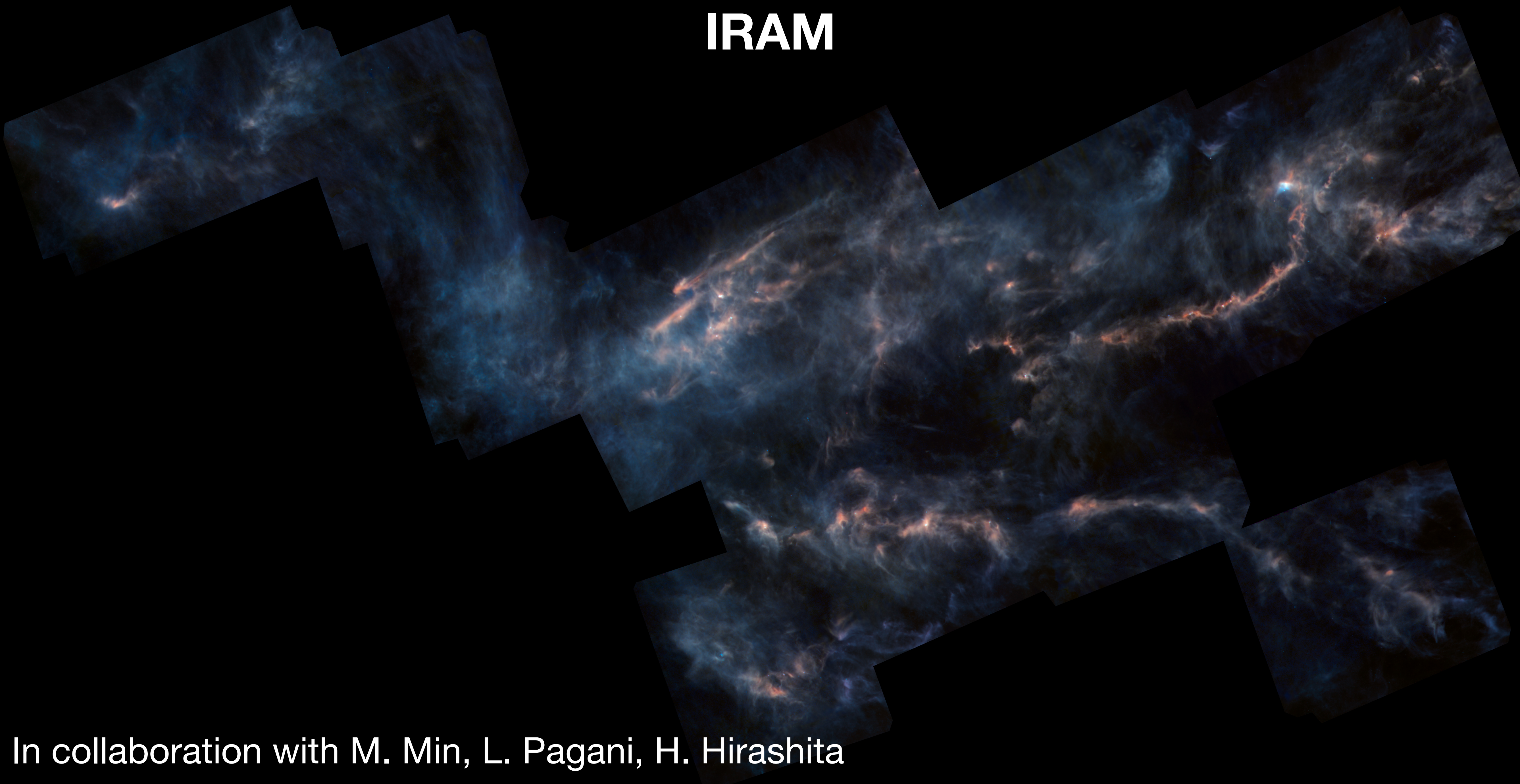
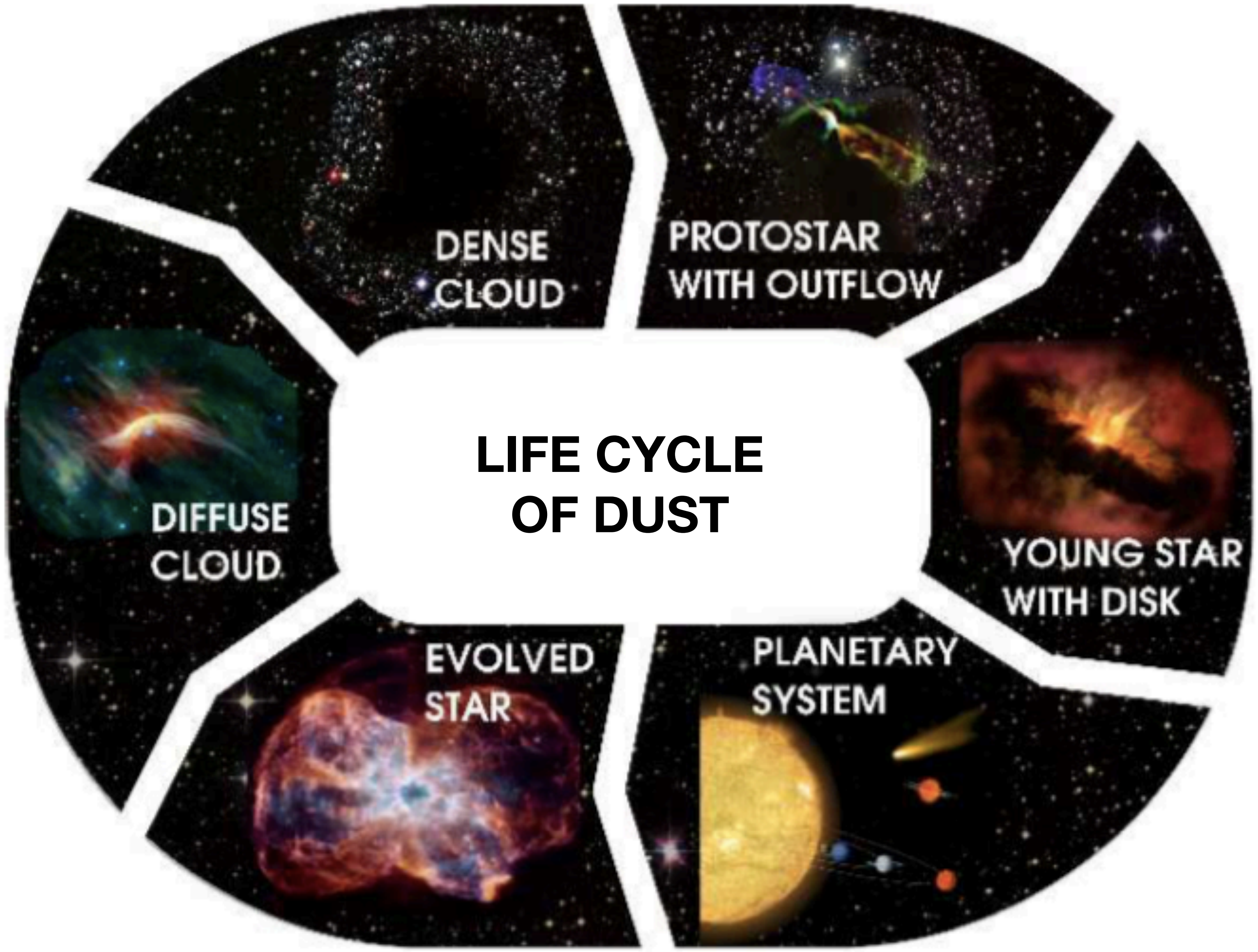
# Dust evolution from prestellar cores

- Charlène Lefèvre -
IRAM

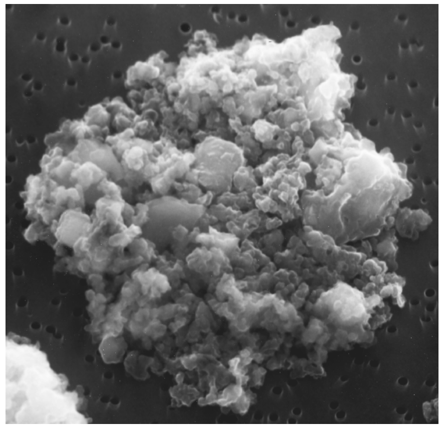


In collaboration with M. Min, L. Pagani, H. Hirashita

# Motivations to study dust in molecular clouds




Credit : M. Persson, ESO/NASA/ESA,ALMA



Grain growth by coagulation well before the formation of future planets

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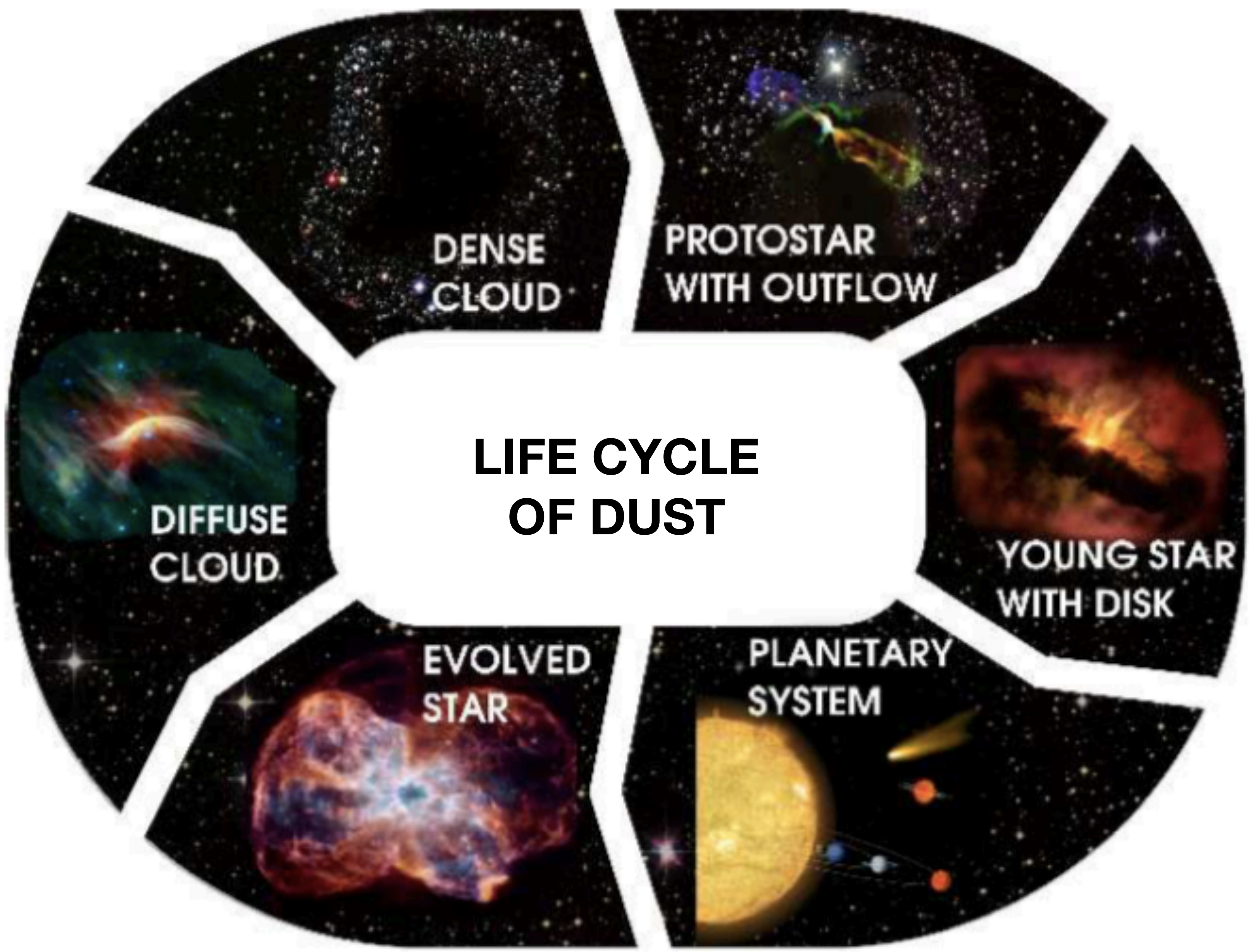


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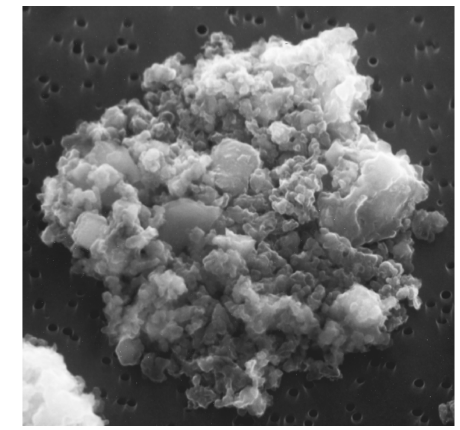
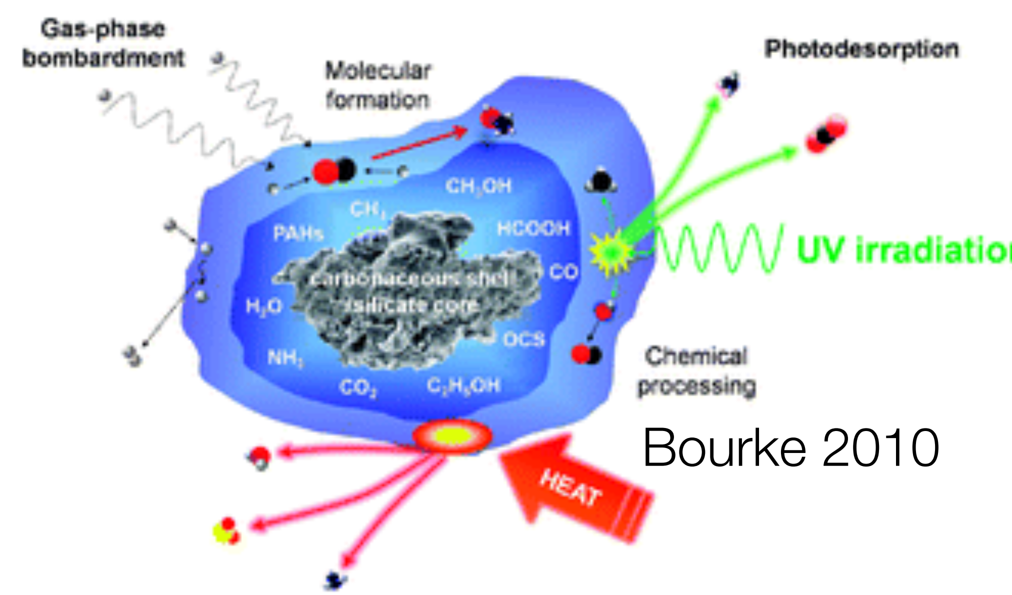


Grain growth by coagulation well before the formation of future planets




Bourke 2010

Molecule formation on top of dust grains = Icy Mantles

# Motivations to study dust in molecular clouds

- **Dust is an indirect tracer of mass**

  pre-stellar cores and disks

- **Mass deduced from mm observations if optically thin :**

$$M_{disk} \propto \frac{\text{Flux}}{\kappa_{abs}(\nu)\,B(\nu, T_{disk})}$$

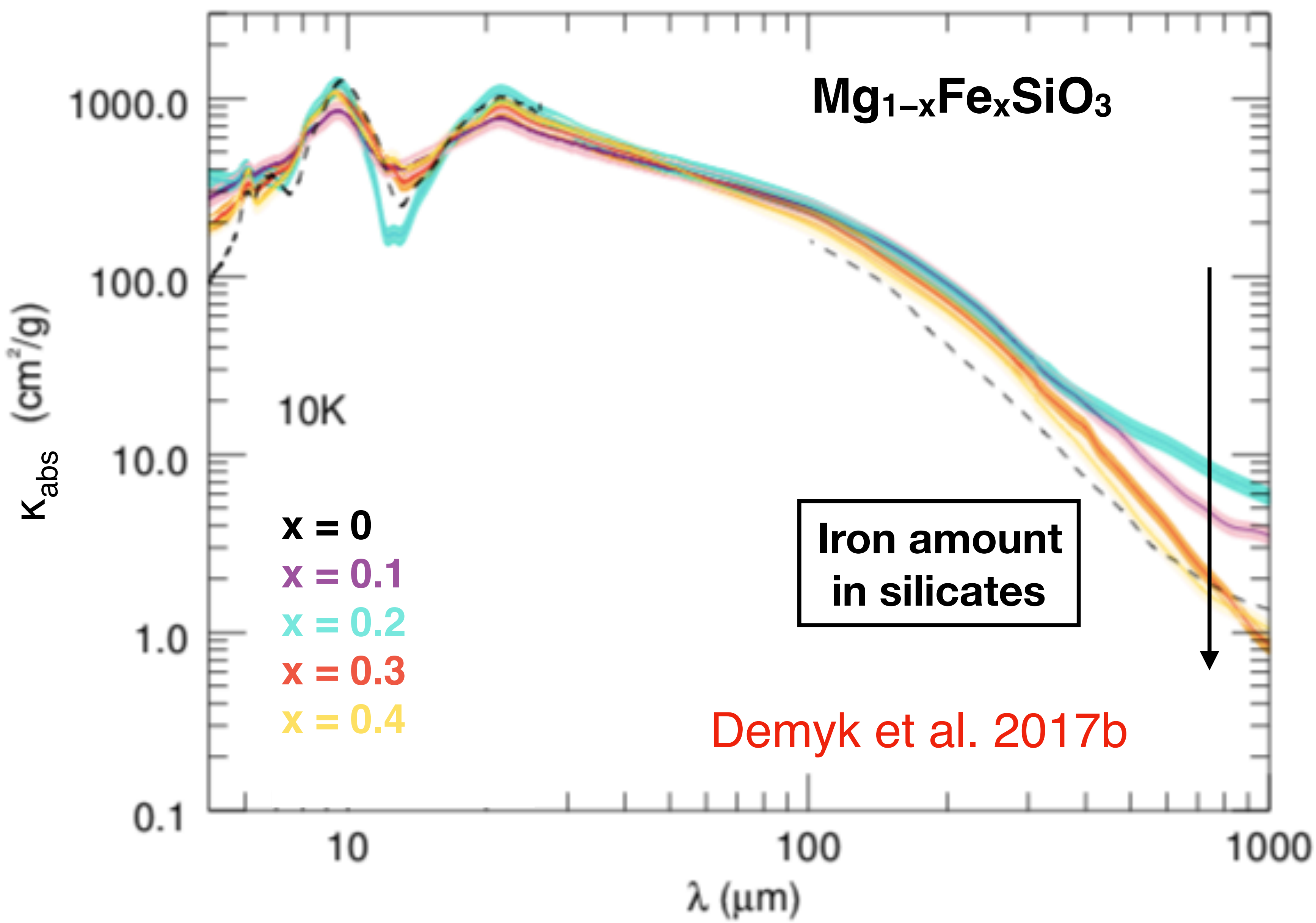
- **Dust emissivity is poorly constrained apart for diffuse ISM :**

  Dust composition

  Dust shape

  Dust size distributions

# Composition: a factor of 10 on emissivity !




**Laboratory measurements (IRAP, Toulouse)**

- Amorphous silicates analogs
- For iron rich silicates the emissivity is decreasing by a factor of 10 at 1 mm (NOEMA/ALMA/**NIKA2**) !
- Dust models based on a fixed composition are too limited.

# Open access code to compute dust properties SIGMA (Lefèvre, Min, et al. subm. 2019)

**https://github.com/charlenelefevre/SIGMA ( DOI 10.5281/zenodo.2573886)**

**Simple Icy Grain Model for Aggregates**

Suitable dust model for :

- Prestellar cores to protoplanetary disks
- Debris disks

Goal is to be able to reproduce models from literature and to be able to deviate from them

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Outputs:

- **dust absorption efficiency ($\kappa_{abs}$)**
- **dust scattering efficiency ($\kappa_{sca}$)**
- **Integrated opacities (hydro simulations)**
- **Scattering phase function (F11)**
- **Polarisation**

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**output of SIGMA**

$$\begin{bmatrix} I_{S,sca} \\ Q_{S,sca} \\ U_{S,sca} \\ V_{S,sca} \end{bmatrix} = \frac{\lambda^2}{4\pi^2 D^2} \begin{bmatrix} F_{11} & F_{12} & 0 & 0 \\ F_{12} & F_{22} & 0 & 0 \\ 0 & 0 & F_{33} & F_{34} \\ 0 & 0 & -F_{34} & F_{44} \end{bmatrix} \times \begin{bmatrix} I_{S,inc} \\ Q_{S,inc} \\ U_{S,inc} \\ V_{S,inc} \end{bmatrix}$$

**Scattered Stokes Vector** **MUELLER MATRIX** **Incident Stokes Vector**

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**SIGMA Originality :**

**Approximate method to reproduce exact computation =** short computation time

Split between dust geometry (shape, sizes) and dust composition

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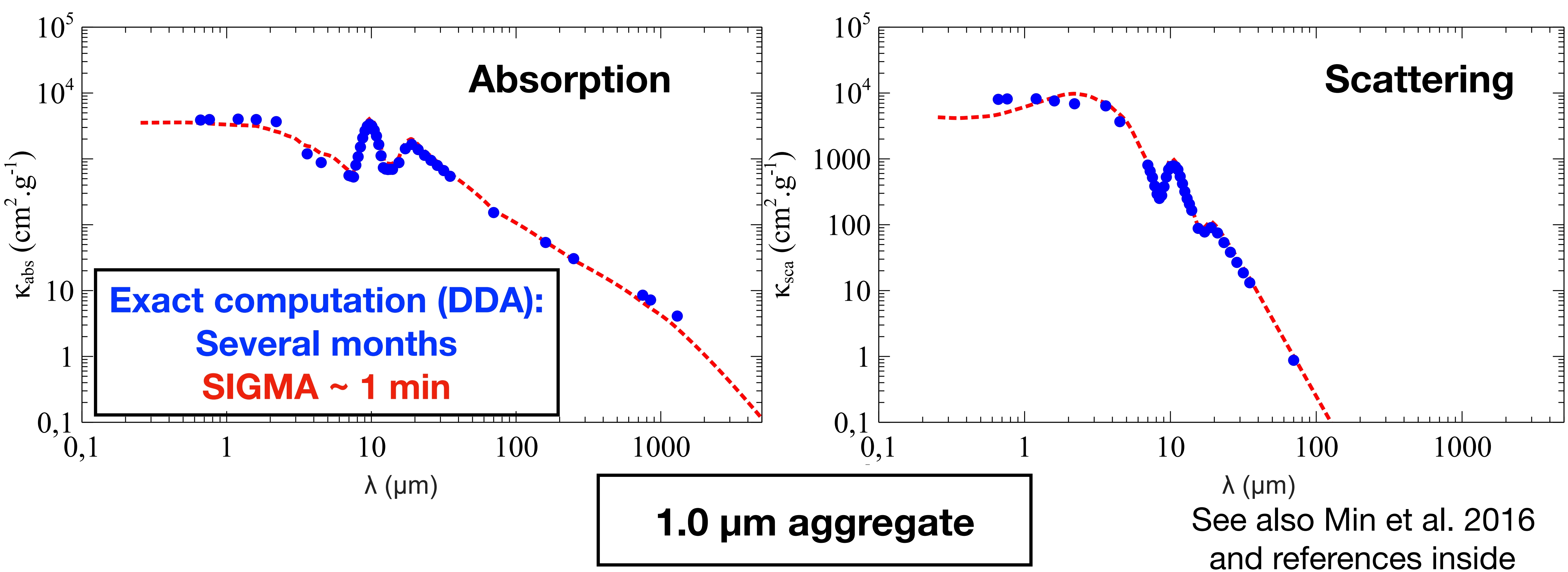


See also Min et al. 2016 and references inside

Effective Medium Theory (**EMT**) and Distribution of Hollow spheres (**DHS**)

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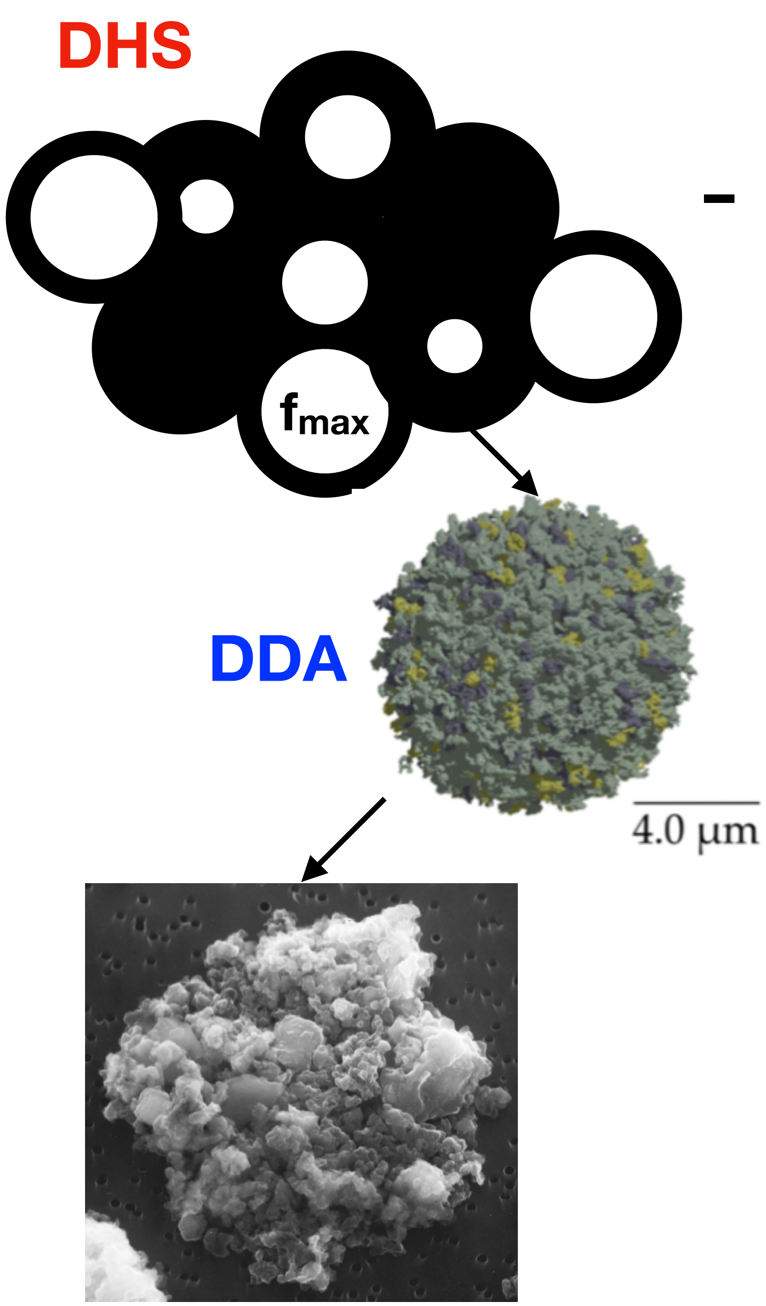


Interplanetary dust

**Free parameters :**

- **Shape :** Aggregate (Distribution of Hollow Spheres DHS)

  Computation trick to mimic departure from spherical shape

  **Method: Min et al. (2003, 2005)**

  **Review of methods: Tazaki et al. 2018**

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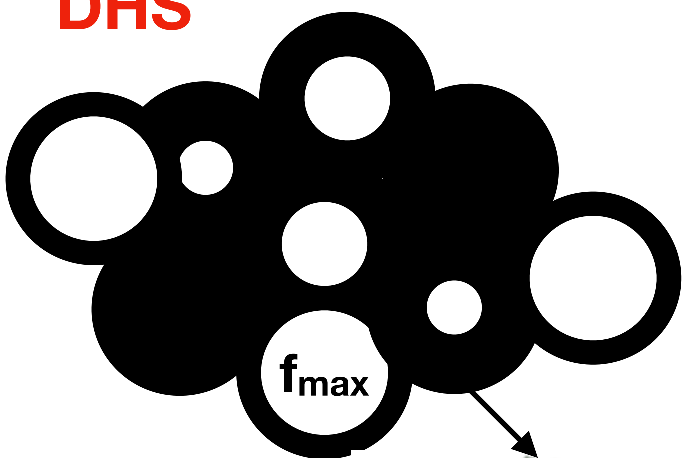
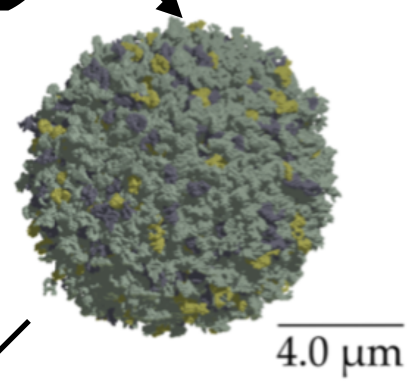
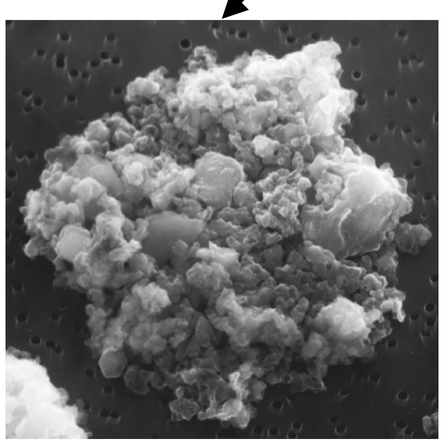
DHS




DDA



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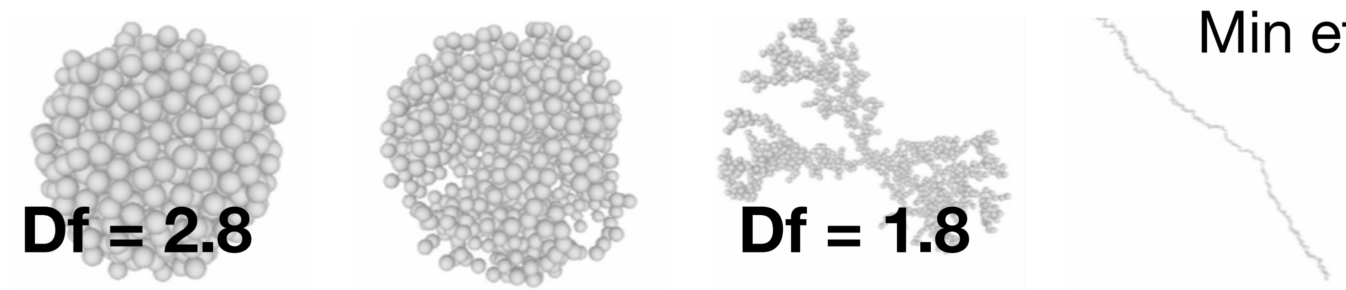
**Grown grains are not spheres, ellipsoids or made of a limited number of subgrains !**



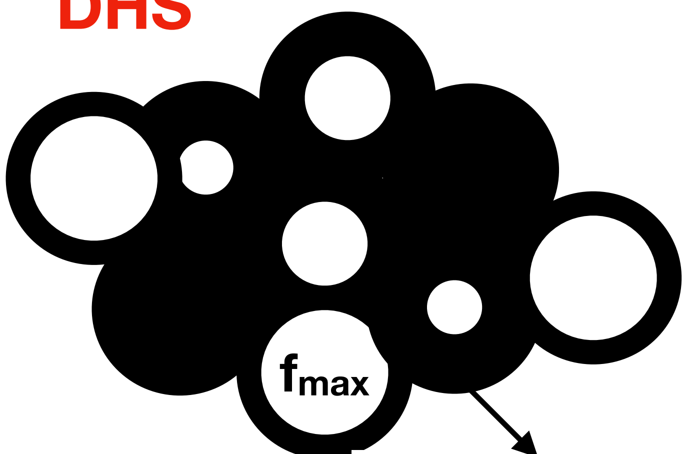

Min et al. 2006

- **DHS** well suited for **compact aggregates** (fractal degree Df ~ 3)
- More elongated grains (Df ~ 1.8) will be implemented in SIGMA in the future (MMF Tazaki et al. 2018)

**The code is thought to evolve and include different methods !**

# Open access code to compute dust properties SIGMA (Lefèvre, Min, et al. subm. 2019)

DHS

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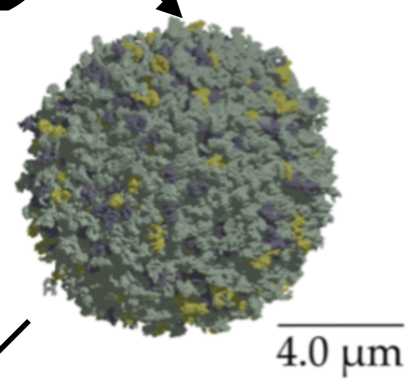


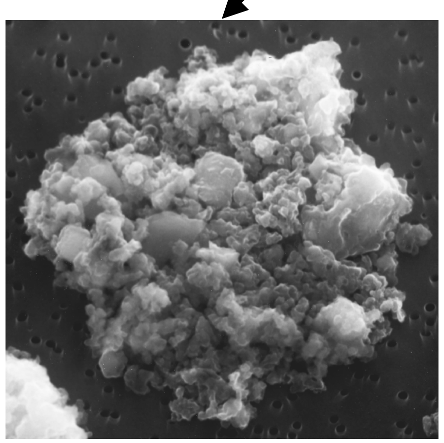

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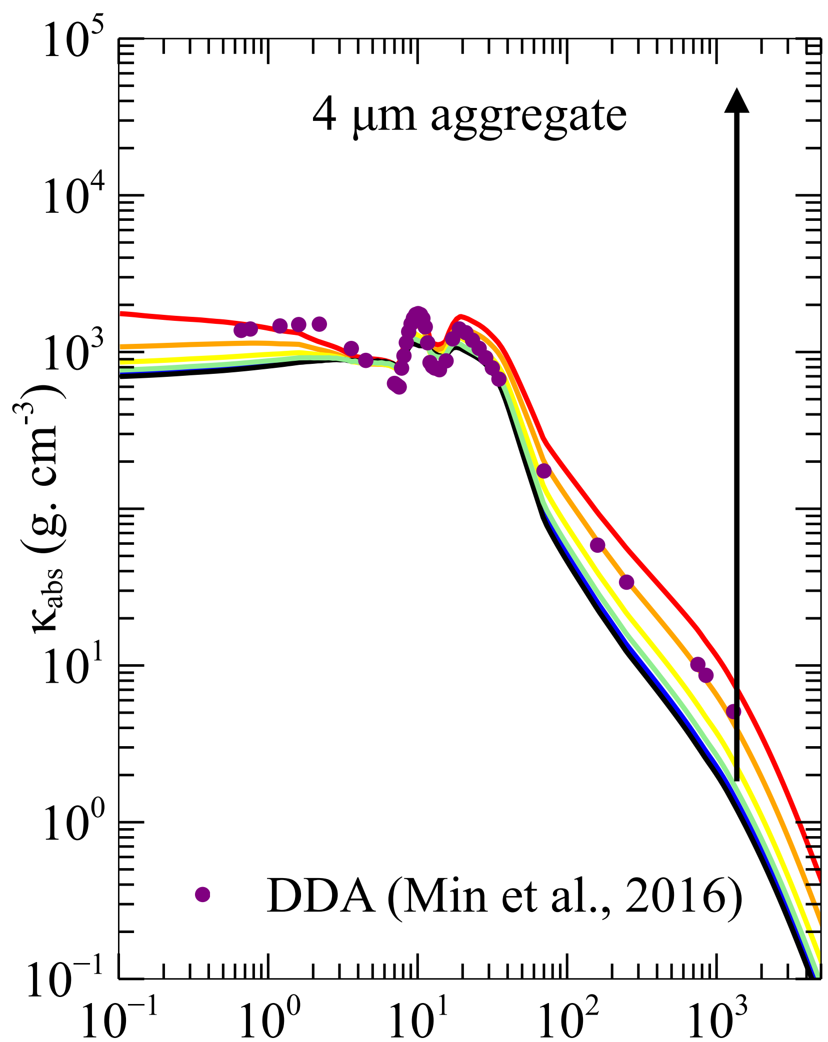


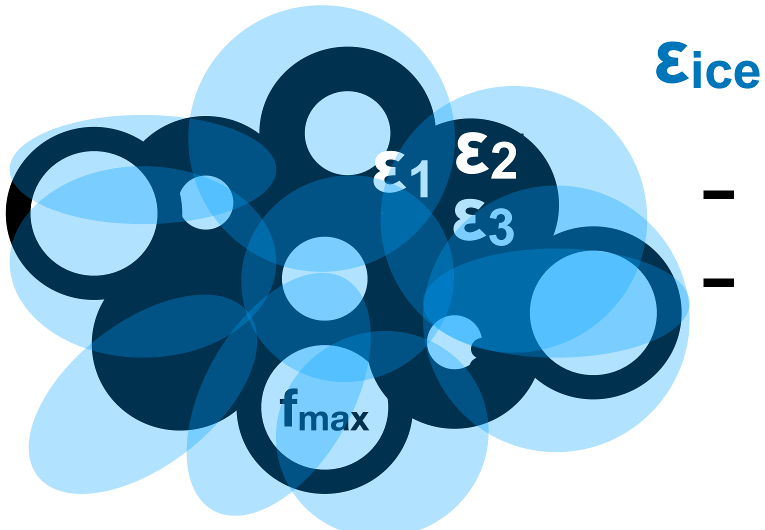

**Lefèvre et al. subm (2019)**

**Deviation from spherical shape**

Emissivity also **increases by a factor 2 to 10** with irregular shapes

+ big impact on scattering

# Open access code to compute dust properties SIGMA (Lefèvre, Min, et al. subm. 2019)



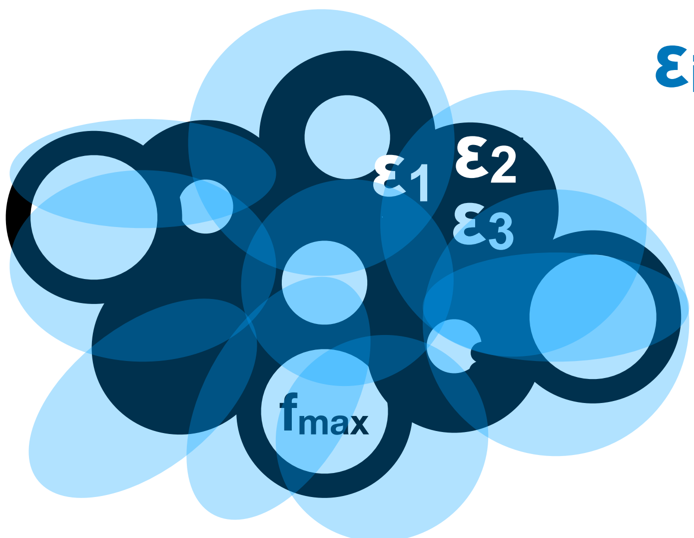

**DHS + EMT**

**Free parameters :**

- **Shape :** Aggregate (Distribution of Hollow Spheres DHS)
- **Composition :** from laboratory measurements mixture + porosity + ice mantles

SIGMA takes **tabulated complex refractive indexes** from any laboratory database (m = n-ik)

# Open access code to compute dust properties SIGMA (Lefèvre, Min, et al. subm. 2019)

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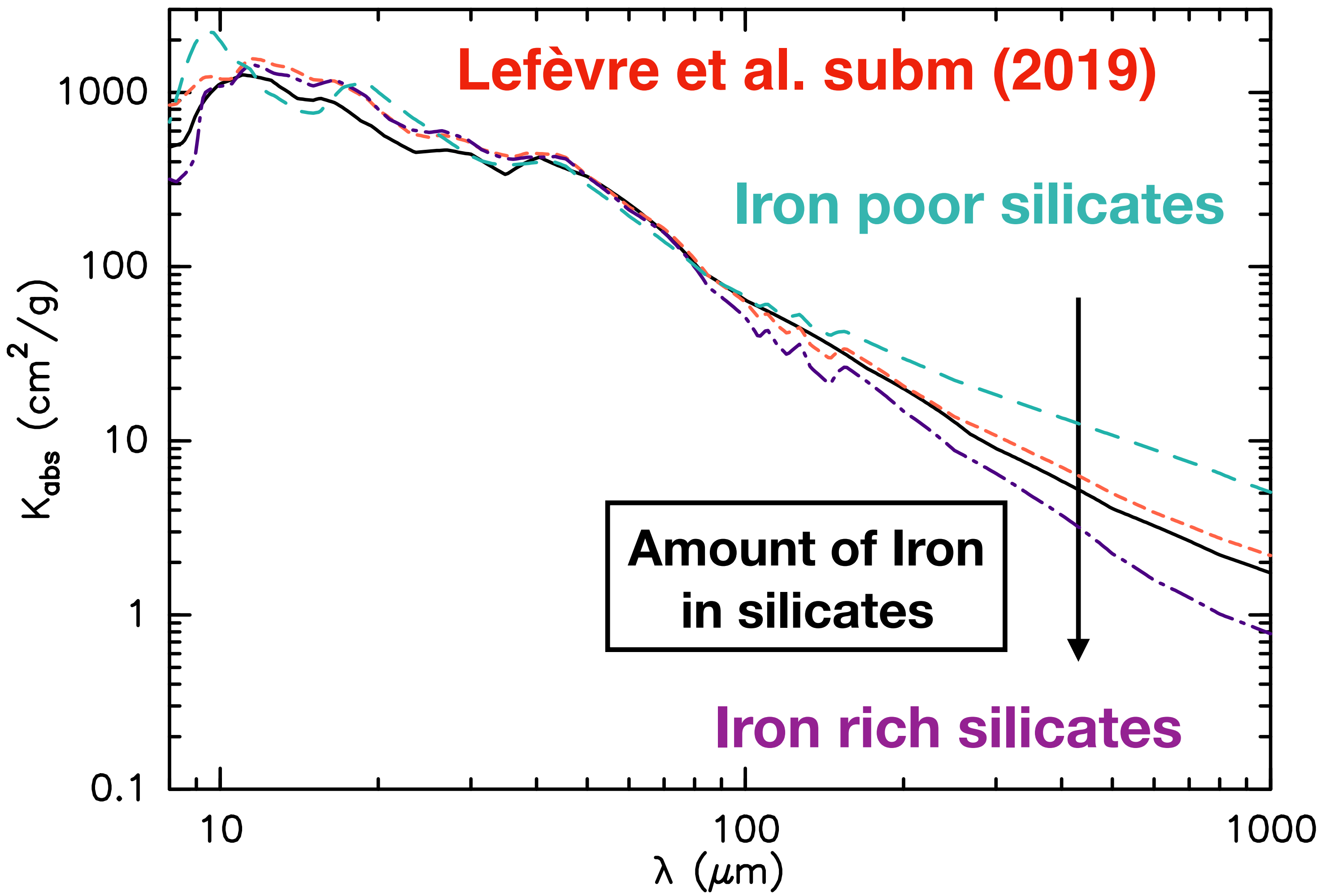
**Computation done with SIGMA:**

Behavior of laboratory measurements is reproduced by SIGMA thanks to flexibility in terms of composition



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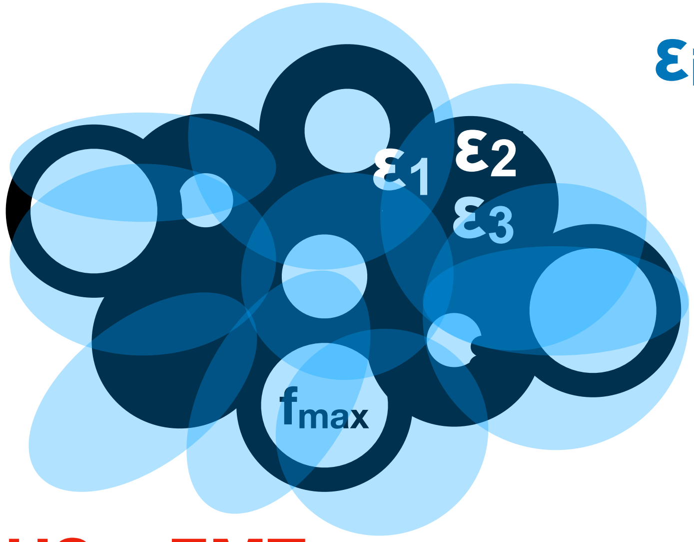


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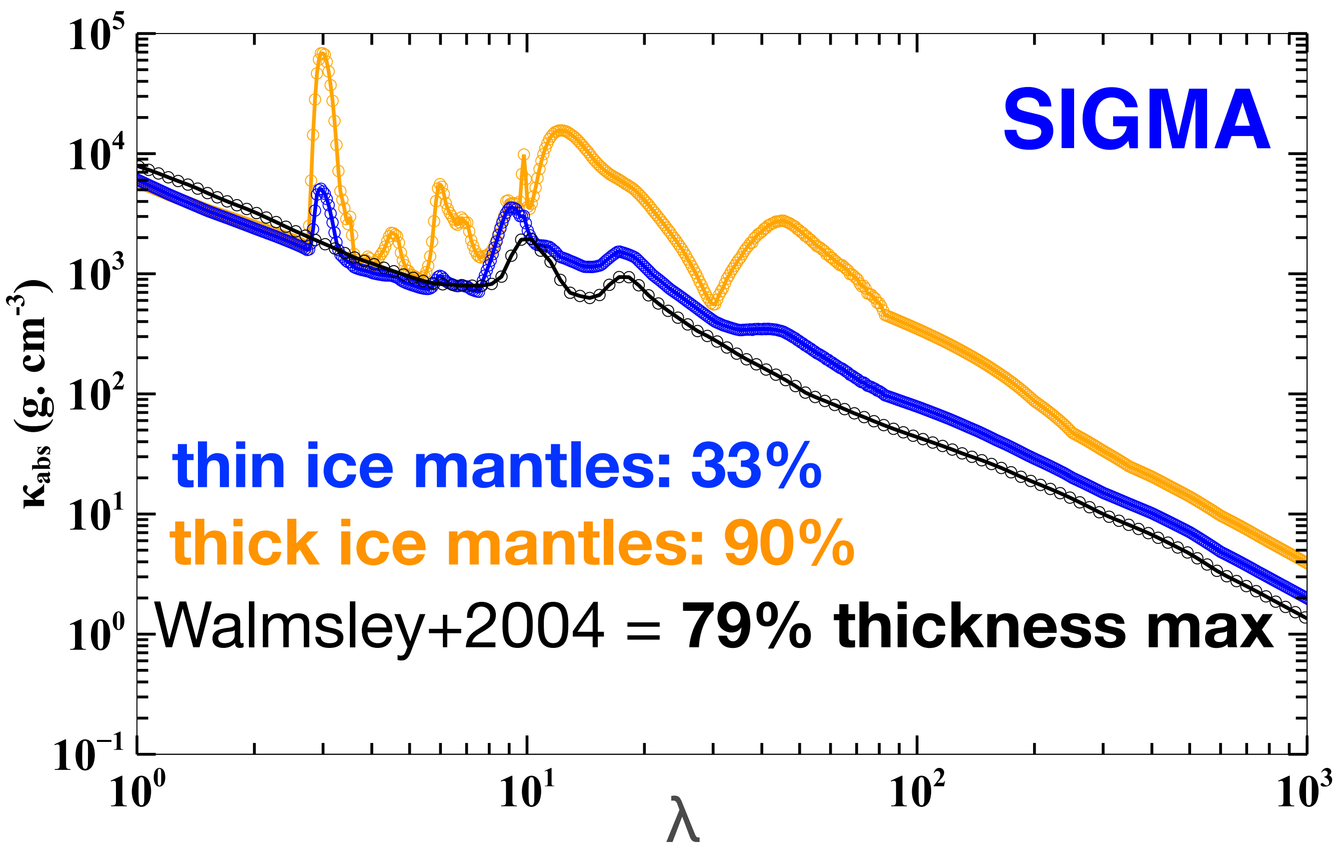


Spherical dust comparable to Ossenkopf (1994)

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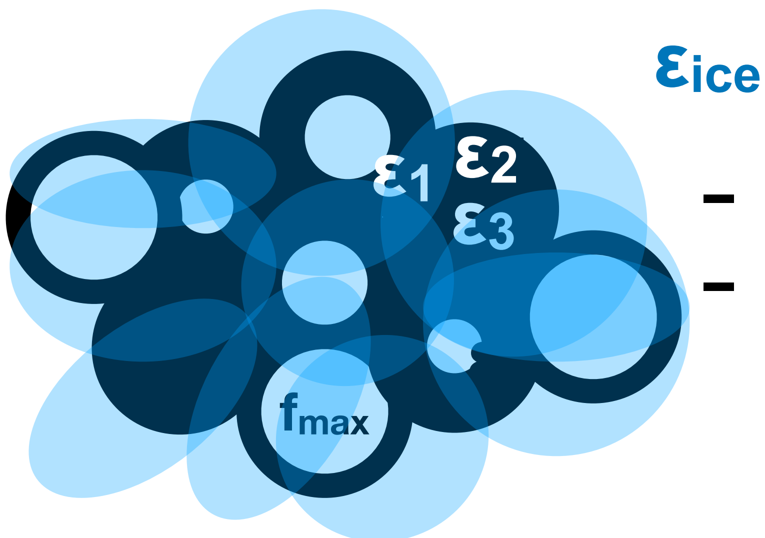


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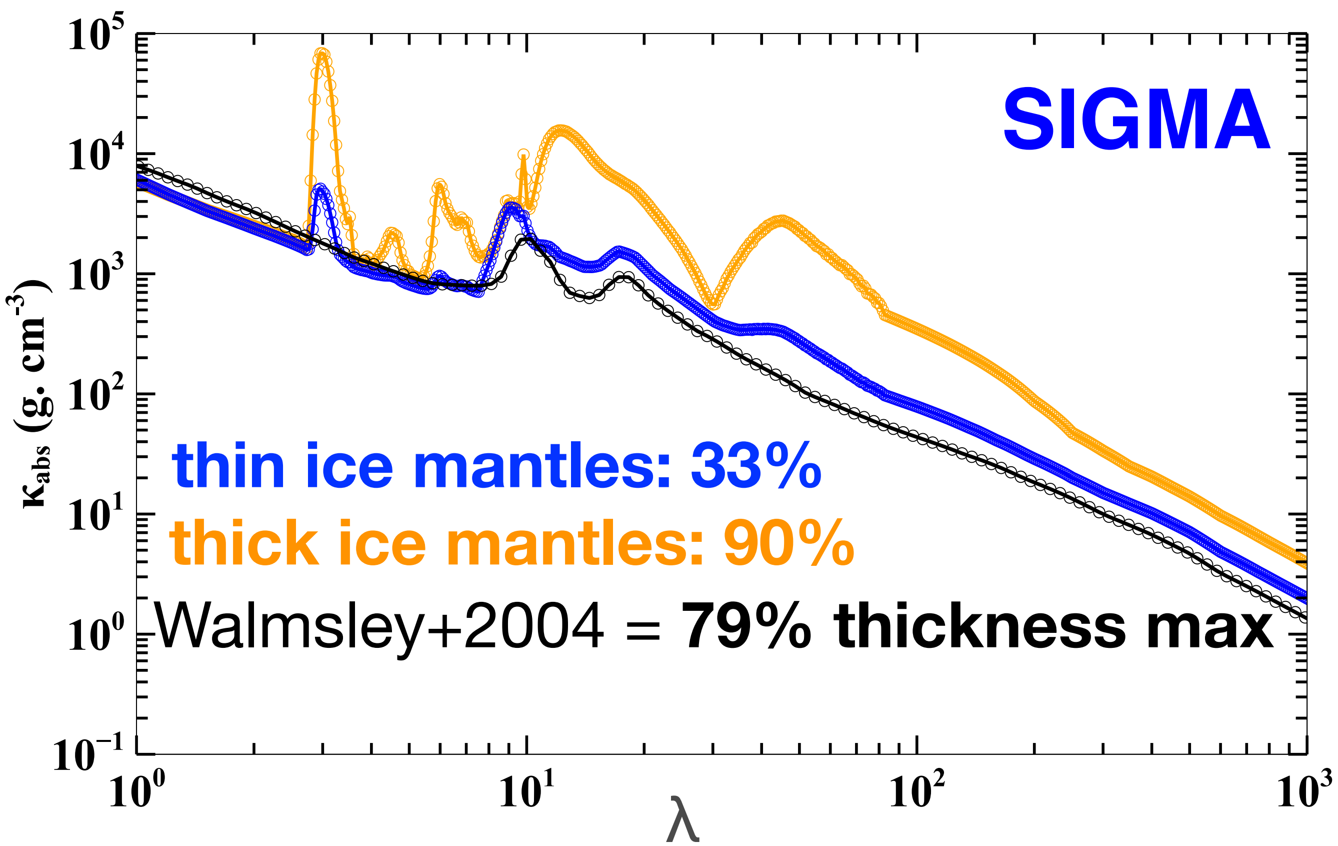


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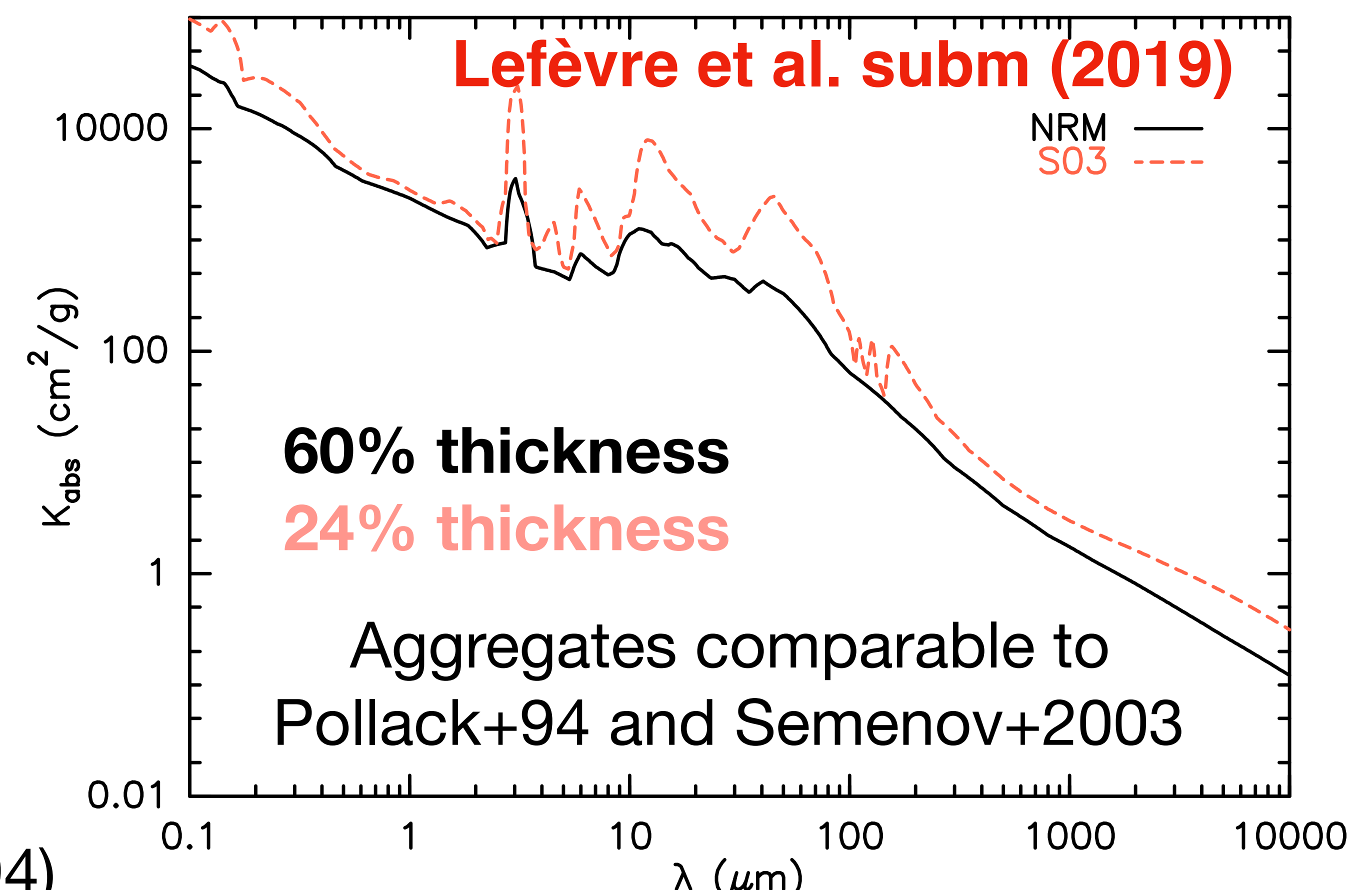

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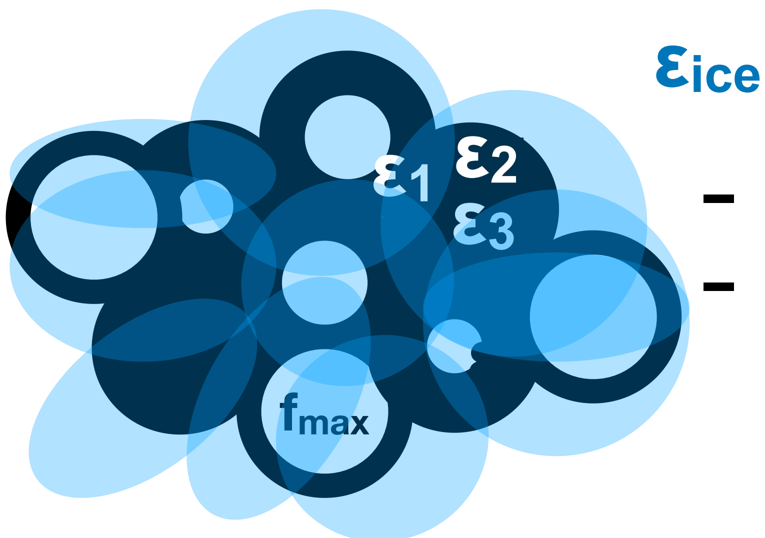


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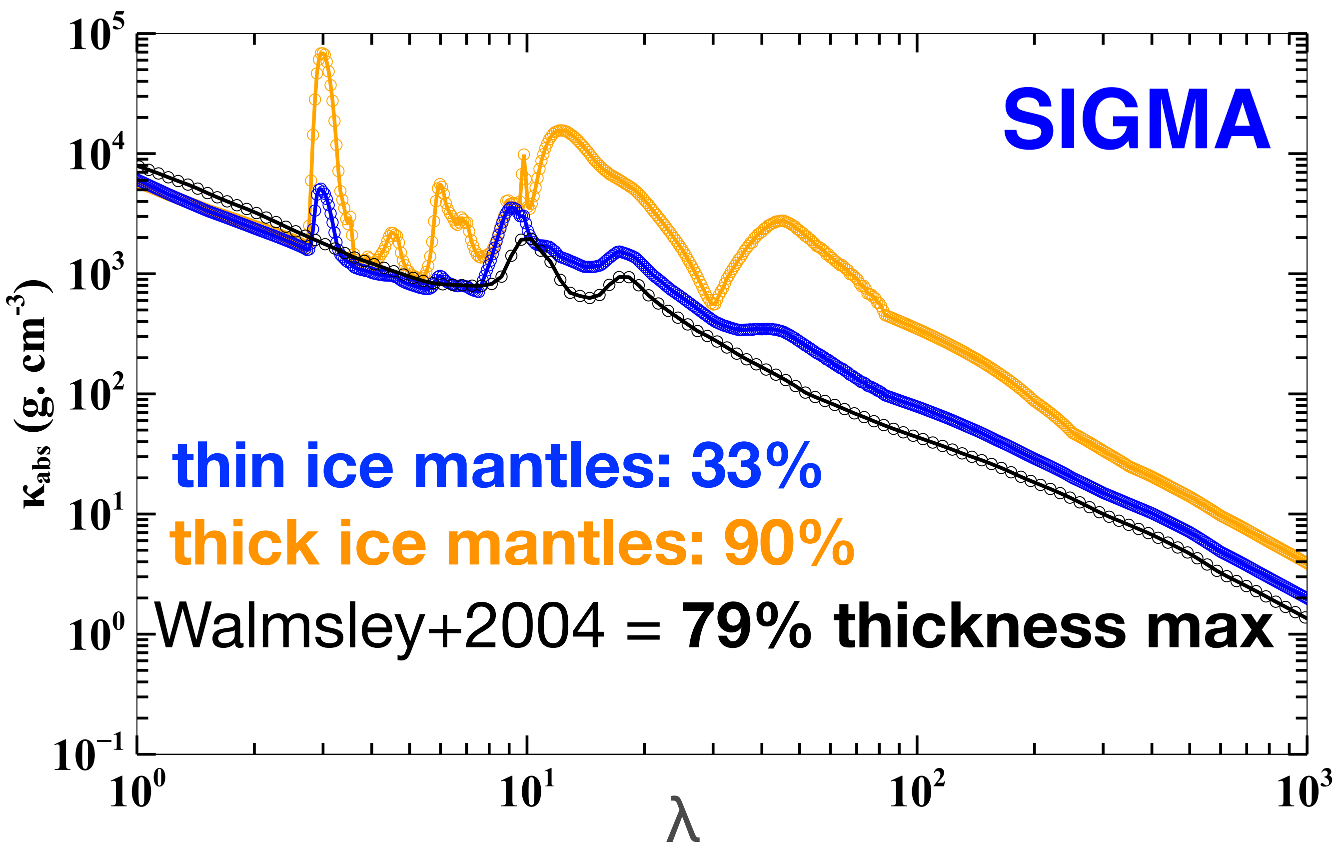


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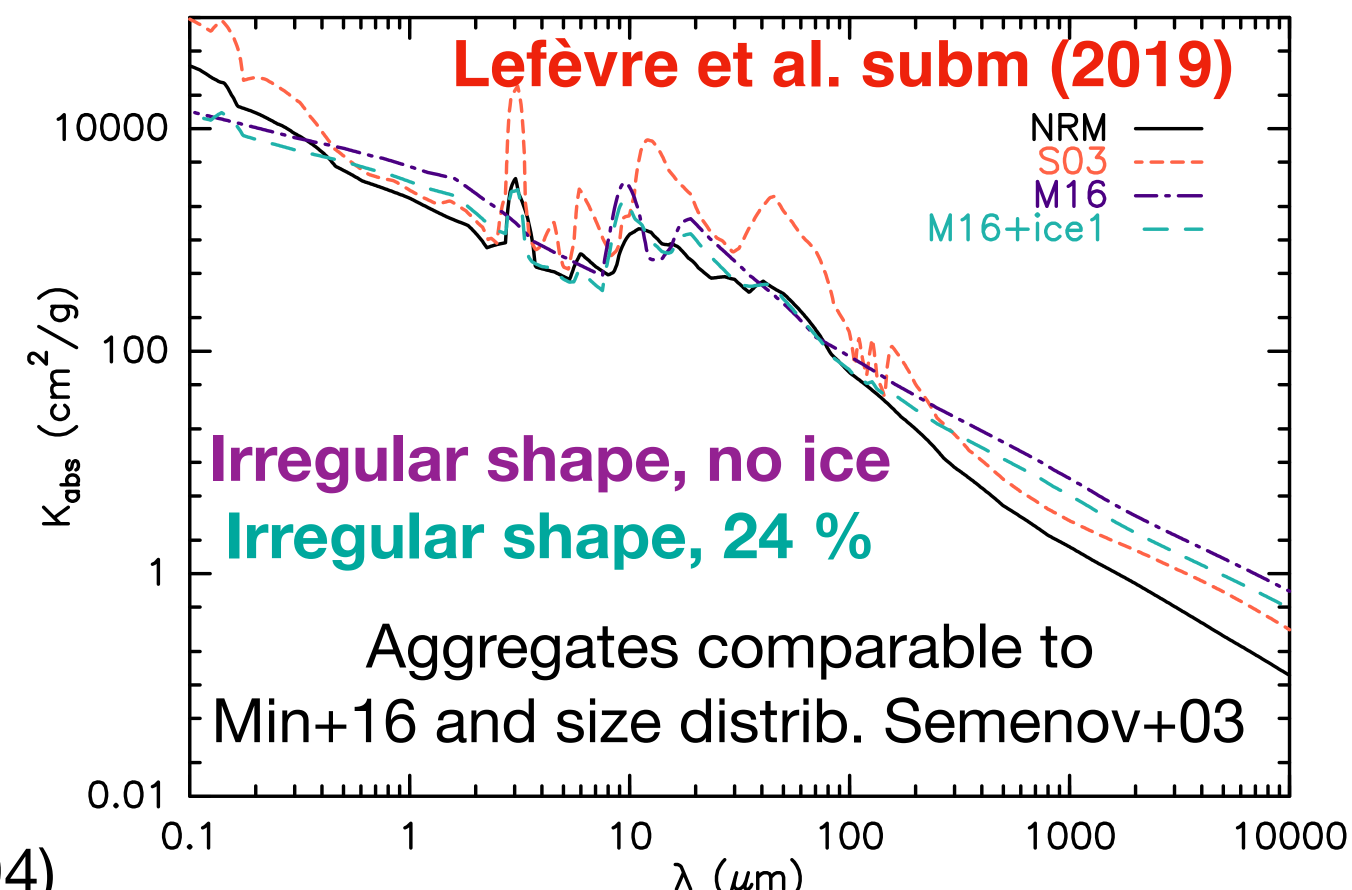


Aggregates comparable to Min+16 and size distrib. Semenov+03

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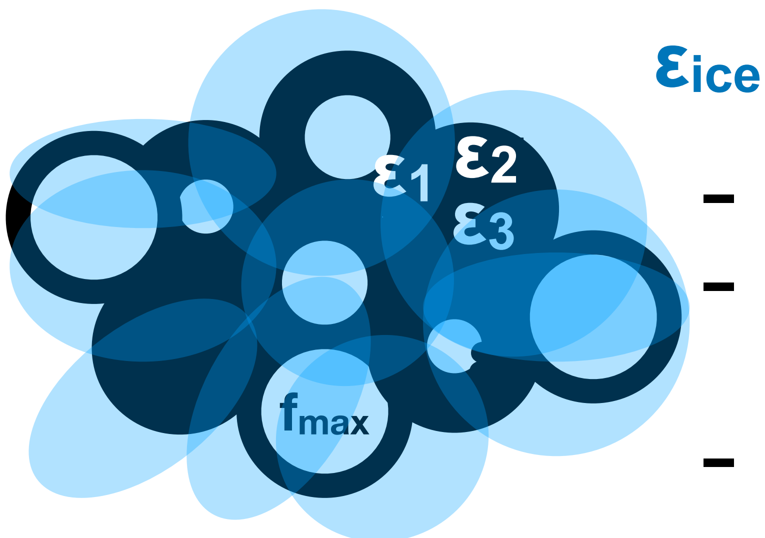


**Free parameters :**

- **Shape :** Aggregate (Distribution of Hollow Spheres DHS)
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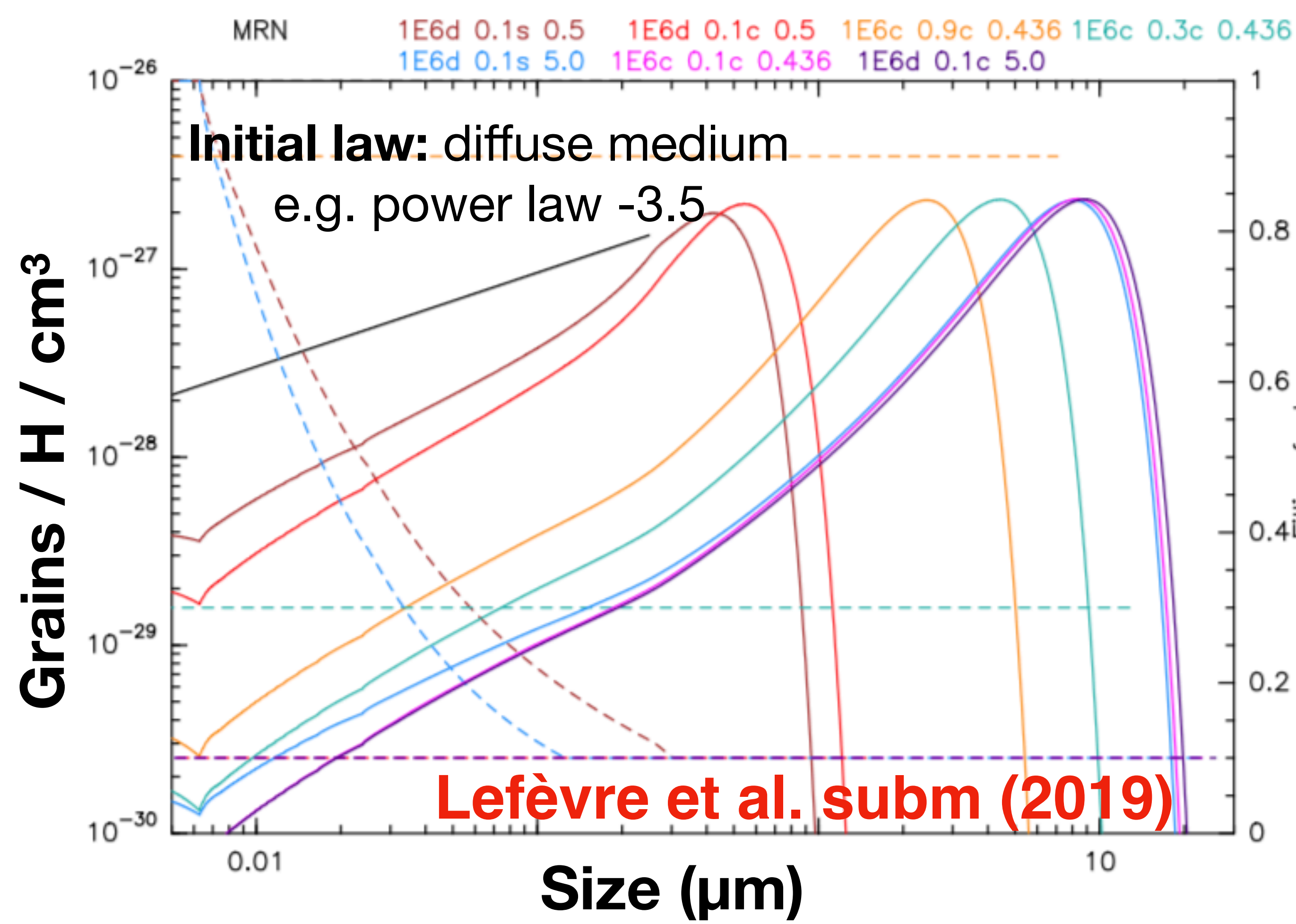
- **Size distribution :** Any kind e.g. power law (collisional cascades) or output of dynamical coagulation

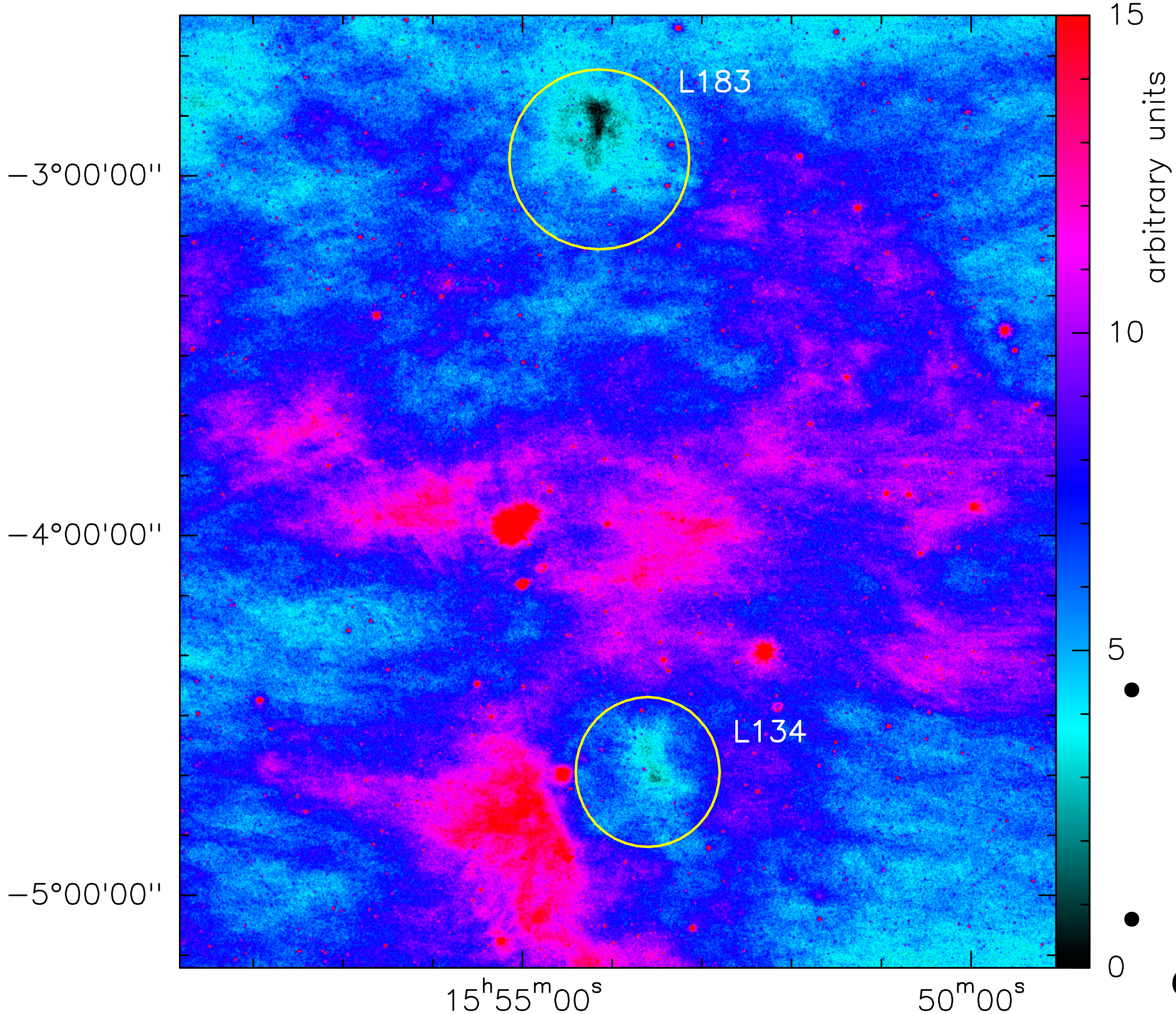
**Dynamical coagulation**
**= evolution of dust size distribution :**

- turbulence (temperature, density)
- relative velocity between grains
- variable porosity as a function of size

**with H. Hirashita**



# What candidates to investigate dust evolution with NIKA2 ?



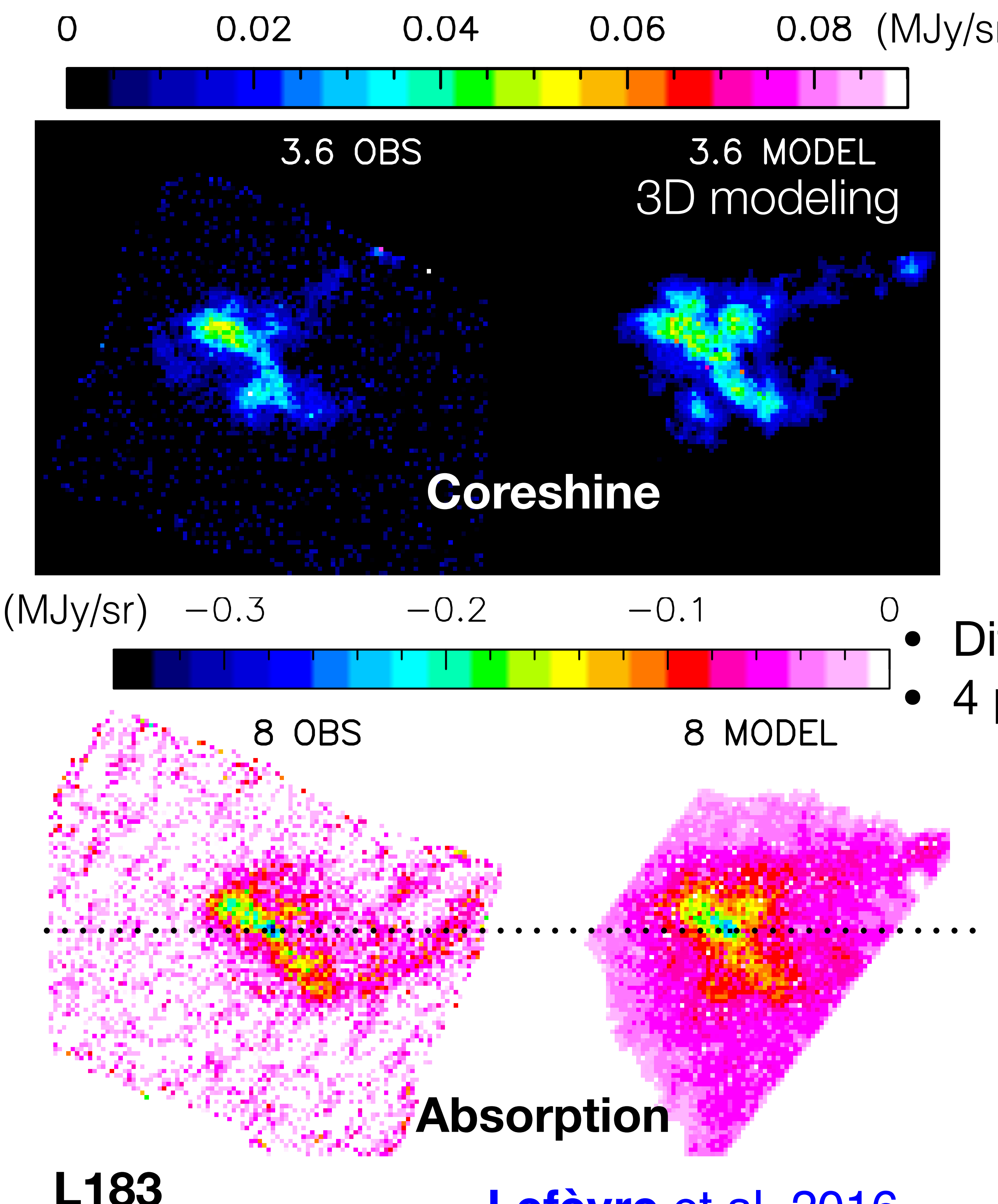

**Joint Spitzer - NIKA 2 observations (open time)**

**Spitzer observations to probe cores with large grains**
(Pagani et al. 2010, Lefèvre et al. 2014)

**2 starless molecular clouds**
**Tdust < 30 K**

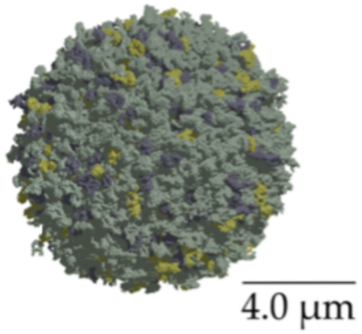
- Spitzer: constraints about dust grain shapes, sizes
- NIKA 2 dust emissivity : composition, shapes, temperature

# Dust evolution in prestellar cores from MIR scattering




**Lefèvre** et al. 2016

**Large Aggregates mandatory to reproduce MIR observations**



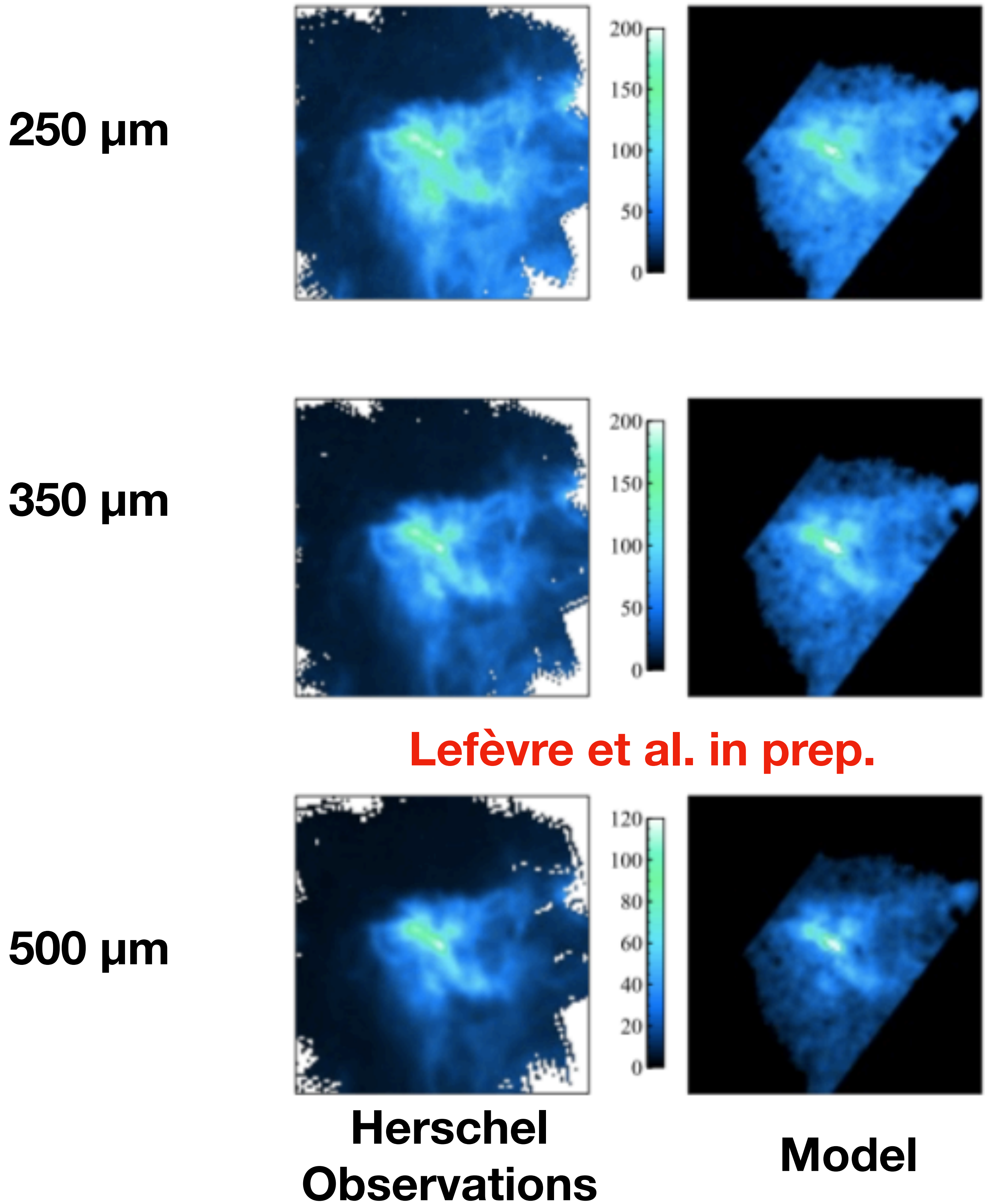

**Mixture made with 2 components from edge to core :**

- Diffuse medium grain (Weingartner & Draine 2001)
- 4 μm aggregates (Min et al. 2016)

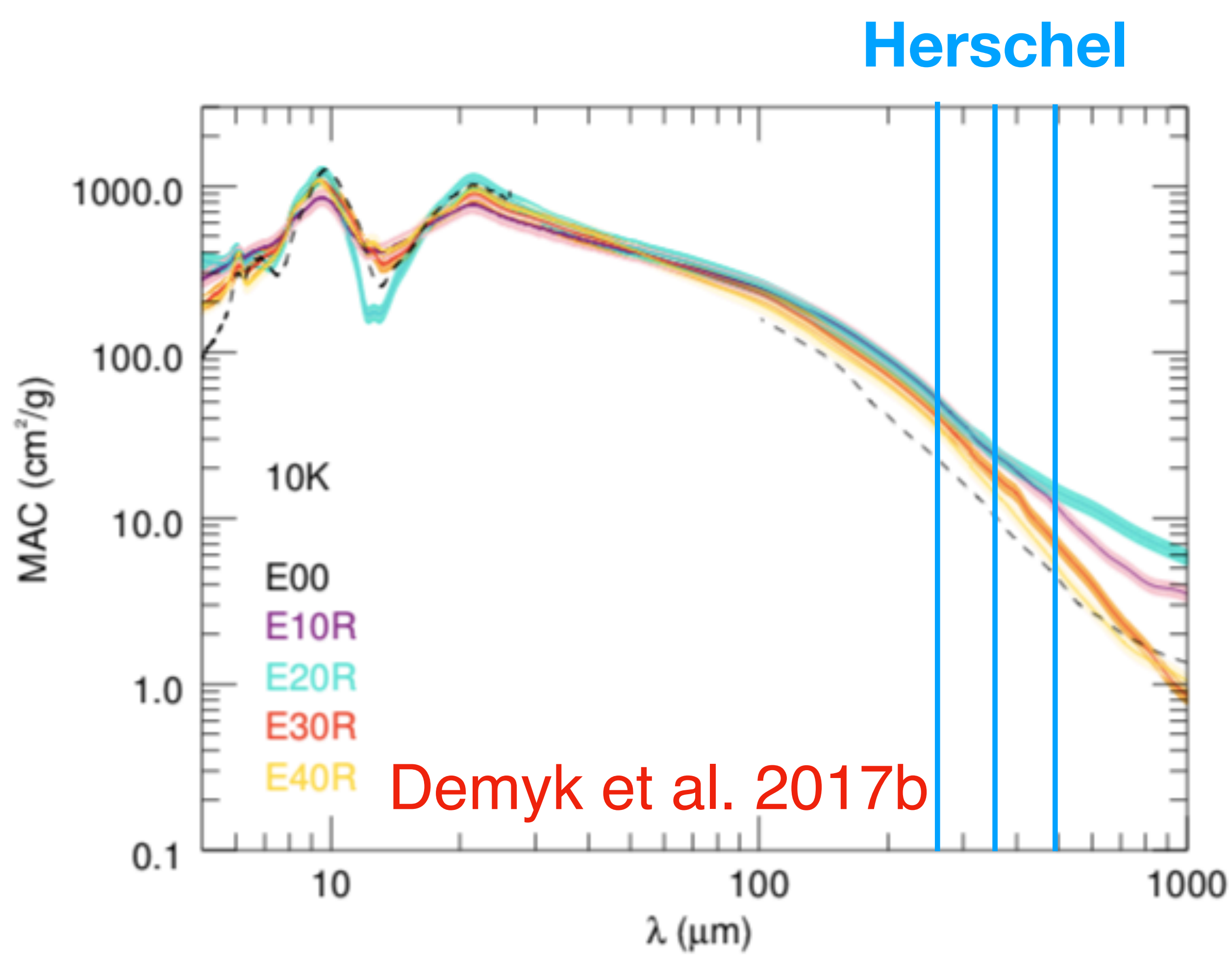
**BUT Iron poor silicate = very emissive**
**Dust model without ice !**

Multiwavelength study to validate model :
Scattering, Absorption, Emission

# Modeling compatible with Herschel observations



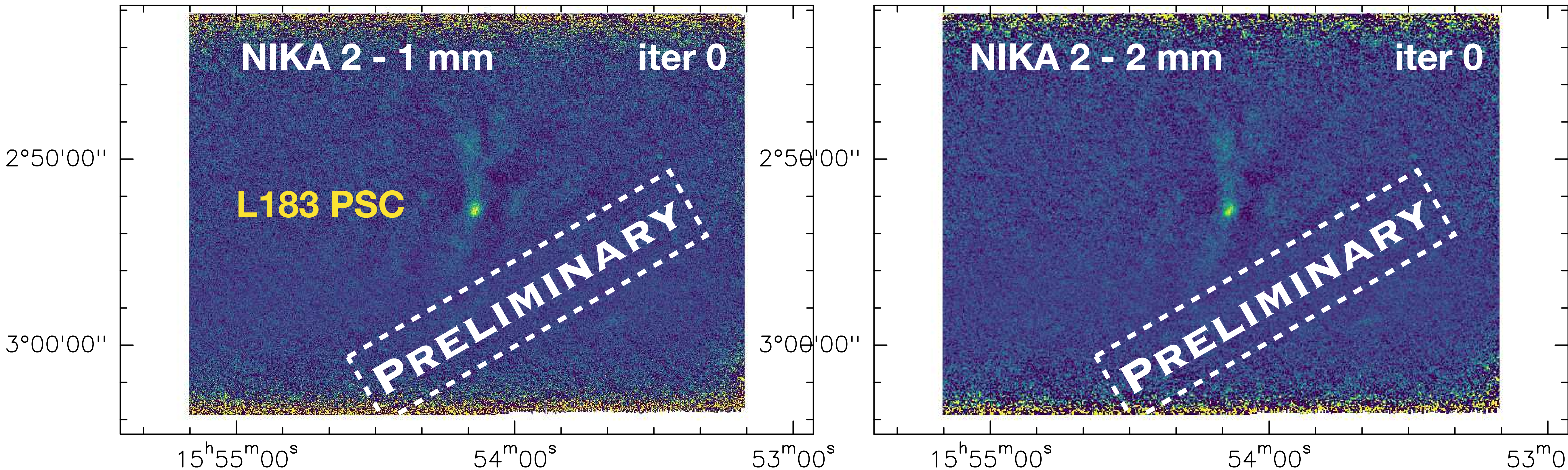

Lefèvre et al. in prep.




Demyk et al. 2017b

→ Indication for too emissive dust but not discriminant enough

# Preliminary maps L183




acknowledgements: N. Ponthieu, B. Ladjelate, J.F. Lestrade and NIKA2 collaboration

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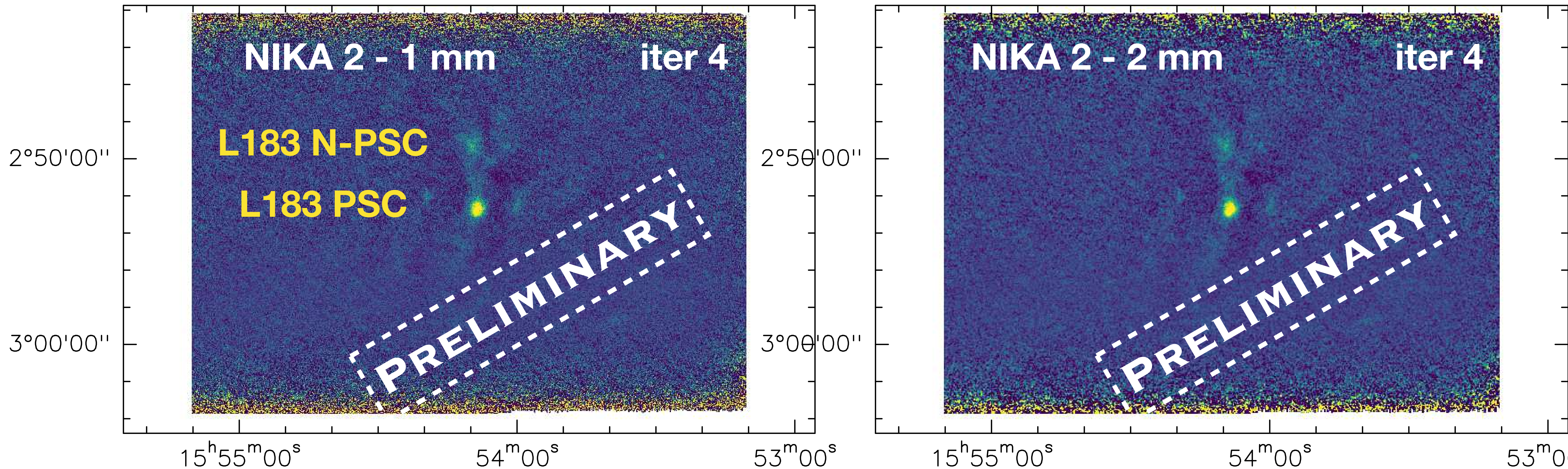


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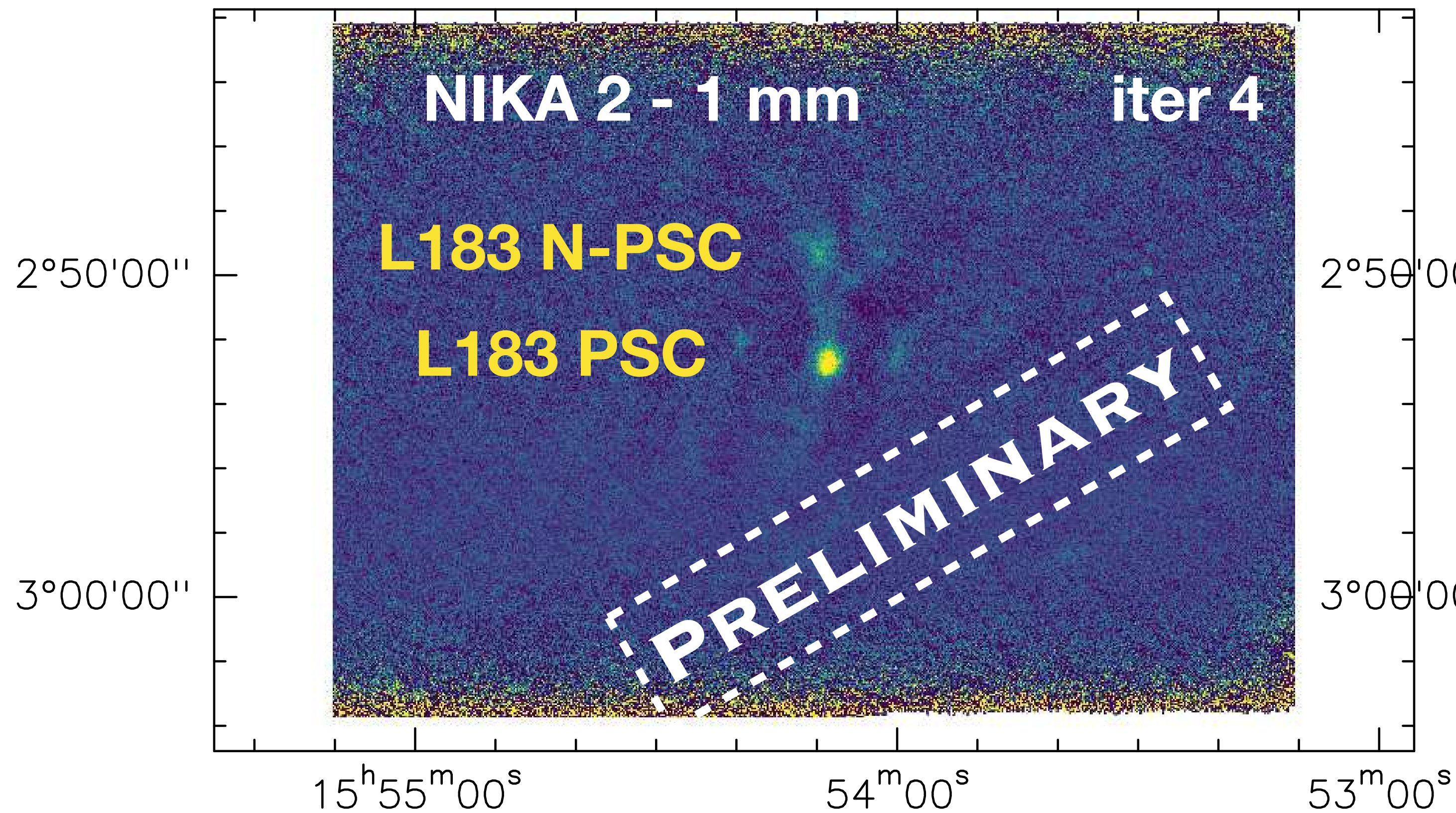


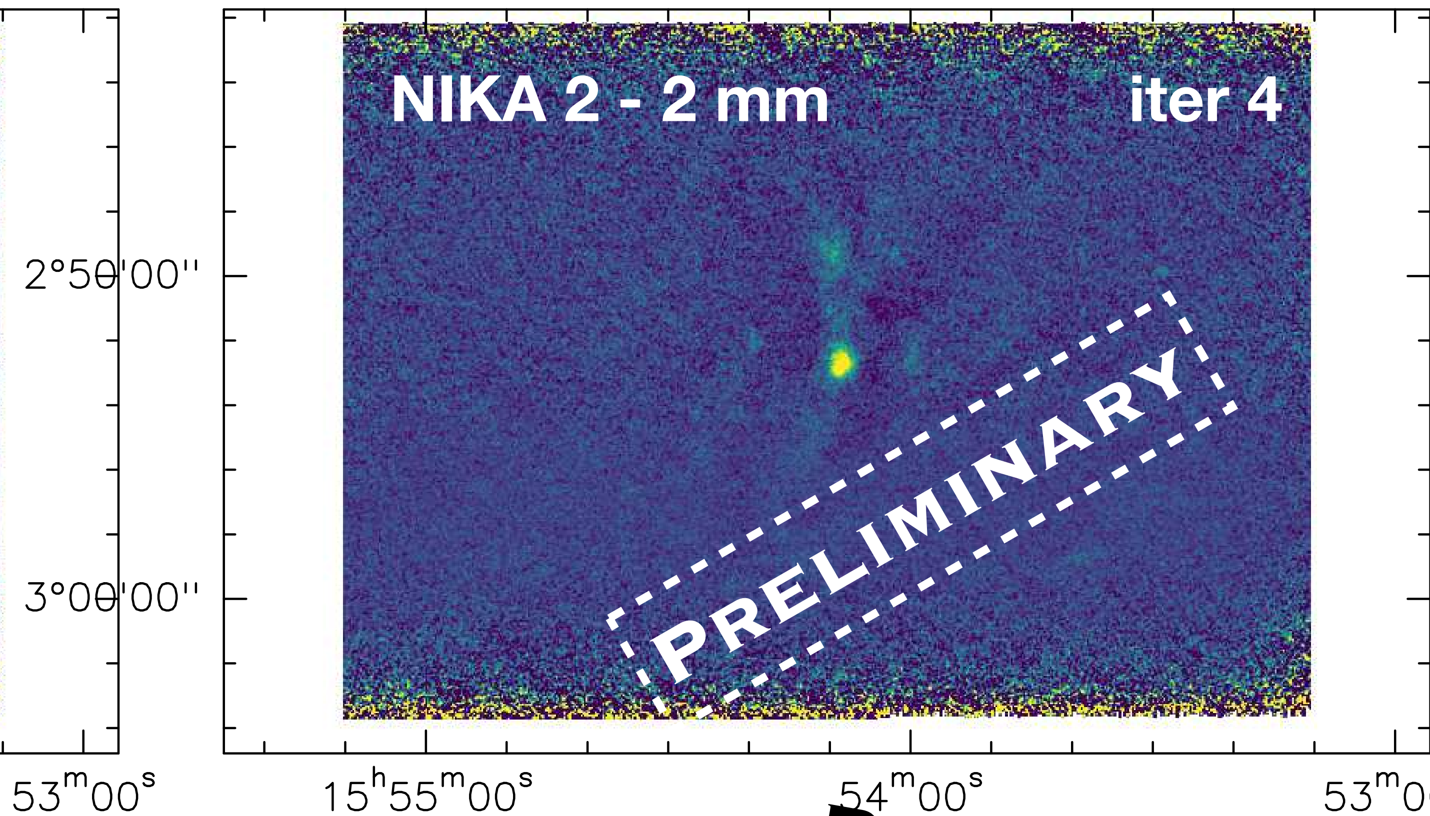


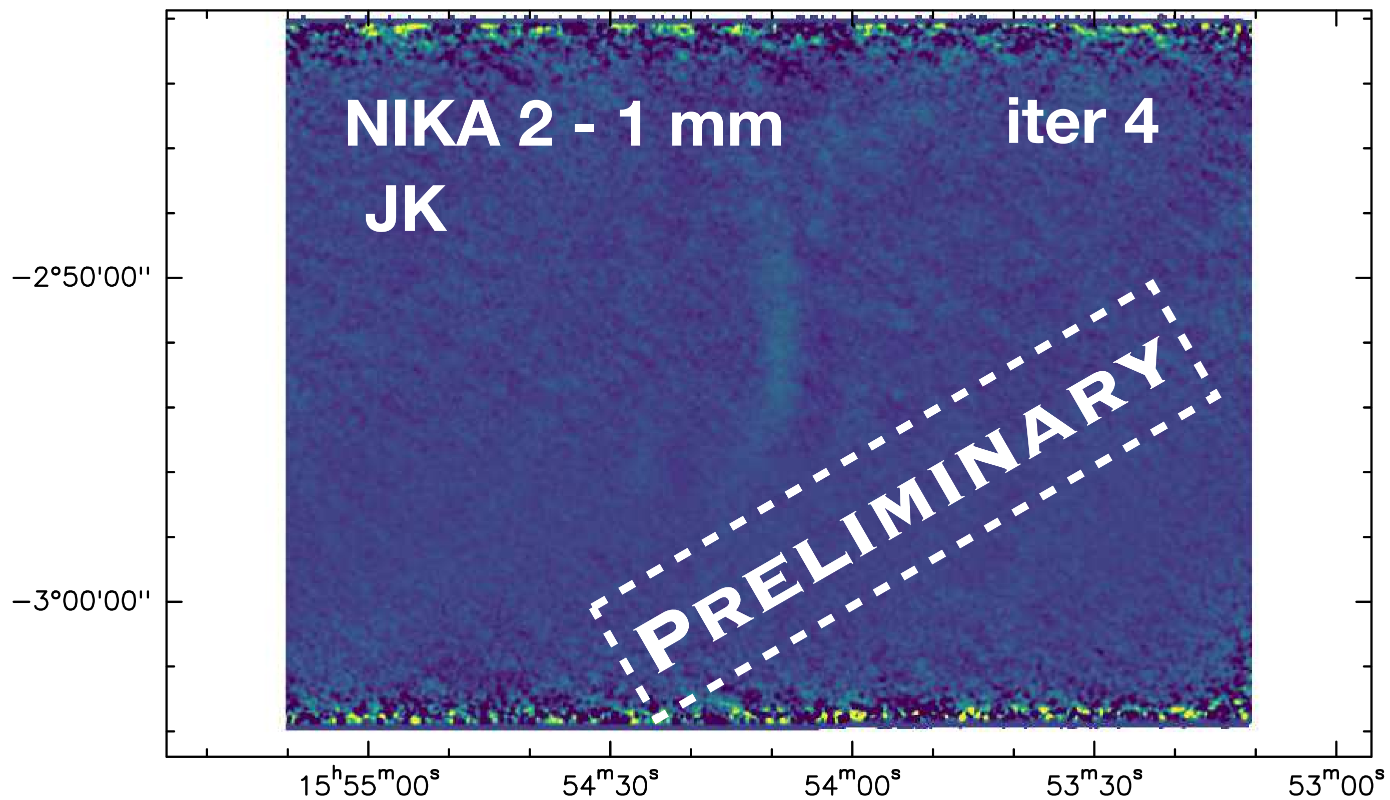


PRELIMINARY

- Some extended signal remains in JK map: all extended emission not catched yet
- ~ 10% of Flux of L183 PSC flux missing compared to MAMBO2 > 30% for N-PSC
- Data reduction still on-going to extract extended emission

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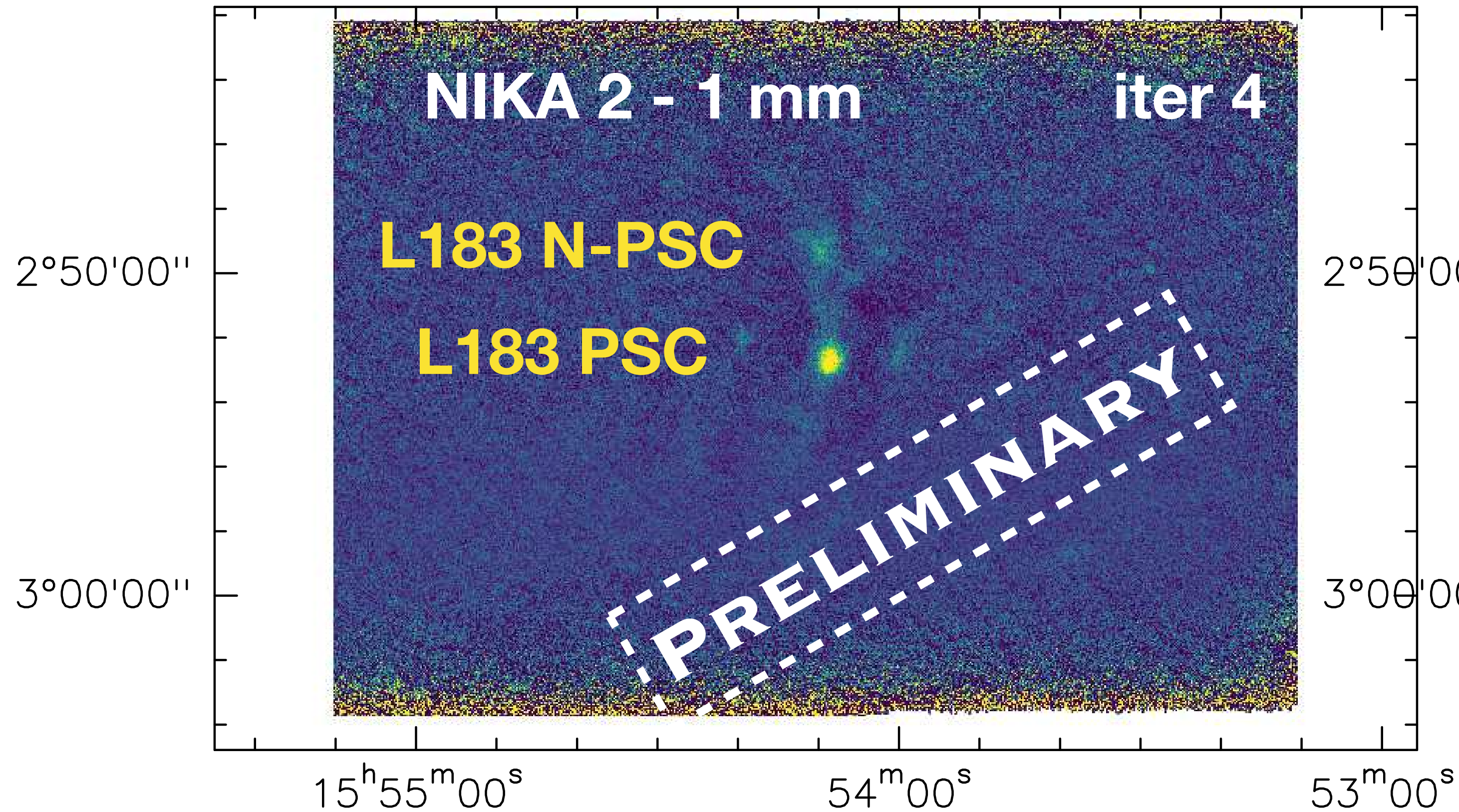


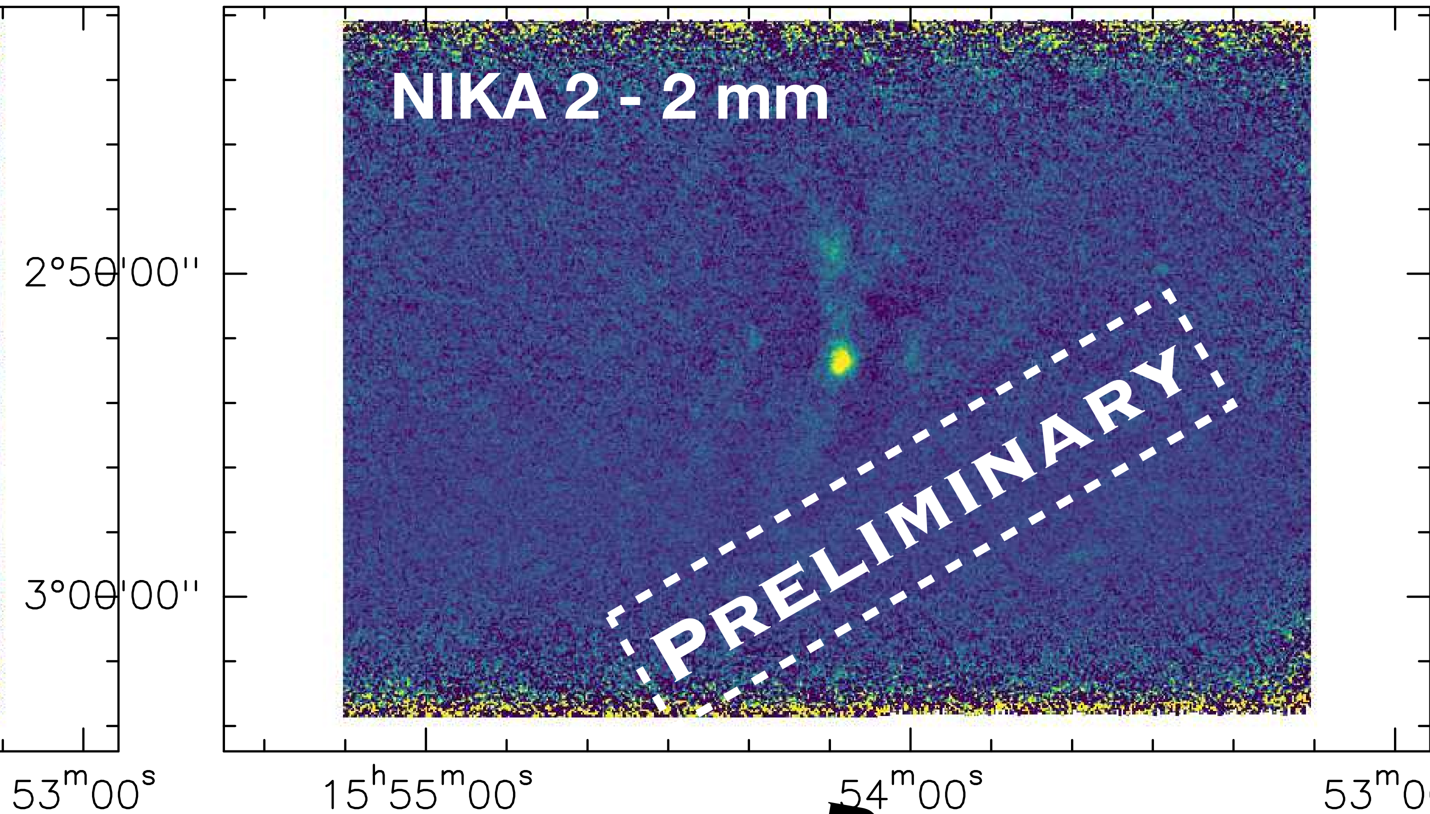


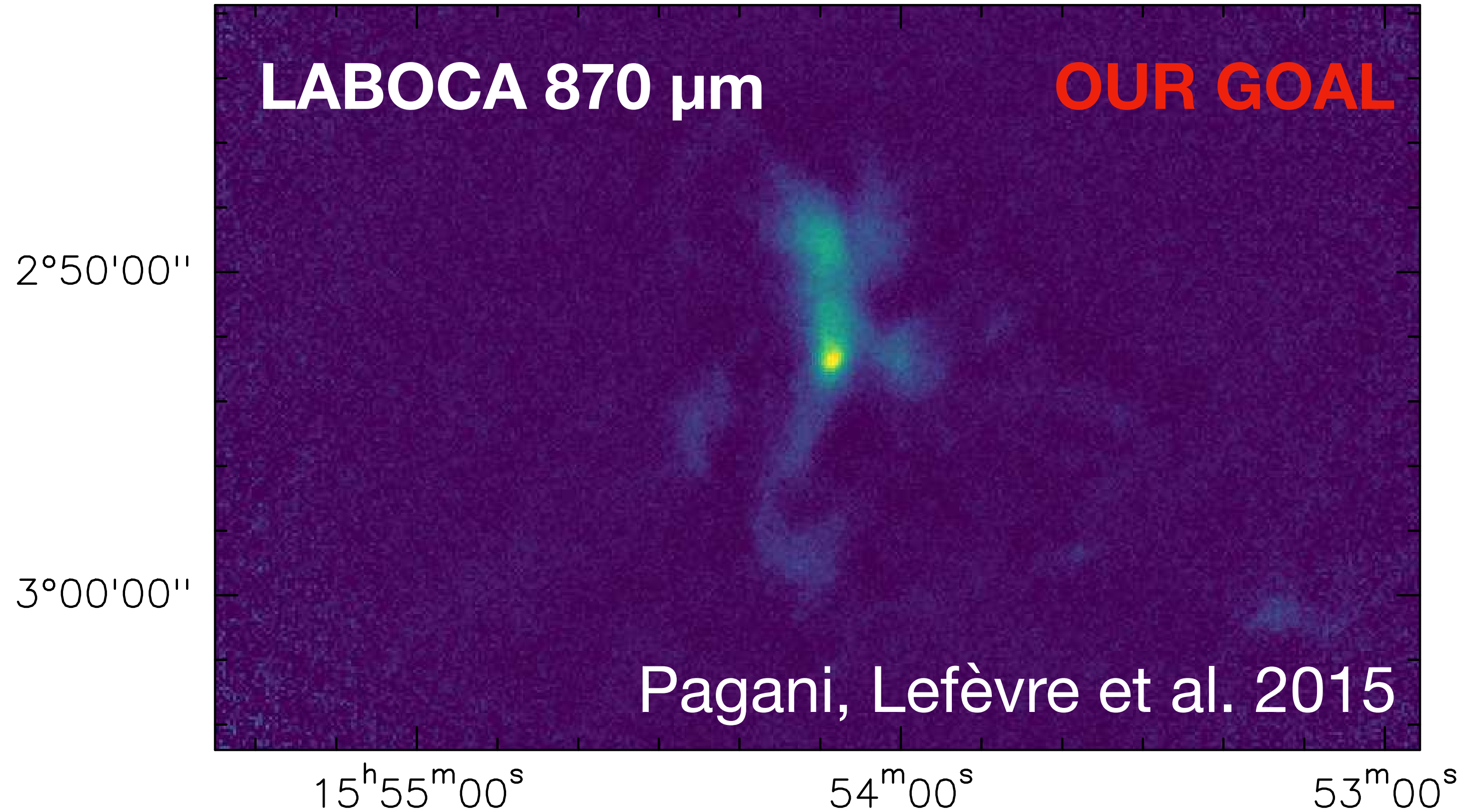


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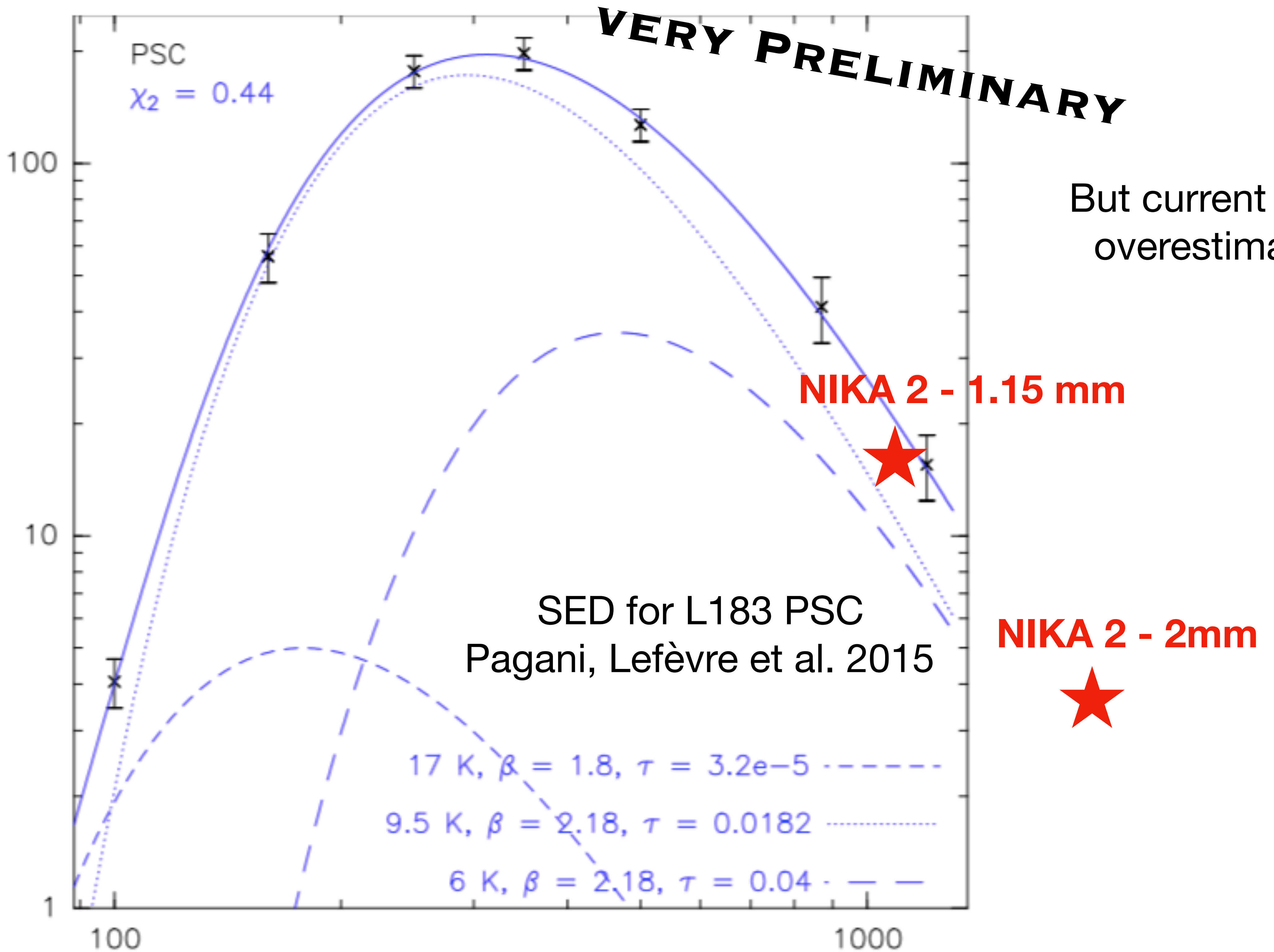
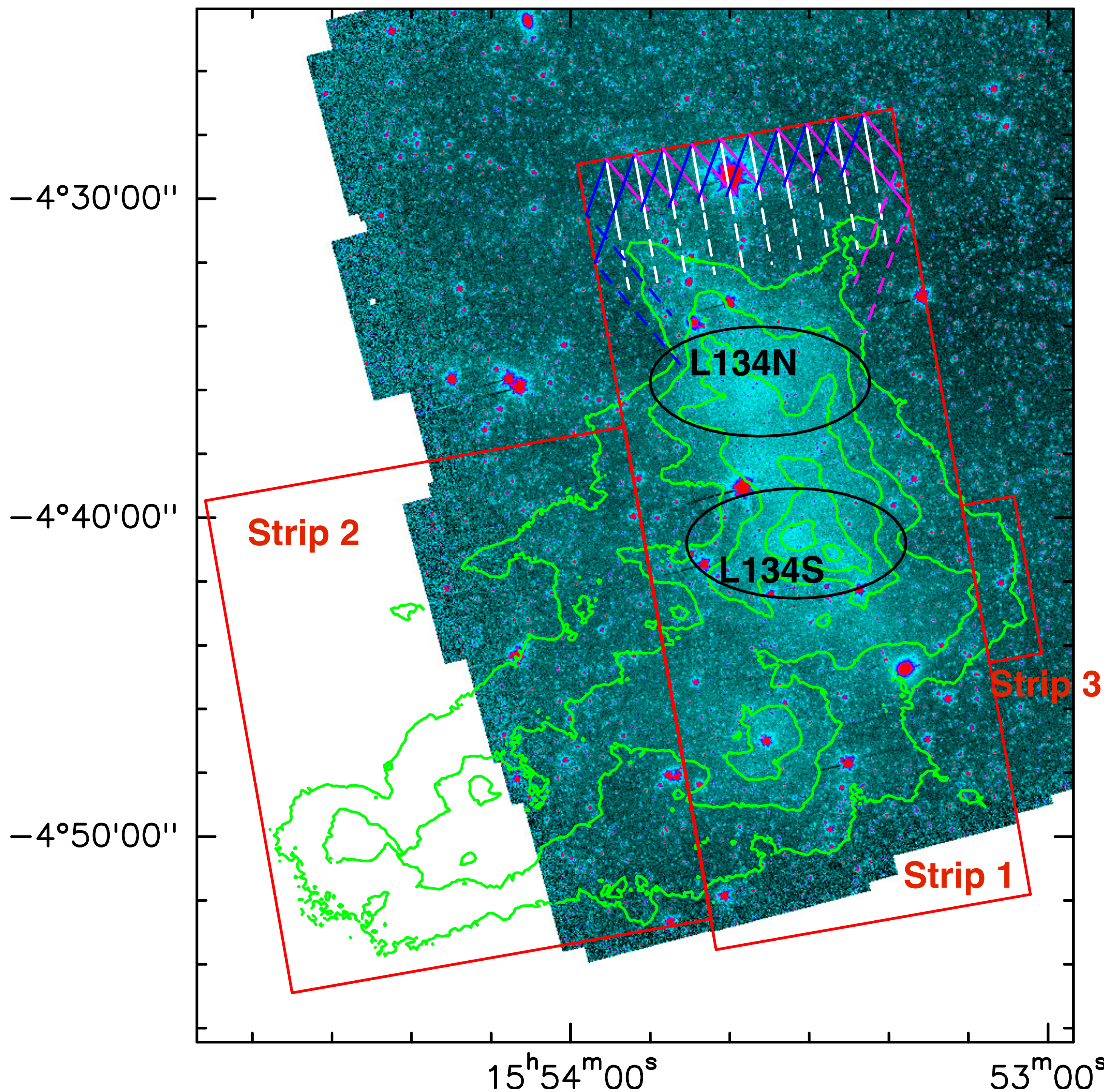
# Preliminary results L183




But current model likely overestimate the flux

# L134

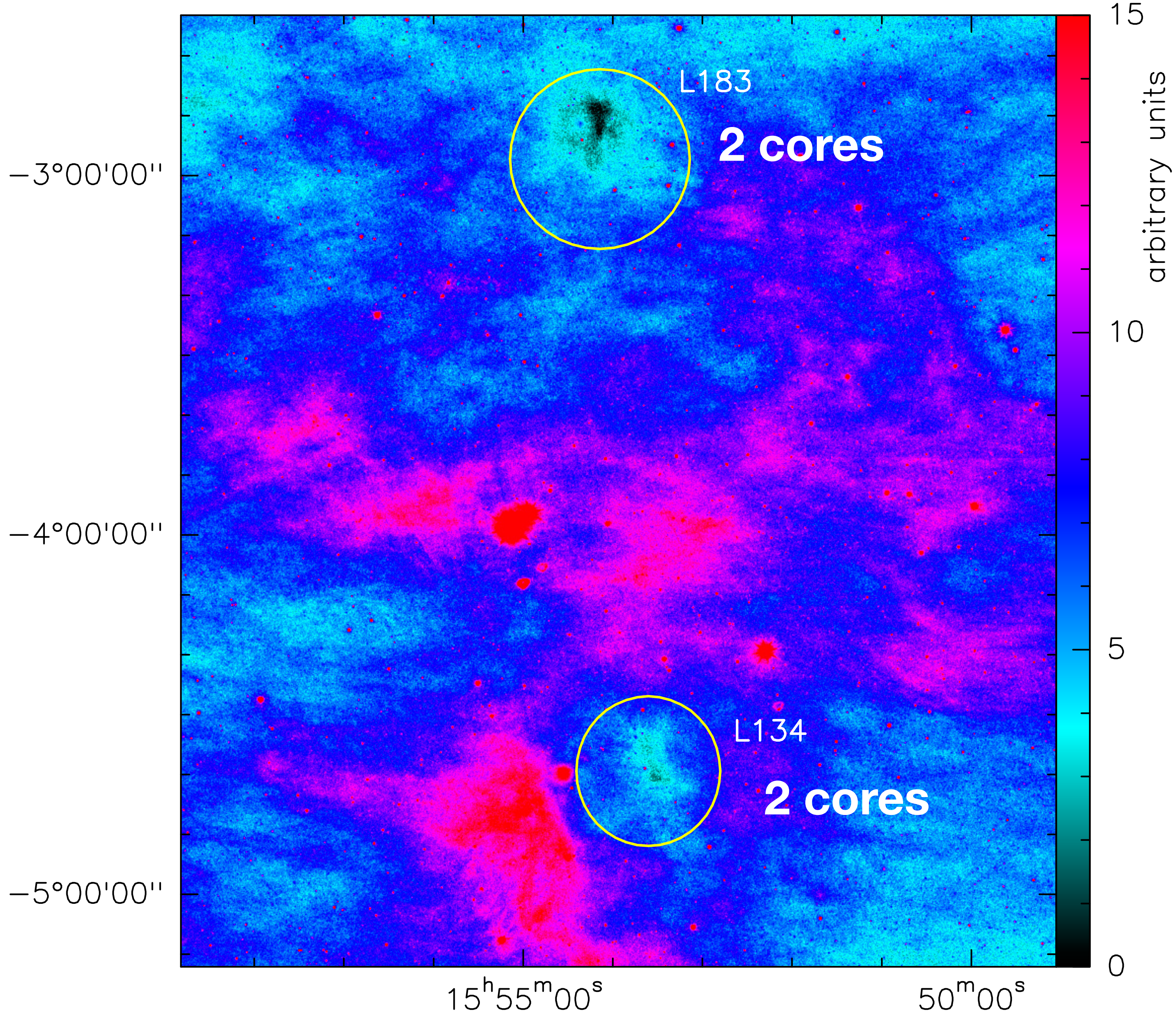



**Spitzer Observations of L134**
**(Lefèvre et al. in prep.)**

**VERY PRELIMINARY**

- Spitzer: L134N and L134S have the same scattering intensity
- NIKA2: Strip 1 was observed but L134S barely detected L134N not yet detected
- Temperature effect and better constraints for Radiation Field

# Summary of goals




**WISE 12 µm map in extinction**

**Thanks to SIGMA + NIKA2**

**Revisit dust content of L183:**

- Dust composition (silicates, ices)
- Coagulation more sophisticated than 2 components from edge to cores

**Comparison with L134 :**

- Same approach (Spitzer + Herschel + NIKA2)
- Coagulation threshold
- Better study dependancy with temperature, turbulence, density