BACKGROUND: MODIFIED FROM AN ARTIST'S VIEW OF CHRX 73 B. CREDITS: NASA, ESA AND G. BACON (STSCI)

A NEW WIDE PLANETARY-MASS COMPANION TO A YOUNG M3 STAR

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Université de Montréal
CRAQ
Fonds de recherche sur la nature et les technologies Québec
CRSNG NSERC

OUTLINE

1. THE OBSERVING PROGRAM
2. THE HOST
3. THE PLANET
4. A BONUS
5. CONCLUSION

1. THE OBSERVING PROGRAM

2. THE HOST

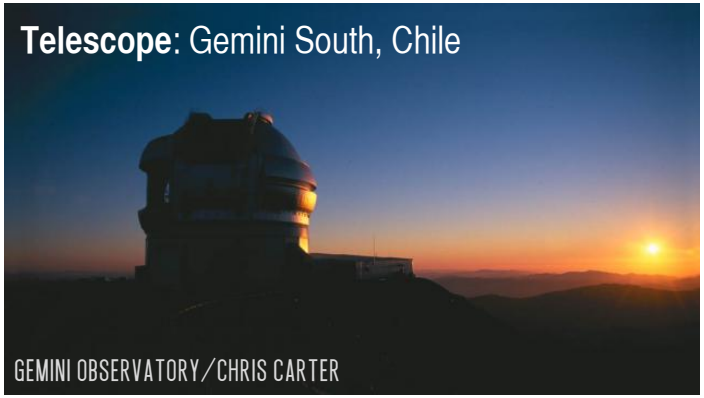
3. THE PLANET

4. A BONUS

5. CONCLUSION

PSYM PLANET SEARCH AROUND YOUNG M-DWARFS

Two surveys using



PSYM

Instrument: NICI

High-contrast Imaging: ADI+SDI in *H* filter

- To find companions
  >$2M_{Jup}$, 15 – 300 AU
- **31 stars surveyed**

PSYM-WIDE

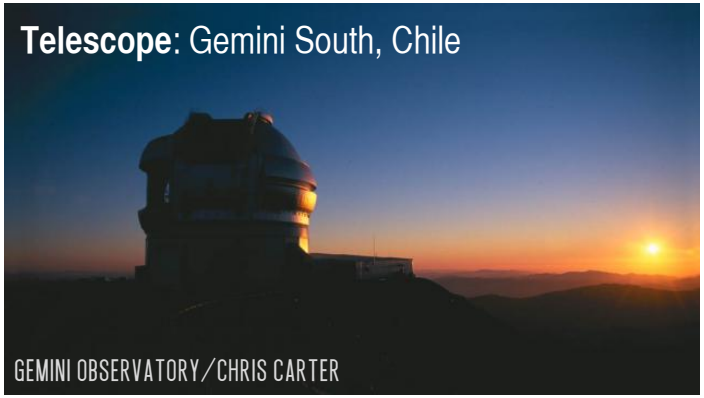
Instrument: GMOS

Imaging in *i* (7870nm) and *z* (900nm) filters

- To find companions
  >3 – $5M_{Jup}$, 100 – 5000 AU
- **91 stars surveyed**

PSYM PLANET SEARCH AROUND YOUNG M-DWARFS

Two surveys using



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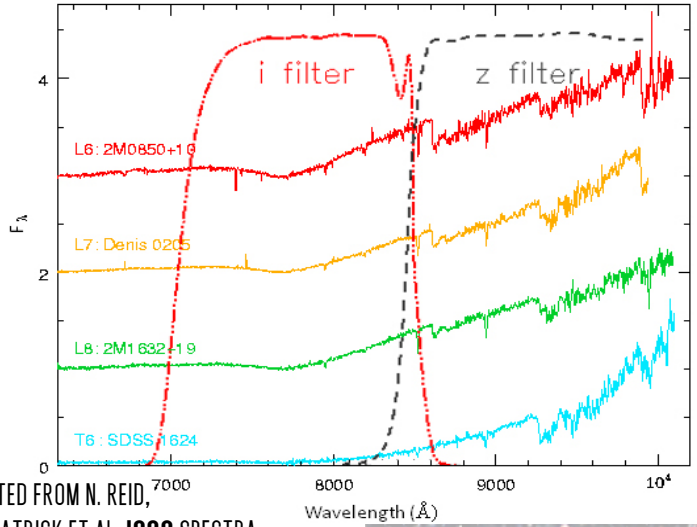
PSYM-WIDE



ADAPTED FROM N. REID, KIRKPATRICK ET AL. **1999** SPECTRA

THE SAMPLE

Malo et al. 2013, ApJ, 762:88

Malo et al. 2014, ApJ, accepted

Gagné et al. 2013, ApJ, 783:121

Newly confirmed members of young local associations

- β Pictoris
- TW Hydraw
- Tucana-Horologium
- Columba
- Carina
- AB Doradus

- Nearby (<100pc)
- Low-mass (K5V-M5V)
- Young ($\lesssim$150Myr) & constrained age

www.astro.umontreal.ca/~malo/banyan

www.astro.umontreal.ca/~gagne/banyanII

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THE HOST STAR

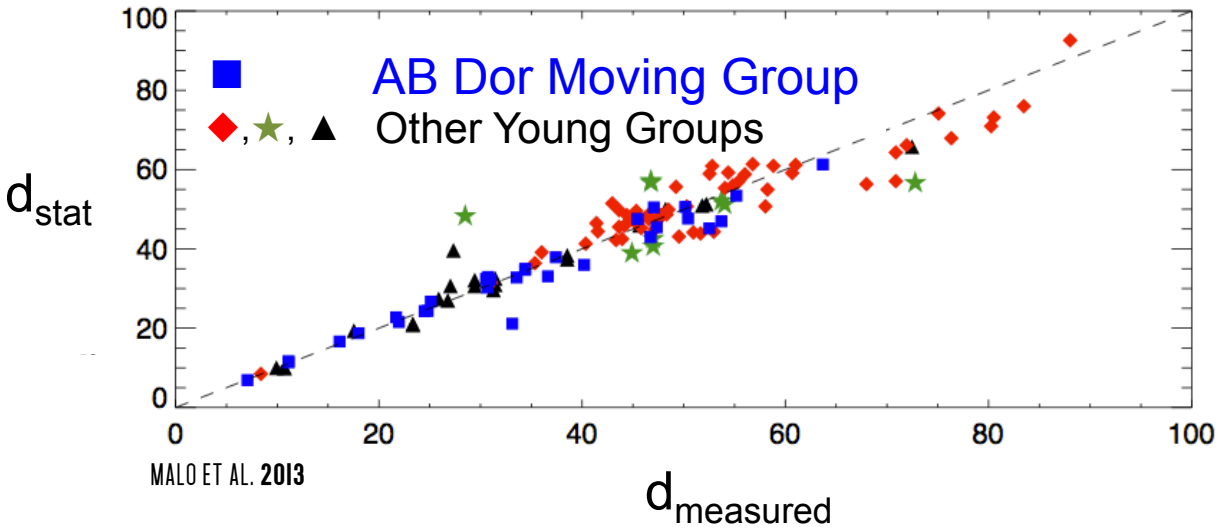
V	13.6
R	12.9
J	10.2
Ks	9.4

- M3 ± 0.5 star

- Kinematic member of AB Dor MG (Malo et al. 2013)
  - Bayesian analysis
  - Confirmed with v_{rad}
  - Other signs of youth

→Age = 70 – 130Myr

→d_{stat} = 48 ± 5 pc



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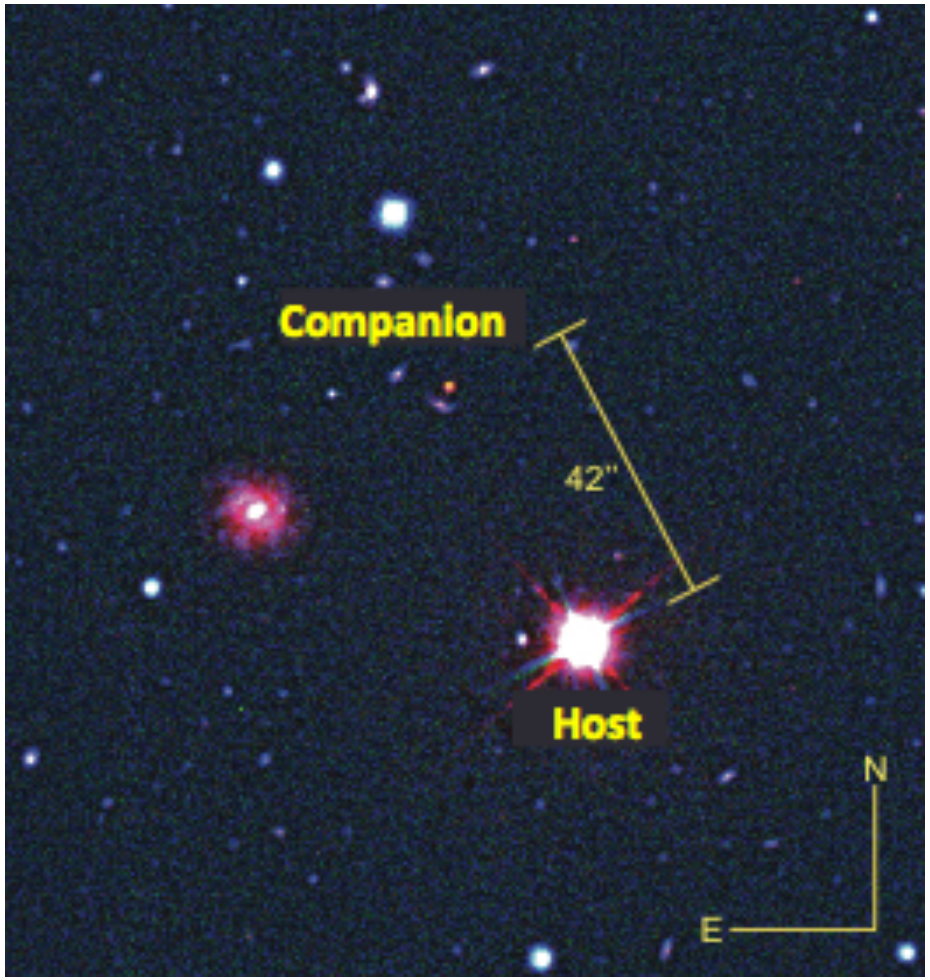
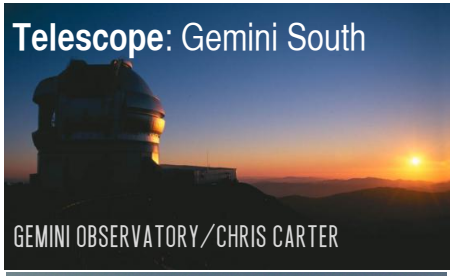
THE PLANETARY-MASS COMPANION

GMOS i and z (discovery) + WIRCam J

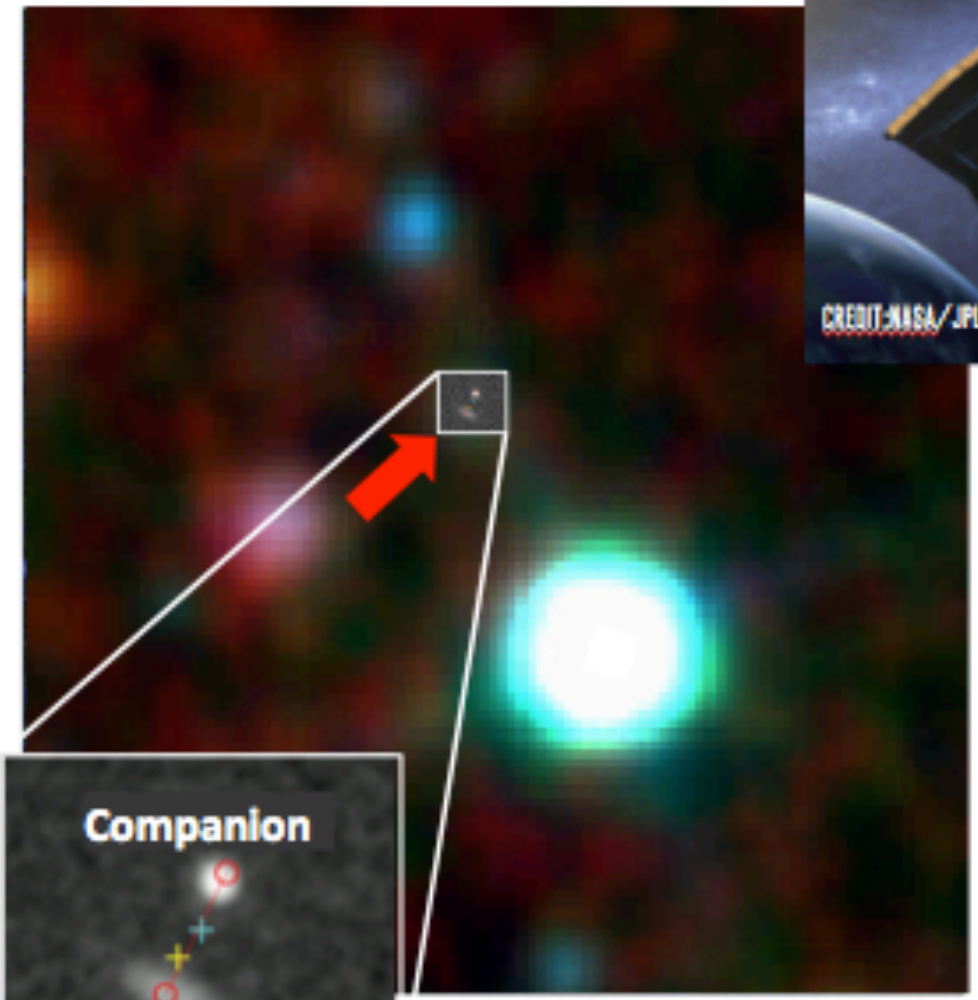


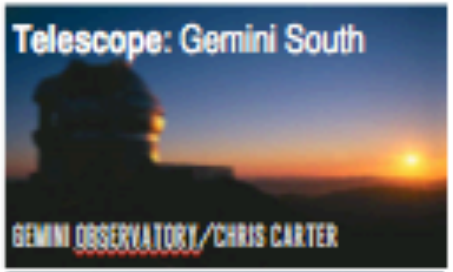


$i_{AB} - z_{AB}$	>3.51
$z_{AB} - J_{MKO}$	3.63
$J_{MKO} - Ks_{MKO}$	0.72

THE PLANETARY-MASS COMPANION

GMOS i and z (discovery) + WIRCam J

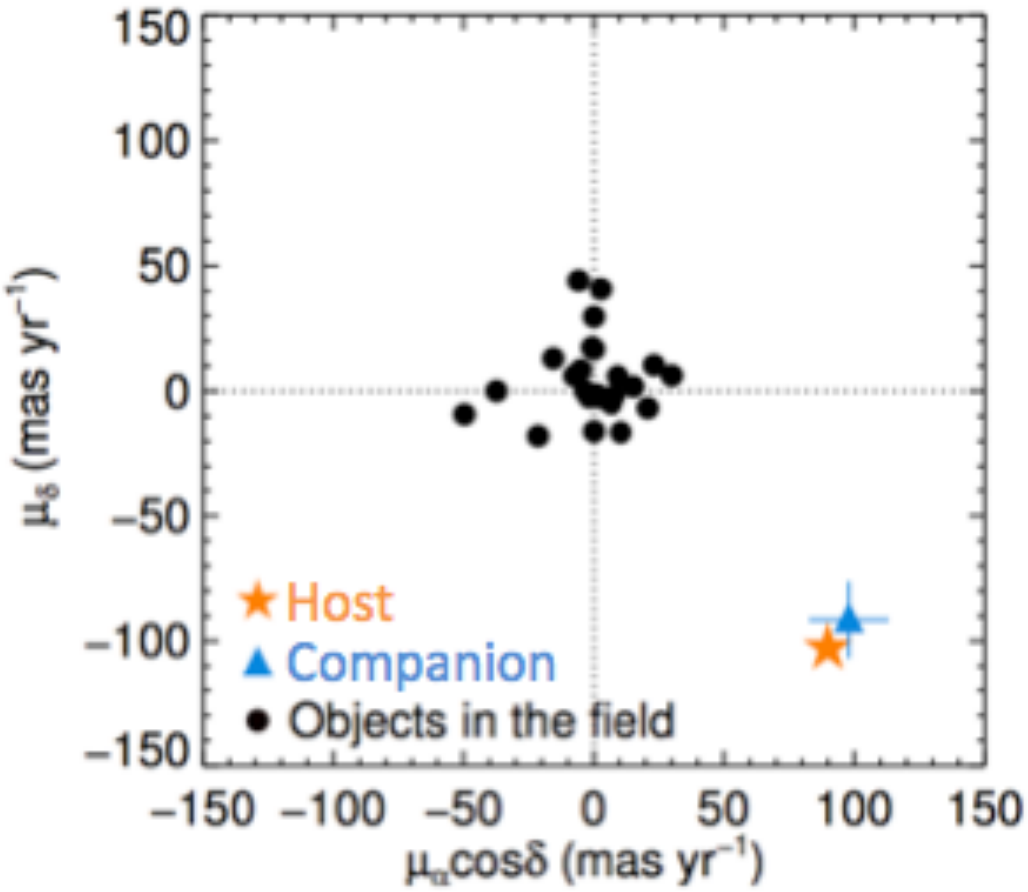




W1	17.2
W2	15.4

$i_{AB} - z_{AB}$	>3.51
$z_{AB} - J_{MKO}$	3.63
$J_{MKO} - Ks_{MKO}$	0.72
$J_{MKO} - W1$	0.95
W1 – W2	1.76

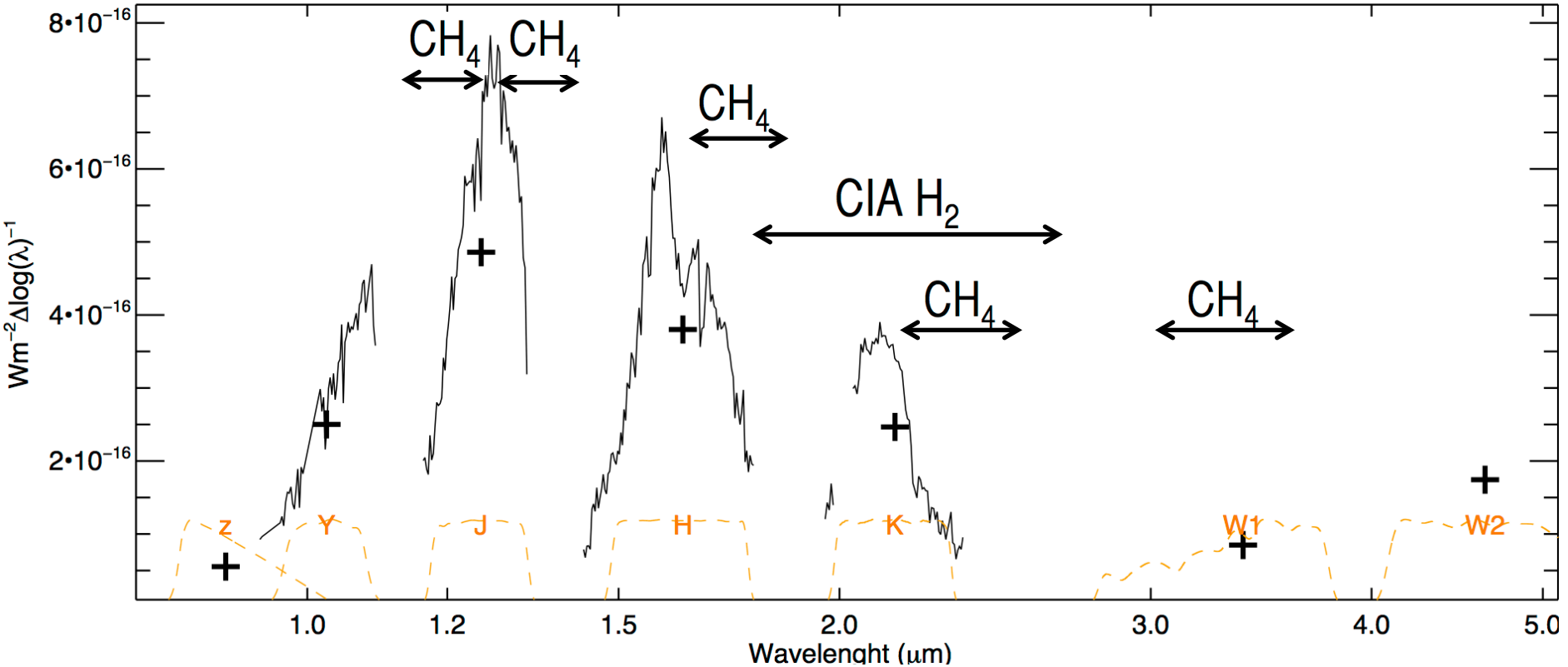
COMMON PROPER MOTION



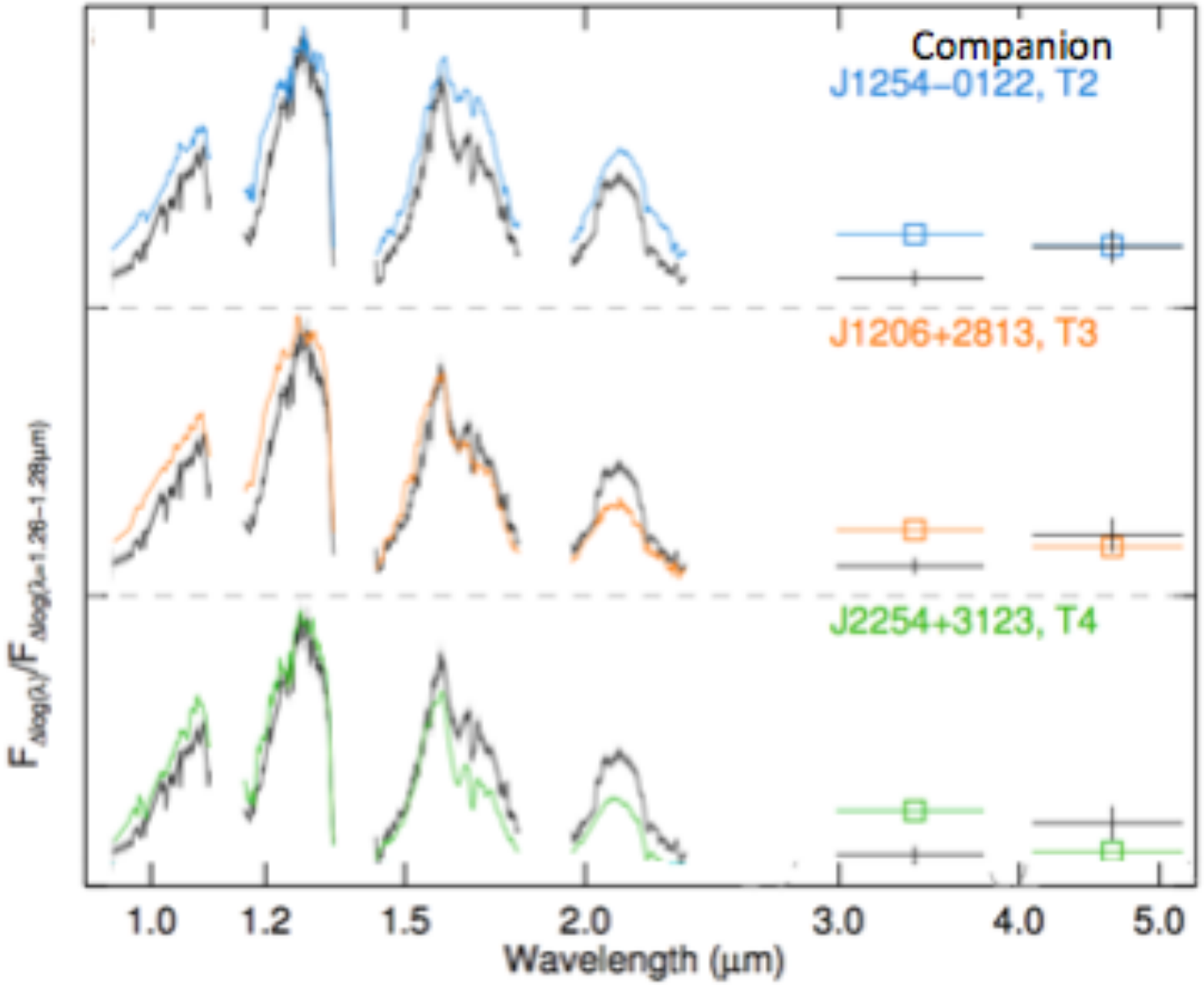
1st epoch: October 2011
2nd epoch: September 2012

SPECTRUM

T3.5 ± 1



SPECTRUM COMPARED TO TEMPLATES



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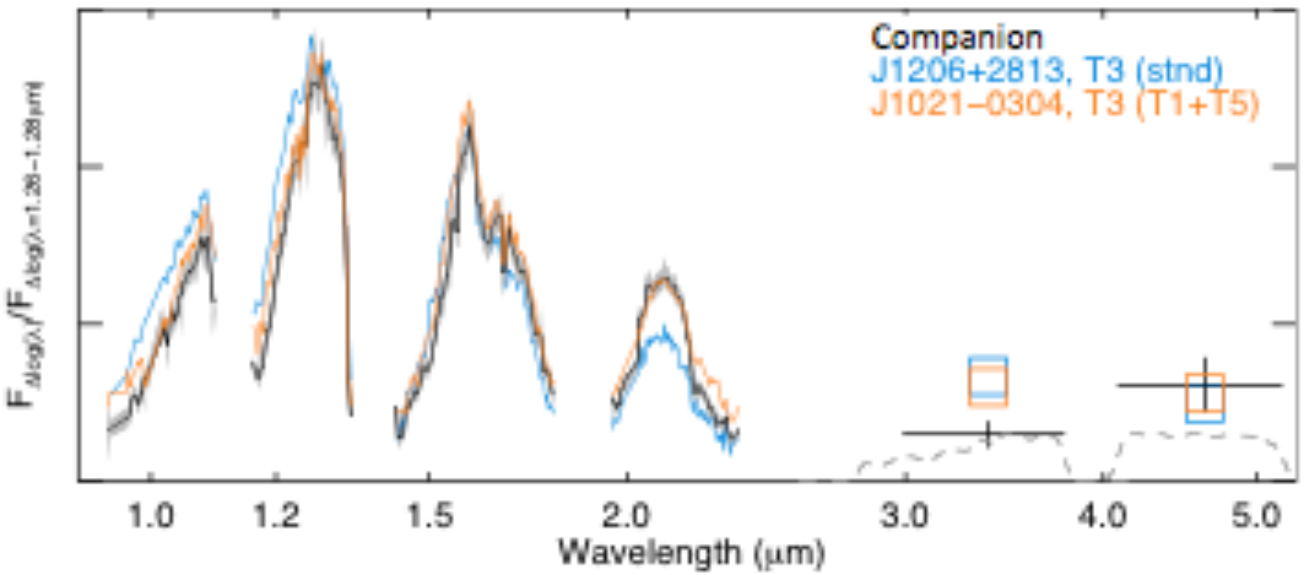
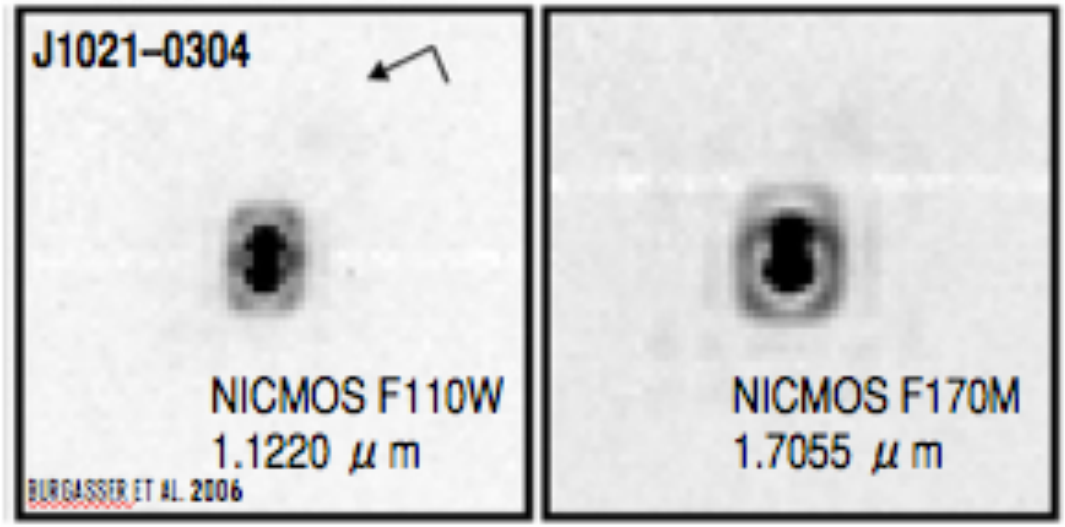
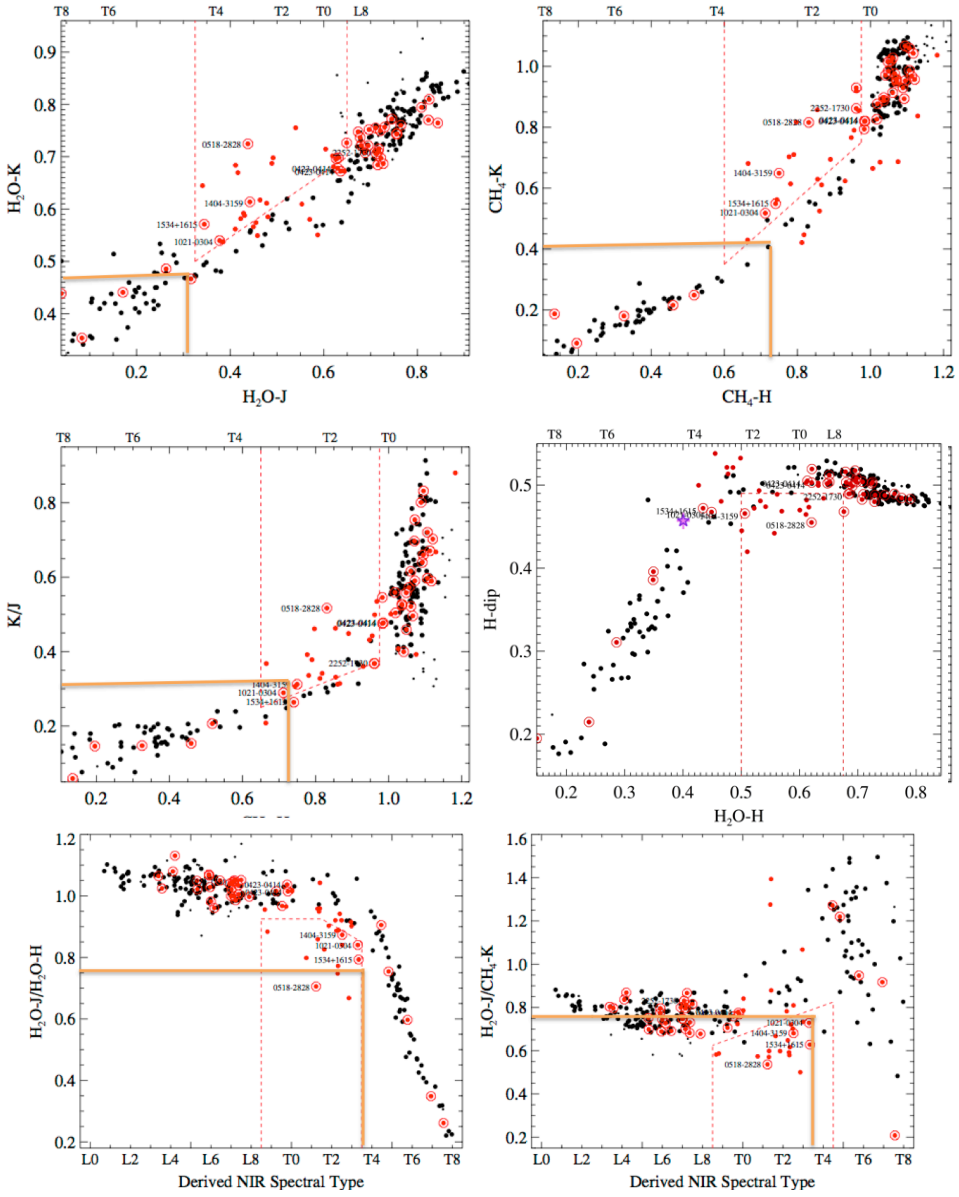




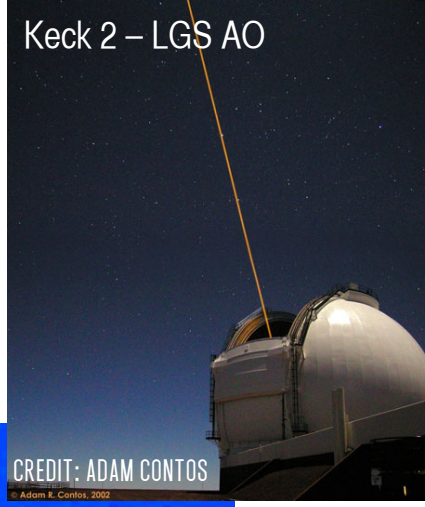
BINARY PLANET?

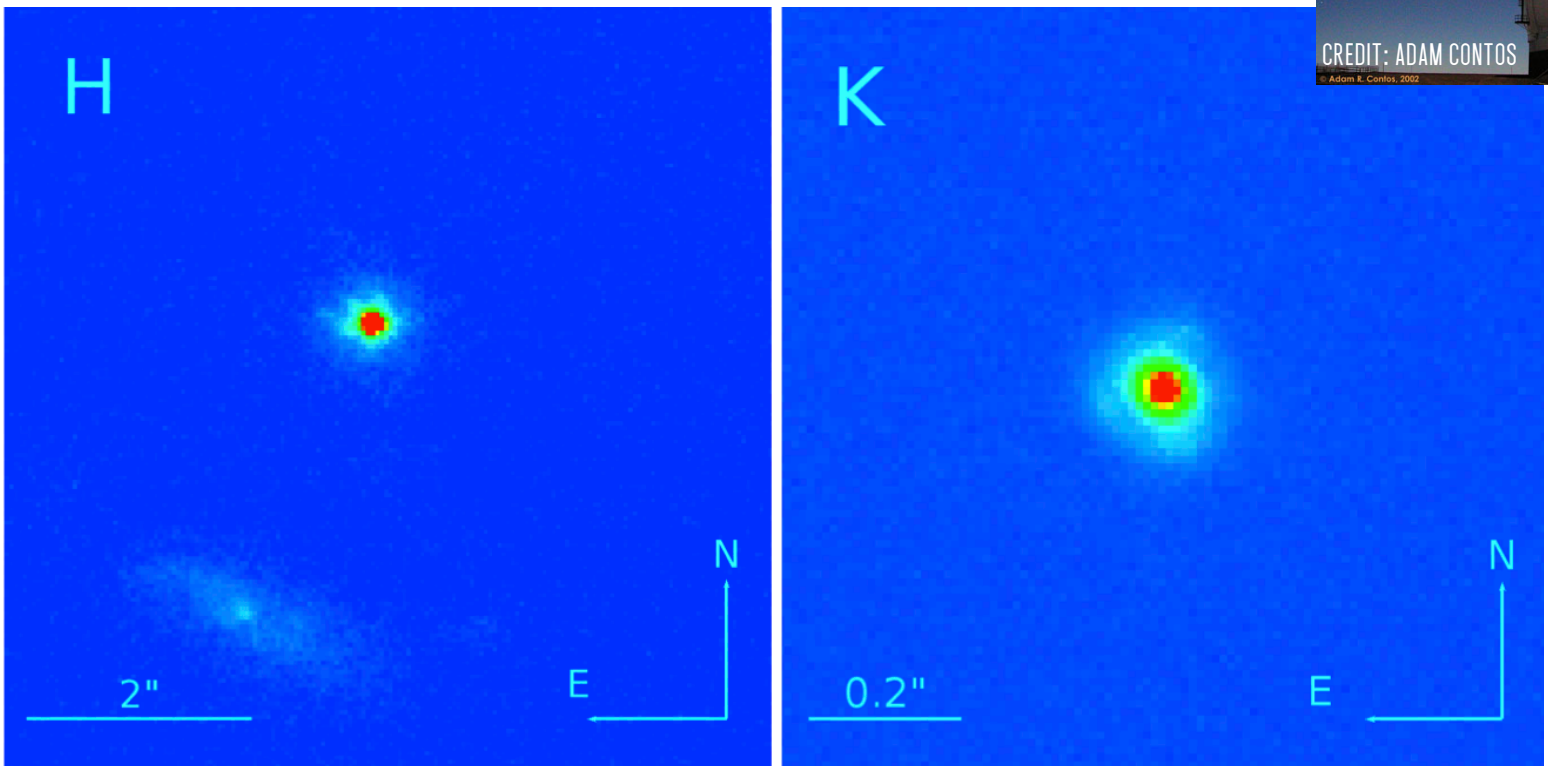


BURGASSER ET AL. **2010**

Burgasser et al. 2010 Indices	Our companion
H_2O-K vs H_2O-J	no
CH_4-K vs CH_4-H	no
K/J vs CH_4-H	yes
H-dip vs H_2O-H	no
H_2O-J/H_2O-H vs SpType	maybe
H^2O-J/CH_4-K vs SpType	yes
Total	2 (3) satisfied
= weak (strong) candidate binary	

BINARY PLANET?





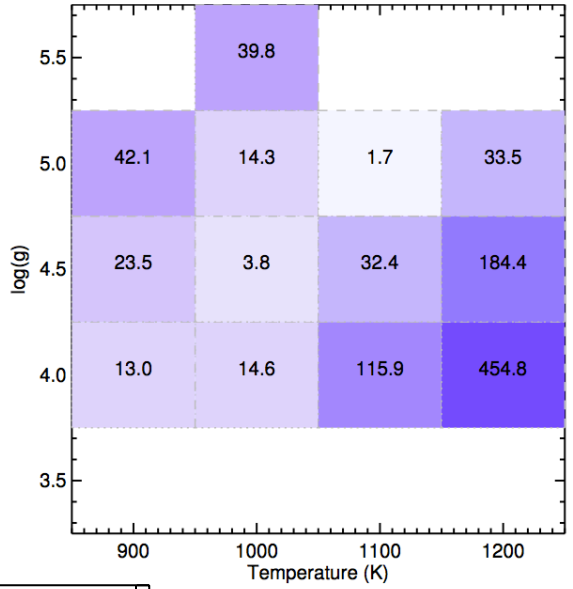
SPECTRUM COMPARED TO MODELS

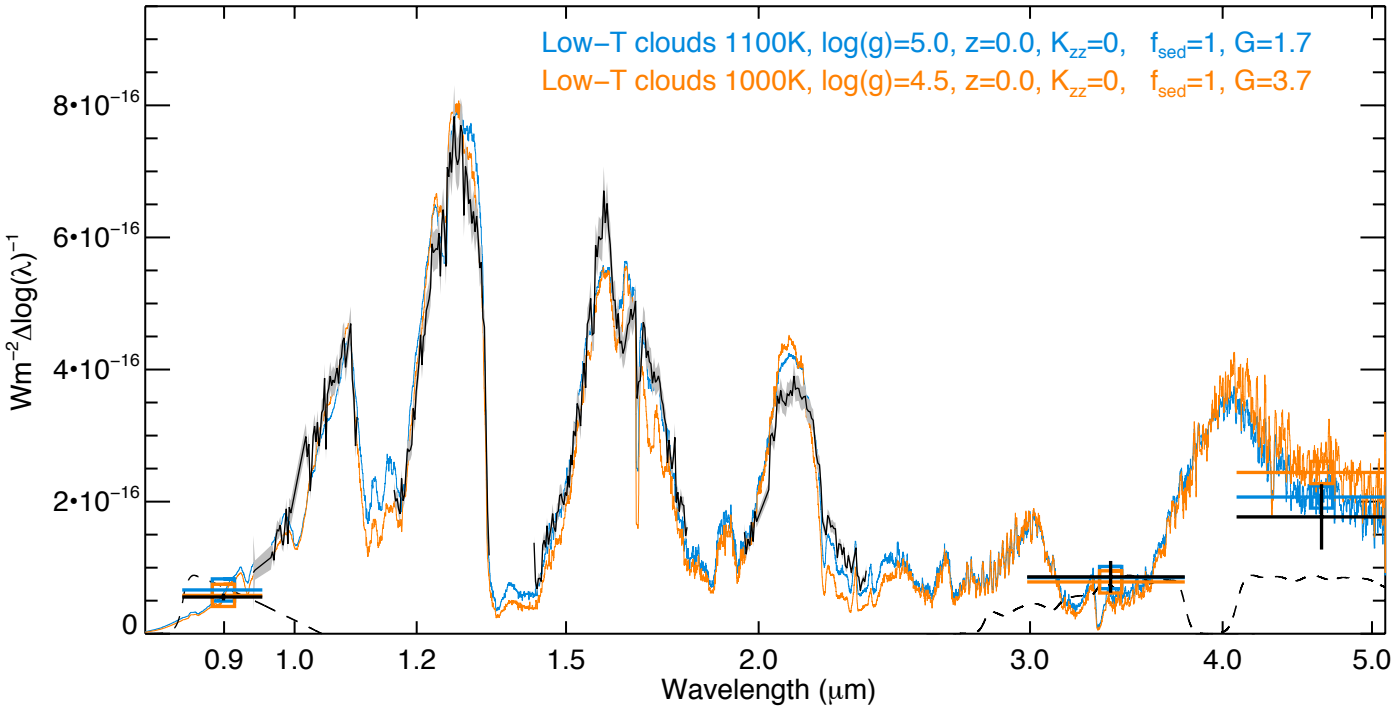
Sulfide Cloud Model Photometry

MORLEY ET AL. **2012**

Models that include Na2S, KCl, ZnS, MnS, and Cr clouds. Models have effective temperatures from 400 to 1200 K, gravities from log g(cgs) 4.0 to 5.5. These models are especially appropriate for **late T dwarfs cooler than ~900 K** (spectral type ~T9).

www.ucolick.org/~cmorley/cmorley/Data.html





SPECTRUM COMPARED TO MODELS

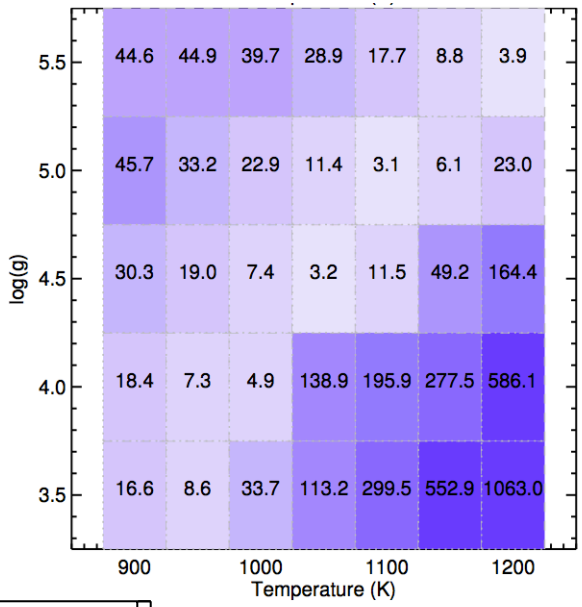
ALLARD ET AL. **2012**

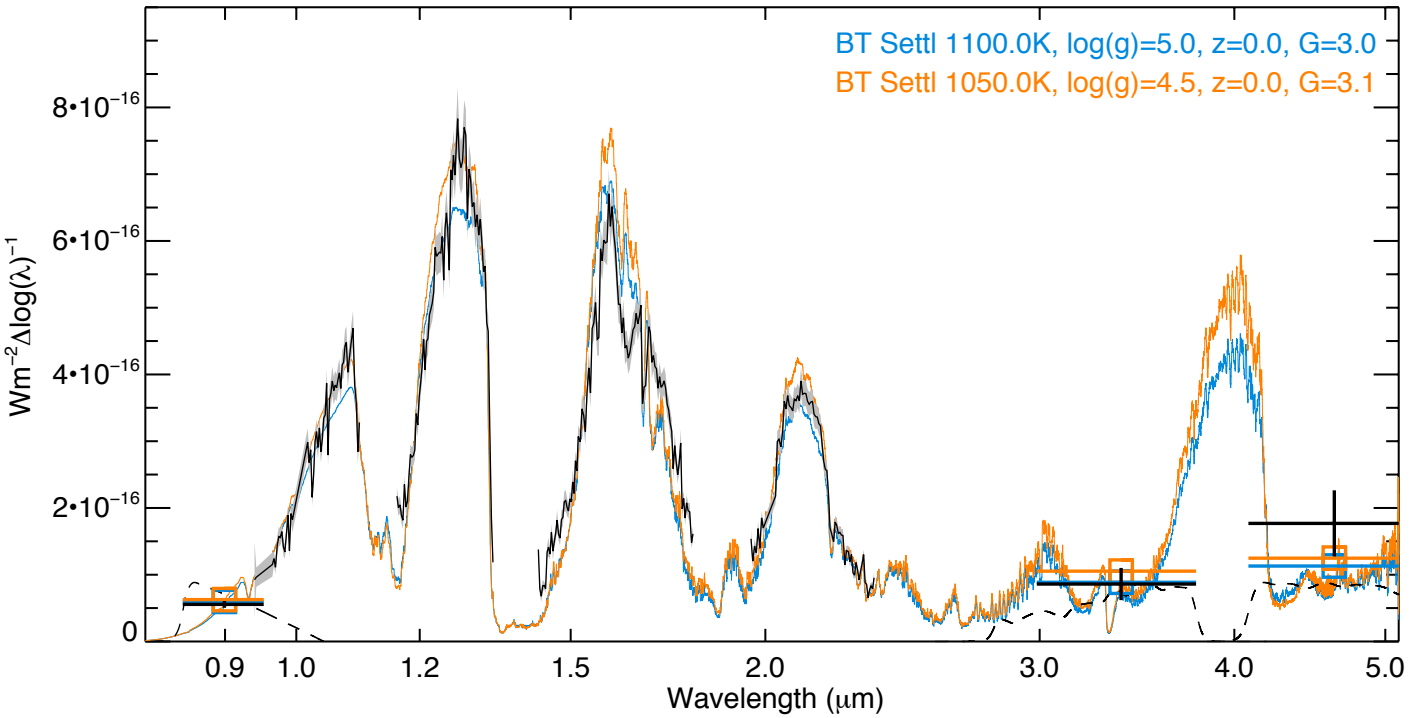
Modèles d'Atmosphères d'étoiles de Faible Masse,
Naines Brunes,
et Planètes Extrasolaires

CRAL-ENS
46, Allée d'Italie
69364 Lyon Cedex 07

BT-Settl (étoiles/naines brunes/planètes (non-irradiées), avec un modèle de nuages)

phoenix.ens-lyon.fr/Grids/BT-Settl/CIFIST2011/





PHYSICAL PARAMETERS

→ T_{eff} ~ 1050 ± 50K

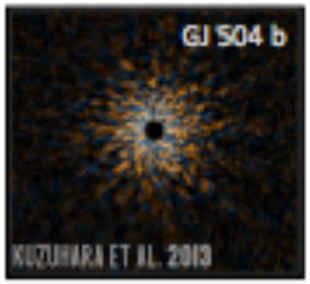
→ Age (AB Dor) = 70 – 130Myr

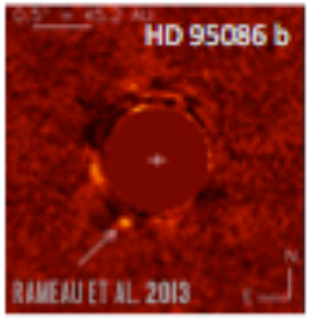
	SAUMON & MARLEY **08** cloudy	SAUMON & MARLEY **08** no cloud	BARAFFE ET AL. **03**
Mass (M_{jup})	10.8 – 12.0	10.4 – 12.1	9.6 – 13.0
Radii (R_{jup})	1.33 –1.38	1.23 – 1.27	1.15 – 1.21
log g	4.18 – 4.23	4.23 – 4.31	4.22 – 4.36
log (L/L_{sol})	-4.80 – -4.60	-4.87 – -4.67	-4.91 – -4.70

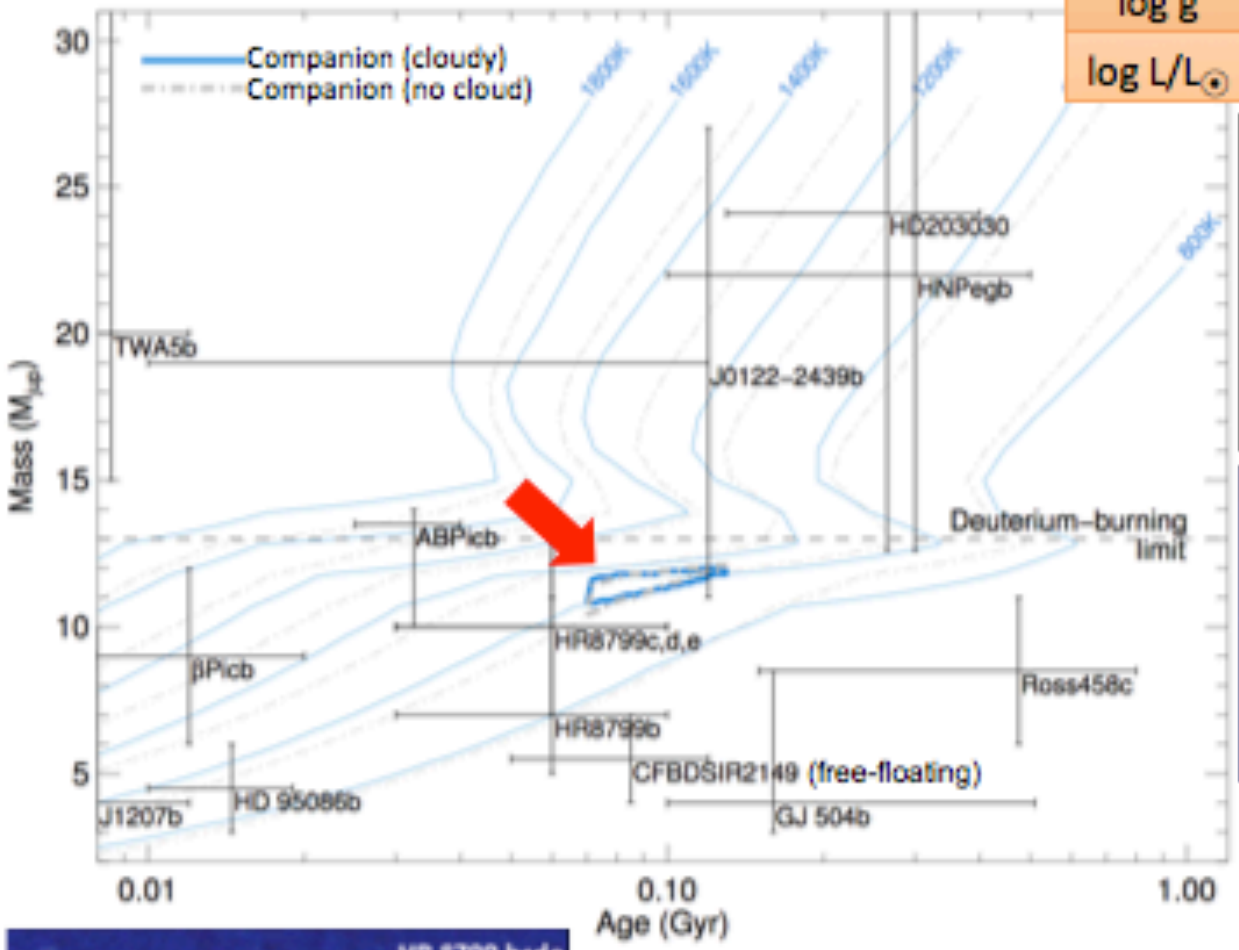
→ M ~ 9 – 13M_{Jup} (planetary-mass)

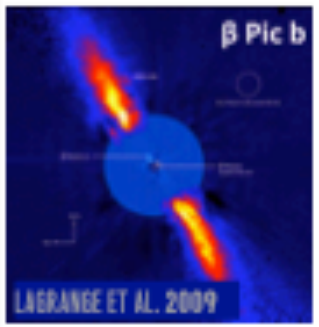
INTEREST OF THE SYSTEM

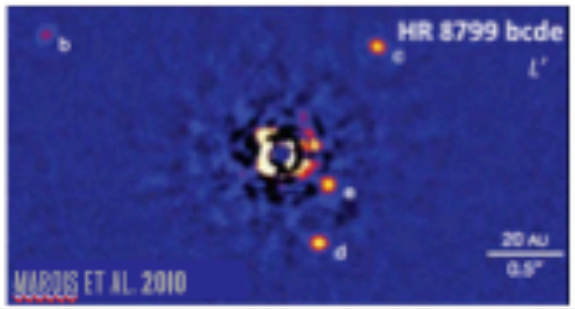
Mass	9.6 – 13.0M_{Jup}
Radii	1.15 – 1.38 R_{Jup}
log g	4.18 – 4.36
log $L/L_{\odot}$	-4.91 – -4.60











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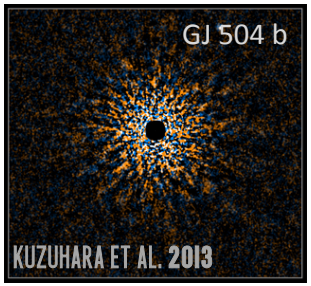

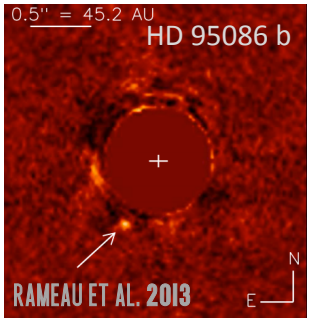

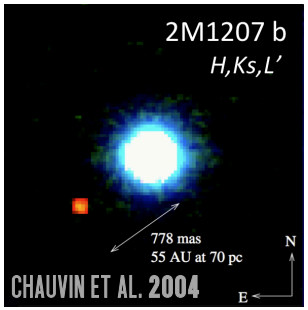

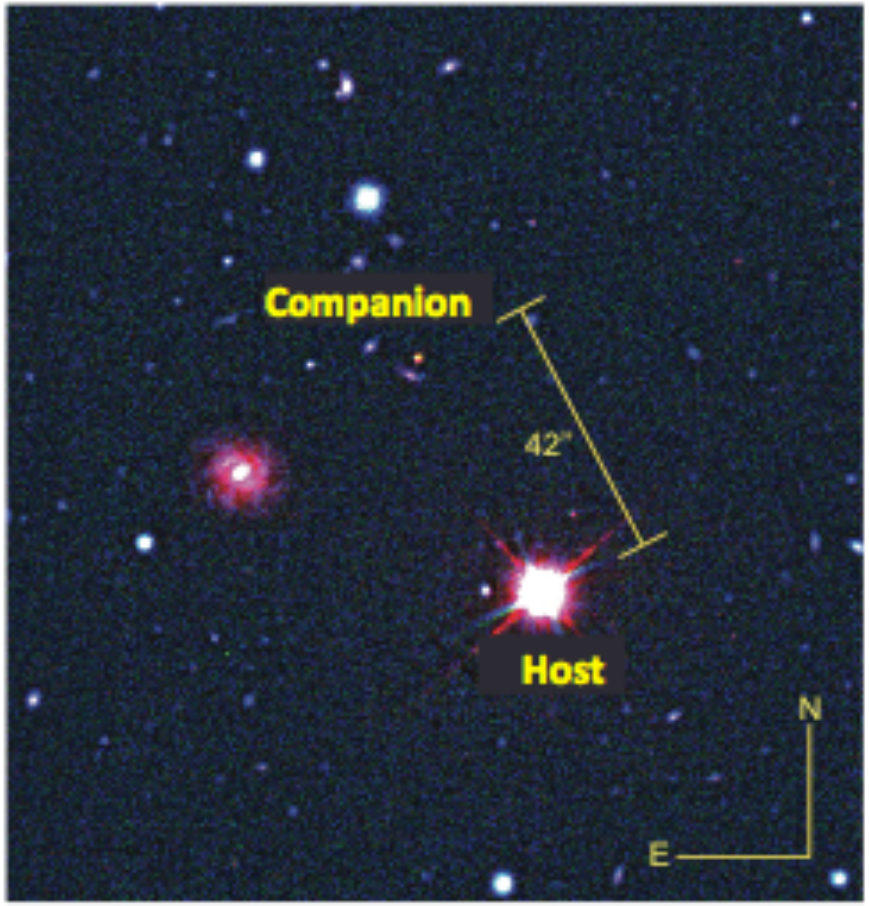

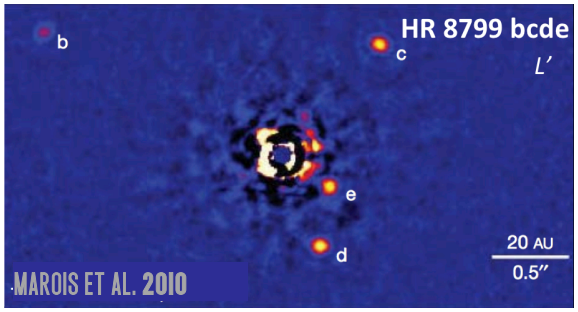

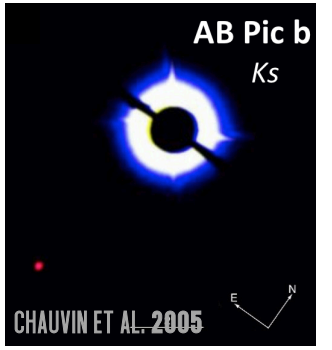

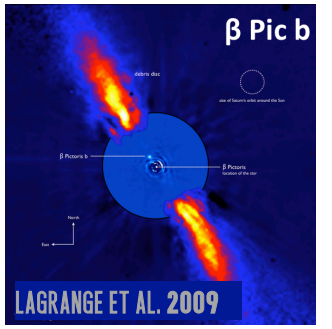

CONCLUSION

- We found a companion
  - With Gemini-South/GMOS i and z photometry
  - That is
    - **Young** (with constrained age) : 70–130Myr
    - **Planetary-mass** : 9 – 13M_{Jup}
    - **Very far** from host : 2000AU

- Direct imaging surveys can detect PM companions.
  - Easier to study than their closer counterparts
  - Can help understand low-g L and T dwarfs and closer-in exoplanets

CONCLUSION

Naud et al. accepted for ApJ (May 10th edition)

TB, TR, APJ/ApJ493915/ART, 16/04/2014

The Astrophysical Journal, 786:1 (16pp), 2014 ???

doi:10.1088/0004-637X/786/1/1

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DISCOVERY OF A WIDE PLANETARY-MASS COMPANION TO THE YOUNG M3 STAR [redacted]

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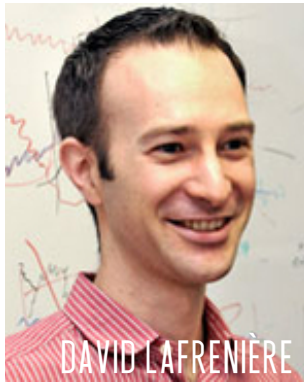
ABSTRACT

We present the discovery of a comoving planetary-mass companion ~42″ (~2000 AU) from a young M3 star, [redacted], likely member of the young AB Doradus Moving Group (ABDMG). The companion was first identified via its distinctively red $i - z$ color (>3.5) through a survey made with Gemini-S/GMOS. Follow-up Canada–France–Hawaii Telescope/WIRCam near-infrared (NIR) imaging, Gemini-N/GNIRS NIR spectroscopy and *Wide-field Infrared Survey Explorer* photometry indicate a spectral type of T3.5 ± 1 and reveal signs of low gravity which we attribute to youth. Keck/Adaptive Optics NIR observations did not resolve the companion as a binary. A comparison with atmosphere models indicates $T_{\rm eff}$ = 1000–1100 K and $\log g$ = 4.5–5.0. Based on evolution models, this temperature corresponds to a mass of 9–13 $M_{\rm Jup}$ for the age of ABDMG (70–130 Myr). The relatively well-constrained age of this companion and its very large angular separation to its host star will allow its thorough characterization and will make it a valuable comparison for planetary-mass companions that will be uncovered by forthcoming planet-finder instruments such as Gemini Planet Imager and SPHERE.



MONTREAL BDS & EXOPLANETS RESEARCH GROUP (MBDERG)

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www.astro.umontreal.ca/mbderg

Including: Rene Doyon, Etienne Artigau, Lison Malo, David Lafreniere, Loic Albert & Jonathan Gagne

Université de Montréal

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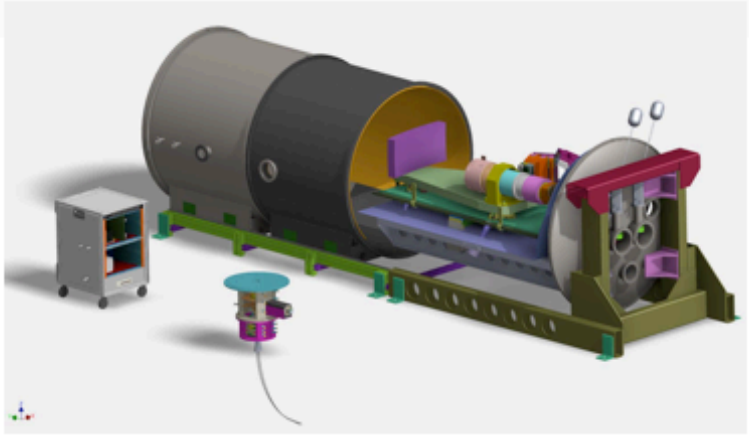
SPIRou - un SpectroPolarimètre Infra-Rouge
A Near-InfraRed Spectropolarimeter

SPIRou is a near-infrared spectropolarimeter and high-precision velocimeter being designed as a new Guest Instrument for CFHT. It will be installed at the Cassegrain telescope focus in 2017 after its design, construction and validation tests are performed by the instrument consortium. The main science goals of SPIRou are the search and characterization of habitable exo-Earths around low-mass stars, and the study of the magnetic topology of young protostars as a tool for investigating star/planet formation mechanisms.

SPIRou news

- April 2014: final desing review for SPIRou, to be held in Toulouse
- January 23, 2014: the SPIRou project presented in the comics "Le Journal de SPIRou" (in French)
- January 16, 2014: progress meeting and pre-FDR review for SPIRou
- November, 5 2013: SPIRou has been chosen as a Guest Instrument and funded by CFHT
- October 2012: SPIRou Preliminary Design Review at CFHT
- June 2011: Kick-off meeting in Paris
- October 2010: SPIRou CoDR at CFHT