

# Far-IR Observations Of Water In Young Stellar Objects (@ 63 $\mu\text{m}$ )

*P. Rivière-Marichalar*



*Water in the Universe, ESTEC, April 2016*

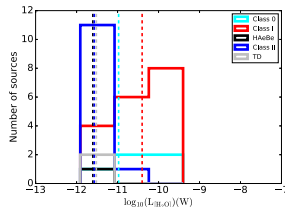
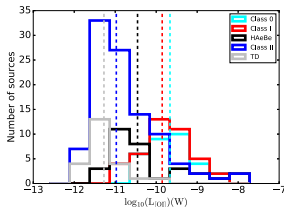
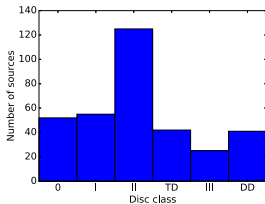
On behalf of C. Eiroa, I. Kamp, B. Merín, B. Montesinos

# Water detections with Herschel-PACS

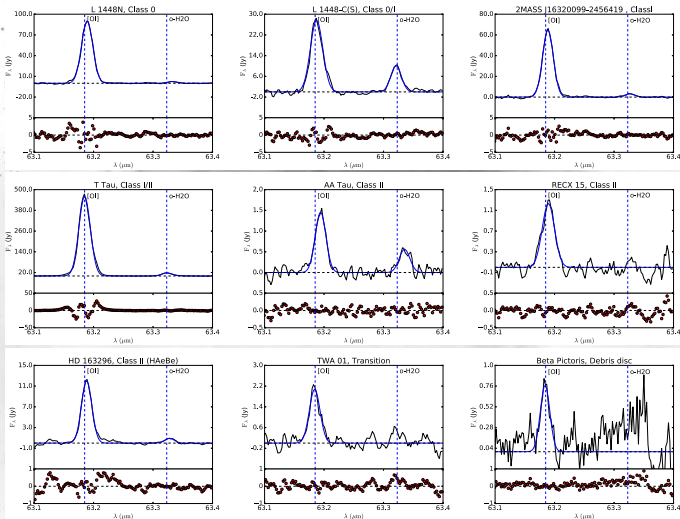
- Herschel-PACS observations of water in YSOs:
  - ▶ Sturm+ (2010), van Kempen+ (2010), Rivière-Marichalar+ (2012), Herczeg+ (2012), Green+ (2013), Kamp+ (2013), Lindberg+ (2013), Karska+ (2013, 2014), Nisini+ (2013), among others...

# The sample

- PACS observations of 357 YSOs from 14 programs (WISH, DIGIT, GASPS, plus 11 OTP).
- Class 0, I, II and III sources.
- Study the [origin of the different emissions](#).
- Present sample: focus on [63.0 to 63.4  \$\mu\text{m}\$](#)  range.



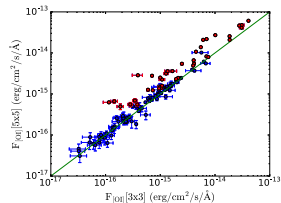
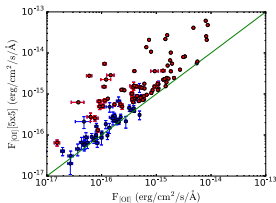
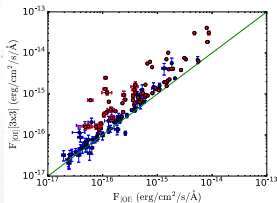
# Example spectra



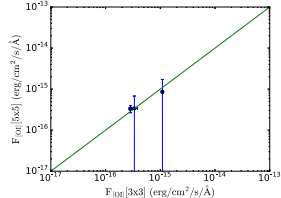
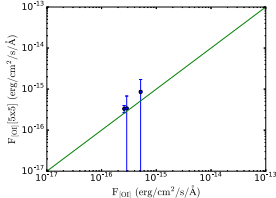
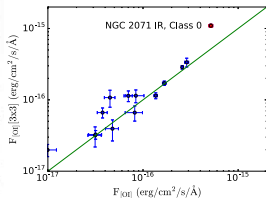
Some sources show **prominent residuals**

# Extended emission

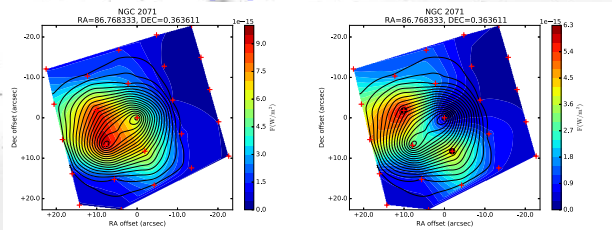
[O]: 77 sources



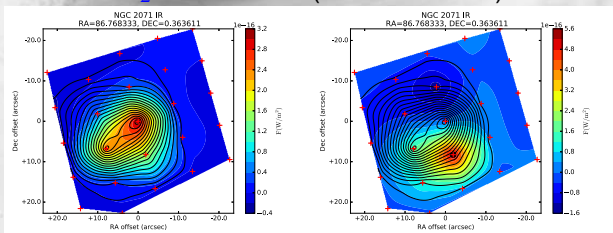
$\text{H}_2\text{O}$ : 1 source (NGC 2071 IR)



# Extended emission [OI]: 72 sources



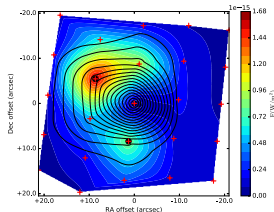
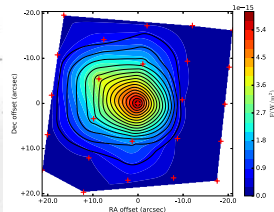
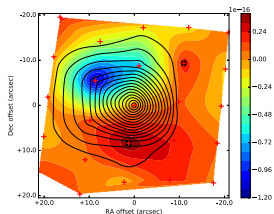
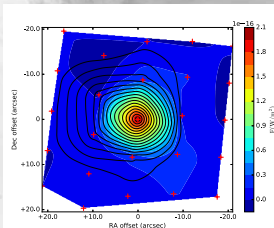
## H<sub>2</sub>O: 1 source (NGC 2071 IR)



[OI] and H<sub>2</sub>O peak at different positions

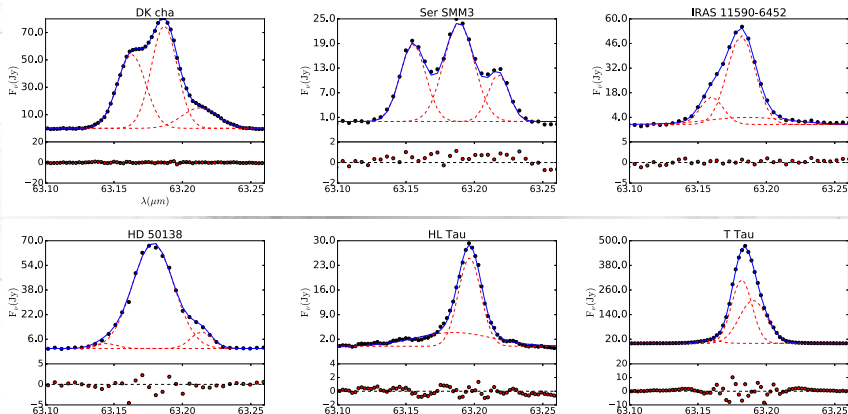
# $\text{H}_2\text{O}$ emission is compact in most sources

[O]

 $\text{H}_2\text{O}$ 

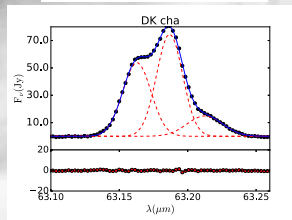
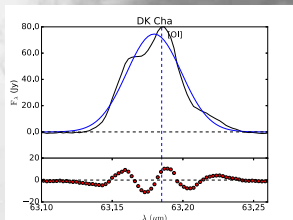
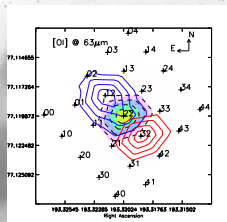
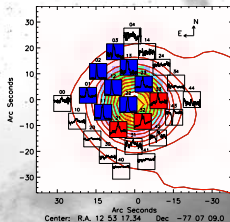
... meaning that we only detected **extended  $\text{H}_2\text{O}$  emission in one source (NGC 2071 IR)**. But  **$3\sigma$  residuals are detected** in some sources...

# [OI] multiple contributions? Multi-Gaussian fit





# [OI] multiple contributions? DK Cha

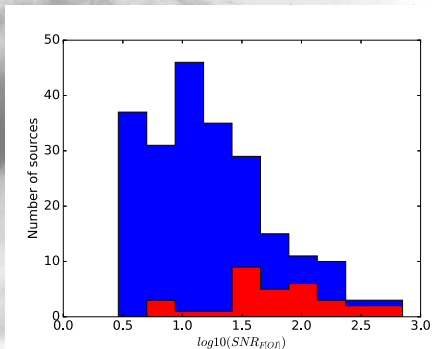


Riviere-Marichalar+ (2015)

...and the prominent residuals disappear

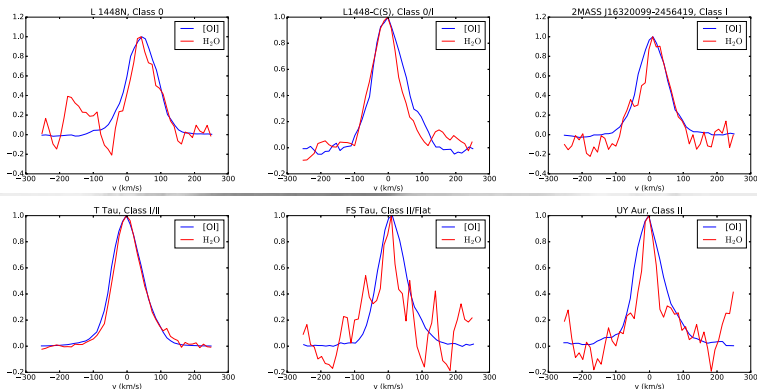
# Water is better reproduced by a single Gaussian, but...

- Multi-Gaussian detections in [O] profiles are biased towards high-SNR sources



Lack of multiple components in  $\text{H}_2\text{O}$  profiles could be linked to low SNR  $\text{H}_2\text{O}$  line fluxes (...too late to test with Herschel)

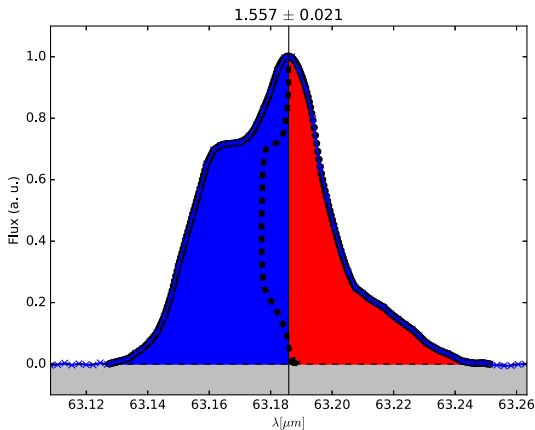
# Are the line profiles similar?



Tentative trend with evolutionary stage...

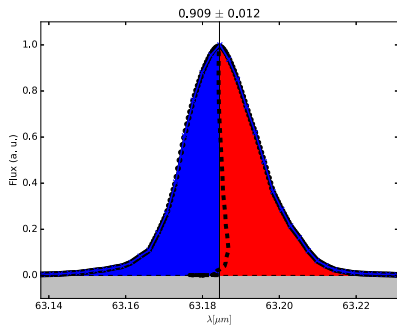
Observations with high spectral resolution (SOFIA) are required

# [OI] asymmetries? DK Cha

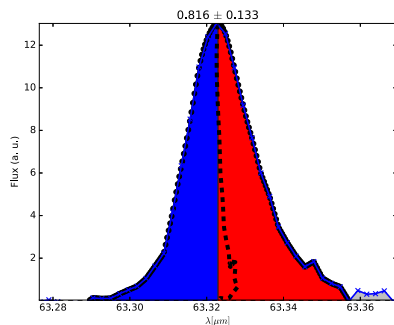


...does H<sub>2</sub>O @ 63  $\mu\text{m}$  show asymmetries?

# Line profile asymmetries: T Tau



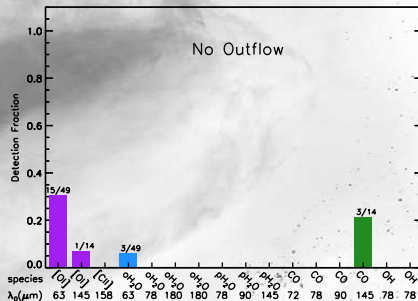
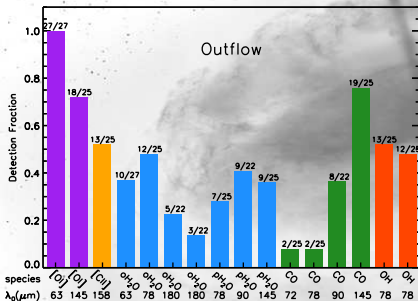
[OI]



H<sub>2</sub>O

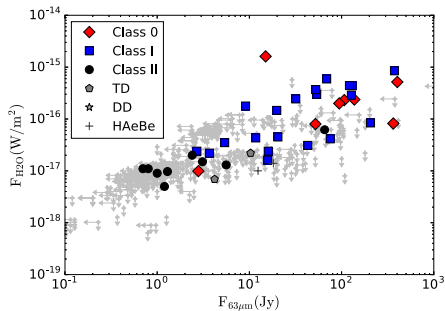
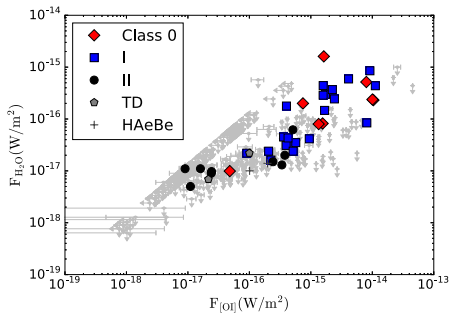
yes, it does

# Sources in Taurus



Alonso-Martín & Rivière-Marichalar+ (in prep.)

# Some correlations



# Summary

- **357 YSOs** observed with Herschel **PACS** in chop-nod, pointed mode @ 63  $\mu\text{m}$ : catalogue is ready (and paper submitted)
- **[OI] extended** in **77** sources
- **H<sub>2</sub>O extended** in **one** source (NGC 2071 IR, Class 0)
- **[OI]** shows evidence for **contributions from different dynamical components**
- **H<sub>2</sub>O does not show evidence** for these many components (may be linked to low SNR), but **asymmetries are observed**, similar to those in **[OI]**



The background of the slide is a grayscale astronomical image showing a young stellar object (protoplanetary disk) with a central star and a surrounding disk of gas and dust. The image is filled with numerous small, dark specks representing distant stars. The text 'Thank you!' is overlaid in the center of the image.

Thank you!