Novel methods to probe exoplanet atmospheres using ground based spectrophotometry

Vatsal Panwar

University of Amsterdam

Jean-Michel Désert (PI, UvA), Kamen Todorov, Jacob Bean, Catherine Huitson, Jonathan Fortney, Kevin Stevenson, Marcel Bergmann

ESO Atmo 2021

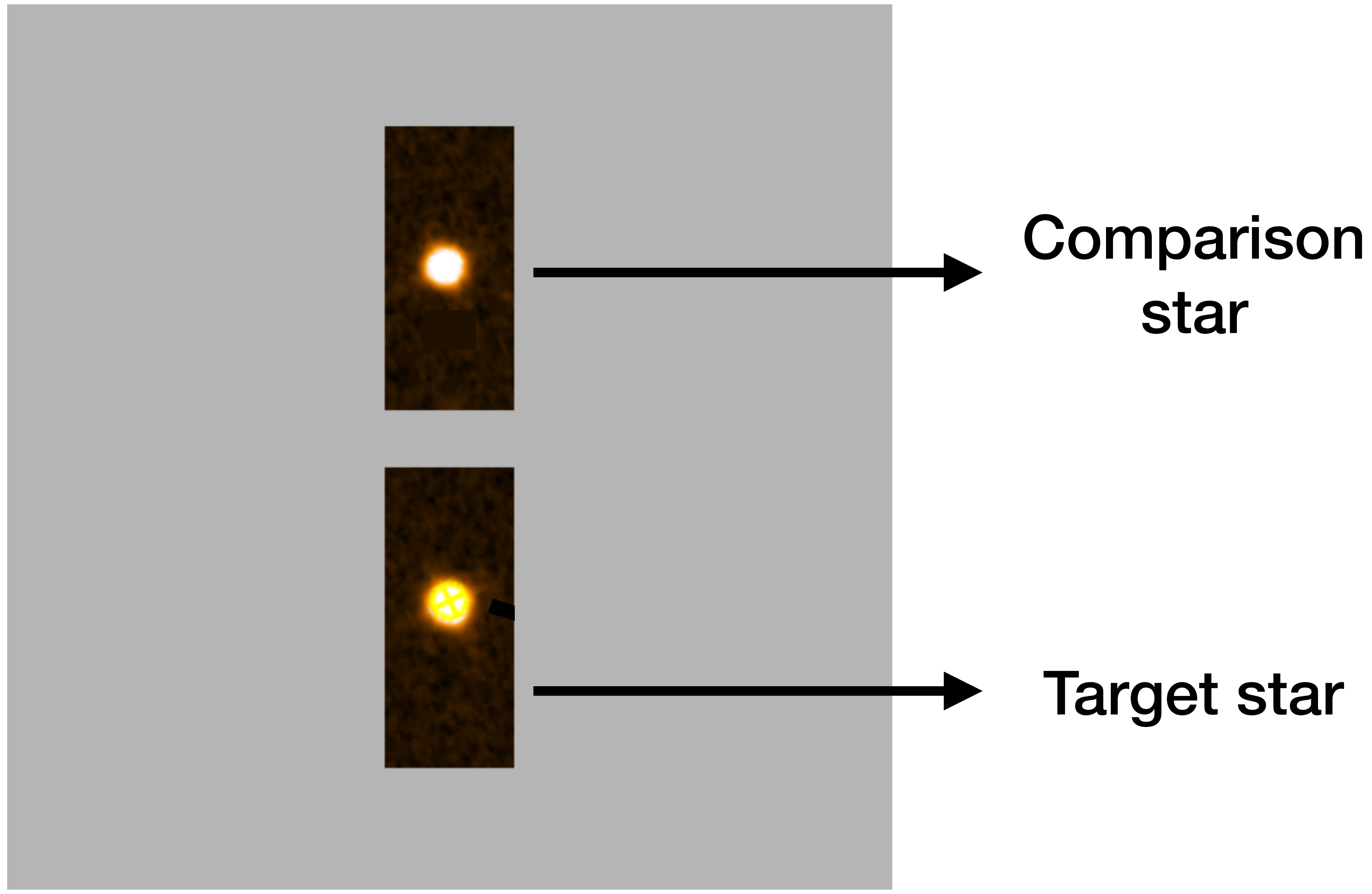
Probing Transiting Exoplanet Atmospheres

from ground, in low-resolution

Probing Transiting Exoplanet Atmospheres

from ground, in low-resolution

Traditional ground-based multi-object spectroscopy (MOS)



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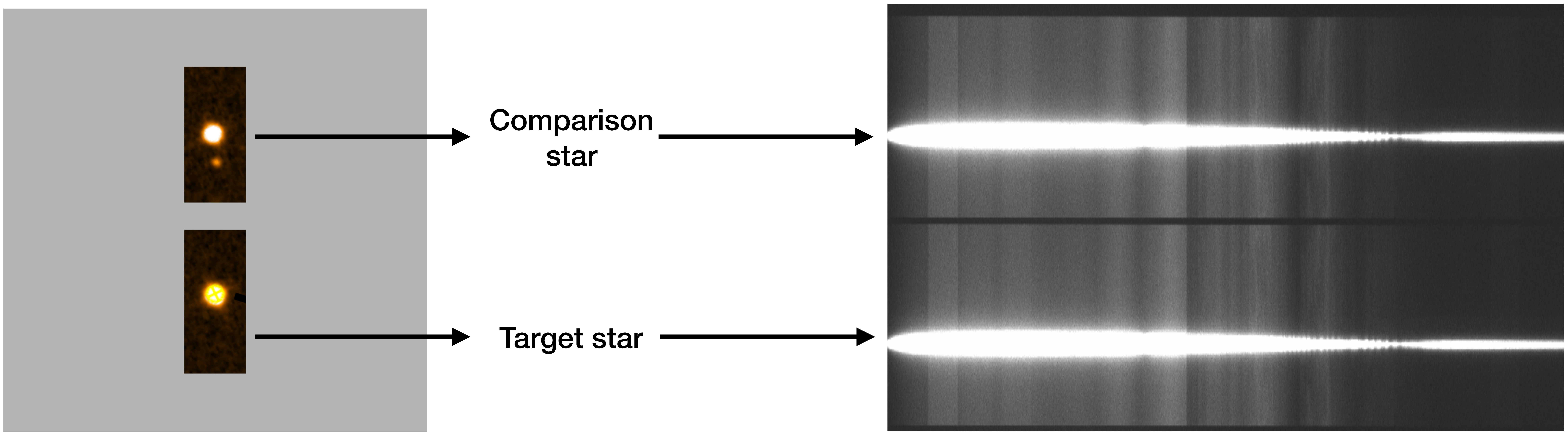

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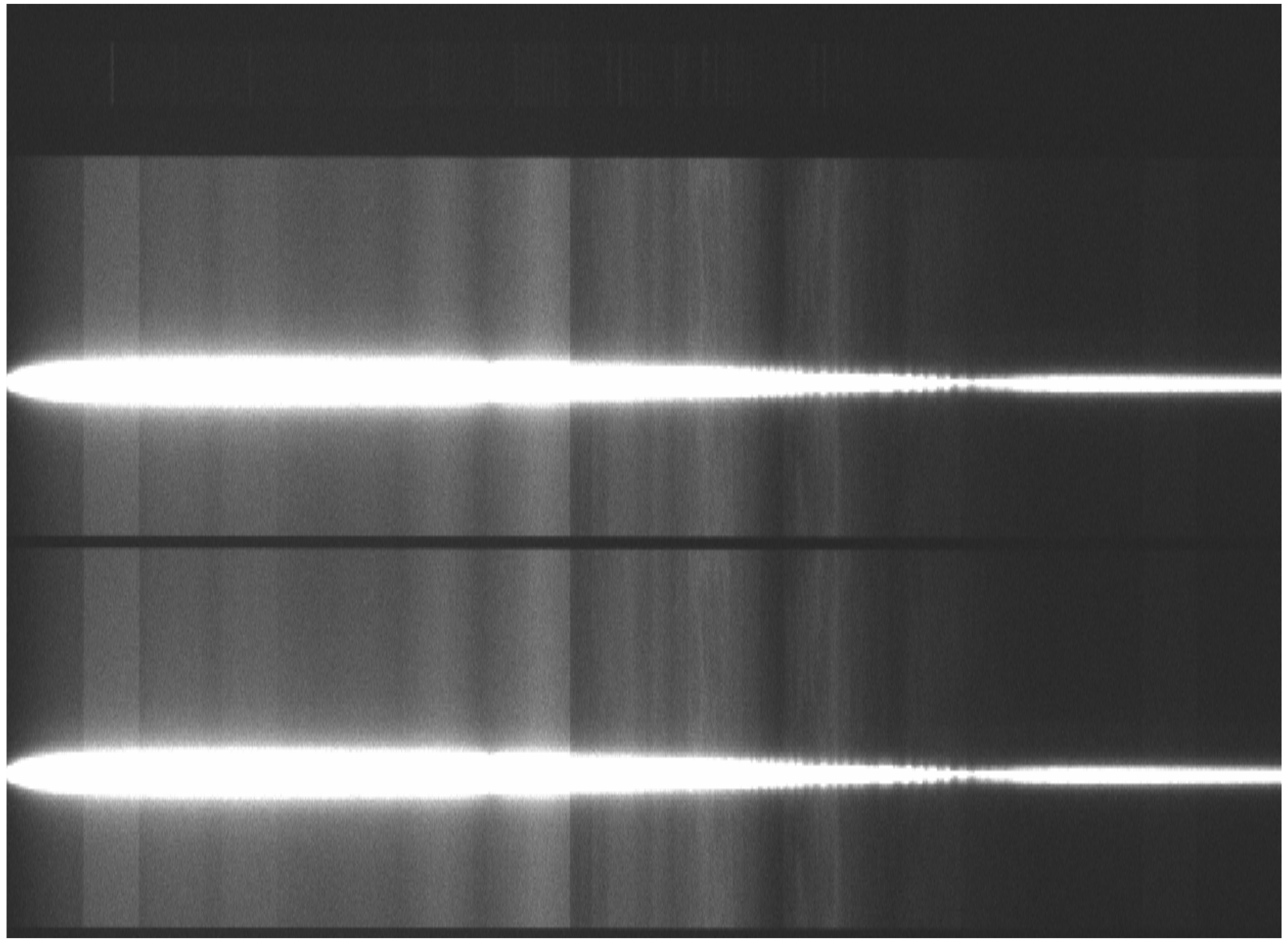

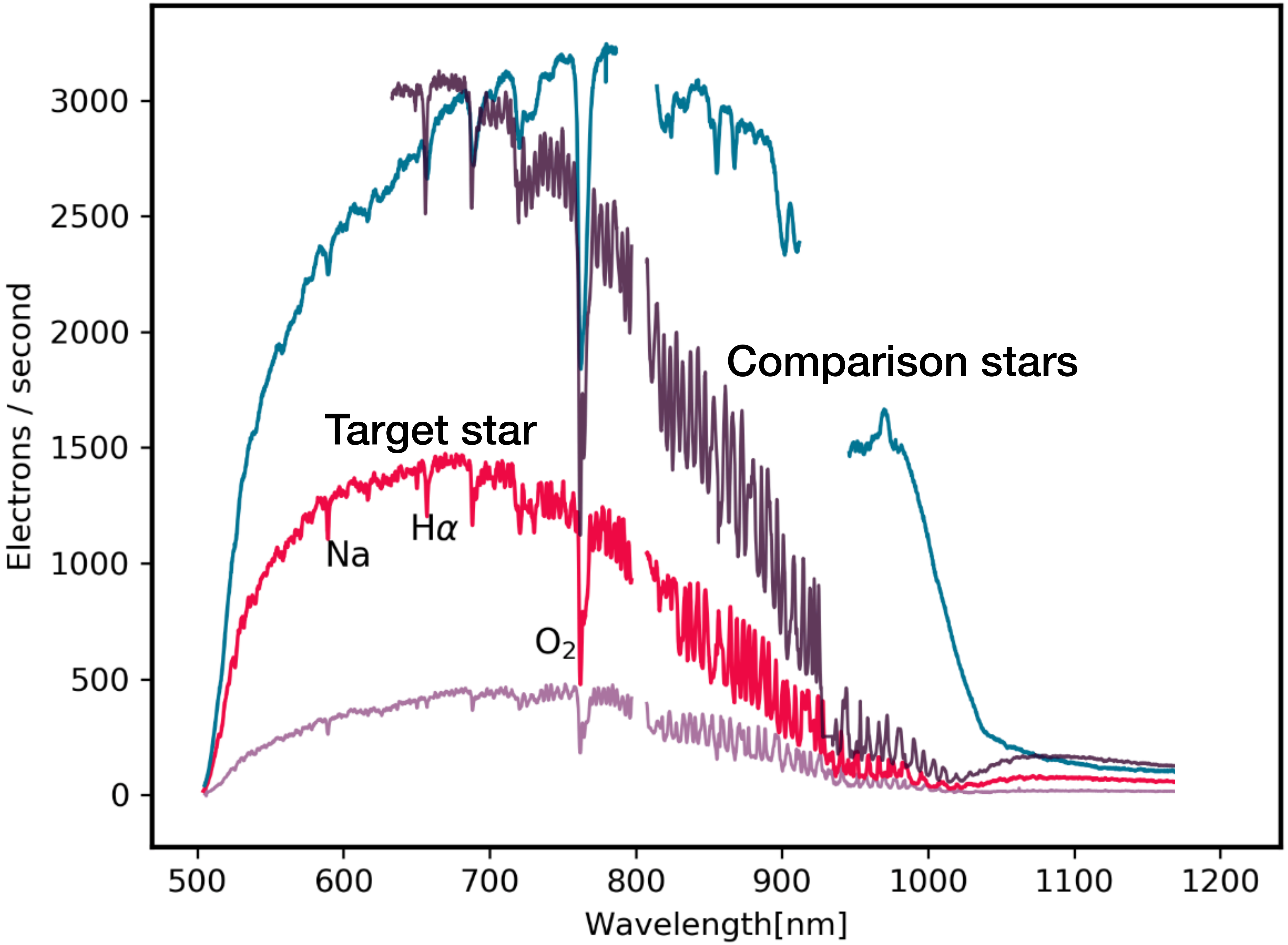

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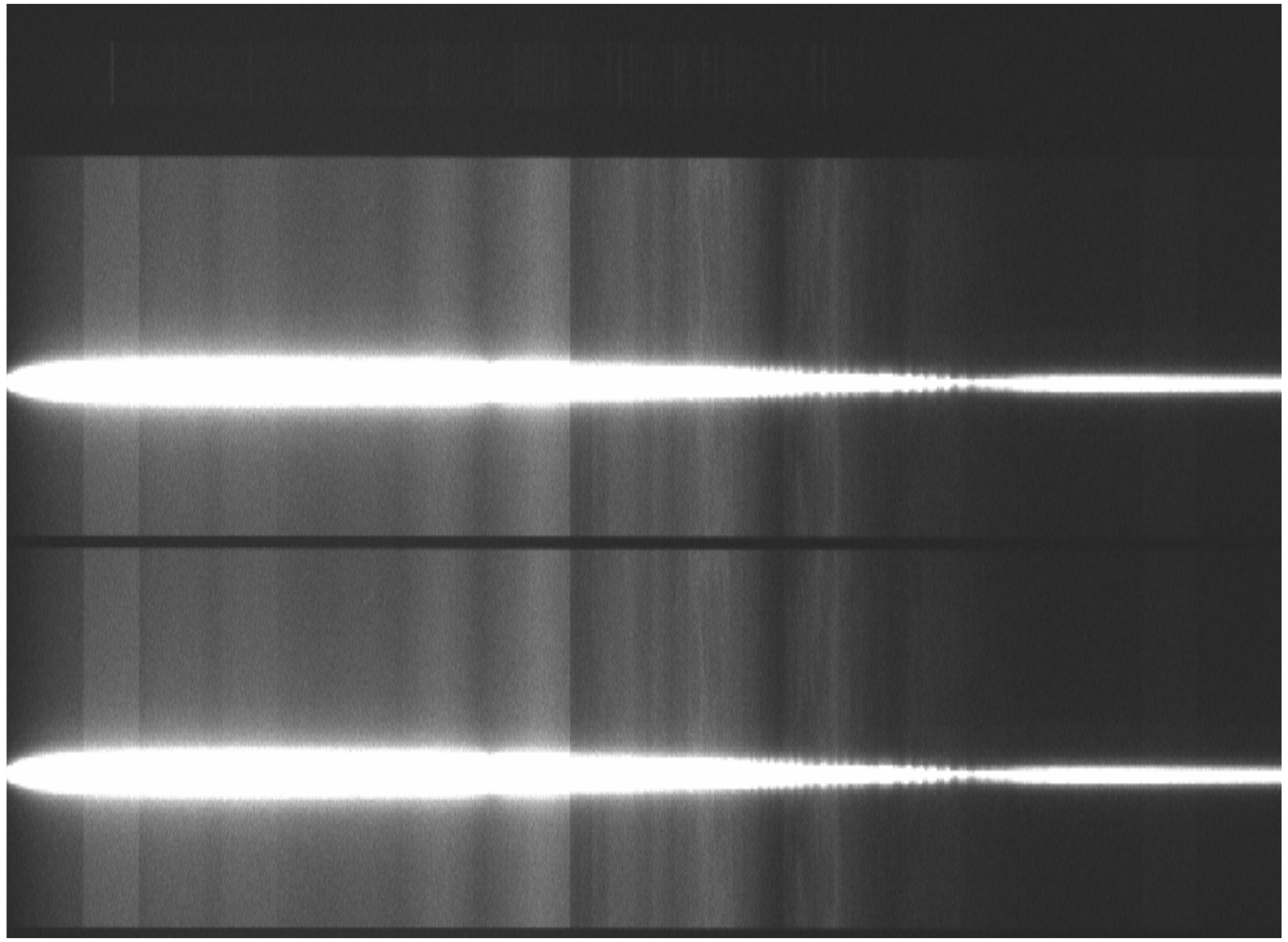
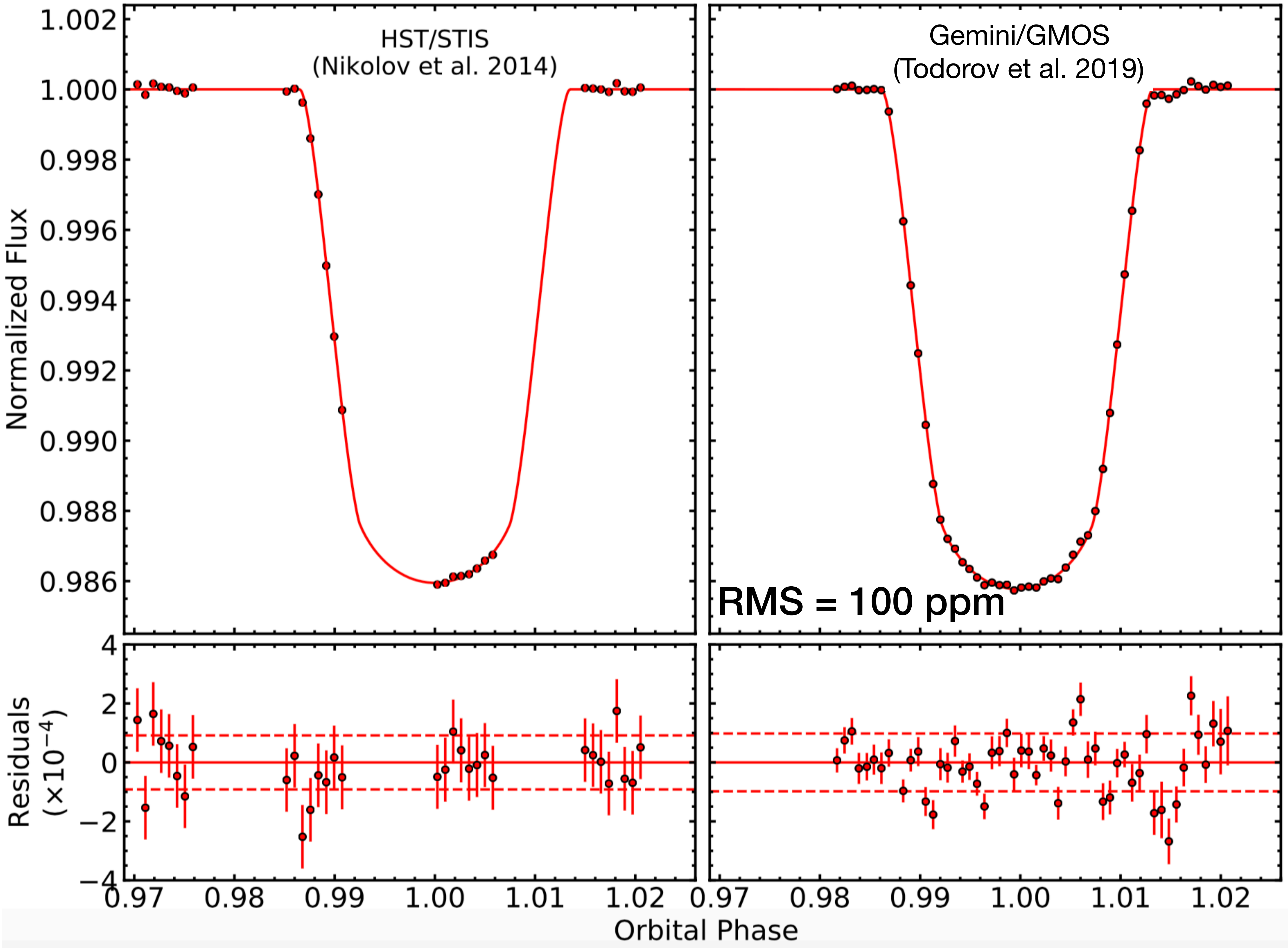
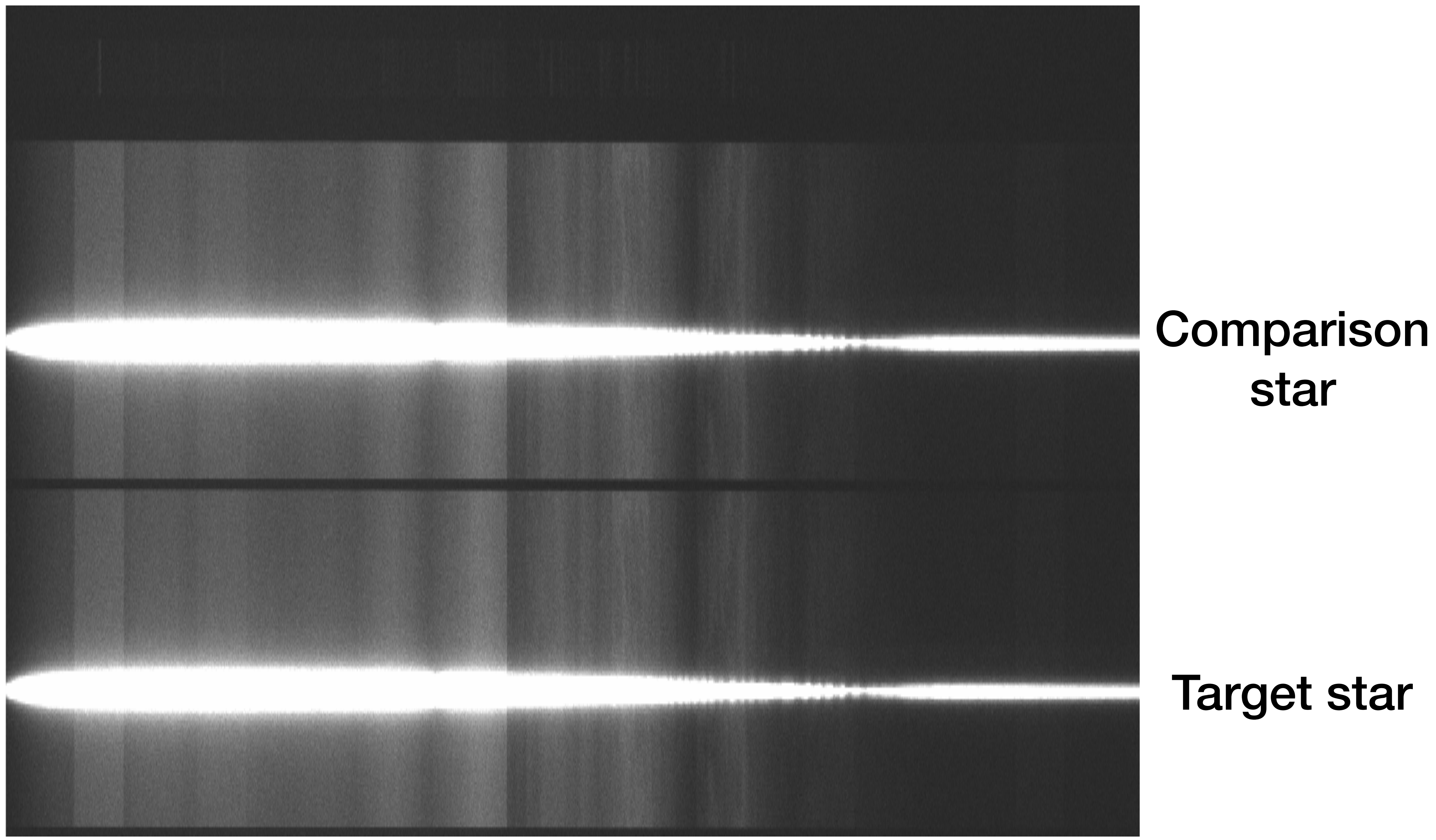


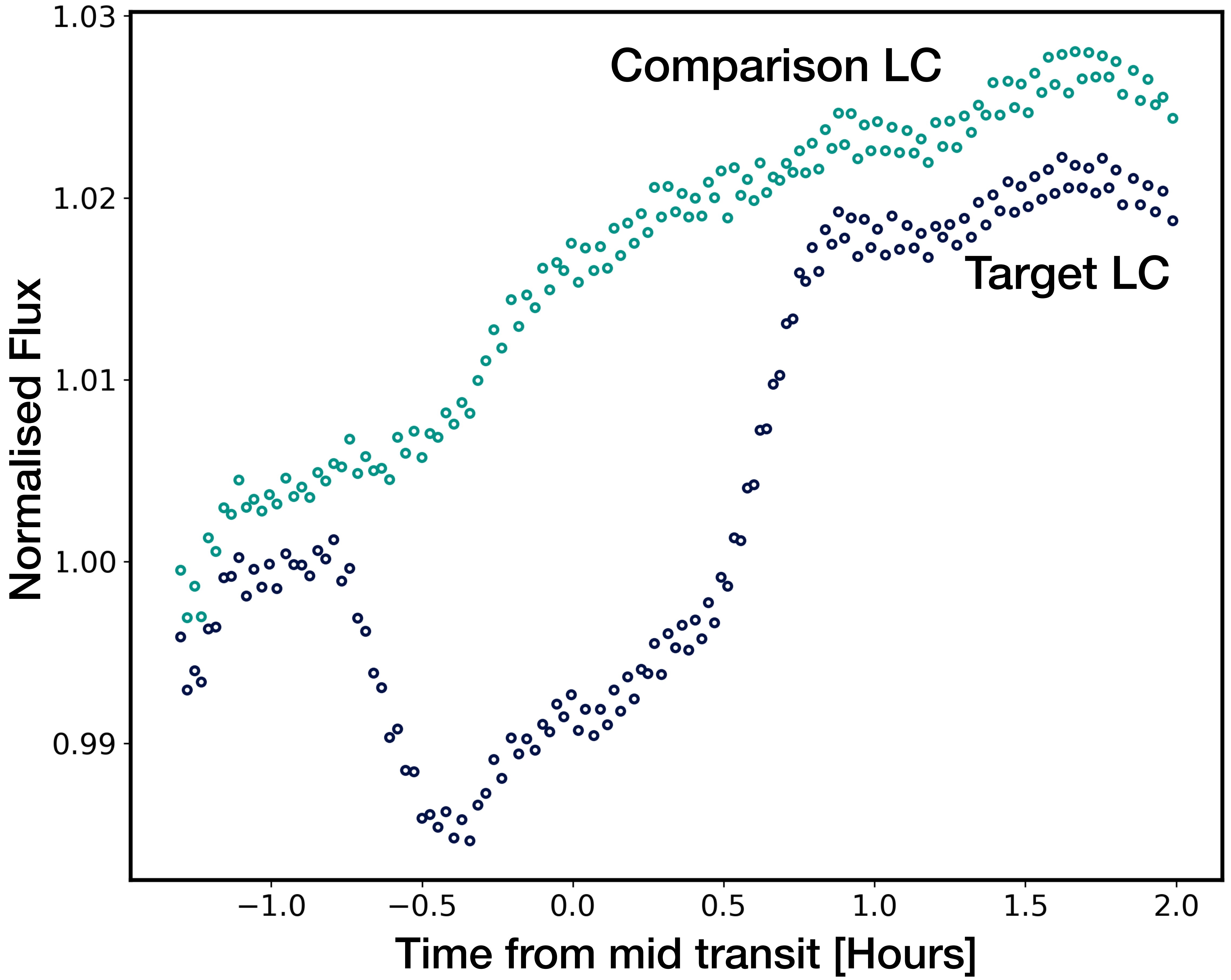
Comparison star

Target star



Revisiting ground-based multi-object spectroscopy (MOS)





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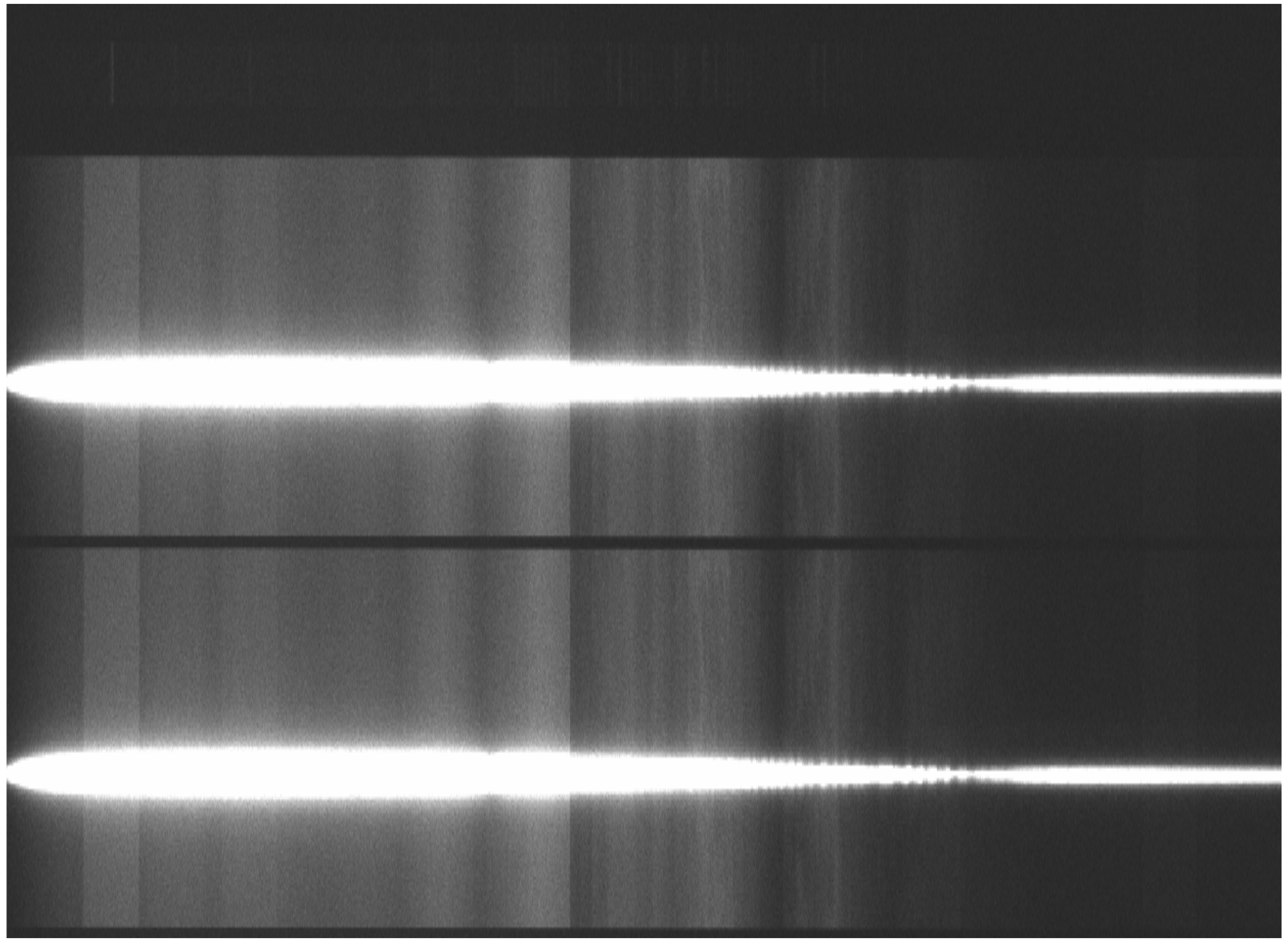

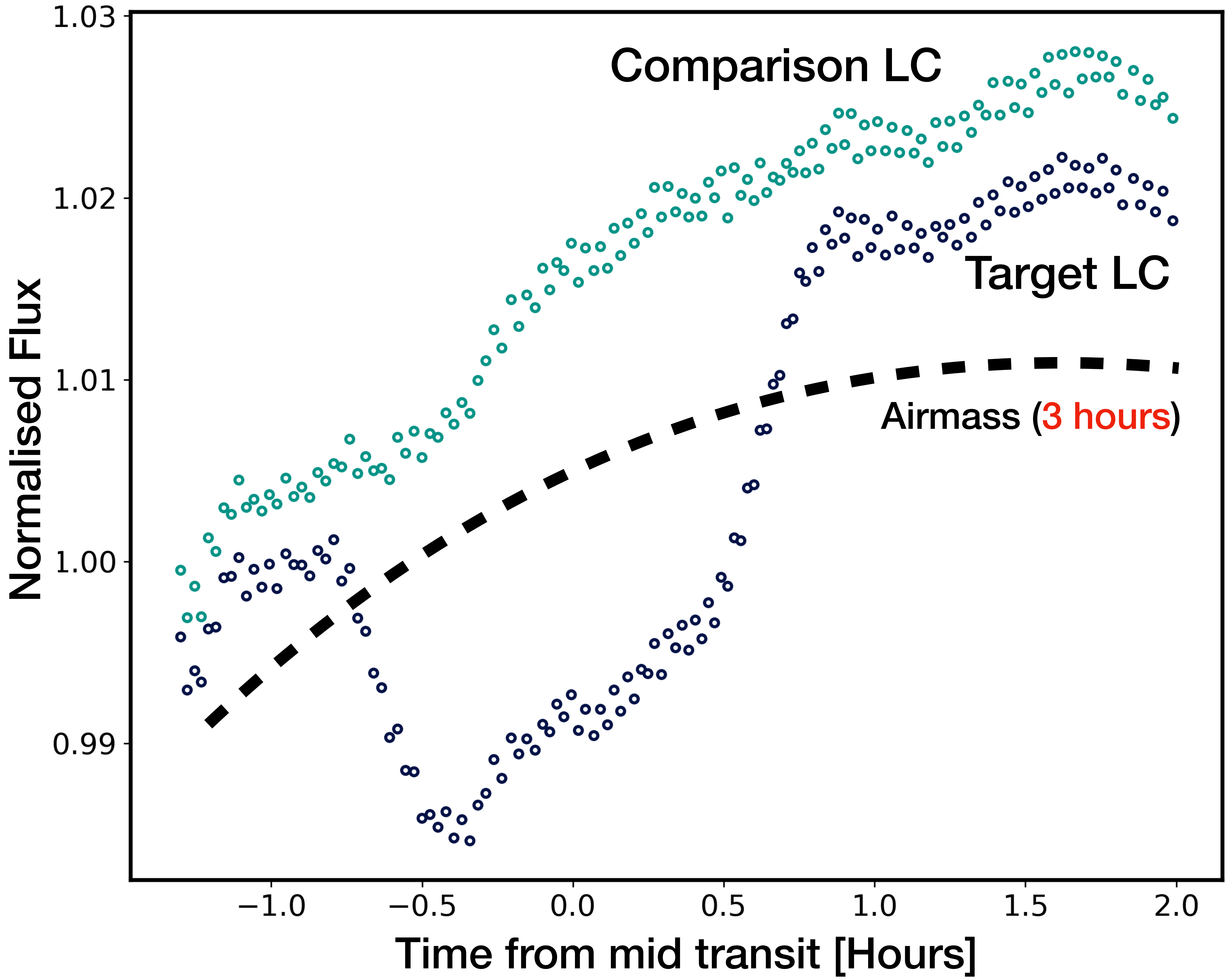

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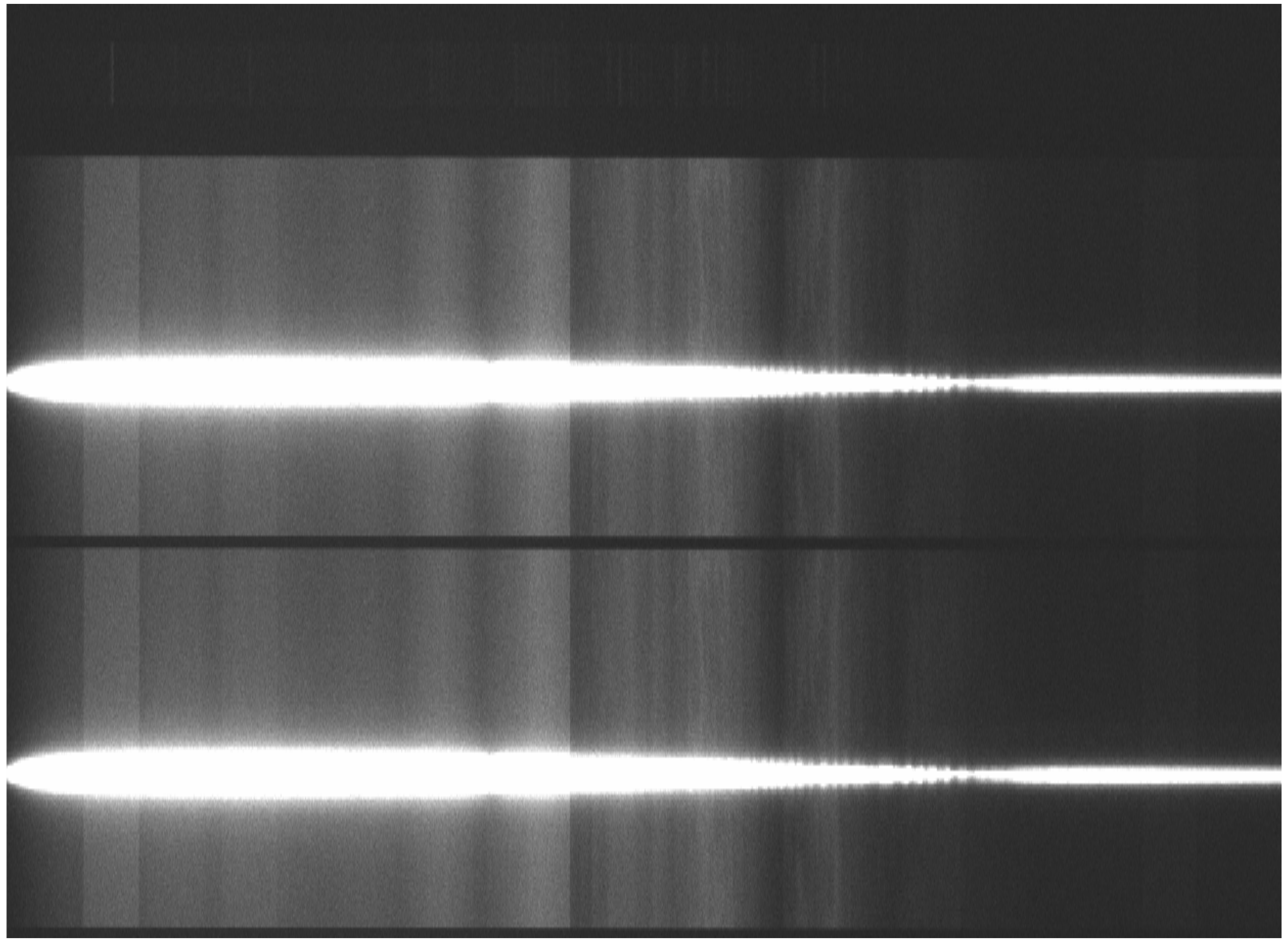
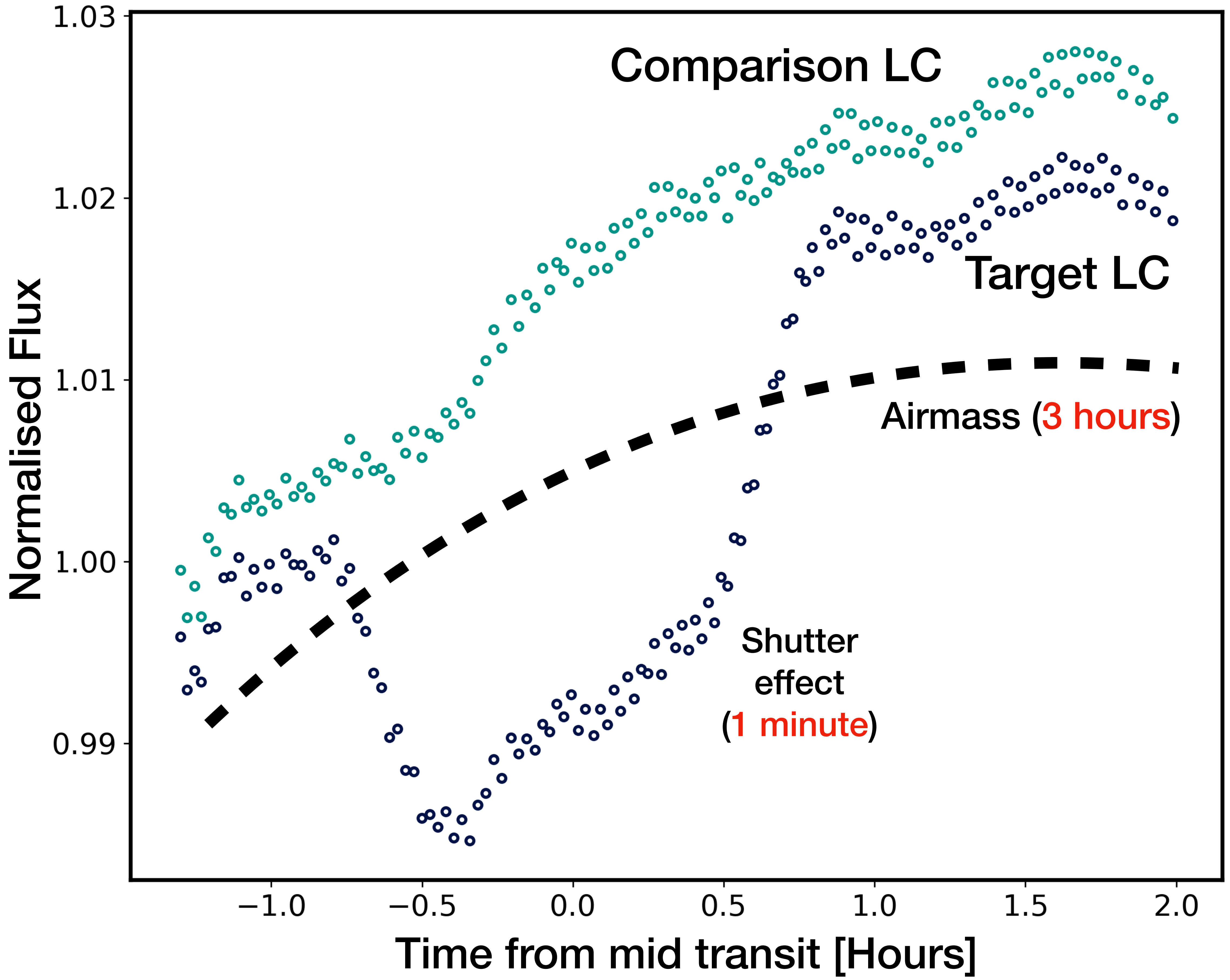
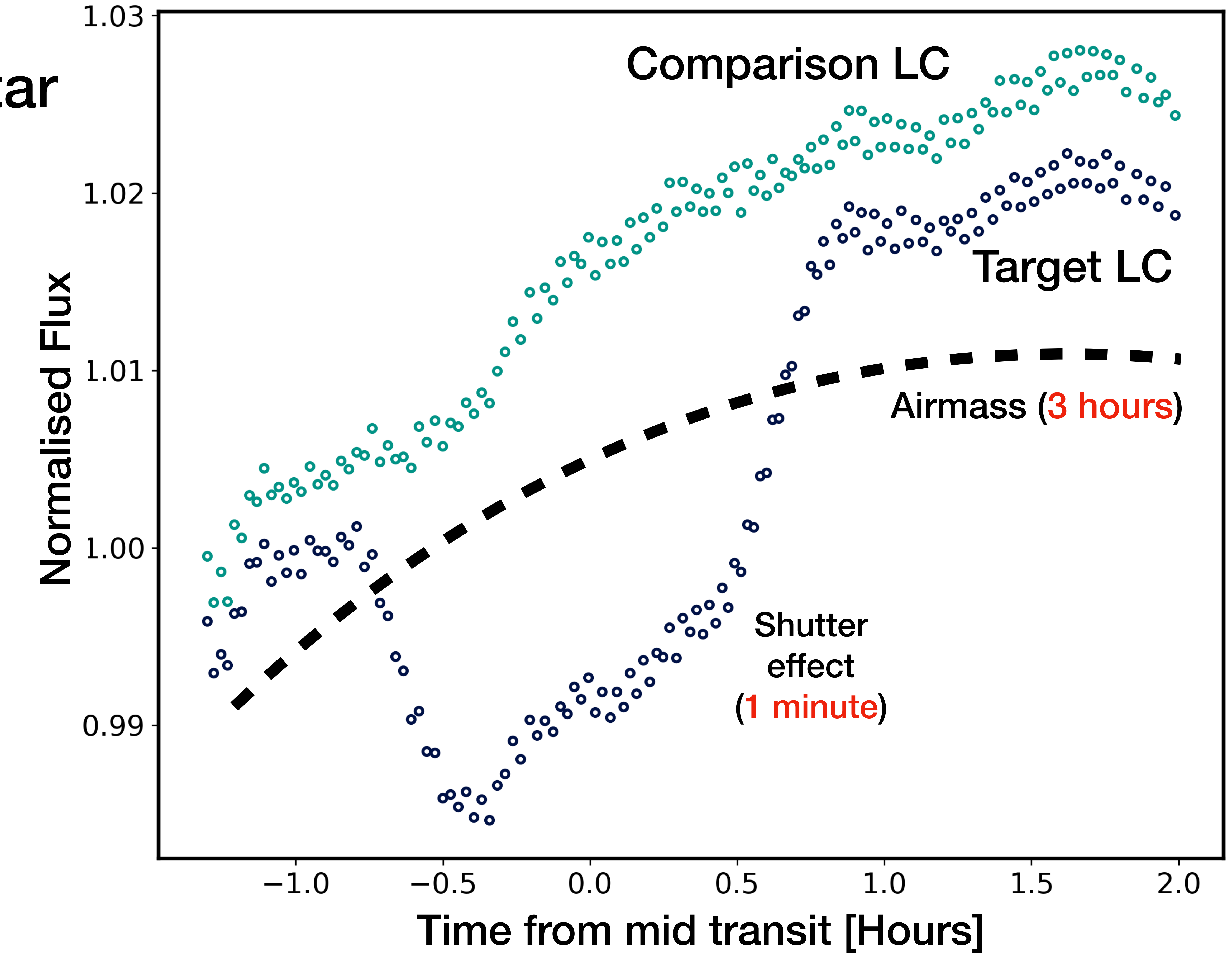




Revisiting ground-based multi-object spectroscopy (MOS)

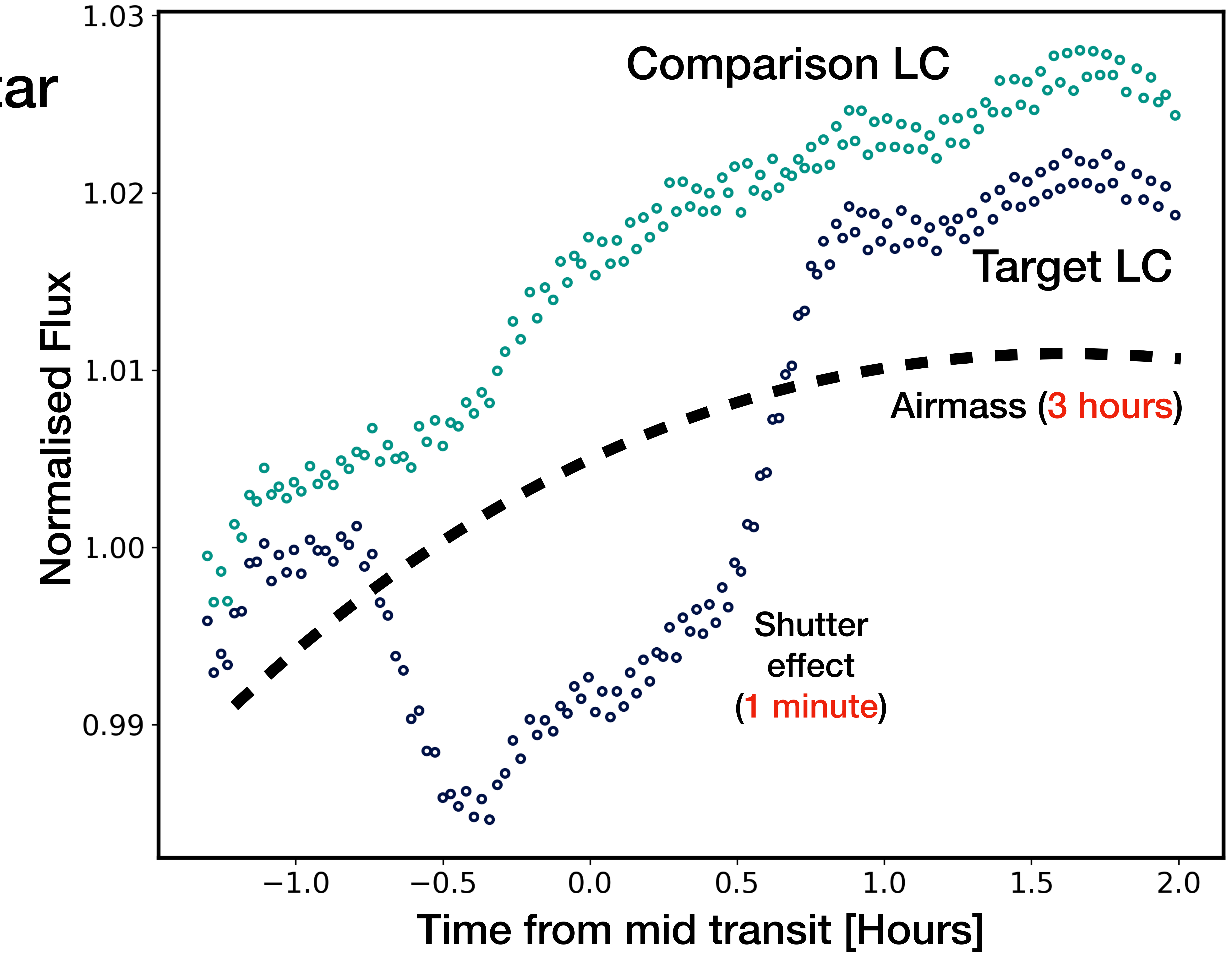
Strategy of Normalising Target by Comparison star is problematic:



Revisiting ground-based multi-object spectroscopy (MOS)

Strategy of Normalising Target by Comparison star is **problematic**:

1. Comparison stars could be **variable**



Revisiting ground-based multi-object spectroscopy (MOS)

Strategy of Normalising Target by Comparison star is **problematic**:

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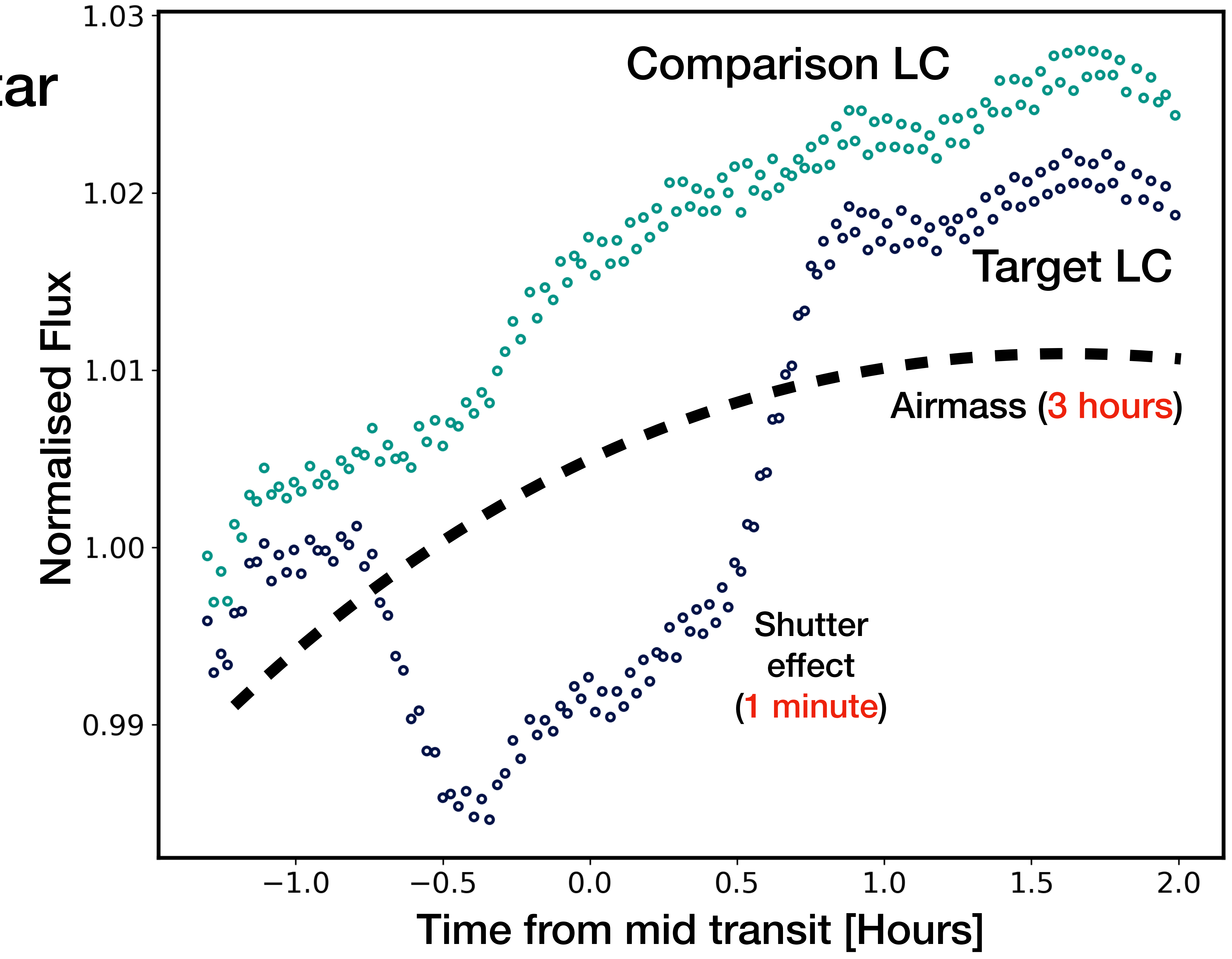
2. The operation of **normalising can add systematics!**



Revisiting ground-based multi-object spectroscopy (MOS)

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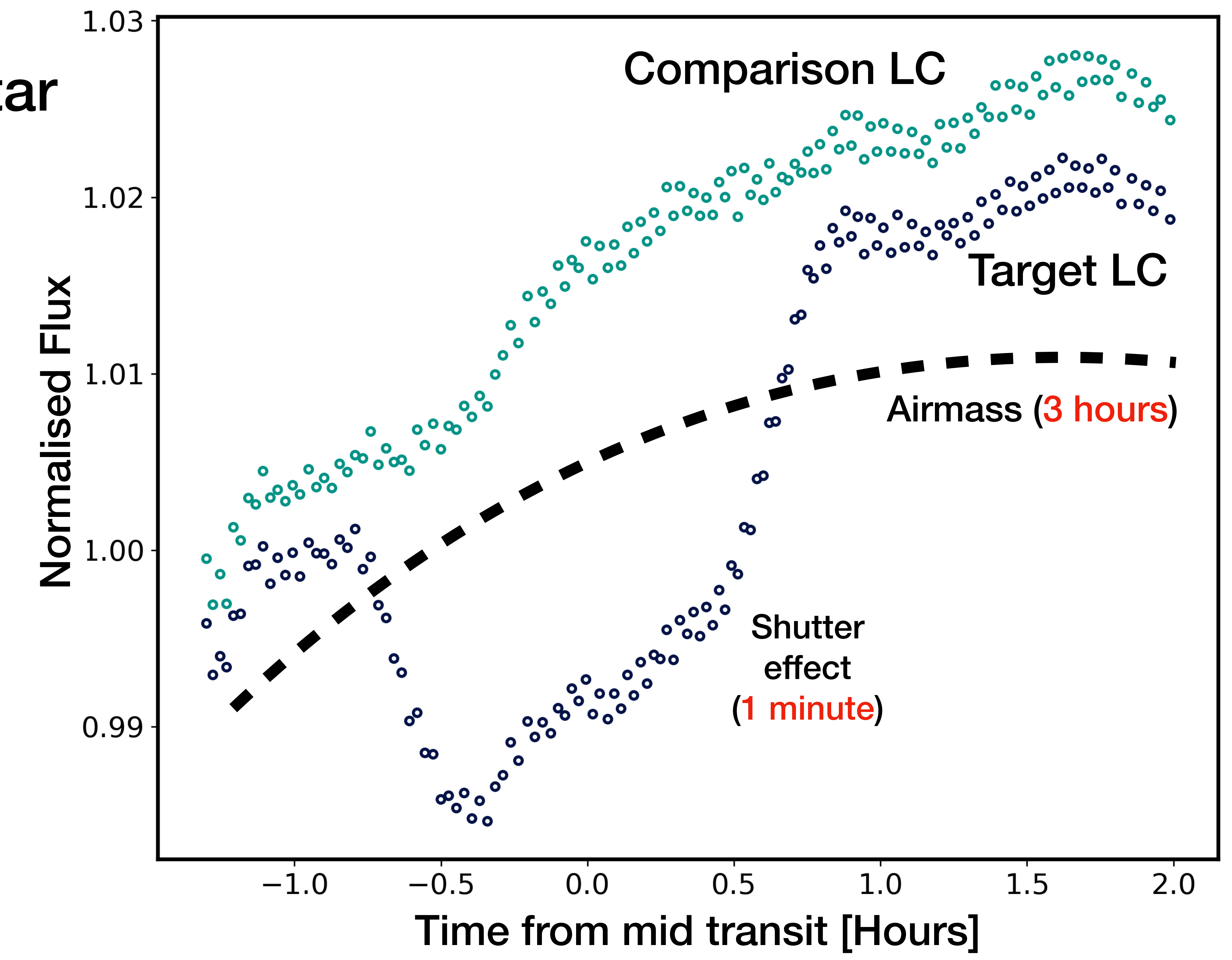
3. **Difficult to follow-up bright targets** with no nearby suitable comparison stars



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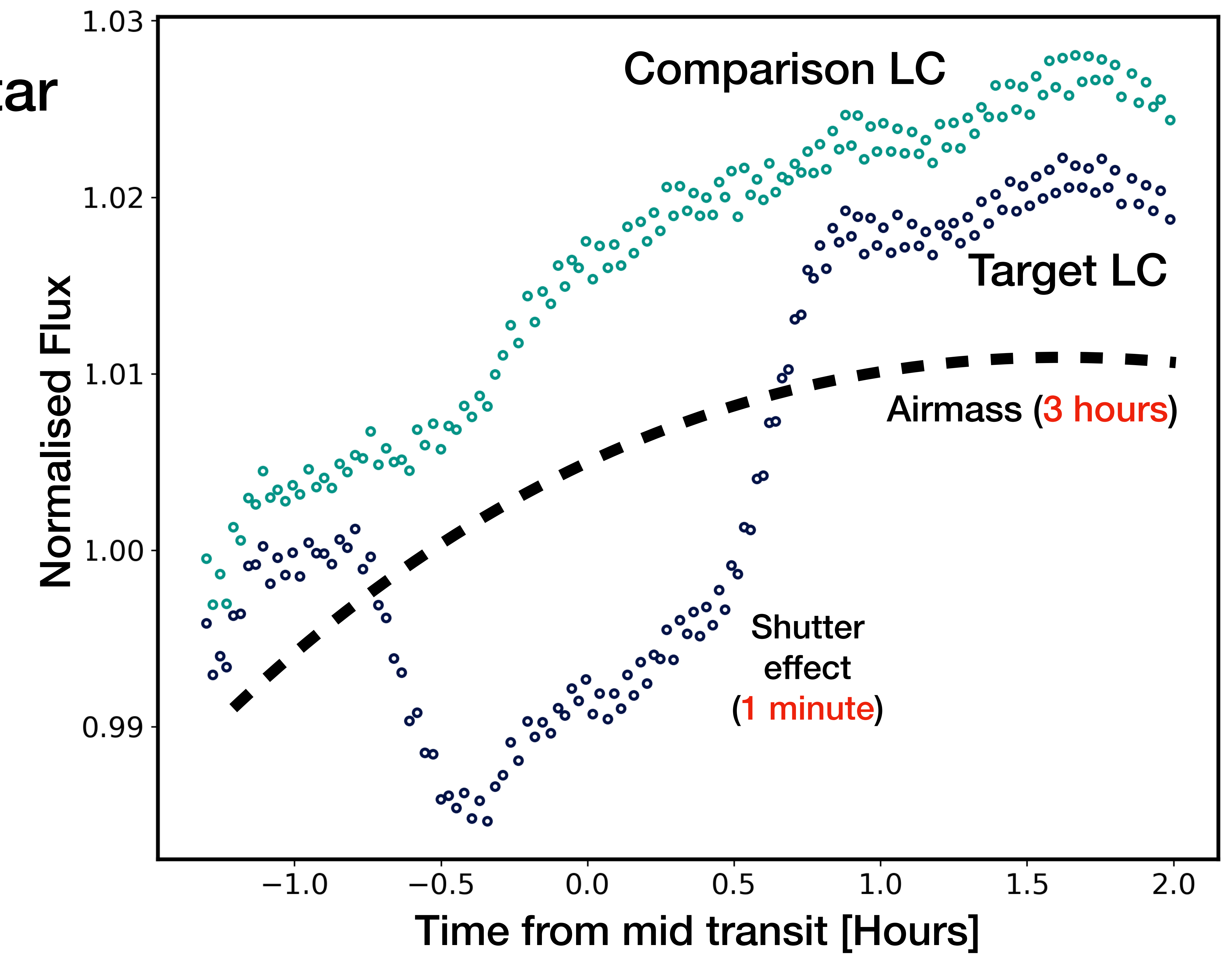
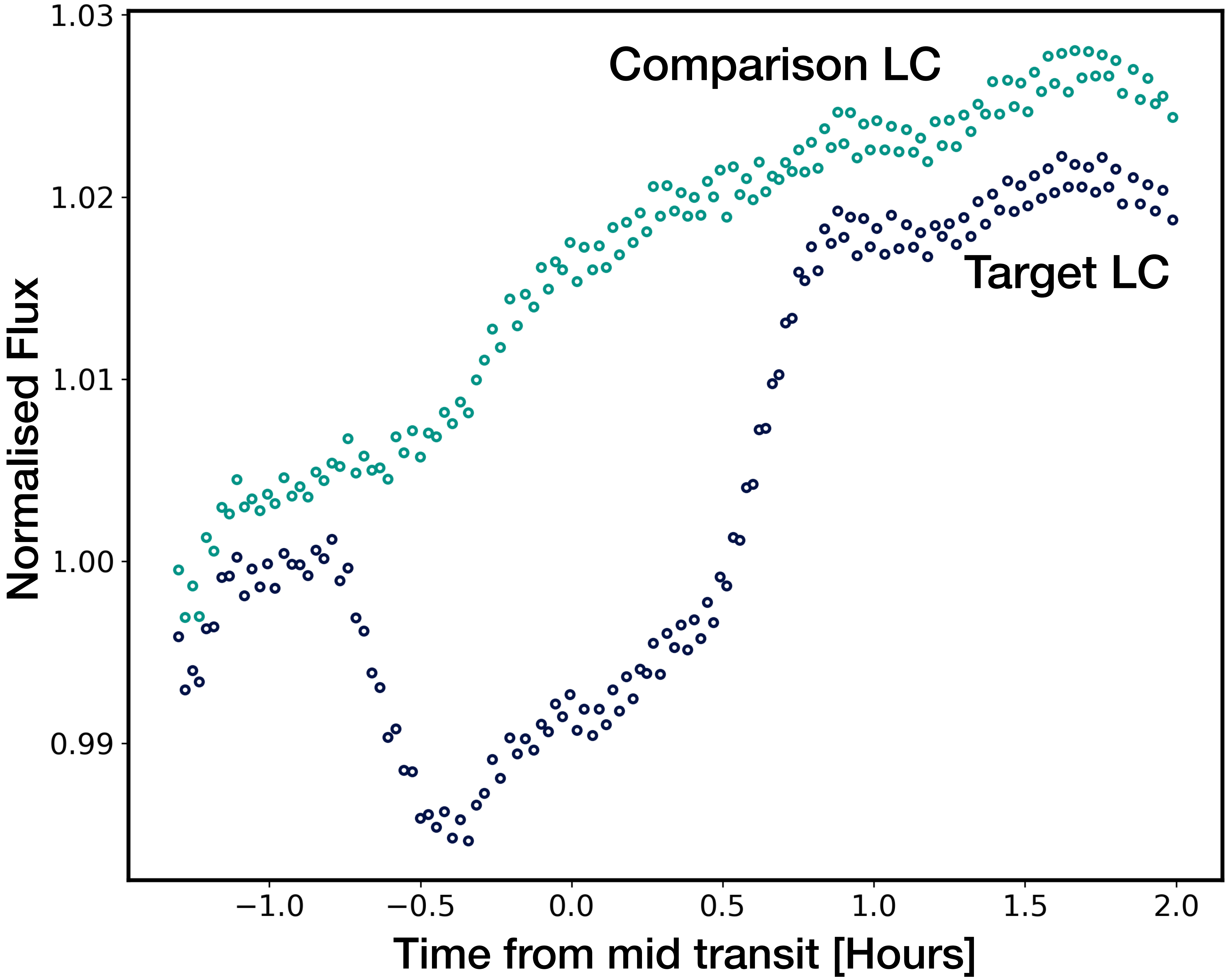


Need for a new method!

New method to correct for systematics in ground based light curves



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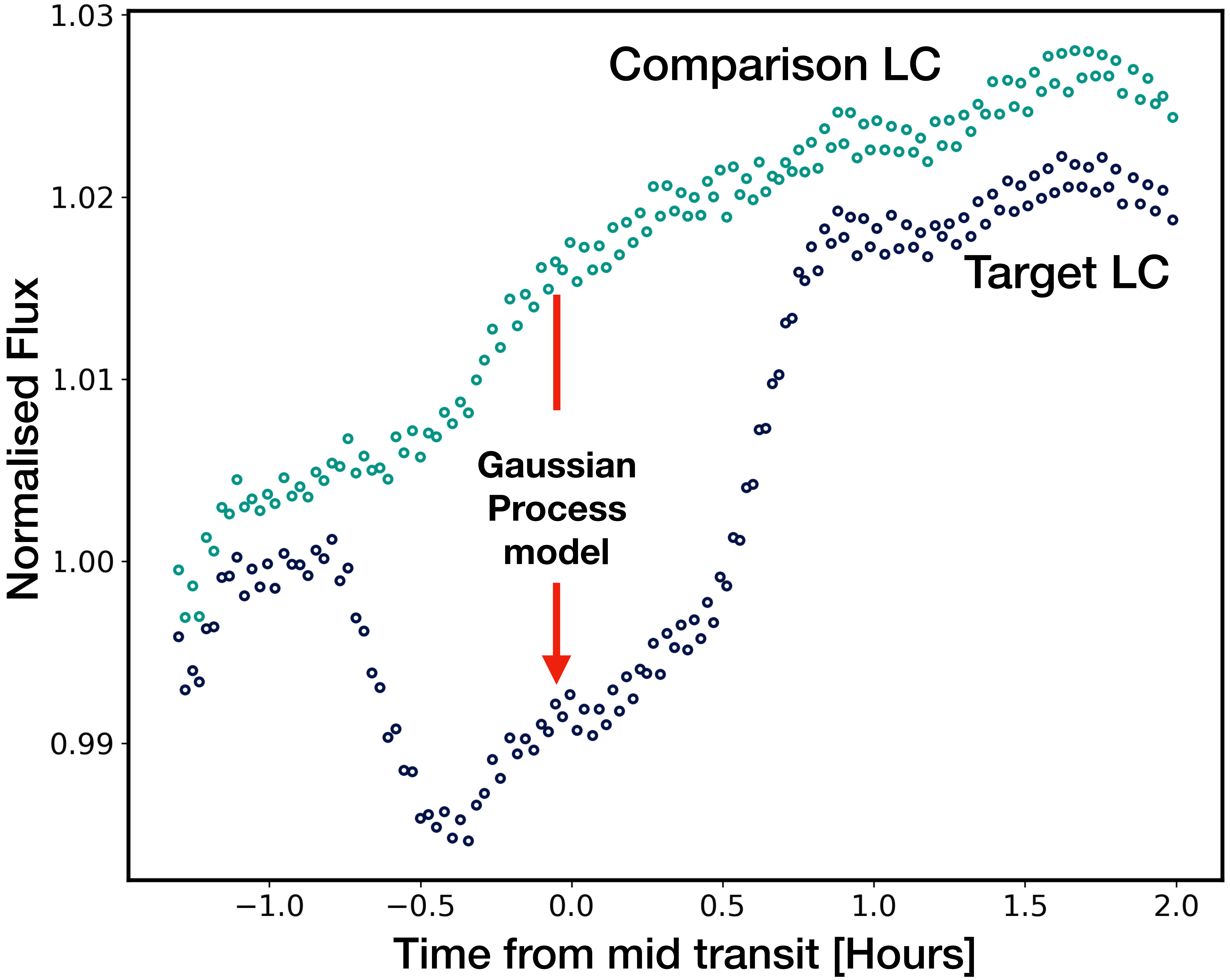

Also see Gibson et al. 2011

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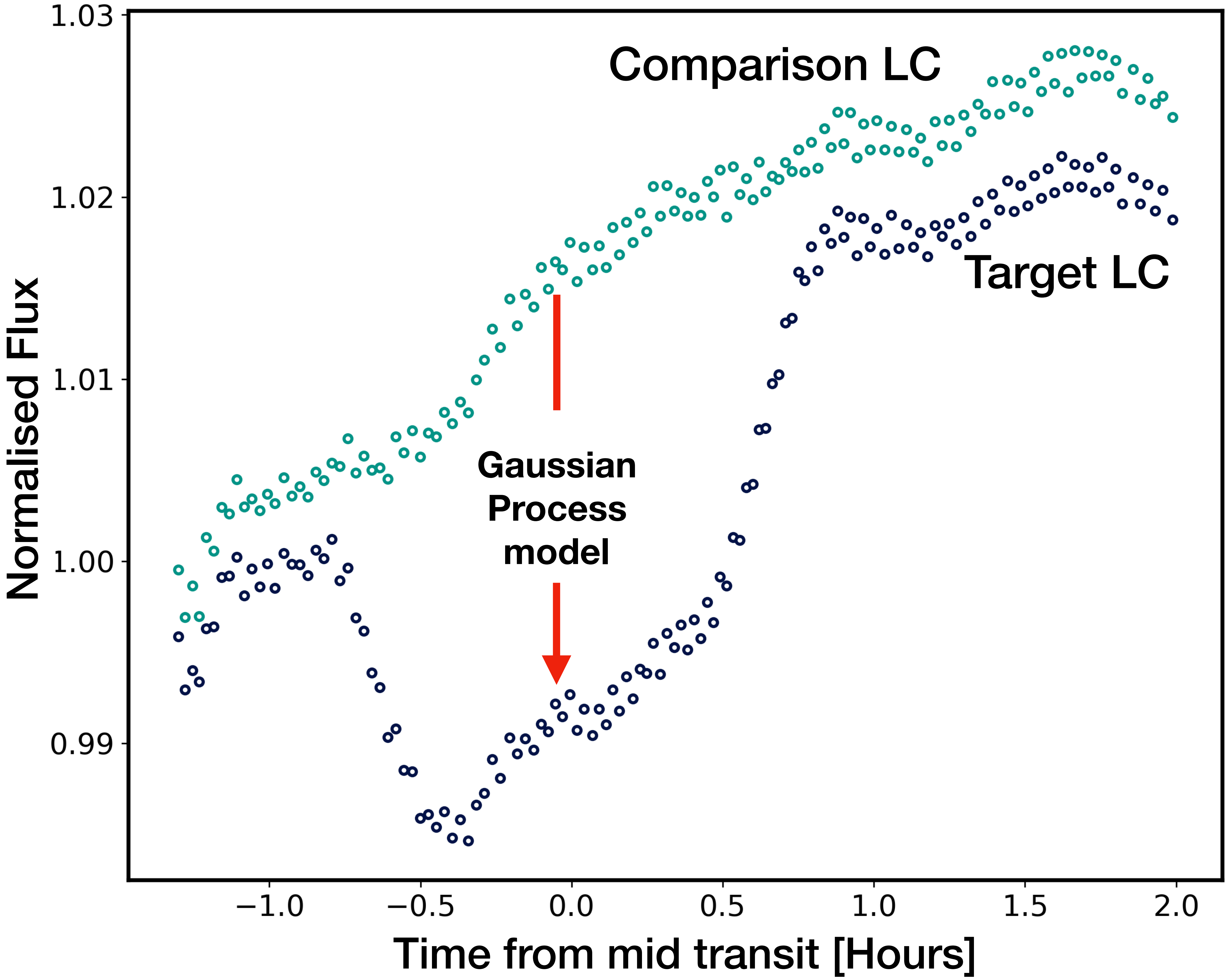
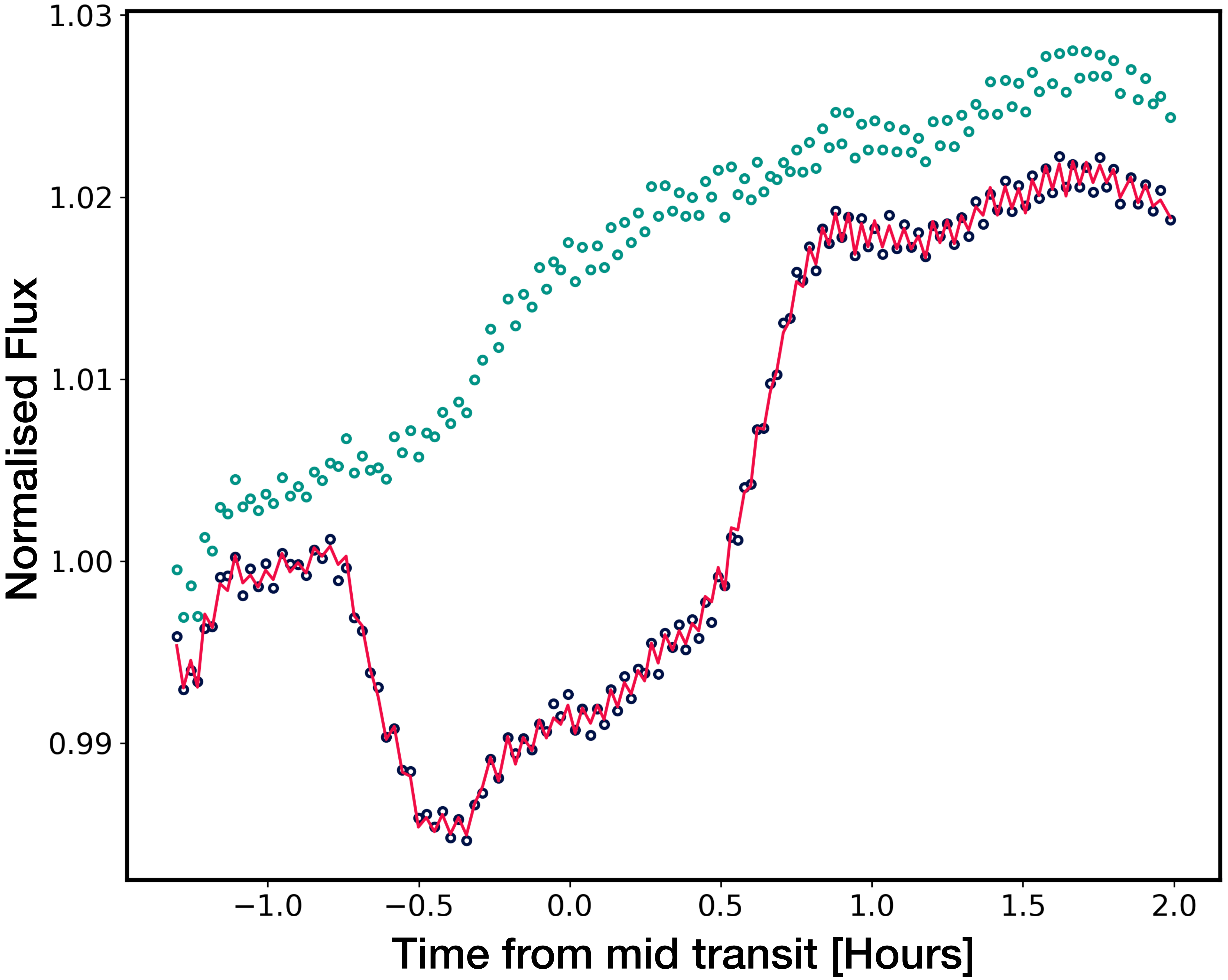
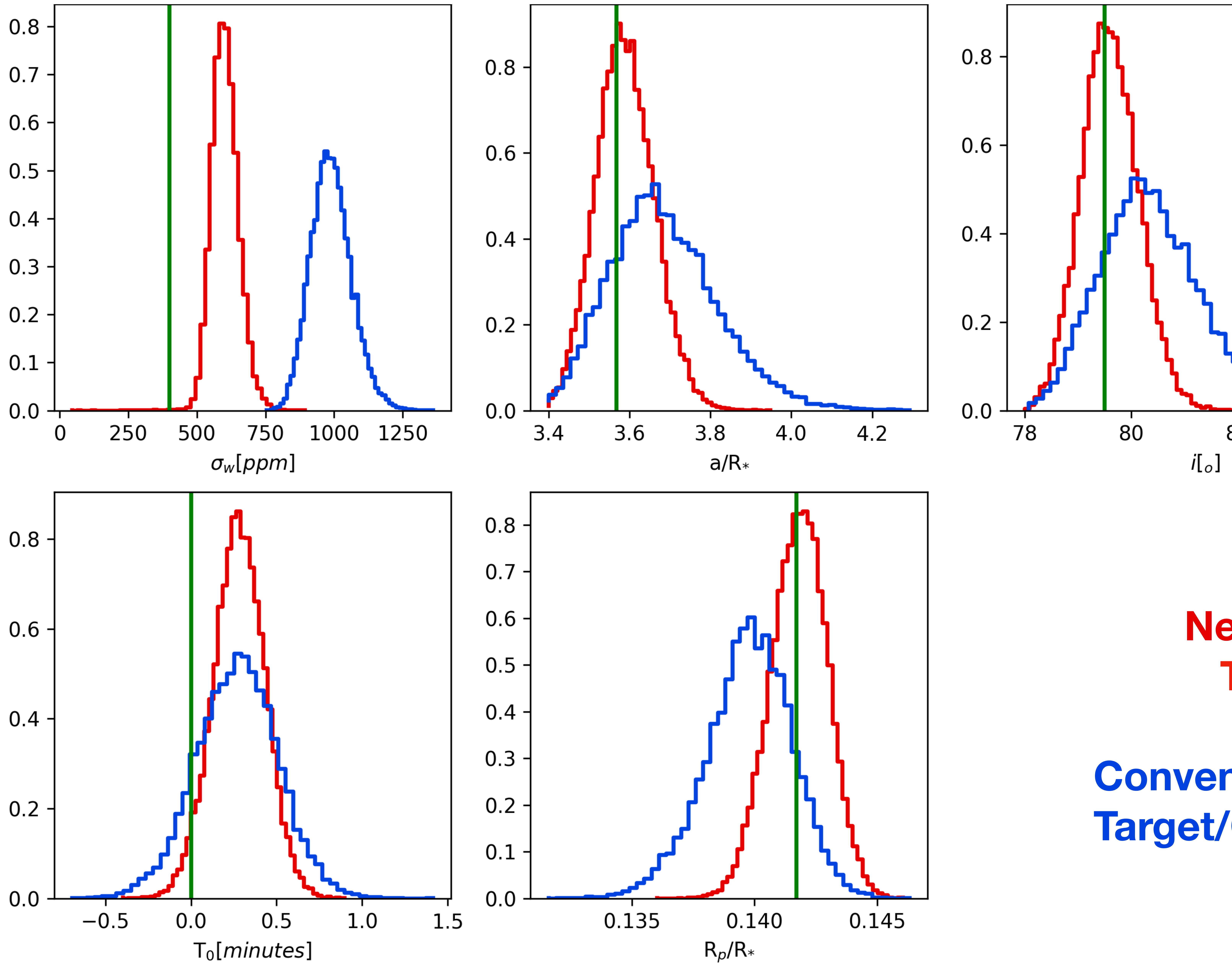




Also see Gibson et al. 2011

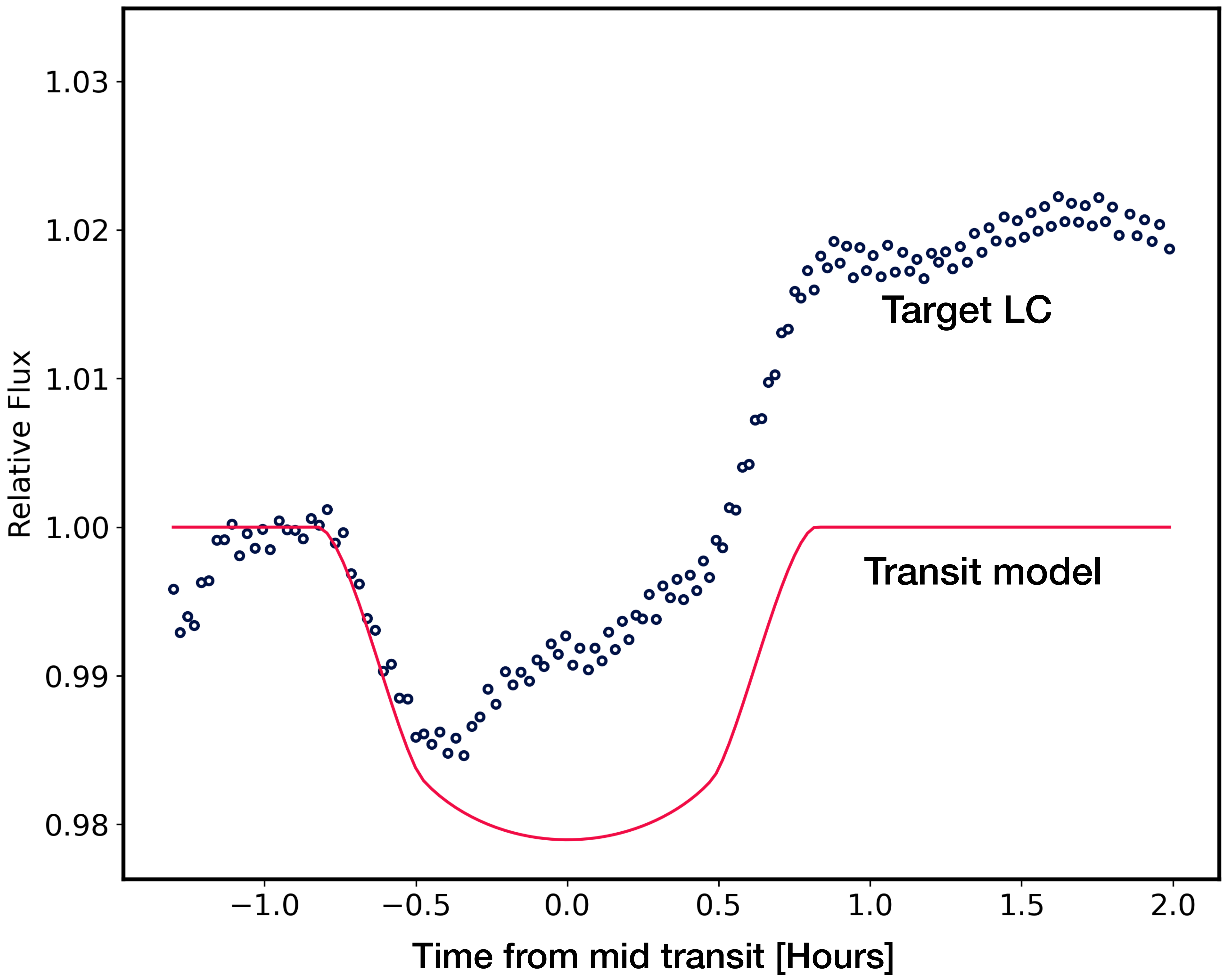
New method improves accuracy and precision of transit parameters



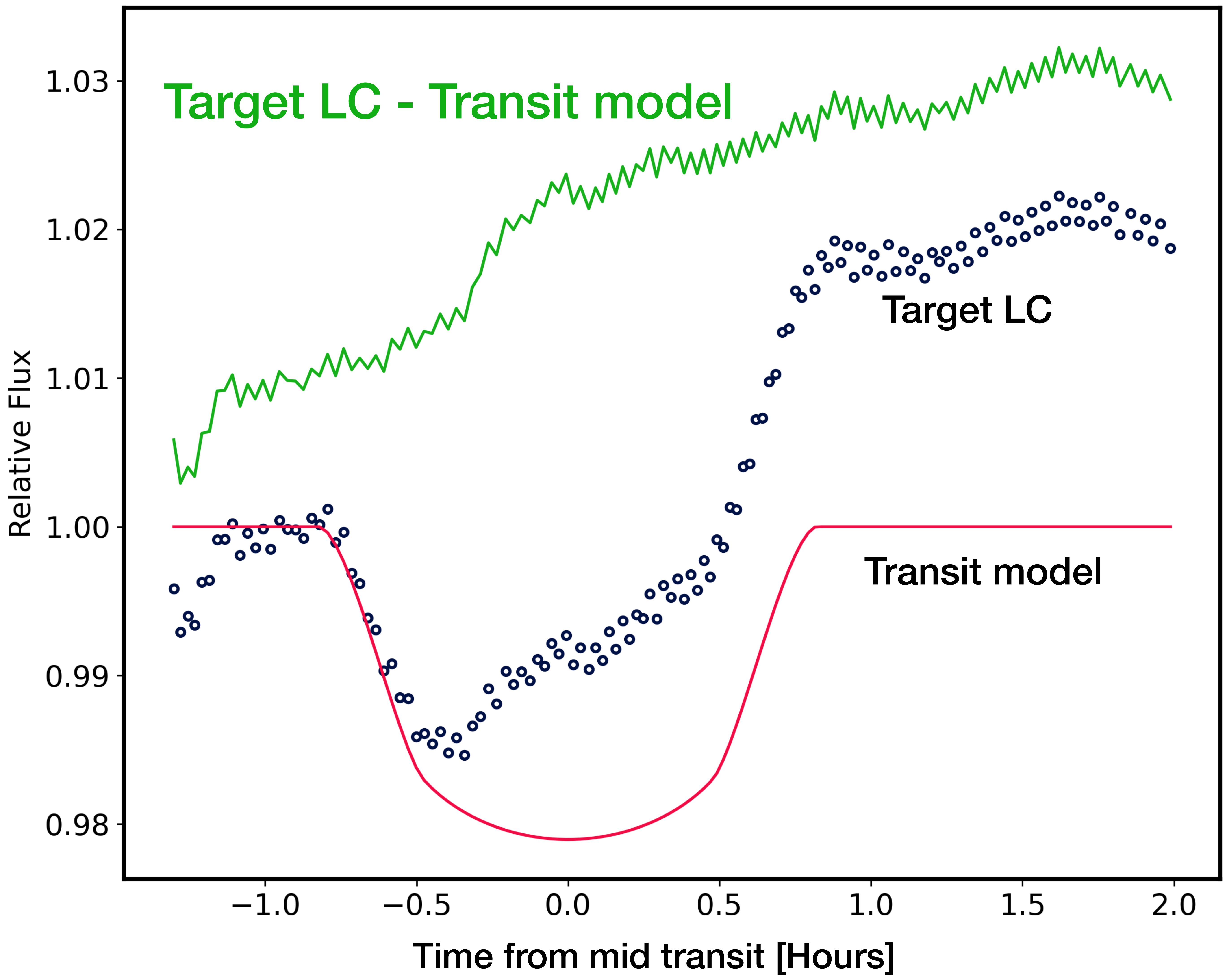
New method:
Target LC

Conventional method :
Target/Comparison LC

Extracting transmission spectrum using only the Target star



Extracting transmission spectrum using only the Target star



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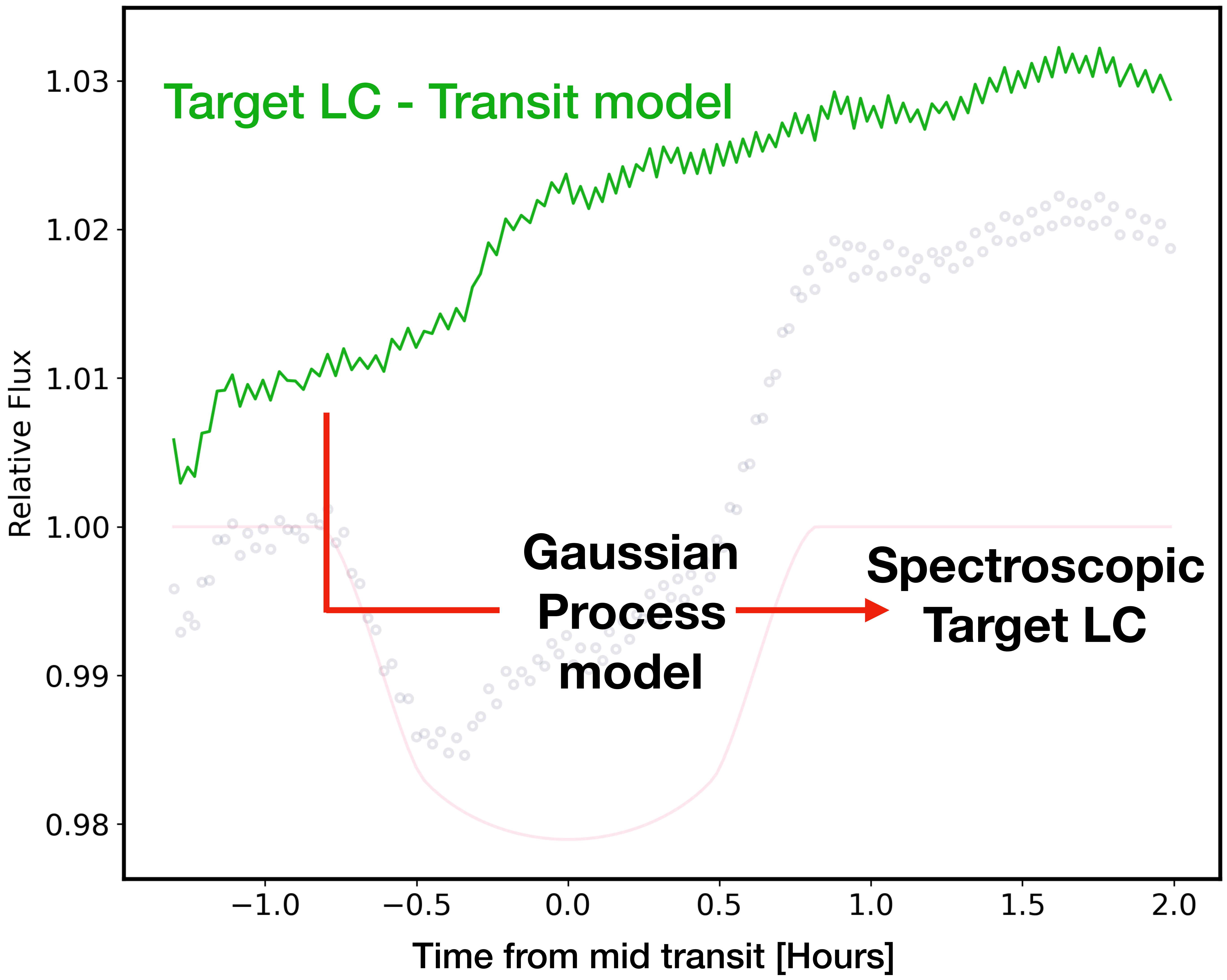
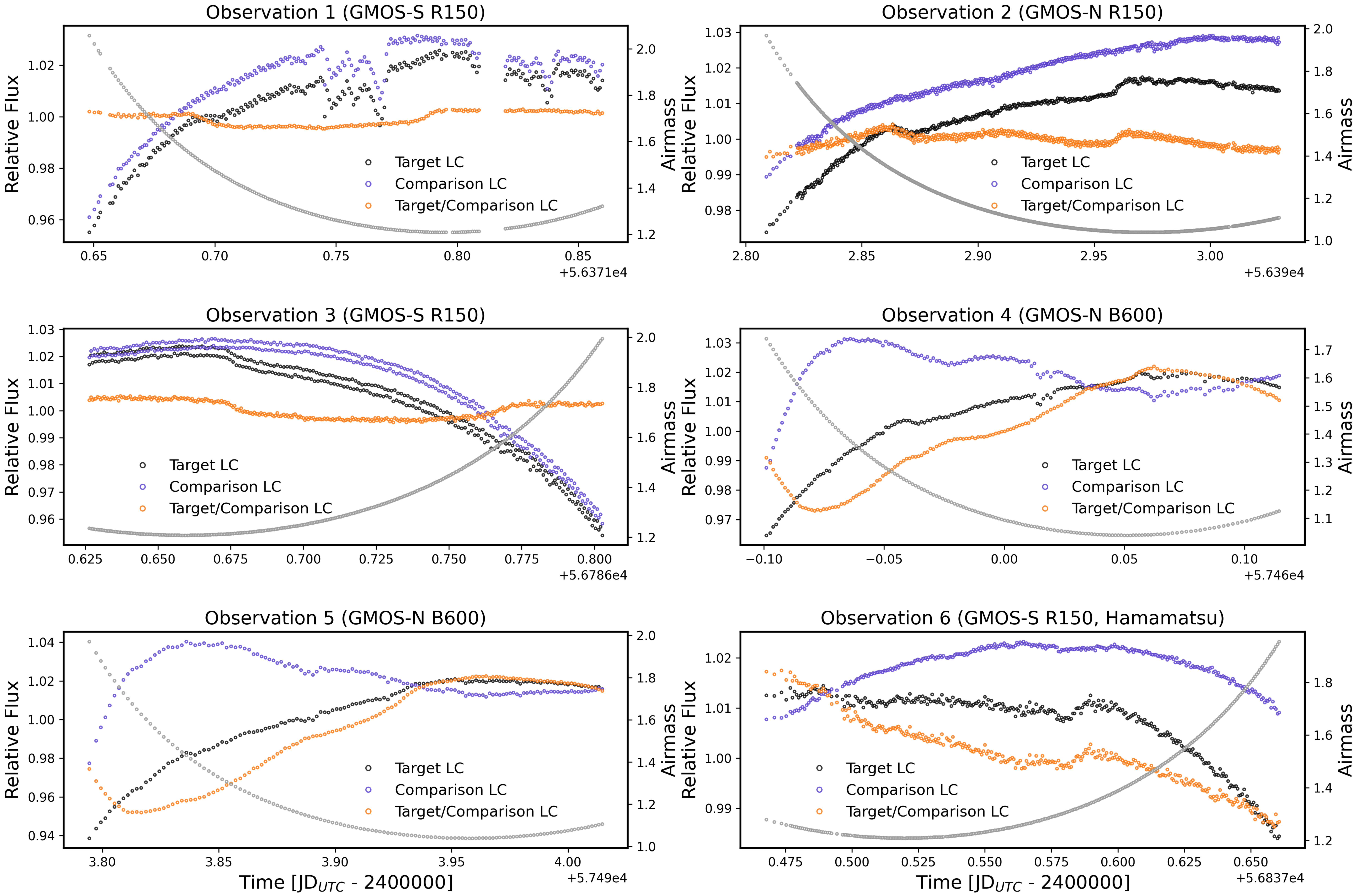


Panwar et al. (in review)

Gemini/GMOS view of the warm Neptune HAT-P-26b



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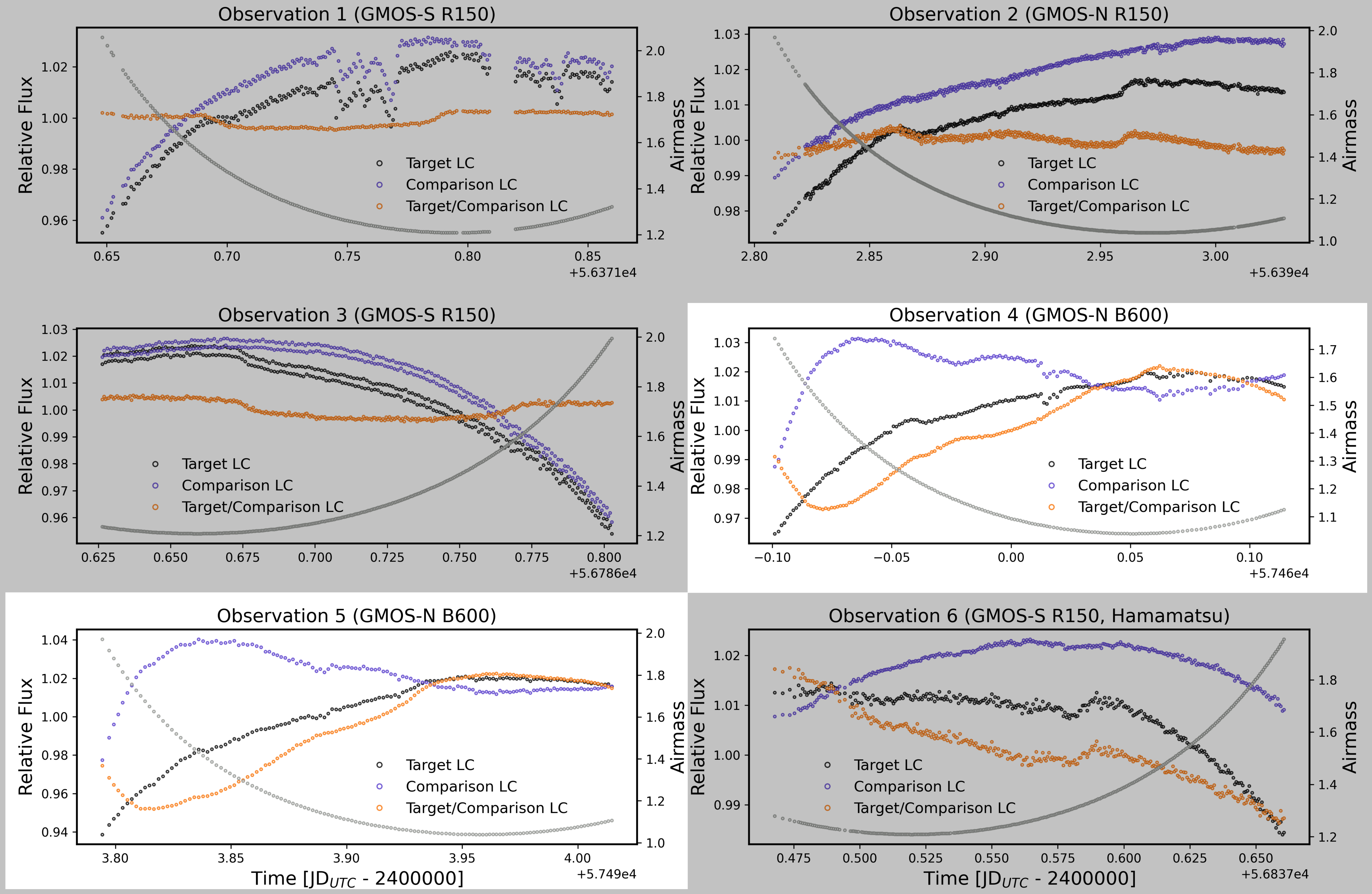


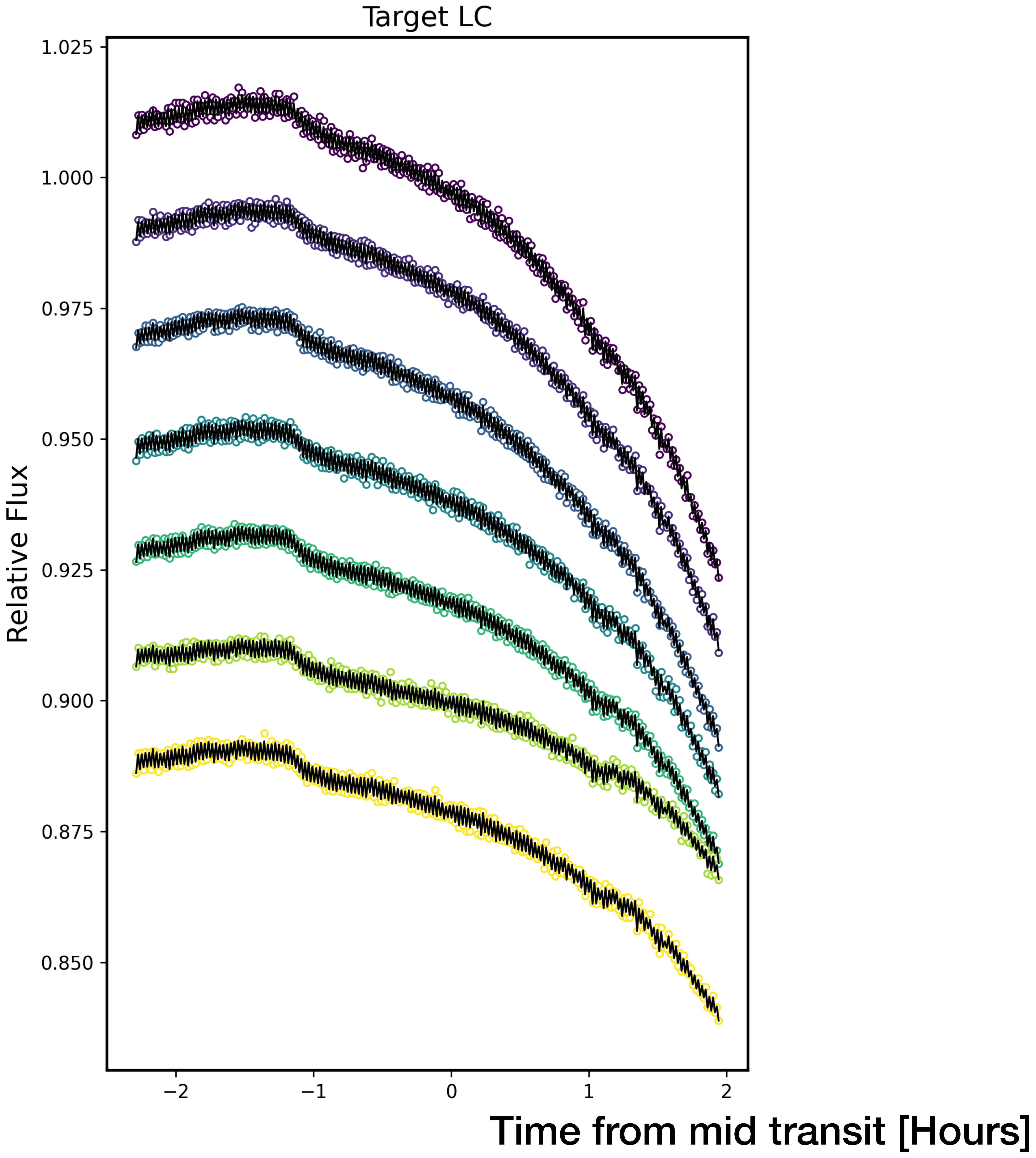
Extracting transmission spectrum using only the Target star

Correcting for

high and **low frequency**,

time and **wavelength**

dependent systematics



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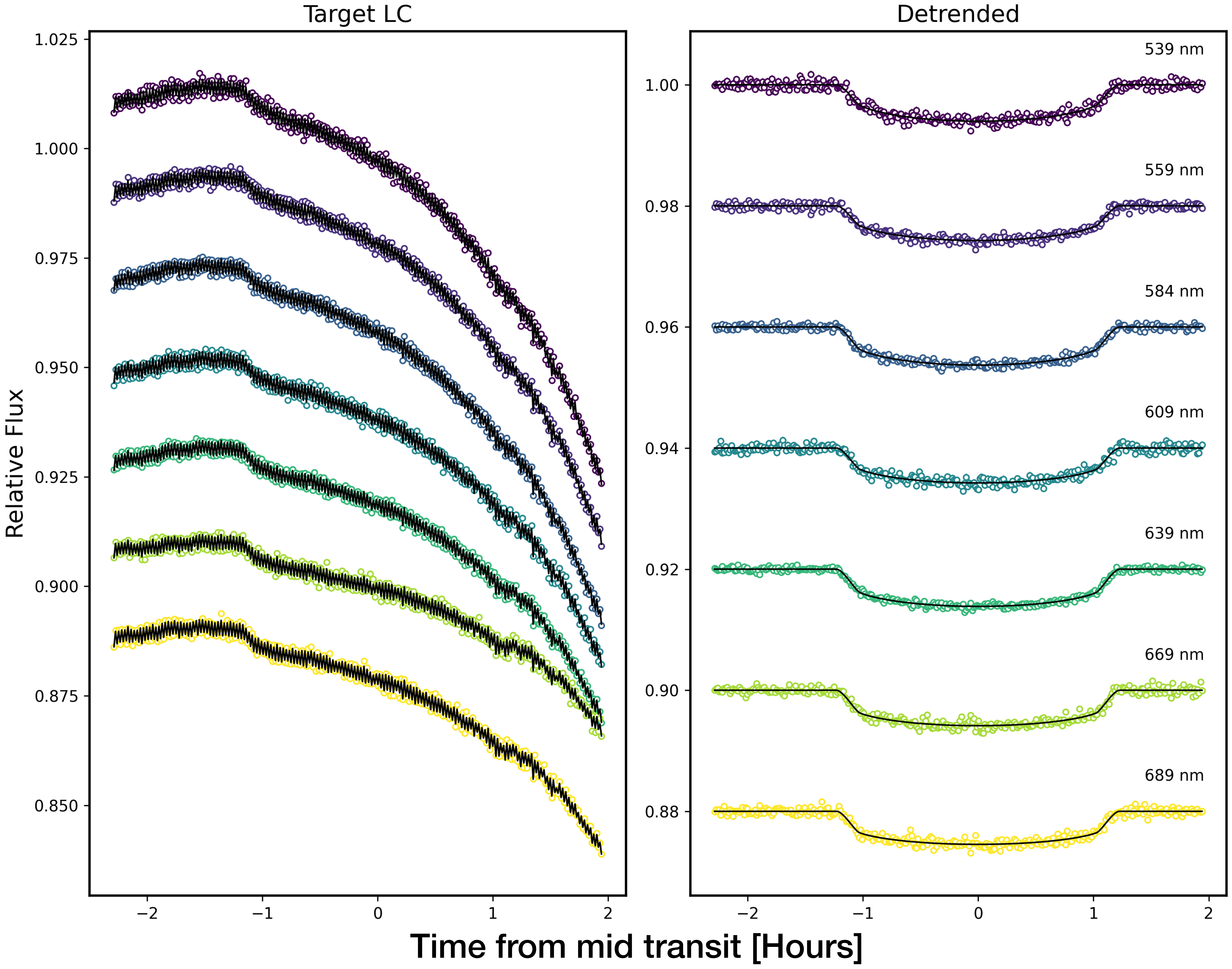

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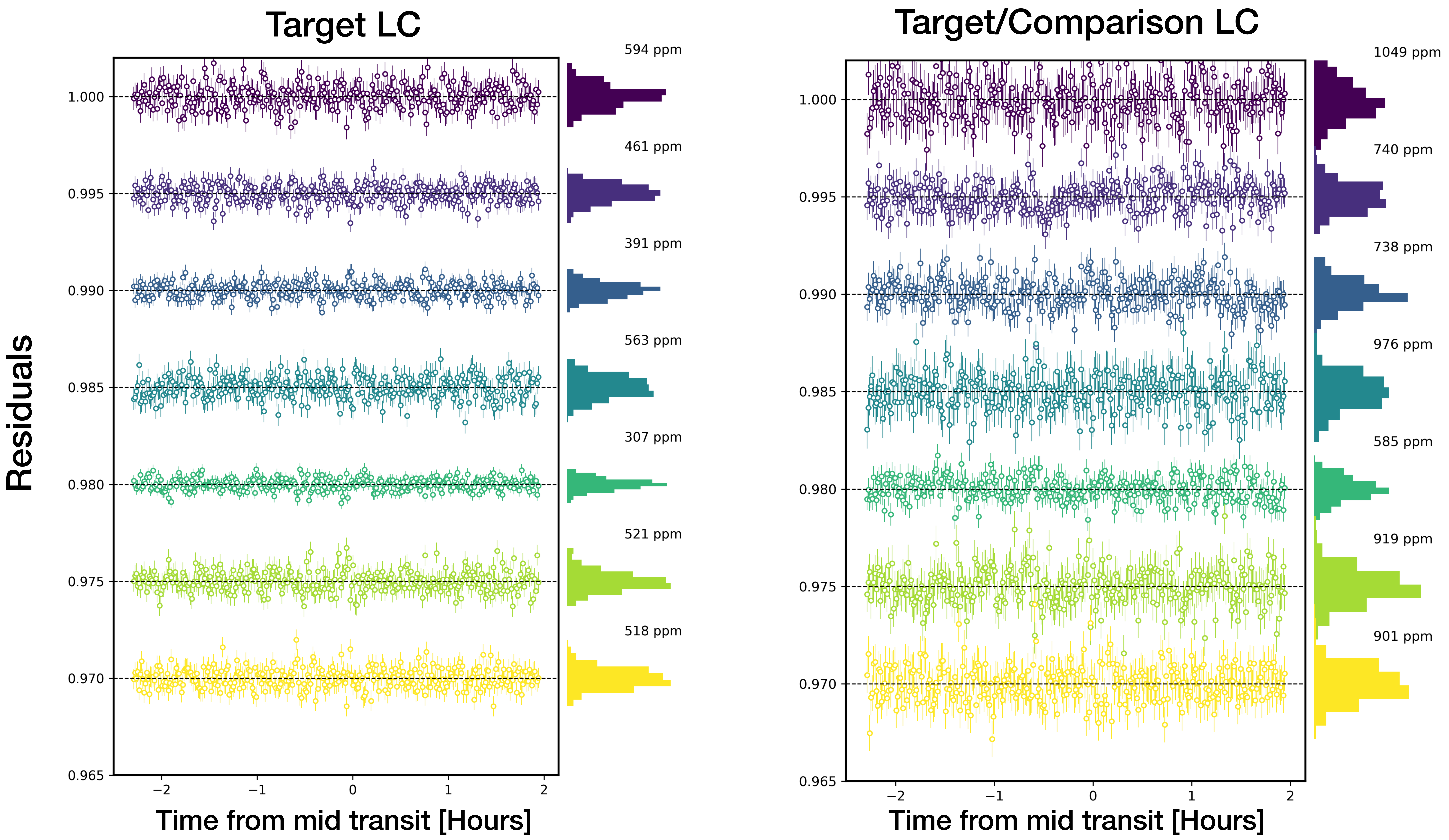
Extracting transmission spectrum: new vs conventional method



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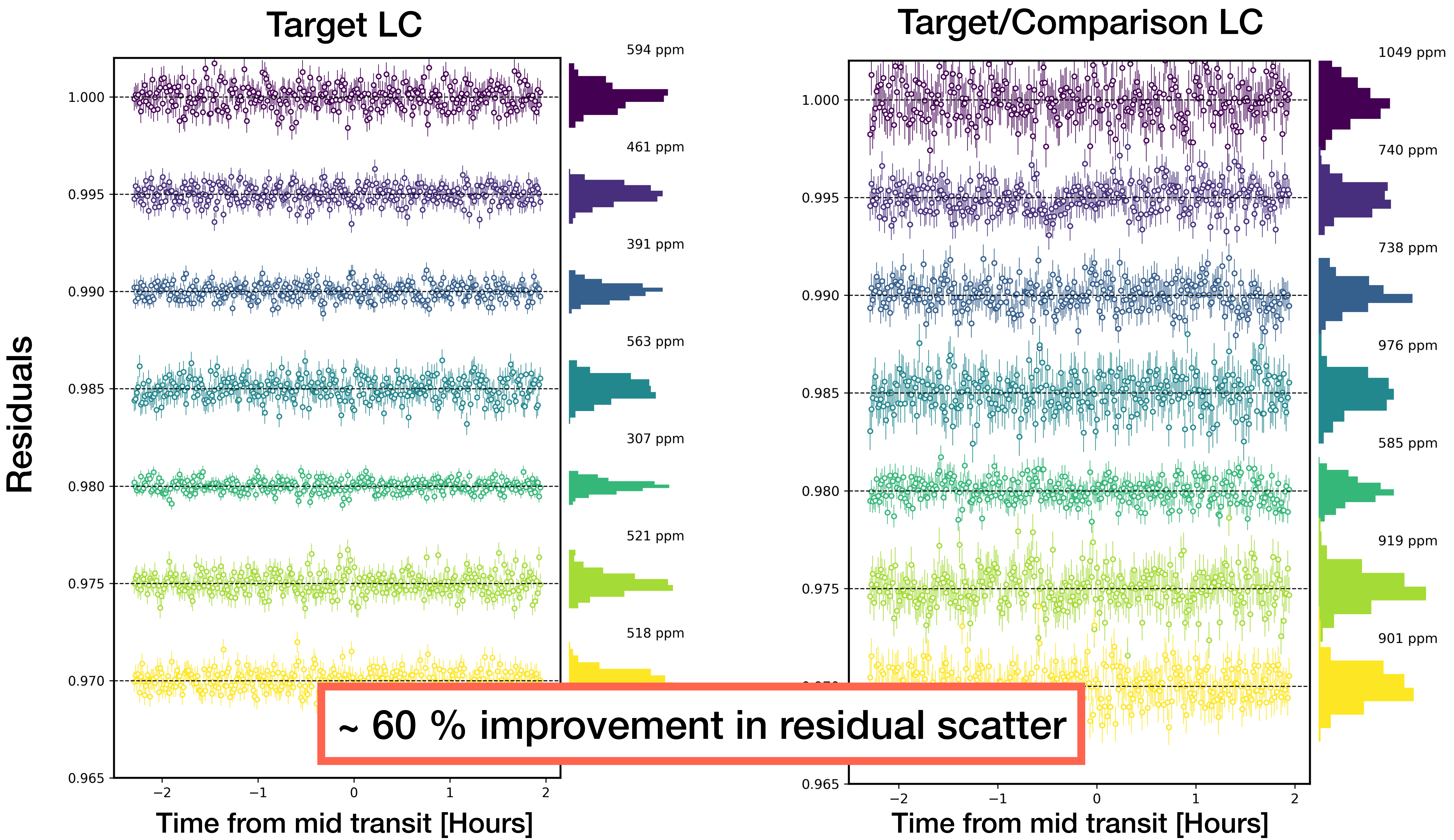

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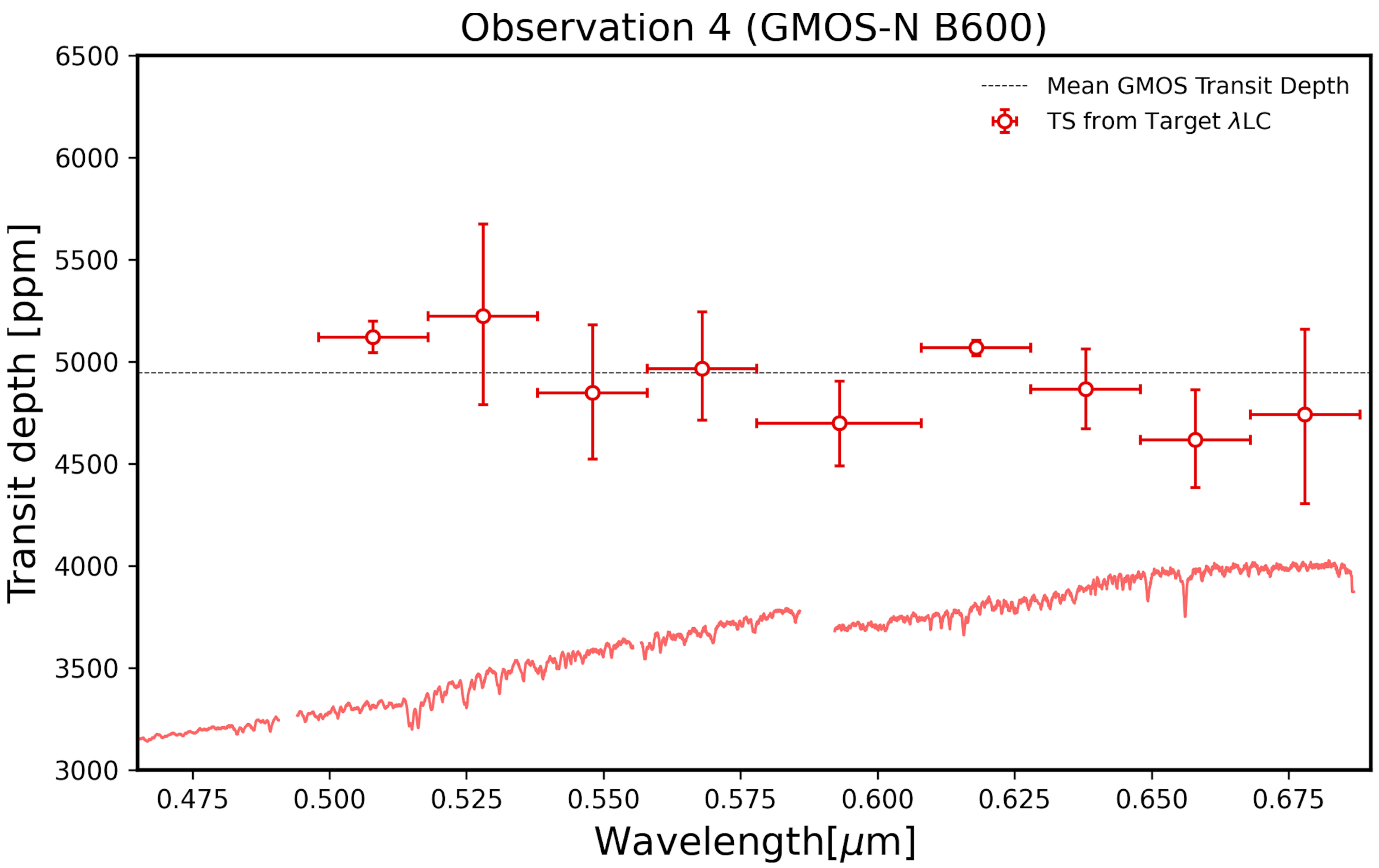

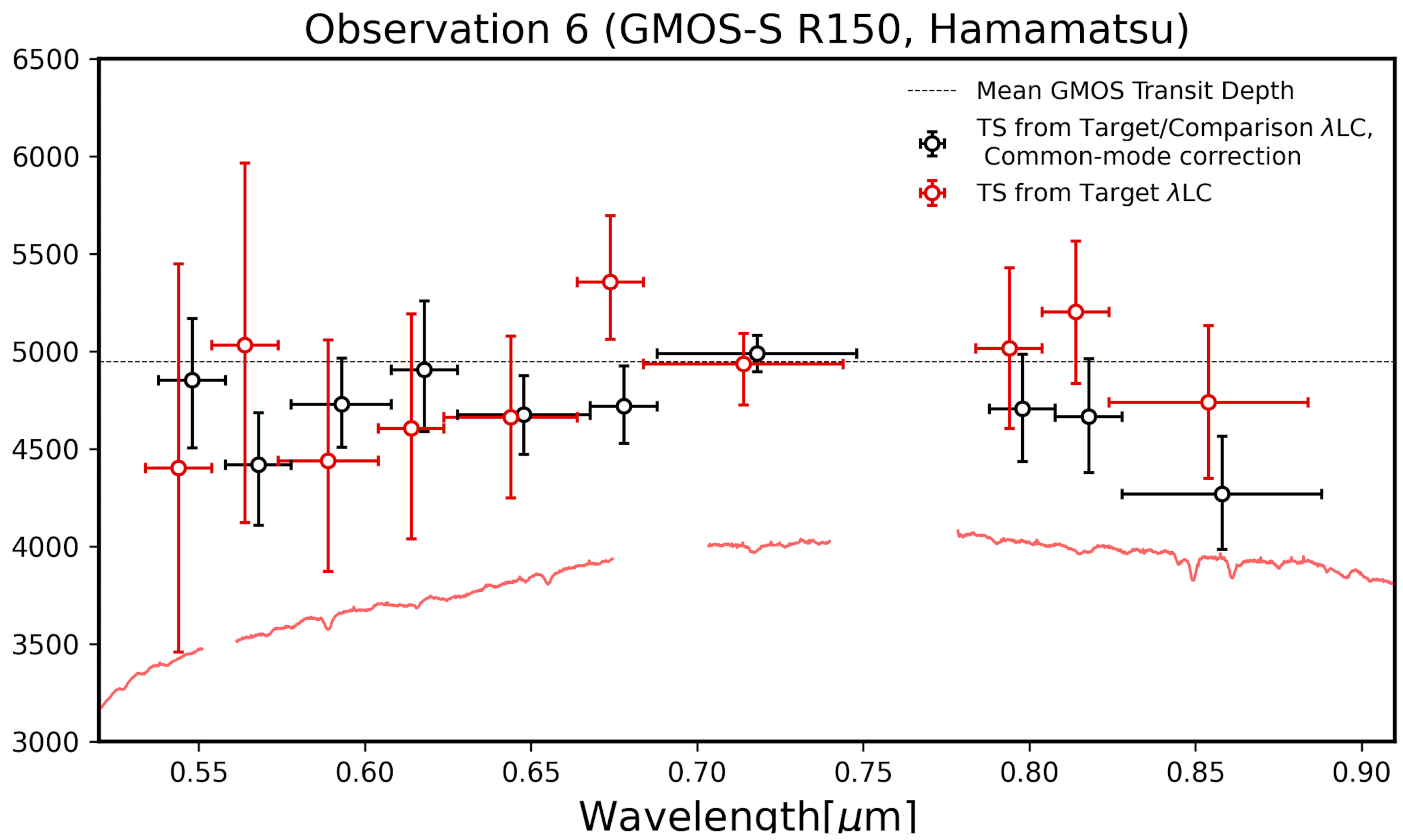

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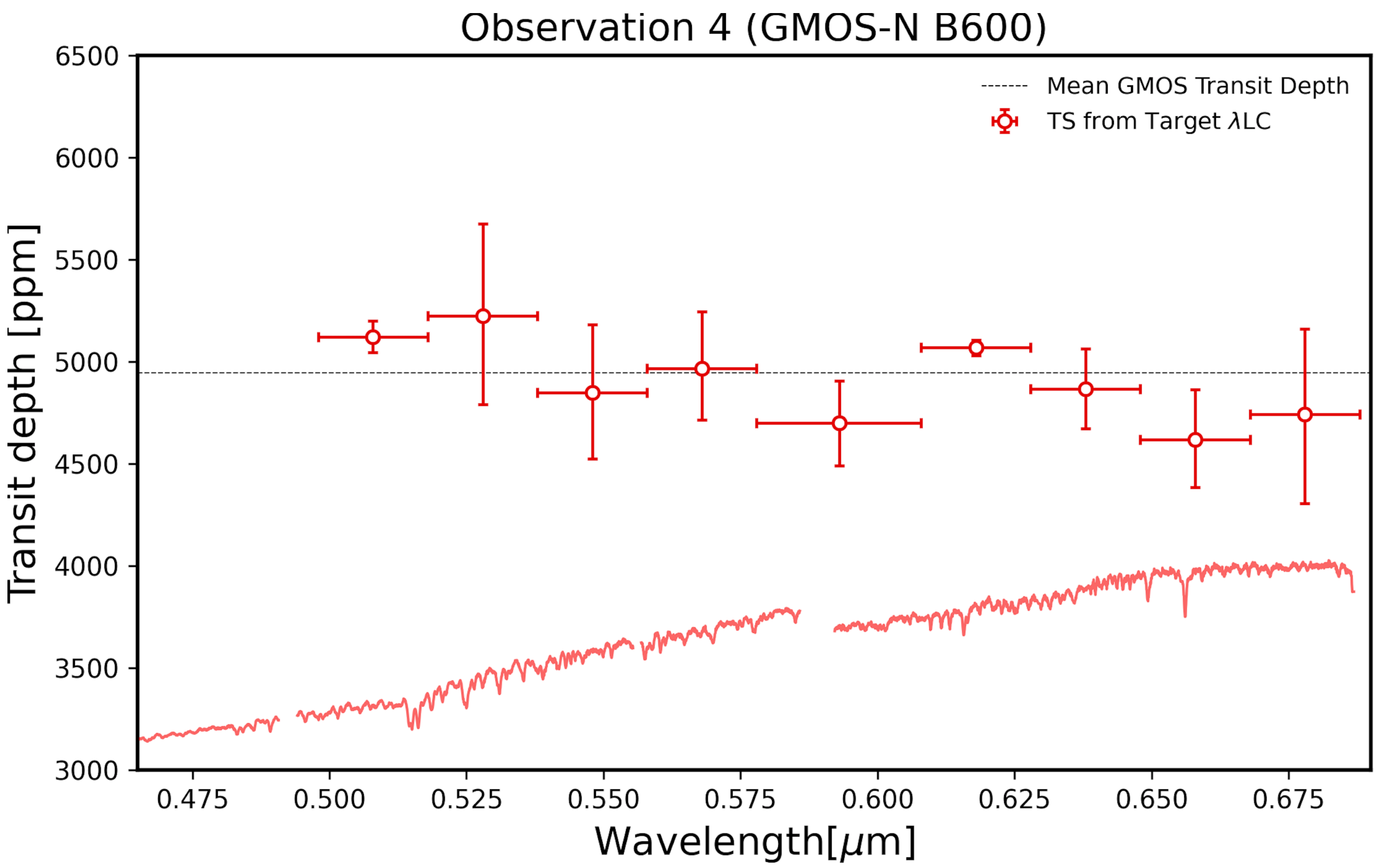
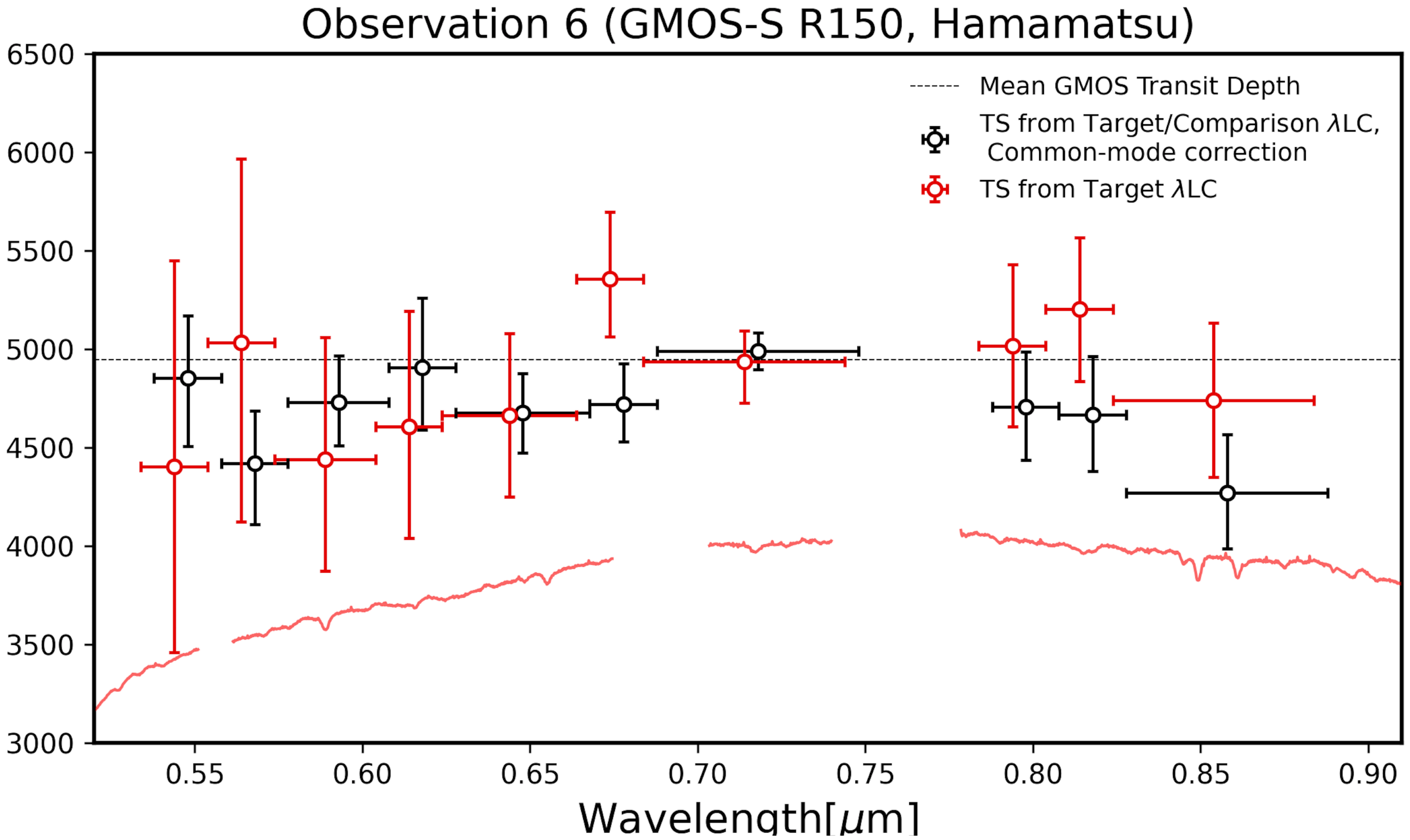
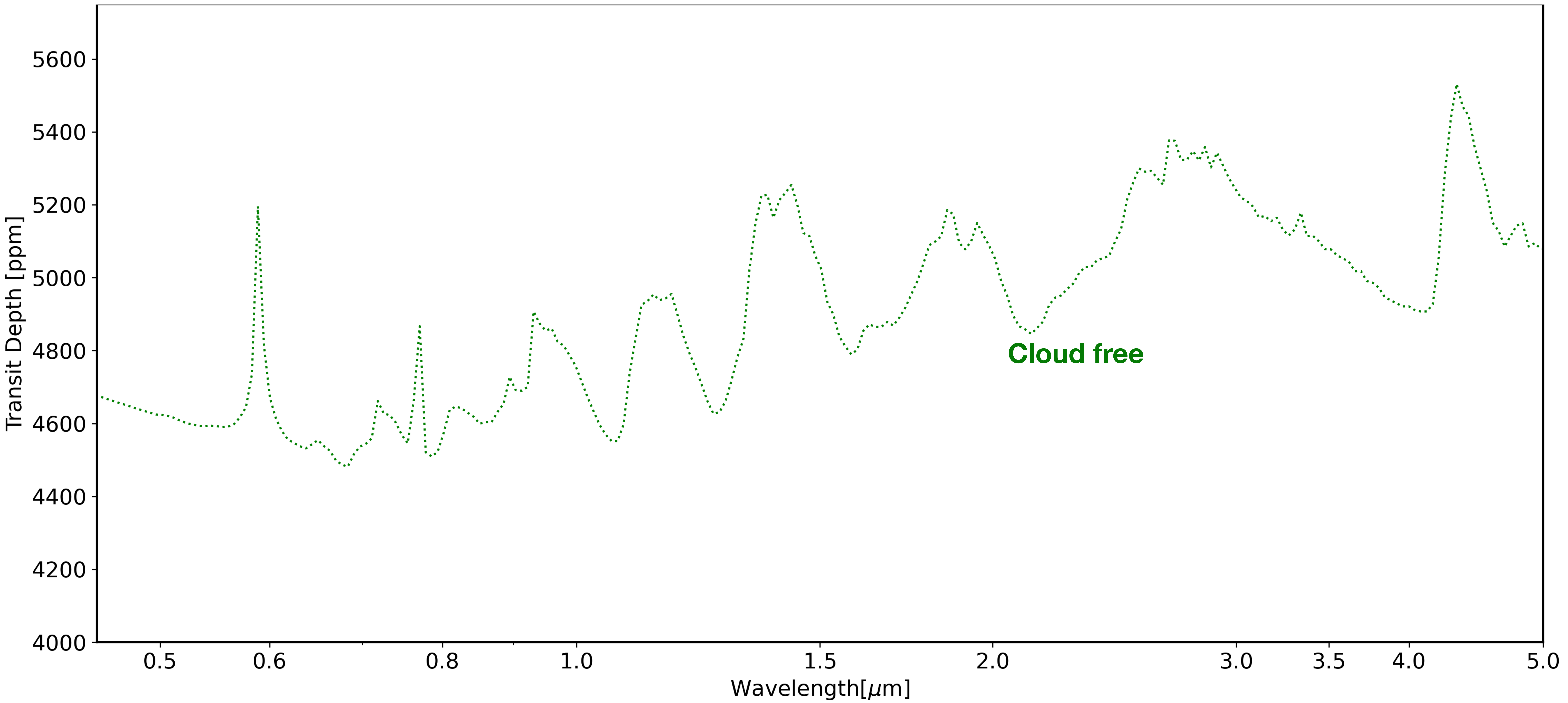




Propagating uncertainties from common mode correction within Bayesian framework of GPs

Panwar et al. (in review)

Gemini/GMOS transmission spectrum of the warm Neptune HAT-P-26b



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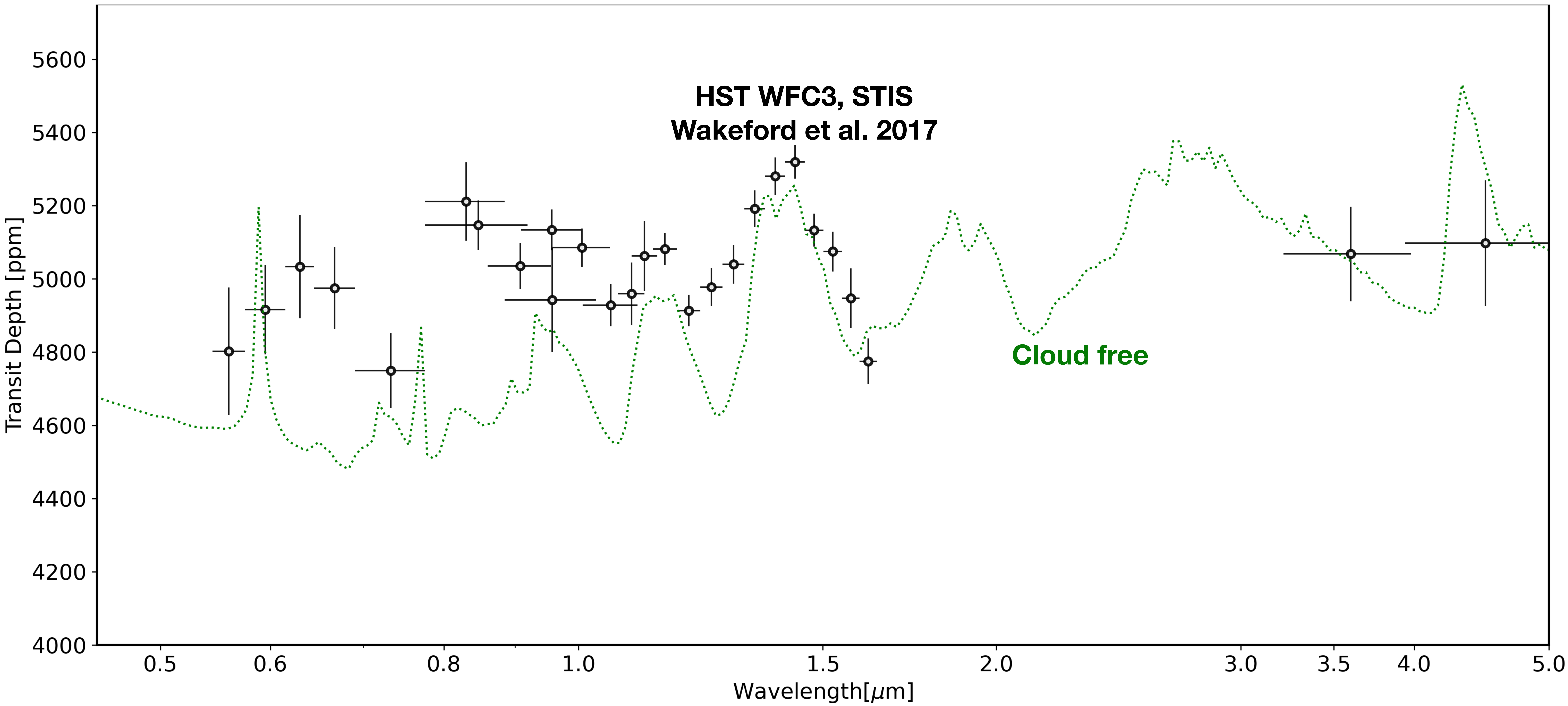

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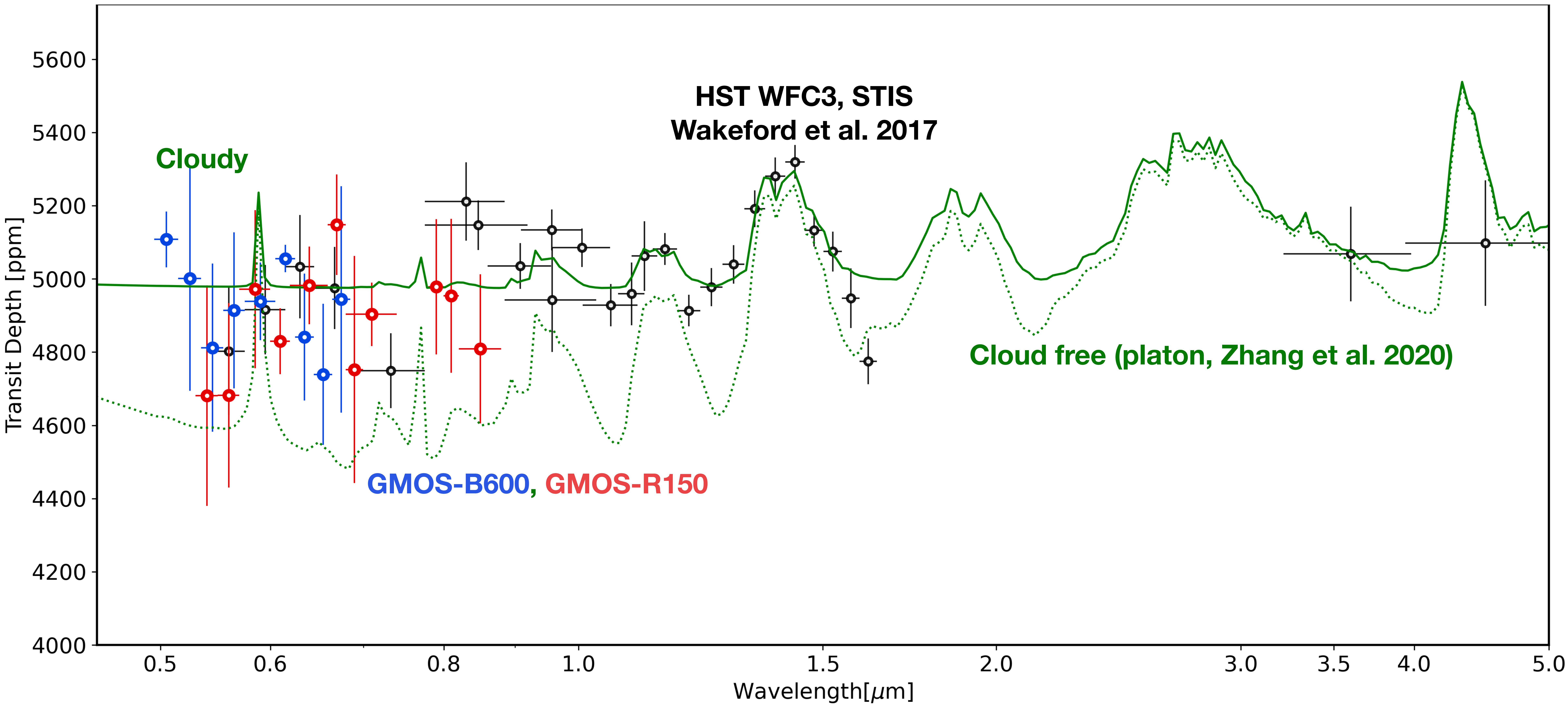
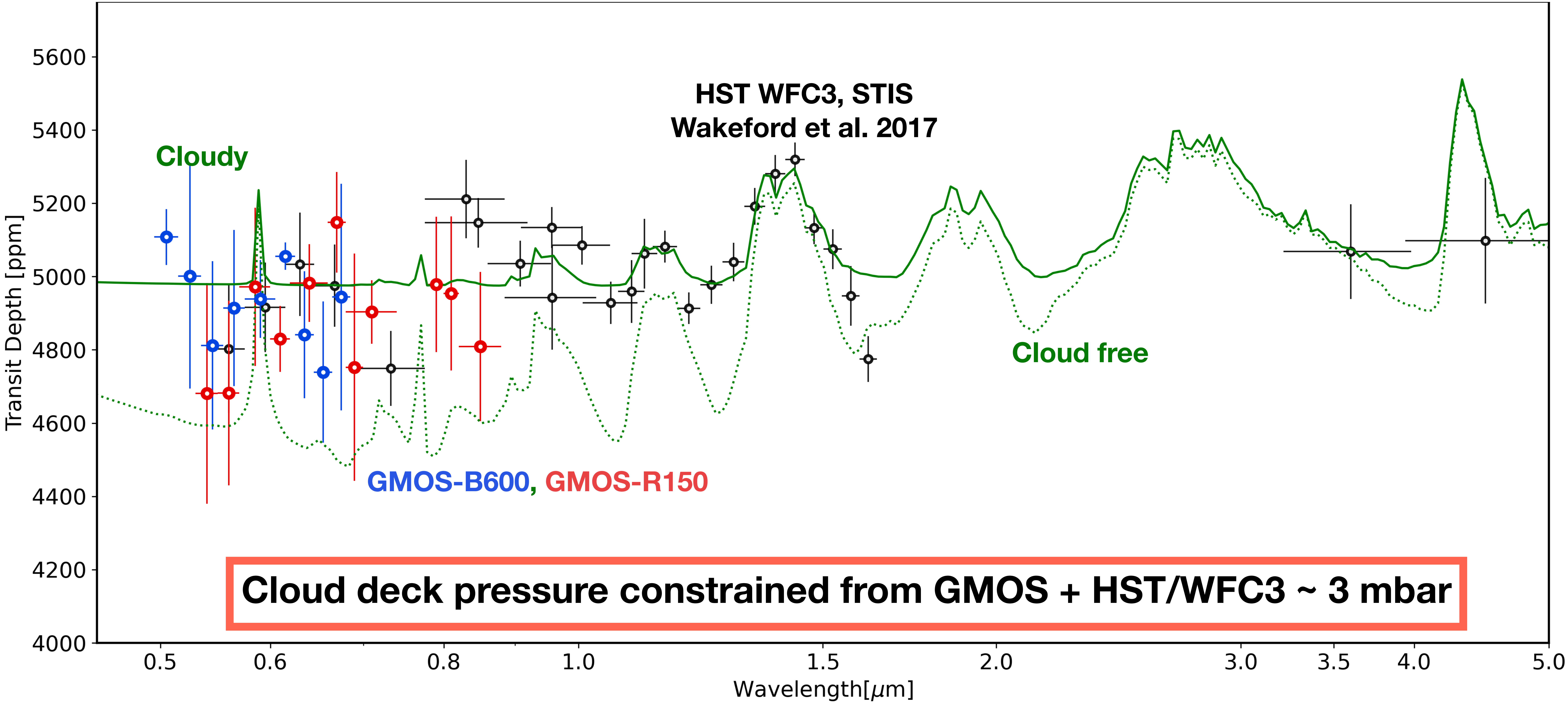


Gemini/GMOS transmission spectrum of the warm Neptune HAT-P-26b

Constraining the cloud deck pressure level



Measuring Accurate transit depth necessary for active host stars

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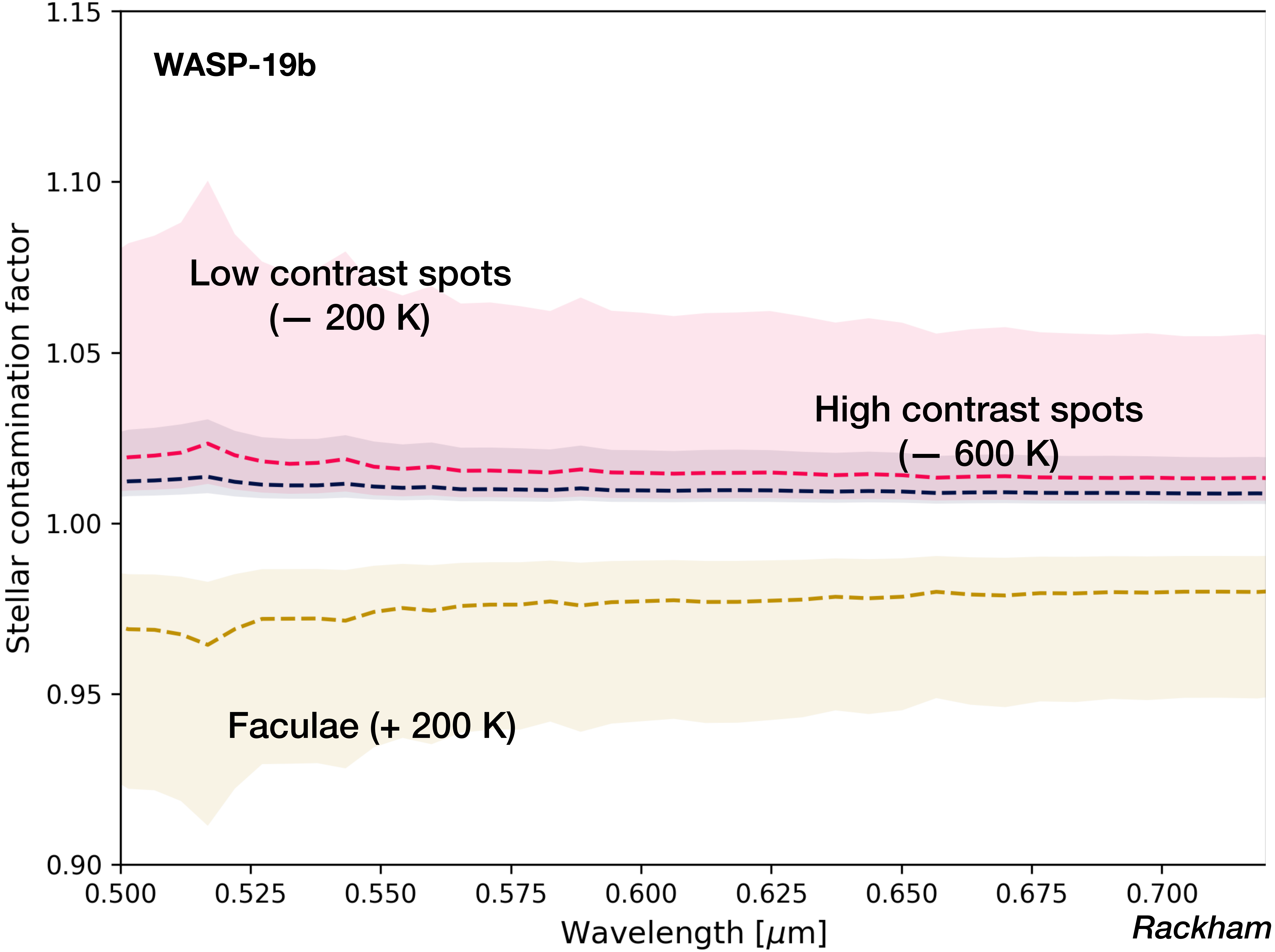
How does this change planet's spectrum?

Contamination of transmission spectrum due to stellar spots/faculae



Rackham et al. 2018,
Stellar spot parameters from Espinoza et al. 2019

WASP-19b observed by Gemini/GMOS over multiple epochs

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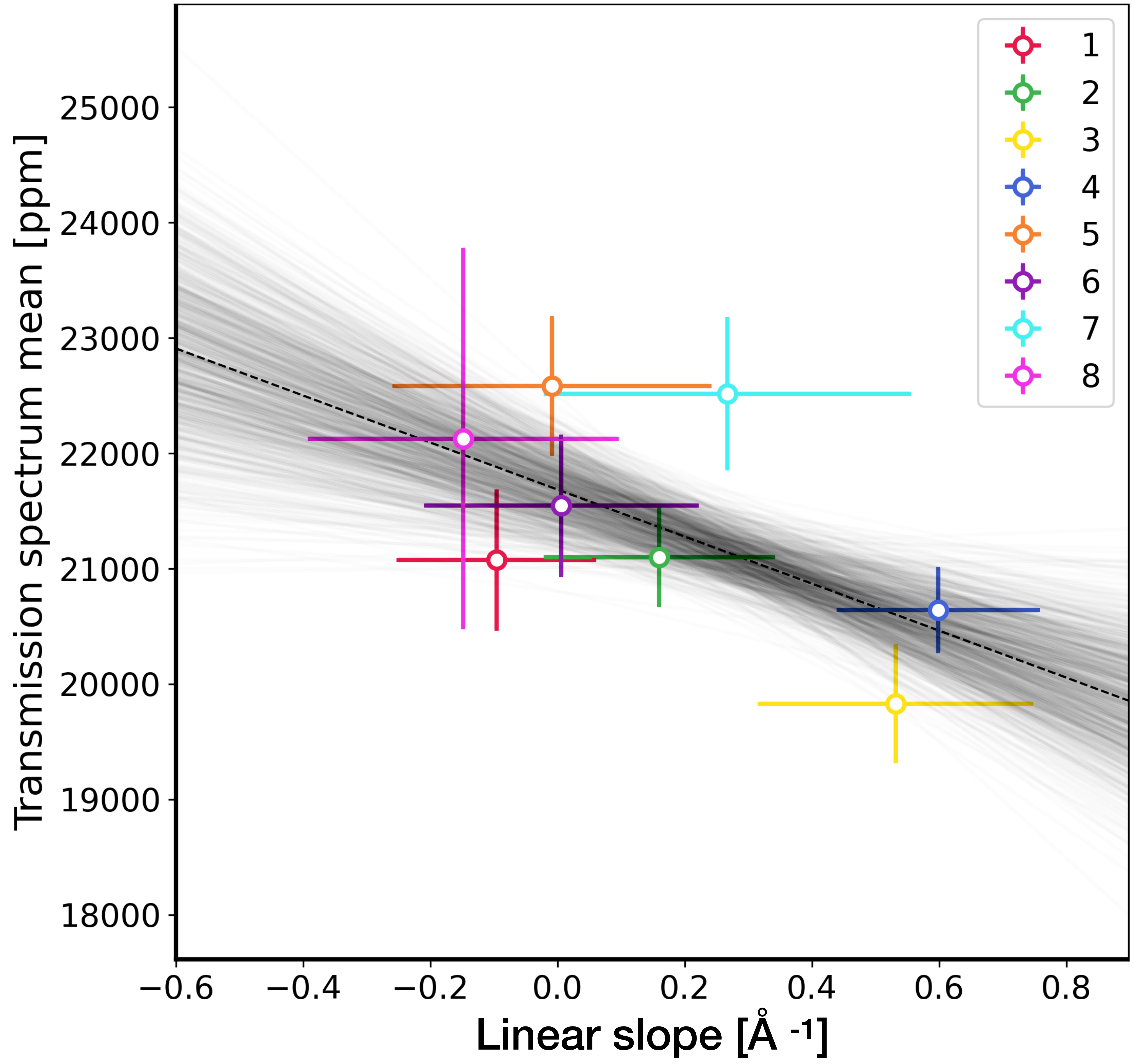
Panwar et al. in prep

Stellar variability: an obstacle to combining multi-epoch spectra



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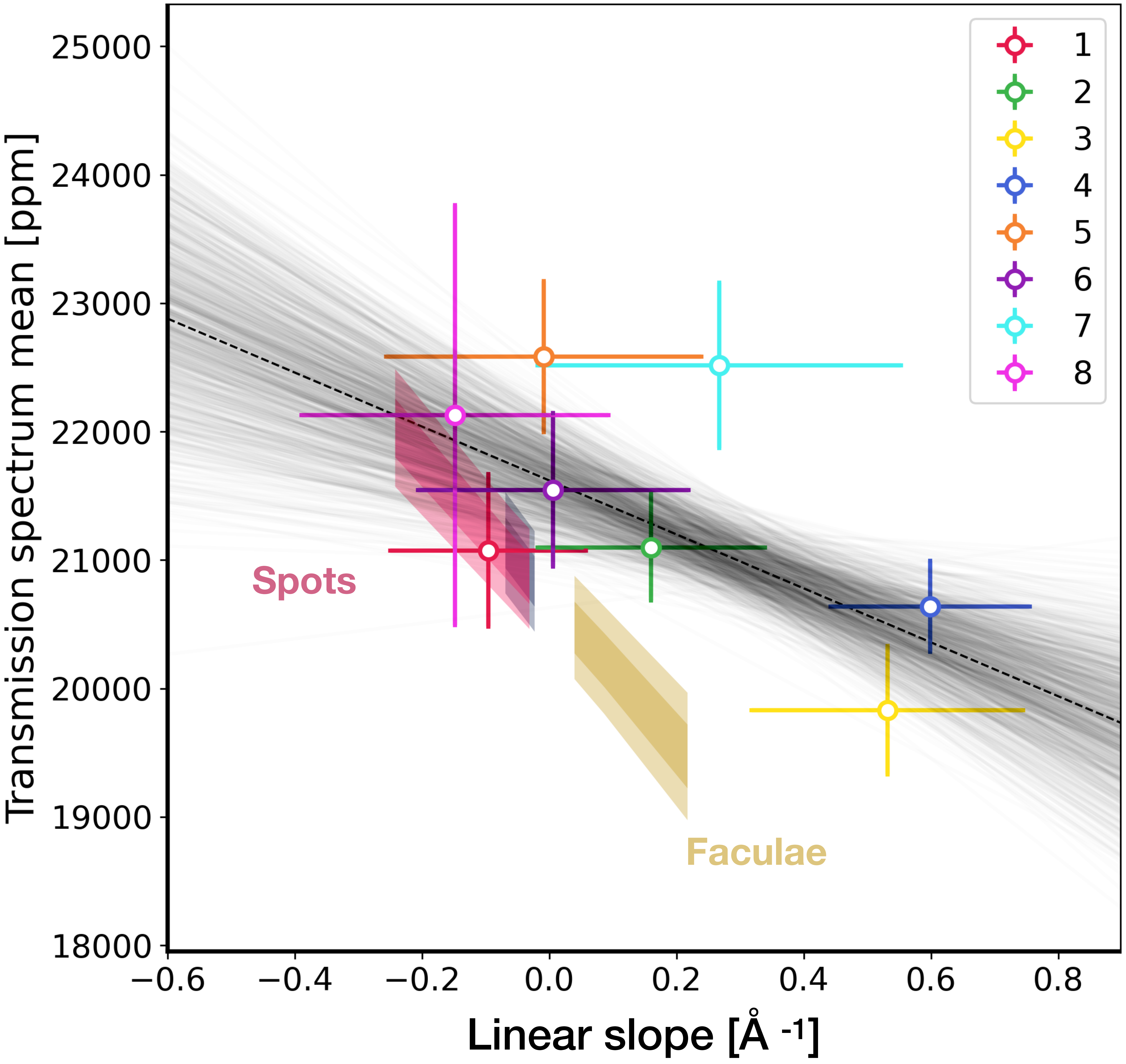

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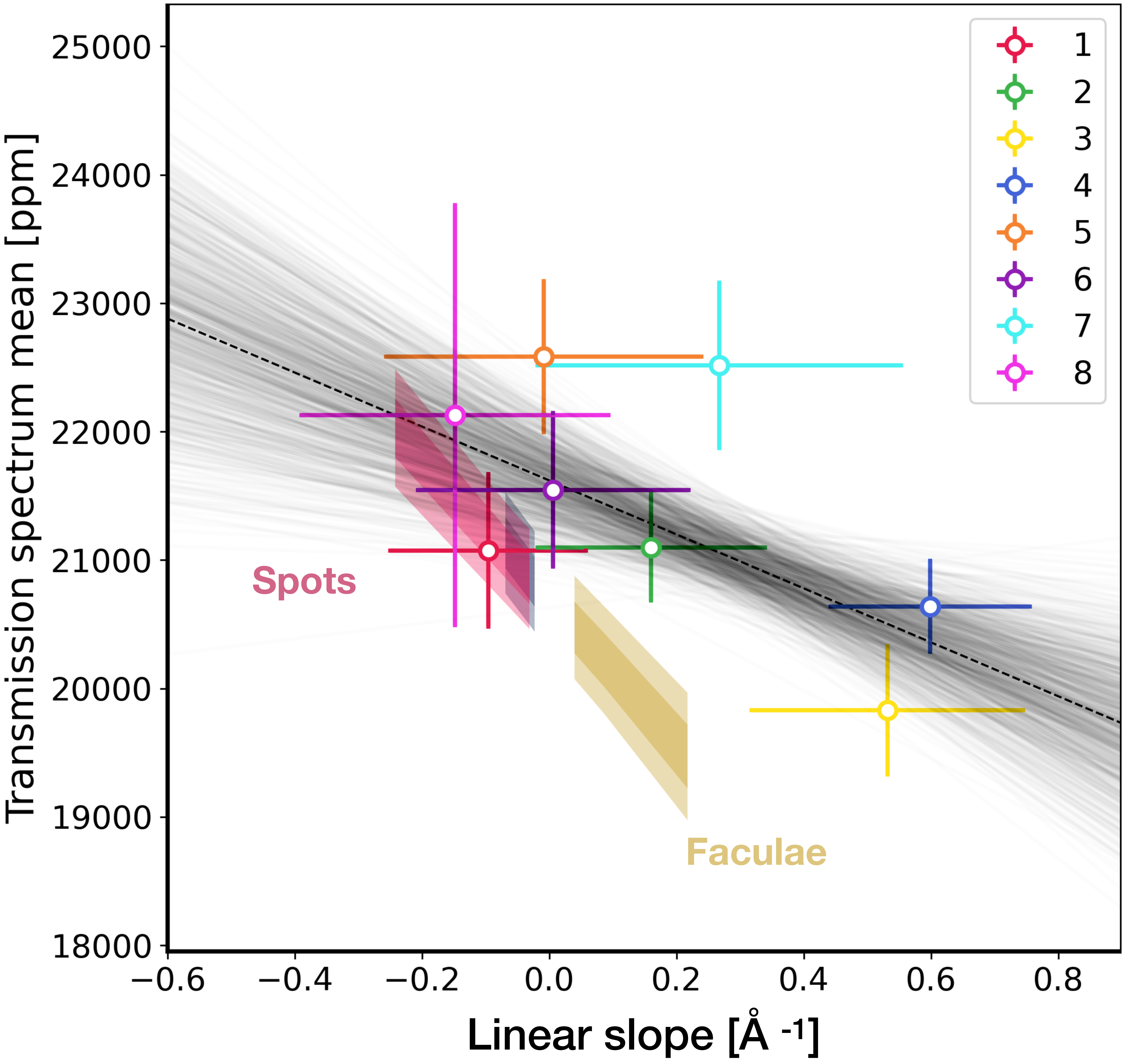

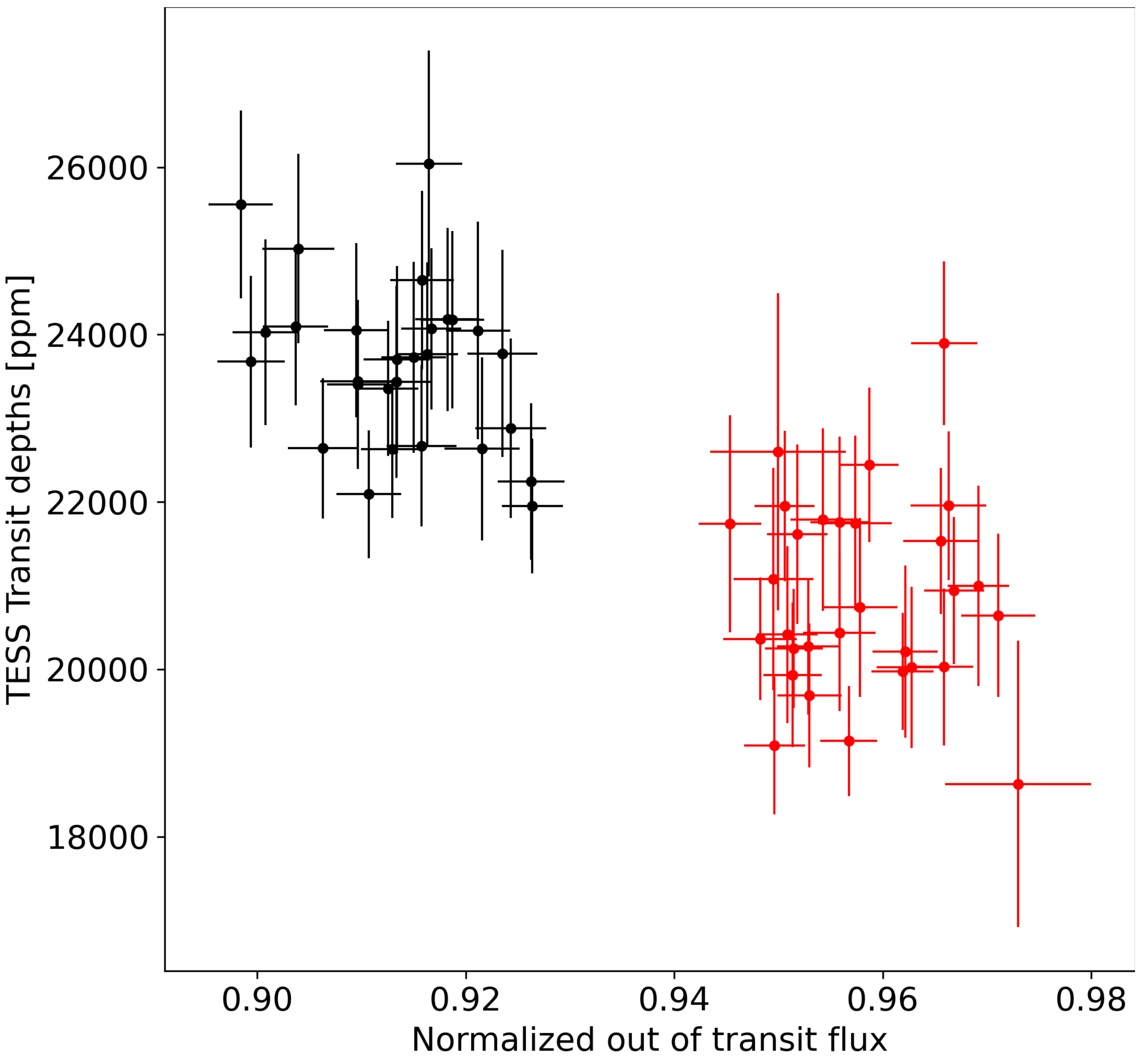

Summary and Conclusions

- We develop a **new method** to extract ground-based transmission spectra that does **not rely on comparison stars**.
- The new method is more **accurate** and more **precise**; it allows to derive **wavelength dependent absolute transit depths.**
- The new method enables **ground-based** atmospheric follow-up of **bright targets** with no suitable comparison stars nearby.
- Contamination due to **stellar variability** raises concerns on reliably combining transmission spectra over multiple epochs.