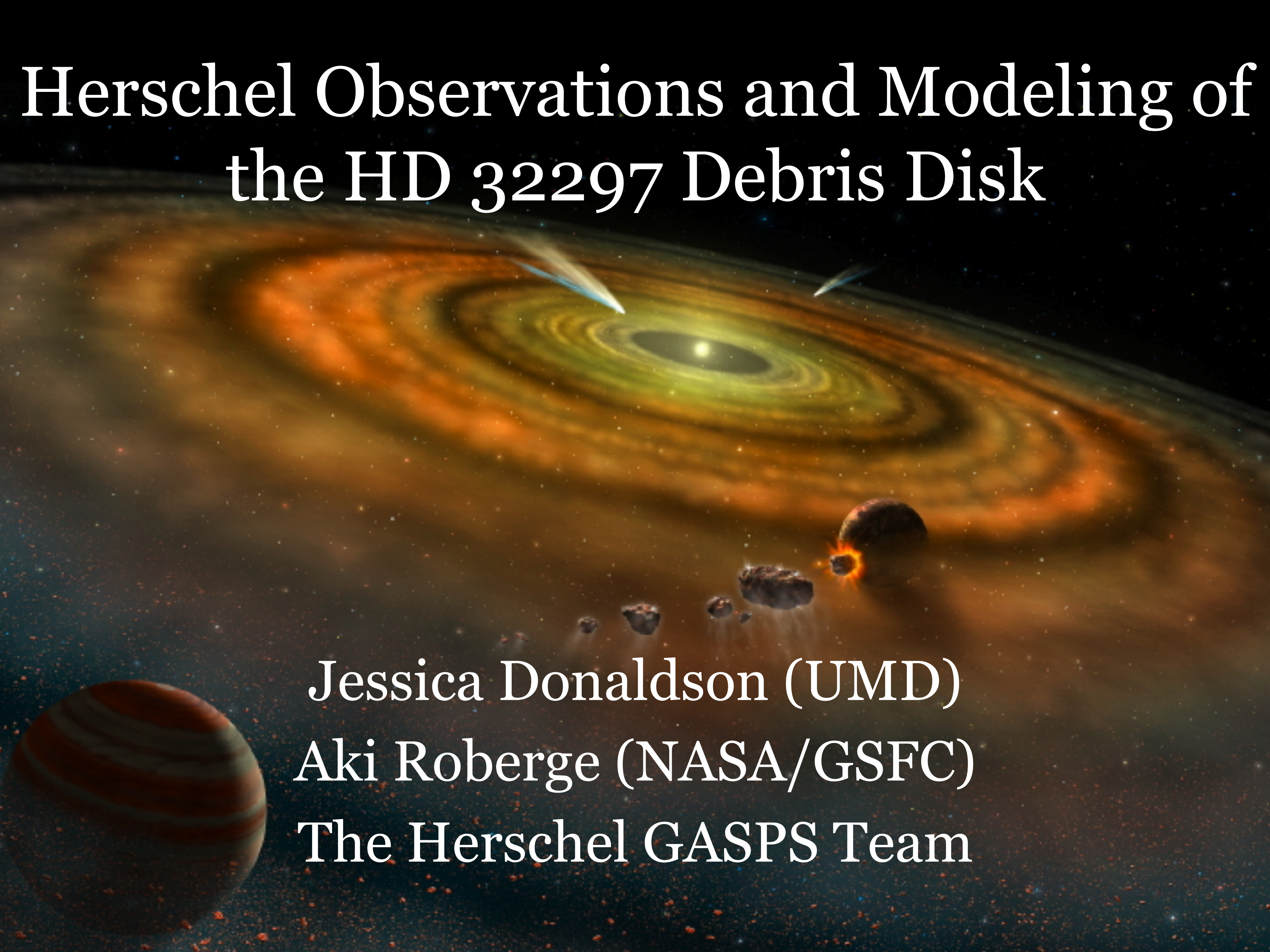
Herschel Observations and Modeling of the HD 32297 Debris Disk



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HD32297 is a bright edge-on disk

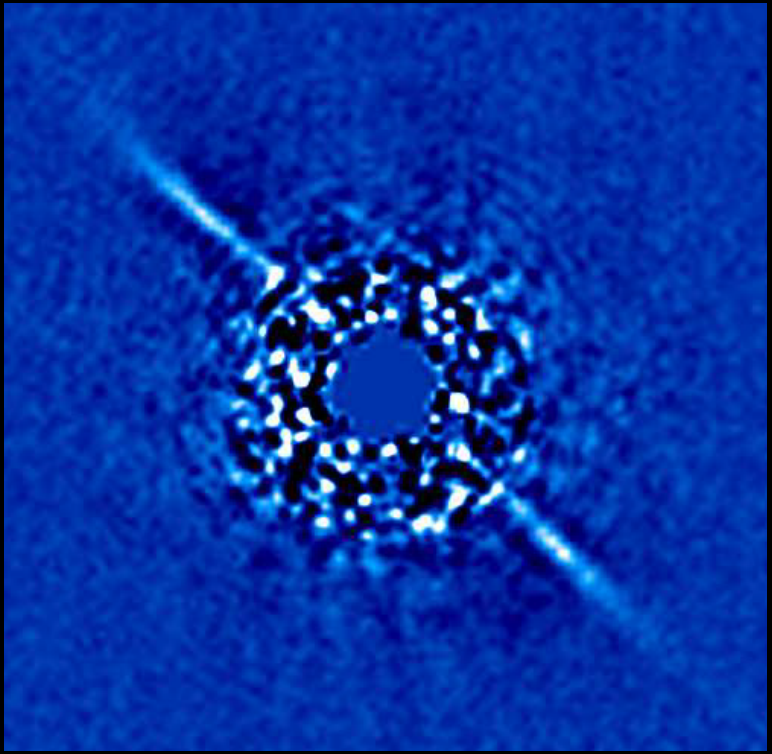
30 Myr-old debris disk

Resolved at several wavelengths

- near-IR (Schneider et al. 2005, Debes et al. 2009, Mawet et al. 2009, Currie et al. 2012, Boccaletti et al. 2012)
- mid-IR (Moerchen et al. 2007, Fitzgerald et al. 2007)
- Millimeter (Maness et al. 2008)

Very Luminous Disk

$$L_{\mathrm{IR}}/L_{\mathrm{star}} \approx 10^{-3}$$



VLT/NACO Ks 2.16 µm image of HD32297 (Boccaletti et al. 2012)

Herschel Observations

- Photometry
  - PACS – Scan map mode at 70, 100 & 160 µm
  - SPIRE – Small map at 250, 350, & 500 µm

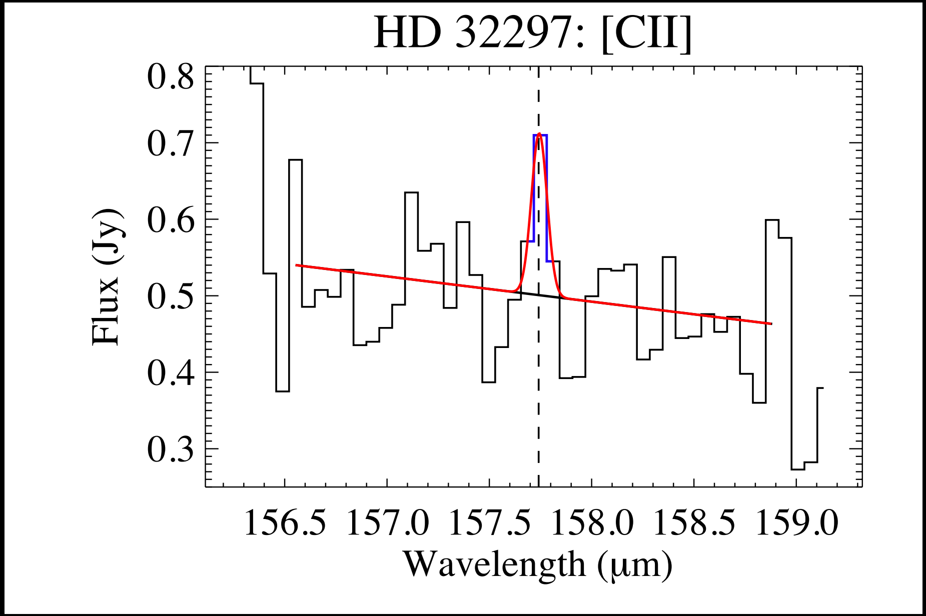
- Spectroscopy
  - PACS LineSpec and RangeSpec modes
  - 8 lines targeted: [OI] 63µm, CO 72 µm, H_2O 79 µm, CO 90 µm. [OI] 145 µm, [CII] 158 µm, H_2O 190 µm

PACS Spectroscopy – CII 158 μm

Lines targeted:

- [OI] 63 μm
- CO 72 μm
- H_2O 79 μm
- CO 90 μm
- [OI] 145 μm
- → [CII] 158 μm
- H_2O 190 μm

Only 1 line detected – [CII] 158 μm



$$F_{\mathrm{line}} = (2.46 \pm 0.72) \times 10^{-18}\ \mathrm{W\,m^{-2}}$$

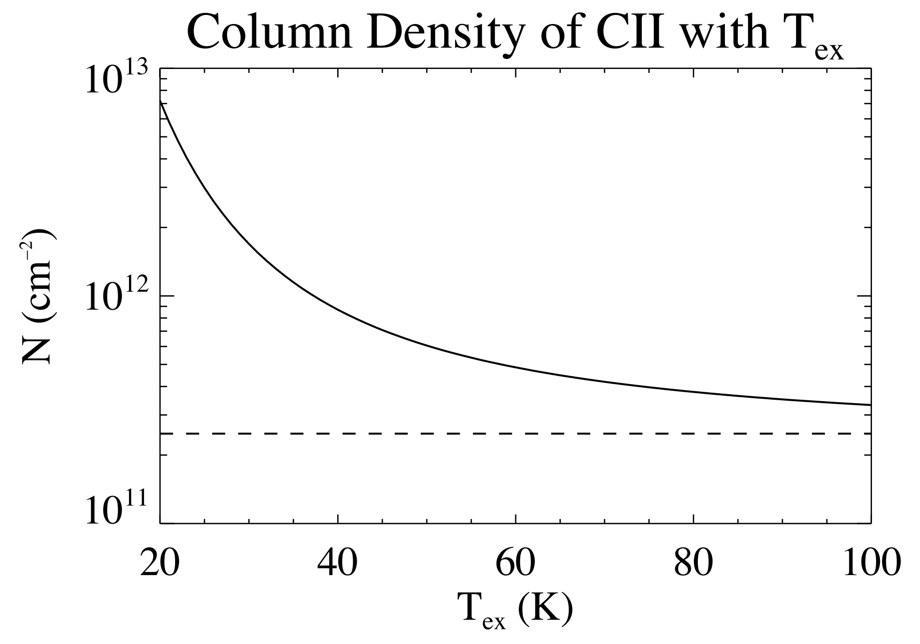
3.4 σ detection of [CII] 158 μm line
from Herschel PACS RangeSpec mode

Lower limit of Column Density

Column density depends on the excitation temperature $T_{\rm ex}$

$T_{\rm ex}$ is unknown → we can only get a lower limit on Column Density

$$N_{\rm [CII]} > 2.5 \times 10^{-11}\,{\rm cm}^{-2}$$



We expect a higher value than the lower limit because NaI column density from Redfield (2007) similar $N_{\rm NaI} = 2.5 \times 10^{-11}\,{\rm cm}^{-2}$

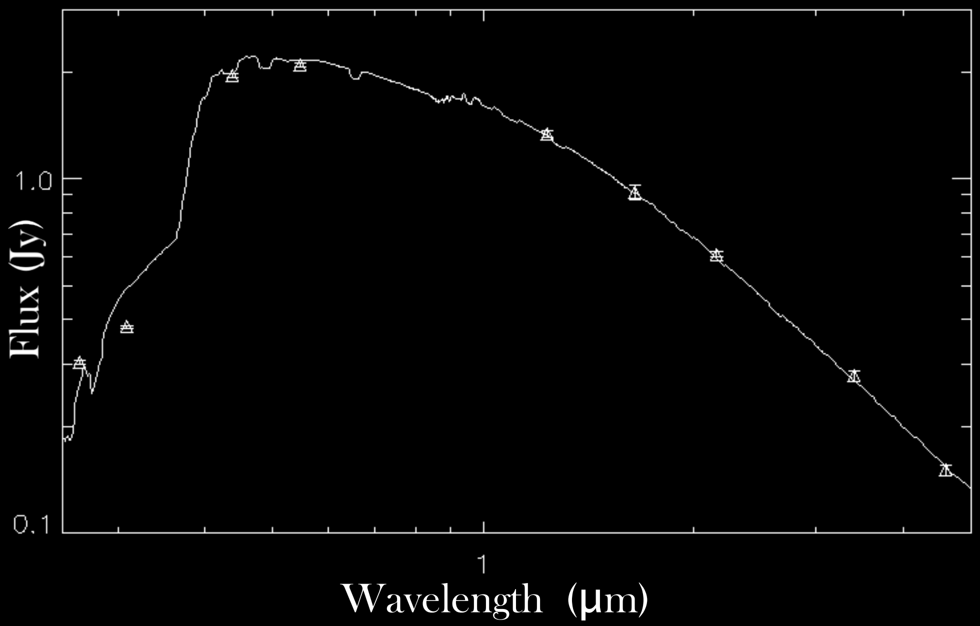
Fit to Stellar Photosphere

Spectral type reported as A0-A5
- but this doesn't fit the photosphere well

Photosphere better fit by high extinction or a lower temperature

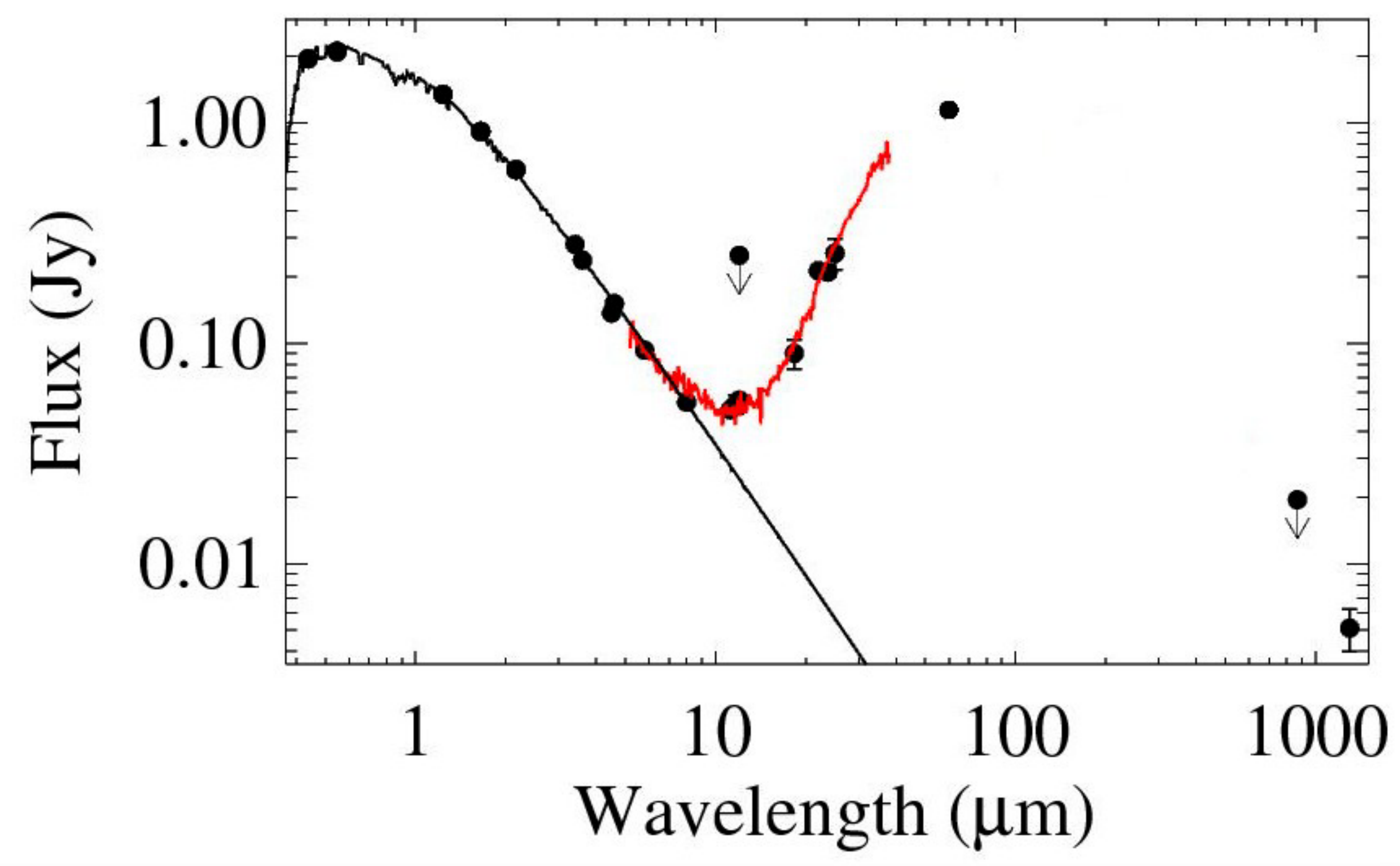
We use UV fluxes from Redfield et al. (in prep.)
- this breaks degeneracy
- lower temperature is best fit

Redfield+ also says UV spectrum is more consistent with A7 or A8

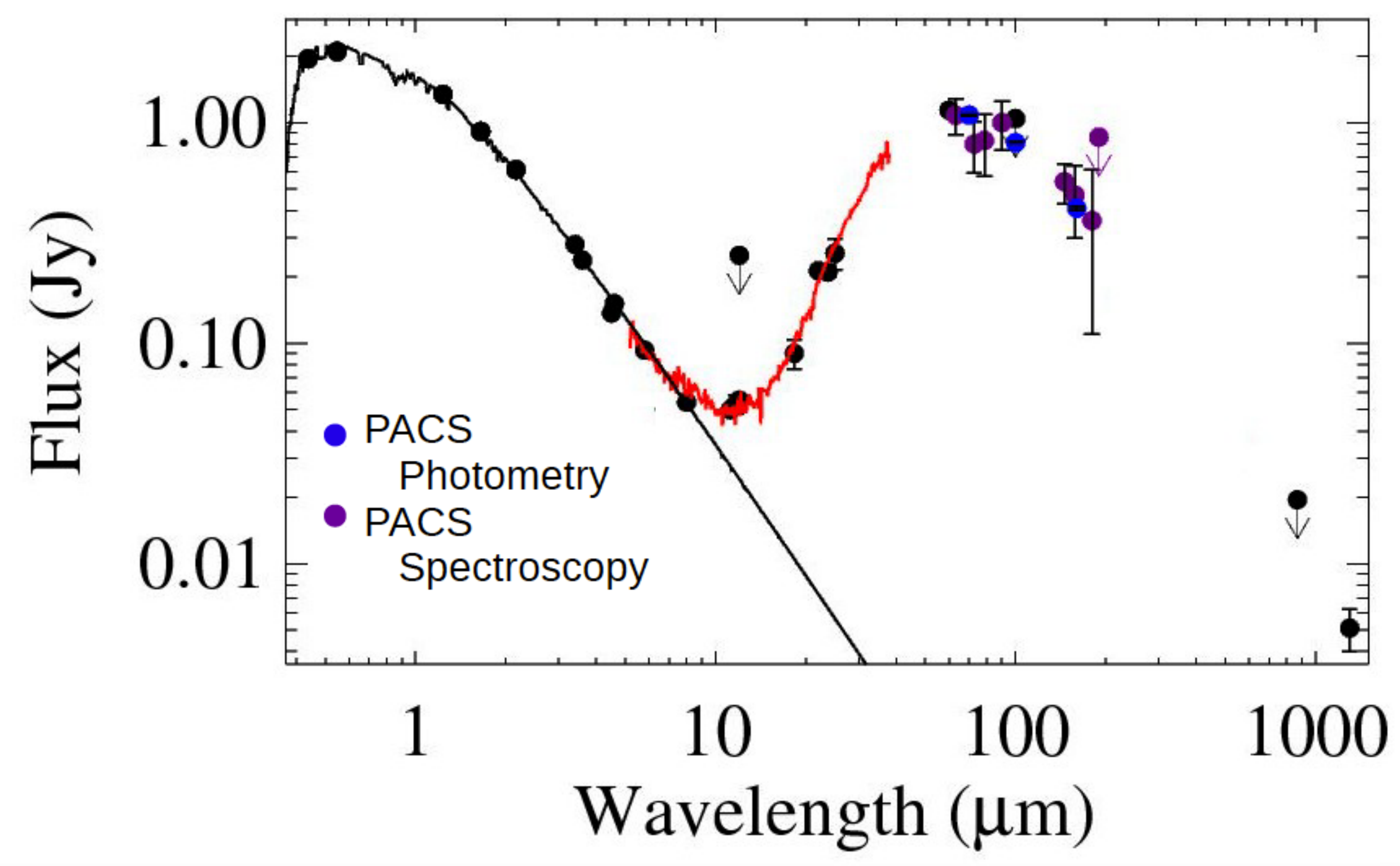


Best fit to the stellar photosphere (0.25-4.6 μm) T = 7750 K

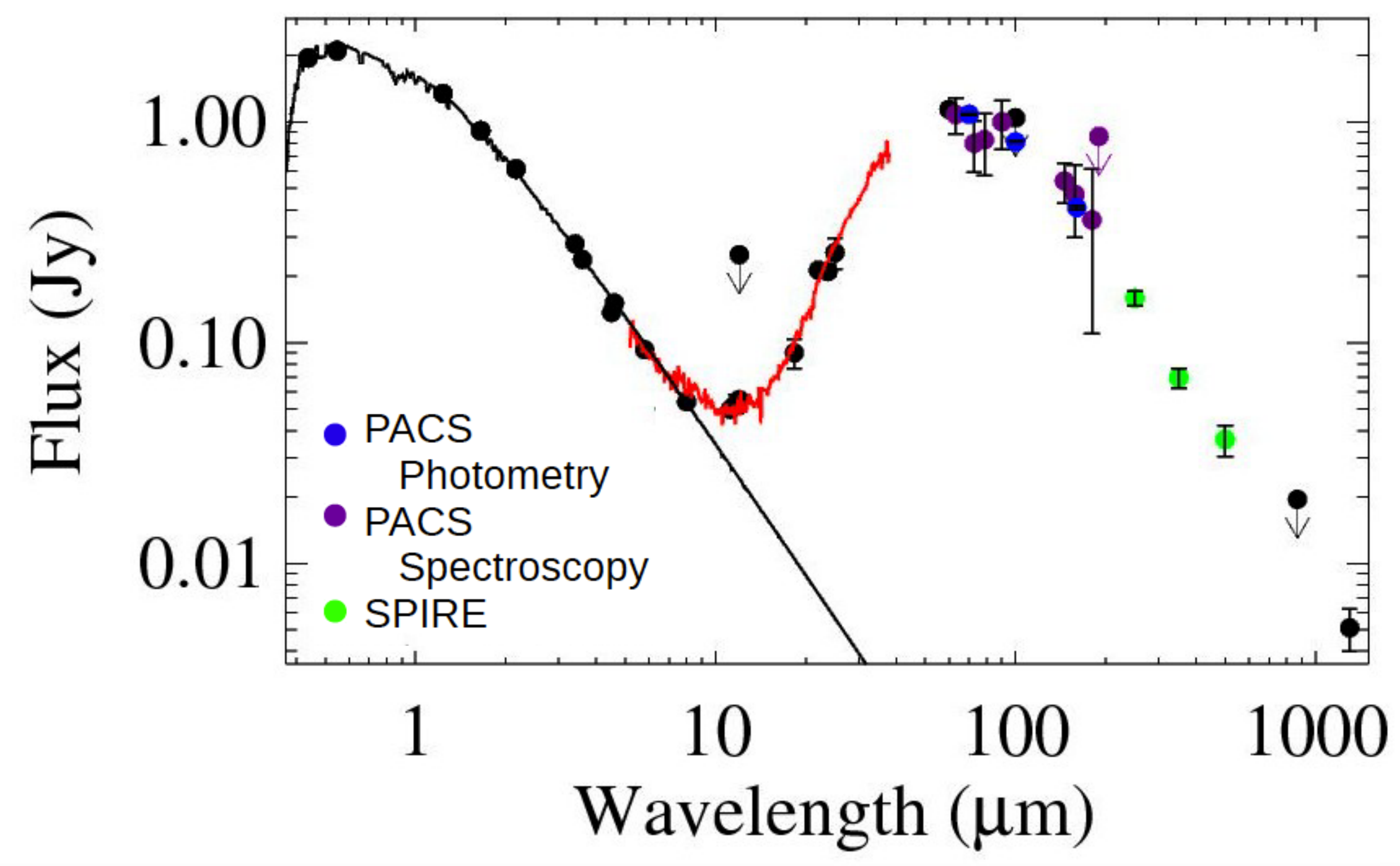
Addition of Herschel data to the SED



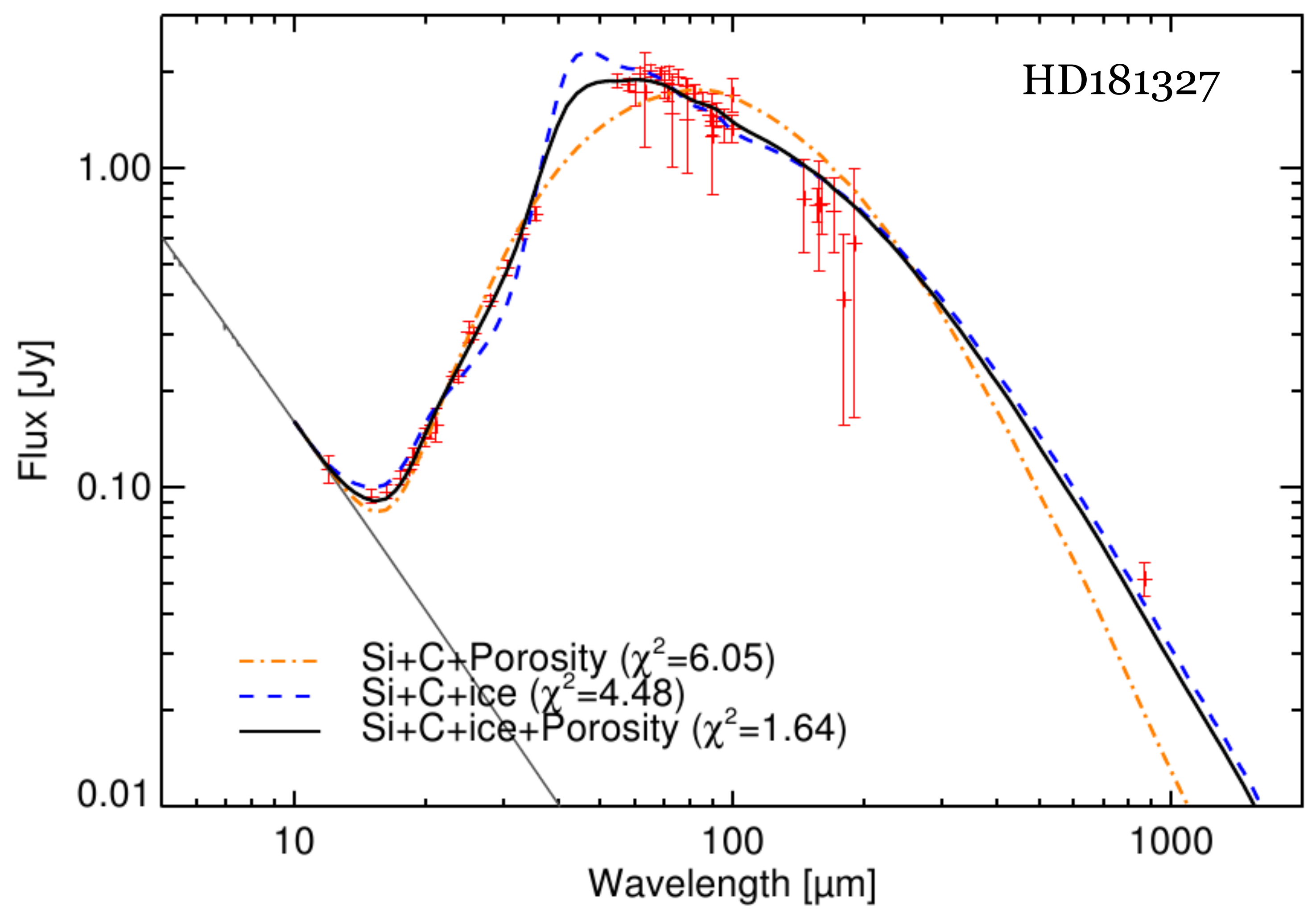
Addition of Herschel data to the SED



Addition of Herschel data to the SED

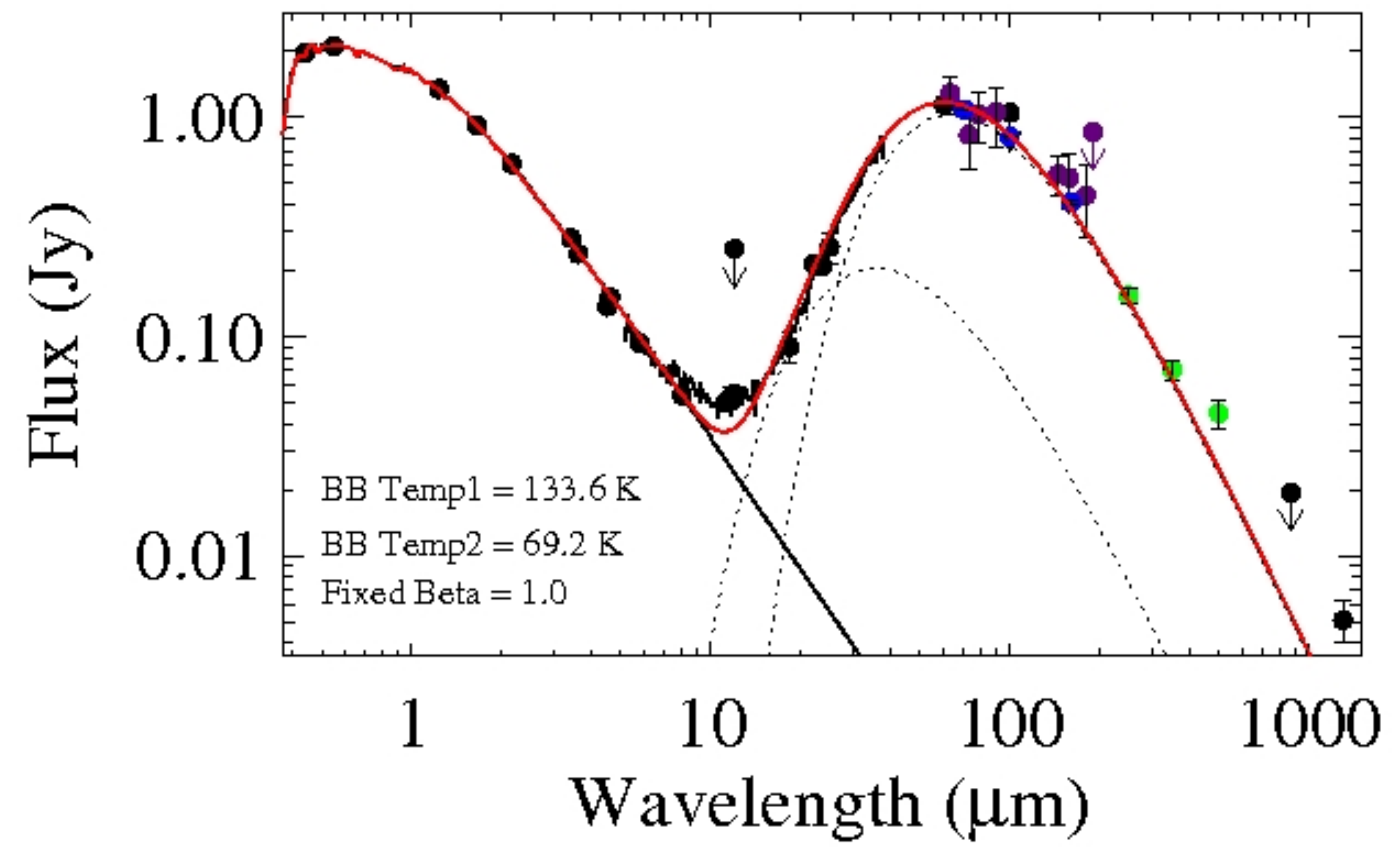


SED fitting with GRaTer



(Lebreton et al. 2012)

Blackbody fits – 2 components



SED fitting – approach

- There are resolved images of the outer disk but not the inner disk

→ 2 Phase modeling approach

- Model the outer disk using constraints on the geometry from image → fit for composition

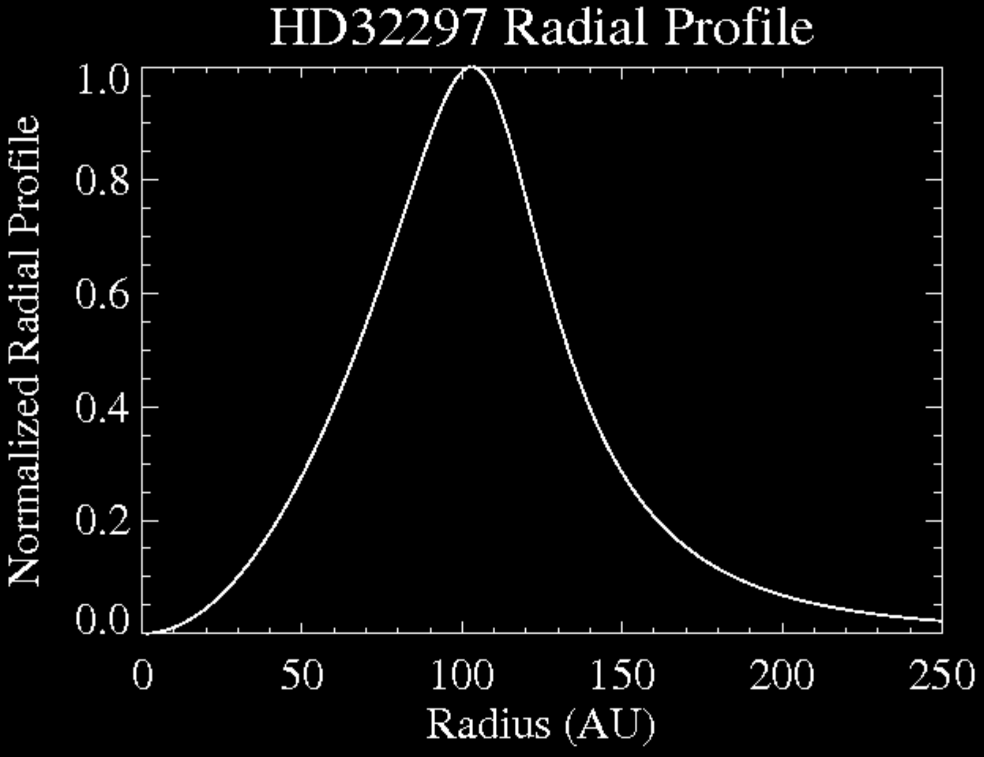
- Model the inner disk with astronomical silicates → fit for geometry

SED fitting – approach

Outer disk:

- Radial profile from Boccaletti et al. (2012).
- GRaTer code
- Various compositional combinations:

  Astronomical silicates
  Carboneous grains
  Water ice
  Porosity



Radial profile from Boccaletti+12

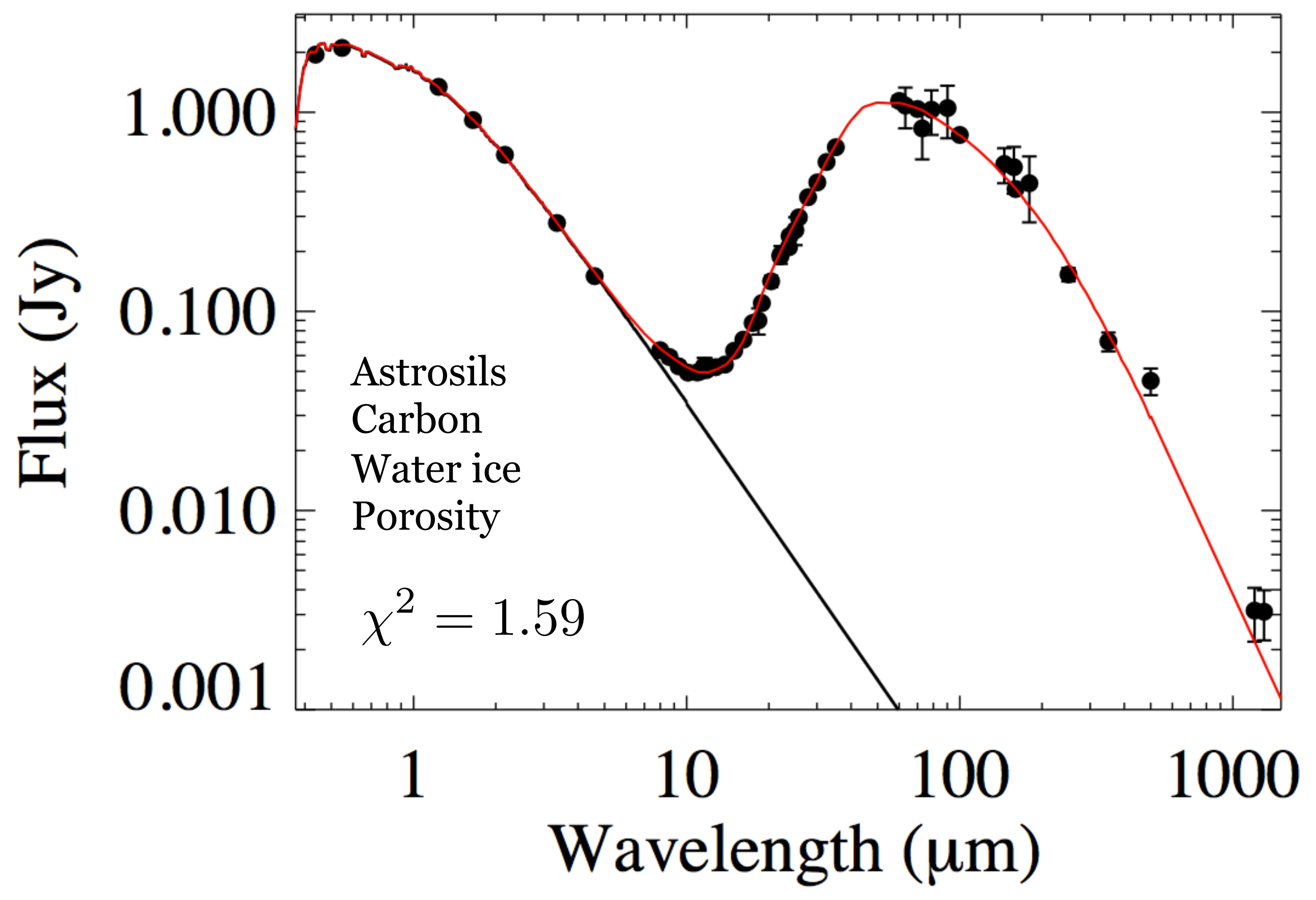
SED fitting – approach

- Inner Disk:
  - Fit residuals from outer disk model
  - Fixed composition: astronomical silicates
  - Fixed outer radius at 5 AU
  - Fixed grain size distribution – power law

$$n(a)da \propto a^{-3.5}da$$

  - Fit for inner radius and minimum grain size

SED Fitting - Results



Astrosils
Carbon
Water ice
Porosity

$\chi^2 = 1.59$

SED Fitting – Results

- Outer disk:

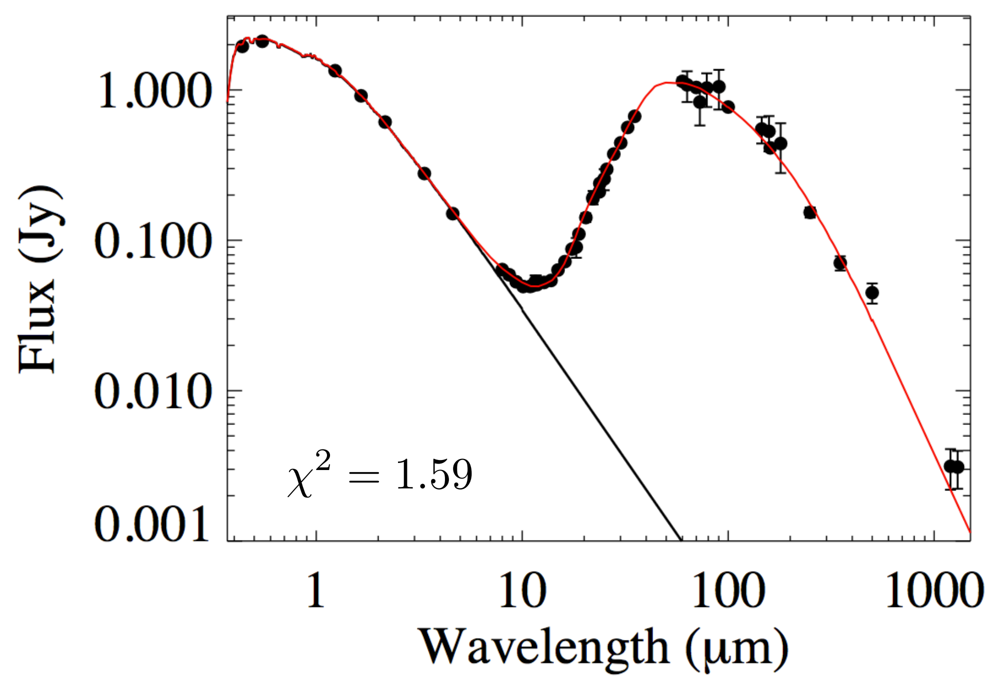
$$a_{\mathrm{min}} = 2.1\,\mu m$$

$$\kappa = -3.29$$

- Inner disk:

$$a_{\mathrm{min}} = 2.2\,\mu m$$

$$r_{\mathrm{min}} = 1.1\,\mathrm{AU}$$



HD32297 – Conclusions

- We used imaging to constrain the geometry of the outer disk
  - Fit for composition: combination of astrosils, carbon, water ice, and porosity

- Fit the inner disk with simple disk model
  - Found inner disk at ~1-5 AU