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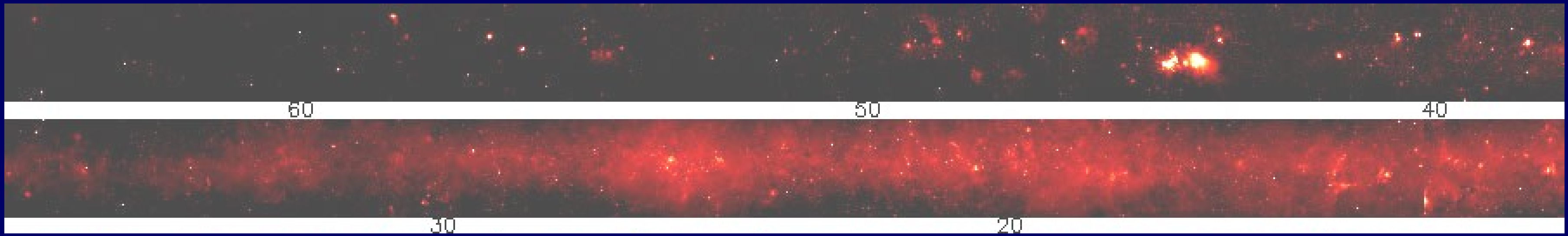
Evolution of Massive YSOs

Heather Cooper & Stuart Lumsden



RMS Team:
Melvin Hoare, Rene Oudmaijer, Nichol Cunningham, Cormac Purcell, Luke Maud (Leeds), James Urquhart, Hugh Wheelwright (MPIfR), Ben Davies (Cambridge), Joe Mottram (Exeter), Toby Moore (Liverpool JMU), Cormac Purcell (Sydney), Michael Burton (UNSW)

Massive Young Stellar Objects

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- Luminous (>10^4 $L_\odot$), embedded IR source (mostly still accreting?). Mostly HMCs?
- Also frequently:
  - Compact, ionised "wind" (emission lines have v~100 km/s) – radio "weak".
  - Supersonic molecular outflow
  - Maser emission

GL2591

Gemini JHK

Evolutionary Outline

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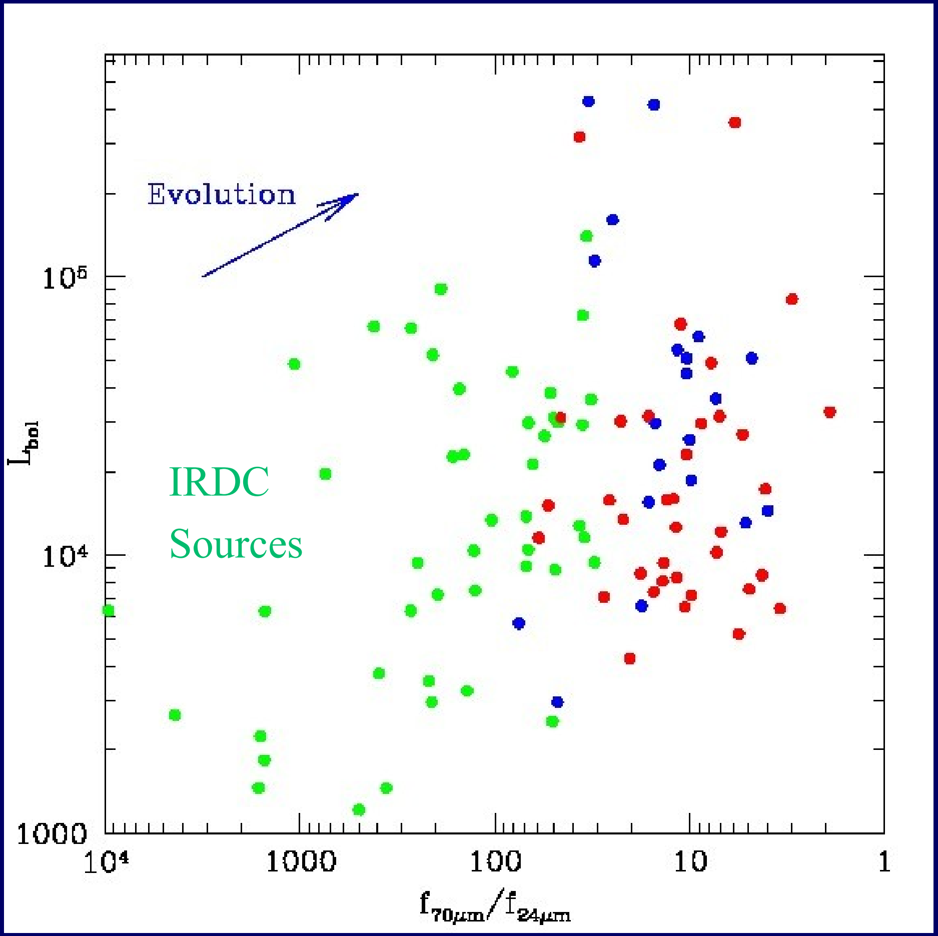

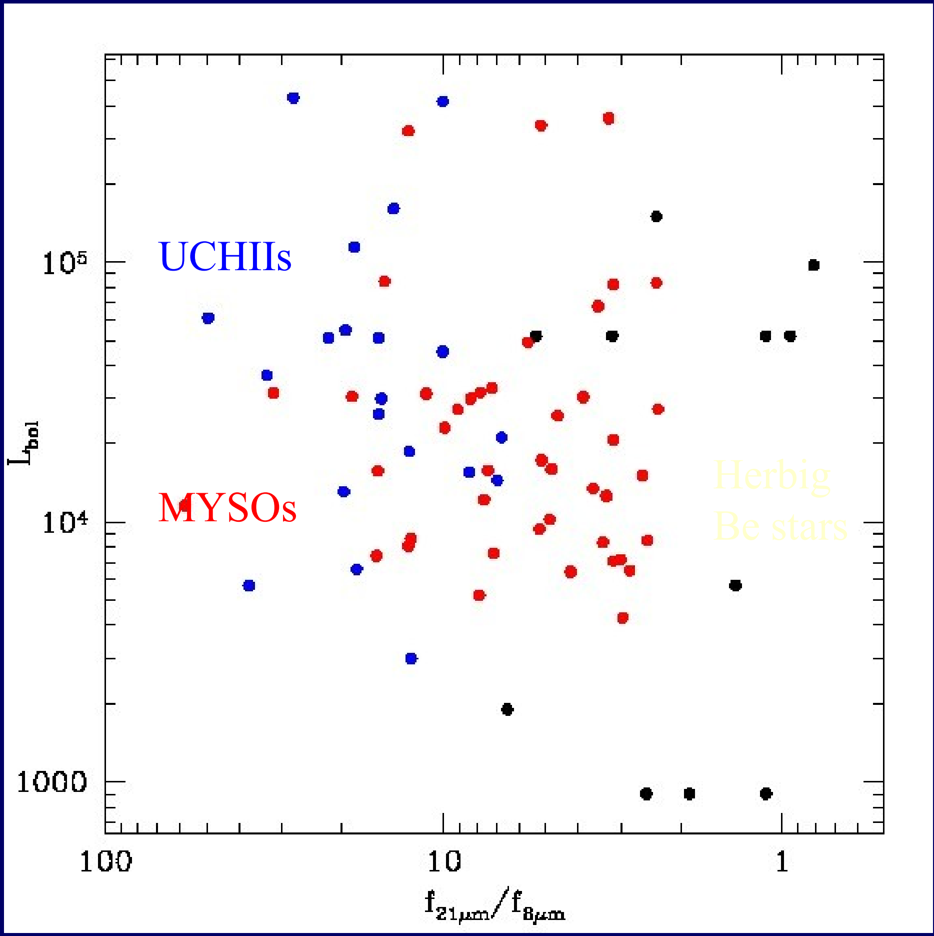

The Red MSX Source (RMS) Survey

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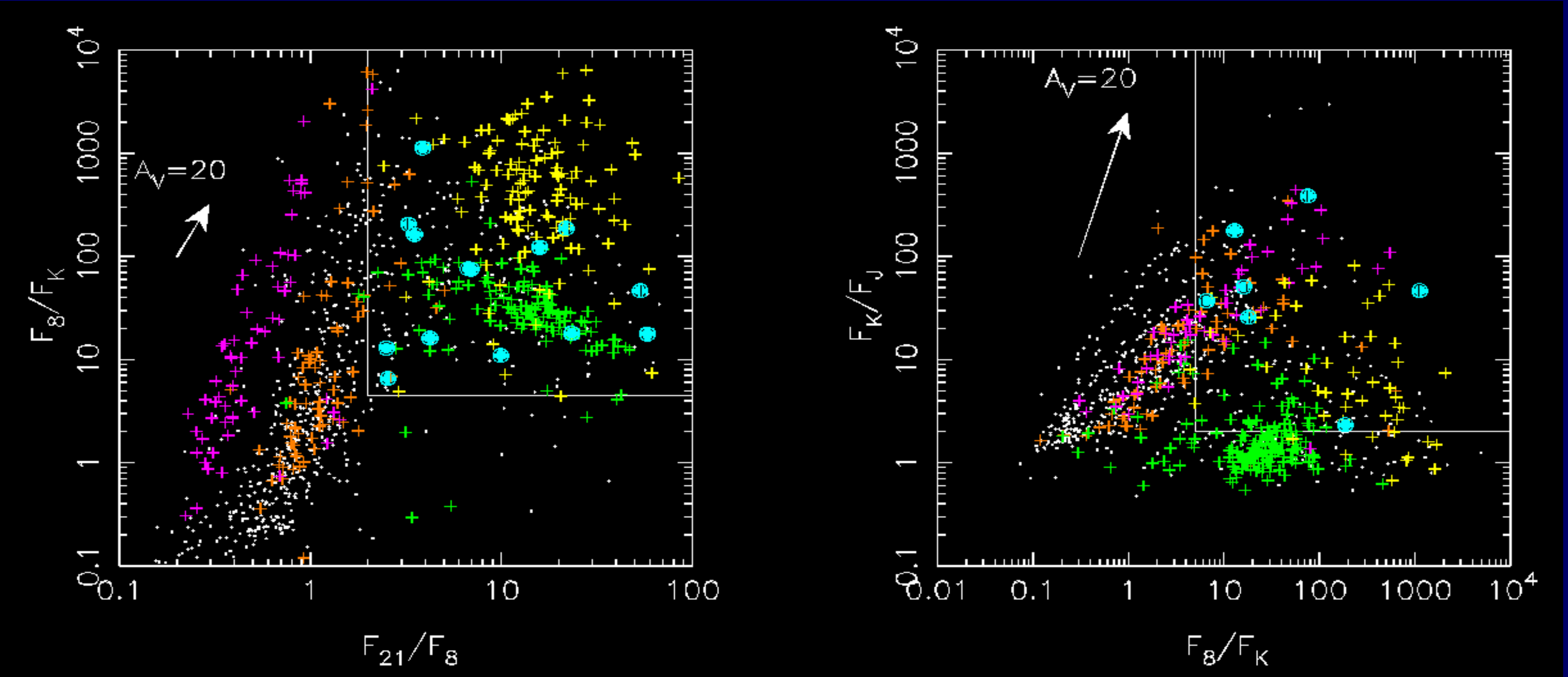
MSX survey: 8, 12, 14 and 21μm, 18″ resolution, |b|<5°

Colour-select from the MSX PSC and 2MASS

Delivers ~2000 candidates: http://www.ast.leeds.ac.uk/RMS

- Massive YSOs + UCHII regions + PN + C stars + OH/IR stars



Why MSX?

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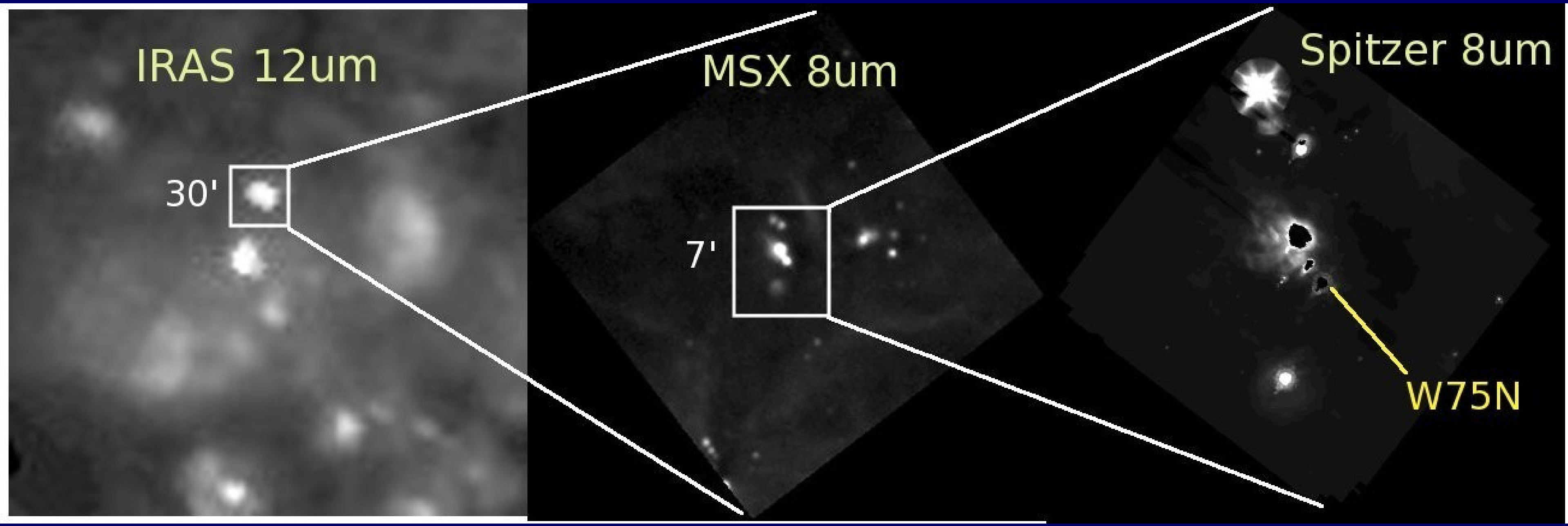

Multi-wavelength Ground-based Follow-up Campaign

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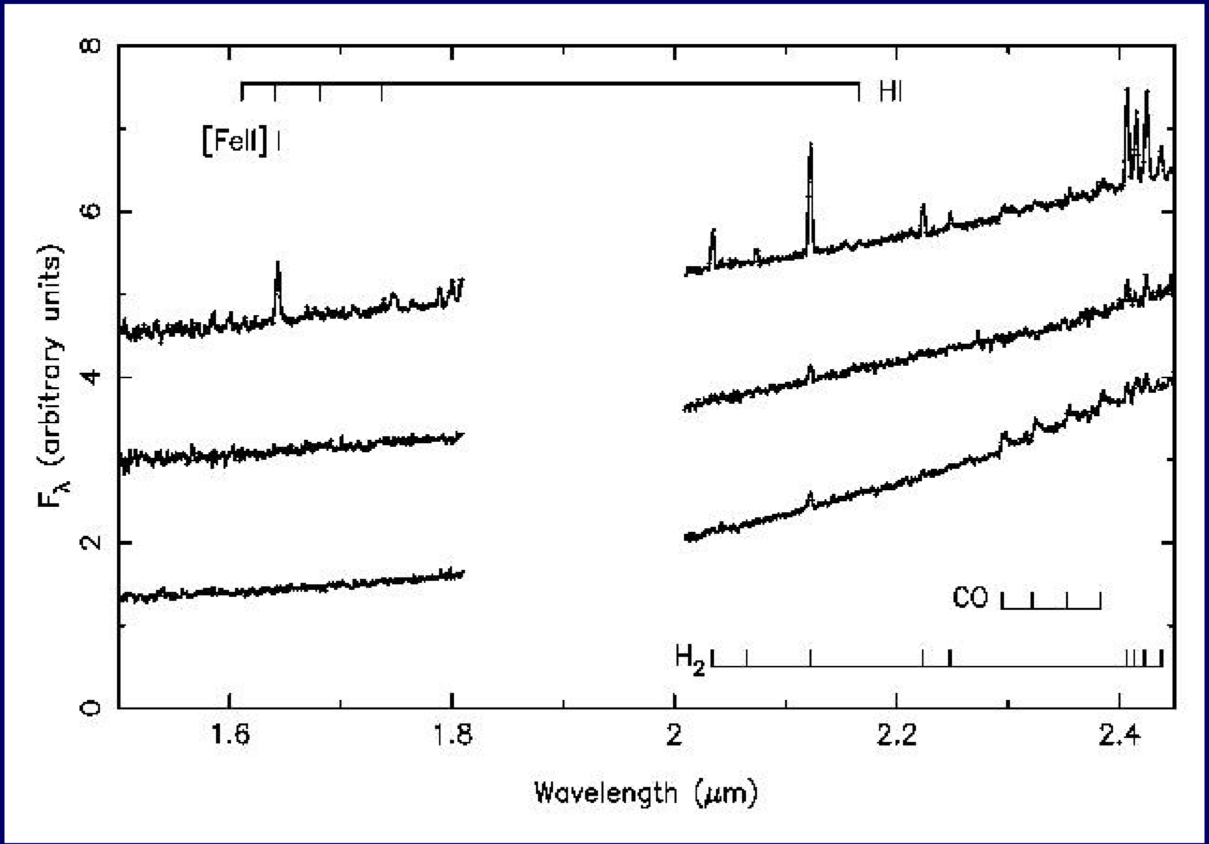
- Radio continuum (Urquhart et al. 2007, 2009) => HII regions
- Mid-IR (Mottram et al 2007) => dust morphology (MYSOs vs HII regions)
- ^{13}CO & HI (Urquhart et al. 2007, 2008, 2010) => distances
- Spitzer MIPSGAL and IRAS IGA => SEDs, Luminosities (Mottram et al 2010a, b)
- Additional data always being added as it becomes available (eg UKIDSS/VISTA)
- www.ast.leeds.ac.uk/RMS
- NIR spectroscopy => final class and characterisation (Cooper et al in prep).

Spectroscopic Results

Largest homogeneous MYSO sample ever studied (Cooper et al in prep)

- Youngest (molecular hydrogen,sometimes shocked [FeII], no ionised gas, sometimes CO) – type I



Spectroscopic Results

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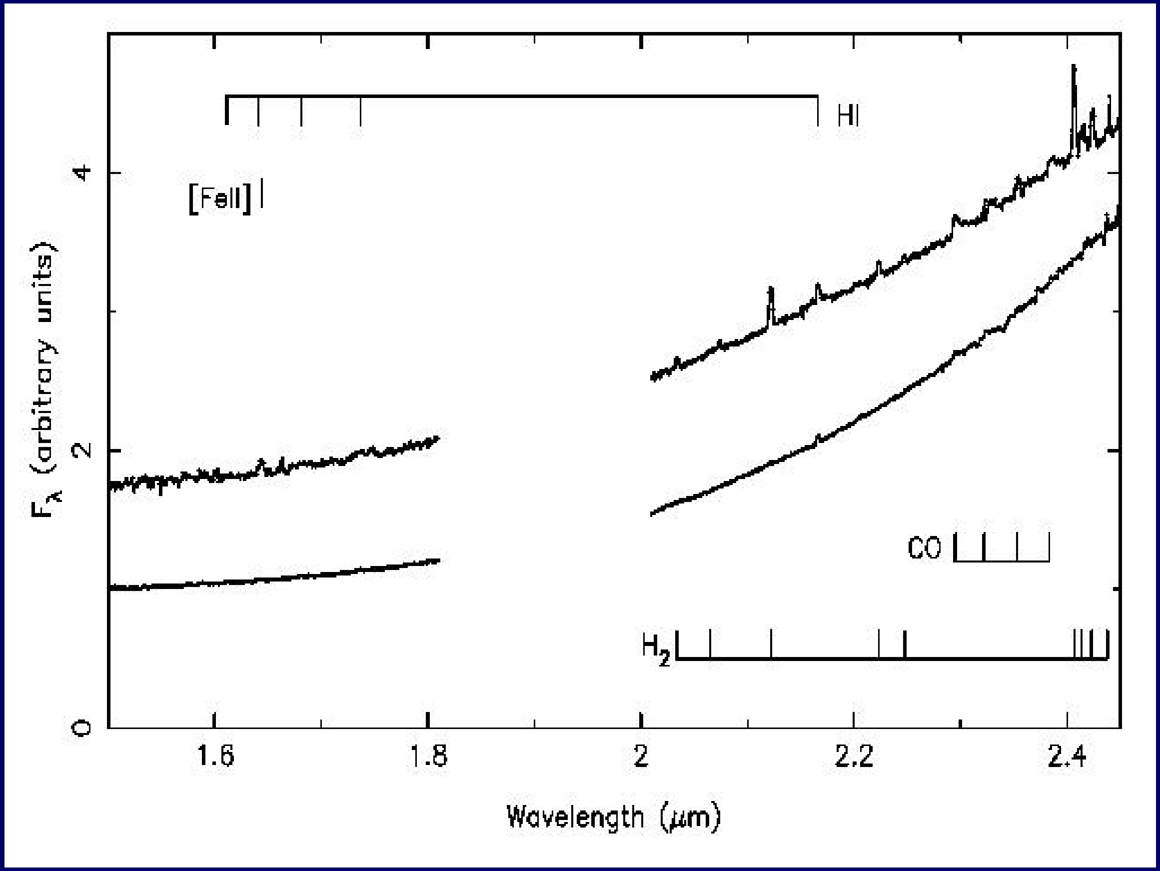
- Mid-stage (sometimes molecular hydrogen and shocked [FeII], weak ionised gas, sometimes CO) – type II



Spectroscopic Results

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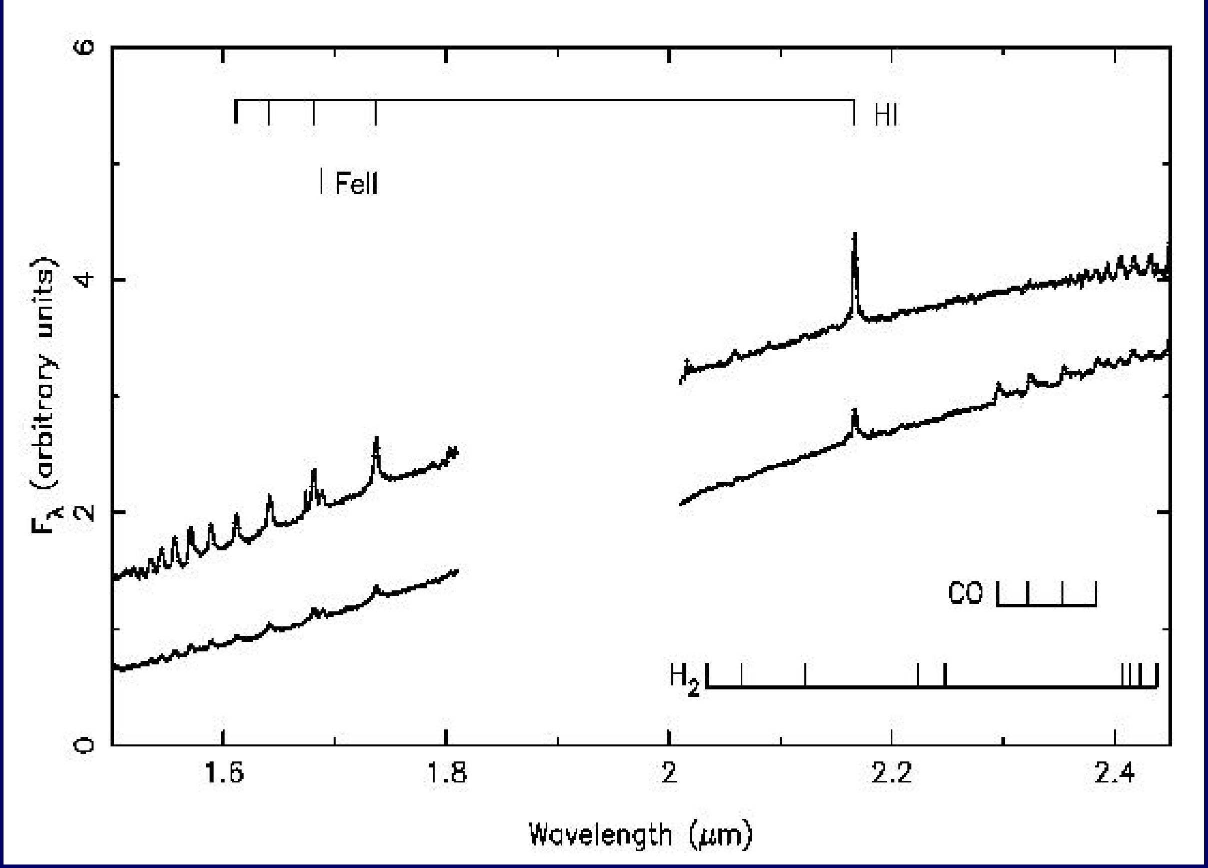
- Oldest (weak/no molecular hydrogen, strong Br lines, occasional CO, fluorescent FeII common) – type III



Spectroscopic Results

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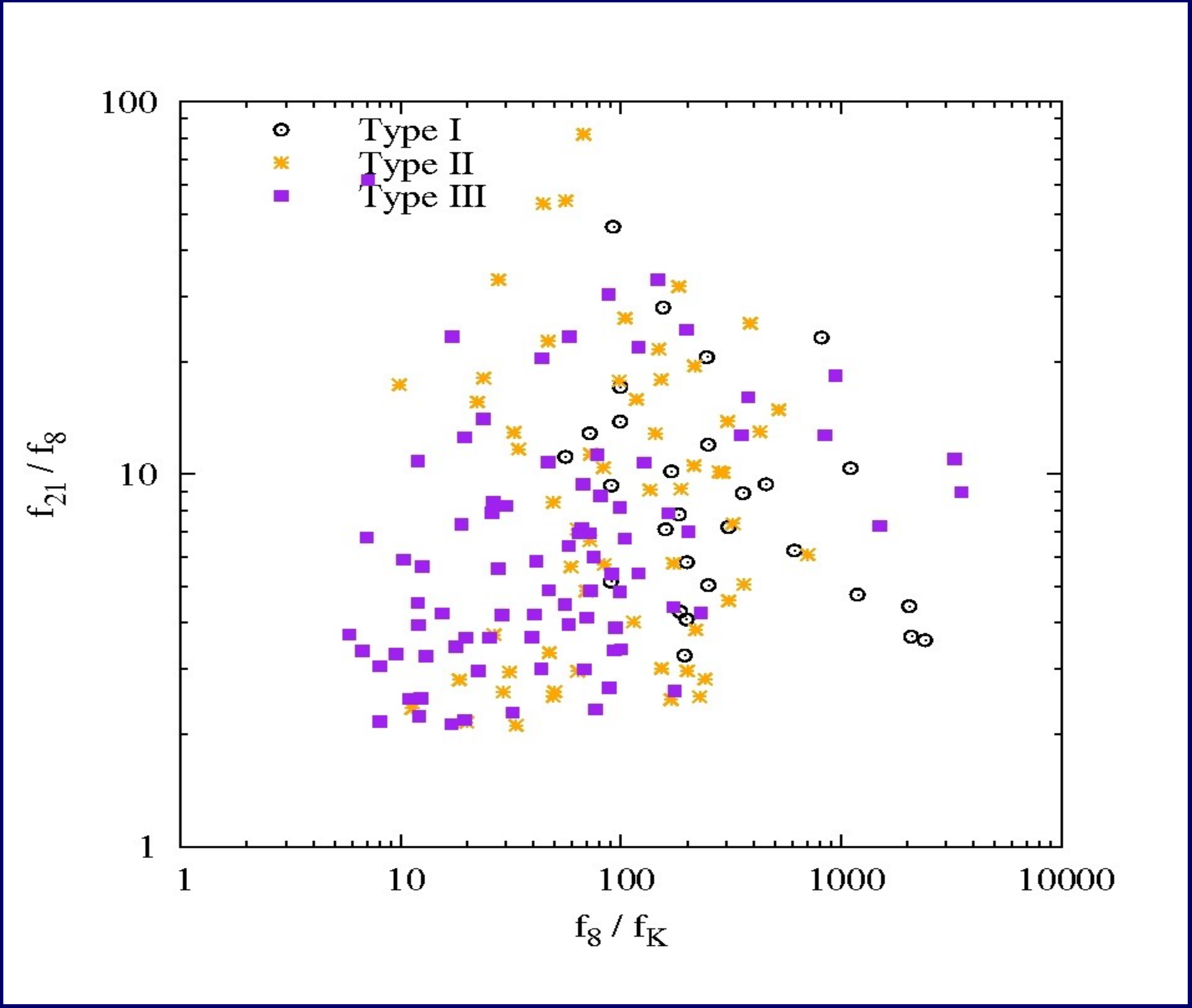
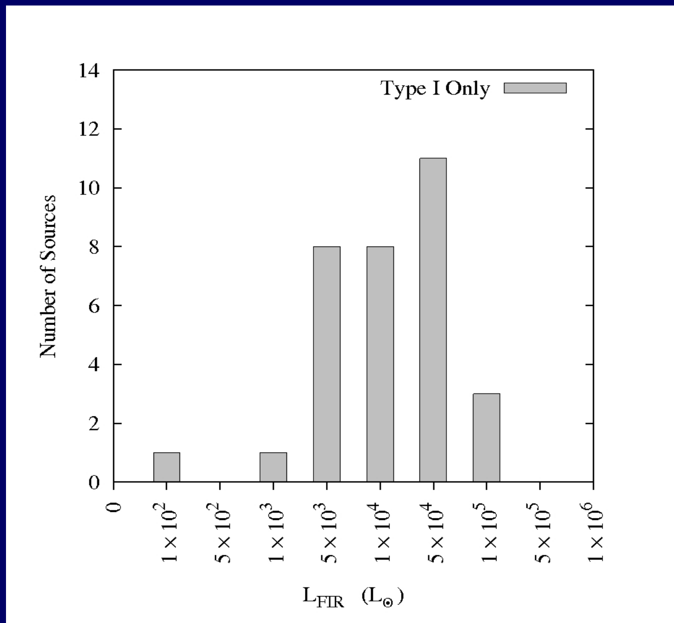
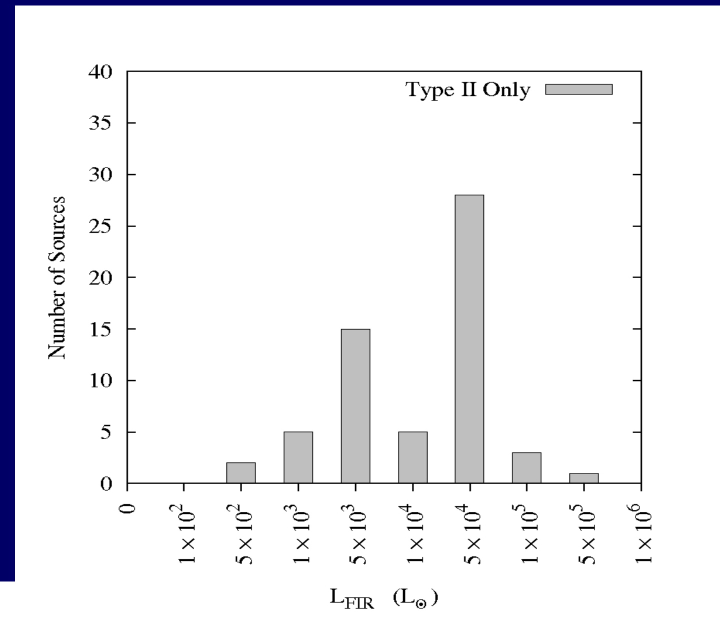
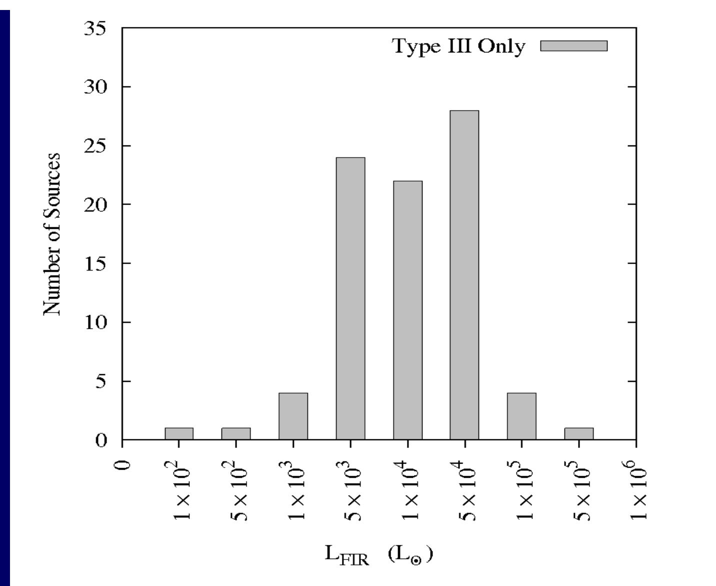
- Colours largely consistent with this



Luminosity Distribution







Emission Line Properties

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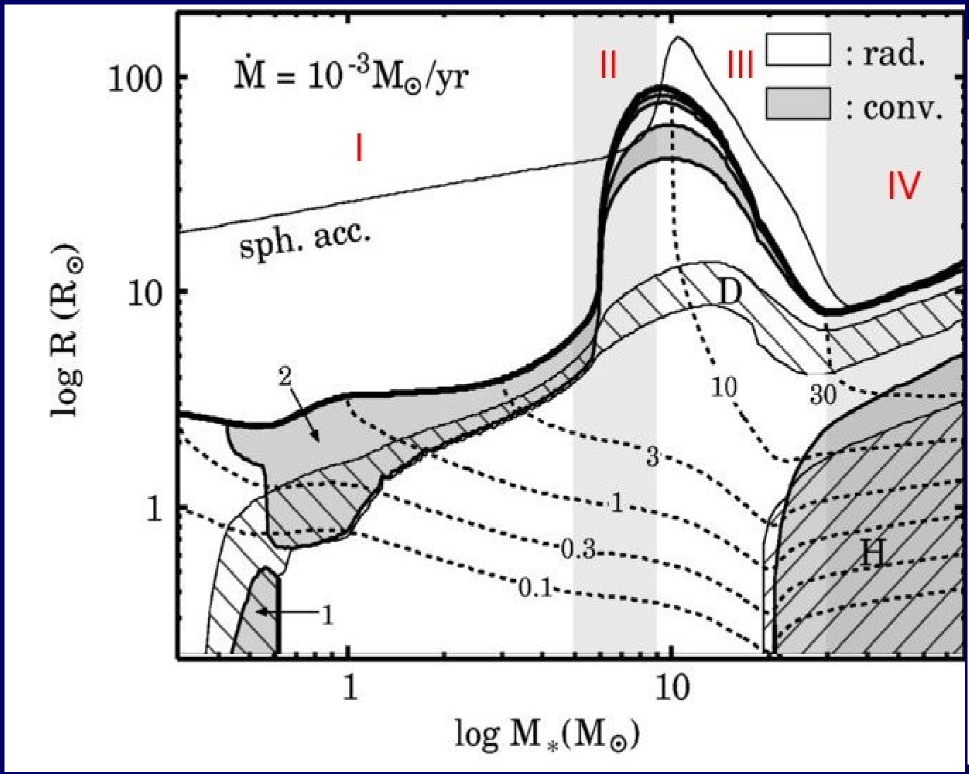

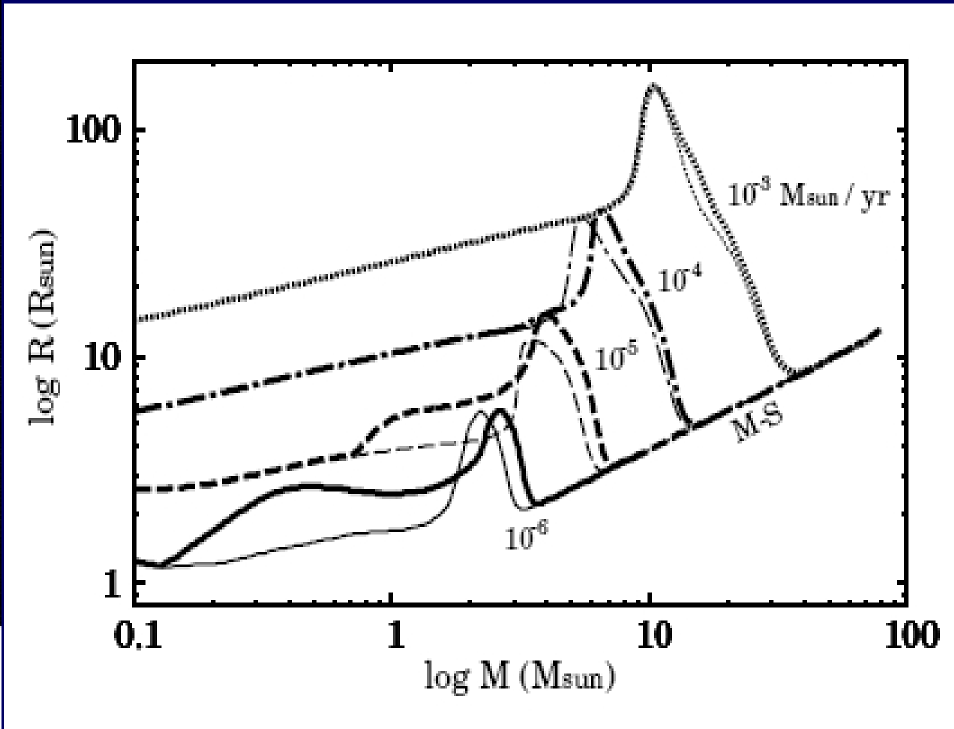

Hosokawa, Omukai & Yorke (2010)

Hosokawa & Omukai (2009)

Equate our type I ~ I/II; II ~ II/III; III ~ III/IV

Contraction Phase

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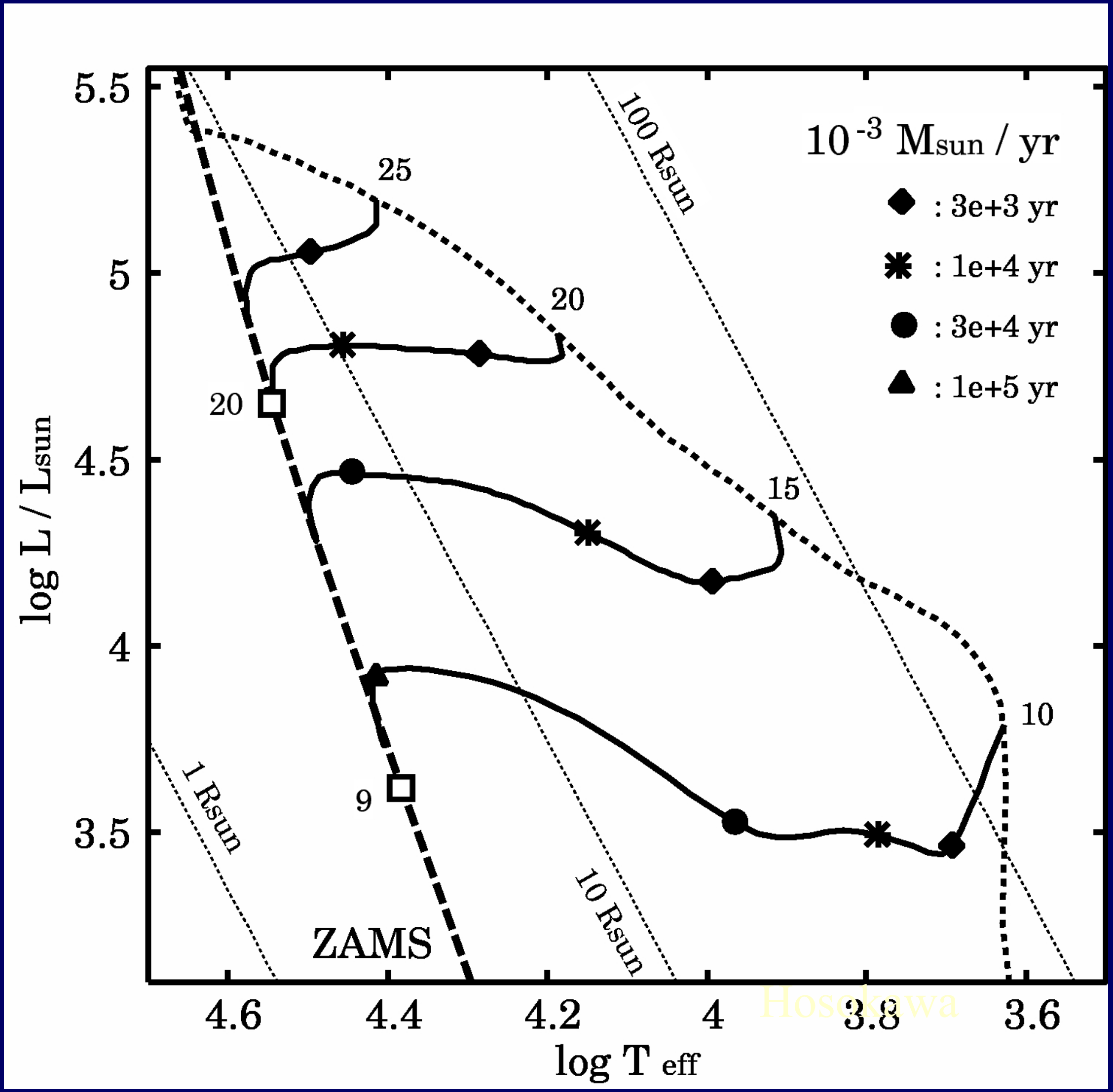
Objects settle down onto Main Sequence in ~ Kelvin-Helmholtz timescale.

For stars with masses >30 $M_\odot$ this is almost instantaneous (no very high mass MYSOs without high accretion).



Emission Line Properties

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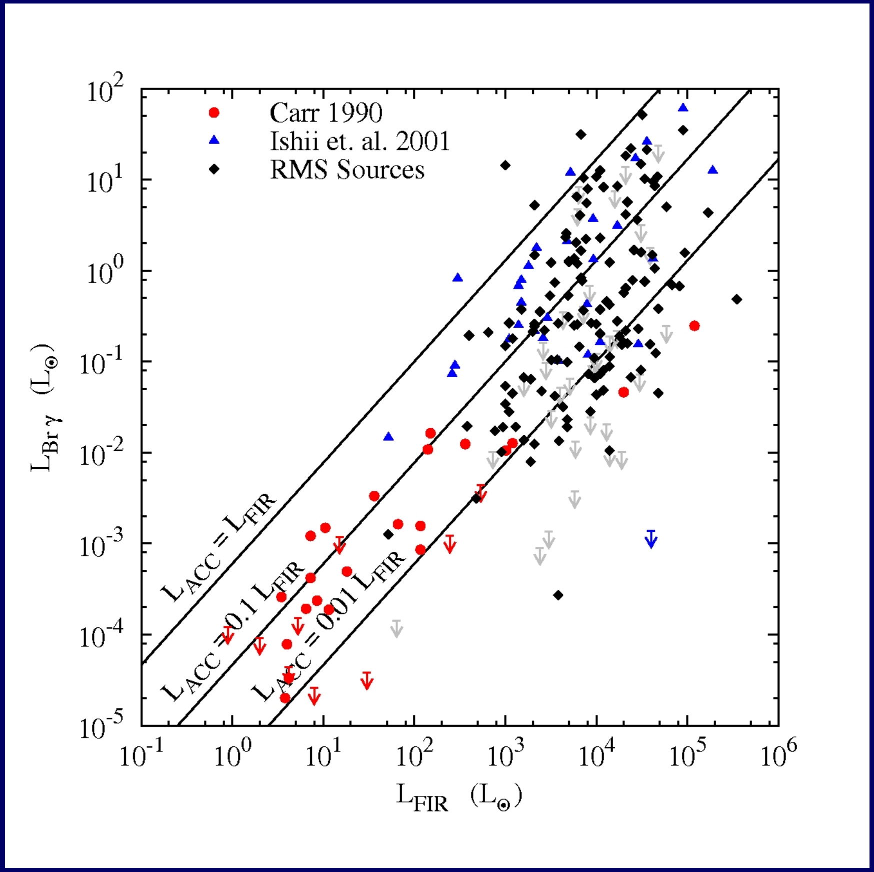
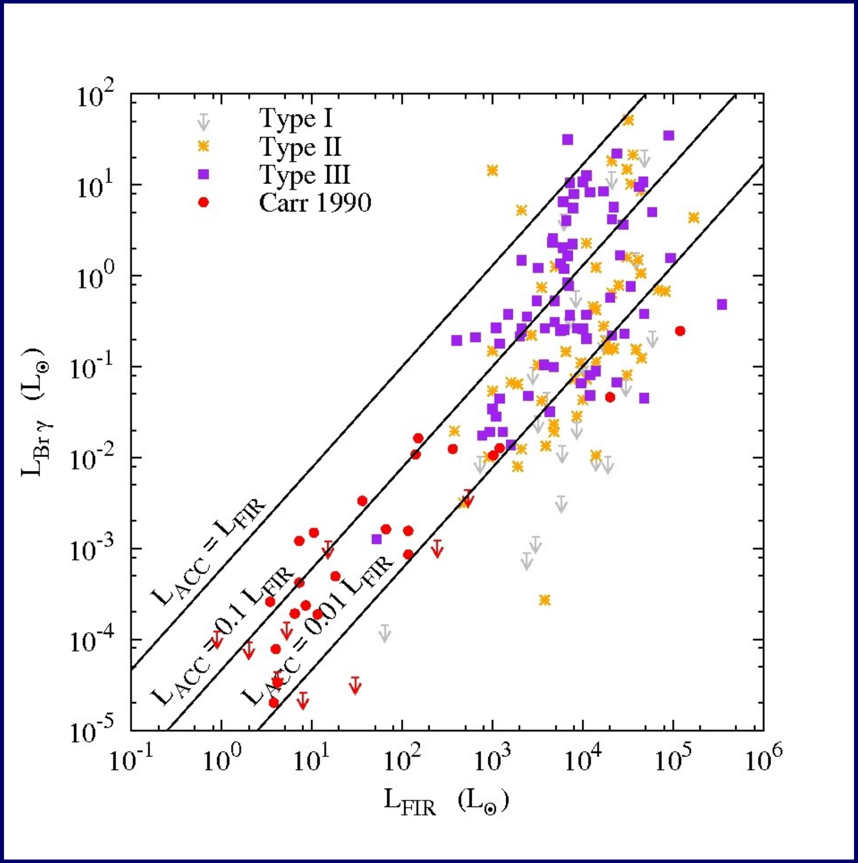
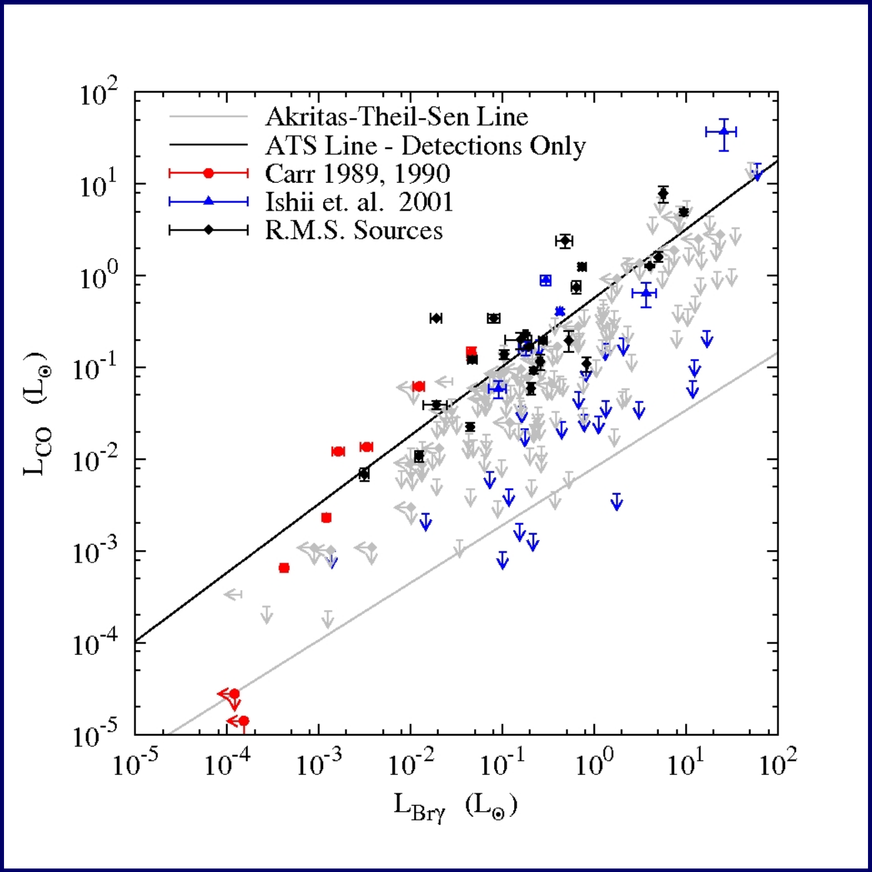
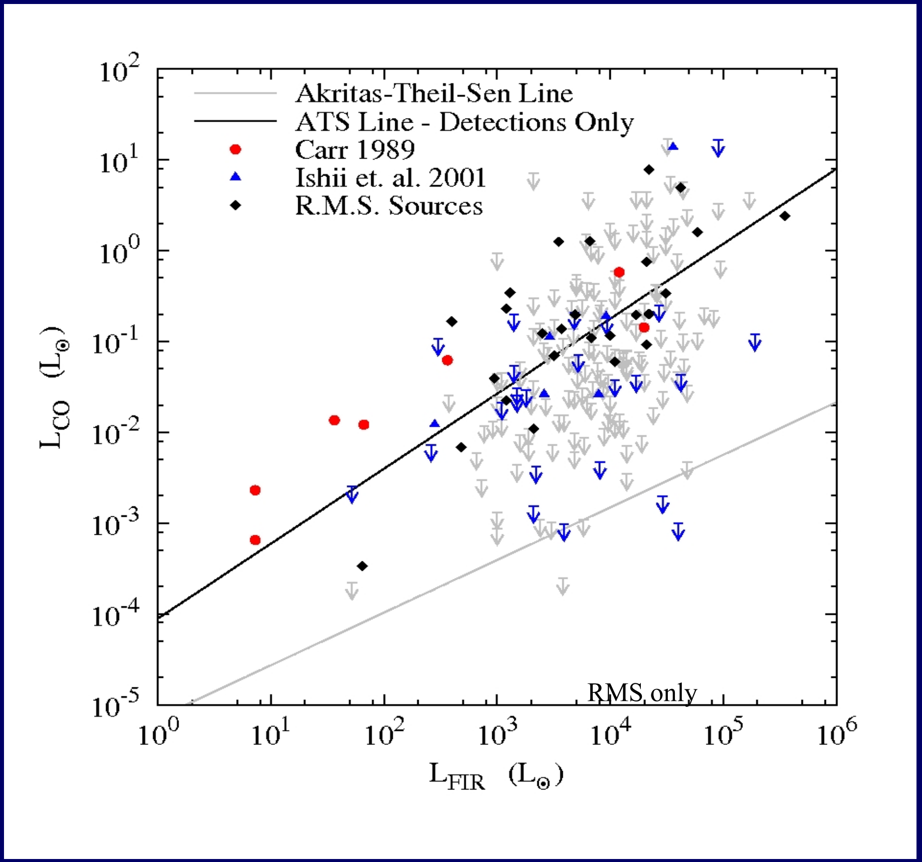




Carr (1990) TTauri stars; Ishii et al (2001) HAeBes

Emission Line Properties





Emission Line Properties

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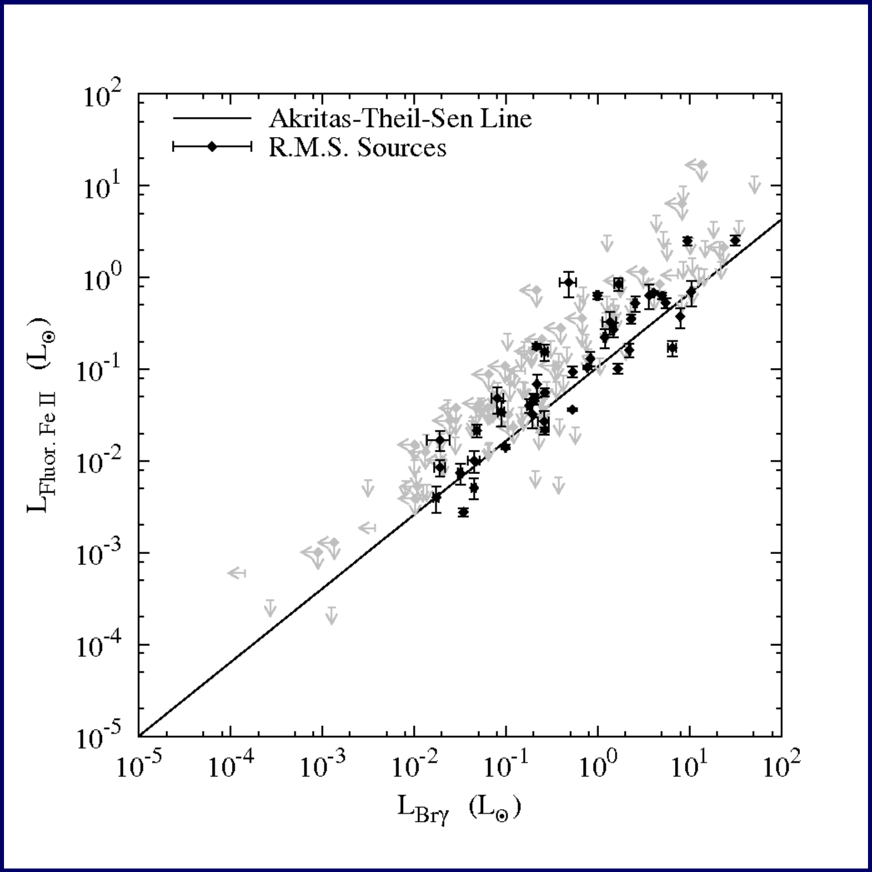

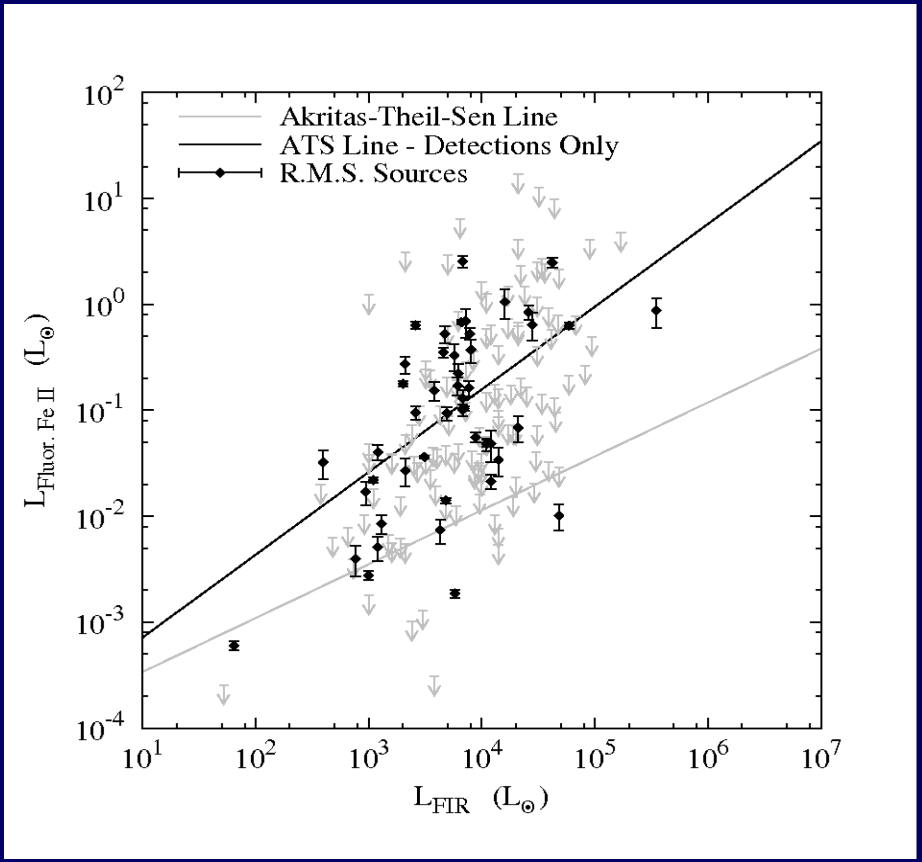

Emission Line Properties

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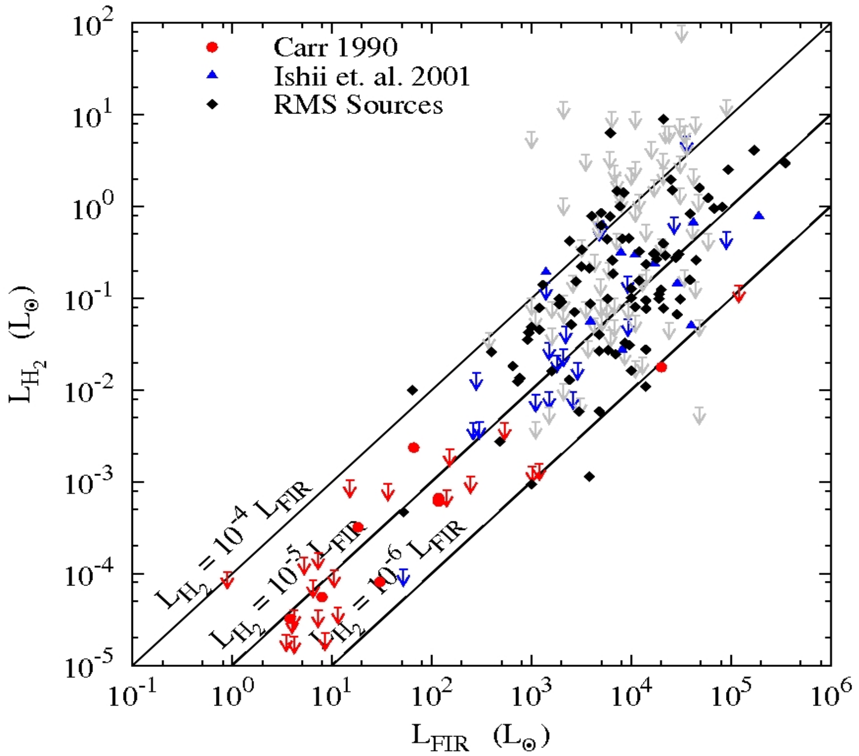

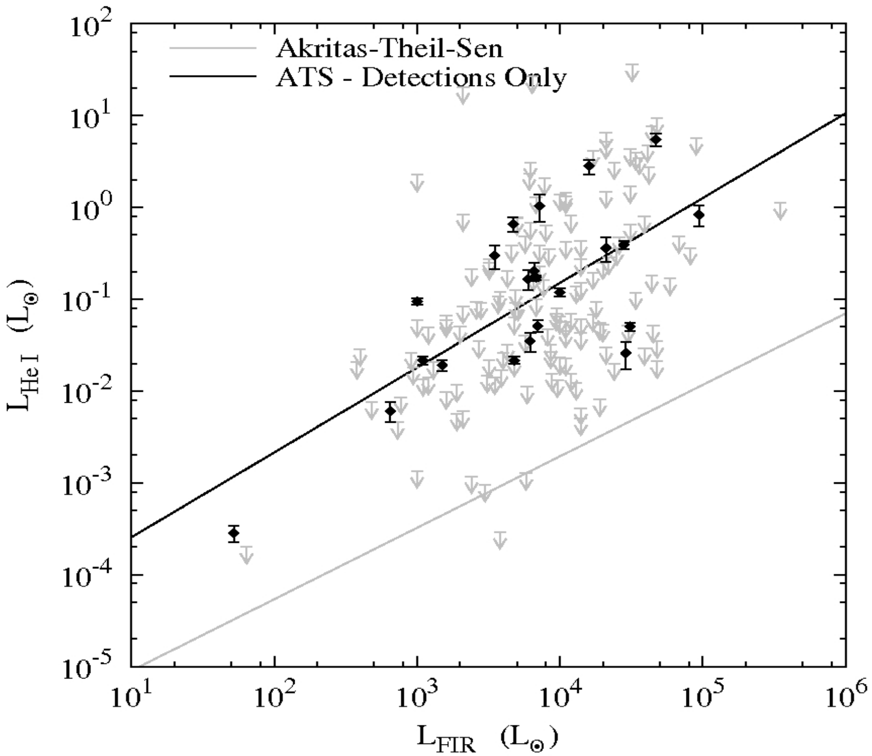

Summary

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RMS survey has delivered ~500 MYSOs and a similar number of compact HII regions across the galaxy.

There is no classical MYSO phase for objects with $L>10^5 L_\odot$ - they can ionise gas from the point at which they are ~ IR bright

Consistent with high accretion rates resulting in swollen (cooler, UV deficient) lower luminosity YSOs around 10^4 -$10^5 L_\odot$

Near IR spectroscopy suggests there is an observable evolutionary sequence