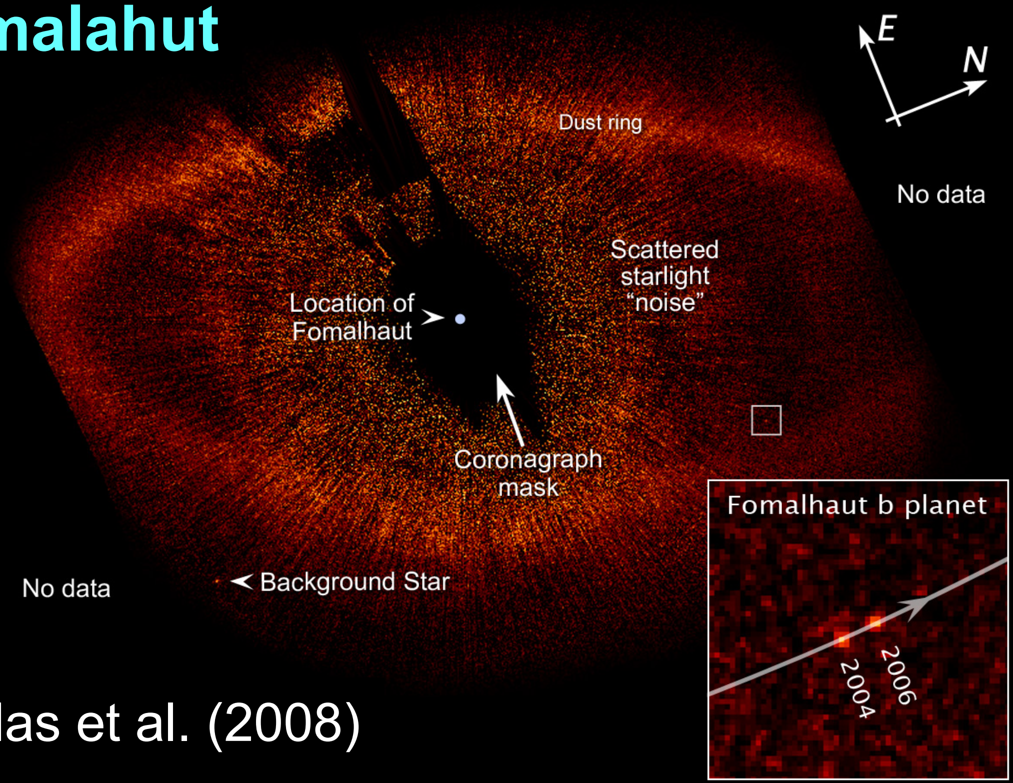
Debris Disks and Exozodi Study Analysis Group

Aki Roberge (NASA GSFC)

Fomalahut



Kalas et al. (2008)

The Problem for Exoplanet Imaging

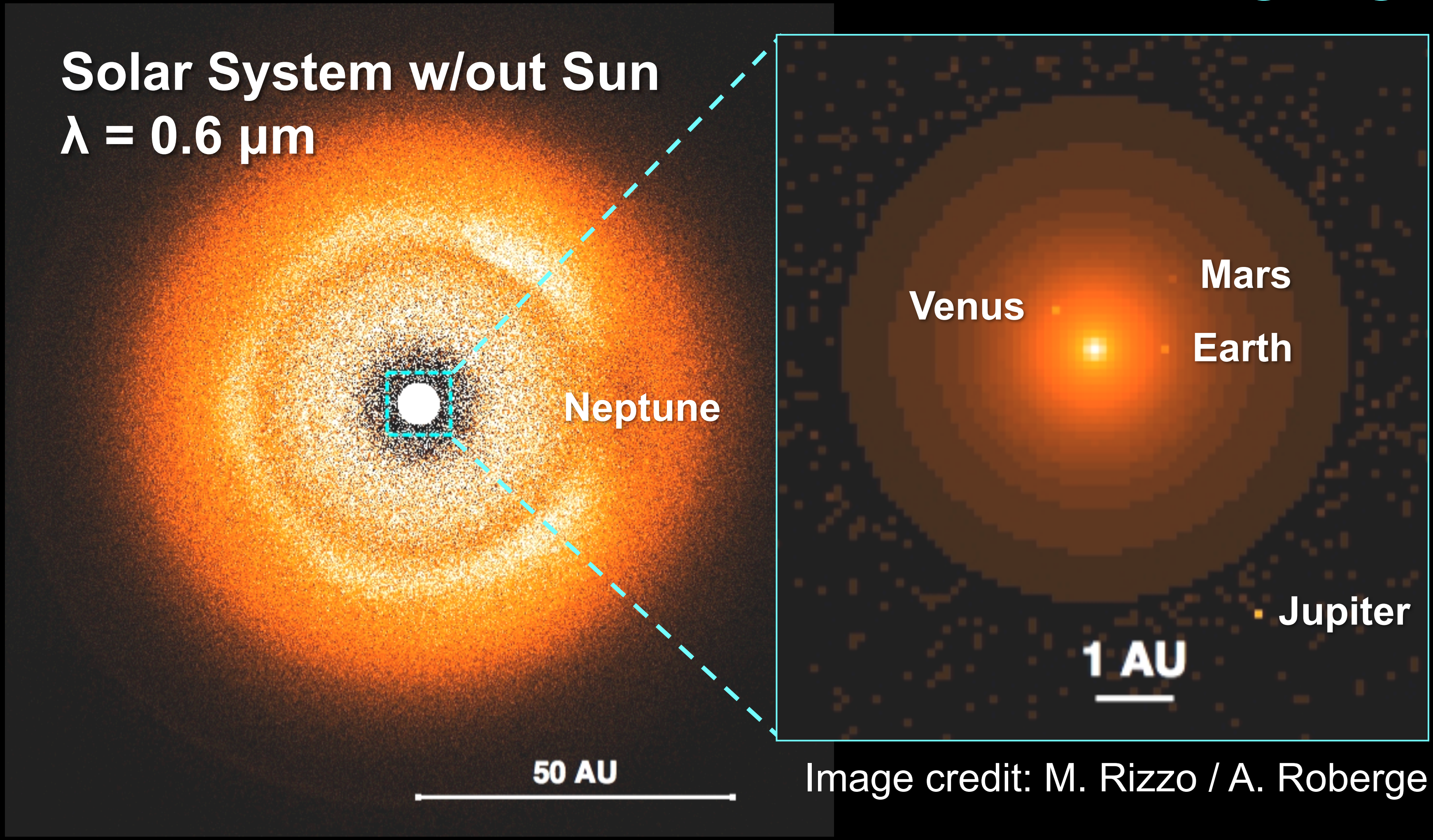


Image credit: M. Rizzo / A. Roberge

- Dust models from Kuchner & Stark (2010), Kelsall et al. (1998) + ZODIPIC

Current SAG Participants

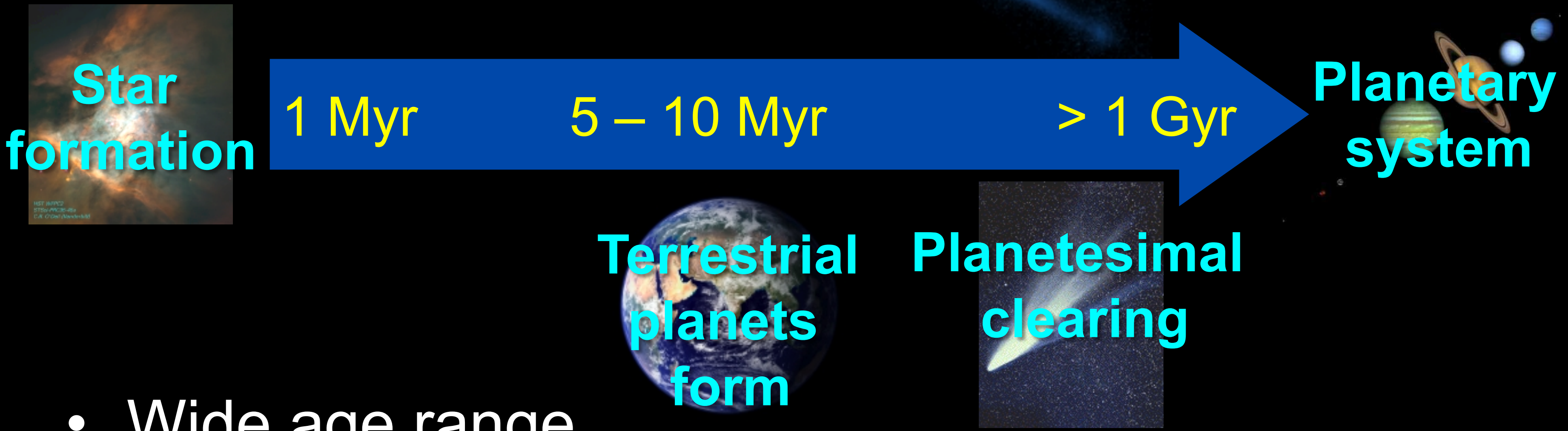
Aki Roberge	(NASA GSFC)
Olivier Absil	(U of Liege)
Geoff Bryden	(NASA JPL)
Christine Chen	(STScI)
Tom Greene	(NASA Ames)
Phil Hinz	(U of Arizona)
Marc Kuchner	(NASA GSFC)
Bruce Macintosh	(LLNL)
Charley Noecker	(Ball)
Stephen Ridgeway	(NOAO)
Remi Soummer	(STScI)
Chris Stark	(CIW DTM)
Alycia Weinberger	(CIW DTM)
Mark Wyatt	(Cambridge)

- To participate, email Aki.Roberge@nasa.gov

Debris Disks

AU Mic − 12 Myr

Krist et al. (2004)



- Wide age range
- Gas-poor, low-mass dusty disks
  - Optically thin, short dust lifetimes
- Secondary material from asteroids & comets

Zodi and Exozodi

- Zodiacal dust > 90% cometary (Nesvorny et al. 2009)
  - Recent asteroid collisions make dust bands

- Debris disk parameters
  1. Fractional IR luminosity (L_{IR}/L_{star}) ➔ dust abundance
  2. Dust temp (T_{dust}) ➔ distance

- Solar System defines “1 zodi”
  - In practice, 1 zodi is $L_{IR}/L_{star} = 10^{-7}$
  - Beta Pic : ~ 10,000 zodis

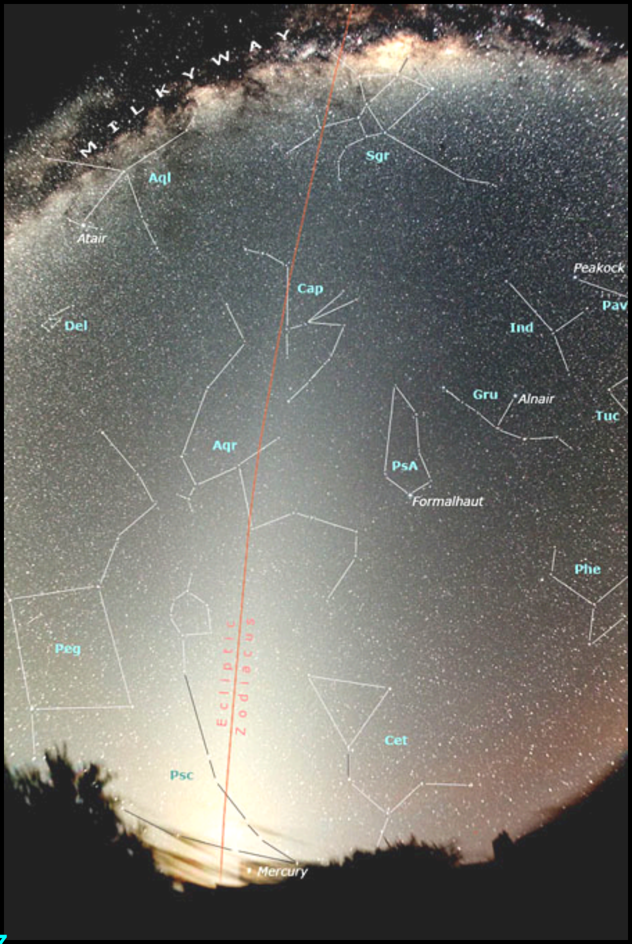
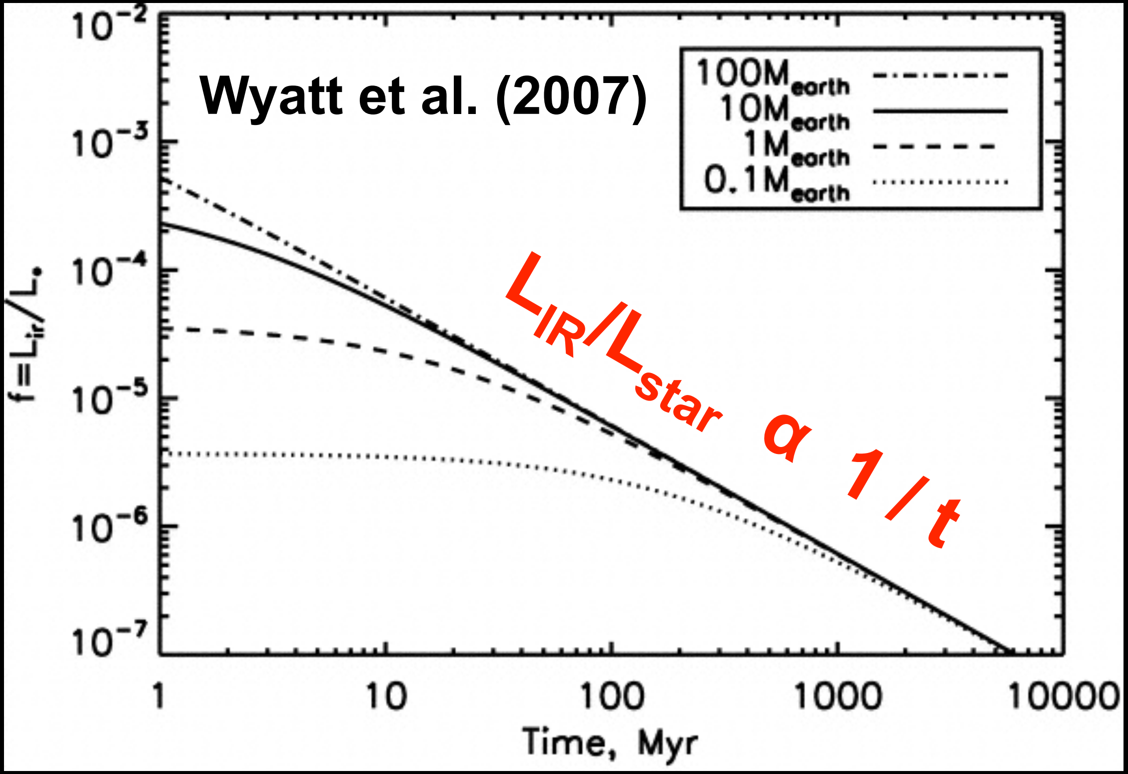


Image credit: S. Seip

Debris Disk Evolution Theory

- Collisional cascade, then dust removed by Poynting-Robertson drag & radiation pressure

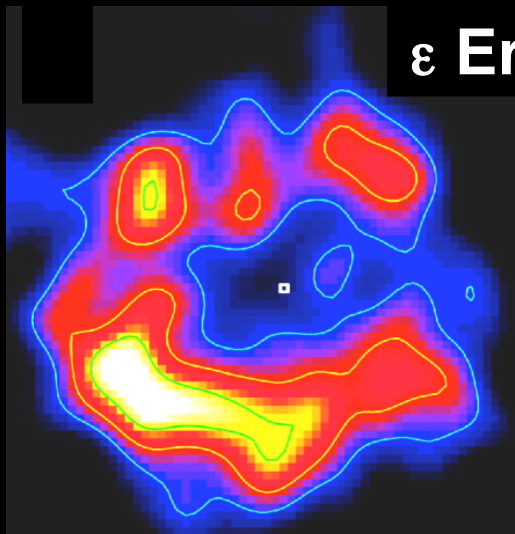


- Broadly consistent w/ debris disk surveys, but absolute abundances uncertain by orders of magnitude

Dust Structures

Clumps

ε Eridani @ 850 μm

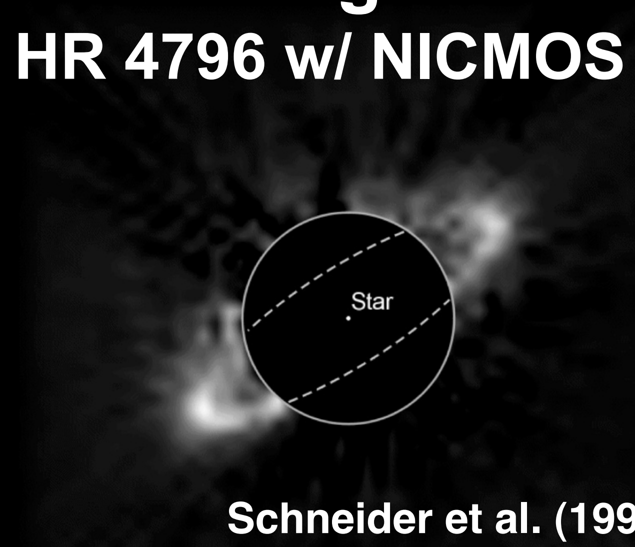


Greaves et al. (2005)

Caused by planets

Rings

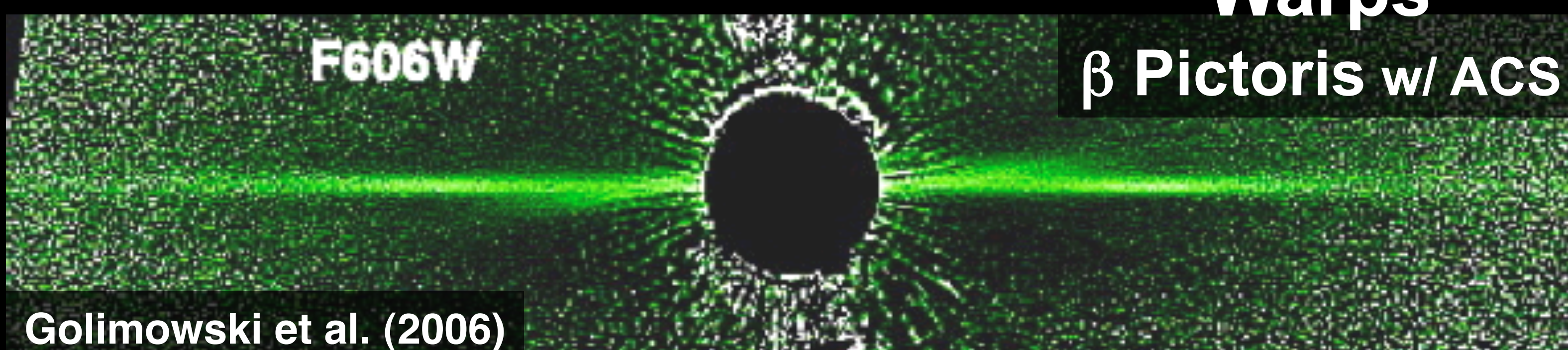
HR 4796 w/ NICMOS



Schneider et al. (1999)

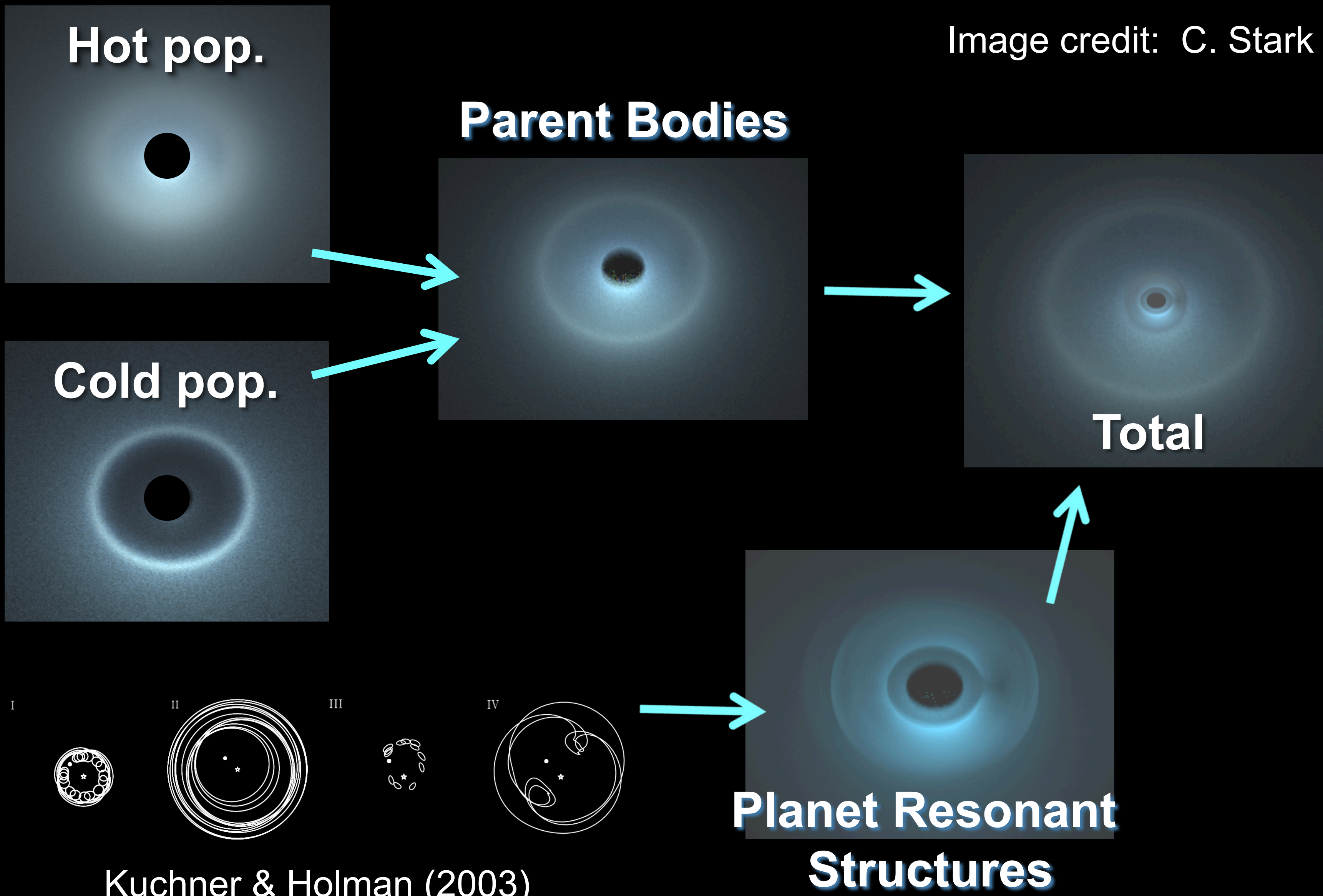
Warps

β Pictoris w/ ACS

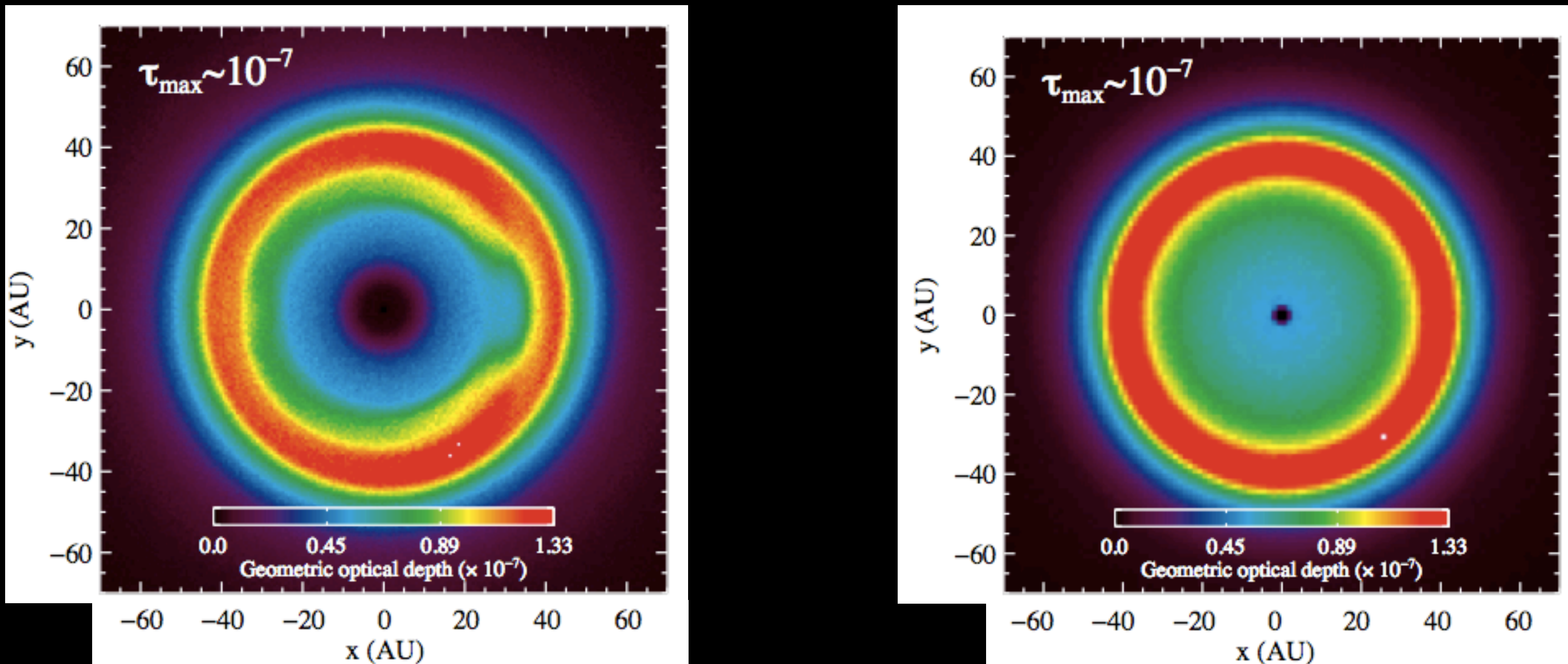


Golimowski et al. (2006)

Dust Structure Models



Impact of Planets



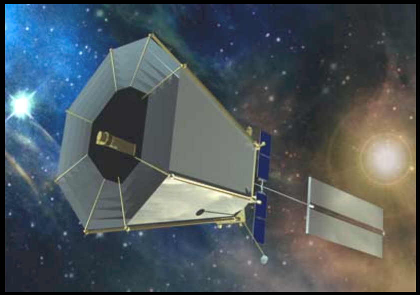
Kuiper Belt dust cloud with 4 outer planets

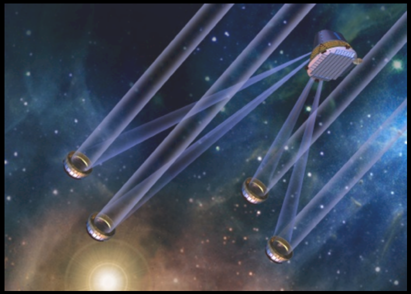
Kuiper Belt dust cloud without planets

- Central hole created by Saturn (Kuchner & Stark 2010)
- Dust optical depth decreased by ~ 20

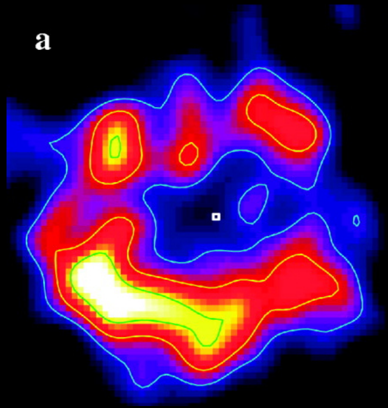
Big Questions

- How well must we know exozodi levels to determine the performance of direct imaging/ spectroscopy exoplanet missions?





- How is the problem complicated by asymmetries in exozodiacal dust disks?



- What are the exozodiacal dust levels around nearby stars?

Initial SAG Tasks

1. Collect existing information re. impact of exozodiacal background on various exoplanet mission concepts
   - Describe additional analyses needed
   - Work with members of past or existing mission concept teams
   - Upcoming talk by Charley Noecker
2. Collect information on expected sensitivity of upcoming facilities to debris dust
   - Upcoming talk by Christine Chen

Task #3

3. Determine how many stars we must observe with what exozodi sensitivity to predict number of feasible targets for direct exoplanet observations

   – Start by organizing theoretical studies to produce expected distribution(s) of exozodi brightness levels

     • Complicated ! Involves variety of modeling

   – May also need to know stellar ages, masses & locations of planetesimal belts and giant planets