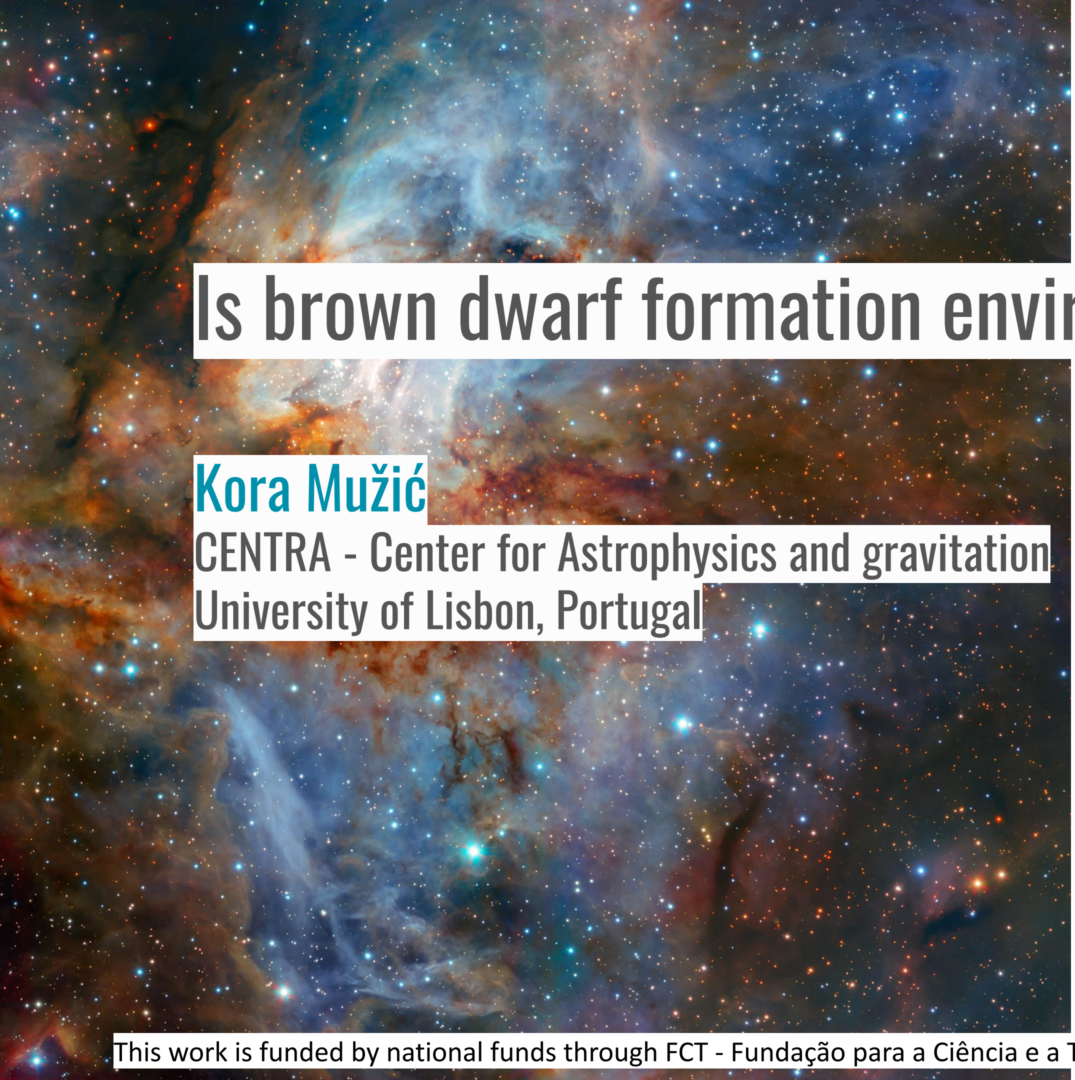

YOUNG BROWN DWARFS

Is brown dwarf formation environment-dependent?

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centra

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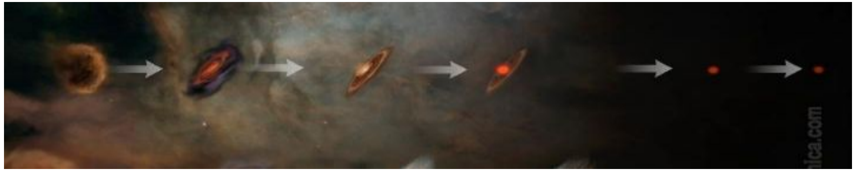
Brown dwarf formation theories

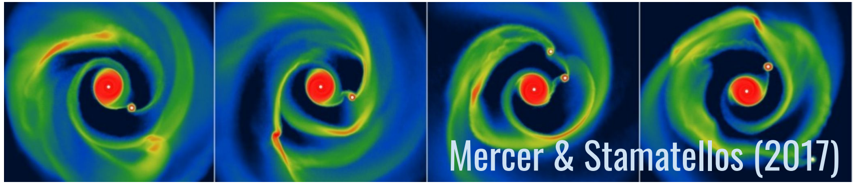
(1) As a star: turbulent fragmentation

(Padoan & Nordlund 2004, Hennebelle & Chabrier 2009)



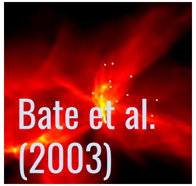
(2) As a giant planet: Disc fragmentation + ejection

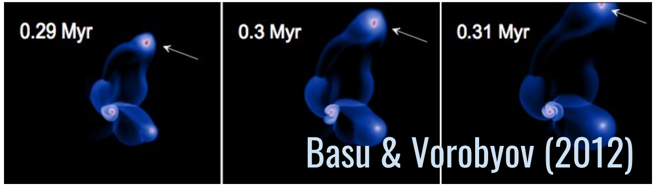
(Stamatellos et al. 2007, Goodwin et al. 2004)



By halting accretion:

(3) Ejection of embryos from multiple systems or disks (Reipurth & Clarke 2001)





(4) Photoevaporation

(Whitworth & Zinnecker 2004)

Clues from the observations

Yoh-BD

Young BDs share many properties with low-mass stars:

- mass distribution
- kinematics and spatial distributions
- disks and outflows
- existence of pre- and proto-BDs (BDs in the process of formation)
- multiplicity properties

Current consensus: majority of brown dwarfs form as stars (at least the more massive ones)

other mechanisms not excluded, but their relative importance is not clear

Multiple unsolved questions in BD formation

How far in mass does the stellar IMF extend?

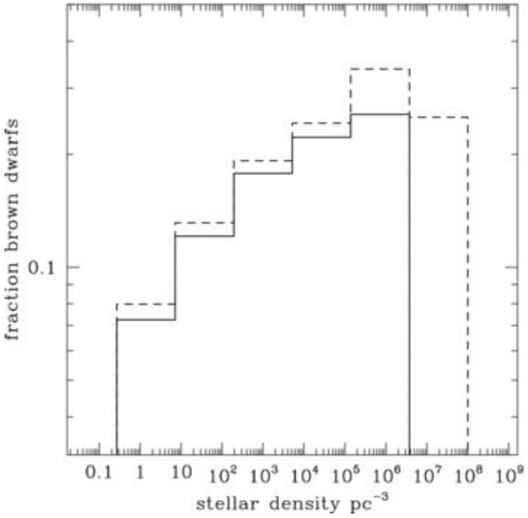
Do the lowest-mass objects form “like stars” or “like planets”?

Is BD formation environment dependent?

Is BD formation environment dependent?

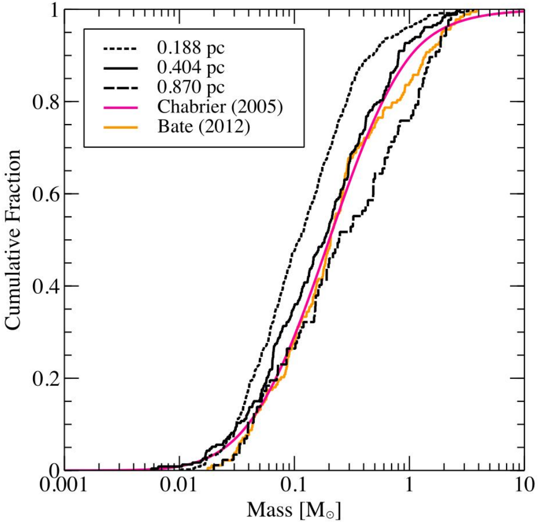
Brown dwarf formation theories: Yes, it should matter

Stellar Density



Bonnell et al. (2008)

Gas Density



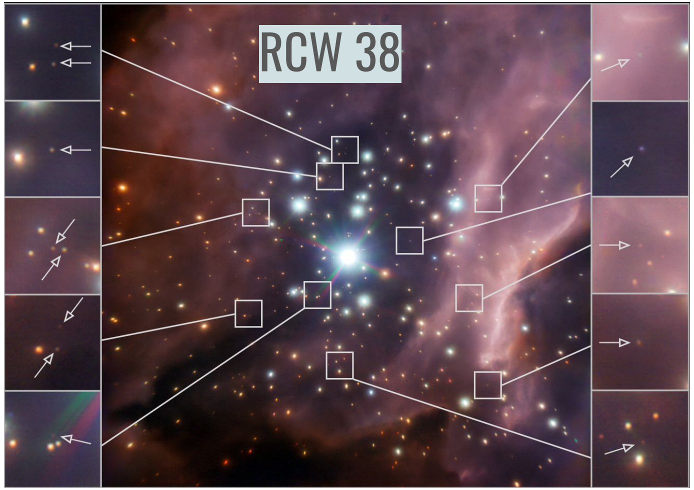
Jones & Bate (2018)

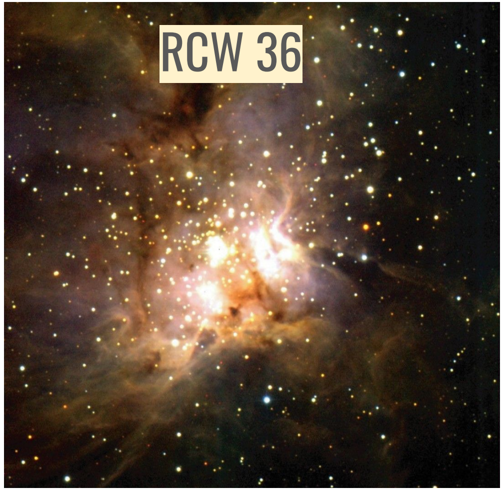
Massive stars

Yo-BD

- Nearby star forming regions (d<400 pc): no strong evidence for environmental effects
- Need to look at substantially different environments: massive clusters

	RCW 38	NGC 2244	RCW 36
Stellar density	✓	✗	✓
Rich in OB stars	✓	✓	✗





Brown dwarfs in massive clusters - dataset

Deep near-infrared imaging (JHK)

FLAMINGOS-2/Gemini-S	NGC 2244	RCW 36	
NACO/VLT			RCW 38
Hawk-I/VLT	NGC 2244	RCW 36	RCW 38

Spectroscopy

KMOS/VLT	NGC 2244		

Yo-BD

Membership determination methods

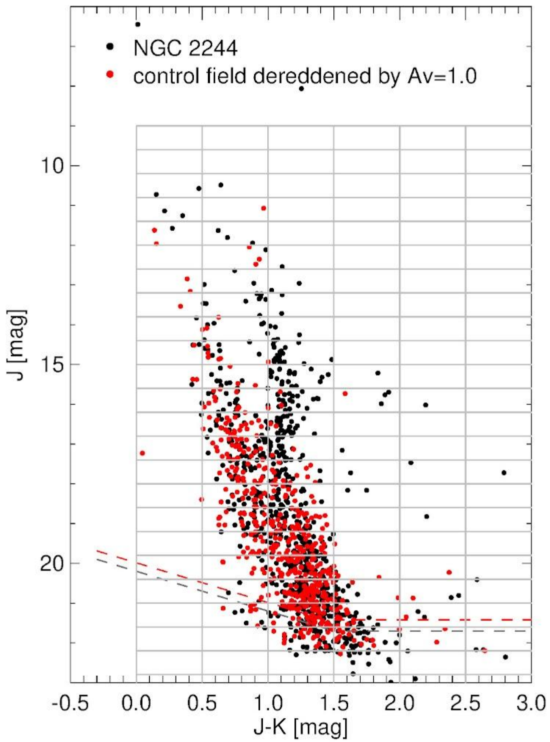
X-ray and MIR-excess
high "success rate", but
do not uncover full populations (bias towards disk-bearing stars)

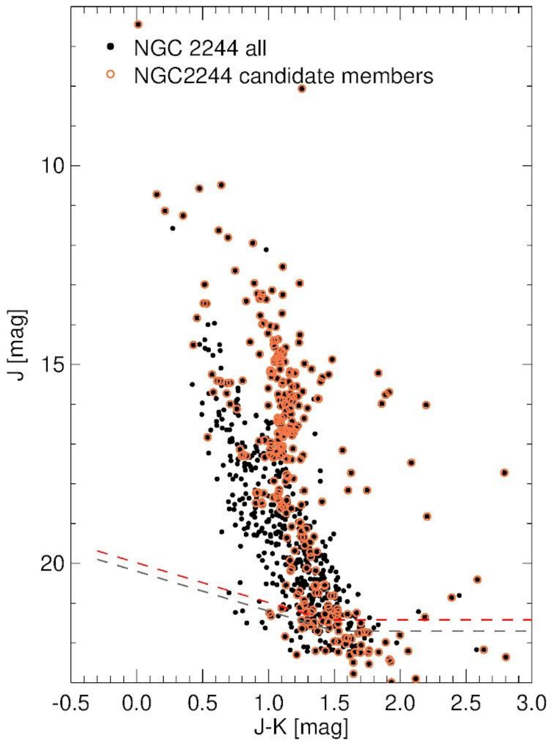
Spectroscopy
best way to determine youth and SpT, but time consuming

Kinematics
powerful to uncover co-moving groups, but difficult, at least until recently

Statistical
comparison to control field
no way to identify individual members

NGC 2244 - statistical determination of membership





- Each star in CMD: Gaussian probability distribution of magnitude and color
- Important parameters: cell size, cell starting position, relative extinction → uncertainties propagated into the IMF

Muzic et al. (2019)

Spectroscopy KMOS/VLT

NGC 2244 (1500 pc, ~2 Myr)

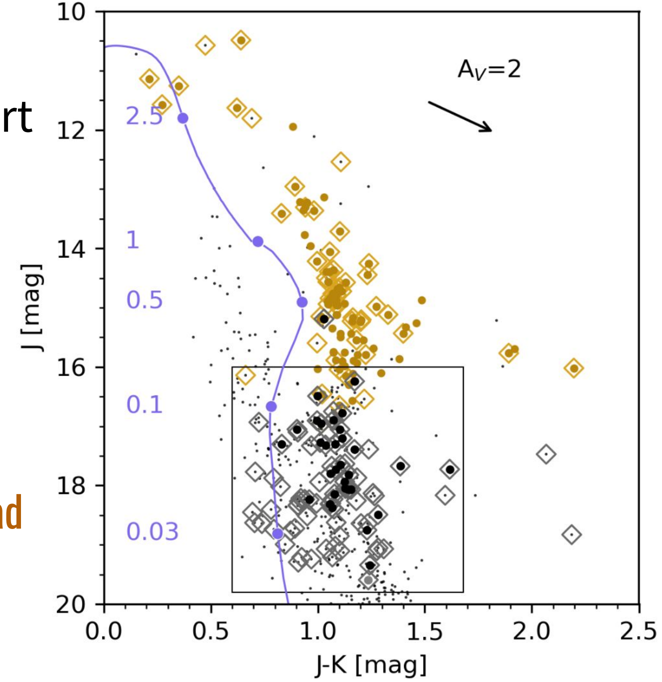
Posters

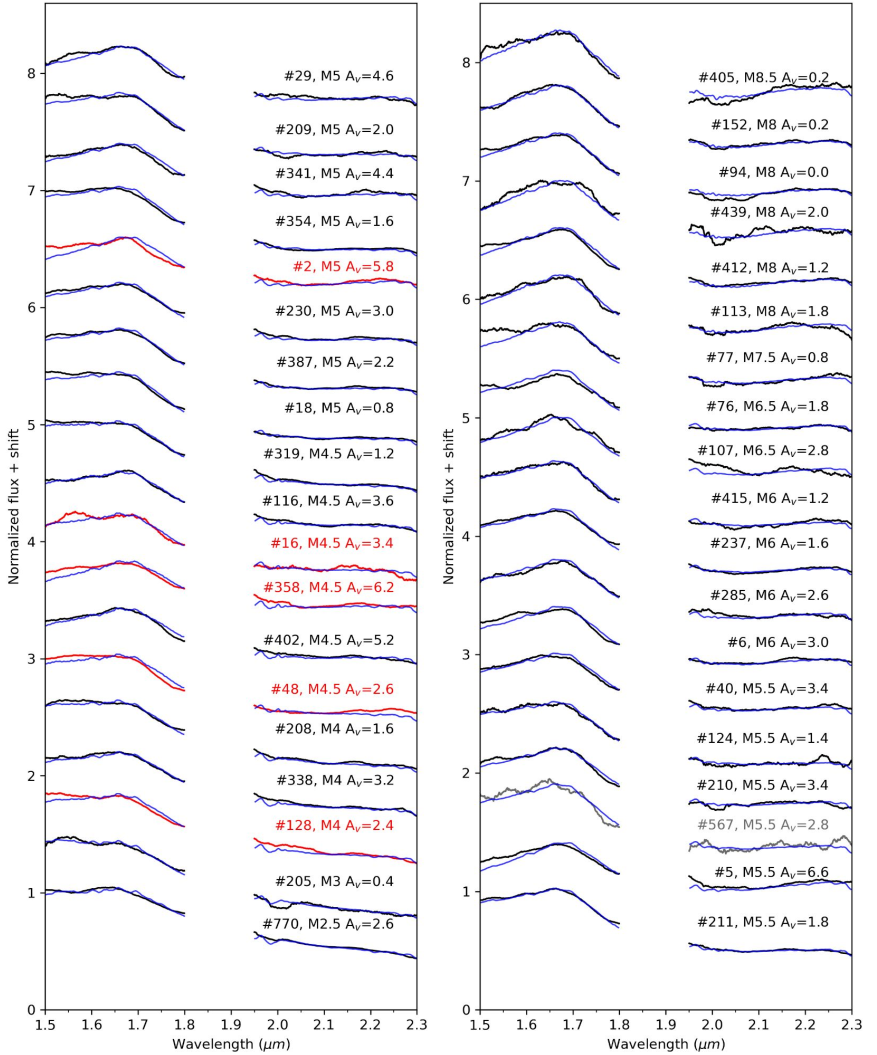
#167 stellar part

#144 BD part

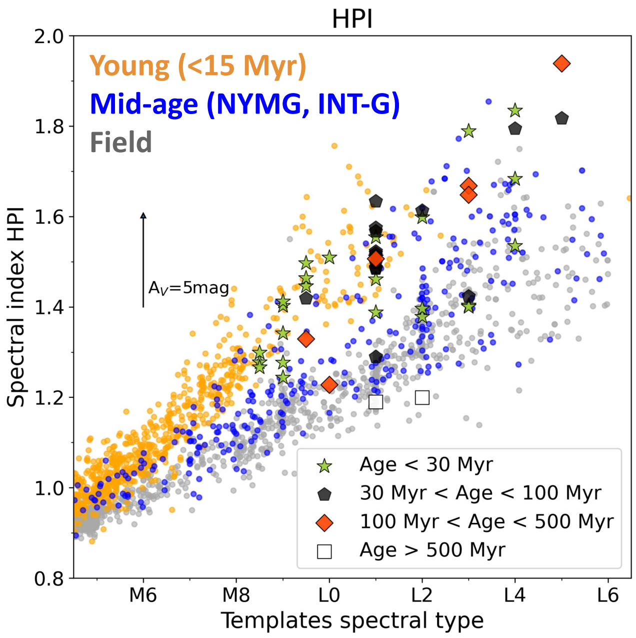
Víctor Almendros-Abad

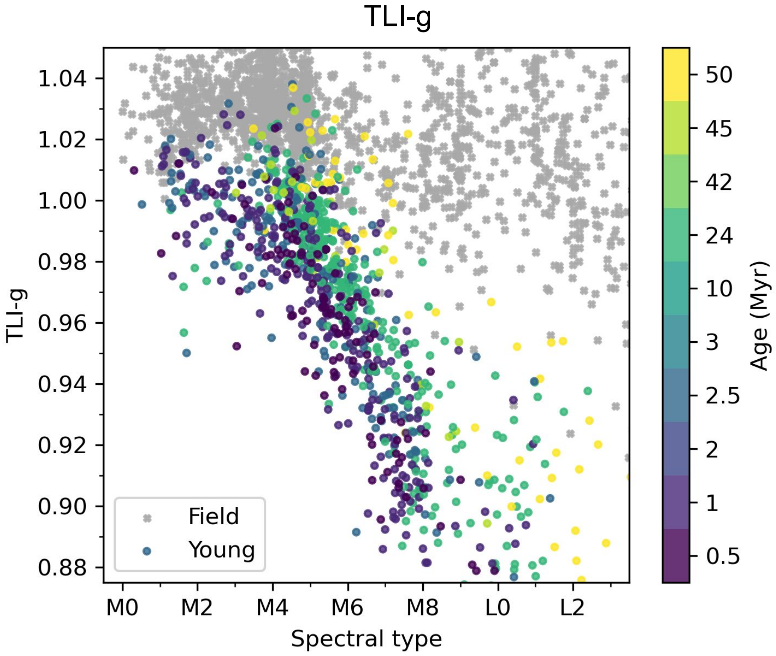
Almendros-Abad et al. (in prep.)





Gravity-sensitive spectral indices





Almendros-Abad et al. (2022)
Piscarreta et al., in prep.

Posters:

#144 **#170**


Víctor Almendros-Abad
Lara Piscarreta

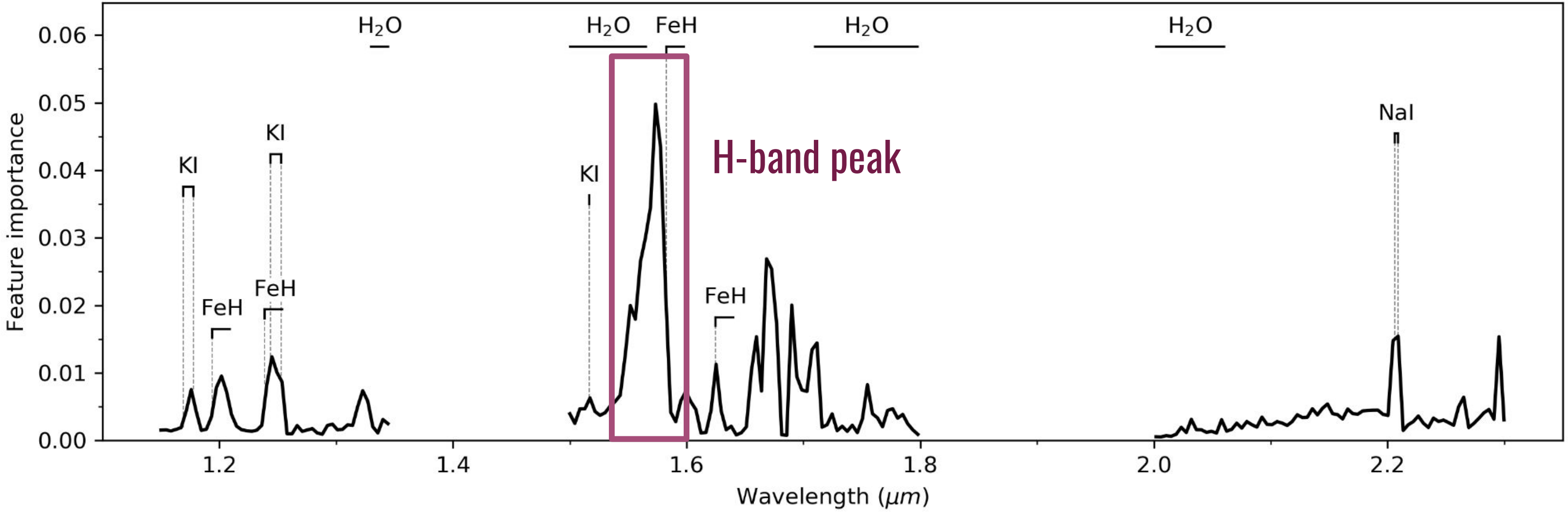
Yo-BD

Youth assessment via machine learning

~2750 JHK spectra M0-L3

Classes:		
	Young	~900
	Intermediate-age	~250
	Field	~1600

Random Forest feature importance



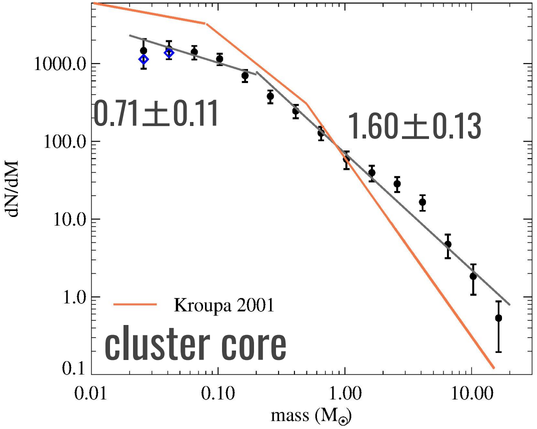
Almendros-Abad et al. (2022)

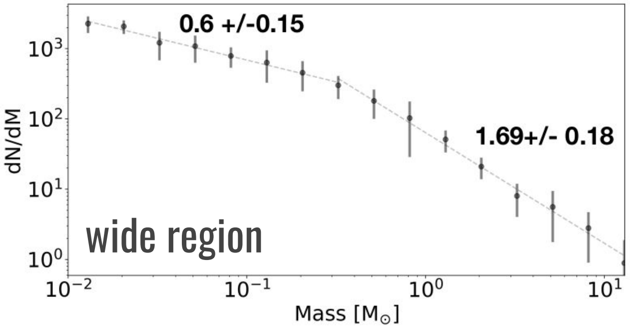
Poster **#144**

Initial Mass Function

Power-law form $dN/dM \propto M^{-\alpha}$

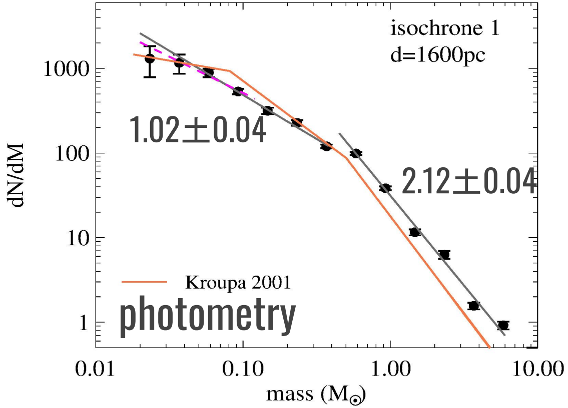
nearby SFRs $\alpha = 0.6 - 1$

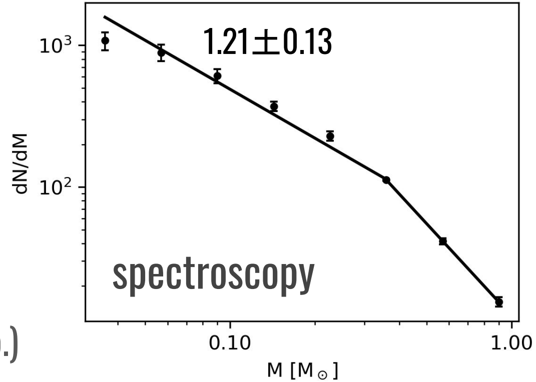




RCW 38	NGC 2244

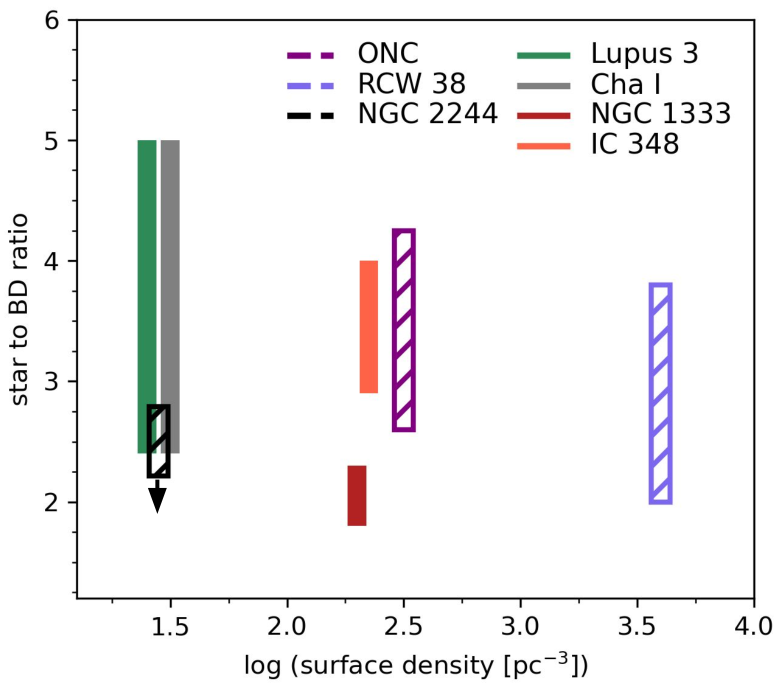
	RCW 38	NGC 2244
Dense	✓	✗
OB stars	✓	✓





Muzic et al. (2017, 2019)
Kubiak et al. (in prep.)
Almendros-Abad et al. (in prep.)

Star-to-BD ratio vs. stellar surface density



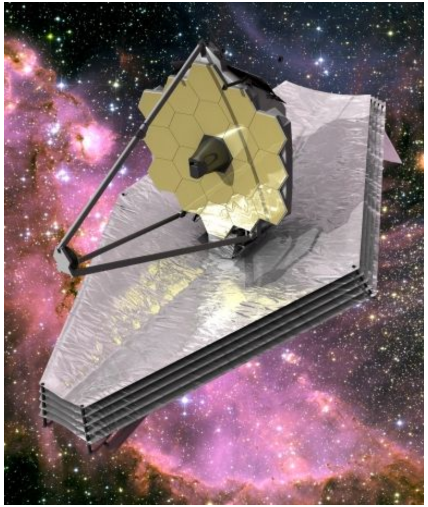
NGC 1333, IC348, Lupus 3, Cha-I: SONYC

ONC: Andersen et al (2008)

dashed boxes: OB stars

$$\frac{N(0.075 - 1\,M_\odot)}{N(0.03 - 0.075\,M_\odot)}$$

Next step: JWST



Cycle 1
PI M. Guarcello

Westerlund 1

Brown dwarfs down to ~20 M_{Jup} in a starburst cluster!

Summary and conclusions

For every 10 star, star forming regions produce 2 - 5 brown dwarfs

Brown dwarf formation in the Milky Way seems to be universal

- no conclusive evidence for variations in the formation efficiency of BDs/VLMS due to the lack or presence of OB stars, or a change in stellar densities
    - but, an overproduction of BD in NGC 2244?
- If environment has an influence on BD formation, this must be on a much more subtle level than the observational uncertainties currently permit us to measure

Thank you for your attention!