

# VLBI imaging of 44 GHz methanol maser sources with KVN+VERA array



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## Introduction:

- About 44 GHz methanol masers (Class I) and 6.7 GHz methanol masers (Class II).

## Observation:

- KVN+VERA observation of 44 GHz methanol maser toward G18.34+1.78 SW.

## Result & Discussion:

- Spectrum (AC/XC) of G18.34+1.78SW
- Spacial distribution of G18.34+1.78SW
- Maser spot size and brightness tempereture of G18.34+1.78SW

# Methanol maser around Massive star forming regions

G19.01-0.03 (EGO)

Cyganowski+2009

**Class I methanol maser  
(44GHz  $7_0-6_1A^+$  etc.)**

There are dozens interferometer images, but no VLBI images.

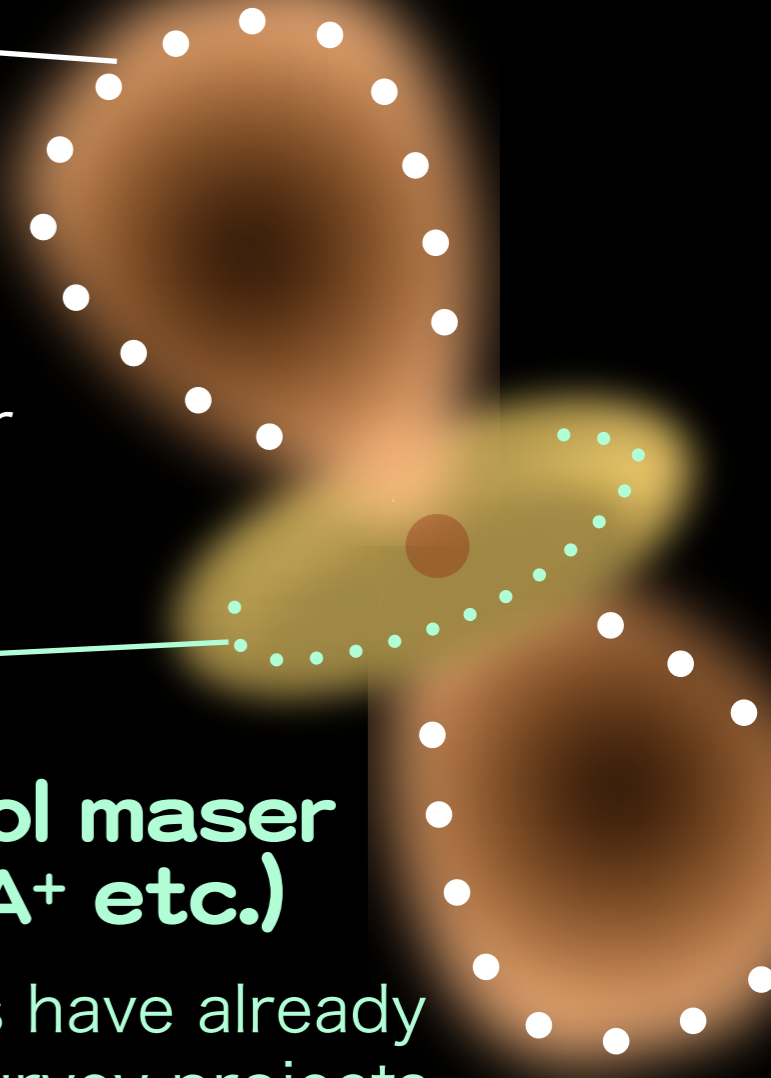
**Class II methanol maser  
(6.7GHz  $5_1-6_0A^+$  etc.)**

Over 1,000 sources have already detected by large survey projects. There are some statistical study with VLBI imaging.

VLBI can detect proper motions and spacial distributions in circumstellar gases with few milli arc second scale.

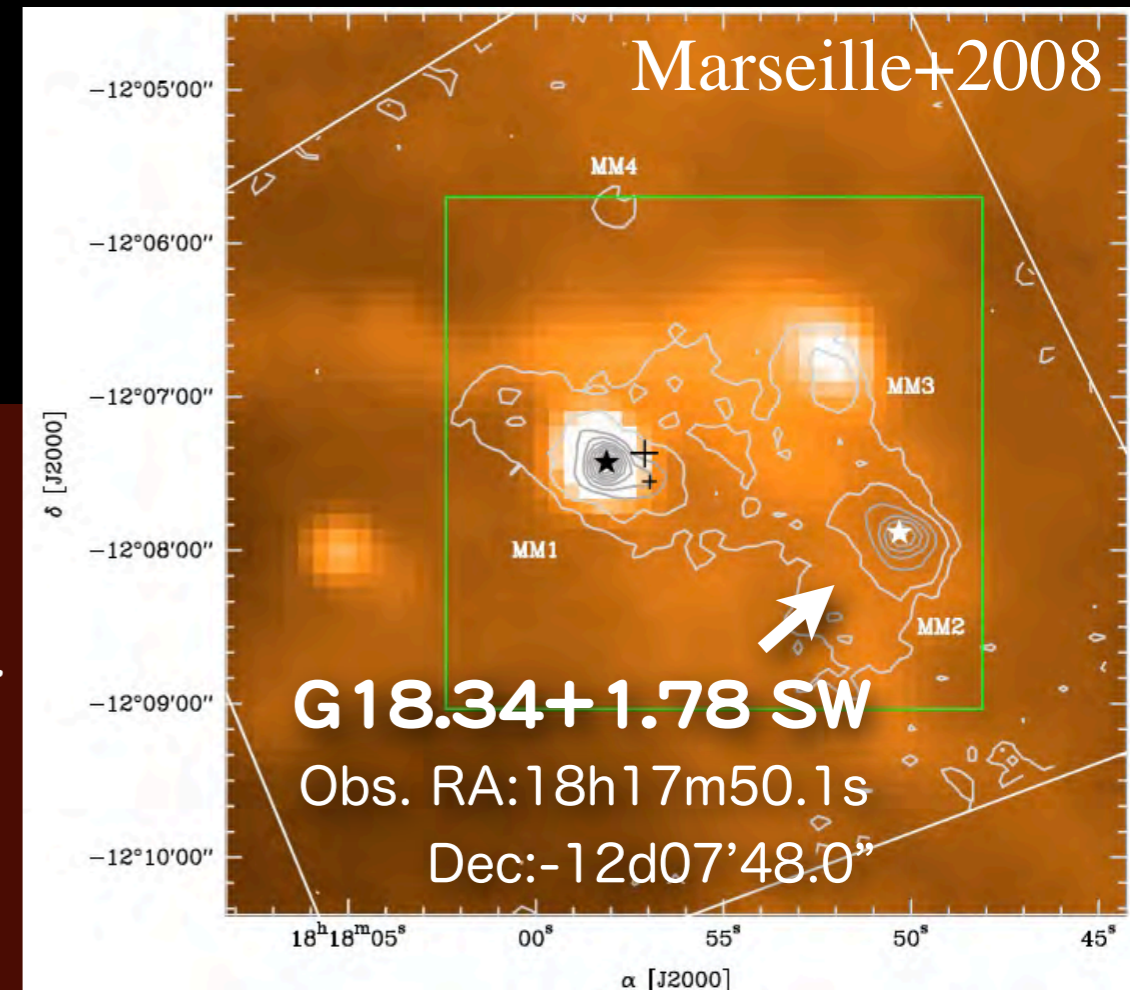
8.0  $\mu\text{m}$  4.5  $\mu\text{m}$  3.6  $\mu\text{m}$  24 $\mu\text{m}$

10" ~ 0.20 pc



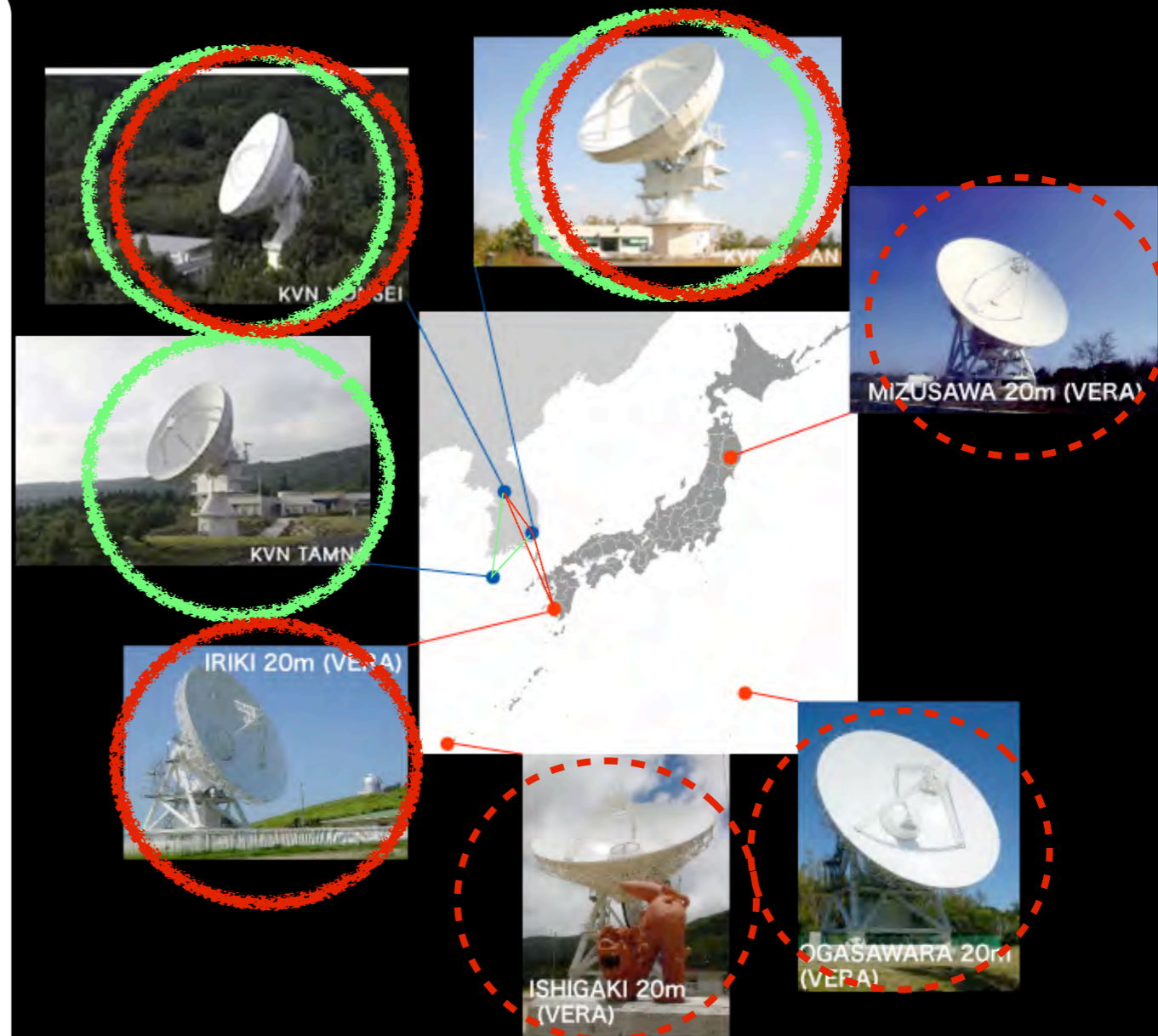
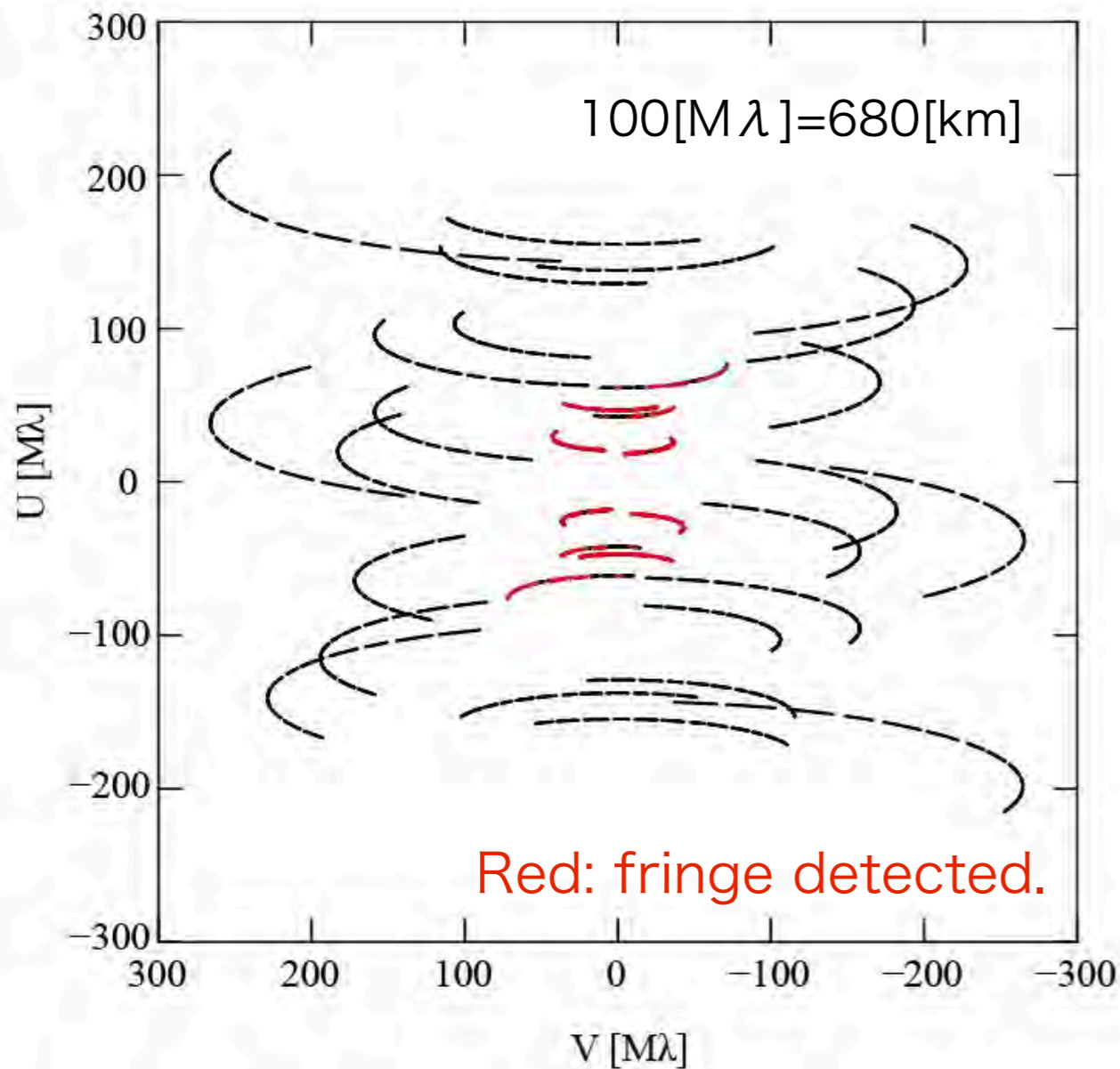
# 1<sup>st</sup> imaging observations of 44GHz methanol maser sources with KVN+VERA

- Date : Apr. 8, 2012, UT 17h - 24h
- Line : 44 GHz Class I methanol maser
- Target : G18.34+1.78 SW
- $D_{\text{kin}}$  :  $\sim 2.7$  kpc
- Data1: KVN(2)+VERA(3) recorded with DIR1000 (16 MHz x 2 ch)
- Data2 : KVN(3) recorded with DiFX(16 MHz x 2 ch,  $\sim 0.22$  km/s/ch)



# UV coverage is improved with KVN+VERA

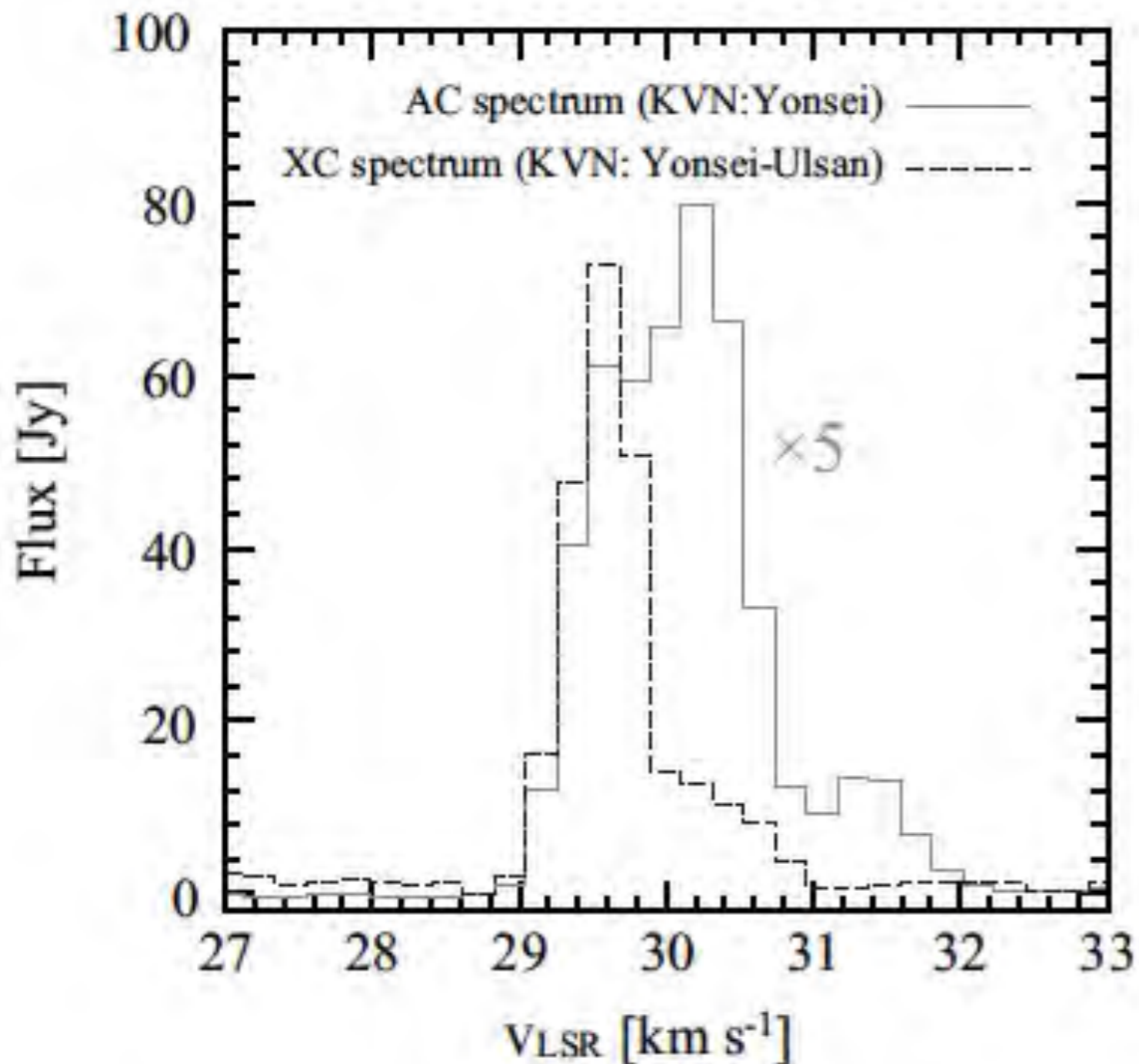
G18.34+1.78 SW (Apr. 8, 2012)



DIR1000, Mark5B

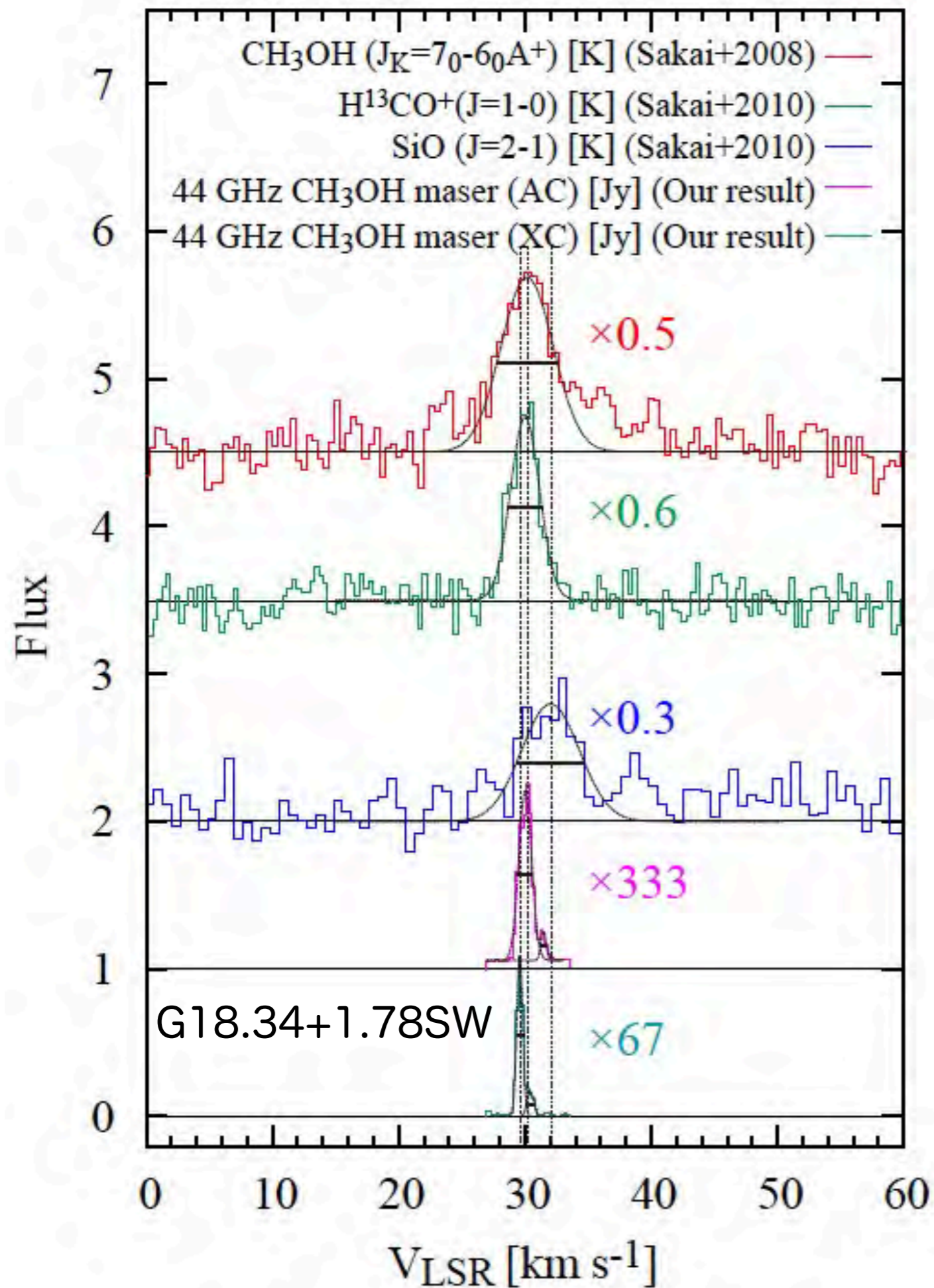
KVN+VERA observations produce a complementary effect.

# Detected AC/XC spectrum



AC: ~400 Jy  
XC: ~75Jy(max)  
>10Jy(Typ.)

44GHz methanol maser  
toward G18.34+1.78 SW (Apr. 8, 2012)



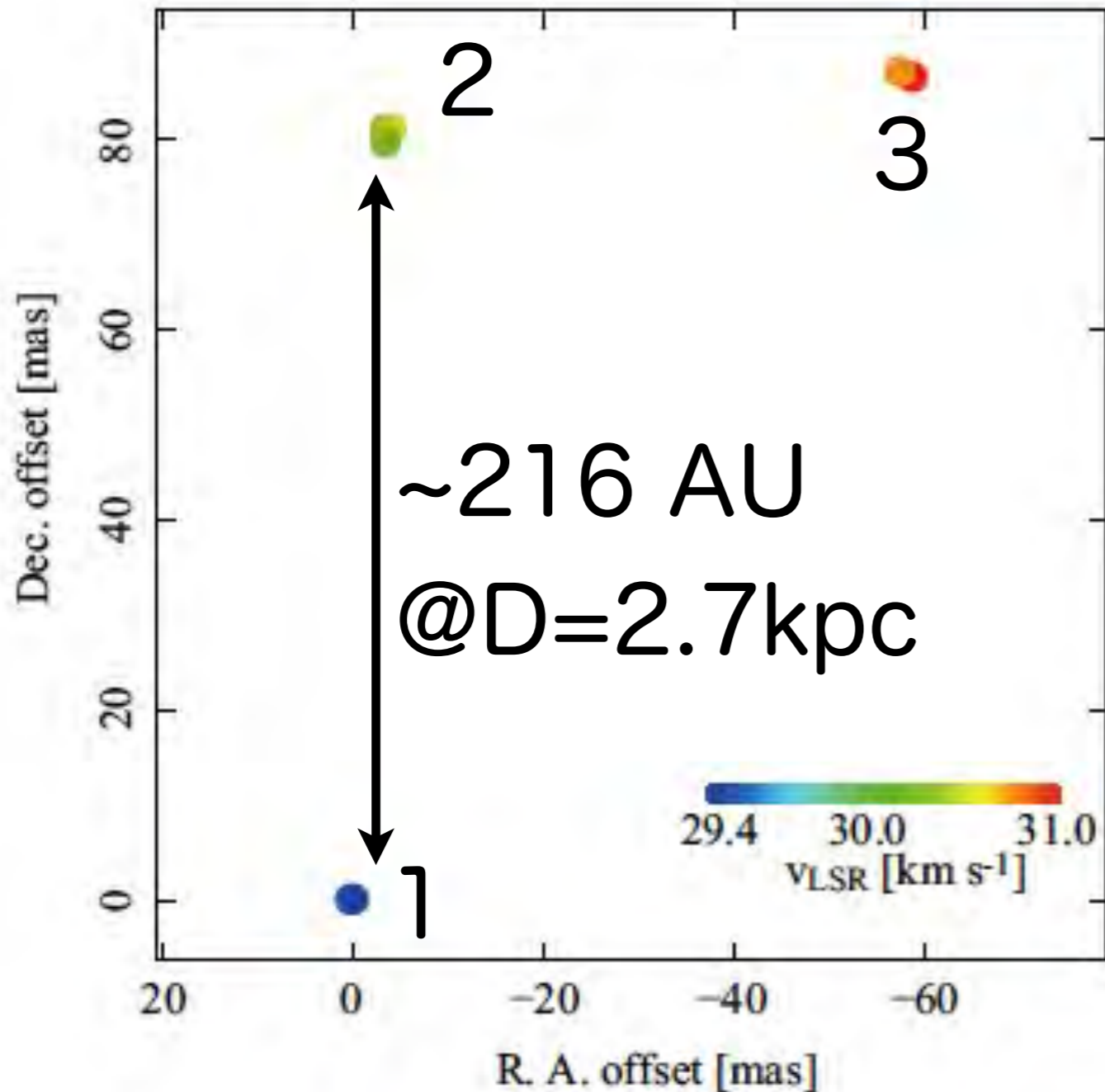
44GHz methanol maser line have almost systemic velocity.

&

44 GHz methanol maser line does not trace the red-shifted component showing in SiO thermal line.

# Detected 3 maser features

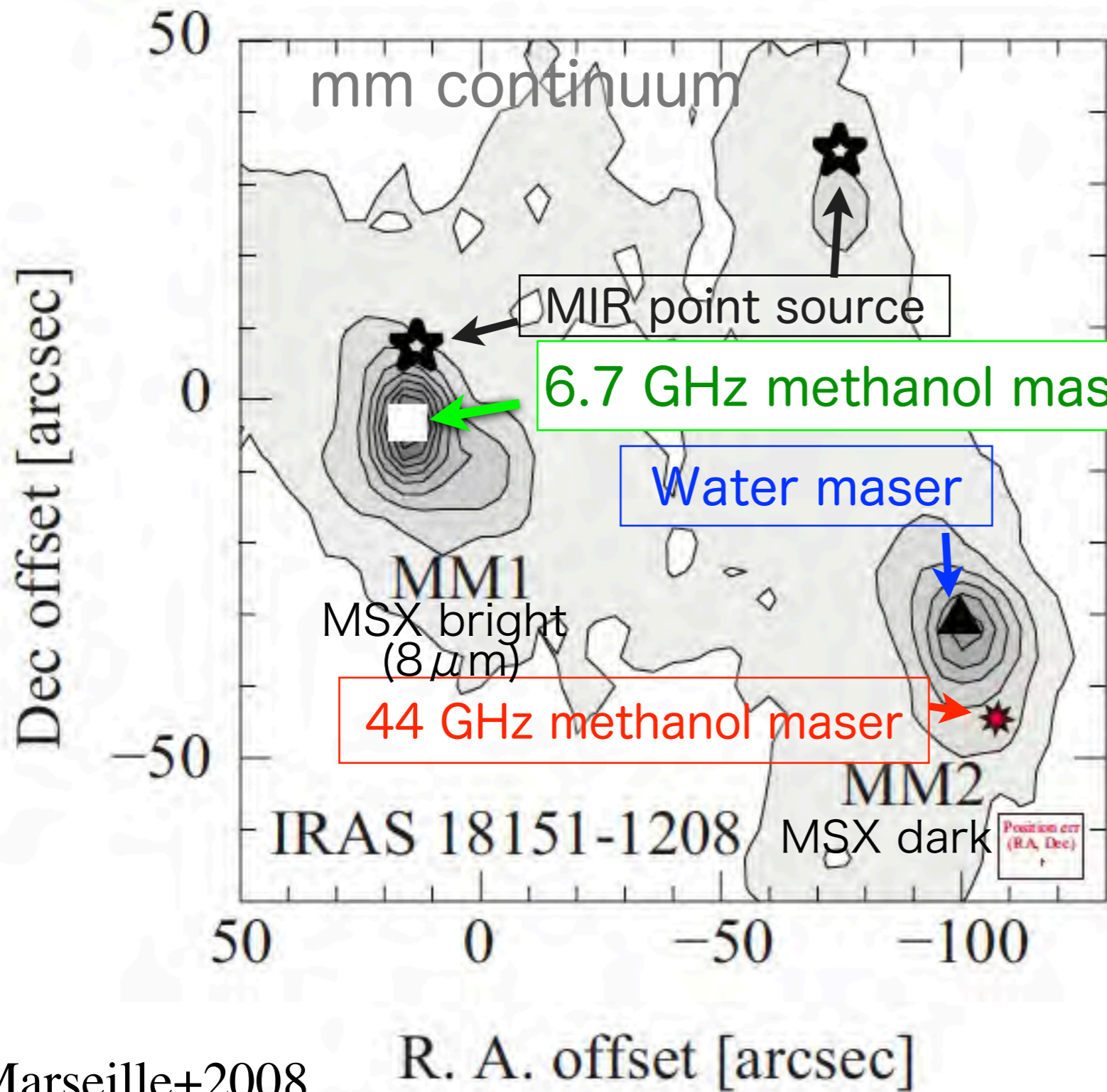
44 GHz methanol maser toward G18.34+1.78 SW



(0, 0) position is  
corresponding to  
RA: 18h17m49.95s±0.02s  
Dec: -12d08'6.48"±1.0"

This is away from MM2  
dust peak by  
dRA~ -2.2s,  
dDec~ -18.5s.





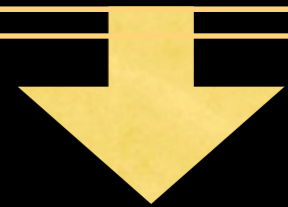
Marseille+2008

44 GHz methanol  
(Class I) @MM2

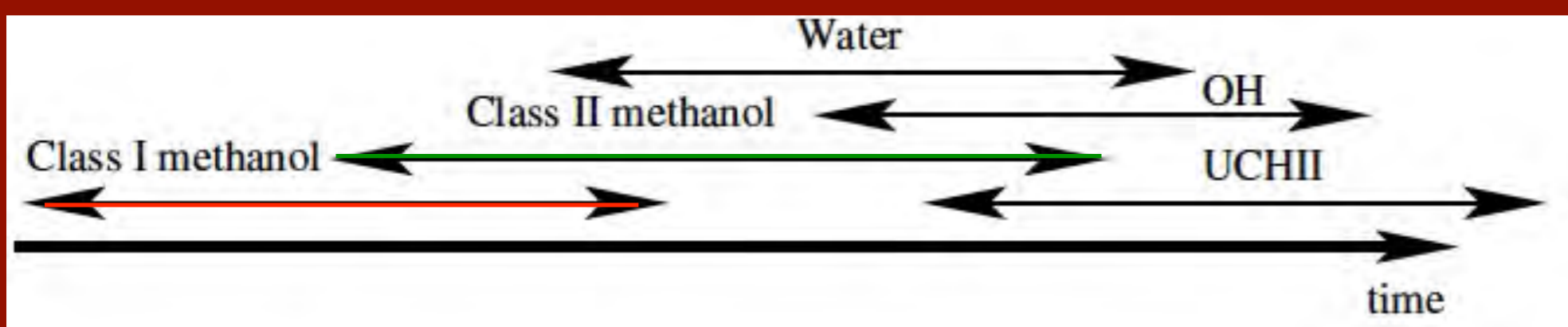
6.7 GHz methanol  
(Class II) @MM1

MM2 is younger  
than MM1.

Class I is younger  
than Class II.

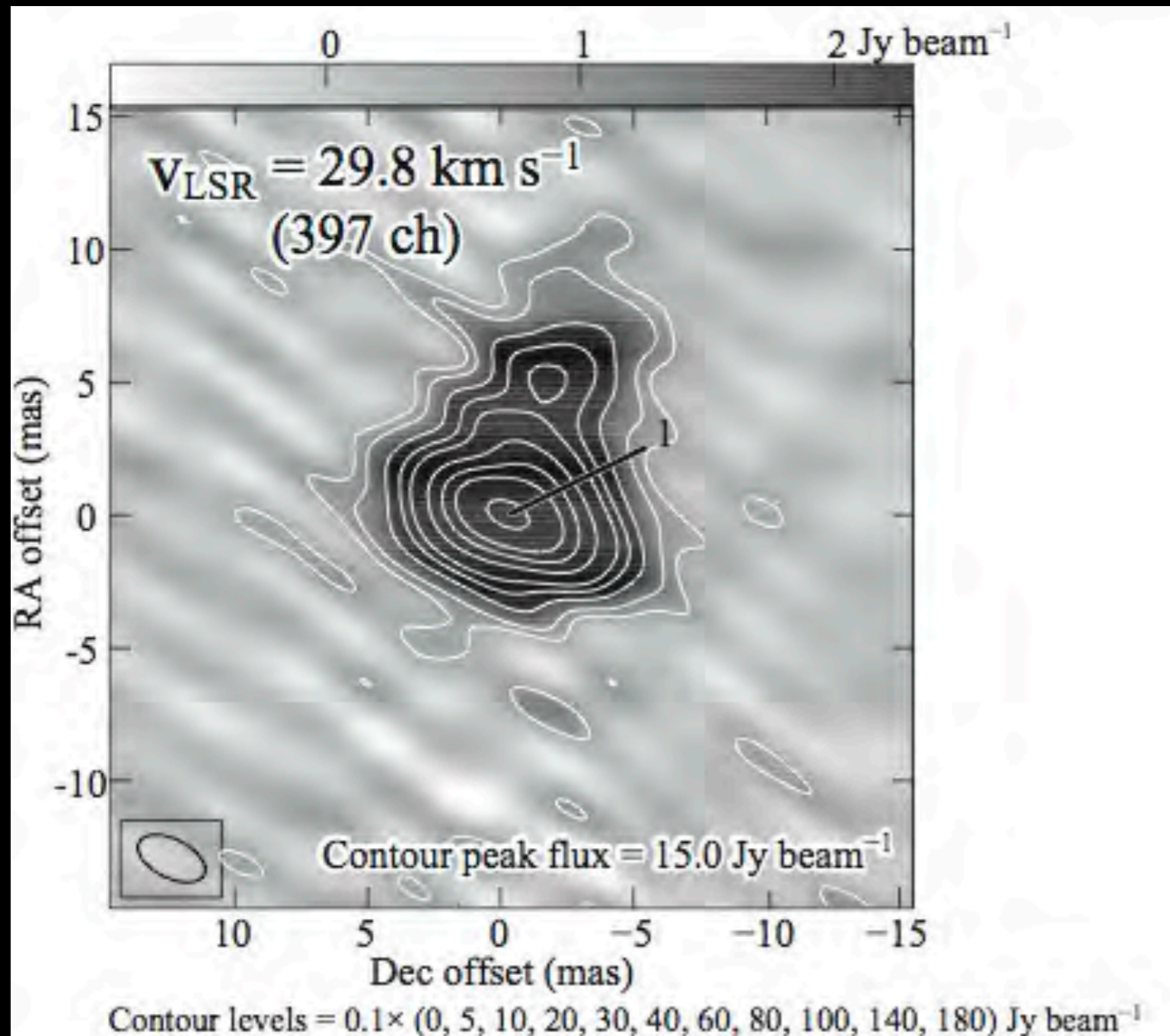


Support  
Ellingsen+07



# Maser spot size & Brightness temperature

## G18.34+1.78SW



Spot size :

$$6.0 \times 3.8 \text{ mas}^2$$

(PA:  $51.2^\circ$ )

Typical size:

$$\sim 6 \times 3 \text{ mas}^2$$

( $\sim 16 \times 8 \text{ AU} @ D = 2.7 \text{ kpc}$ )

From gaussian fitting:

Peak flux =  $14.3 \pm 0.1 \text{ [Jy/beam]}$

$$T_b \sim 9.0 \times 10^9 \text{ [K]}$$

Cf. NGC6364I:

$$T_b \sim 3.6 \times 10^8 \text{ [K]}$$

Kogan&Slysh 1998

$$\theta_{\text{beam}} \sim 2.7 \times 1.5 \text{ mas}^2 \text{ (PA: } 63.7^\circ)$$

# Summary

- VLBI imaging observations of 44 GHz methanol maser were conducted in 2012~2013 with KVN+VERA array.
- For G18.34+1.78 SW (Matsumoto et al.):
  - $V_{\text{LSR}}$  is almost the systemic velocity.
  - Detected 3 compact maser features.
  - Brightness temperatures  $\sim 10^{8-9}$ [K].
  - Typical maser spot size  $\sim 6 \times 3 \text{ mas}^2$  ( $\sim 16 \times 8 \text{ AU}^2 @ D=2.7 \text{ kpc}$ ).
- There are compact maser spots in 44 GHz methanol maser.
- 44 GHz methanol maser is younger than 6.7 GHz methanol maser in G18.34+1.78 region, which support Ellingsen+2007.
- We need more sample for static investigation about maser spot size of 44 GHz methanol maser.

*Fin.*