

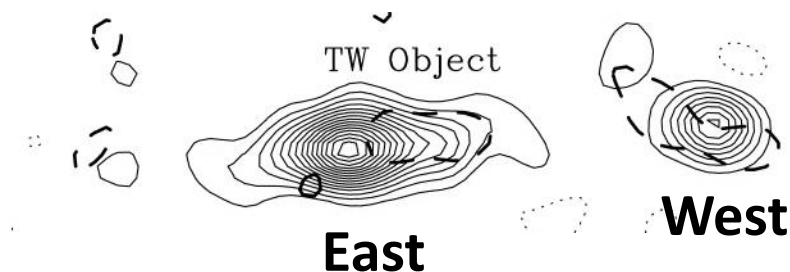
# velocity field of water masers in W3(H<sub>2</sub>O)

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# Introduction: protobinary system W3(H2O)

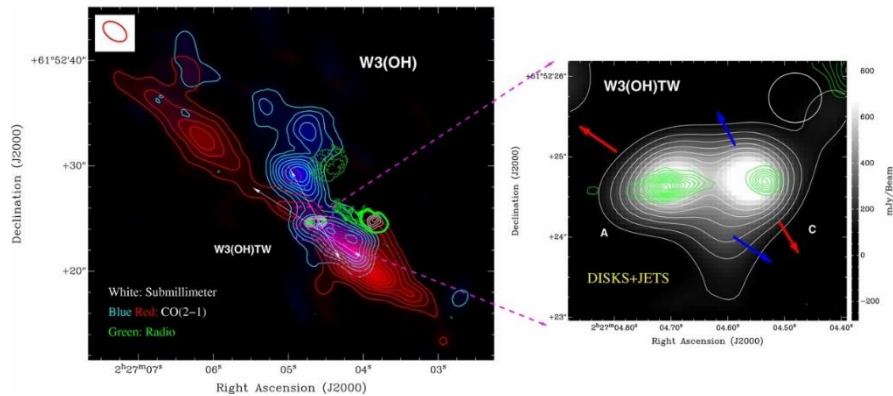
- W3(H2O) East
  - Mass: 13 Msun (Zapata+ 2011)
  - Synchrotron emission (Reid+ 1995)
  - Wiggling structure
    - Precession jet (Wilner+ 1999)
    - Warp of disk (interaction disk wind with disk) (Shchekinov+ 2004)
- W3(H2O) West
  - Mass: 4 Msun (Zapata+ 2011)
- Proto-binary (Chen+ 2006, Zapata+ 2011, Ahmadi + 2018)



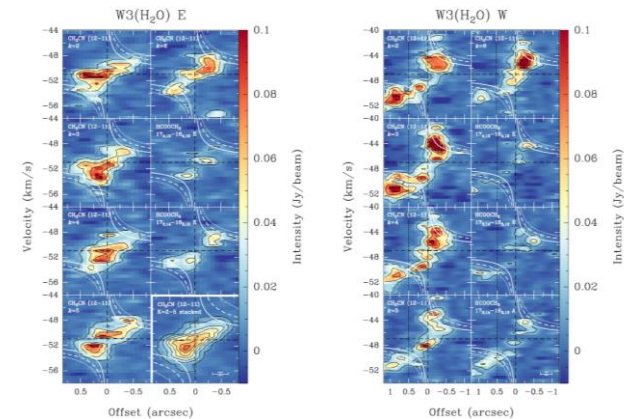
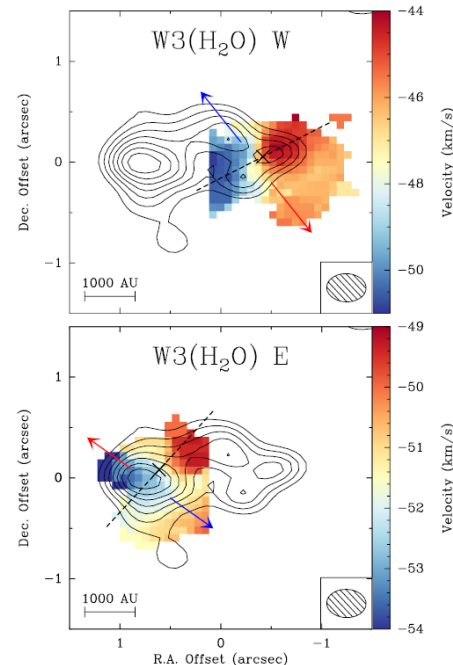
Wilner+ 1999

# Molecular outflows and disks of W3(H2O)

- There are two outflows which originates from W3(H2O) East and West
  - CO (SMA obs. by Zapata+ 2011, ), HCN (SMA obs. Qin+ 2016, CO (NOEMA obs. Ahmadi+ 2018)
  - P.A:  $+40^\circ$  (W3(H2O)East),  $+15^\circ$  (W3(H2O)West) (Zapata+ 2011) and same results (Qin, Ahmadi)
- CH3CN disk at both W3(H2O) East and West (Ahmadi+ 2018) and direction of disks are perpendicular of outflow
  - Perhaps W3(H2O) East is protobinary



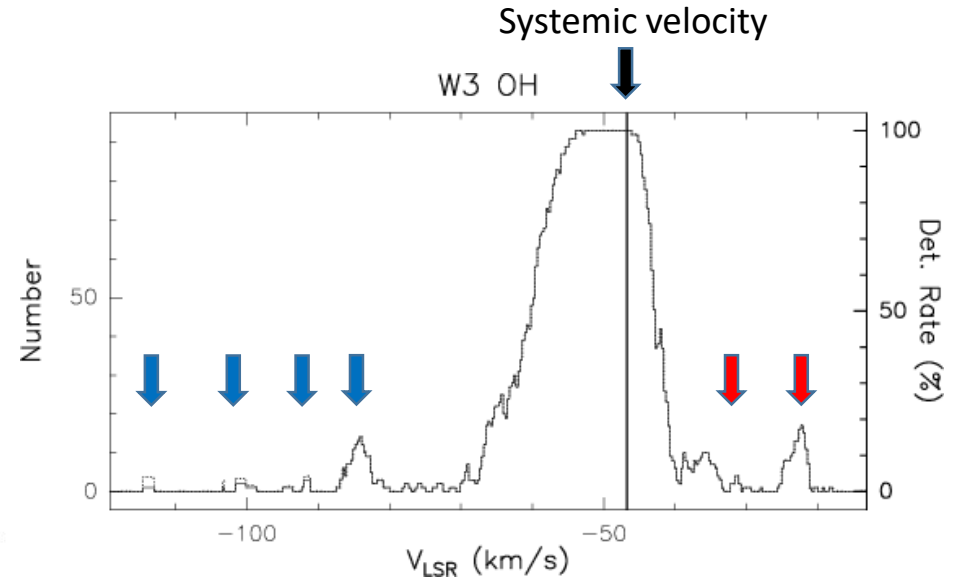
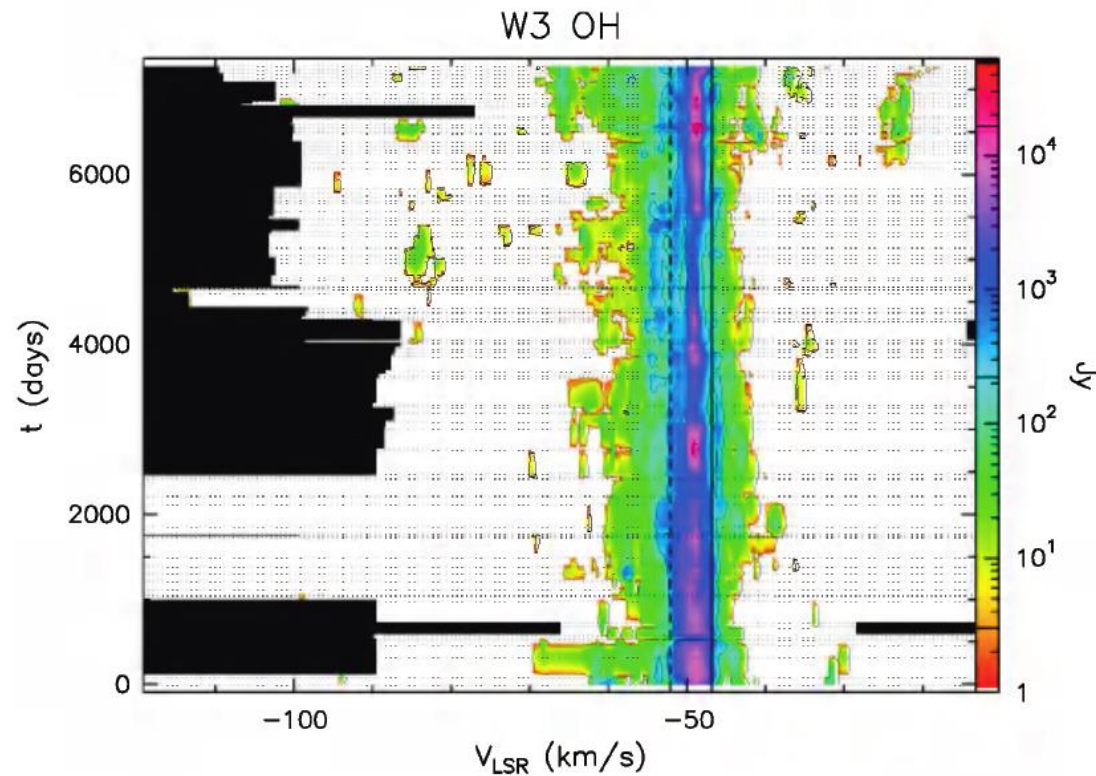
CO outflow and 890um continuum (Zapata+ 2011)



CH3CN 1<sup>st</sup> moment map (left) and position velocity map of CH3CN and HCOOCH2) (Ahmadi+ 2018)

# Single dish very long monitor of H<sub>2</sub>O maser spectra of W3(H<sub>2</sub>O) for 20 years (Felli+ 2007)

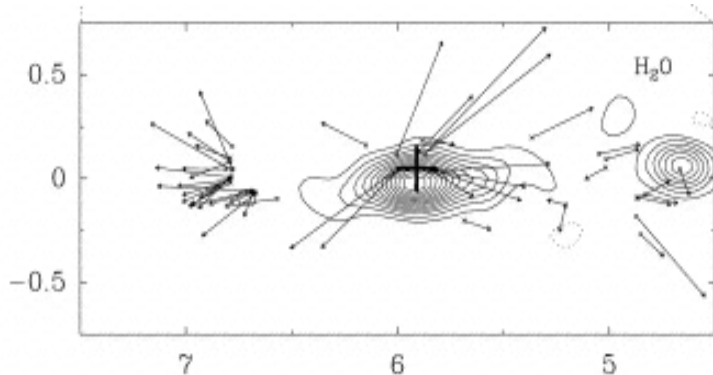
- 1987/Mar to 2007/Feb



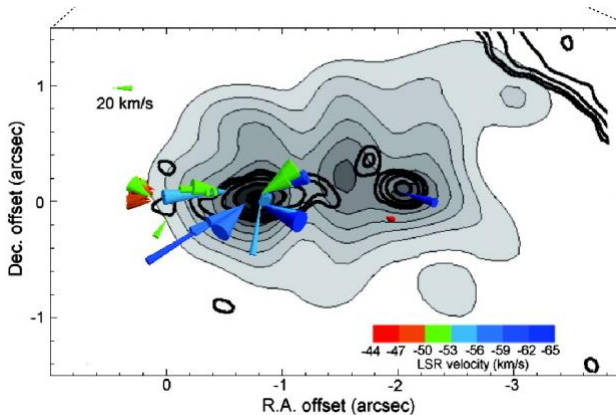
- Detection rate of maser features.
- High velocity maser features are rare.

# H<sub>2</sub>O maser jet by past VLBI observation

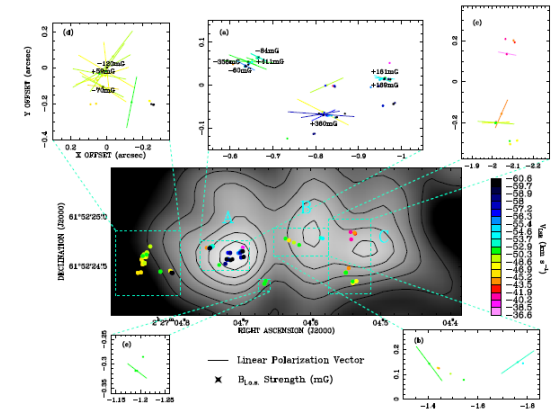
- H<sub>2</sub>O maser jet (or outflow) from W3(H<sub>2</sub>O) East (Alcolea+ 1993, Hachisuka+2006, Goddi+ 2017)
  - Proper motion shows outflow is parallel to sky plane
  - P.A. : 90° (same as elongation of W3(H<sub>2</sub>O) East at 8.4 GHz)
  - Typical radial velocity range : -45 to -64 km/s
- Properties of H<sub>2</sub>O masers in W3(H<sub>2</sub>O) West is still unknown



Proper motions of H<sub>2</sub>O masers  
(Alcoela et al. 1993)



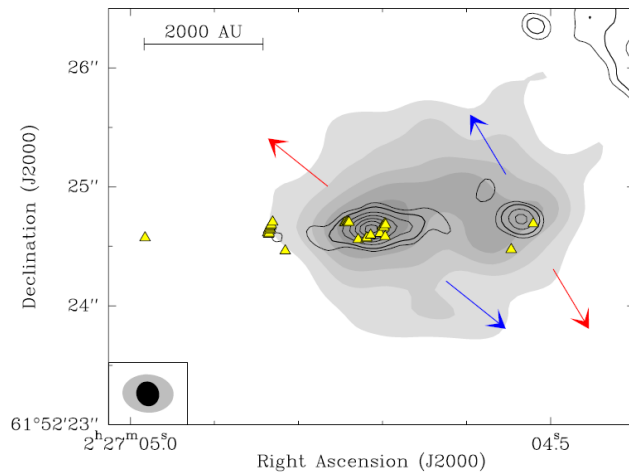
Proper motions of H<sub>2</sub>O masers  
(Hachisuka et al. 2006)



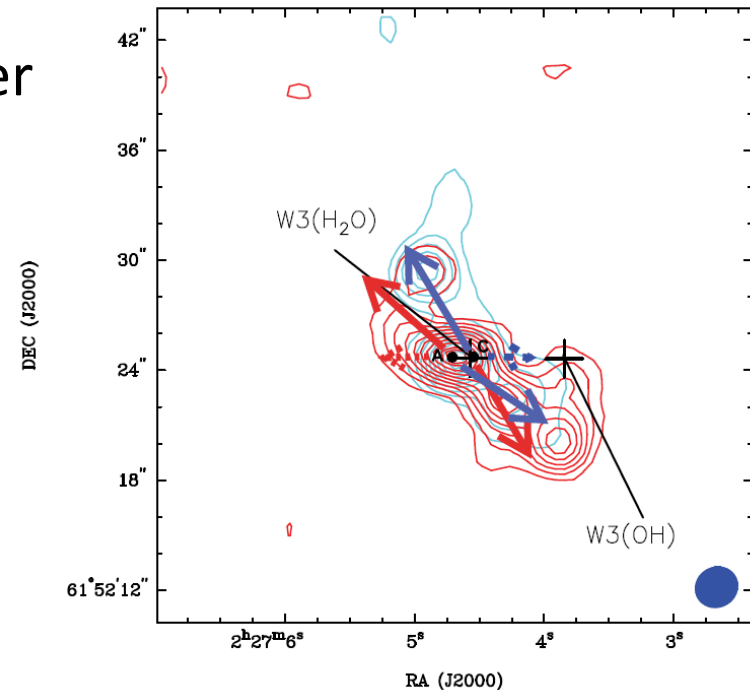
Map of H<sub>2</sub>O masers  
(Goddi et al. 2016)

# (one of ) mystery in W3(H2O) : the different directions between molecular outflow and H2O maser jet

- direction of outflow and jet
  - Molecular outflow: 15 to 54°
  - Water maser: 90°
- The maser jet (outflow) bends at larger scale?



1.3mm continuum (grey scale), 8.4 GHz continuum (contour), H2O maser (yellow triangle), direction of CO outflow (arrow) (Ahmadi+ 2018)



HCN outflow (contour), direction of CO outflow (solid arrows), direction H2O maser jet (dashed arrow) (Qin+ 2016)

I cannot show the results now.  
I am sorry.

# VERAアーカイブデータを 解析していて個人的に思うこと

- 水メーザーのVLBIマッピングはアウトフローやジェット  
の方向を教えてくださいますが、マップや運動が複雑過ぎたり  
解析者の想像力が豊か過ぎて結局何をトレースしている  
か良く分からない場合もあると思います
- しかし長期間のVLBIデータはそんな複雑なメーザーの運  
動や放射位置などに若干の（時には大きな）制限を与え、  
その星周環境を理解することに役立つと思います
- もしVERAで観測する天体が無くなった場合、面白そうな  
（できれば他波長データがある）水メーザー天体の長期  
VLBIモニターをやってみても良いかと思います