Planetary system insights from spatially resolved debris disks

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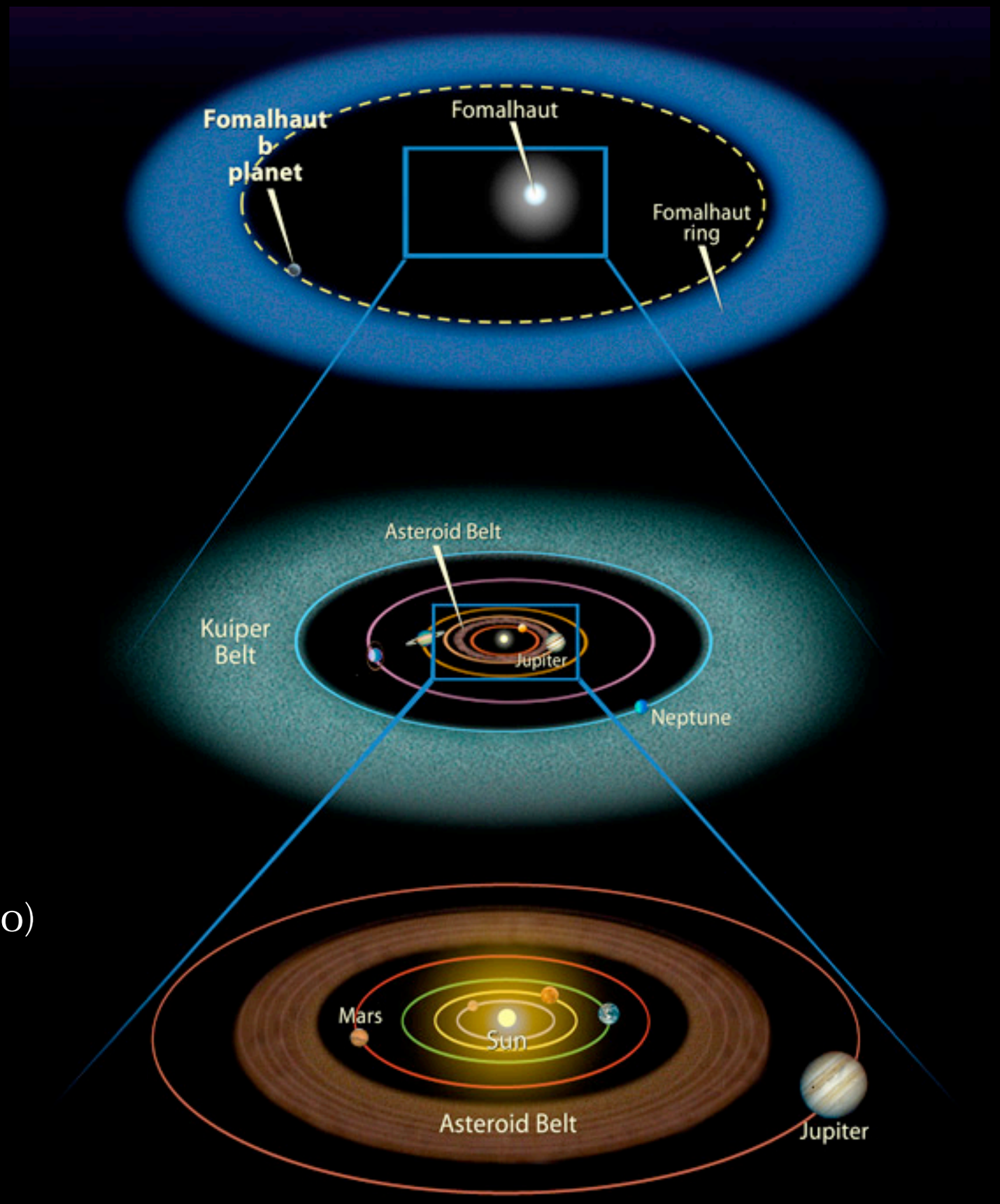

image credit: NASA/ESA/A. Feild (STScI)


Dust loss timescales << stellar age


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Observed dust must be replenished


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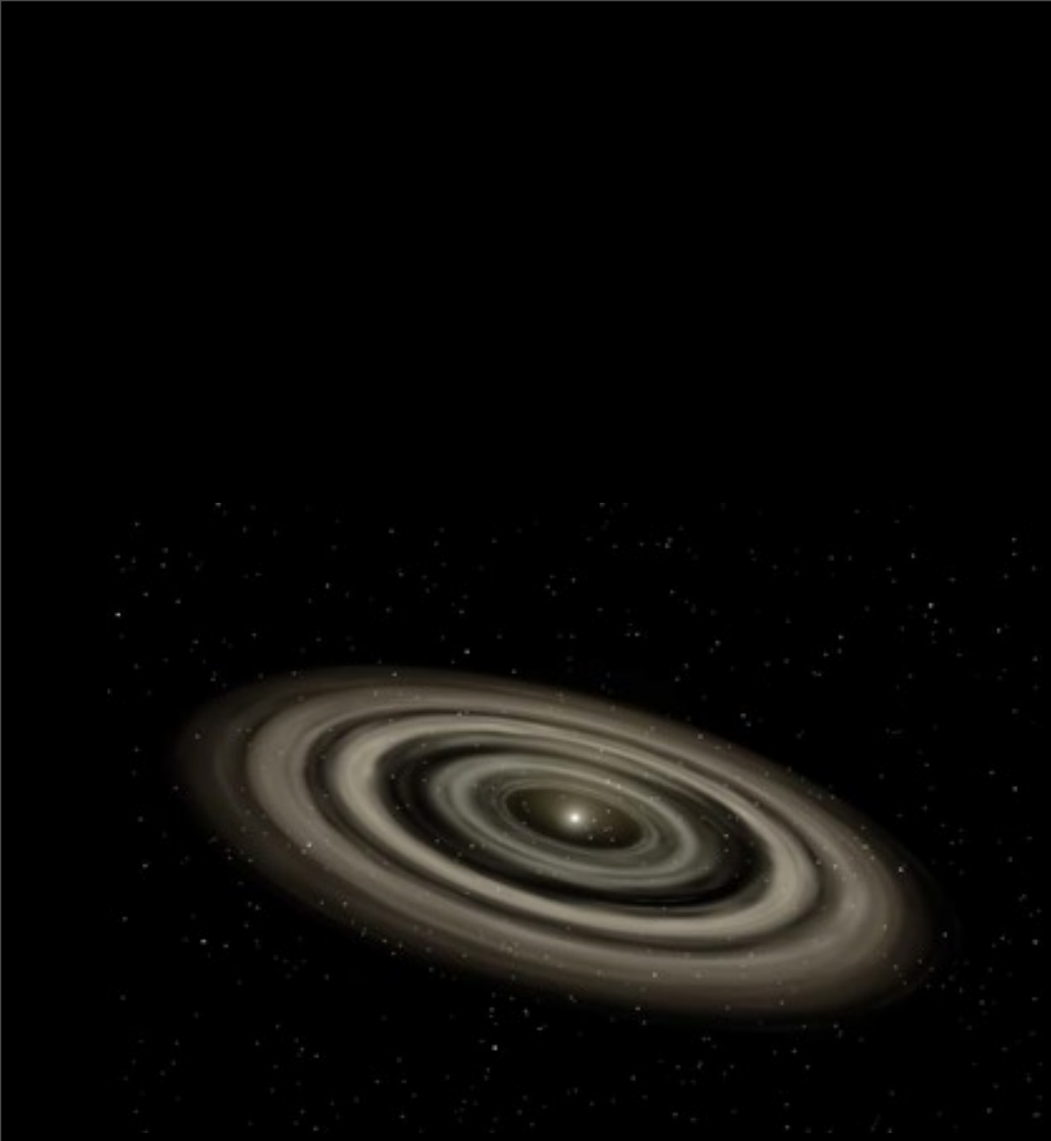
Continuous progression from primordial disk



Dust loss timescales << stellar age

Observed dust must be replenished

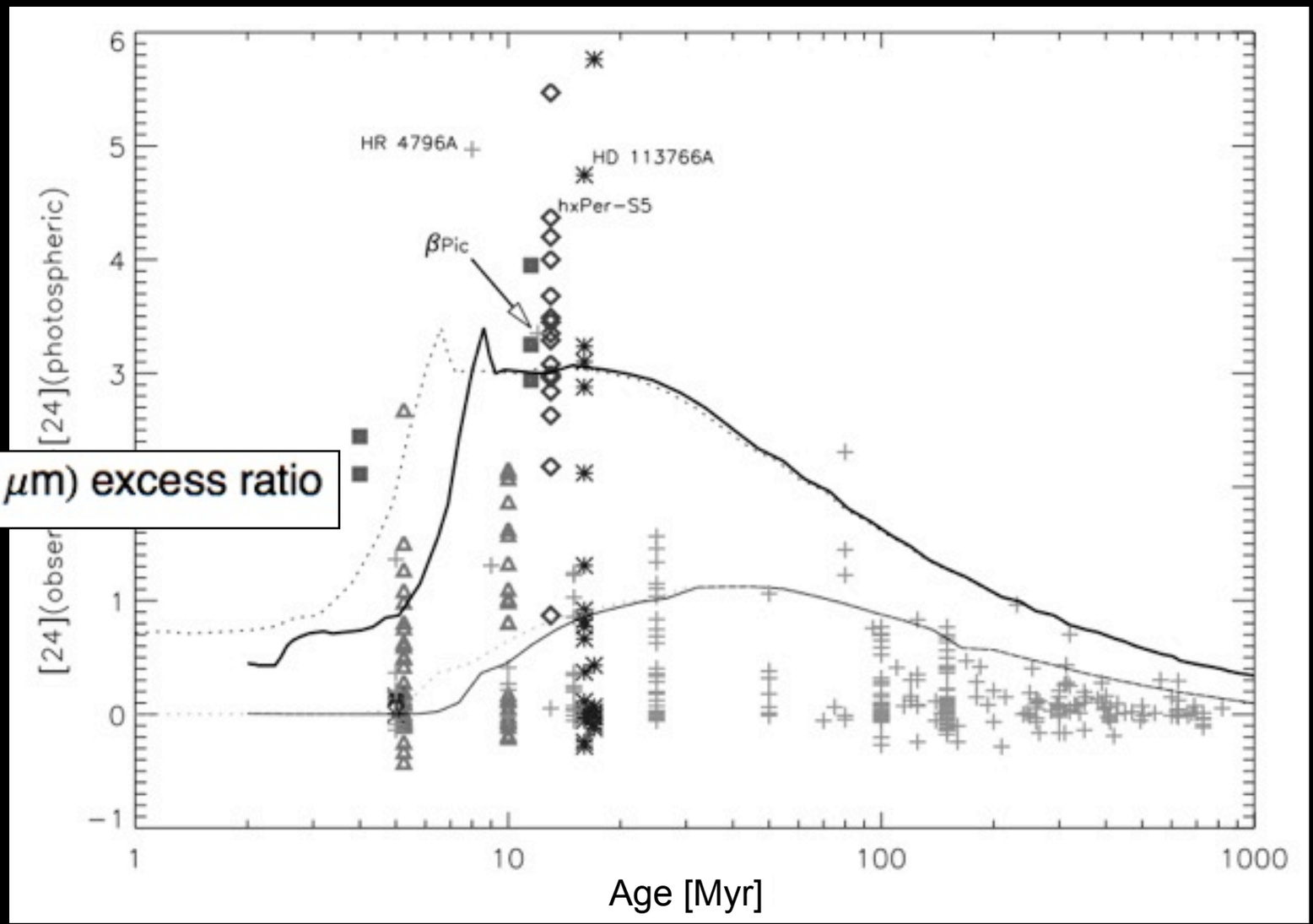
Continuous progression from primordial disk

Our debris disk =
zodiacal dust from asteroidal collisions;
dust from cometary ejecta; dust from KBO collisions

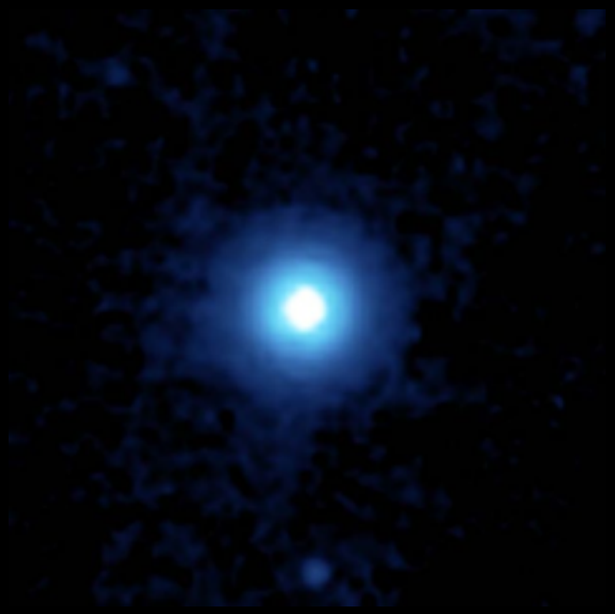
Age

Dust disk brightness

$F_{obs}(24\ \mu m)/F_{phot}(24\ \mu m)$ excess ratio

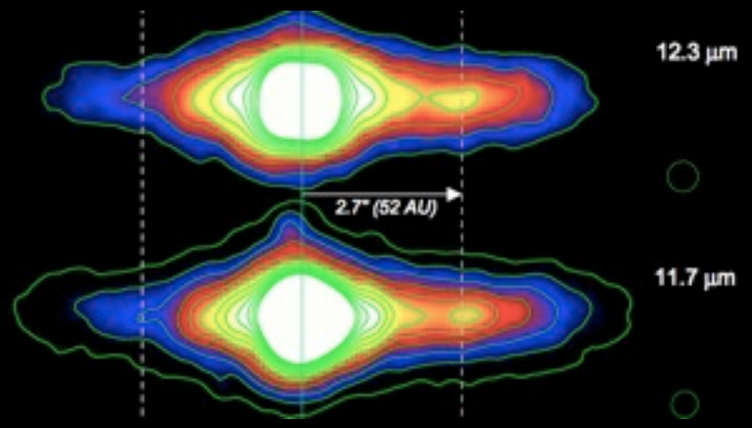


Currie et al. 2008
(with models from Kenyon & Bromley 2004)



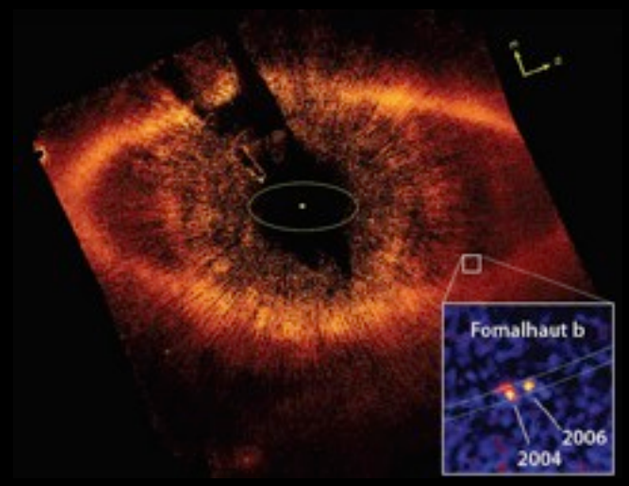
~14″ resolution

Vega; Su et al. 2005
Spitzer/MIPS



~0.3″ resolution

Beta Pic; Telesco et al. 2005
Gemini/T-ReCS

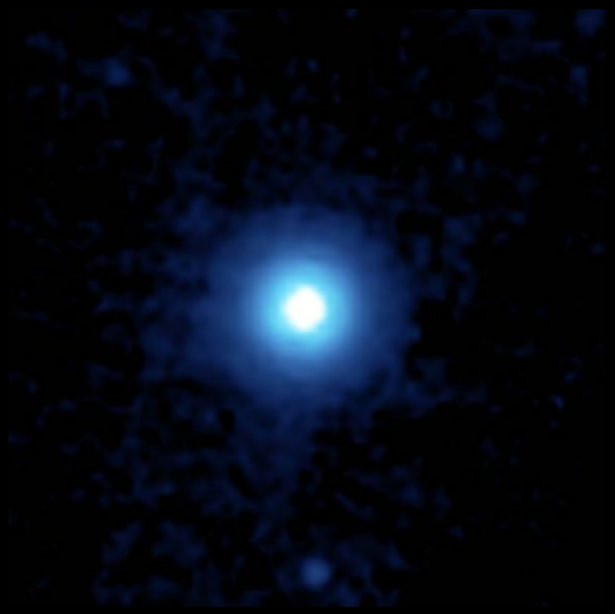


~0.05″ resolution

Fomalhaut; Kalas et al. 2008
HST/ACS

disk truncation by a companion or planet
disk warping by a companion or planet
} particle size & wavelength independent

bright clumps at sites of recent collisions
bright clumps at sites of resonant trapping
} particle size & wavelength dependent



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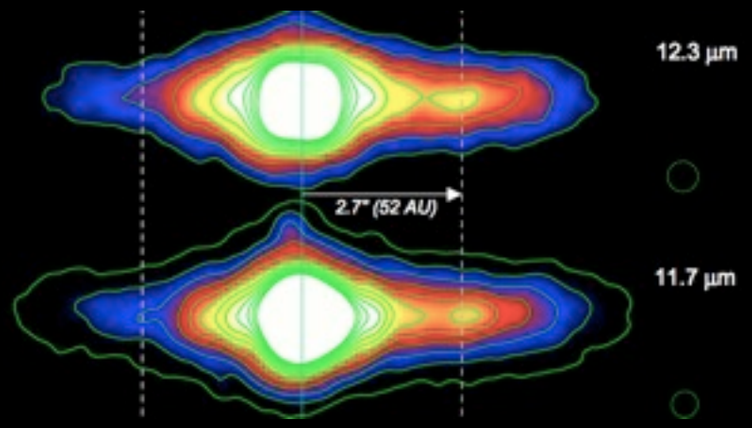

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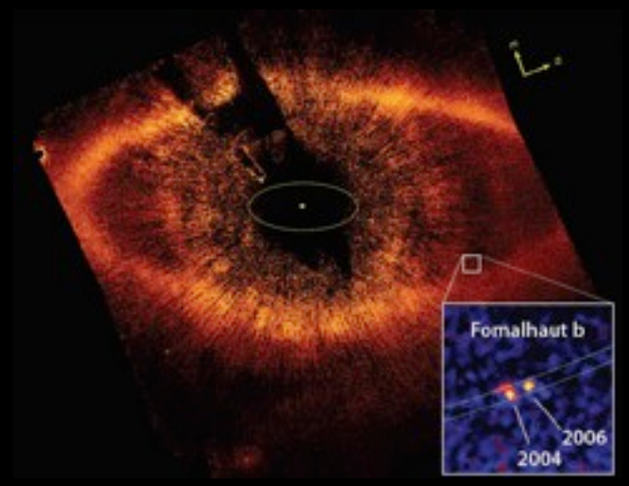

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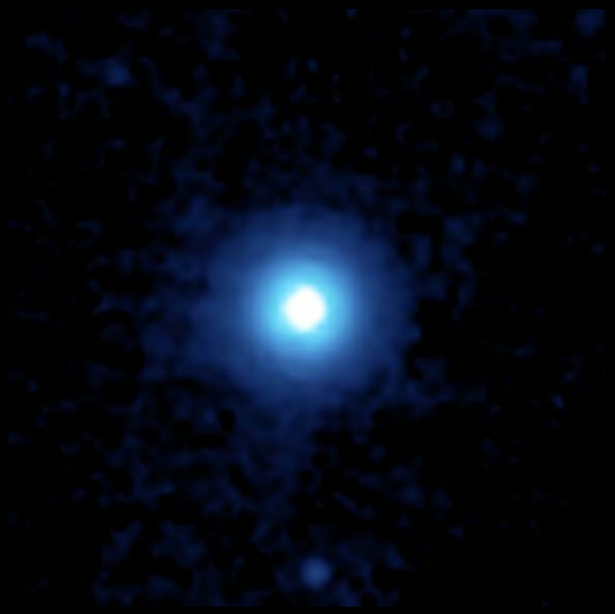

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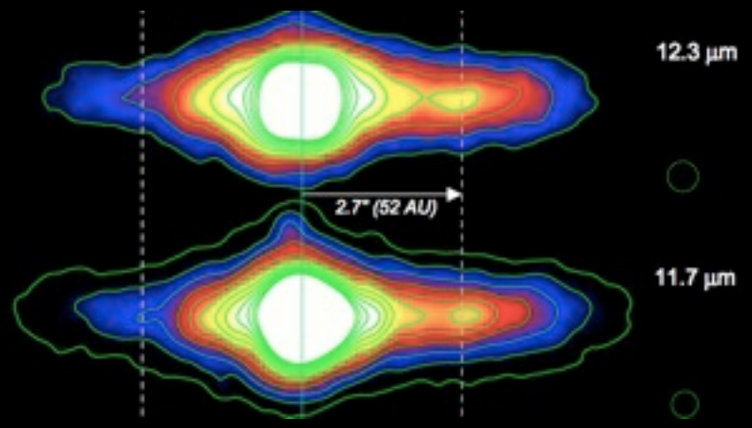

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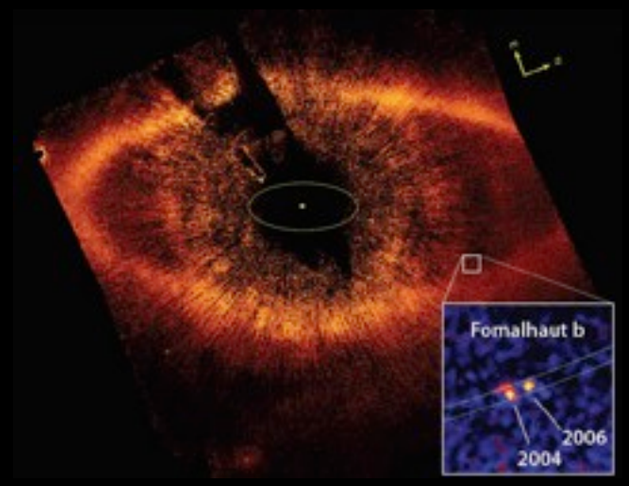

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Fomalhaut; Kalas et al. 2008
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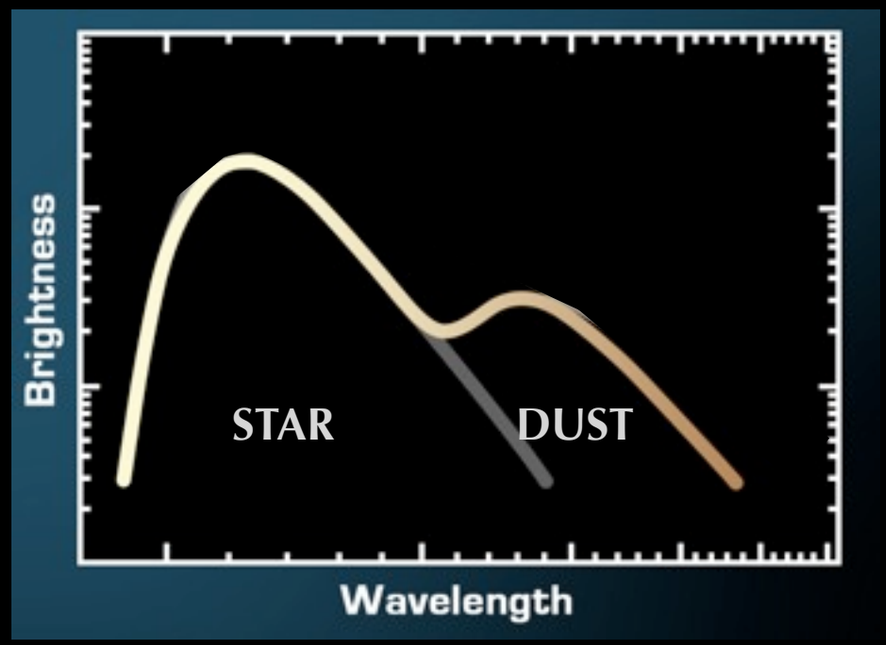
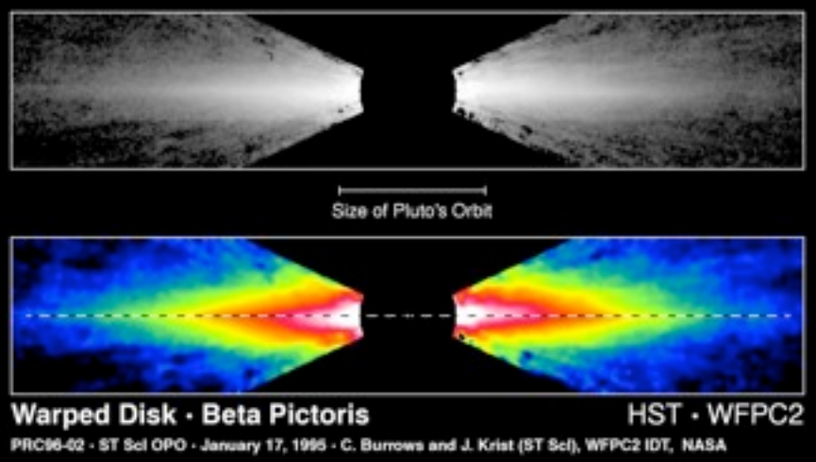
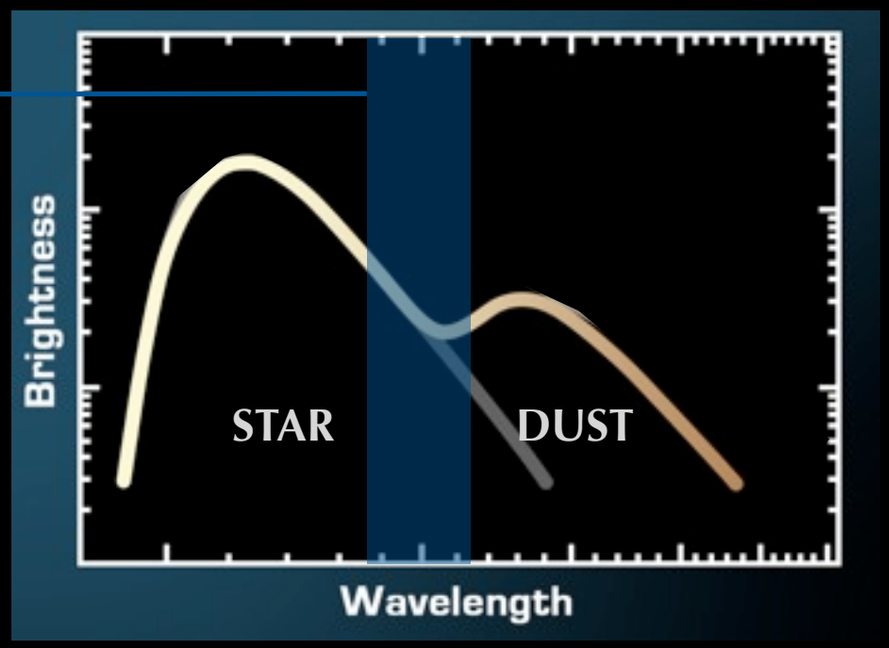
Key goal:
Investigate physical processes in debris disks by characterizing the disk structure and composition

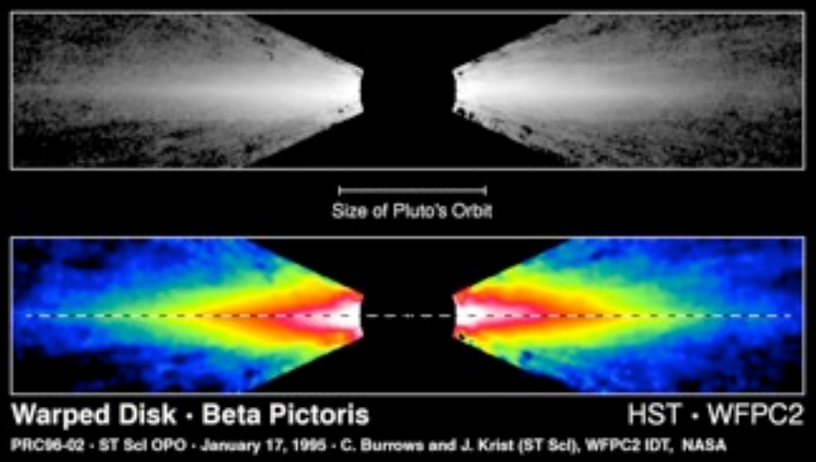

Brightness
STAR
DUST
Wavelength

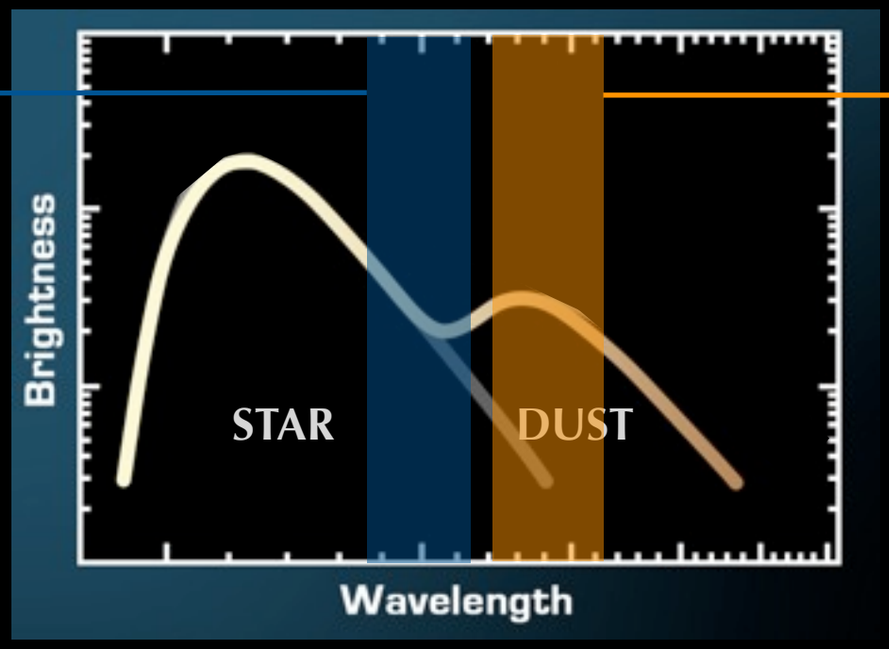
scattered light imaging



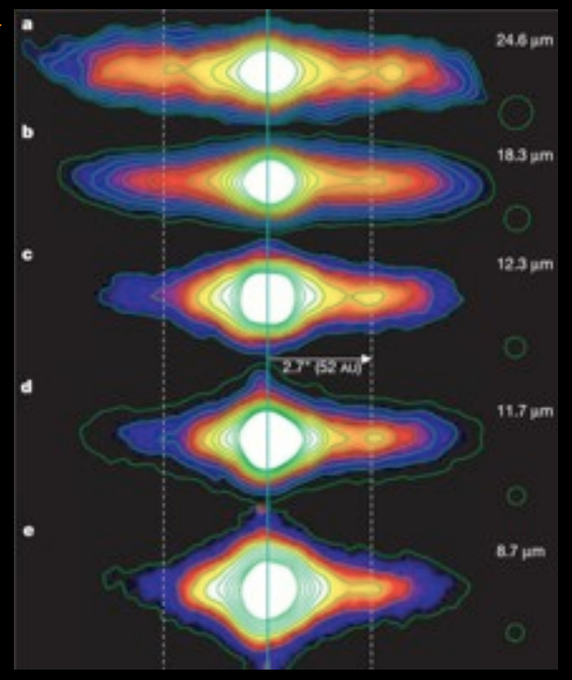


scattered light imaging

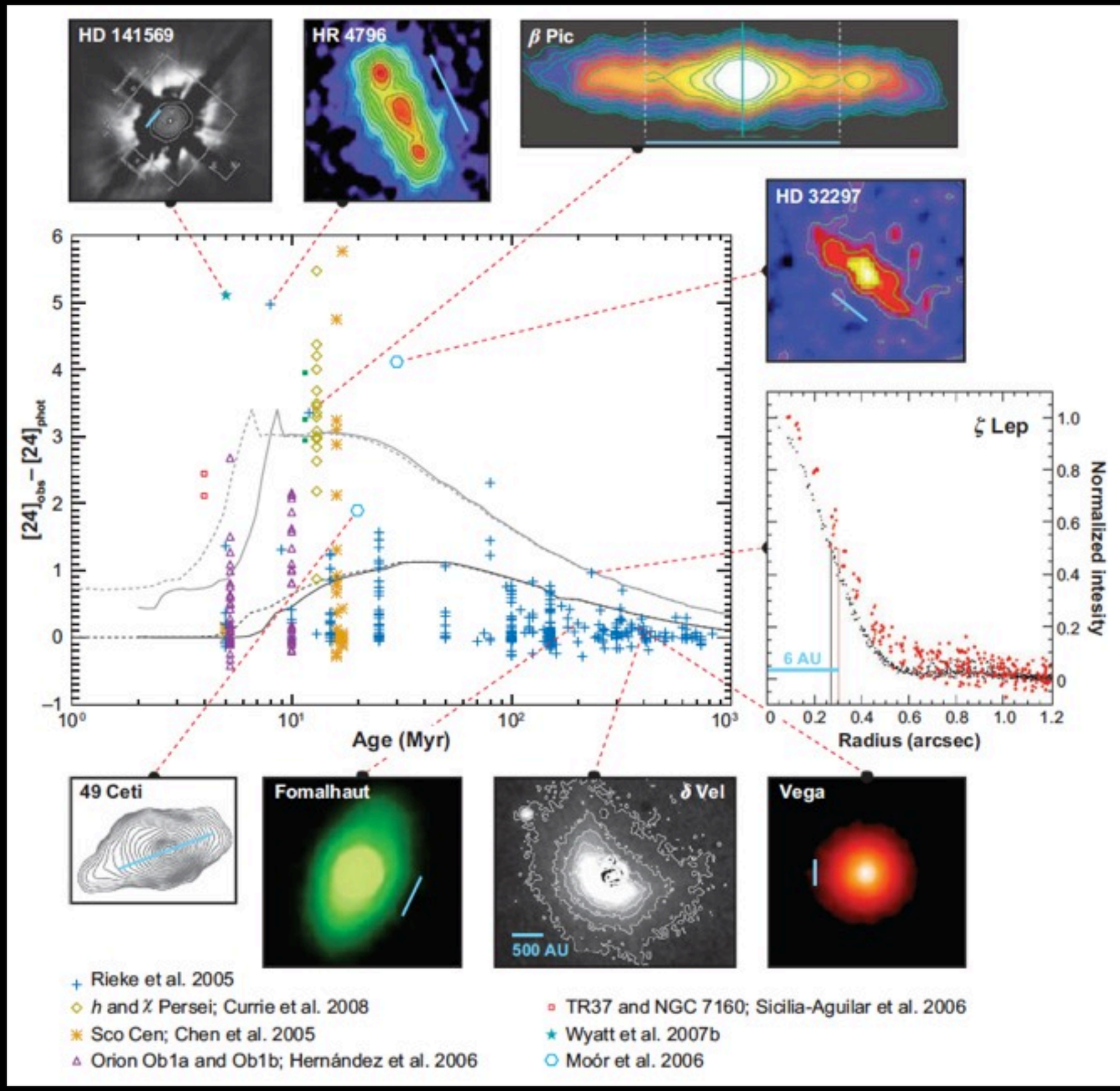




thermal emission imaging



Telesco et al. 2005


HD 141569
HR 4796
β Pic
HD 32297
ζ Lep
6 AU
Normalized intesity
Radius (arcsec)
[24]obs − [24]phot
Age (Myr)
49 Ceti
Fomalhaut
δ Vel
500 AU
Vega
Rieke et al. 2005
h and χ Persei; Currie et al. 2008
Sco Cen; Chen et al. 2005
Orion Ob1a and Ob1b; Hernández et al. 2006
TR37 and NGC 7160; Sicilia-Aguilar et al. 2006
Wyatt et al. 2007b
Moór et al. 2006

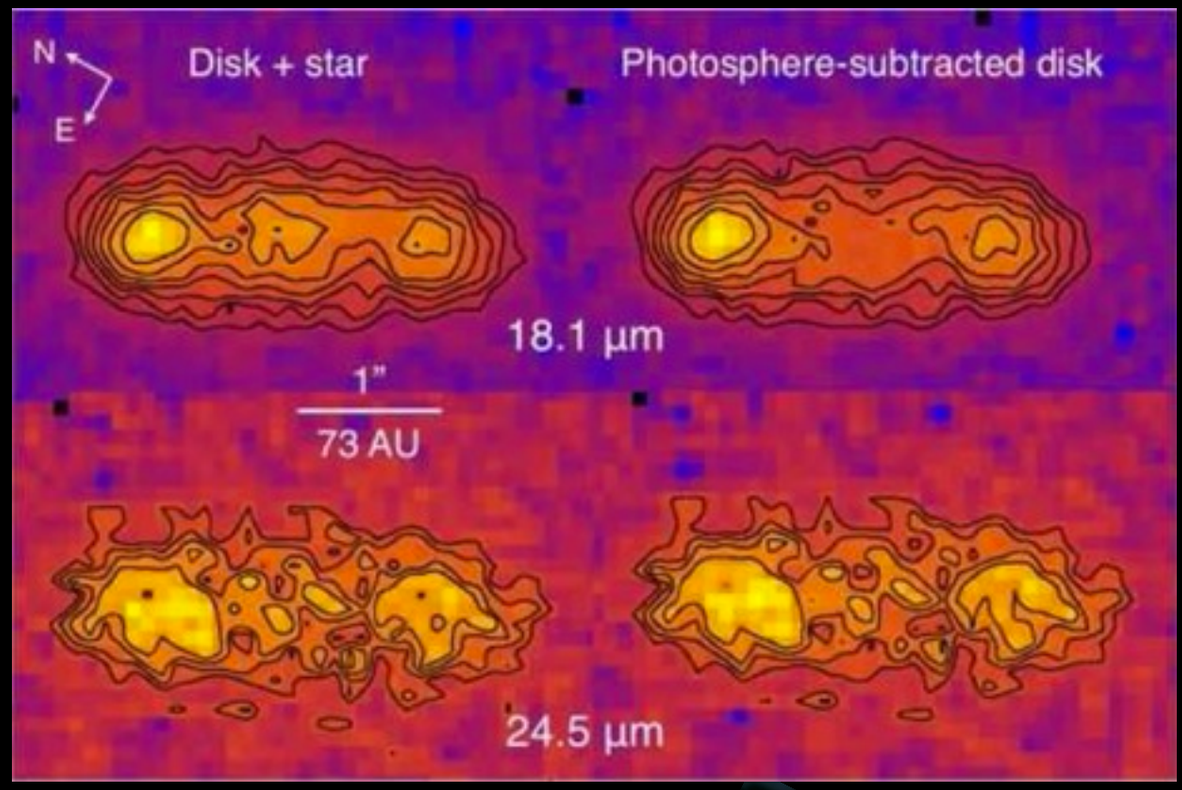
Wyatt 2009

HR 4796A

Distance = 73 pc

Dust annulus radius = 76 AU

Dust annulus width = 19 AU



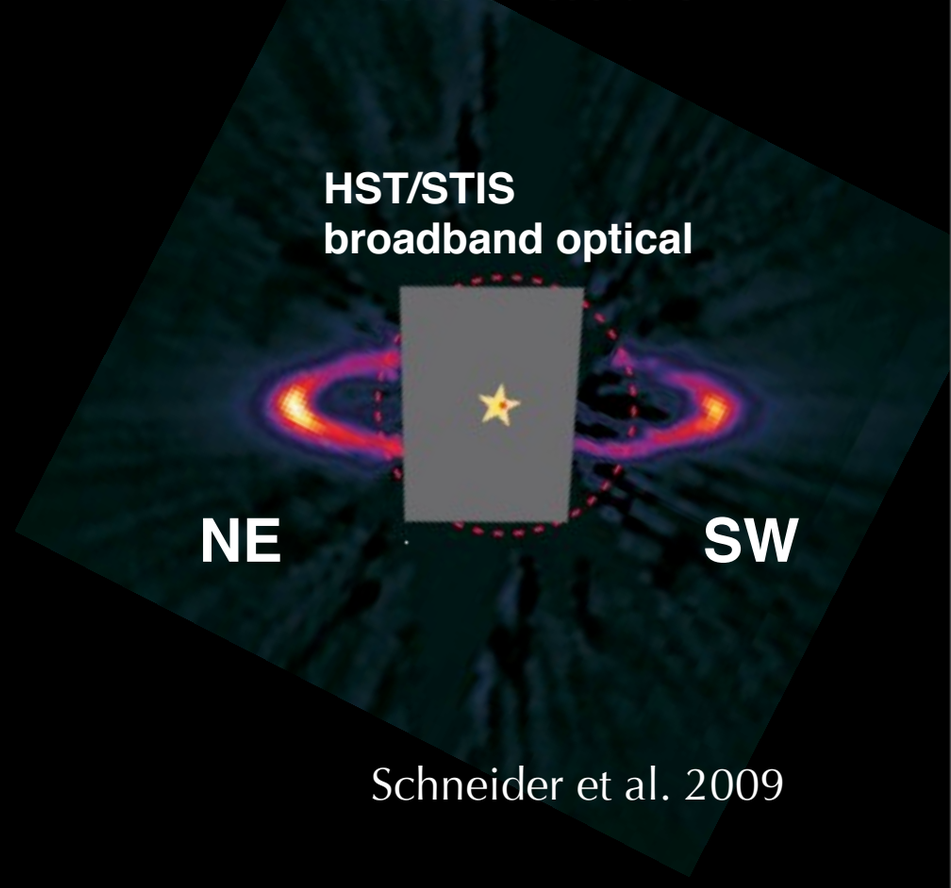
Moerchen et al. 2011

- Highest fractional luminosity among debris disks

  $L_{IR}/L_* = 5 \times 10^{-3}$

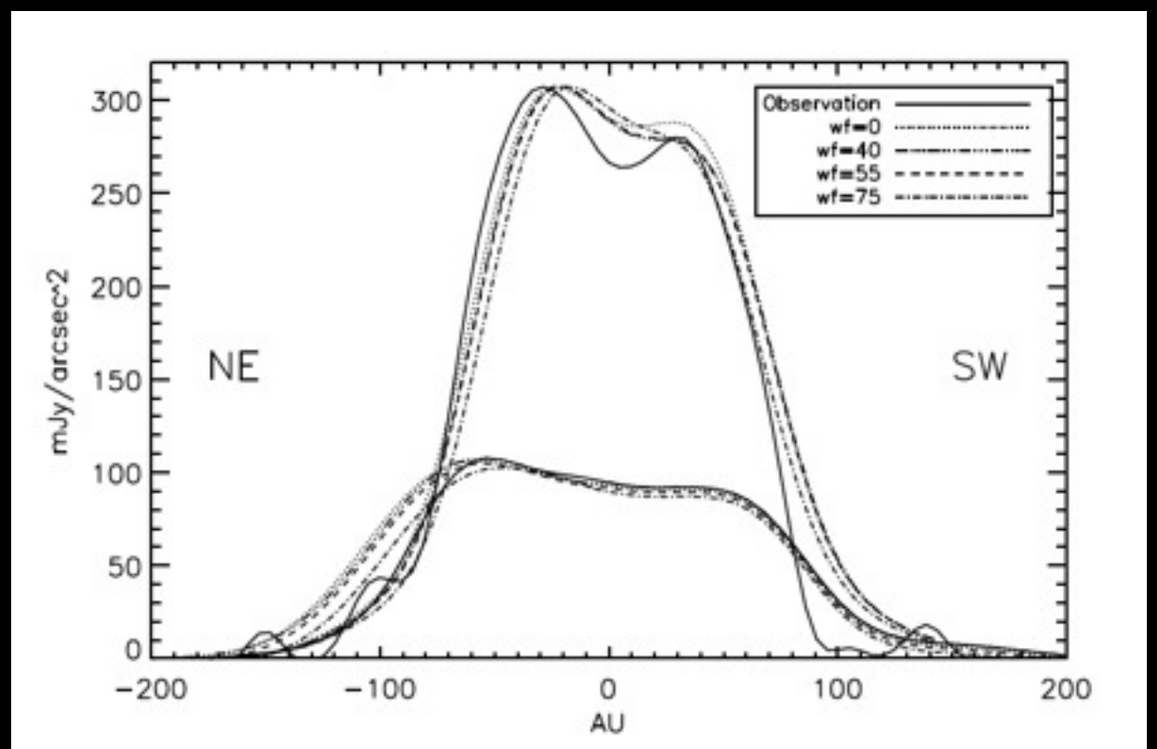
- First resolved by ground-based MIR images
  (OSCIR at CTIO, Jayawardhana et al. 1998)
  (MIRLIN at Keck, Koerner et al. 1998)

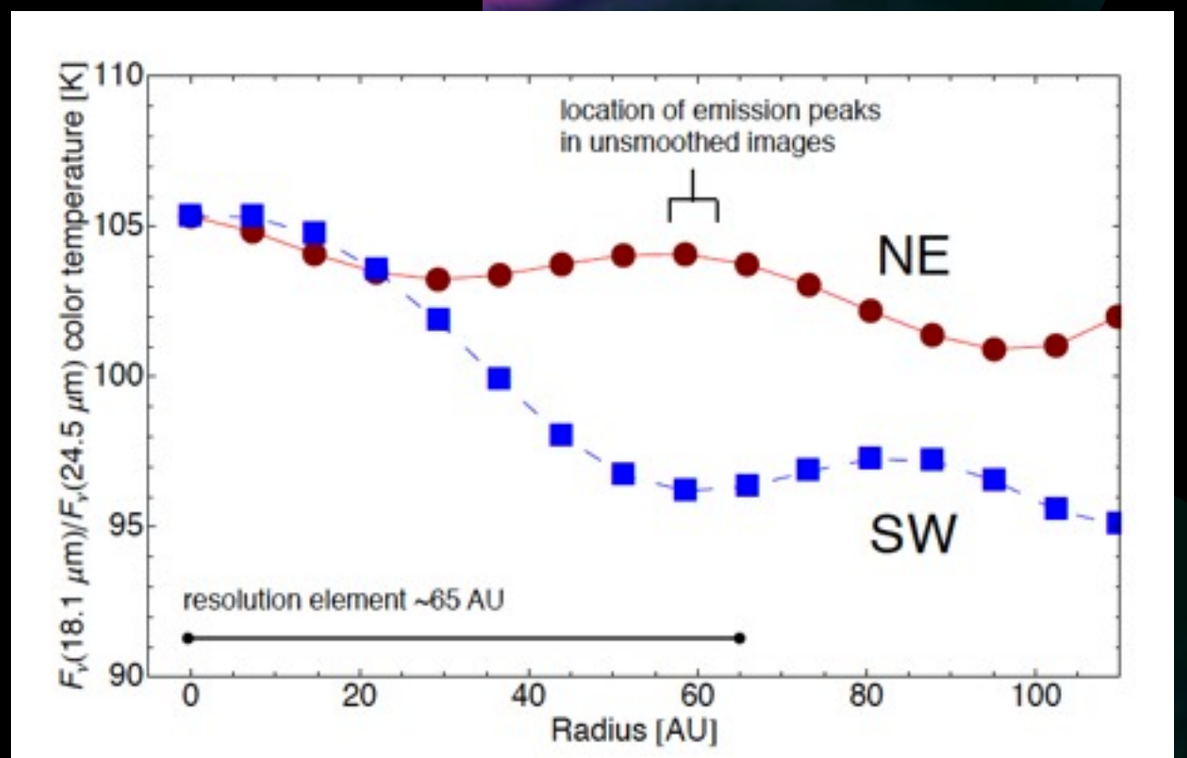
- Resolved also in space-based NIR images
  (HST NICMOS, Schneider et al. 1999, 2009)

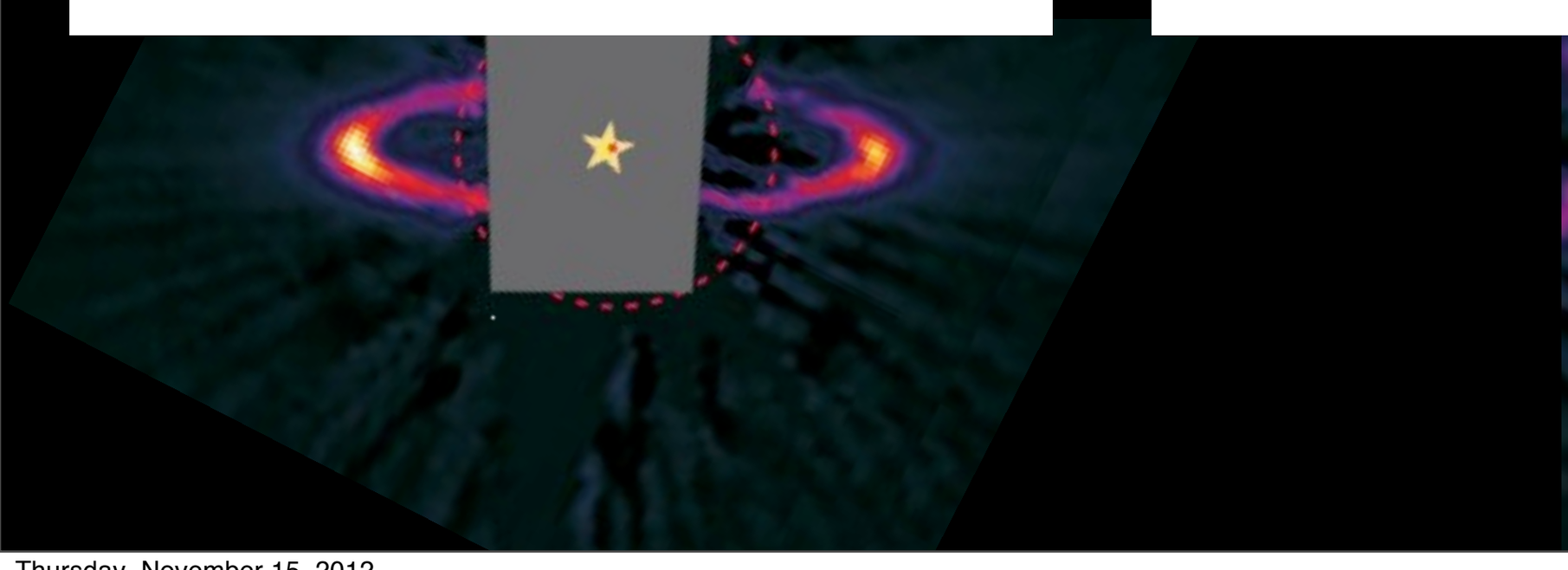


Schneider et al. 2009

Temperature asymmetry



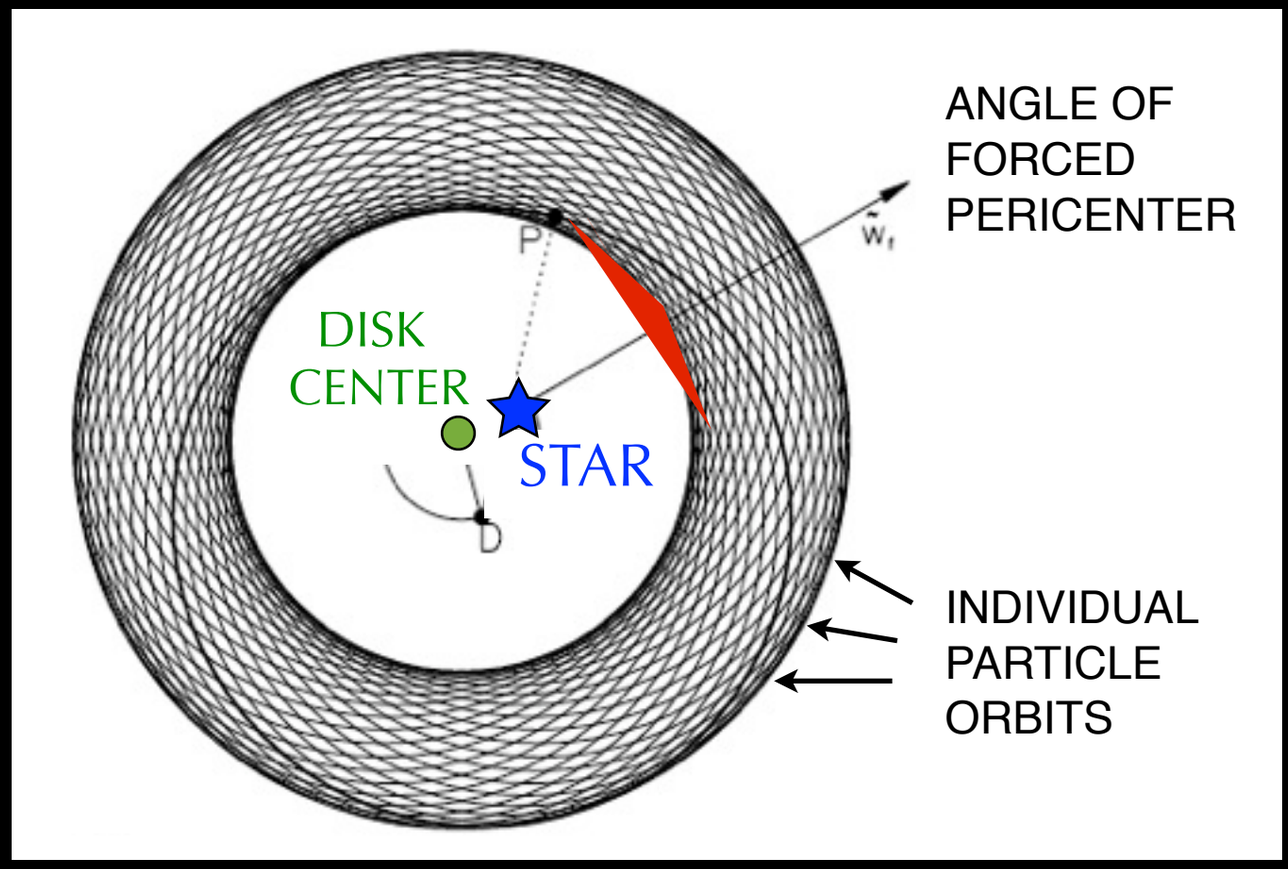




Moerchen et al. 2011
Schneider et al. 2009

Pericenter glow in HR 4796A

- Dust particle orbits experience secular perturbations by a planet on an eccentric orbit
- Center of disk is offset opposite direction of forced pericenter
- Dust closer to star is heated more



Wyatt et al. 1999

Temperature & brightness asymmetry (MIR) can be replicated in disk models with a 0.06 forced eccentricity

possibly due to the influence of a giant planet

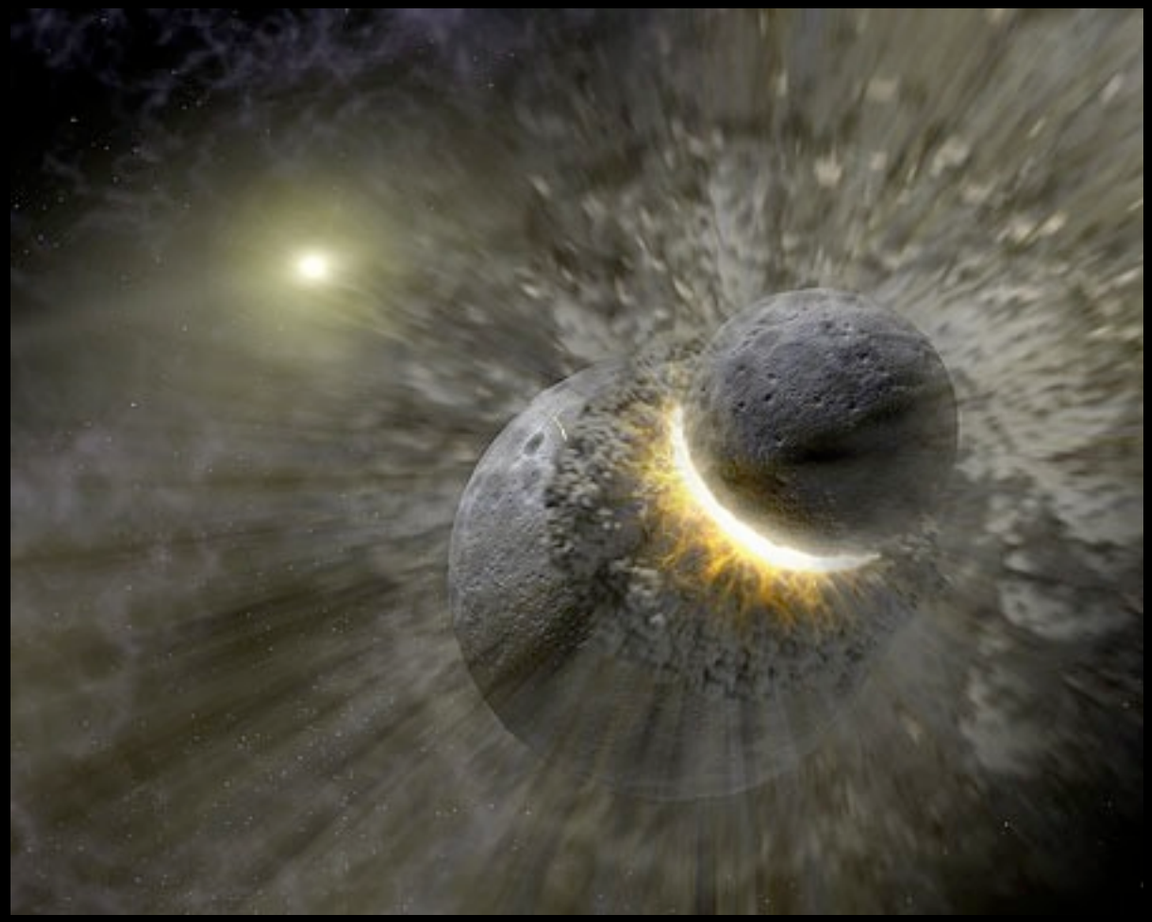
Moerchen et al. 2011

Next debris disk studies

Continue search for resolved disks (likely in IR) - *WISE follow-up sources*

Add polarimetry and spatially resolved spectroscopy to study changes in dust properties with radius - *HST/NICMOS archival programs*

Make coherent models with all available datasets for most-studied disks



NASA/JPL-Caltech