Exploring M Dwarf Systems with JWST NIRCam Coronagraphy

Ellis Bogat

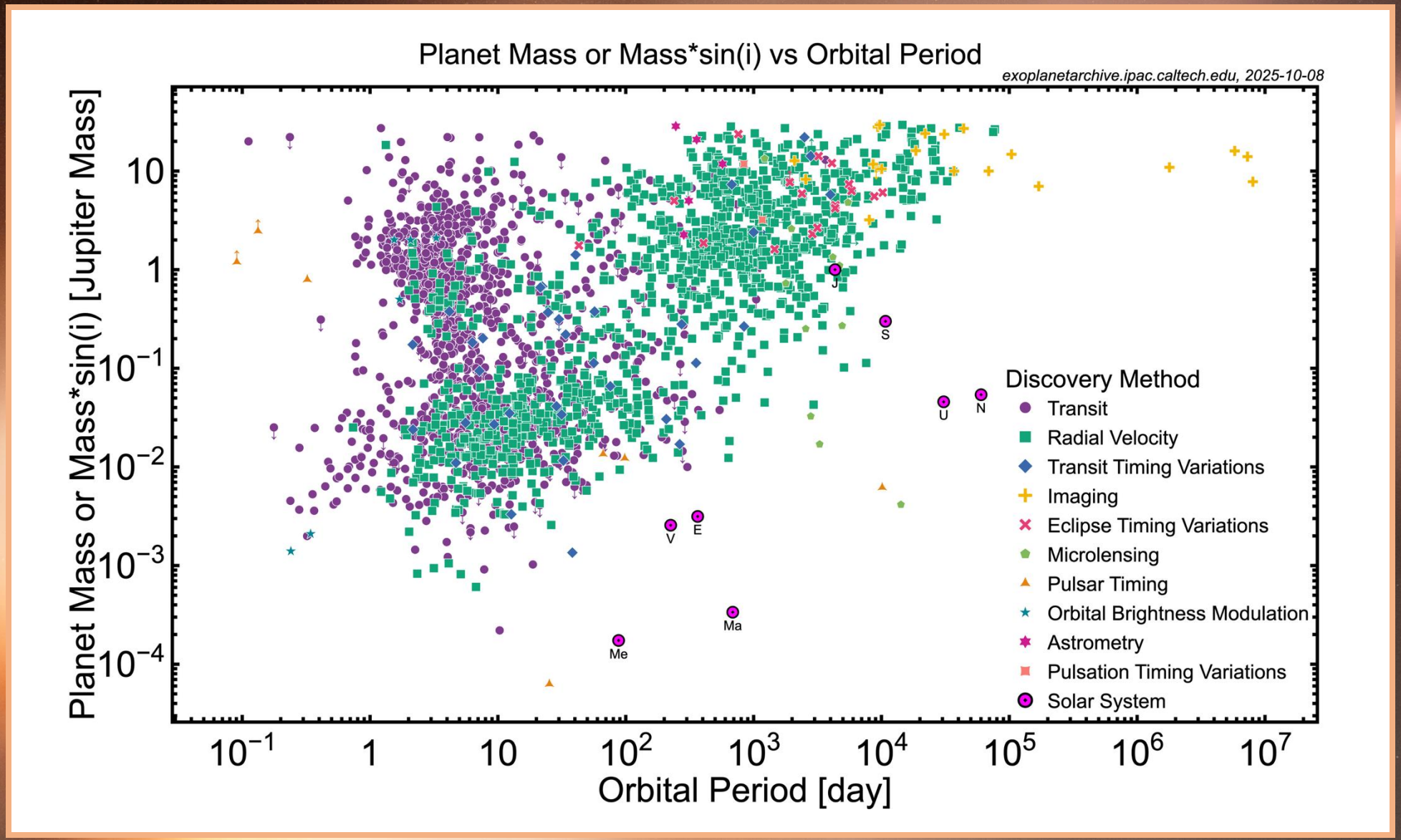
Univ. Maryland / NASA GSFC

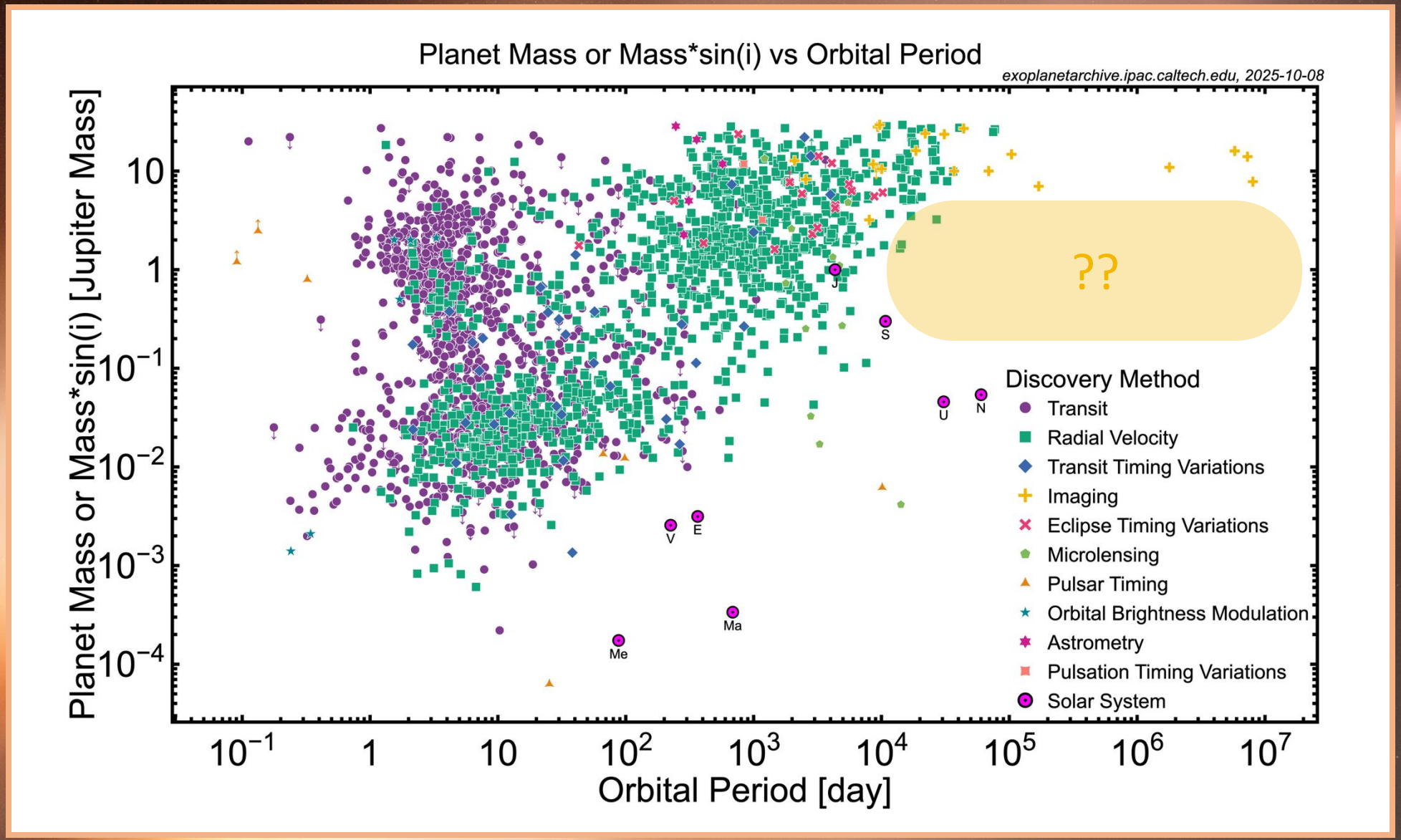
51 Pegasi b 30th Birthday

October 9, 2025

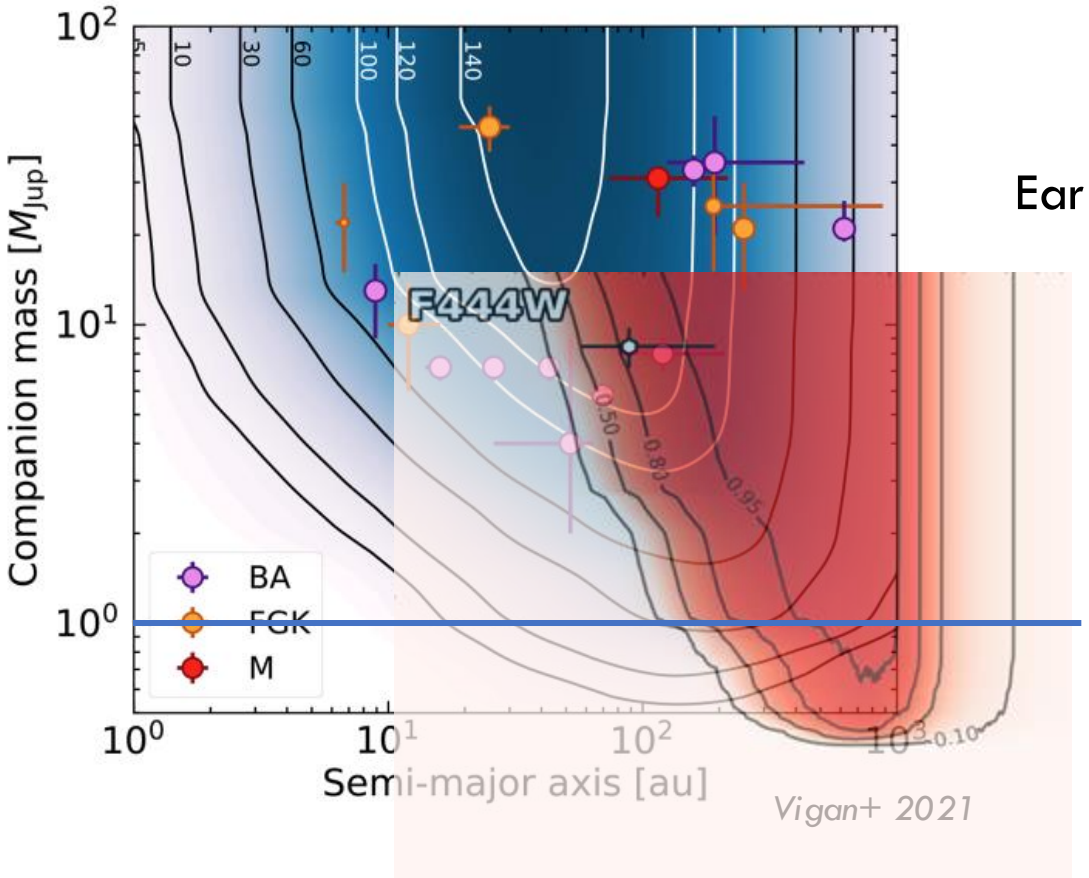
Collaborators: Joshua Schlieder, Kellen Lawson, Tom Barclay, Yiting Li, Jarron Leisenring, Michael Meyer, Chas Beichman, et al.

Image: ESO/L. Calçada


Planet Mass or Mass*sin(i) vs Orbital Period
exoplanetarchive.ipac.caltech.edu, 2025-10-08
Planet Mass or Mass*sin(i) [Jupiter Mass]
Orbital Period [day]
Discovery Method
Transit
Radial Velocity
Transit Timing Variations
Imaging
Eclipse Timing Variations
Microlensing
Pulsar Timing
Orbital Brightness Modulation
Astrometry
Pulsation Timing Variations
Solar System
Me
V
E
Ma
J
S
U
N


Planet Mass or Mass*sin(i) vs Orbital Period
exoplanetarchive.ipac.caltech.edu, 2025-10-08
Planet Mass or Mass*sin(i) [Jupiter Mass]
Orbital Period [day]
??
Discovery Method
Transit
Radial Velocity
Transit Timing Variations
Imaging
Eclipse Timing Variations
Microlensing
Pulsar Timing
Orbital Brightness Modulation
Astrometry
Pulsation Timing Variations
Solar System
Me
V
E
Ma
J
S
U
N

SPHERE infrared survey for exoplanets (SHINE)

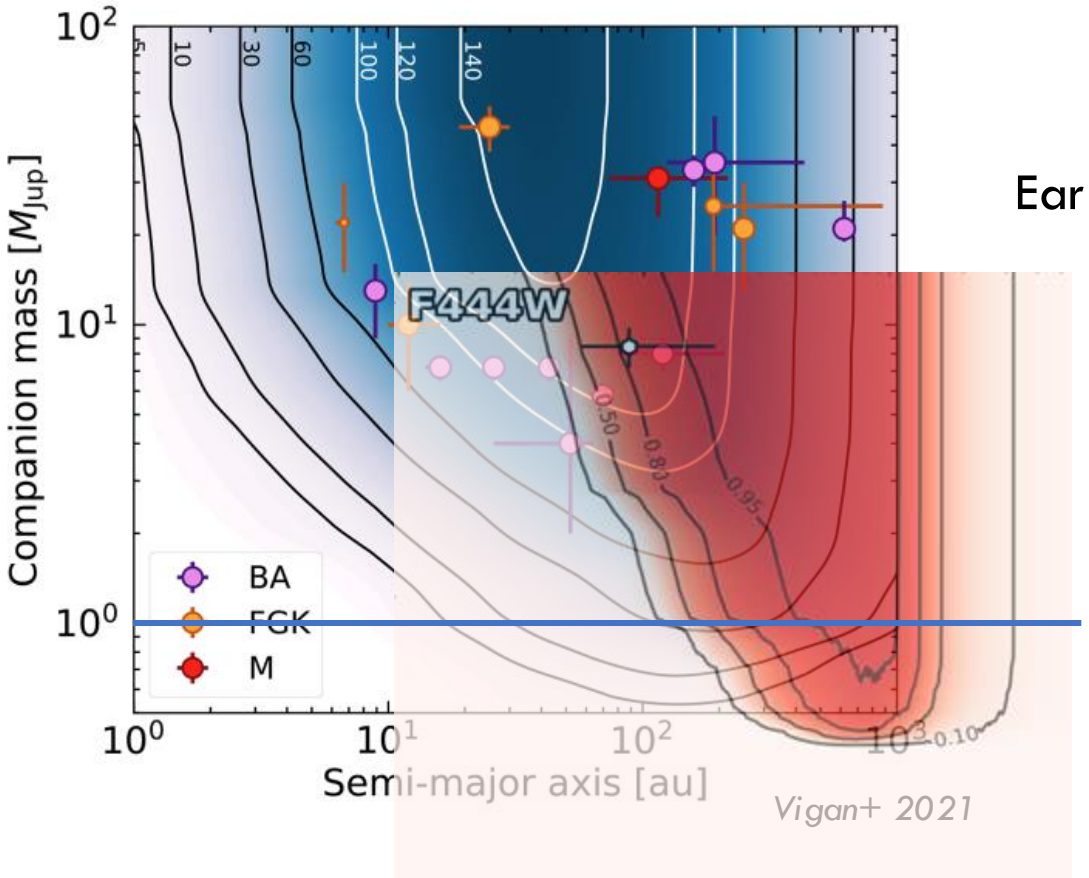


Carter+ 2023

Early-Release Science with JWST NIRCam

What is the best mass sensitivity we can achieve with ideal targets?

SPHERE infrared survey for exoplanets (SHINE)



Carter+ 2023

Early-Release Science with JWST NIRCam

What is the best mass sensitivity we can achieve with ideal targets?

JWST Guaranteed Time Observation Program 1184

PI Joshua Schlieder

A JWST NIRCam Coronagraphic Imaging Survey of Nearby, Young M Dwarfs

Bogat+ 2025

JWST Guaranteed Time Observation Program 1184

PI Joshua Schlieder

A JWST NIRCam Coronagraphic Imaging Survey of Nearby, Young M Dwarfs

see closer to the star

Bogat+ 2025

JWST Guaranteed Time Observation Program 1184

PI Joshua Schlieder

A JWST NIRCam Coronagraphic Imaging Survey of Nearby, Young M Dwarfs

see closer to the star

maximize planet luminosity

Bogat+ 2025

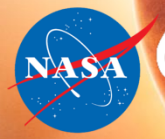
JWST Guaranteed Time Observation Program 1184

PI Joshua Schlieder

UNIVERSITY OF MARYLAND

JPL

Jet Propulsion Laboratory
California Institute of Technology



Goddard
SPACE FLIGHT CENTER

ARIZONA

A JWST NIRCam Coronagraphic Imaging Survey of Nearby, Young M Dwarfs

see closer to the star | *maximize planet luminosity* | *minimize stellar luminosity*

Bogat+ 2025

GTO 1184: Survey Design

Name	Spectral Type	Distance (pc)	Age (Myr)
AU Microscopii	M1	9.9 ± 0.10	24 ± 3
HIP 17695	M3	16.1 ± 0.80	149^{+51}_{-19}
G-7-34	M4	13.6 ± 0.20	149^{+51}_{-19}
TYC 5988	M3	16.3 ± 0.40	149^{+51}_{-19}
2MJ0944	M5	13.3 ± 0.15	50^{+5}_{-10}
Fomalhaut C	M4	7.6 ± 0.07	440 ± 40
V-AP-COL	M4.5	8.4 ± 0.07	50^{+5}_{-10}
LP-944-20	M9	6.4 ± 0.04	329 ± 80
2MJ0443	M9	21.1 ± 0.45	24 ± 3

known disks!

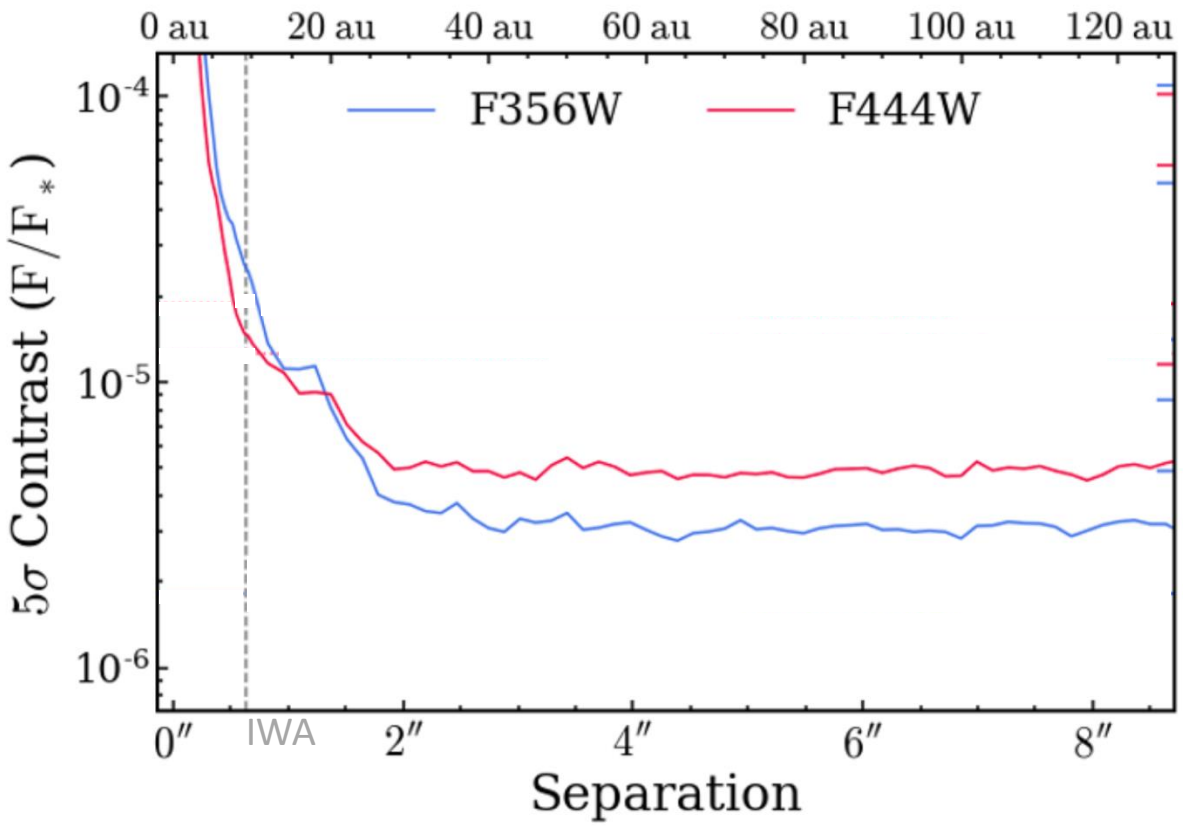
M Stars

within ~21 pc

younger than ~450 Myr

Contrast (and Mass) Sensitivity

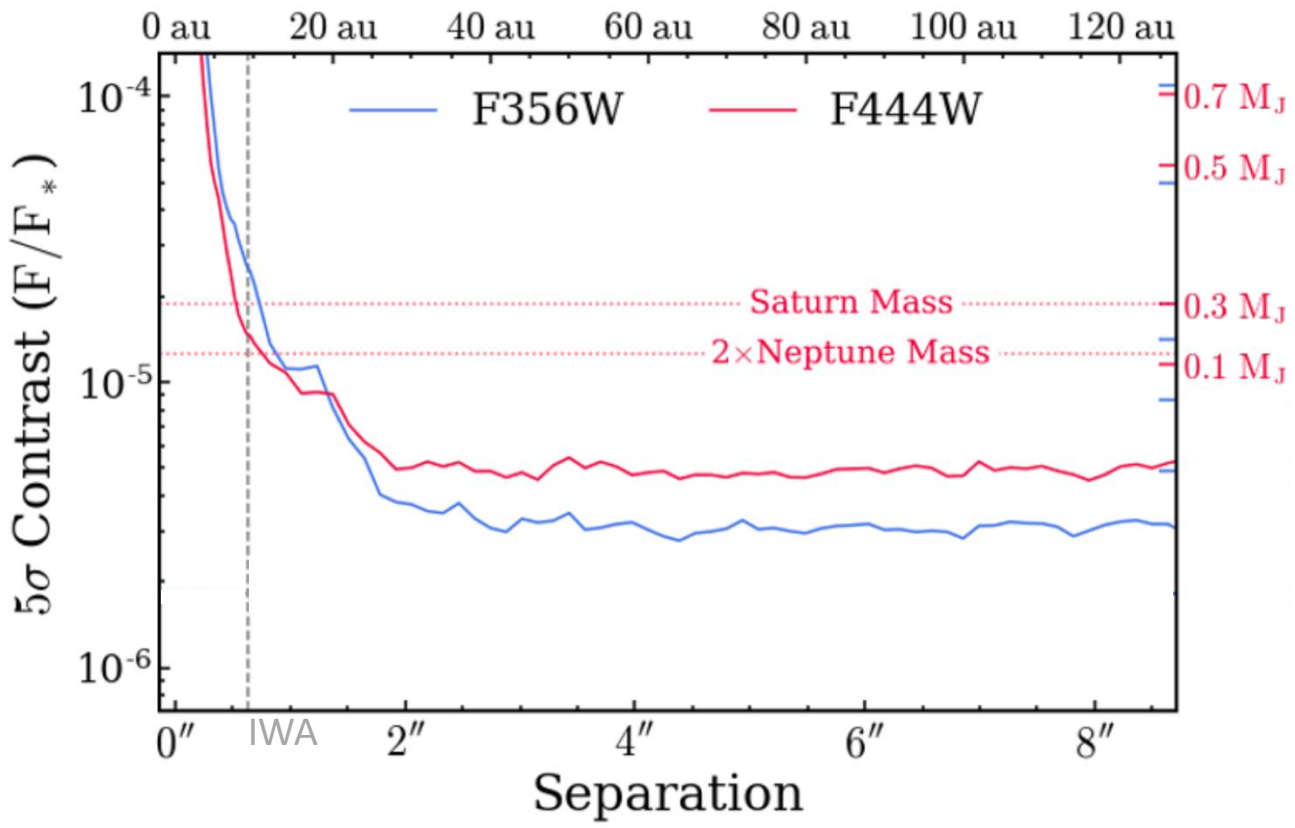
Example Target: G 7-34



Bogat+ 2025

Contrast (and Mass) Sensitivity

Example Target: G 7-34

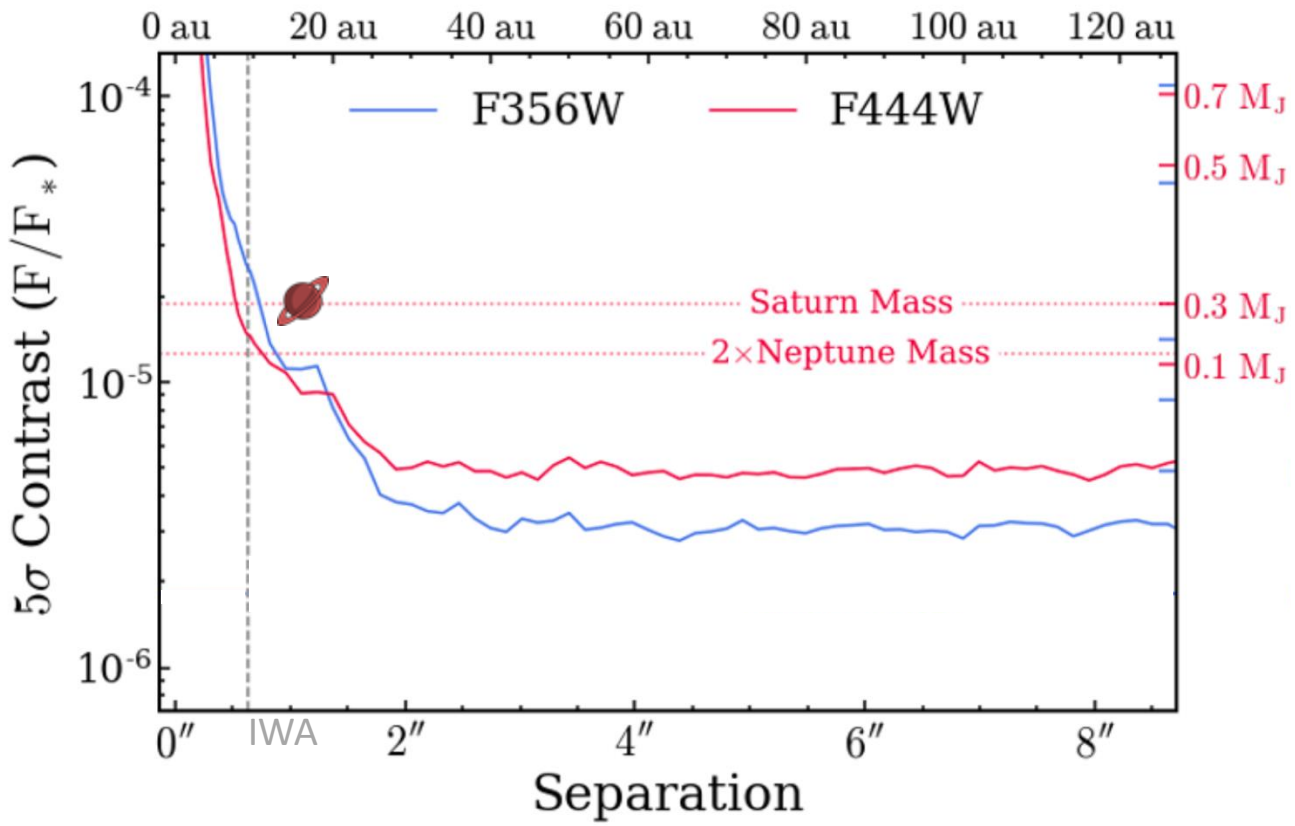


- Mass conversion using atmospheric evolution models (Linder+ 2019)

Bogat+ 2025

Contrast (and Mass) Sensitivity

Example Target: G 7-34

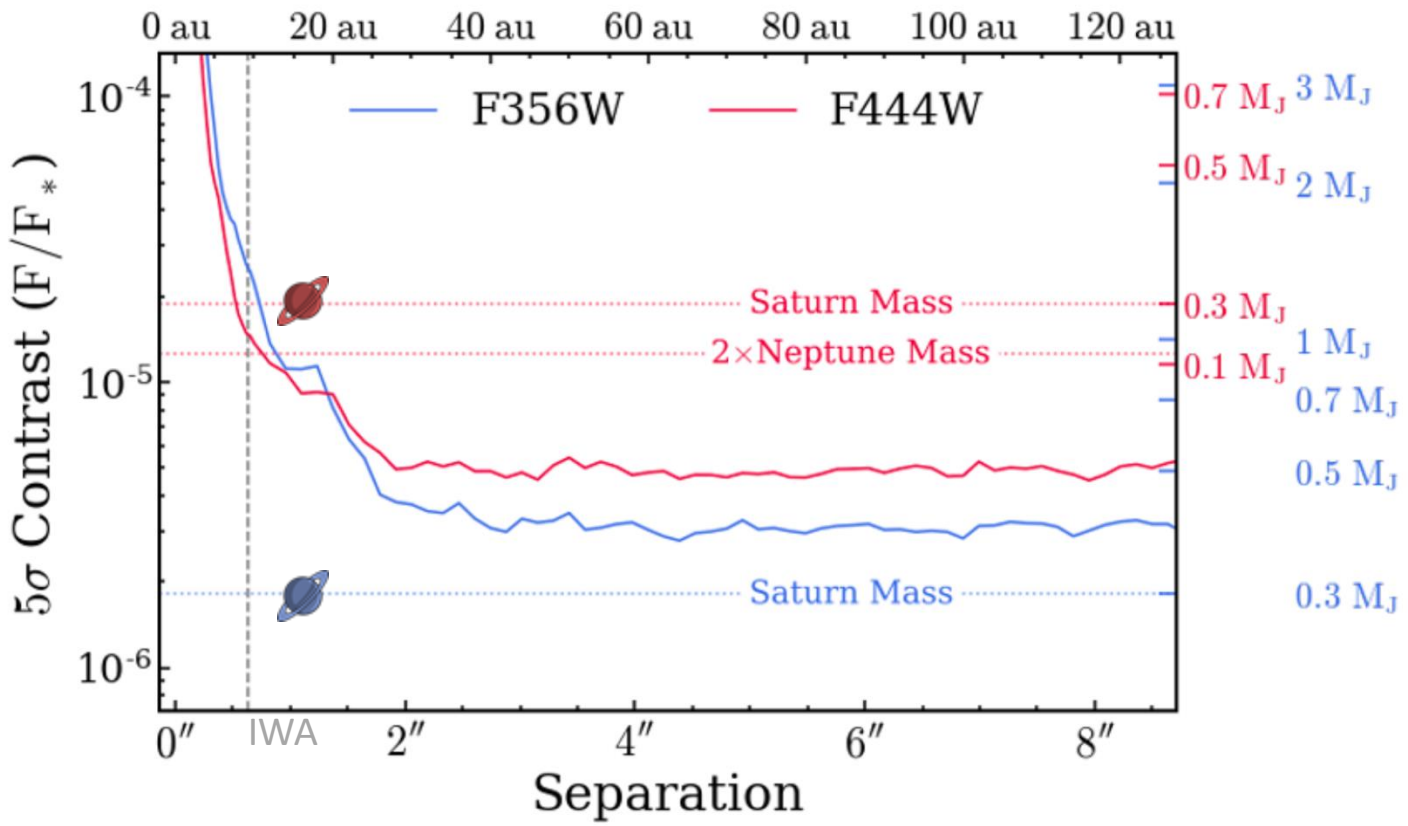


- Mass conversion using atmospheric evolution models (Linder+ 2019)
- Sensitivity to young **Saturn analogues** at **Saturn-like separation**!

Bogat+ 2025

Contrast (and Mass) Sensitivity

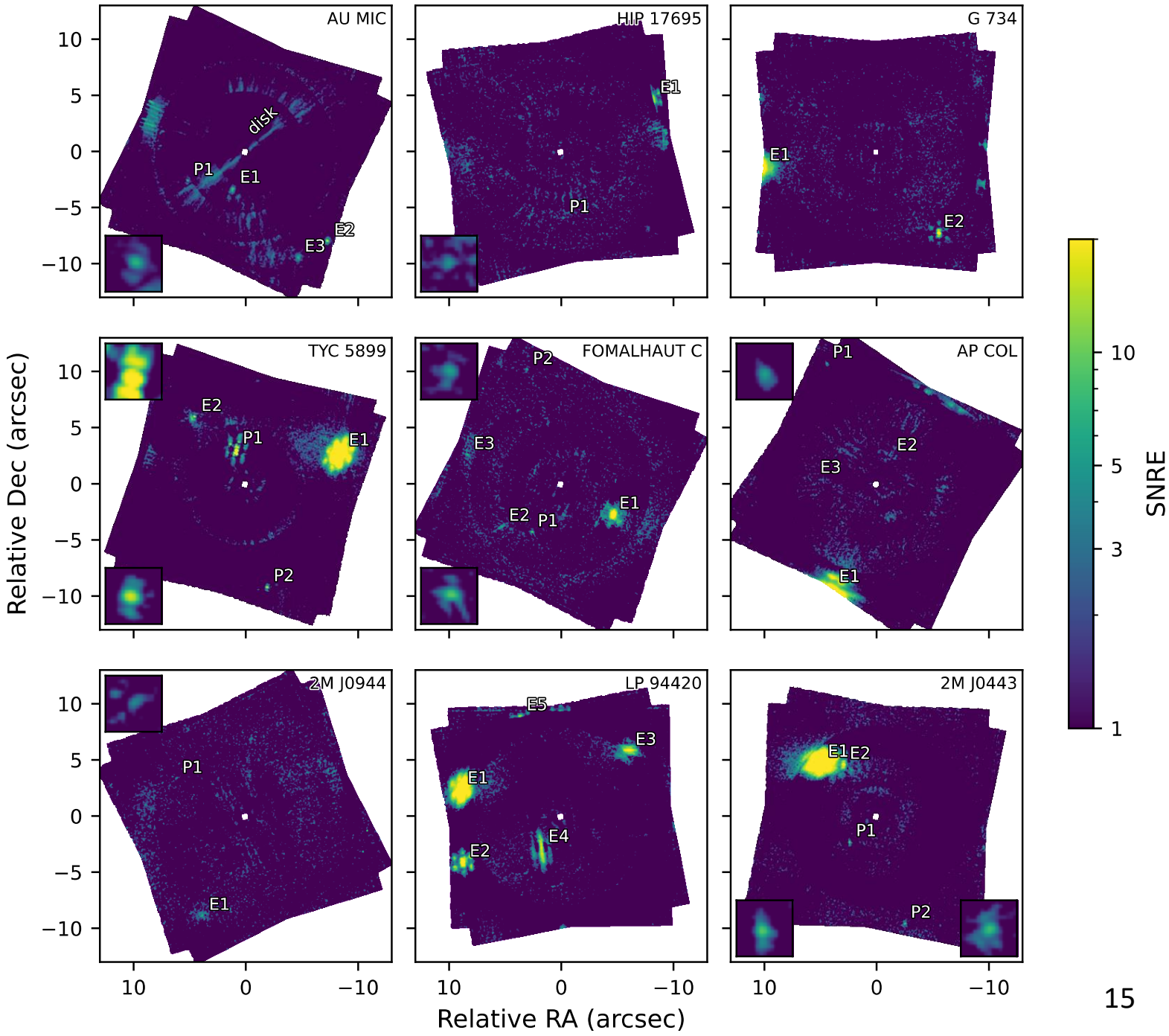
Example Target: G 7-34



- Mass conversion using atmospheric evolution models (Linder+ 2019)
- Sensitivity to young **Saturn analogues** at **Saturn-like separation**!
- Expect Saturn (and sub-Saturn!) mass planets to be detectable at 4 microns but not at 3 microns

Bogat+ 2025

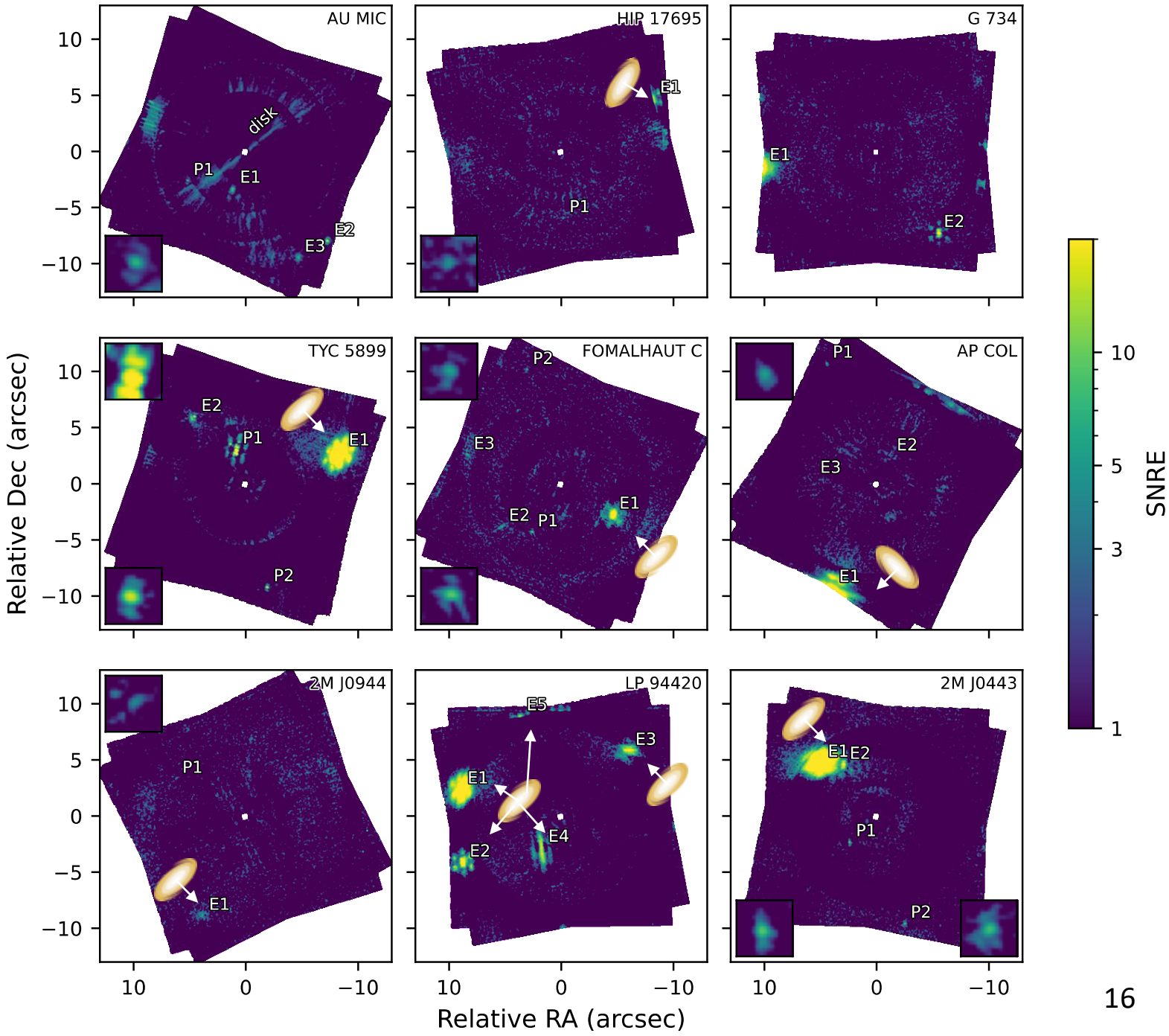
Survey Results



Bogat+ 2025

Survey Results

- Many background galaxies!

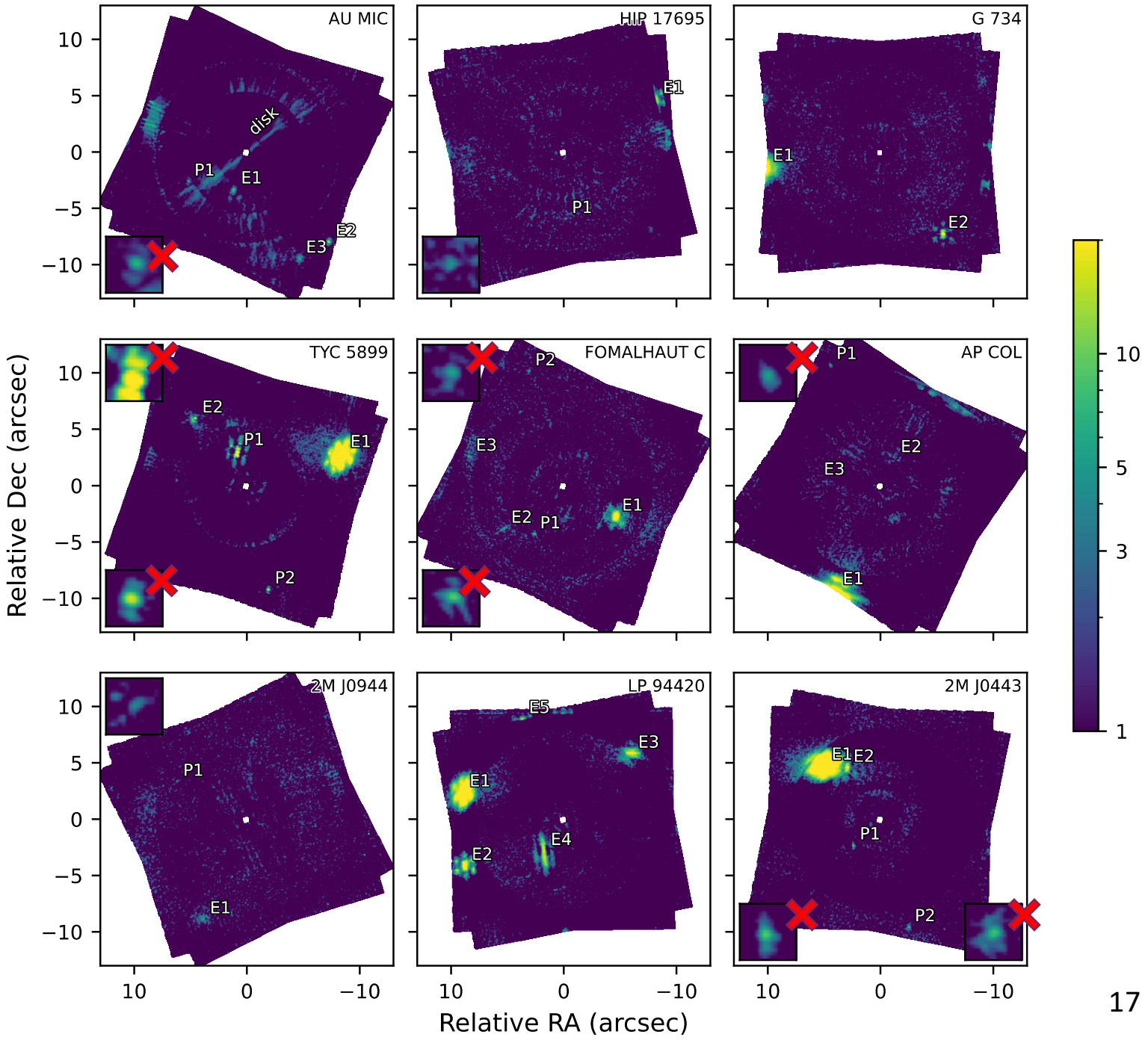


Bogat+ 2025

Survey Results

- Many background galaxies!
- No sources consistent with brown dwarf or Jupiter+ mass companions

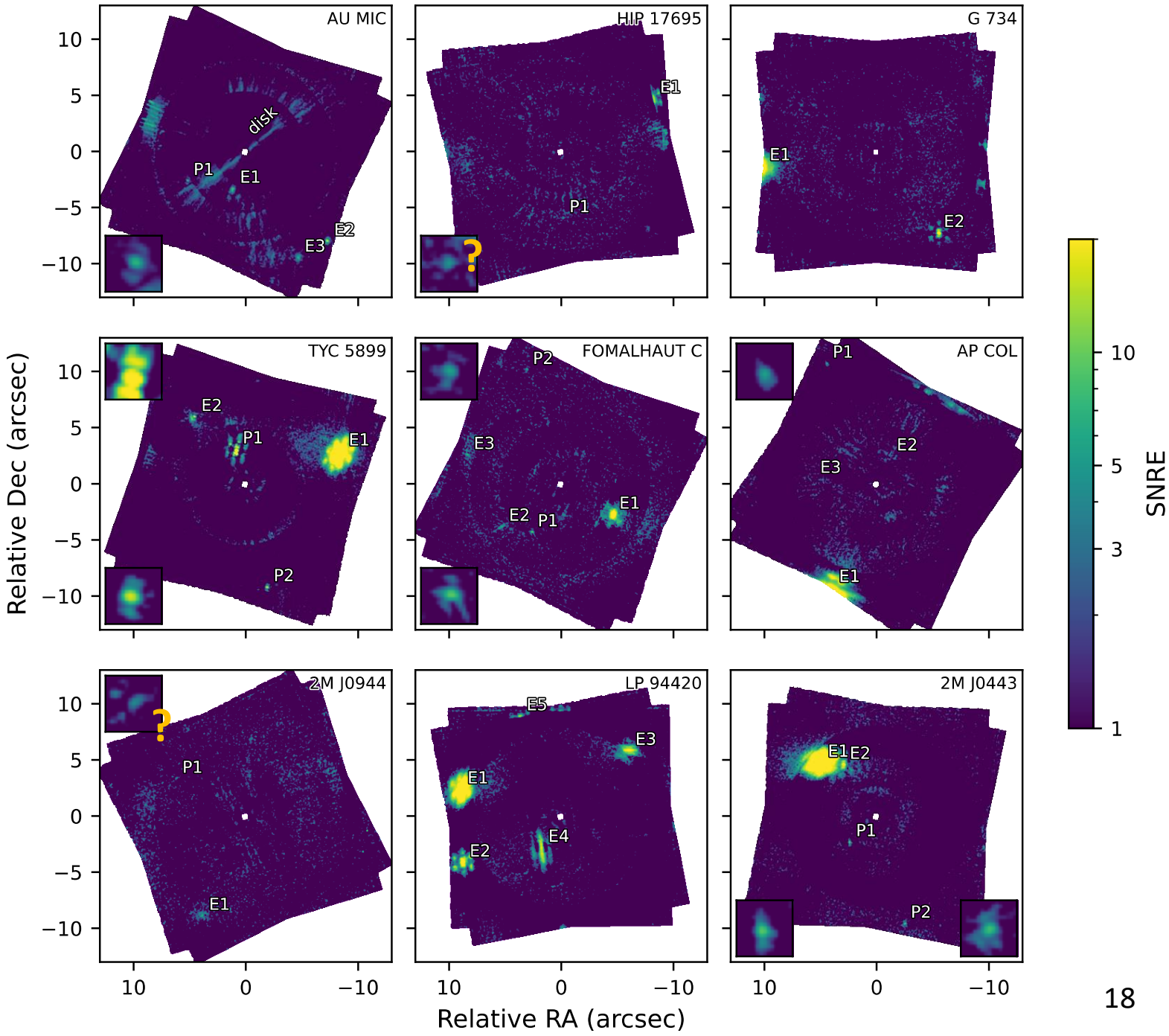
Bogat+ 2025



Survey Results

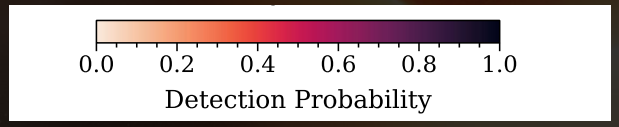
- Many background galaxies!
- No sources consistent with brown dwarf or Jupiter+ mass companions
- A few marginal sub-Saturn mass exoplanet candidates!

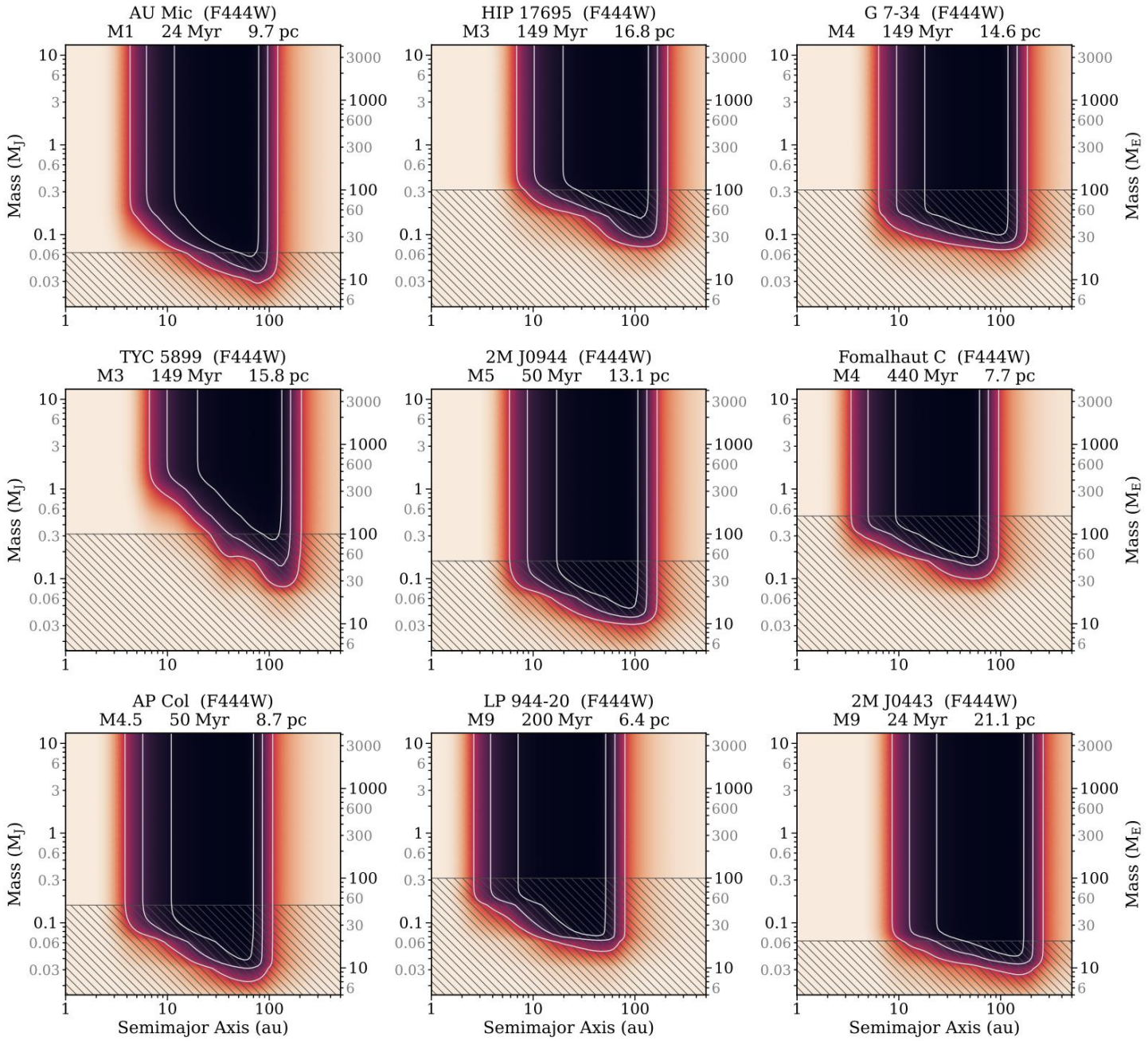
Bogat+ 2025



Key Takeaways

- Unprecedented access to wide-orbit sub-jupiters
- Looking forward to atmospheric models below 200K (e.g. next-gen Sonora models)
- M dwarfs still don't make lots of giant planets (f < 0.16 for 0.1-1.0 M_{Jup} , 10-200 AU)

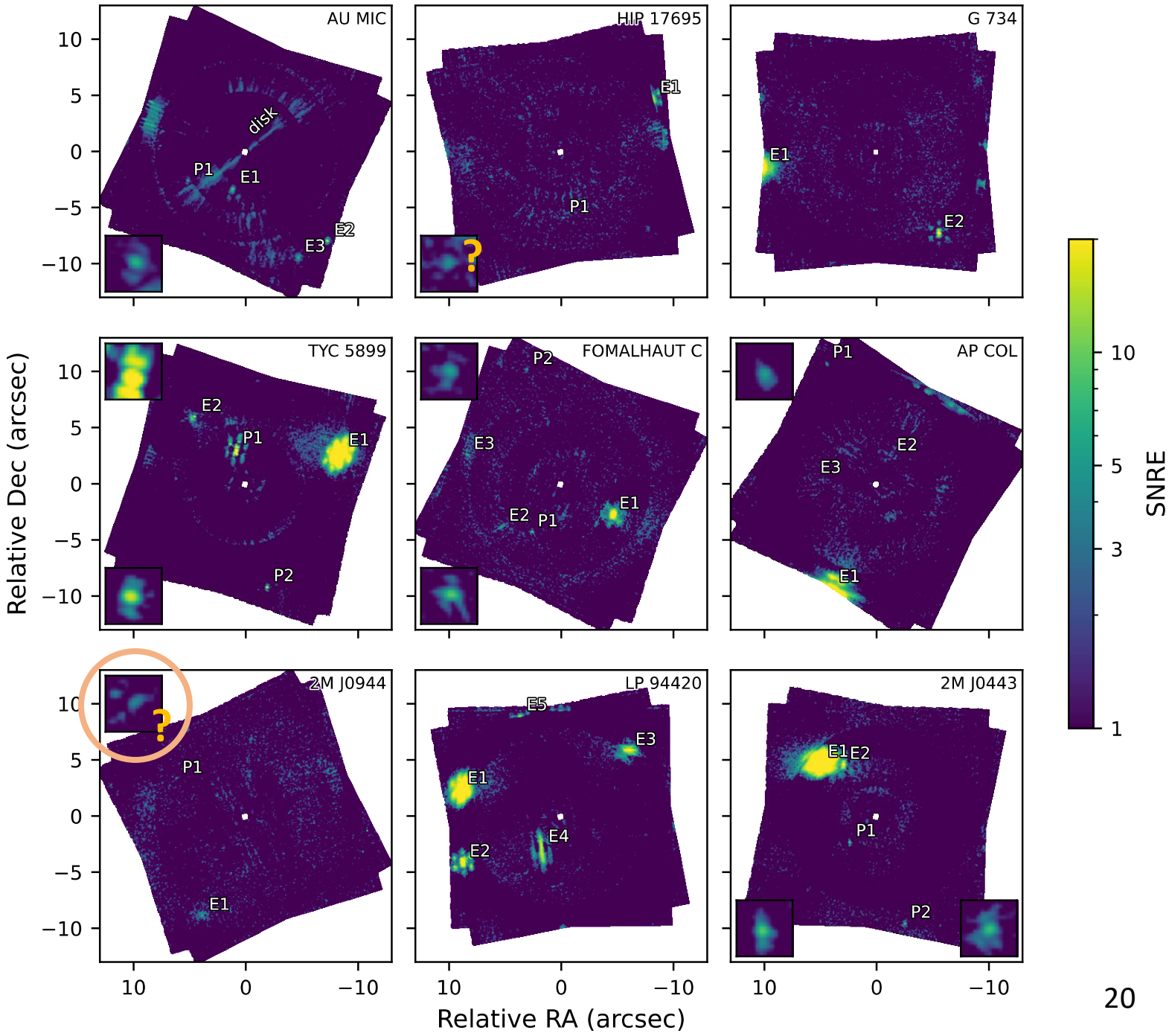




Survey Results

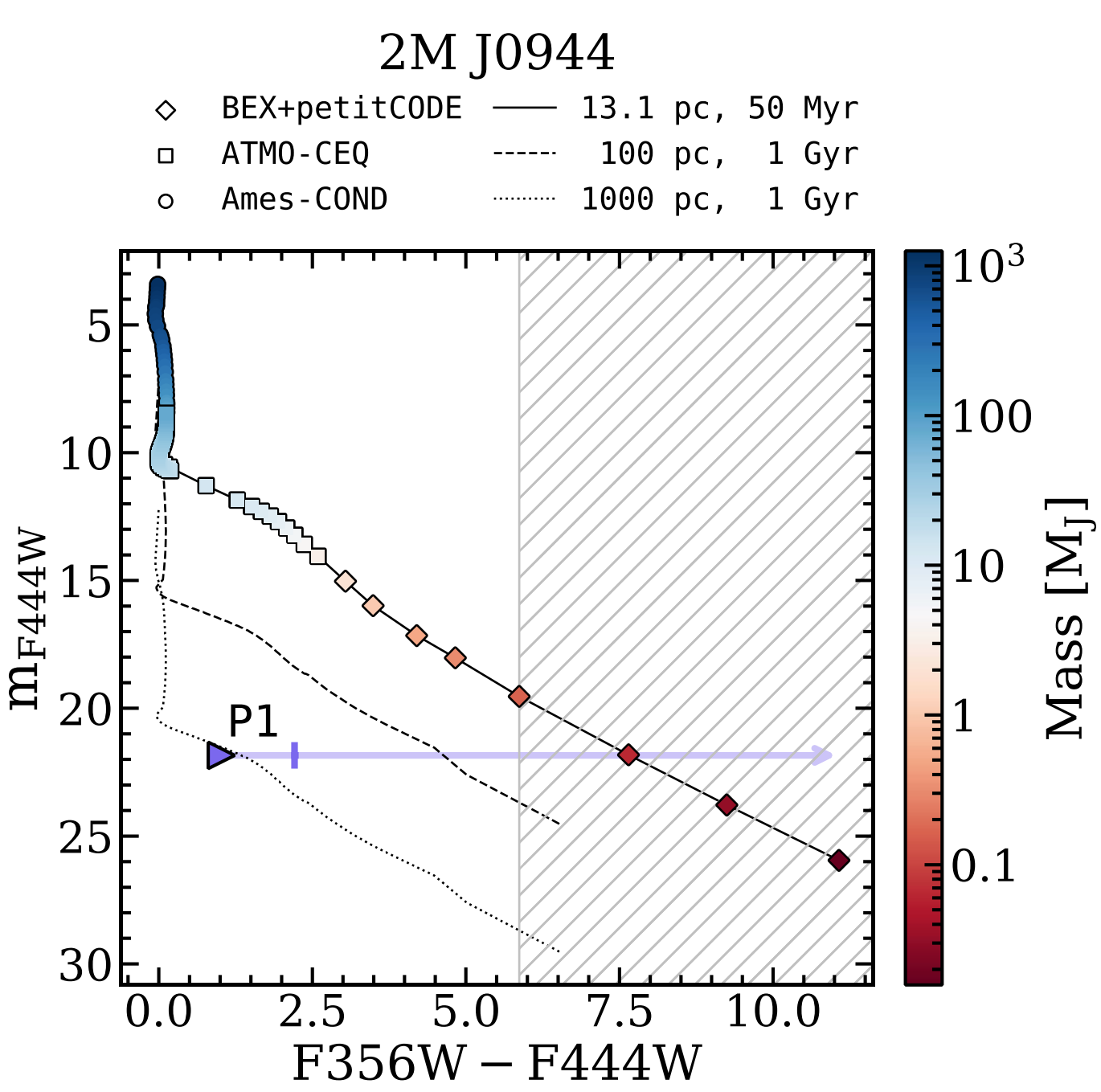
- Many background galaxies!
- No sources consistent with brown dwarf or Jupiter+ mass companions
- A few marginal sub-Saturn mass exoplanet candidates!

Bogat+ 2025



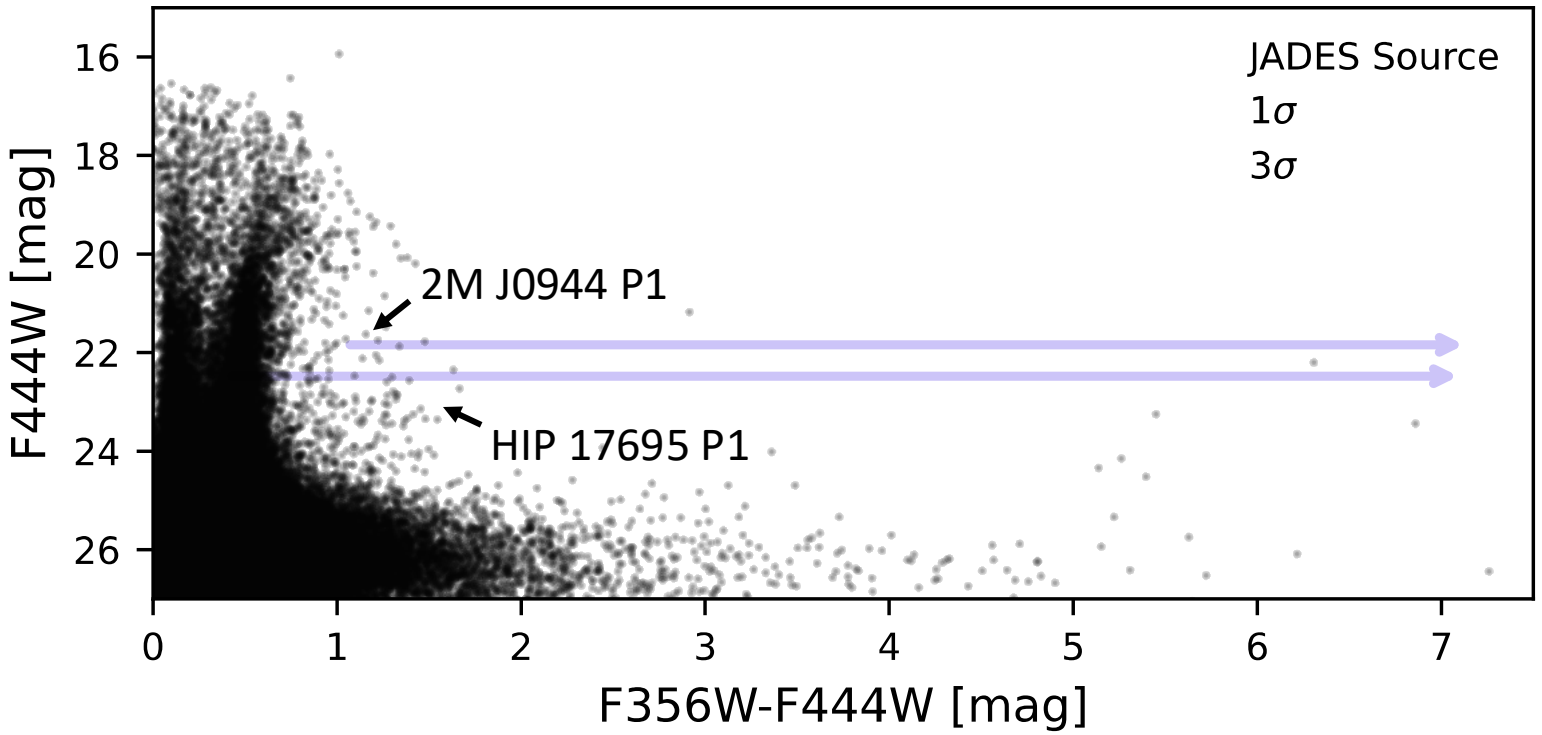
Background Source Rejection

- Isochrone analysis:
  - rules out stars, field brown dwarfs still possible



Background Source Rejection

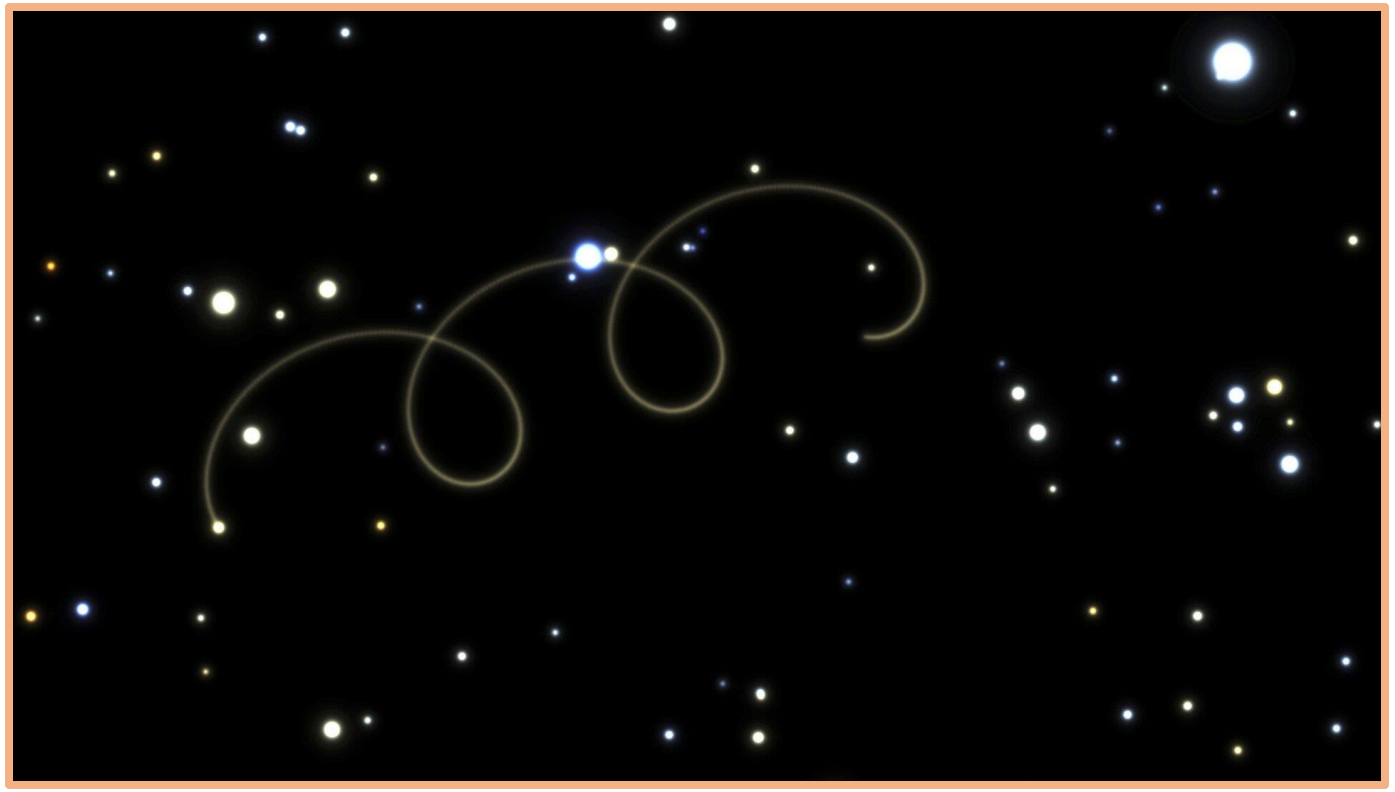
- Isochrone analysis:
  - rules out stars, field brown dwarfs still possible
- JADES photometry:
  - expected number of false-positive galaxies in this observation is 0.041



Background Source Rejection

- Isochrone analysis:
  - rules out stars, field brown dwarfs still possible
- JADES photometry:
  - expected number of false-positive galaxies in this observation is 0.041
- To be certain:
  - Follow-up imaging to confirm common proper motion!

GO 3840: Follow-up Observations of a Sub-Jupiter Mass Candidate



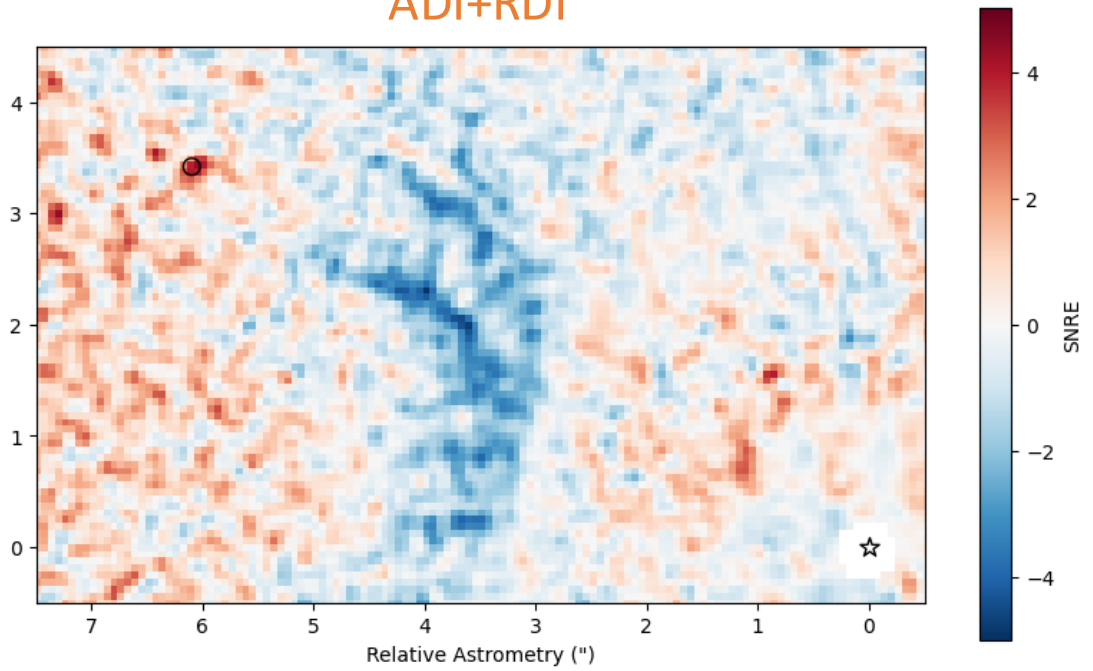
Background Source Rejection

- Isochrone analysis:
  - rules out stars, field brown dwarfs still possible
- JADES photometry:
  - expected number of false-positive galaxies in this observation is 0.041
- To be certain:
  - Follow-up imaging to confirm common proper motion!

GO 3840: Follow-up Observations of a Sub-Jupiter Mass Candidate

CYCLE 1

ADI+RDI



PRELIMINARY

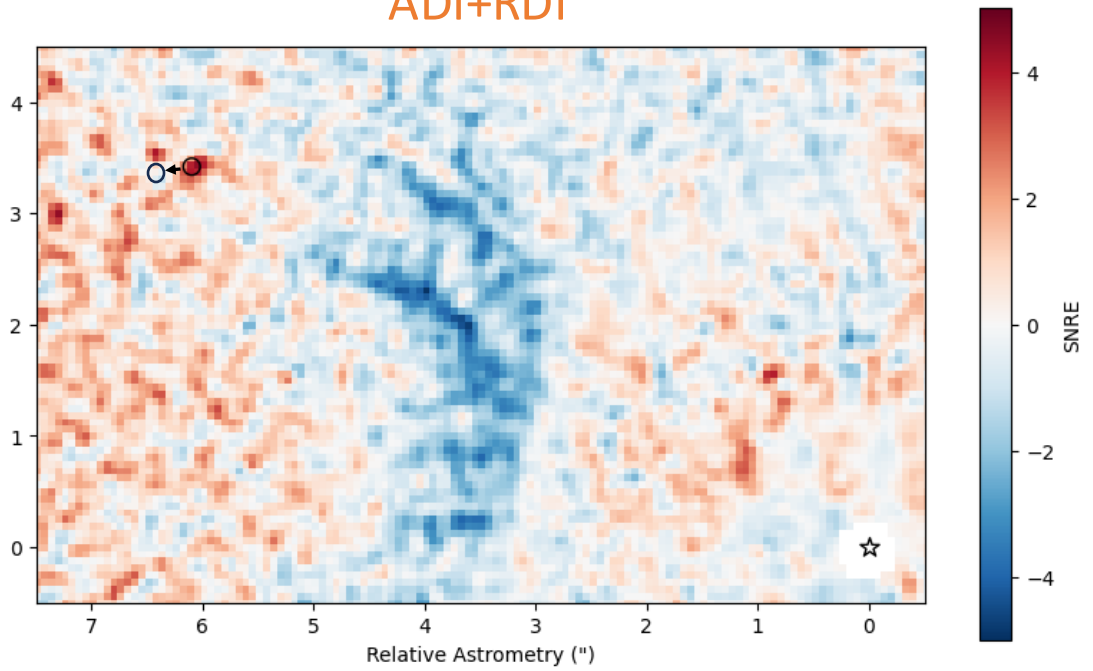
Background Source Rejection

- Isochrone analysis:
  - rules out stars, field brown dwarfs still possible
- JADES photometry:
  - expected number of false-positive galaxies in this observation is 0.041
- To be certain:
  - Follow-up imaging to confirm common proper motion!

GO 3840: Follow-up Observations of a Sub-Jupiter Mass Candidate

CYCLE 1

ADI+RDI



PRELIMINARY

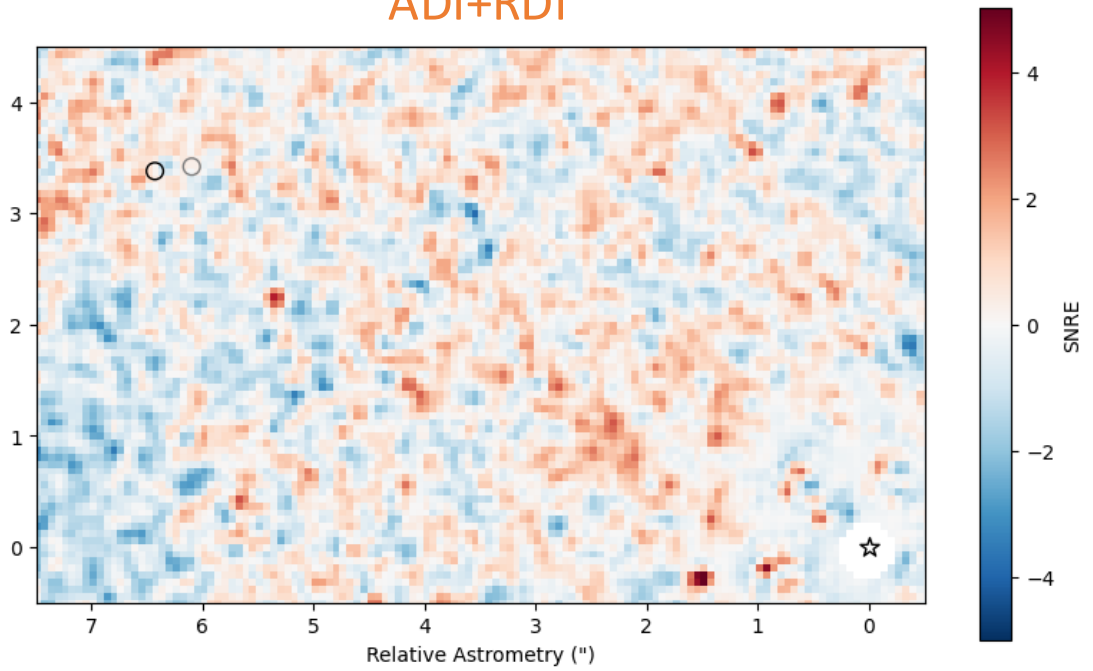
Background Source Rejection

- Isochrone analysis:
  - rules out stars, field brown dwarfs still possible
- JADES photometry:
  - expected number of false-positive galaxies in this observation is 0.041
- To be certain:
  - Follow-up imaging to confirm common proper motion!

GO 3840: Follow-up Observations of a Sub-Jupiter Mass Candidate (RIP ☹)

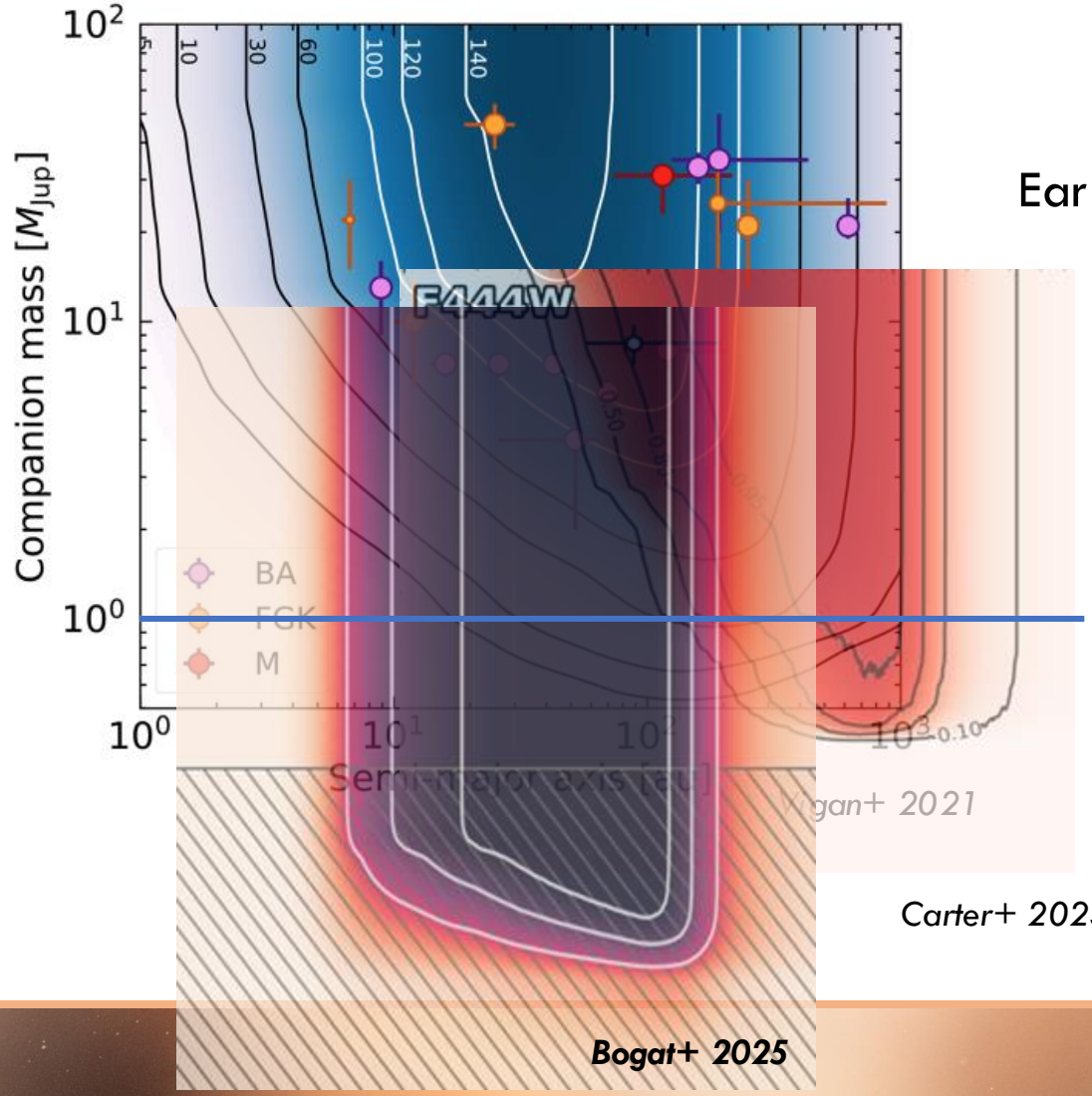
CYCLE 2

ADI+RDI



PRELIMINARY

SPHERE infrared survey for exoplanets (SHINE)



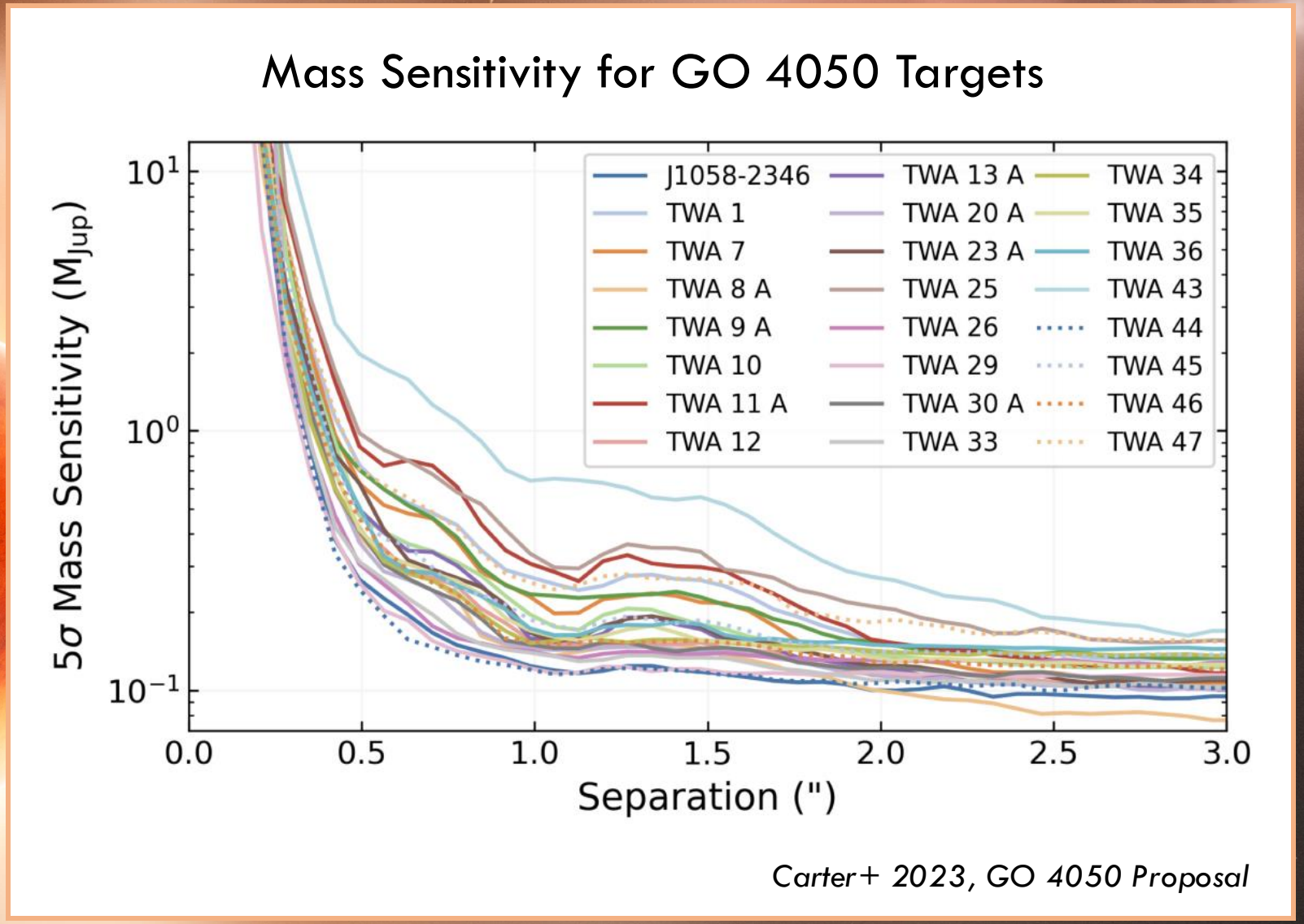
Carter+ 2023

Early-Release Science with
JWST NIRCam

What is the best mass sensitivity we can achieve by picking the ideal targets?

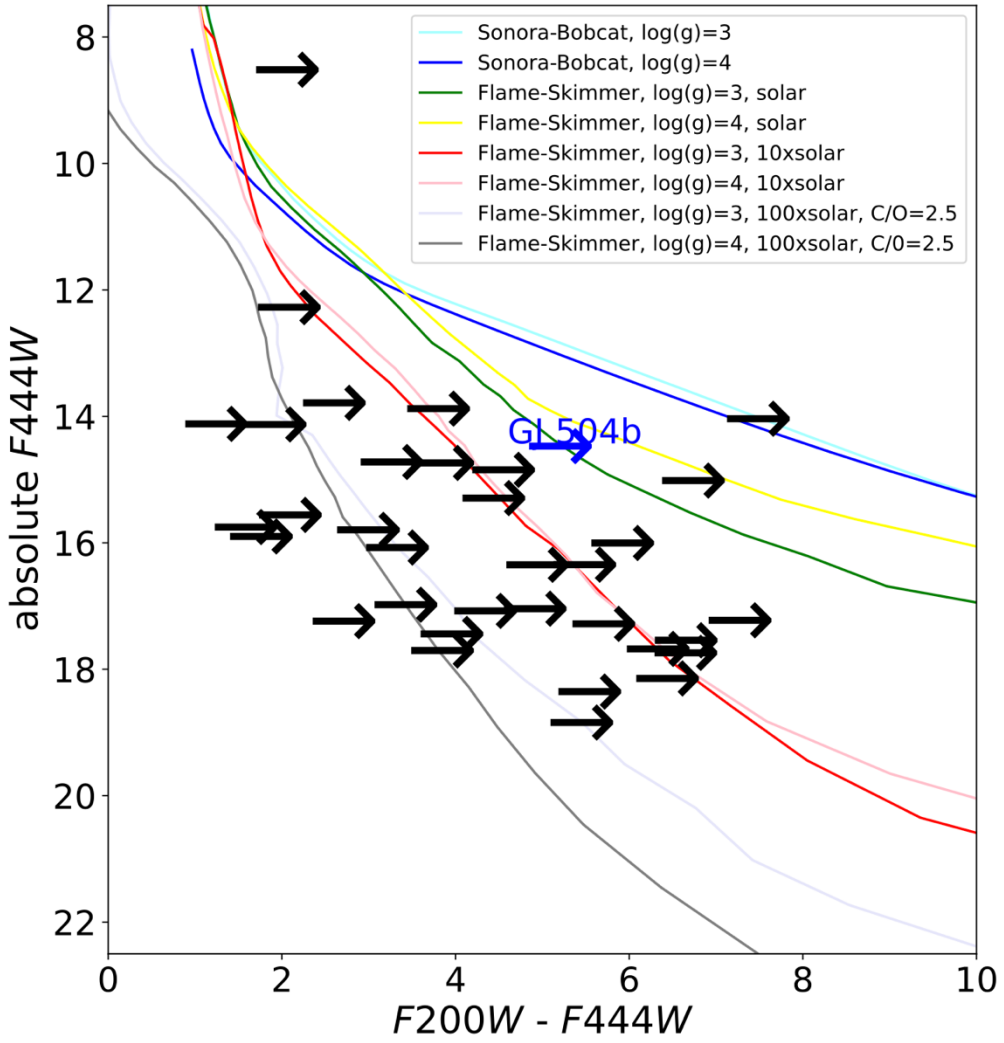
Coming Soon: Many More JWST Observations!

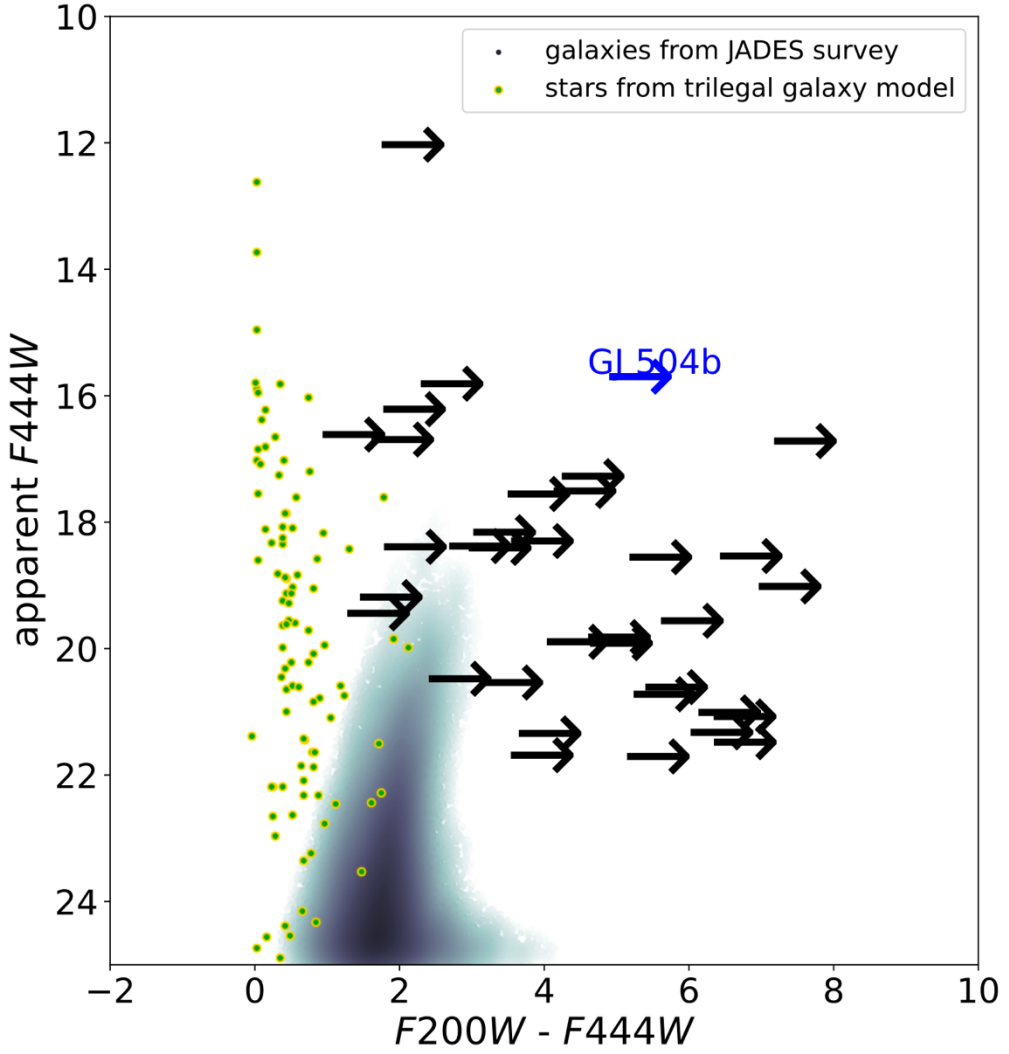
- Aarynn Carter and Beth Biller
  - 142 hrs of observations
  - 88 targets
- Build up statistics on wide-orbit sub-jupiters



Carter+ 2023, GO 4050 Proposal

Coming Soon: Many More Planet Candidates!





Key Takeaways

- Unprecedented access to wide-orbit sub-jupiters
- Looking forward to atmospheric models below 200K (e.g. next-gen Sonora models)
- M dwarfs still don't make lots of giant planets (f < 0.16 for 0.1-1.0 M_{Jup} , 10-200 AU)