# *Probing the small dust properties in the diffuse galactic plane using the Spitzer – Herschel synergy*

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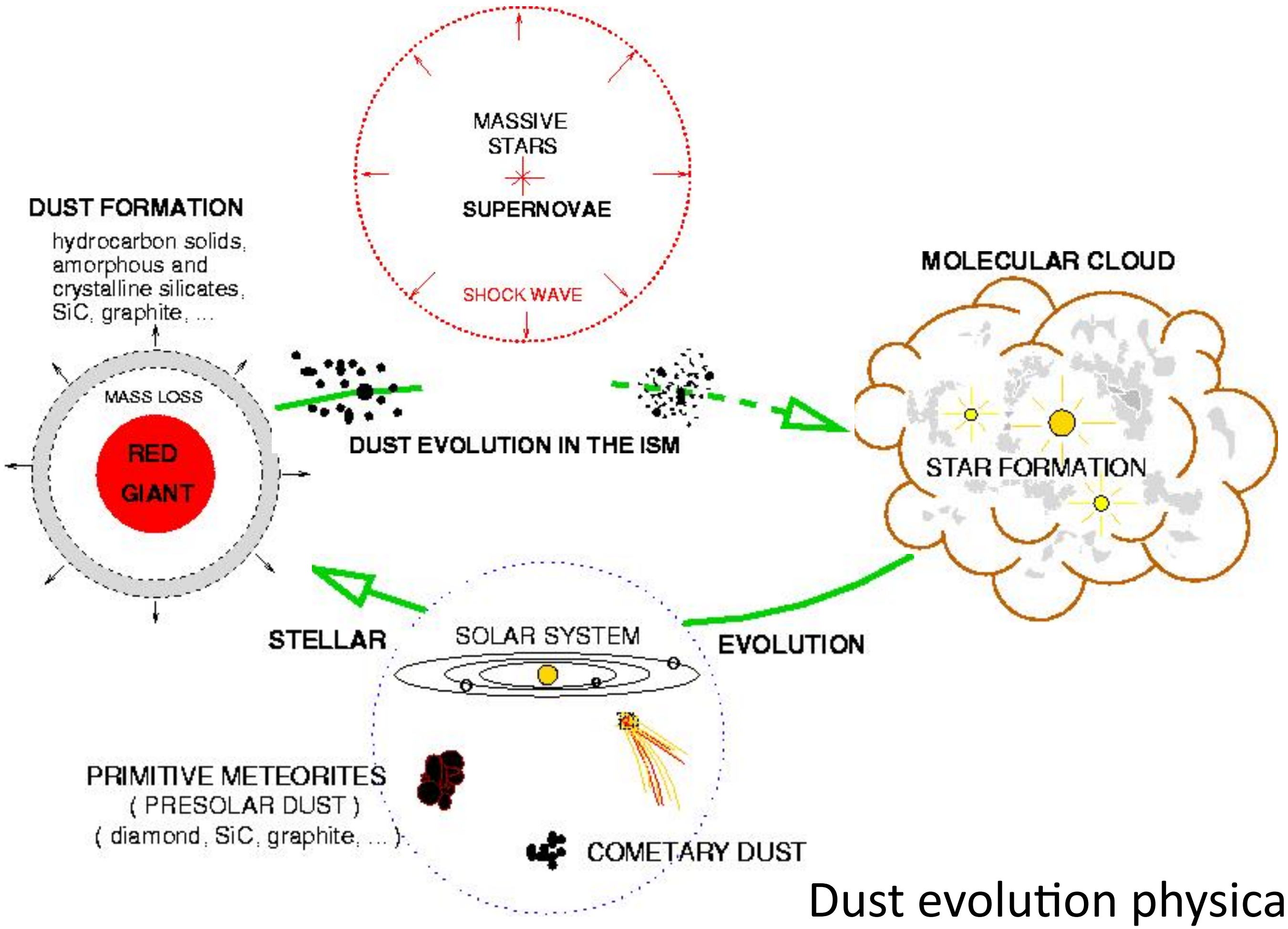
# *Studying the dust evolution*

ISM cycle stellar evolution dust life cycle




- Dust has a great impact on ISM physics and chemistry
- This impact depends on their properties
- Dust properties evolves depending on the physical properties of the ISM

Dust evolution physical processes characterization
→ dust impact on the ISM all-over the ISM cycle
→ build physical scenario for SED interpretations

# *Aims - Goals*

Full (mid-IR - submm) SED fitting using a dust model :

- (Demonstration of) the Spitzer–Herschel synergy to study the dust evolution

- Why does PACS 70 looks like shorter wavelengths ?
  - What lights up PACS observed emission ?
  - What is the contribution of very small stochastically heated grains (VSGs) to the PACS observed emission ?

- What does the IRAC 8 μm trace ?

# *The data : Hi-Gal / MIPSGAL / GLIMPSE*

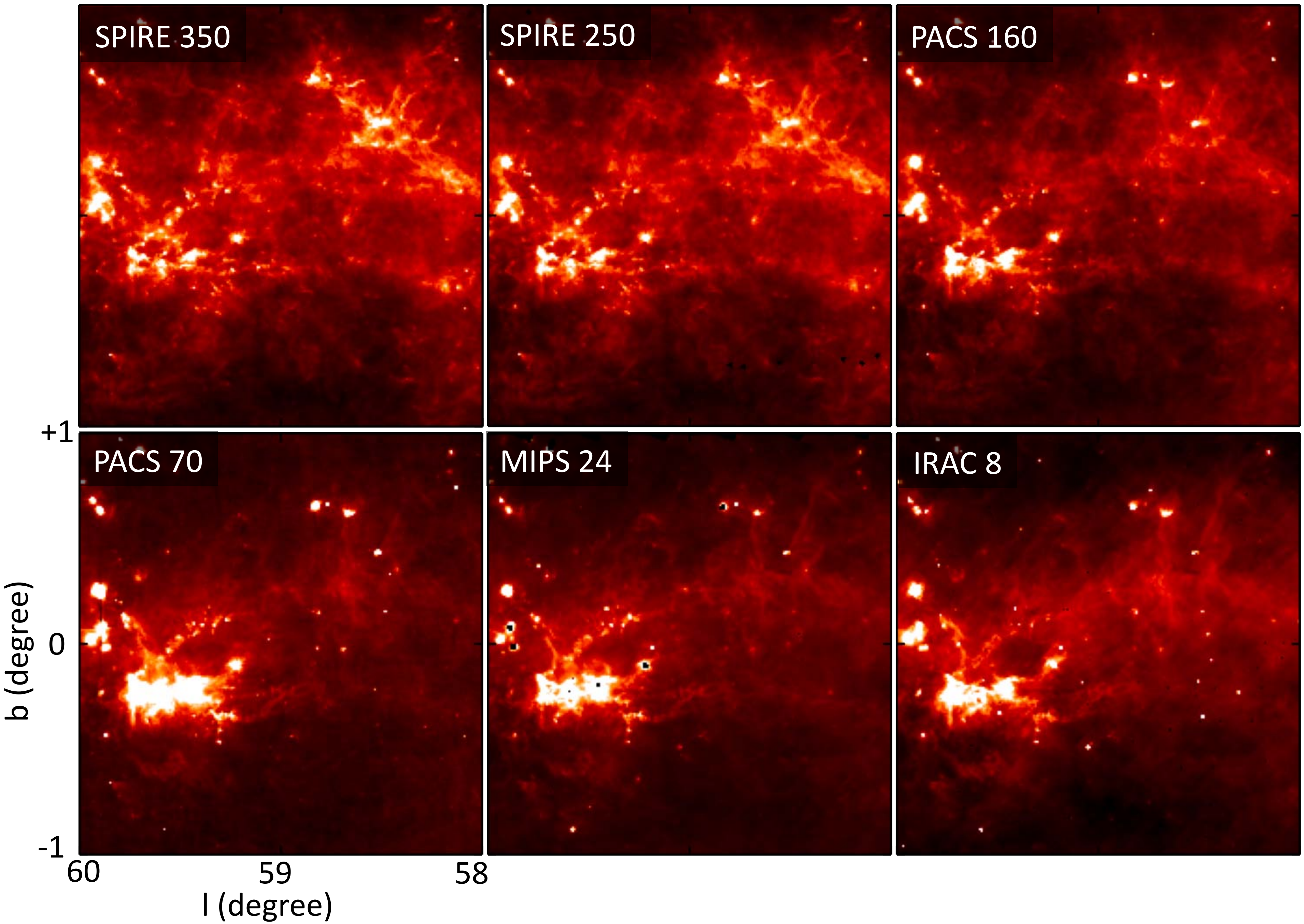
- Spitzer : GLIMPSE and MIPSGAL (8 & 24 µm)
  - These are zodi-subtracted
  - IRAC 8µm is point sources subtracted

- PACS 70 is the ROMAGAL map X-calibrated on MIPS70 (zodi corrected)

- PACS 160, SPIRE 250 & SPIRE 350
  - ROMAGAL maps & official calibration
  - Offset correction (Planck, private comm.)

- All data brought in the SPIRE350 resolution and grid
  - Resolution matching using a Gaussian of appropriate width

# Hi-Gal SDP field l=59°



# *DUSTEM model (I)*

• DUSTEM provides dust extinction and emission (and soon a spinning dust component, the polarization, β(T) and β(λ))

• dP/dT computation based on Désert, Boulanger & Shore (1986)

• DUSTEM is a versatile & user friendly model :

✓ Arbitrary number of dust population

✓ All dust properties defined through input files

✓ Tabulated (arbitrary) size distribution allowed

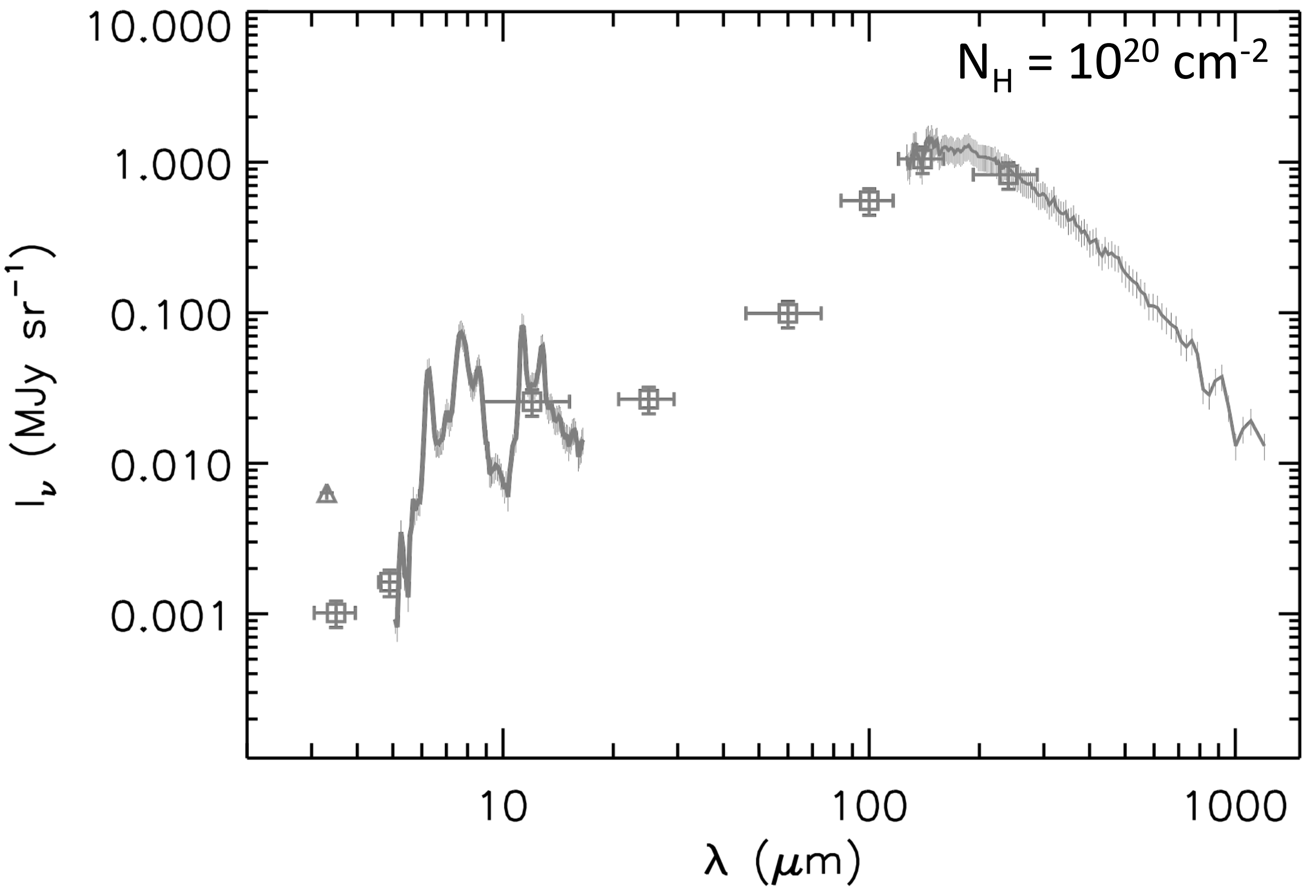
✓ Includes a Interactive Data Language (IDL) wrapper for the SED fitting

→ new dust properties easily implemented

• Publicly available online in couple of weeks, after the paper submission (Compiègne, Verstraete et al., 2010 : watch astro-ph !)

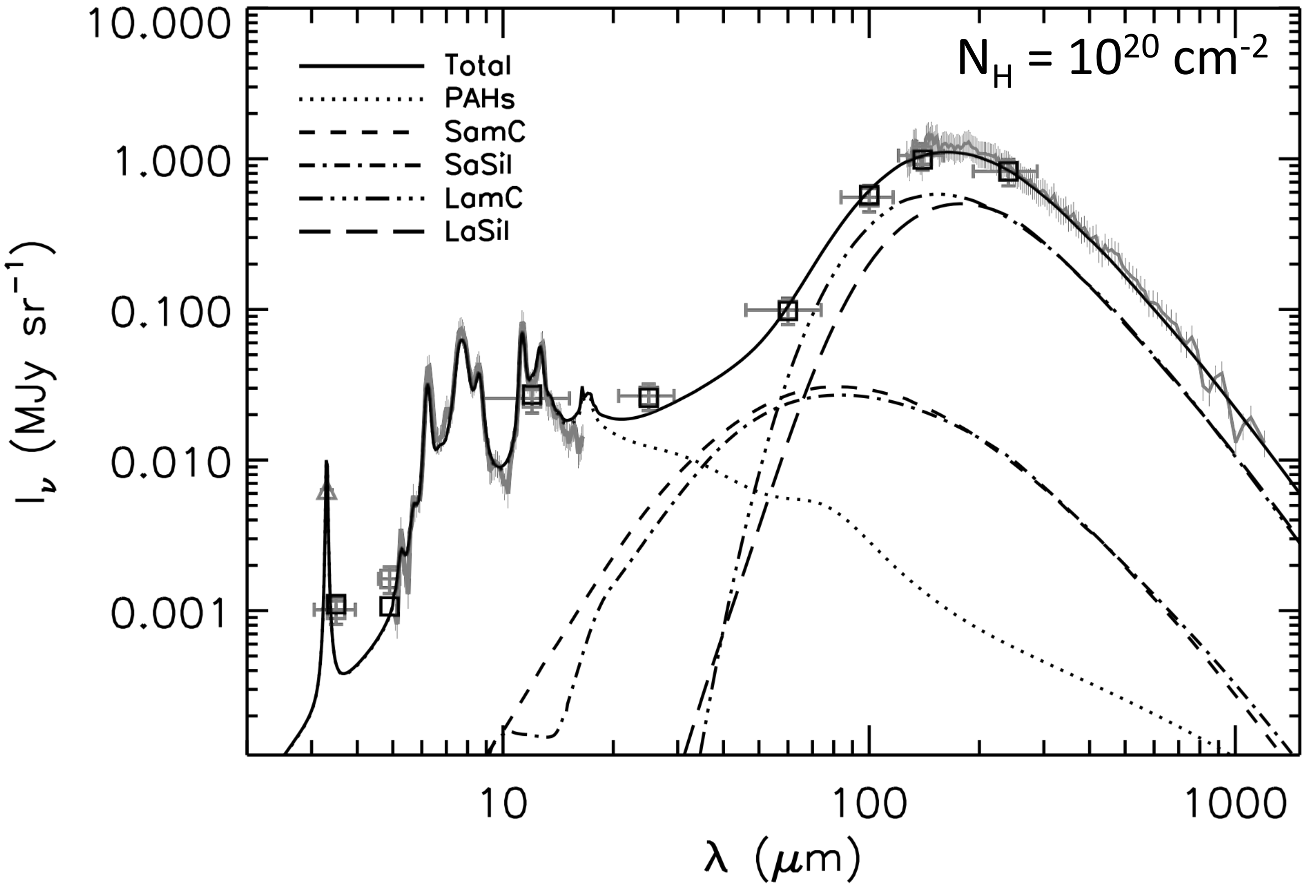
# *DUSTEM model (II)*

• *Reference SED :* Diffuse High Galactic Latitude SED for |b|> 15° and $I_{HI}$ < 300 K Km $s^{-1}$



# DUSTEM model (II)

- Reference SED : Diffuse High Galactic Latitude SED for |b|> 15° and $I_{HI}$ < 300 K Km $s^{-1}$
- DUSTEM → reference dust properties from the reference SED

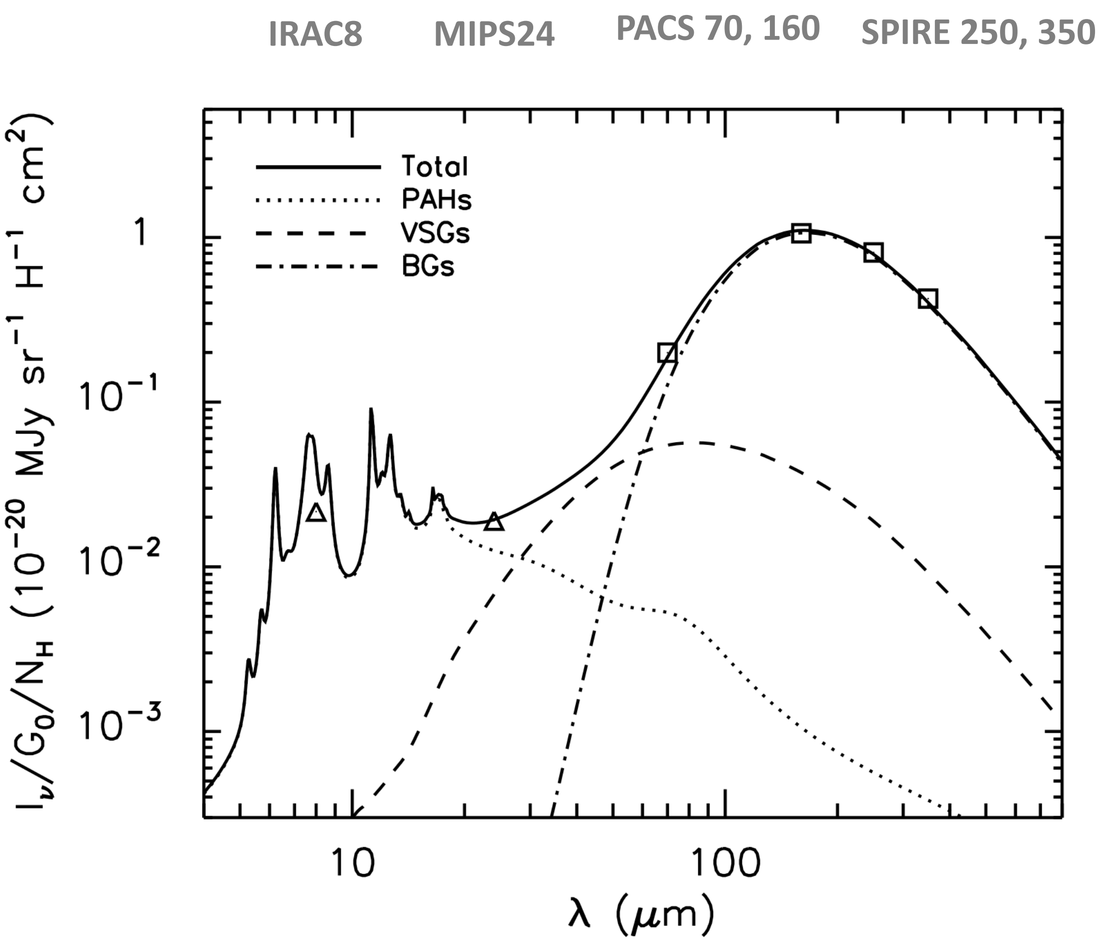



3 grain types :

- **PAHs**
- **Amorphous carbon**
- **Astro-Silicates**

- Also satisfies the measured extinction, albedo and abundances

# The SED fitting procedure (I)



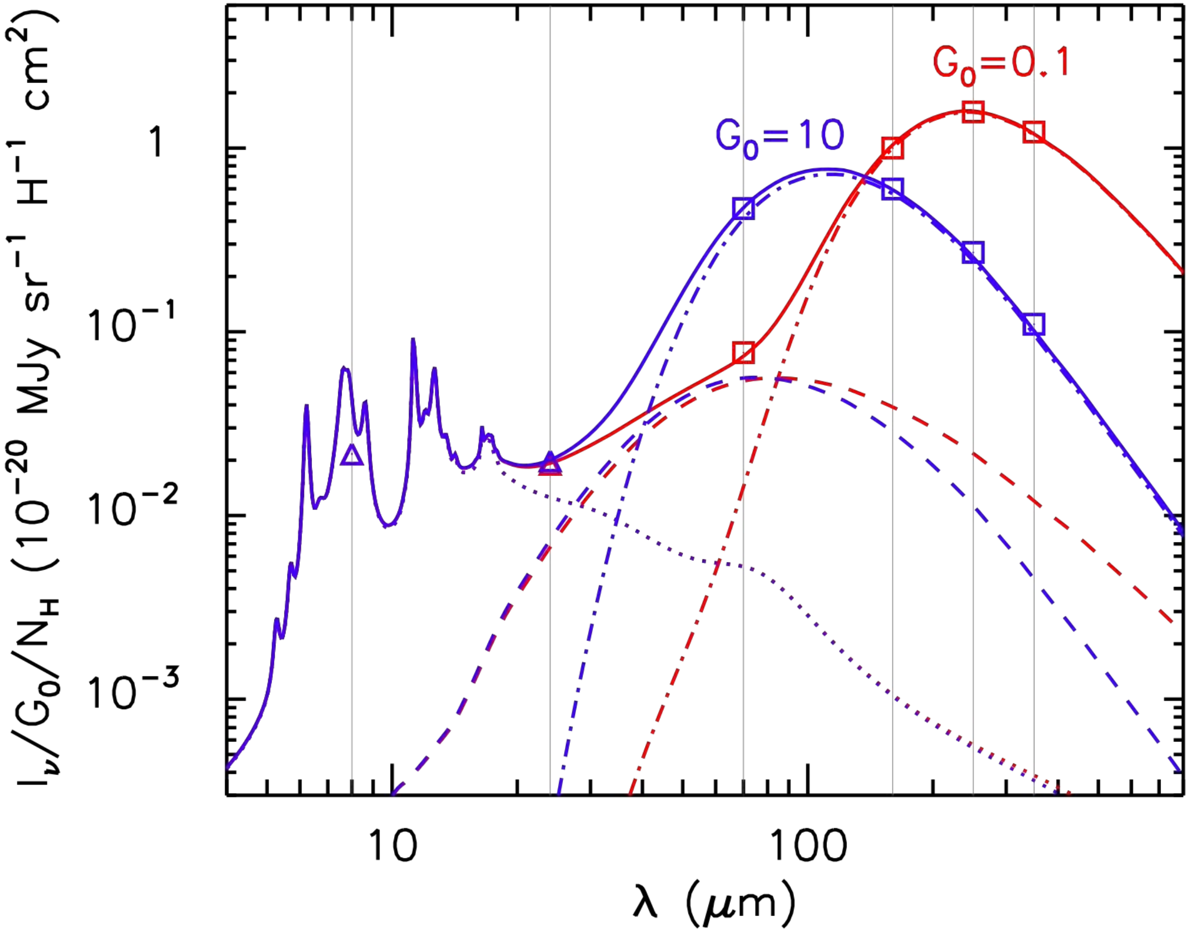

- DUSTEM populations merged:
  *PAHs*
  SamC + SaSil = *VSGs*
  LamC + LaSil = *BGs*

- Fitting of the photometric point by adjusting :
  - ✓ $Y_{PAH}$ and $Y_{VSG}$ : abundance relative to BGs
  - ✓ $N_H$ : Column density
  - ✓ $G_0$ : scaling factor of the radiation filed

- BG properties are constants (e.g. emissivity and abundance)

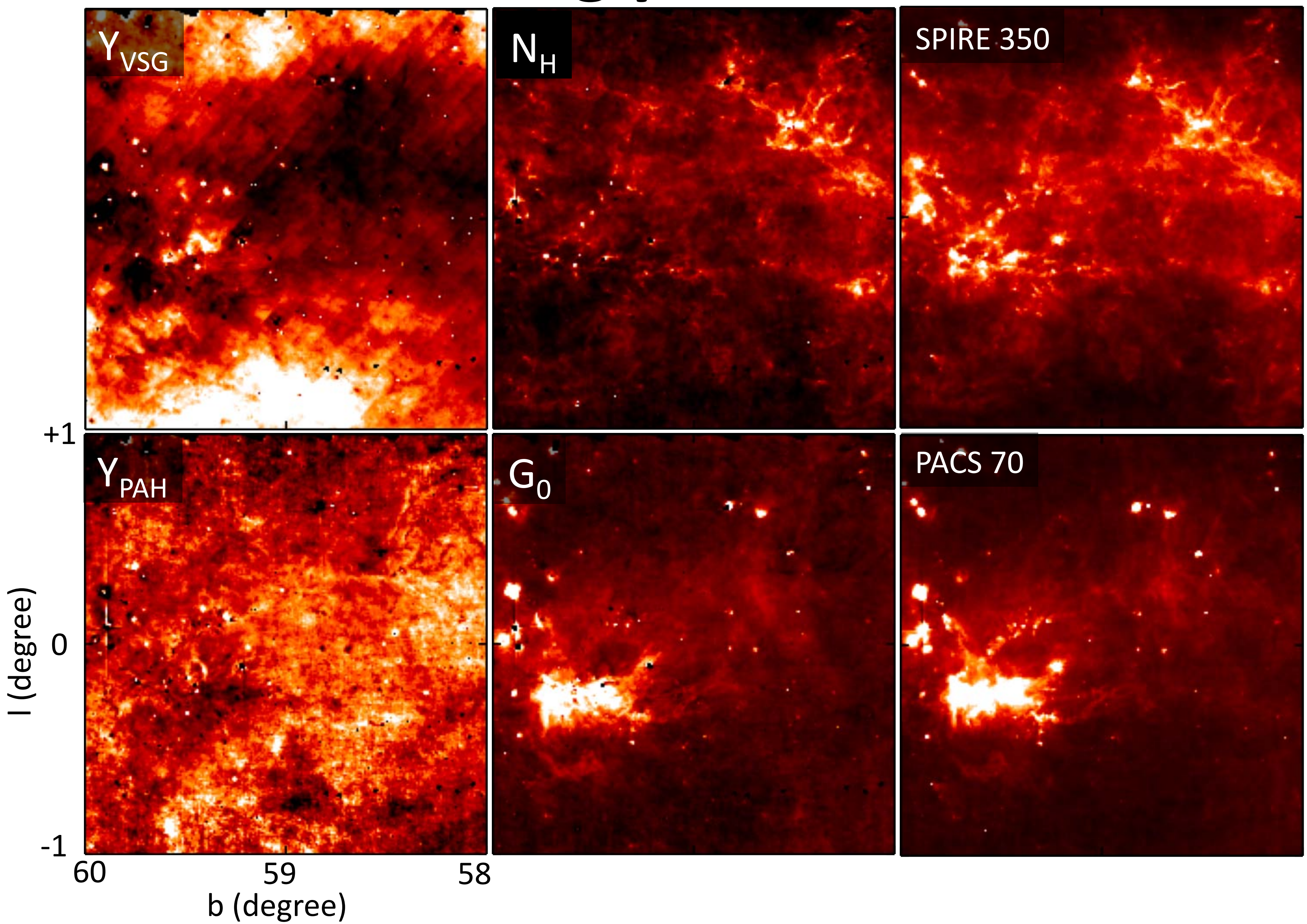
- Effect of extinction on the line of sight is accounted for (important at 8 µm) assuming $I_\lambda = I_{0,\lambda} \frac{1-e^{-\tau_\lambda}}{\tau_\lambda}$

# *The SED fitting procedure (II)*

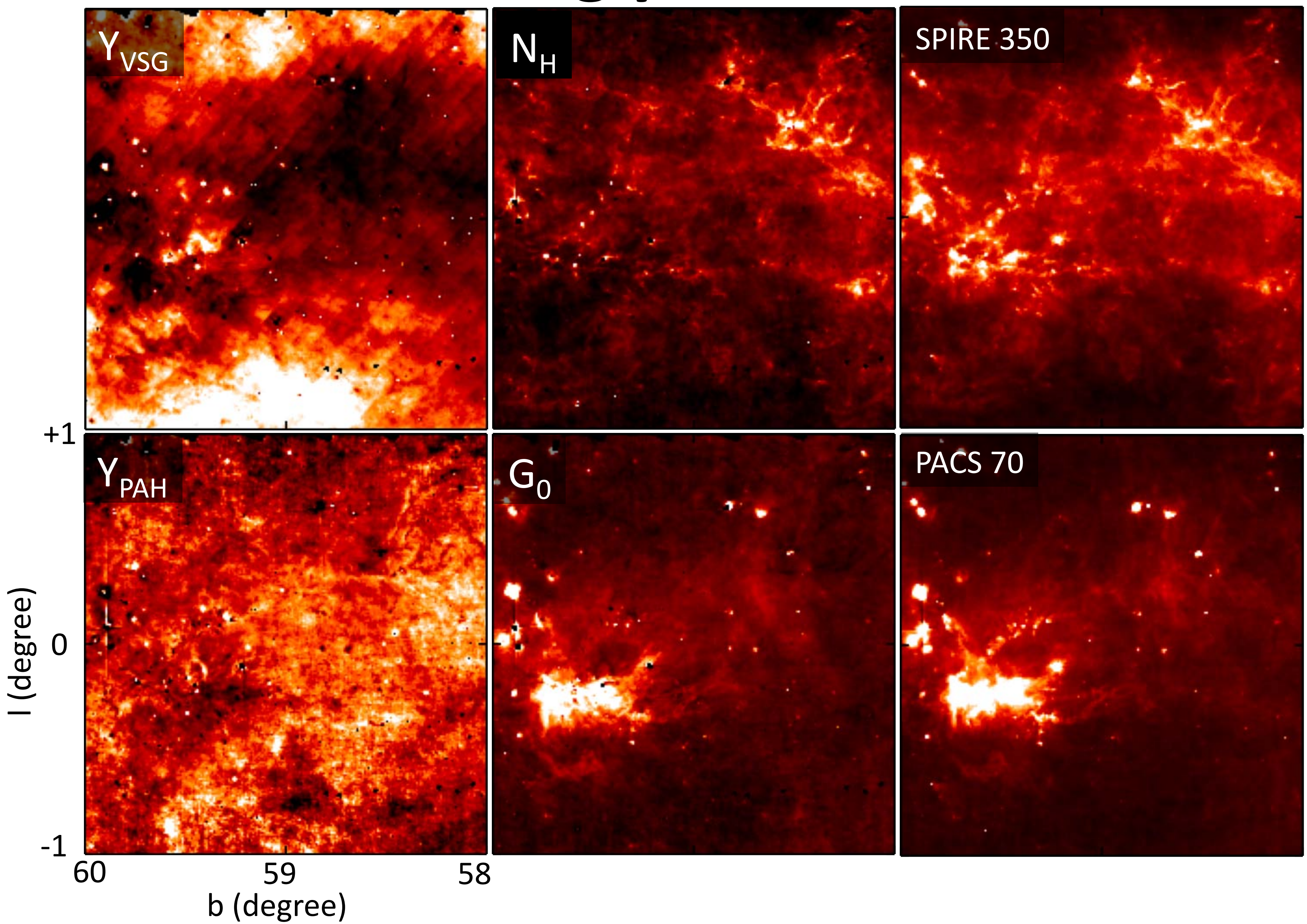



- Thermal equilibrium grains spectrum shape = fct($G_0$)
- PACS160, SPIRE250 and 350 → $N_H$ & $G_0$
  IRAC 8, MIPS24 → $Y_{PAH}$
  MIPS24, PACS70 → $Y_{VSG}$
- For higher $G_0$, smaller species at thermal equilibrium
  → degeneracy between $N_H$ and $Y_{VSG}$ then $Y_{PAH}$

# *Fitting products*



# Fitting products

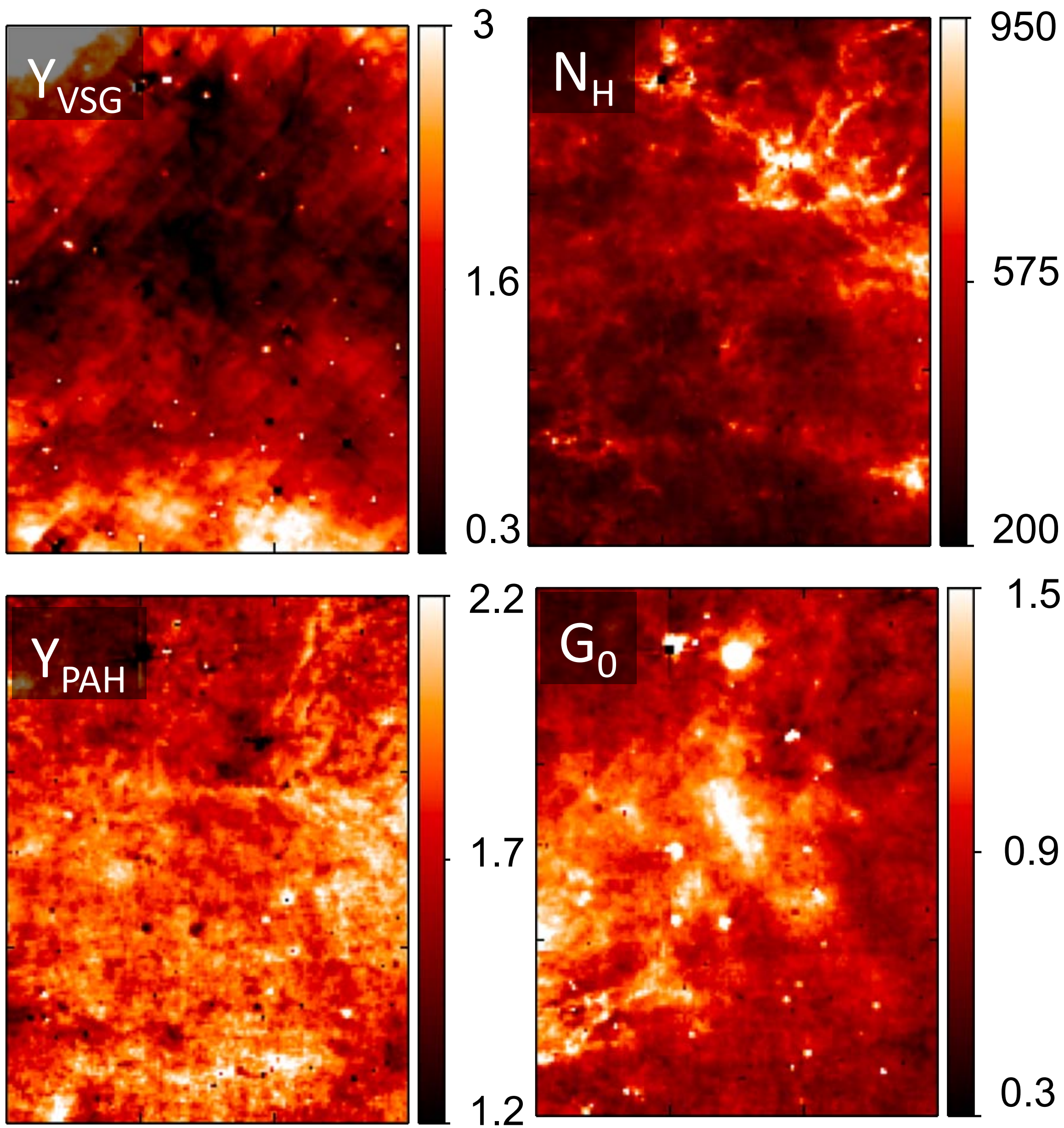


# *Fitting produced quantities*

**$Y_{PAH}$** and **$Y_{VSG}$** : PAH and VSG abundances relative to BG. 1 is the value for DHGL medium (|b| > 15°)

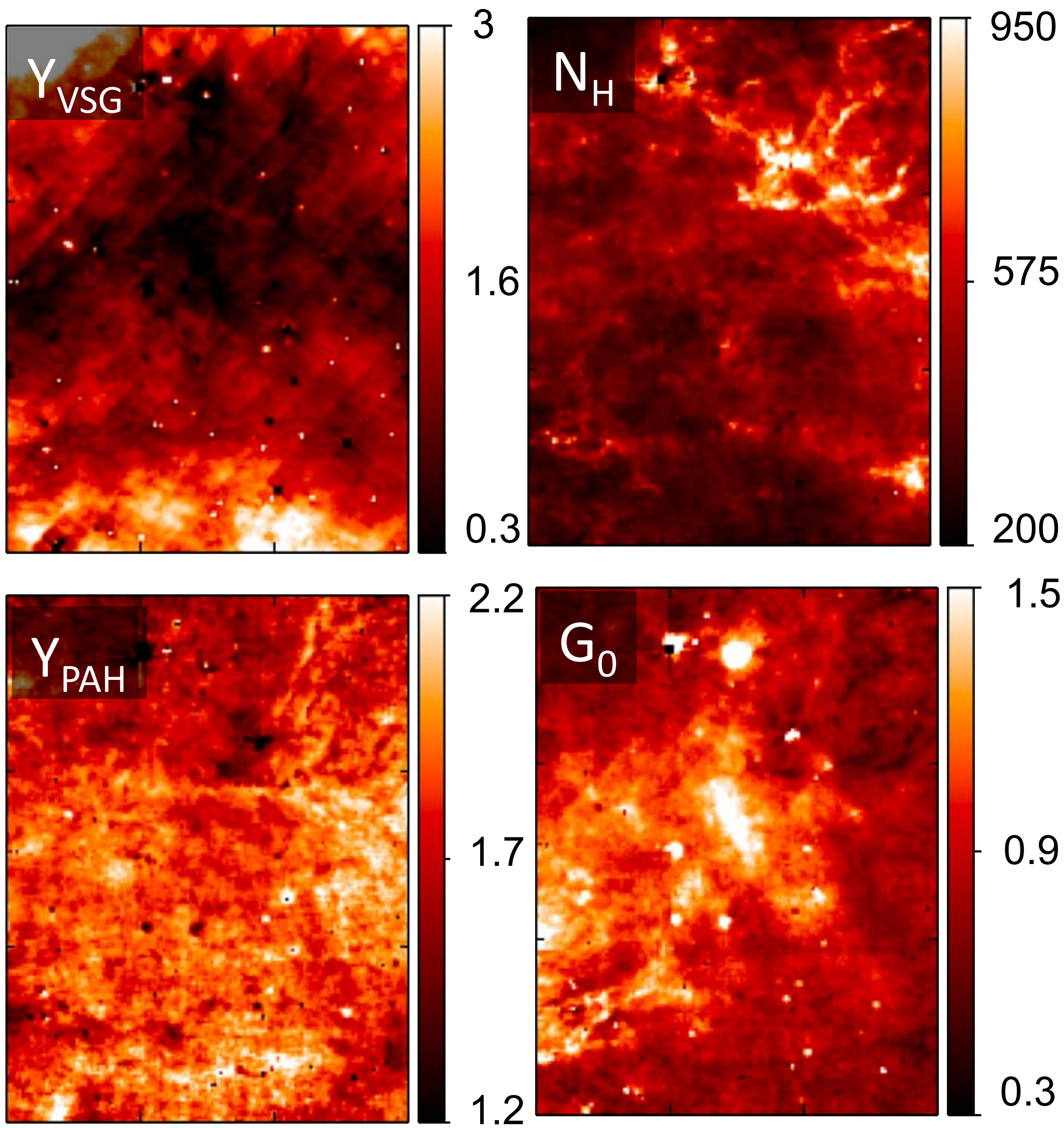
**$G_0$** : Scaling factor of the Mathis, Mezger, Panagia, (1983) radiation field intensity

**$N_H$** : column density in unit of $10^{20}$ H cm$^{-2}$

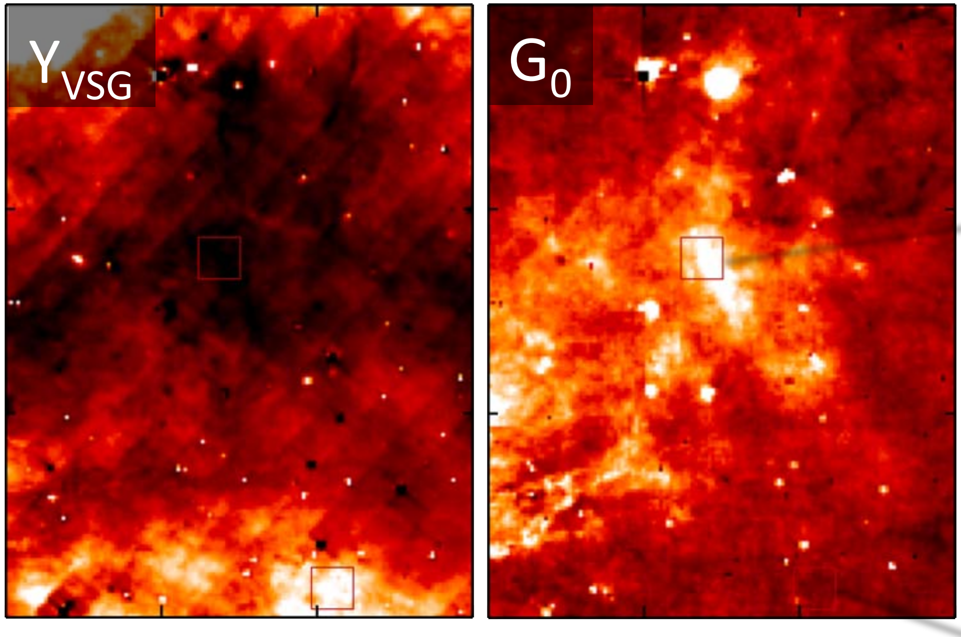


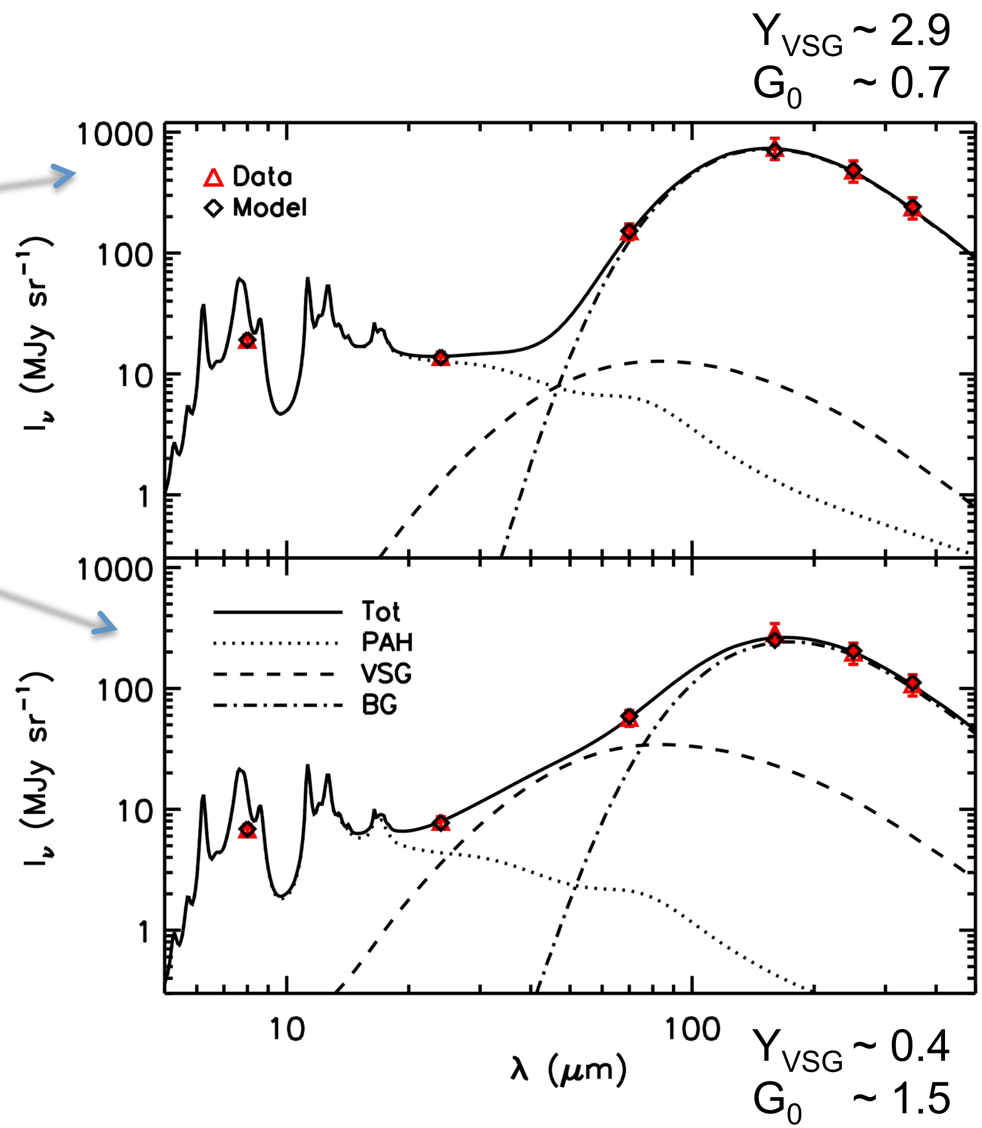
# *First conclusions*

- $Y_{PAH}$, $Y_{VSG}$, $N_H$ and $G_0$ has consistent values and behavior
- $Y_{PAH}$ and $Y_{VSG}$ decrease toward dense filamentary structures
- Lack of correlation of $Y_{PAH}$ and $Y_{VSG}$ especially at large spatial scales.



# *What lights up PACS 70 µm ?*



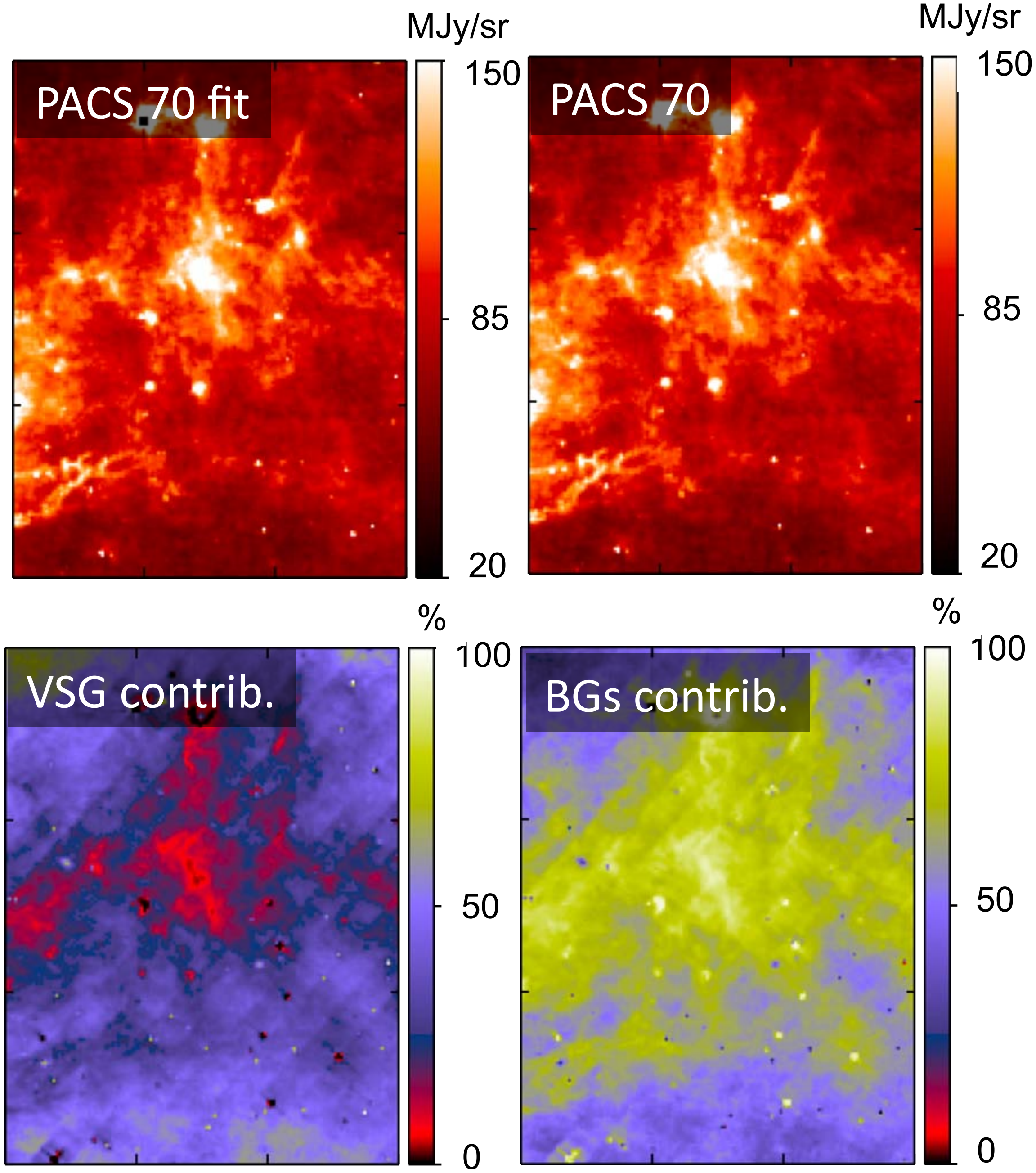

In this field, PACS 70 is enlighten by VSGs (stochastically heated) and Wien part of the BGs spectrum

→ Very sensitive to $G_0$

→ Looks like shorter wavelengths

→ VSG contribution can varies depending on $Y_{VSG}$ and $G_0$

# PACS 70 VSG contribution (I)

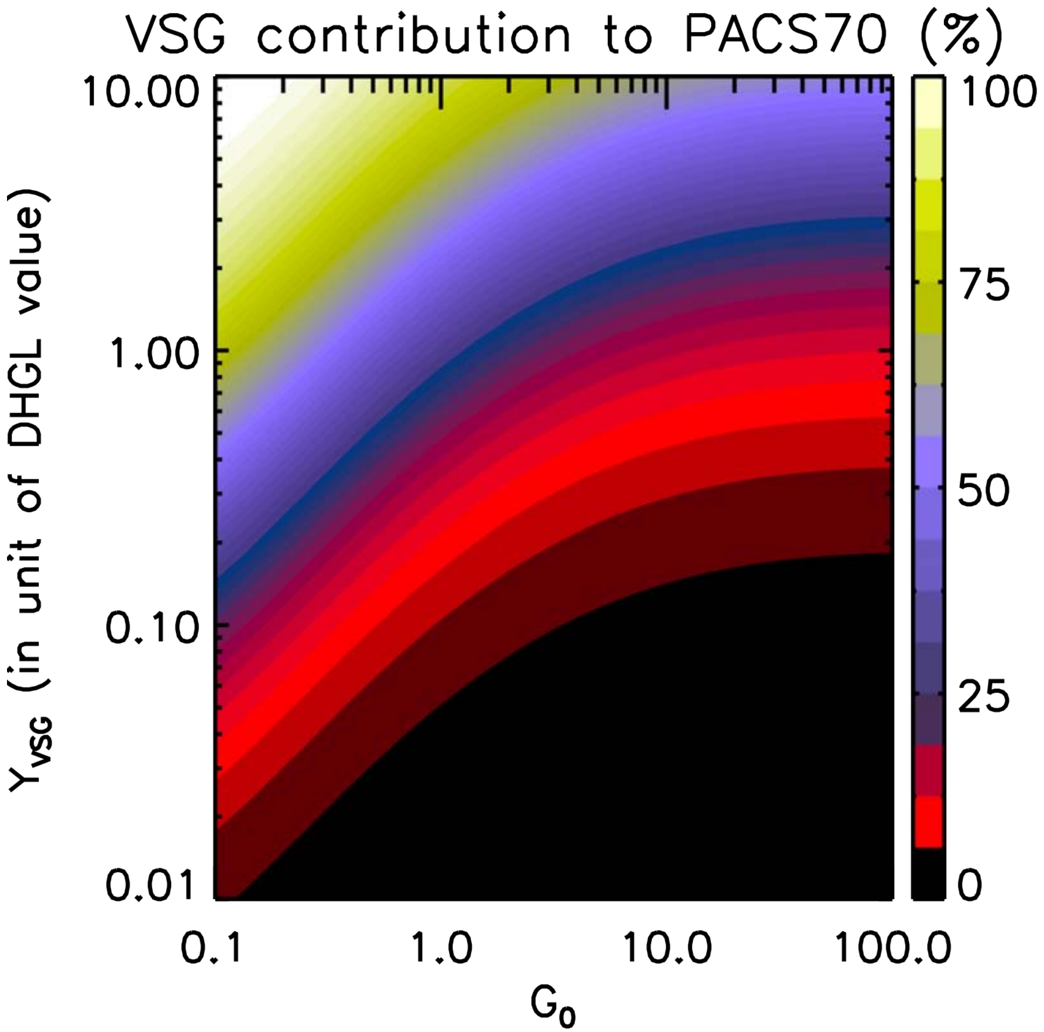



- From the modeled PACS images resulting from the fit :

→ PACS 70 VSG relative contributions : 56% and 9%

→ PACS 100 : 23% and 3 %
→ PACS 160 : 9% and 1%

# *PACS 70 VSG contribution (II)*



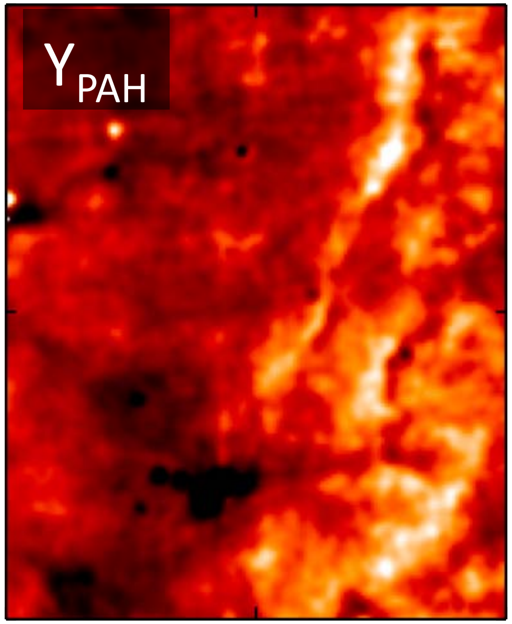

- At a given $G_0$, the contribution scales linearly with $Y_{VSG}$

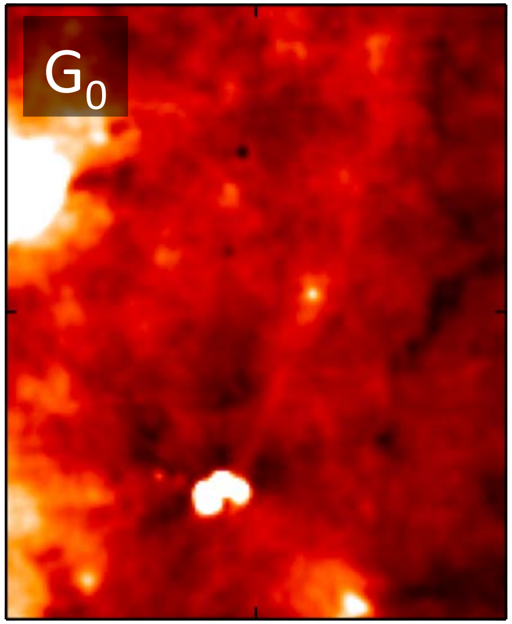
- At a given $Y_{VSG}$, VSG contribution decrease with $G_0$ Increasing.
  - ✓ $Y_{VSG}$= 1

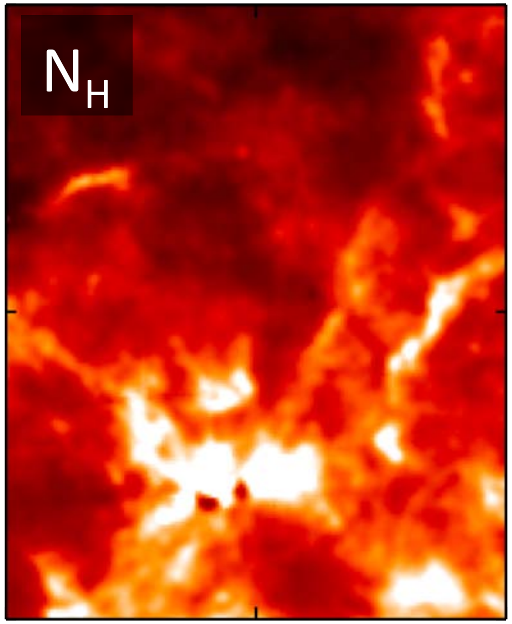
| $G_0$ | VSG contrib. |
|---|---|
| 0.5 | 37% |
| 1 | 25% |
| 10 | 11% |
| 100 | 9% |

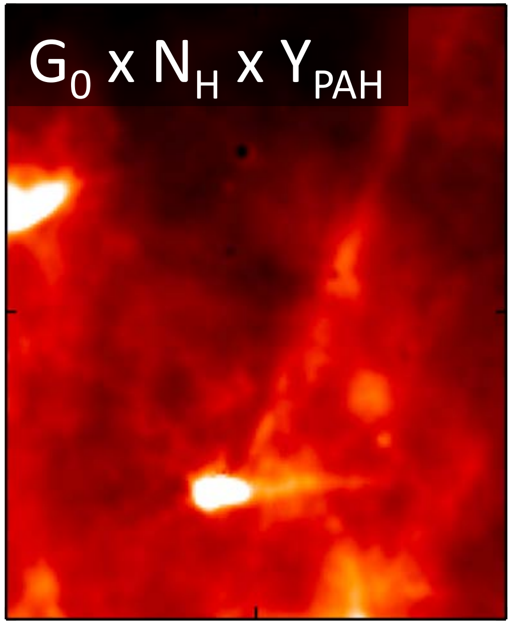
  - ✓Asymptotic for $G_0$>100 cause VSGs starts being at thermal equilibrium and behave like BGs.

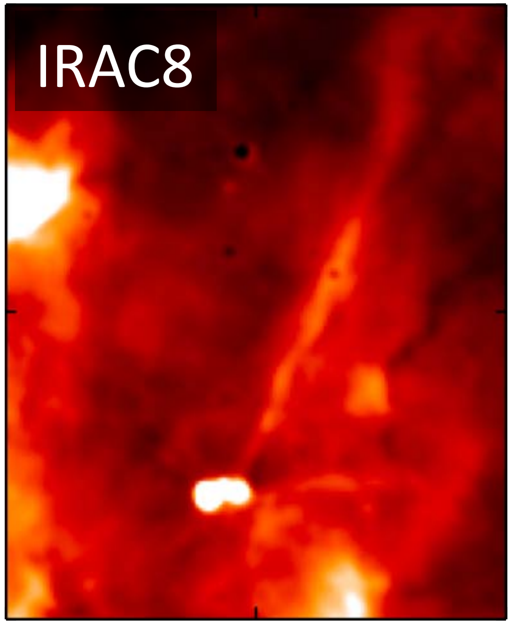
# *What does the IRAC 8 µm trace ?*




- IRAC8 does not trace $Y_{PAH}$
  Stochastically heated particles :
  $I_{PAH,\lambda} \propto G_0 \times N_H \times Y_{PAH}$

- Now by constraining $N_H$ and $G_0$ with BGs emission - we can actually constrain $Y_{PAH}$

- Extinction in IRAC8 map regarding $G_0 \times N_H \times Y_{PAH}$

# *Summary*

- PACS70 looks like shorter wavelengths cause it's enlighten by Wien part of BG emission (at $G_0$<100) and by VSGs

  → Very sensitive to $G_0$ (regarding longer wavelengths)

- VSG contribution can be very important in PACS70 (up to 56% in our field)

  → Dust model is needed to account for it depending on $Y_{VSG}$ and $G_0$ (a grey body does not do a good job)

- "Spitzer – Herschel" synergy + dust model fitting is very promising to quantify dust properties evolution on the entire galactic plan

  → Very near future :

  ✓ Correlation with BGs emissivity evolution (implemented in the fitting process)

  ✓ Correlation with gas physical properties (CO and HI cubes available)

  ✓ Can do that systematically and homogeneously overall the galactic plane