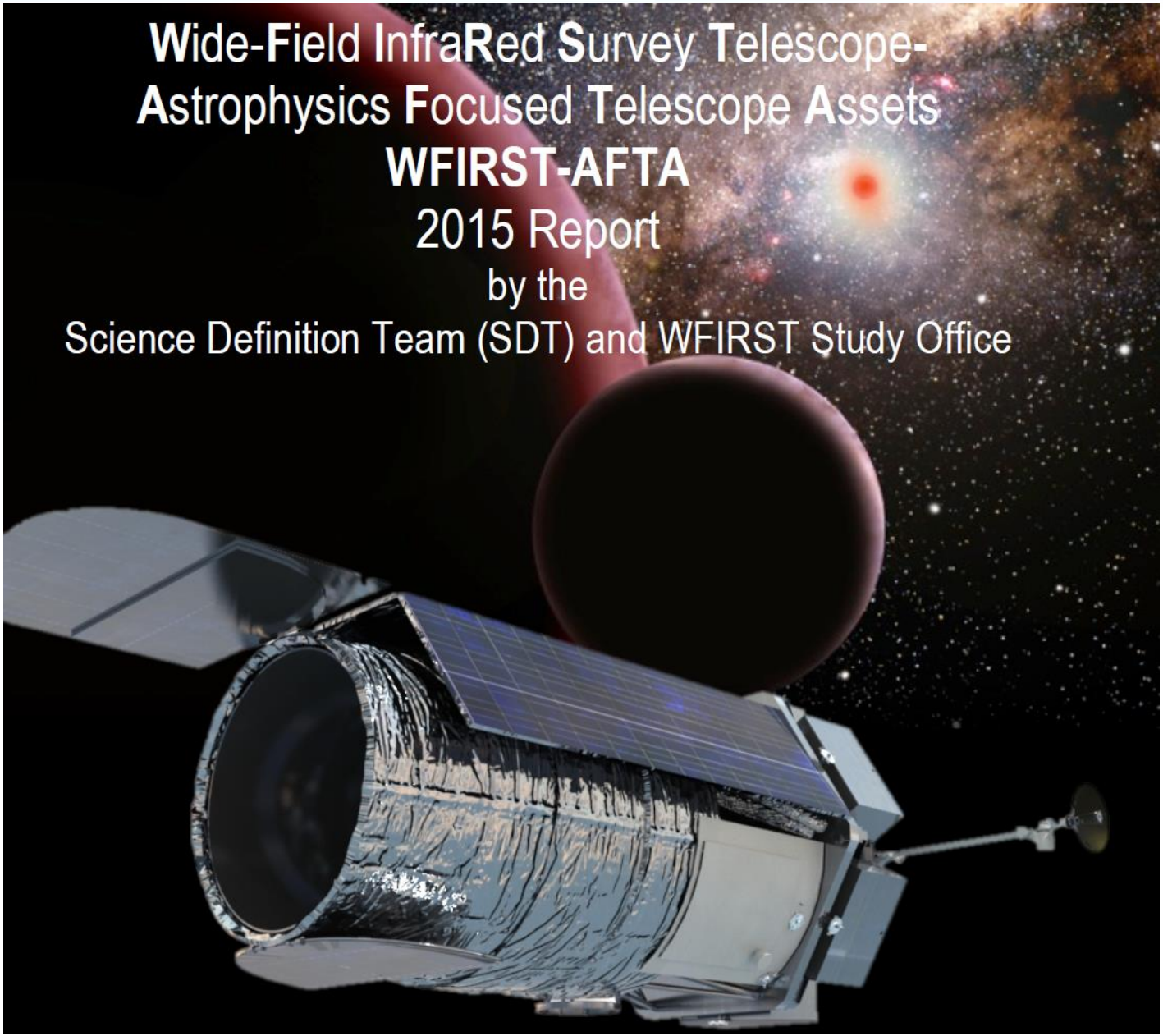
Jet Propulsion Laboratory
California Institute of Technology

Coronagraph Instrument on WFIRST-AFTA

Wes Traub

ExoPAG Meeting, Chicago
13 June 2015



AFTA WFIRST
Wide-Field Infrared Survey Telescope

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Gravitational Microlensing

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WFIRST-AFTA Exoplanet Discoveries

WFIRST-AFTA will be sensitive to exoplanets with mass greater than Ganymede, or roughly twice the mass of the moon. It will detect **2600** total bound exoplanets in the range of 0.03-1,000 Earth masses, including **1030** "Super-Earths" (roughly 10 times the mass of Earth), **370** Earth-mass planets, and **50** Mars-mass planets. This would enable the measurement of the mass function of cold exoplanets to better than ~7% per decade in mass for masses >0.3 M_{Earth}, and an estimate of the frequency of Mars-mass embryos accurate to ~15%.

Free-floating planets

WFIRST-AFTA will measure the frequency of free-floating planetary-mass objects in the Galaxy over nearly six orders of magnitude in mass, and will detect **30** free-floating Earth-mass planets, if there is one per star in the Galaxy.

These estimates are likely conservative. With more observing time, better optimization of the target fields, and more accurate event rates in the target fields, the exoplanet yield of WFIRST may be up to a factor of two higher.

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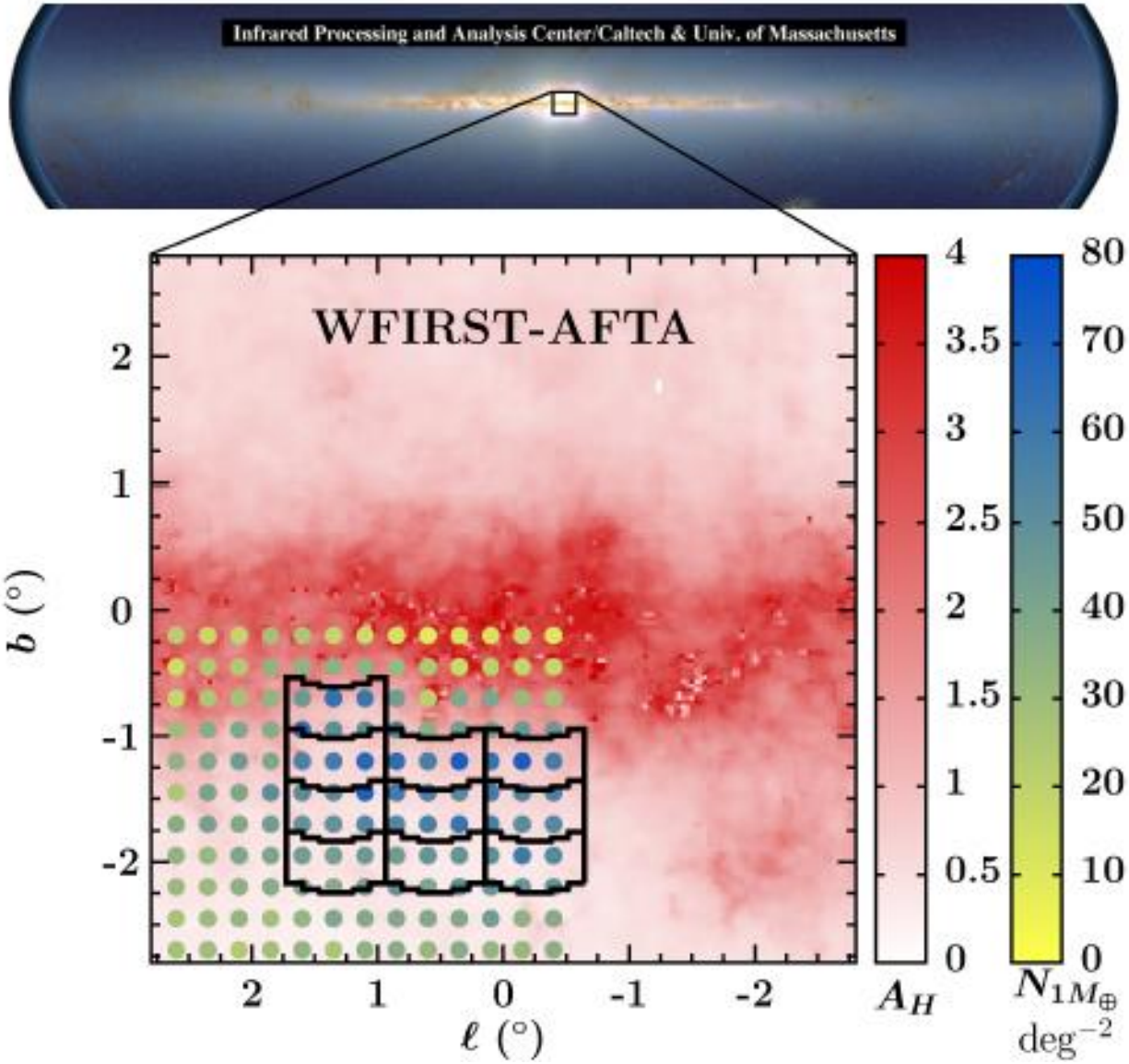
Microlensing target area



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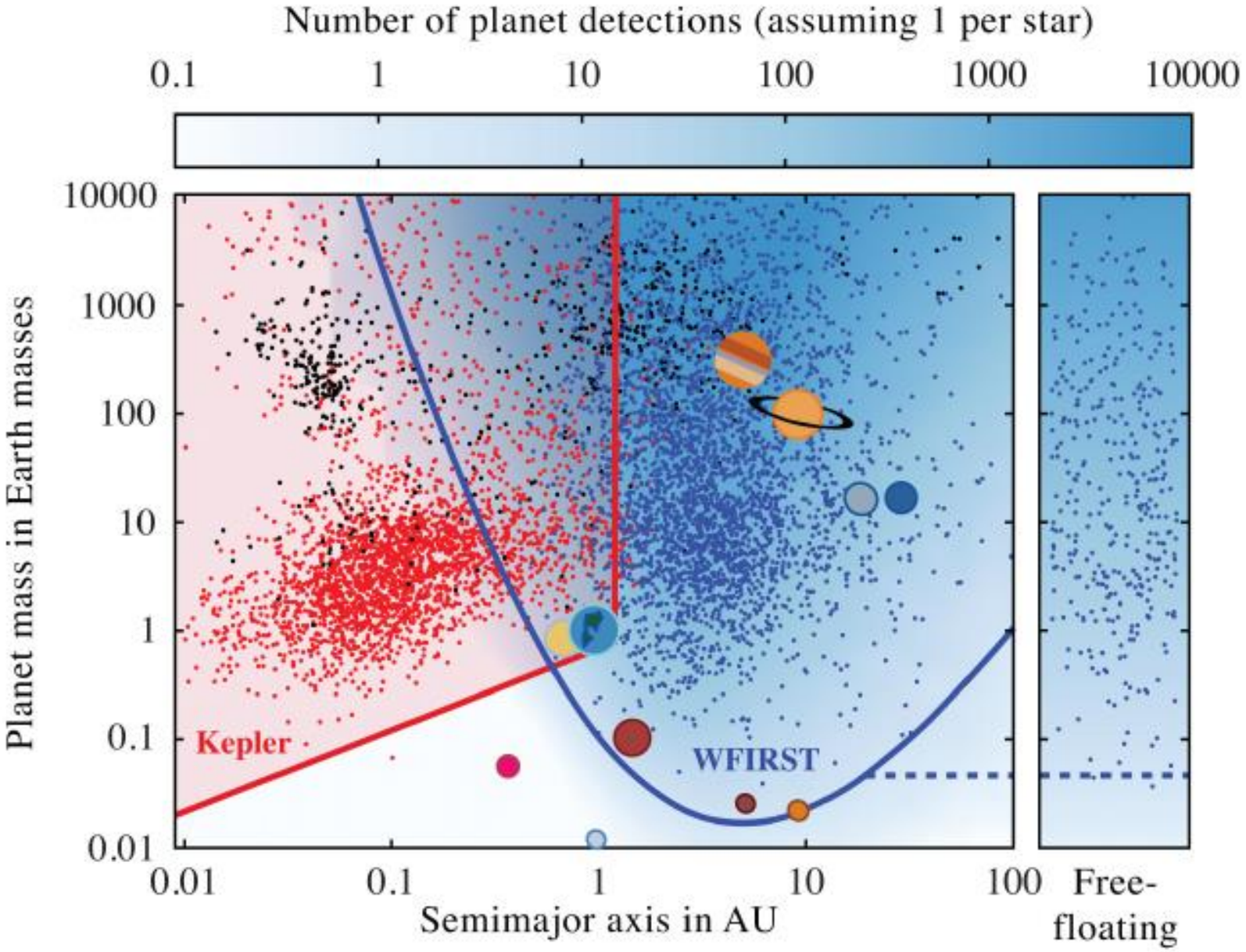
Population beyond the ice line



Coronagraph Instrument

Coronagraph Instrument (CGI)

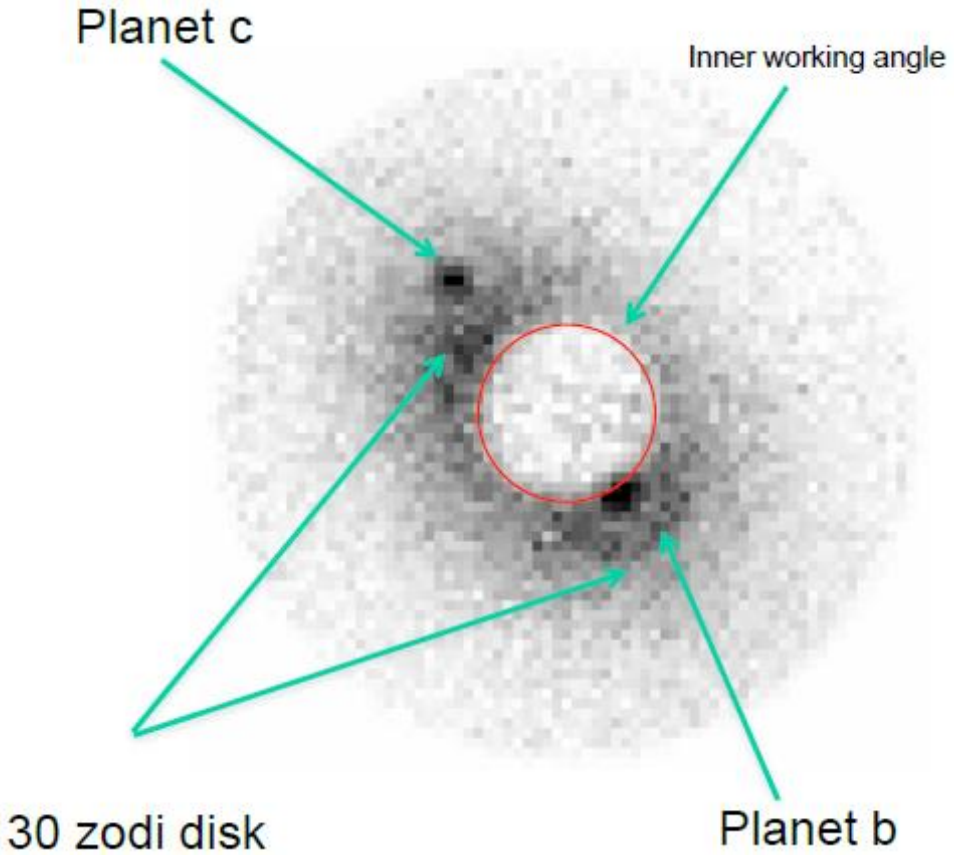


Figure 2-35: Simulated WFIRST-AFTA coronagraph image of the star 47 Ursa Majoris, showing two directly detected planets. Simulation parameters: 10 hr exposure time, 525-580 nm, Hybrid Lyot Coronagraph. Field of view of 0.518 arcsec radius. A PSF reference has been subtracted, improving the raw contrast by a factor of 10.

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Giant planet spectra

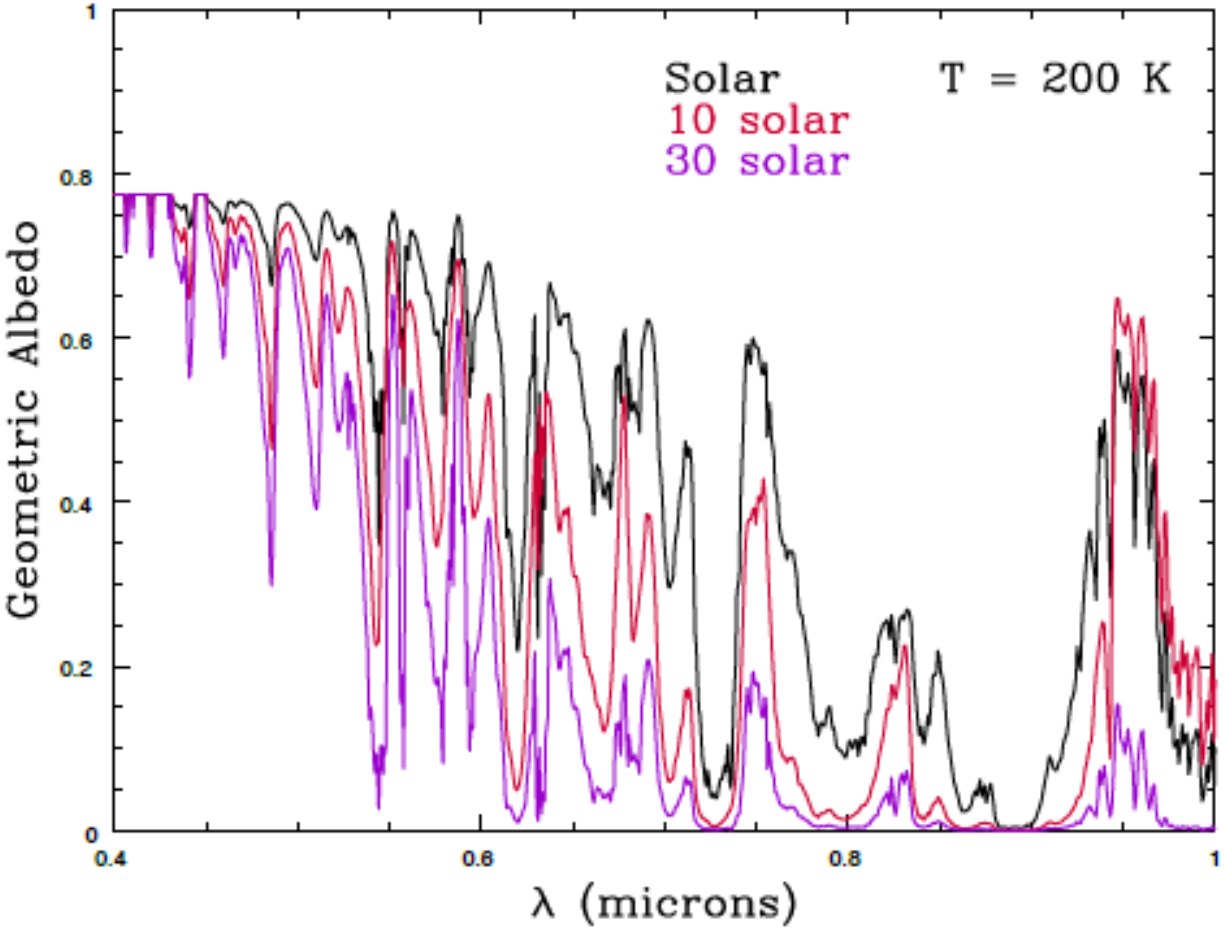


Figure 2-38: Giant planet albedo spectra for homogenous model atmospheres at T=200K as a function of atmospheric metallicity. These models are cloud-free. From Burrows (2014).

Disk images

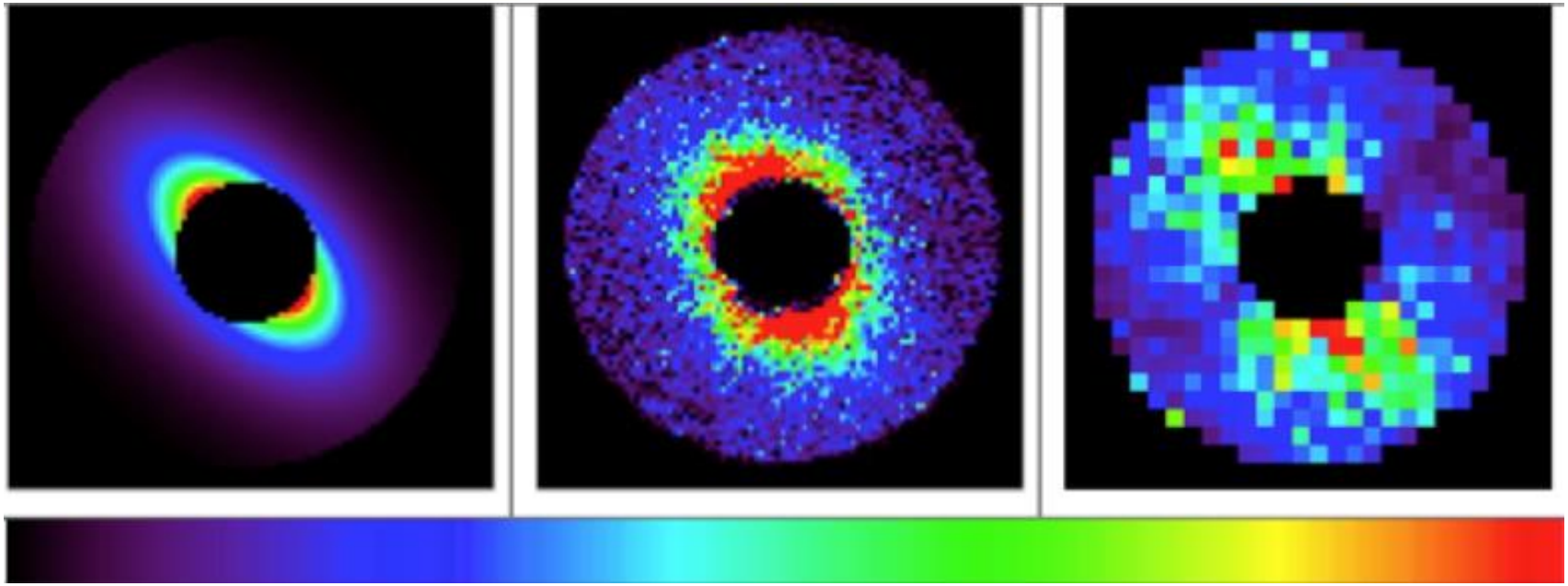
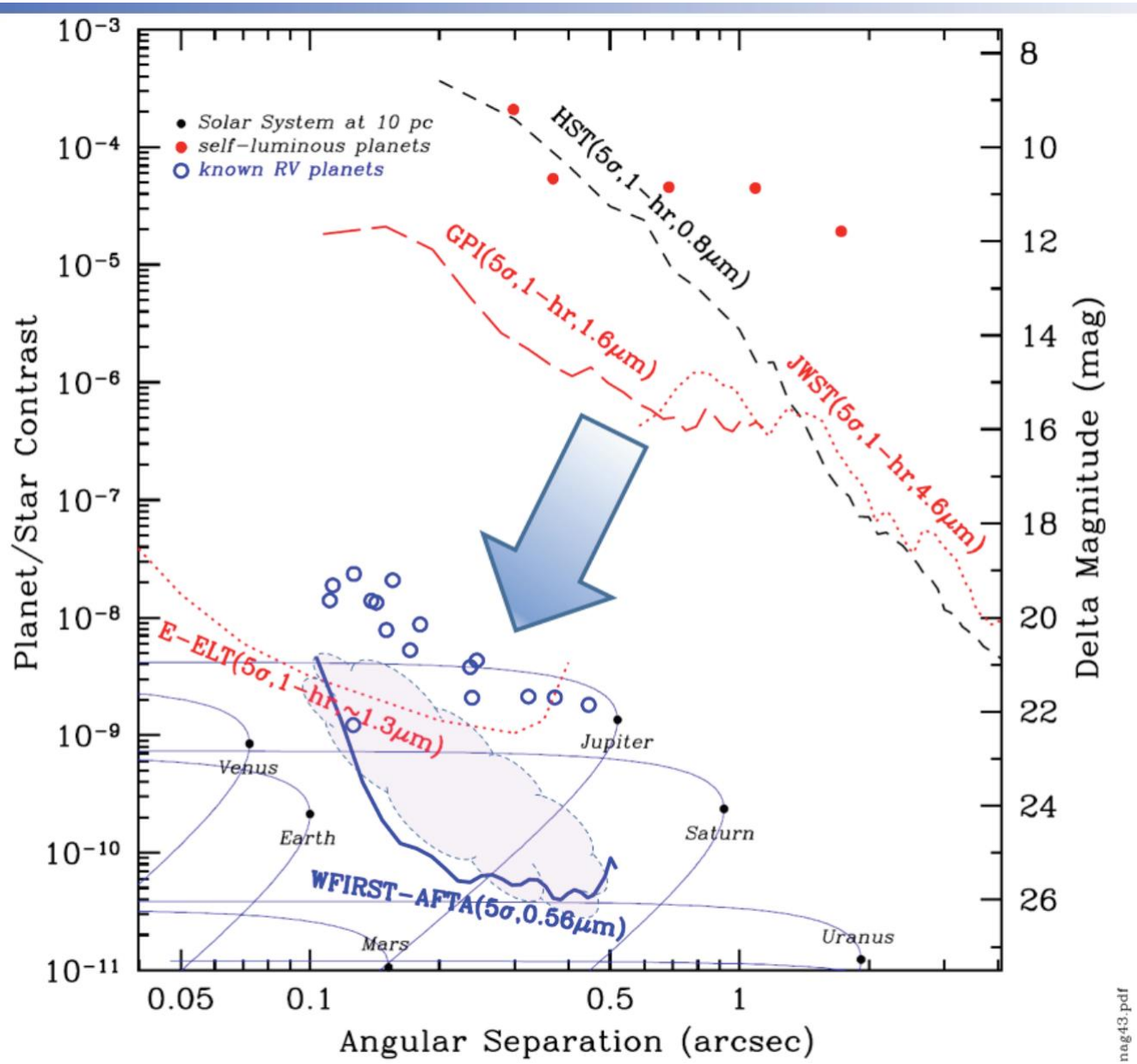


Figure 2-41: Simulated WFIRST-AFTA CGI images of a 30 zodi disk around 47 UMa. The noiseless zodipic model is shown at left, a 10 hour simulated shaped pupil coronagraph image is in the middle, and the significance of the detection is shown on the right. The right panel shows signal-to-noise per 1.2λ/D resolution element (about 10 pixels), scaled from SNR = 1 – 15 (from Schneider 2014). The system's 2 known RV planets are detectable with WFIRST-AFTA but are not included in the simulations.

The ground-space gap in contrast



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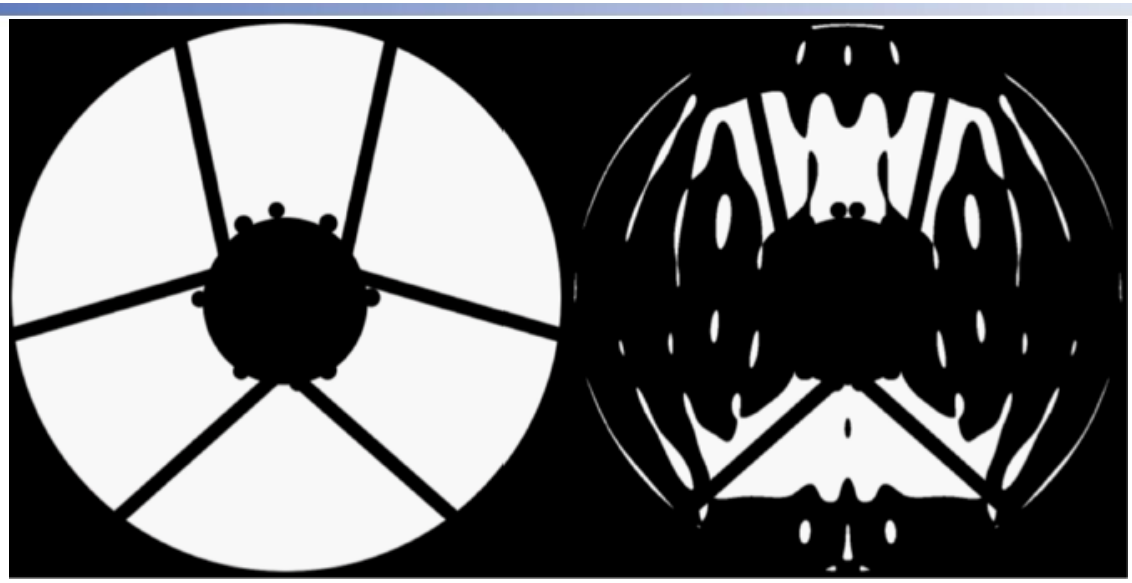
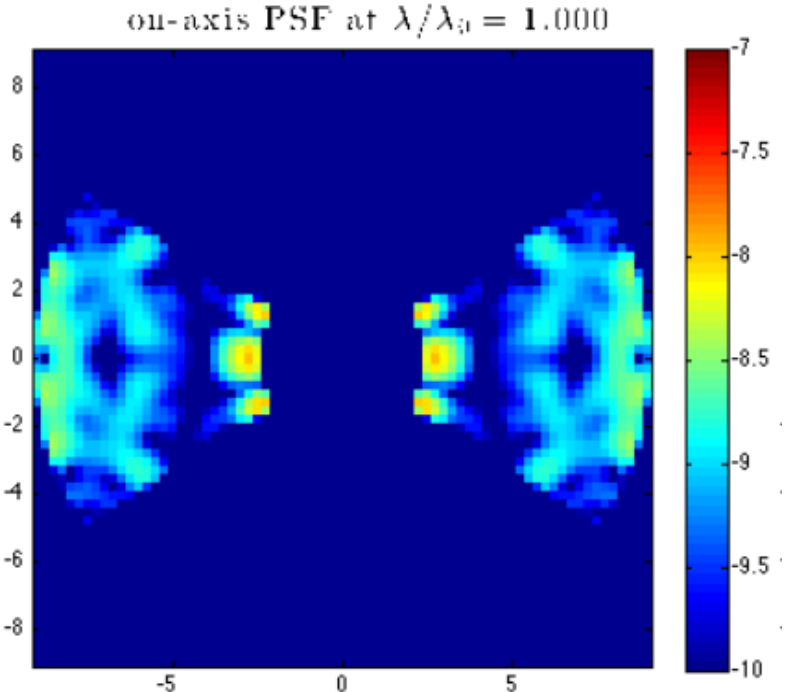
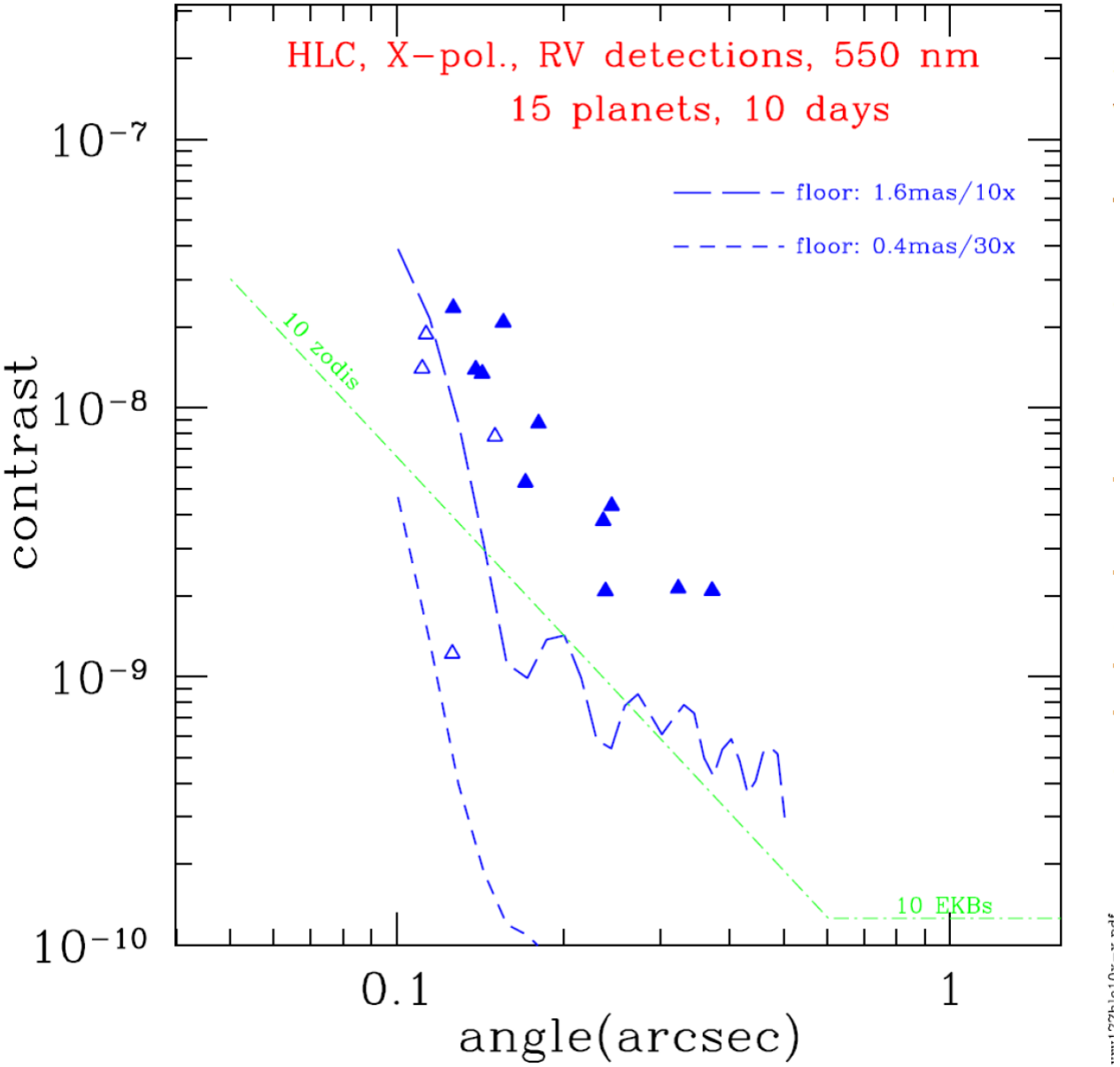
Shaped pupil coronagraph





Hybrid Lyot coronagraph



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Expected yield from CGI

Science Program	Number of giant planets (4-15 R_E) with photometry	Number of sub-Neptune planets (2-4 R_E) with photometry	Number of super-Earth planets (1-2 R_E) with photometry	Number of planets (1-15 R_E) with R=70 spectral characterization
Known RV studies	16	0	0	7
180-day new planet search	2	6	4	9
Total	18	6	4	16

Table 2-8: Summary of expected coronagraph science yields - number of RV planets that are potentially detectable and photometrically or spectrally characterizable and mean number of planets discovered in simulated searches for new planets. Not listed are the additional planets from future expanded RV searches. The numbers are uncertain, but may be comparable to the current known RV yield (see Figure F-6). The yield is evaluated for 0.4 mas residual image motion and x30 speckle post-processing attenuation. See Appendix F for details.

Time allocation

L1 Product	Rqmt.	Performance Assessment	Inst.	Comment	Clock Time (days)
Exoplanet Images	>12 planets	16 RV planets in 10 days at 565 nm, x-pol.	HLC	HLC meets rqmts, with margin	40
		16 RV planets in 10 days at 465 nm, x-pol.			
		16 RV planets in 10 days at 565 nm, y-pol.			
		16 RV planets in 10 days at 660 nm, x-pol.			
Exoplanet Spectra	>6 planets	7 RV spectra in 38 days, 660 nm, unpol.	SPC	SPC meets rqmts, with margin	98
		6 RV spectra in 40 days, 770 nm, unpol.			
		3 RV spectra in 20 days, 890 nm, unpol.			
Disk Images	Several disks	During all imaging observations	HLC	Probably OK, need detailed simulations	10
		Additional 10 days dedicated to disks			
New Planet Searches	None	Expect ~2.5 planets per star accessible range of radii and periods	HLC	Need detailed simulations	70
GO Programs	25% of Time	General Observer projects	HLC, SPC	Community proposals	91
Overhead	None	16 days for each initial RV obs.	HLC	Set-up times and stability need detailed simulations	56
		~0.25 days per target, for ~160 additional observations	HLC		
Total Time					365

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Thank you!