THE DISPERSAL OF PLANET-FORMING DISCS

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A NEW GENERATION OF X-RAY PHOTO-EVAPORATION MODELS

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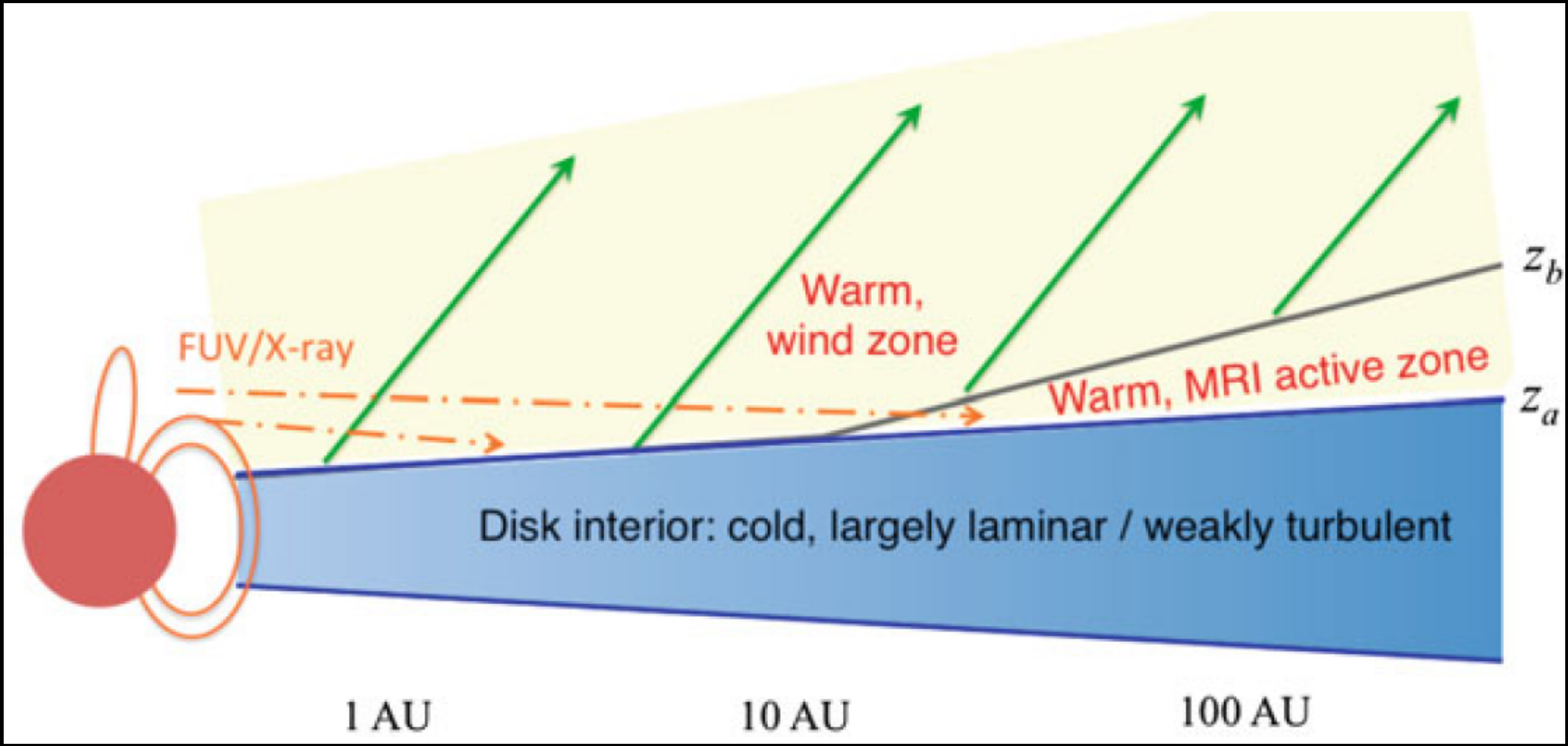
OSSERVATORIO ASTRONOMICO DI ROMA - JUNE 27TH, 2018

1. DISC WINDS

DRIVERS OF ANGULAR MOMENTUM AND MASS LOSS

DISC EVOLUTION

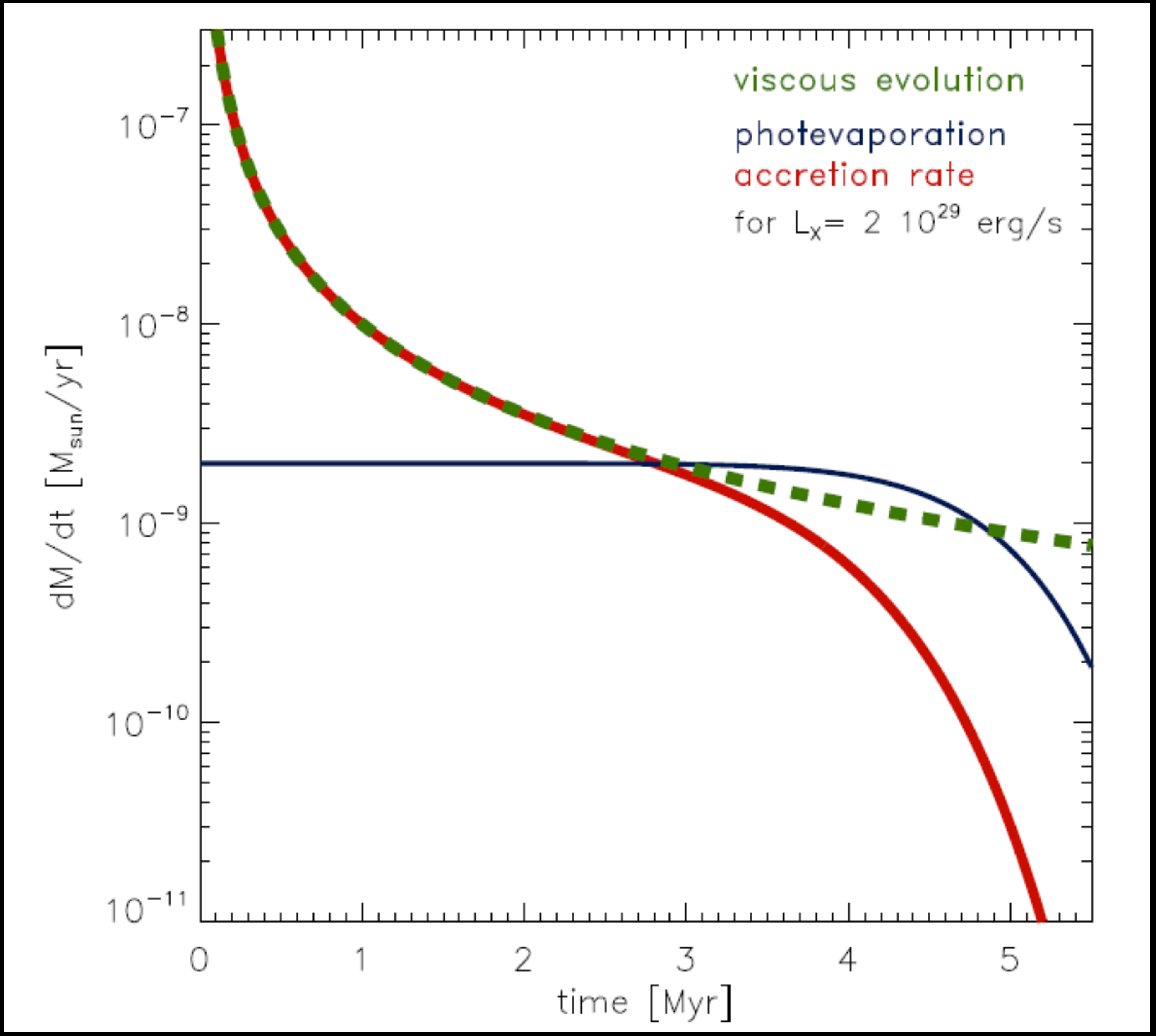
Extract angular momentum



Bai et al., 2016

DISC DISPERSAL

Mass-loss rate becomes greater than accretion rate after few Myr

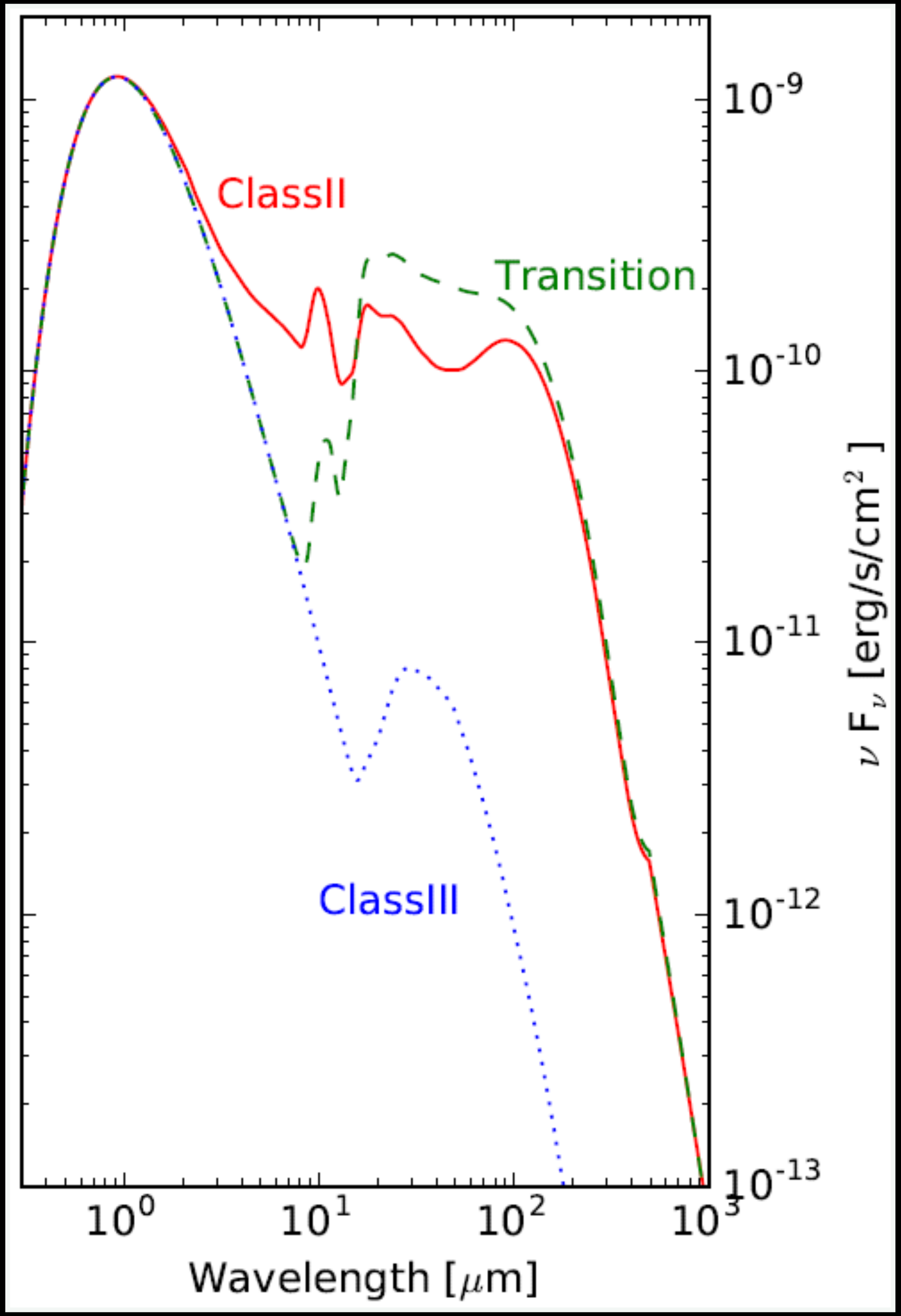


2. TRANSITION DISKS

BASIC CONCEPTS

DEFINITION

- firstly defined observationally (Strom+, 1989)
- stars with significantly reduced NIR excess emission in their SED
- the fraction of protoplanetary discs that are Transition Discs is ~13% (Luhman+, 2010)

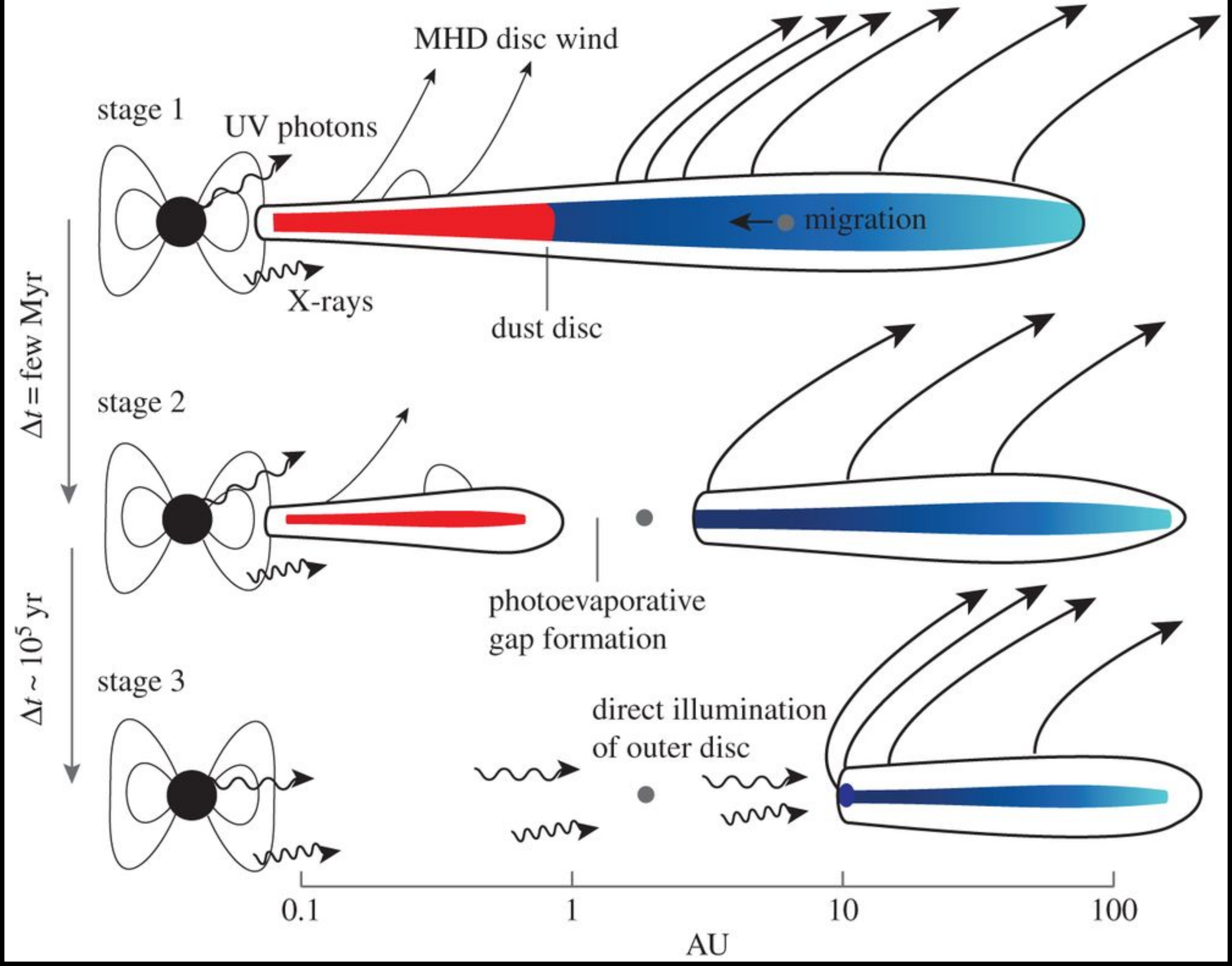


Pascucci et al., 2010

FORMATION

Type I - X-F(E)UV photoevaporation (i.e. see Elisabetta's talk)

- when photo-evaporation opens a gap in the disc, it removes it on a short time-scale the disc

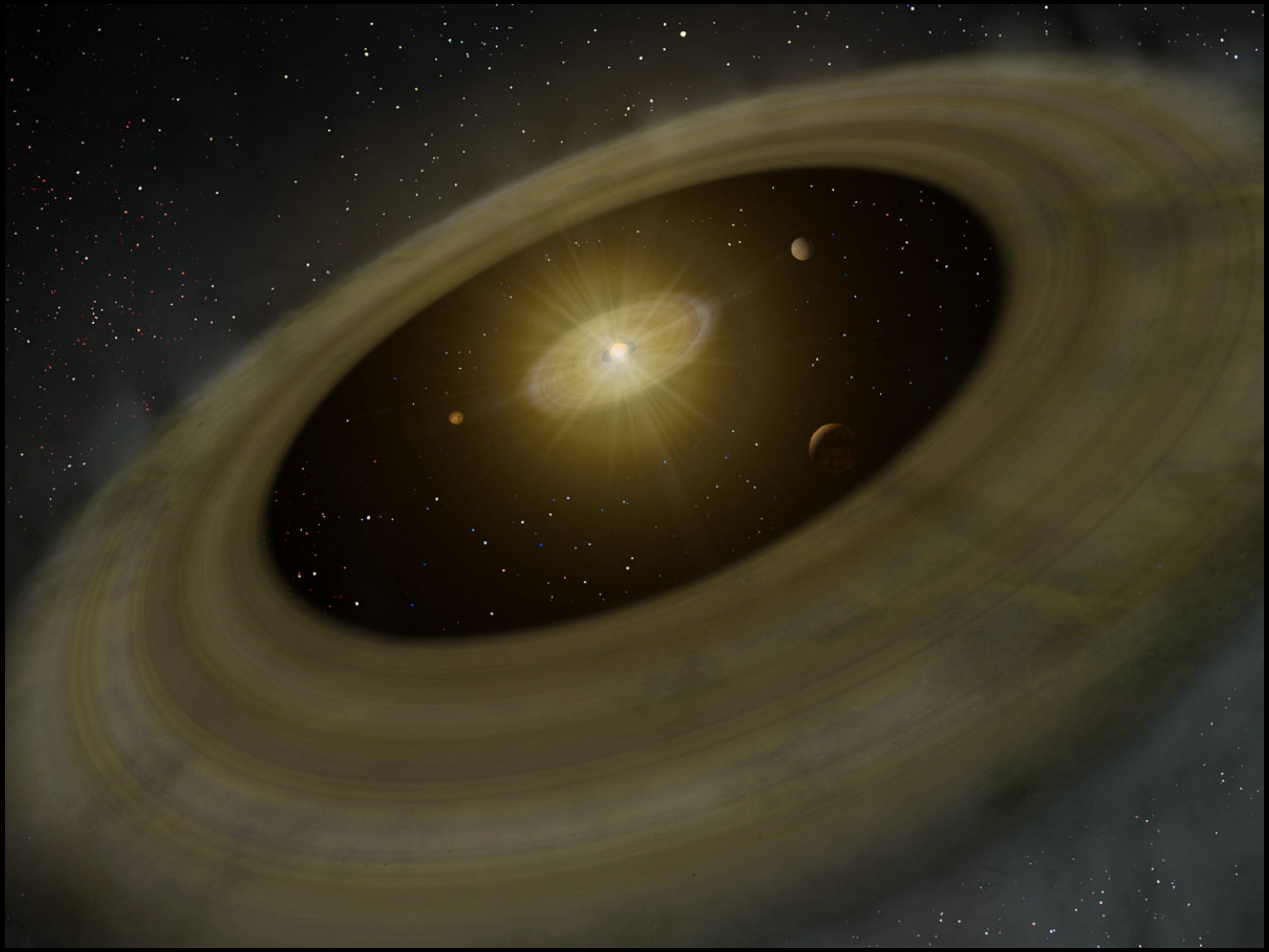


Alexander et al., 2014

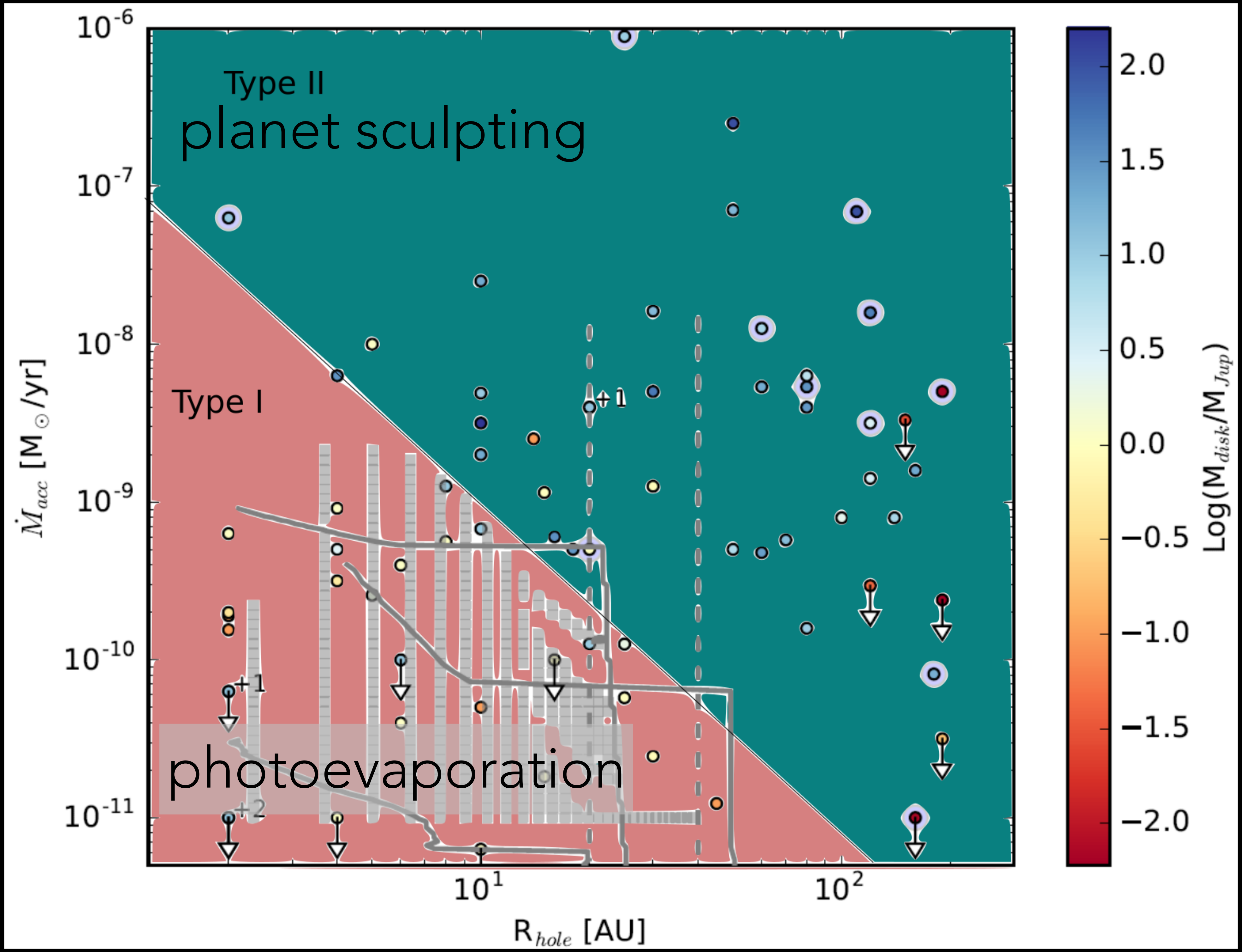
FORMATION

Type II - Planetary (binary) sculpting (i.e. Daniel Price's view)

- systems of 3–6 giant planets are needed, binary (misaligned) companion



DATASET



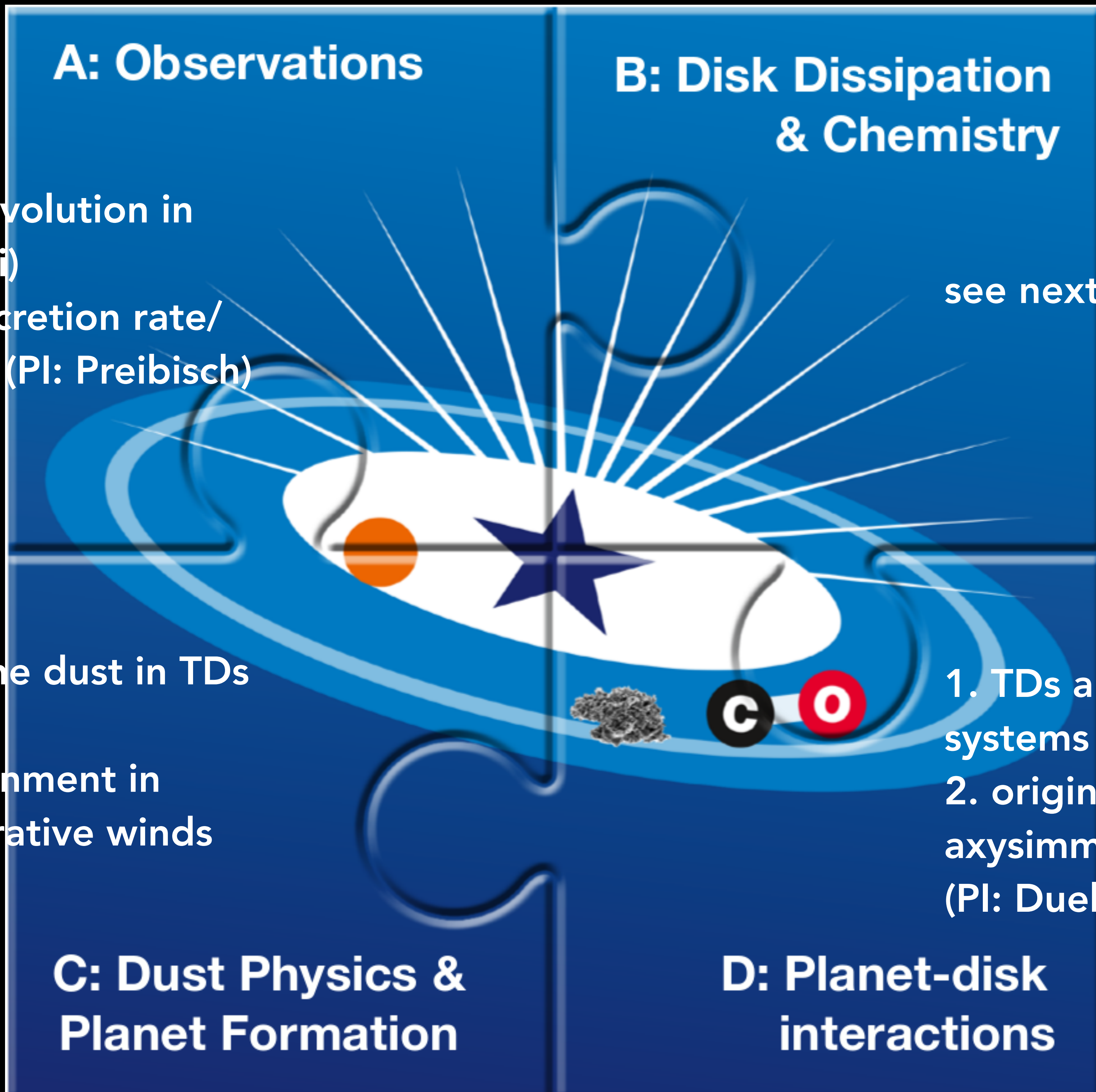
Type II
planet sculpting
Type I
photoevaporation
+1
+1
+2
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
$\dot{M}_{acc}$ [$M_\odot$/yr]
10^{1}
10^{2}
R_{hole} [AU]
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
Log(M_{disk}/M_{Jup})

3. RESEARCH UNIT

A TASK FORCE TO UNDERSTAND TDS

JEDI
JETS & DISKS @ INAF

PLANET FORMATION WITNESSES AND PROBES: TRANSITION DISCS



1. solid/gas evolution in discs (PI: Testi)
2. relation accretion rate/ X-ray activity (PI: Preibisch)

see next slide

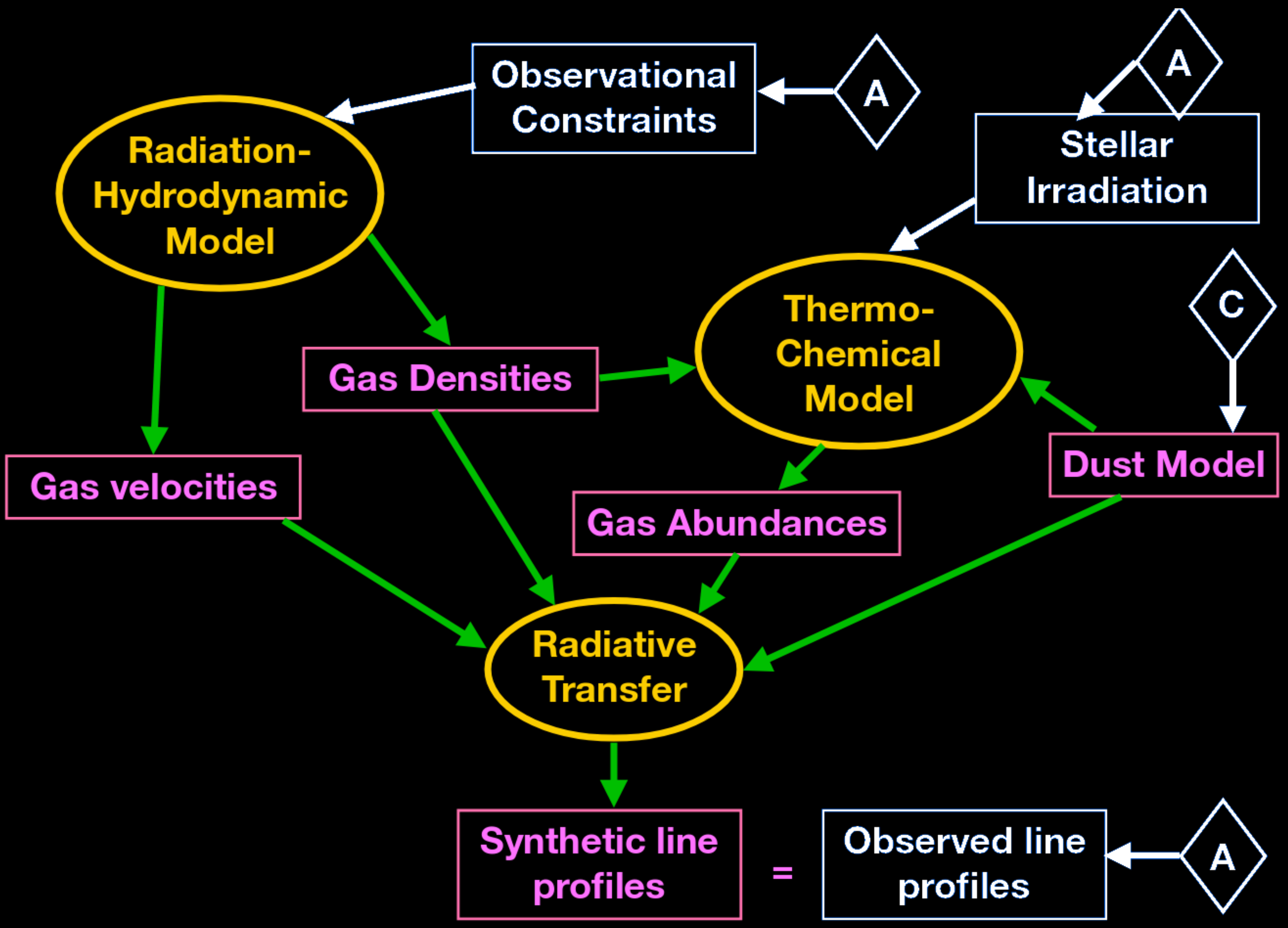
1. trapping the dust in TDs (PI: Birnstiel)
2. dust entrainment in photo-evaporative winds (PI: Ercolano)

1. TDs and planetary systems (PI: Kley)
2. origin of non-axysimmetric features in TD (PI: Duellemond)

PROJECT B

1. radiation-hydrodynamics models of photo-evaporative discs + chemistry (PI: Ercolano)

2. astrochemistry in the atmospheres and winds of TDs (PI: Caselli)



TEMPERATURE

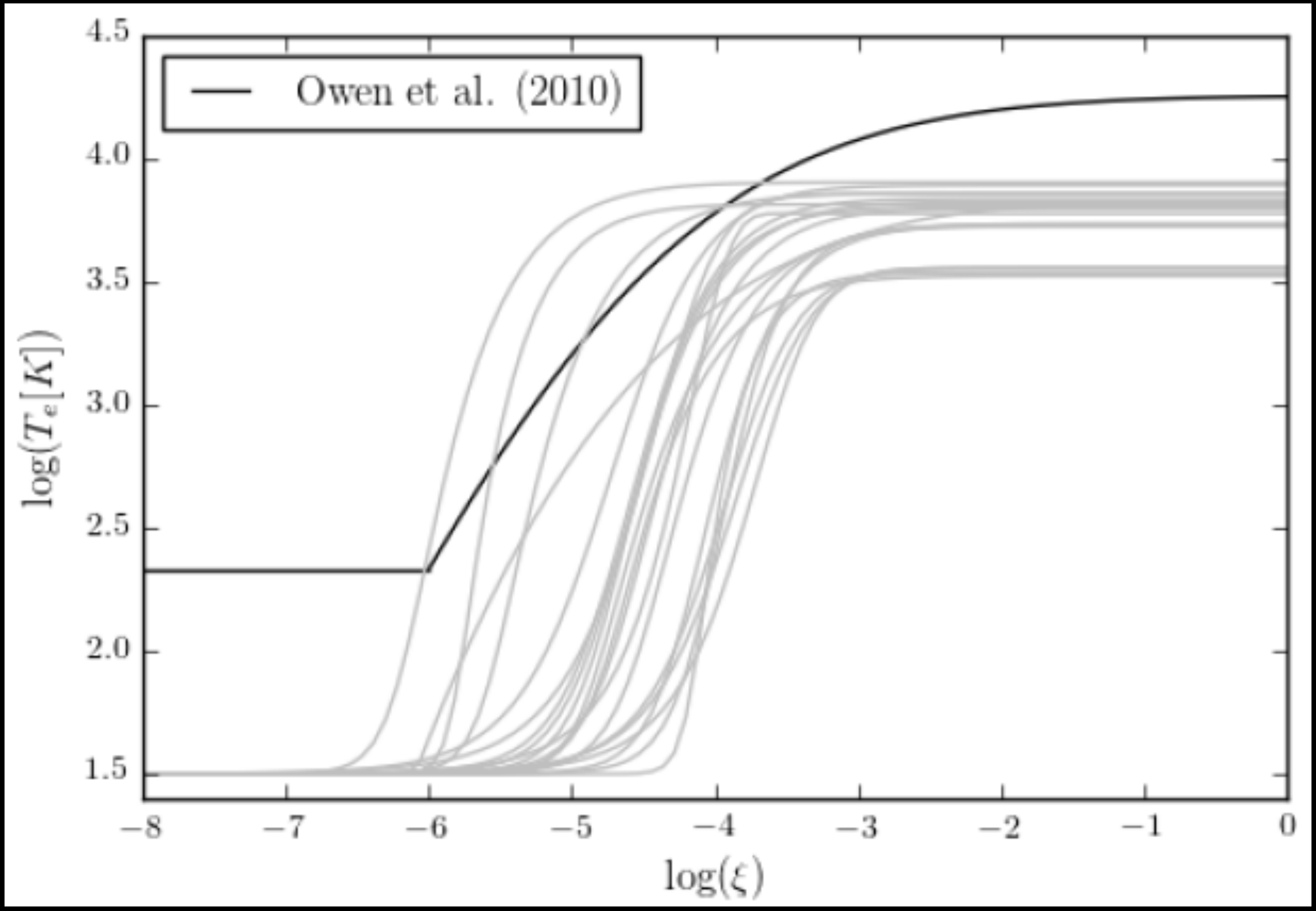
$\xi = L_X/nr^2$

+ column density

NEW!

MOCASSIN → T_{gas}

(Radiative Transfer)



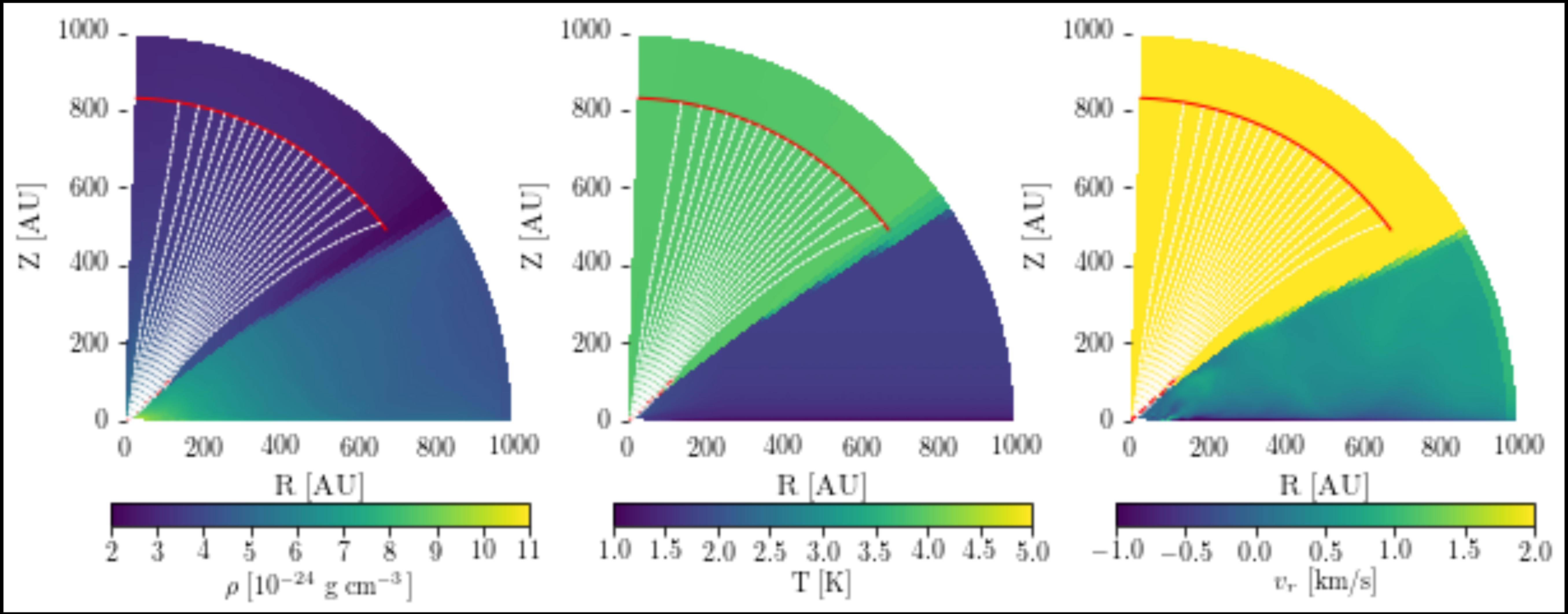
Picogna et al., in submission

PARAMETER SPACE

PARAMETER	VALUE
CODE	PLUTO (MIGNONE+2007)
RADIAL RANGE	0.33-1000 AU
VERTICAL RANGE	0.005-PI/2
LOG(LX)	28.3,29.3,29.8,30.3, 31.3,31.8 ERG/S
INNER HOLE	0,4.6,14.1,21.2,30.3 AU
CARBON DEPLETION	C/3, C/10, C/100
STAR MASS	0.3 - 2.0 SOLAR MASSES

RESULTS

Disc without hole

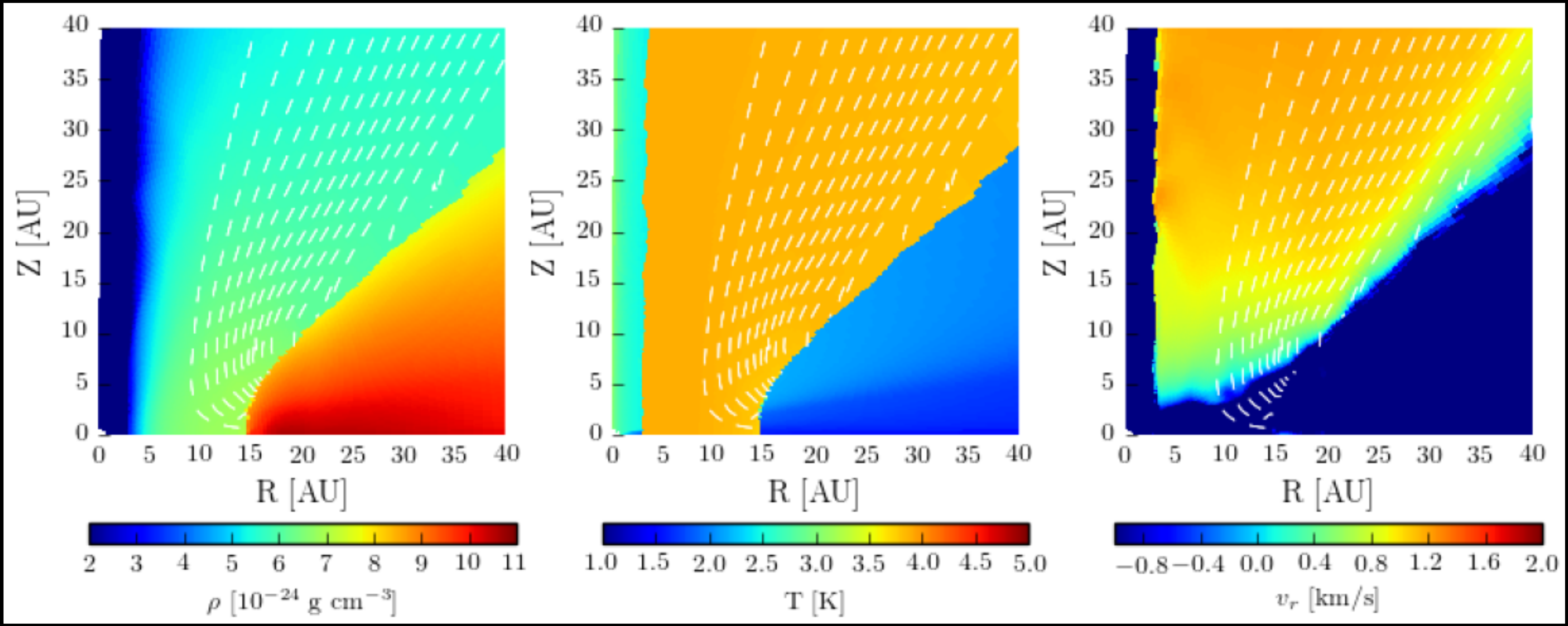


density temperature radial velocity

Picogna et al., in submission

RESULTS

Disc with 15 AU hole

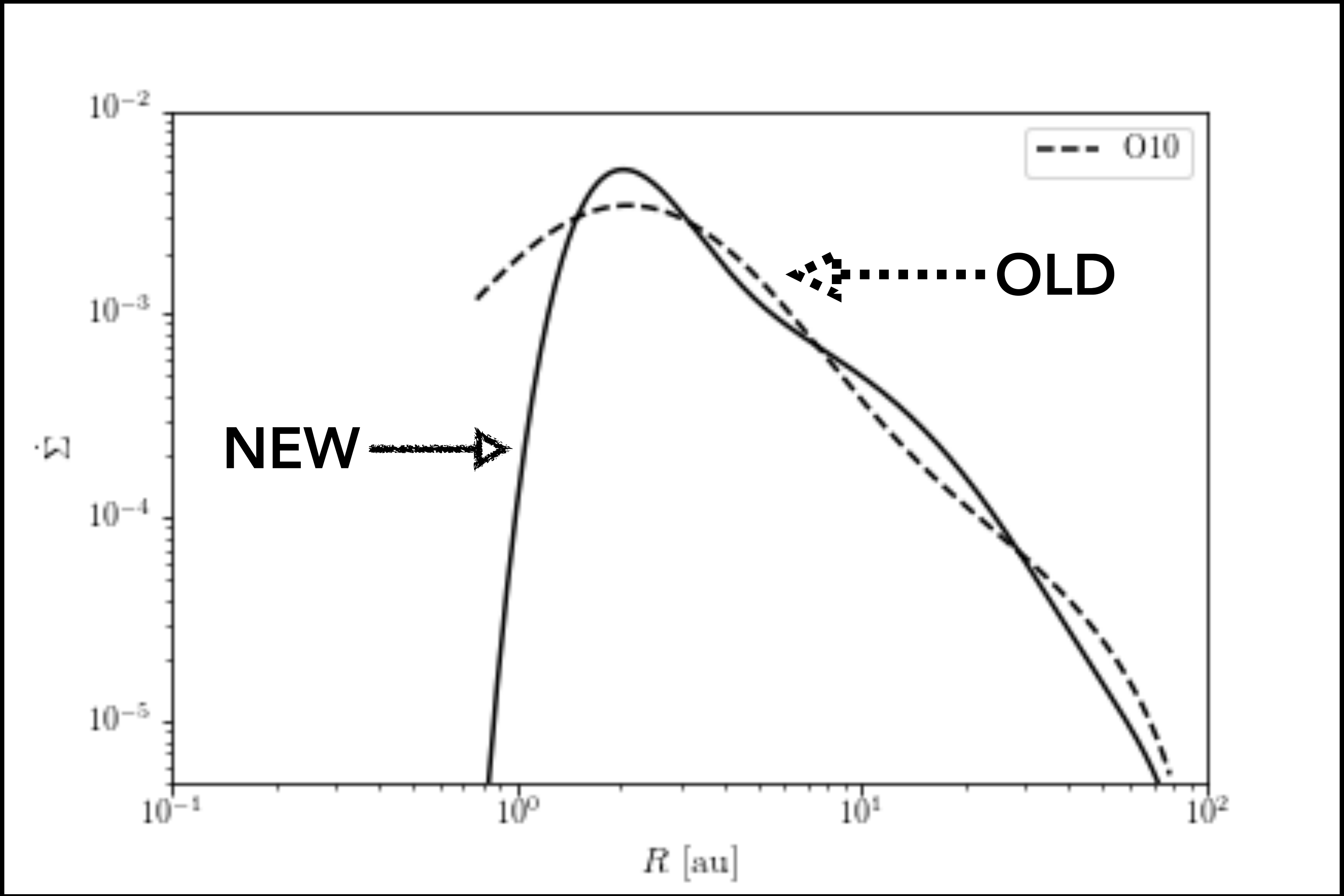


density temperature radial velocity

Picogna et al., in submission

WIND PROFILES

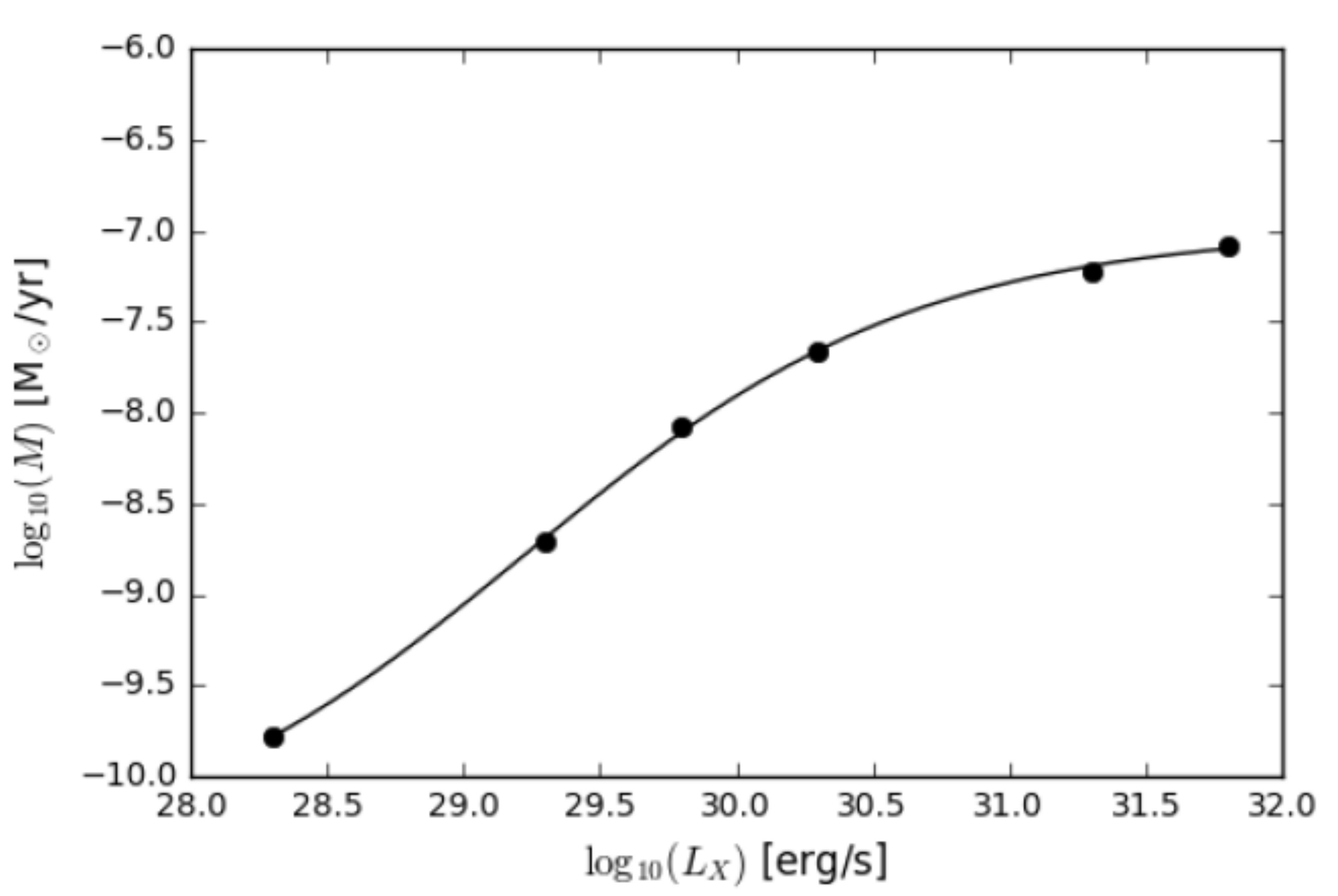
Total Mass-loss rate is more than 2 times larger than in the old prescription: > 2*10^(-8) solar masses/year



Picogna et al., in submission

WIND DEPENDENCE

Cumulative Mass-loss rate

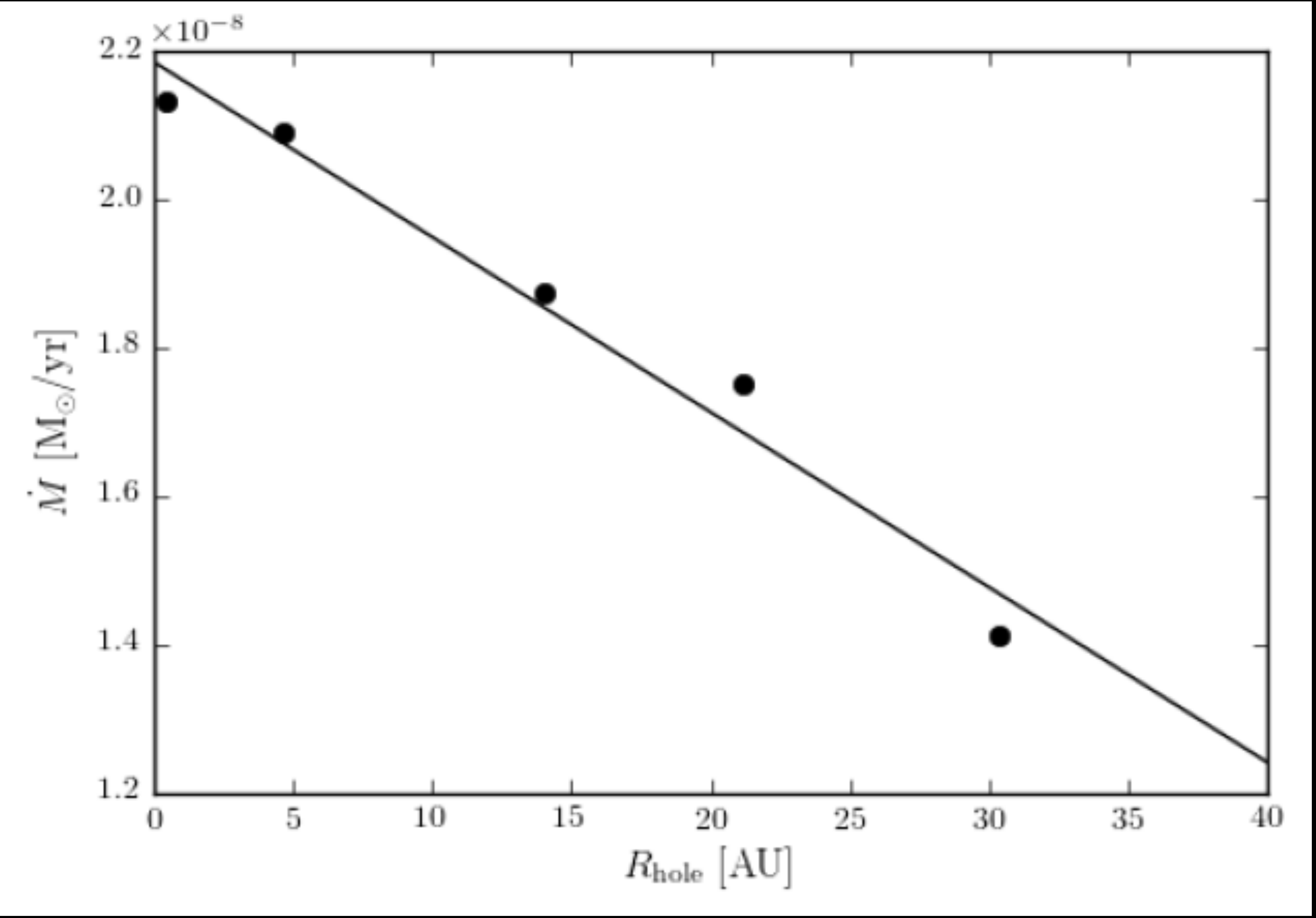


Picogna et al., in submission

X-ray luminosities

WIND DEPENDENCE

Cumulative Mass-loss rate



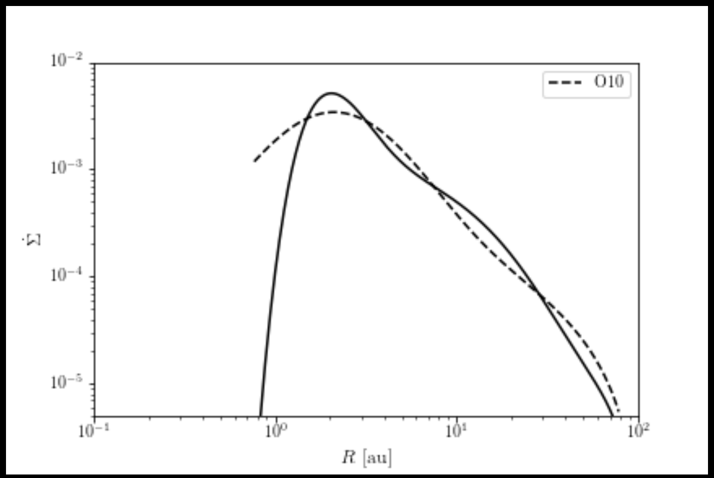
Hole radius

Picogna et al., in submission

4. OBSERVATIONAL CONSTRAINTS

OBSERVABLES

Disc wind profiles



SPOCK

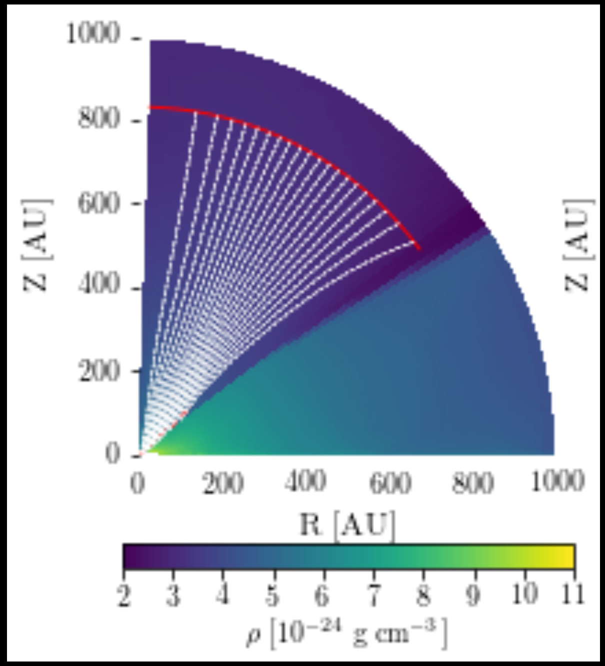
(1D viscous evolution)

OBSERVABLES

Disc demographics

Synthetic line profiles

PLUTO
Hydro simulations

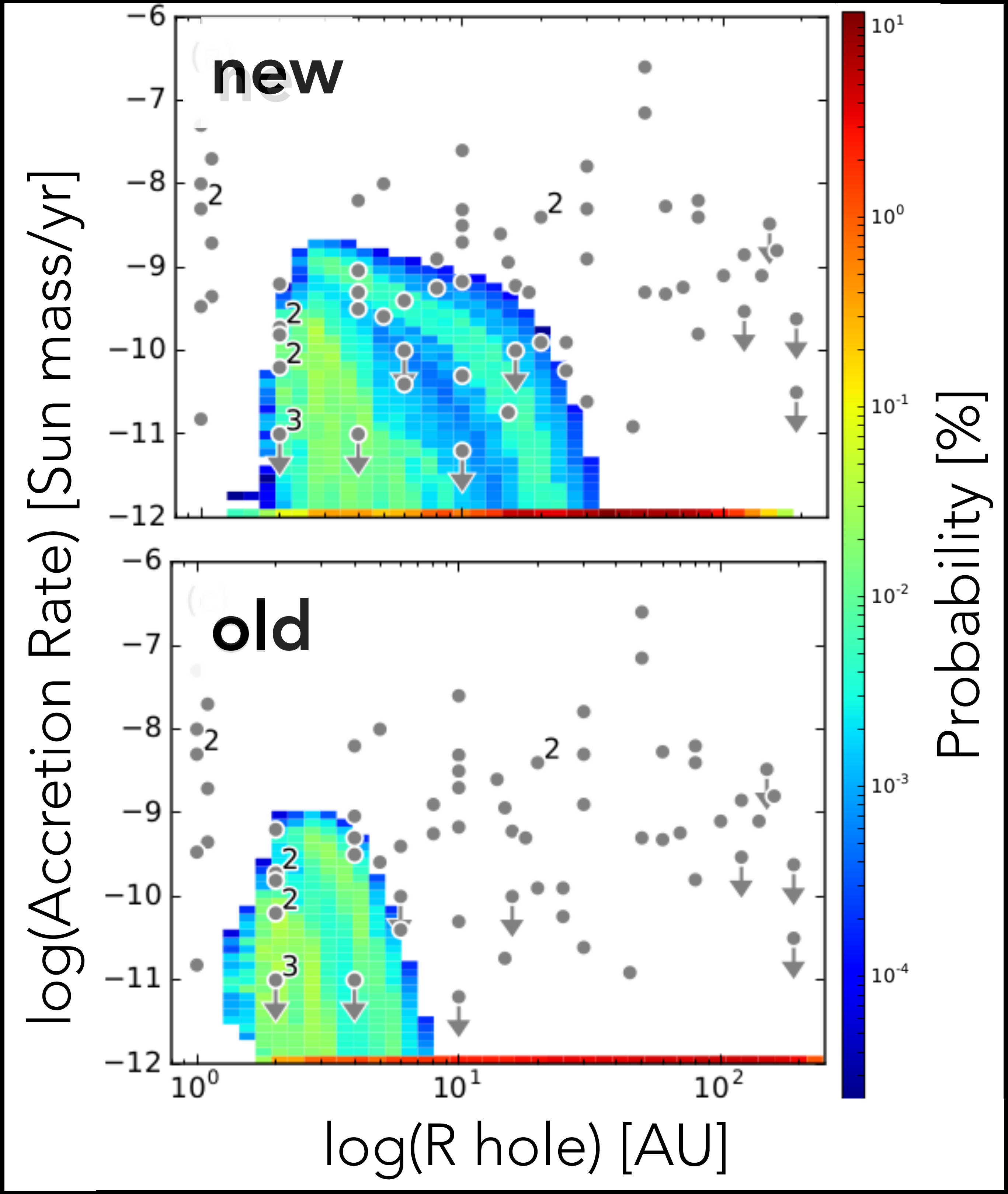


integrate streamlines

MOCASSIN (Radiative Transfer)

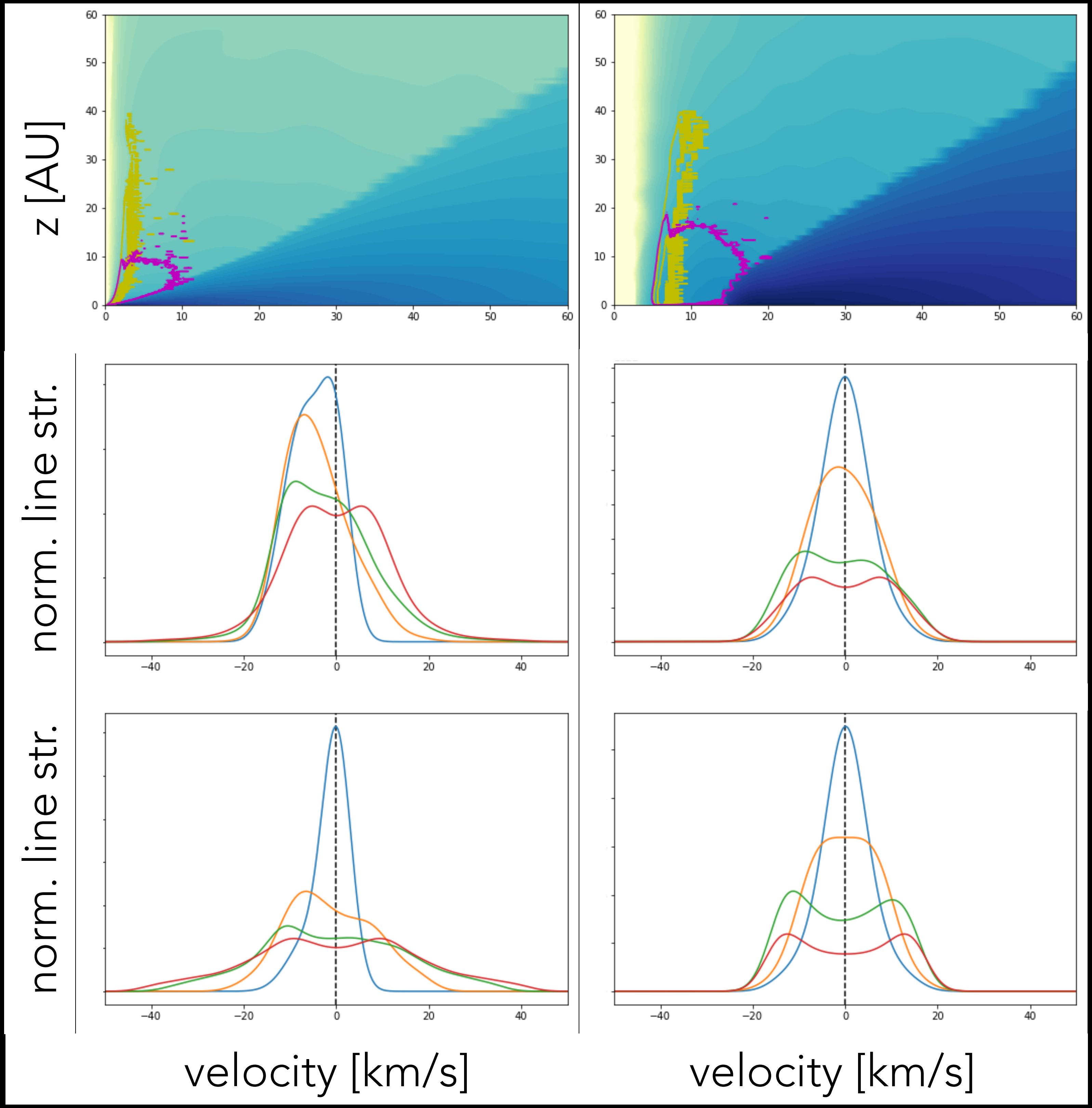
DISC DEMOGRAPHICS

- we applied the wind profiles to a 1D viscous evolution code (SPOCK)
- we run a parameter space analysis finding the probability to observe a transition disc with a specific accretion rate and inner radius



Picogna et al., in submission

EMISSION LINES



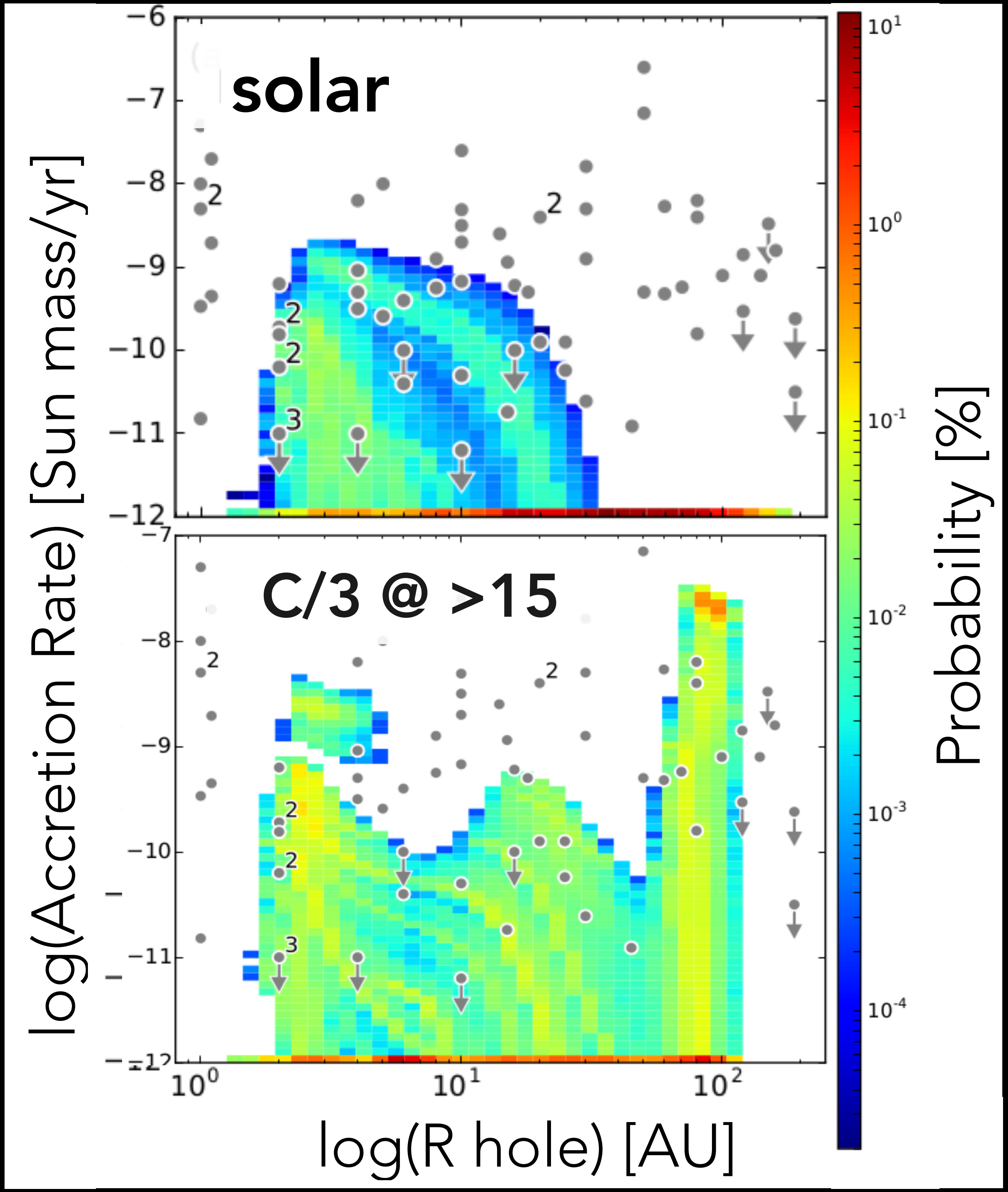
[NeII]
purple

[OI]
yellow

Picogna et al., in submission

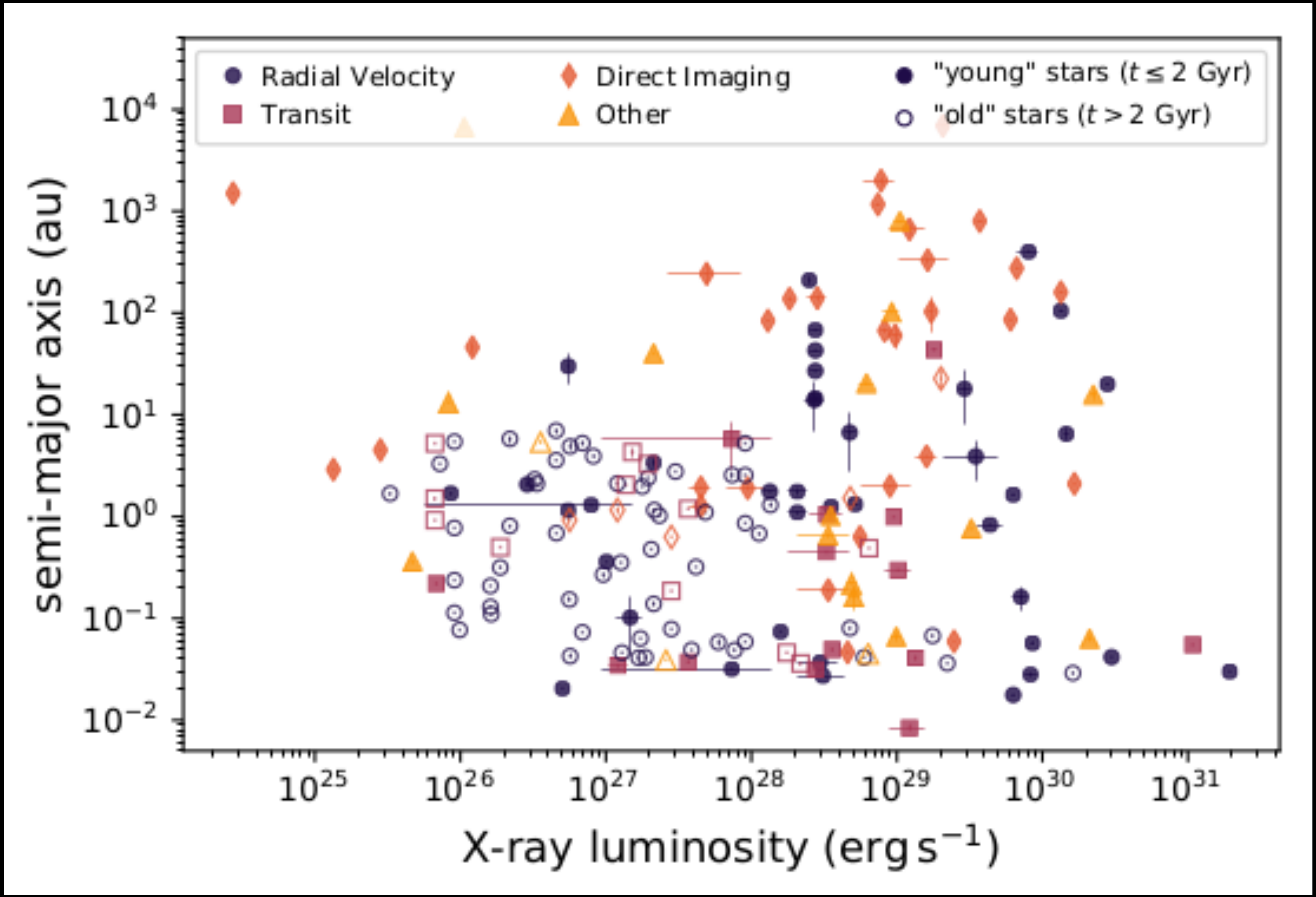
METAL DEPLETION

- Carbon and Oxygen seems to be depleted in the outer disc due to freez-out (Anna/Cecile's talk)
- C/3 extend the area affected by disc photoevaporation



Wölfer et al., in preparation

A NEW DATABASE



Monsch et al., submitted

CONCLUSIONS

- there is not a clear cut between Transition Discs (TD) explainable by photo-evaporation and planet sculpting
- TDs contain a wide range of different protoplanetary discs not exaplainable by a single model
- new improved models predict a higher mass loss rate
- this database of hydro models will be the backbone for our Research Unit on TDs
- stay tuned (more info at transitiondiscs.com)