

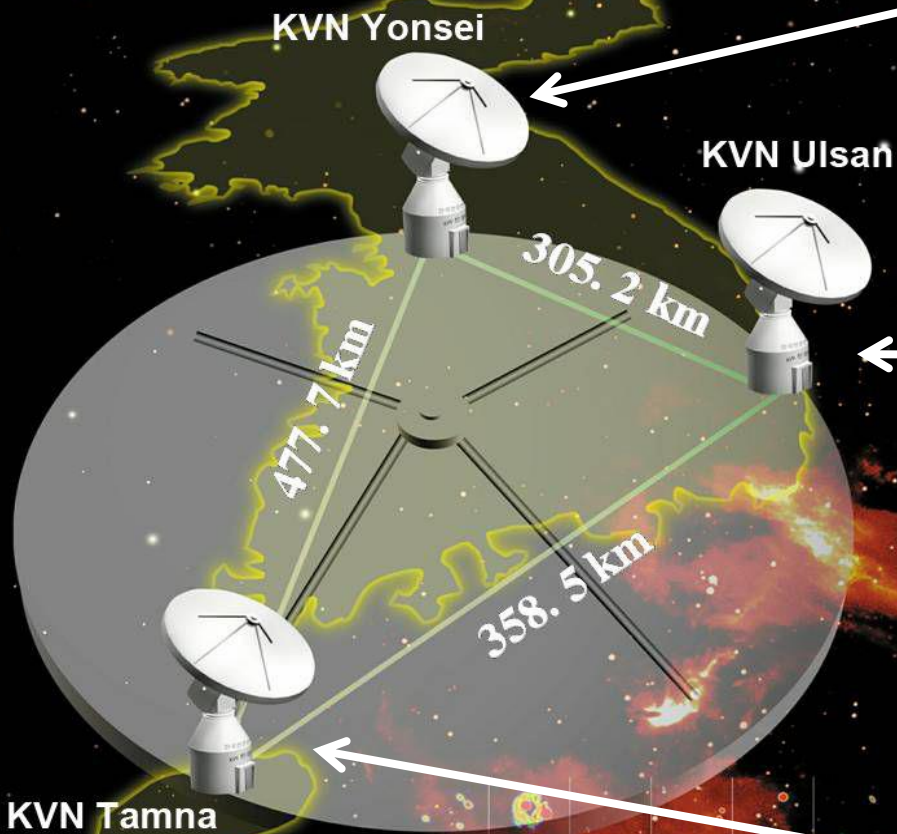
# Recent Results of KVN Multi-Frequency Observations

Do-Young Byun (KASI)  
Florence ERATEC Workshop 2015

# Outline

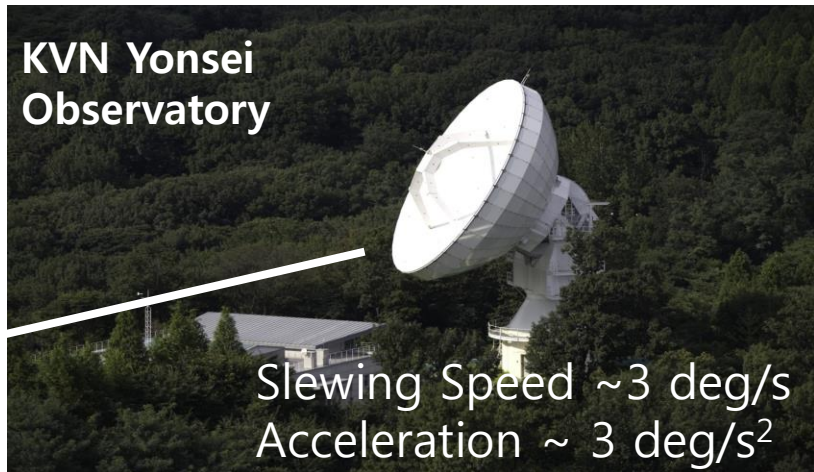
- Introduction to KVN
- Observational Results
  - Evolved Stars
  - AGN monitoring
- Upgrade Activities & Future Prospect

# KVN 한국우주전파관측망 Korean VLBI Network



$\theta_{\text{HBPW}} \sim 6 \text{ mas @ } 22$   
 $\sim 1 \text{ mas @ } 129$

KVN Yonsei  
 Observatory



KVN Ulsan  
 Observatory

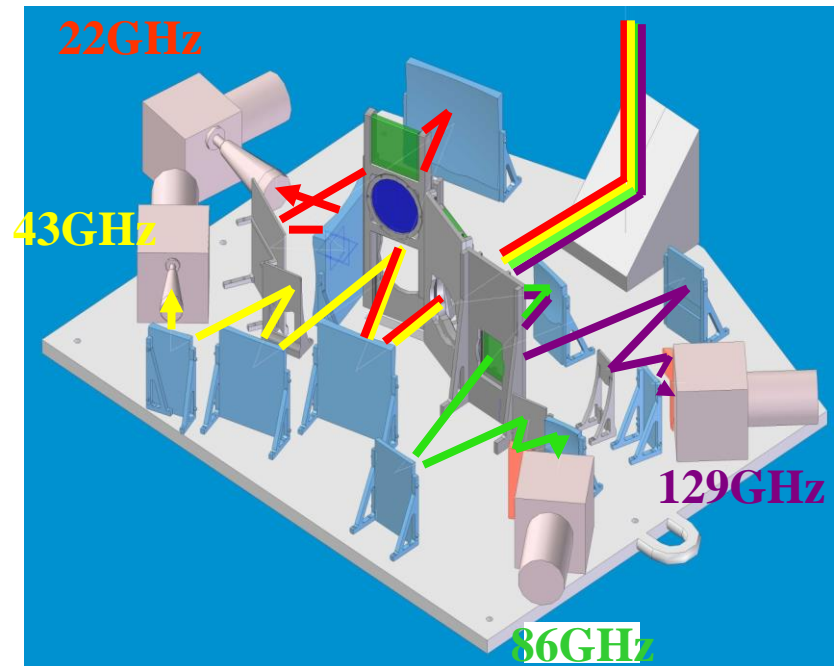
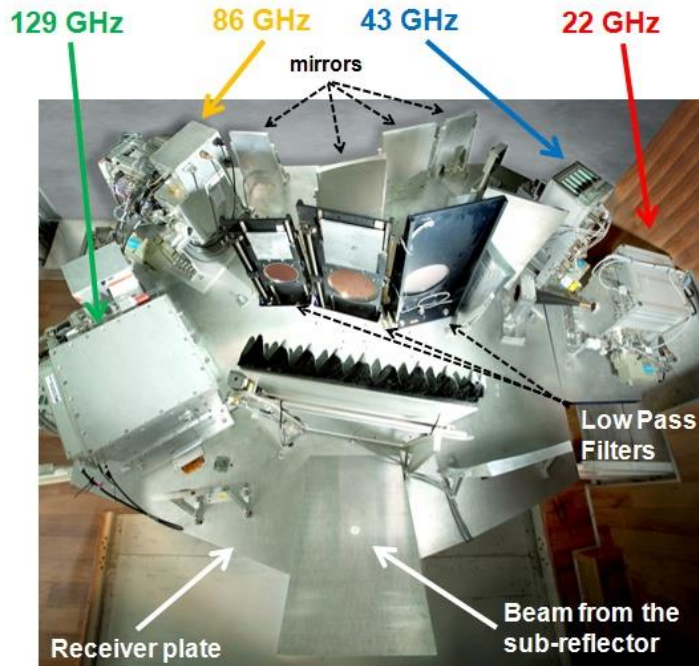


KVN Tamna  
 Observatory

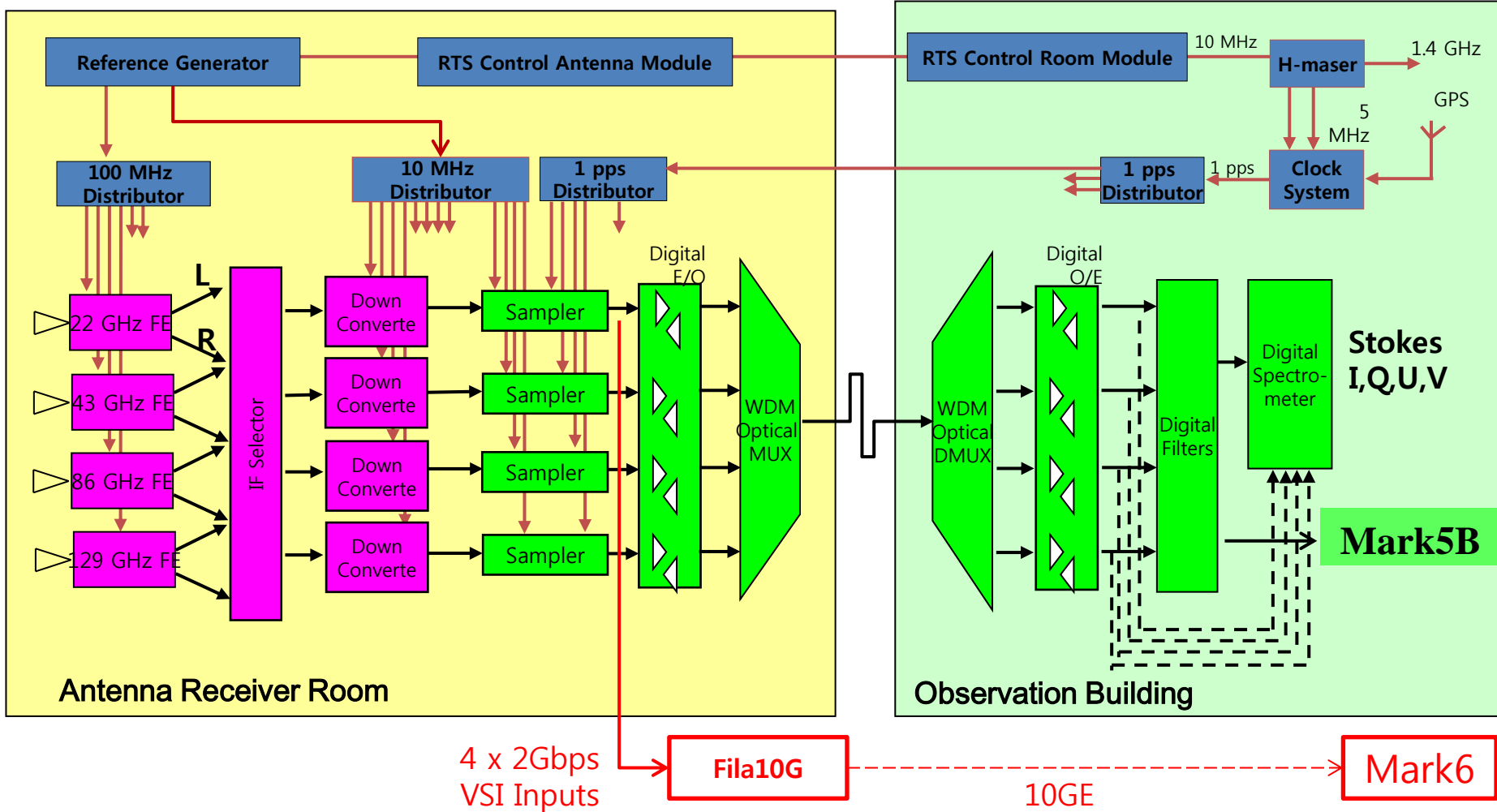


# Multi-Frequency Receiving System of KVN

- Simultaneous Multi-frequency Observation
  - @ 22/43/86/129GHz (Aperture Efficiencies: 60 – 30%)
  - integration time > 5 min @ 130GHz
- Dual Pol : LCP & RCP
  - Simultaneous 2 bands w/ full stokes



# KVN Data Acquisition System



# Science Cases using KVN Multi-Freq. Capability

- **Weak sources at high frequency ( $> 86\text{GHz}$ )**
- Chromatic Astrometry using SFPR
  - AGN Core Shift (Rioja+ 2015, Zhao+ in prep)
  - Registration of multi-transition masers
    - : **Water + SiO Masers of Evolved Stars**
    - : Water + 44G Methanol Masers of Massive SFRs
- AGN Jets
  - Spectral Index Distribution
  - Faraday Rotation (Polarization)

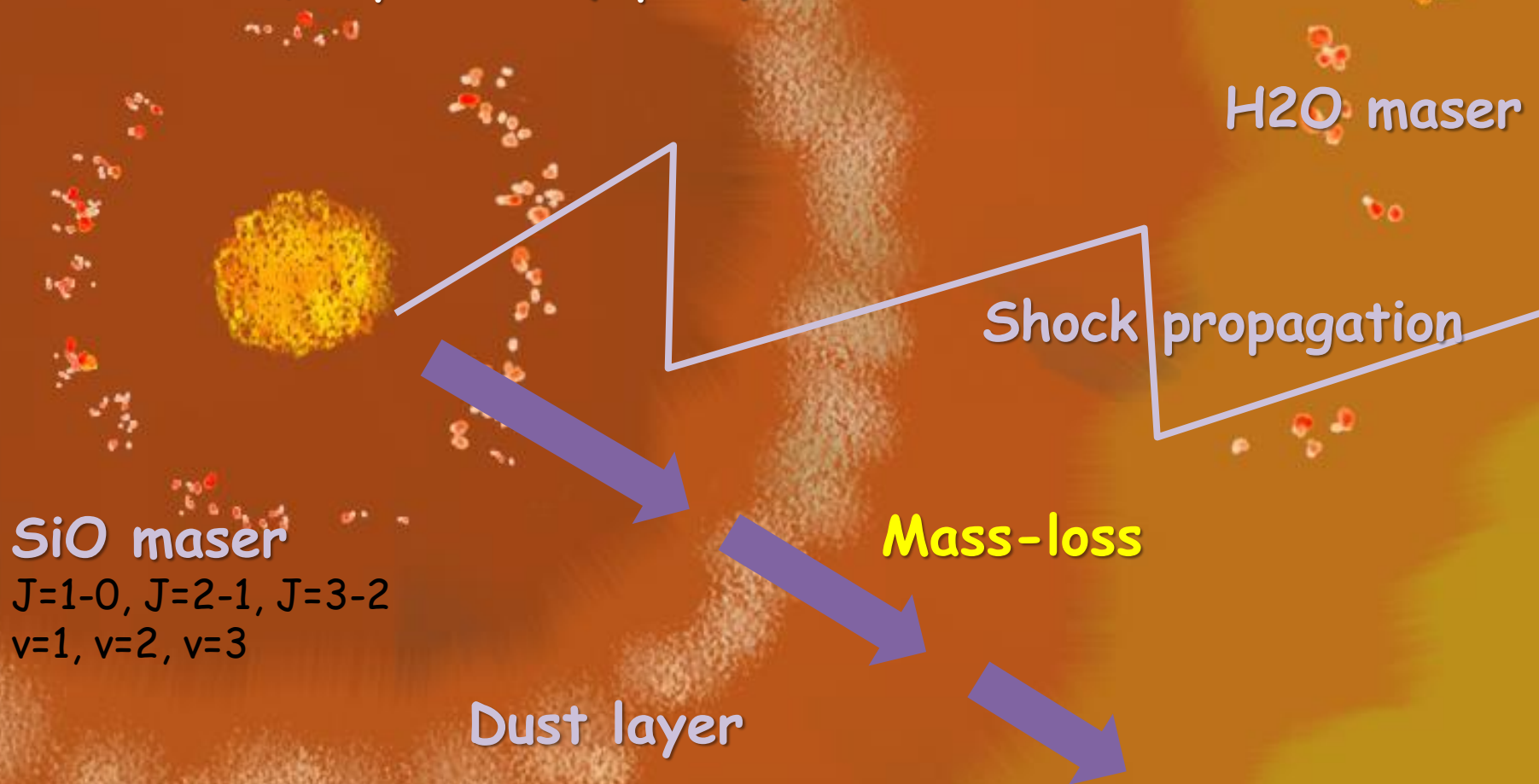
# KVN Key Science Projects

- KVN 4 band monitoring of Evolved Stars
- Interferometric MOnitoring of GAMMA-ray Bright Agn (iMOGABA)
- Started in 2014
  - 3-year term, ~300h / yr
- Multi-frequency Agn Survey with the KVN (MASK) : *See Taehyun Jung's talk*

# KSP 1 : KVN 4 band monitoring of Evolved Stars

## 15 Late-type stars (from AGB to PPN) ; Se-Hyung Cho +

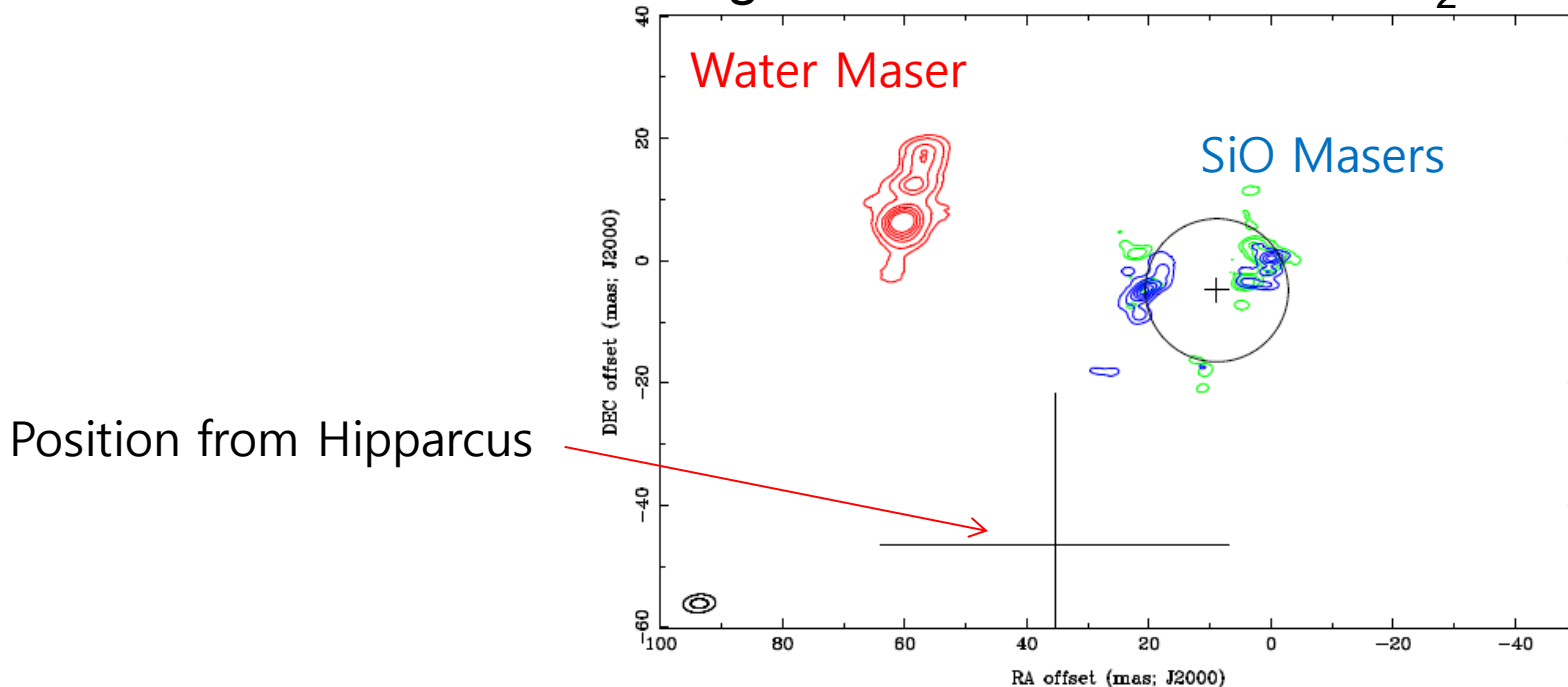
- Stellar pulsation → shock wave → mass-loss
- Physical Properties and Dynamical Variation of inner and outer region
- Mass Loss, Asymmetric (Bipolar) Structure





# Demonstration of SFPR for Stellar Maser Lines

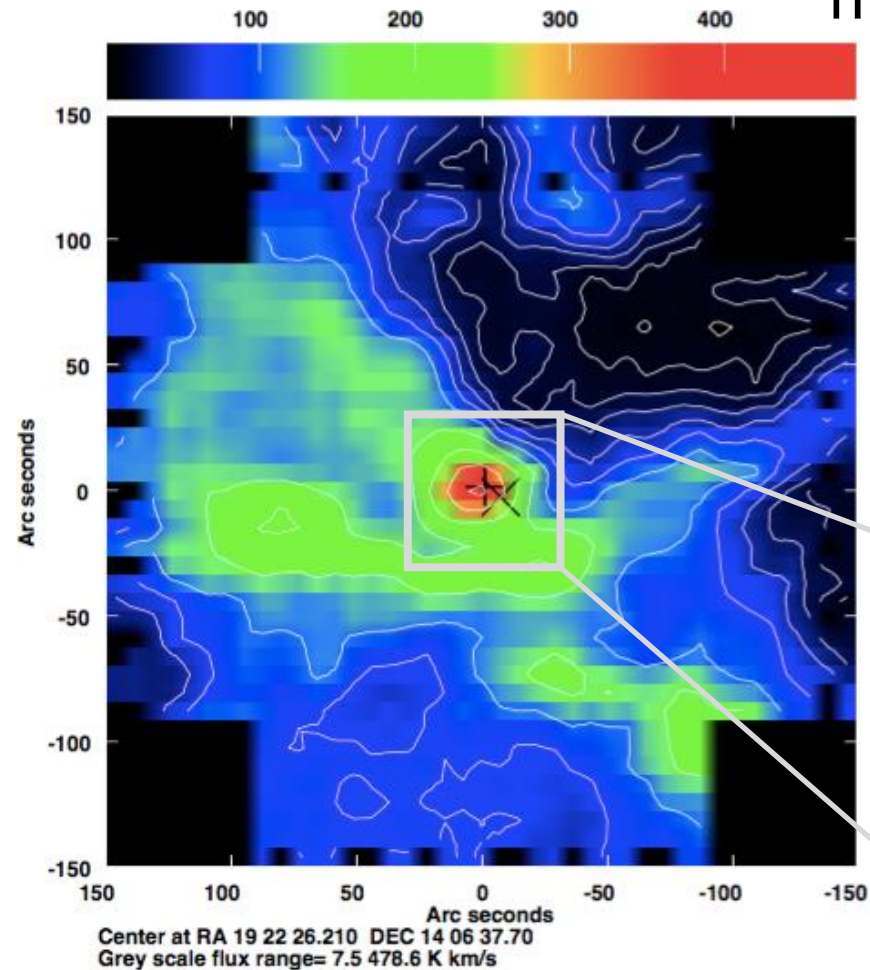
- Richard Dodson+, 2014, AJ
- R LMi (obs. : 2011)
  - H<sub>2</sub>O at 22GHz and SiO (v=1,v=2) at 43GHz
  - Reference : 4C39.25 ~ 6 deg away
  - T (2min) – R (2min) – T(2min) – R (2min)
- mas-level astrometric alignment of SiO maser wrt H<sub>2</sub>O maser



# Successful SFPR Maps of H<sub>2</sub>O and SiO Masers

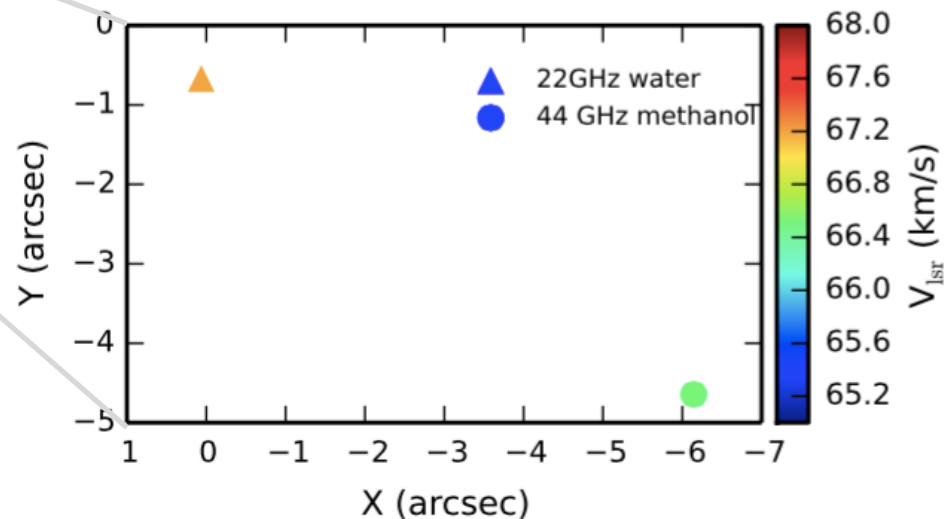
- H<sub>2</sub>O and SiO J=1-0 Maps of V1111 Oph and VX Sgr
- First 4 band SFPR Map of VY CMa

# SFPR between H<sub>2</sub>O and 44GHz CH<sub>3</sub>OH masers from Massive SFR AMGPS72N



(contour/color) 345 GHz CO image with JCMT  
(plus sign) the position of the water maser  
(cross) the position of the methanol maser

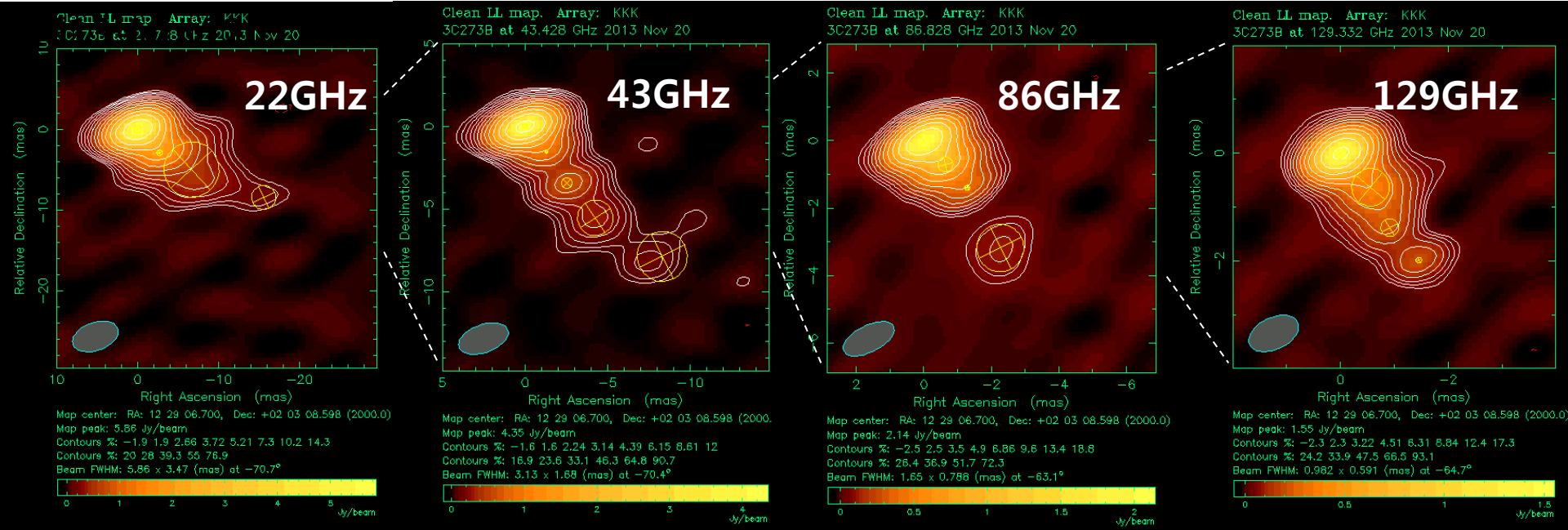
SFPR positions of maser features w/ KVN



by Kim, M.-K.

# KSP2 : iMOGABA

(Interferometric MOnitoring of GAMMA-ray Bright AGN)



- PI: Sang-Sung Lee
- Orion of gamma-ray flares in AGN
- Monthly VLBI monitoring of ~30 AGN with 4 frequency bands
  - Snap Shot Imaging : 5-min scan , 2-10 scans / source
- Complementary to VLBA monitoring at 15 & 43GHz ( MOJAVE , BU)

# 129GHz Imaging

- Frequency Phase Transfer for iMOGABA ( Algaba JKAS submitted)
  - 12 sources were failed in imaging by conventional method
  - $1 \sigma \sim 100$  mJy @ 129GHz (t=30 sec , BW = 64MHz)

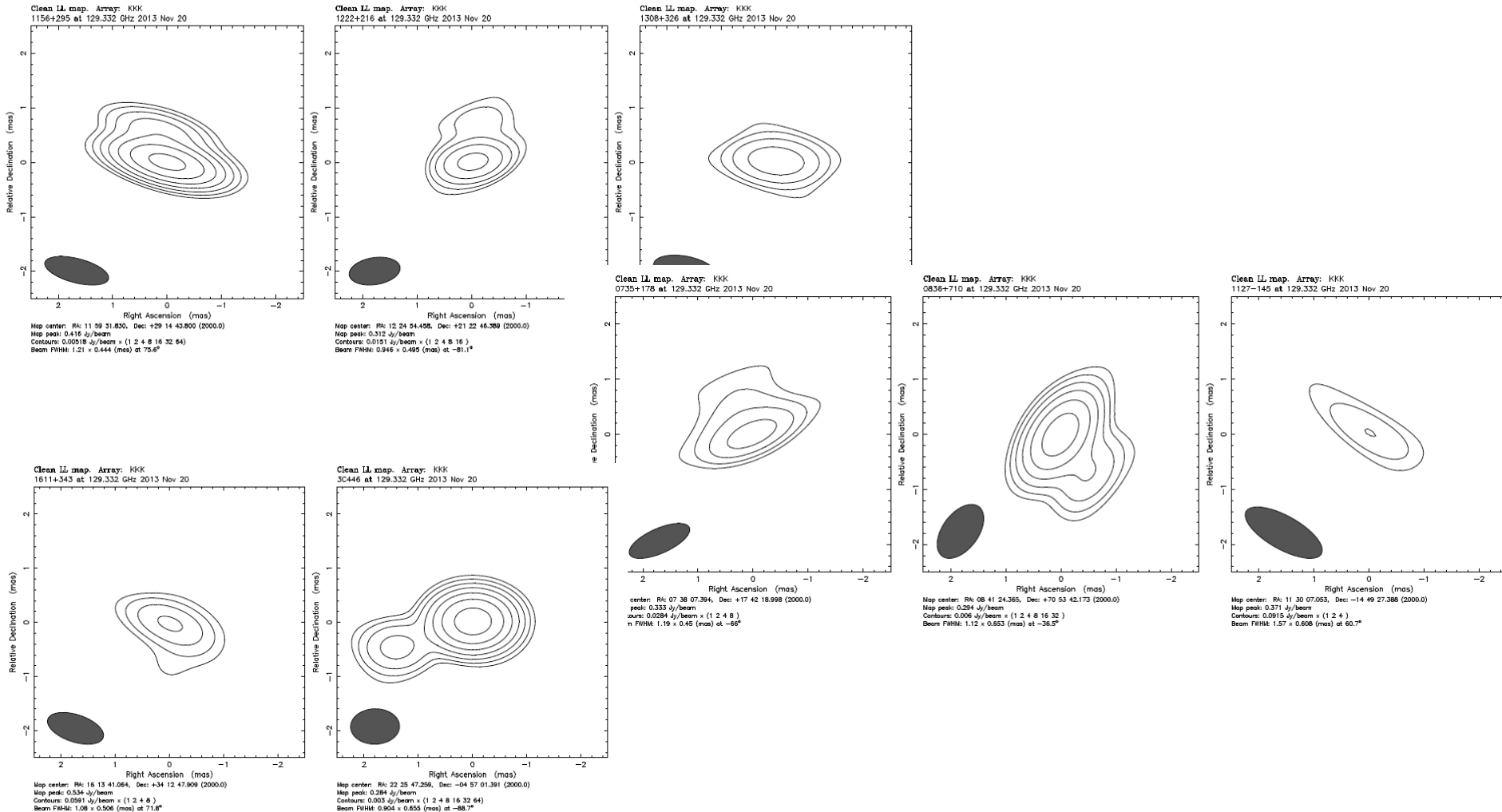
iMOGABA9 Expected Detection Limits at 129 GHz

Obs. 2013 Nov

Source	SEFD (Jy)	$S^{129}$ (mJy)	$\text{SNR}_{30s}^{129}$	$\text{SNR}_{300s}^{129}$
0235+164	5600	260	3	8
0528+134	5300	300	3	10
0735+178	5900	380	4	11
0827+243	8000	100	1	2
0836+710	6100	270	2	8
1127-145	8000	750	5	16
1156+295	5100	500	5	17
1222+216	5300	340	3	11
1308+326	5900	360	3	11
1343+451	5300	90	1	3
1611+343	5900	540	5	16
3C446	5100	250	3	8

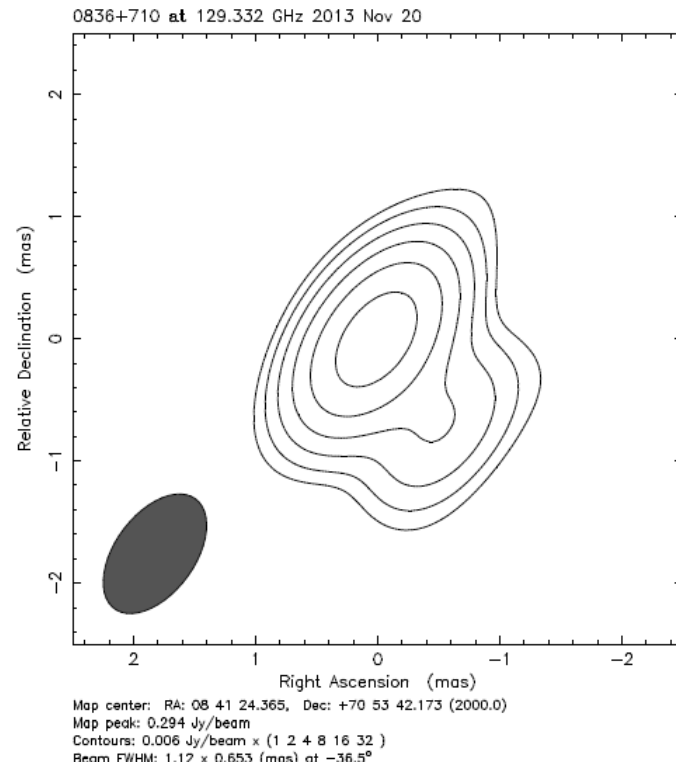
# Imaging after FPT

- Success for 8 Sources w/ t=300s after FPT

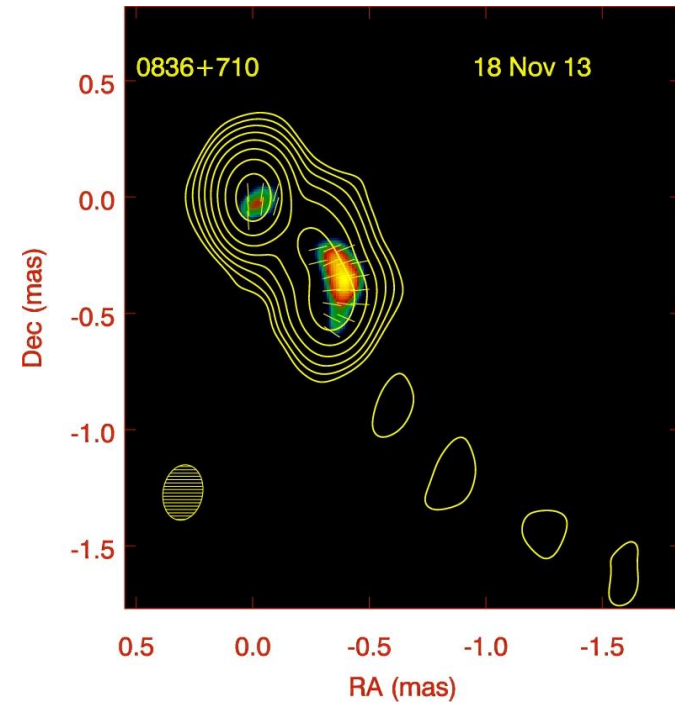


# Comparison of Images

## iMOGABA FPT 129GHz



## BU VLBA Monitoring 43GHz



## iMOGABA9 Expected Detection Limits at 129 GHz

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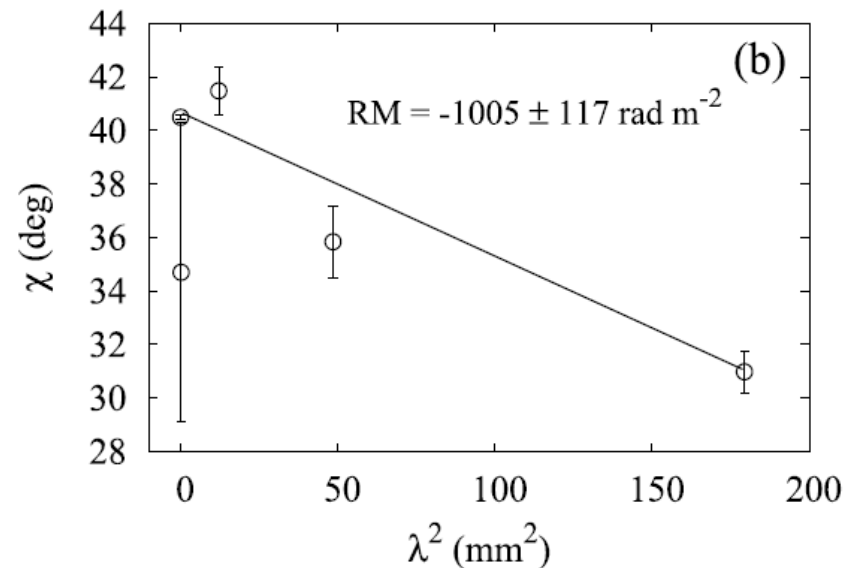
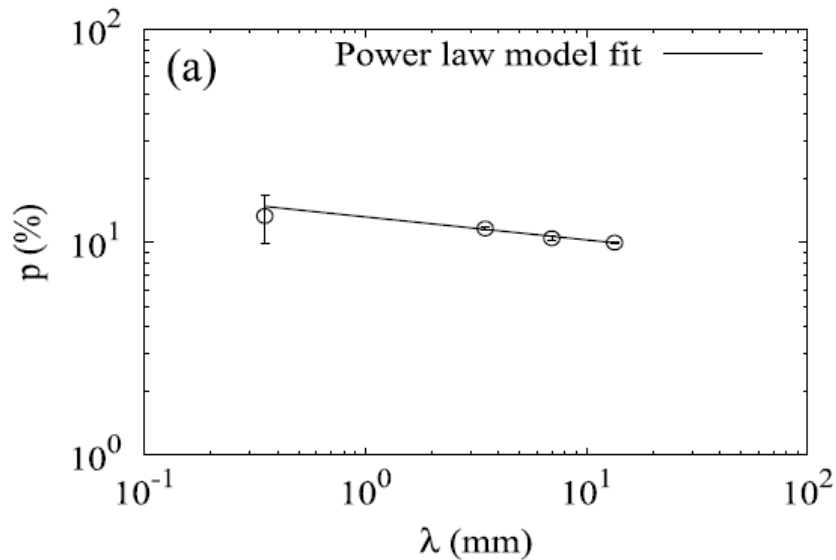
failed

iMOGGABA9 provides 129GHz images for 26 sources among 30. FPT enables us to extend integration time at least up to 300 sec.



# SD Polarizations w/ KVN & CSO

- Lee + (2015 ApJL)
  - 3C279
  - CSO (350 $\mu$ m)
  - KVN (3.5, 7, 14mm) YS & US
  - Fractional Linear Polarizations
  - Polarization Angles  $\rightarrow$  RM



# Upgrade Activities

- Wide Bandwidth & full stokes of 4 bands
  - 4 x 2Gbps operation from 2016
  - New digital backend with > 32Gbps
- More Stable Instrumental Phase
  - New HVAC System ( $\Delta T$  in Rx Room  $\sim 0.1K$ )
  - Multi-Frequency P-Cal (See Taehyun Jung's talk)

# Future Prospect

- Collaboration for Multi-Frequency Operation
  - VERA Miz (& Iriki), Yebes 40m, ATCA sub array, Sejong 22m (*See Richard's Talk*)
- Multi-Frequency + High Speed ADC & Recorder
  - New Digital Backend : DBBC3, RDBE, OCTAD
  - Much higher sensitivity at (sub) mm wave
  - SFPR + Polarization

# Summary

- 2 KSPs using Multi-Frequency Capability
  - 4-band monitoring of Evolved Star
  - AGN Monitoring (iMOGABA)
- SFPR technique are successfully applied to both continuum and maser sources
  - First 4 bands overlap image (VY-CMa)
- Collaboration for Multi-Frequency Capability
  - VERA Miz & Iriki, Yebes 40m, ATCA sub array, Sejong 22m