

Looking for Giant Planets at the Ice Line with Thermal Infrared Coronagraphic Imaging

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The Ice Line:

A Prime Location for Giant Planets?

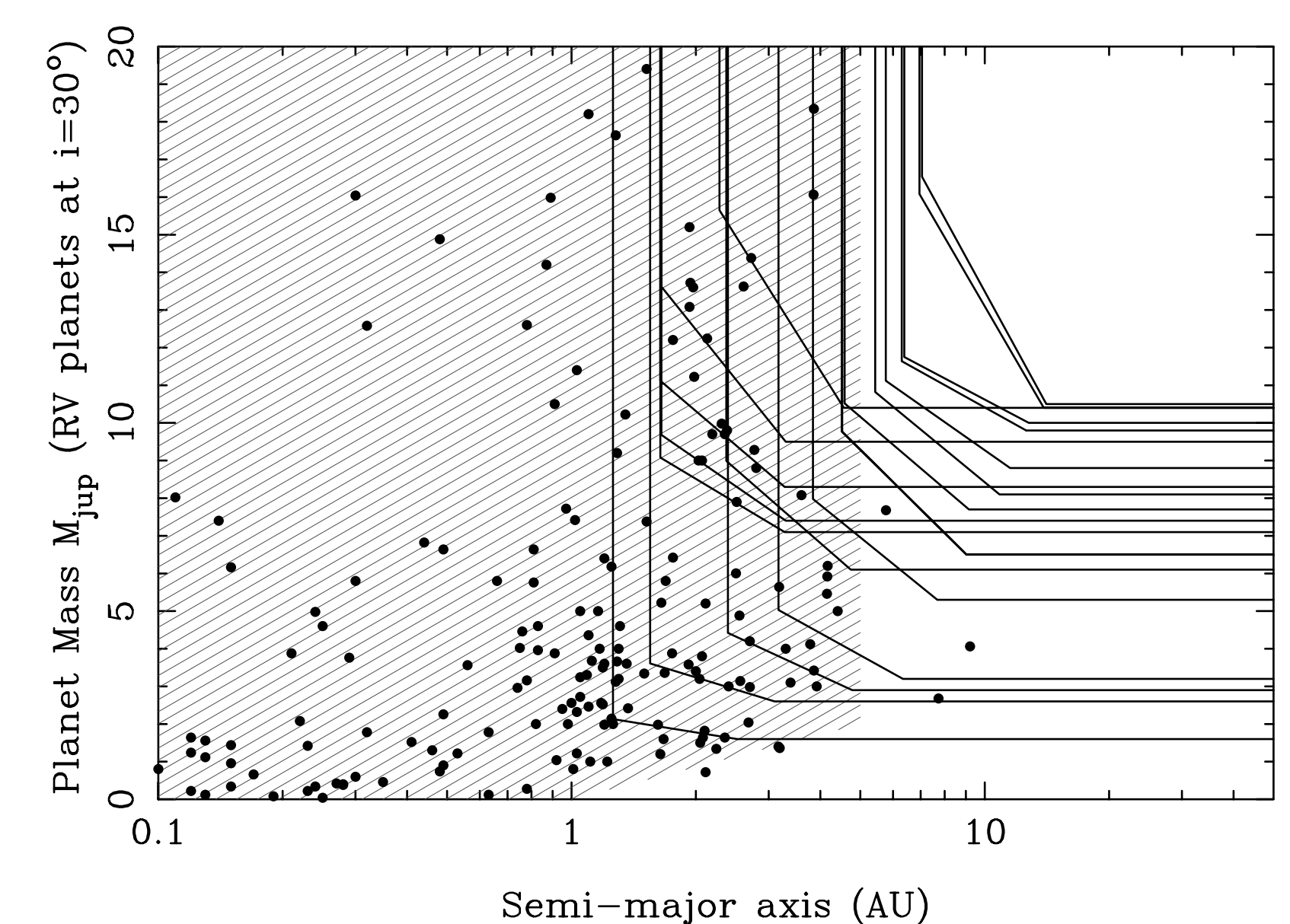
- In the core accretion theory of planet formation, the “ice line” could be the site of enhanced giant planet formation. (Ida & Lin 2004)
- The ice line radius is typically 3 AU for $1M_{\text{Solar}}$ out to 7 AU for $2M_{\text{Solar}}$ stars.
- Difficult to reach with direct imaging

Introduction

Direct imaging surveys around nearby young stars have placed constraints on giant planet populations in to 20 AU (Lafreniere et al. 2007, Biller et al. 2007, Apai et al. 2007, Heinze et al. 2008).

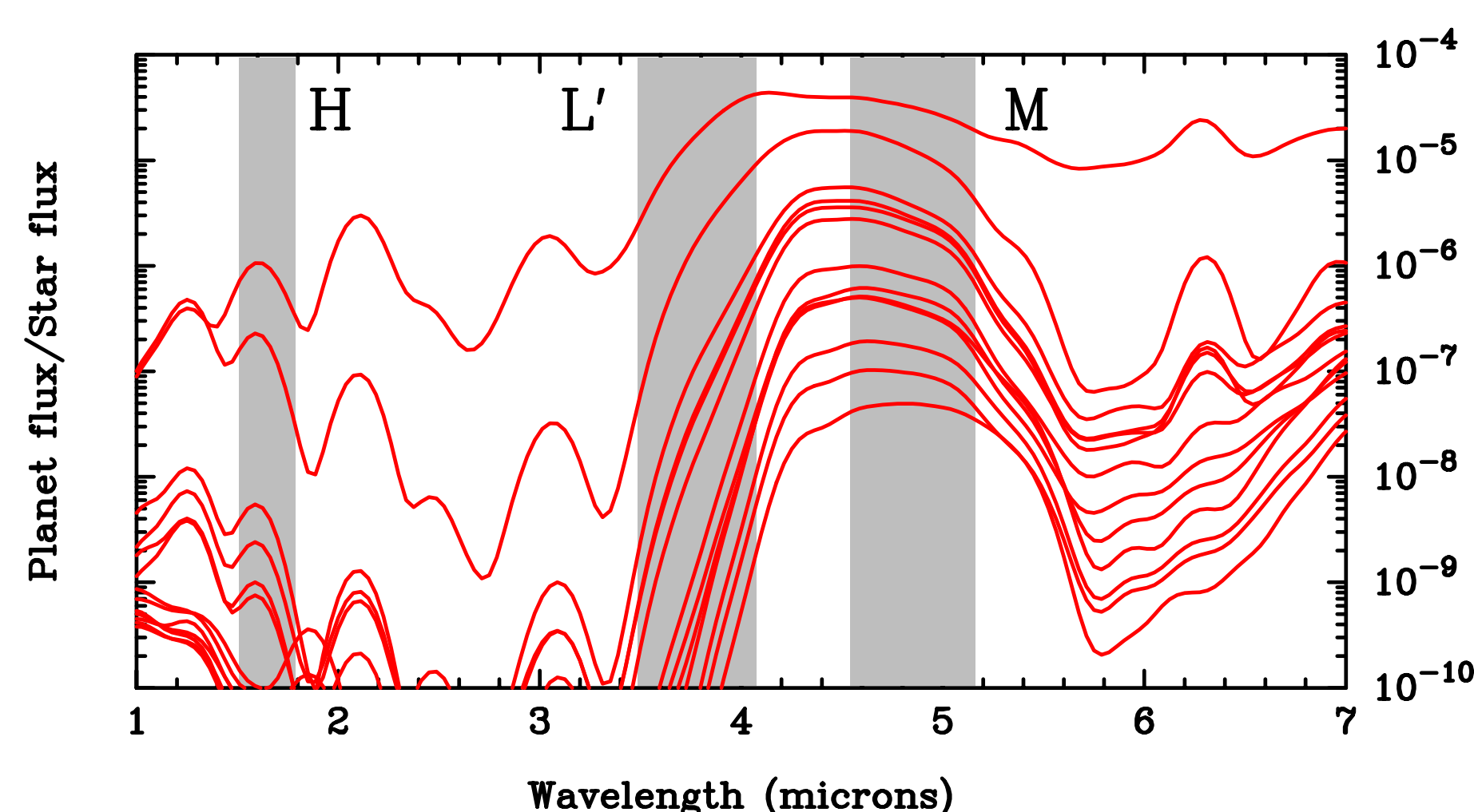
We are carrying out an M band survey using a new type of coronagraph to look in to the ice line (5 - 7 AU).

Our Survey Sensitivity



- 20 nearby stars (AFGK)
- Sensitivity overlaps with known RV planets

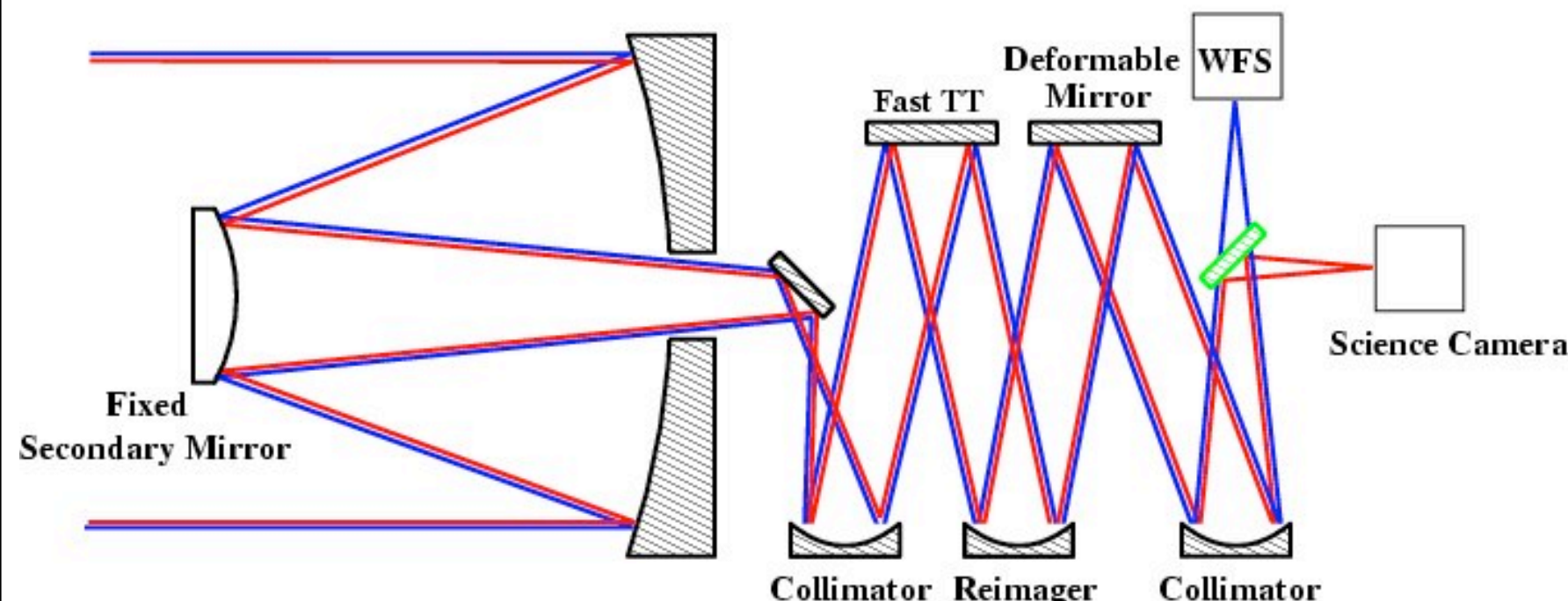
Where Giant Planets Glow



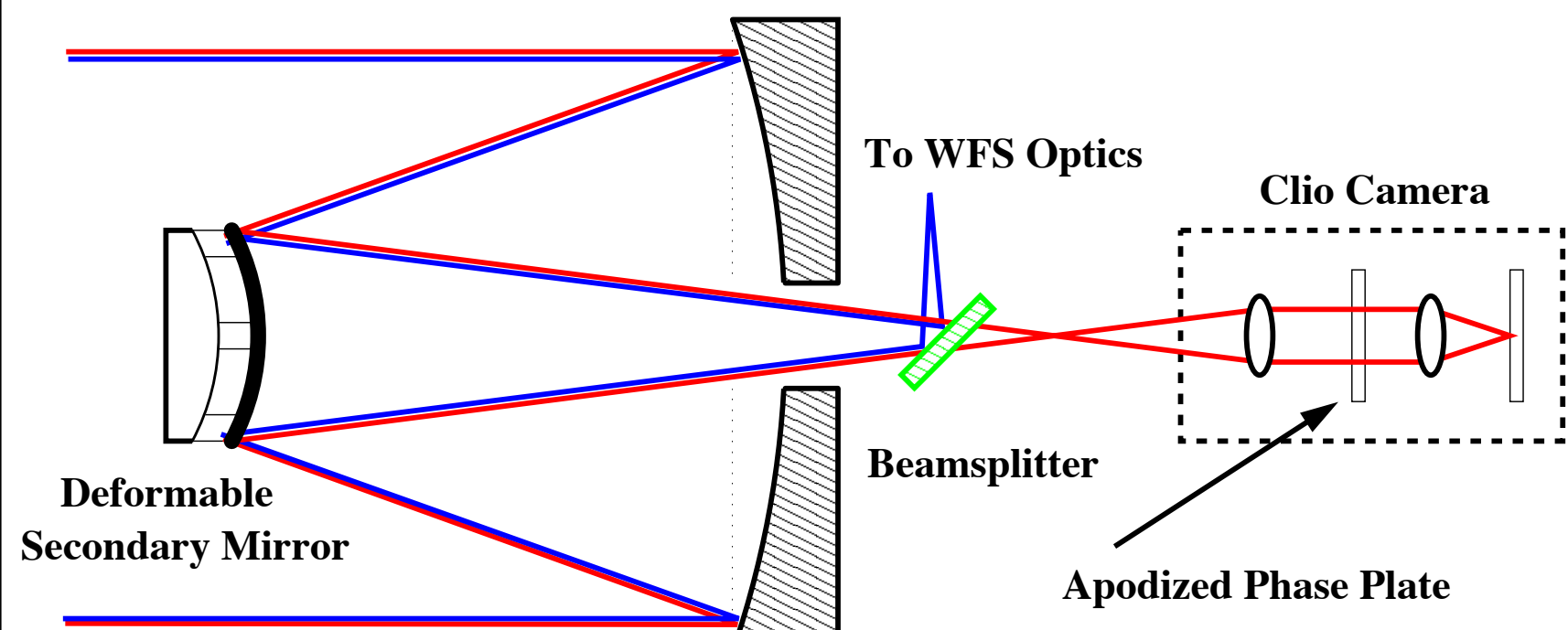
- Burrows 2004 models for 13 nearby systems
- M band has better contrast than H

Mid IR Imaging at the MMTO

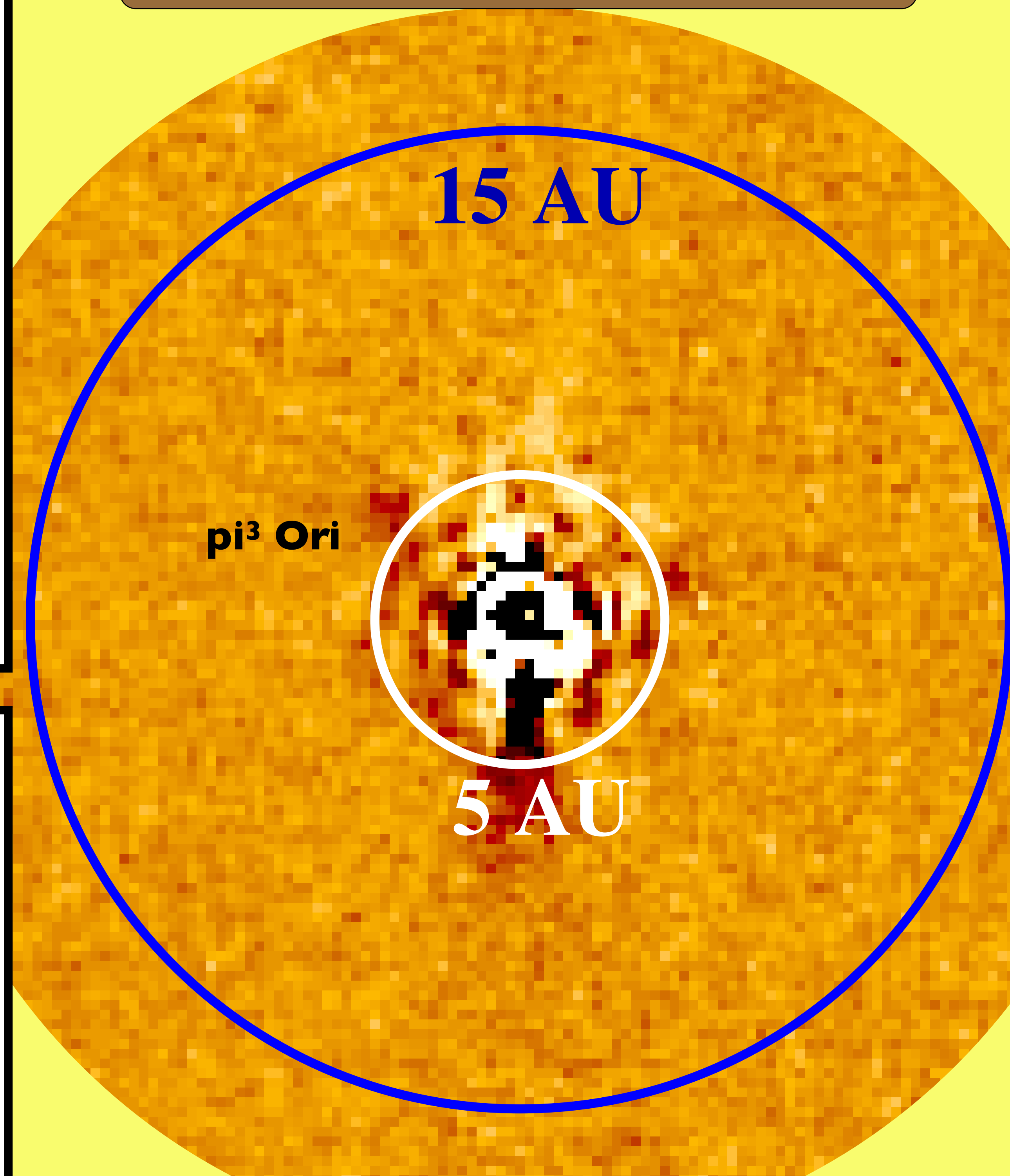
Typical AO System



Deformable Secondary AO System



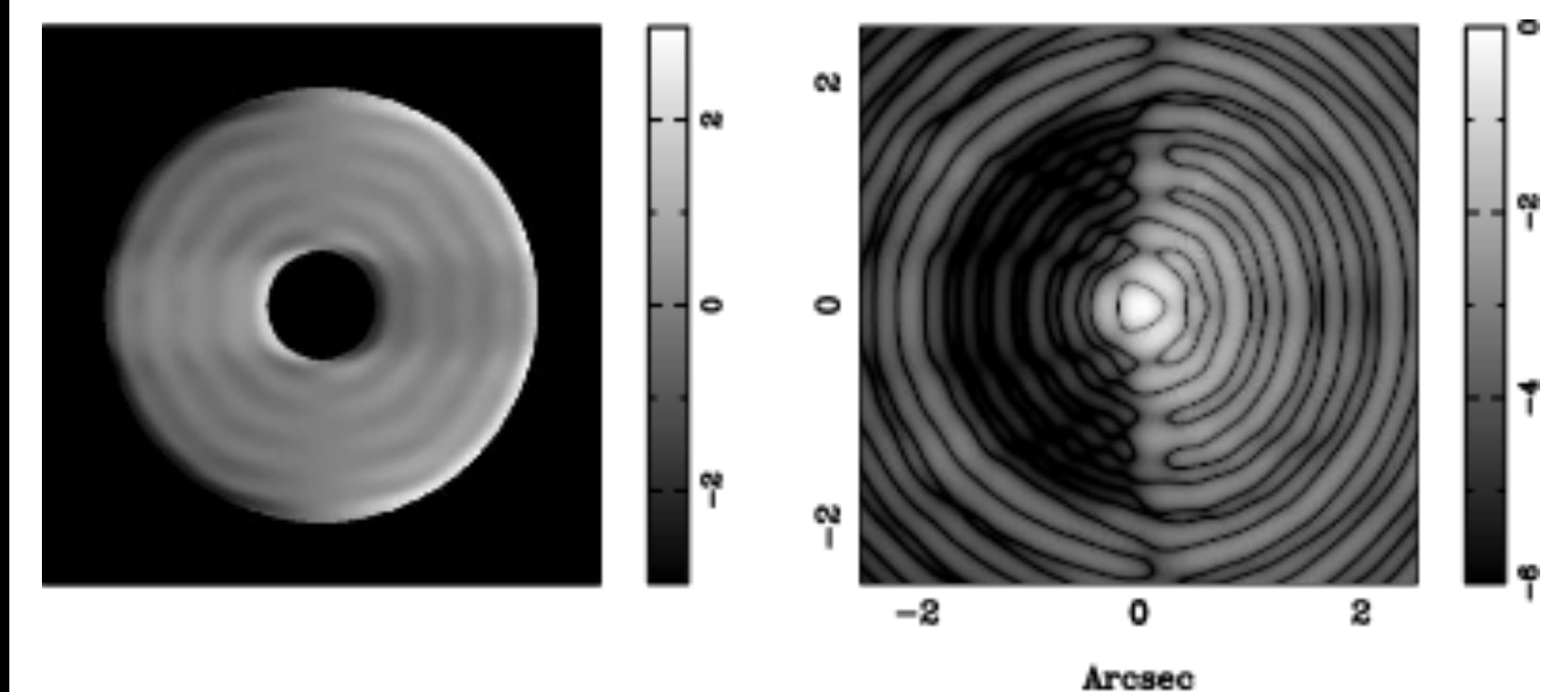
- Thermally clean and simple science light path with adaptive secondary mirror AO system
- High Strehl ratio (90% at 5 microns)
- 3 to 5 micron imaging with Clio camera



Typical Observation

	<u>π^3 Ori</u>	<u>Median</u>
Distance :	7 pc	6 pc
Age :	1.7 Gyr	0.8 Gyr
Mass :	11 M_{Jup}	6 M_{Jup}
Inner Radius :	5 AU	4 AU

Coronagraphy Without Focal Plane Masks



Apodizing Phase Plate

(Codona 2008, Kenworthy et al. 2007)

Preserves angular resolution

Works in to $2\lambda/D$

(0.45 arcsec at M band)

$\Delta = 12\text{mag}$ at $3\lambda/D$

Current Status

- 8 stars observed to date (April 2008)
- 2 stars examined have no candidate planets
- 4 nights in next trimester will bring survey up to 16 stars.