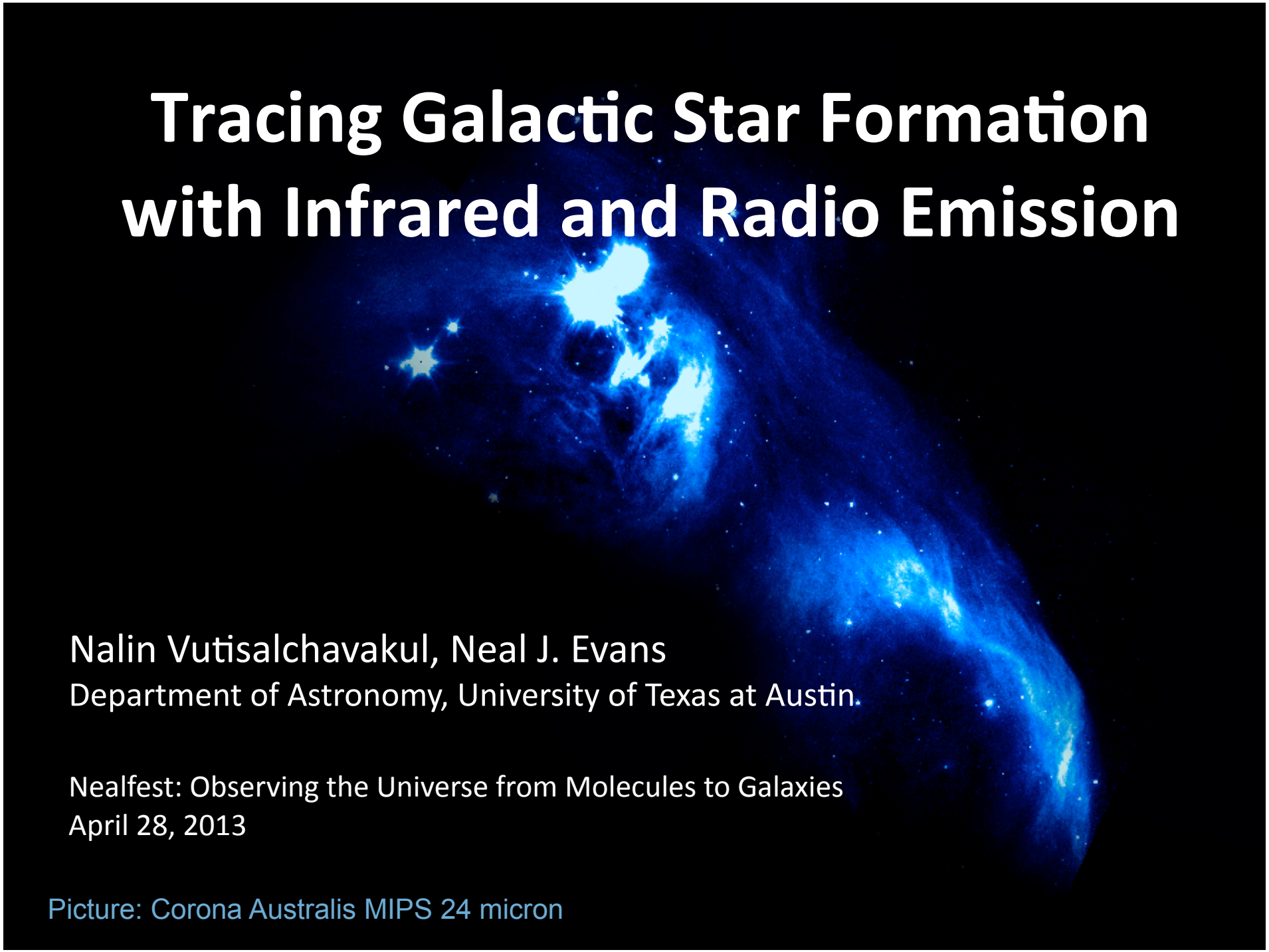
Tracing Galactic Star Formation with Infrared and Radio Emission



Nalin Vutisalchavakul, Neal J. Evans
Department of Astronomy, University of Texas at Austin.

Nealfest: Observing the Universe from Molecules to Galaxies
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Picture: Corona Australis MIPS 24 micron

Questions on Star Formation

I. What controls star formation in molecular cloud

- Star formation and molecular gas distribution
- Properties of molecular clouds

II. Connecting Galactic and extragalactic star formation

- Tracing star formation
- How reliable are the star formation rate (SFR) tracers
- Star formation in the Milky Way
    - compare to other galaxies
    - Difference between Galactic and Extragalactic star formation law

header: Spitzer GLIMPSE

How good are the SFR tracers?

SFR calibrations

SFR Tracers: IR (total IR luminosity, 24 micron), recombination lines (Hα), UV, radio continuum

Kroupa IMF

24 micron

$$\mathrm{SFR}(M_\odot\ \mathrm{yr}^{-1}) = 1.27 \times 10^{-38} [L_{24\,\mu m}(\mathrm{ergs\ s}^{-1})]^{0.8850},$$

Total Infrared Luminosity

$$\mathrm{SFR}(M_\odot\ \mathrm{year}^{-1}) = 3.125 \times 10^{-44} L_{\mathrm{TIR}}\ (\mathrm{erg\ s}^{-1}),$$

Radio continuum

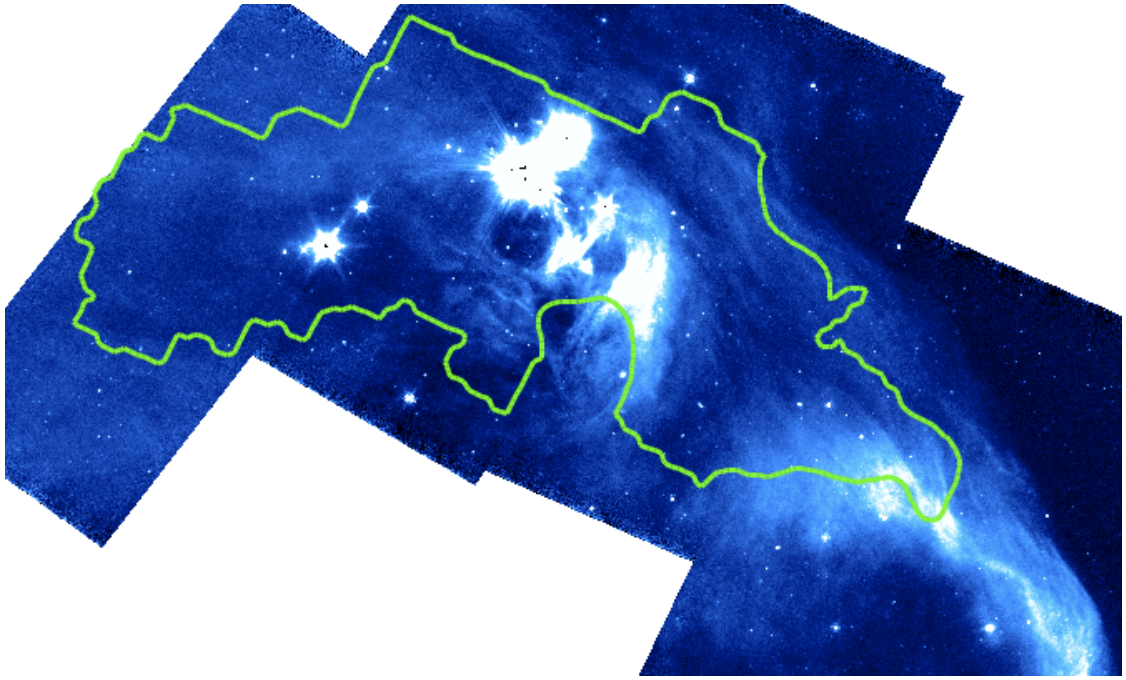
$$\frac{\mathrm{SFR}}{M_\odot \mathrm{yr}^{-1}} = 0.47 \times 10^{-20} \left(\frac{\nu}{\mathrm{GHz}}\right)^{0.1} \left(\frac{L_T}{\mathrm{W\ Hz}^{-1}}\right).$$

Calzetti et al. 2007, Kennicutt 1998, Chomiuk et al. 2011, Condon 1992

How good are the SFR tracers?

1. Nearby Molecular Clouds

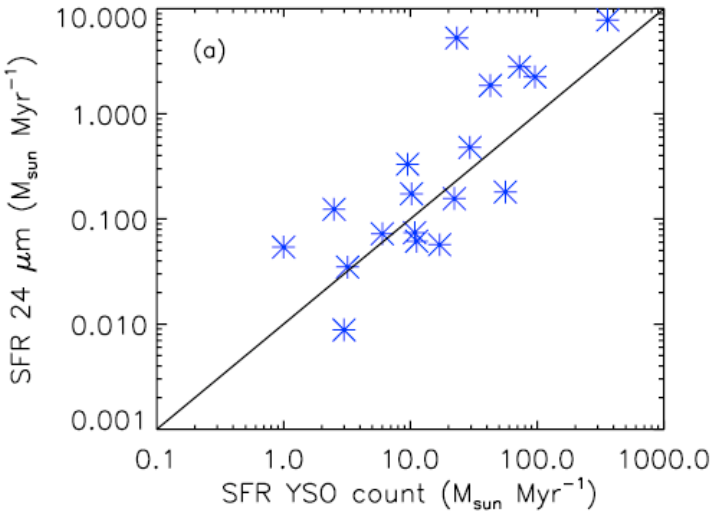
- Spitzer Core to Disk (c2d) And Gould's Belt Legacy Survey (Evans et al. 2007, Allen et al.)

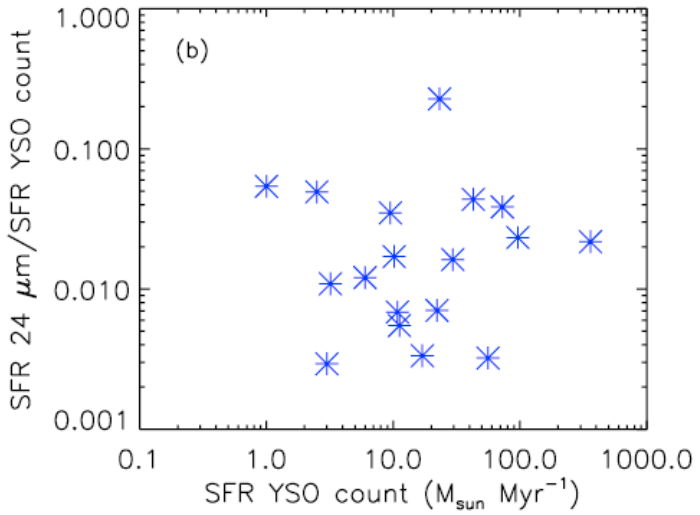


- 20 clouds within 1 kpc from the Sun
- Extinction Map
- Spitzer MIPS (24, 70, 160 micron)
- IRAS (12, 25, 60, 100 micron)

Young Stellar Objects (YSO) , L(24), L(TIR)

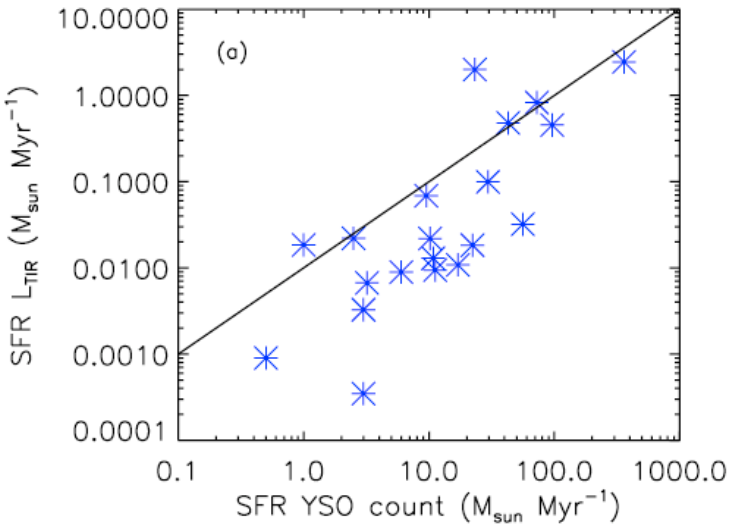
Result - How good are the SFR tracers?

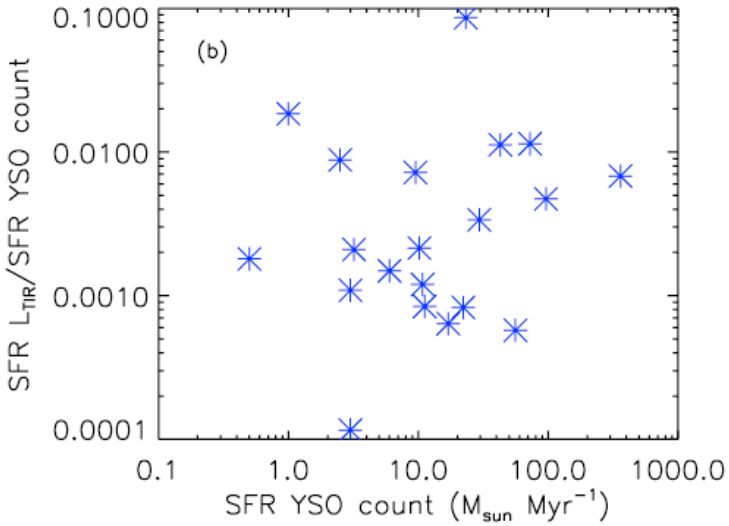




Average ratio SFR(YSO)/ SFR(24) ~ 107 ± 109

Average ratio SFR(YSO)/ SFR(LIR) ~ 960 ± 1870





How good are the SFR tracers?

2. Massive Dense Clumps

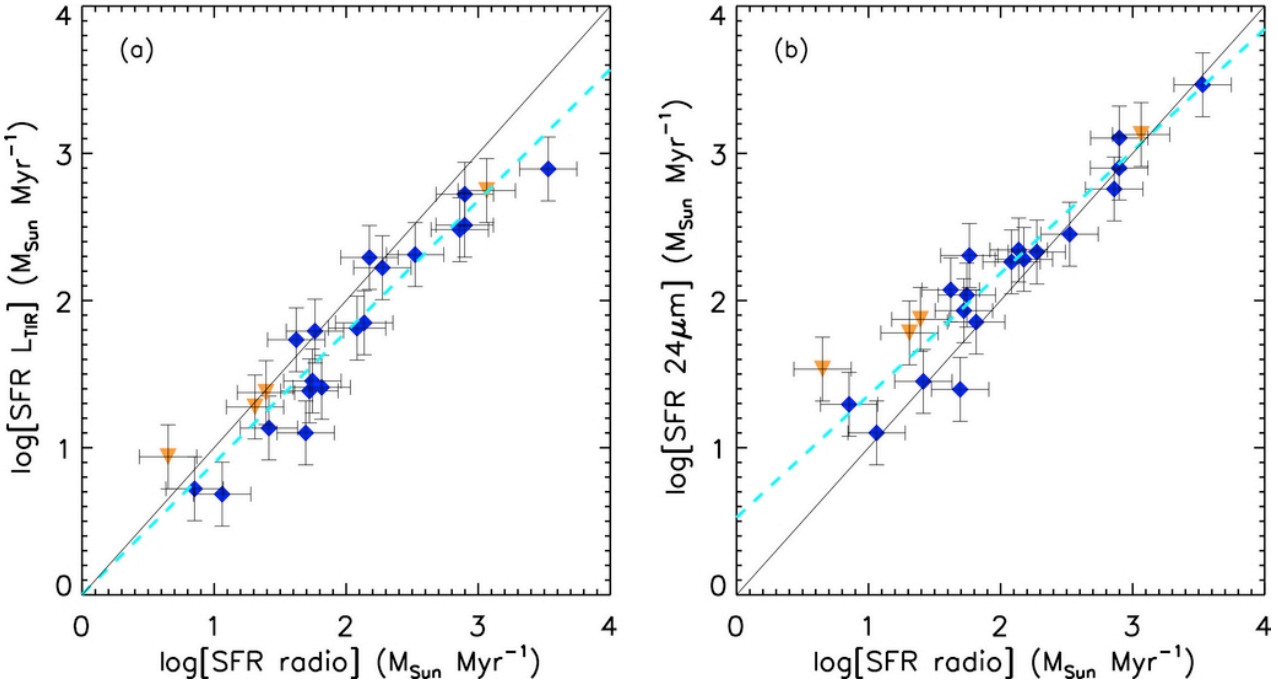
High mass star forming regions (Wu et al. 2010)

(D ~ 4kpc, ρ ~ 10^6 cm^{-3}, M ~ 10^3 M_{SUN})

-IRAS IRIS Image photometry ➔ L24, LIR

- Radio continuum – Survey of Galactic Plane at 4.875 GHz (Altenhoff et al. 1978)

<SFR(Radio)/SFR(LIR)>
~ 1.8 ± 0.9
median of 1.9



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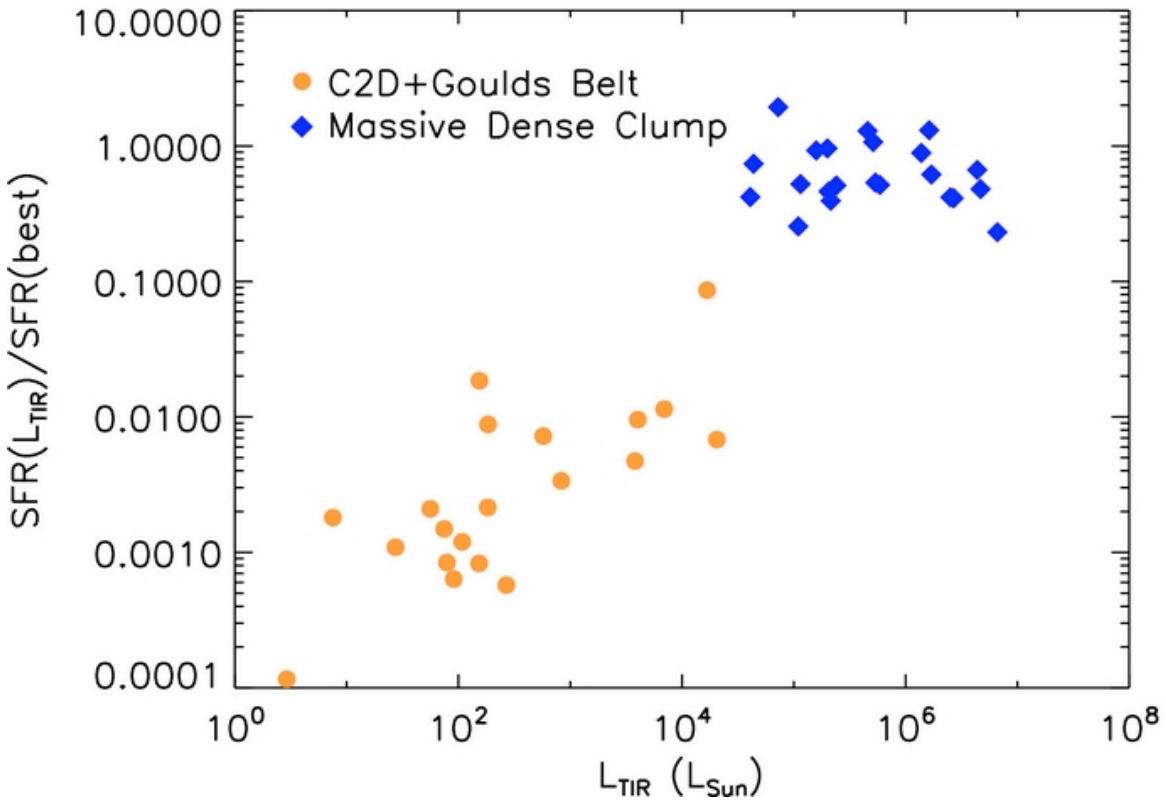
How good are the SFR tracers?

Combining both Regions



SFR(best) is SFR(YSO count) for low mass regions and SFR(Radio) for high mass regions

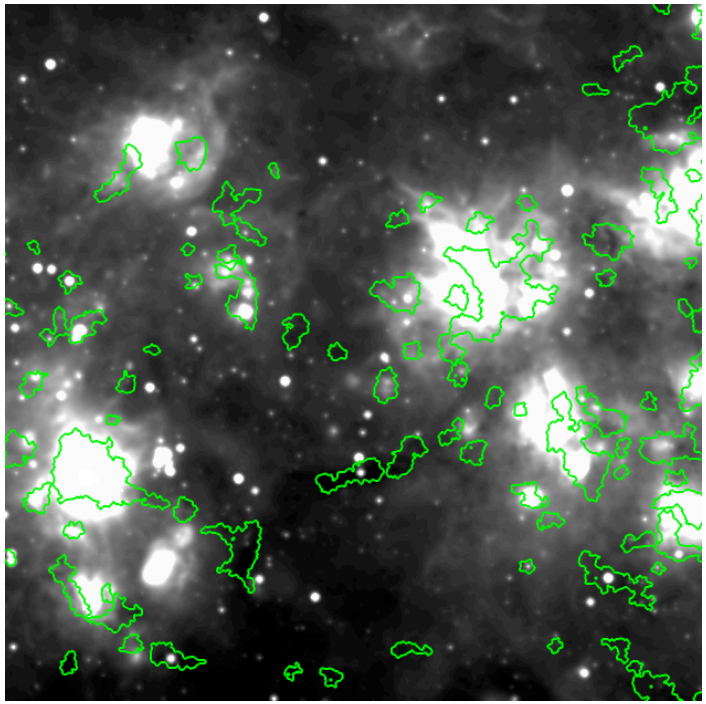
- General correlation between SFR ratio and LIR

Star Formation in the Galactic Plane

Combining several Galactic plane surveys:

Galactic Ring Survey	13CO1-0
Bolocam Galactic Ring Survey	1.1 mm, dense gas tracers
MIPSGAL, GLIMPSE	MIR + NIR
Hi-GAL	FIR (70-500 micron)

(the Herschel infrared Galactic Plane Survey)



WISE 22 micron + BGPS source contour