Tests, lessons a successes of exoplanet transit observations with the GTC

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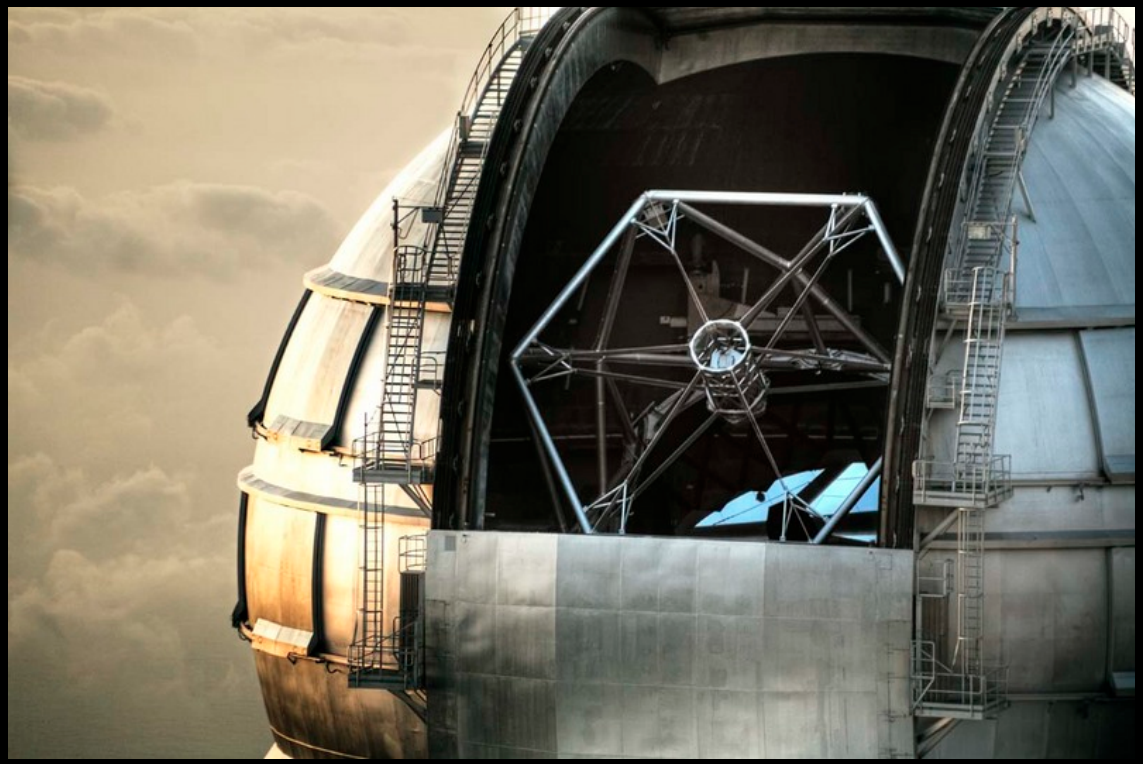
Exoplanets and the E-ELT, ESO, 2014

The Gran Telescopio Canarias

10.4 m telescope
Segmented mirror

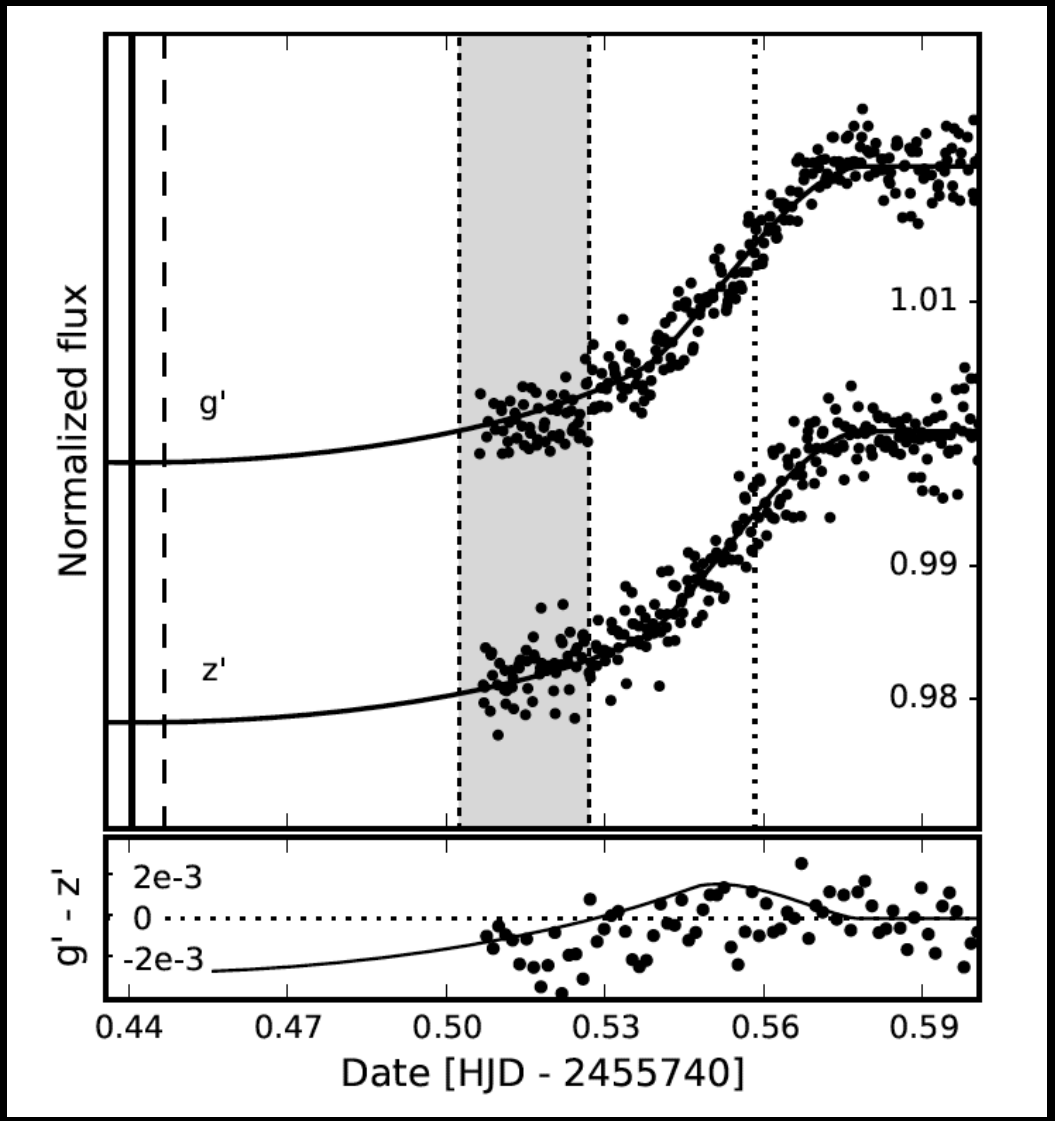


OSIRIS

Visible imager and spectrograph
2CCDS, 2048x4096 pix
7.8x7.8 arcmin FOV

- Imaging
- Tunable filter imaging
- Long-slit spectroscopy

Broadband photometry in the visible with OSIRIS @GTC



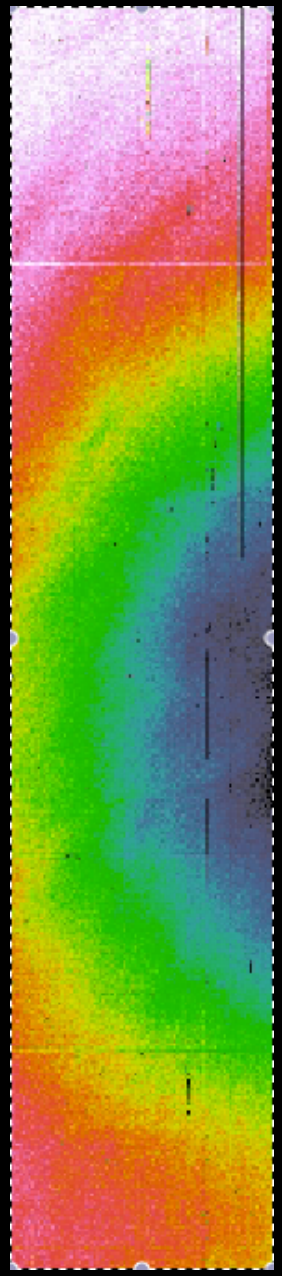
KOI – 806 b
V=15.4

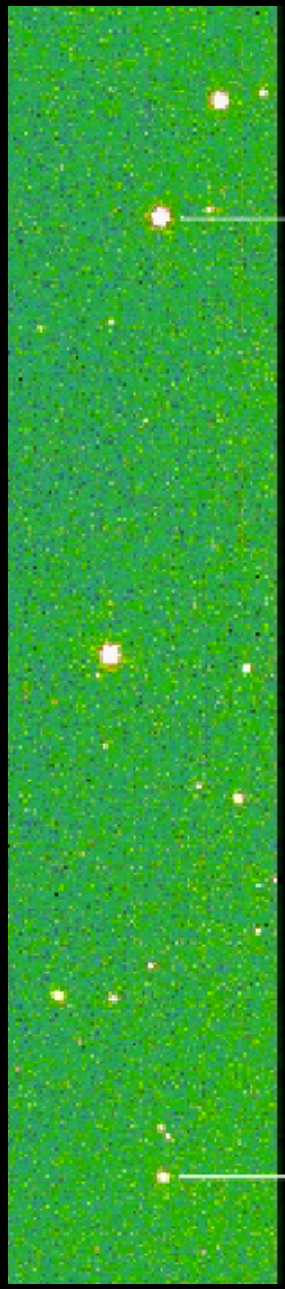
Detection of transit color signature and TTVs

Photometric accuracy not as good as expected

Tingley et al, A&A, 2011

Tunable filter observations with OSIRIS @GTC



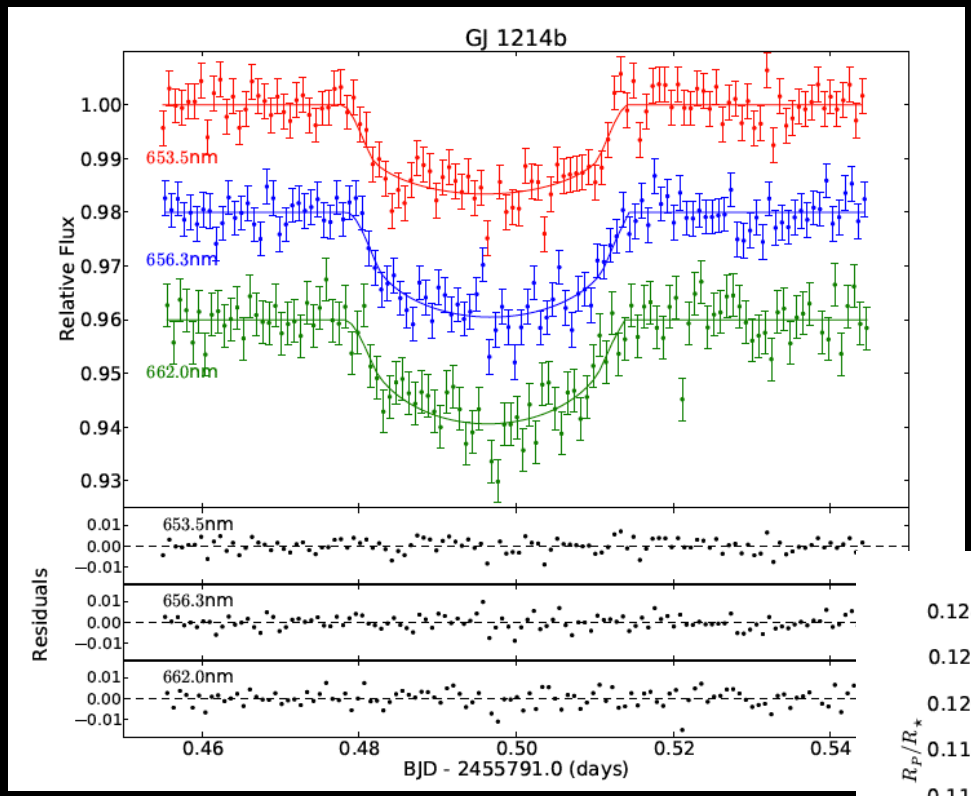


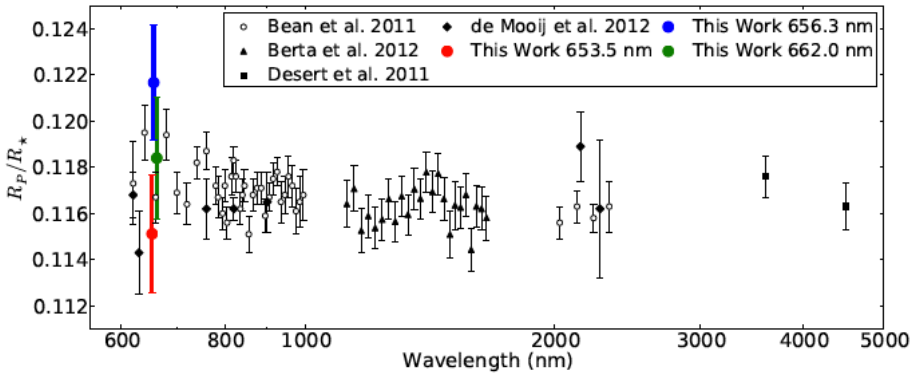
GJ 1214b
V=14.7

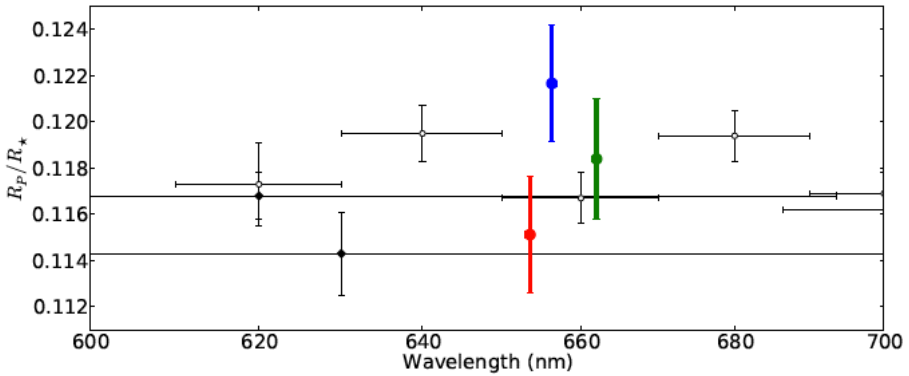
Observations centered on H-alpha line and nearby continuum

Murgas et al, A&A, 2012

Tunable filter observations with OSIRIS @GTC





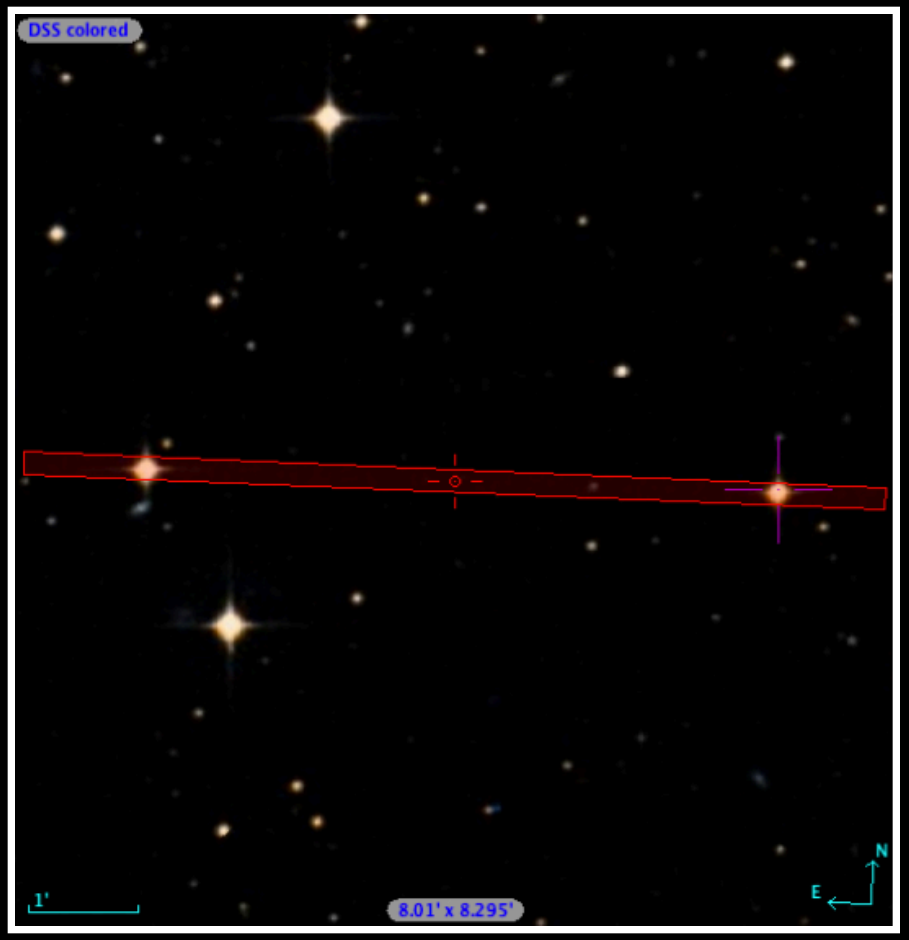


A "hint" of larger Rp at H-alpha line

Murgas et al, A&A, 2012

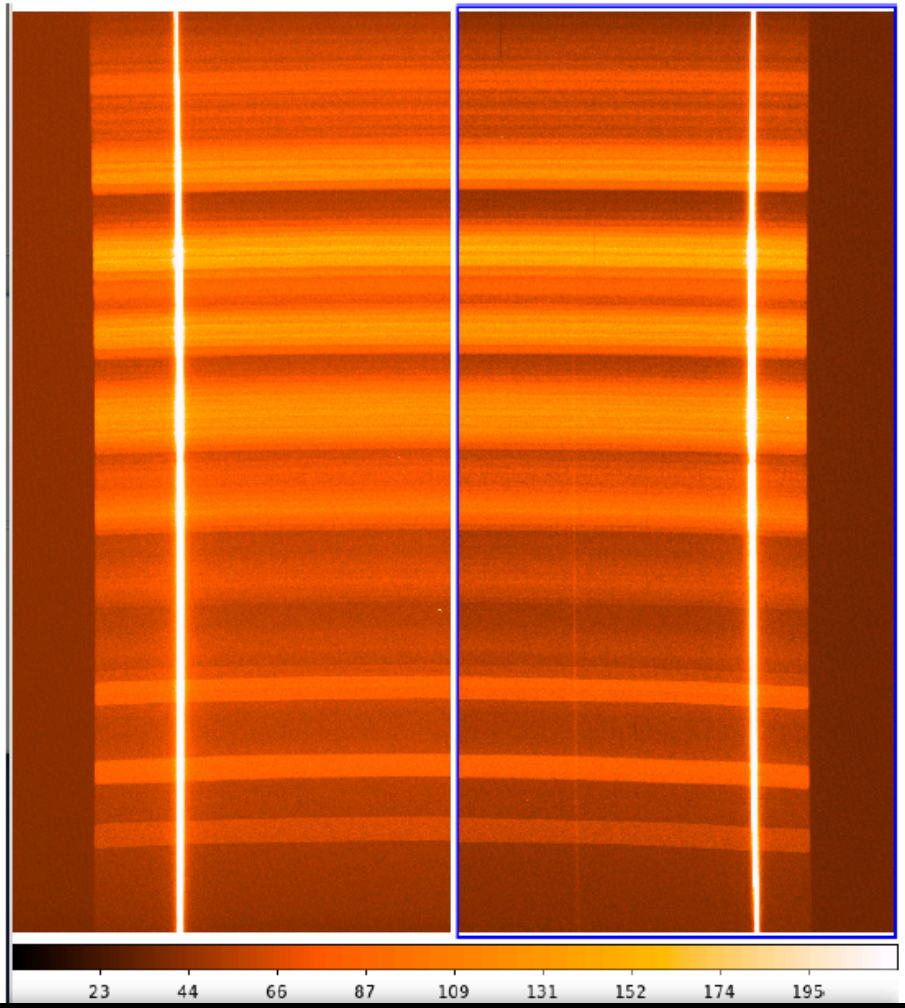
Transit spectroscopy in the visible with OSIRIS @GTC

WASP-43b



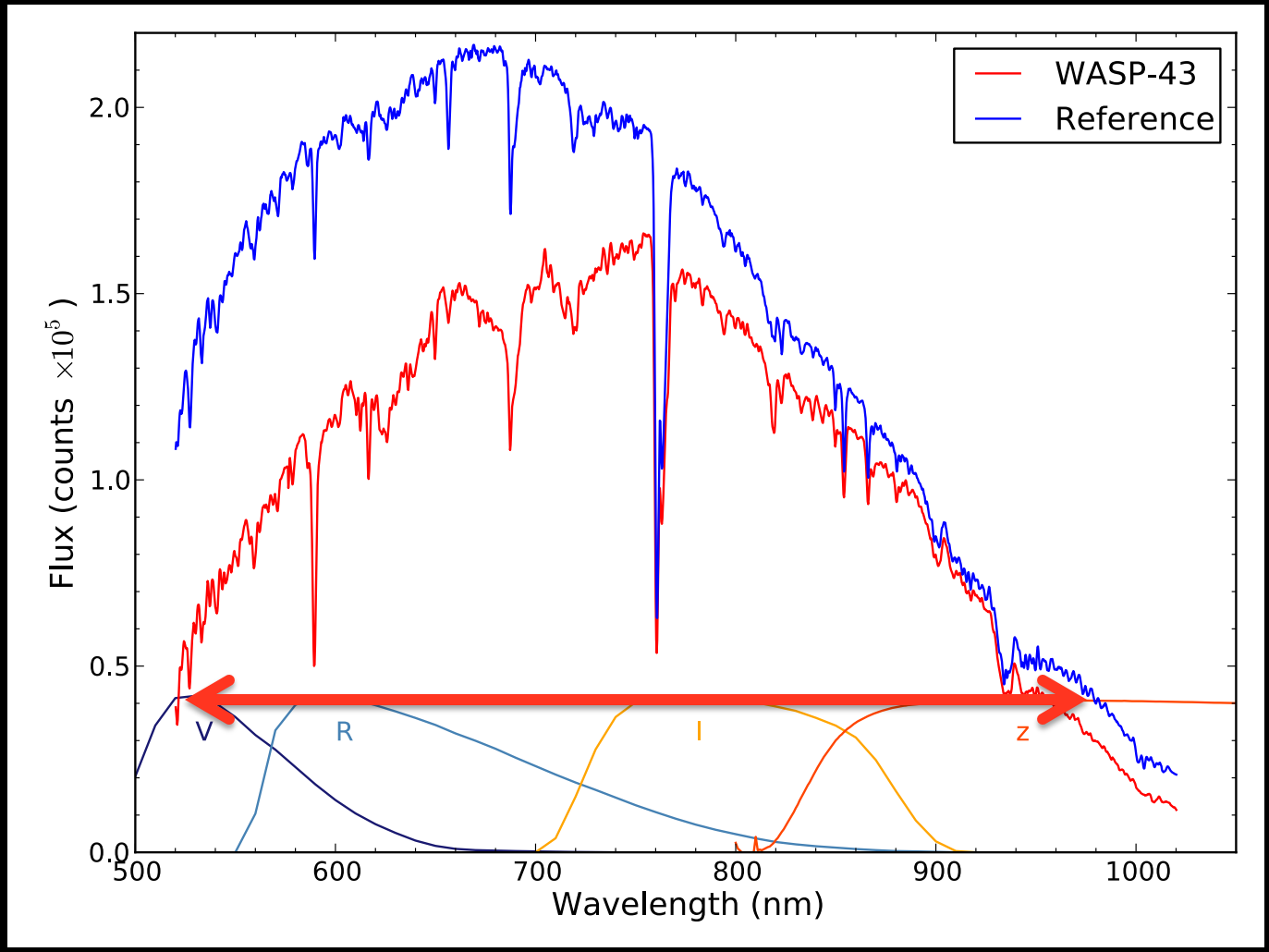
- Discovered by Hellier et al. 2011
- K7V star, $V = 12.4$ mag
- $Rp = 1.036 R_{Jup}$, $Mp = 2.03 M_{Jup}$
- $P = 0.813$ days ~ 19 hrs
  Orbital decay?
- $T = 1684$ K at 3.6 μm, $T = 1485$ K at 4.5 μm (Blecic et al. 2013)

Transit spectroscopy in the visible with OSIRIS @GTC

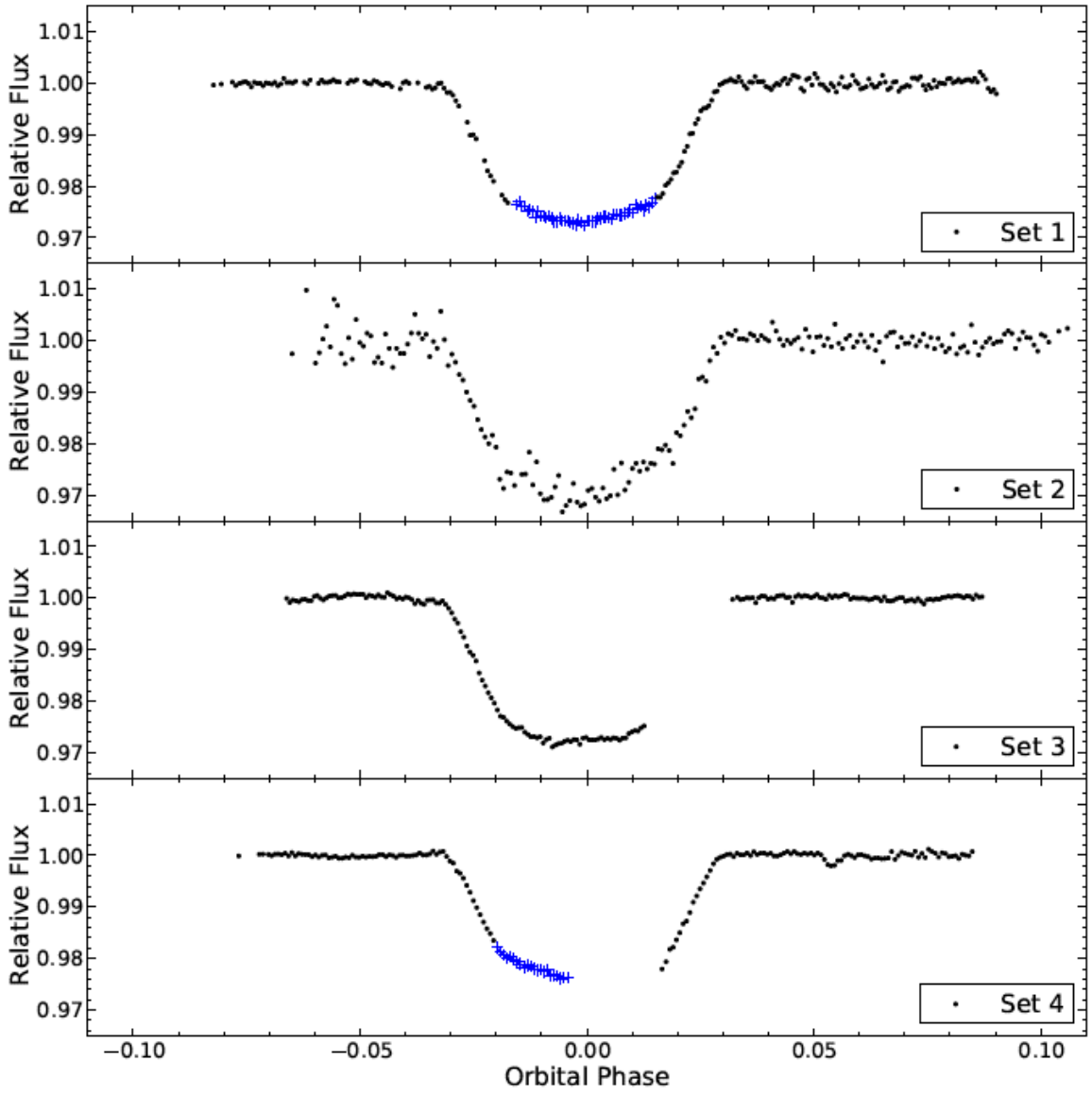


- Long-slit spectoscopic mode
- Slit width: 12 arcsec
- R1000R grism
- λ coverage 520-1020 nm
- Data reduction: semi-automatic script
- 1 full event and 4 partial observations

Transit spectroscopy in the visible with OSIRIS @GTC



A difficult learning curve



WASP-43b

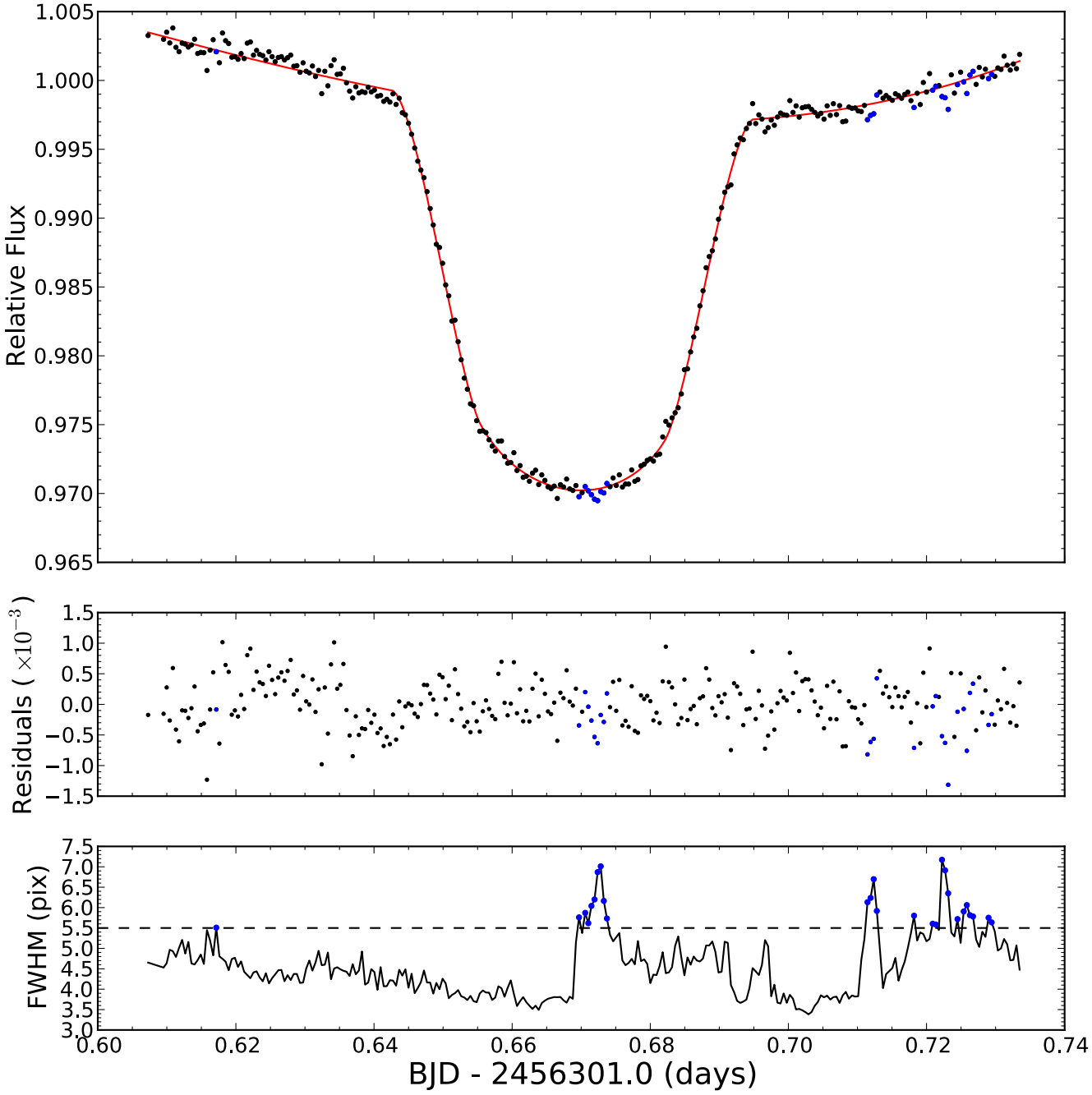
K star

V= 12.4

Four transit sets 2011-2012

Technical/ weather failures

rms 0.4 mmag



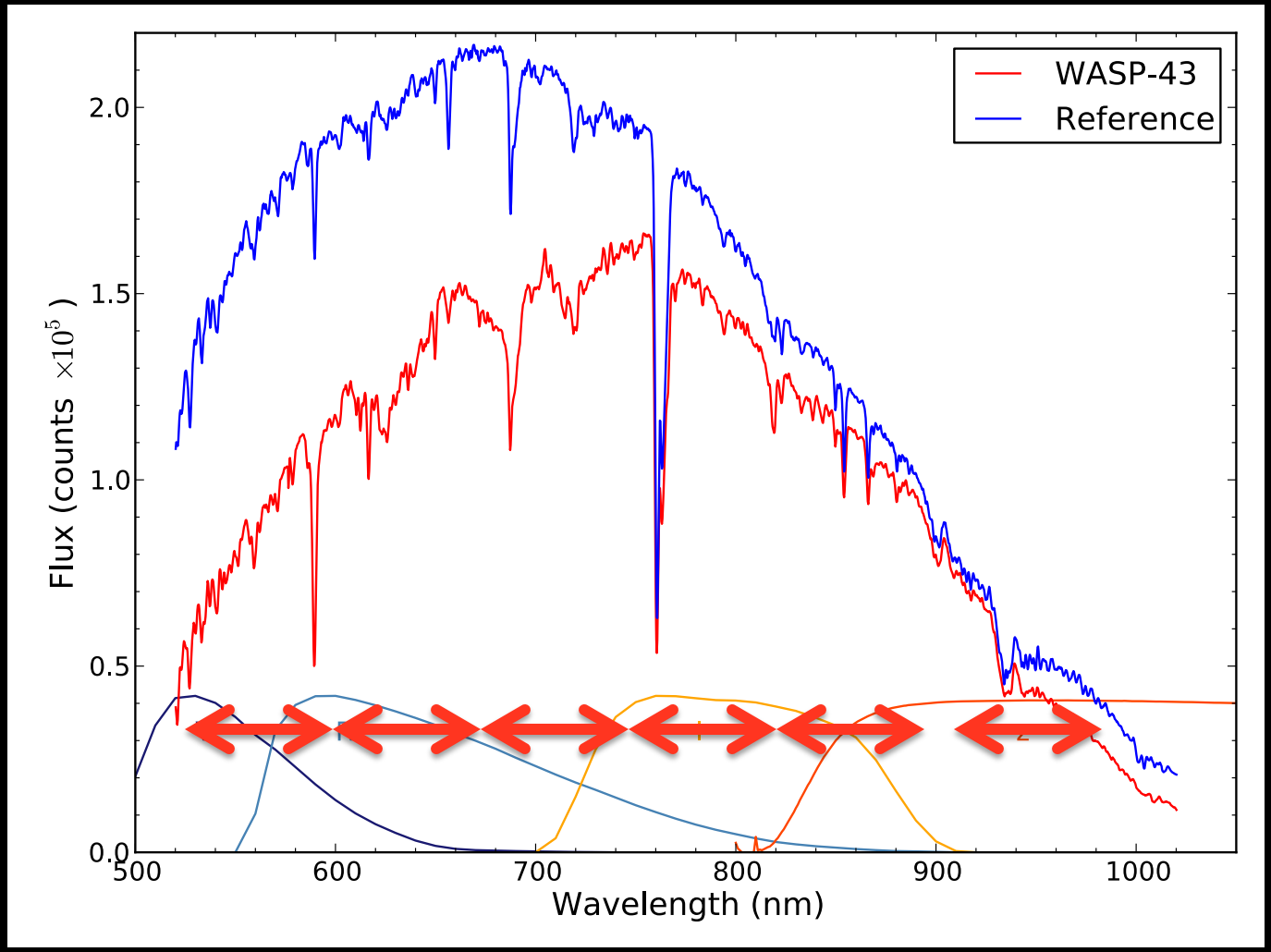
January 2013

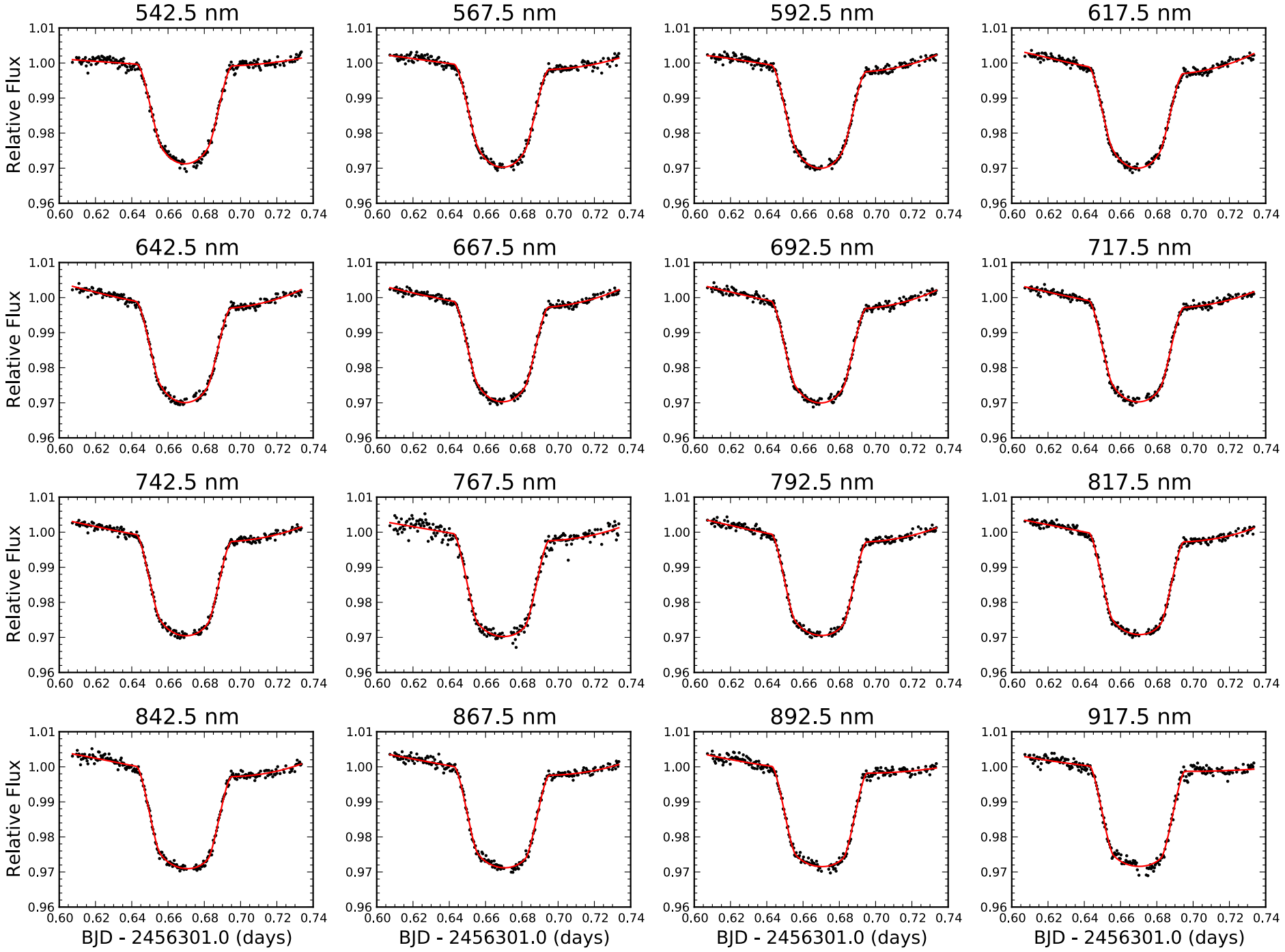
S1: 664.9 ppm
S2: 2277.6 ppm
S3: 420.1 ppm
S4: 454.0 ppm
S5: 586.8 ppm

Room for improvement !!

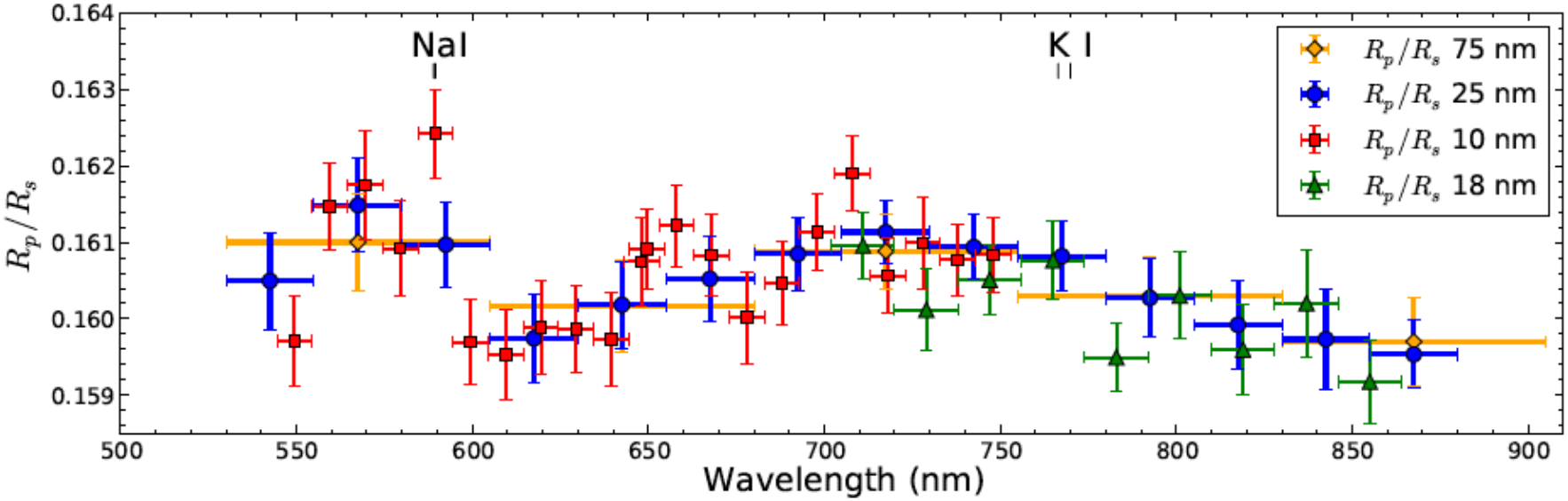
Murgas et al, ApJ, 2014

Transit spectroscopy in the visible with OSIRIS @GTC



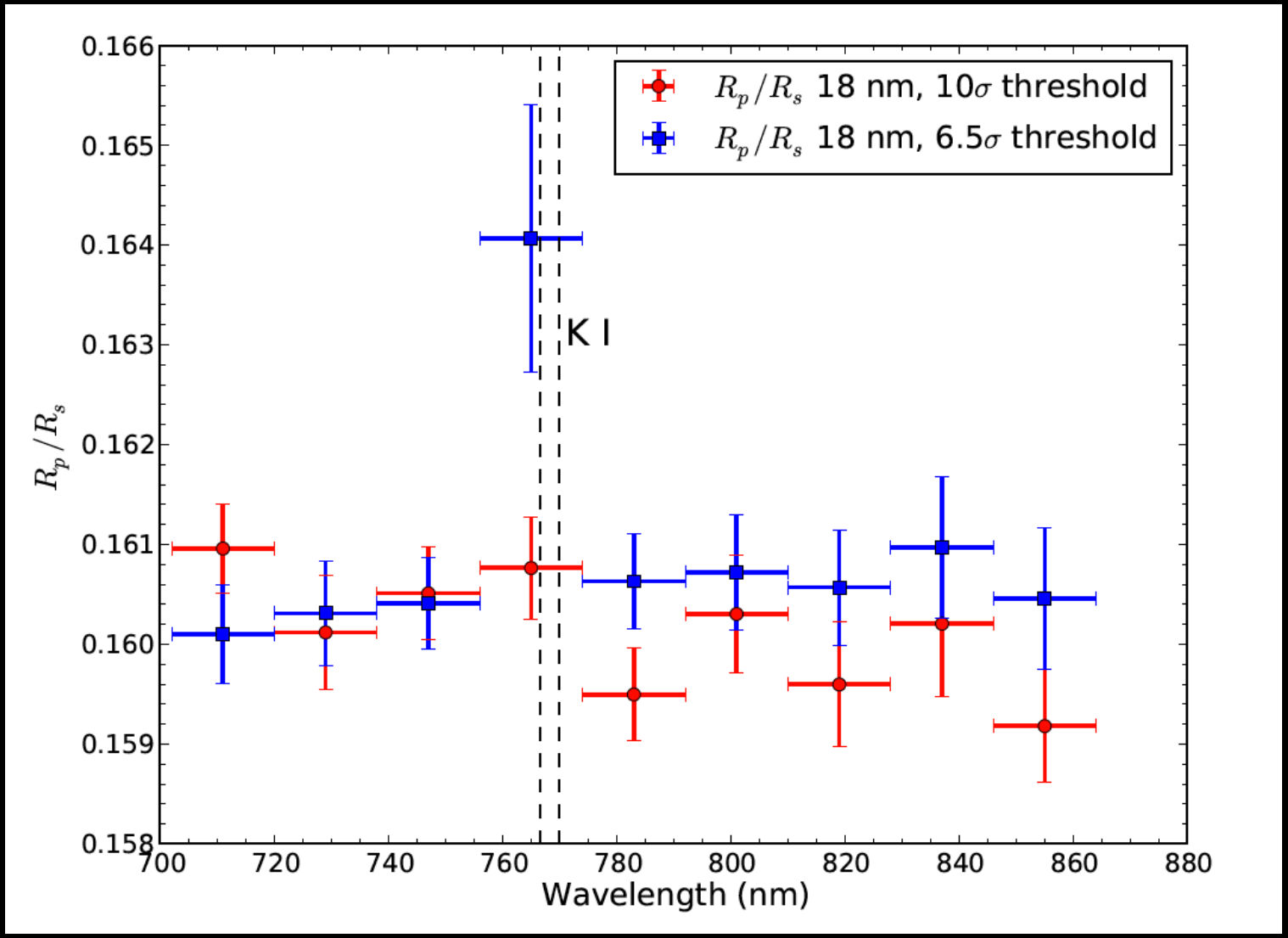

542.5 nm
567.5 nm
592.5 nm
617.5 nm
642.5 nm
667.5 nm
692.5 nm
717.5 nm
742.5 nm
767.5 nm
792.5 nm
817.5 nm
842.5 nm
867.5 nm
892.5 nm
917.5 nm
Relative Flux
BJD - 2456301.0 (days)

Transit spectroscopy in the visible with OSIRIS @GTC

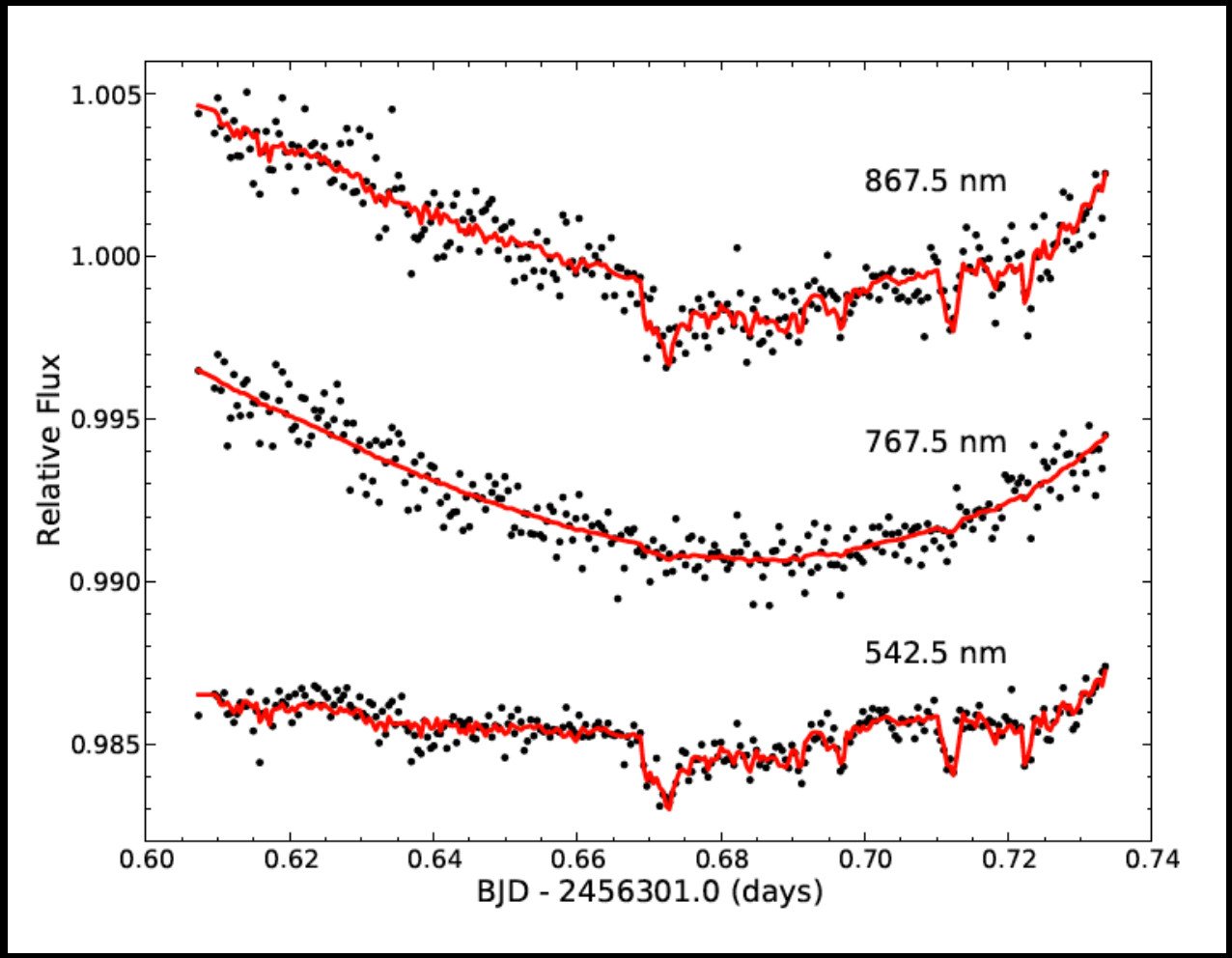


Murgas et al, ApJ, 2014

A cautionary tale

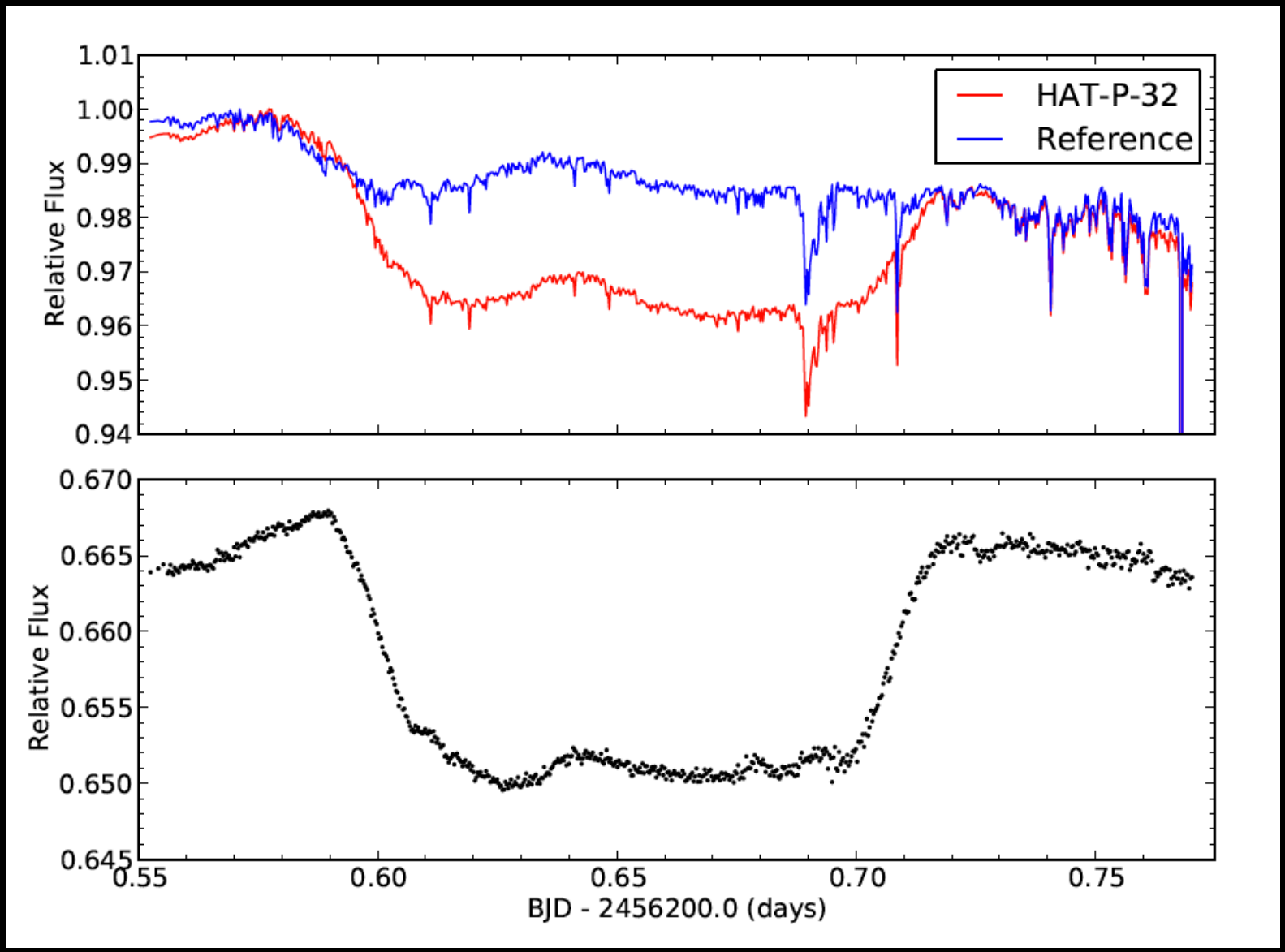


Transit spectroscopy in the visible with OSIRIS @GTC

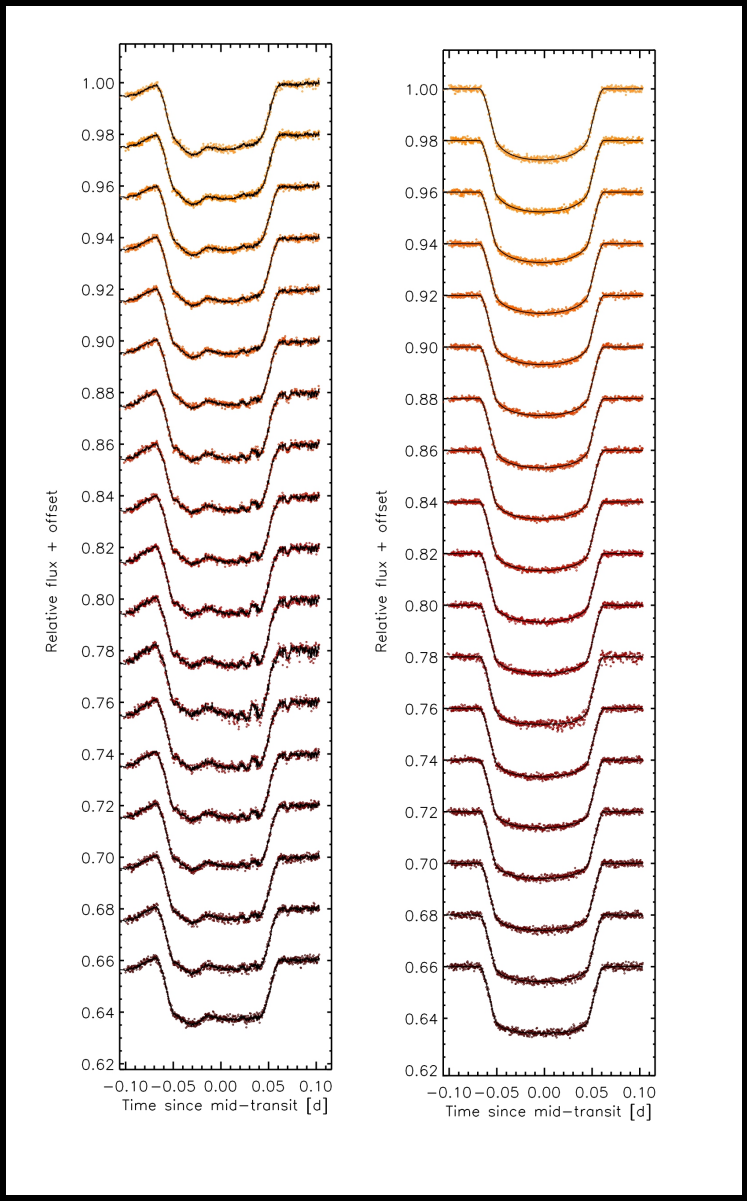


Even with a 12" slit, flux losses are measurable

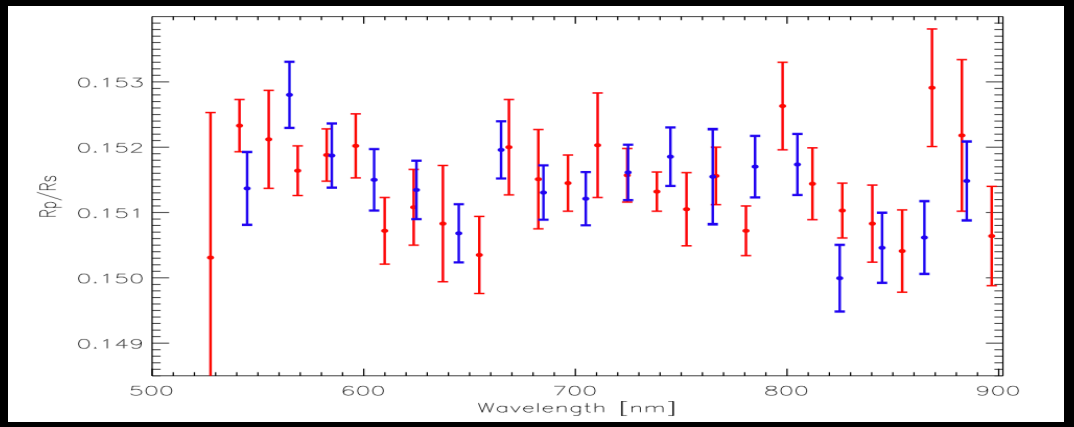
Transit spectroscopy in the visible with OSIRIS @GTC

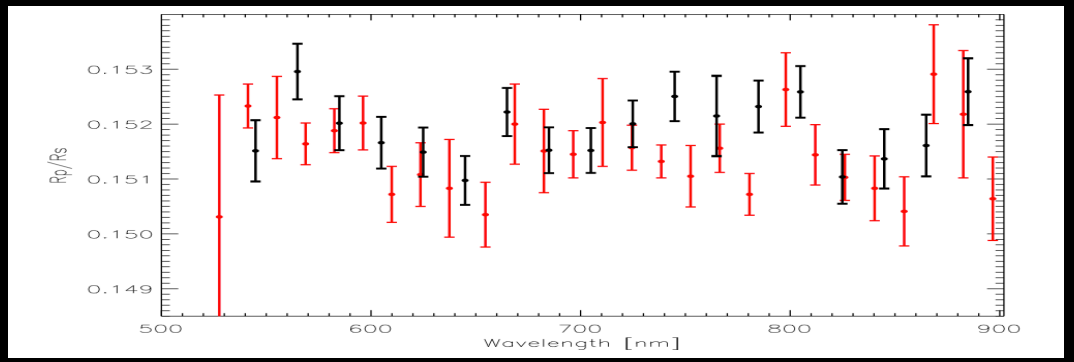


Transit spectroscopy in the visible with OSIRIS @GTC



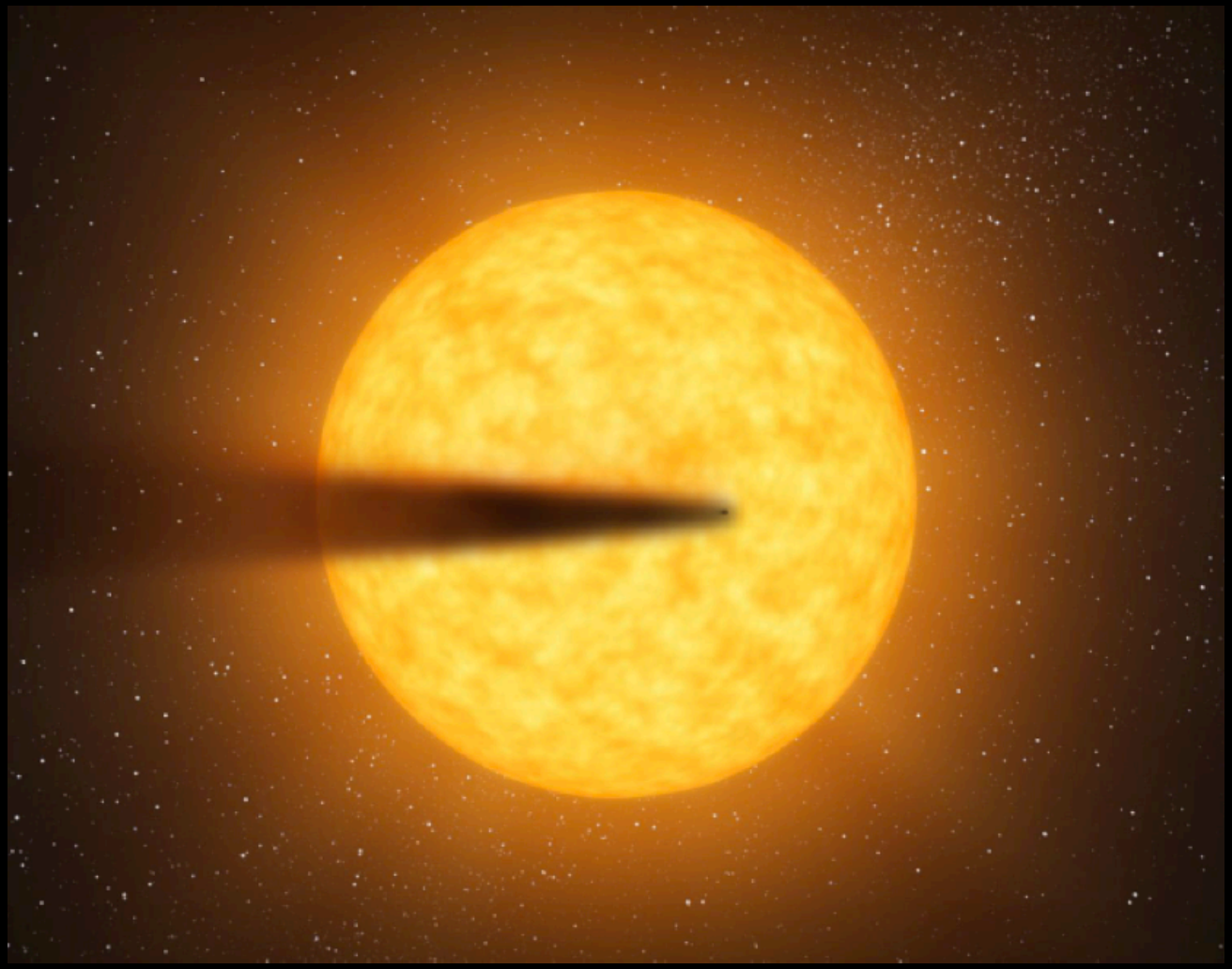
rms 600 ppm, *work in progress*





Similar spectrum to Gibson et al, 2013, 1 transit instead of two, smaller rms

Transit spectroscopy in the visible with OSIRIS @GTC



KIC12557548b

K dwarf

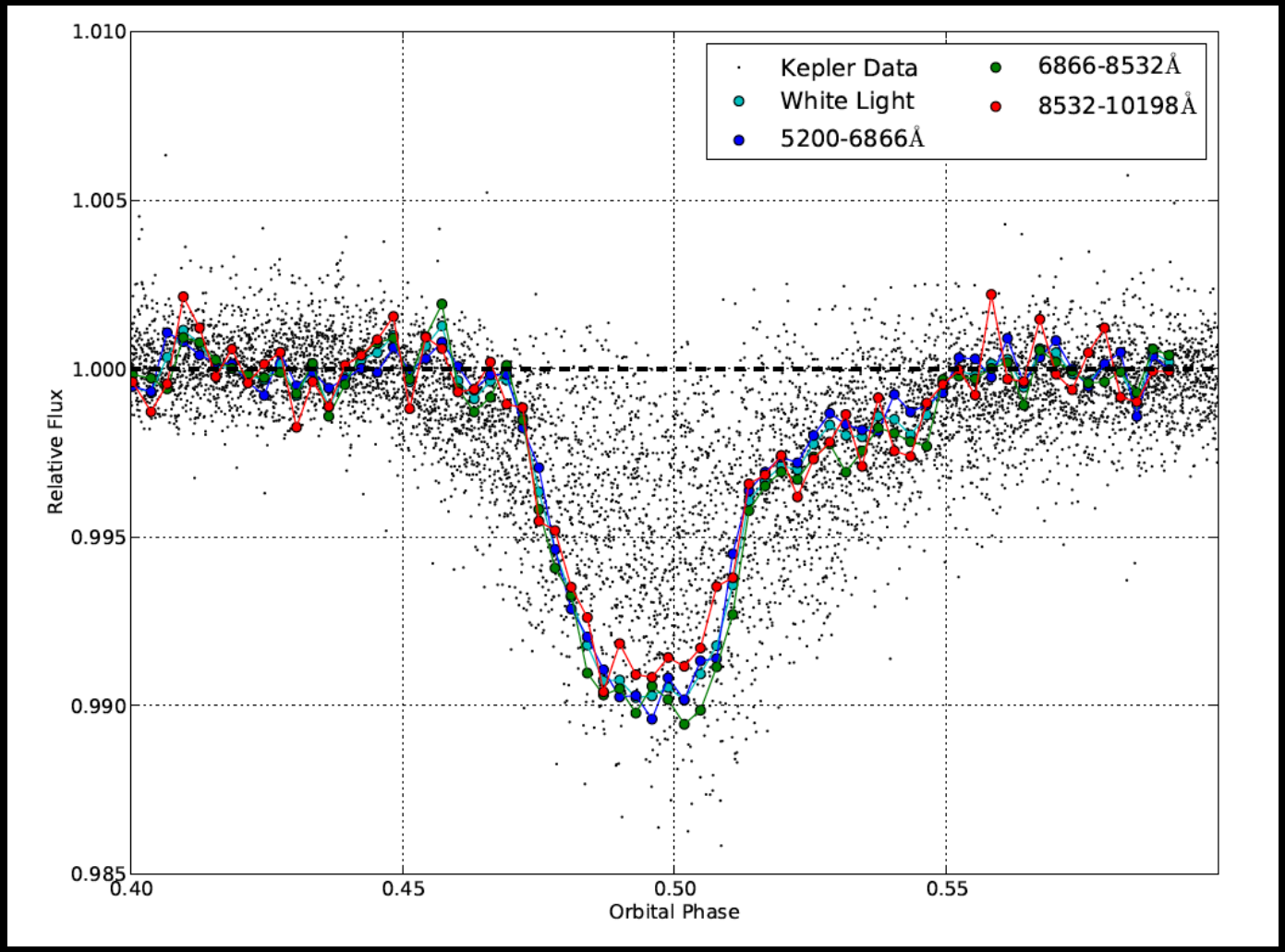
V = 16

P = 15.7 h

Variable transit depths

Discovered by Rappaport et al, 2012

Transit spectroscopy in the visible with OSIRIS @GTC



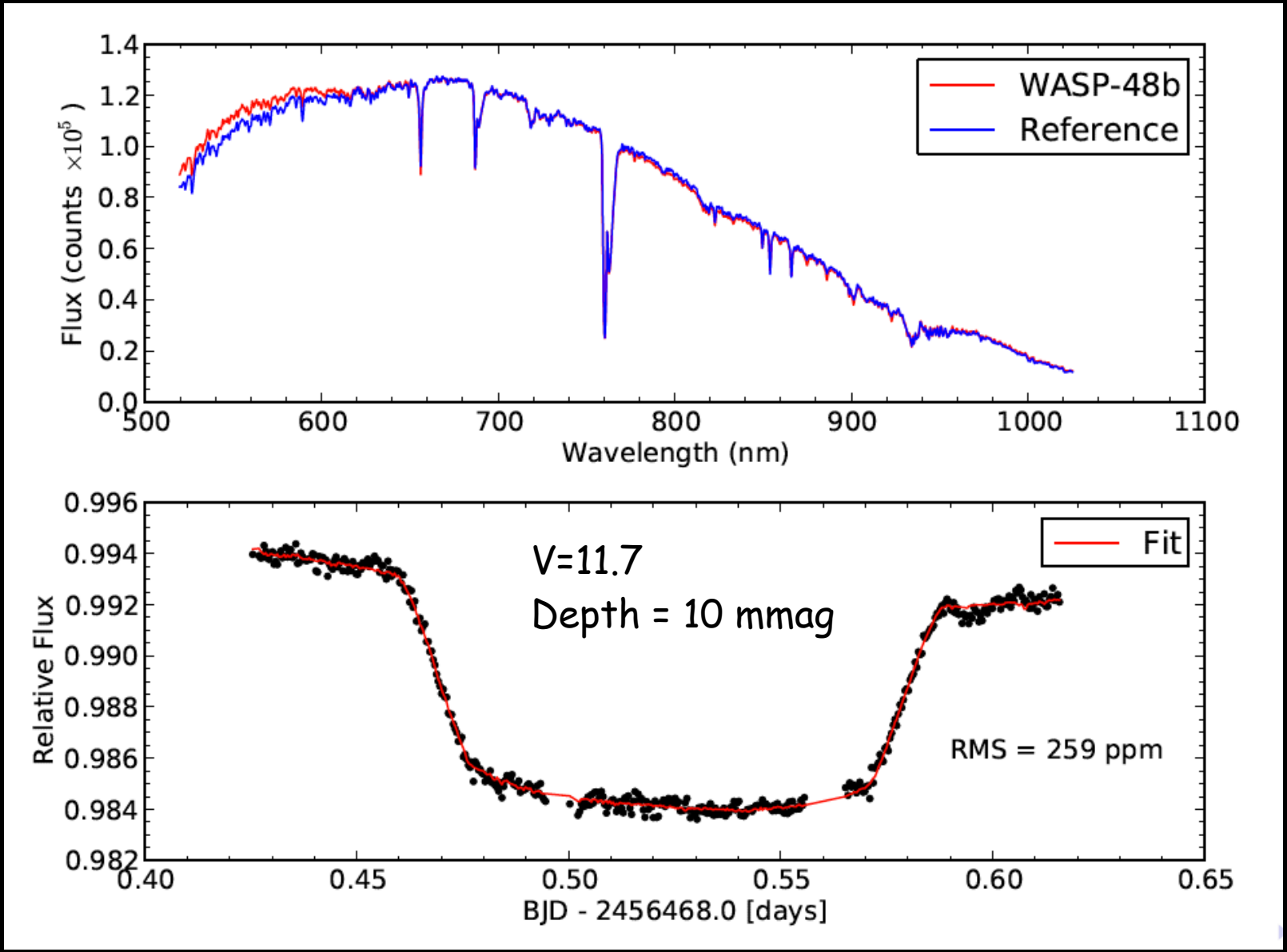
No color differences

Constraints on the particles sizes of the planet/comet tail

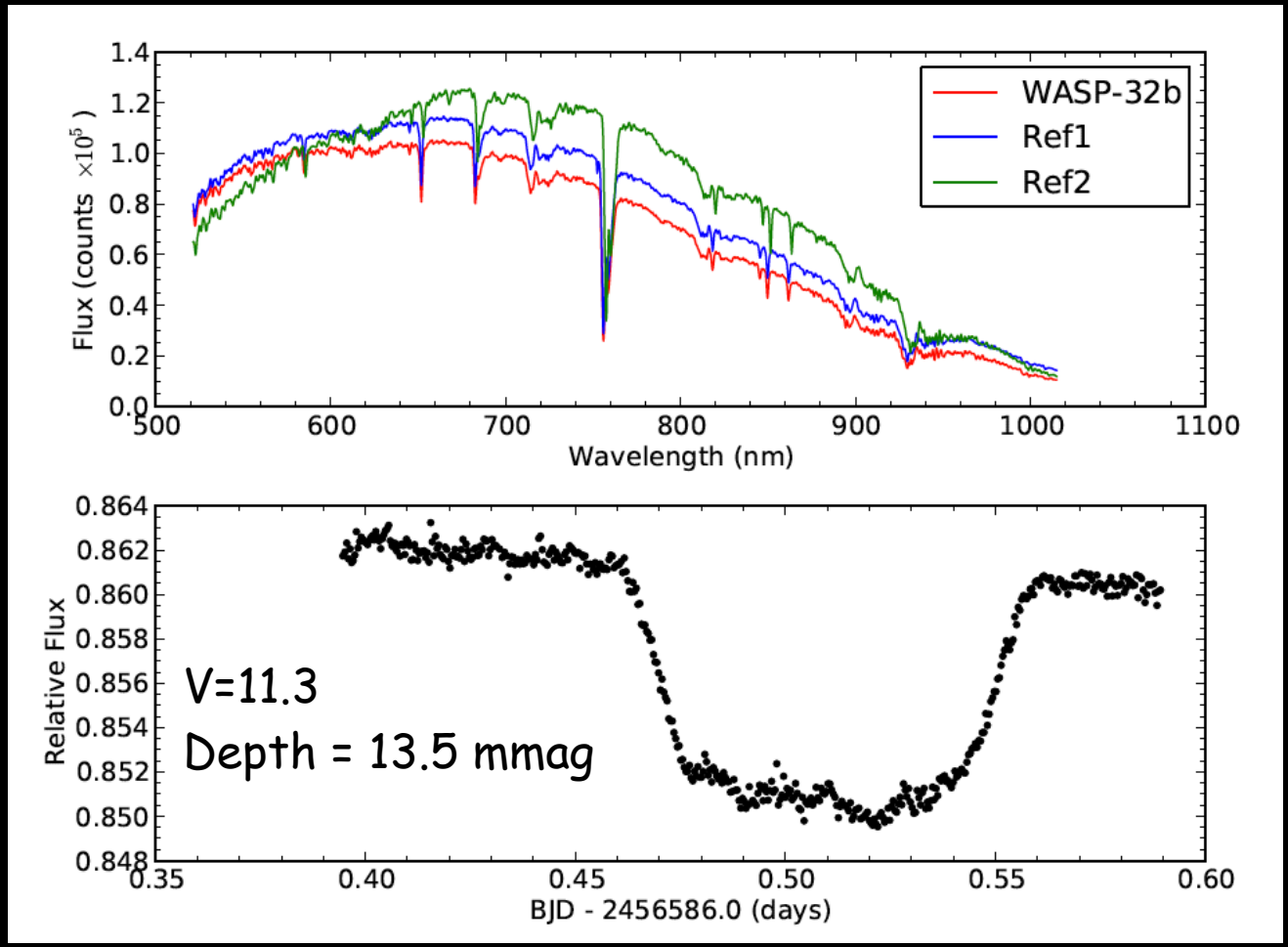
Dust silicate features 0.3-0.4 micron

Alonso et al, in prep

Transit spectroscopy with OSIRIS @GTC



Current work: New slit sets and MOS spectroscopy



Already limited by seeing

30-40" slits widths

Slitless spectroscopy

Rare cases: MOS masks

Concluding remarks

- Broadband photometry with GTC does not provide the jump in precision expected from a 10-m telescope

  Segmented mirror?

  Tests?

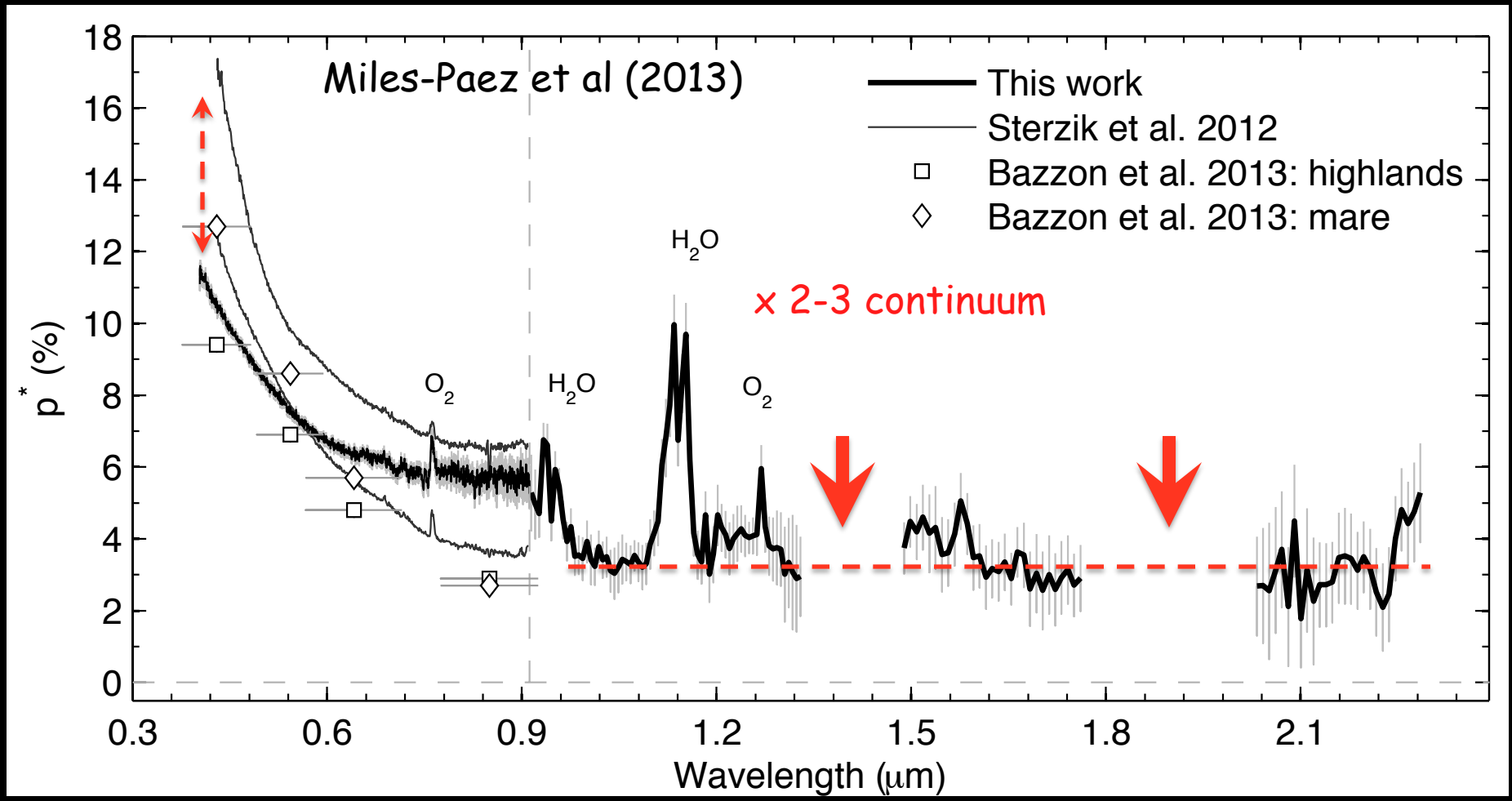
- Tunable filters are not as good a tool fro transiting planets due to systematic effects

- Transit spectroscopy are the way to go:
  - Accurate TTVs
  - Transit color (confirm planetary nature)
  - Transmission spectroscopy

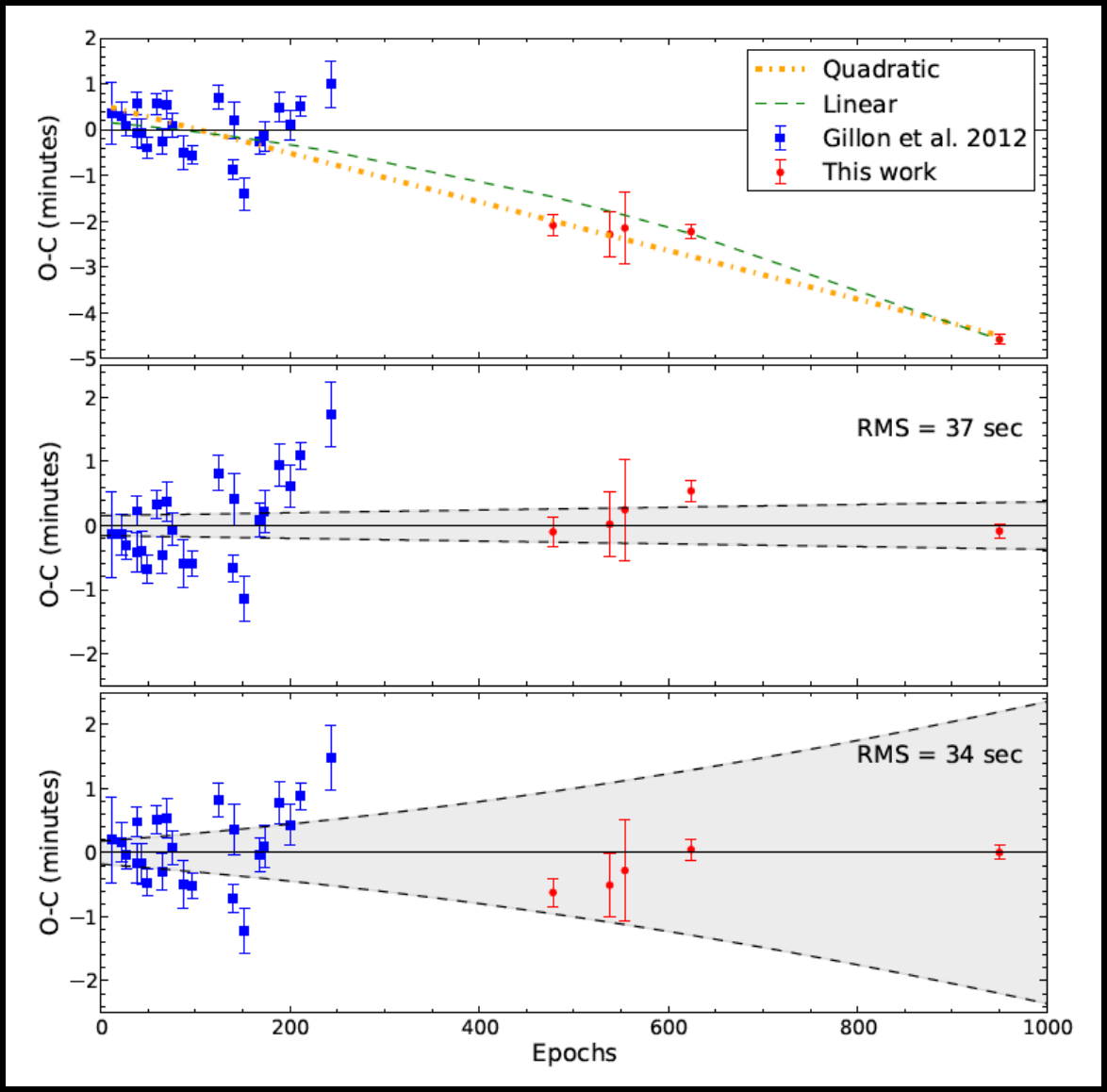
- Future: OSIRIS CCD upgrade and EMIR near-IR spectrograph

Thanks

Earth atmospheric polarization signal



Bazzon et al (2013) - Mean P of the Earthshine is 9-12% (x 2-3 in bands)



Four out of the five datasets are good enough to measure with accuracy the central transit times

Transit timing error for three of them ranging from 6 to 10 seconds