The methanol maser ring G23.657-0.127 after (almost) 9 years

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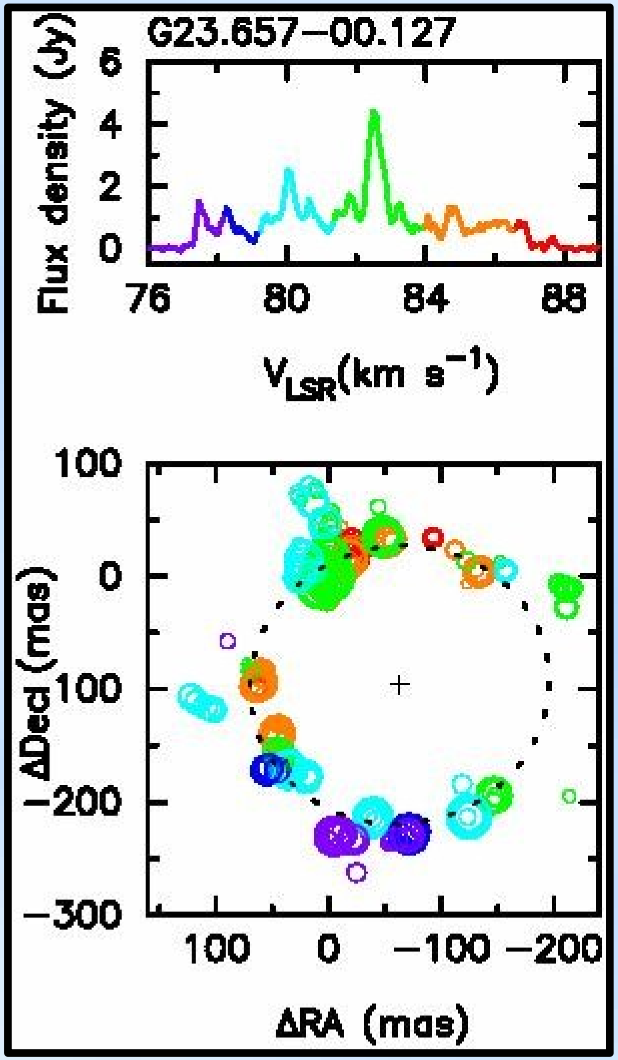
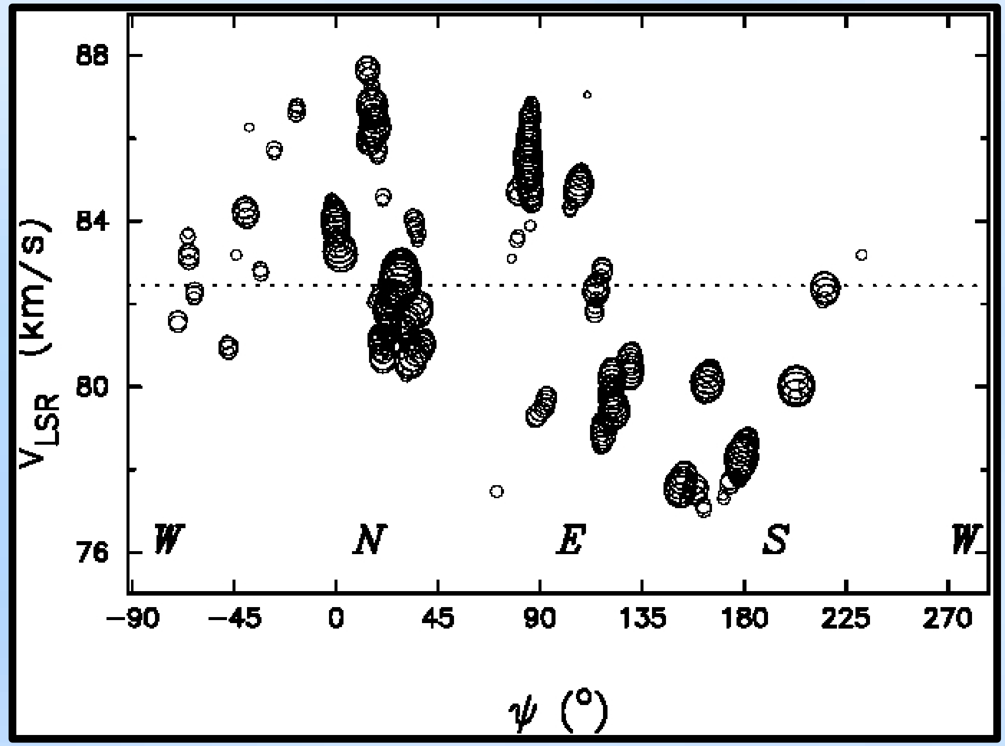
In 2004 we imaged the first ring-like morphology of 6.7 GHz methanol maser in HMSFR, the G23.657-0.127 source (Bartkiewicz, Szymczak, van Langevelde 2005).

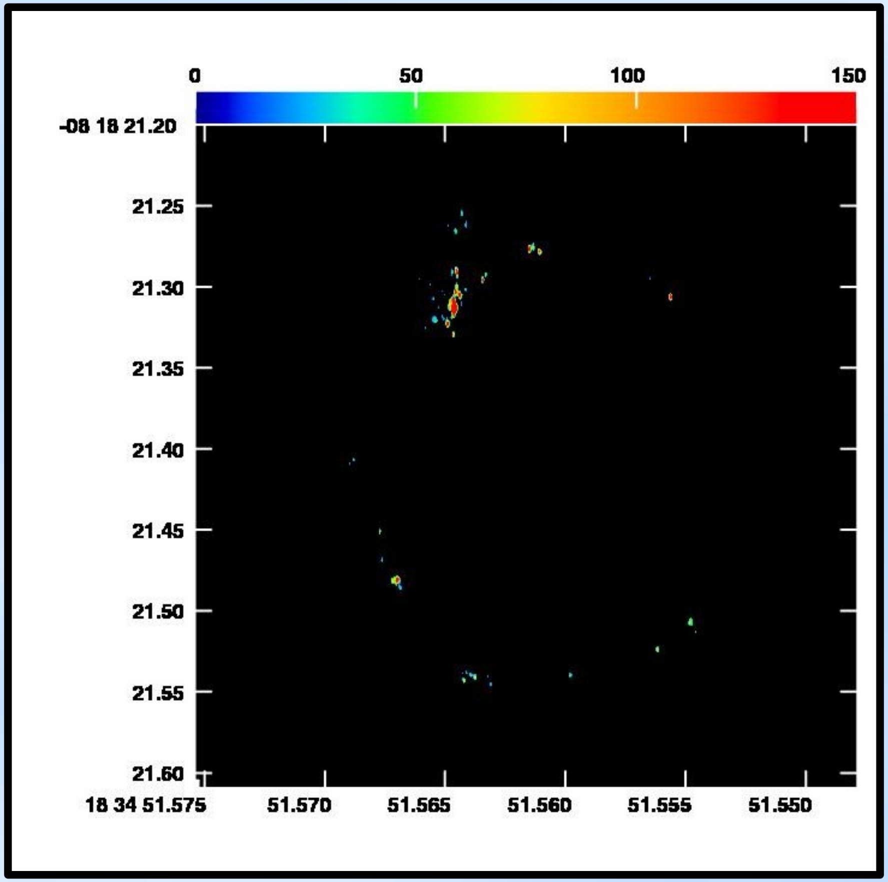




a=127 mas, b=133 mas, PA = -9^{o}

V_{rot}= 7.3 km/s, V_{exp}= 2.6 km/s

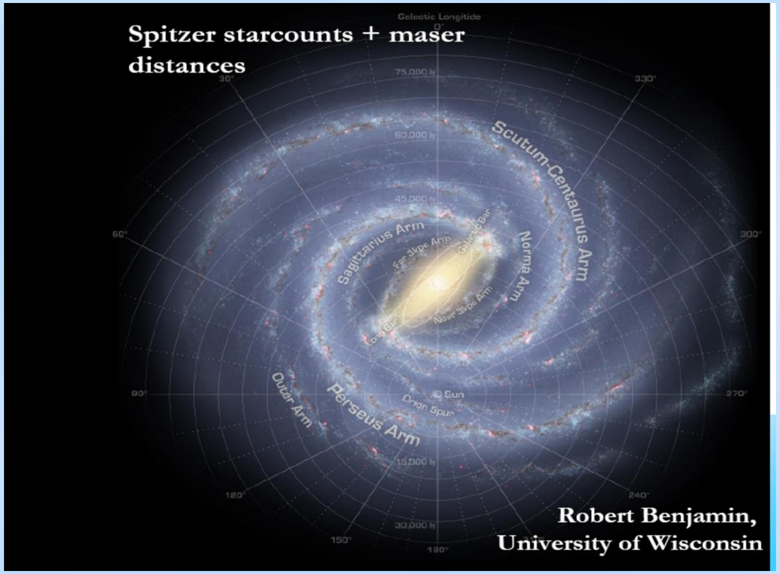
In 2006-07 we used VLBA to measure the parallax of 12.2 GHz methanol masers that coincided with 6.7 GHz ones (Bartkiewicz et al. 2008).



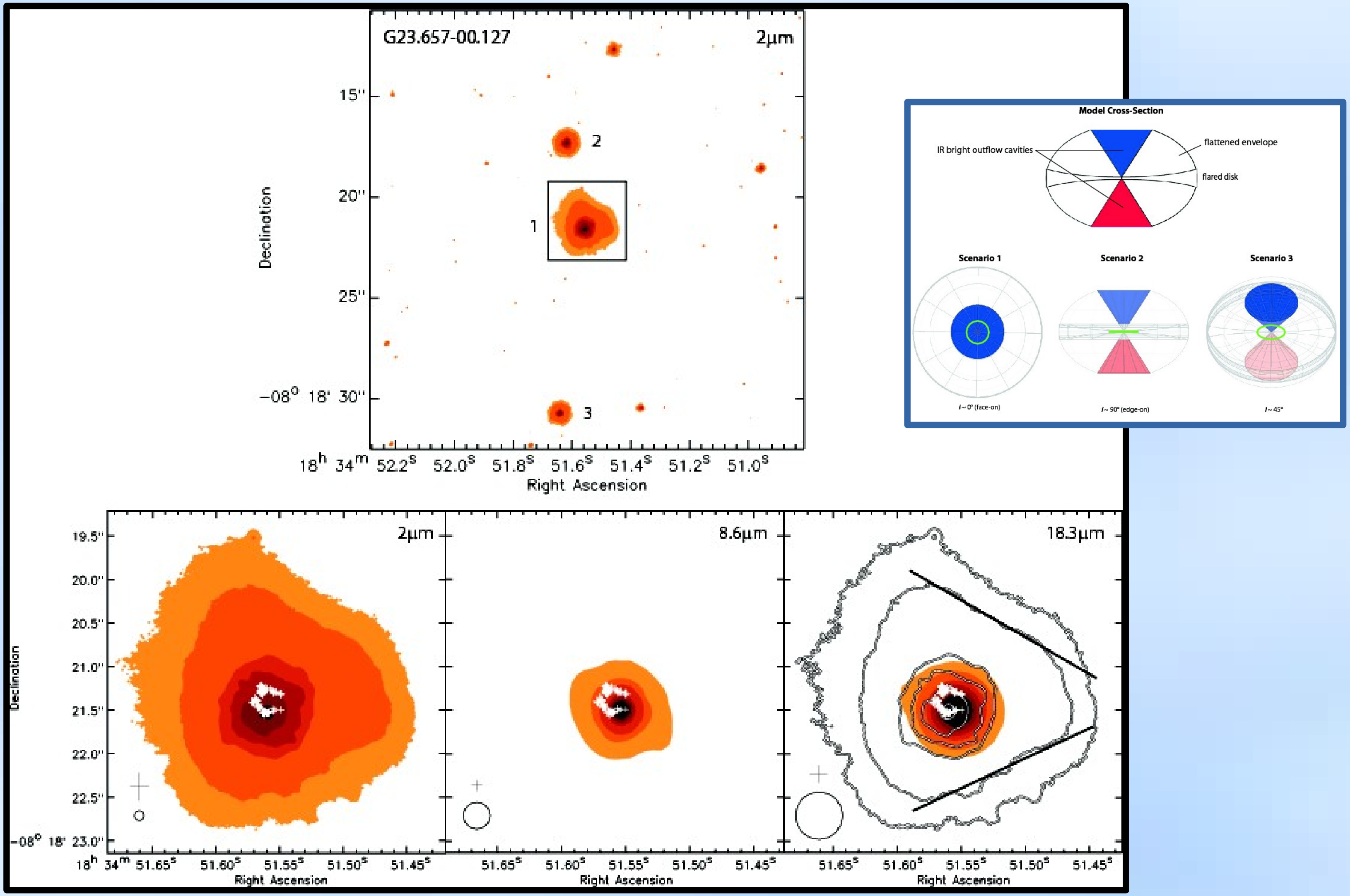
π = 0.313+/- 0.039 mas

D = 3.19 (+0.46, -0.35) kpc

Close to the Scutum Arm



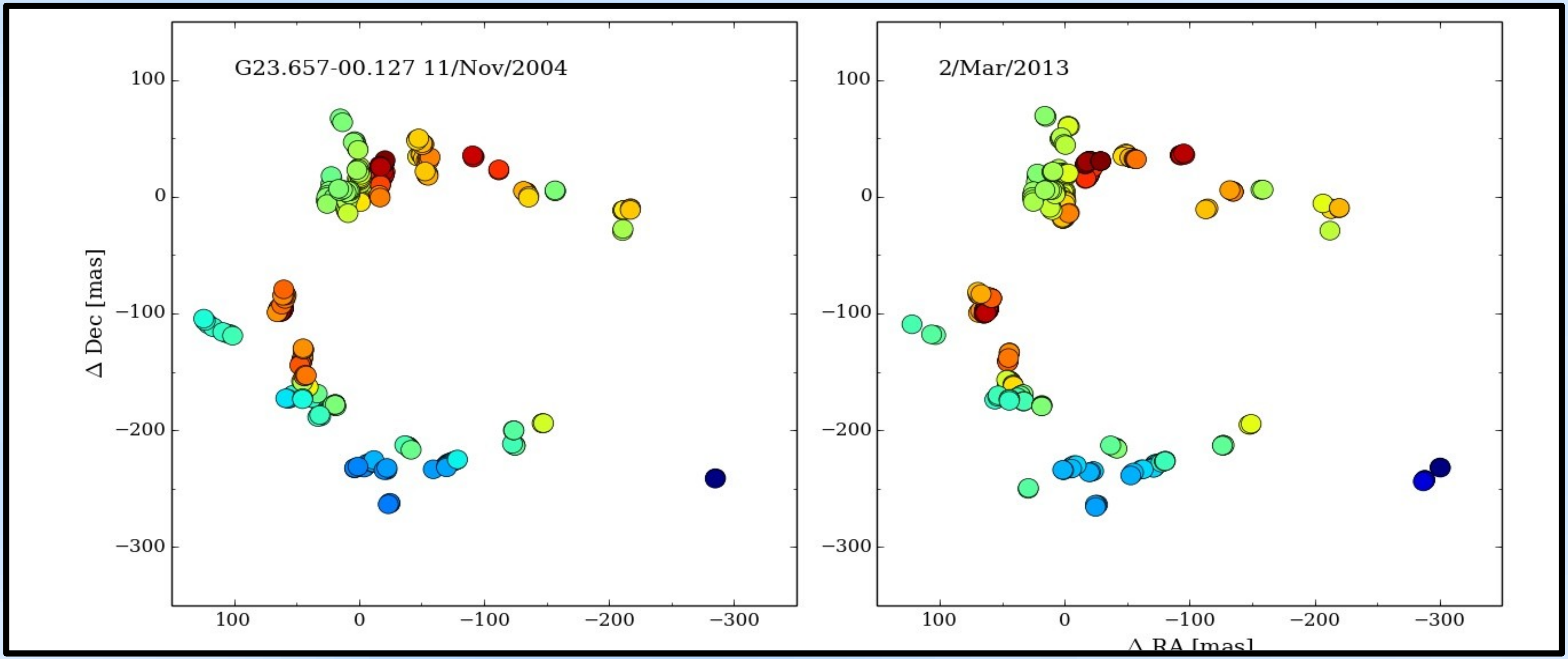
High-angular resolution images at near and mid-infrared to look at the center of the ring (De Buizer et al. 2012). Outflow cavities are the source of the IR emission from the MYSO.



Next, we proposed proper motion studies using EVN (EB052). The first epoch was observed in March 2013 and the second will be observed in 2015.

Useful data were obtained from the following antennas:
Ef, Jb, Mc, On, Tr, Nt, Wb, Ys.
Two correlation passes: continuum and line data to obtain better signal-to-noise ratio on the phase-reference source.
On-source time: 1.25hr.
Spectral resolution: 0.098 km/s.

Assuming a rotating or expanding motion of 10 km/s,
the expected shift of a single maser spot would be 0.6 mas per year.



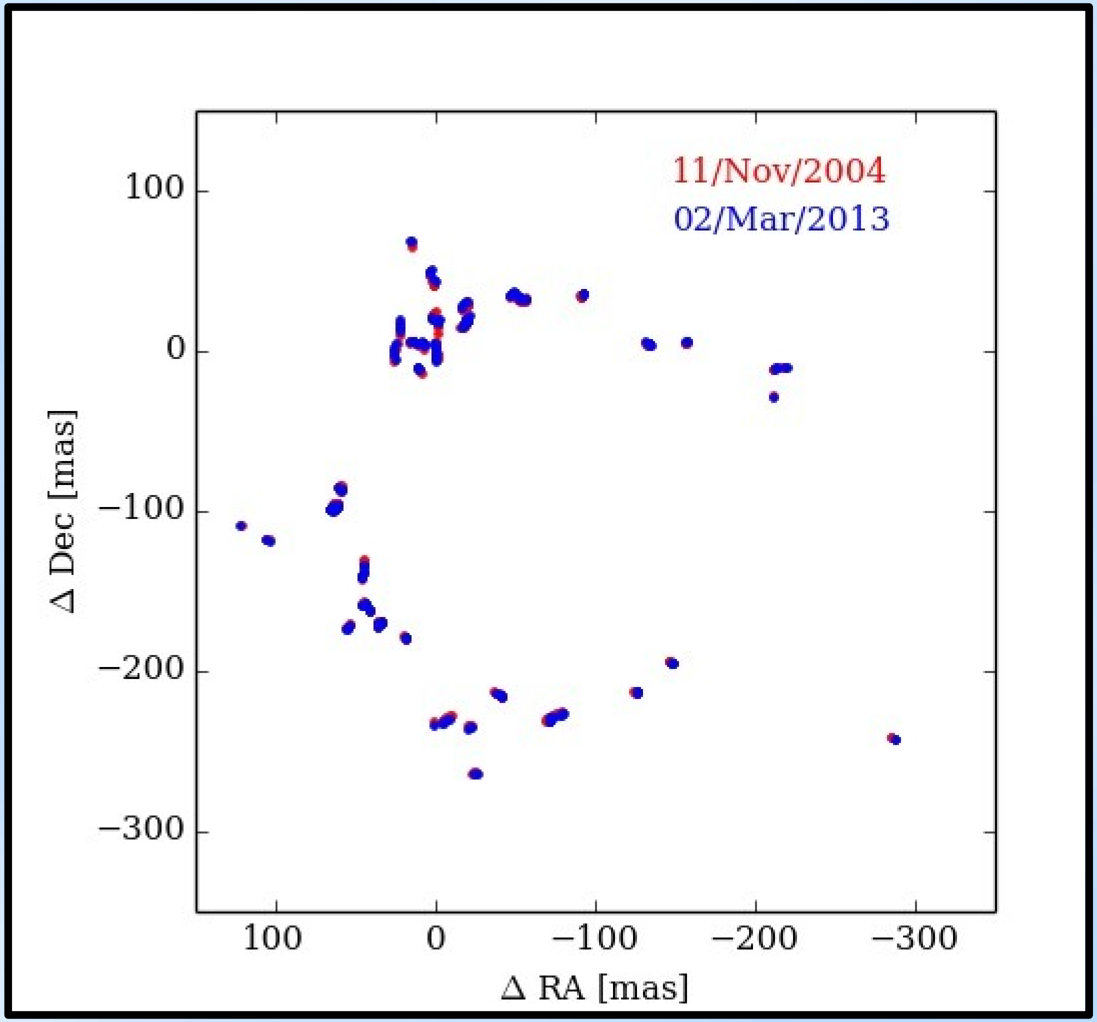
316 maser spots (77.4 – 87.9 km/s)
Flux density: 4.6 Jy (max), 50 mJy (min)

325 maser spots
2.2 Jy (max), 26 mJy (min)

(0,0) corresponds to the coordinates of the brightest spot in each epoch.

Phase-referenced observations, however relative motions due to the Galactic rotation and parallax motions.

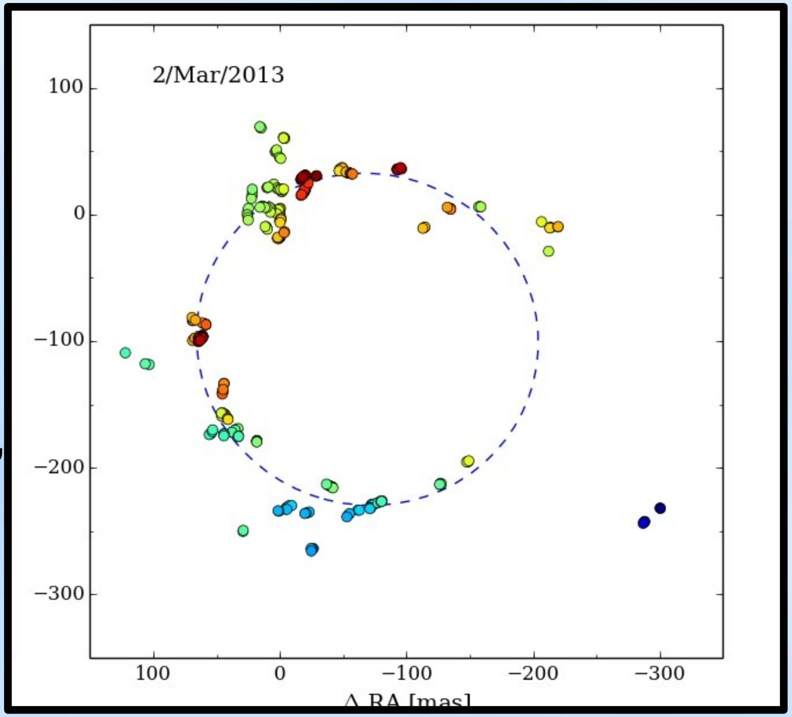
We selected 236 spots that appeared at both epochs. These spots are distributed over the whole ring.
The selection criteria were: the same LSR velocity and similar groups of spots (with similar relative positions within a few mas).



Fitting of ellipses (flux-weighted) without two offset spots (e.i. blue-shifted ones at SW):

2004:
centre = (-68.8472 mas, -98.6996 mas),
semi major-axis = 135.3346 mas,
semi minor-axis = 129.6905 mas
position angle of major axis = 14^{o}

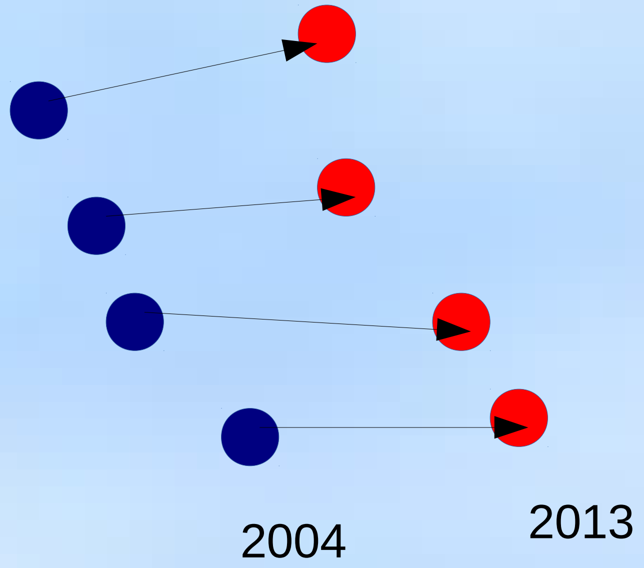
2013:
centre = (-69.0390 mas, - 98.5851 mas),
semi major-axis = 135.3346 mas,
semi minor-axis = 130.6610mas
position angle of major axis = 17^{o}



The difference of the coordinates of the centre: (-0.20 mas, 0.11 mas).

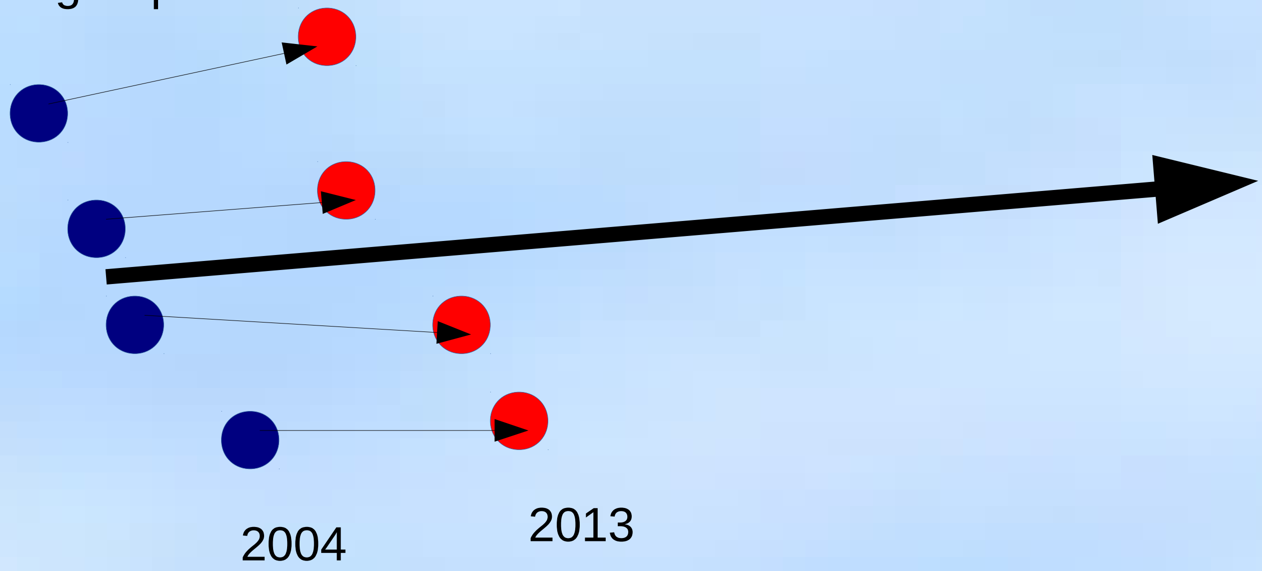
- We shifted the 2013 data to have the centres of the fitted ellipses at both epochs at the same point.

- Within each group of maser spots we plotted the vector corresponding to the sum of shifts of each spot(2004)-spot(2013) shift – the motion vector [mas].



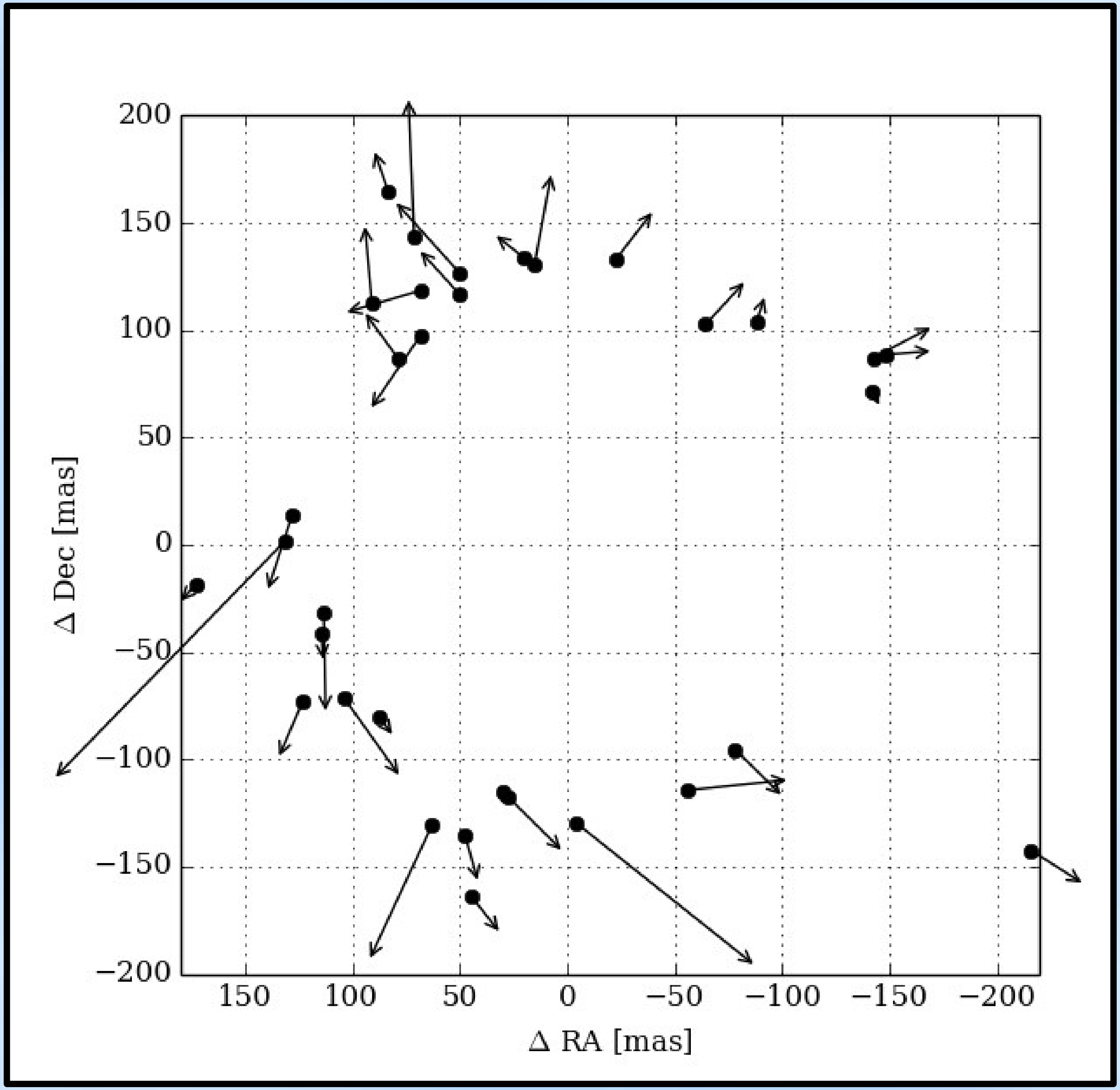
- We shifted the 2013 data to have the centres of the fitted ellipses at both epochs at the same point.

- Within each group of maser spots we plotted the vector corresponding to the sum of shifts of each spot(2004)-spot(2013) shift – the motion vector [mas].
- In total: 34 maser groups.



The overall view: barycentres of each groups and their motion vectors (multiplied by 5 for the clarity).

Rotation or expansion ???



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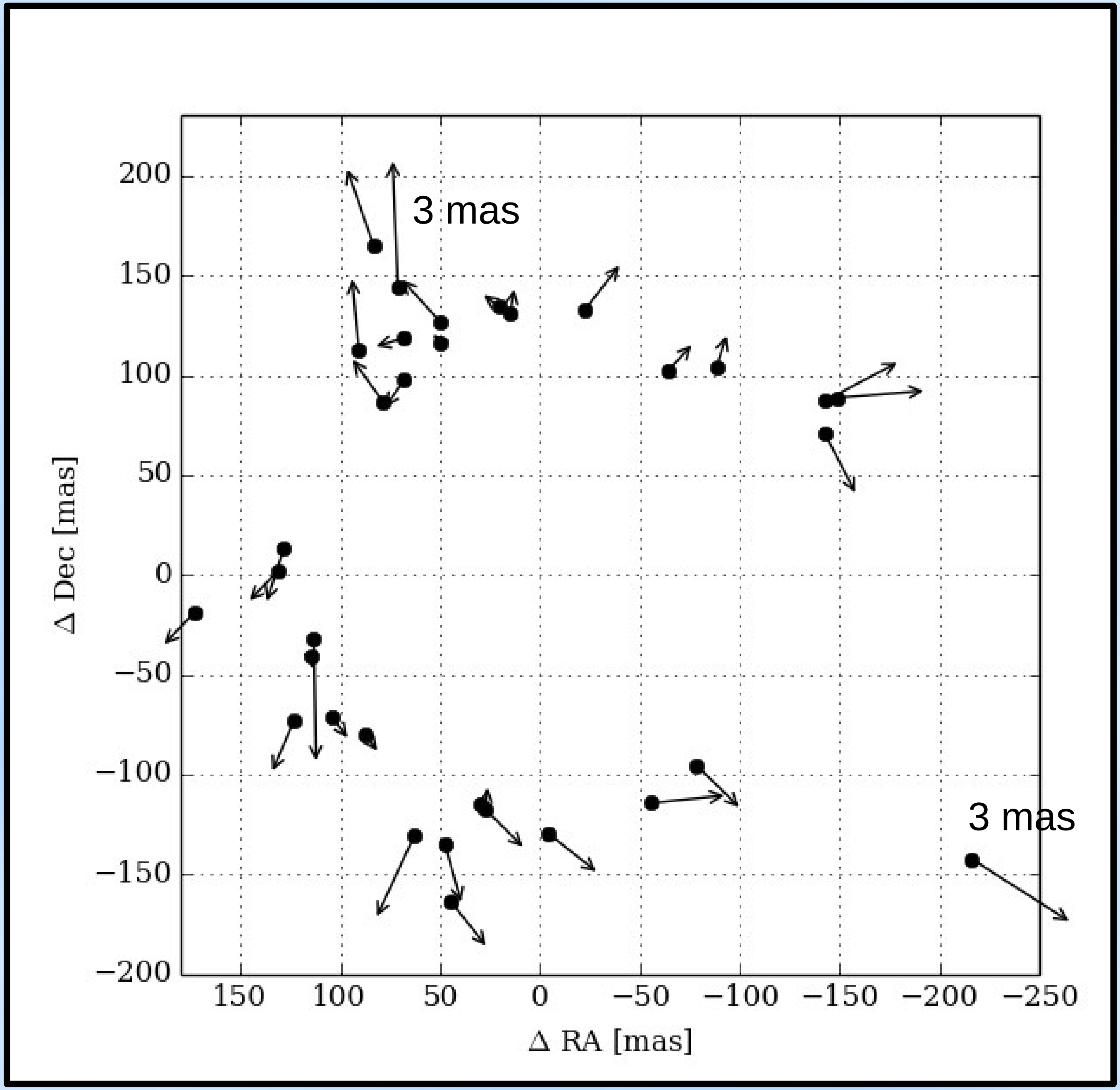
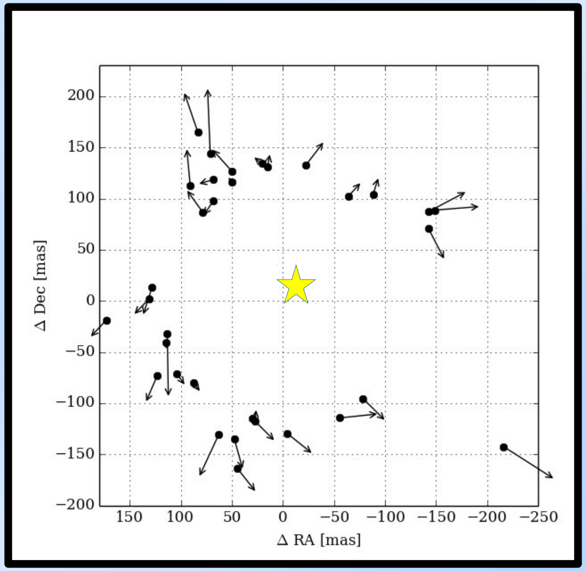
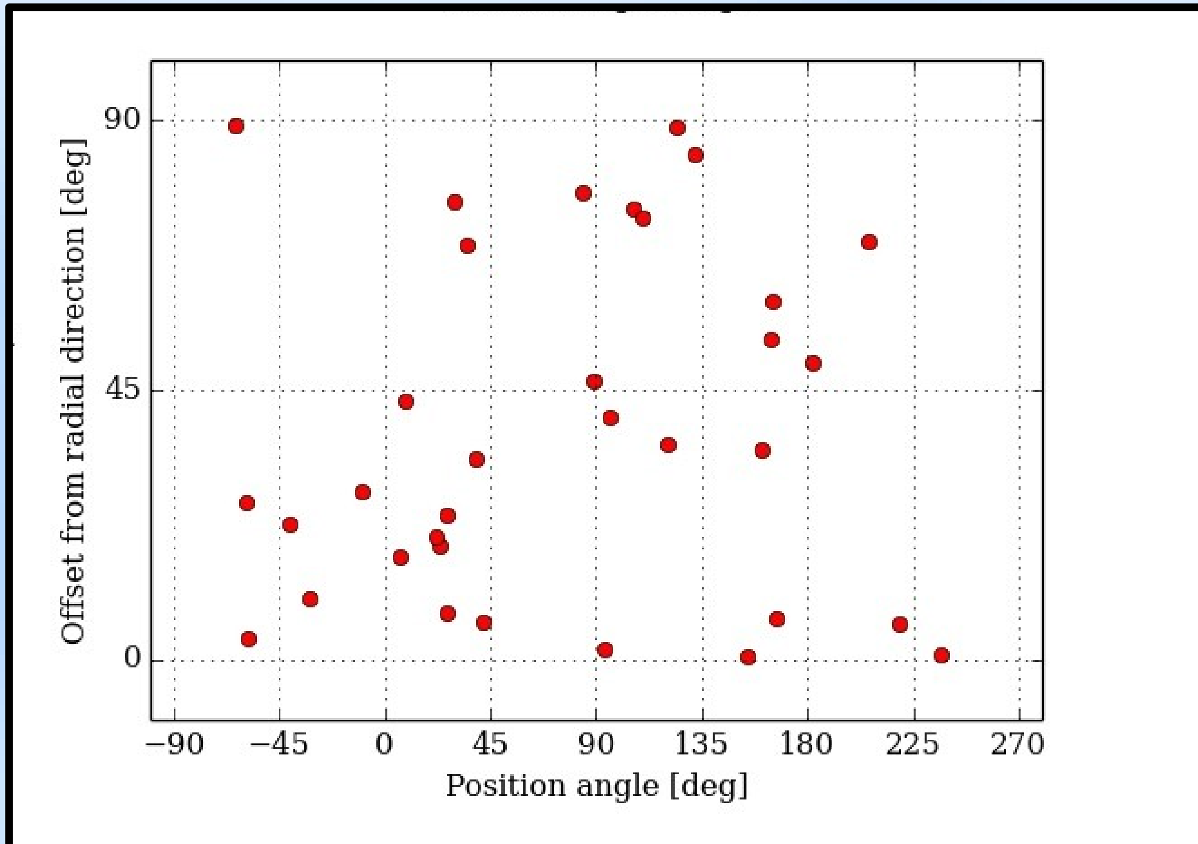


The offsets of motions from radial direction: the position angle of motion vector vs. position angle of spot's group.

0^{o} for radial motion (expansion)

90^{o} for transversal motion (rotation)





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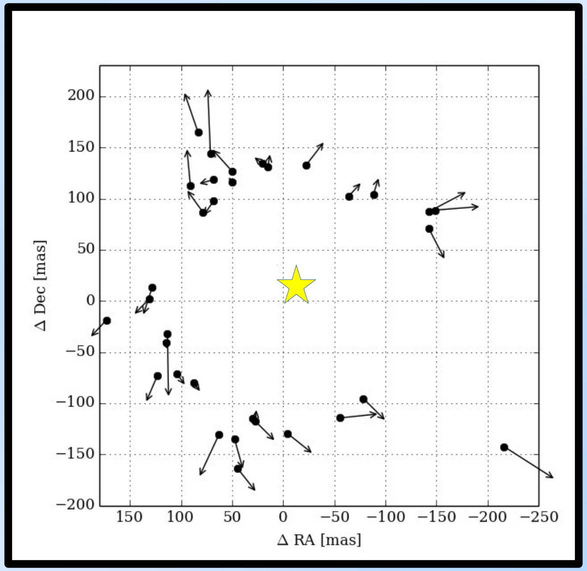
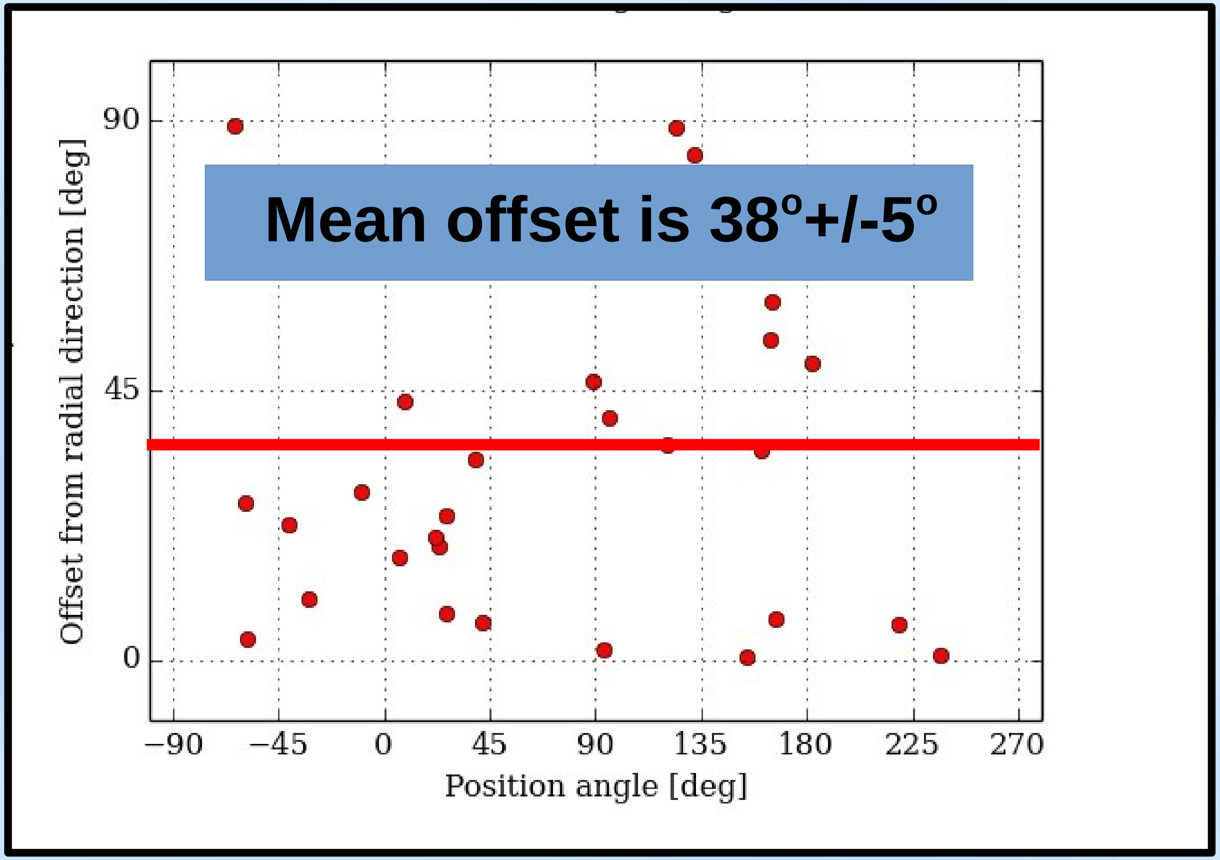
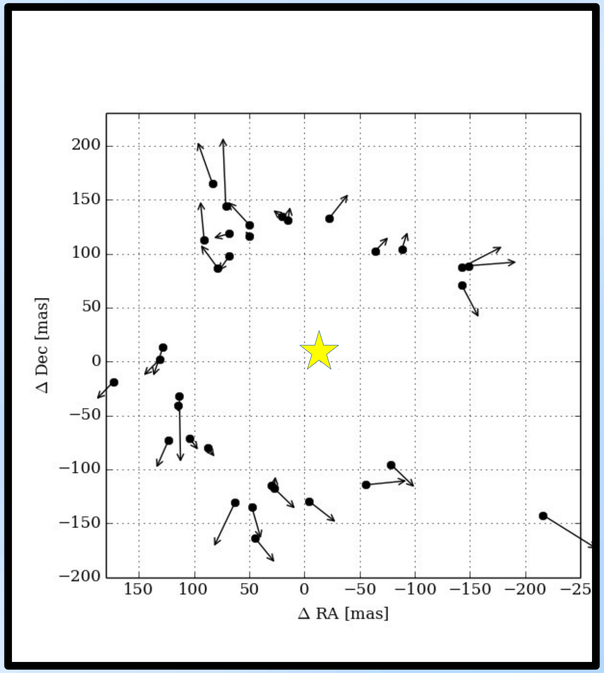
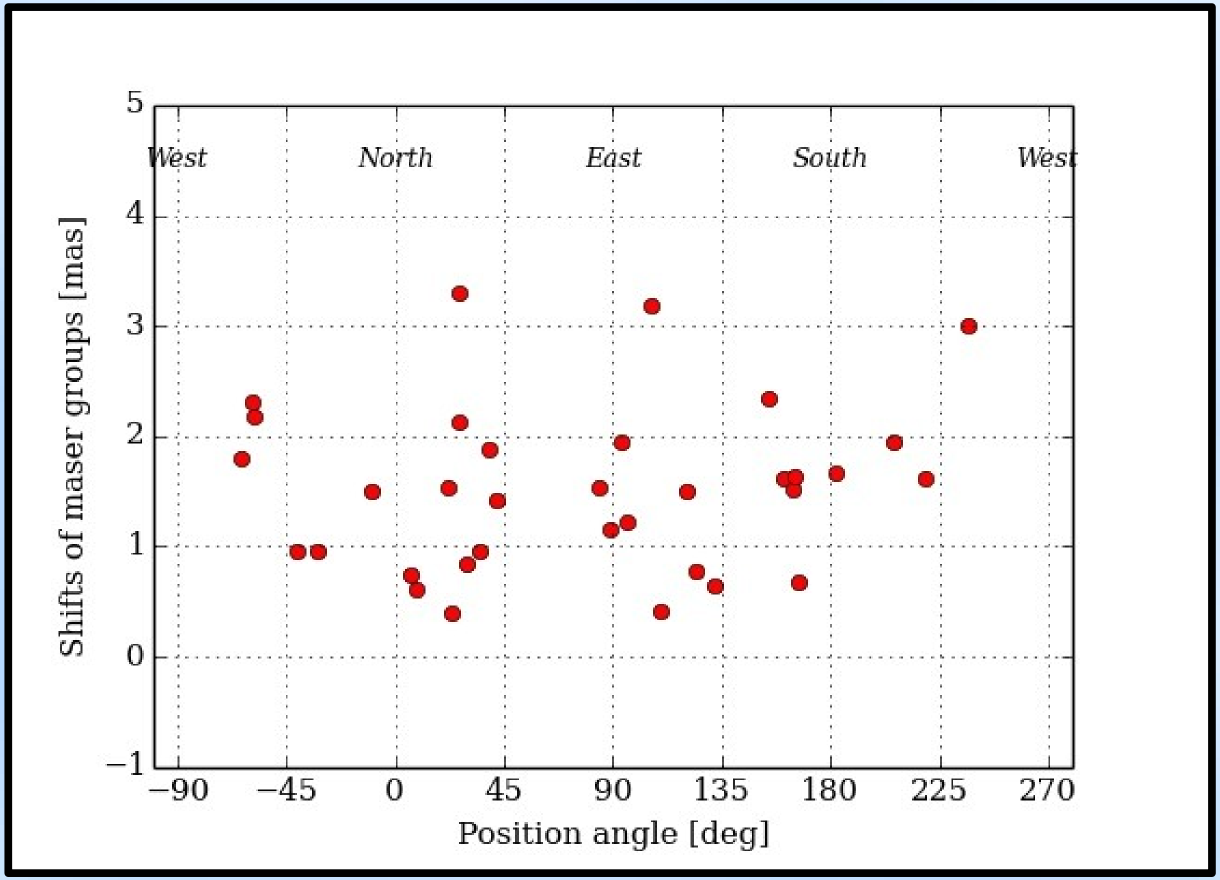




The offset of barycentre vs. the position angle of spot's group.





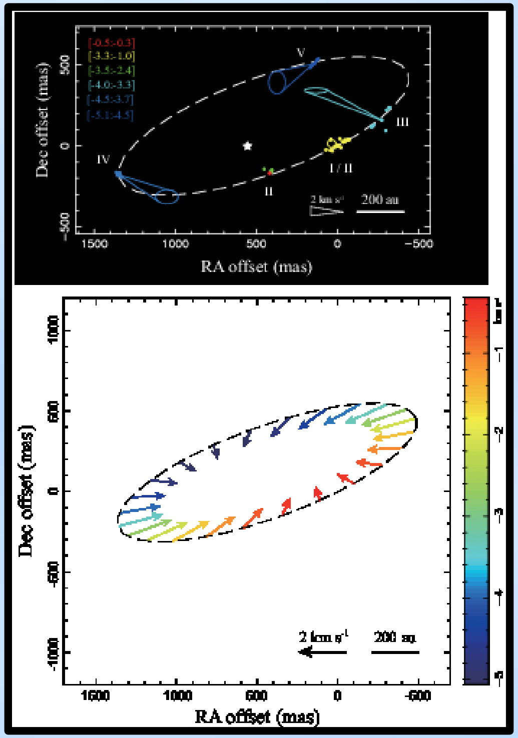
The 2 mas shift at 3.19 kpc during 8.5 years corresponds to **3.6 km/s**.

Summary:

- After 8.5 years the spots from the G23.657-0.127 methanol maser ring shifted about 1-3 mas indicating velocities of 1.8-5.4 km/s.

- These shifts are not consistent with a simple scenario of an expanding outflow or a rotating disc.

- We do not notice a rotation and infall like in Cep A where the ring was also imaged (Sugyjama et al. 2014).



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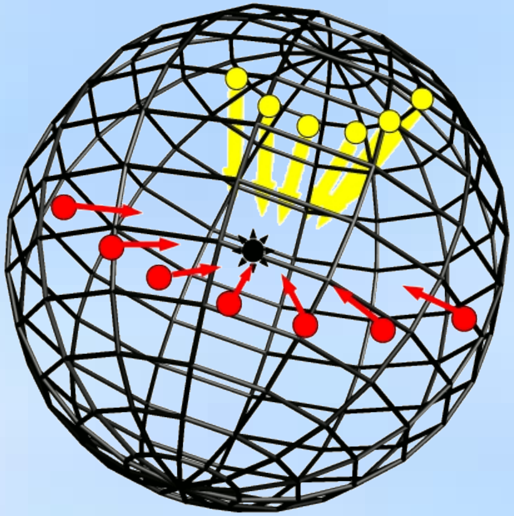

First direct measurements of gas infall onto a protostar traced with 3D velocities.

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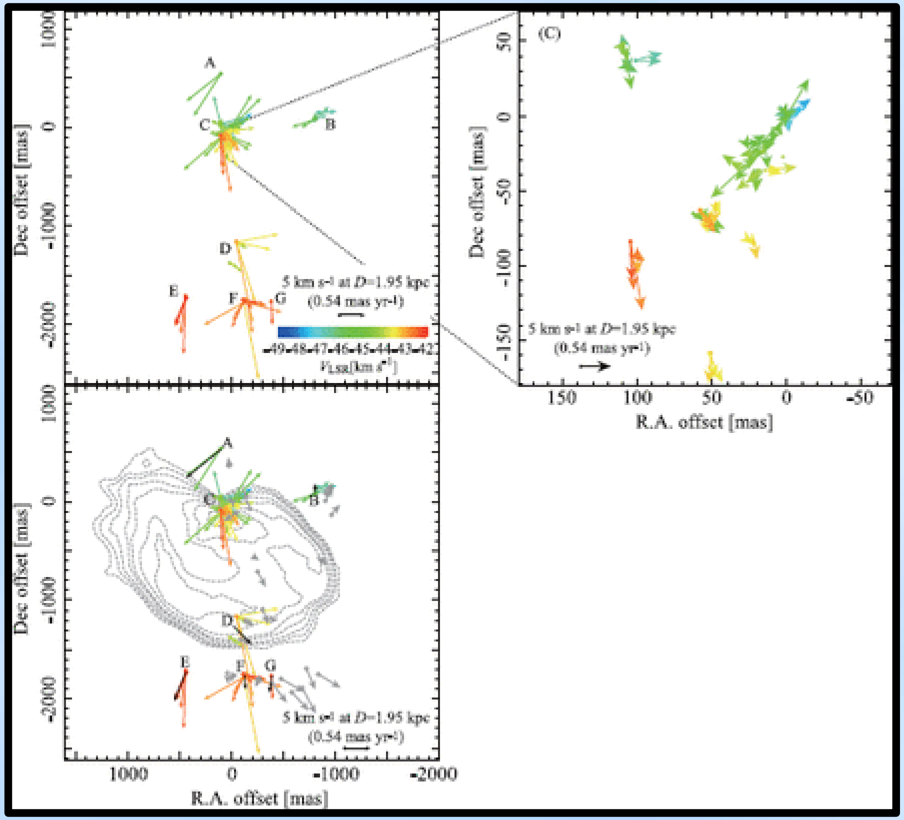
- These shifts are not consistent with a simple scenario of an expanding outflow or a rotating disc.

- We do not notice a rotation and infall like in Cep A where the ring was also imaged (Sugyjama et al. 2014).

- Likely the rotation and expansion exist like e.g. in W3OH reported by Matsumoto et al. (2011).



Acknowledgments

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