


Towards high-performance mm-VLBI science operations with multi-band receivers
28-31 October 2025 / Bologna, Italy

Development of Radio Astronomy Infrastructure in Thailand: The Thai National Radio Telescope (TNRT) and Beyond

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

Bannawit "Bank" Pimpanuwat **Researcher / Commissioning Scientist**

On behalf of: TNRO colleagues and CRAE members at NARIT.

Slides credit: Koichiro Sugiyama

National Astronomical Research Institute of Thailand (Public Organization)

Since July 2024 ~

Center for Radio Astronomy and Engineering

Other Centers/Divisions/GPs

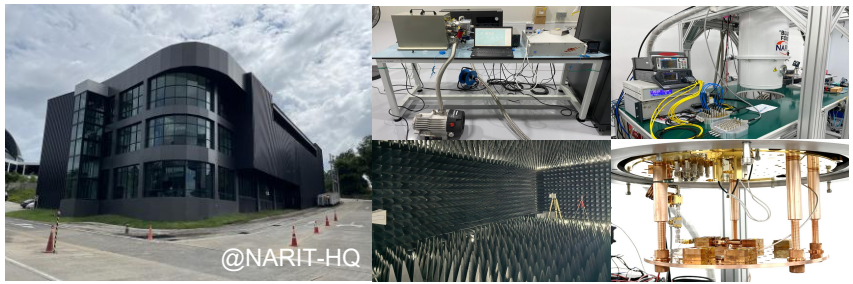
Thai National Radio Astronomy Observatory


Thai National Radio Telescope (TNRT) 40-m

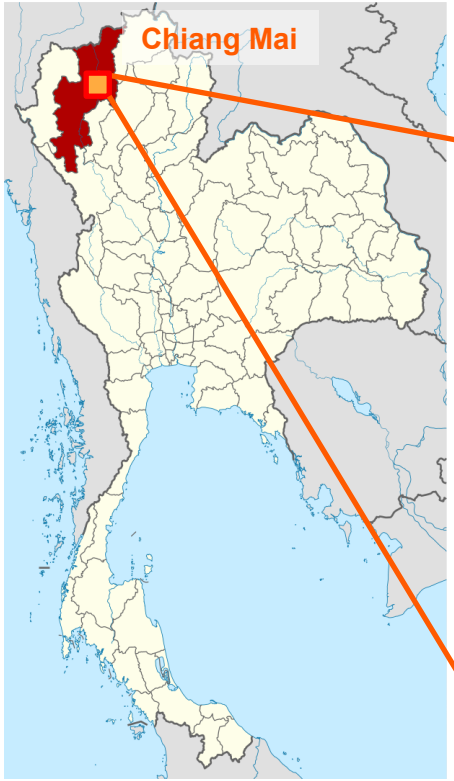

VGOS telescopes


VLBA DiFX correlator
Credit: W. Brisken (NRAO)

Advanced Radio Frequency Laboratory


@NARIT-HQ

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)

Big Lift in Feb 2020
Installed receivers in 2022

L-band
(1.0-1.8 GHz)

K-band
(18-26.5 GHz)

"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

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

Beam size: 13.4 arcsec – 1.43 degree

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

The 2nd Call for Proposals with TNRT, Cycle 1

Webpage:

- **Received 14, and Accepted 11 Proposals**
- What's new?
  - Upgraded spec. : Perfection of dynamic pointing tuning, & Mitigation of RFI impacts
  - Frequency range : 1.63 − 1.67 GHz ➔ **1.0 − 1.8 GHz**, full band in L-band
  - Polarizations : V ➔ **V & H** (* NOT "full-stokes of polarimetry" mode yet)
  - Observation modes : OH maser lines, Continuum, **+ 21-cm HI line** emissions
- Open-use hours : **1,000 hrs**
- Shared-risk observations: continuum, solar system objects
- Privilege for students, encouraging science proposals from youth!
- **Next cycle: announcement likely in December 2025**

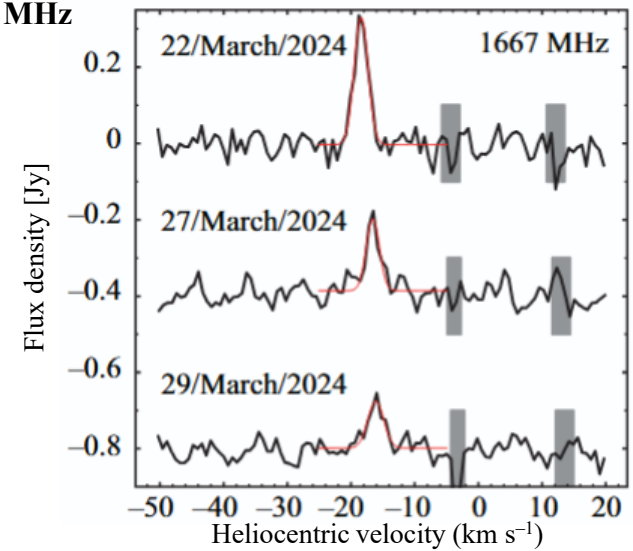
TNRT Cometary DataBase project

Slide Credit: N. Sakai

Planetary Science Journal* (Q1), *in press

12P/Pons-Brooks (a Halley-type comet)

OH radical (maser) both at 1665 & 1667 MHz



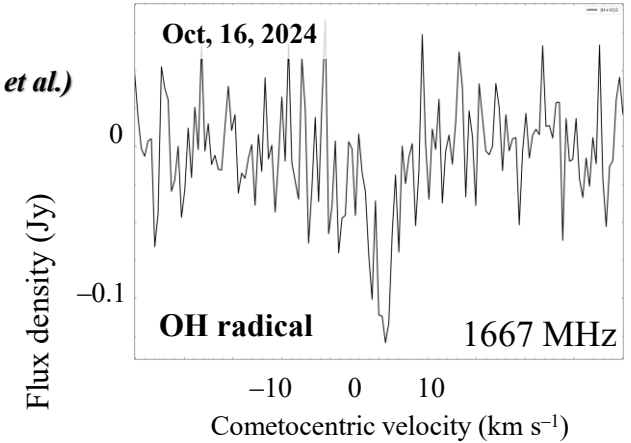
- Comets retain the information of solar system formation
- 1.6-GHz OH-radical observations of comets determine
  - **OH/Water production rate [s^{-1}] ($Q_{H_2O} \propto Q_{OH}$)**
  - **Expansion velocity of comet's atmosphere (coma)**

TNRT proposals:

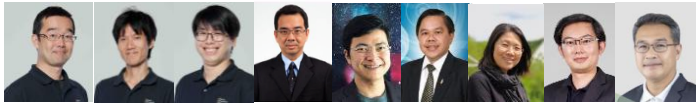
TNRTDDT_001 & 002

(Sakai, N., Poshyachinda, S., Sugiyama, K., Rujopakarn, W., Pimpanuwat, B., et al.)

C/2023 A3 (Tsuchinshan–ATLAS)



Commissioning:



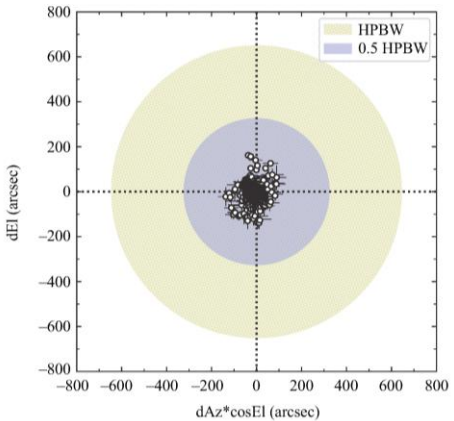
and TNRO team members

Status of the 40-m TNRT with the L-band system

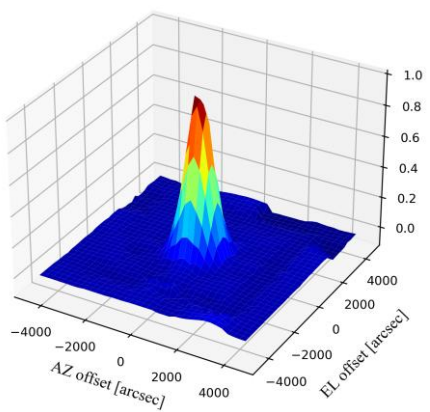
Koichiro Sugiyama, N. Sakai, B. Pimpanuwat, P. Jaroenjittichai, A. Leckngam, B. Soonthornthum, B. H. Kramer, W. Rujopakarn, …, and S. Poshyachinda, Astonomical Journal, in prep.

- Publish the commissioning result in L-band as performances at initial phase in a peer-reviewed paper
- Based on publicized information in the 2nd Call for Proposals: https://indico.narit.or.th/event/218/
  - Pointing, Beam-pattern, Aperture efficiency, NS temperature, Skyline & RFI bird's-eye, Linearity, Allan variance.

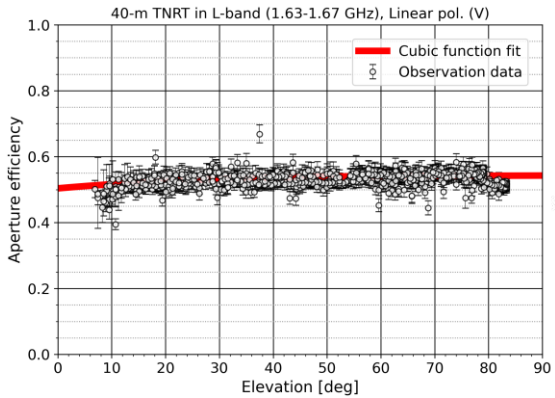
Latest Pointing (Credit: N. Sakai)



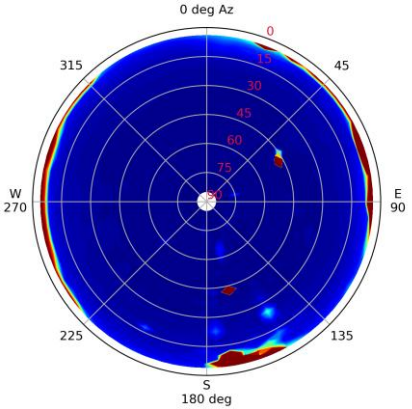
Beam-pettern



Aperture efficiency with EL dependence



Skyline bird's-eye view



Credit: 2nd CfP of the 40-m TNRT, Cycle 1 (https://indico.narit.or.th/event/218/

Commissioning: *Latest update on the K-band*

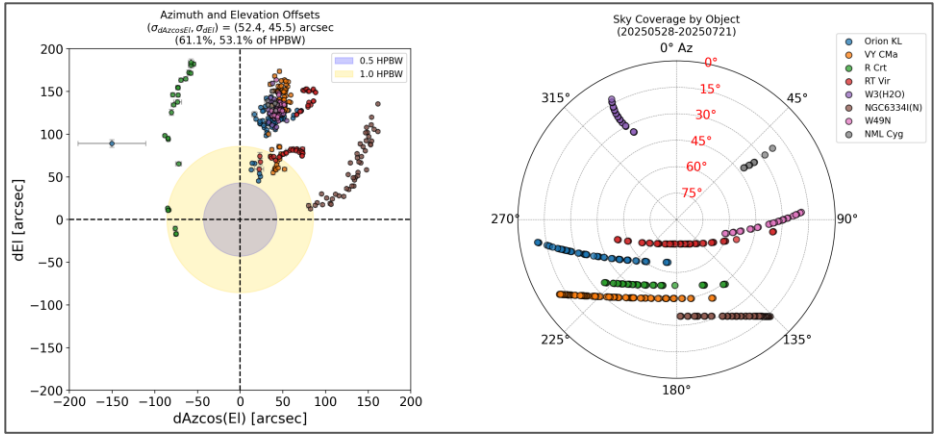
and TNRO team members

Preliminary results for:

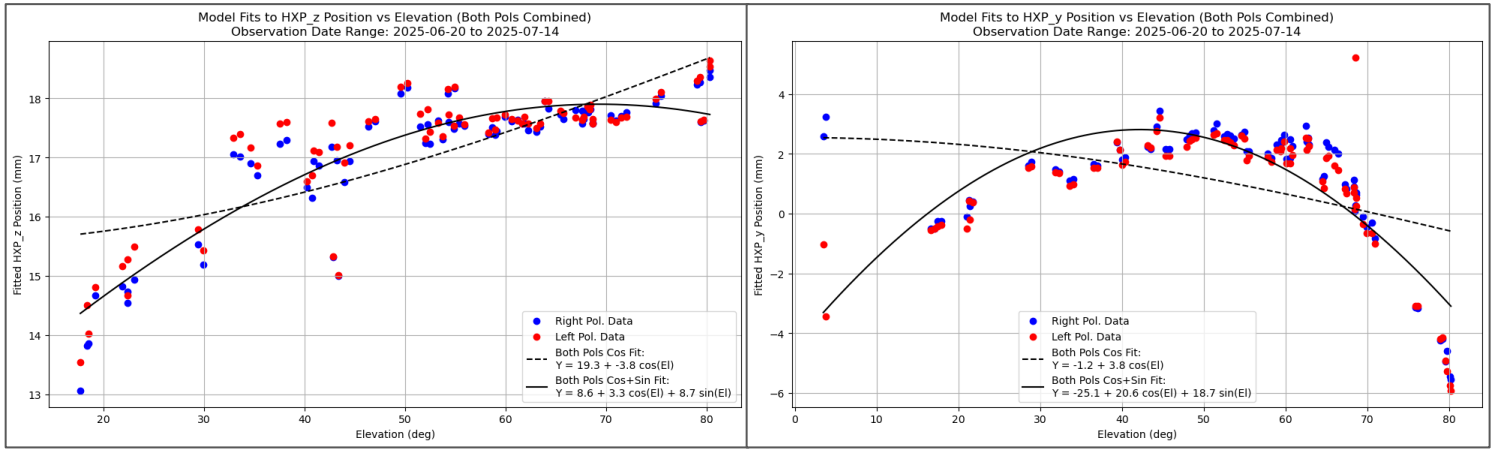
- Dynamic pointing
- Sub-reflector model in 2/5 axes

However, still need investigation on

- The above…
- Atmospheric refraction
- Hysteresis: El, sub-reflector offsets
- Etc.



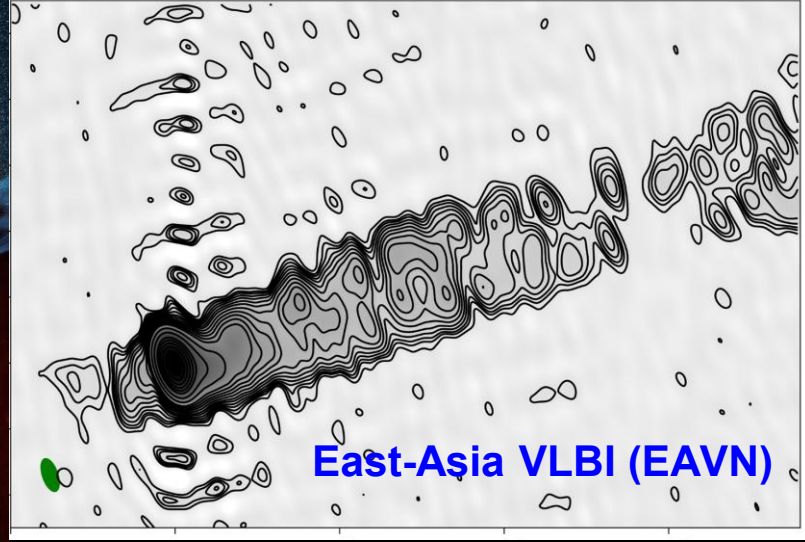
Plan to complete by the **end of 2026**



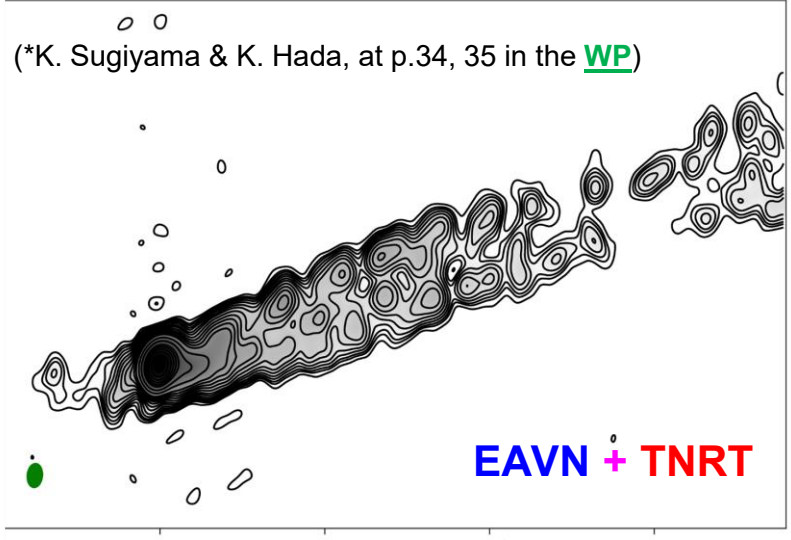

~8,500 km
VLBI Experiments with TNRT
Effelsberg Radio Telescope
(100-m)
Thai National Radio Telescope
(40-m)
NARIT
Amplitude
Delay (us)
Delay Rate (ps/s)
ก้าวไปอีกขั้น! กล้องโทรทรรศน์วิทยุแห่งชาติ
เชื่อมต่อกับกล้องของเยอรมนีด้วยเทคนิค VLBI
สำเร็จเป็นครั้งแรก
www.NARIT.or.th

Active Galactic Nuclei
(AGN)

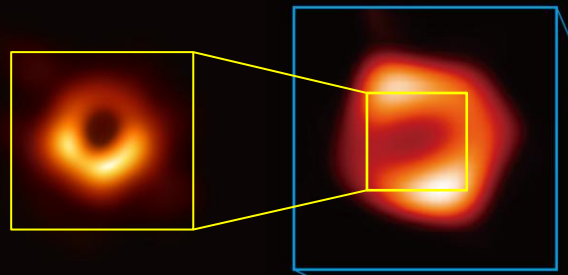
Illustration of AGN
©NASA/JPL-CALTECH



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

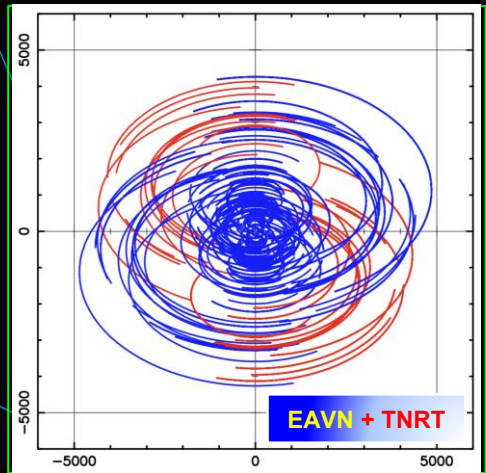


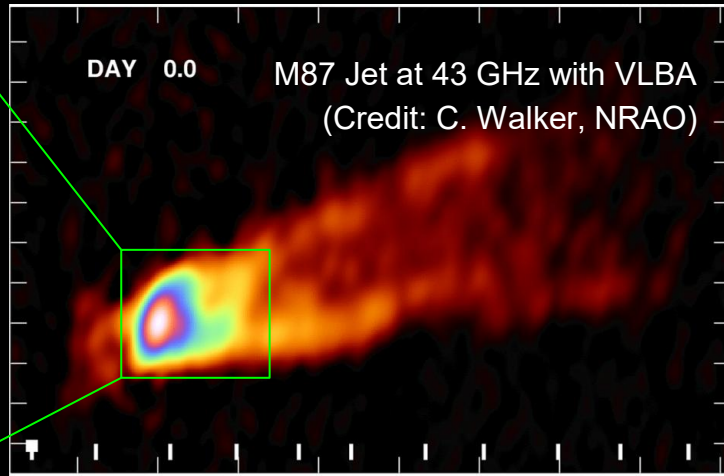
Simulated results of VLBI obs case towards Active Galactic Nucleus M87 at 22 GHz in K-band.



SMBH in M87
Credit: EHT Collaboration

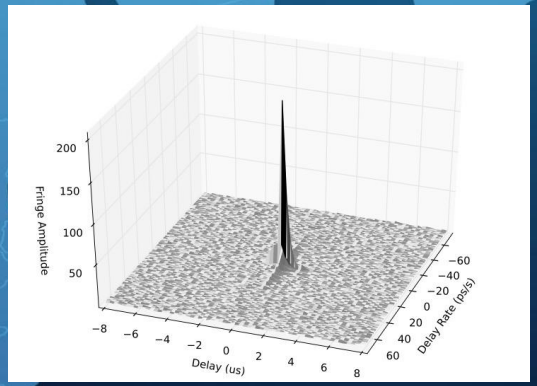
Accretion Disk & Root of Jet in M87
Credit: Lu et al. (2023); composition by F. Tazaki





Milestone of the 1st VLBI Fringe Detection of TNRT with Effelsberg 100m in L-band, 16th May 2024

~8,500 km



Effelsberg Radio Telescope
(100-m)

Thai National Radio Telescope
(40-m)

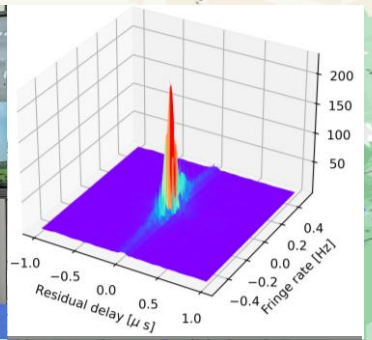
ก้าวไปอีกขั้น! กล้องโทรทรรศน์วิทยุแห่งชาติ เชื่อมต่อกับกล้องของเยอรมนีด้วยเทคนิค VLBI สำเร็จเป็นครั้งแรก

NARIT: Eng ver., Thai ver., Facebook; *MPIfR*: Eng ver., German ver.

www.NARIT.or.th

VLBI experiments / success of TNRT with Chinese telescopes, Jun-Aug 2024

on 22 August 2567



Credit: Wu Jiang (SHAO)

Credit: NARIT Facebook

TNRT

FAST

Tianma 65-m

1,500 km

1,100 km

2,600 km

Background Credit:
Yuwei Liu, + in SHAO-VGOS team

INAF - NARIT - MPIfR

(M. Giroletti, K. Sugiyama, G. Wieching, et al.)

Invited Dr. Marcello Giroletti from INAF, to NARIT, 11-14 November 2024.

E. Barr
N. Esser
A. Kraus
U. Bach
J. Wagner

~8,500 km

7,500-8,000 km

N. Sakai
Y.-A. Chen
T. Chairin
B. Pimpanuwat

- Stations
  - Medicina 32-m
  - TNRT 40-m
  - Effelsberg 100-m
- High-sensitivity with large telescopes: **sub-mJy** with a few min
- Frequencies: **L-band**
- Bandwidth: 64 MHz
- Target: Quasar/OH-maser
- Correlator: DiFX at INAF, MPIfR, & NARIT
- Date: **29 September 2025**

Image credit of background world-map: Illust AC

VGOS Radio Telescopes

Grand Opening of VLBI Global Observing System (VGOS) telescope in Chiang Mai, on **16 May 2025!!**

Apichat Leckngam

In collaboration with **Shanghai Astronomical Observatory, Chinese Academy of Sciences, China**

Credit
Facebook of NARIT,
and Web-page

Big Lift of VGOS in Nakhon Si Thammarat, on 22 Sep 2025!!

President of Walailak Univ.
Prof. Dr. Sombat Thamrongthanyawong

Executive Director of NARIT
Dr. Wiphu Rujopakarn

Credit: Facebook of Walailak University and NARIT, & Web-page

แผนดำเนินการติดตั้งกล้องโทรทรรศน์วิทยุแบบวีกอสในประเทศไทย

Thai National VLBI Array (TVA), Phase 1

กล้องโทรทรรศน์วิทยุแห่งชาติ

Thai National Radio Telescope (TNRT)

ขนาดเส้นผ่านศูนย์กลาง 40 เมตร

รับสัญญาณได้ในช่วงความถี่ 0.3 - 115 GHz

Operation since 2023

กล้องโทรทรรศน์วิทยุแบบวีกอส

VLBI Geodetic Observing System Radio Telescope (VGOS)

ขนาดเส้นผ่านศูนย์กลาง 13 เมตร

รับสัญญาณได้ในช่วงความถี่ 2 - 14 GHz

VGOS telescopes

Operation since 2025

เชียงใหม่ **Chiang Mai**

ที่ตั้ง: หอสังเกตการณ์ดาราศาสตร์วิทยุแห่งชาติ
ภายในศูนย์ศึกษาการพัฒนาห้วยฮ่องไคร้
อันเนื่องมาจากพระราชดำริ
อ. ดอยสะเก็ด จ. เชียงใหม่

Big lift on 22 Sep 2025

Nakhon Si Thammarat

นครศรีธรรมราช

ที่ตั้ง: มหาวิทยาลัยวลัยลักษณ์
ต. ไทยบุรี อ. ท่าศาลา จ. นครศรีธรรมราช

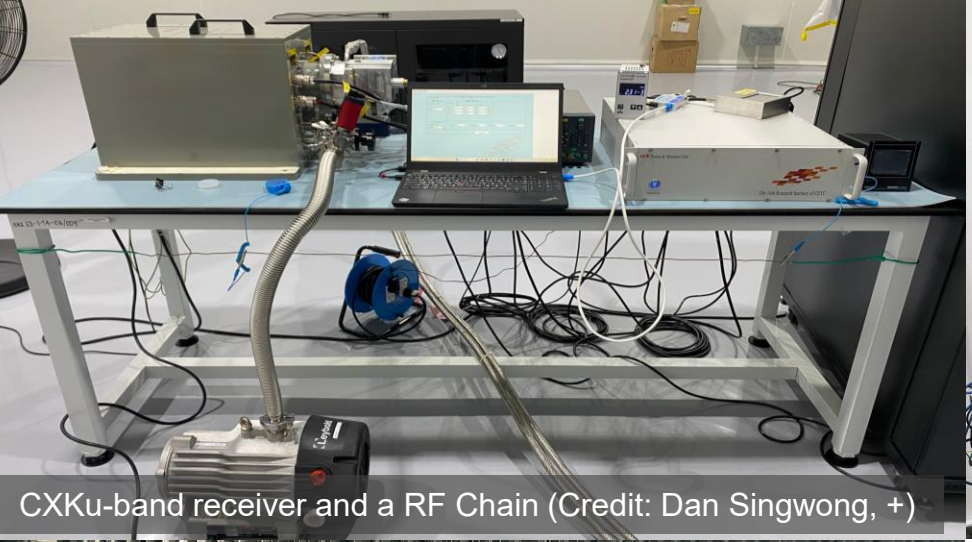
Songkhla

สงขลา Construction ongoing

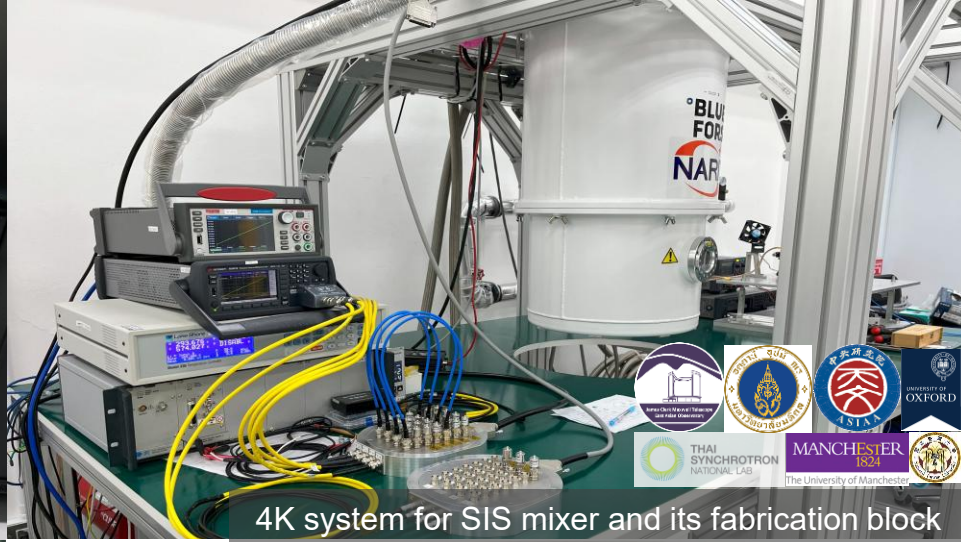
ที่ตั้ง: หอดูดาวเฉลิมพระเกียรติ
7 รอบ พระชนมพรรษา สงขลา
ต. เขารูปช้าง อ. เมืองสงขลา จ. สงขลา
มีกำหนดติดตั้งกล้องในเดือนธันวาคม 2568

Slide Credit: Division of Public Relations, NARIT.

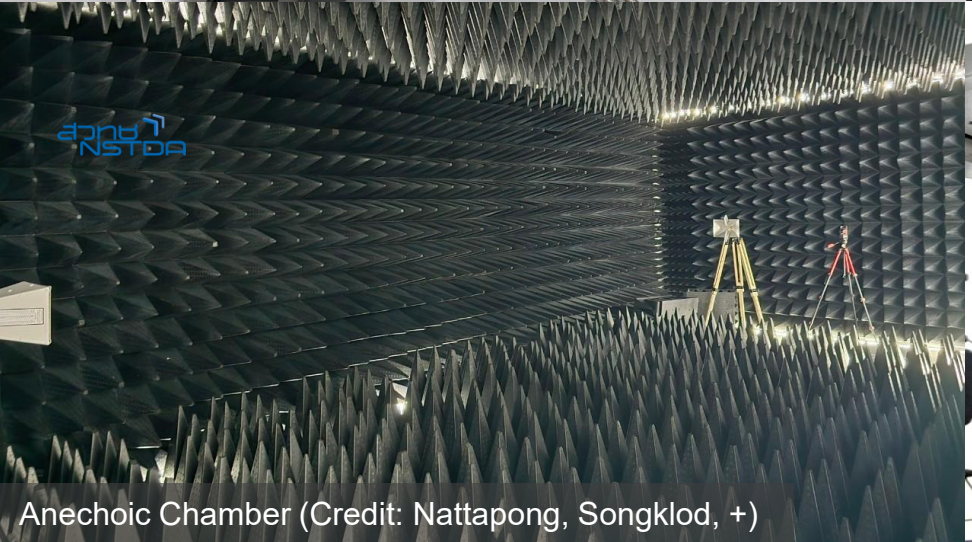
Short-term Vision for the Future of CRAE in Thailand, & SE Asia



CXKu-band receiver and a RF Chain (Credit: Dan Singwong, +)



4K system for SIS mixer and its fabrication block at 230/350 GHz (Credit: Dan Singwong, +)



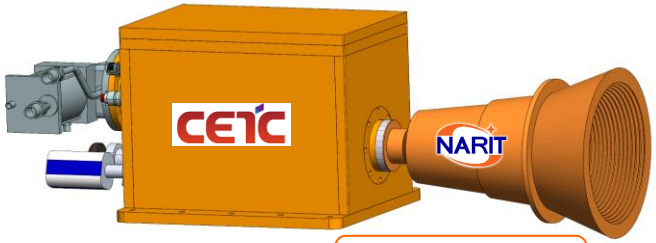
Anechoic Chamber (Credit: Nattapong, Songklod, +)

CXKu-band Development with CETC16−CAS & MPIfR

CETC16−CAS, China: Wideband low-noise CXKu-band receiver, 4.55-13.65 GHz

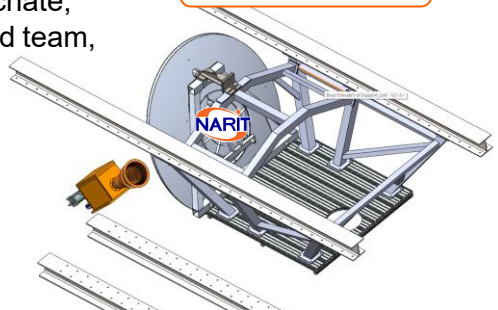
NARIT, Thailand: Colgate feedhorn and Mirror for CXKu-band system

MPIfR, Germany: Backend of D/C and EDD (Annex since Sep 2024 ~)



Preliminary

Credit: Dan, Pichate, with his frontend team, NARIT, MHESI



Credit: CETC16, CAS

VLBI Data Correlation Center at Center for IT, NARIT

Installation Success on Aug 14, 2025.

Supported by
NARIT CIT, SimpleHPC company, and Director of NARIT Wiphu, & SHAO correlator GP leader (F. Shu)

Server Specifications

Compute	> 48 cores: Intel Xeon Gold CPU @2.80GHz
Memory	> 263 GB
Storage	> System: 446 GB - RAID1 > Data: 163 TB - RAID6
Networking	> Infiniband: 56 Gbps > Fiber Optic Bond Connection: 2x10 Gbps
System Softwares	> CentOS7 > DiFX, HOPS, nuSolve, SKED, PGPLOT

Slide Credit: Yu-An Chen (Victor)

Preliminary Correlation Result

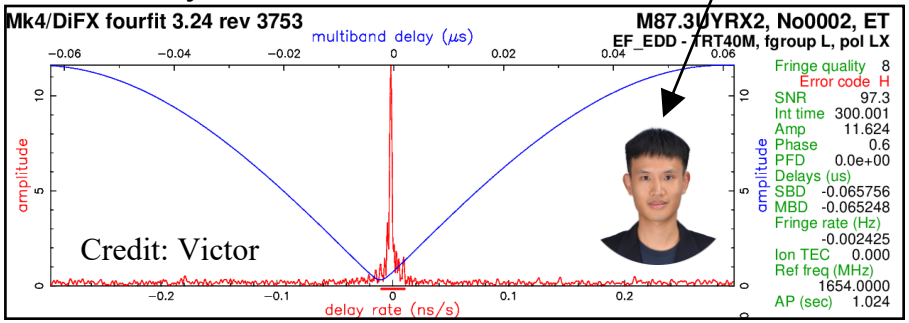


Figure 1. Fringe Detection Plot Generated from NARIT Correlator

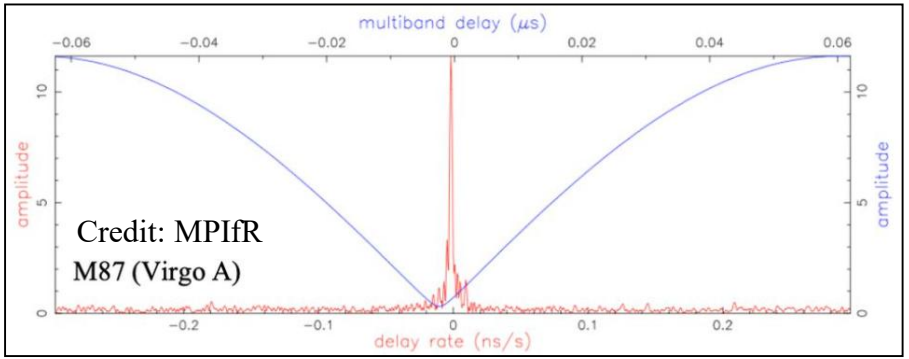
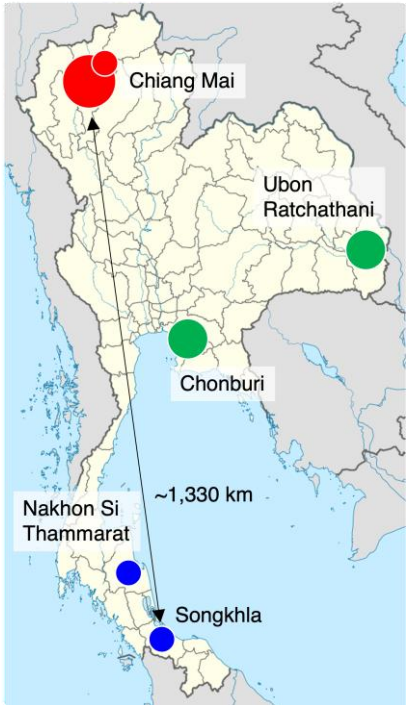


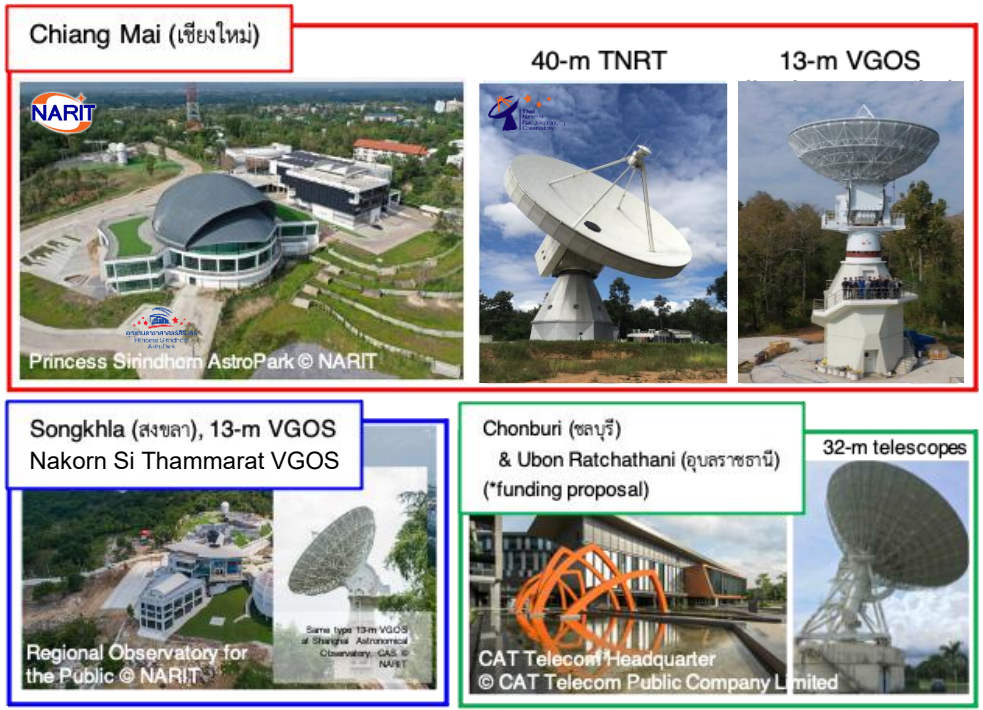
Figure 2. Fringe Detection Plot Generated at MPIfR in 2024

Vision for the Future: TVA, Phase 2

in C/X/Ku/K-bands, 2028 (?) ~



Background © NordNordWest in Wikipedia

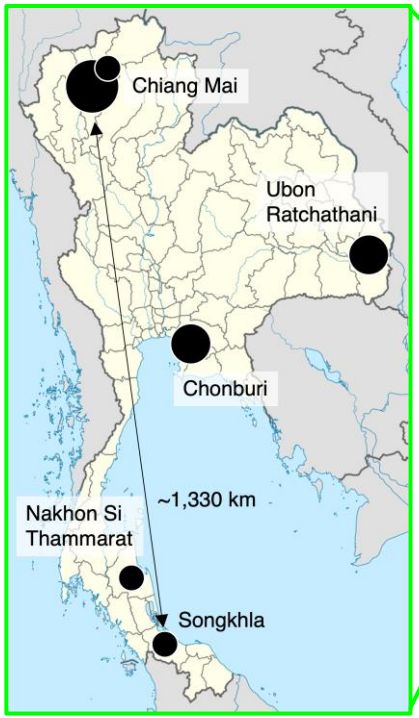


Antenna Conversion

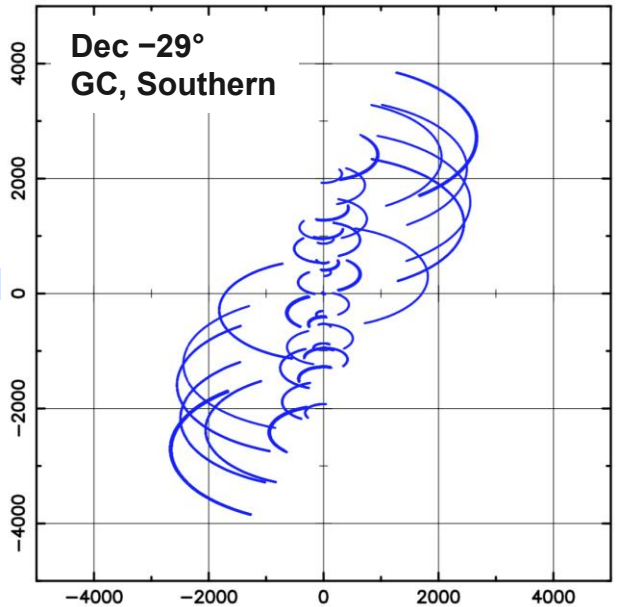
SHAO DiFX Credit: Xuan He
(Petrov et al. 2007, AJ, 133, 2487)

Vision for the Future: South-East Asian VLBI Network

in C/X/Ku/K-bands, 2027-2028 (?) ~

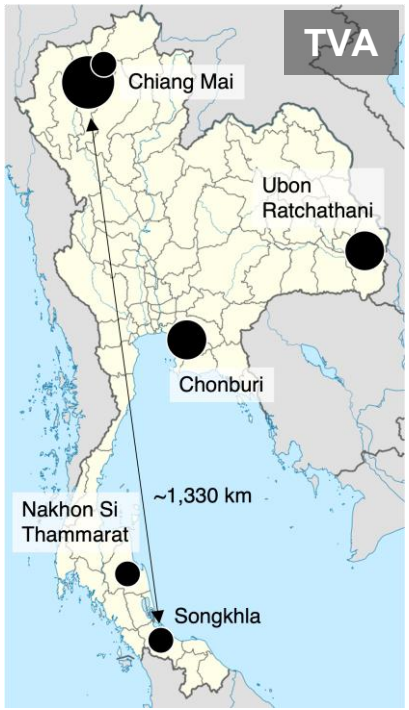


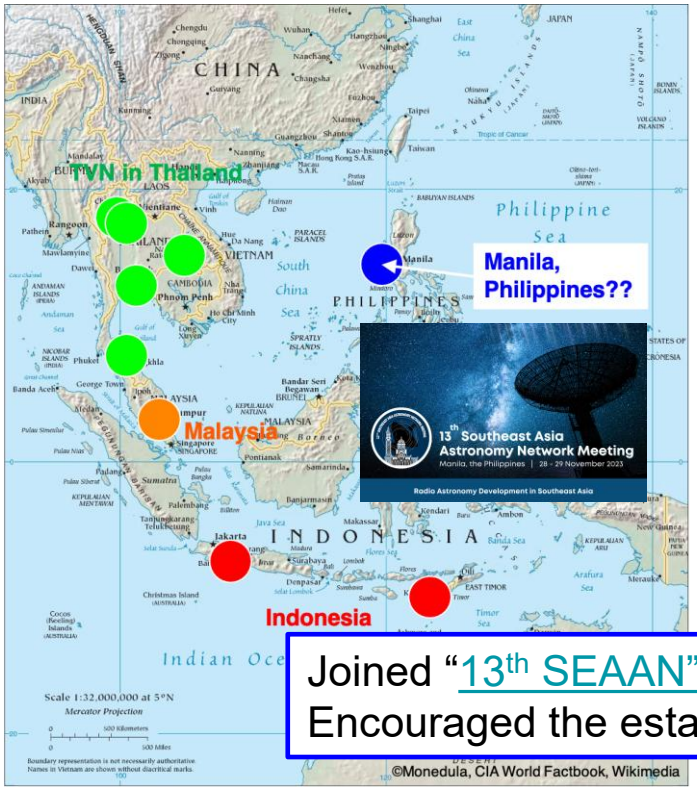
Background © NordNordWest in Wikipedia

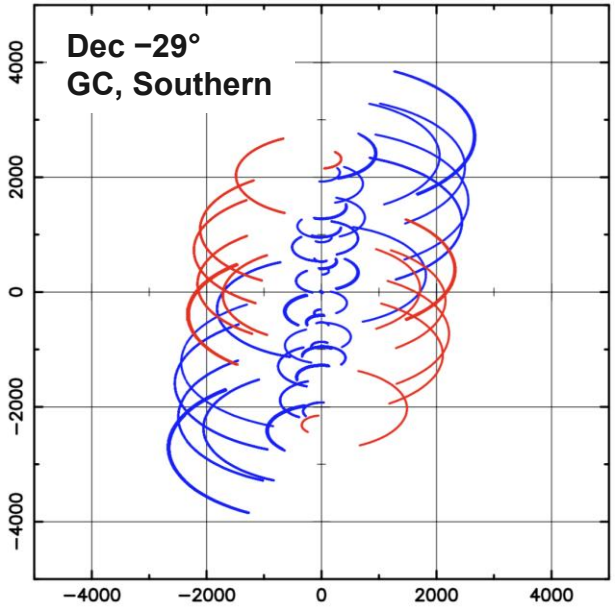


Vision for the Future MORE?: **SEAVN + Philippines?**

in C/X/Ku/K-bands, ???? ~





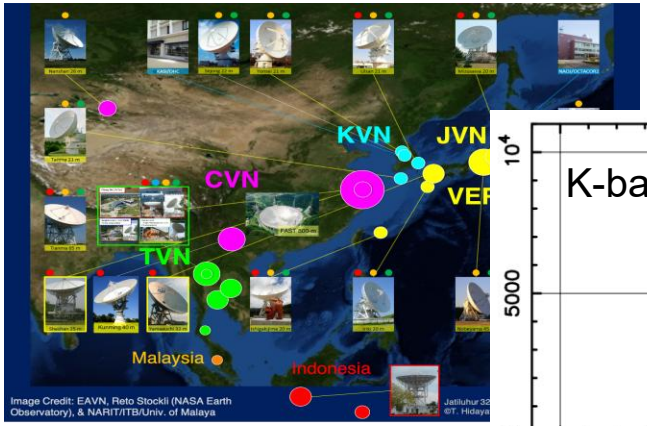


Joined "13th SEAAN" in Philippines, 28-29 Nov 2023
Encouraged the establishment of SEAVN together!

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

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

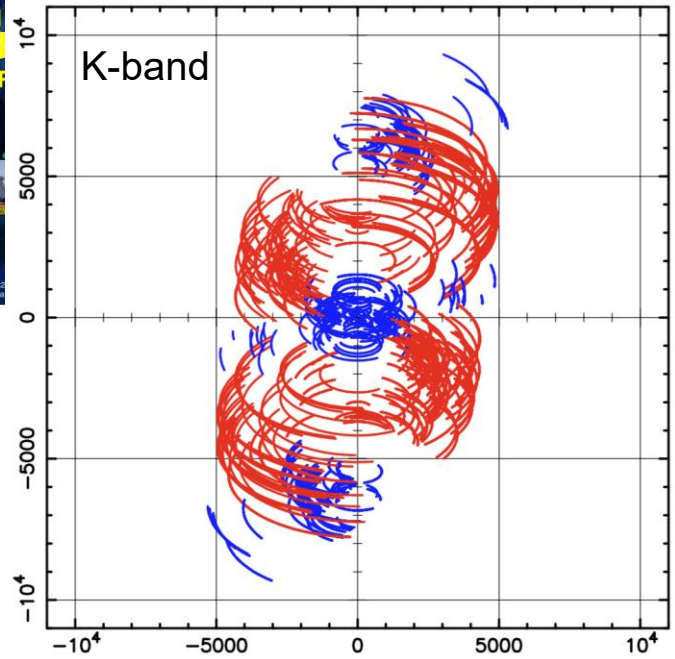
Reboot of Asia-Pacific Telescope (APT)



EAVN + LBA **+ SEAVN**

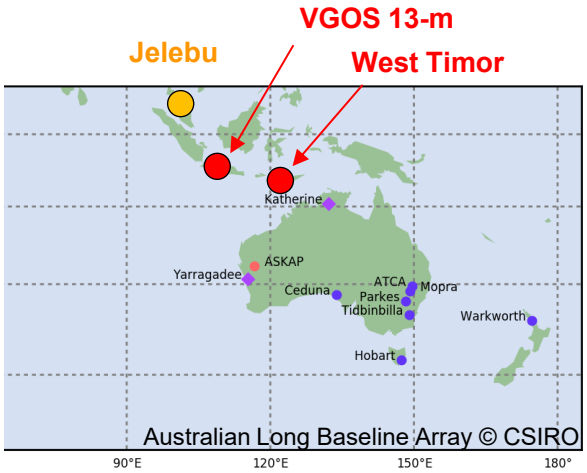
= **Asia-Pacific Telescope (APT)**

Sgr A* (GC)



(since ~1990 yrs:

JAXA/ISAS, CSIRO, NAOJ, etc)



➔ Accelerate

Global VLBI Alliance

(Colomer, Kobayashi, Slowikowska, et al.)

basis for future collab with **EVN**, SKA & ngVLA!

Vision for TNRO Project in Thailand & Regional VLBIs

【Construction】

- Big Lift
- Assembly System
- AZ/EL Movement

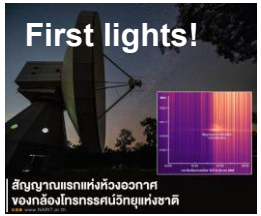
2020 ~ 2021

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

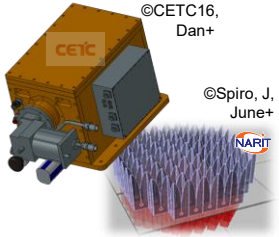
【Installation】

- L/K-band receivers
- Ku Holography
- Call for Proposals

2022 ~ 2023

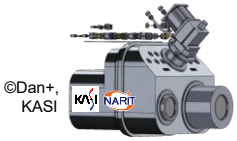


【Upgrade】



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

2024 ~ 2026



【VGOS stations】

- VGOS Building
  - Chiang Mai, Nakorn Si Thammarat, & Songkhla
- Develop Receivers
- Commissioning

2025 ~ 2027

2026 ~ 2028

【Establish Regional VLBI Networks】

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