Profiling Young Massive Stars

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Thesis work - UNSW

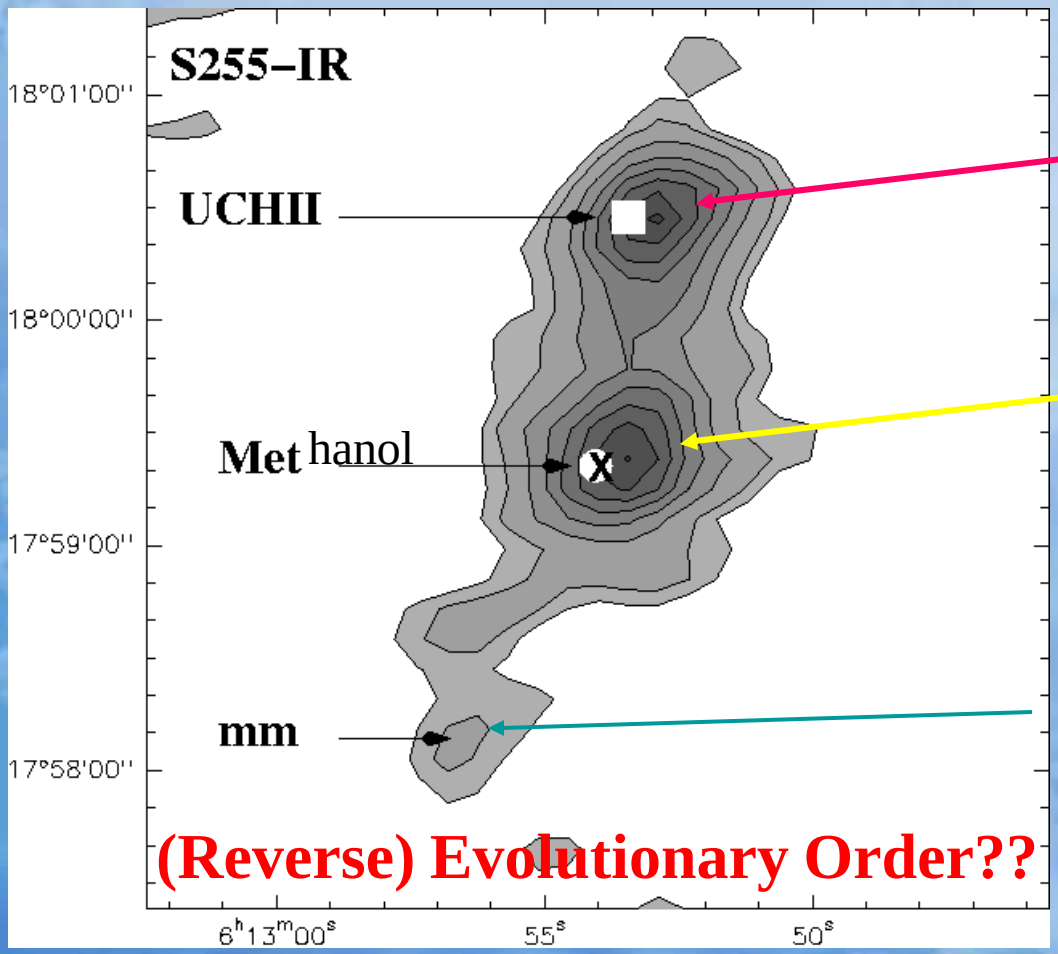
with M Burton, M Cunningham, V Minier

Massive Star Formation

- Study is hindered – recall talk by de Buizer
- Optically obscured prior to main sequence evolution.
- Difficult to pinpoint individual stages of evolution.
- Low mass SF models?
- IR excellent tracer:
  - Stars emit bulk of radiation at wavelengths shorter than Lymann continuum limit
  - Circumstellar dust envelope absorbs radiation and re-emits in the infrared.
- Massive stars associated with infrared radiation (IRAS & MSX), UC HII regions, maser sources, millimetre & submillimetre emission.
- Do maser species trace different evolutionary stages?
  - Walsh et al (1998): Masers are the first readily detectable tracer of MSF

A Range of MSF Cores

1.2mm Continuum, SEST/SIMBA



Ionized Core (UC HII region)

Hot Molecular Core

Cold Core

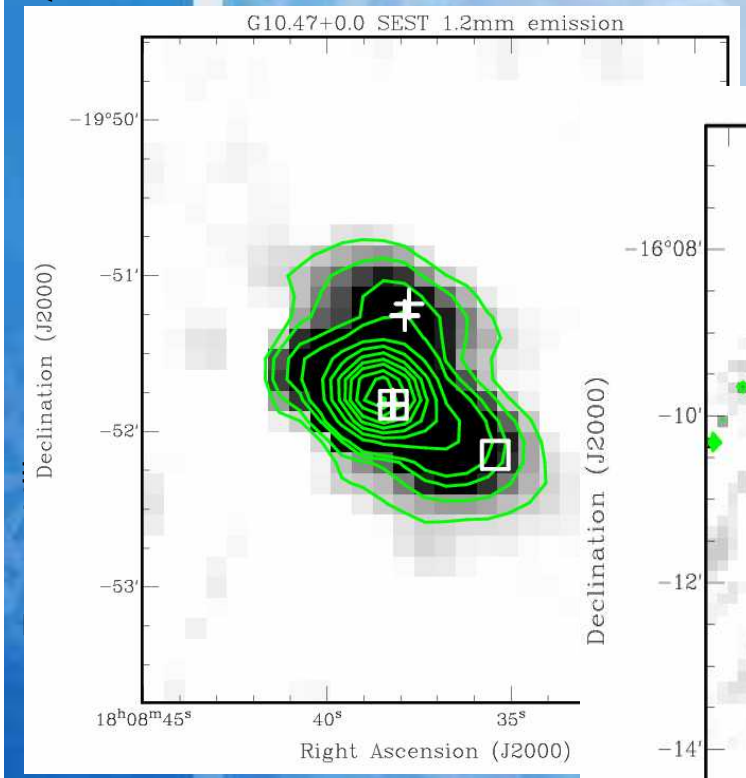
Minier, Hill et al, 2005

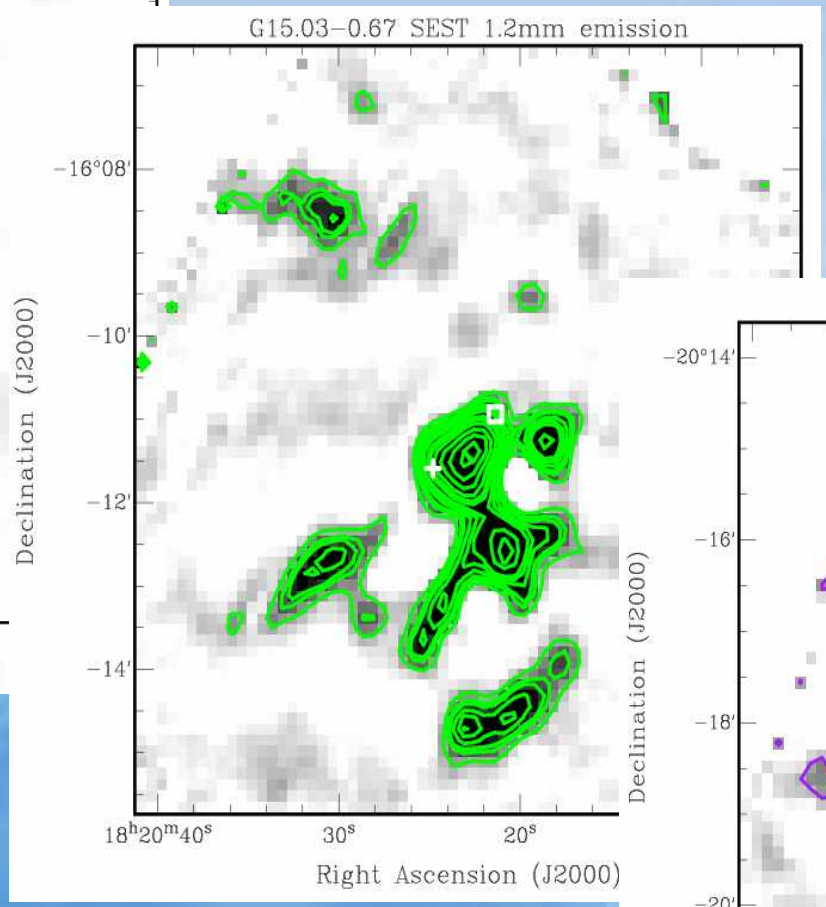

So what happens before the
onset of maser emission?

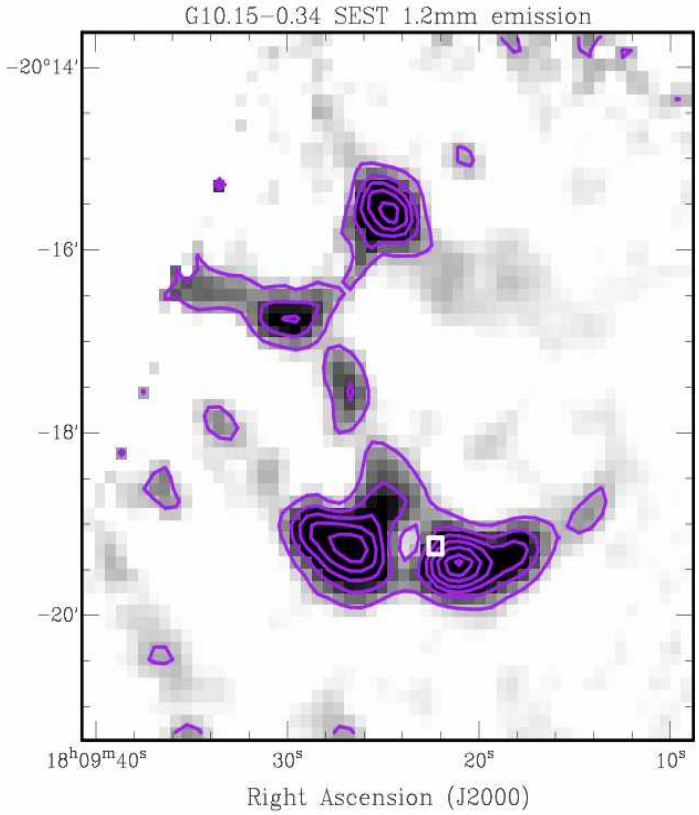
SEST/SIMBA

- Search for cold cores that mark the earliest stages of MSF
- SEST: Targeted positions of known methanol maser & UC HII sources (131)
- SIMBA: large F.O.V (240'' x 480'')
- 405 sources detected (3-σ)
- Generally, tracer position correlates with mm peak
- Evidence of star formation devoid of methanol masers and UC HII regions ("mm-only cores")

SIMBA maps


G10.47+0.0 SEST 1.2mm emission
−19°50′
−51′
−52′
−53′
Declination (J2000)
18h08m45s
40s
35s
Right Ascension (J2000)


G15.03−0.67 SEST 1.2mm emission
−16°08′
−10′
−12′
−14′
Declination (J2000)
18h20m40s
30s
20s
Right Ascension (J2000)


G10.15−0.34 SEST 1.2mm emission
−20°14′
−16′
−18′
−20′
Declination (J2000)
18h09m40s
30s
20s
10s
Right Ascension (J2000)

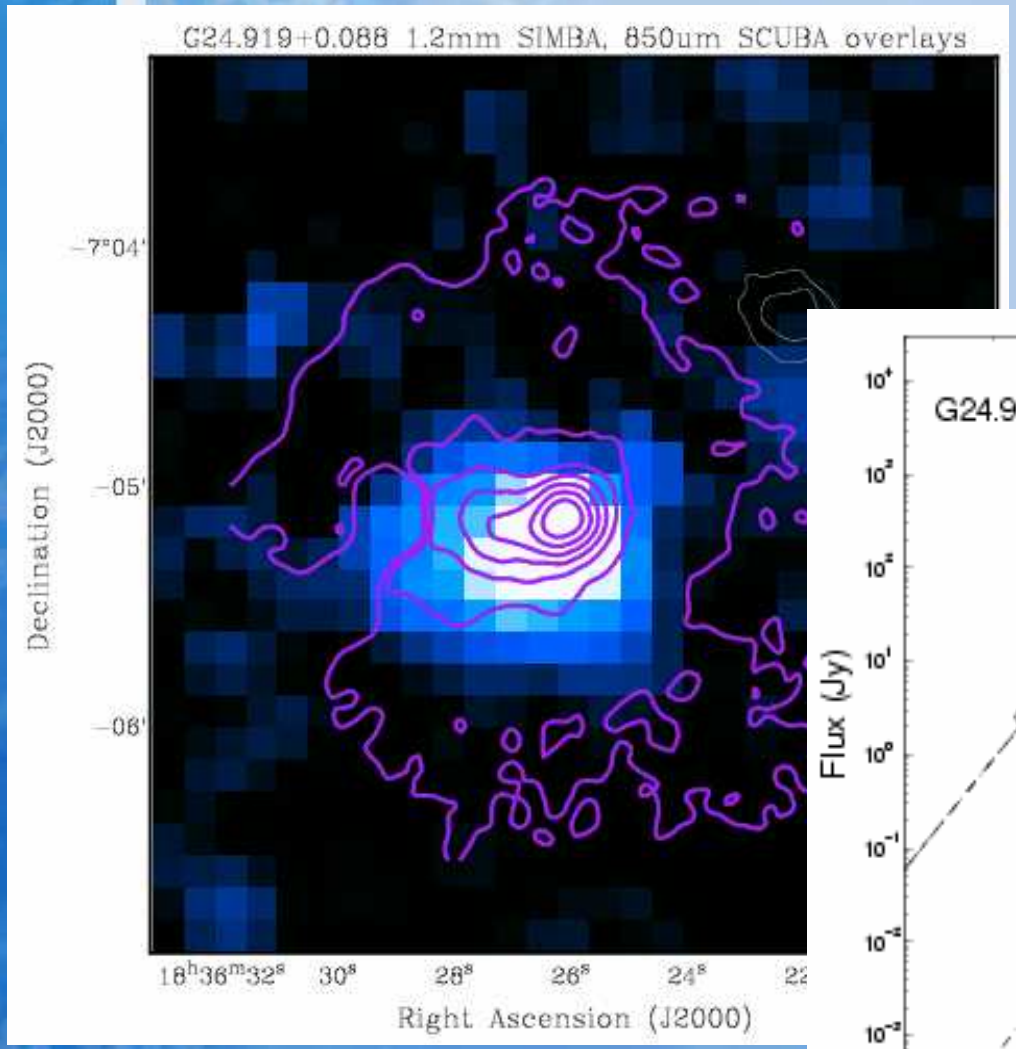
Introducing the 'mm-only' core

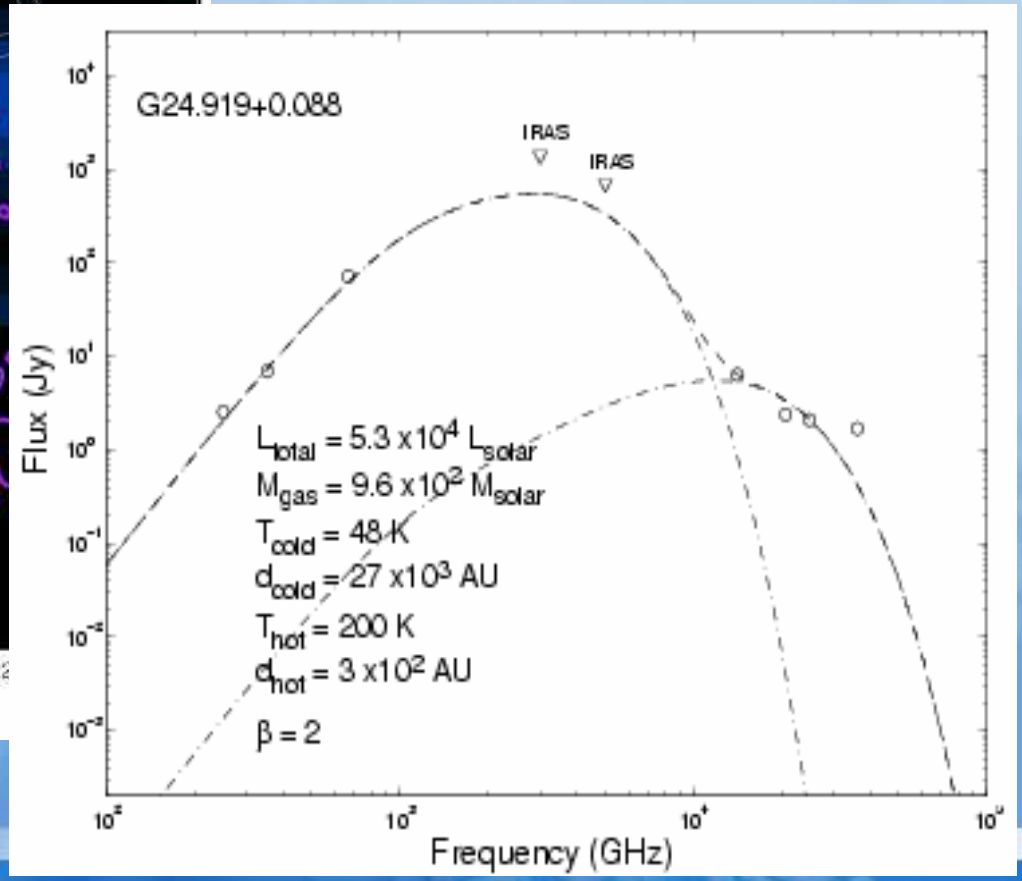
- ~ 60% sources (255/405) detected have no maser &/or UC HII (mm-emission only). mm-only core
- ~ 45 % do not have mid-IR MSX emission. [lower limit] or are devoid of a mid-IR source.
- What is their story?
  - Younger? Deeply embedded?
  - Intermediate mass? combination?

Profiling Young massive Stars

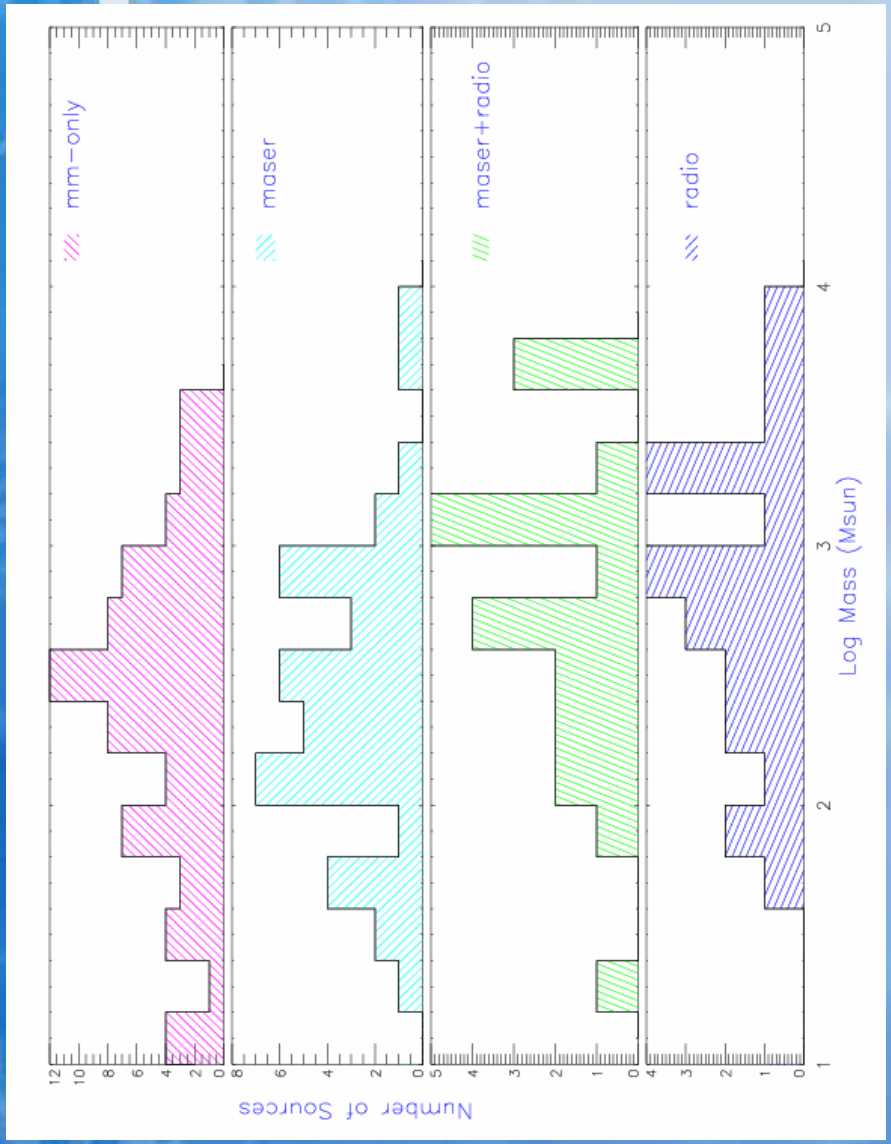
- Using: SIMBA, SCUBA, MSX, sometimes IRAS
- Assuming $\beta = 2$ (Hill et al. 2006)
- Levenberg-Marquardt least squares fit
  - 162 sources (of 405)
- Fit results in 6 parameters:
  - Temperature, luminosity, mass, H_2 number density, surface density, Lum/Mass
- 8 parameters known (+ radius, distance)
- Analysis = >

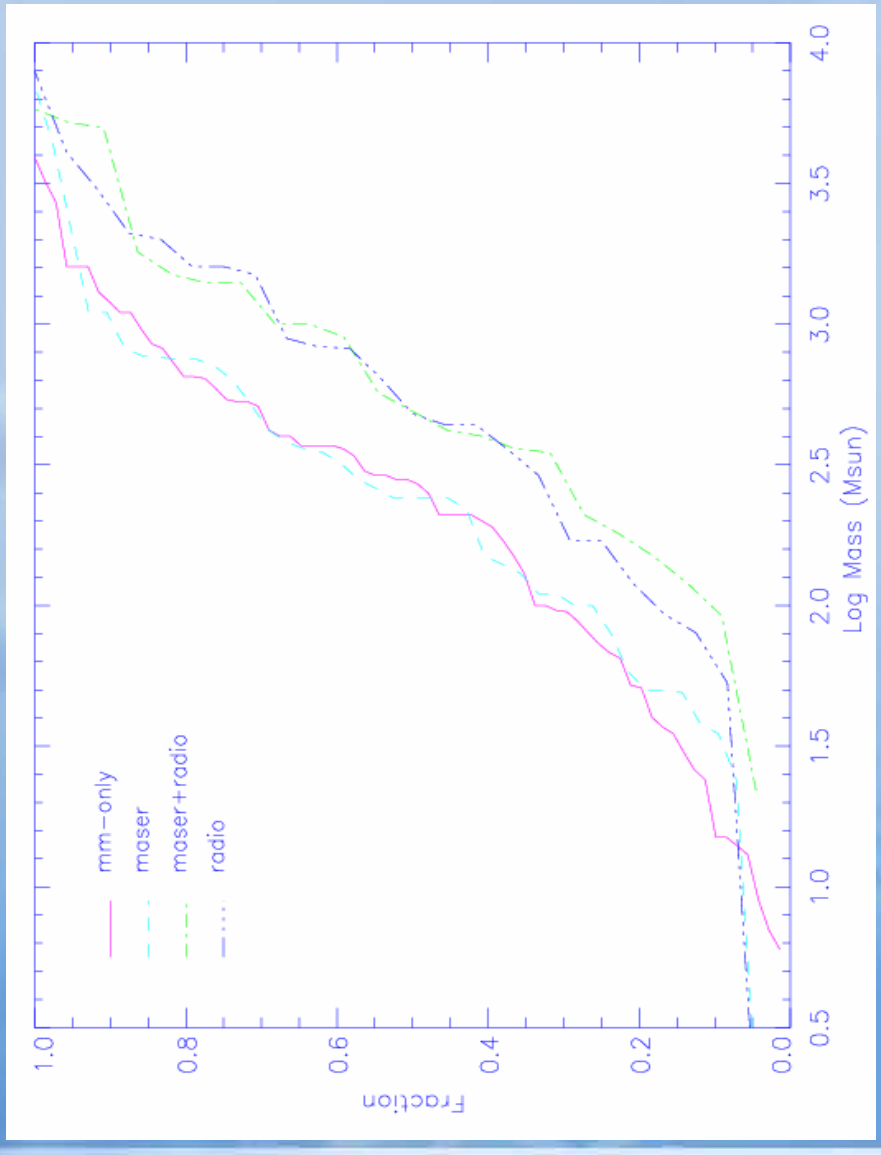
Example SED mm-only core



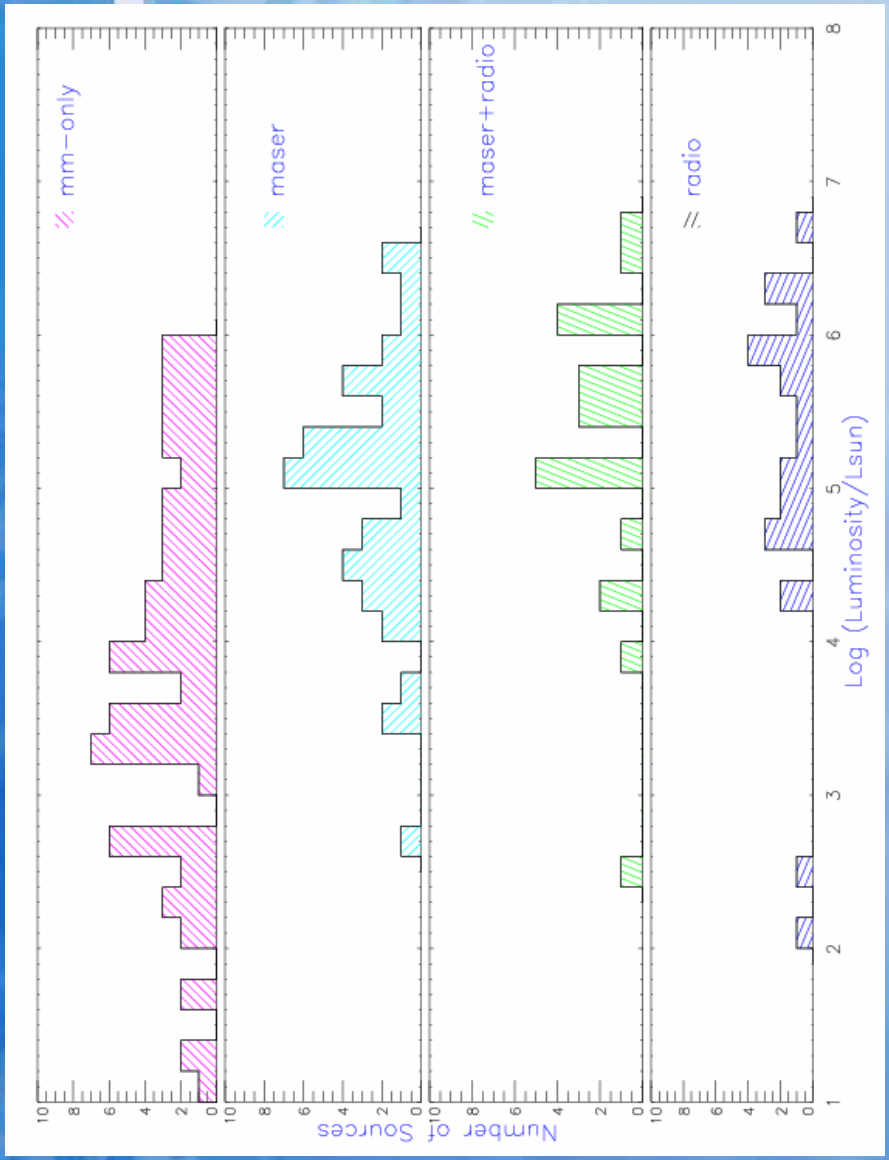


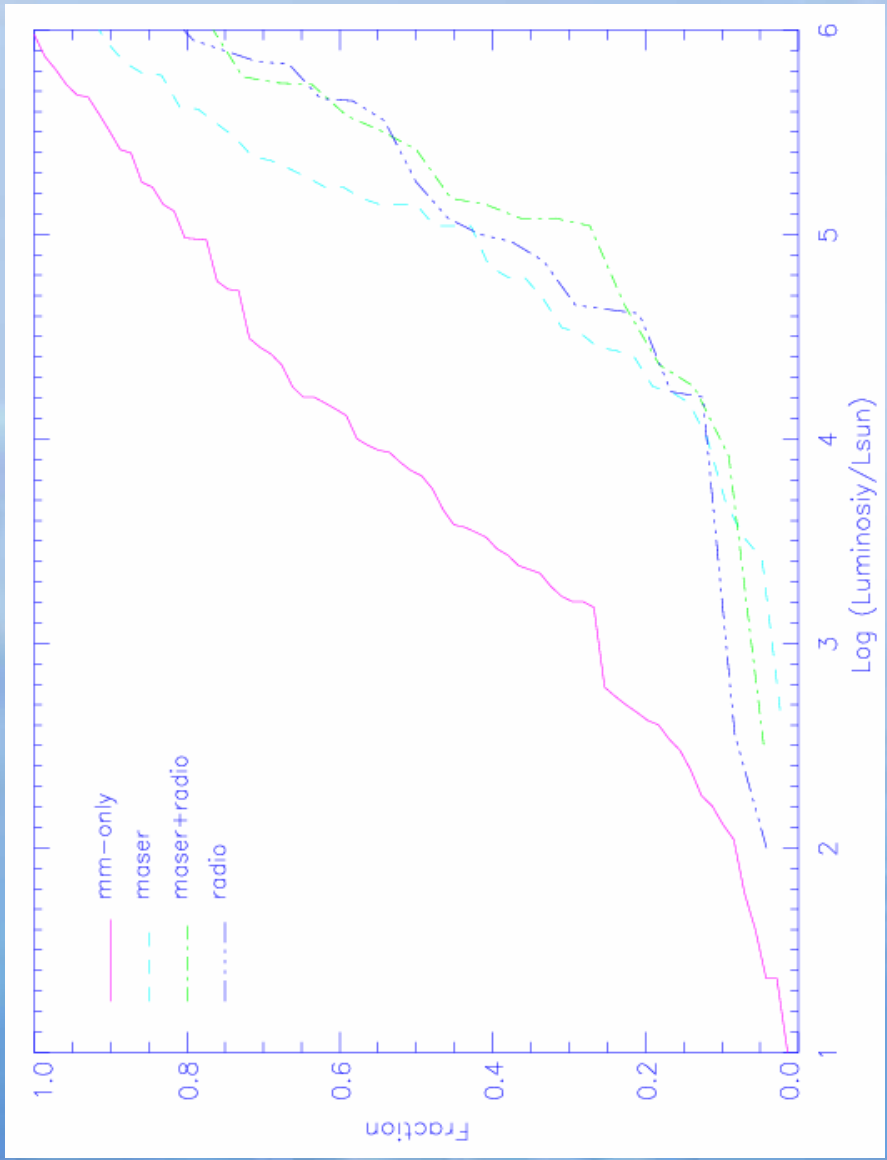
Mass


mm−only
maser
maser+radio
radio
Number of Sources
Log Mass (Msun)

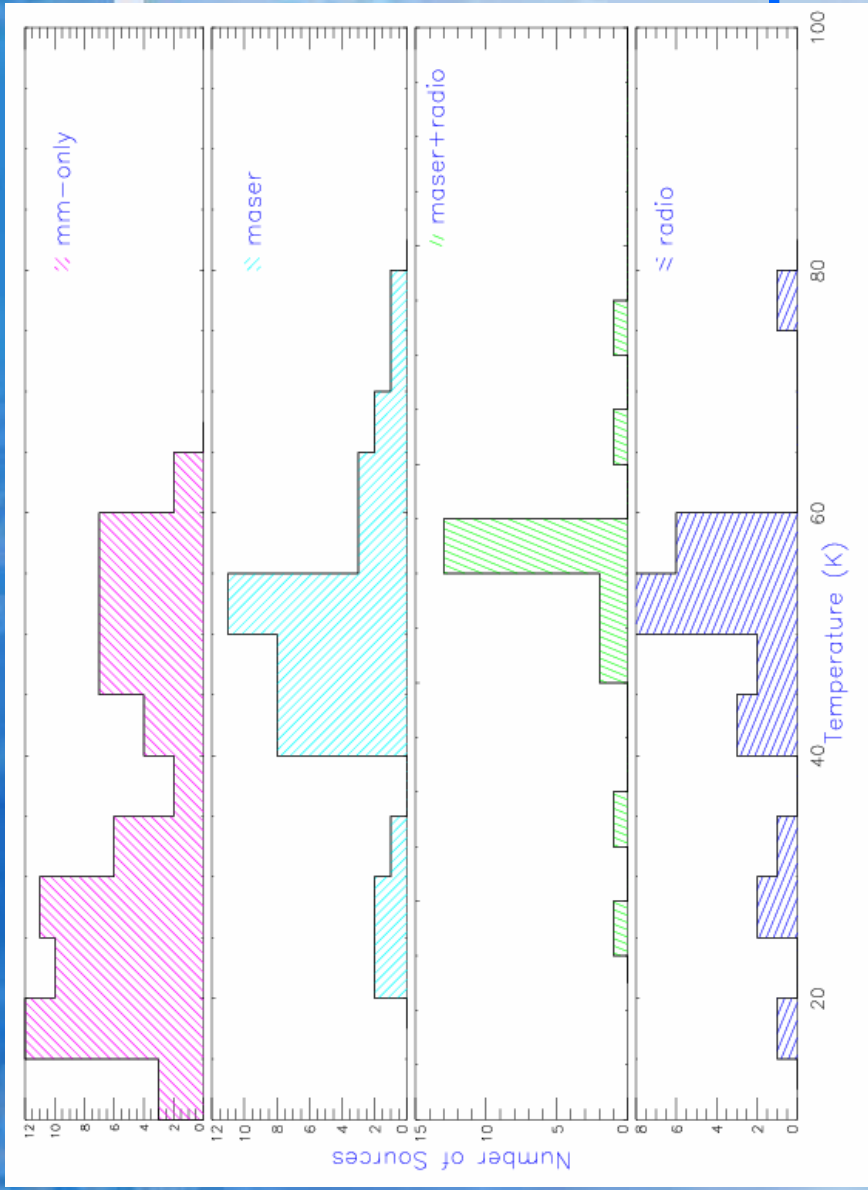

mm−only
maser
maser+radio
radio
Fraction
Log Mass (Msun)

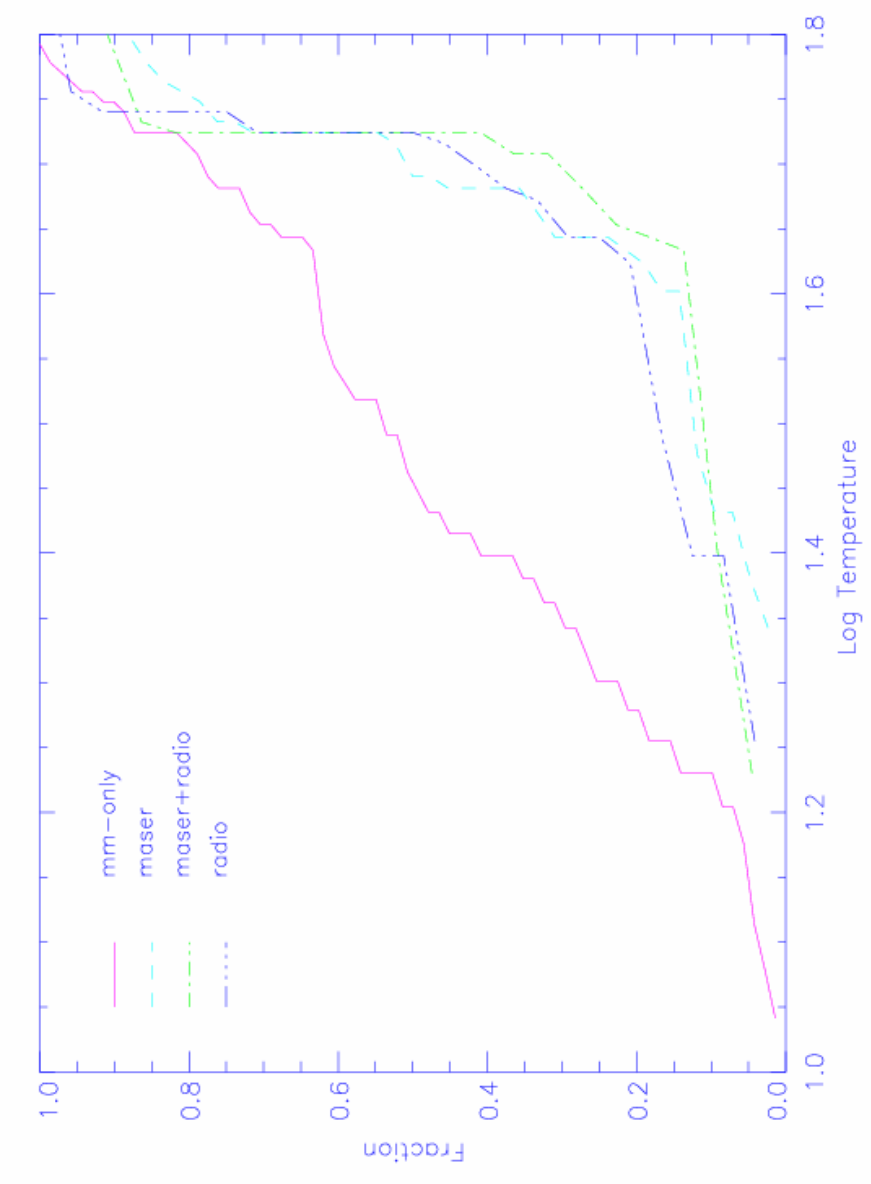
Luminosity


mm−only
maser
maser+radio
radio
Number of Sources
Log (Luminosity/Lsun)

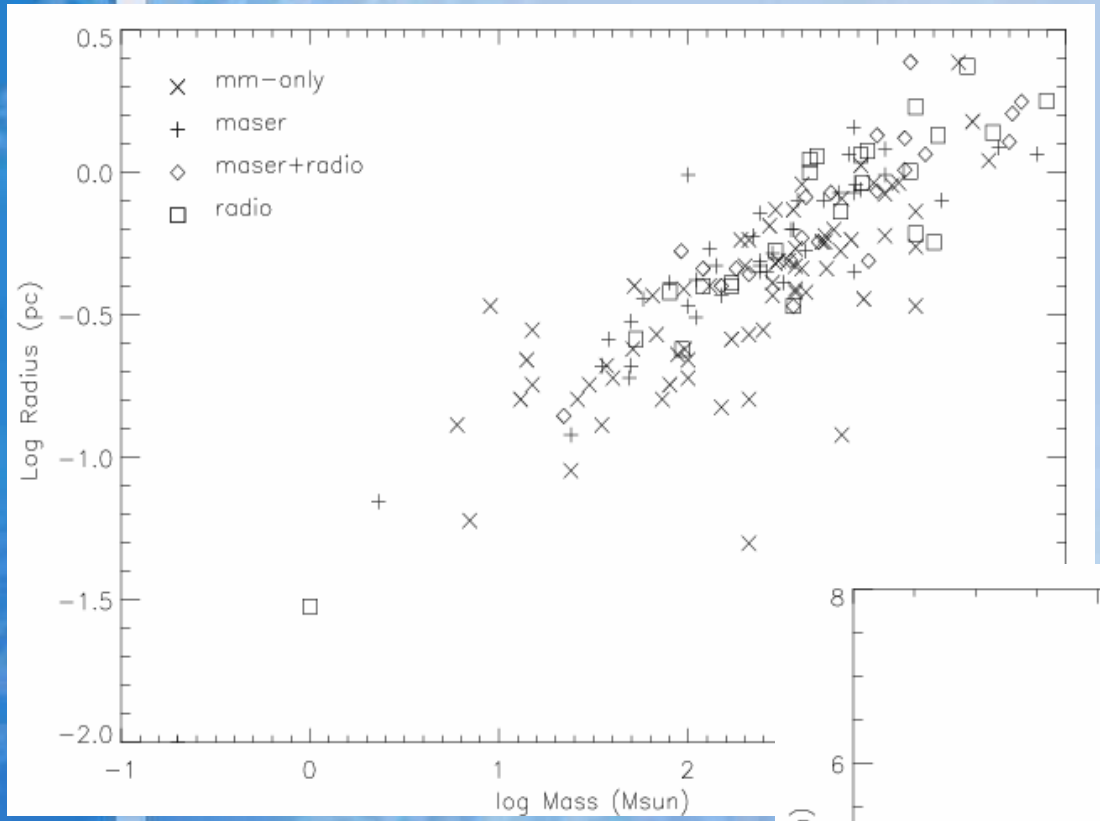

mm−only
maser
maser+radio
radio
Fraction
Log (Luminosiy/Lsun)

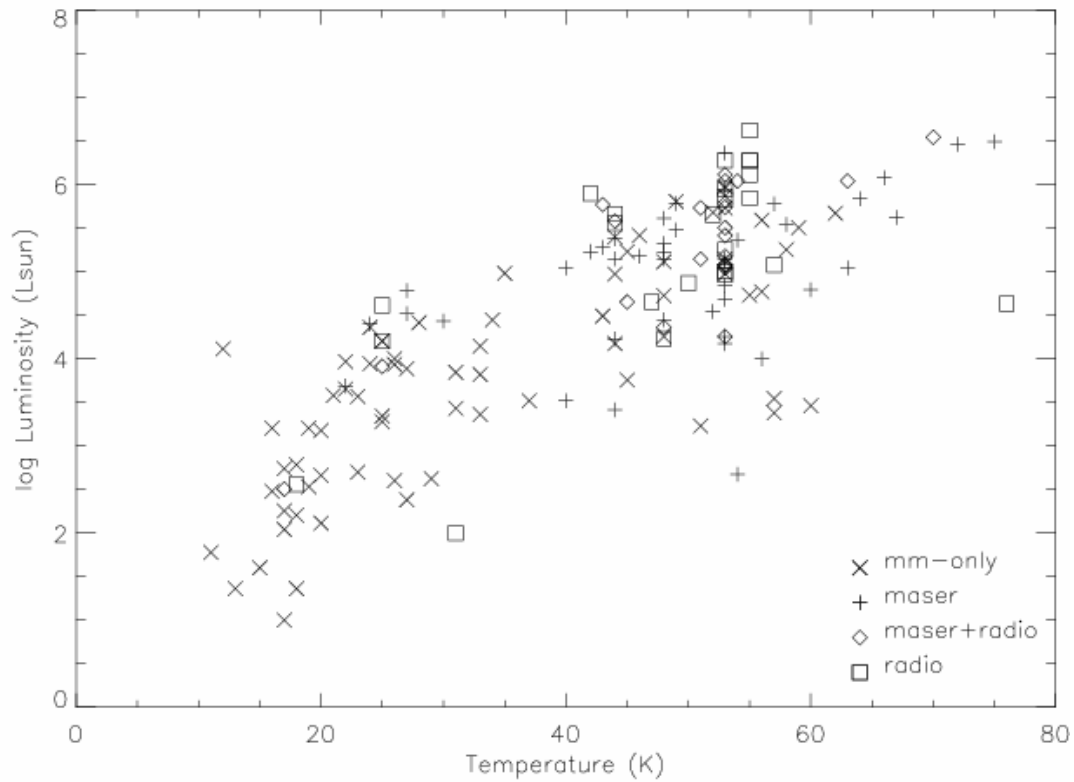
Temperature





Correlation plots





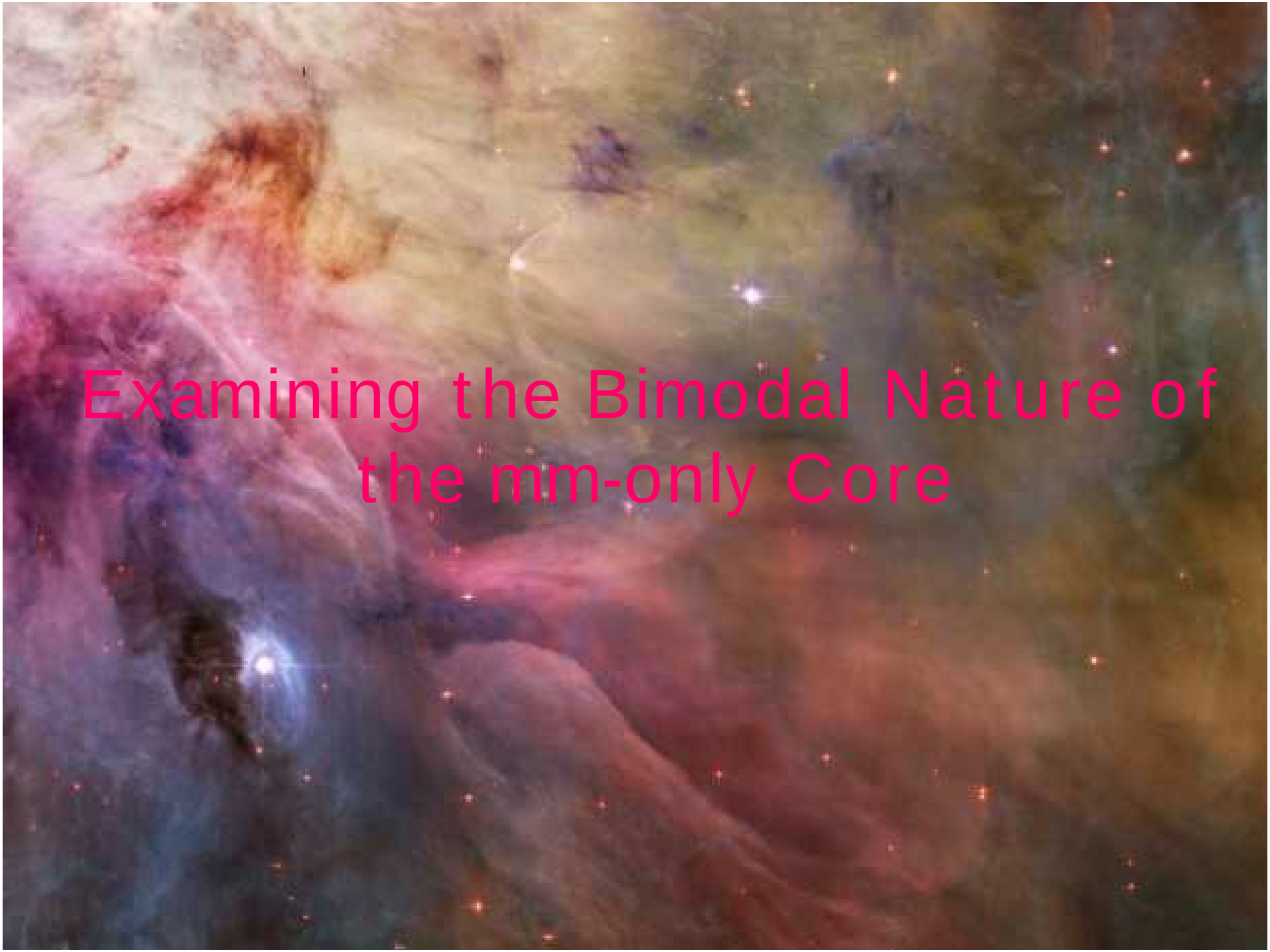

So what's up with the mm-only core?

Results: mm-only core

- Comparable mass to sources with methanol maser &/or UC HII
- But:
  - Smaller , Less luminous, Smaller L/M
  - and cooler
  - More dense (H_2 and surface)

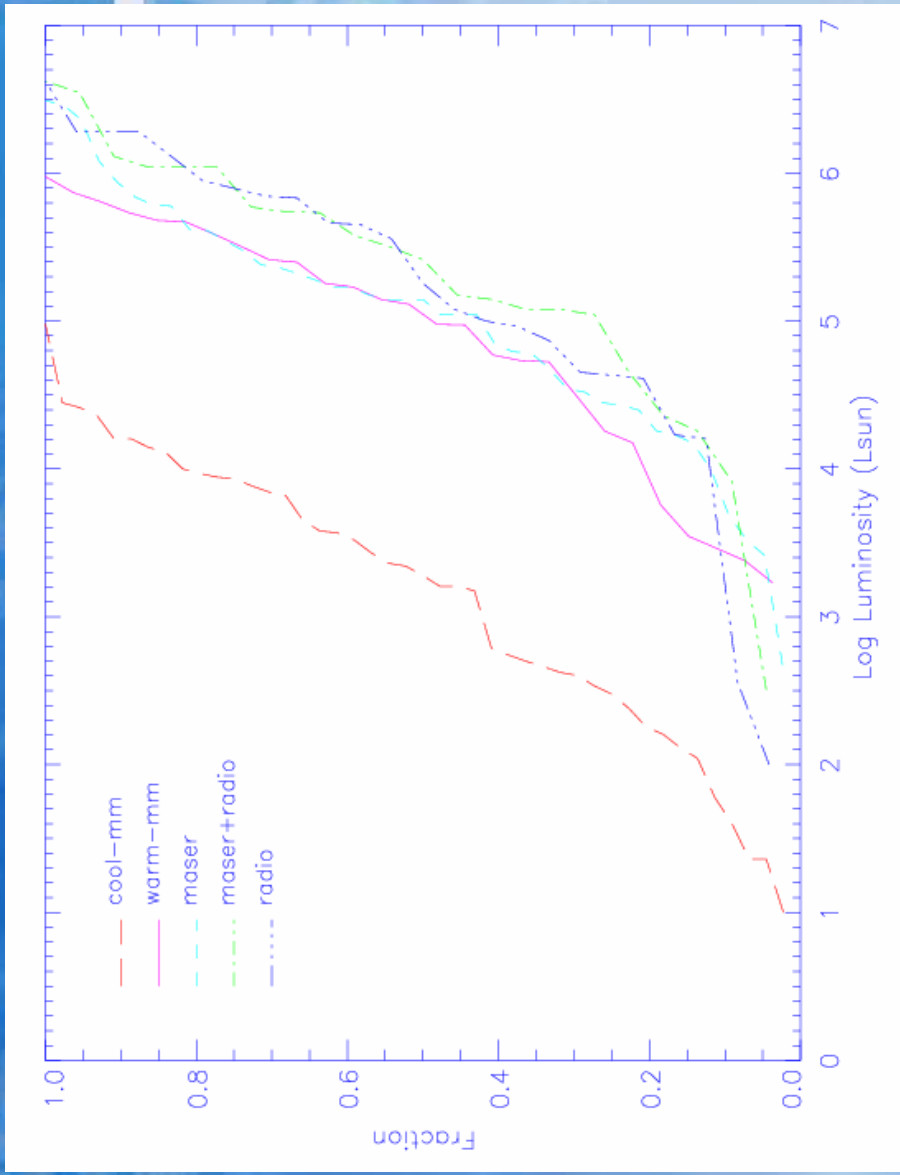
than sources with methanol maser/radio continuum.

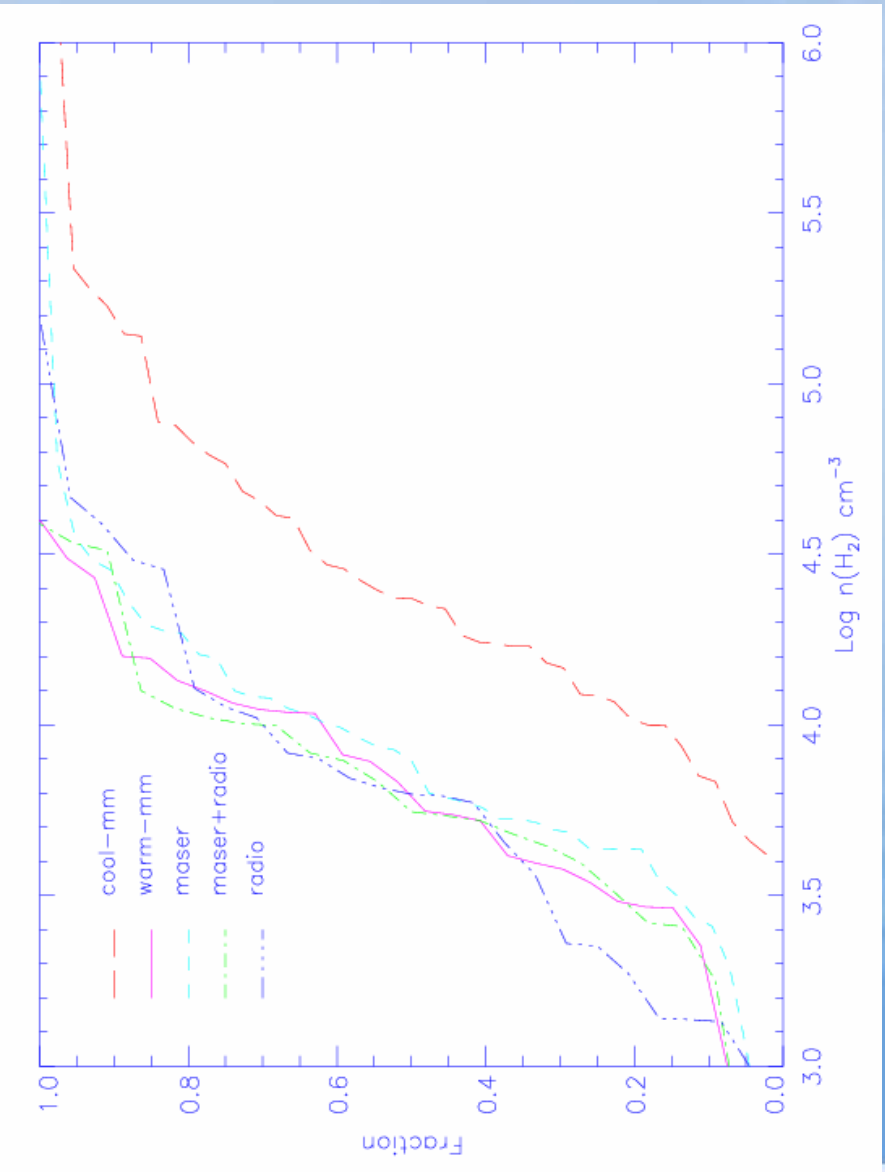
- KS test: distinctly different for luminosity, temperature, and L/M
- An earlier stage of massive star evolution?
- Bimodal temperature population!



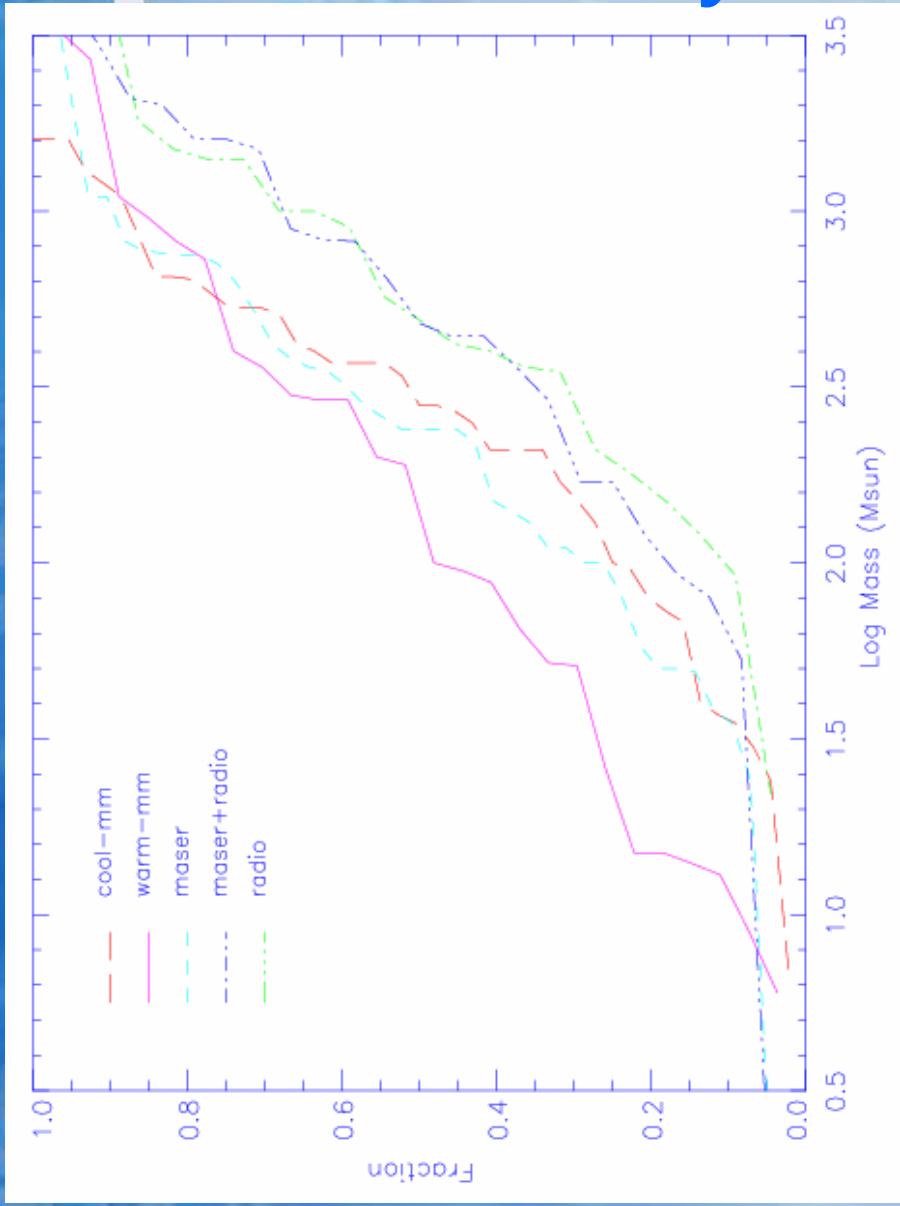
Examining the Bimodal Nature of the mm-only Core

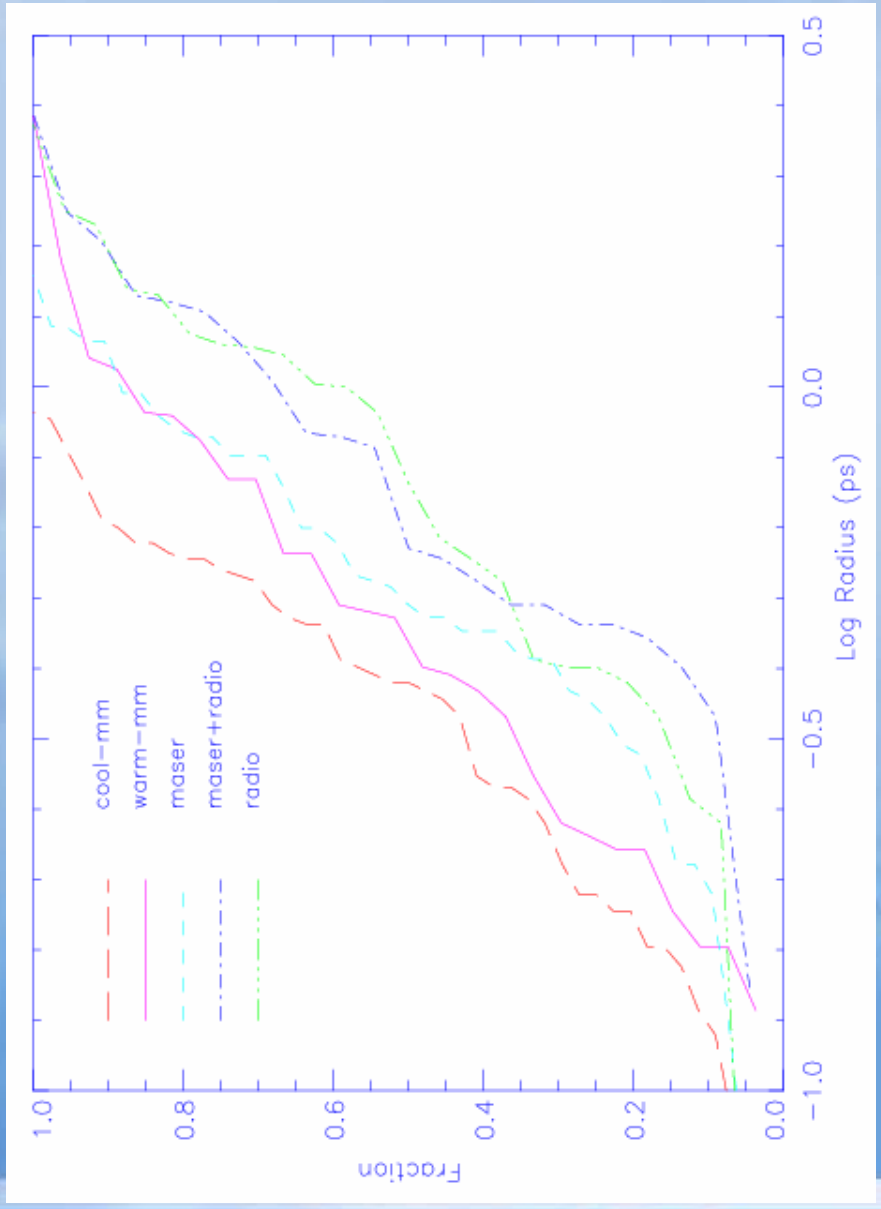
Bimodal mm-only Population





Analysis cont….





Analysis revealed….

- Little distinction between warm-mm & sources with methanol maser and/or radio continuum source for all parameters tested.
- Cool-mm sources are distinctly different from the warm-mm sources, methanol maser and/or radio continuum source for all parameters tested bar for mass and radius
- Cool-mm: less luminous, lower L/M, higher H_2 number and surface densities (Σ). They have smaller radii than those sources with an UC HII region.
- The warm-mm display similar characteristics to those known to be forming massive stars (those with methanol maser &/or UC HII).

mm-only core:example of evolution?

- Indications: mm-only cores are younger examples of massive star formation
  - Prior to the onset of methanol maser emission
- mm-only comprised of two populations
  - Distinguished by temperature
  - Populations distinct from each other
- Warm-mm sources examples of young massive stars – hot cores?
- Cool-mm sources examples of failed/starless cores? (e.g. Vasquez-Semadeni et al. 2005)