Status Report on SOFIA Exoplanet Transit Capability

user perspective

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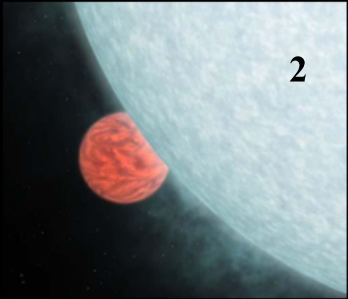
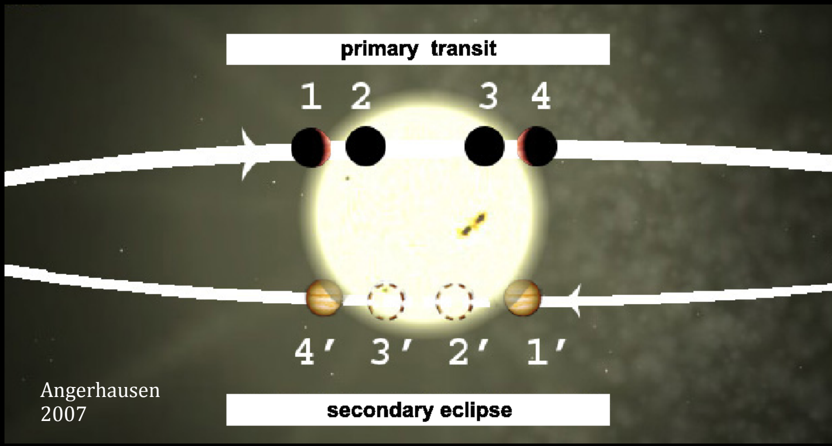
SOFIA Community Tele-Talk Series
01-29-2014

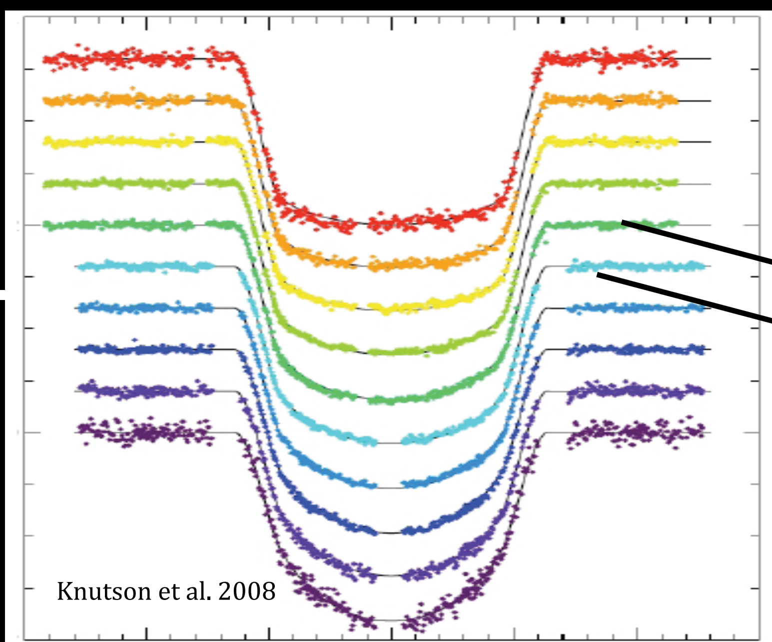


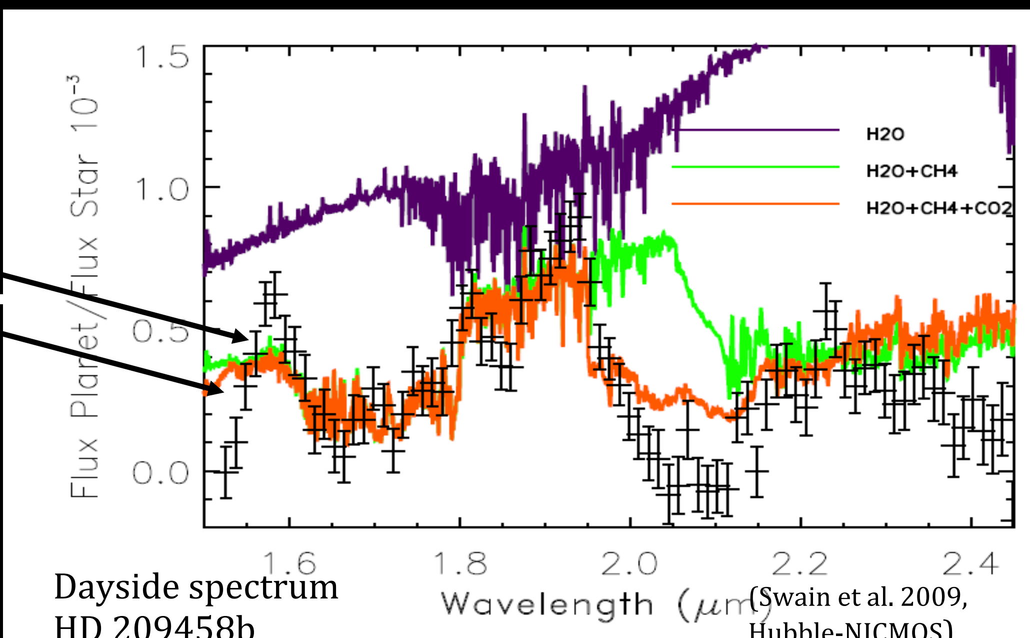
Spectrophotometry in 30s



-Atmospheric composition
-Atmospheric structure (T/P profile, day night side hea
exchange)
-formation history
-next generation instruments: biomakers (?)

S/N > 1000 in ~2h , stars mag 6-10

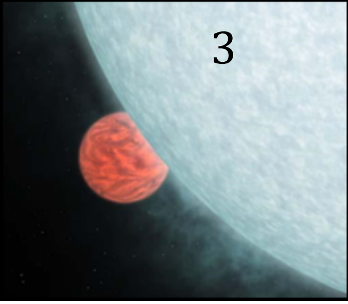




Dayside spectrum
HD 209458b

(Swain et al. 2009,
Hubble-NICMOS)

SOFIA – in theory



ADVANTAGES

Flexibility
- timing
- mobility
- instrumentation

Low telluric influence
- absorption
- background

Unique phase space
- IR- and V-band coverage
- IR coverage betw. HST and Spitzer

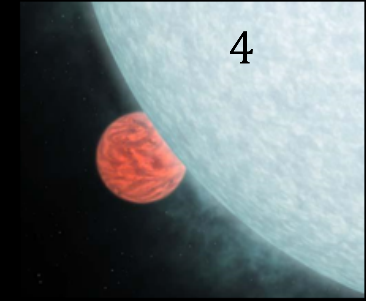
SCIENCE

High precision photometry
- improved parameters
- moons, rings etc

Planetary atmospheres
- redistribution
- temperature inversion
- abundances

Stellar atmospheres
- starspot temperatures
- limb darkening

SOFIA will carry out new and competitive transit observations.

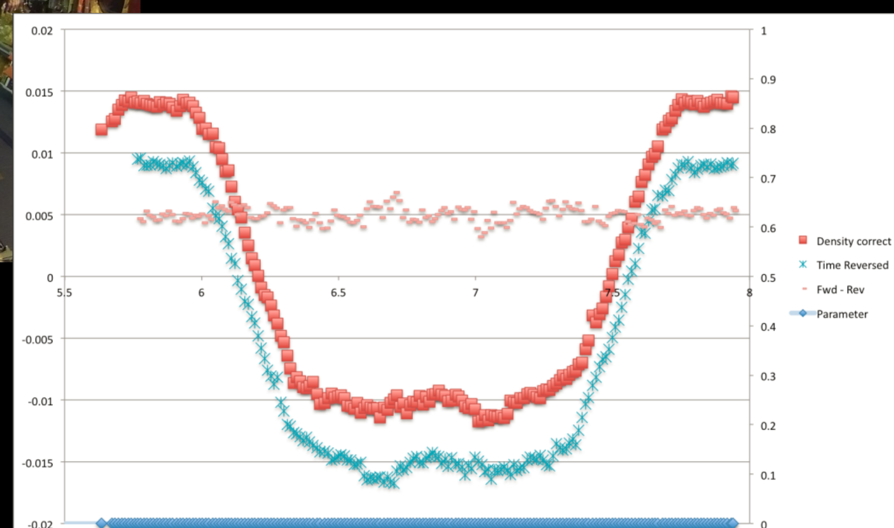


SOFIA – in practice

-First exoplanet transit observation :

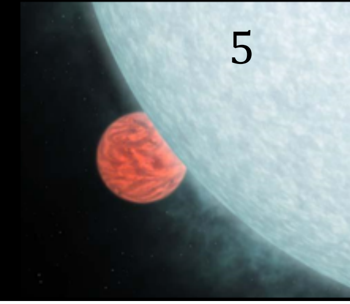
1 October 2013 with FLIPO

-two (independent) reductions



VIDEO (featured on NASA TV etc.):

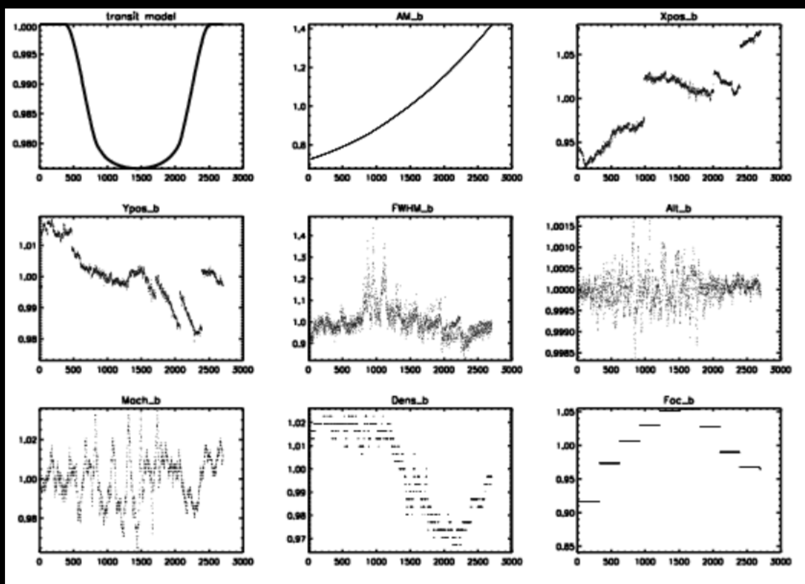
http://www.youtube.com/watch?v=y-W3xoOu0NE

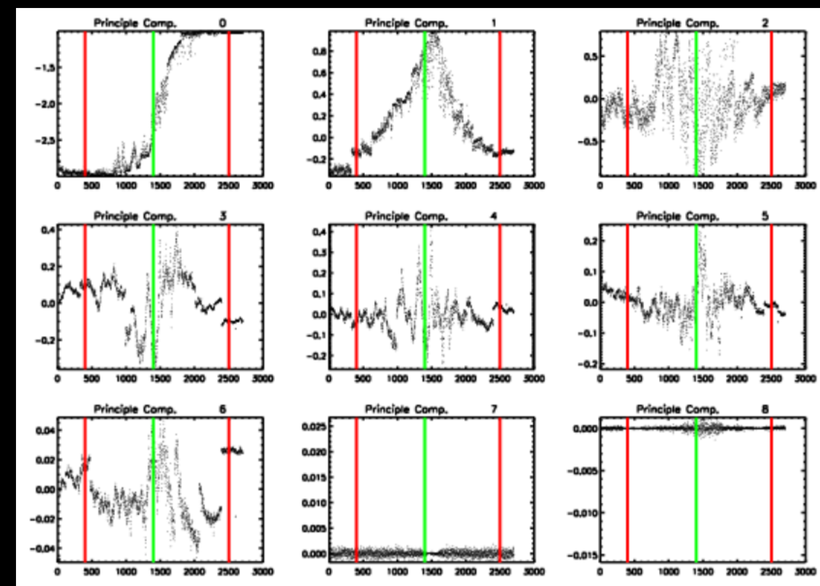


Decorrelation via PCA

observational Parameters → principle components

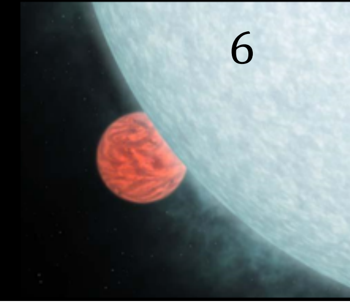
(PSF, “weather”, telemetry etc.)





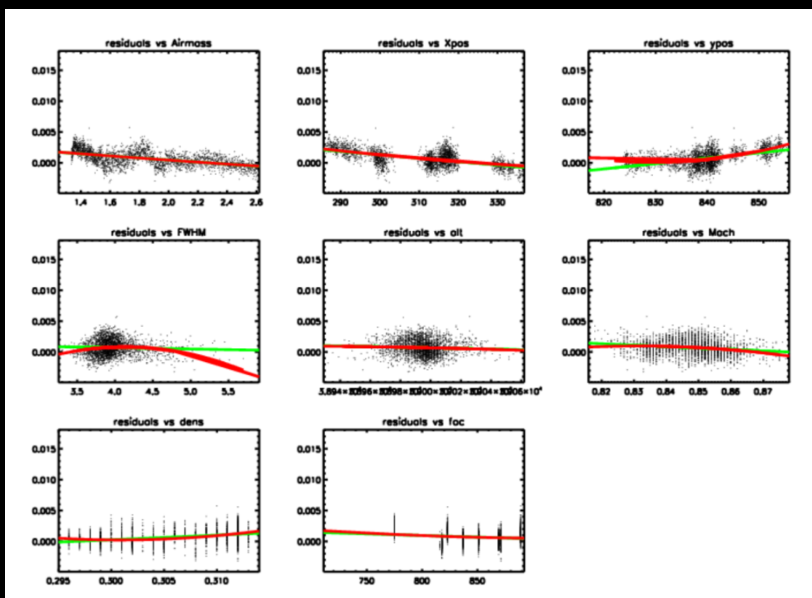
Advantages: solves degeneracies between parameters,
reduces number of fitting parameters

Disadvantage: loss of physical insight

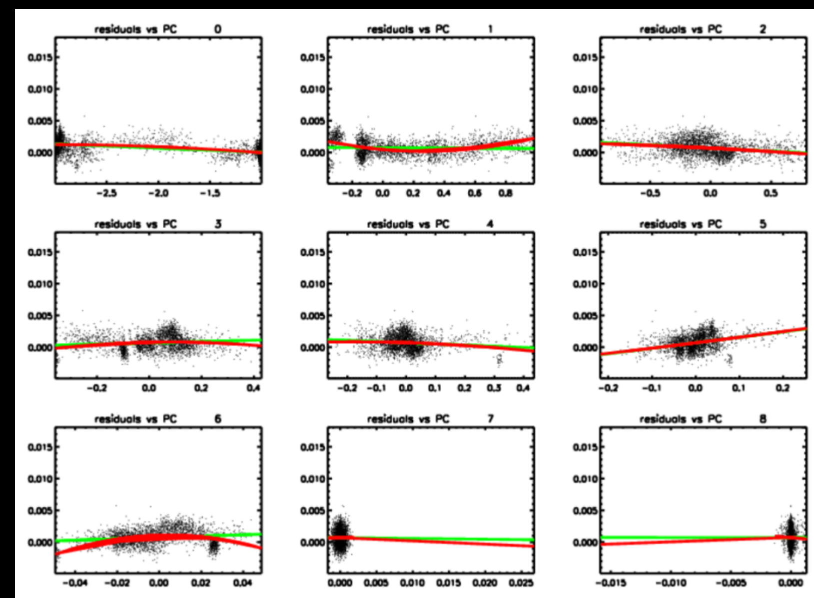


Decorrelation vs. residuals

observational Parameters

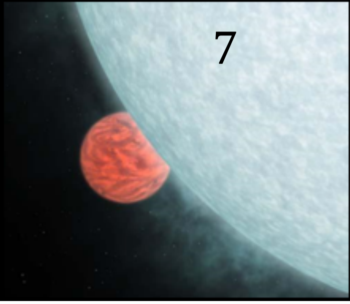


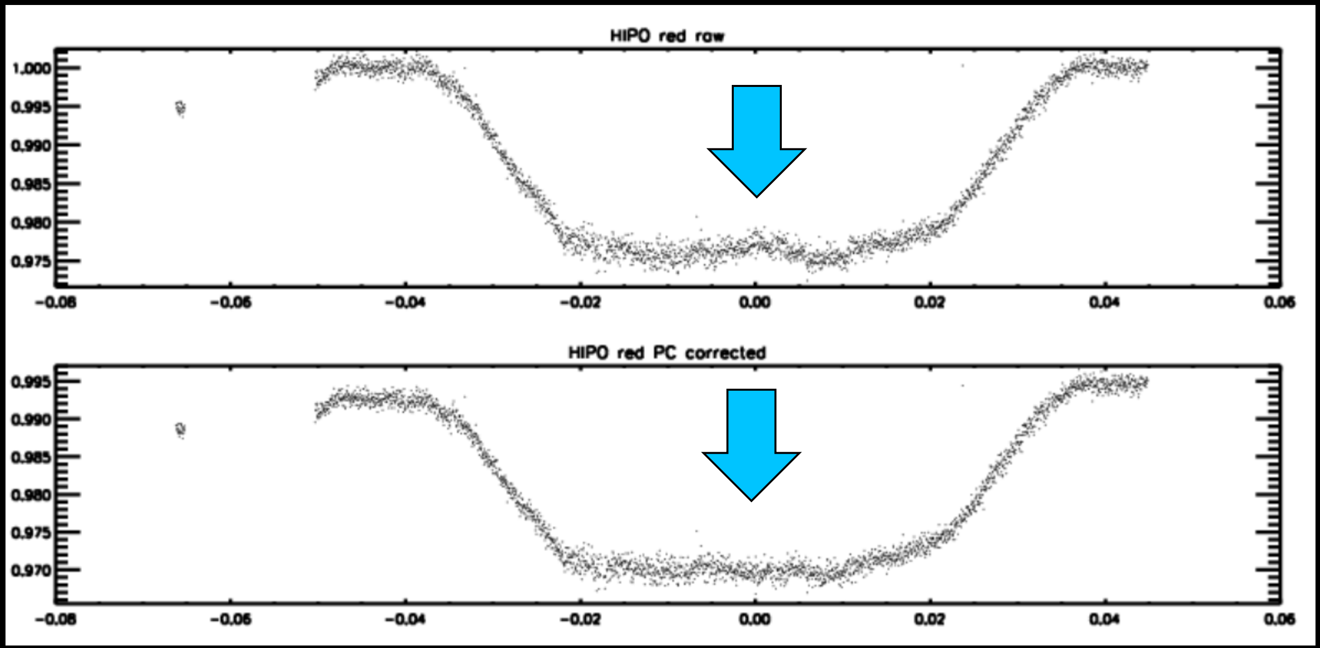
principle components

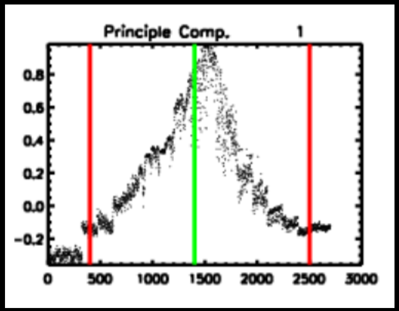


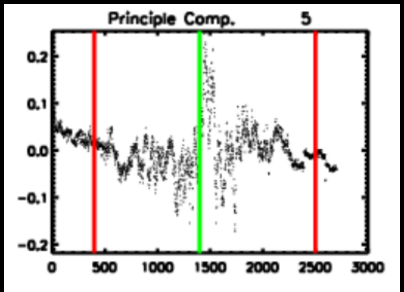
Green: linear; red: 2nd order

Spot or not?



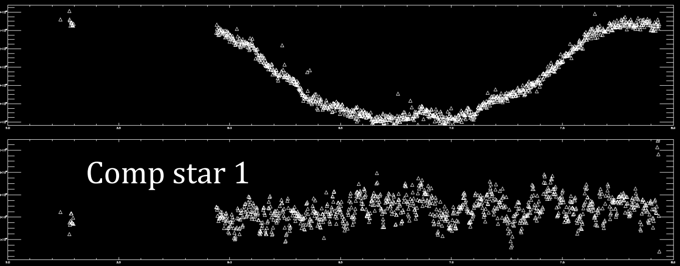




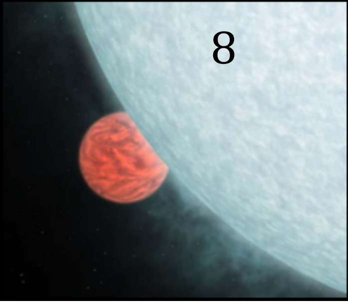


-”spot signature” disappears in the z’ lightcurve , after principle component correction, remains in blue, also partly present in comp. stars

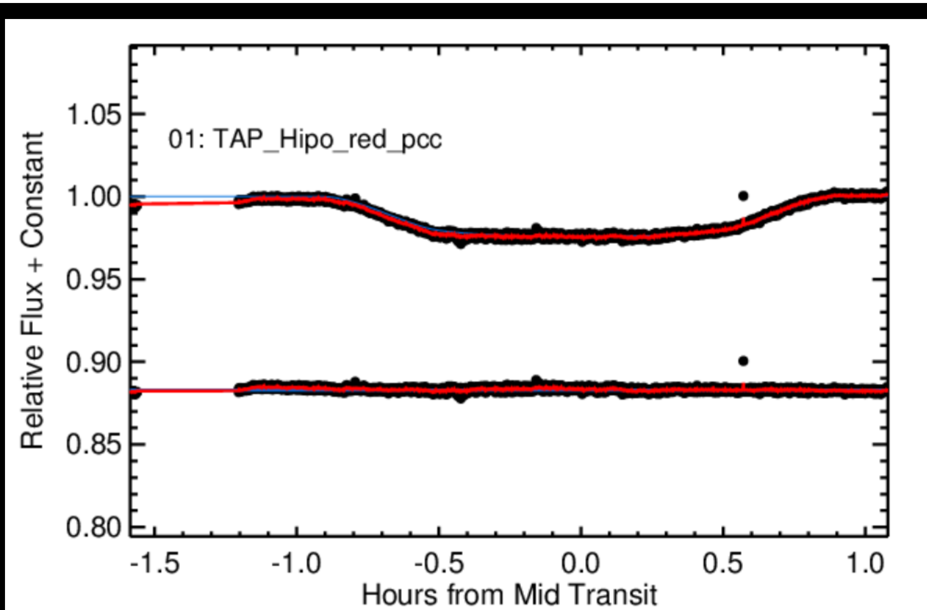
→ most probably (achromatic!) systematic effect (density?, ozone?)

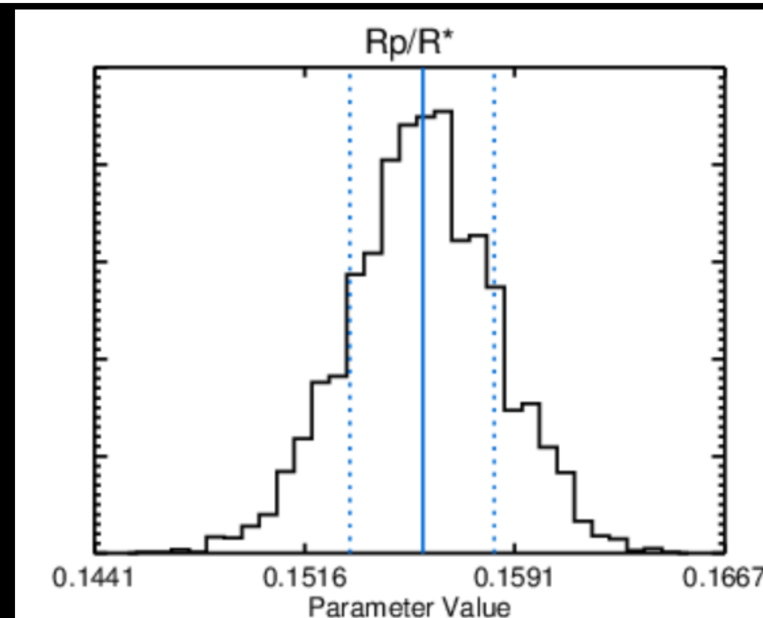


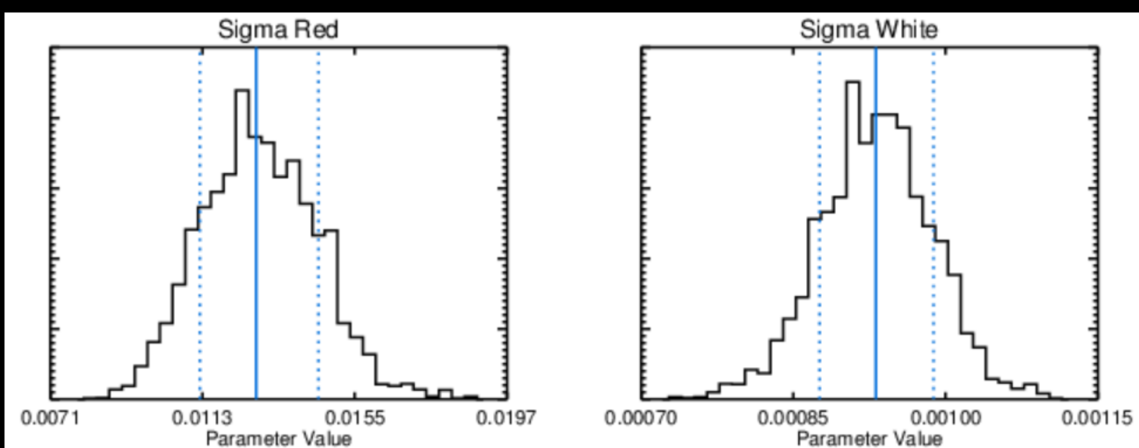
However, this means we are actually able to see these effects if they were real – only possible with >2 simultaneous channel (HIPO, FLIPO)



MCMC transit fits



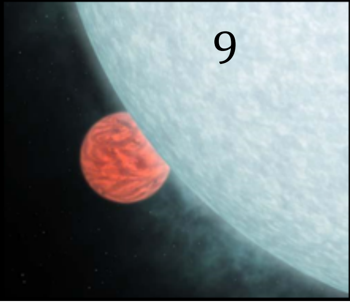


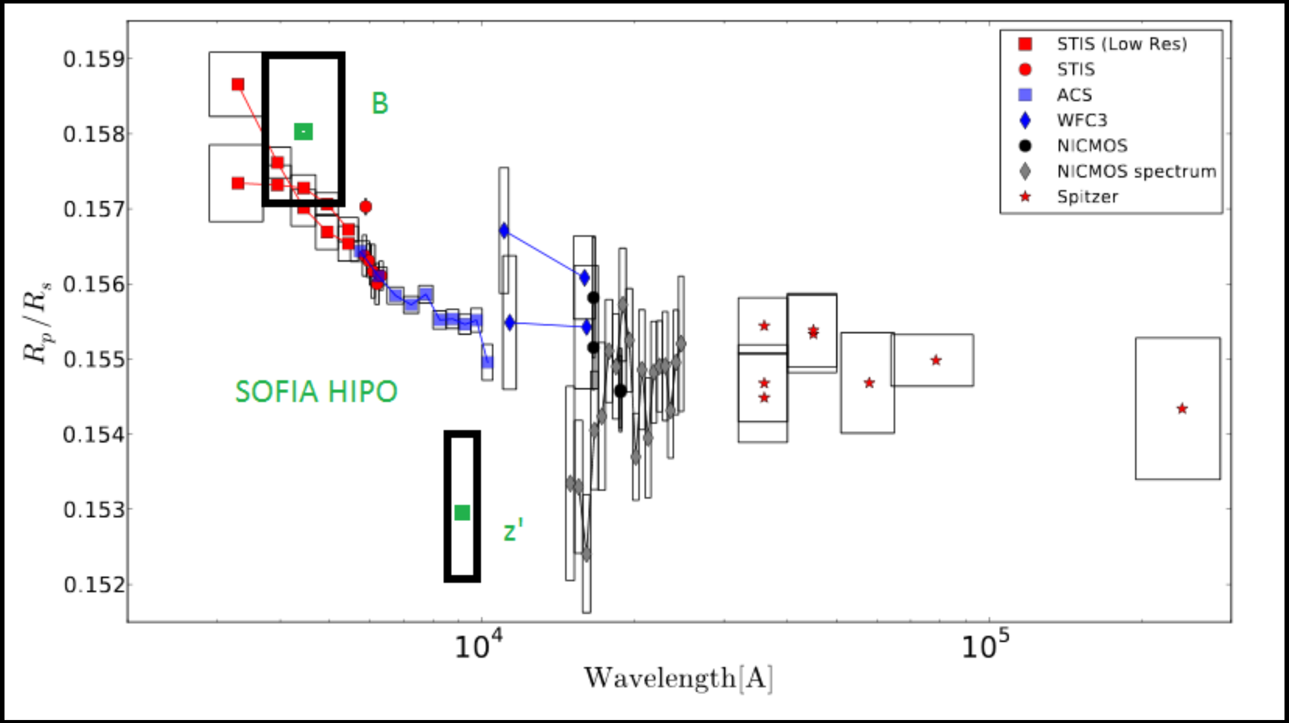


wavelet-based
noise analysis
(Carter and Winn 2009):

(still) red noise dominated

Results (work in progress)



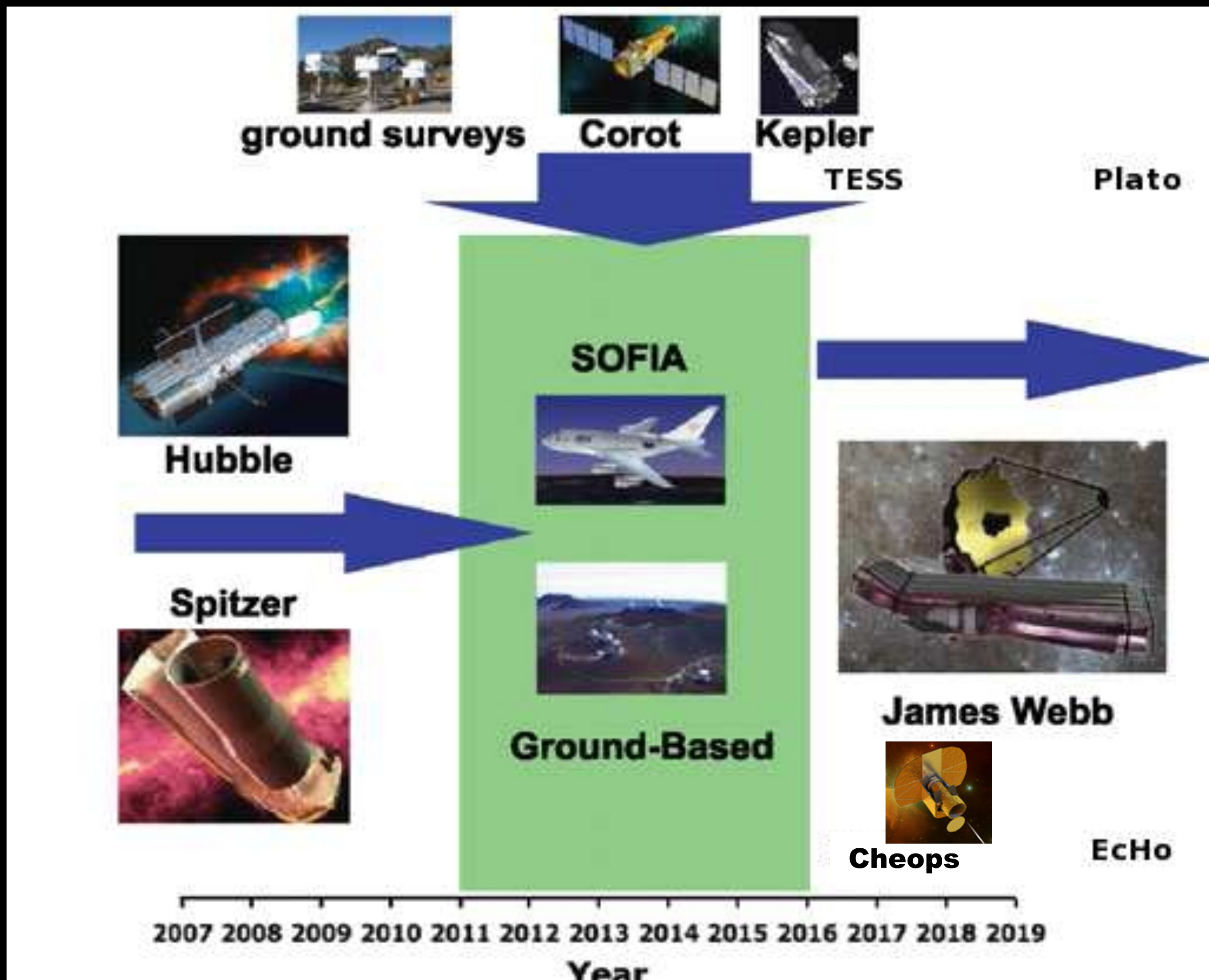


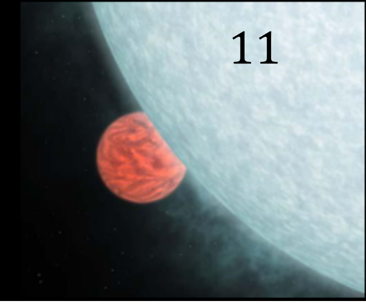
- Keep in mind: -still room for improvement (systematics),
  - almost no baseline for this observation,
  - inefficiency of tertiary

→ Comparable to HST results

If we reach similar sensitivities also in the NIR, we can do even cooler (literally) science.

The next decade





SOFIA & other platforms

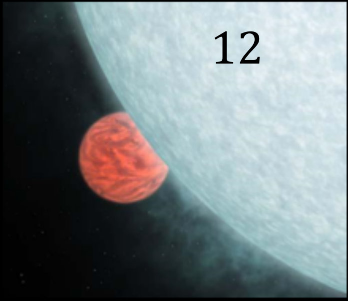
-Obvious synergies with ground-based telescopes:
SOFIA "filling the gaps" between bands,
very important channels for water, methane (see backup slides: science case II)

-until JWST , SOFIA is the only quasi space based platform > 1.7 micron (HST limit):
Kepler (II) follow-Up and Pre-JWST Characterization of Hot Jupiters
and Super-Earths down to mag~12 : H_2O, CH_4, CO_2, PAHs etc.

-even with JWST more synergies than competition:

- variable systems, long period planets → single transit observation combining e.g. HST (optical), SOFIA (opt. & NIR), JWST (MIR) – not possible with ground-based platforms, SOFIA's mobility

- different targets: e.g. for SOFIA characterization of "one-shot" gas-giants, while JWST for "multi-transit" deep analysis of super-earths



Conclusion

user perspective

-Absolute (!!!) photometry in HIPO data, proof that we have a quasi space based platform for photometry (in the optical)

-still more work to understand the red noise

-great EPO success (e.g. 450 shares on NASA's facebook)

-goal: expand to the NIR (with FLITECAM and/or 2nd gen.)

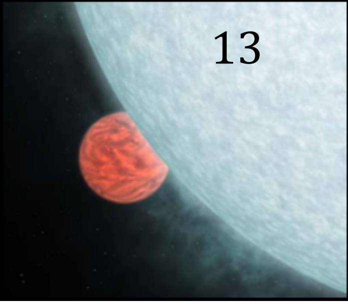
-3 more observations in cycle 2 (see backup slides)

-Also in practice:

SOFIA does carry out new and competitive transit observations.

Wishlist

user perspective



-Give us enough time:

"We need 8 hours." -- "Do it in 2!"

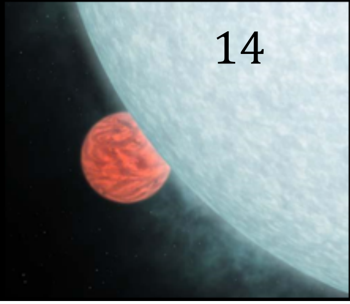
works on NCC-1701 but not on NASA-747

(deployments?)

-systematics tests with FLIPO on ~1h leg

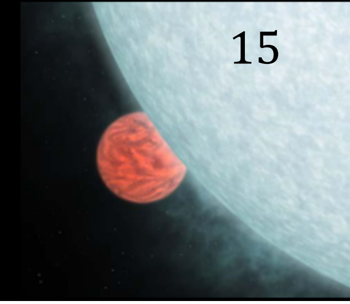
-fully reflective tertiary

-dedicated 2nd generation instrument: NIMBUS (see backup slides)



Thank you!

Backup slides



Science case I:

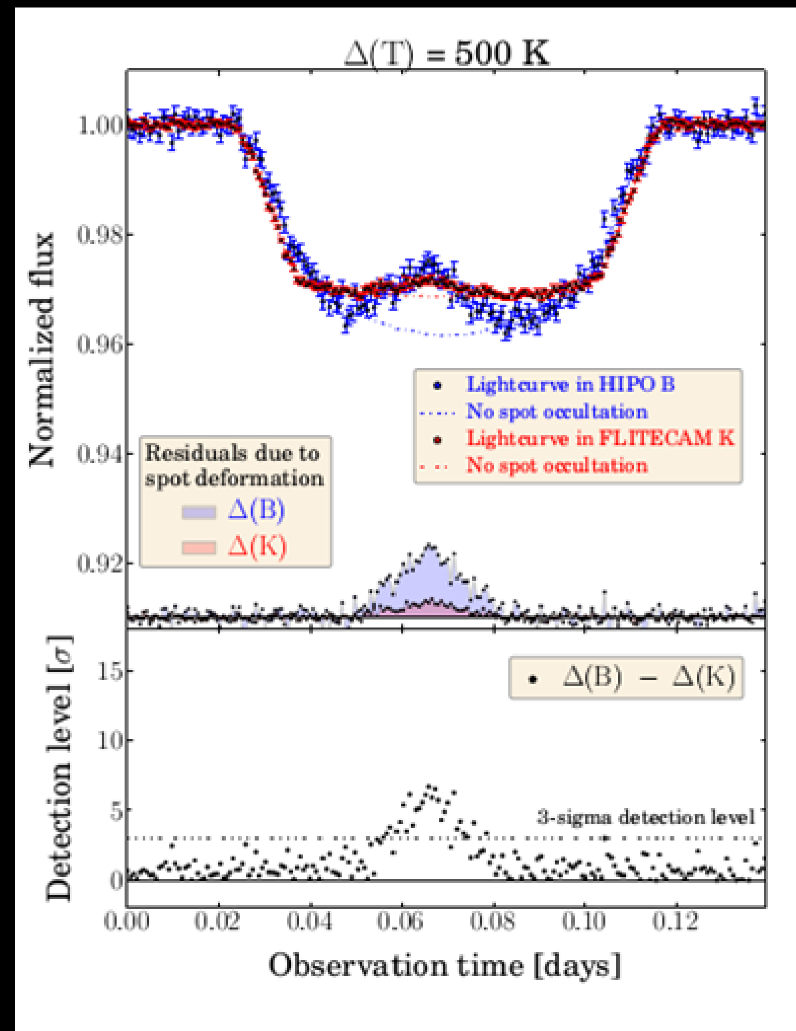
HIPO and FLITECAM multi-band of the young planetary system CoRoT-2

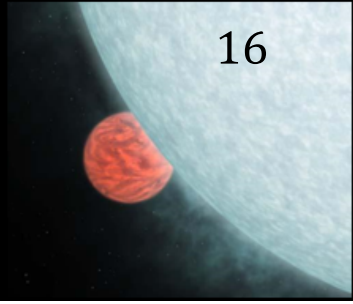
(1) Is CoRoT-2b really an inflated planet?

(2) What is CoRoT-2A's total spot coverage fraction?

(3) What is the spot temperature on CoRoT-2A?

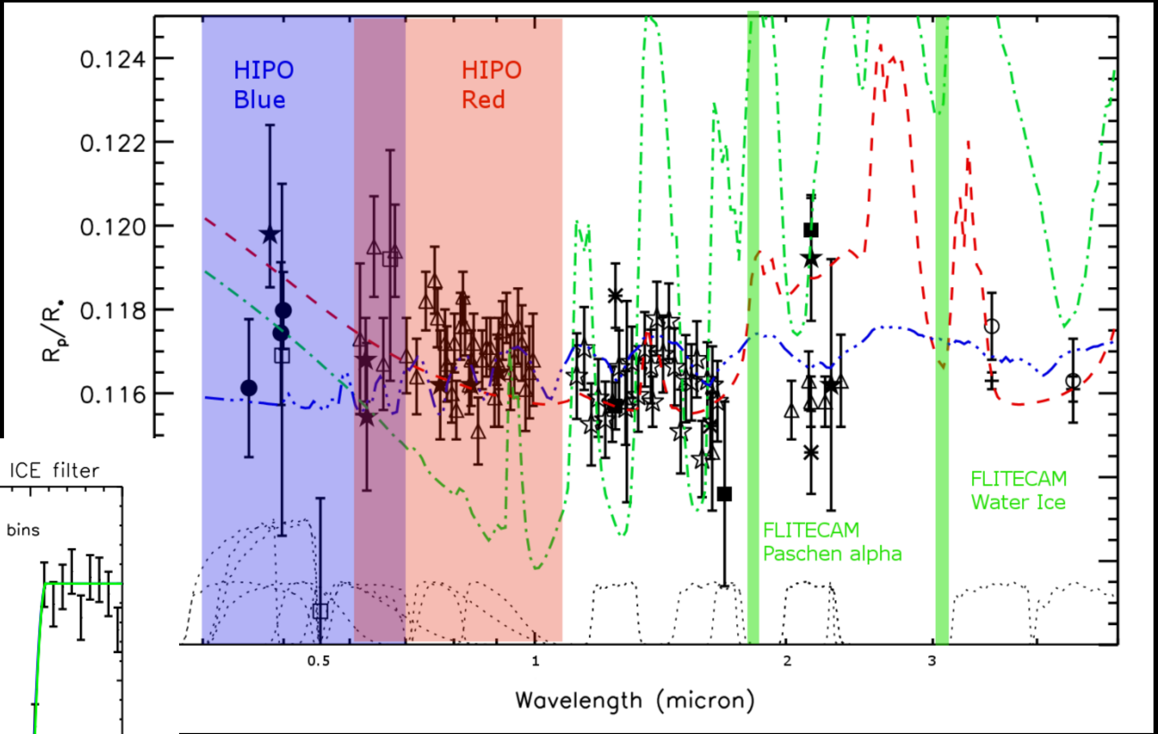
Only FLIPO (HIPO+FLITECAM) on SOFIA at "quasi space-based" precision

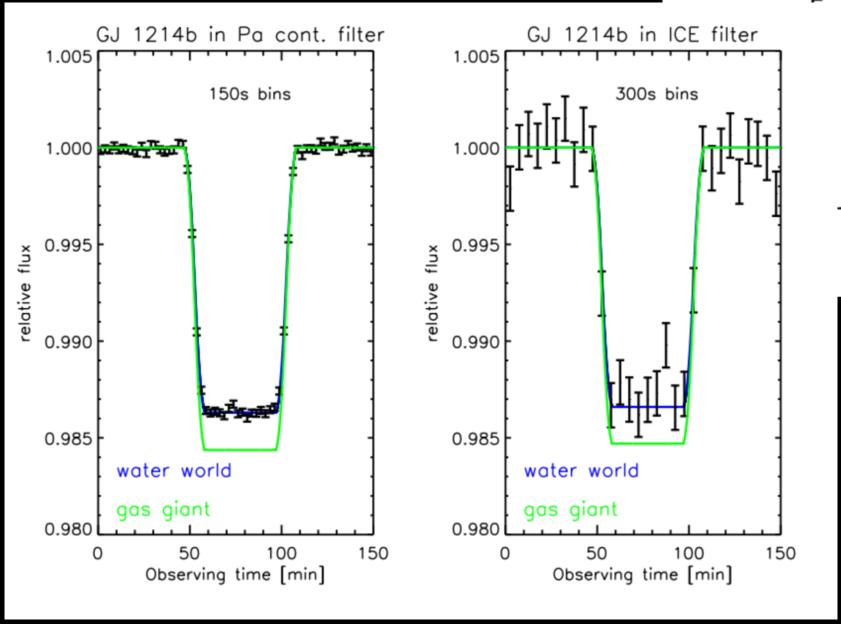




Science Case II

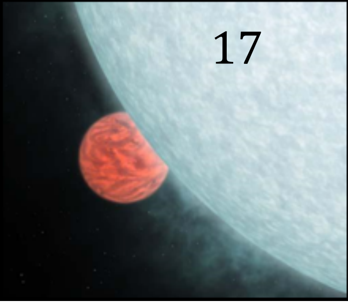
GJ 1214b: mini-neptune or super-earth?





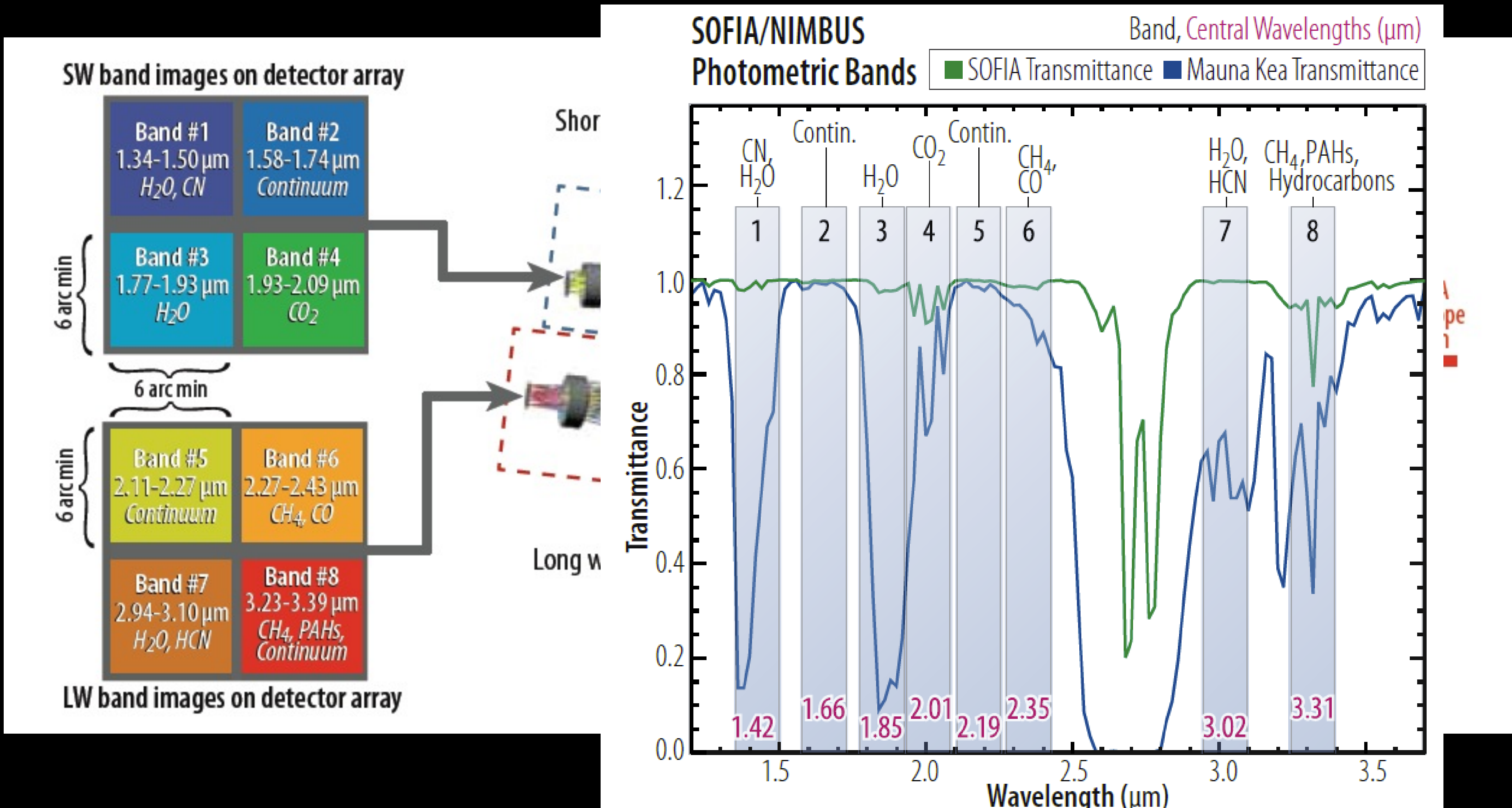
SOFIA:

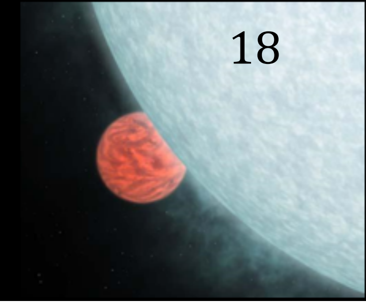
-crucial wavelength region not observable from the ground: FLITECAM Paschen alpha and „Ice“; 1.9 and 3.05 micron



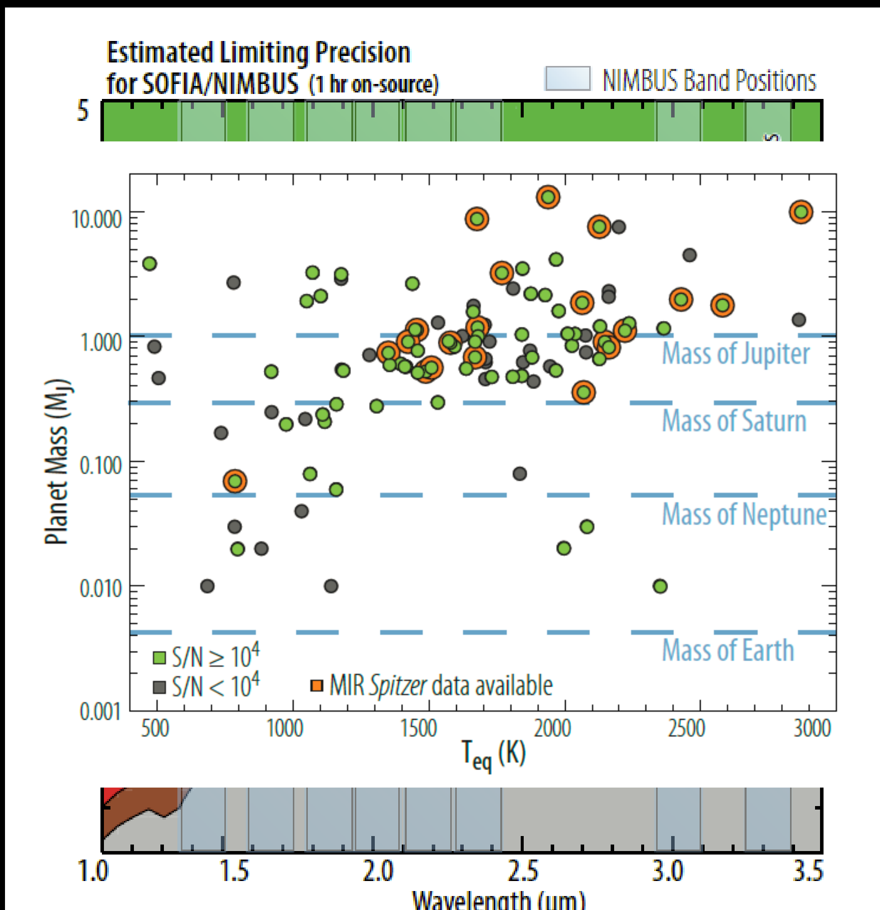
NIMBUS

The Near-Infrared Multi-Band Ultraprecise Spectroimager for SOFIA





NIMBUS



Kepler Follow-Up and Pre-JWST Characterization of Hot Jupiters and Super-Earths down to mag~12 : H_2O, CH_4, CO_2, PAHs etc.

NIMBUS: EChO/Finesse 'lite' in 3-5 years

NASA-GSFC: compl. Phase A study, optical assembly, detectors

Additional science:

Trans-Neptunian Objects (TNO), Solar System occultations, brown dwarf atmospheres, carbon chemistry in globular clusters, chemical gradients in nearby galaxies, and galaxy photometric redshifts.