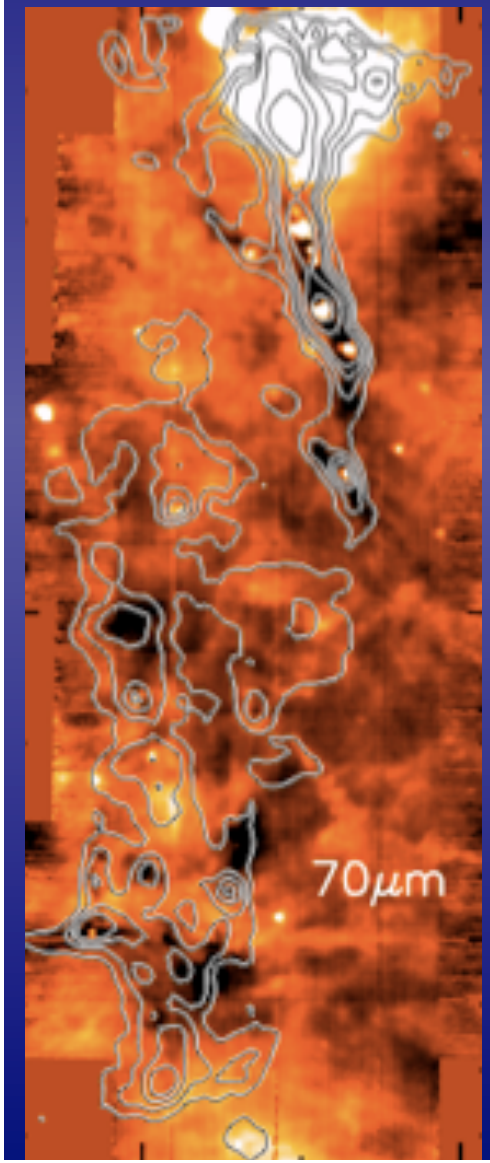
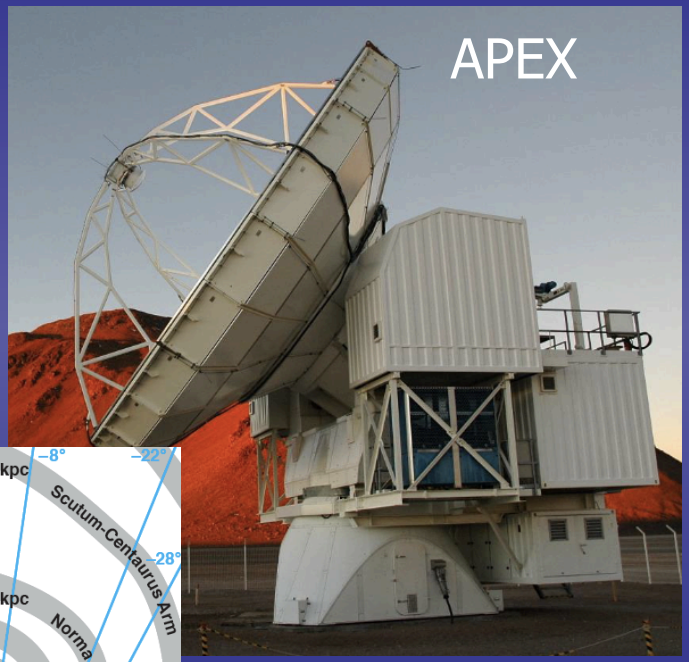
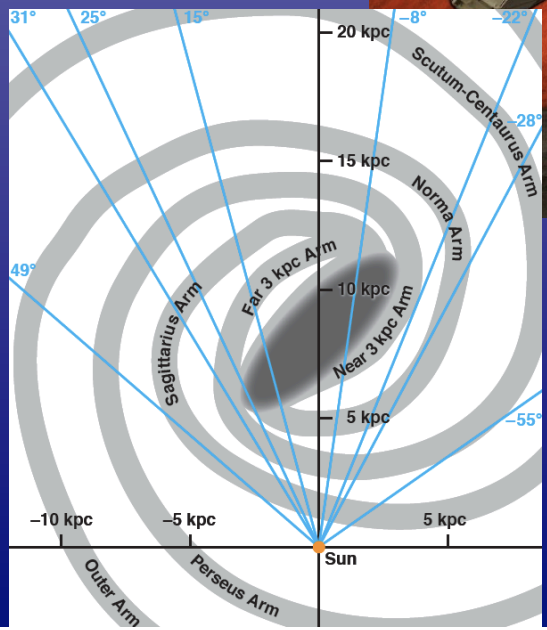
Milky Way Structure and the Initial Conditions for High-Mass Star Formation

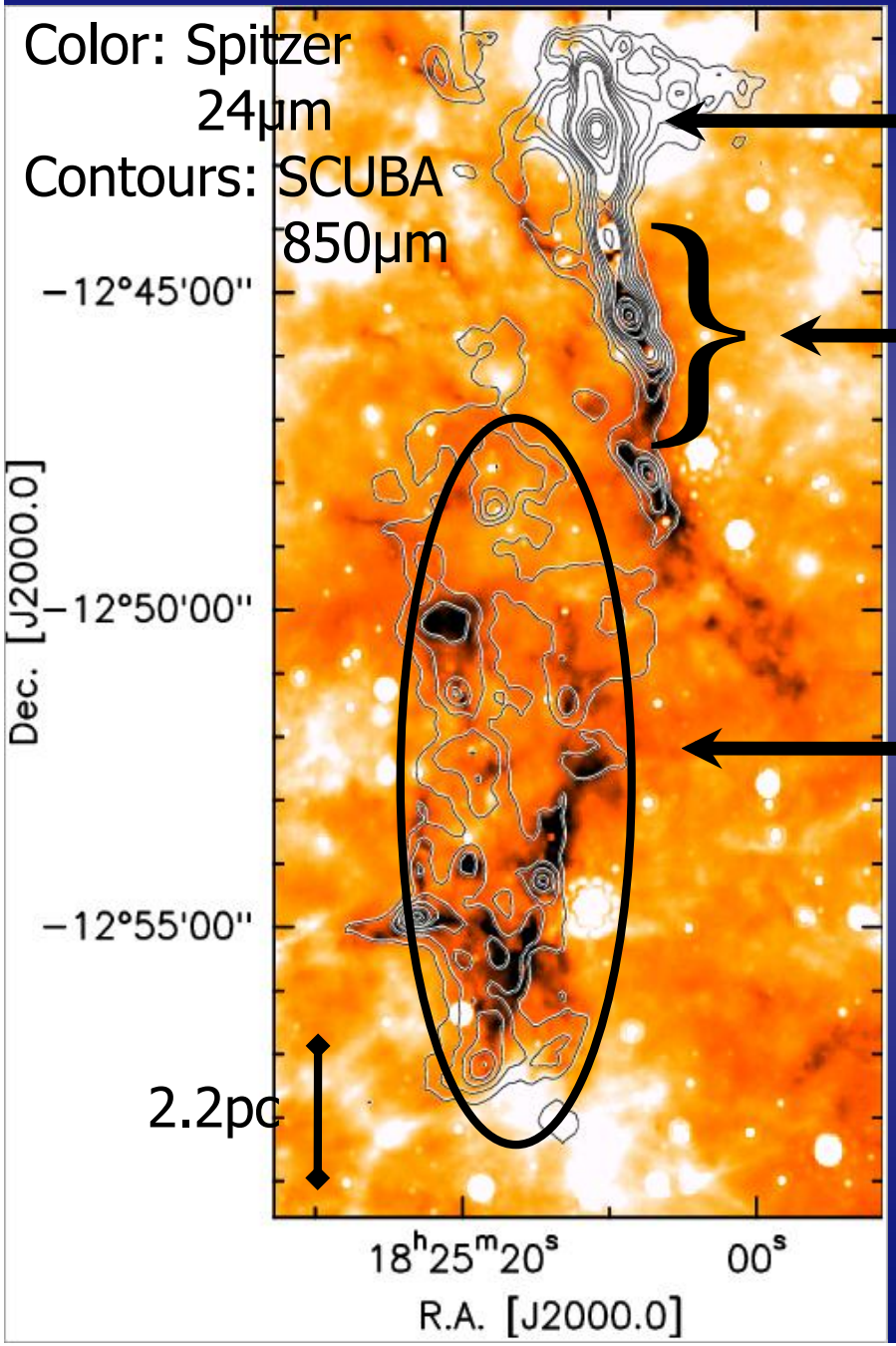
Henrik Beuther, MPIA Heidelberg







Evolutionary sequence and wavelengths



High-Mass Protostellar Objects

High-Mass Cores With Embedded Intermediate-mass Protostars

High-Mass Starless Cores

Evolutionary Sequence

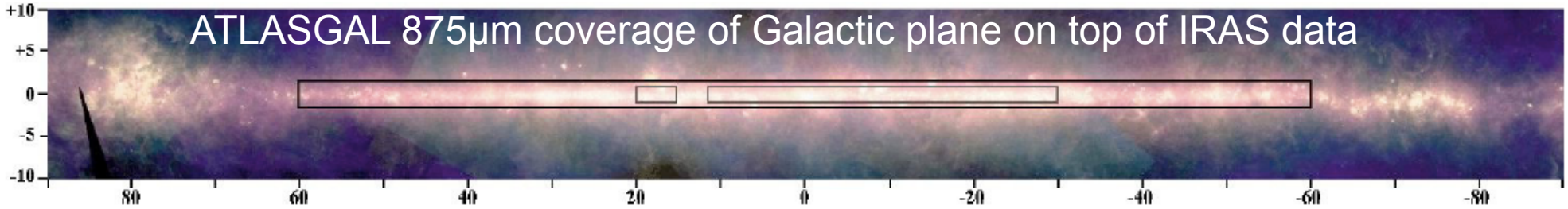
mm single-dish resolution between 11" and 23" → 40000 to 85000AU
Interferometers <=1" → order 2000AU

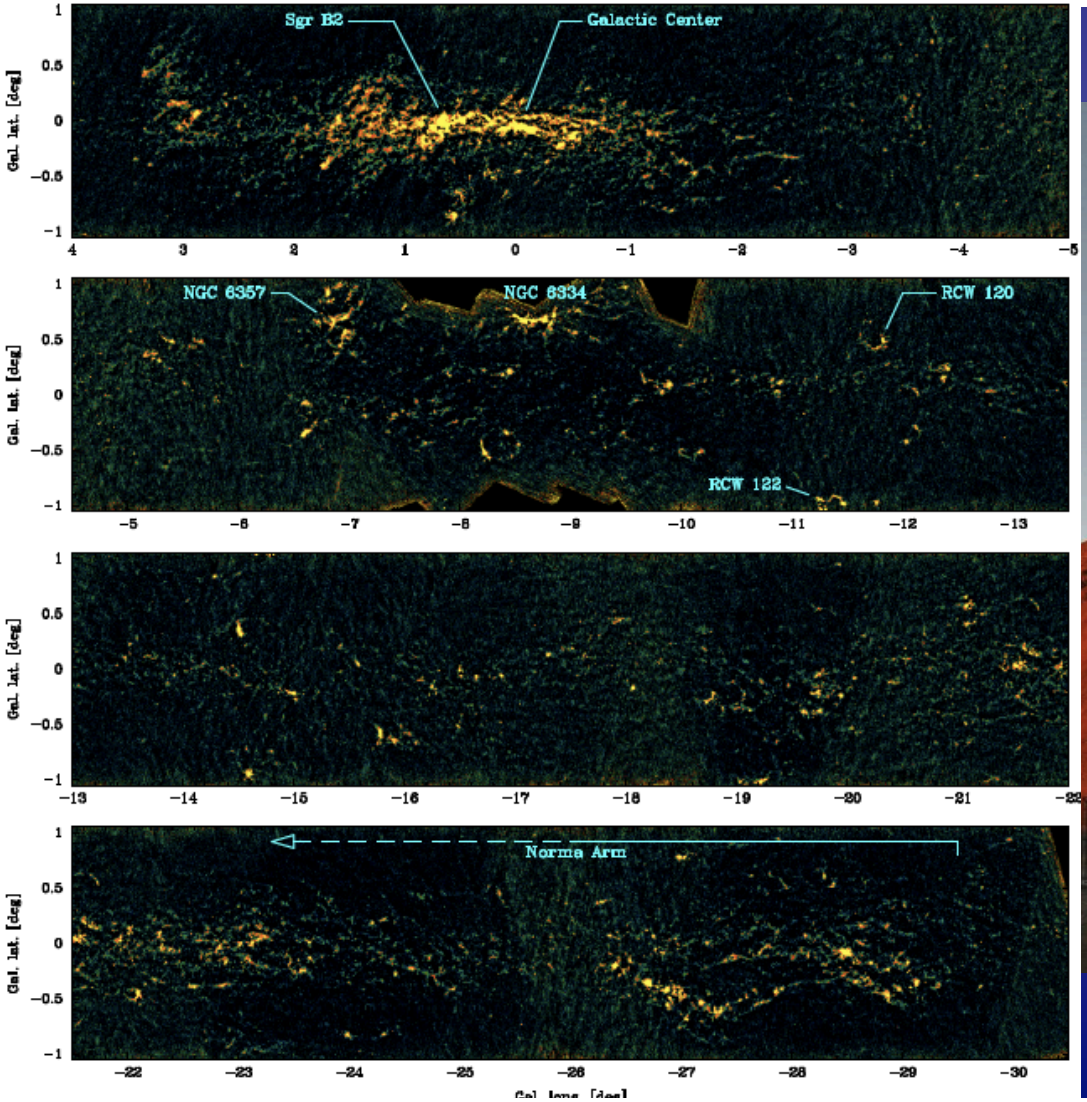
Topics

- Galactic structure and starless clump timescales inferred from ATLASGAL observations

- The earliest evolutionary stages as revealed by Herschel

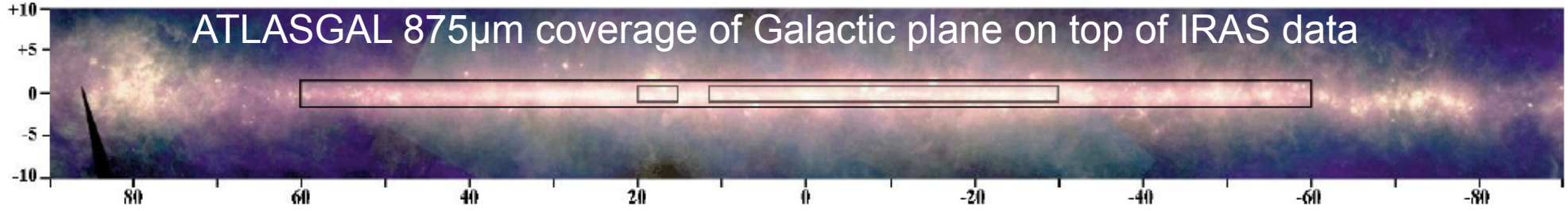
Galactic structure from ATLASGAL data I

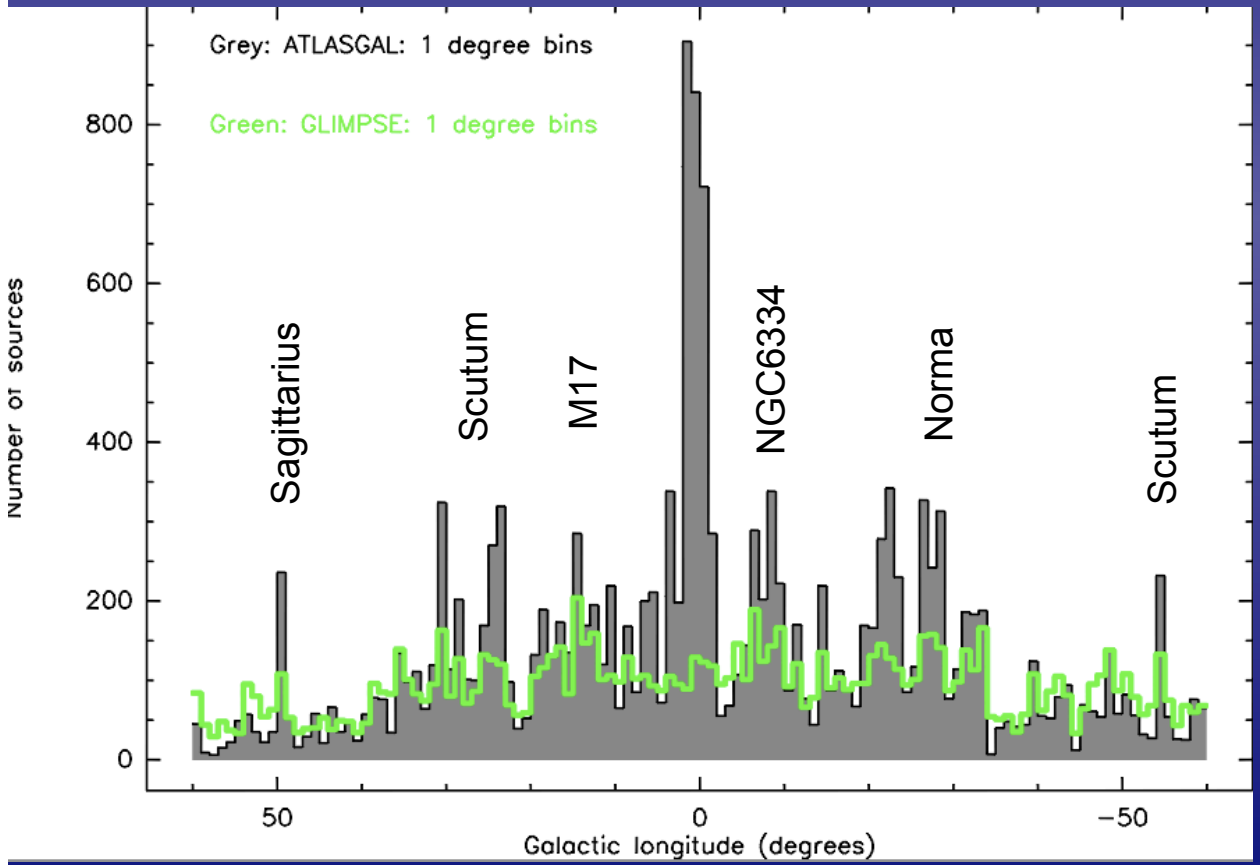


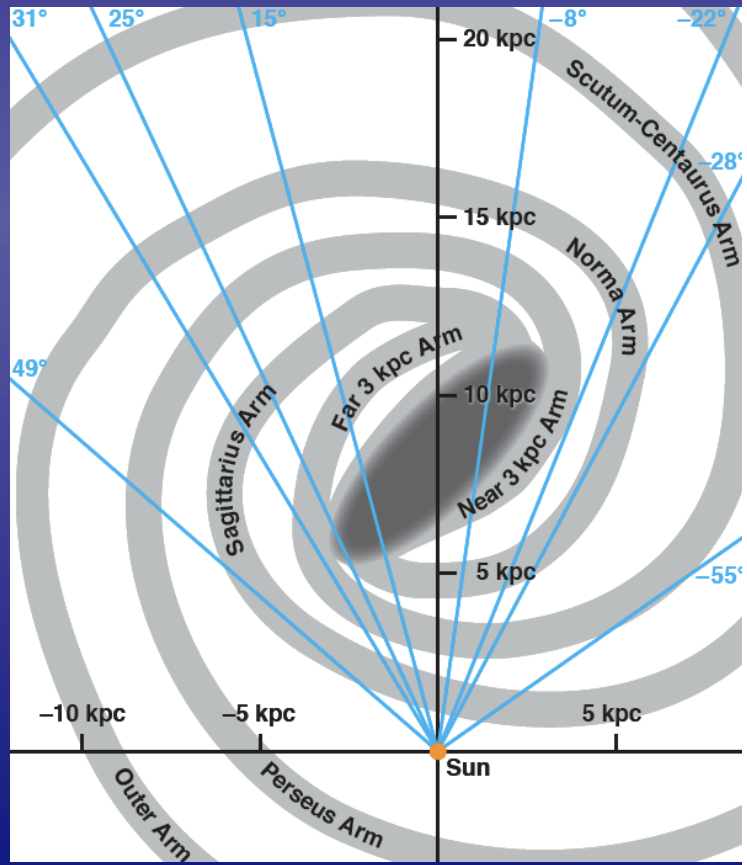


Schuller et al. 2009

Galactic structure from ATLASGAL

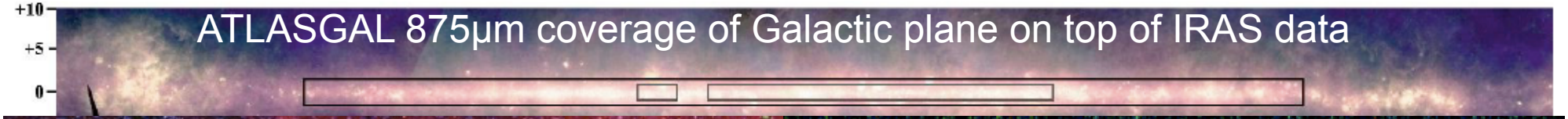


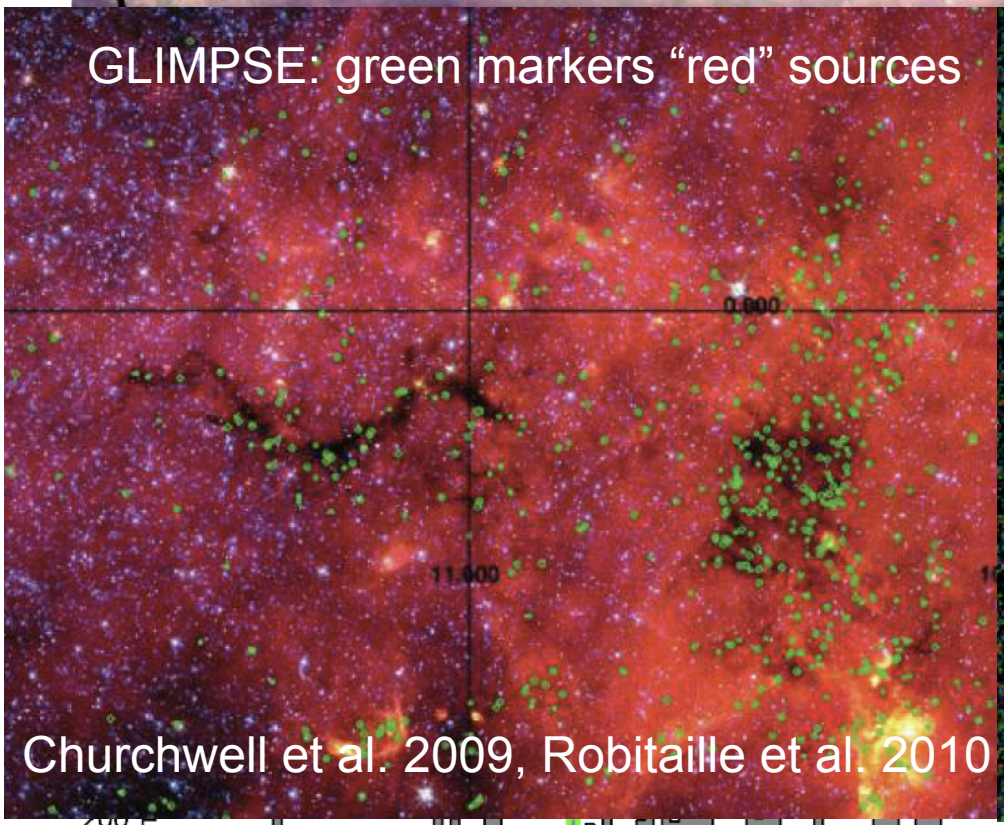


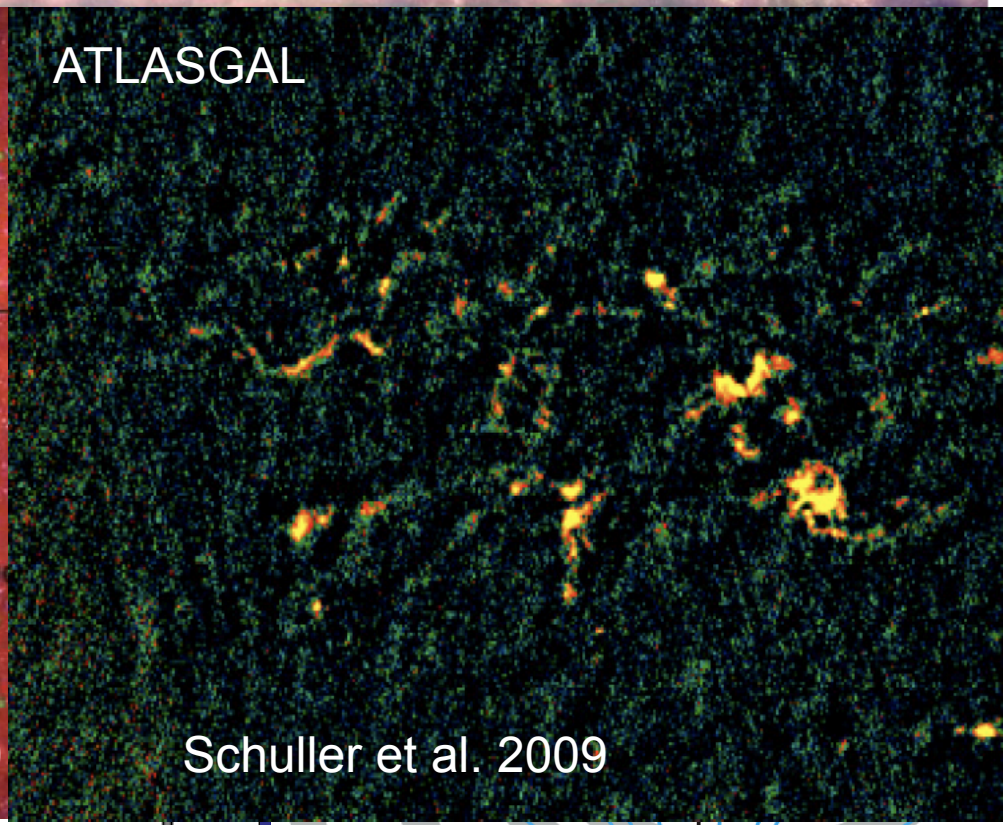


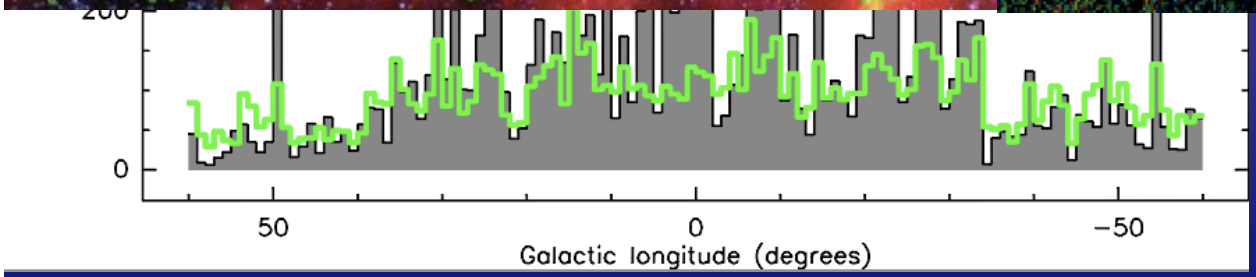
Beuther et al. 2012

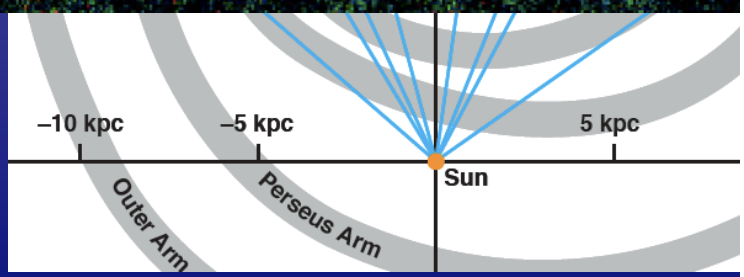
Galactic structure from ATLASGAL





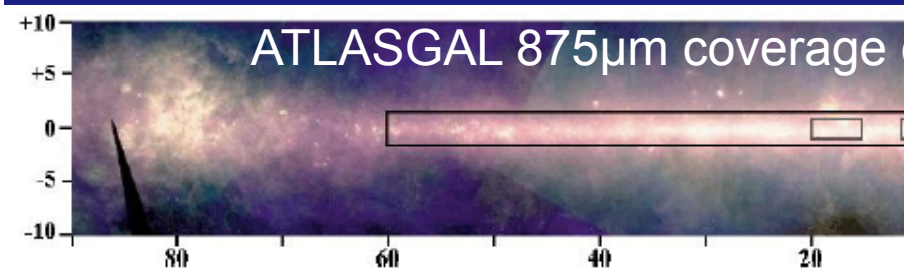


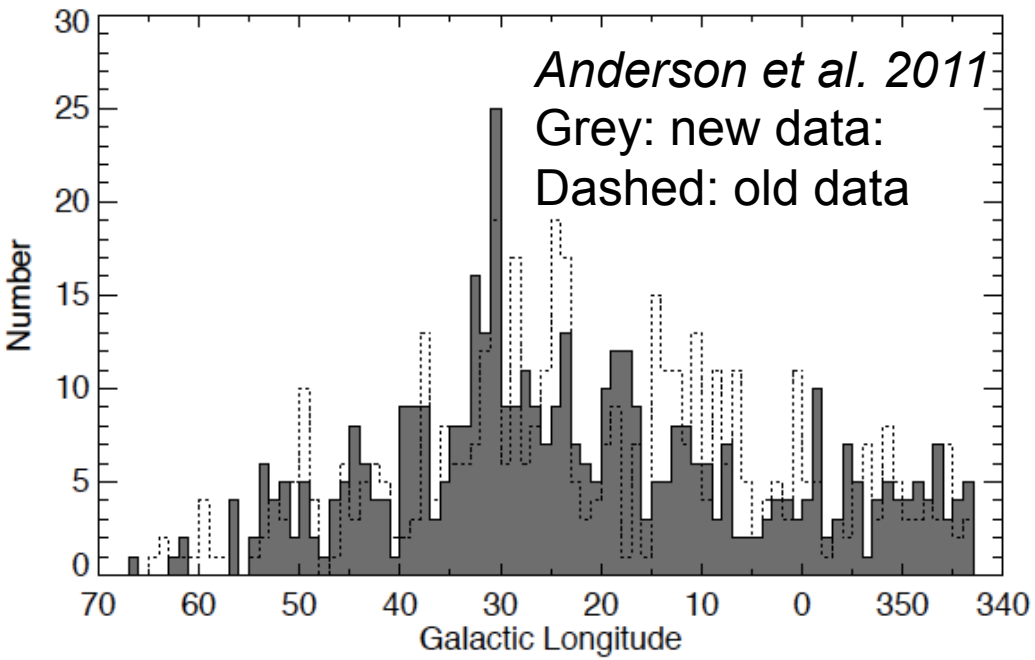


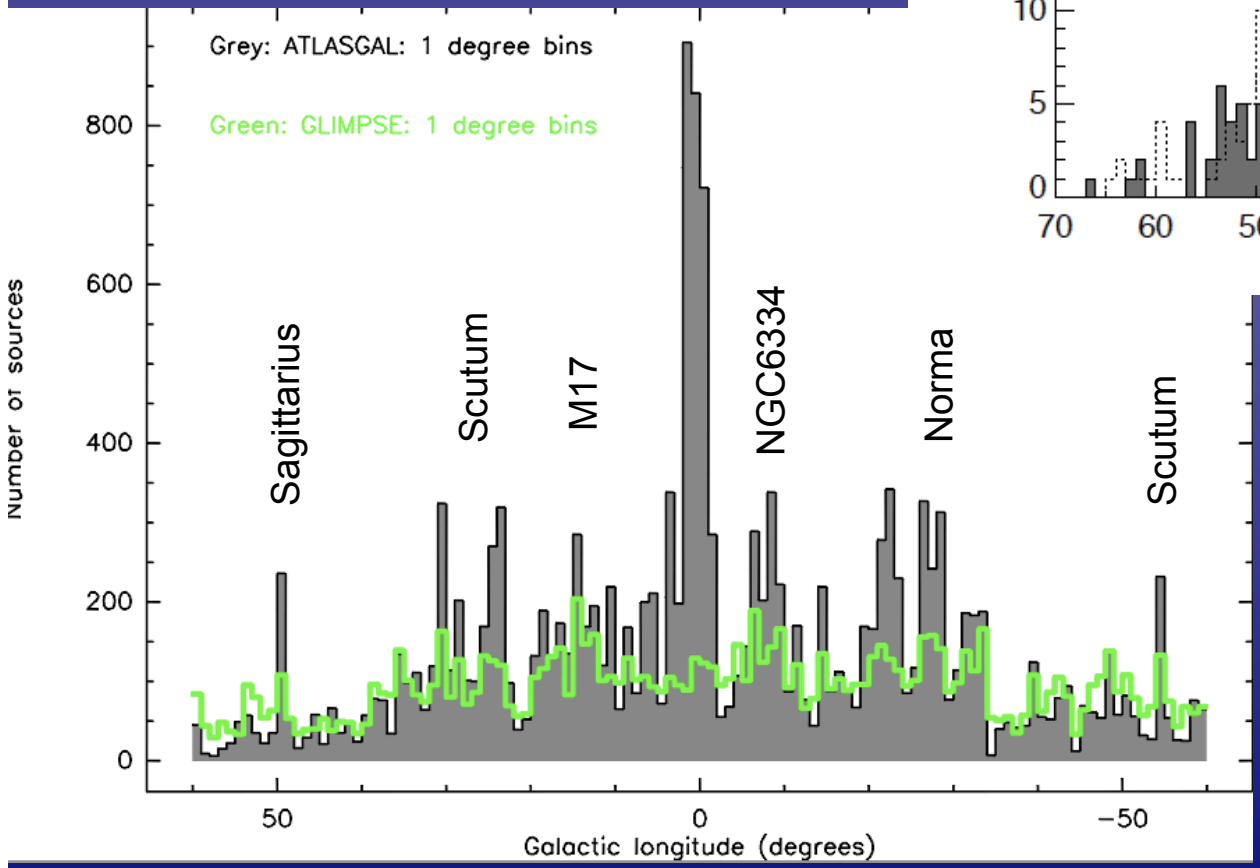


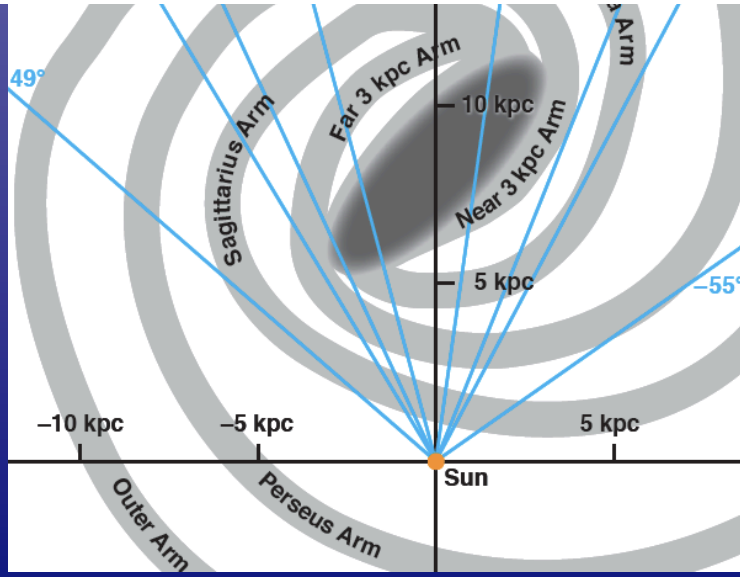
Beuther et al. 2012

Galactic structure from ATLASGAL



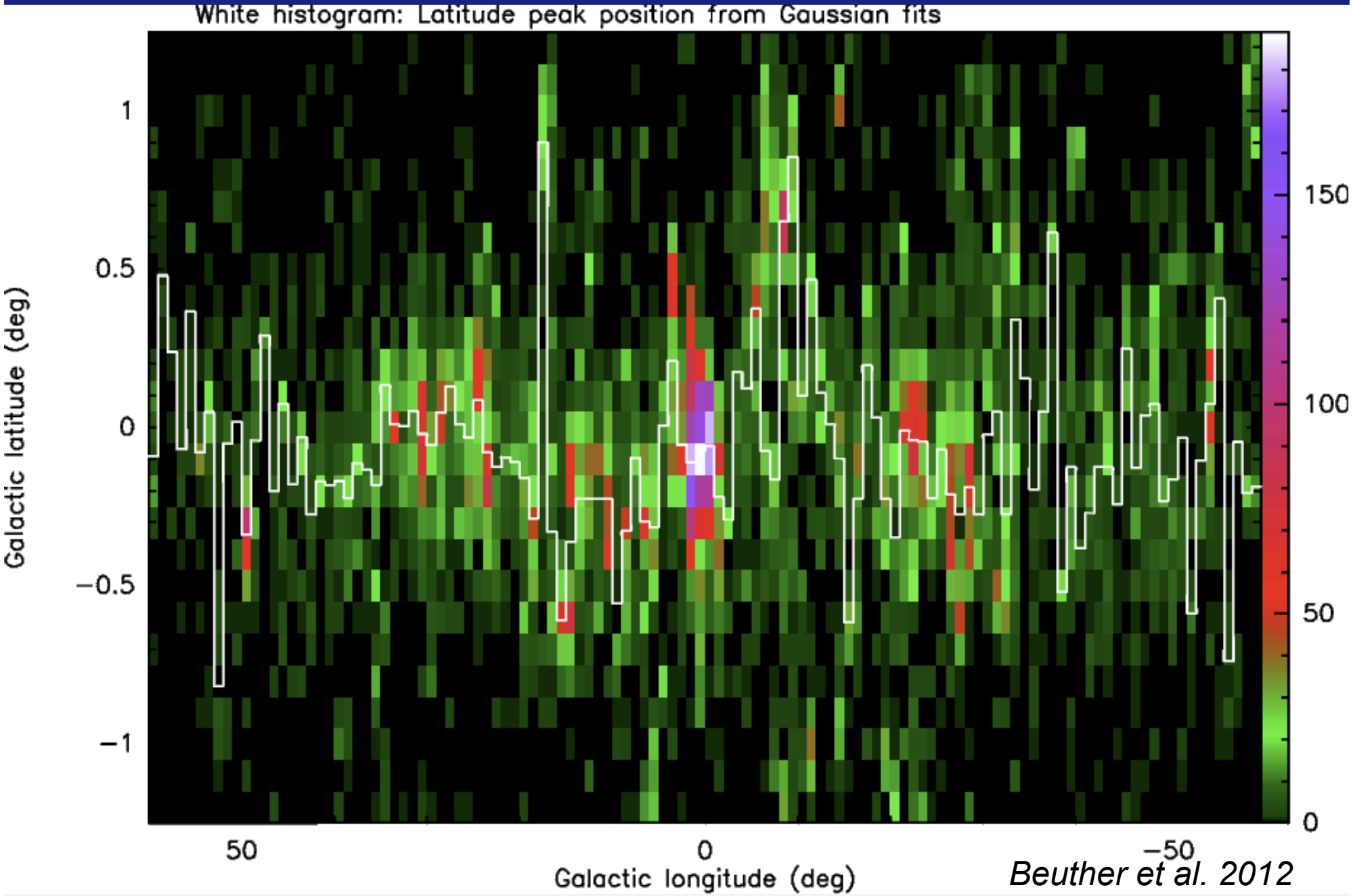






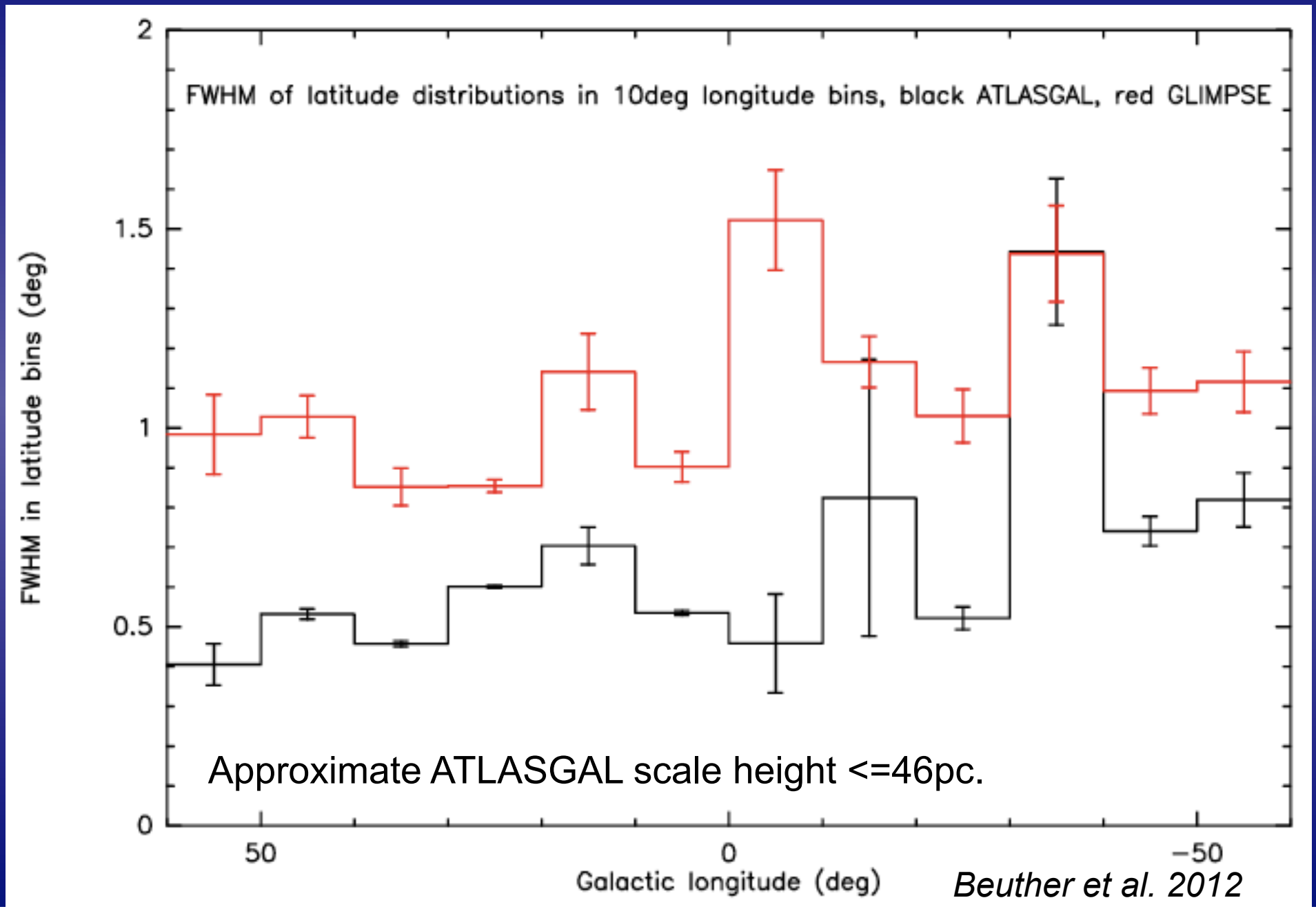
Beuther et al. 2012

Galactic structure from ATLASGAL data III

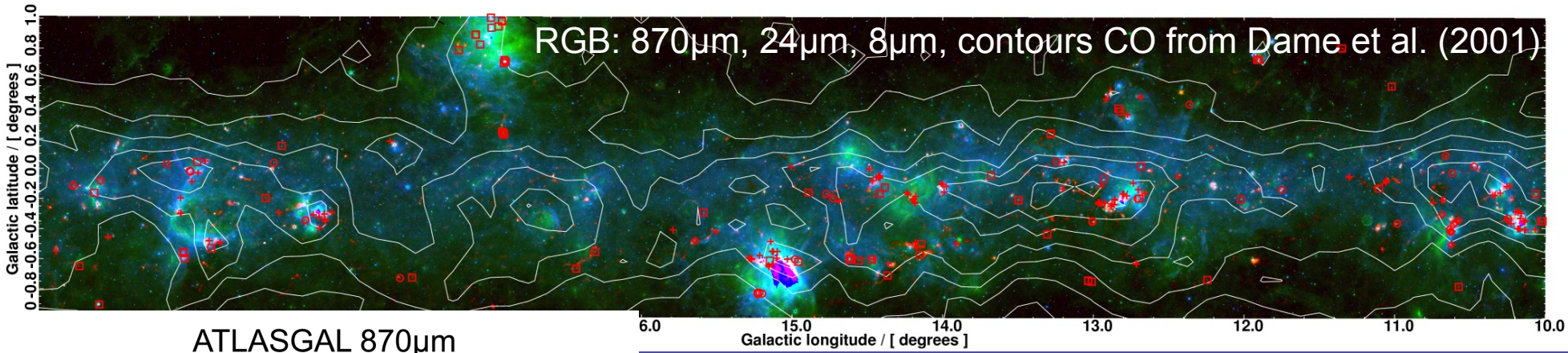


Beuther et al. 2012

Galactic structure from ATLASGAL data IV



Zooming into ATLASGAL - Timescales



ATLASGAL 870µm
-> cold dust

searching peaks with clumpfind

CLUMPS
column density > $1x10^{23}cm^{-2}$

GLIMPSE catalog
->YSO / class I

MIPSGAL 24µm
-> warm dust

starless clump candidates

visiual inspection of starless clump candidates

STARLESS CLUMPS

- In $20deg^2$, 210 out of 901 clumps starless
  → about 25%, column density thresshold
  > $1x10^{23}cm^{-2}$
- 14 > $1000M_{sun}$, 3 > $3000M_{sun}$
- Lifetime estimate $(5+-4)x10^4yr$

Tackenberg et al. 2012

Topics

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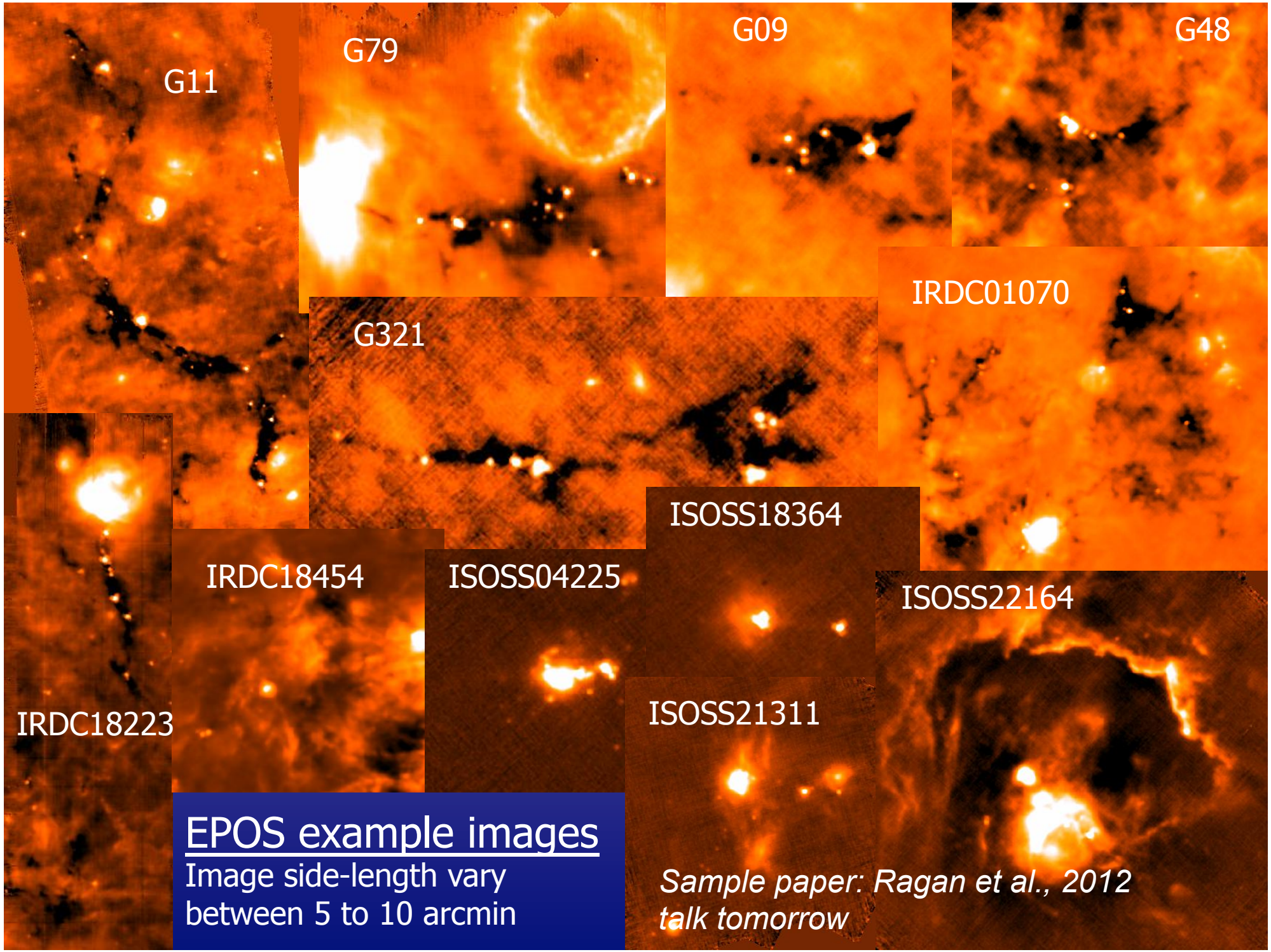
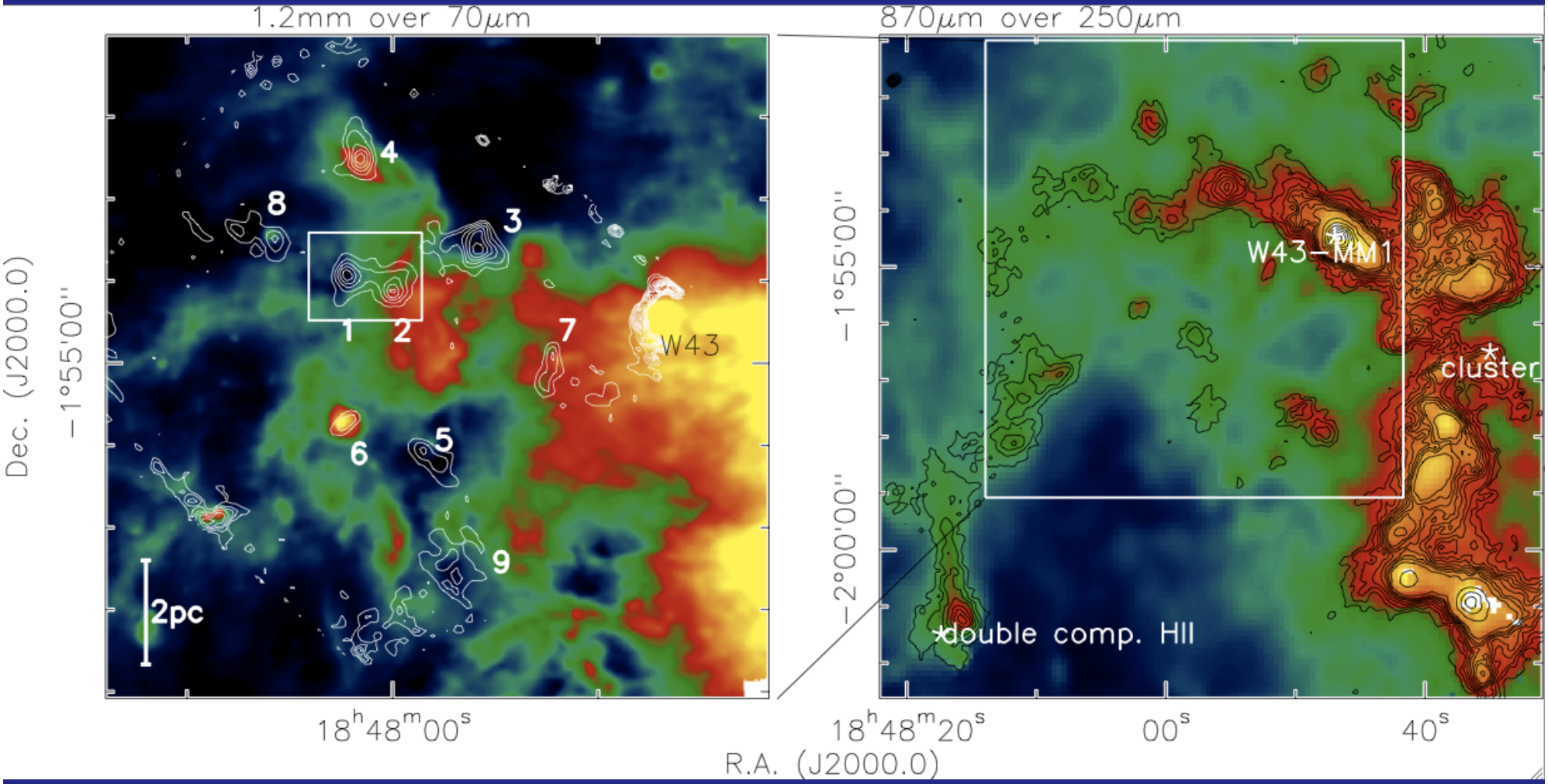


EPOS example images

Image side-length vary between 5 to 10 arcmin

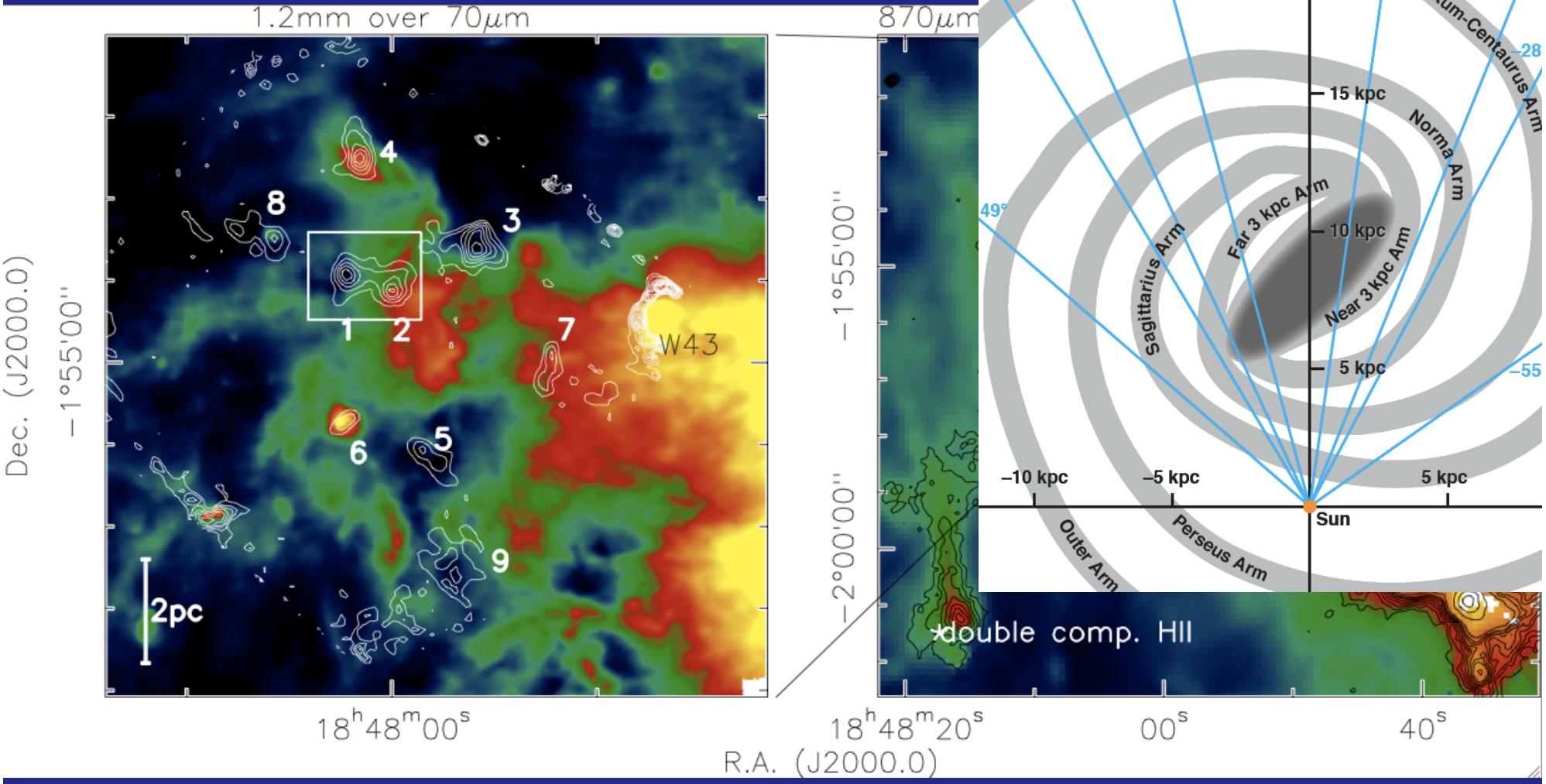
Sample paper: Ragan et al., 2012
talk tomorrow

Quiescent cores near the mini-starburst W43



Beuther et al. 2012

Quiescent cores near the mini-starburst W43



Beuther et al. 2012

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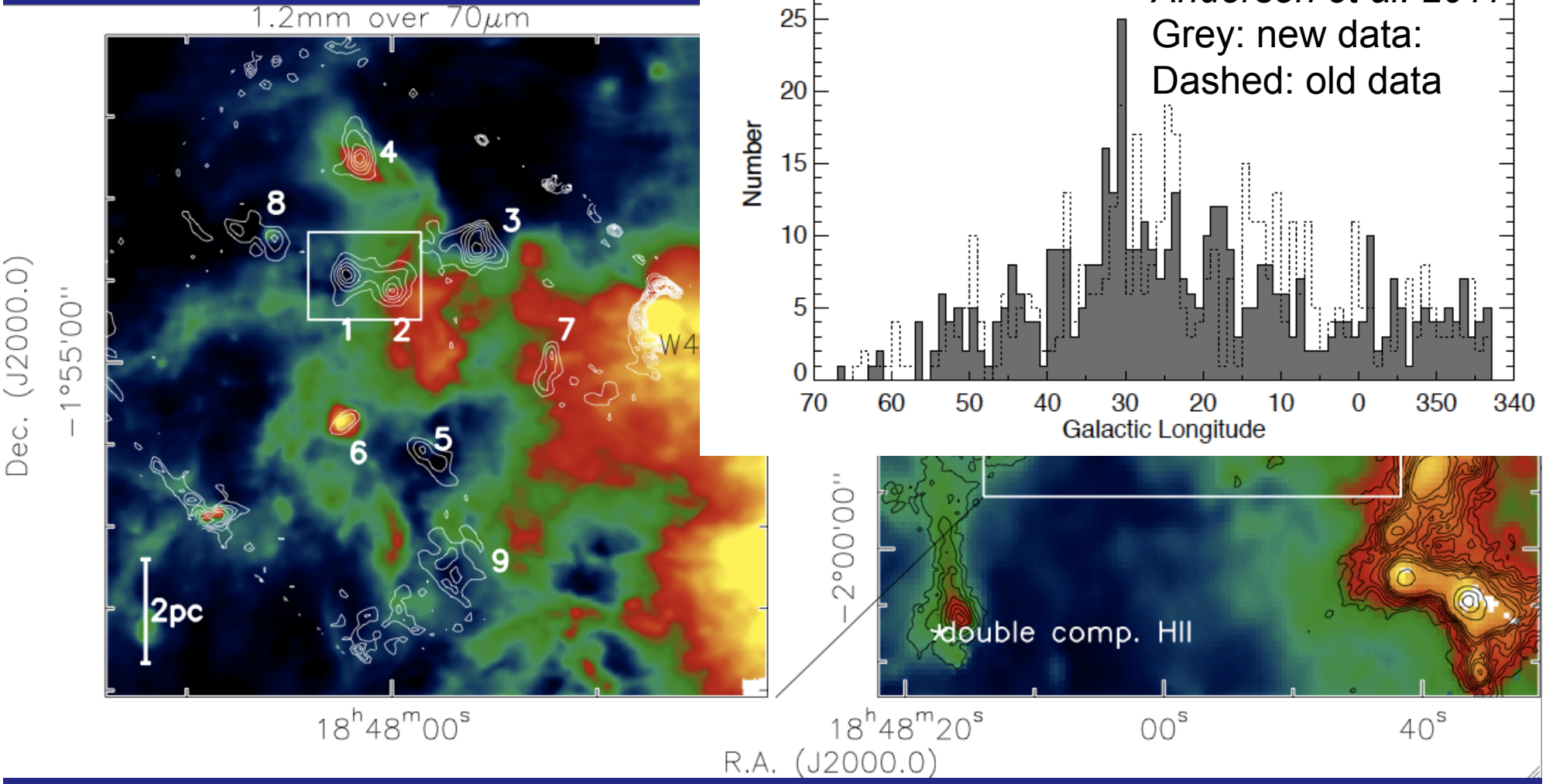
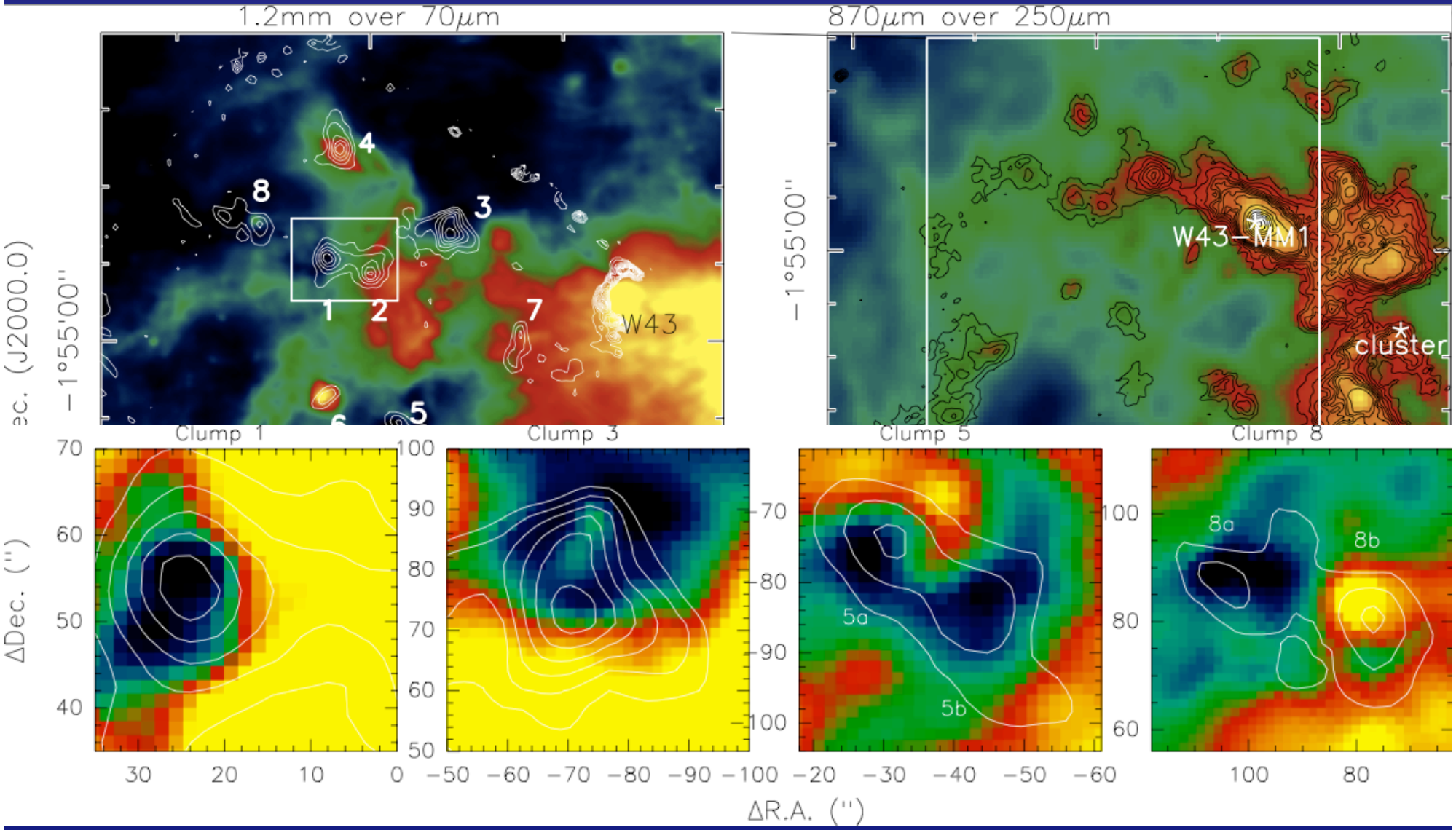


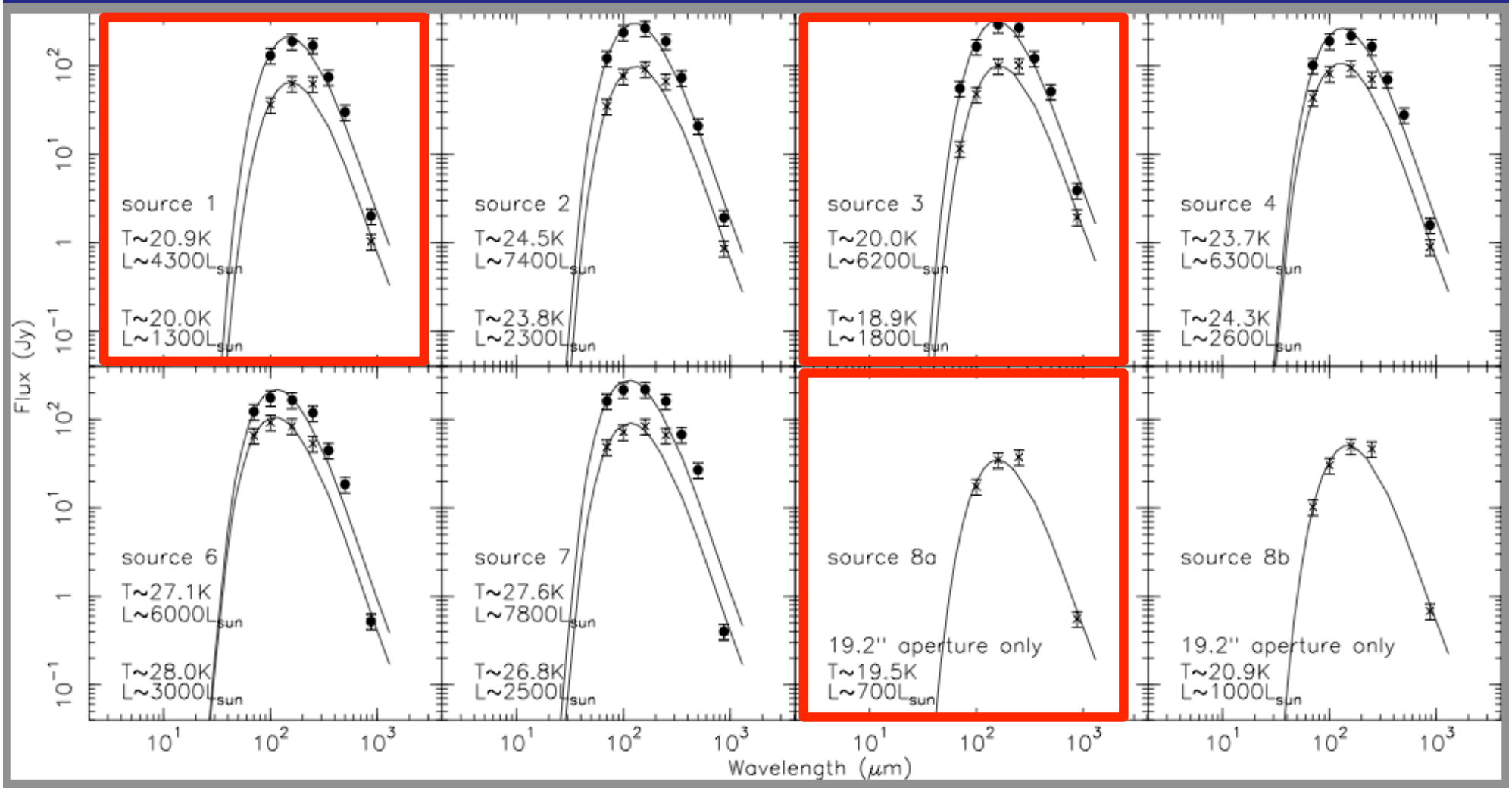
Beuther et al. 2012

Quiescent cores near the mini-starburst W43



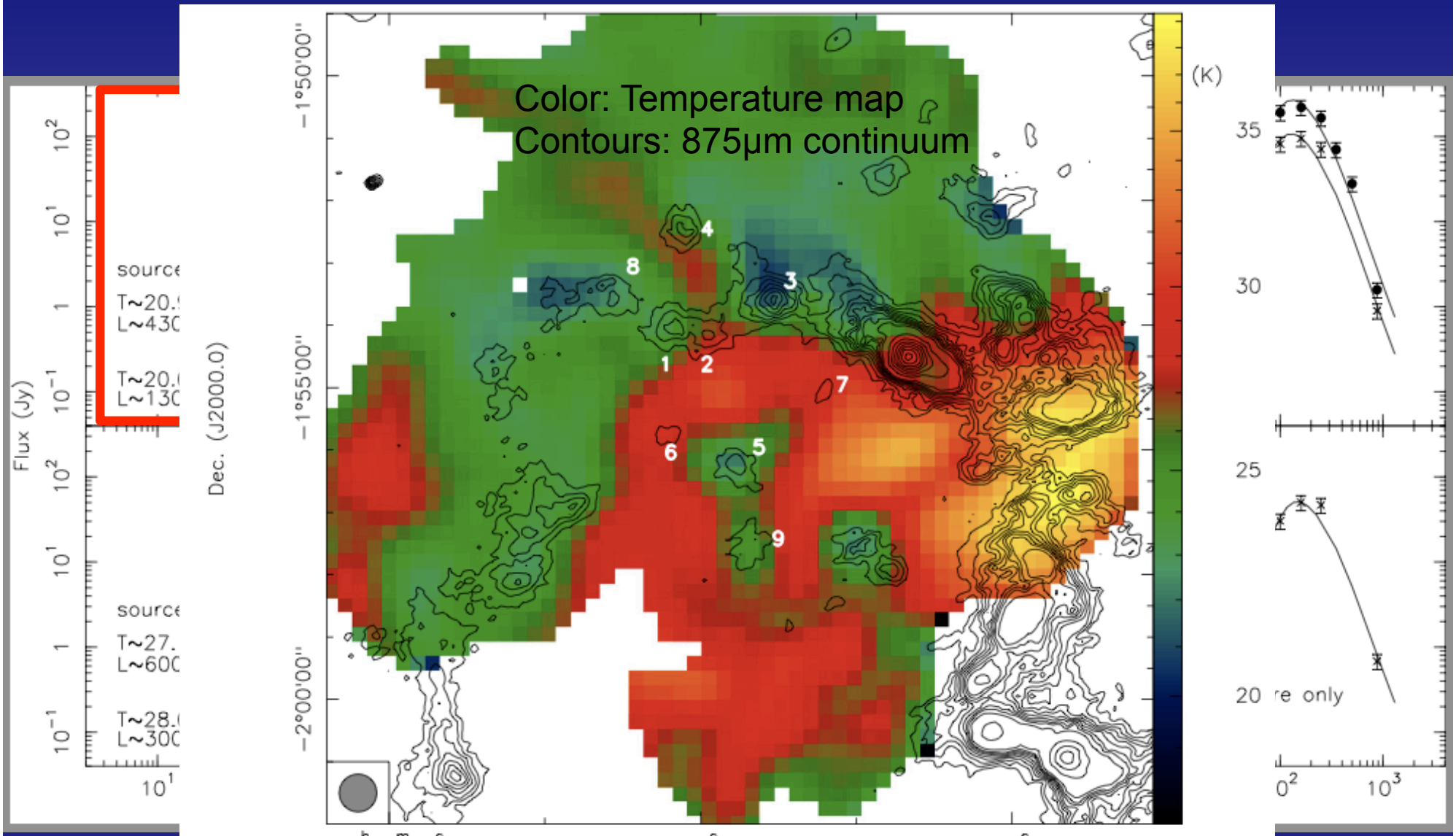
Beuther et al. 2012

Spectral energy distributions



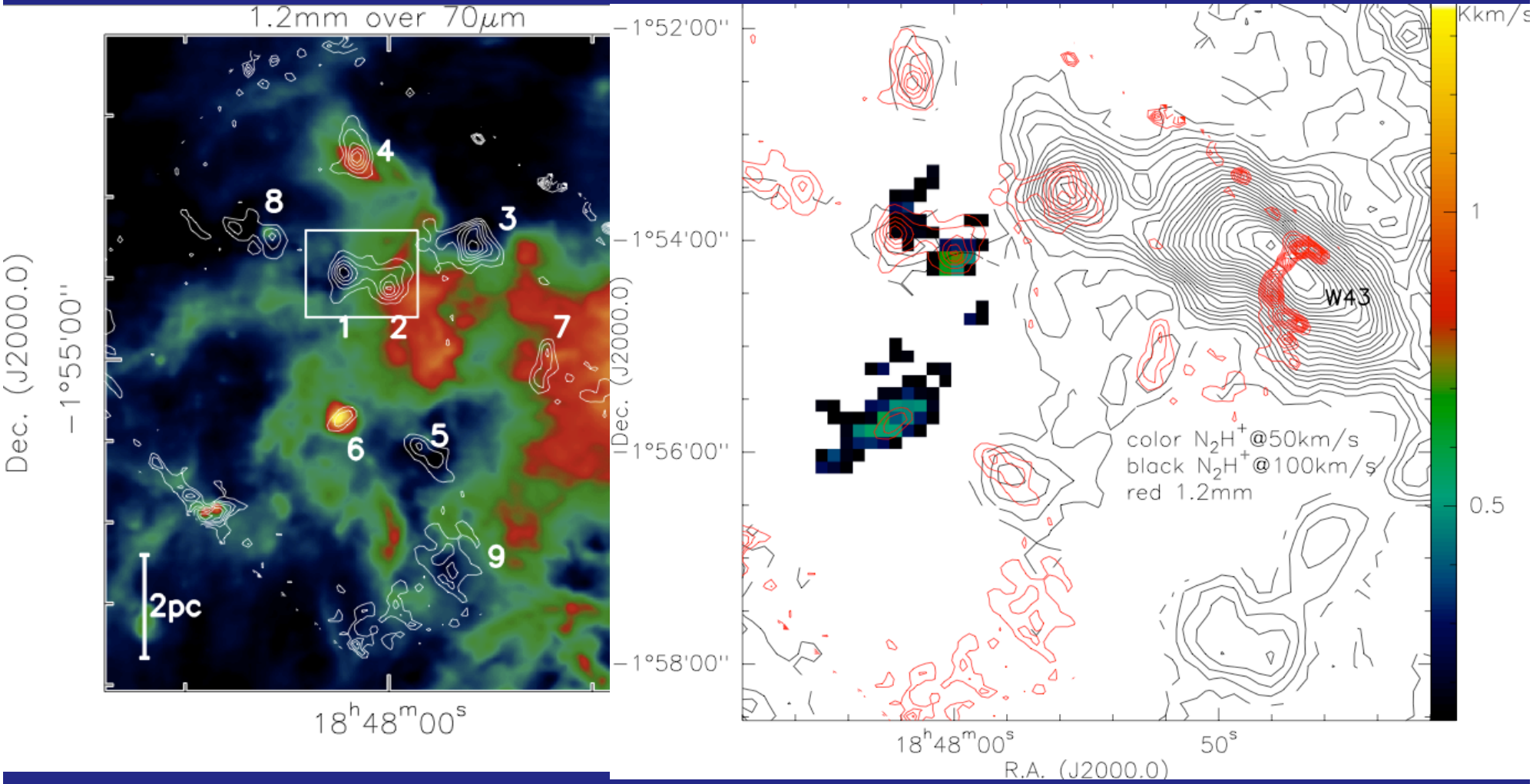
Beuther et al. 2012

Spectral energy distributions



Beuther et al. 2012

Quiescent cores near the mini-starburst W43



Beuther et al. 2012

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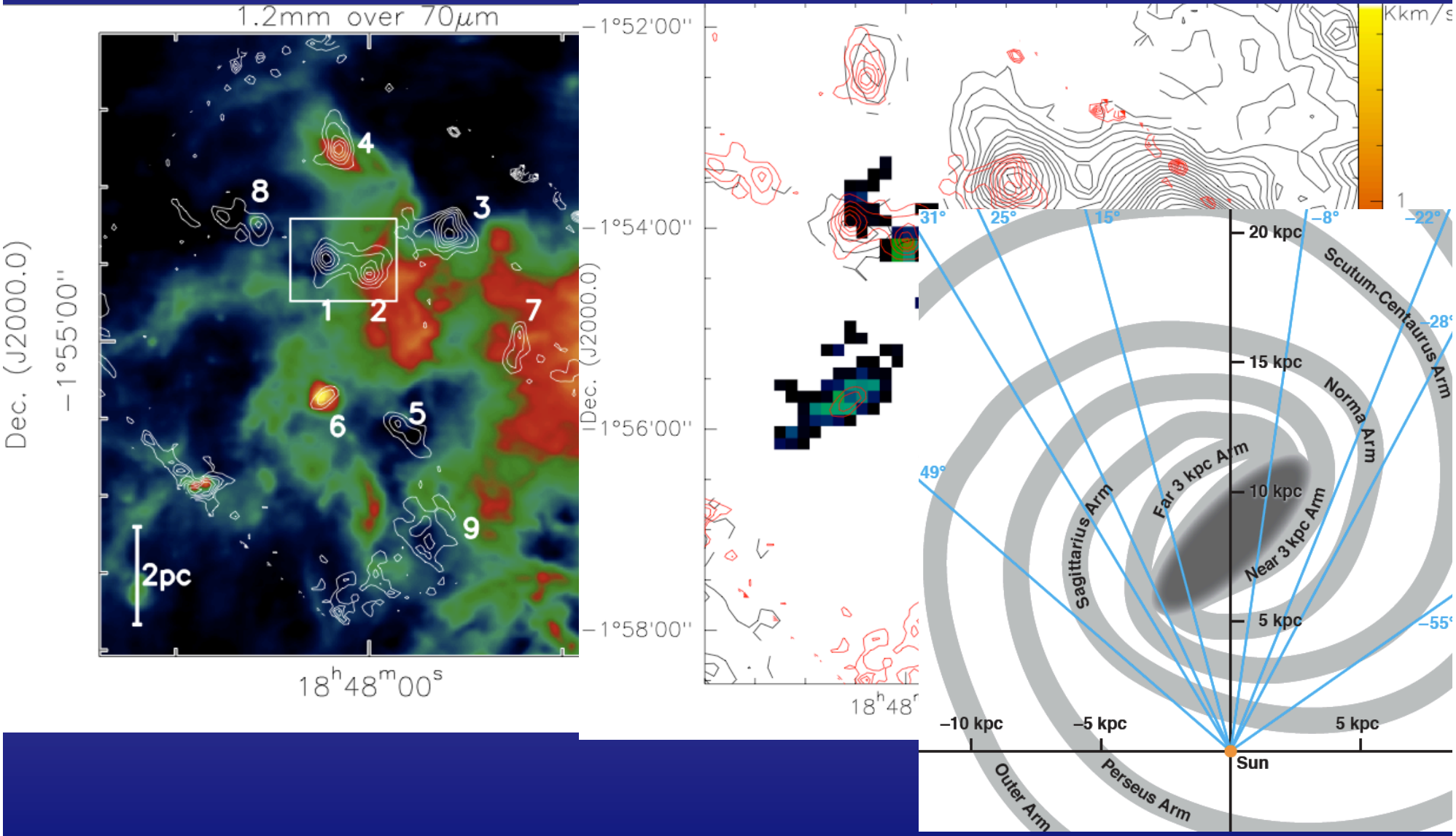
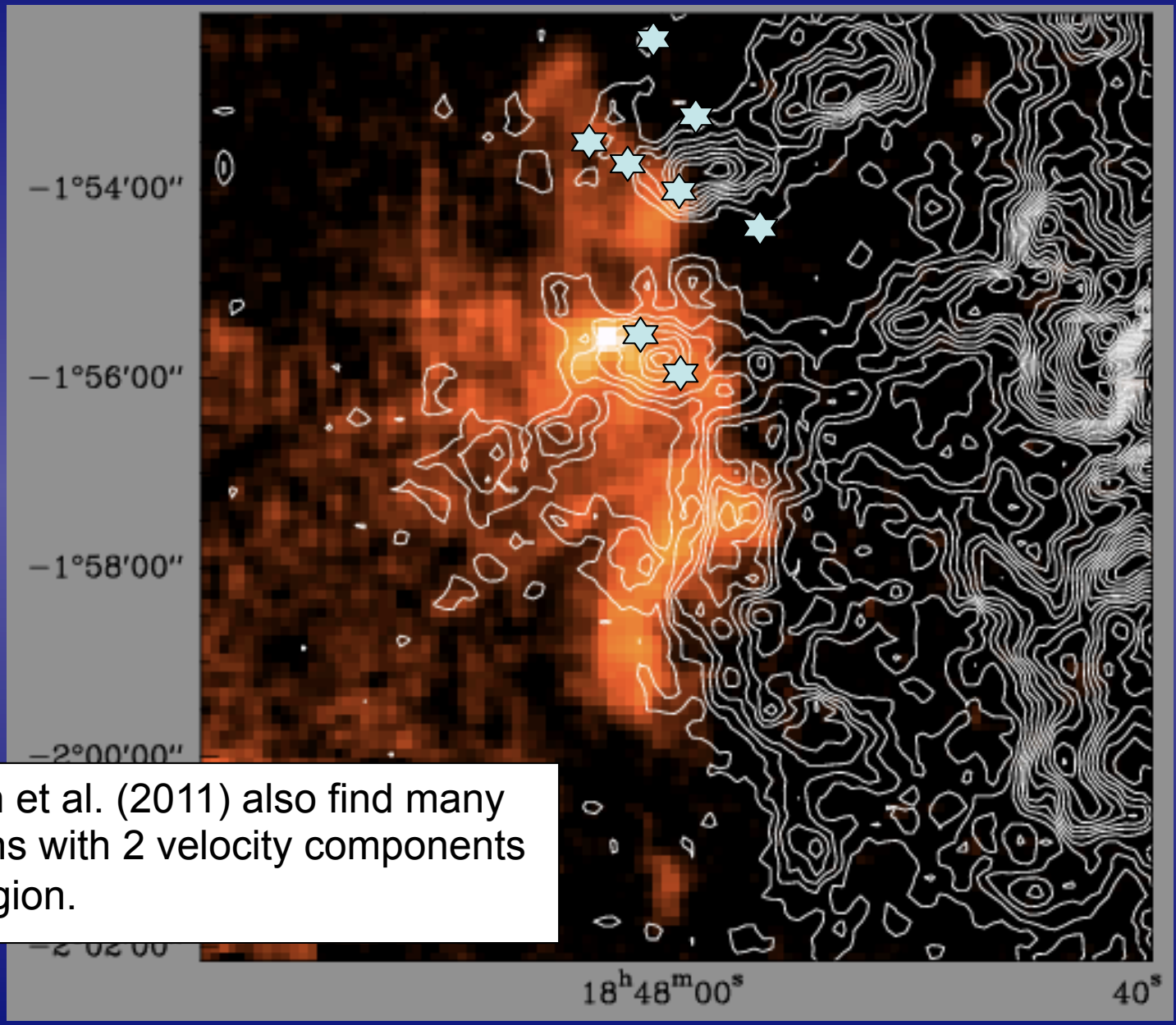


Beuther et al. 2012

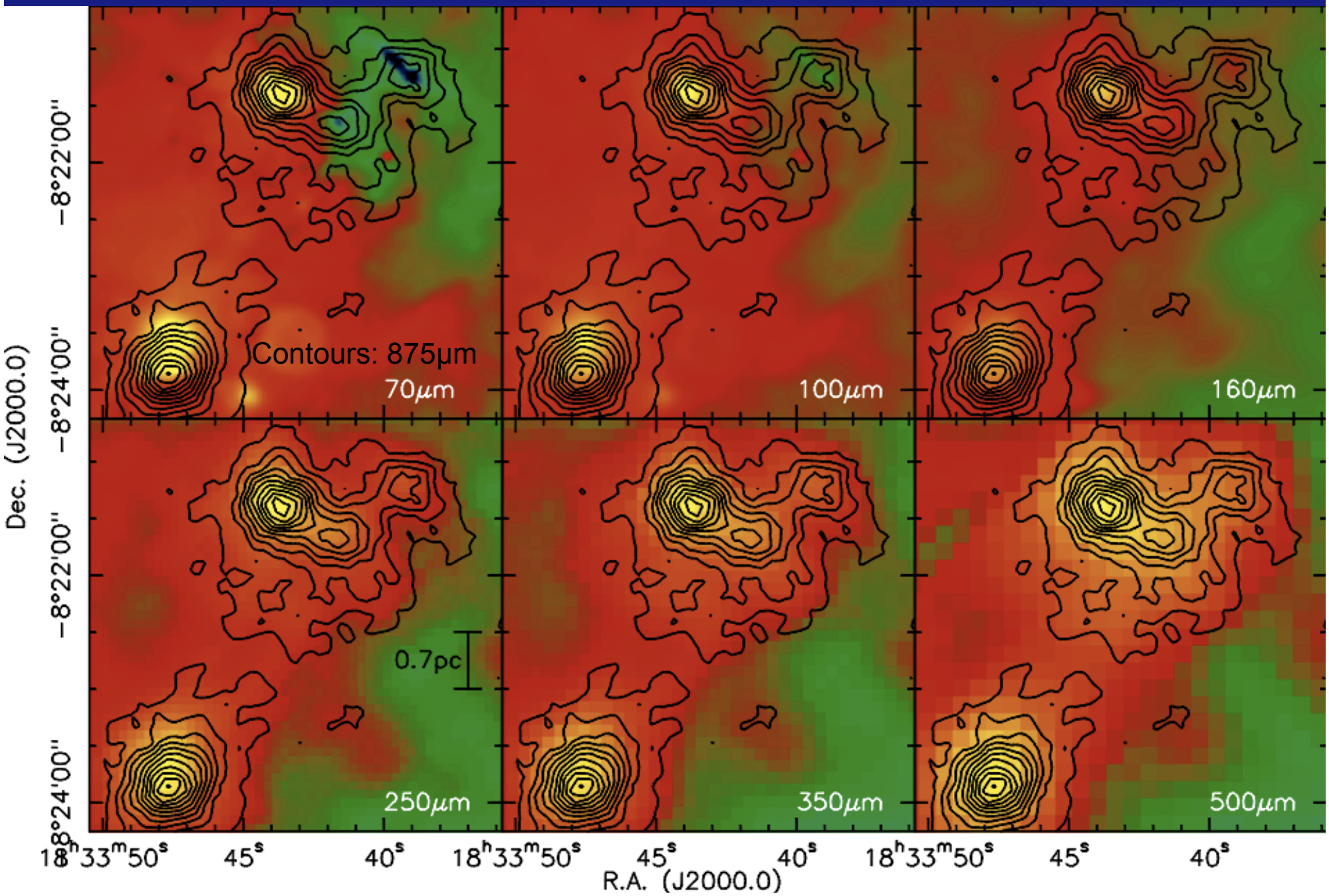
W43 13CO IRAM large program



Anderson et al. (2011) also find many HII regions with 2 velocity components in that region.

Color: 40km/s, contours: 100km/s

A very massive starless clump in IRDC18310-4



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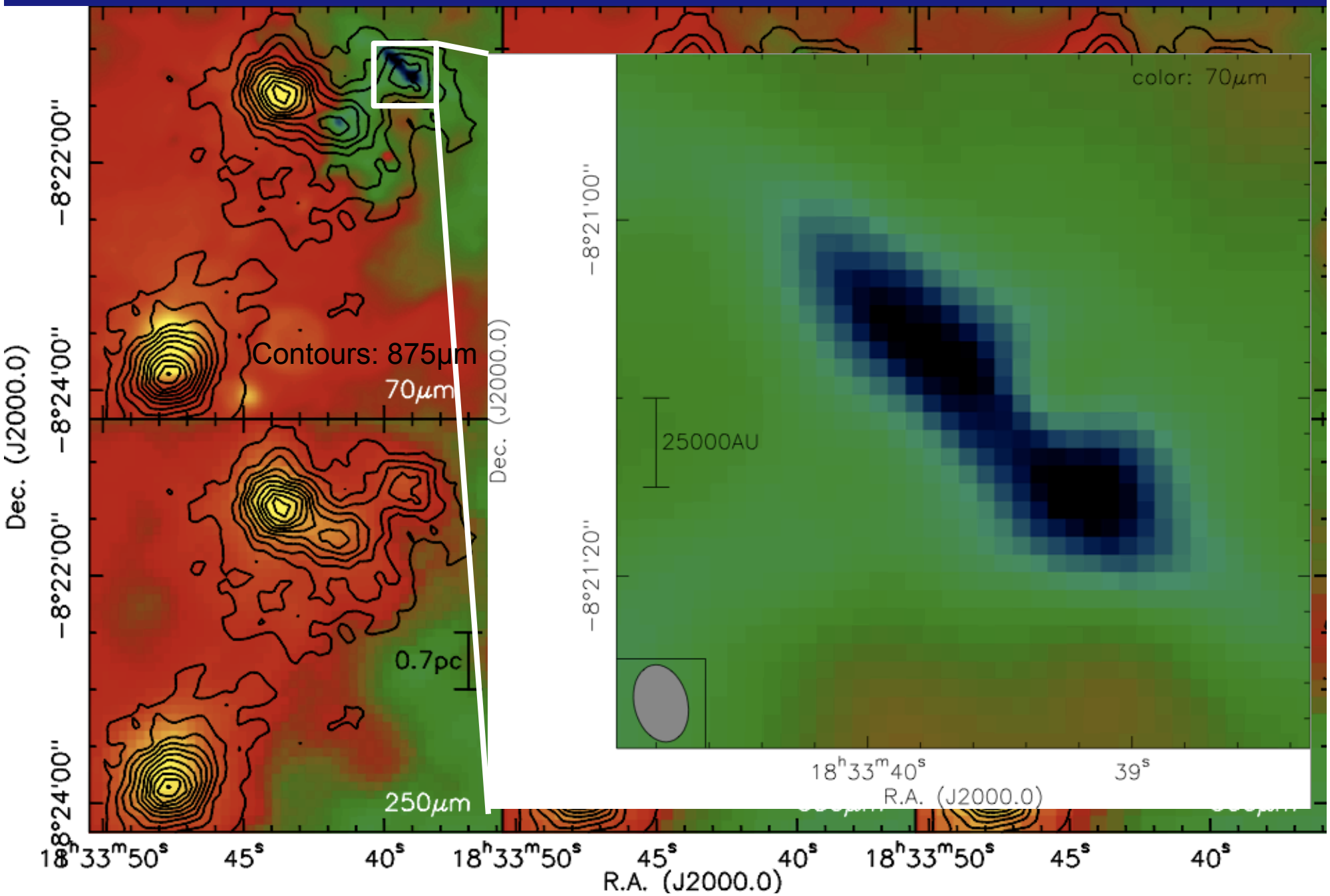

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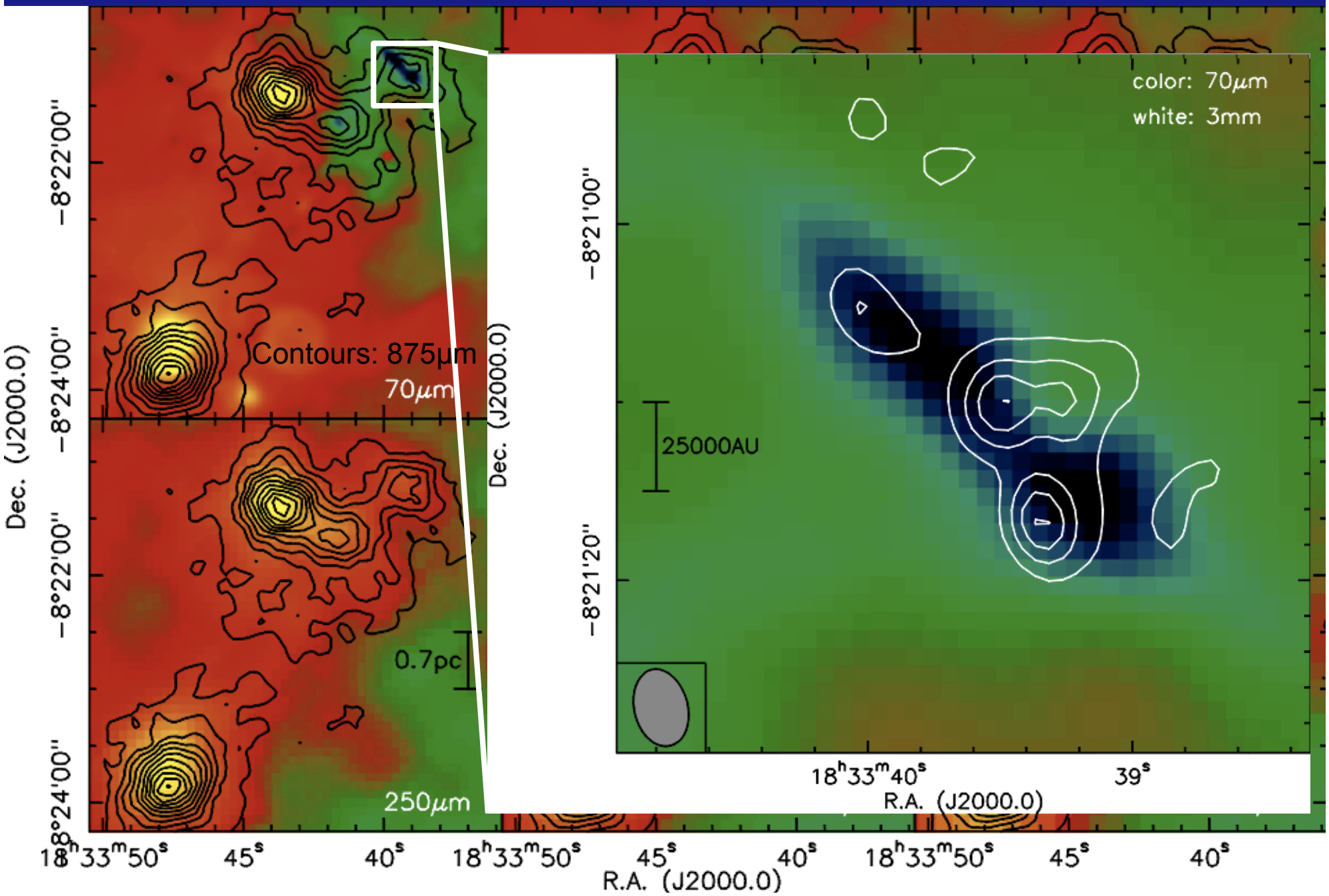

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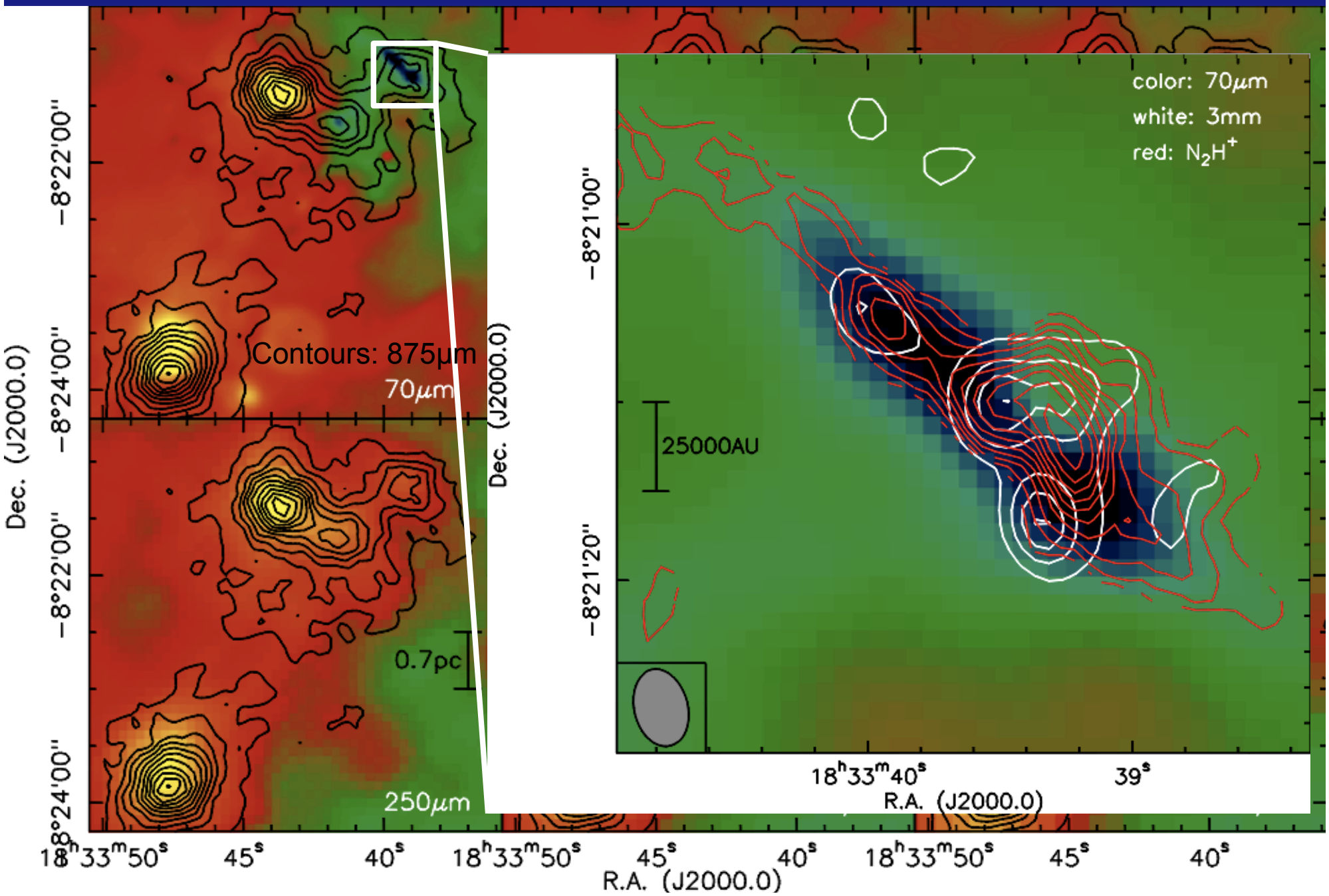

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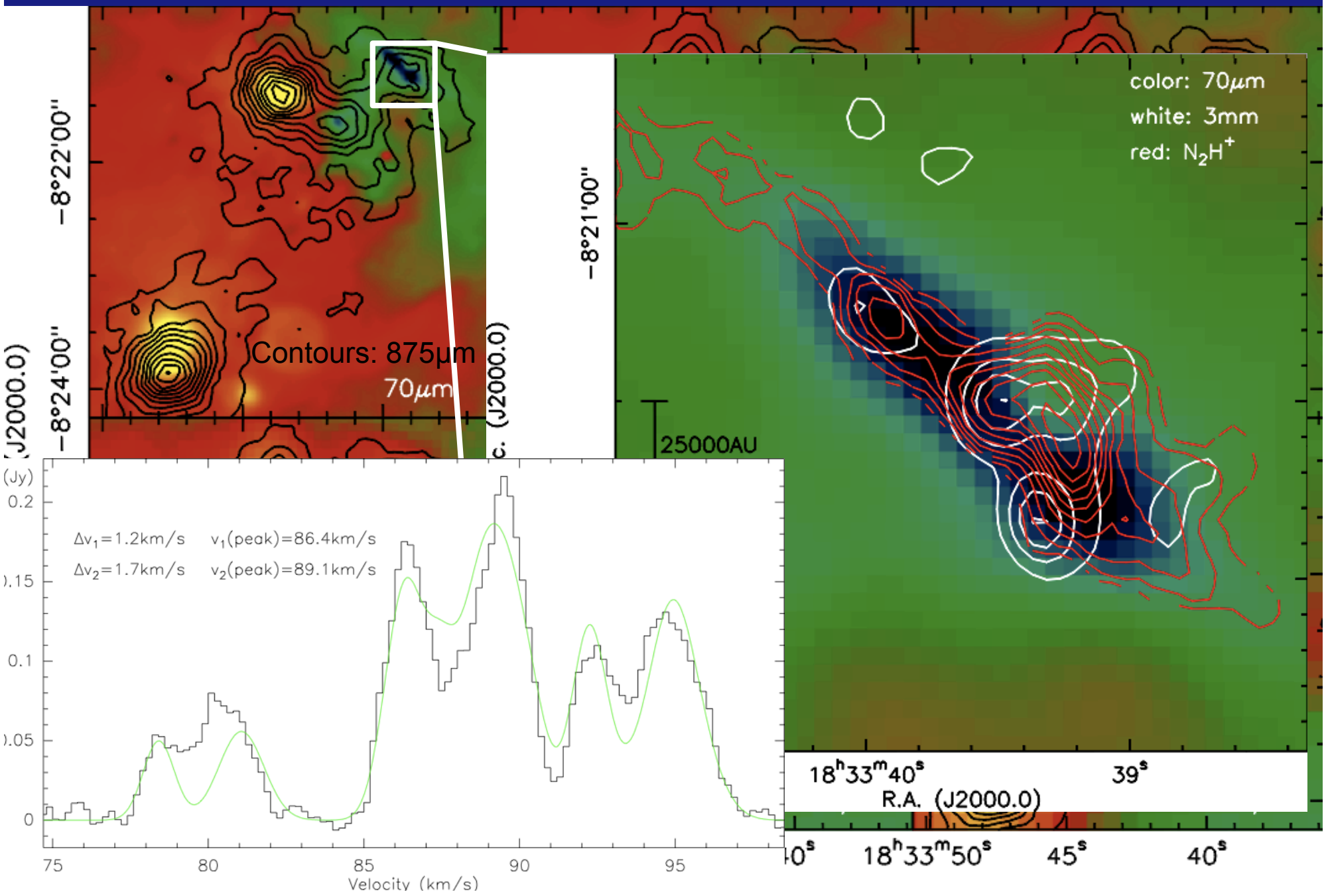


Summary and Outlook

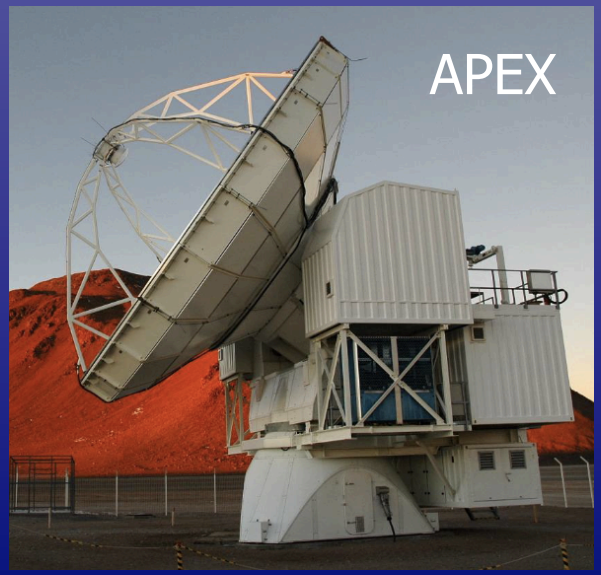
- Galaxy-wide surveys allow us to study the Milky Way as a whole (spiral and bar structures, scale height …)

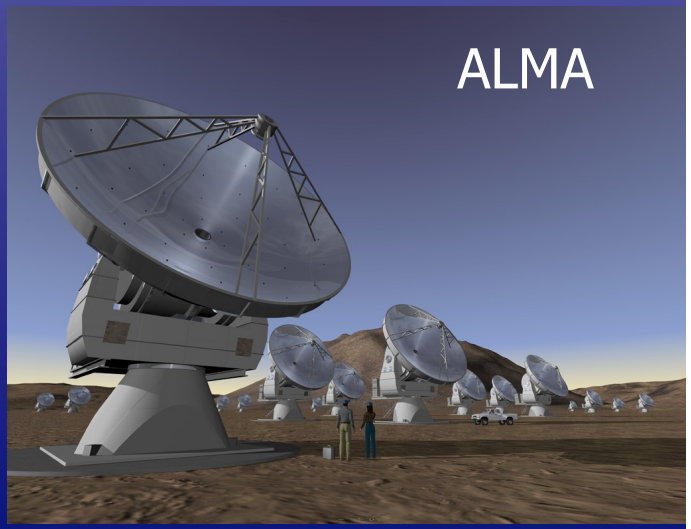
- Starless clump time scale or order 5×10^4yr

- Herschel starts to unravel the earliest formation stages.

- We find peculiar velocity structures in W43. Chance projection or real physics?

- Spectral line data important to study dynamics!





- Lots to come in the field with Herschel/SOFIA and now also ALMA.