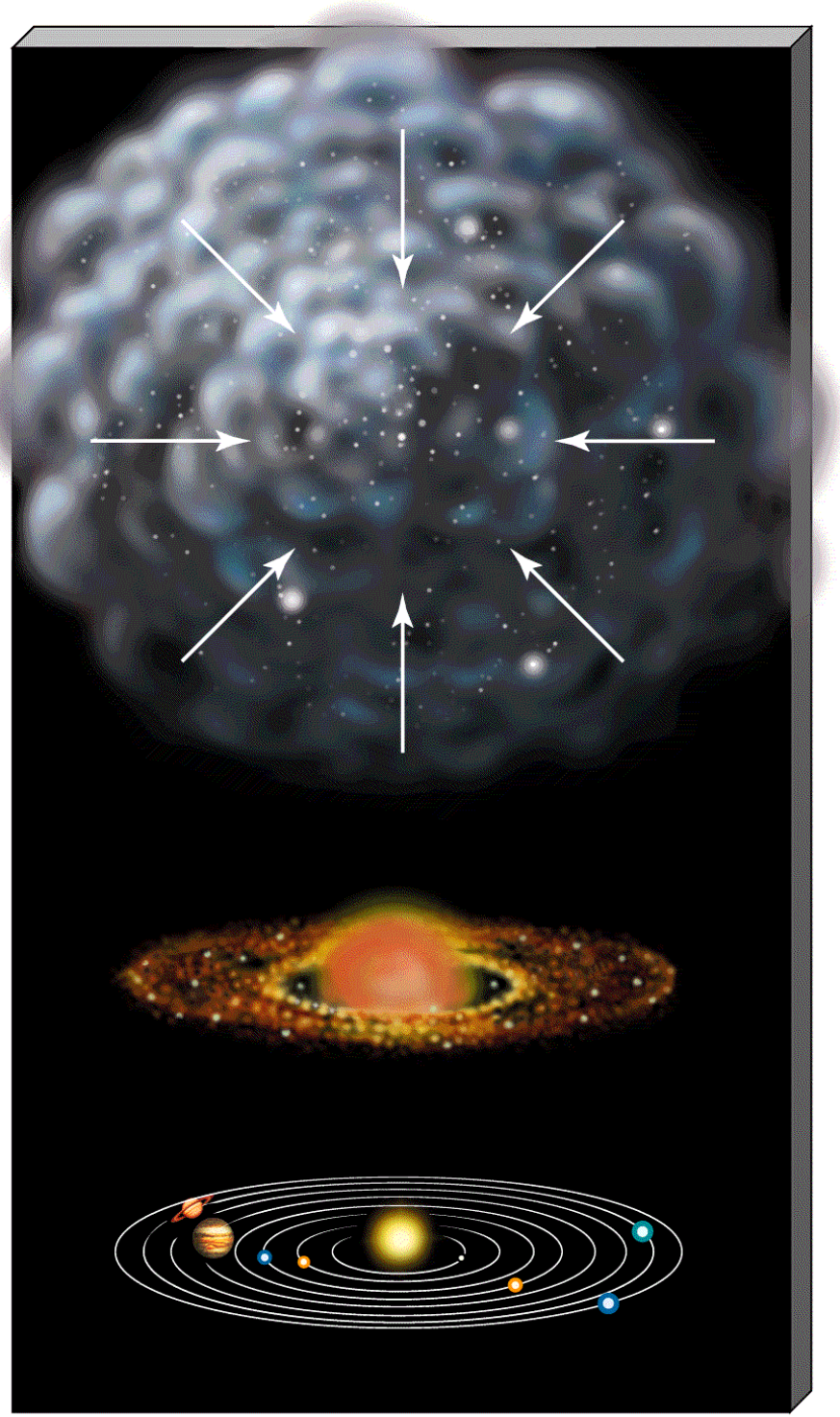
Locating dust crystals in protoplanetary disks with PACS

Gijs Mulders

University of Amsterdam

DIGIT: Dust, Ice and Gas In Time

Mineralogy

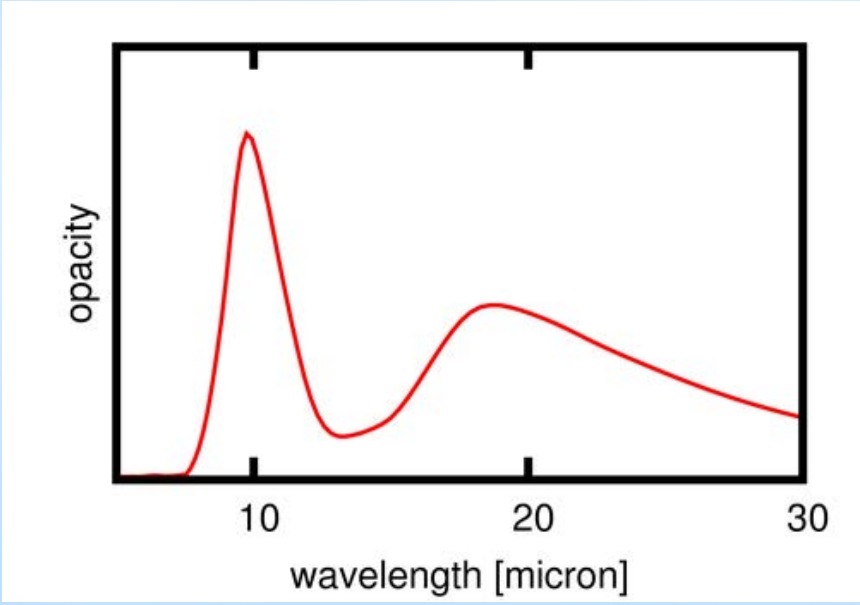


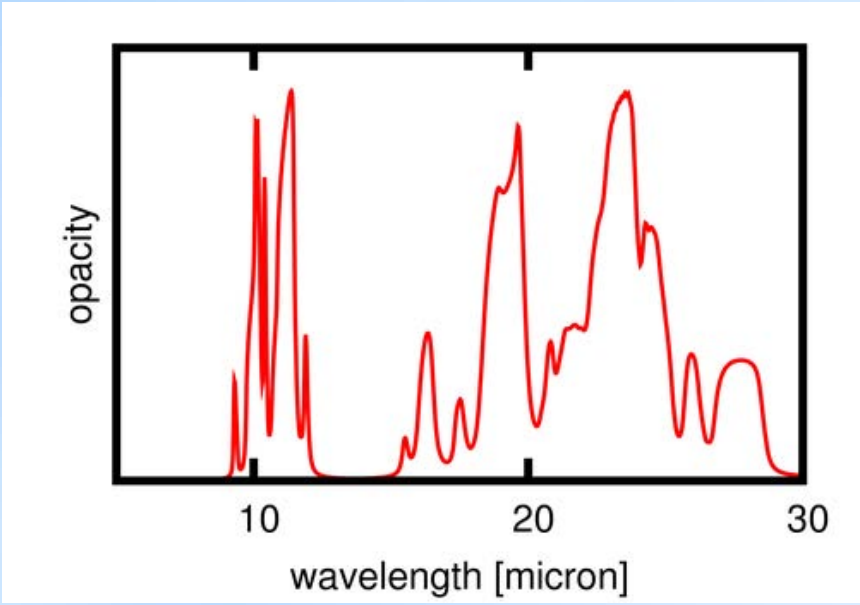
Mineralogy

>1000K

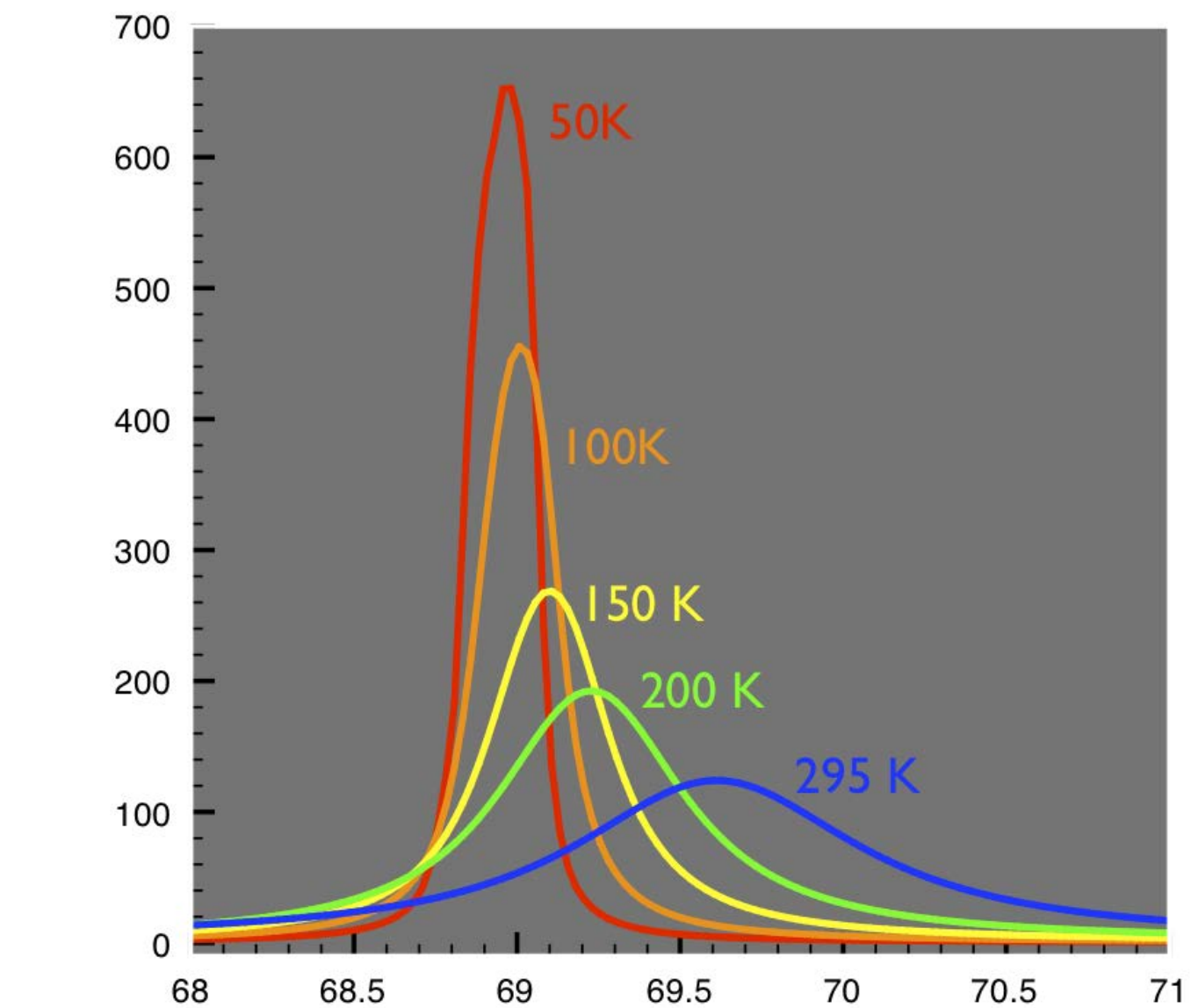
Mineralogy

>1000K





Forsterite: 69 μm feature

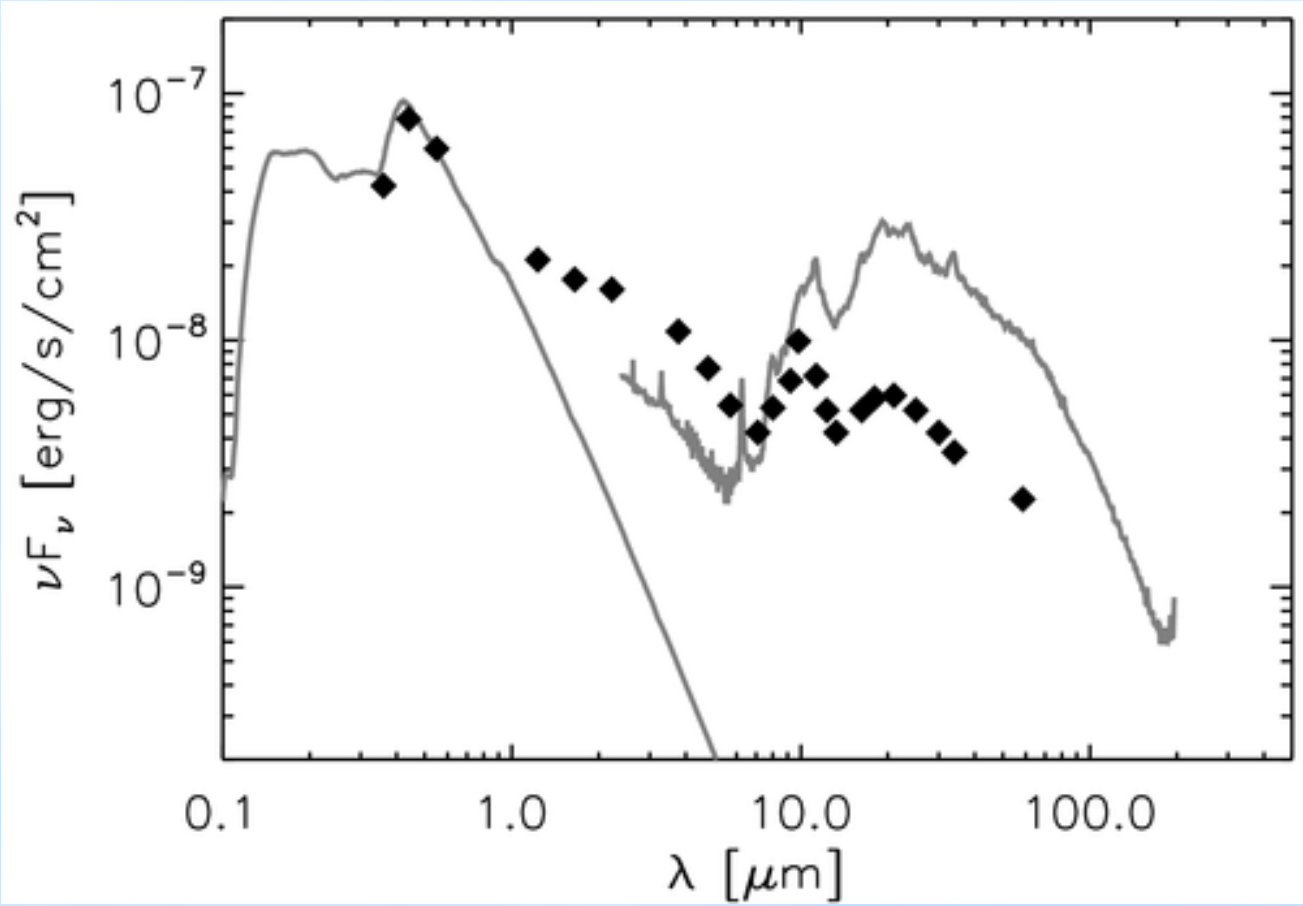


Suto et al. 2006
Koike et al. 2003

Caveat: iron content

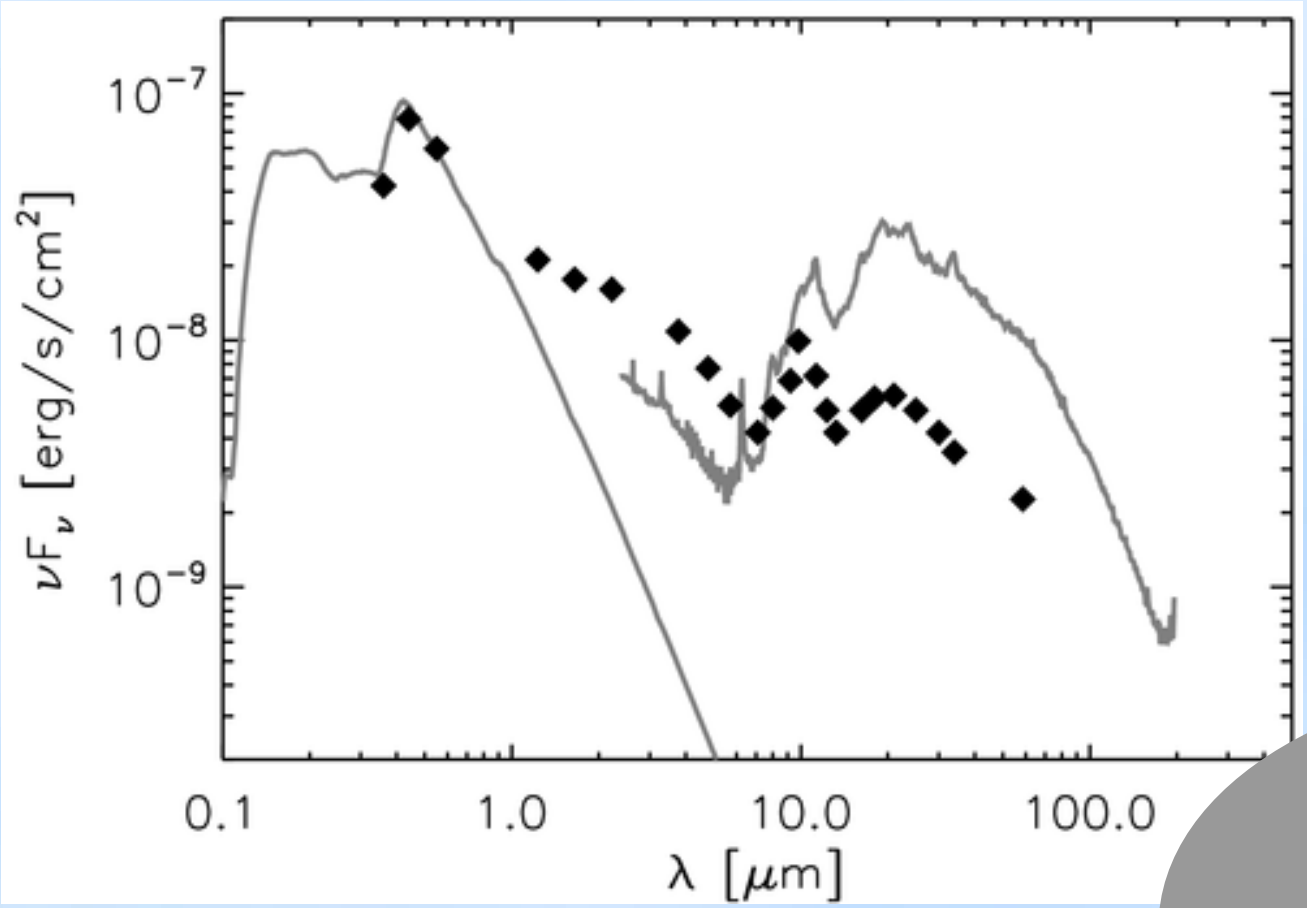
- 69 μm: 6 detections
  (Sturm et al. in prep)
- HD 100546
  (Mulders et al. 2011)
- HD 169142
  IRS 48
  (Maaskant et al. in prep)

HD 100546

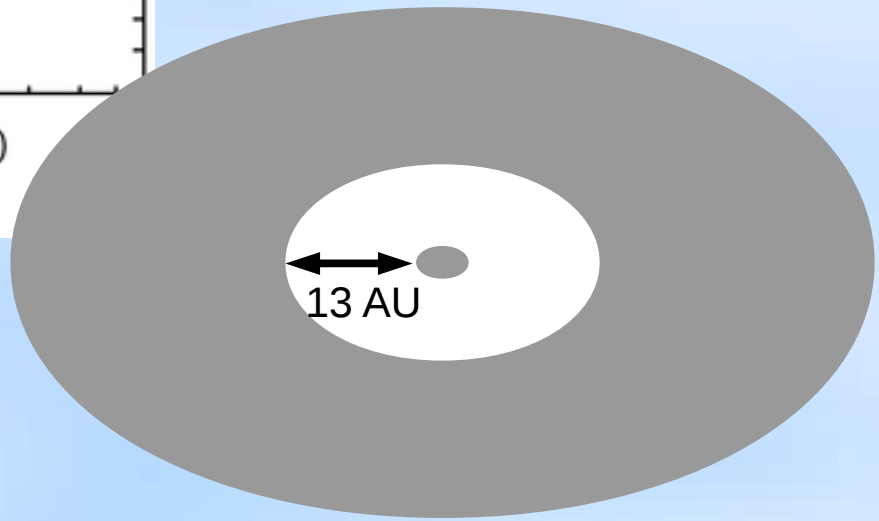


Malfait et al. 1998
Mulders & Dominik 2012

HD 100546



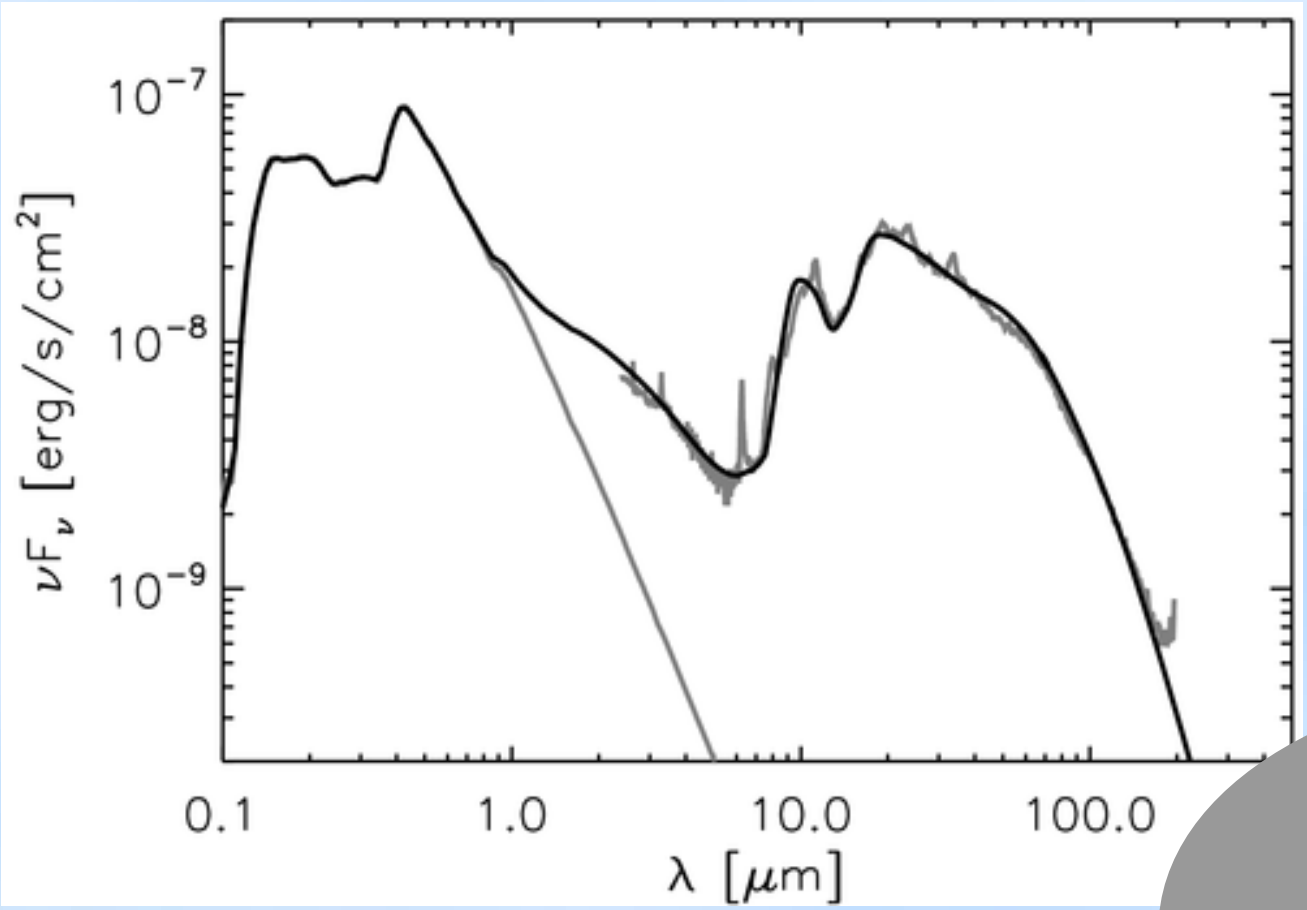
Malfait et al. 1998
Mulders & Dominik 2012

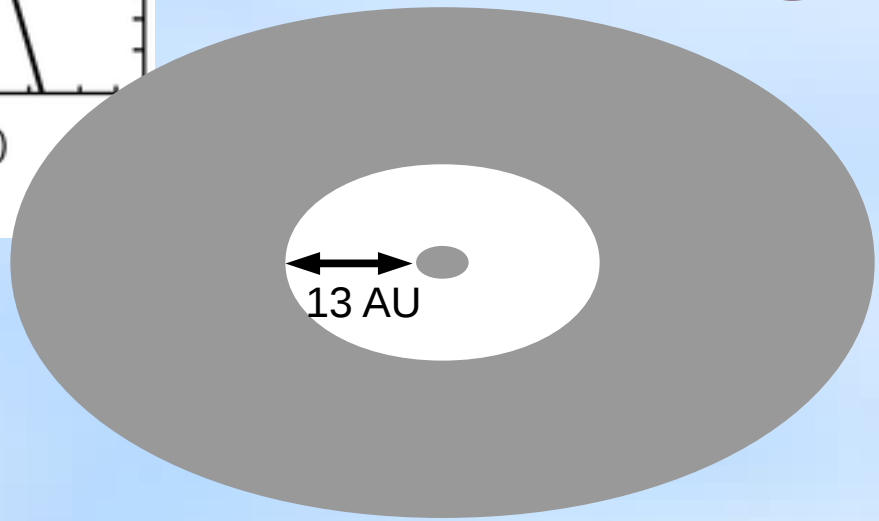


Bouwman et al. 2003
Grady et al. 2007
Benisty et al. 2010

T_{wall} = 200 K

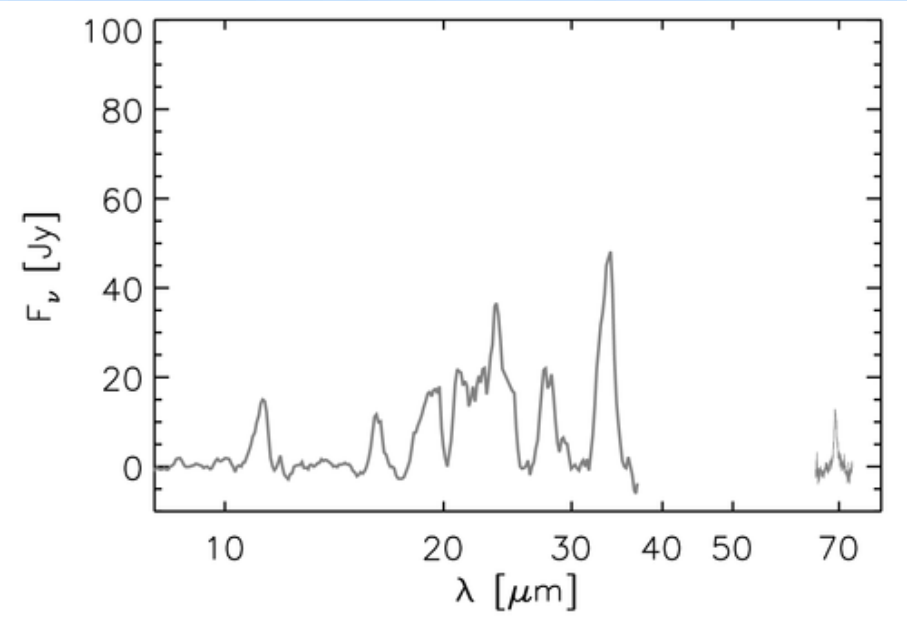
HD 100546

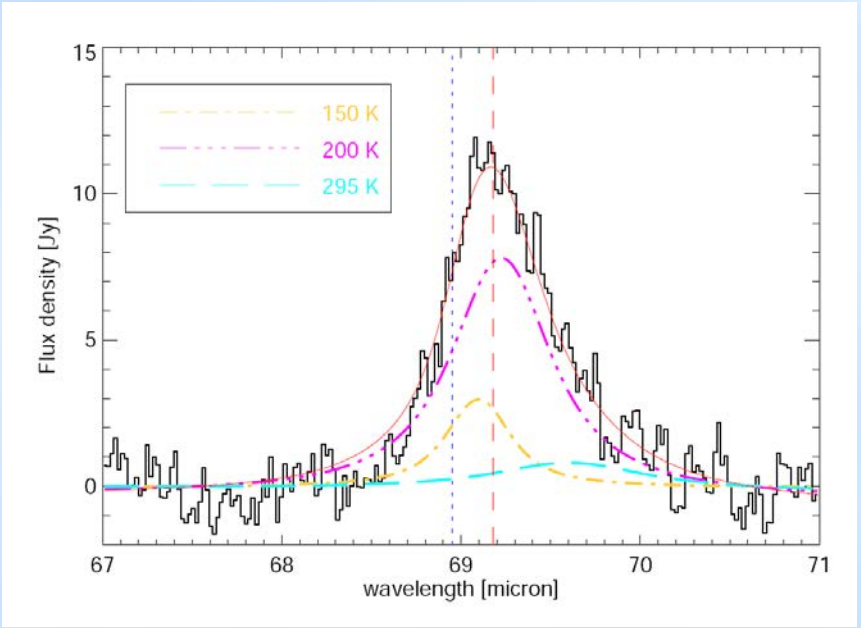




T_{wall} = 200 K

Mulders et al. 2011

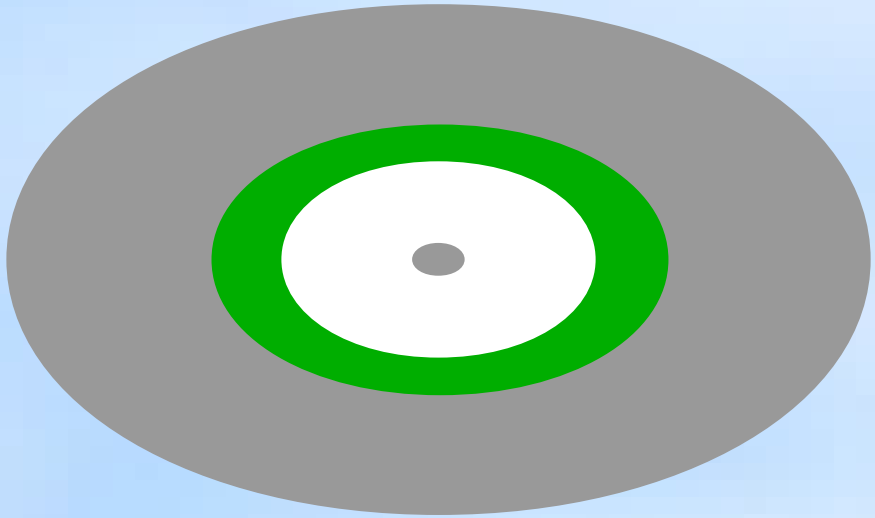


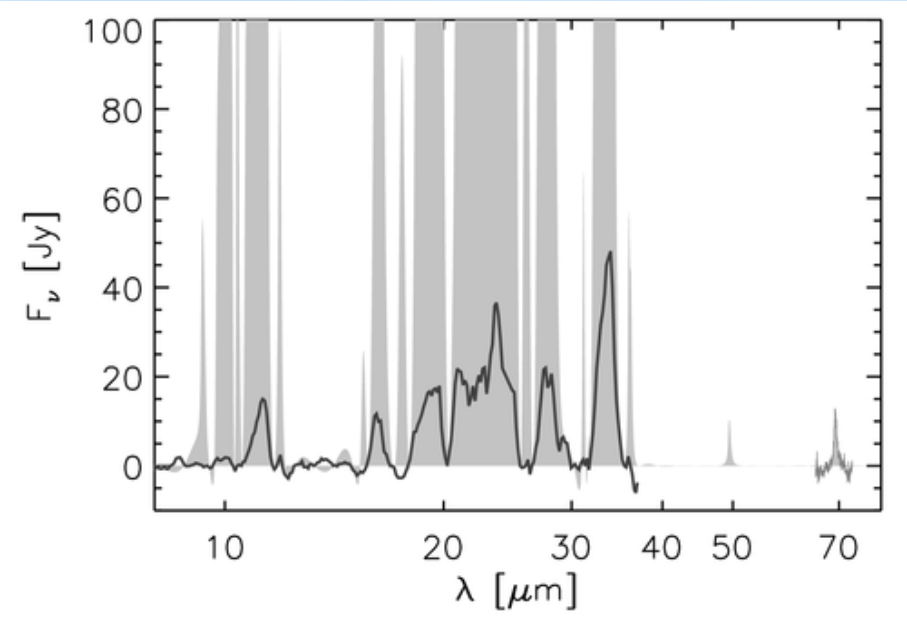


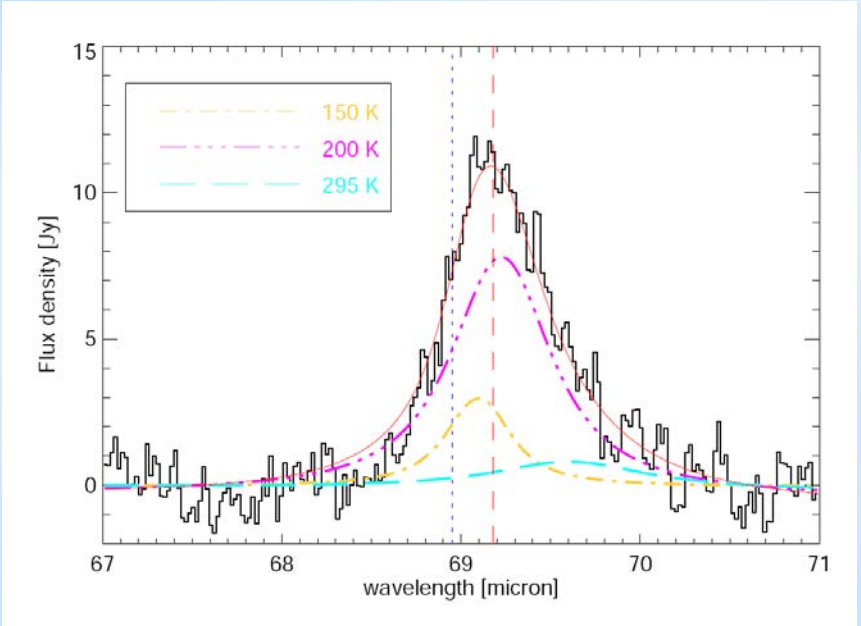
Sturm et al. 2010

Feature strength

69 μm shape





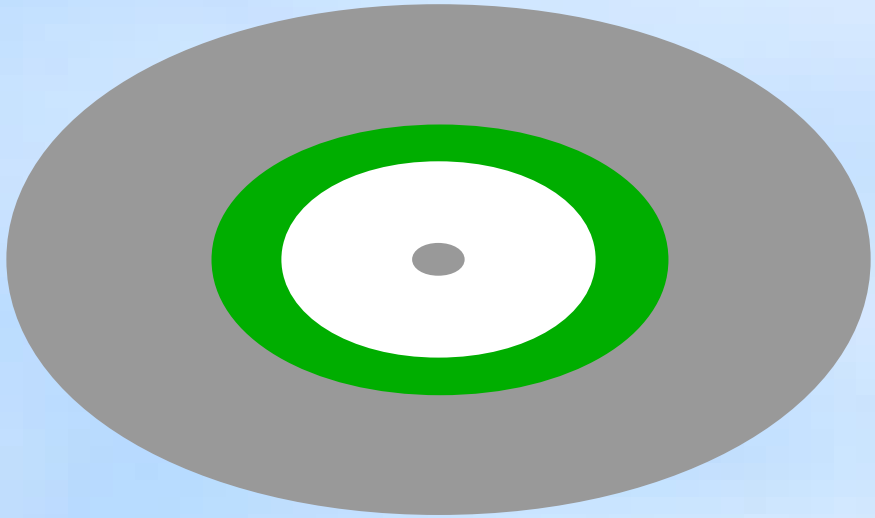


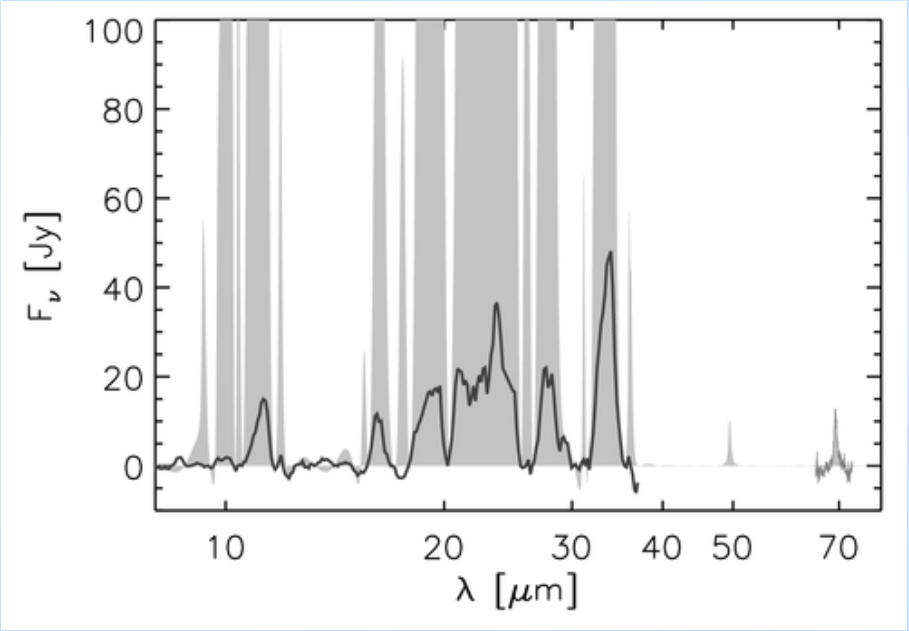
Sturm et al. 2010

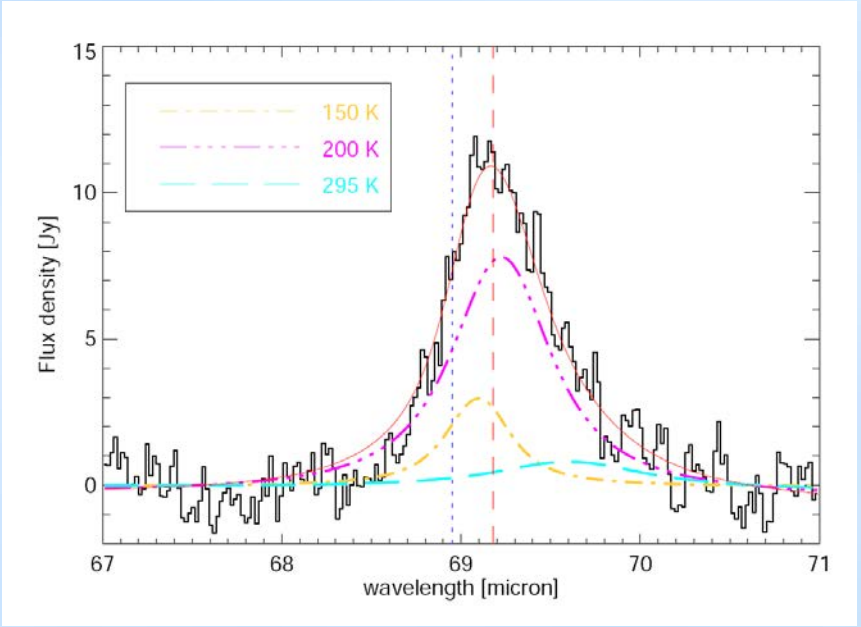
Feature strength

69 μm shape

- Iron (few %)
- Optical depth effects



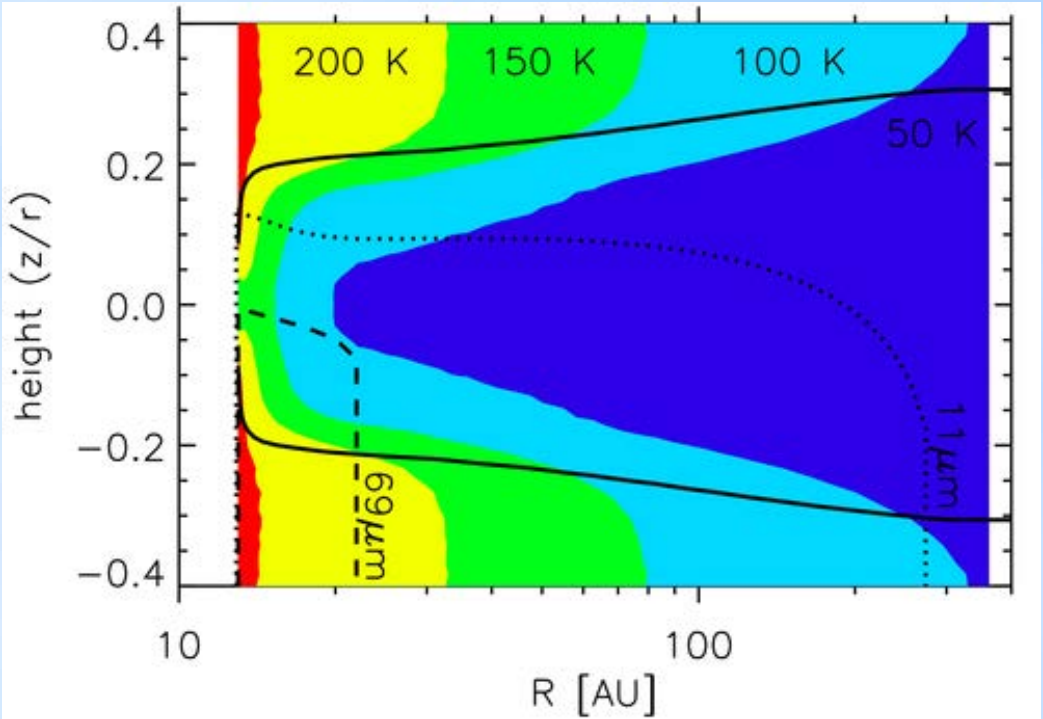


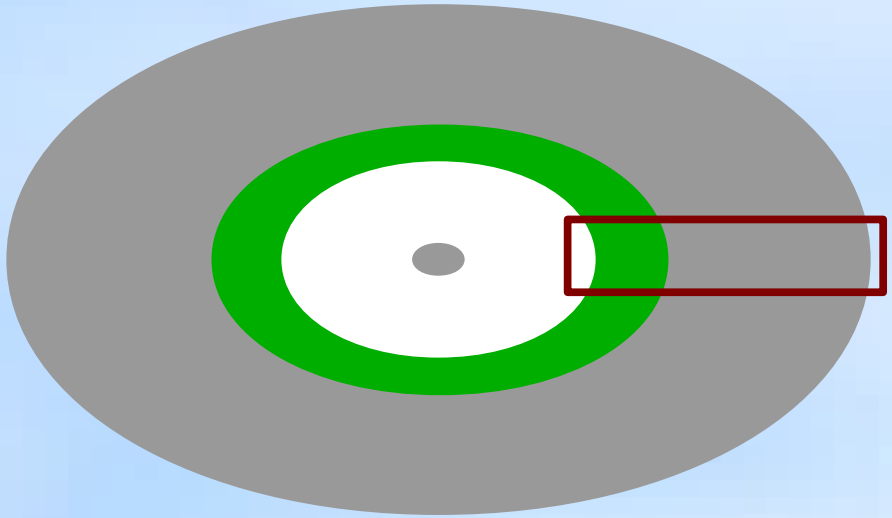


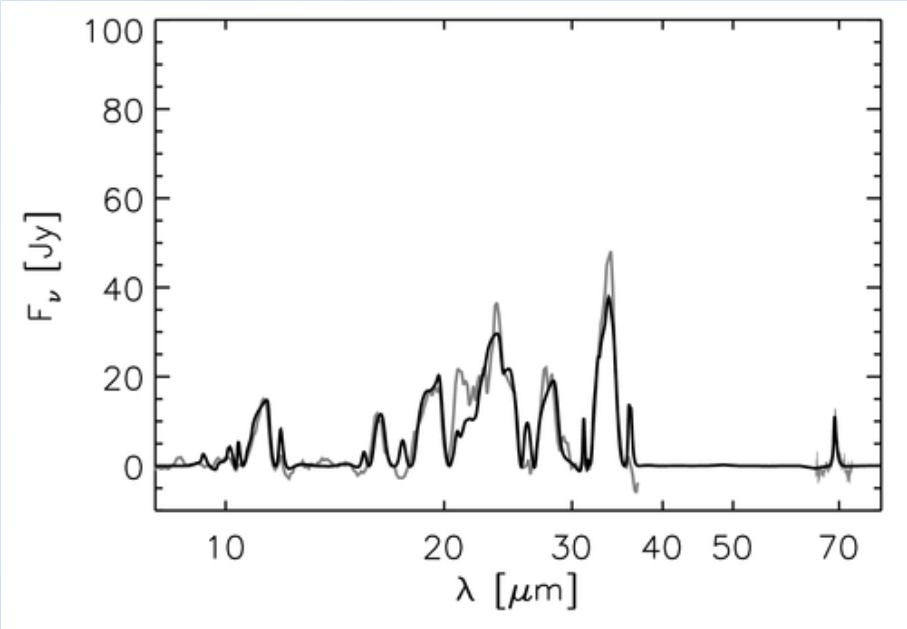
Sturm et al. 2010

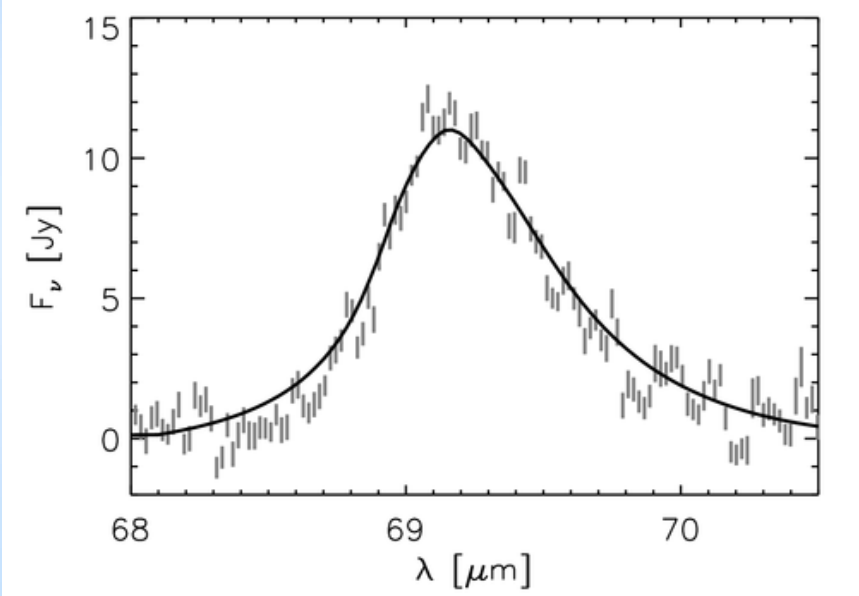
Feature strength

69 μm shape



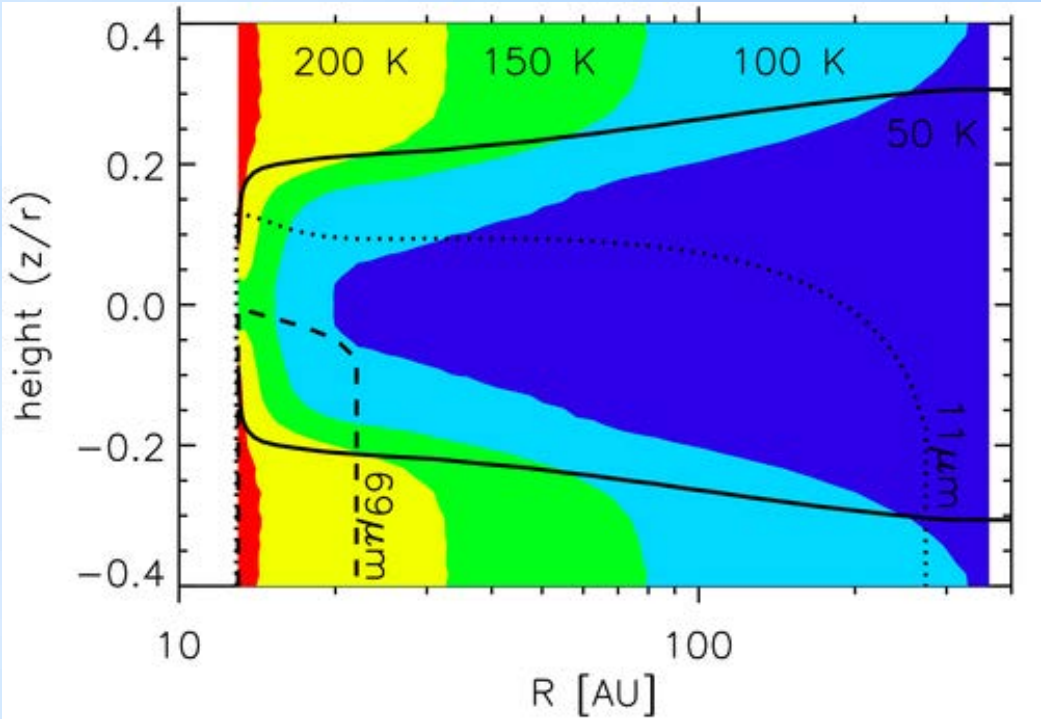


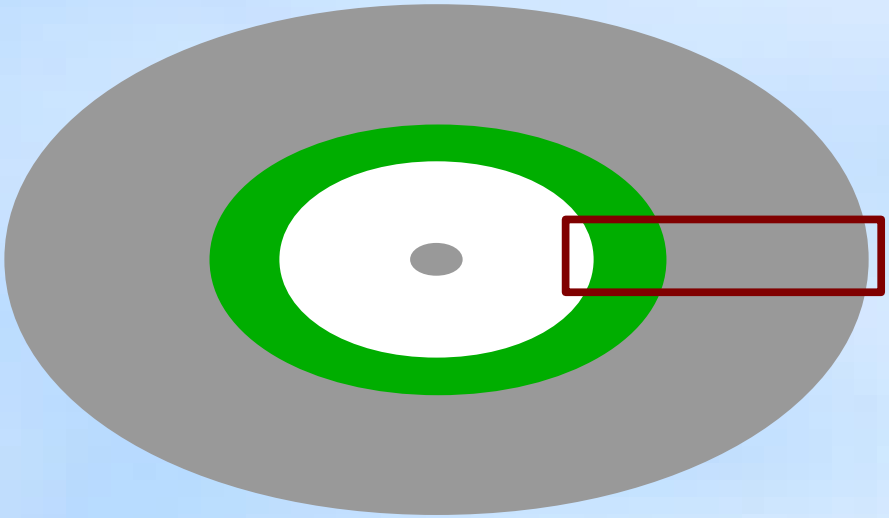




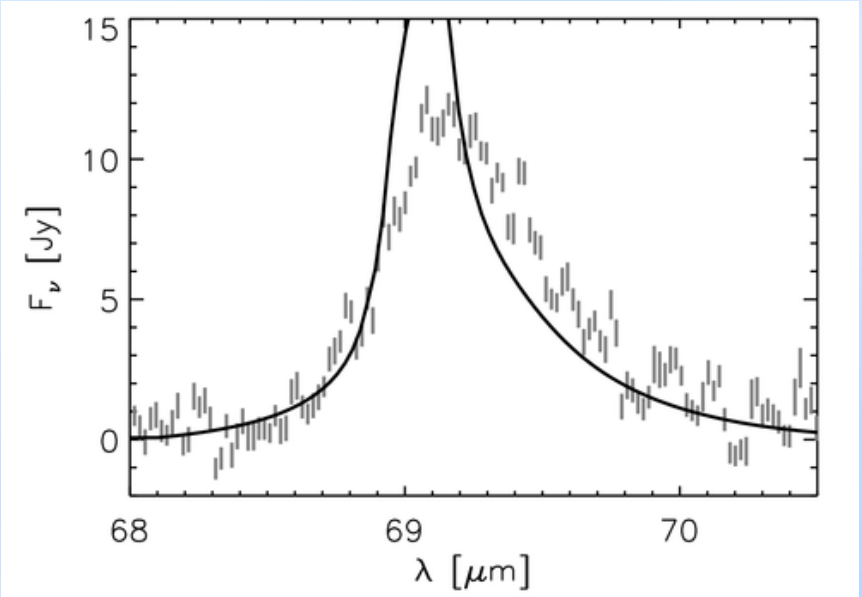
Feature strength

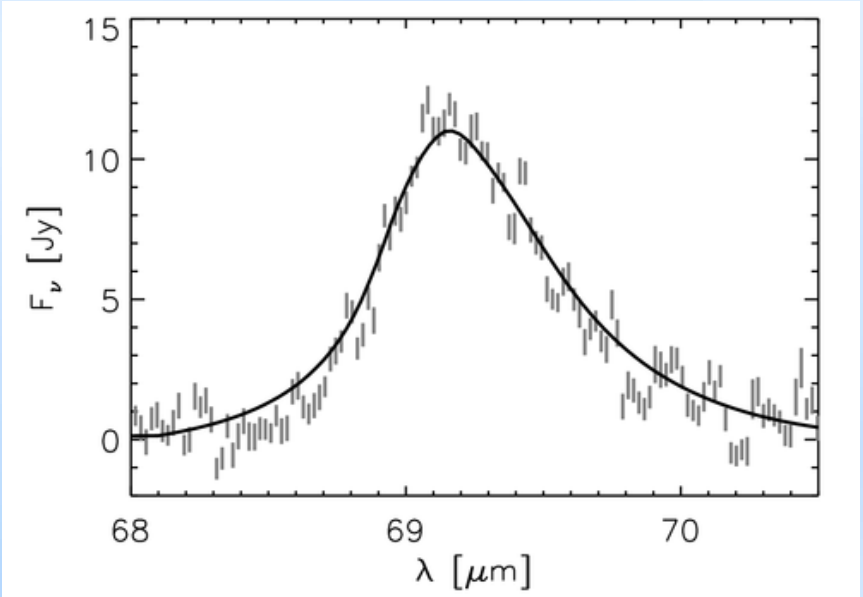
69 μm shape



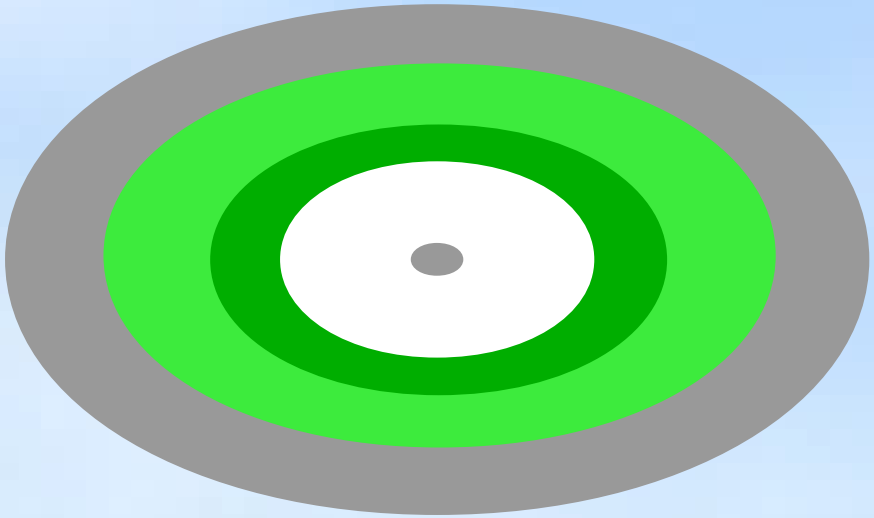


Forsterite distribution

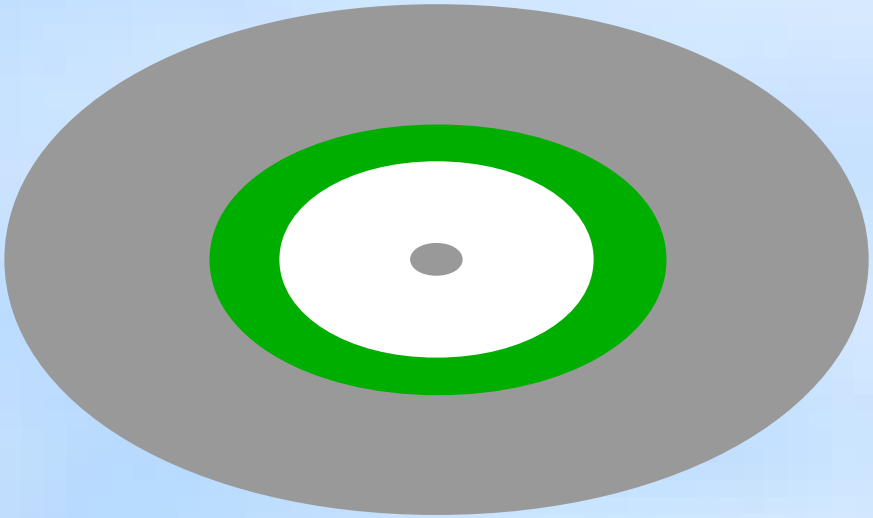




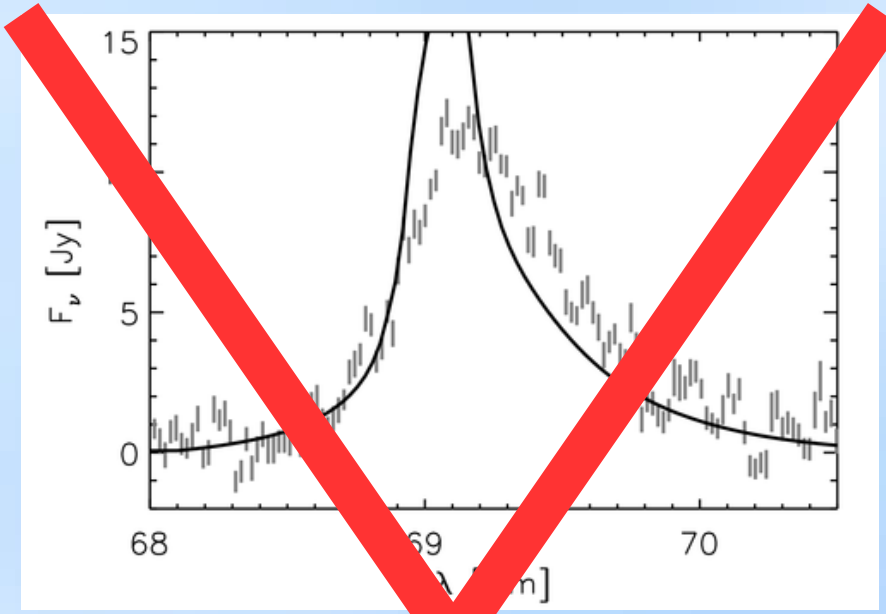
gradient

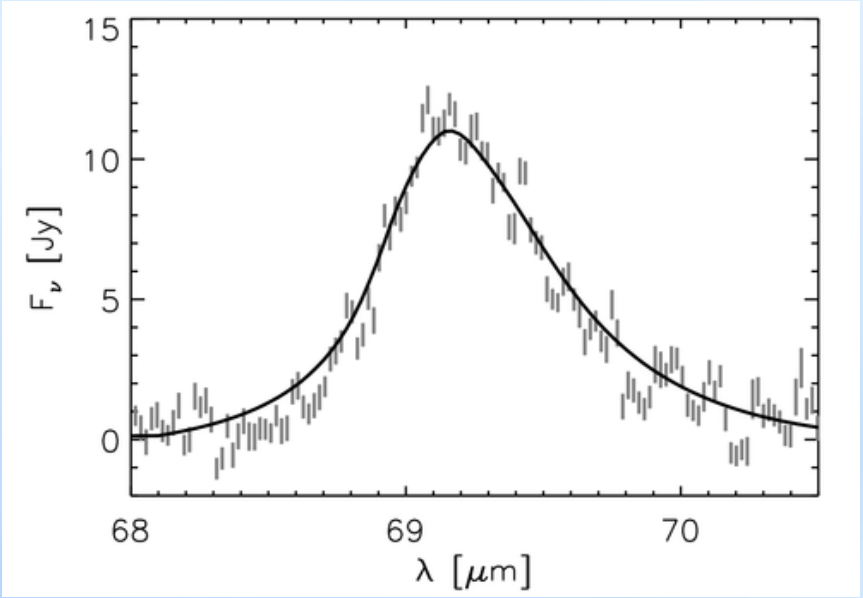


ring



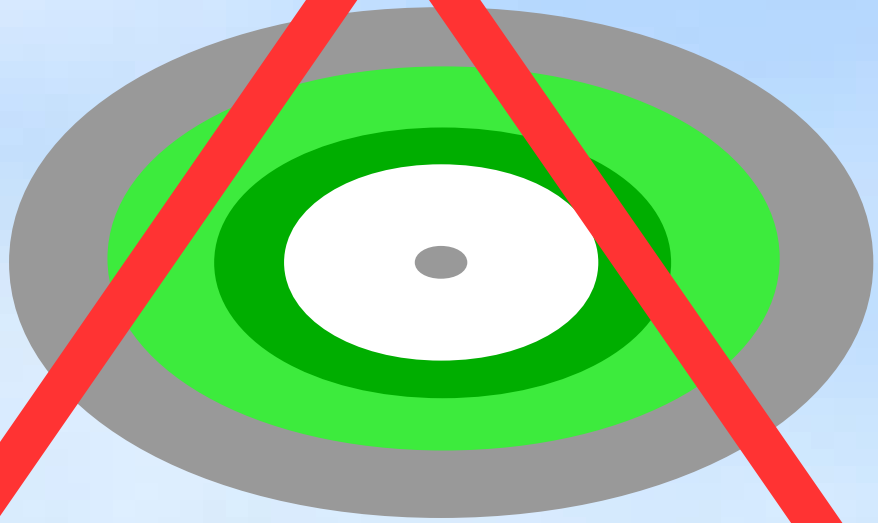
Forsterite distribution

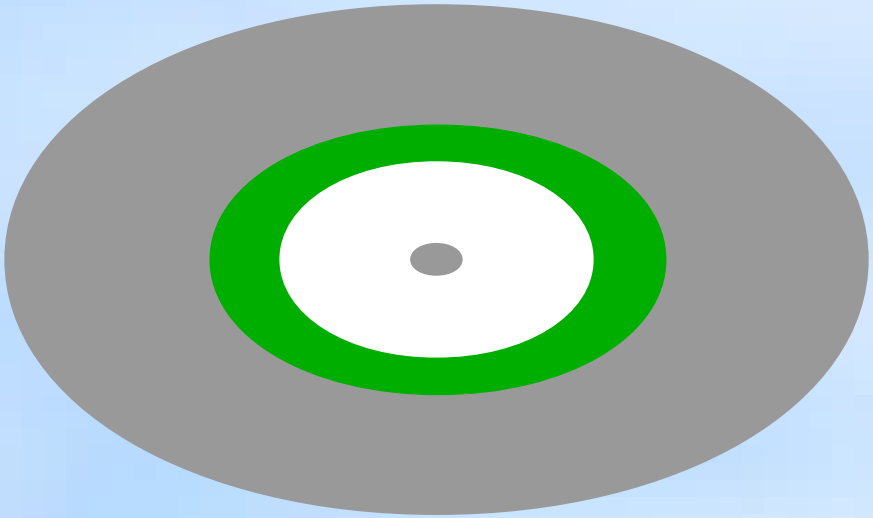




~~gradient~~

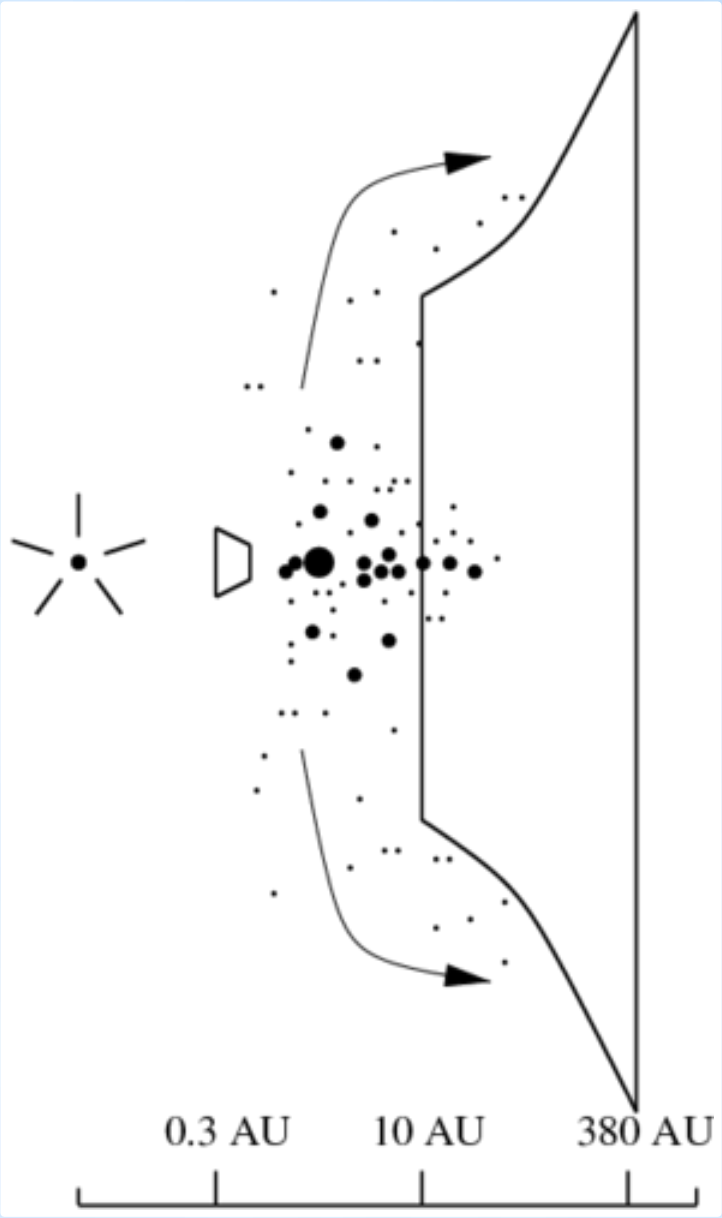
40%, 13-20 AU





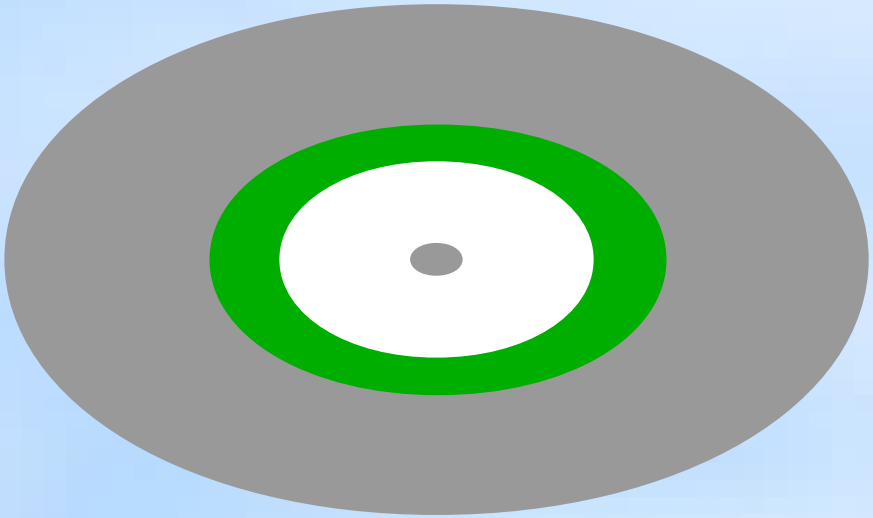
iron <0.3%

Crystal origin



Bouwman et al. 2003

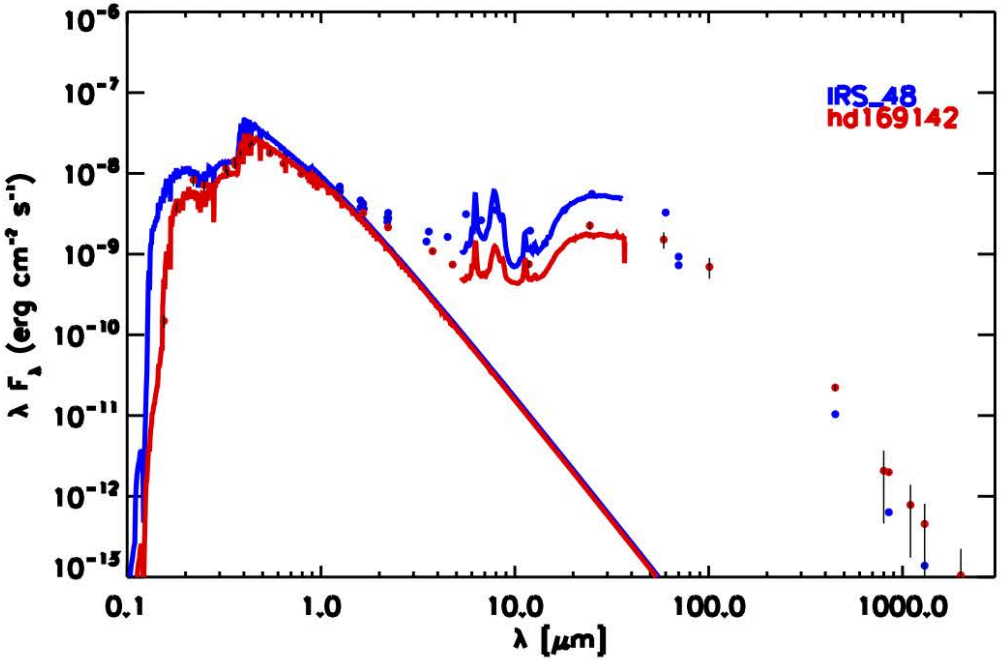
- Shocks
- Collisions
- **Parent-body processing**



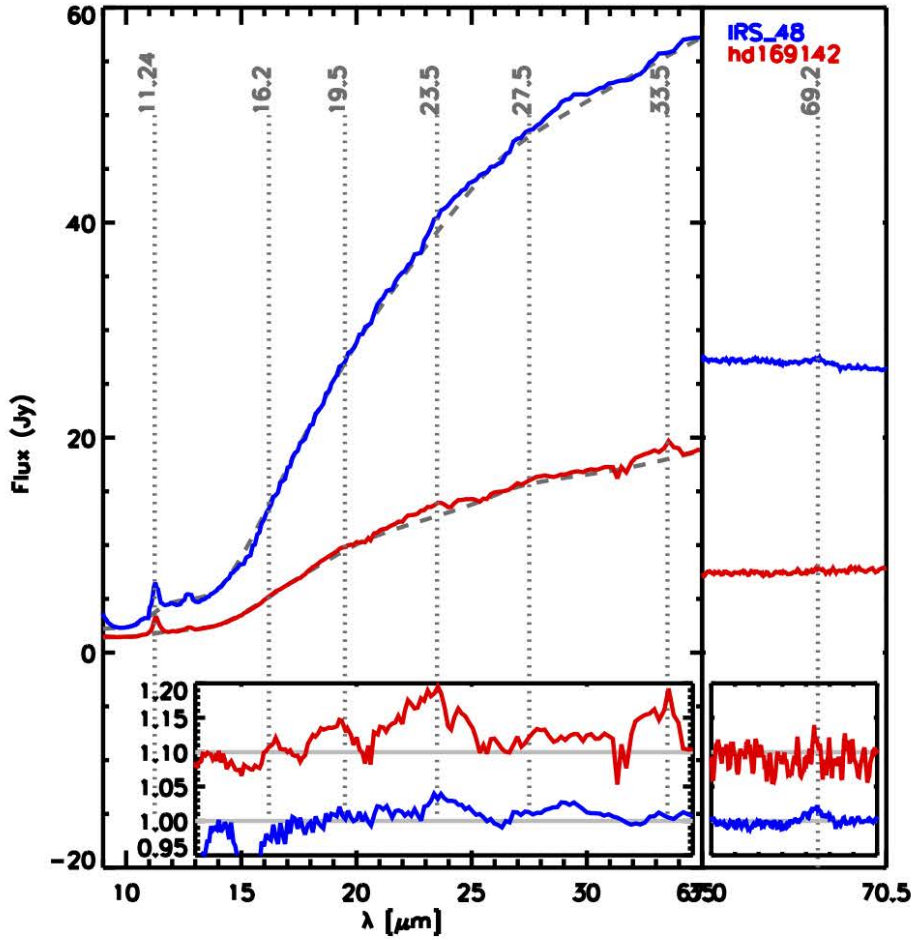
Comparison of forsterite in:

HD169142 gap 23 AU *(Honda et al submitted)*

IRS 48 gap >50 AU *(Geers et al 2007)*

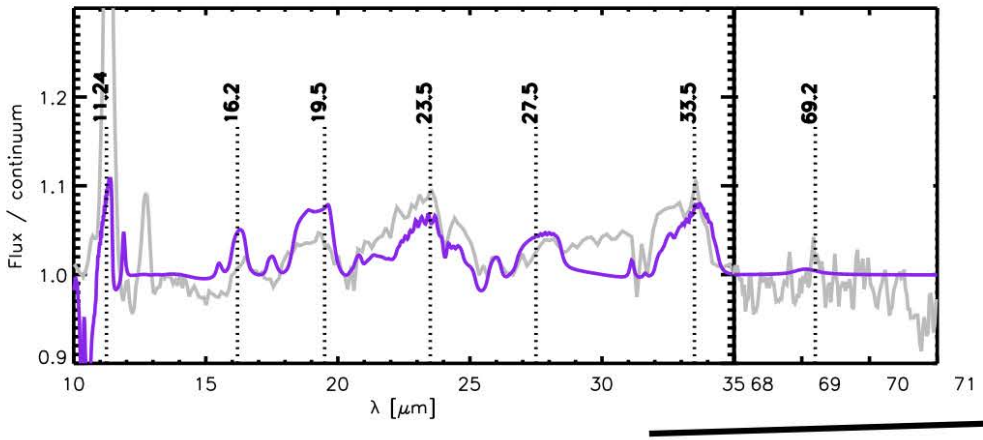


Maaskant et al in prep

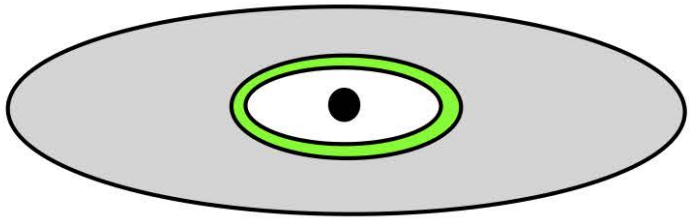


Radiative transfer solutions...

HD169142



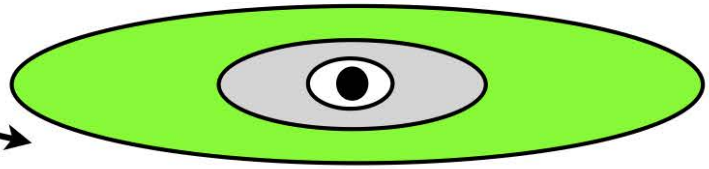
wall

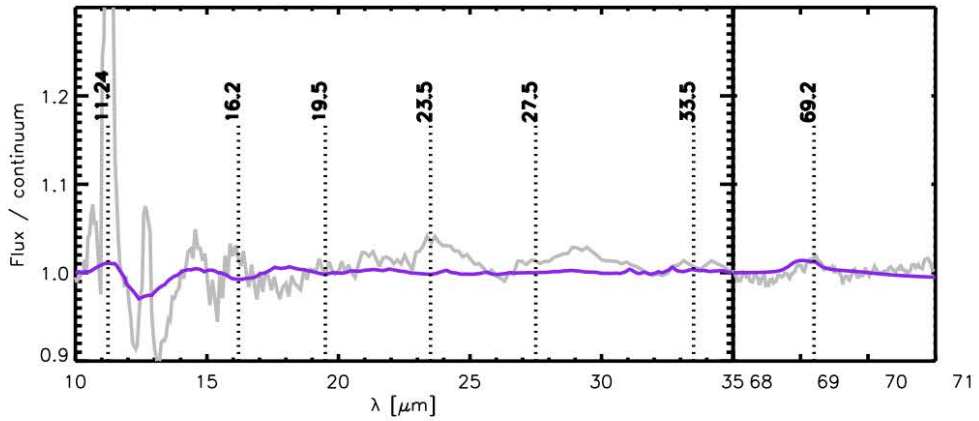


IRS 48

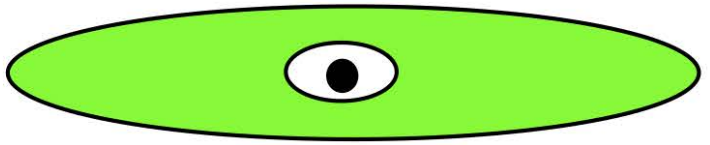
?

outer disk





large >10 micron grains
whole disk



Maaskant et al in prep

Locating dust crystals in protoplanetary disks with PACS

- Temperature dependent 69 μm feature
- 2D radiative transfer
- Near disk gap (2x), unrelated (1x)
- Local production
  (Shocks, collisions, **parent-body processing**)
- Iron poor (<0.3%)