# Galactic Dust Properties

*Déborah Paradis*
*CNES Post-doc*
*IRAP, Toulouse*

# BG emissivity

$$I_\nu(\lambda) = \underbrace{Q_{abs}(\lambda_0)\left(\frac{\lambda}{\lambda_0}\right)^{-\beta}}_{\text{emissivity} = \tau/N_H} B_\nu\left(T_{eq},\lambda\right) N_H$$

β : spectral index

*$Q_{abs}$ : absorption efficiency*

*$B_\nu(T,\lambda)$ : Planck function*

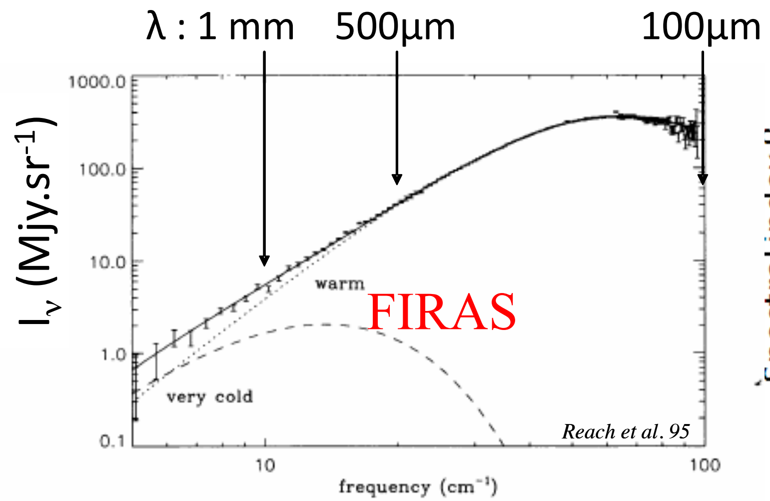
*$N_H$ : column density*

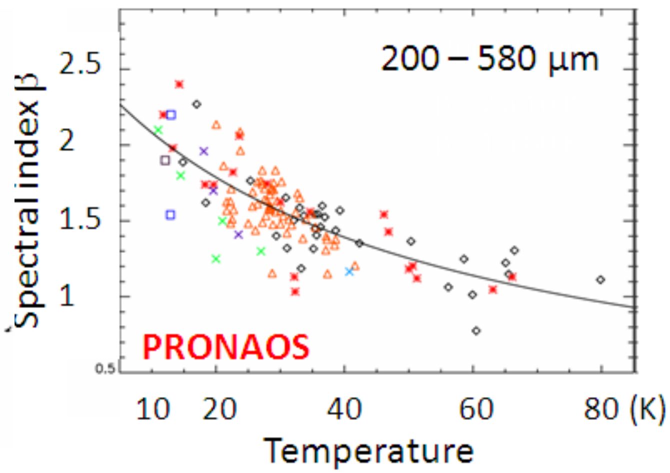
Conventionally admitted **: β = 2**

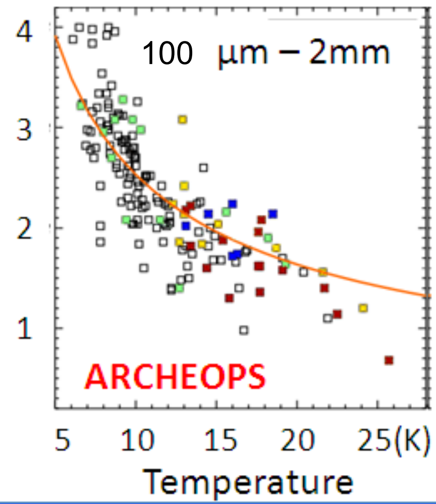
<u>But recent observations:</u>

FIRAS (COBE), PRONAOS (200-600 µm) et ARCHEOPS (550-3000 µm)

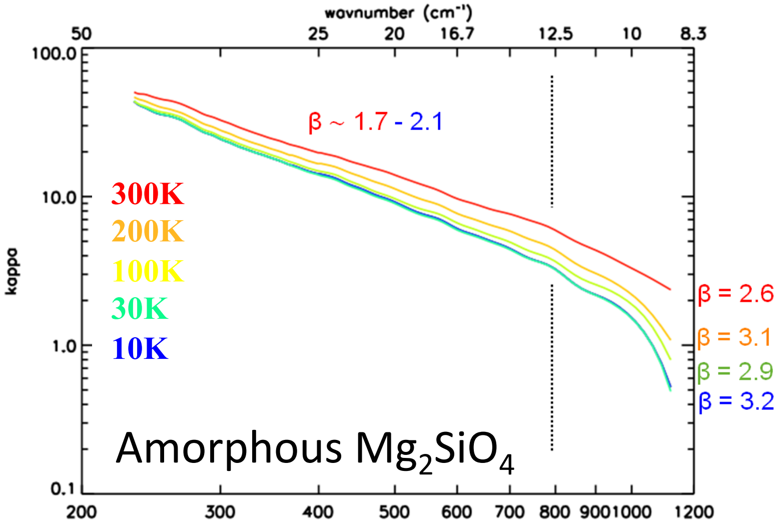
**β ≠ 2 and varies with T and λ**

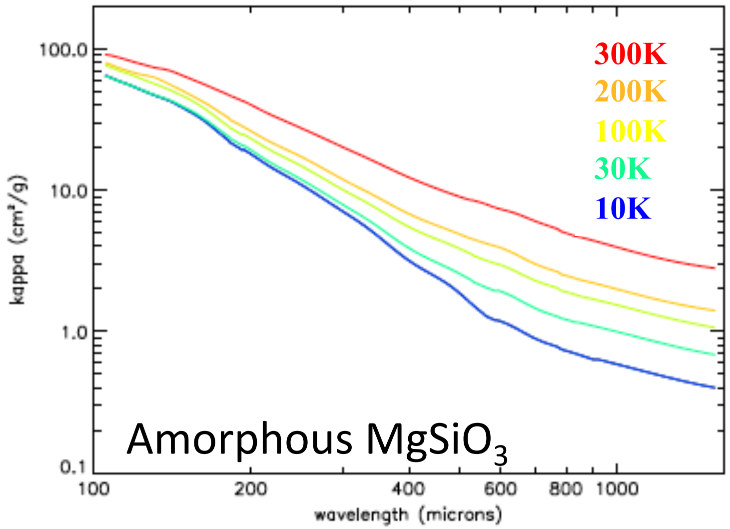


# Laboratory Data: ESPOIRS Project




*Coupeaud et al. A&A, 2011, submitted*

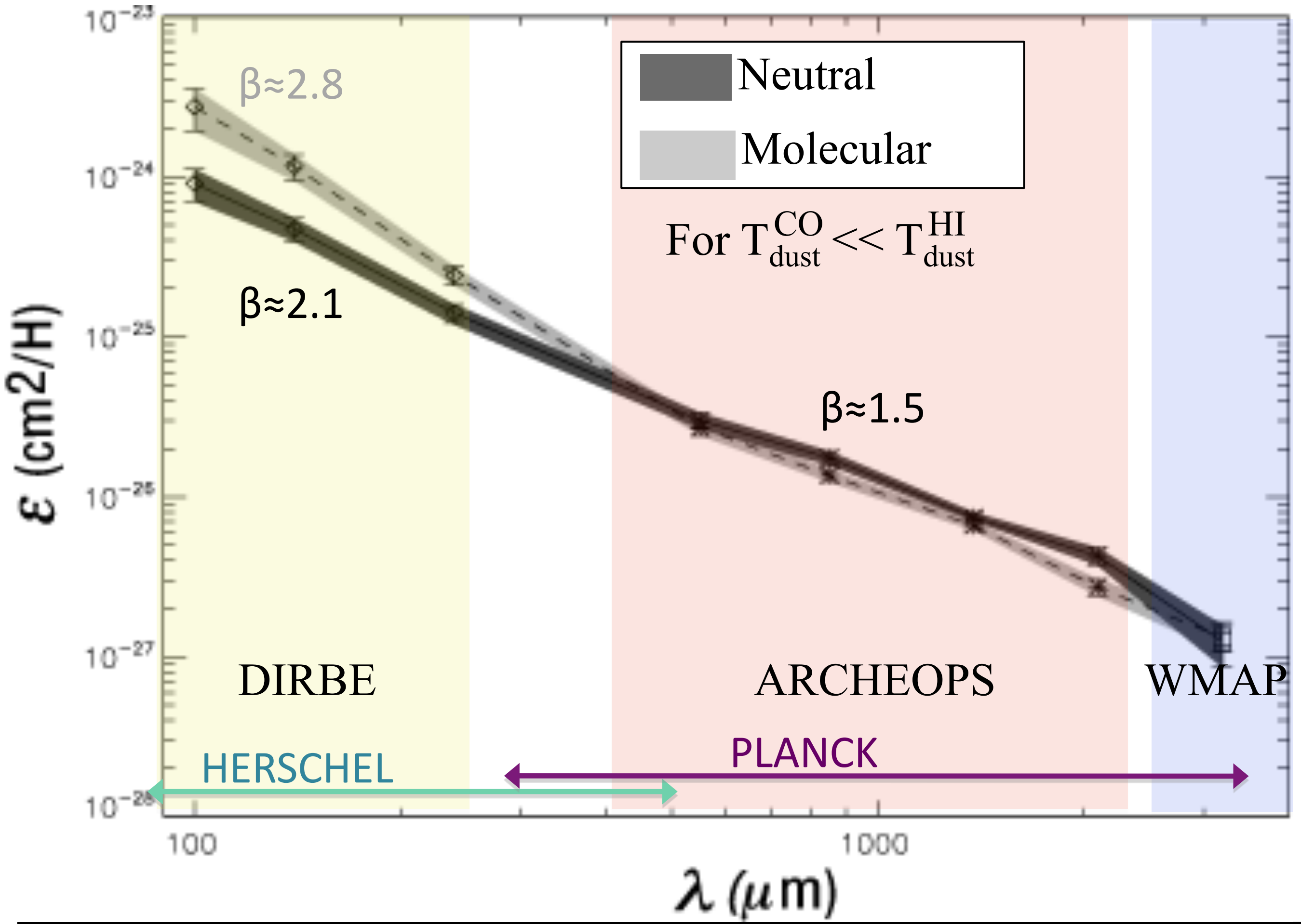
Most dust (98%) in ISM is amorphous (Kemper 2004)

Laboratory measurements of dust analog materials show that the internal structure of the grain (amorphous vs crystalline) affects the emissivity shape

- Emissivity spectrum changes at long wavelengths (from IR to submm)
- Emissivity spectrum flattens with temperature

# Evolution of dust properties from diffuse to dense medium

*Paradis, Bernard et al., 2009a, A&A 506, 745*




**=> Emissivity excess in dense environments**
**⇒ changes in dust properties in the cold molecular phase**
**=> Formation of dust aggregates**

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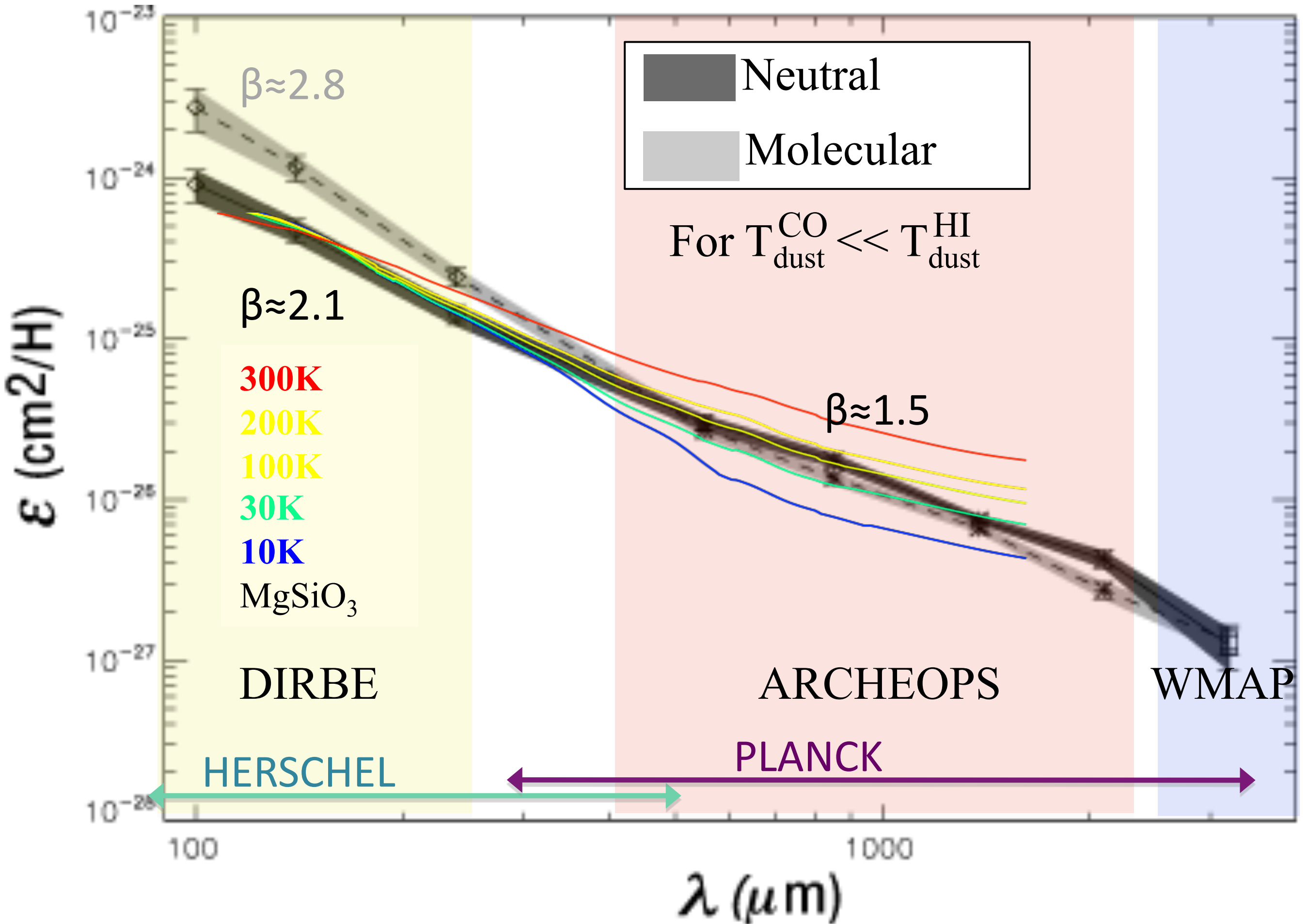


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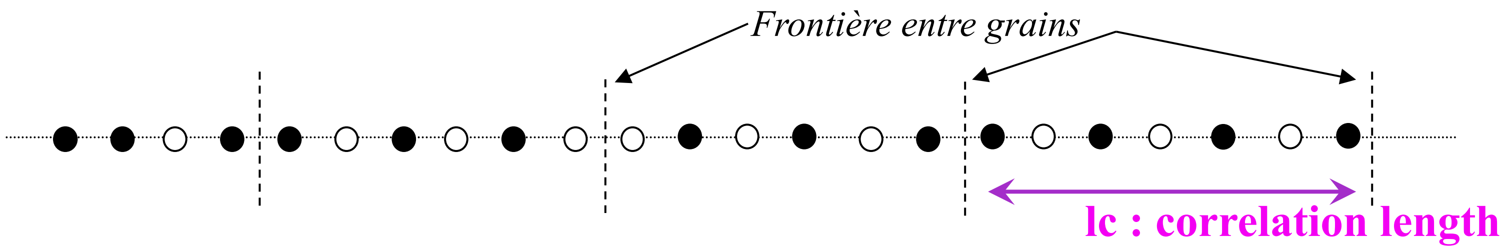
# A model of amorphous dust: the TLS model

➢ 98% of amorphous dust in the ISM but no model takes into account this evidence!

➢ Double description of disorder in amorphous solids: the TLS model *Mény et al., 2007*

• Disordered Charge Distribution (DCD): interaction between the electromagnetic wave and acoustic oscillations in the disordered charge of the amorphous material (Vinogradov, 1960; Schlomann, 1964) => T-independent




• Two Level System (TLS): interaction of the electromagnetic wave with a simple distribution of asymmetric double-well potential => T-dependent

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**Parameters of the TLS model:**
- Dust temperature : Td
- Correlation length : lc
- Intensity of the TLS processes with respect to the DCD part : A

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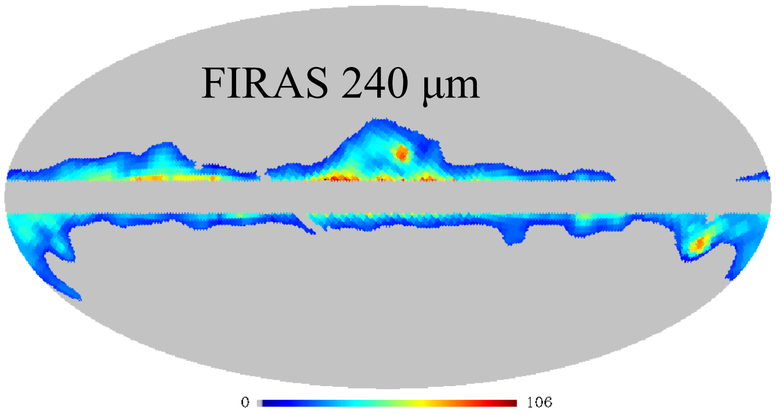
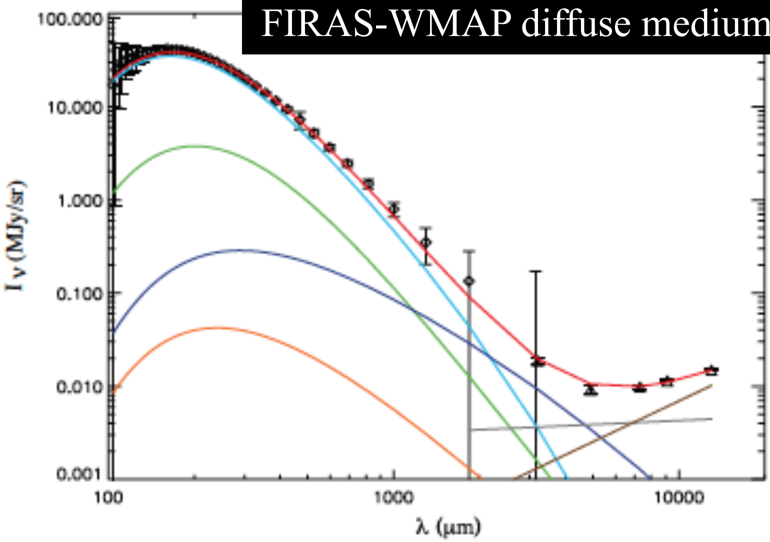
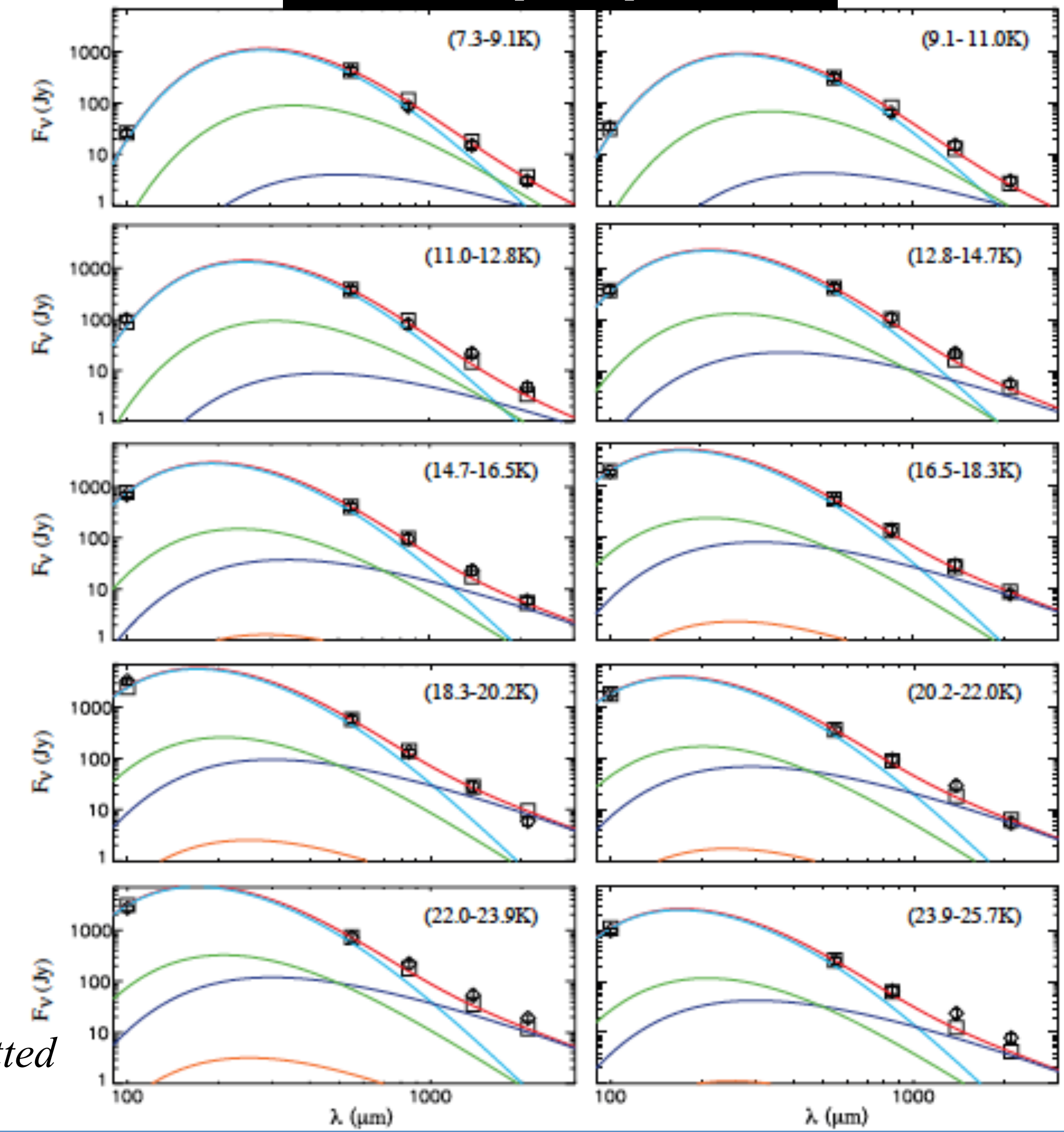
# A model of amorphous dust: the TLS model




FIRAS-WMAP diffuse medium




IRAS-Archeops compact sources




*Paradis, Bernard et al., 2011c, A&A submitted*

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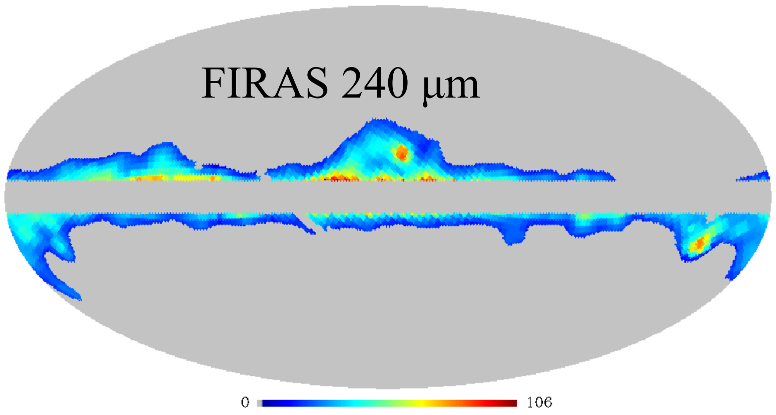
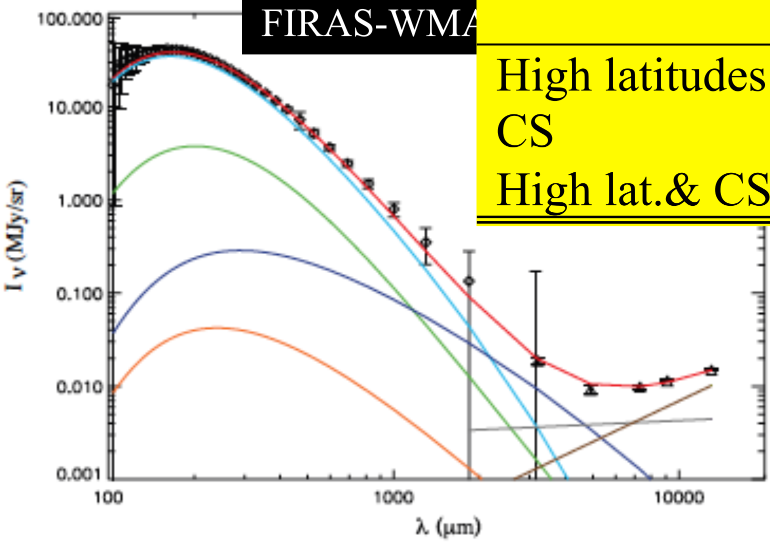
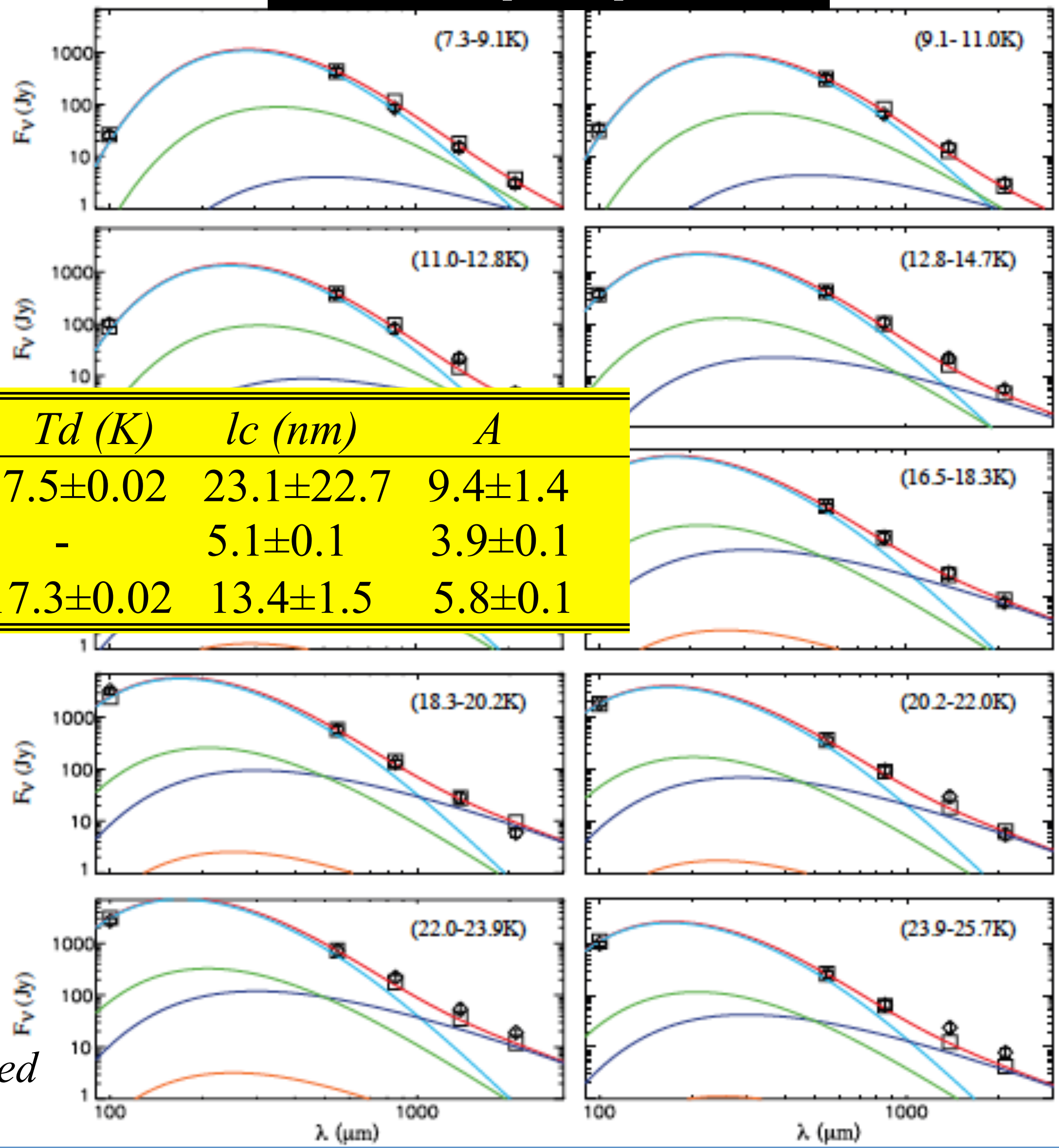



FIRAS-WMA




| | Td (K) | lc (nm) | A |
|---|---|---|---|
| High latitudes | 17.5±0.02 | 23.1±22.7 | 9.4±1.4 |
| CS | - | 5.1±0.1 | 3.9±0.1 |
| High lat.& CS | 17.3±0.02 | 13.4±1.5 | 5.8±0.1 |

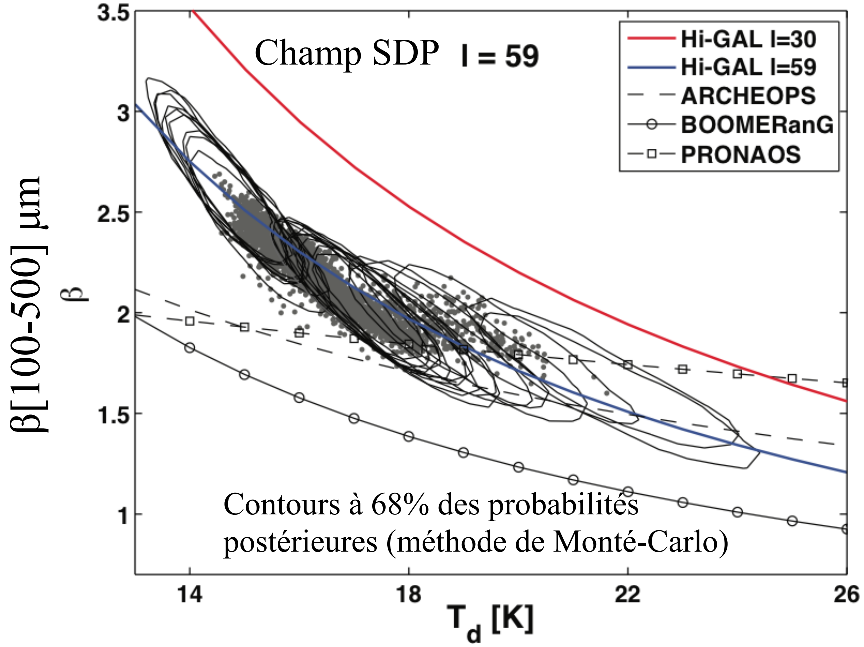
IRAS-Archeops compact sources




*Paradis, Bernard et al., 2011c, A&A submitted*

# Dust properties along the Galactic Plane (GP)

Herschel Hi-GAL




*Paradis, Veneziani et al., 2010, A&A, 520, 8*

⇒T-β anti-correlation in the inner GP, already highlighted in external regions and in the solar neighborhood (Dupac et al. 2003, Désert et al., 2008, Veneziani et al., 2010)

⇒Different T-β trend with respect to previous observations based on BOOMERanG, Archeops and Pronaos, probably because of different dust properties

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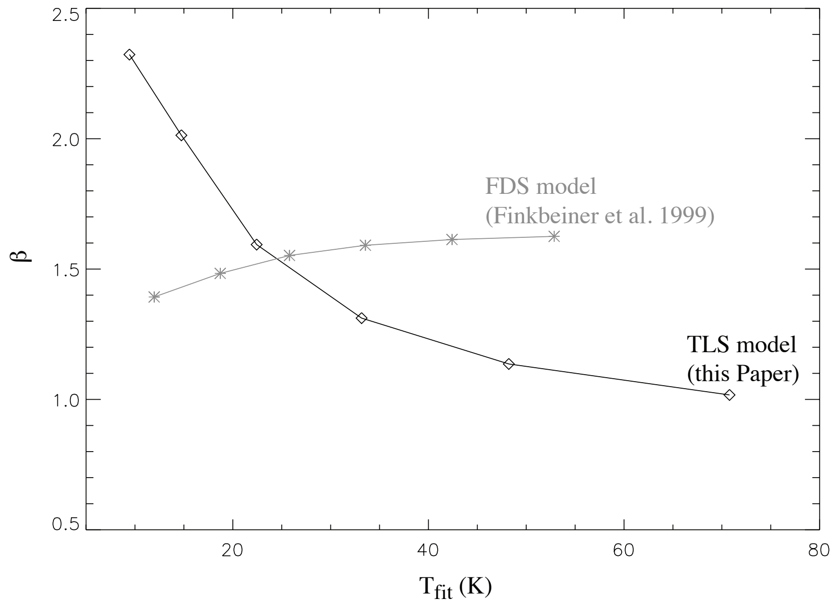


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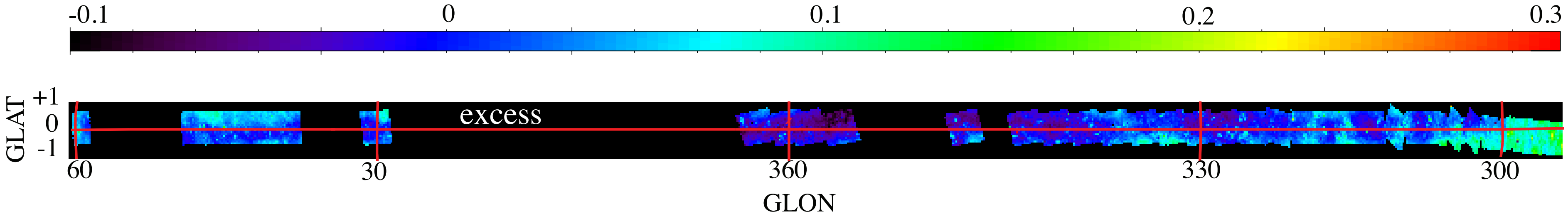
⇒Different T-β trend with respect to previous observations based on BOOMERanG, Archeops and Pronaos, probably because of different dust properties

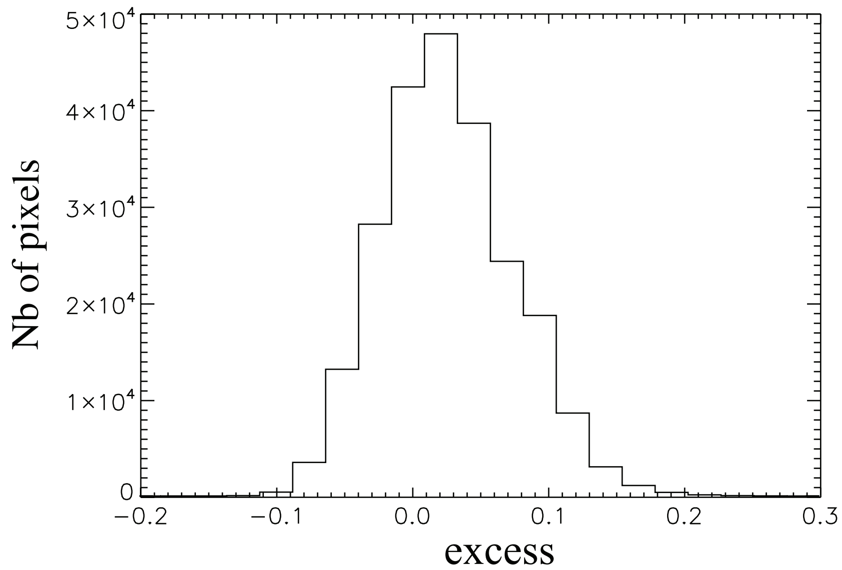
⇒ The TLS model predicts a similar T-β behavior, as opposed to a 2-component model (Finkbeiner et al., 1999)

=> The TLS model is a promising model to characterize this foreground emission

# Dust properties along the Galactic Plane (GP)

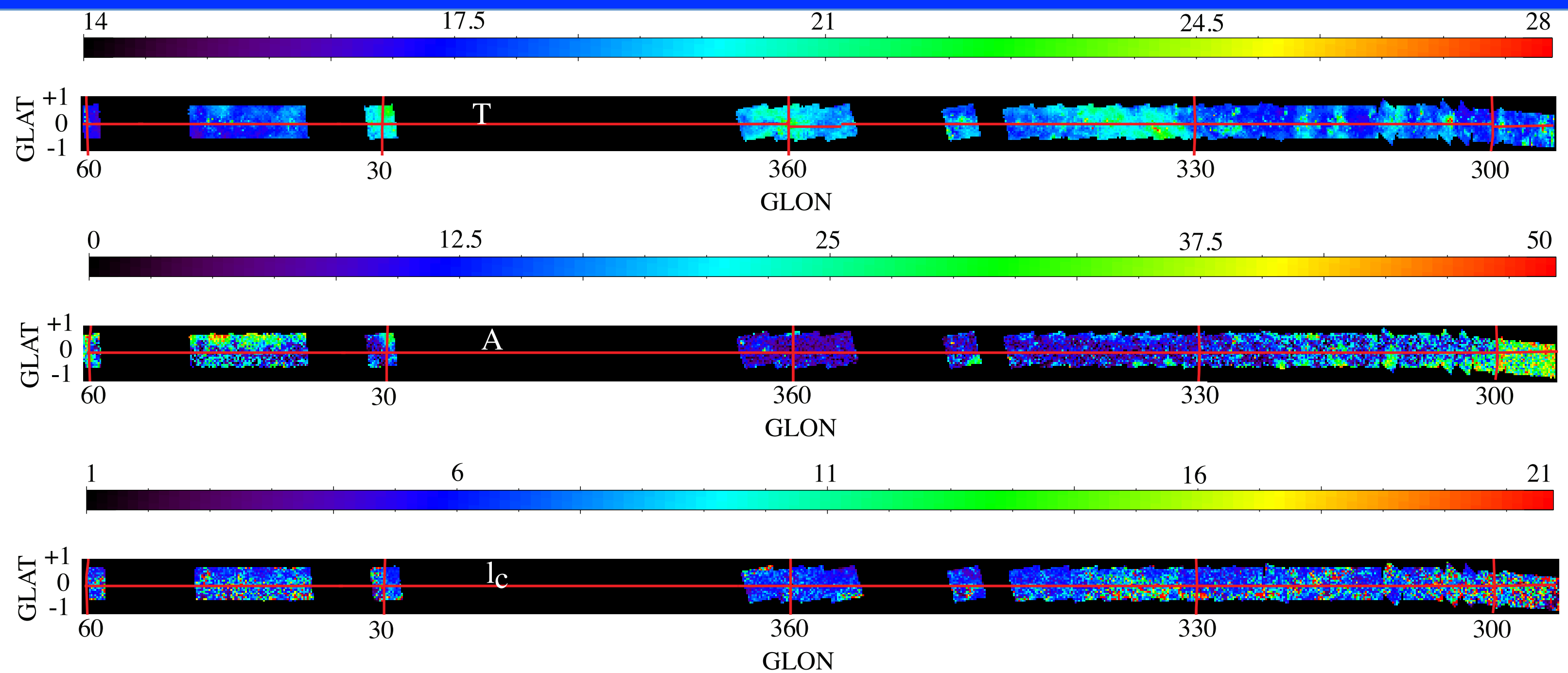
IRAS+Hershel => 4' resolution




- 500 µm emissivity excess in the outer parts of the GP, as compared to a power law in $\lambda^{-2}$, that can represent 15-20% of the emissivity
- median value of the excess along the GP : 2%
- no excess in the Galactic Center
- most likely related to the flattening of the spectra observed in the submm/mm (Reach et al., 1995; Finkbeiner et al., 1999; Paradis et al., 2009, Planck Collaboration, 2011u)

# Dust properties along the Galactic Plane (GP)




| | *Td (K)* | *lc (nm)* | *A* |
|---|---|---|---|
| All GP | 18.5±1.4 | 7.1±5.9 | 14.6±11.0 |
| External GP | 18.0±1.3 | 7.5±6.6 | 19.7±11.5 |
| Inner GP | 19.5±1.3 | 6.8±4.6 | 9.9±6.5 |
| FIRAS high lat. | 17.5±0.02 | 23.1±22.7 | 9.4±1.4 |
| Arch. CS | - | 5.1±0.1 | 3.9±0.1 |
| FIRAS & Arch | 17.3±0.02 | 13.4±1.5 | 5.8±0.1 |

- Inner parts warmer than outer parts
- Increase of *A* from the inner to the outer GP
  => changes in dust properties
- *lc* ≈ constant along the GP

- *A* larger in the GP compared to high latitudes and CS
  => grains in the GP could be characterized by a degree of amorphization more important in the GP, and the degree or amorphization increases in outer parts.

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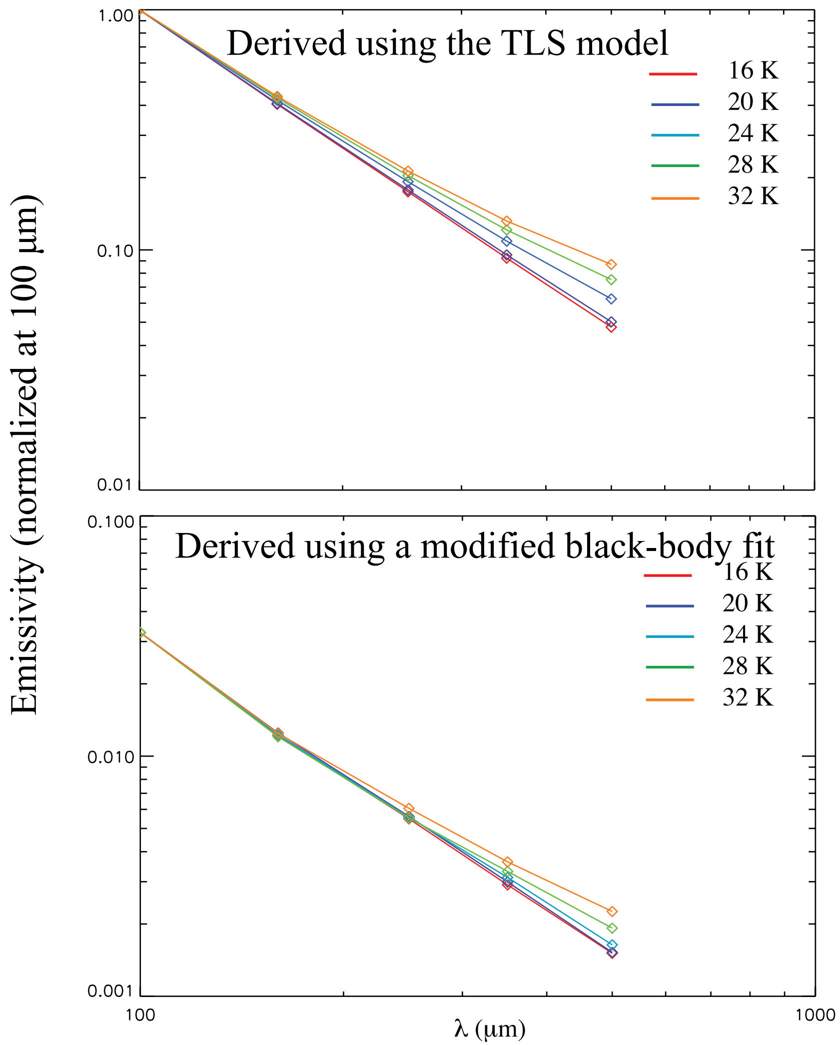

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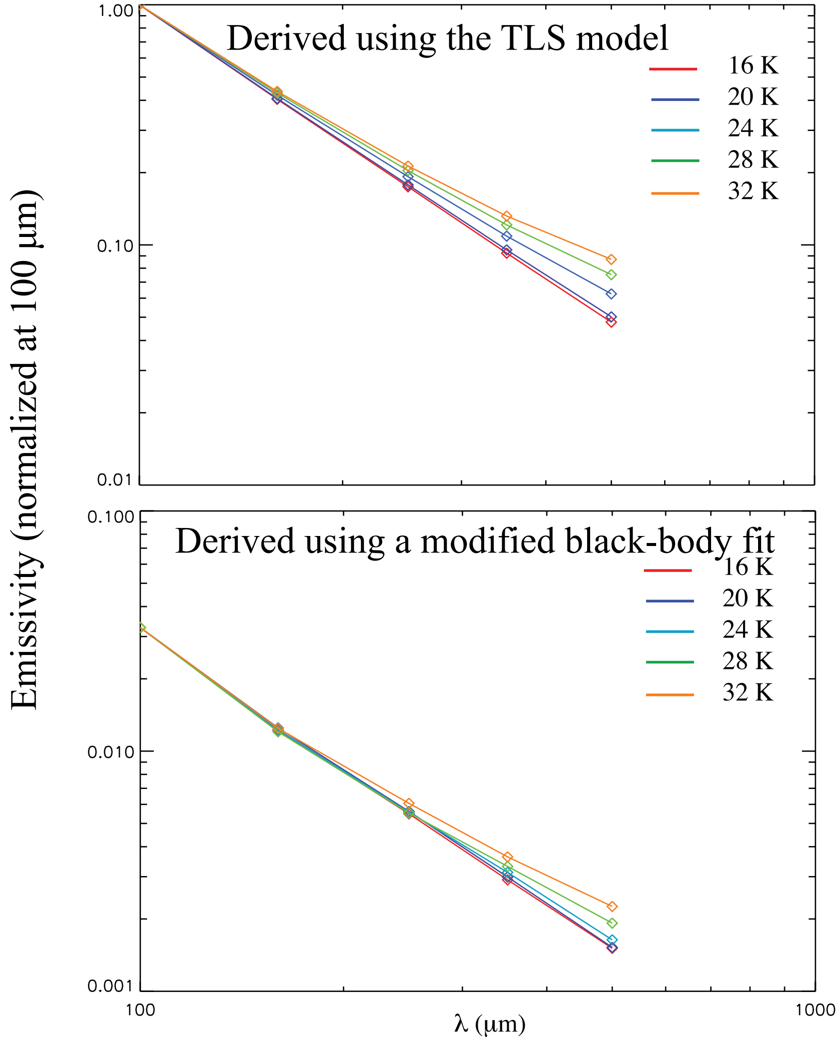
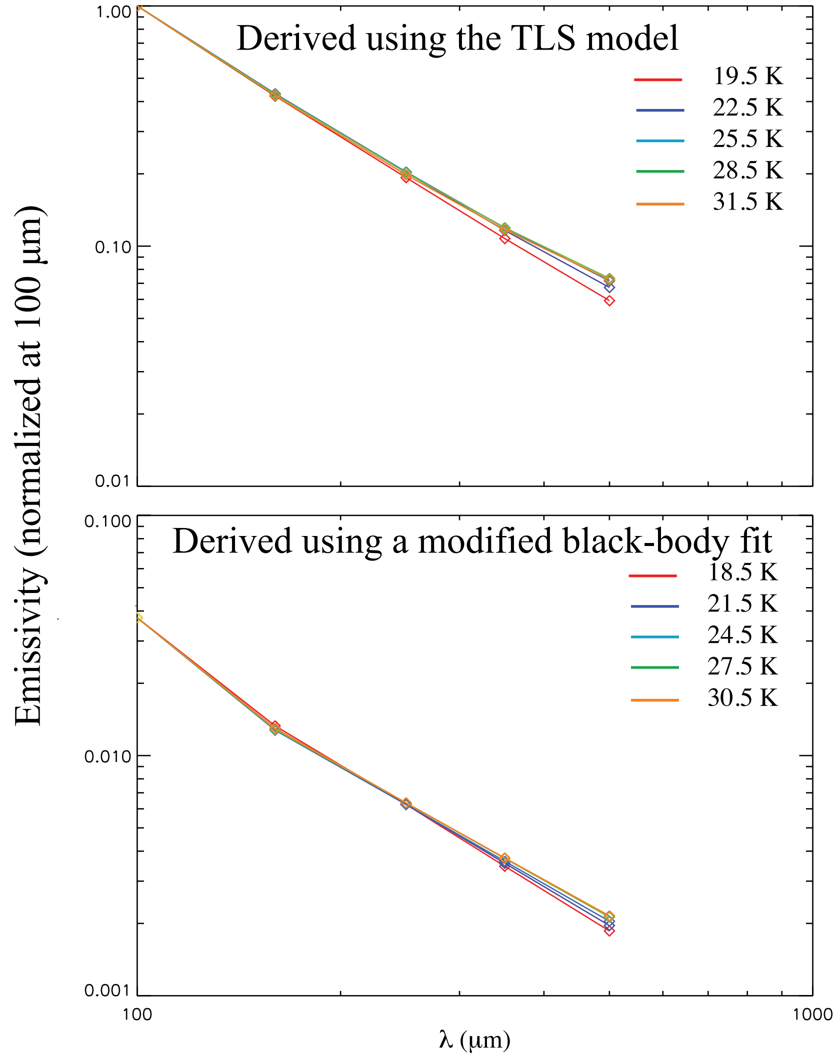



[T-mixing along the LOS (following Dale et al., 2001)]



# Conclusions

✓Understanding emission of the BG dust component and especially its variation with λ and T is an important aspect of component separation.

✓Comparison between the TLS model and astrophysical/laboratory data allow us now to deduce informations on the amorphous state of the grain itself

✓ Extrapolating emissivity spectrum from the submm/mm to the FIR with $\beta=2$ and without any dependency with T can induce important errors on the emissivity and therefore on mass estimates

✓ Dust properties seem to vary with environment : diffuse / dense medium, high latitudes / along the Galactic Plane, in the inner parts / outer parts of the GP …