Massachusetts Institute of Technology

Near-infrared observations of the "Super-Neptune" HD 149026b

Josh Carter

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Joshua N. Winn, Ronald Gilliland, Matthew J. Holman

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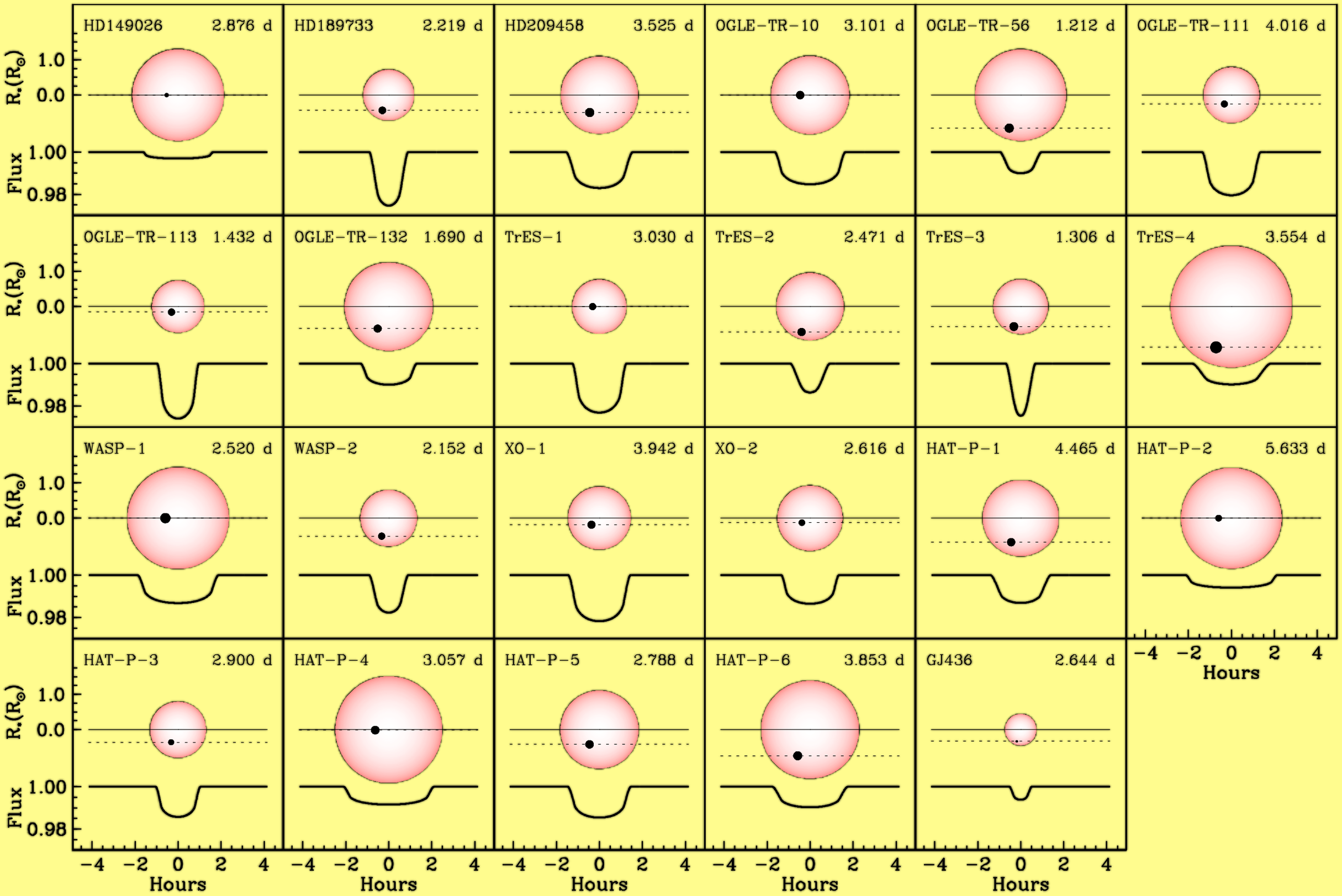
- "Hottest" exoplanet (Harrington et al. 2007); Novel atmosphere?
- Very dense relative to "Hot Jupiter" class; massive metal-rich core? (Sato et al. 2005, Fortney et al. 2006, Ikoma et al. 2006, Broeg & Wuchterl 2007, Burrows et al. 2007)

Torres, Winn, & Holman (2008)



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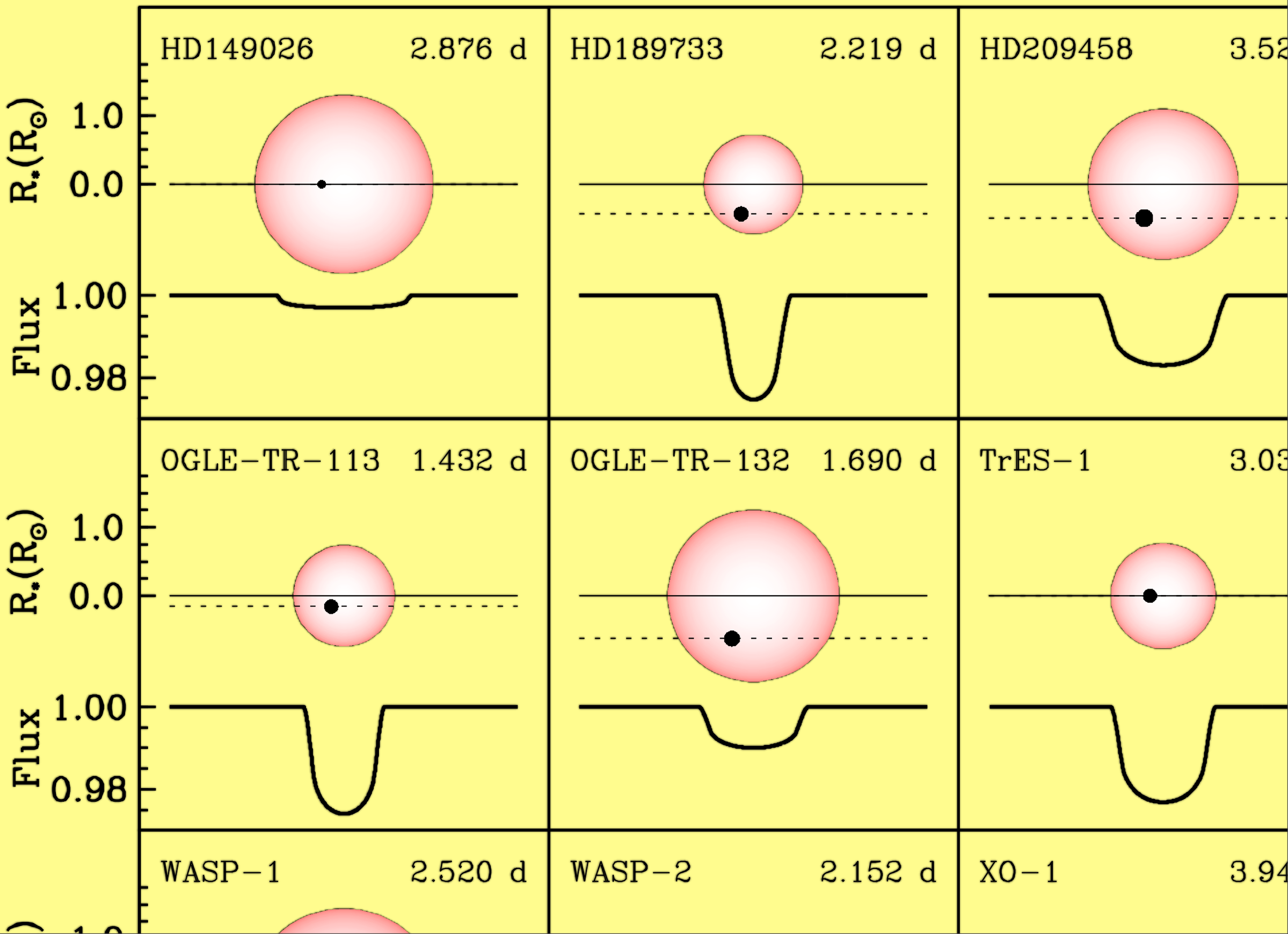
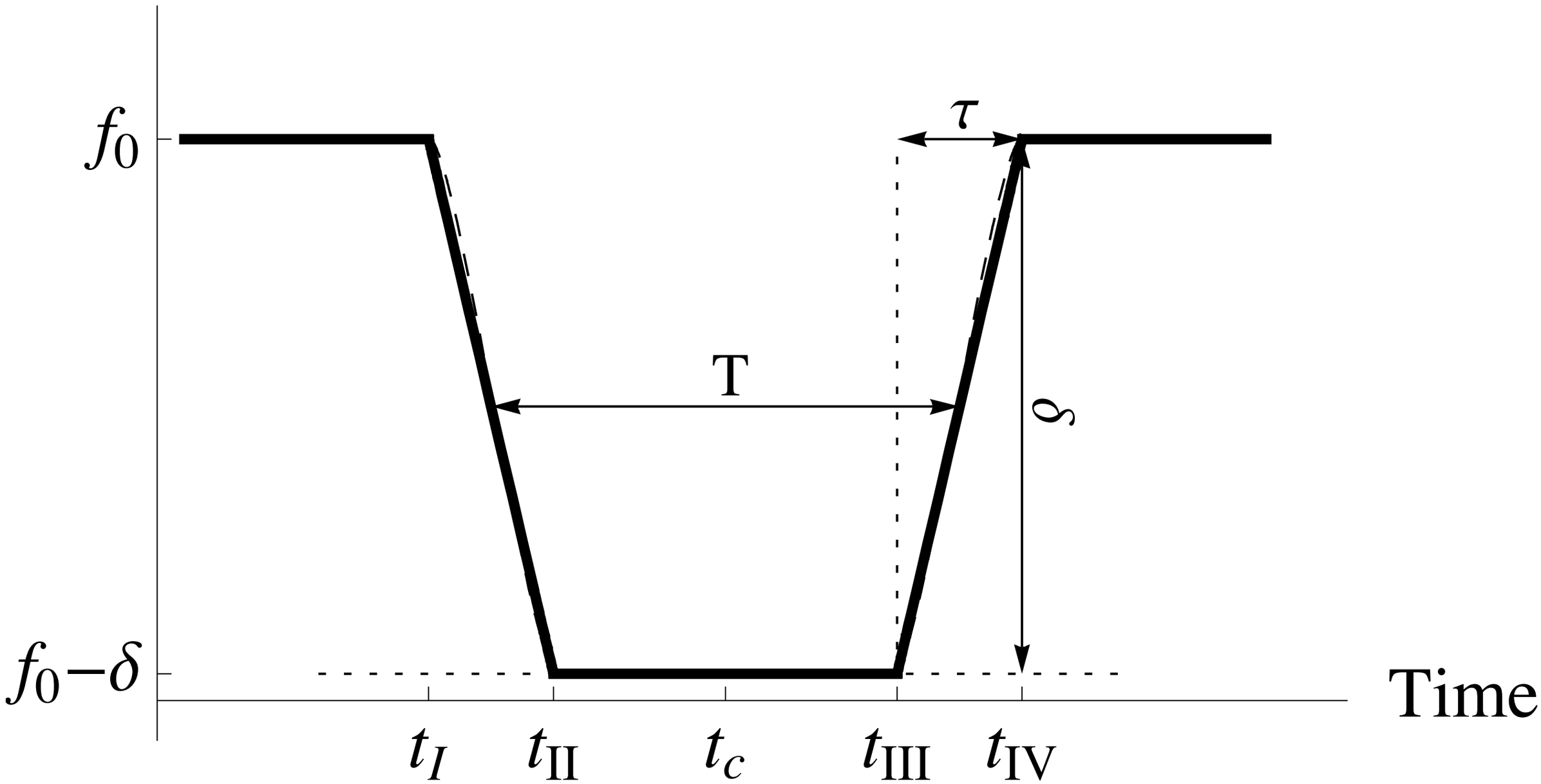


Task I

Task I

Carter et al. (2008)



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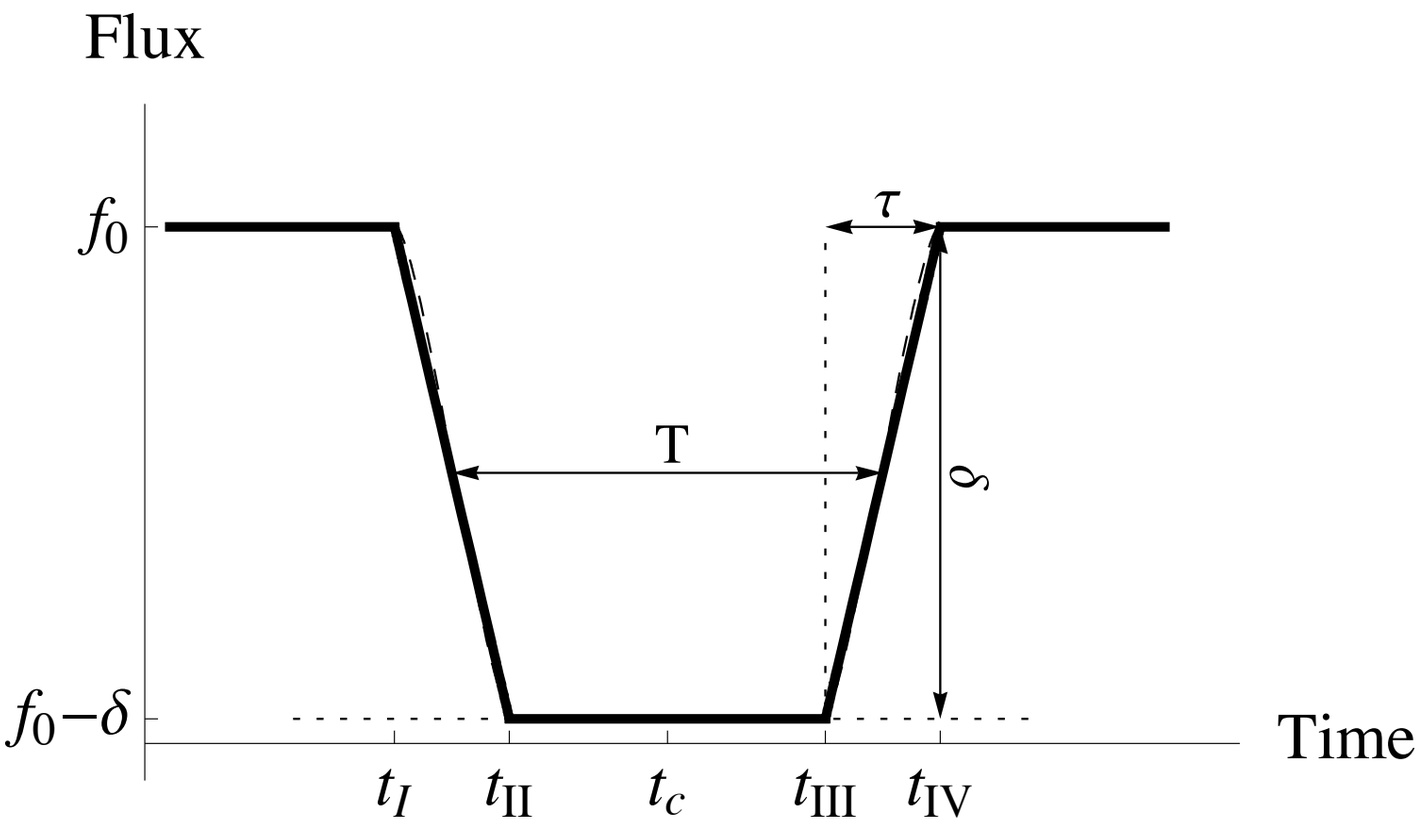

$$\rho_\star \propto \left(\frac{T\tau}{\delta}\right)^{\frac{3}{2}}$$

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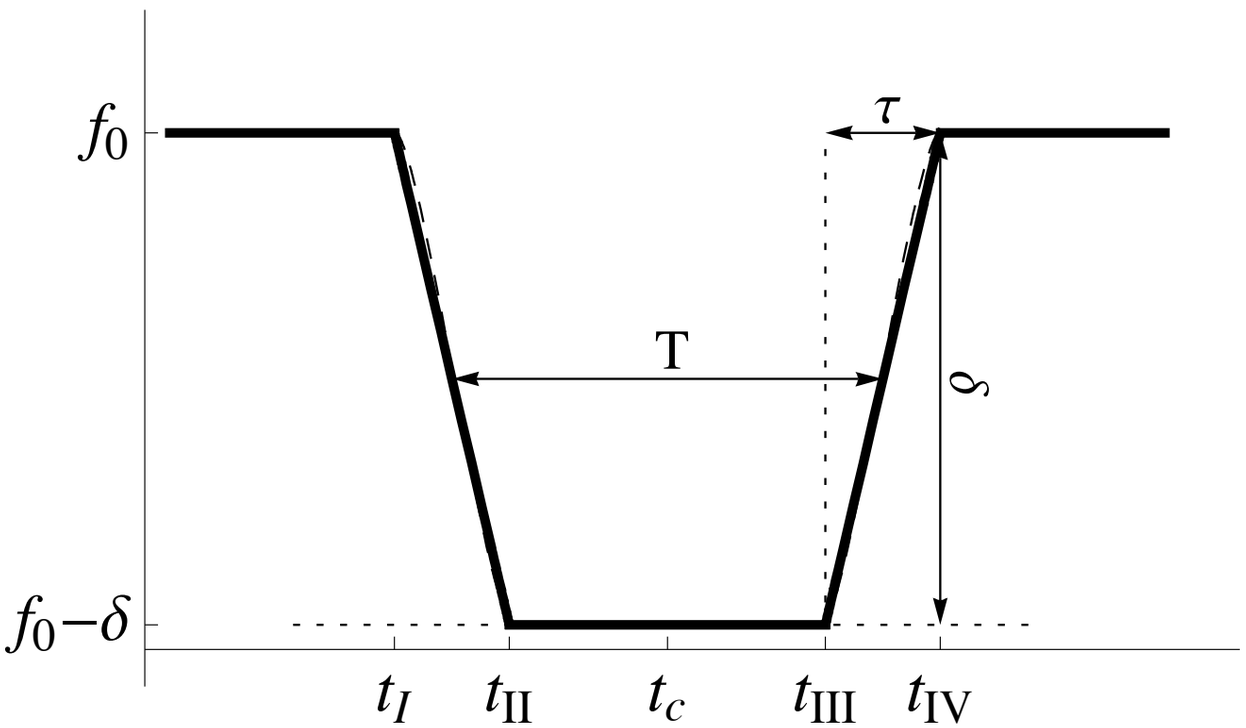

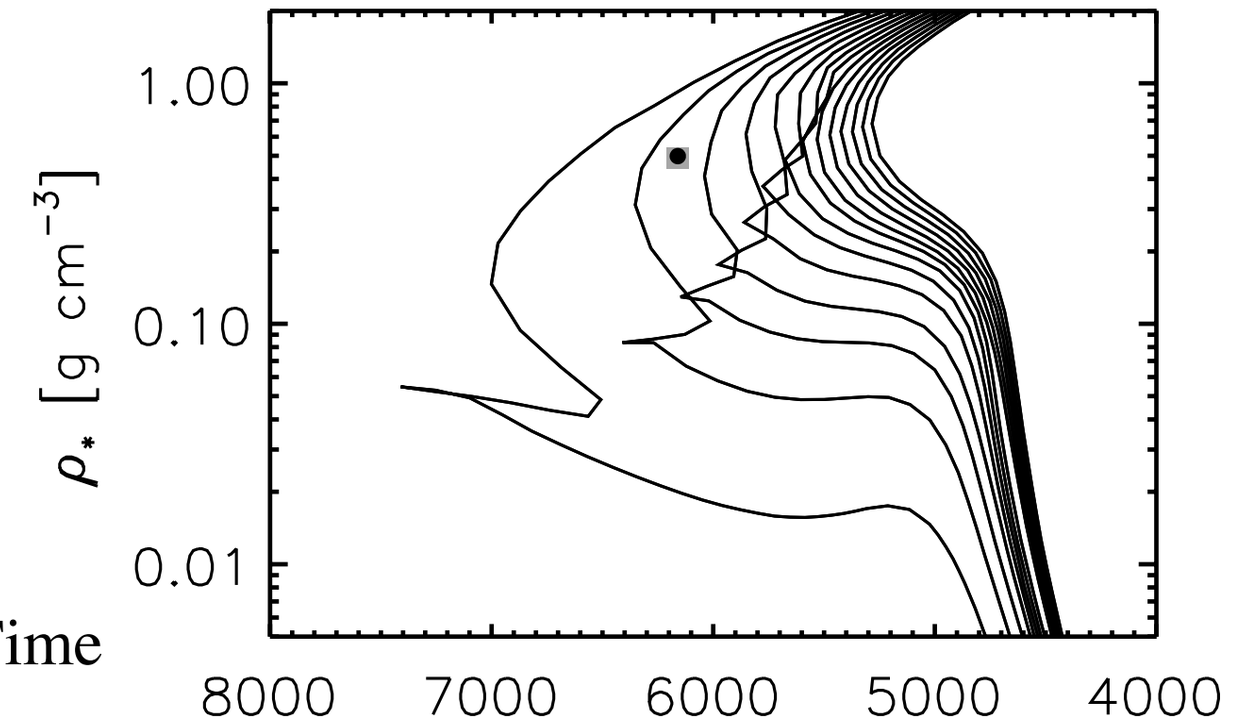

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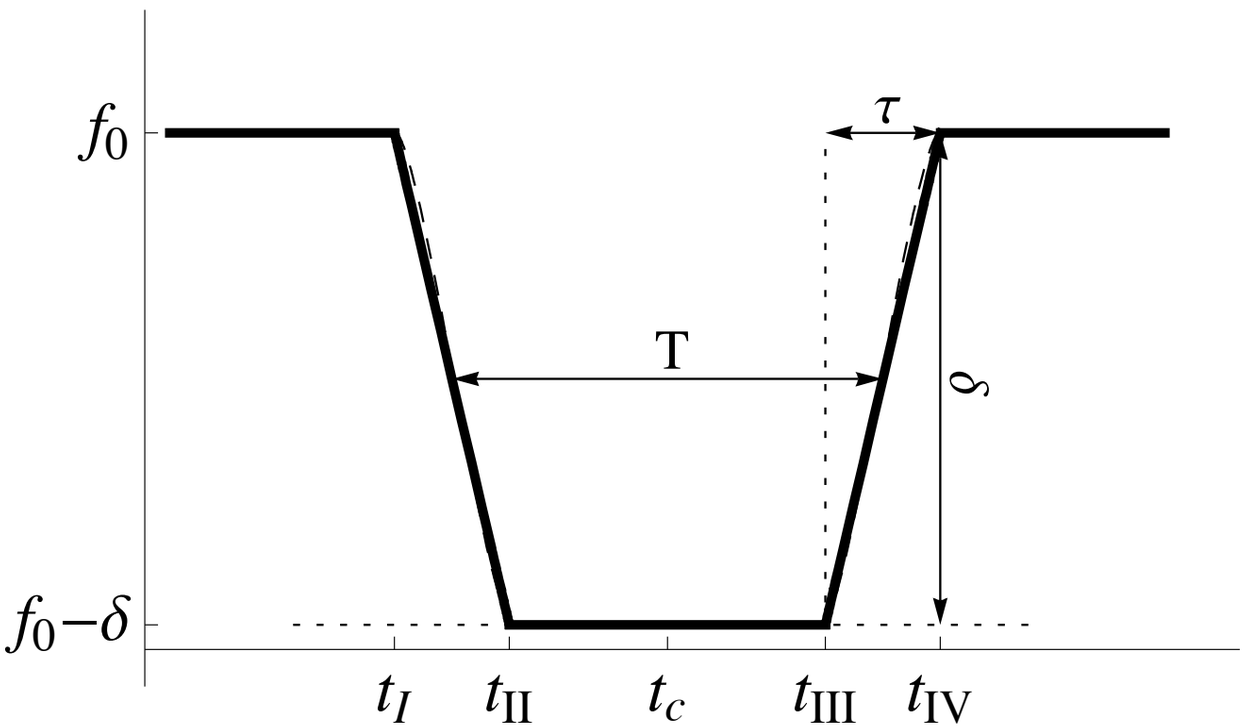

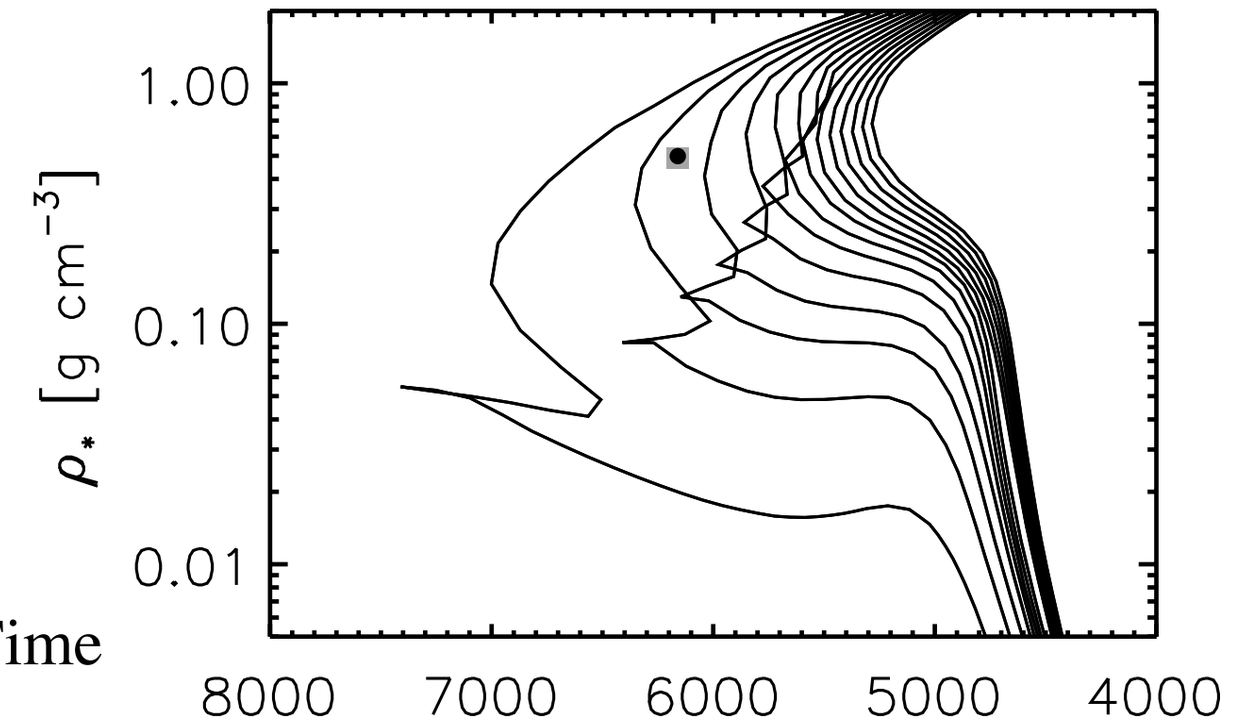

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Stellar Parameters

Task II: Transmission Spectroscopy

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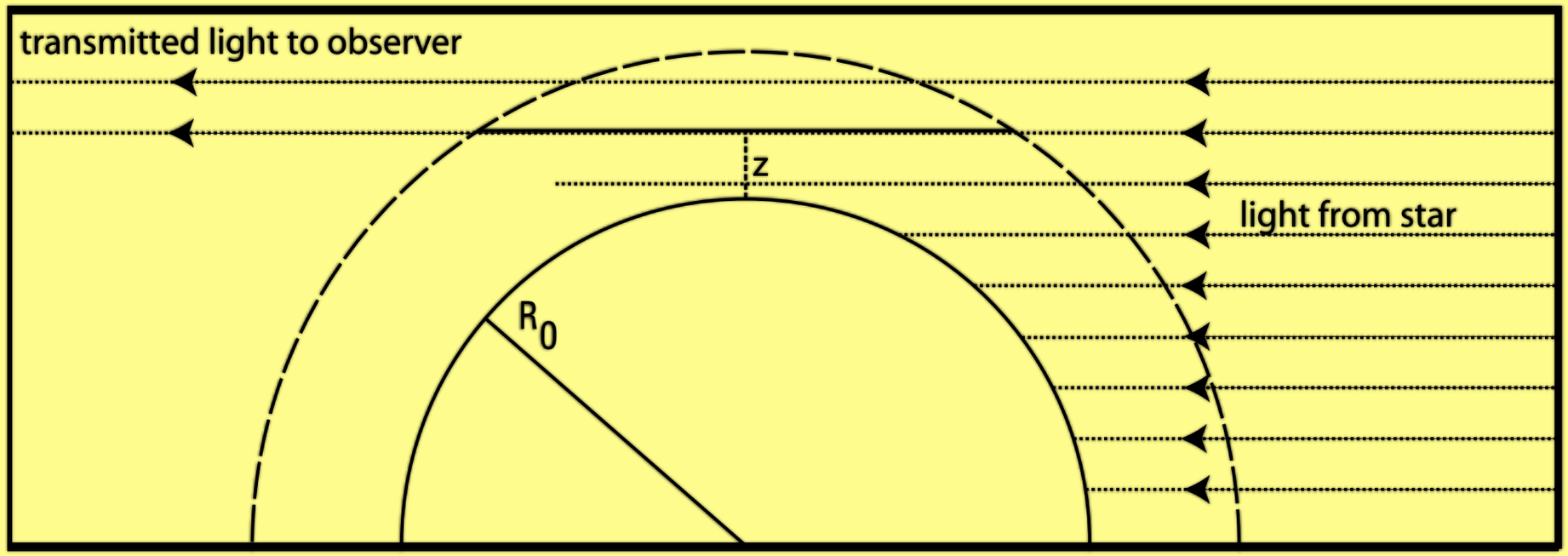

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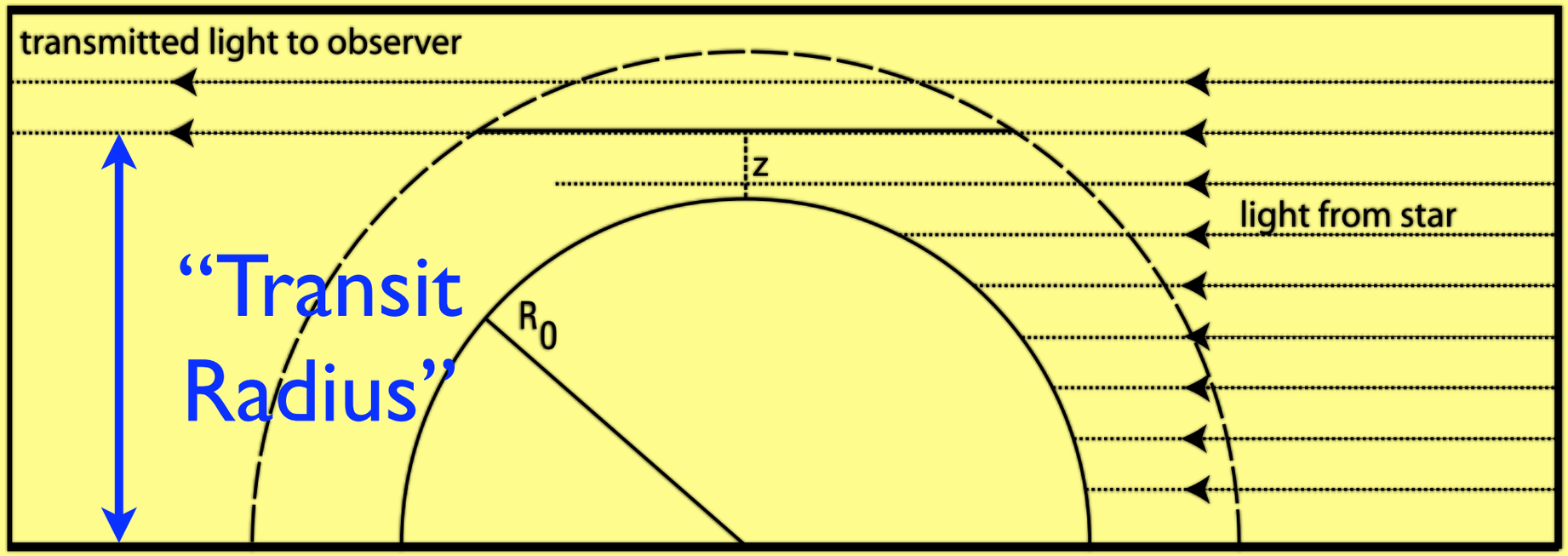

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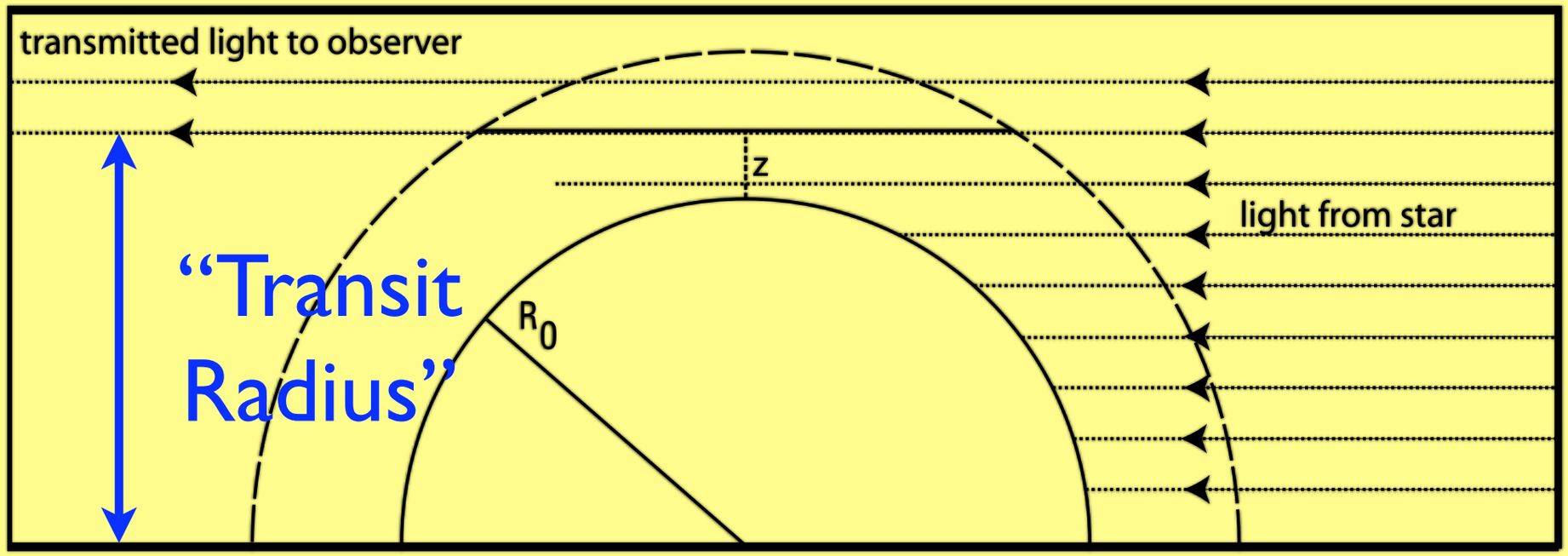

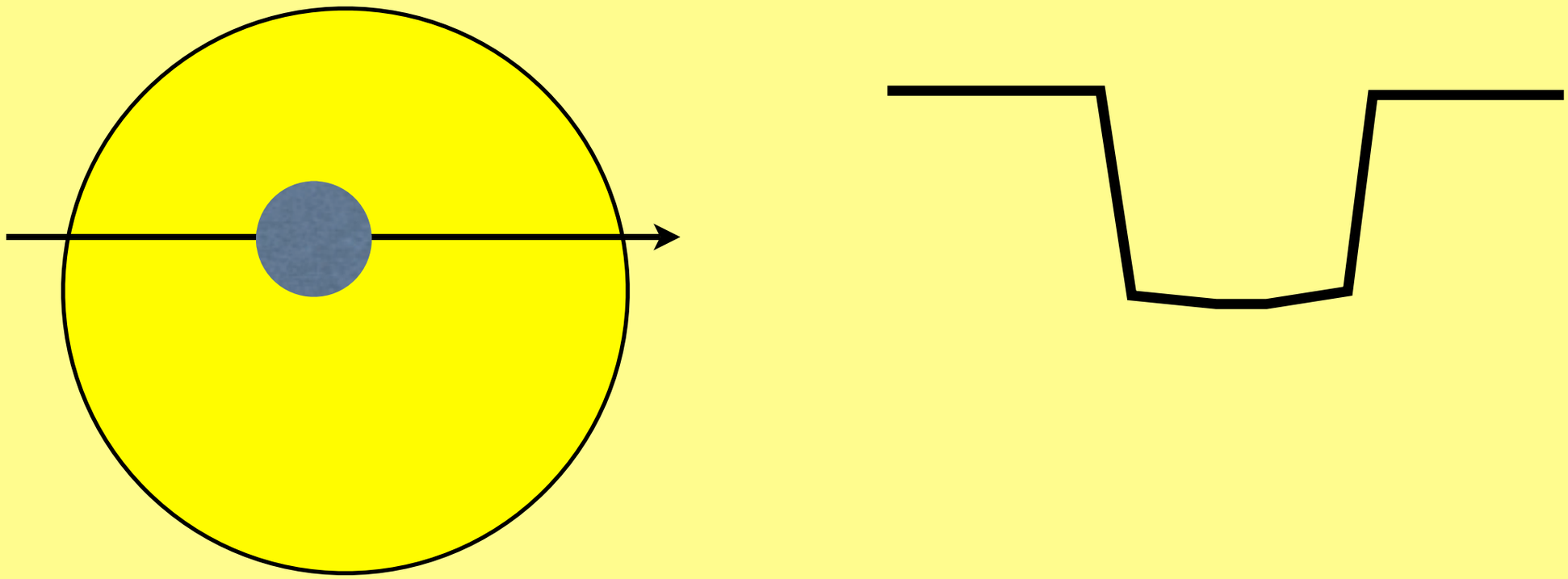

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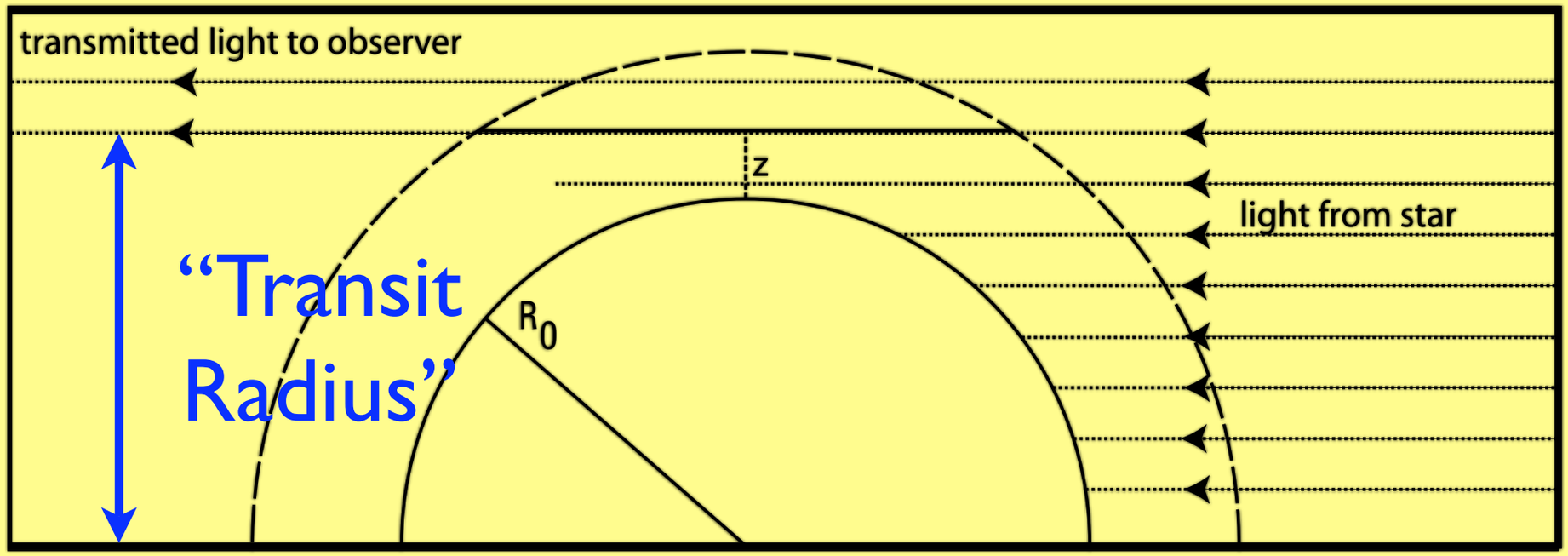

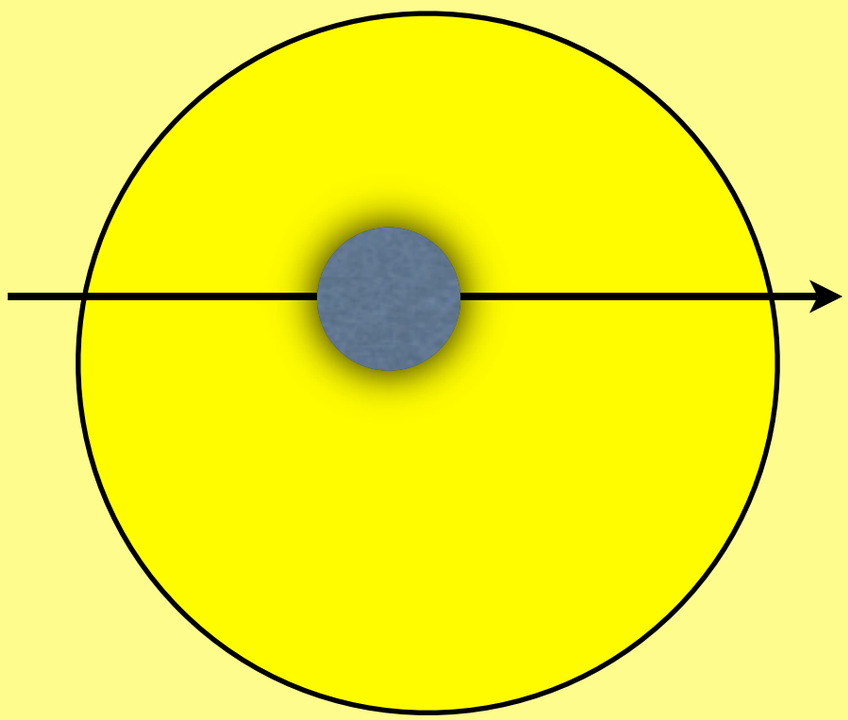

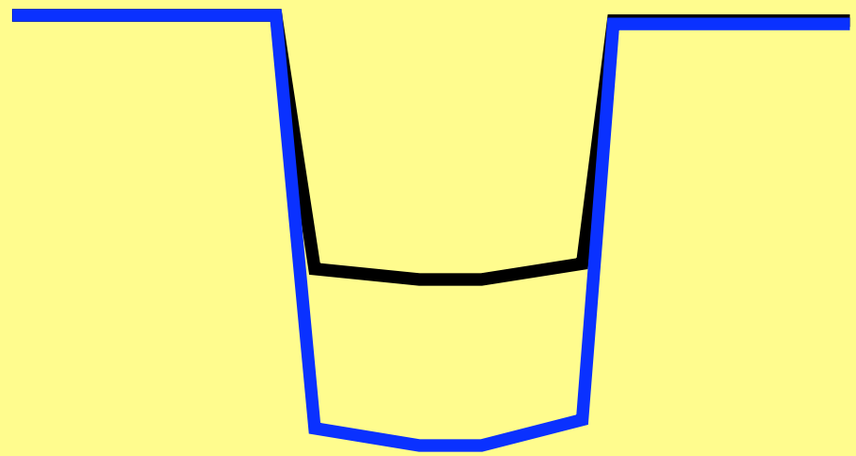

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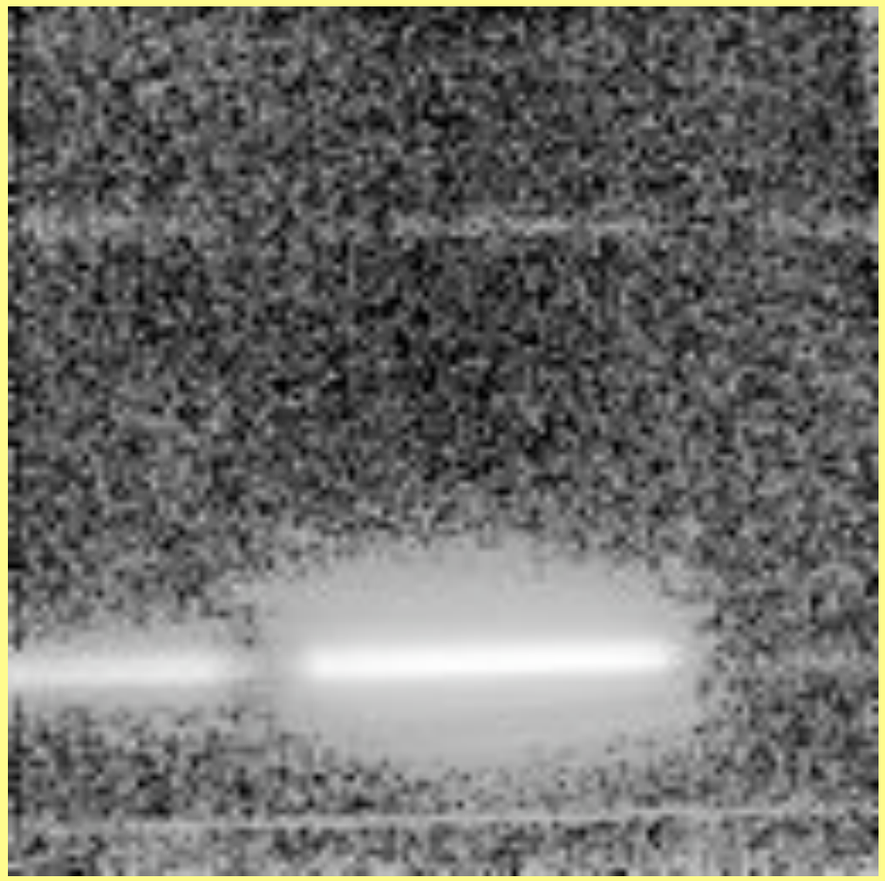
- Defocused G141 Grism
  (1.1-1.9 microns, R ~ 30).



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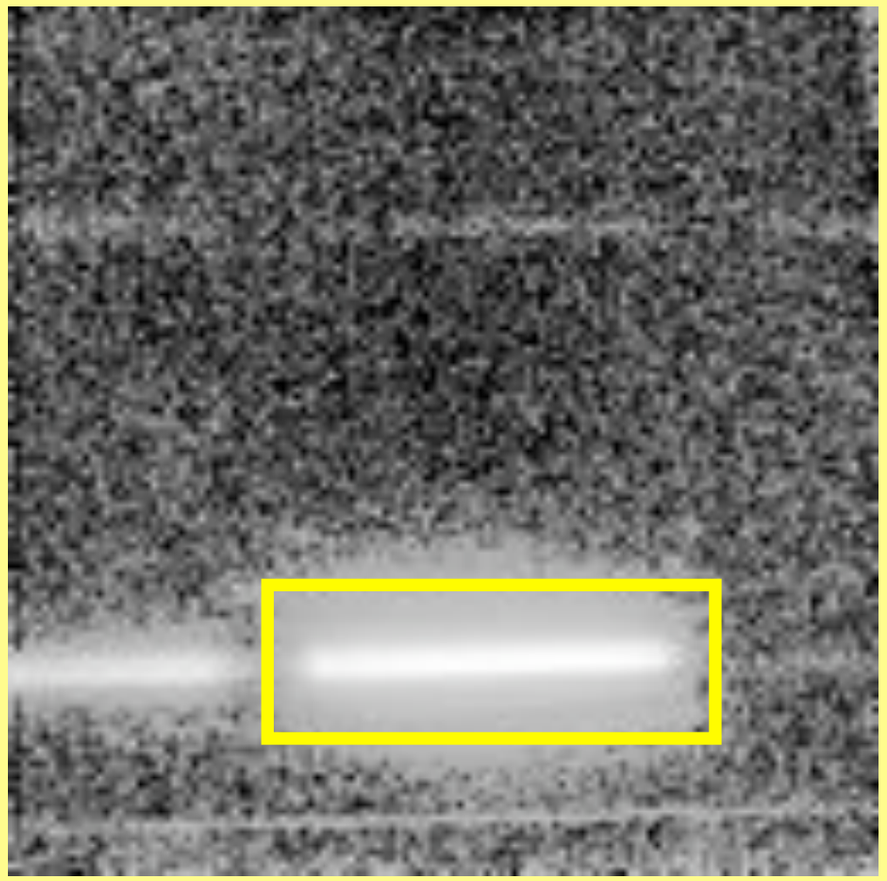

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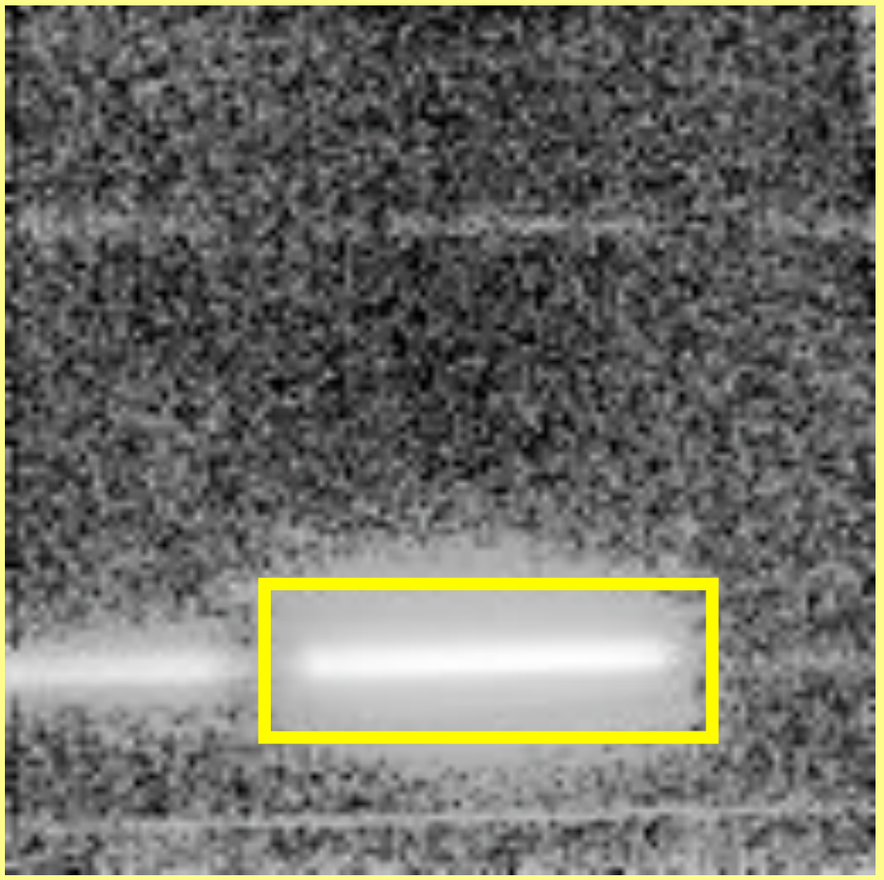

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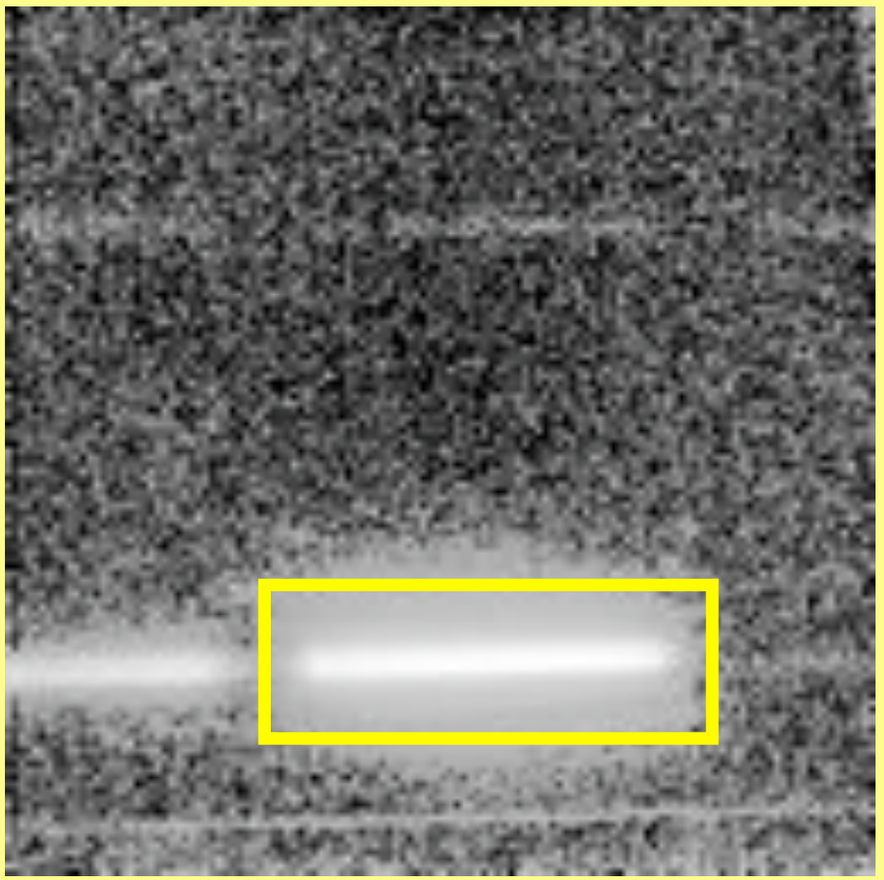

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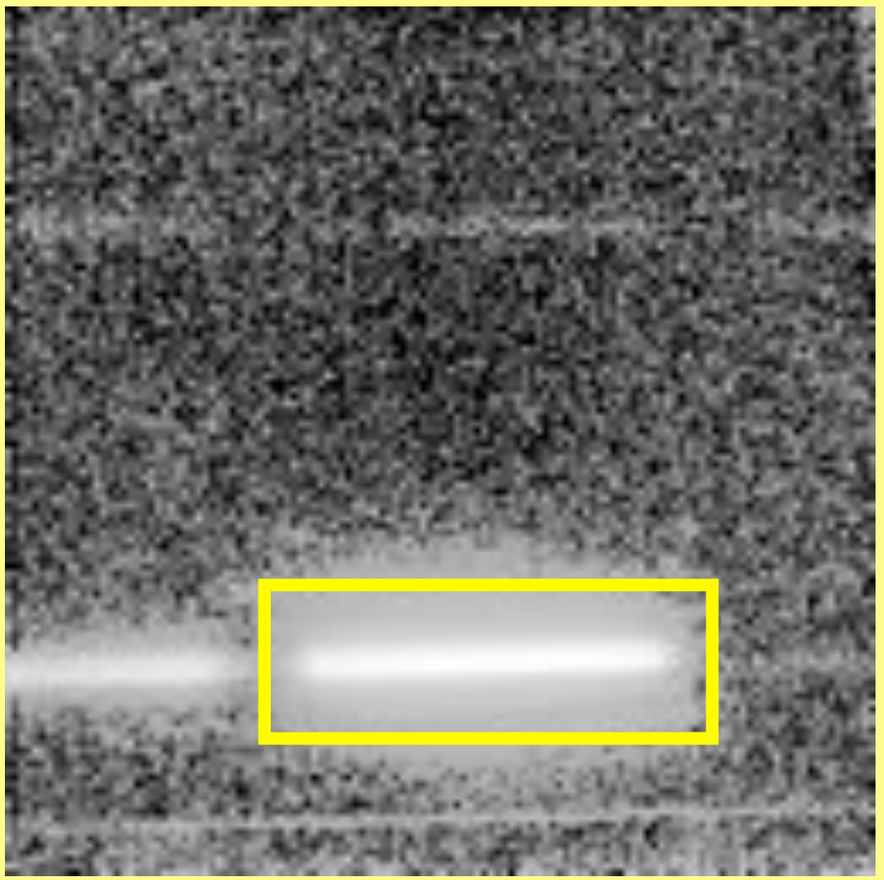

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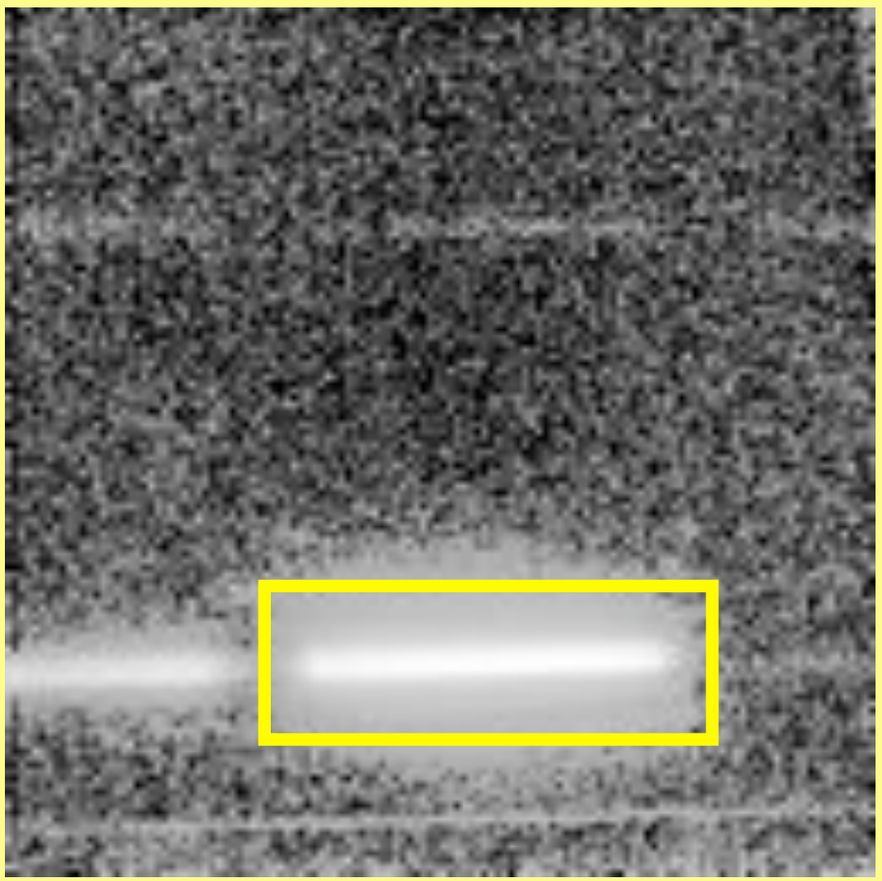

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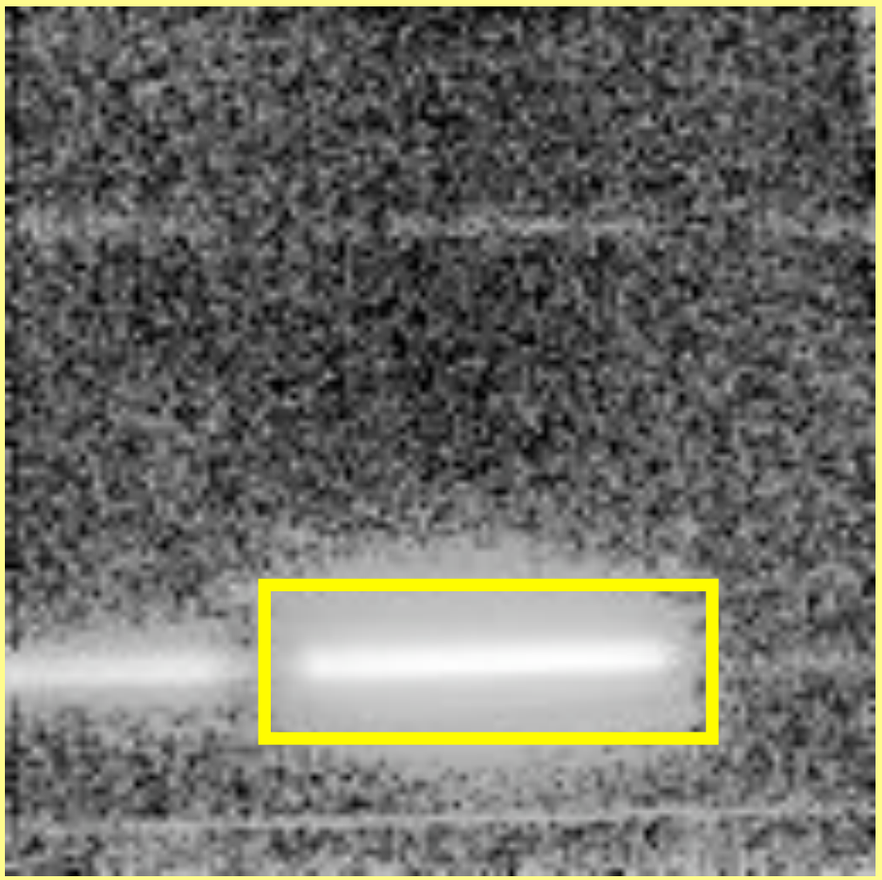
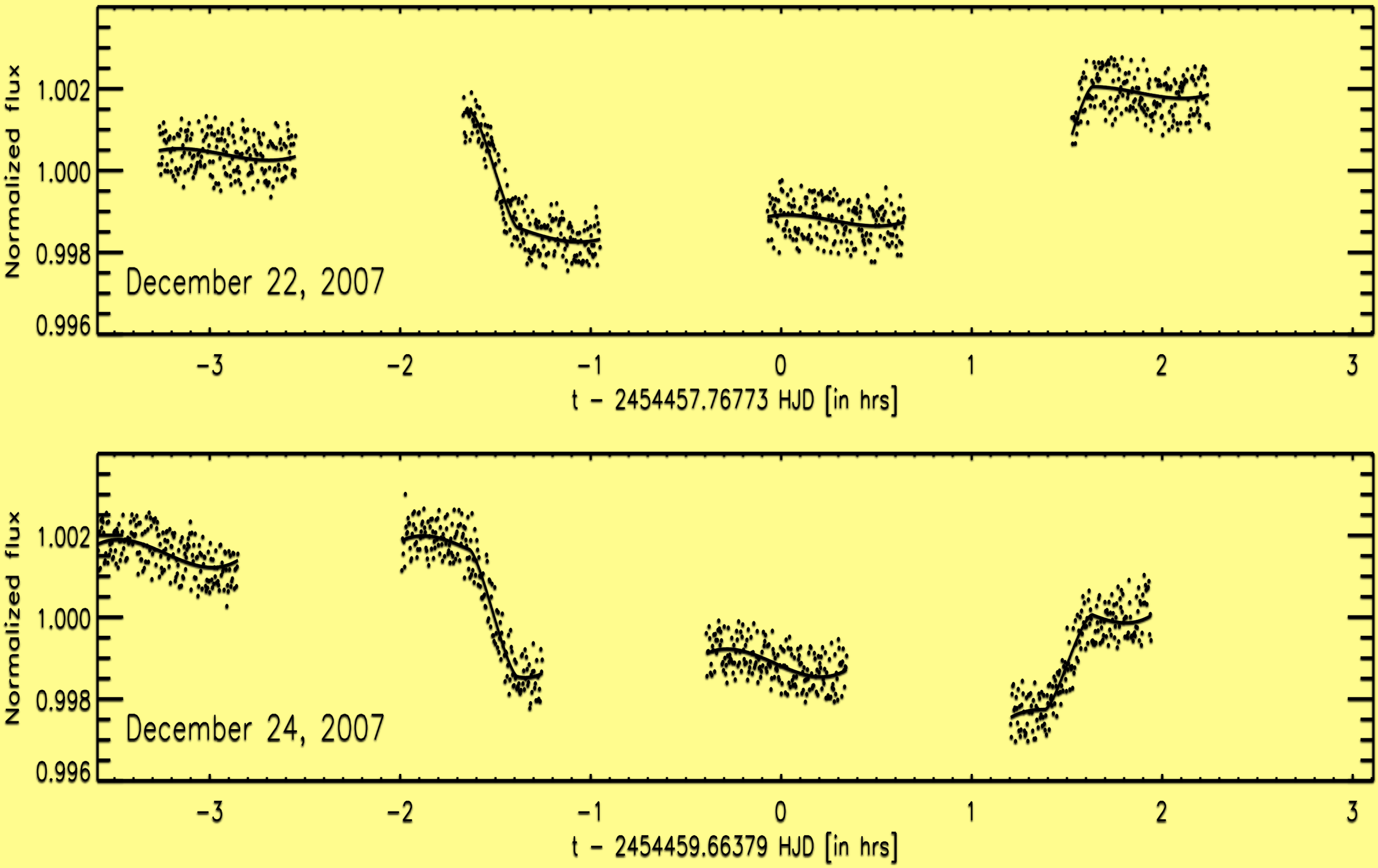
- Band coverage includes important molecular transitions




Normalized flux
1.002
1.000
0.998
0.996
December 22, 2007
−3
−2
−1
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1
2
3
t − 2454457.76773 HJD [in hrs]
Normalized flux
1.002
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0.998
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December 24, 2007
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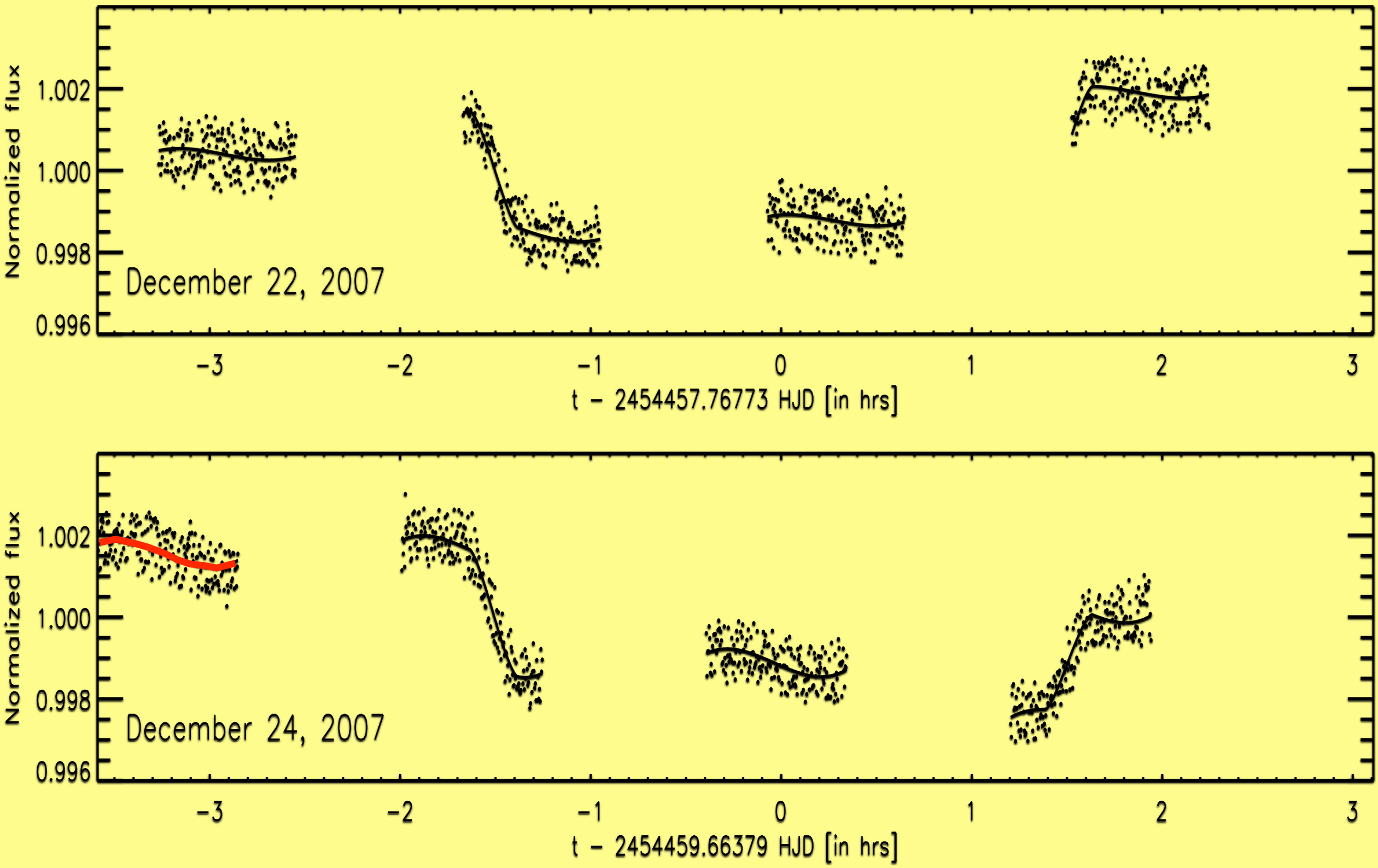
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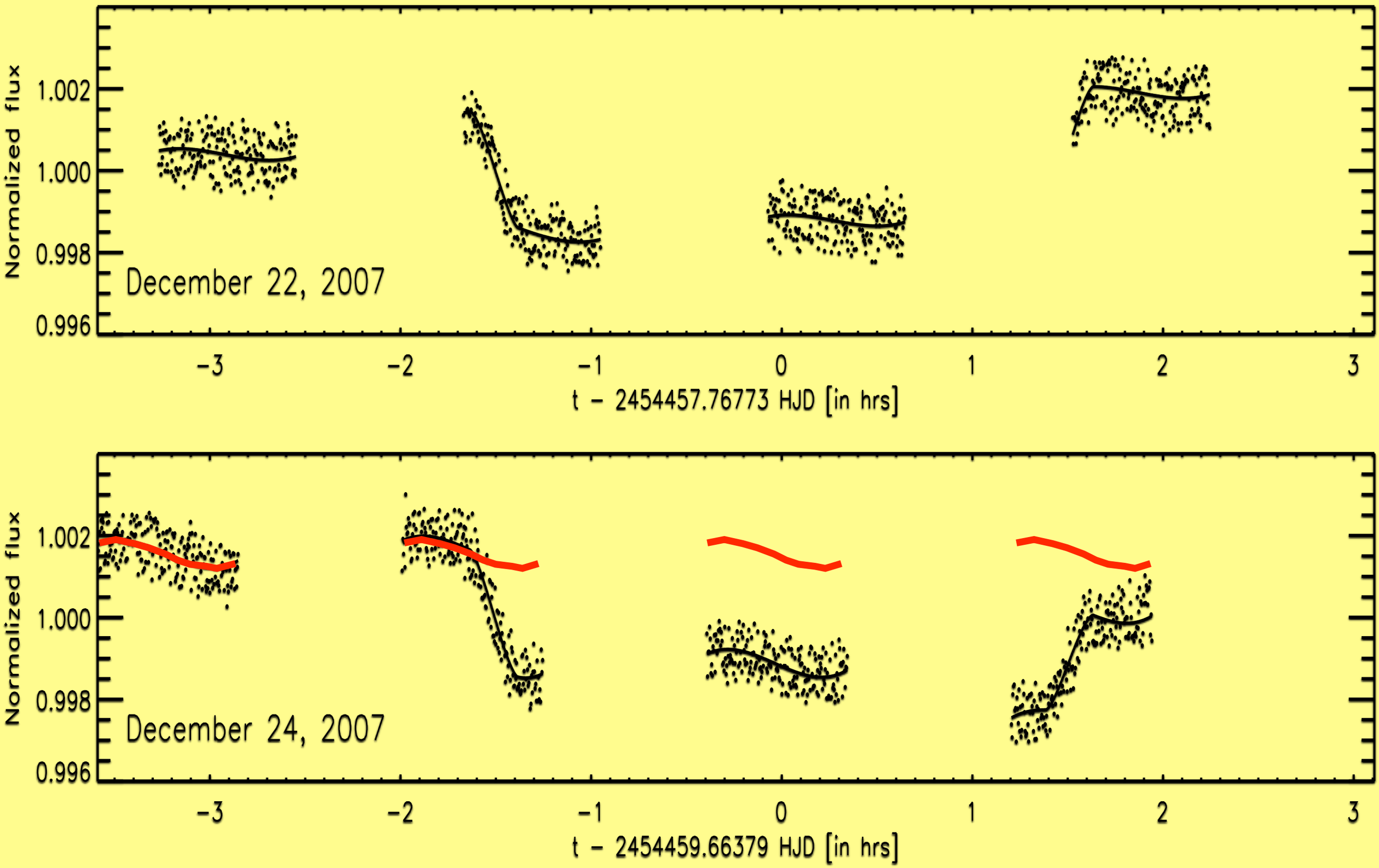
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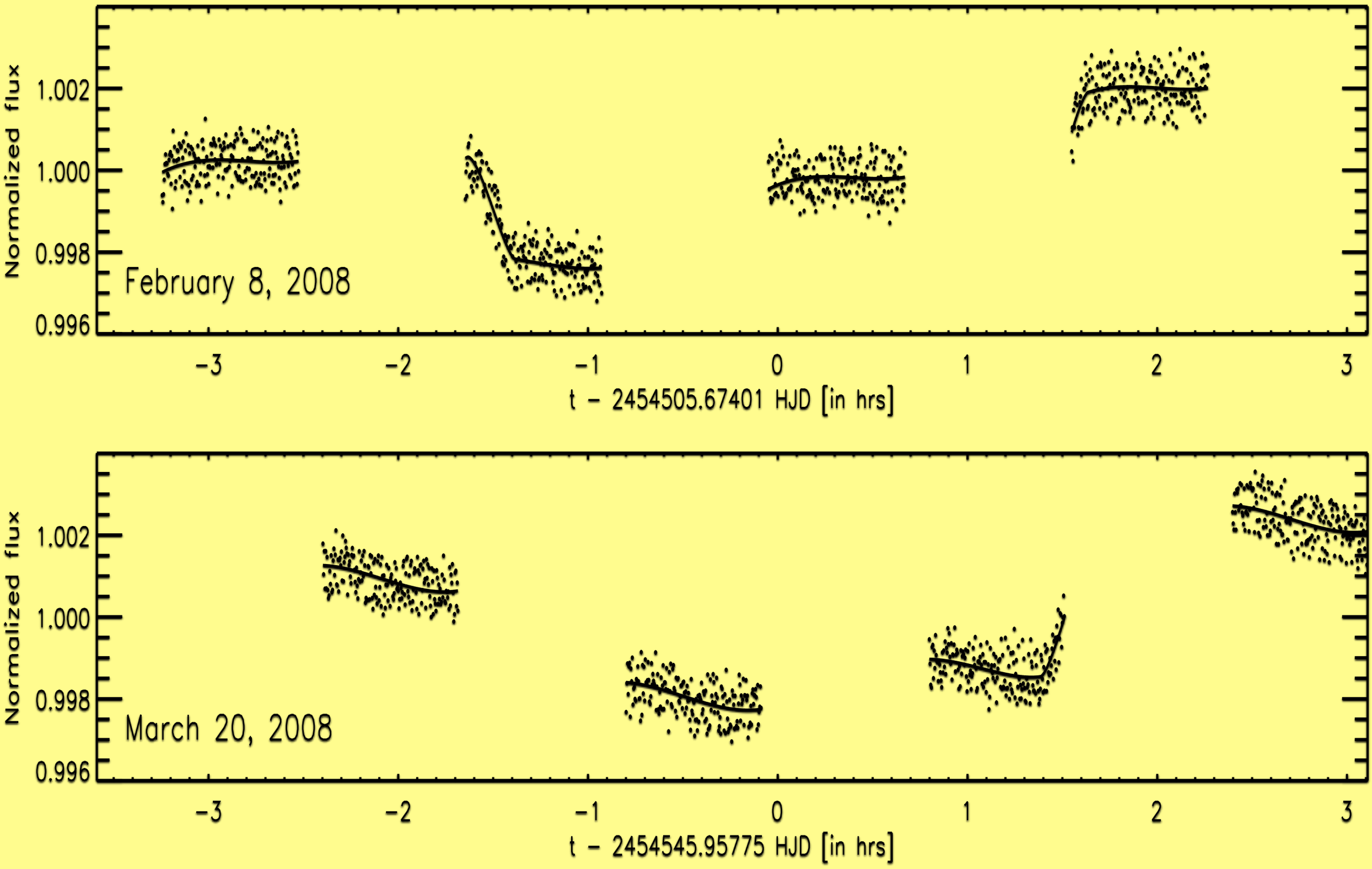
Normalized flux
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1.000
0.998
0.996
February 8, 2008
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t − 2454505.67401 HJD [in hrs]
Normalized flux
1.002
1.000
0.998
0.996
March 20, 2008
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−2
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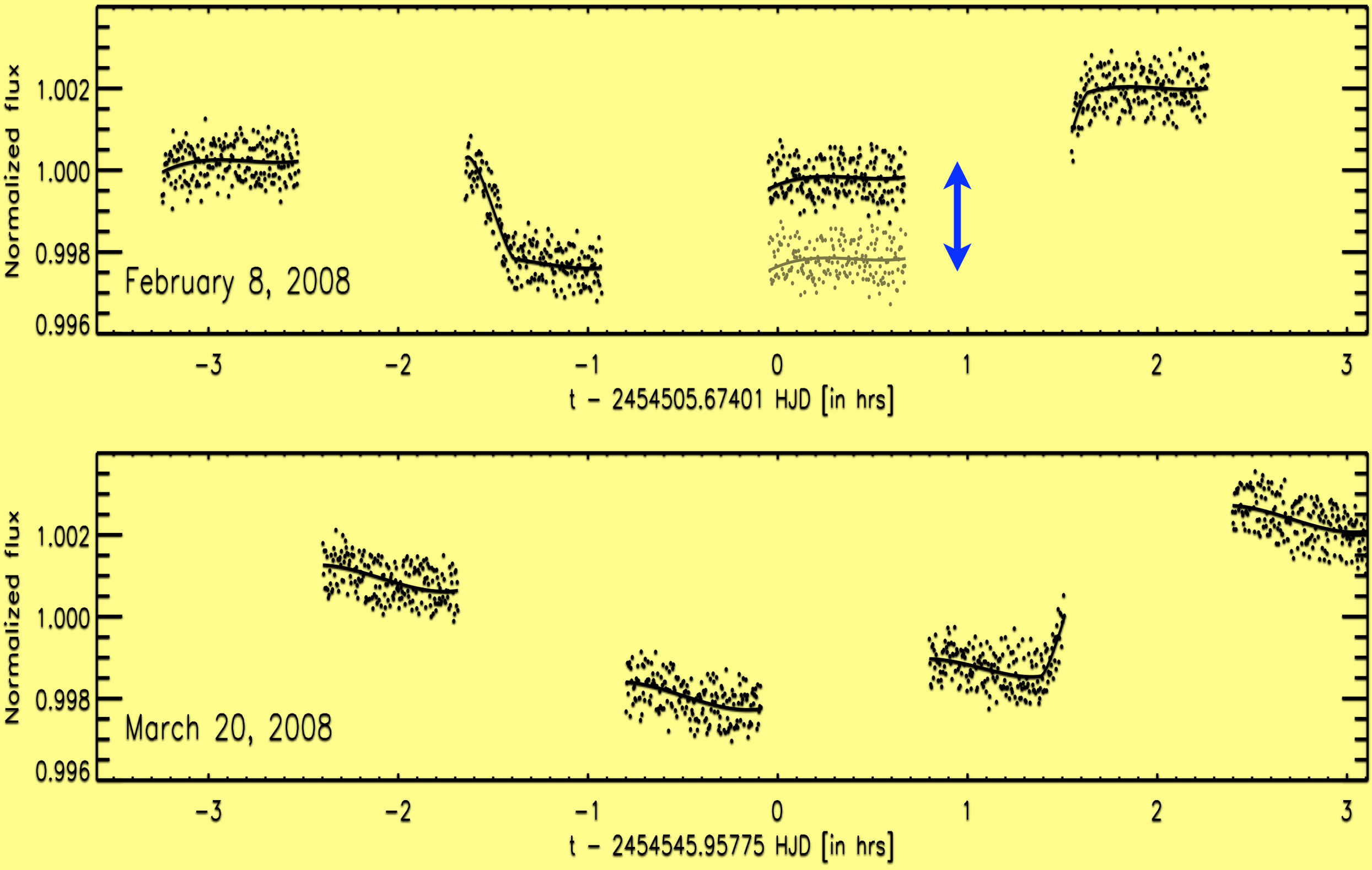
t − 2454545.95775 HJD [in hrs]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Systematics correction factor

$$f = f_o^v(1 + c_0^v\phi + c_1^v\phi^2 + c_2^v\phi^3)$$

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orbit specific offset

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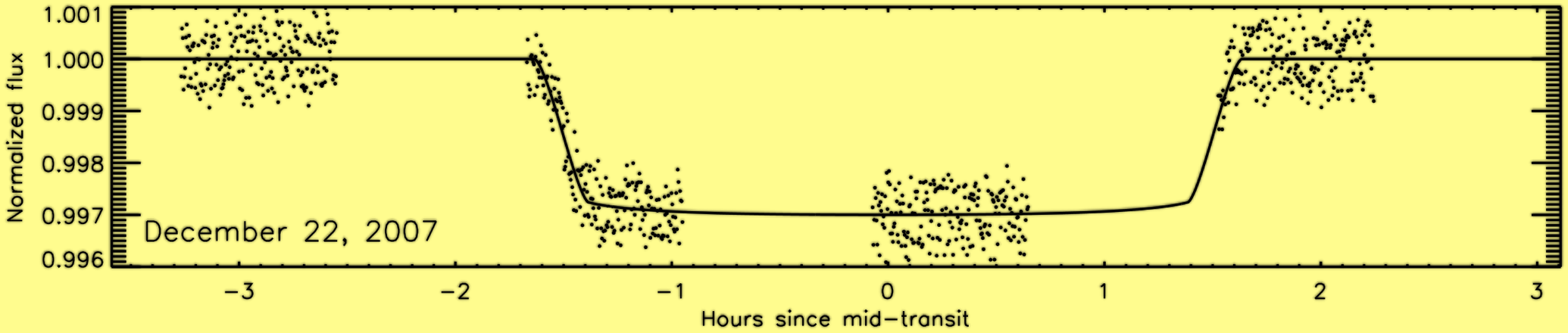
visit specific variation with HST orbital phase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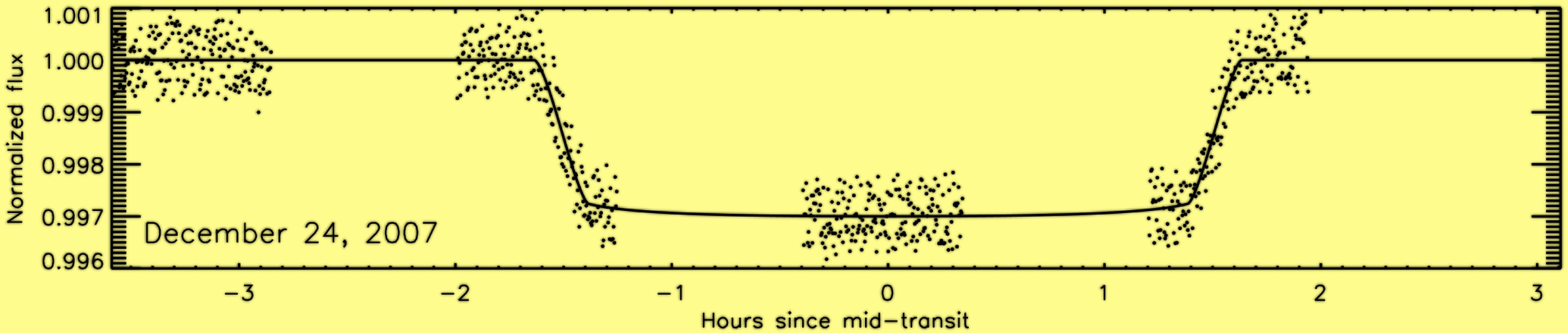
Hours since mid−transit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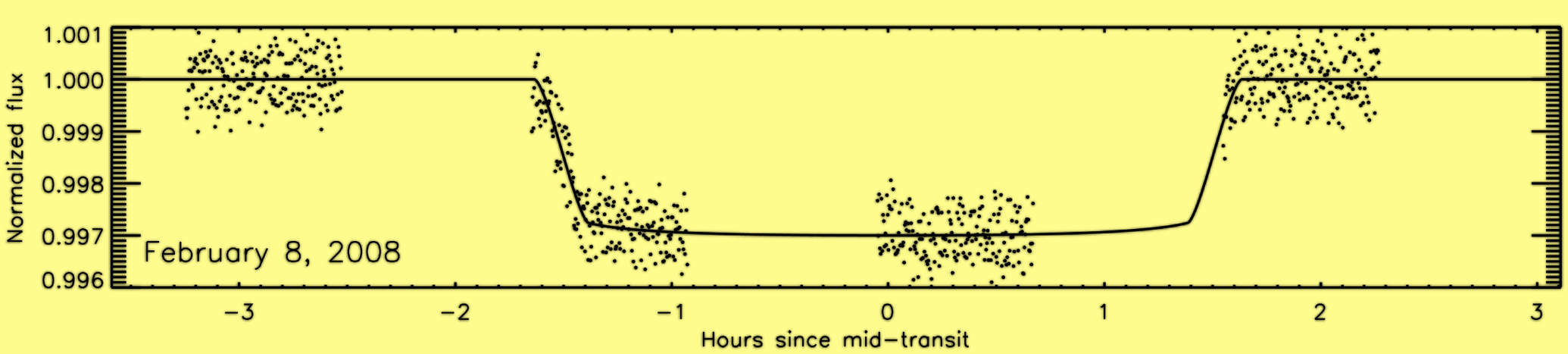
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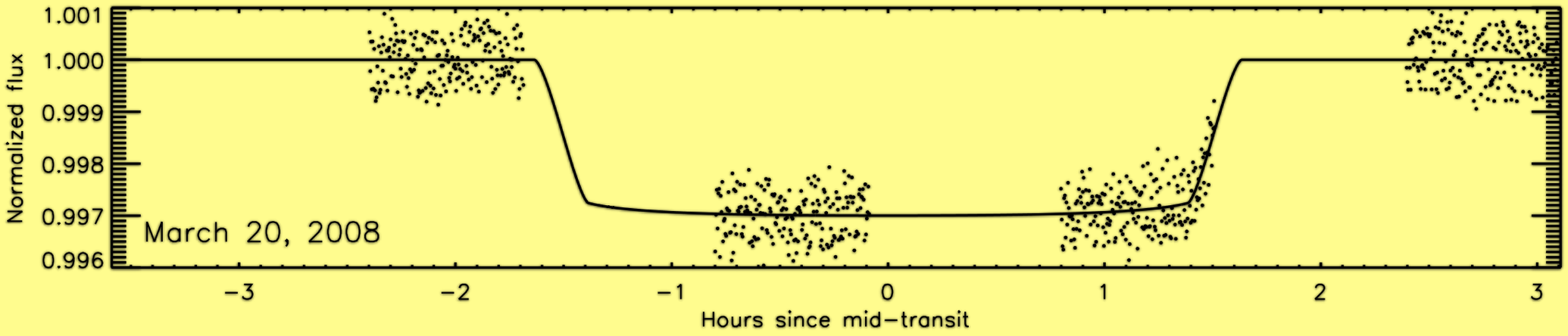
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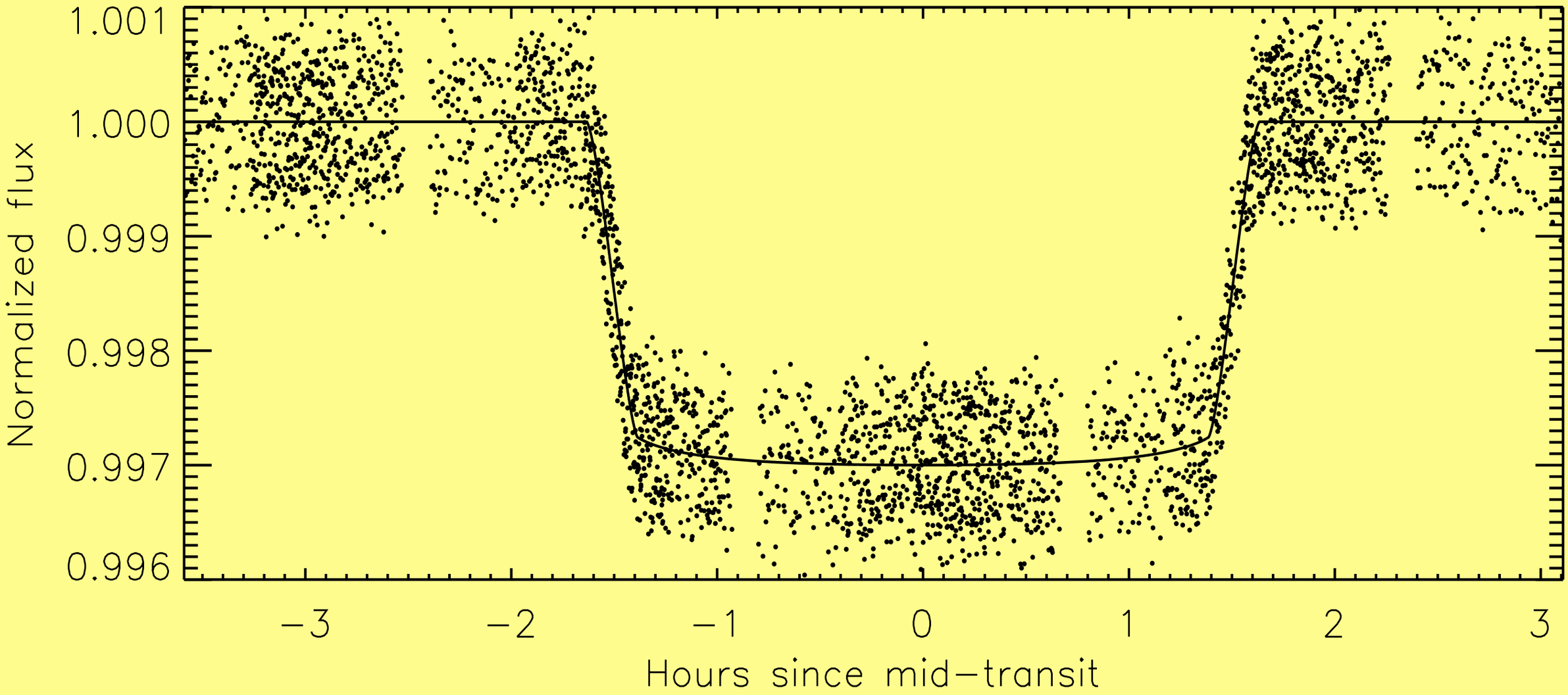
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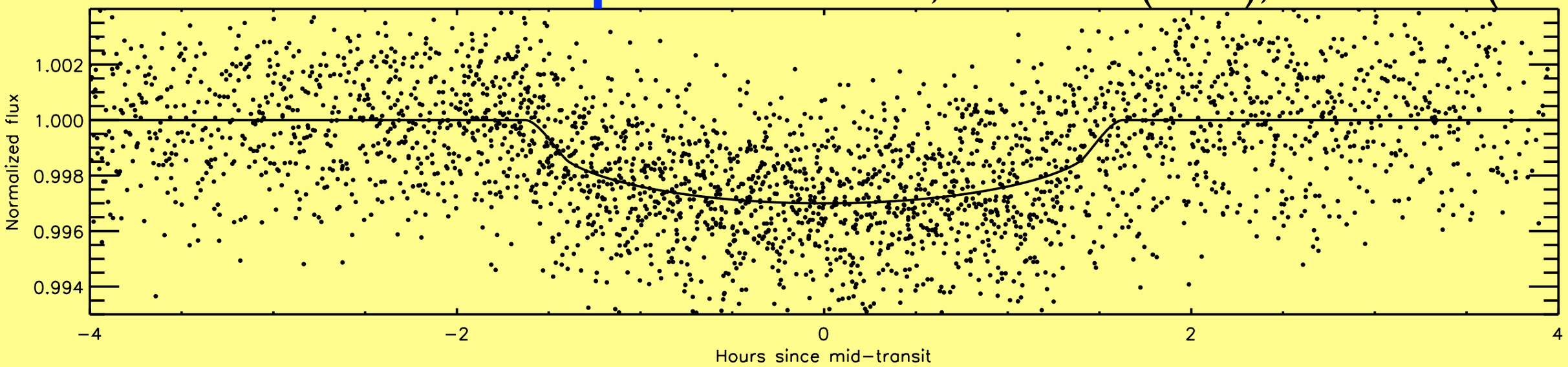
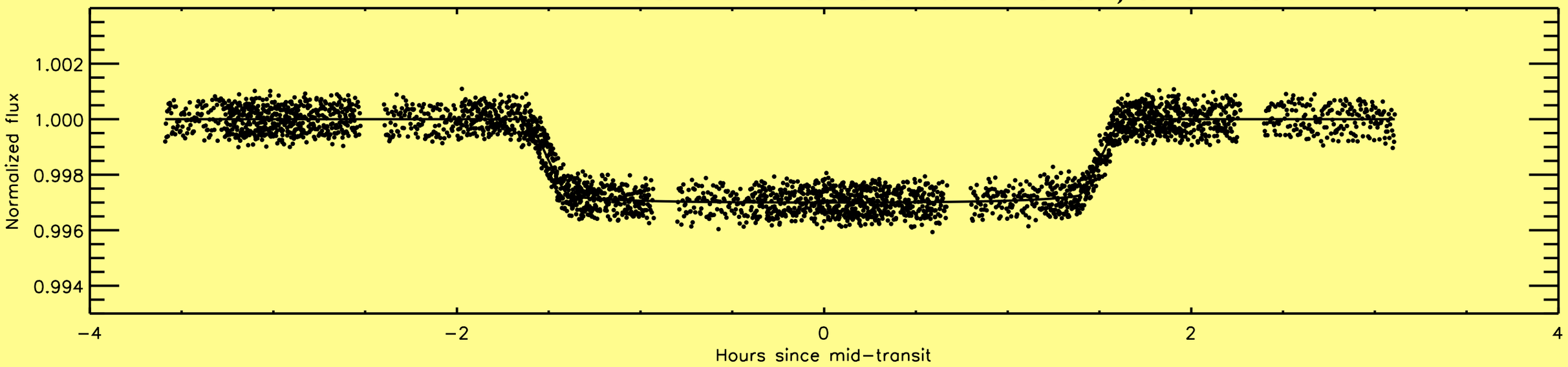
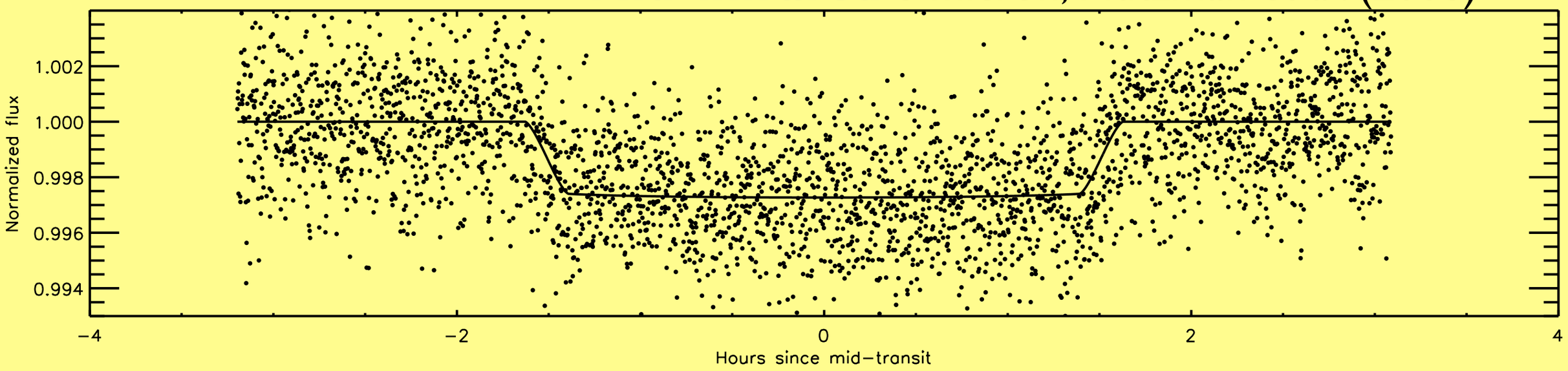
Optical 0.5 micron, Sato et al. (2005), Winn et al. (2008)



Near-infrared 1.4 micron, this work



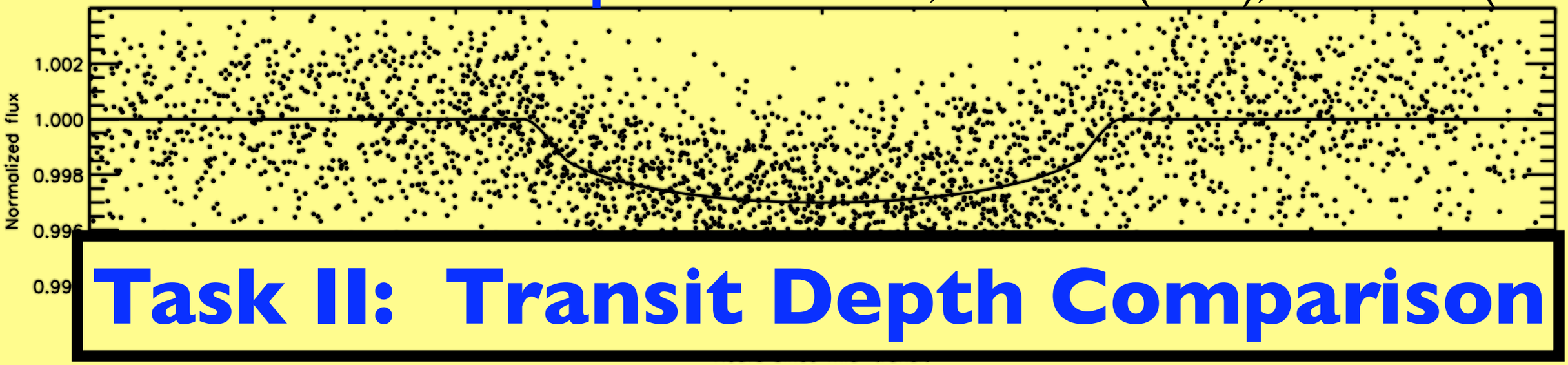
Mid-infrared 8 micron, Nutzman et al. (2008)



Results: Task I

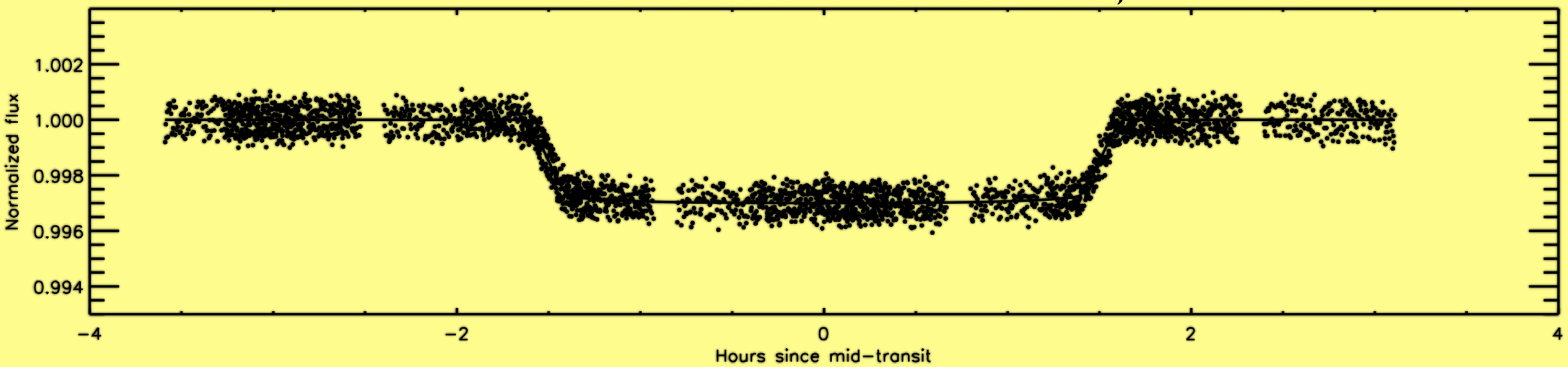
- We estimate the mean stellar density, 0.491+/-0.05 g cm^-3 to 10%.
- We estimate a refined stellar radius to 3%
- Previous most precise estimates
  - 7% (Sato et al. 2005)
  - 5% (Nutzman et al. 2008)
- Still very dense with new stellar radius estimate

Optical 0.5 micron, Sato et al. (2005), Winn et al. (2008)

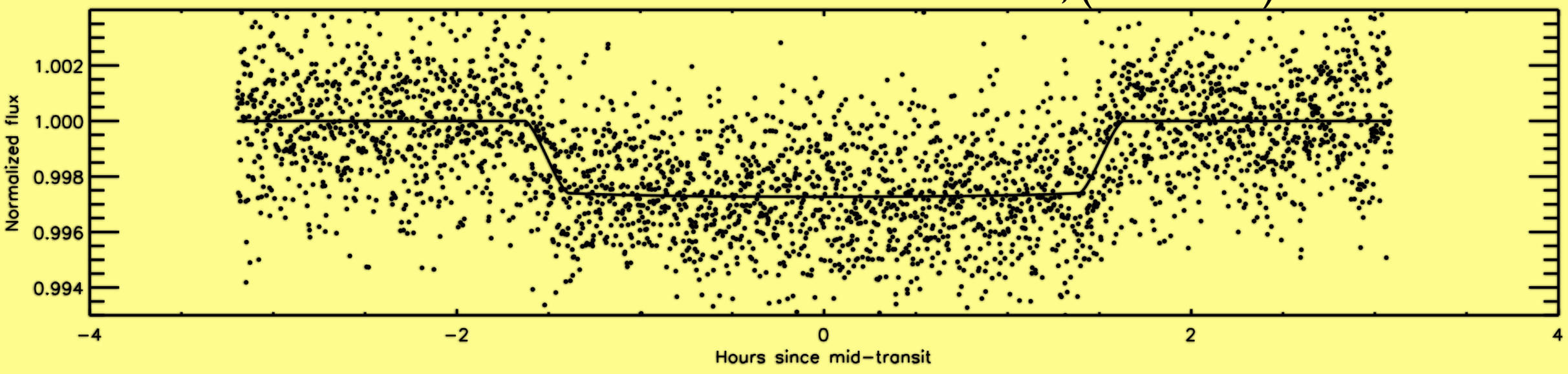


Task II: Transit Depth Comparison

Near-infrared 1.4 micron, this work



Mid-infrared 8 micron, (Nutzman) et al. 2008



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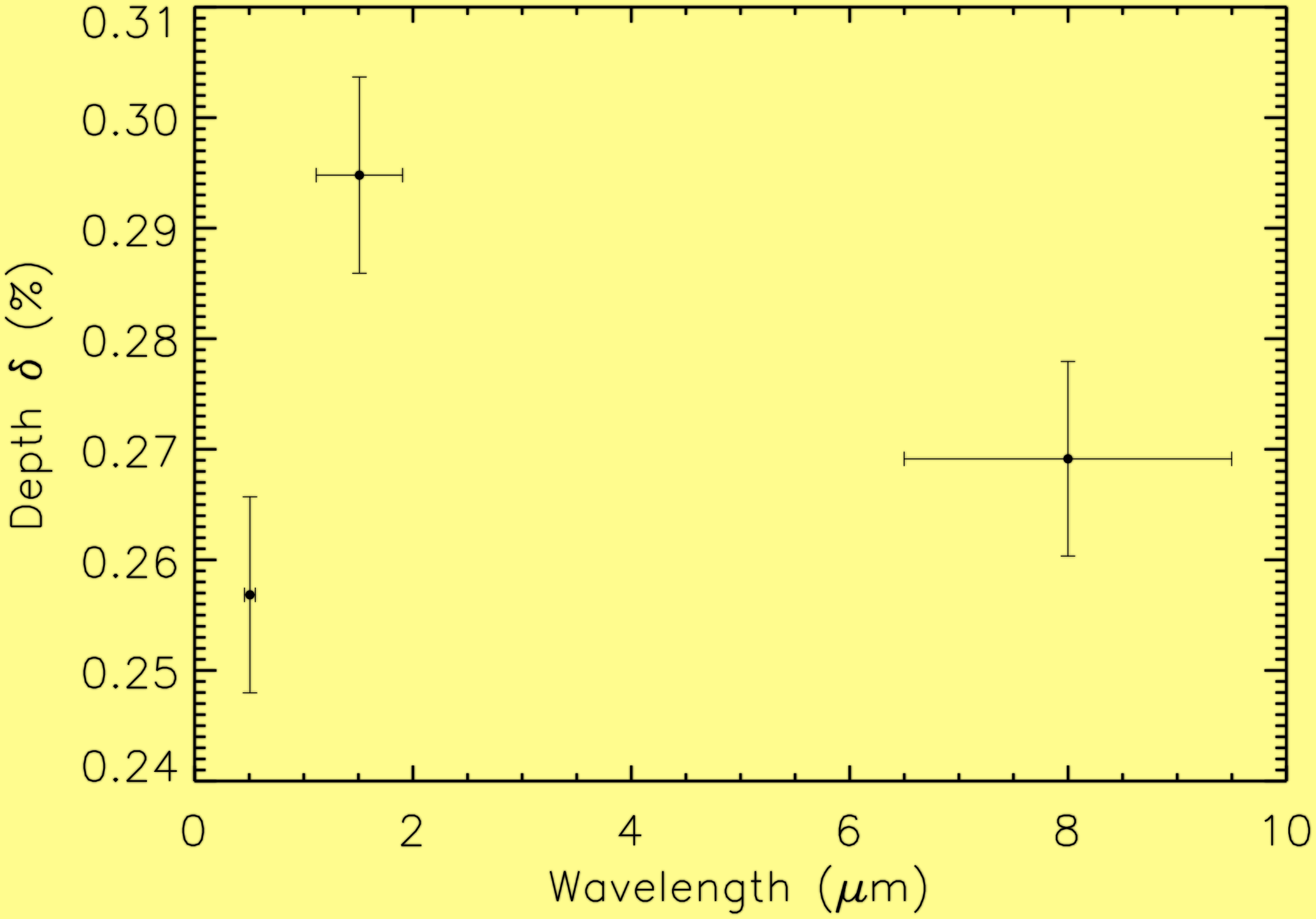

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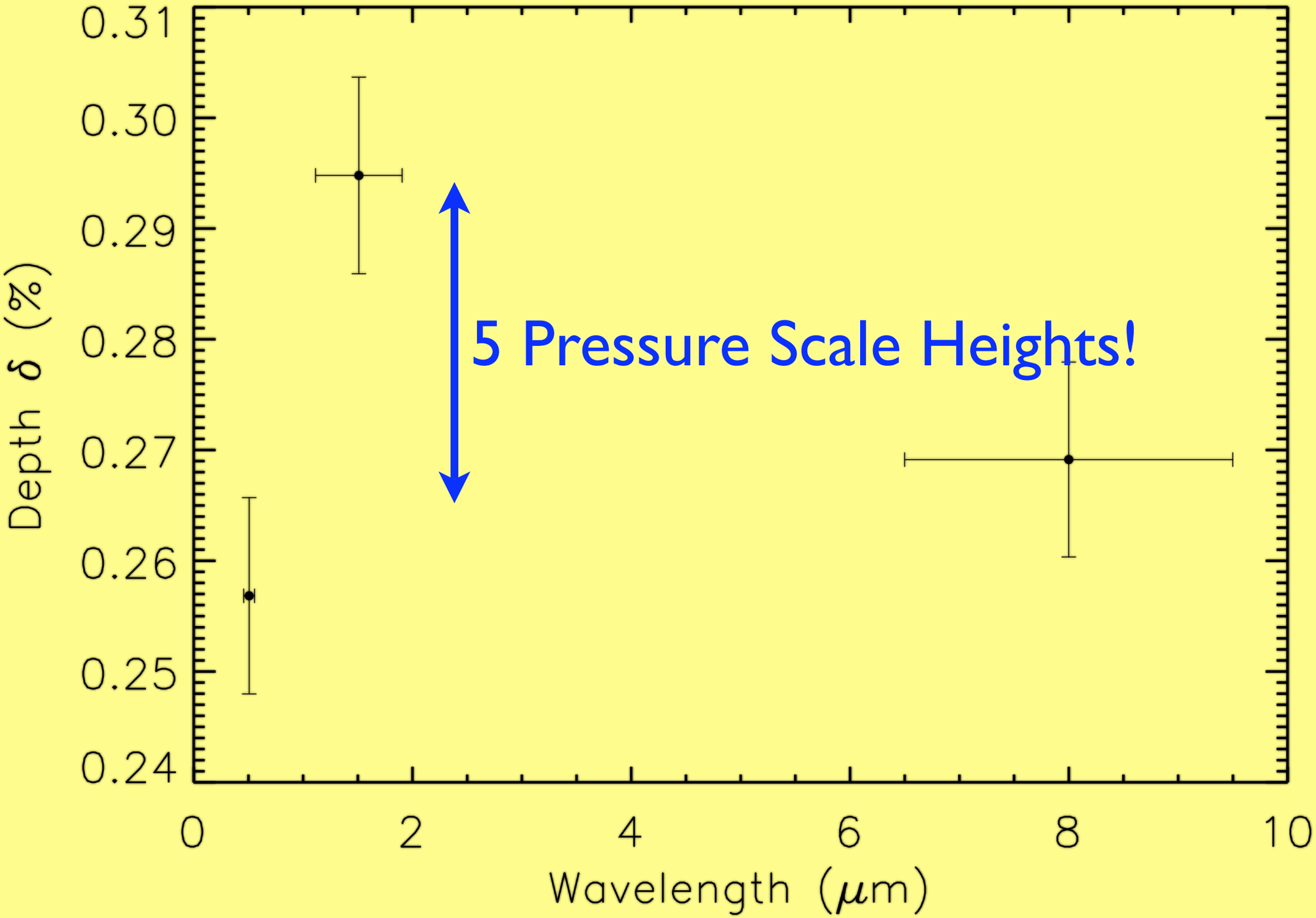
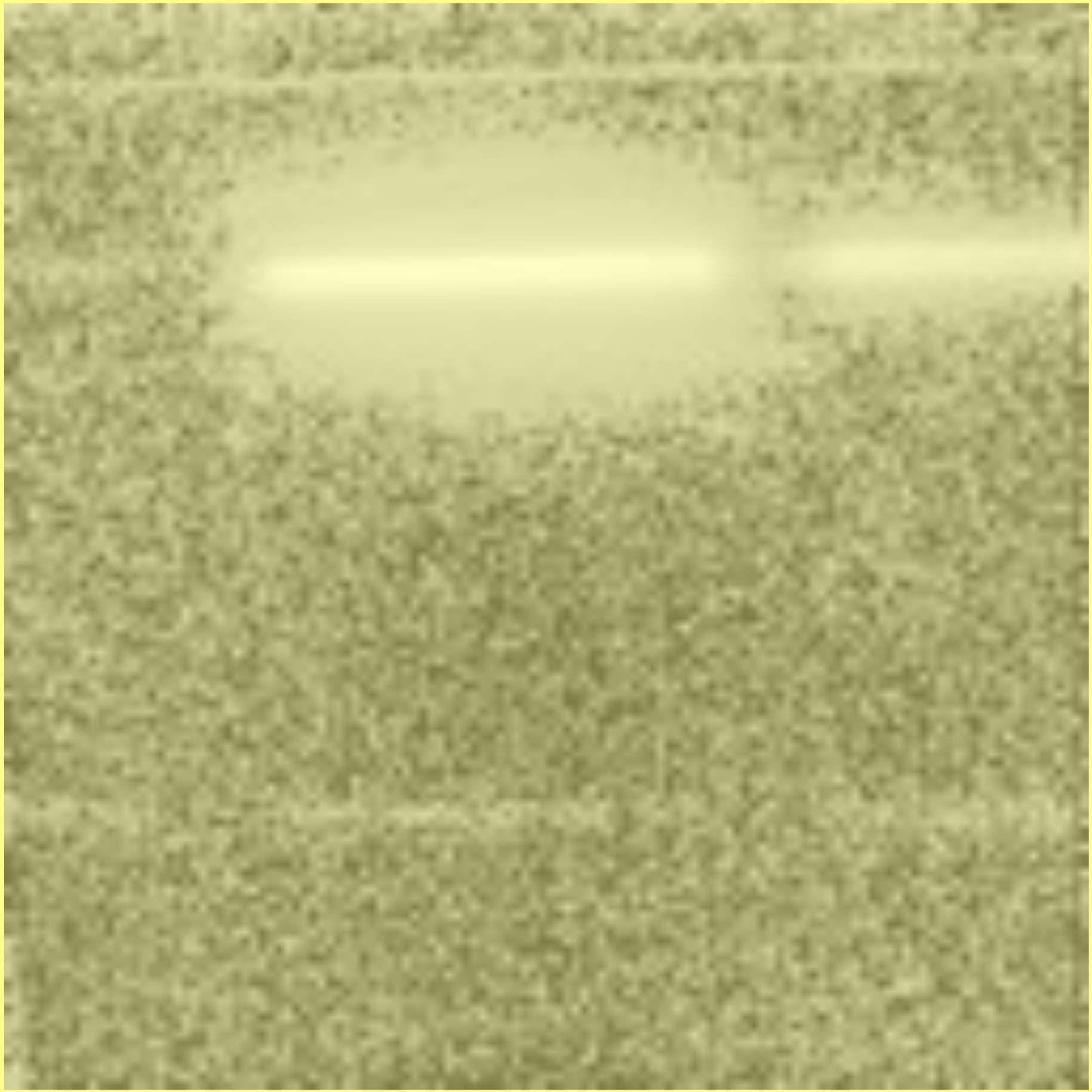
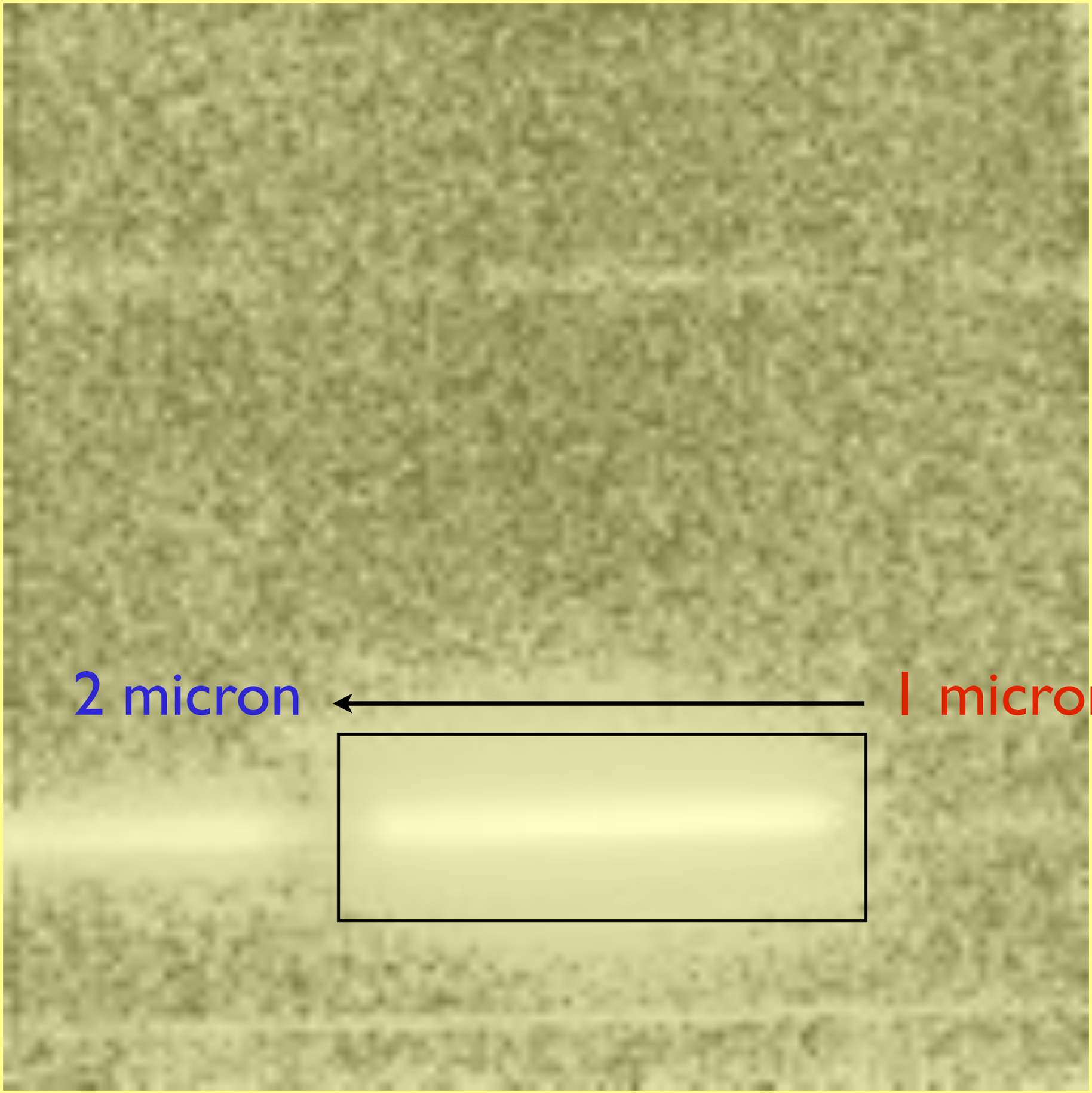
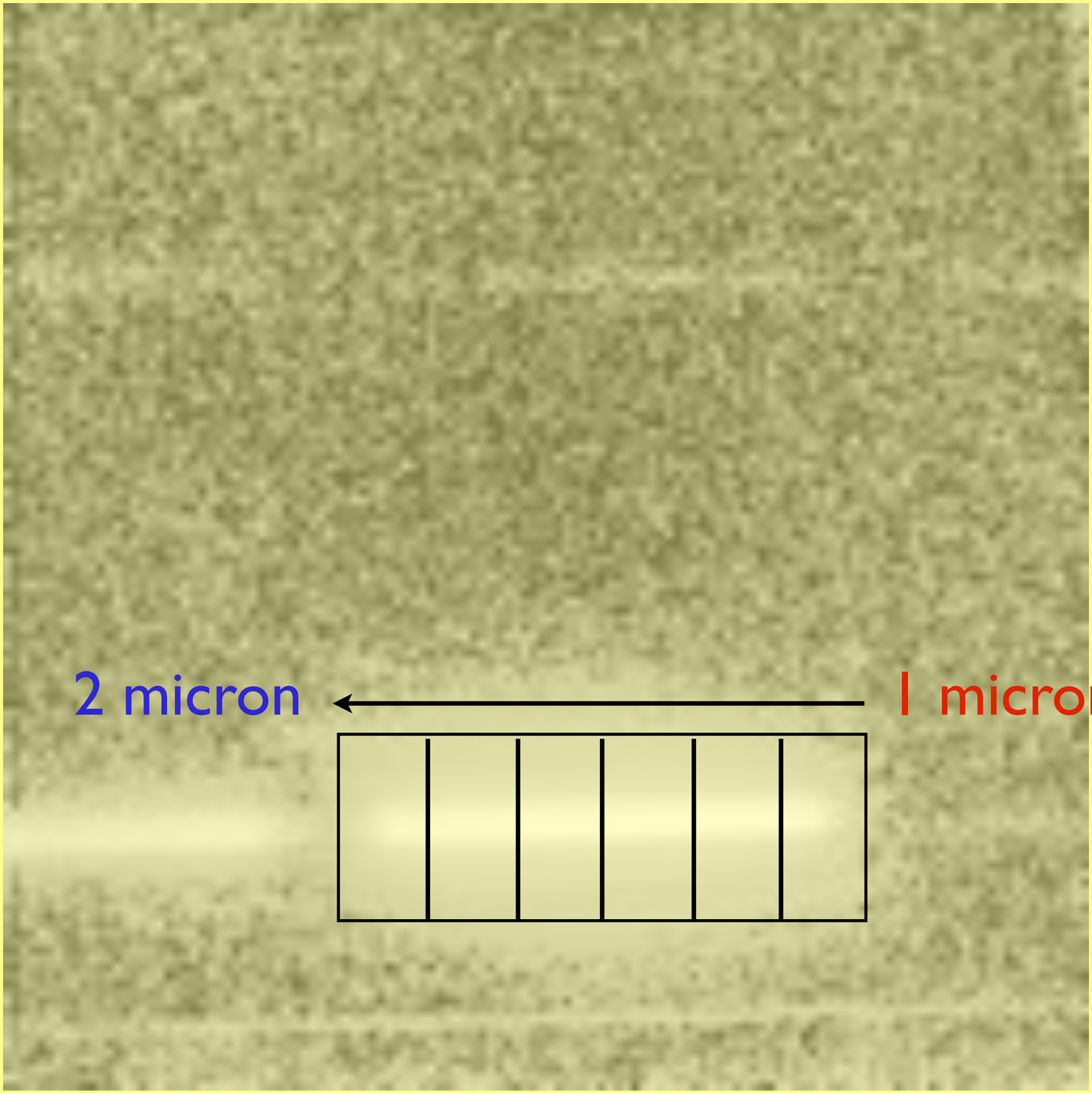
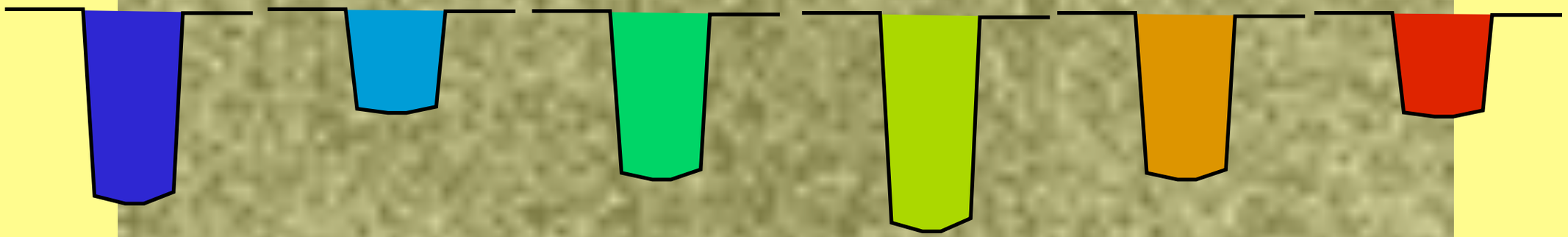




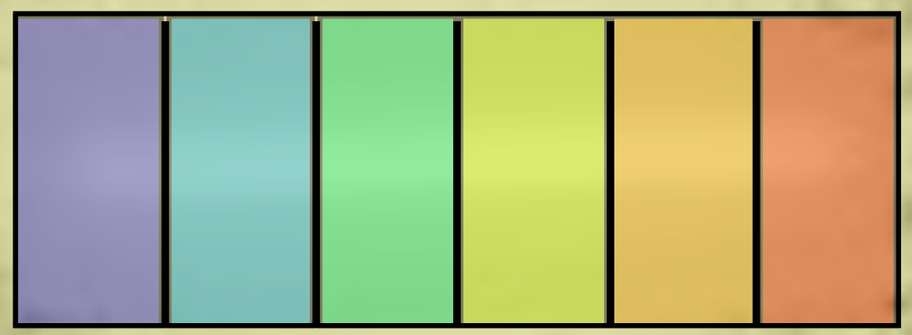

2 micron
1 micron


2 micron
1 micron



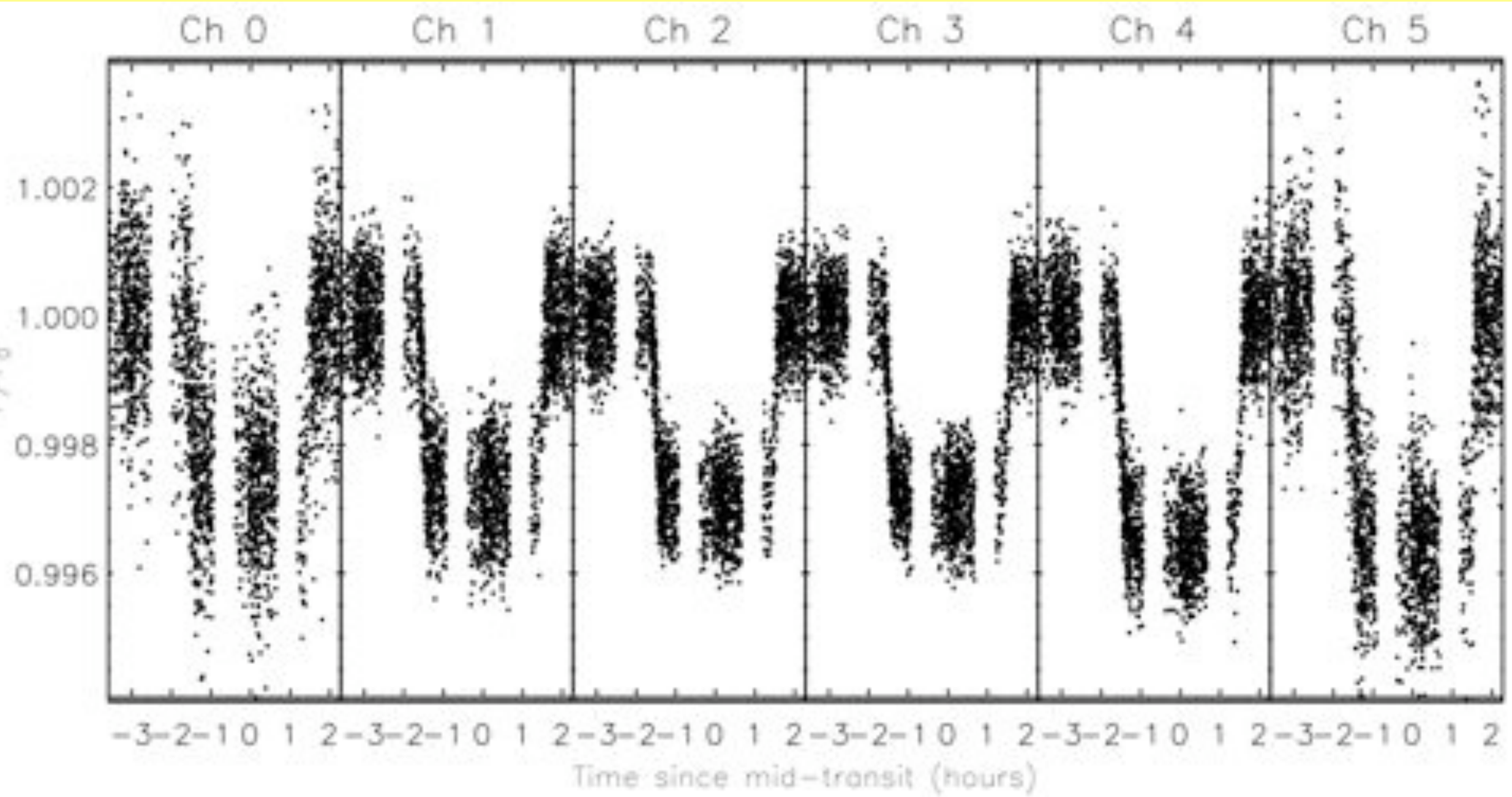
2 micron

1 micron



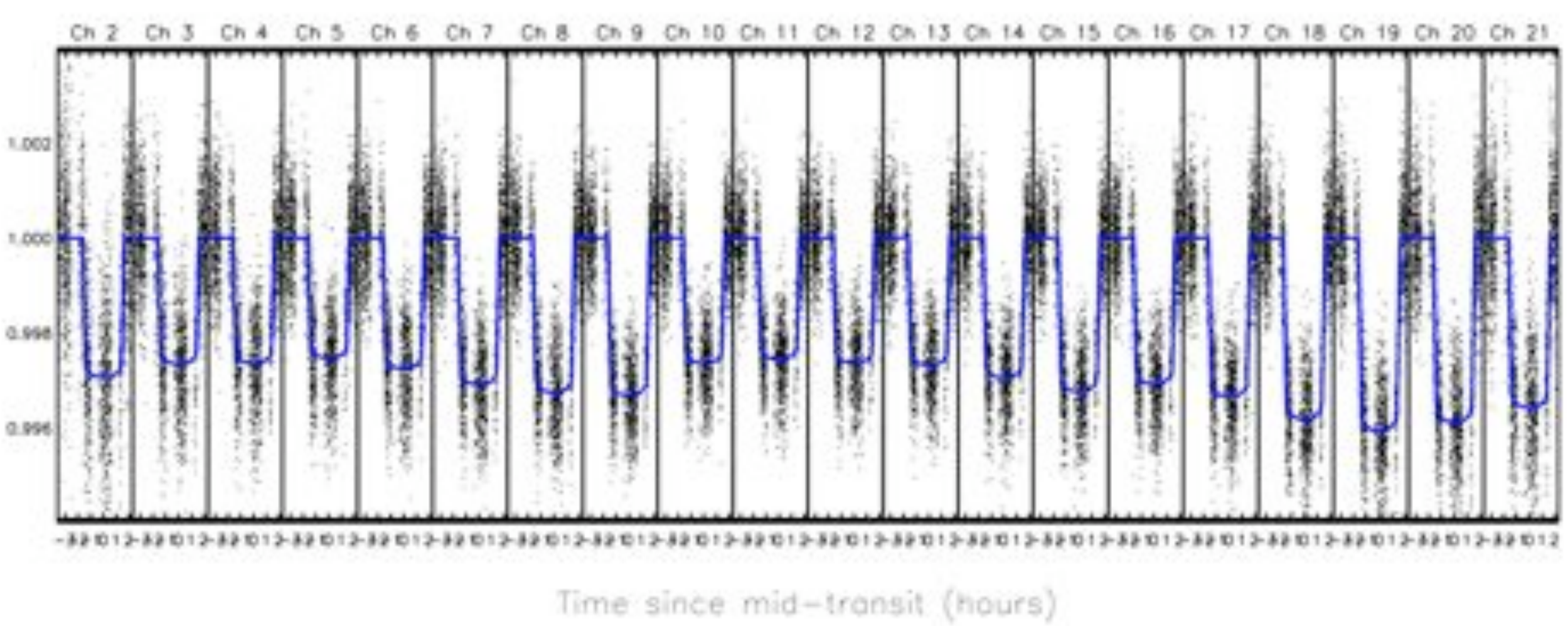
And in practice...

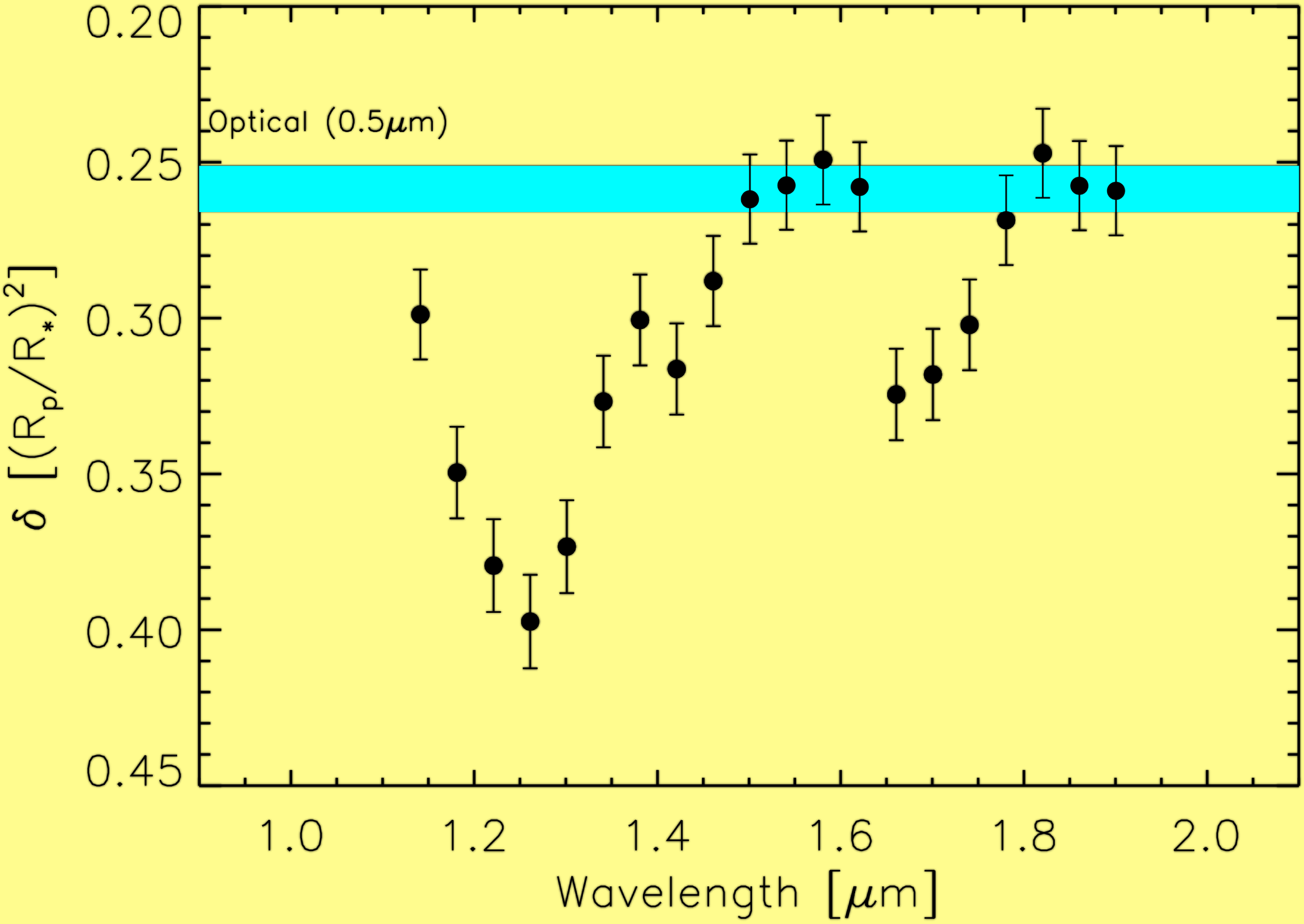
And in practice...

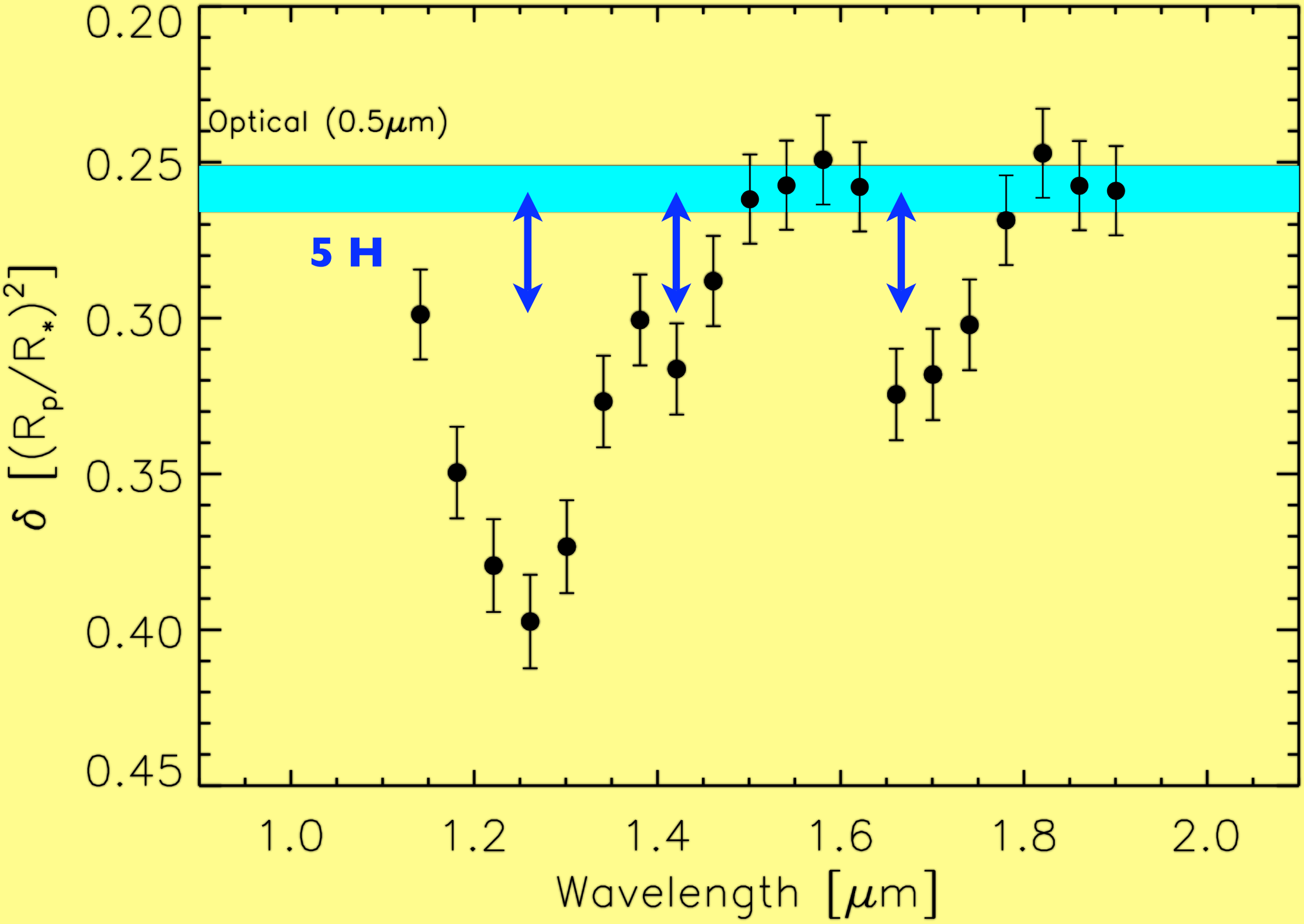


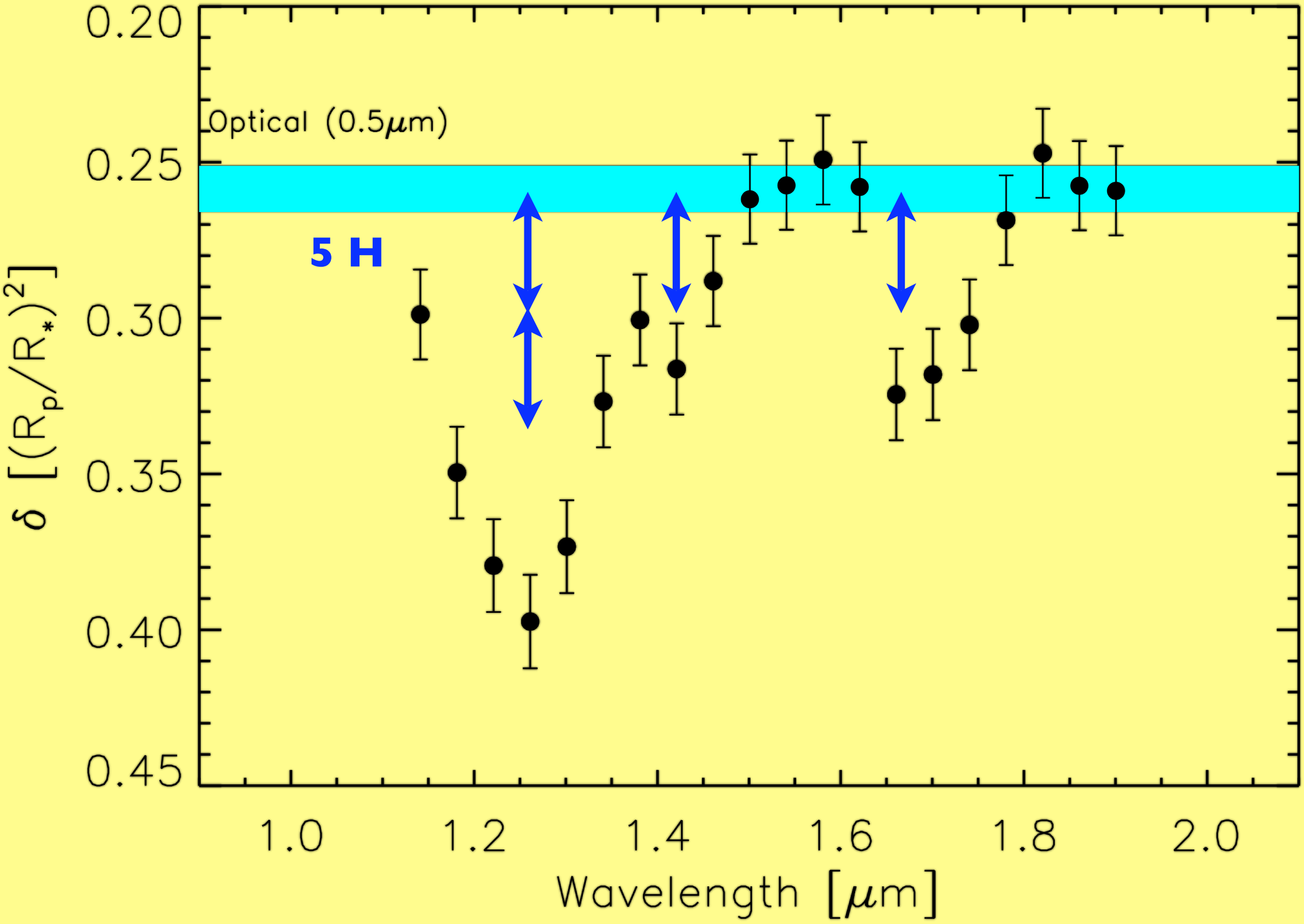
And taken to the limit...

And taken to the limit...




Optical (0.5μm)
0.20
0.25
0.30
0.35
0.40
0.45
δ [(R_p/R_*)^2]
1.0
1.2
1.4
1.6
1.8
2.0
Wavelength [μm]


Optical (0.5μm)
5 H
0.20
0.25
0.30
0.35
0.40
0.45
δ [(Rp/R*)2]
1.0
1.2
1.4
1.6
1.8
2.0
Wavelength [μm]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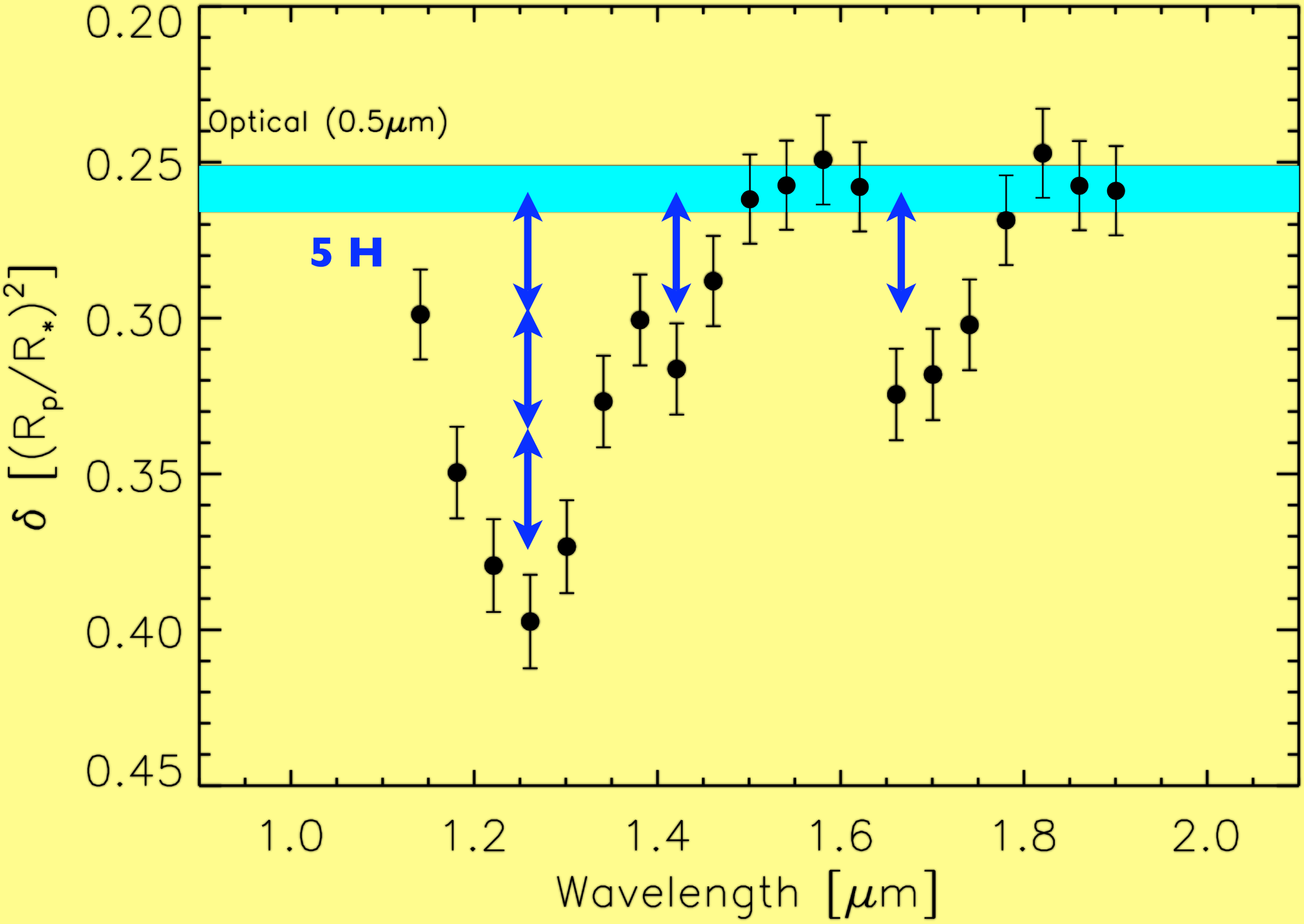
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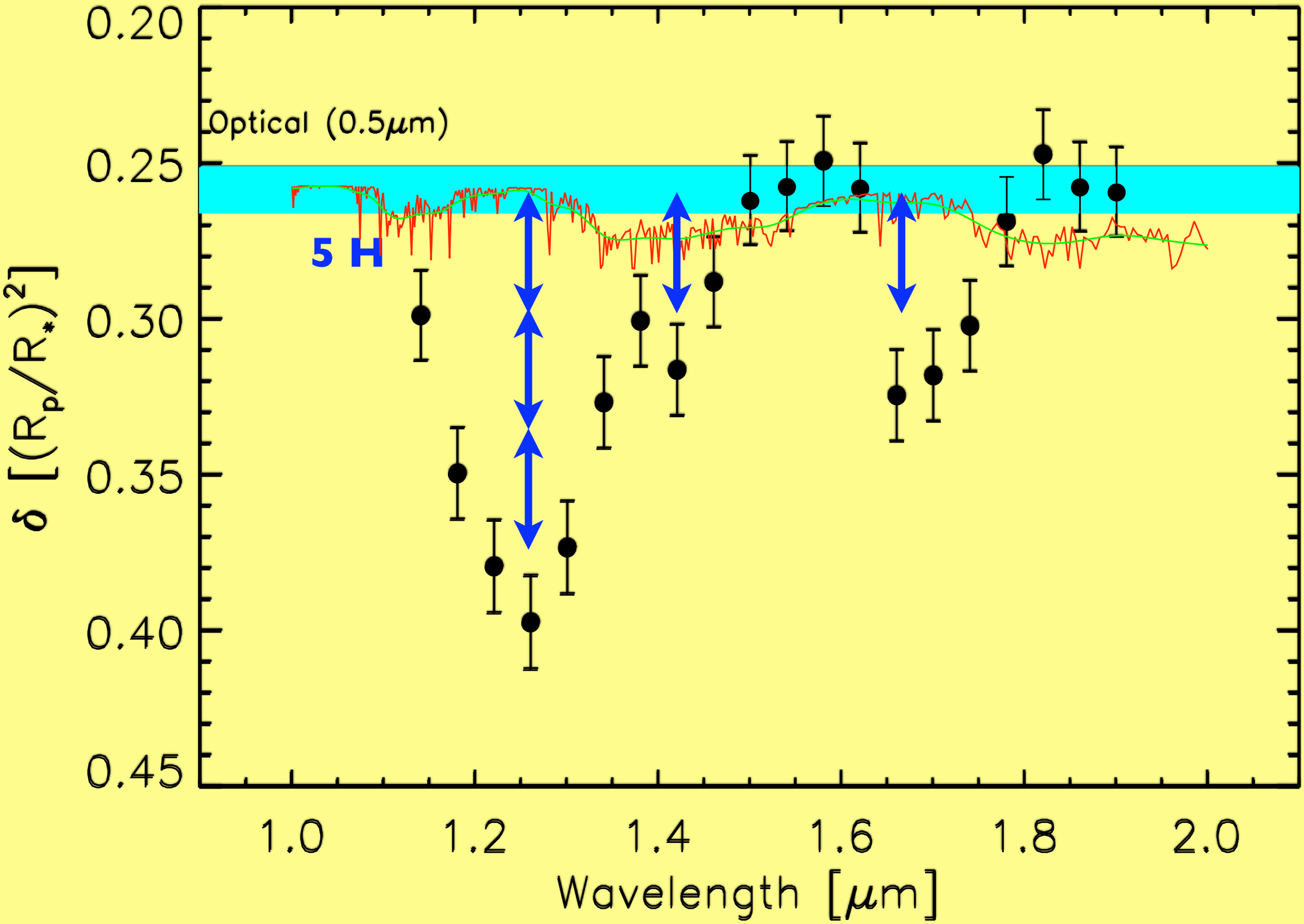
2.0
Wavelength [μm]


Optical (0.5μm)
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δ [(Rp/R*)2]
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1.2
1.4
1.6
1.8
2.0
Wavelength [μm]

Conclusions

- HD 149026b is an interesting exoplanet!
- Task I: We have pinned down the stellar mean density, constraining the stellar radius to 3%.
- Task II: We have identified a currently unexplained depth variation with wavelength.
- Next task is clarify/identify the wavelength dependent structure