M dwarf Metallicities and Temperatures from K-band

And longer wavelengths

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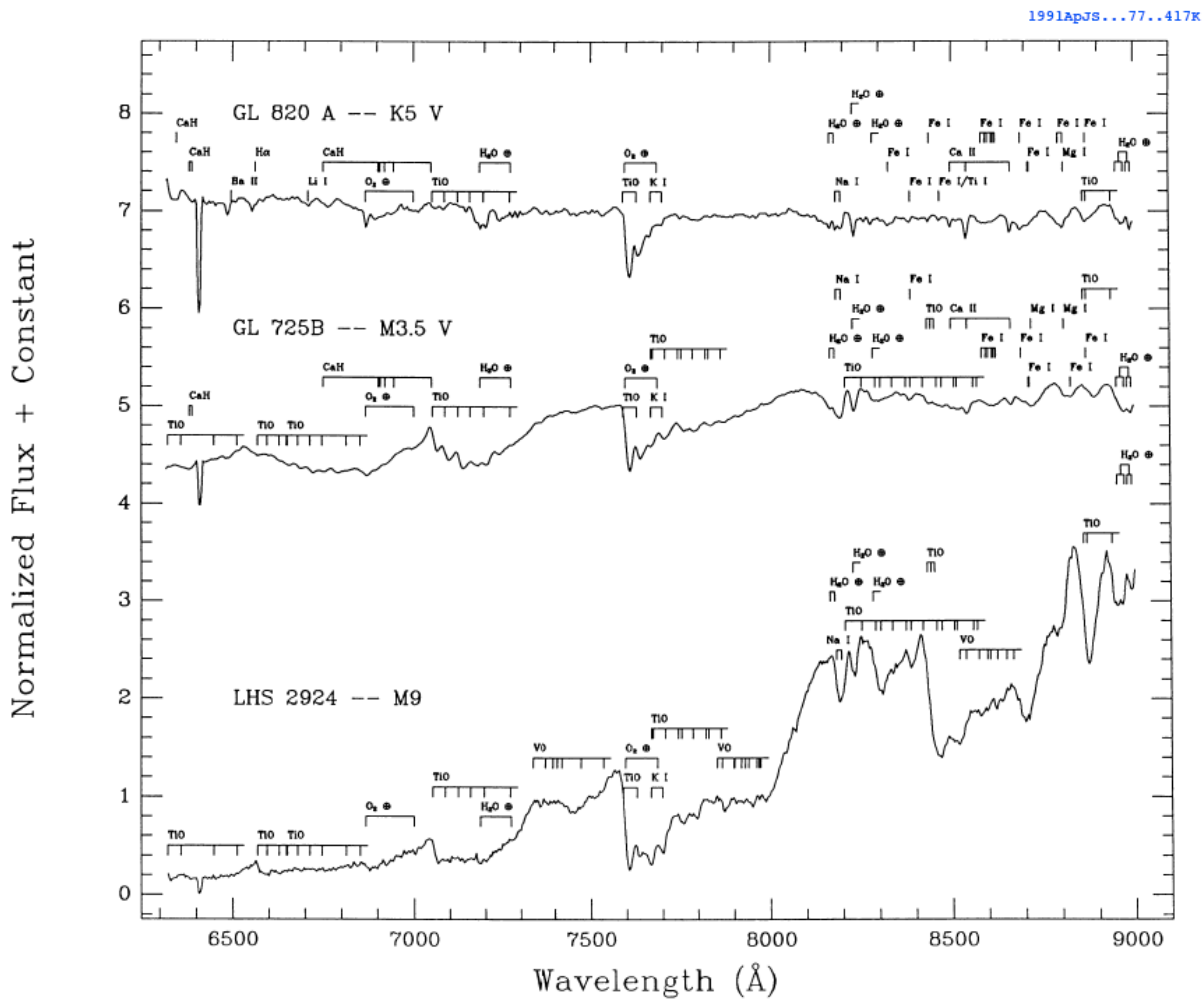
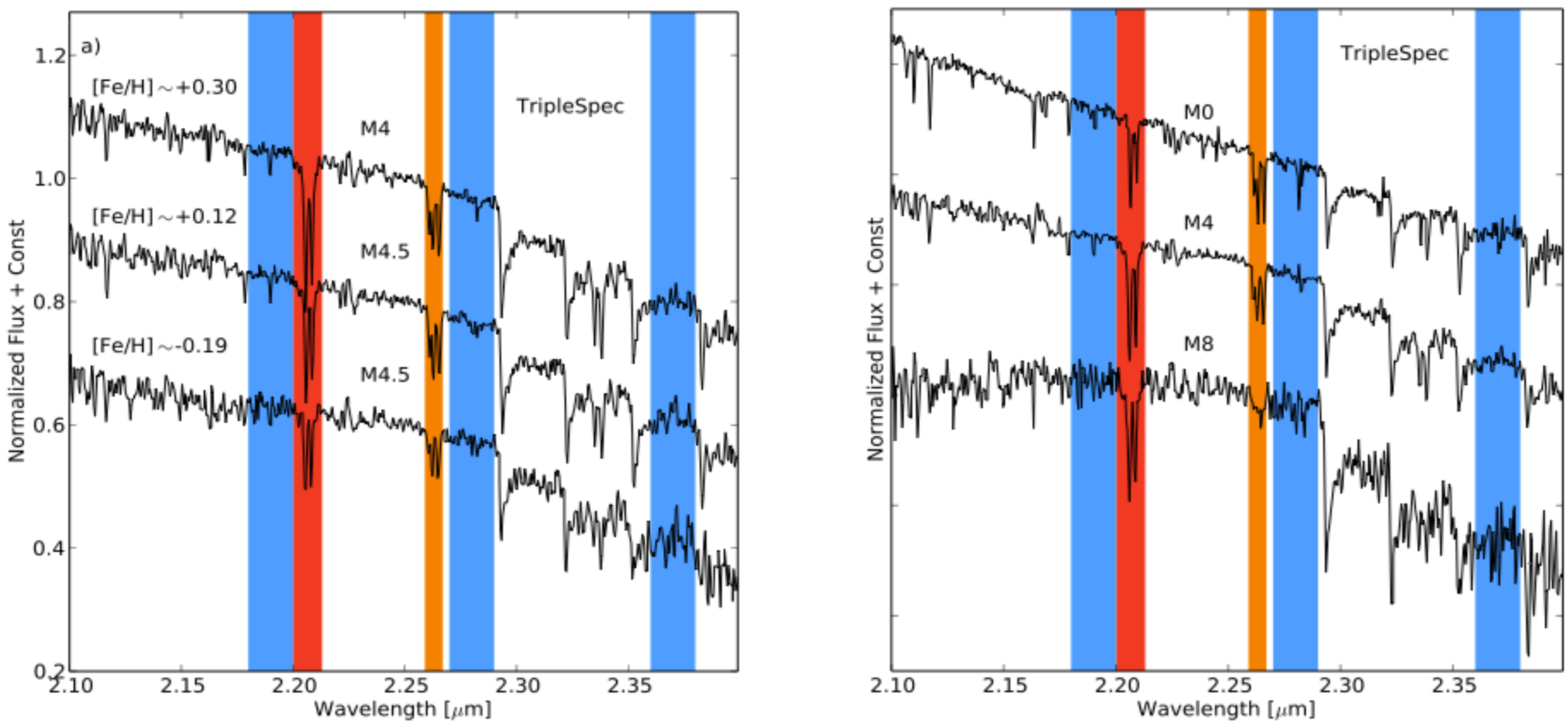
dMs: Not your standard Blackbody



Kirkpatrick et al. 1991

K-band Na I, Ca I and water can reveal the metal abundance of M dwarfs

Rojas-Ayala et al. 2010



- Na I doublet (2.206 μm & 2.209 μm)
- Ca I triplet (2.261 μm, 2.263 μm & 2.265 μm)
- H_2O-K Index Bands (Covey et al. 2010)

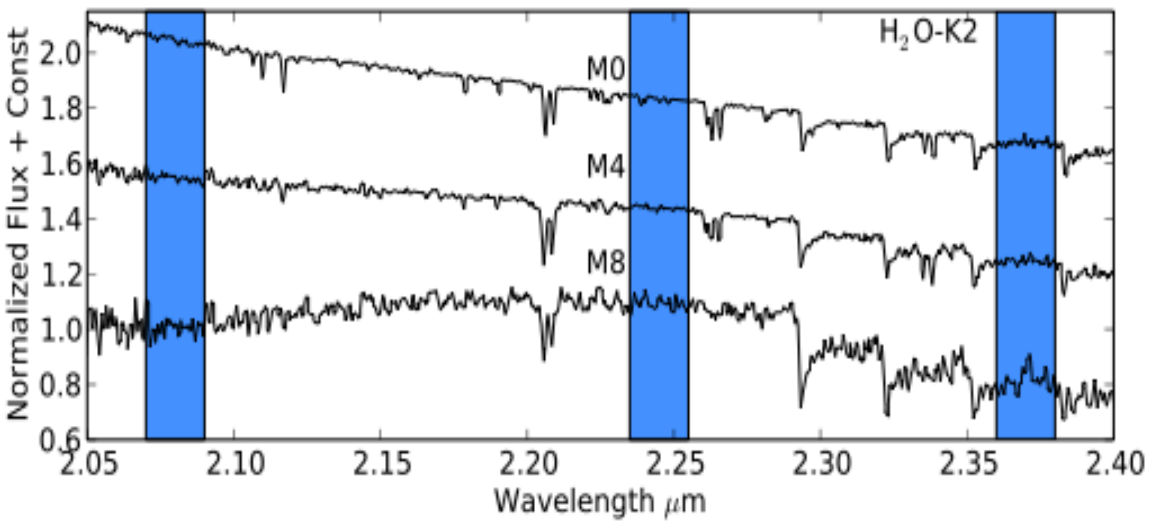
Na I and Ca I → **Temperature & Metallicity**

H_2O-K → **Temperature**

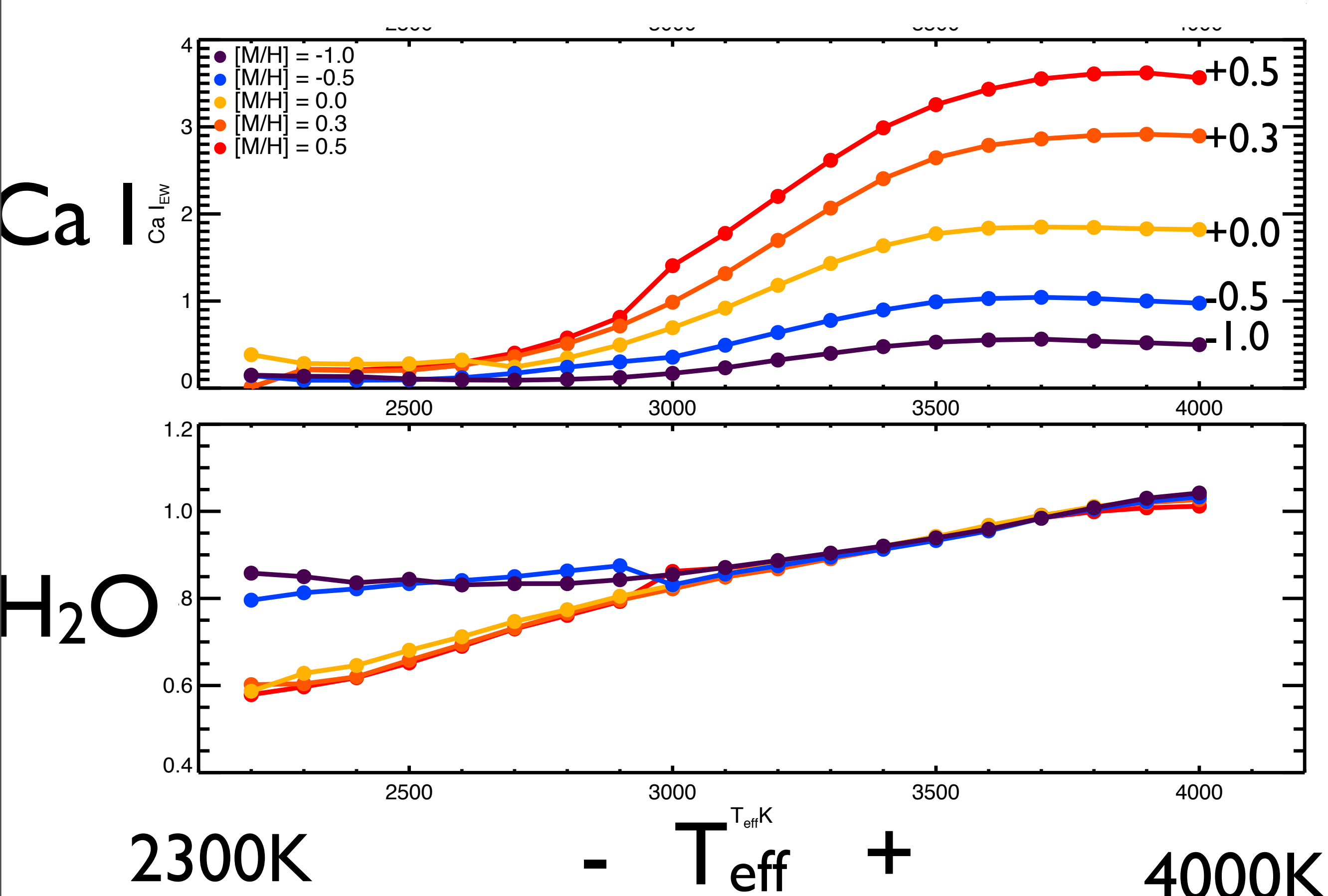
Spectral Types and Temperature of M dwarfs can be obtained from K-band water absorption

Rojas-Ayala et al. 2012

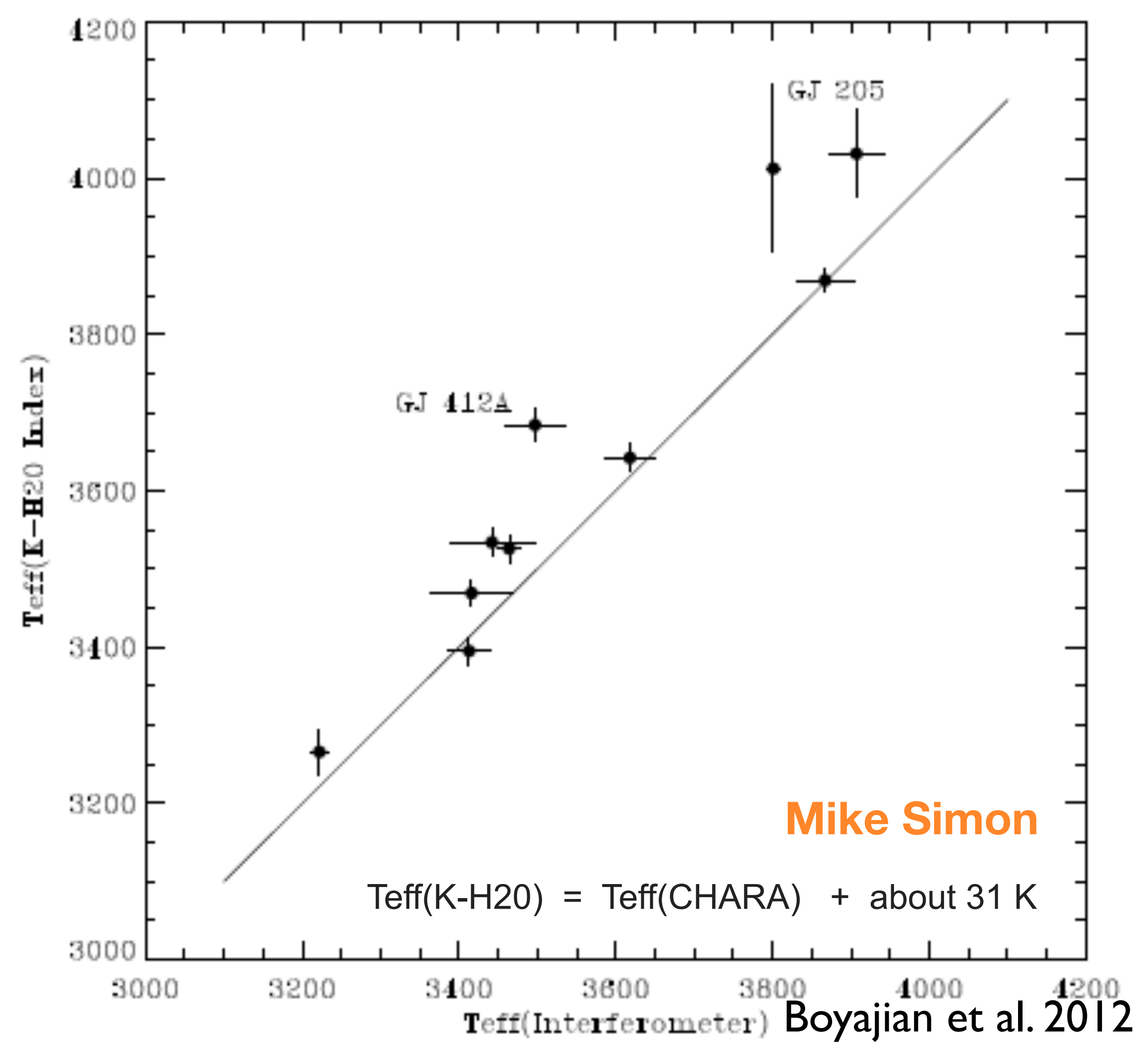
H_2O-K2 Index



$$\text{M subtype} = A + B\,(H_2O\text{–}K2)$$
$$A = 24.699 \pm 0.930$$
$$B = -23.788 \pm 1.067$$
$$\text{RMSE(M subtype)} = 0.624$$



BT-Settl 2010 (Allard et al 2010)



K-band Na I, Ca I and water differentiate super-solar and sub-solar [M/H] M dwarfs

Rojas-Ayala et al. 2012 in ApJ

18 [M/H] Calibrators

Nearby dMs

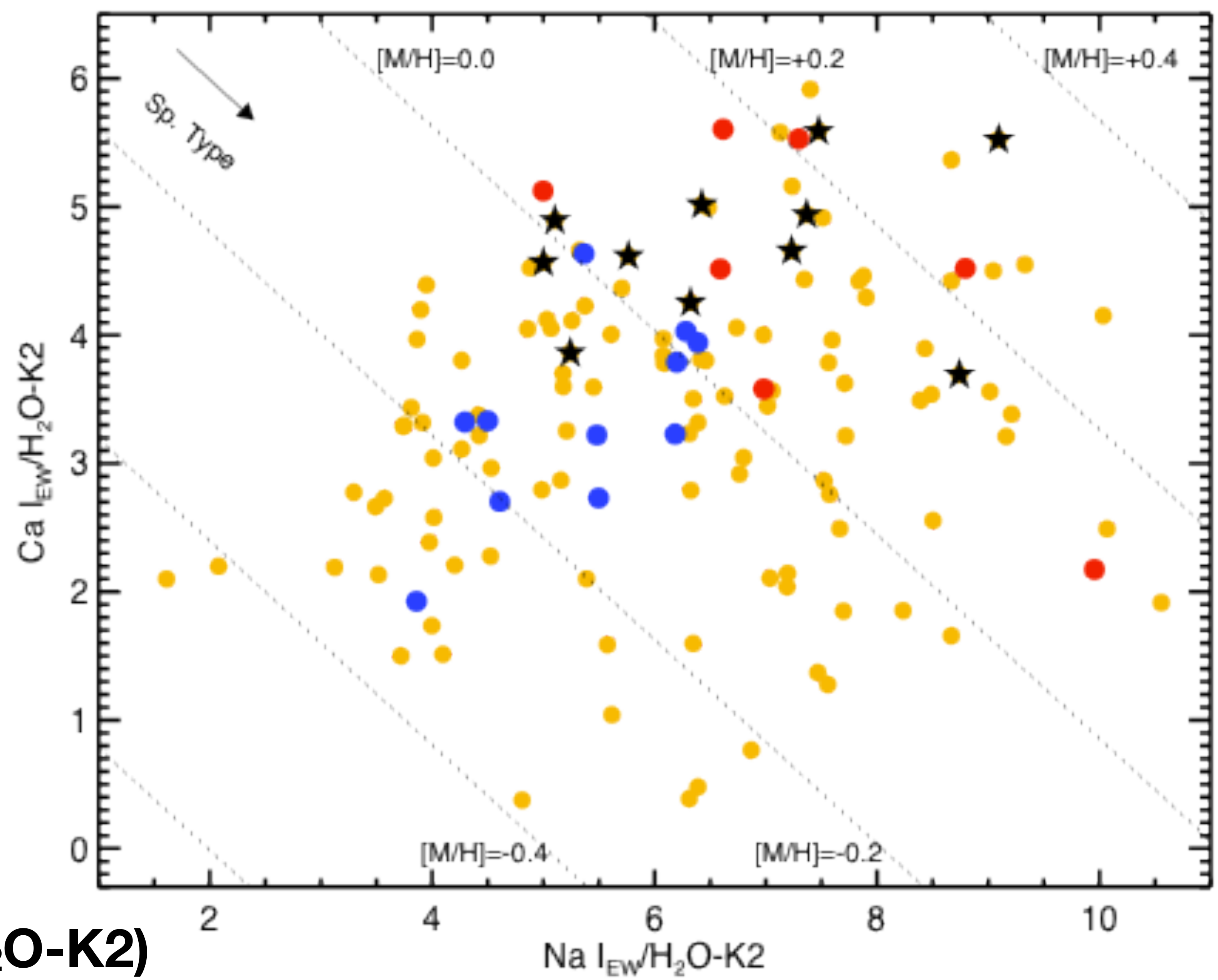
[M/H] ≥ 0.0*

[M/H] < 0.0*

* SPOCS

Planet Hosts

The 2012 K-band [M/H] Scale



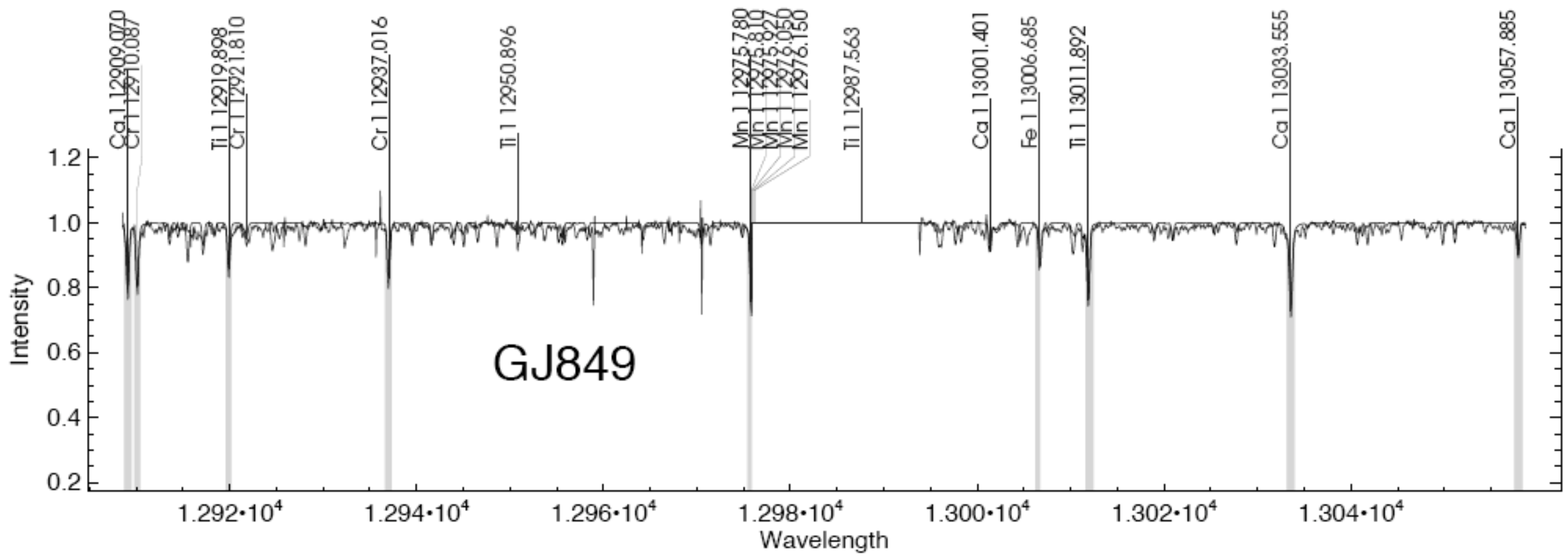
$$[M/H] = -0.724 + 0.066 * (NaI_{EW}/H_2O\text{-}K2) + 0.095 * (CaI_{EW}/H_2O\text{-}K2)$$

RMSE[M/H] = 0.09, R^2_a([M/H]) = 0.66

FGK + dM systems

Alternative NIR techniques

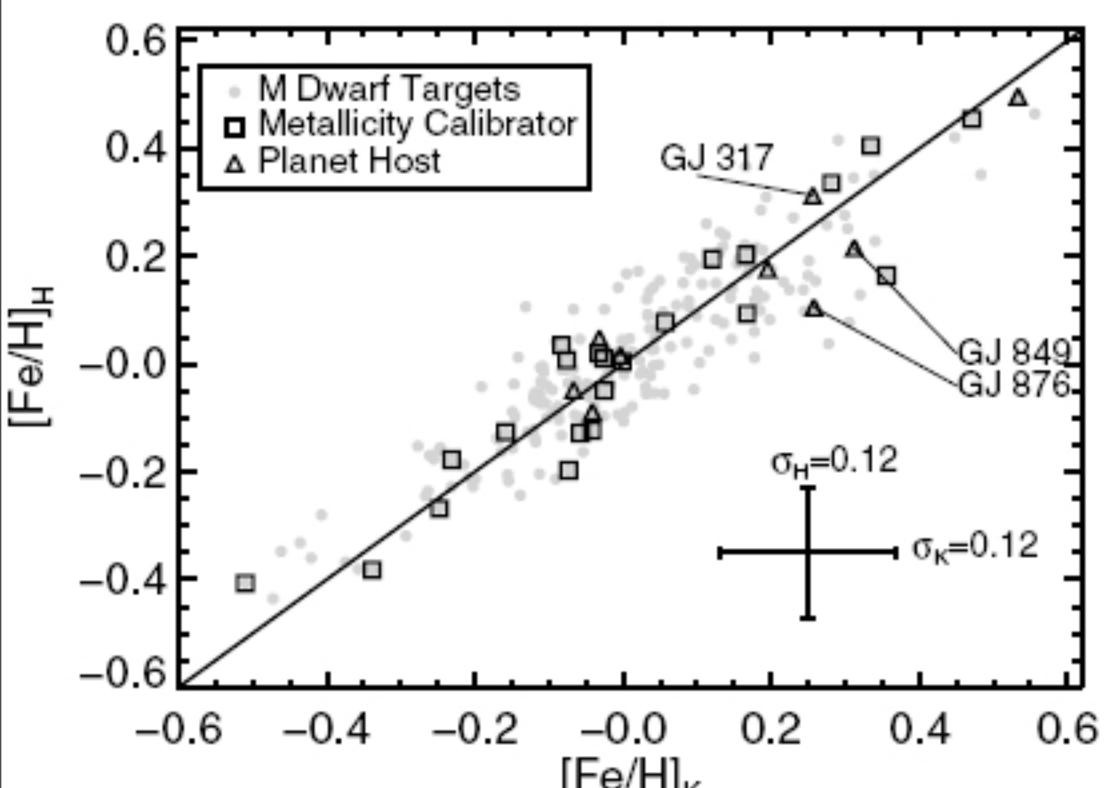
Önehag et al. 2011

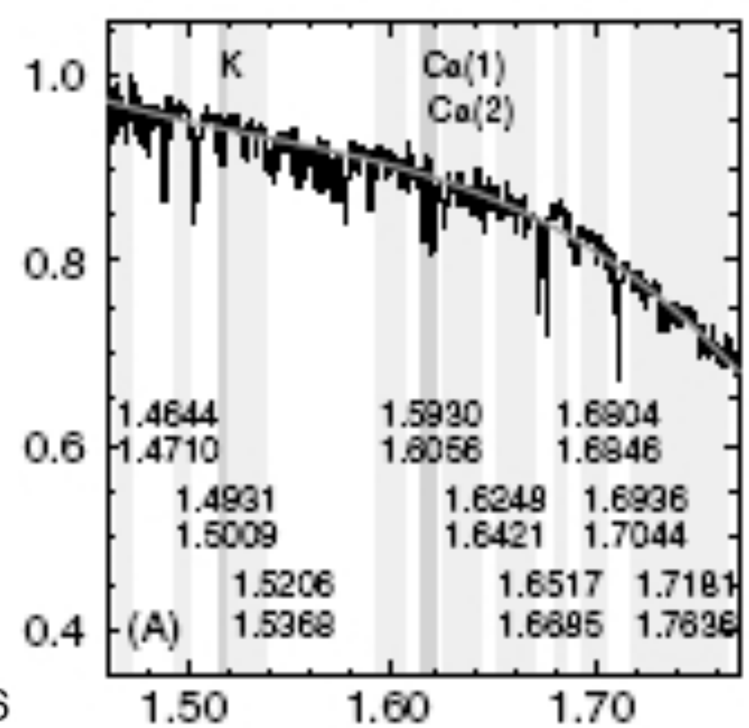


R∼50,000

J-band Fe I, Ca I, Ti I, Mn I, Mg I, Si I, Cr I, Co I

Terrien et al. 2012





R∼2000 H band

Na I, Ca I and Water

Neptunes do not discriminate, Jupiters like rich stars ...

RV surveys

Mayor et al. 2012

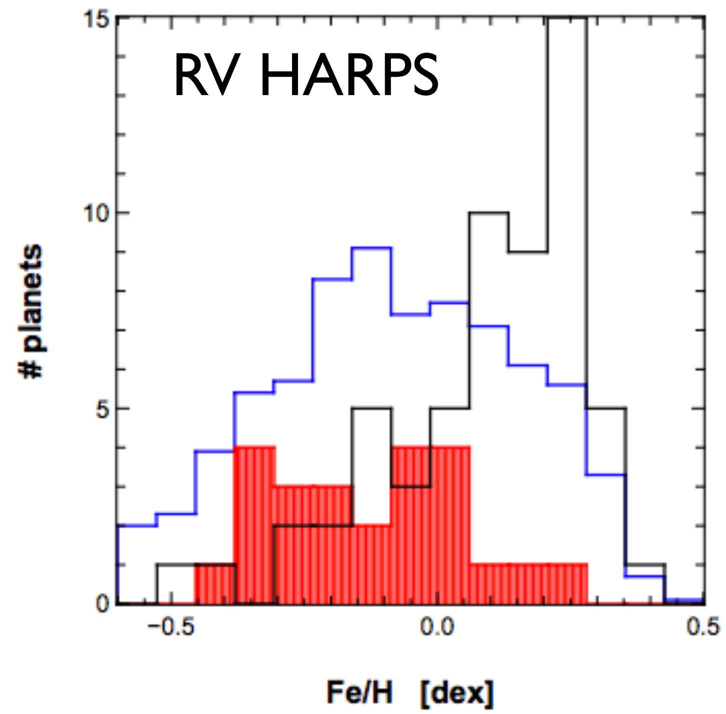
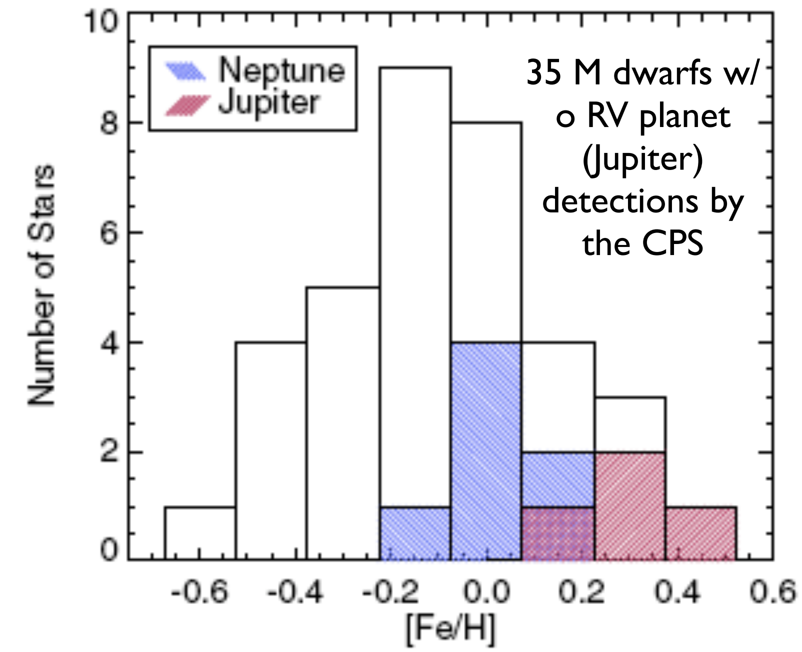


Fig. 16. Histograms of host star metallicities ([Fe/H]) for giant gaseous planets (black), for planets less massive than 30 M⊕ (red), and for the global combined sample stars (blue). The latter histogram has been multiplied by 0.1 for visual comparison reason.

Rojas-Ayala et al. 2012



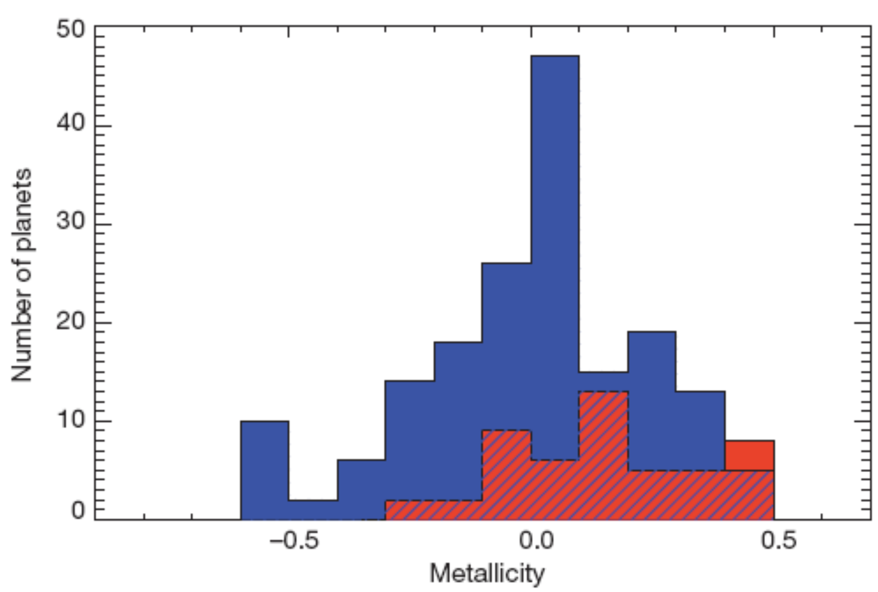
Two-sided K-S test

Jupiter	Neptune
0.8%	8.6%

chance they are drawn from the same parent distribution with the CPS stars

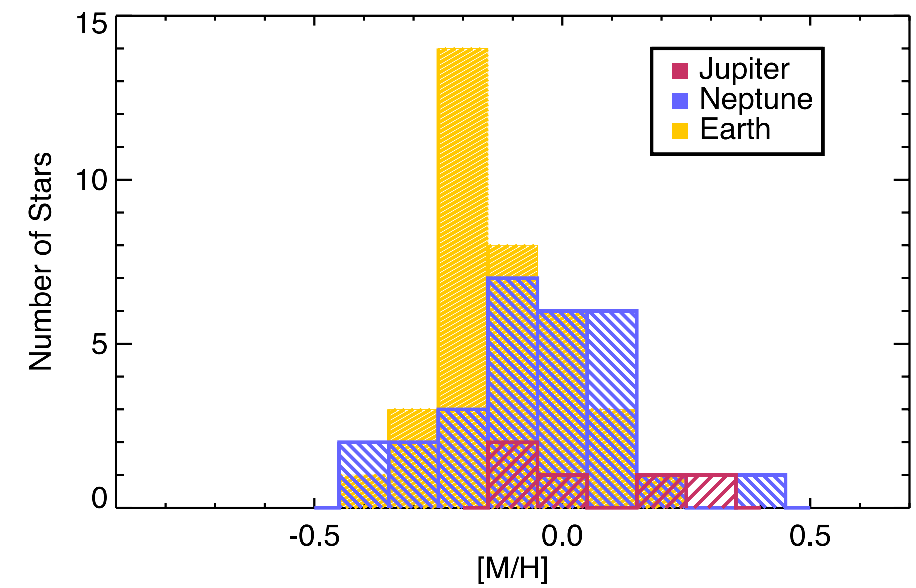
Kepler

Buchhave et al. 2012



Red ≥ 4R⊕ ≥ Blue

Babs from **Muirhead et al. 2012**



Jupiter ≥ 5.5R⊕ ≥ Neptune ≥ 1.9R⊕ ≥ Earth

Cool KOIs

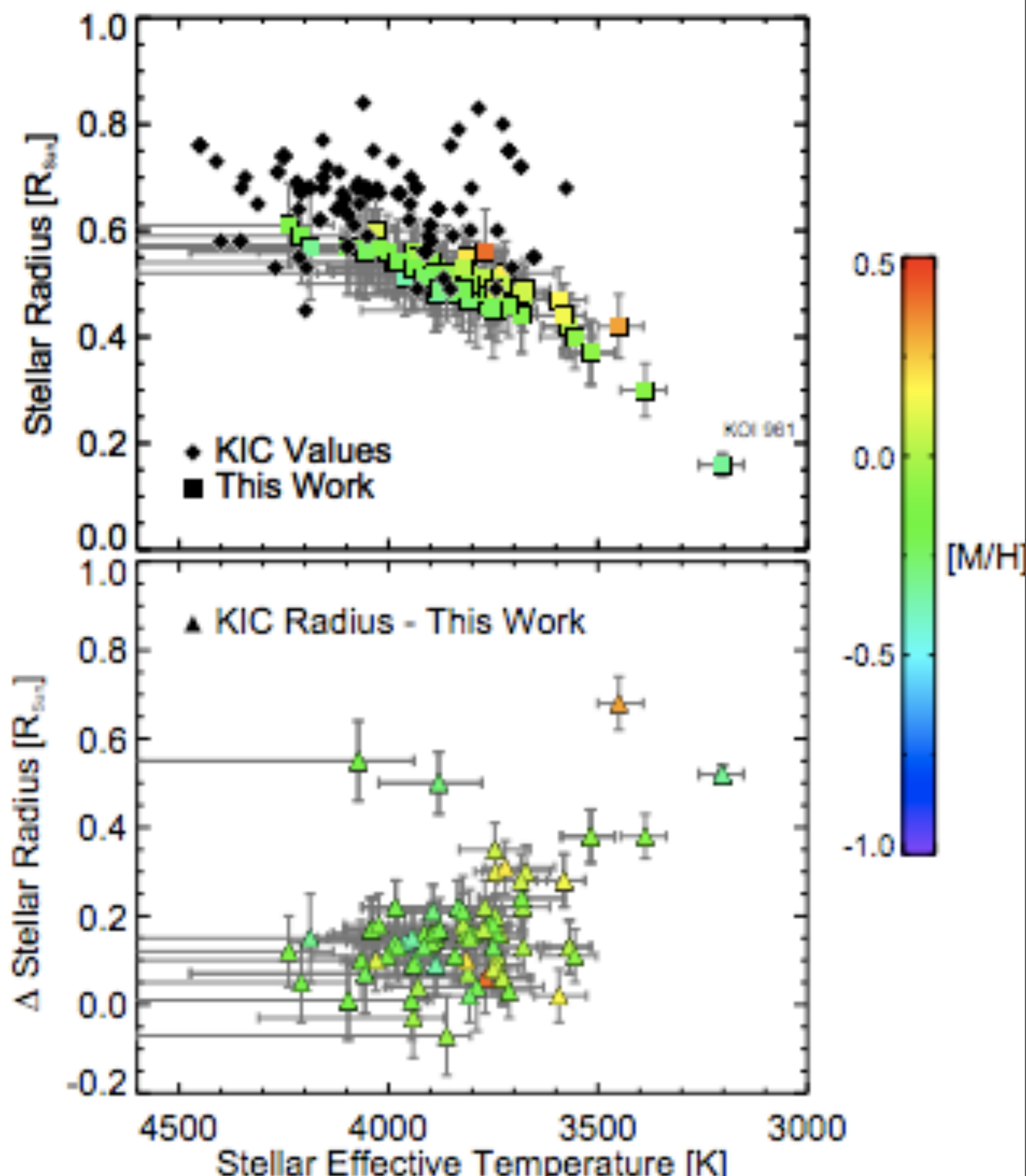
New* Radii estimates for M dwarfs KOIs from: K-band [M/H], Teff

Rojas-Ayala et al. 12

+

Dartmouth Models

Dotter et al. 08



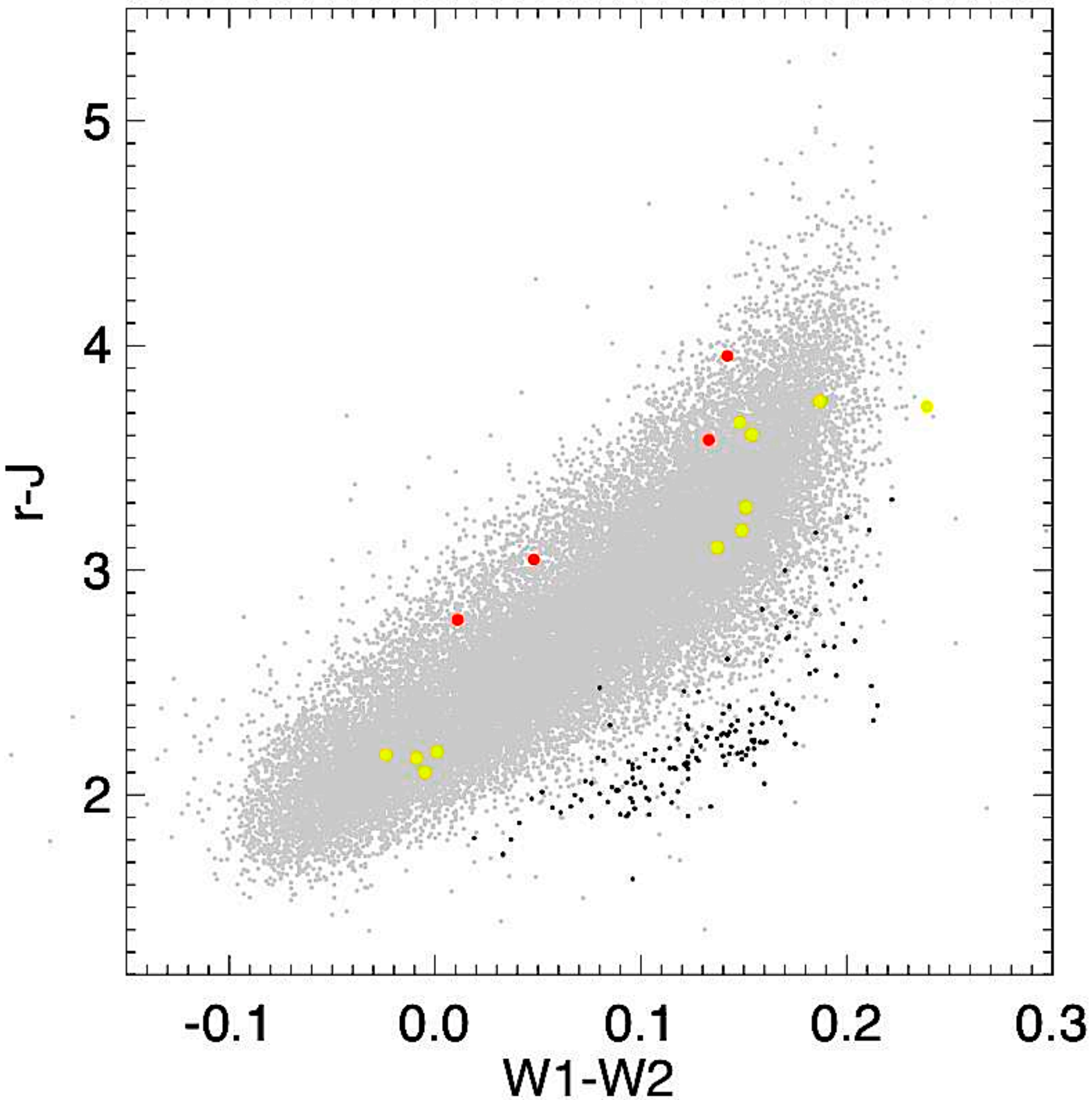
Muirhead et al. 12

Smaller! "Rocky" Planet Candidates!

KOI 463.01, KOI 812.03, and KOI 854.01

New Photometric Metallicities for M stars

Rojas-Ayala et al. (almost ready!)



~38,000 M stars from SUPERBLINK (Lépine & Shara. 2005)

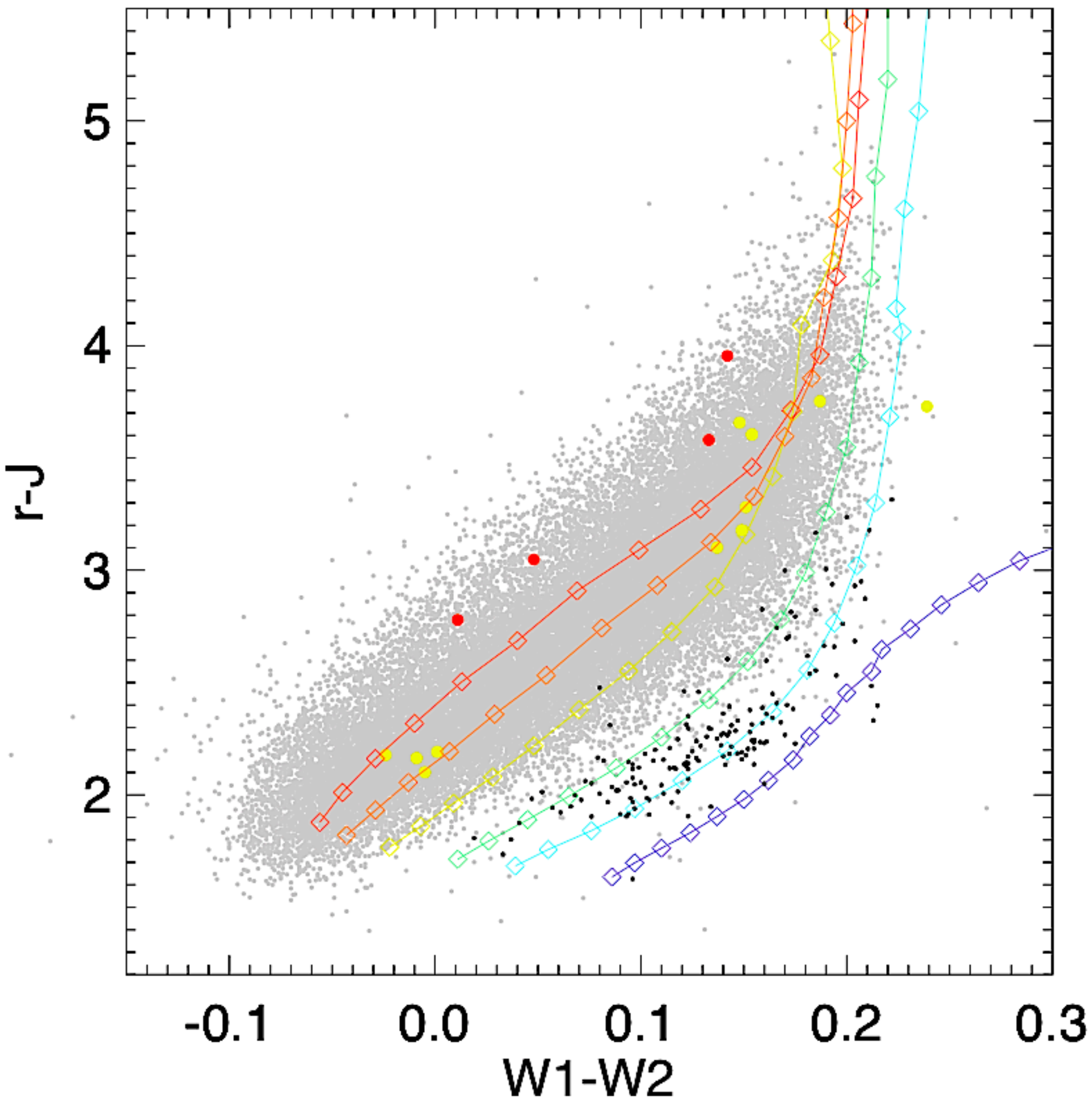
M dwarfs within ~100pc

Works with V and gri magnitudes!

Alternative to M_k vs V-K techniques

- (red) [Fe/H] > +0.2 dex
- (yellow) - 0.2 dex < [Fe/H] < +0.2 dex
- (black) Spectroscopic M Subdwarfs

New Photometric Metallicities for M stars



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M dwarfs within ~100pc

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Alternative to M_k vs V-K techniques

BT-Settl
- [M/H] = +0.5 dex
- [M/H] = +0.3 dex
- [M/H] = 0.0 dex
- [M/H] = - 0.5 dex
- [M/H] = - 1.0 dex
- [M/H] = - 3.0 dex

Summary

- The EWs of the Ca I triplet and the Na I doublet, and water absorption in the K-band differentiate metal-rich and metal-poor M-dwarfs (including other features in J and H bands)
- This method does not depend on parallaxes or accurate V magnitudes, allowing us to cover a larger sample of cooler and distant M-dwarfs.
- No need of high-resolution spectra. It simply requires K-band modest resolution spectra (efficiently obtained with current NIR-spectrographs)

Needs improvement but … it seems to work well!

Jovian M-dwarf planet hosts are more metal-rich than Neptune/Super Earth M-dwarf planet hosts, which is in agreement with the metallicity distribution of their FGK counterparts...

NIR [Fe/H] and Teff are useful information that can help us constrain the masses and radii of M dwarfs

New Color-Color diagram can provide metallicity information for ~39000 M dwarfs