



# Evolution of interstellar dust (Preliminary results)

**Alain Abergel**

On behalf of the ISM SPIRE consortium group:

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# Scientific goals

- **Survey of the properties of interstellar dust with different conditions**  
Av, Illumination, Density, History, Star forming activity
- **Combination of Mapping and Spectroscopy (SPIRE and PACS)**  
Dust SED : Continuum  
Physical conditions : CI, CII, OI, high-level lines of CO.

## Contribution of all processes acting on the dust particles

Fragmentation / Coagulation / Condensation / Evaporation / Photo-processing

## ... in all interstellar environments :

- Most diffuse regions: 2 fields
- Cirrus, Molecular Clouds: 4 objects
- PDRs: 15 sources with different physical conditions
- Pre-stellar cores and clas-0 and class-1 protostars: 12 objects

## Selected targets in nearby regions,

with precise physical conditions and simple geometry, in order to derive the emission properties of dust

Source	$I_{100}^{-1}$
Shock processed dust	
Spica H II	1-4
IVC G86.5+59.6	1-2
Cirrus to Molecular Clouds	
Ursa Major	4-8
Polaris flare	5-10
G300-17/Cham III	8-18
Taurus filament	10-20
PDRs	
NGC7023	1000
Horsehead	500
IC63	100
Ced201	100
$\rho$ Oph filament	500
NGC7023 E	200
NGC2023	2000
IC59	100
Orion Bar	20,000
L1721	100
California	100
Hot PDRs with H II regions	
Sh2-104, Cygnus	
RCW 79	
RCW 82	
RCW120	
Pre-stellar cores	
L1544, Taurus	
L1521 E, Taurus	
L1521 F, Taurus	
L1689B, Ophiuchus	
Class 0 protostars	
IRAM04191, Taurus	
IRAS16293, Ophiuchus	
N1333-IRAS4, Perseus	
N6334I(N), NGC6334	
Class I protostars	
IRAS04191, Taurus	
L1489-IRS, Taurus	
EL29, Ophiuchus	
N6334I, NGC6334	

# Observations

## SPIRE and PACS photometers in the Science Demonstration Phase:

RCW 120

NGC 7023

Polaris (common field with the Gould belt KP)

## SPIRE/FTS (single pointings) in the Performance Verification Phase:

Orion Bar

Other galactic objects:

G29.96-0.02

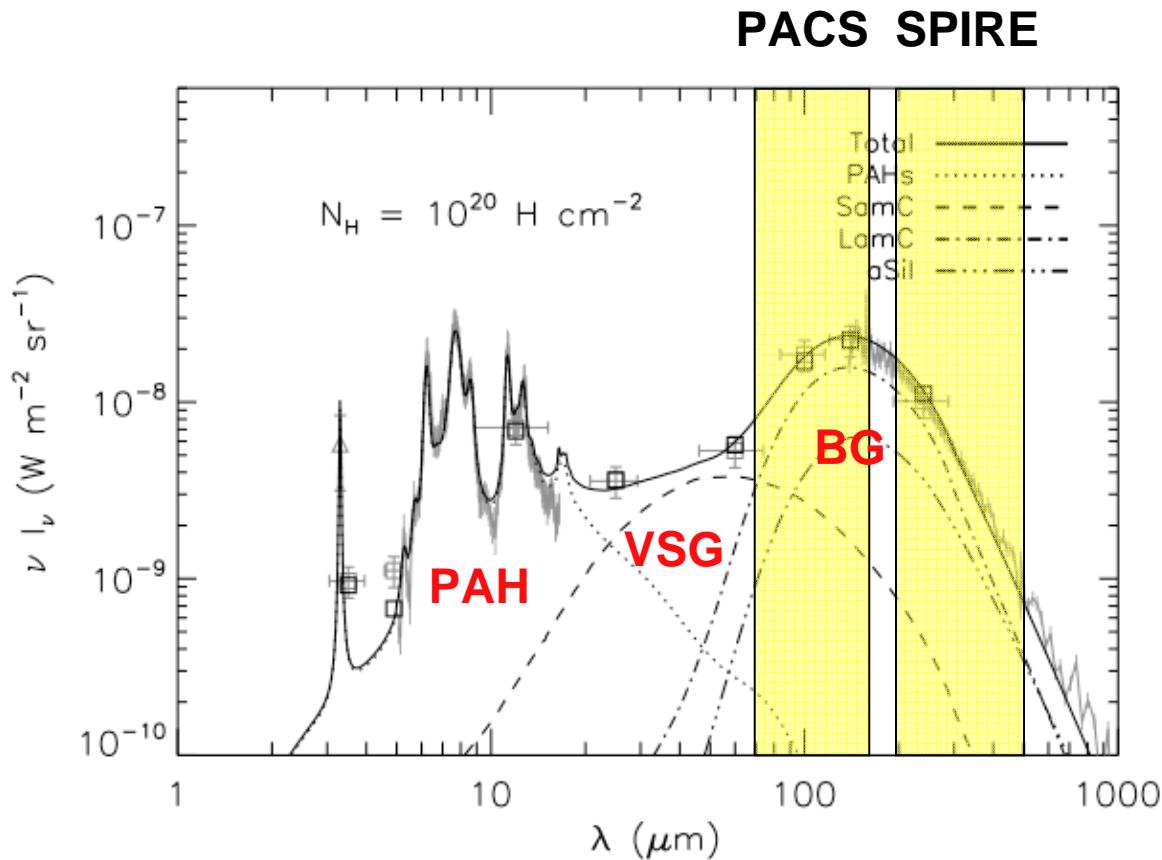
Compact HII region (9 kpc)

G32.80+0.19

Compact HII region (13 kpc)

All results are preliminary

# Dust emission spectrum (diffuse medium)



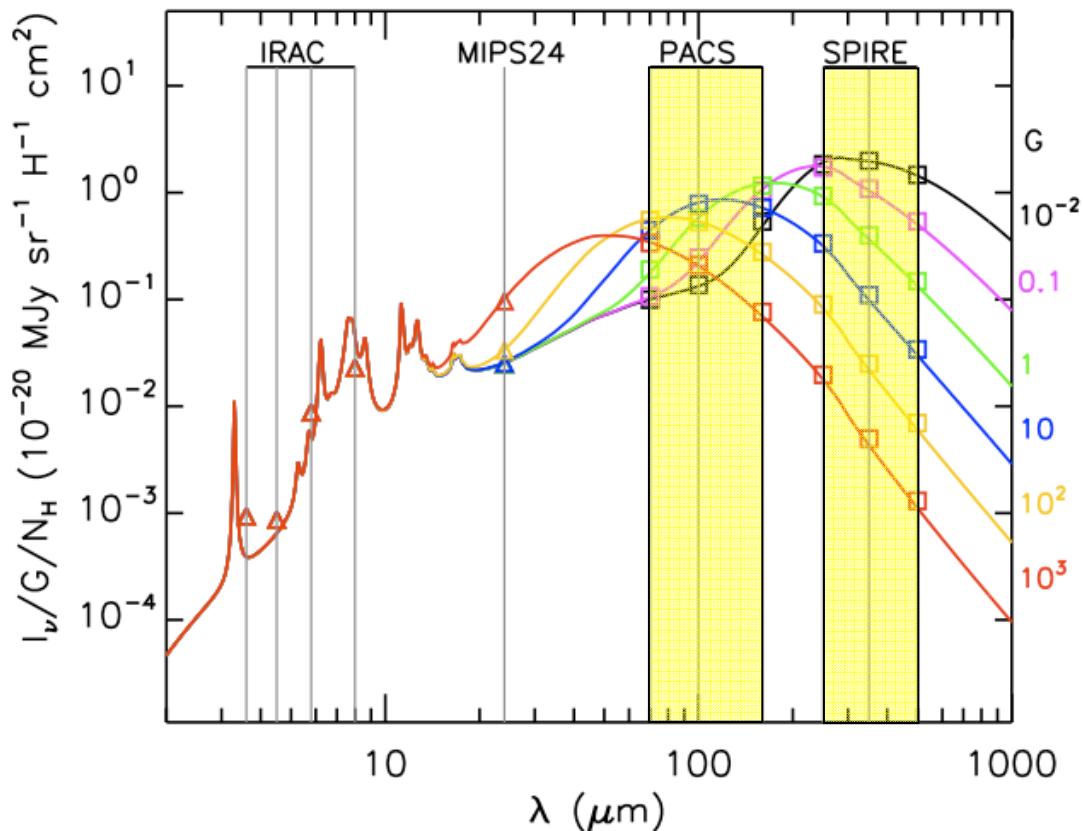
Dust Model : Compiegne et al. 2010 (update of Desert et al. 1990)

Polycyclic Aromatic Hydrocarbons (0.4-1 nm) : Aromatic IR Bands + FUV extinction

Very Small Grains (1-10 nm) : IR continuum + UV extinction

Big Grains (10-100 nm) : sub-mm emission + extinction

# Variation with the excitation



$$I_{\lambda} = \tau_{\lambda_0} \left( \frac{\lambda}{\lambda_0} \right)^{-\beta} B_{\lambda}(T)$$

PACS alone: T

SPIRE alone:  $\beta$

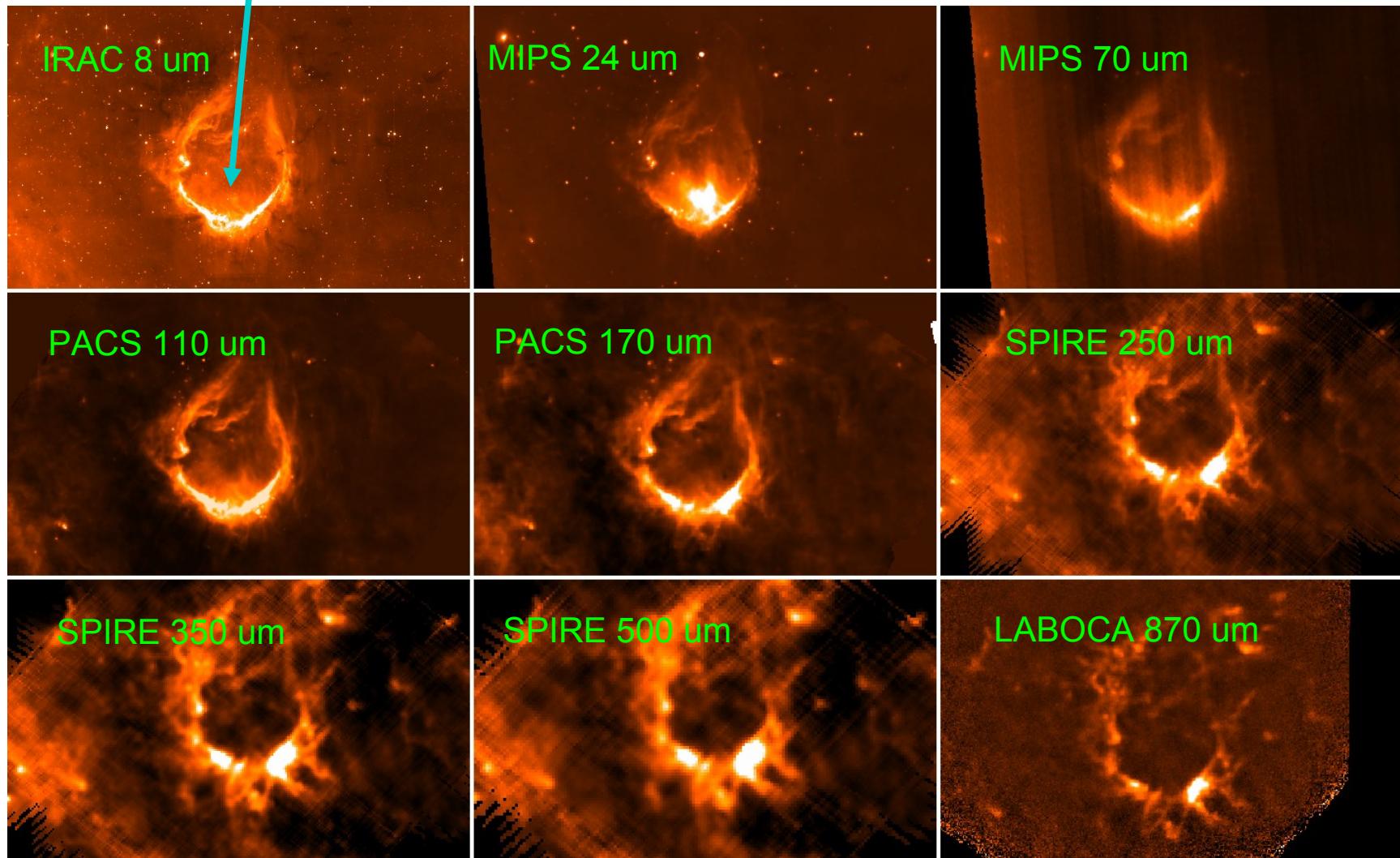
T below 10 K

PACS+SPIRE: T,  $\beta$

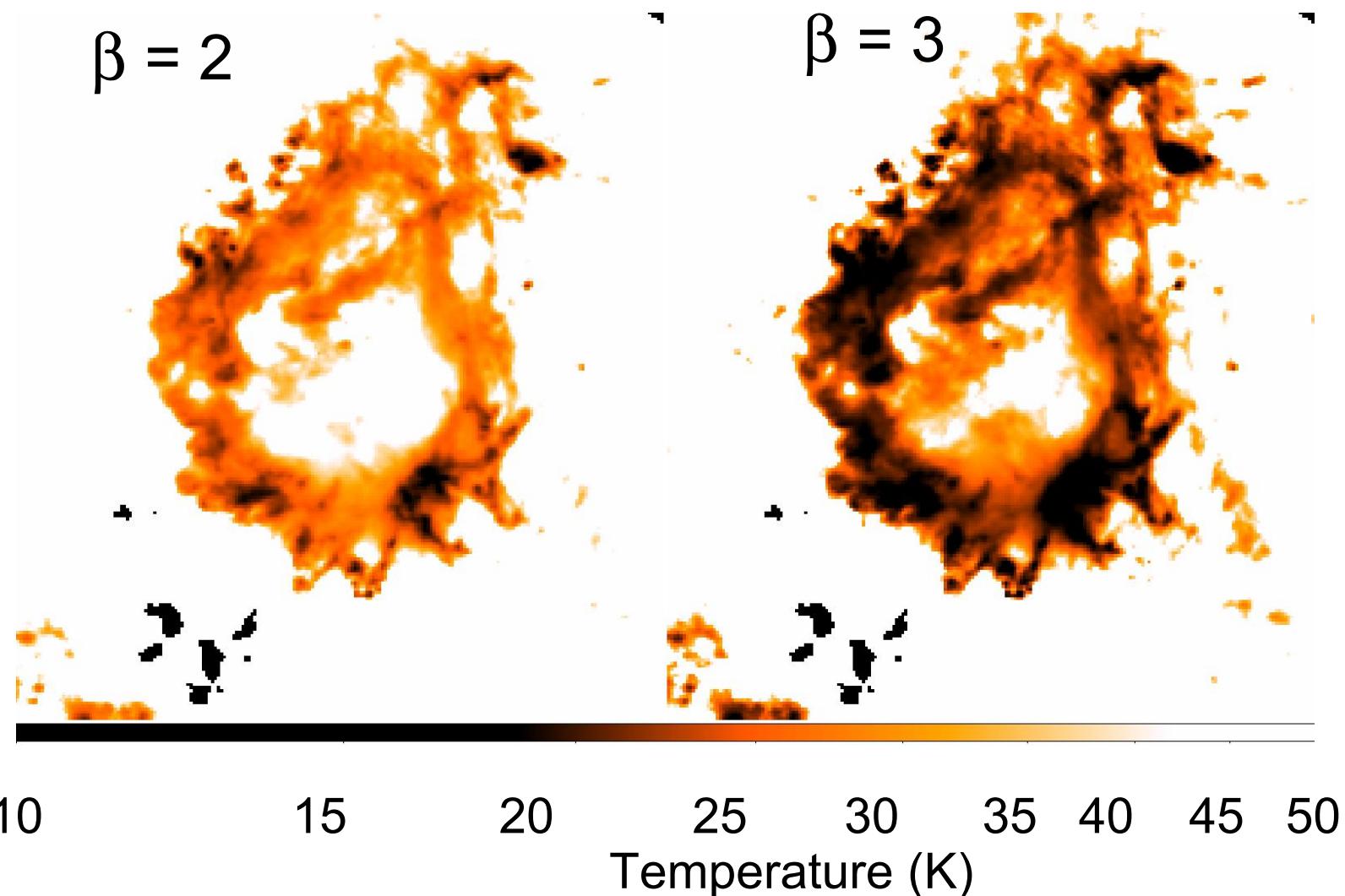
Compiegne et al. 2010

# Hot PDR: RCW 120, d= 1200 pc

O8 Star CD-38.11636 08, T= 40,000 K



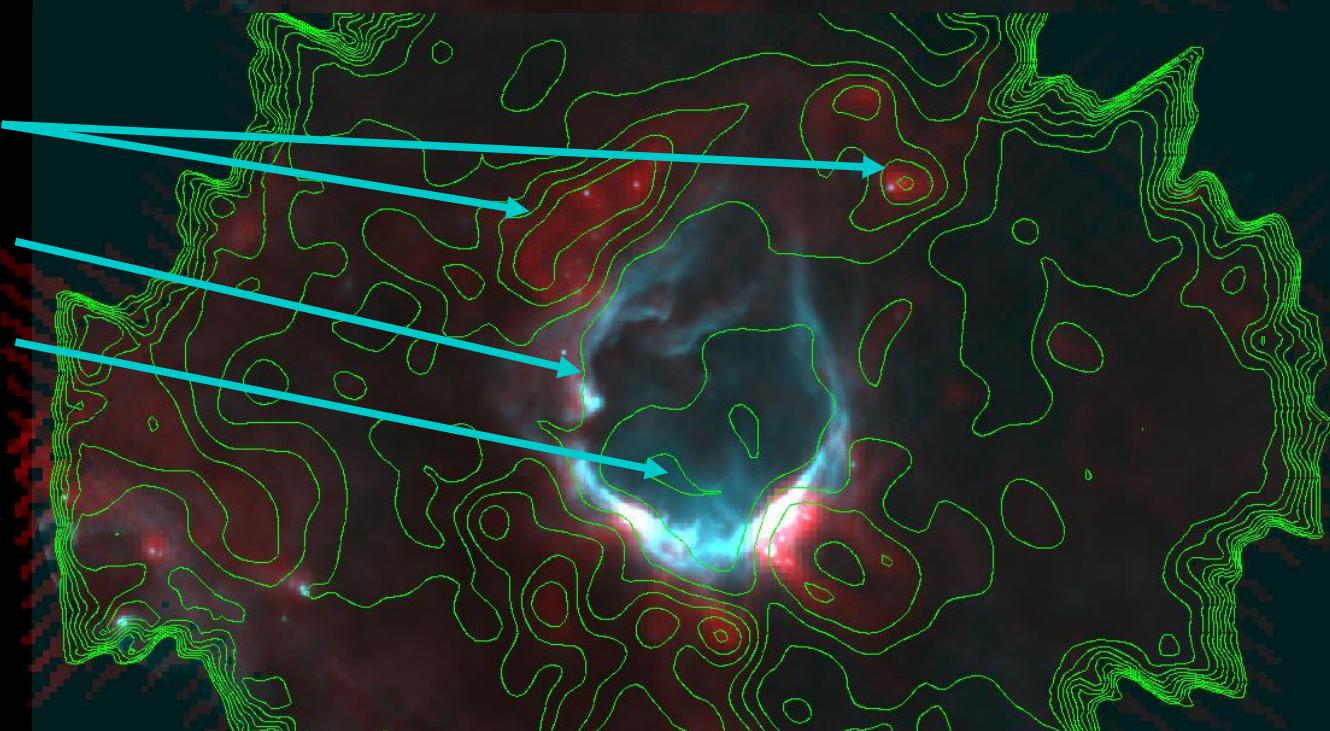
# RCW 120: Temperature Maps from 170/110 Flux Ratio (preliminar)



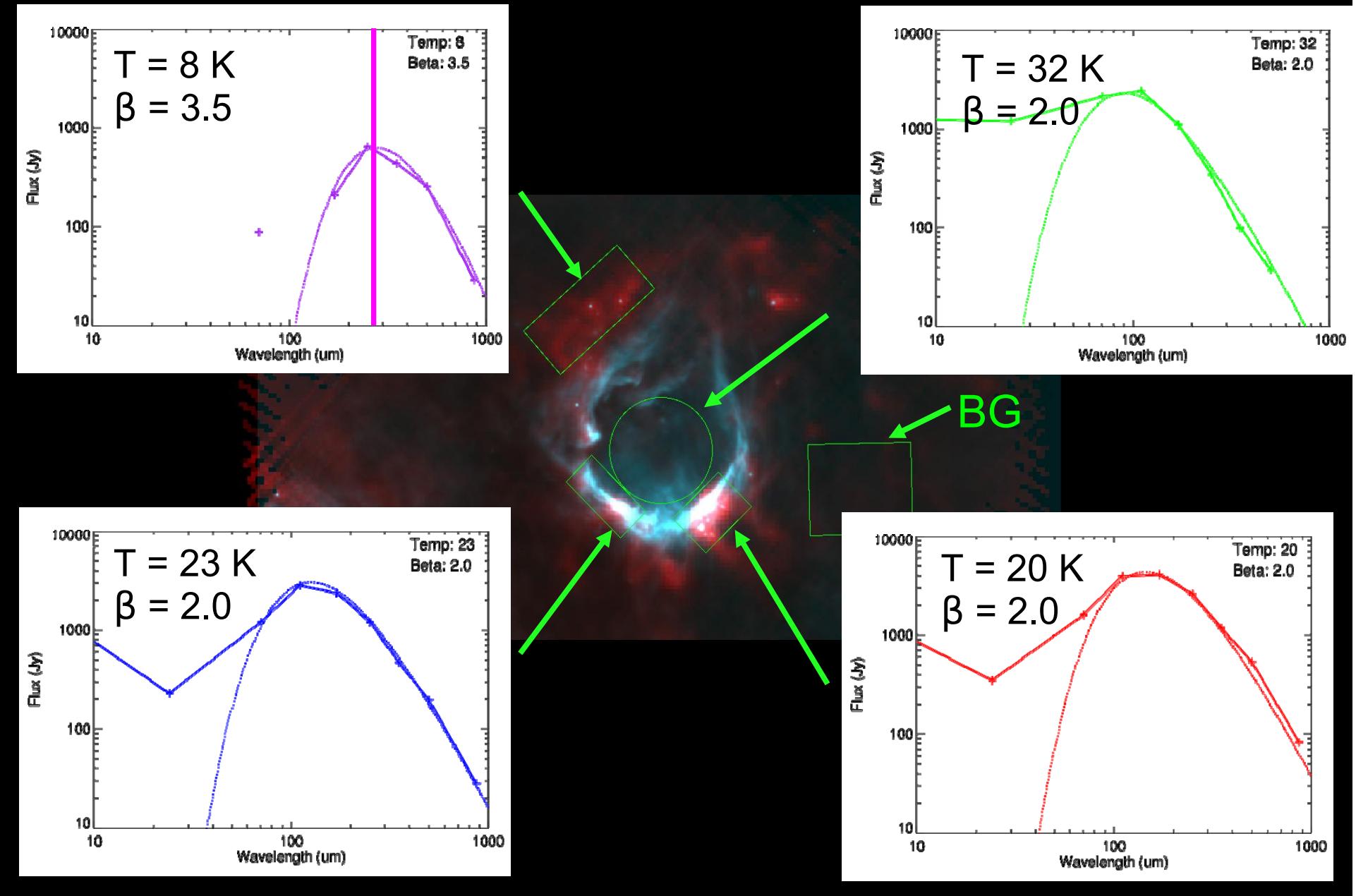
PACS 110  $\mu\text{m}$   
SPIRE 500  $\mu\text{m}$

SPIRE + PACS  
SED Fitting

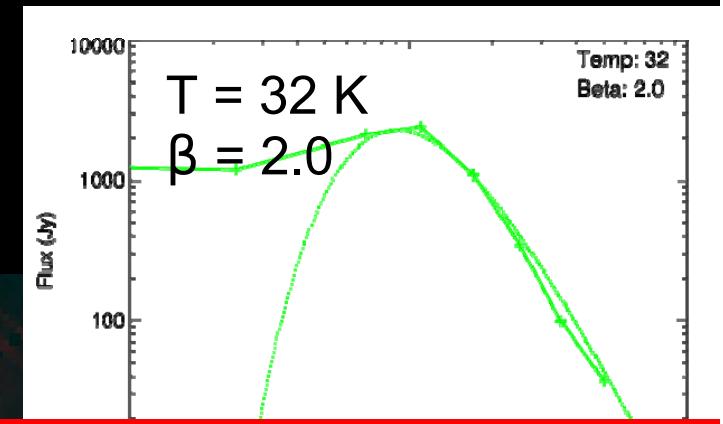
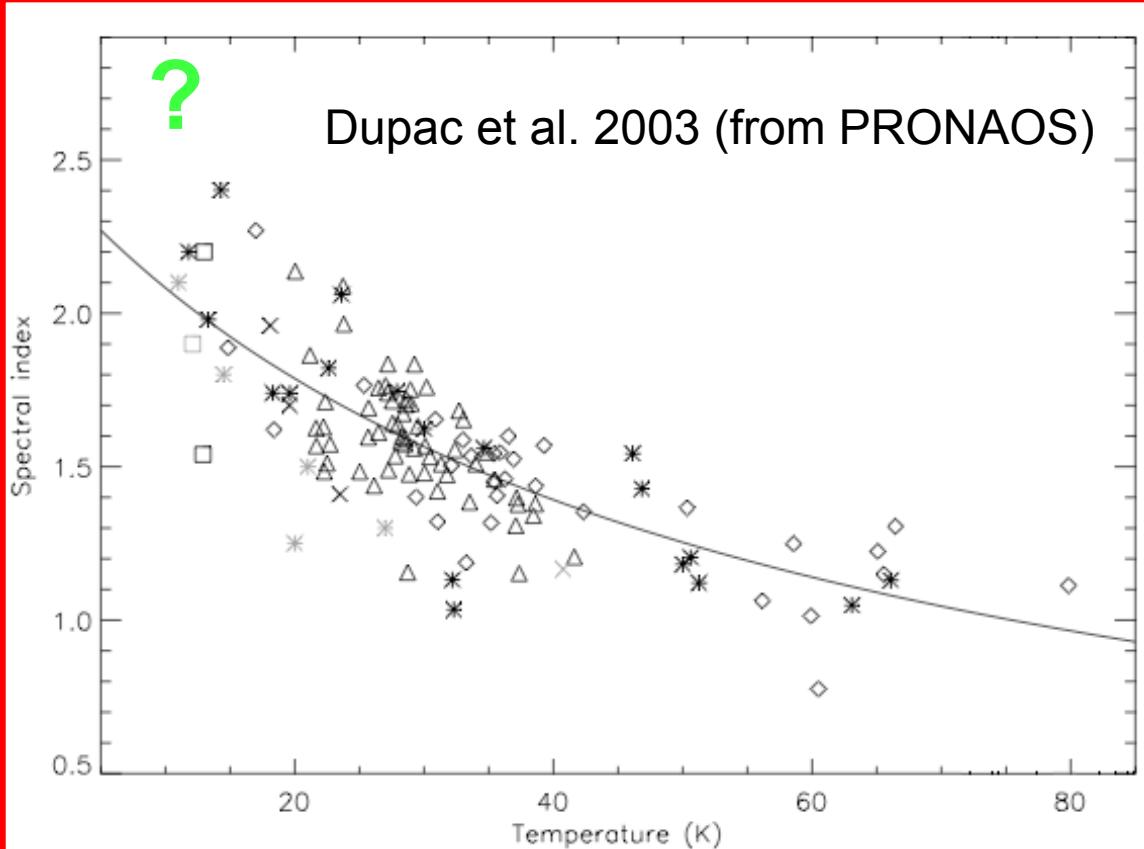
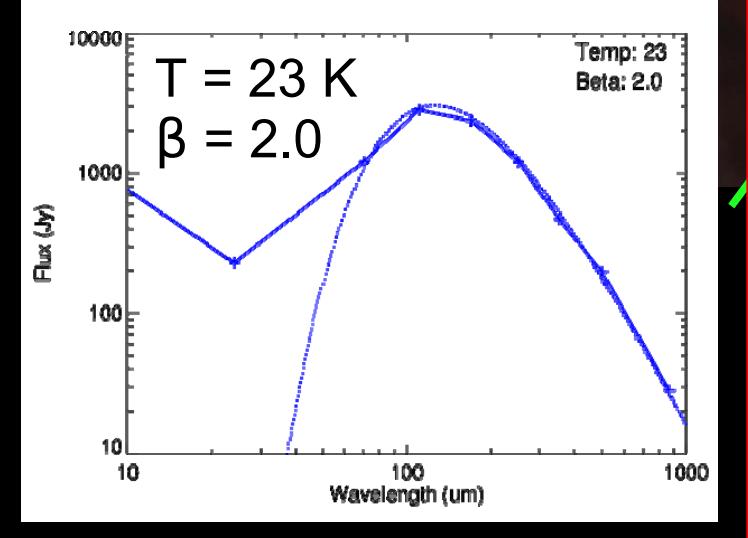
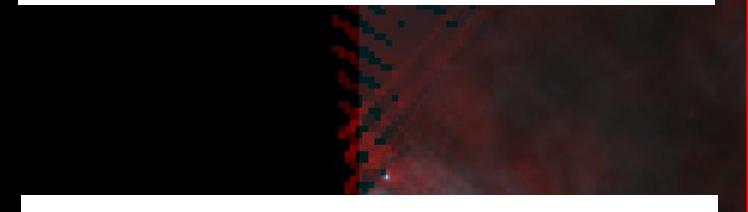
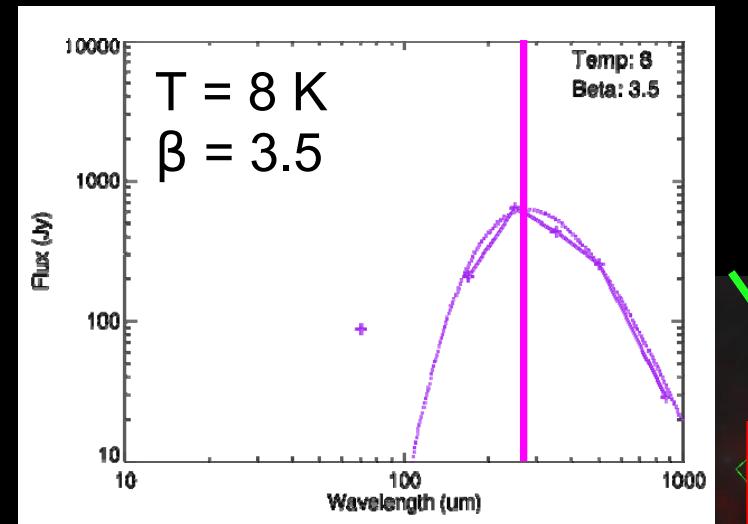
15 K  
20 K  
23 K



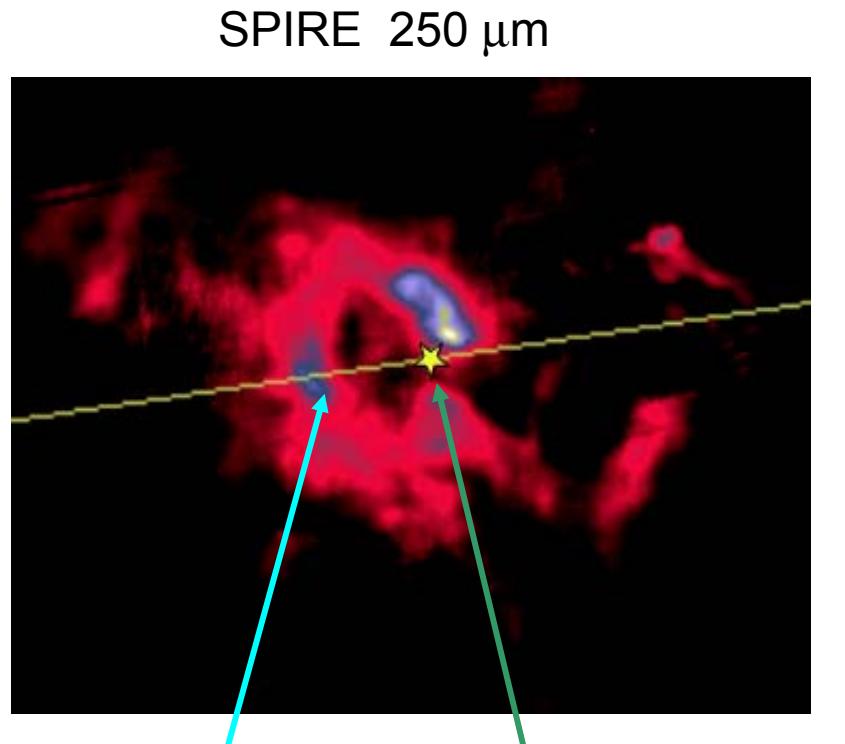
# Aperture Photometry (preliminar)



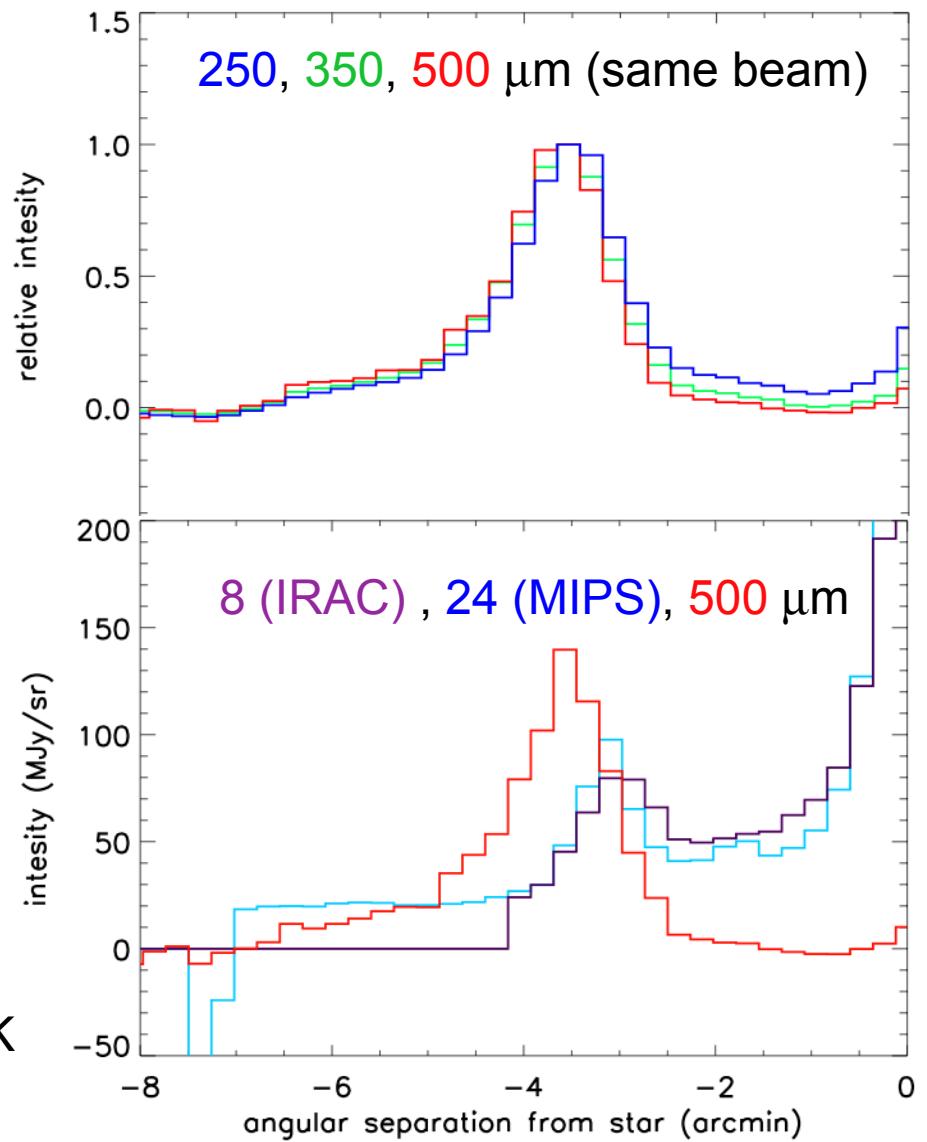
# Aperture Photometry (preliminar)



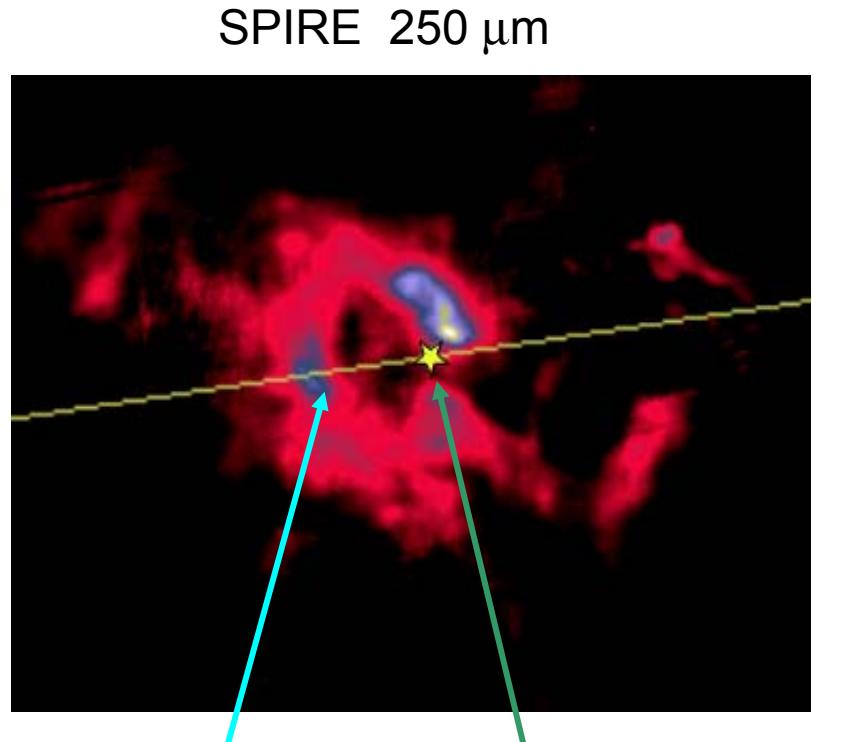
# Classical PDR : NGC 7023, $d = 440$ pc



$G_0 = 200$   
 HD 200775  
 B2Ve,  $T = 17,000$  K



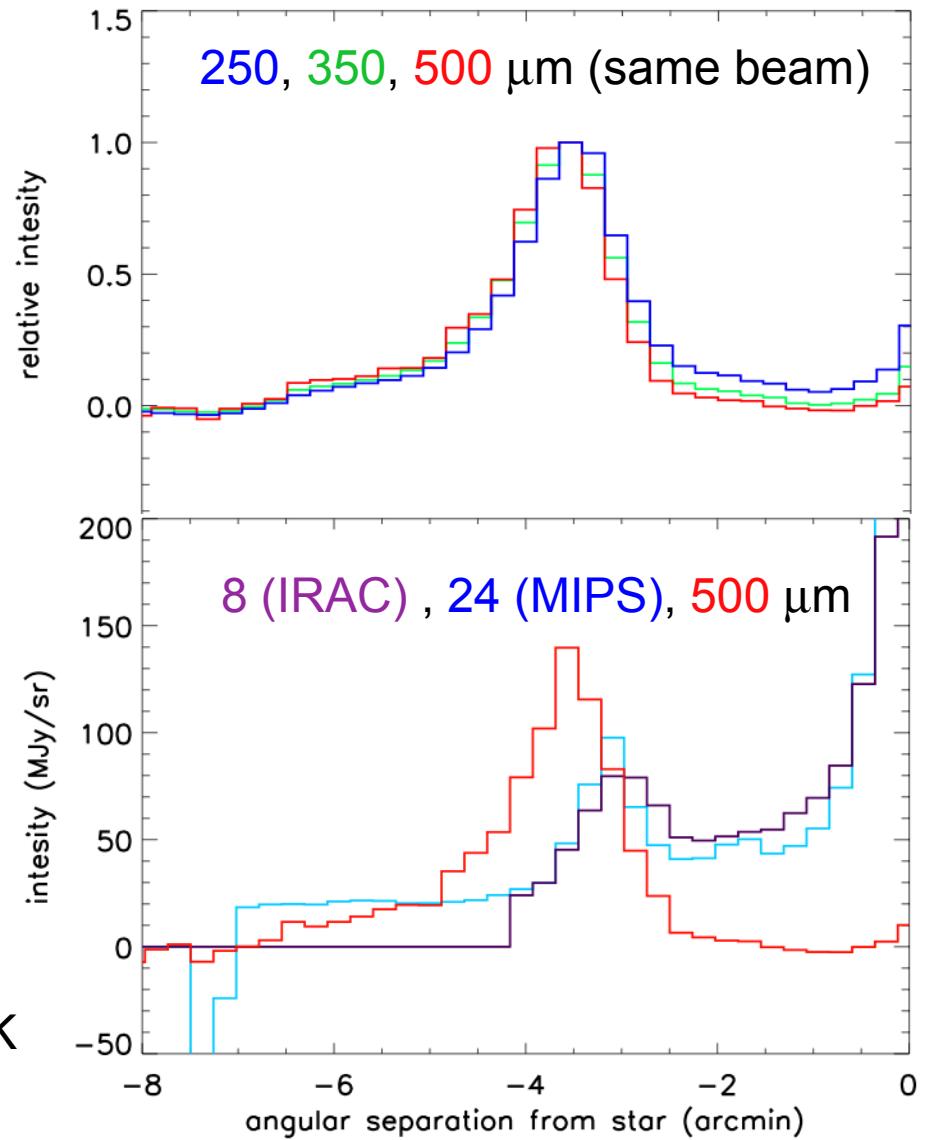
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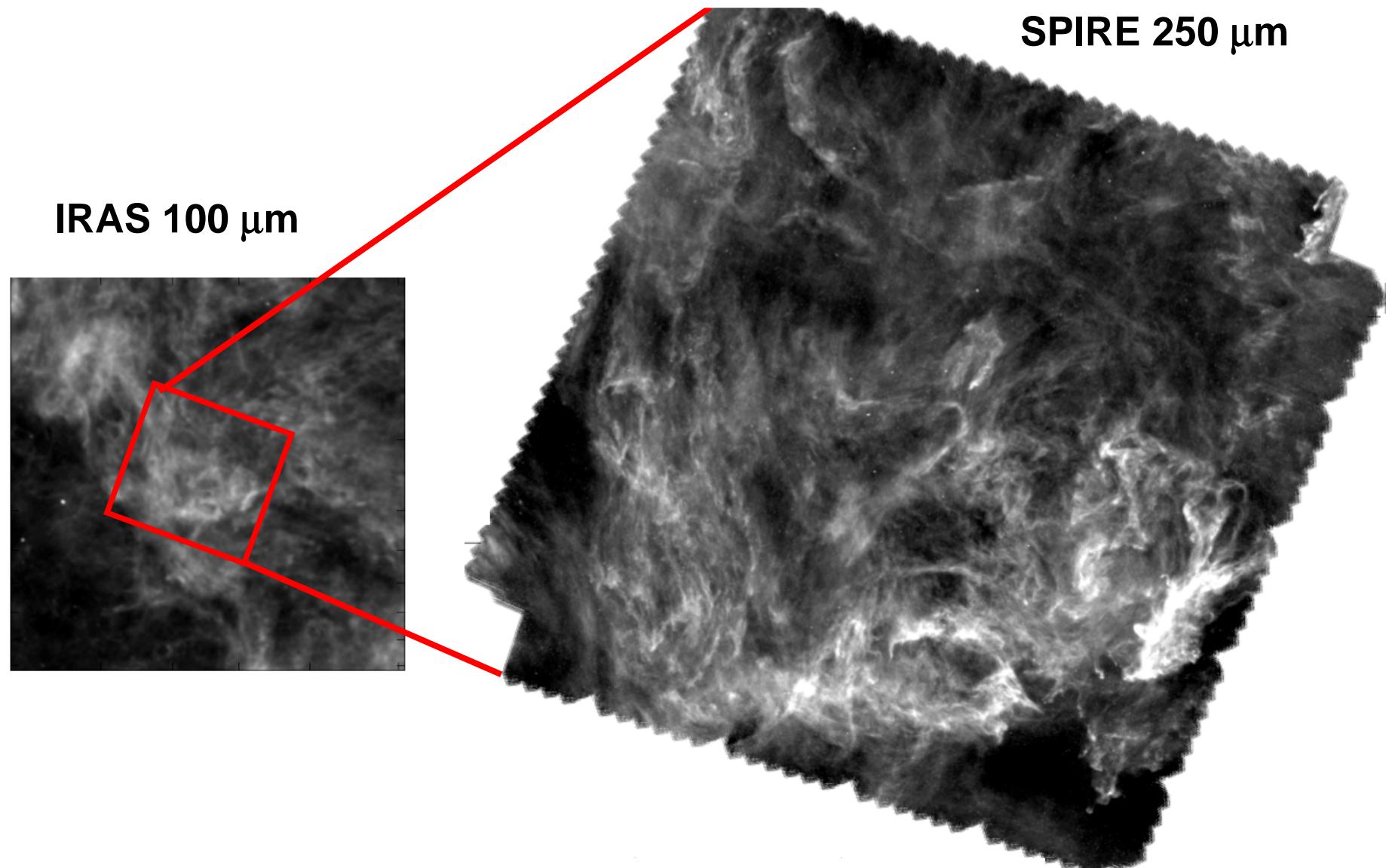
$G_0 = 200$

HD 200775

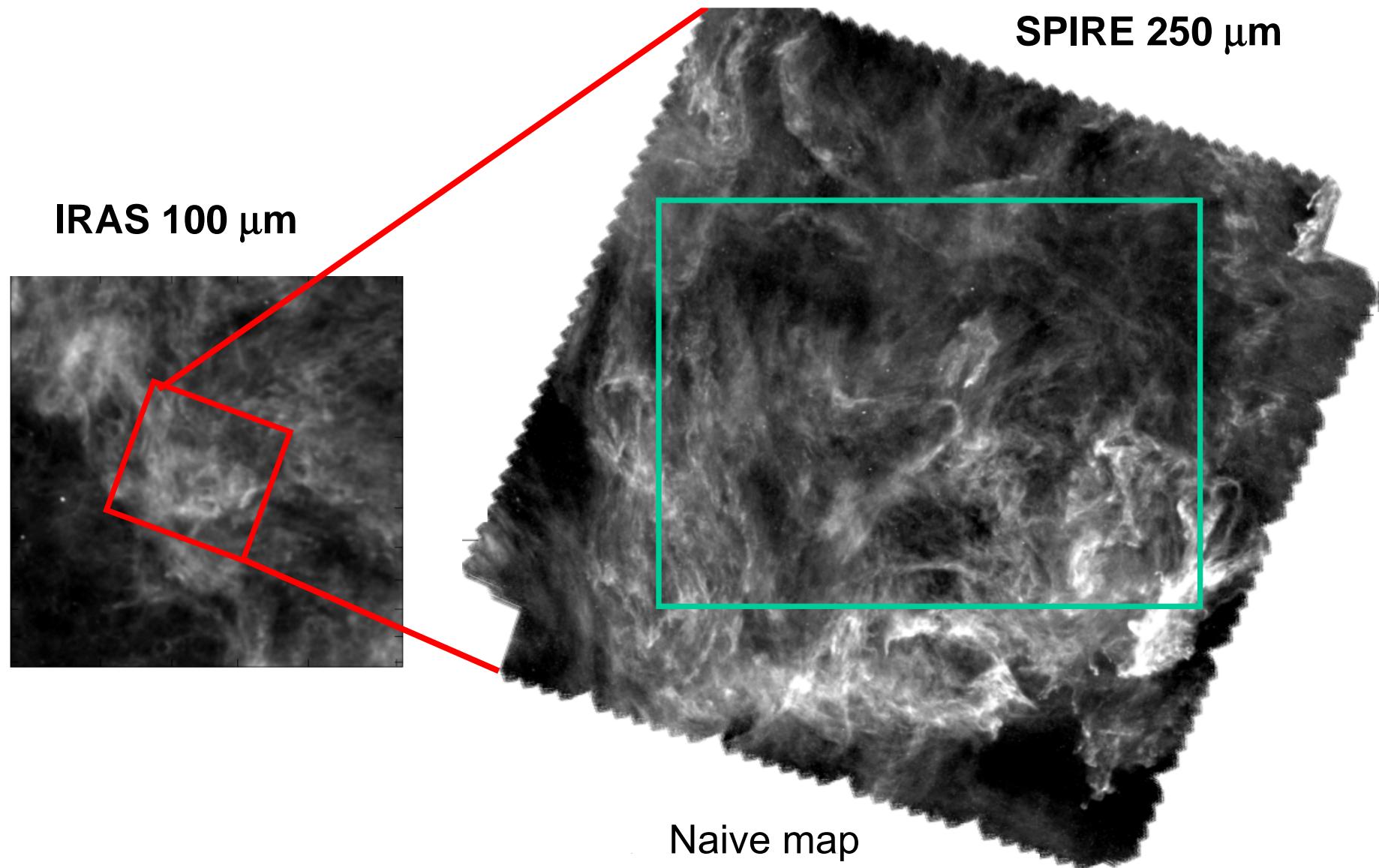
B2Ve,  $T = 17,000$  K

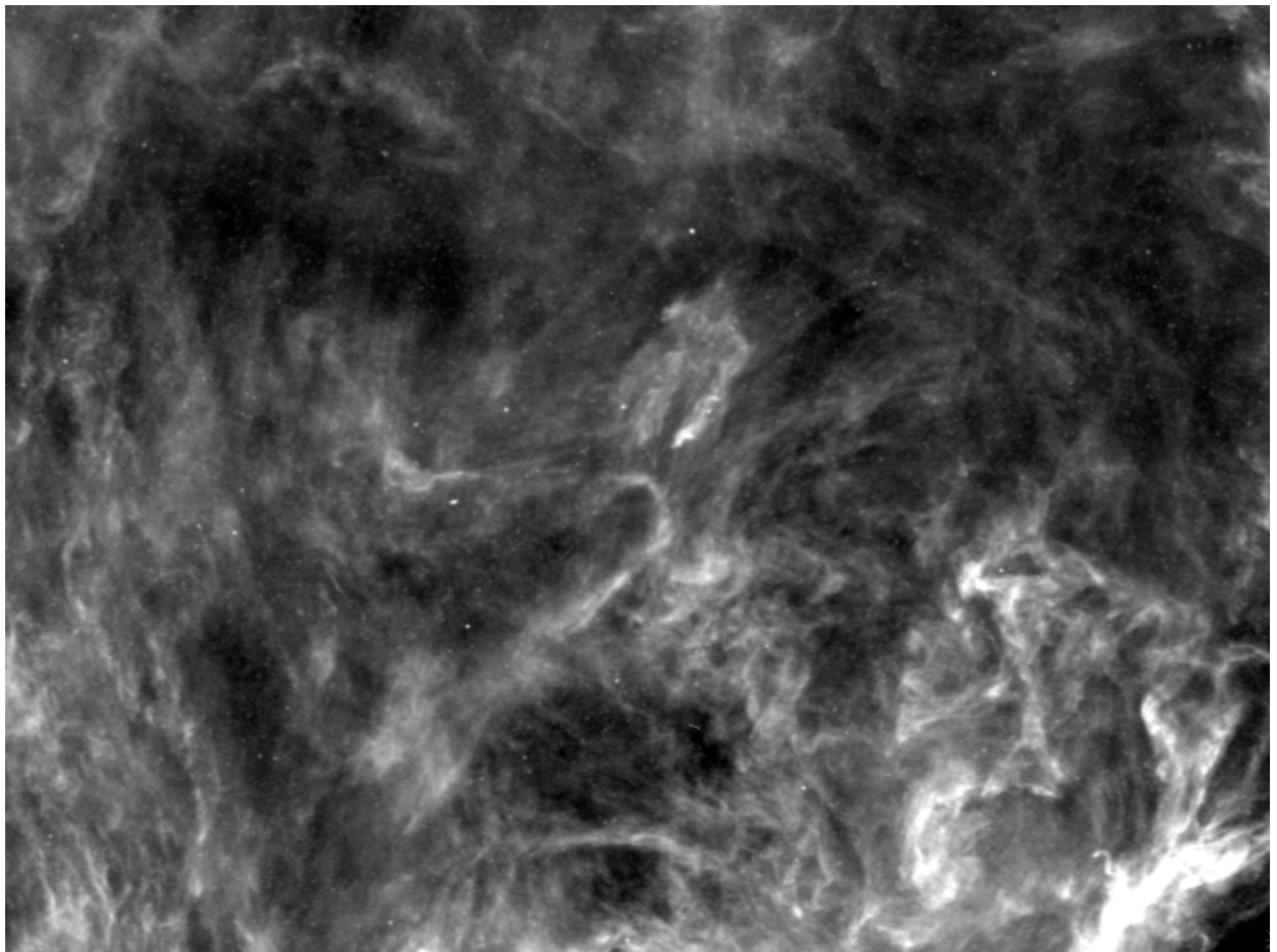


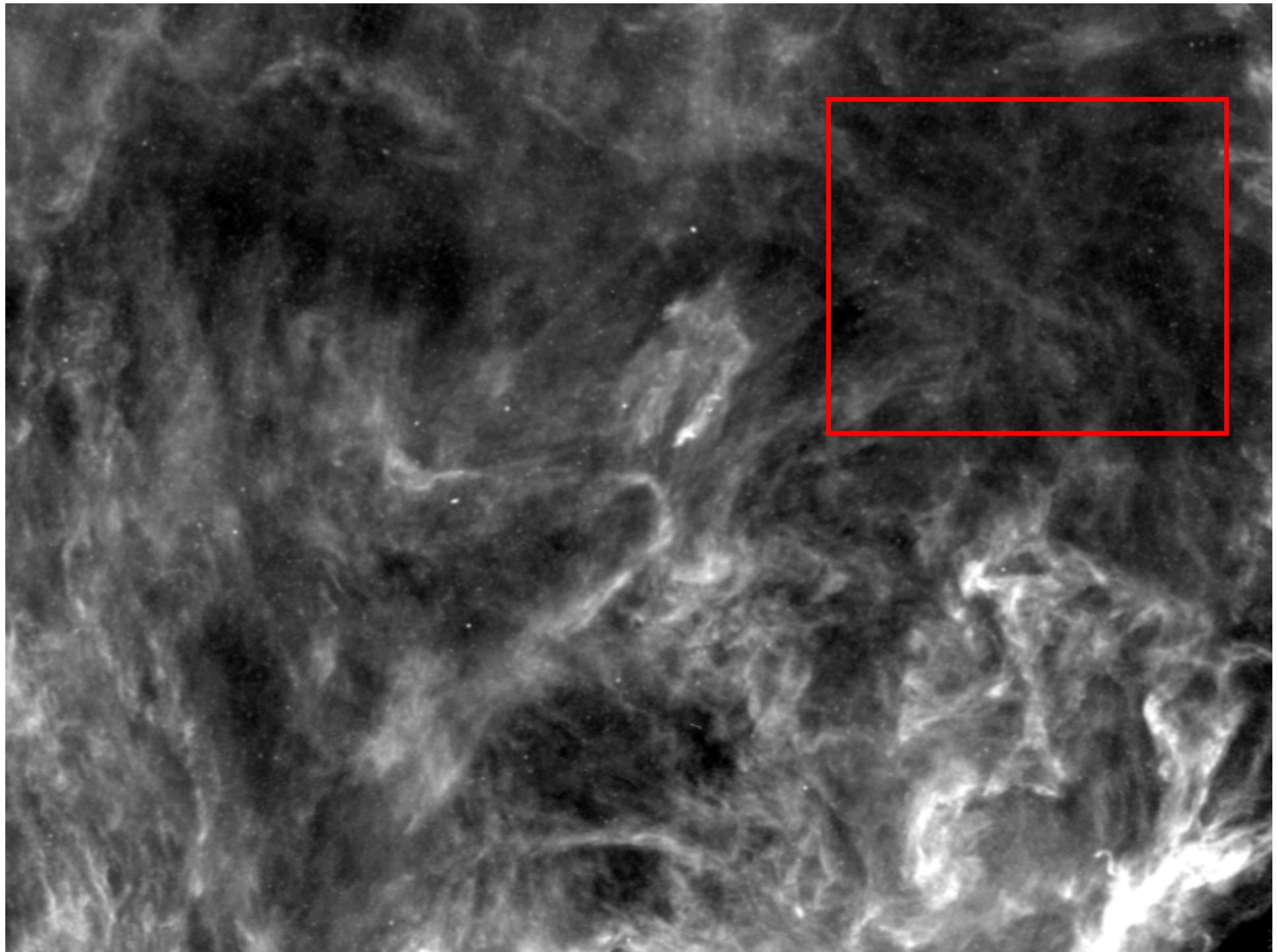
# Polaris : a cirrus/molecular cloud

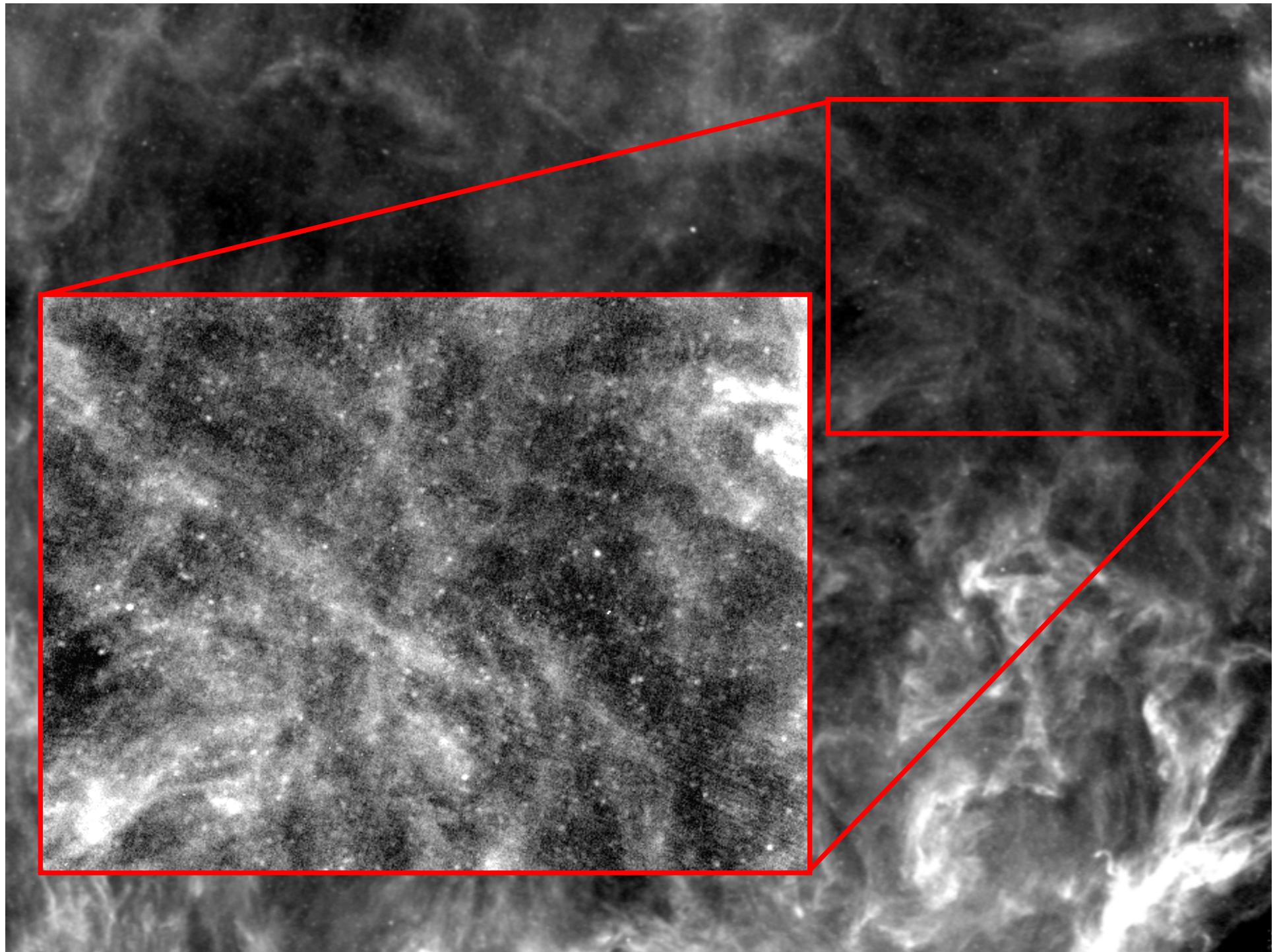


# Polaris : a cirrus/molecular cloud

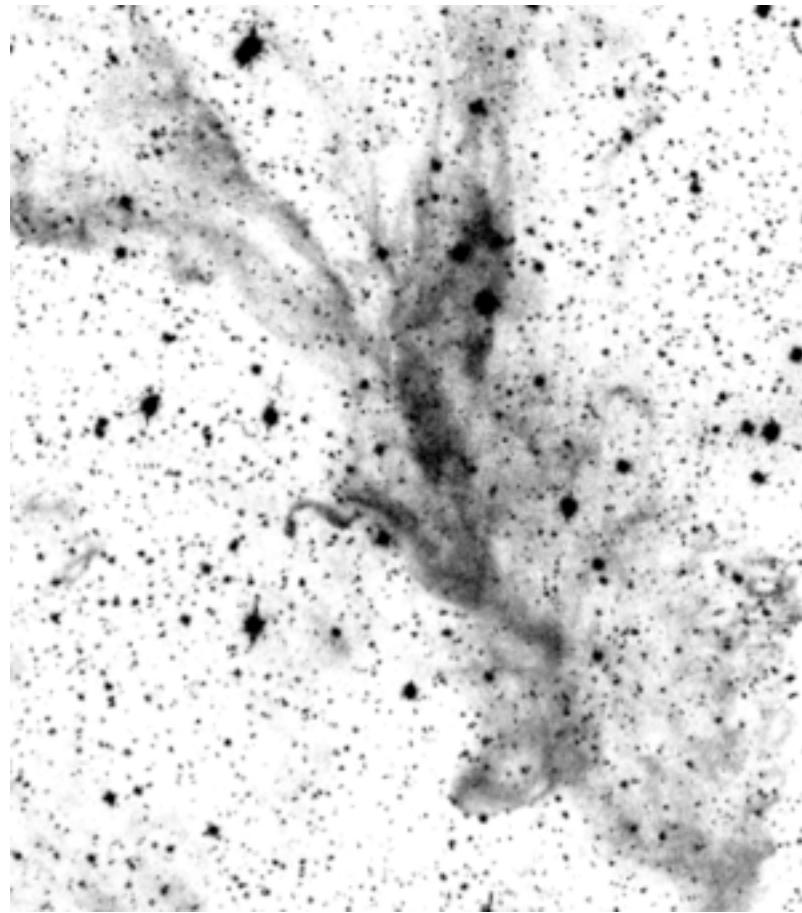






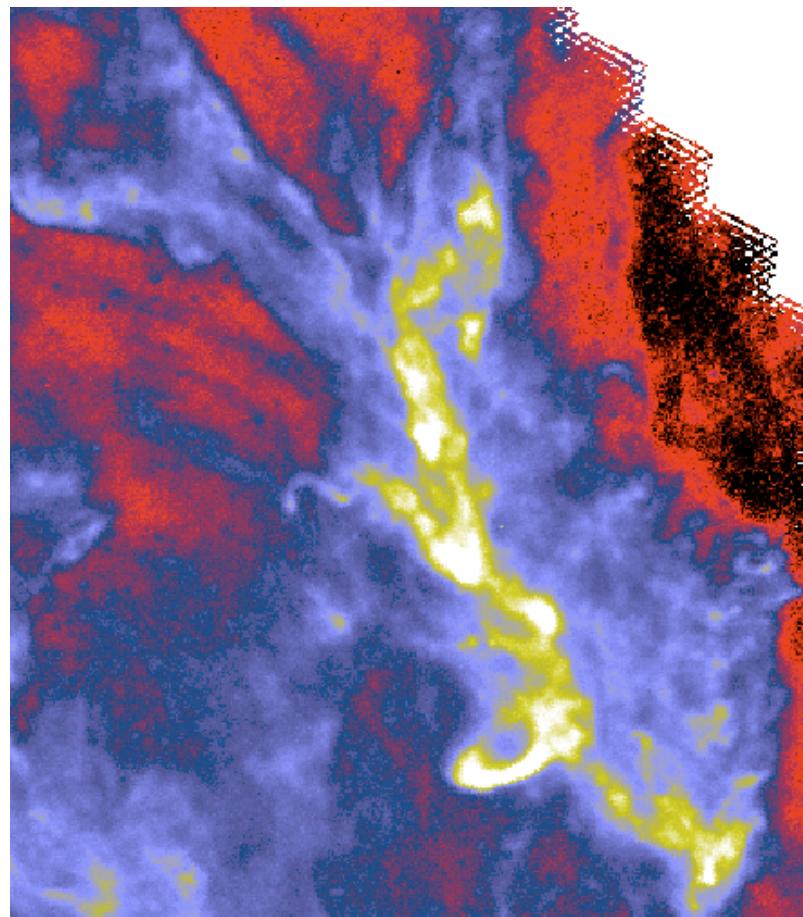


Optical image (I band)



Zagury et al. 1999

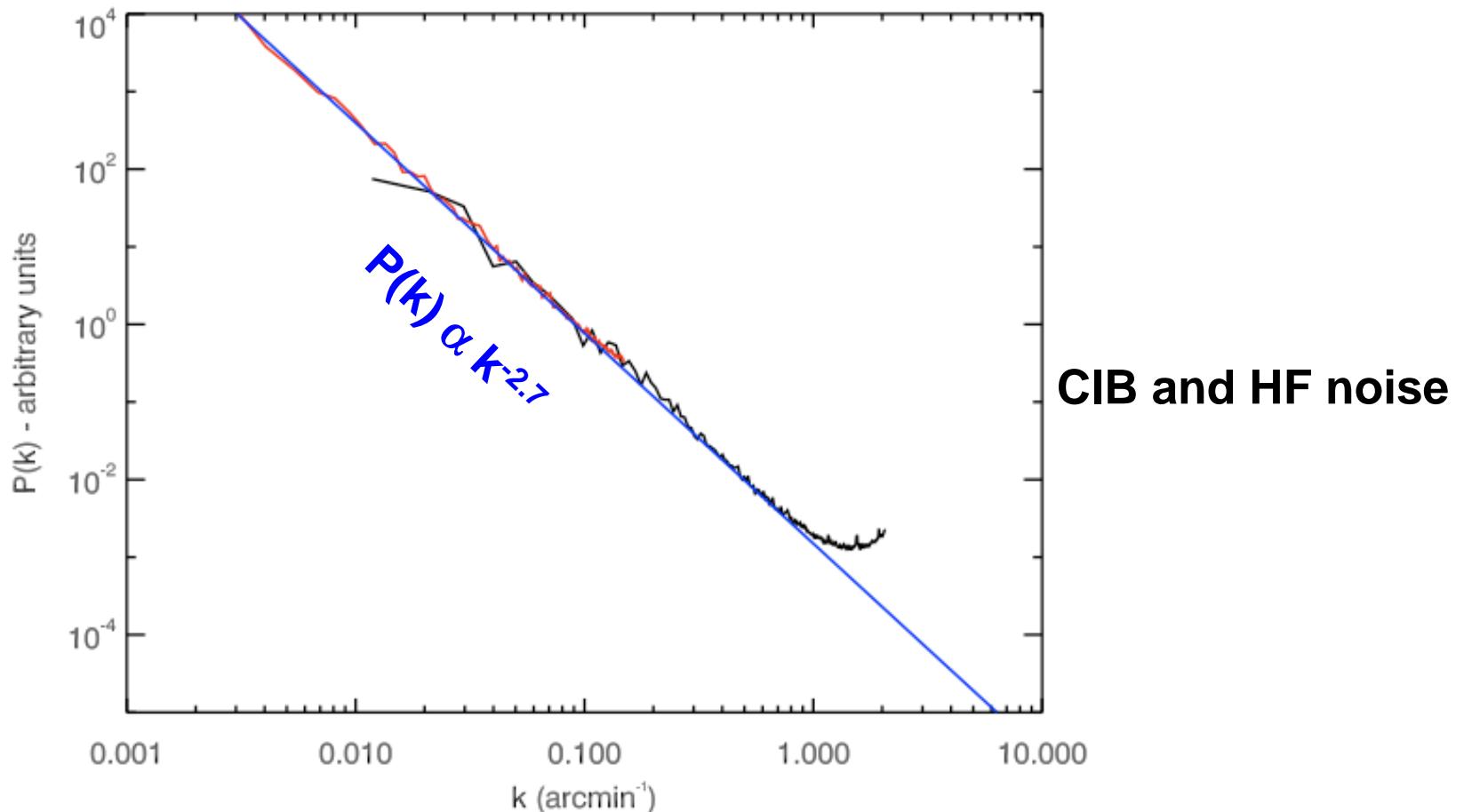
SPIRE 250  $\mu\text{m}$



# Polaris at 250 mm

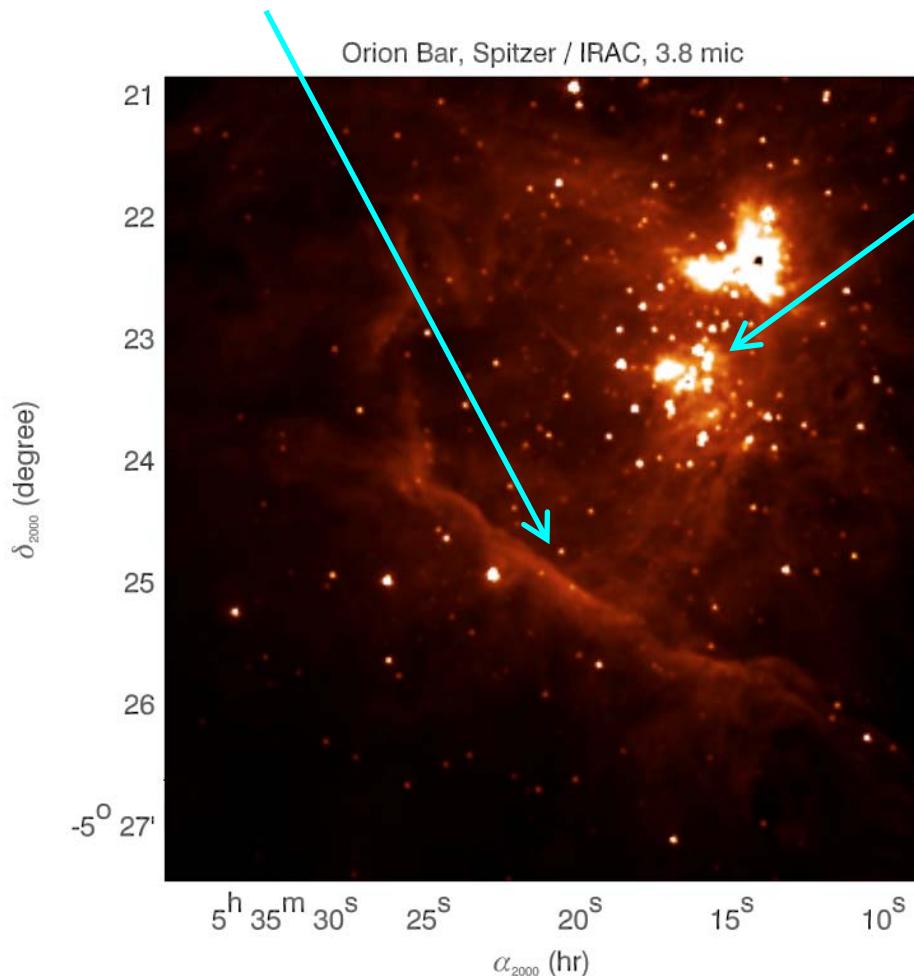
## Power spectrum (preliminar)

IRAS 100  $\mu\text{m}$  SPIRE 250  $\mu\text{m}$  (PSF corrected)



# Orion Bar

$\chi = 4.4 \cdot 10^4$

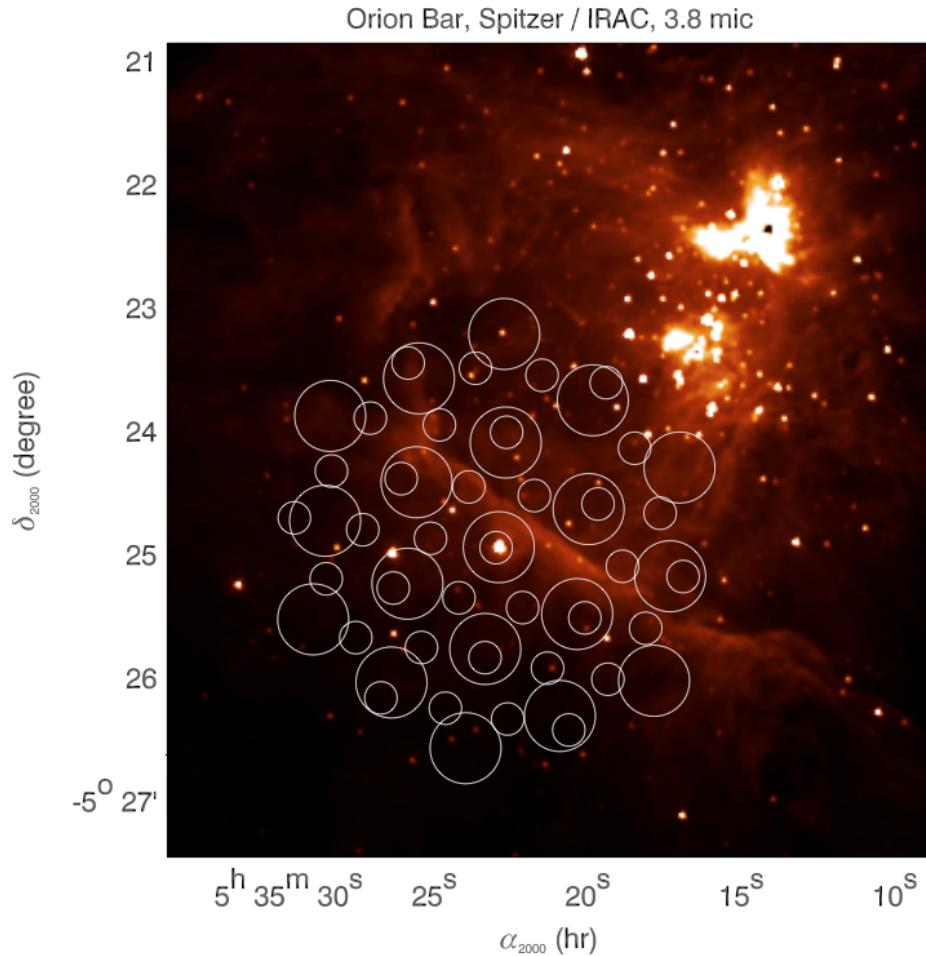


Main heating source:  
Trapezium OB association  
 $\Theta^1 C\,Ori, O6pe, T = 40,000\,K$

QuickTime™ et un décompresseur sont requis pour visionner cette image.

Pellegrini et al. (2009)

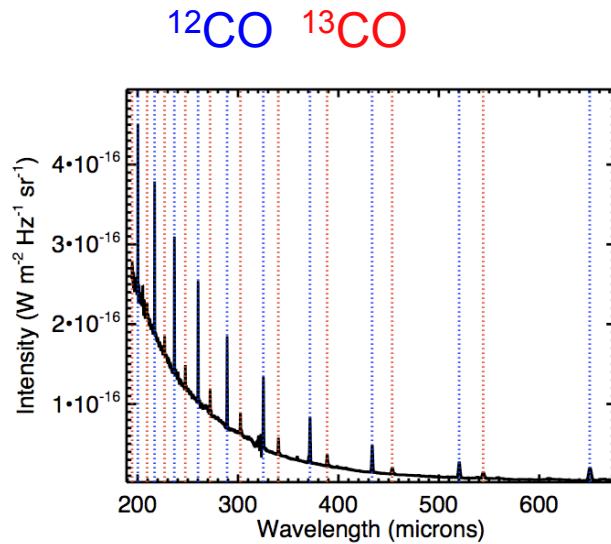
# Orion Bar: SPIRE/FTS observations



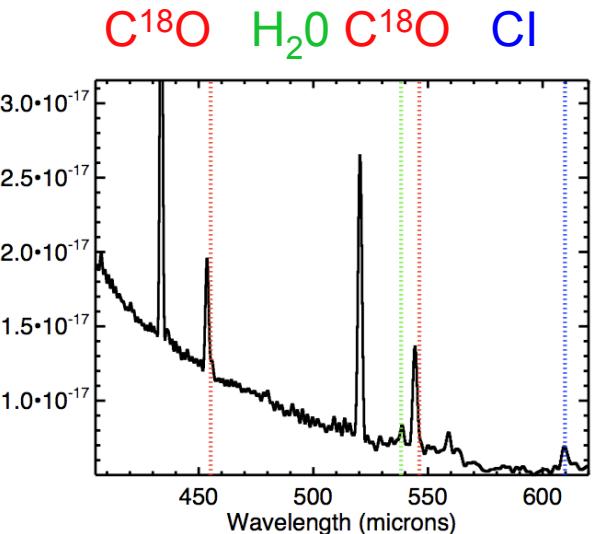
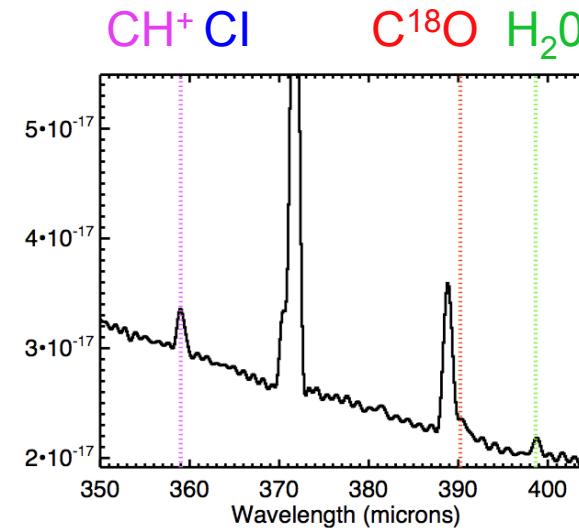
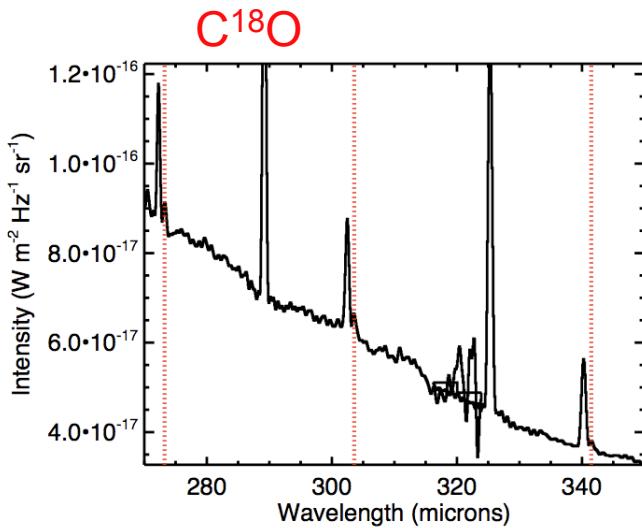
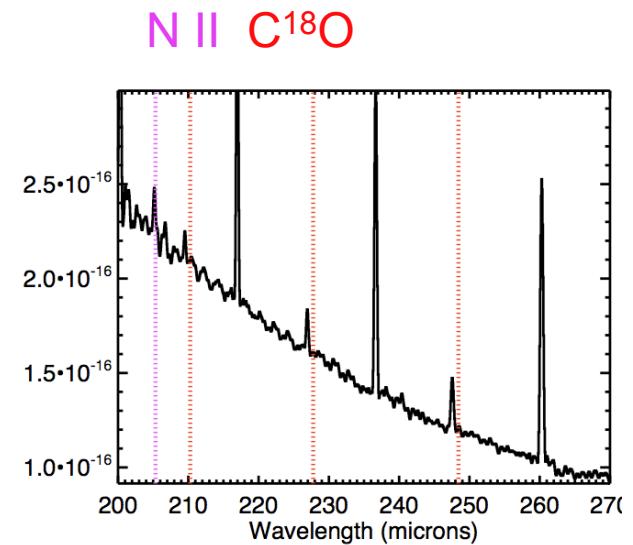
Single pointing, HR, Duration: 266.45 s, 2 repetitions (2 scans/repetition)

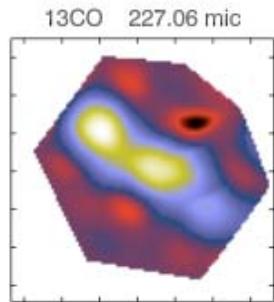


# Orion Bar : On-axis pair of bolometers Detected gas lines (preliminar)



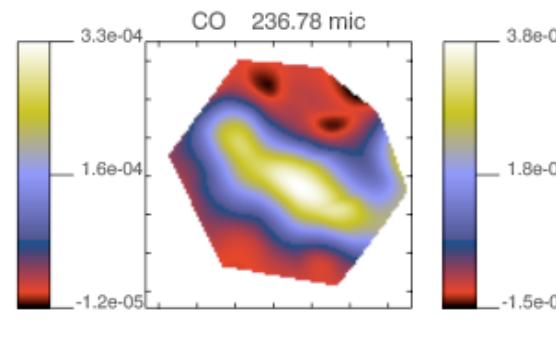
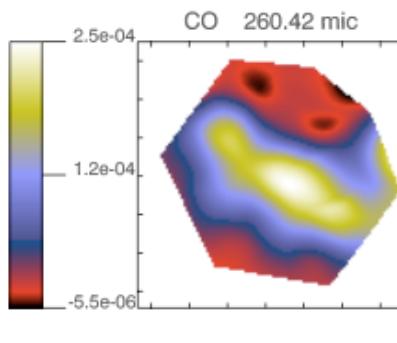
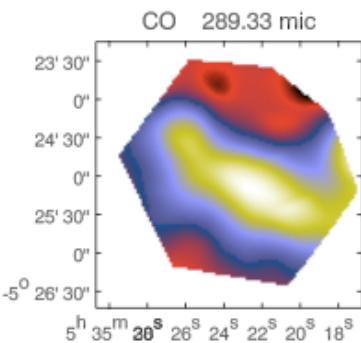
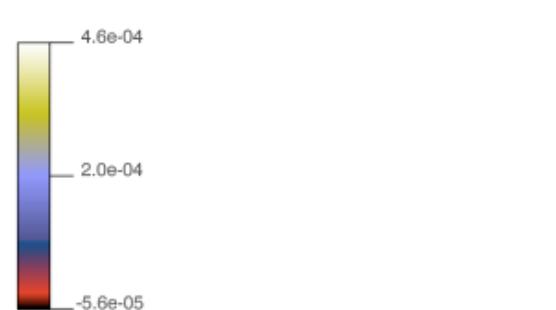
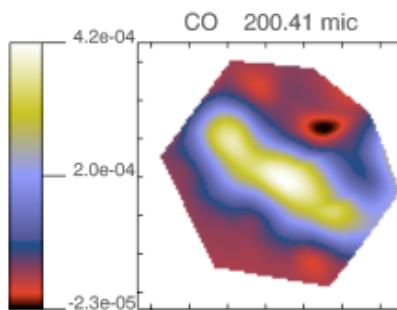
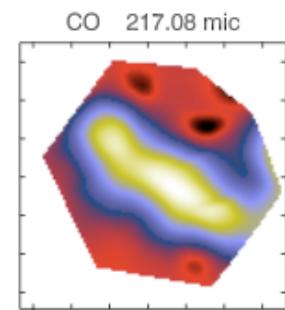
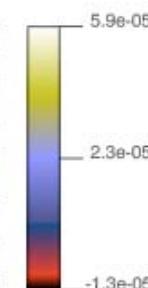
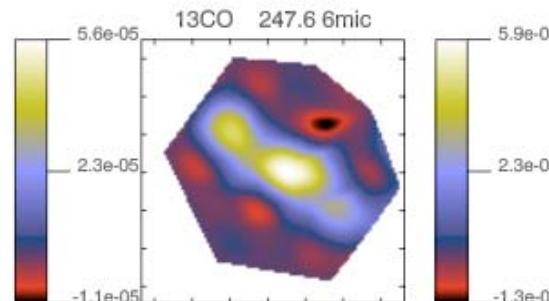
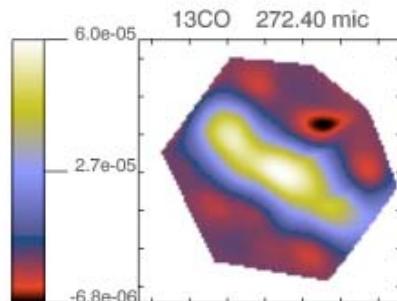
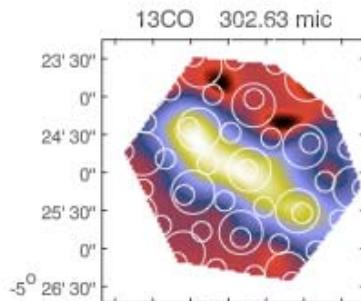
$^{12}\text{CO}$  and  $^{13}\text{CO}$ : J=5-4 to 13-12  
+ J = 4-3 for  $^{12}\text{CO}$   
Most of the  $\text{C}^{18}\text{O}$  lines  
 $\text{C I}$  carbon lines  
 $\text{N II}$   
 $\text{H}_2\text{O}$   
 $\text{CH}^+$



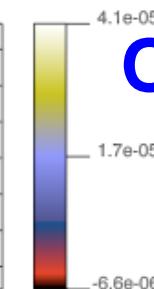
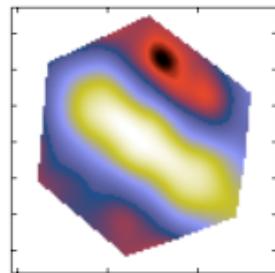


# Orion Bar in CO and $^{13}\text{CO}$ lines (SW)

**Warning: Unproperly sampled  
Full sampling observing mode to be released  
Off-axis calibration not guaranteed**

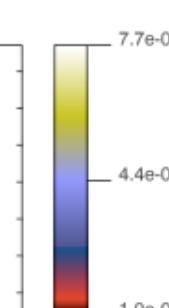
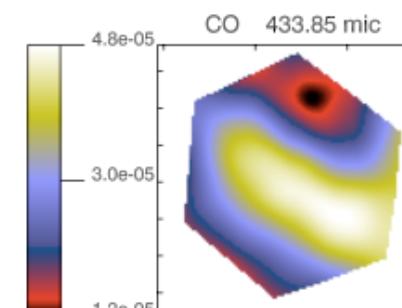
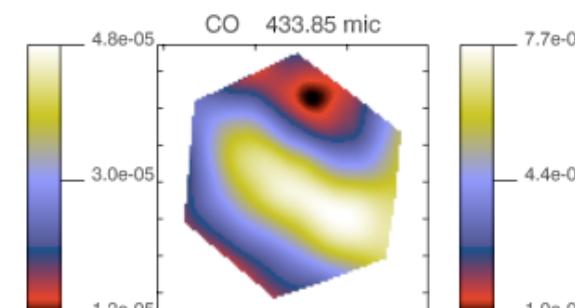
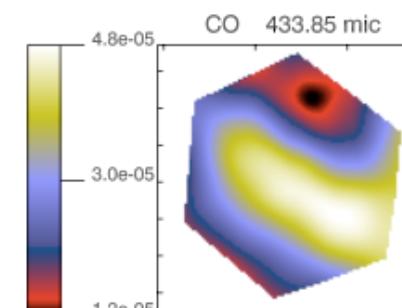
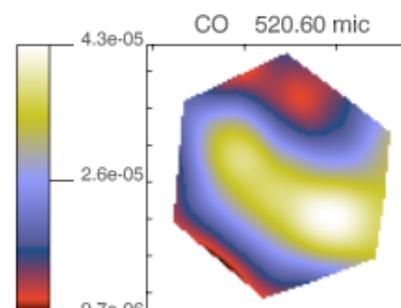
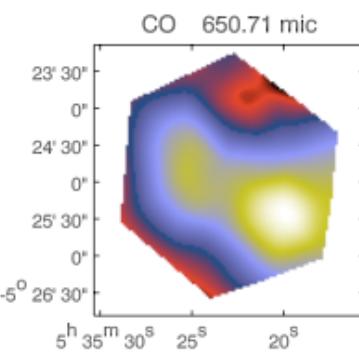
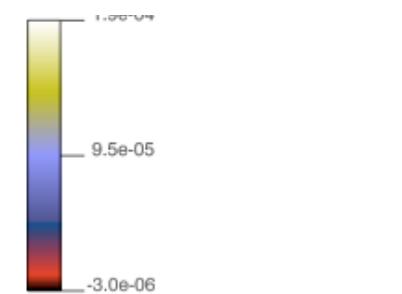
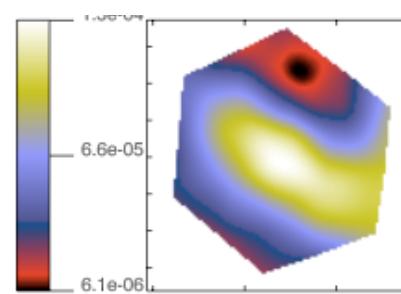
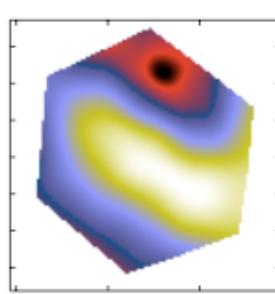
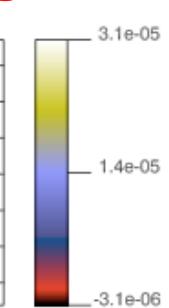
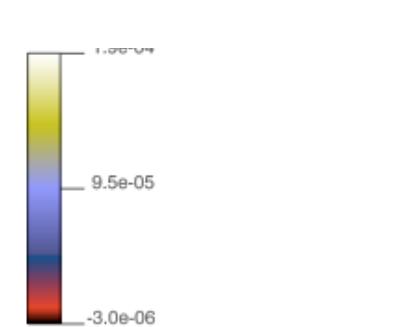
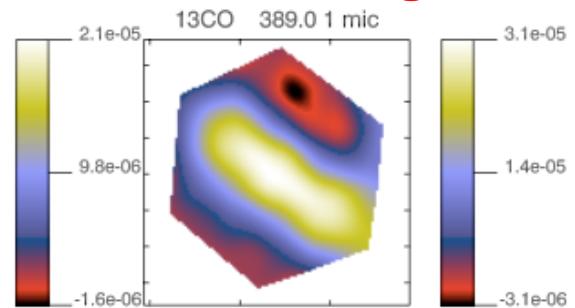
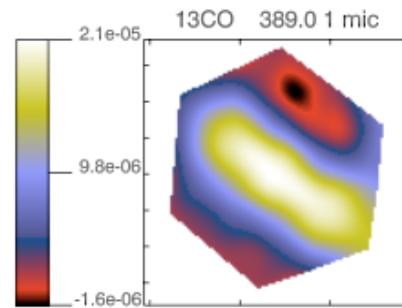
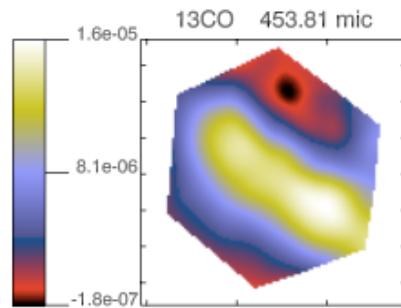
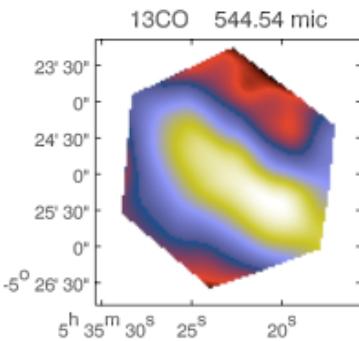


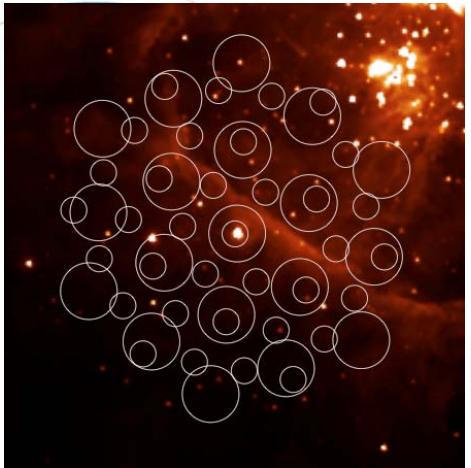
13CO 340.42 mic



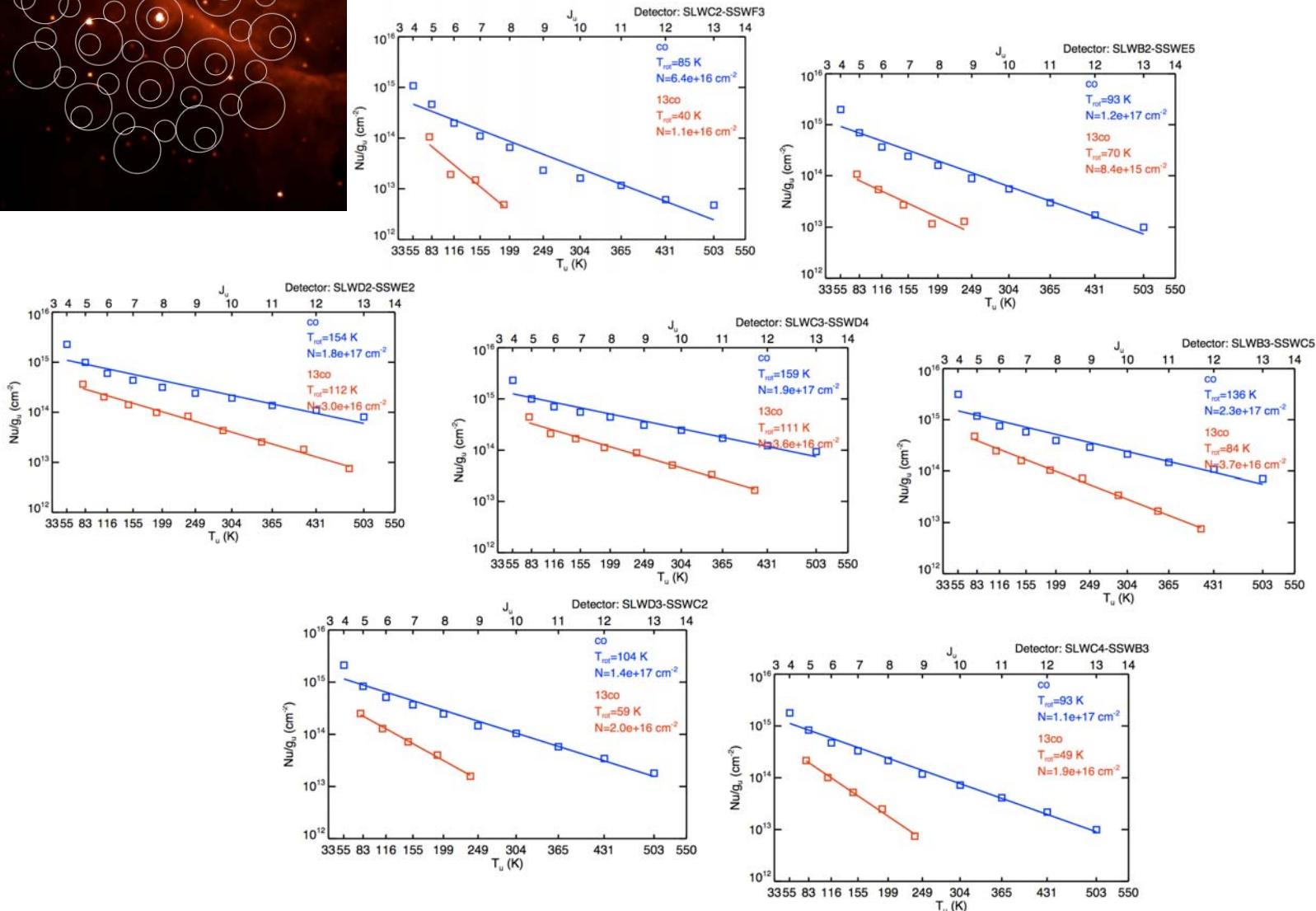
# Orion Bar in CO and $^{13}\text{CO}$ lines (LW)

**Warning: Unproperly sampled  
Full sampling observing mode to be released  
Off-axis calibration not guaranteed**





# $^{12}\text{CO}$ and $^{13}\text{CO}$ excitation diagrams (in the simple hypothesis of optically thin lines)



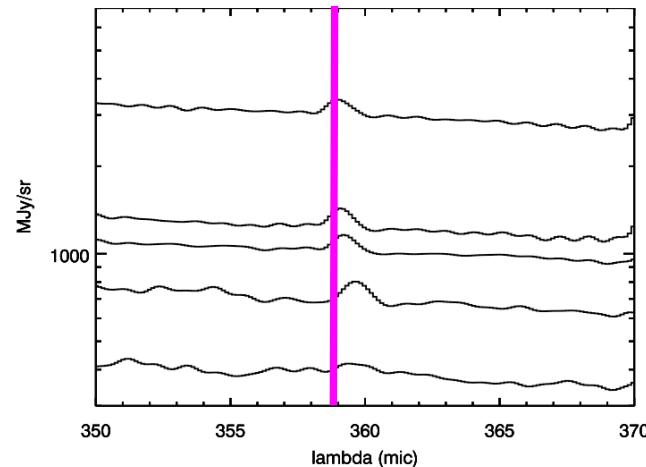
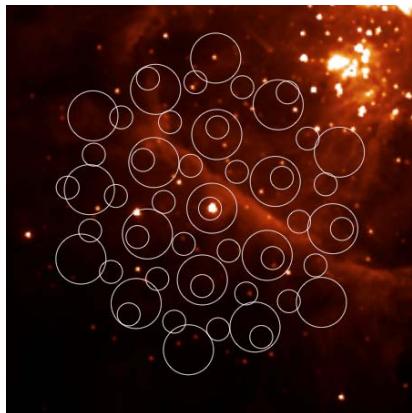
# CH<sup>+</sup>

- First molecular ion discovered in the ISM ( Douglas & Herzberg 1941)
- Visible absorption lines against bright stars
- Key specy in the Carbon chemistery but still a puzzling question :
  - Formation route highly endothermic (dynamical effects needed)
  - Destruction processes very efficient
- J = 2-1, 3–2, and 4–3 rotational transitions in emission with the LWS (Cernicharo et al. 1997)
- Possible detection in absorption of the J=1-0 line of <sup>13</sup>CH<sup>+</sup> (Falgarone et al. 2005)
- CH<sup>+</sup> J=1-0 fundamental rotational transition line
  - Lab measurement (Pearson & Drouion 2006)
  - Never detected in the sky before Herschel

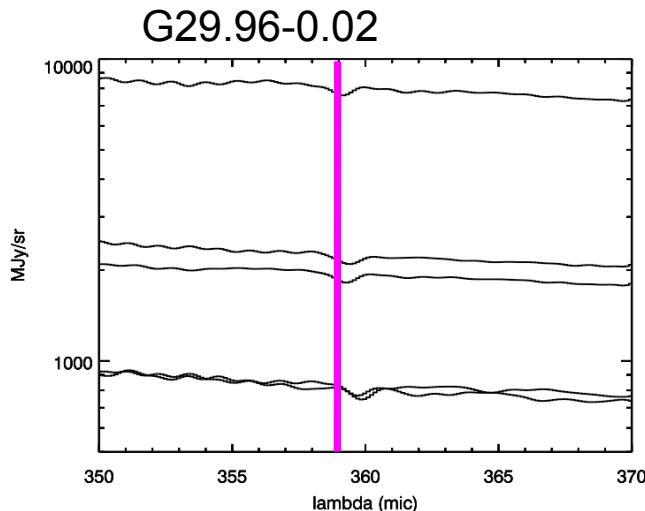
# SPIRE detection of a $359 \mu\text{m}$ line attributed to the $J = 1-0$ $\text{CH}^+$ line

In the Orion Bar:

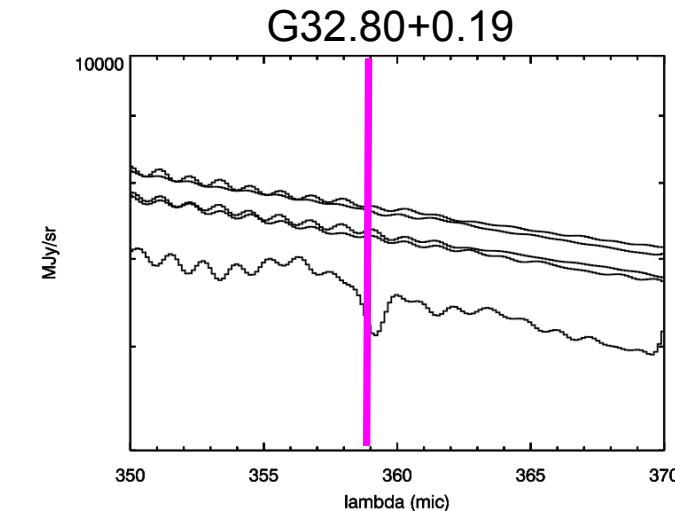
Peak position (preliminay) : around a few  $10^{13} \text{ cm}^{-2}$  ( $T = 10-300 \text{ K}$ , optically thin)



In 2 galactic compact HII regions:



KP Evolution of Interstellar Dust

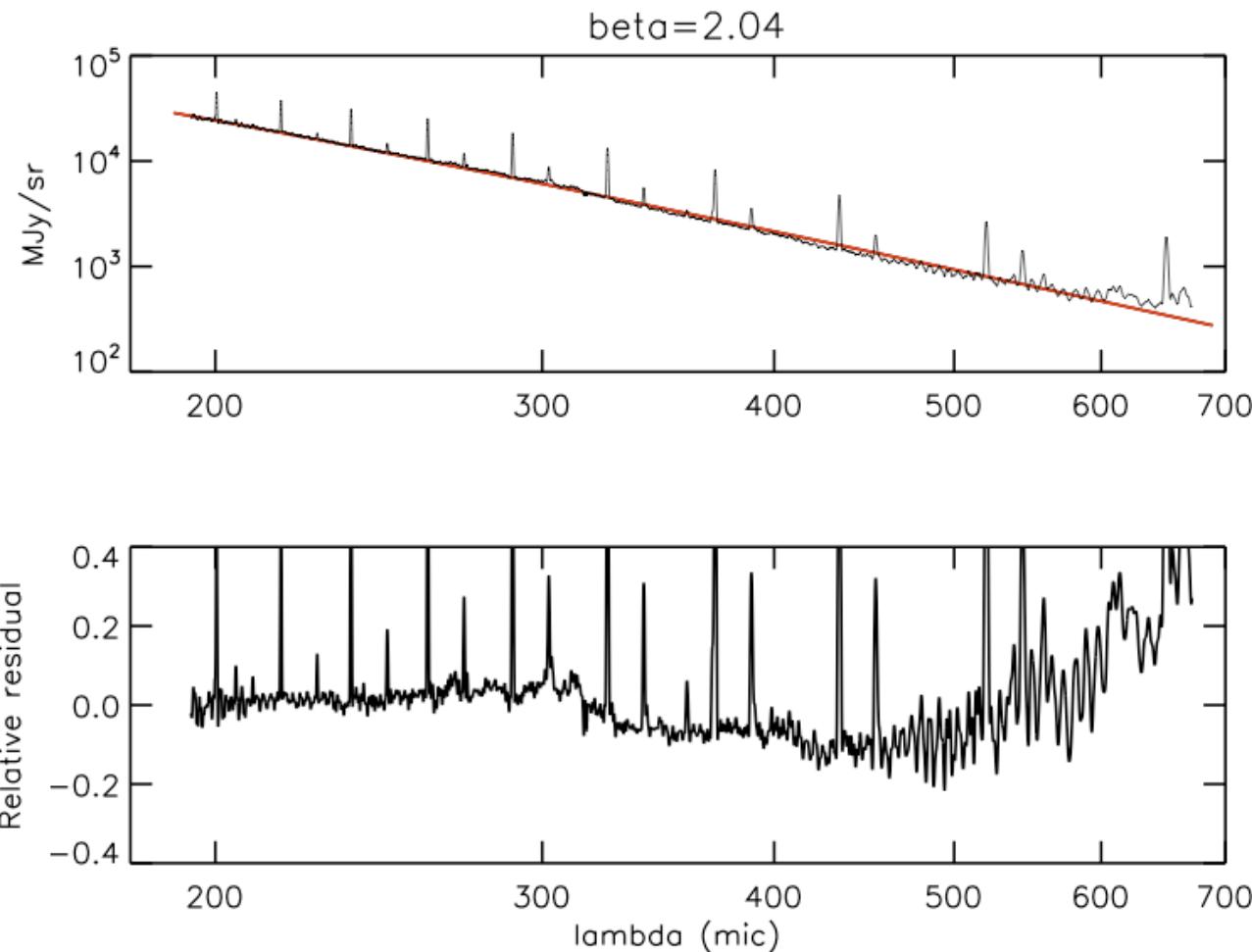


A. Abergel

17-18 December 2009

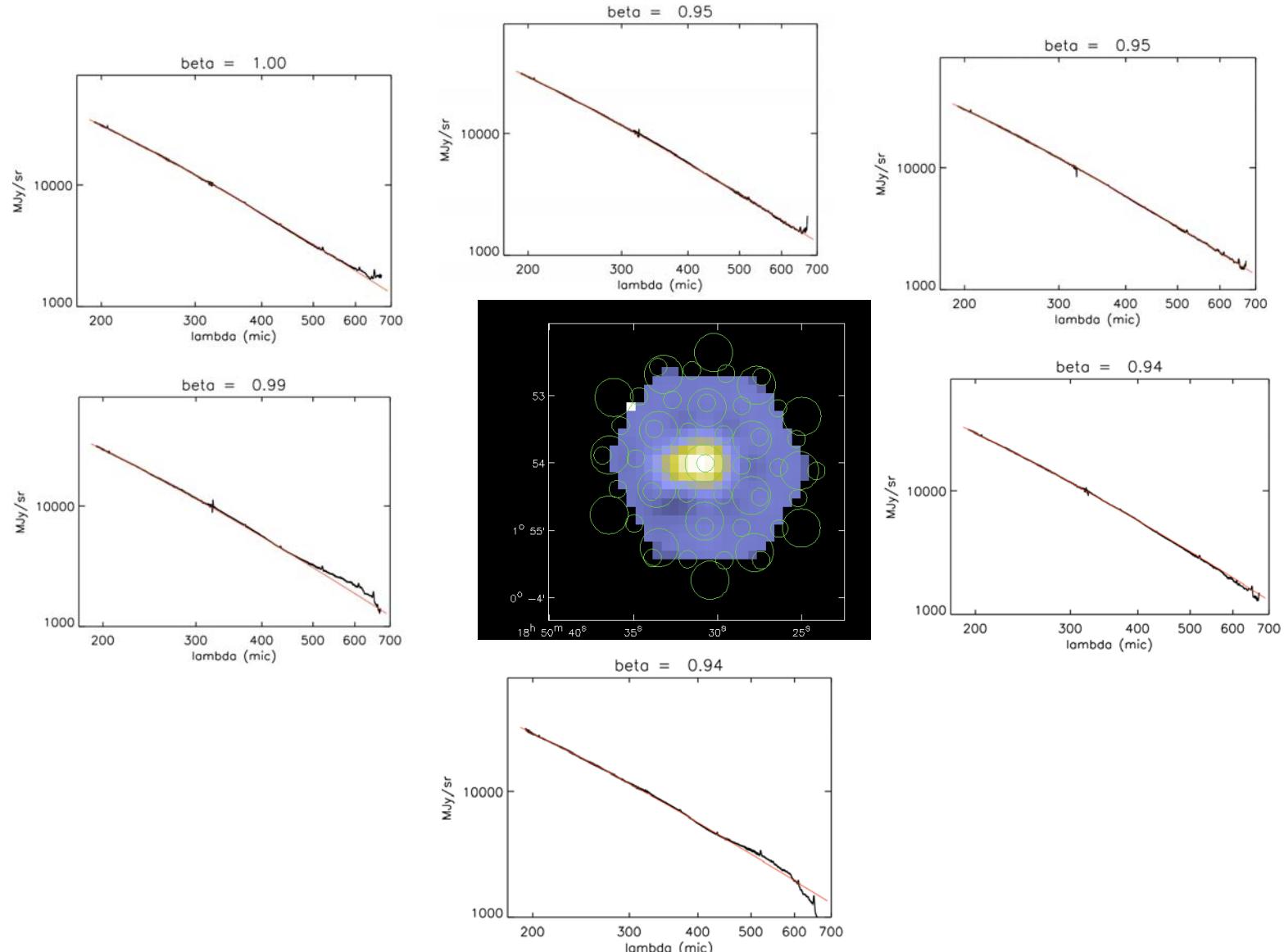
Off-axis calibration to be improved

# Orion Bar : SPIRE FTS, central bolometers

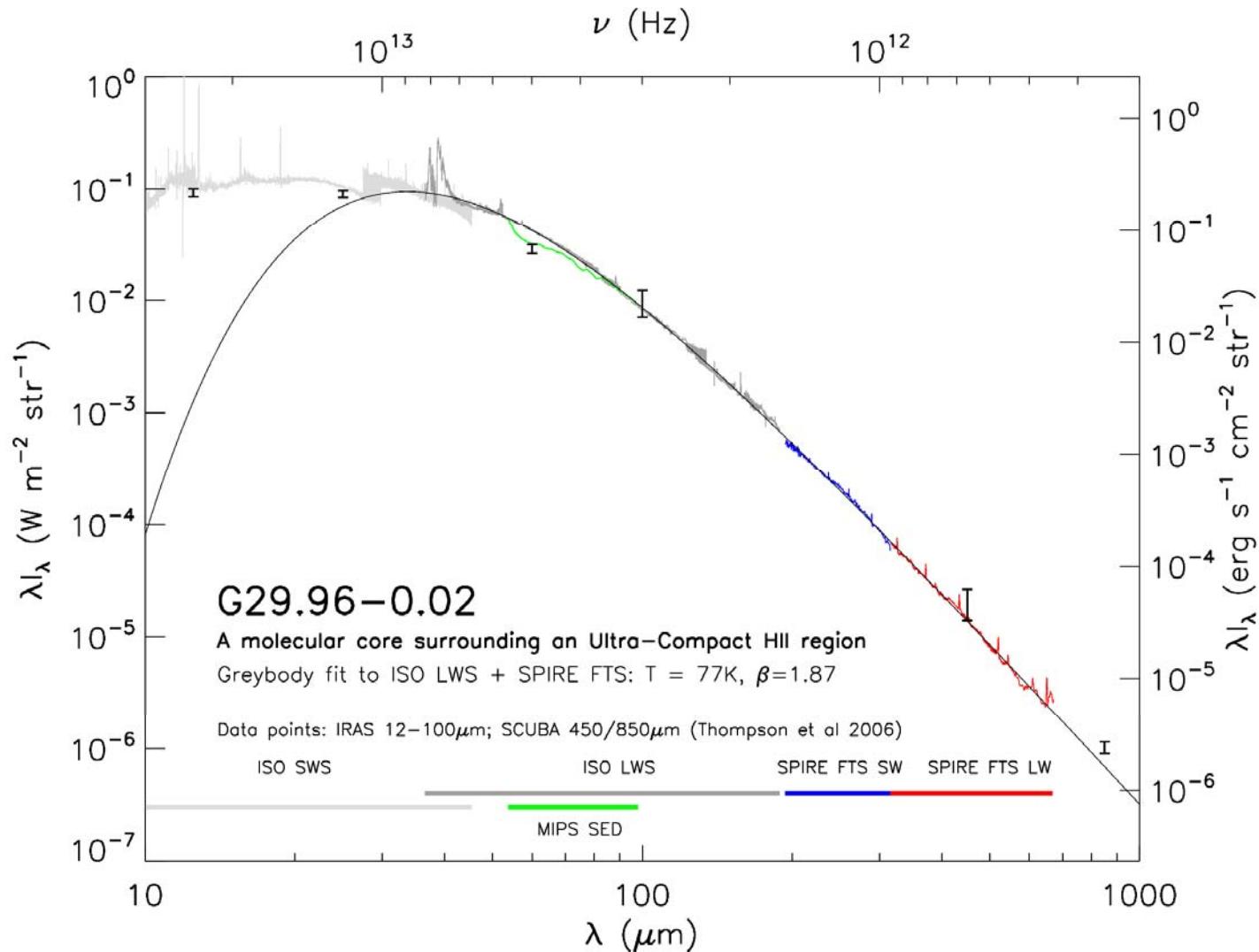


PACS data needed to compute the temperature

## G32.80+0.19: Compact HII region SPIRE FTS, 6 bolometers around the central bolometers



# G29.96-0.02 : on-axis central bolometers



Single pointing, HR, Duration: 266.4 s, 2 repetitions (2 scans/repetition)

# Conclusions

## Fantastic data :

- to reveal the evolution of the dust and gas components across individual objects  
Modelling of the dust and gas emissions
- to detect faint lines
- to study the small scale structure of the ISM from star forming regions to diffuse regions

Need SPIRE/FTS data with intermediate/full spatial samplings, PACS spectroscopic data

Need to push the data processing as far as possible (a lot already done by the ICC)

Optimise the correction of the “ $1/f$ ” noise components

Go deeper in the extraction of gas lines

Increase of the resolution ?

    Use instrument model in the pipeline: increase of the angular resolution

    (on-going validation of the Bayesian inversion proposed for SPIRE by Orieux 2009)

    Spectral deconvolution of FTS data ?

Complementary observations with HIFI will bring crucial information