The future of ground-based high-dispersion spectroscopy

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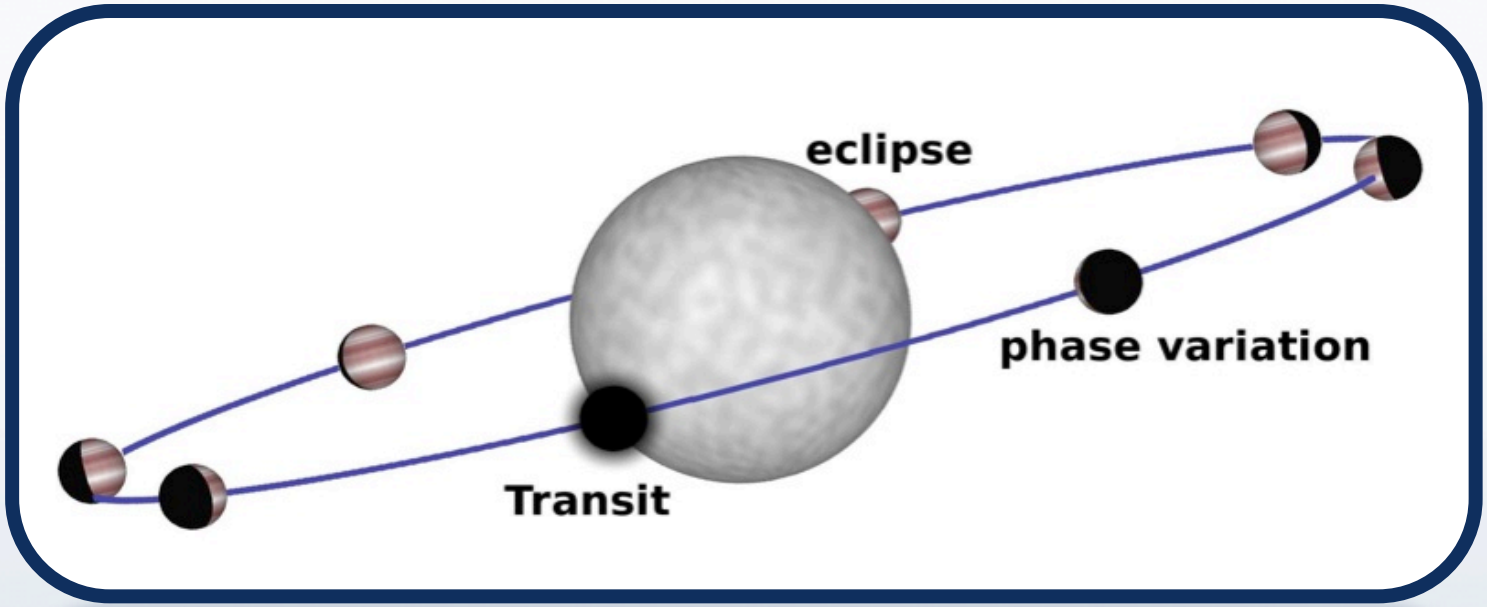
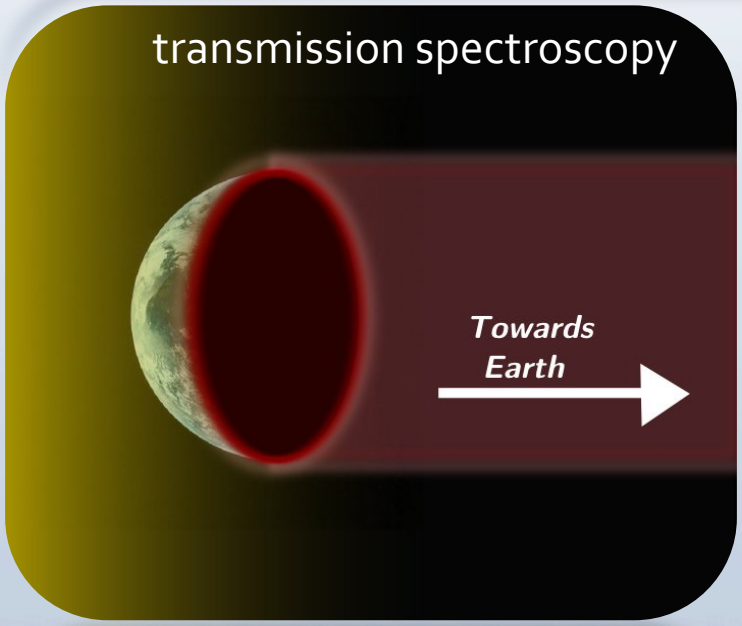
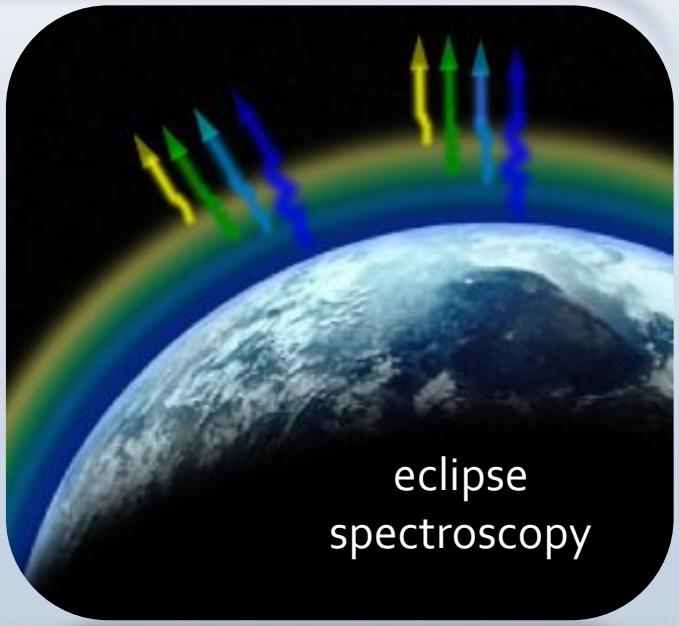
Exoplanet atmospheres

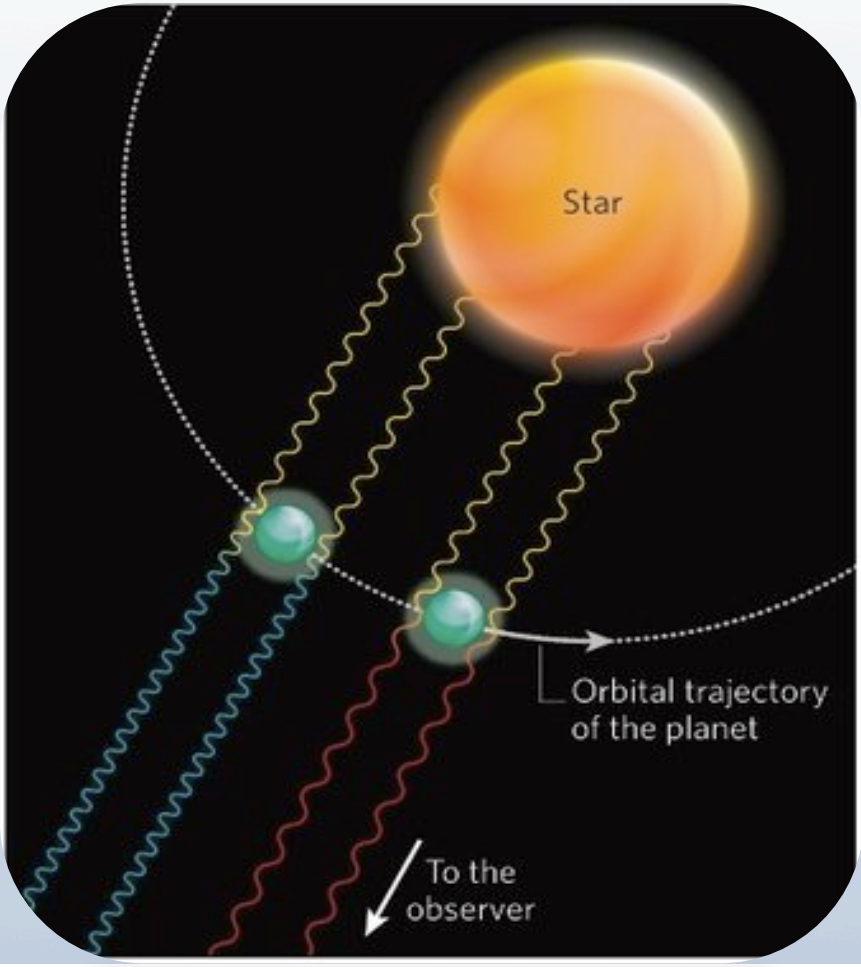


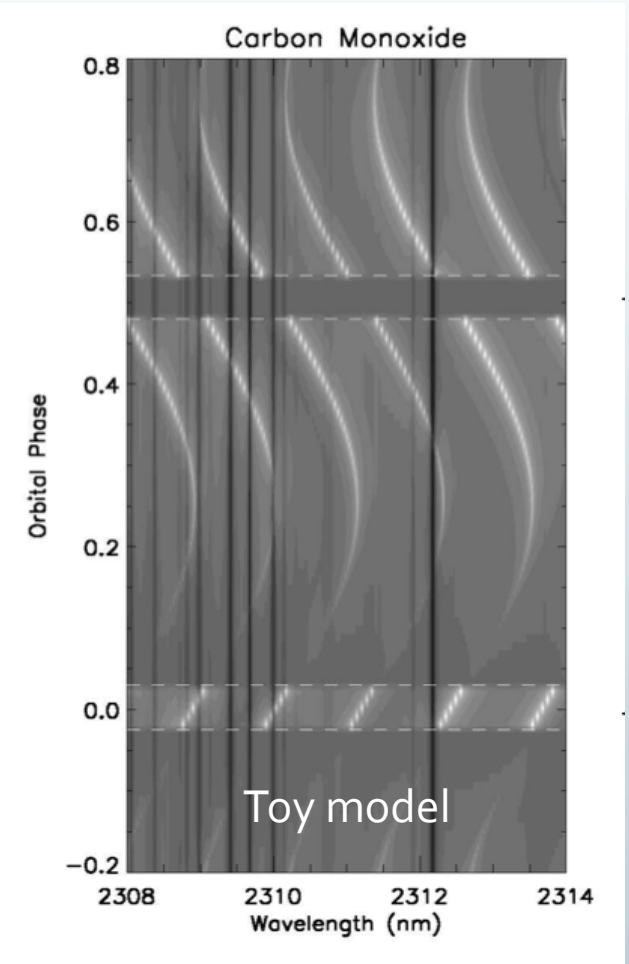




Ground-based High-dispersion spectroscopy

- At R=100,000 molecular bands are resolved in tens of individual lines
- Strong doppler effects due the orbital motion of the planet (up to >150 km/s).
- Moving planet lines can be distinguished from stationary telluric + stellar lines

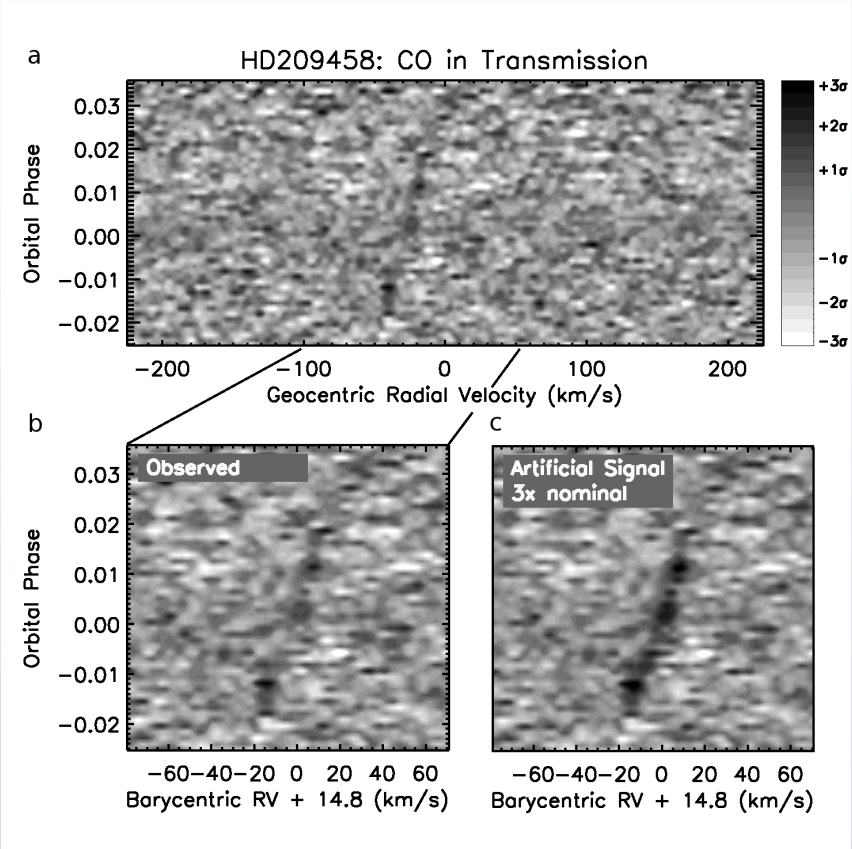




CRIRES@VLT

Detection of CO in transmission of HD209458b

(Snellen et al. Nature 2010)

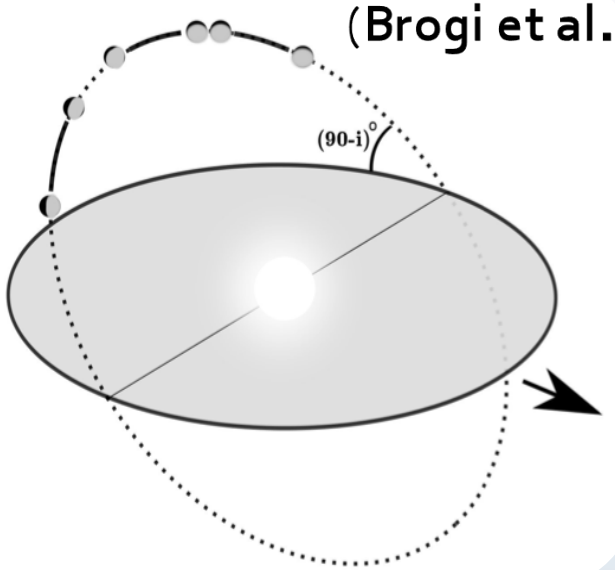


- Reveals planet orbital velocity
- Solves for masses of both planet and star (model independent)
- Evidence for blueshift (high altitude winds?)

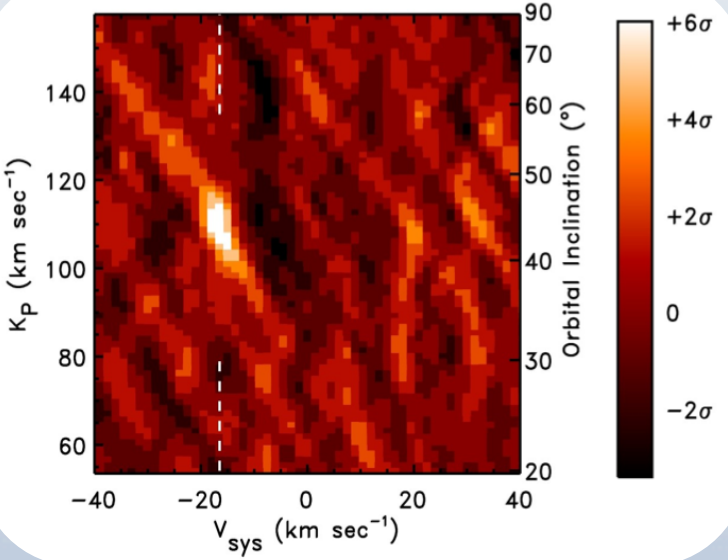
CRIRES@VLT

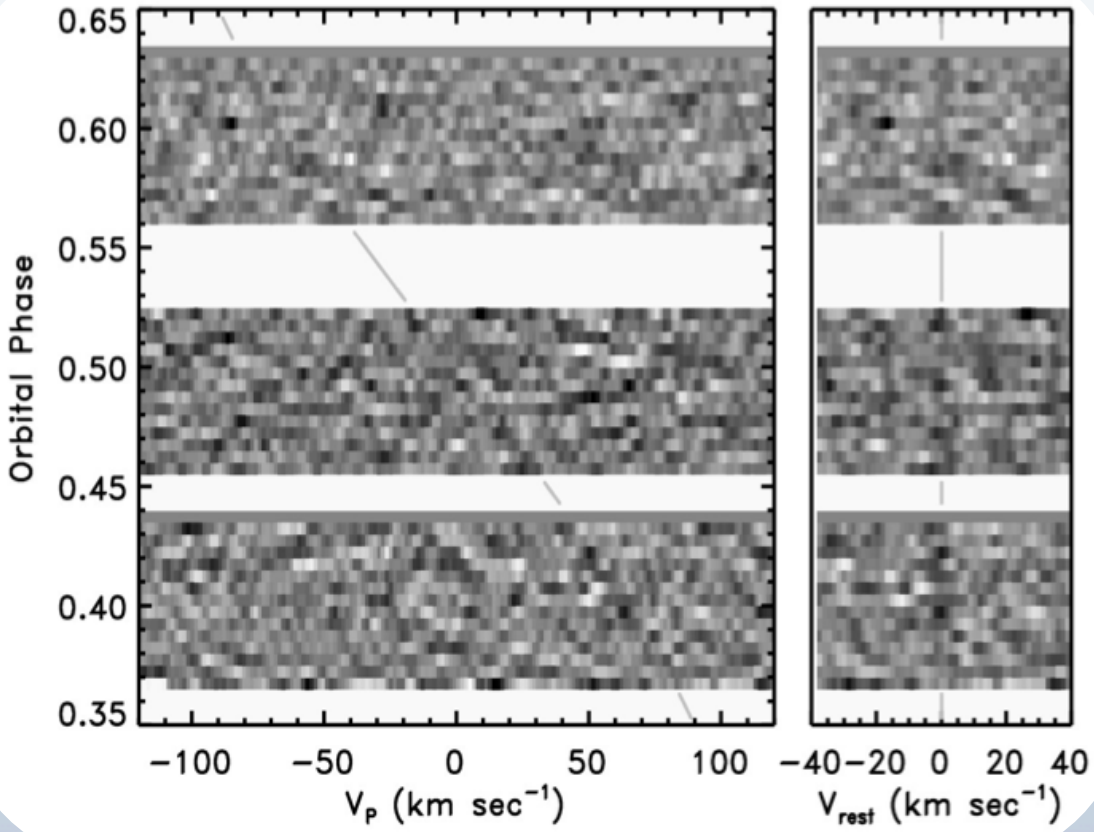
Detection of CO in dayside spectrum of tau Bootis b

(**Brogi et al. Nature 2012 – see also Rodler et al. 2012**)



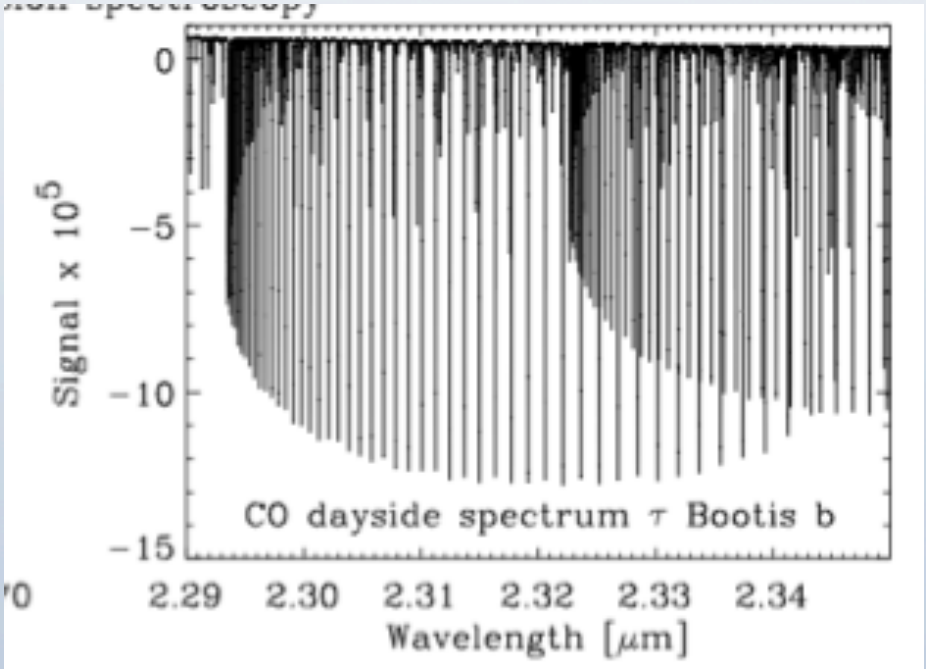
First detection of non-transiting planet→ inclination, mass

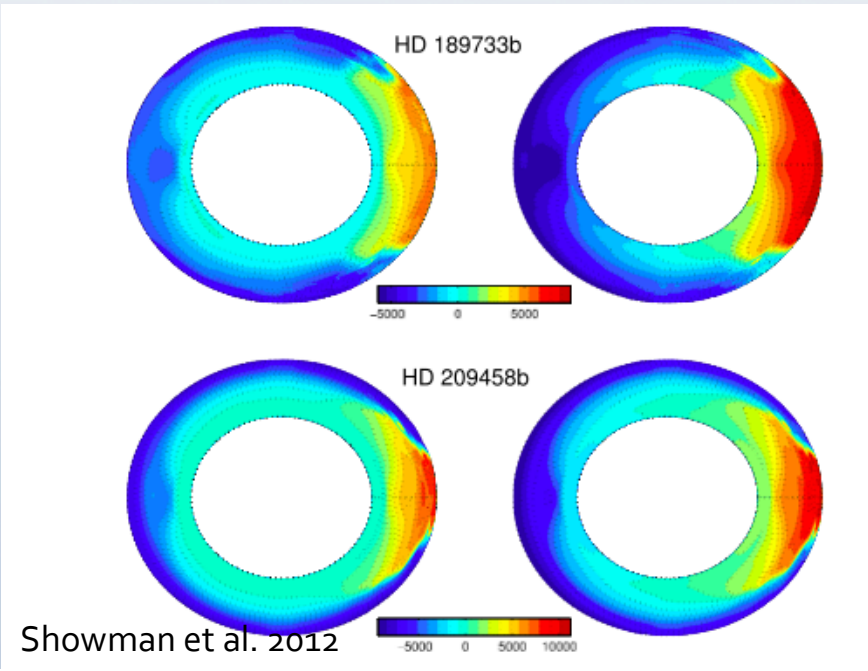




E-ELT science

- HIRES (<2.5 um) and METIS (>2.9 um) R=100,000 → a SNR increase of factor 5
- Orbital inclinations and masses of >100 non-transiting planets
- Detection of the individual lines (instead of cross-correlation) → T/P profile; unambigous detections of inversion layers
- Line broadening → planet rotation and circulation



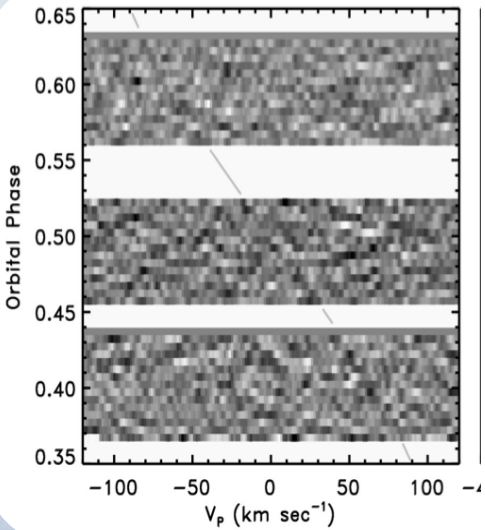


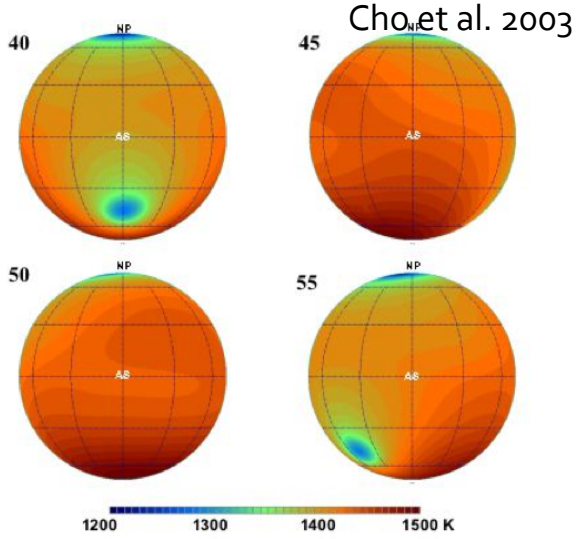
Showman et al. 2012

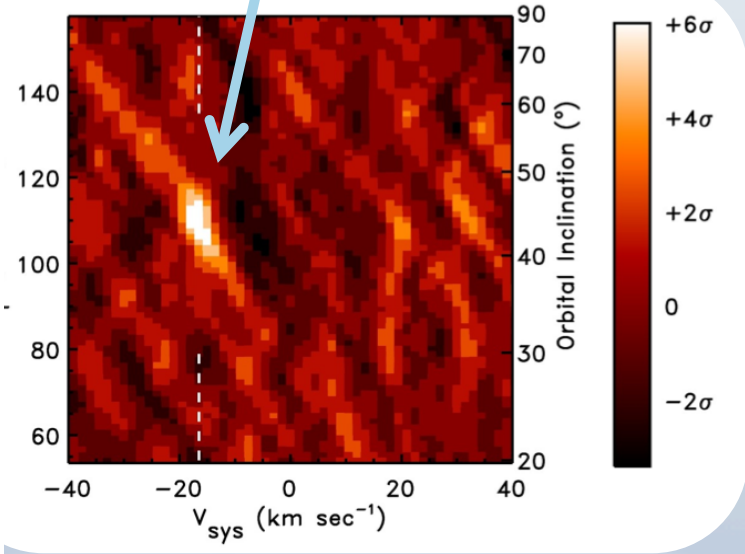
E-ELT science

- HIRES (<2.5 um) and METIS (>2.9 um) R=100,000 → a SNR increase of factor 5
- Molecular spectra (CO, CO_2, H_2O, CH_4) as function of orbital phase → photochemistry, T/P versus longitude
- Isotopologues? → evolution of planet atmosphere

$^{12}C^{16}O$







How far can ground-based high-res work be pushed?

Consider twin-Earth planets:

- mid-infrared (ozone) has too high background
- H_2O, CO_2, CH_4 absorption in the same regions as telluric
- O_2 in transmission is possible!