LINKING EXOPLANET STATISTICS WITH GIANT PLANET FORMATION

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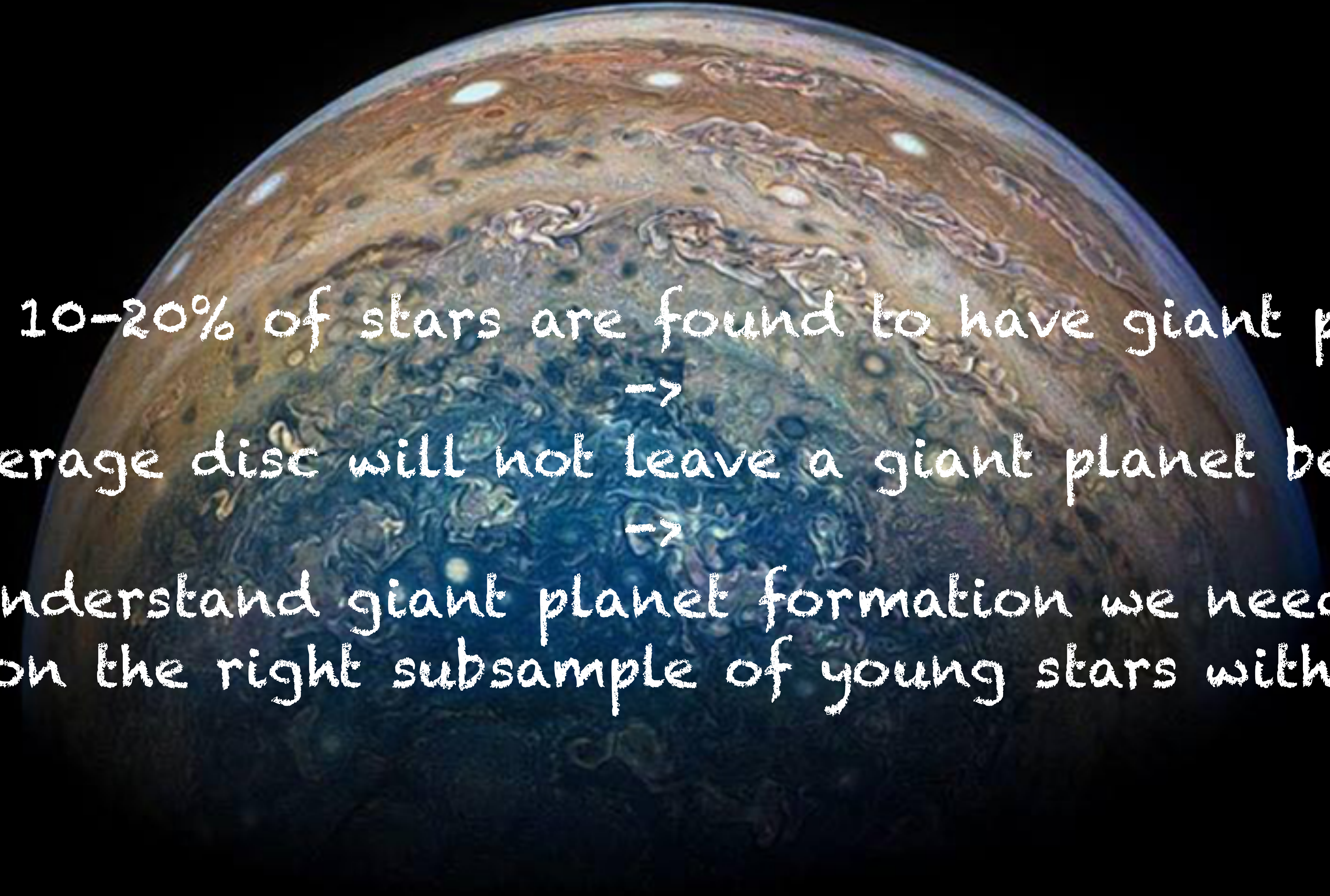
THE ROYAL SOCIETY



At best 10-20% of stars are found to have giant planets

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An average disc will not leave a giant planet behind

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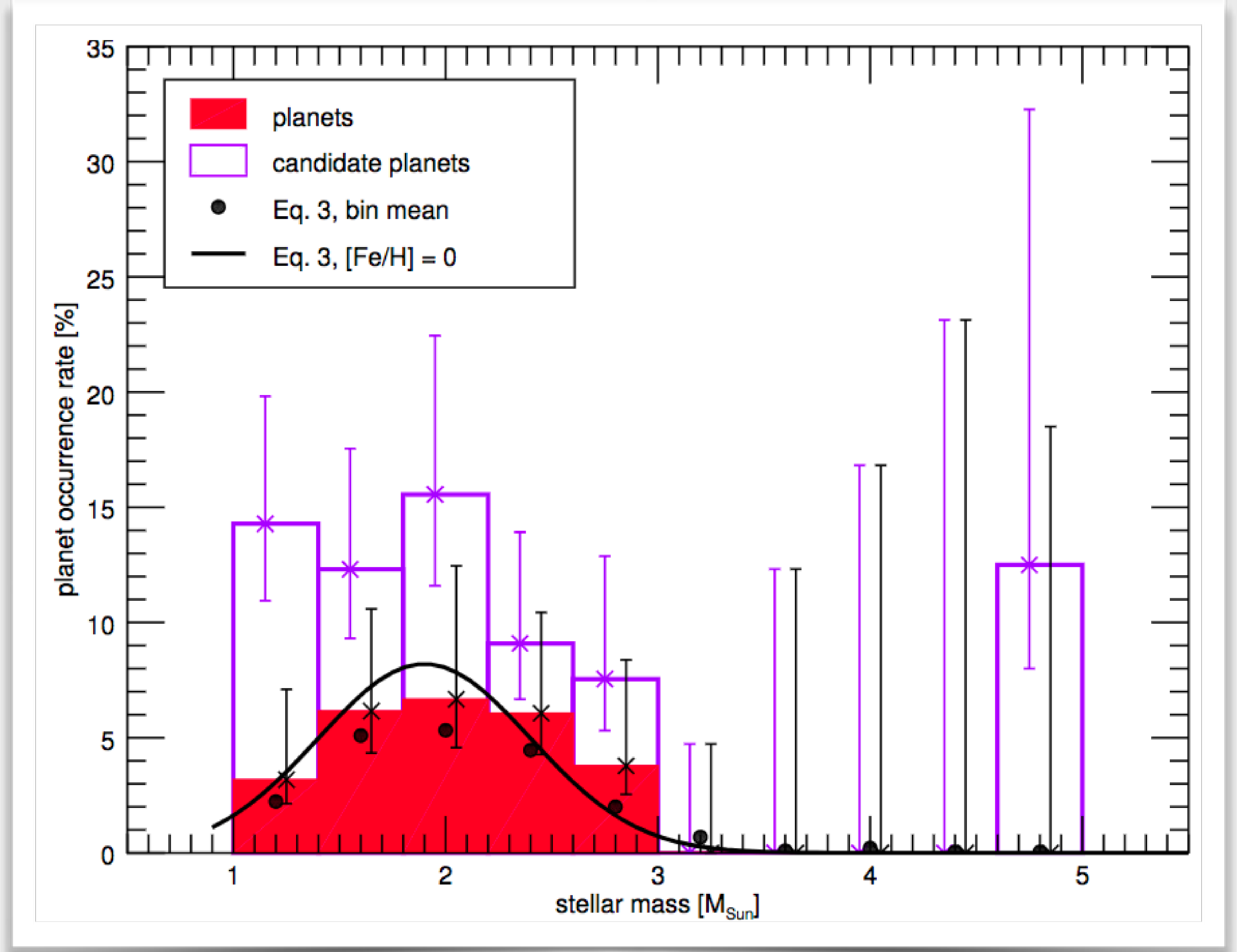
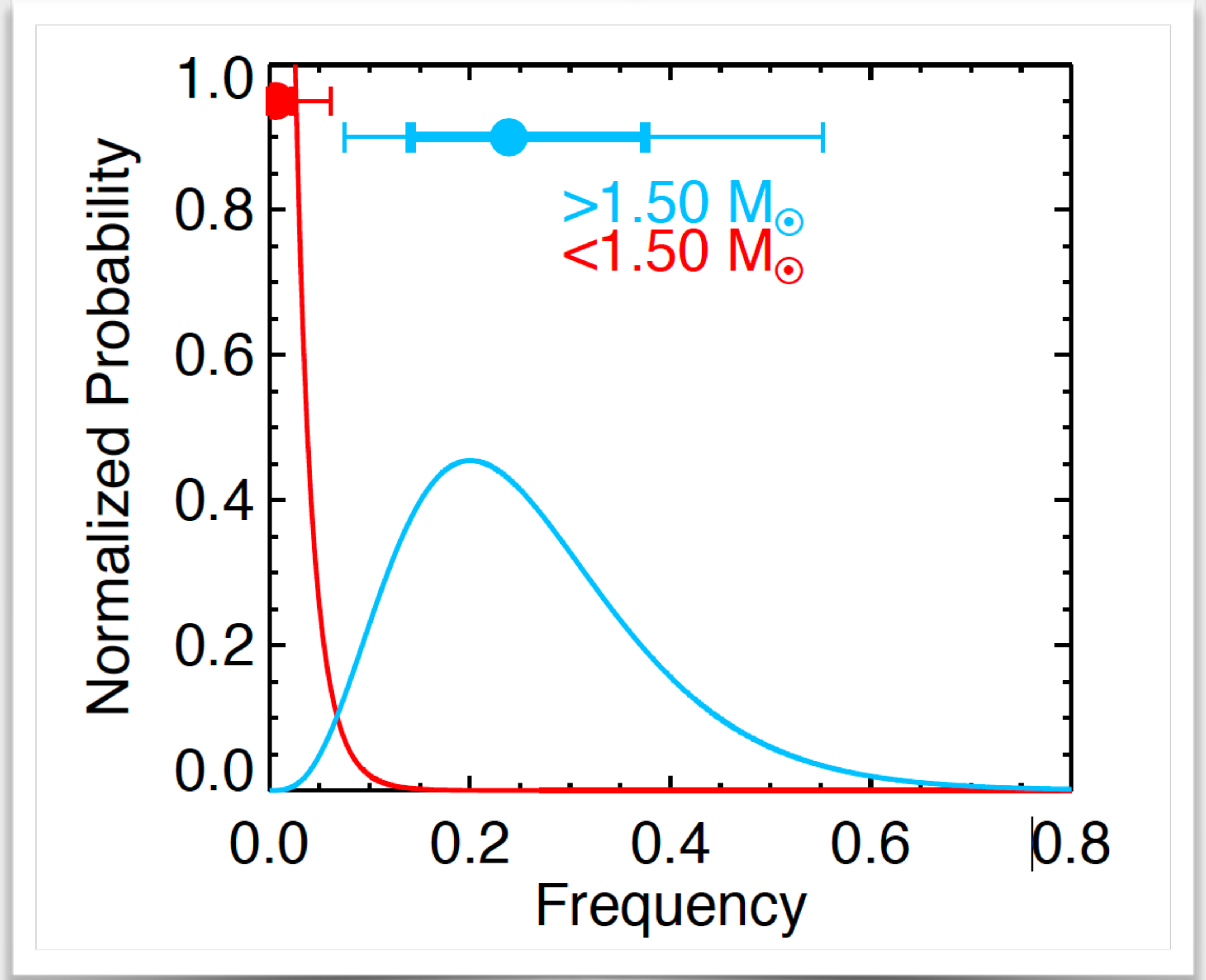
To understand giant planet formation we need to focus on the right subsample of young stars with discs

Intermediate mass stars (~2Msun)





- The most frequent giant planet hosts (Reffert et al. 2016)

- Higher frequency of directly imaged giant planets (Nielsen et al. 2019)

Question 1:

Are the discs around IMSs massive?

Solid mass problem

- Giant planets contain >10Mearth of solids (Thorngren et al. 2016)

BUT

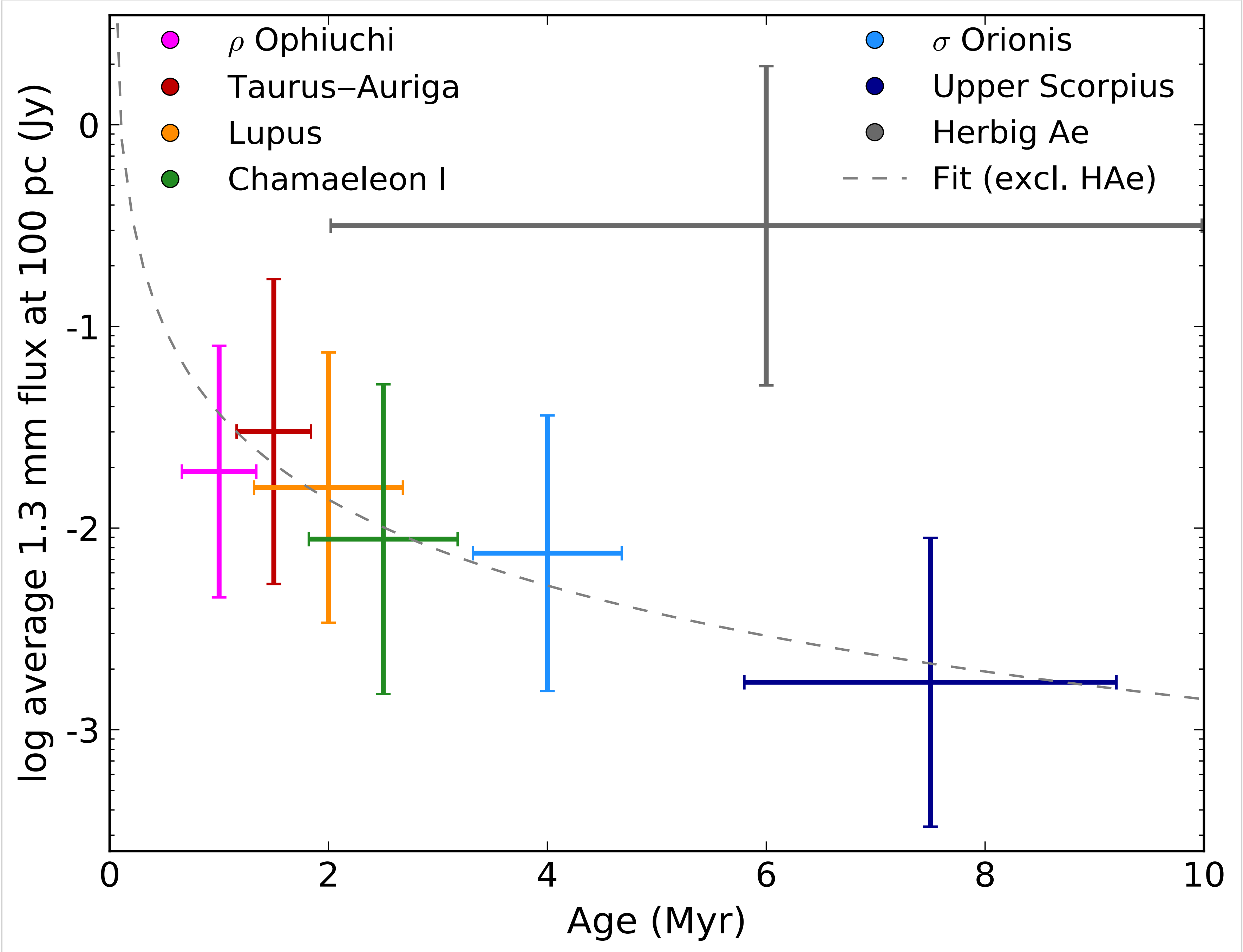
- Typical discs dont have this much dust mass (e.g., Manara et al. 2018)

- We carry out an ALMA survey of discs around IMSs (P.I. Panic') and complement our dust continuum meausurements with around 40 more from sub millimetre archives and literature

We infer the mass reservoirs using:

- Mm continuum - Optically thick? Scattering? Solids hidden in larger bodies?
- CO isotopologues - Optically thick? Isotope-selective photodissociation? Freeze-out? Carbon sequestration?

No dust mass problem for IMSs

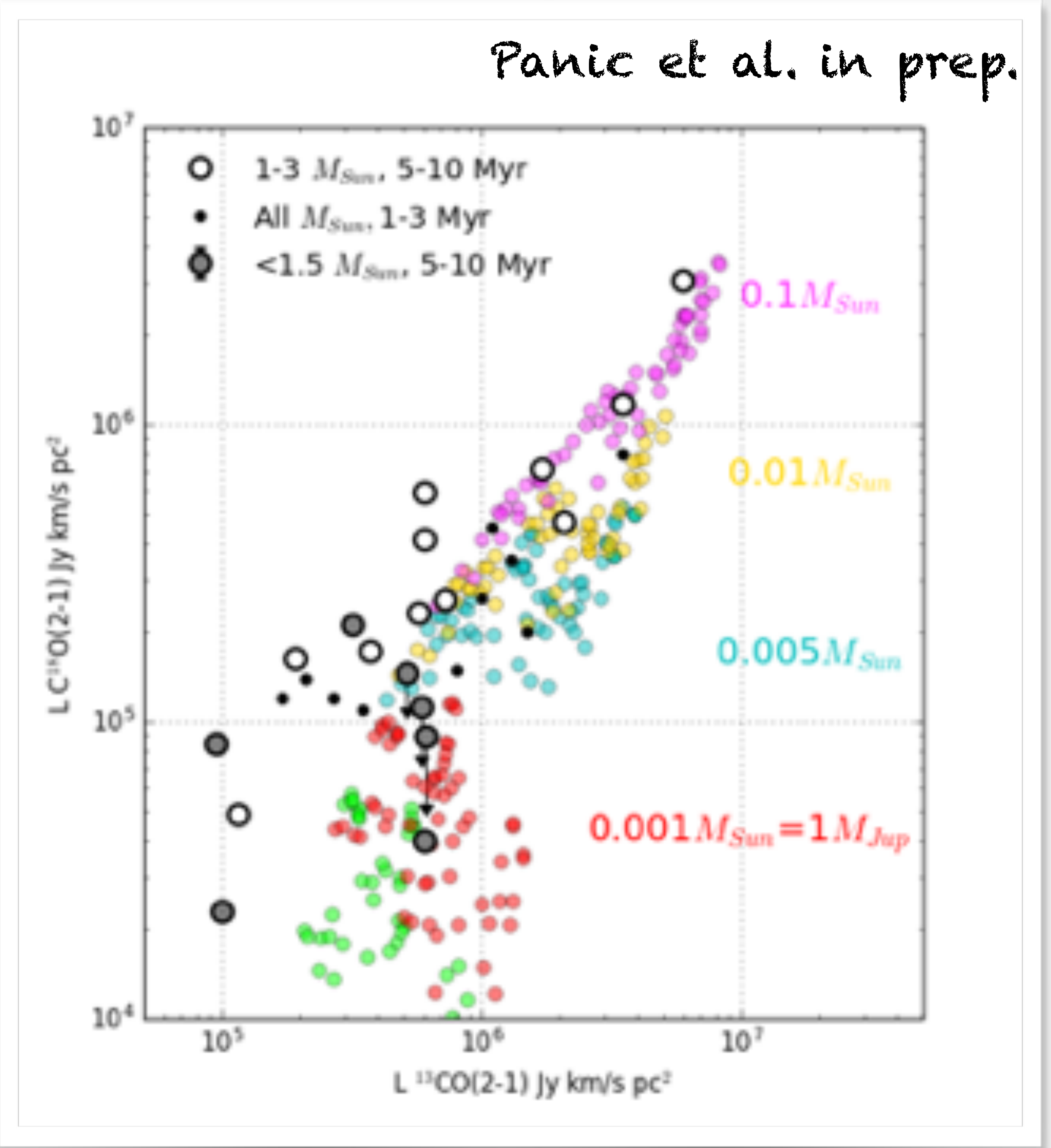


Average dust mass 100Mjup for discs around IMSs!

Panic et al. in prep.

Note: only 10% of Lupus discs reach this mass (e.g., Miotello et al. 2016)

Discs around IMSs have large gas masses

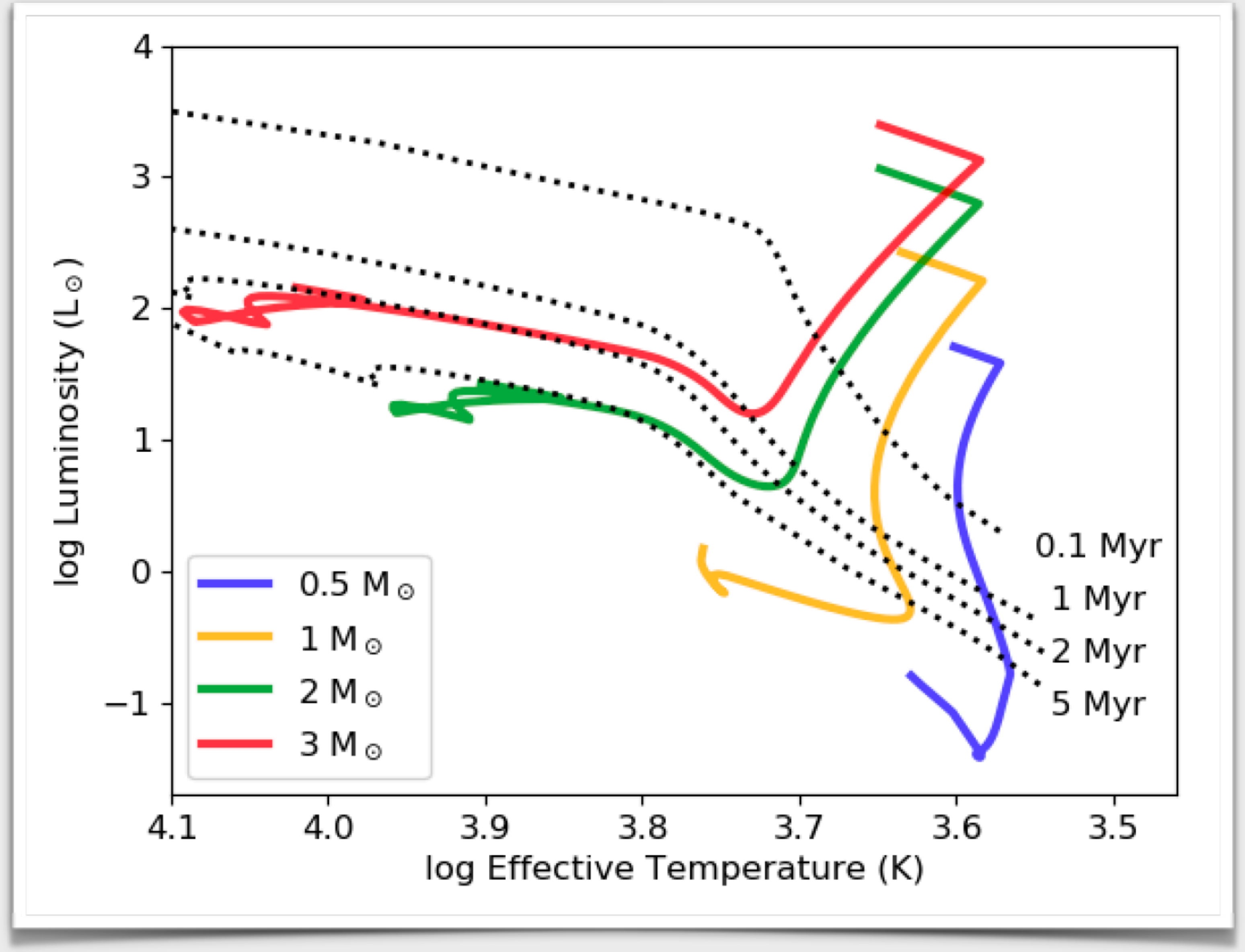


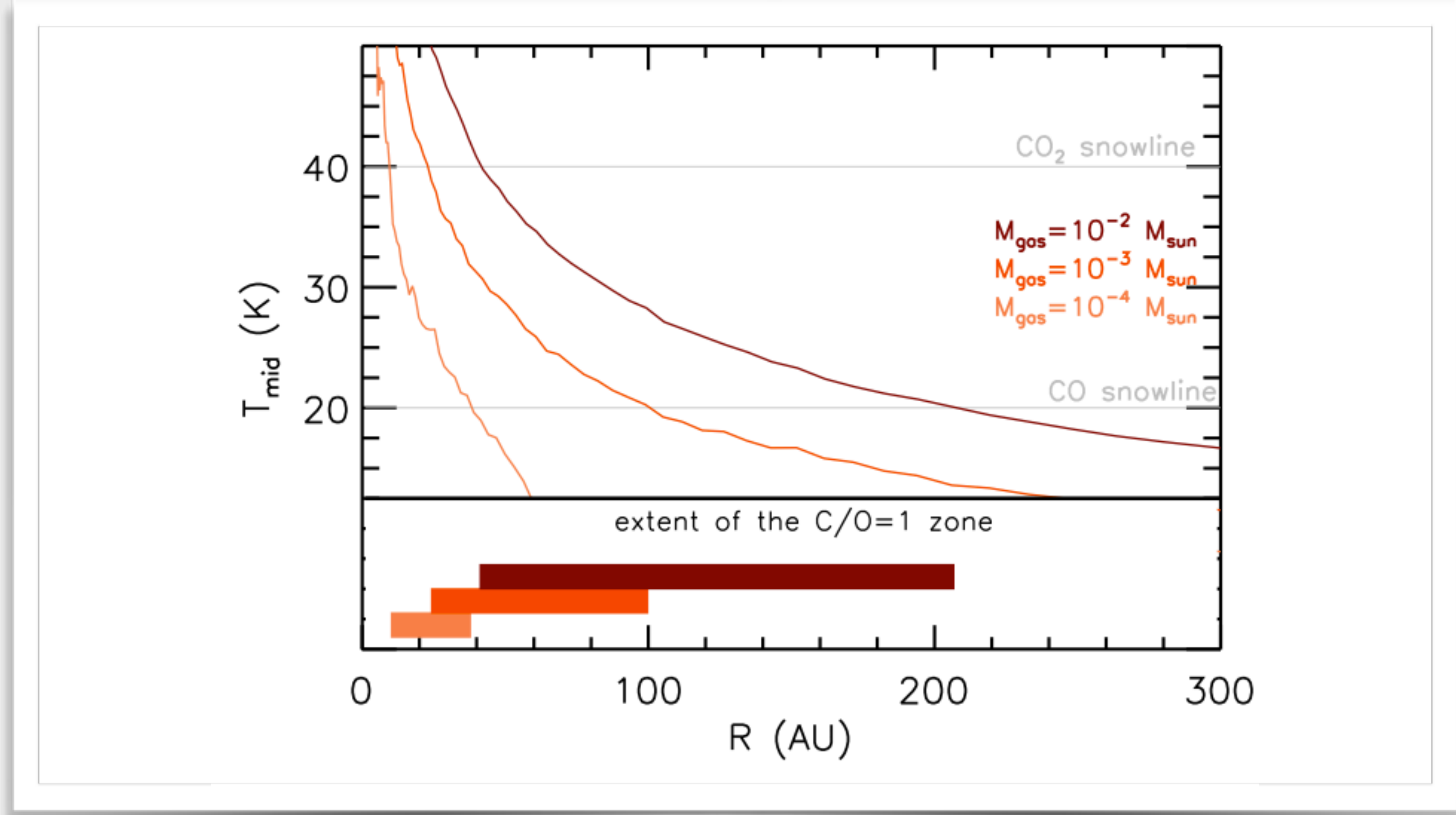
(comparison to Miotello et al. 2016 model grid)

- Gas masses >MMSN
- At 5Myr, gas masses comparable to the most massive discs in Lupus (at 1-3Myr)

Question 2:

Are the discs around IMSs special in terms of their thermal/chemical histories?





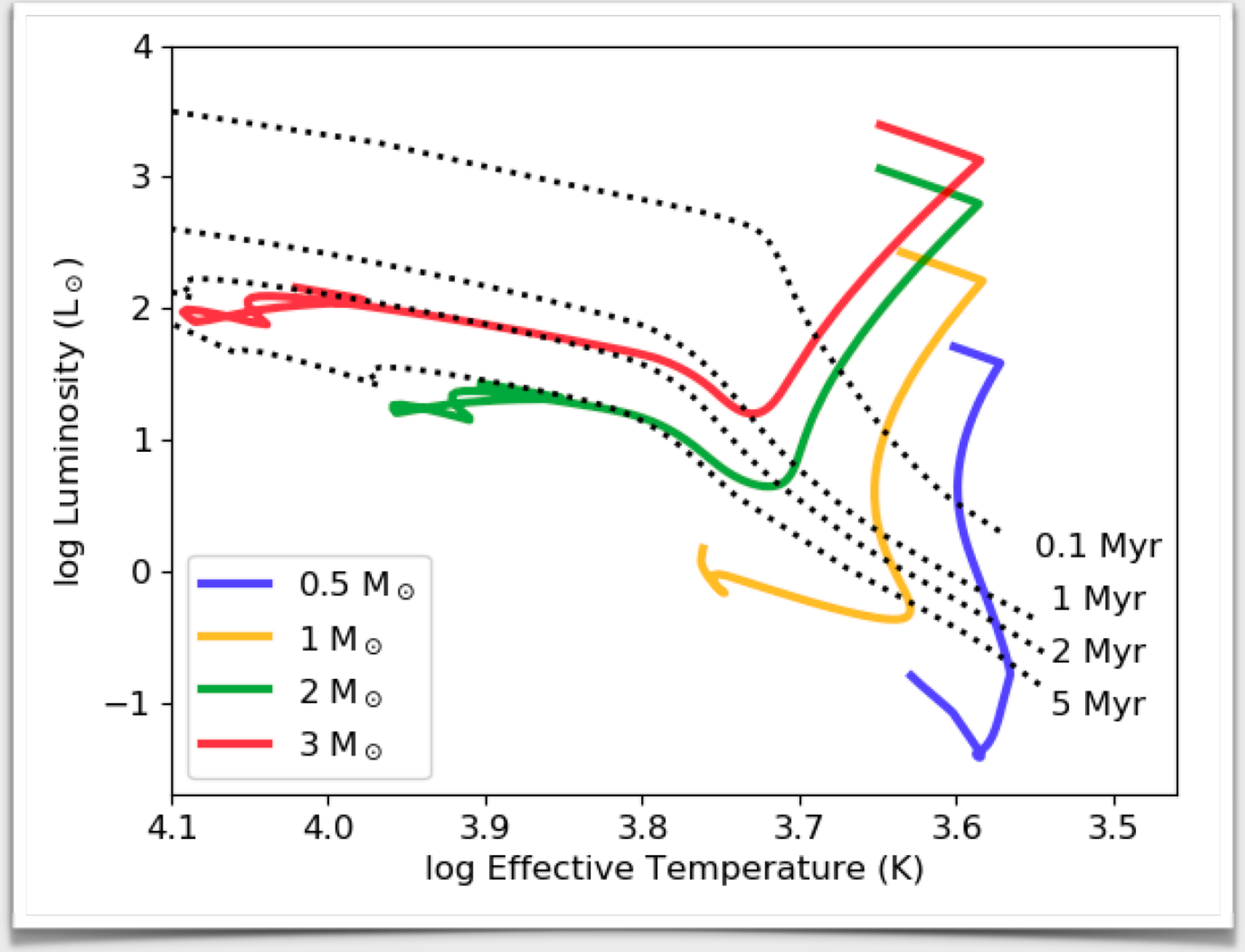
- Stars evolve differently on the pre-main sequence, depending on their mass (e.g., Palla& Stahler 1994, Siess et al. 2000, Baraffe et al...)

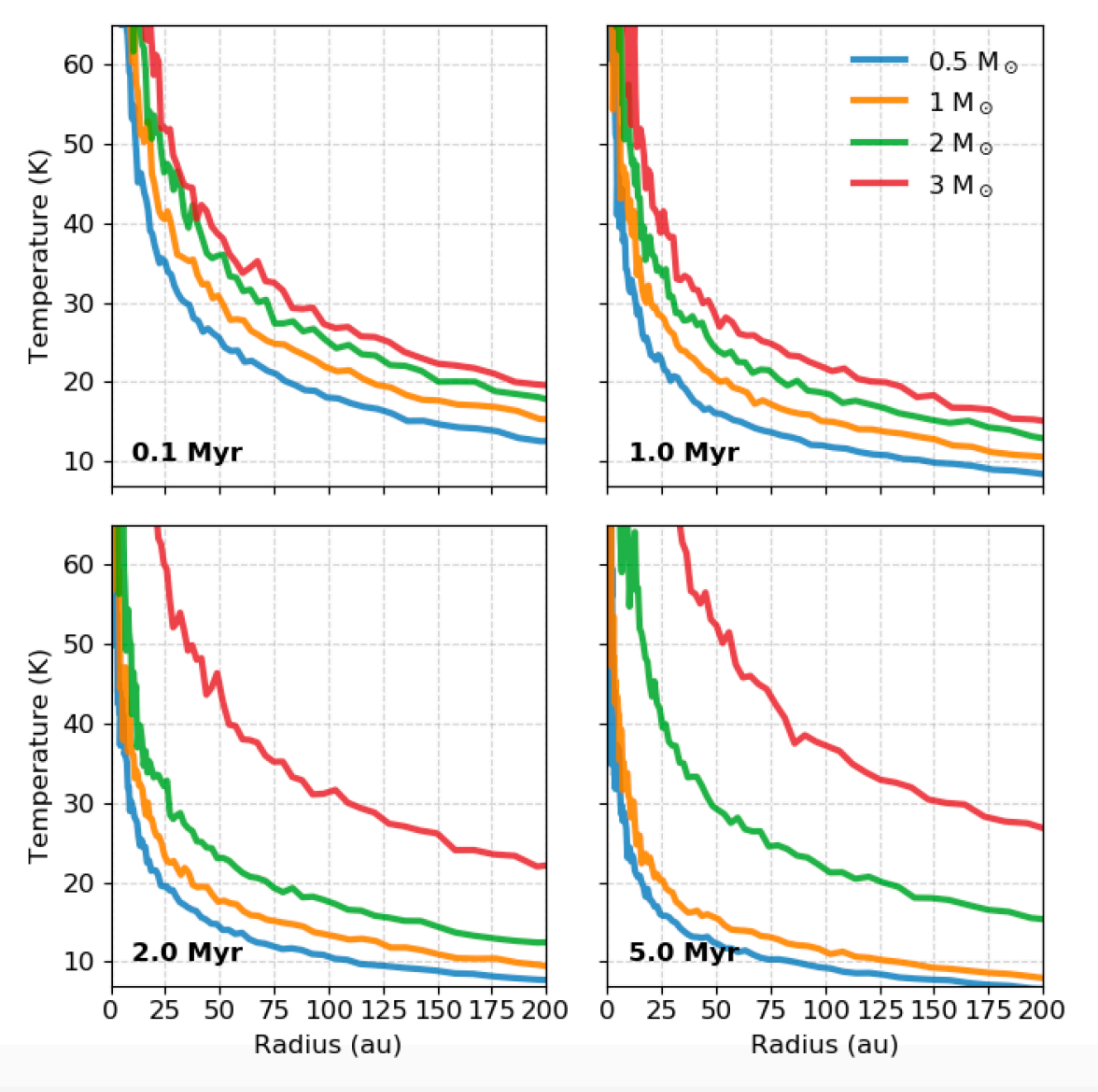
- Massive discs around A type stars are warm and CO rich (Panic & Min 2017)

- We use a grid of irradiated (Min et al. 2009) disc models with Mdisc=0.1Msun:
  - Mstar=0.5...3,5Msun
  - age=0.1...10Myr

-> disc temperatures, snowline locations

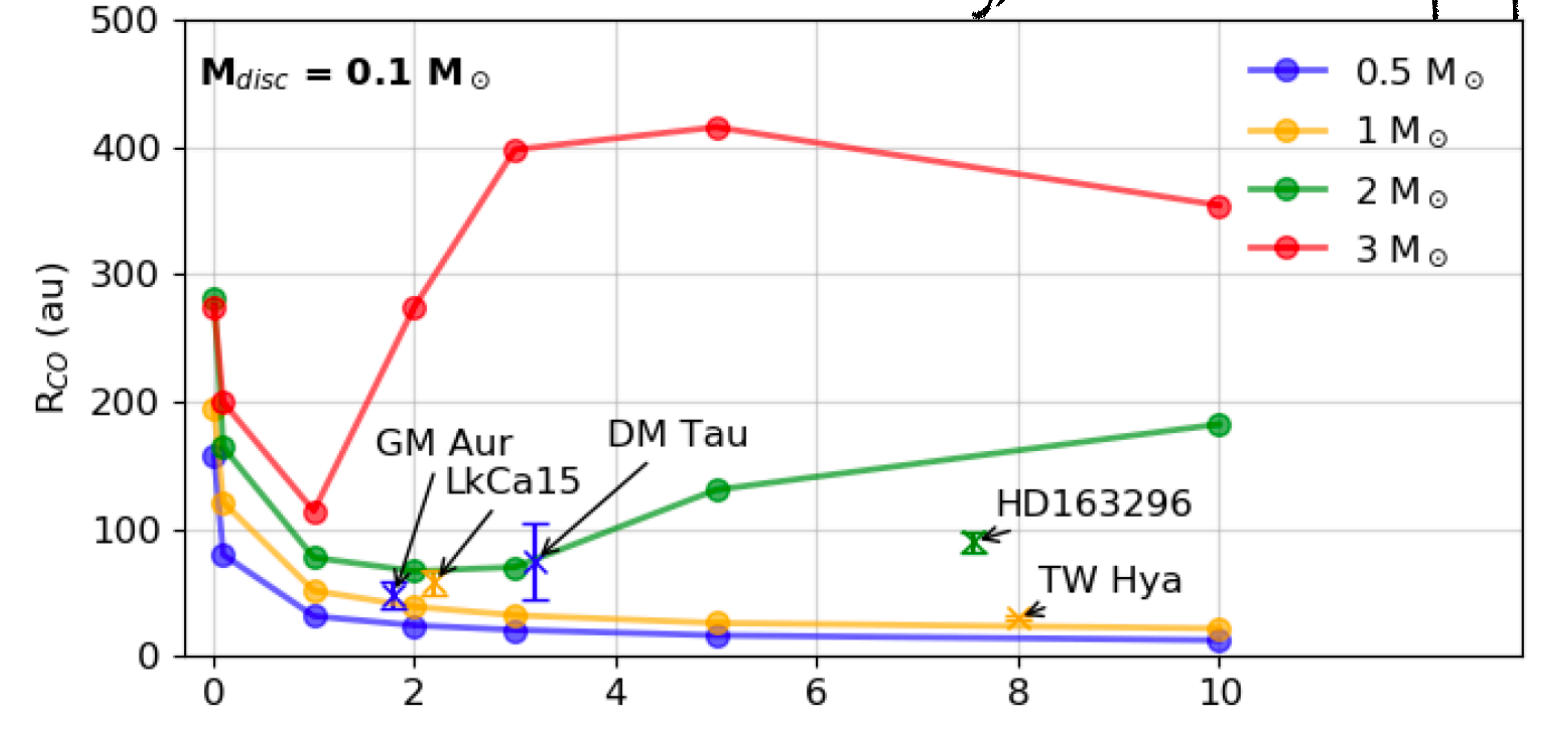
Miley, Panic et al. in prep.





- As stars evolve, the midplane temperature profiles of discs around them begin to diverge: 1Msun stars' discs get colder, while 2-3Msun stars' discs become increasingly warm

Miley, Panic et al. in prep.



- For a disc massive enough to form giant planets, the CO snowline is:
  - always >100au around a 3Msun star
  - >100au only at >4Myr around 2Msun stars
  - Never >100au except for a very brief first 10k years for lower mass stars

Question 1:

Are the discs around IMSs massive?
-> Yes, both in gas and dust

Question 2:

Are the discs around IMSs special in terms of their thermal/chemical histories?
-> Yes, they are warm and have extended C/O=1 regions