

COCONUTS: COol Companions ON Ultrawide orbits

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OVERVIEW

★ Value of wide-orbit (>500 au) planetary-mass and brown dwarf companions:

- Wide-orbit companions are essential to investigate the formation of the outer architecture of planetary systems around *Gaia* and *TESS* targets.
- Wide-orbit companions provide excellent laboratories to study physical and chemical processes in self-luminous exoplanet atmospheres.

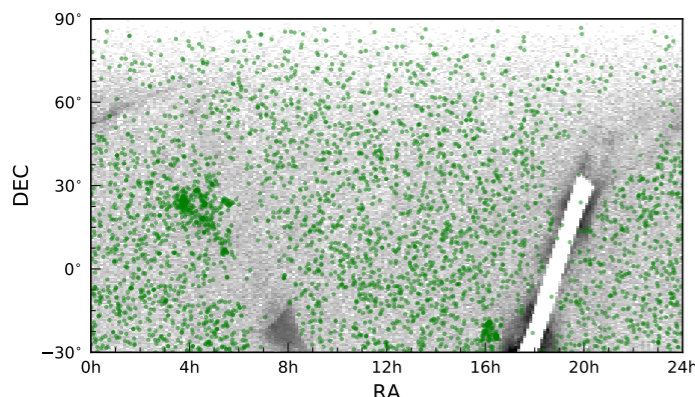
★ COCONUTS: A volume-limited search for wide-orbit companions:

- Nearly 40 wide-orbit (>500 au) planetary-mass and substellar companions are known to date, spanning M6–Y0 spectral types with ages from 1 Myr to 10 Gyr.
- The current companion census is incomplete: a few large-scale companion searches have been conducted (e.g., Pinfield et al. 2006, Deacon et al. 2014) but their primary star samples are not volume-limited and they relied on 2MASS, whose sensitivity has since been surpassed by the latest wide-field sky surveys.
- COCONUTS is expanding the current companion census using the latest sky surveys: *Gaia*, Pan-STARRS1, and AllWISE.

SURVEY DESIGN

★ A Volume-Limited Primary Star Sample

- Our primary star sample contains all $\approx 300,000$ objects within 100 pc from *Gaia* DR2, much larger than previous companion searches. This is essential given that the occurrence rate of wide substellar companions (5–70 M_{Jup} and >500 au) might be as low as $\approx 0.1\%$ (as extrapolated from Brandt et al. 2014).



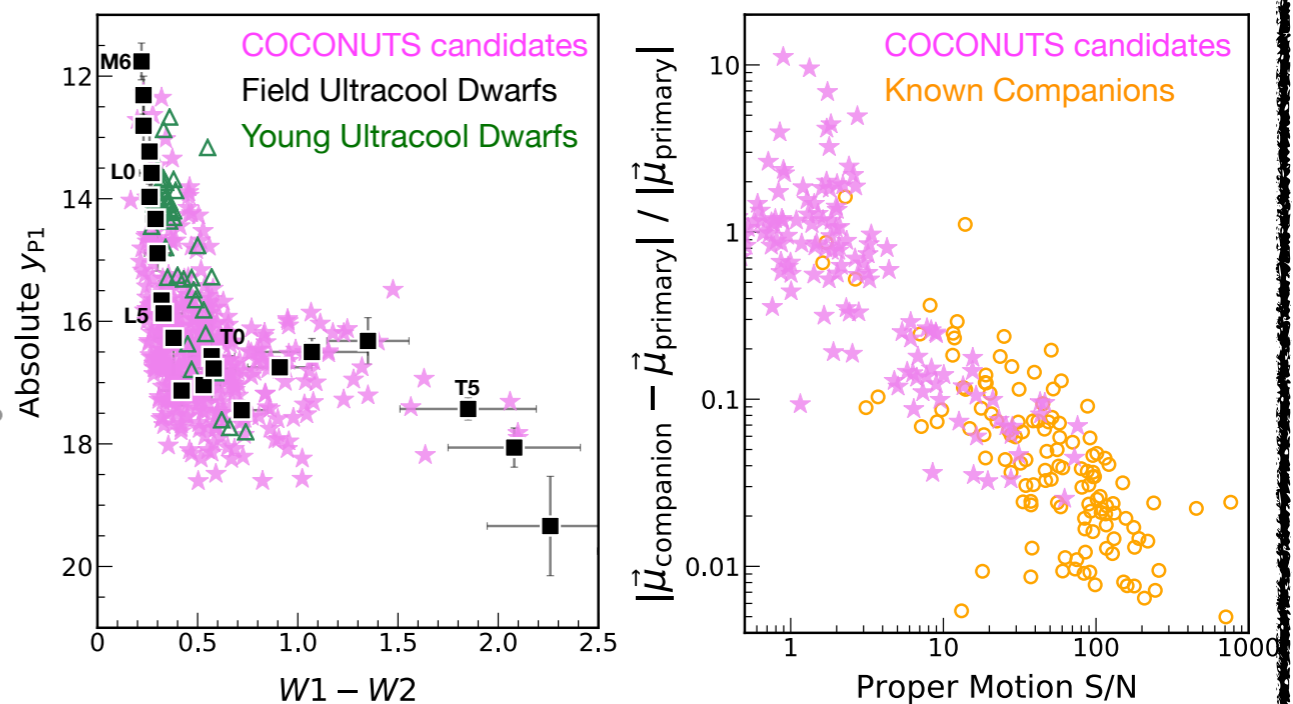
- Field-age primary stars
- Young field stars and moving group members

★ Follow-up Strategy

- UKIRT/WFCAM: astrometry of candidates with no or low-S/N proper motions.
- IRTF/SpeX + Gemini/GNIRS: spectroscopy of bright co-moving candidates.
- CFHT/WIRCAM: photometry (e.g., *W* band) of faint co-moving candidates.
- Gemini/GMOS + UH88/SNIFS: spectroscopy of confirmed companion hosts.

★ Candidate Companions

- We use astrometry and photometry from Pan-STARRS1 and AllWISE data.
- We select candidates with (1) colors and absolute magnitudes (assuming their primary stars' distances) expected for gas-giant planets and brown dwarfs, and (2) common proper motions with their primary stars.



DISCOVERIES

★ A Vastly-Expanded Sample of Wide-orbit Brown Dwarf companions by COCONUTS

- Thus far, we have spectroscopically confirmed 52 new wide-orbit (> 500 au) brown dwarf companions.
- Our spectroscopic follow-up has a high success rate (84%) of identifying substellar objects, indicating our candidate selection is robust.
- The first COCONUTS discovery, COCONUTS-1AB, is a rare system of a brown dwarf companion (T4 spectral type) to a white dwarf (Zhang et al. 2020a).
- COCONUTS discoveries have more than doubled the current census and represent an order-of-magnitude larger yield than any previous search.

