The IR dust bubble S24: Gas, dust, and star formation

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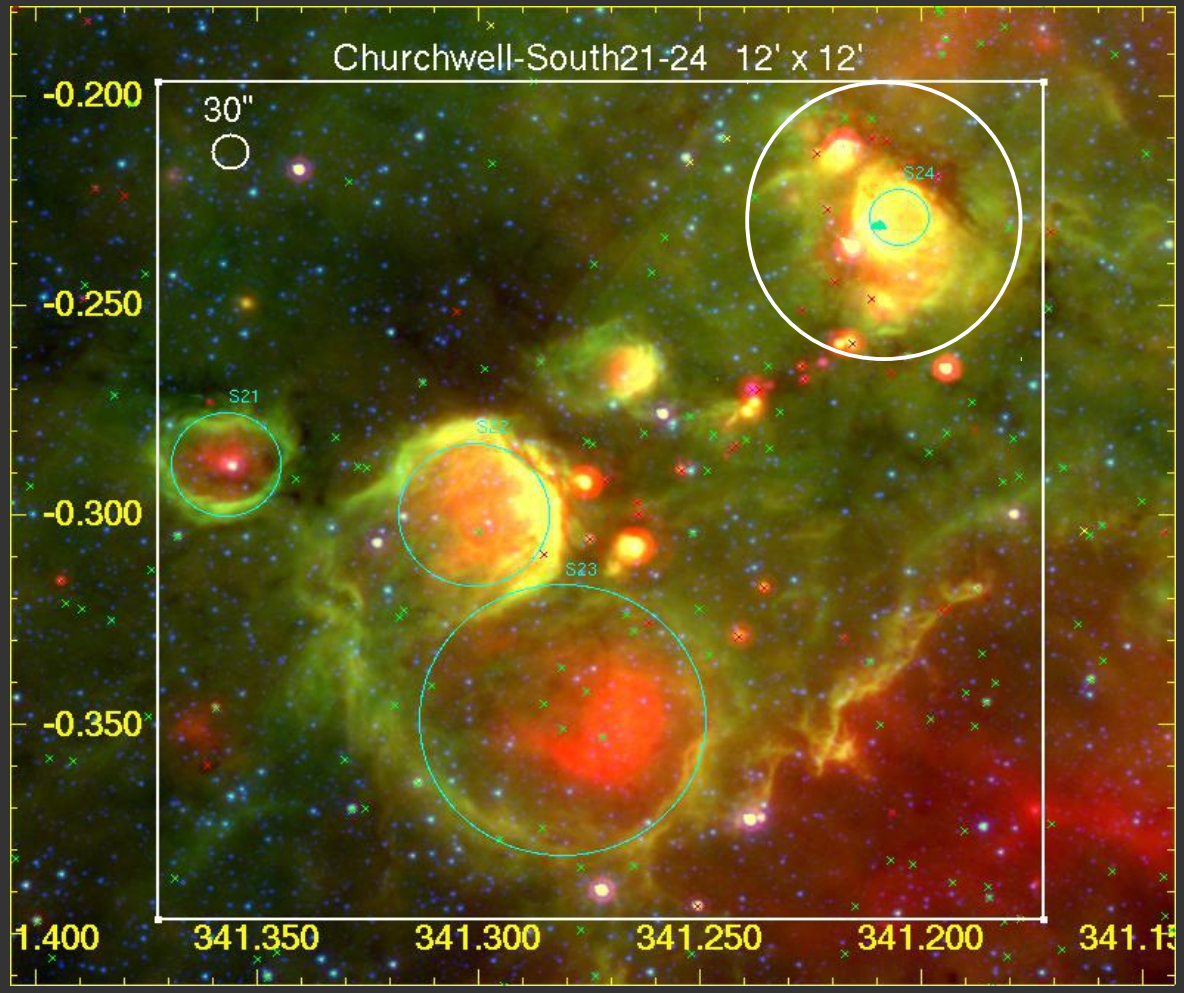
Soul of massive stars
Puerto Varas, March 16th, 2015

IR dust bubbles

- 600 IR dust bubbles identified at 8 μm (Churchwell+2006, 2007) 2007 in images of the Spitzer-GLIMPSE survey
- More than 5000 IR dust bubbles identified in the Milky Way project (Simpson+2012)



Group of IR dust bubbles at *l* = 341°
(Churchwell+ 2006)

4.5 μm
8.0 μm
24 μm

The S24 region

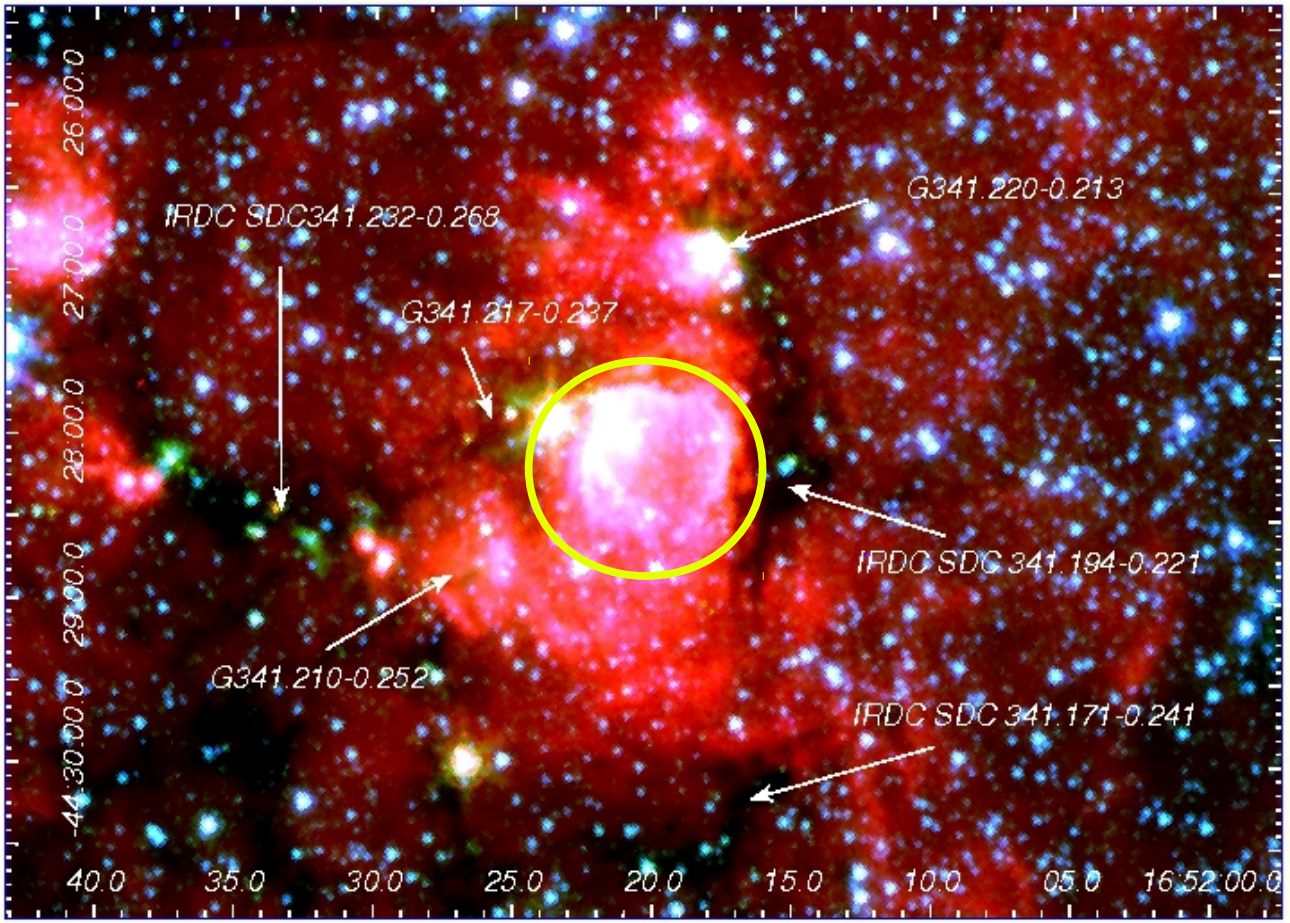
S 24 bubble

- IRAS 16487-4423
- Complete shell
- R = 28”
- CS(2-1) -44 km/s

(Bronfman+1996)

- D = 3.7 kpc

IRAC: 3.6 µm, 4.5 µm, 8.0 µm

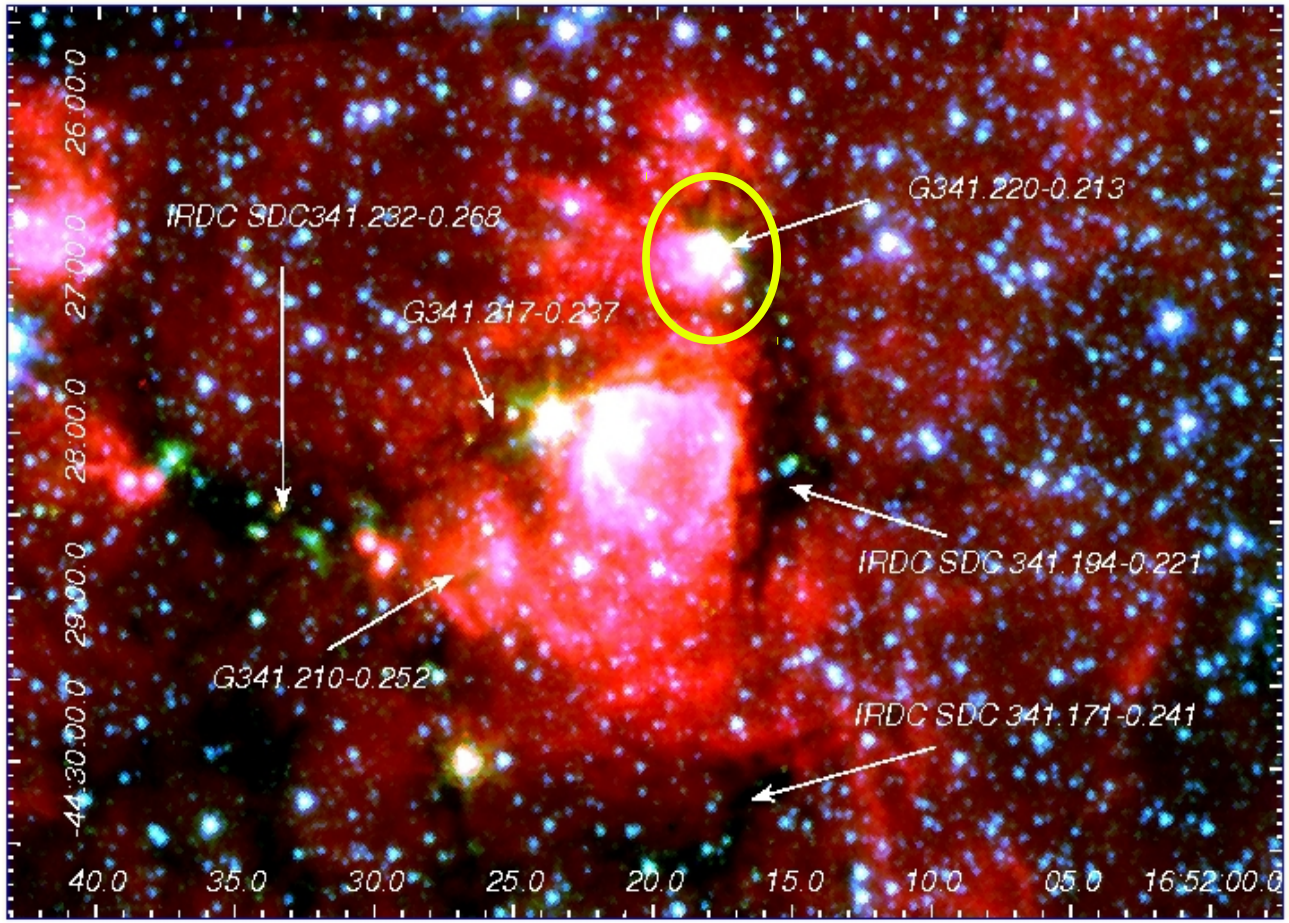


The S24 region

G341.220-0.213

- **R = 10”**
- **At 8 μm horseshoe morphology**
- **Maser emission** (methanol + water, Bayandina+2012, Urquhart+2013, Walsh+2014)

IRAC: 3.6 μm, 4.5 μm, 8.0 μm

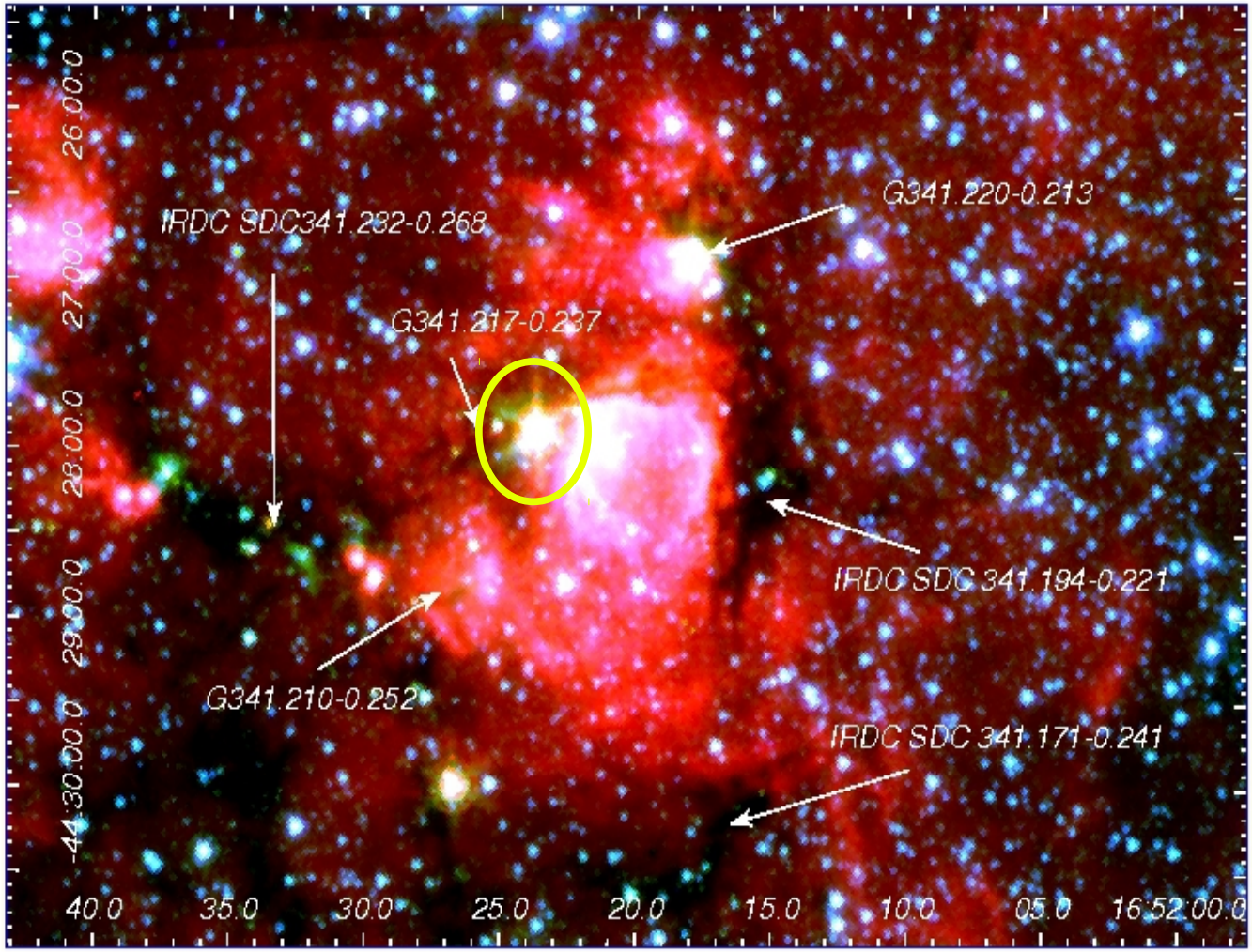


The S24 region

G341.217-0.237

- **R = 5”**

IRAC: 3.6 μm, 4.5 μm, 8.0 μm

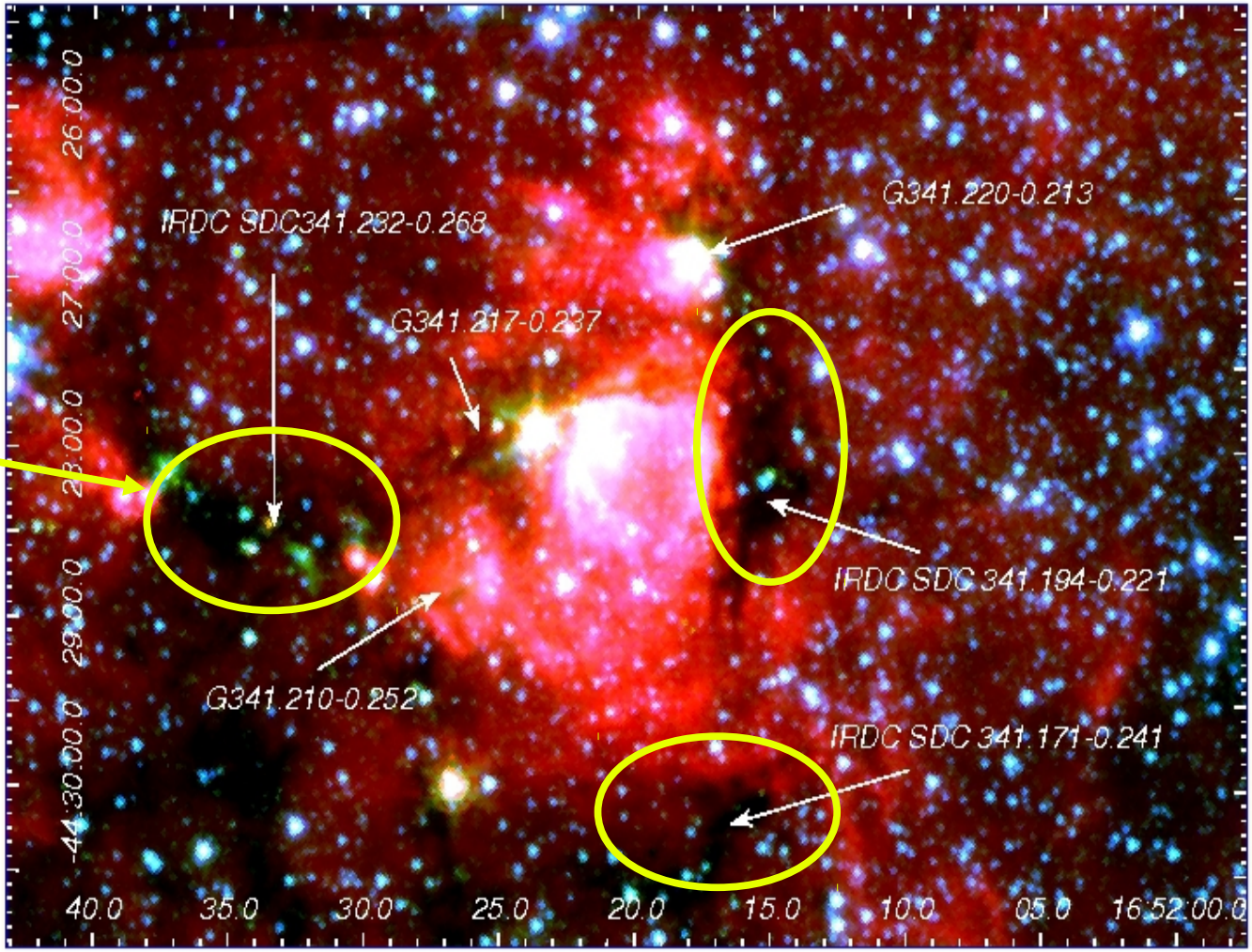


The S24 region

IRAC: 3.6 µm, 4.5 µm, 8.0 µm

- IRDCs

See poster 10 by Vasquez+



Observations

Molecular data: APEX

- APEX 1: CO(2-1) at 230.54 GHz y ^{13}CO(2-1) at 220.40 GHz, 28 arcsec
- APEX 2: ^{13}CO(3-2) at 330 GHz, 20”

Dust continuum emission at 345 GHz: APEX

- LABOCA (19.2”) at 870 μm (ATLASGAL, Schuller+2009)

Near- and mid IR:

Spitzer-GLIMPSE 3.6, 4.5, 5.8, 8.0 μm and MIPS 24 μm

Far-IR:

Herschel-PACS: 70 and 160 μm

Herschel-SPIRE: 250, 350, and 500 μm

Cold dust

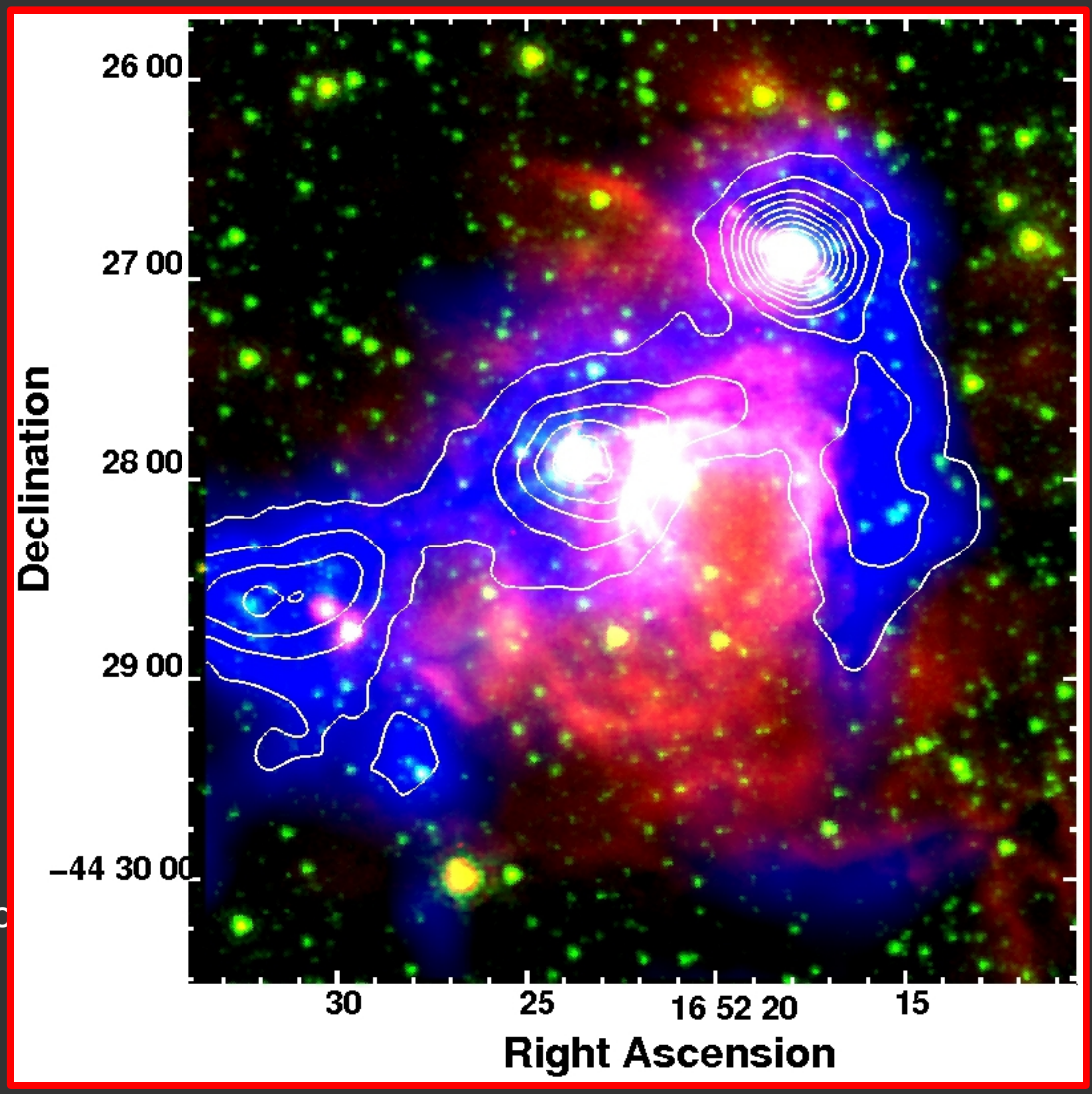
SPIRE 250 μm and
ATLASGAL 870 μm:

- ✓ Excellent correlation of the emission at both wavelengths: IRDC + IR sources
- ✓ Dust masses:

G341.220-0.213: 13 M_o

G341.217-0.237: 22 M_o

Total mass: 3700±2000 M_o



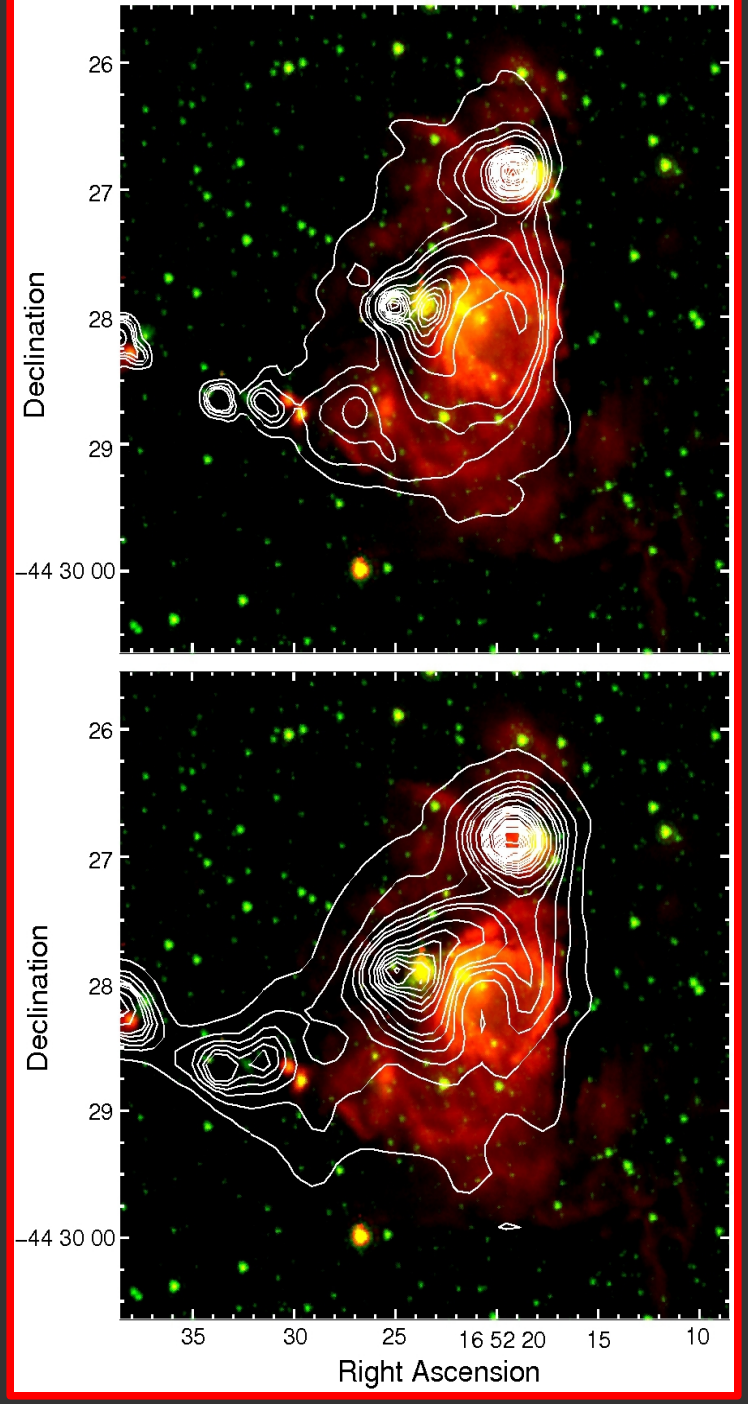
Cold dust

Colorscale: 8.0 µm
Contours: 70 µm

PACS 70 and 160 µm:

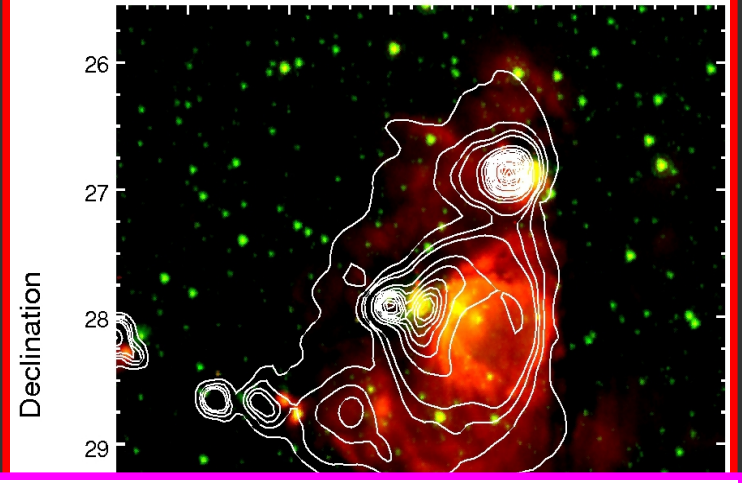
- ✓ Emission differs from SPIRE and ATLASGAL: S 24 + IR sources are detected

Colorscale: 8.0 µm
Contours: 160 µm



Cold dust

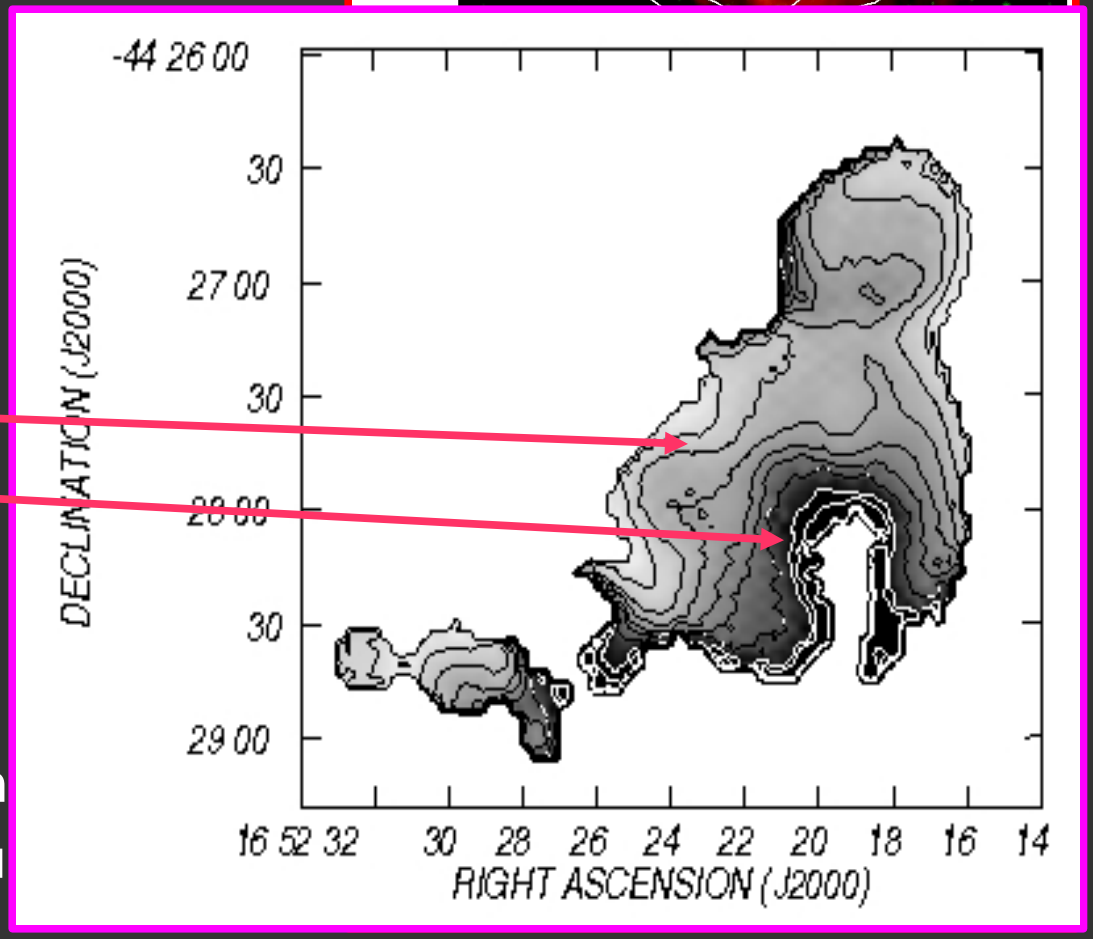
Colorscale: 8.0 µm
Contours: 70 µm



PACS 70 and 160 µm:

- ✓ Dust temperatures:
  S 24: gradient:
  From 26 K
  to 60 K
  (compatible with Anderson+2012)
  Presence of ionizing sources

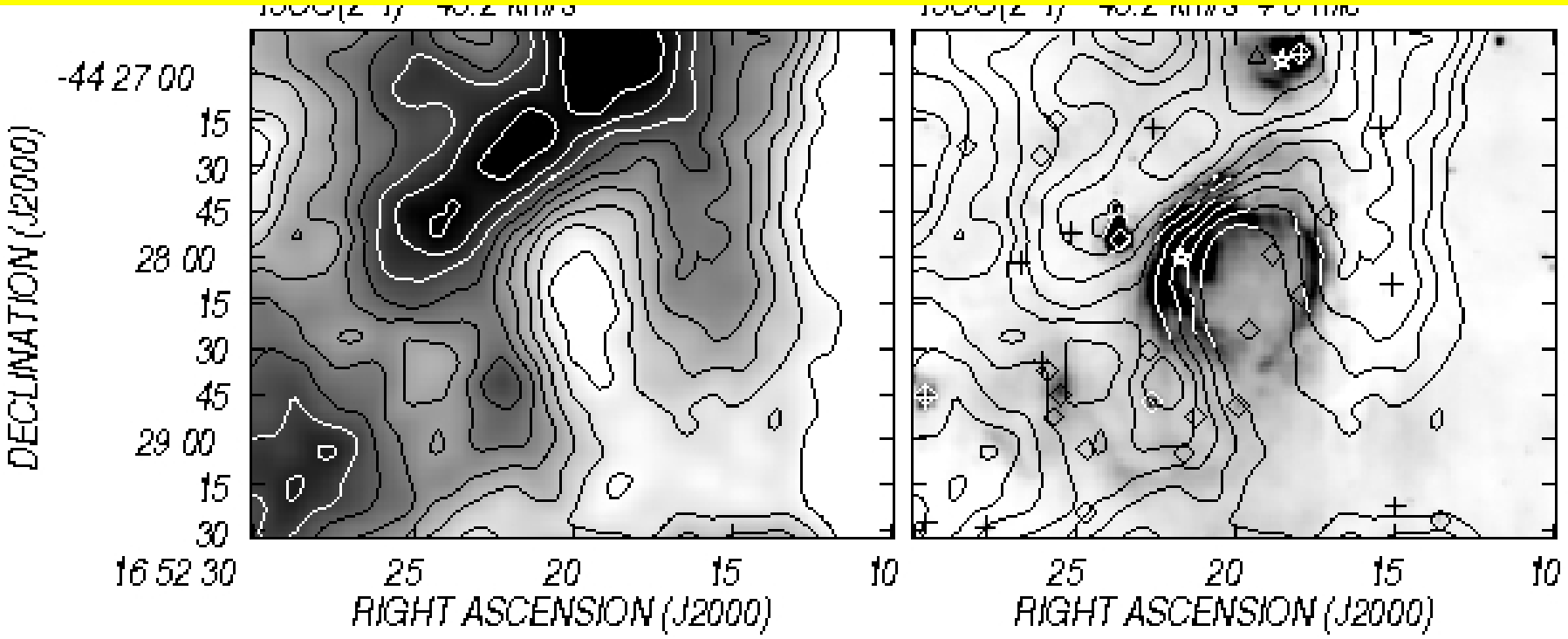
Colorsca
Contou



S24 bubble: molecular gas

- Complete molecular shell encircling the S24 bubble
- ΔV = [-46,-42.5] km/s; R_co = 54” = 0.8 pc
- $M(H_2) = 3100\ M_o$; $n(H_2) = 2.5 \times 10^4\ cm^{-3}$
- Western section: IRDC SDC341.194-0.221

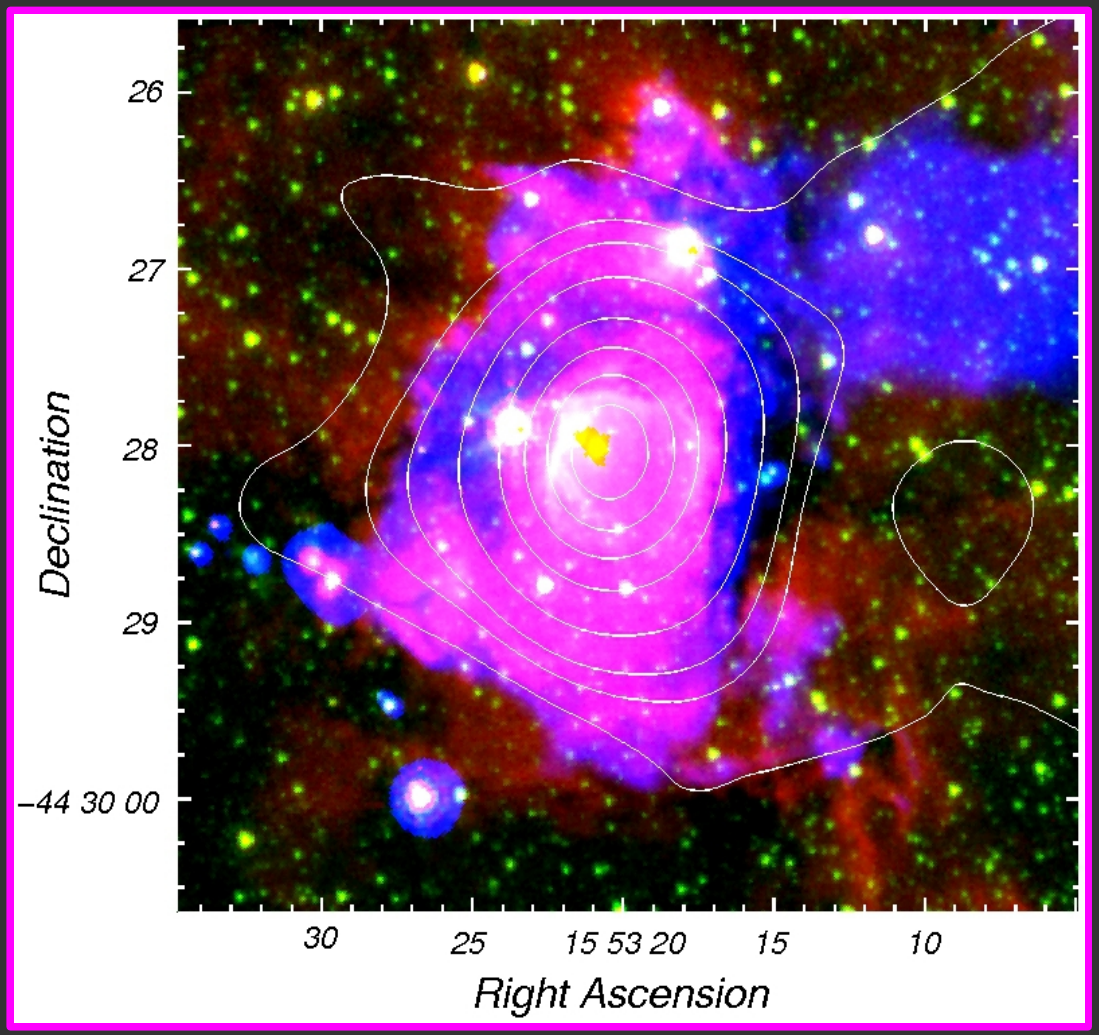
13CO(2-1) -43.2 km/s **13CO(2-1) + 8 μm (grayscale)**



S24 bubble: ionized gas

24 μm; 8 μm; 3.6 μm

Contours: 843MHz

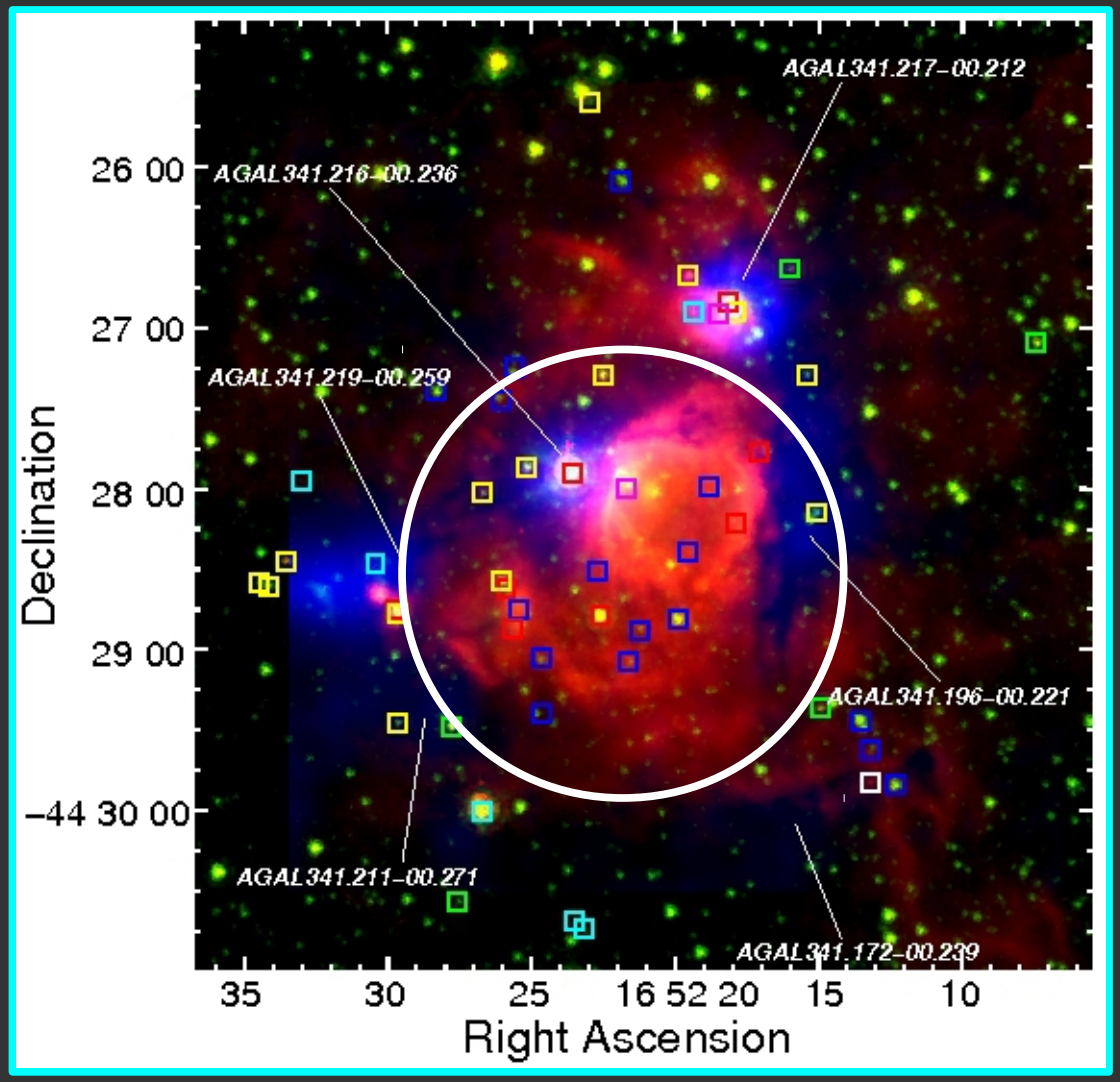


- Thermal emission: **HII region (UCHII)**
- 24 μm: warm dust inside
- Presence of excitation sources

- R = 0.33 pc
- O5V-O9V star
- t_dyn = (9-43)x10^3 yr

S24 bubble: triggered star formation?

870 μm; 8 μm; 3.6 μm



- **Search for YSOs (MSX, 2MASS, Spitzer, WISE)**
- Many candidates onto the molecular shell

- **Collect & Collapse process?**

(Whitworth+1994):

- O5V-O9V
- n(H2) = 5900 cm^{-3}
- The HII region is too young for triggering to have begun

G341.220-0.213: molecular gas

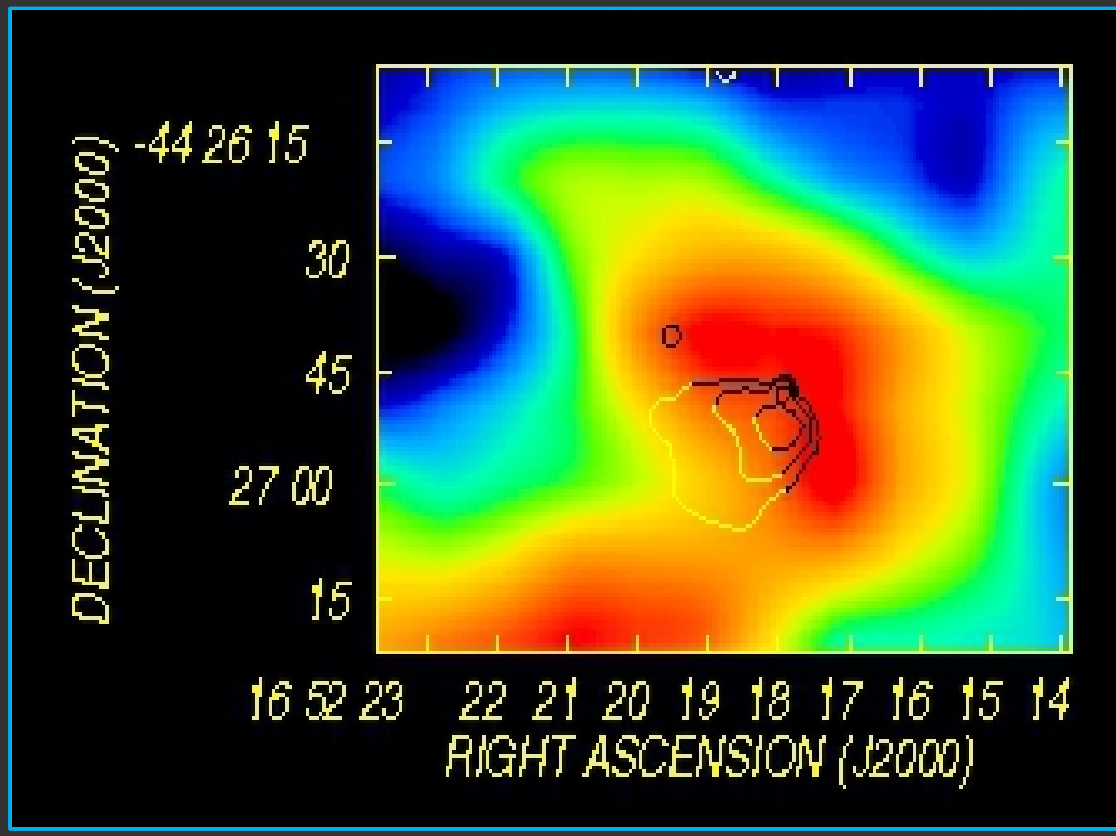
Arc-like structure encircling the “horseshoe”

- ΔV = [-44,-40.5] km/s
- R_co = 0.44 pc

- IR source interacts with molecular gas
- Evolving in a density gradient

- $M(H_2) = 1550\ M_{0,}$

$n(H_2) = 6.6 \times 10^4\ cm^{-3}$



Contours: 8 μm

Colorscale: 13CO(2-1)

G341.220-0.213: star formation

Signs of star formation:

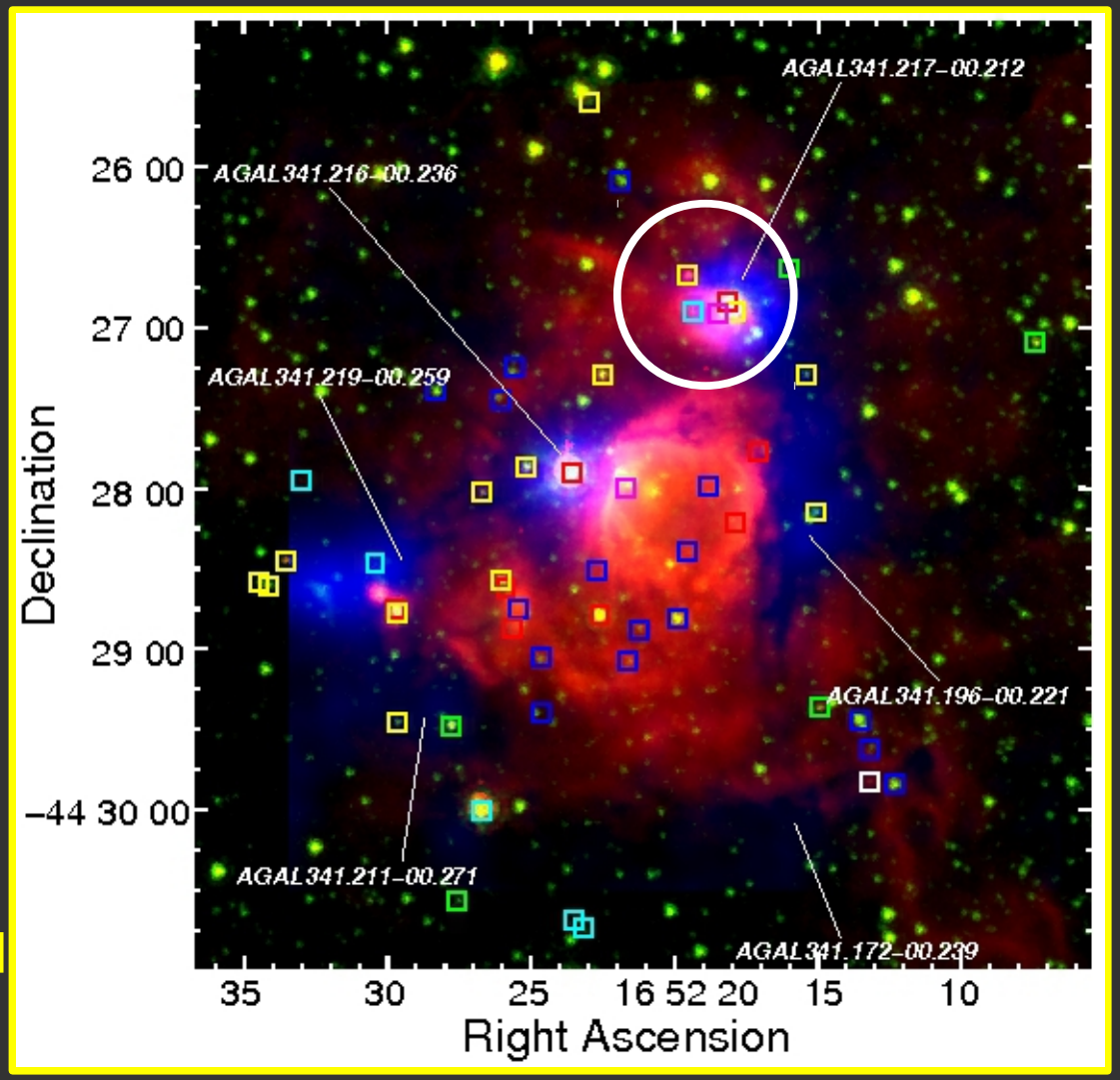
- ✓ Maser emission (methanol and water)

v = [-50,-38] km/s

Results from our search:

- ✓ MSX source: MYSO
- ✓ 2MASS YSO
- ✓ Spitzer (Class I)
- ✓ WISE (Class I)

- ✓ Coincidence with gas and dust



870 µm; 8 µm; 3.6 µm

G341.220-0.213: star formation

SED (Robitaille's tool)

Central source:

M = 10 M_o

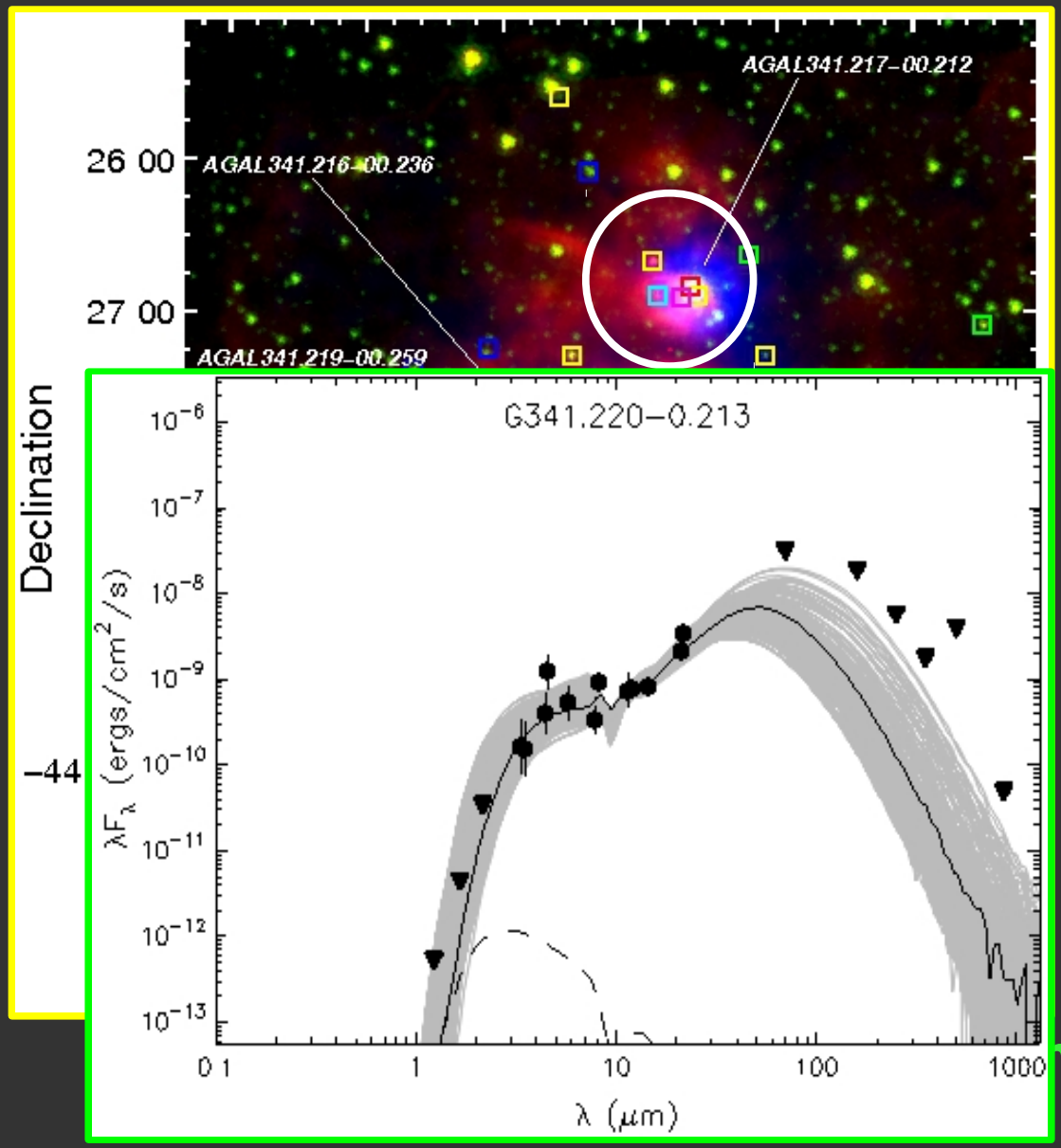
Mdisk = 5 x 10^{-4} Mo

Menv = 21 Mo

T = 1x10^6 yr

Stage II source

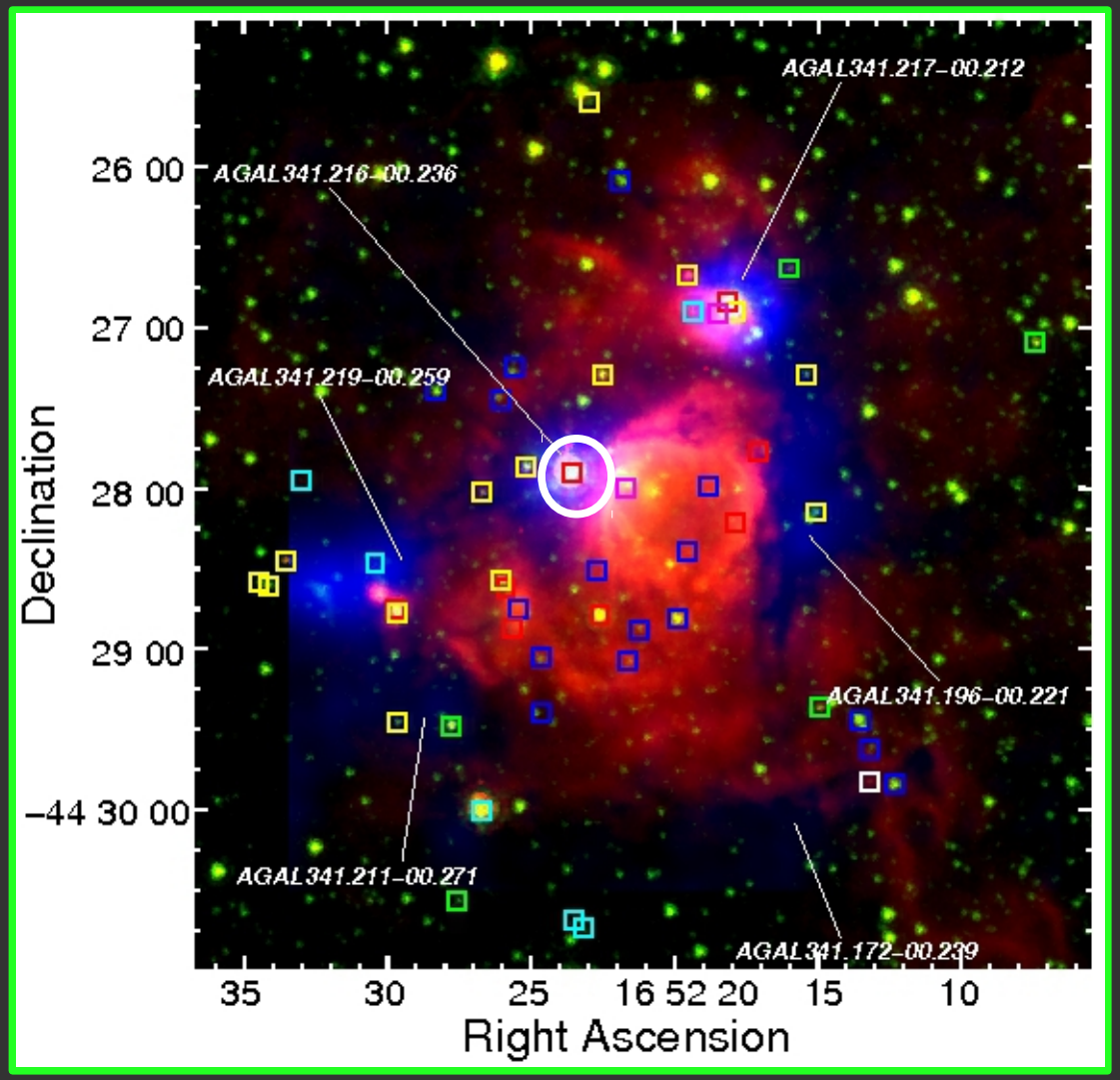
We propose that this object has started to dissociate and ionize its environs



G341.217-0.217: star formation

Results from our search for YSOs:

- ✓ **WISE (Class I)**



870 µm; 8 µm; 3.6 µm

G341.217-0.217: star formation

Results from our search for YSOs:

- ✓ **WISE (Class I)**

- ✓ SED:

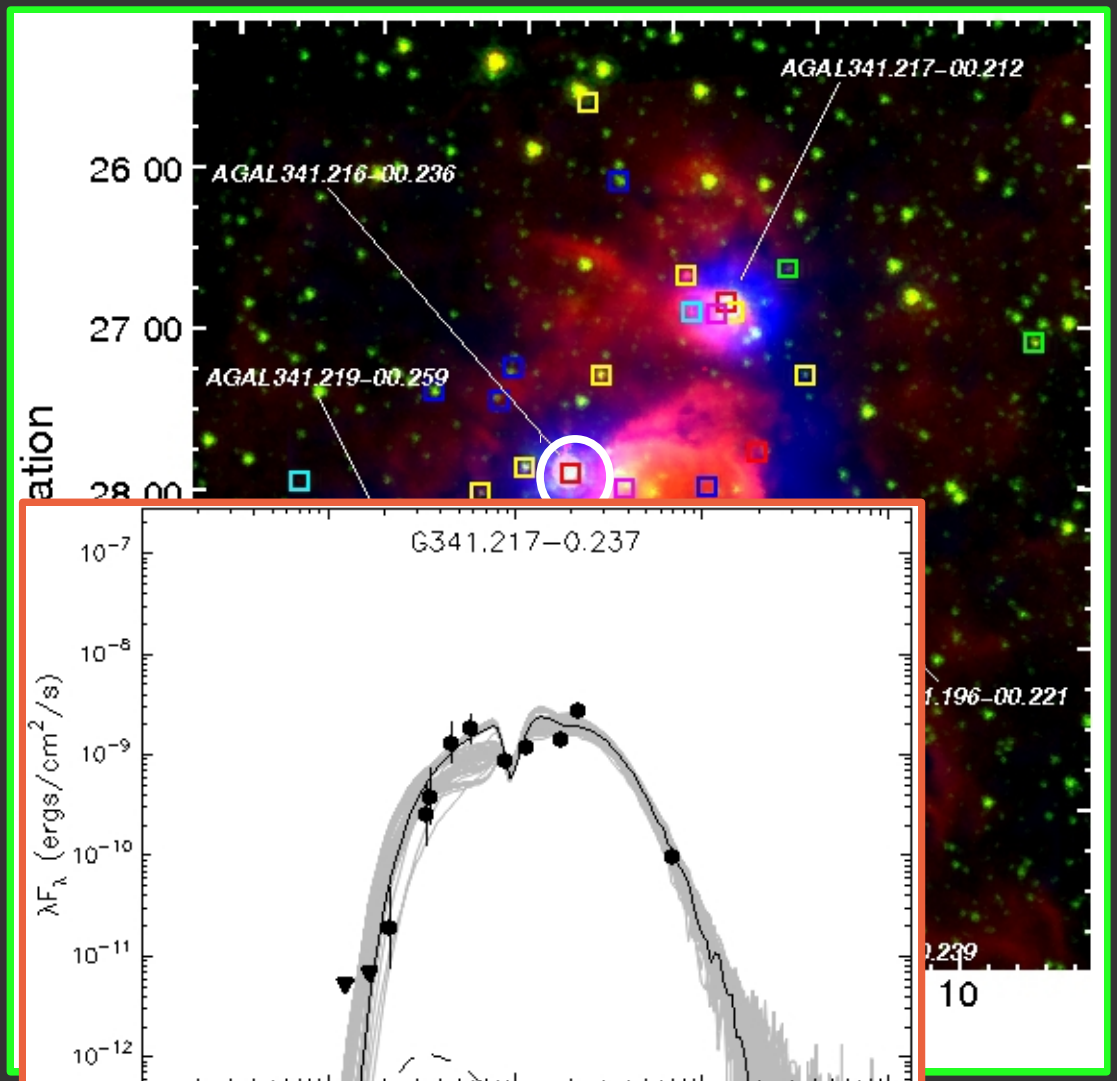
Central source:

M = 15 Mo

Mdisk = 8 x 10^{-3} Mo

T = 1.3x10^{6} yr

Stage III source



Summary

- We performed a multiwavelength study of the S24 region to investigate the molecular gas and dust distribution, and the star formation status.
- **S24 bubble:** Compact HII region surrounded by a molecular shell, coincident with cold dust and YSOs. Collect & Collapse process is not supported, probably because the HII region is too young.

  It has characteristics of typical IR dust bubbles.
  - $M(H_2)$ = 3100Mo,

    $n(H_2) = 25 \times 10^3$ cm^{-3}
- **G341.220-0.213:** An arc-like molecular structure borders the brightest region of the source, which coincides with cold dust. Star formation is active, with a central Class I object of 10 Mo.
  - $M(H_2)$ = 1550 Mo,

    $n(H_2) = 66 \times 10^3$ cm^{-3}.
- **G341.217-0.237:** Coincides with molecular gas and cold dust. Linked to a central object of 15 Mo.
- Total molecular mass: 10300Mo

  n(H2) ambient density: 5.9×10^3 cm^{-3}

IR dust bubbles

- Identifued at 8 μm (Churchwell+2006, 2007)

  600 IR dust bubbles in images of the Galactic Legacy Mid-Plane Extraordinaire (GLIMPSE), obtained with the Infrarred Array Camera (IRAC)

- Main characteristics (Churchwell+ 2006, Deharveng+ 2010 [100 IR-B], Watson + 2009, Parón+ 2010, Zhang & Wang 2012):
  - Most of them linked to HII regions and massive stars
  - Associated with UCHII
  - Concentrated towards the galactic Plane
  - Linked to molecular gas and PDRs
  - Inner region: Emission at 24 μm from warm dust
  - Excitation sources
  - Many of them include active areas of star formation