Colour-Magnitude Diagrams of Exoplanets

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Dransfield & Triaud in prep

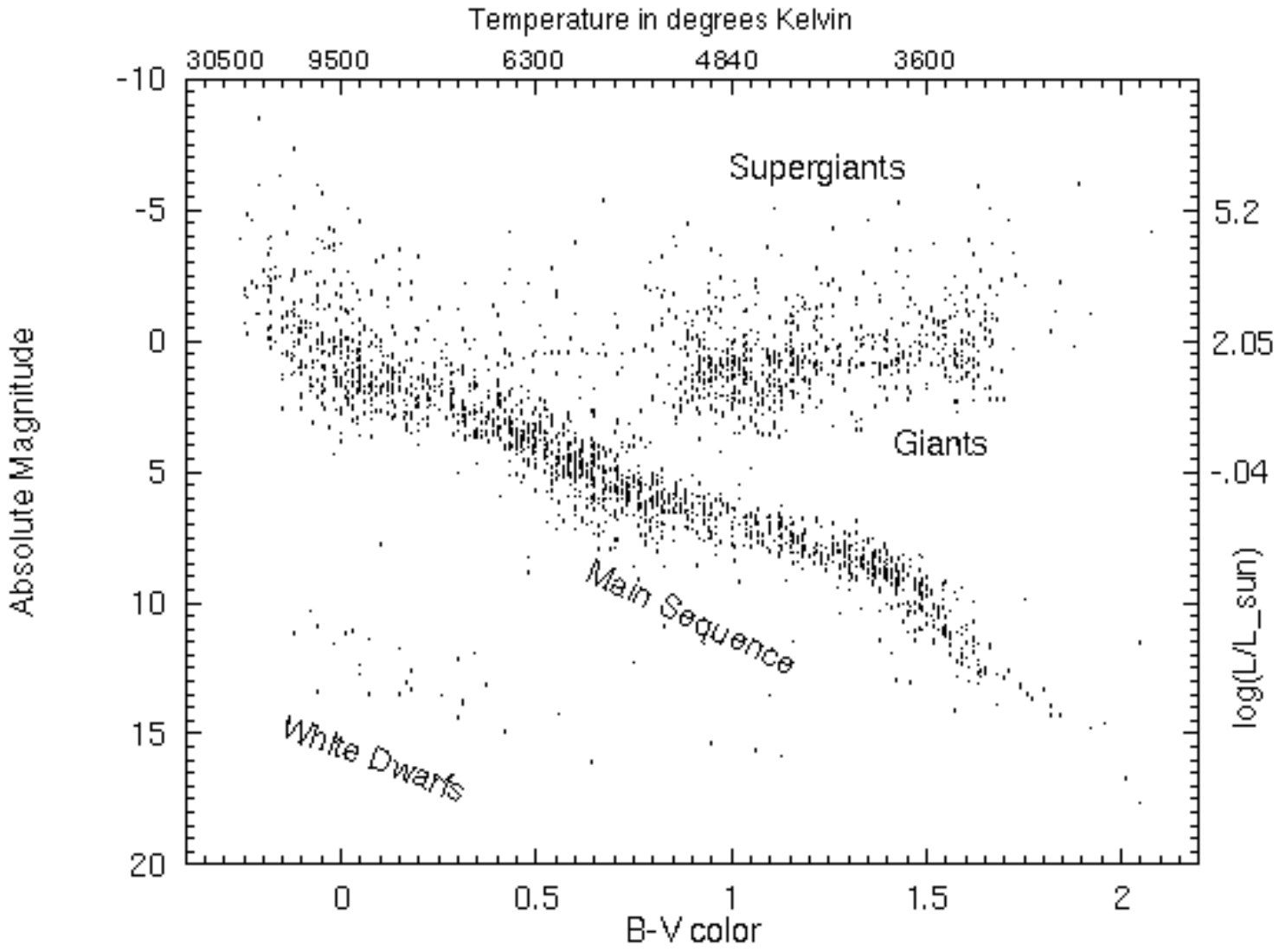
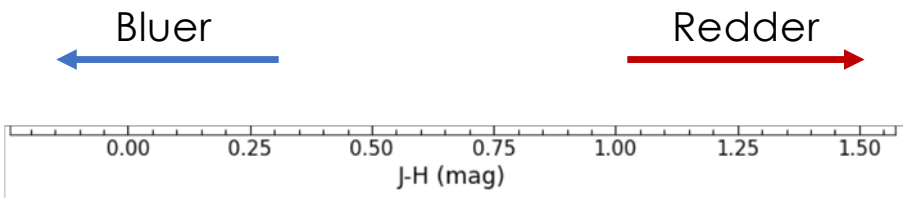


Image credit: http://www.astronomynotes.com/starprop/s13.htm

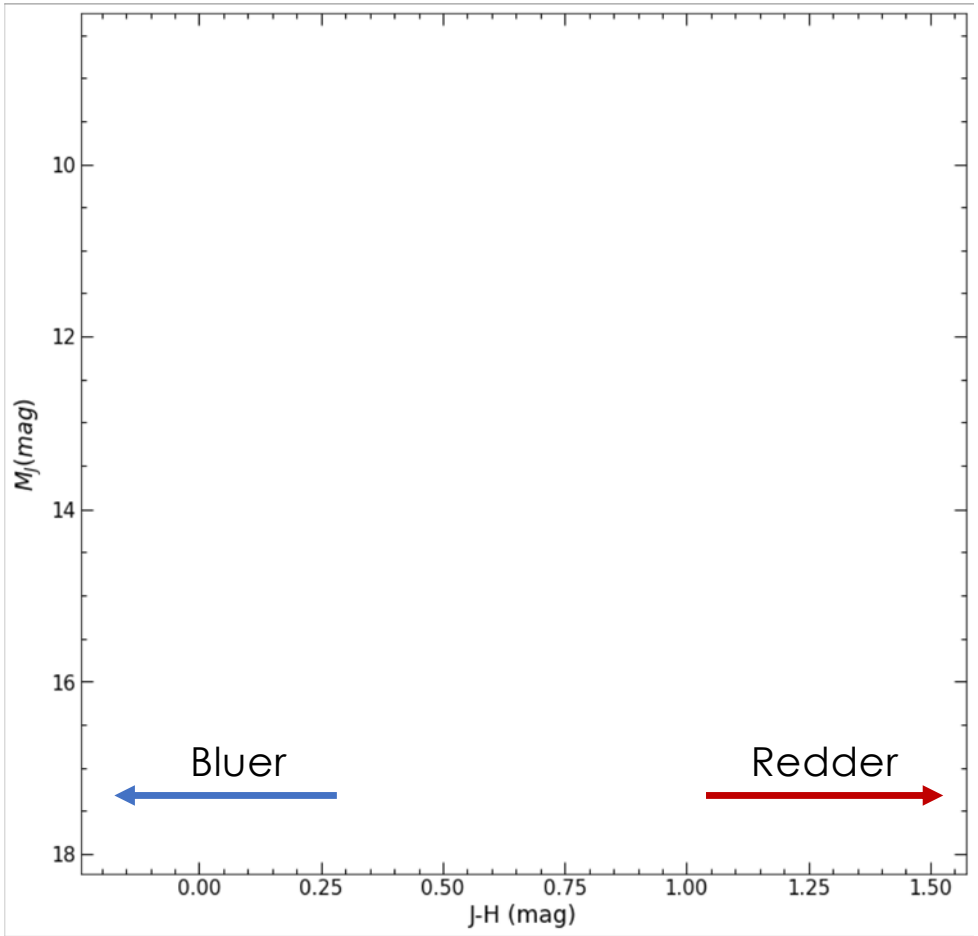
Talk Structure

1. How we build a Colour-Magnitude Diagram
2. Sales Pitch: Why Colour-Magnitude Diagrams + Why make them with our tools
3. Conclusion

Building a Colour-Magnitude Diagram



Building a Colour-Magnitude Diagram



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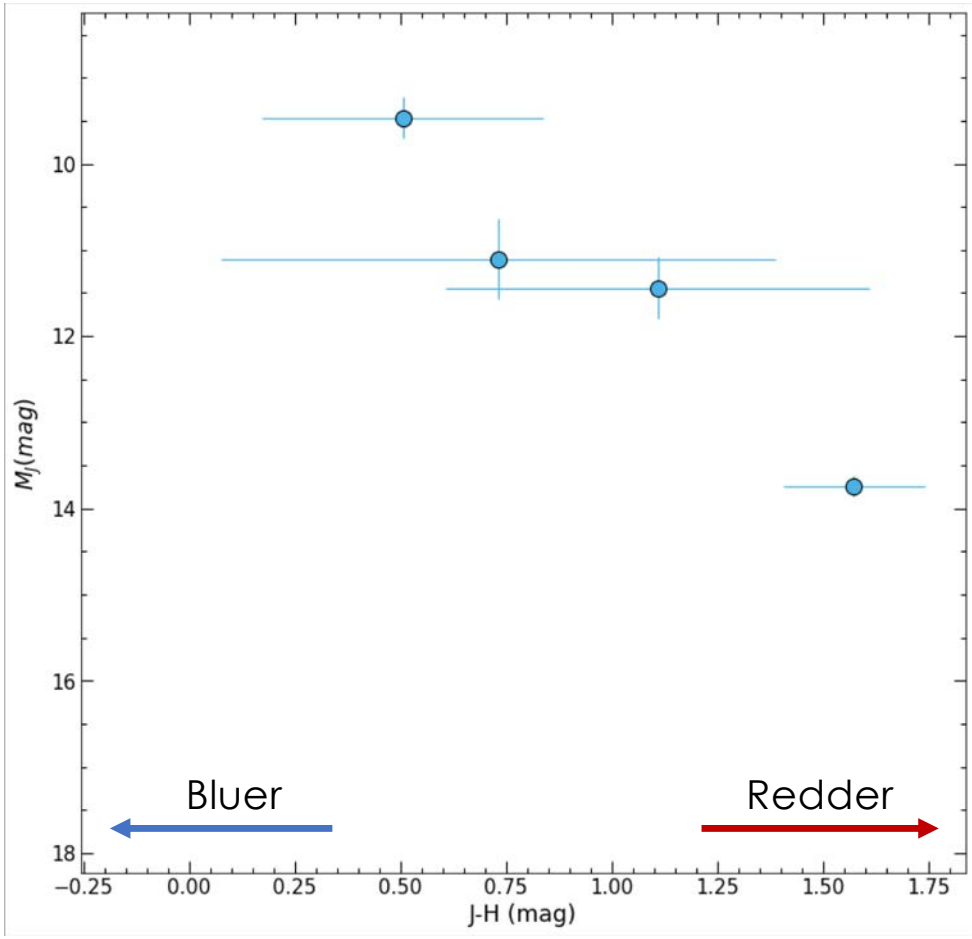
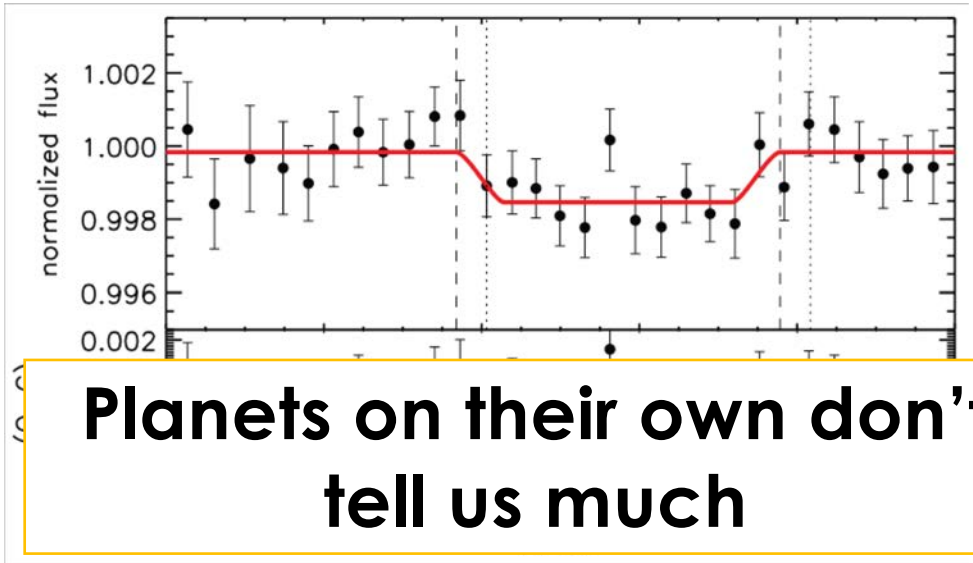


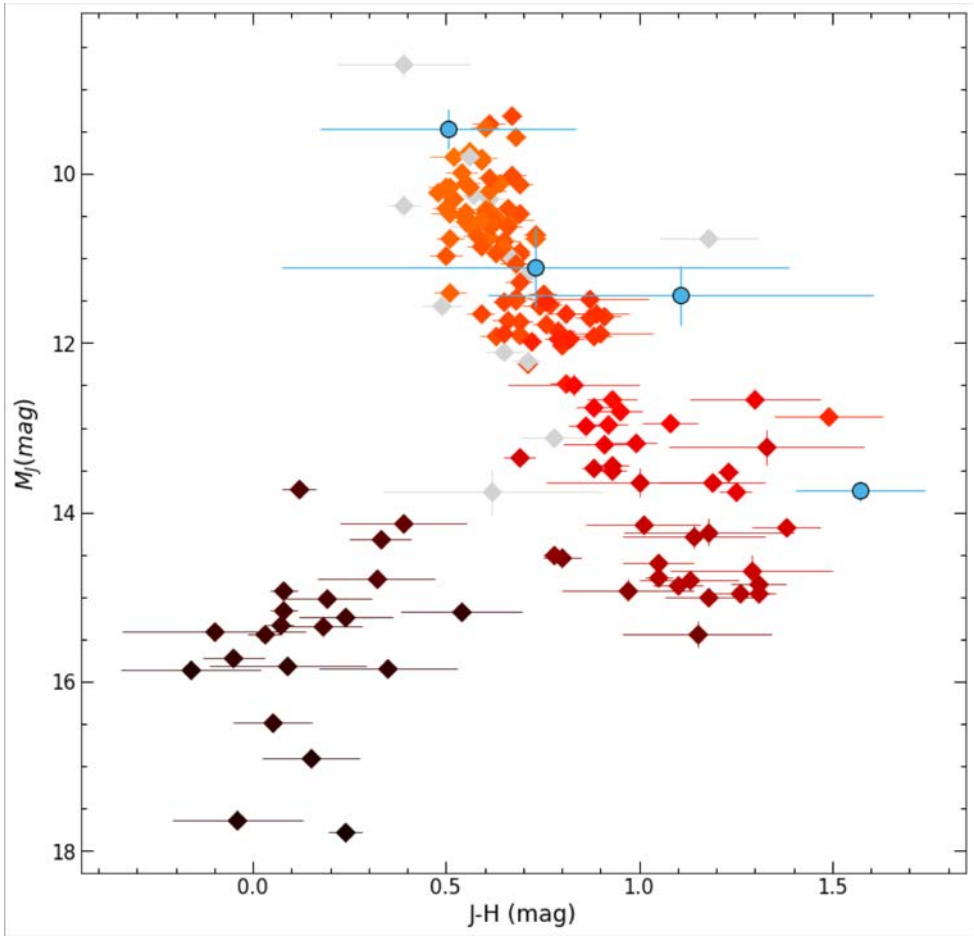
$$m_p = -2.5 \log_{10}\left(\frac{f_p}{f_s}\right) + m_s$$



Planets on their own don't tell us much

Cruz et. al. 2018

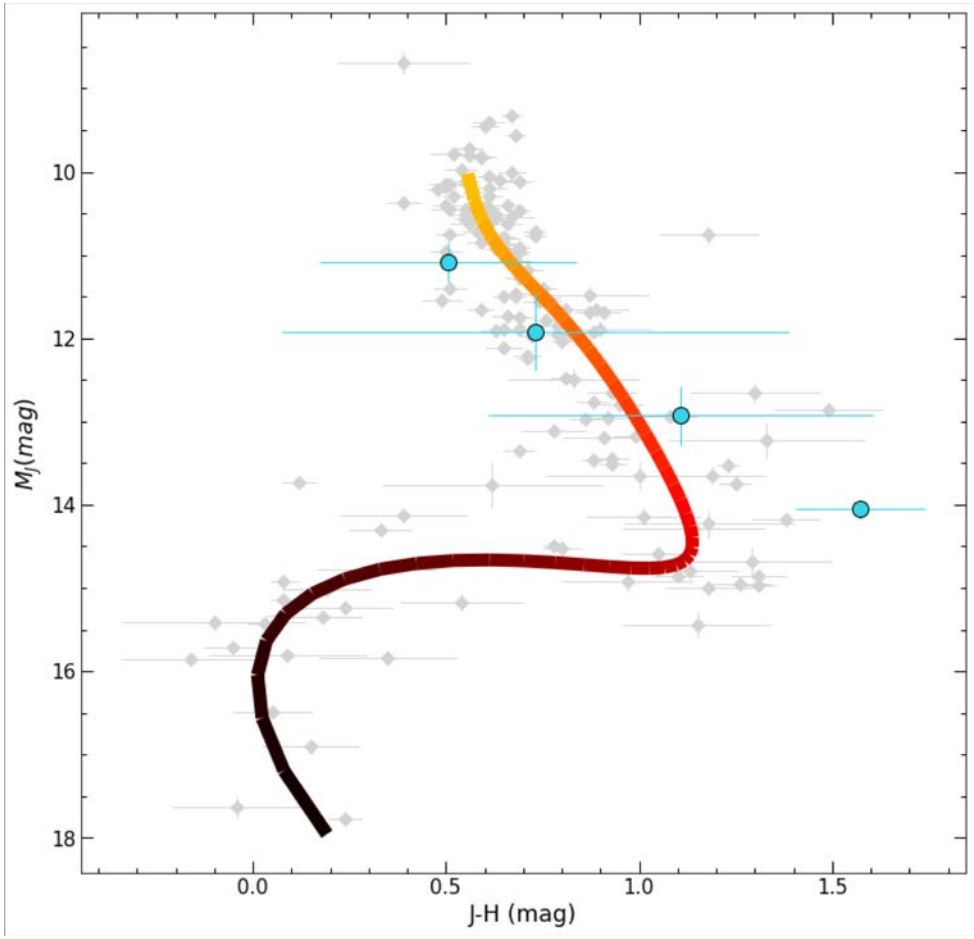
Building a Colour-Magnitude Diagram



$$L \propto R^2 T^4$$

Planets on their own don't tell us much

Building a Colour-Magnitude Diagram



We adjust the planet magnitudes to match the Dwarfs, i.e. ~0.9R_J

We have a tool for that!

Sales Pitch

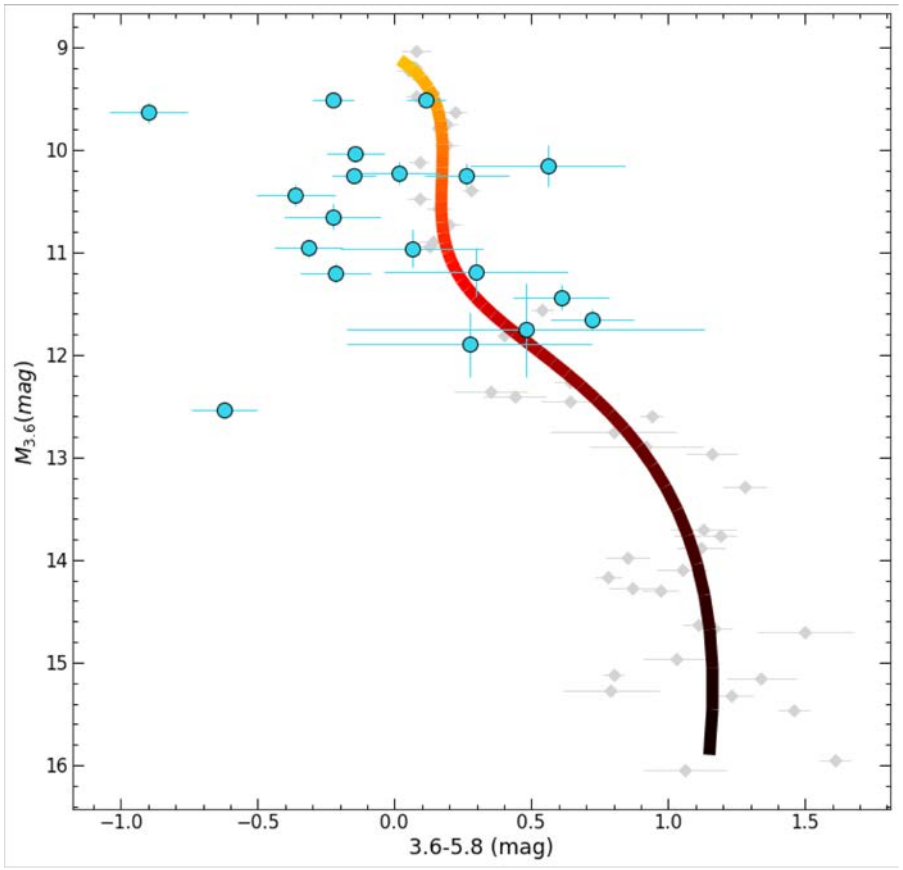
1. Identifying Outliers for follow-up (select for Tier 2)

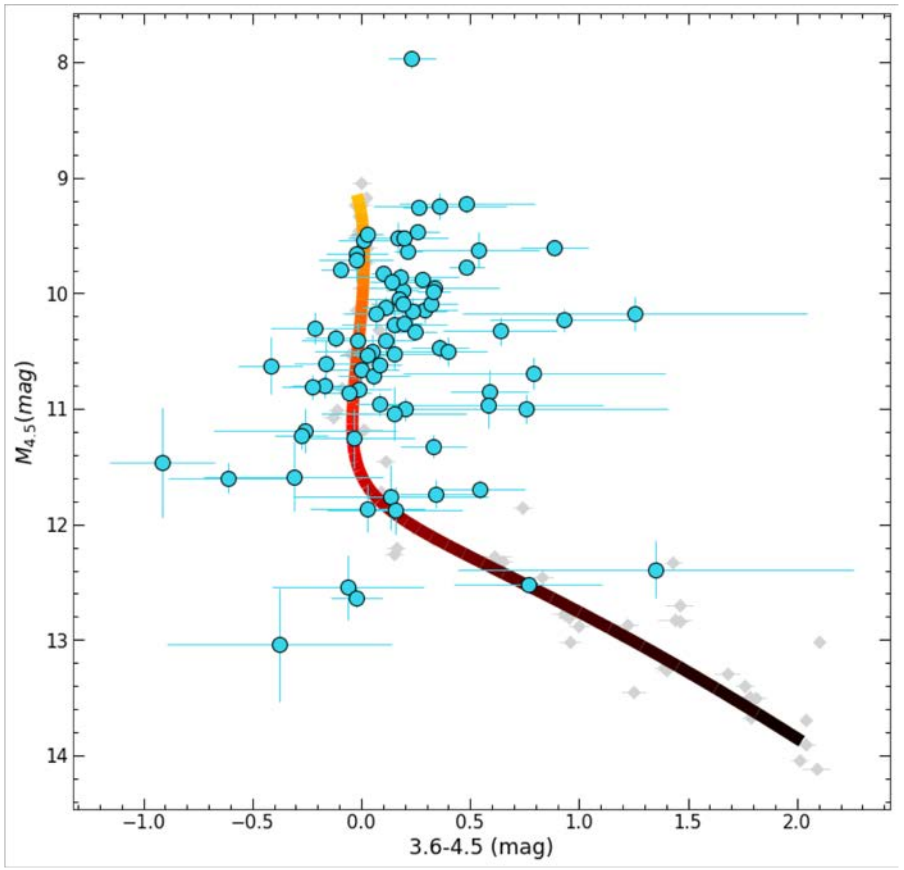
2. Identifying molecules

3. Constraining C/O ratio & sub-populations

1. Identify Outliers

ARIEL will produce beautiful spectra; we want to cut it up and make photometry.

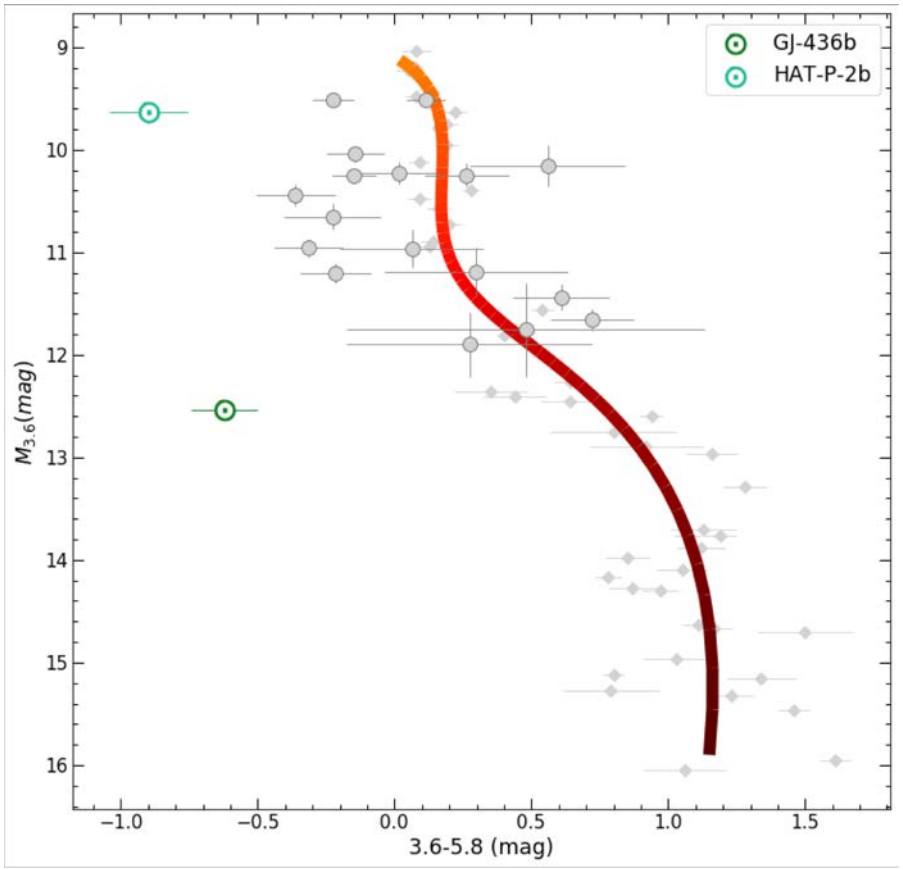


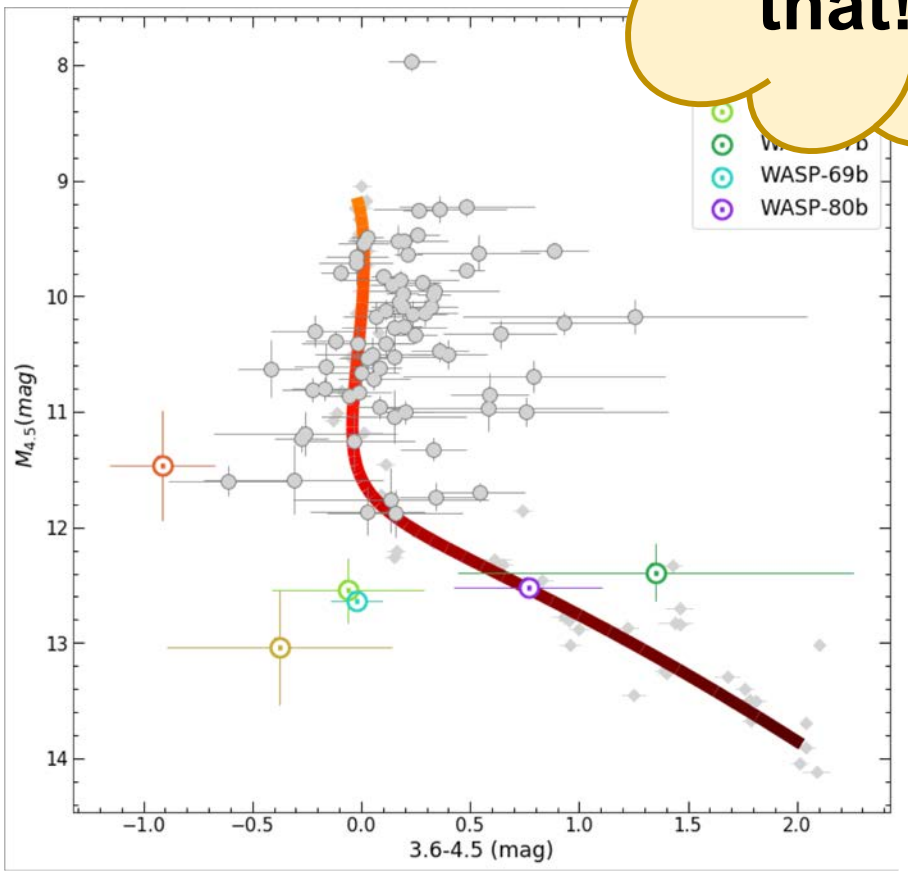


1. Identify Outliers

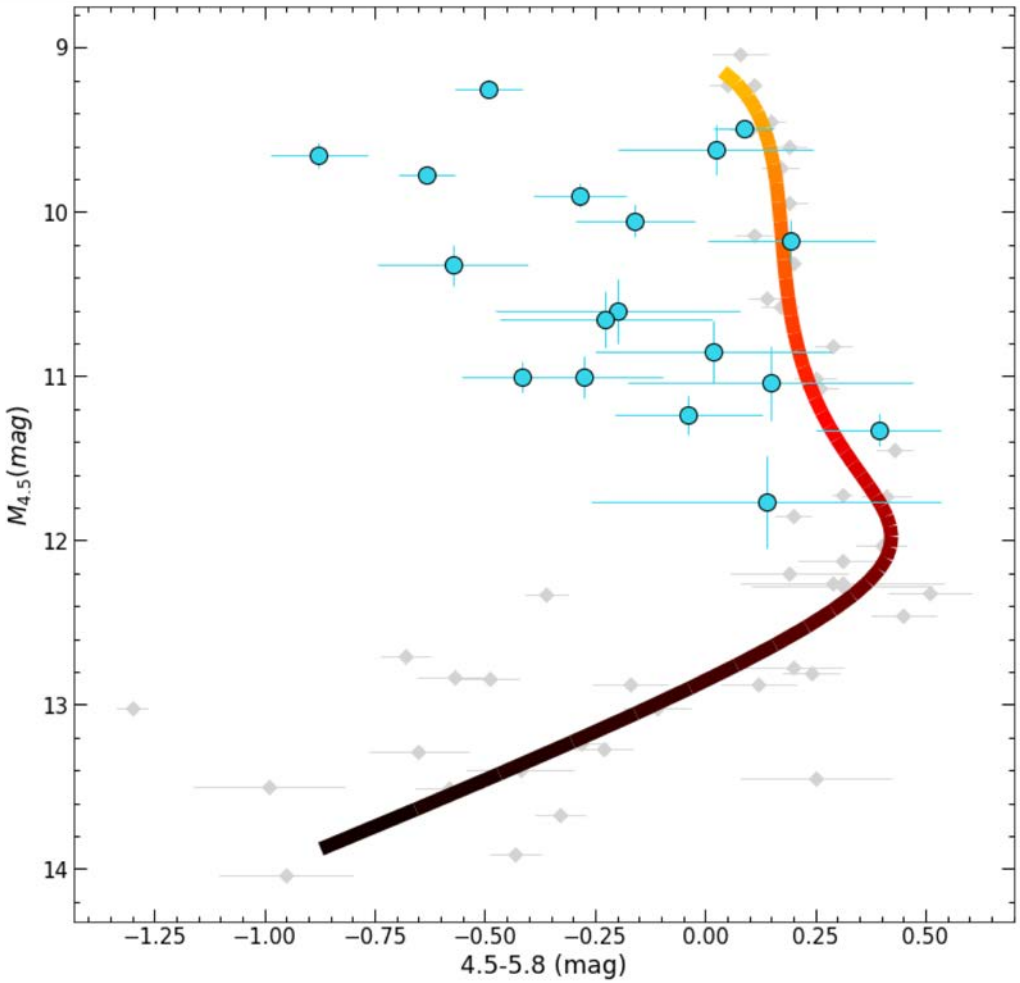
We can easily pick interesting targets for follow-up

We have a tool for that!





2. Identifying Molecules

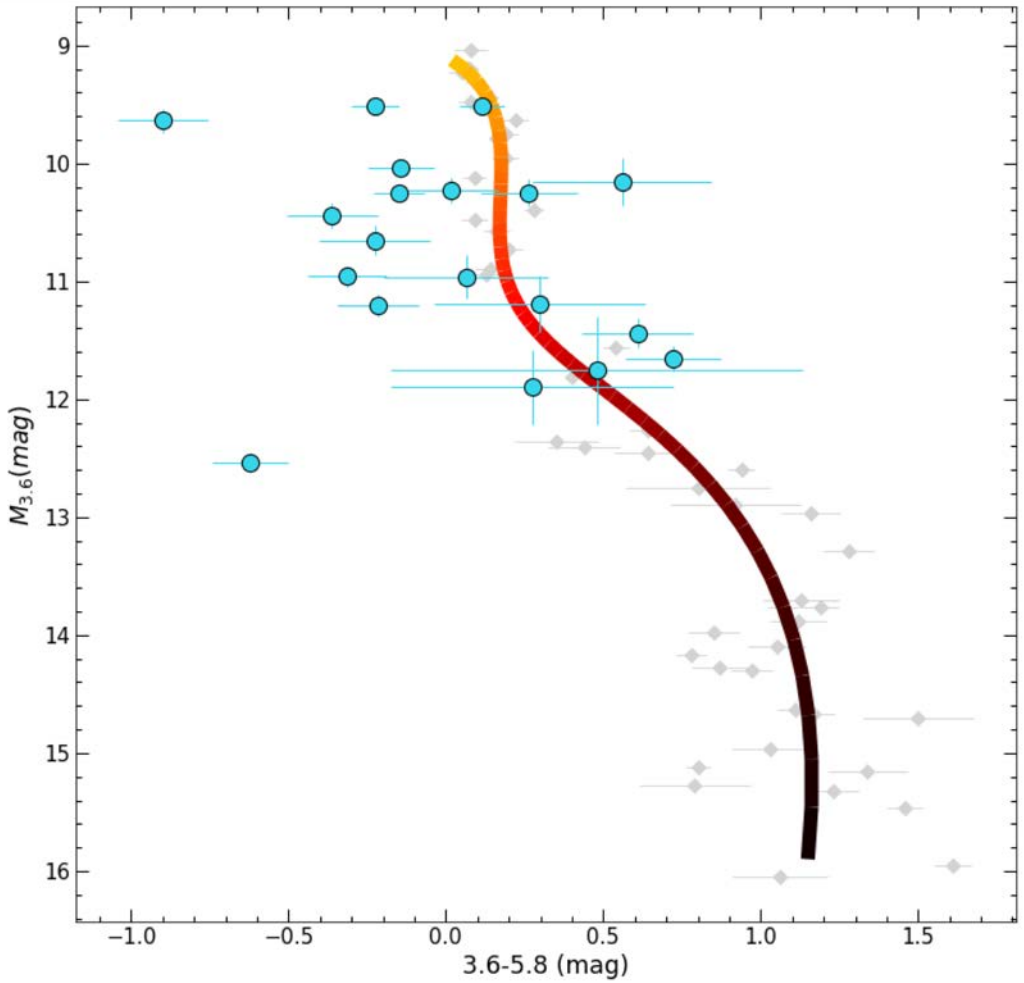


Brown Dwarfs and Hot Jupiters *are* different.

- We know:

✓ The difference is in the 4.5 micron flux

2. Identifying Molecules



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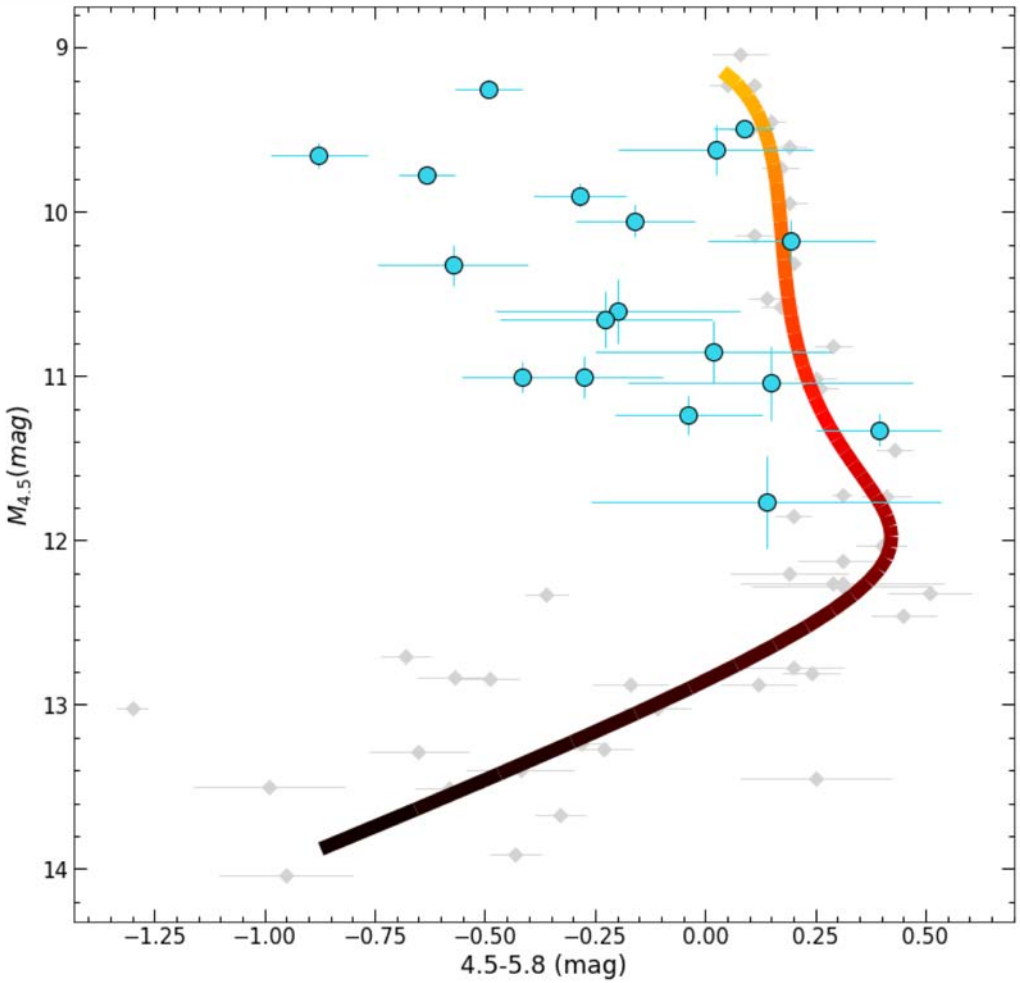

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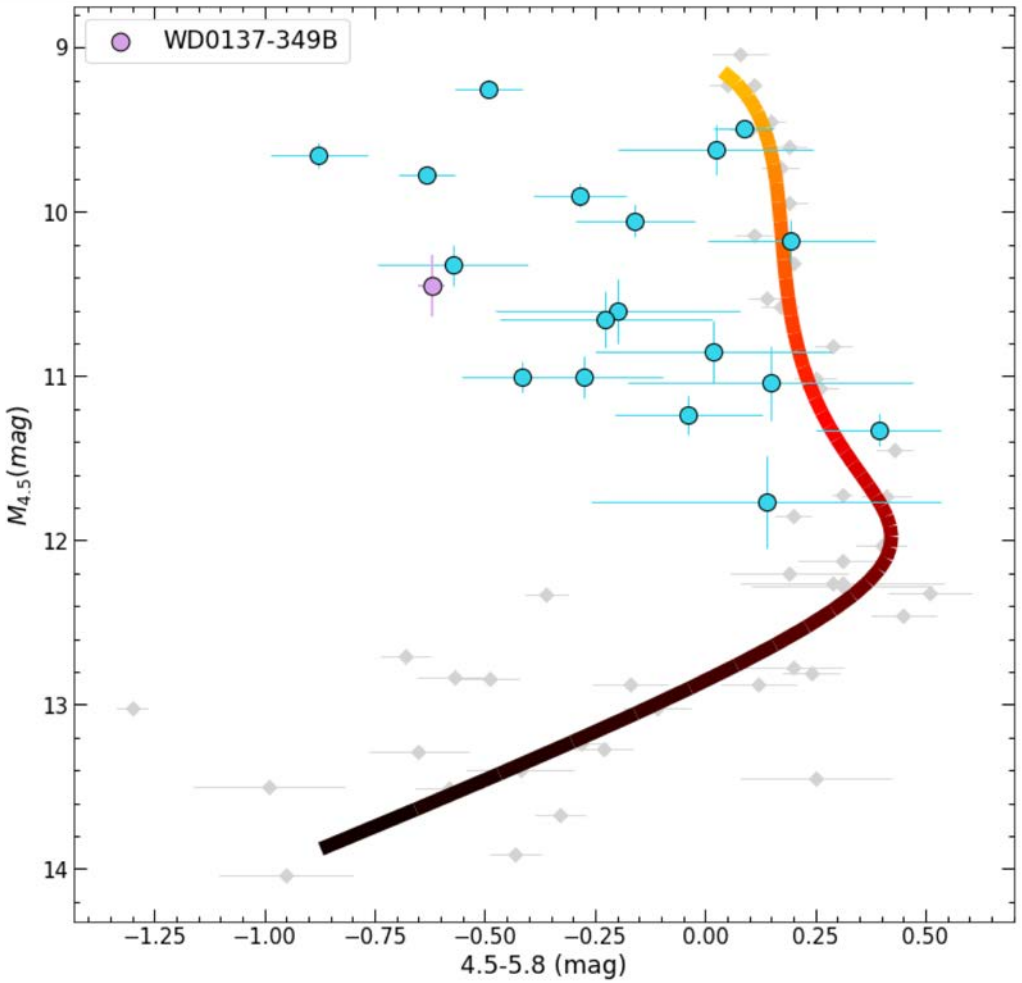


Brown Dwarfs and Hot Jupiters *are* different.

- We know:

✓ The difference is in the 4.5 micron flux

✓ It is caused by irradiation (Casewell, 2015)

➢ Hypothesis: Brown Dwarfs have an additional absorber in the 4.5 micron band which is absent in irradiated objects.

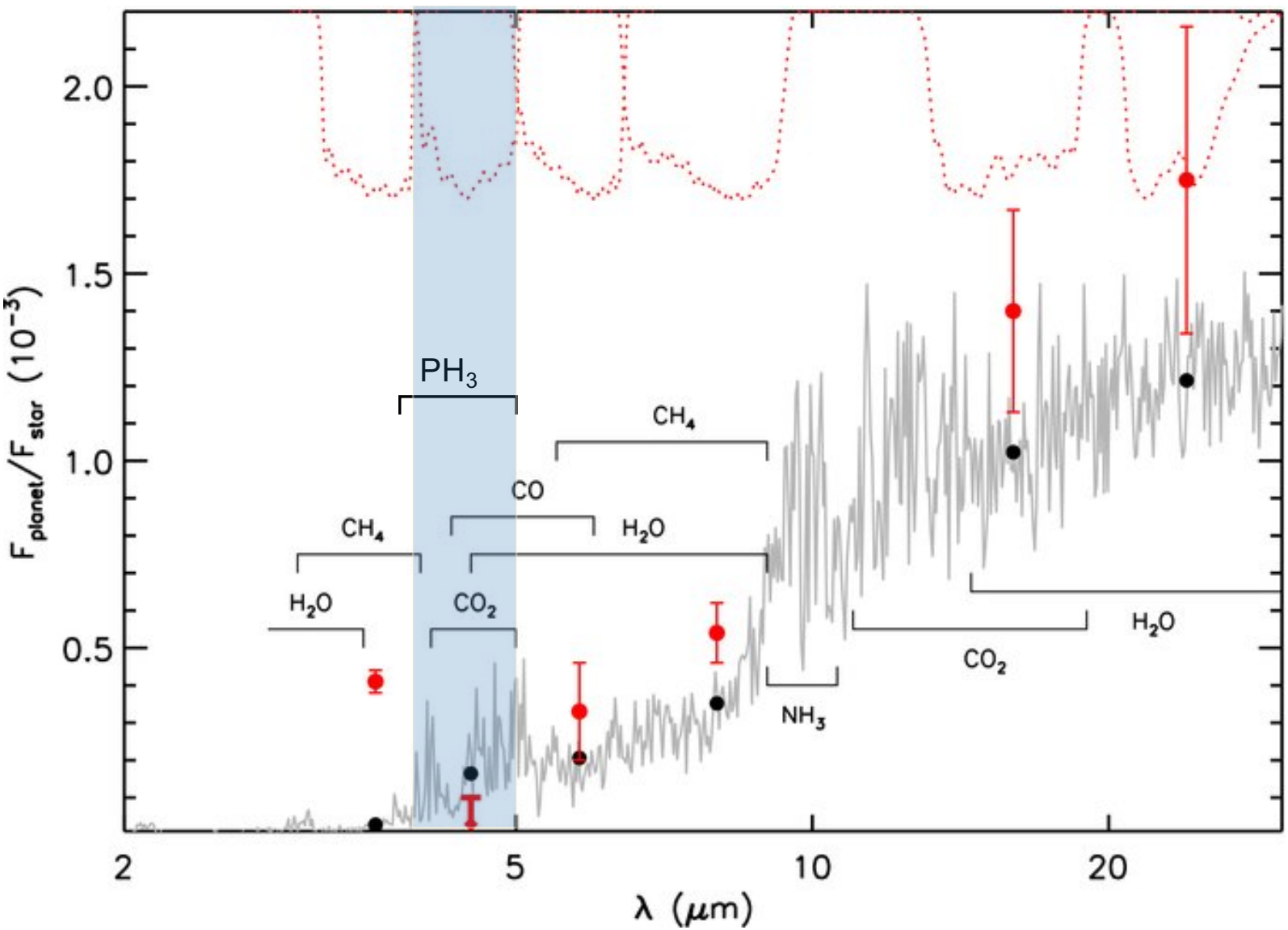


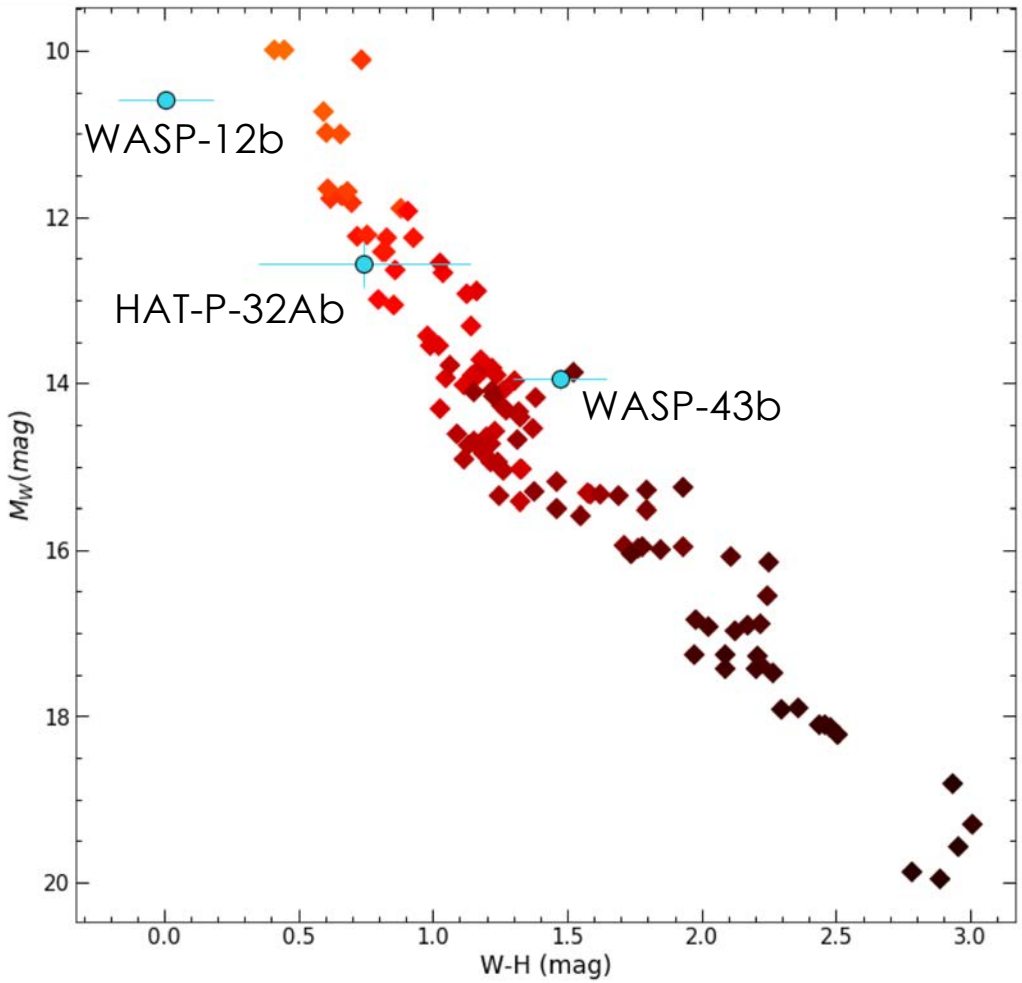
Image credit: Madhusudan & Seager, 2011

Phosphine?

- Phosphine (PH_3) is the most likely Phosphorus bearing molecule for Brown Dwarfs in the temperature range 1000-1400K (Visscher et al. 2006)
- Phosphine gets photolysed by strong irradiation (Sousa-Silva et al. 2019)
- Phosphine might explain low 4.5 micron flux on the nightside of HD-189733b (Steinrueck et al. 2019)

➢ **We will be able to use the ARIEL IR Spectrograph to look for Phosphine in less irradiated exoplanets.**

3. Constrain C/O Ratio



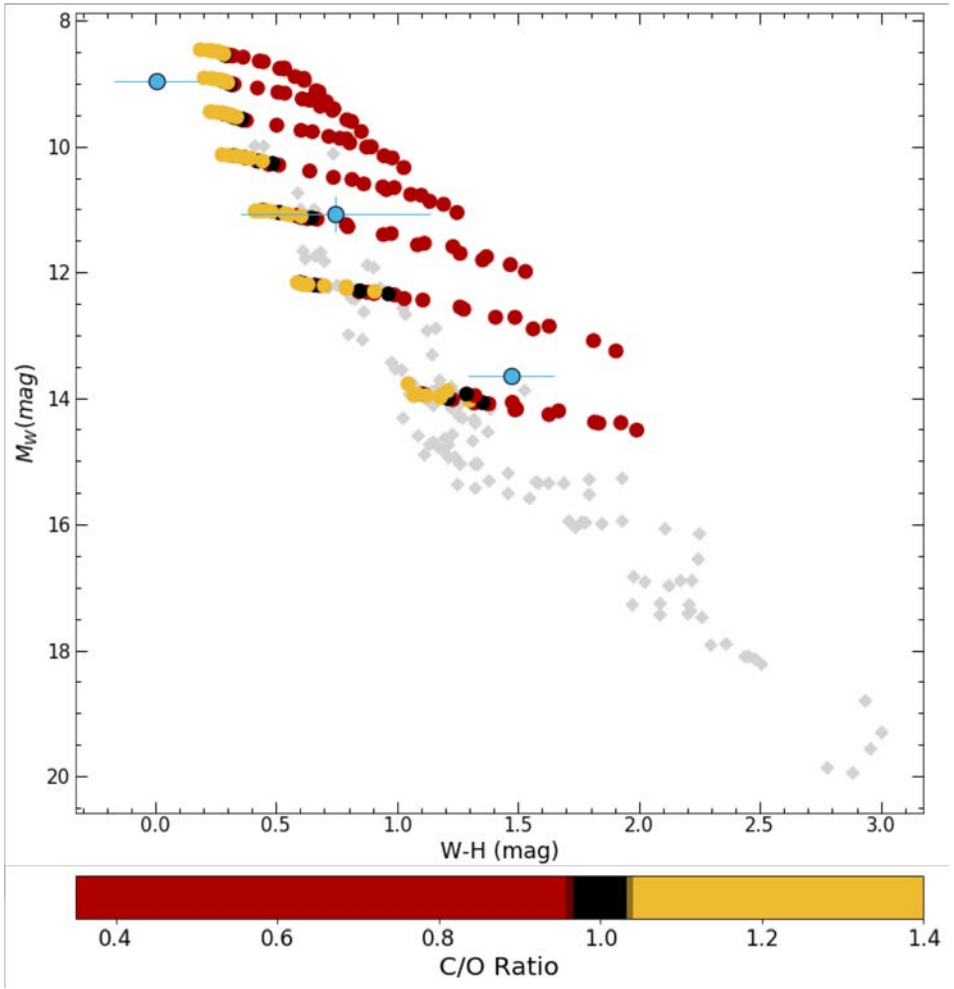
W-band is a synthetic band centred on 1.4 microns

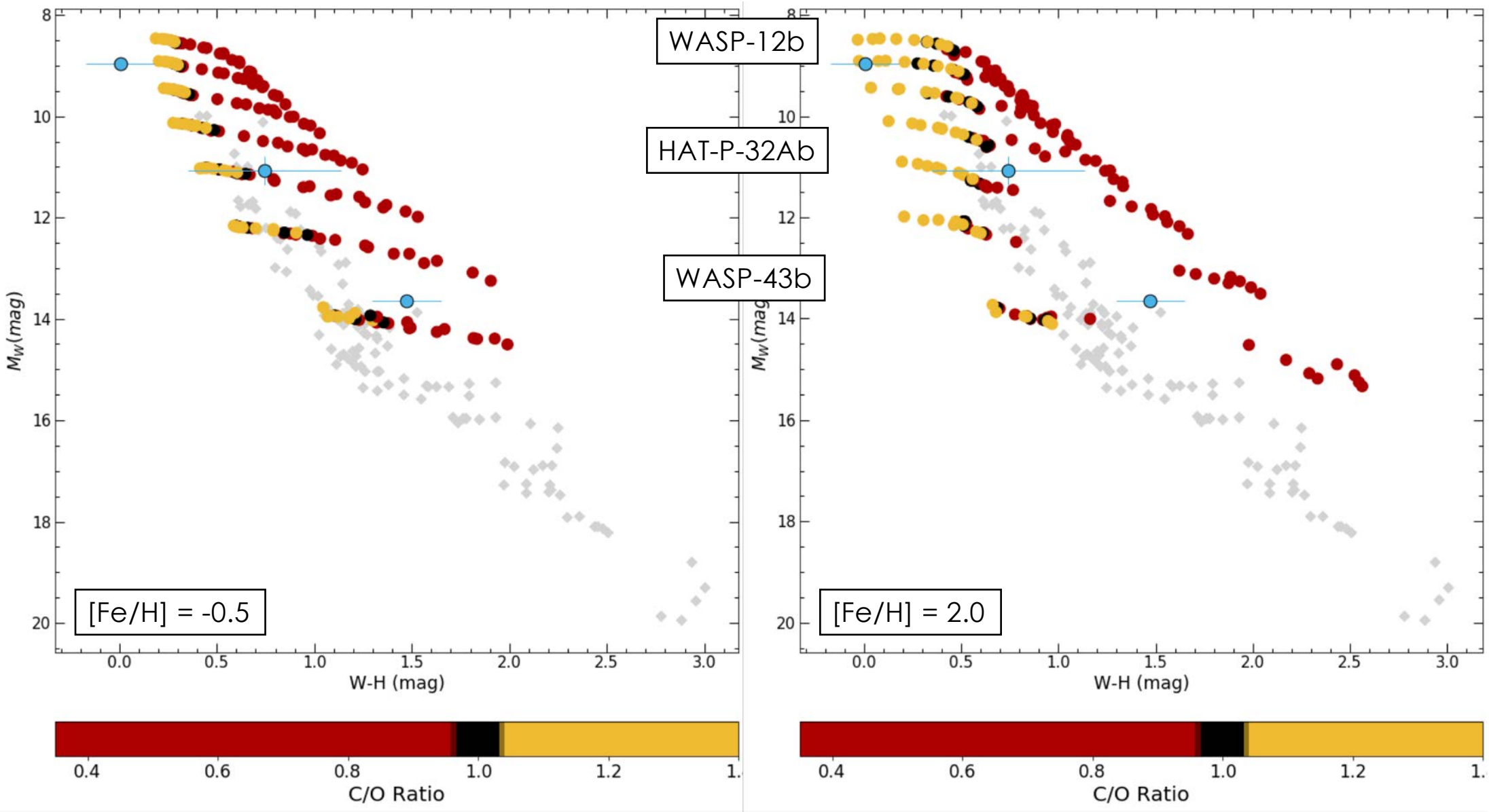
We have a tool for that!

Another Comparison Sample

- We made synthetic photometry from Molliere's model exoplanet spectra (Molliere et al. 2015)

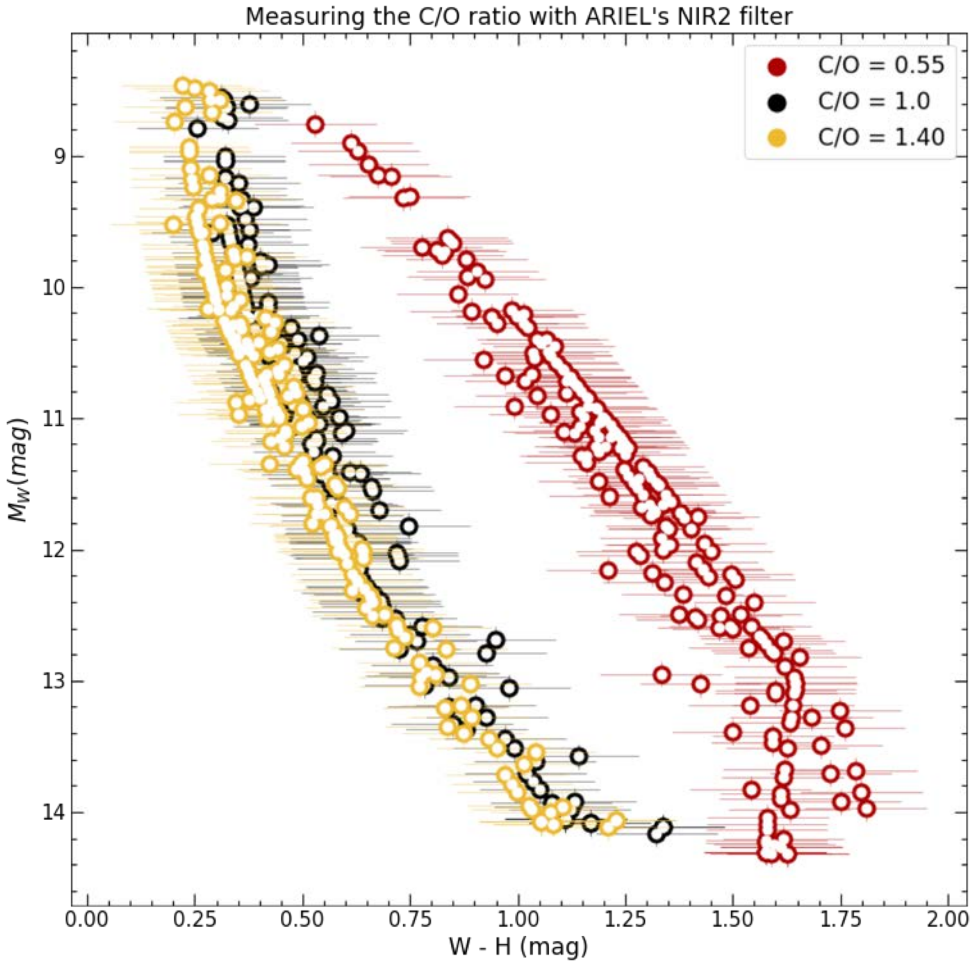
We have a tool for that!




WASP-12b
HAT-P-32Ab
WASP-43b
[Fe/H] = -0.5
[Fe/H] = 2.0
M_W(mag)
W-H (mag)
C/O Ratio
8
10
12
14
16
18
20
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0.4
0.6
0.8
1.0
1.2

ARIEL Simulation for NIRSpec

- We were able to find constraints on R, Teq, SpT, stellar FeH for 210 targets on the published list (Edwards et. al. 2019) .
- Closest Molliere model spectrum was selected for each to make *[W-H] vs W* plot.
- NIRSpec covers the necessary wavelengths to make synthetic photometry in the *W* and *H bands*



To Sum Up

- A Colour-Magnitude Diagram will never replace a full spectrum, but it can give valuable constraints to **select interesting targets for Tier 2 & Tier 3**, or any follow-up.
- A Colour-Magnitude diagram can **identify molecules,** such as lack of Phosphine in exoplanetary atmospheres.
- A Colour-Magnitude Diagram can be used to **constrain the C/O of planets**.

ALL OF THE ABOVE CAN BE DONE WITH OUR TOOLS.

Thanks + Questions?