

# Mid-IR High-Contrast Imaging with LBTI at >100 Myr



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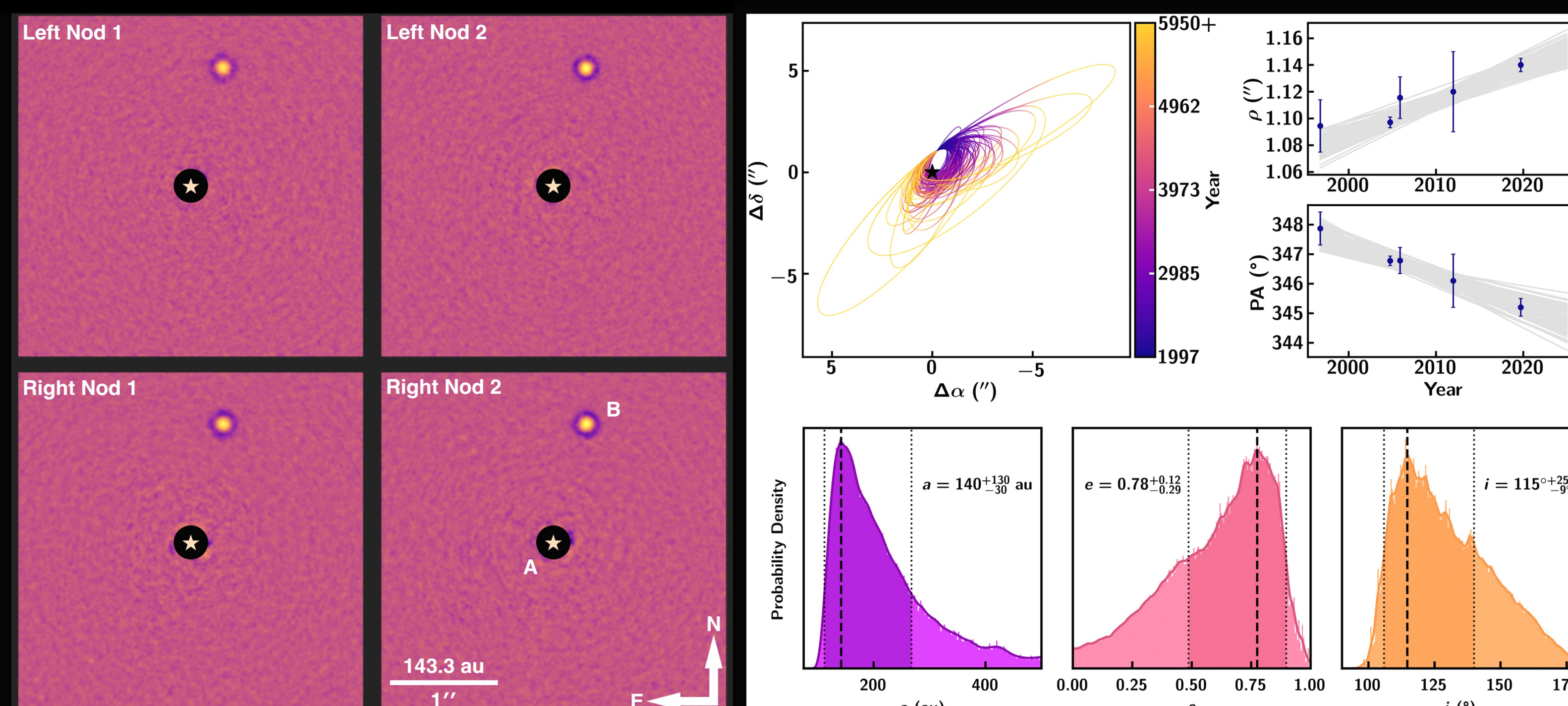


Intermediate-Age Gas Giants + Brown-Dwarf & Low-Mass Stellar Companions

## Targets

- HII 1348 B: a Pleiades (~112 Myr) BD companion of ~60 Jupiter-masses — orbiting a K-type SB2 binary (Weible et al. 2025)
- Alcor B: an M-dwarf companion to a naked-eye star in the Big Dipper (~500 Myr; Weible et al., in prep.)
- Proposed: LBTI/LMIRcam L' "PLEIAD" survey of accelerating Pleiades members

HII 1348: 2019 @ L' (3.7  $\mu$ m), + Orbit Fit (Weible, Wagner, Stone et al. 2025)



## Orbital Modeling

- We use the *orbitize!* Python package (Blunt et al. 2020) to fit  $10^7$  posterior orbits to 23 years of relative astrometry for HII 1348B
  - ptemcee parallel-tempered MCMC sampler (Vousden et al. 2015)
- Alcor B has been observed to orbit to the other (projected) side of Alcor A from 2007 to 2023
  - The first orbital modeling of Alcor B is forthcoming, following a similar analysis to that applied to HII 1348B

## Formation Inferences

- Eccentricity is especially relevant to formation and dynamical history
  - See Bowler et al. 2020
- Objects that formed in disks should have smaller eccentricities without later scattering
- Large orbital eccentricities for brown-dwarf companions often resemble wide stellar binaries
- We find  $e = 0.78 (+0.12, -0.29)$  for HII 1348B  $\rightarrow$  HII 1348B likely formed via gravitoturbulent processes

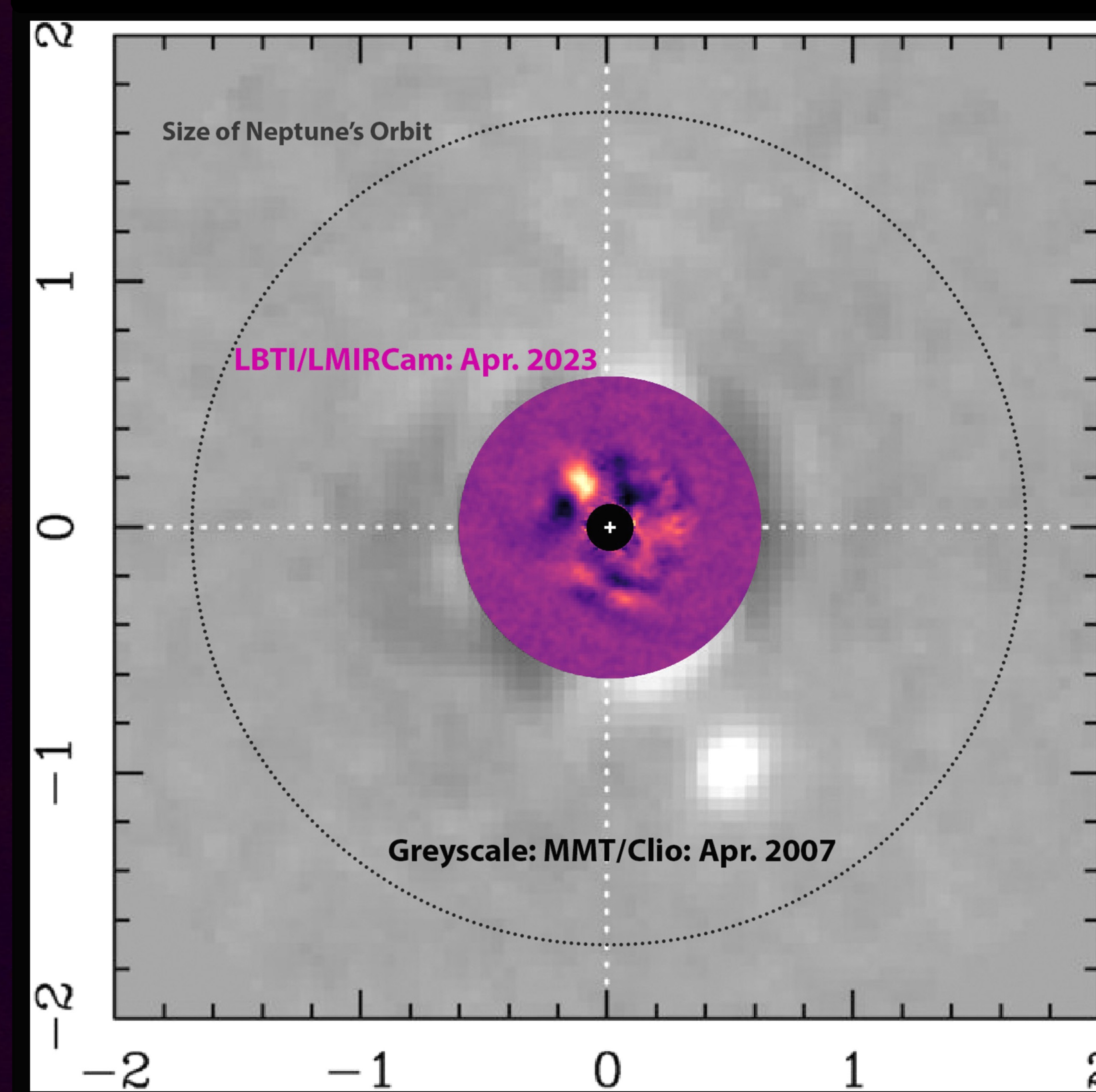
## Conclusions

- LBTI offers sensitive, diffraction-limited AO imaging at L'- and M-band, optimized for relatively "old" substellar companions
- Weible et al. 2025 presents the first orbital modeling and L'-band imaging of the likely very eccentric Pleiades BD companion HII 1348B
  - Suggests a star-like formation mechanism and/or subsequent dynamical scattering
- M-band observations of Alcor B show substantial orbital motion from the discovery images taken (exactly) 16 years prior
  - Solar-system scale resolution at 500 Myr — also a likely sextuple system with the Mizar quadruple
- LBTI/LMIRcam L' imaging could enable the proposed PLEIAD survey to discover the lowest-mass imaged BD companion or the first image of a super-Jovian planet in the Pleiades

## Why >100 Myr?

- Most imaging surveys: <40 Myr
  - Rationale: younger exoplanets, BDs are brighter
- Beyond ~100 Myr, there is a significant discovery space for the older counterparts of super-Jovian imaged planets and BD companions
  - E.g., older counterparts to Beta Pic b,c (~23 Myr, ~10–12  $M_J$ ), Kappa And b (<74 Myr, ~13  $M_J$ )
- Well-constrained ages of clusters/associations like the Pleiades enable benchmark measurements
  - Especially true when dynamical masses are measured
- L- and M-band capture the peak flux of intermediate-age/temperature substellar companions (Skemer et al. 2014)
- Allows for studies of atmospheric evolution (e.g., cooling) with age

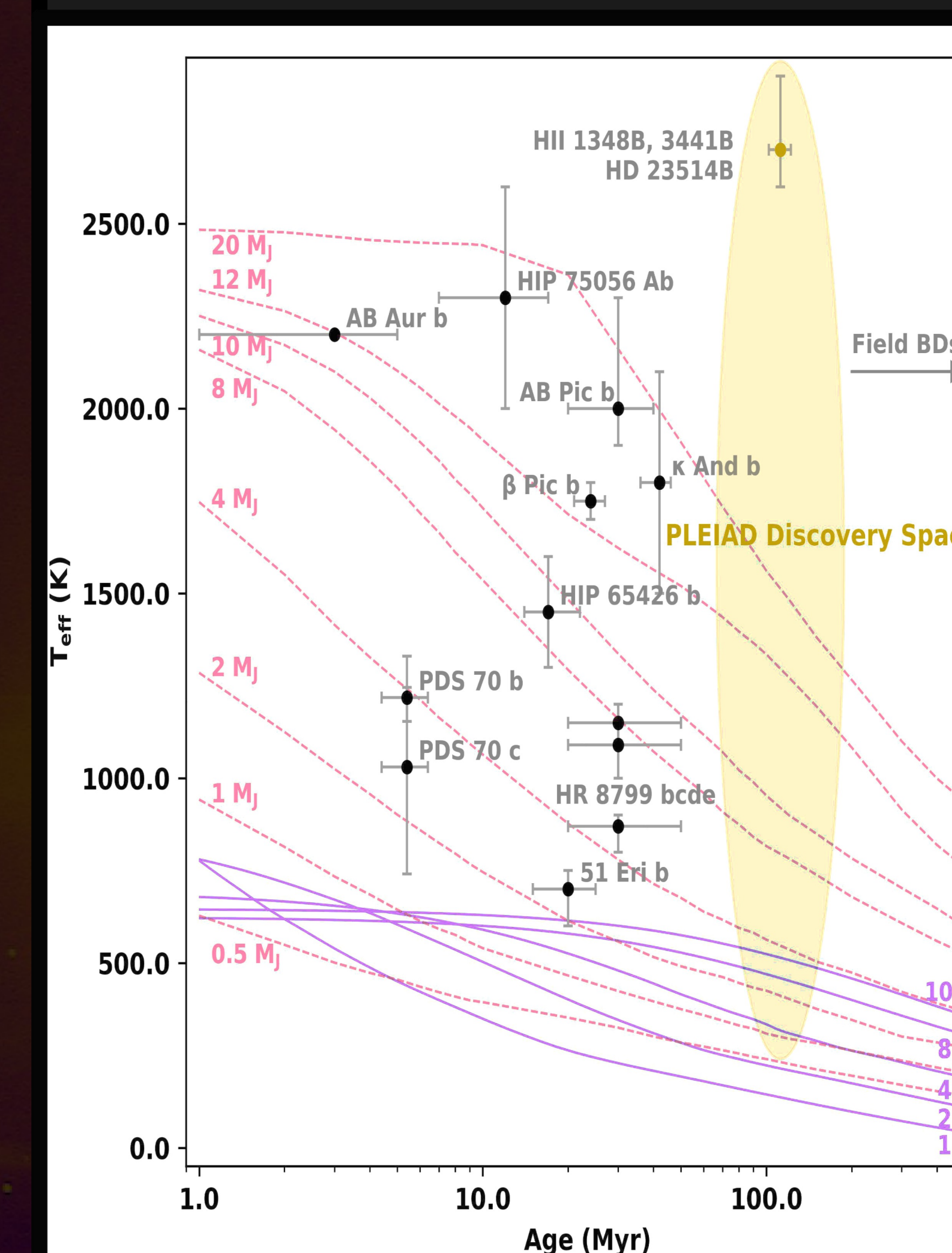
Alcor: 2007  $\rightarrow$  2023 @ M (4.8  $\mu$ m)



## PLEIAD Survey

- Proposed "Pleiades L-band Exoplanet Imaging and Discovery"
- The Pleiades are a nearby (~140 pc) open cluster of >1000 stars aged 112  $\pm$  5 Myr
- No imaged Pleiades planets to date — 3 imaged BD companions (incl. HII 1348B)
- L' matches BB peak of 4–8  $M_J$  with "hot-start" models at Pleiades-age
- Expected sensitivity to 5–10  $M_J$  companions beyond ~25 au projected separation
- HGCA used to inform target selection (Brandt 2021)

PLEIAD Survey  $T_{\text{eff}}$  vs. Age



## HCI Observations w/LBTI

- The Large Binocular Telescope Interferometer (LBTI) is located on Mt. Graham in AZ
- LBTI uses 2 x 8.4 m apertures which can be treated as semi-independent telescopes
- Nodding the telescope yields up to four semi-independent datasets
- LMIRcam: sensitive AO-assisted imaging at L', M

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## References

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