



EVN TOG Meeting, 13/14 December 2023  
@Institute of Astronomy, in Toruń, Poland.

# Thai National Radio Astronomy Observatory Project & the Future Vision

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

**Koichiro Sugiyama**, Chief Scientist of TNRO Project,

Phrudth Jaroenjittichai, Apichat Leckngam, Wiphu Rujopakarn, Boonrucksar Soonthornthum, Busaba H. Kramer (MPIfR), Nobuyuki Sakai, Taufiq Hidayat (ITB), Zamri Zainal Abidin, Juan Carlos Algaba (Universiti Malaya), Pham Ngoc Diep (VNSC), and Saran Poshychinda (Executive Director of NARIT),

on behalf of the Project Team Members of *Thai National Radio Astronomy Observatory*

# NARIT Infrastructure

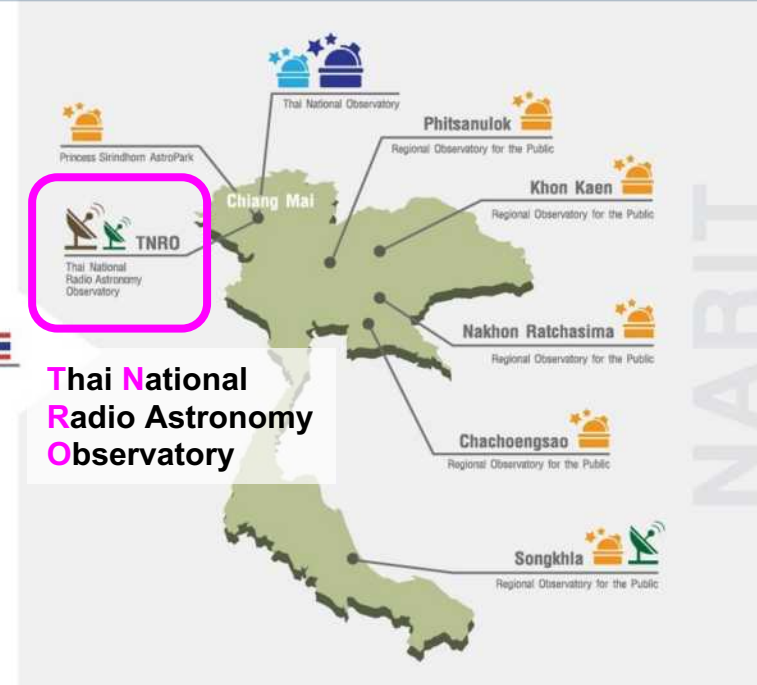


Dr. Saran  
Poshyachinda

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

Project Leaders



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

*“Capacity Building Through  
Radio Astronomy & Geodesy”*

Speaker: KS





# Acknowledgement



- International Technical Advisory Committee (ITAC) members:
  - Hideyuki Kobayashi (Chair, NAOJ), Busaba H. Kramer (Secretariat, MPIfR/NARIT), Do-Young Byun (KASI), **Francisco P. Colomer (JIVE, retired)**, 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!

# Outline

1. Overview of 40 m **Thai National Radio Telescope**
2. Science Cases with TNRT
3. Commissioning and Call for Proposal
4. Vision for the Future in Radio Thailand / ASEAN

# Outline

- 1. Overview of 40 m Thai National Radio Telescope**
2. Science Cases with TNRT
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# Thai National Radio Astronomy Observatory



- 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





# The 40 m Thai National Radio Telescope (TNRT)

Big Lift in Feb 2020



“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  $\mu\text{m}$  (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



L-band  
(1.0-1.8 GHz)

K-band  
(18-26.5 GHz)



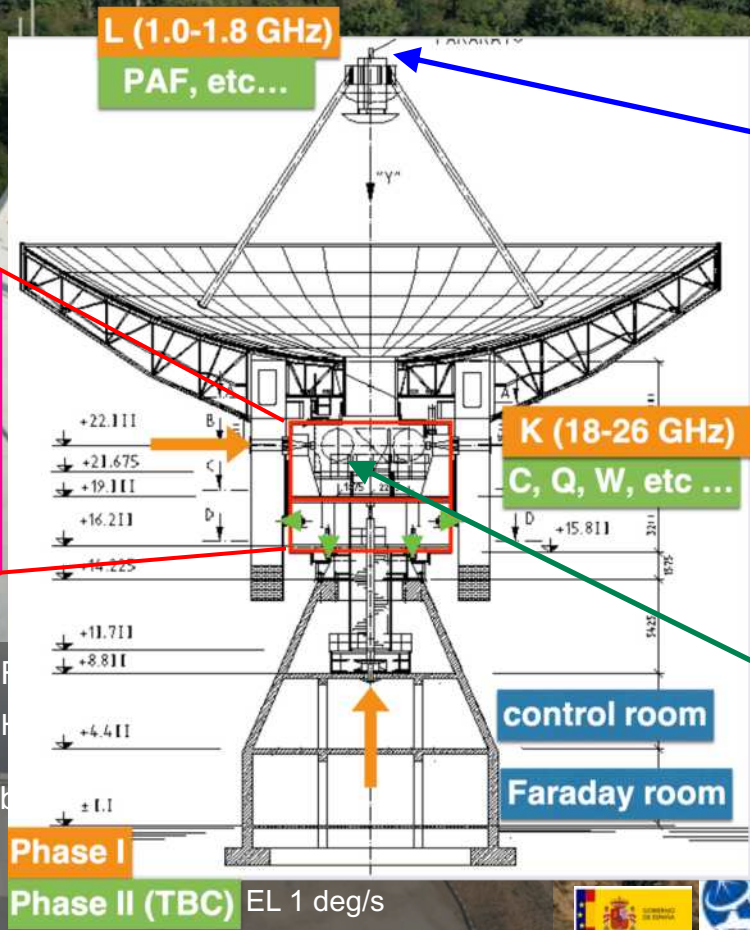


# USB: Universal Software Backend Installation & Implementation

Assembly the system in 2021–2022



# The 40 m Thai National Radio Telescope (TNRT)

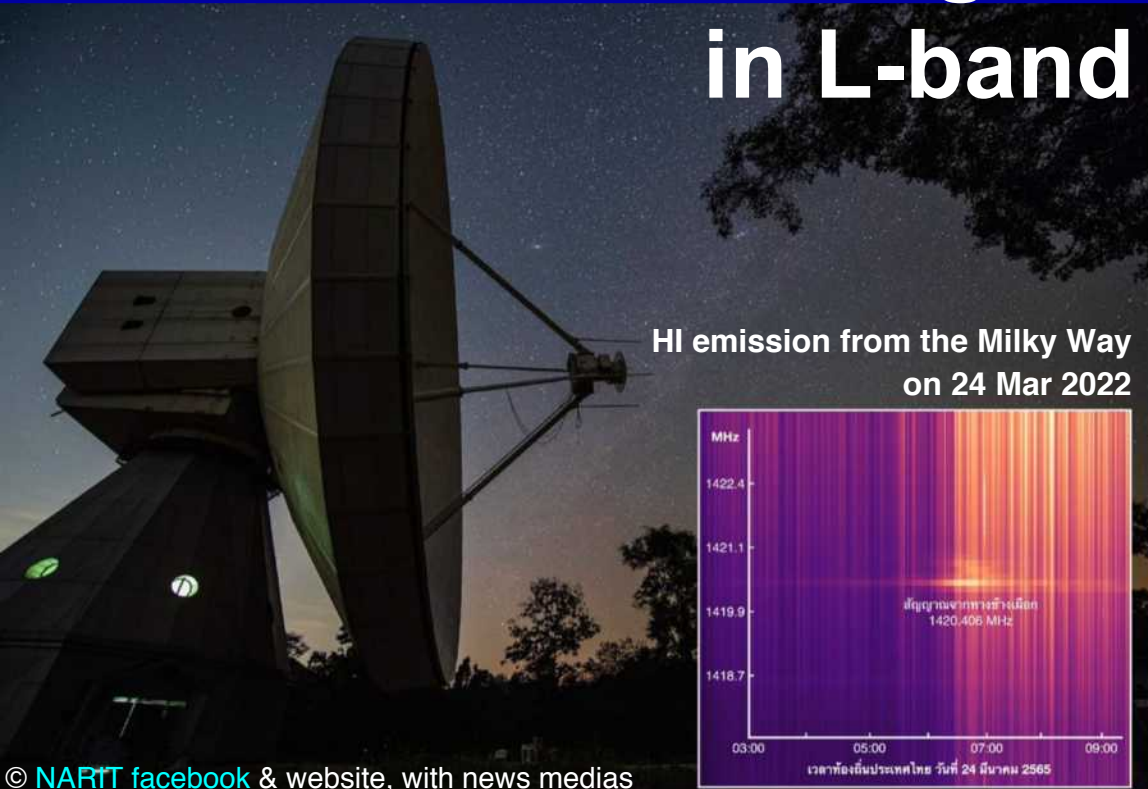


“Upgraded” version of IGN’s Yebes 40-m PFTU  
With Prime-Focus Tetrapod Head Unit (THU)

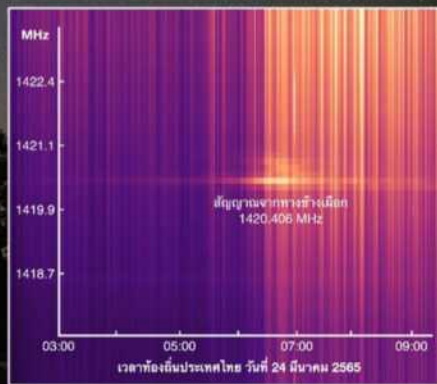
**0.3 – 115 GHz** : P/L/C/X/Ku/K/Q/W-bands  
150  $\mu$ m (rms) total surface accuracy  
Pointing: 2" (no wind), 6" (5 m/s wind)



# The 1<sup>st</sup> lights in L-band

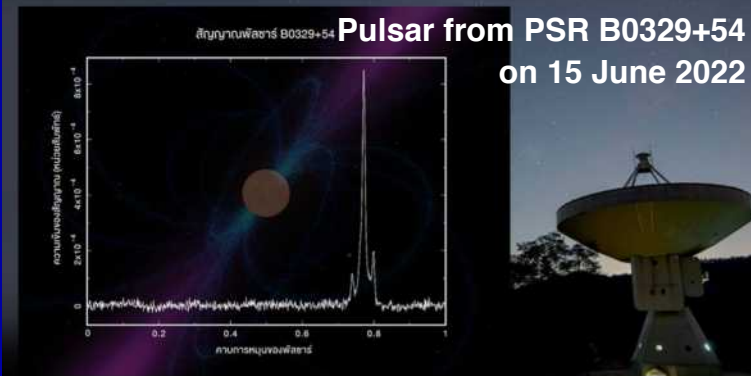


HI emission from the Milky Way  
on 24 Mar 2022



© [NARIT facebook](#) & website, with news medias

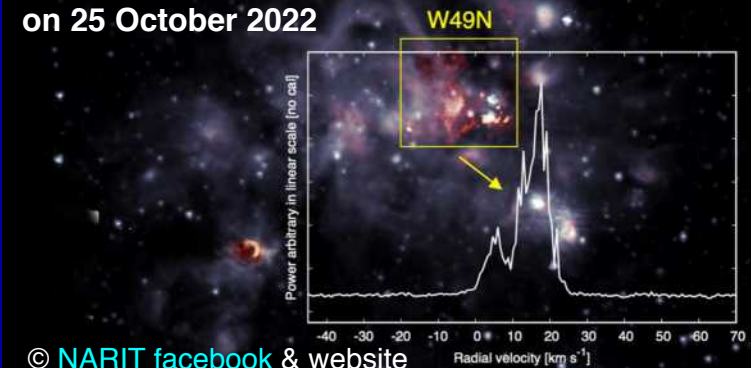
สัญญาณแรกแห่งห้วงอวกาศ  
ของกล้องโทรทรรศน์วิทยุแห่งชาติ  
www.NARIT.or.th



สัญญาณพัลซาร์ B0329+54  
on 15 June 2022

สัญญาณพัลซาร์แรก  
จากกล้องโทรทรรศน์วิทยุแห่งชาติ  
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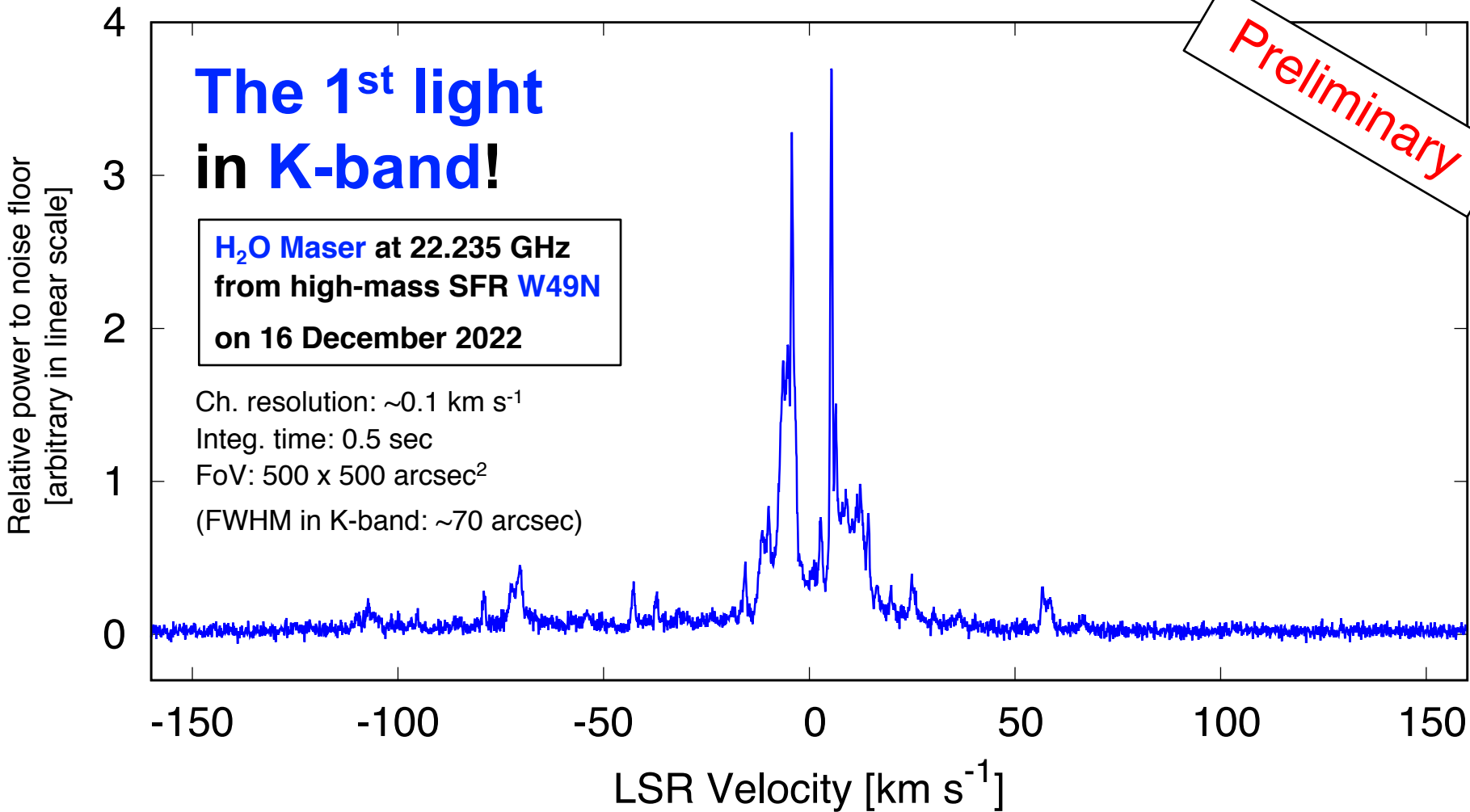
OH Maser from high-mass SFR W49N  
on 25 October 2022



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# Outline

1. Overview of 40 m Thai National Radio Telescope
- 2. Science Cases with TNRT**
3. Commissioning and Call for Proposal
4. Vision for the Future in Radio Thailand / ASEAN

# White Paper for TNRT



Sciences with Thai National Radio Telescope

arXiv: arXiv:2210.04926

Editors

on 12 Oct 2022

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Yadav, Ram Kesh<sup>1</sup>, Zhang, Bo<sup>19</sup>, Zheng, Xing Wu<sup>20</sup> and Poshychinda, Saran<sup>1</sup>

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

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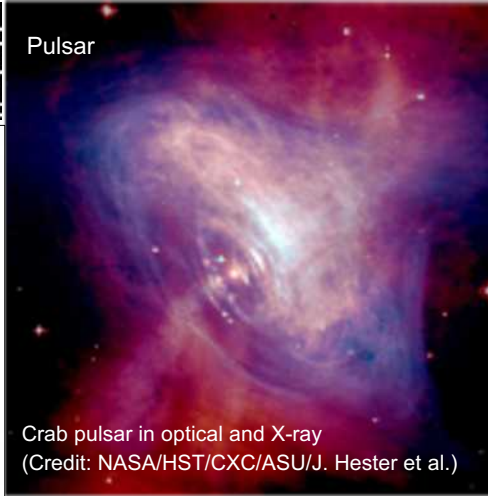
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Pulsar



Crab pulsar in optical and X-ray  
(Credit: NASA/HST/CXC/ASU/J. Hester et al.)

High-mass Star-Forming Region



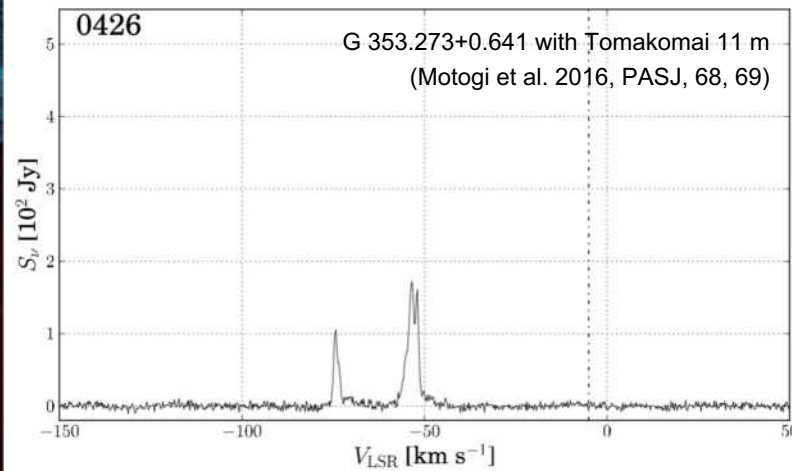
Artist's conception of W33A  
(Credit: Gemini Observatory, by Lynette Cook)

Active Galactic Nuclei



Illustration of AGN  
©NASA/JPL-CALTECH

## Time-Domain Sciences with TNRT





# World-wide Collaboration for VLBI

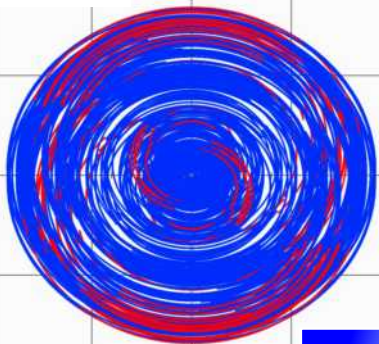
- EAVN
- EVN
- LBA
- GMRT



# World-wide Collaboration for VLBI

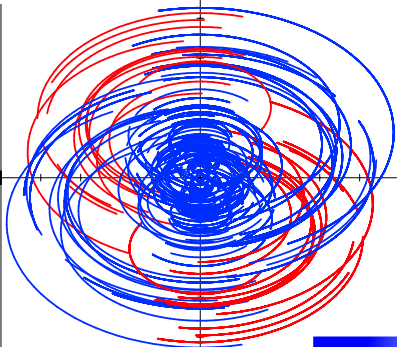
- EAVN
- EVN
- LBA
- GMRT

Dec +60 d



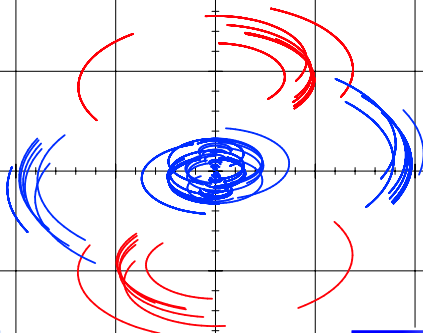
EVN + TNRT

Dec +40 d

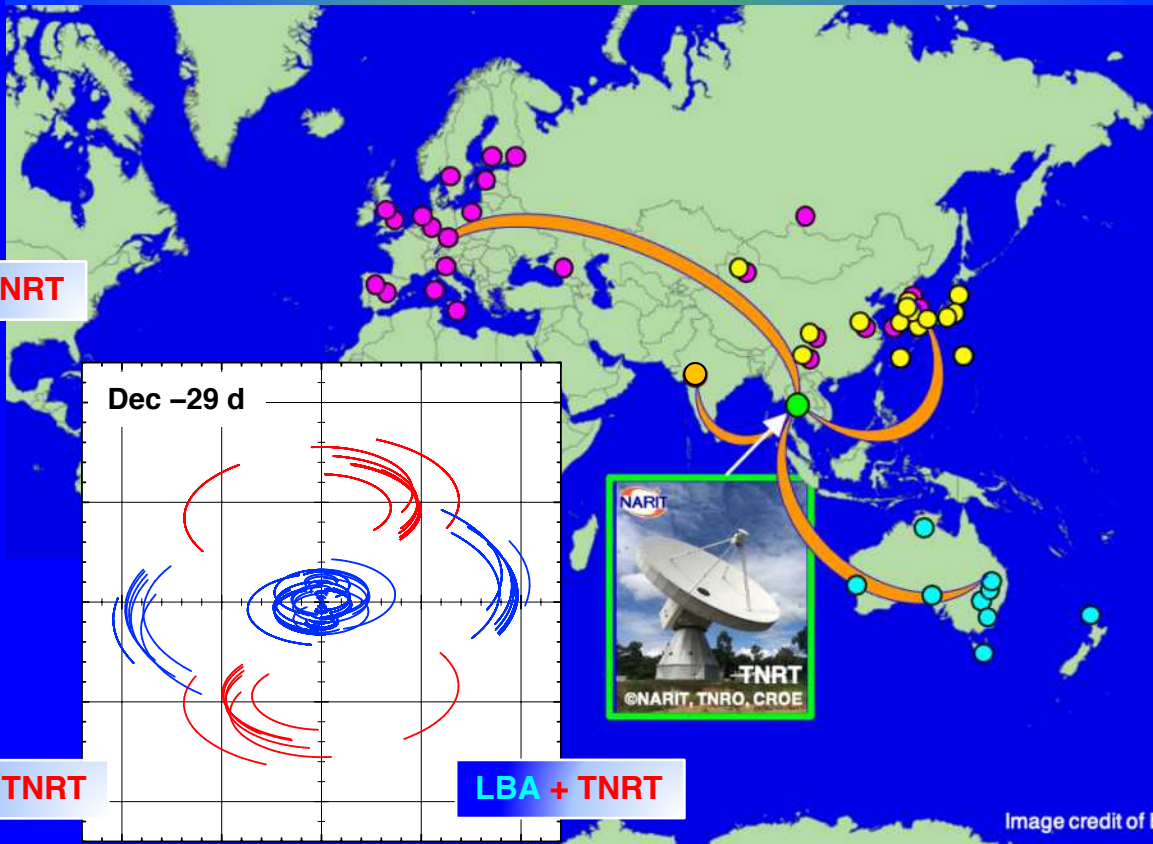


EAVN + TNRT

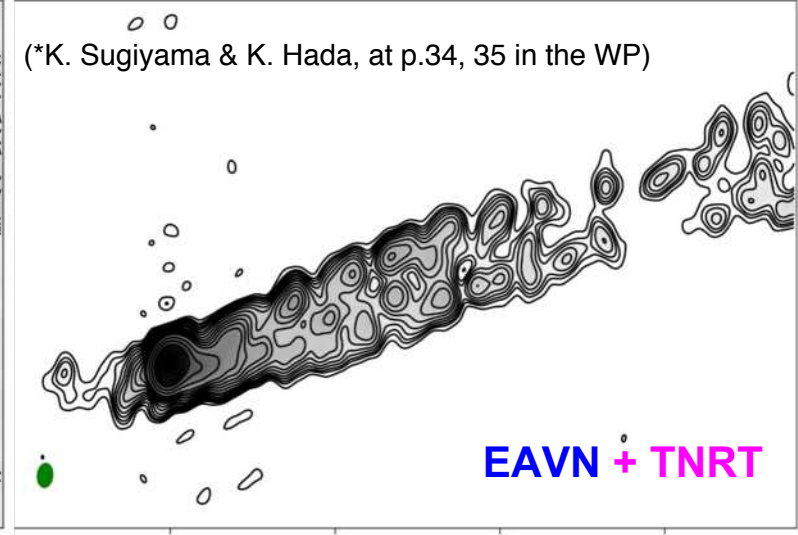
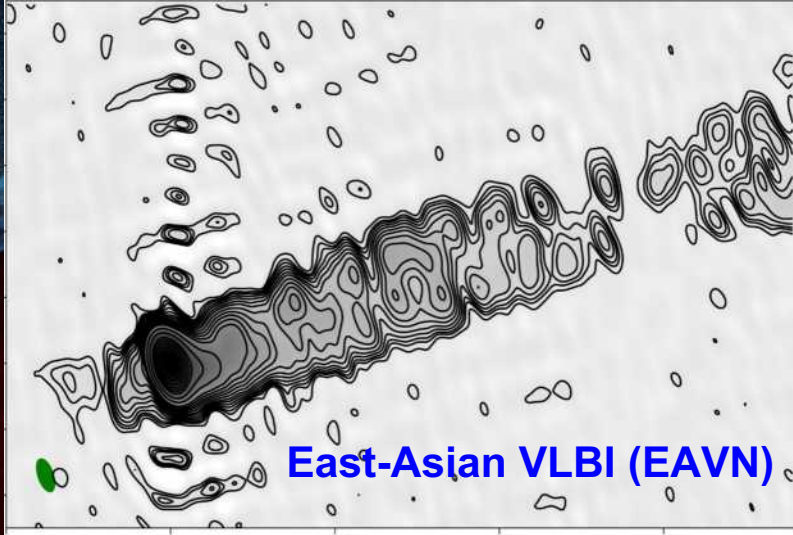
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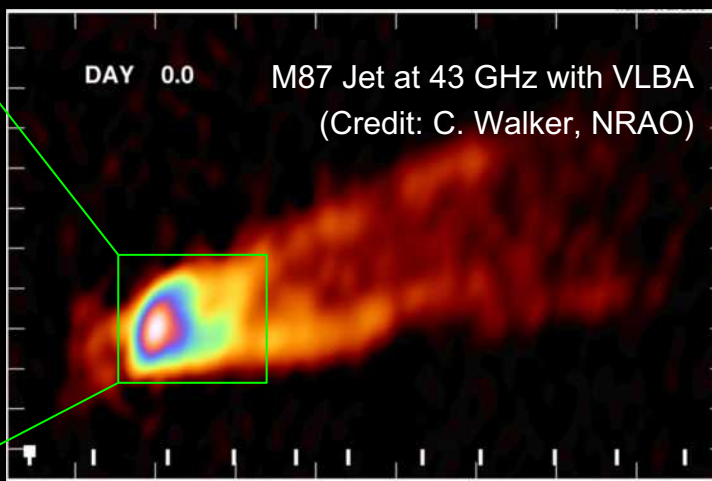
LBA + TNRT







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



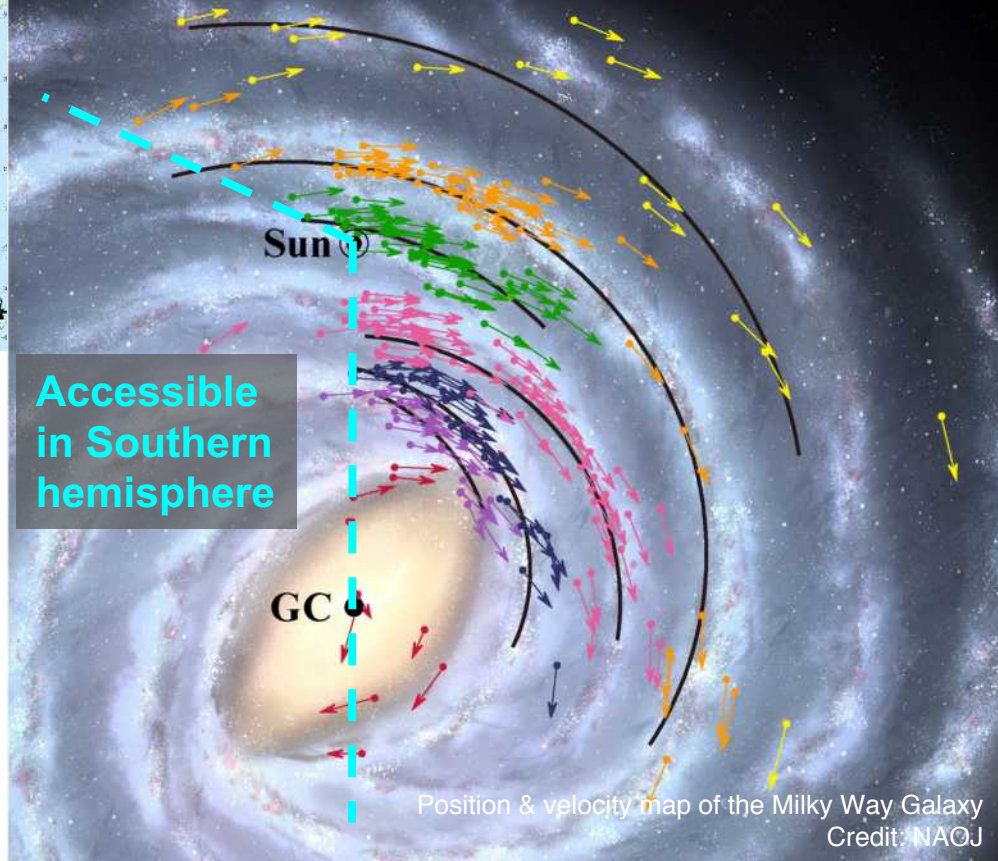
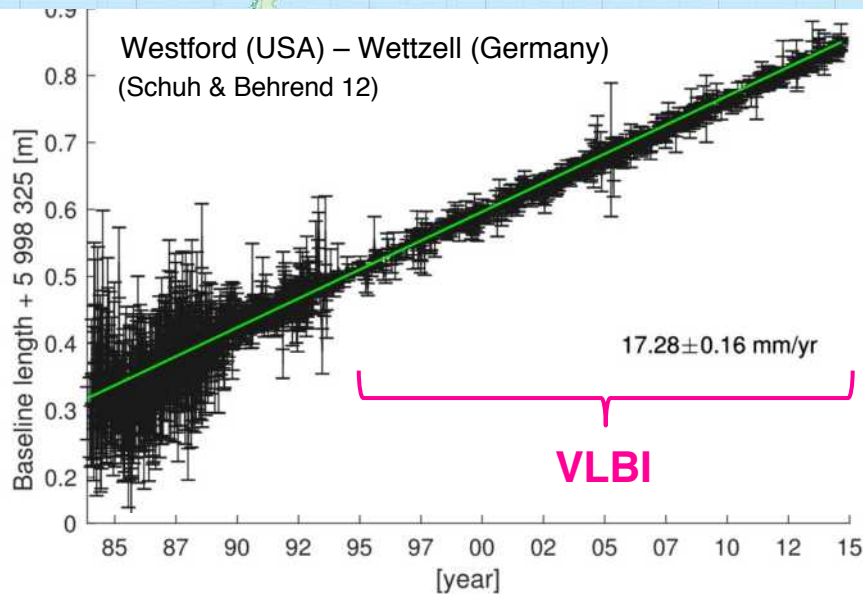


# Geodetic VLBI & Astrometry

by Nobuyuki Sakai,  
N. Thoonsaengngam, et al.



Credit: IVS



Results of VERA Collaboration, Hirota, + (2020) for 99 srcs and combined with BeSSeL proj. (Reid, Menten, + 2019) in total 224 srcs

Position & velocity map of the Milky Way Galaxy  
Credit: NAOJ

# Outline

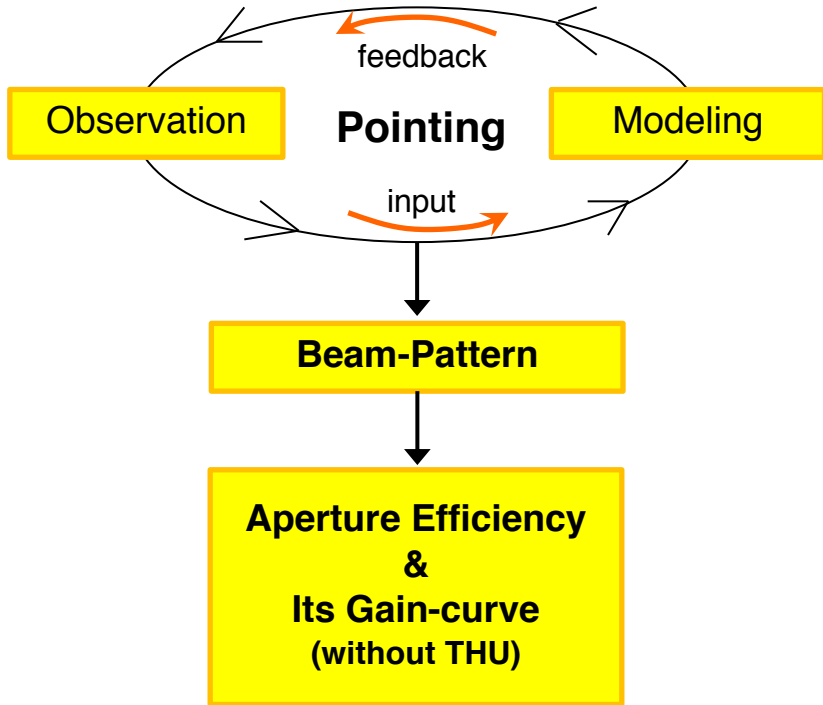
1. Overview of 40 m Thai National Radio Telescope
2. Science Cases with TNRT
- 3. Commissioning and Call for Proposal**
4. Vision for the Future in Radio Thailand / ASEAN



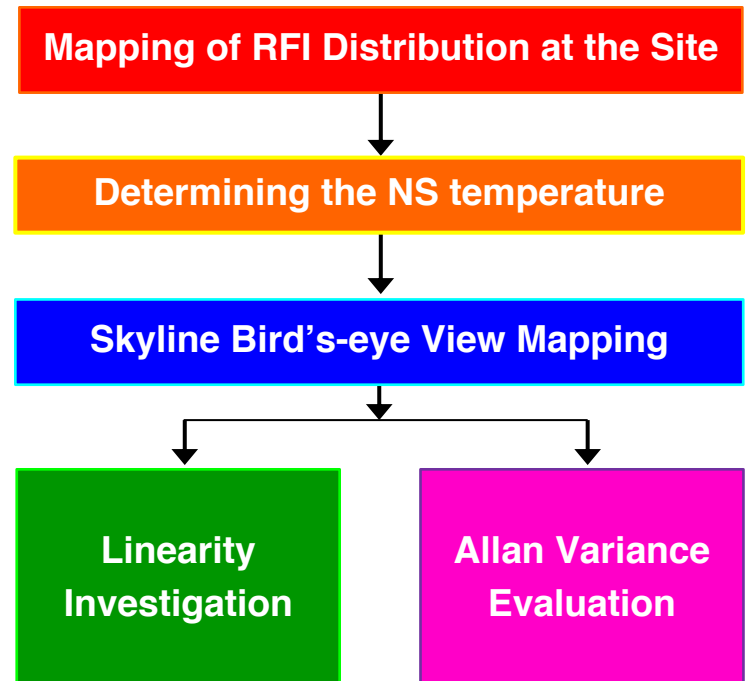
Since November 2022 ~

# General (Engineering) Commissioning in L-band

## Pointing (relevant) Part

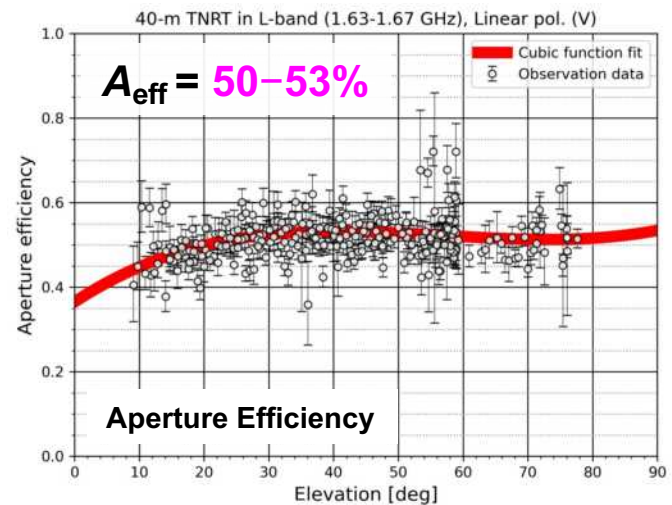
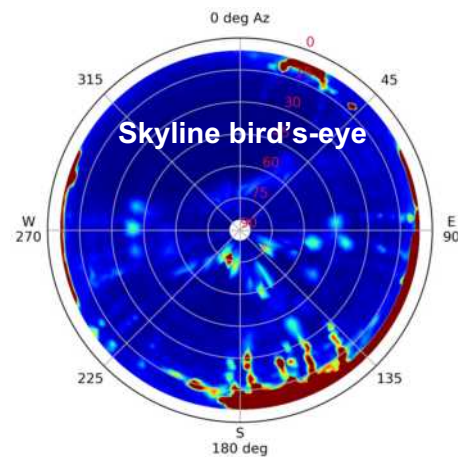
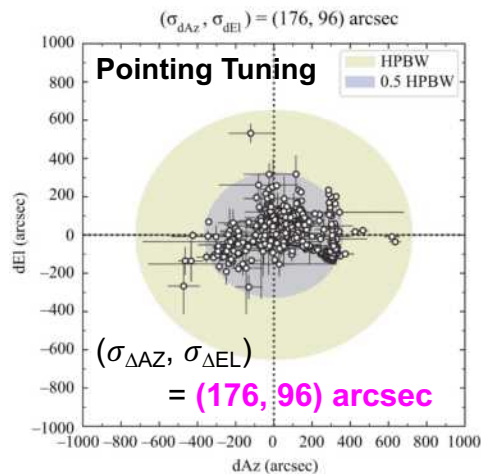
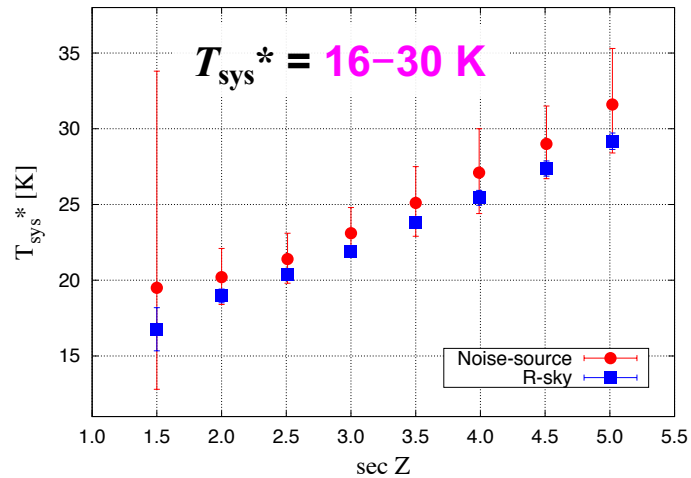
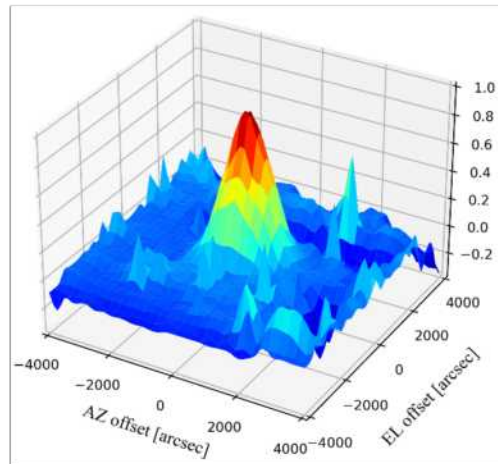
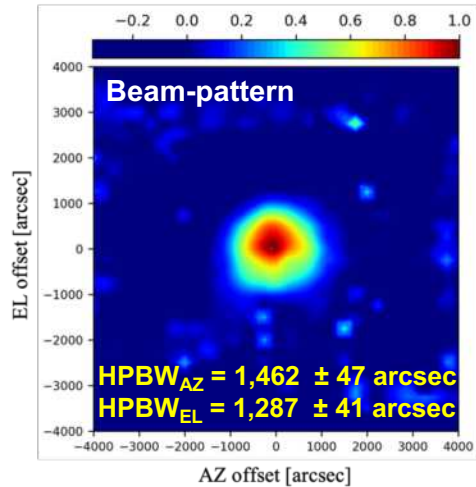


## Basic Part





Normalized  $T_a^*$





# Outline

1. Overview of 40 m Thai National Radio Telescope
2. Science Cases with TNRT
3. Commissioning and Call for Proposal
4. **Vision for the Future in Radio Thailand / ASEAN**



# Vision for TNRO Project in Thailand & Regional VLBI

## 【Construction】



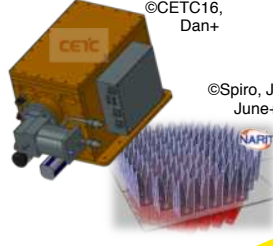
- Big Lift
- Assembly System
- AZ/EL Movement

## 【Installation】



- L/K-band receivers
- Ku Holography

## 【Upgrade】



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

©Dan+, KASI



2025 ~ 2026

## 【VGOS stations】



Artist's illustration (refer from Apichat)

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

2024 ~ 2025

2022 ~ 2023



สัญญาณแรกๆที่มองเห็นจากกล้องโทรทรรศน์วิทยุแห่งชาติ

2020 ~ 2021

Big Lift Movie:  
<https://youtu.be/wmFGBUDjw>

2026 ~ 2027

## 【Establish Regional VLBI Networks】

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



# VGOS in Chiang Mai



NARIT hosting one of the International Chinese VGOS stations, based on signing MoU with SHAO, CAS (Zhiqiang Shen, Jinling Li, et al.) in 2017, and constructing telescope tower / installing the 13-m VGOS telescope in Chiang Mai.

**Special Thanks to SHAO, CAS, Chinese colleagues:** Prof. Zhiqiang Shen, Chao Shen, Prof. Jinling Li, Yuwei Liu, Cong Liu, Chengkai Wan, Zhengxiong Sun, Prof. Jinqing Wang, Prof. Rongbing Zhao, Prof. Fengchun Shu, Zhong Chen, Jiangying Gan, Xuan He, Li Guo



Image credit: SHAO

Background ©NordNordWest in Wikipedia

Photo credit: Yuwei Liu (SHAO, CAS)

Current at TNRO, Tower by NARIT

# VGOS in Chiang Mai & Songkhla

NARIT hosting one of the International Chinese VGOS stations, based on signing MoU with SHAO, CAS (Zhiqiang Shen, Jinling Li, et al.) in 2017, and constructing telescope tower / installing the 13-m VGOS telescope in Chiang Mai.

Besides, another VGOS station will be built in Songkhla (Southern), together with the receiver development at Yeibes (**Special thanks to Pablo de Vicente, José A. López-Pérez, et al.**).



Current at TNRO, Tower by NARIT



Background ©NordNordWest in Wikipedia



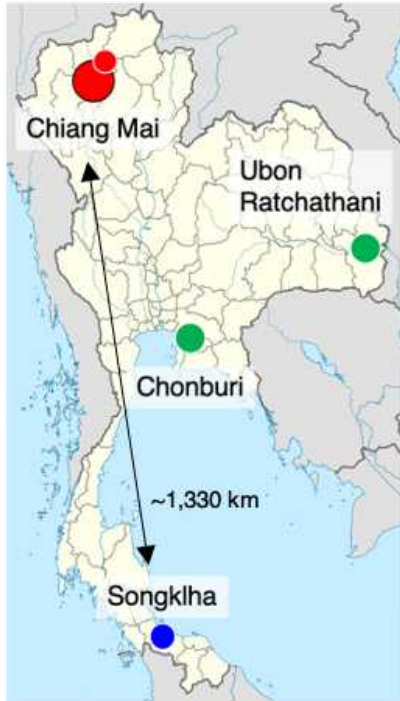
Artist's illustration of VGOS Songkhla

Refer from A. Leckngam



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

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



**Chiang Mai (เชียงใหม่)**

Princess Sindhorn AstroPark © NARIT

**40-m TNRT**

**13-m VGOS (\*under construction)**

Same type 13-m VGOS at Shanghai Astronomical Observatory, CAS © NARIT

**Songkhla (สงขลา), 13-m VGOS (\*under construction)**

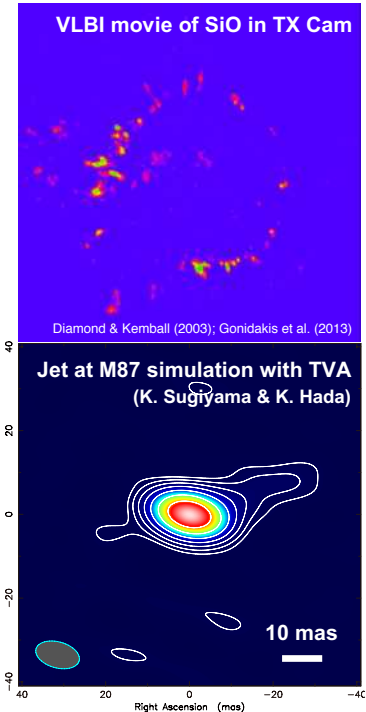
Regional Observatory for the Public © NARIT

Same type 13-m VGOS at Shanghai Astronomical Observatory, CAS © NARIT

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

CAT Telecom Headquarter © CAT Telecom Public Company Limited

**32-m telescopes**



# Vision for the Future: **South-East Asian VLBI Network** in C/X/Ku/K-bands, 2027 (?) ~



Background © NordNordWest in Wikipedia

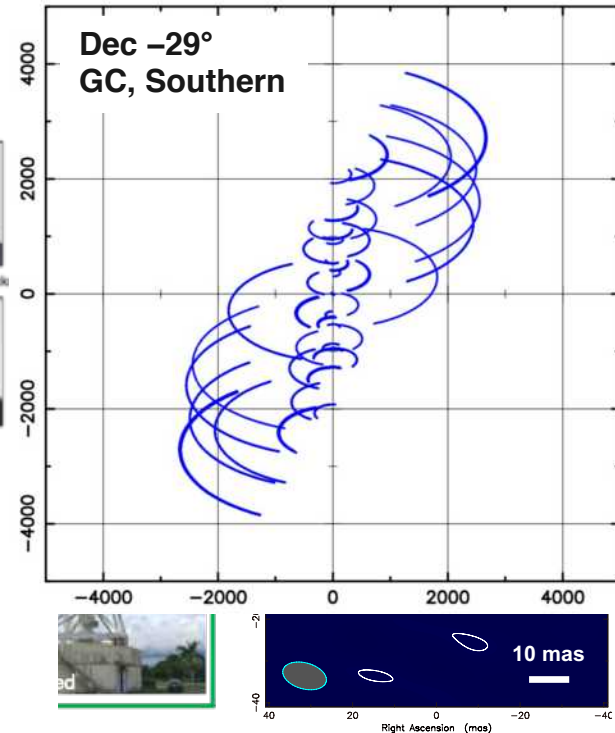






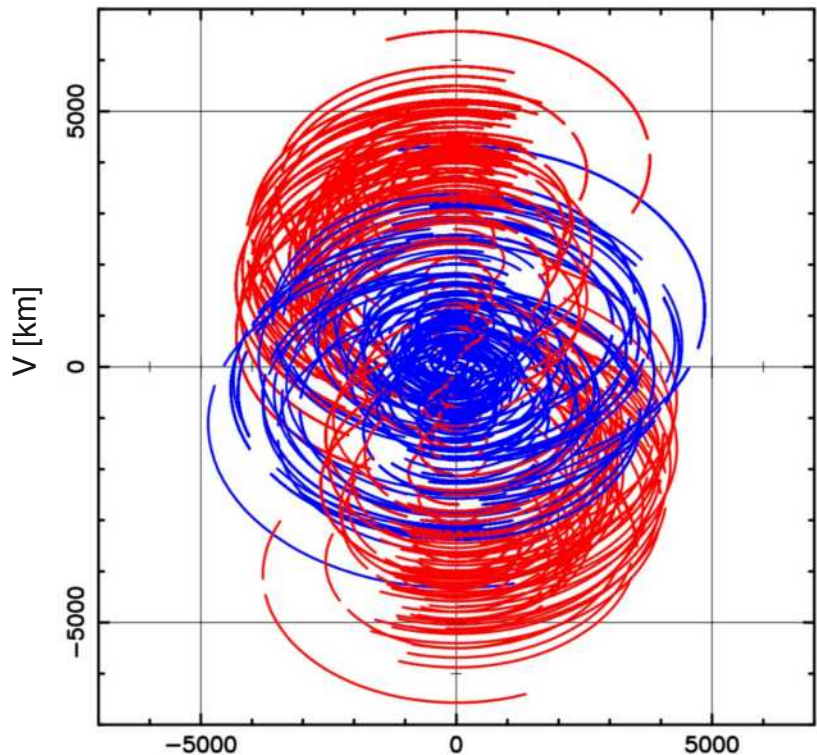
Image Credit: EAVN, Reto Stockli (NASA Earth Observatory), & NARIT / ITB / Univ. of Malaya

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

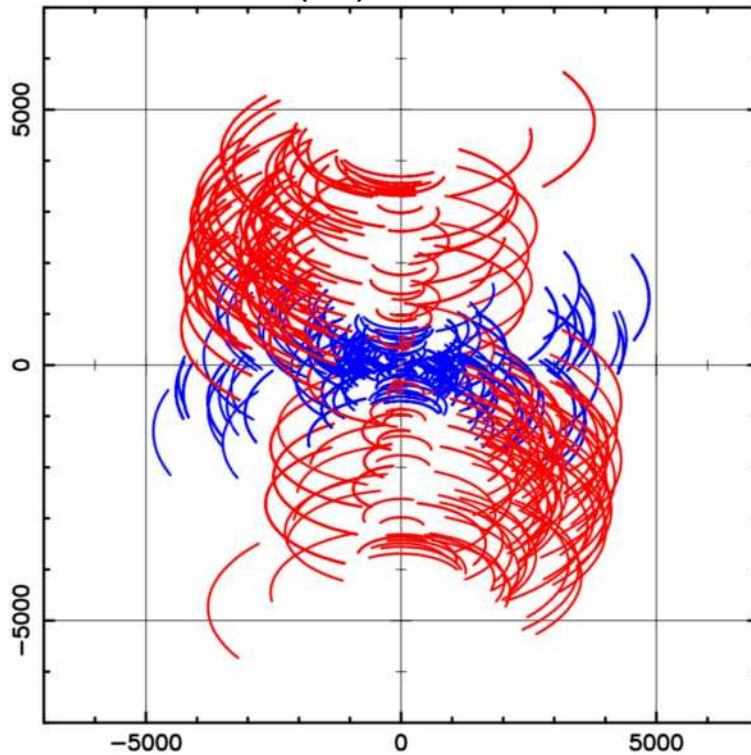


# UV-coverage : EAVN + SEAVN in K-band: ngEAVN??

Declination +40°, Northern



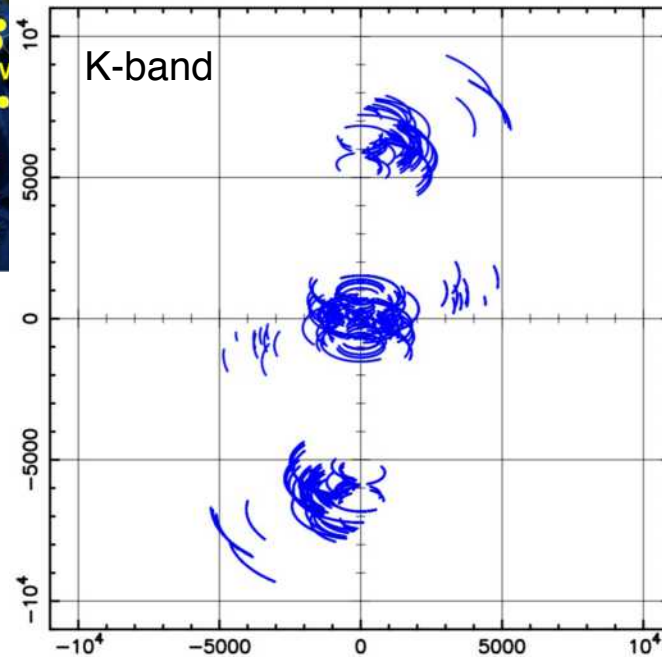
Declination -29°(GC), Southern



# Reboot of Asia-Pacific Telescope (APT)



EAVN + LBA  
Sgr A\* (GC) = Asia-Pacific Telescope (APT)



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

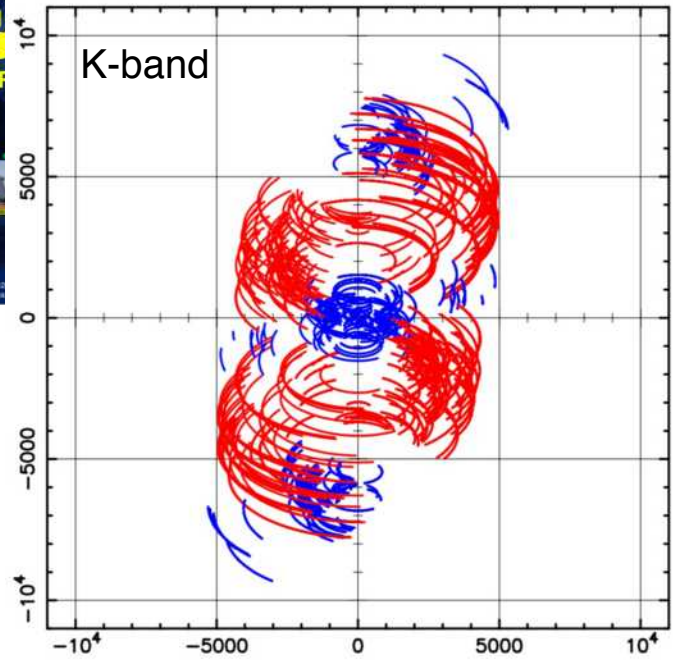


# Reboot of Asia-Pacific Telescope (APT)

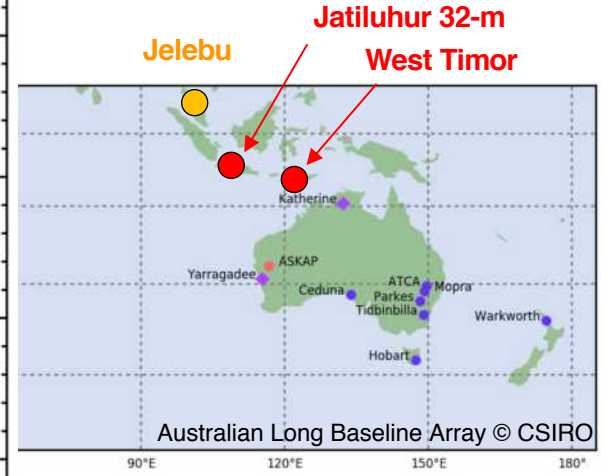


→ Accelerate  
Global VLBI Alliance  
(Colomer, Kobayashi, et al.)  
with **EVN/JIVE** !!

Sgr A\* (GC) EAVN + LBA + **SEAVN**  
= **Asia-Pacific Telescope (APT)**



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



Australian Long Baseline Array © CSIRO





Signing MoU with JIVE on 7 Nov 2019 @Chiang Mai, Thailand



Signing MoU with EAVN on 16 Aug 2022



Signing MoU with UM (Malaysia) on 29 Jun 2021



Signing Letter of Intent with ATNF/CSIRO on 9 May 2018



Renewal of MoU with ITB (Indonesia) on 12 Jan 2023

# Summary

## [Current Status of 40-m TNRT]

- 1<sup>st</sup> lights of lines/continuums/pulsar in L/K-bands
- Key science cases with 40-m TNRT ... [arXiv:2210.04926](https://arxiv.org/abs/2210.04926)
  - Single-dish : Time-domain / Unbiased-survey
  - VLBI : Astronomy / Geodesy with drastic better imaging quality



## [General Commissioning in L-band at 1<sup>st</sup> phase]



- Completed in Sep 2023 (Pointing, Beam-pattern, RFI/Skyline bird's-eye view,  $T_{\text{sys}}^*$ ,  $A_{\text{eff}}$ /Gain-curve, etc)
- [Call for Proposal \(Cycle 0, RSRO style\)](#) was announced on 10<sup>th</sup> Oct 2023, 10 TST at the end!

## [Future]

- Upgrade of TNRT (L-/K-bands in a year) & On-going building **VGOS x 2**
- **TVA** – Thai National VLBI Array, since 2026 (?): **[40-m TNRT] + [VGOS x 2] + [32-m telecom x 2]**
- To be foundation of **SEAVN**: South-East Asian VLBI Network, with Indonesia/Malaysia/Vietnam
  - Upgrade EAVN, Reboot APT, & Accelerate [Global VLBI Alliance](#) with **EVN/JIVE** ([Colomer, Kobayashi, et al.](#))



# Thank you very much for your attention, Dziękuję bardzo!



40-m Thai National Radio Telescope  
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