

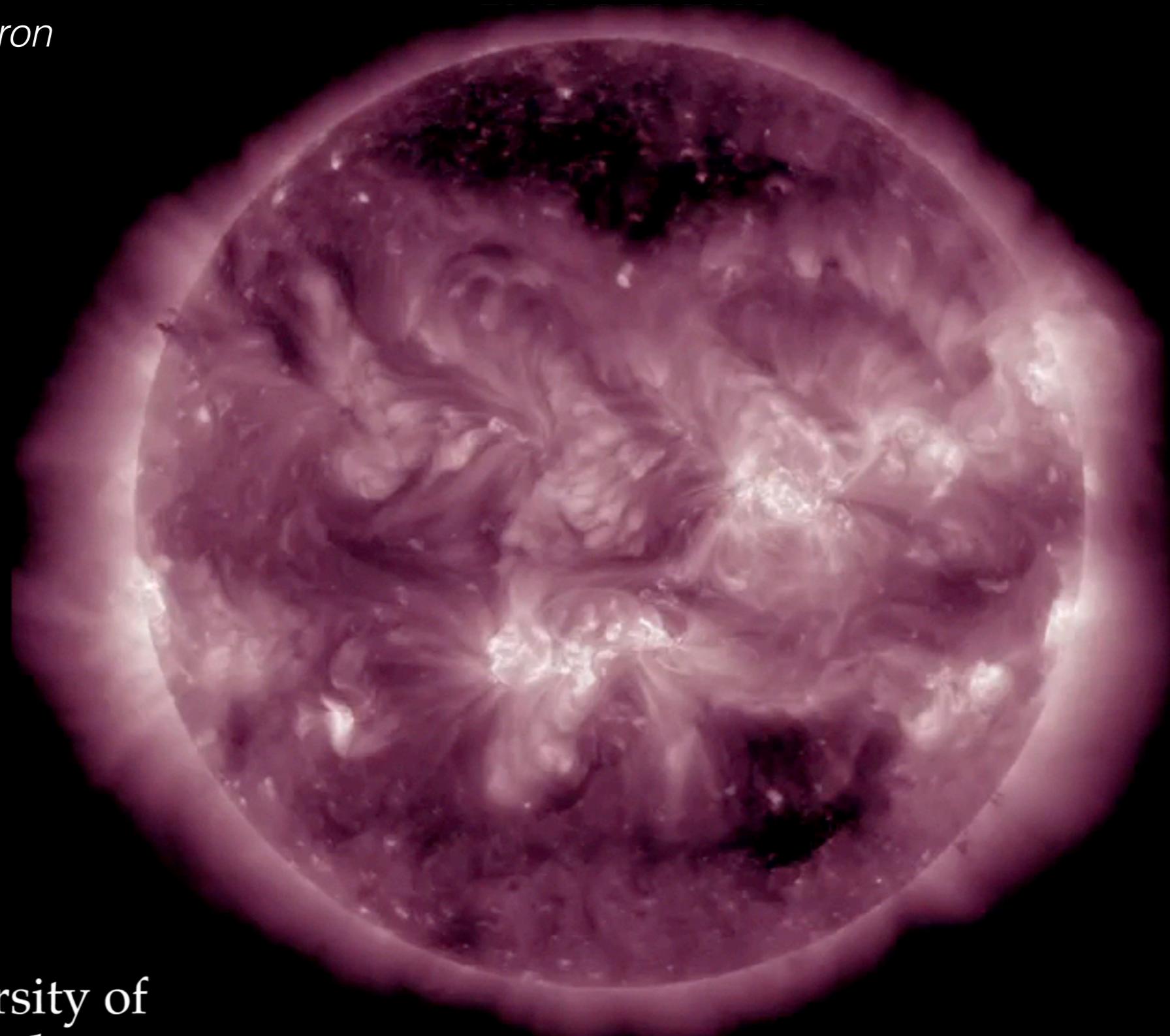
# Stellar activity effects on high energy transits

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*Evgenya Shkolnik*

*Andrew Cameron*

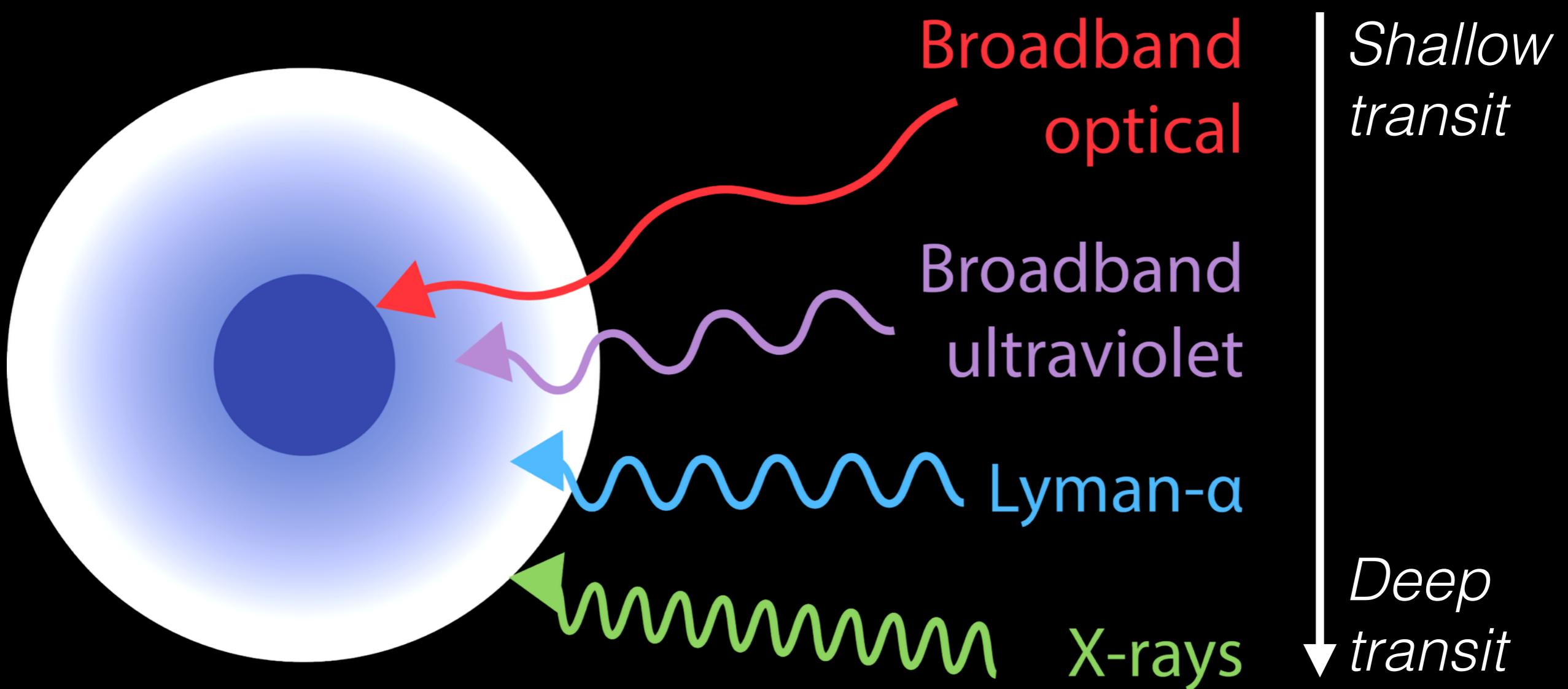
*Moira Jardine*



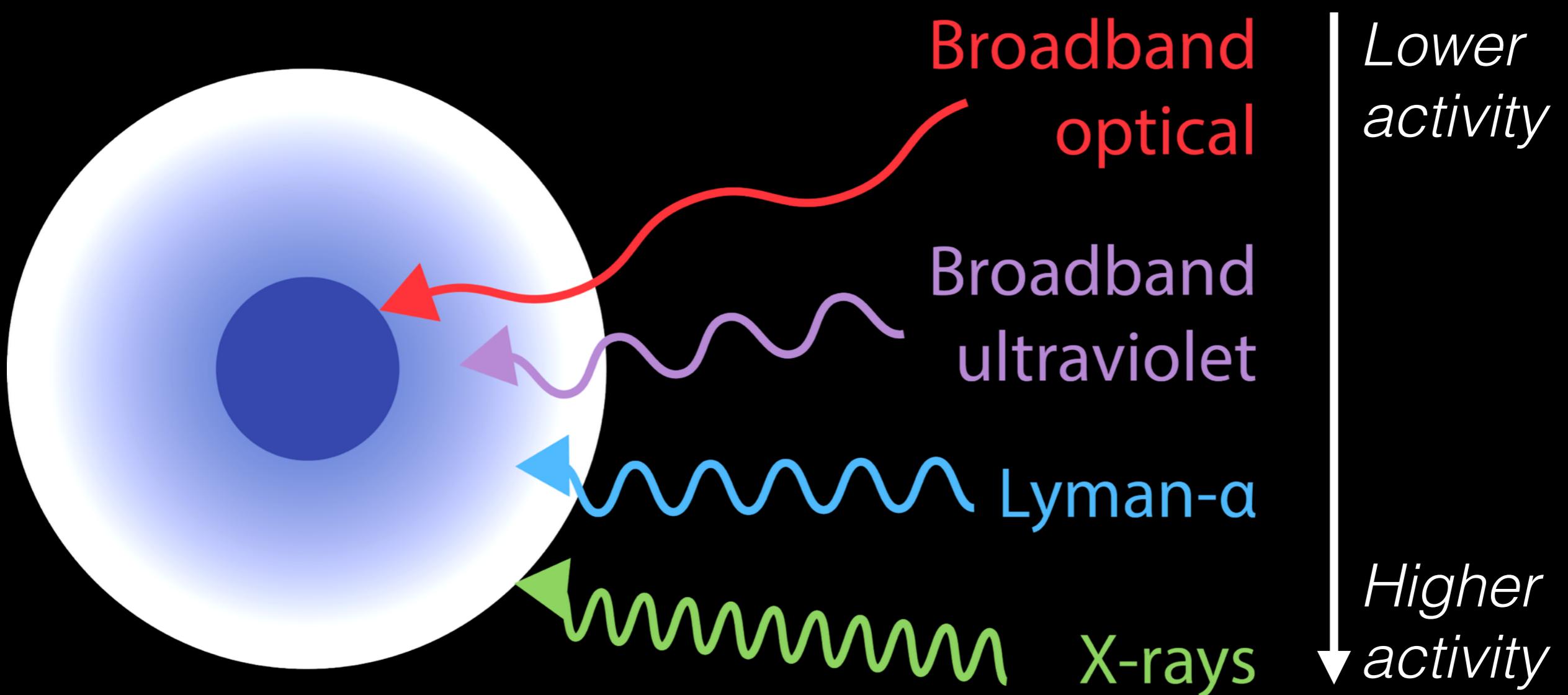
University of  
St Andrews



# Why observe high energy transits?

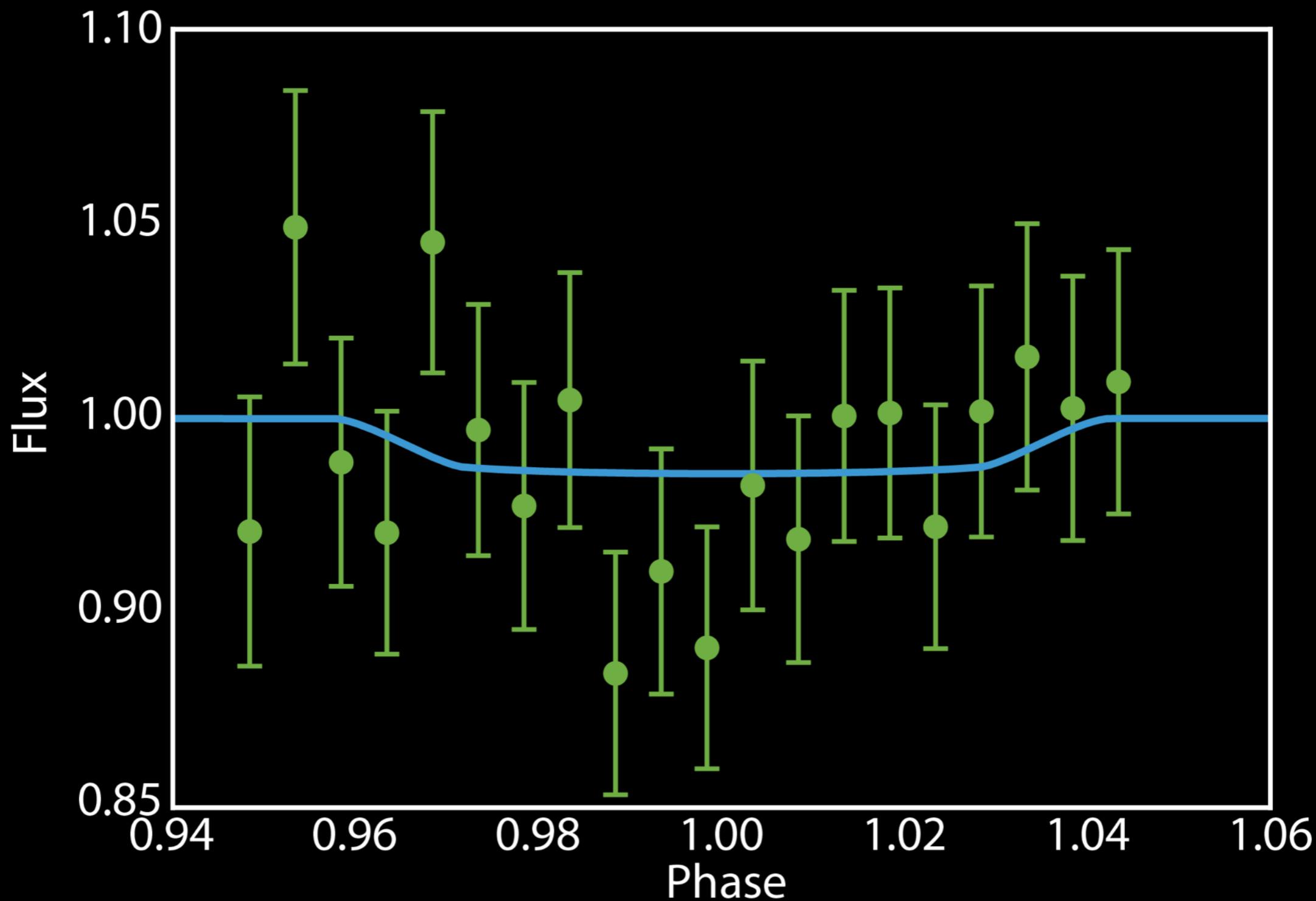


# Why observe high energy transits?



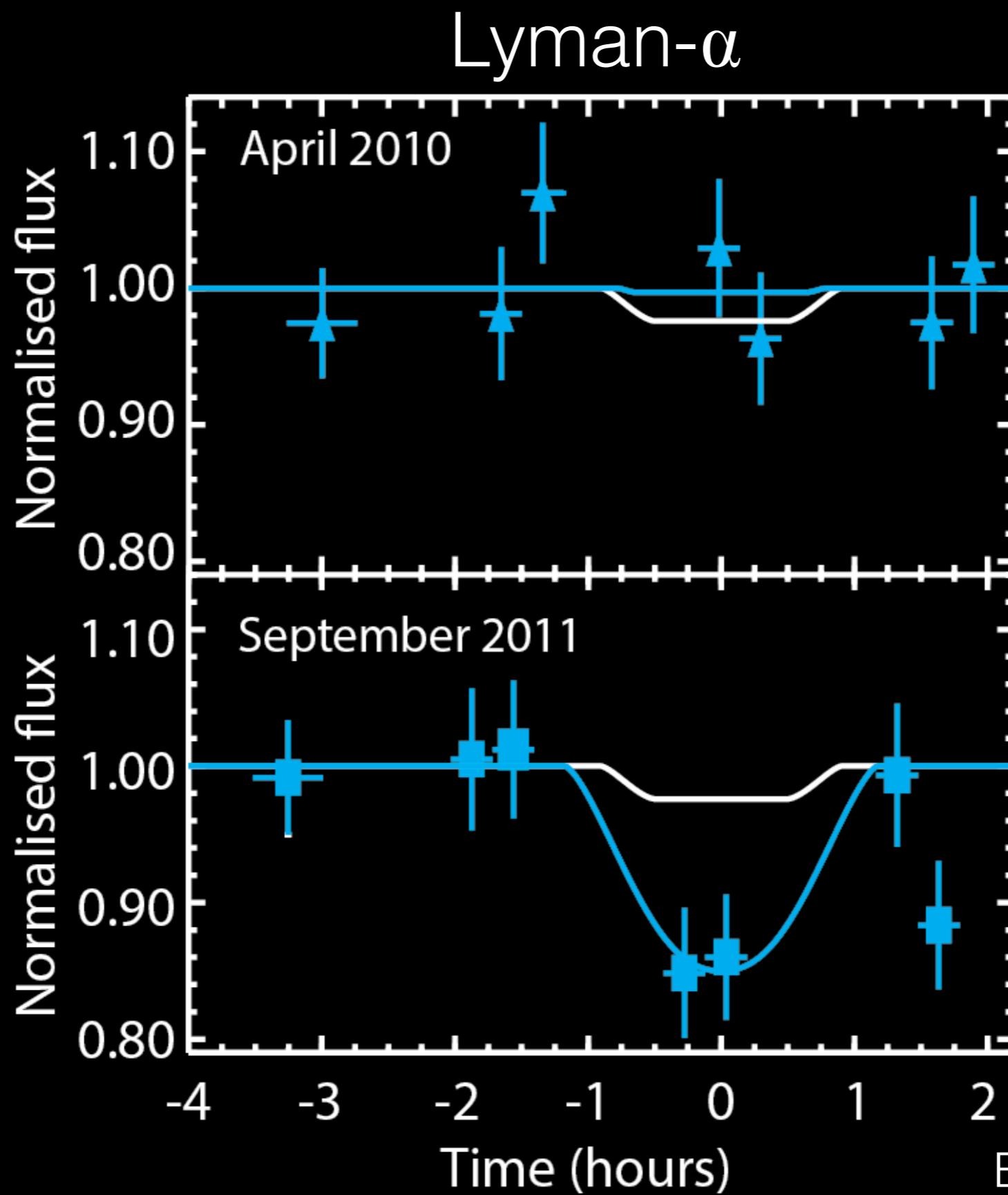
# High energy transits of HD 189733b

X-rays



Poppenhaeger et al. (2013)

# High energy transits of HD 189733b



# The ultraviolet Sun

Soft X-Ray  
9.4 nm  
 $6.3 \times 10^6$  K



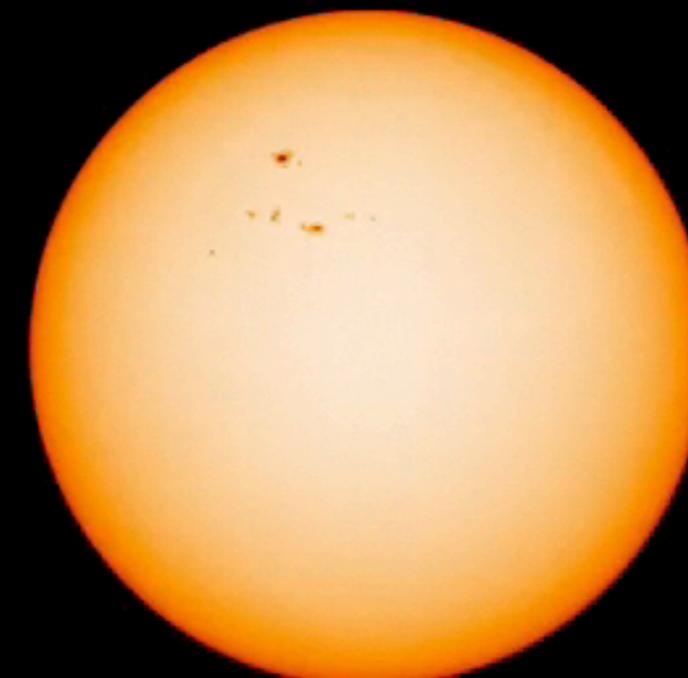
Extreme UV  
21.1 nm  
 $2.0 \times 10^6$  K



Far UV  
170 nm  
 $5 \times 10^3$  K

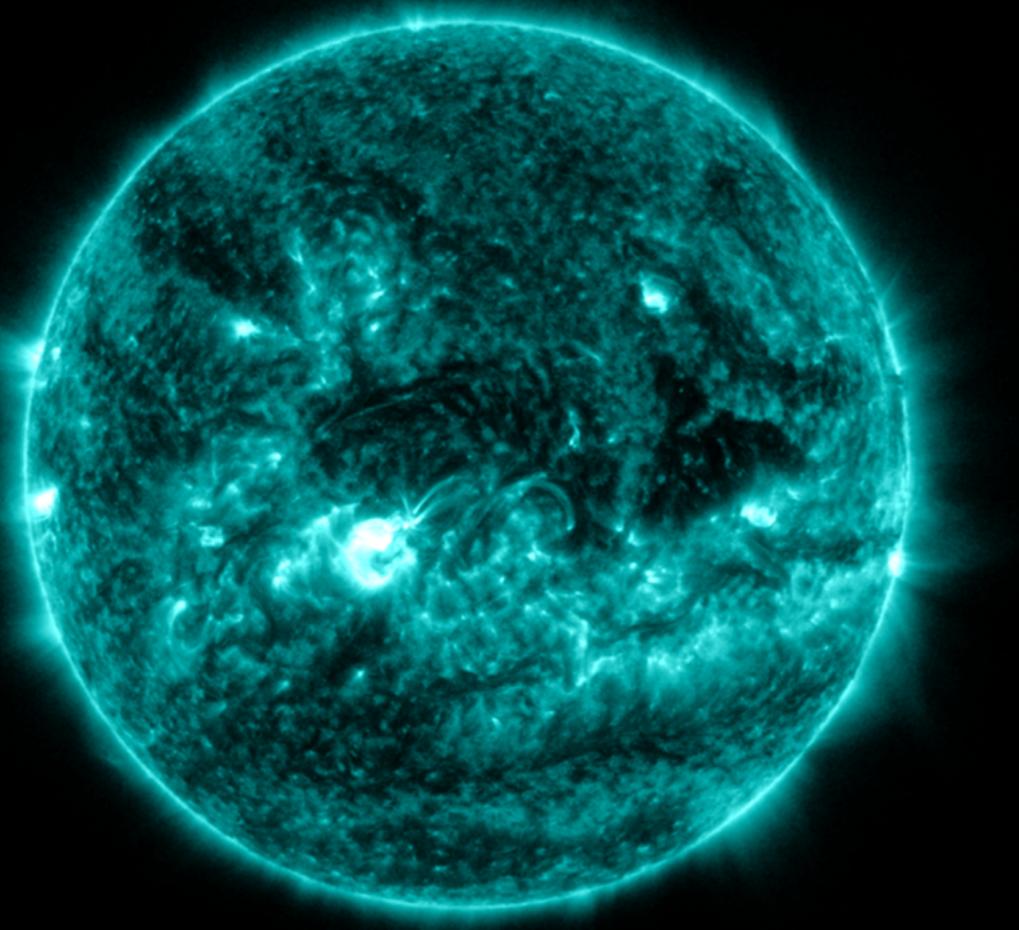


Optical  
450 nm  
 $5 \times 10^3$  K

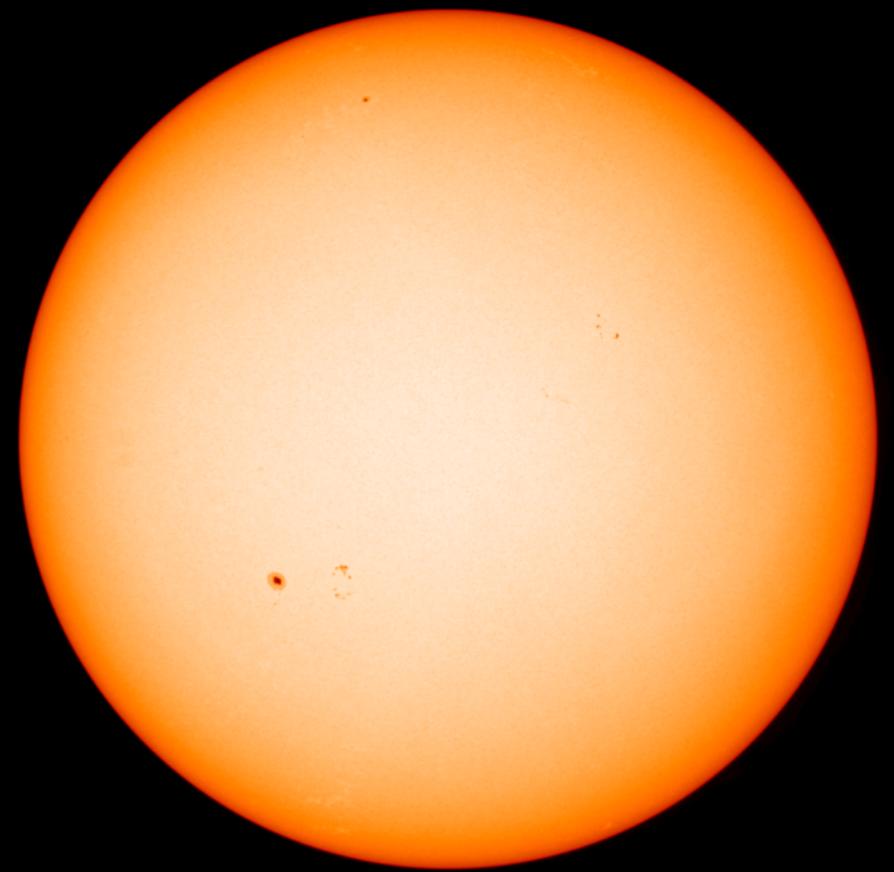


# Limb-brightened transits

13.1 nm (EUV)

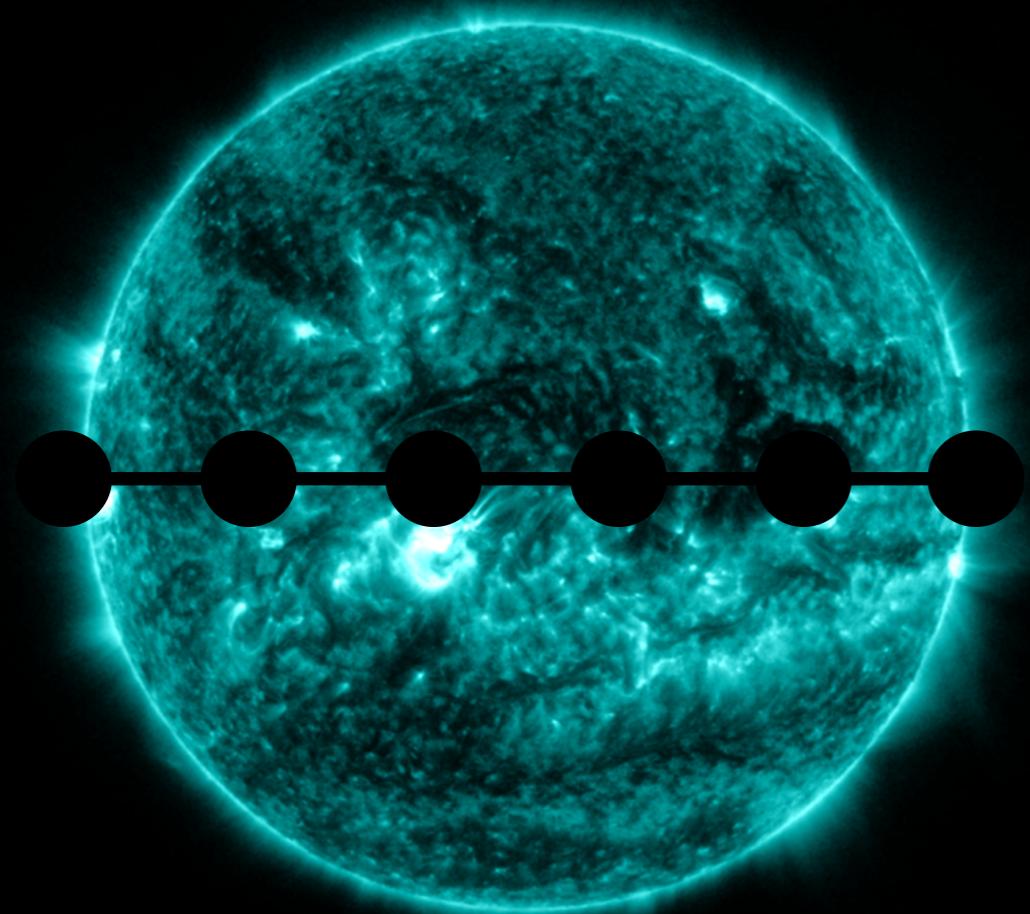


450 nm (optical)

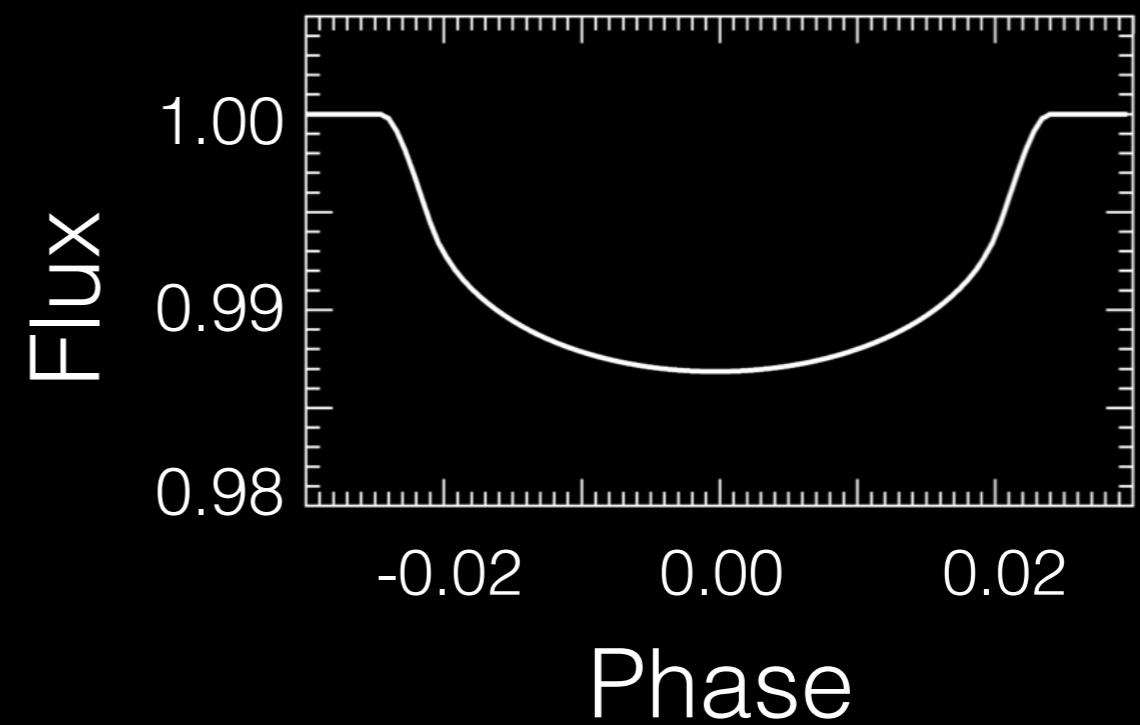
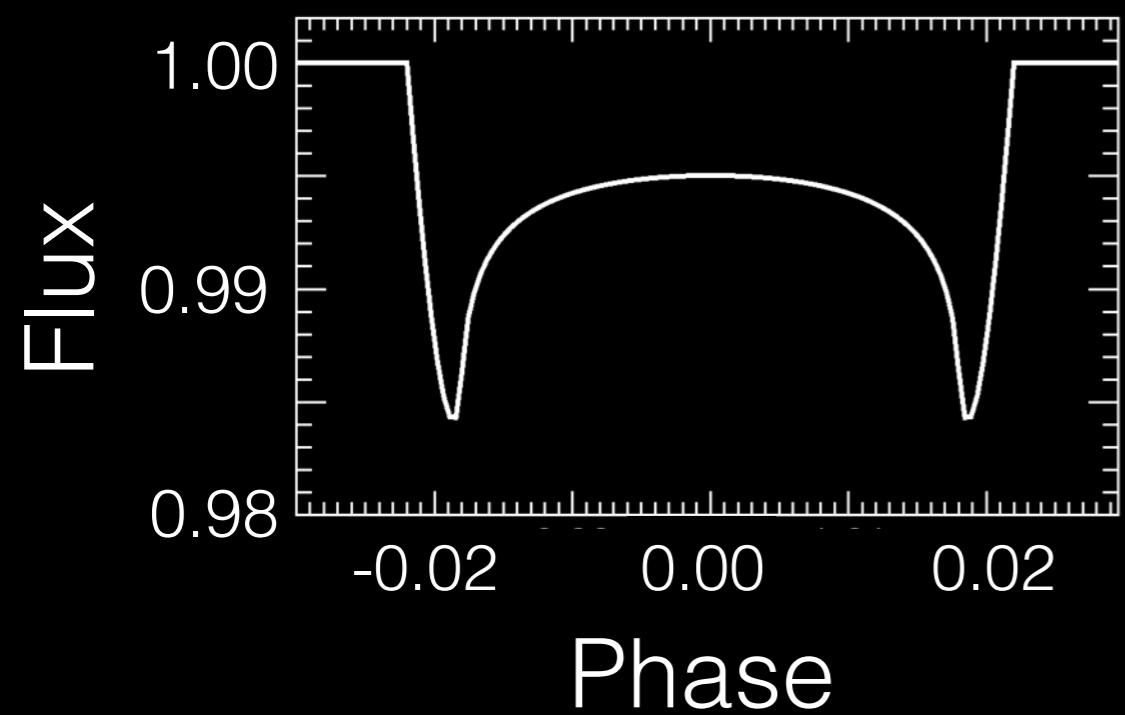
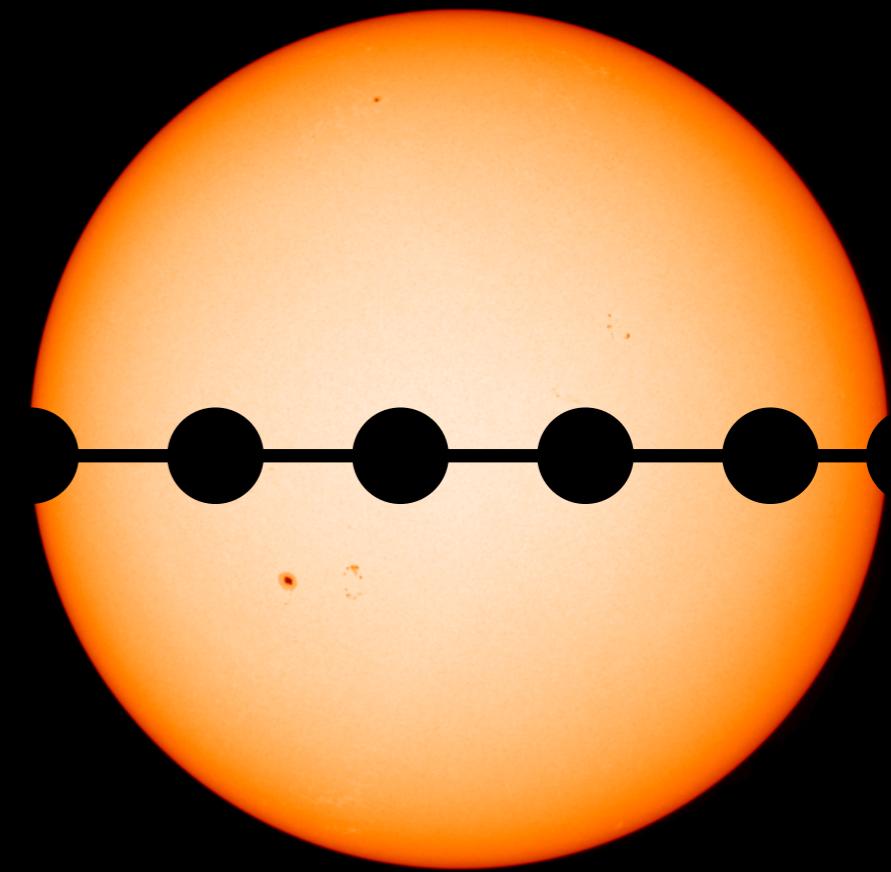


# Limb-brightened transits

13.1 nm (EUV)

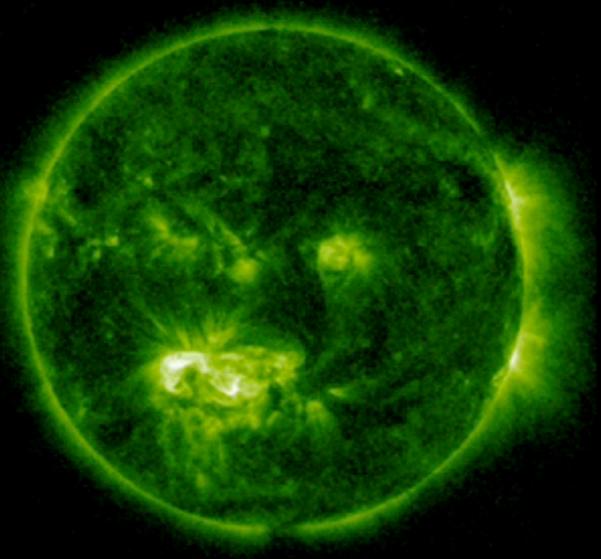


450 nm (optical)

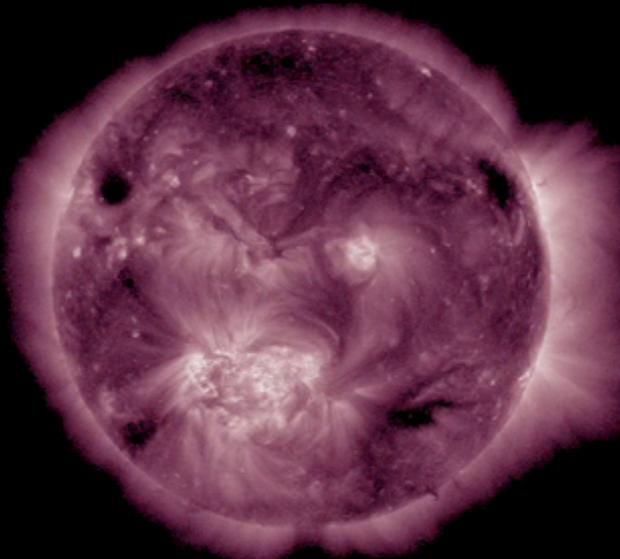


# Transiting the Sun I

Soft X-Ray  
9.4 nm



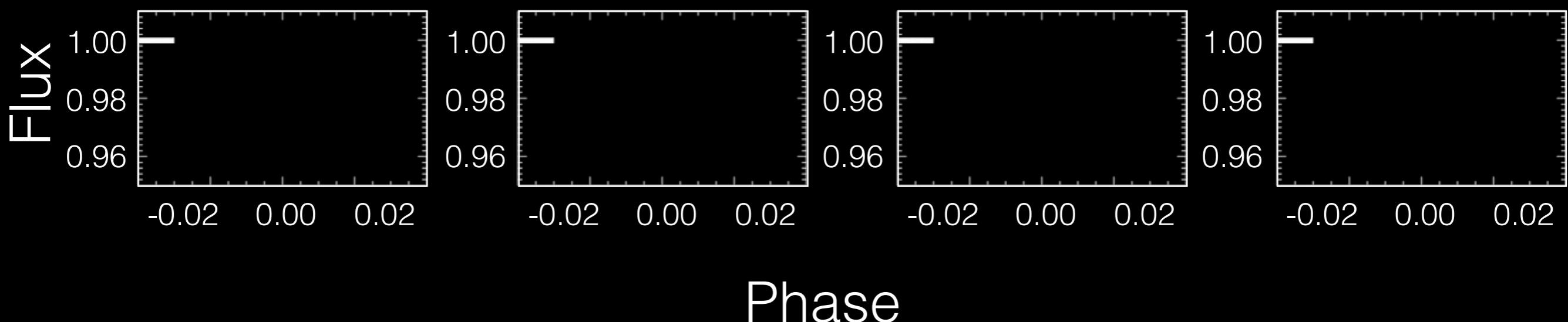
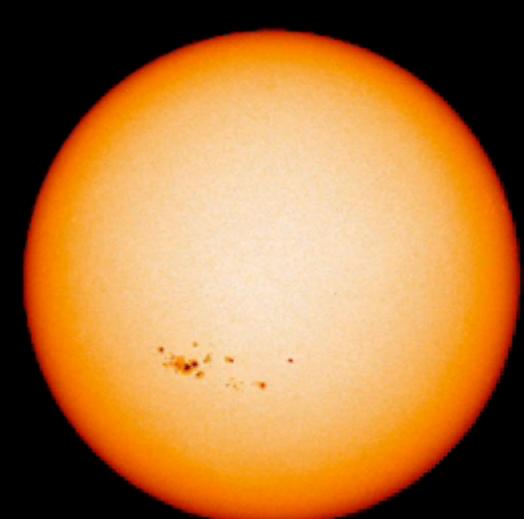
EUV  
21.1 nm



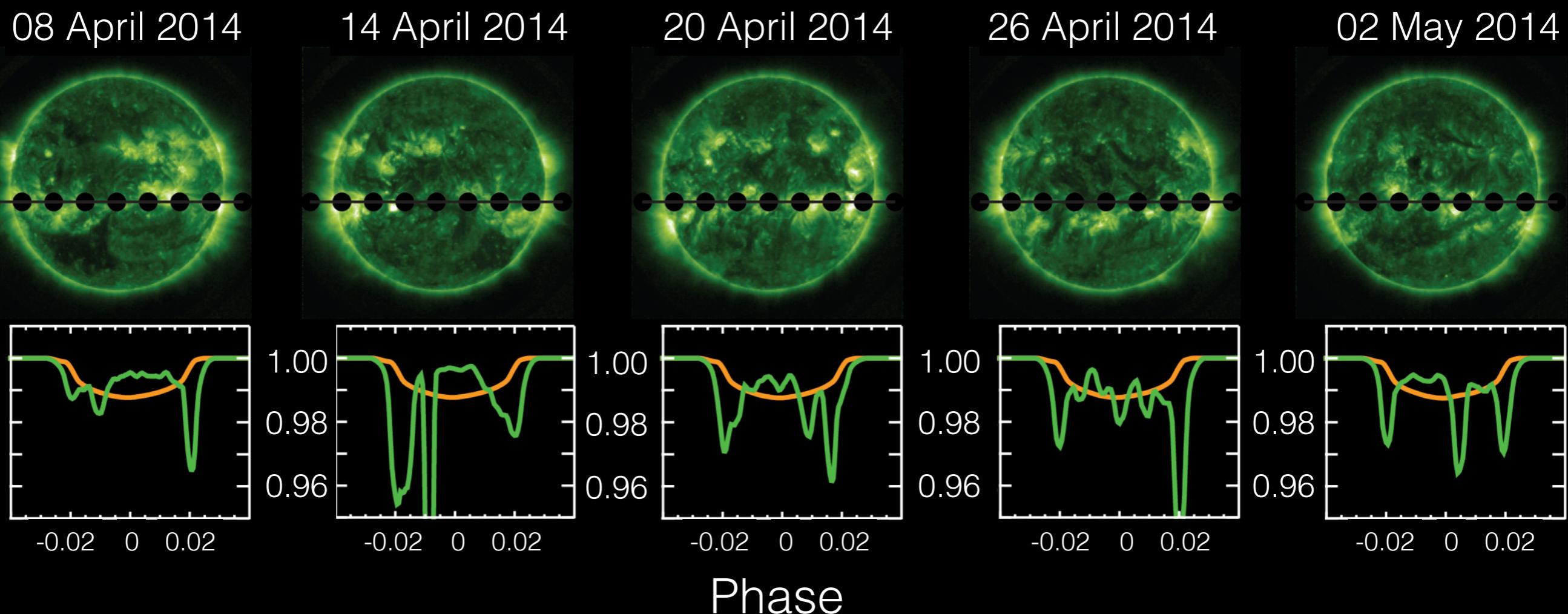
FUV  
170 nm



Optical  
450 nm



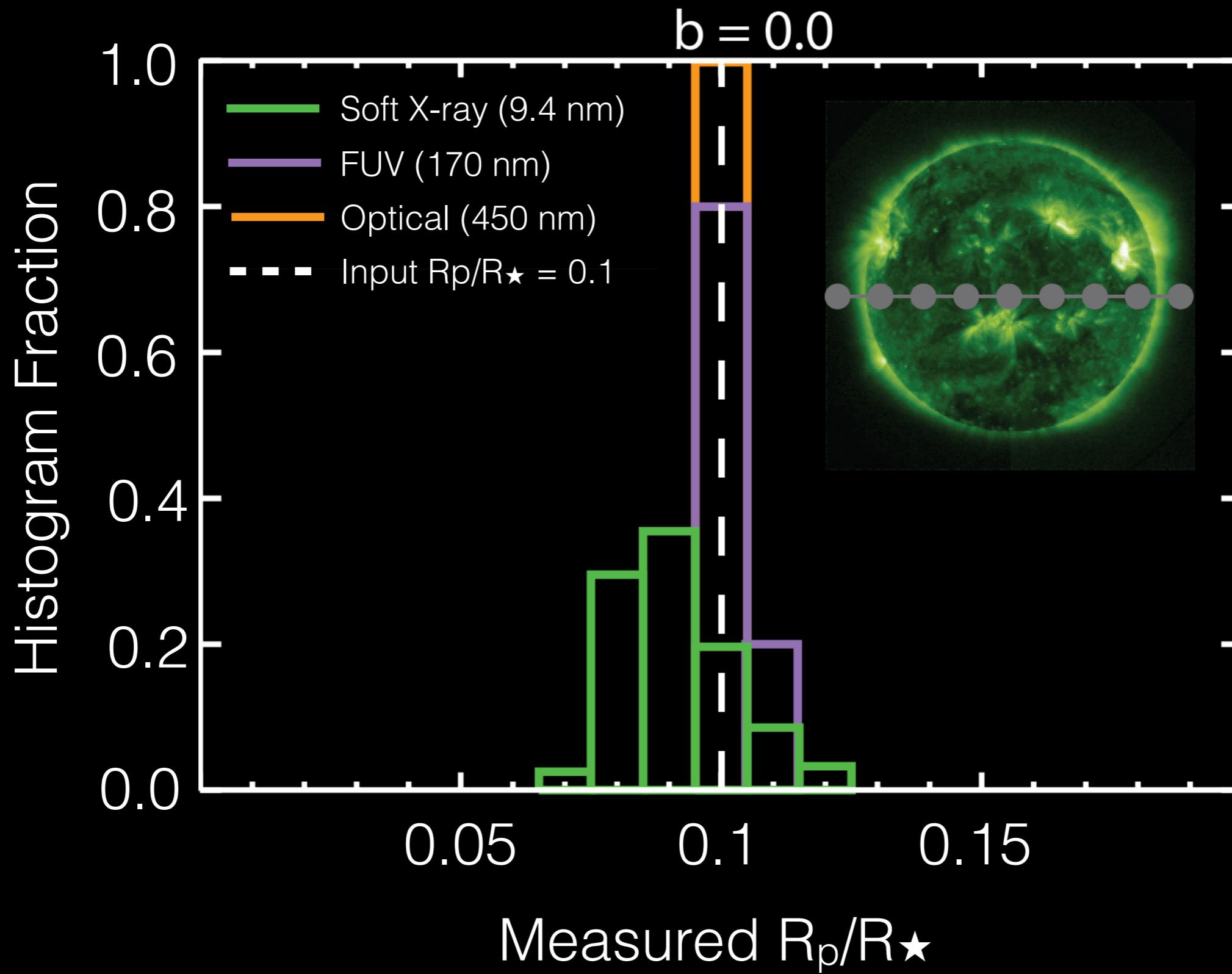
# Transiting the Sun I



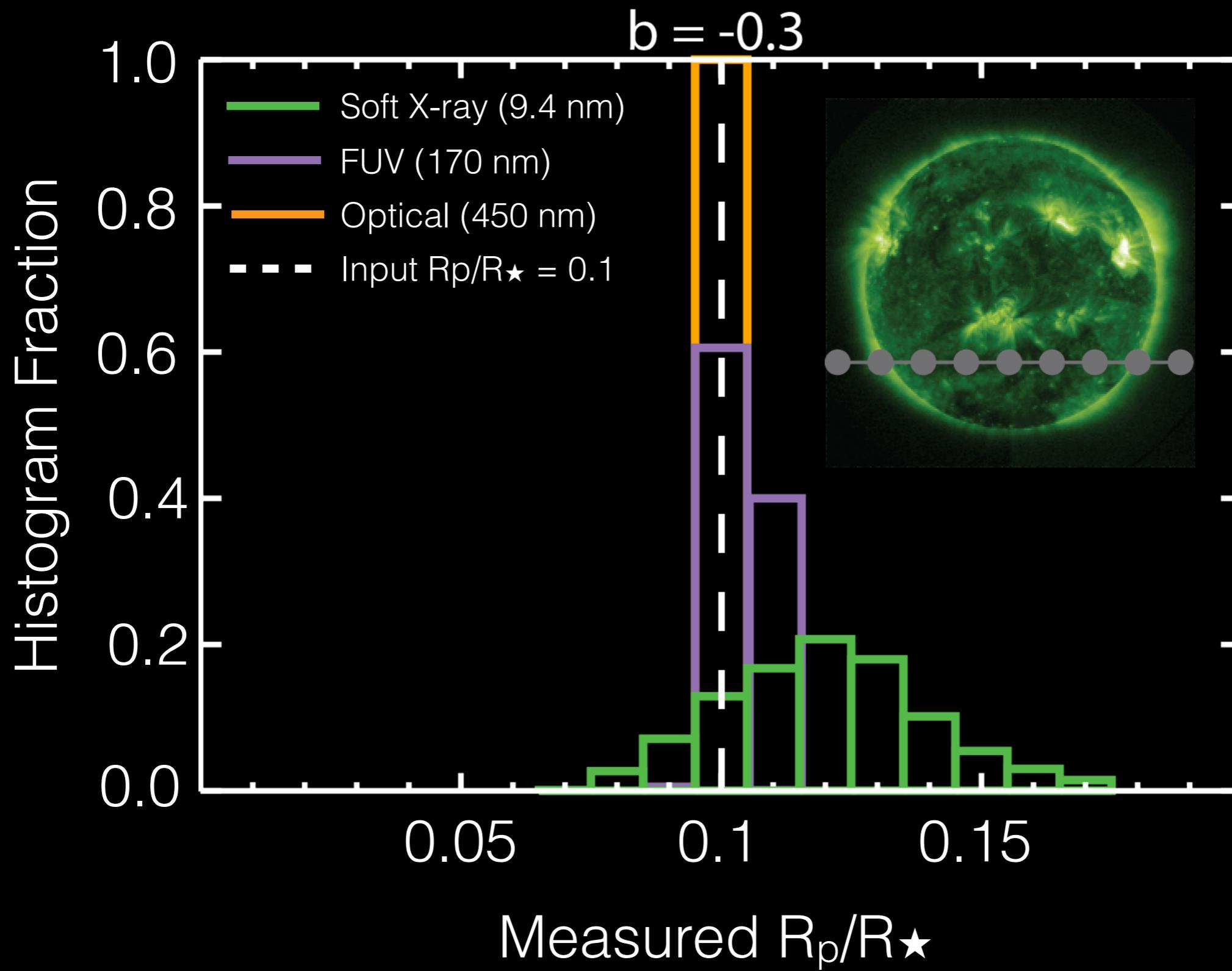
Carrington rotation 2149 (April 2014)

Llama & Shkolnik (2015)

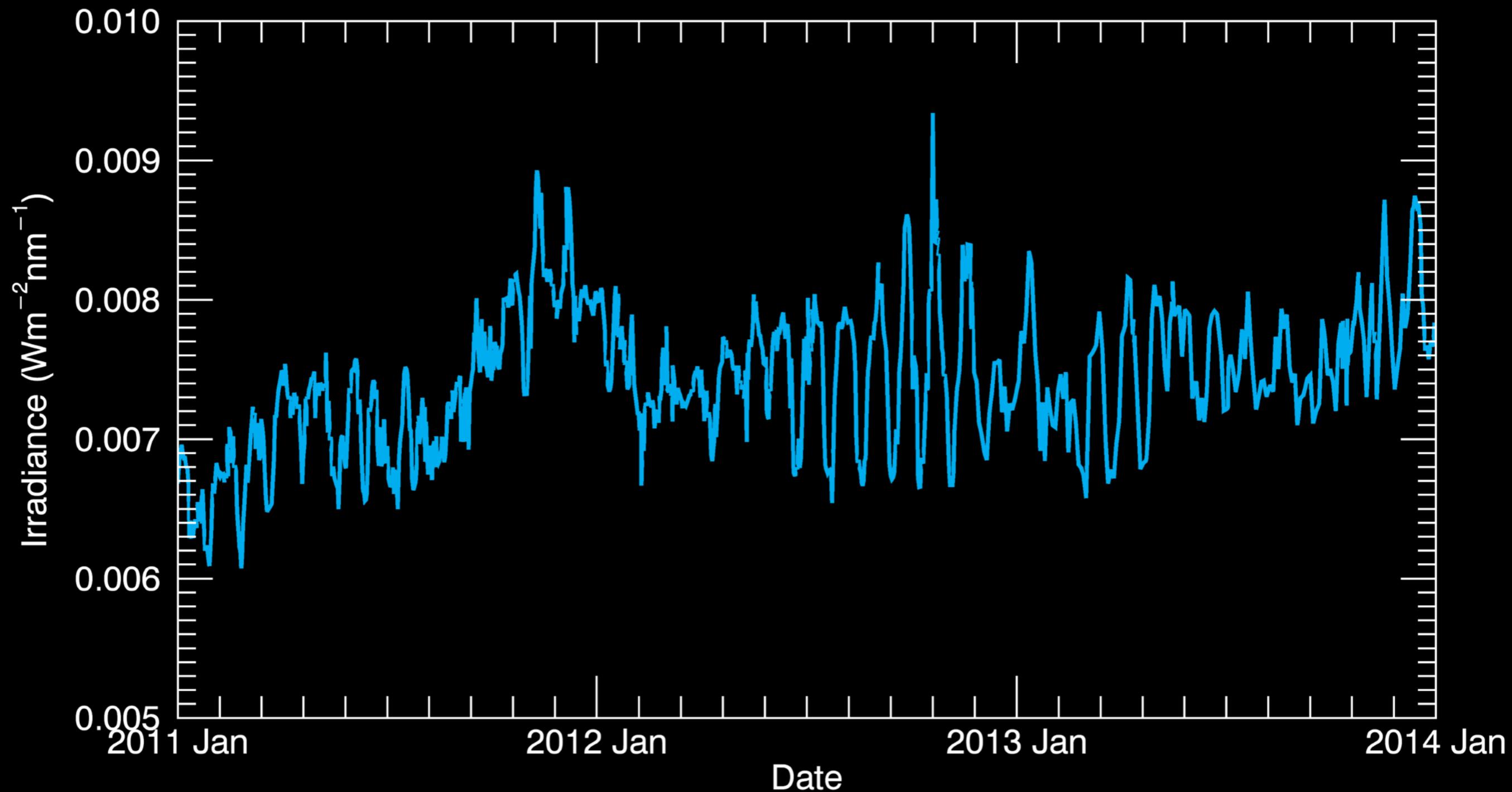
# Transiting the Sun I



# Transiting the Sun I

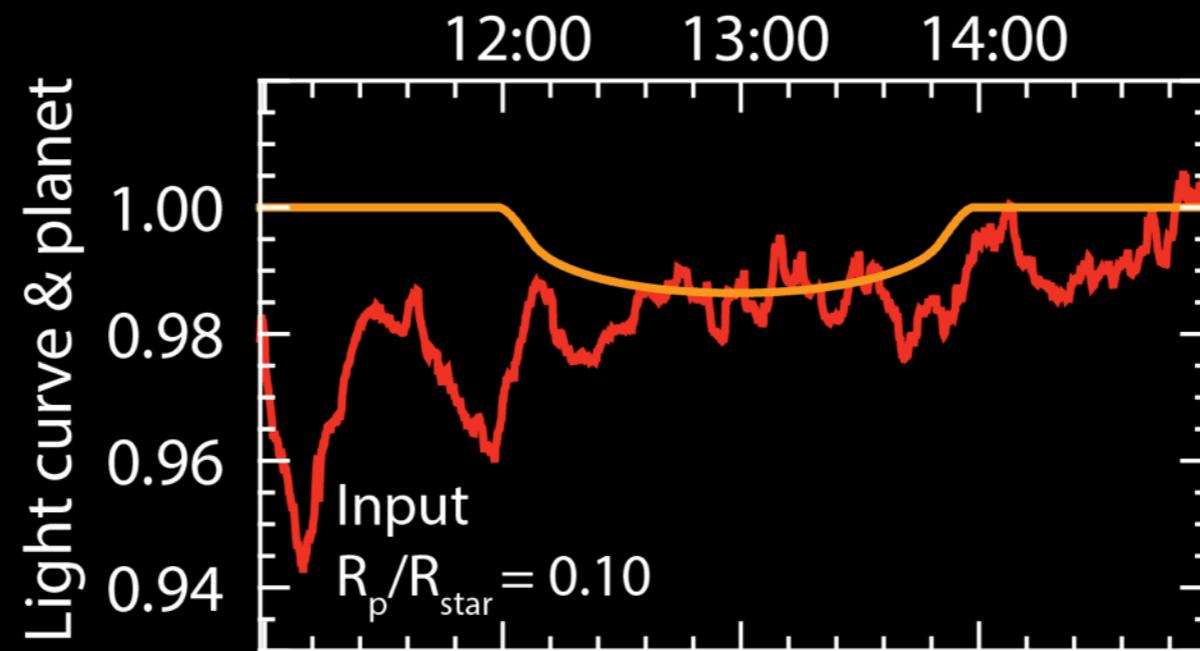


# Transiting the Sun II: Lyman- $\alpha$



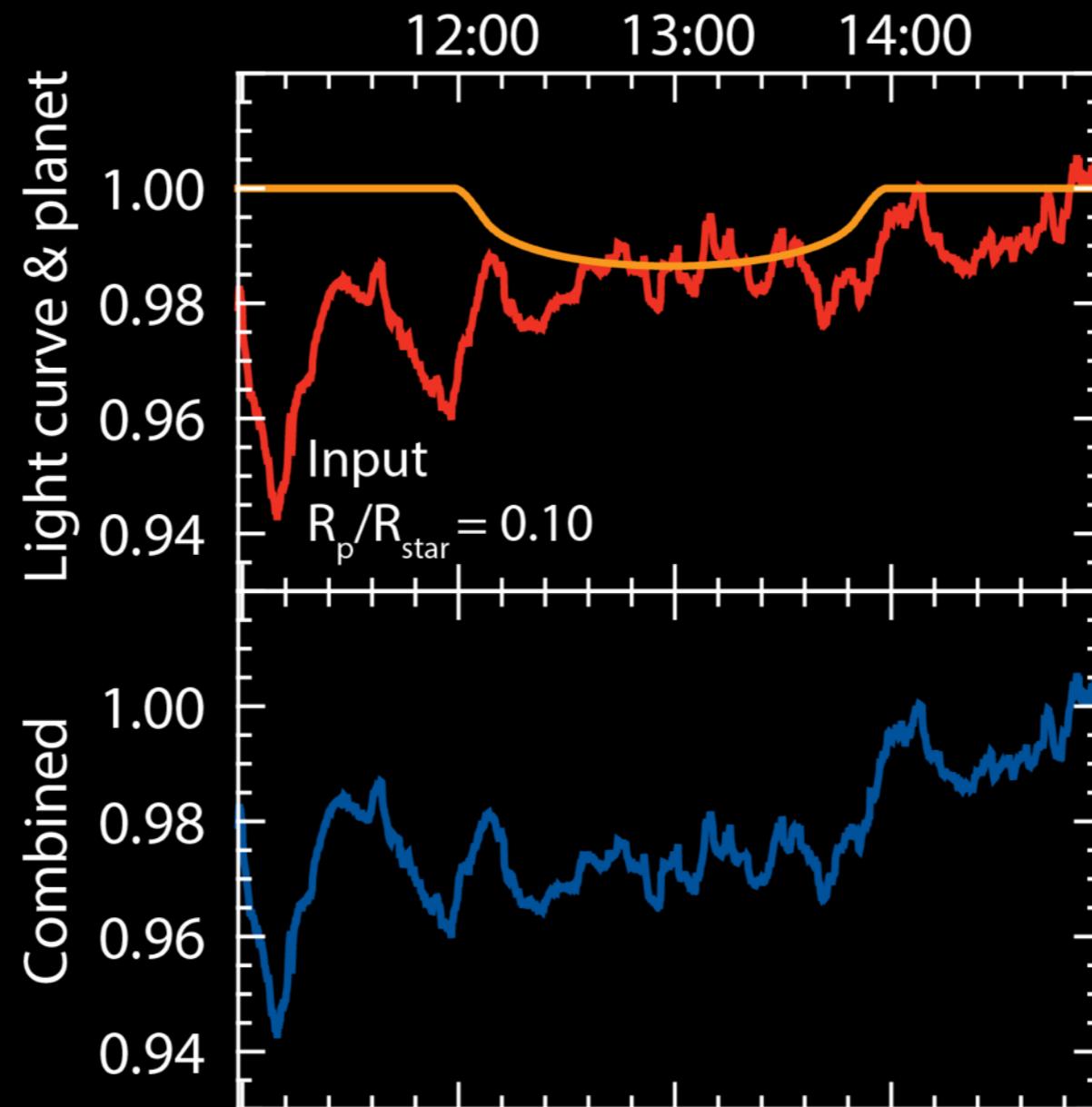
# Transiting the Sun II: Lyman- $\alpha$

2011 June 24



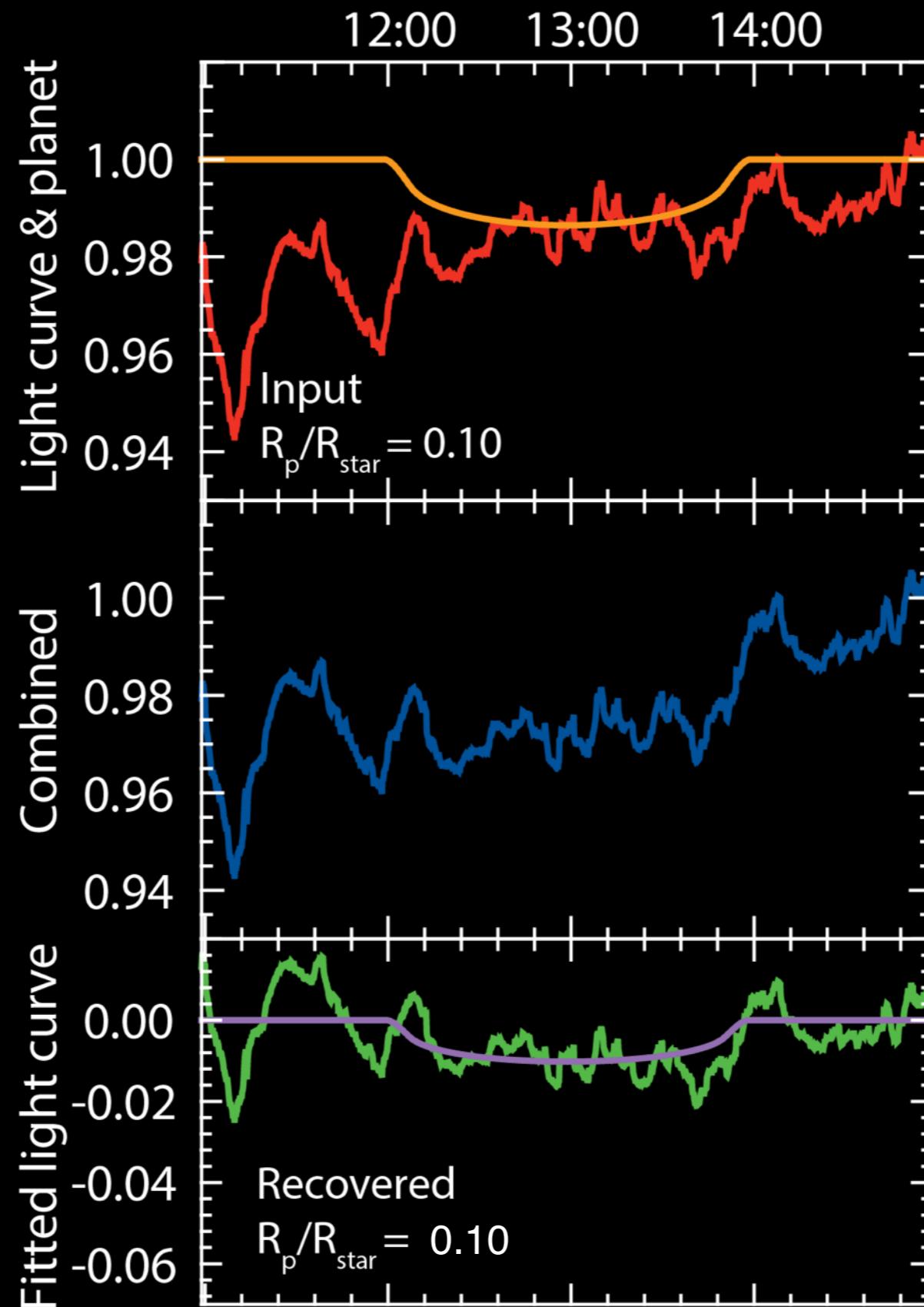
# Transiting the Sun II: Lyman- $\alpha$

2011 June 24



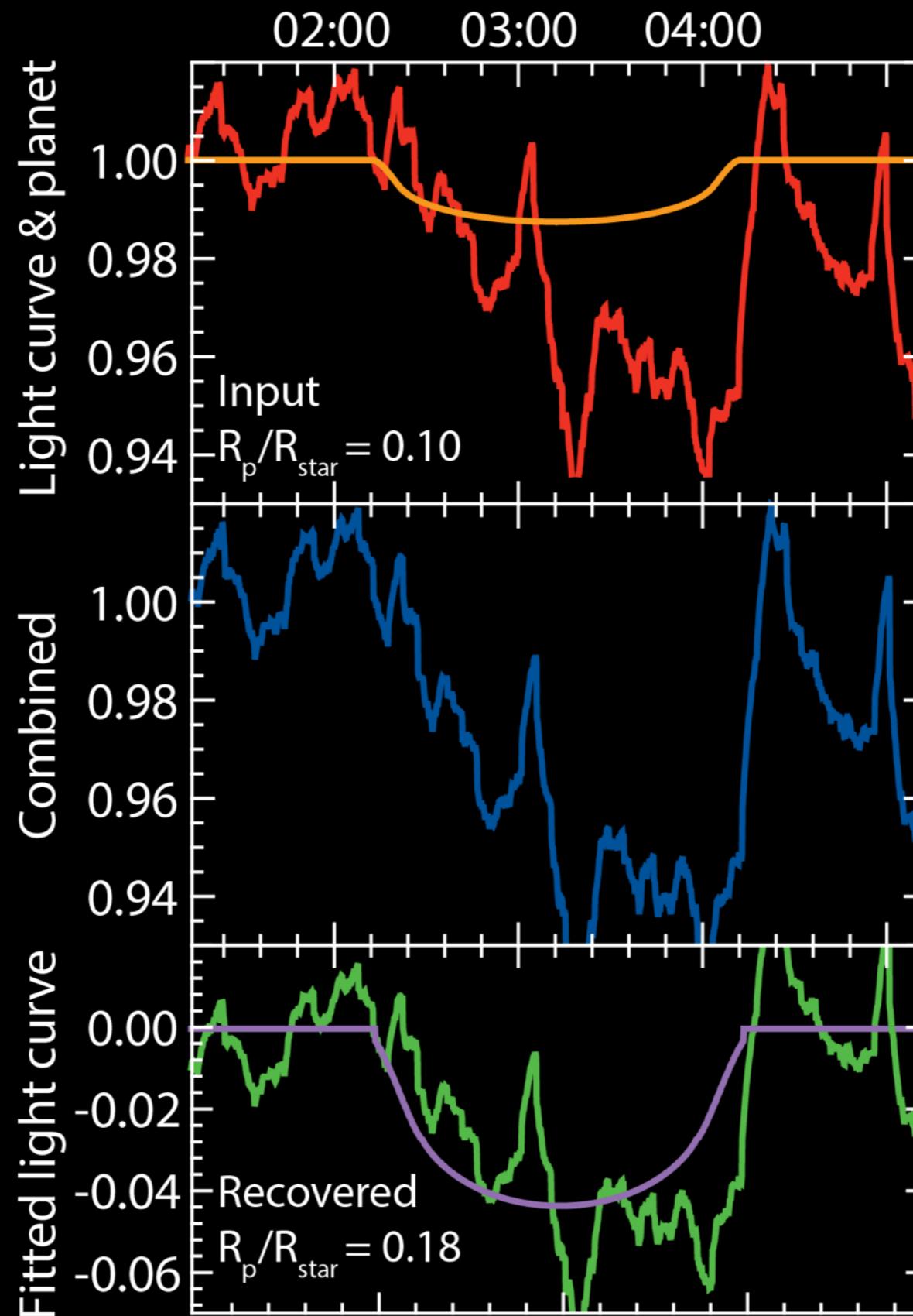
# Transiting the Sun II: Lyman- $\alpha$

2011 June 24

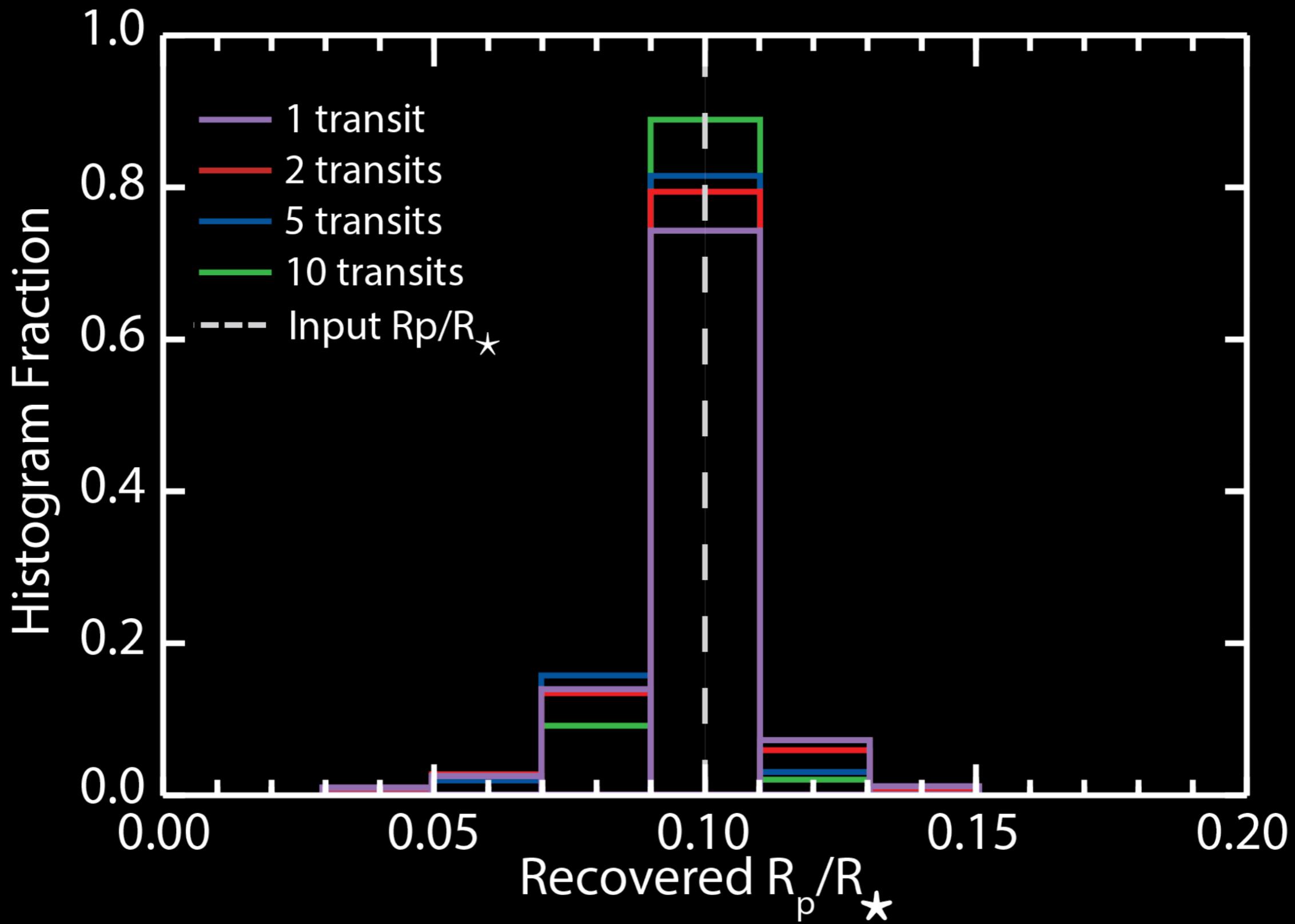


# Transiting the Sun II: Lyman- $\alpha$

2011 May 06



# Transiting the Sun II: Lyman- $\alpha$



# Summary

- Stellar activity needs to be taken into account in the interpretation of these observations.
- Simultaneous optical observations **may** help disentangle stellar activity signatures in high energy transits.
- X-ray / UV transits are a great tool to investigate the upper atmospheres of exoplanets.