NIRSPEC RV Measurements of Late-M Dwarfs

by

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with
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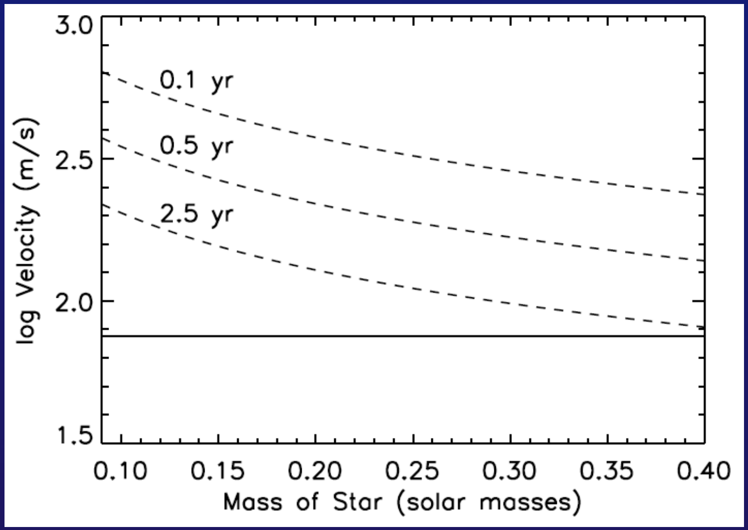
M dwarfs are compelling planet search targets



1) M dwarfs are abundant and close

Within 10 pc there are 173 M dwarf primaries
Within 25 pc there are ~1400 M dwarf primaries

2) We are sensitive to lighter planets

A super Earth (10 Msun) in a 1 AU orbit makes a radial velocity signature of 3 m/s around an 0.1 Msun M dwarf compared to 1 m/s around a 1 Msun G dwarf.

3) RV surveys reach in the habitable zone

The HZs are at 0.24, 0.07 and 0.01 AU for a M0, M6 and M9 dwarf

4) Once found, they make ideal planet transit targets

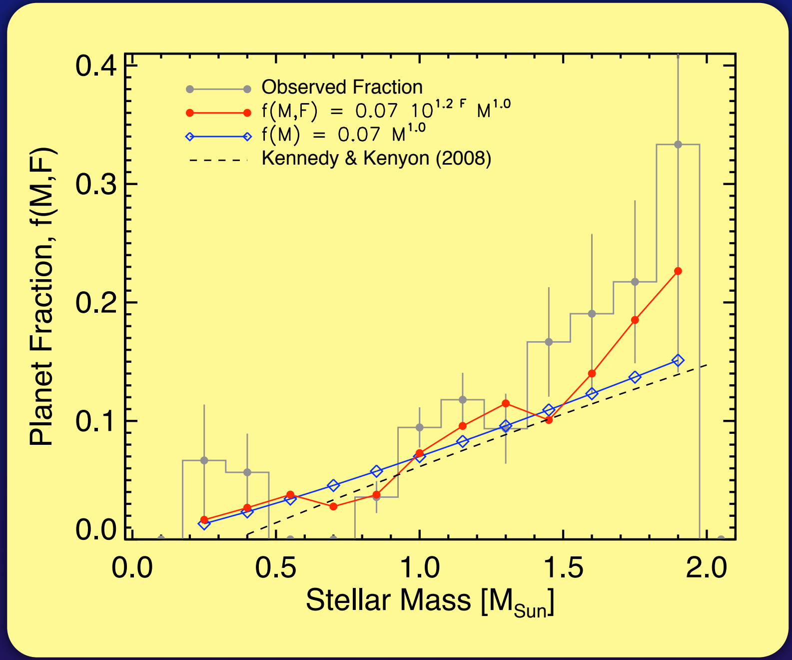
The corresponding transit depth of a Jupiter is 8-10% compared to 1% for a G dwarf

~50% of young M dwarfs (M0-9) have disks (Luhman 2005, Liu 2003, Jayawardhana 2003)

Optical RV surveys suggest Jupiters are rare around M dwarfs

Endl et al. (2006), Zeichmeister et al. (2009)

- 90 M dwarfs with RV precision of ~2.5 m/s and found NO planets with Msini>3.8 M_J at a < 0.7 AU
- Observations from the HET, Keck and VLT telescopes
- The frequency of such planets is <1.27%
- Within 10 pc there are 173 M dwarf primaries with 5 having planets, for a rate of 2.9%.



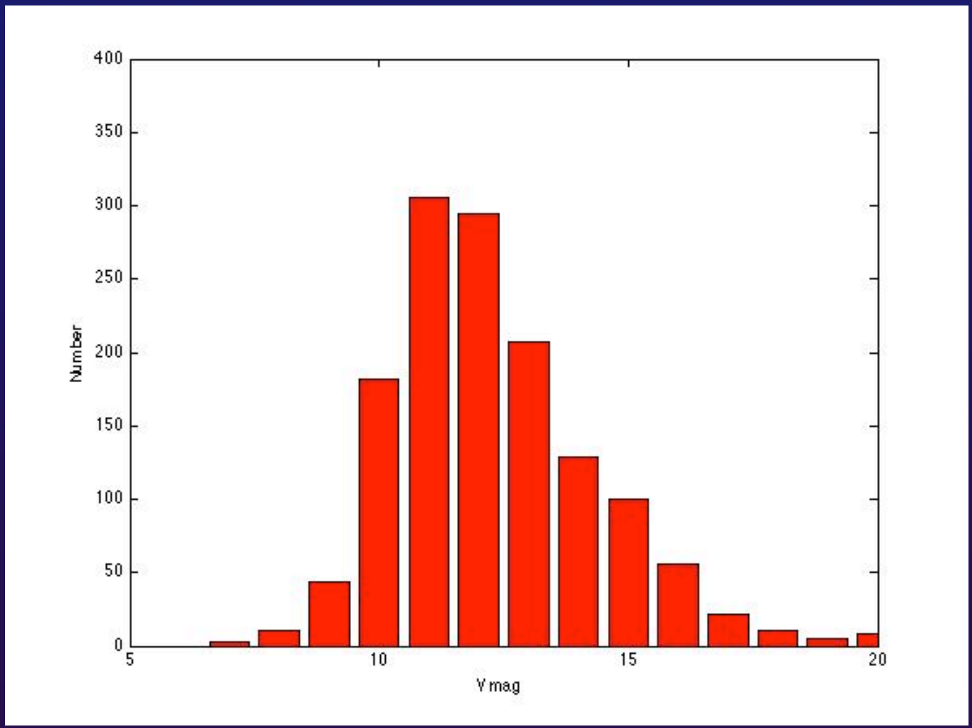
Johnson et al. 2007, 2010

While there is a trend in planet fraction vs. stellar mass, M dwarfs surveys are still maturing and we are sensitive to smaller planet masses

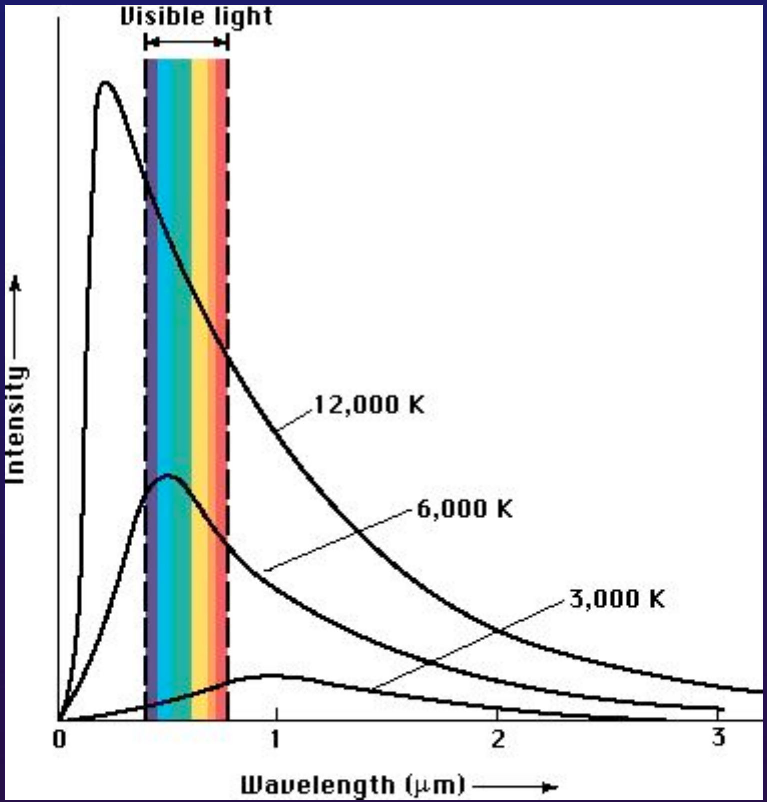
Infrared RV Surveys are Ideal for M dwarfs

- M dwarf flux peaks in IR

- Contrast ratio of star spots is smaller in IR resulting in less of an influence on the RV signal (Eiroa et al. 2002)



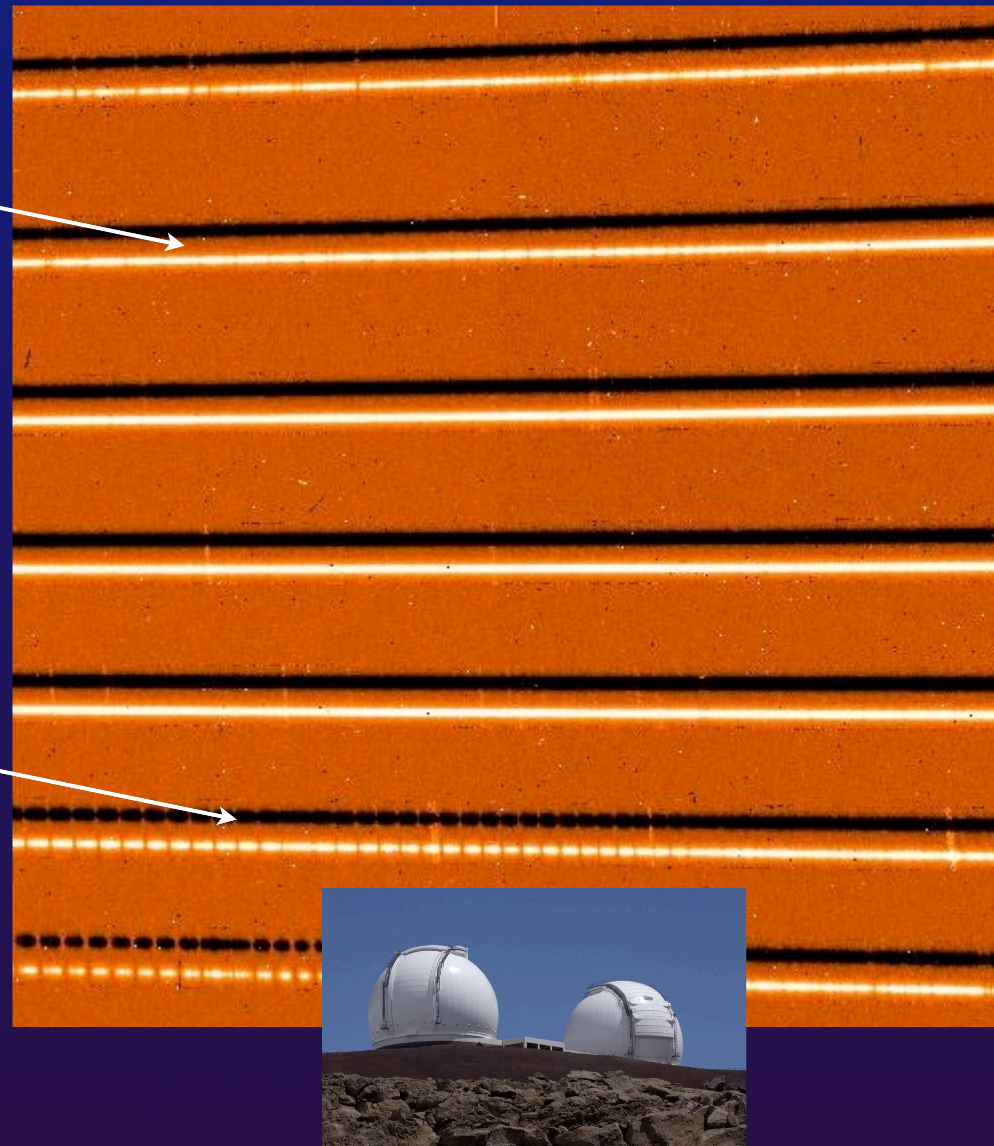
V mags of M dwarfs < 25 pc



IR RV Surveys with NIRSPEC

Properties:

Keck II
0.95-5.5 microns
R=25000
Slit = 0.432X12
SNR~100-150
7 orders with NIRSPEC-7 filter

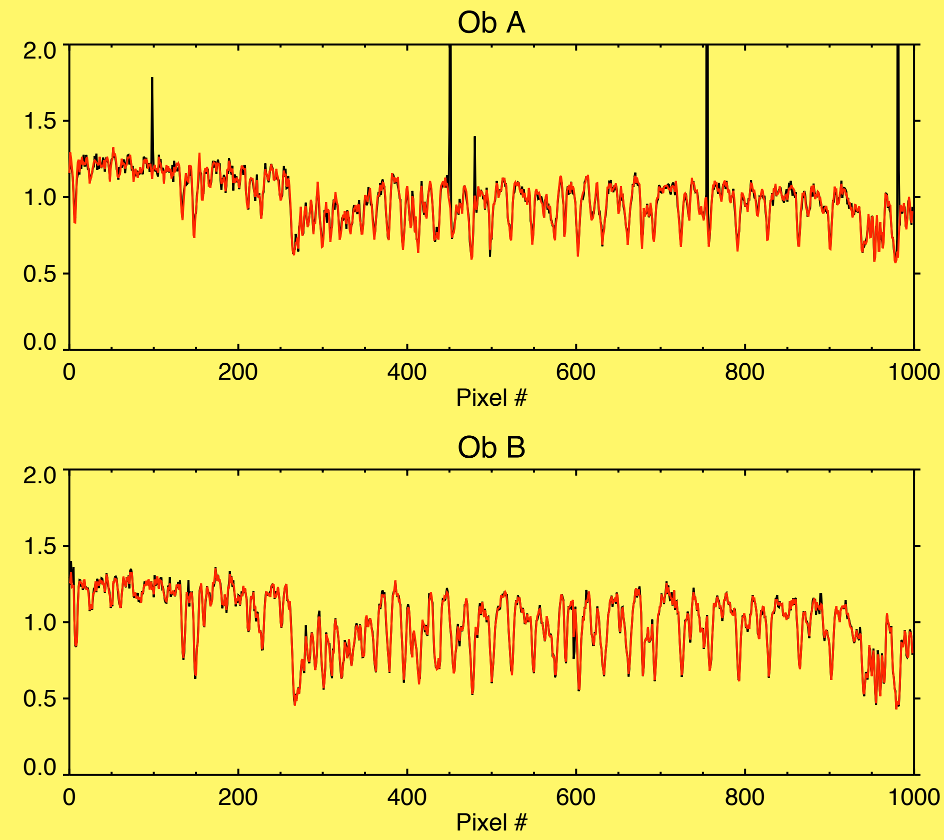


NIRSPEC RV Programs:

Young stars - White/Bailey
Late-M stars - Tanner
Brown Dwarfs - Blake

Spectral Extraction

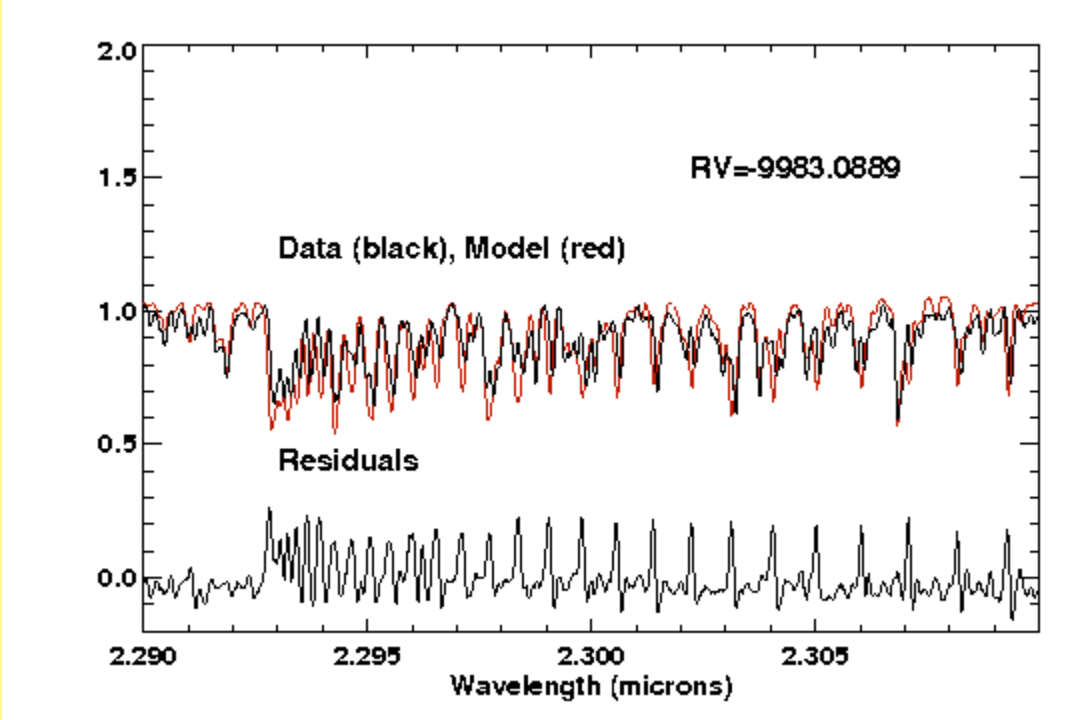
black = standard
red = optimal



Used optimal extraction to increase SN and remove bad pixels (Piskinov & Valenti 2002; Horne et al. 1986)

Spectral Fitting

Minimize chi^2 with AMOEBA minimization algorithm

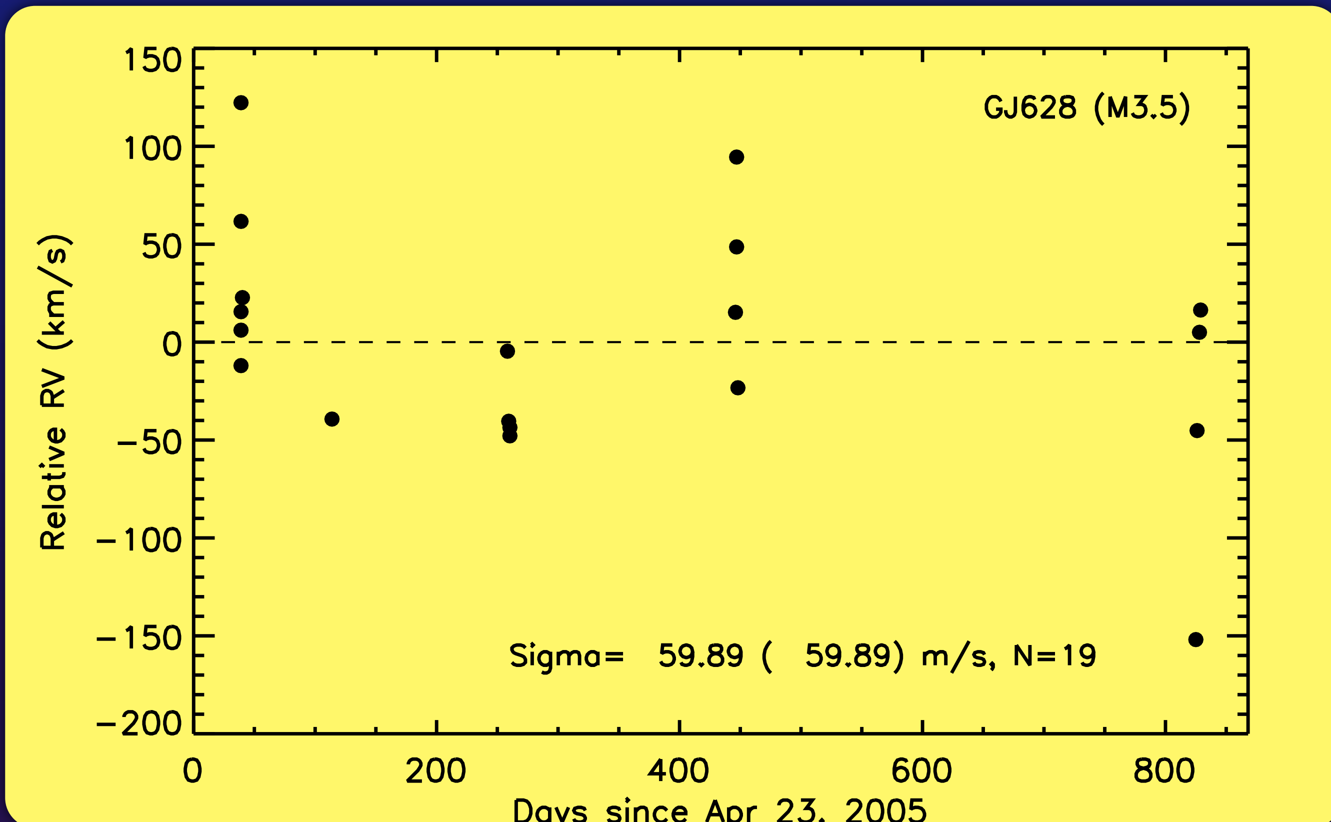


Assume log g = 4.5
Teff = 2400 K

Free parameters include: RV, vsini, wavelength solution, airmass, normalization, & instrument profile

Dispersions from early M Standard stars

GJ 628 - M3.5V, V=10.1, 4.26 pc



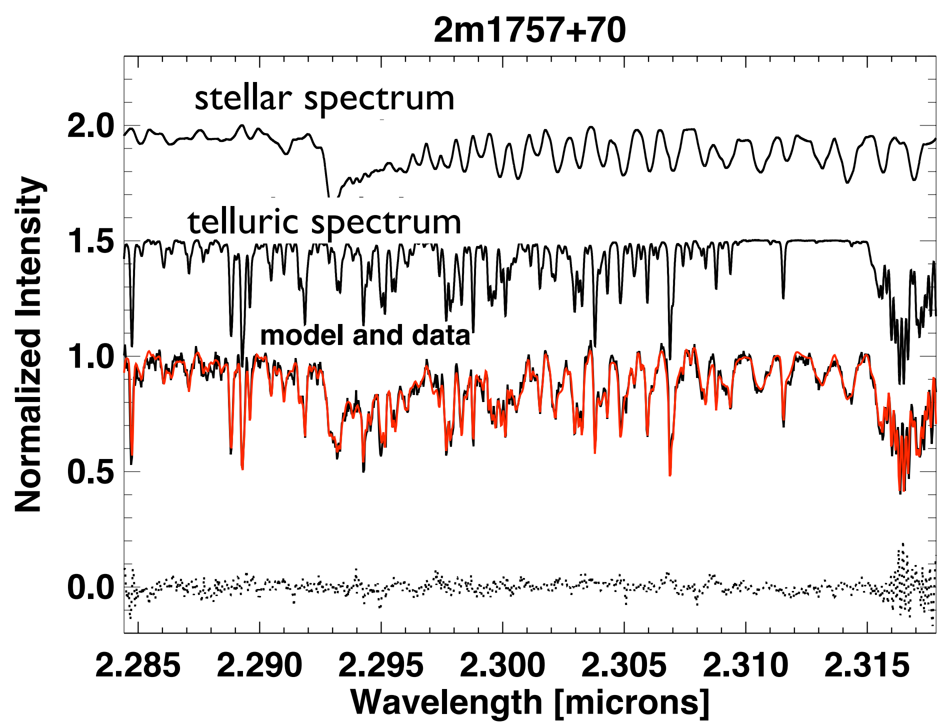
GJ 725a/b give rms values of ~50 m/s

Pair averaged theoretical error is 20-30 m/s

Apply same technique to late-type Ms

Sample of 30 late (7-9.5) Ms including VB 10

9/30 have > 3 epochs collected to date



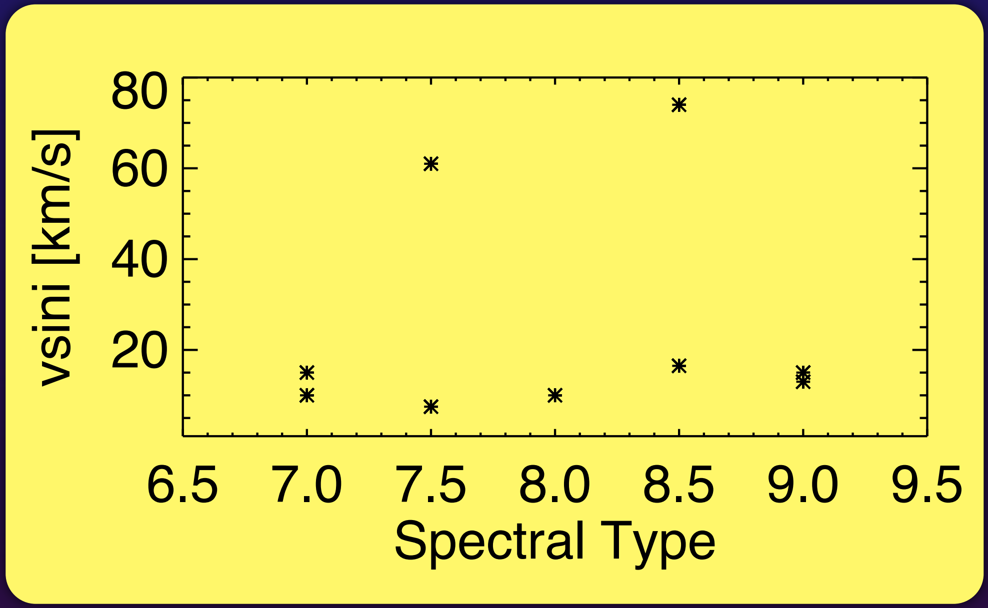
Get an rms of 200 m/s for this M8 dwarf
Theoretical error is 100 m/s

Dispersions of 150-200 m/s for our sample of Late M dwarfs

★ Can rule out ~8 MJ planets in 10 day orbits

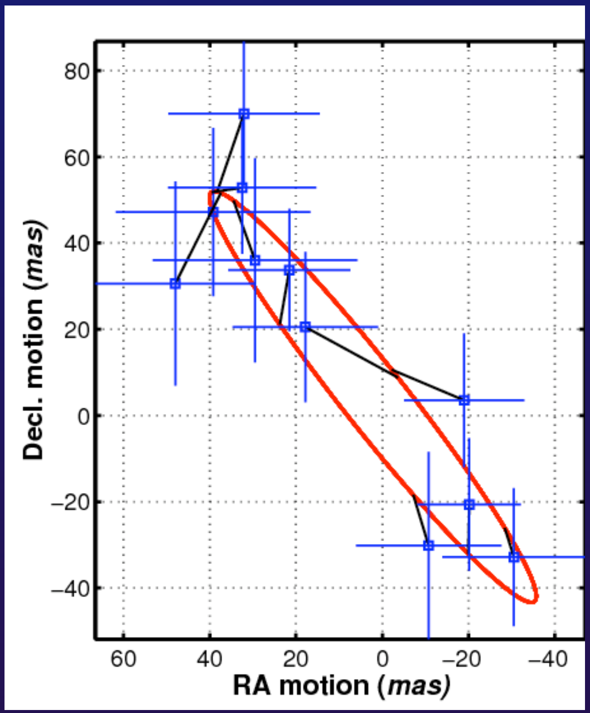
★ Theoretical dispersions are 20-70 m/s based on SNR and spectral resolution

★ NIRSPEC detector upgrade and improved spectral templates could improve precisions



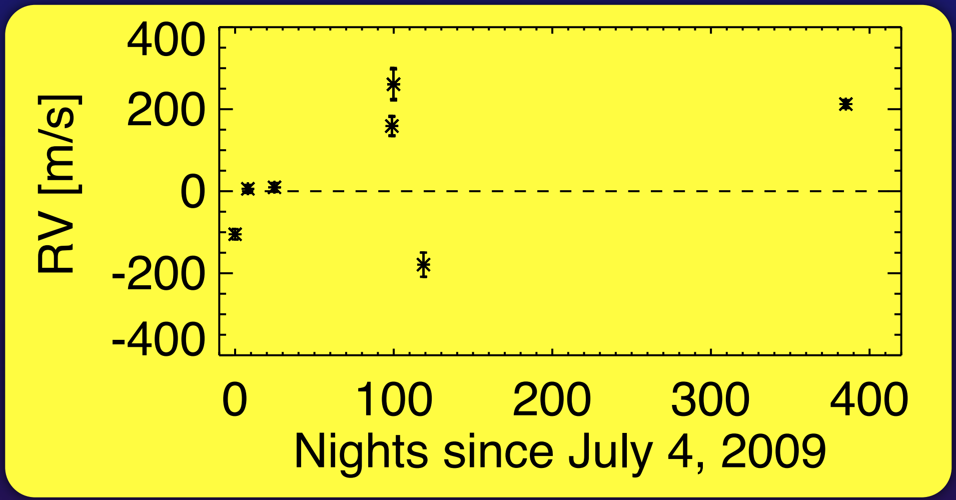
VB 10

A 6.4 Mj planet with a 0.74 yr period detected with STEPS astrometry at Palomar? Pravdo & Shaklan (2009)



Planet would produce an RV amplitude of 1 km/s

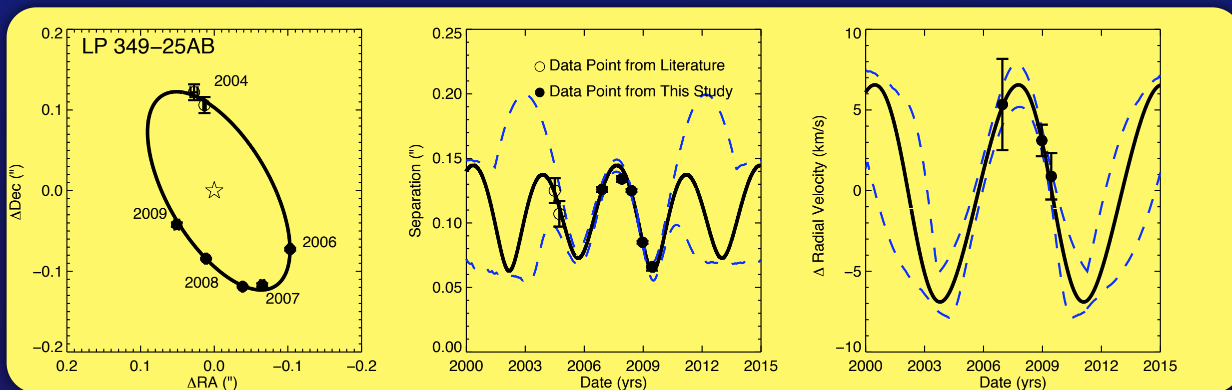
We get an rms of ~200 m/s



VLT/CRIRES data have an RMS of 11 m/s ruling out the planet at 30 sigma (Bean et al. 2009)

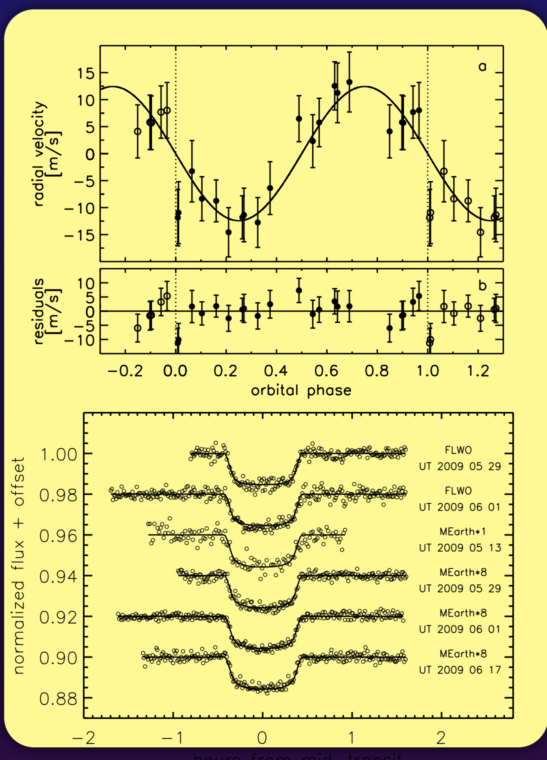
Additional Uses for IR Spectra and RVs

Brown Dwarf Masses



Konopacky et al. 2010

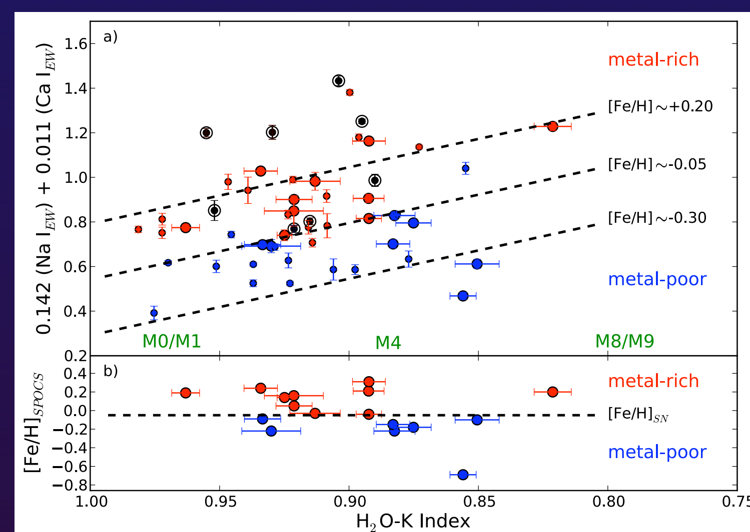
Transit Follow-up



Charbonneau et al. 2009

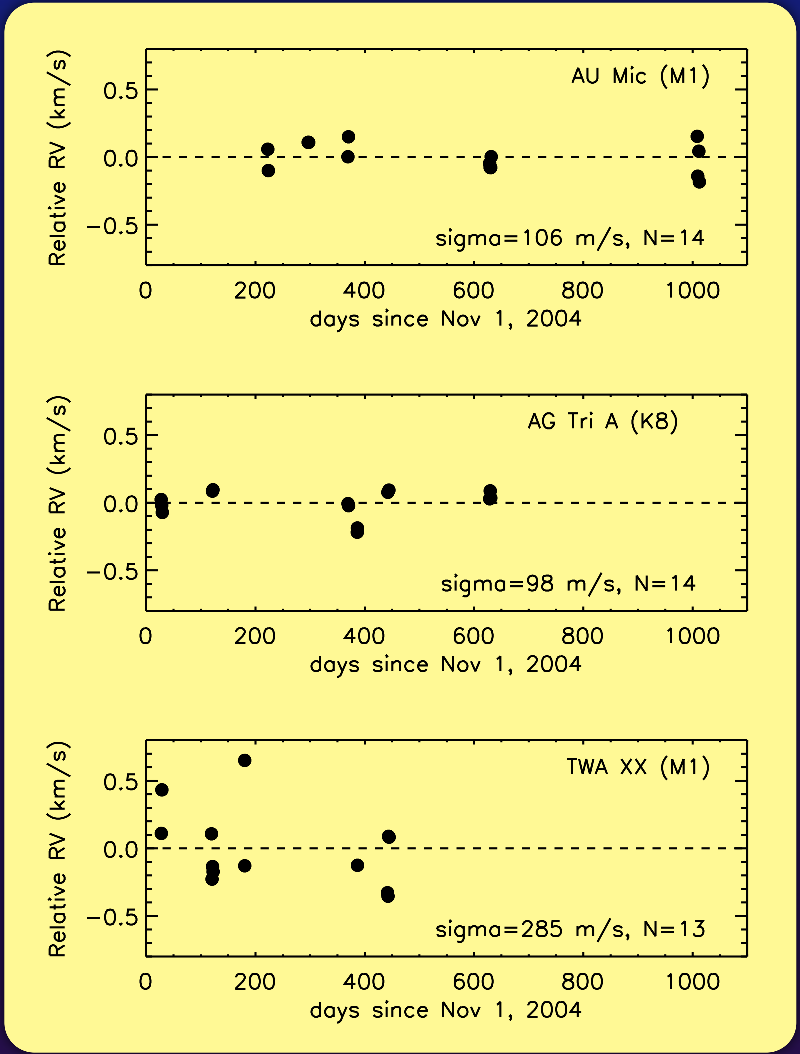
GJ1214
M=0.16 Msun, M4.5
V=14.6, K=12.2 m/s

M dwarf Metallicities



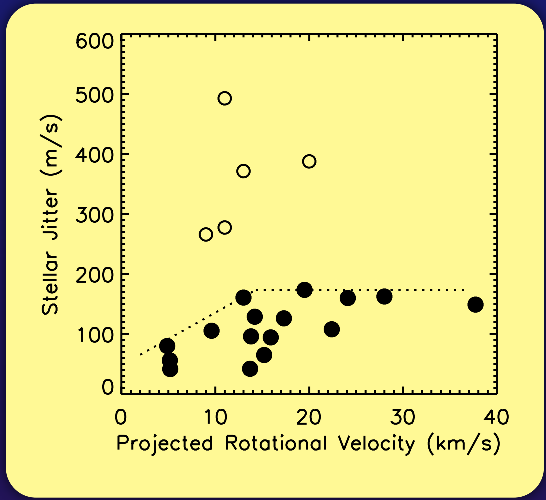
Rojas-Ayala et al. 2010

High Precision Infrared Radial Velocities and the Search for Young Planets - Bailey et al 2010, in prep



2 MJ planet in <10 d orbit ruled out for AU Mic

20 stars from beta Pic and TW Hydra



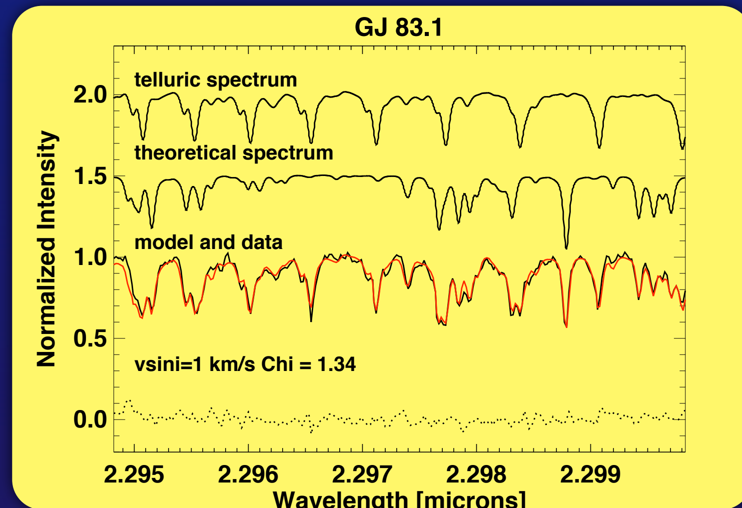
Solid = this work
Empty = optical RVs

See R. White poster

Additional GSU IR RV programs

IRTF CSHELL

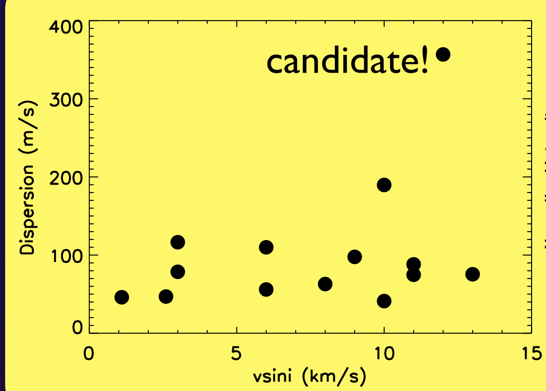
R=30000
Single Order
Nearby mid-M dwarfs + CTIO astrometry
Cassey Davidson PhD thesis

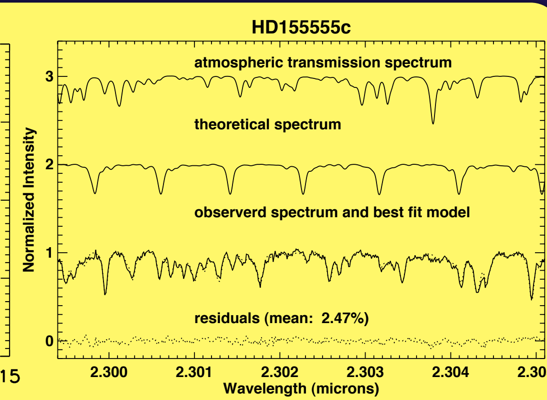


See R. White poster

Gemini Phoenix

R=50000
Young stars
Justin Cantrell PhD thesis





What to take with you …

- M dwarfs are compelling planet-search targets that will eventually allow us to detect nearby Earth-mass planets

- Telluric infrared RV measurements with NIRSPEC are maturing with 50 m/s precision for early- to mid- Ms and 150-200 m/s for late-Ms

- Don't need < 100 m/s precision to do interesting science and there are additional applications for near-IR spectra

- IR RV's are ideal for young star planet searches