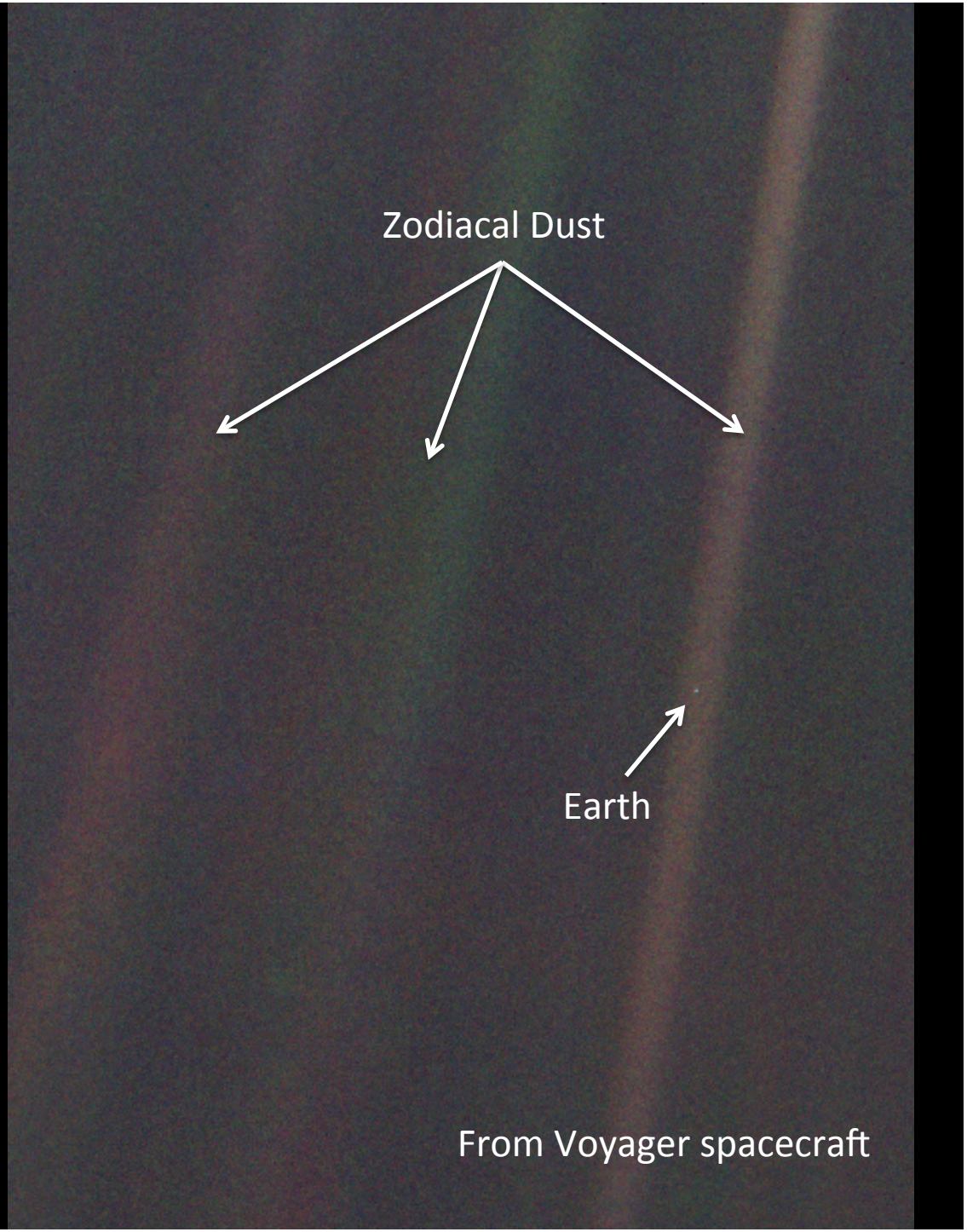
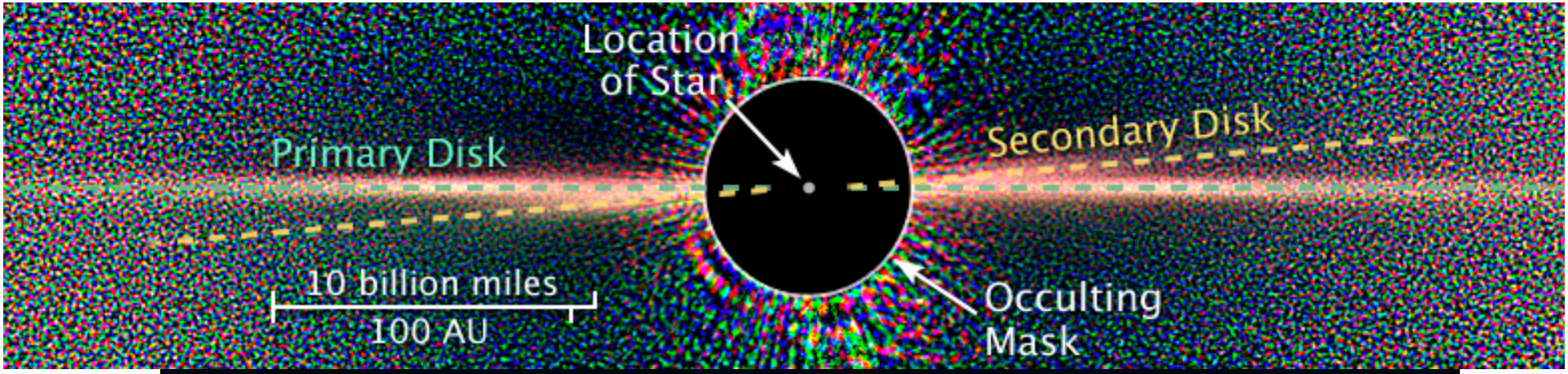
Exoplanets and Disks

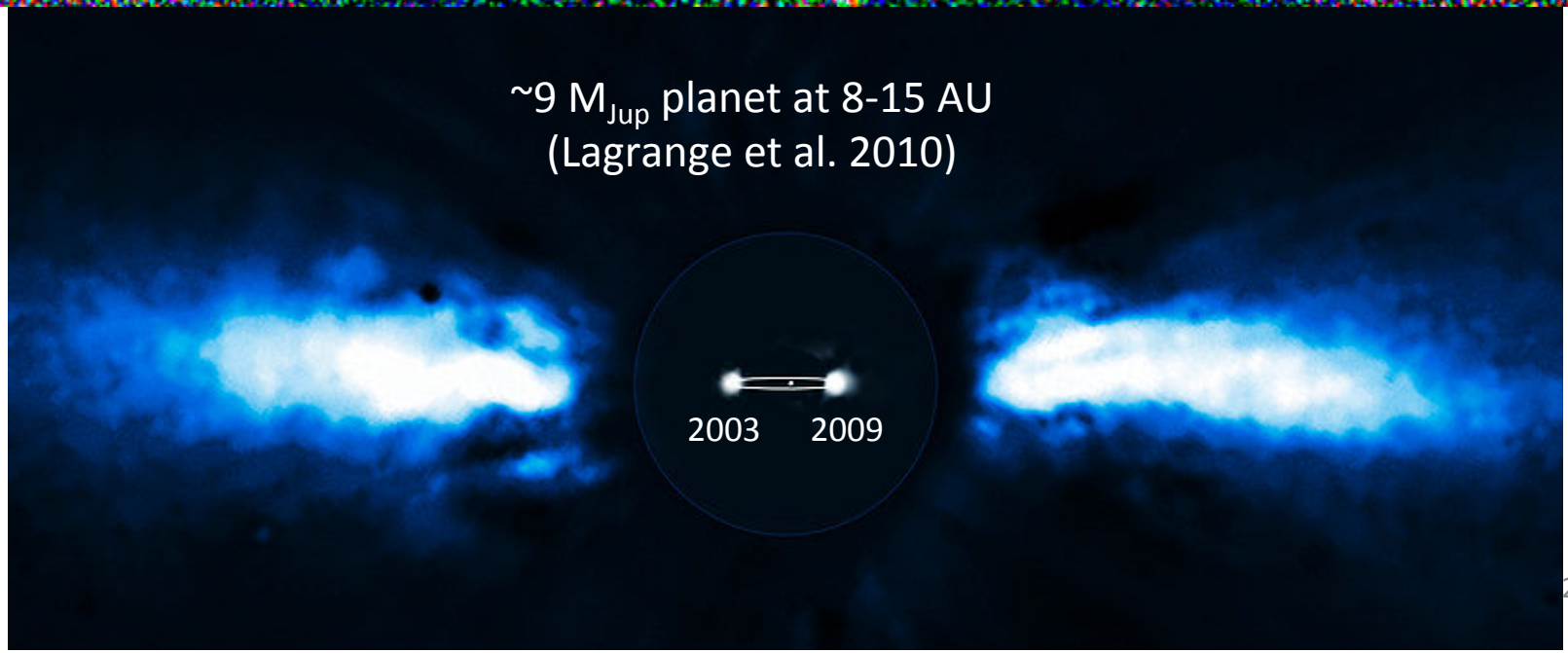
Christine Chen
STScI
cchen@stsci.edu



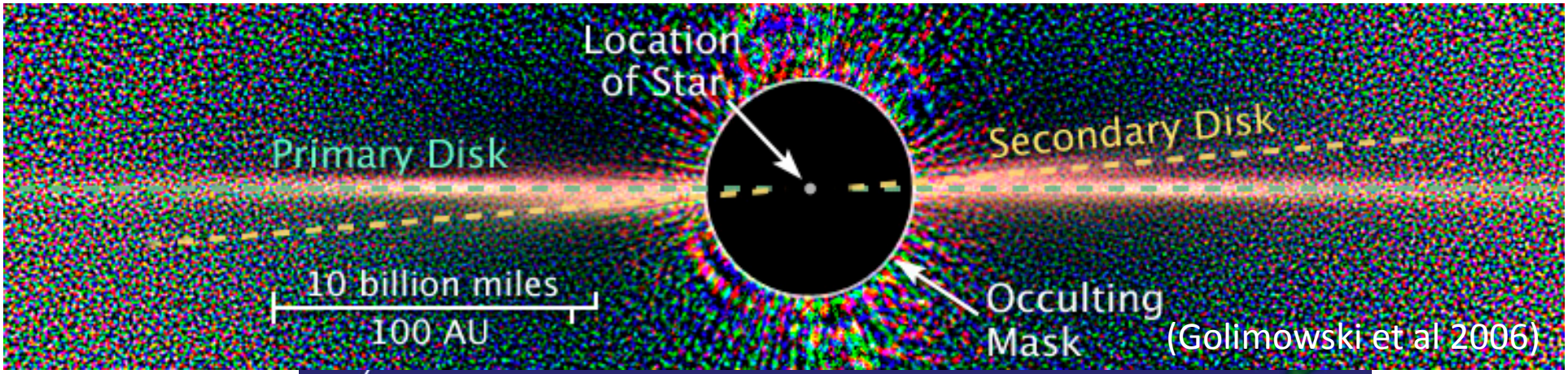
Reconstructing the β Pictoris Planetary System

Extended disk of small grains up to ~1400 AU from the star (Golimowski et al. 2006)



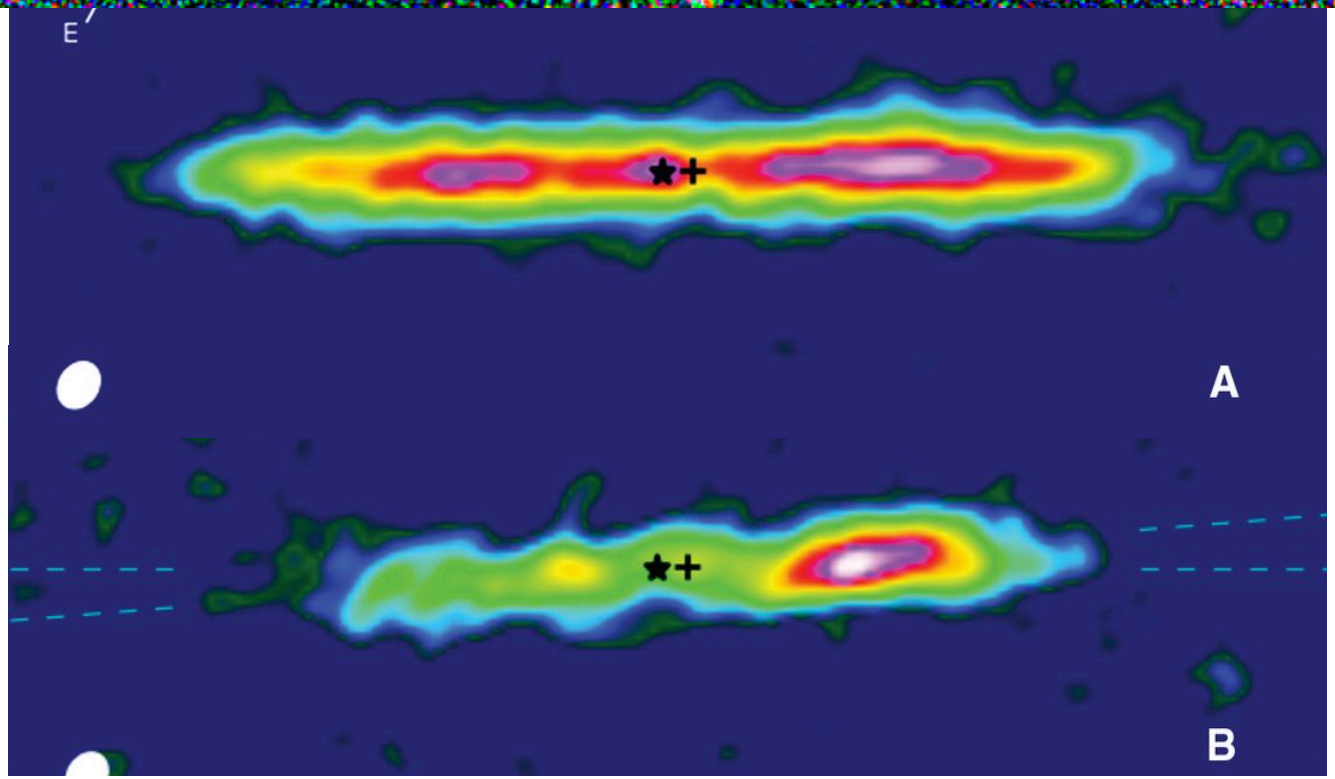


Reconstructing the β Pictoris Planetary System



Ring of large grains at 95 AU (Dent et al. 2014)

Clump of comets at 50 -60 AU (Dent et al. 2014)



Known Exoplanet/Disk Targets

Excellent candidates for further study with WFIRST coronagraph

Table 1. Exoplanet Host Stars with *Spitzer* IRS or MIPS 24 μm Excess

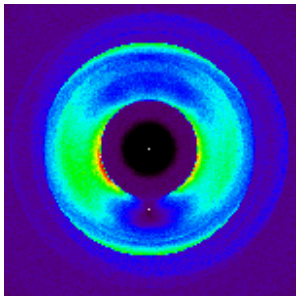
Name	Spectral Type	Distance (pc)	Age (Myr)	Planet Mass (M_{Jup})	Semi-Major Axis (AU)
HD 10647	F8V	17.4	2300	0.9	2.1
τ Cet	G8.5V	3.7	5800	0.01, 0.01, 0.01, 0.02	0.2, 0.4, 0.6, 1.4
ϵ Eri	K2V	3.2	850	1.6	1.9
β Pic	A6V	19.1	12	9	8-15
HD 69830	K0V	40.7	5600	0.03, 0.04, 0.06	0.08, 0.2, 0.6
1 RXSJ1609	M3	145	5	8	330
HD 95086	A8III	90.4	17	5	56
HD 106906	F5V	92.1	13	11	650
61 Vir	G7V	8.6	6100	0.02, 0.03, 0.07	0.05, 0.2, 0.5
70 Vir	G4V	18.0	7100	7.5	0.5
HR 8799	F0V	39.4	60	7, 10, 10, 10	15, 24, 38, 68

Science Goals

- What is the spatial distribution of the dust? In particular, how much dust is located in the WFIRST field of view?
- How do planets with a variety of masses and orbital properties modify the spatial distribution of the dust?
- How does this dust impact the detectability of additional low mass planets?
- What is the composition, size distribution, porosity and shape of dust particles within debris disks?

How does the dust scattered light impact the detection and characterization of planets within debris disks

WPS Program Overview



Observations (Scattered Light and Thermal Emission Maps, SEDs)

Dynamical Structure from Hypothetical Planets

Disk Models

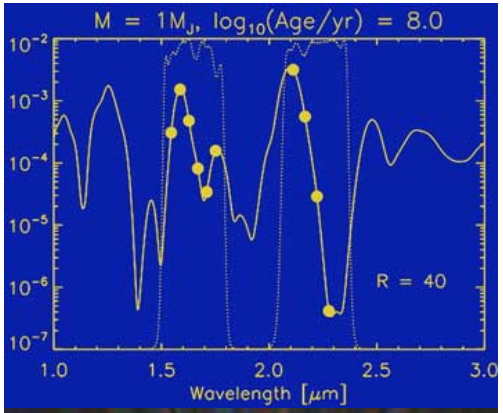
Planet + Disk WFIRST Simulation

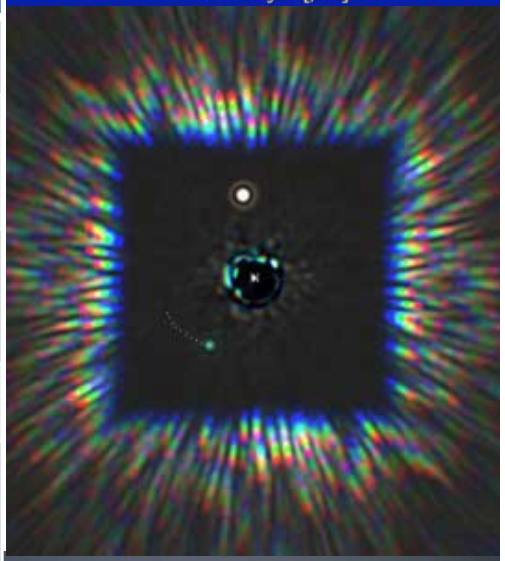
Planet + Disk PSF Subtraction

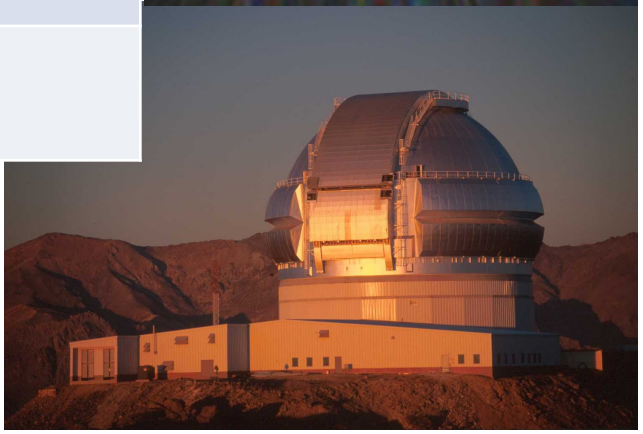
Exozodi Simulation Catalog developed by Chris Stark
http://asd.gsfc.nasa.gov/Christopher.Stark/catalog.php
That have planet mass and grain size ($\beta = F_{rad}/F_{grav}$) as free parameters

GPI is Complementary

	WFIRST-AFTA	GPI
Bandpass	400 nm – 1 micron	950 nm – 2.4 micron
IWA	100 mas at 400 nm 250 mas at 1 micron	78 mas at *Y*-band 153 mas at *K*-band
OWA	1 arcsec at 400 nm 2.5 arcsec at 1 micron	2.8 arcsec on a side
Contrast	10^{-9}	10^{-7}
Spectral Resolution	70	35 at *Y*-band 70 at *K*-band
IFS Spatial Sampling	17 mas	14 mas

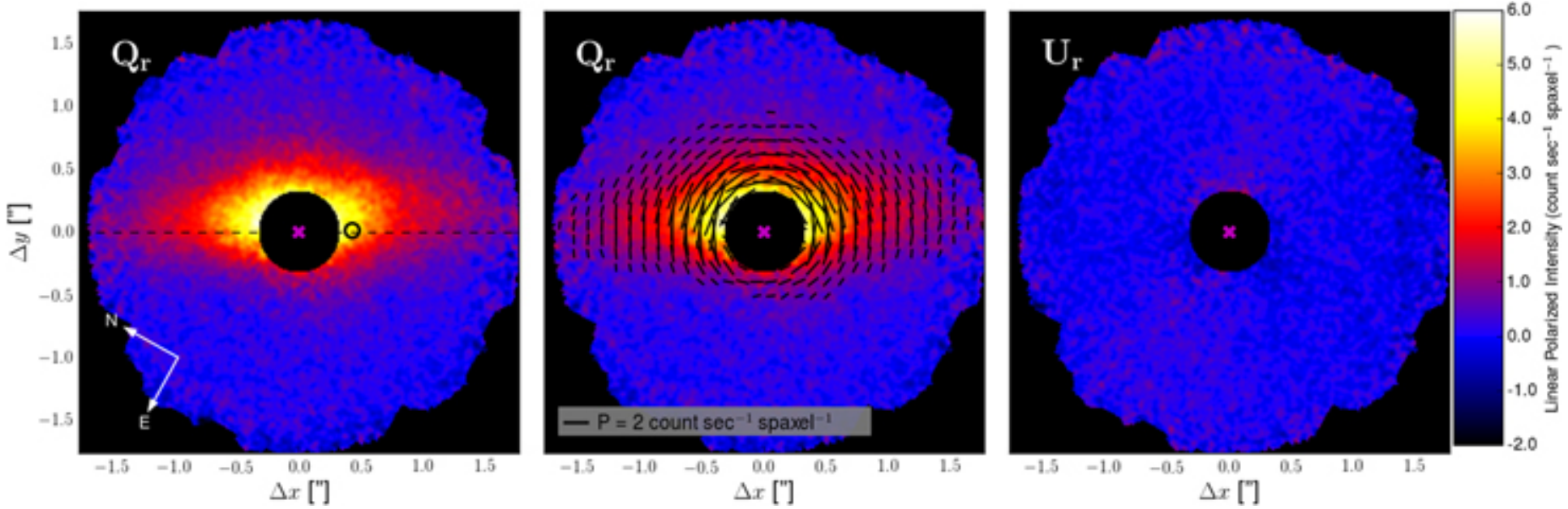






Approved GPI Programs

- GPI Exoplanet Survey (PI Macintosh GPIES) with Debris Disk component led by Kalas and Fitzgerald
- Gemini Large and Long Program (PI Chen "Characterizing Dusty Debris in Exoplanetary Systems")



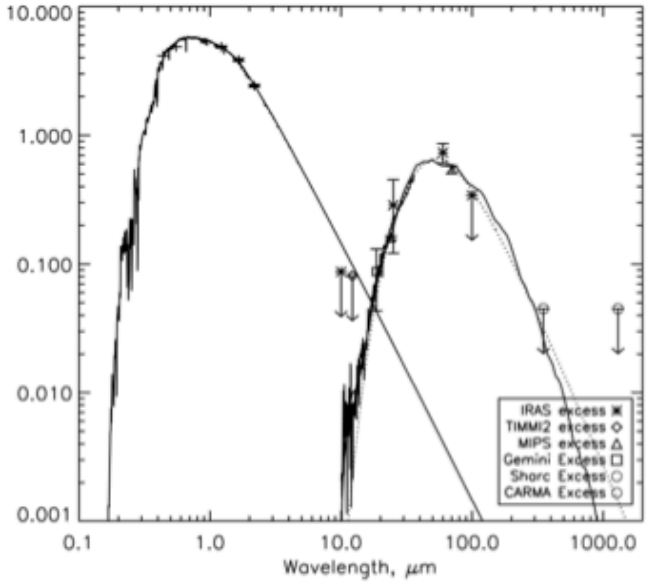
Millar-Blanchaer et al. 2015

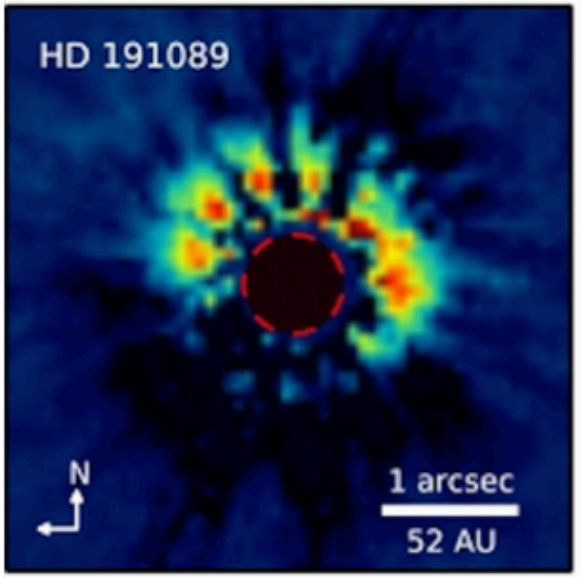
GPI Observations Executed Thus Far

Name	IFS	Pol	Planet	Disk
HD 10647	*J, H*	*H*	✖	✔
Eps Eri	*H*	*H*	✖	✖
Beta Pic	*Y, J, H,* K_1	*H*	✔ Chilcote et al. 2014 Millar-Blanchaer et al. 2015	✔ Millar-Blanchaer et al. 2015
HD 95086	*H,* K_1		✔ Galicher et al. 2014	✖
HD 106906	*H*	*H*	✖	✔ Kalas et al. 2015
HR 8799	*H,* K_1, K_2		✔ Ingraham et al 2014.	✖

Multi-Wavelength Observations

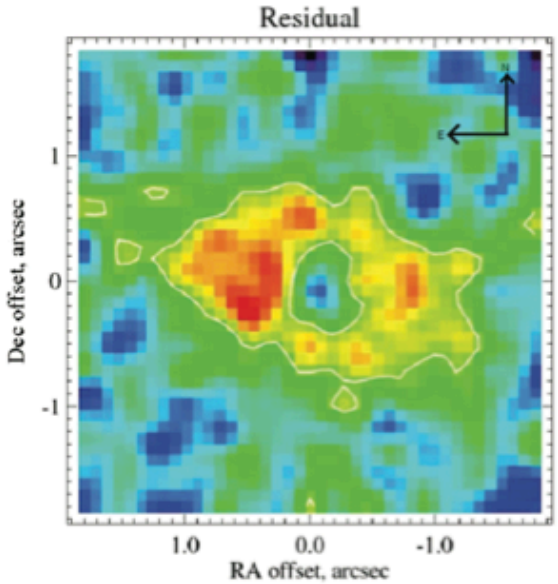
Unresolved SED (Churcher et al. 2011)

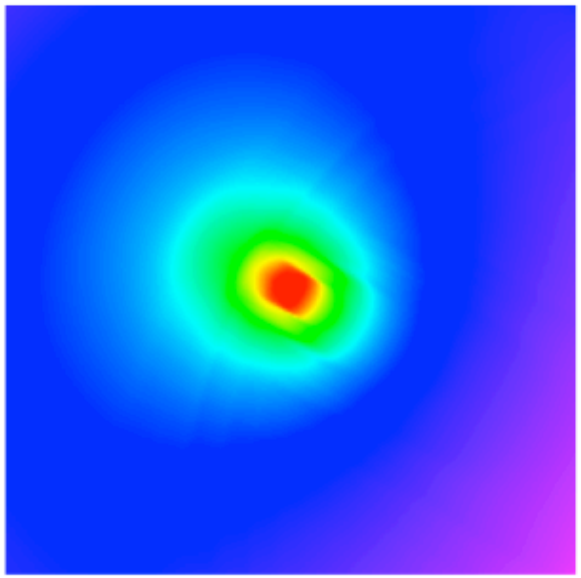




NICMOS F110W Map (Soummer et al. 2014)

Gemini T-ReCS Map (Churcher et al. 2011)





Synthetic V-band scattered light map

Milestones

- Model dynamical structures expected from planets embedded in disks (C. Stark)
- Model PSFs (J. Krist)
- Develop WFIRST-AFTA PSF subtraction infrastructure (R. Soummer)
- Acquire GPI observations of β Pic (12/7/2015) and HD 106906 (3/28/2016)
- Assemble scattered light and thermal emission data for targets in Table 1 (2/29/2016)
- Generation of multi-wavelength disk models based on assembled observations (8/31/2016)
- Generation of planet perturbation models for disks (12/31/2016)
- Simulation of modeled planet+disk observations (5/31/2016)

WPS Study Team

- STScI
  - Christine Chen
  - Dean Hines
  - Remi Soummer
  - Christopher Stark
- JHU
  - Colin Norman
- JPL
  - John Krist
  - Bertrand Mennesson