A multi-wavelength investigation of RCW175: an HII region haboring spinning dust emission

Christopher Tibbs

IPAC/Caltech

In collaboration with:
Roberta Paladini, Mathieu Compiègne, Clive Dickinson, Marta Alves, Nicolas Flagey, Sachindev Shenoy, Alberto Noriega-Crespo, Sean Carey, Simon Casassus, Rod Davies, Richard Davis

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Why RCW175?

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ANOMALOUS MICROWAVE EMISSION FROM THE H II REGION RCW175

C. Dickinson[1], R. D. Davies[2], J. R. Allison[3], J. R. Bond[4], S. Casassus[5], K. Cleary[6], R. J. Davis[2], M. E. Jones[3], B. S. Mason[7], S. T. Myers[8], T. J. Pearson[6], A. C. S. Readhead[6], J. L. Sievers[4], A. C. Taylor[3], M. Todorović[2], G. J. White[9], and P. N. Wilkinson[2]

[1] Infrared Processing and Analysis Center, California Institute of Technology, M/S 220-6, 1200 E. California Blvd., Pasadena, CA 91125, USA
[2] Jodrell Bank Observatory, University of Manchester, Lower Withington, Macclesfield, Cheshire, SK11 9DL, UK
[3] Oxford Astrophysics, University of Oxford, Denys Wilkinson Building, Keble Road, Oxford, OX1 3RH, UK
[4] Canadian Institute for Theoretical Astrophysics, University of Toronto, Toronto, Canada
[5] Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile
[6] Chajnantor Observatory, California Institute of Technology, M/S 105-24, Pasadena, CA 91125, USA
[7] National Radio Astronomy Observatory, Green Bank, WV, USA
[8] National Radio Astronomy Observatory, Socorro, NM, USA
[9] Rutherford Appleton Laboratory, Didcot, OX11 0QX, UK

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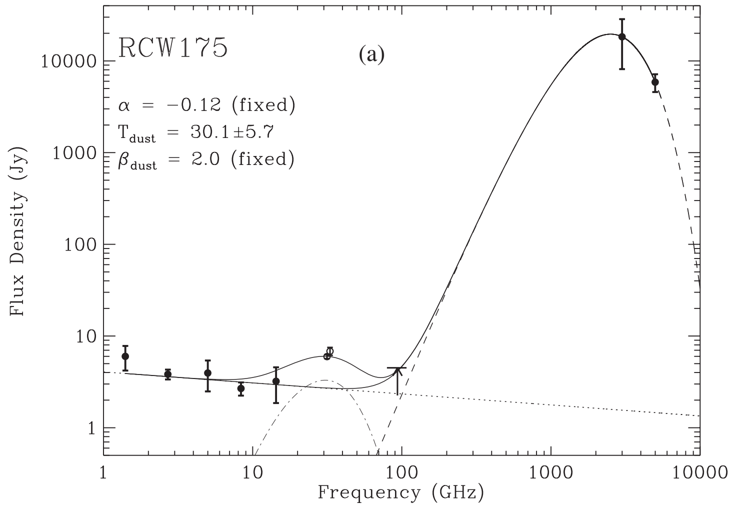
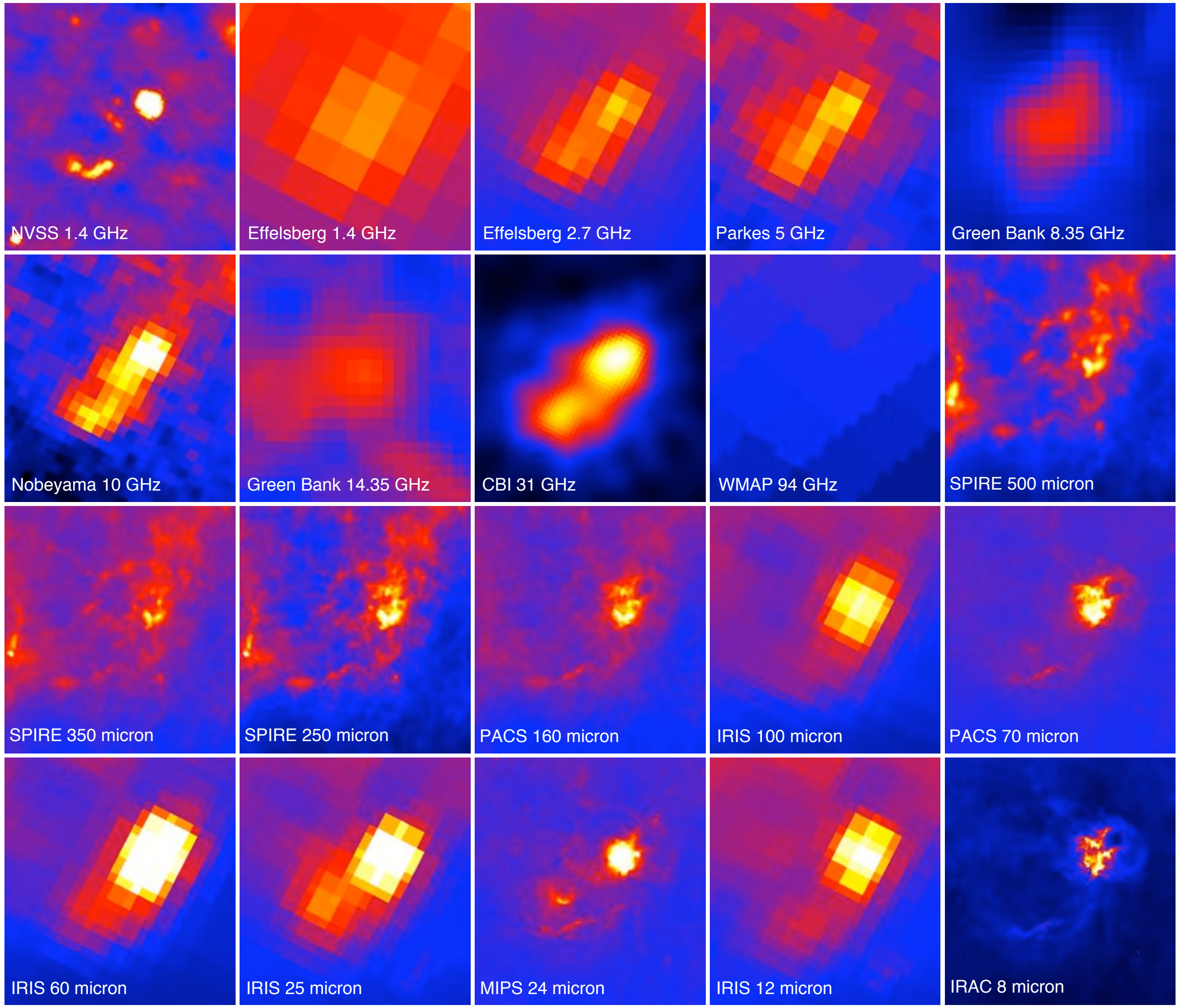


RCW175 Observations

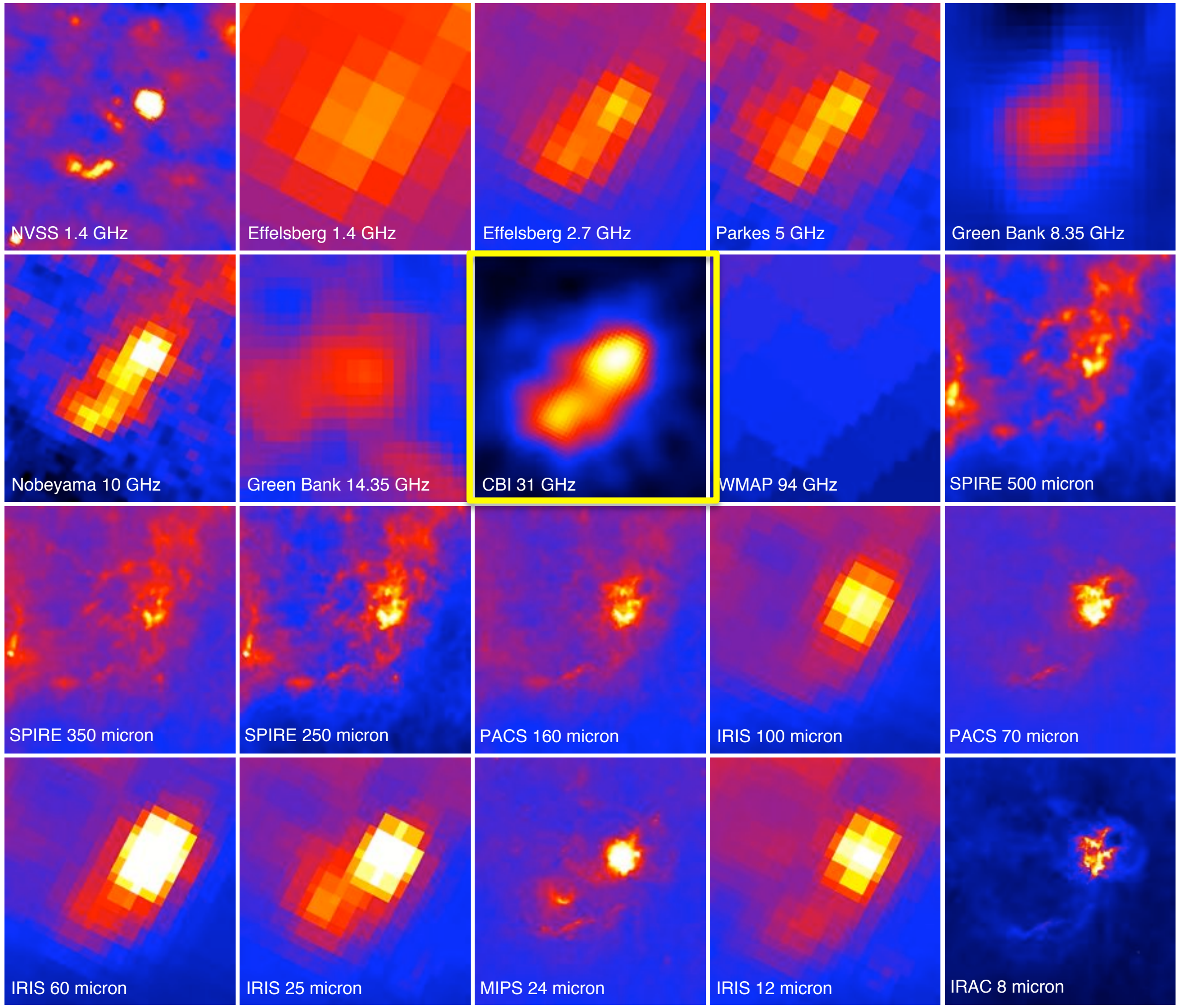
- RCW175 has been observed extensively all the way from radio to mid-IR wavelengths.

Frequency (GHz)	Telescope/ Survey	Reference for Data	Angular Resolution (arcmin)
1.4	Effelsberg 100 m	Reich et al. (1990a)	9.4
2.7	Effelsberg 100 m	Reich et al. (1990b)	4.3
5	Parkes 64 m	Haynes et al. (1978)	4.1
8.35	Green Bank 13.7 m	Langston et al. (2000)	9.7
10	Nobeyama 45 m	Handa et al. (1987)	3.0
14.35	Green Bank 13.7 m	Langston et al. (2000)	6.6
31	CBI	Dickinson et al. (2009)	4.3
94	WMAP	Jarosik et al. (2011)	13.2
599.6 (500 μm)	*Herschel*/SPIRE	Molinari et al. (2010)	0.6
856.5 (350 μm)	*Herschel*/SPIRE	Molinari et al. (2010)	0.4
1199.2 (250 μm)	*Herschel*/SPIRE	Molinari et al. (2010)	0.3
1873.7 (160 μm)	*Herschel*/PACS	Molinari et al. (2010)	0.2
2997.9 (100 μm)	IRIS	Miville-Deschênes & Lagache (2005)	4.3
4282.7 (70 μm)	*Herschel*/PACS	Molinari et al. (2010)	0.1
4996.5 (60 μm)	IRIS	Miville-Deschênes & Lagache (2005)	4.0
11991.7 (25 μm)	IRIS	Miville-Deschênes & Lagache (2005)	3.8
12491.4 (24 μm)	*Spitzer*/MIPS	Carey et al. (2009)	0.1
24982.7 (12 μm)	IRIS	Miville-Deschênes & Lagache (2005)	3.8
37474.1 (8 μm)	*Spitzer*/IRAC	Churchwell et al. (2009)	0.03

RCW175 Observations

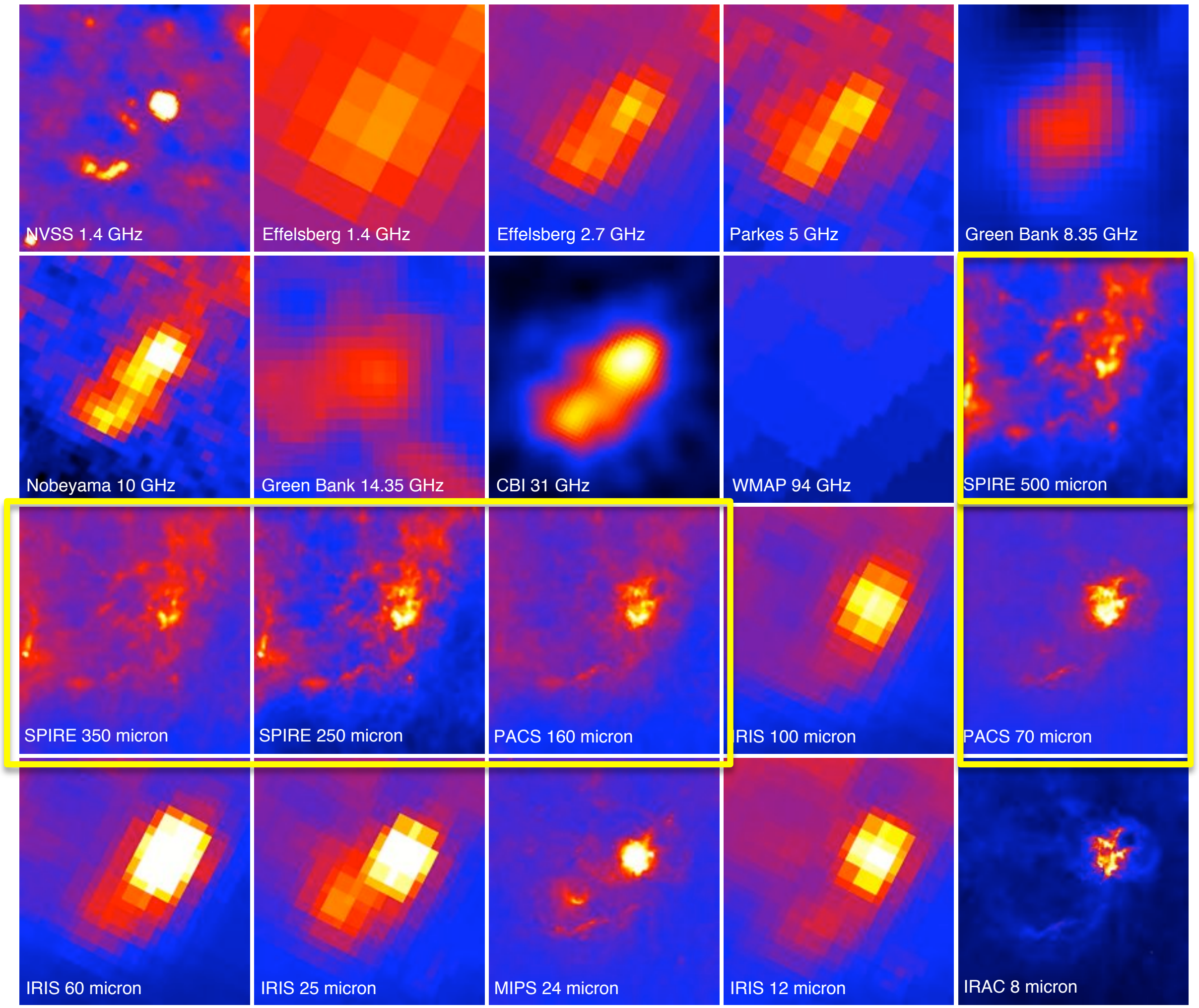


RCW175 Observations



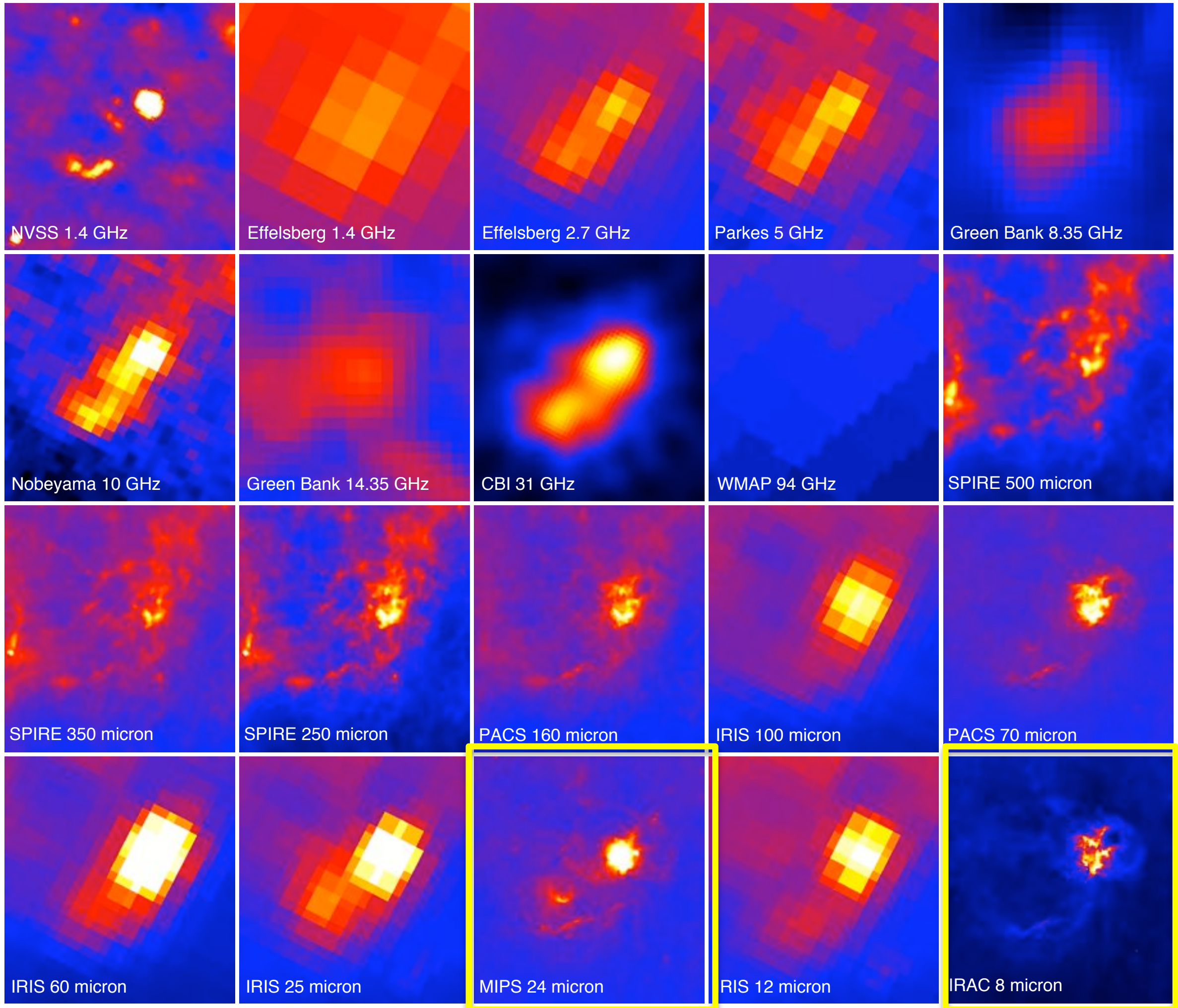
Cosmic Background Imager (CBI) data at 31GHz
(Dickinson et al. 2009)

RCW175 Observations



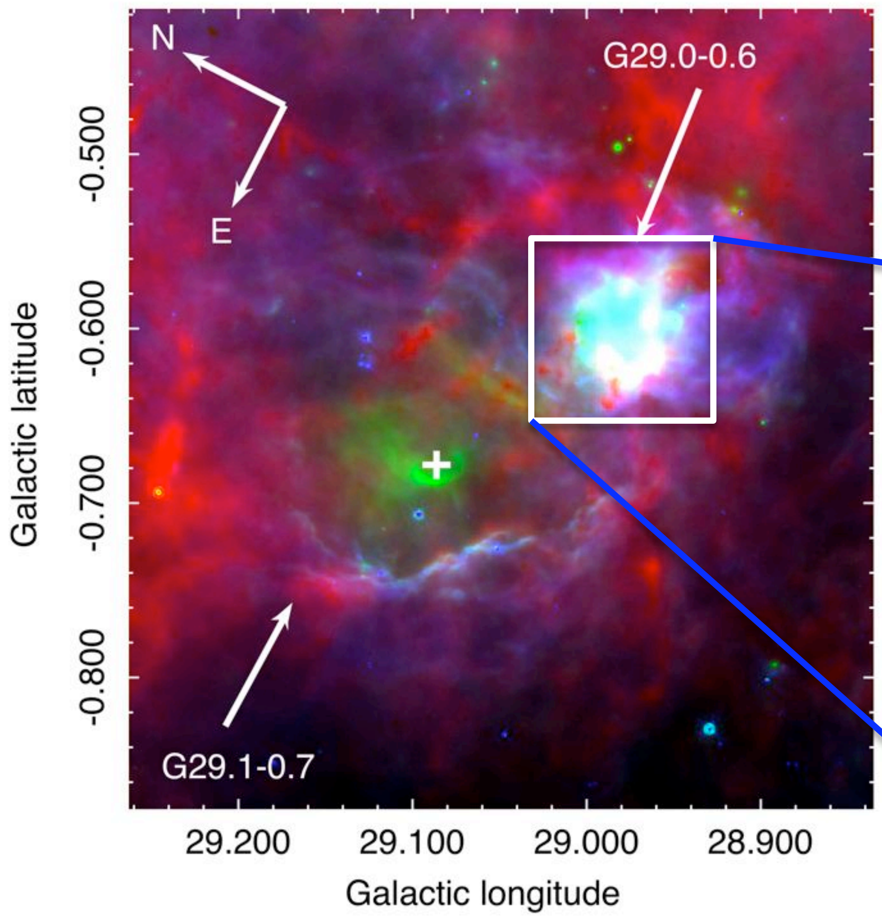
Herschel HiGal 70, 160, 250, 350 and 500μm data
(Molinari et al. 2010)

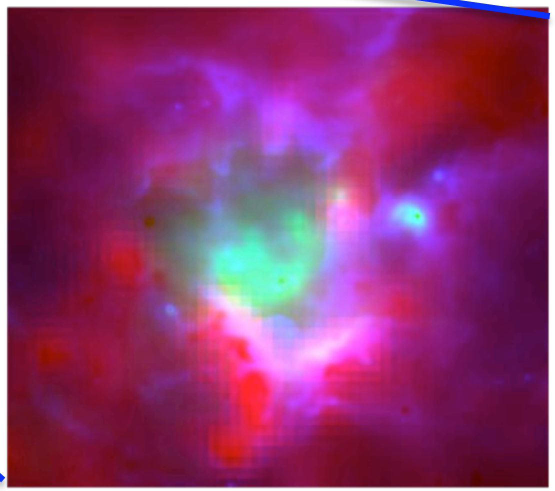
RCW175 Observations



Spitzer MIPSGAL 24μm data (Carey et al. 2009) and GLIMPSE 8μm data (Churchwell et al. 2009)

Morphology of RCW175



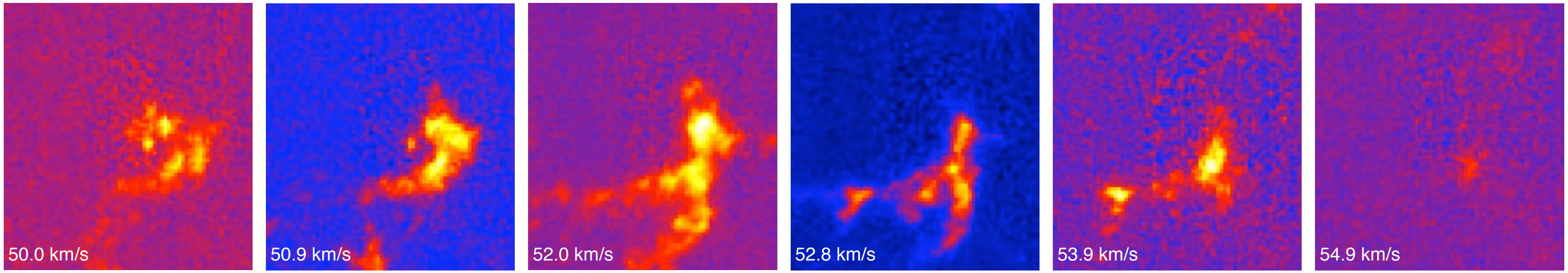


Blue = 8μm, green = 24μm, red = 350μm

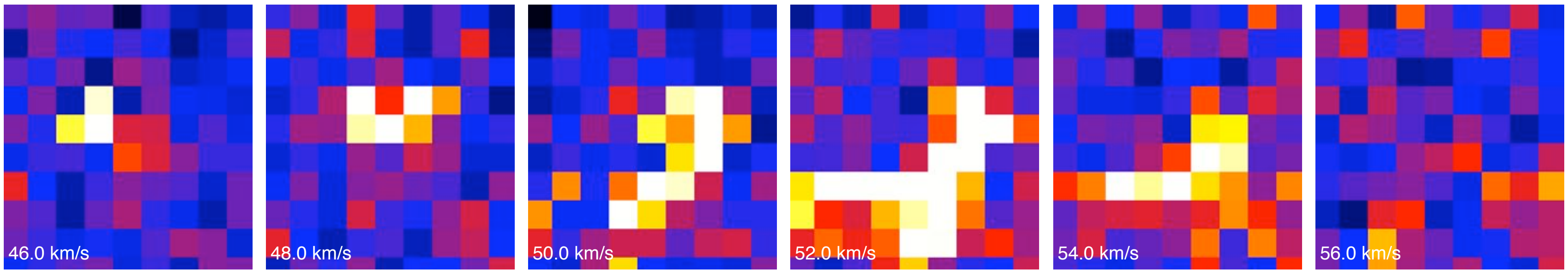
- Galactic HII region originally identified by Sharpless (1959)
- Consists of 2 separate components, G29.1-0.7 and G29.0-0.6

RCW175 Observations

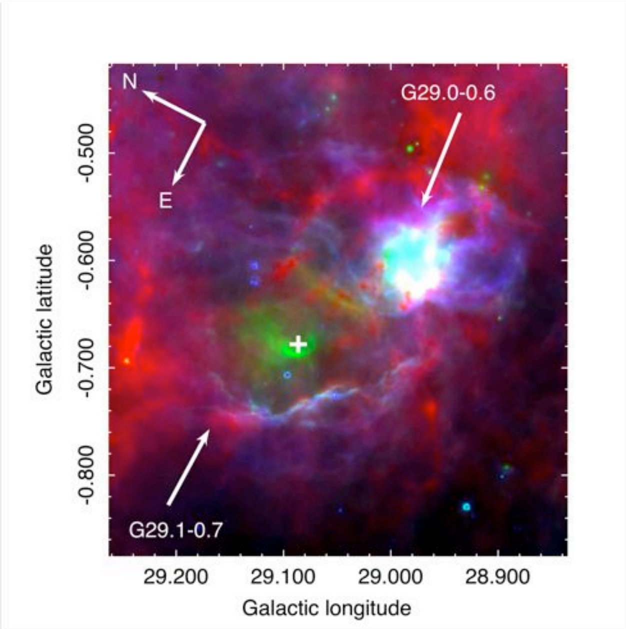
^{13}CO (1-0) data from the Galactic Ring Survey (Jackson et al. 2006)



^{12}CO (1-0) data from the Massachusetts-Stony Brook Galactic Plane Survey (Sanders et al. 1986)

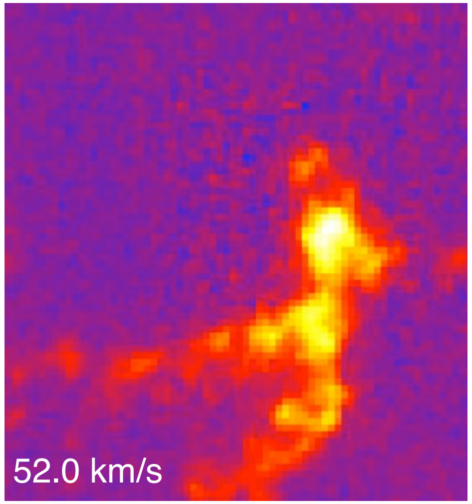


Morphology of RCW175



^{12}CO (1-0)

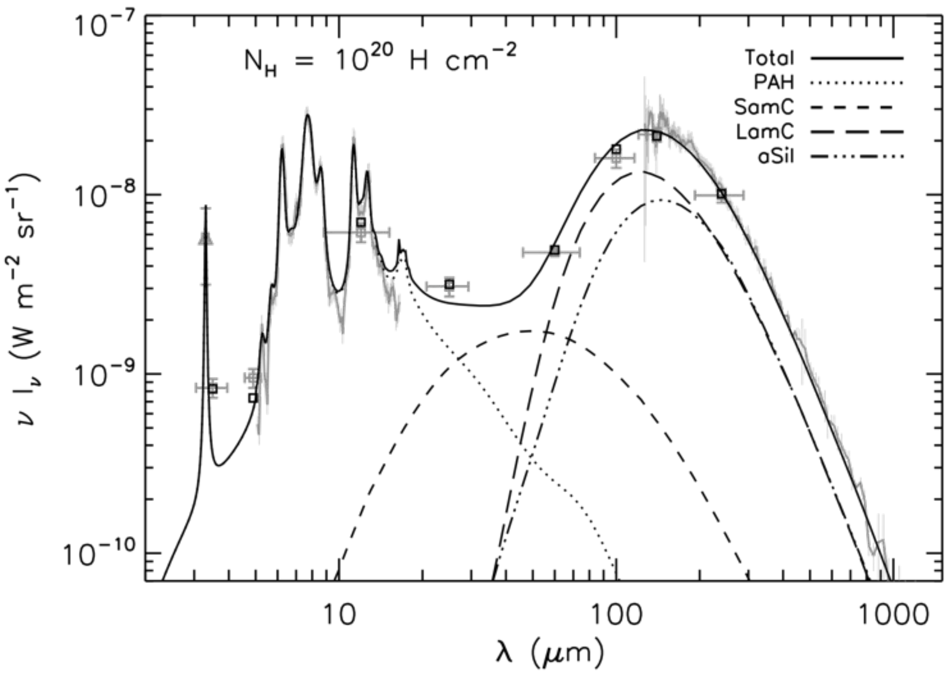
^{13}CO (1-0)



- CO traces the compact component G29.0-0.6 and the dust filament along the edge of G29.1-0.7.
- Similarity between the CO data and the Herschel data.

Dust Modelling

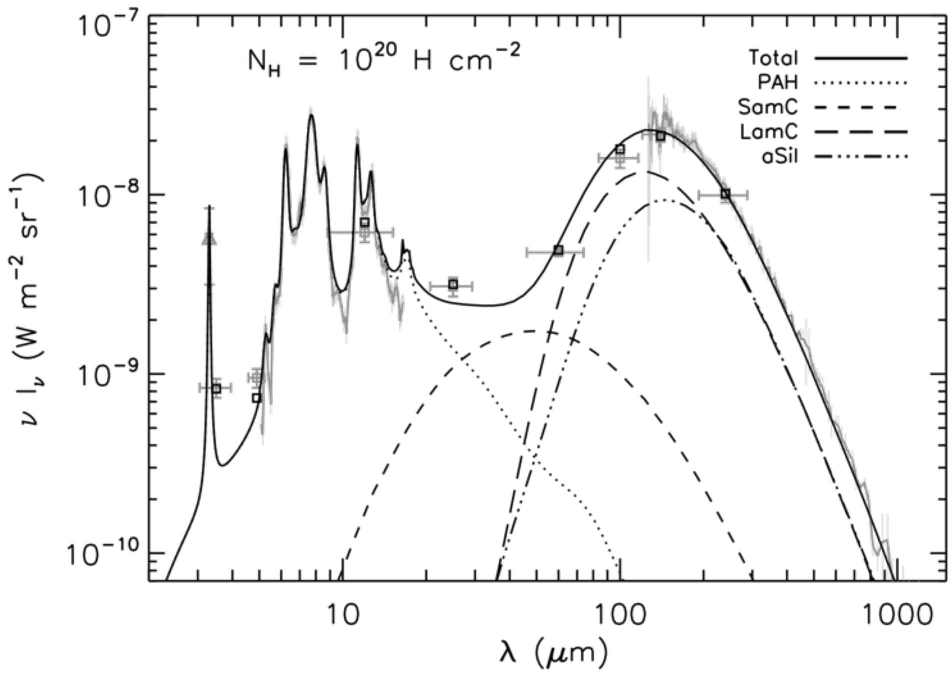
- DUSTEM (Compiègne et al. 2011) is a dust emission model based on the formalism of the Desert et al. (1990) model.
- Previously been used to characterise the dust properties:
  - in the regions of diffuse emission on the Galactic plane (Compiègne et al. 2011)
  - in the Eagle Nebula (Flagey et al. 2011)
  - in the Perseus molecular cloud (Tibbs et al. 2011)



Compiègne et al. (2011)

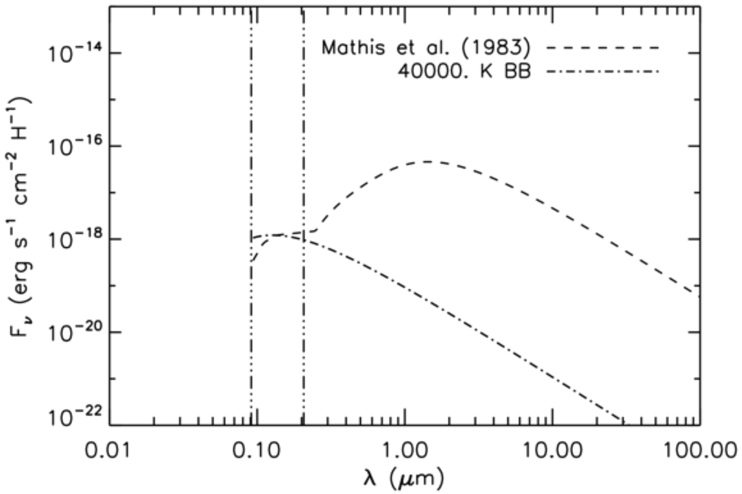
Dust Modelling

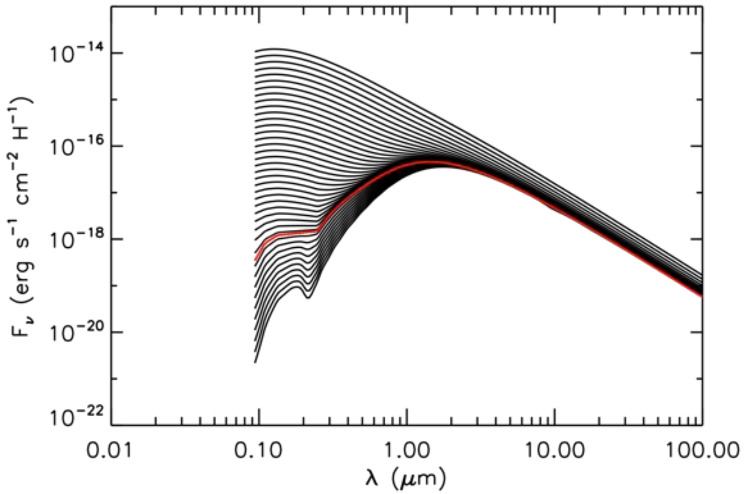
- Use IR data 8, 24, 70, 160, 250, 350 and 500μm.
- Convolve all maps to common angular resolution of 35 arcsec.
- Use DUSTEM with grain species:
  - PAH^{o} + PAH^{+} => PAHs
  - SamC => VSGs
  - LamC + aSil => BGs
- Fit for:
  - Abundance of PAHs and VSGs with respect to BGs (Y_{PAH} and Y_{VSG})
  - Exciting radiation field (χ_{ERF})
  - Column density of hydrogen (N_H)
- Account for the effect of extinction on the line of sight: $I_\lambda = I_{o,\lambda} (1-e^{-\tau})/\tau$



Compiègne et al. (2011)

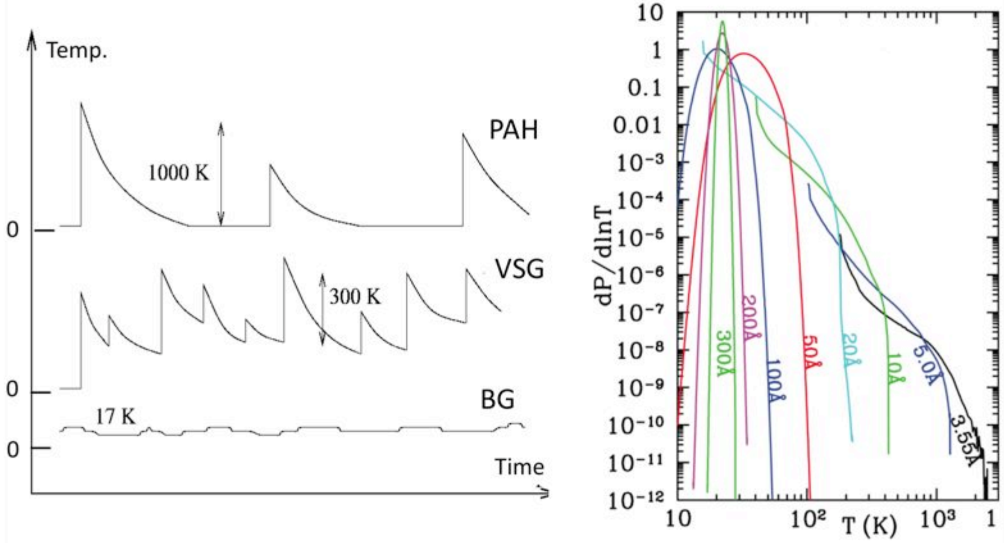
Dust Modelling





- $\chi_{ERF} < 1$ => use Mathis et al. (1983) radiation field extinguished by dust
- $\chi_{ERF} = 1$ => use Mathis et al. (1983) radiation field
- $\chi_{ERF} > 1$ => use Mathis et al. (1983) radiation field + 40,000 K blackbody

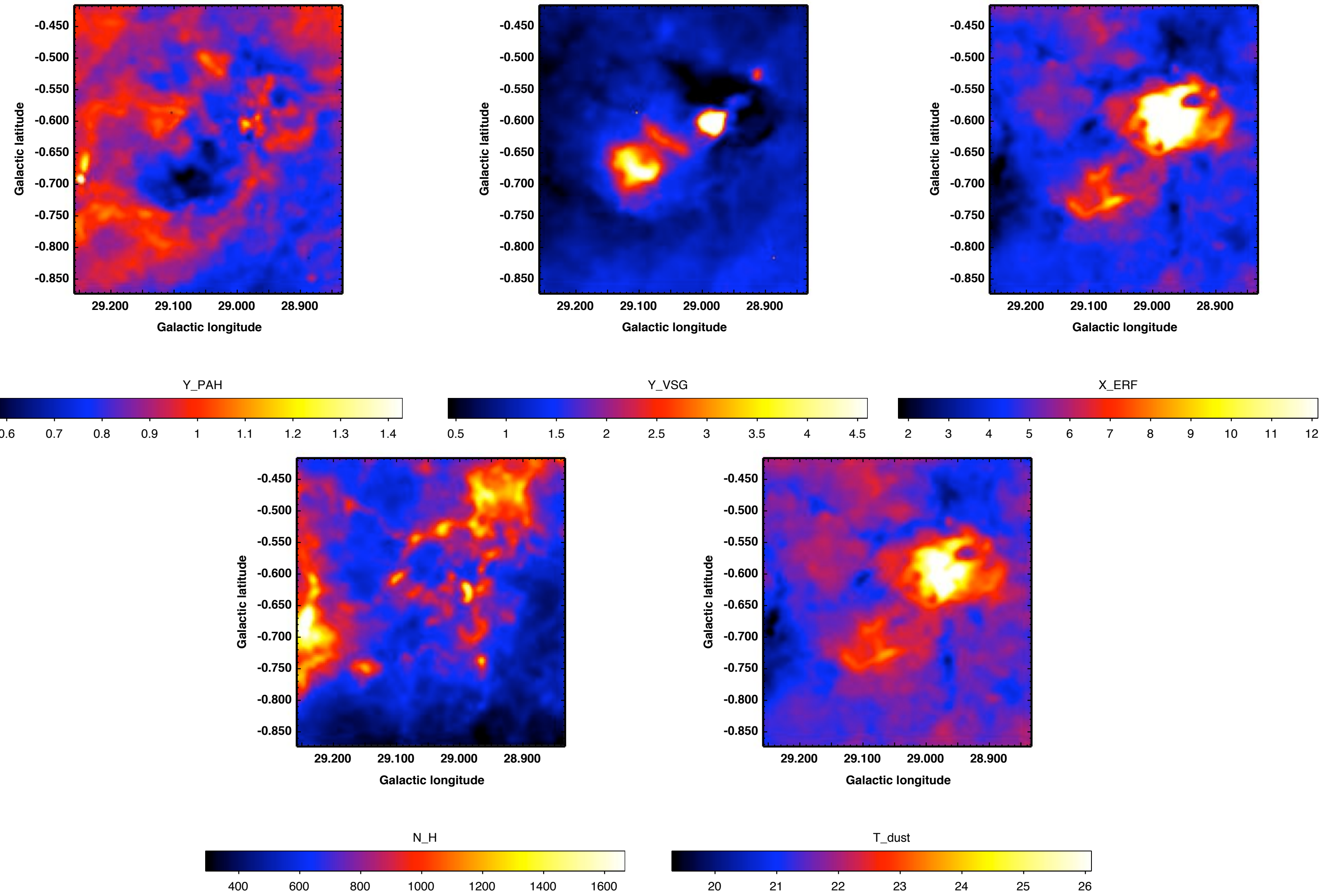
Dust Modelling



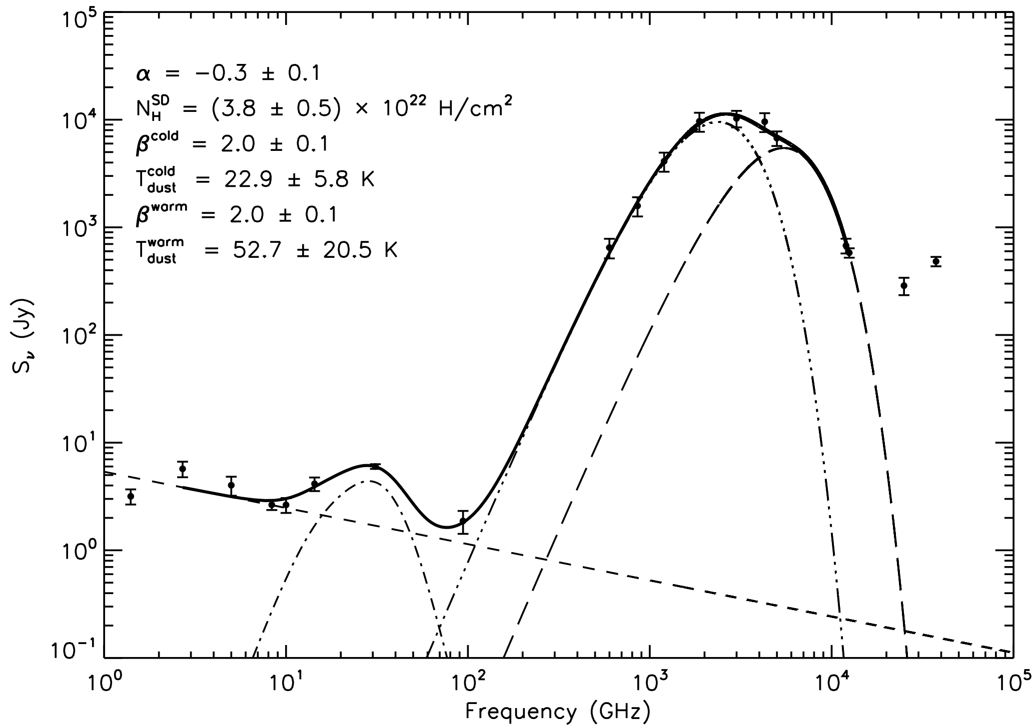
○ DUSTEM combines the optical and thermal properties of the grains with the given radiation field to produce a temperature distribution for each bin of size for each dust grain species.

○ Only BGs in thermal equilibrium, therefore we compute the median temperature for the BGs and use this as an estimate of the dust temperature.

Dust Modelling



SED



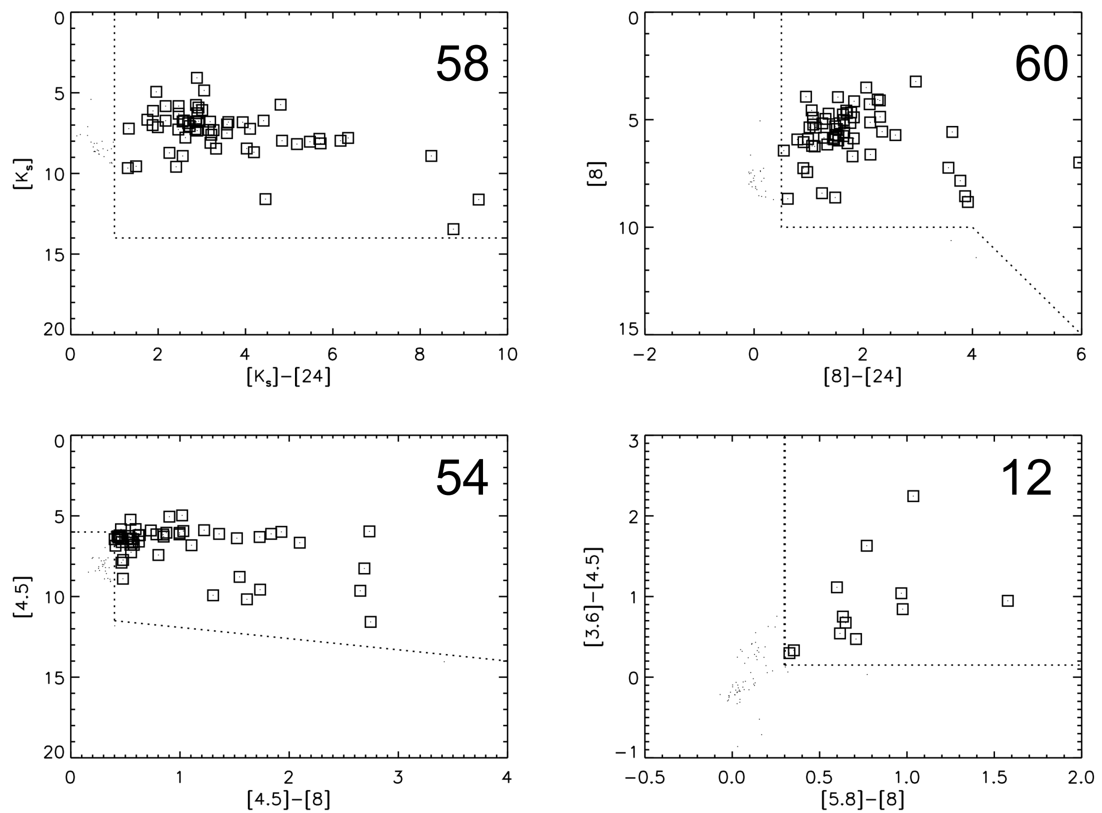
$S_{31GHz}/S_{100\mu m} = 5.8 \pm 1.1 \times 10^{-4}$

~70% of the 31GHz is anomalous

- Compute flux densities of RCW175 from the radio to the mid-IR using aperture photometry.
- This is an update of the SED produced by Dickinson et al. (2009) for this region.
- We simultaneously fit the data for:
  - free-free emission
  - spinning dust emission
  - thermal dust emission
- Possible synchrotron contribution from nearby SNRs.
- We model the thermal dust emission using 2 components to represent the cold and warm dust as we know the entire region is not at one temperature.
- We fit a generic WIM spinning dust model.

YSO Candidates

- Use the MIPSGAL Point Source catalogue (Shenoy et al. in prep) which is band merged with the GLIMPSE (3.6, 4.5, 5.8 and 8μm) and 2MASS (J, H and K) source catalogues.
- We select only sources with > 95% reliability, and find 95 sources with vicinity of RCW175.
- To find YSOc we implement a colour-colour selection criteria adopted from Rebull et al. (2010).



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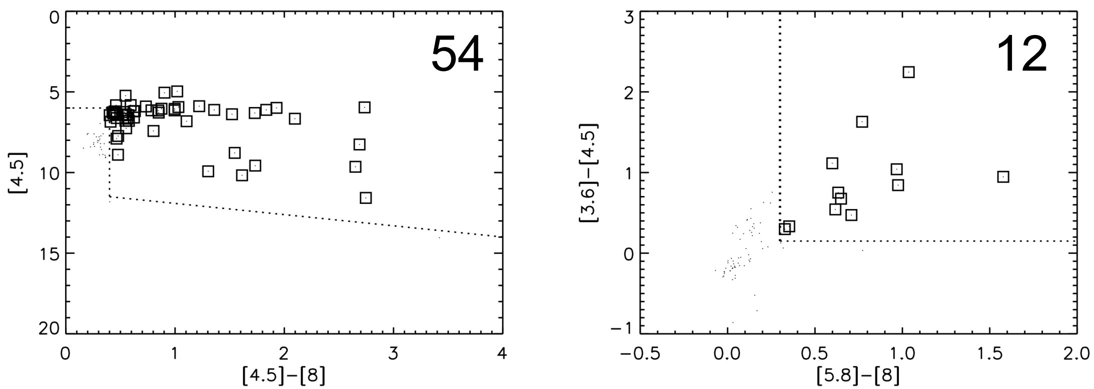
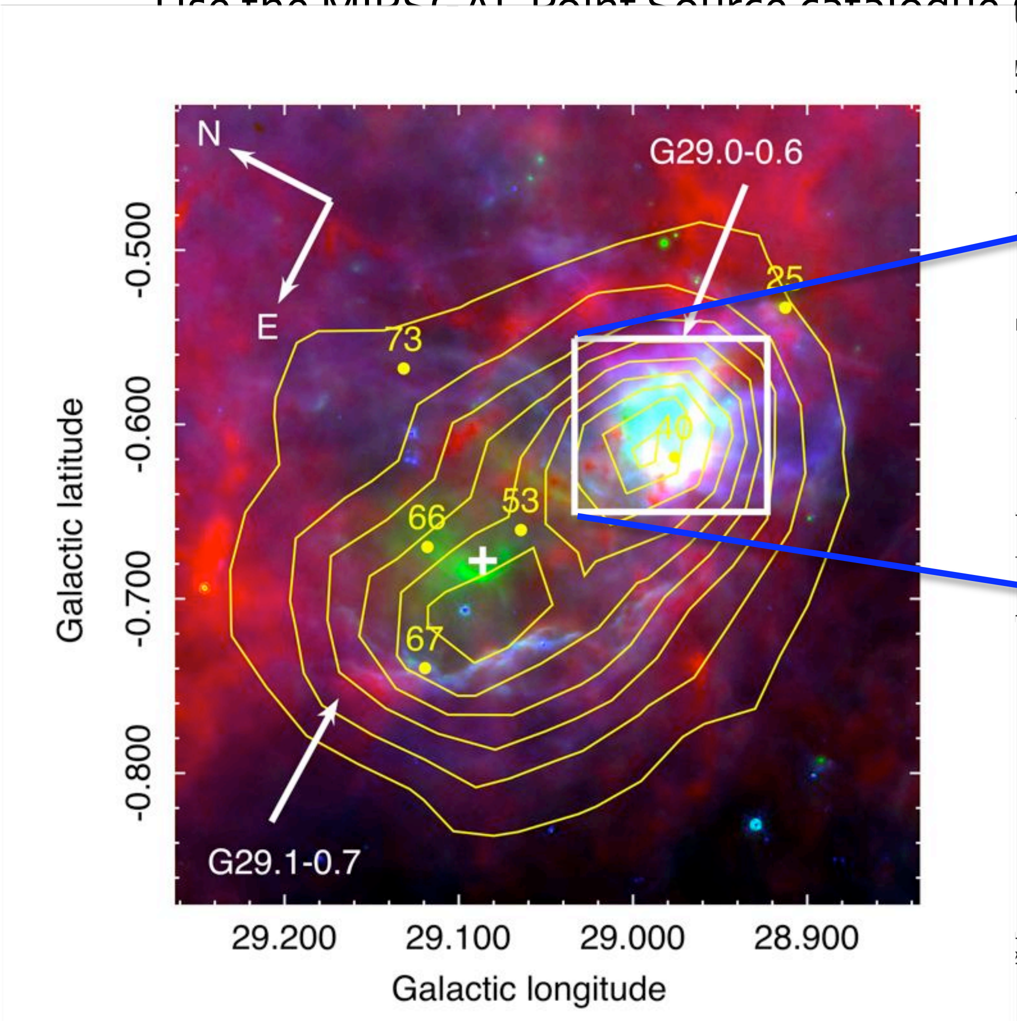
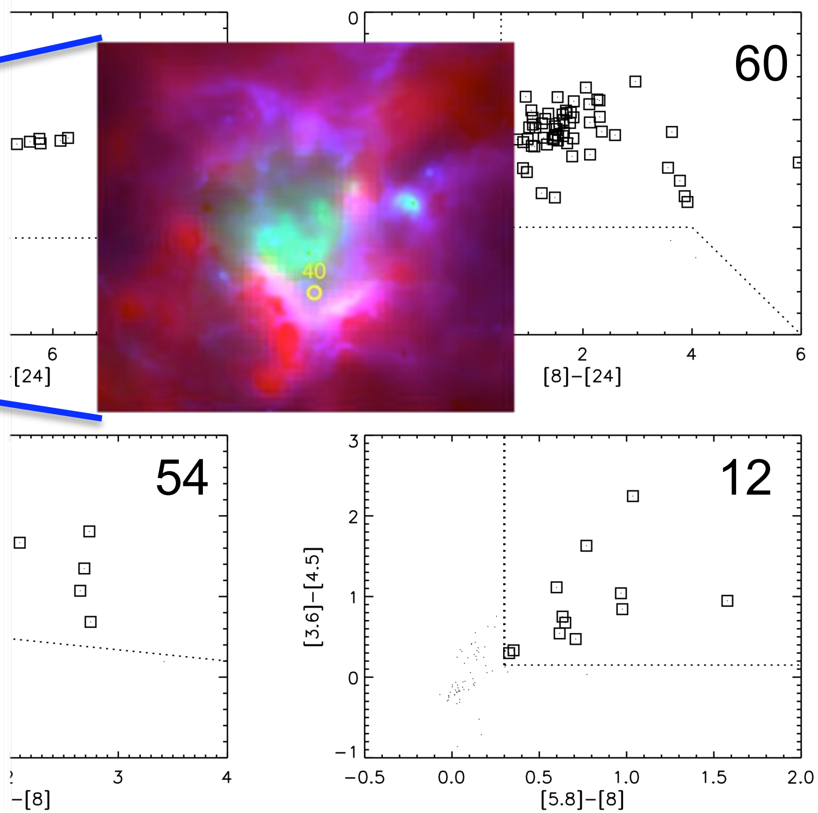
- We select only sources with > 95% reliability, and find 95 sources with vicinity of RCW175.
- To find YSOc we implement a colour-colour selection criteria adopted from Rebull et al. (2010).
- End up with 6 YSO candidates
  - one of which has previously been identified as a possible YSOc.
  - other 5 have no counterparts in SIMBAD.



Origin of the AME

Use the MIPSCAL Point Source catalogue (Shenoy et al. in prep) which is
5.8 and 8μm) and 2MASS (J, H





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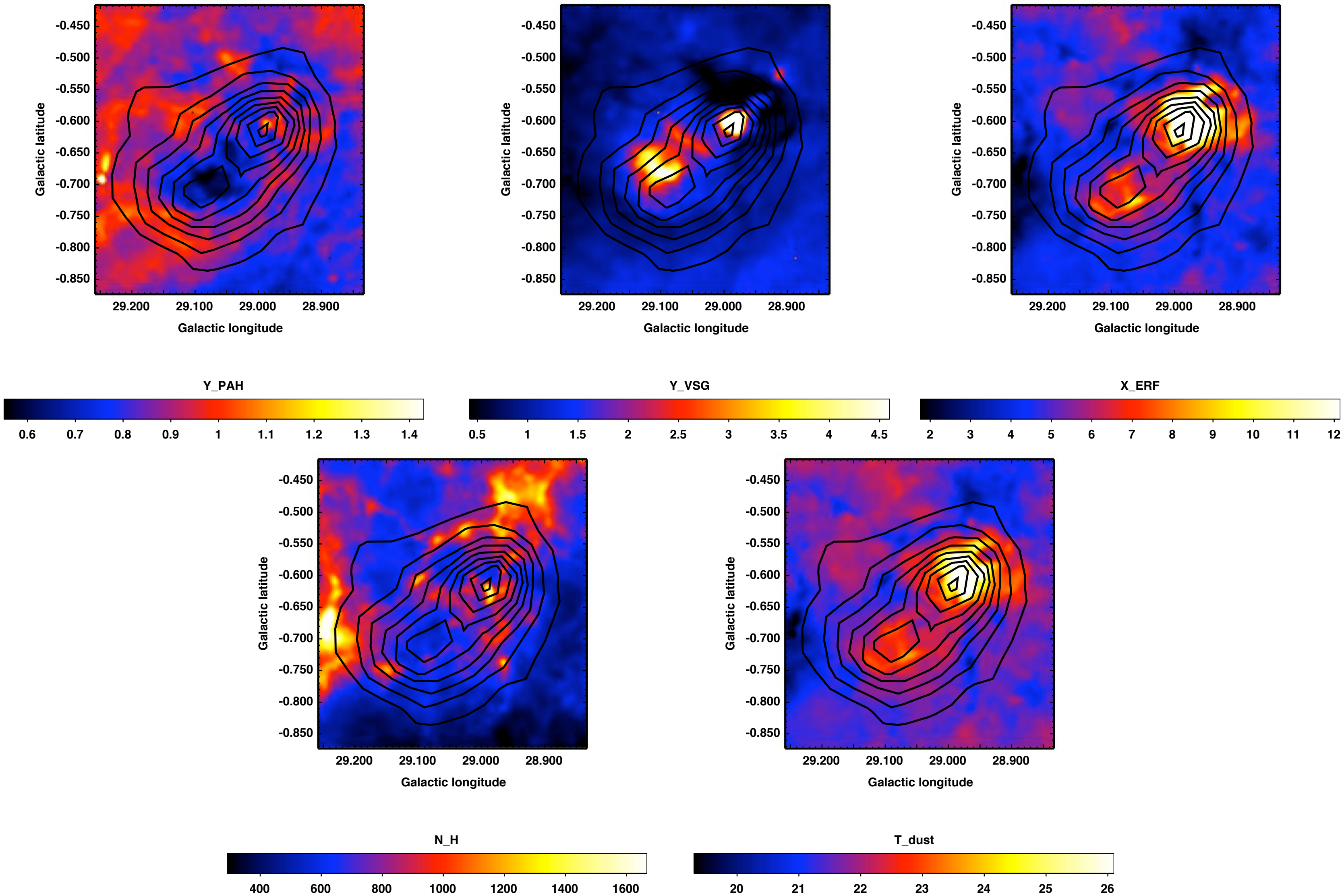

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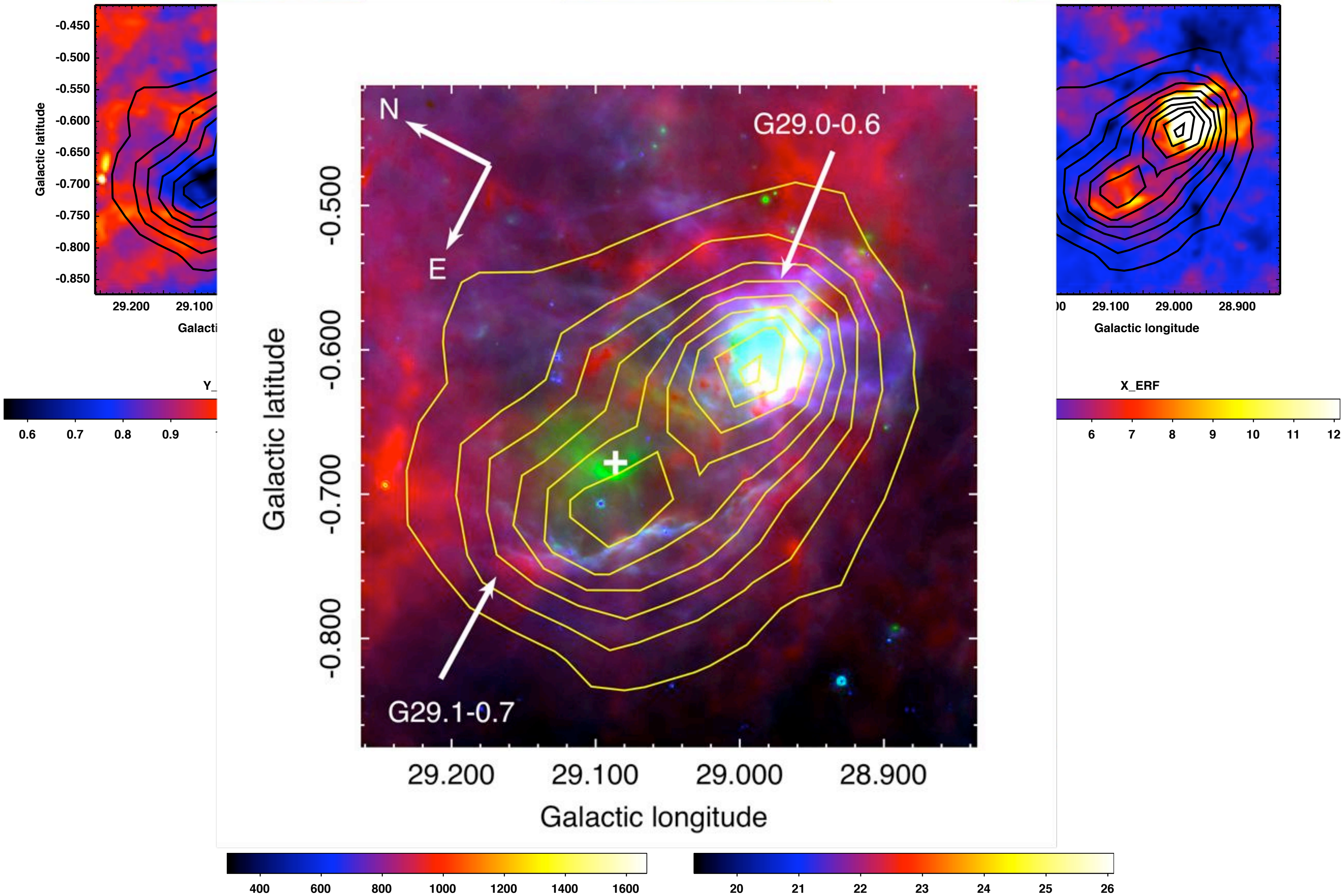
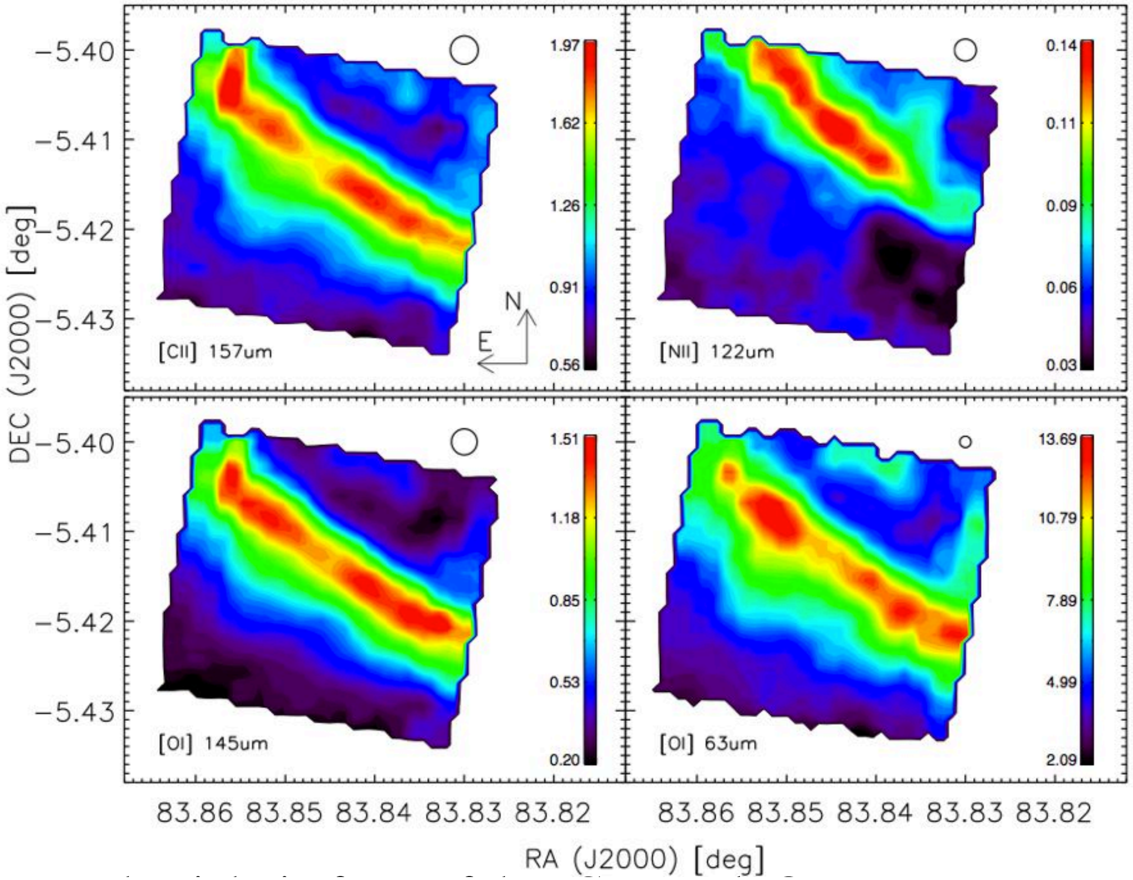


Origin of the AME

- The Orion Bar in the Orion nebula
- Exposed to a strong radiation field => PDR
- Many studies on this region.
- One such study by Bernard-Salas et al. (2011) which shows the stratification present in PDRs.



Bernard-Salas et al. (2011)

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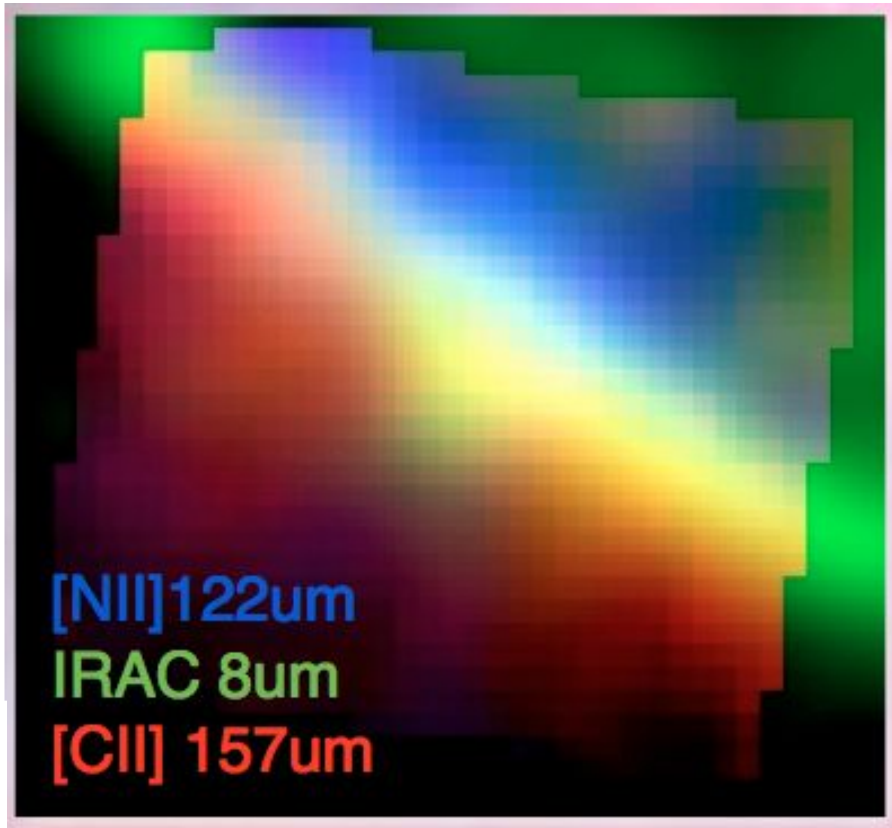

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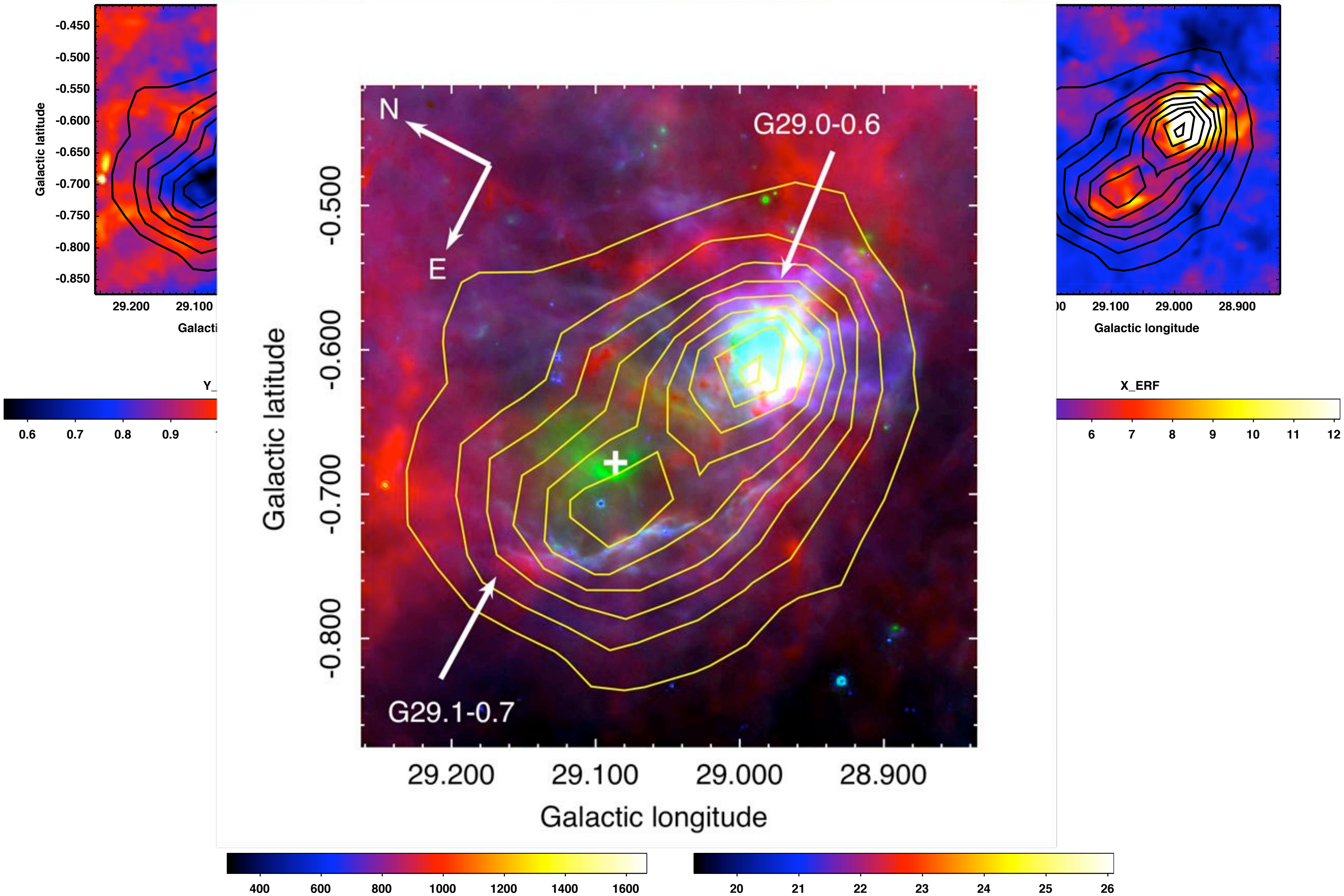
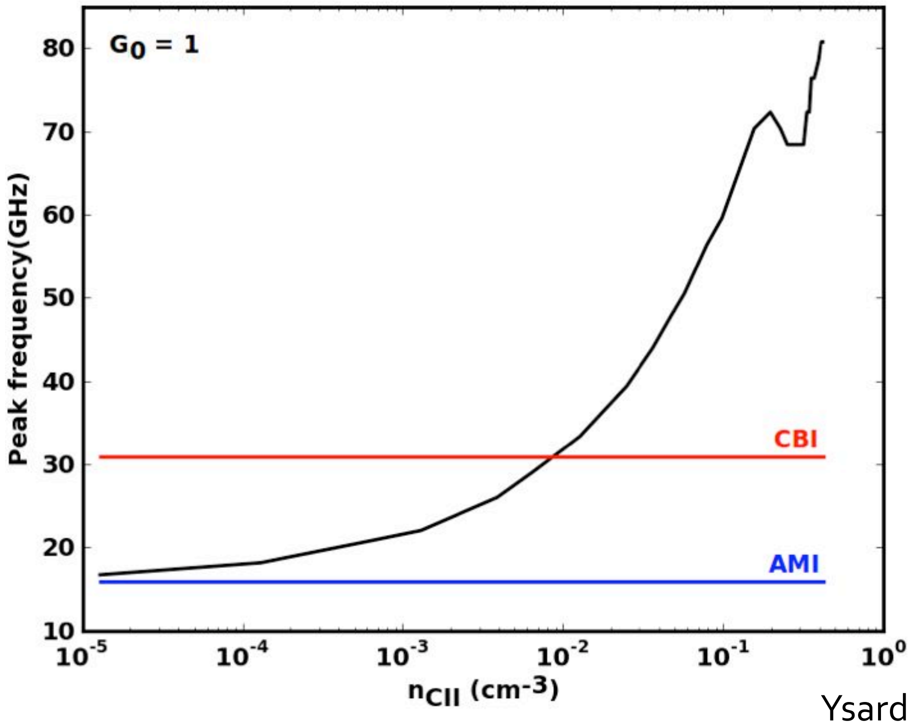
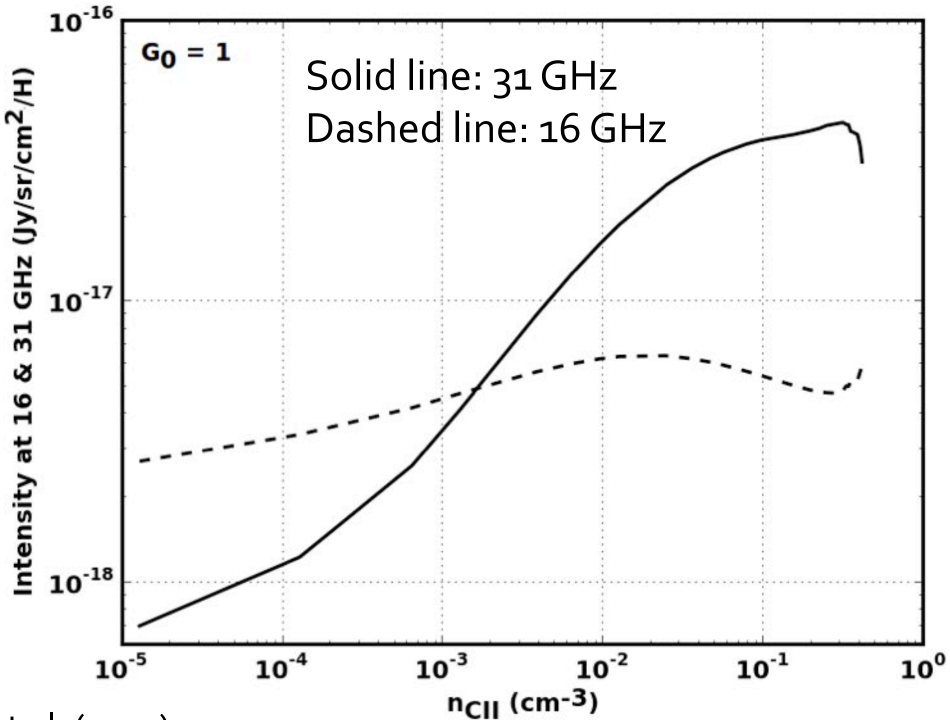


Origin of the AME

The smallest dust grains producing the spinning dust emission are sensitive to the ionisation state of the gas, i.e. the abundance of the major charged species. Therefore, one would expect that the spinning dust emission is also sensitive to the ionisation state of the gas. Recent work by Ysard et al. (2011) has shown that this is indeed the case.





Ysard et al. (2011)

Conclusions

- We have performed a detailed investigation of RCW175 using data from the radio to the mid-IR.
- RCW175 consists of 2 HII regions, G29.1-0.7 and G29.0-0.6.
- Both components appear to be interacting with each other, and G29.0-0.6 may even have formed as a result of the expansion of G29.1-0.7 into the surrounding ISM.
- DUSTEM has been used to produce parameter maps of Y_{PAH} , Y_{VSG}, χ_{ERF}, NH and T_{dust}.
- AME is originating from both components of RCW175.
- The AME is not spatially correlated with the YSO identified YSO candidates.
- The AME is correlated with the exciting radiation field in both components.
  - This suggests that the AME is due to electric dipole emission arising from spinning dust grains spun-up by photon-grain interactions.
- The AME in G29.1-0.7 is not correlated with the PAHs in the PDR and we speculate that the major gas ions may be contributing to the observed spinning dust.