FCLA
French-Chilean Laboratory for Astronomy

Astronomía
FACULTAD DE CIENCIAS FÍSICAS Y MATEMÁTICAS UNIVERSIDAD DE CHILE

ATMOSPHERES AS A CLUE TO DISTINGUISH BETWEEN FORMATION MECHANISMS

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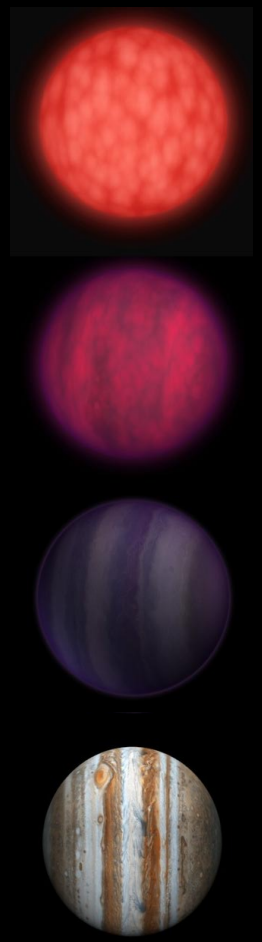
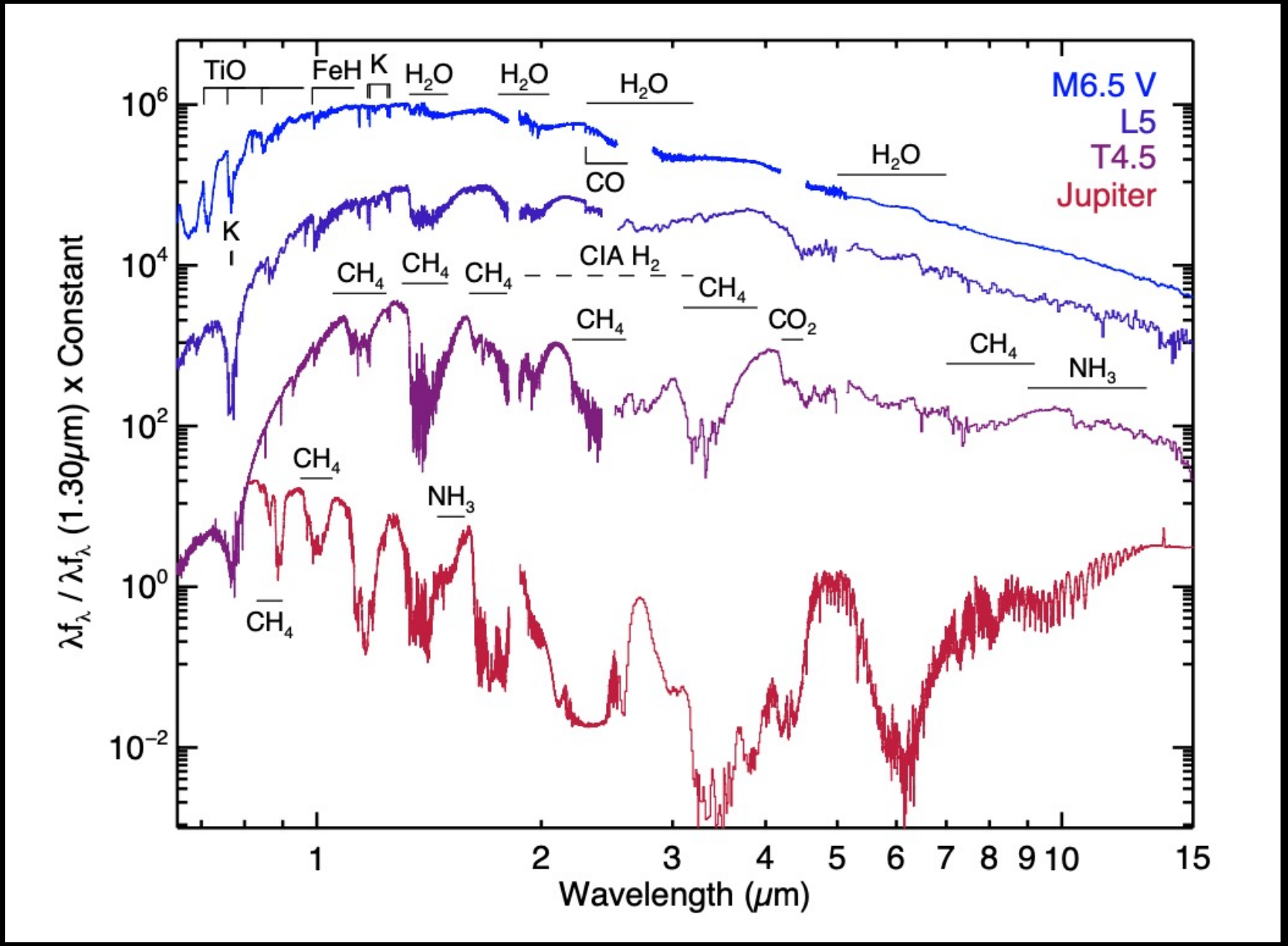
I. Background
II. Targets & Observations
III. Models
IV. Limitations

How do we distinguish a massive planet from a brown dwarf?





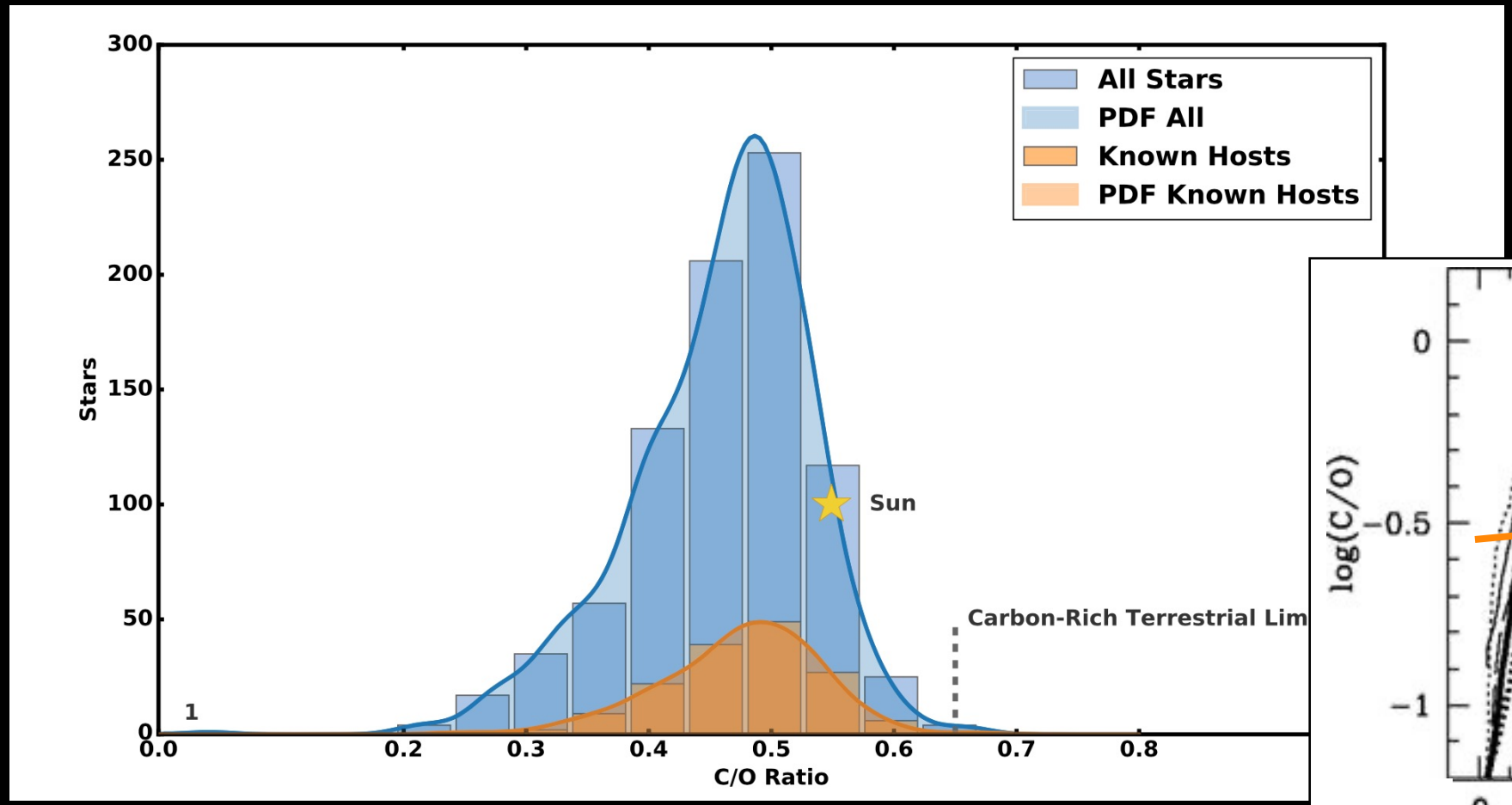
Fortney (2018)

Can we relate the atmospheric features to a formation process?

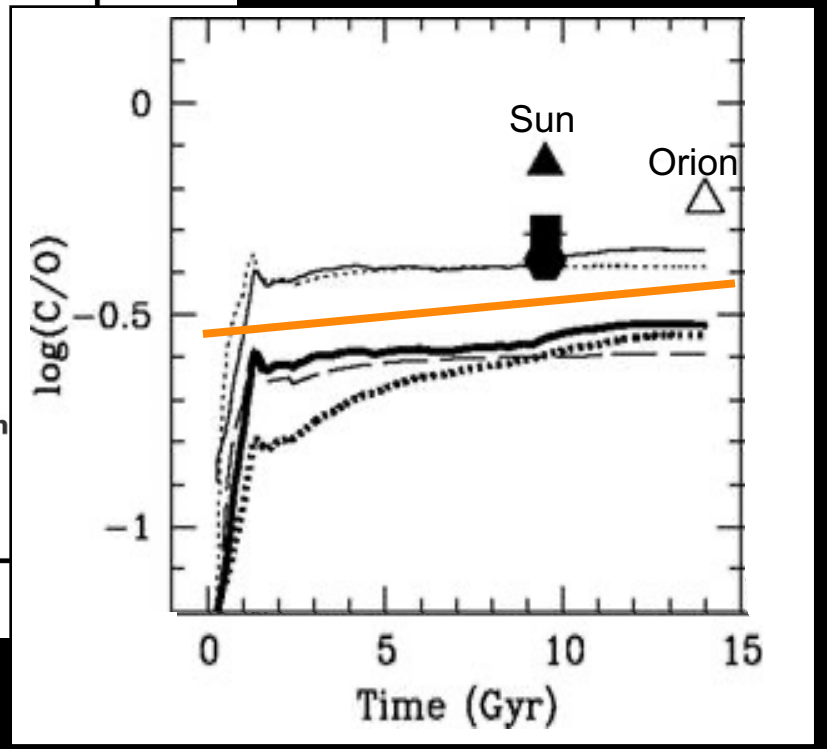
Probably yes, through the study of their composition

C/O, $[Fe/H]$, …

What is the C/O ratio of stars in general?



Brewer & Fisher (2016)



Chiappini et al. (2003)

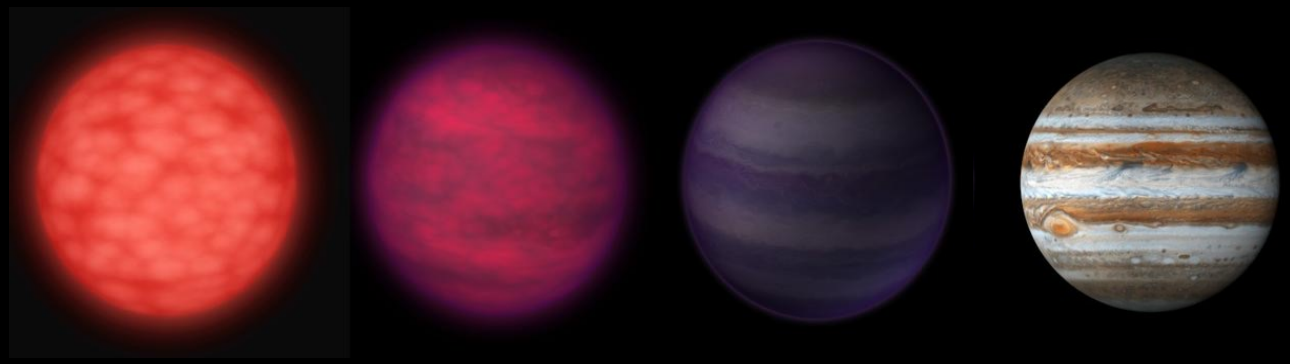
Brown Dwarfs

Gravoturbulent Fragmentation

Exoplanets

Core (Pebble) Accretion

Gravitational Instabilities (GI)



Migration

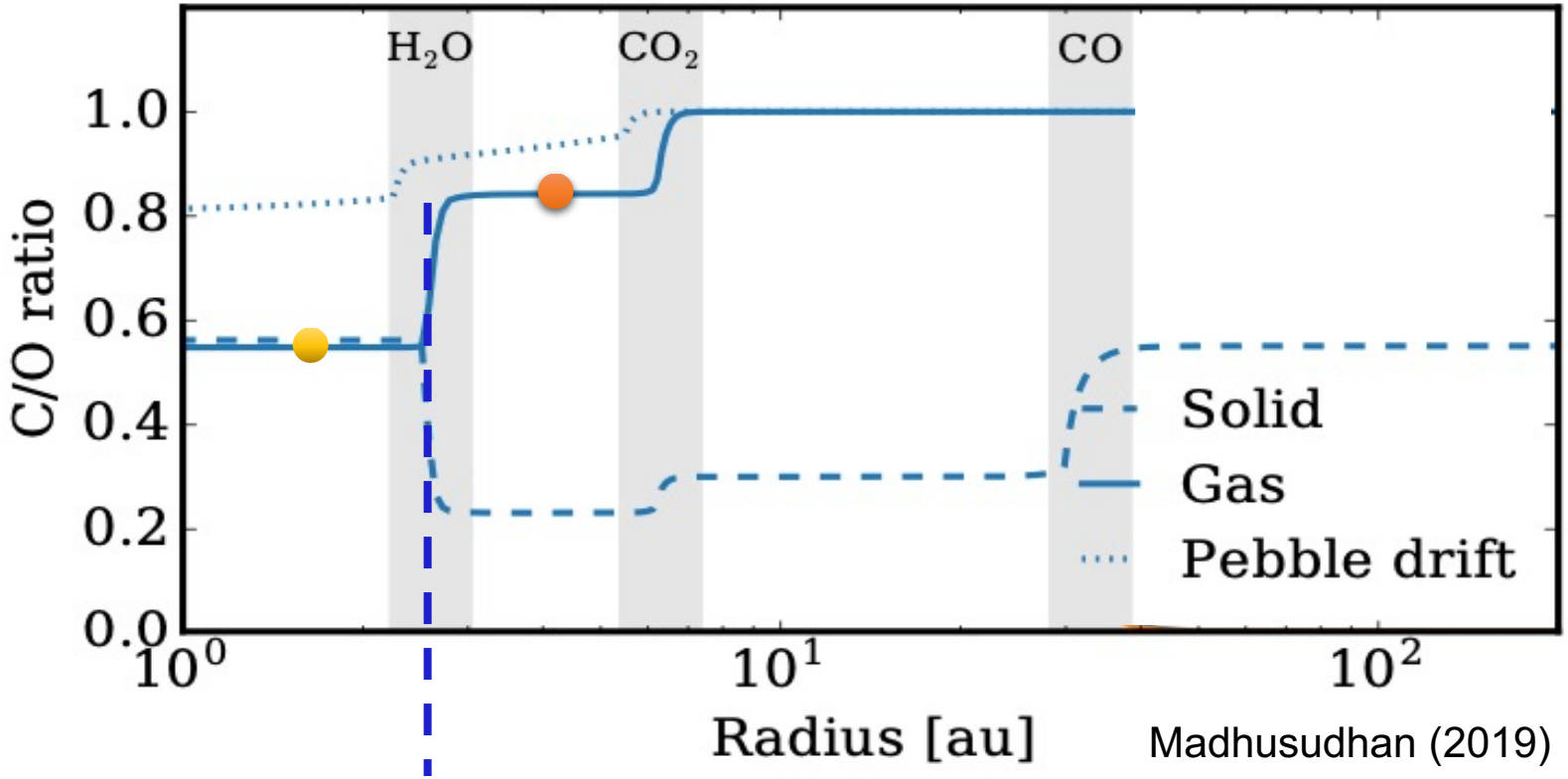
Type I

Type II

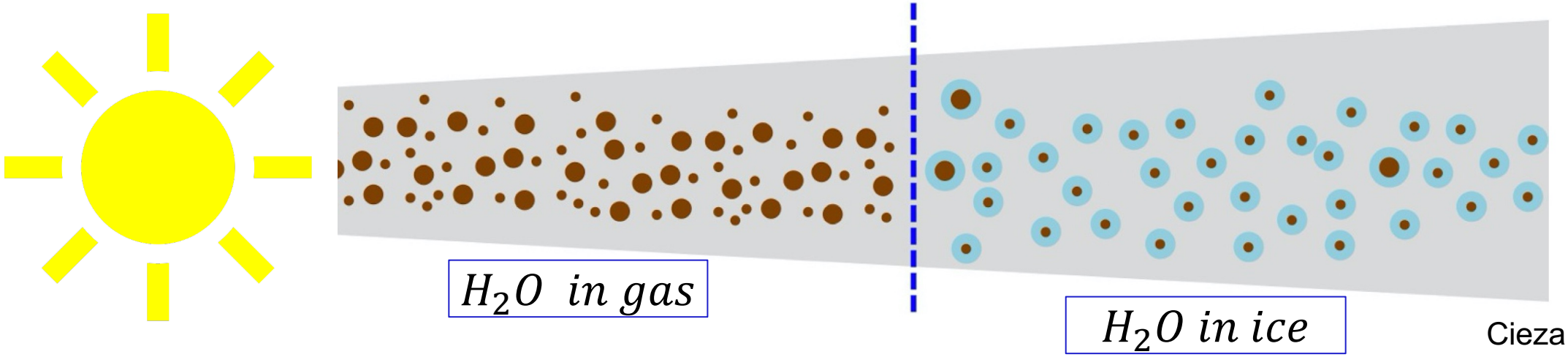
Type III

Planet-Planet Scattering

Snow Lines & C/O

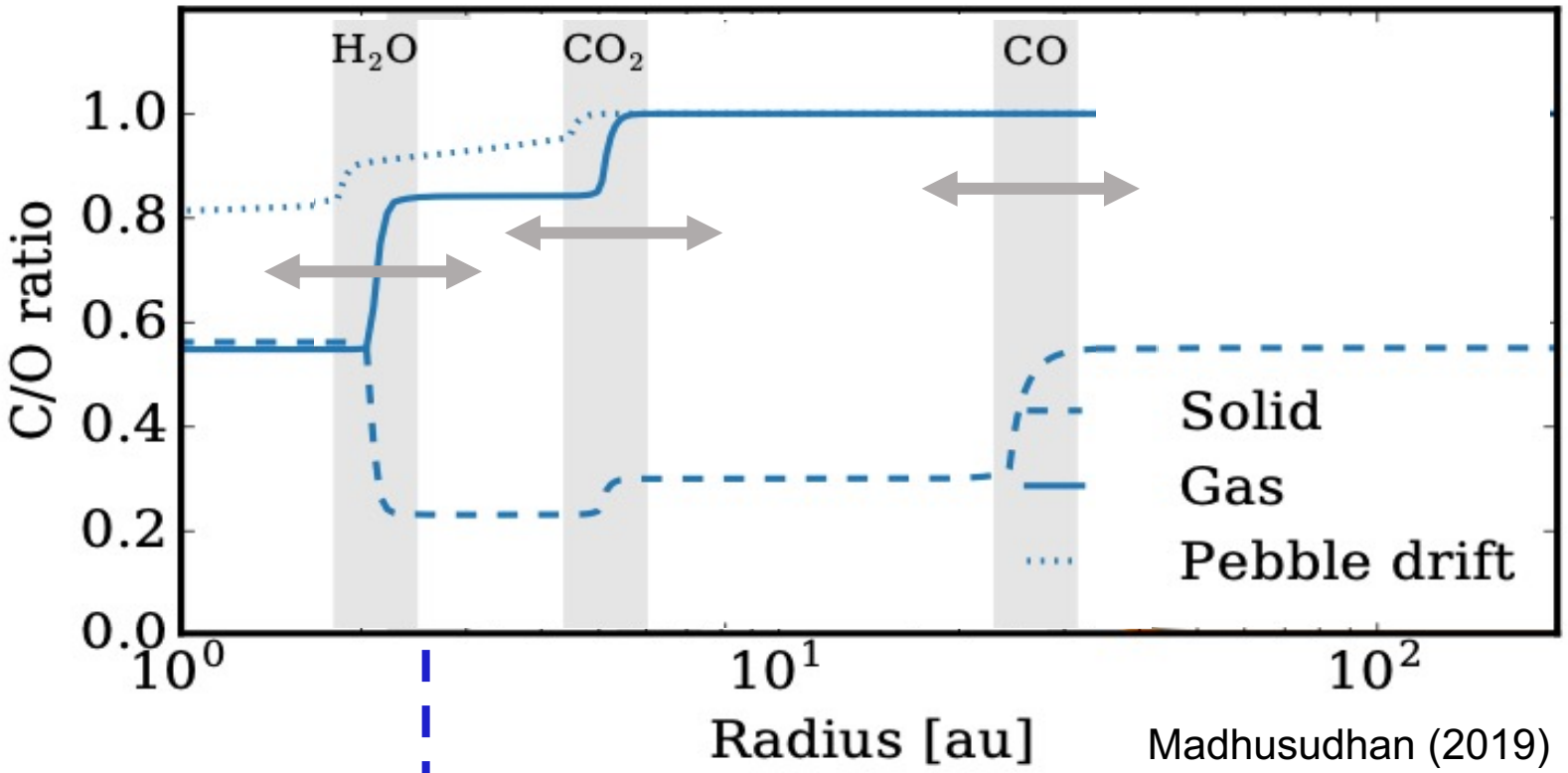


Madhusudhan (2019)

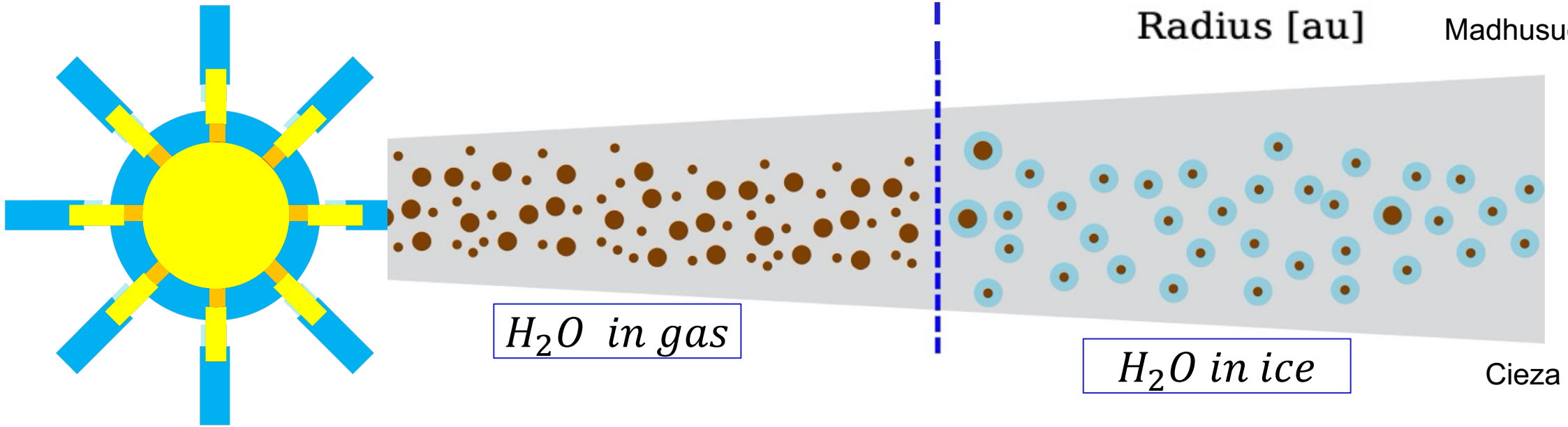


Cieza et al. (2016)

Snow Lines & C/O

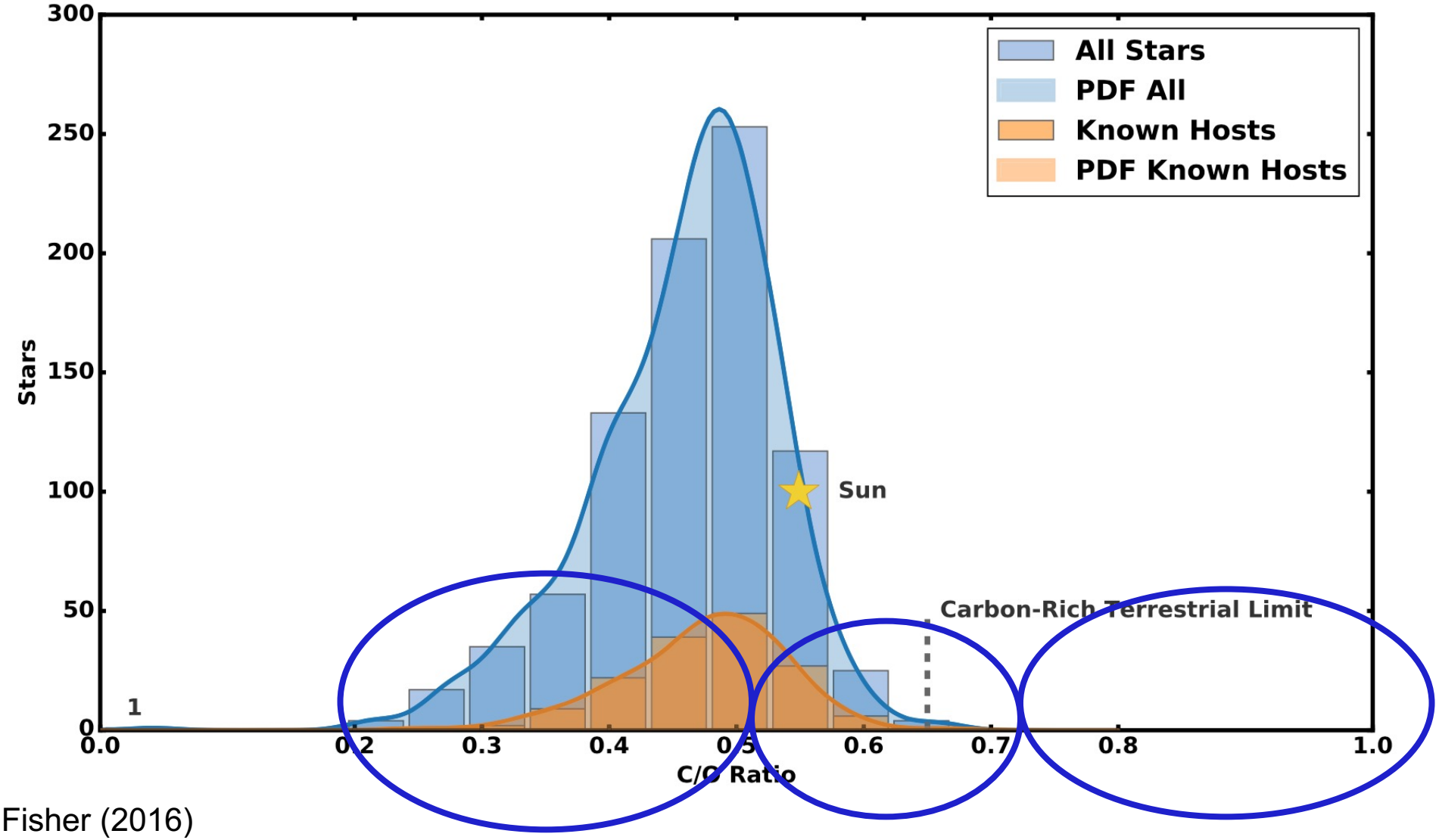


Madhusudhan (2019)



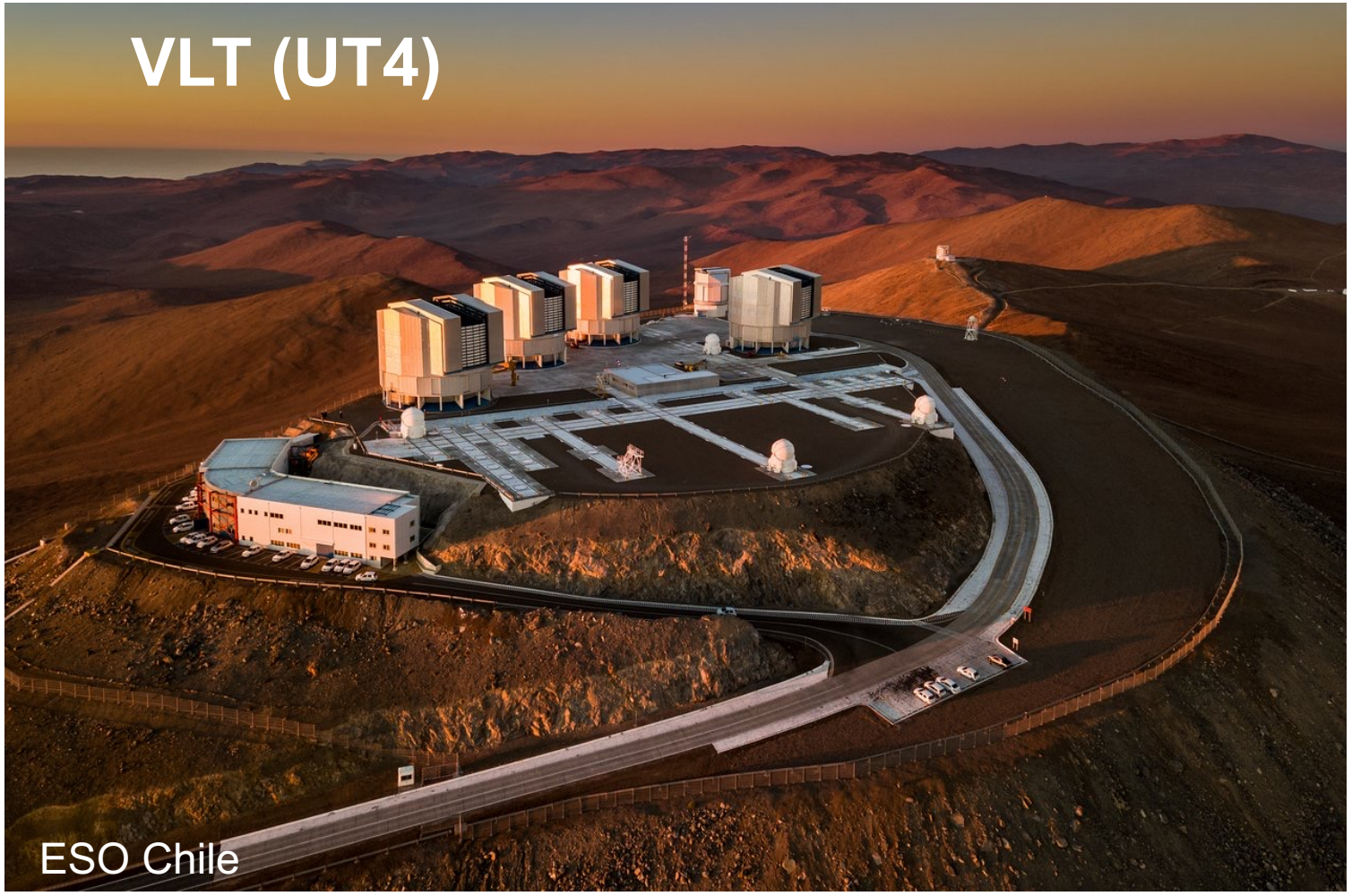
Cieza et al. (2016)

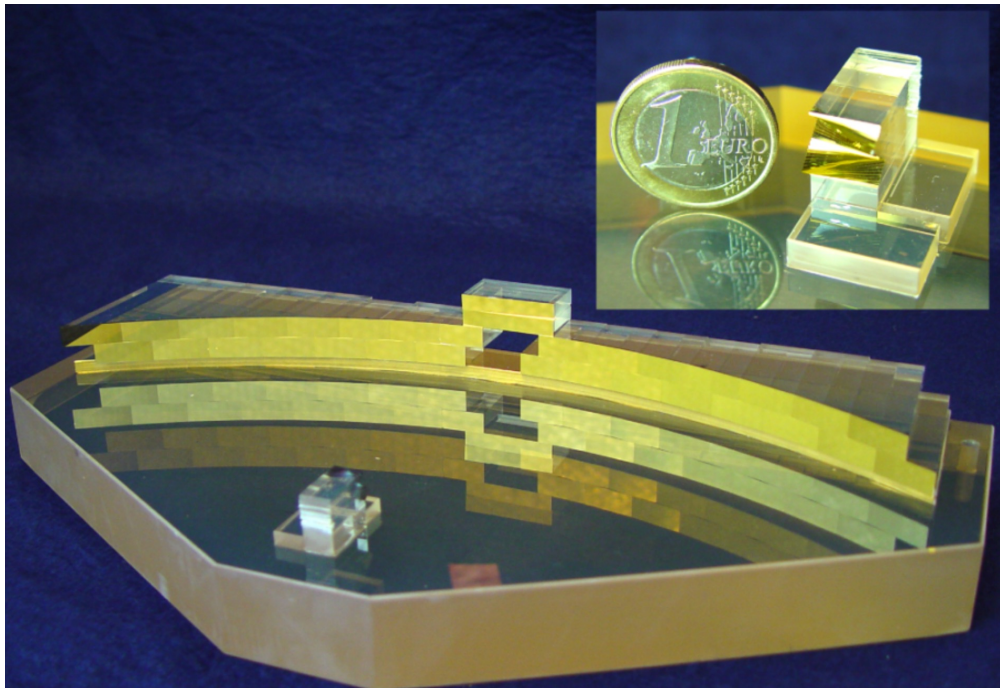
What is expected?



Brewer & Fisher (2016)

SINFONI Integral Field Spectrograph





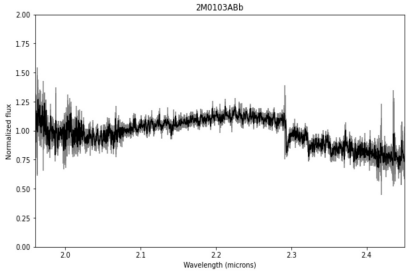
AO Mode: NGS/ NoAO

K-band (1.95 – 2.45 μm)

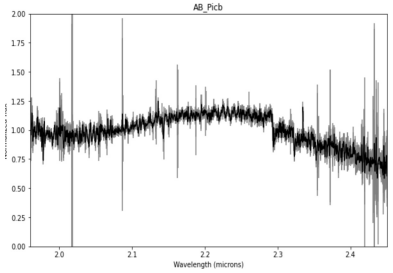
Resolution of 4000

Platescales of 0.25”/ 0.1”/ 0.025”

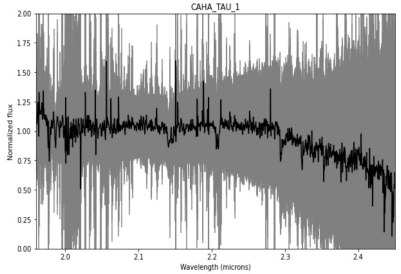
2M0103ABb



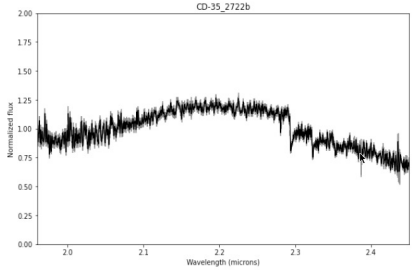
AB Pic b



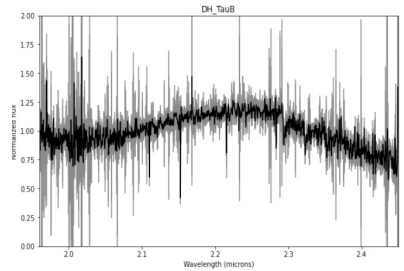
CAHA TAU 1



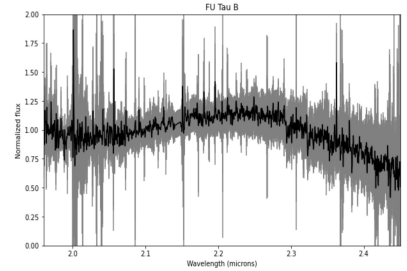
CD-35 2722B



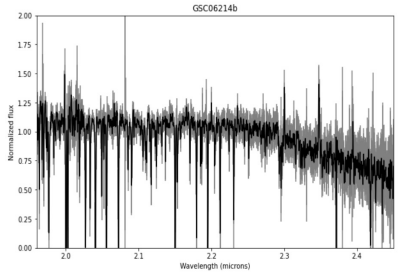
DH Tau b



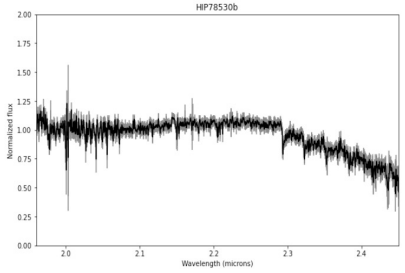
FU Tau B



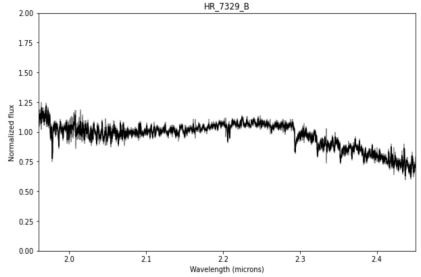
GSC 06214 b



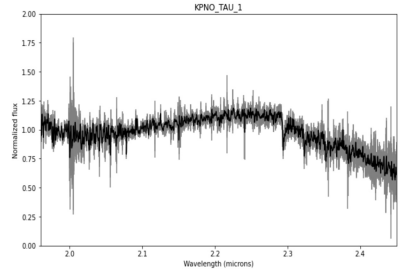
HIP 78530b



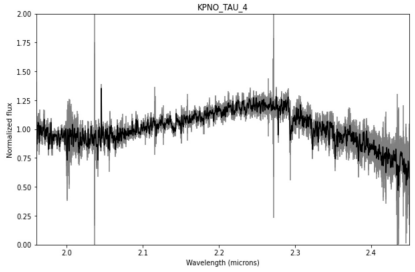
HR 7329 B



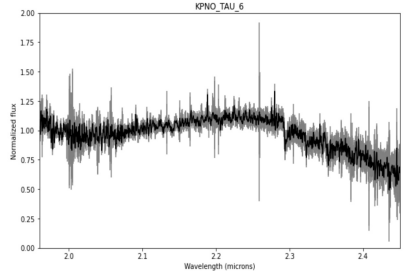
KPNO TAU 1



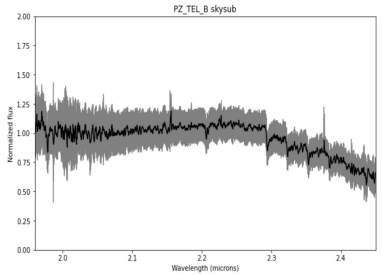
KPNO Tau 4



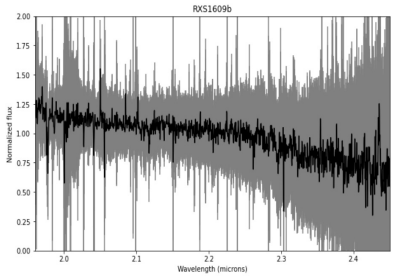
KPNO TAU 6



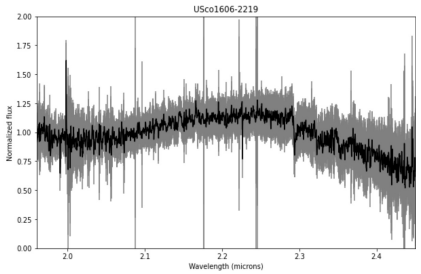
PZ Tel B



RXS 1609 B



Usco 1606-2219



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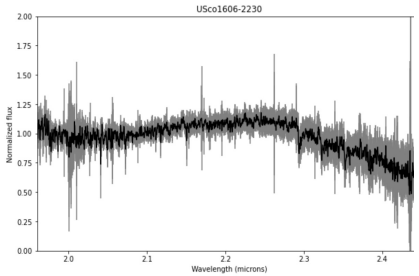

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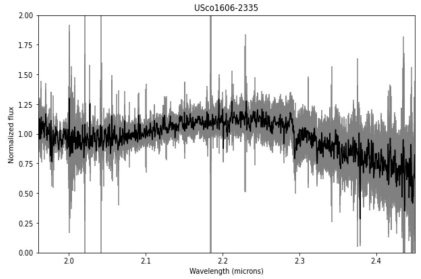

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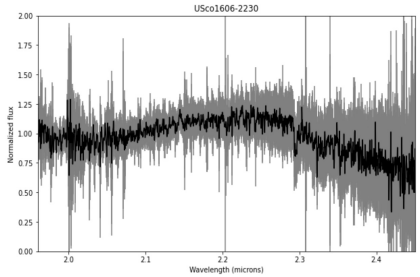

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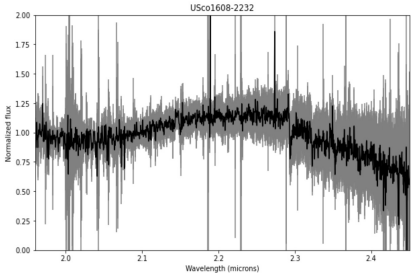

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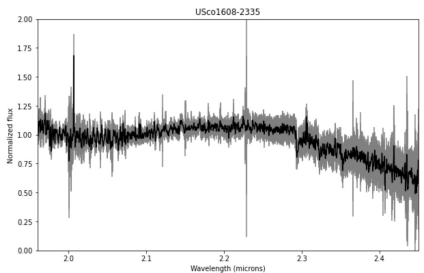
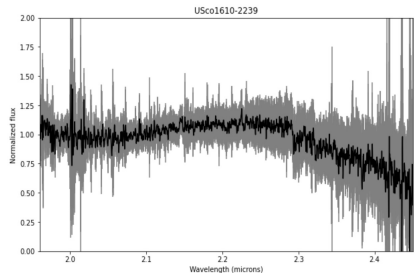


Usco 1610-2239



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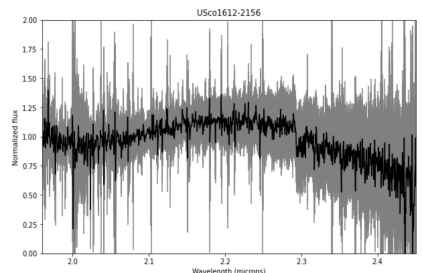
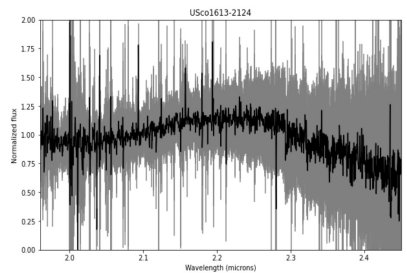
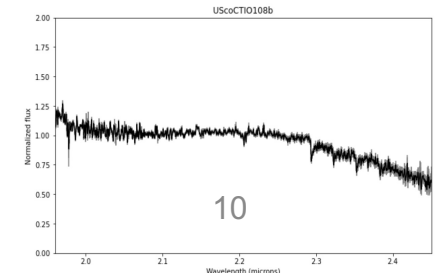
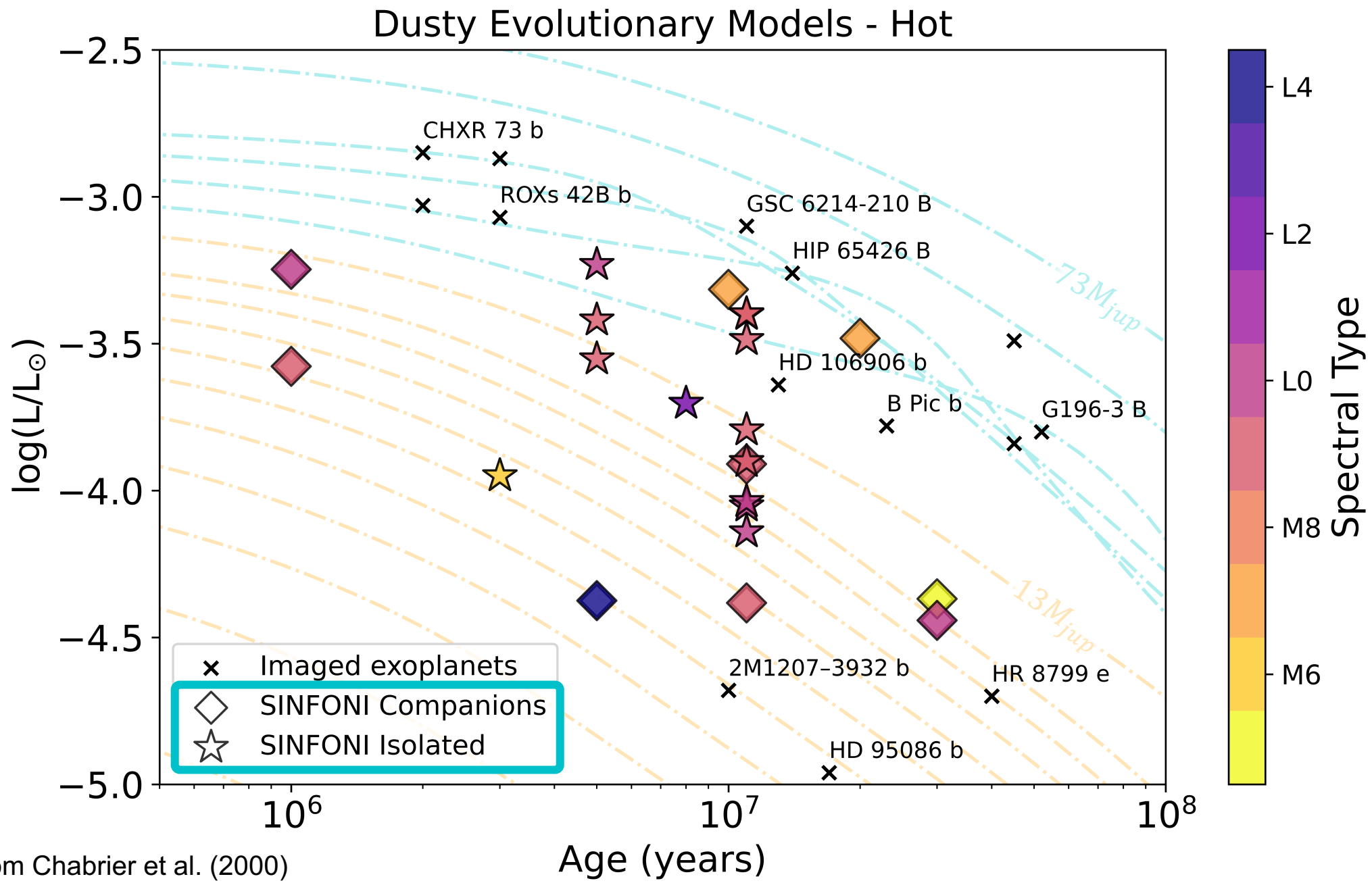


Usco 1613-2124



Usco CTIO 108 AB

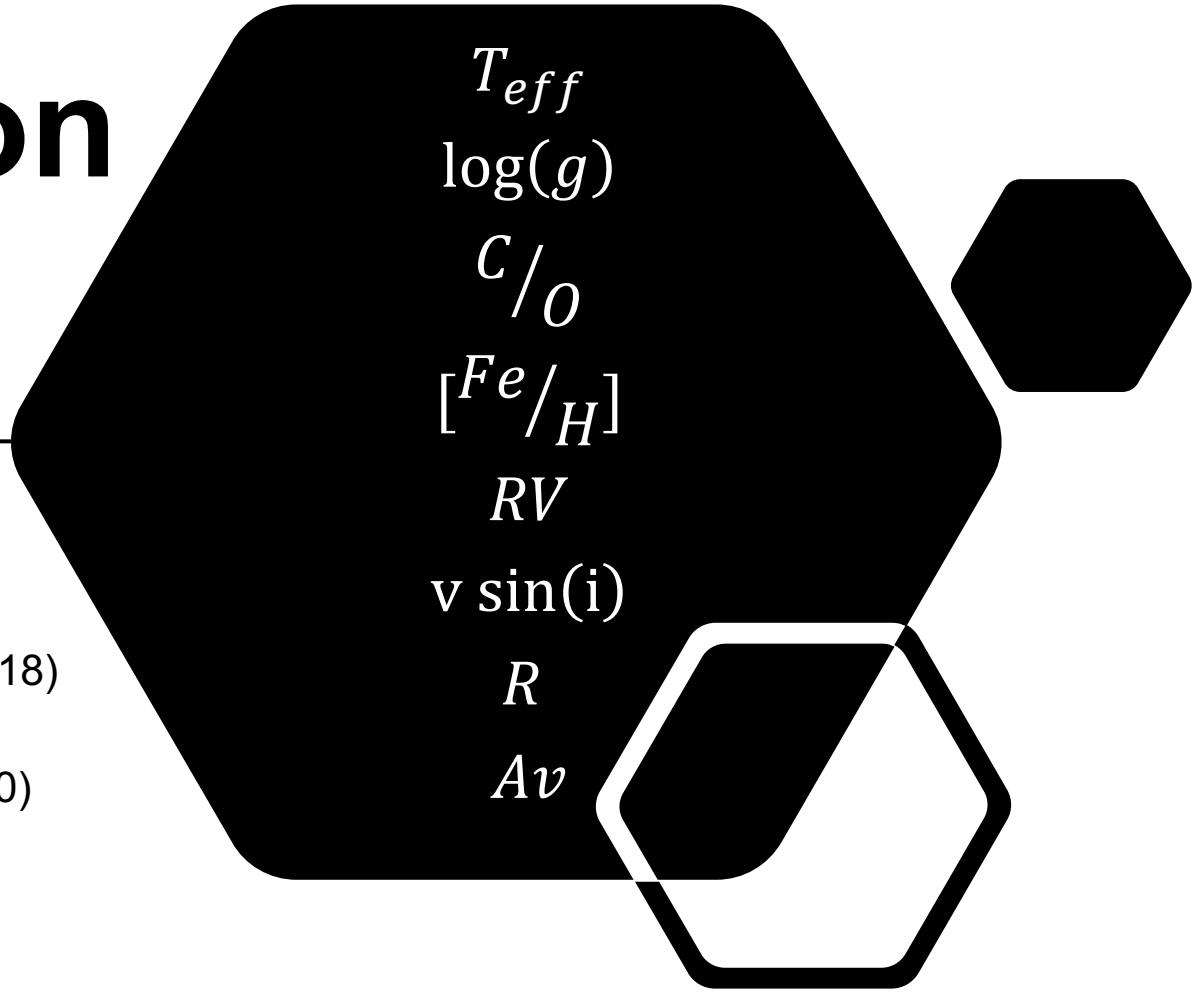




Models from Chabrier et al. (2000)

Model exploration with **ForMoSA**

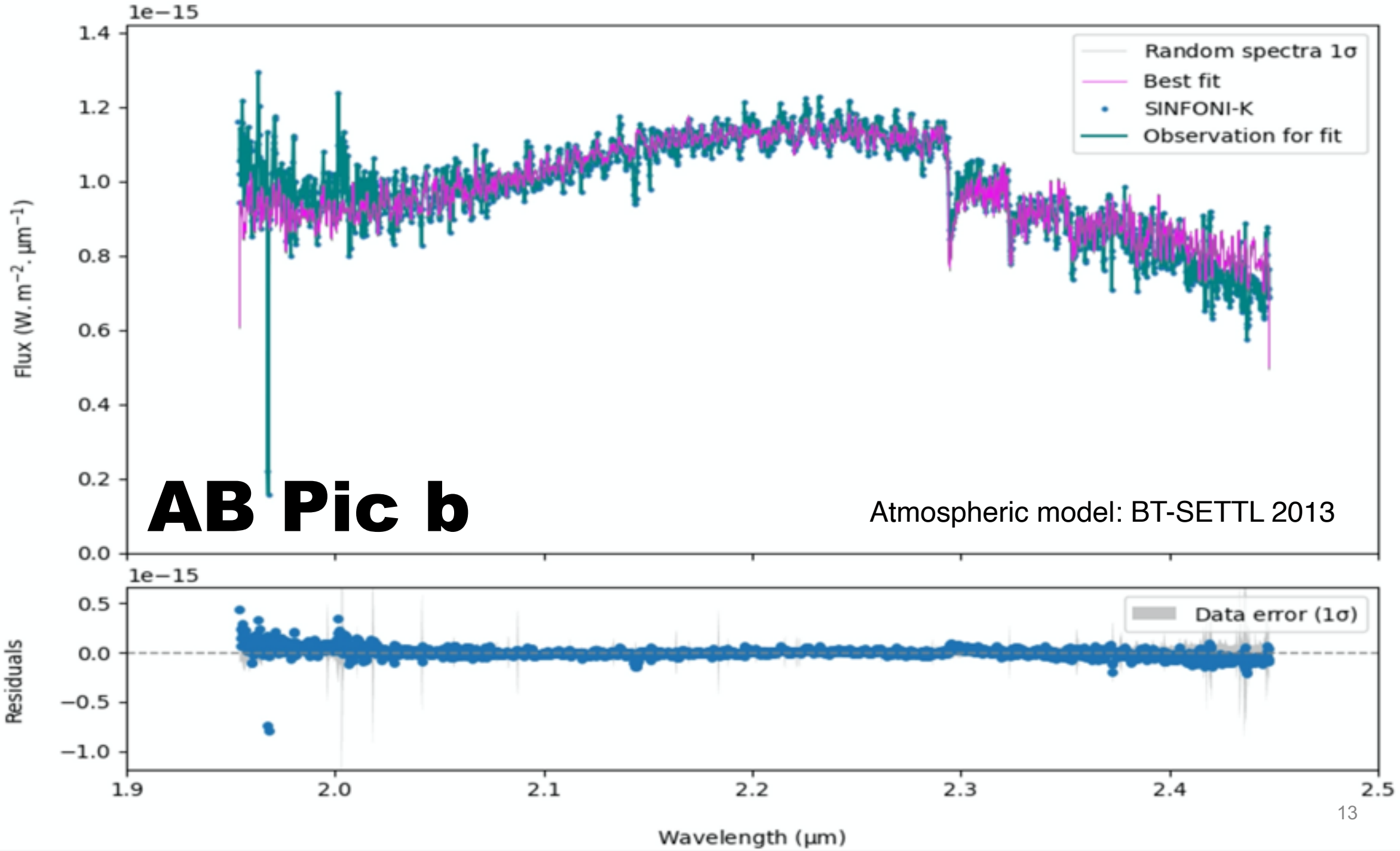
Petru et al. (2020)



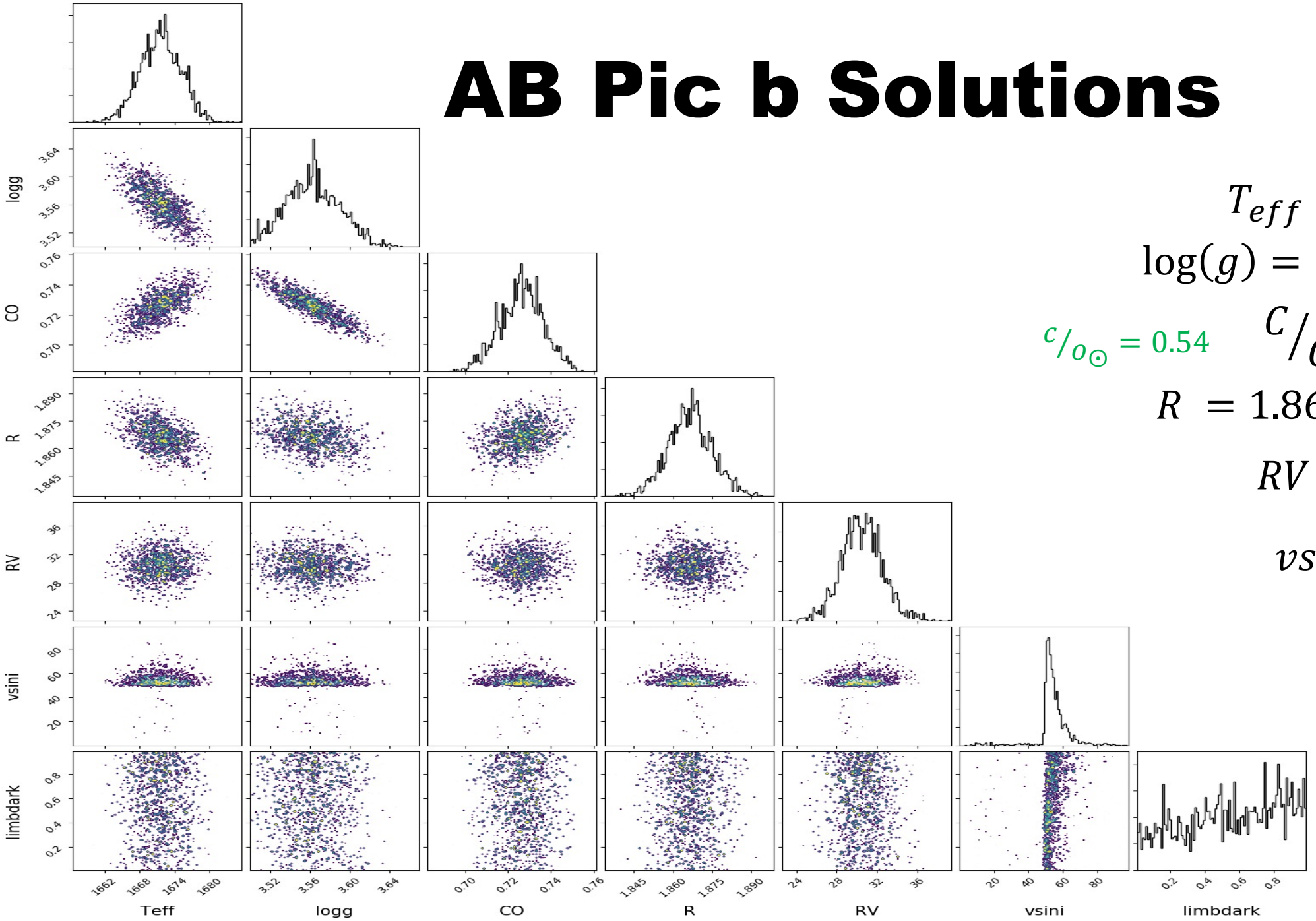
BT-SETTL 2013 **Allard (2013)**

Exo-REM Charnay et al. (2018)

ATMO 2021 Phillips et al. (2020)


1e−15
Random spectra 1σ
Best fit
SINFONI-K
Observation for fit
Flux (W.m^{-2}.μm^{-1})
AB Pic b
Atmospheric model: BT-SETTL 2013
1e−15
Data error (1σ)
Residuals
Wavelength (μm)

AB Pic b Solutions



$T_{eff} = 1671 \pm 10\ K$

$\log(g) = 3.56 \pm 0.04\ dex$

$^{C}/_{O_{\odot}} = 0.54$ $\quad ^{C}/_{O} = 0.73 \pm 0.02$

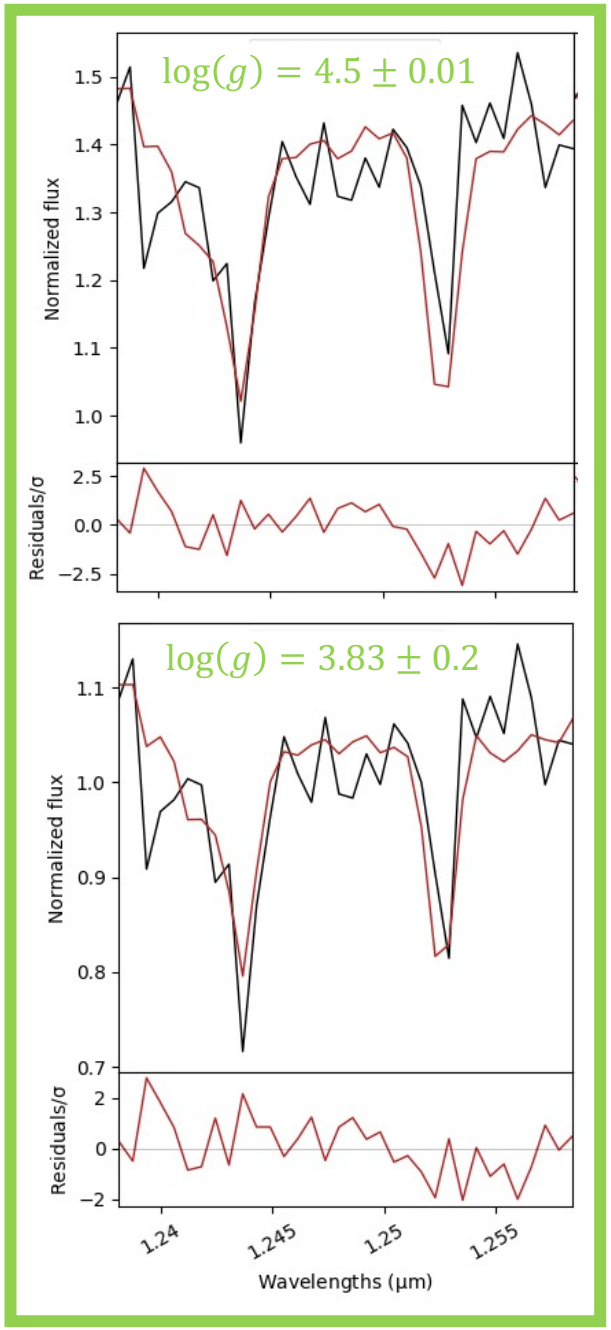
$R = 1.868 \pm 0.005\ R_{jup}$

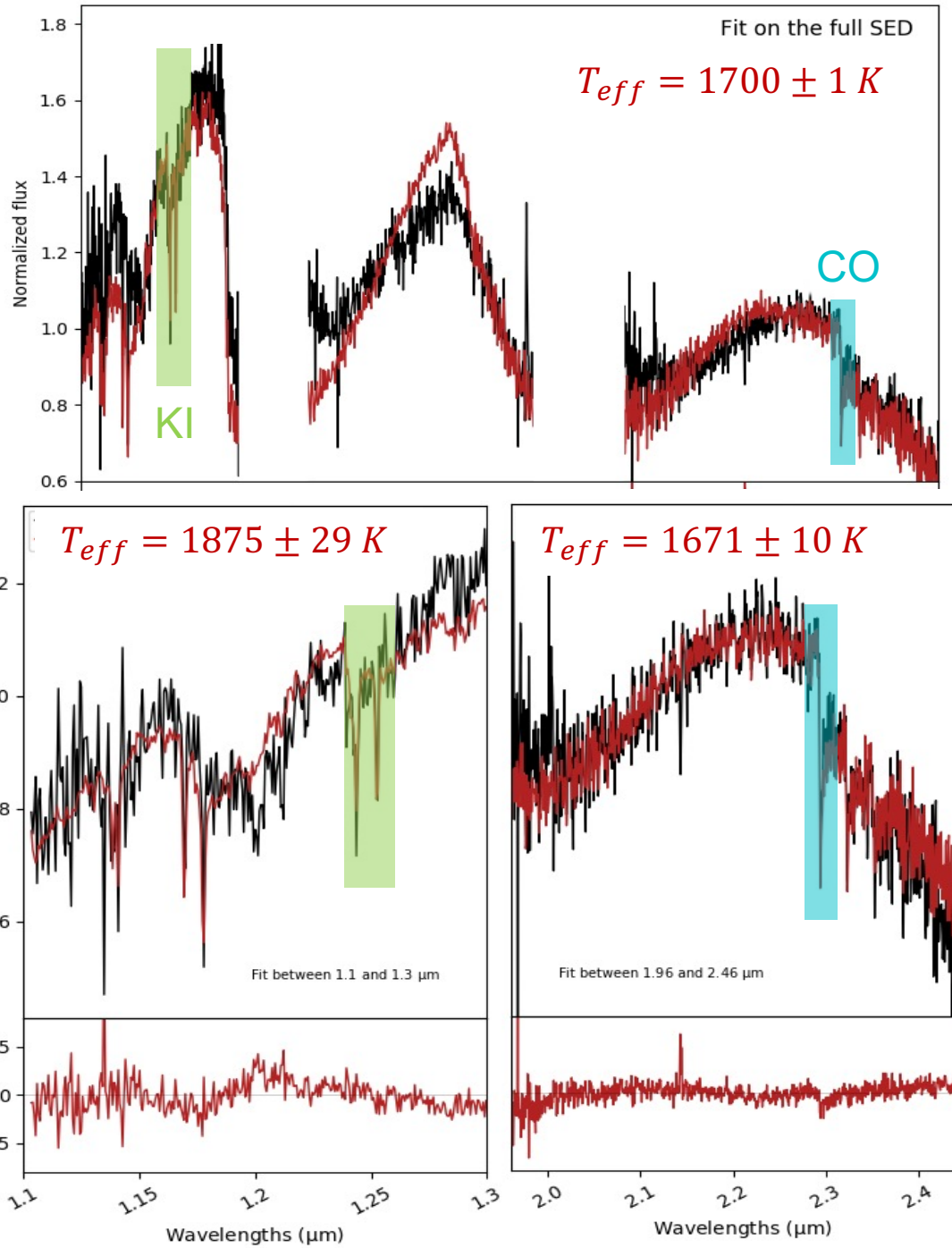
$RV = 30 \pm 2\ ^{km}/_{s}$

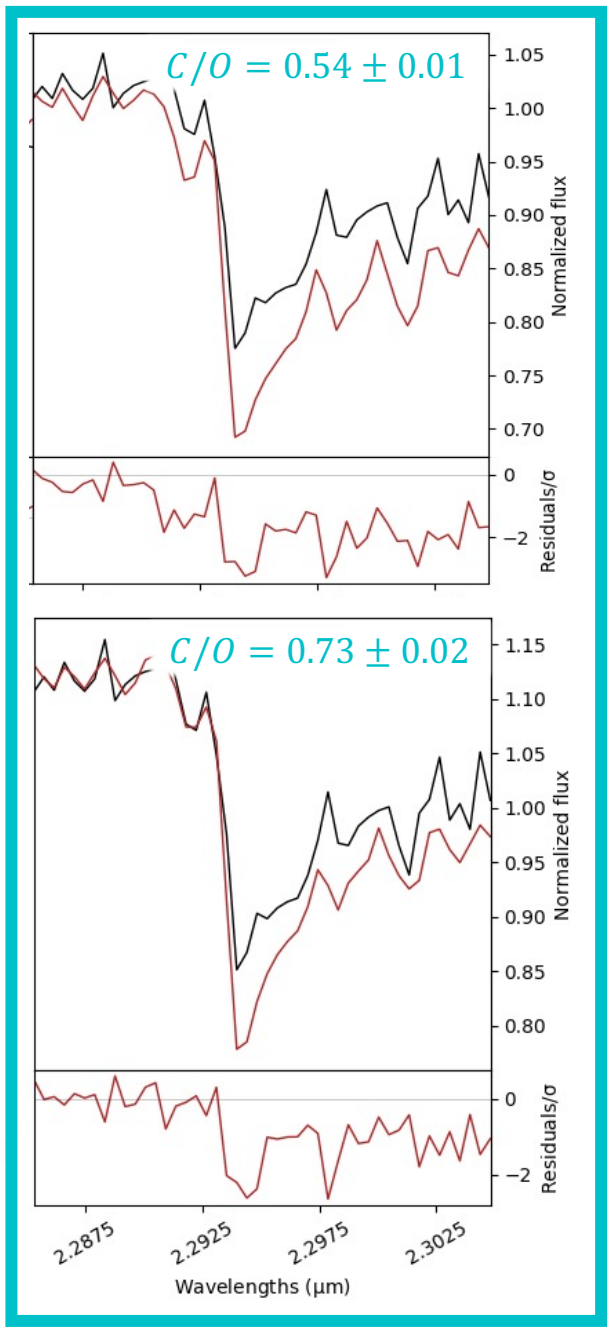
$vsin(i) > 48\ ^{km}/_{s}$

limbdark

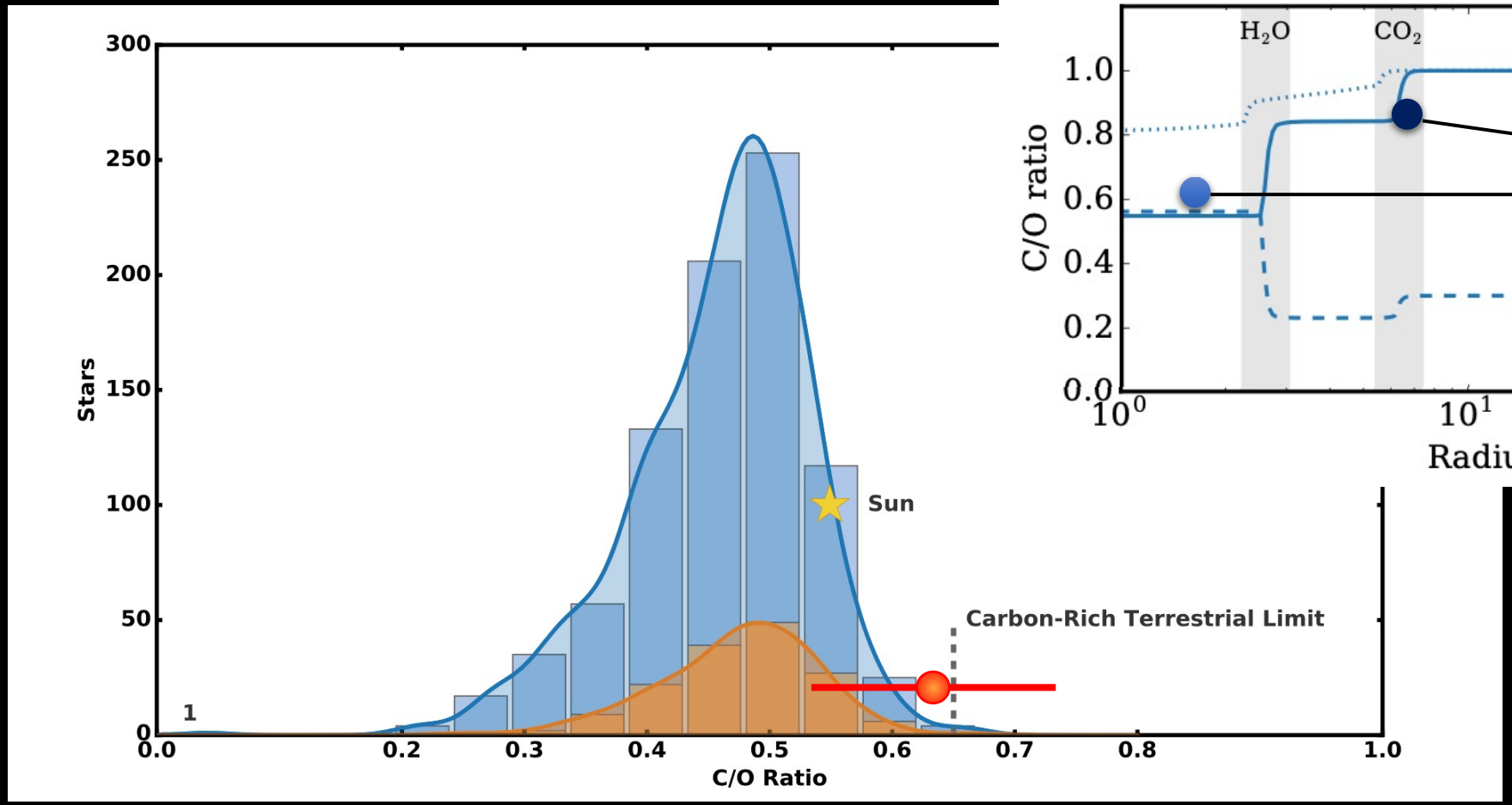
Can we trust these results?

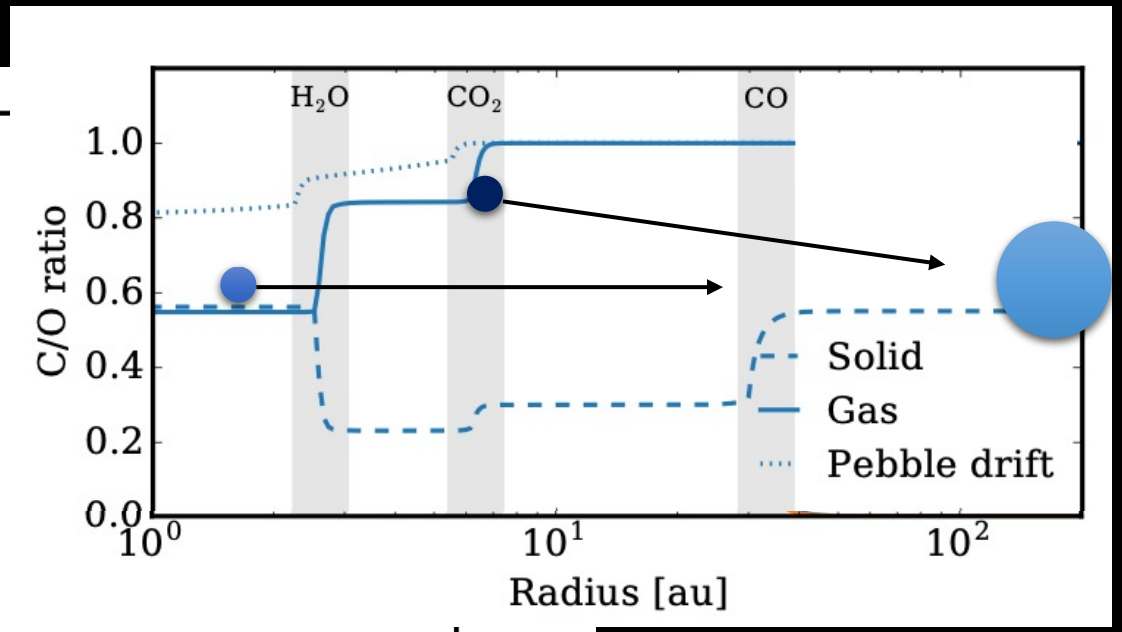

$\log(g) = 4.5 \pm 0.01$
$\log(g) = 3.83 \pm 0.2$
Normalized flux
Residuals/σ
Wavelengths (μm)


Fit on the full SED
$T_{eff} = 1700 \pm 1\ K$
$T_{eff} = 1875 \pm 29\ K$
$T_{eff} = 1671 \pm 10\ K$
KI
CO
Fit between 1.1 and 1.3 μm
Fit between 1.96 and 2.46 μm
Normalized flux
Residuals/σ
Wavelengths (μm)


$C/O = 0.54 \pm 0.01$
$C/O = 0.73 \pm 0.02$
Normalized flux
Residuals/σ
Wavelengths (μm)

Whow does AB Pic b compare with the stars?





Brewer & Fisher (2016)

- $^{C}/_{O}$ and $[^{Fe}/_{H}]$ can trace the origin of formation
  - Precise spectral analysis is challenging

- We have to be sure that $T_{eff} - \log(g) - {}^{C}/_{O} - [{}^{Fe}/_{H}]$ are not biased before getting any conclusions.

- This is the start of a systematic analysis to fill $^{C}/_{O}$ and $[^{Fe}/_{H}]$ histograms which will serve as a reference for exoplanets.