Determining the systematic errors in fits of dust thermal emission

The role of laboratory data in upcoming models

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Hilo, Apr 10th 2018

Intro: what is dust?

"Soot and sand in space"
– *A. P. Jones*

CARBON
- Amorphous?
- Graphite?
- Hydrogenated?

SILICATES
- Mostly amorphous (98%)
- Mineralogy?
- Embedded metals?

ICES
- Inside dark clouds
- Rich chemistry

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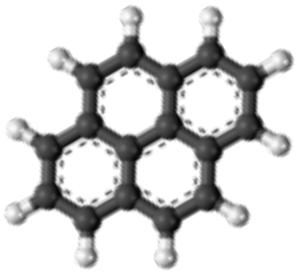
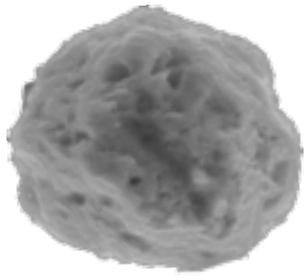
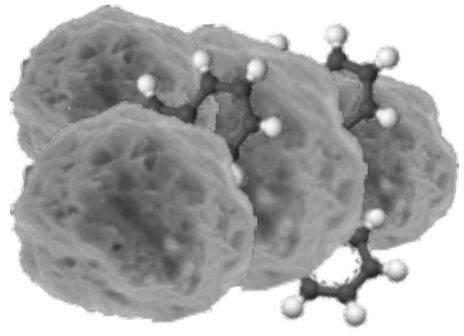


Molecules (PAH?)
< 1 nm



"Big" grains
≳ 100 nm



Aggregates

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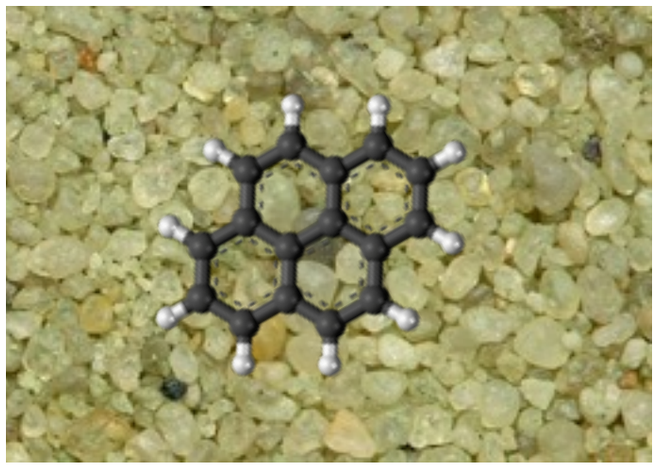
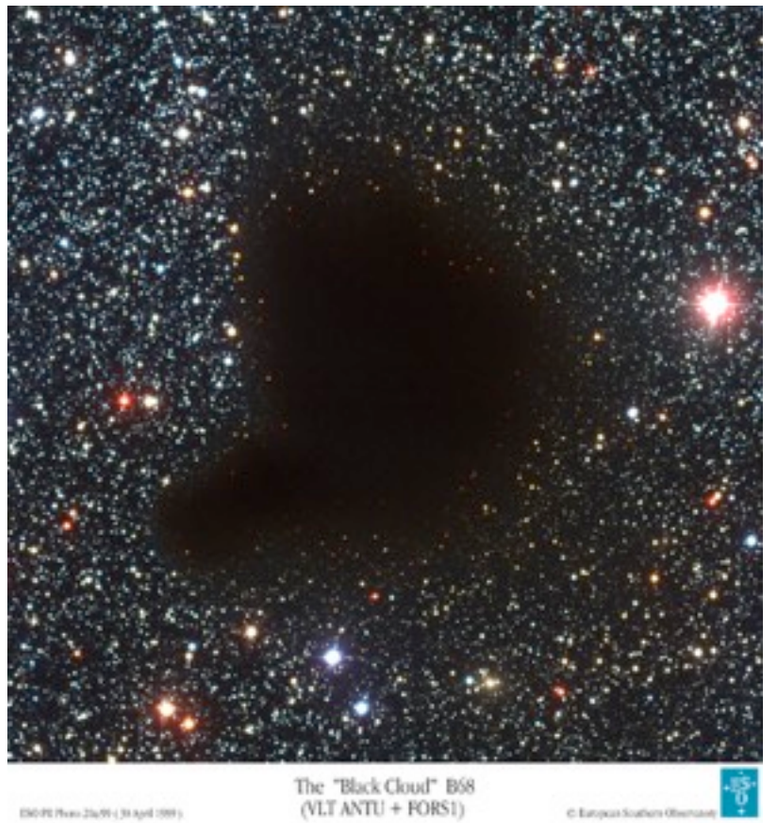
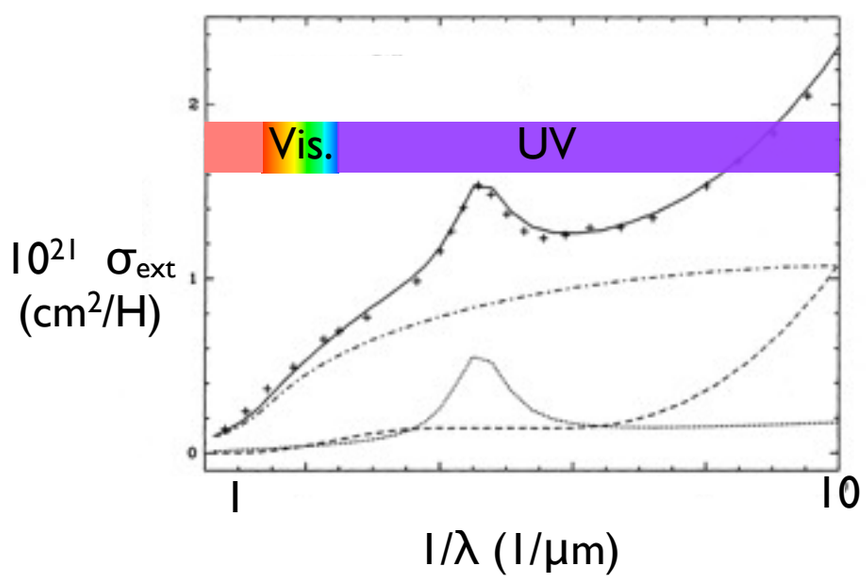


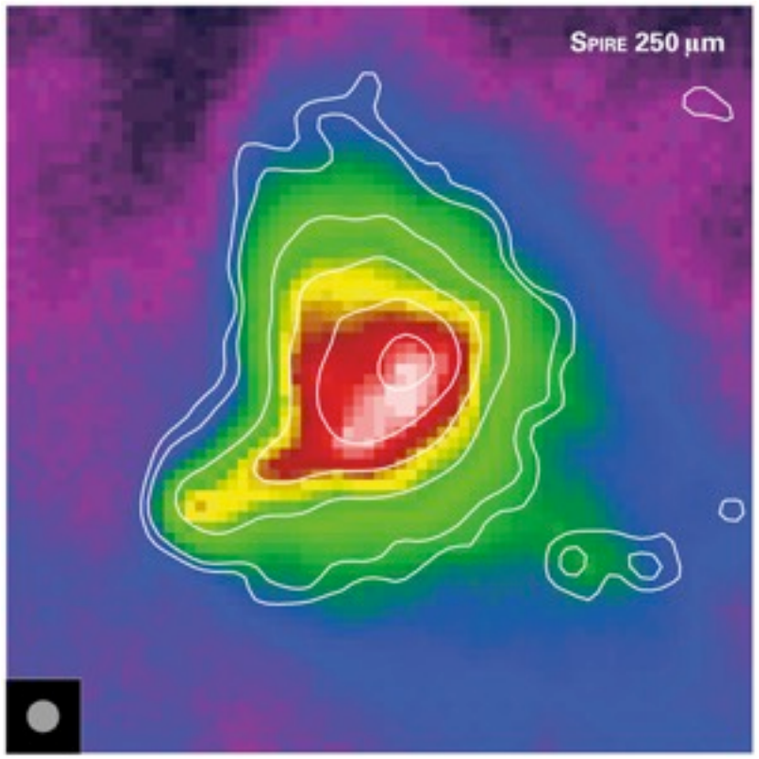
Intro: observing dust

Extinction

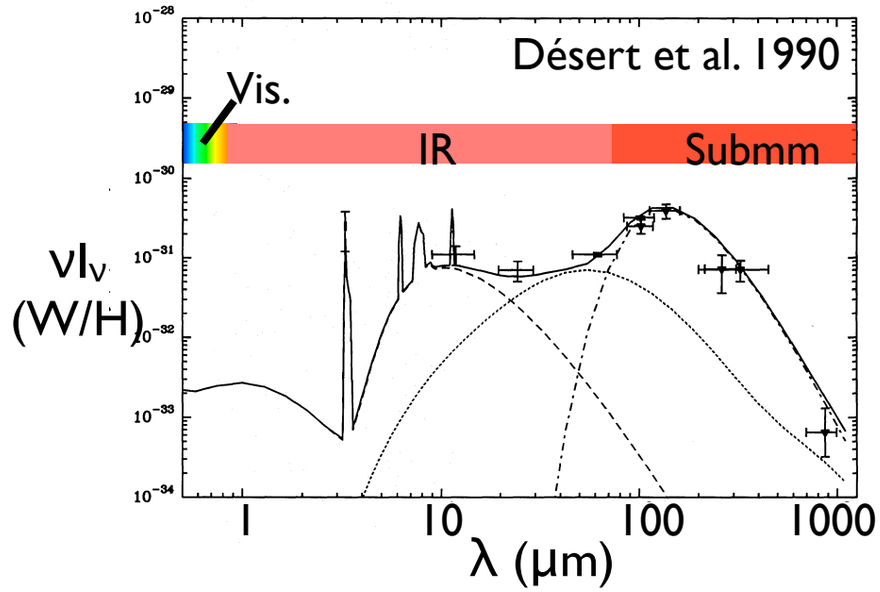




Emission



MPIA - Markus Nielbock



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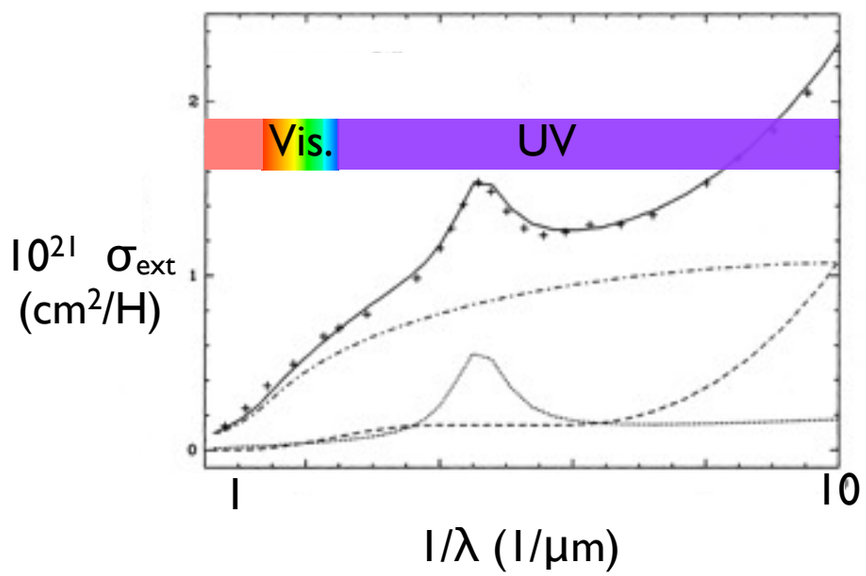

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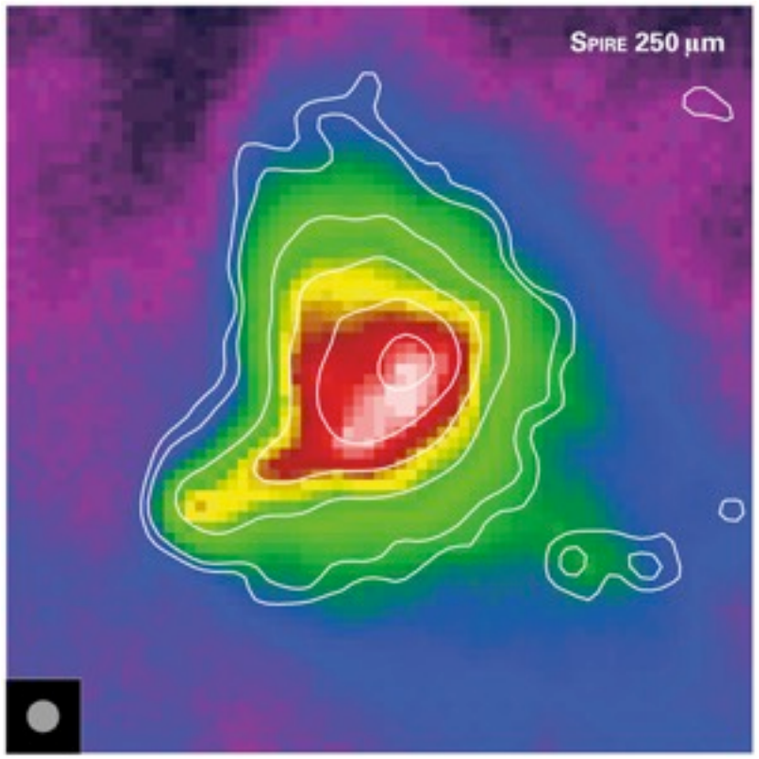

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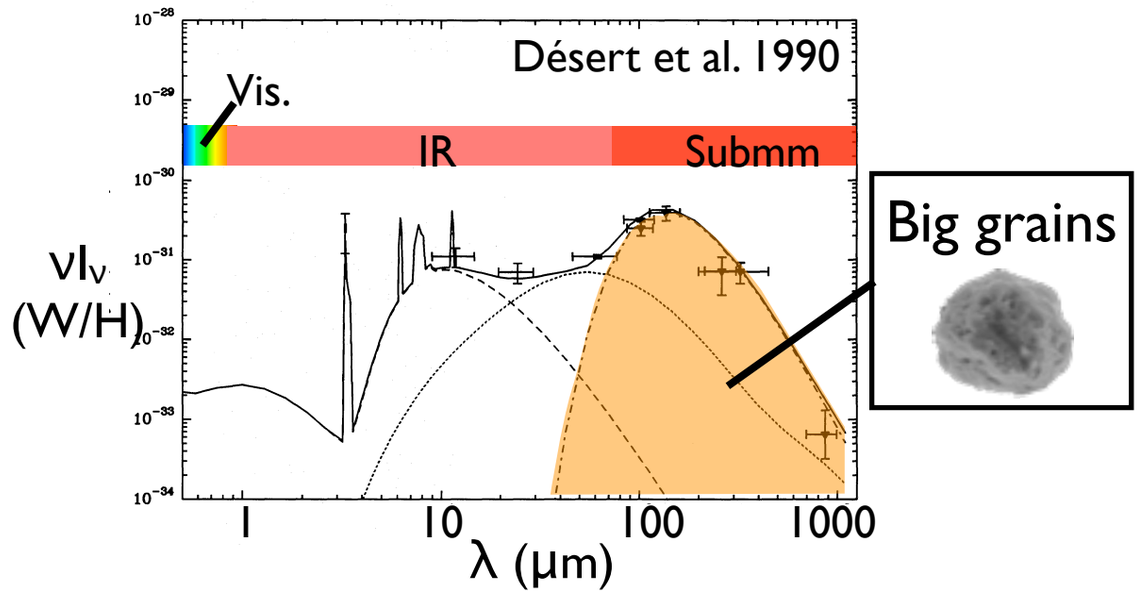
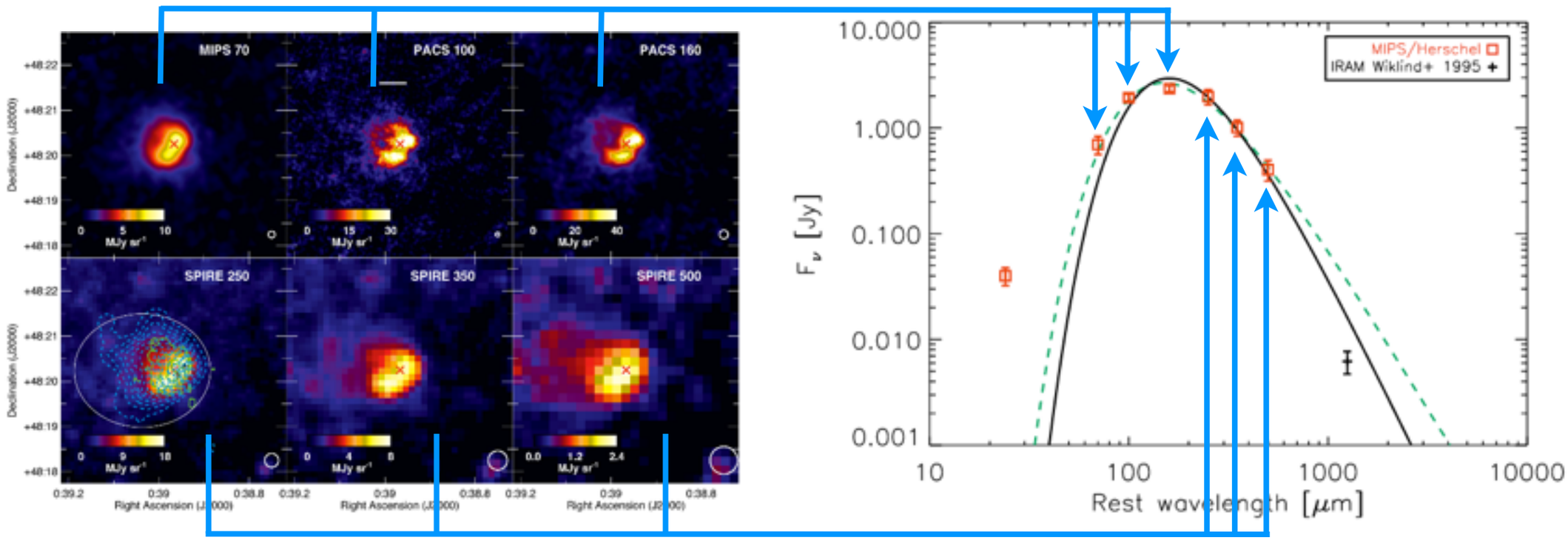


Intro: SED fitting



NGC 185 (De Looze+16)

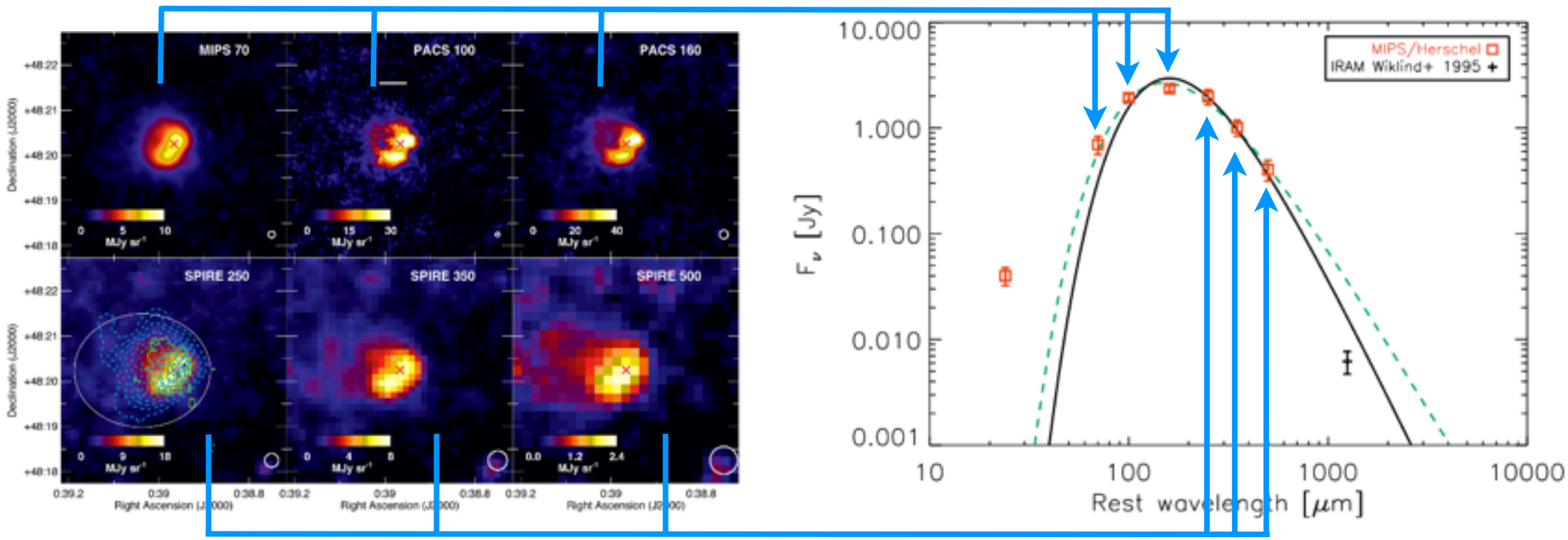
$$F_\lambda = \overbrace{M_{d,surf} \times \kappa_\lambda}^{\tau_\lambda} \times B_\lambda(T)$$

Dust masses → Gas masses

Dust T → ISRF

Polarization → Magnetic field

Intro: SED fitting



NGC 185 (De Looze+16)

$$F_\lambda = \overbrace{M_{d,surf} \times \underbrace{\kappa_\lambda}_{\kappa_0 \times (\lambda/\lambda_0)^{-\beta}}}^{\tau_\lambda} \times B_\lambda(T)$$

→ T, β, τ_0 [κ_0]

- Dust masses → Gas masses
- Dust T → ISRF
- Polarization → Magnetic field

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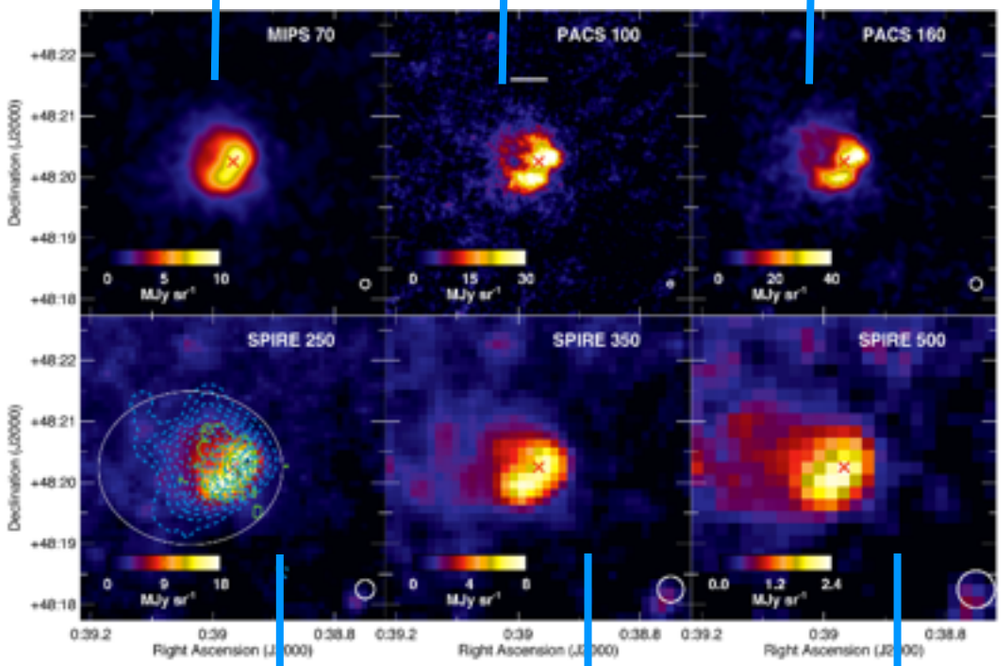

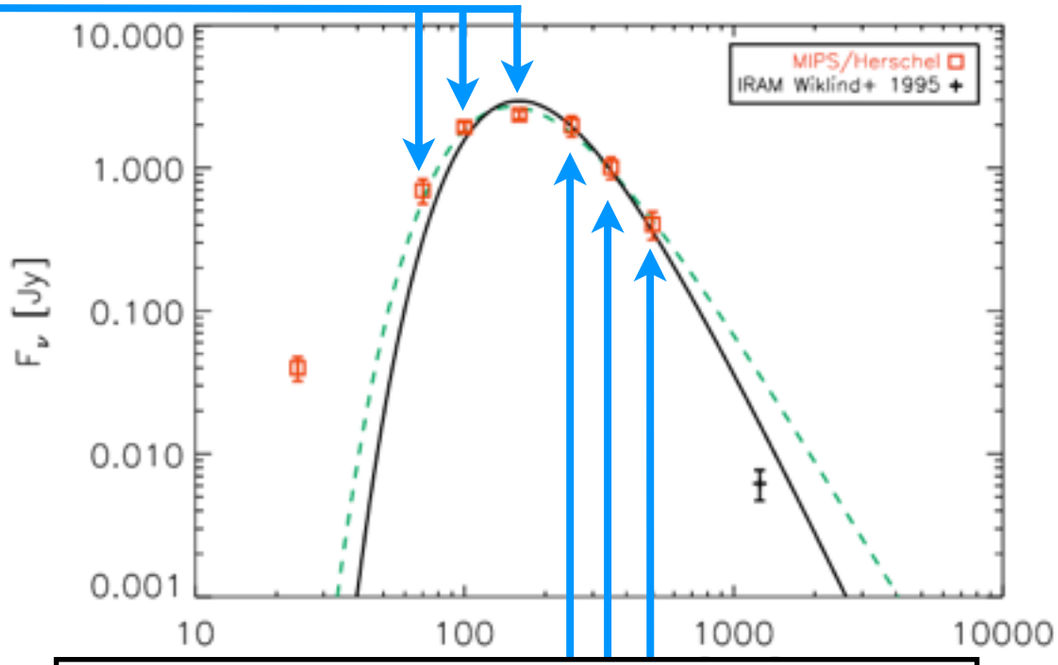

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→ T, β, τ_0 [κ_0]

Issues:

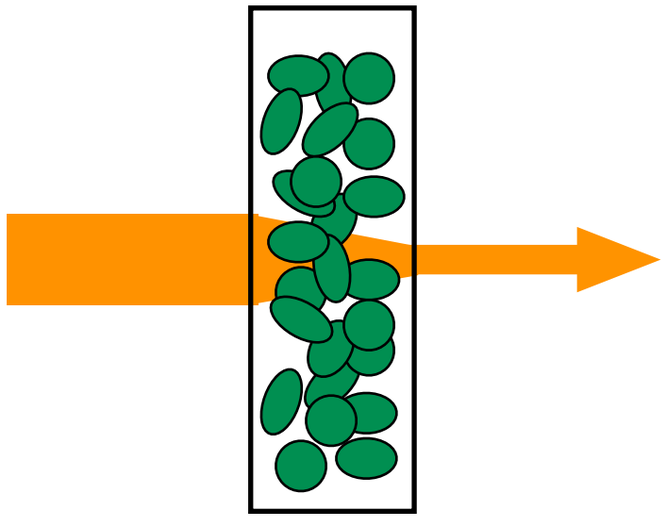
- Parameter degeneracy
- No single T
- No constant β / simple power law
- κ_λ depends on many things:
  - Temperature
  - Composition
  - Grain shape

asses

c field

Optical properties: lab vs observations

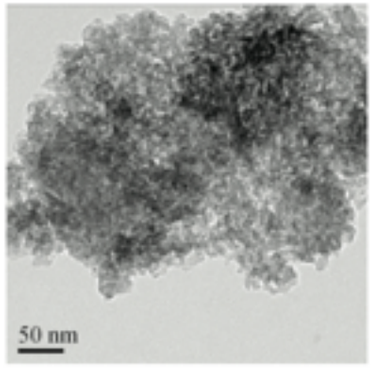
Laboratory measurements



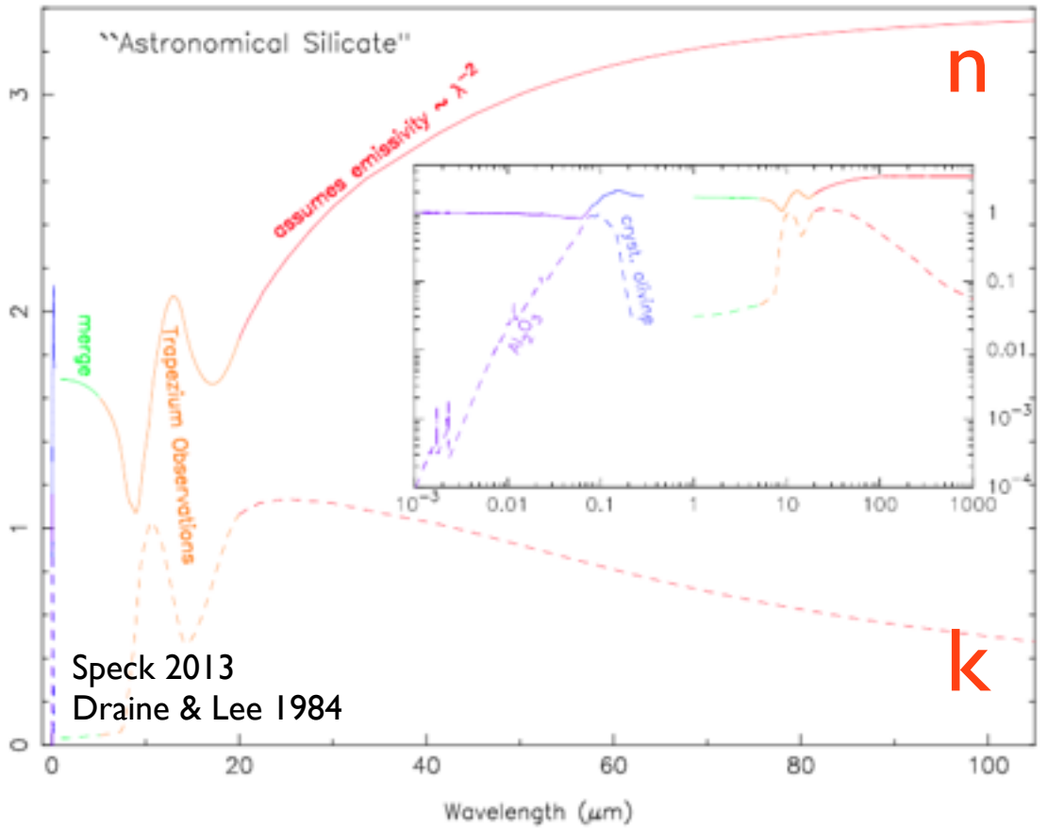
$$I_\lambda = I_0\, e^{-\tau(\lambda)}$$
$$= I_0\, e^{-\kappa(\lambda)\cdot\rho\cdot x}$$

Depends on:

- Optical "constants" (n,k)
- Concentration reduction factor g(ε,f)
- Grain structure

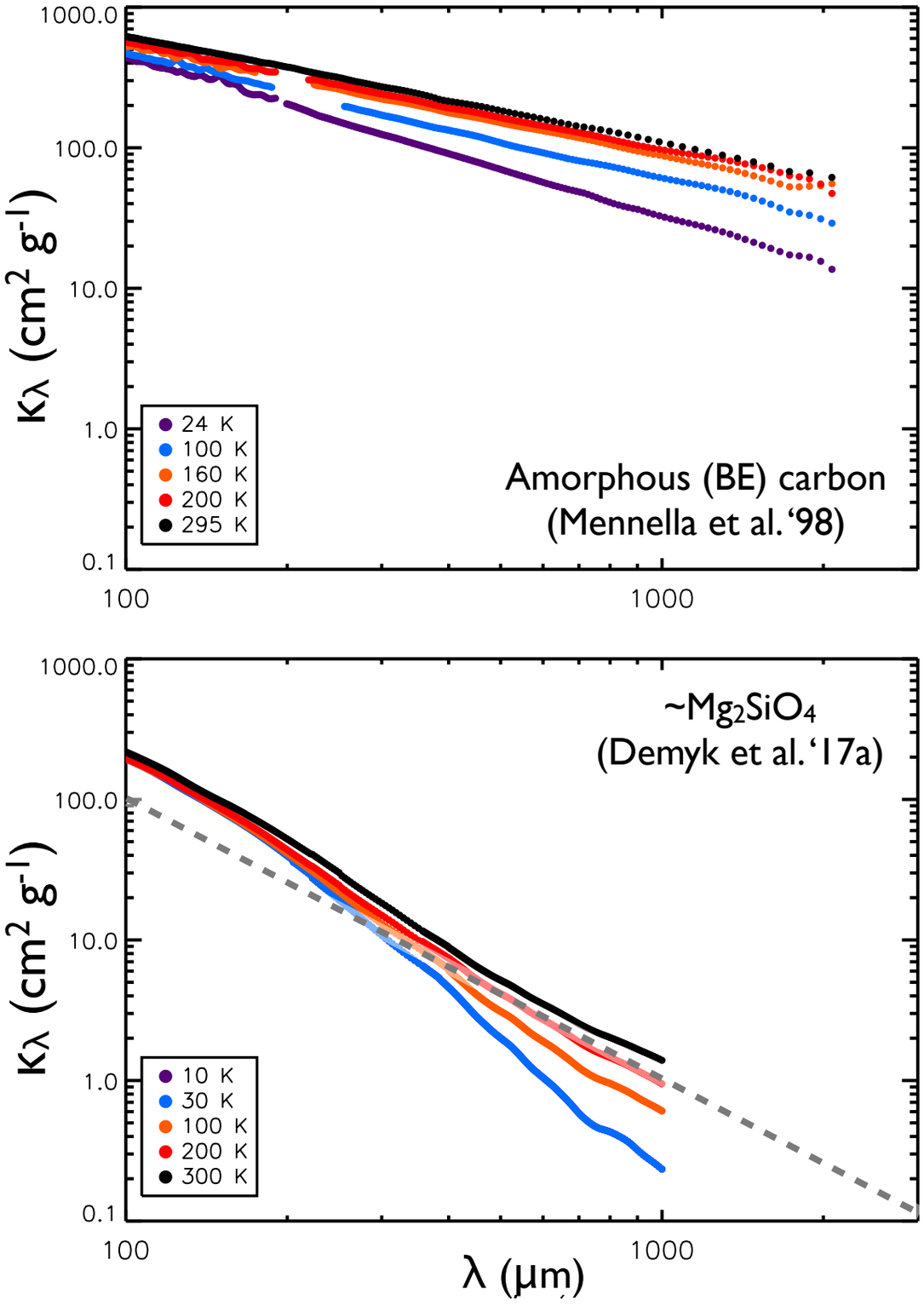


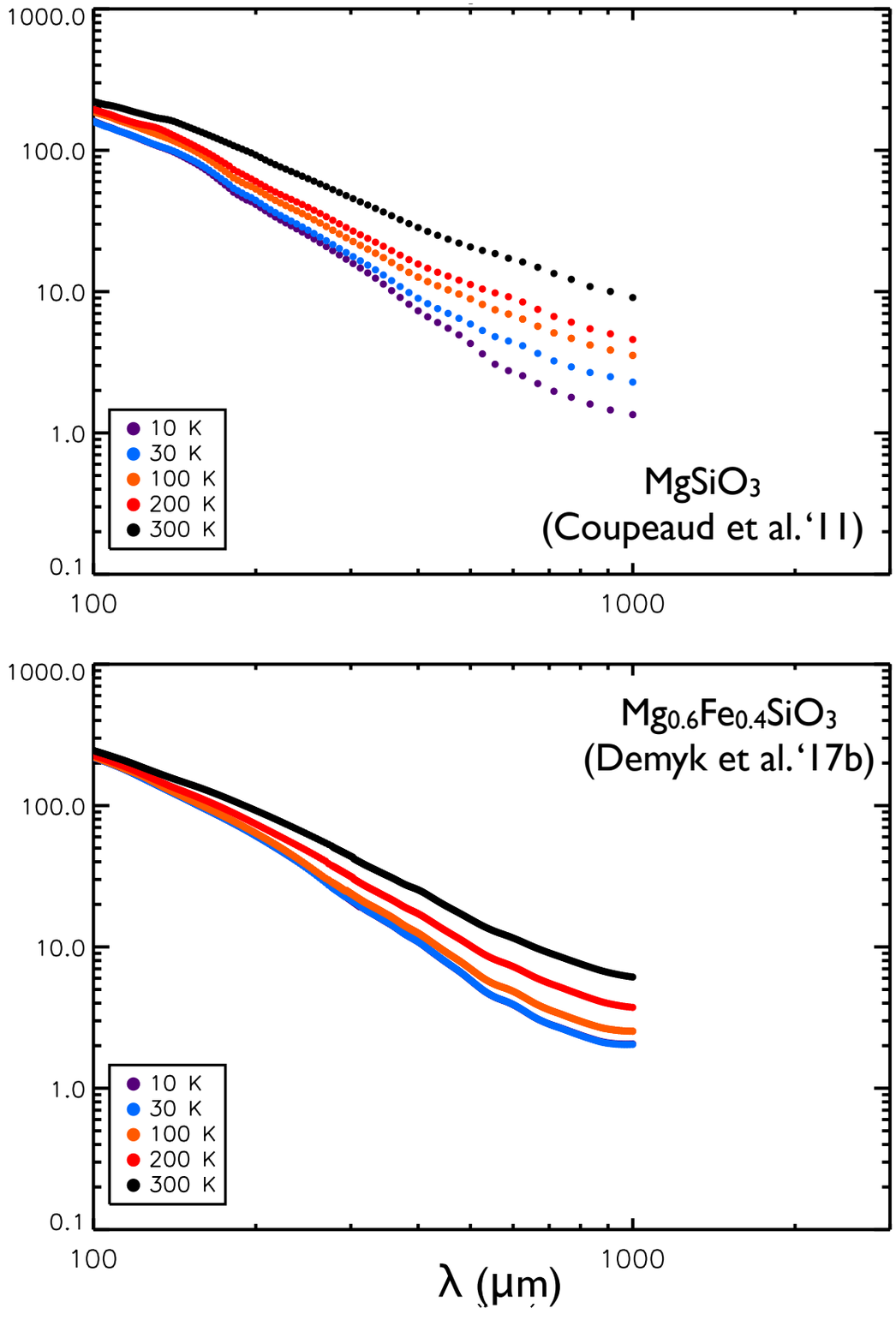
Observationally derived



- Certain to fit (some) observations
- Unknown material
- Cannot track dust variations

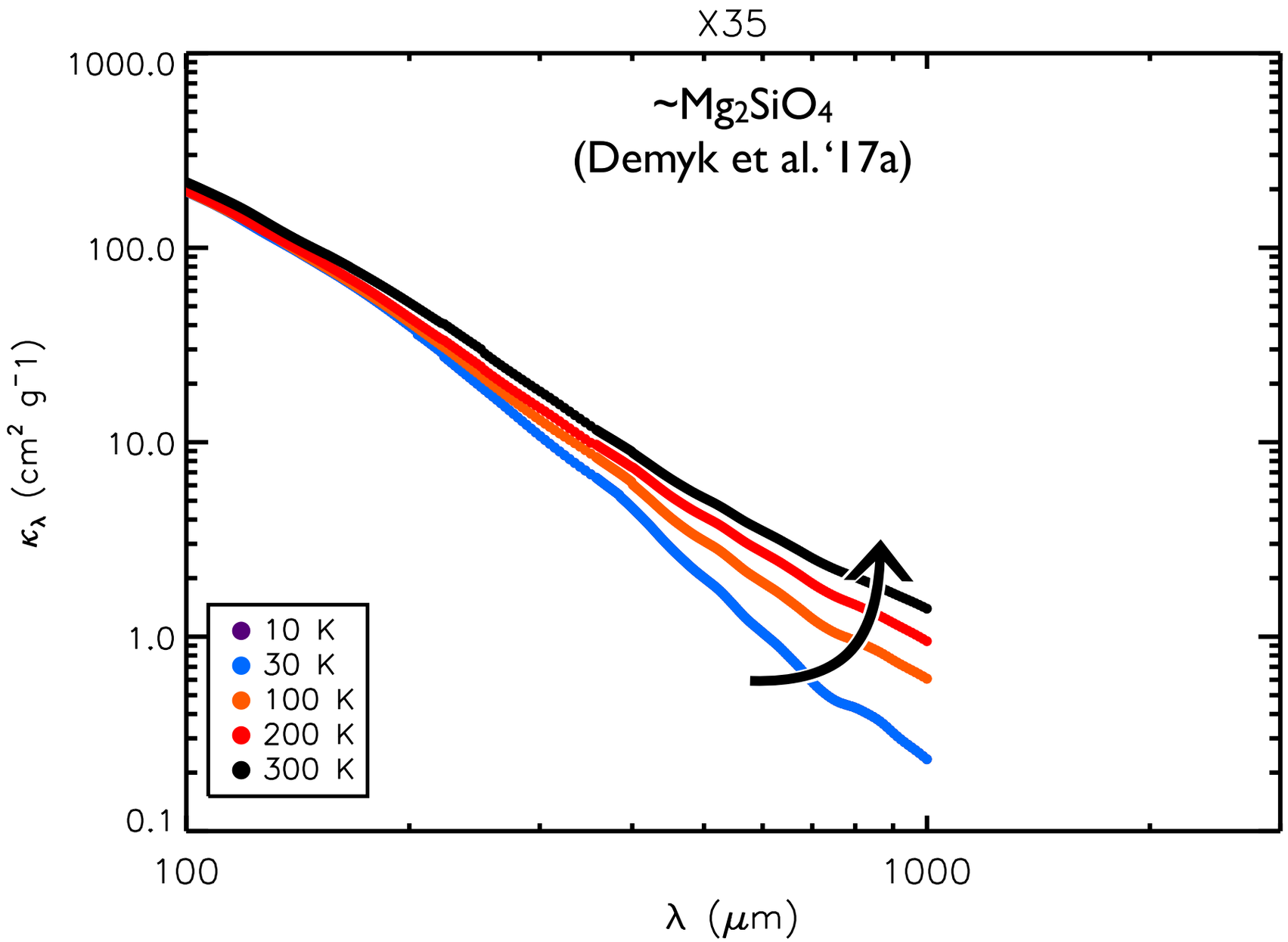
Laboratory dust opacities





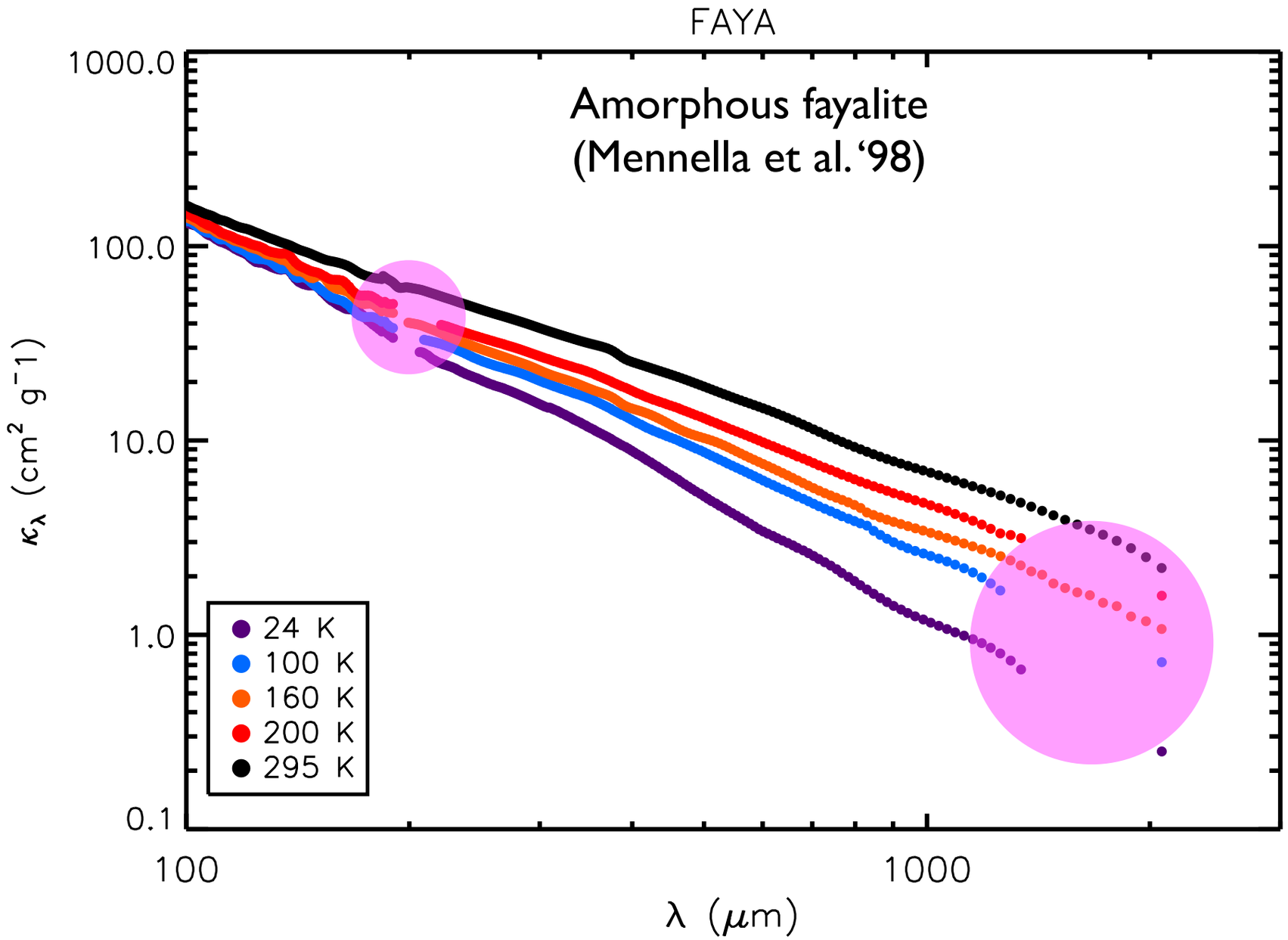
Laboratory dust opacities

- Interpolation on T



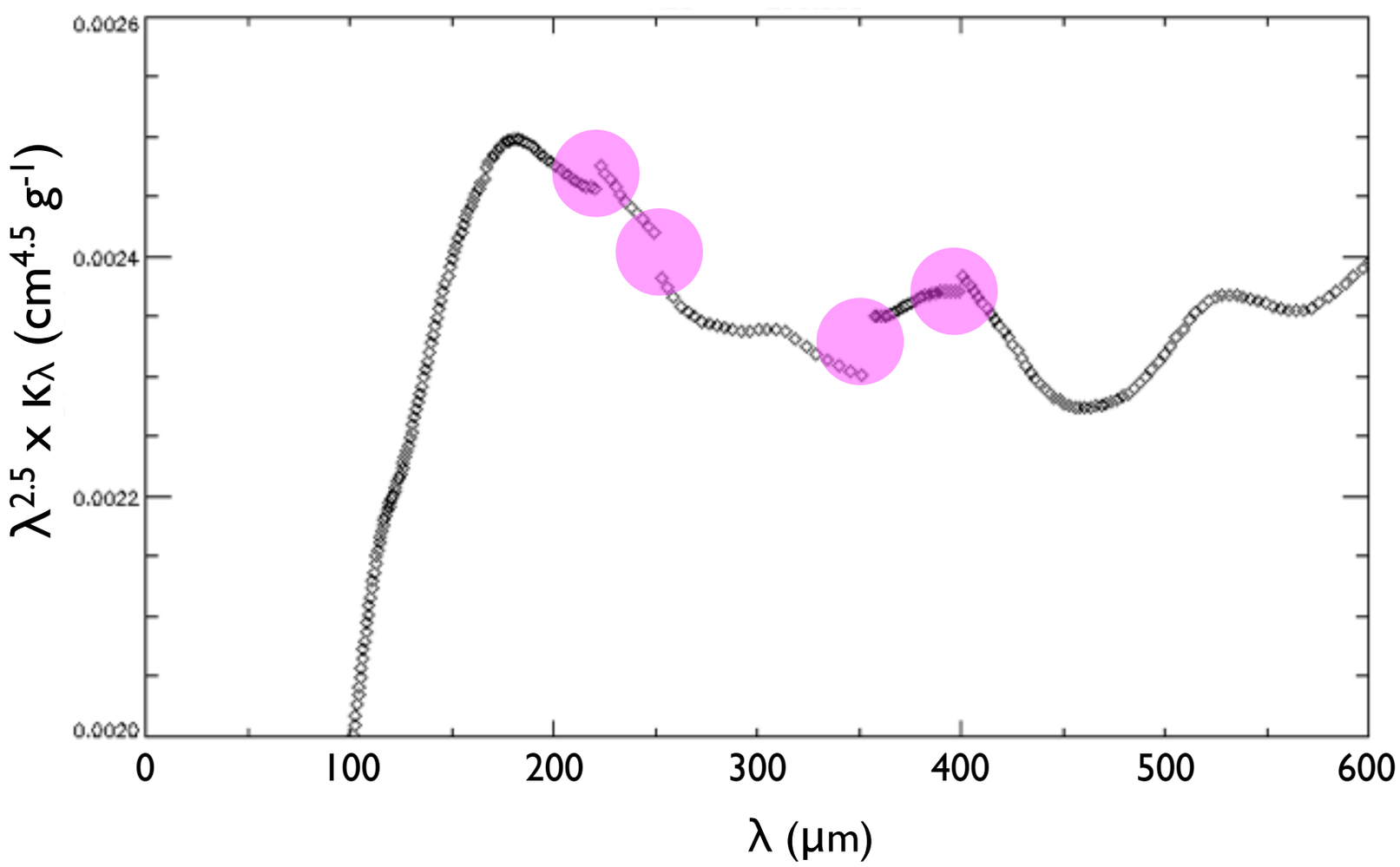
Laboratory dust opacities

- Interpolation on T
- Interpolation on λ
  - 2D interpolation



Laboratory dust opacities

- Interpolation on T
- Interpolation on λ
  - 2D interpolation
- Smooth (if necessary)
- Correct for artifacts



Laboratory dust opacities

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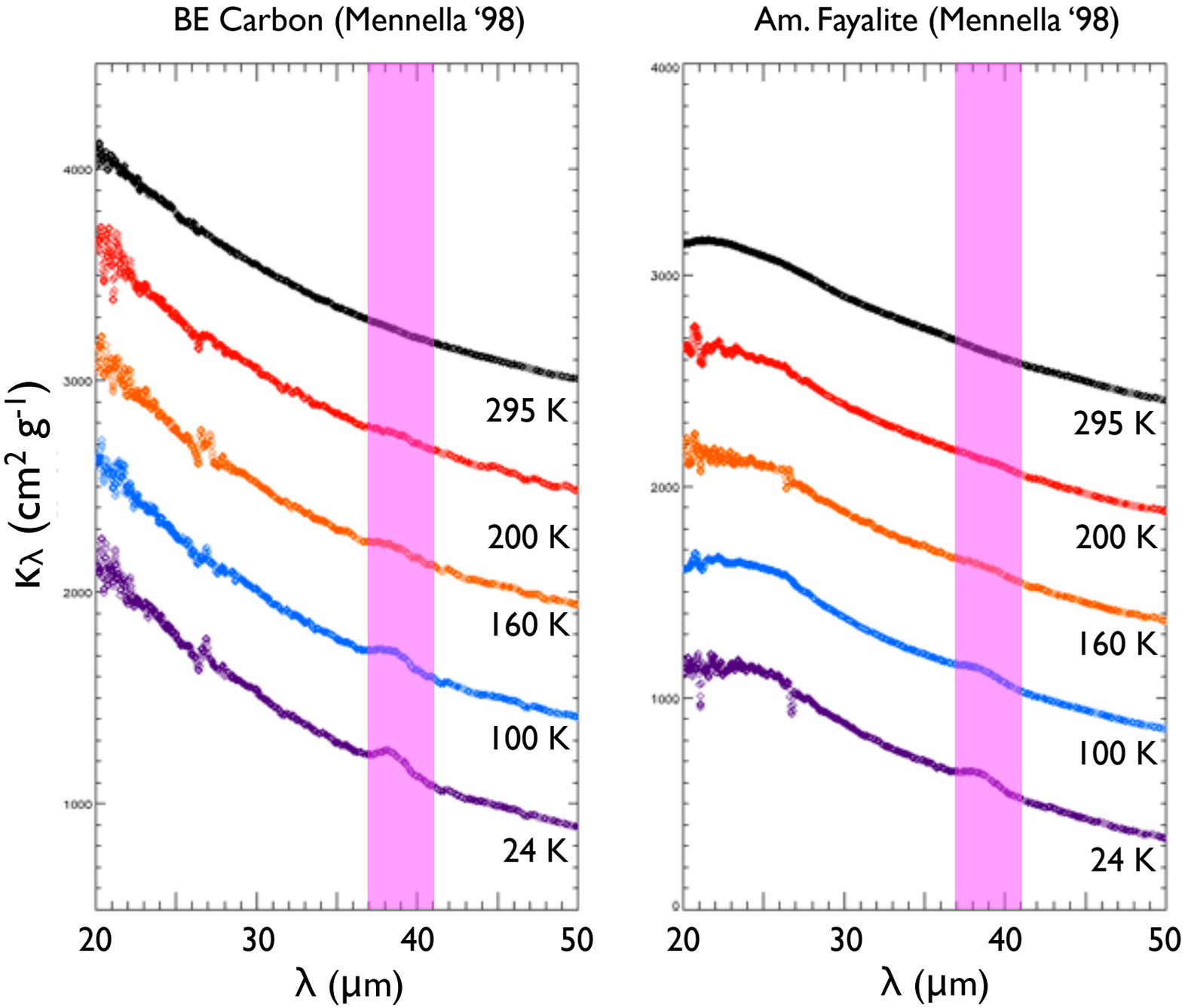
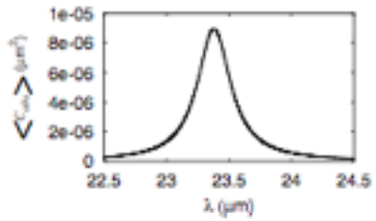
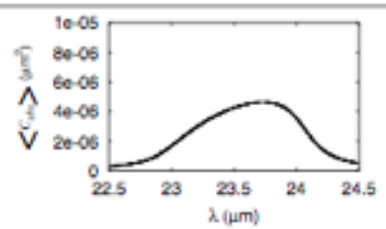
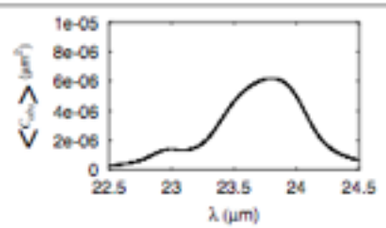
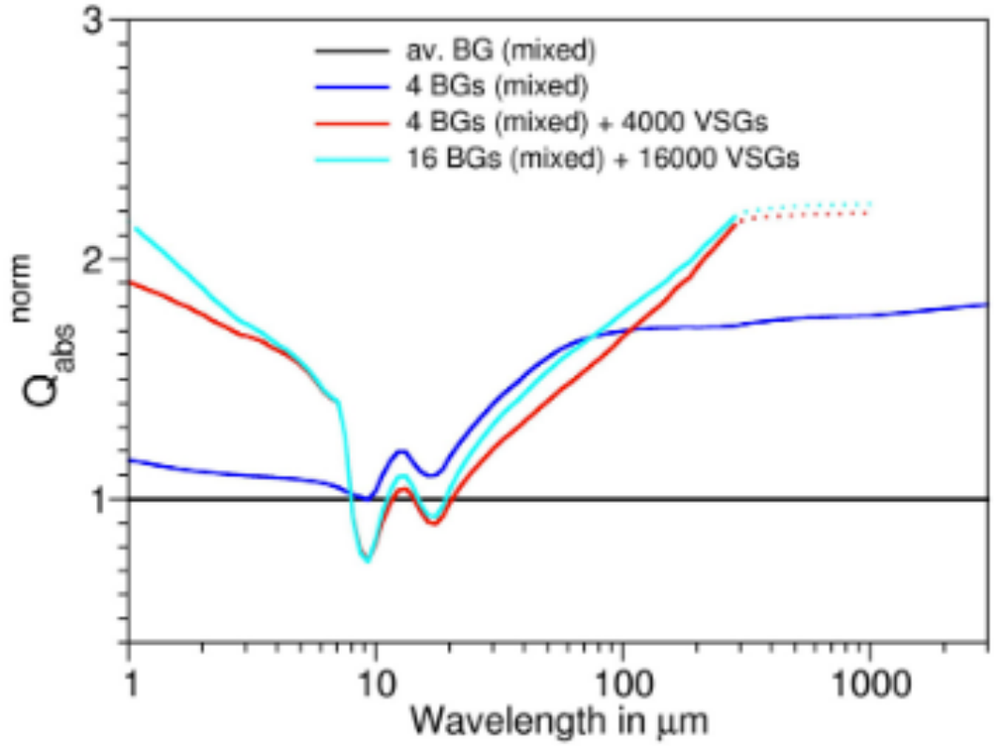


Laboratory dust opacities

Grain shape and aggregates

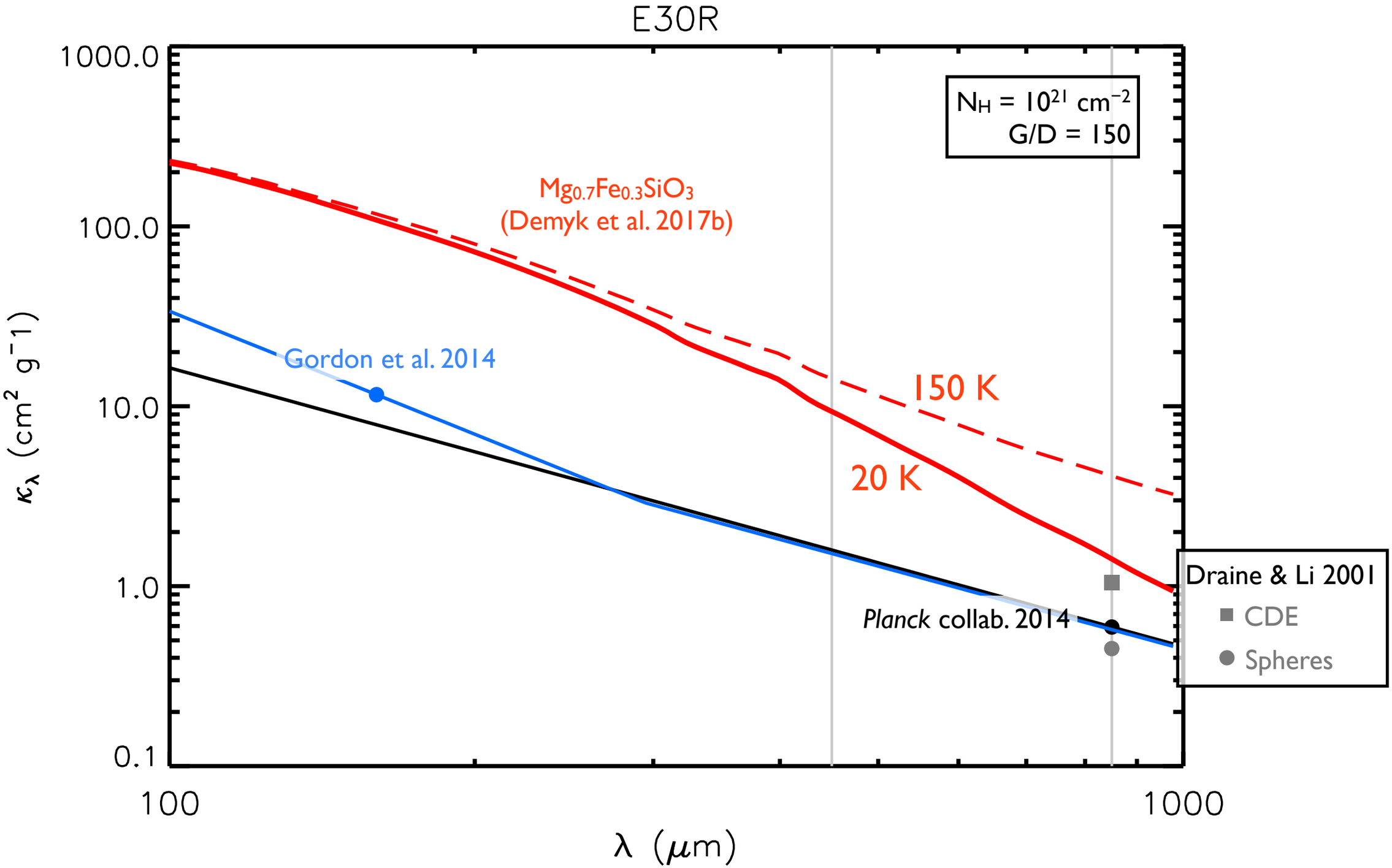
Name	Typical feature shape	Characteristics
Homogeneous Spheres		$\lambda_{max} = 23.38\ \mu m$ $FWHM = 0.32\ \mu m$
CDE		$\lambda_{max} = 23.73\ \mu m$ $FWHM = 1.01\ \mu m$
Distribution of Hollow Spheres		$\lambda_{max} = 23.80\ \mu m$ $FWHM = 0.74\ \mu m$

Min et al. 2003

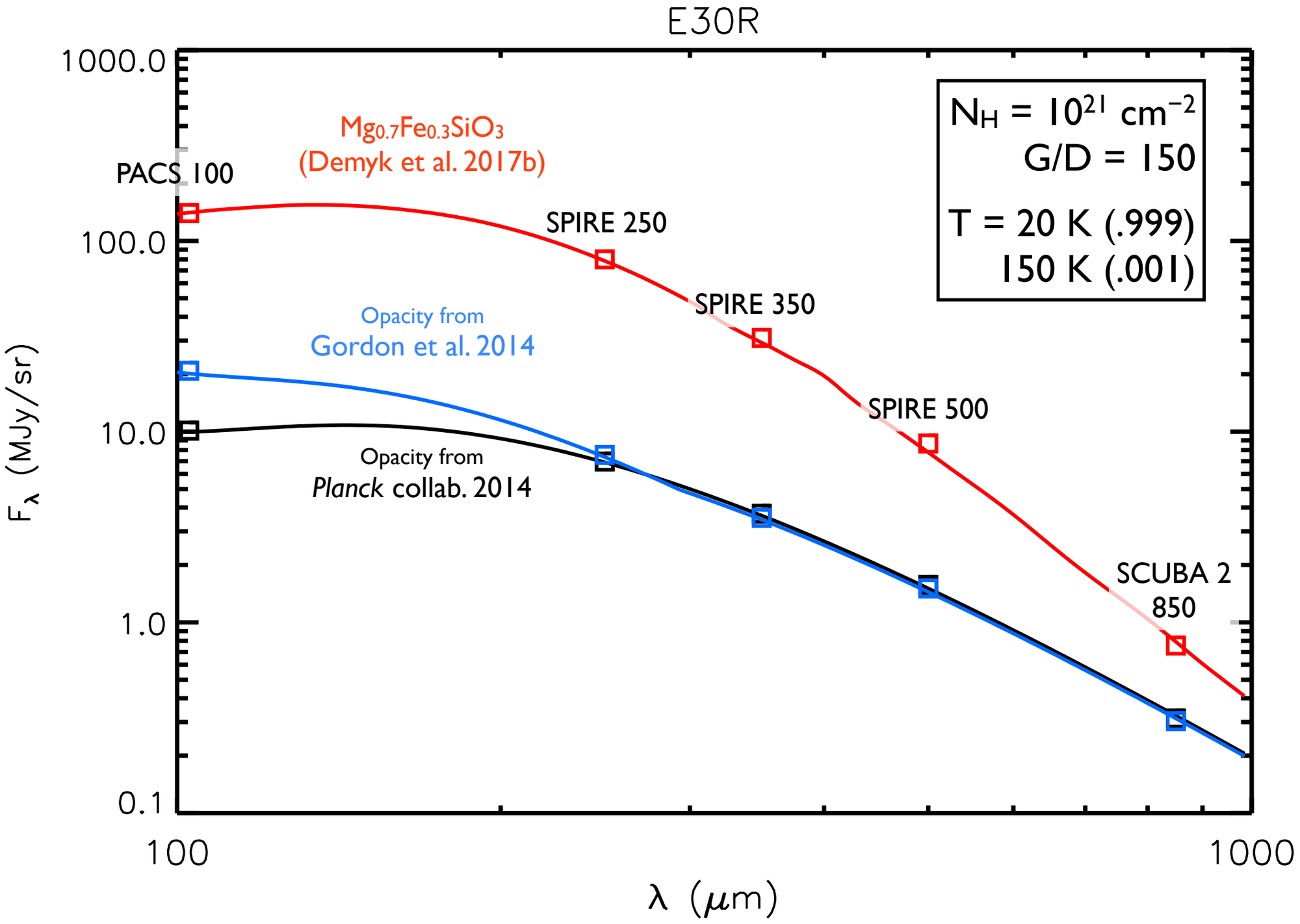


Köhler et al. 2012

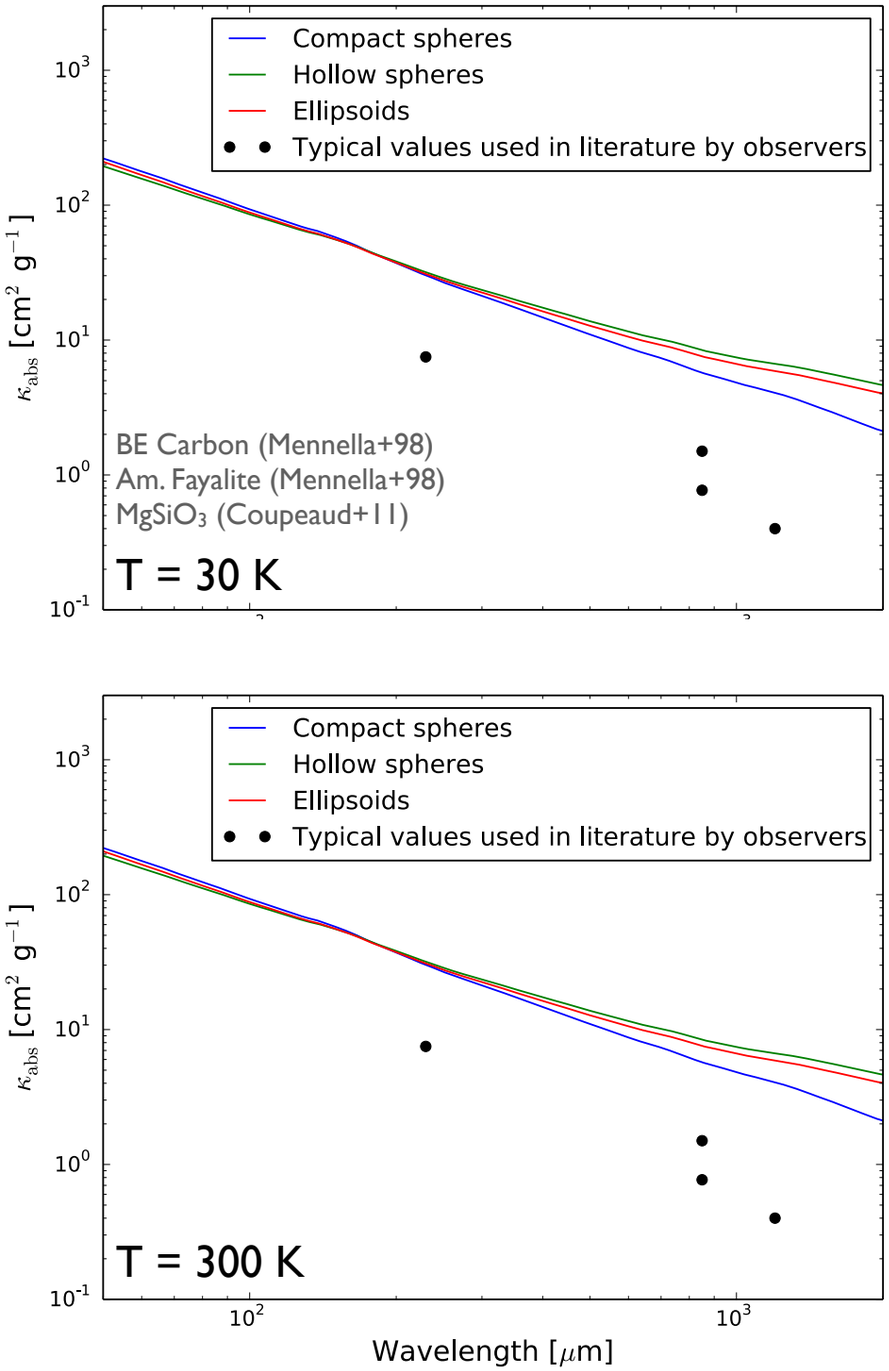
Lab results vs. observations

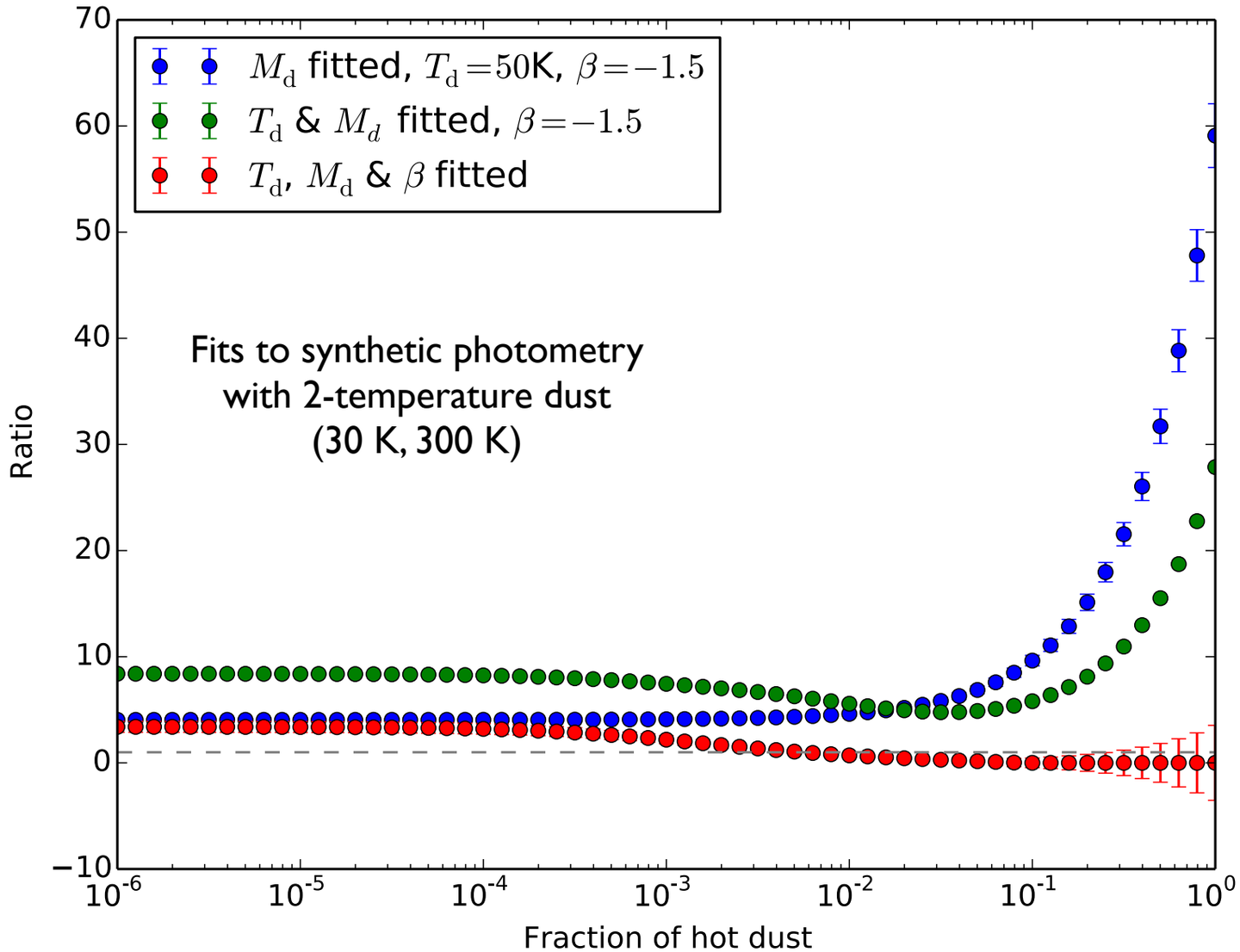


Lab results vs. (synthetic) observations



Bias estimation (Work by Peter Scicluna)





Conclusions

- Dust mass determination depends on choice of opacity
- Large differences between lab-derived and observation-derived opacities
  - Power law (single-β) model inadequate
  - Dependence on T
- Fits of synthetic photometry

  ➠ Mass overestimated by up to ~10x

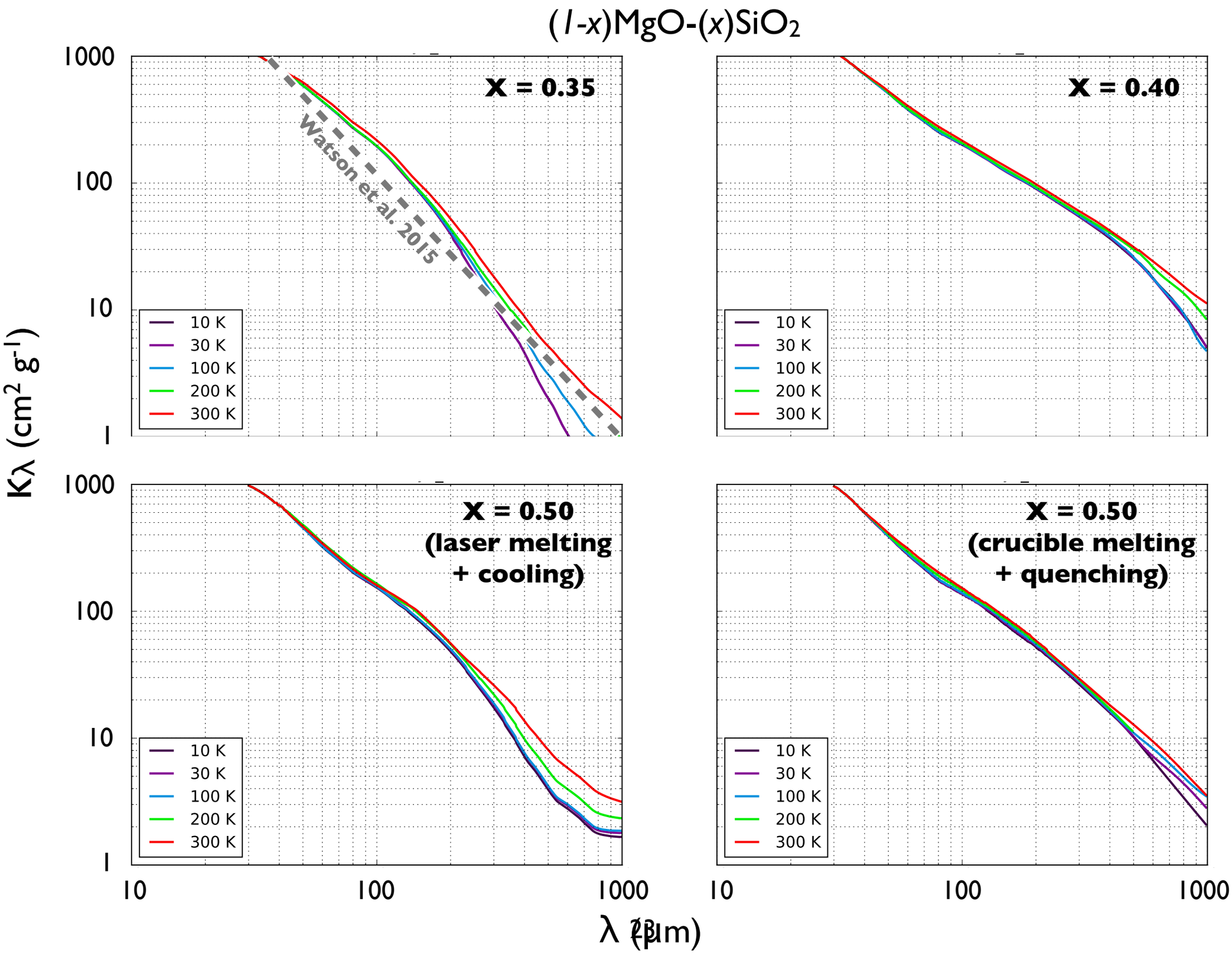
PRELIMINARY

- To solve: What effect of shape distribution? Cogulation?

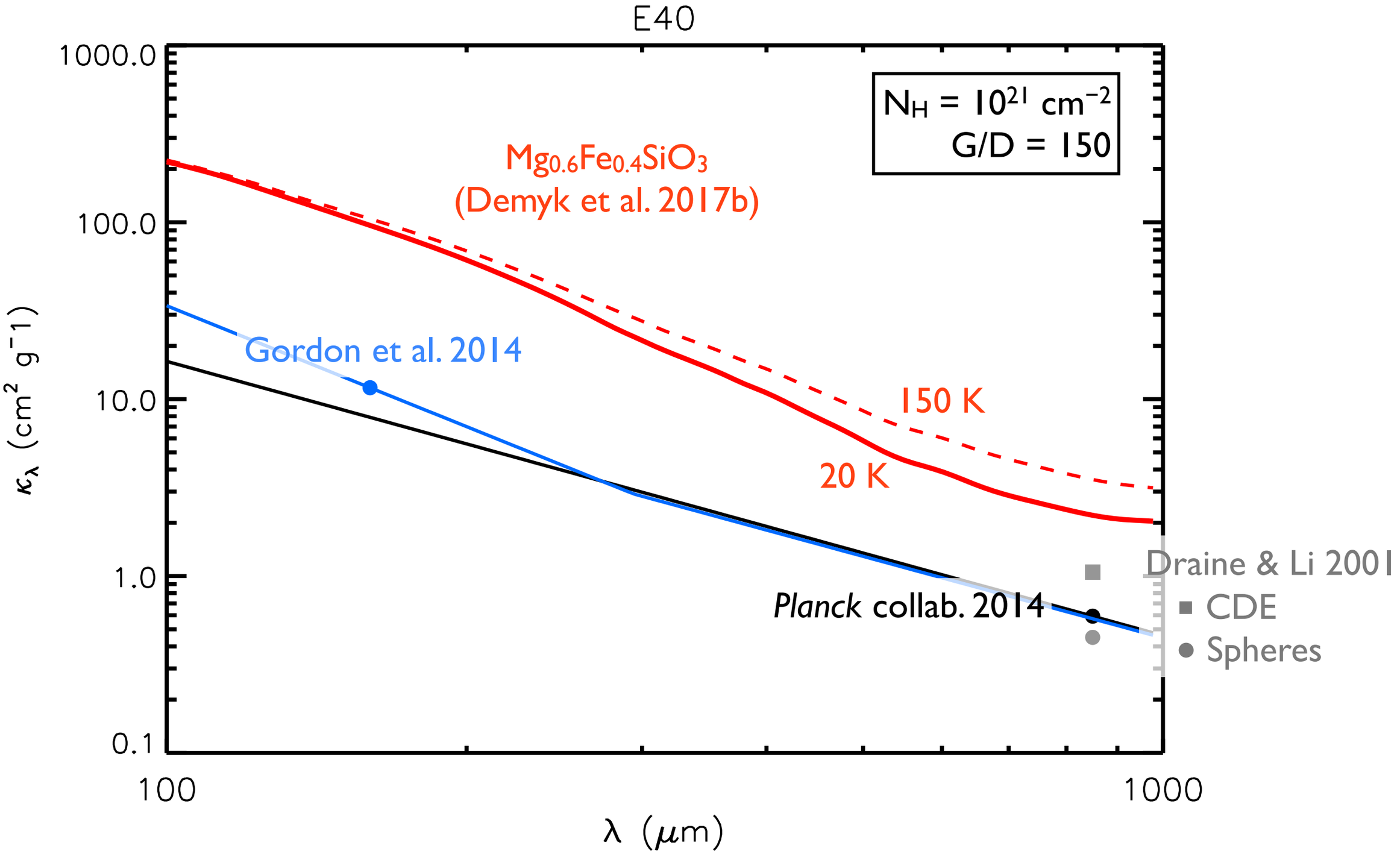
Thank you for your attention!

Extra Material

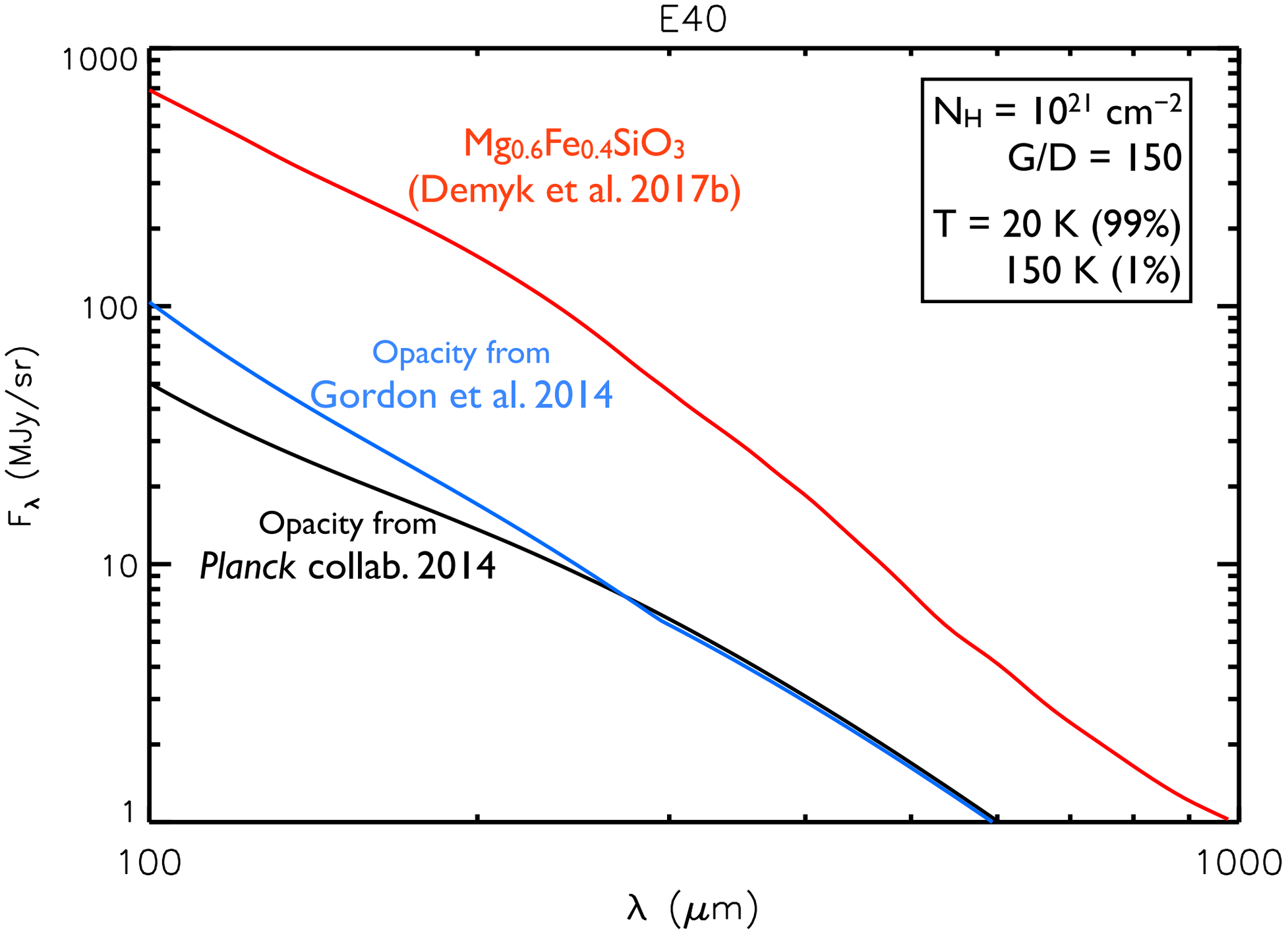
Kλ: Demyk et al. 2017



Lab results vs. observations



Lab results vs. (synthetic) observations



Work by Peter Scicluna, z = 1