2	4.0	1.8	7.4	7.6	4.9	2.3	5.3	1.8	4.9	4.9	6.6		5769
TNRT	2.6	1.9	0.6	2.0	0.9	3.8	3.9	2.5	1.2	2.7	0.9	2.5	2.5	3.4	2.5	

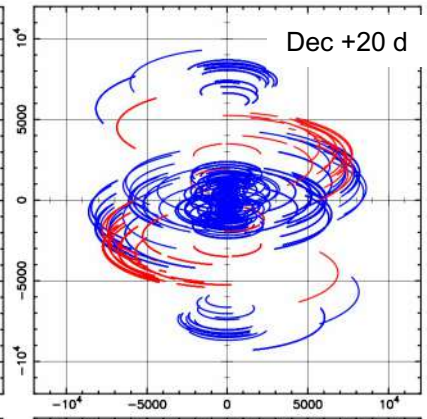
Baseline sensitivity as 5σ [mJy]: $\Delta\nu = 512$ MHz, $t = 120$ sec, 2-bit sampling

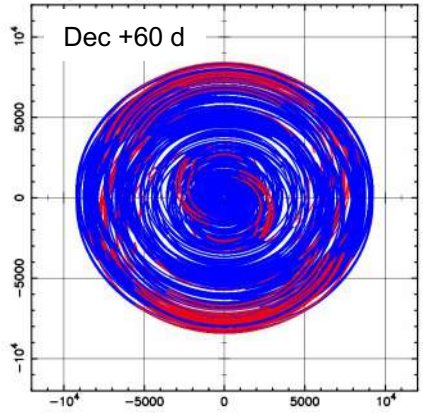
K-band

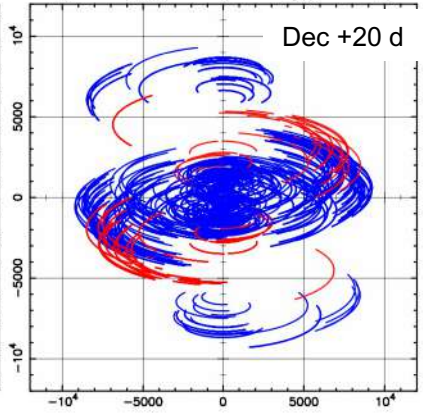
	Bd	Cm	Ef	Hh	Jd	KVY	KVU	KVT	Mc	Mh	Nt	On	Sr	Sv	T6	Tr	Ur	Ys	Zc	TNRT
B[illegible]				9833	6156	2479	2777	2810	6087	4552	6418	5272	6549	4282	2748	5200	1452	7080	4405	3620
C				8309	198	8133	8359	8429	1205	1737	2056	958	1573	2029	8392	1253	5957	1314	3156	8250
E				8042	700	7988	8221	8272	757	1535	1644	832	1238	1804	8203	853	5652	1352	2687	7935
H				8442	10583	10659	10482	7453	8673	6713	8525	7061	8697	10157	8108	8853	7492	7355	8388
Jd	26.1	26.2	8.2	41.5		8140	8364	8442	1402	1788	2248	1012	1757	2082	8418	1388	6028	1412	3310	8334
KVY	30.0	30.2	9.4	47.8	34.0		305	476	8150	6738	8430	7378	8552	6500	894	7353	3360	8994	6589	3381
KVU	29.1	29.3	9.2	46.4	33.0	38.0		358	8382	6091	8655	7620	8776	6757	901	7599	3632	9206	6843	3461
KVT	28.7	28.9	9.0	45.8	32.5	37.5	36.4		8401	7056	8640	7689	8784	6818	558	7639	3530	9246	6798	3437
Mc	22.9	23.0	7.2	36.4	25.9	29.8	28.9	28.5		1935	894	1429	593	2140	8284	1078	5631	1285	2368	7777
Mh	44.1	44.4	13.9	70.2	49.9	57.5	55.9	55.1	43.8		2661	784	2519	299	7004	868	4408	2869	2151	6959
Nt	24.4	24.6	7.7	38.9	27.7	31.9	30.9	30.5	24.3	46.8		2280	581	2809	8473	1818	5781	1616	2360	7697
On	29.9	30.1	9.4	47.6	33.9	39.0	37.9	37.4	29.7	57.3	31.8		1992	1080	7645	637	5119	2153	2538	7561
Sr	10.1	10.2	3.2	16.2	11.5	13.2	12.8	12.7	10.1	19.4	10.8	13.2		2718	8652	1666	6030	1057	2697	8031
Sv	23.0	23.2	7.2	36.6	26.1	30.0	29.1	28.7	22.9	44.1	24.4	29.9	10.1		6759	1071	4127	3130	2015	6713
T6	8.6	8.7	2.7	13.7	9.8	11.3	10.9	10.8	8.6	16.5	9.2	11.2	3.8	8.6		7550	3245	9168	6579	2593
Tr	19.3	19.5	6.1	30.8	21.9	25.2	24.5	24.1	19.2	37.0	20.5	25.1	8.5	19.3	7.2		4875	2139	1971	7261
Ur	16.5	16.6	5.2	26.2	18.7	21.5	20.9	20.6	16.4	31.6	17.5	21.4	7.3	16.5	6.2	13.8		6735	3586	2926
Ys	12.2	12.3	3.8	19.5	13.8	15.9	15.5	15.3	12.1	23.4	13.0	15.9	5.4	12.2	4.6	10.3	8.7		3614	8756
Zc	23.0	23.2	7.2	36.6	26.1	30.0	29.1	28.7	22.9	44.1	24.4	29.9	10.1	23.0	8.6	19.3	16.5	12.2		5769
TNRT	15.1	15.3	4.8	24.1	17.1	19.8	19.2	18.9	15.0	29.0	16.1	19.7	6.7	15.1	5.7	12.7	10.8	8.0	15.1	

Baseline sensitivity as 5σ [mJy]: $\Delta\nu = 512$ MHz, $t = 30$ sec, 2-bit sampling

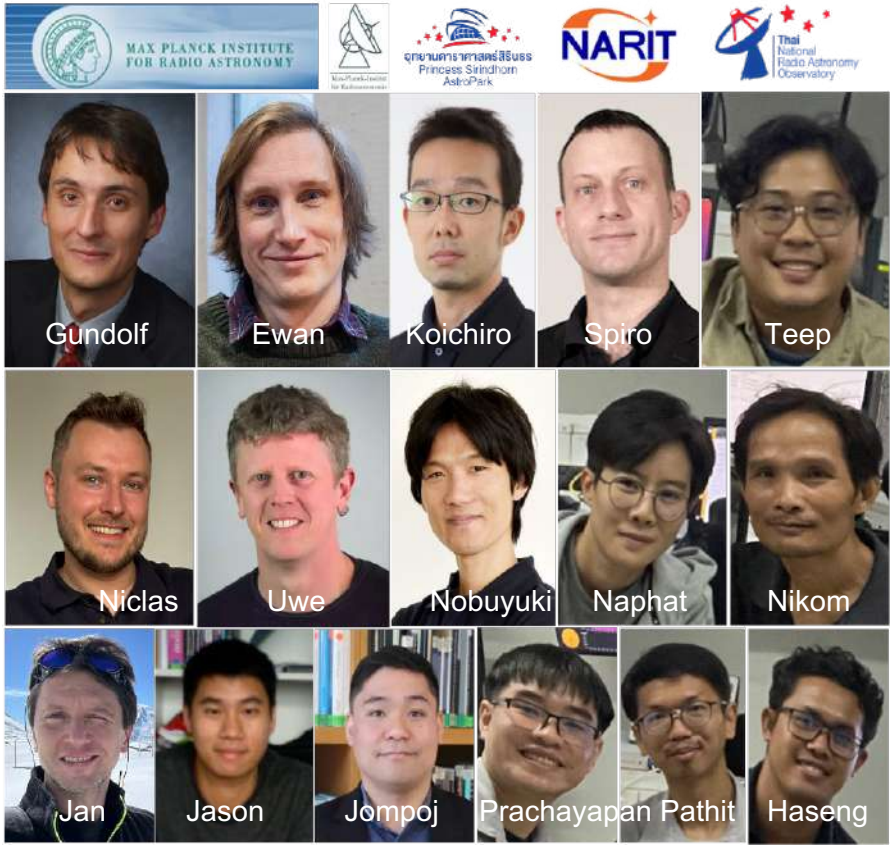








The 1st VLBI Fringe Detection of TNRT with Effelsberg 100m in L-band, 16th May 2024: 1.658-1.674 GHz



Task force members for this trial

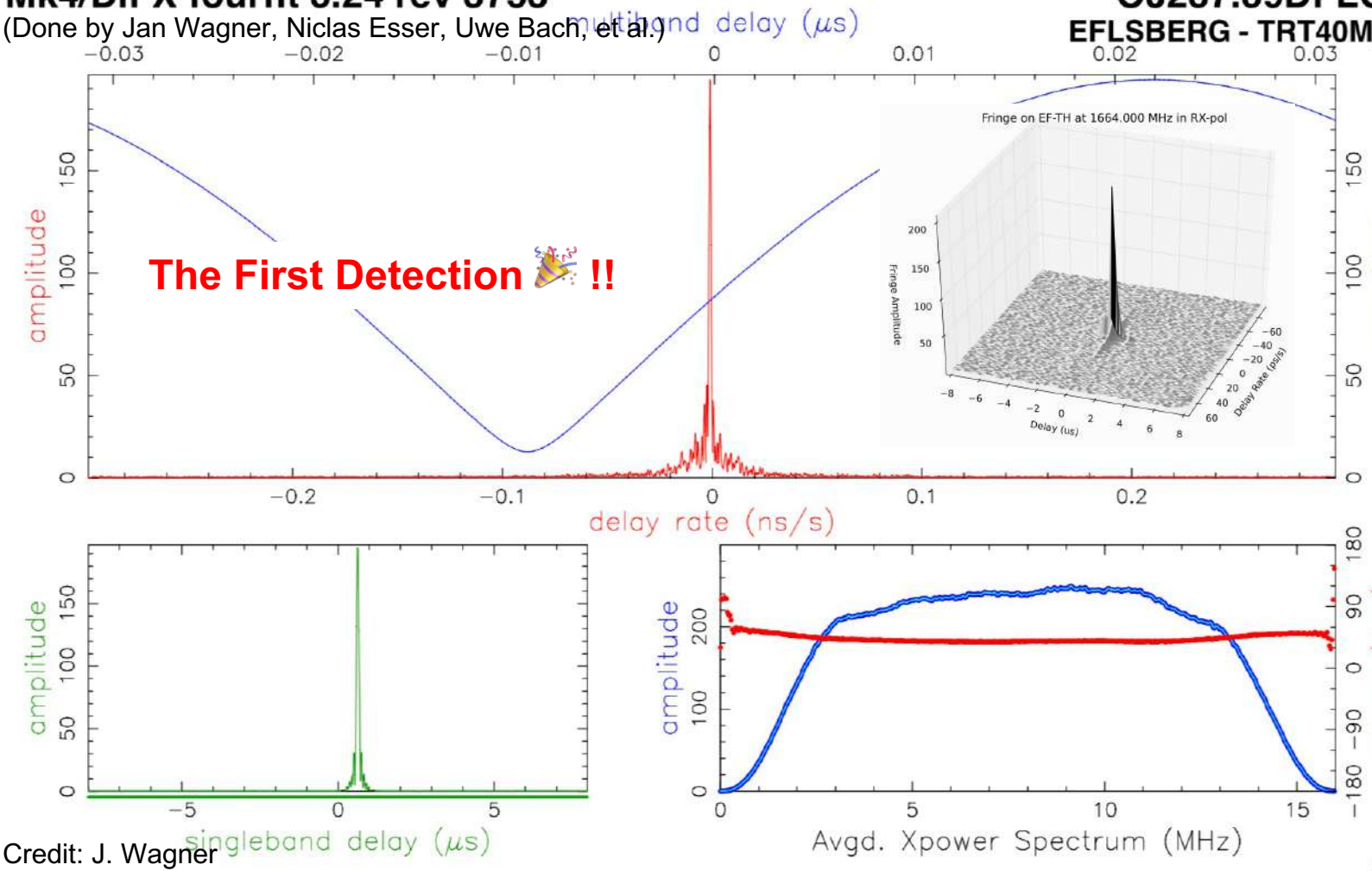
L-band, Linear/Circular pol., Continuums, on 16th May 2024
Baseline: ~8,500 km = 4.4 mas in 1.658-1.674 GHz
Backend: TNRT - EDD & Effelsberg - EDD & DBBC3/Mark6

Mk4/DiFX fourfit 3.24 rev 3753

(Done by Jan Wagner, Niclas Esser, Uwe Bach, et al.)

OJ287.39DFLO, No0009, BT

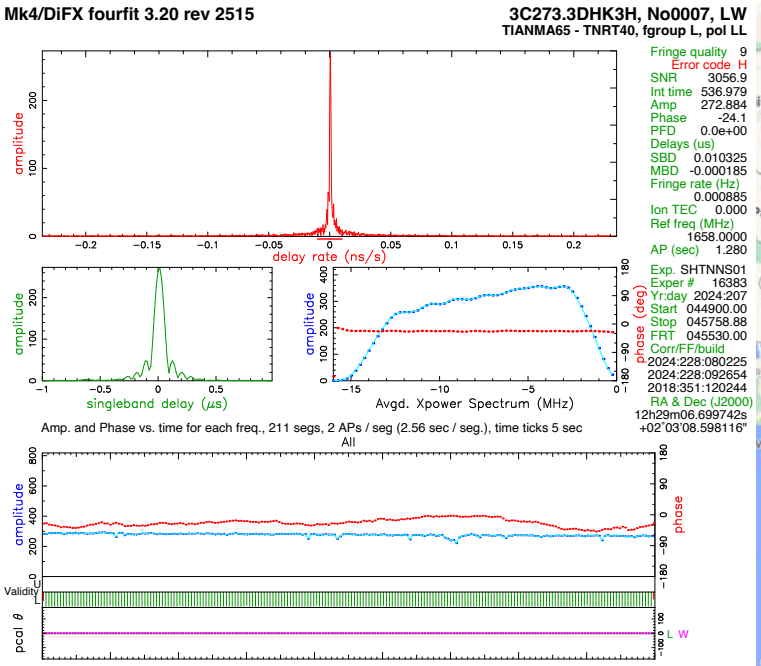
EFLSBERG - TRT40M, fgroup L, pol LX



Fringe quality	8
SNR	3214.1
Int time	569.948
Amp	196.931
Phase	-3.0
PFD	0.0e+00
Delays (us)	
SBD	0.632300
MBD	0.022609
Fringe rate (Hz)	
	-0.001995
Ion TEC	0.000
Ref freq (MHz)	
	1642.0000
AP (sec)	1.024
Exp.	trt516
Exper #	1234
Yr:day	2024:137
Start	152500.00
Stop	153430.37
FRT	152945.00
Corr/FF/build	
	2024:148:091905
	2024:148:092210
	2023:348:201250
RA & Dec (J2000)	
	08h54m48.874928s

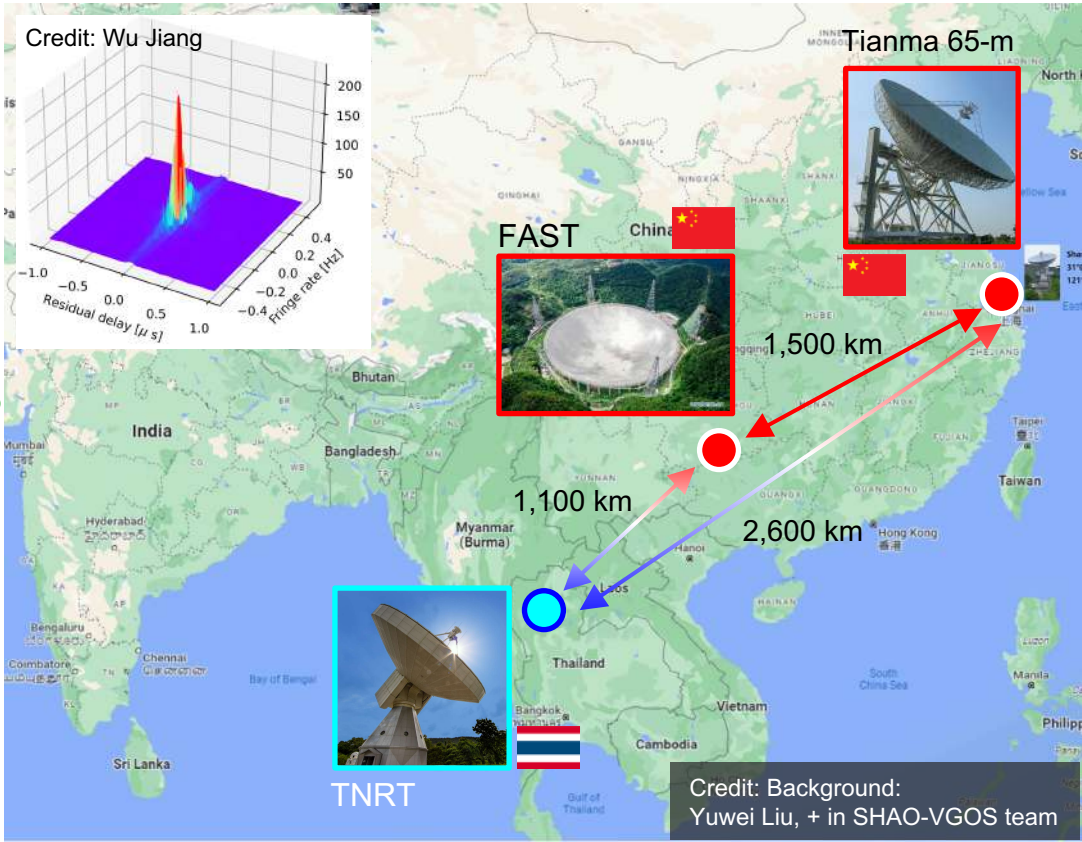
Credit: J. Wagner

Continuous VLBI experiments with CVN



Tianma/SHAO – TNRT/NARIT , 25 July 2024

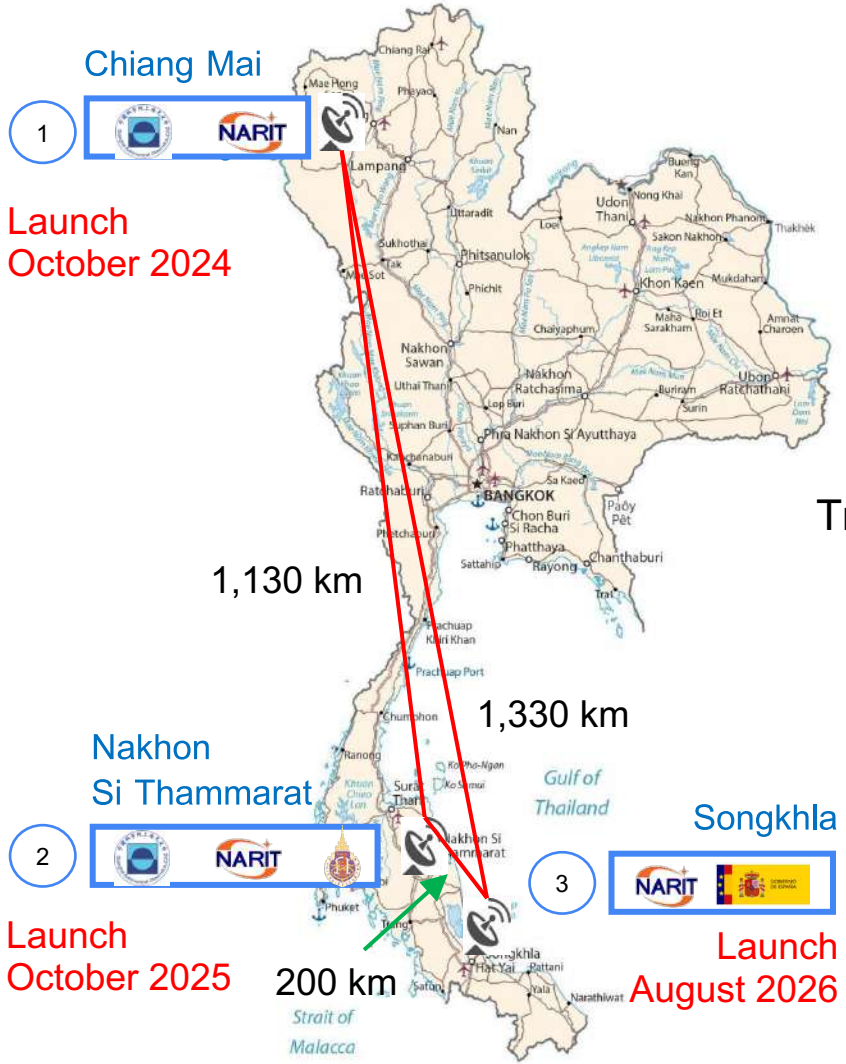
Credit: Wu Jiang, Zhiqiang Shen (SHAO, CAS), et al.



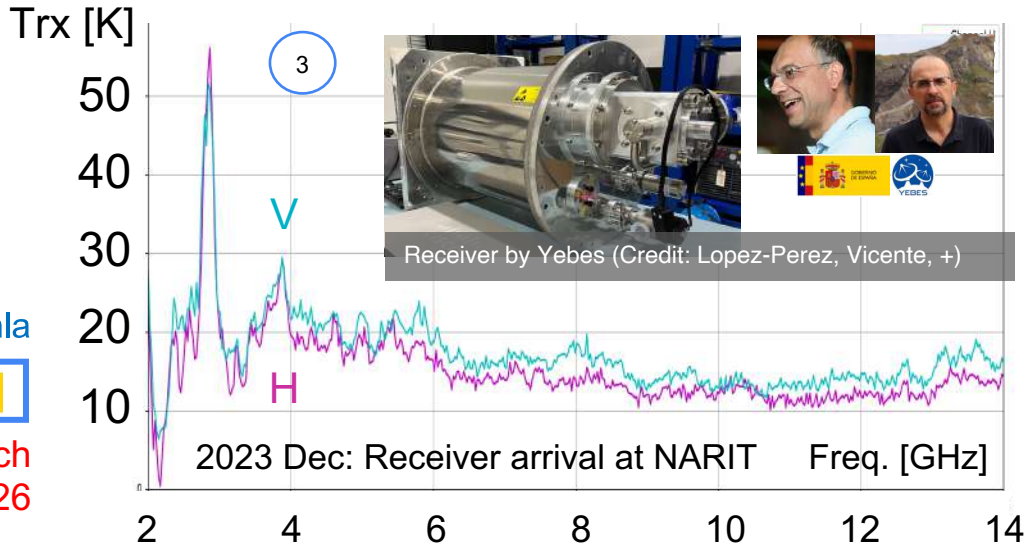
2. VGOS Radio Telescopes



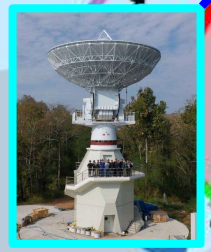




Chiang Mai
1
NARIT
Launch
October 2024
1,130 km
1,330 km
Nakhon
Si Thammarat
2
NARIT
Launch
October 2025
200 km
Gulf of
Thailand
Strait of
Malacca
Songkhla
3
NARIT
Launch
August 2026
BANGKOK


1
2024 JAN
Big Lift
2024 AUG
1st Firinge!
Prof. Z. Shen, Prof. J. Li
SHAO
NARIT
NARIT


Trx [K]
50
40
30
20
10
3
V
H
Receiver by Yebes (Credit: Lopez-Perez, Vicente, +)
2023 Dec: Receiver arrival at NARIT
Freq. [GHz]
2
4
6
8
10
12
14

Address Two Unique Tectonic Plates



Chiang Mai

Nakorn Si Thammarat & Songkhla

Persia-Tibet-Burma Orogeny

Yangtze Plate

Eurasian Plate

Indian Plate

Philippine Sea Plate

Philippines Orogeny

Ninety East-Sumatra Orogeny

Australian Plate

36 15 54 71 17 84 92 70 57 11 15 44 70

Background Credit: Alataristarion, Wikipedia

3. Vision for the Future of TNRO in Thailand and Southeast Asia

Vision for TNRO Project in Thailand & Regional VLBIs

【Construction】

- Big Lift
- Assembly System
- AZ/EL Movement

Big Lift Movie:
https://youtu.be/_wmFGBUDjiw

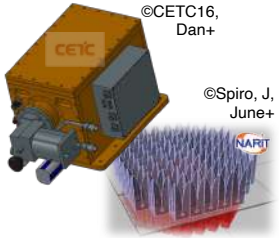
2020 ~ 2021

【Installation】

- L/K-band receivers
- Ku Holography

2022 ~ 2023

【Upgrade】



- Upgrade L-band with MPIfR (Gundolf, Christoph, +)
- Develop & Install C/X/Ku-bands receiver
- Prototype L-band PAF
- Designing Q/W-bands receiver

2024 ~ 2025

【VGOS stations】

- VGOS Building
  - Chiang Mai & Songkhla
- Develop Receivers
- Commissioning

2025 ~ 2026

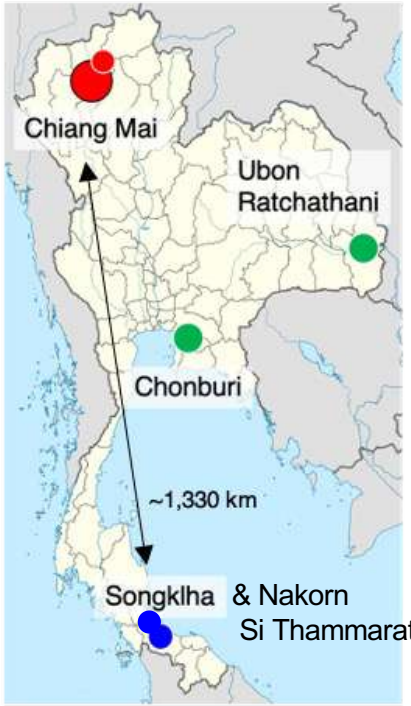
2026 ~ 2027

【Establish Regional VLBI Networks】

- Thai National VLBI Array
- South-East Asia VLBI Network

Vision for the Future: **Thai National VLBI Array (TVA)**

in C/X/Ku/K-bands, 2026 (?) ~



Chiang Mai (เชียงใหม่)

40-m TNRT

13-m VGOS

Songkhla (สงขลา), 13-m VGOS
Nakorn Si Thammarat VGOS

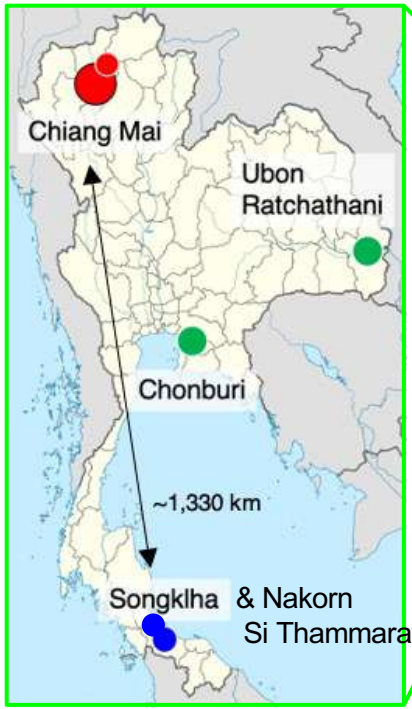
Chonburi (ชลบุรี)
& Ubon Ratchathani (อุบลราชธานี)
(*funding proposal)

32-m telescopes

VLBA DiFX correlator
Credit: Walter Brisken (NRAO)

Vision for the Future: **South-East Asian VLBI Network**

in C/X/Ku/K-bands, 2027 (?) ~



Background © NordNordWest in Wikipedia

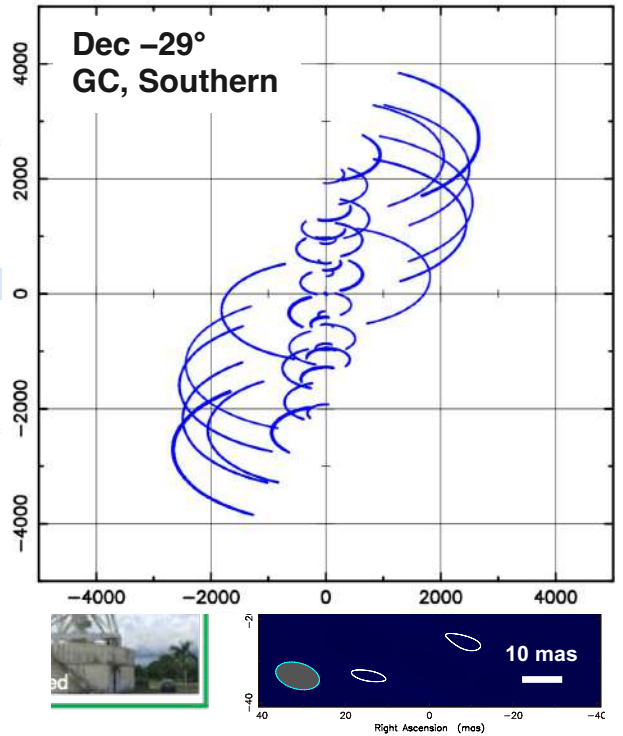
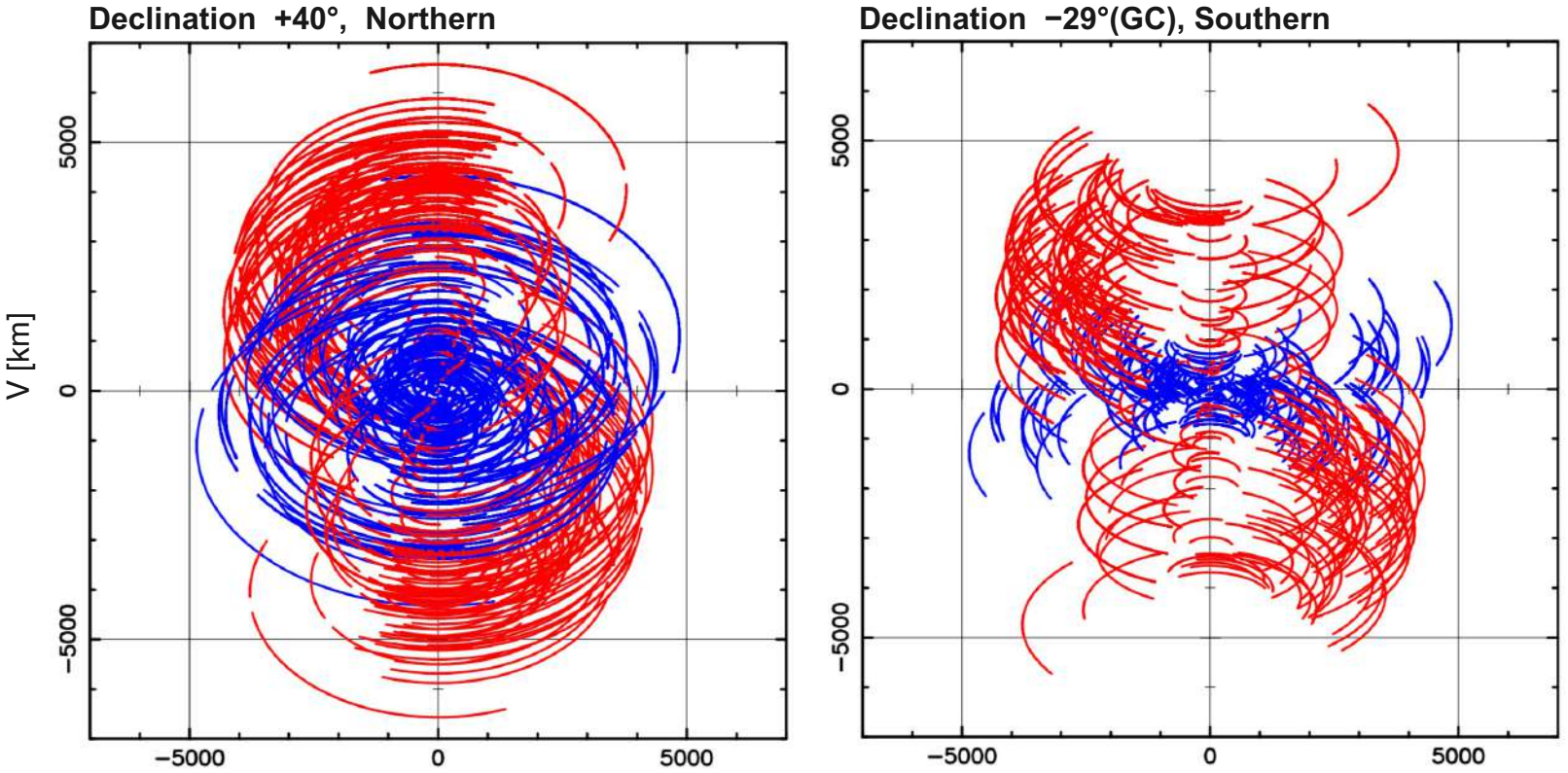


Image Credit: EAVN, Reto Stockli (NASA Earth Observatory), & NARIT / ITB / Univ. of Malaya

Jatiluhur 32-m
©T. Hidayat, I. N. Huda+ in EAVW21

UV-coverage : EAVN + SEAVN in K-band: ngEAVN??

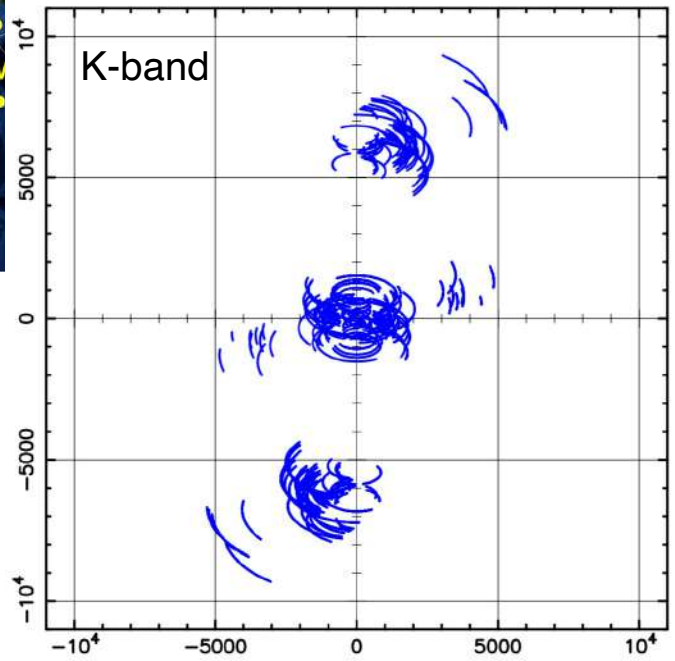


Reboot of Asia-Pacific Telescope (APT)

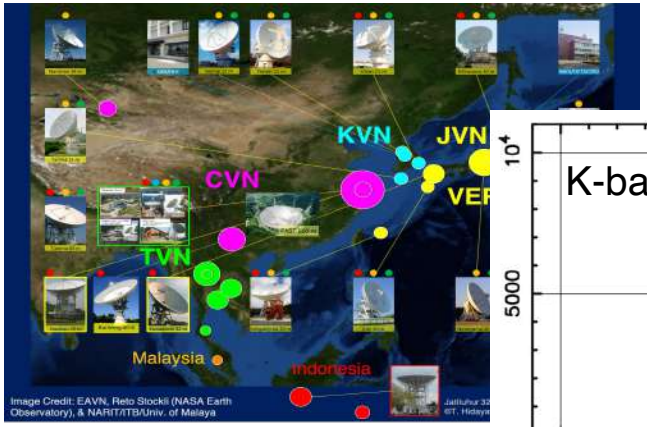
EAVN + LBA

Sgr A* (GC) = **Asia-Pacific Telescope (APT)**

(since ~1990 yrs:
JAXA/ISAS, CSIRO, NAOJ, etc)



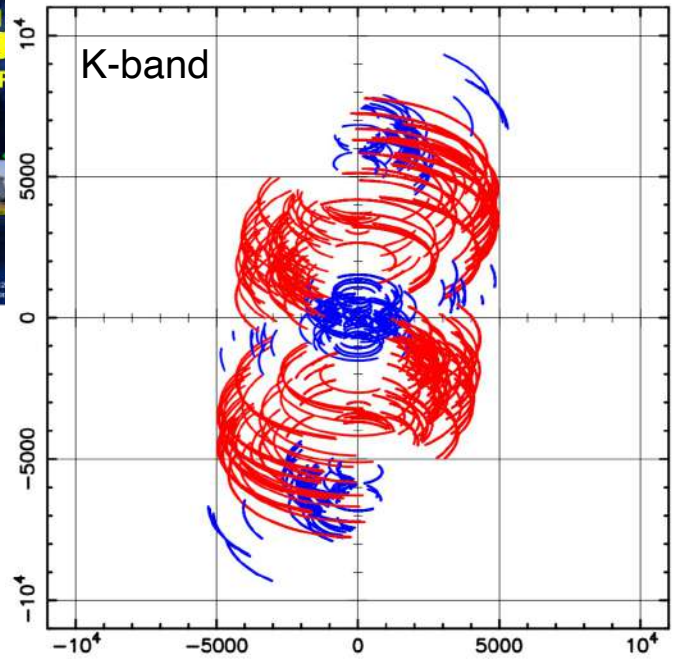
Reboot of Asia-Pacific Telescope (APT)



EAVN + LBA **+ SEAVN**

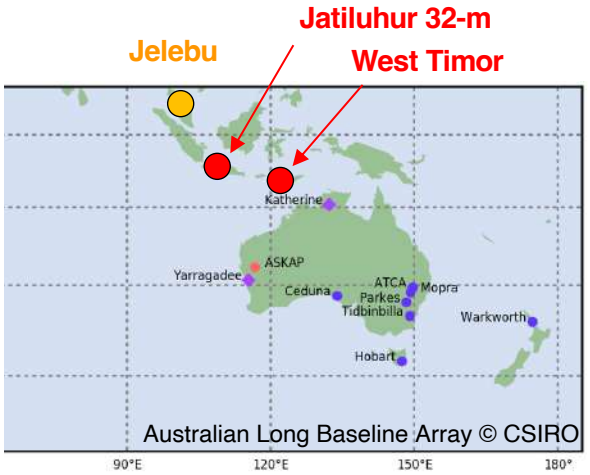
= **Asia-Pacific Telescope (APT)**

Sgr A* (GC)



(since ~1990 yrs:

JAXA/ISAS, CSIRO, NAOJ, etc)



➔ Accelerate

Global VLBI Alliance

(Colomer, Kobayashi, Slowikowska, et al.)

with **EVN/JIVE** !!

Thank you / Danke!

40-m Thai National Radio Telescope
©D. Singwong, N. Thoonsaengngam,
& NARIT / TNRO / CROE

European VLBI Network
©EVN-HP: evlbi.org

East-Asian VLBI Network
©EAVN, Reto Stockli (NASA Earth Observatory), & NARIT/ITB/Univ. of Malaya

Southern Long Baseline Array
©Brian Boyle/CSIRO/IRASR