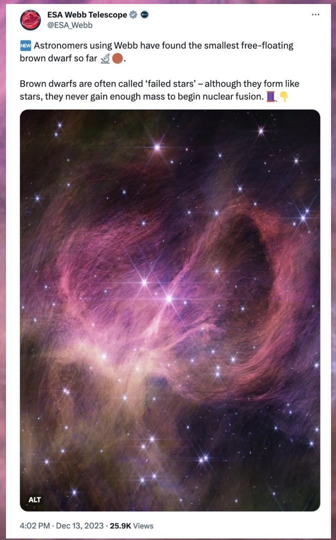
JWST unveils faint brown dwarfs and an unexpected molecular discovery

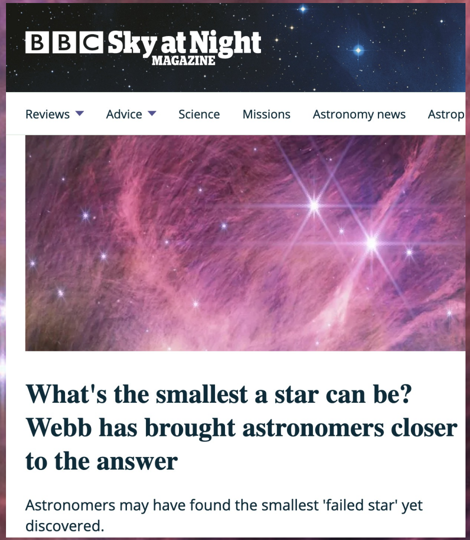
Catarina Alves de Oliveira
ESA SCI-SD @ ESAC
24/01/2024

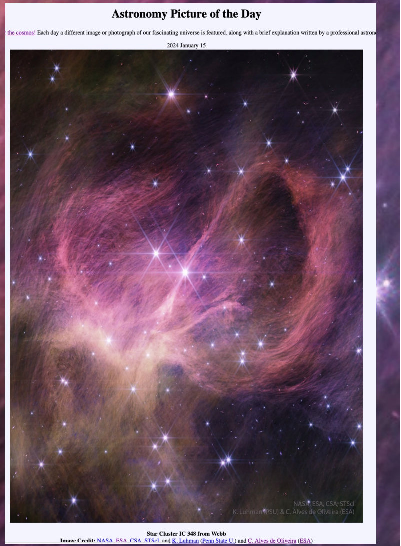
Brown Dwarfs Unveiled: JWST's Molecular Surprise!

Catarina Alves de Oliveira
ESA SCI-SD @ ESAC
24/01/2024

Get the data on ESASky!





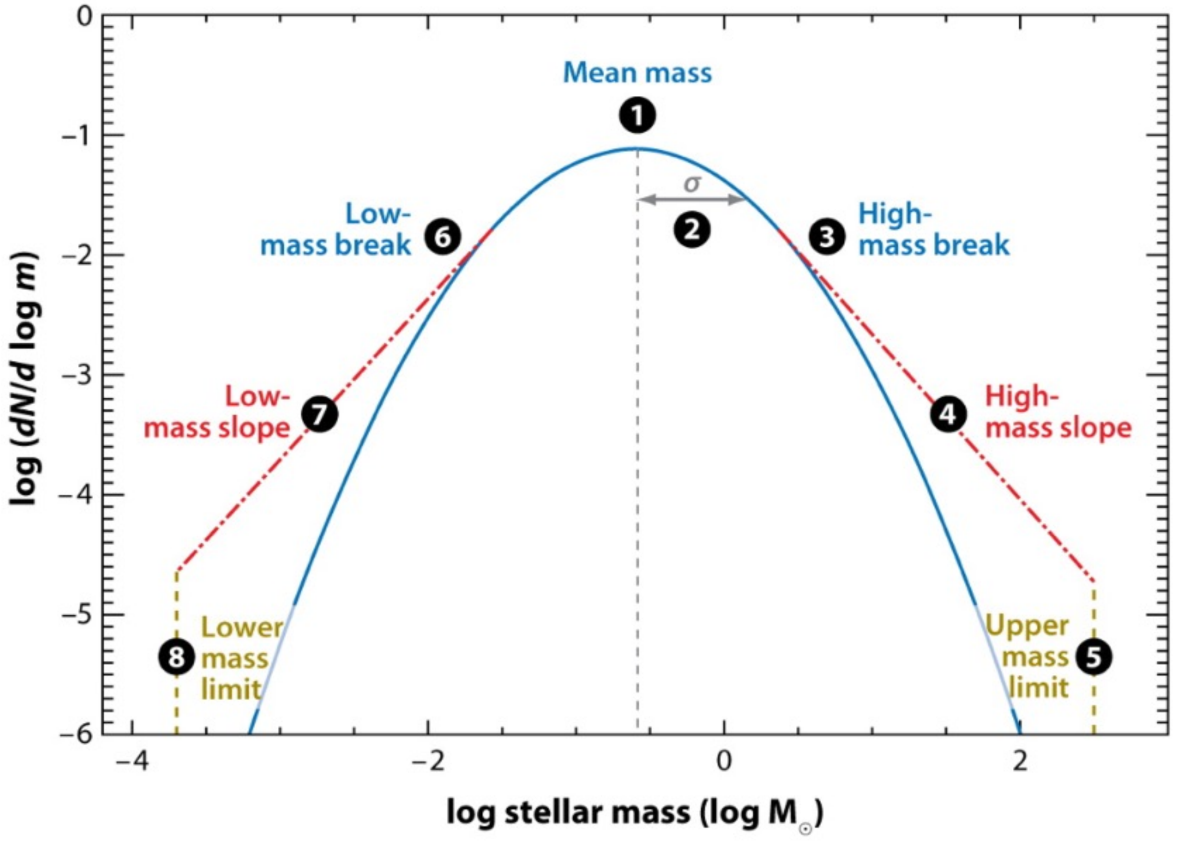


Star formation

The initial mass of a star determines its evolutionary path, but what dictates its initial mass?

Stars are fundamental components of our visible universe:

- Host planetary systems
- Building blocks of galaxies
- Source of chemical elements
- Progenitors of supernovae and black holes



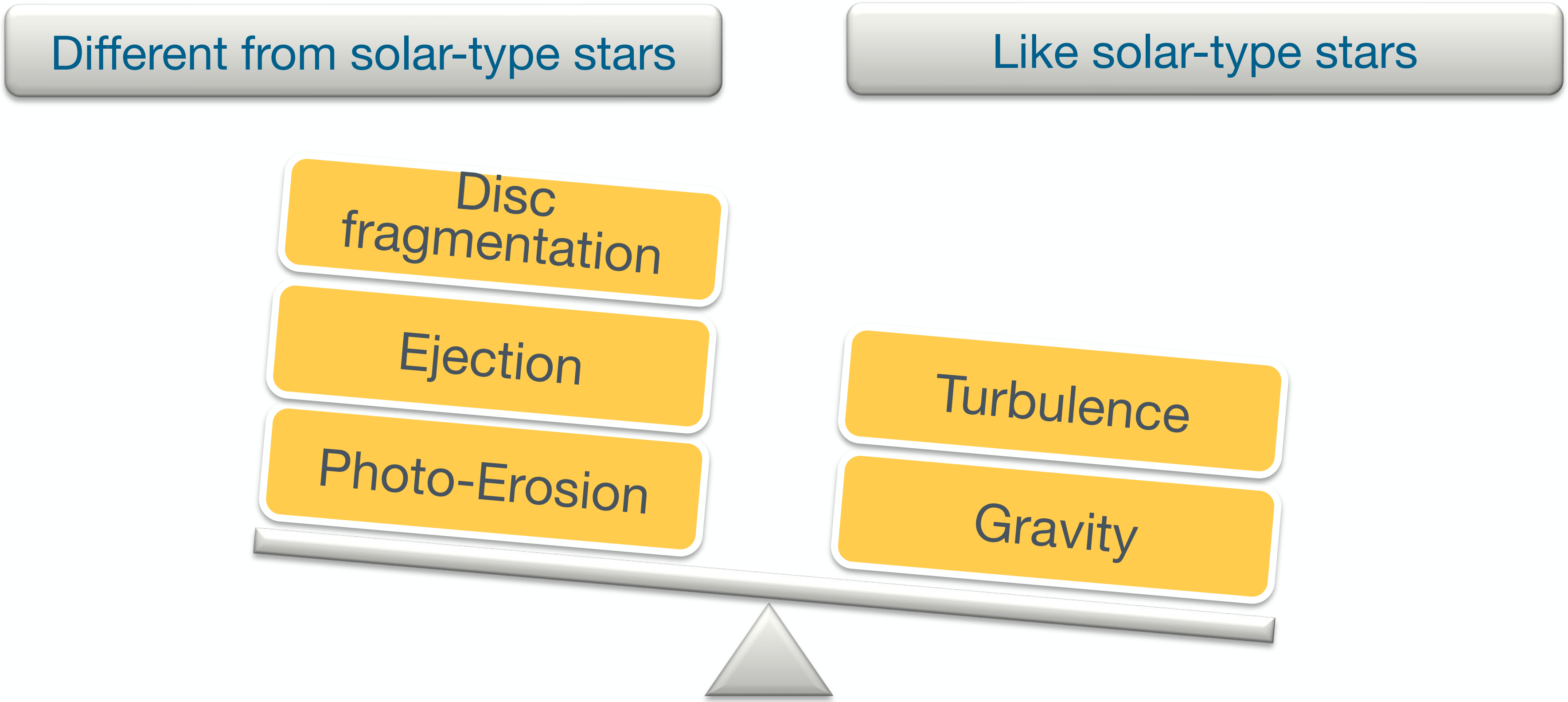
The Initial Mass Function, Bastian N, el al. 2010, AR, 48:339-89

The brown-dwarf regime

Brown dwarfs, lacking the mass for stable hydrogen fusion and extending down to few Jupiters in mass, prompt the question: How do these objects form?

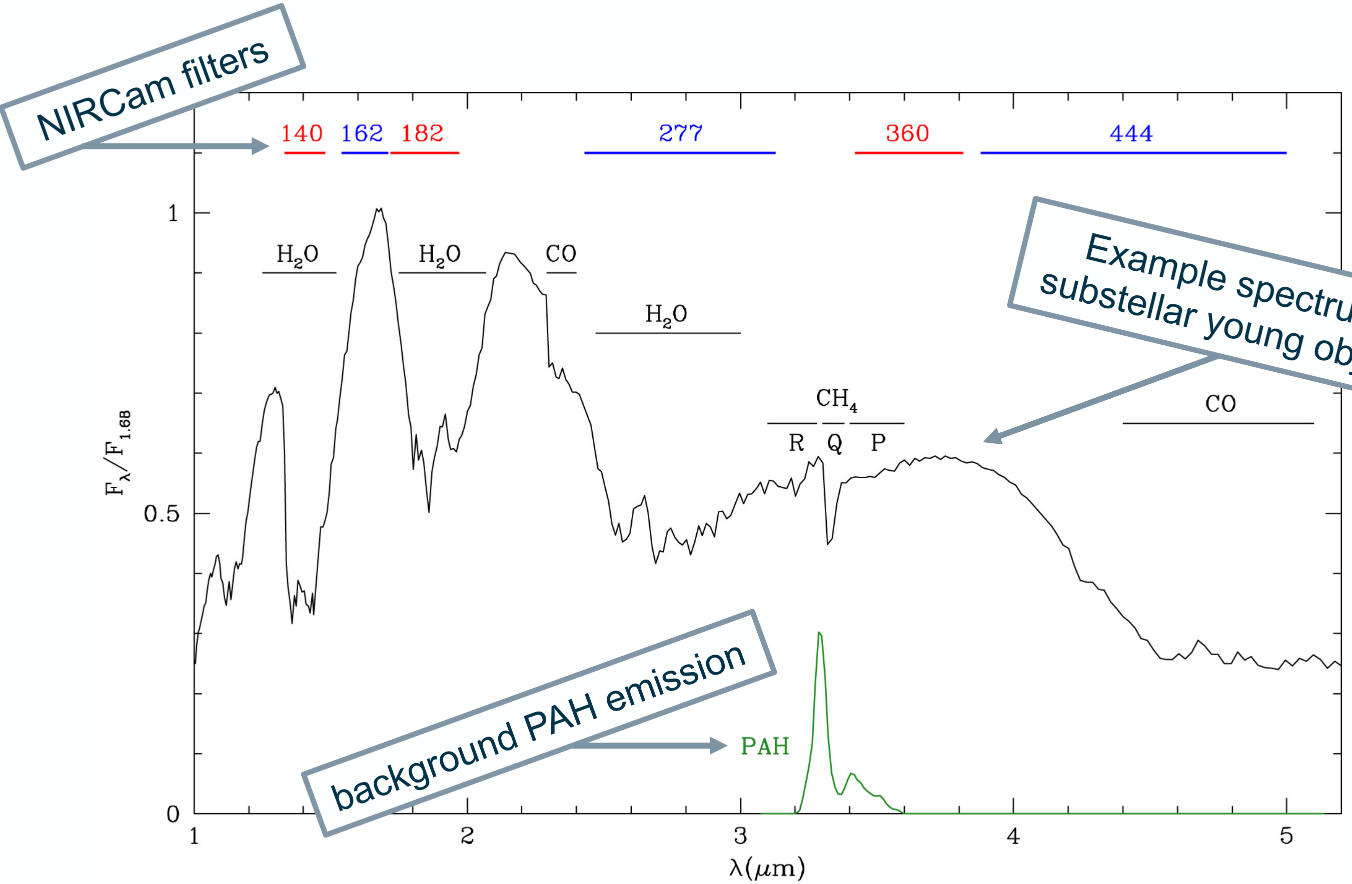
Relevance of mass function studies in the low-mass regime:

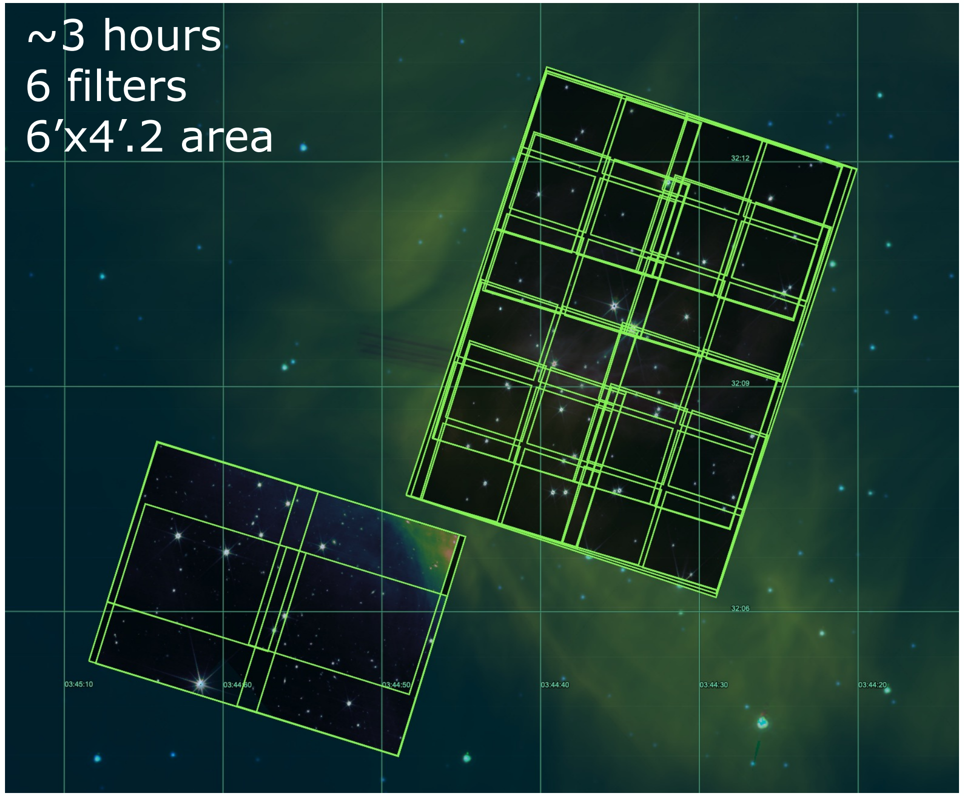
- Constrain the stellar and planet formation process
- Probe the universality and continuity of the mass function
- Drive census of these objects



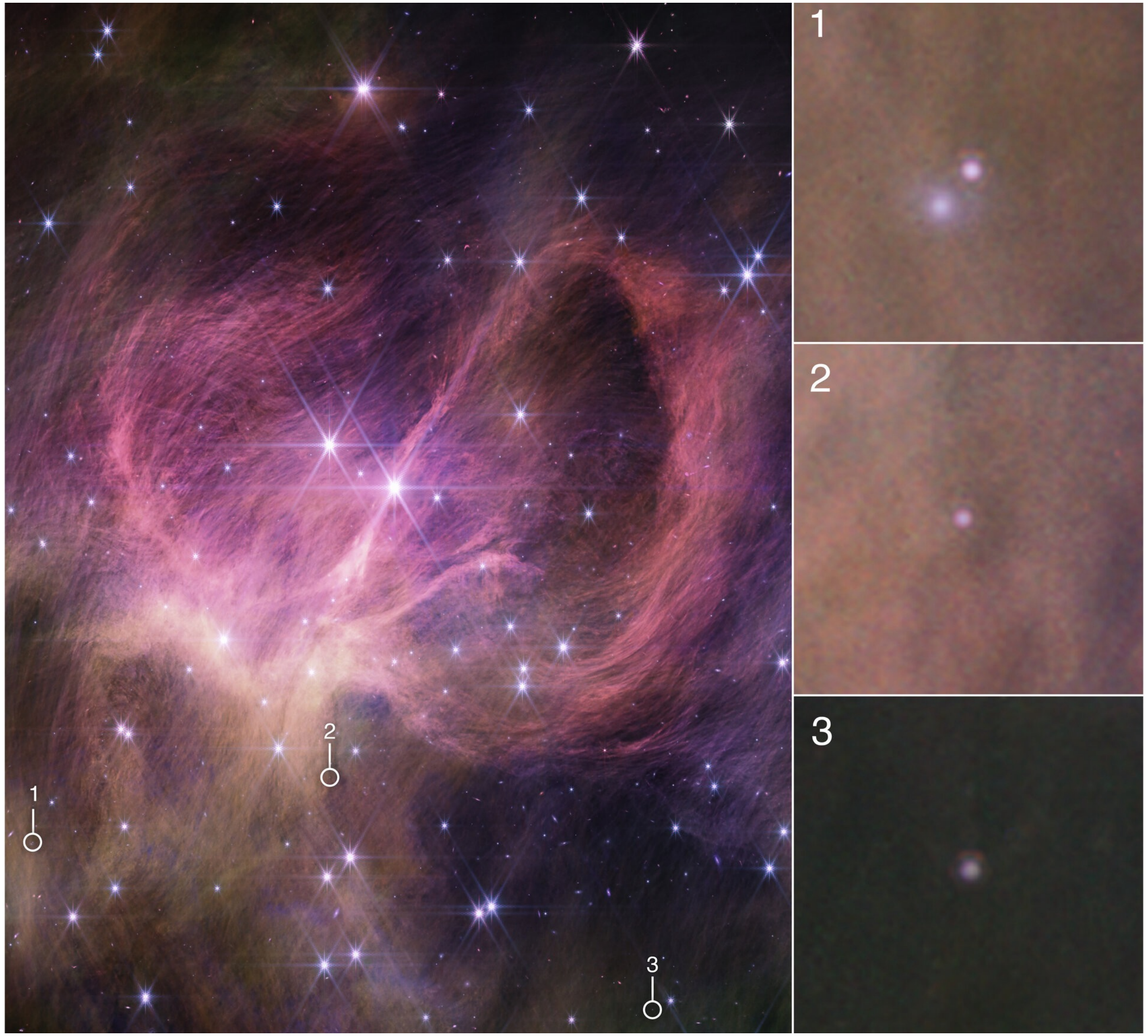
Design of the observing program with JWST/NIRCam

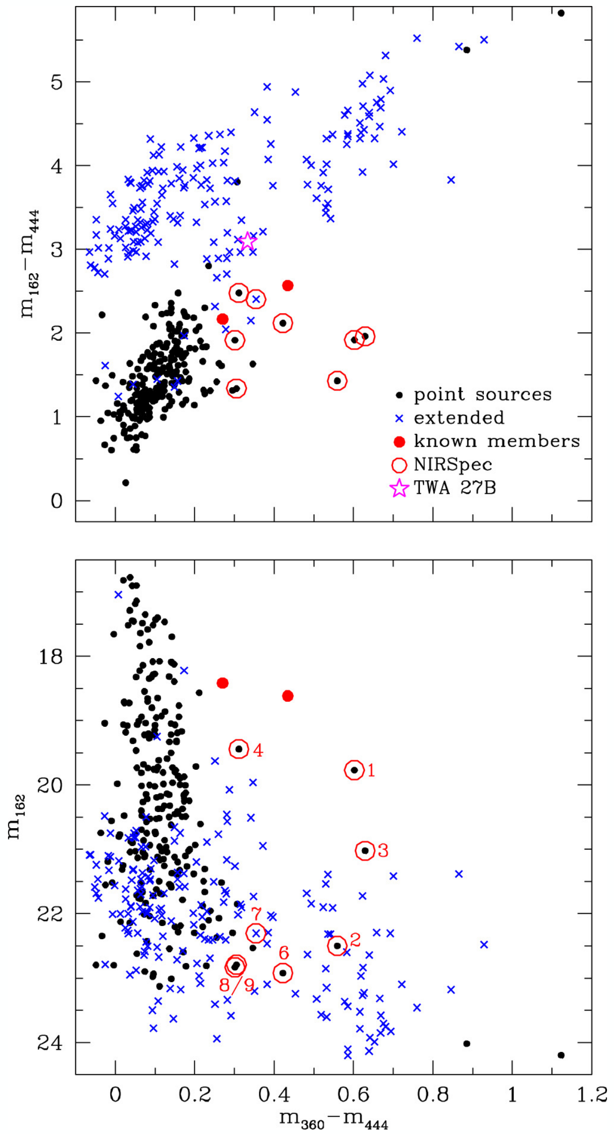
- Based on known-spectra of brown-dwarfs, select best photometry filters to uncover new low-mass objects
- Design a mosaic pattern centred on the cluster IC 348 (distance~400 pc, age~3 Myr)





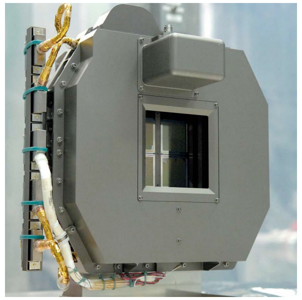
Uncovering the most promising candidate brown-dwarfs

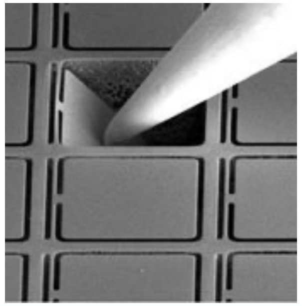


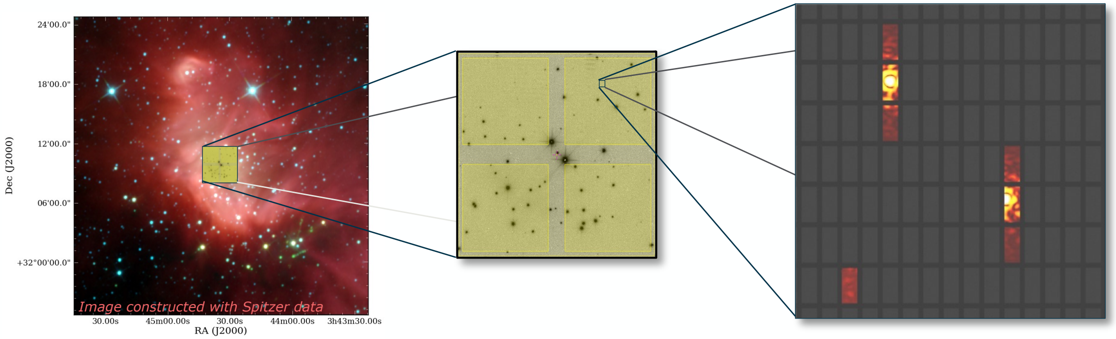


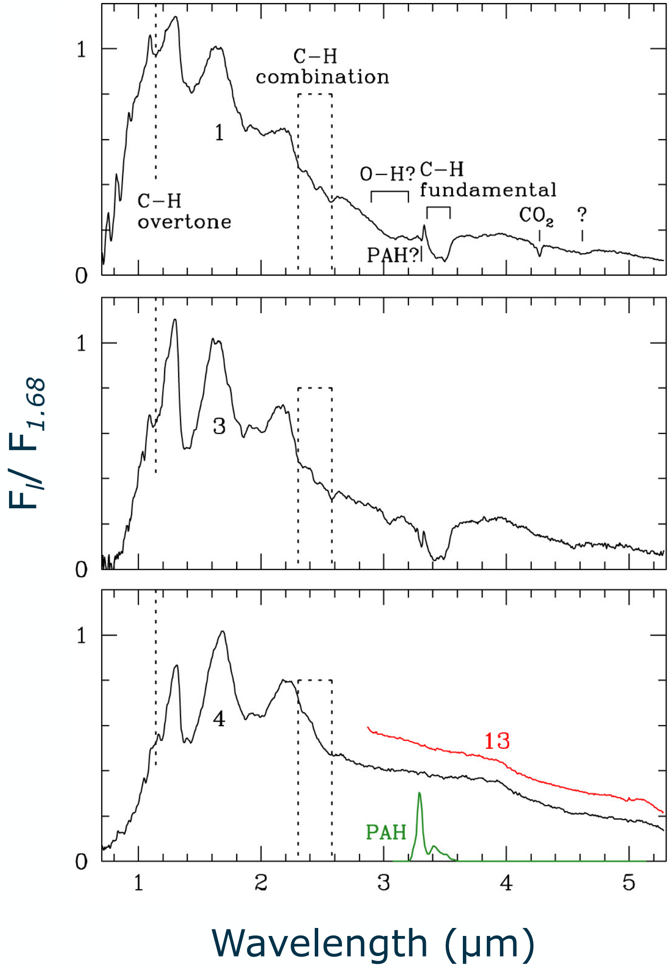
- Observations: 28-August-2022
- Use the objects shape and photometric colours (differences in magnitudes from different filters) to select candidates
- Selected 4 high-priority targets and 5 complementary ones for spectroscopic follow-up

Using JWST/NIRSpec to study brown dwarf candidates







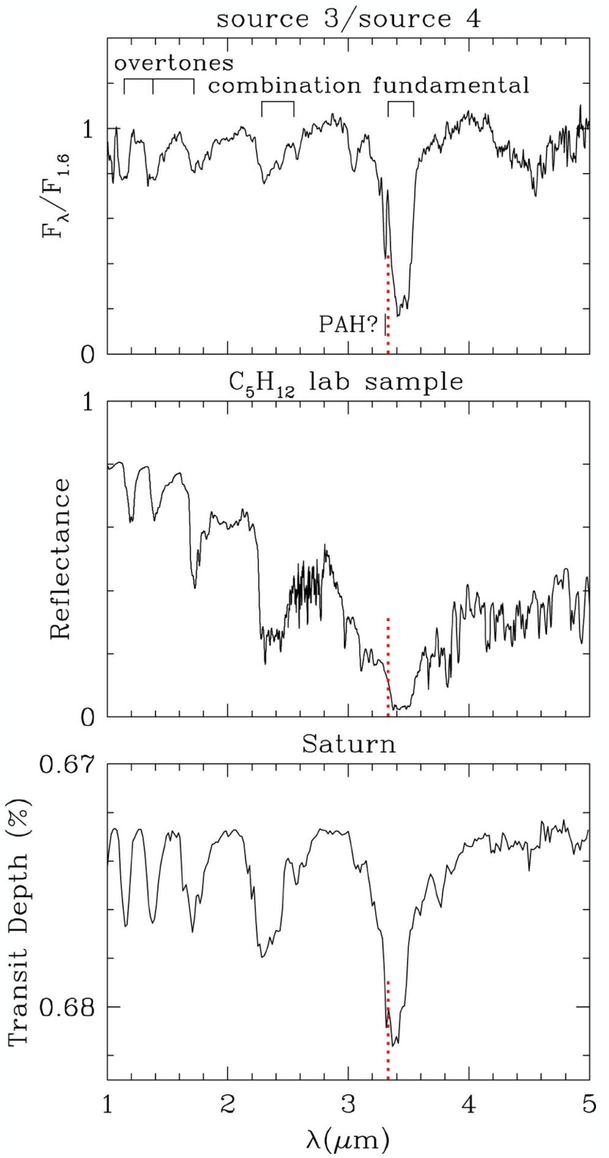


- ➢ Observations:
  03-February-2023
  (4.5 hours)

- ➢ Discarded 5 sources:
  - Reddened field dwarfs in the background
  - 1 field star or galaxy

- ➢ Confirmed 3 new members:
  - Comparision between estimated luminosity to evolutionary models result in temperatures of 1100-1800K and 3-8MJup
  - Source 3 is a contender for the least massive free-floating brown dwarf directly imaged to date

Molecular discovery and open questions



- 2 sources show a spectral signature of an unidentified hydrocarbon
- First time this molecule is detected in the atmosphere of an object outside our solar system
- Same infrared signature was detected by Cassini mission in the atmospheres of Saturn and its moon Titan, and modelled in terms of methane and other hydrocarbons, with a large component of the absorption still due to an unidentified aliphatic hydrocarbon
- One possibility is that these newly found objects inhabit a regime of physical properties that is previously unexplored (e.g., low temperature, low surface gravity, and thinning clouds)

Next steps

Reference: Luhman, K., Alves de Oliveira, C. et al. 2024, AJ 167,19L https://doi.org/10.3847/1538-3881/ad00b7

- Planned observations in 2024 of these objects with higher resolution spectroscopy
- Proposals submitted to study these targets in the mid-IR, and also map a wider and deeper part of the cluster

Thank you