Transit Observations with the Spitzer Low Resolution Spectrograph

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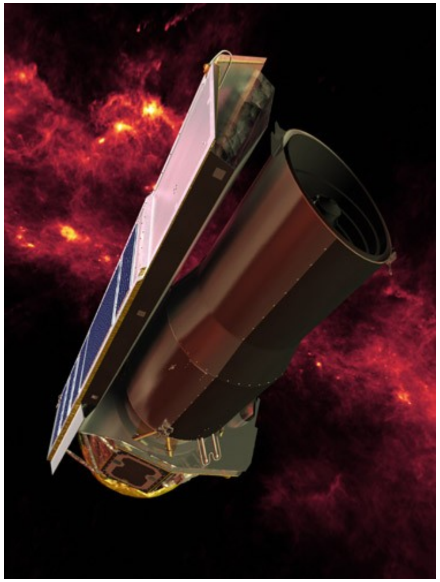
Spitzer Low-Resolution Spectrograph: Issues in Data Reduction

The Spitzer Space Telescope:
- 85 cm telescope, fully cooled

The Spitzer low resolution spectrograph:
- long narrow slit (2 pixels wide; 3.6")
- Spectral resolution of ~ 100
- Spectra between 5 to 15 micron in 2 orders
- 128x128 pixels (effectively 30x128 in 1 order)
- Detector type: arsenic-doped silicon (Si:As) array

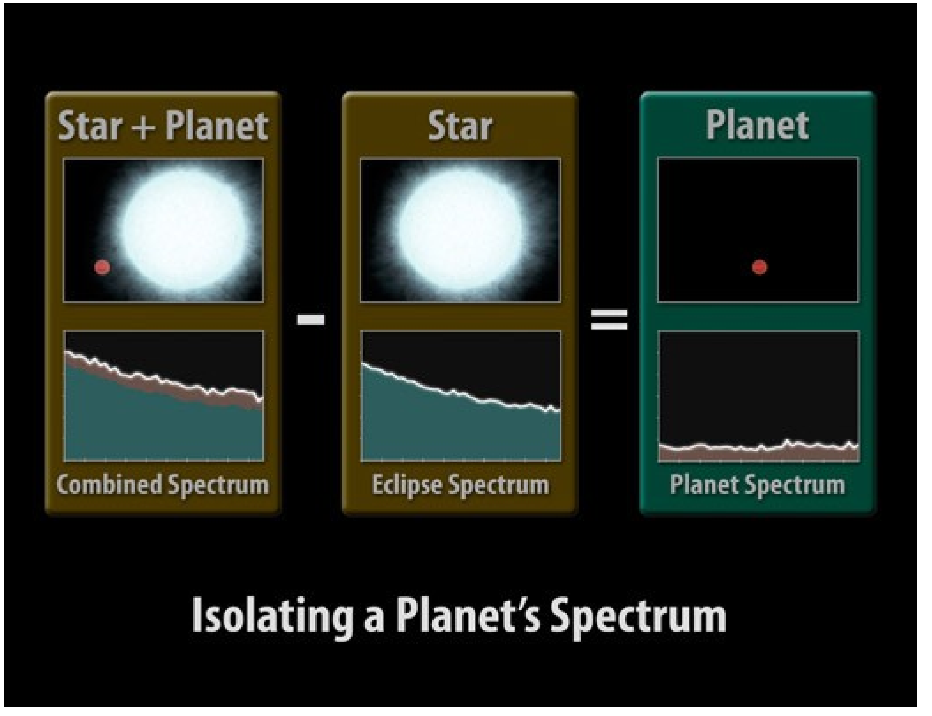


Spitzer Data Reduction Issues:

Pointing:
Initial pointing uncertainty and pointing drifts during observation cause the source to move in the narrow slit.

Detector:
Several electronic stability issues of which "Charge-trapping" (see e.g. Smith et al 2008 SPIE 7021) had the most severe impact on the flux stability.

Spitzer Transit Spectra with IRS: Secondary Eclipse



Publications only for 2 objects: HD189732 and HD209458

Grillmair et al. 2007, ApJ 658; Grillmair et al. 2008,Nature 7223

Richardson et al. 2007, Nature 445; Swain et al. 2008, ApJ 674

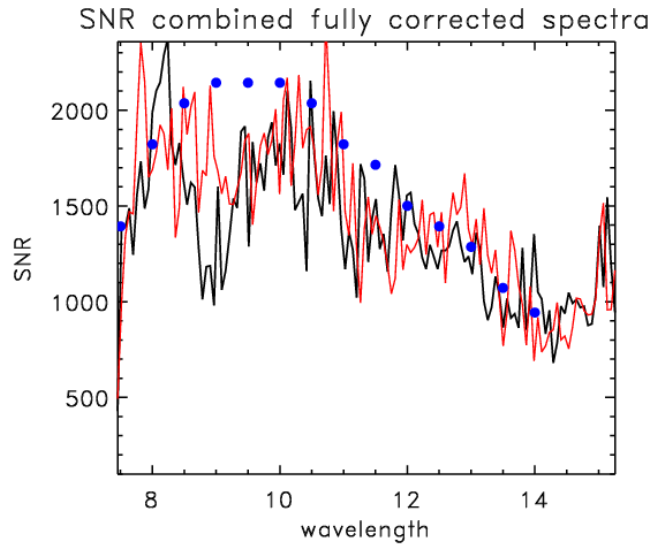
Spitzer Transit spectroscopy:
SNR Considerations for Target Selection

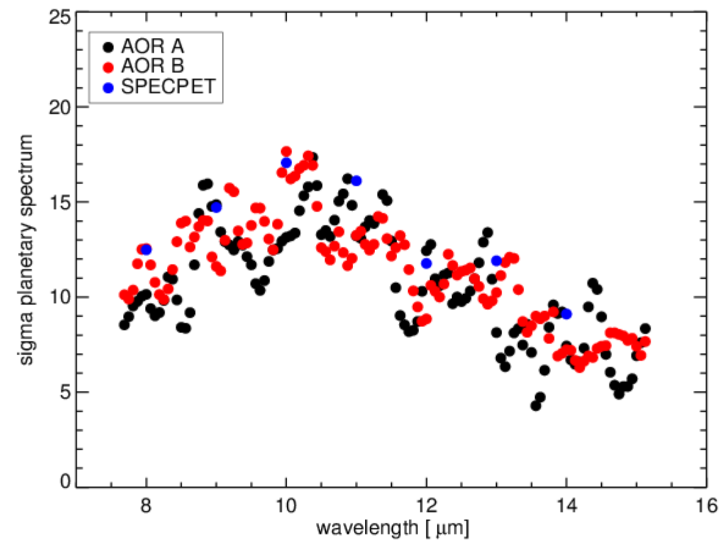
Maximum SNR on K~6 star is ~2500 in 1 h.

This is enough to detect atmospheric emission a few tens of a percent above the stellar atmosphere.

Transmission spectroscopy more favorable at shorter wavelengths

2 Hot Jupiters ideal for observing with Spitzer: HD189733 and HD209458

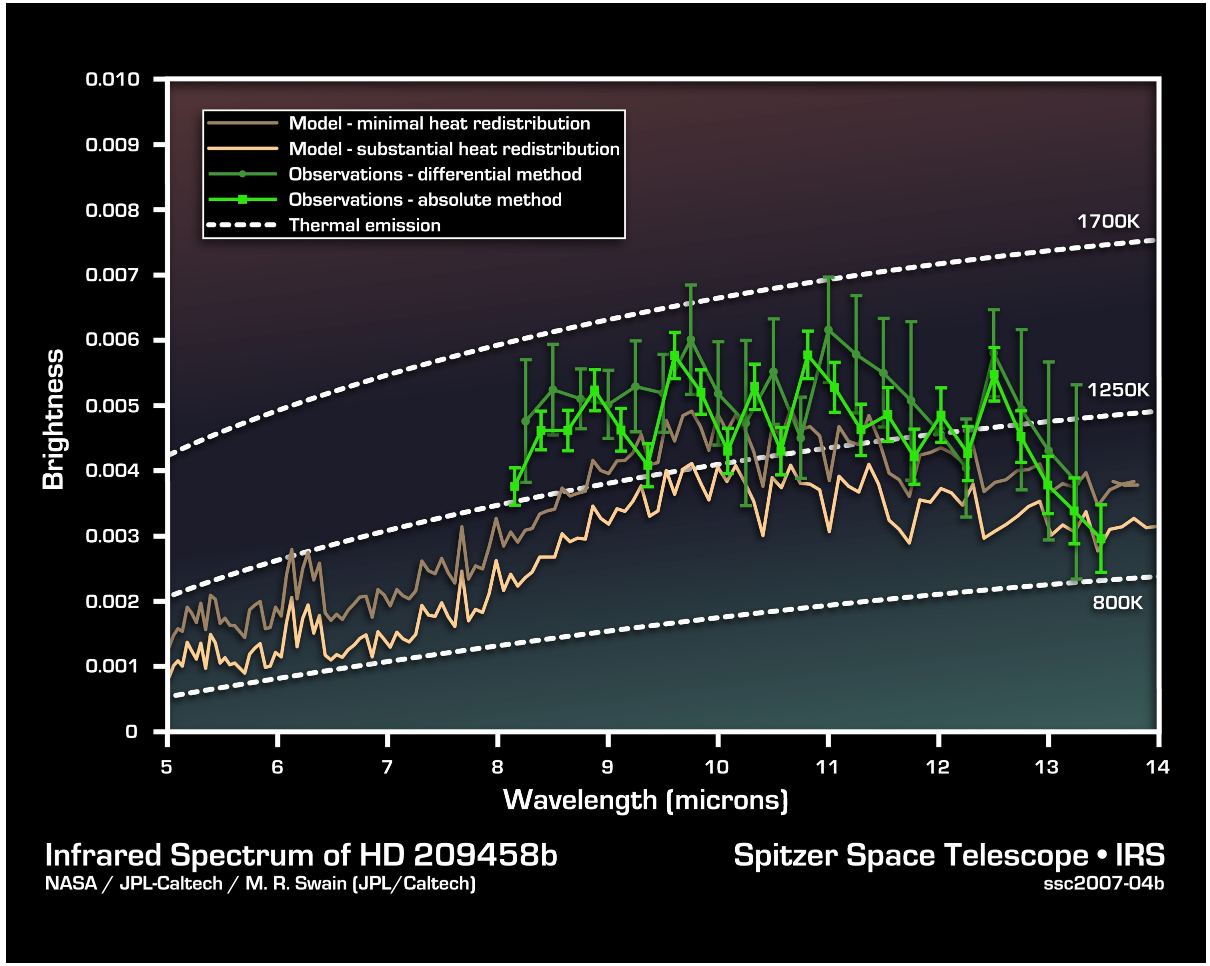




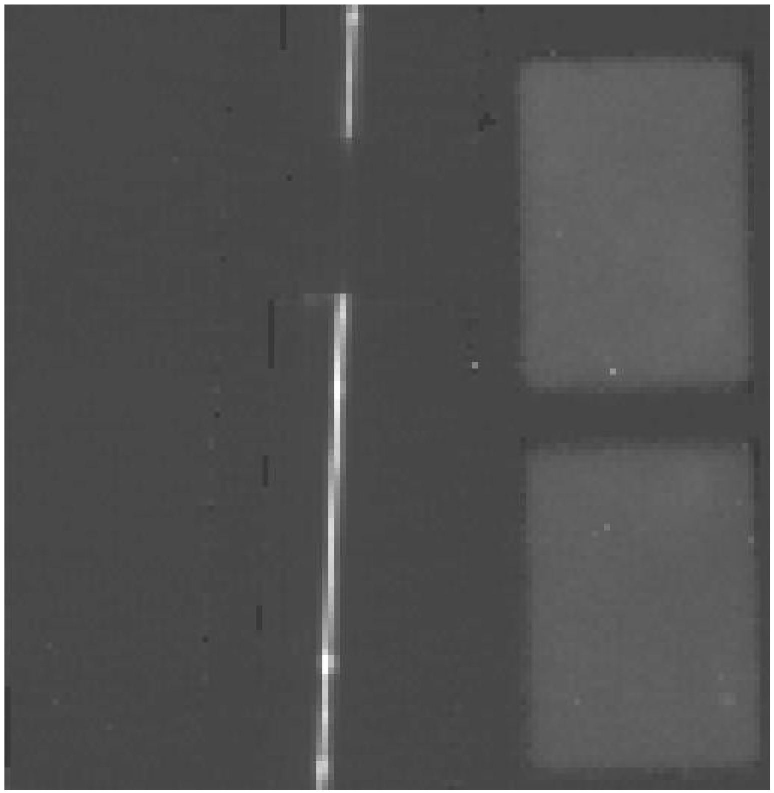
Example: HD209548

Featureless thermal emission with 8-9 μm excess. No water detected and a possible indicator of clouds

But: Evidence for Water in HD189733 though the SNR of the initial spectra was not optimal to detect molecular features.



Approach to Provide near Photon Noise Limited Spitzer Spectra



- background subtraction
- extract data
- pointing correction
- flatfield correction
- Charge trapping correction
- construct spectrum

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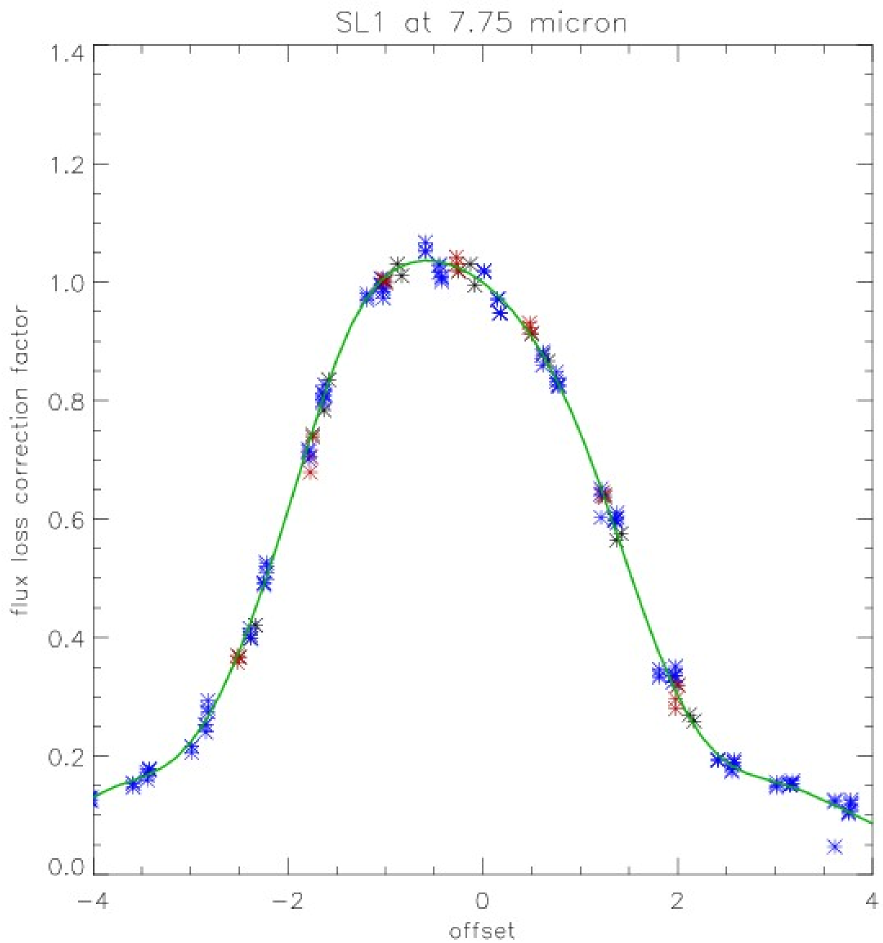
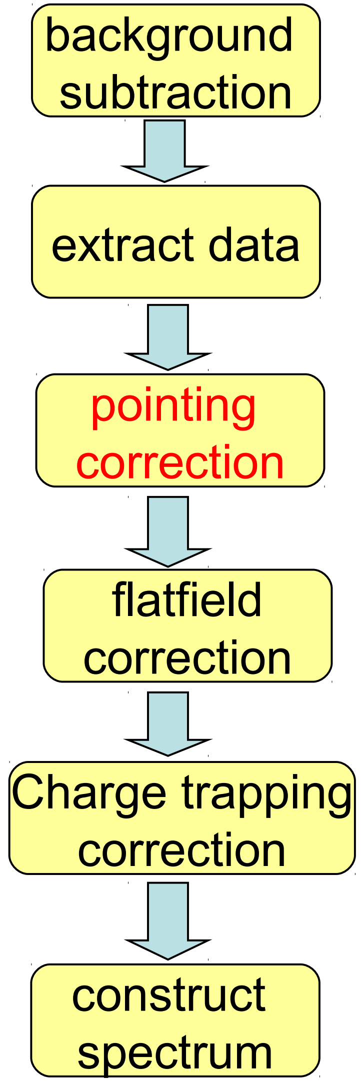
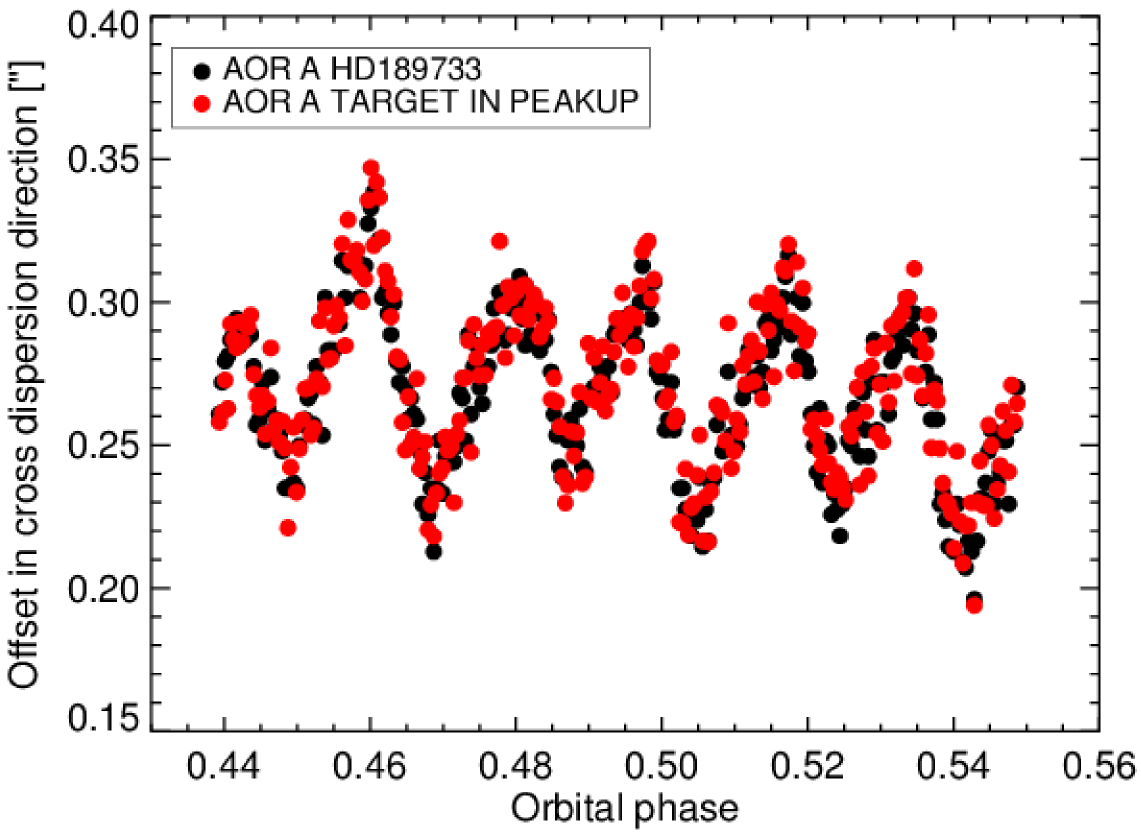




Our Approach to Provide Photon Noise Limited Spitzer Spectra



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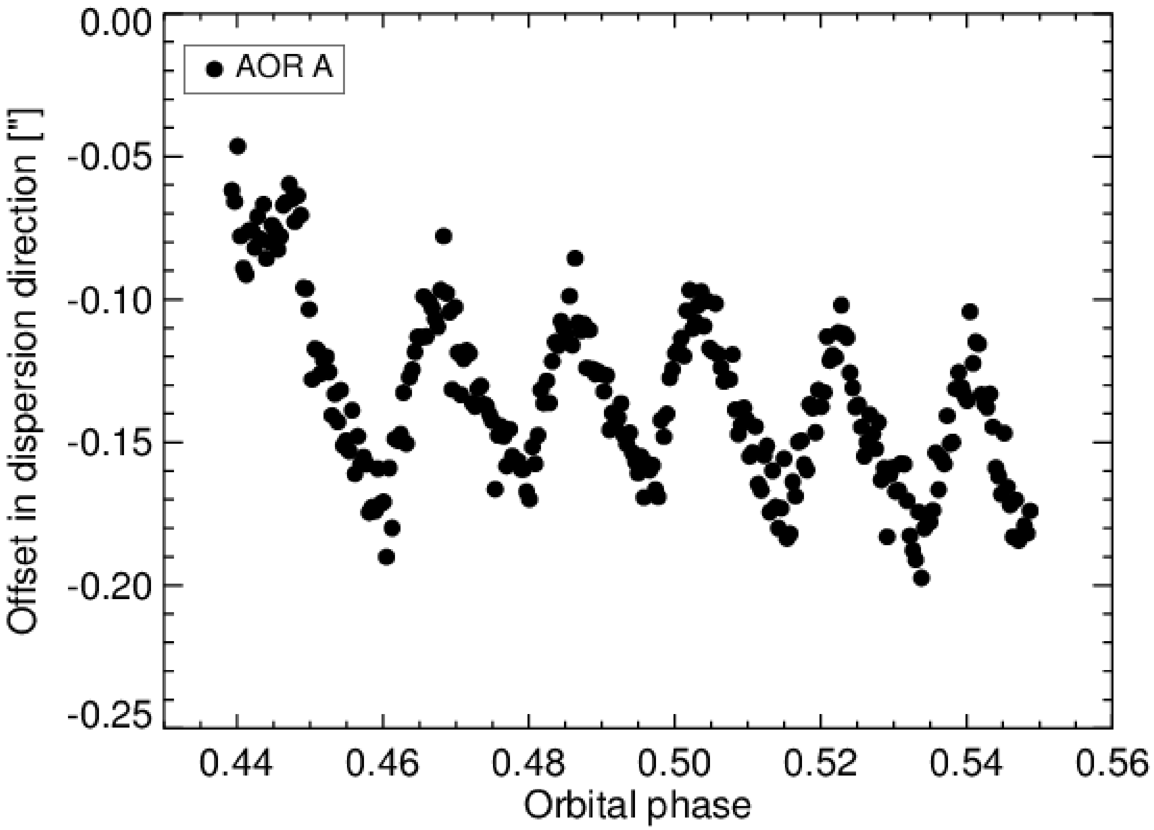

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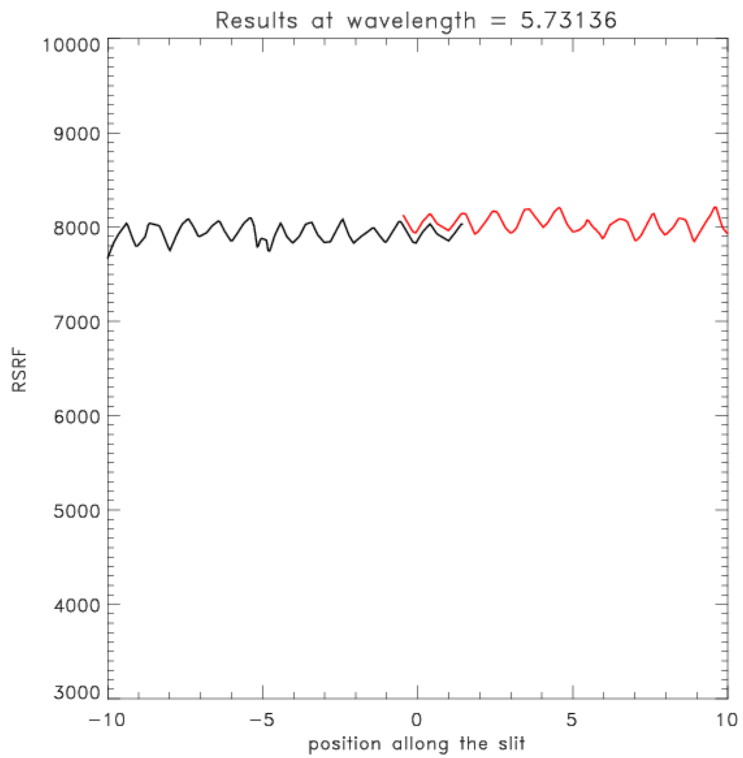
Approach to Provide near Photon Noise Limited Spitzer Spectra

JWST Transit Workshop Pasadena



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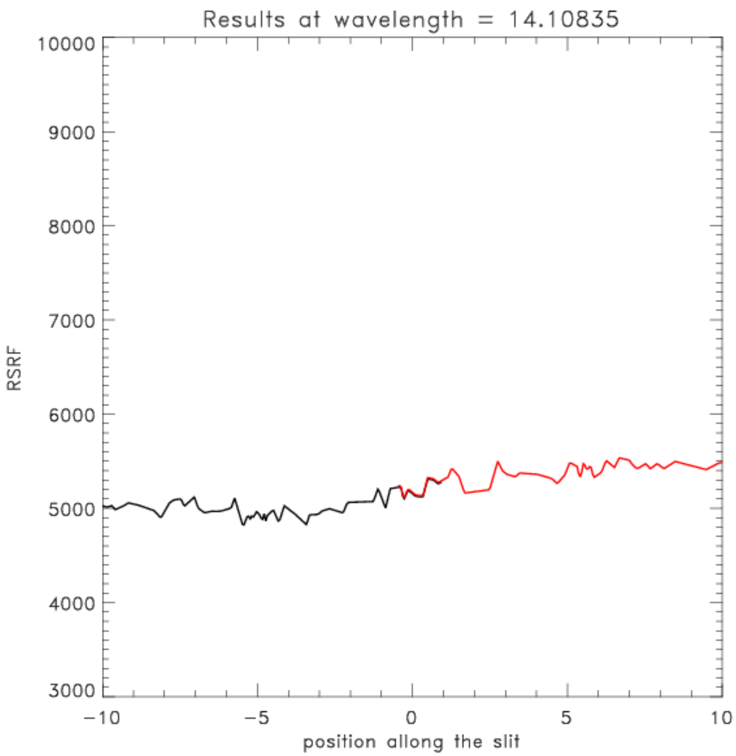

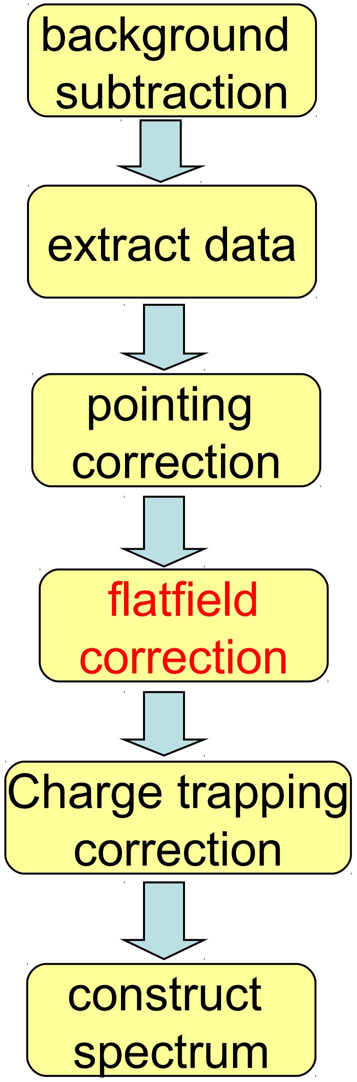

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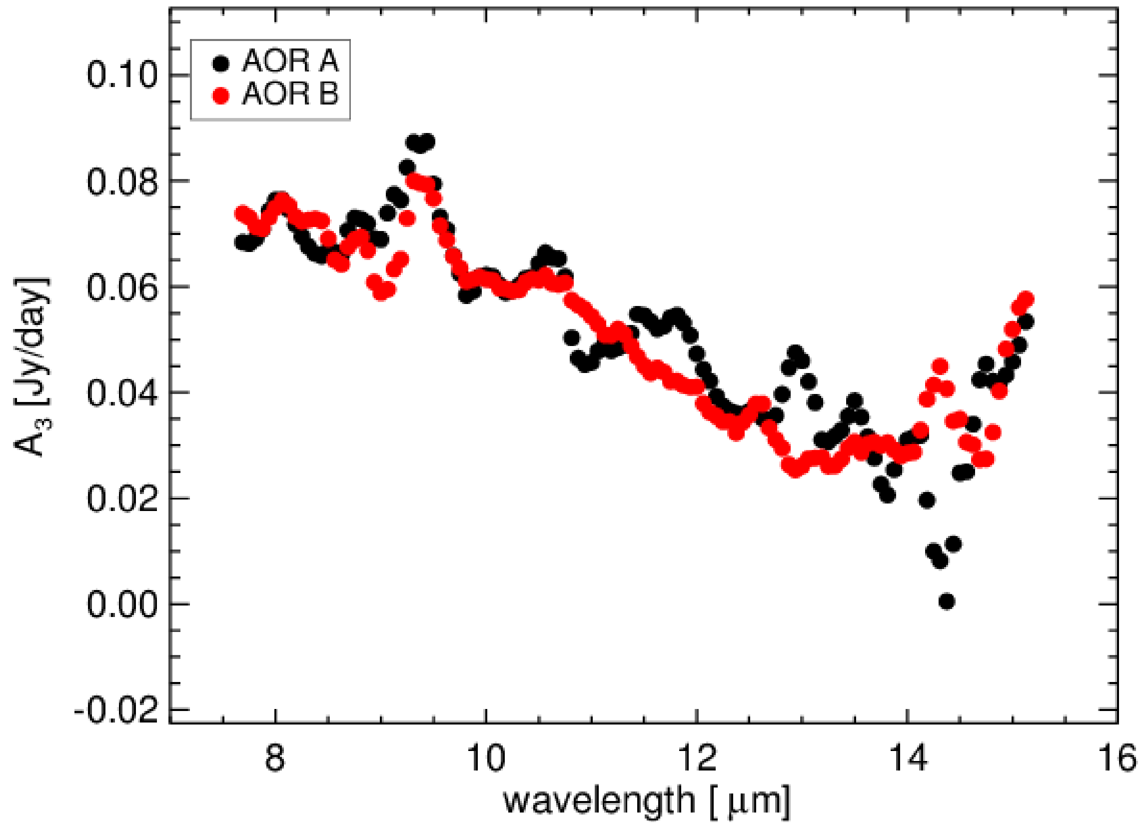
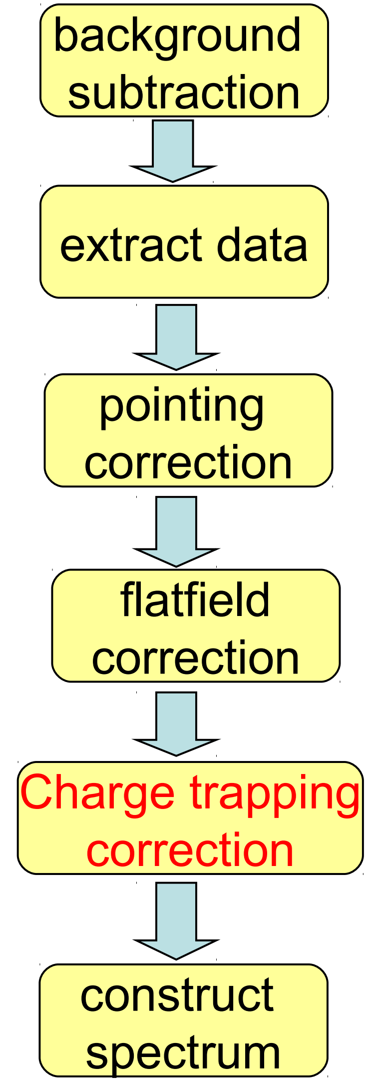
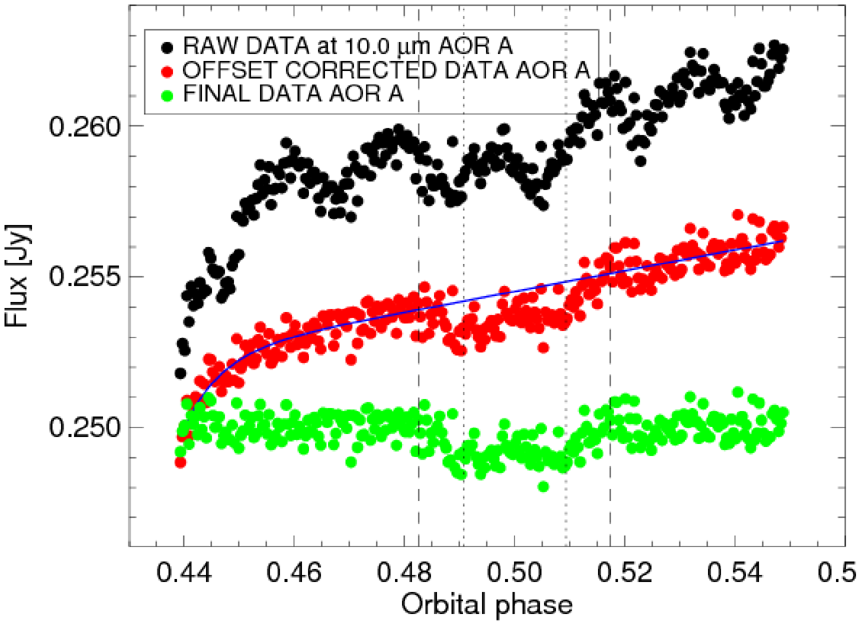
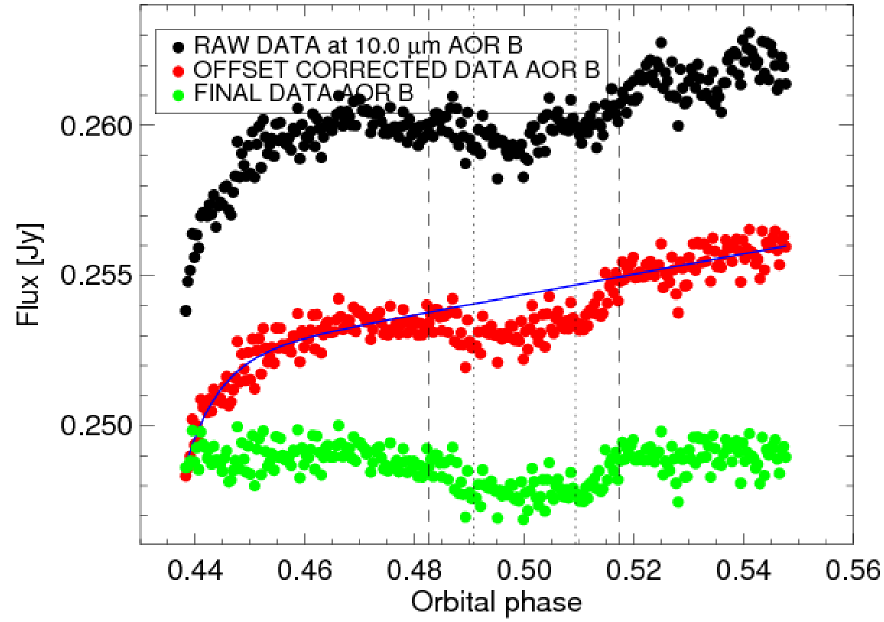


(see also Smith et al 2008 SPIE 7021)



Spitzer Lightcurves of HD189733b





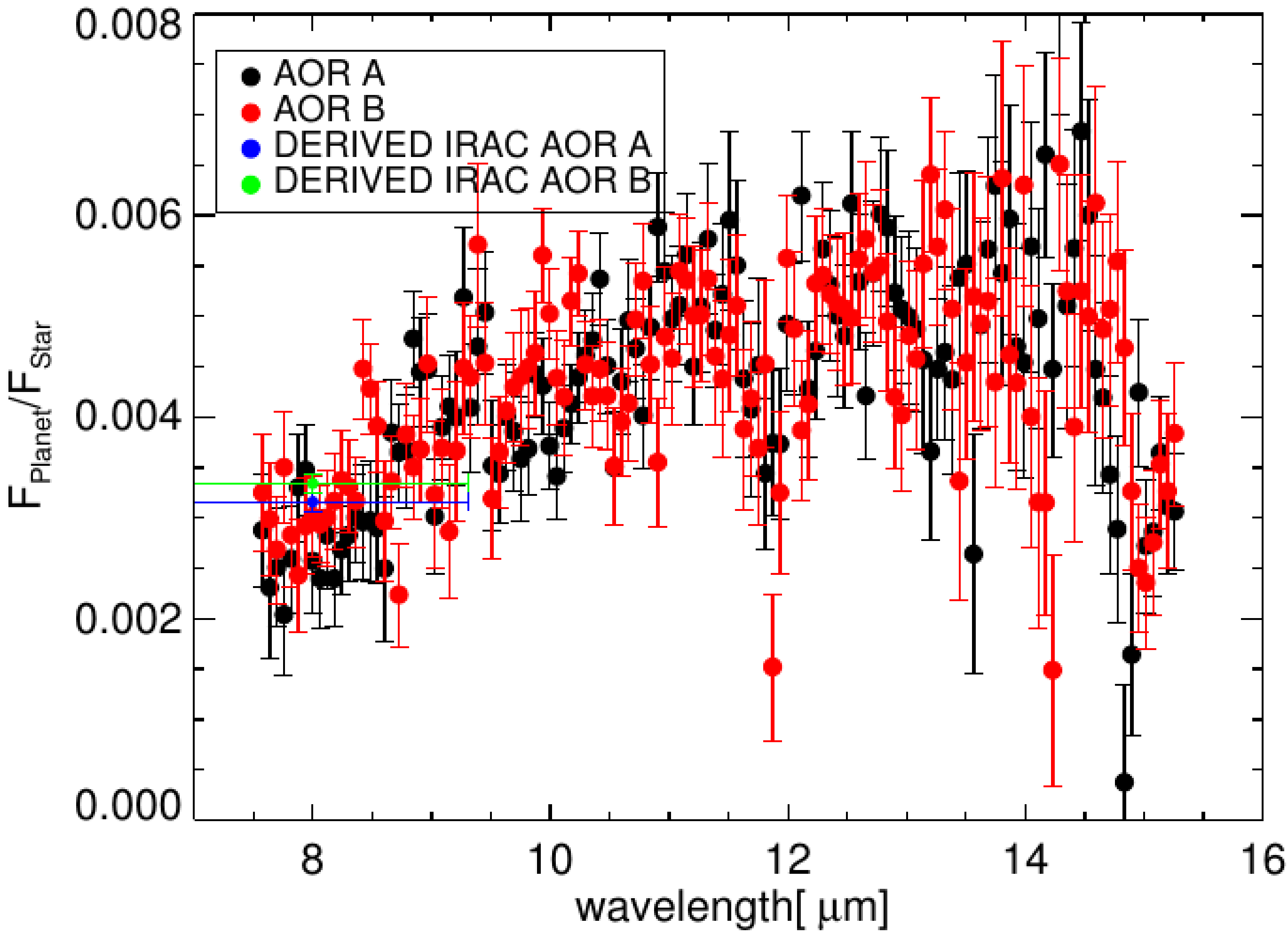
Breakthrough in Spitzer Calibration: Pointing of telescope could be determined from background stars in peak-up (imager) field.

Lessons Learned:

Need to know pointing (optical channel, zero order of IR spectra)

Need to know detector behavior (including House keeping data of bias voltages, Detector temperatures etc.)

Infrared Emission Spectra of the Dayside of HD189733b



Bouwman, Crossfield et al. in prep.

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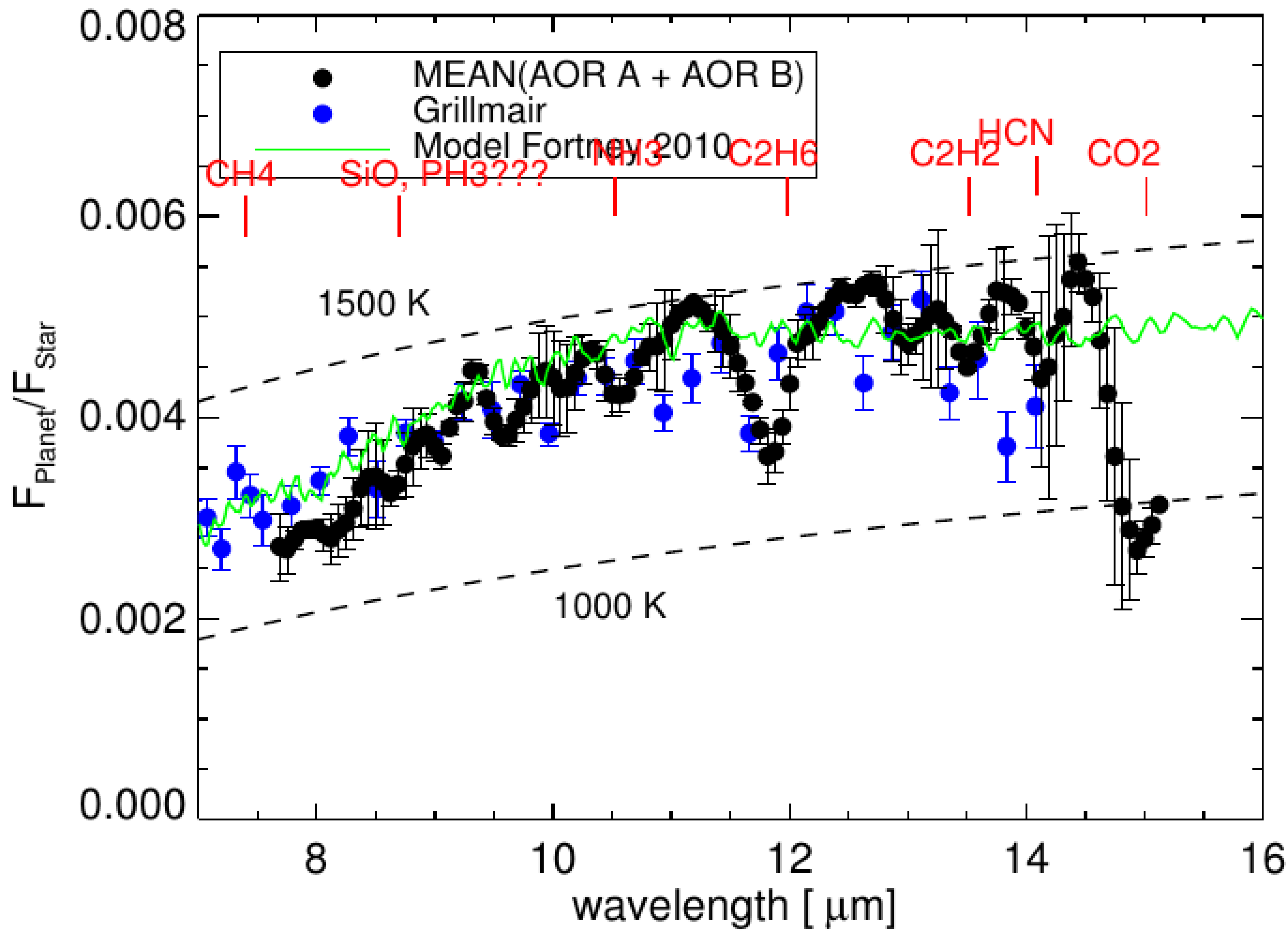

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Lessons Learned for EChO

Spitzer (and also HST) has demonstrated that transit spectroscopy is possible

A SNR in the order of 2500 could be reached during the transit observation of a K~6 star, resulting in our detection of molecular features in the spectrum of HD189733b.

For this substantial instrumental artifacts had the be calibrated out to reach the photon-noise limit. Especially pointing drifts in combination with a narrow slit, and electronic instabilities caused a substantial noise exceeding the planetary signal.

Breakthrough only possible after determining telescope pointing from background object in peak-up field.

Lessons Learned for JWST:
No Slit and known pointing (optical channel)
Known detector behavior (House keeping data of bias voltages, temperature etc.)

But!
The stability reached must be at least a factor of 10 larger with JWST compared to Spitzer in the Mid-IR to reach the photon-noise limit. Need to work on intrinsic stability at high flux!. (Note: this was not a design driver for Spitzer or JWST)

End