

ESTEMA and HINOTORI

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On behalf of

ESTEMA (EAVN Synthesis of Stellar Maser Animations) Team

and

HINOTORI

(Hybrid Installation Project in Nobeyama, Triple-band Oriented)
Team

Two large projects for circumstellar masers (and wider new science cases)

ESTEMA (KaVA Large Program)

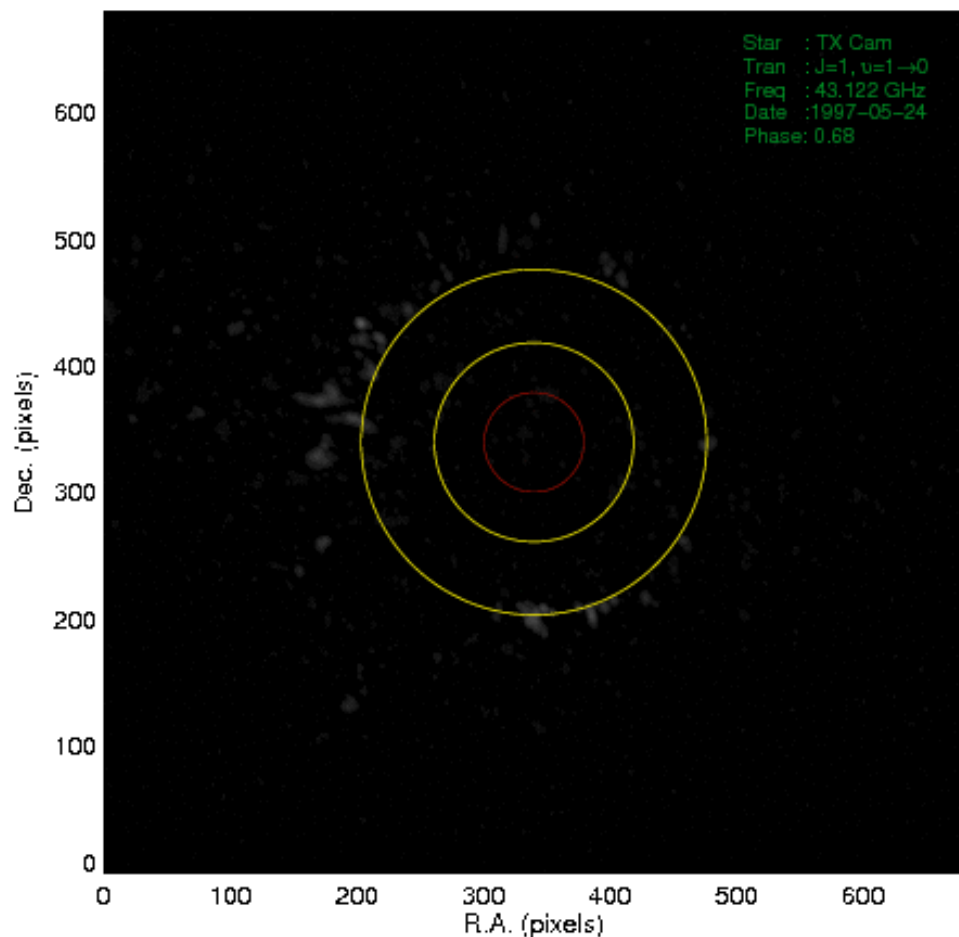
Long term (~2 stellar pulsation cycles) intensive (every 3—4 weeks) VLBI monitoring of circumstellar H₂O and SiO (J=2→1 & 1→0) masers

HINOTORI (Two KAKENHI Programs)

Updating NRO 45 m telescope for triple-band simultaneous VLBI observation capability

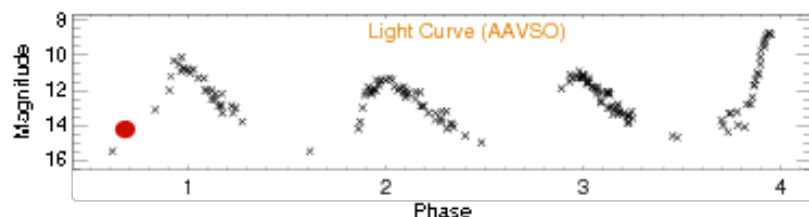
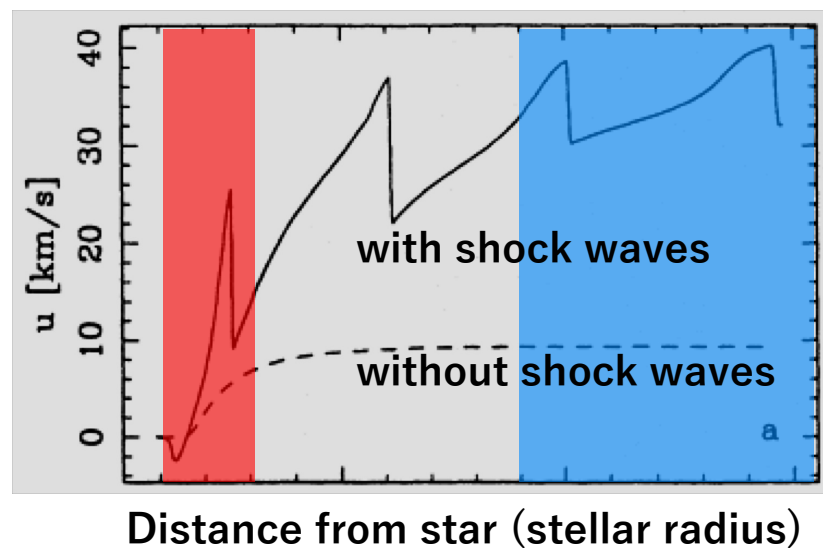


Goal of ESTEMA visualization of dynamic stellar mass loss



SiO maser region

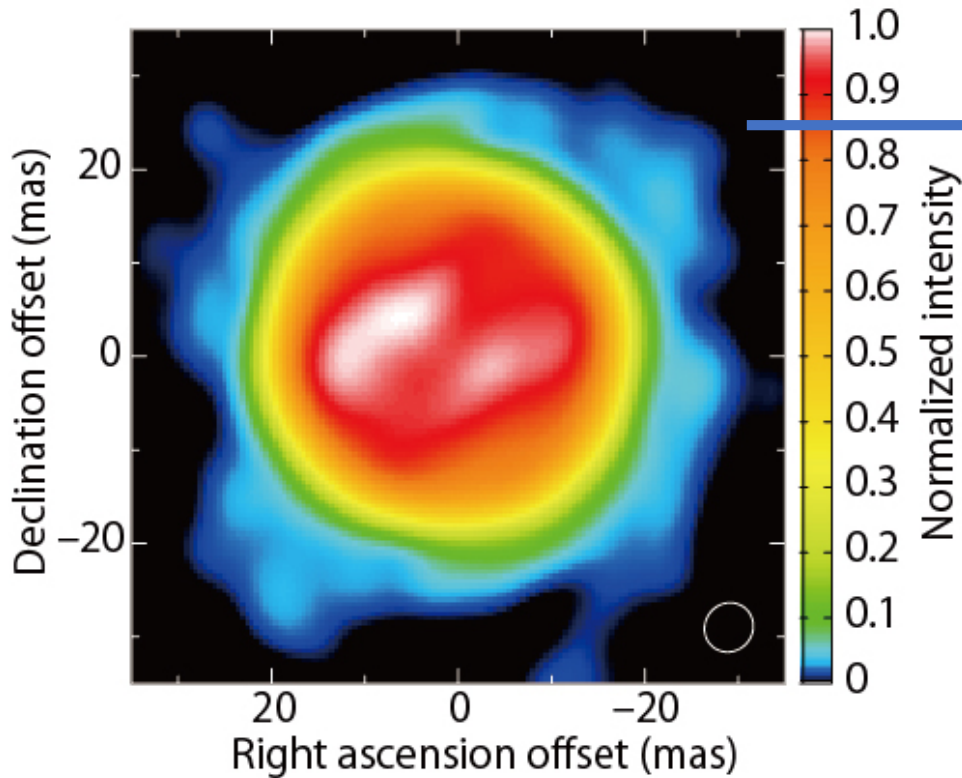
H₂O maser region



Shock waves in C-rich envelope (Höfner et al. 1995)

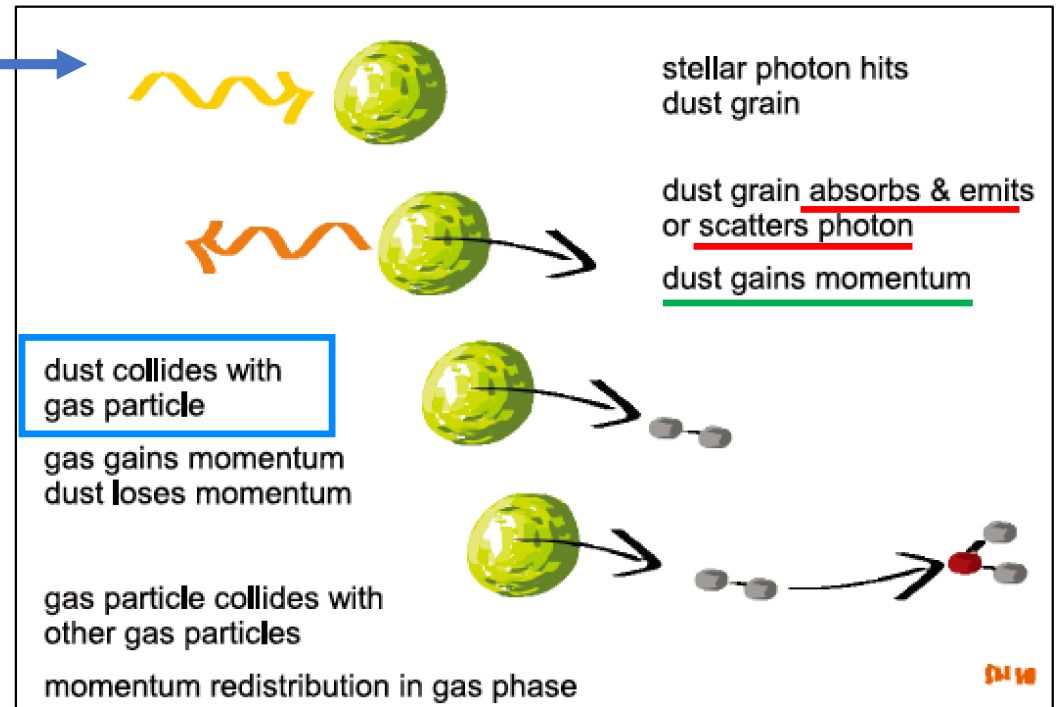
SiO $v=1$ $J=1 \rightarrow 0$ masers around TX Cam (Gonidakis et al. 2013)

How are materials on the stellar surface lifted up outward in a circumstellar envelope?



Antares In CO line center
($2.31 \mu\text{m}$) (Ohnaka et al. 2017)

Höfner (2011)



Under periodic stellar pulsation and inhomogeneous mass ejection

Our challenges 1: simultaneous mapping of SiO maser transitions with H₂O masers

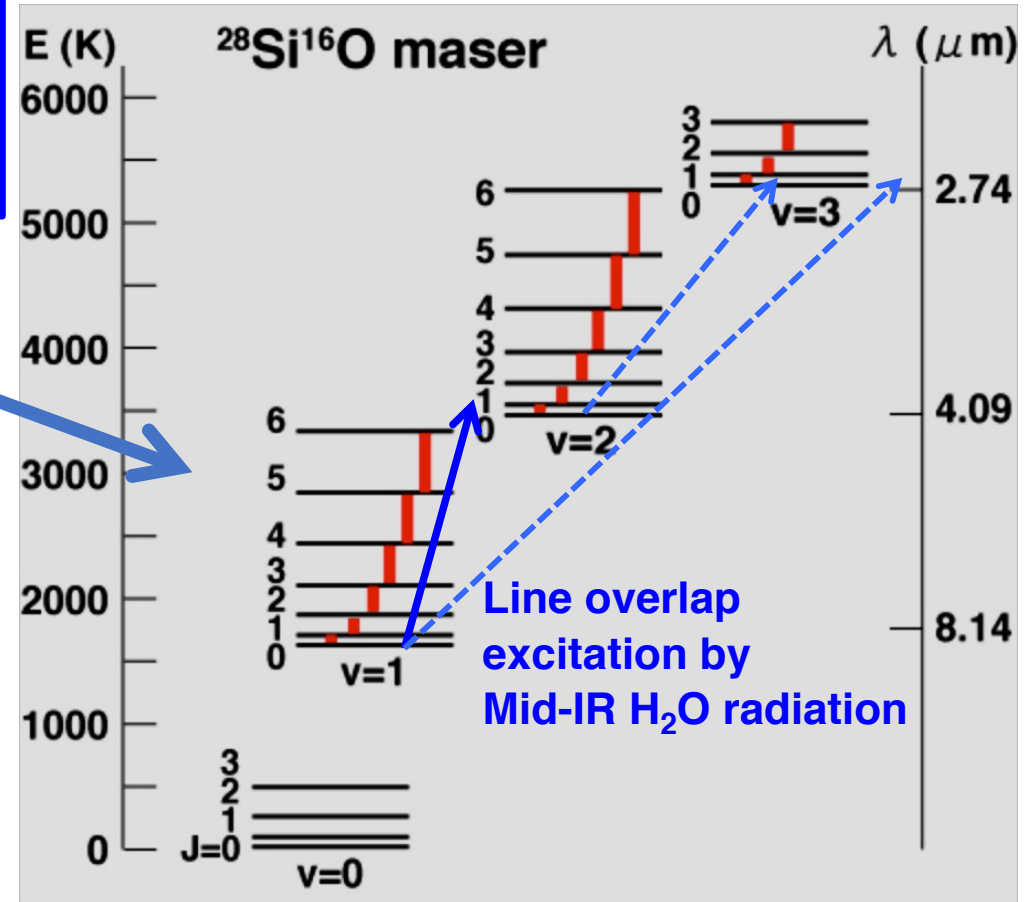
How to collocate these maser line regions throughout stellar pulsation cycles?

$$T_{\text{envelope}} = T_* \left(\frac{R}{R_*} \right)^{-2/5}$$

$T_* \approx 3000 \text{ K}, R_* \approx 1-10 \text{ AU}$

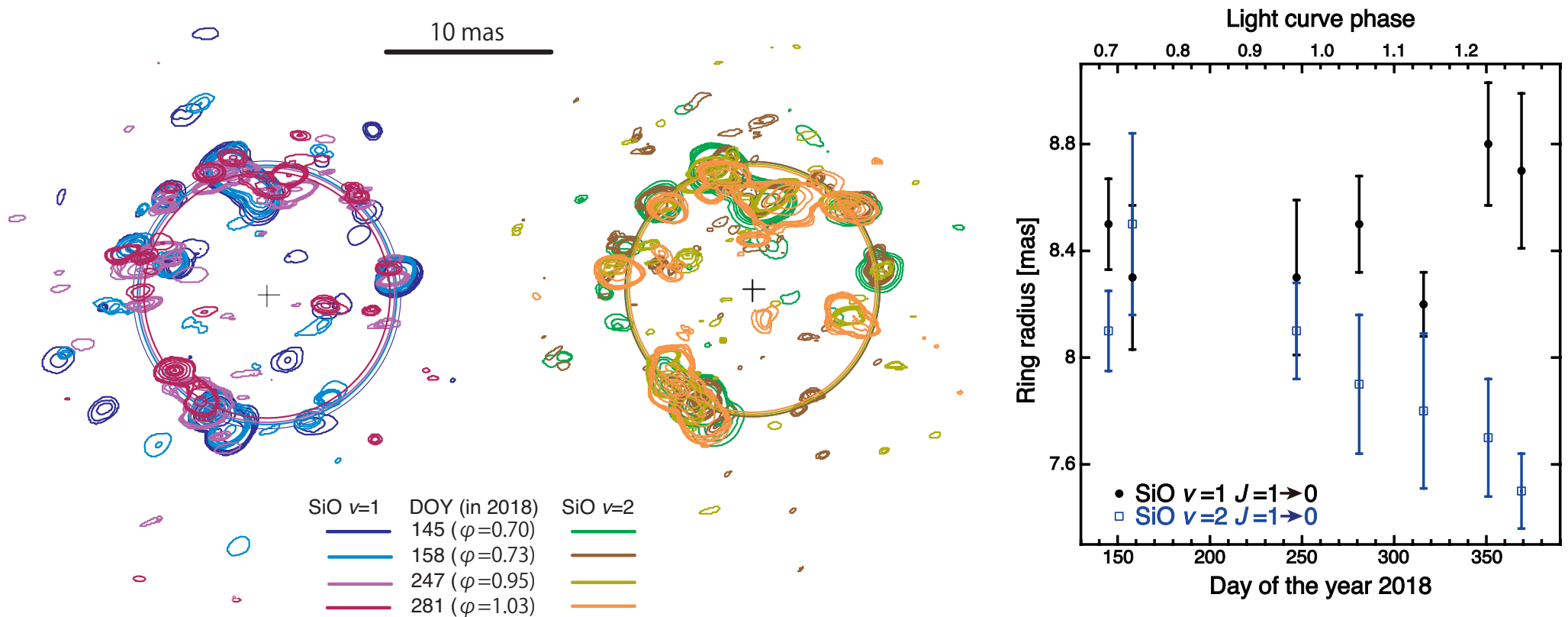
Are we really watching true physical gas motions in these maser lines?

SiO maser lines
 ($J \rightarrow J-1, J=1,2,3, \dots; \nu \approx 43 \times J [\text{GHz}]$)



Resolving different performances in SiO masers ($\nu=1&2 J=1\rightarrow 0$)

Contracting only clumps hosting $\nu=2$ SiO masers while they may exist with clumps hosting $\nu=1$ SiO masers?



By M. Oyadomari

HINOTORI's four-year achievement

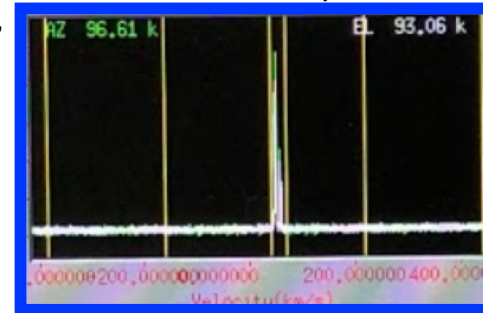
NRO 速報 NO.137

周波数分離フィルタを用いた3バンド同時観測

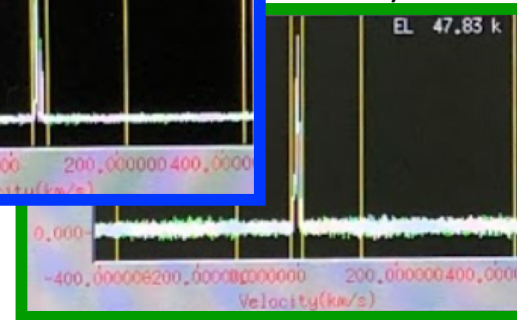
First light
第2弾!

HINOTORI (Hybrid Installation Project in Nobeyama, Triple-band Oriented) チームは、2017年に続き2枚目の多孔板型周波数分離フィルタを開発し、復活したTZ受信機と合わせて2019年11月8日、3つの受信器を同時に使った22GHz/43GHz/86GHz帯同時観測を実現させました(このプロジェクトは、鹿児島大学、山口大学、大阪府立大学、茨城大学、国立天文台が共同で進めています)。

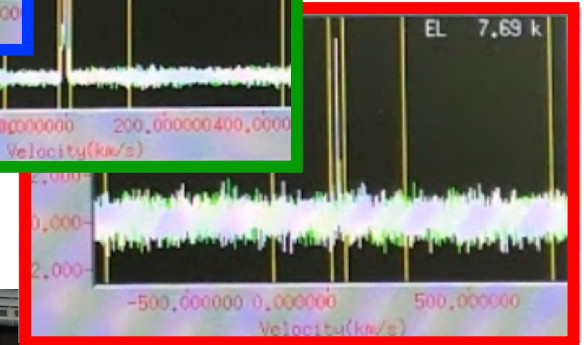
上) 22GHz帯H₂Oメーザー



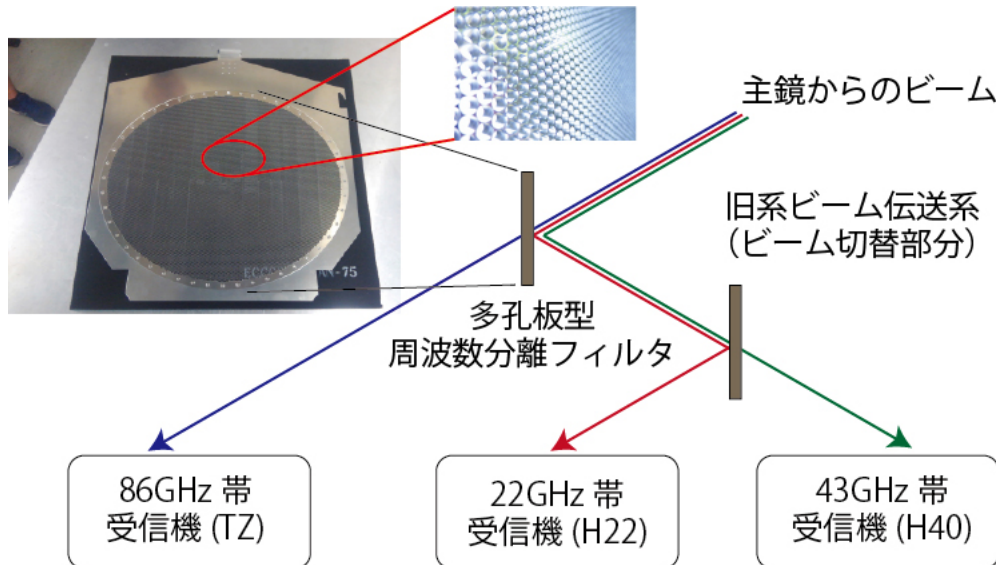
中央) 43GHz帯SiOメーザー



下) 86GHz帯SiOメーザー



赤色巨星R Cas

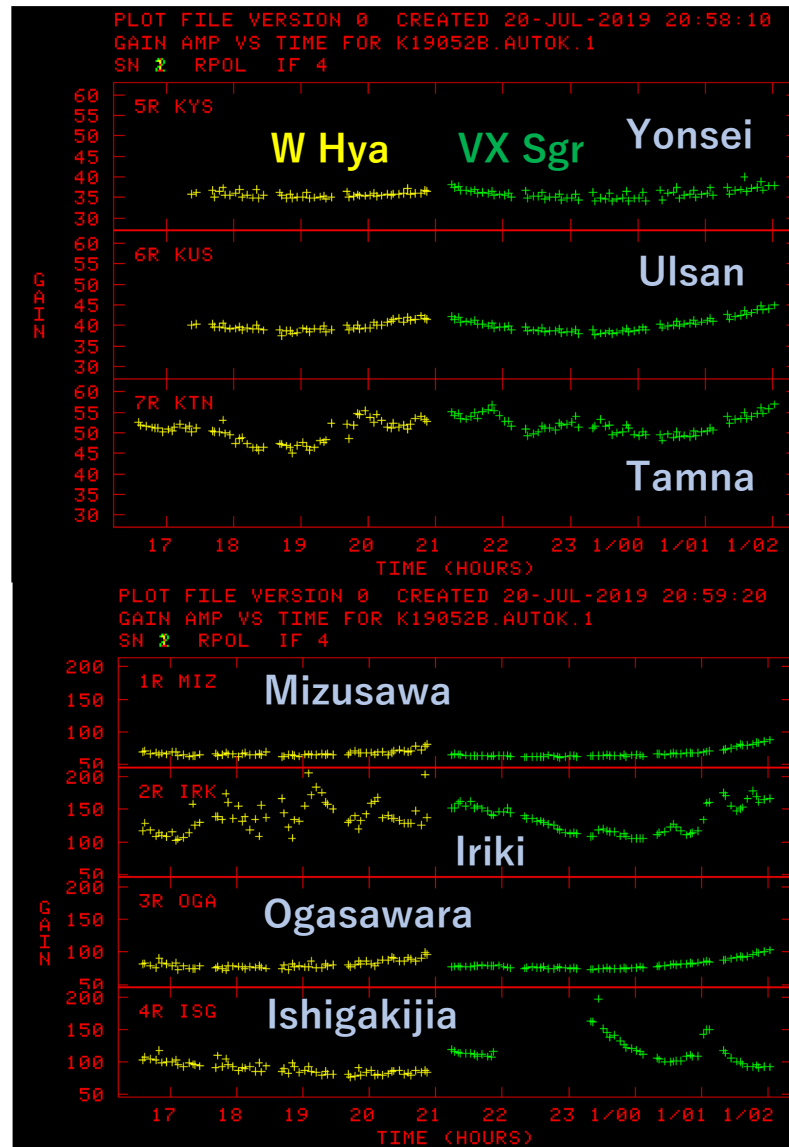


Commissioning of K/Q-band quasi-optics in VERA

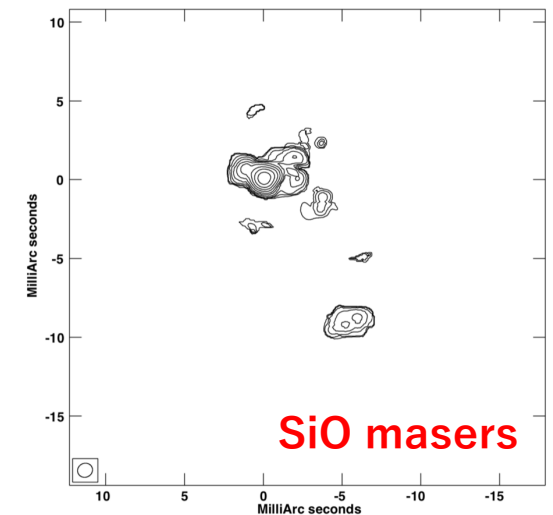
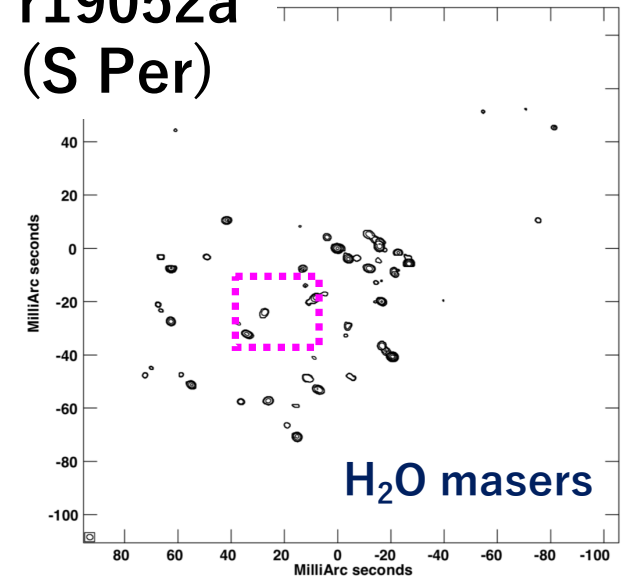
r19052b
(W Hya and VX Sgr)

Gain loss less than 10% (<uncertainty) by 20" beam offset (in Ishigakijima)

Source-frequency phase-referencing technique should be tested.



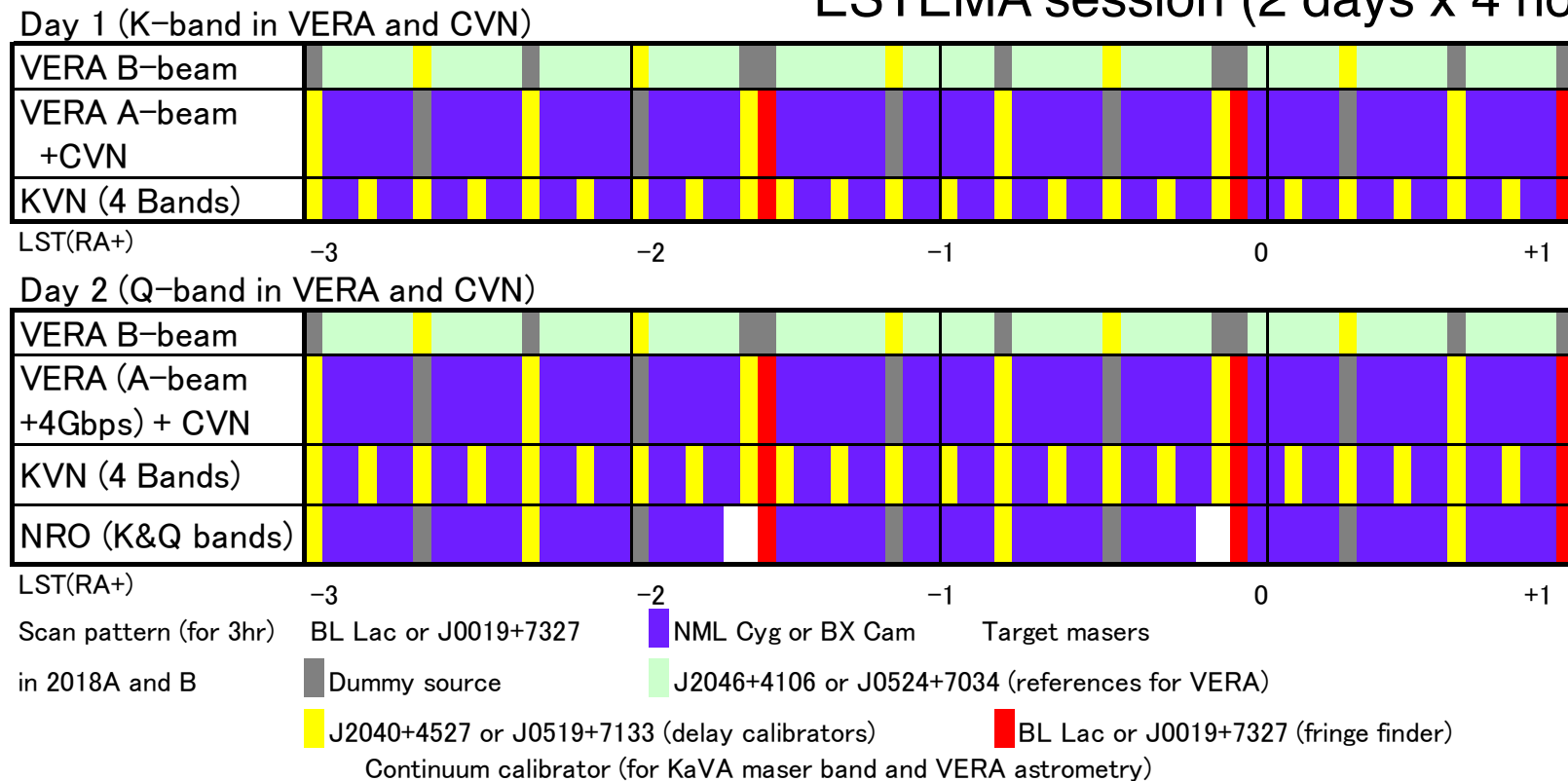
r19052a
(S Per)



Our challenges 2: operating “hybrid” mode

Three vex files for one-day block

ESTEMA session (2 days x 4 hours/day)



- KaVA/EAVN: mapping H₂O and SiO (43 GHz) masers → **should be made in one day in future**
- KVN: band-to-band phase transfer calibration for SiO masers (43/86/129 GHz)
- VERA: dual-beam astrometry and wide-band recording (for SiO $\nu=3$ and $\nu=0$ $J=1 \rightarrow 0$ masers)

Saved to a one-day session after installation of RF/IF signal switch modules supported by AGARC

Summary

- **ESTEMA: one of key science cases with EAVN in a coming decade**

→ **For fully understanding the physics of astronomical masers and the dynamics of stellar mass loss**

- **HINOTORI: one of key projects yielding W-band VLBI in East Asia (NRO 45m + KVN + JMCT + GLT+ ...)**

→ **With higher flexibility and higher sensitivity for extended structures than GMVA**

→ **Enabling new science cases in W-band VLBI**

My proposals

- Why don't you make a more intensive synergy between Mizusawa and Nobeyama in JVN and EAVN?

Should be a key domestic VLBI array

- When are K/Q-band simultaneous observations regularly operated with VERA?

Should be done before reducing the operation time

- Astrometry for high accuracy measurement of space-time in the local universe

Only masers sources for targets of astrometry?