Water masers as tracers of post-AGB evolution

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Outline of the talk

- Characteristics of water masers
- Water masers in post-AGB stars - water fountains
- Water masers in PNe
- A few words on IRAS 15103-5754
- Conclusions

Water masers

- Where are they found ?
  - In the environments of YSO and star forming regions
  - In AGNs
  - In evolved objects : AGB, post-AGB, PN

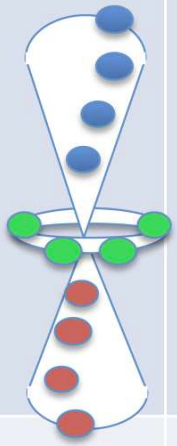
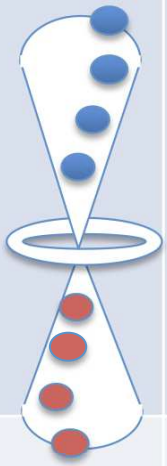
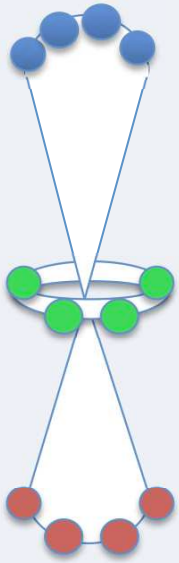
- Which physical processes ?
  - Hyperfine transition between two rotational states : $6_{16} \rightarrow 5_{23}$
  - Excitation mainly by shocks or by IR radiation

- Which physical conditions ?
  - Special conditions in T and P -- $T \approx 100K$
  - Abundances: $n(H_2O)/n(H_2) \rightarrow 2\text{-}4 \times 10^{-4}$
  - $nH_2 \leq 10^{11}$

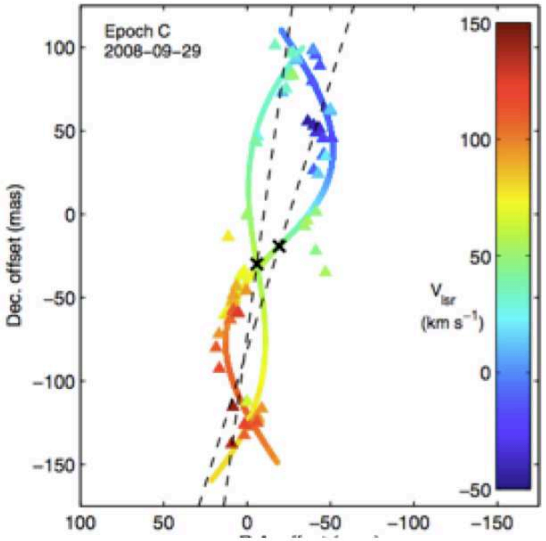
- Advantages :
  - Information about position, velocity, and proper motions

The « water fountains »

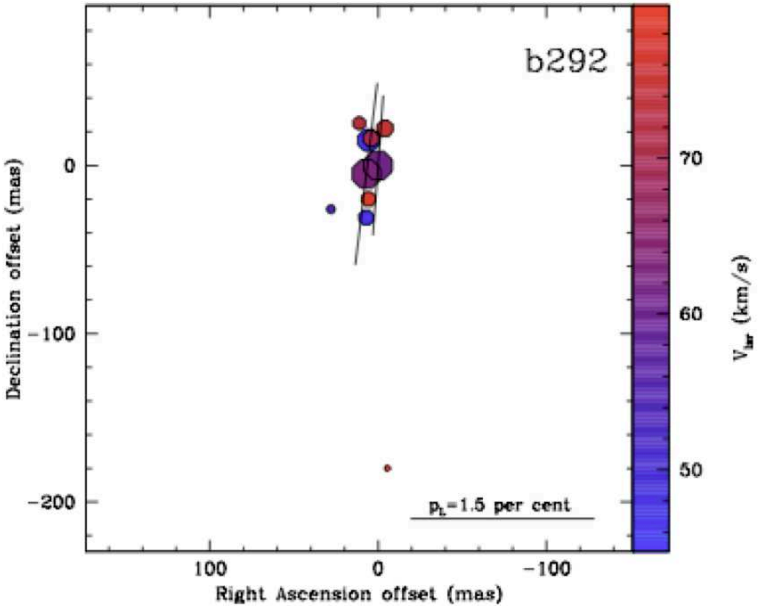
- What are they?
  - Evolved stars with water masers with components with velocities on the order of 100 km/s – tracing jets
  - First named by Likkel & Morris (1988) for IRAS 16342 – 3814
- Type of objects
  - Late AGB stars, post-AGB… and PN
  - Bipolar
  - Obscured at visible wavelengths – “anonymous”
  - Massive (see talk by Carolina Duran-Rojas)
  - 14 “classic” water fountains known – phenomenon not so rare (?)
- What do they imply?
  - First manifestation of axisymmetric jets
  - Key objects to trace the emission of the jets that shape the PNe
  - Formation of the cavities present it the PNe (Koning et al. 2013)

	Masers at the equatorial outflow		No masers at the equatorial outflow	
Masers on the jet		I15103 *(Suarez et al 2012+Bendjoya et al.-poster 17)* W43A – 50 yr *(Vlemmings et al.2006)* I18286 – 56-73 yr *(Yung et al. 2011)*		
Masers in bow-shocks		I18460 – 6 yr *(Imai et al.2013)*		OH12.8-0.9 – 70 yr *(Boboltz& Marvel 2005)* I19134 – 40 yr *(Imai et al 2007)* I19190 – 59 yr *(Day et al. 2010)* I16552 *(Suárez et al. 2008)* I16342 – 100 yr *(Sahai et al. 1999)* I18113 *(Gómez et al.2011)* I15445 *(Pérez Sanchez et al. 2011)* I18043 *(Pérez Sanchez et al. 2011)*

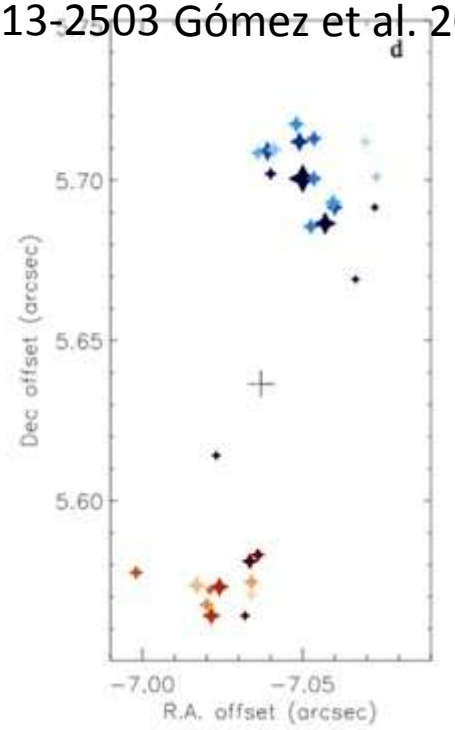
I18286-0959 Yung et al. 2012



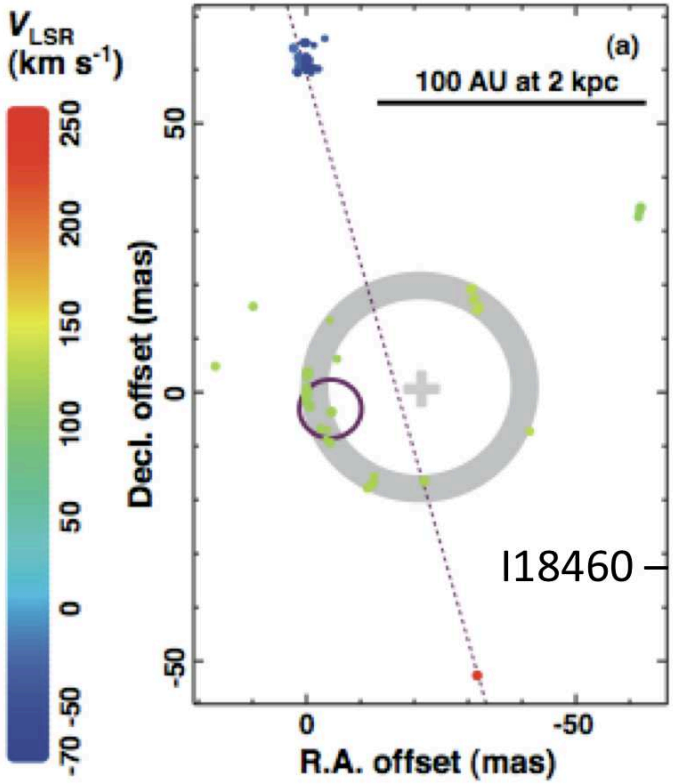
Pérez-Sanchez et al. 2011



I18113-2503 Gómez et al. 2011



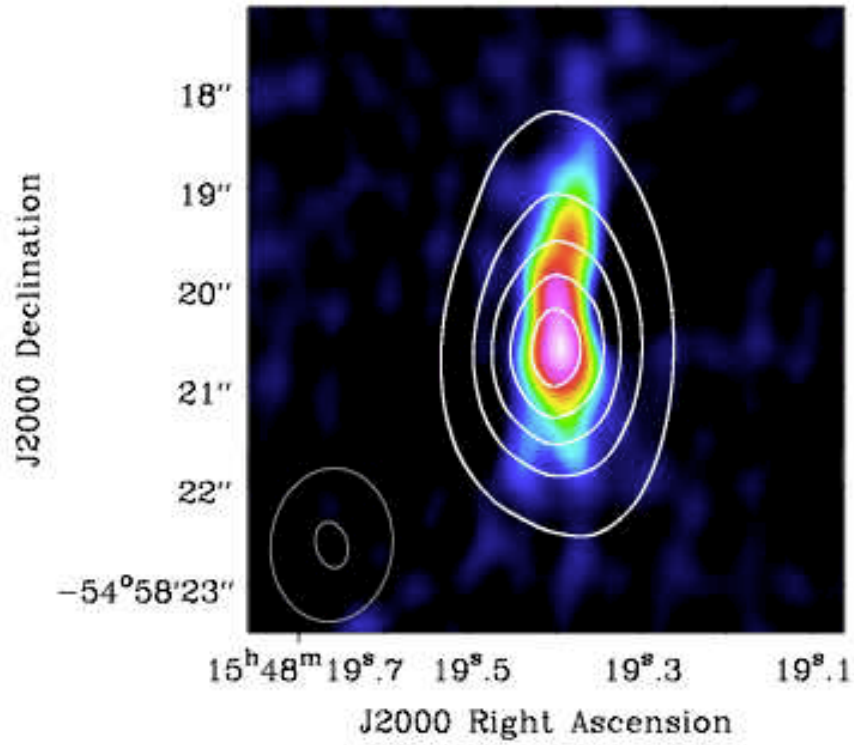
I18460 – Imai et al. 2013



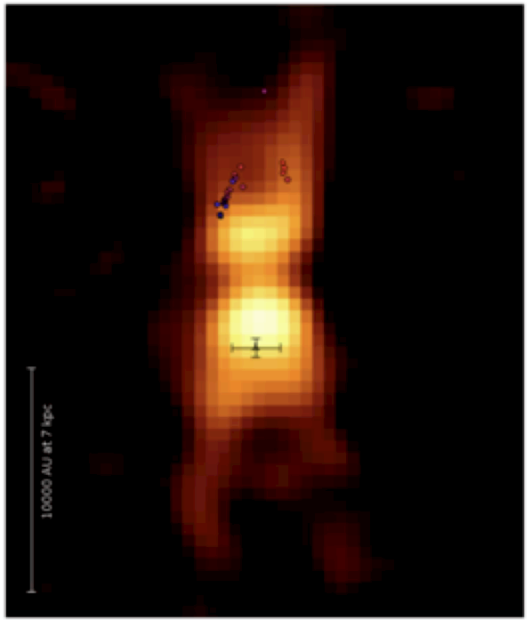
The driven mechanisms of the jets

- Magnetically collimated jet - synchrotron radiation – *Perez-Sanchez et al. 2013*

ATCA – 22 & 5 GHz



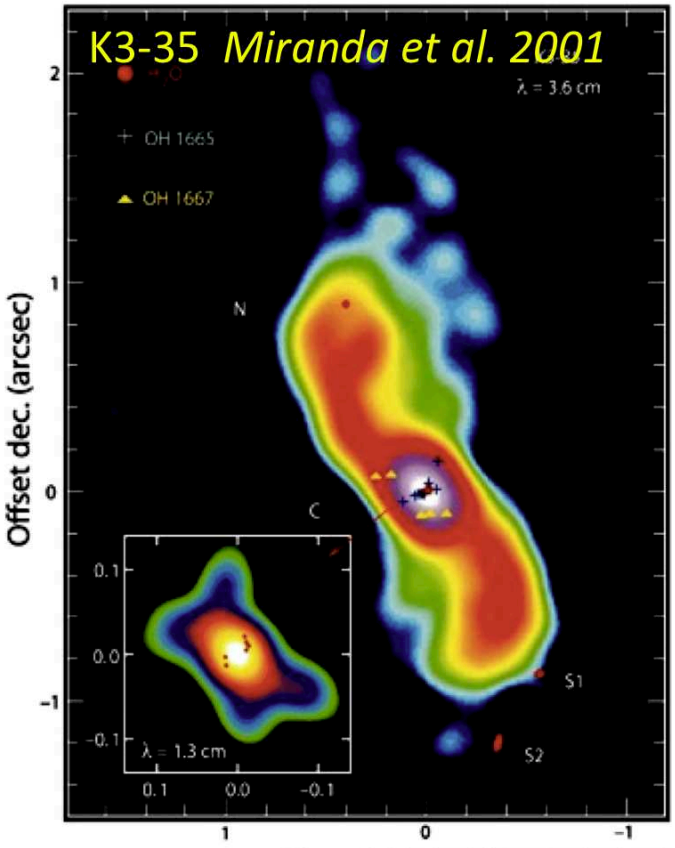
IR (Lagadec et al. 2011) +
ATCA (Perez-Sanchez et al. 2011)



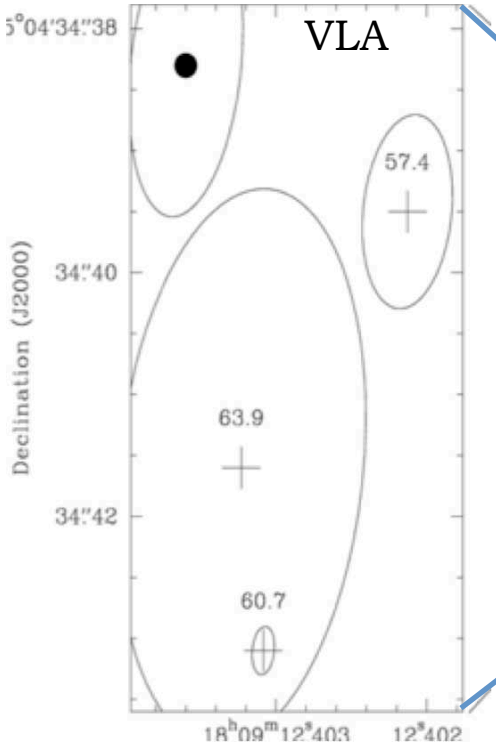
- Jet precession – sign of binarity ?

Water masers in PNe

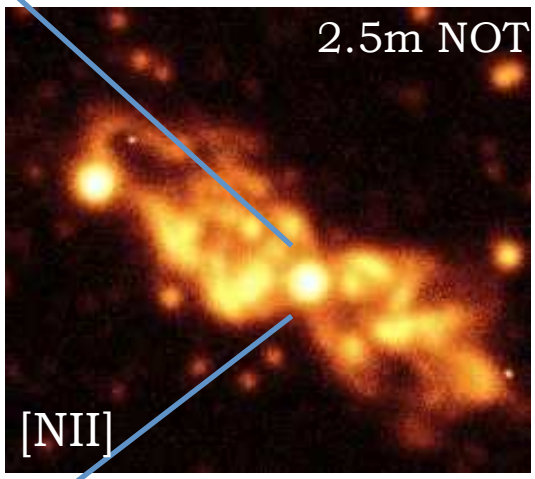
- Believed impossible before 2001, now 5 H_2O-PNe confirmed
  - K3–35 (Miranda et al. 2001)
  - IRAS 17347 – 3139 (de Gregorio Monsalvo et al. 2004)
  - IRAS 18061 – 2505 (Suárez et al. 2007, Gómez et al.2008)
  - IRAS 15103 – 5754 (Suárez et al.2012, see poster by Ph. Bendjoya, n.17)
  - IRAS 16333 – 4807 (Uscanga et al. in prep.)
- Characteristics :
  - All bipolar
  - Masers close to the central star – not high velocity except for I15103
  - 2 optically visible, 3 obscured



Gómez et al. 2008



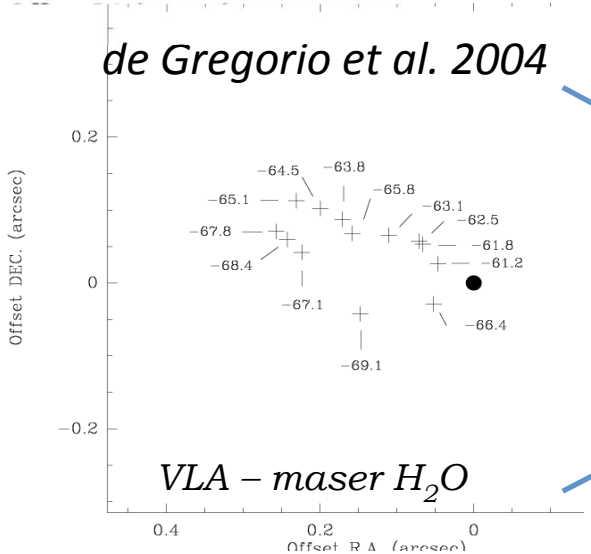
I18061



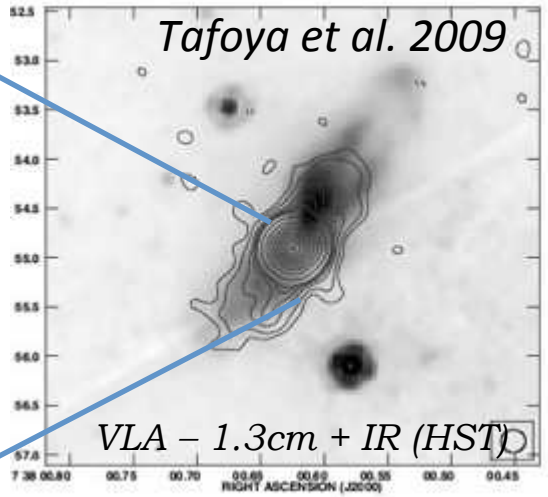
Suárez et al. (2006)

I17347

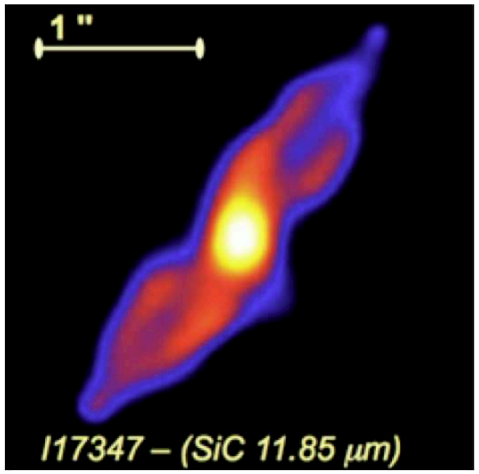
de Gregorio et al. 2004



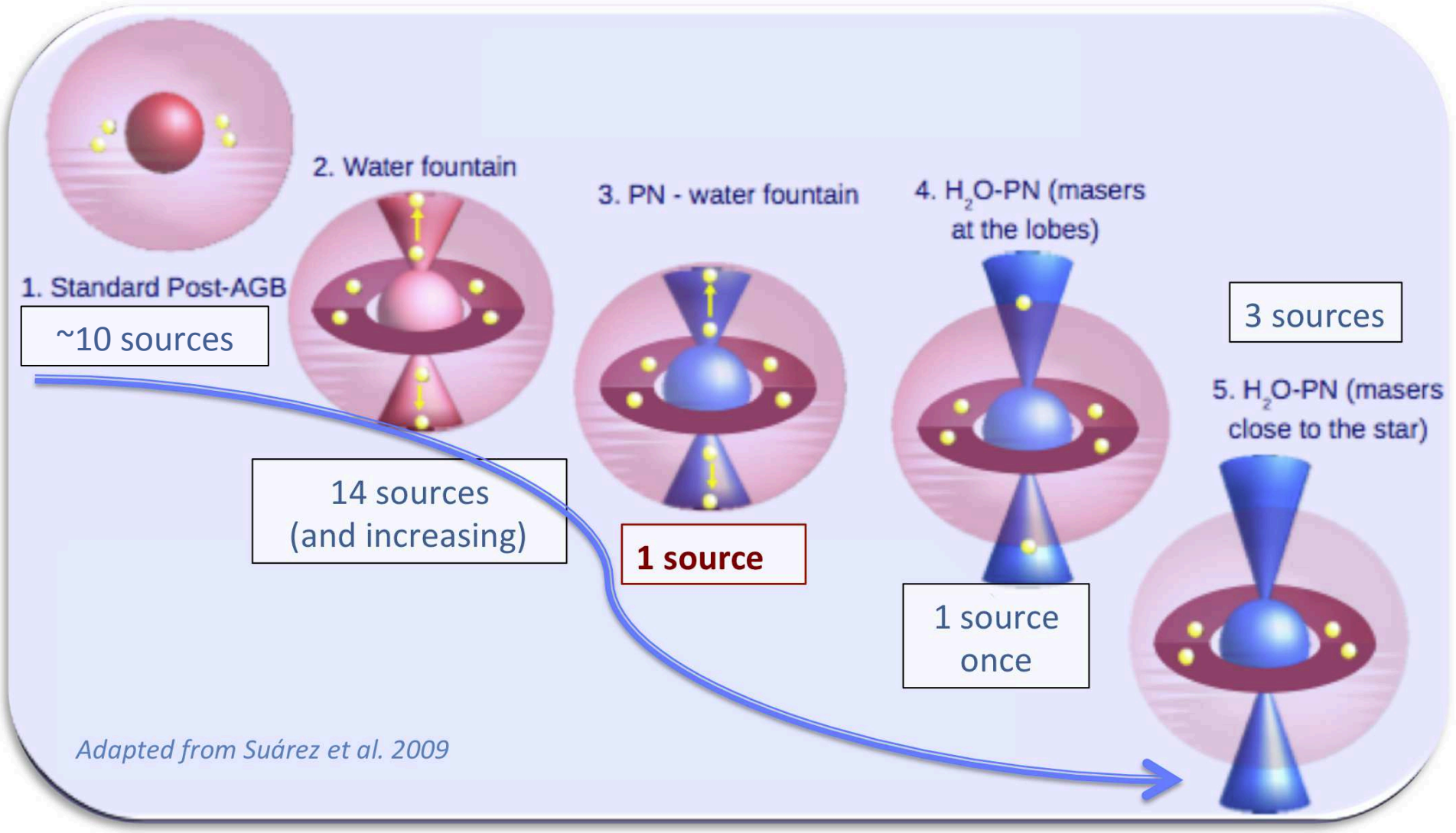
Tafoya et al. 2009



Lagadec et al. 2011



Sketch of the possible water maser evolution



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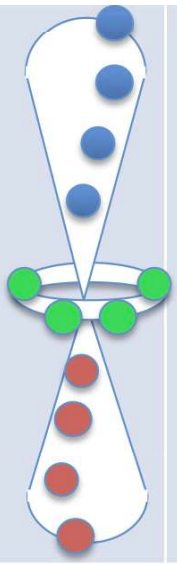
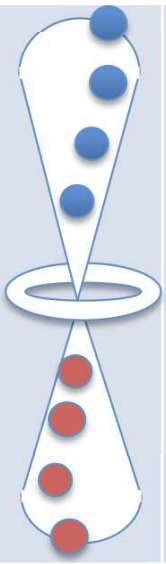
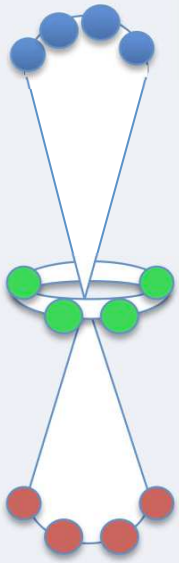
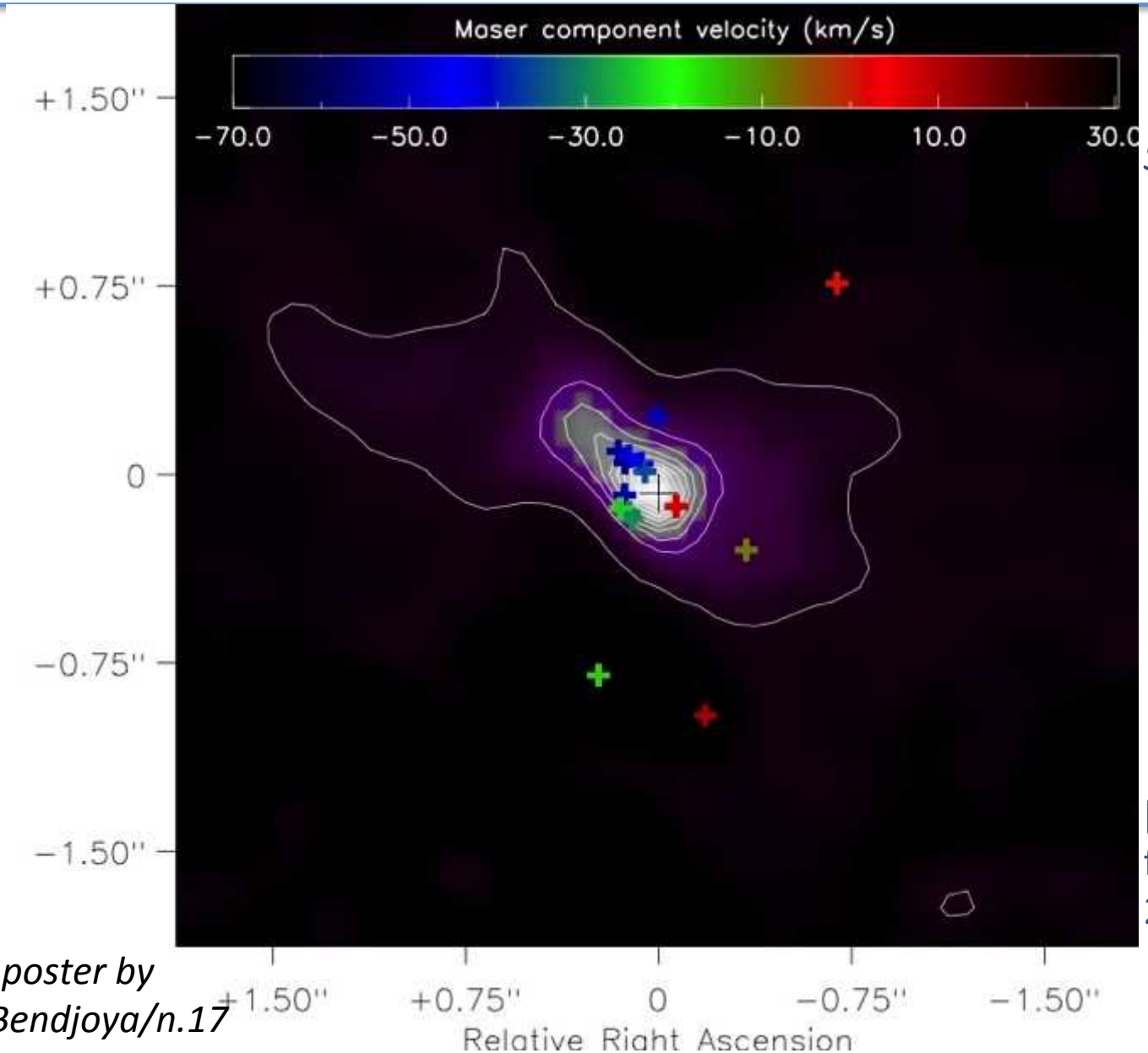
Masers on the jet		I15103 *(Suarez et al 2012+Bendjoya et al.-poster 17)* W43A – 50 yr *(Vlemmings et al.2006)* I18286 – 56-73 yr *(Yung et al. 2011)*		I15445 *(Pérez Sanchez et al. 2012)* I18043 *(Pérez Sanchez et al. 2012)*
Masers in bow-shocks		I18460 – 6 yr *(Imai et al.2013)*		OH12.8-0.9 – 70 yr *(Boboltz& Marvel 2005)* I19134 – 40 yr *(Imai et al 2007)* I19190 – 59 yr *(Day et al. 2010)* I16552 *(Suárez et al. 2008)* I16342 – 100 yr *(Sahai et al. 1999)* I18113 *(Gómez et al.2011)*

The missed link : IRAS 15103

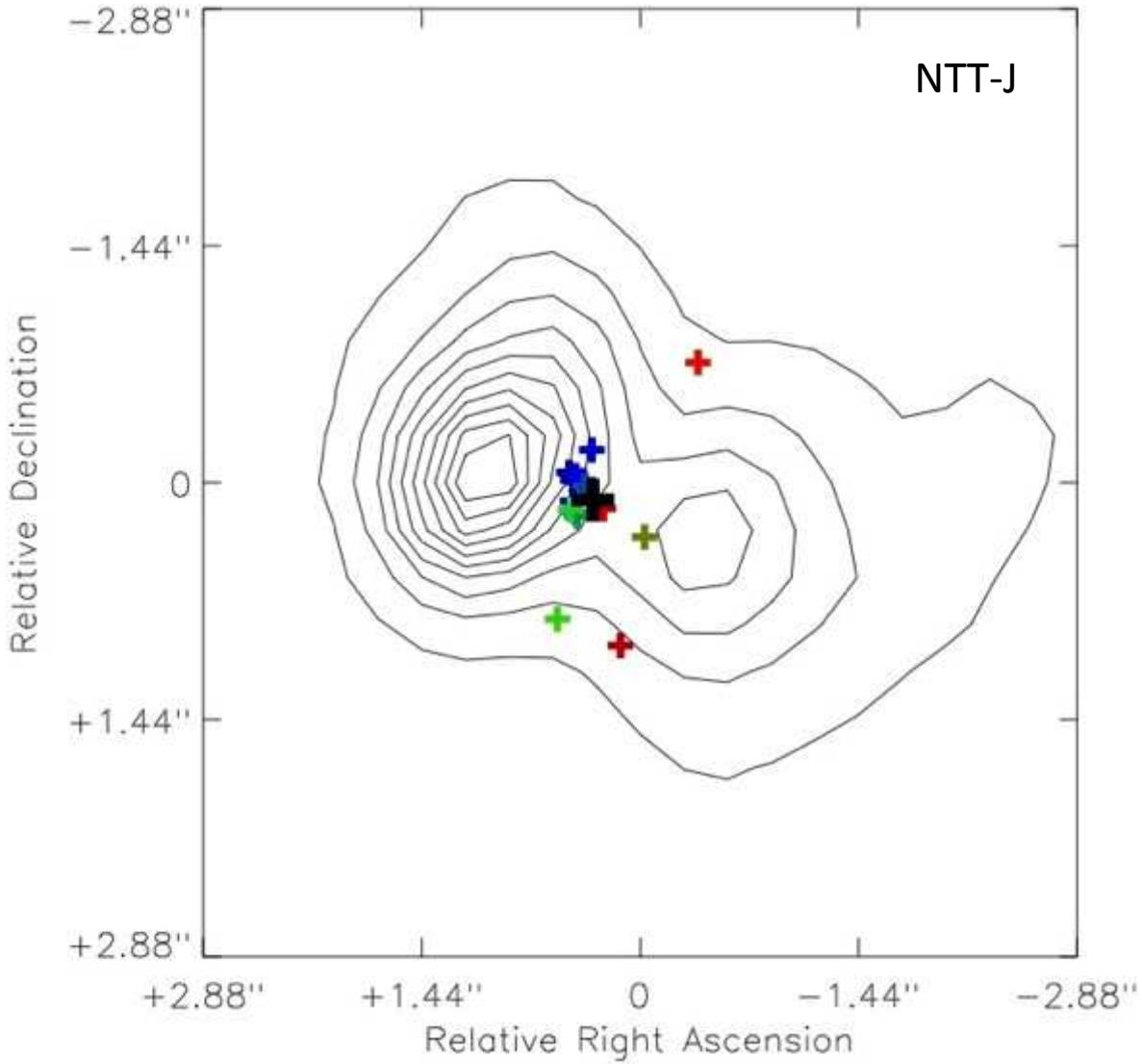


Suárez et al. submitted

[NII] image (12.8 μm) from Lagadec et al. 2011

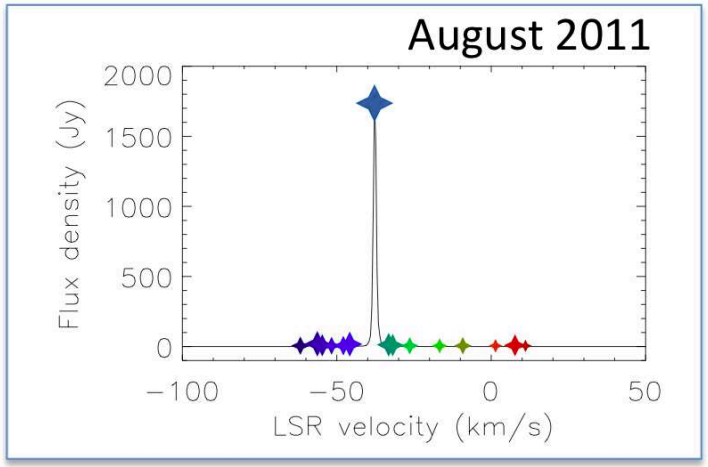
See poster by Ph.Bendjoya/n.17

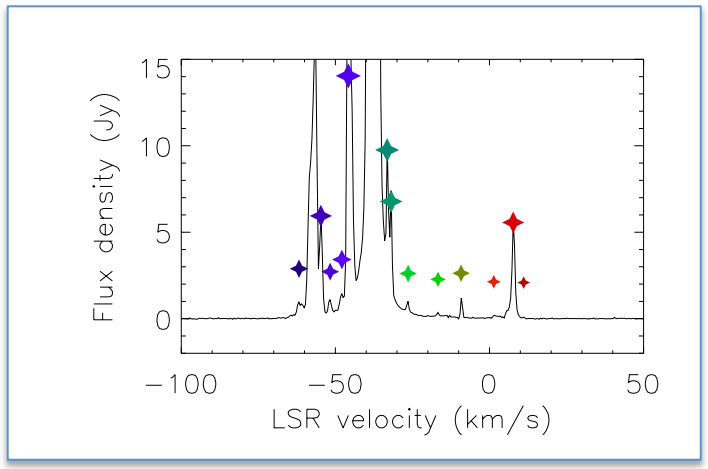
The missed link : IRAS 15103

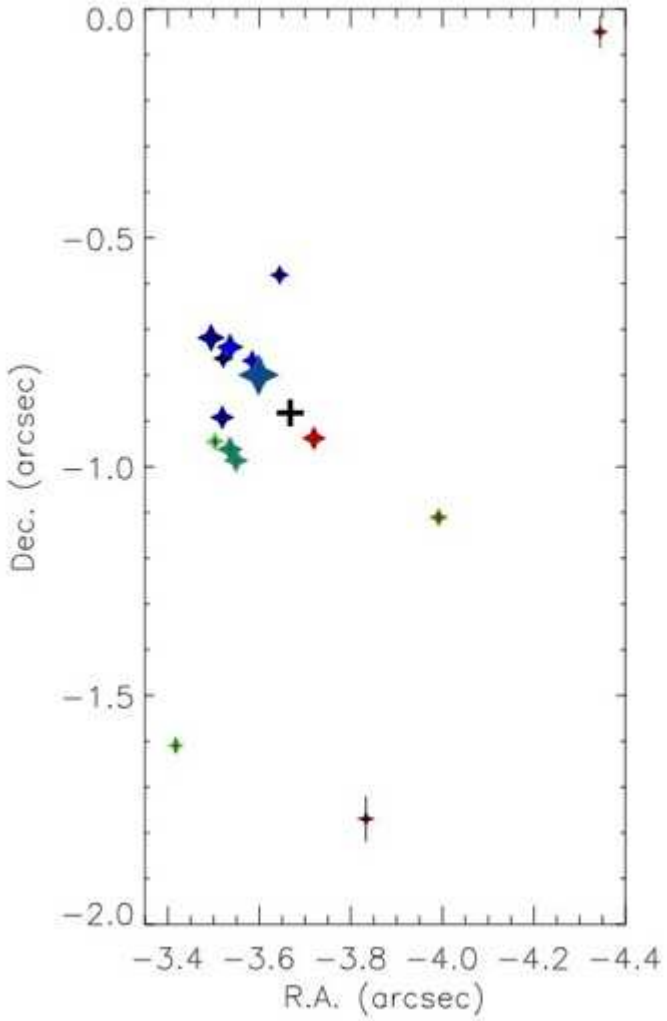


NTT - J image
Ramos-Larios et al. 2012

Maser distribution







Conclusions

- Water masers trace the jets that shape the PNe -> water fountain stars
- Water masers follow the transition to the PN phase and they disappear shortly
- Important to increase the number of wf known -> statistics
- Look for binaries…