

**FIRE SPECTROSCOPY
OF THE ULTRA-COOL
BROWN DWARF,
UGPS 0722-05**

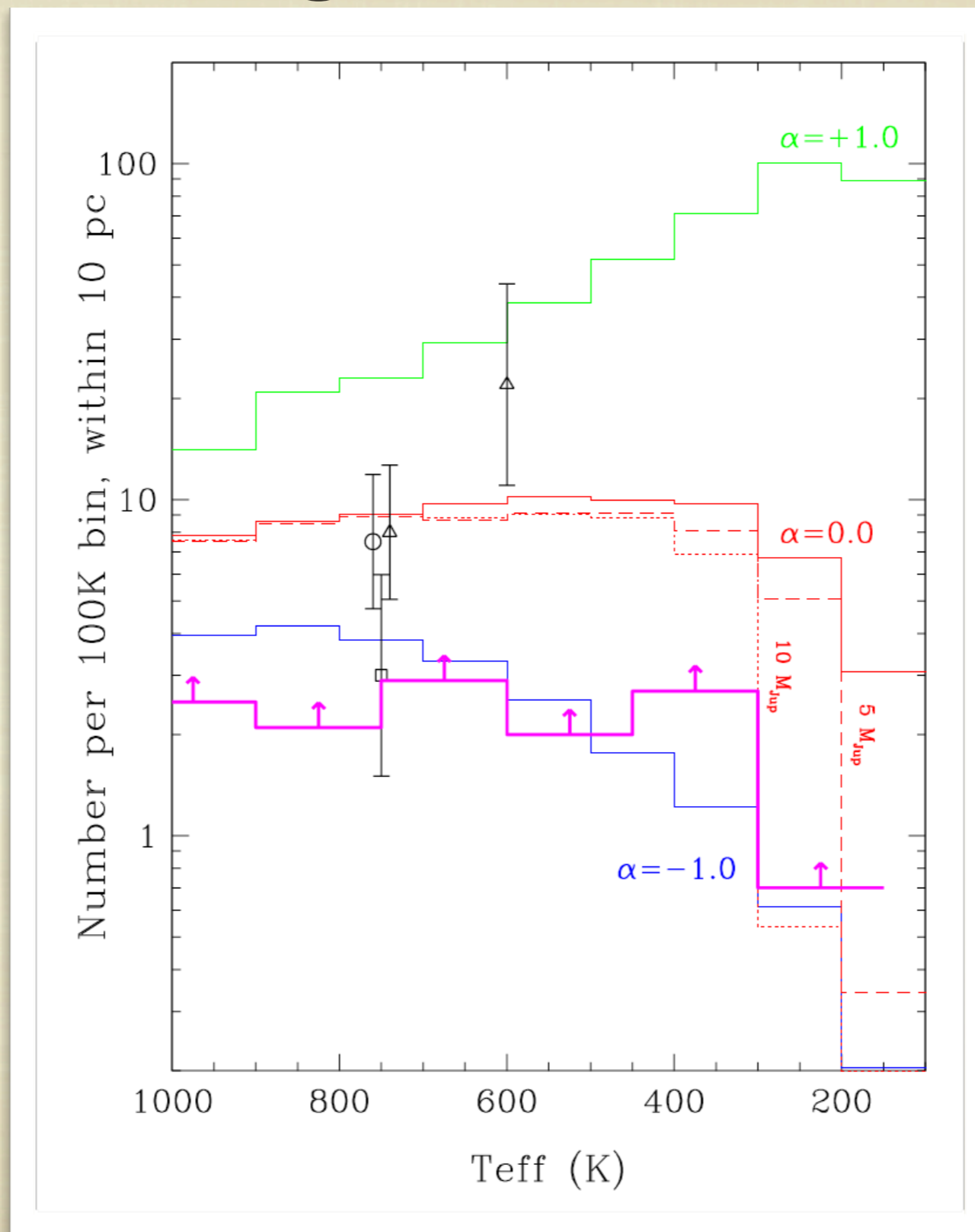


JOHN BOCHANSKI, PENN STATE

ADAM BURGASSER (UCSD), ROB SIMCOE (MIT), ANDREW WEST (BU)

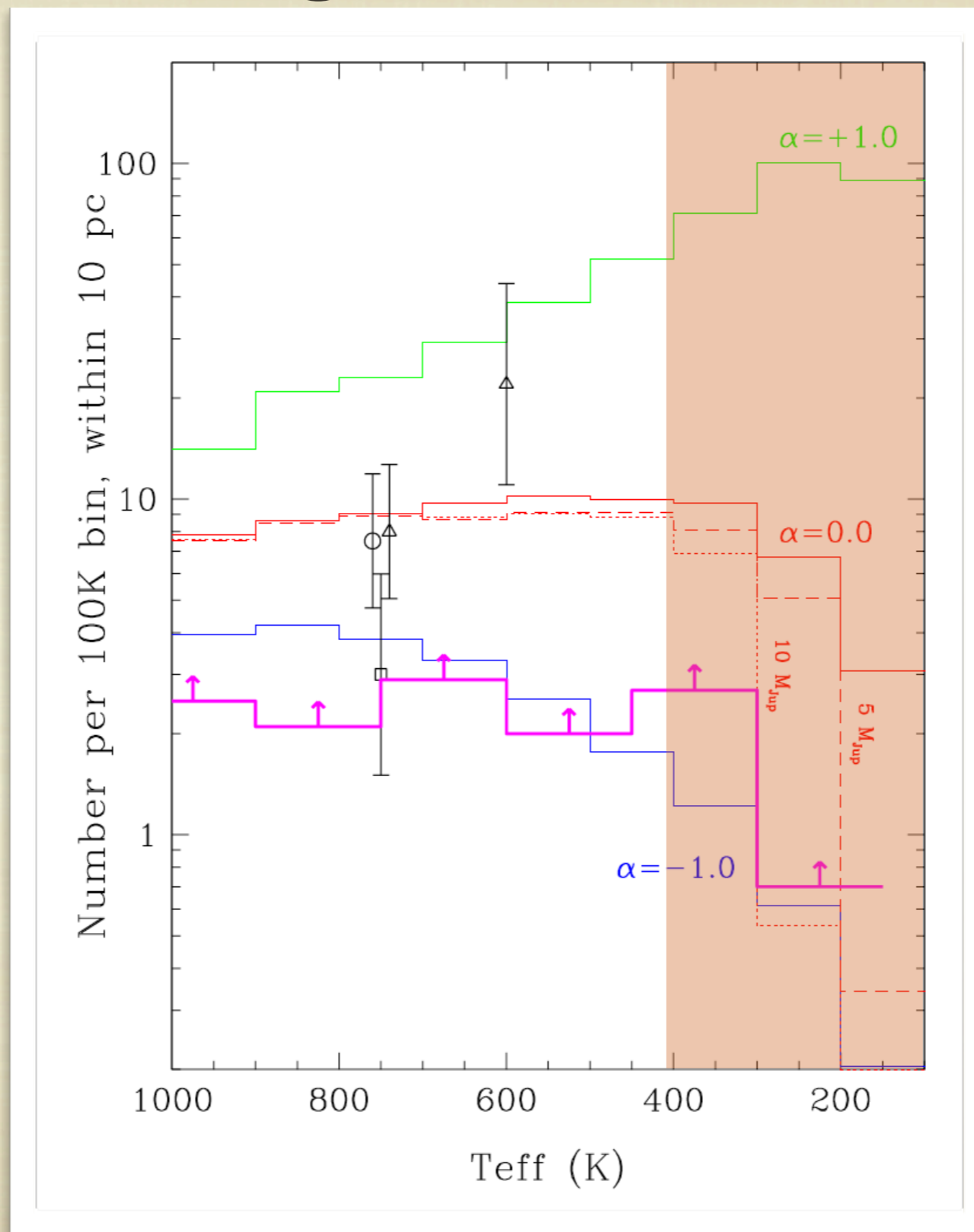
**FORMATION AND EARLY EVOLUTION OF
VERY LOW MASS STARS AND BROWN DWARFS
ESO, GARCHING, GERMANY, OCT 14TH 2011**

Ultra-cool brown dwarfs are important for understanding star formation.



Kirkpatrick et al. 2011

Ultra-cool brown dwarfs are important for understanding star formation.



Kirkpatrick et al. 2011

Clusters offer a good opportunity to observe low-mass brown dwarfs.

- Lodieu: $\sim 10 M_{\text{Jup}}$ (Upper Sco)
- Alves de Oliveira: $\sim 10 M_{\text{Jup}}$ (ρ Oph & IC 348)
- Muzic: $\sim 10 M_{\text{Jup}}$ (ρ Oph)
- Peña Ramirez: $\sim 4 M_{\text{Jup}}$ (σ Ori)
- Bayo: $\sim 10 M_{\text{Jup}}$ (Collinder 69; λ Ori)
- Downes: $\sim 20 M_{\text{Jup}}$ (25 Orionis)

Observations of field brown dwarfs now approaching a lower mass limit.

- IR observations from:

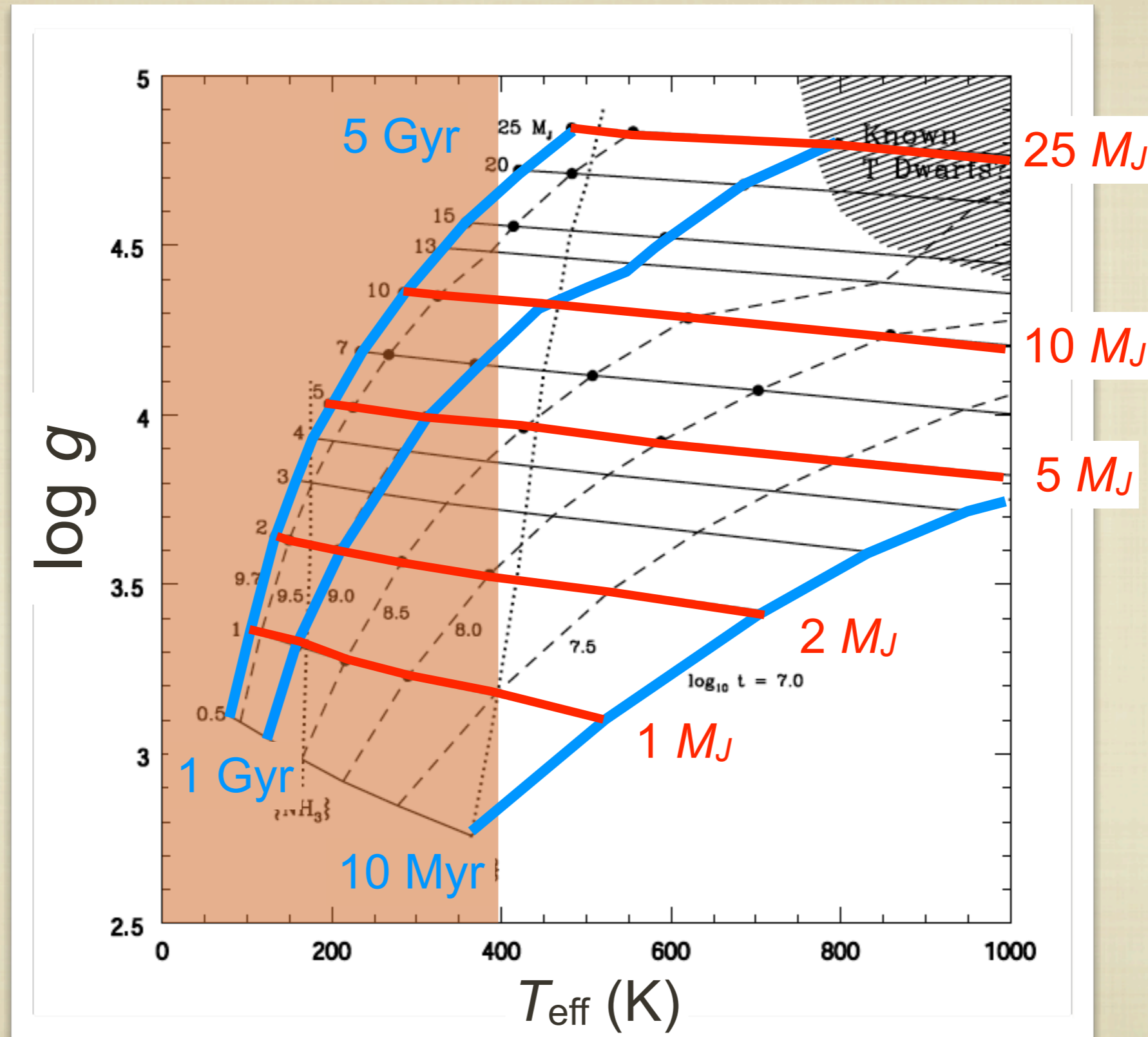
- **WISE** (e.g., Cushing et al. 2011, Kirkpatrick et al. 2011, Scholz et al. 2011)

- **Spitzer** (e.g., Luhman, Burgasser & Bochanski, 2011, Leggett et al., 2010)

- **UKIDSS** (e.g., Lucas et al. 2010, Burningham et al. 2010, Bochanski et al. 2011)

- **CFBDSIR** (e.g., Delorme et al. 2010, Liu et al. 2011)

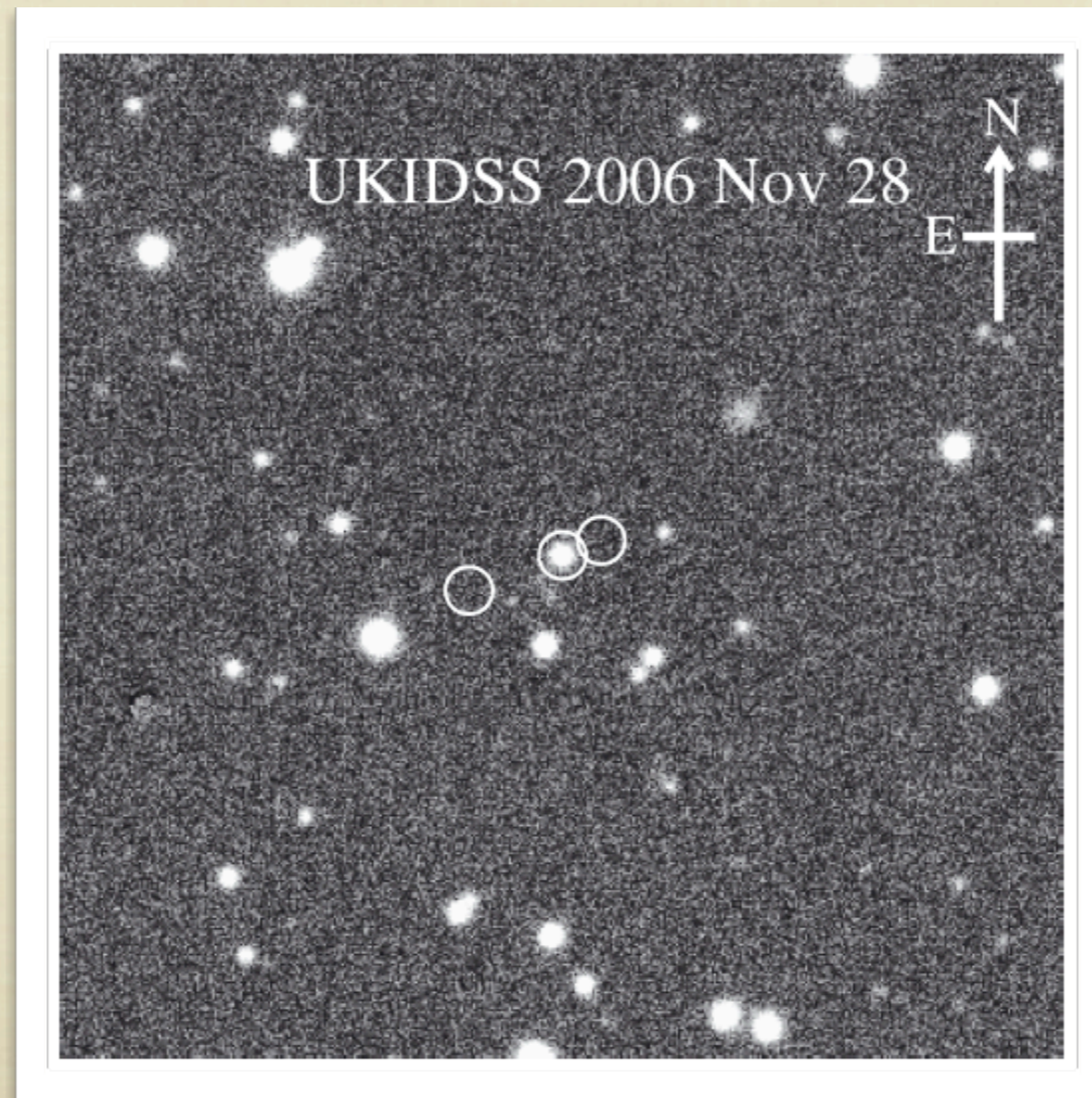
Most cold field BDs are low mass.



Burrows et al. 2003

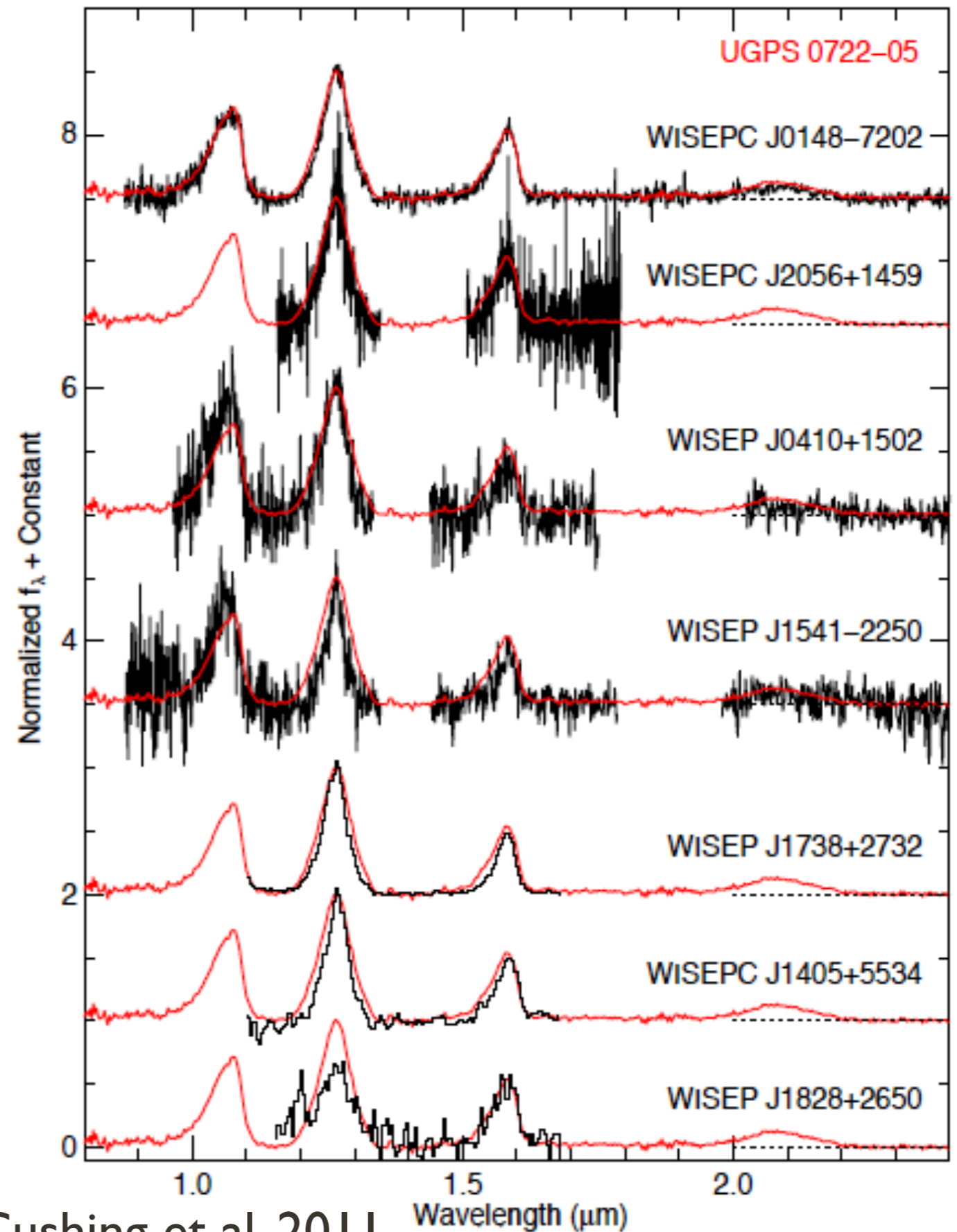
UGPS 0722-05

- Discovered in UKIDSS Galactic Plane Survey by Lucas et al. 2010



UGPS 0722-05

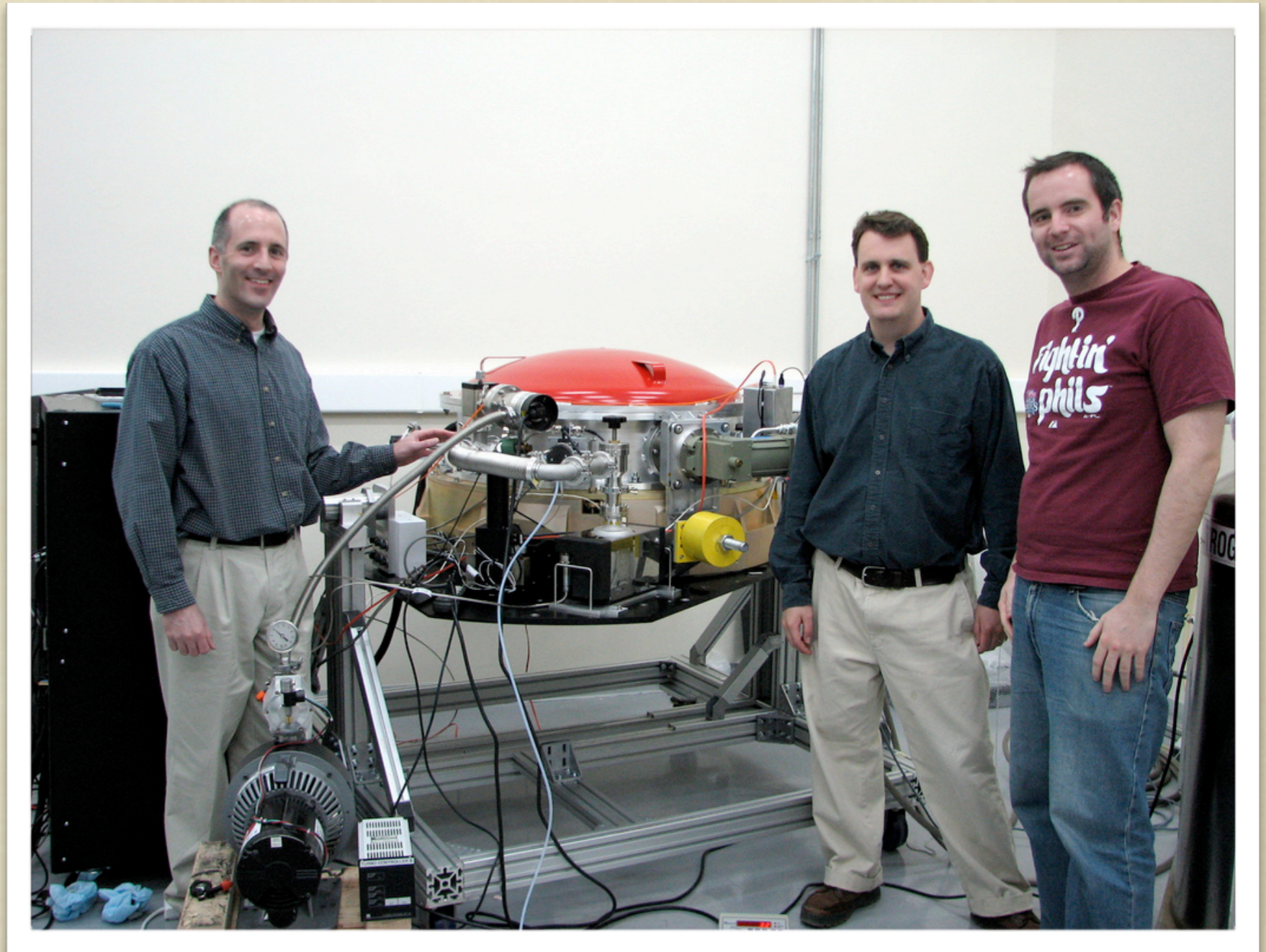
- Defined as T9 spectral standard by Cushing et al. 2011



Cushing et al. 2011

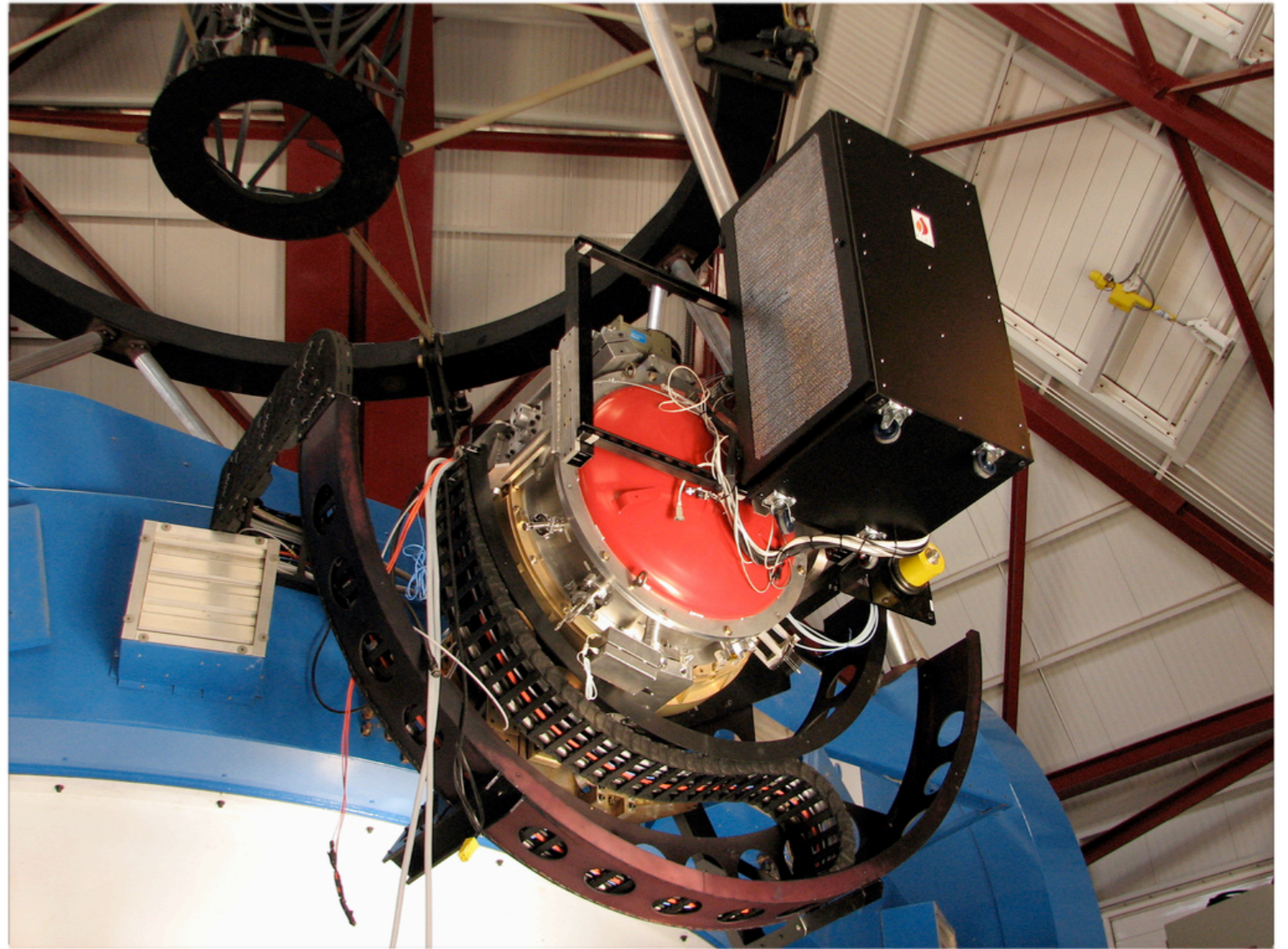
FIRE

- **F**olded-port
Infrared
Echellette
Spectrograph
- $R \sim 6,000$
yJHK coverage
- Two modes:
Cross-dispersed
echelle &
low-dispersion
single order



FIRE

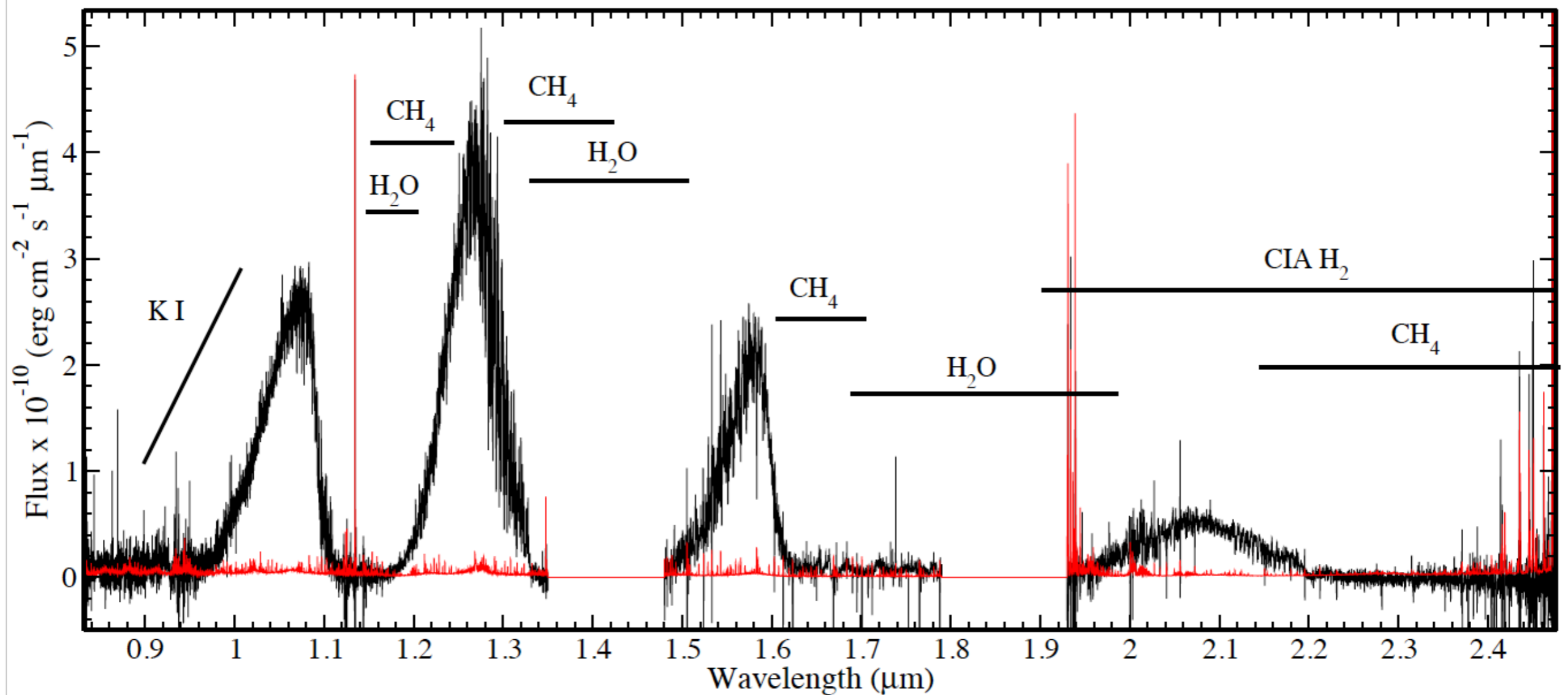
- Commissioned during February & March 2010 at Magellan
- Lucas et al appeared on astro-ph on April 2nd 2010



FIRE observations of UGPS 0722-05

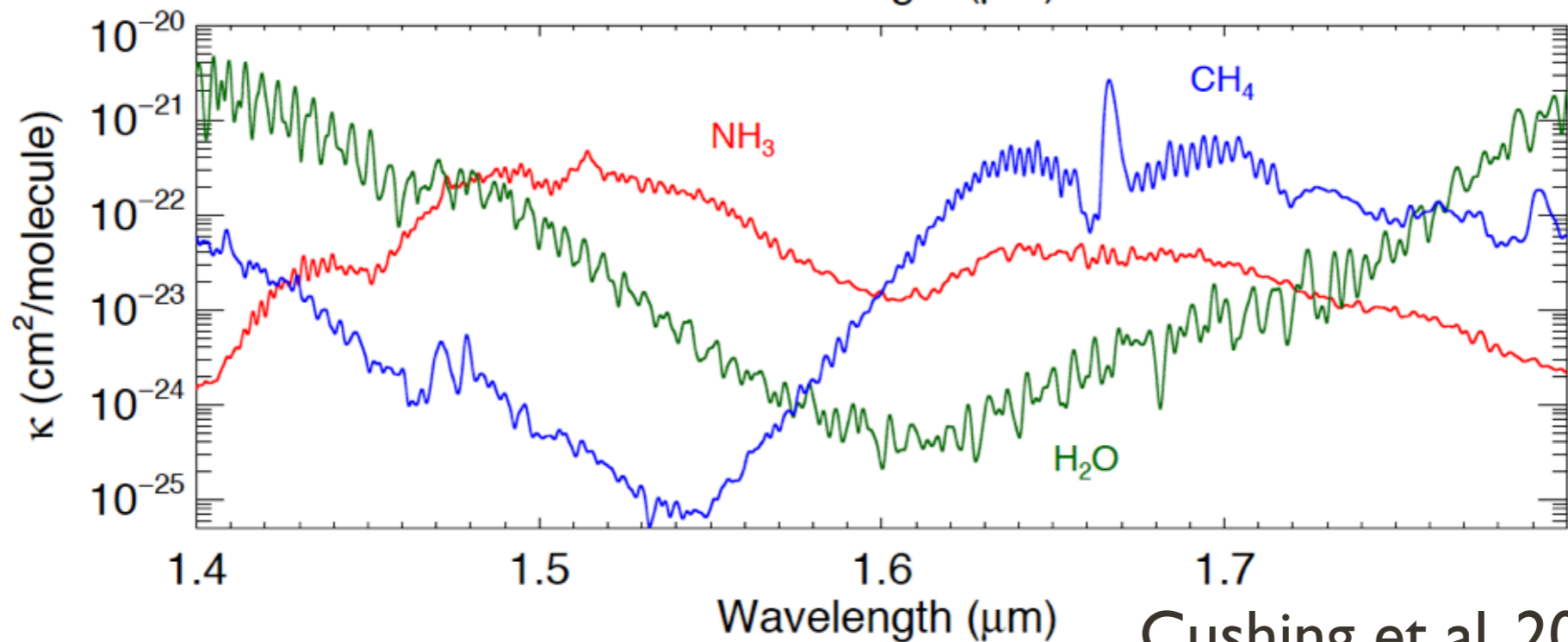
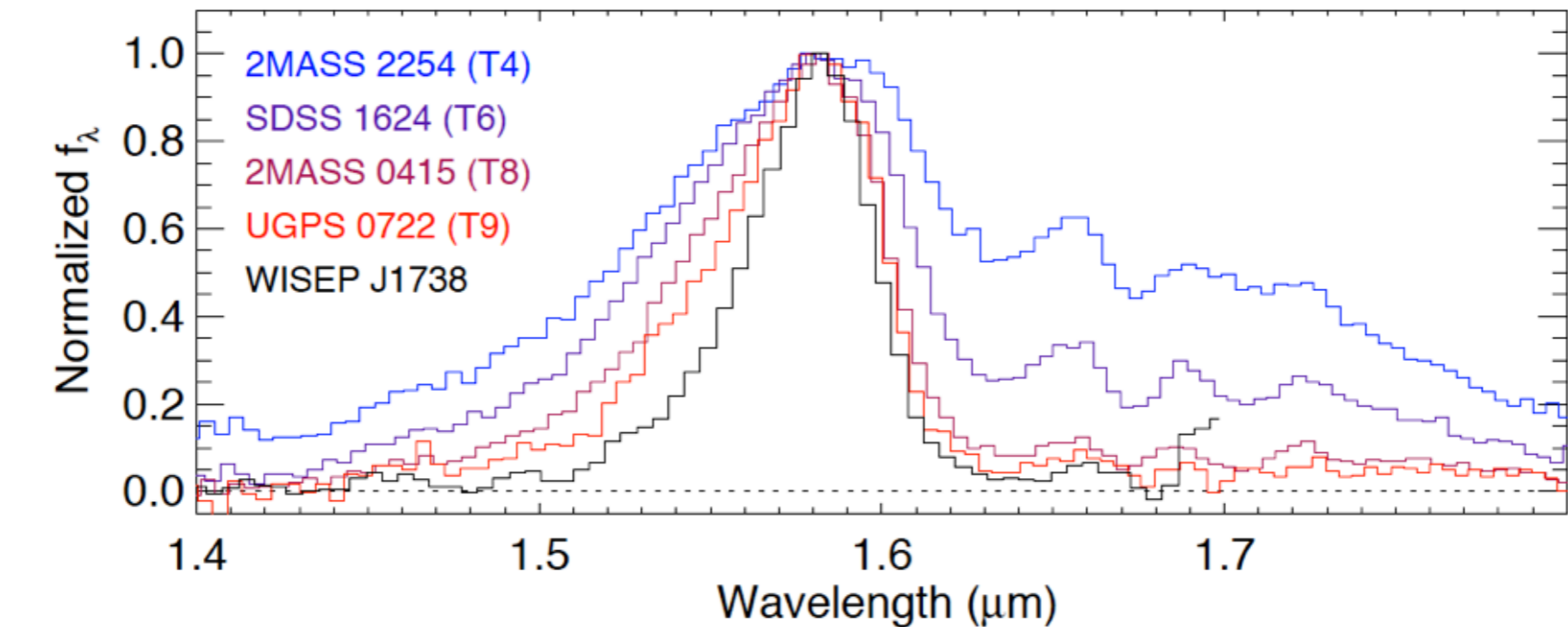
- We sought to measure:
 - Molecular features - What molecules are forming in cool atmospheres?
 - Radial velocity - Combined with proper motions and parallax yields full space motion (and probable membership in thin disk, thick disk or halo).
 - Rotational velocity - Most field L and T dwarfs are rapidly rotating and suggest weak magnetic braking.

Observed spectrum suggests a
 $T \sim 500$ K, $\log g \sim 4.5$ brown dwarf.



Bochanski et al. 2011

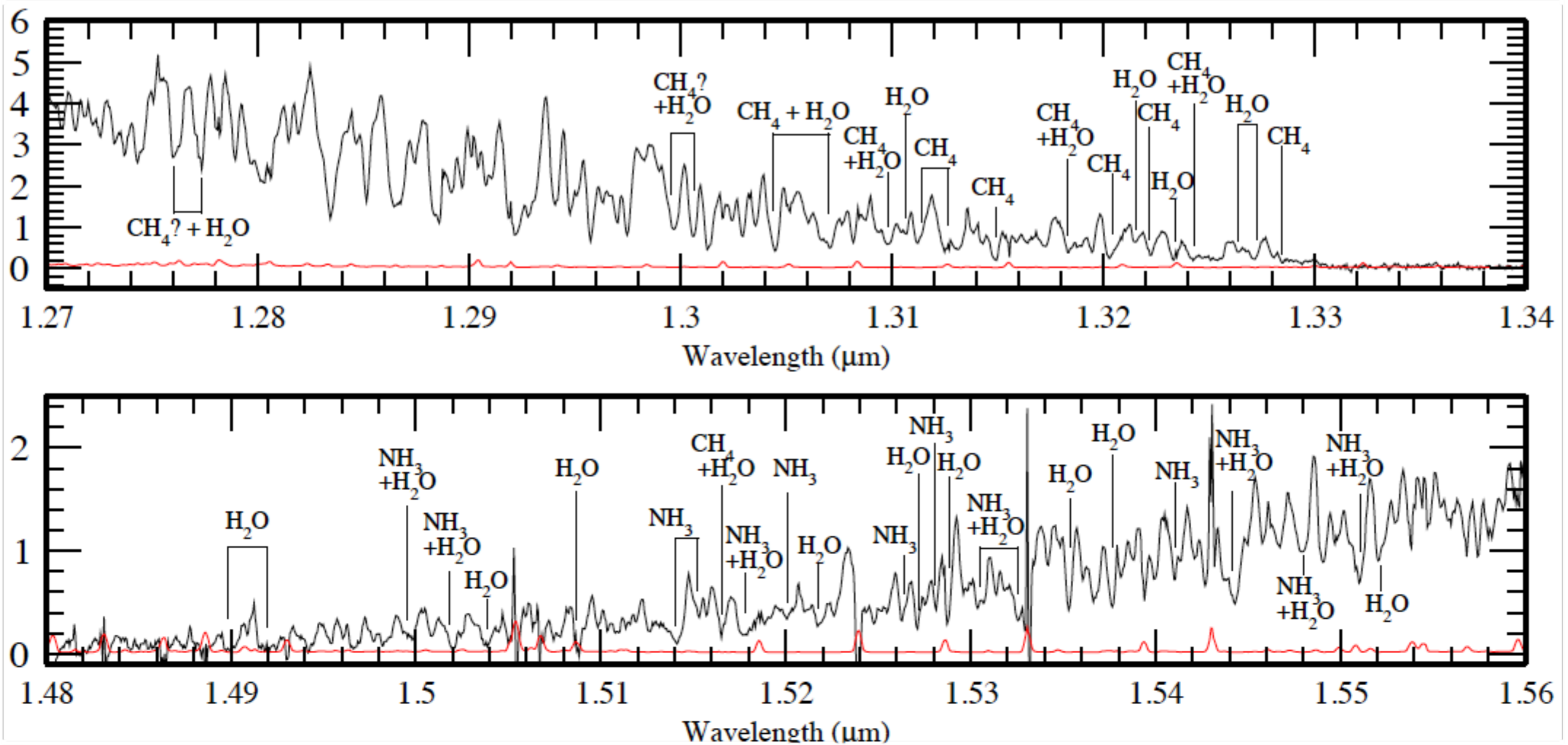
Molecular features were identified by comparing to recently published line lists.



Cushing et al. 2011

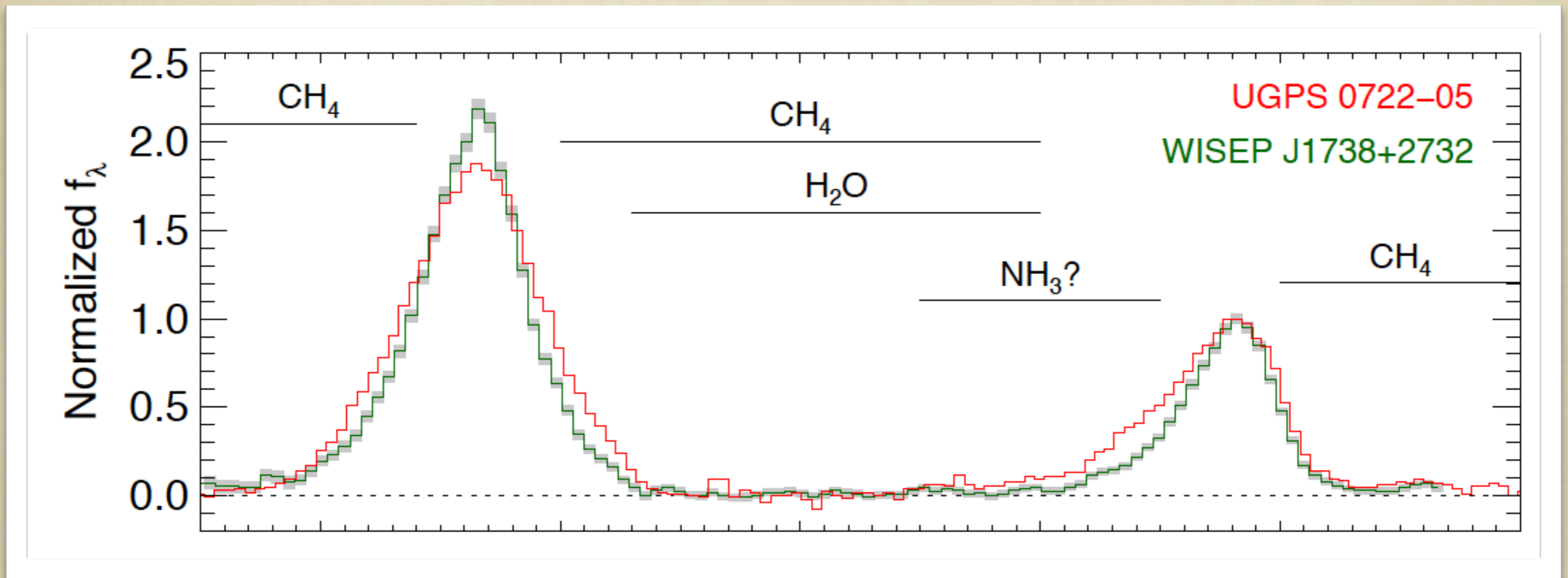
Polinovskyi
poster at
this
meeting

We detect resolved NH_3 features, even in a late T dwarf.



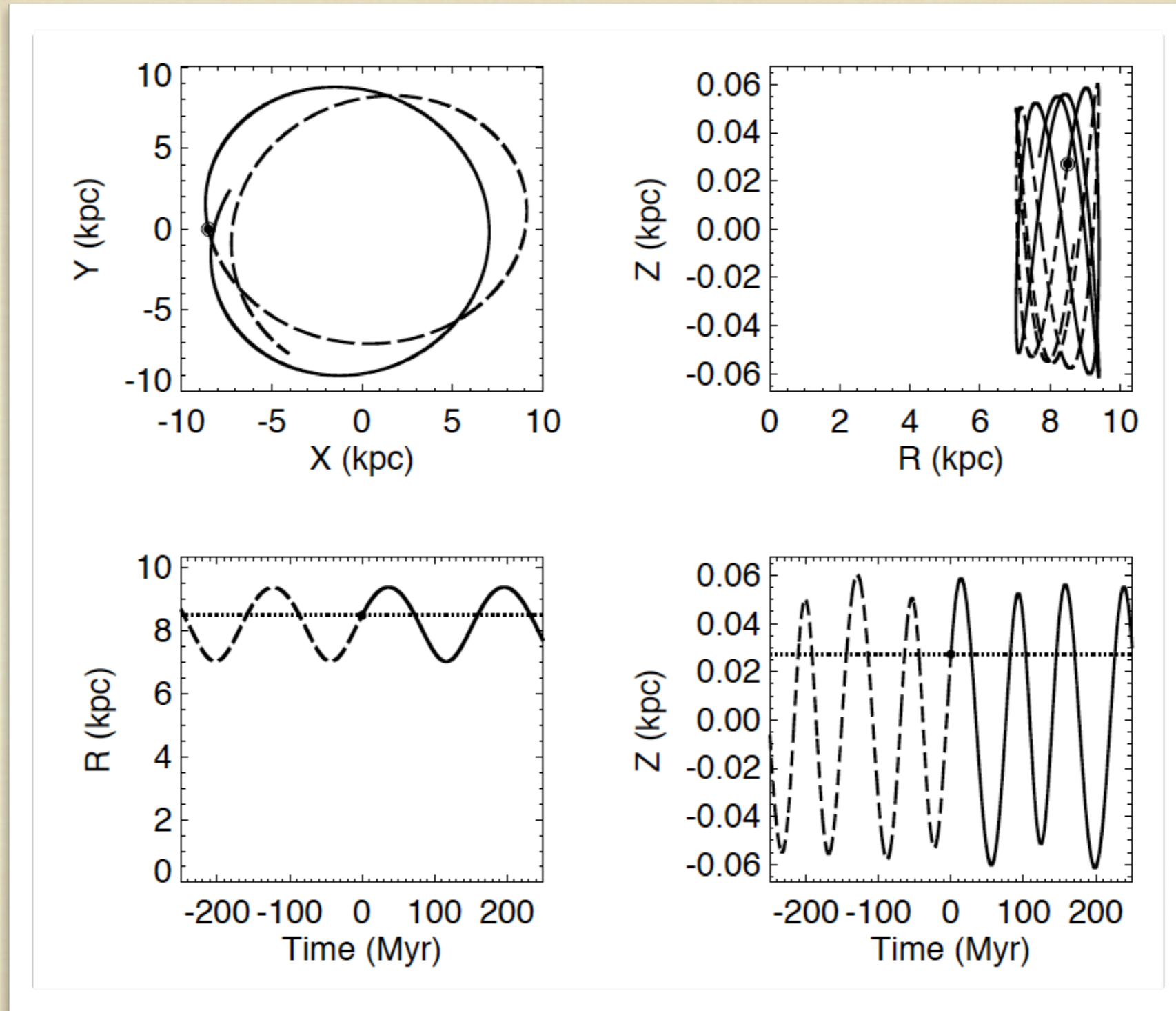
Bochanski et al. 2011

NH₃ strengthens with decreasing temperature.



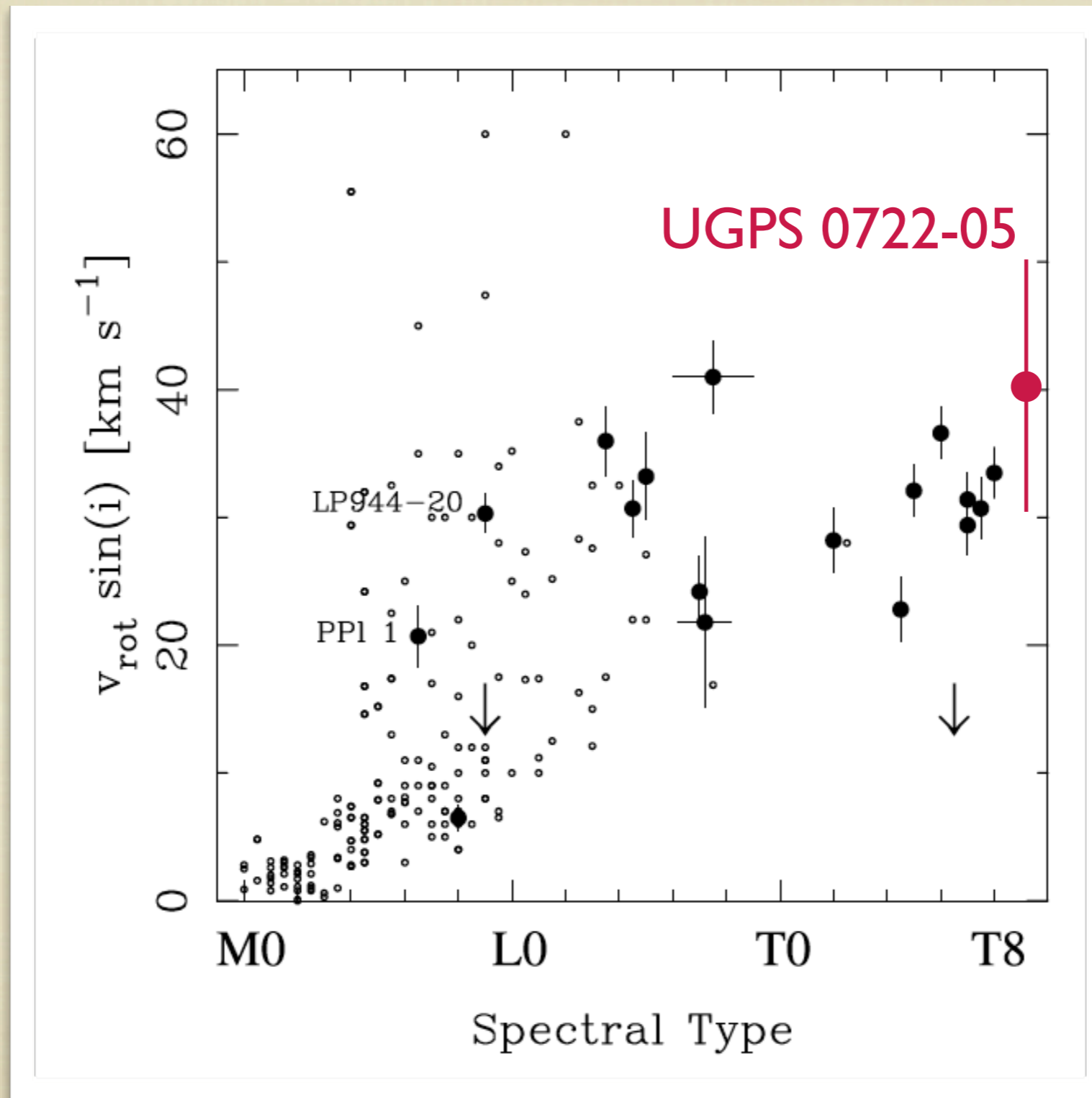
Cushing et al. 2011

Radial velocities and space motions suggest a thin disk membership (and young age).



Bochanski et al. 2011

Our measured rotational velocity is similar to other L and T dwarfs.



Zapatero Osorio
et al. 2006

Summary



- Ultra-cool field brown dwarf observations now probing the limits of star formation.
- FIRE is well matched to observing faint, ultra-cool BDs.
- NH_3 has been detected and resolved in the NIR.
- Rotation velocity of UGPS 0722 confirms previous trends for L & T dwarfs.