



# 「宇宙の間欠泉」から新たに出現した 双極高速ジェットからの同時噴出ガス塊

今井 裕, 宇野友理, 前山大地, 山口諒祐, 甘田 溪, 濱江勇希(鹿児島大学),

Ross Burns(国立天文台), Gabor Orosz (タスマニア大学),

José Francisco Gómez (スペイン高等学術研究院),

Daniel Tafoya (オンサラ天文台), Lucero Uscanga(メキシコ自治大学)



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# Water fountains

## Fast bipolar jets from dying stars traced by H<sub>2</sub>O masers

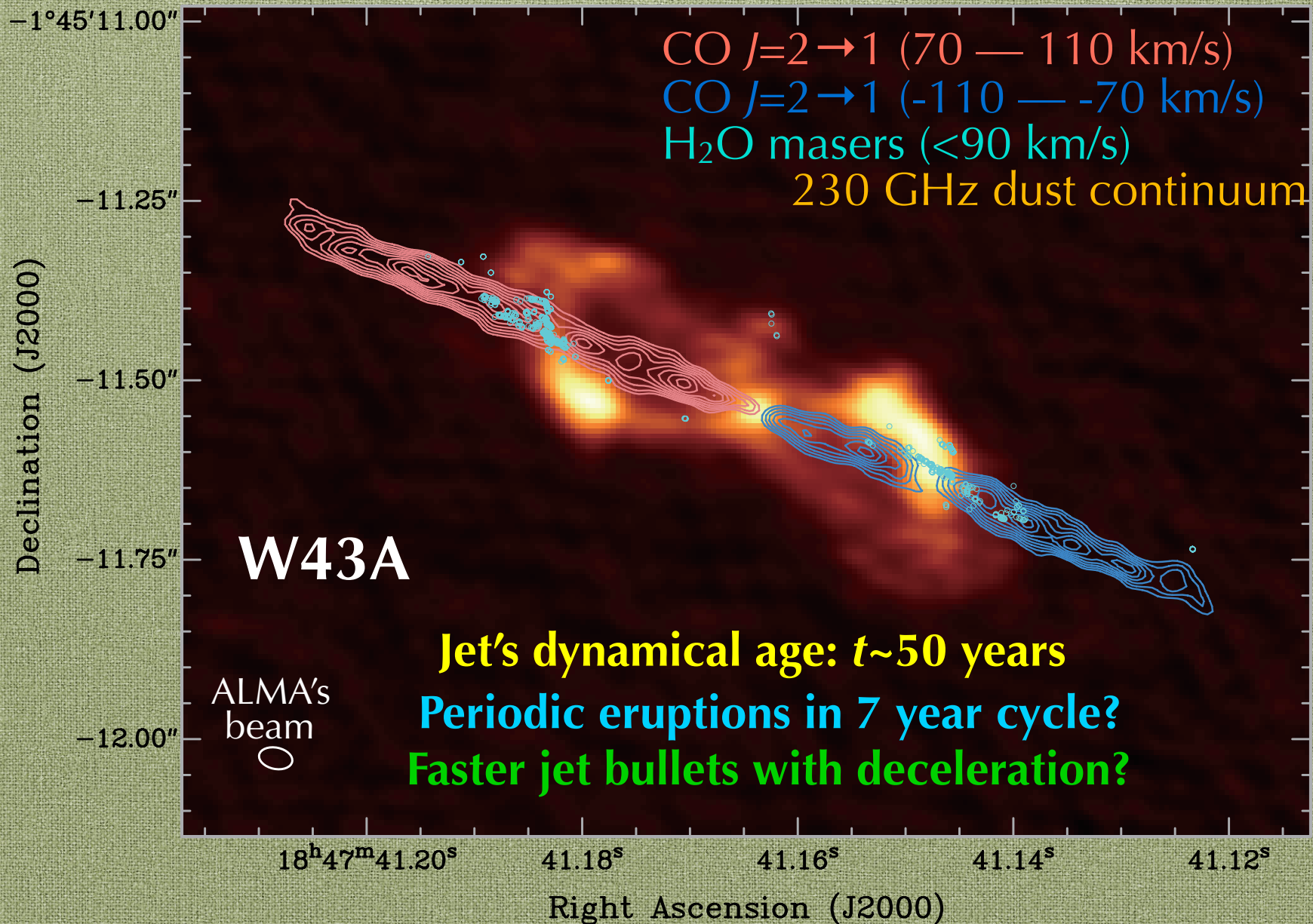


Image with ALMA+VLBA (Tafoya, Imai et al. in prep.)



# FLASHING

## Finest Legacy Acquisitions of SiO- and H<sub>2</sub>O-maser Ignitions by Nobeyama Generation

- ❖ Using Nobeyama 45-m telescope
  - + **Perforated frequency separation filter plate**  
(Okada et al. 2020, PASJ) developed by HINOTORI  
(Hybrid Installation Project in Nobeyama, Triple-band Oriented)
- ❖ Conducted as a Backup Program during  
2018 December—2019 May (~260 hours)
- ❖ Towards 17(+2) water fountains and candidates
- ❖ 3—14 observation sessions per source
- ❖ Velocity resolution: 0.42 km/s (H<sub>2</sub>O) and 0.22 km/s (SiO)
- ❖ Velocity coverage: 1258 km/s (H<sub>2</sub>O)
- ❖ Follow-up VLBI target-of-opportunity observations soon after new ignitions of highest velocity H<sub>2</sub>O maser components  
Will be registered in M2O (maser monitoring organization)



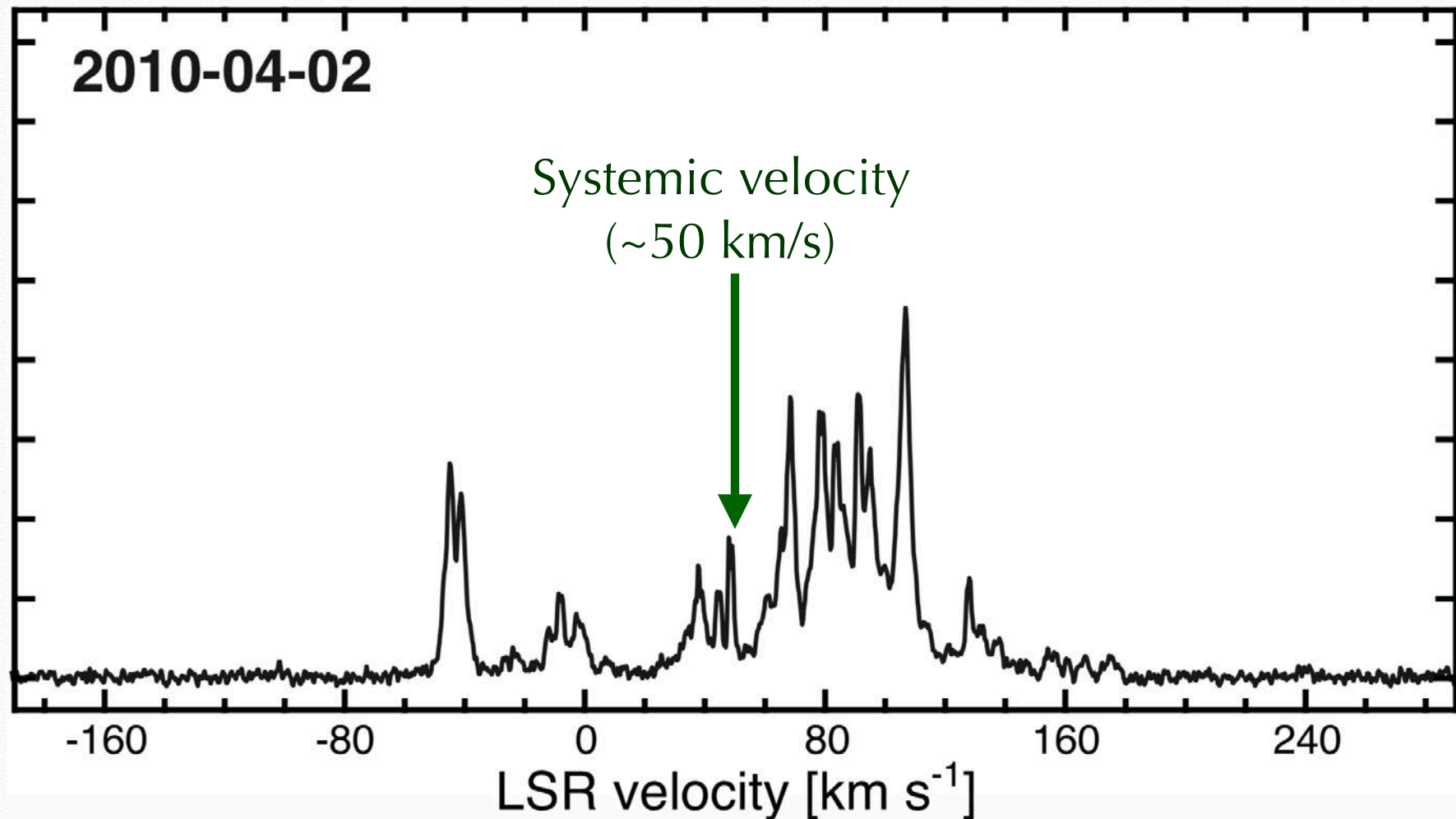
# Science goals of FLASHING

- ❖ Monitoring 17 water fountains and candidates
  - ❖ Flux periodicity caused by stellar pulsation (1—5 years)
  - ❖ Permanent death, evolving to a planetary nebula (~10 years)
  - ❖ Recurrent outbursts caused by interactions in a binary system with a large eccentricity (>5 years)
  - ❖ Line-of-sight velocity drifts caused by jet deceleration

**Very long time-baseline/domain astronomy**

2019 December—2020 March (~120 hours) awarded

# Before ignitions of the highest velocity H<sub>2</sub>O maser components

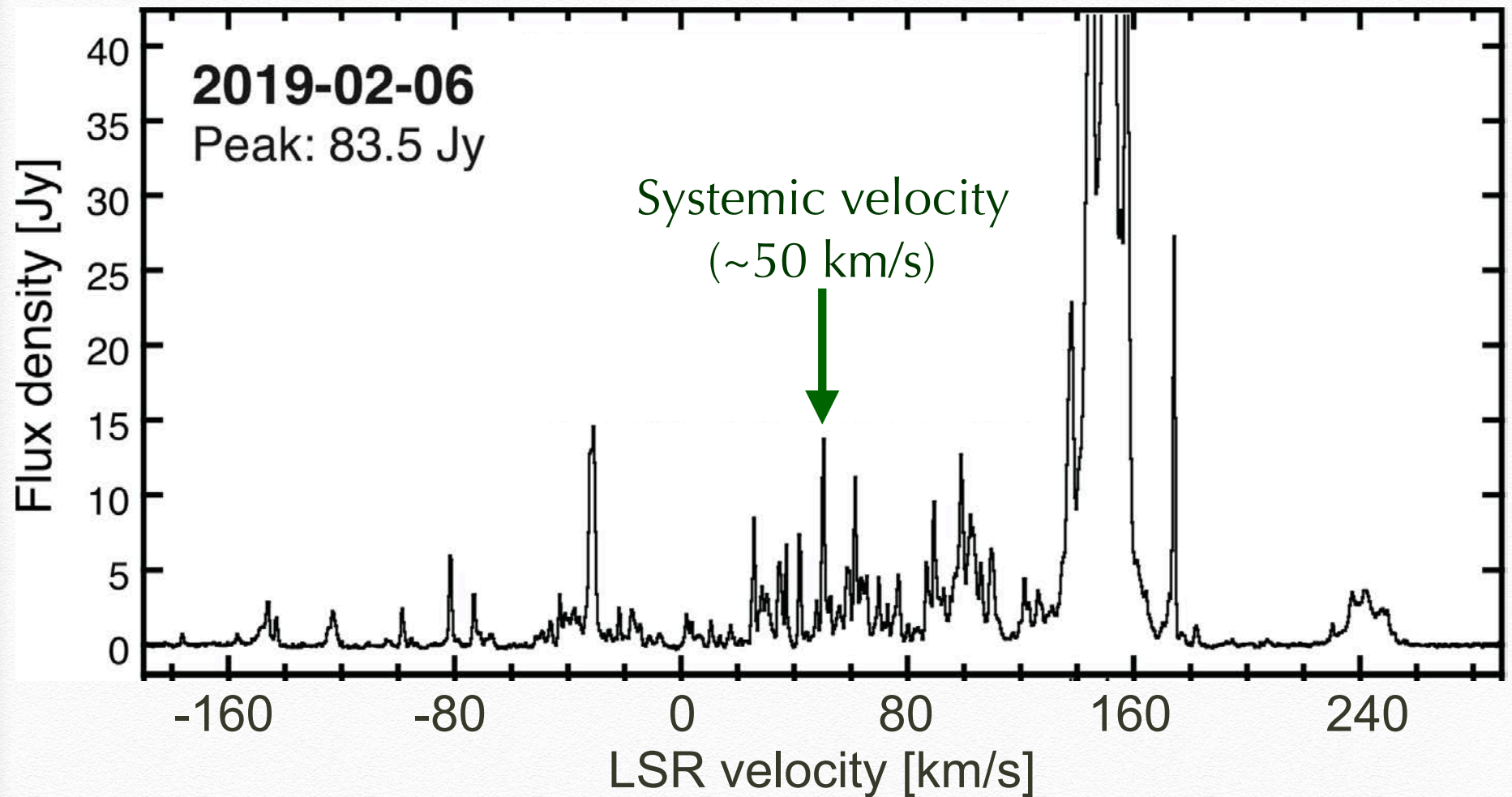


**IRAS 18286-0959**

Imai et al. (2020, PASJ VERA Special Issue)



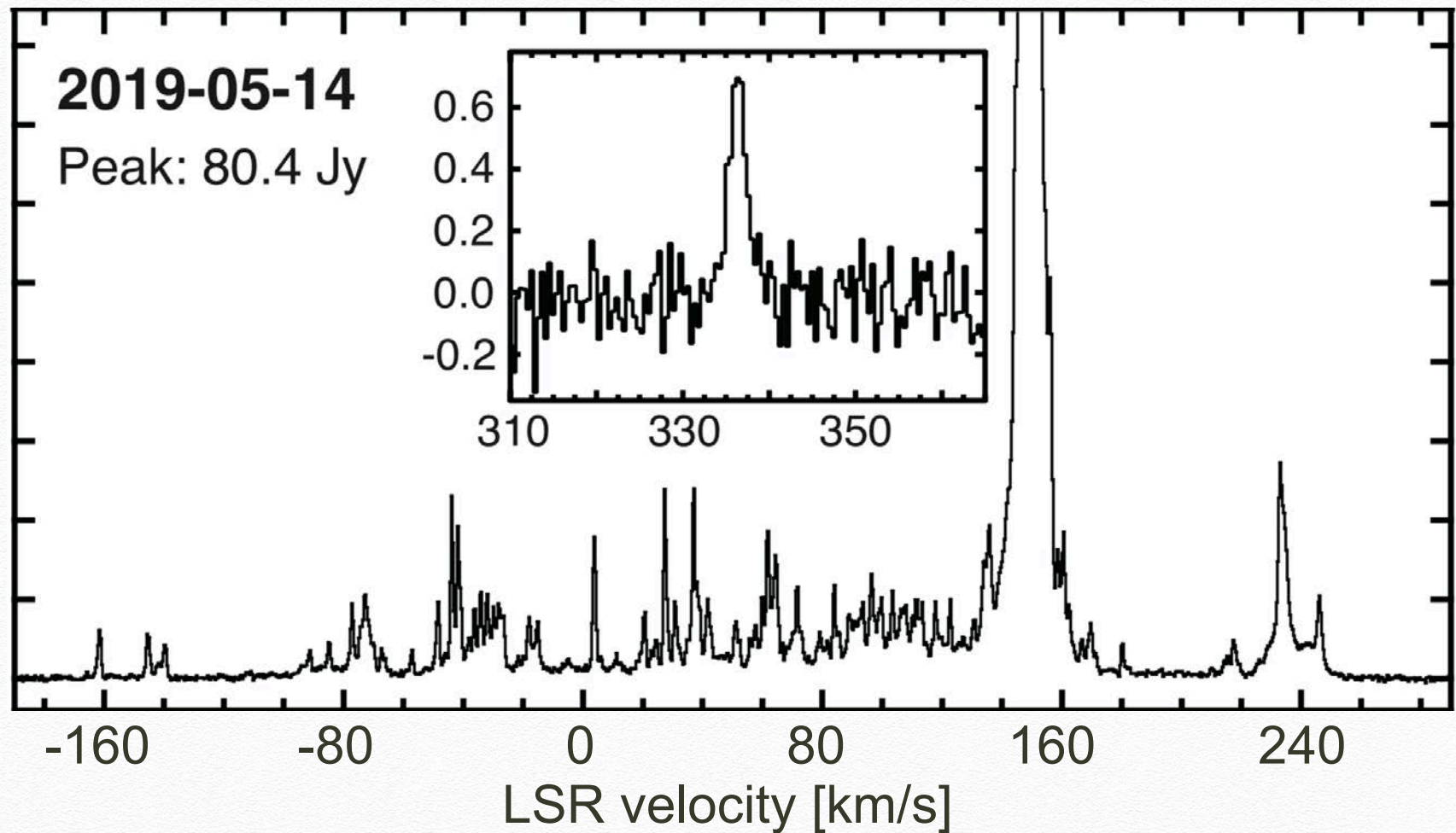
# New ignitions of the highest velocity H<sub>2</sub>O maser components



**IRAS 18286-0959**

Imai et al. (2020, PASJ VERA Special Issue)

# New ignitions of the highest velocity H<sub>2</sub>O maser components

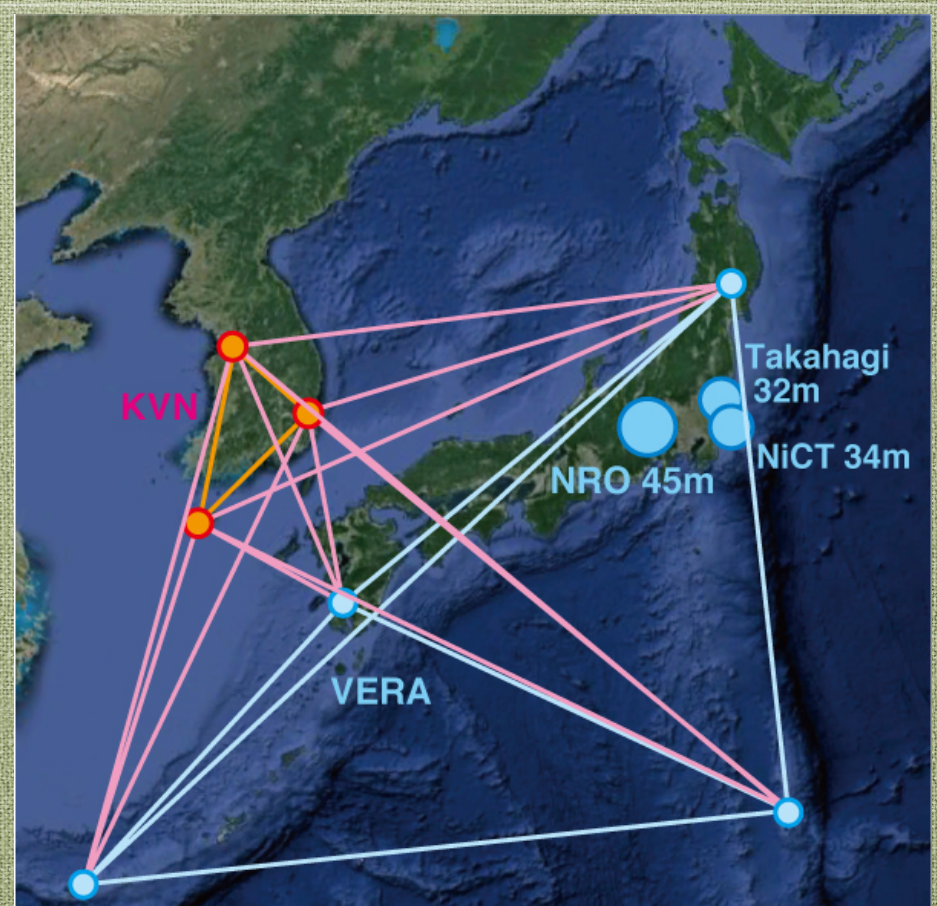


Imai et al. (2020, PASJ VERA Special Issue)



# KaVA ToO follow-up

- ❖ Epoch: 2019 March 4  
for 6 hours
- ❖ Participating telescopes:
  - 4 VERA and 3 KVN antennas in LHCP
- ❖ 1 Gbps recording  $\rightarrow$  Velocity coverage 1727 km/s
- ❖ 4096 channels  $\rightarrow$  Velocity resolution 0.42 km/s
- ❖ Synthesized beam:  $2.1 \times 1.4$  mas, P.A. = -18 deg.
- ❖  $1-\sigma$  noise level:  $\sim 20$  mJy/beam
- ❖ Maser spot identification:  $> 7-\sigma$  noise level

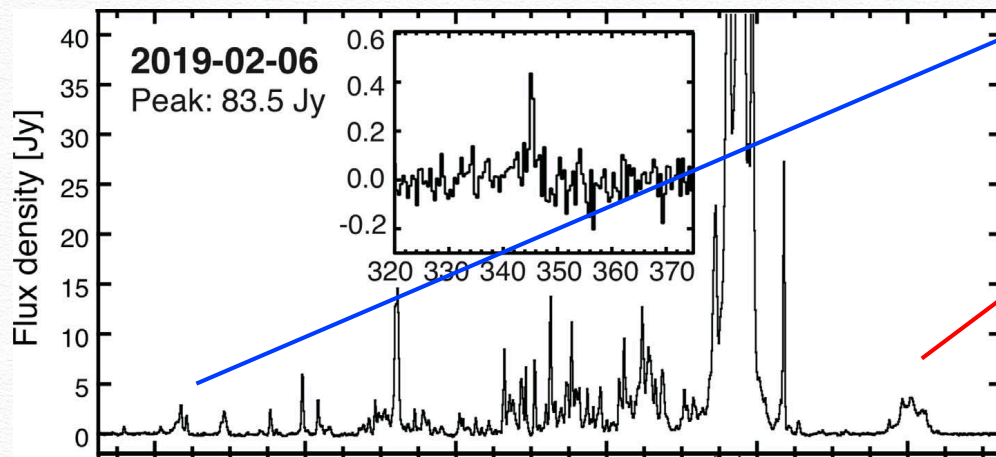




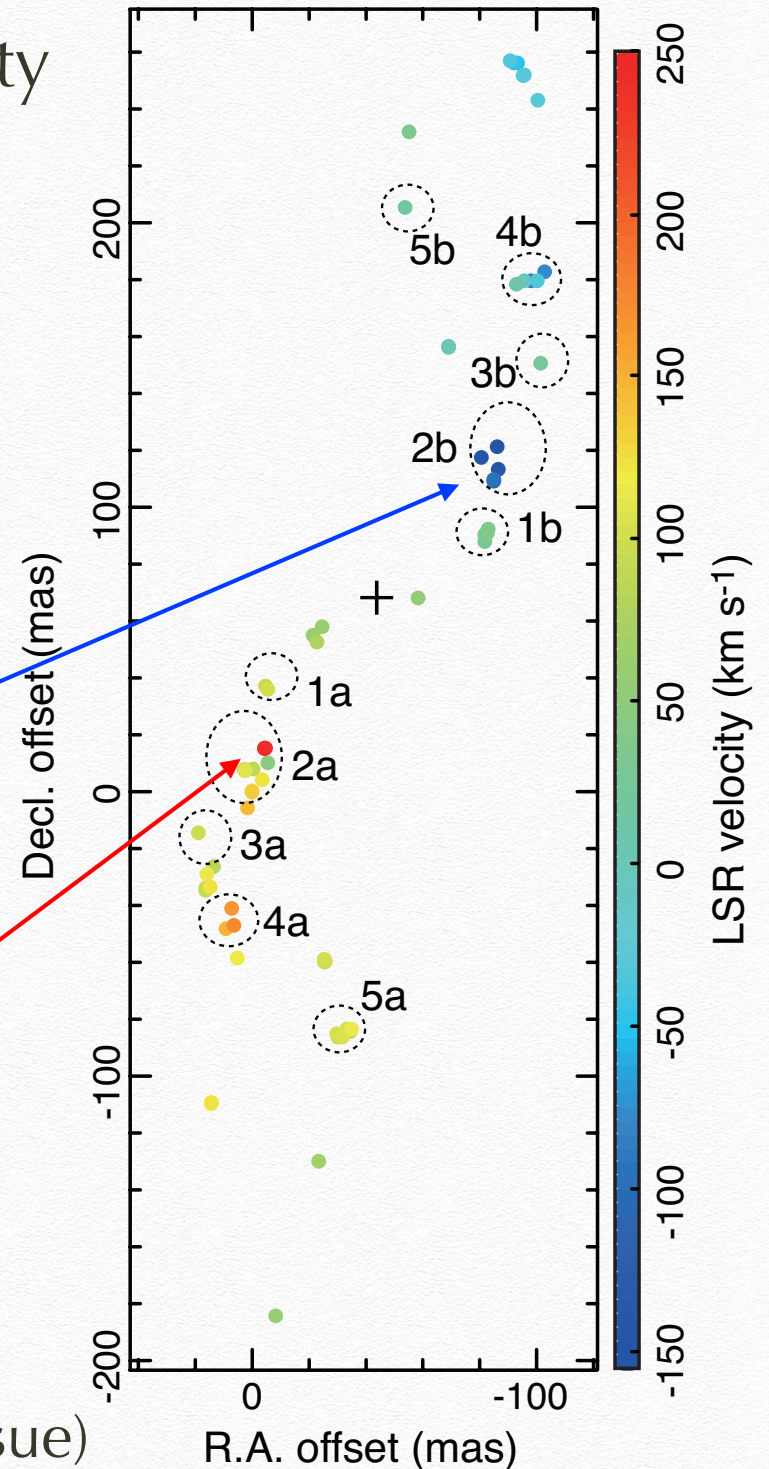
# Localization of the highest velocity H<sub>2</sub>O maser components

Highest velocity jet before deceleration

Point symmetric pattern of maser distribution in a ~3.5 year spacing



Mapped with KaVA  
(KVN and VERA Combined Array)  
on 2019 March 6



Imai et al. (2020, PASJ VERA Special Issue)



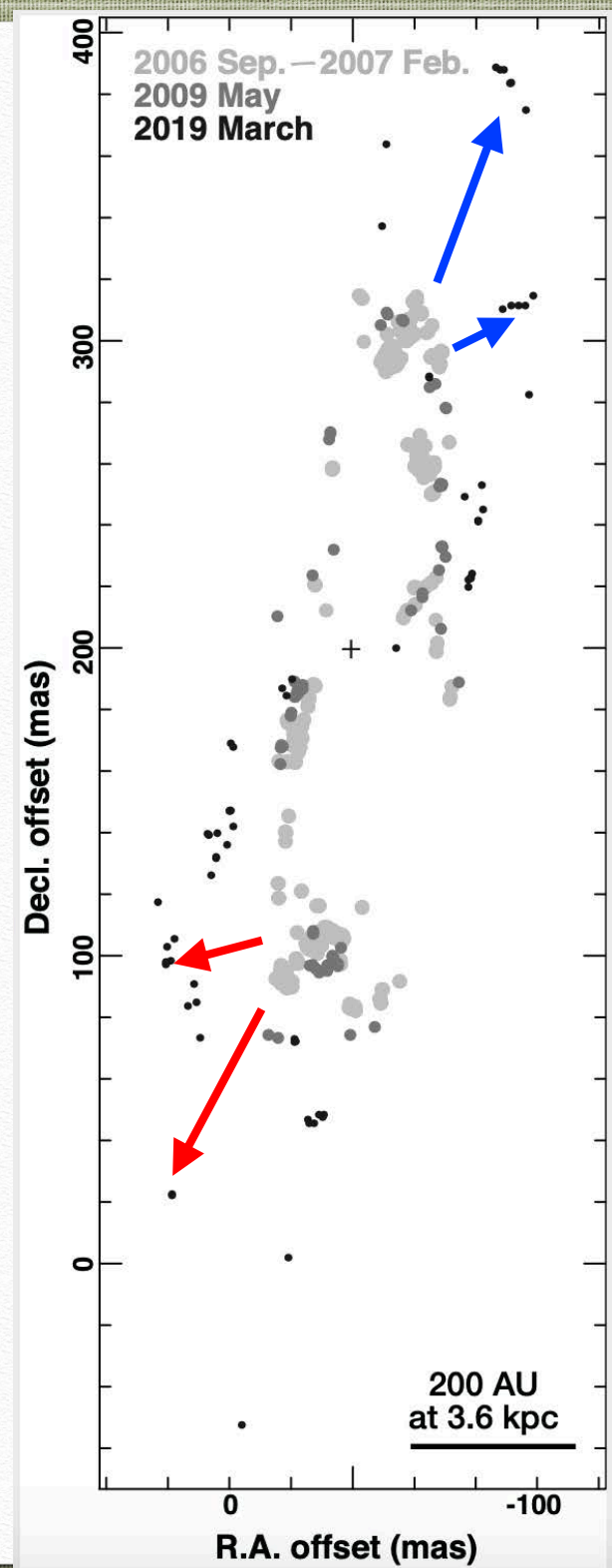
# Decadal jet evolution

- ❖ **Clockwise precession and lobe expansion of the bipolar jet**
- ❖ **Dynamical age ~30 years**
- ❖ New maser ignition after 2011
  - Short-lived ( $t < 1$  month) spots before 2011?
  - Previous maser ignition before 2006?
- ❖ Jet deceleration from 300 km/s to 110 km/s so as to mix with entrained material in ~3.5 years(?)



**Velocity drift over ~10 km/s/yr!**

Imai et al. (2020, PASJ VERA Special Issue)





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