Young brown dwarfs in the JWST era

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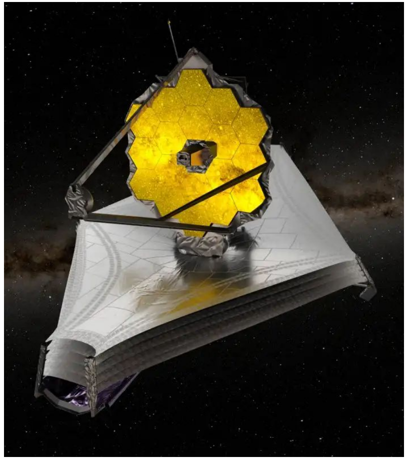
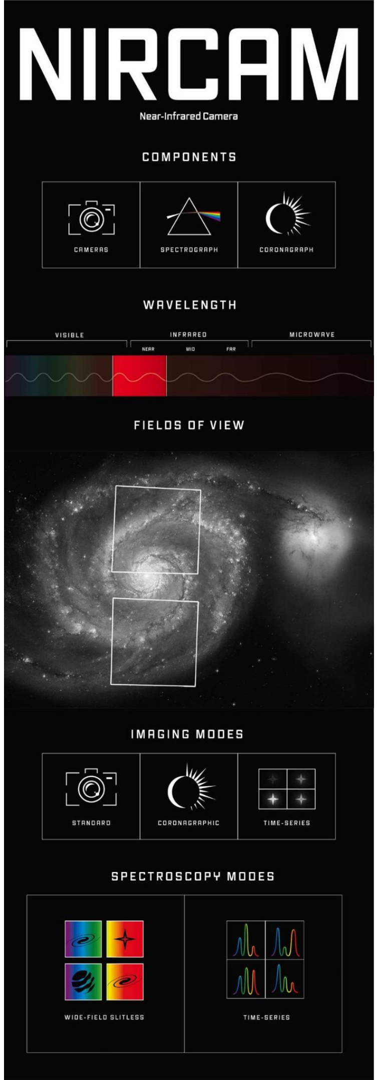
JWST




NIRCAM
Near-Infrared Camera
COMPONENTS
CAMERAS
SPECTROGRAPH
CORONAGRAPH
WAVELENGTH
VISIBLE
INFRARED
MICROWAVE
NEAR
MID
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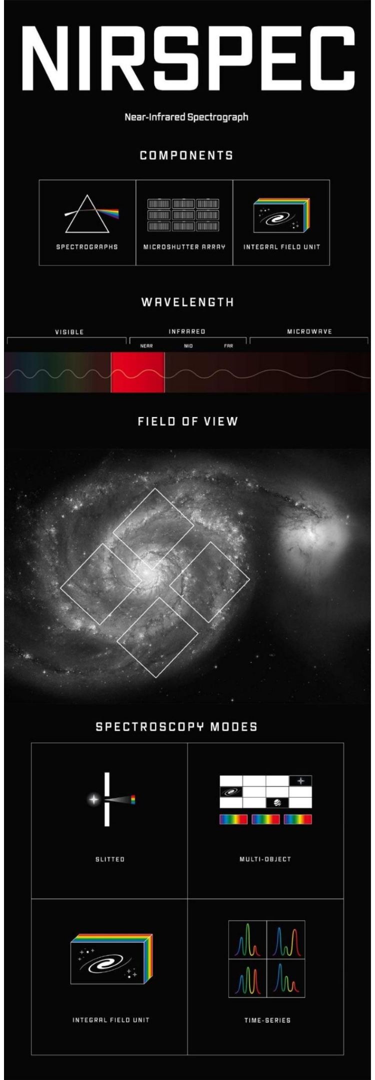
FIELDS OF VIEW
IMAGING MODES
STANDARD
CORONAGRAPHIC
TIME-SERIES
SPECTROSCOPY MODES
WIDE-FIELD SLITLESS
TIME-SERIES


NIRSPEC
Near-Infrared Spectrograph
COMPONENTS
SPECTROGRAPHS
MICROSHUTTER ARRAY
INTEGRAL FIELD UNIT
WAVELENGTH
VISIBLE
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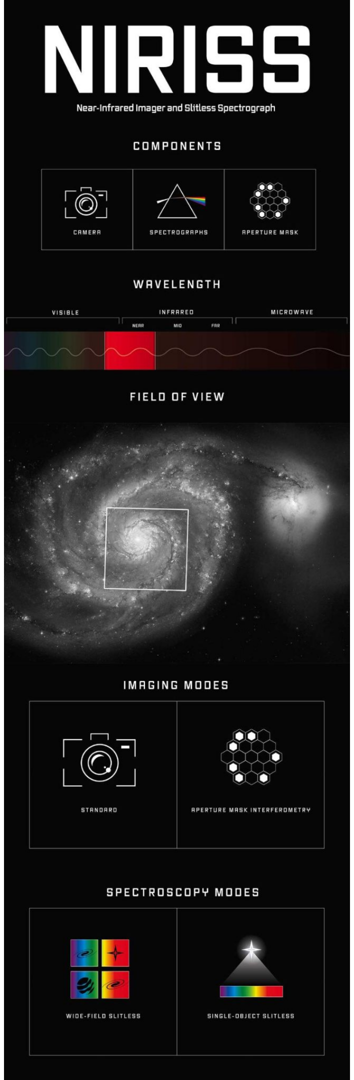
SPECTROSCOPY MODES
SLITTED
MULTI-OBJECT
INTEGRAL FIELD UNIT
TIME-SERIES


NIRISS
Near-Infrared Imager and Slitless Spectrograph
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CAMERA
SPECTROGRAPHS
APERTURE MASK
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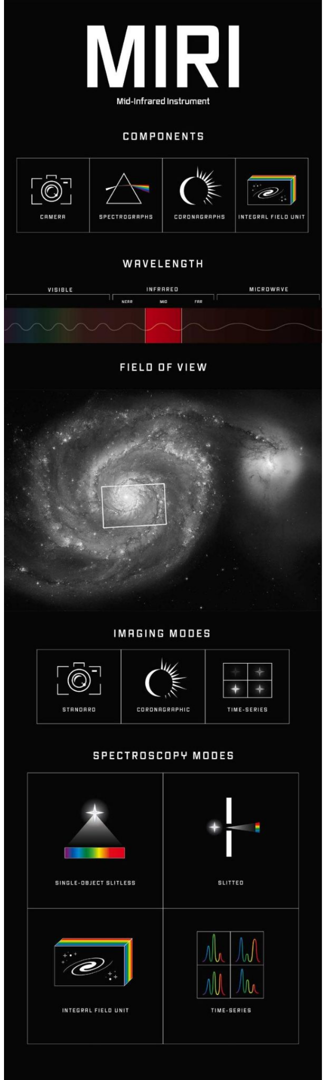
SPECTROSCOPY MODES
WIDE-FIELD SLITLESS
SINGLE-OBJECT SLITLESS


MIRI
Mid-Infrared Instrument
COMPONENTS
CAMERA
SPECTROGRAPHS
CORONAGRAPHS
INTEGRAL FIELD UNIT
WAVELENGTH
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MICROWAVE
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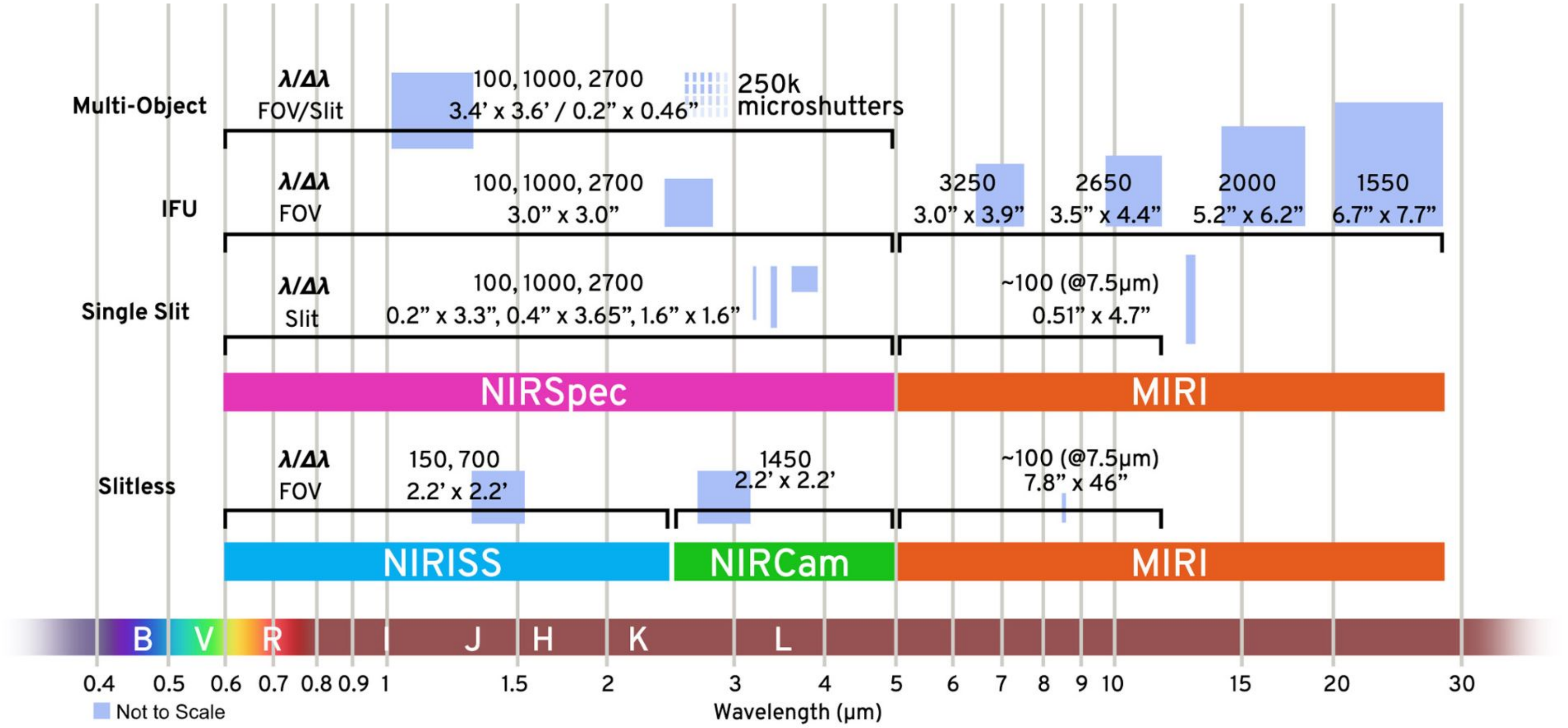
TIME-SERIES
SPECTROSCOPY MODES
SINGLE-OBJECT SLITLESS
SLITTED
INTEGRAL FIELD UNIT
TIME-SERIES

JWST: spectroscopic capabilities



This talk

Concentrate on **young** BDs

- Substellar populations and the IMF
  - Planetary-mass objects and the bottom of the IMF
  - Exploration of different environments
- Atmospheres
- Disks and their chemistry
- Accretion

What did we know about BD statistics before JWST

- The initial mass function is continuous across the H-burning limit
- BDs are less common than stars

N(BD) / N(★) = 20 to 50 %

- PMOs (<12 M_{JUP}) are even more rare

N(PMOs) / N(★+ BD) = 2 to 10 %

- The lowest-mass PMOs confirmed from the ground have ~5 MJup

talks by C. Alves de Oliveira
& M. R. Zapatero Osorio

Current frontiers in IMF studies

The quest for the depth

- planetary-mass objects and their statistics
- where is the bottom of the IMF?
- can we identify a population of genuine free-floating planets?

Current frontiers in IMF studies

The quest for the depth

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Diversity of environments

- stellar densities
- FUV flux
- metallicity

Searches for PMOs in young clusters

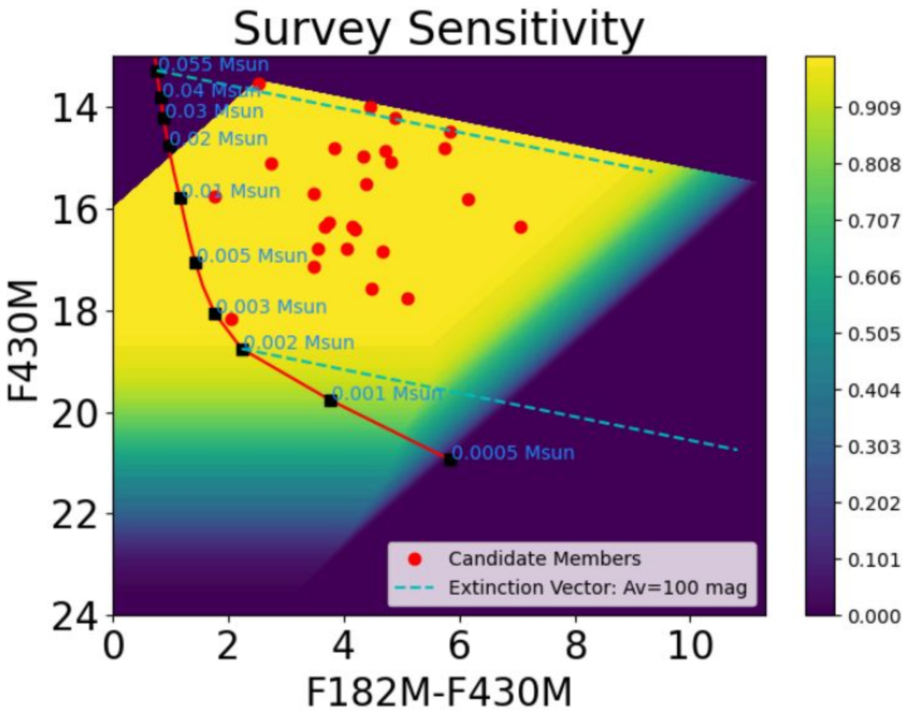
Imaging

- **NGC 2024** (De Furio et al. 2024)

Imaging+spectroscopy

- **IC 348** (Luhman et al. 2024, Luhman & Alves de Oliveira 2025)
- **NGC 1333** (Langeveld et al. 2024)
- **ONC** (Luhman et al. 2024, Luhman 2025)

NGC 2024



De Furio et al. (2024)

- 400 pc, 1 Myr

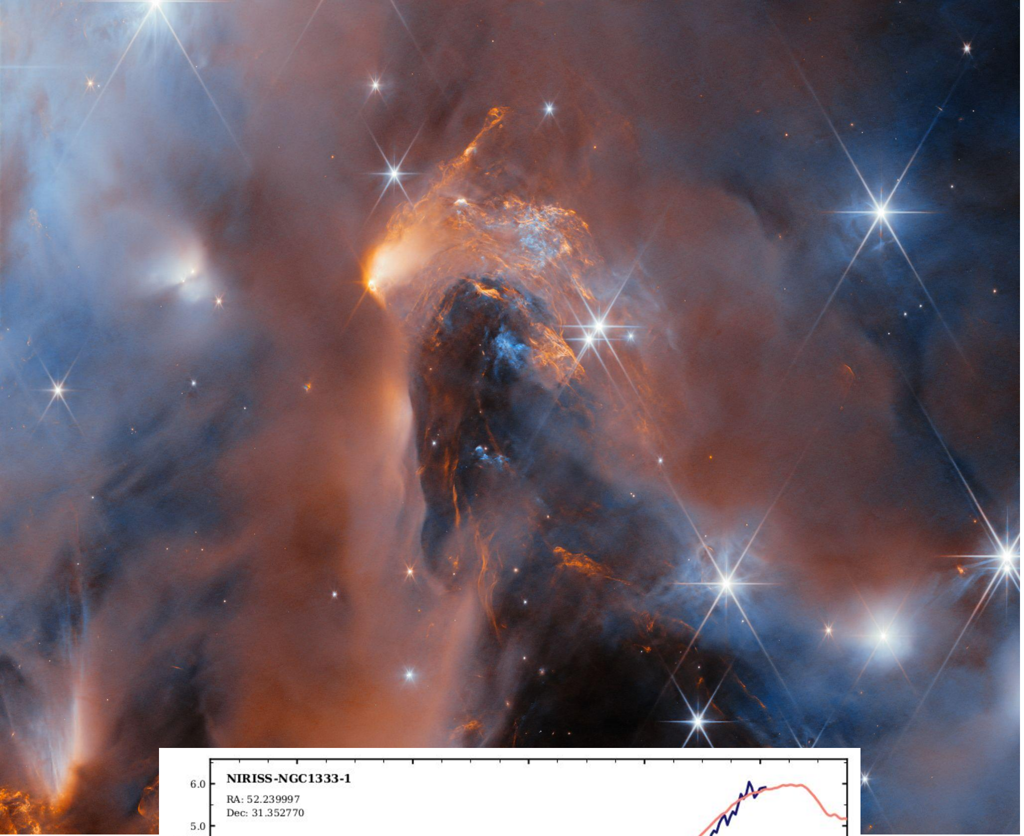
survey sensitivity:

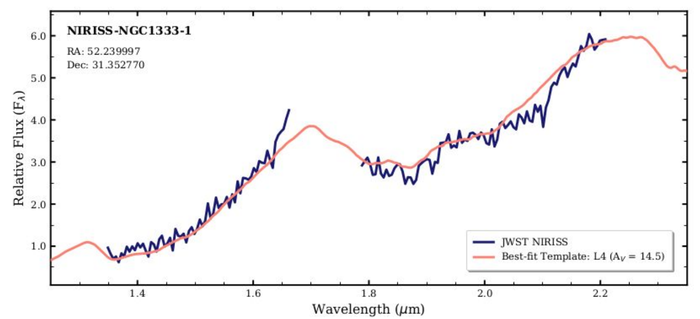
1- 2 M_{Jup} @ AV < 50 - 30 mag

no detections below ~ 3 M_{Jup}

awaiting spectroscopy

- GO 5409 (PI De Furio)





NGC 1333

Langeveld et al. (2024)

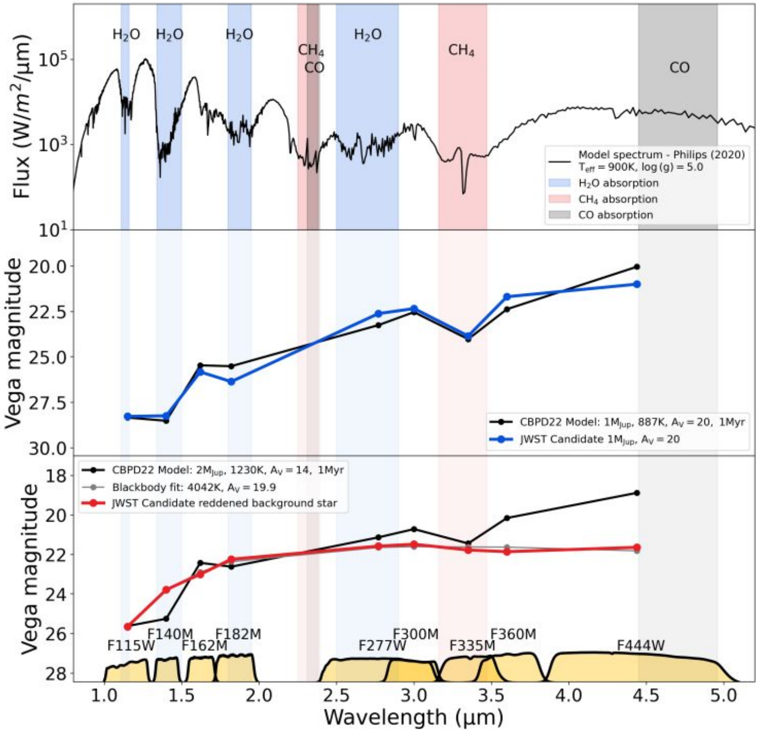
- 300 pc, 1-3 Myr
- slitless spectroscopy (NIRISS-WFSS)
- 6 new PMO candidates
- estimated masses 5 - 15 M_{Jup}
- sensitivity: early T-dwarfs with Av < 20

Clear lack of late-L and T-dwarfs

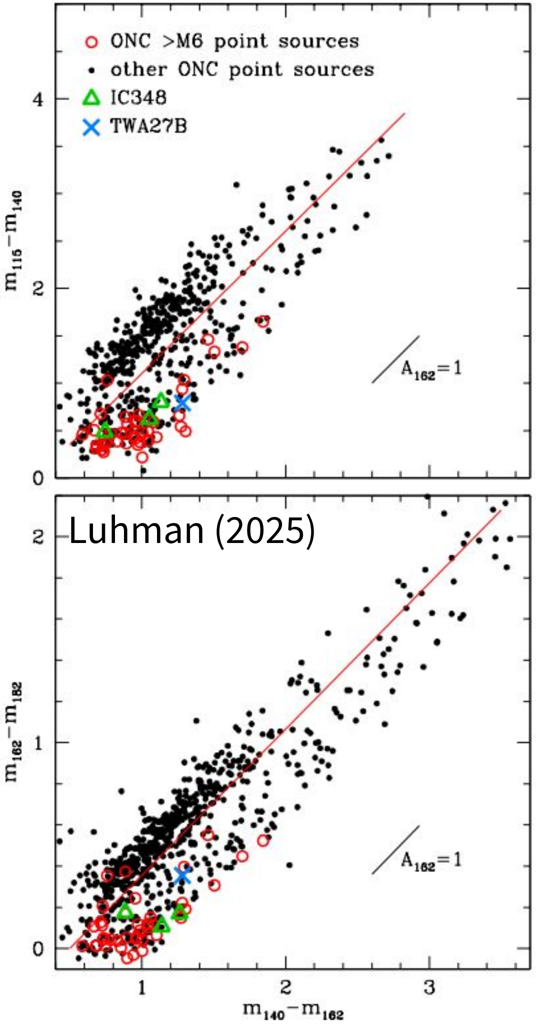
The bottom of the IMF?

Orion Nebula Cluster

- 400 pc, 1-3 Myr



Pearson & McCaughrean (2023), preprint



imaging survey sensitivity: ~1M_{Jup}

P & M (2023):

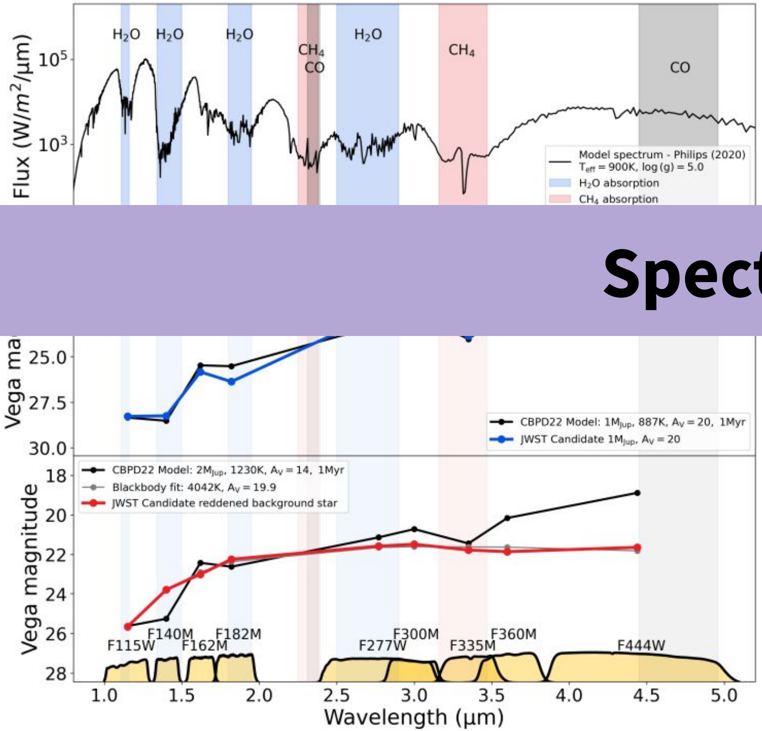
> 500 PMOs and 9% of these in binaries (JuMBOs)

Luhman (2025):

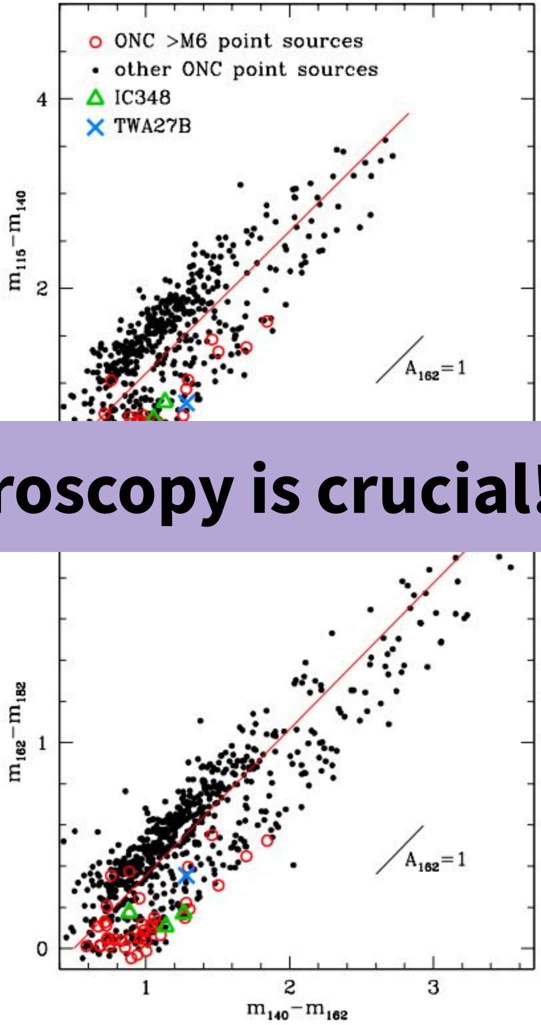
- ~240 PMO candidates
- majority of JuMBOs are contaminants

Orion Nebula Cluster

- 400 pc, 1-3 Myr



Pearson & McCaughrean (2023), preprint



imaging survey sensitivity: ~1M_{Jup}

P & M (2023):

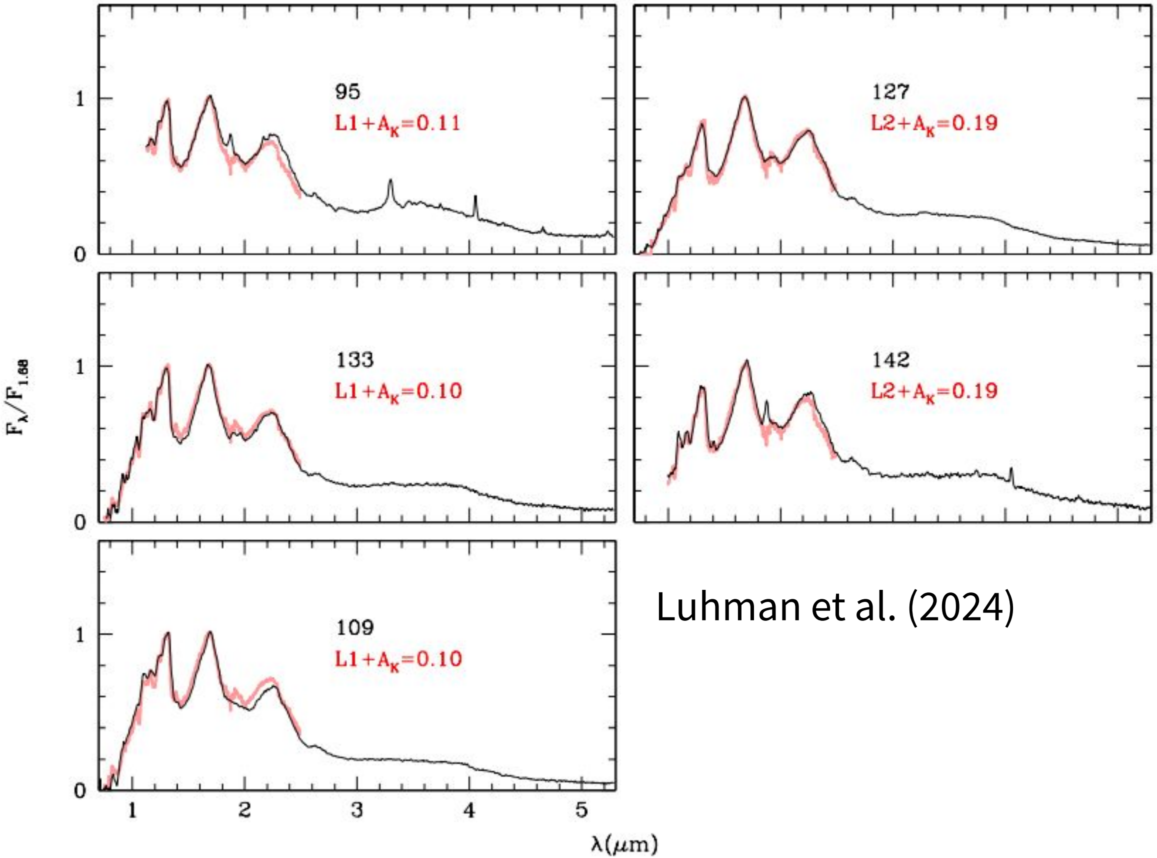
> 500 PMOs and 9% of these in binaries

Spectroscopy is crucial!

Luhman (2025):

- ~240 PMO candidates
- majority of JuMBOs are contaminants

Orion Nebula Cluster

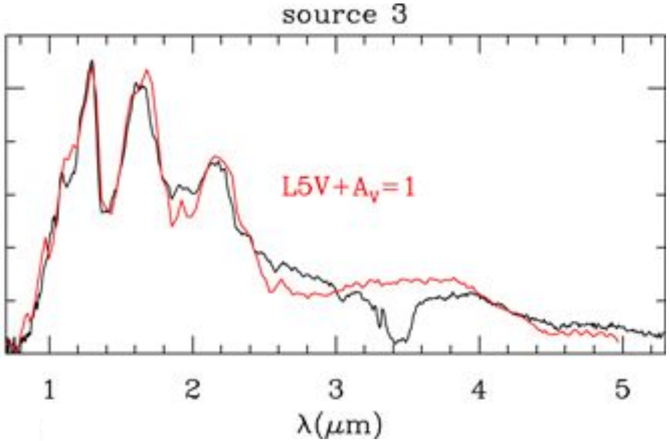


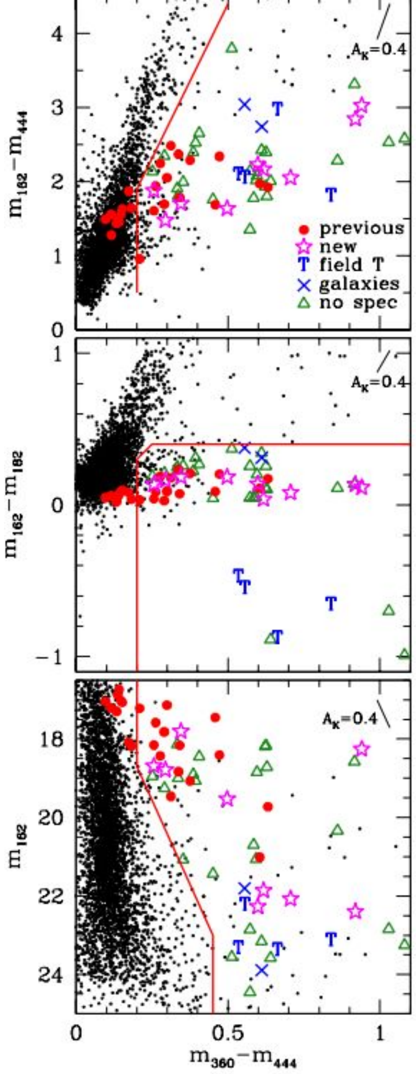
0.003 - 0.007 $M_\odot$
(@ 1–5 Myr)

Luhman et al. (2024)

IC 348

- 300 pc, 3-5 Myr
- ~ dozen new BDs

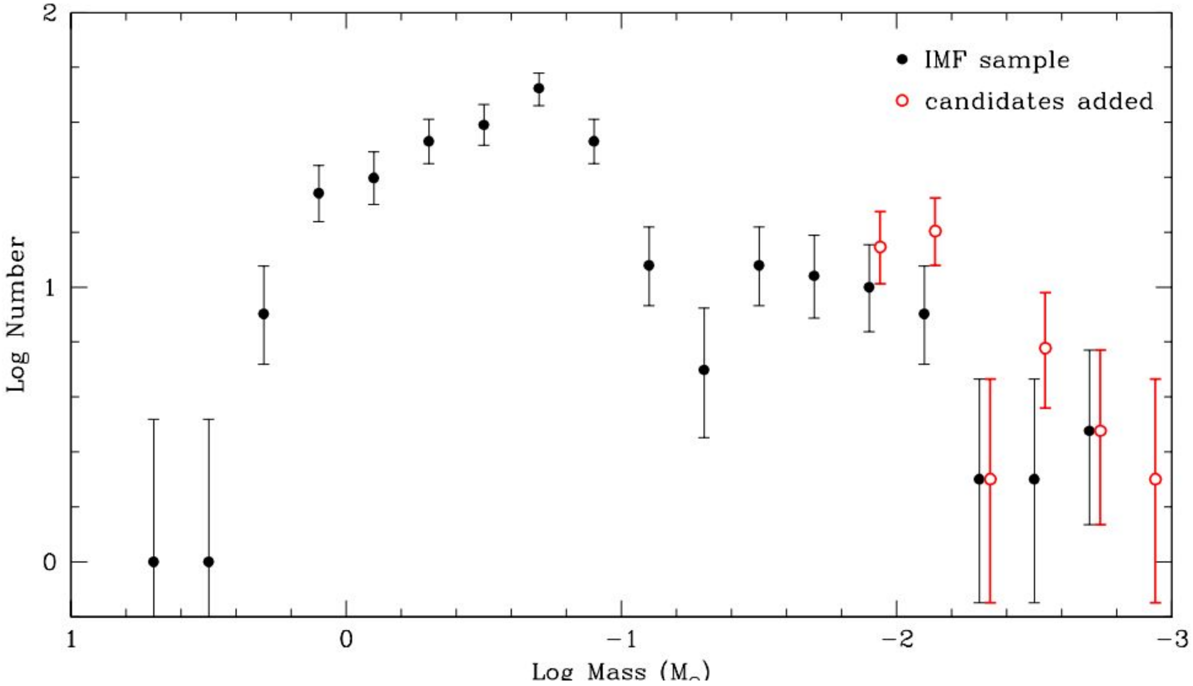




Luhman et al. (2024)

Luhman & Alves de Oliveira (2025

The IMF in IC 348



down to ~2 M_{JUP}

(but, without methane absorption)

talk by C. Alves de Oliveira

Luhman & Alves de Oliveira (2025)

PMOs with JWST

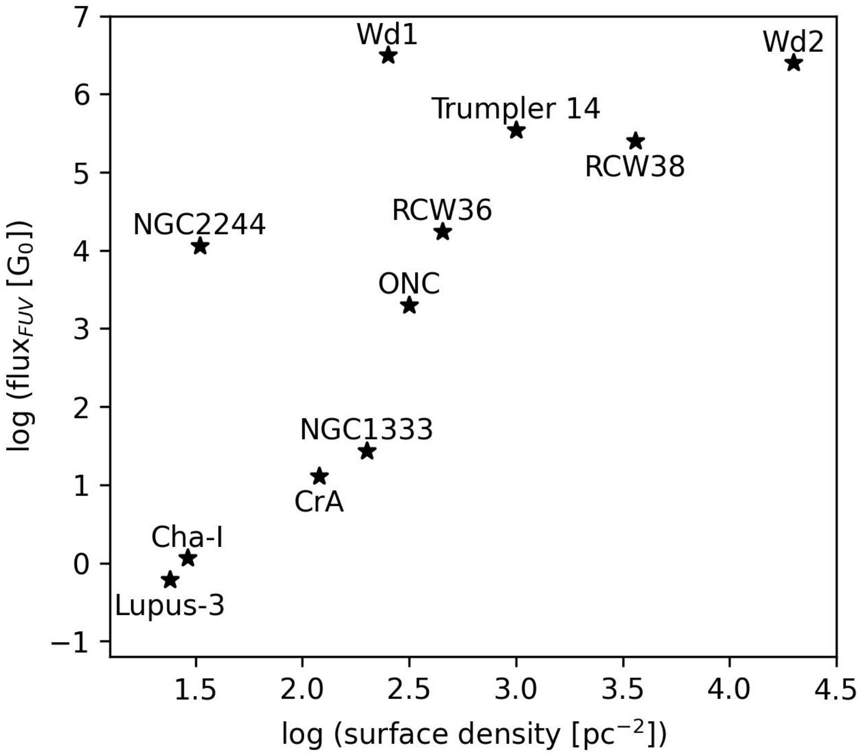
So far, it seems that the number of PMOs decreases with mass

- PMOs found in nearby SFRs probably form as stars (?)

What about a genuine free-floating planet (ejected) population?

- Does it exist?
- In principle, the number of FFPs should increase with decreasing mass and should be environment-dependent

Star forming environments



RCW 38

- GO 7607 (PI Muzic)
- down to 2-3 M_{JUP}

Westerlund 1 & 2

- EWOCS (PI M. Guarcello)
- sensitive to BDs, but not PMOs

talk by V. Almendos-Abad

NGC 2244

- GTO 4545 (PI McCaughrean)
- down to 1 M_{Jup}

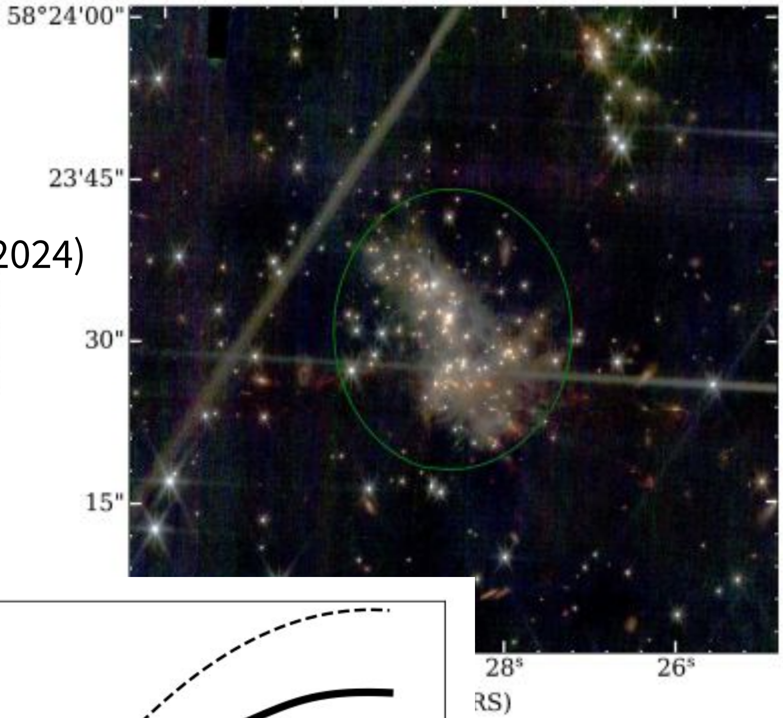
Effects of metallicity: Digel 2

<1 Myr

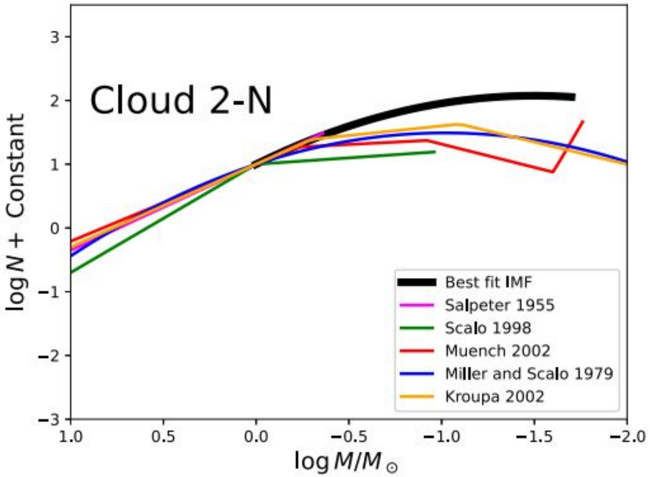
~8 kpc

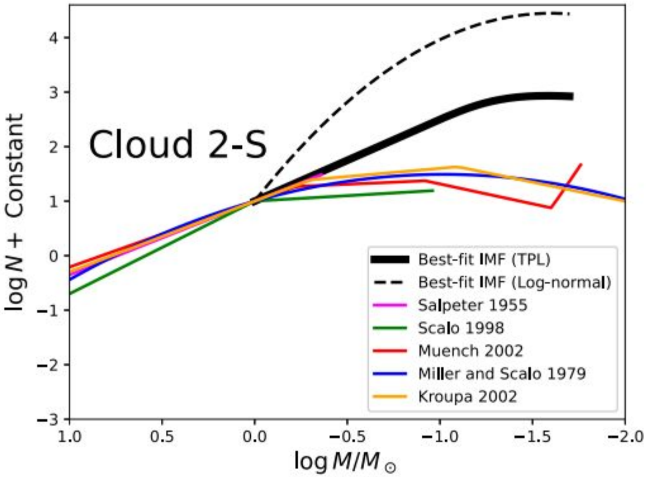
$Z \approx 0.2\ Z_\odot$

Yasui et al. (2024)



IMF peak shifted to substellar masses?





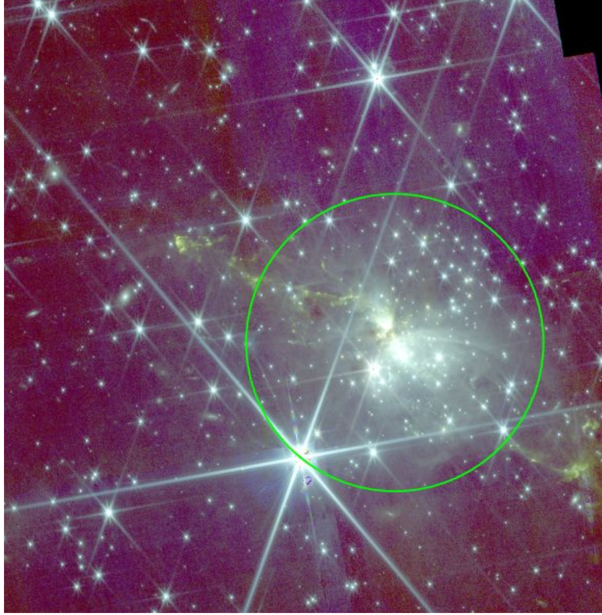
Effects of metallicity: Sh2-284

~1 Myr

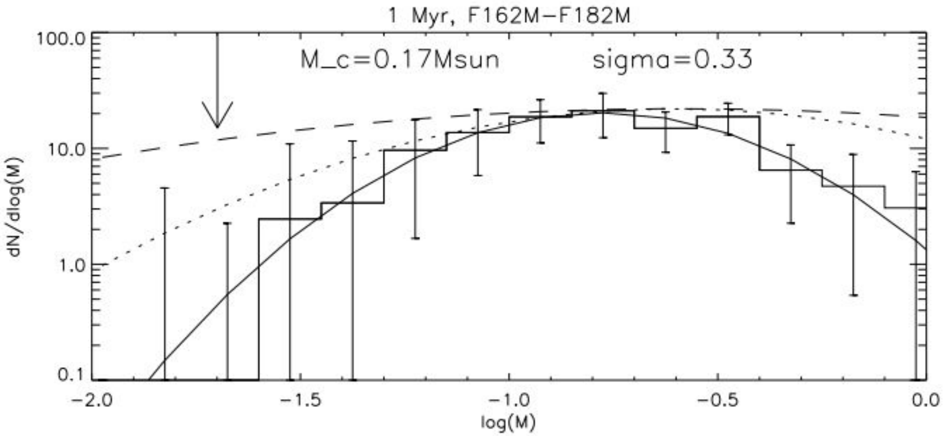
4.5 kpc

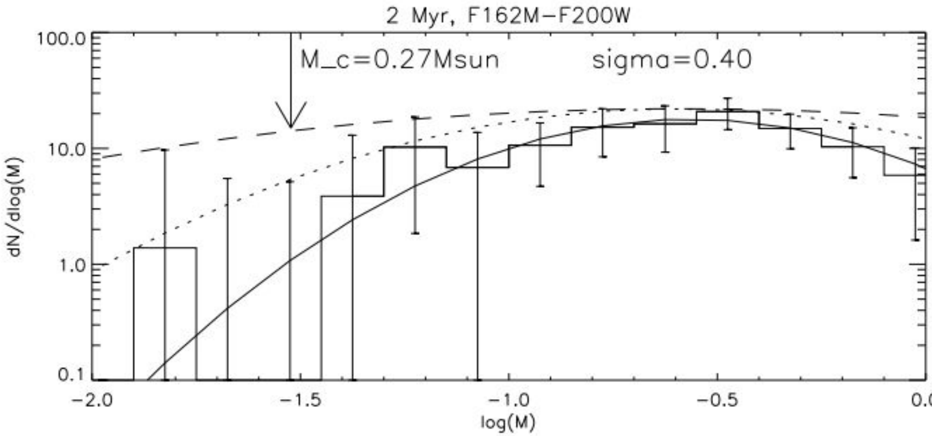
$Z \approx 0.3\ Z_{\odot}$

Andersen et al. (2025)



IMF peak shifted to lower masses?





Effects of metallicity: NGC 602 (SMC)

2-3 Myr

62 kpc

$Z \approx 0.2–0.5\ Z_\odot$

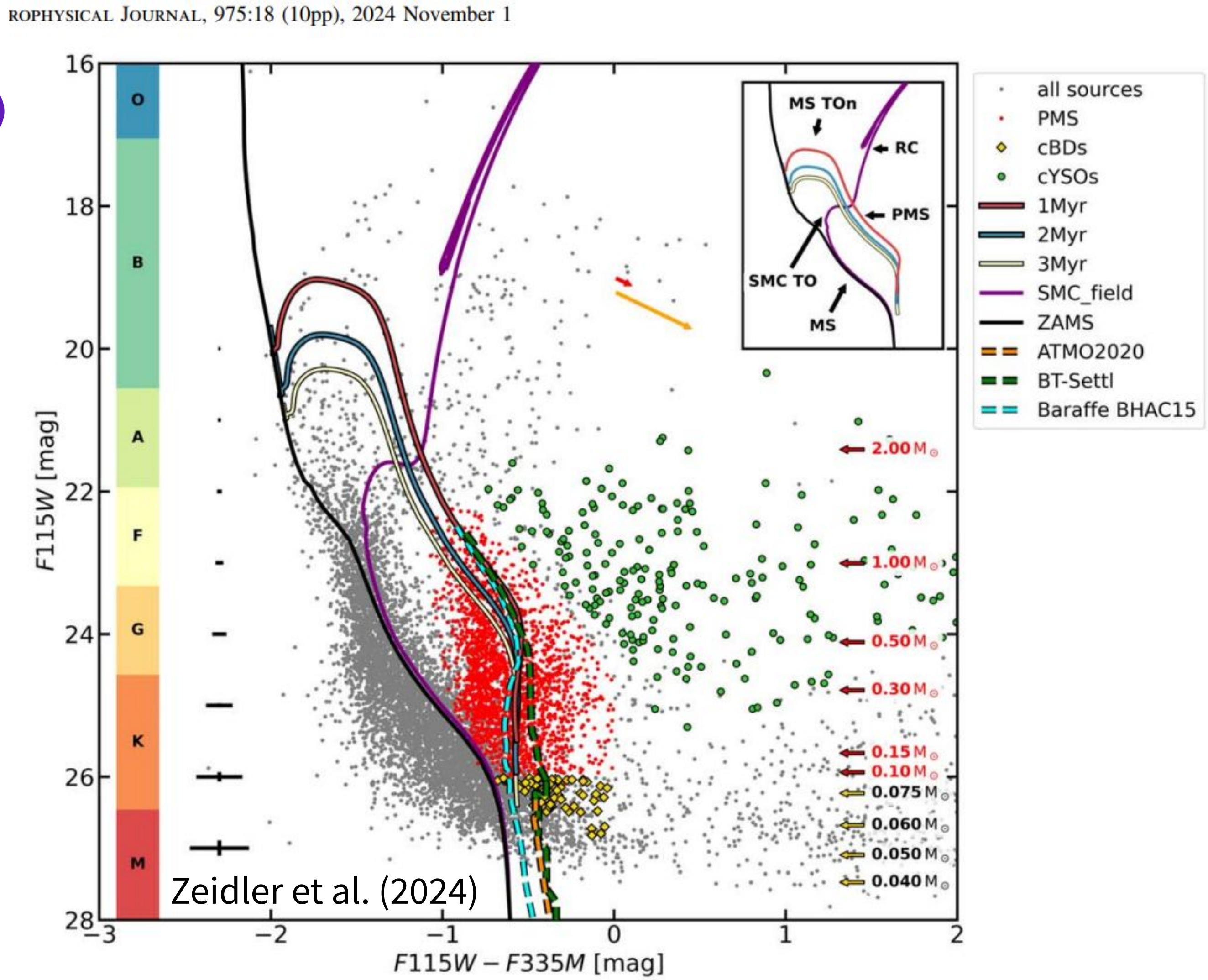
Zeidler et al. (2024)

NGC 602 (SMC)

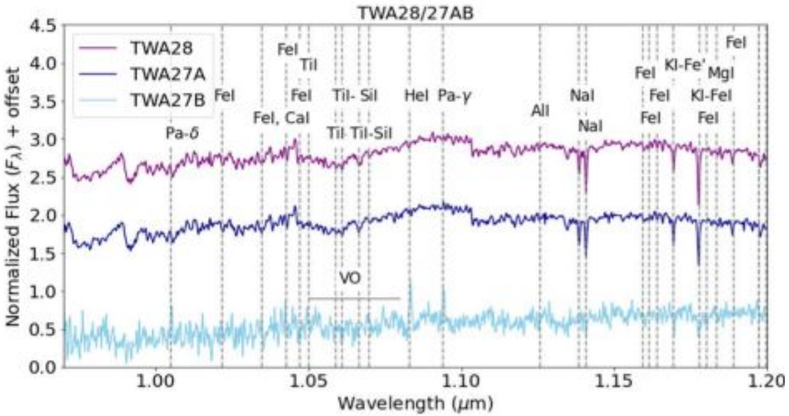
first detection of a young BD population outside the MW

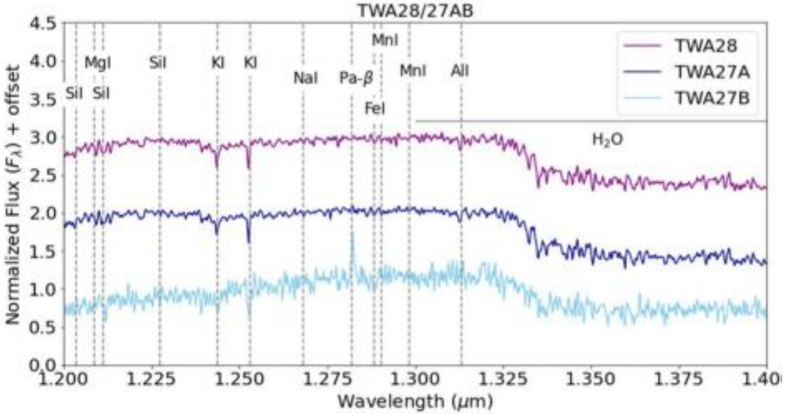
spectroscopy needed to confirm candidates and derive the IMF

GO 7035 PI Zeidler

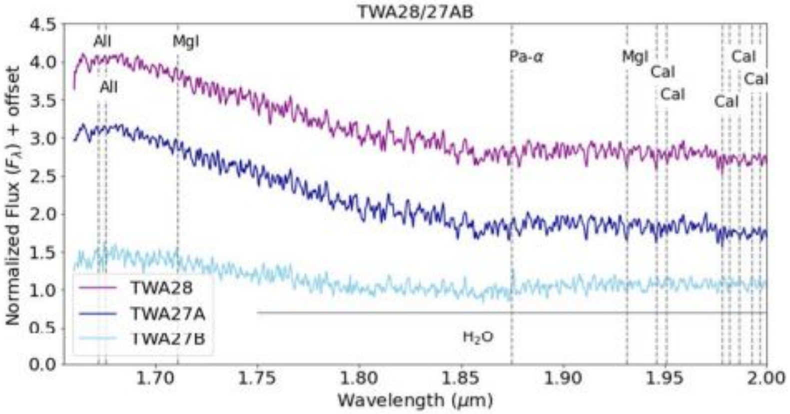


Brown dwarf atmospheres - TWA (~10 Myr)

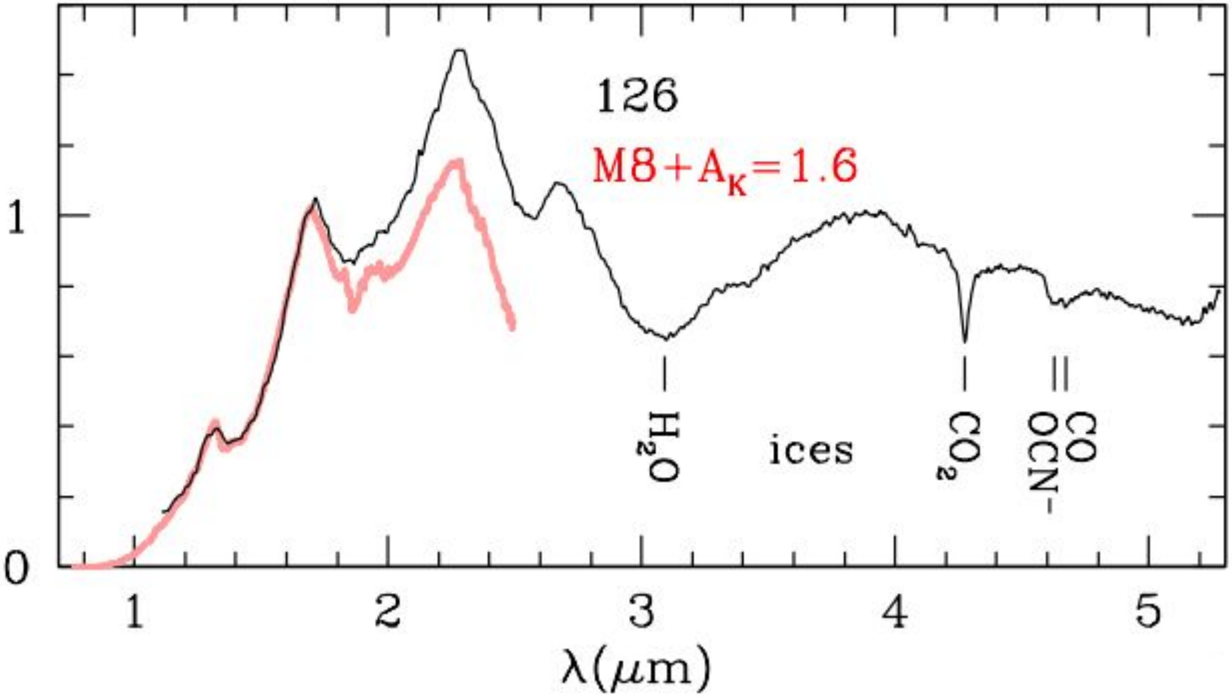




Manjavacas et al. (2024)



Ices



Luhman et al. (2024)

ONC

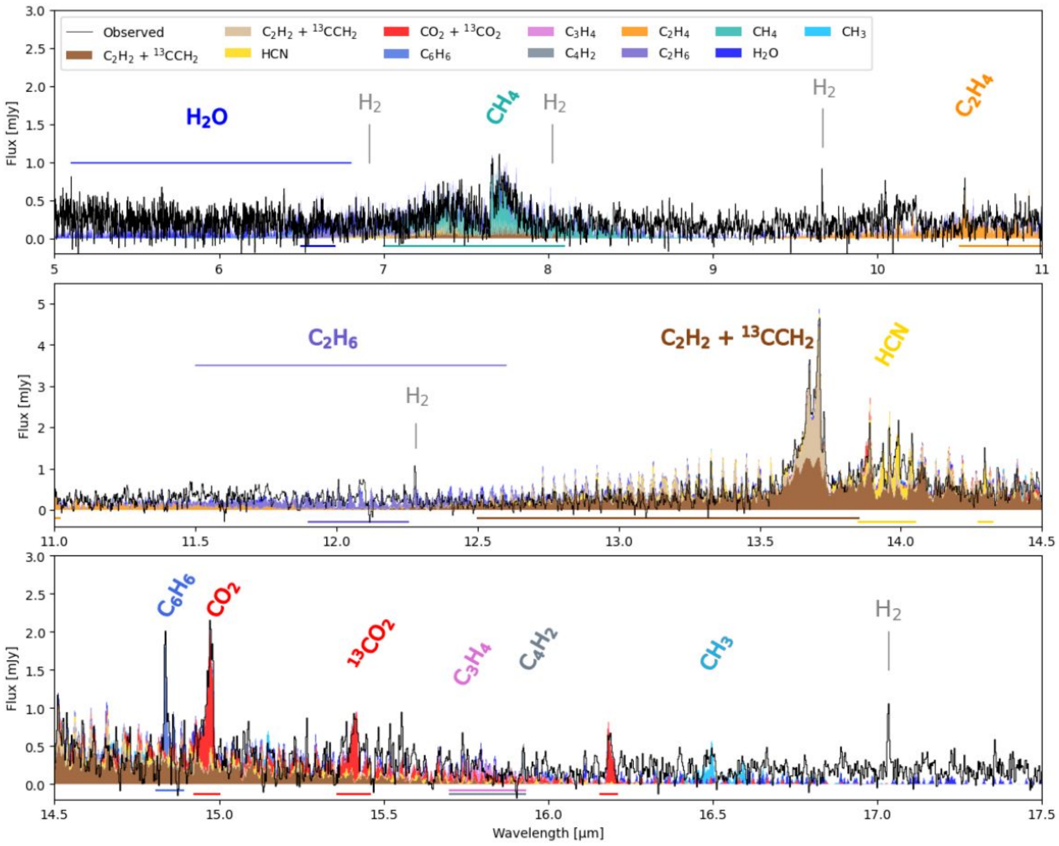
proto-BD candidate

BD disks and chemistry

Morales-Calderón et al. (2025)

MINDS (MIRI mid-INfrared Disk Survey) + others

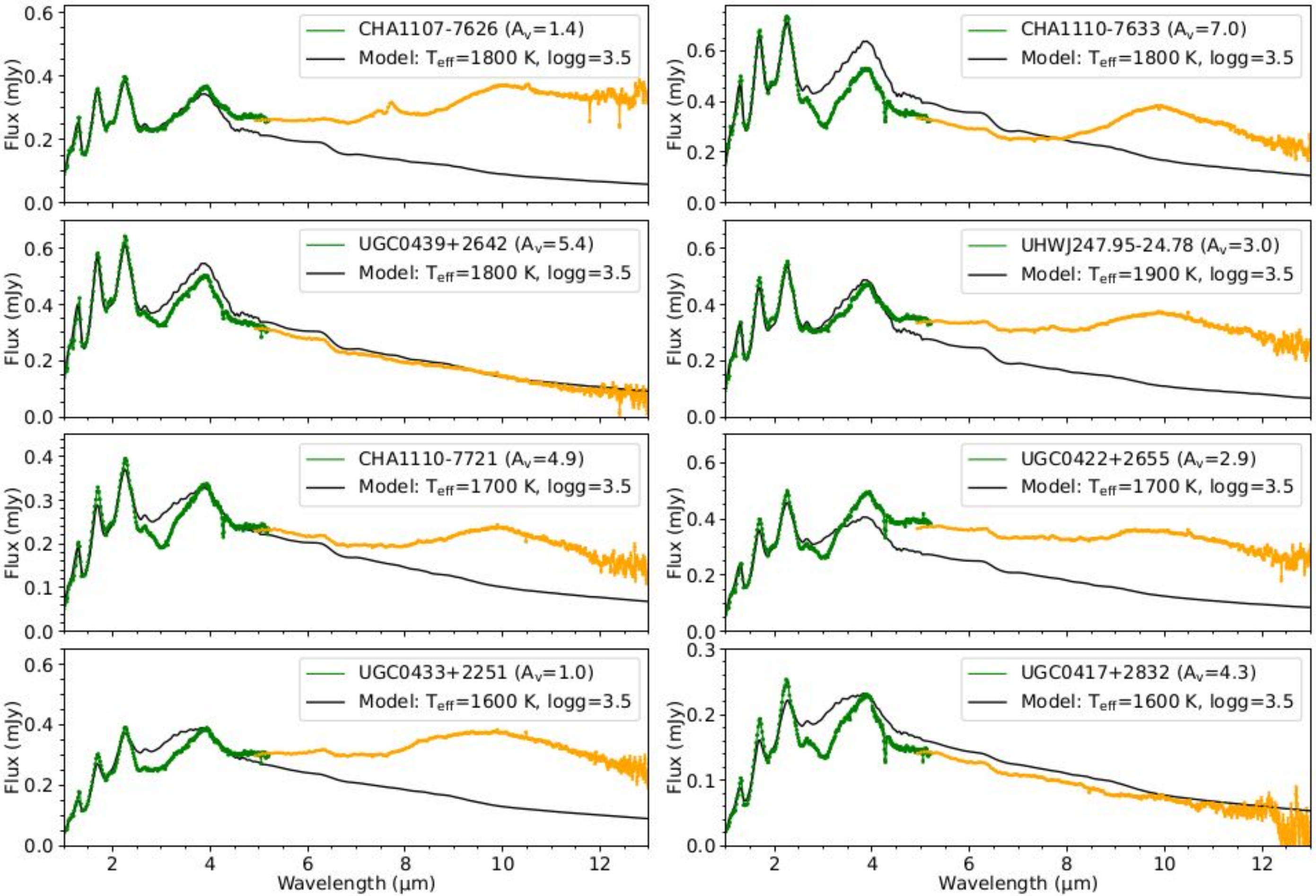
- VLMS/BDs: rich hydrocarbon chemistry
- BD disks:
  - hydrocarbons
  - typically, C/O > 1
  - silicates



Tabone et al. 2024, Arabhavi et al. 2024, Morales-Calderón et al. 2025, Patapis et al. 2025, Kanwar et al. (2025)

PMO disks

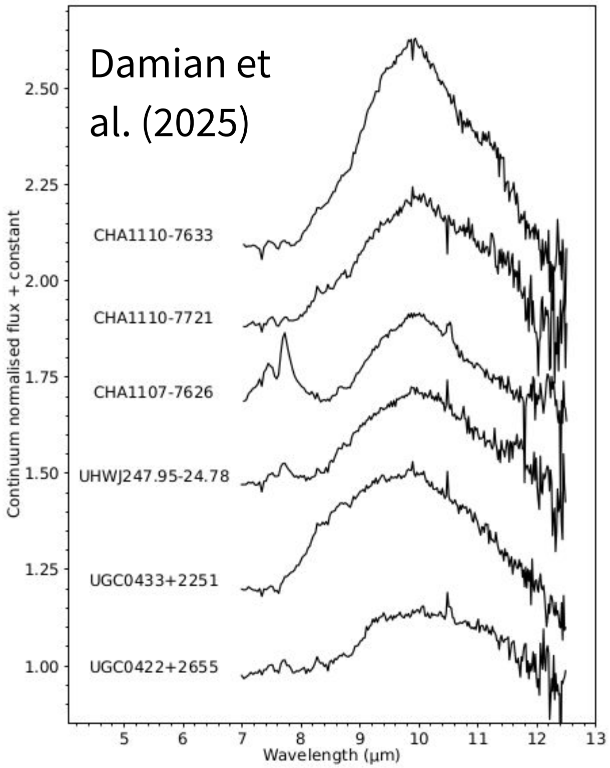
5-10 M_{JUP}



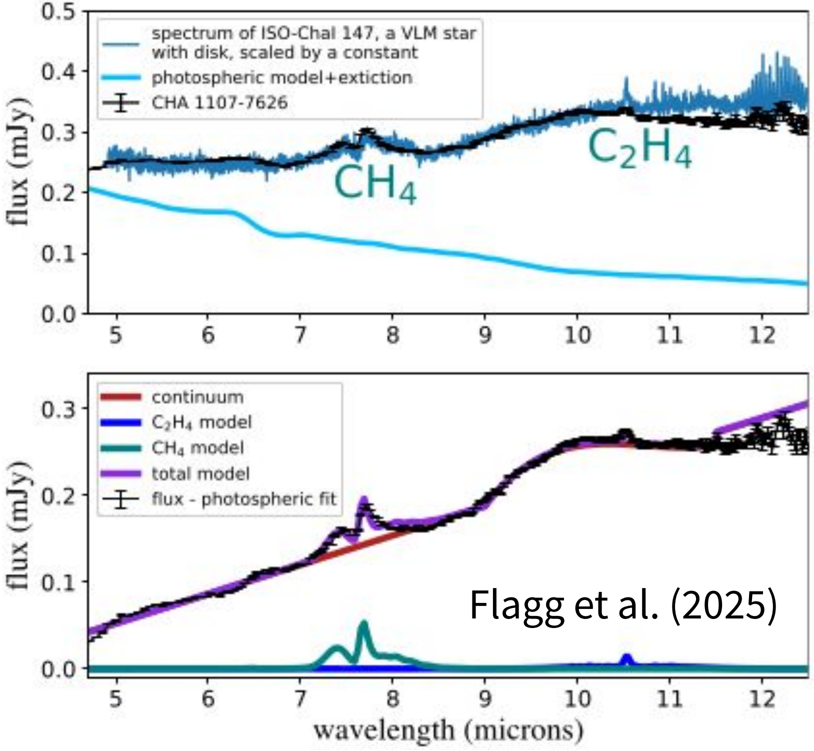
Damian et al. (2025)

PMO disks

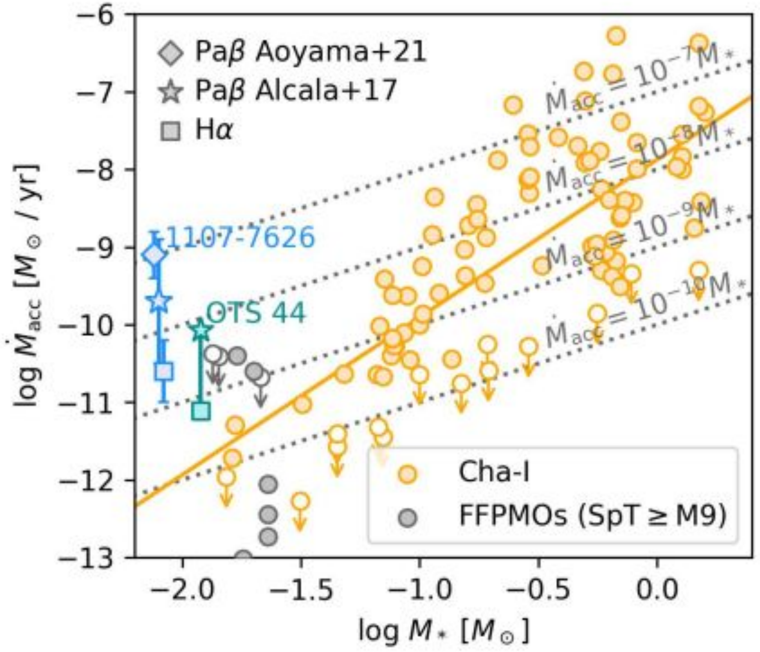
silicates



hydrocarbons in Cha 1107-7626

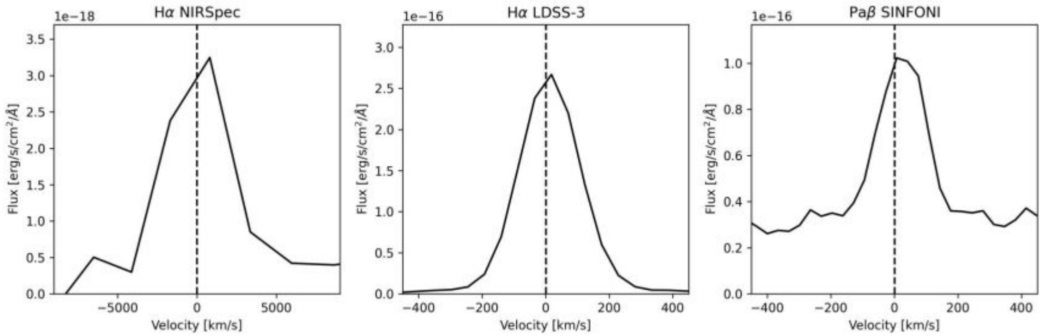


Accretion



Cha 1107-7626

So far, the lowest mass objects showing active accretion



Flagg et al. (2025)

Summary and outlook

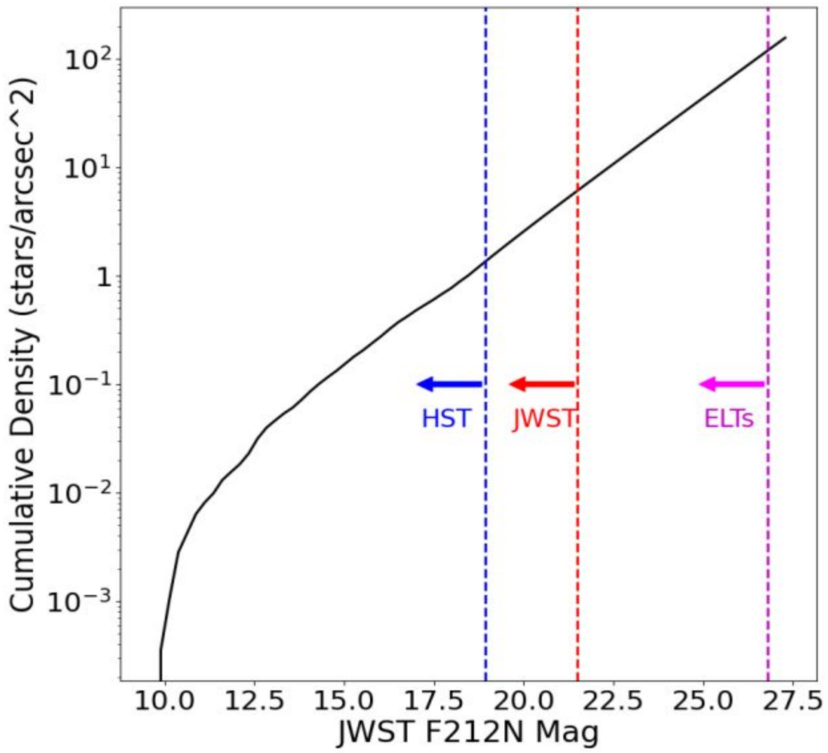
JWST offers a wealth of capabilities for young BD studies

- identify and characterize Jupiter-mass objects & IMF
- detect BDs in clusters at unprecedented distances, reaching completely new star-forming environments
- characterization of BD atmospheres (need for improved models in MIR)
- chemical inventory of BD inner disks
- accretion at the bottom of the mass scale
- proto-BDs discoveries

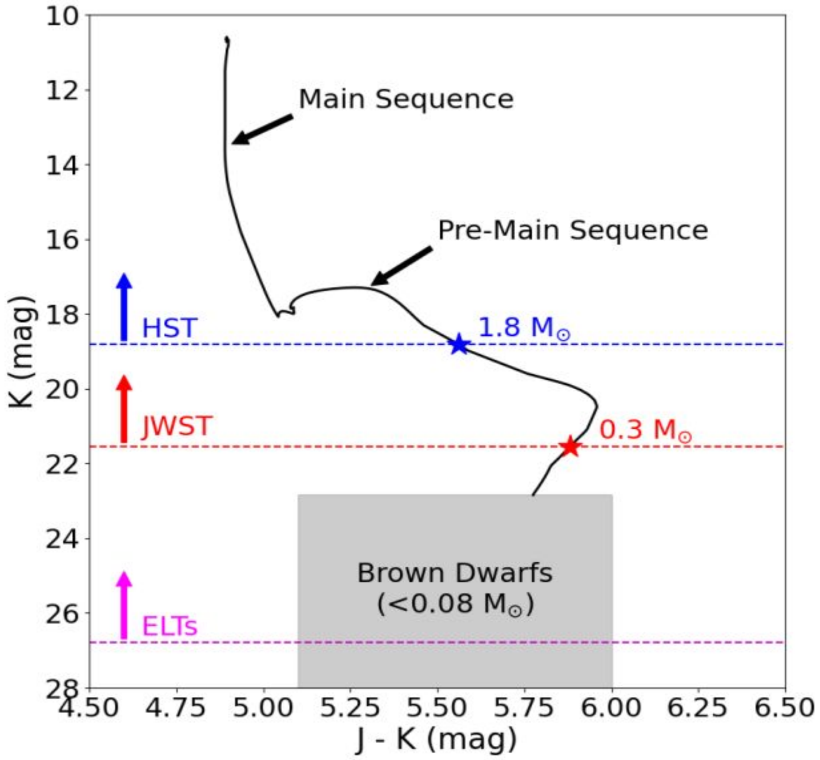
Future of brown dwarf science: exciting times are ahead

Thank you for your attention!

BDs at the Galactic Center?

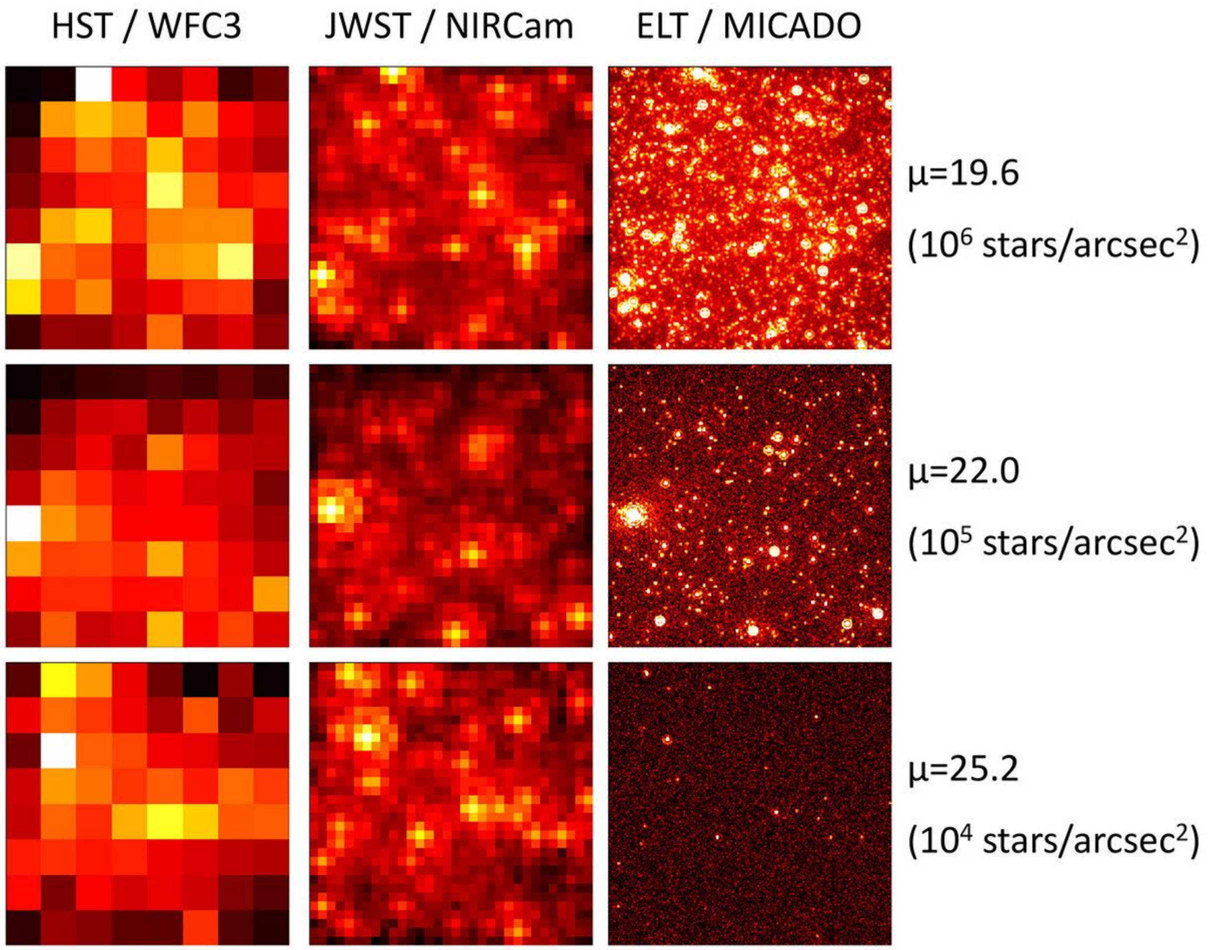


JWST & ELTs confusion limits



Plot credits: Matthew Hosek's talk @ ELT Science in light of JWST

Crowding

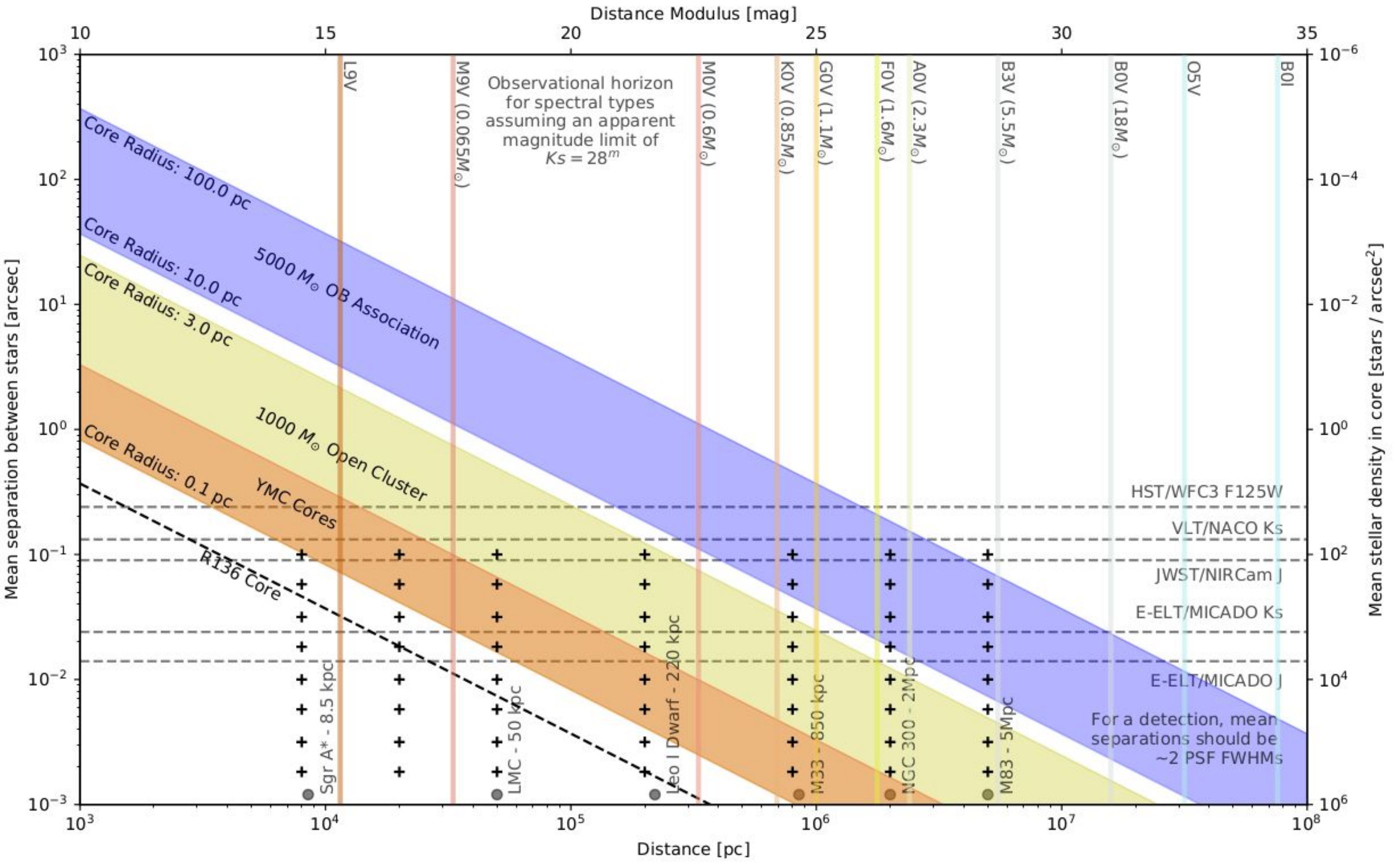


ESO/MICADO consortium

IMF with MICADO/ELT

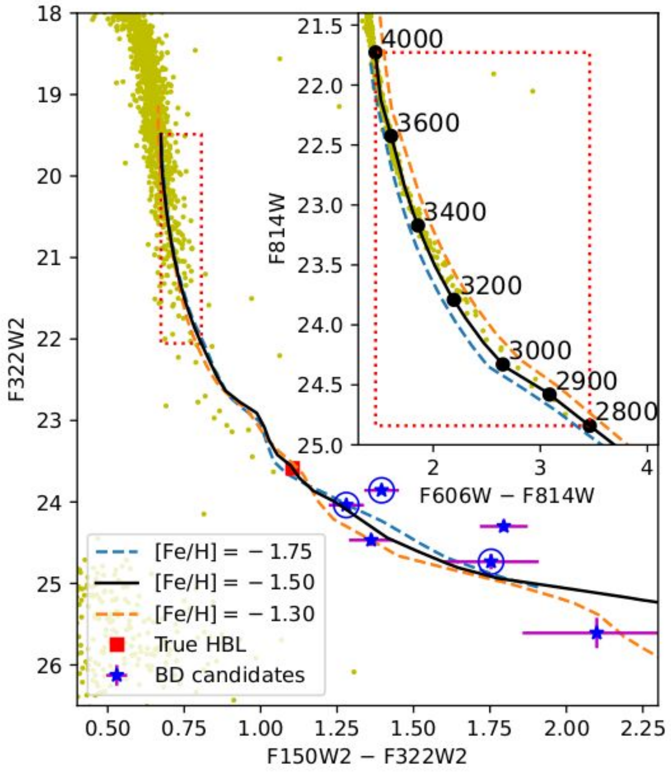
Leschinski & Alves (2020)

10 M_{Jup} accessible for clusters within 8 kpc

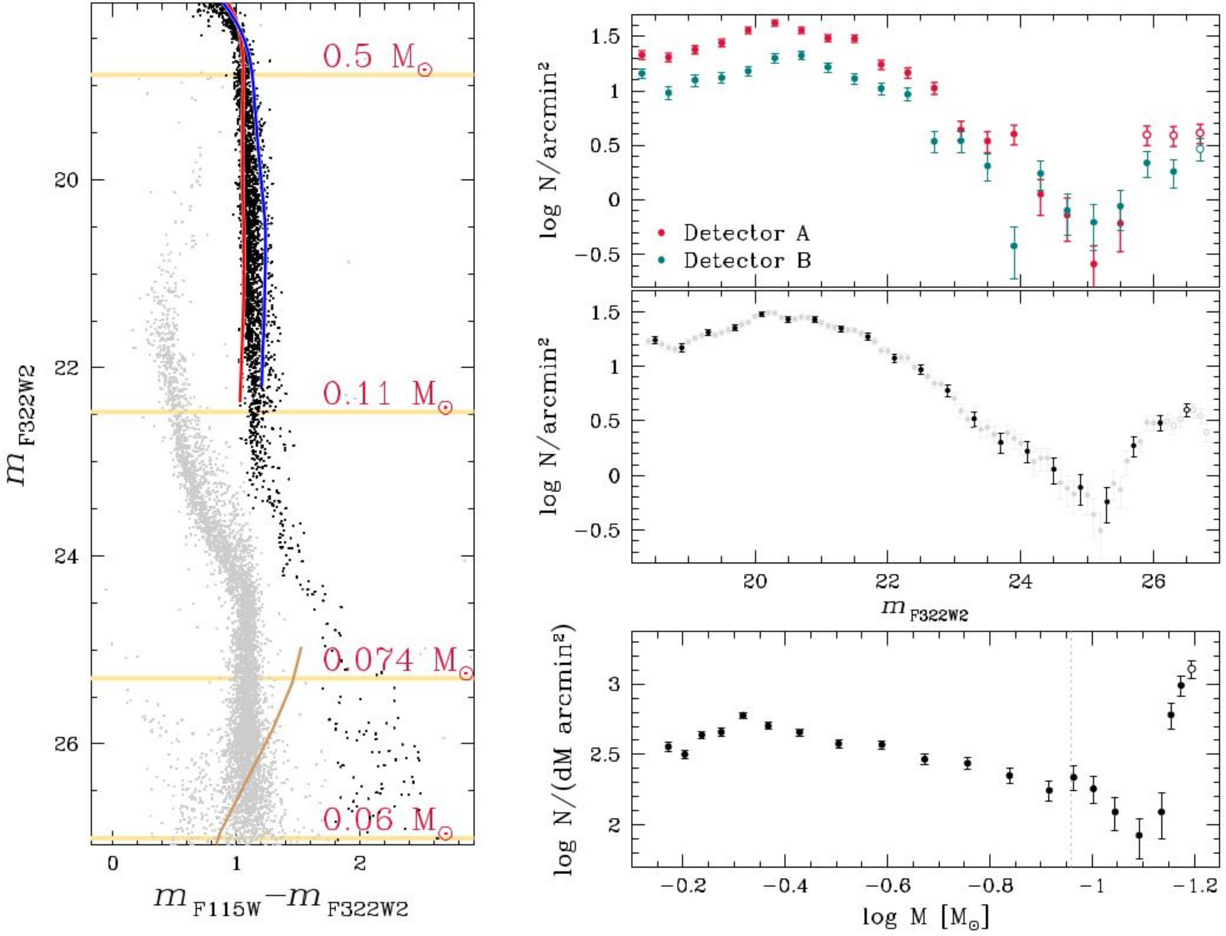


BDs in globular clusters

NGC 6397 (Gerasimov et al. 2024)



- current studies in the field limited by uncertainties in mass, age, metallicity
- BDs in GCs help break degeneracies
- a gap between the end of the MS and the most massive BDs (if properly modelled) ⟶ independent age-dating
- see Burgasser et al. Astro2020



Marino et al. (2024)

47 Tuc

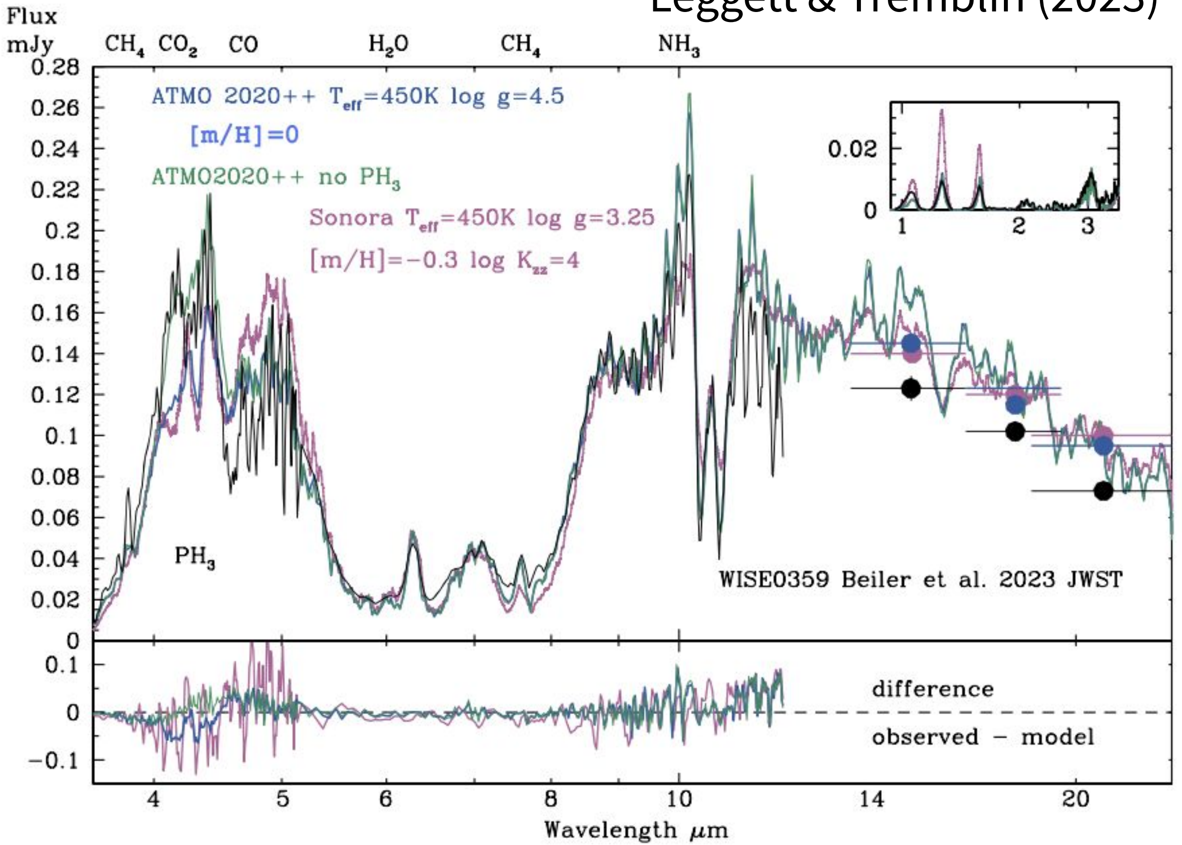
see also Nardiello et al. (2023)

Brown dwarf atmospheres

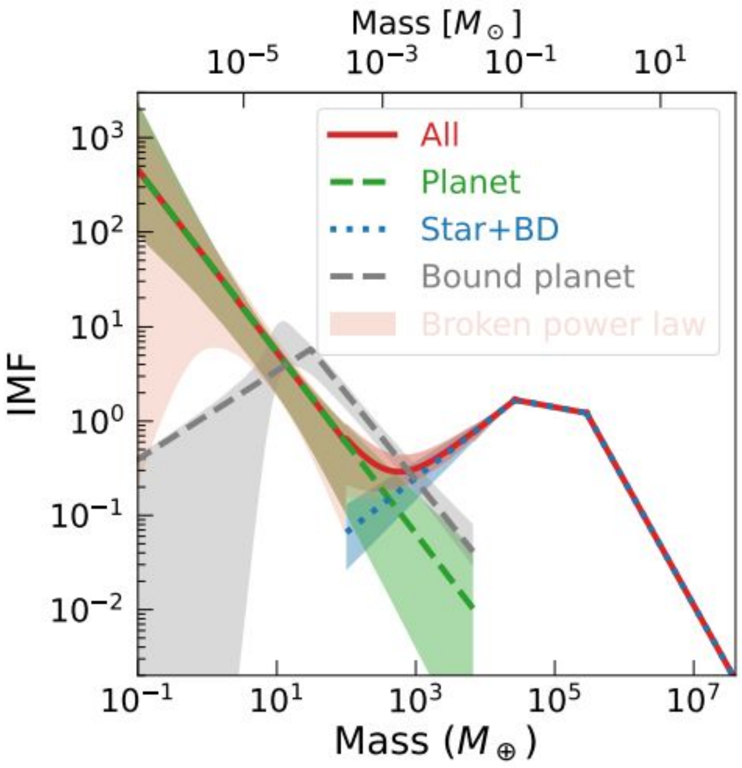
Leggett & Tremblin (2023)

The first JWST Y-dwarf spectrum

- atmospheric chemistry out of equilibrium
- the P-T profile is not in the standard adiabatic form



Microlensing surveys



Sumi et al. (2023)

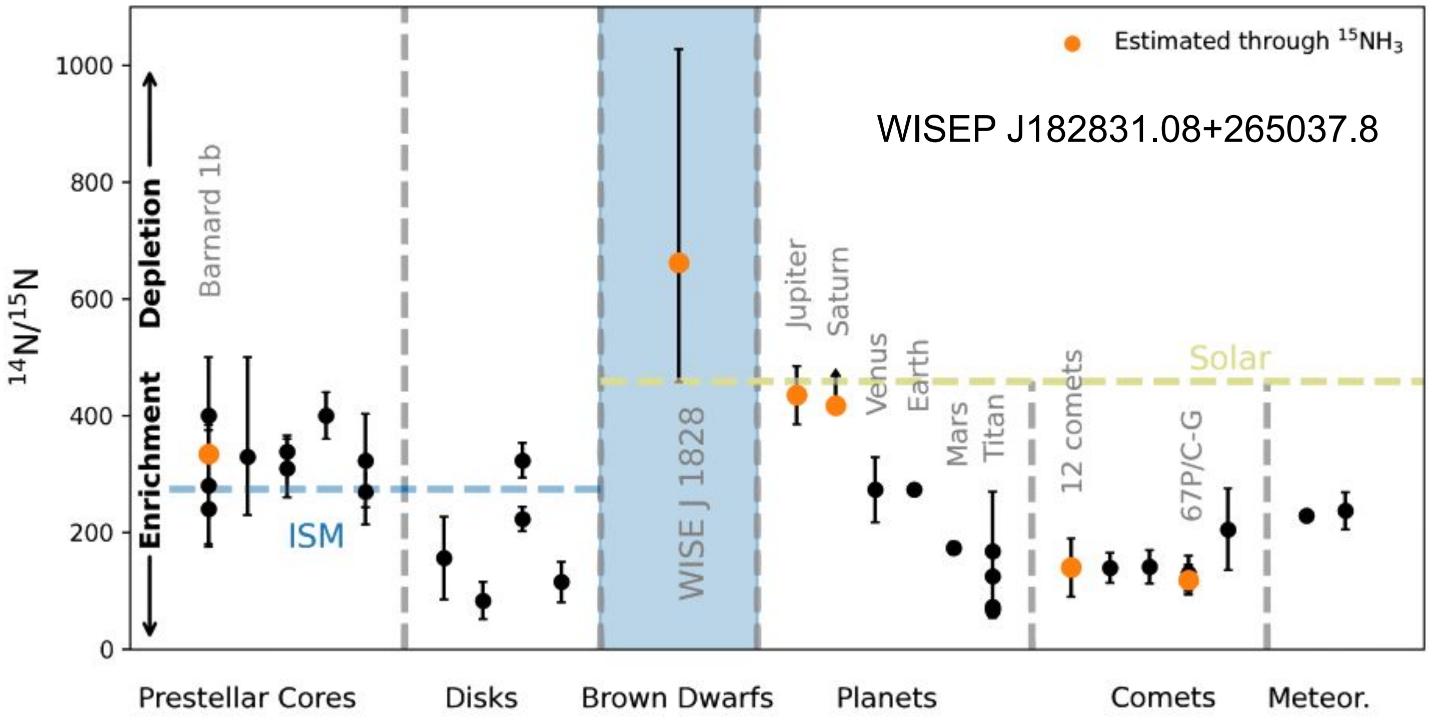
Microlensing surveys and those in young SFRs are at odds with each other

- MF increases below 20 M_{Jup}

Are ejections more likely to happen in different types of environments?

- interplay of stellar density, UV flux, shielding…

Isotopic ratios in BD atmospheres



~380K Y-dwarf

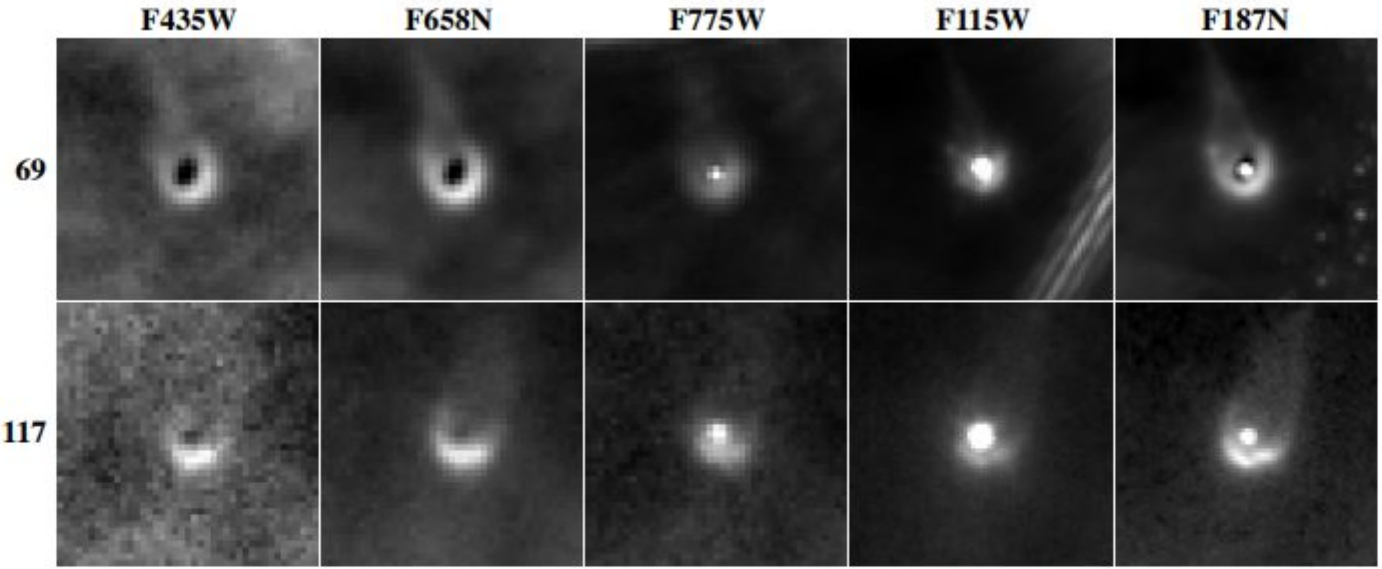
isotope ratios serve as formation tracers

Barrado et al. (2023)

ONC Proplyds

SpTs M6.5 and M7.5

the coolest and least massive known proplyds



Luhman et al. (2024)