

Studies of methanol maser rings

**Anna Bartkiewicz,
Marian Szymczak, Huib van Langevelde,
James De Buizer, Ylva Pilhström,
Andreas Brunthaler, Anita Richards, Mark Reid**

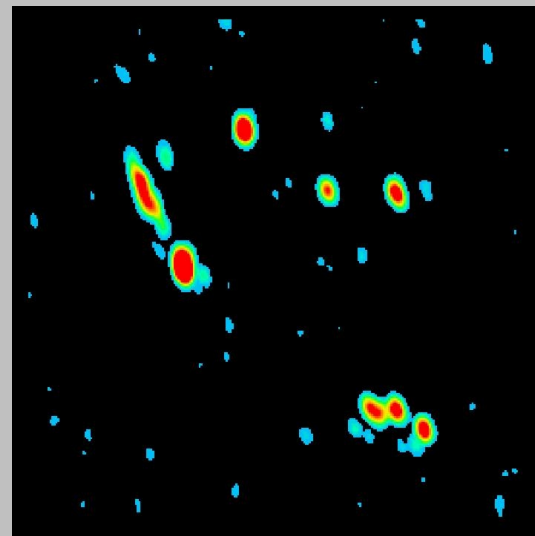
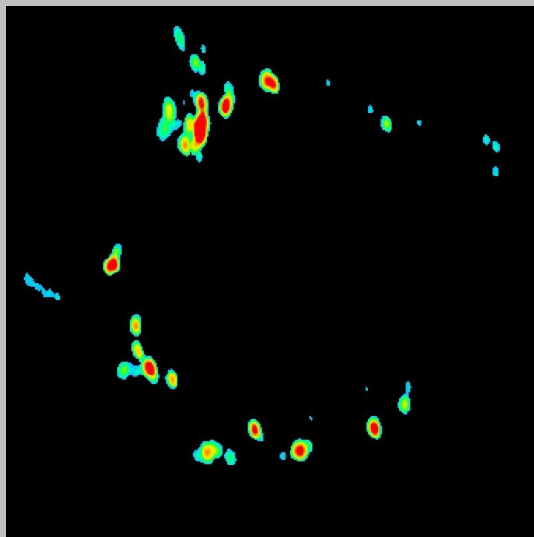


**Consortium for Very Long Baseline
Interferometry in Europe**

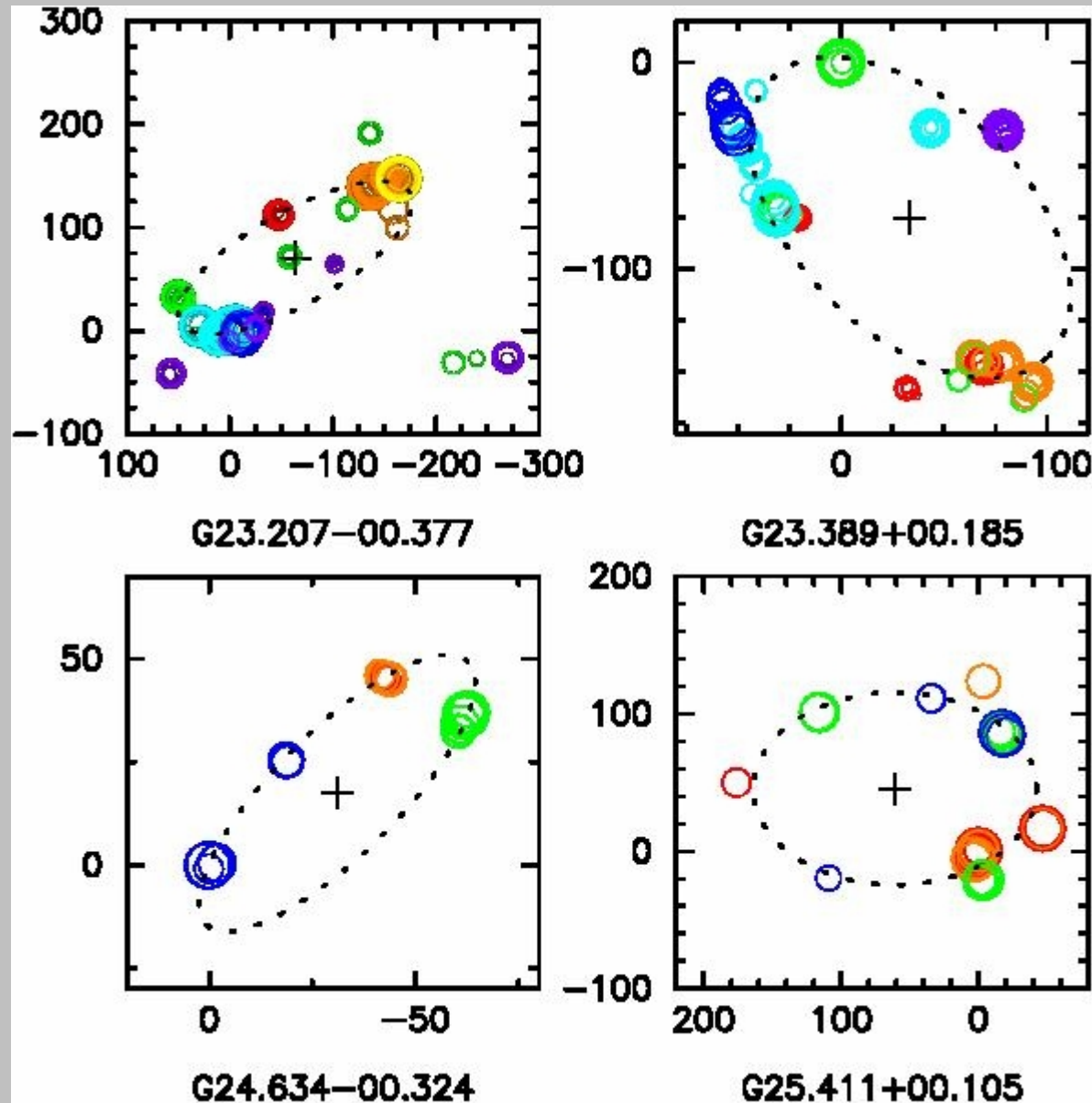


Introduction

In 2003-07 we used EVN (6 runs = 74 hours) to image 31 methanol maser sources at 6.7 GHz discovered earlier using Torun 32 m dish (Szymczak et al. 2002). We registered a new class of „RING-LIKE” methanol masers that were surprisingly common: they appeared in ~30 per cent of the sample (**9 sources**) (Bartkiewicz et al. 2009). Why? The EVN increased its sensitivity and we focused on relatively weak masers. The kinematics of the maser spots were not consistent with Keplerian discs and indicated the strong influence of outflow or infall (see talk of Huib van Langevelde).



Examples



Bartkiewicz et al. 2009

Observations:

We used:

- **VLA** at 8.4 GHz to investigate the presence, position and distribution of radio continuum emission associated with the methanol masers (18/08/2007) – A conf.
- **VLA** at 22 GHz to search for water maser emission (4/06/2009) – CnB conf.
- **Gemini telescopes** to image near-IR and mid-IR emission towards the methanol maser rings (July-October 2009) – 5 sources.



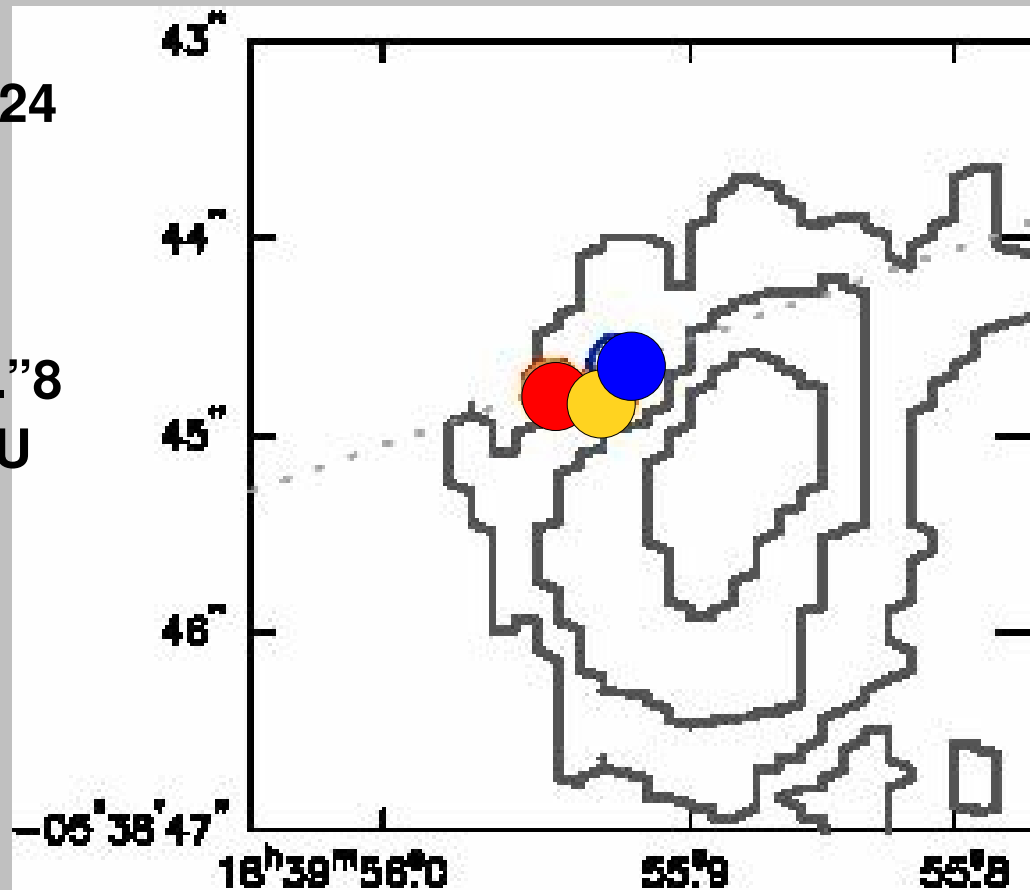
Results (VLA 8.4 GHz):

We found only one 8.4 GHz sources coinciding with the methanol maser rings.

In total only four cases of detections of continuum emission towards the whole sample of 31 methanol masers.

G26.598-00.024

Separation
maser -
H II centre: $0.''8$
(i.e., ~ 1500 AU
for the near
kin.dist.)



Bartkiewicz et al. 2009

Results (water masers using VLA):

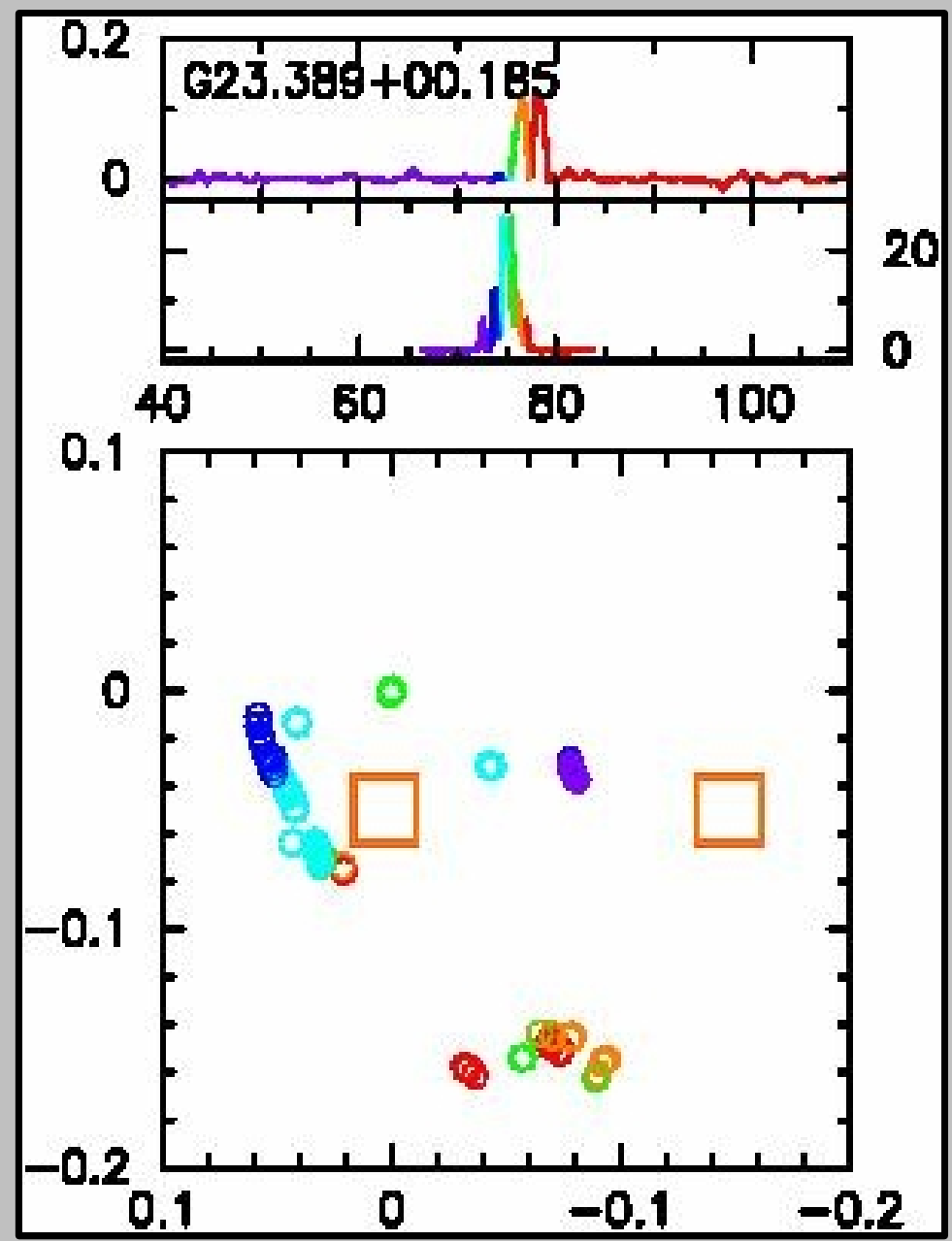
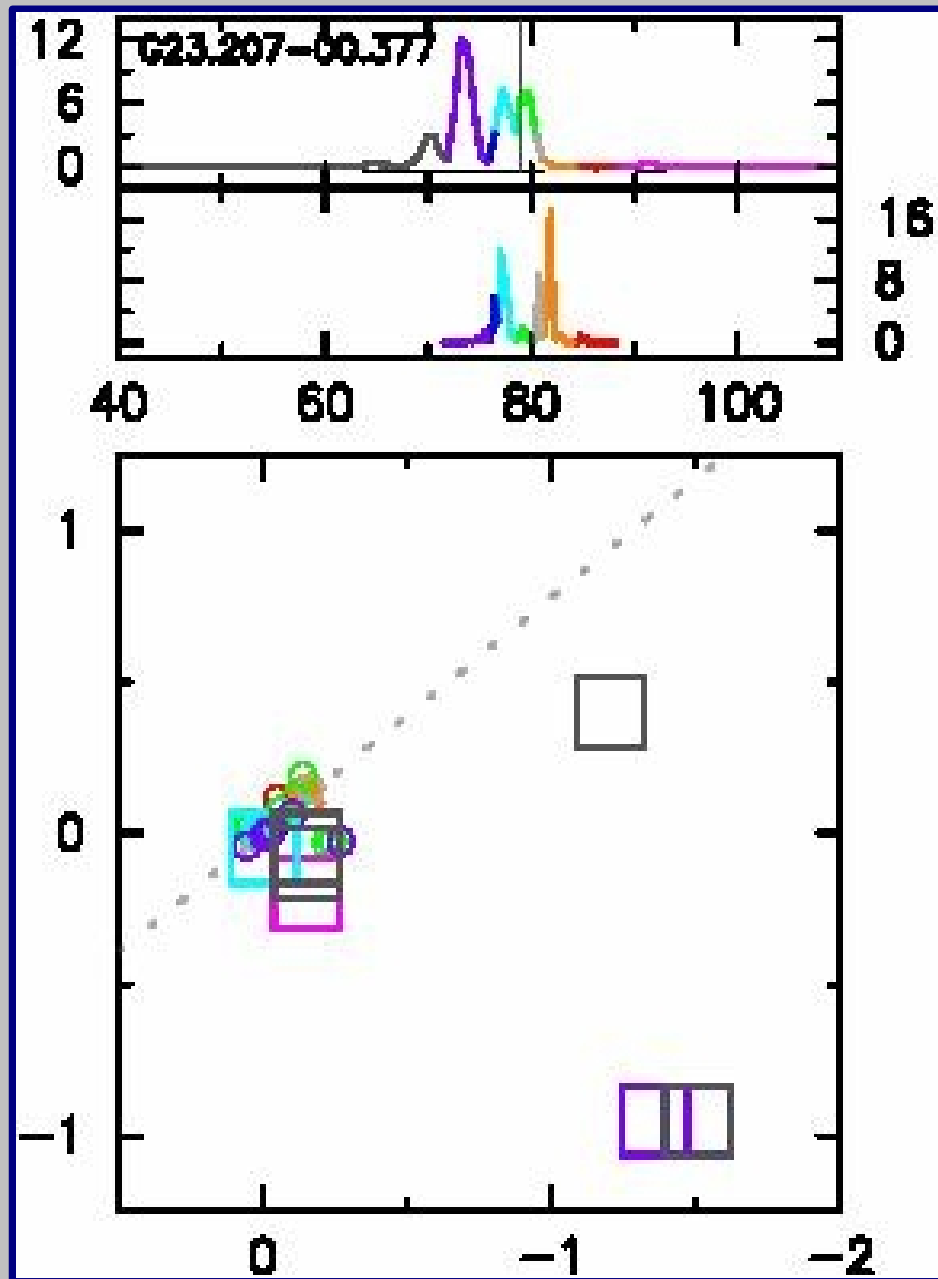
In total we detected 22 water maser sources associated with methanol sources (the sample of 31). 5 out of 9 methanol maser rings showed 22 GHz water maser emission. In 4 out of these 5 rings, the associated water masers are weaker than methanol masers. In 4 out of the 5 cases the position angle of the main axis of the water maser structure is crudely orthogonal (60-120 deg) to the major axis of the methanol ring.

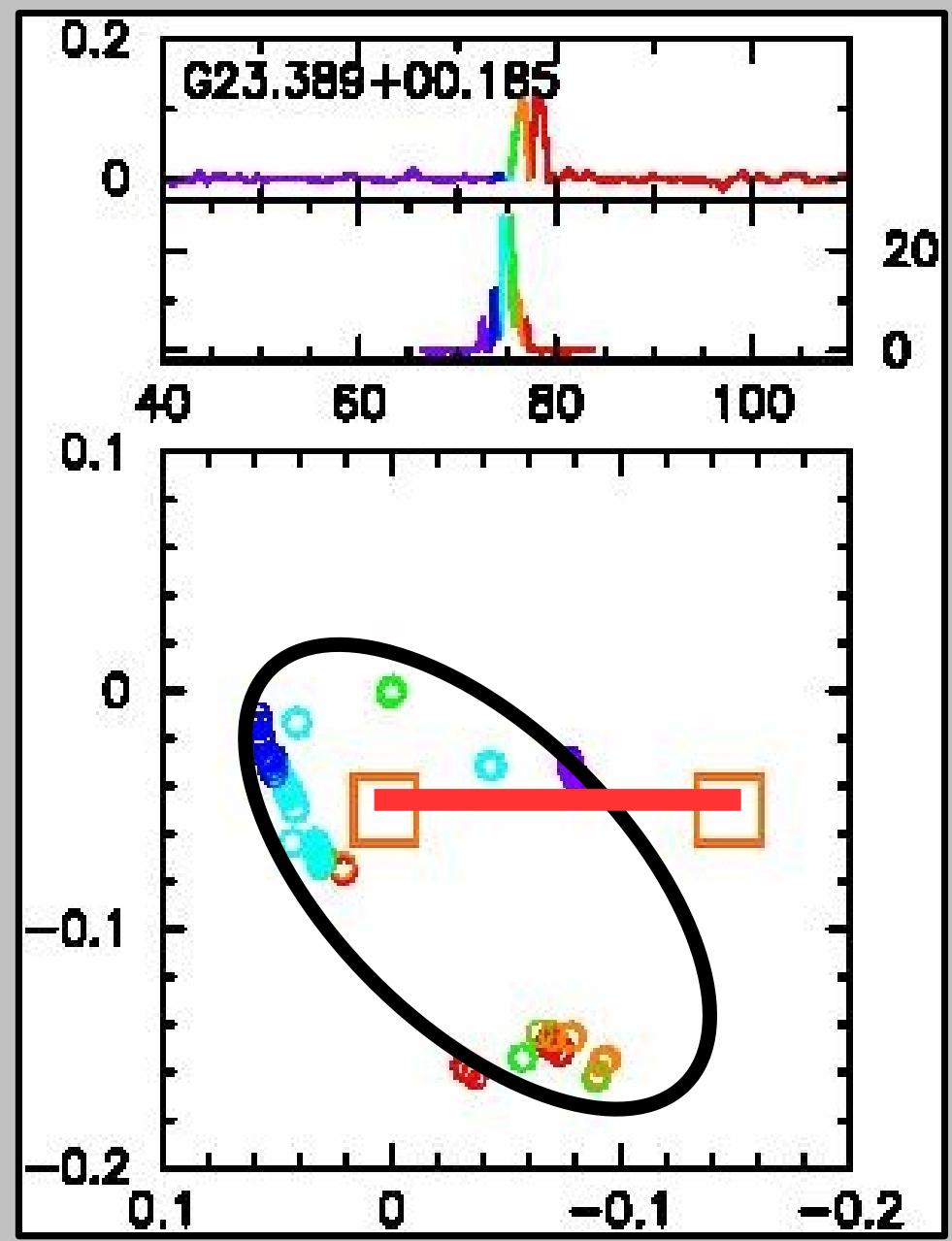
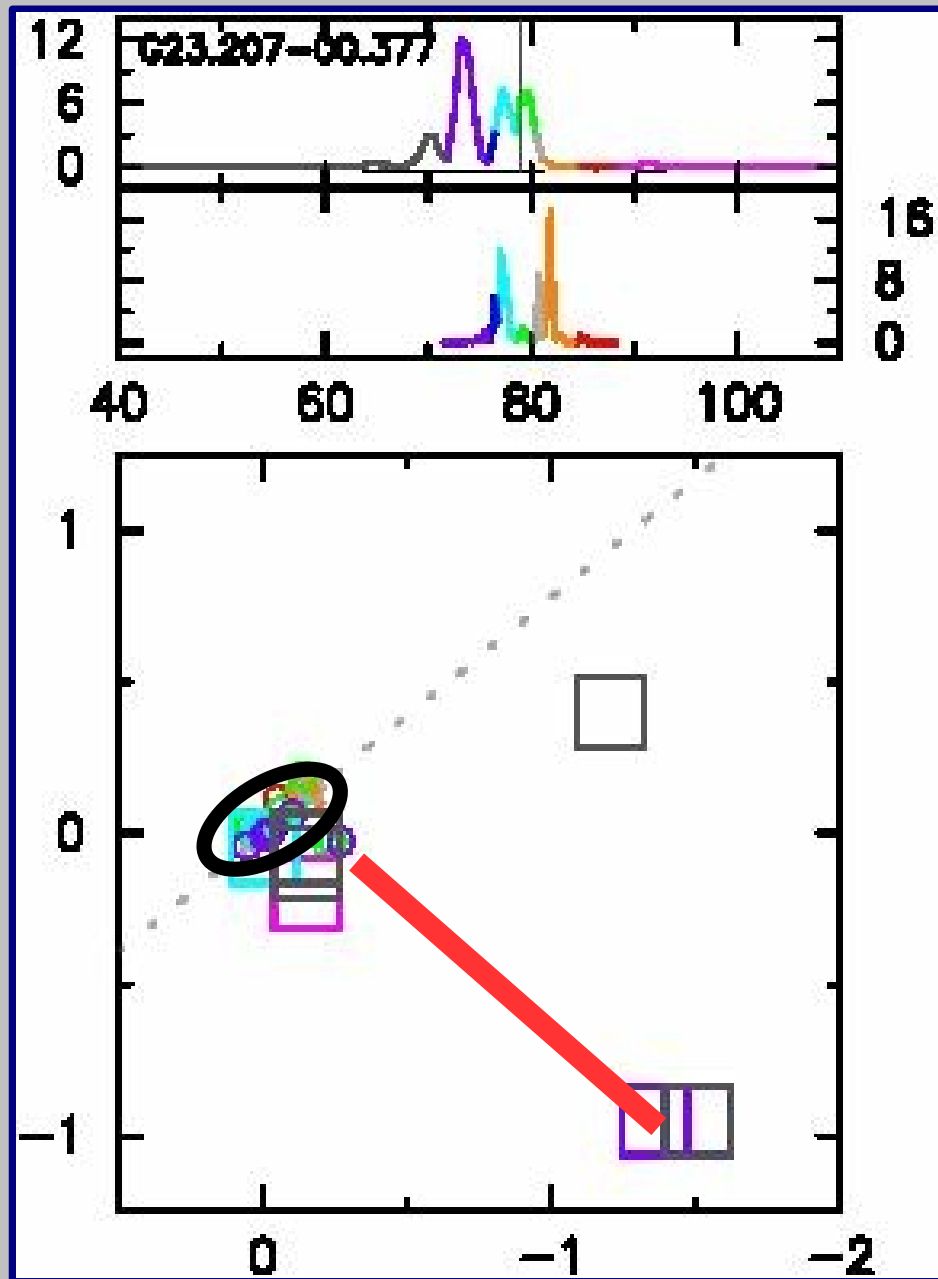
Is it a disc-outflow scenario? - EVN observations

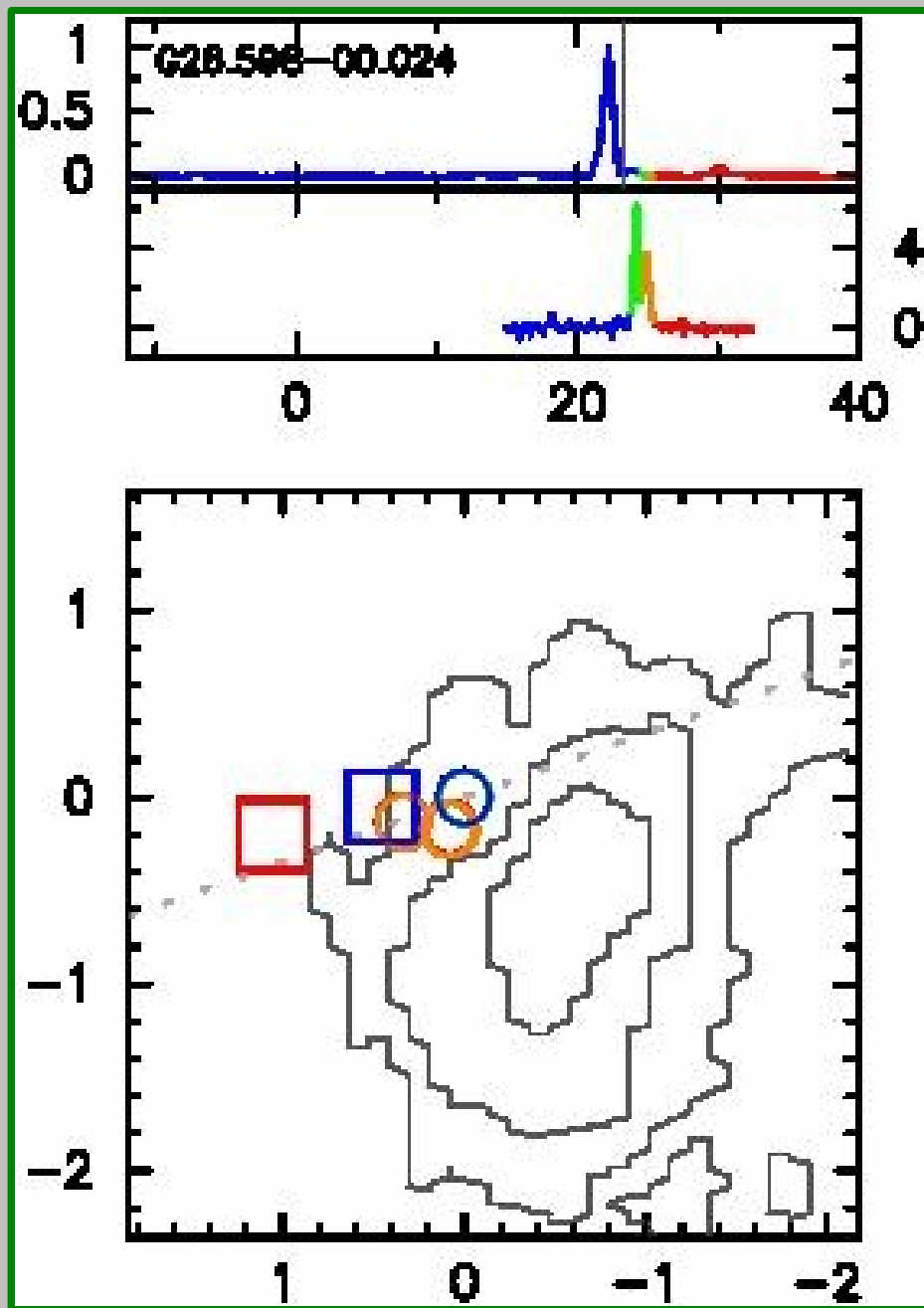
In the rest 4 out of 9 rings we did not register any water masers.

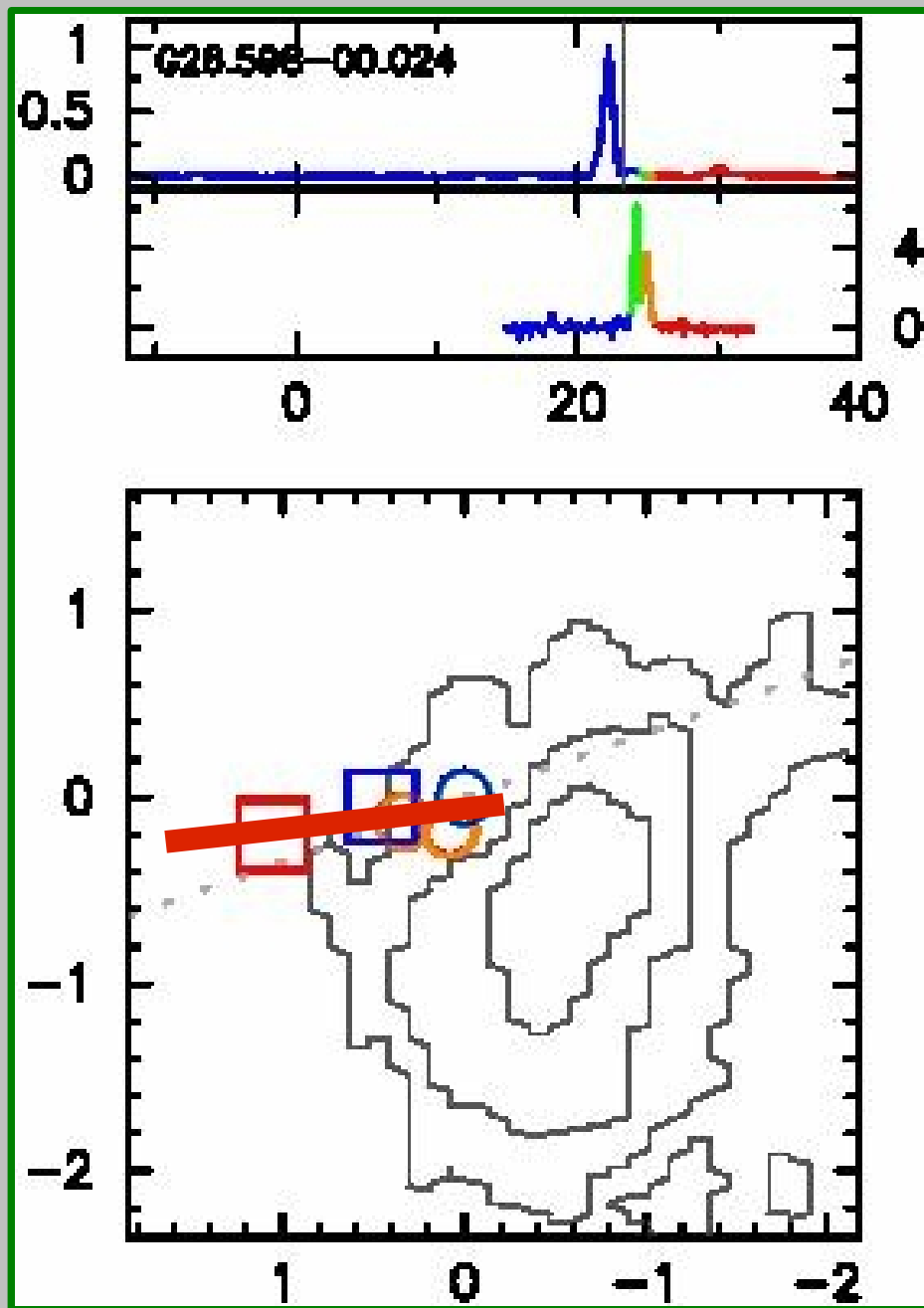


Artistic view from Kraus et al., 2010, ESO







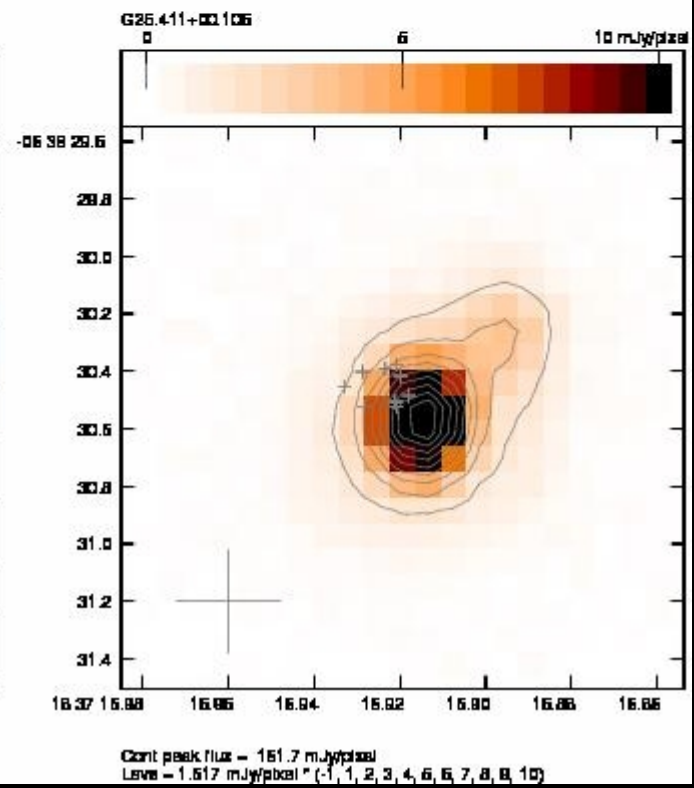
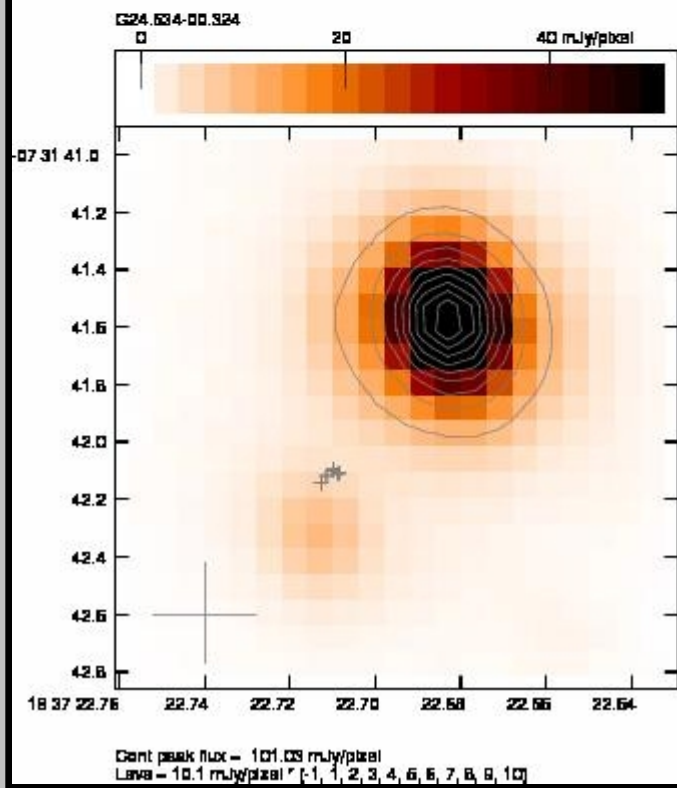
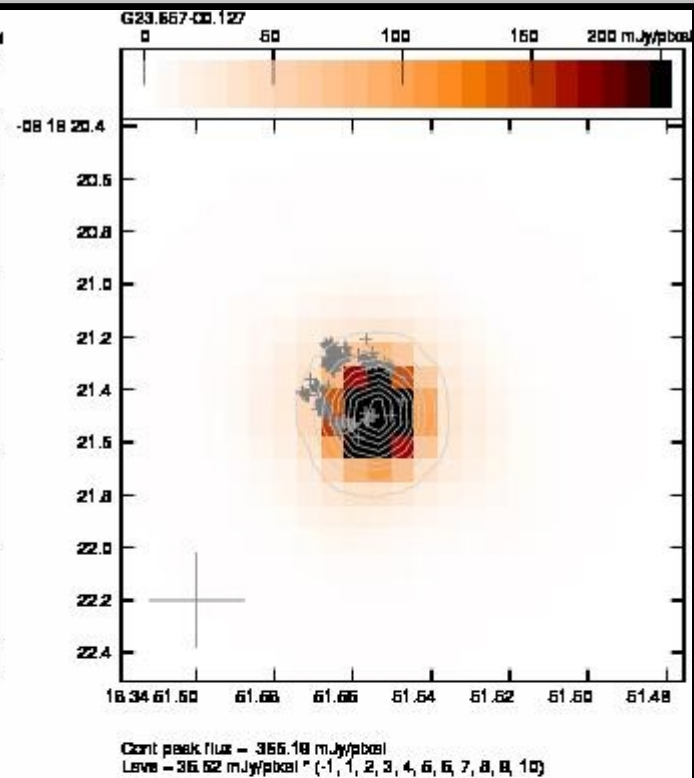
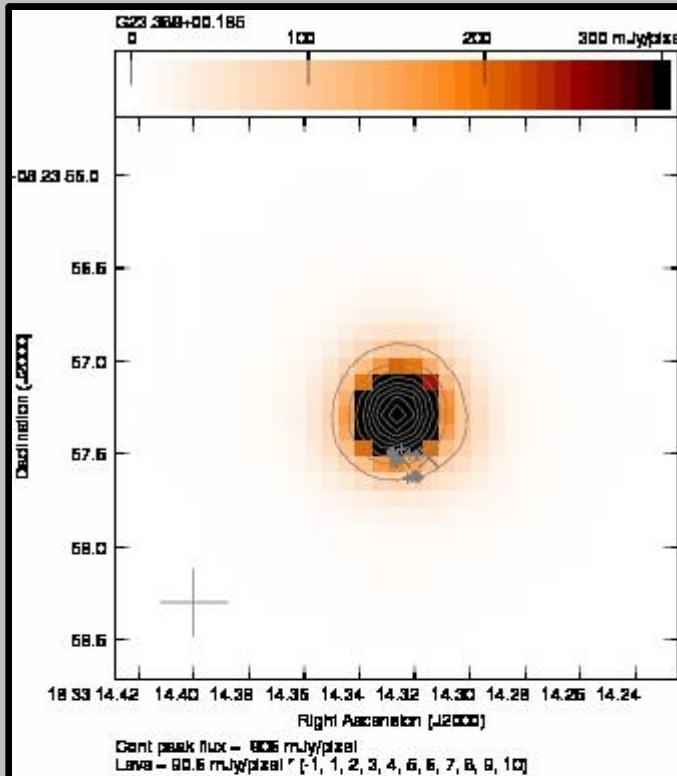
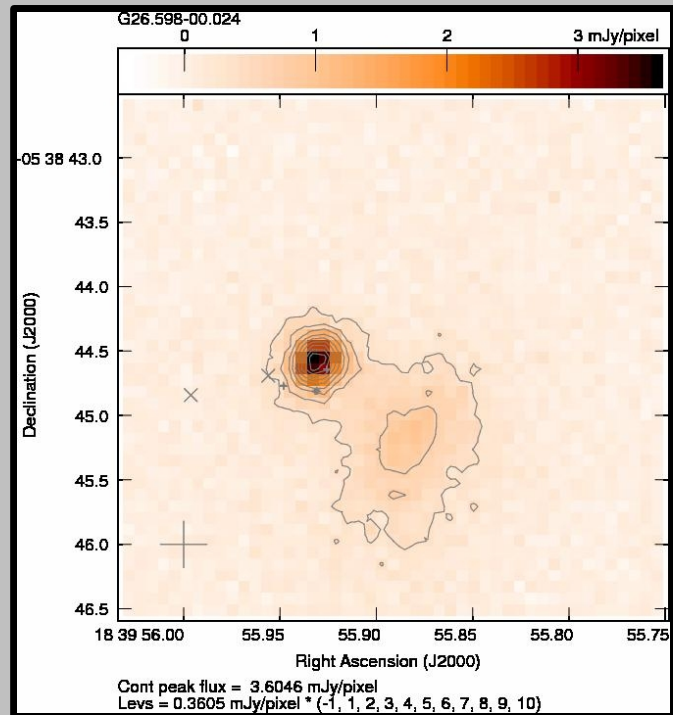


Outflow?

Results (8 and 18 μ m Gemini):

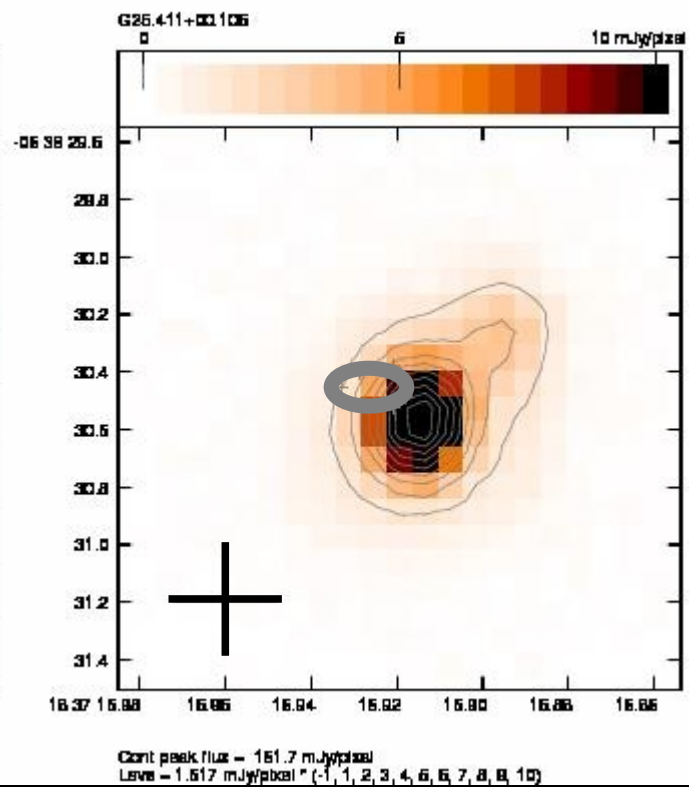
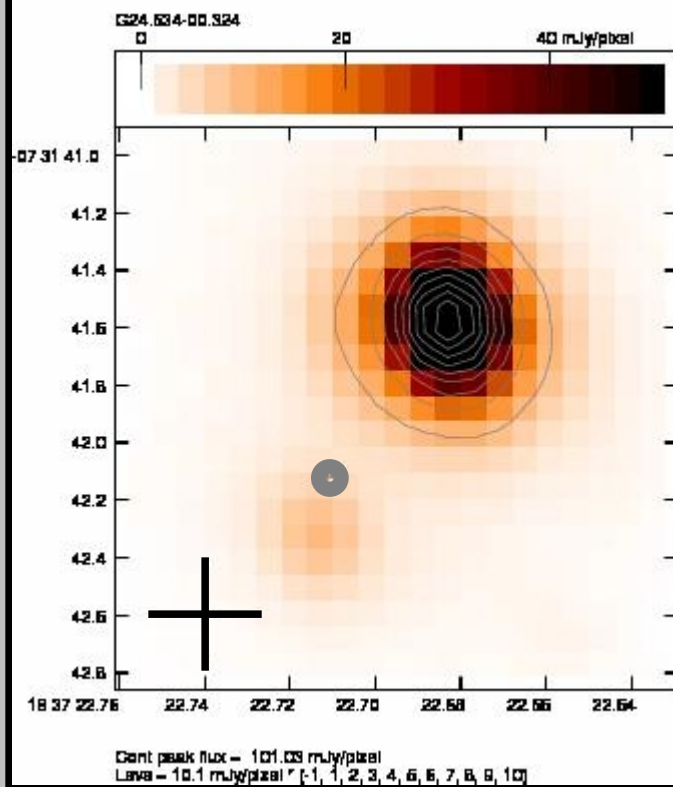
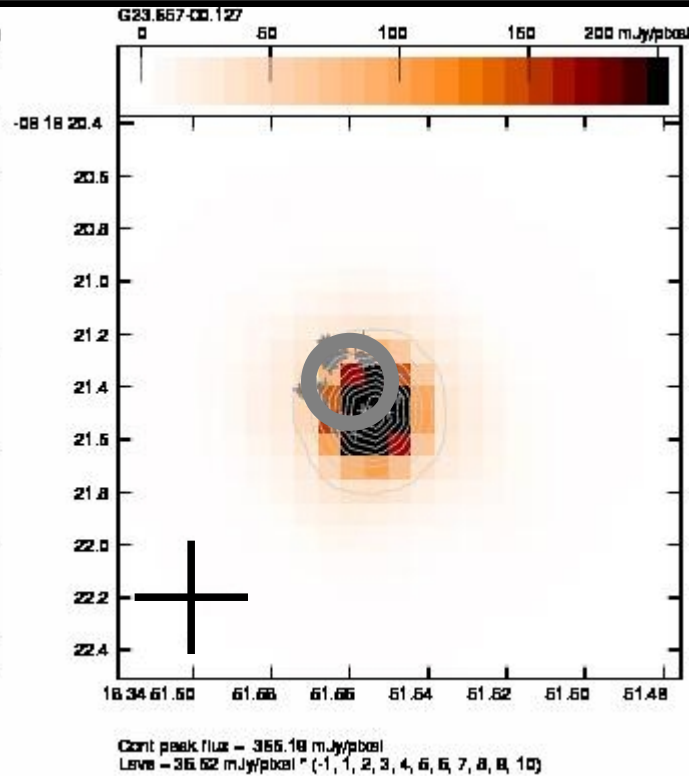
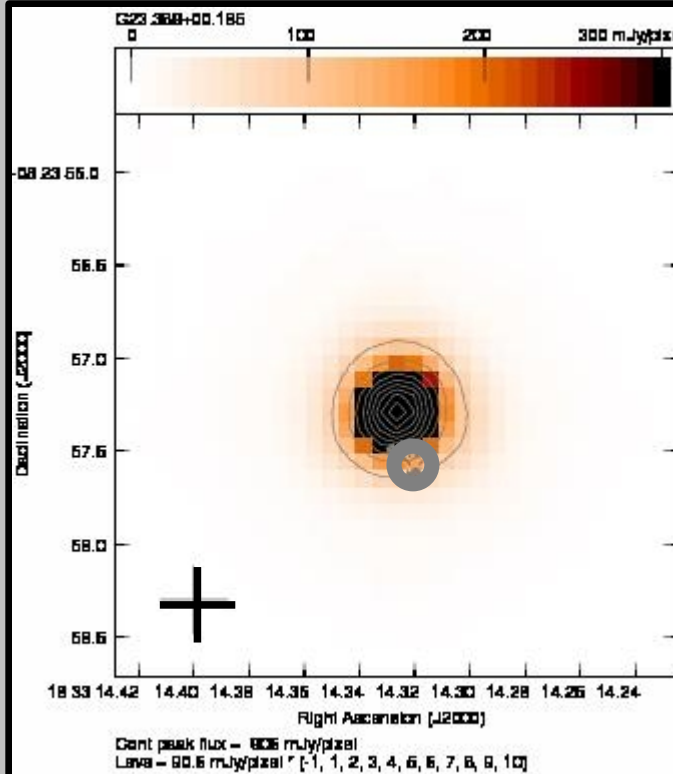
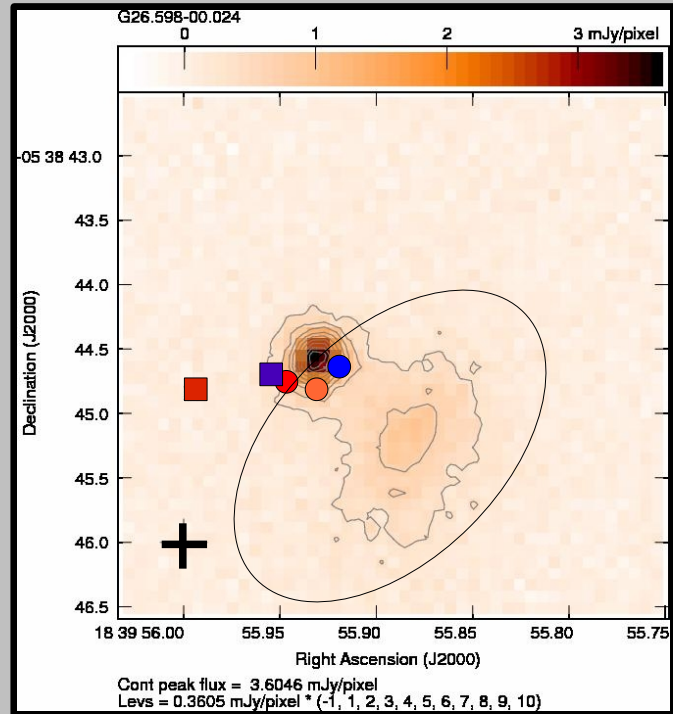
We imaged mid-IR emission at 8 and 18 μ m towards five methanol rings. The targets were selected inspecting the Spitzer data.

In 4 of the 5 cases the mid-IR (8 μ m) emission is extended or complex (multiple sources).



8um

21 September 2010



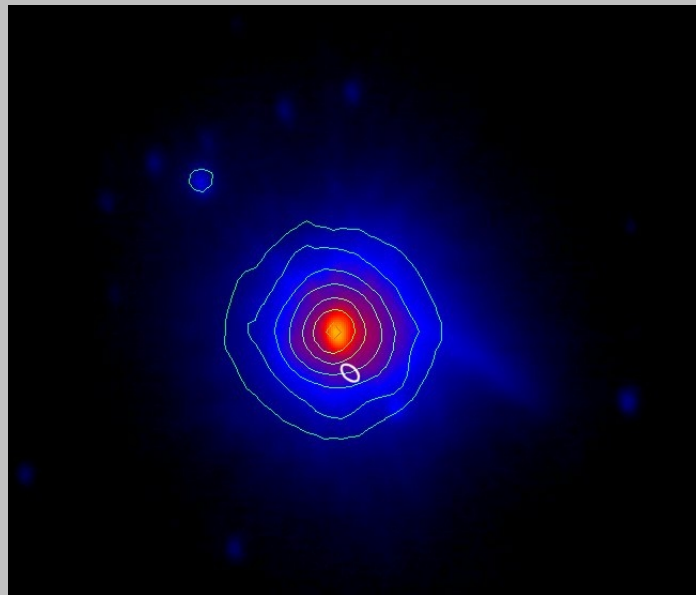
8um

Bartkiewicz et al. in prep

21 September 2010

Results (2um Gemini):

We imaged near-IR emission at 2 um towards three methanol rings using the high spatial resolution afforded by the adaptive-optics (110-160 mas).



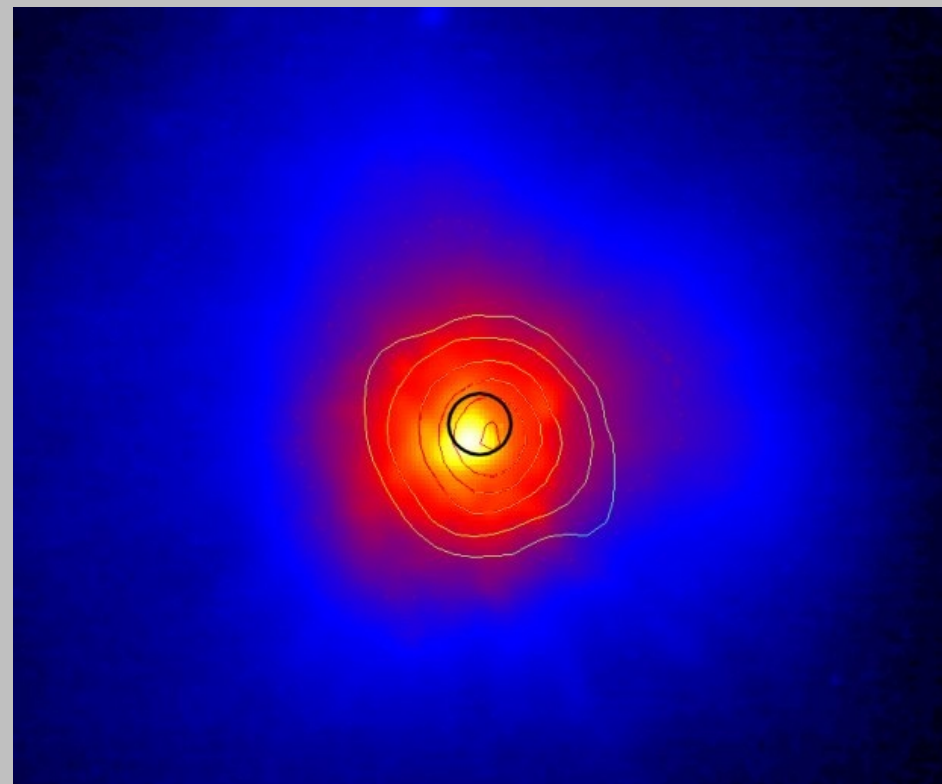
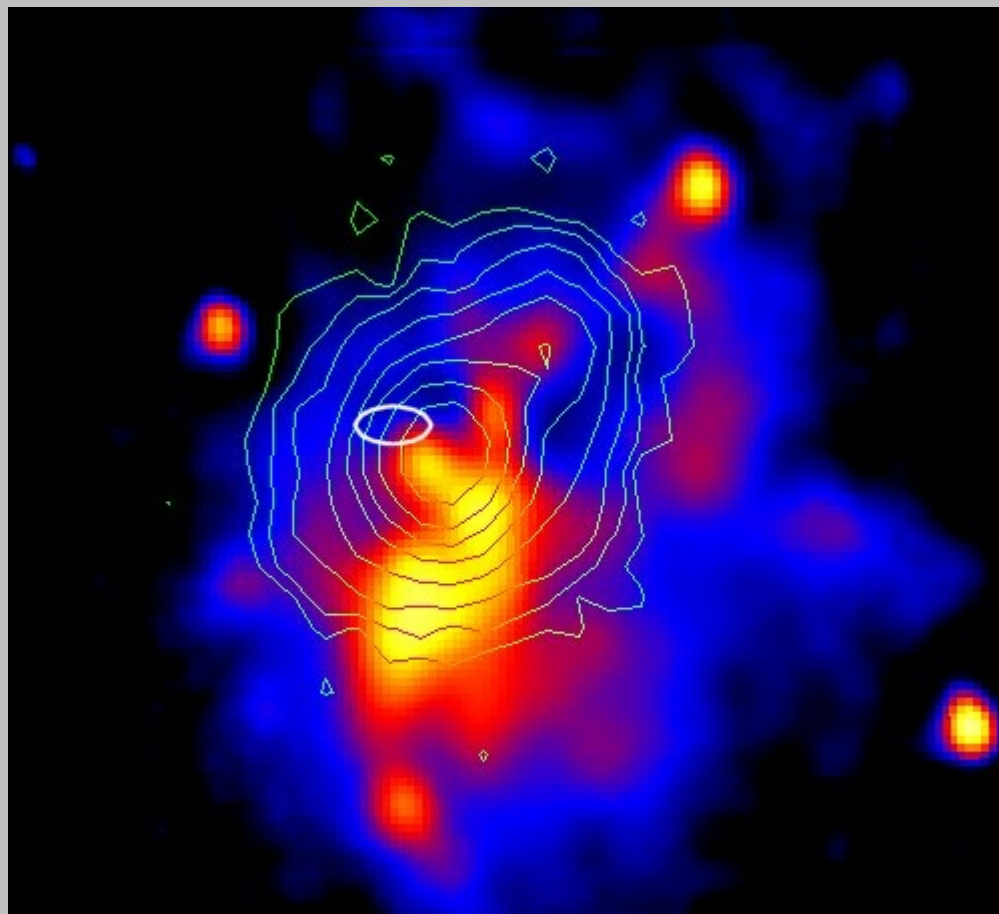
G23.389+00.185

Resolved but still circularly symmetric structure.
The peaks of 2 and 8 um coincide within 1 sigma.
The methanol ring is offset in Dec
by $\sim 0.''08$ (4sigma) – a significant offset.

2 um – colors, 8 um - contours

G25.411+00.105 A complex structure of NIR emission. The ring is located 1."2 from the brightest NIR component.

2."5



1"

G23.657-00.127 Bright and point like emission at 2 μ m. The ring lies within 1 sigma with the NIR/MIR peaks.

Bartkiewicz et al. in prep

Conclusions:

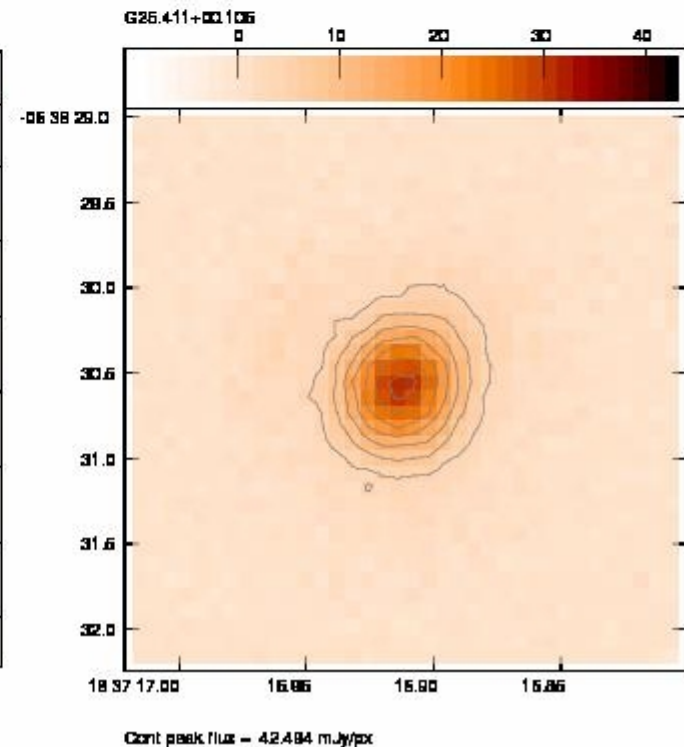
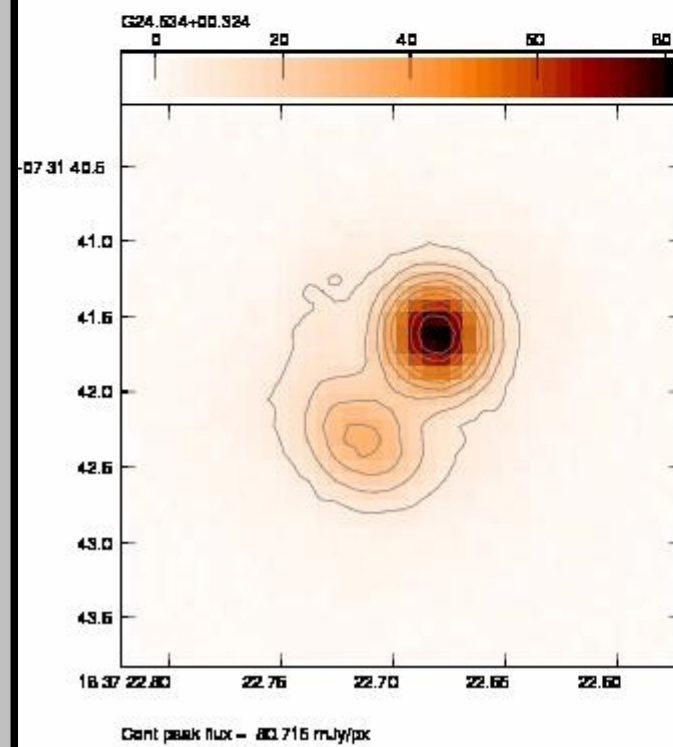
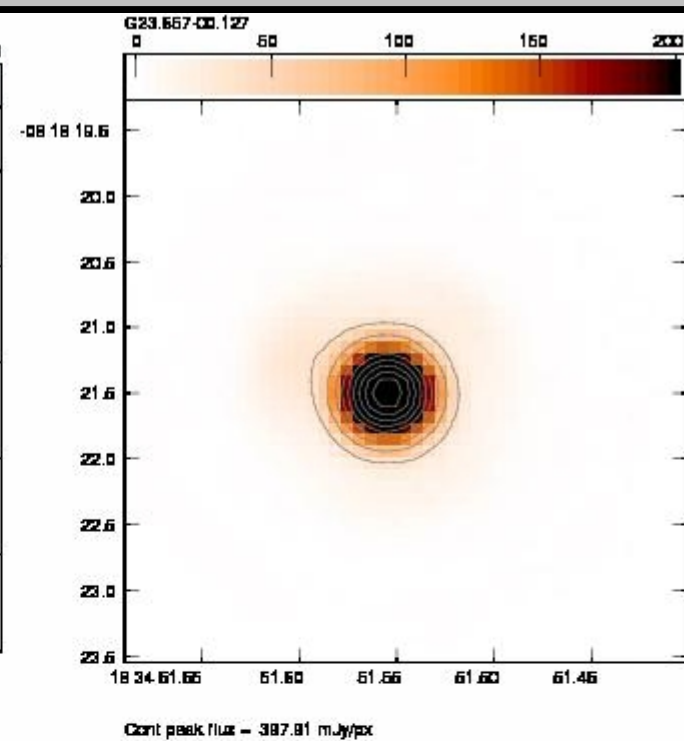
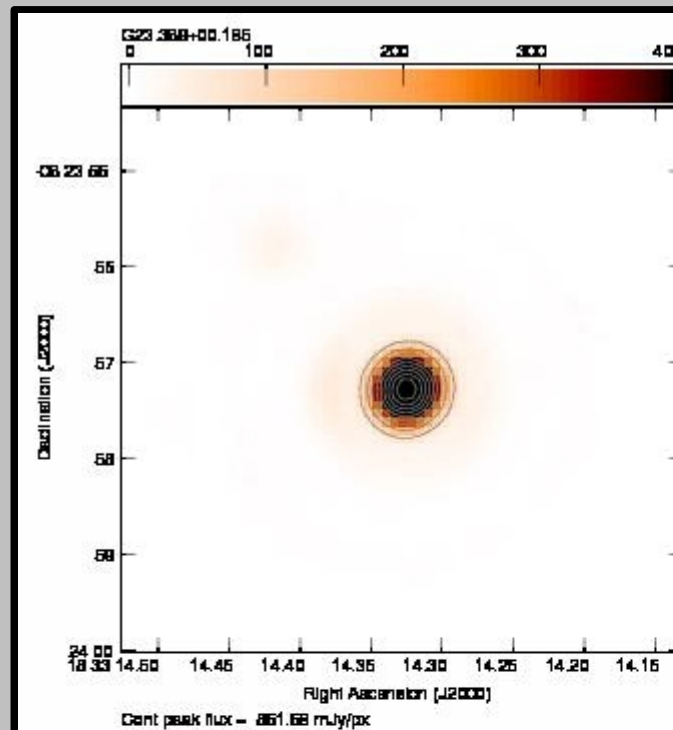
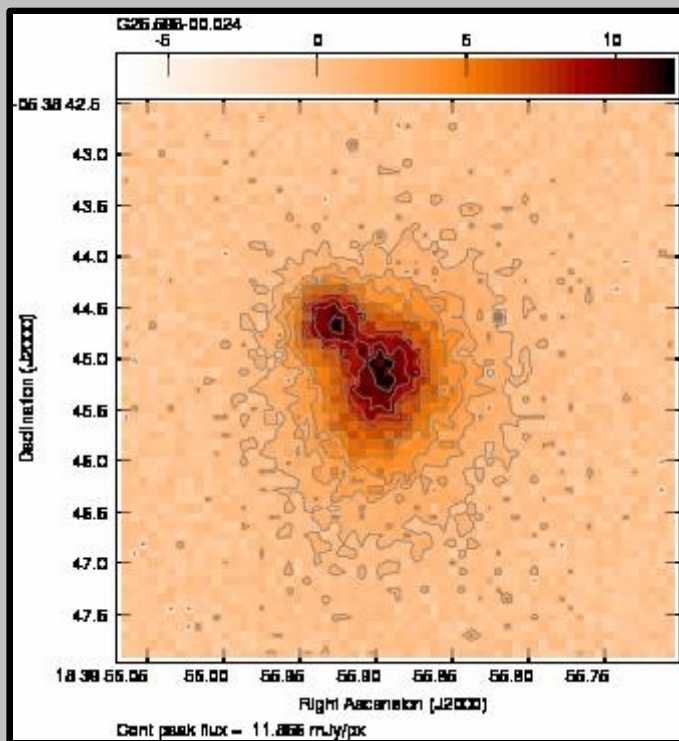
The methanol maser rings are associated with an very early stage of high massive star forming regions (before outflows have started):

**none (5 out 9) or weak (4 out 9) water maser emission,
none (8 out 9) continuum emission at cm wavelengths.**

A less regular methanol morphology would appear in later stages and could be related with outflows traced by water masers. Alternatively, the other structures are related with another mechanisms (shock?).

Only one ring (G23.657-00.127) coincides within the near and mid-IR emission and can be a manifestation of a disc or a torus around a massive protostar.

Thank you!



18um

21 September 2010