
Credit: Gemini/AURA

Characterizing Exoplanet Atmospheres with Gemini/GMOS: First Results

Catherine Huitson,
University of Colorado, Boulder

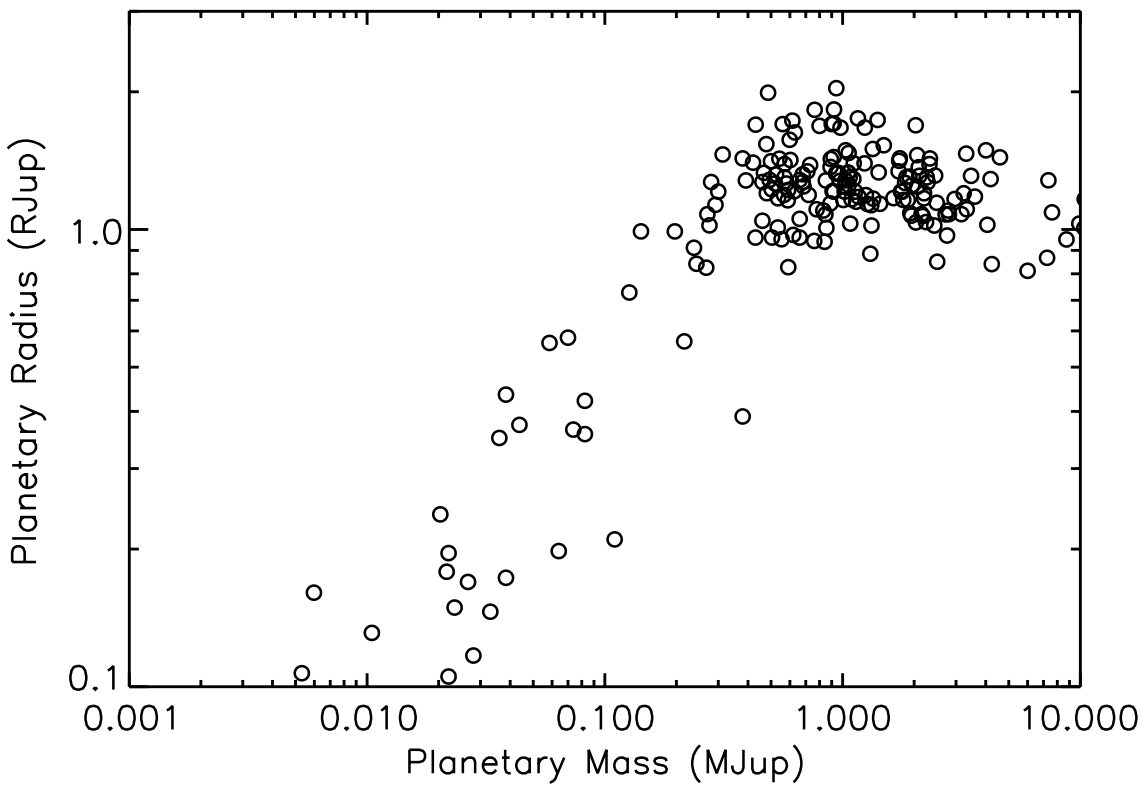
P.I. J-.M. Désert

Collaborators: J. Bean, J. Fortney, K. Stevenson, M. Bergmann, D. Deming, S. Seager

University of Colorado

Introduction to the GMOS Survey

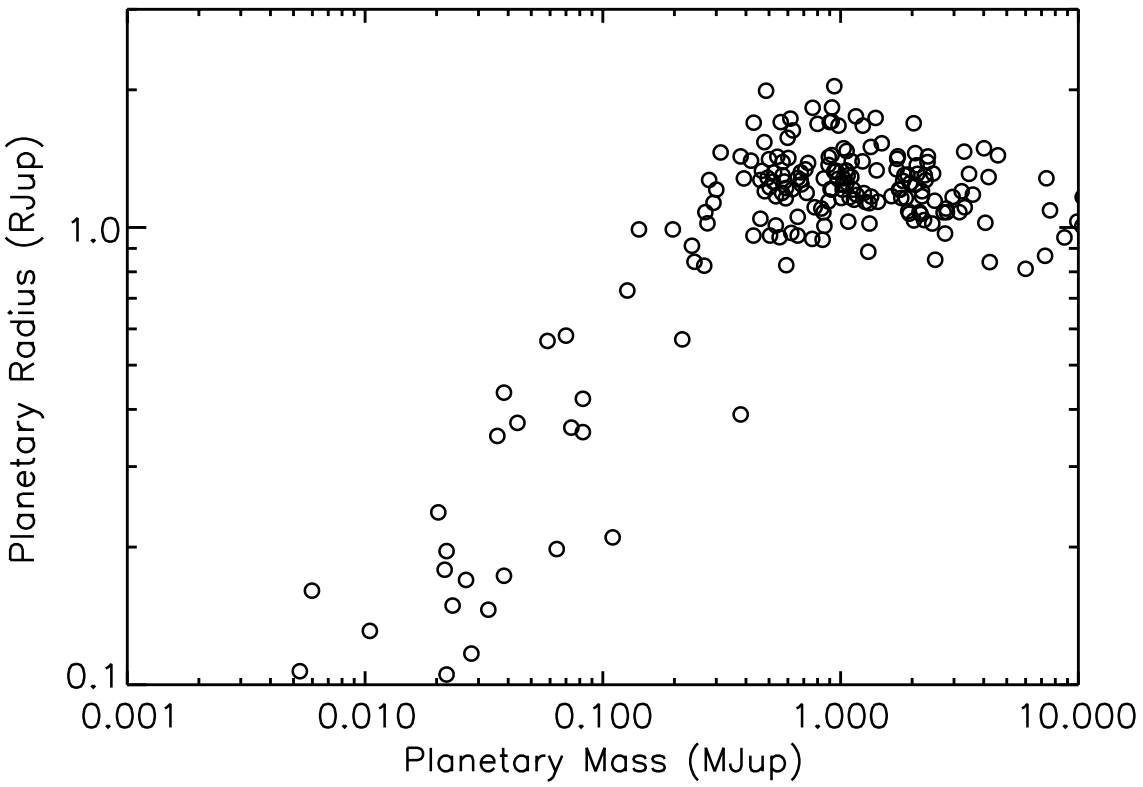
P.I. J-.M. Désert



Introduction to the GMOS Survey

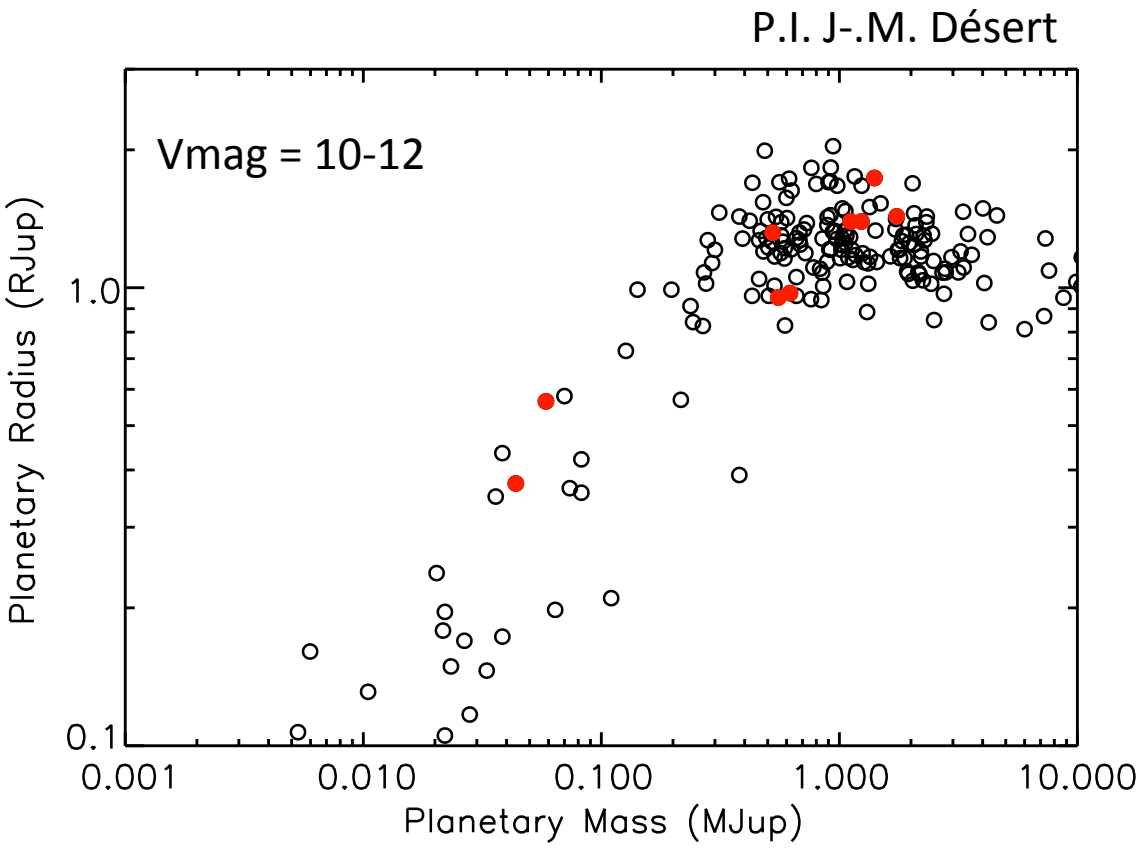
- **Aims**
  - Measure dominant atmospheric absorbers
  - Broad-band low-resolution (~3-10 Å) optical coverage

P.I. J-.M. Désert



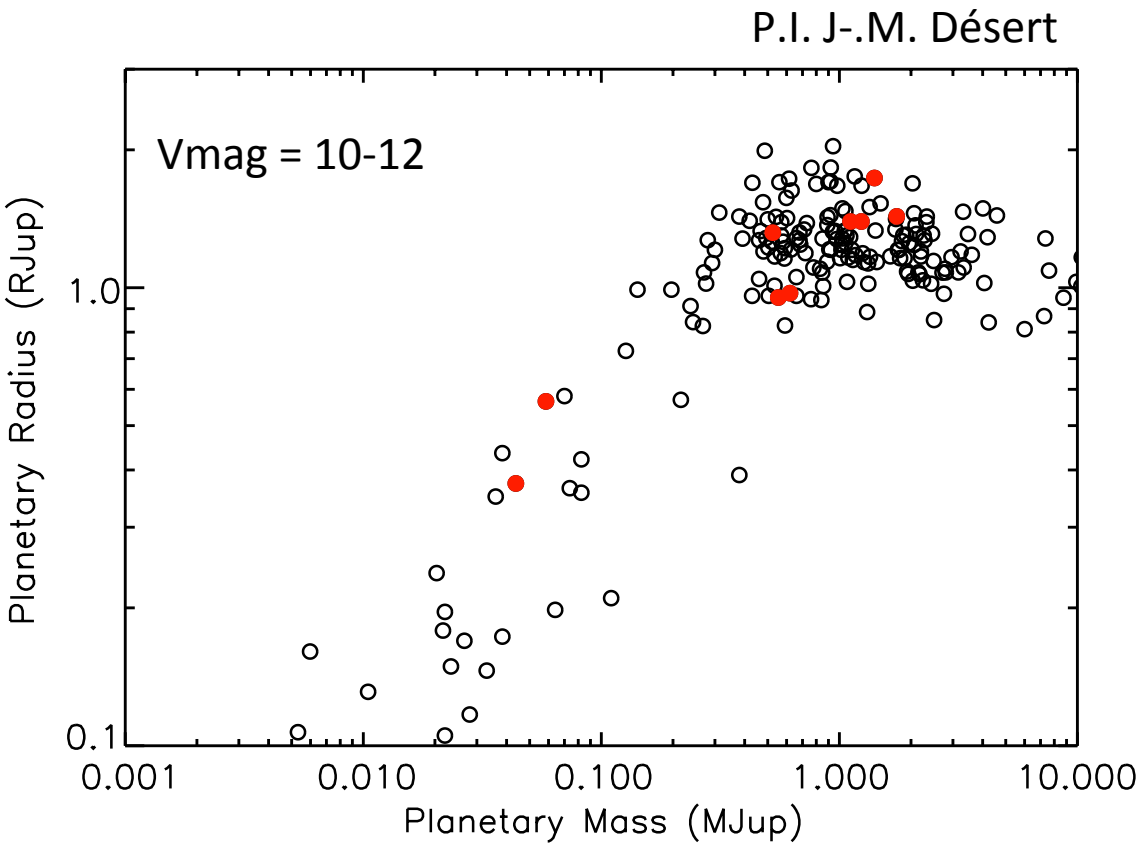
Introduction to the GMOS Survey

- **Aims**
  - Measure dominant atmospheric absorbers
  - Broad-band low-resolution (~3-10 Å) optical coverage
- **9-Planet Sample**
  - Low densities, good comparison star
  - Comparative study
  - Understand systematic noise



Introduction to the GMOS Survey

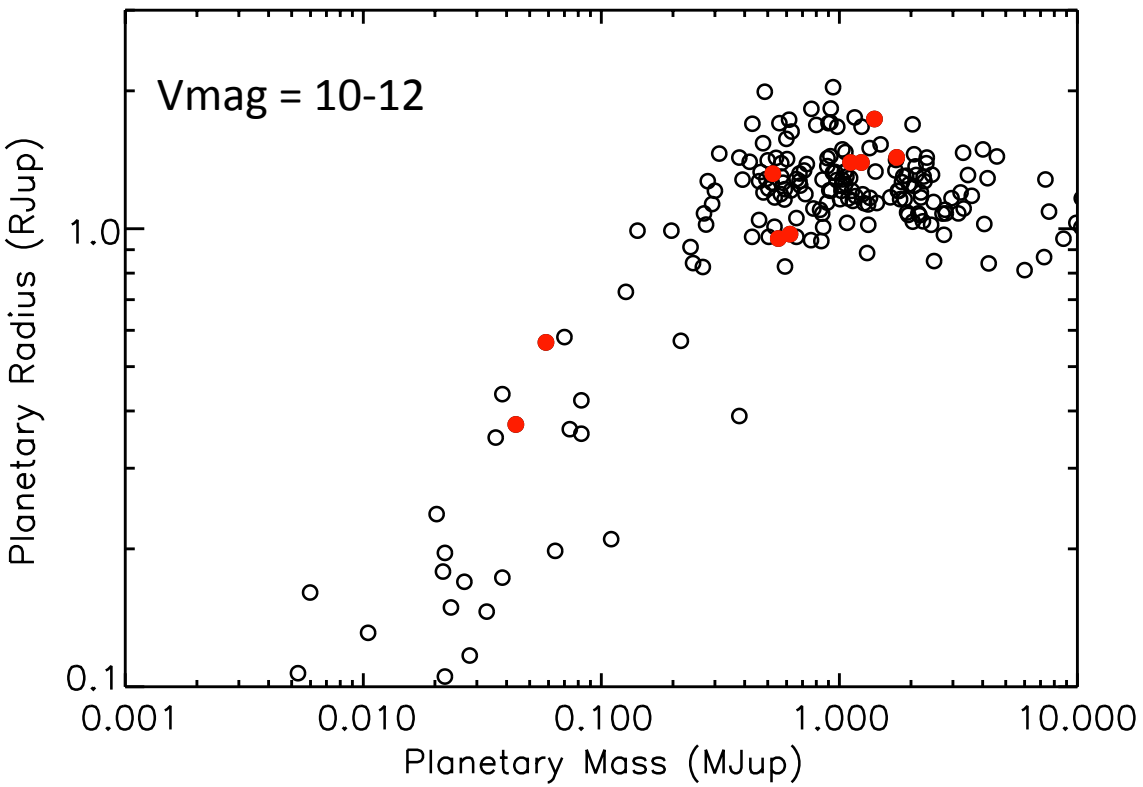
- **Aims**
  - Measure dominant atmospheric absorbers
  - Broad-band low-resolution (~3-10 Å) optical coverage
- **9-Planet Sample**
  - Low densities, good comparison star
  - Comparative study
  - Understand systematic noise
- **3-Year Survey**
  - Attain high S/N
  - Repeatibility: 4 transits/ object



Introduction to the GMOS Survey

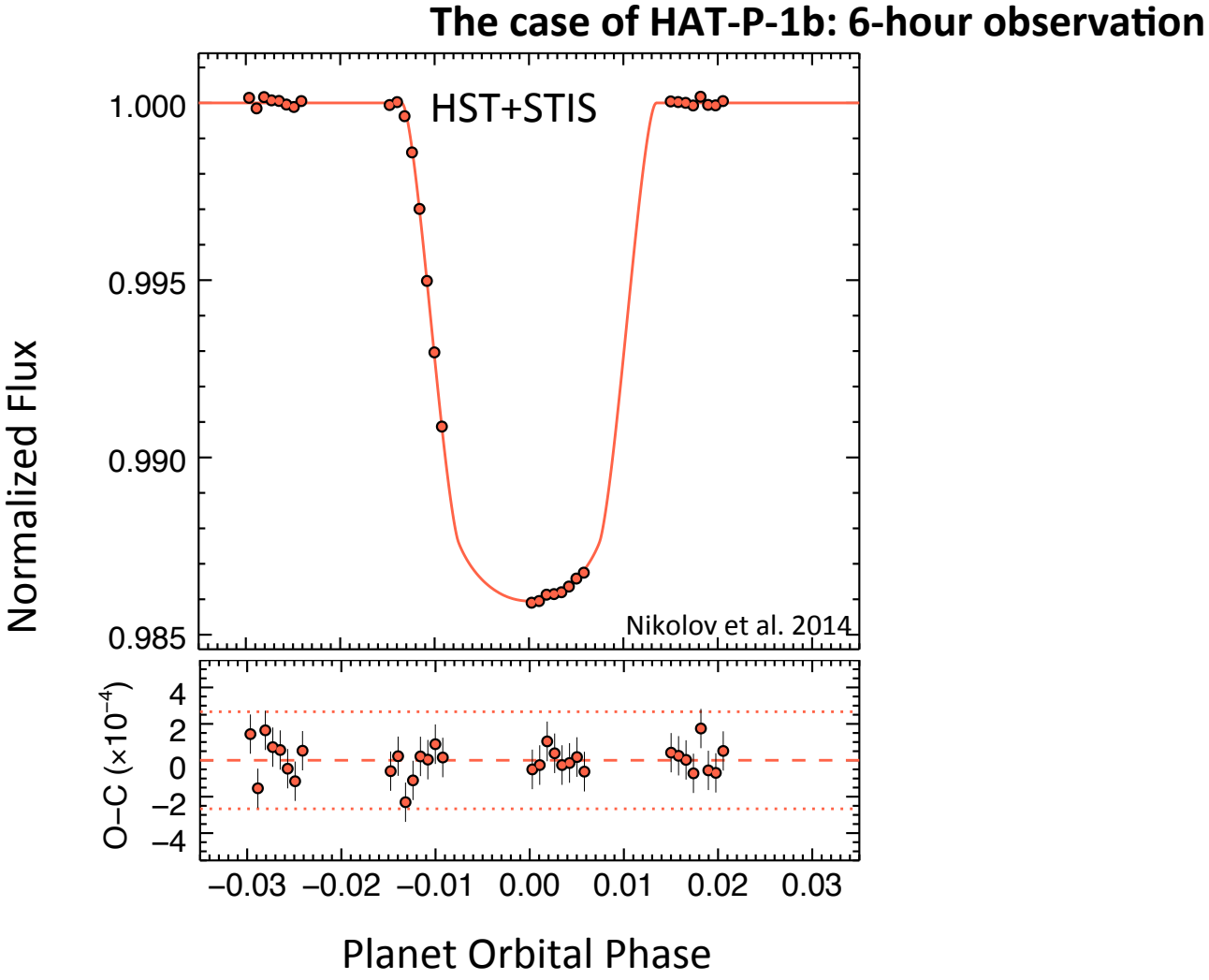
- **Aims**
  - Measure dominant atmospheric absorbers
  - Broad-band low-resolution (~3-10 Å) optical coverage
- **9-Planet Sample**
  - Low densities, good comparison star
  - Comparative study
  - Understand systematic noise
- **3-Year Survey**
  - Attain high S/N
  - Repeatibility: 4 transits/ object

P.I. J-.M. Désert

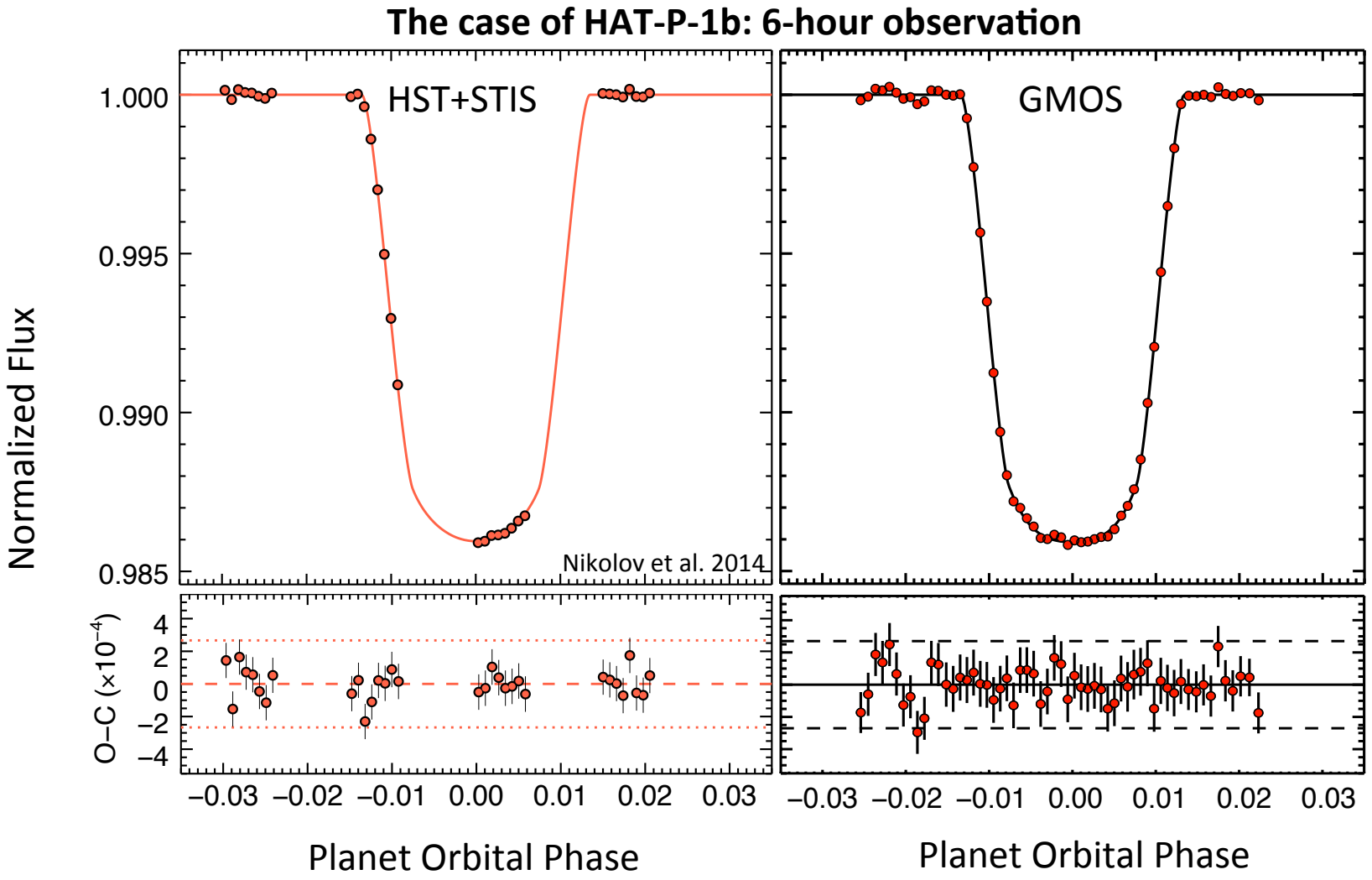


Total = 29 transits, 193 hours

Why Gemini/GMOS?



Why Gemini/GMOS?

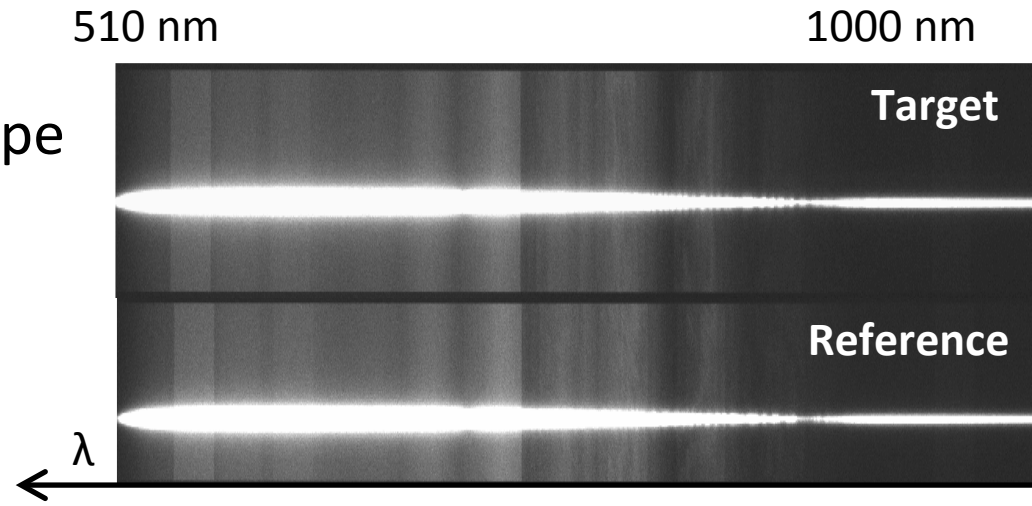


Why Gemini/GMOS?

- Ground-based
- Multi-Object optical spectroscopy
- Fully-sky coverage with GMOS instruments
- Large 5 x 5 arcmin FOV
- Queue mode

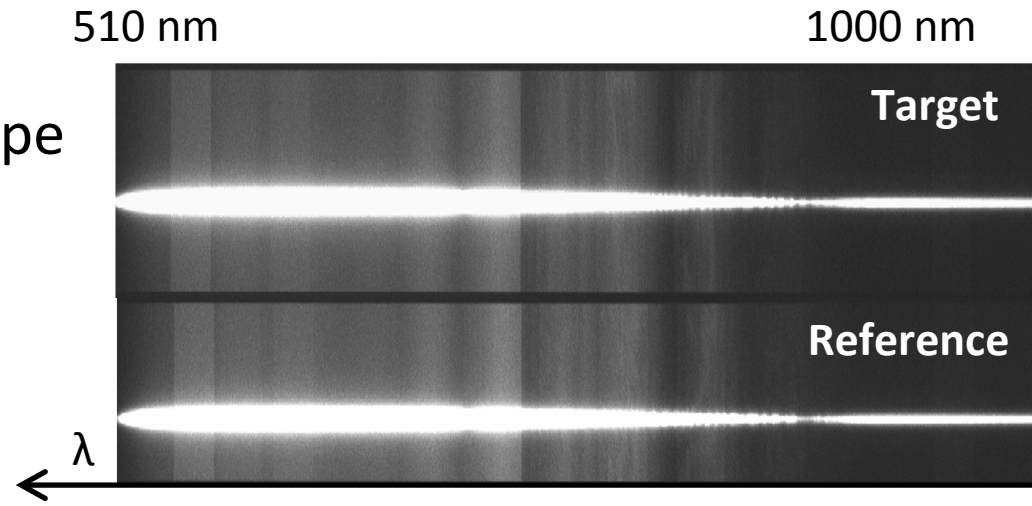
Our Technique: MOS (GMOS)

- Target + reference stars: same magnitude & spectral type
- This technique allows us to correct for systematics wavelength by wavelength
- Wide 10” slit to improve spectrophotometric precision (avoid slit losses)



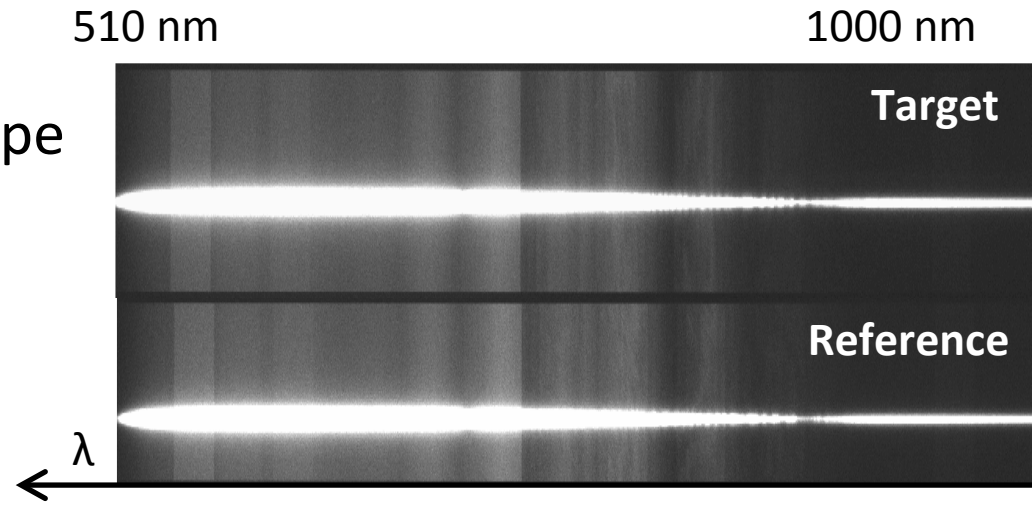
Our Technique: MOS (GMOS)

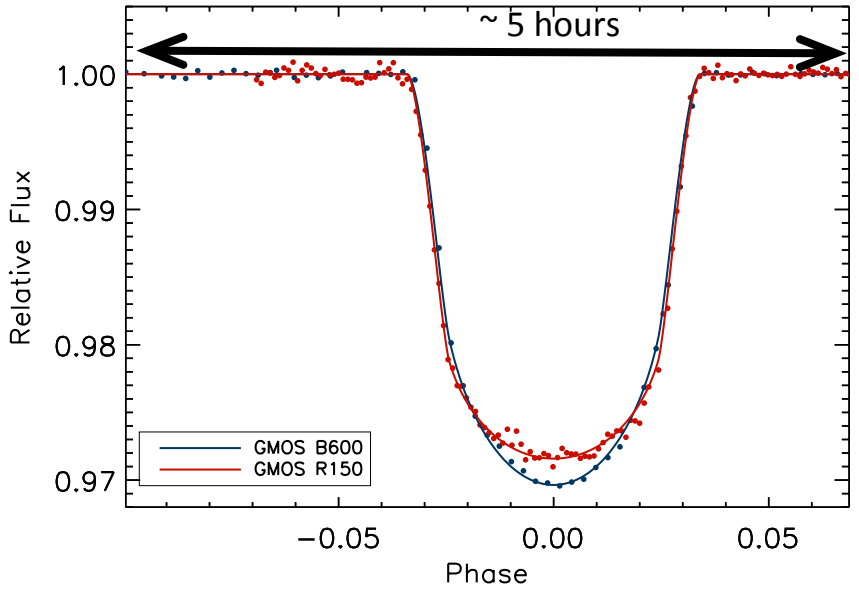
- Target + reference stars: same magnitude & spectral type
- This technique allows us to correct for systematics wavelength by wavelength
- Wide 10” slit to improve spectrophotometric precision (avoid slit losses)
- We get a frame every ~ 50 s and build transit lightcurves



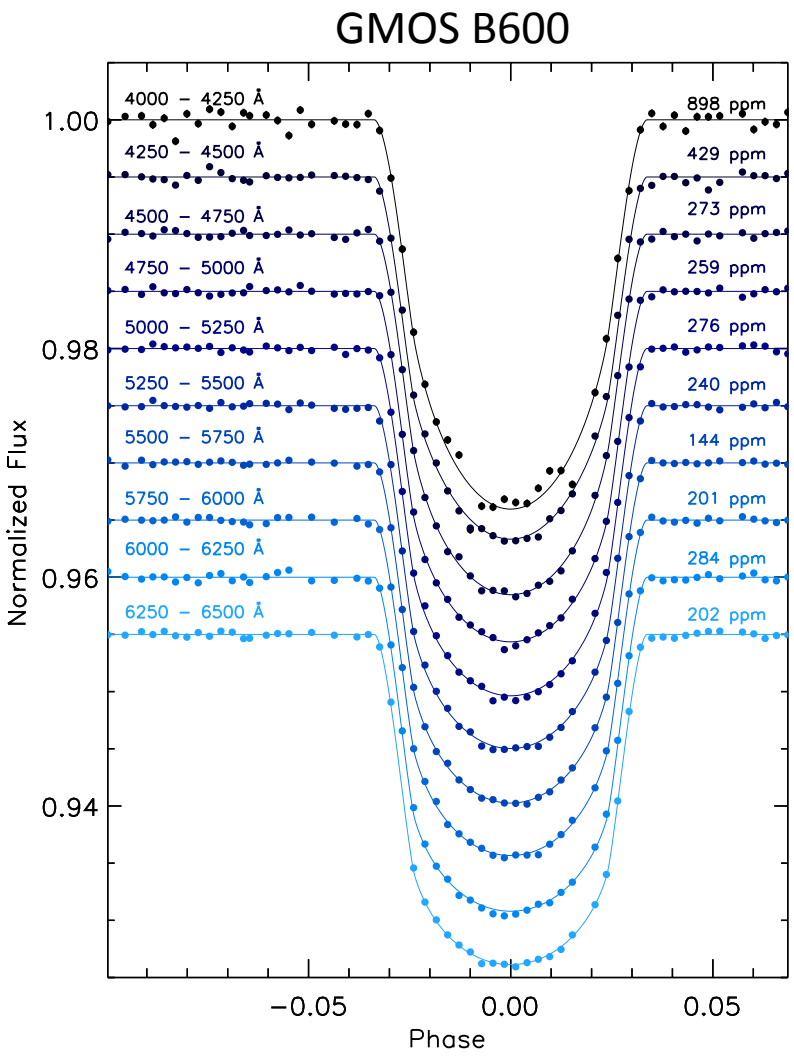
Our Technique: MOS (GMOS)

- Target + reference stars: same magnitude & spectral type
- This technique allows us to correct for systematics wavelength by wavelength
- Wide 10” slit to improve spectrophotometric precision (avoid slit losses)
- We get a frame every ~ 50 s and build transit lightcurves

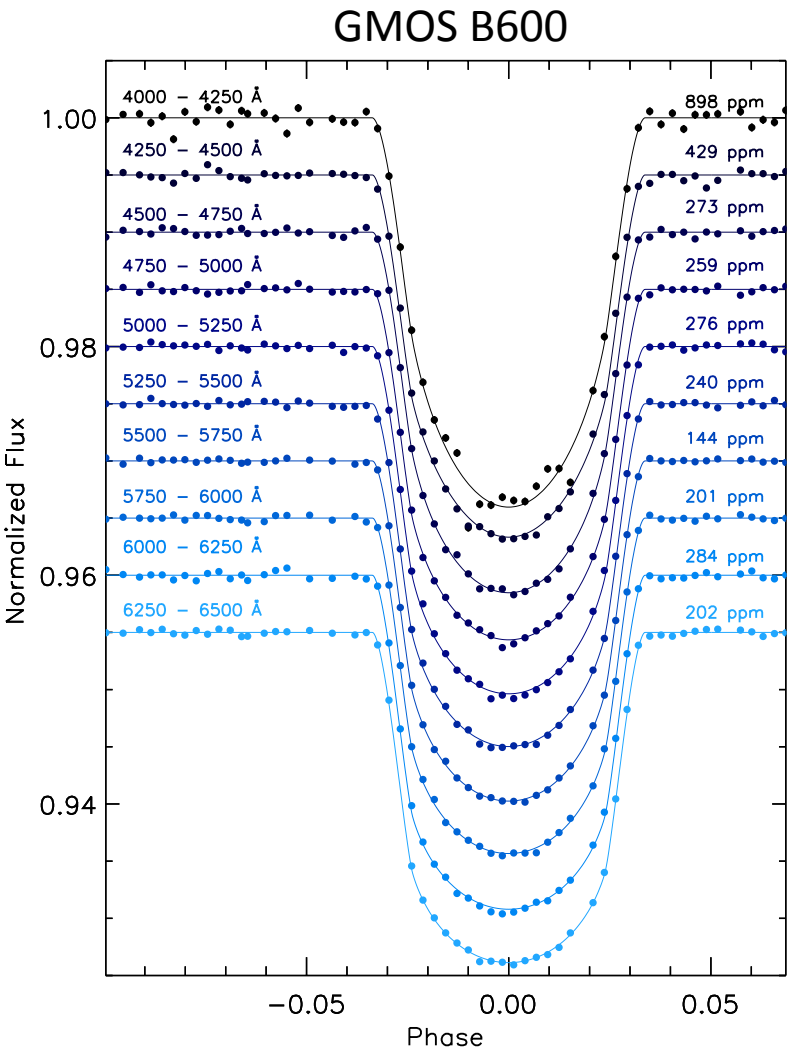


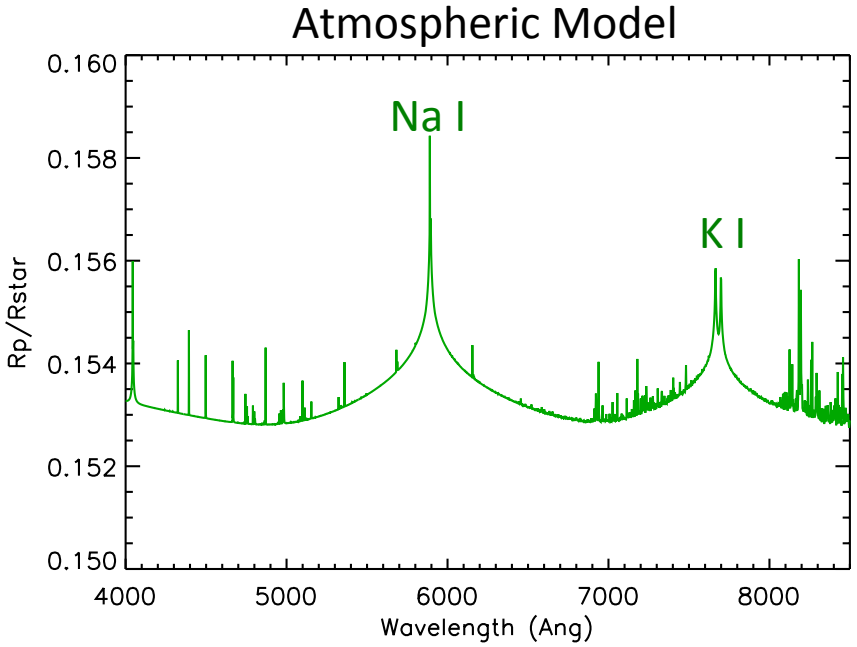


Transmission Spectra



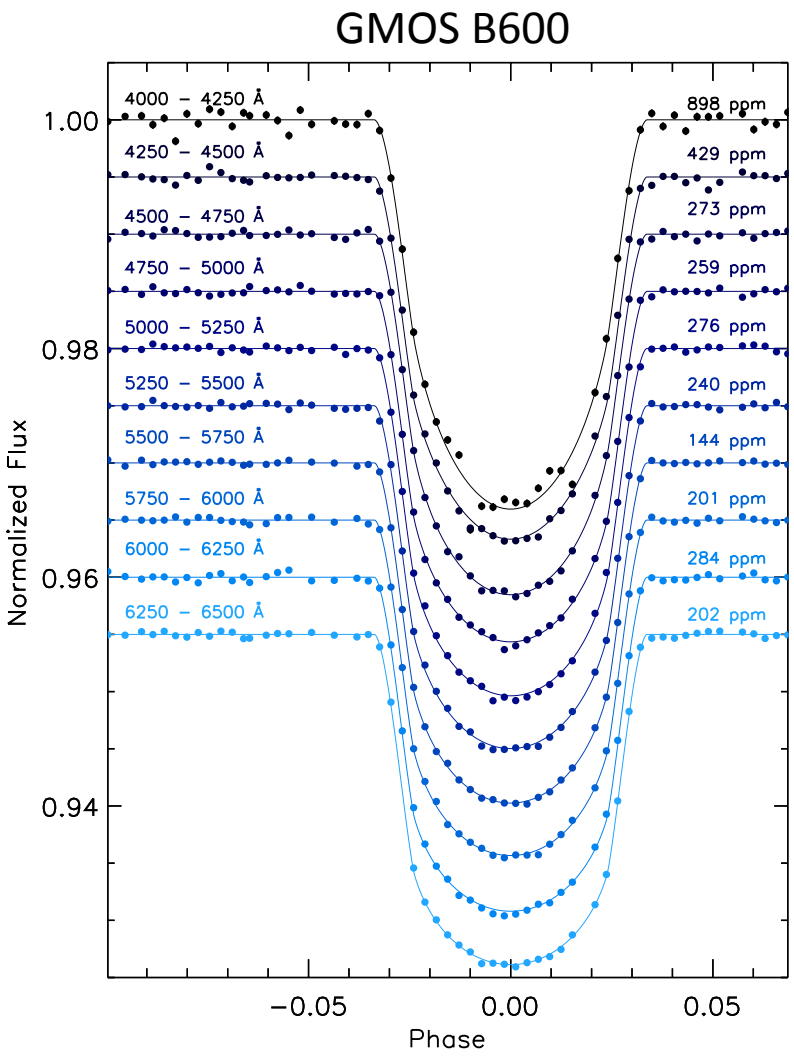
Transmission Spectra: WASP-4b

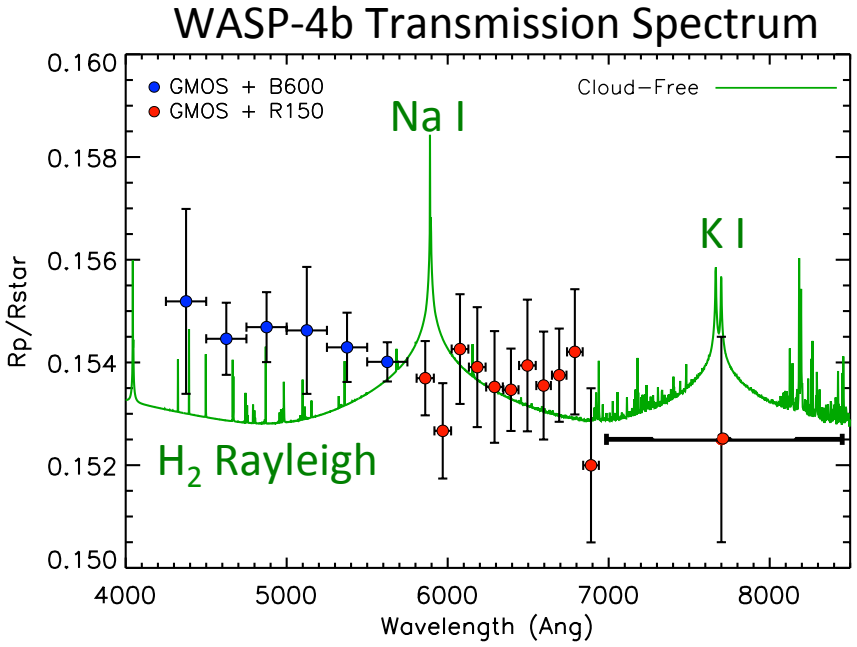




Model: Fortney et al. (2008,2010)

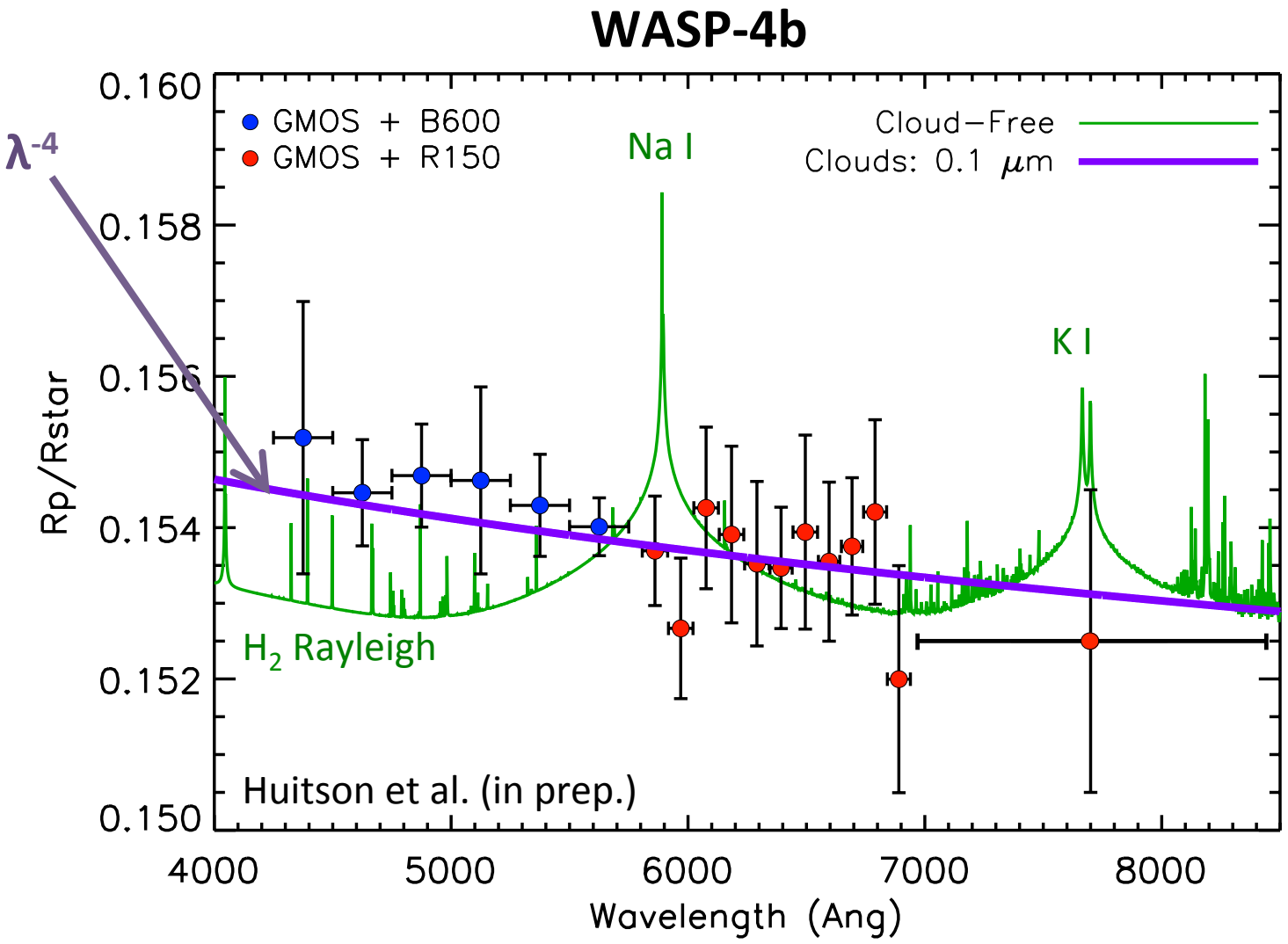
Transmission Spectra: WASP-4b





Model: Fortney et al. (2008,2010)

WASP-4b: Cloud-Dominated



Challenges

- Requirement:

  100 ppm/10 nm

Challenges

- Requirement:

  100 ppm/10 nm

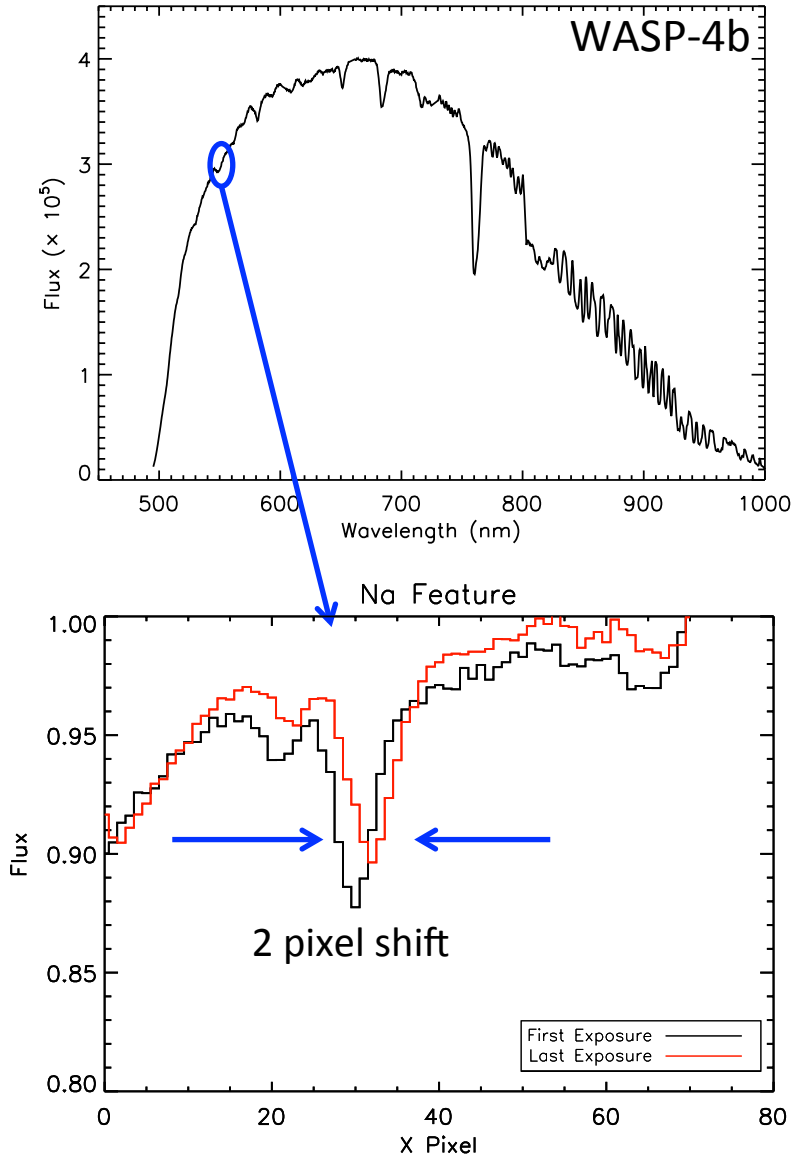
- Problem: Wavelength solution changes in time

Challenges

- Requirement:

  100 ppm/10 nm

- Problem: Wavelength solution changes in time

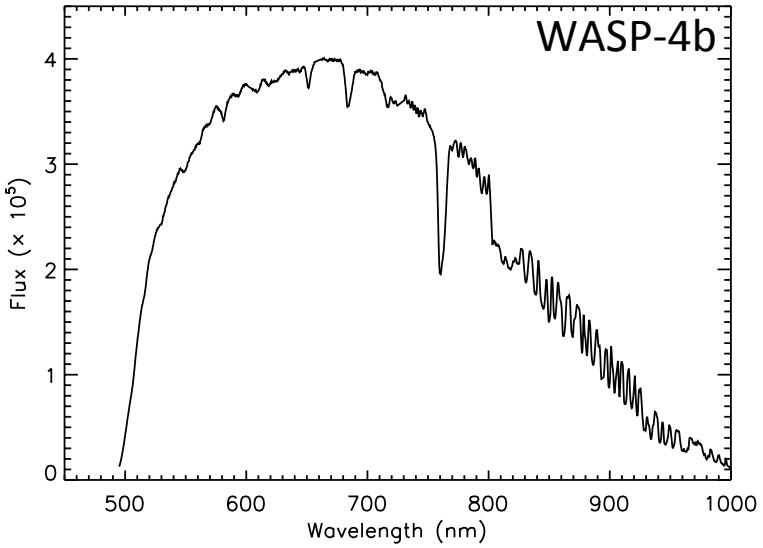


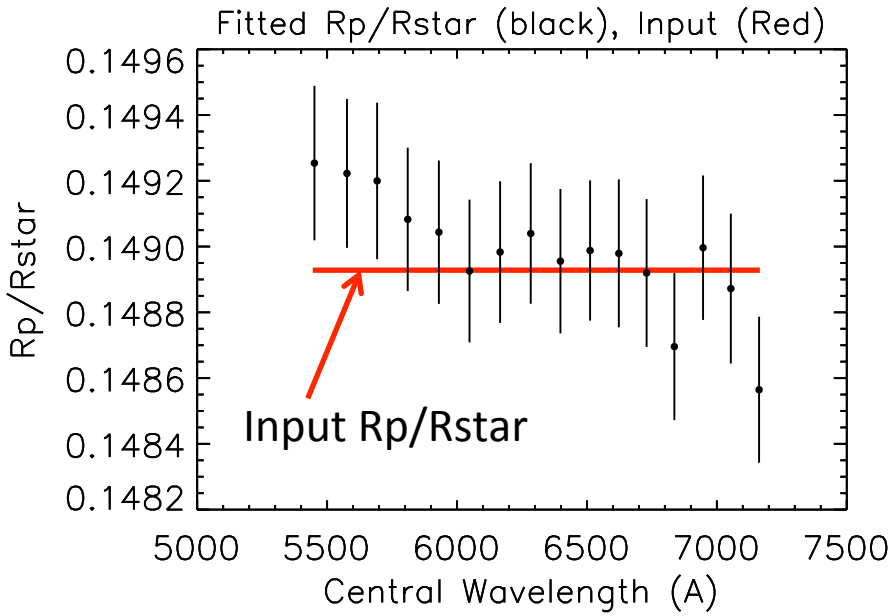
Challenges

- Requirement:

  100 ppm/10 nm

- Problem: Wavelength solution changes in time



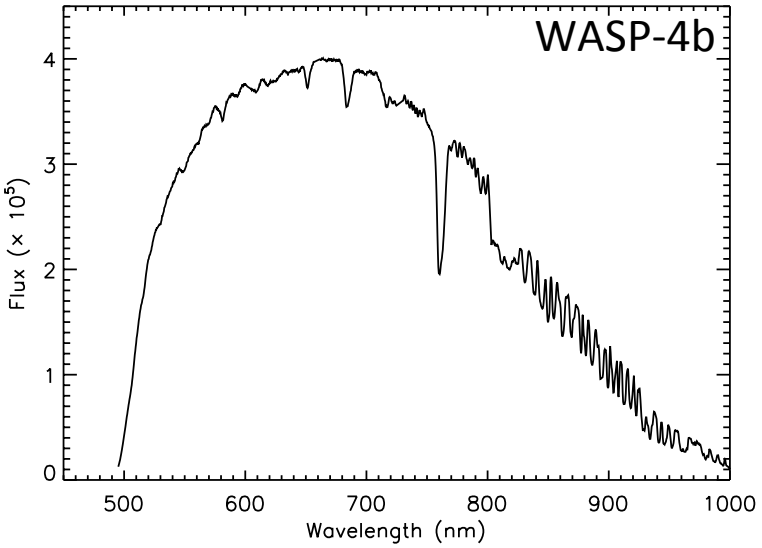


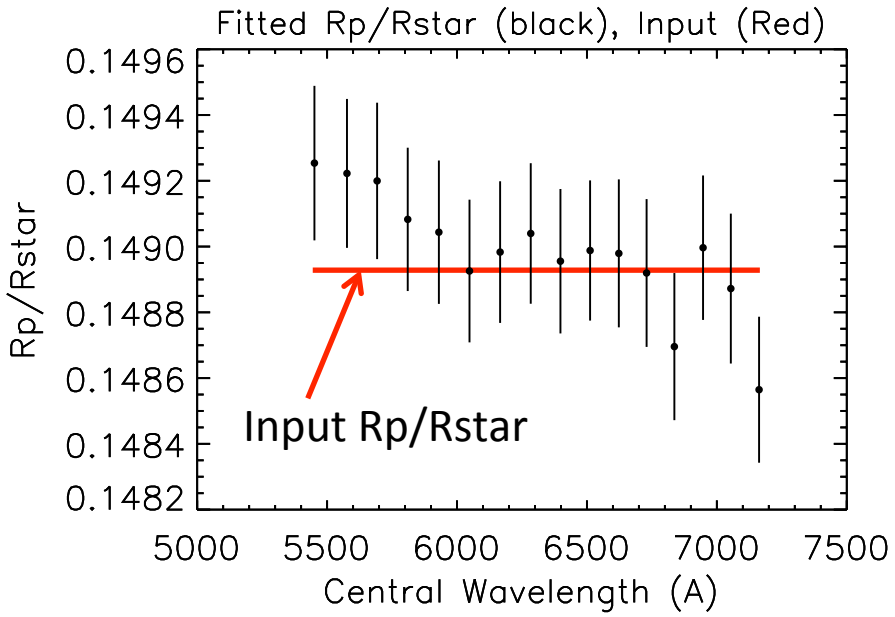
Challenges

- Requirement:
  100 ppm/10 nm

- Problem: Wavelength solution changes in time

- Solution: procedures to measure and correct shifts in focal plane
  - Precision improved 2x

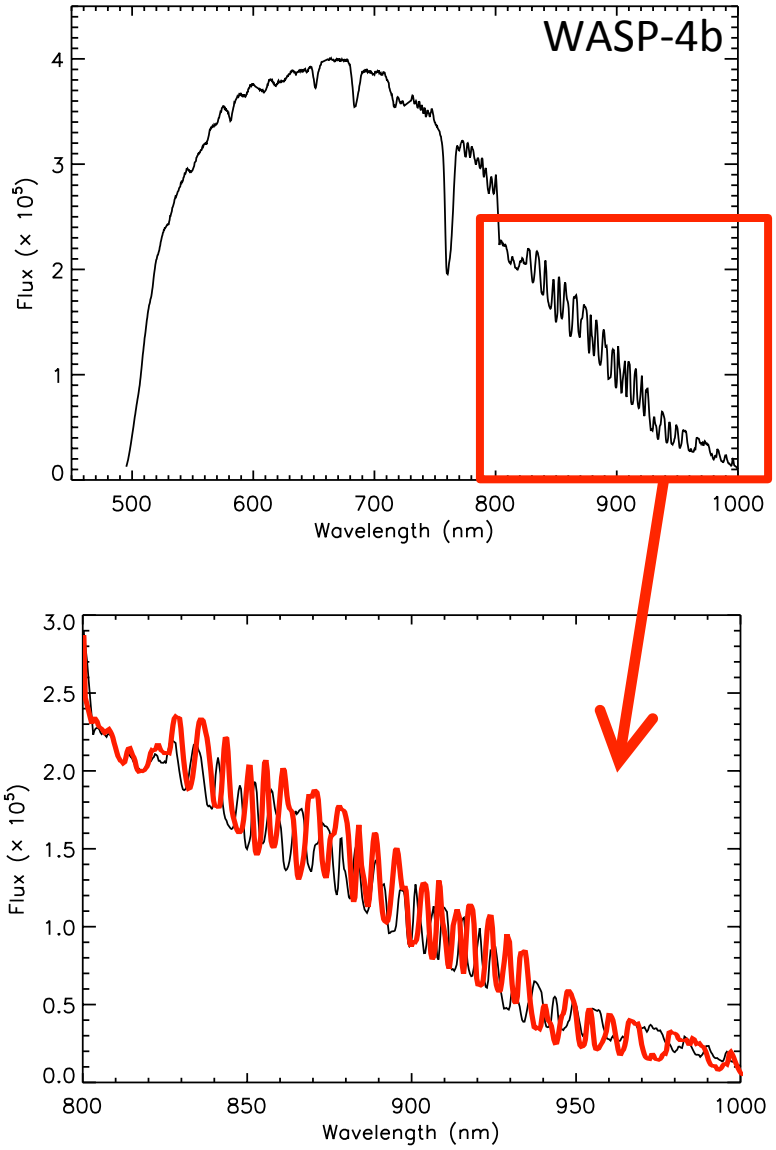




Challenges

- Requirement:
  100 ppm/10 nm

- Problem: Fringing at 10% amplitude

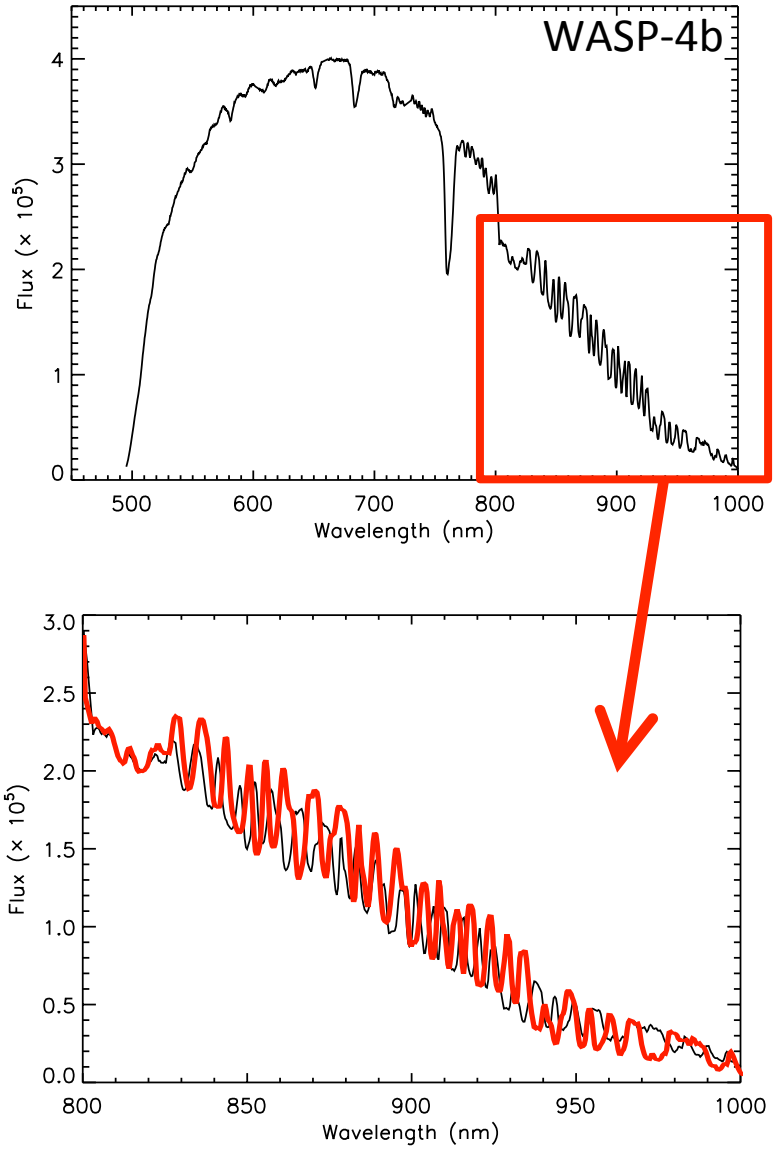


Challenges

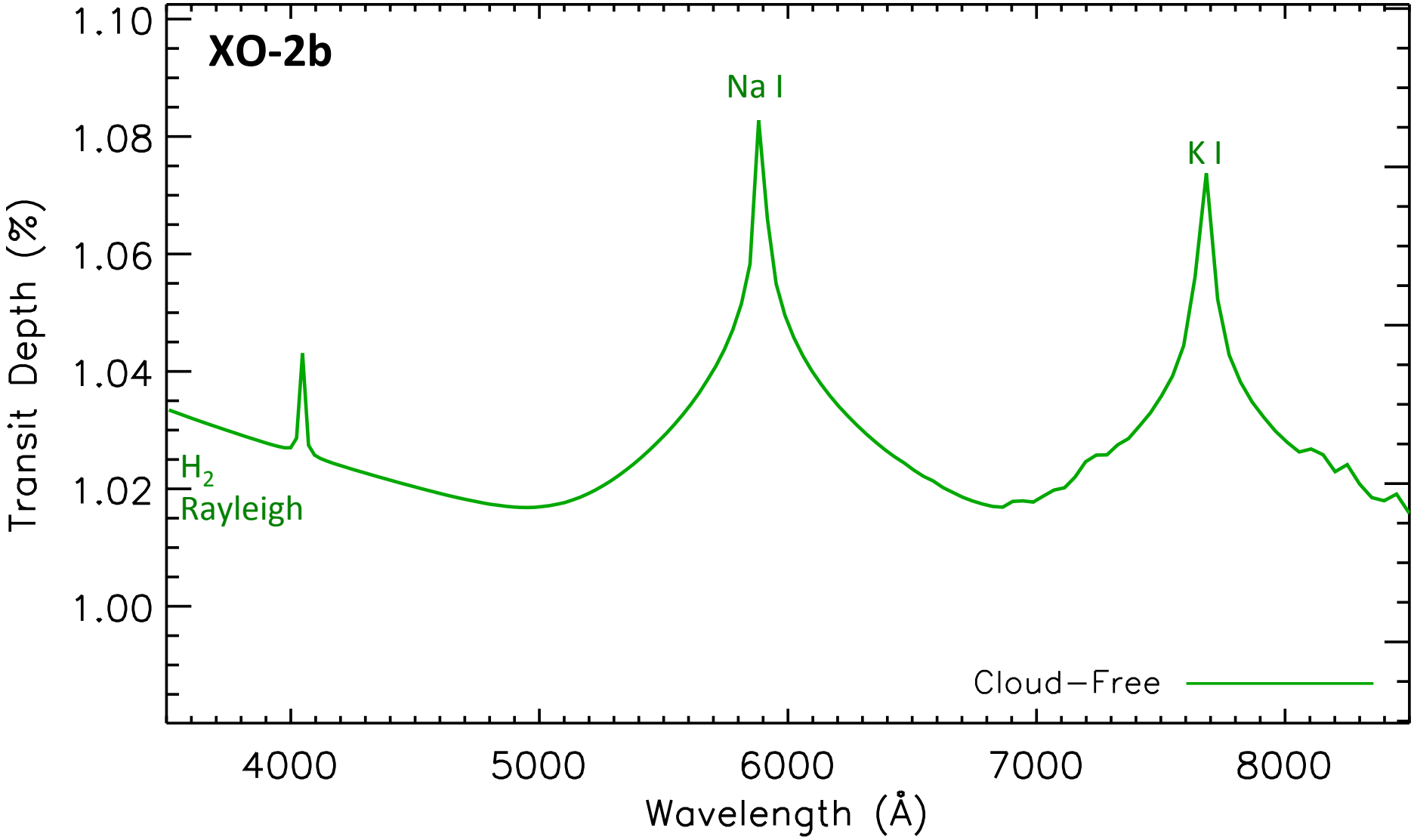
- Requirement:
  100 ppm/10 nm

- Problem: Fringing at 10% amplitude

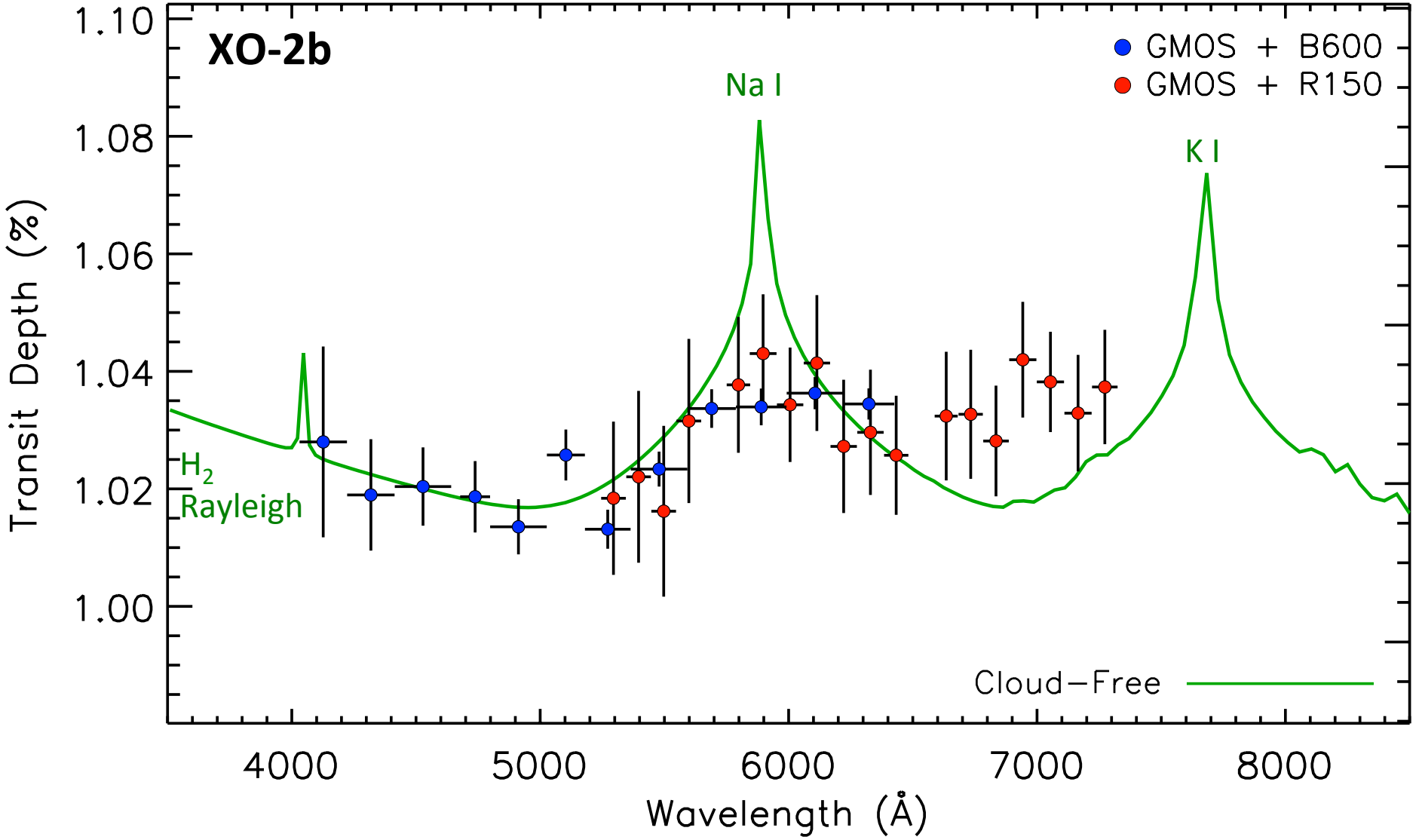
- Solution: Use large photometric bin to measure continuum level



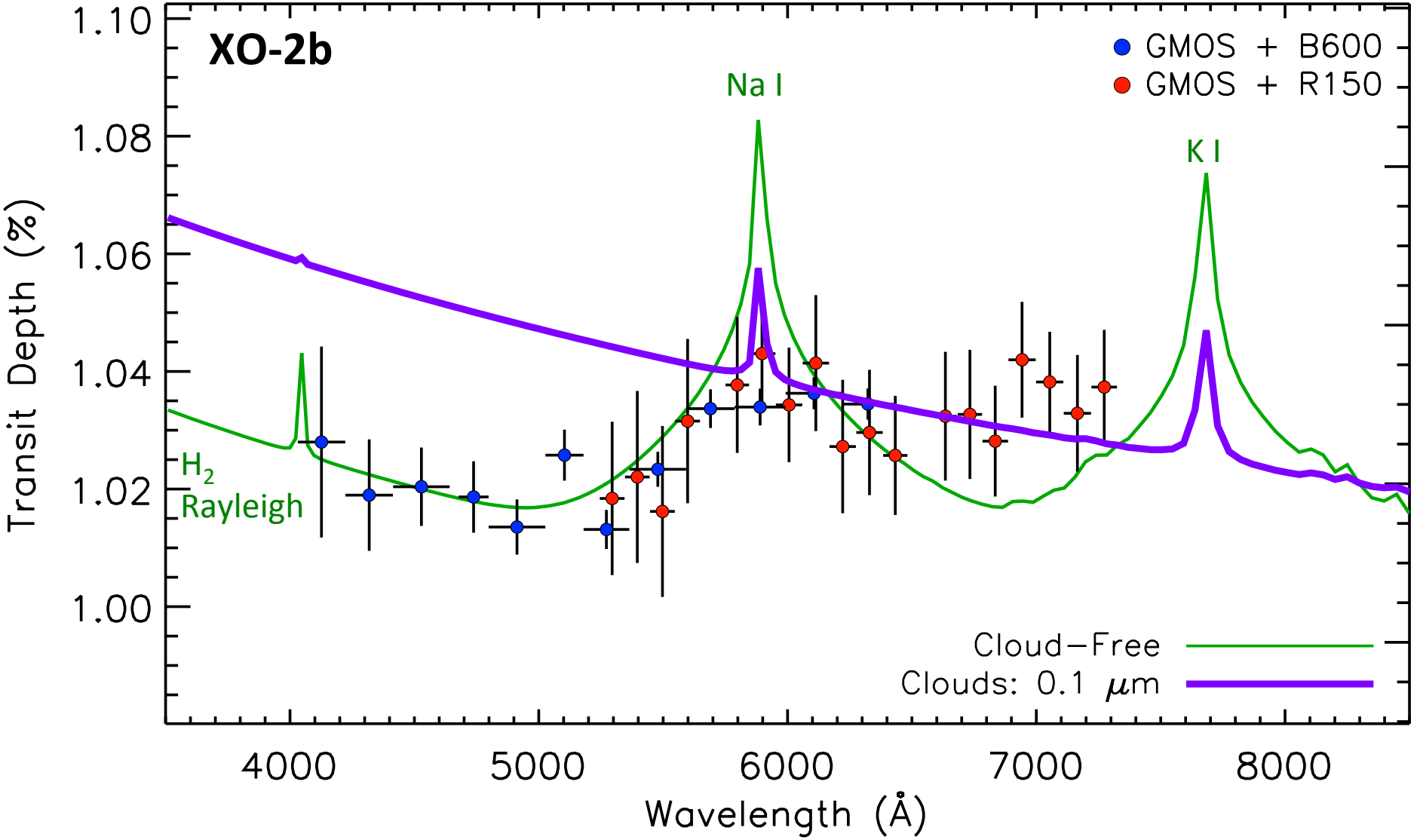
Second Result: XO-2b



XO-2b: Detection of Na

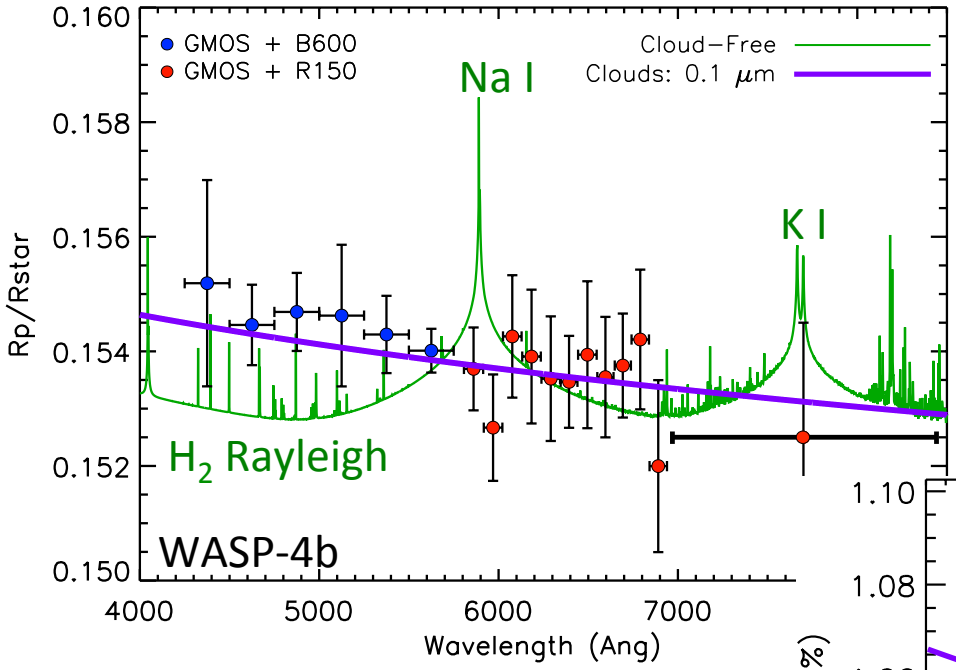


XO-2b: Cloud-Free



First Results from GMOS Survey

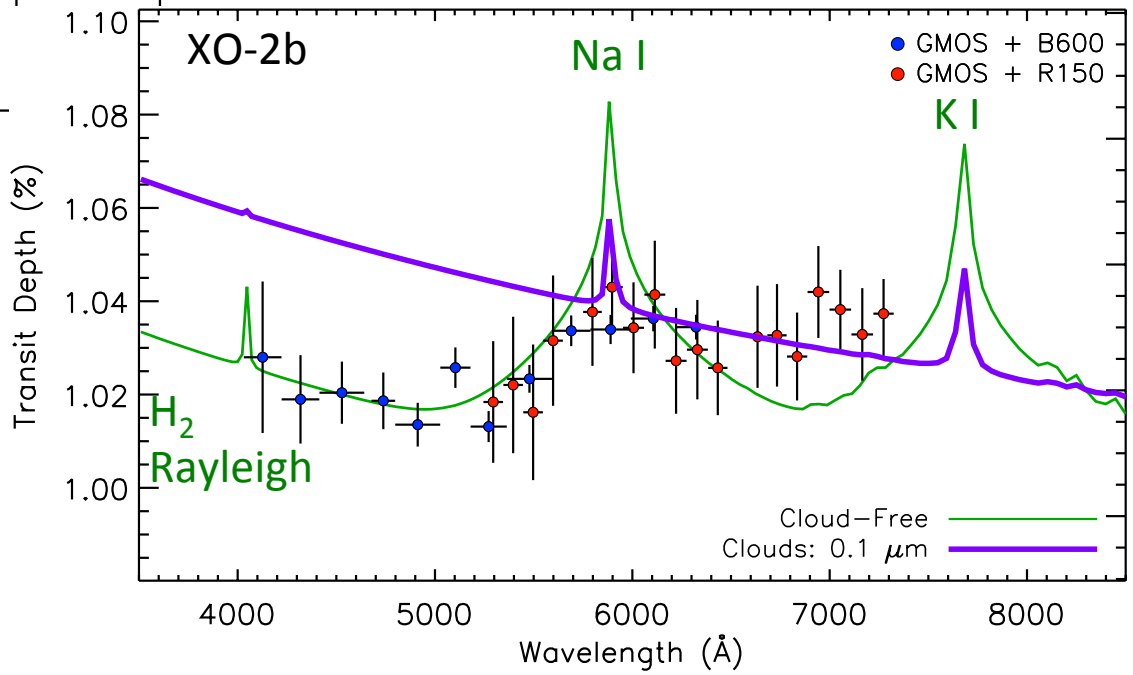
Clouds detected



First Important Result

Two planets similar, yet two different signatures => diversity

No Clouds, detection of Na



Summary

- Conducted a 9-planet survey
- Worked in-depth on 2 targets
- Preliminary results show diversity in planet atmospheres
- Pathfinder for MOS technique (e.g. Keck, VLT).
- Lessons:
  - Repeatibility
  - MOS provides the precisions that we require
  - Scheduling
  - Shifting of spectra can introduce spurious signal and must be corrected
- Require dedicated instrument in order to improve on stability