

# HST best performances and best practices

David K. Sing

UNIVERSITY OF  
EXETER



Science & Technology  
Facilities Council



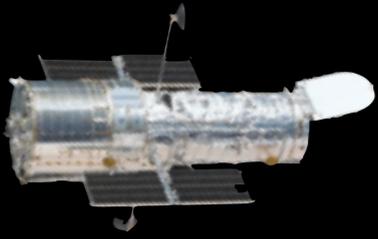
European Research Council  
Established by the European Commission

# HST spectrophotometry



- Thermal breathing - telescope focus changes
- Thermal breathing - day/night differences solar/battery power
- Electronics
- Highly repeatable (30 ppm or better in depths)
- Many of the same trends evident in different cameras (STIS, NICMOS, ACS, WFC3)
- Very high S/N : saturate CCD; spacial scan





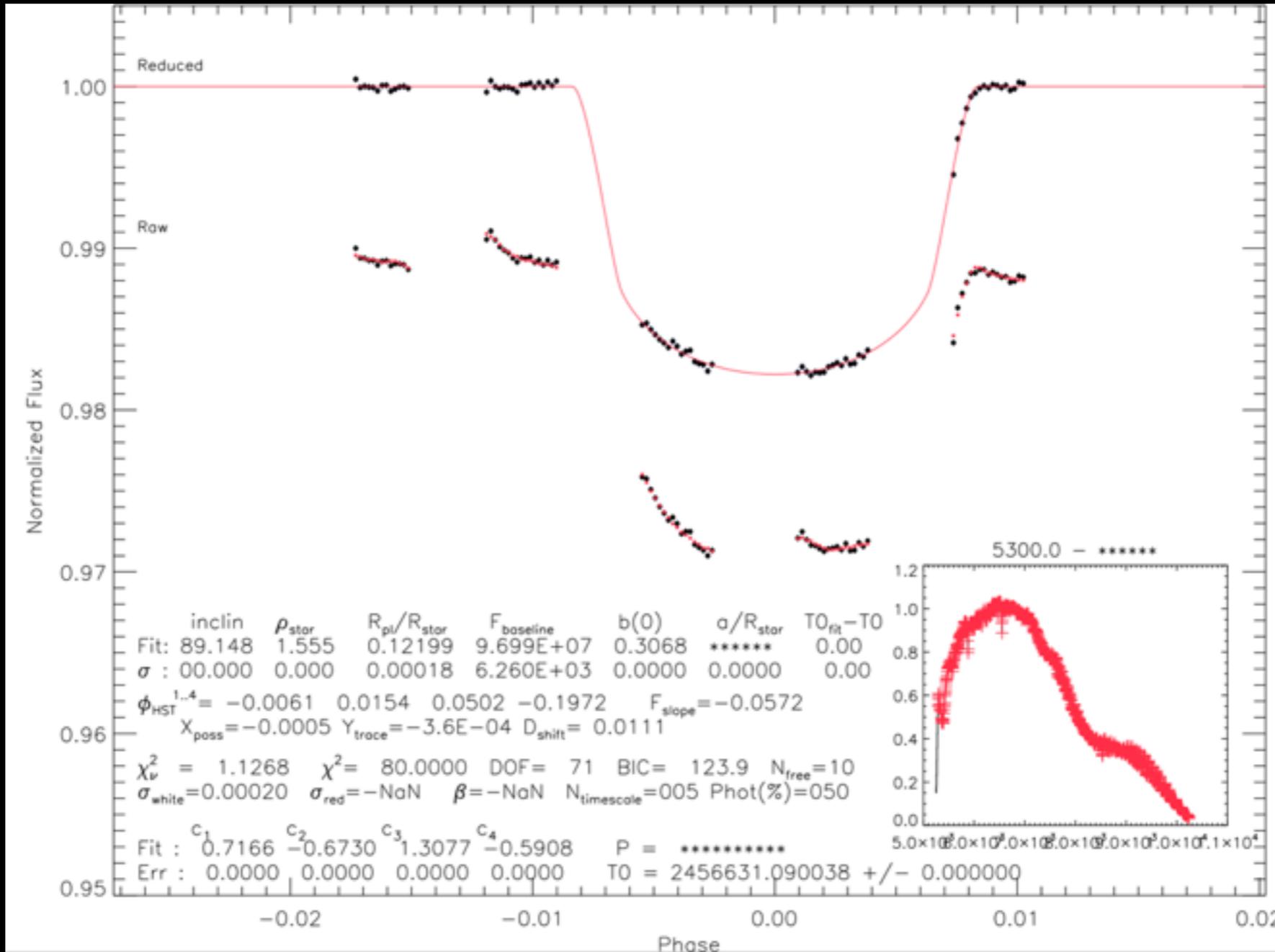
# Hat-P-17b

'breathing  
systematic'

day/night Temp  
varies

Telescope  
expands &  
contracts

focus changes



PI Huitson

1st orbit systematics are almost always different

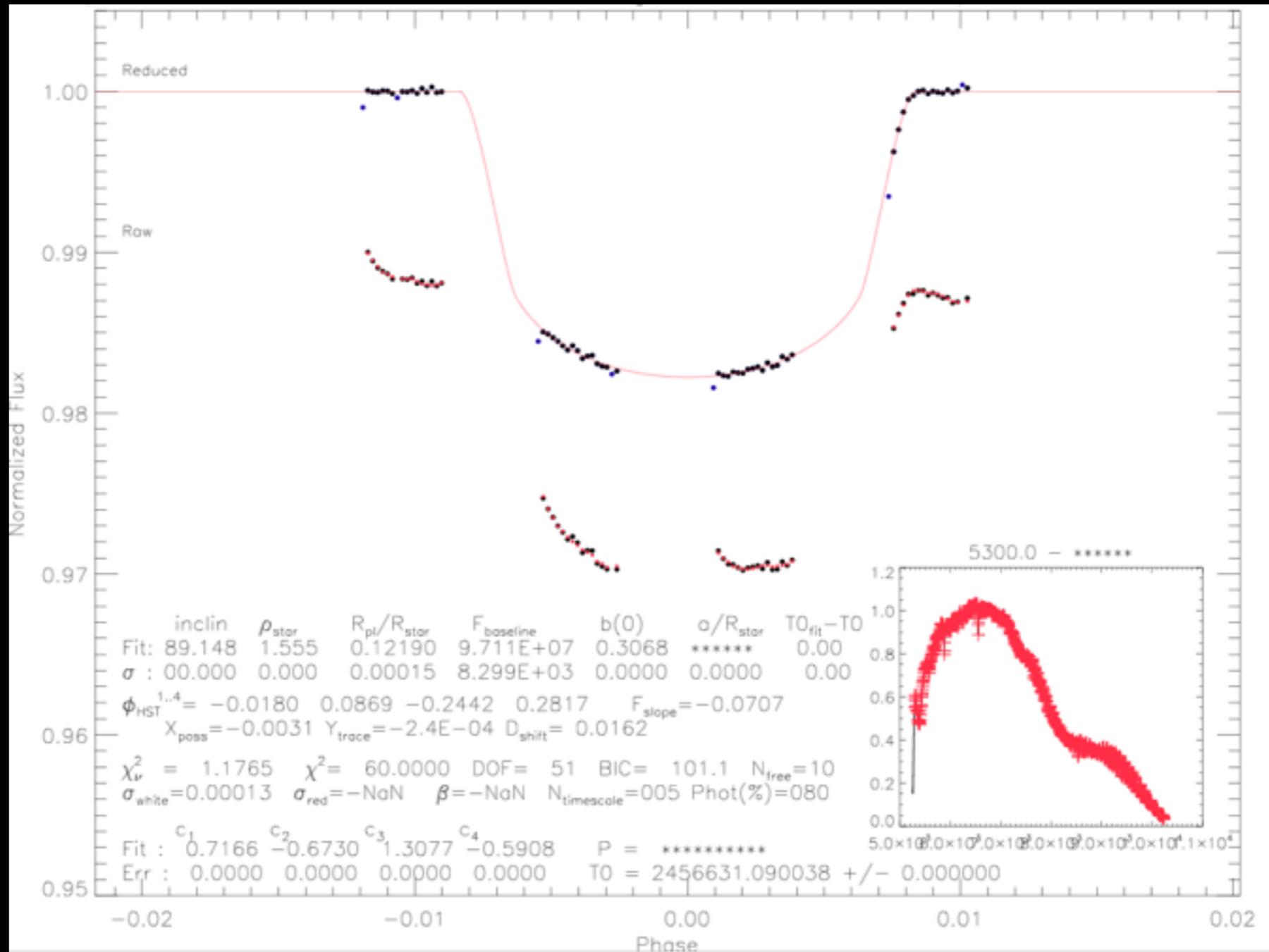
Standard procedure is to schedule 1 extra orbit well in advance of transit, then discard

# Hat-P-17b

1st exposure  
systematic

electronics?

solution: short exp



standard

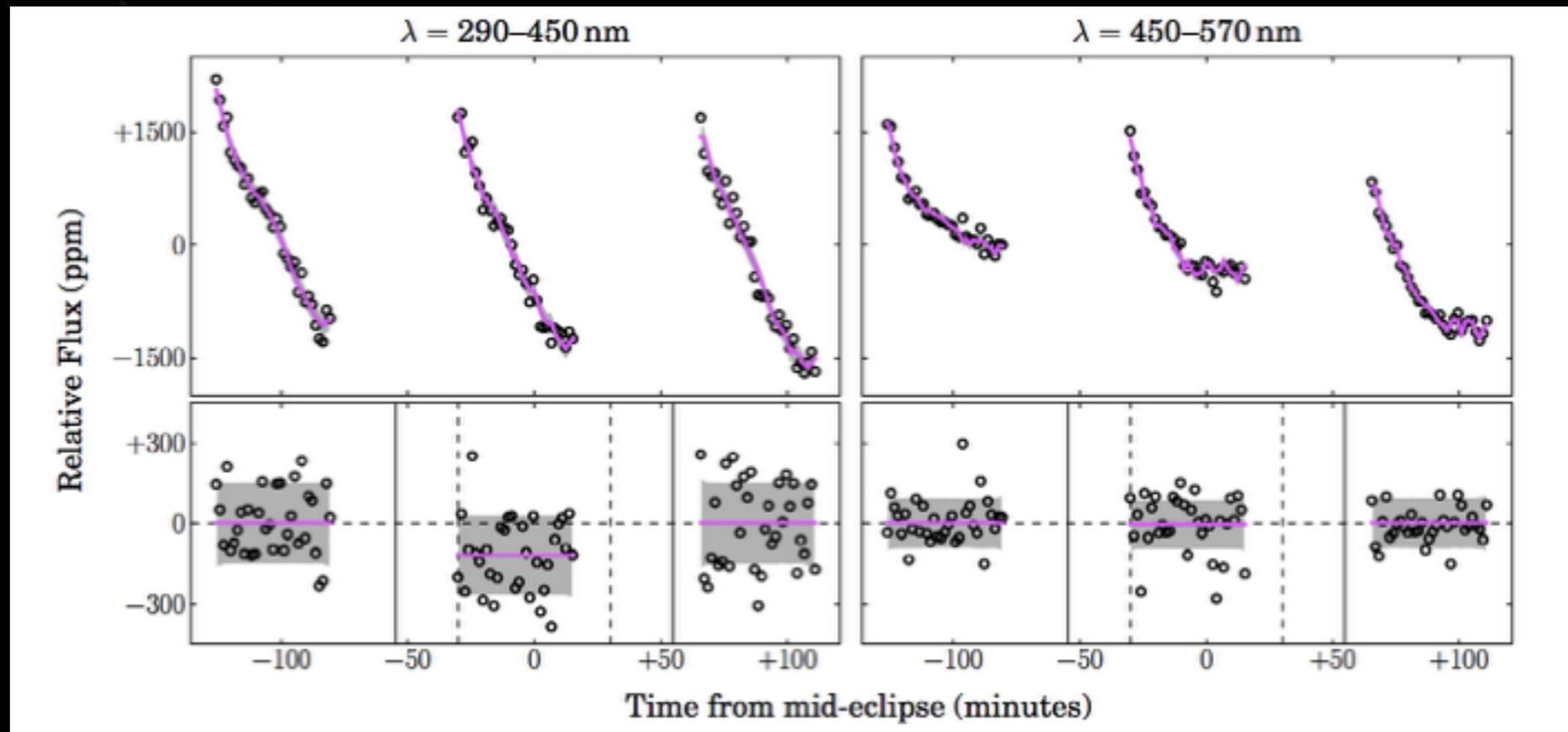
systematics model:  $c_0 F_{\text{slope}} + c_1 \phi + c_2 \phi^2 + c_3 \phi^3 + c_4 \phi^4 + c_5 X + c_6 Y + c_7 D_{\lambda\text{shift}}$

common mode removal:  $c_0 F_{\text{slope}} + c_1 \phi + c_2 \phi^2 - \text{CM}$

PI Huitson



# HD 189733b eclipse



Evans et al. (2013)

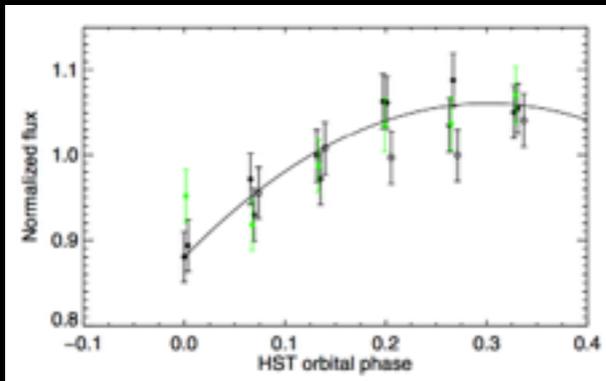
advanced

systematics model: Gaussian Processes

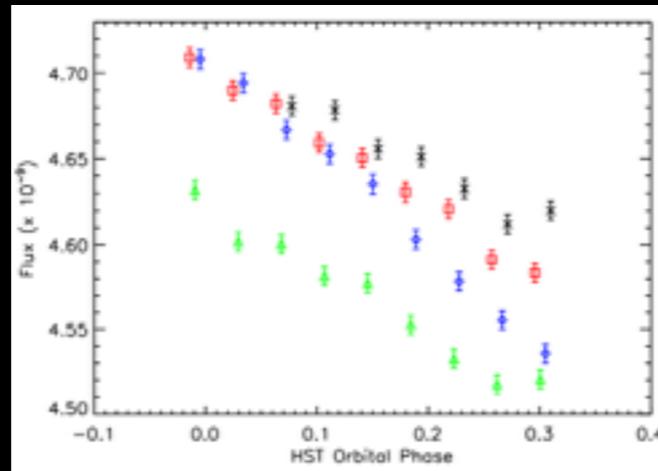
eliminates need to choose functional form of detrending parameters

# Similar Breathing Trends have been seen in nearly all transit observations

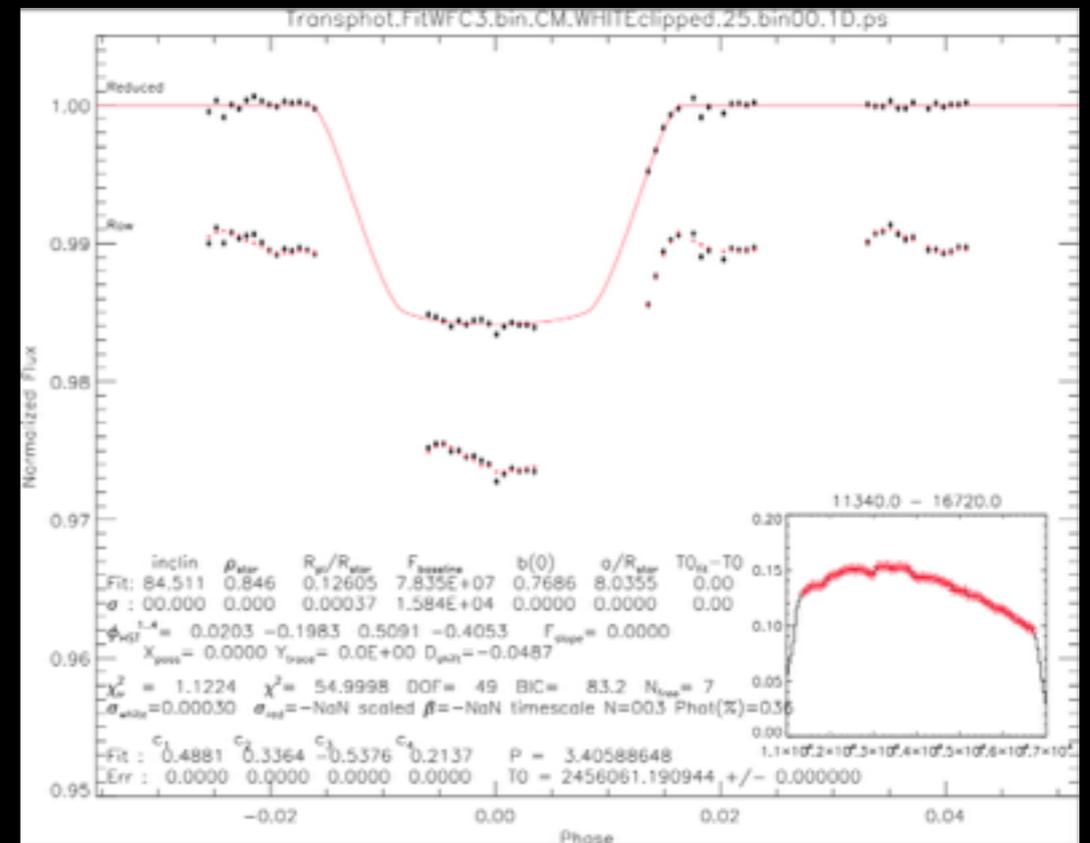
STIS, ACS, NICMOS, WFC3



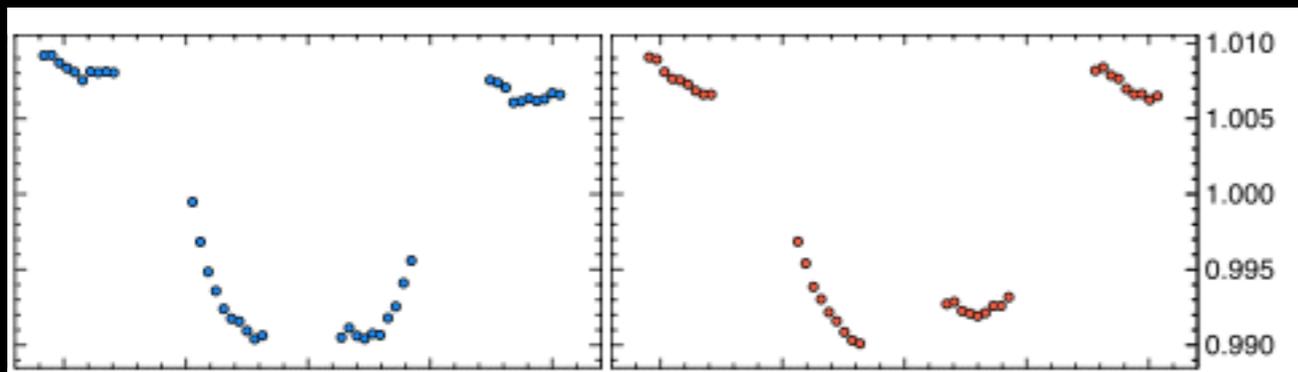
Bourrier et al. (2013)  
STIS - MAMA G140M



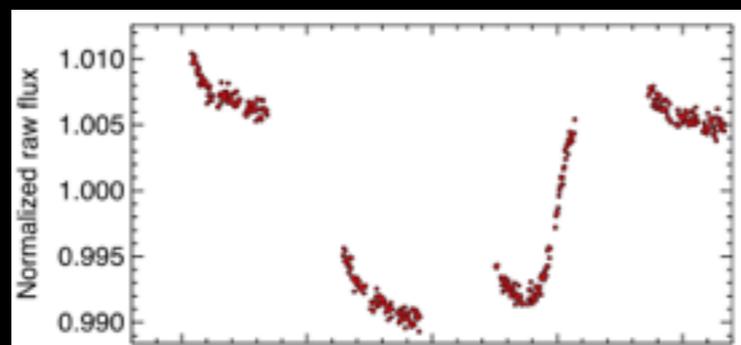
Vidal-Madjar et al. (2013)  
STIS - MAMA E230M



Sing et al. (in prep)  
WFC3 - G141 spacial scan



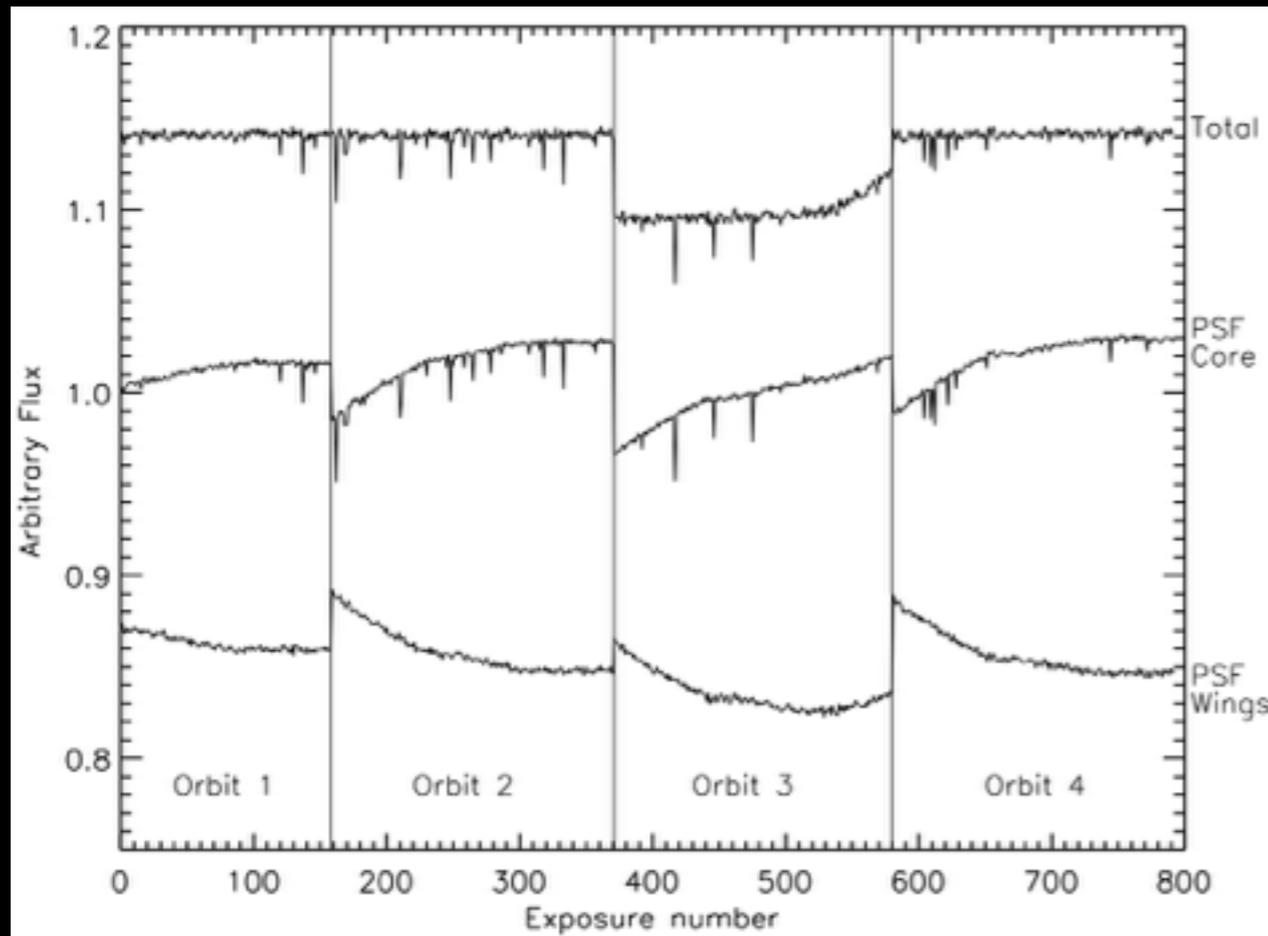
STIS



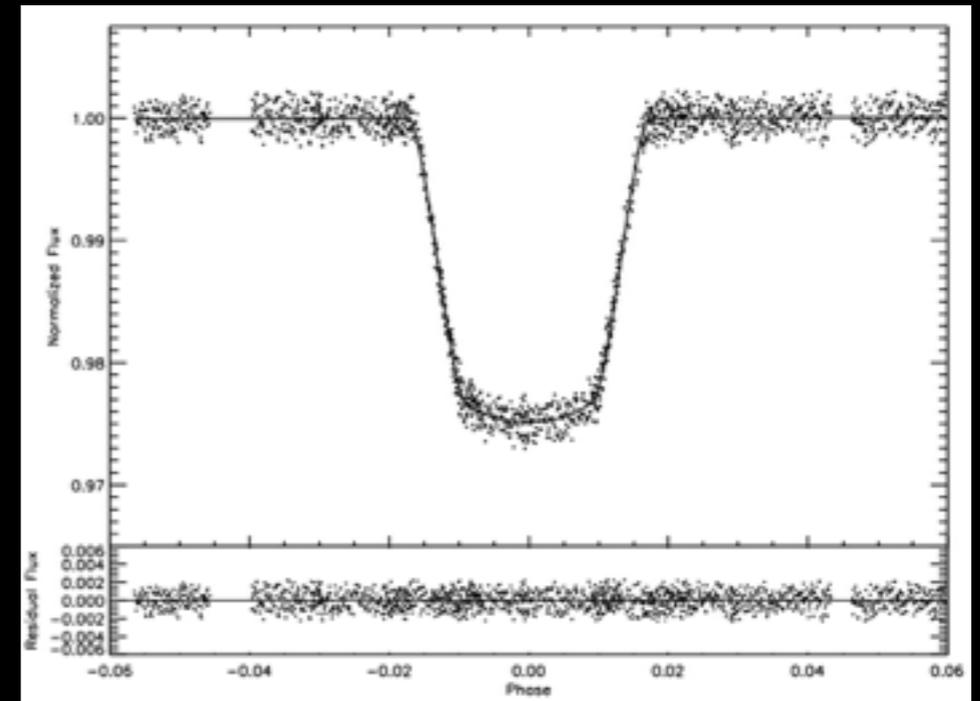
Sing et al. (2014)

WFC3 - G141 stare mode

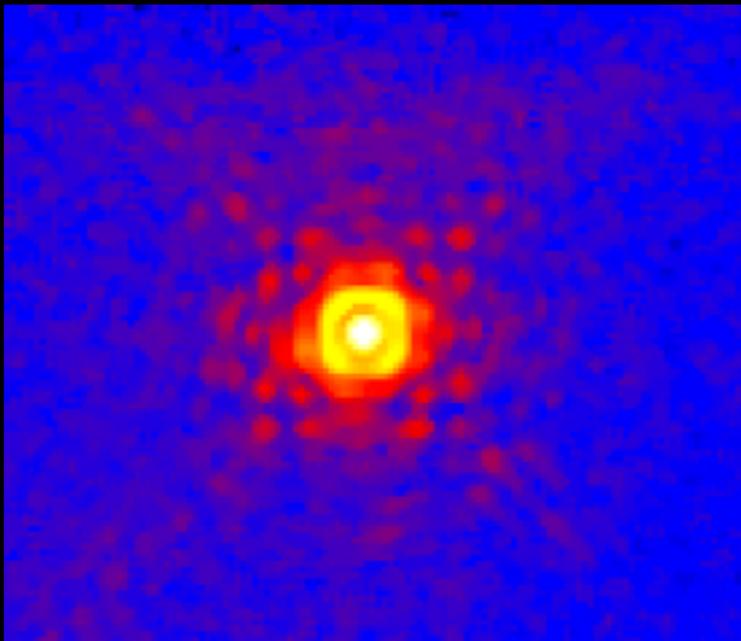
# Breathing trends & effect on PSF



HD 189733b NICMOS 1.87  $\mu\text{m}$

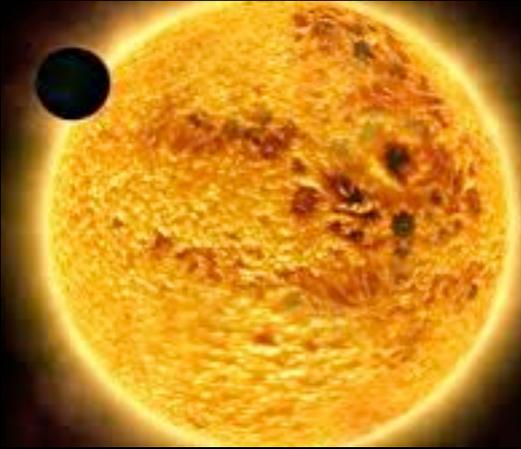


Sing et al. (2009)



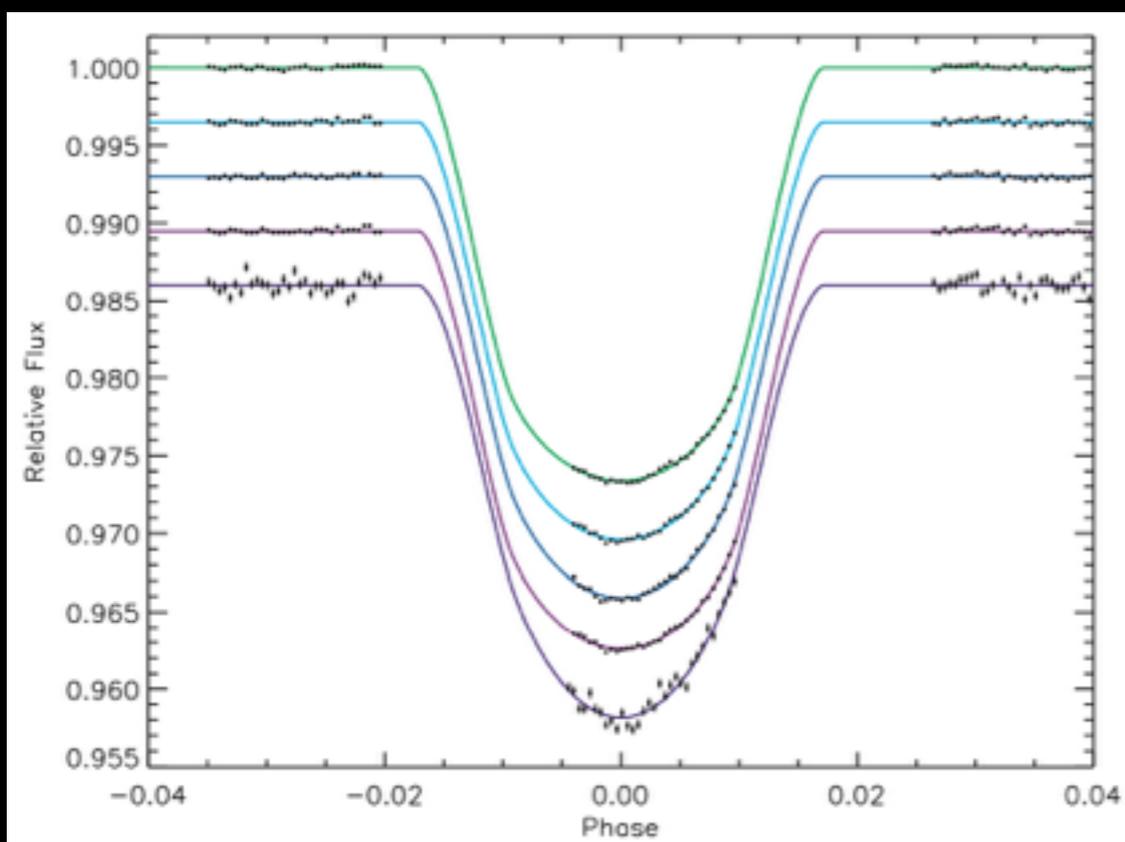
Optimal Aperture for STIS is  $\sim 13$  pixels

To much readnoise with wider Aper. though breathing trends are reduced



# Pushing to higher S/N

- Saturate CCD (ACS, STIS)
- Spacial Scan (WFC3) - control of psf
- More counts by spreading over detector



HD 189733b STIS G430L (4x saturated)

Light curves 90 ppm  
64 sec exp., 500 Å bandpass

Sing et al. (2011)



# Summary

- HST now gives 10's ppm accuracy spectra (nUV - Opti. - nearIR)
- Thermal breathing - well understood observatory trends can help interpretation of all instruments
- For current instruments systematic trends not main limitation (benefited from lessons learned, ~15 yrs of data & large programs)
- Can easily avoid some through setup

