CHARACTERIZING LHS1140-C USING ECLIPSE PHOTOMETRY

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Université de Montréal

Foundation familiale Trottier Family Foundation

Institut Trottier de recherche sur les exoplanètes

Trottier Institute for Research on Exoplanets

iREx

Image source: yandrela, Wallpapers.com

THE SYSTEM LHS1140

☆ Calm, old M4.5 dwarf

☆ T_{eff} 3096 K

Parameters (Cadieux et al. 2024)

	c	b
Mass (Earth masses)	1.9	5.6
Radius (Earth radii)	1.3	1.7
Period (days)	3.8	24.7

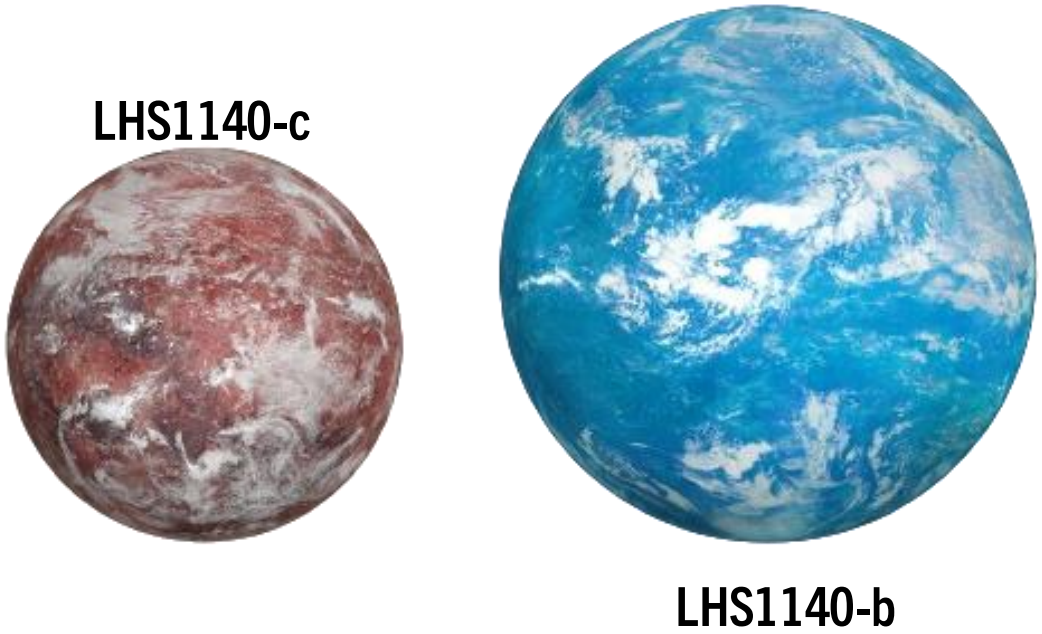

Image source: Terrestrial planets - Halcyonmaps.com

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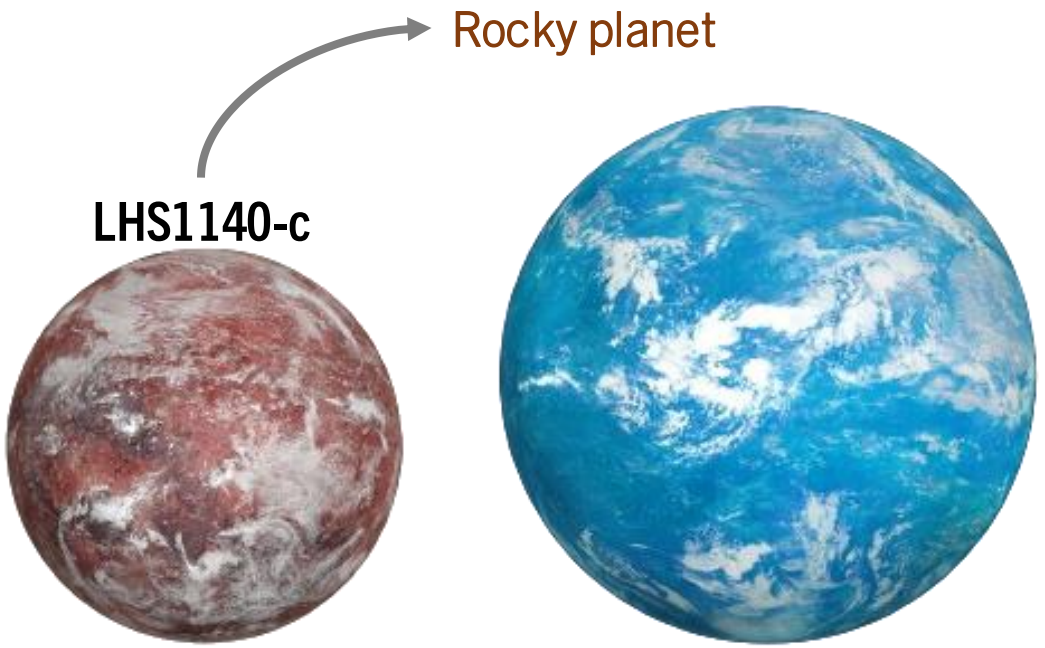

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ECLIPSE PHOTOMETRY

Probe light emitted from dayside

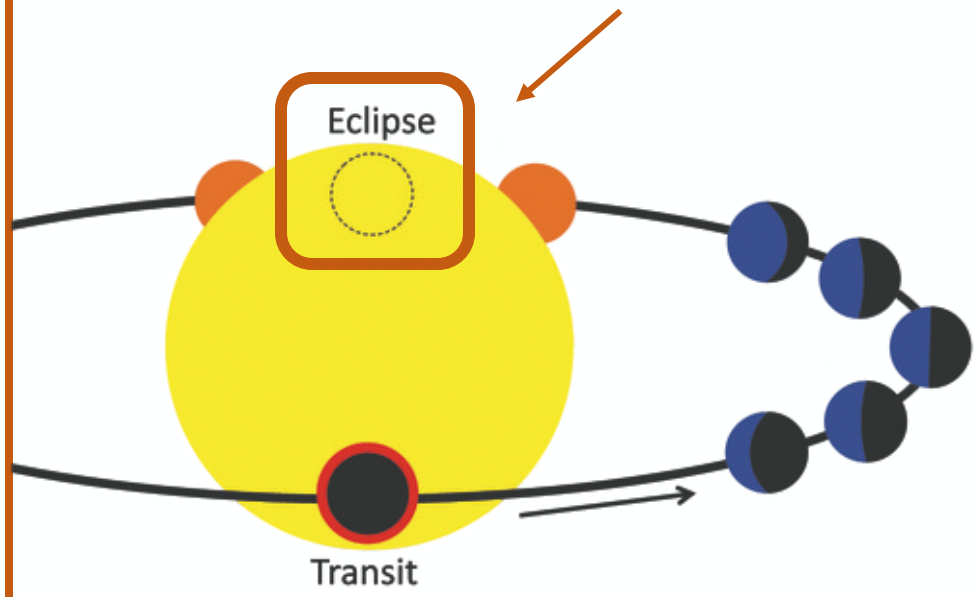
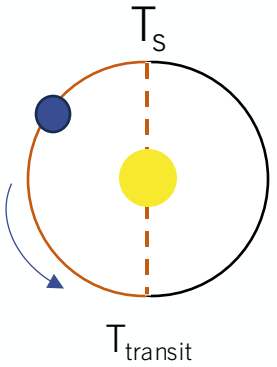
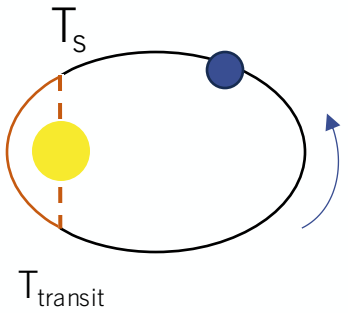


Illustration from Cowan (2014)

Two important measures:

1. Time of mid eclipse (T_s) to constrain eccentricity





2. Eclipse depth → Brightness temperature

OBSERVATIONS

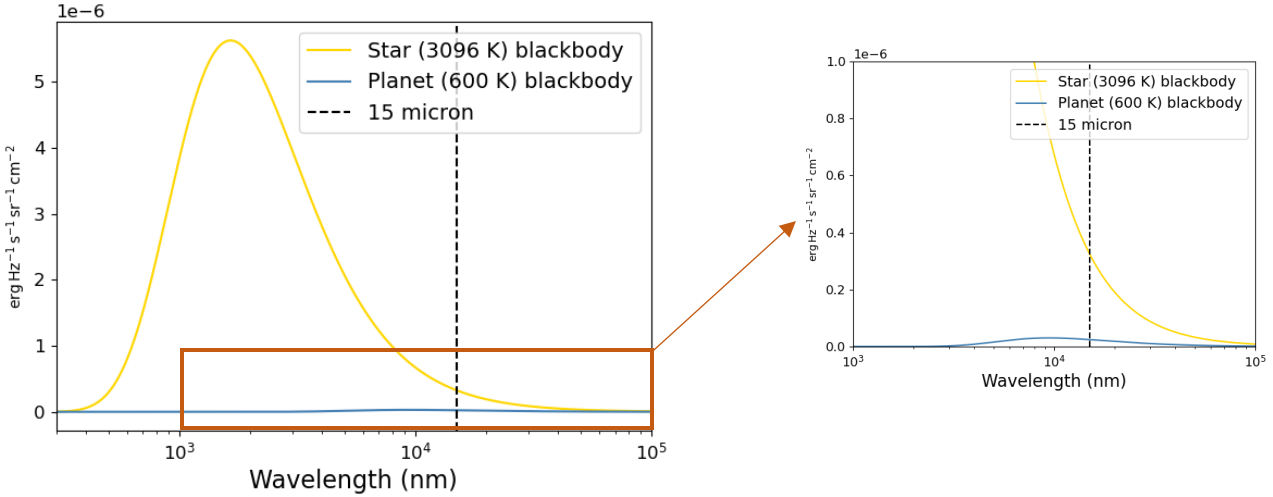
Mid-Infrared Instrument (MIRI)

Photometry – Imaging mode

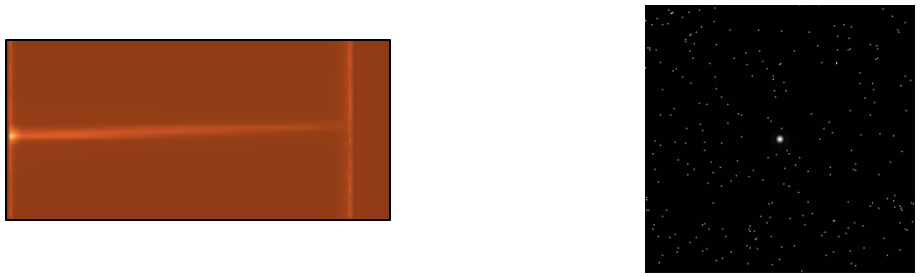
15 microns - F1500W

3 eclipses observed

Why 15 microns?



JWST spectra & photometry



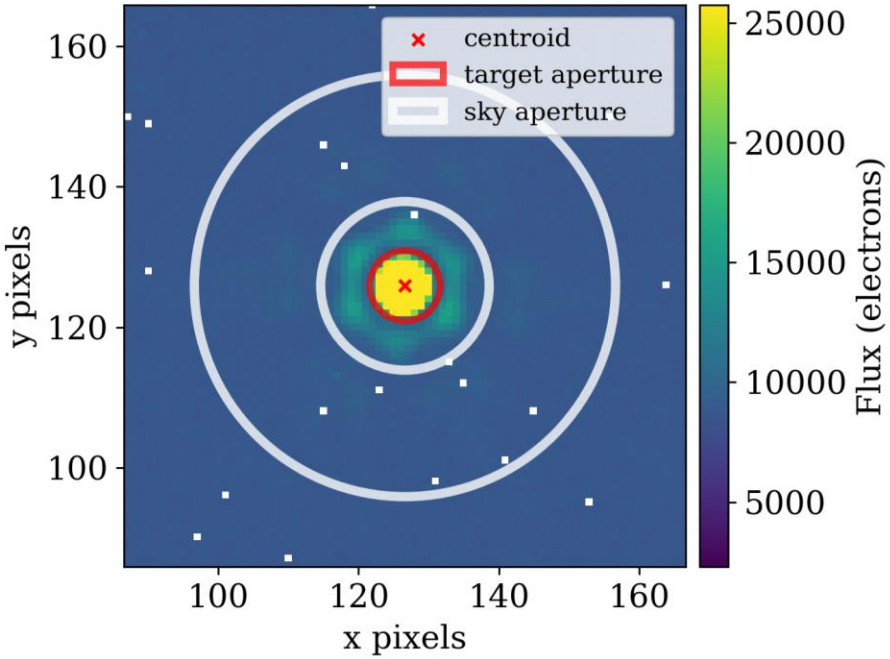
Images source: eurekadocs.readthedocs.io

Image source: NASA

INITIAL DATA REDUCTION

Eureka! pipeline:

- Calibration
- Background subtraction
- PSF centering
- Extraction of spectra



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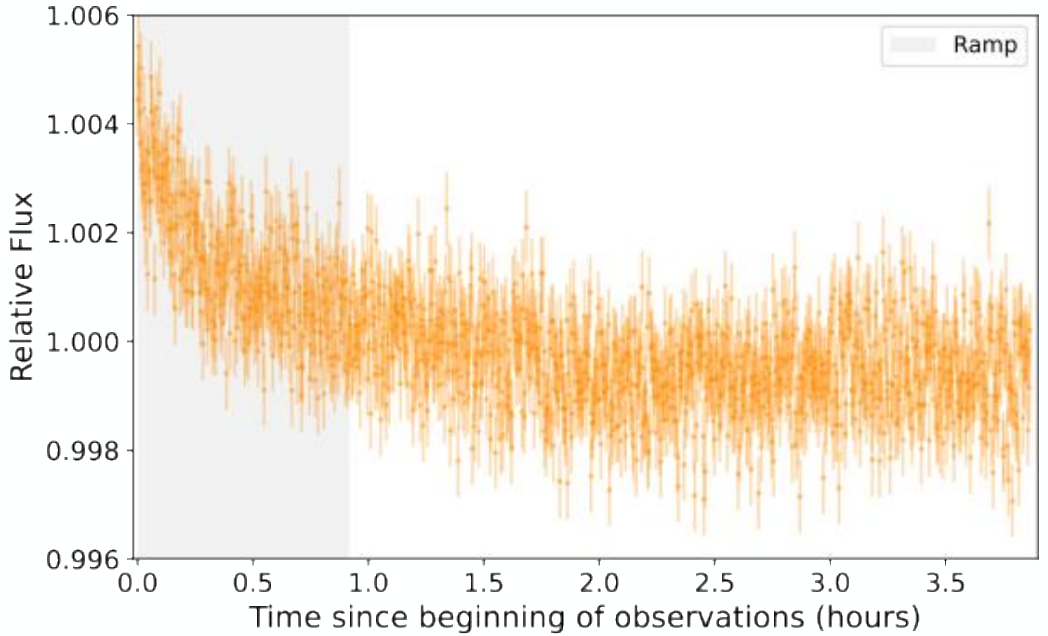

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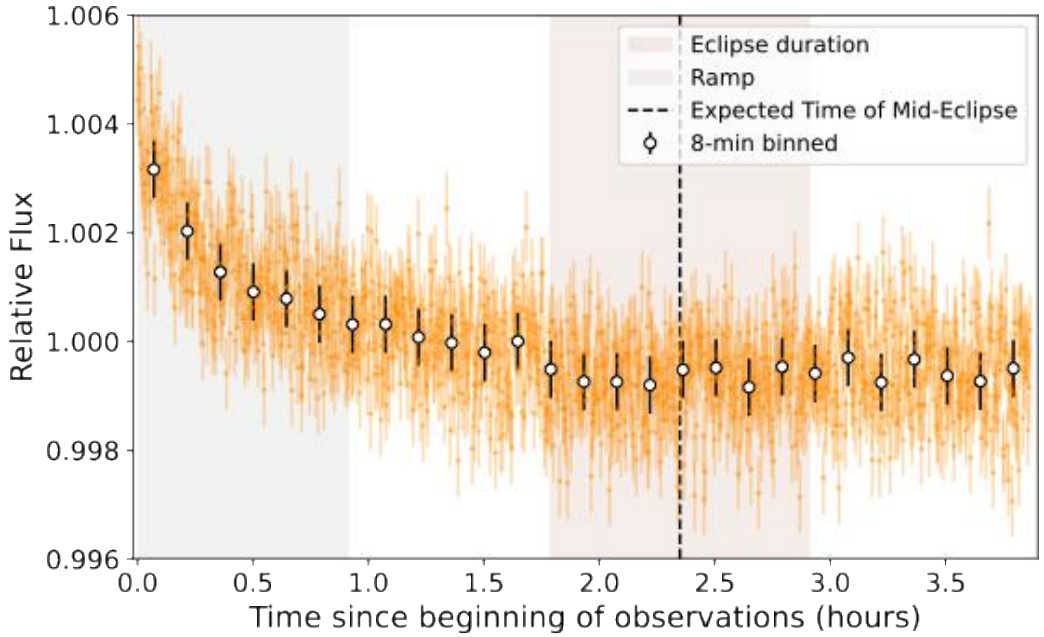

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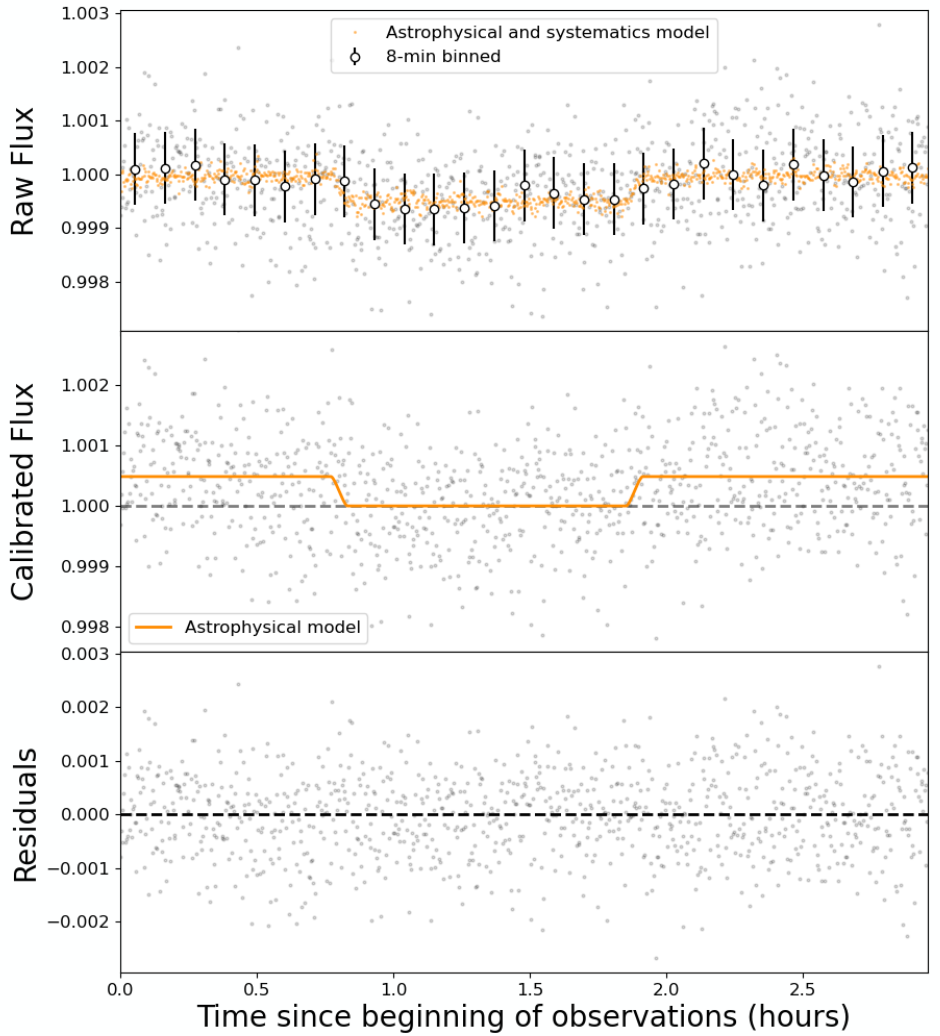
ECLIPSE FITTING

- Removed first ~50 mins and a linear trend
- Simultaneously fit the astrophysical signal (A) and the detector systematics (D) with an MCMC

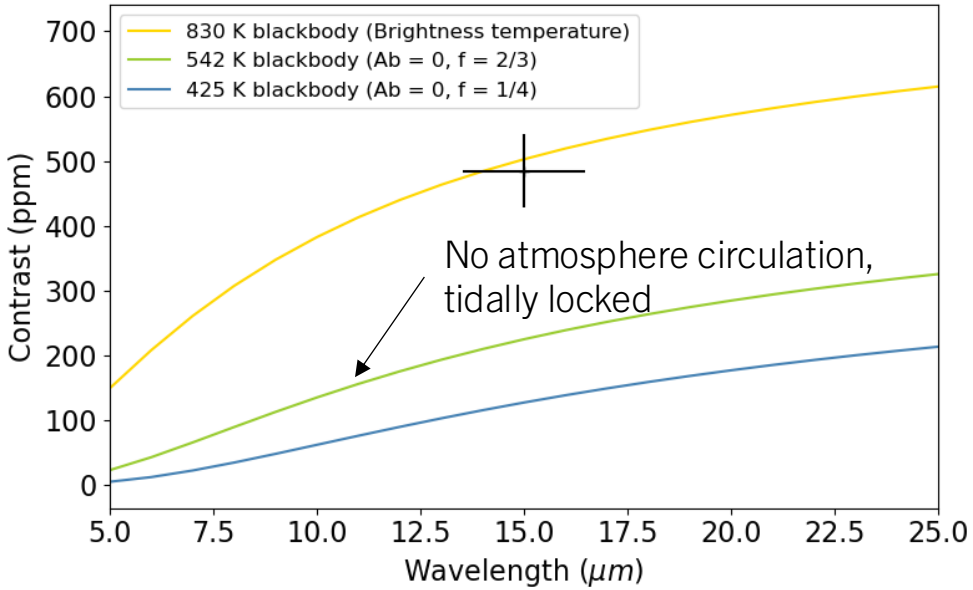
$$\text{Model} = A(t) \times D(x_0, y_0)$$



PRELIMINARY RESULTS

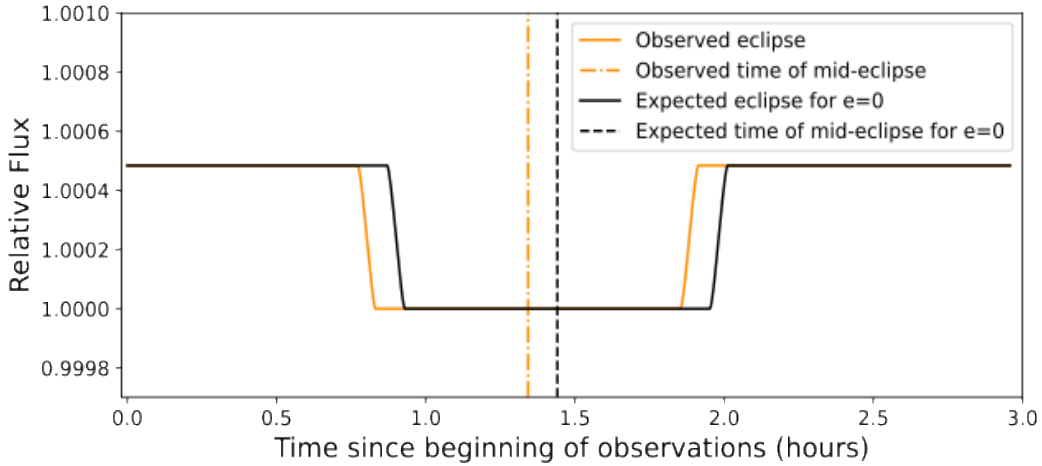
Temperature

- Eclipse depth: **484 ± 55 ppm**, 8σ detection
- Derived brightness temperature of 830 K
- Much hotter than expected!



Eclipse Timing

- Time of mid-eclipse 4σ from expected value
- **ΔT = 5.9 ± 1.44 min**
- Suggests an orbital eccentricity (e ≠ 0) or TTVs



Takeaways & Limitations

- Eclipse depth of 484 ± 55 ppm
- Derived brightness temperature of 830 K
- Constrained the eclipse timing
- Only 1 of 3 eclipses analyzed → need to repeat results
- Oversimplified noise model

Next Steps

1. Fit remaining two eclipses & joint fit of all 3 observations
2. Improve detector systematics model
3. Constrain the eccentricity of LHS1140-c to inform future observations of the LHS1140 system

ACKNOWLEDGEMENTS

I thank Professor René Doyon and Dr. Lisa Dang for their support and expertise during this project, as well as the Trottier Institute for Research on Exoplanets at the Université de Montréal for the opportunity.

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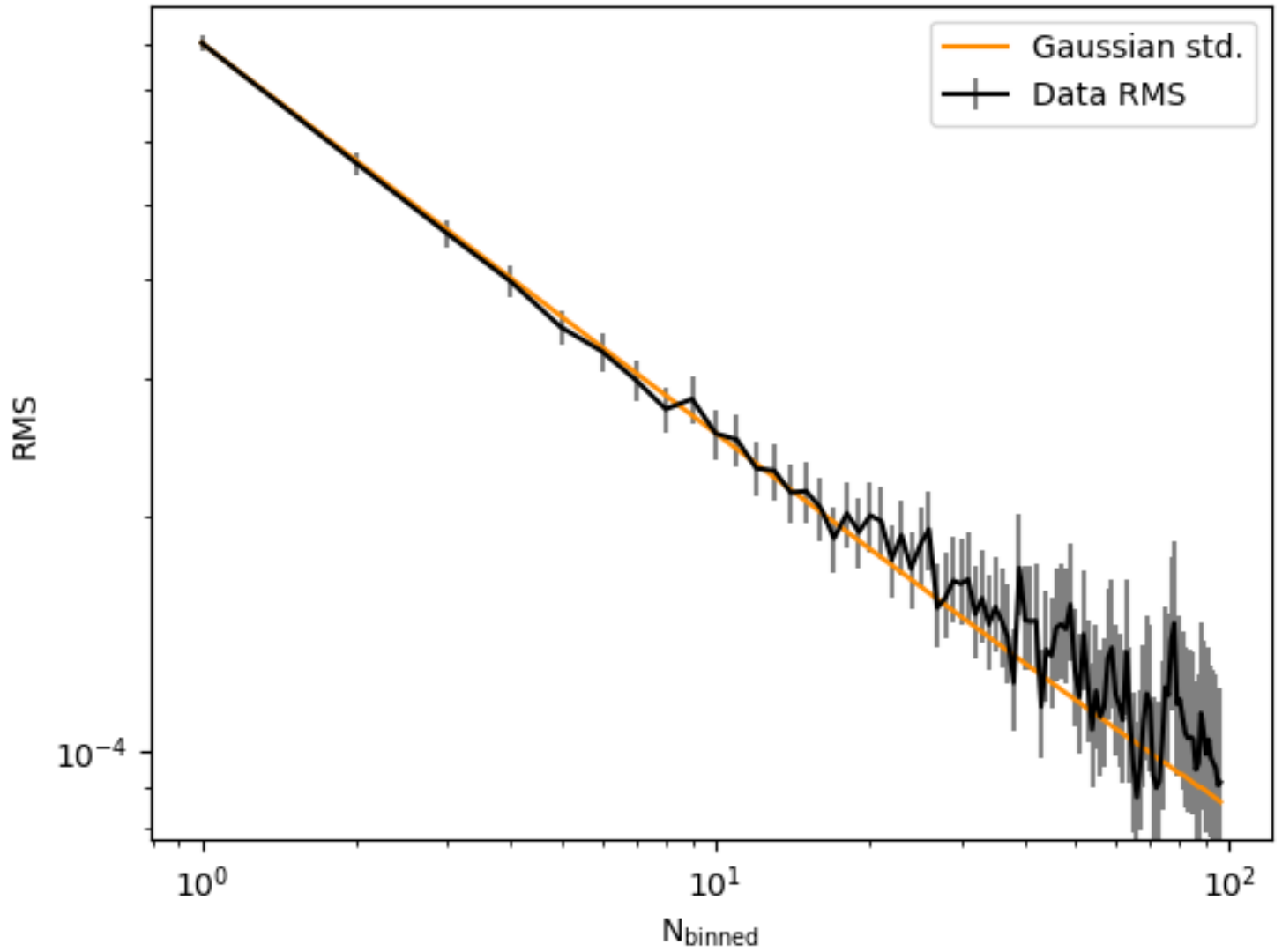
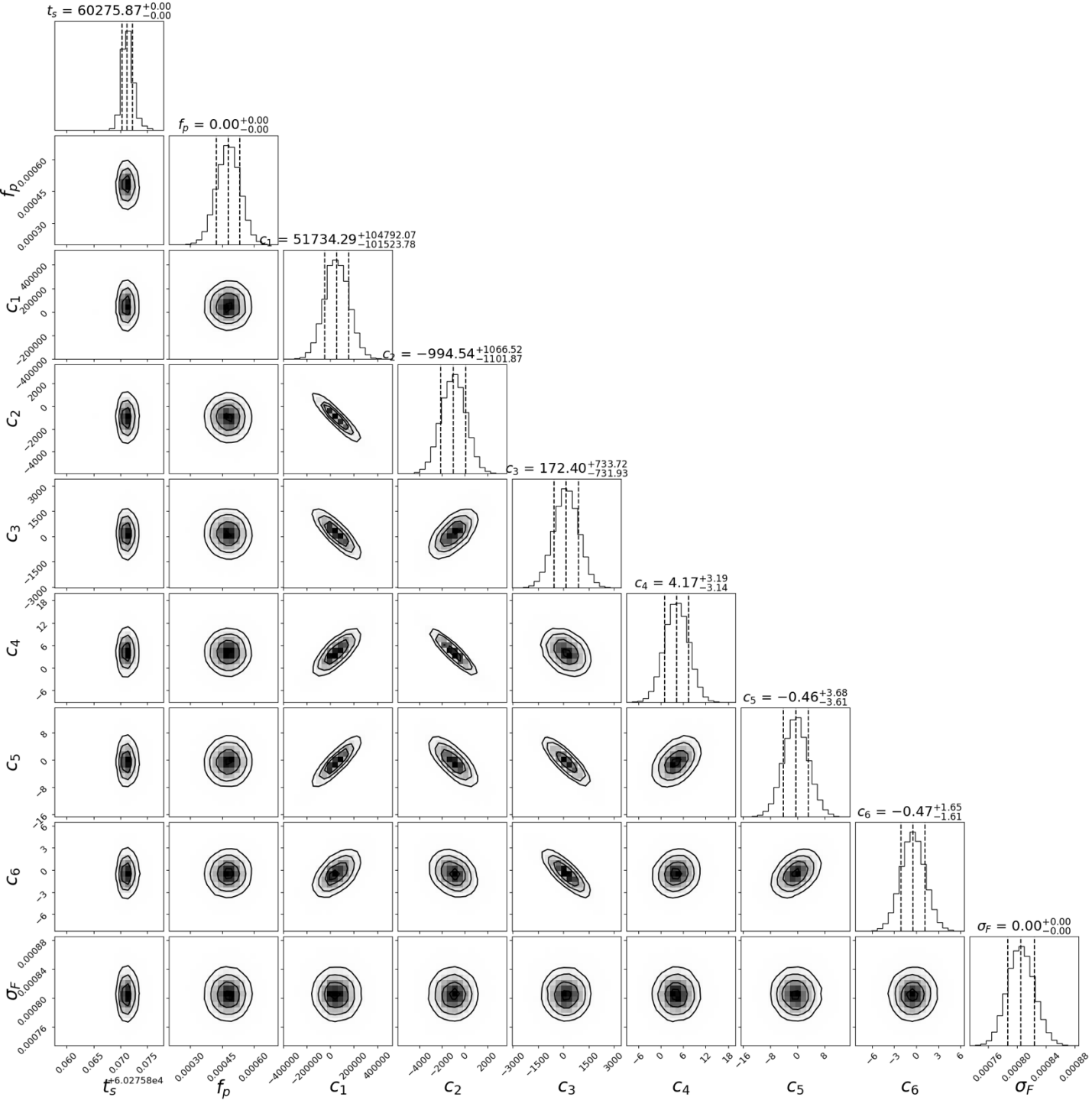
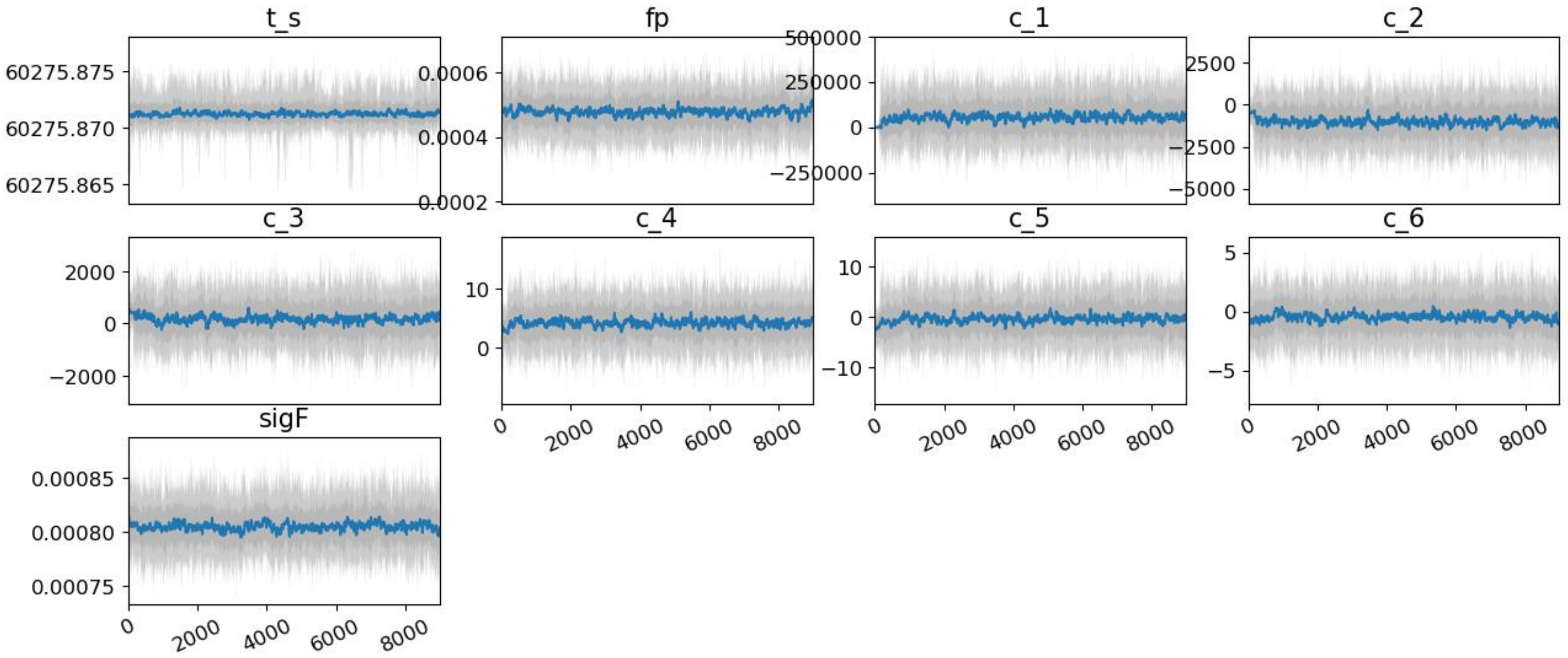

Gaussian std.
Data RMS
RMS
10^{-4}
10^{0}
10^{1}
10^{2}
N_{binned}


$t_s = 60275.87^{+0.00}_{-0.00}$
$f_p = 0.00^{+0.00}_{-0.00}$
$c_1 = 51734.29^{+104792.07}_{-101523.78}$
$c_2 = -994.54^{+1066.52}_{-1101.87}$
$c_3 = 172.40^{+733.72}_{-731.93}$
$c_4 = 4.17^{+3.19}_{-3.14}$
$c_5 = -0.46^{+3.68}_{-3.61}$
$c_6 = -0.47^{+1.65}_{-1.61}$
$\sigma_F = 0.00^{+0.00}_{-0.00}$
t_s
+6.02758e4
f_p
c_1
c_2
c_3
c_4
c_5
c_6
σ_F


t_s
60275.875
60275.870
60275.865
fp
0.0006
0.0004
0.0002
c_1
500000
250000
0
−250000
c_2
2500
0
−2500
−5000
c_3
2000
0
−2000
c_4
10
0
c_5
10
0
−10
c_6
5
0
−5
sigF
0.00085
0.00080
0.00075
0
2000
4000
6000
8000