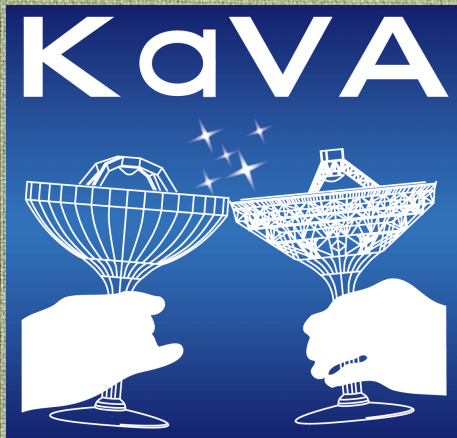




「宇宙の間欠泉」から新たに出現した 双極高速ジェットからの同時噴出ガス塊

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)

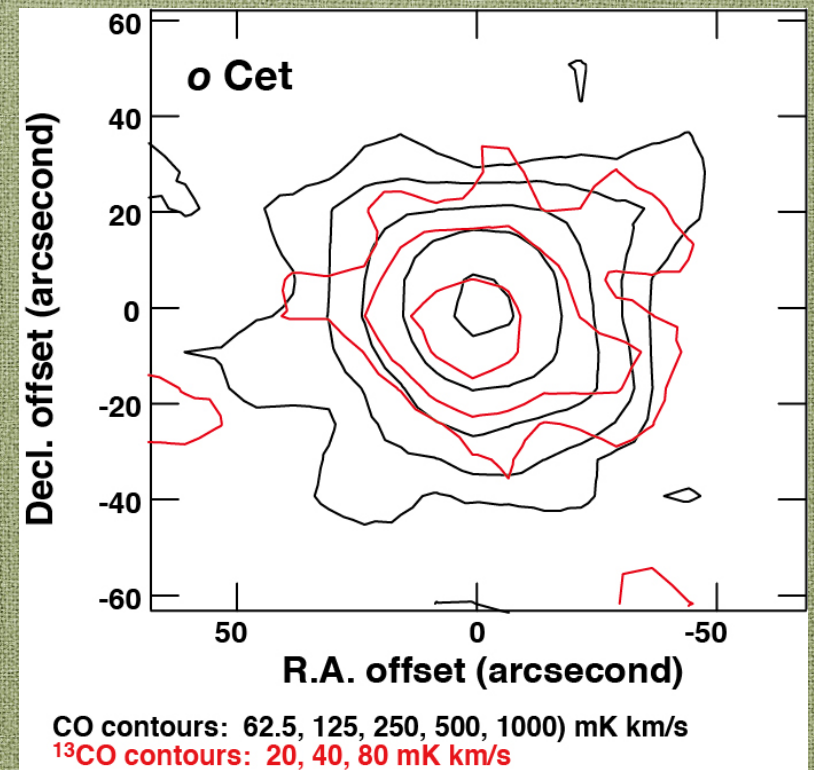
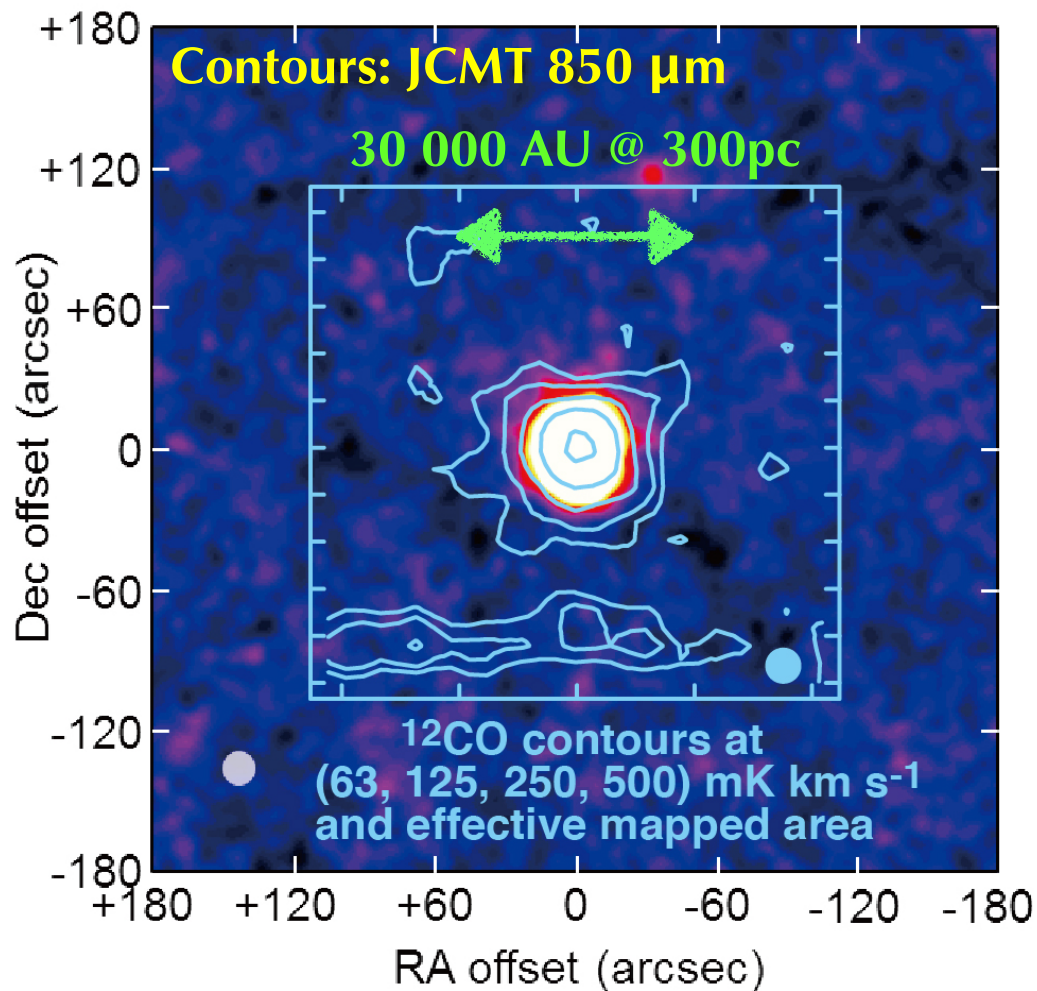


2019年度連星系・変光星研究会

@中京大学 2019年11月30日

NESS-NRO

Comprehensive mapping of cold circumstellar envelopes in CO / ^{13}CO $J=1 \rightarrow 0$ lines



Amada, Imai et al. in prep.

Water fountains

Fast bipolar jets from dying stars traced by H₂O masers

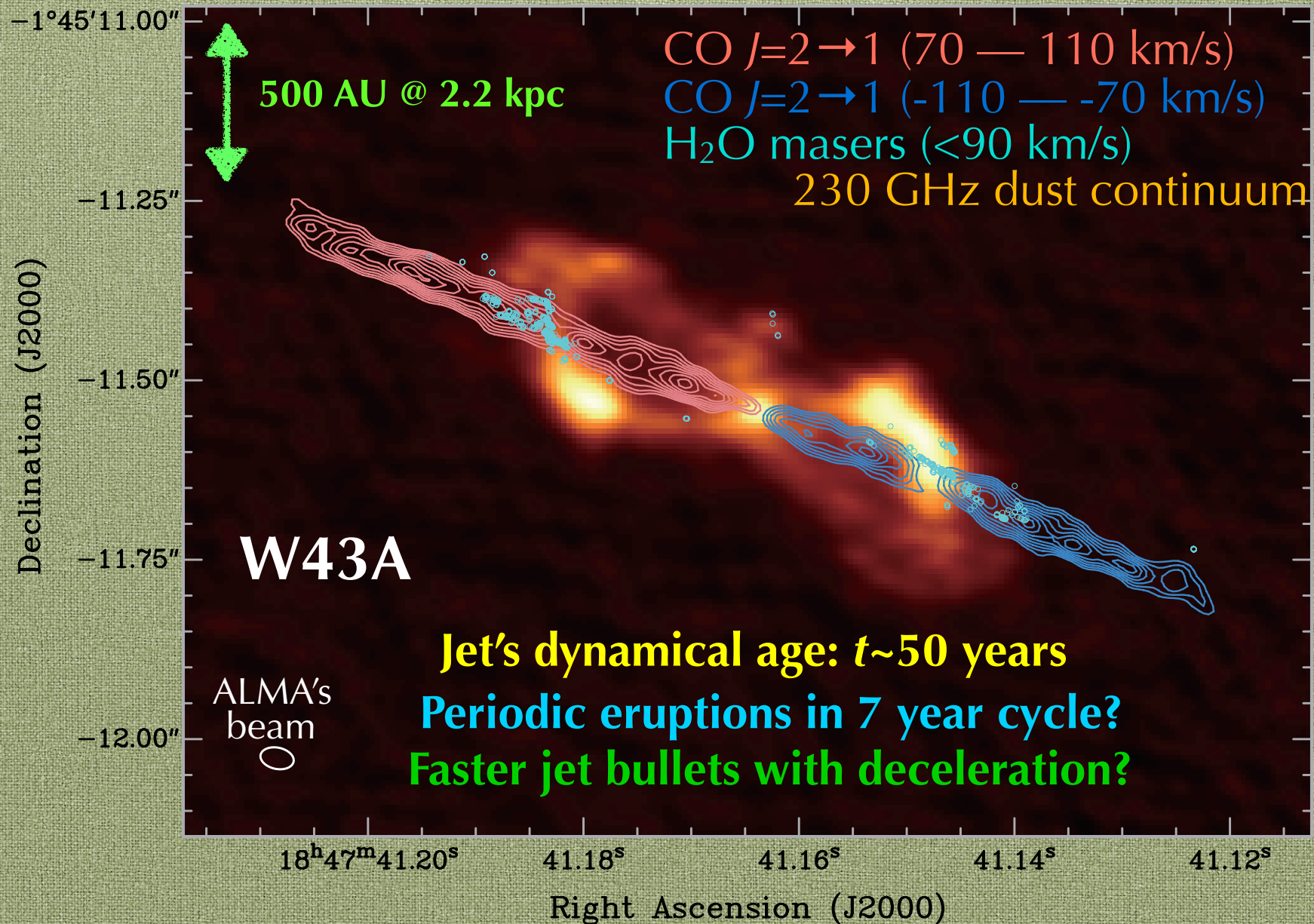


Image with ALMA+VLBA (Tafoya, Imai et al. in prep.)

FLASHING

Finest Legacy Acquisitions of **SiO**- and **H₂O**-maser Ignitions by Nobeyama Generation

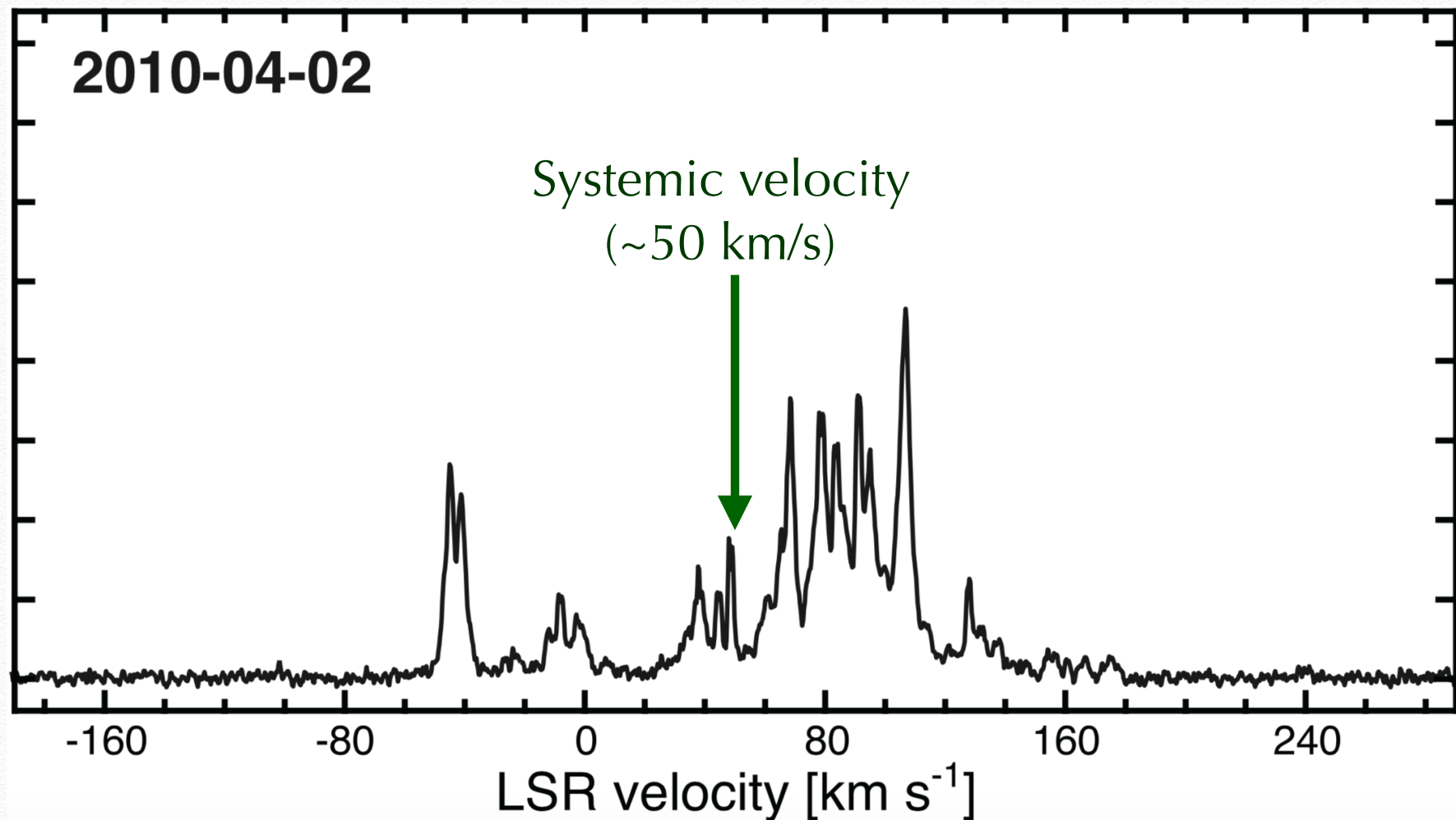
- ❖ Using Nobeyama 45-m telescope
 - + **Perforated frequency separation filter plate**
(Okada et al. 2020, PASJ) developed by HINOTORI
(Hybrid Installation Project in Nobeyama, Triple-band Oriented)
- ❖ Conducted as a Backup Program during
2018 December—2019 May (~260 hours)
- ❖ Towards 17(+2) water fountains and candidates
- ❖ 3—14 observation sessions per source
- ❖ Velocity resolution: 0.42 km/s (H₂O) and 0.22 km/s (SiO)
- ❖ Velocity coverage: 1258 km/s (H₂O)
- ❖ Follow-up VLBI target-of-opportunity observations soon after new ignitions of highest velocity H₂O 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 baseline
time-domain radio astronomy**

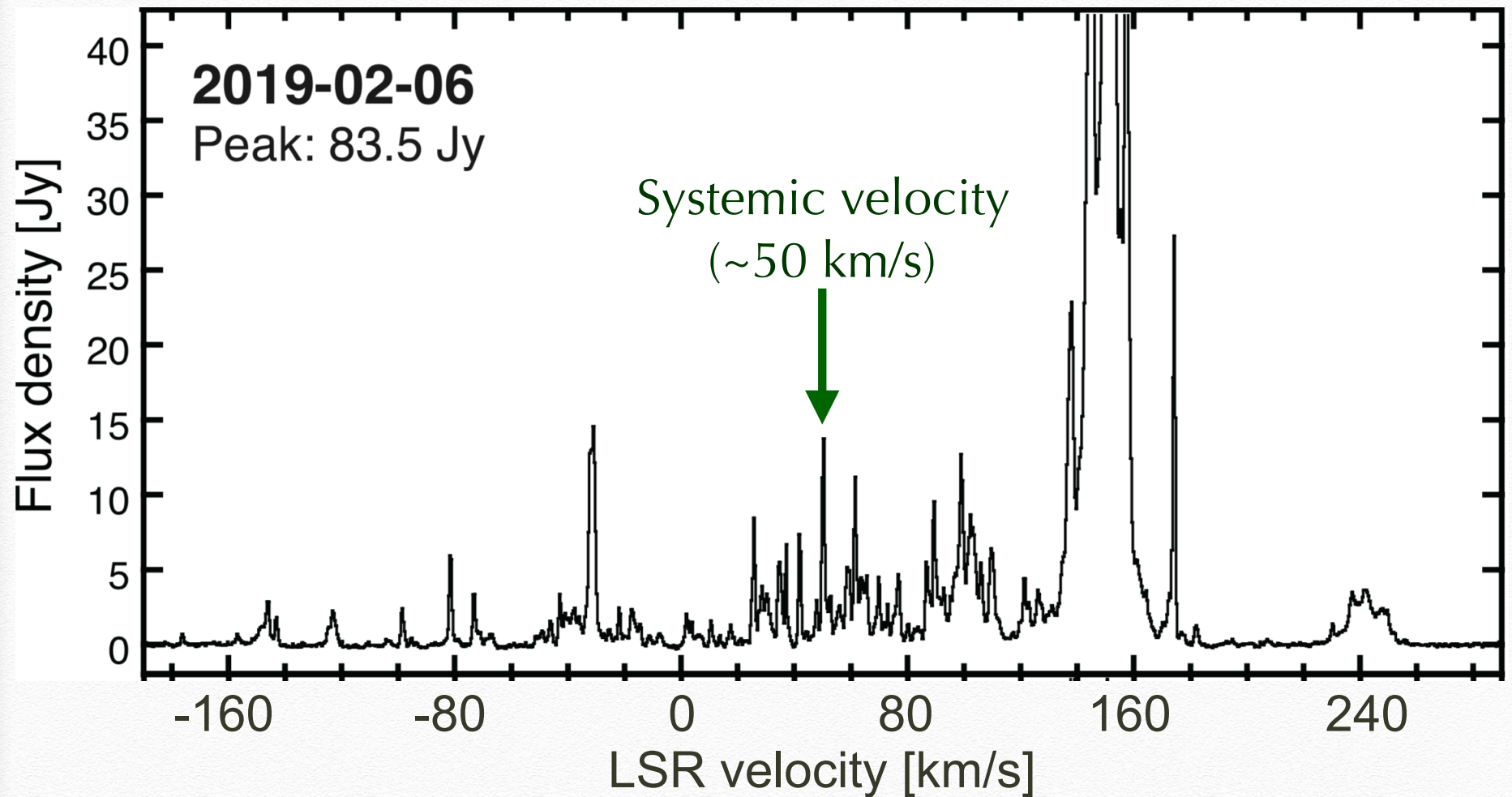
Before ignitions of the highest velocity H_2O maser components



IRAS 18286-0959

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

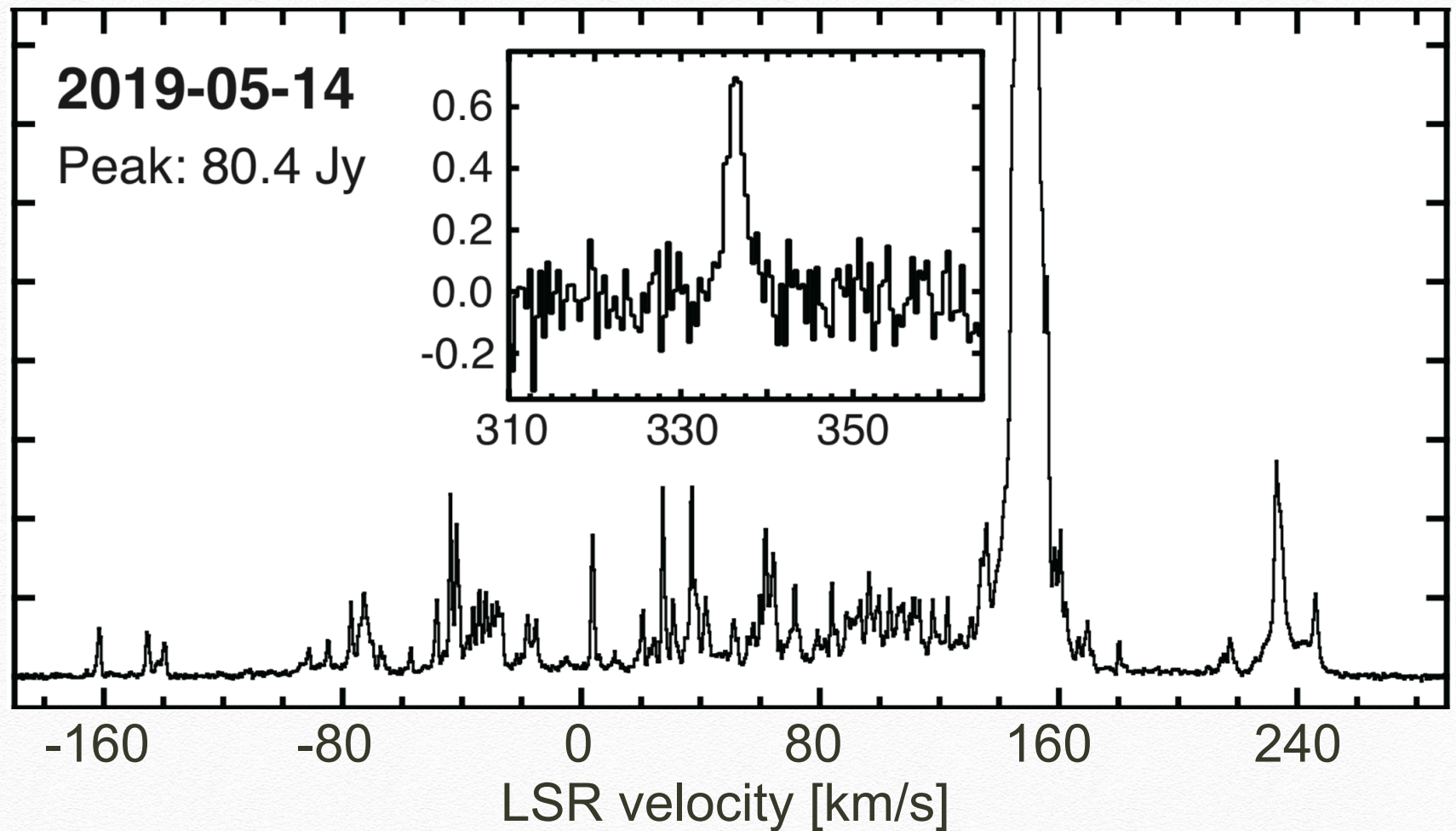
New ignitions of the highest velocity H_2O maser components



IRAS 18286-0959

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

New ignitions of the highest velocity H_2O maser components



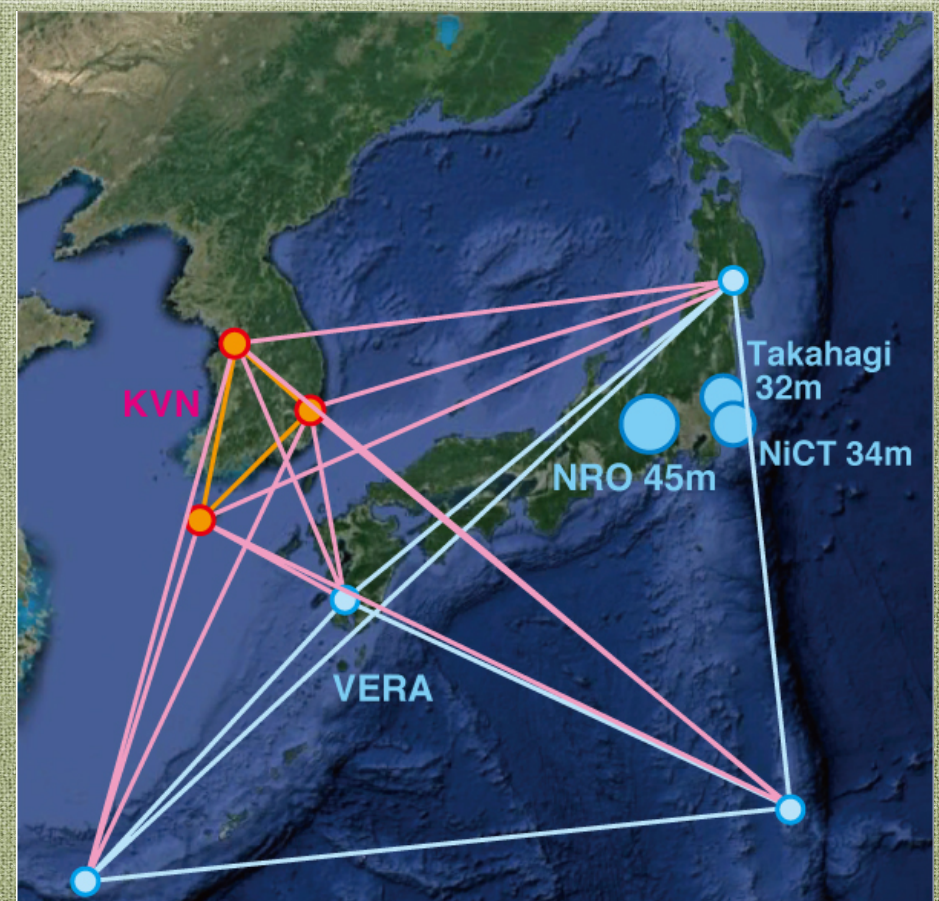
Imai et al. (2020, PASJ VERA Special Issue)

KaVA

(KVN and VERA Combined Array)

target-of-opportunity follow-up

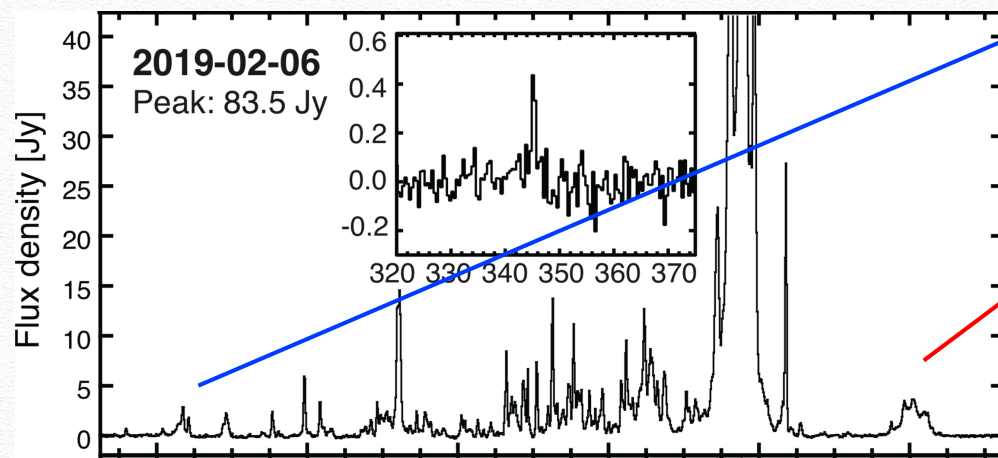
- ❖ Epoch: 2019 March 4
for 6 hours
- ❖ Participating telescopes:
 - 4 VERA and 3 KVN antennas in LHCP
- ❖ 1 Gbps recording $\rightarrow$ Velocity coverage 1727 km/s
- ❖ 4096 channels $\rightarrow$ Velocity resolution 0.42 km/s
- ❖ Synthesized beam: 2.1×1.4 mas, P.A. = -18 deg.
- ❖ 1- σ noise level: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



Localization of the highest velocity H_2O maser components

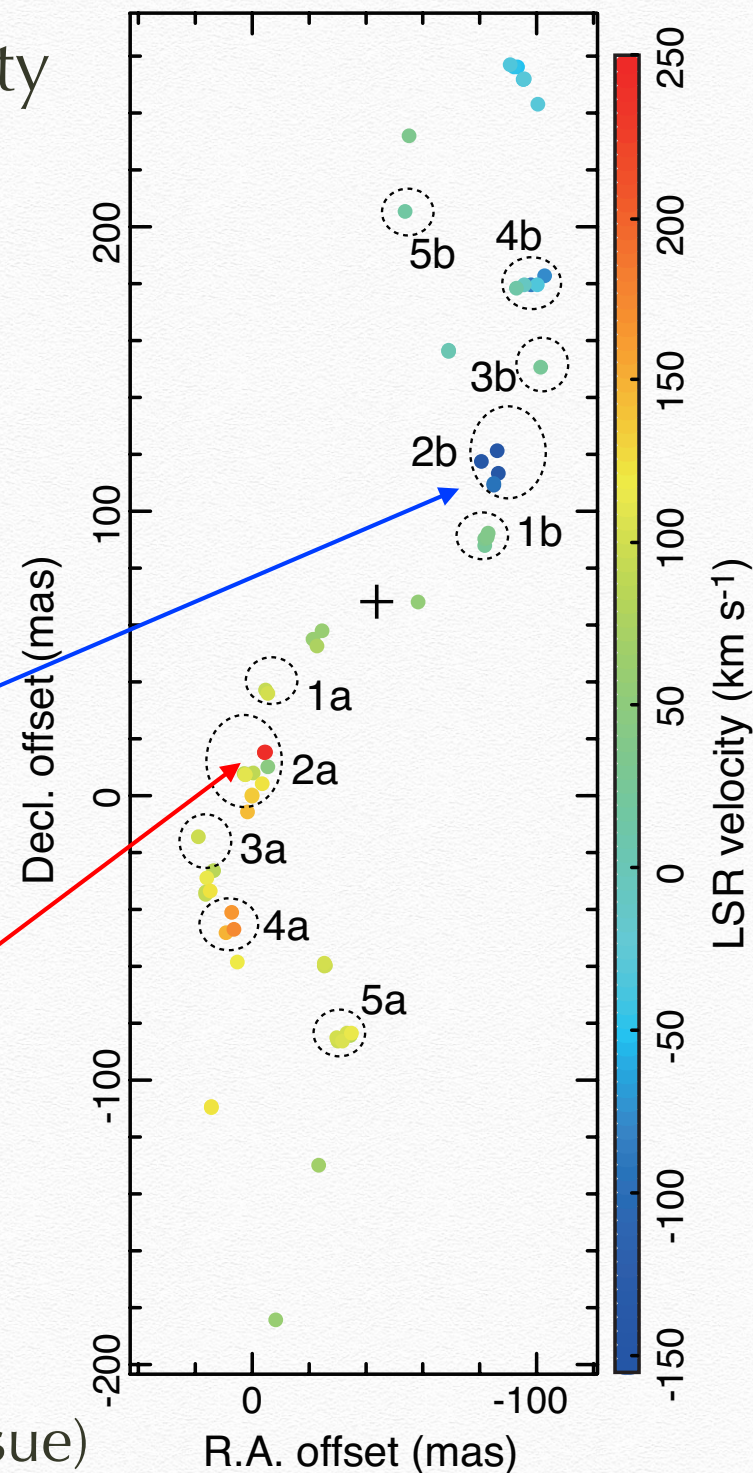
Highest velocity jet before deceleration

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)



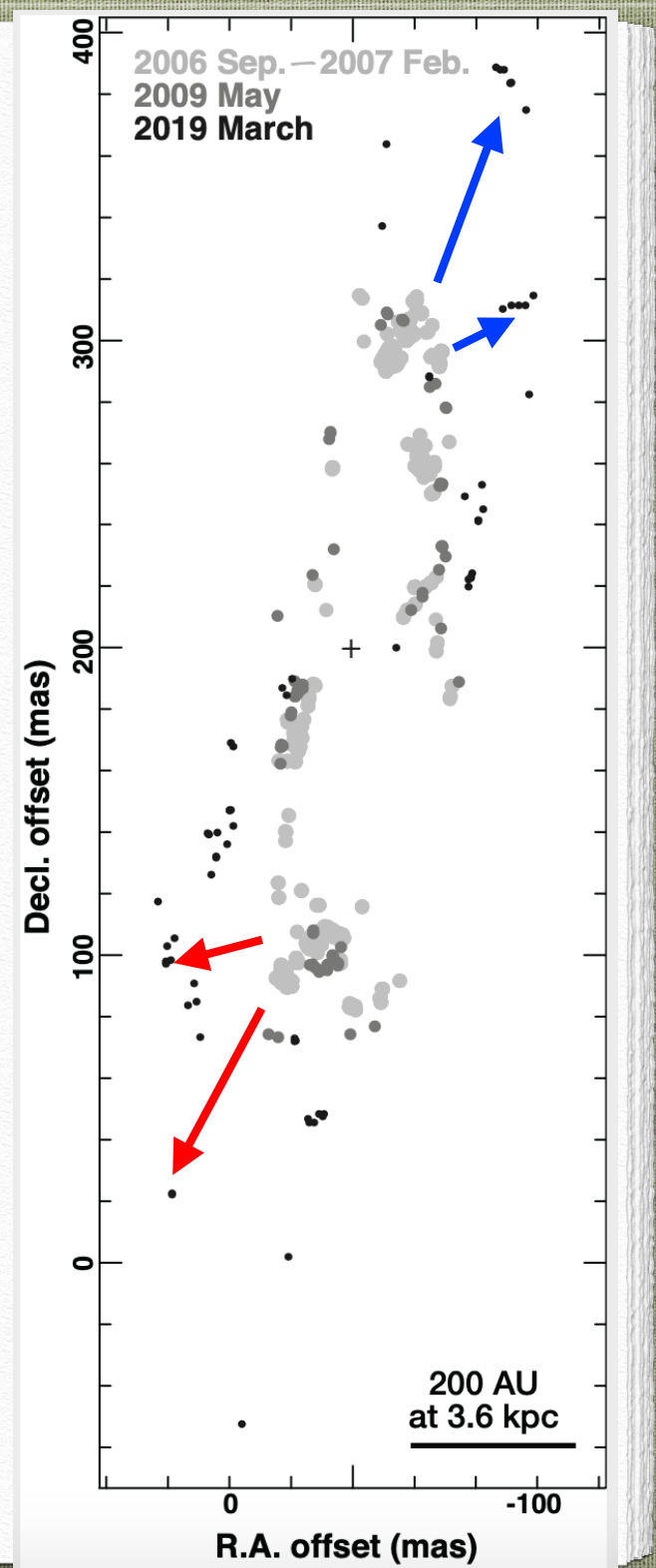
Decadal jet evolution

- ❖ **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!

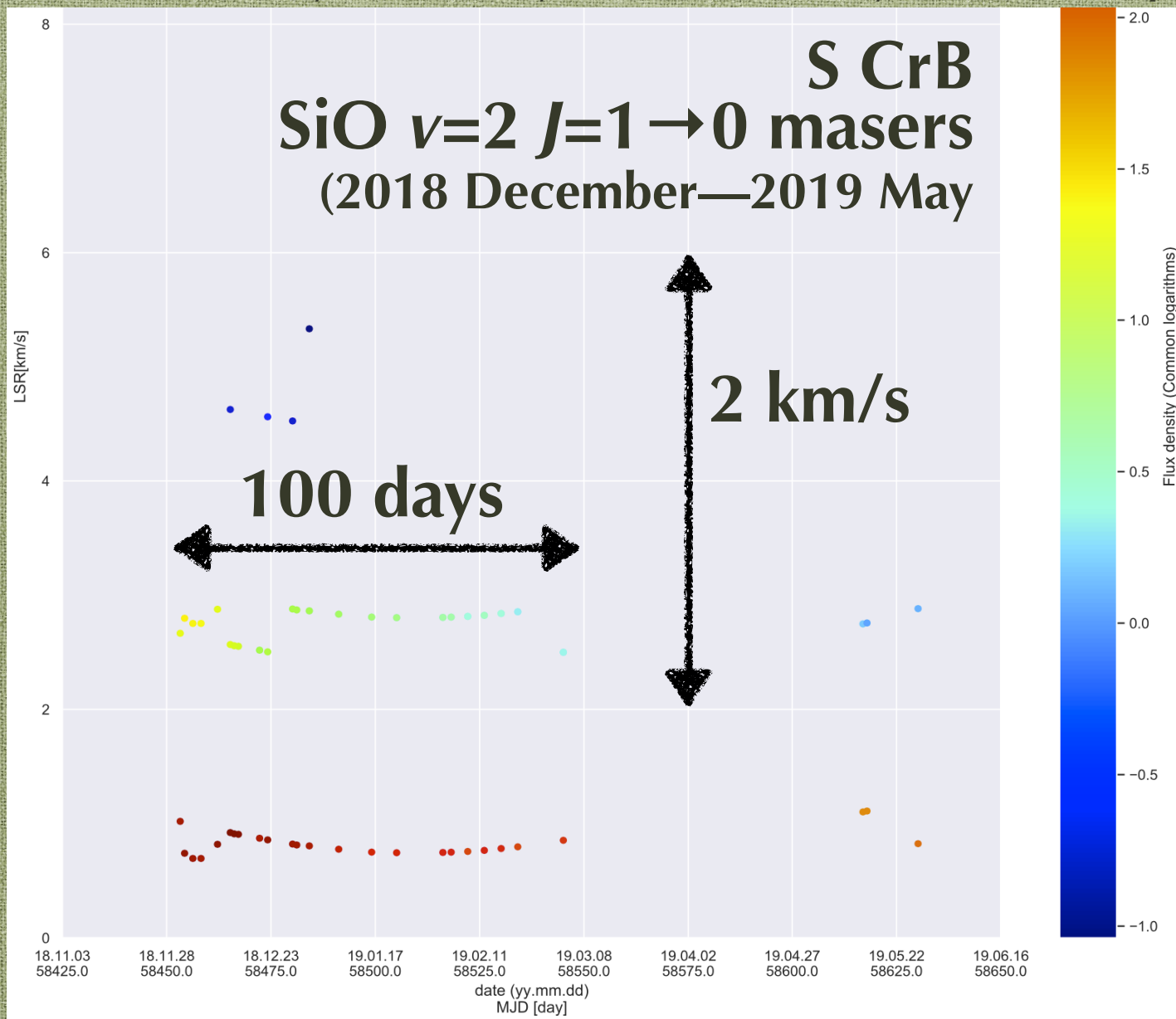
Imai et al. (2020, PASJ VERA Special Issue)



By-product of FLASHING

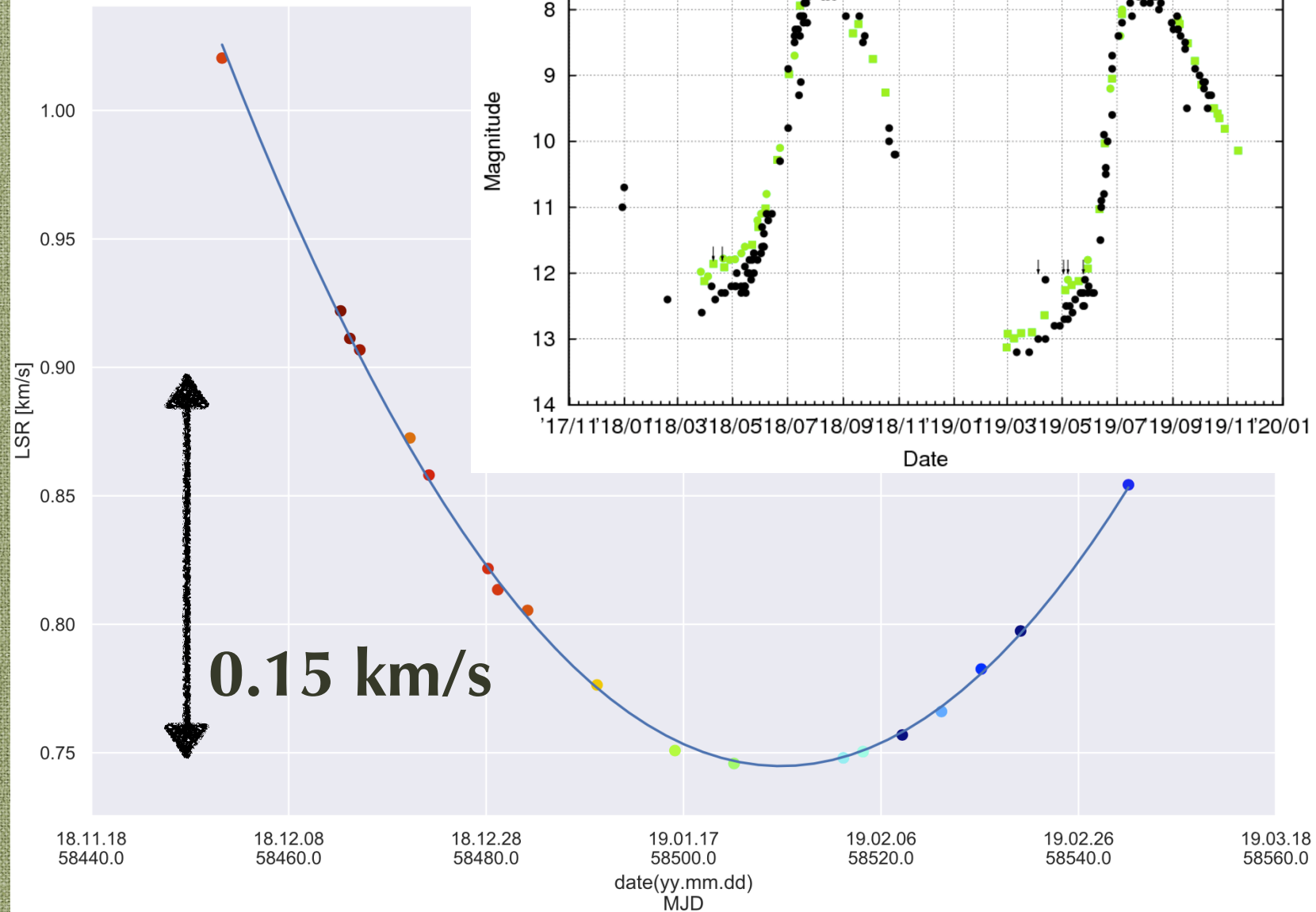
Watching propagation of a shock wave?

Systemic velocity $V_{\text{LSR}} \sim -5$ km/s (Famaey et al. 2005, A&Ap, 430, 165)



By-product of FLASHING

Or watching
mis-calculation
of LSR velocity..... ?



Acknowledgements

- ❖ Very thanks to
 - ❖ Nobeyama Radio Observatory
(Development Proposal 4171001)
 - ❖ Mizusawa VLBI Observatory
 - ❖ KVN/KASI
 - ❖ AGARC, Kagoshima University
 - ❖ FLASHING Team
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- ❖ NAOJ Development Program
 - ❖ P.I. Takeshi Manabe (FY2016, FY2017)

