Another look at LDN 1622

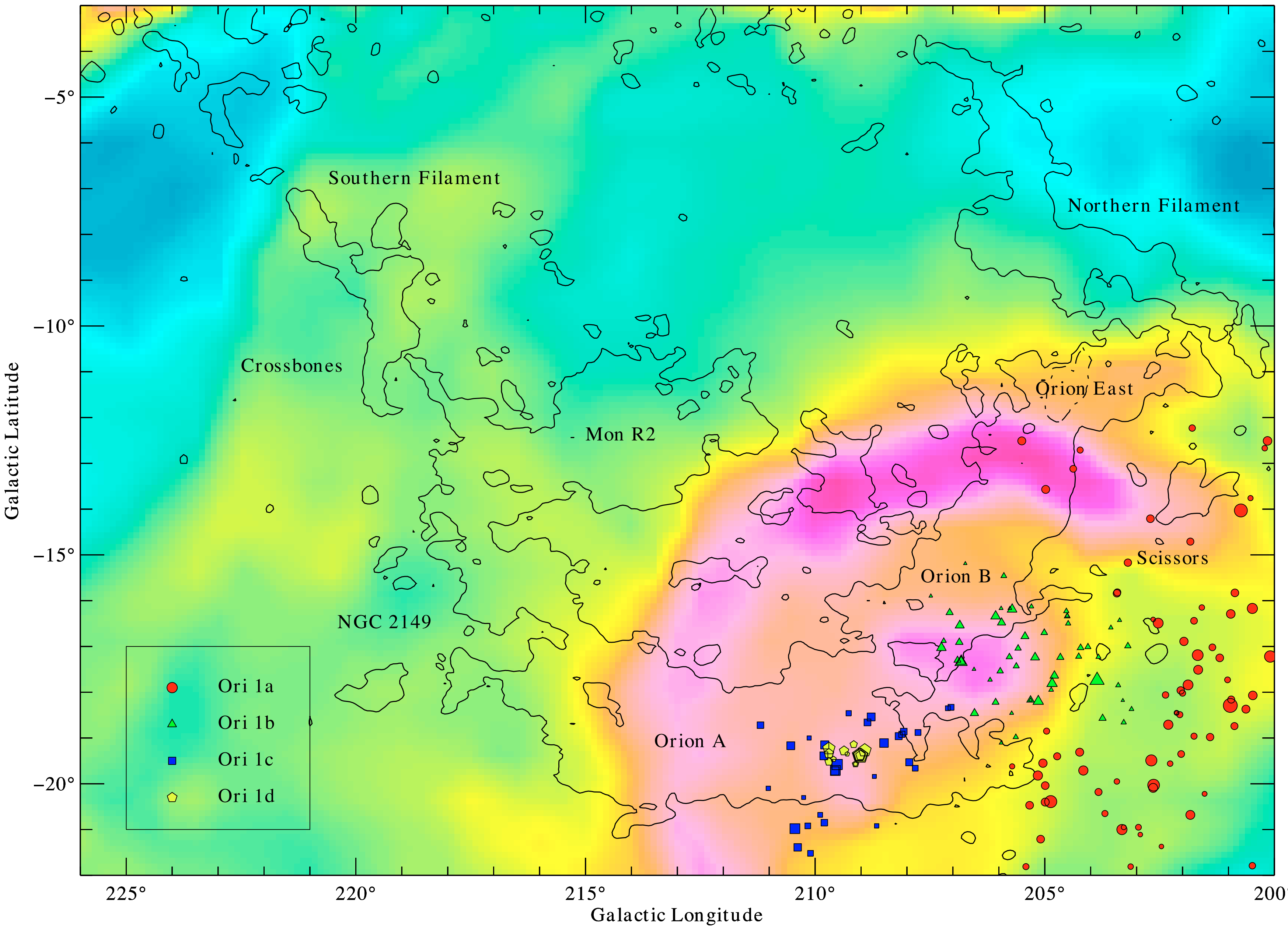
Kieran Cleary

Manchester AME Workshop

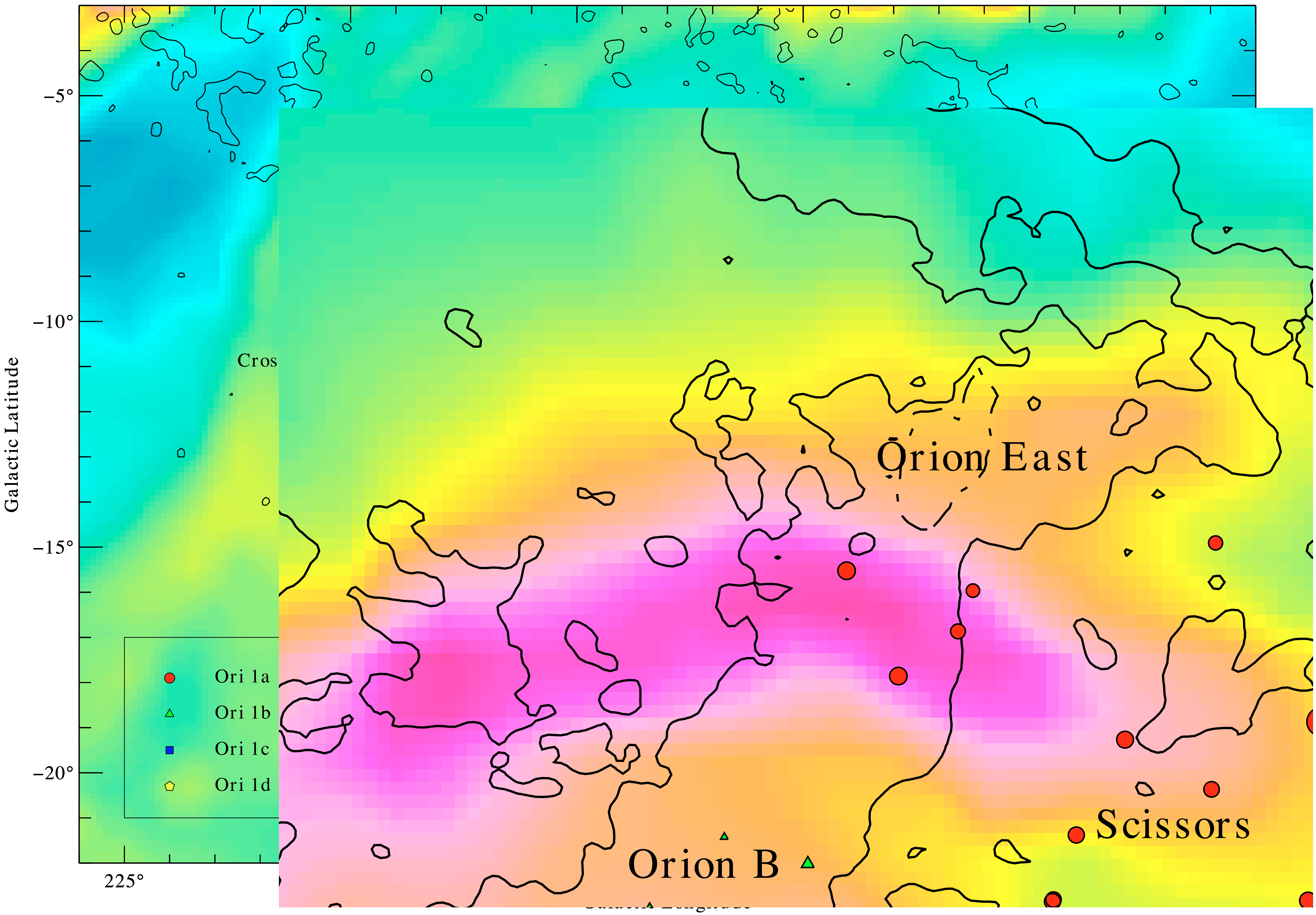
July 2-4, 2012

Overview

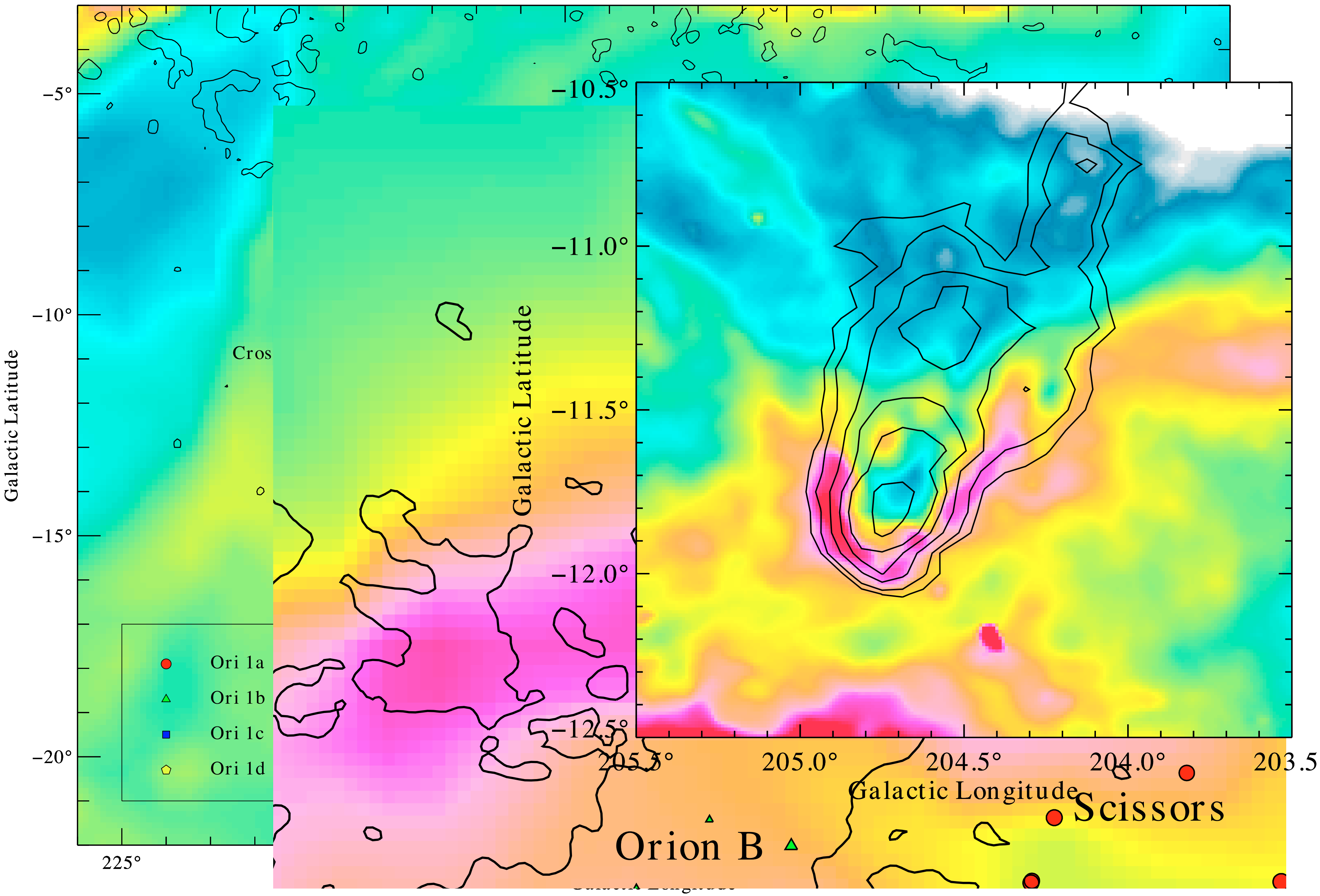
- Observational status of LDN 1622
- New CARMA & AMI data
- Spitzer spectral mapping



Wilson et al. (2005), A&A, 430, 523



Wilson et al. (2005), A&A, 430, 523



Wilson et al. (2005), A&A, 430, 523

The Astrophysical Journal, 566:898–904, 2002 February 20

TENTATIVE DETECTION OF ELECTRIC DIPOLE EMISSION FROM RAPIDLY ROTATING DUST GRAINS

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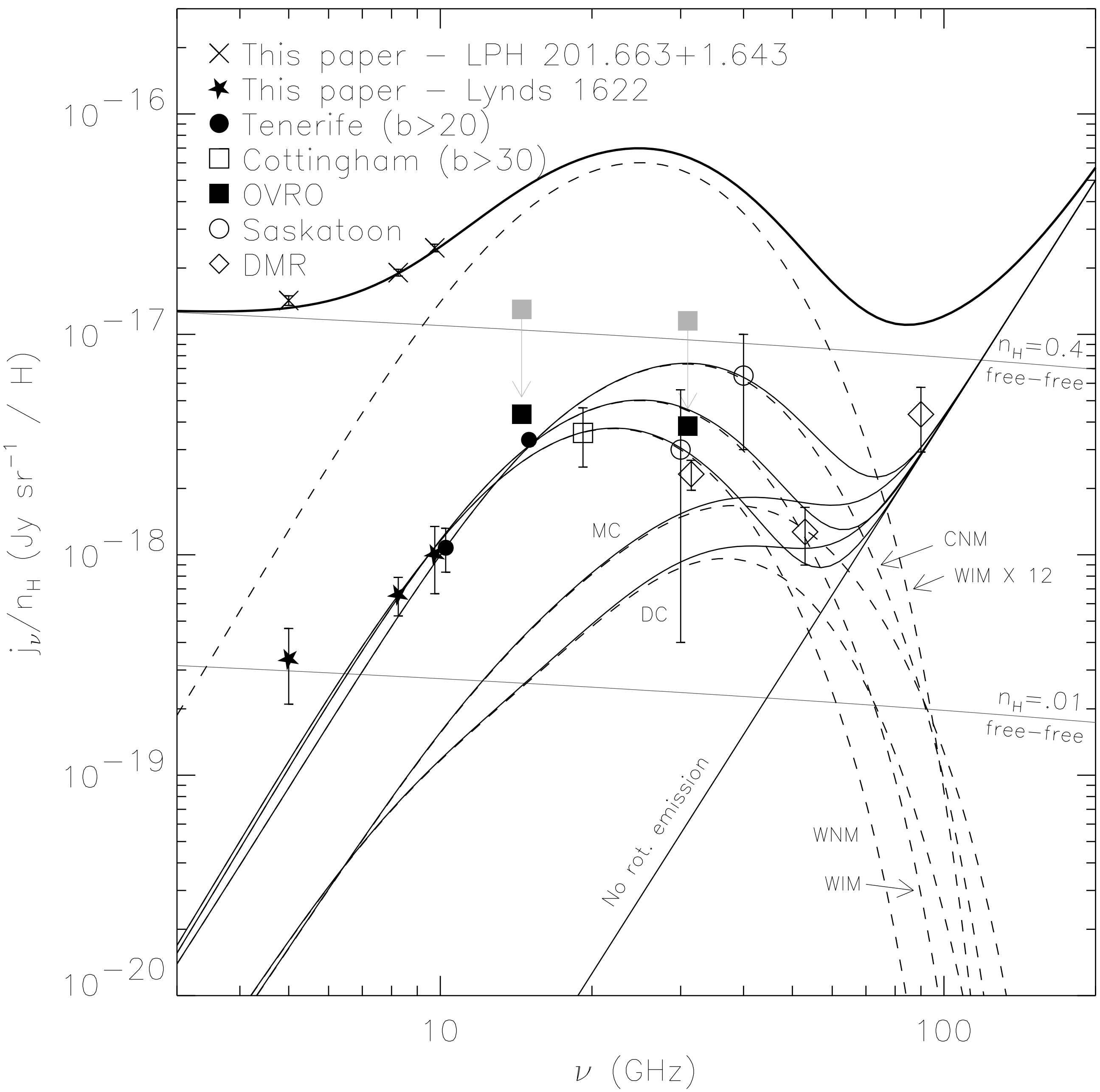
Received 2001 July 5; accepted 2001 October 22

TABLE 1

Correlation Slopes

		RCP		LCP			
Name	ν	Forward	Return	Forward	Return	Average	N_σ
L1622......	5.00	1.29 ± 0.39	3.49 ± 0.84	0.48 ± 0.38	3.05 ± 0.77	1.31 ± 0.25	5.3
L1622......	8.25	1.25 ± 0.29	0.26 ± 0.37	0.67 ± 0.41	0.52 ± 0.35	0.75 ± 0.17	4.4
L1622......	8.25	1.14 ± 0.37	1.24 ± 0.44	1.05 ± 0.38	1.11 ± 0.33	1.13 ± 0.19	6.1
L1622......	9.75	1.65 ± 0.67	0.76 ± 0.77	0.84 ± 0.73	0.78 ± 0.65	1.03 ± 0.35	2.9
LPH	5.00	53.16 ± 5.28	57.01 ± 5.68	54.12 ± 5.39	58.05 ± 5.90	55.41 ± 2.77	20.0
LPH	8.25	25.45 ± 1.69	25.92 ± 1.91	29.16 ± 1.93	29.50 ± 2.25	27.22 ± 0.96	28.4
LPH	9.75	23.96 ± 2.09	23.33 ± 1.70	27.89 ± 2.49	27.17 ± 1.90	25.25 ± 0.99	25.4

Note.—Correlation slopes for forward and return scans of RCP and LCP polarizations. These correlation slopes are for T_B vs. a prediction of 50 μK/I_{100}, where I_{100} is the DIRBE temperature-corrected *IRAS* intensity at 100 μm in MJy sr^{-1}. This temperature-corrected map may be obtained by dividing the SFD98 $E(B-V)$ prediction by 0.0184. The prediction used includes a factor of $\frac{1}{2}$ for single-polarization measurements, so RCP and LCP are combined by averaging, not adding. Values in the table may be multiplied by 50 to obtain units of μK/I_{100} in order to compare to, e.g., de Oliveira-Costa et al. 1999. Note that L1622 was observed twice at 8.25 GHz.



This paper – LPH 201.663+1.643
This paper – Lynds 1622
Tenerife (b>20)
Cottingham (b>30)
OVRO
Saskatoon
DMR
n_H=0.4
free–free
n_H=.01
free–free
MC
DC
CNM
WIM X 12
WNM
WIM
No rot. emission
10^{-16}
10^{-17}
10^{-18}
10^{-19}
10^{-20}
10
100
j_ν/n_H (Jy sr^{-1} / H)
ν (GHz)

The Astrophysical Journal, 639:951–964, 2006 March 10

MORPHOLOGICAL ANALYSIS OF THE CENTIMETER-WAVE CONTINUUM IN THE DARK CLOUD LDN 1622

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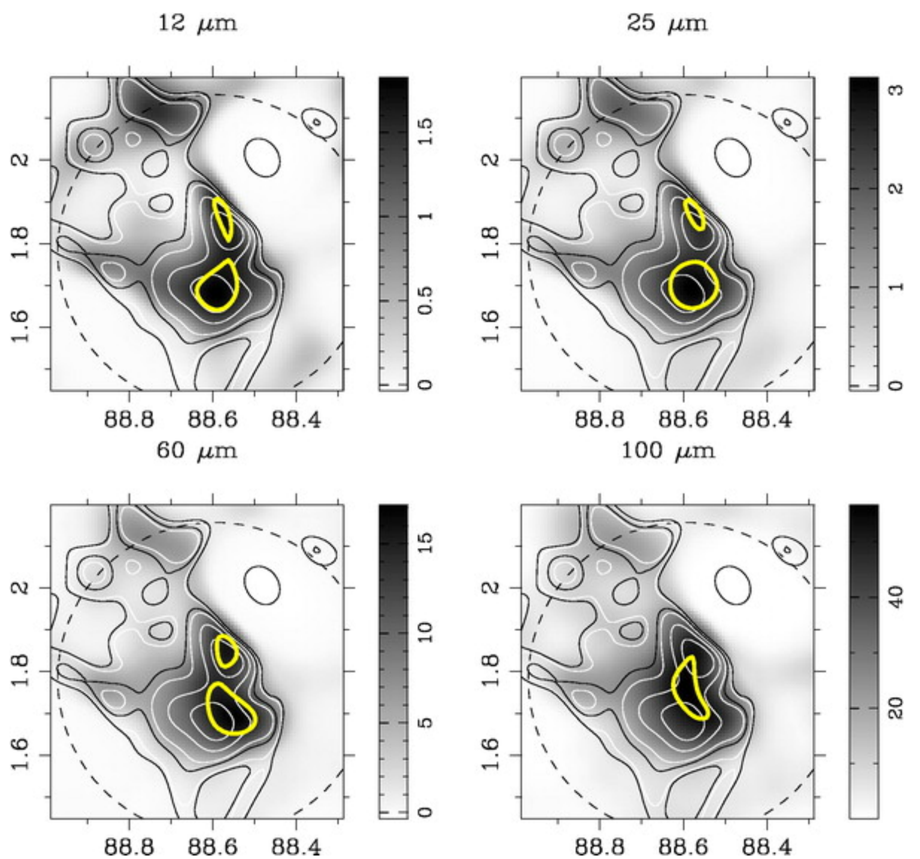
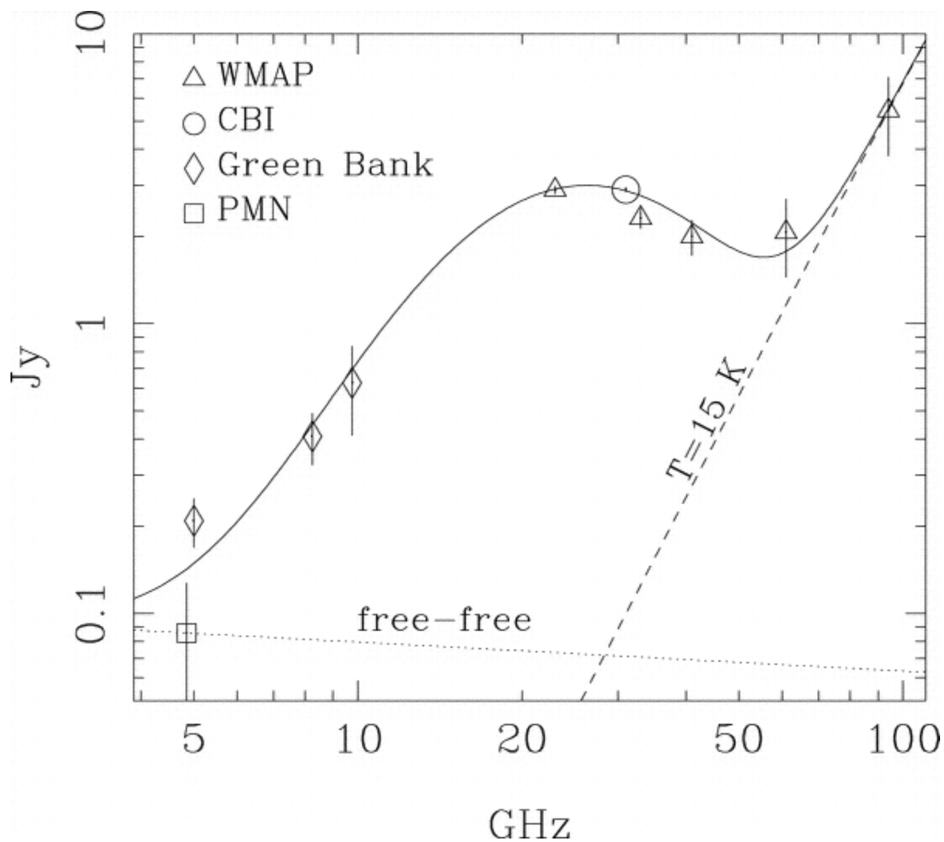
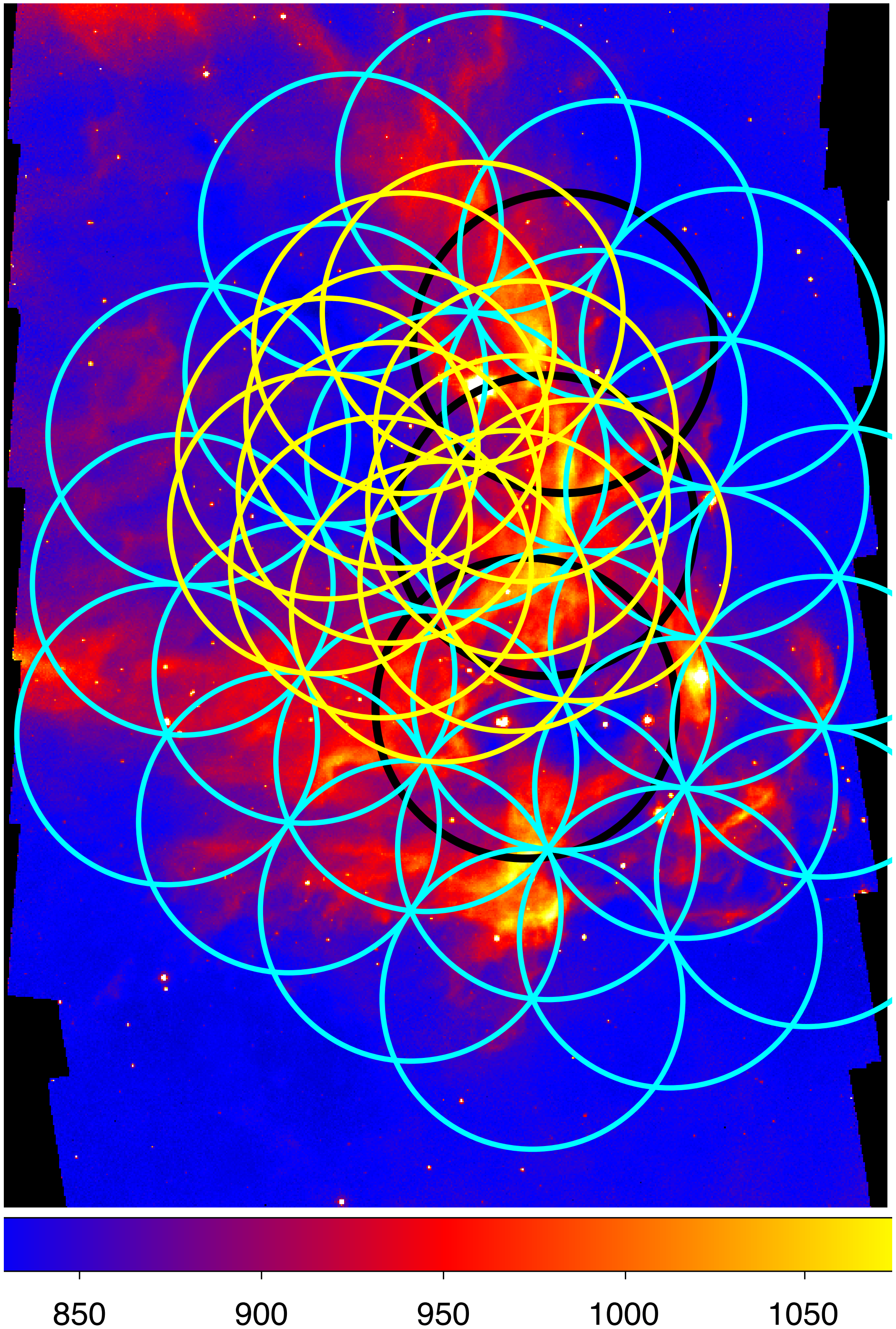
Received 2005 June 10; accepted 2005 November 9







CARMA 26-36 GHz Observations:

Matt Sieth (Stanford)

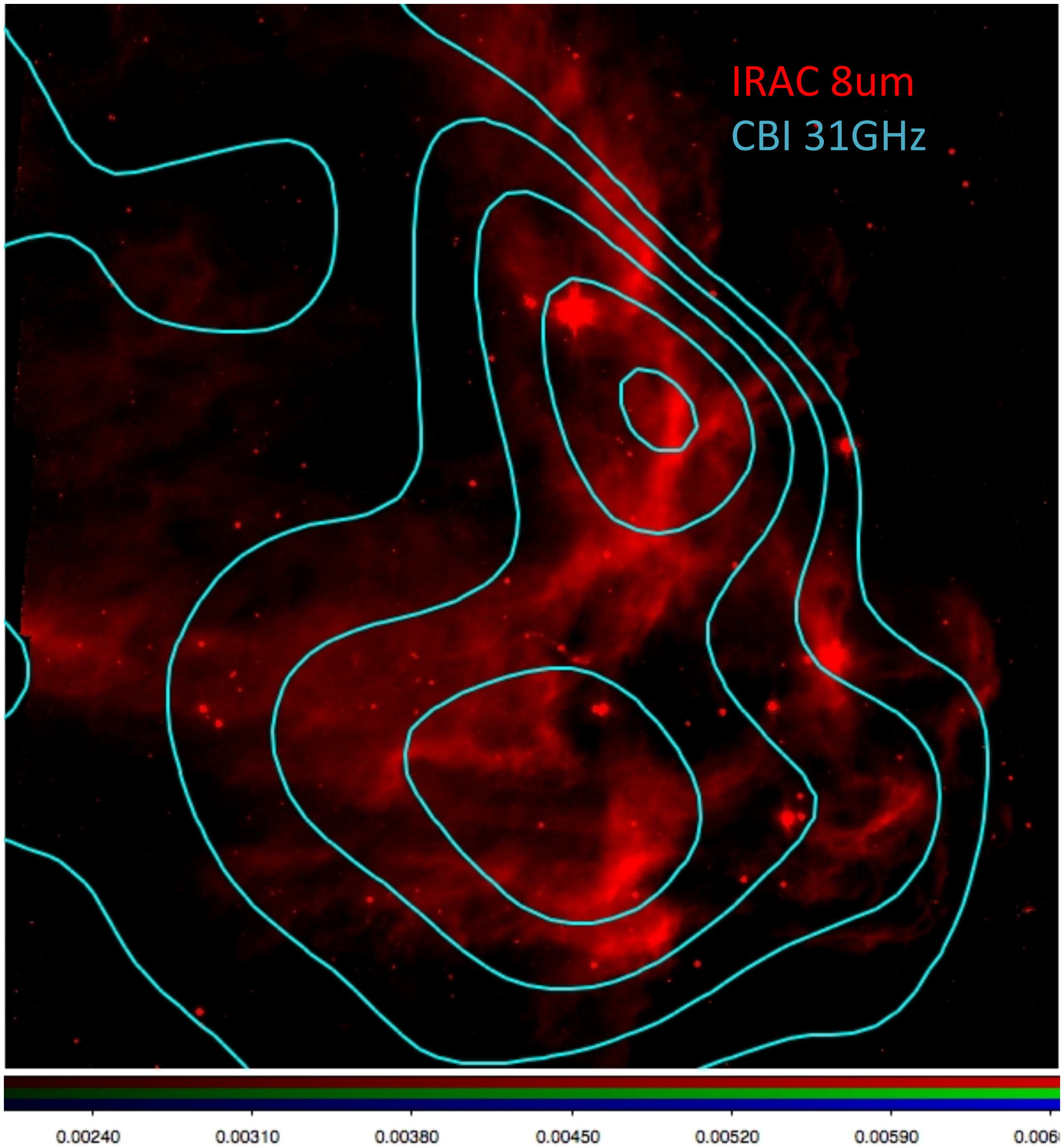
Combined observations from

Summer school
Separate proposal (PI **Villadsen**)

Eight 3.5-m antennas (formerly the SZA), of which two outriggers

Primary beam: 11 arcmin

Sensitive to scales: 3-7 arcmin (with the 6 compact antennas)

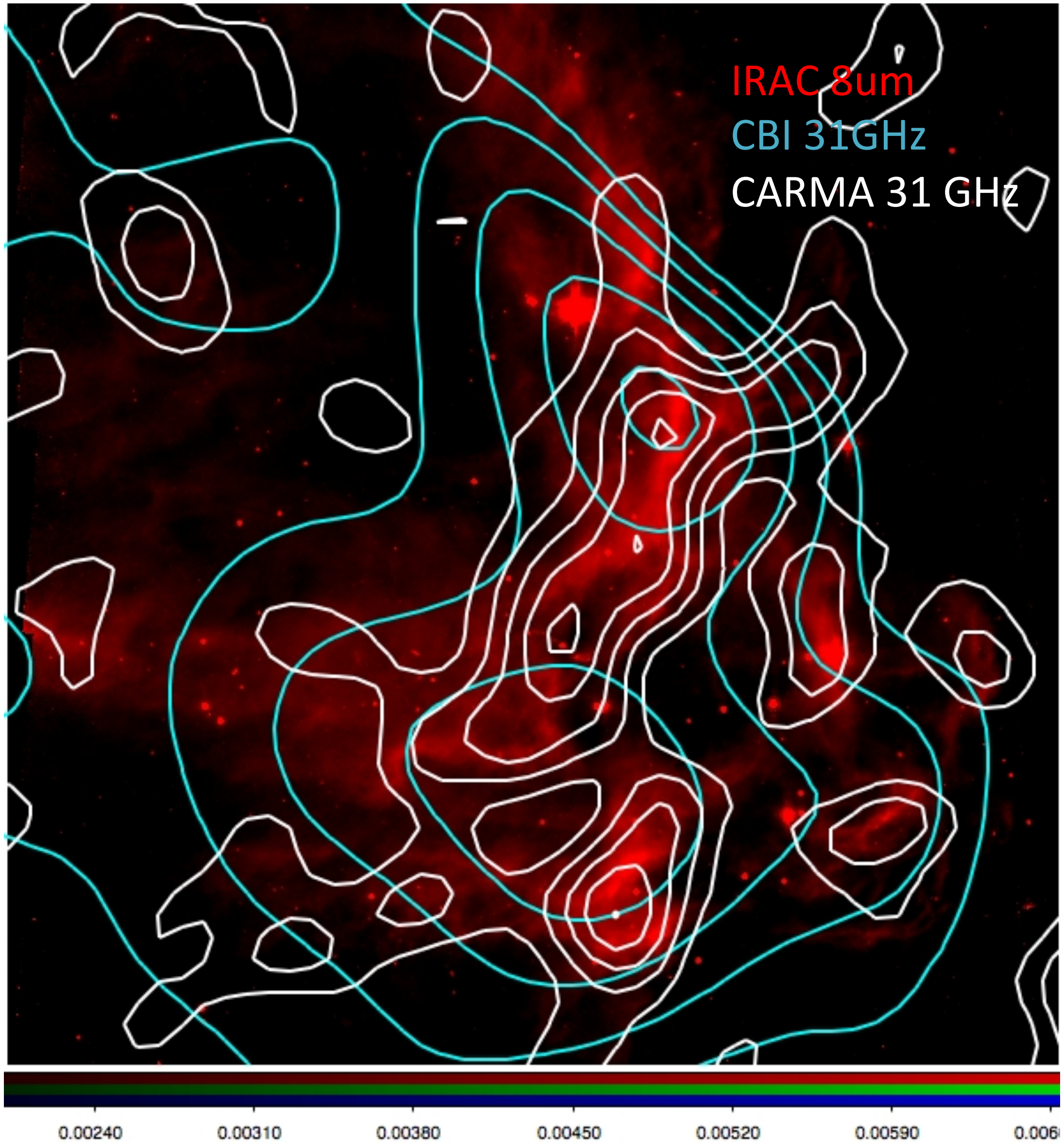


CBI contours: 0.01, 0.02, 0.031, 0.042, 0.052 MJy/sr

CARMA 26-36 GHz Observations:

Matt Sieth (Stanford)

CBI contours on IRAC 8um



CARMA 26-36 GHz Observations:

Matt Sieth (Stanford)

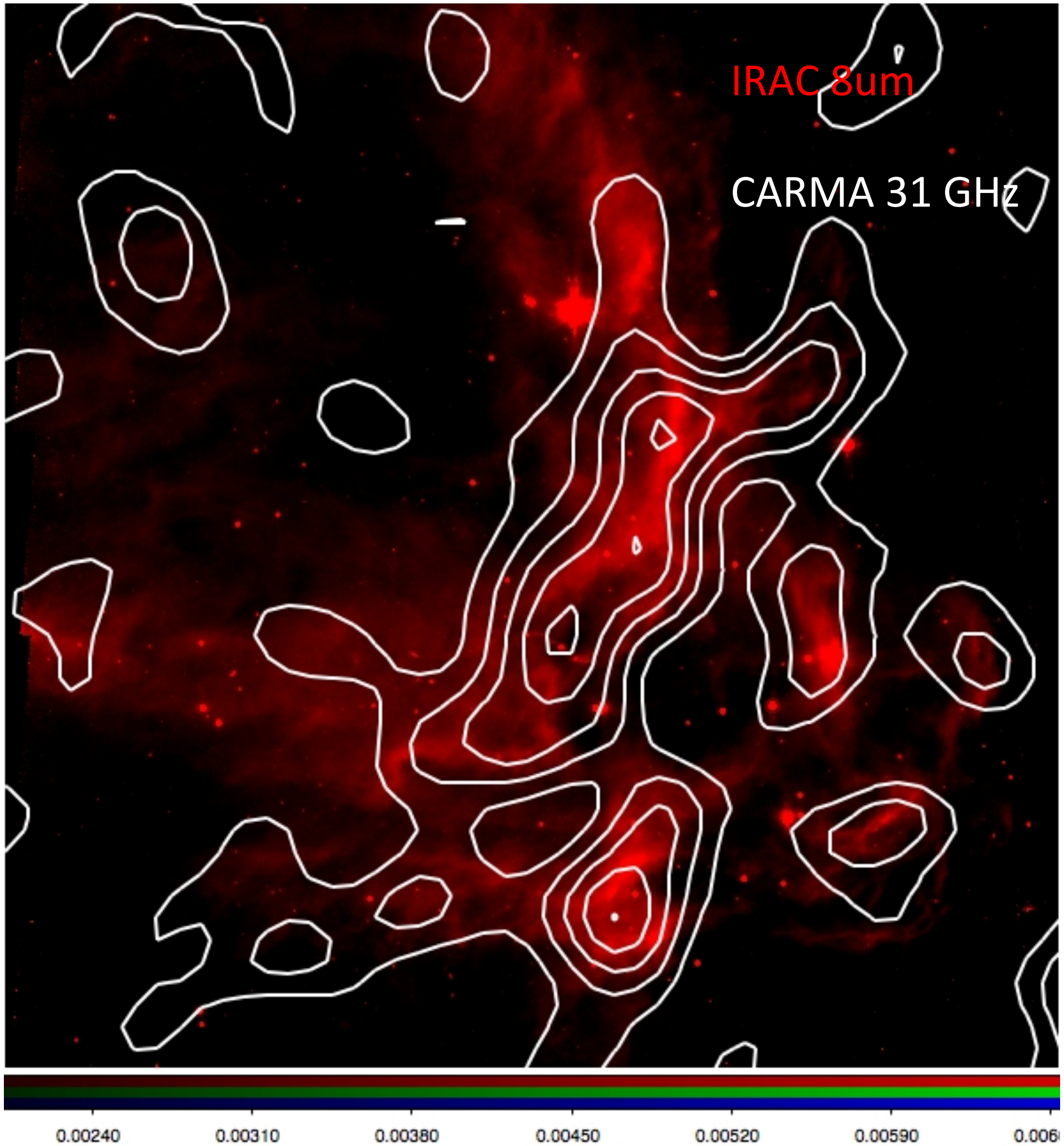
Northern CBI/CARMA peak locations match

Southern CBI peak encompasses two higher resolution peaks

CBI sensitive to ~9-34 arcmin
CARMA sensitive to 3-7 arcmin

CARMA resolving out all the emission seen by the CBI

CBI contours: 0.01, 0.02, 0.031, 0.042, 0.052 MJy/sr
CARMA contours: 0.005, 0.011, 0.017, 0.023, 0.029 MJy/sr



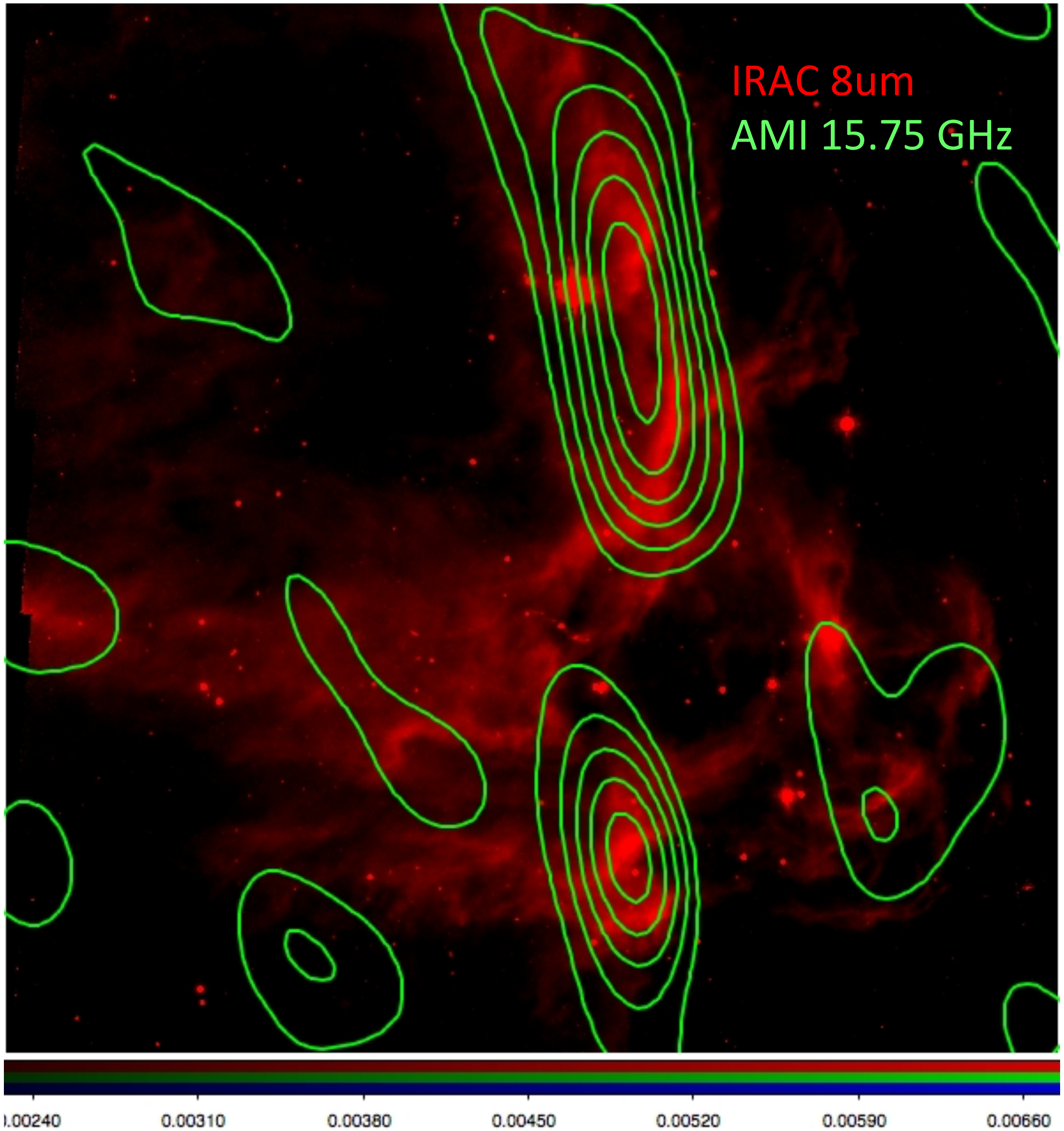
CARMA 26-36 GHz Observations:

Matt Sieth (Stanford)

Reverting to the CARMA image using all the data…

CARMA data trace 8 um emission very well

CARMA contours: 0.005, 0.011, 0.017, 0.023, 0.029 MJy/sr



AMI 13.5-18 GHz Observations:

Yvette Perrott (Cambridge)

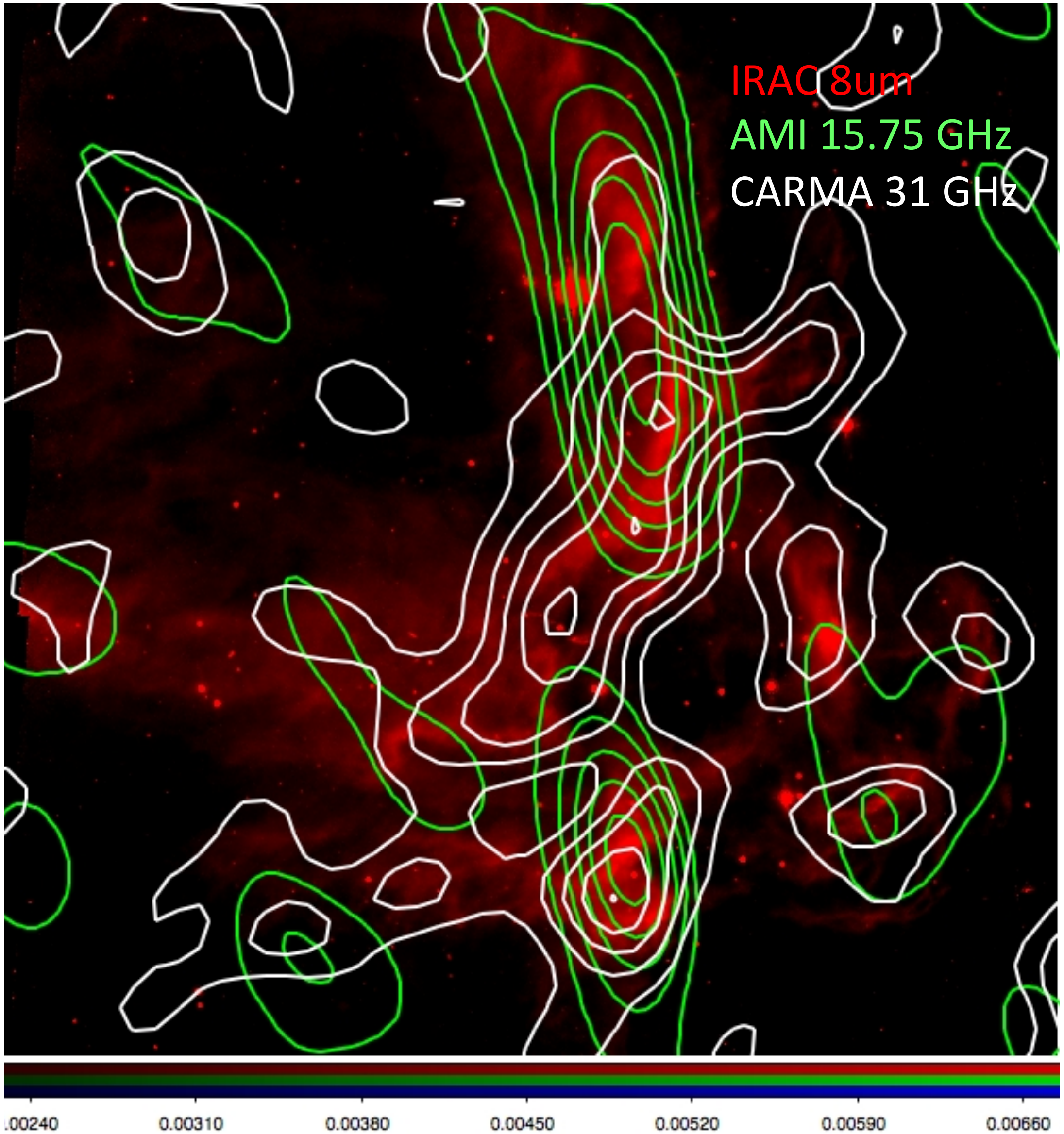
AMI SA observations

Ten 3.7-m antennas

Primary beam: 20 arcmin

Sensitive to scales: ~3-13 arcmin

AMI contours: 0.001, 0.003, 0.004, 0.006, 0.007, 0.009 MJy/sr



AMI 13.5-18 GHz Observations:

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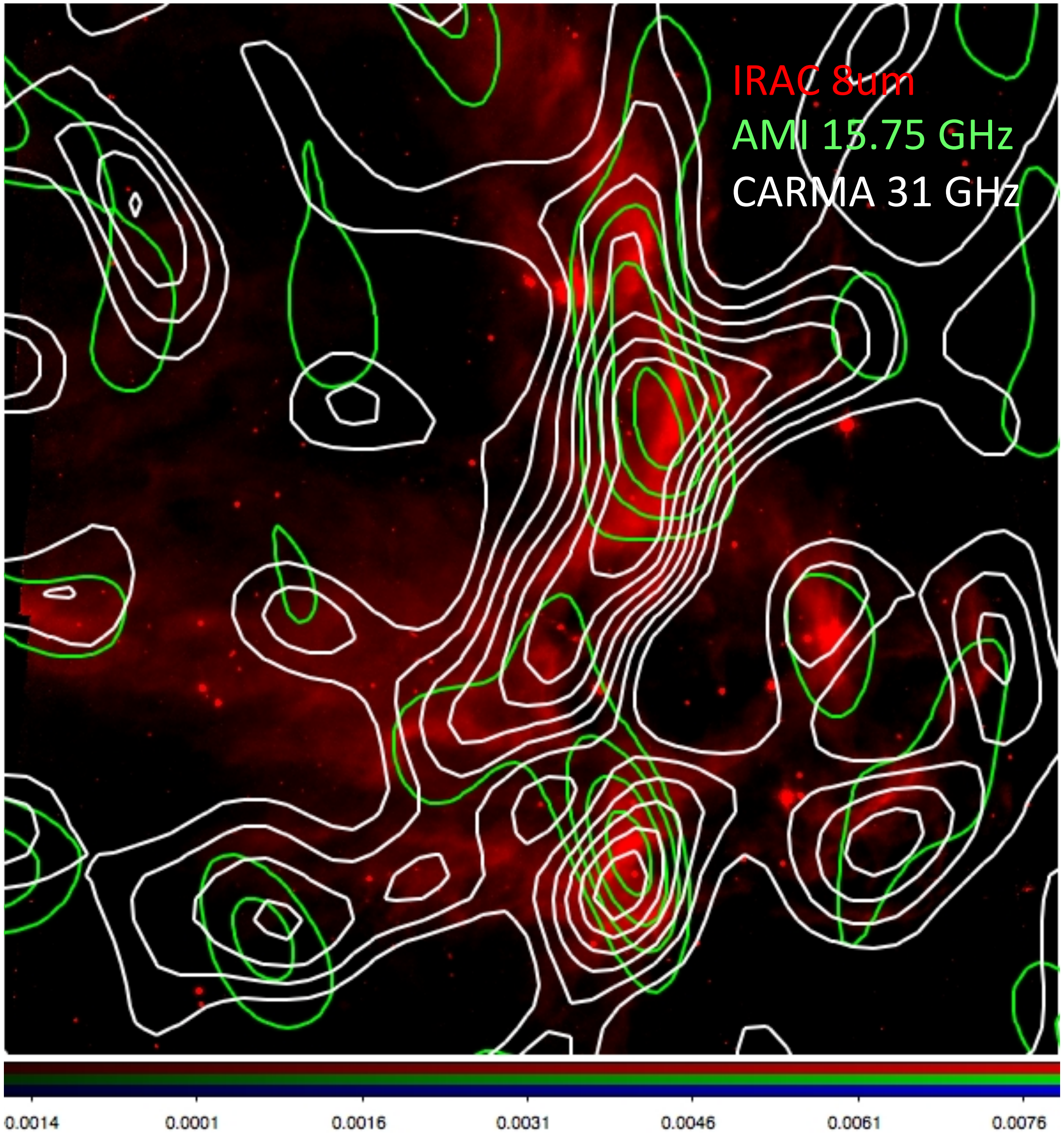


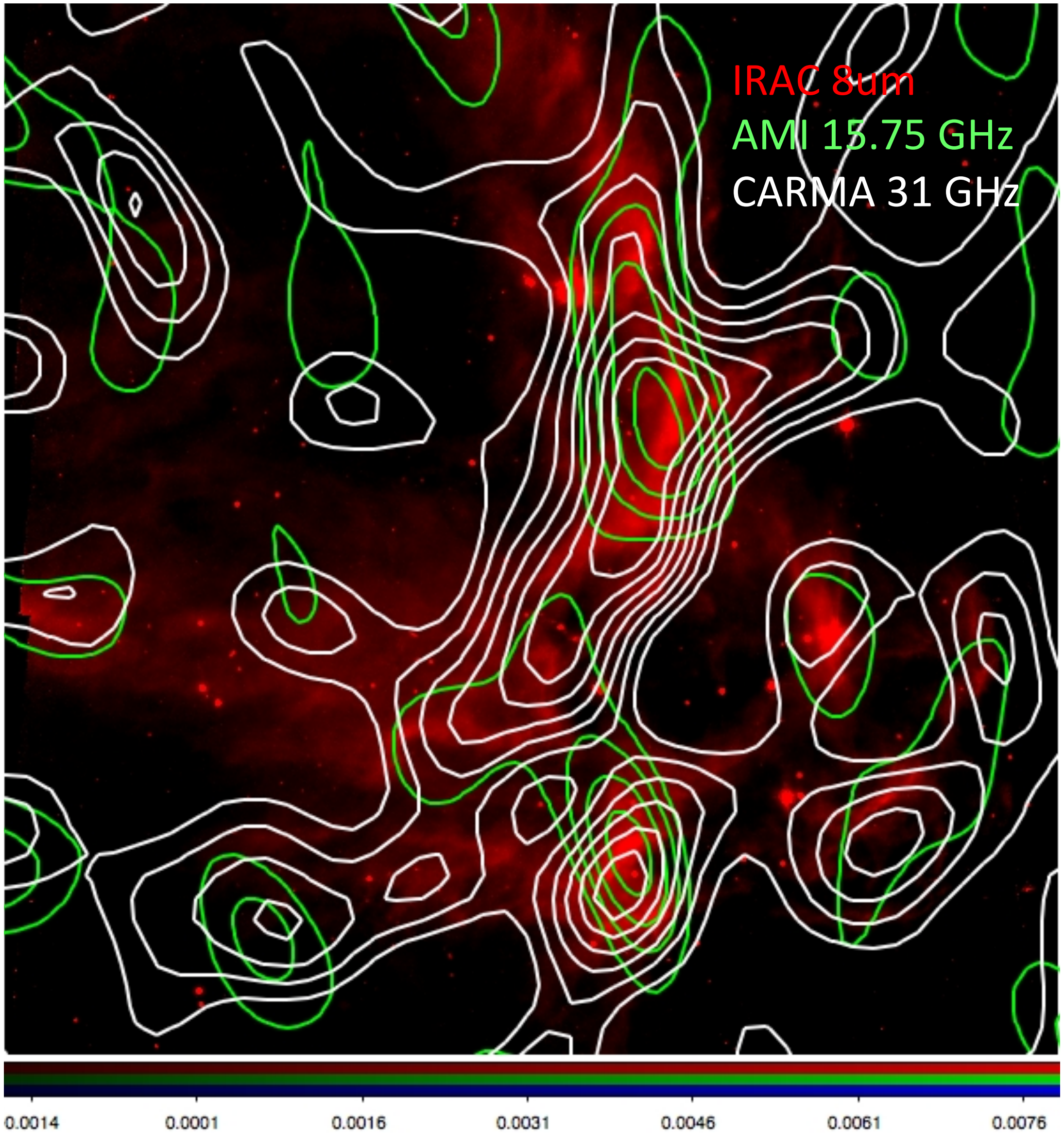
CARMA 26-36 GHz Observations:
AMI 13.5-18 GHz Observations:

Matt Sieth (Stanford)
Yvette Perrott (Cambridge)

With matched uv coverage, now better correspondence between AMI & CARMA for northern lobe

Still regions where 31 GHz emission is detected but no 15 GHz.

AMI contours: 0.001, 0.003, 0.004, 0.006, 0.007, 0.009 MJy/sr
CARMA contours: 0.005, 0.011, 0.017, 0.023, 0.029 MJy/sr



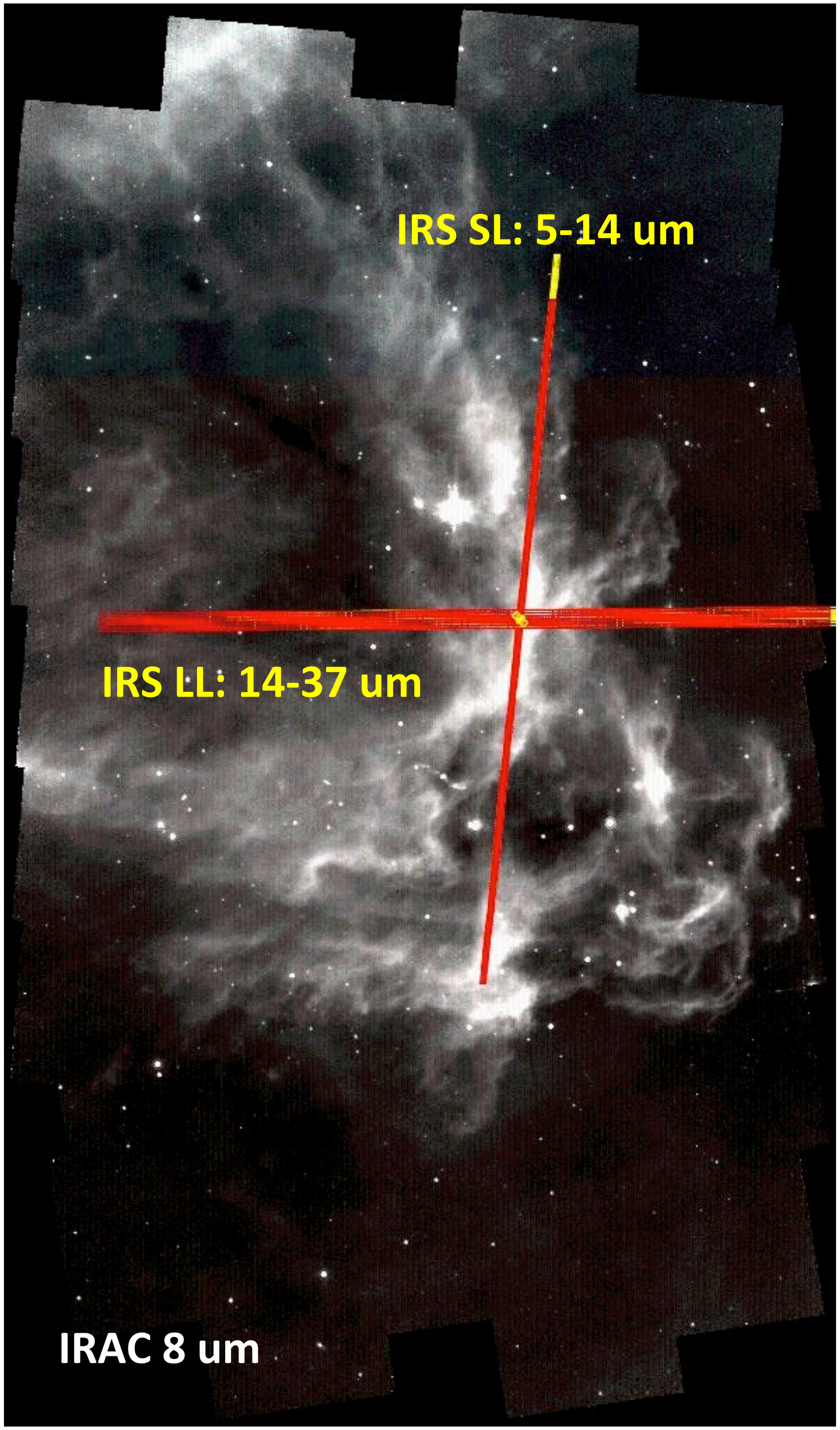
CARMA 26-36 GHz Observations:
AMI 13.5-18 GHz Observations:

Matt Sieth (Stanford)
Yvette Perrott (Cambridge)

Next steps:

1. Push deeper on AMI
2. Examine spectral indices in high SNR regions

AMI contours: 0.001, 0.003, 0.004, 0.006, 0.007, 0.009 MJy/sr
CARMA contours: 0.005, 0.011, 0.017, 0.023, 0.029 MJy/sr

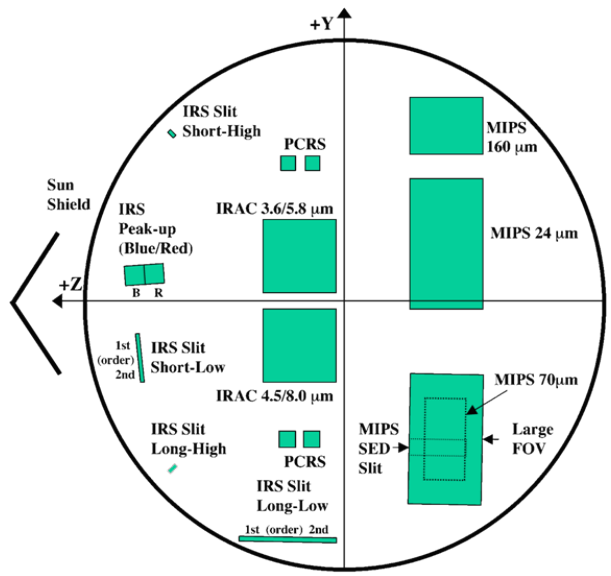


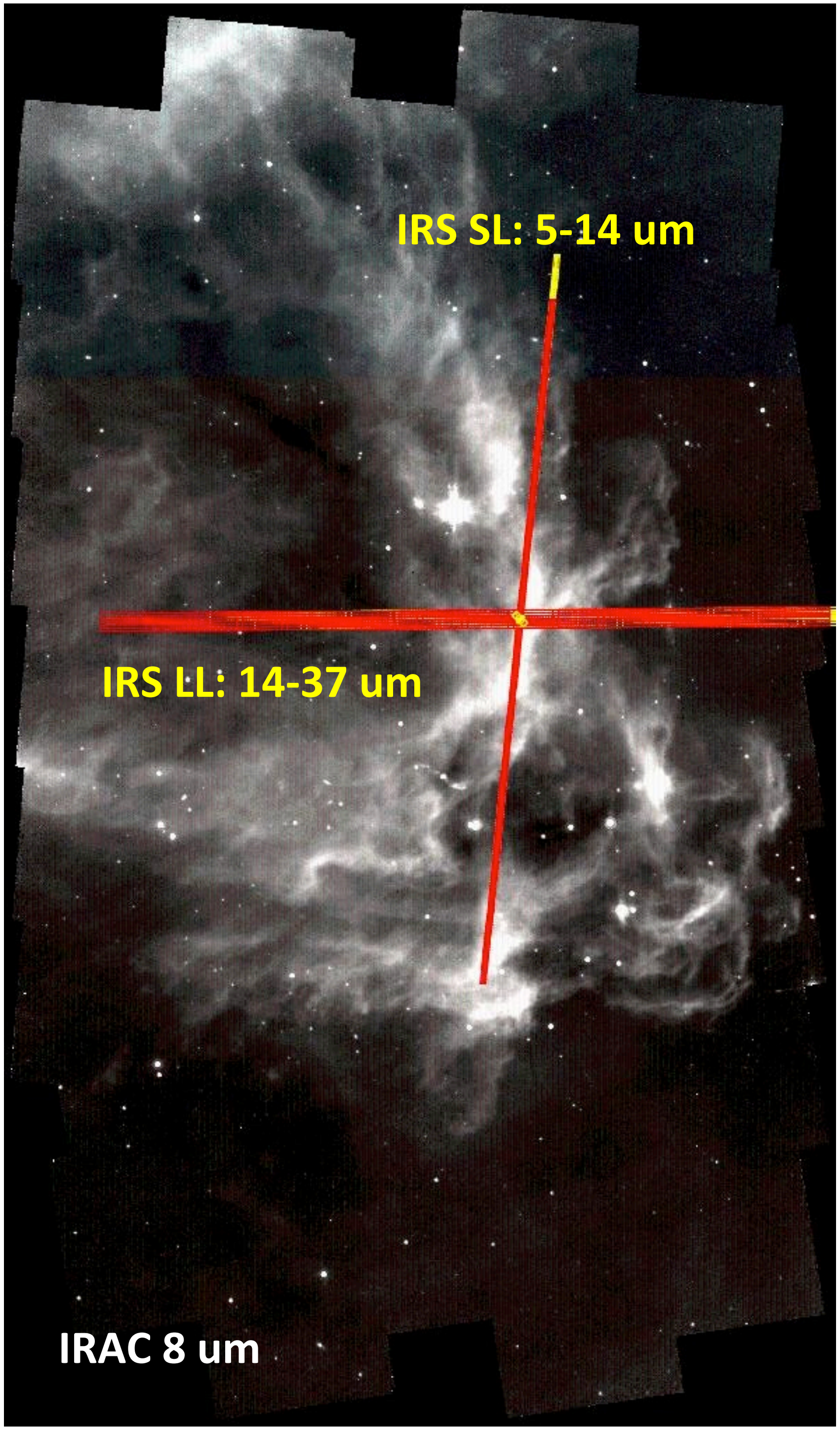
Characterizing the Dust-Correlated Emission in LDN 1622

K. Cleary (PI), C.R. Lawrence, C. Dickinson, S. Casassus

Low-resolution IRS modules, SL and LL
R ~ 60-130

SL coverage: 9” x 18’ (1-D slice)
3”.4 resolution at 14 um





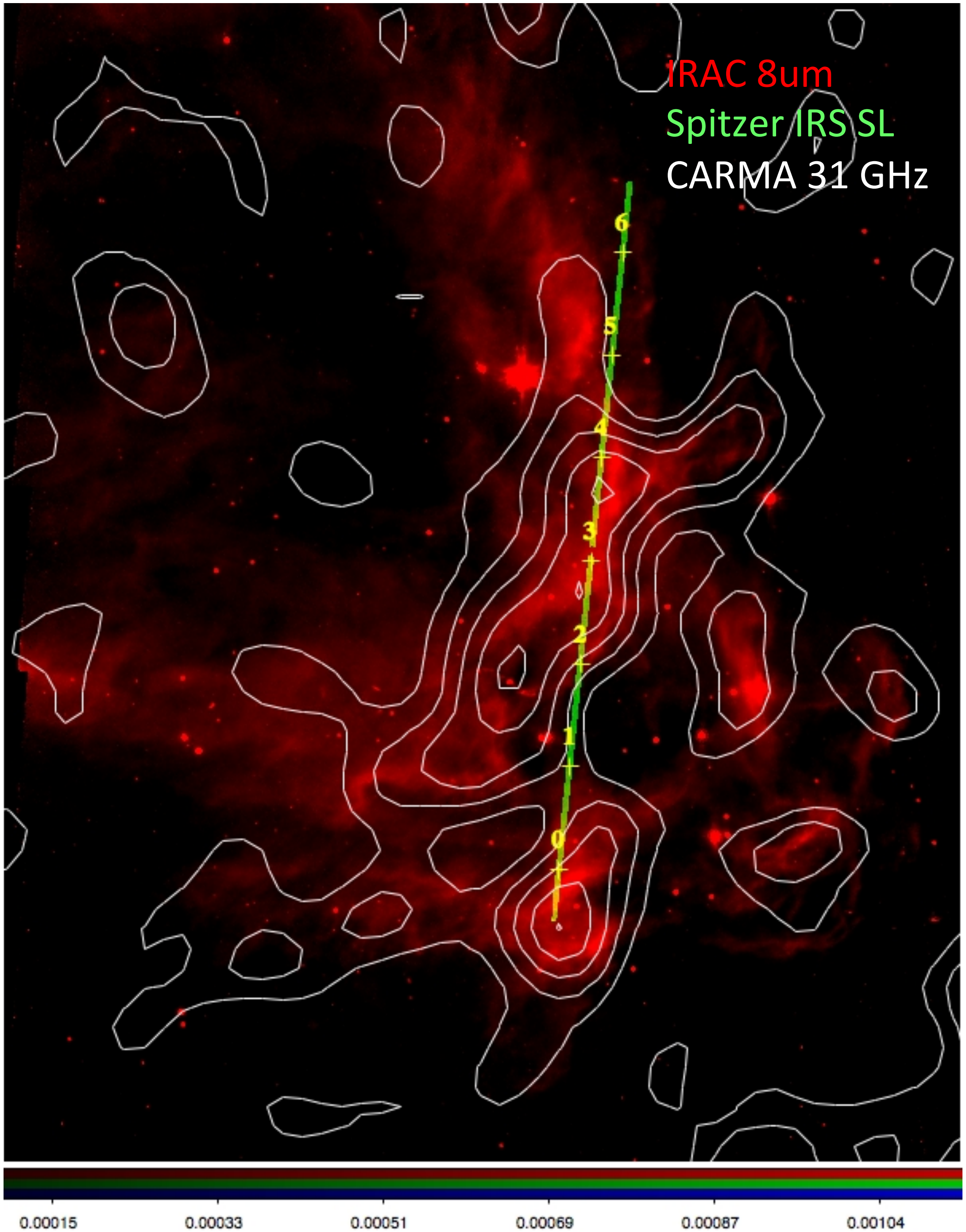
Characterizing the Dust-Correlated Emission in LDN 1622

Aims:

Are IRAS 12um and 25 um tracing VSG emission in LDN 1622?

Contamination by ionic lines ([Ne II] 12.8 um) or H_2 pure-rotational lines?

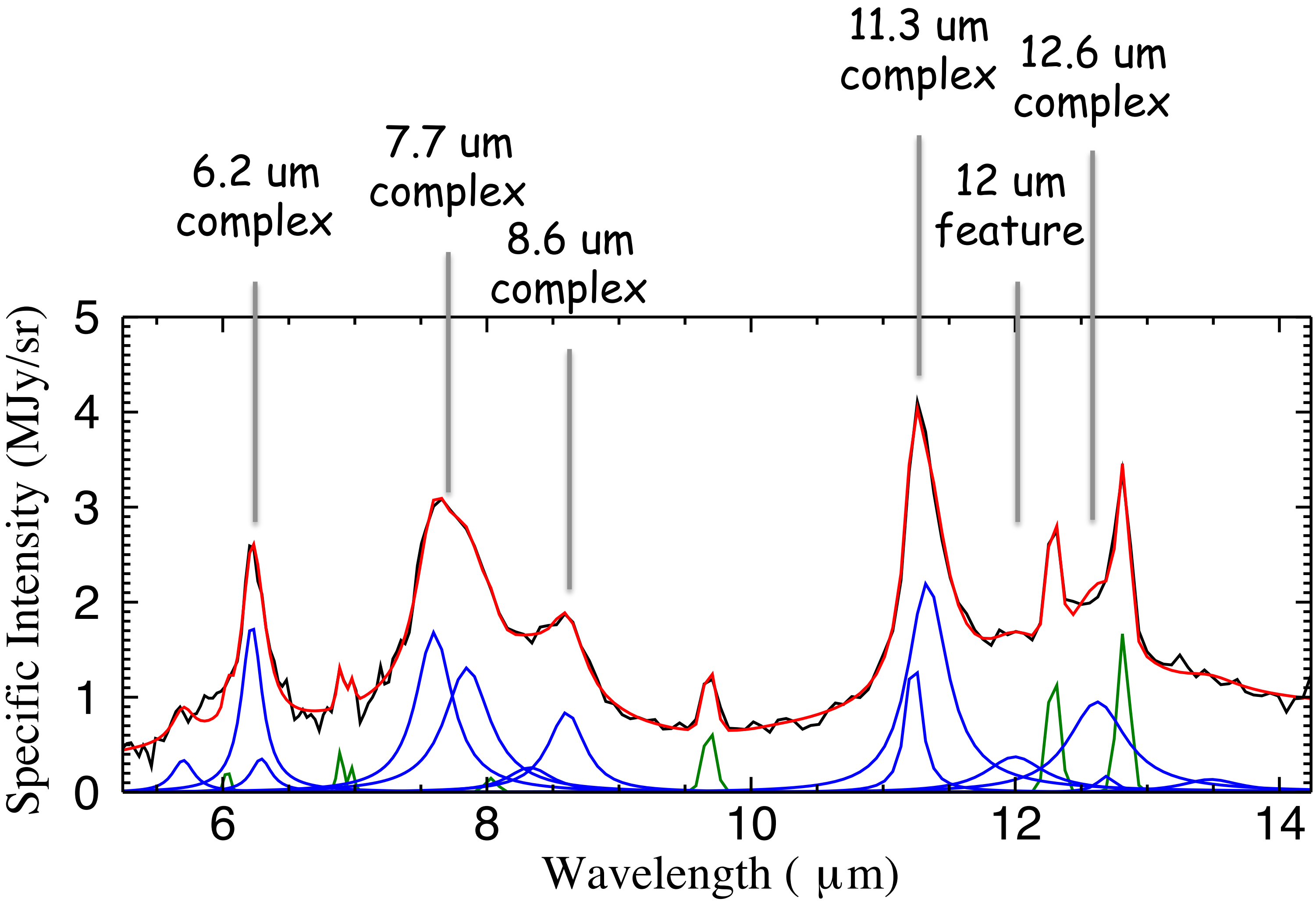
In general, what features (line or continuum) best correlate with cm-wave emission?



Characterizing the Dust-Correlated Emission in LDN 1622

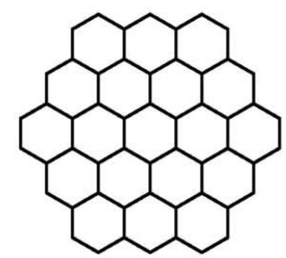
Need high-resolution radio data to match infrared

CARMA has ~3 arcmin resolution

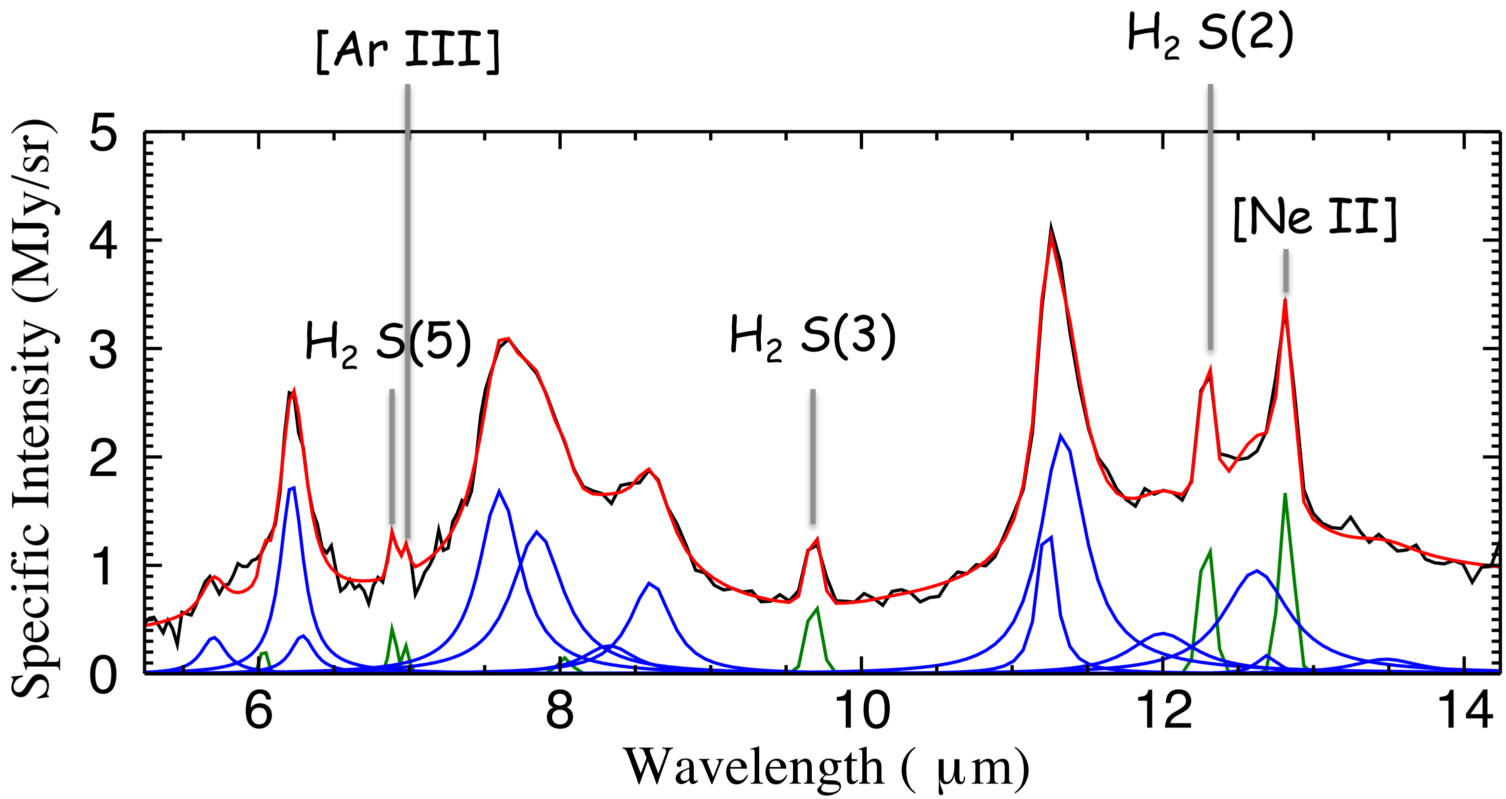


Vibrational de-excitation
of
Polycyclic Aromatic Hydrocarbons (PAH)!

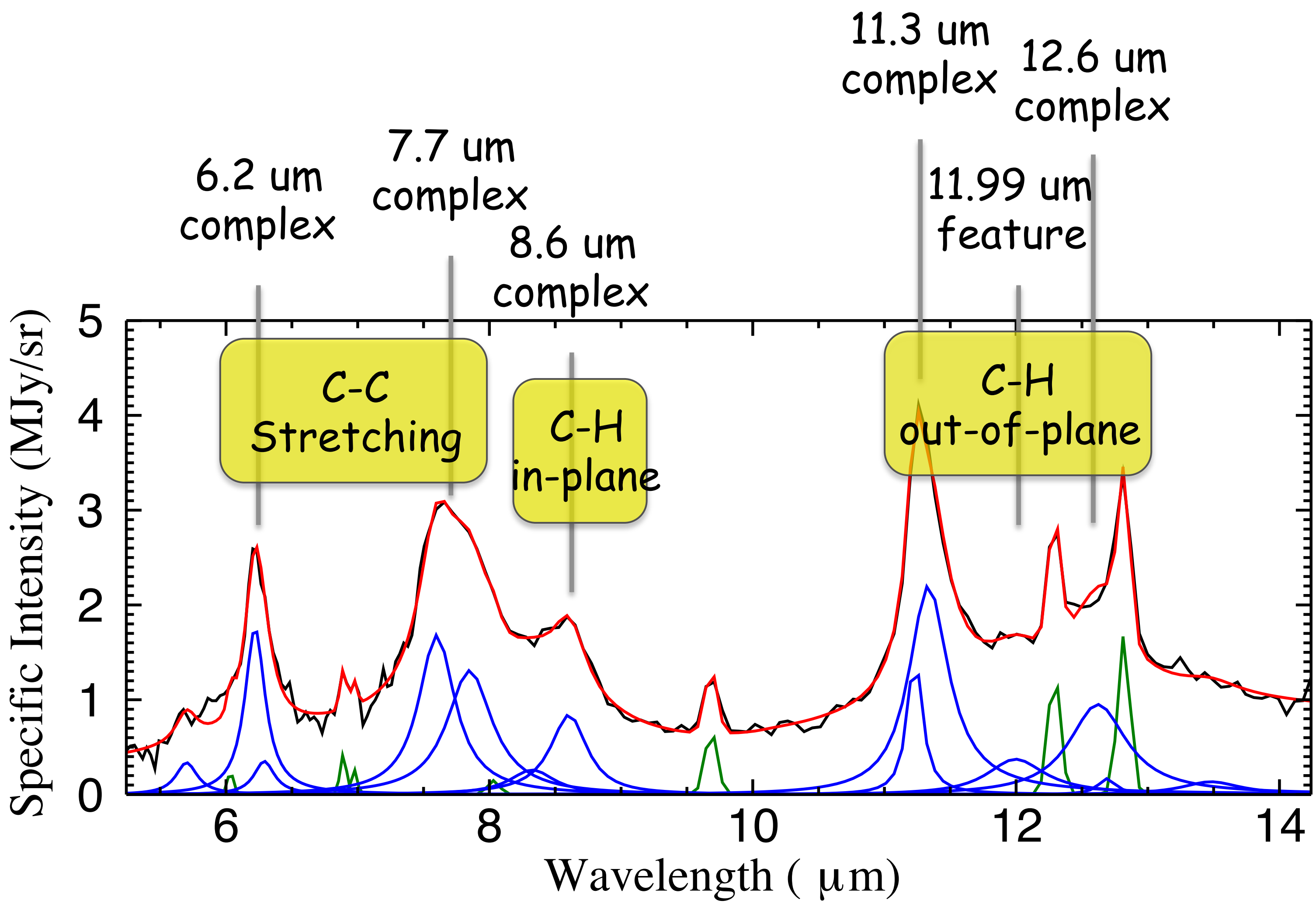
$C_{24}H_{12}$

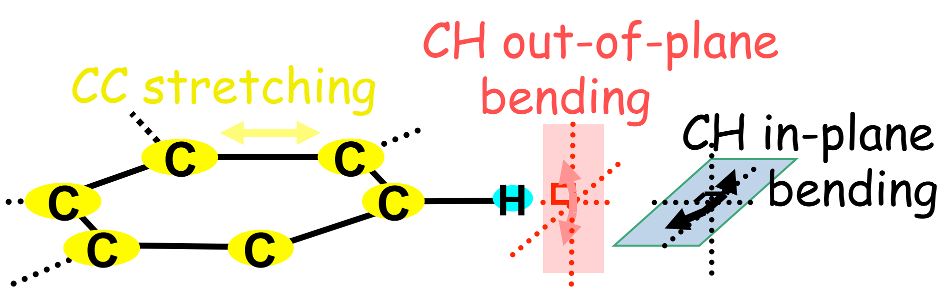


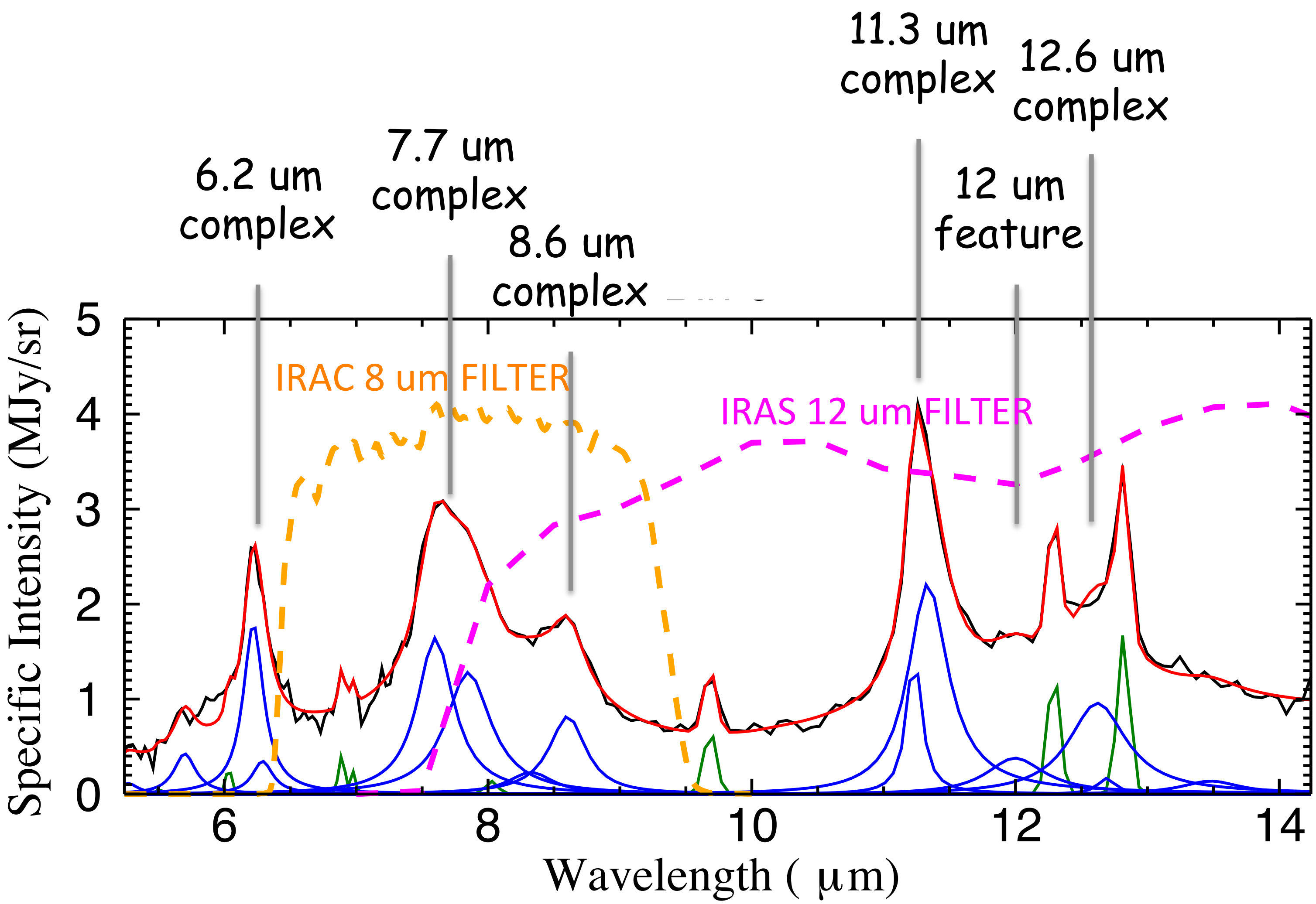
$C_{54}H_{18}$



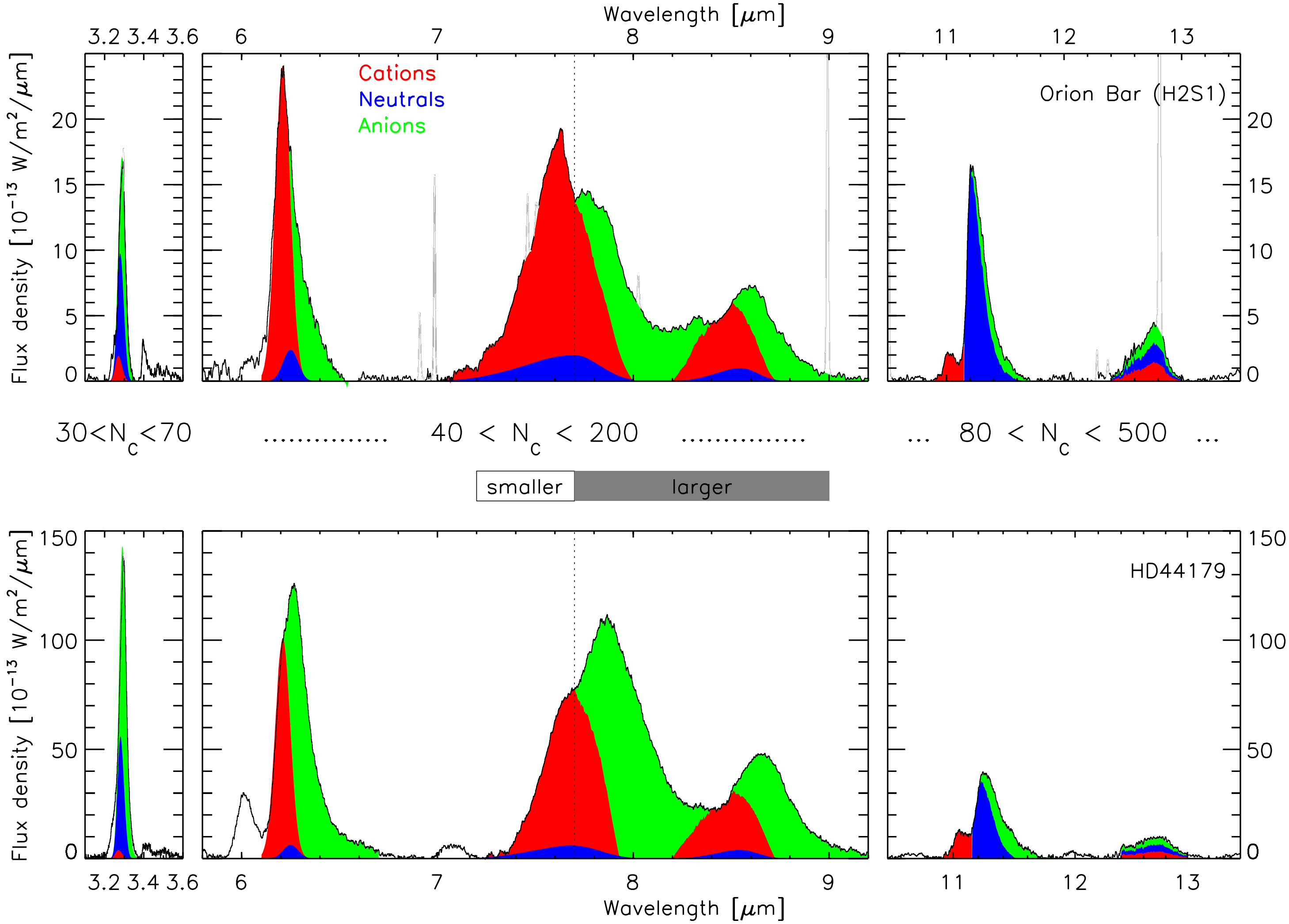
[Ar III]
H2 S(2)
[Ne II]
H2 S(5)
H2 S(3)
Specific Intensity (MJy/sr)
Wavelength (μm)
0
1
2
3
4
5
6
8
10
12
14


6.2 um
complex
7.7 um
complex
8.6 um
complex
11.3 um
complex
11.99 um
feature
12.6 um
complex
C-C
Stretching
C-H
in-plane
C-H
out-of-plane
Specific Intensity (MJy/sr)
Wavelength (μm)
0
1
2
3
4
5
6
8
10
12
14


CC stretching
CH out-of-plane
bending
CH in-plane
bending
C
C
C
C
C
C
H

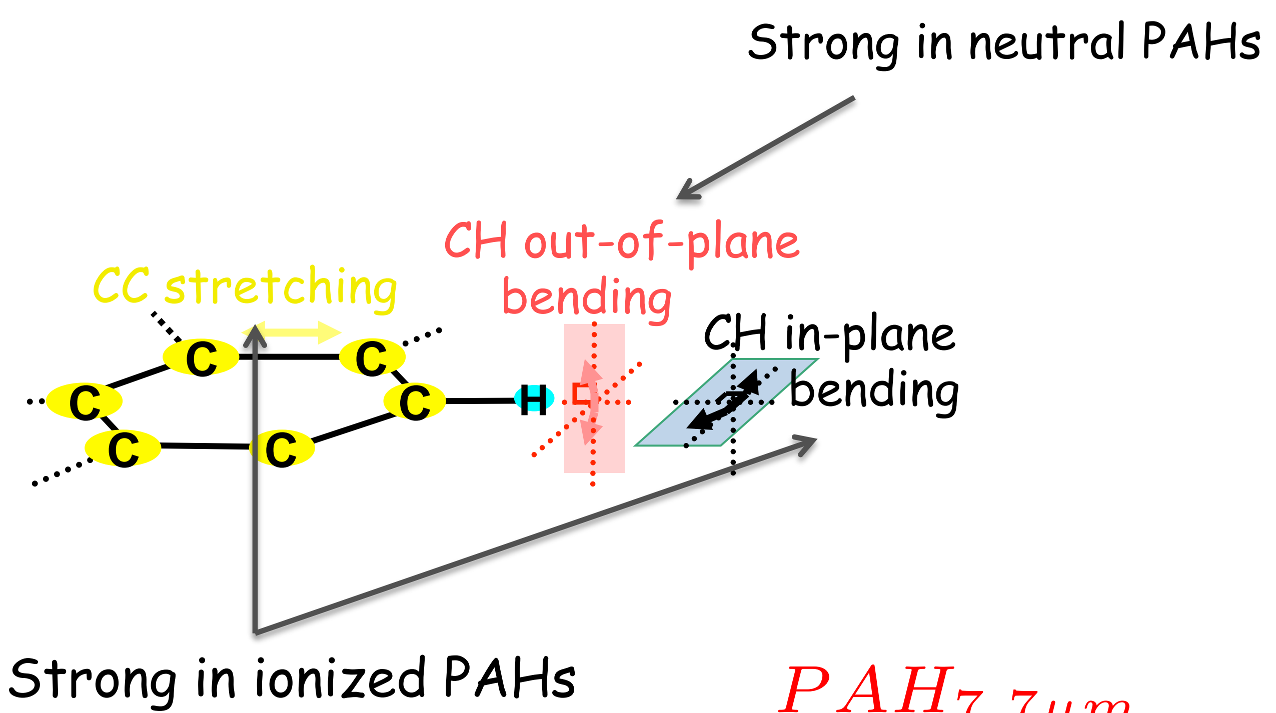


6.2 um complex
7.7 um complex
8.6 um complex
11.3 um complex
12.6 um complex
12 um feature
IRAC 8 um FILTER
IRAS 12 um FILTER
Specific Intensity (MJy/sr)
Wavelength (μm)
0
1
2
3
4
5
6
8
10
12
14


Wavelength [μm]
3.2 3.4 3.6
6
7
8
9
11
12
13
Flux density [10⁻¹³ W/m²/μm]
Cations
Neutrals
Anions
Orion Bar (H2S1)
30<Nc<70
40 < Nc < 200
80 < Nc < 500
smaller
larger
HD44179
0
5
10
15
20
50
100
150

Diagnostics of physical conditions from MIR

- Degree of PAH ionization



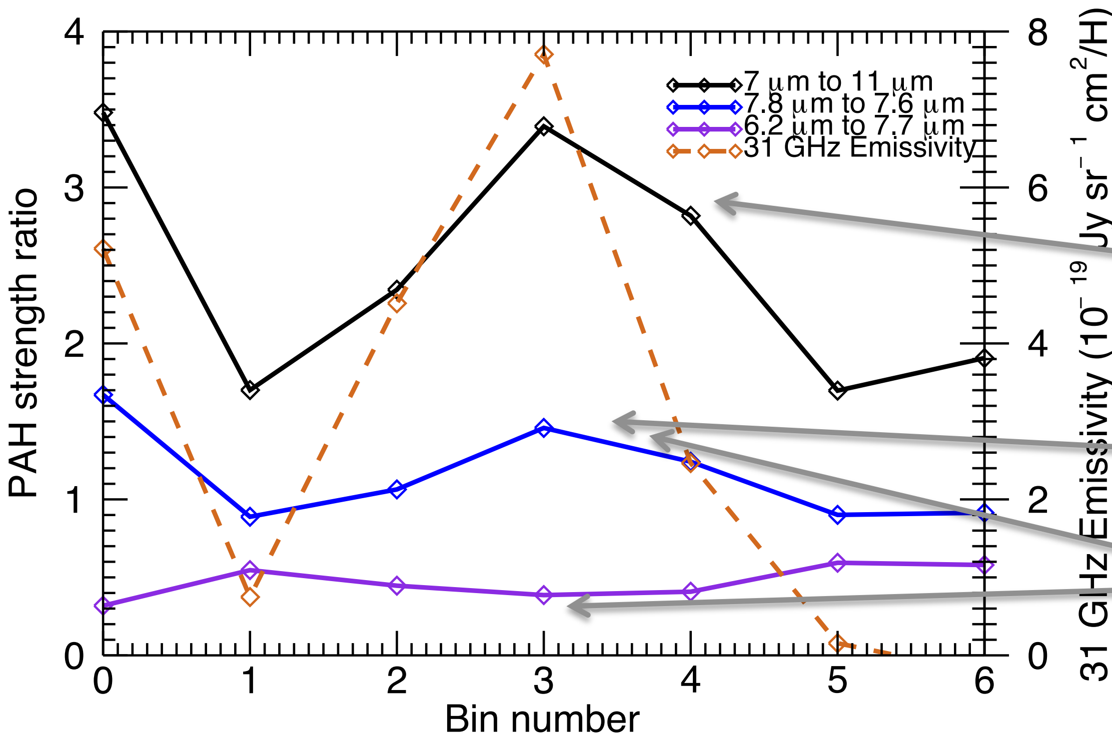
$$\frac{PAH_{7.7\mu m}}{PAH_{11.3\mu m}} \propto \mathrm{Ionization}$$

Diagnostics of physical conditions from MIR

- PAH size

$$\frac{PAH_{6.2\mu m}}{PAH_{7.7\mu m}} \propto \mathrm{N_C}$$

  – Smaller PAHs emit at shorter wavelengths, larger at longer
  – 8.6 um feature due to large PAHs
  – In 7.7 um complex,
    - small PAH cations -> 7.6 um component
    - ‘large’ (N_C > 100) PAH anions -> 7.8 um component



Spinning dust emissivity correlated with:

Increased PAH ionization

Negative PAH charge state

Larger PAH size

Electron photo-ejection -> positively charged

Charge balance: $$\frac{\chi\sqrt{T}}{n_e}$$

Electron attachment -> negatively charged

Future Work

- New data on LDN 1622
  - Increased resolution from CARMA and AMI
  - Spatial variation of 15-31 GHz spectral index
- Mid-infrared spectral map from Spitzer
  - Rich phenomenology of PAH features
  - Shed light on physical conditions and PAH population
  - Investigate relation with spinning dust emissivity
  - Higher resolution radio data would be nice!