The Far-Infrared

A missing link in disk evolution, planet formation and earth-like planets

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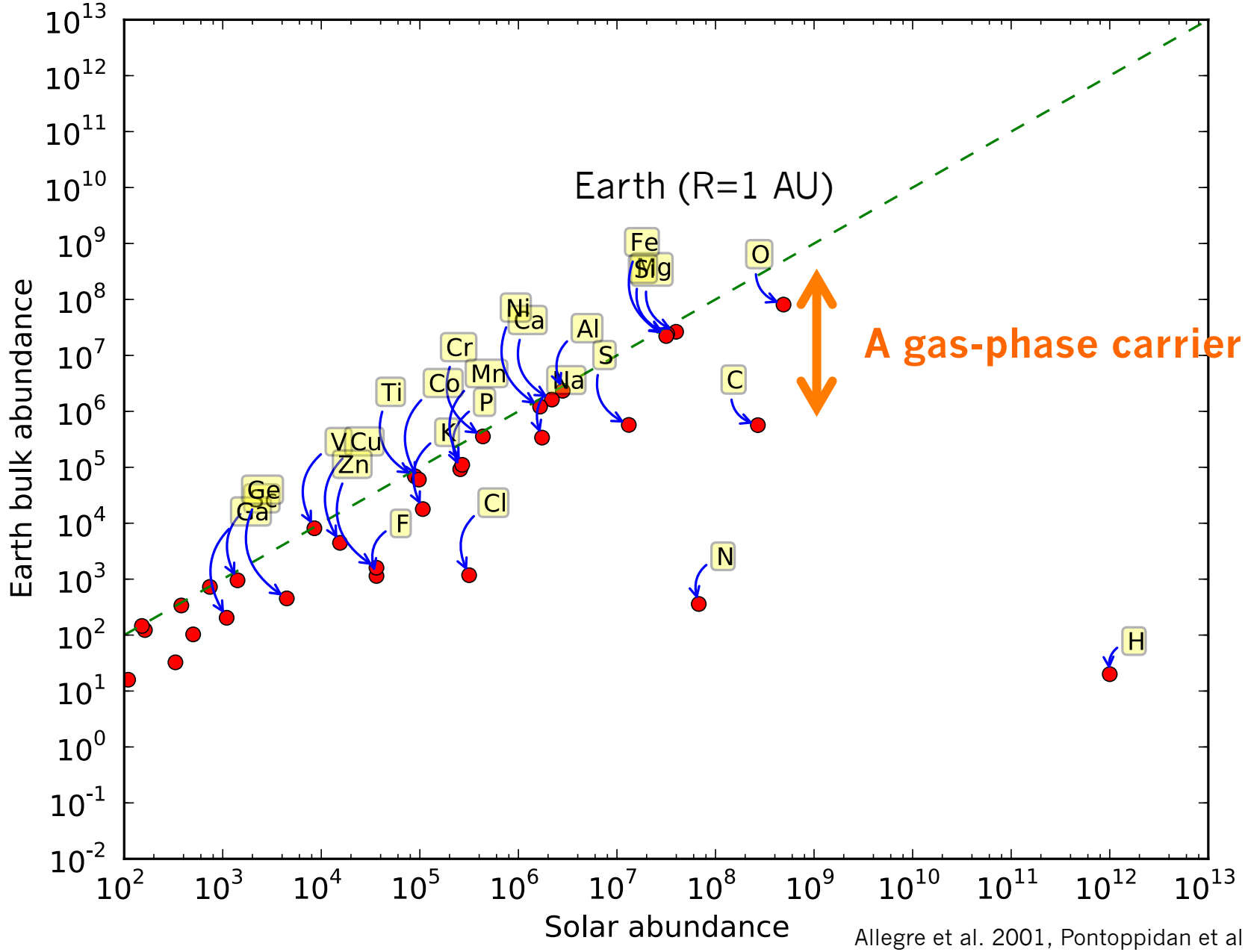
Space Telescope Science Institute

Bringing Fundamental Astrophysical Processes Into Focus:
A Community Workshop to Plan the Future of Far-Infrared Space Astrophysics

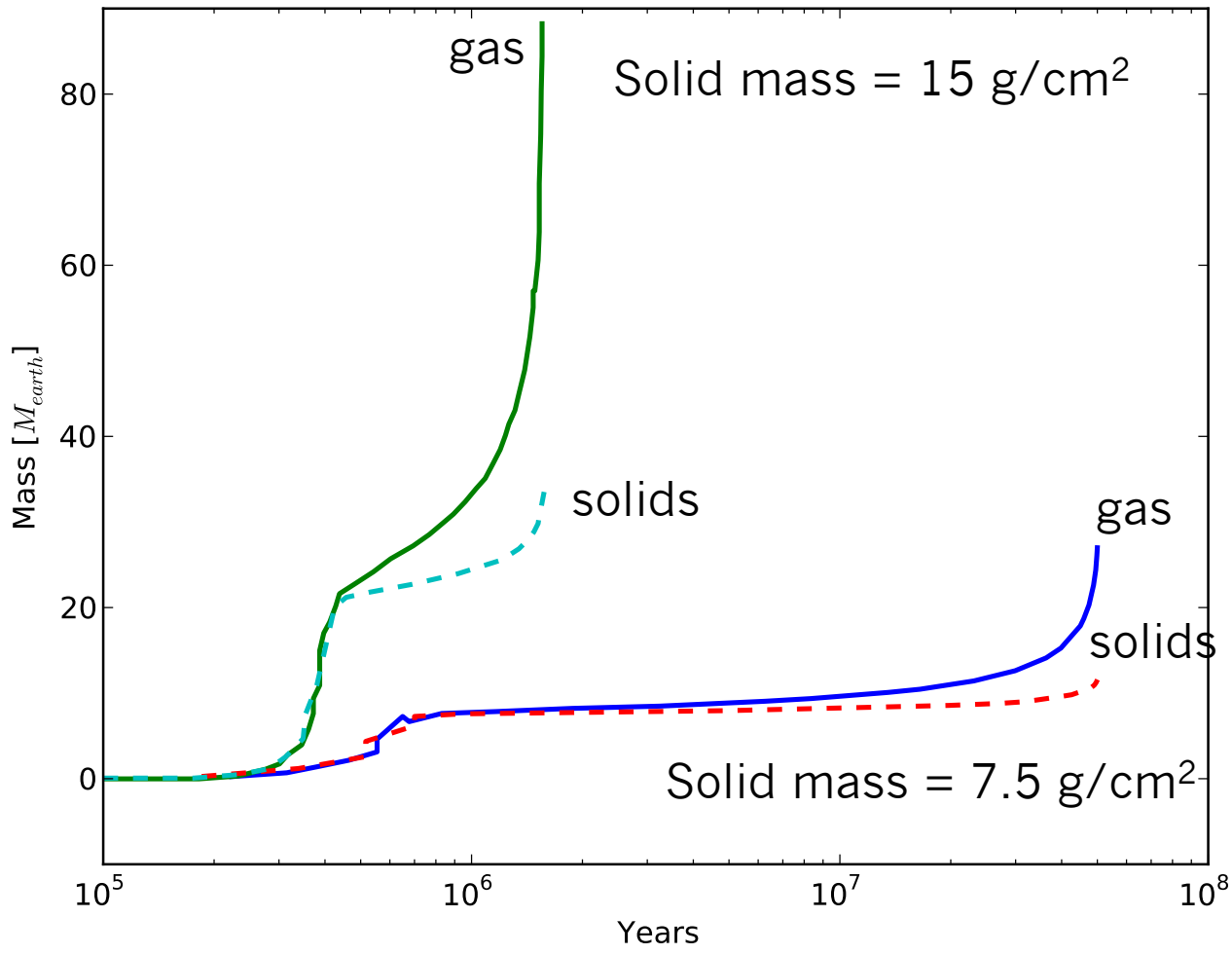
May 13, 2014

Volatiles depleted in the Earth are observable in the gas-phase



Allegre et al. 2001, Pontoppidan et al. 2014

A factor 2 in solid mass makes a difference in giant planet formation



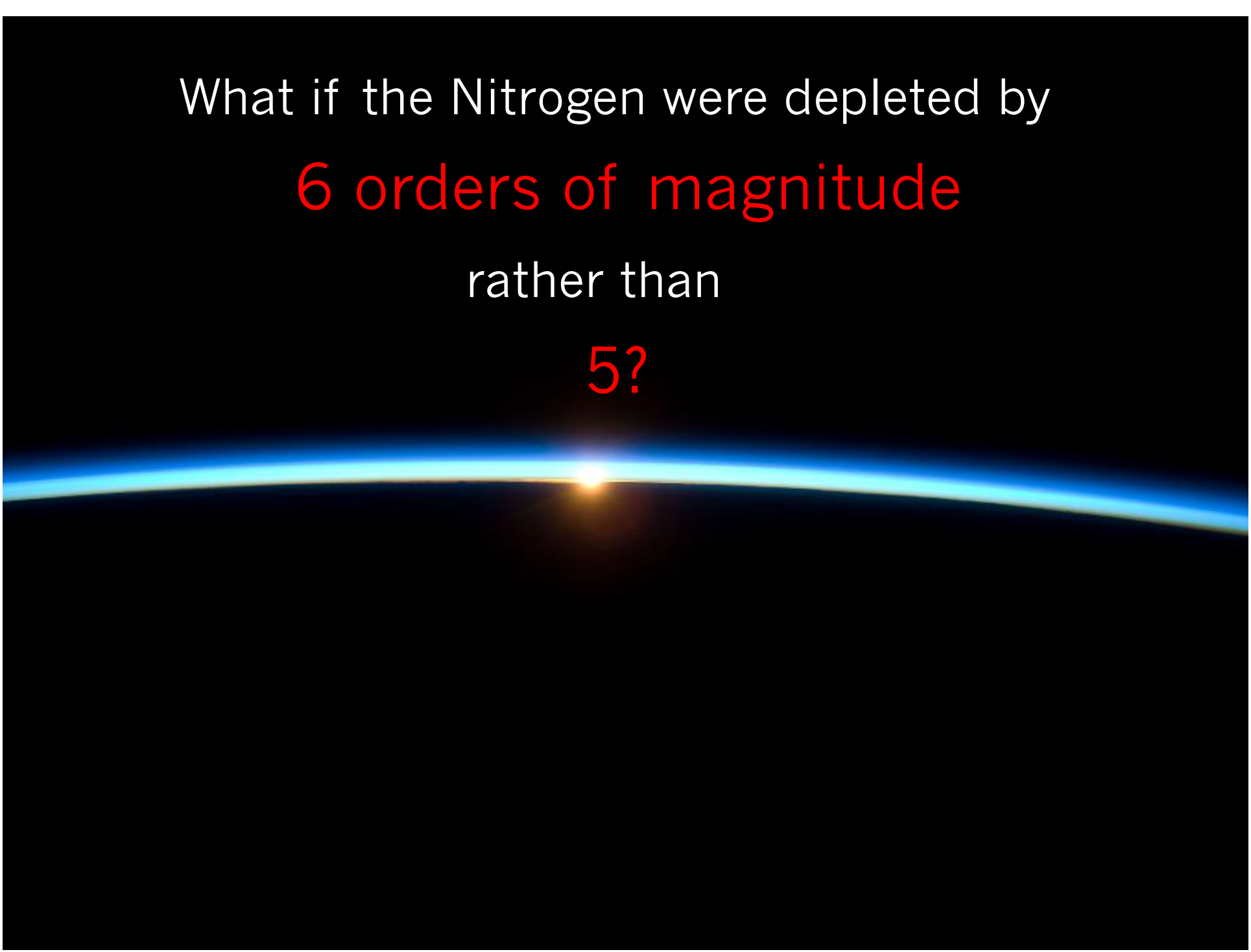
Adapted from Pollack et al. 1996

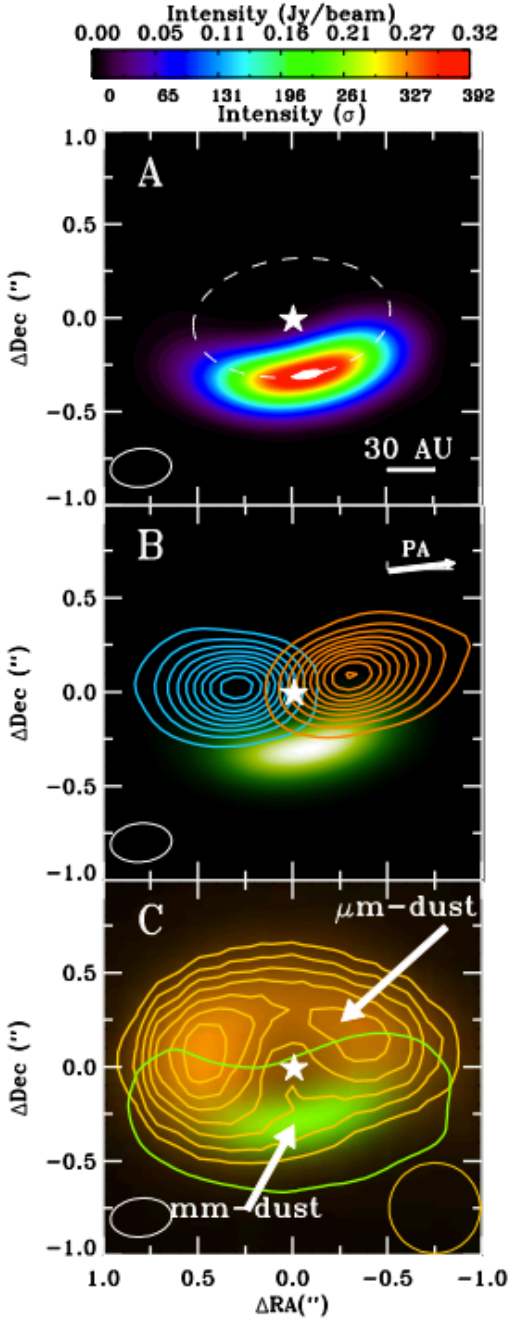
What if the Nitrogen were depleted by

6 orders of magnitude

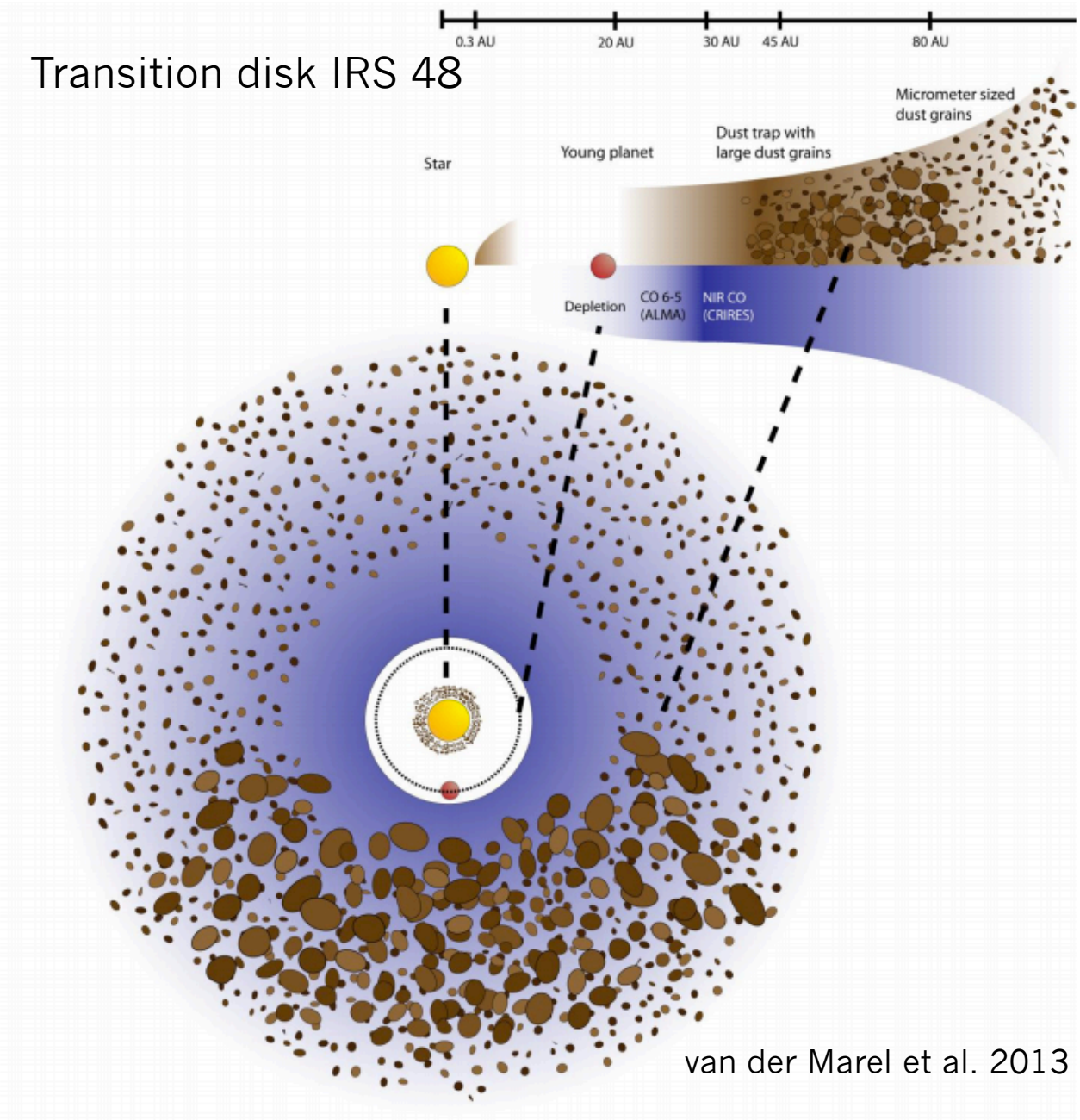
rather than

5?



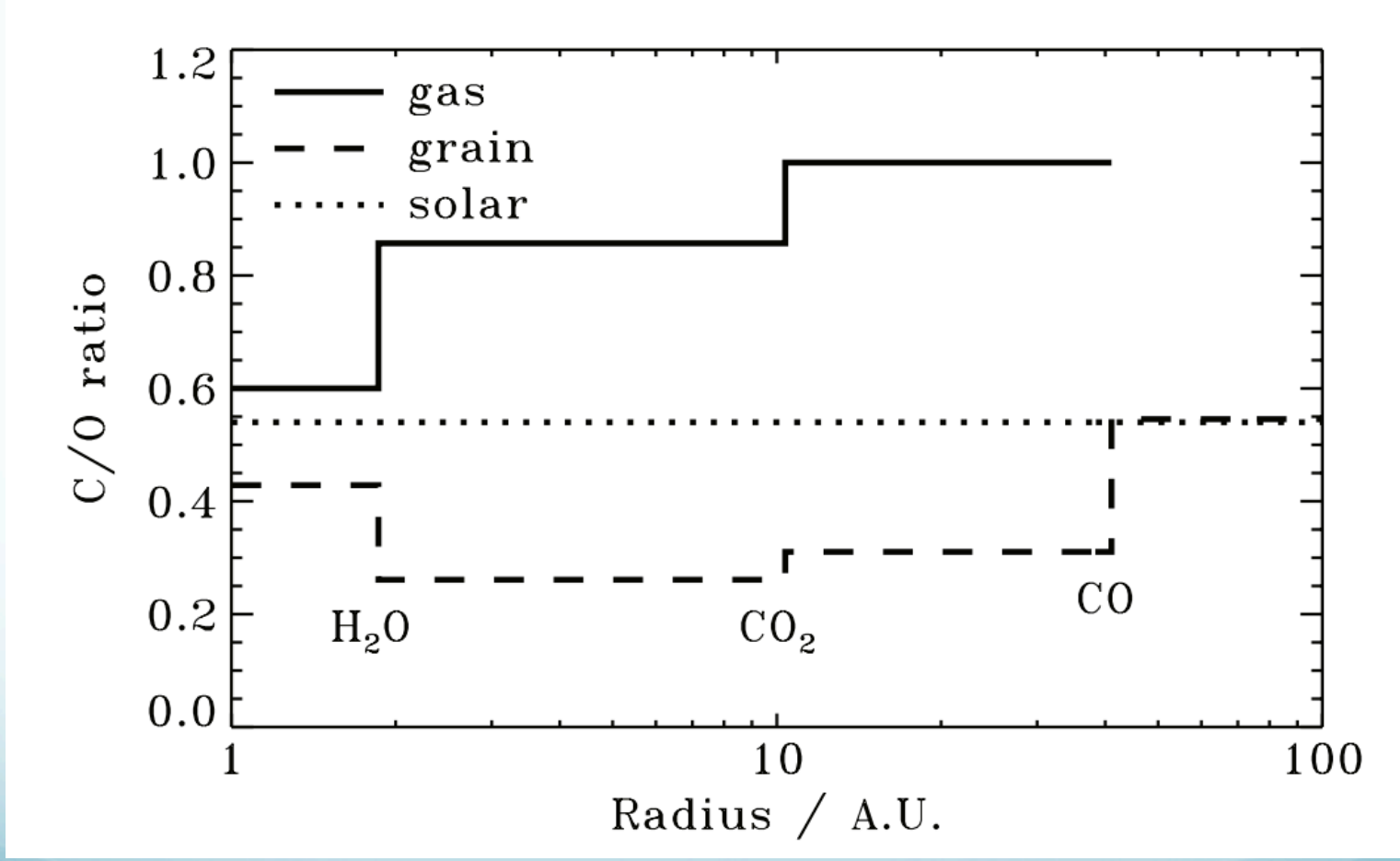


Transition disk IRS 48



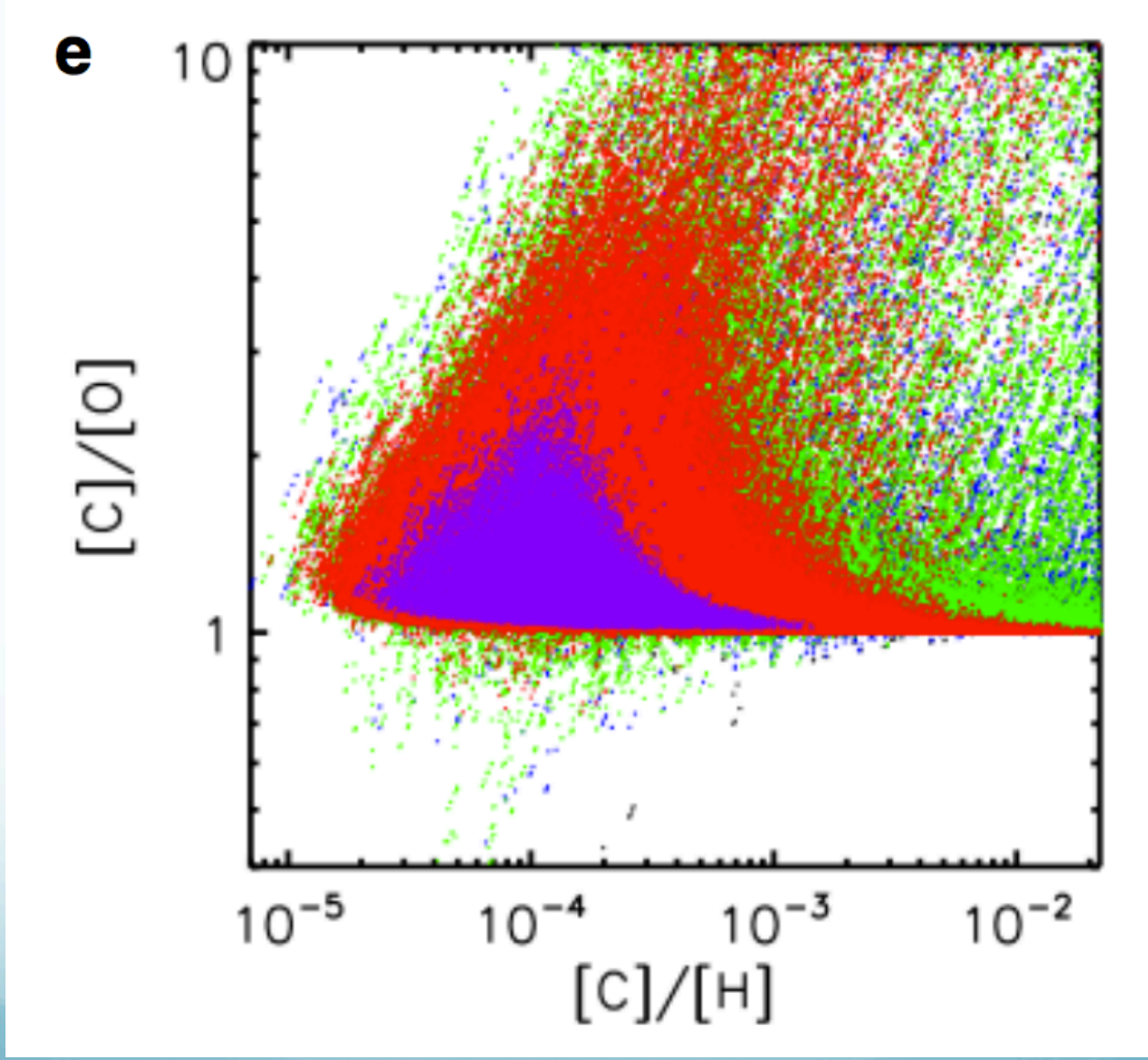
van der Marel et al. 2013

Planet C/O ratios depend on disk chemistry



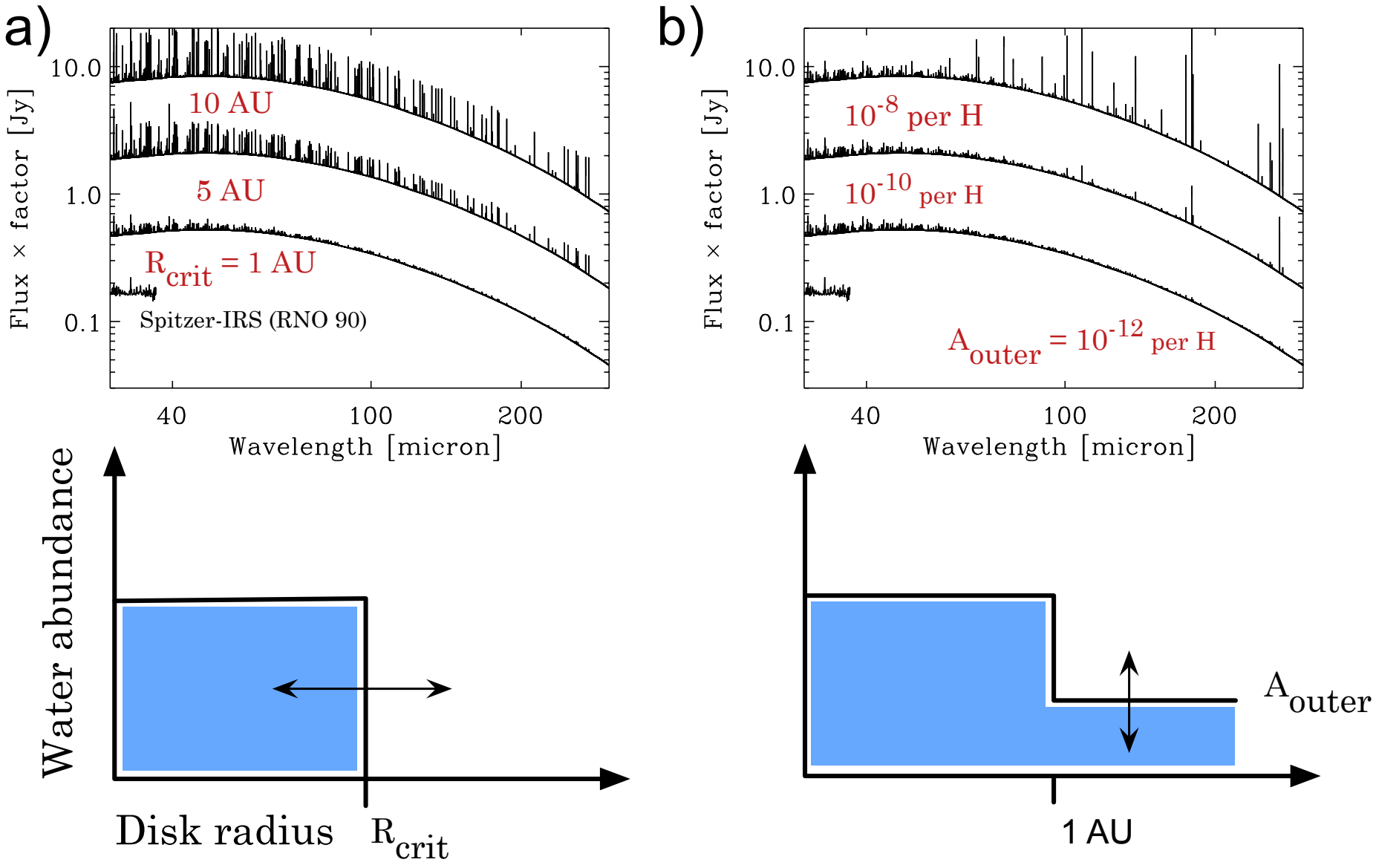
Oberg et al. 2011

WASP 12b has been claimed to have C/O>~1

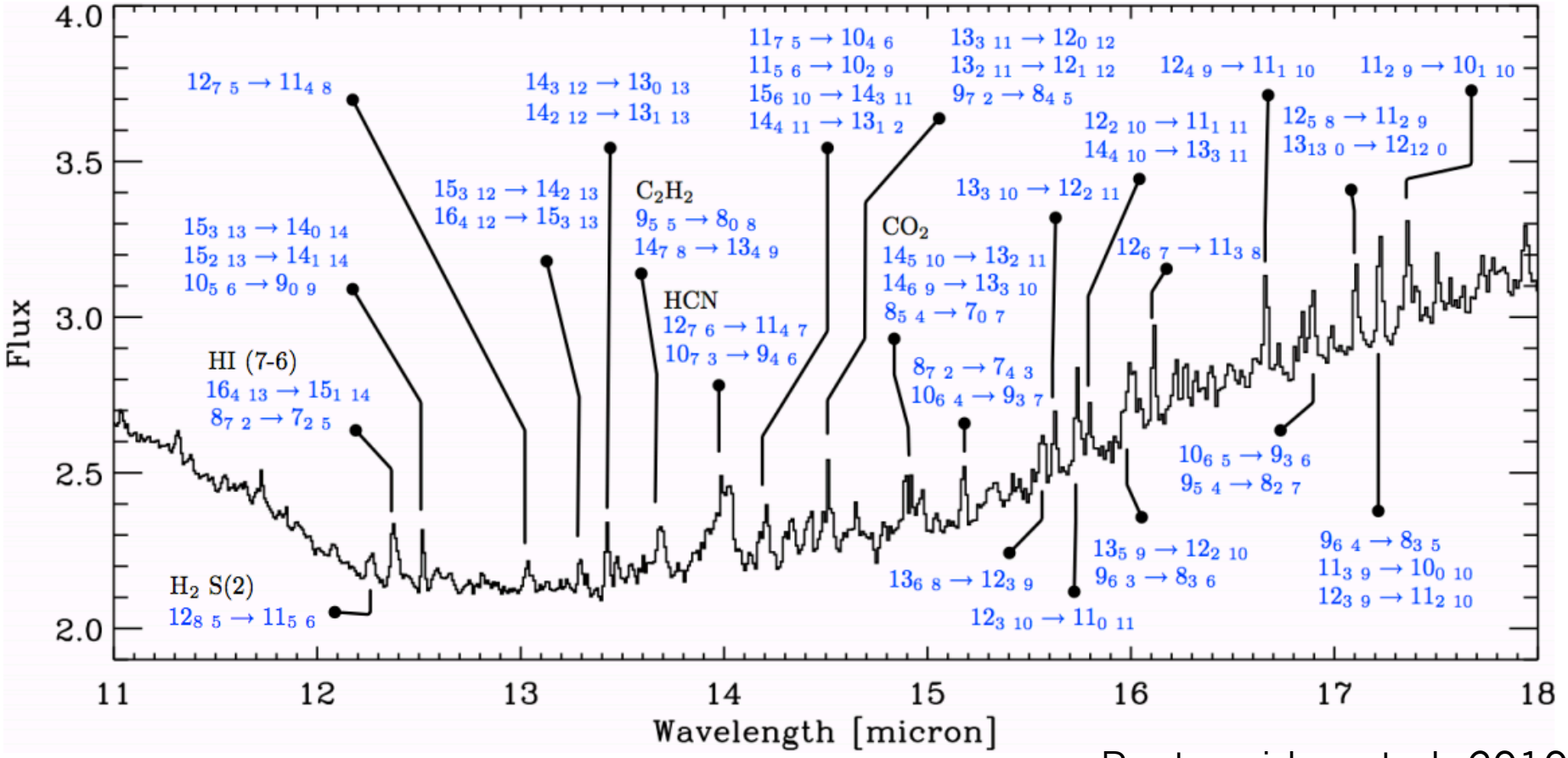


Madhusudhan et al. 2011

Measuring snow lines



Inner disks around solar type stars are abundant in water and organics

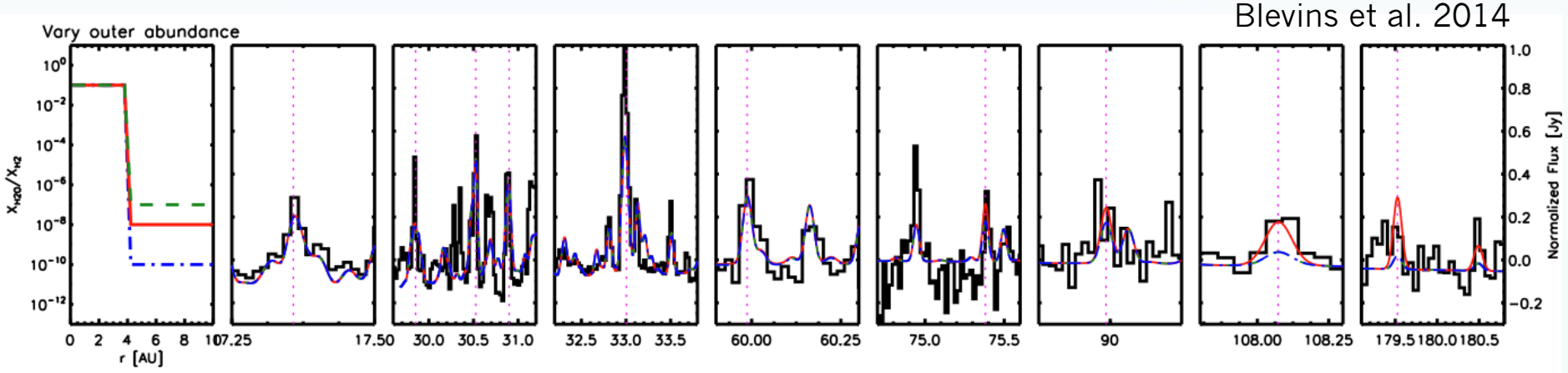


Pontoppidan et al. 2010

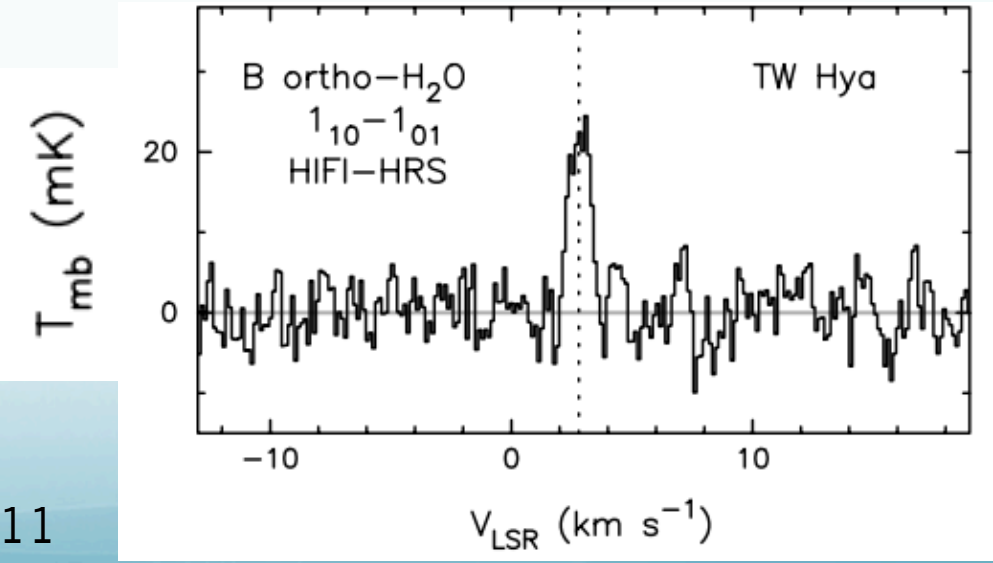
Also, John Carr, Joan Najita, Colette Salyk, Ilaria Pascucci

The observed H2O line SED

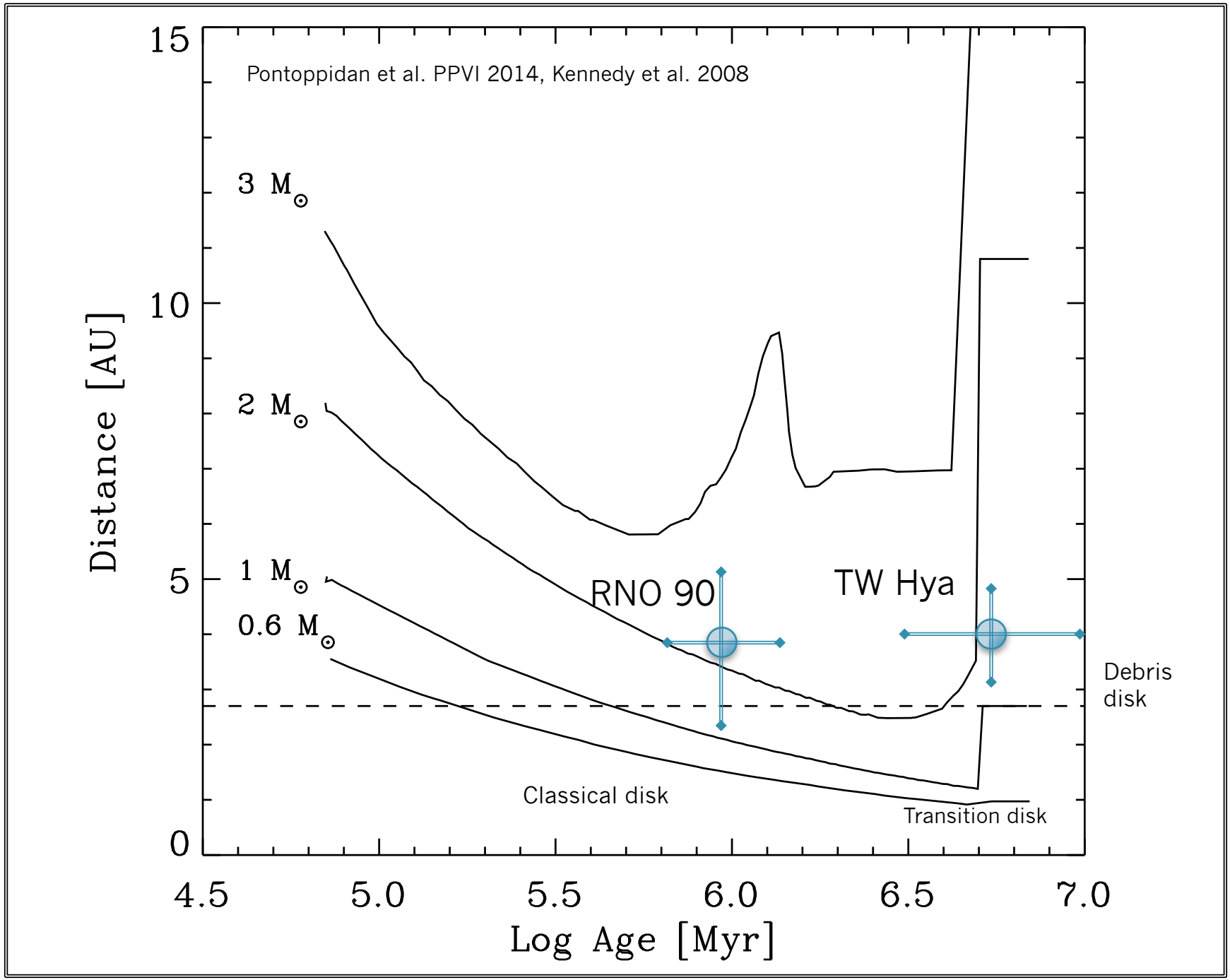
Blevins et al. 2014



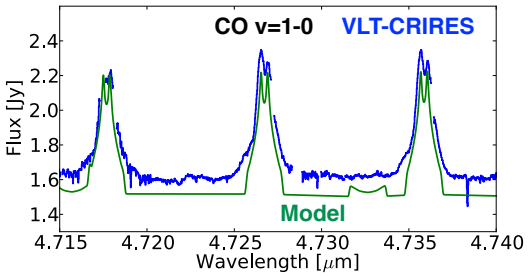
30 mu 60 mu 179.5 mu

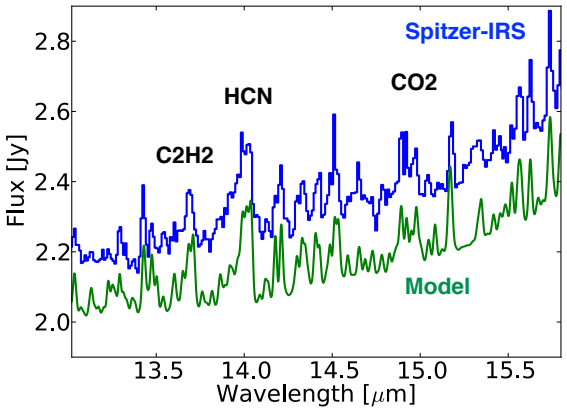


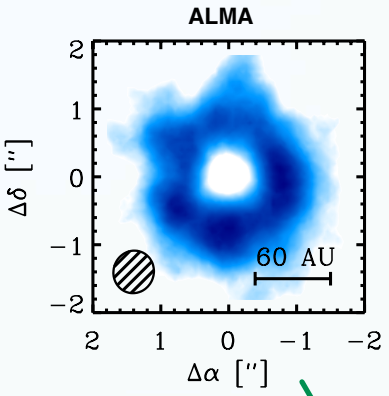
Hogerheijde et al. 2011

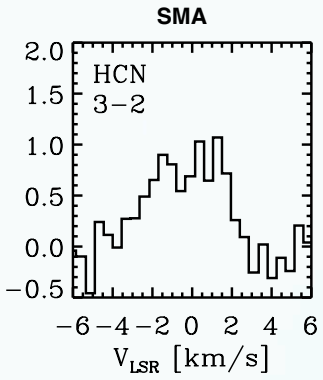

Pontoppidan et al. PPVI 2014, Kennedy et al. 2008
3 M⊙
2 M⊙
1 M⊙
0.6 M⊙
RNO 90
TW Hya
Debris disk
Classical disk
Transition disk
Distance [AU]
Log Age [Myr]
15
10
5
0
4.5
5.0
5.5
6.0
6.5
7.0

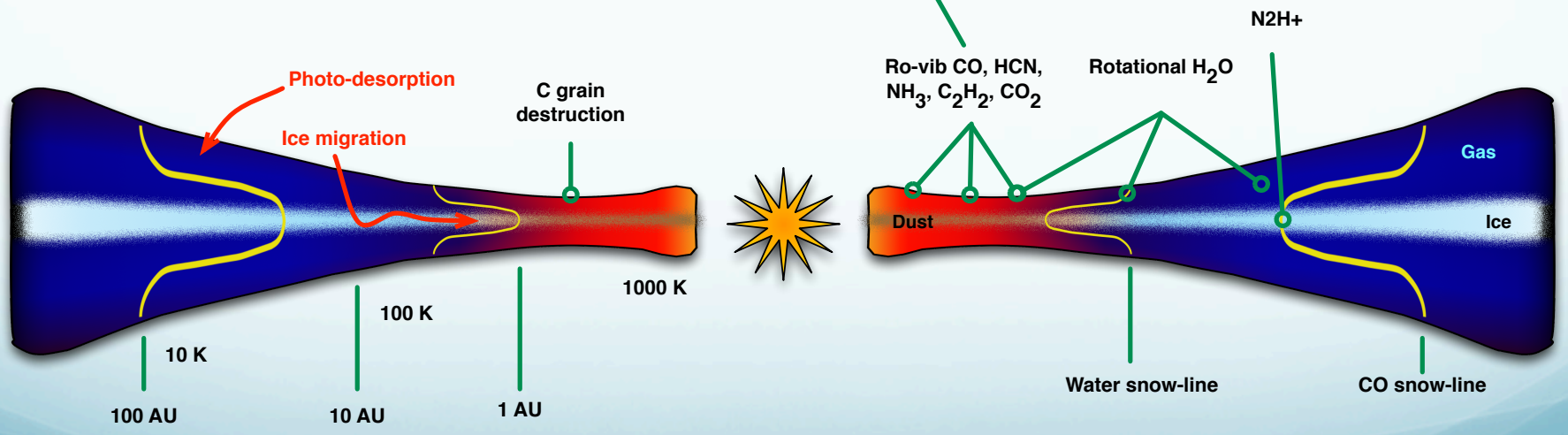
Volatiles in disks are traced in the mid-infrared to sub-millimeter wavelengths





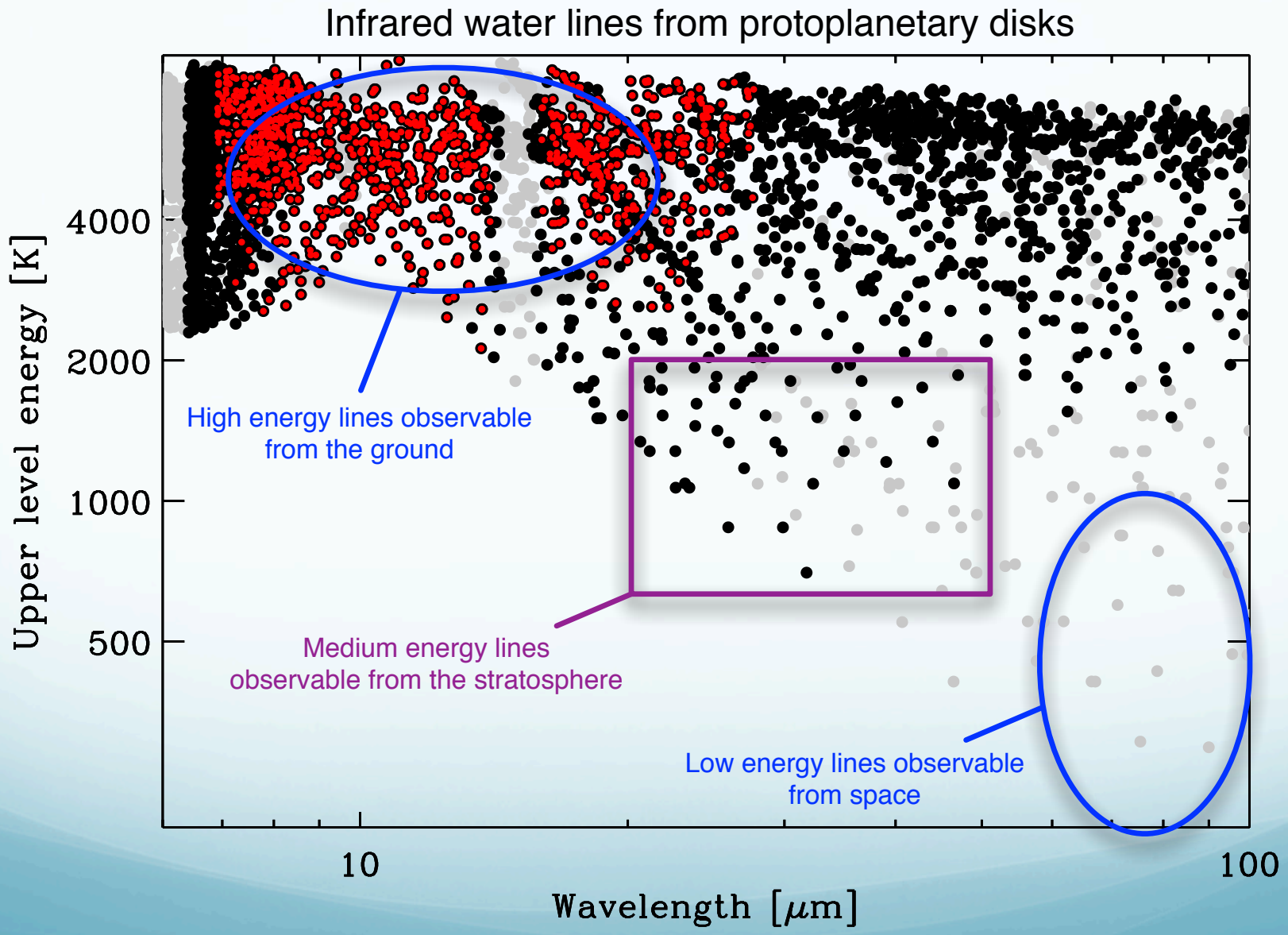




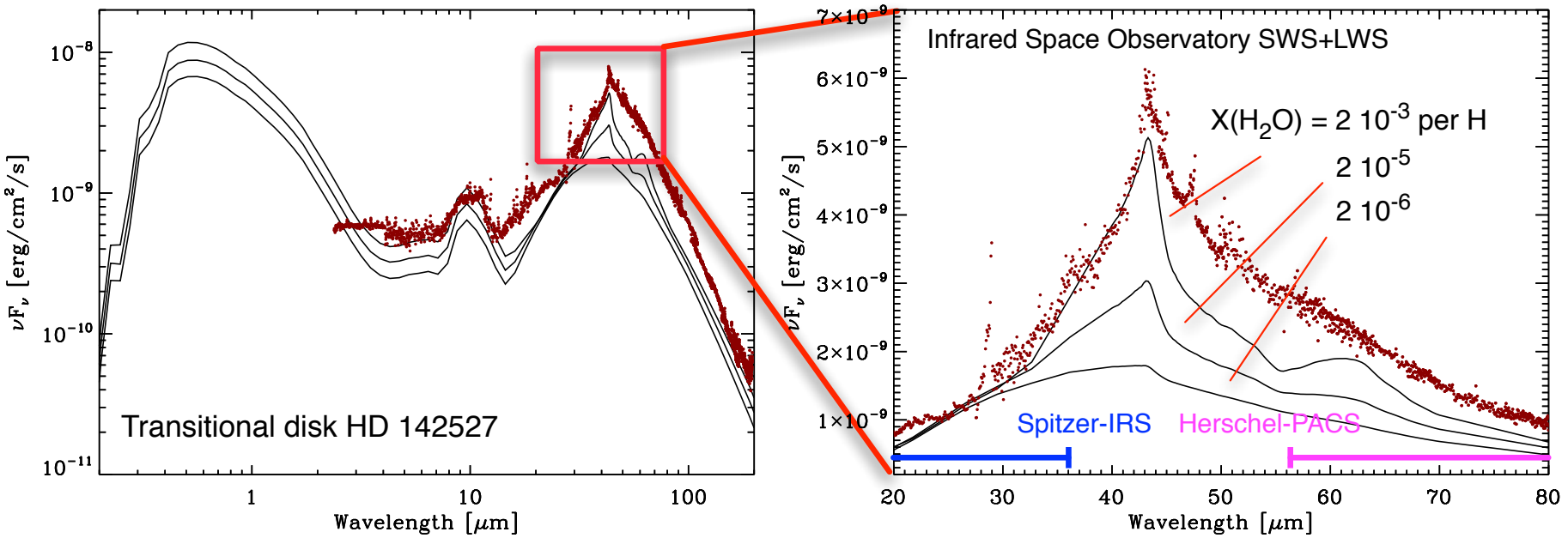


K. Pontoppidan
K. Oberg
E. Bergin

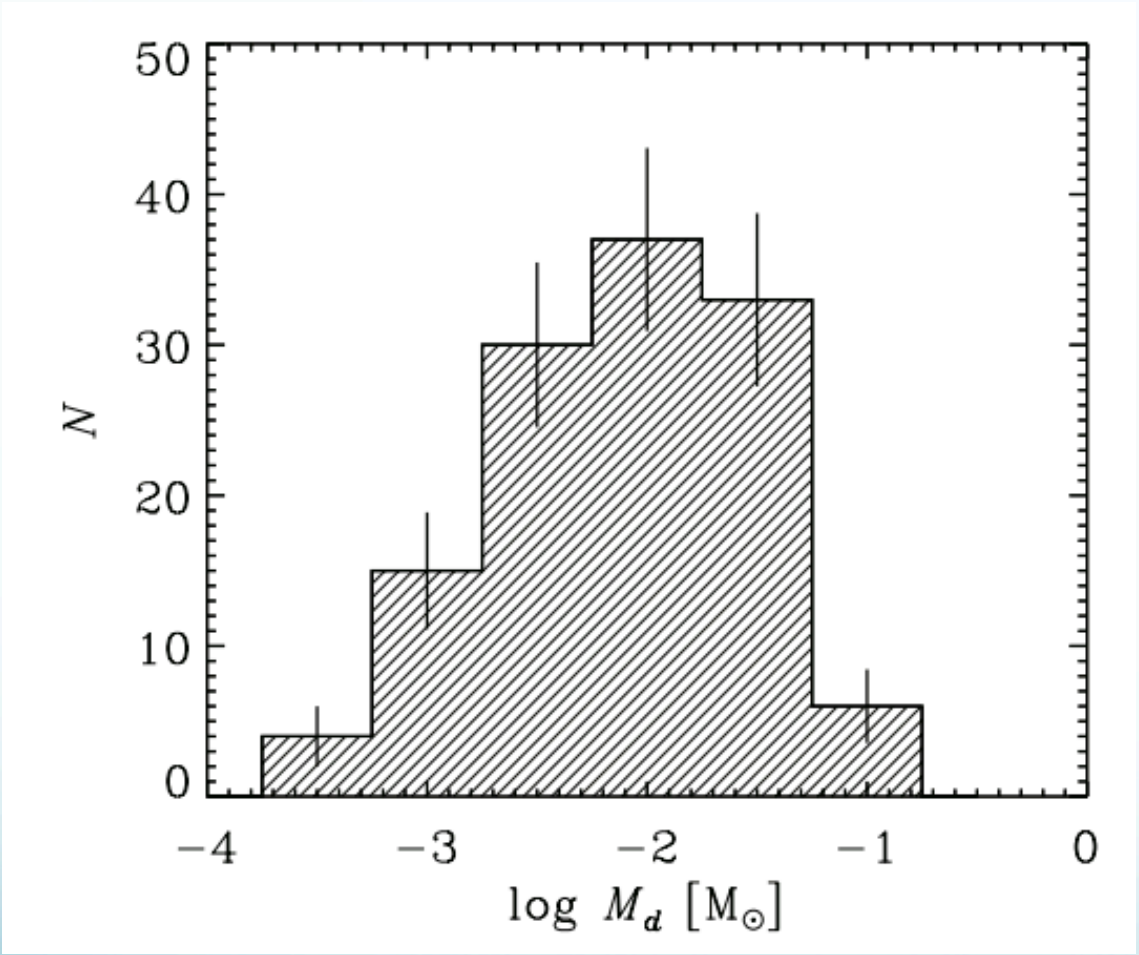
Observability of water



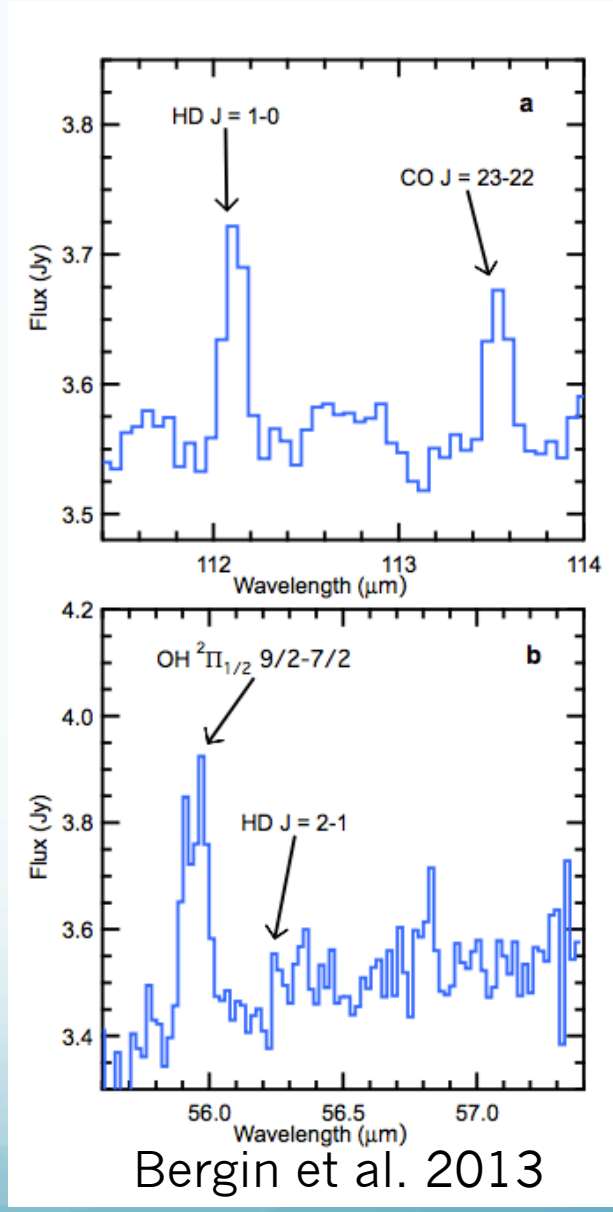
The FIR can (uniquely) see ice emission.



The holy grail: HD measures the disk gas mass



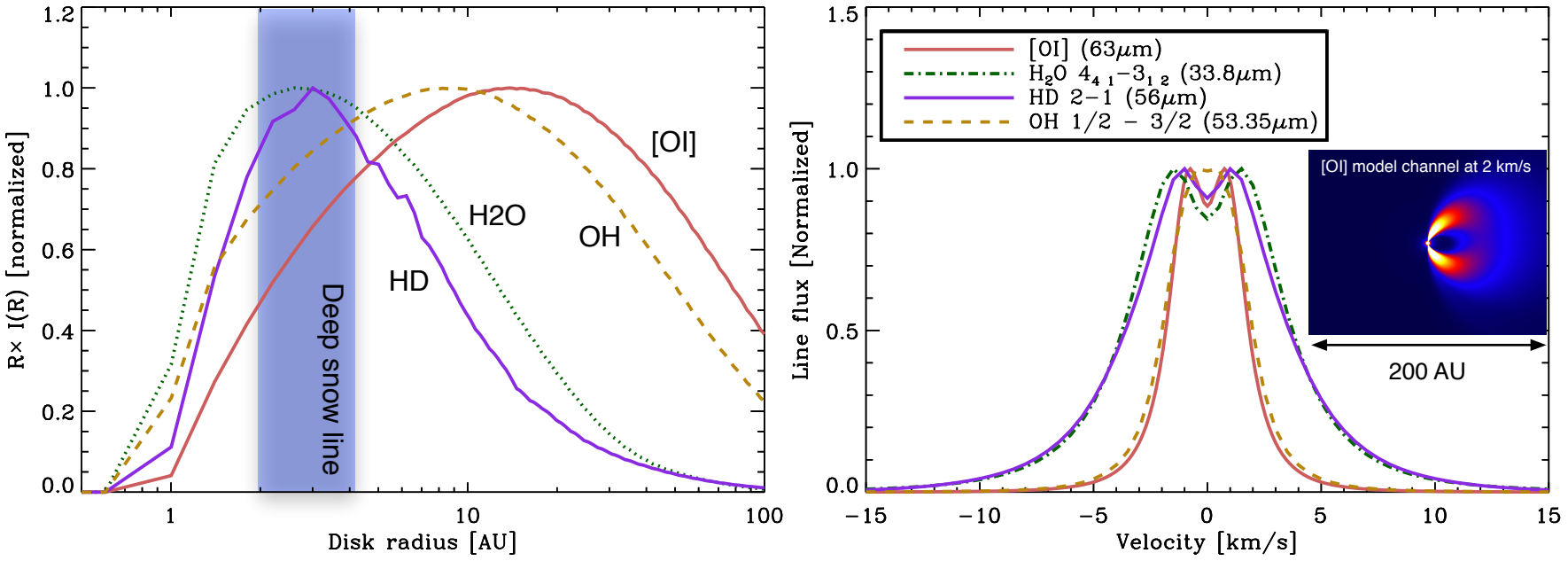
Andrews & Williams 2007



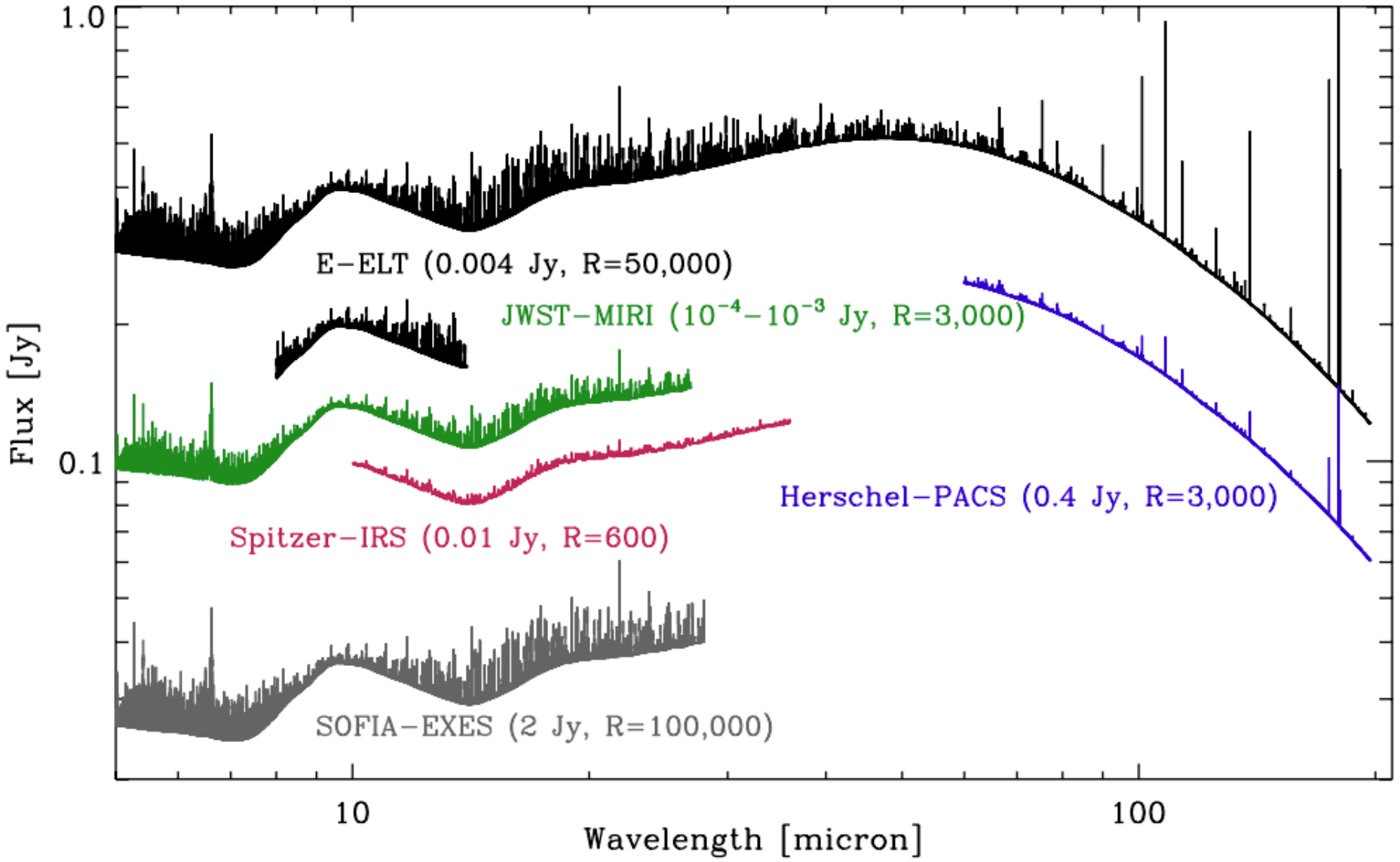
Bergin et al. 2013

Requirements for a FIR mission

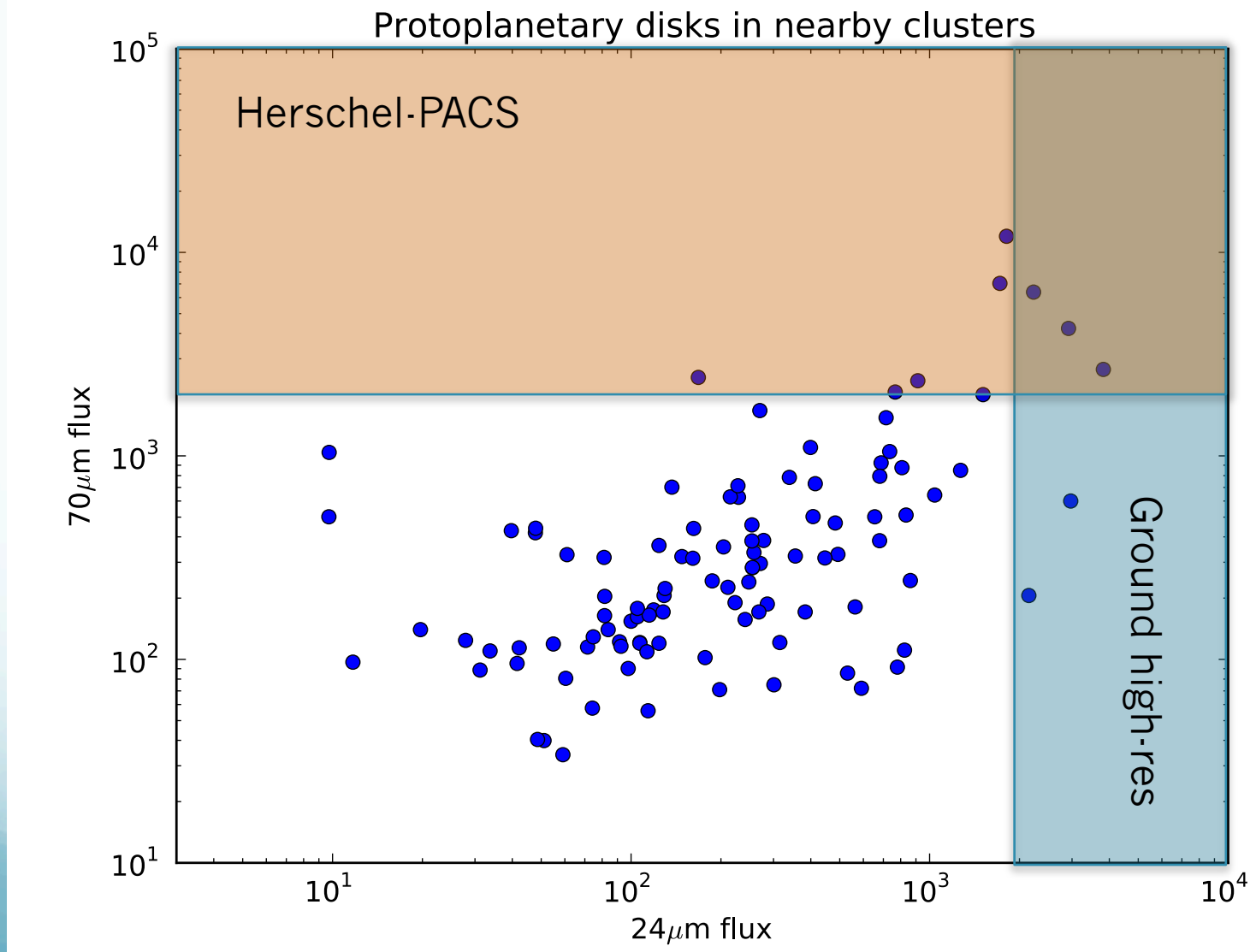
Spatial tracers in the FIR



Astronomical facilities sensitive to water in protoplanetary disks



Current sensitivities are just out of range



Killer science cases

- Snow lines (H_2O, but also other species). Compare to ALMA CO snow lines. Both ice and gas.
- HD direct disk gas mass measurements.
- Direct detection of disk ice using the 43 micron ice band.
- Energy balance of disk surfaces using velocity-resolved [OI] 63 micron (constrain thermochemical models).

Desired Measurement Capabilities

Parameter	Units	Value or Range
Wavelength range	μm	25-500
Angular resolution	arcsec	0.5-5.0
Spectral resolution, ($\lambda/\Delta\lambda$)	dimensionless	10,000 (minimum), 50,000 (ideal)
Continuum sensitivity	μJy	1,000 (1sig, minimum)
Spectral line sensitivity	10^{-19} W m^{-2}	--
Instantaneous FoV	arcmin	1
Number of target fields	dimensionless	100-1000
Field of Regard	sr	>2pi

N.B. In case the symbols don't display properly, the units of wavelength are microns, and the units of continuum sensitivity are micro-Janskys. Spectral resolution is lambda/(delta lambda).