The Role for Adaptive Optics - with Examples

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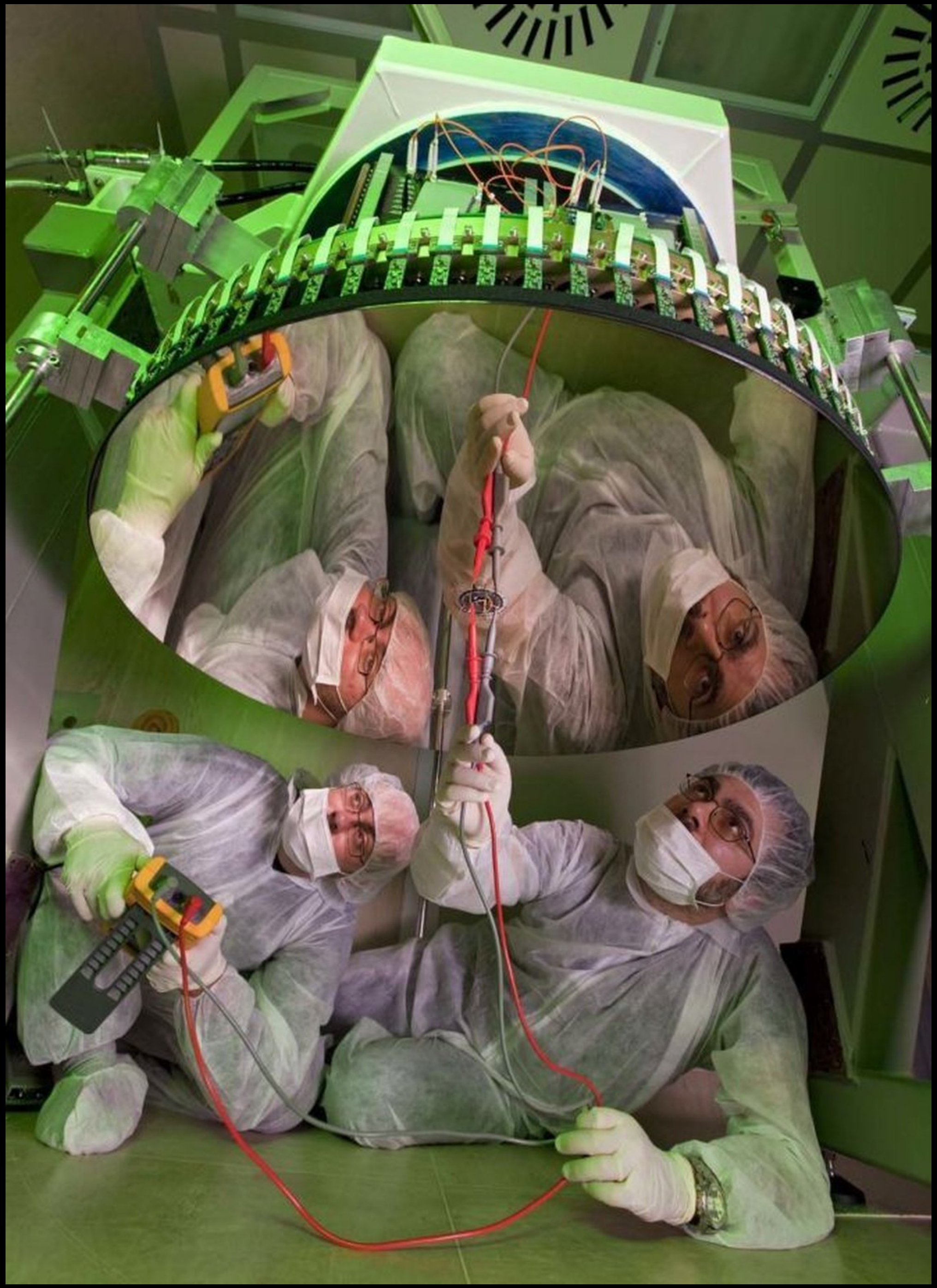
The evolution of AO

- AO is, traditionally, a “follow up” technology.
  - AO allows us to figure out how things actually work.
- For most current systems, AO was implemented as an add-on instrument to the classical telescope.
  - Extra Optics
  - Vibrations and environment not optimized for high precision imaging.
  - Dedicated instruments
- Broader science becomes possible with increasing capabilities and integration.
  - LGS enables many extragalactic science cases.
  - Broader wavelength coverage is important for followup and characterization.
  - Ground-layer AO (GLAO) enables wide, deep surveys.

AO in the next decade

- AO will be integrated into the telescope facility.
- Wide-field observations
  - GLAO or MOAO can provide multiplexing advantages.
- mid-IR observations
  - Broaden wavelength coverage.
  - Support JWST observations.
- Short wavelength observations
  - Provide the sharpest images possible (sharper than JWST).

Technology Example: Adaptive Secondary Mirrors

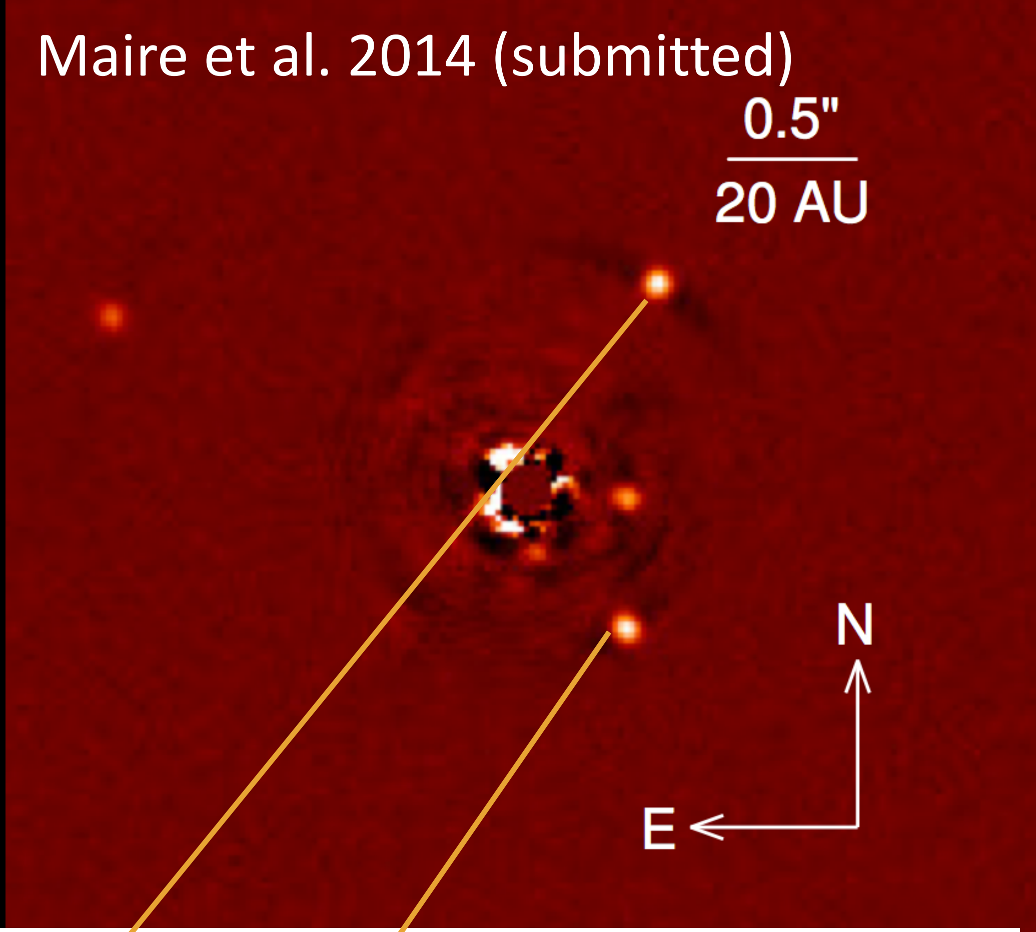


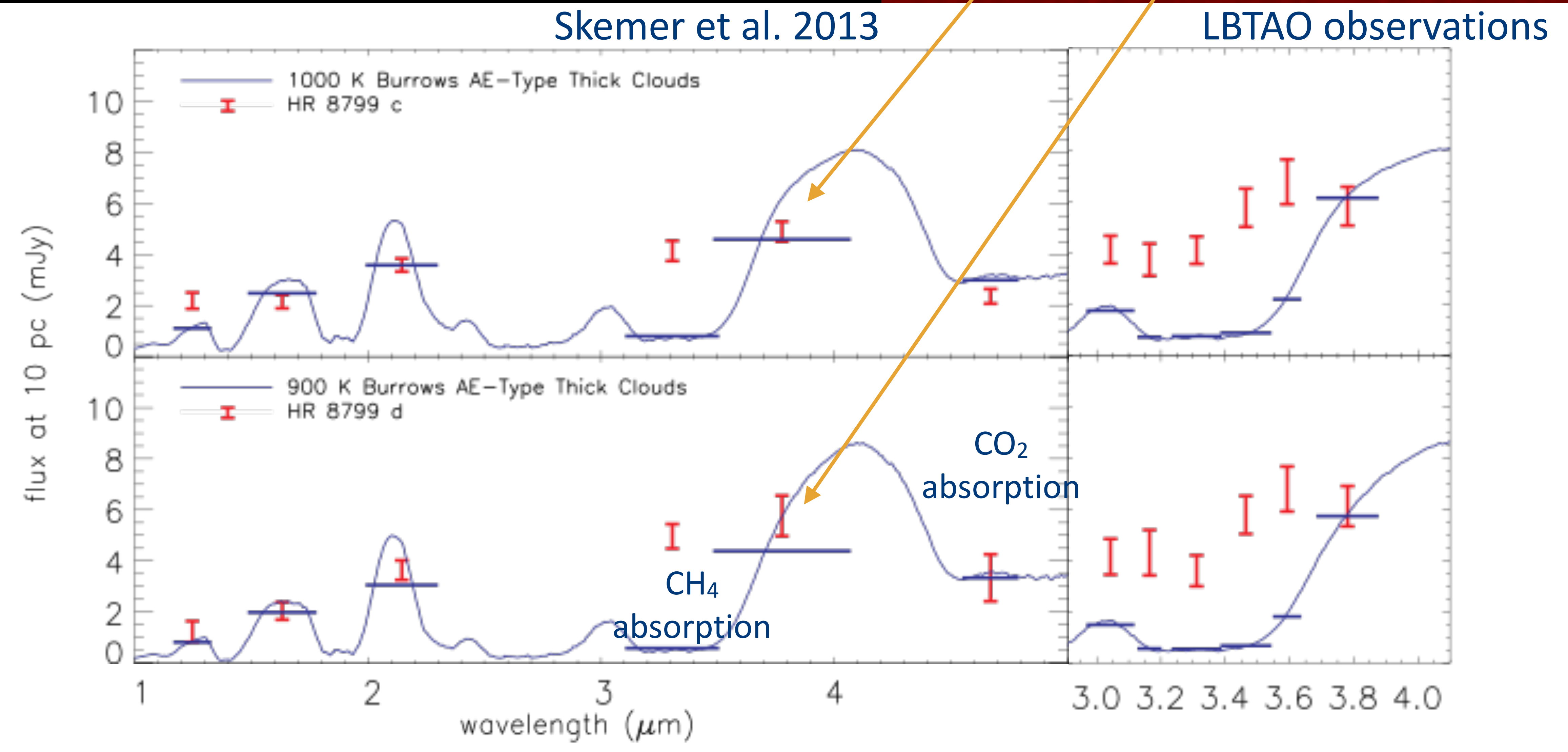
State of the art: LBTAO with 80 % Strehl ratio at H-band and 95% Strehl at L'.

- Joint Arizona/Italy development in 1990s and 2000s.
- Recent development lead by European community through ESO.

Example 1: Exoplanet Characterization.

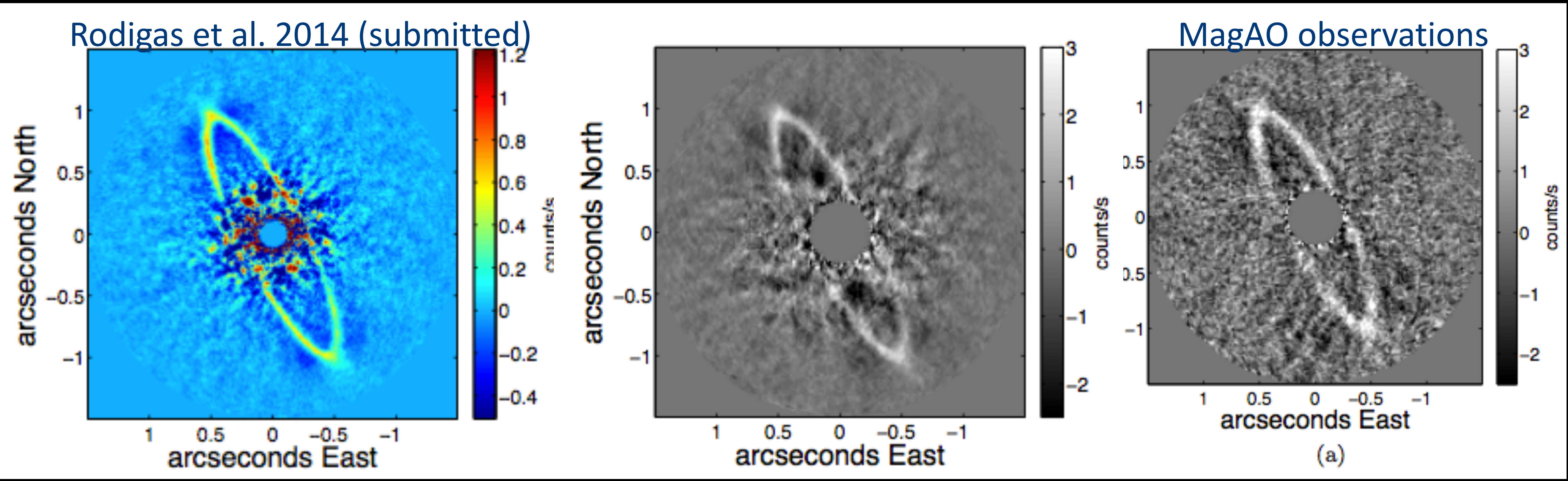
- Fundamental physical parameters (temperature, chemical makeup, etc.) can be probed with direct imaging





Example 2: Scattered and Thermal Light from Debris Disks

- Imaging debris disks in both scattered and emitted light allows more solid determination of grain size and composition.

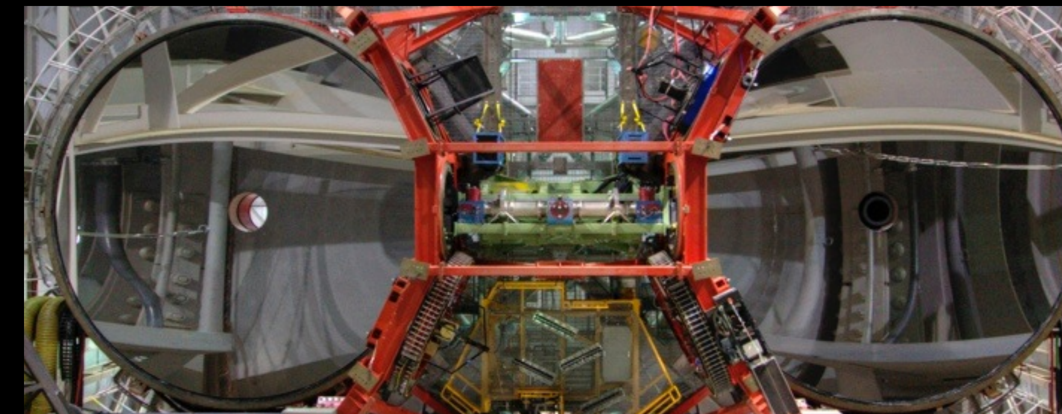


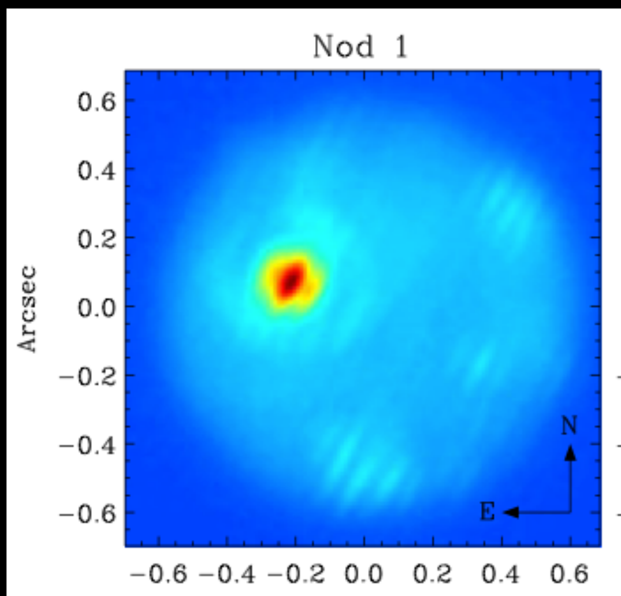
0.95 μm

2.2 μm

3.8 μm

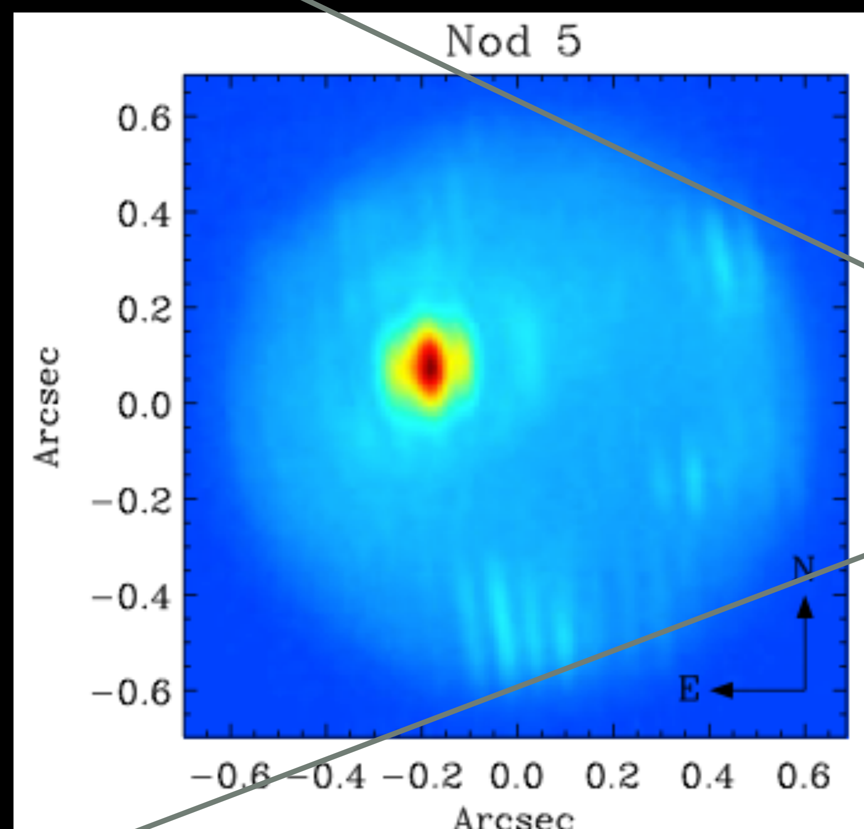
Example 4: High resolution of time-variable structure

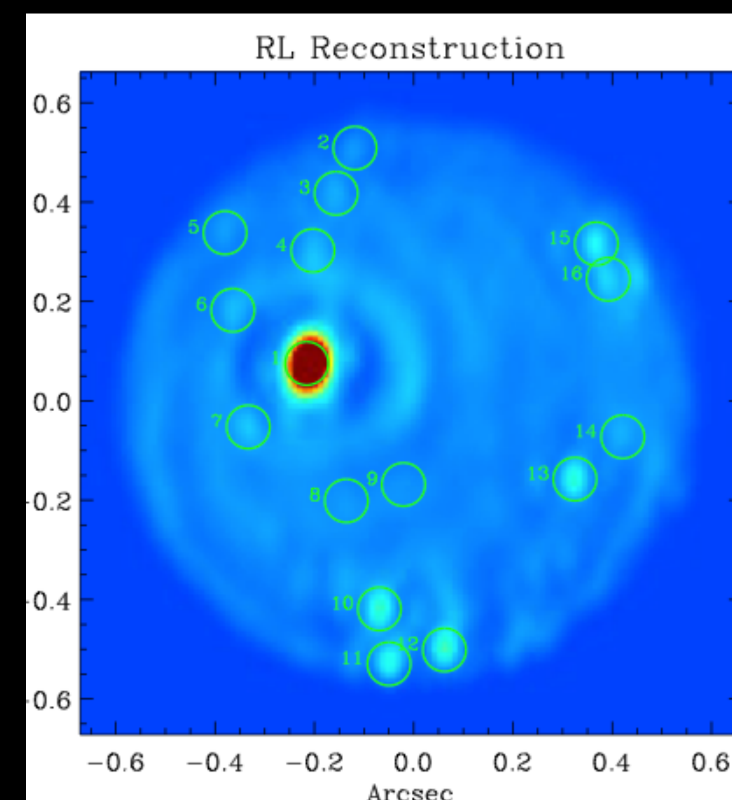


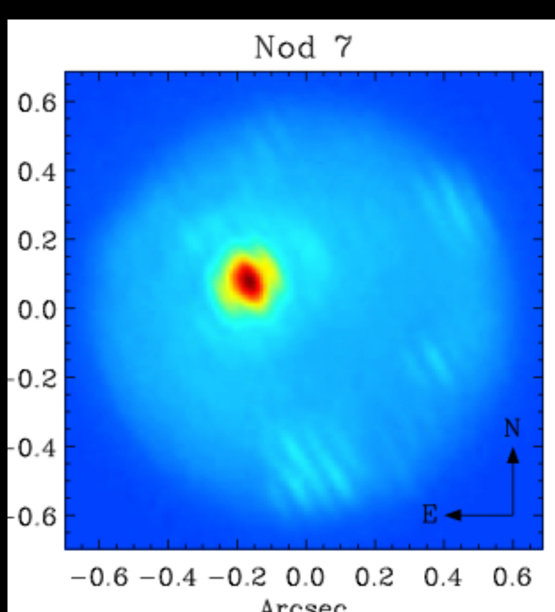


Jupiter's moon Io, at 4.7 μm wavelength

14 volcanoes resolved







43 mas resolution on a complex structure

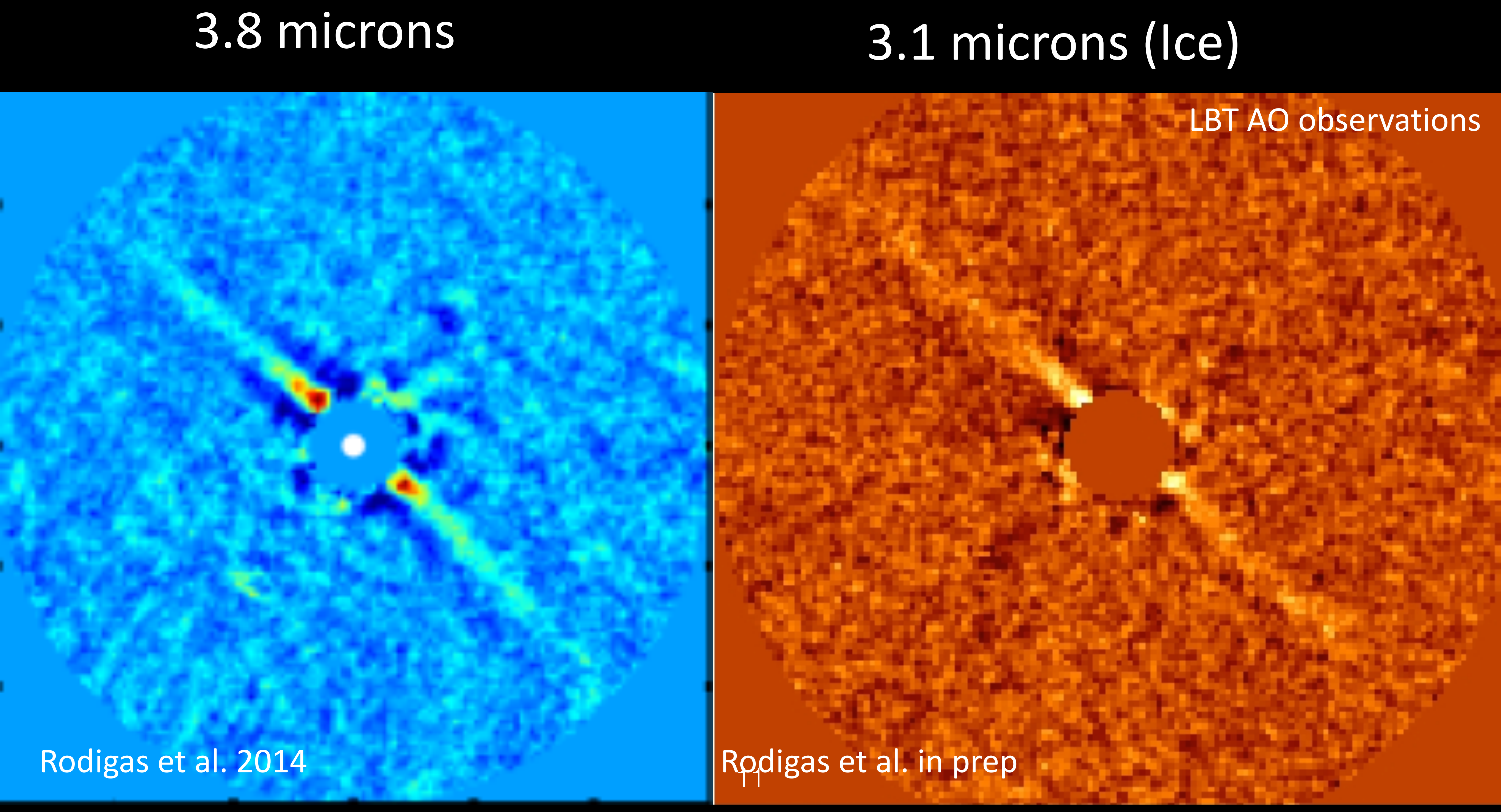
Leisenring et al. 2014

Summary

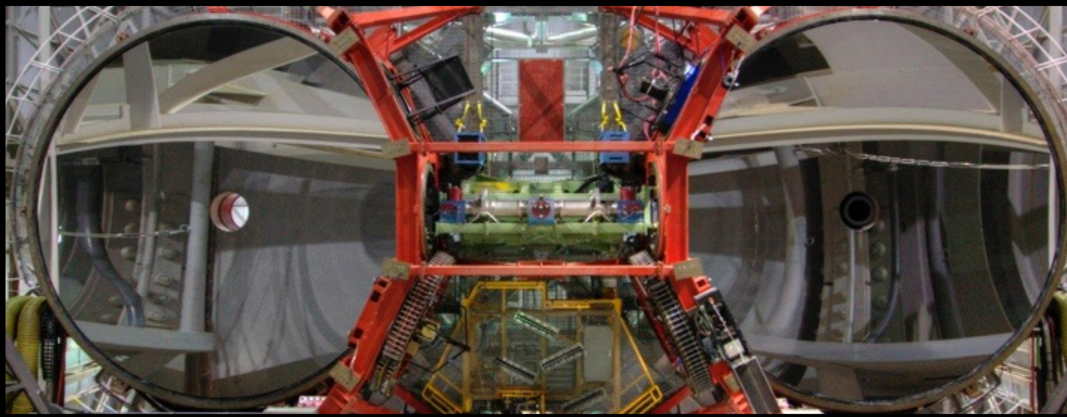
- Exoplanet science with AO is here today and will become increasingly important (GPI, SPHERE, LBT, ELTs).
- In the coming decade, AO will be integrated into the telescope system and instrumentation.
  - These projects require “implementation” engineering to be robust.
- ASMs are a good example of an AO technology development that enable science goals laid out in NWNH.
  - A robust ATI and/or MSIP program is important for continued progress.
  - A lack of technology development path risks ceding future followup opportunities to the European community.

Example 3: Ice-band Imaging

- Existence and location of the "snow line" can be probed in young planetary systems.

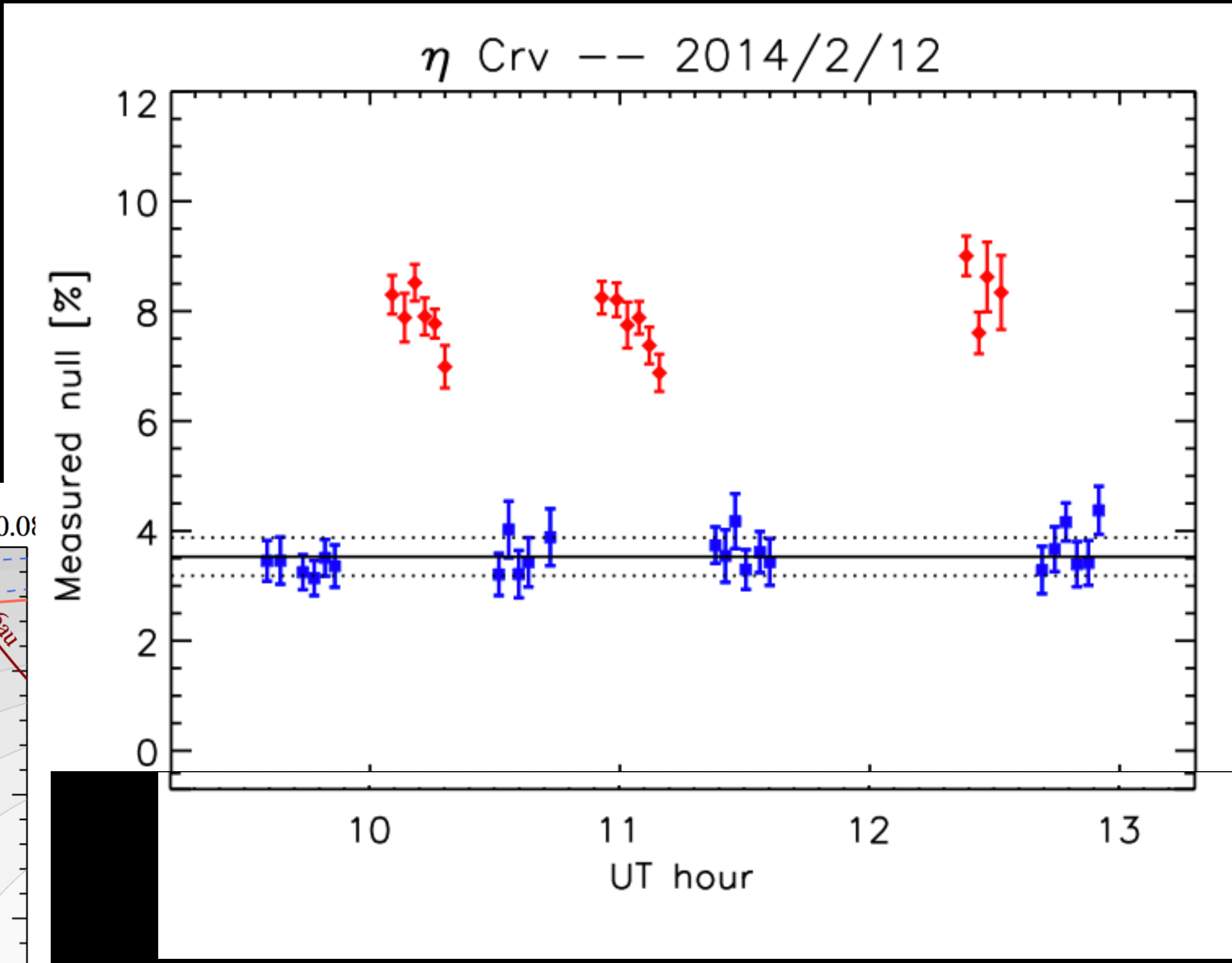


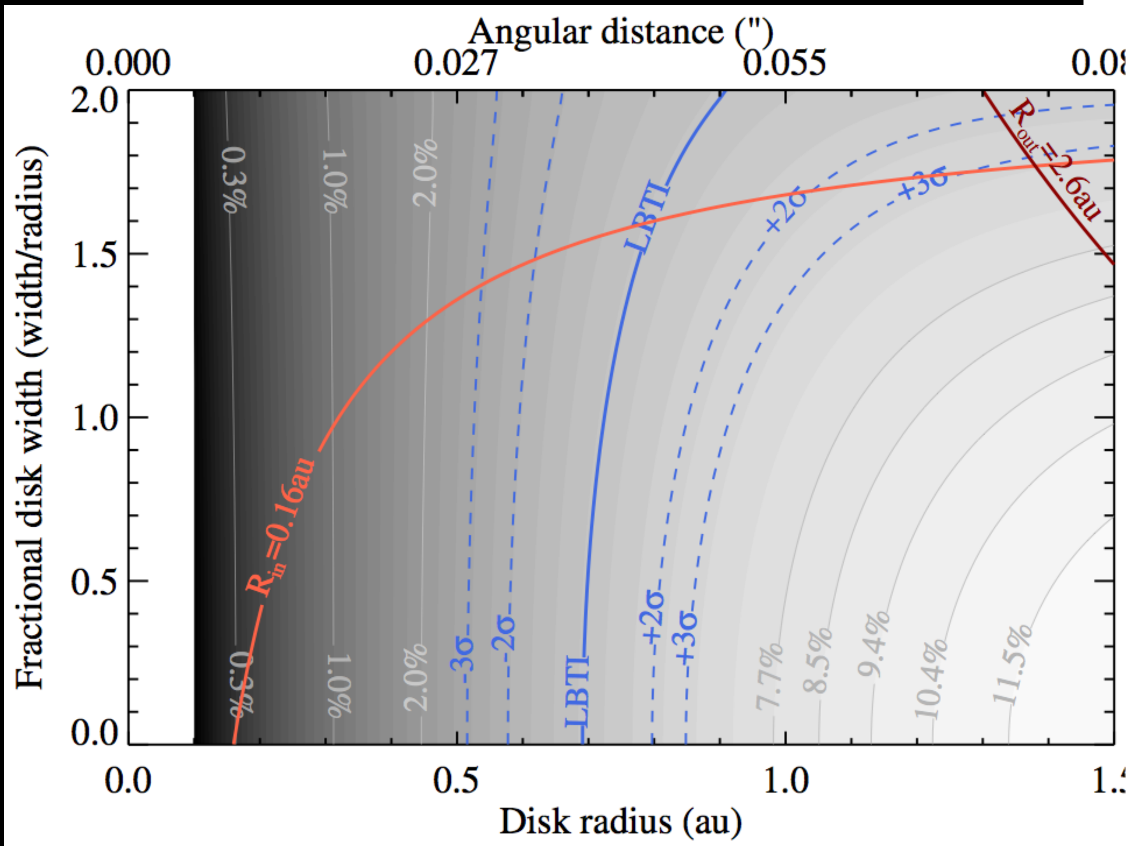
Example 5: Dust disk detection in preparation for an exoplanet imaging mission



Dust shows up as an “excess” amount of light that cannot be removed from the focal plane (red points).Excess is calibrated by stars without dust (blue points).

Combined with Spitzer data, the best model is a ring of dust at ~0.7 AU





Defrere et al. 2014 (submitted)