

THE INTERPLAY BETWEEN IONIZED REGIONS AND STAR FORMATION

WHAT CAN WE LEARN FROM *HERSCHEL*?

Outline

Models (see Tremblin et al. 2012, A&A 546, A33)

Herschel observations: ongoing studies

HOBYs and ISM programs + dedicated OT programs

Hi-GAL

Conclusions and Perspectives

Posters: M. Samal - V. Minier – K. Rygl – M. Chevance - ...

Thanks

J.-P. Baluteau, L. Deharveng, D. Russeil

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F. Motte and the HOBYS consortium (SAG 3)

P. André ad the Gould Belt consortium (SAG 3)

A. Abergel and the ISM consortium (SAG 4)

S. Molinari and the Hi-GAL team

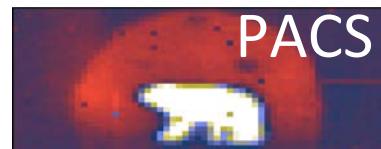
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T. Moore**

CNES (M. Rouzé)

SPIRE and PACS instrument teams

ATLASGAL team

MALT90 team



Models

Impact of ionization and HII regions' expansion on star formation

Collect and collapse process (Elmegreen & Lada 1977)

Different mechanisms can trigger star formation at the edges of HII regions (Deharveng et al. 2010)

Deharveng et al. (2010)

Gravitational instabilities
in the collected layer

Small scale

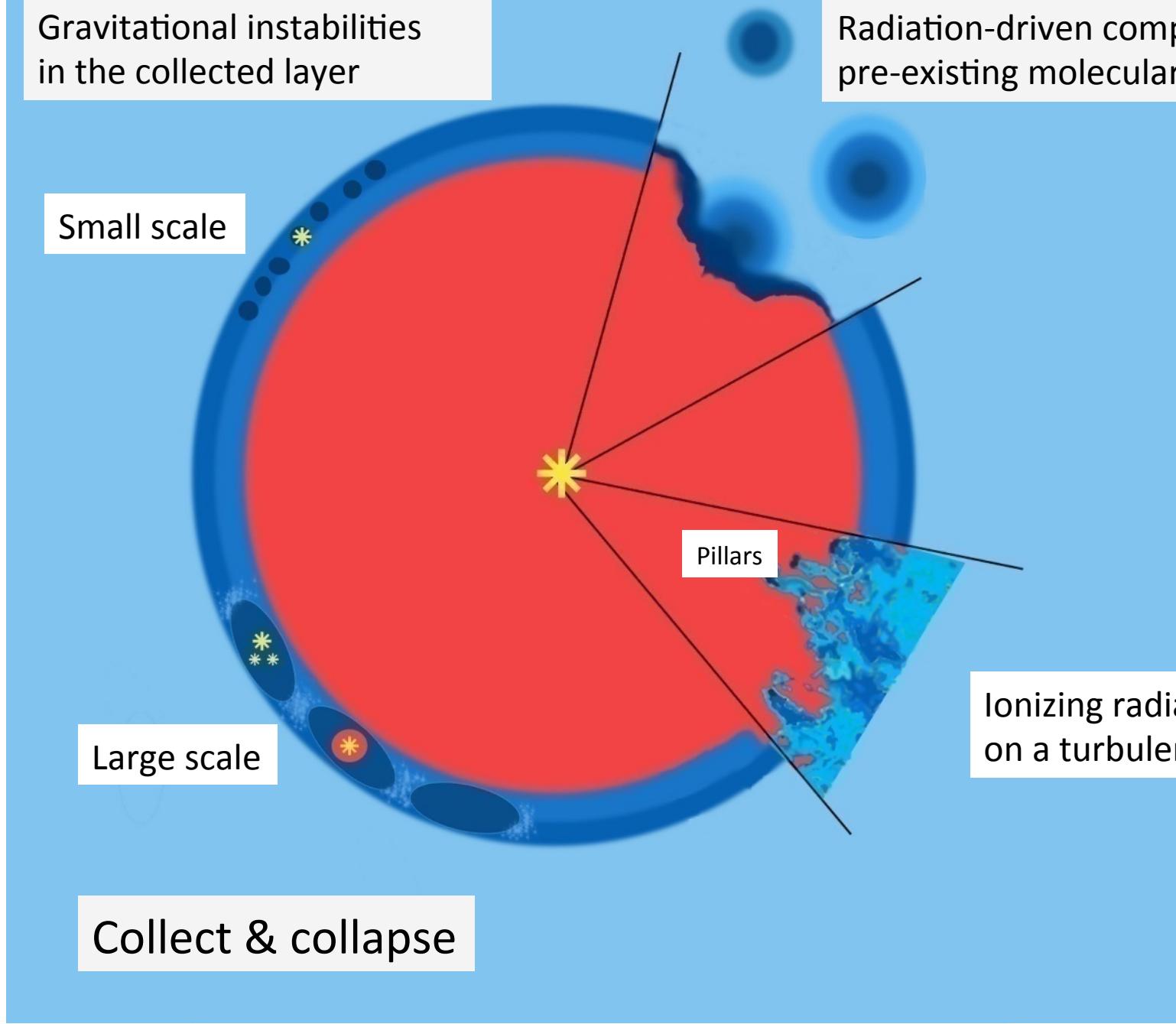
Large scale

Collect & collapse

Radiation-driven compression of
pre-existing molecular clumps

Pillars

Ionizing radiation acting
on a turbulent medium



Herschel observations of Galactic HII regions

Pointed observations of a sample of 8 Galactic HII regions (bubble shape)

Images with PACS and SPIRE

→ column density and temperature maps

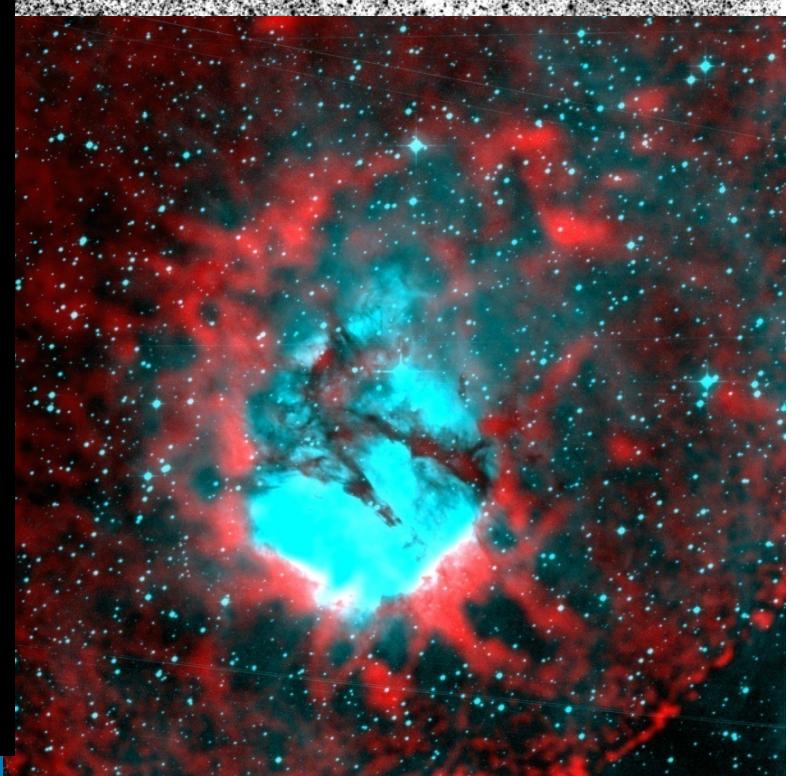
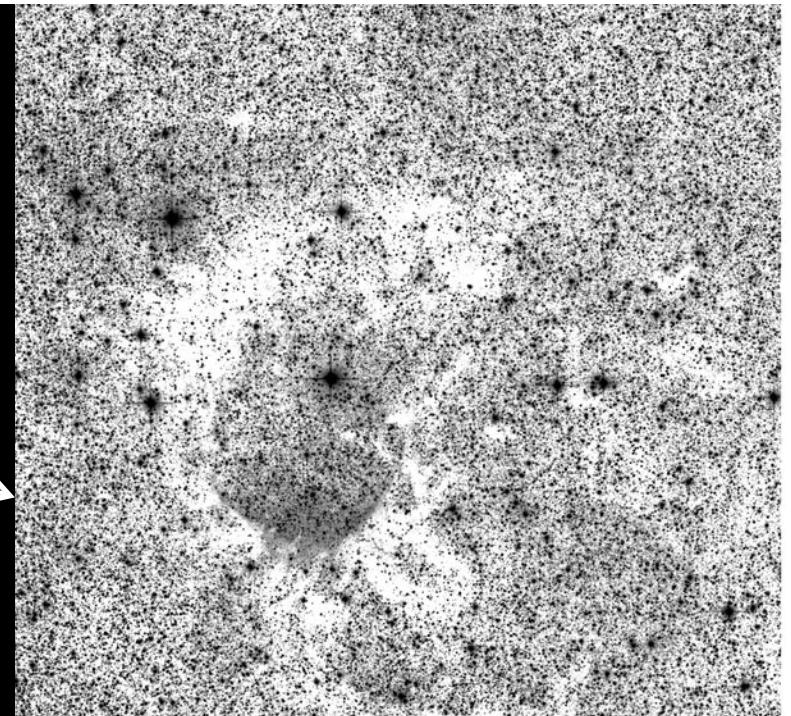
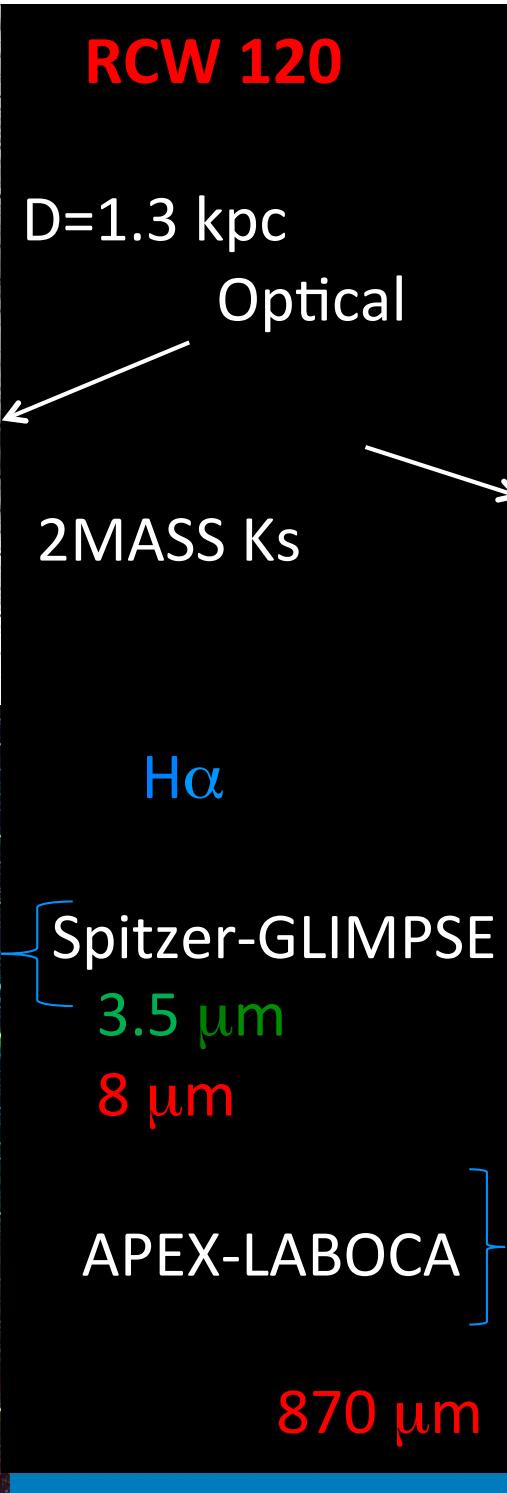
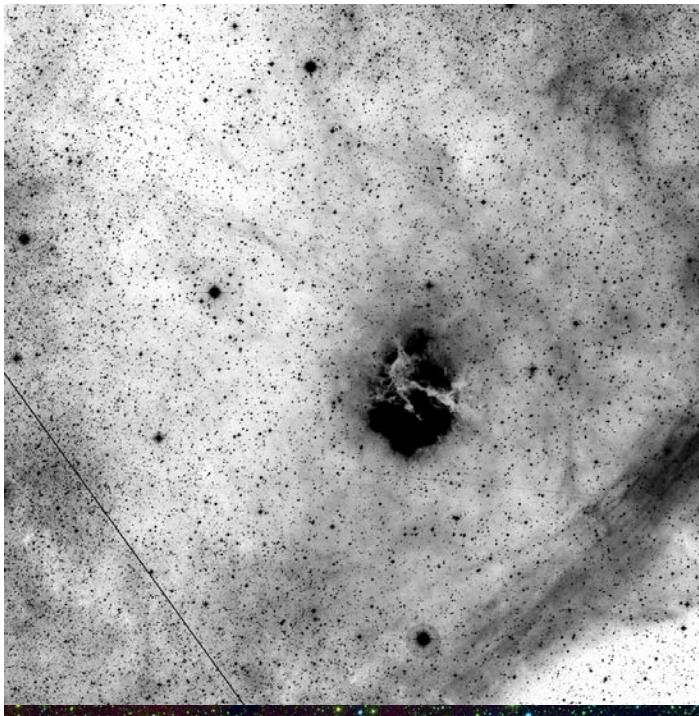
→ sources detection, properties (M_{env} , L_{bol} , T_{env}), evolution stage

PACS and SPIRE-FTS spectroscopy

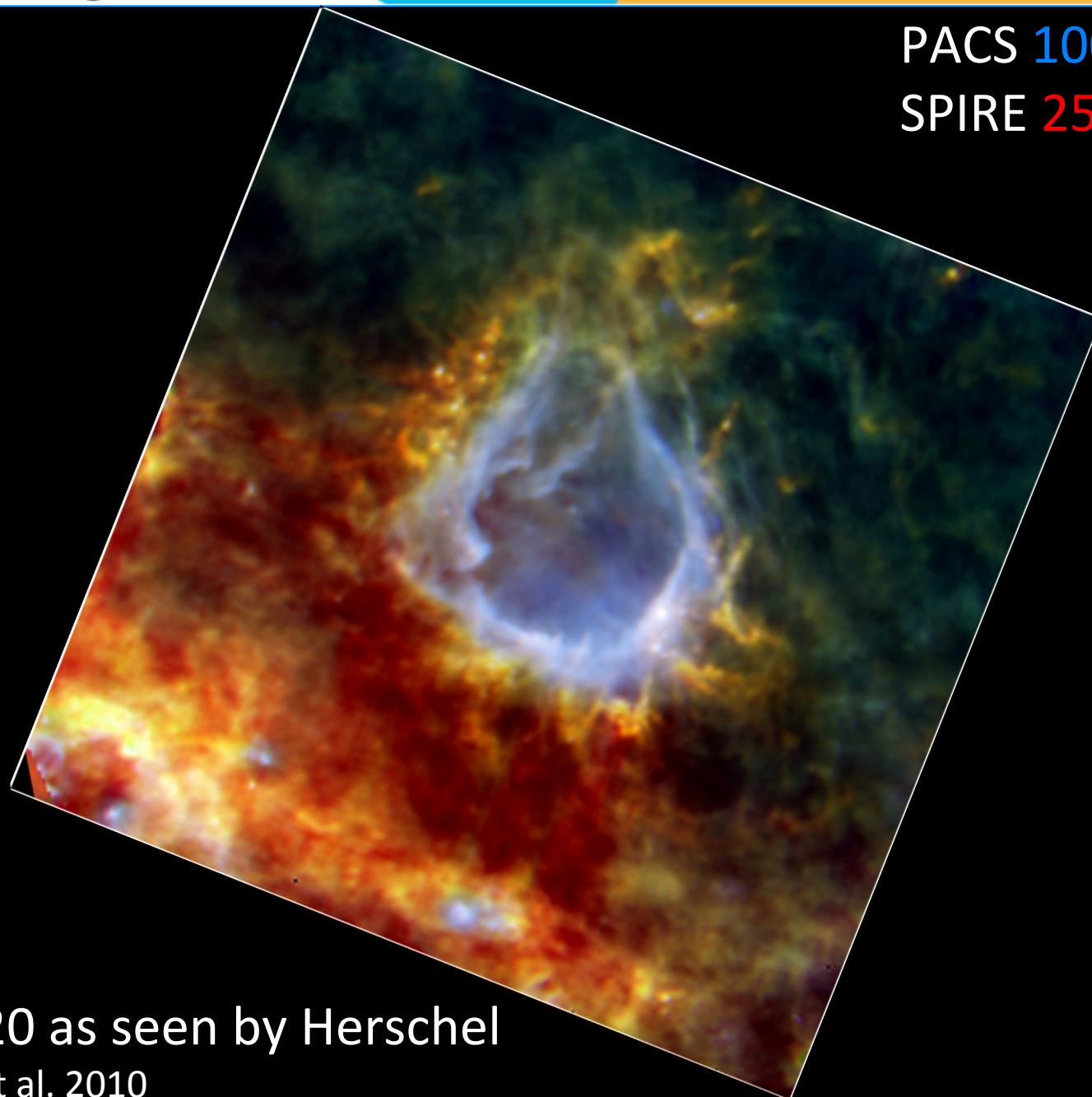
physical conditions

evolution stage

Examples: RCW 120, RCW 79

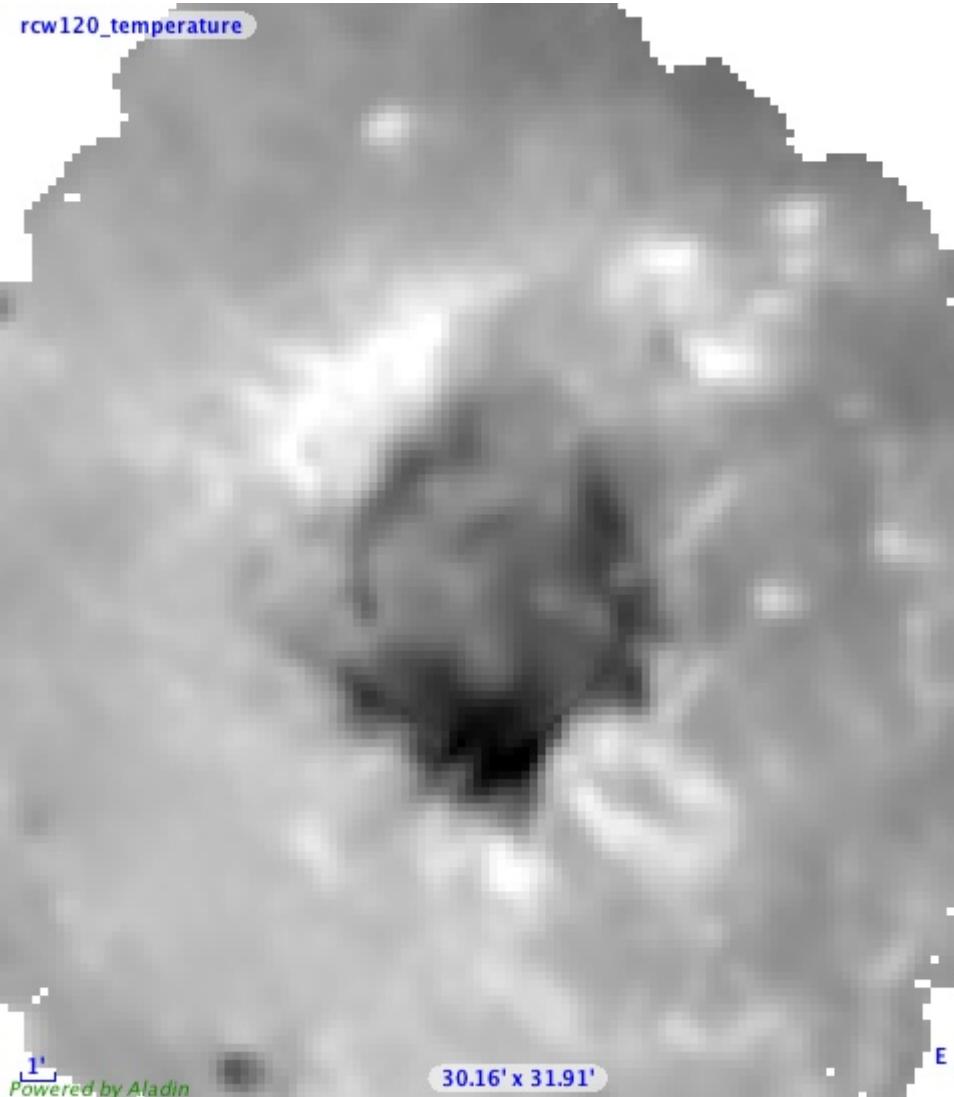
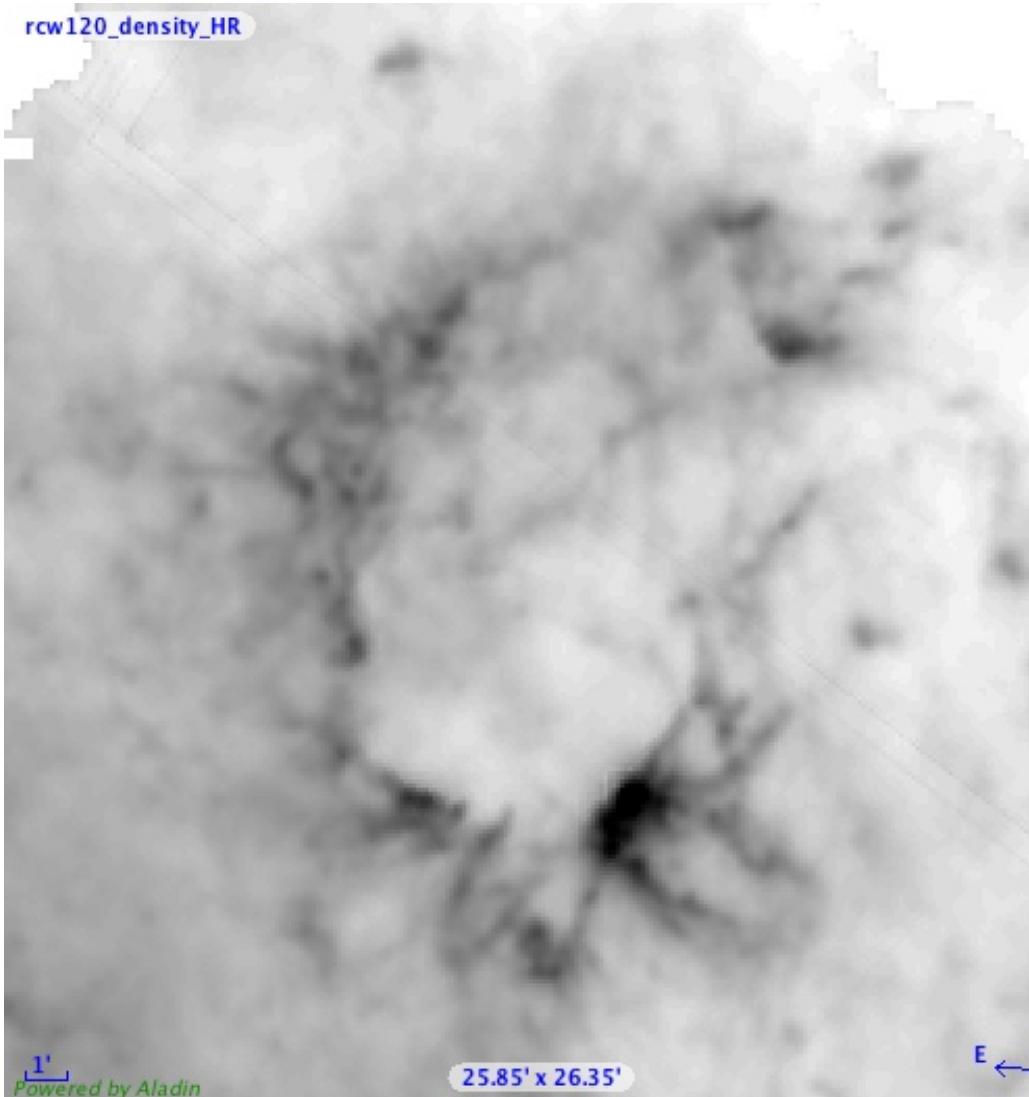


PACS 100 and 160 μm
SPIRE 250 μm



RCW 120 as seen by Herschel
Zavagno et al. 2010

Column density and temperature maps

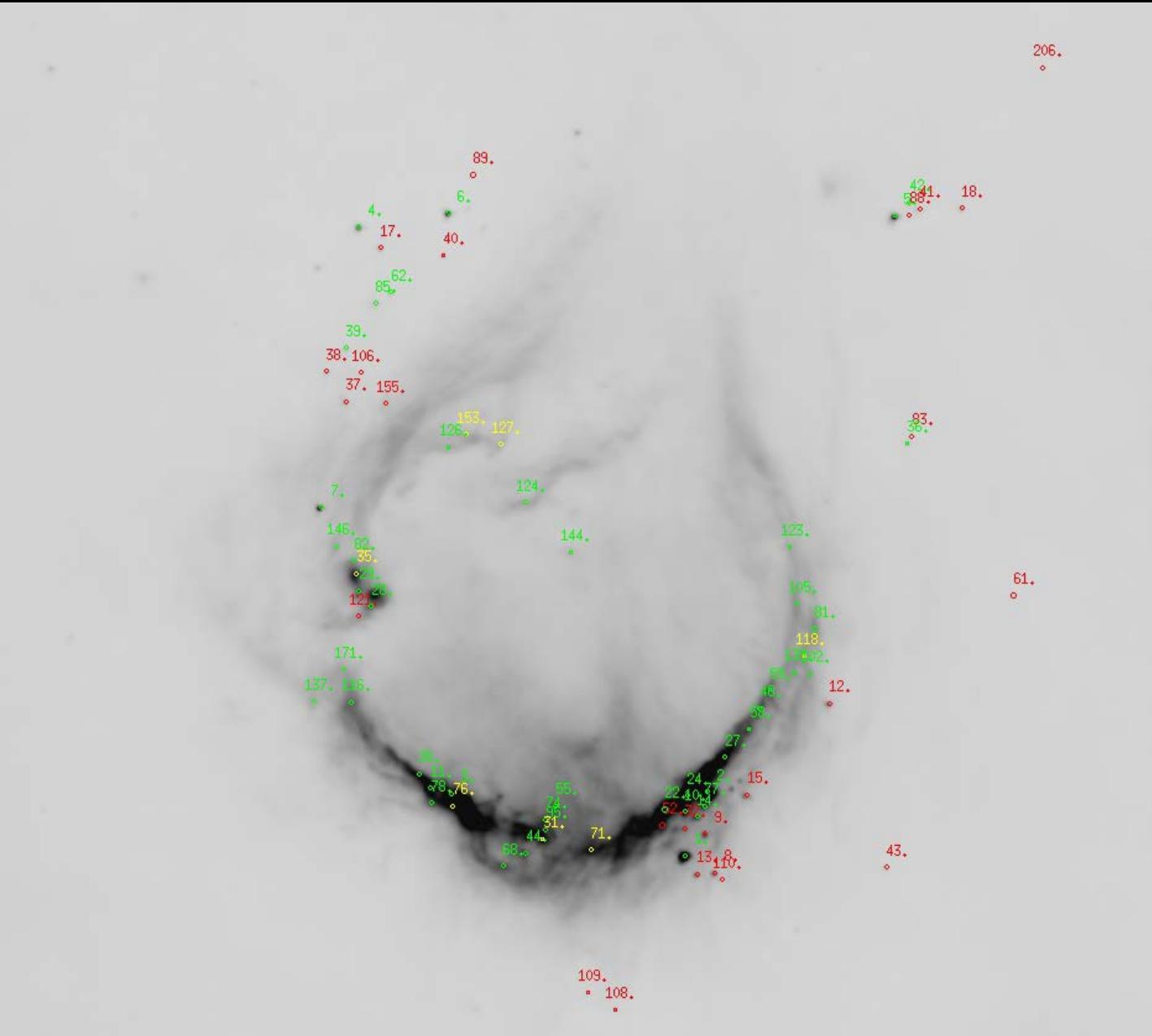


$3 \times 10^{21} - 7 \times 10^{22} \text{ cm}^{-2}$

15 – 24 K

Spatial distribution of sources as a function of their SED emission peak

Zavagno et al. in prep.



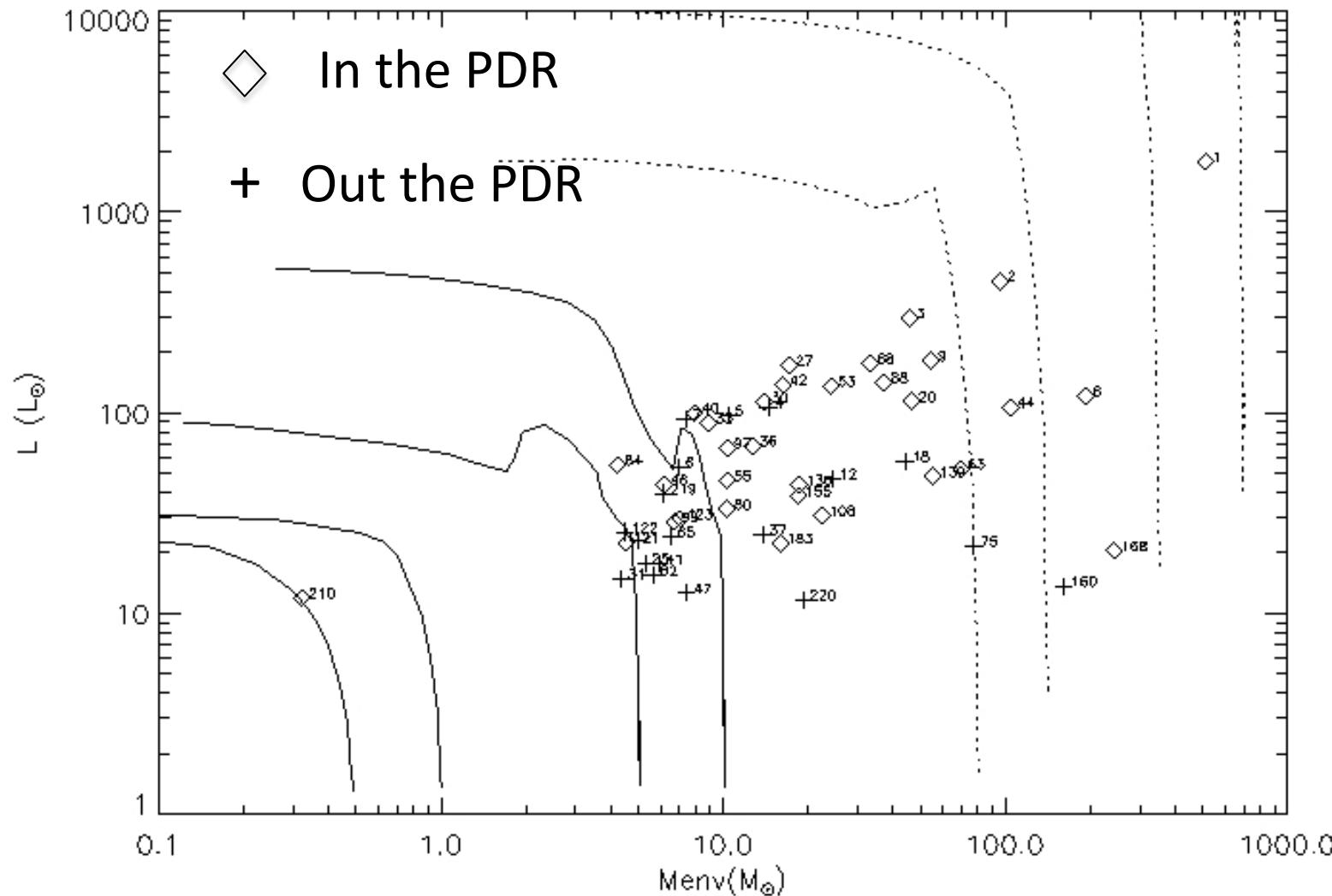
70 or 100 μm
160 μm
SPIRE

Sources's
extraction
Getsources

Men'shchikov
et al. 2012

Towards an age gradient ?

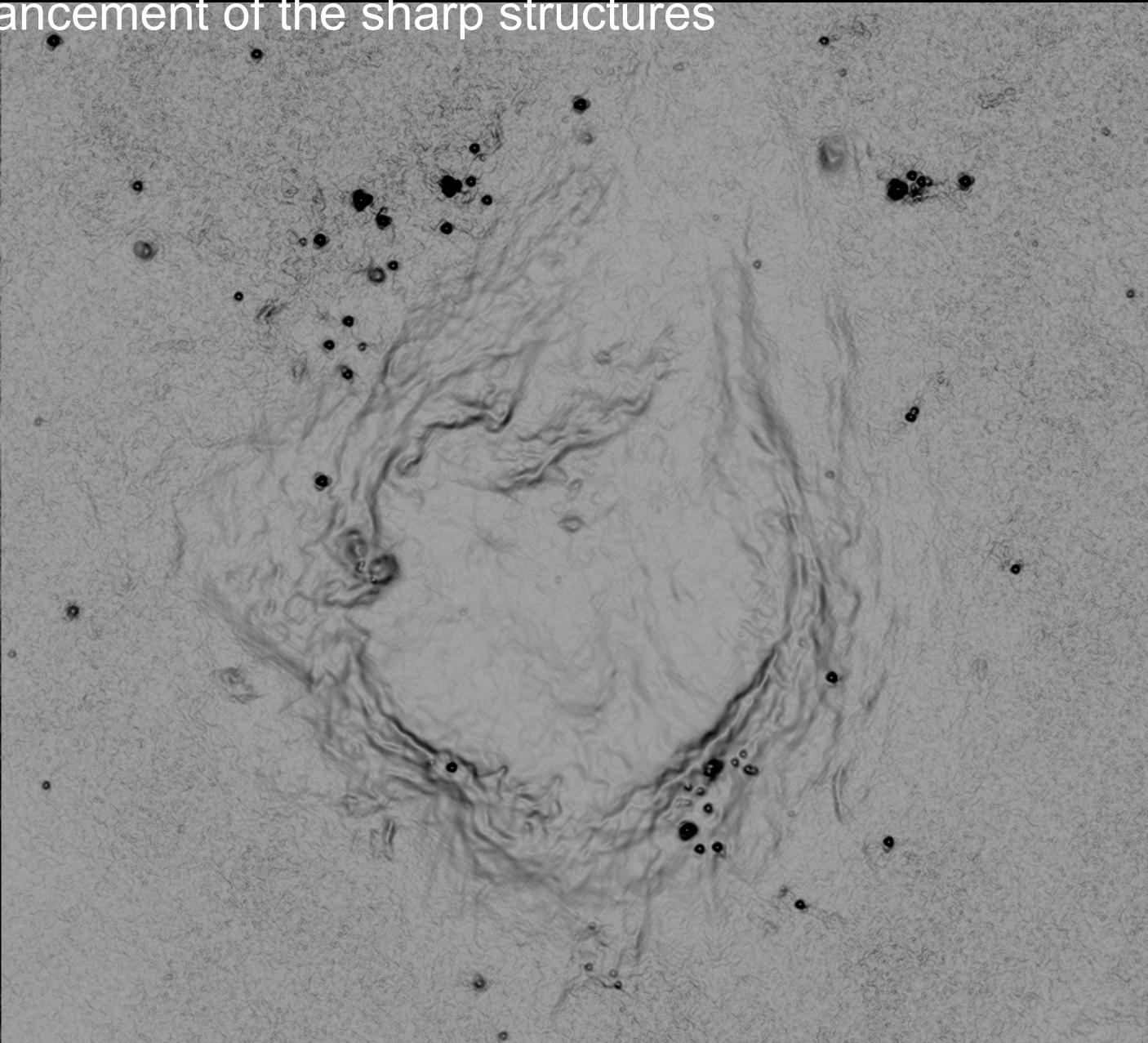
For a given envelope mass, sources in PDR are more evolved

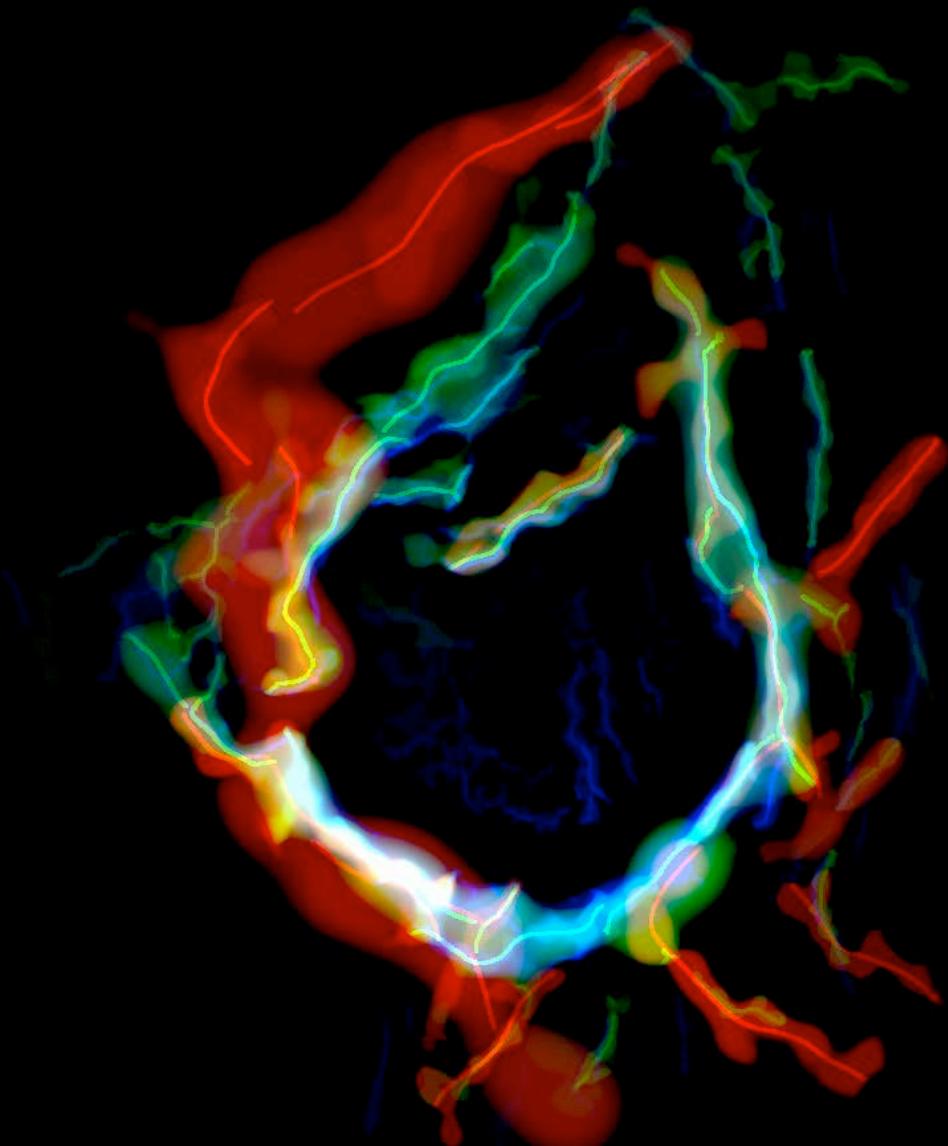


Gradient filter applied to the PACS 70 μm image of RCW120

Enhancement of the sharp structures

Zavagno et al. in prep.





RCW120

Filaments' extraction

Getfilaments

Men'shchikov et al. 2013

70 μm

160 μm

350 μm

Herschel PACS and SPIRE-FTS spectroscopy

Pointed spectroscopic observations associated with the imaging program
→ derive the physical conditions of gas and dust towards the regions using PDR model (Meudon code – see E. Habart's talk)

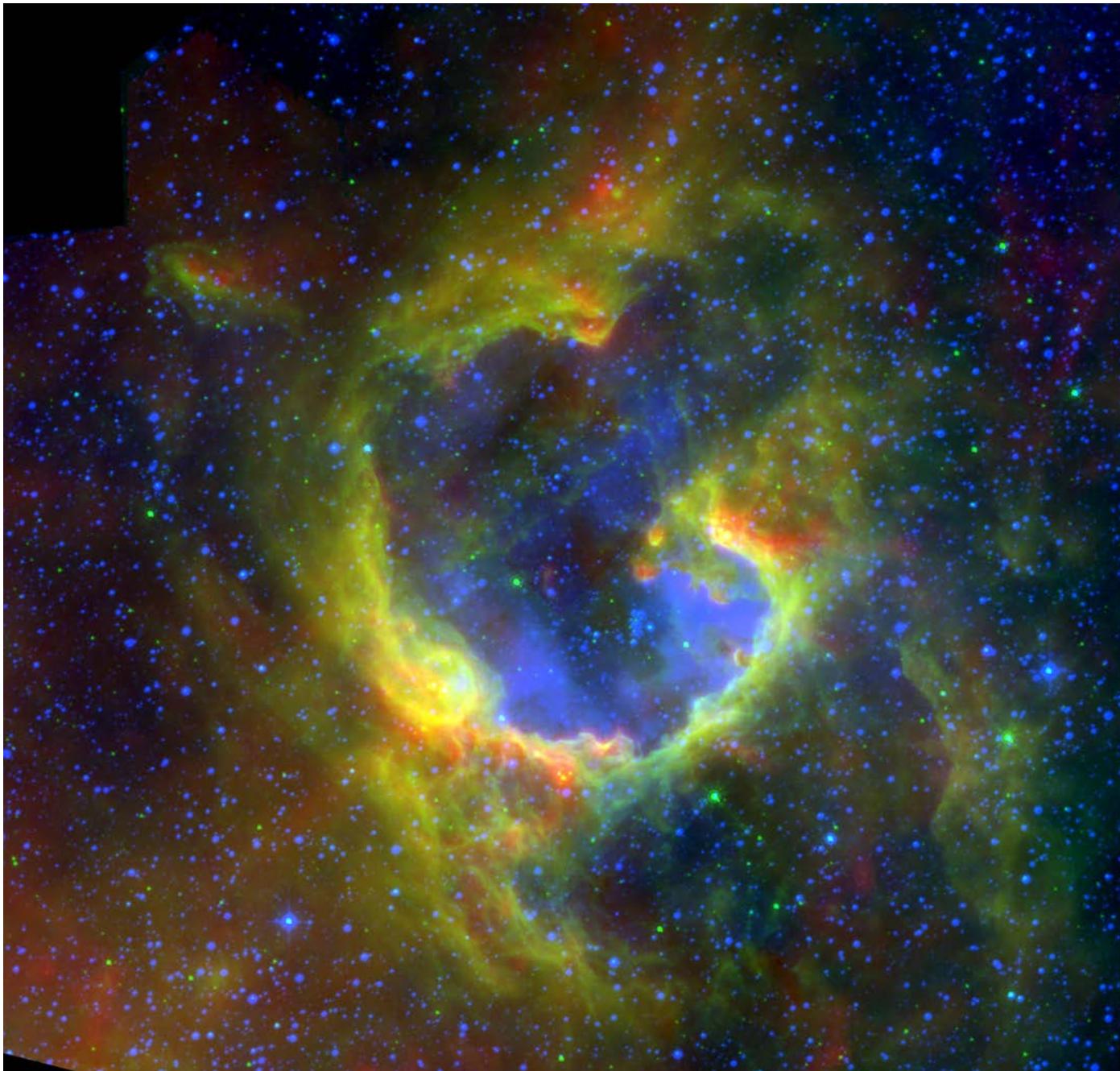
Case of RCW 120 Rodón, Zavagno, et al. 2013, A&A in press: Herschel SPIRE-FTS observations of RCW 120

Case of RCW 79 Pinto, Zavagno et al., in prep.

Herschel Images and Spectroscopy + existing data + model

- good knowledge of the ionizing flux, visual extinction and density
 $10^5 \text{ cm}^{-3} < n_{\text{H}_2} < 3 \cdot 10^6 \text{ cm}^{-3}$, $2 \text{ mag} < \text{Av} < 18 \text{ mag}$, $150 < G_0 < 1000$
- comparisons of the different diagnostics (near IR images, evolutionary stage of the YSOs – see Martins et al. 2010)

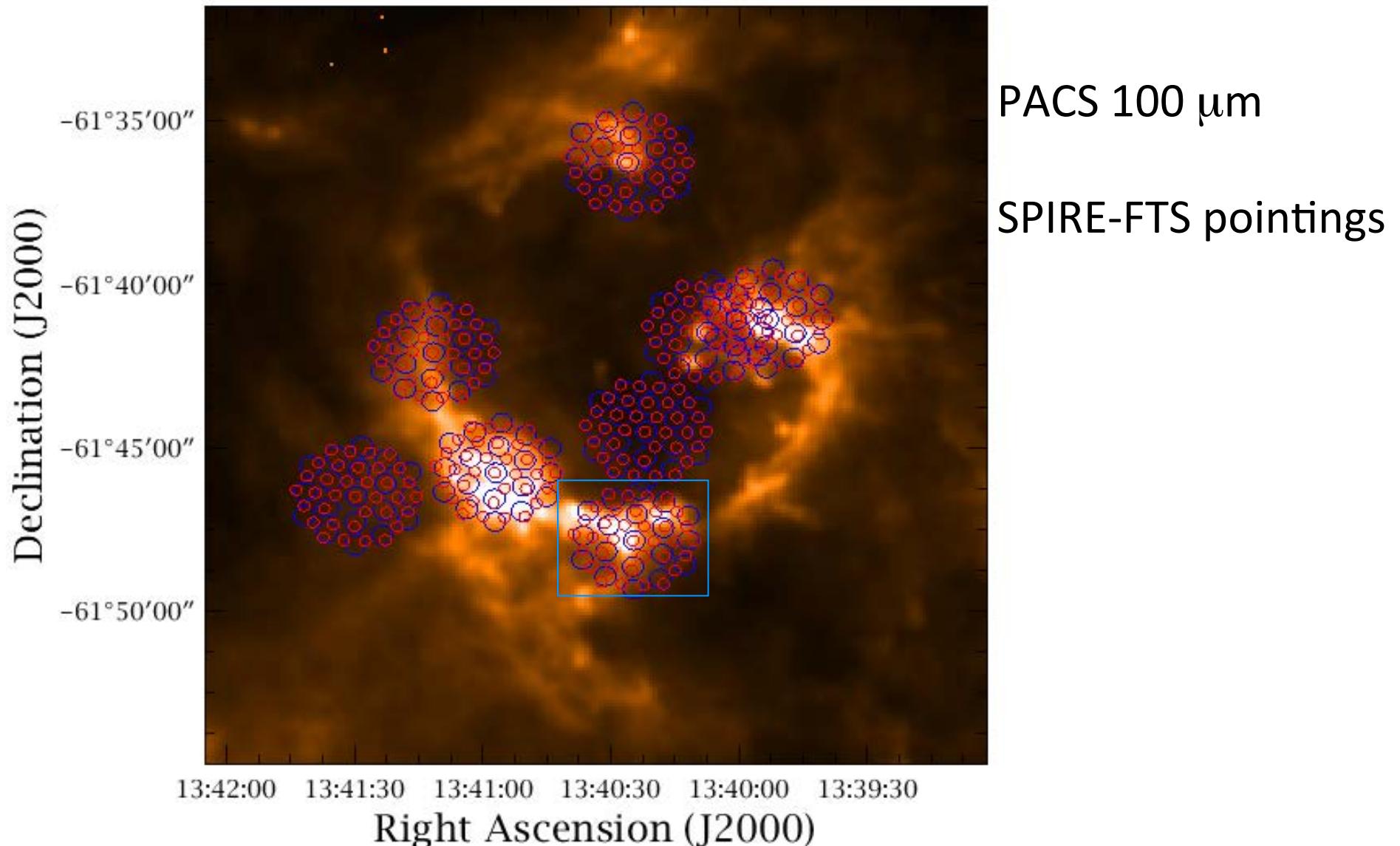
new (chemical) insights on triggered star formation

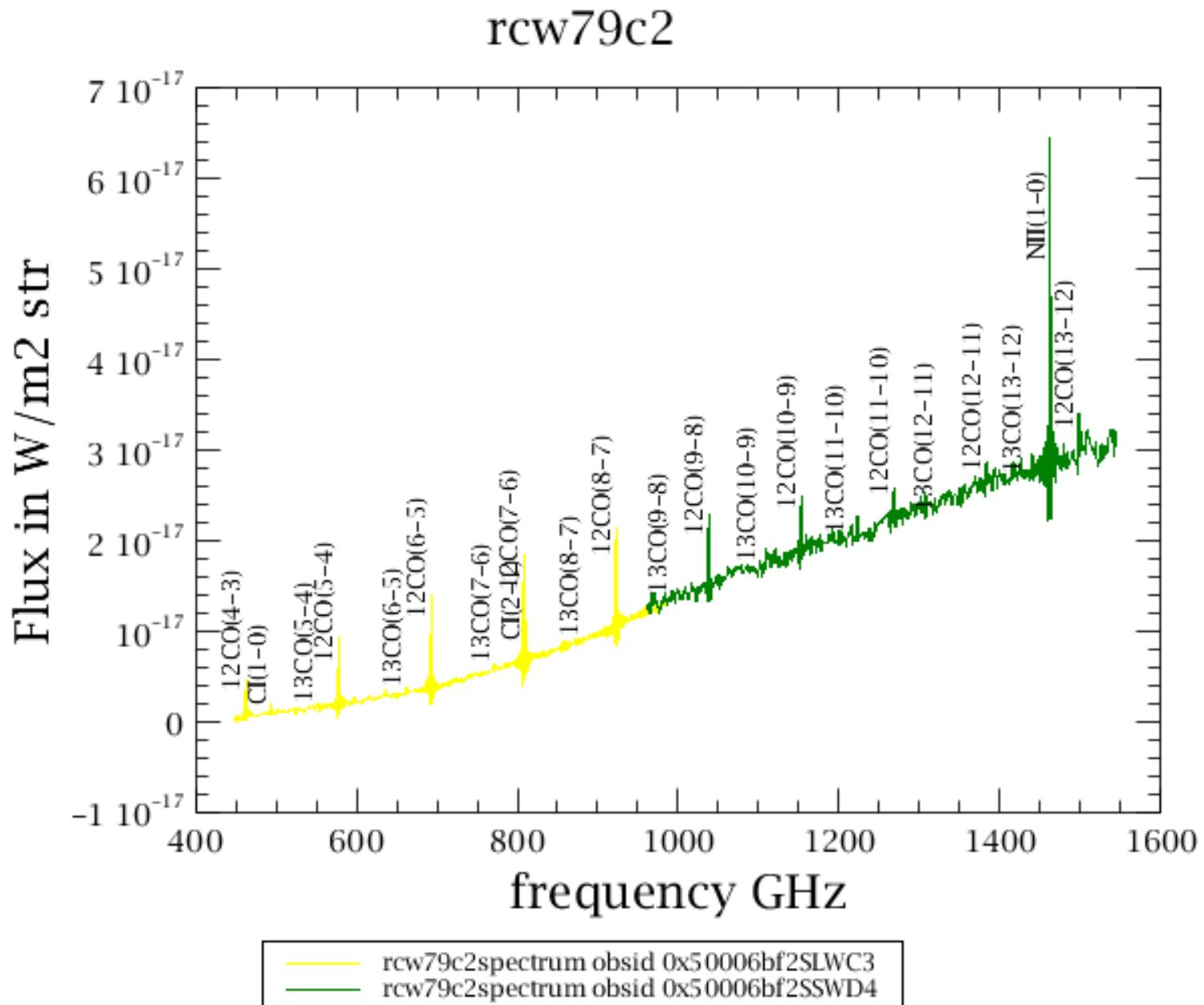


RCW 79

H α
8 μ m
250 μ m

RCW79 SPIRE (FTS+PHOTOM)





Hi-GAL: towards a global view

Thousands HII regions in the Galaxy

How efficient is the star formation triggered by HII regions ?

Studies from limited samples of HII regions

~ 30% of massive YSOs are observed at the edges of HII regions

(Kendrew et al. 2012, Thompson et al. 2012, Deharveng et al. 2010)

Global study with Hi-GAL data

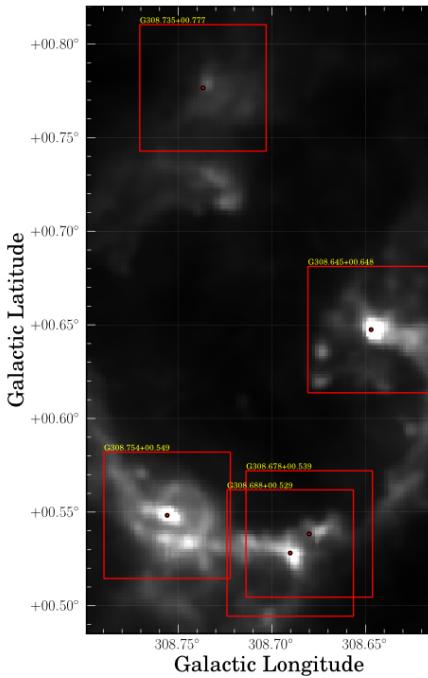
300 Southern HII regions (to be extended)

Velocity fields with MALT90 data: how many condensations are associated with a given ionized region ?

Corresponding Hi-GAL sources: evolutionary stage

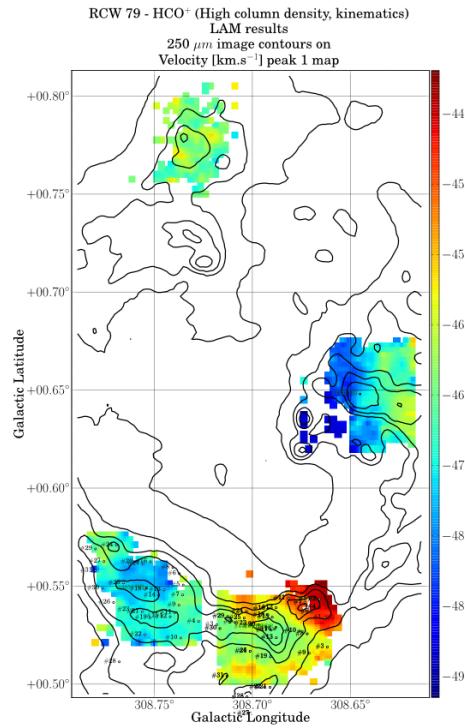
MALT90 data for the 300 HII regions: N₂H⁺, HCO⁺, HCN Velocity, integrated intensity, FWHM maps (D. Brérot)

Region RCW 79 with selected MALT90 (red squares)
Image from Herschel SPIRE (Hi-Gal) (250

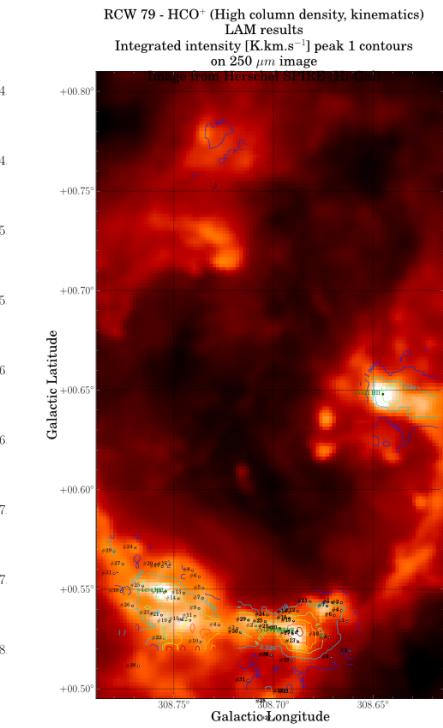
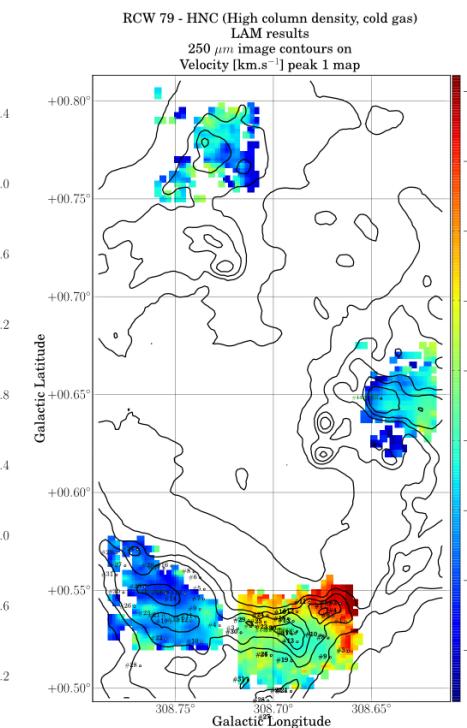


RCW79

Hi-GAL 250 μm
MALT90 cubes



Hi-GAL 250 μ m (contours)
HCO⁺
velocity map



Hi-GAL 250 μ m
CUTEX sources (M. Pestalozzi)
HCO⁺ integrated intensity

Conclusions and Perspectives

Causal link between the first and (possible) second generation stars

Evolution stage of YSOs observed at the edges of HII regions

Age determination

Physical conditions

Detection and properties of filaments

Small scale: structure of photodissociation regions

Large scale: role and impact of ionized regions ?

Density structure of photodissociation regions and models

PDF analysis : see P. Tremblin and N. Schneider talks

Young cluster properties at high angular resolution

Using adaptive optics in the near infrared (GeMS on GEMINI)

Triggered star formation in the Large Magellanic Cloud

Using adaptive optics in the near infrared + existing data

Announcements

Meeting

Galactic and Extragalactic Star Formation: recent results and common perspectives

Marseille, Le Pharo, September 8-12 2014

Positions at LAM

Galactic structure and distances

Detailed studies of HII regions

Global star formation

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