Progress of the 40m Thai National Radio Telescope & RANGD project

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NARIT

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Pitak Kempet, Kitiyanee Asanok, Nattaporn Thoonsaengngam, and RAOC/SAT members at NARIT

杉山 孝一郎 and 砂田 和良 (NAOJ) as well

Japan VLBI Consortium Symposium 2019
November 23 and 24, 2019

Radio Astronomy Network and Geodesy for Development (RANGD) 2017-2021

"Capacity Building Through Radio Astronomy"

- Thai National Radioastronomy Observatory (**TNRO**)
    - 40m Thai Radio Telescope (**TNRT**)
    - 13m VGOS Telescope
    - Visitor Centre
- Receiver and Electronics Laboratories

Human Expertise

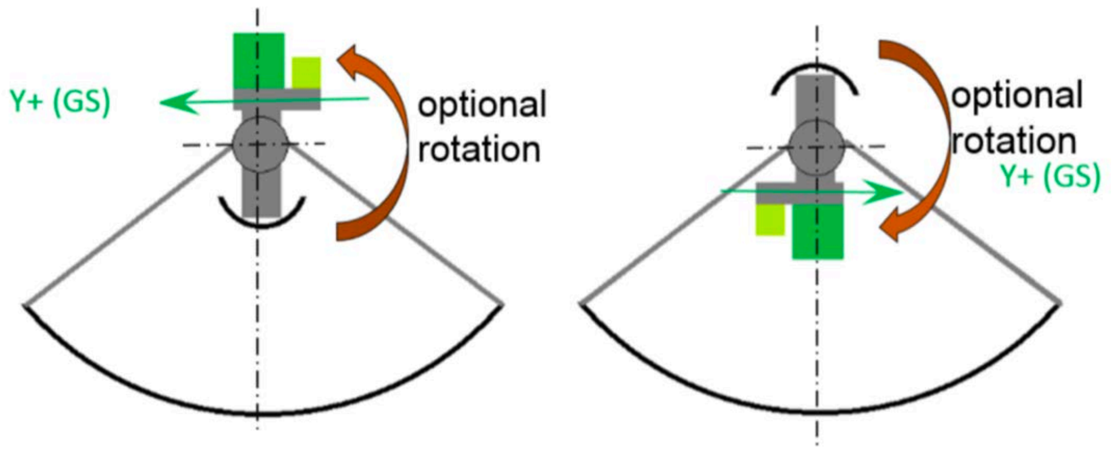
- Workshops & Seminars
- Trainings & Staff exchange

History

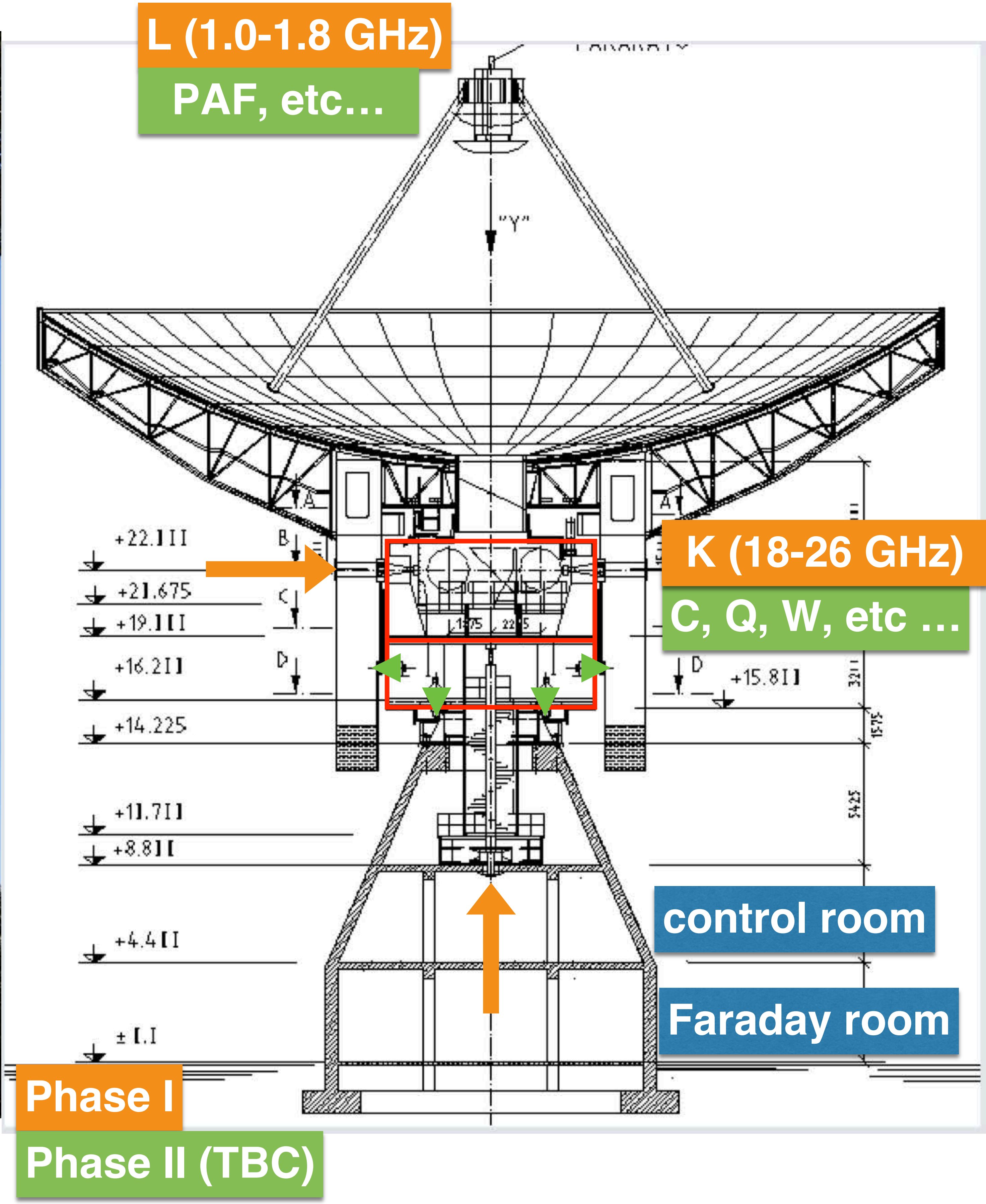
	Workshop	Telescope	Site
…-2013		• 3m SRT, 4.5m SRT	• **RFI U. of Malaya** (with Roslan Umar supervised by Dr. Zamri)
2014	• NARIT-KASI winter school	• **Present the idea to MOST Minister**	• RFI 100-3300 MHz x 6 locations in Chiang Mai
2015	• Radio Astronomy Workshop (P. Thommasson) • Radio Astronomy & Geodesy Workshop (H. Schuh)	• EAVN workshop 2015 (Hokkaido) • AOV meeting @Hobart	• RFI-PTEC 20 MHz - 26.5 GHz @AstoP. @Jomthong • Meeting with Chancellor of Mae Fah Luang University, Chiang Rai
2016	• NARIT-KaVA winter school • Training on Radio Telescope Principles (P. Thommasson)	• **RANGD Proposal Submitted** • KaVA meeting @Krabi • **RANGD Project Approval** • **TVN Collaborative Workshop @Krabi**	• RFI 20 MHz - 6 GHz @alternative sites, Phrae, Maejo, Doisaket • Prime candidate @HHK
2017	• Newton Fund I seminar series • Newton Fund I summer school • 2nd Radio Astronomy & Geodesy Workshop (H. Schuh)	• Contract Awarded to MTM • TNRT subsystem projects started • Site permission from King Rama IX’s office	• RFI 20 MHz - 6 GHz @HHK • **Site concluded @ HHK**
2018	• NARIT-SOKENDAI Winter School 201 • …		Site construction started…

Thai National Radio Telescope

- `Updated' version of IGN's 40m Yebes Radio Telescope
- 40m Paraboloid Antenna, Cassegrain-Nasmyth optics
- 150 um (rms) total surface accuracy (@52EL)
- 300 MHz - 115 GHz
- Slew: Az 3 deg/s, EL 1 deg/s
- Pointing: 2" (no wind),
  6" (5 m/s wind)
- Prime-Focus Tetrapod Head Unit (THU)

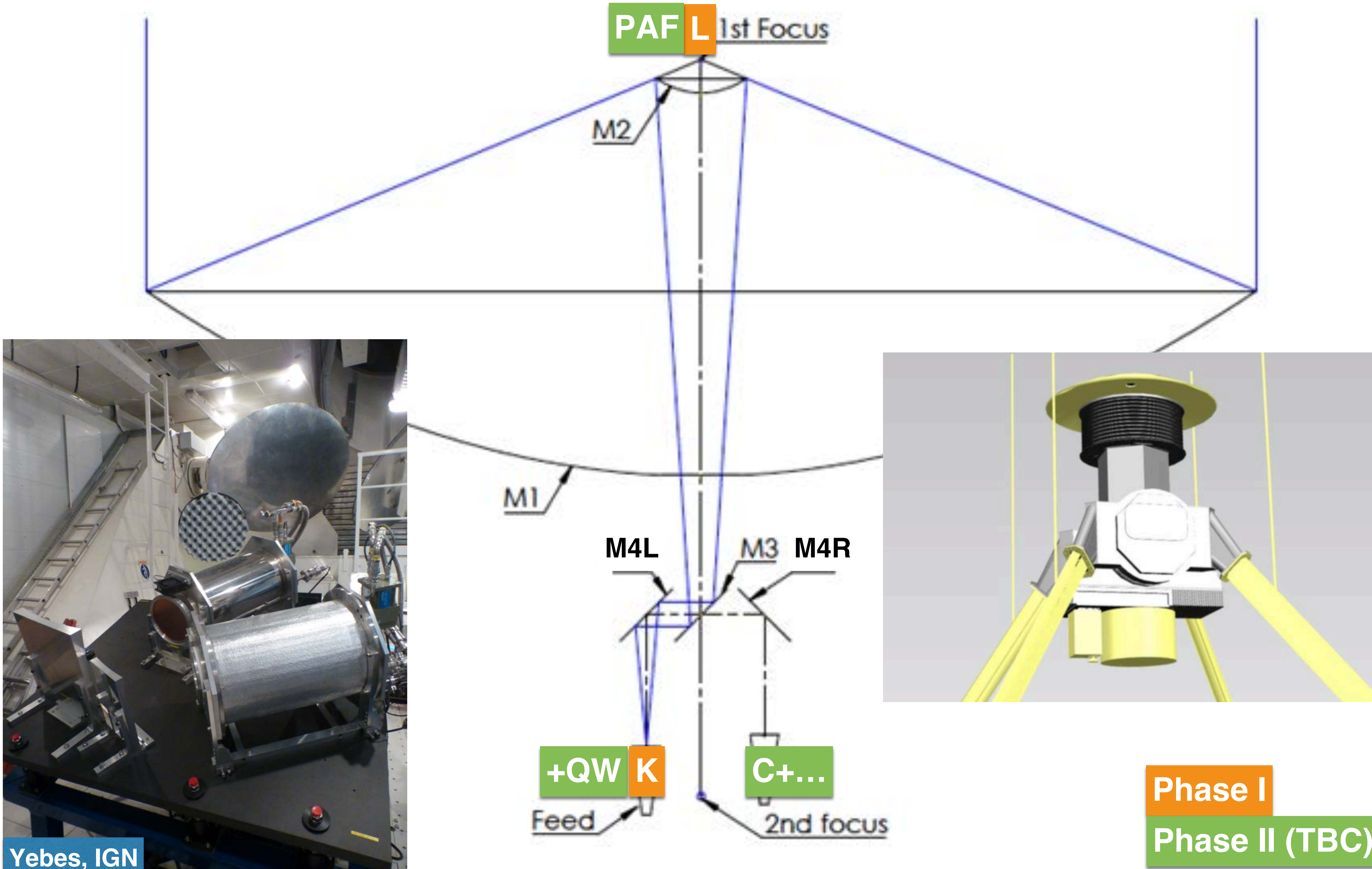


Thai National Radio Telescope



MINISTERIO DE FOMENTO
DIRECCIÓN GENERAL DEL INSTITUTO GEOGRÁFICO NACIONAL
CENTRO NACIONAL DE INFORMACIÓN GEOGRÁFICA

Optics



Phase I

Phase II (TBC)

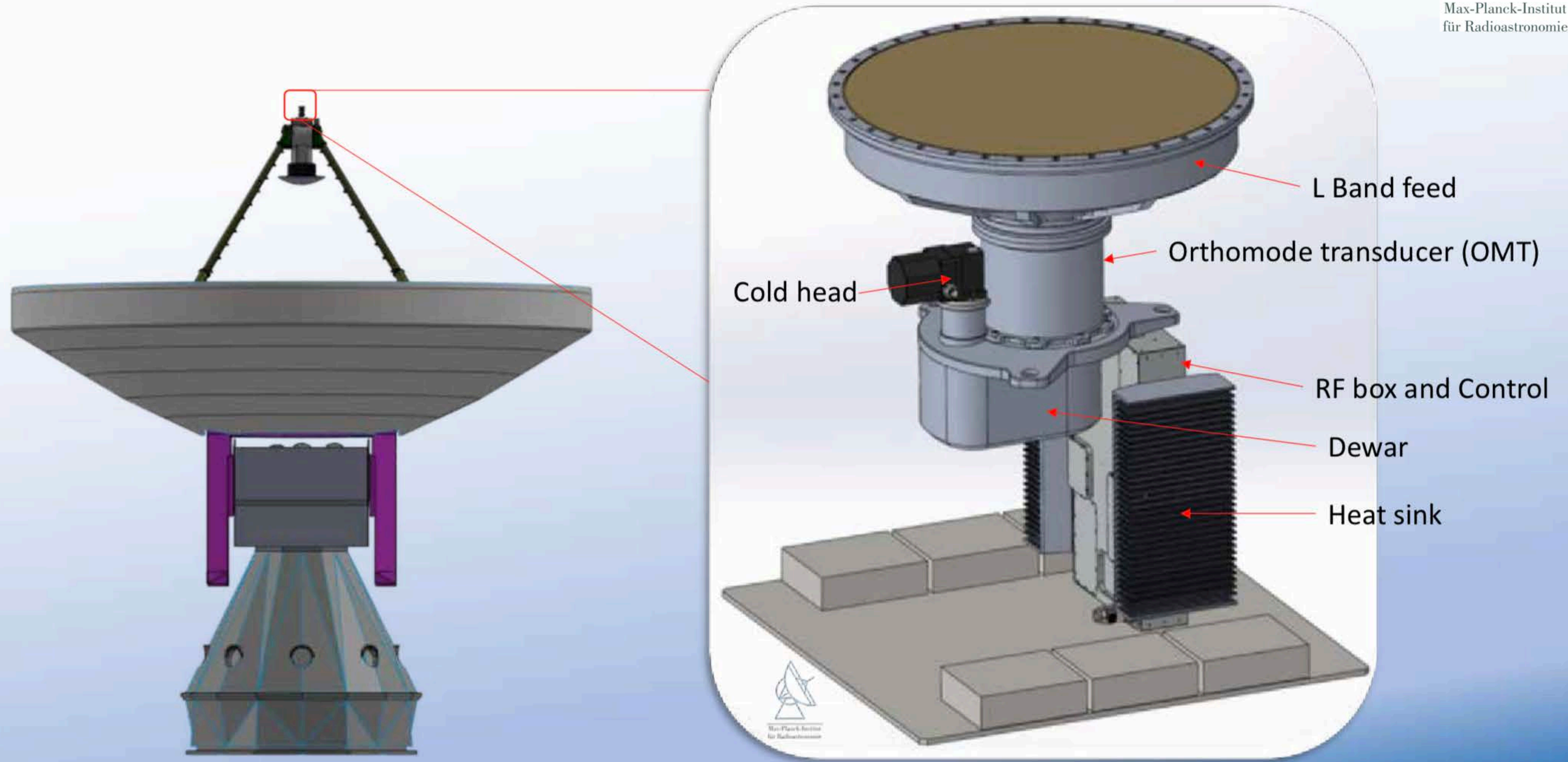
Phase I Rx's: L-band & K-band

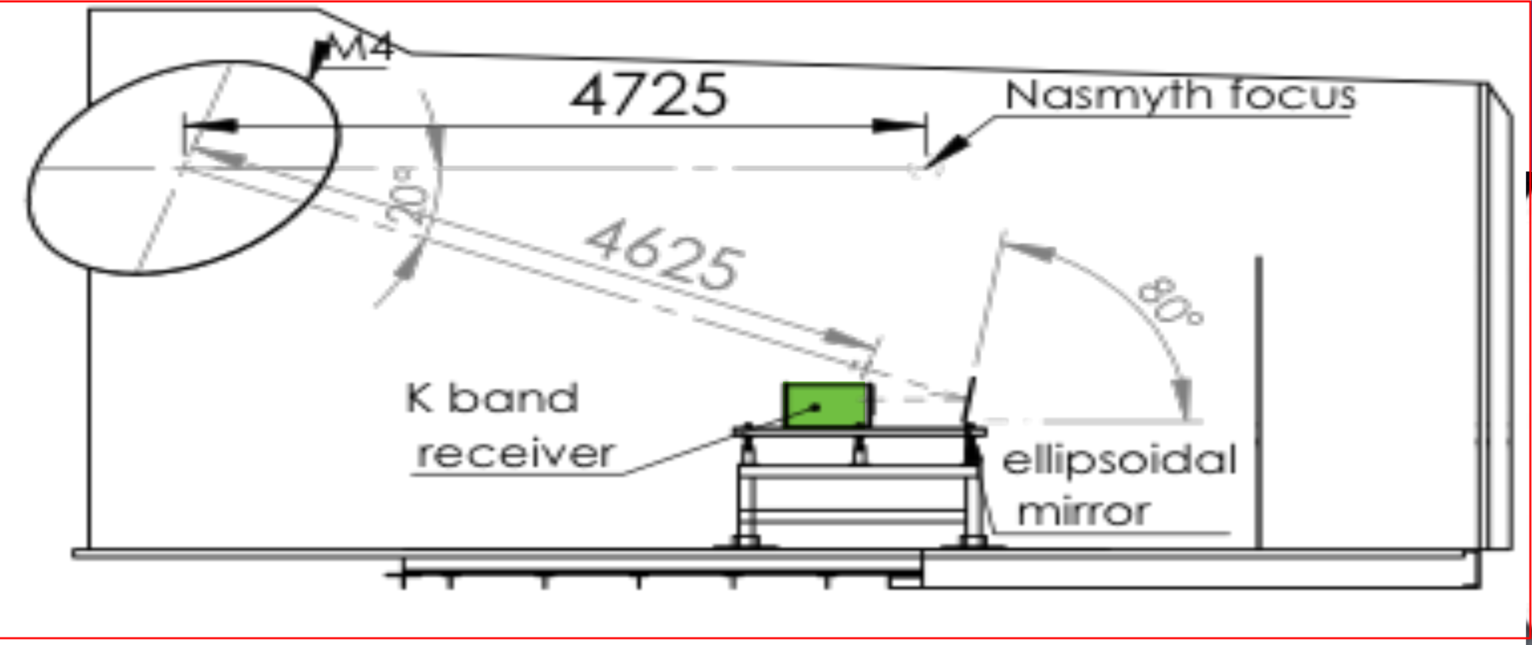
	L-band	K-band
Position	Primary Focus	Nasmyth Focus
Frequency range (GHz)	**1.0-1.8**	**18.0-26.5**
Centre wavelength (cm)	21.4	1.36
Beam width (arcmin)	22	1.4
Polarisation	Linear	Circular
Cross polarisation	-25 dB	-25 dB
RF BW	**800 MHz**	8 GHz
sampler	3 Gsps	>4 Gsps
Packetizer BW	1.5 GHz	**>2 GHz**
digitisation bits	< 12 bit	< 12 bit
Digitizer Output	2 x 40 Gbps	2 x 40 Gbps
Total efficiency	0.7	0.5
Gain (K/Jy)	0.32	0.23
Trx	13	20
Tsky (K)	12	50
Tsys (K)	25	70
SEFD (Jy)	**78**	**304**

L-band

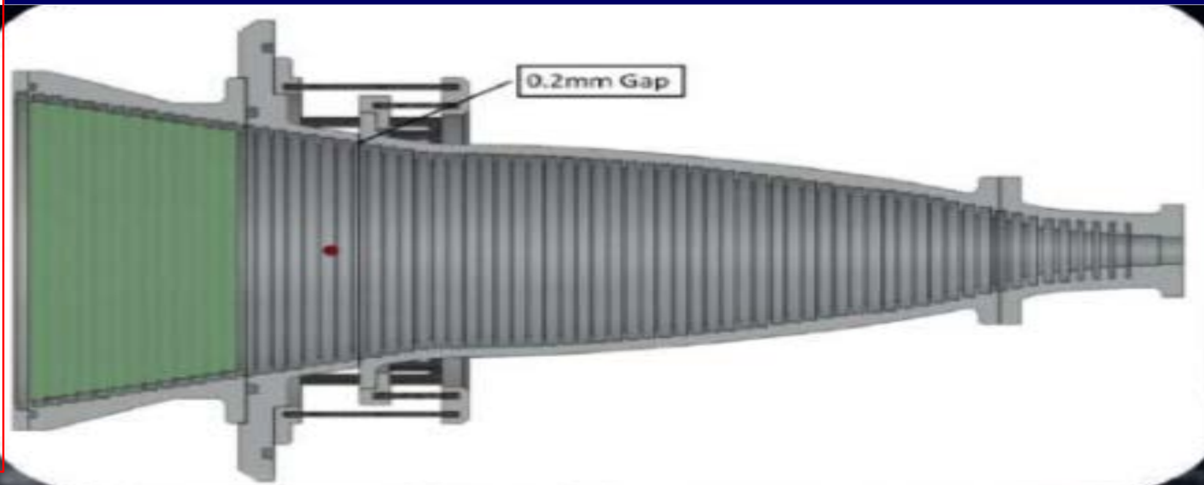
D. Singwong

Max-Planck-Institut für Radioastronomie





K-band

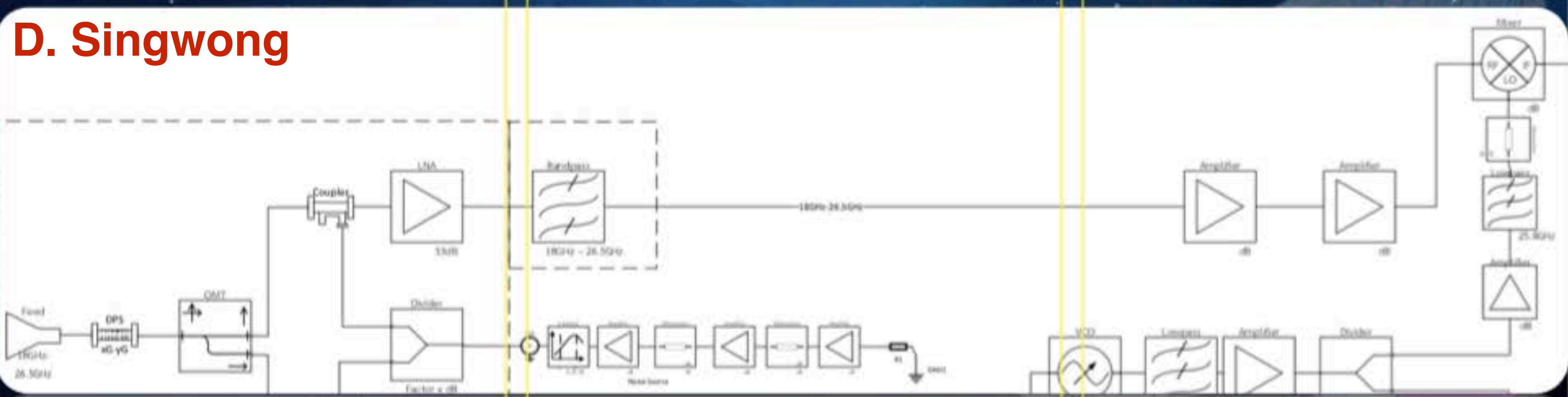


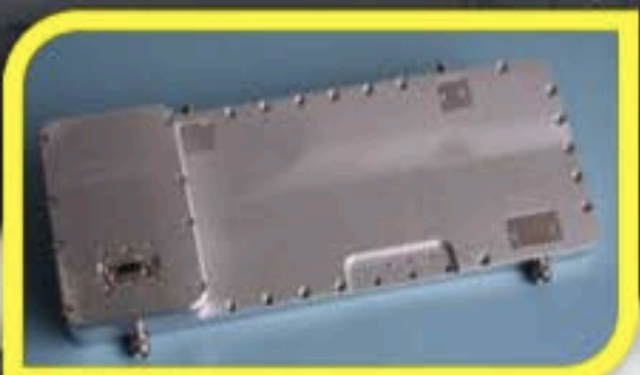
Frontend Part
18-26.5G

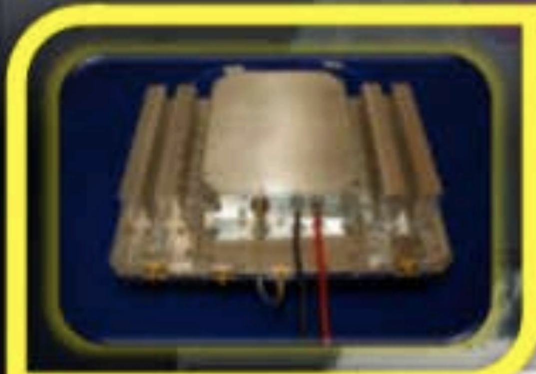
Downconverter
18-26.5=>3-6GHz/2-4GHz
Bandwidth 3GHz /2GHz

IF Amplifier
3-6GHz/2-4GHz
Bandwidth 3GHz/2GHz

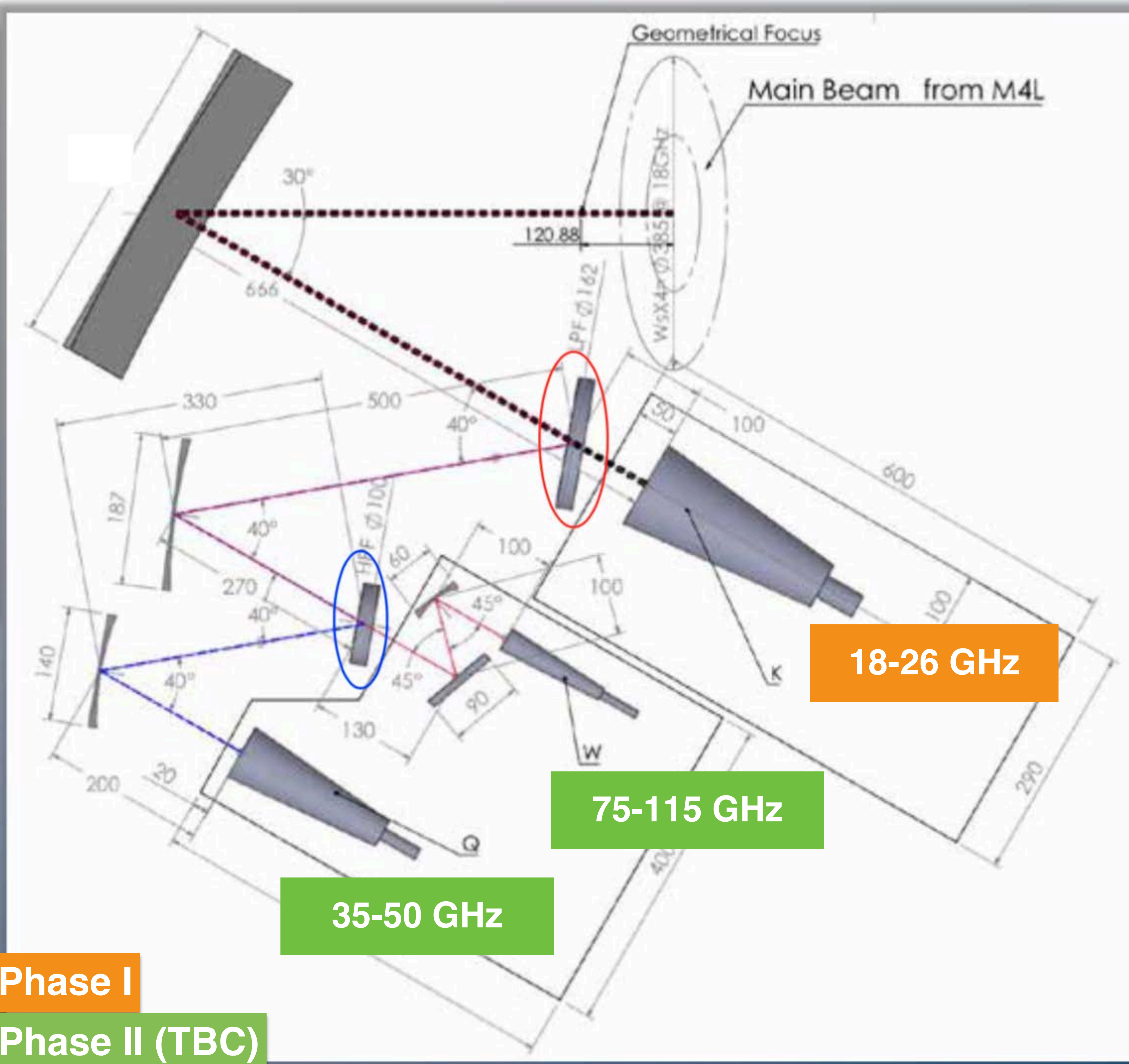
D. Singwong

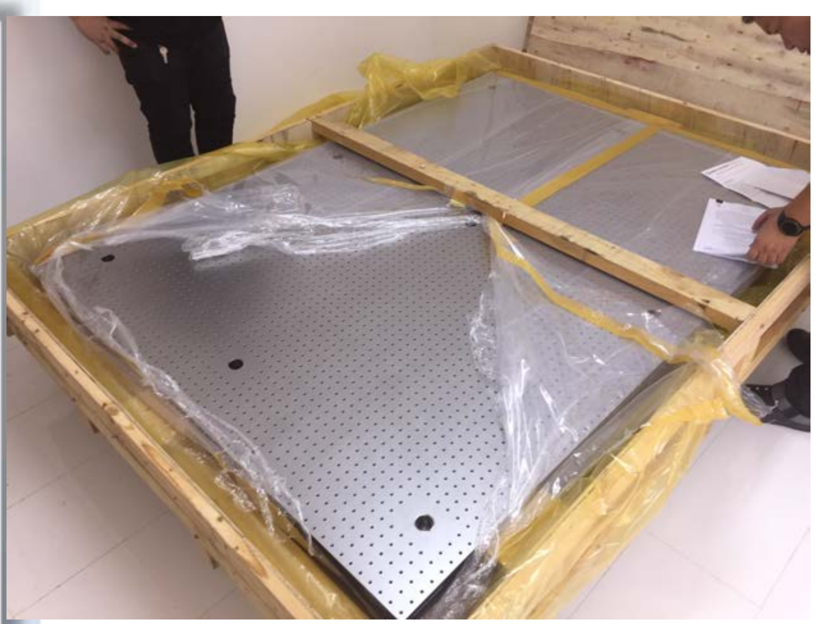


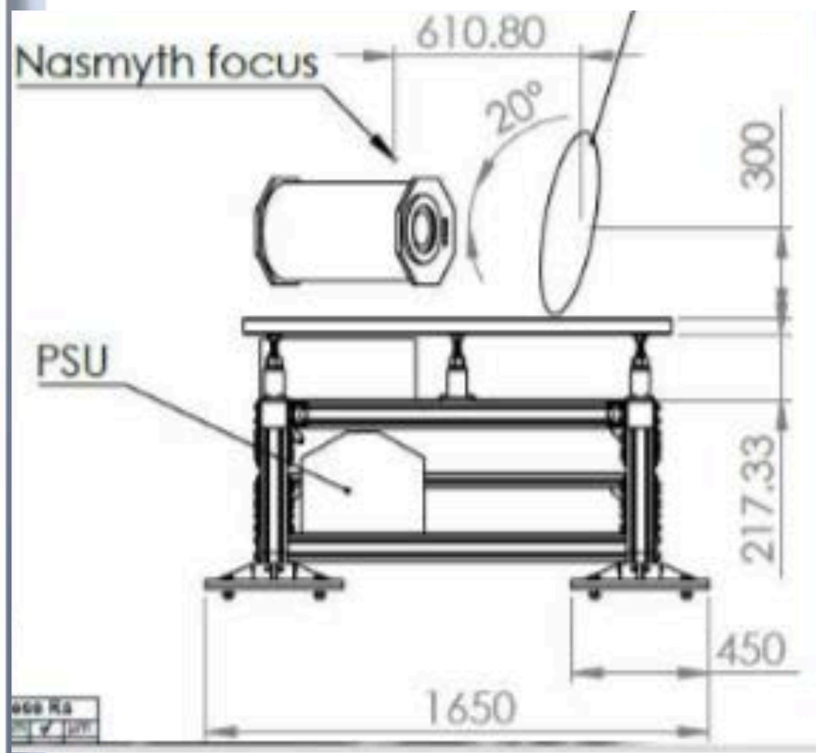




Quasi-optics & simultaneous KQW

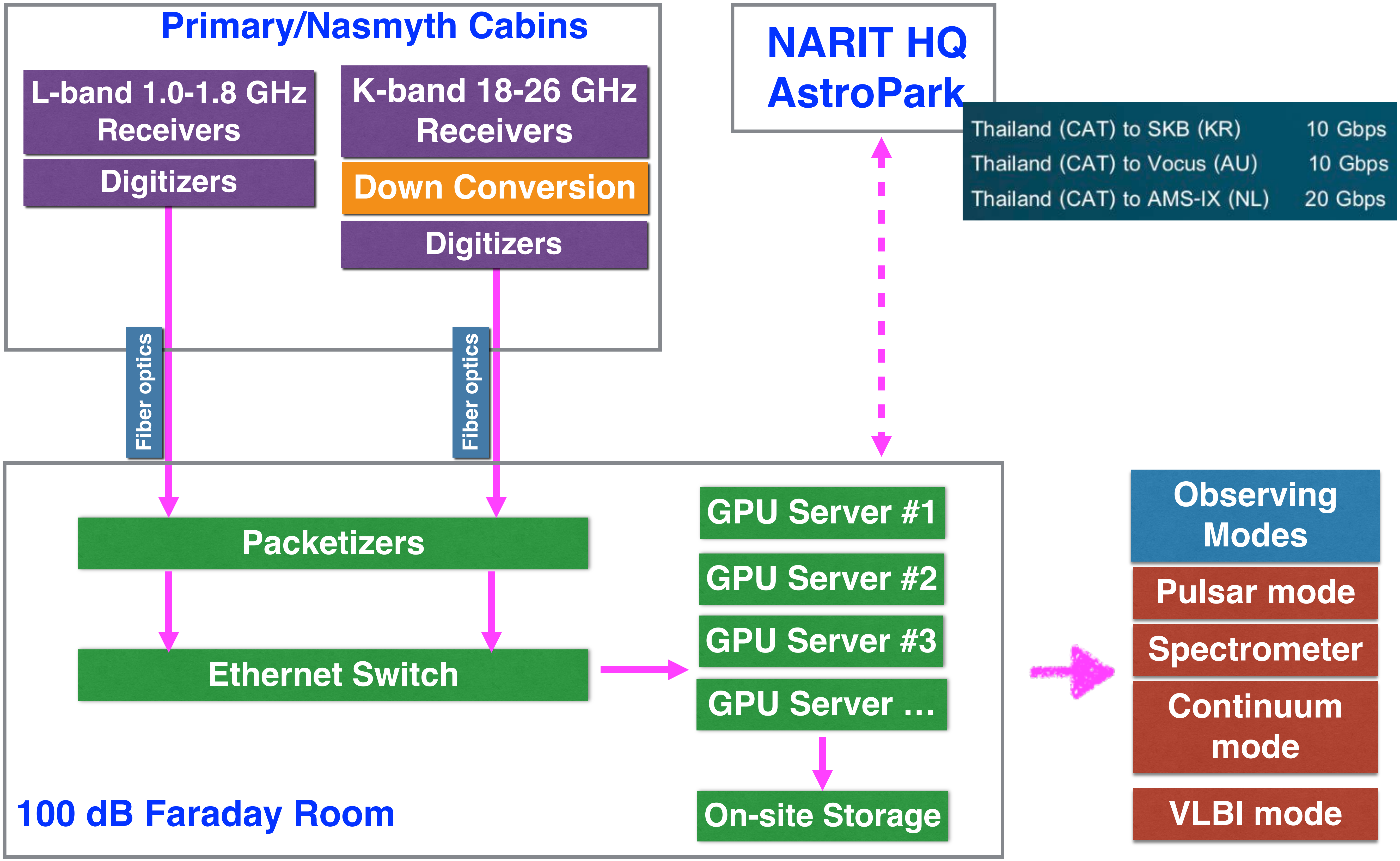






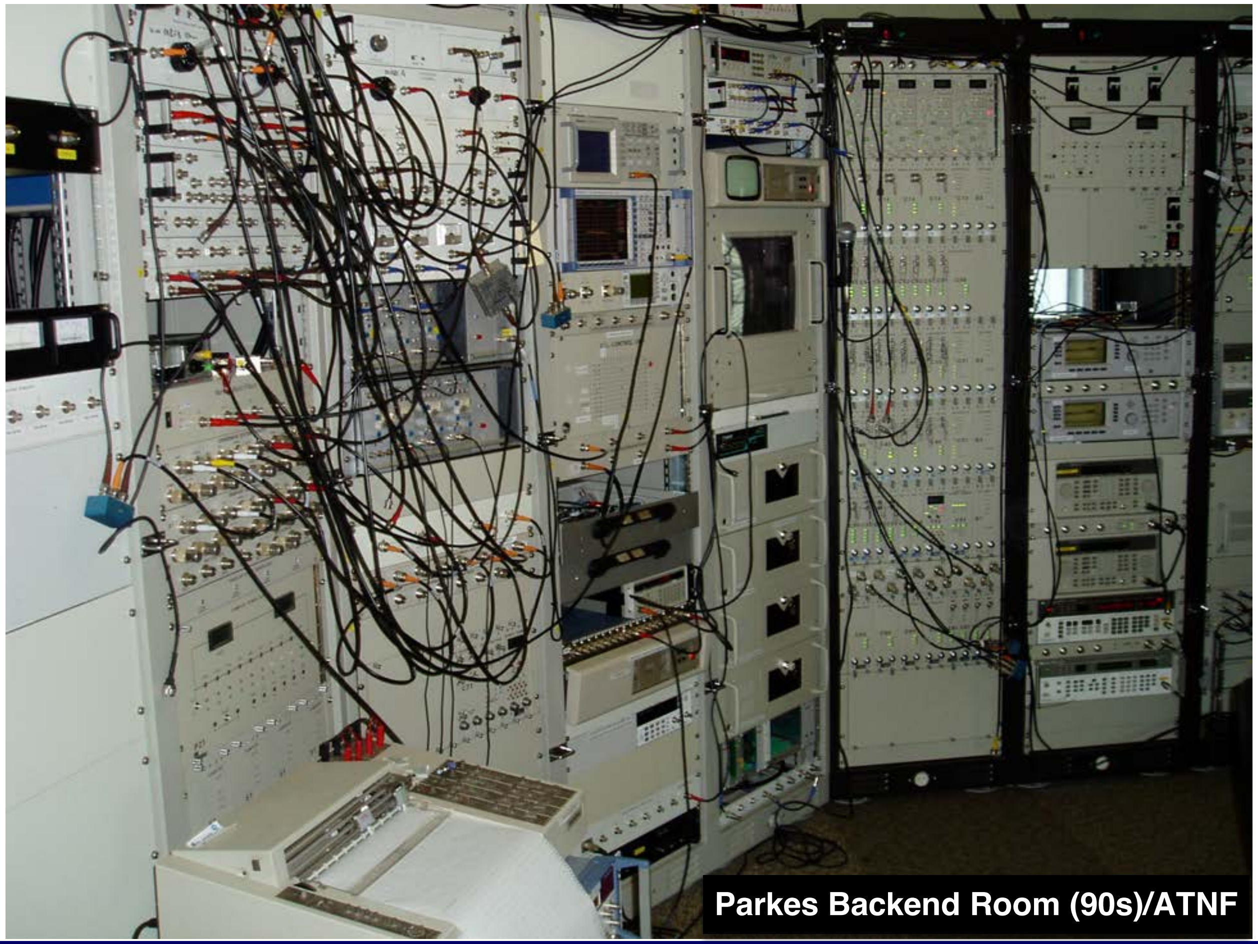
D. Singwong
ST. Han

Signal diagram



Thailand (CAT) to SKB (KR)	10 Gbps
Thailand (CAT) to Vocus (AU)	10 Gbps
Thailand (CAT) to AMS-IX (NL)	20 Gbps

Universal Software Backend

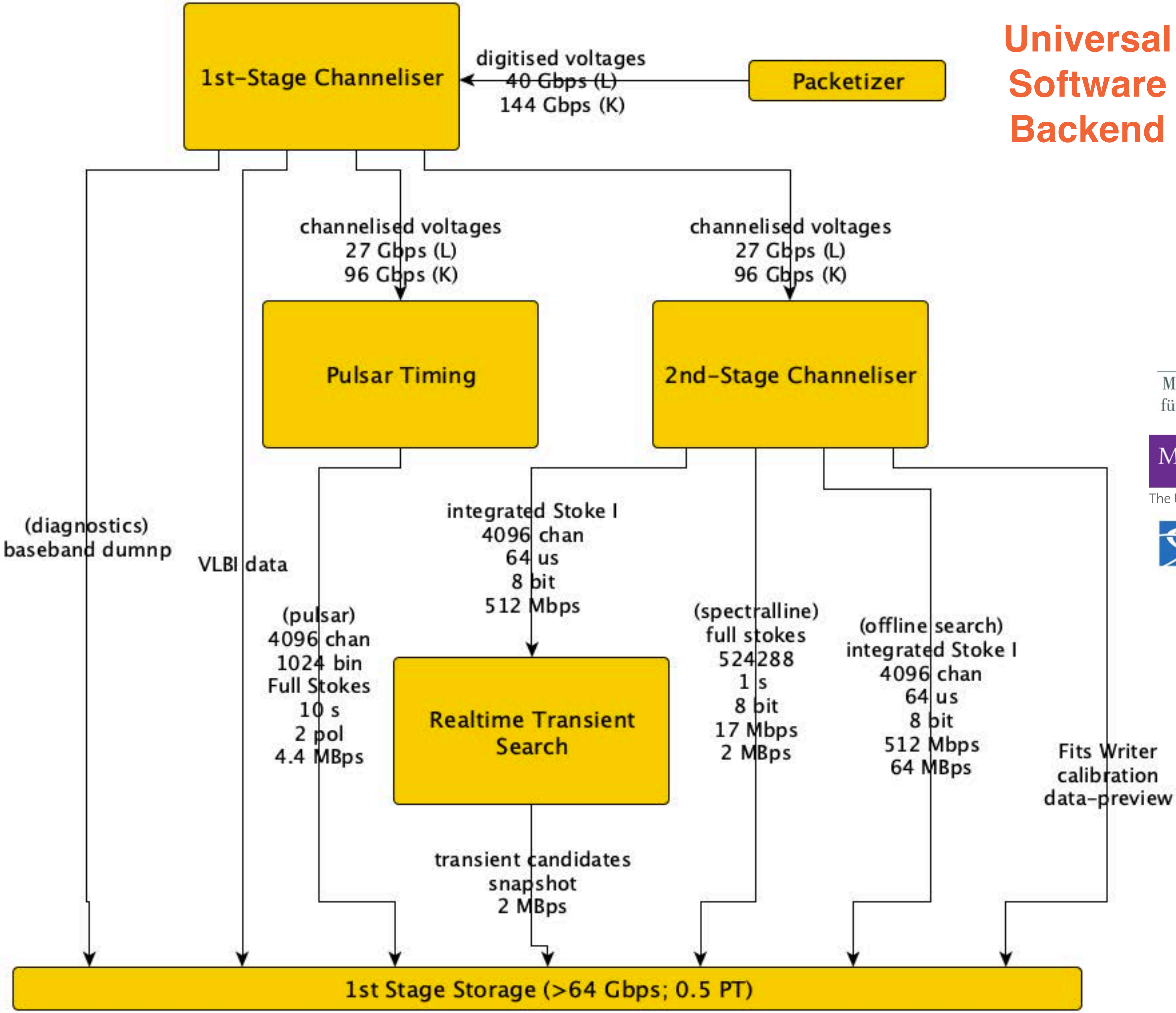


- Versatile; one for all
- Commercial Of The Shelf systems
- Easy to update, scalable
- Community Software

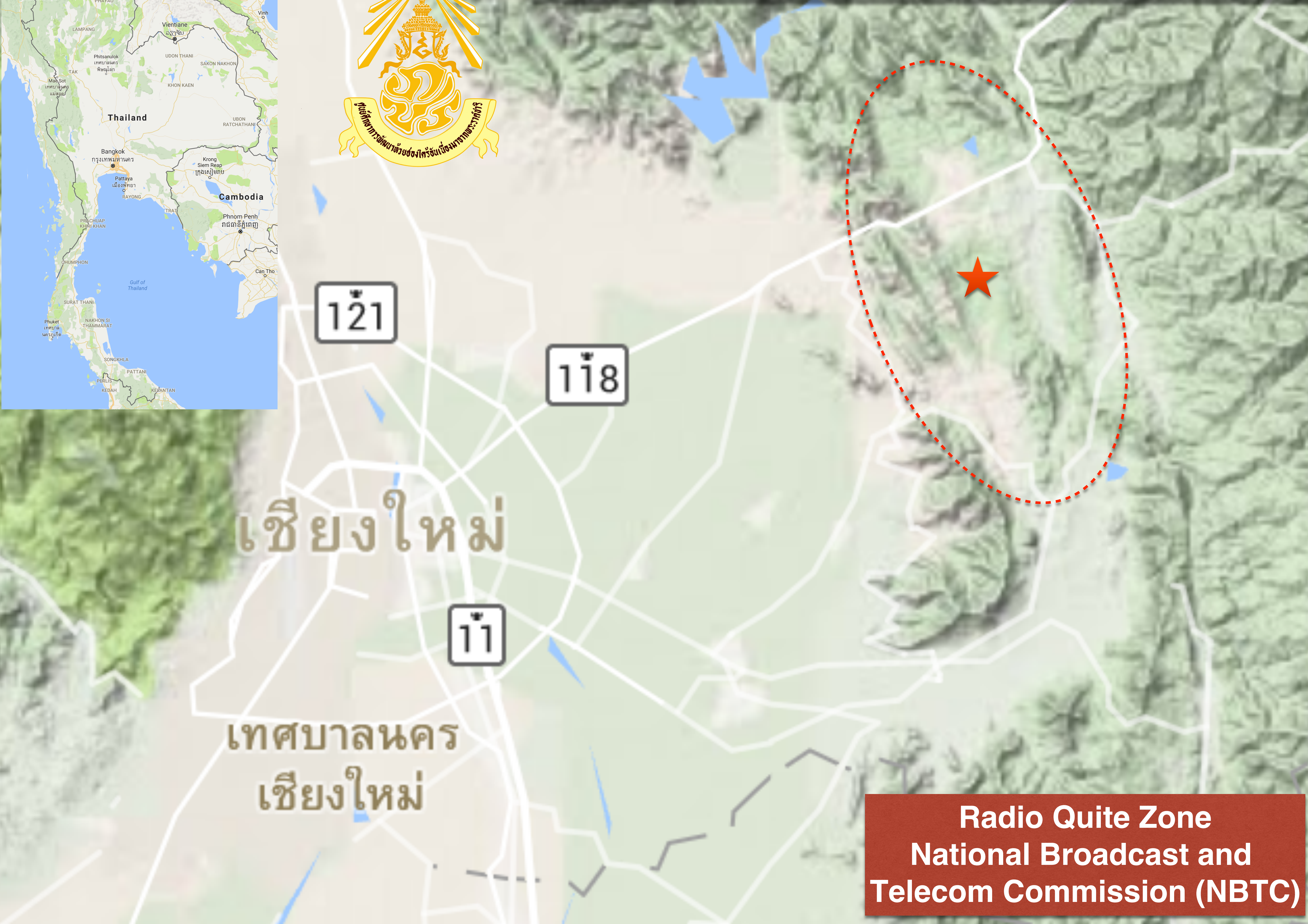
- TNRT USB modes/demand
  - Raw input @~144 Gbps
  - 1st stage Channelisation
  - 2nd stage
    - Pulsar Timing (output 8 Mbps)
    - Pulsar Search (output 512 Mbps)
    - Spectrometer (output 16 Mbps)
    - VLBI (output 32 Gbps)
  - On-site storage 320 TB @32 Gbps
  - Placed inside 6x4x4 sqm Faraday Room

- Specifications 8 USB nodes
  - dual Xeon Gold 12 core 3.0 GHz
  - RAM 64 GB
  - 10 x 8 TB HDD
  - 512 GB SSD
  - 100 Gbps Ethernet
  - 100 Gbps InfiniBand
  - 2 x RTX 2080 Ti

Universal Software Backend



Huai Hongkhrai Royal Development Study Center



Radio Quite Zone
National Broadcast and Telecom Commission (NBTC)


July 2019

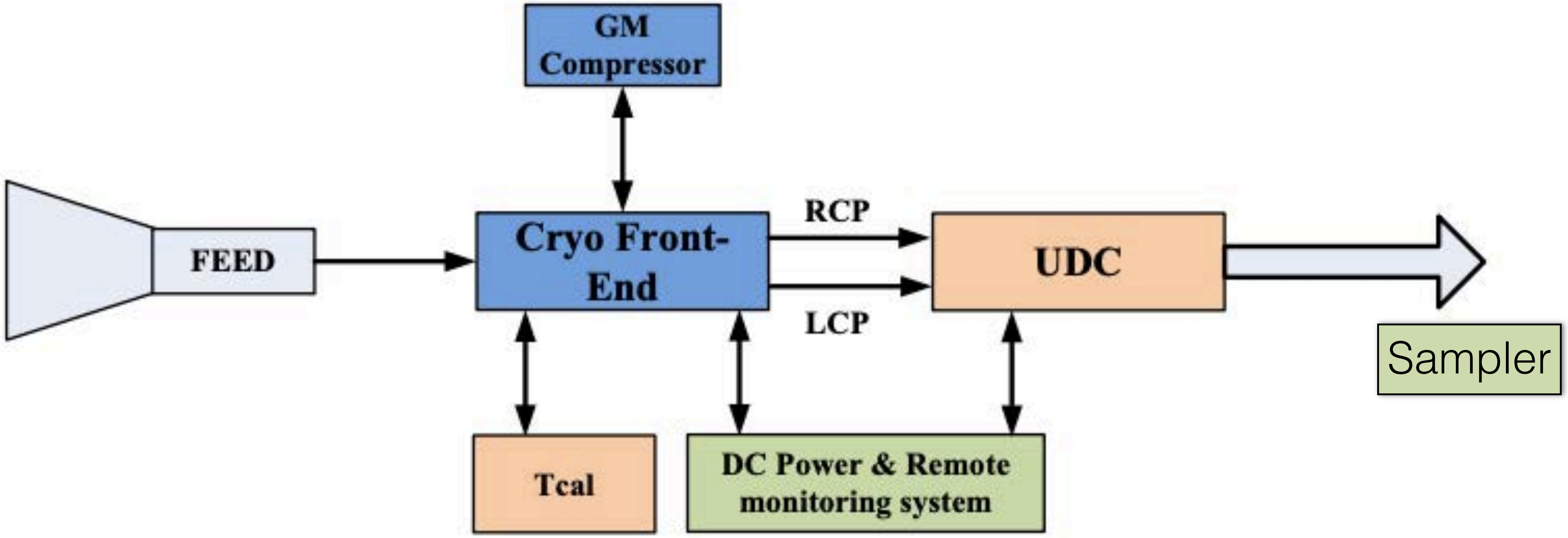
September 2019


September 2019

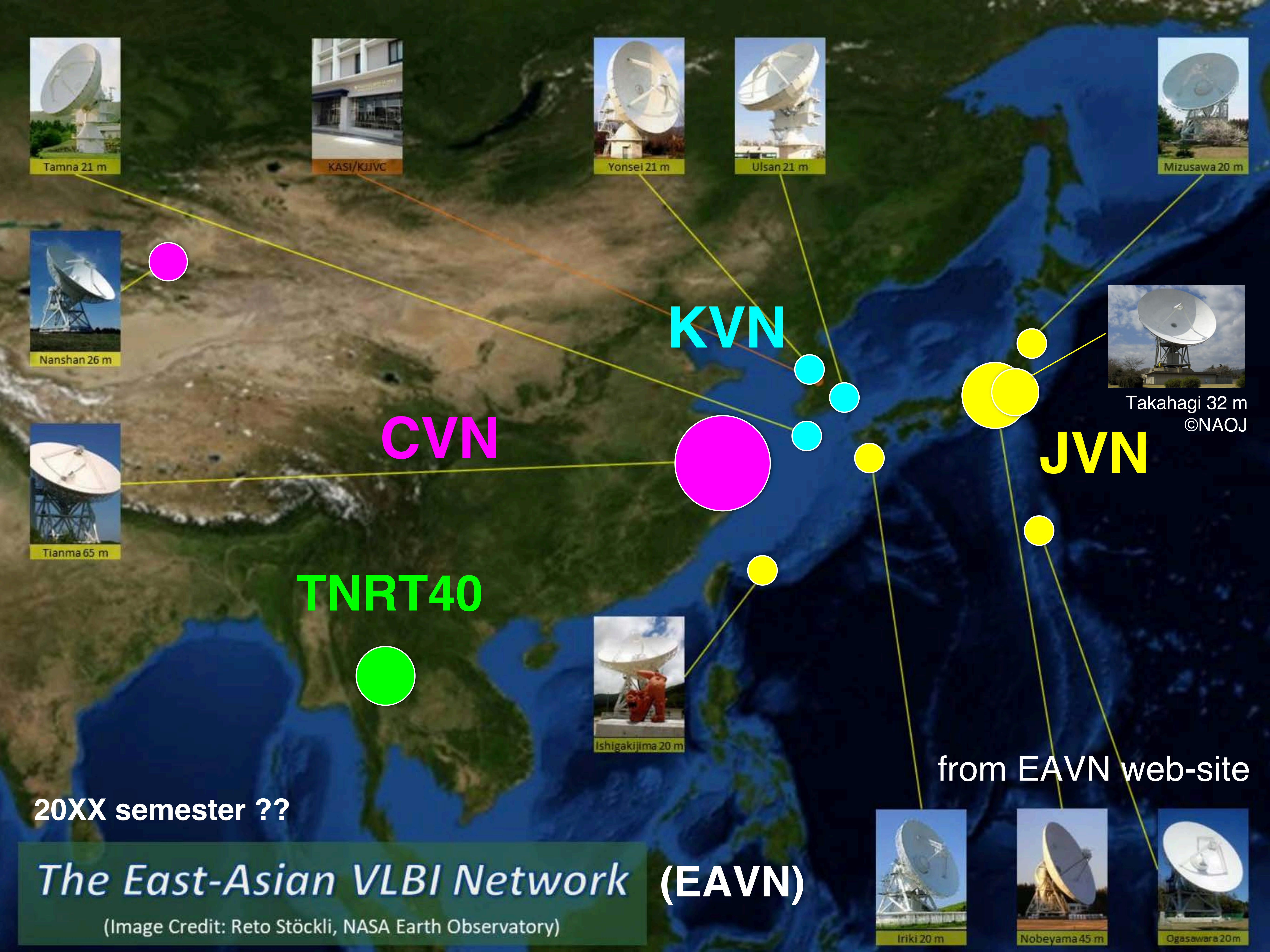
C-band (Sino-Thai/SciTech; funded)

RF band	4.55-13.65 GHz
Polarisation	Linear
IF band	???
ADC	>2 GHz

FDR	1/2020
development	2020
final assembly	early 2021
TNRT installation	mid 2021



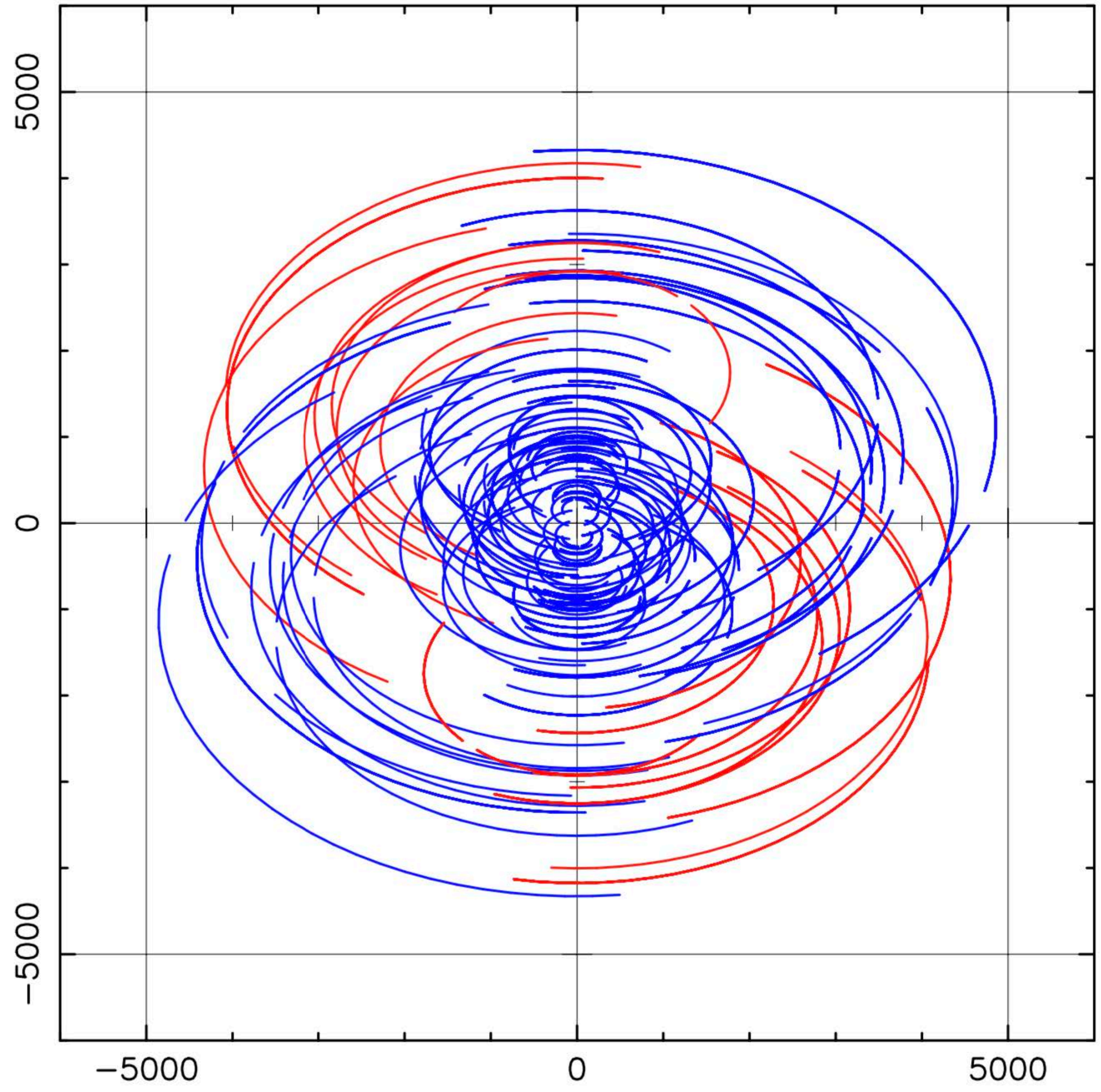
	2019				2020							2021	2022
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	jul-dec		
MTM assembly	alignment/sub-assembly					big lift	final assembly-tracking	photogrammetry	SAT (Site Acceptance Test) & technical tests			Single Dish/VLBI commissioning	
L-/K-band	L- assembly			K-fabrication/assembly		Final Test/training	Shipment	Site Installation					
Holography	RF/mechanic fabrication		Ship to Yebes	RF assembly/tests	Shipment	Final assembly at NARIT							
Telescope Control System	Finalise SAT test pipeline		TCS-USB interface		TCS-Holography component	Full Backend Implementation (TCS-USB-T&F)							
Universal Software Backend	Interface protocol	USB-Spectrometer implementation on GPU-server @Astropark		USB-pulsar mode @Manchester	USB full functions on GPU server @Astropark								
Time & Frequency	Hmaser & GPU delivered		Time & Frequency test setup										



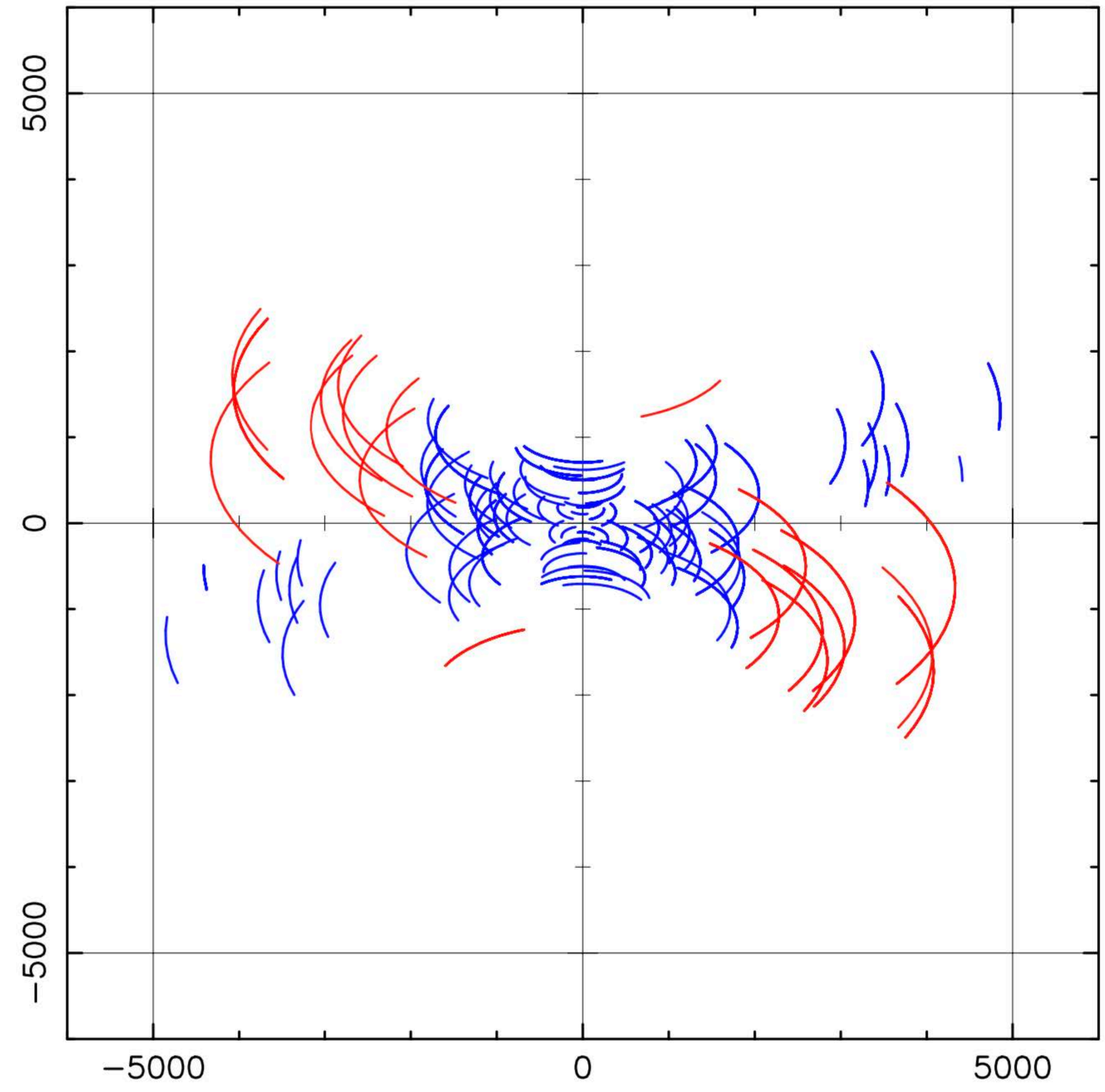
Tamna 21 m
KASI/KJJVC
Yonsei 21 m
Ulsan 21 m
Mizusawa 20 m
Nanshan 26 m
KVN
Takahagi 32 m
©NAOJ
CVN
JVN
Tianma 65 m
TNRT40
Ishigakijima 20 m
from EAVN web-site
20XX semester ??
The East-Asian VLBI Network (EAVN)
(Image Credit: Reto Stöckli, NASA Earth Observatory)
Iriki 20 m
Nobeyama 45 m
Ogasawara 20m

UV-coverage : EAVN + TNRT40

Declination +40°



Declination –29°



4.5m Small Radio Telescope

- HTSC receiver (collaboration with Toshiba co.)
  - 1400-1427 MHz (HI)
  - 1610-1670 MHz (OH)
  - 2200-2350 MHz
- Tsys 200-300
- Being used for HI galaxy rotation/sky survey
- Plan to upgrade for Pulsar observation
  - Software Defined Radio (SDR) (ettus N310, 100 MHz bandwidth, 16bit)
  - baseband dump, psrfits/psrdada, off-line dspsr folding.

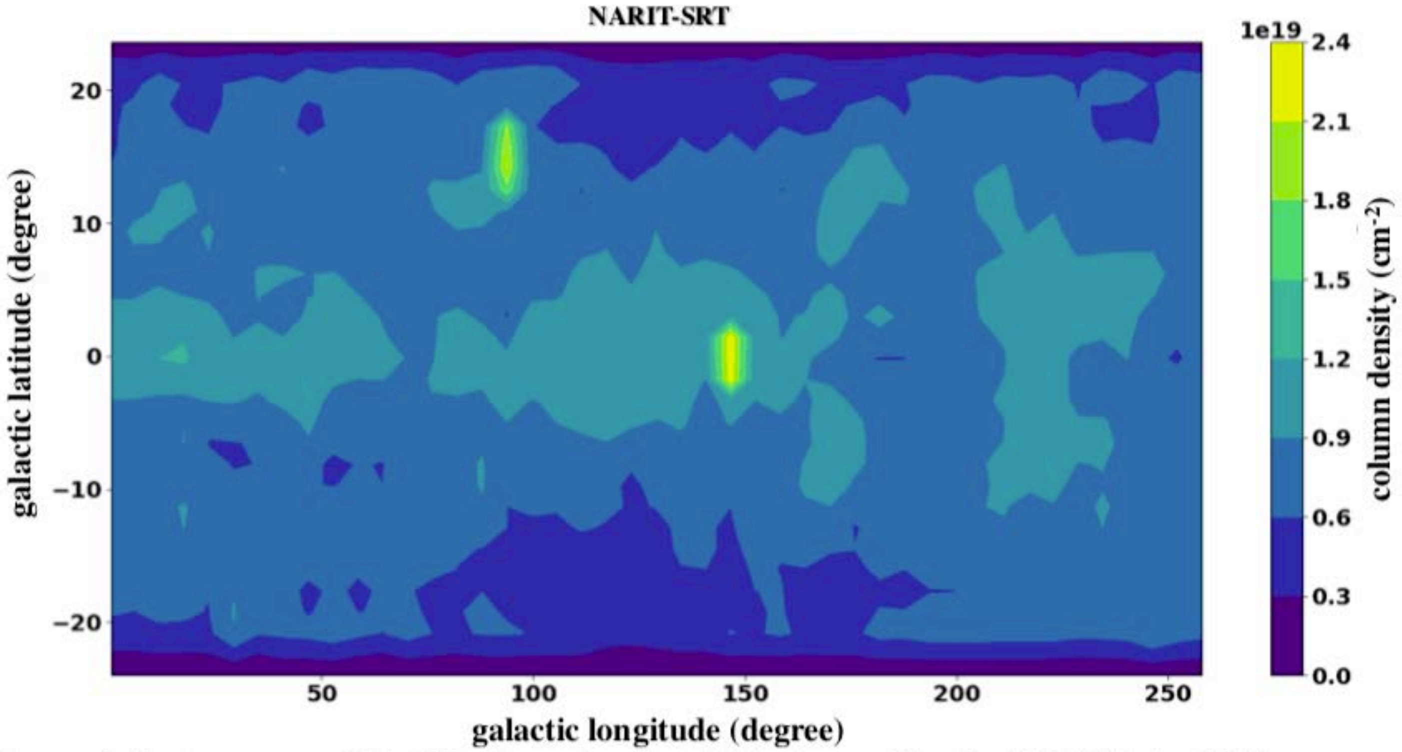
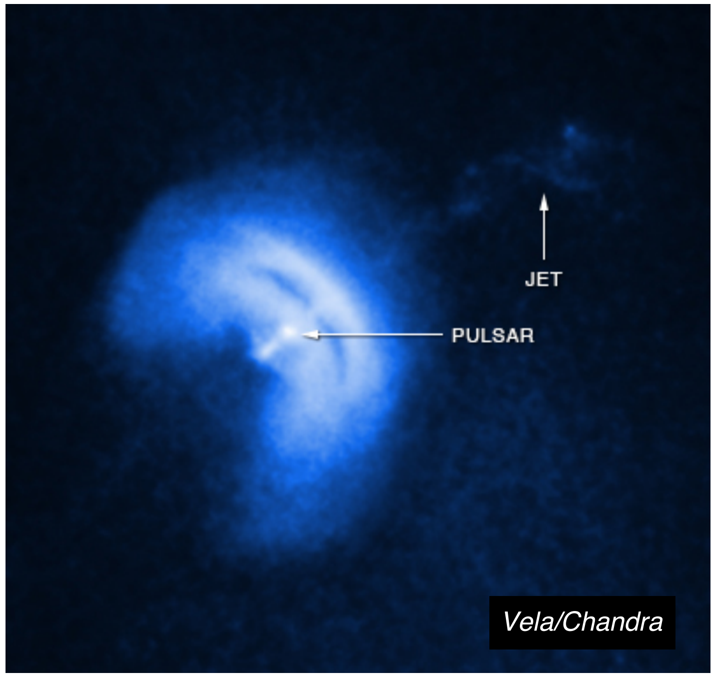
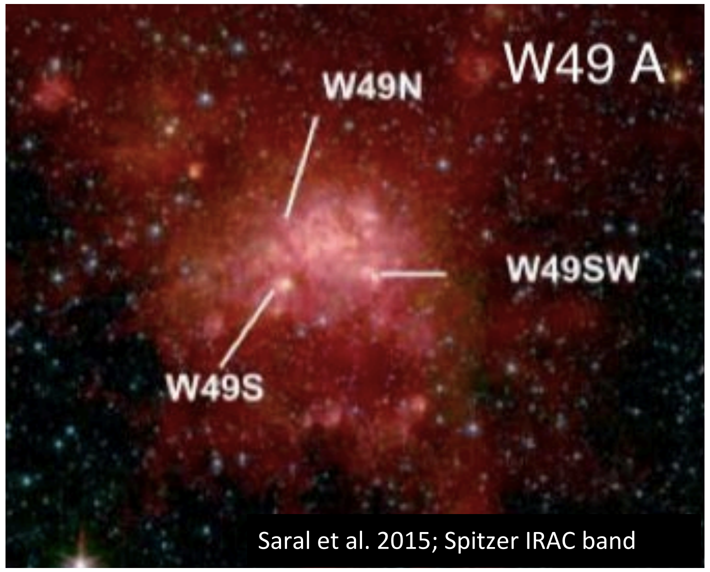
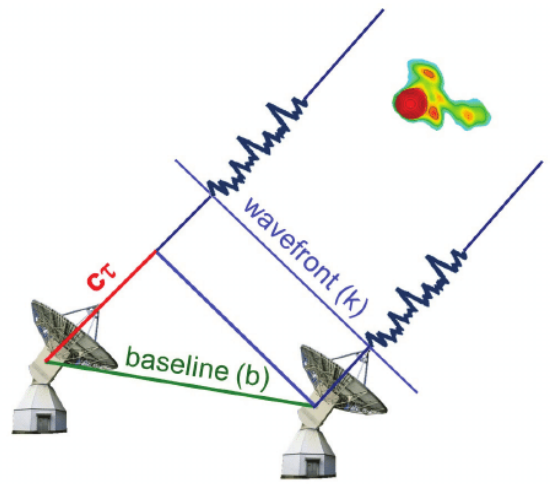


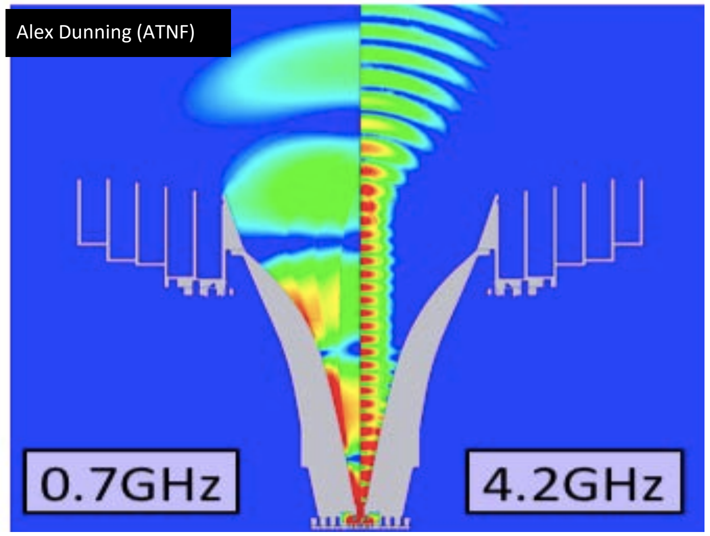
Figure 6. Contour map of the HI column density which observed by the NARIT 4.5m SRT

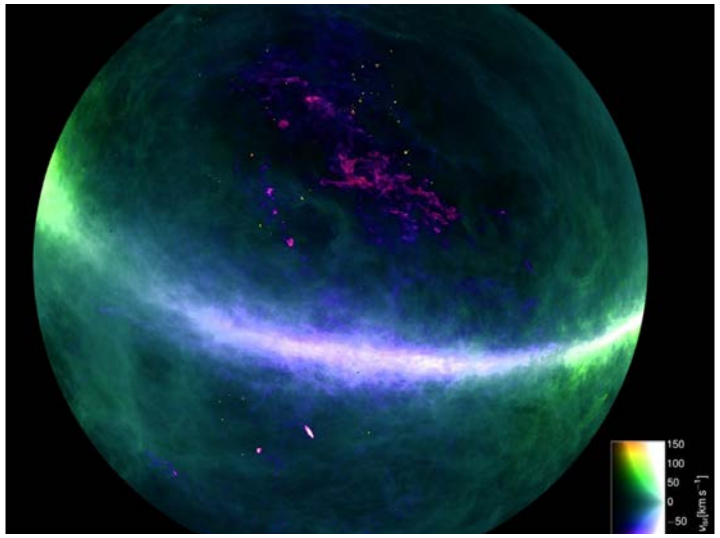
Research & Job Opportunity











- **Research topics in Astronomy & Engineering**
  - Pulsars:
    - Pulse profile evolution
    - Glitches & timing noise
    - Fast photometry for pulsar astronomy
    - DSP with SDR and pulsar backend
    - RFI mitigation
  - Star-forming regions:
    - Periodic / accretion bursting masers
    - Complete molecular / maser line survey
  - Galaxy / AGN / Magnetar / Eclipse binary / VLBI
  - Instrumentation:
    - Optical design for feed & passive component
    - Dual-pol feed & receiver systems of 4.5m SRT
    - Optical telescope for TNRT's pointing model

- **Radio Astronomy Lecture(s) @CMU/Physics**
  - Astrophysics/radio telescope principles
  - Hands-on data analysis

- **Recruitments**
  - 2 telescope operators (2020)
  - research assistants/supporting scientists