The Red MSX Source (RMS) Survey

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Talk Outline

- Introduction
- Colour selection of MYSOs
- Follow-up programme
- Mopra observations
- Preliminary results and summary
- Future programmes

What is a MYSO?

- Mid and Near-IR bright
- Luminous (>10^4 L_o)
- Radio quiet → UCHII region has not formed
- Often associated maser emission
- Bipolar molecular outflow → accretion is still taking place

GL2591:Gemini JHK

MYSO samples

- Well characterised MYSOs number in the tens
- Not systematically found and mostly nearby
- Most samples IRAS colour selected:
  - Bias towards bright isolated sources
  - tend to avoid dense clustered environments and the Galactic mid-plane where majority of MYSOs are expected - scale height massive stars ~30' (Reed 2000)
- The limited number and selection method means they may not be representative of the general population of MYSOs

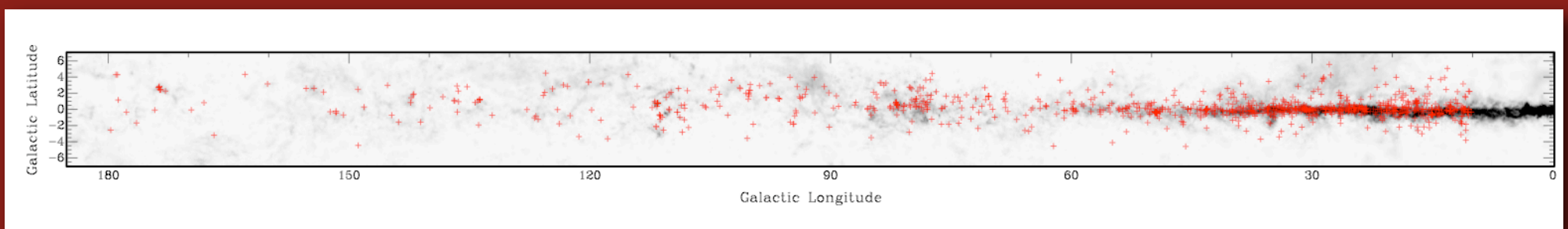
- Need well-selected sample that number in the hundreds
- Can then study properties in a statistically robust way

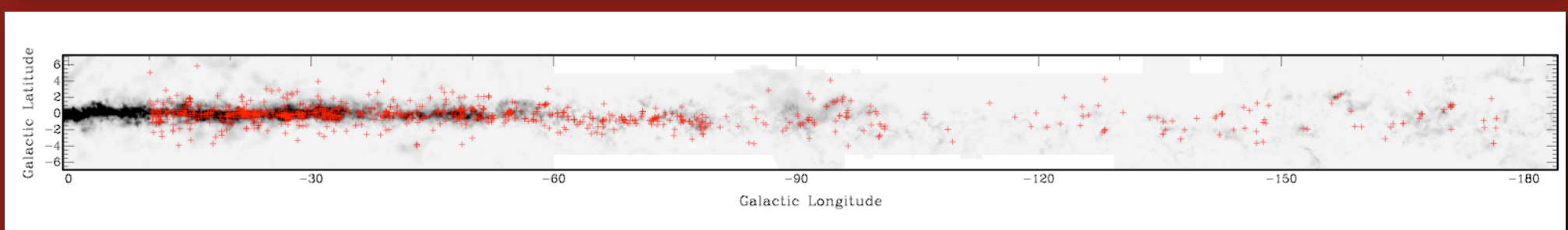
Searching for MYSOs

- Too obscured in near-IR
- Radio continuum too weak
- No single maser transition always present
- Molecular cores do not necessarily contain YSOs
- Need to use IR where bulk of energy emerges
- IRAS-based searches suffer from confusion

Colour Selection of MYSOs

- MSX survey: 8, 12, 14 and 21μm, 18″ resolution, |b|<5^{o}
- Colour-select massive YSO candidates from the MSX PSC and 2MASS near-IR survey (Lumsden et al. 2002)
- Delivers ~2000 candidates
- Many other object types with similar near- and mid-IR colours





The RMS Survey

Colour Selection of MYSOs

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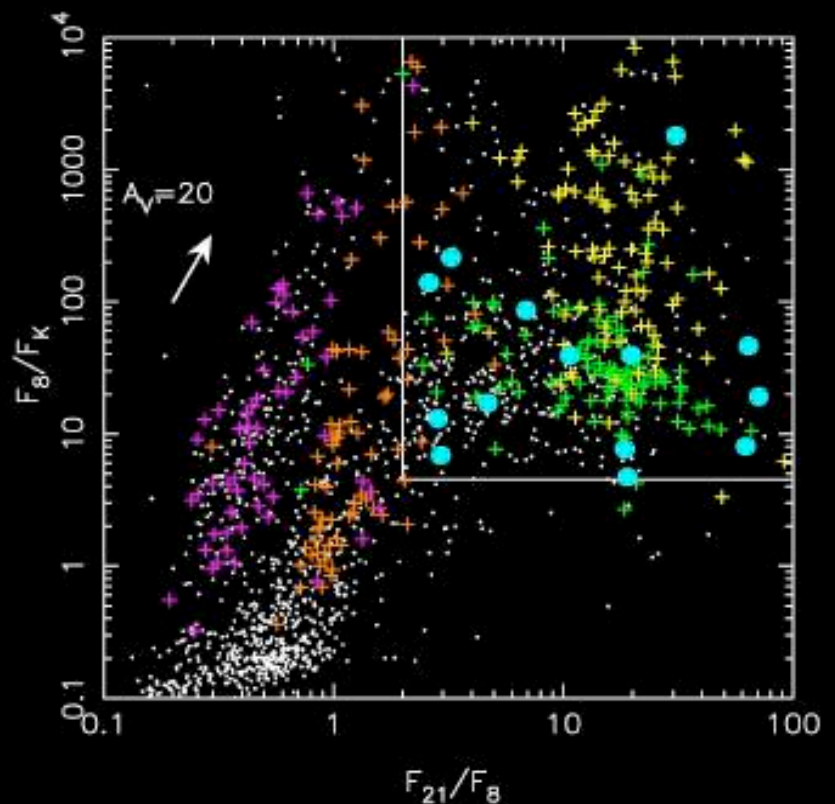
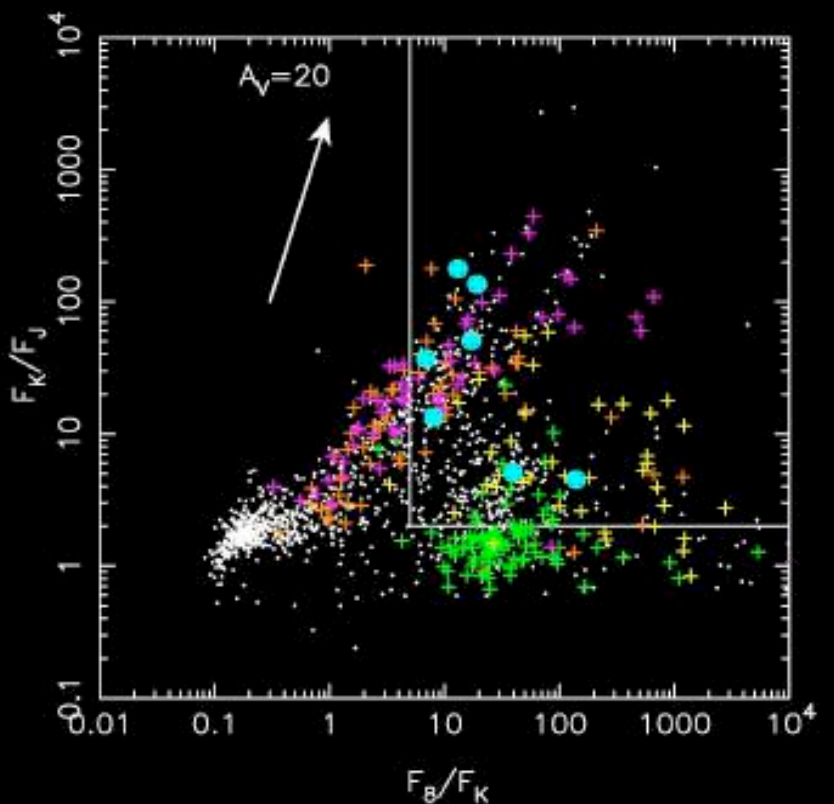




• Massive YSOs + UCHII regions + C stars

+ PN + OH/IR stars

Multi-wavelength follow-up campaign

Observational Programme

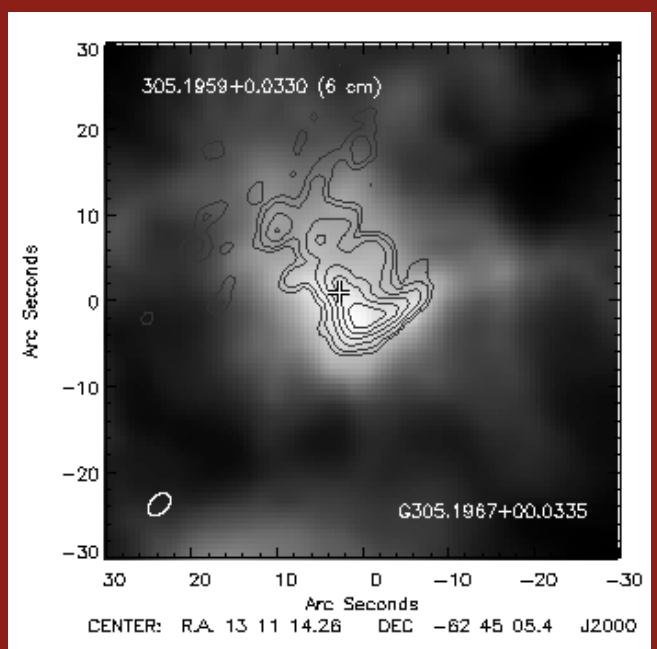
- Identify and eliminate confusing sources
- Begin characterisation of the massive YSOs
- Observational programme includes
  - Mid-IR imaging (UKIRT, Gemini)
  - Radio continuum (VLA & ATCA)
  - Molecular lines (^{13}CO and CS; Mopra, JCMT, PMO, Onsala, FCRAO)
  - Near-IR imaging and spectroscopy (AAT, UKIRT, NTT)

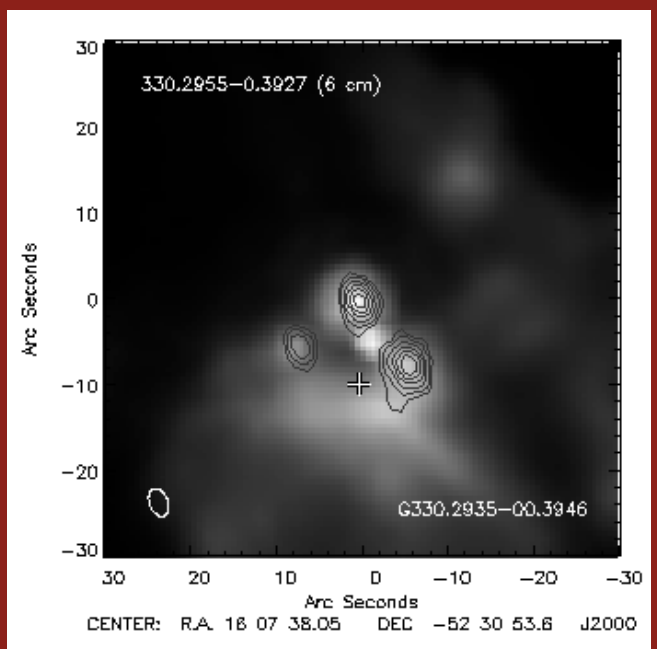
Multi-wavelength follow-up campaign

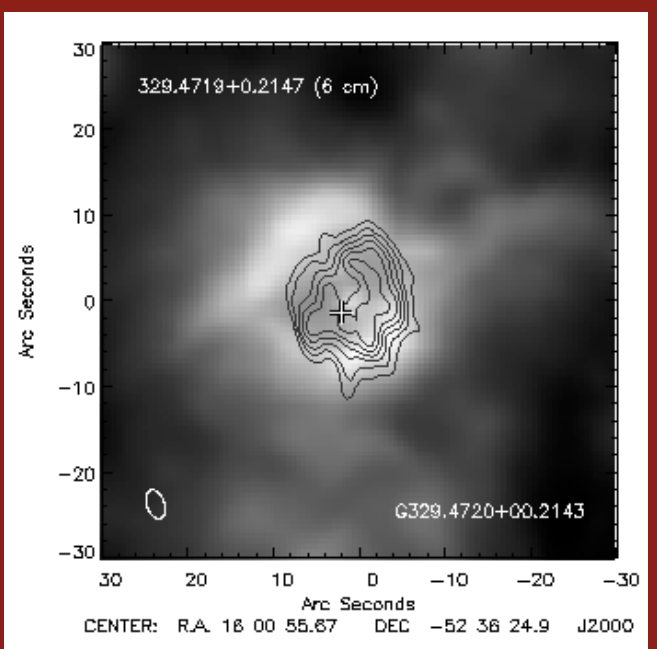
Radio Continuum

Australia Telescope National Facility

- Identify UCHII regions and small number of PNe
- 5 GHz, 2″ resolution, 0.3 mJy/beam noise level at VLA & ATCA
- 2000 objects observed (Urquhart et al. 2007, Urquhart et al. in prep.)
  - ~25% of sources detected in radio
- Morphologies, distribution and spectral indices consistent with UCHII regions



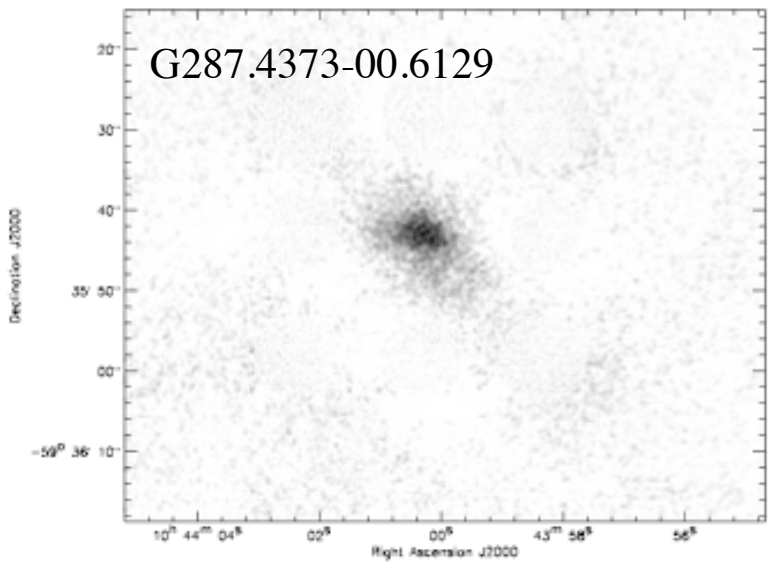


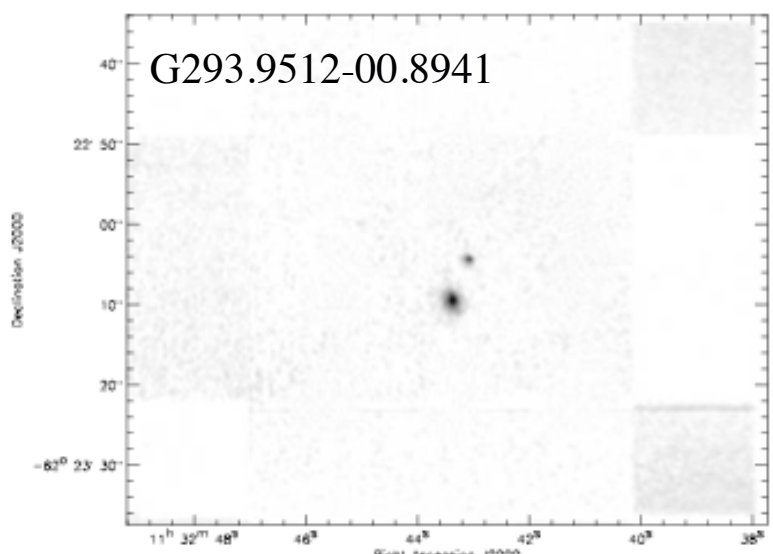


Multi-wavelength follow-up campaign

Mid-IR Imaging

- 10μm, 0.8″ resolution at 700 objects observed & GLIMPSE
- Distinguish between UCHII regions and MYSOs
  - UCHII → Extended
  - MYSO → Point like
- Mid-IR imaging complements radio imaging in cases where UCHII and MYSOs are in close proximity





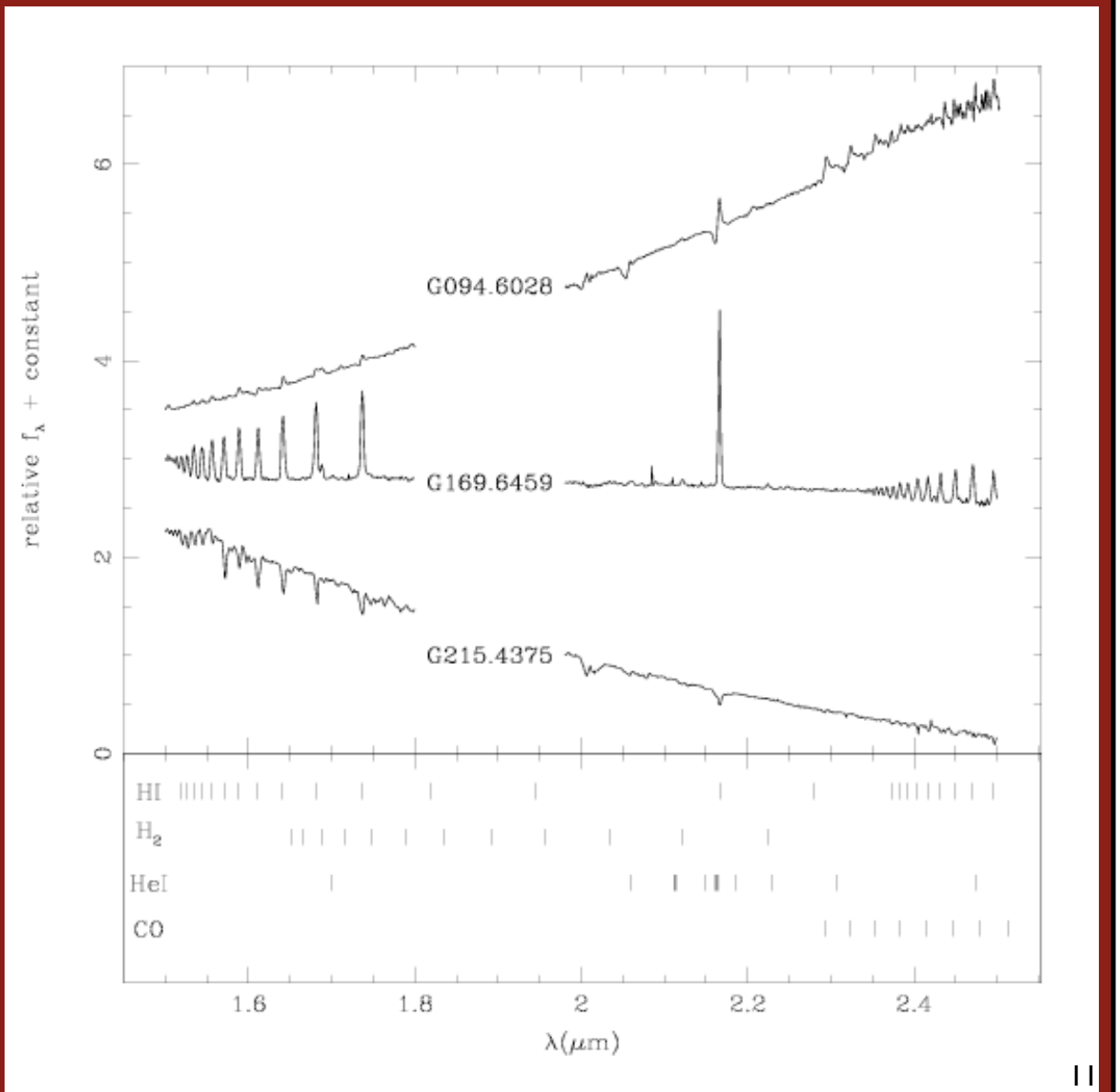
Mottram et al. 2007

Multi-wavelength follow-up campaign

Near-IR Imaging and Spectroscopy

Australia Telescope National Facility

- Identify remaining evolved stars and confirm identified MYSOs
- K-band imaging + 2MASS
- 400 targets observed
- H+K band spectroscopy
- ~250 targets observed



Mopra Milky Way Survey 03/11/2008

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Multi-wavelength follow-up campaign

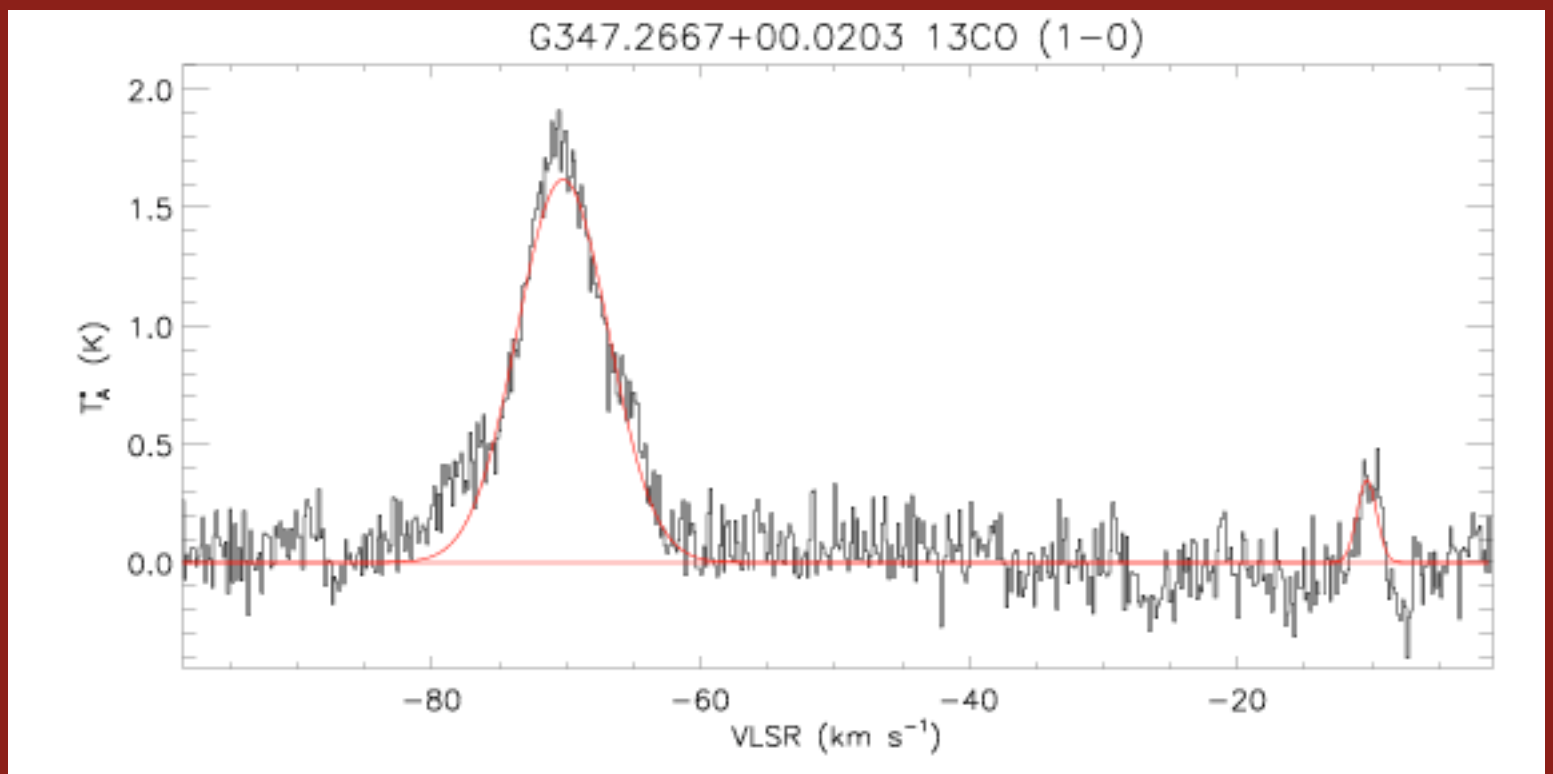
Millimetre Line Observations

- Crucial for accurate distance determination
  - bolometric luminosity
  - mass
  - size
- MYSOs and UCHII regions expected to be associated with spiral arms
  - determining their location within the Galaxy can help improve understanding of Galactic structure

Mopra Results

Example Spectra

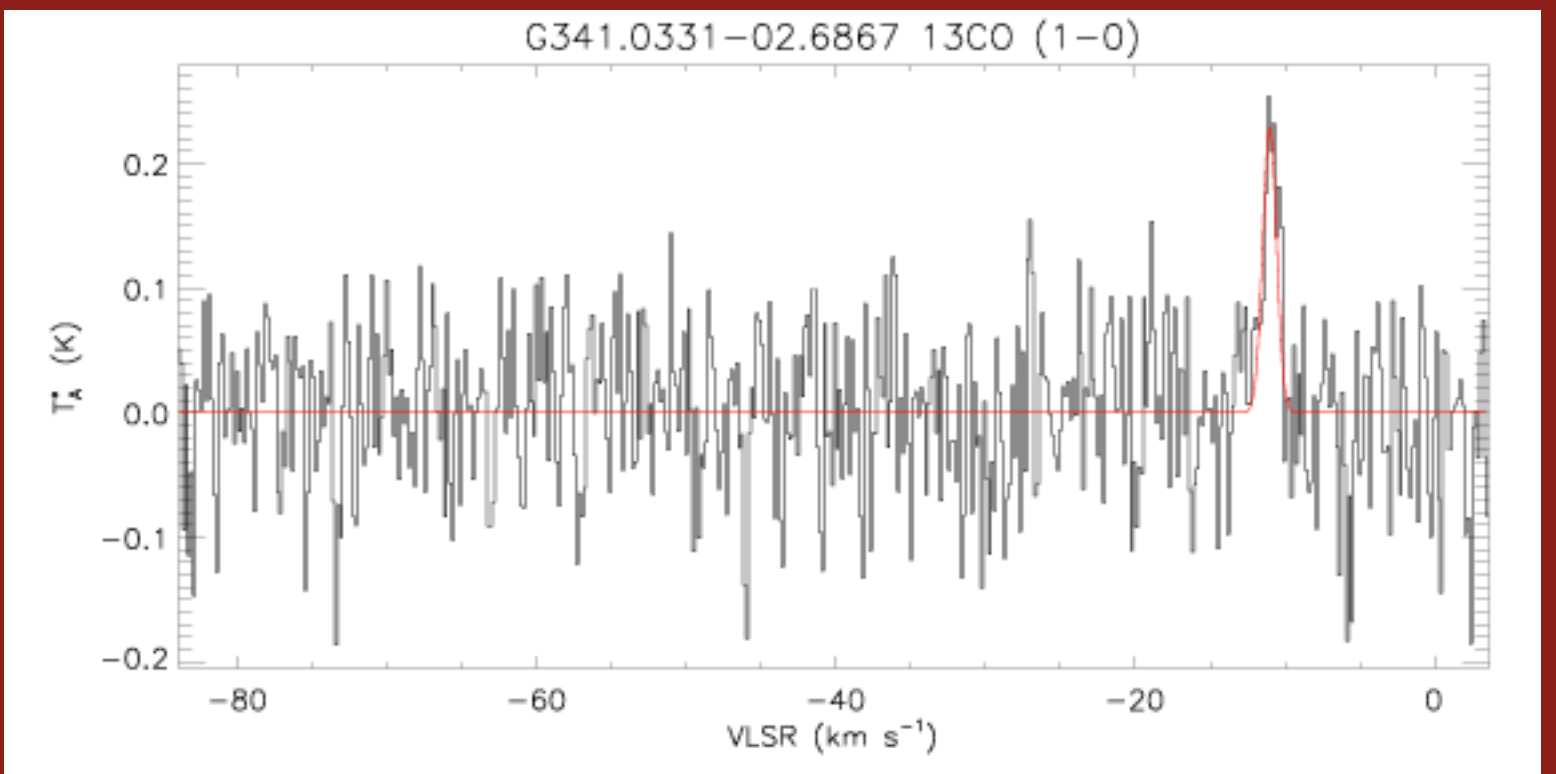
Australia Telescope National Facility



Mopra Results

Example Spectra

Australia Telescope National Facility



Mopra Results

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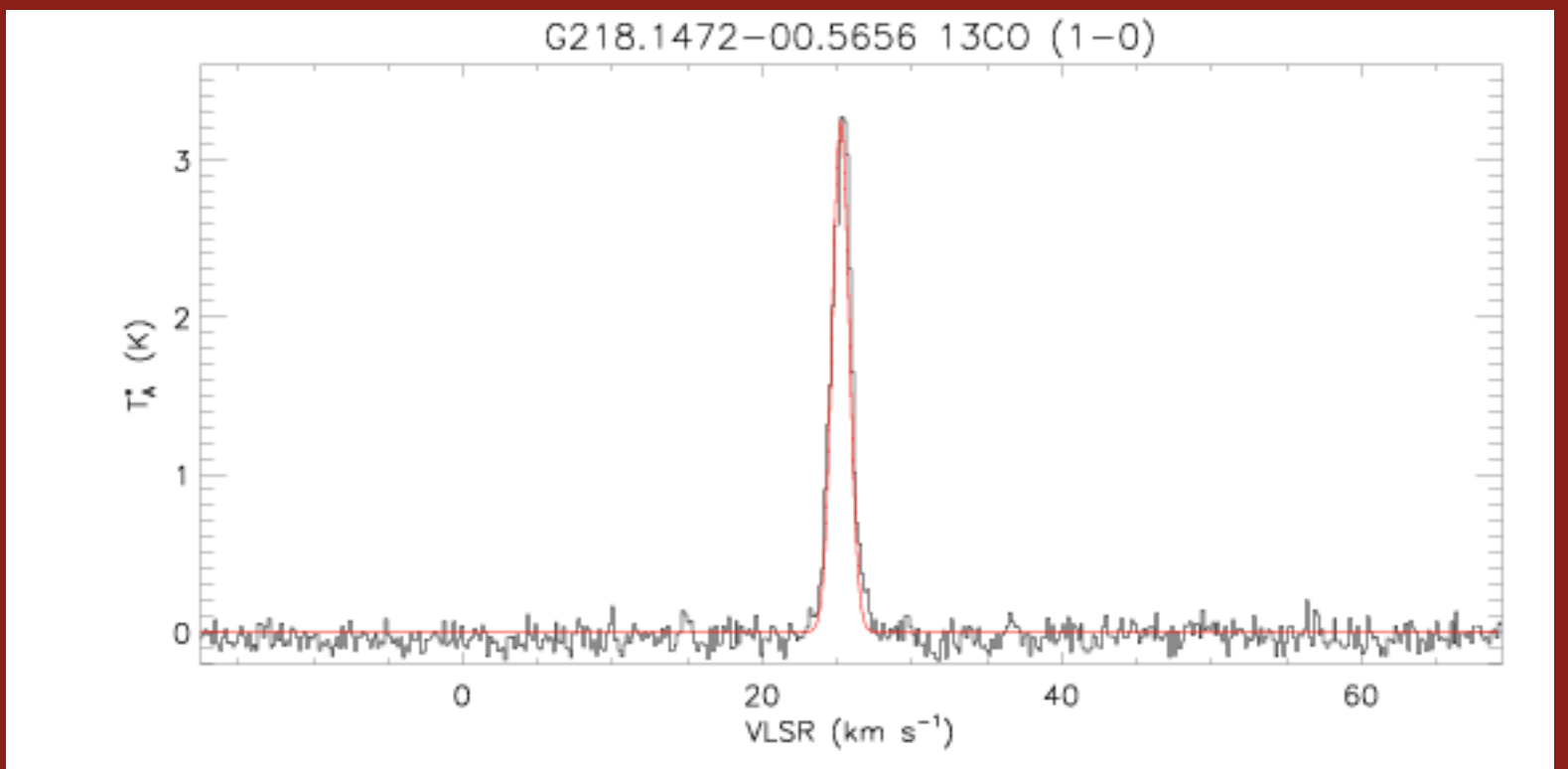
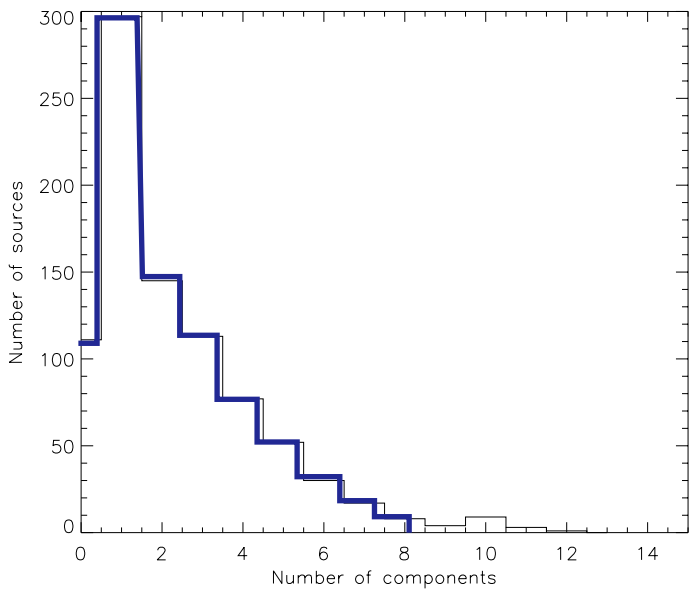


Mopra Results

Multiplicity Problem

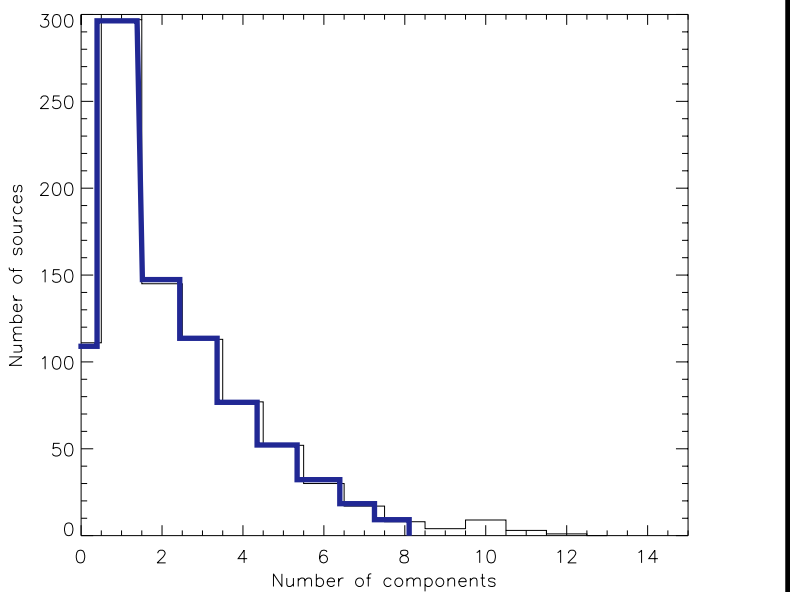


Multiple components detected towards 60%

Mopra Results

Multiplicity Problem

Australia Telescope National Facility



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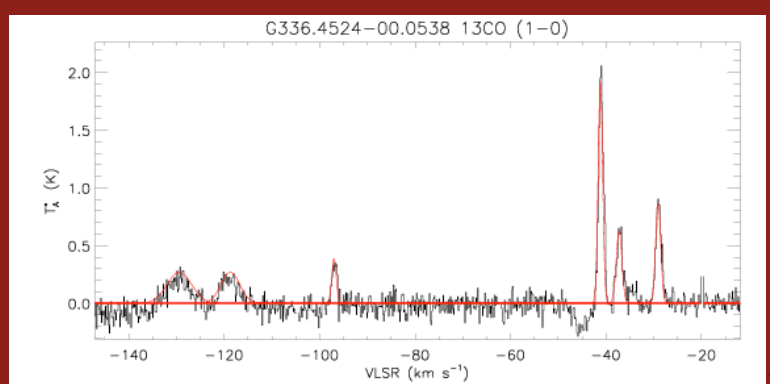

Mopra Results

Multiplicity Problem

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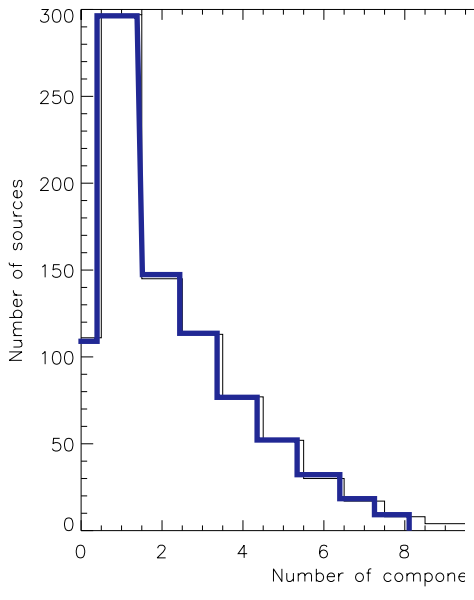

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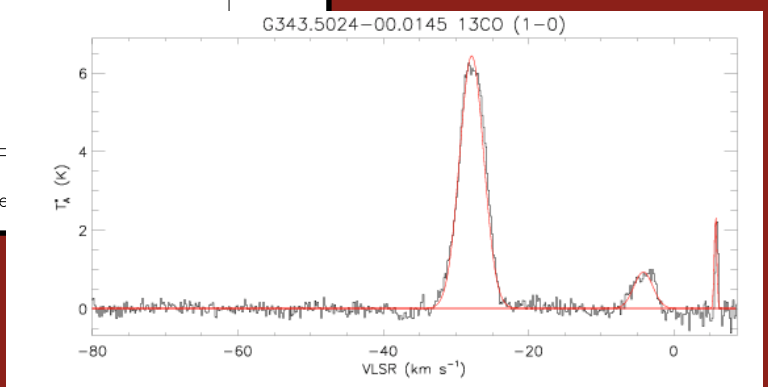

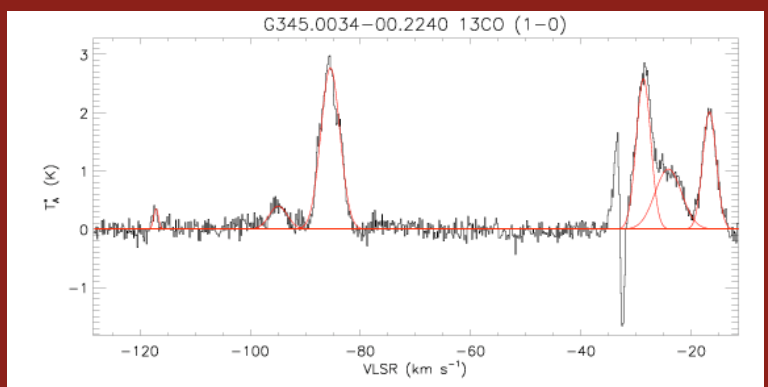

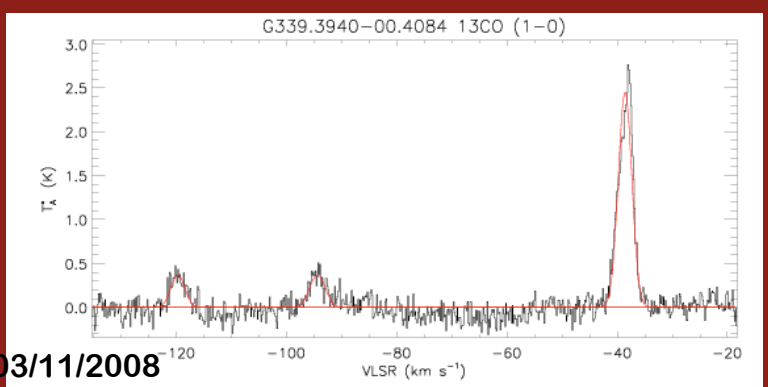

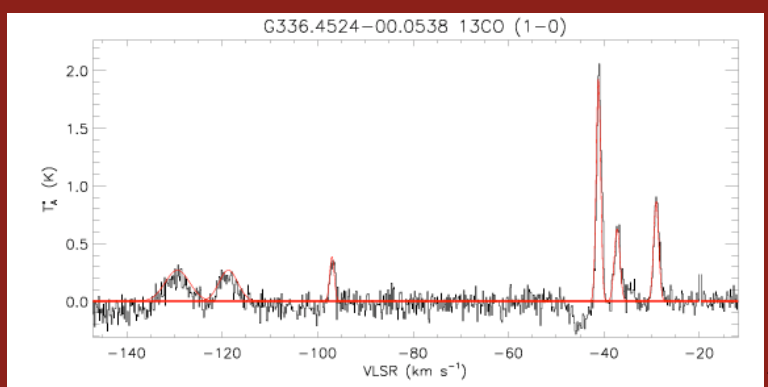

Mopra Results

Detection Results

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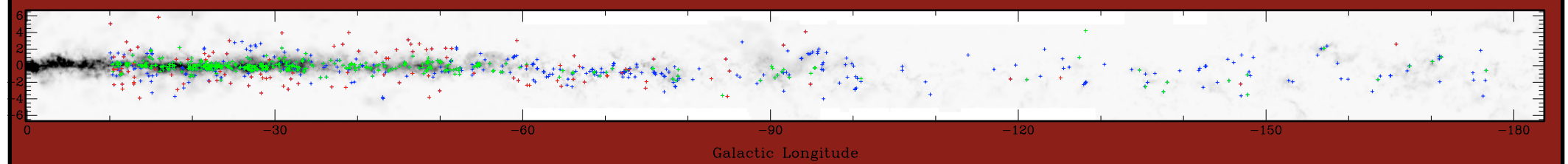

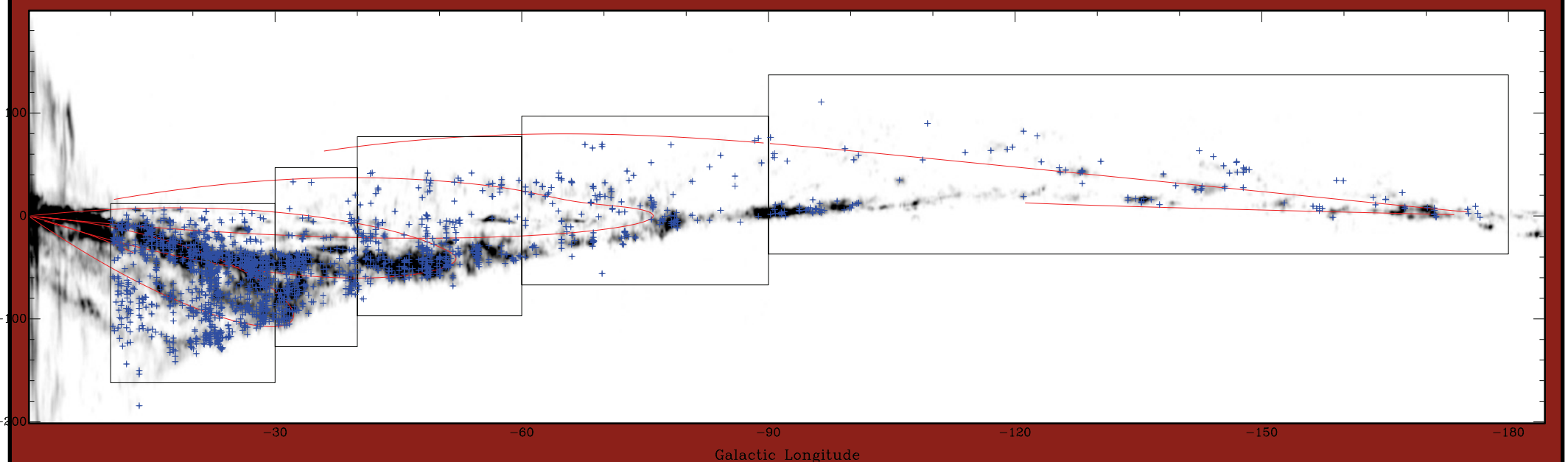

Urquhart et al. 2007

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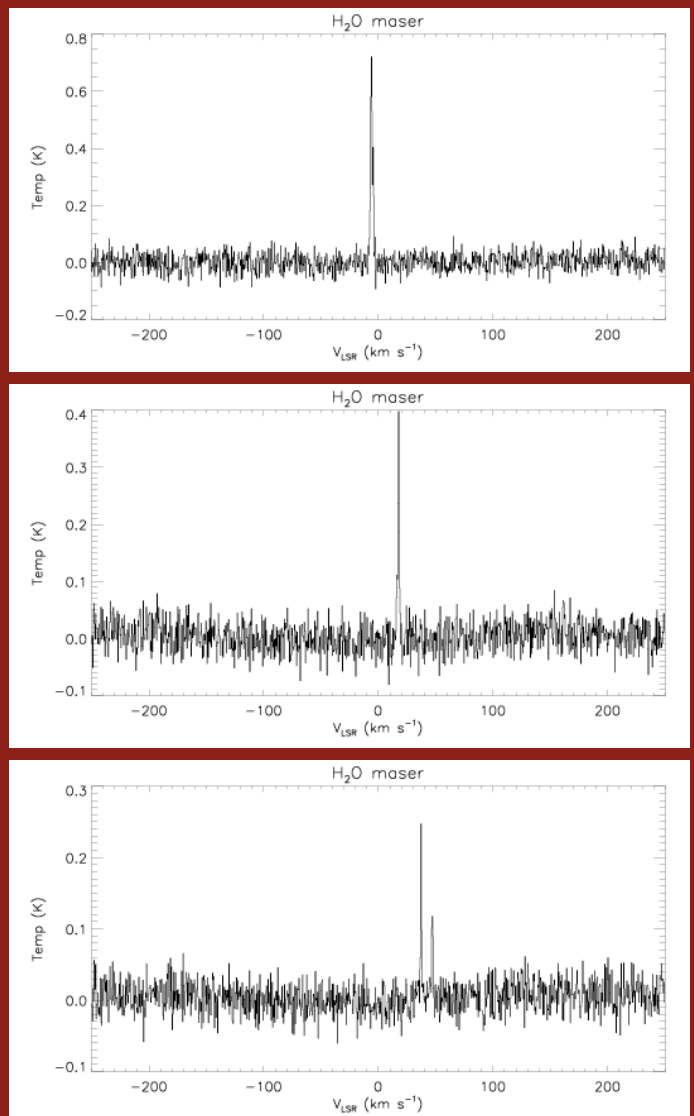
Resolving the Multiplicity

- Made CS observations towards brighter sources
- Water maser and Ammonia observations: ~500 YSOs
  - > 100 Water masers detected
  - Similar number of Ammonia detections
- CO mapping towards more elusive sources

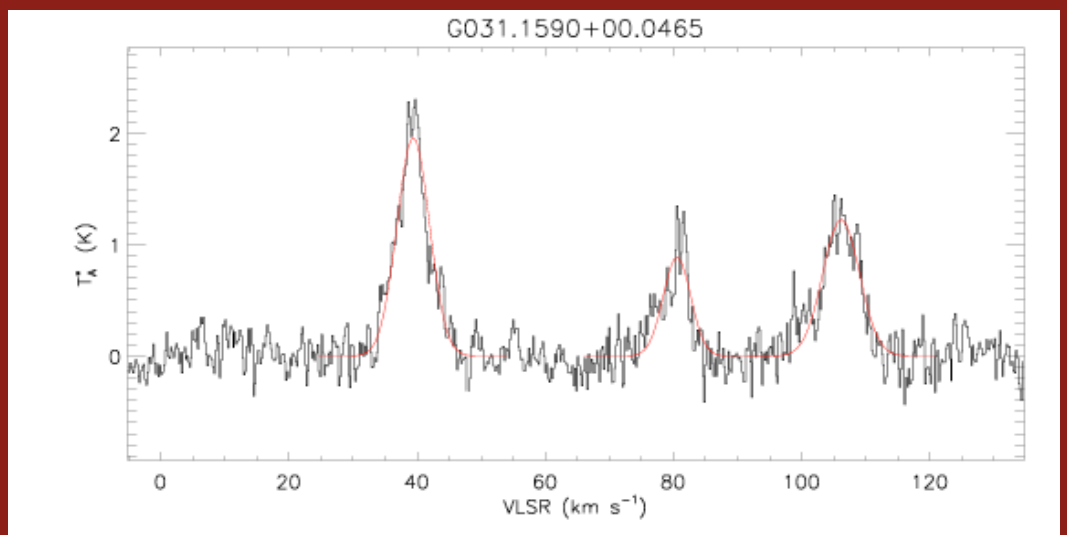
- So far we have determined kinematic velocity to ~1800 RMS sources (~90%)
- Data either in hand or observations scheduled for the rest

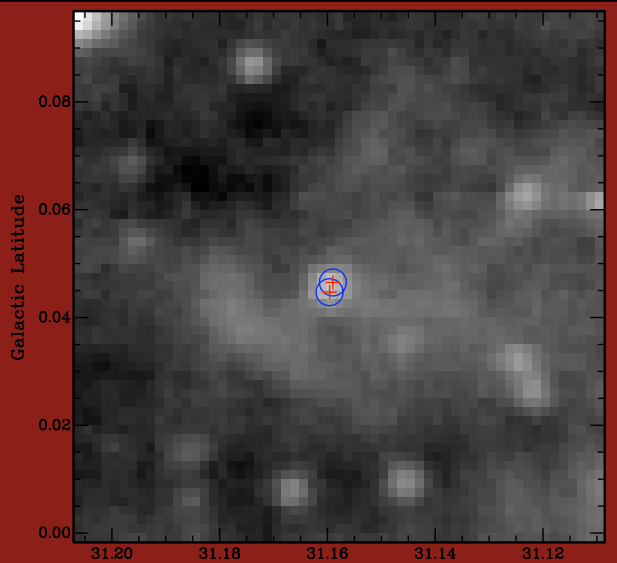


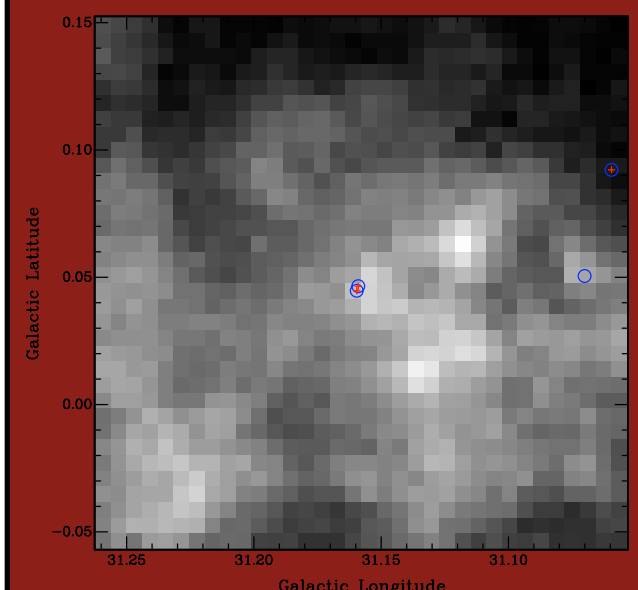
Molecular Line Data (GRS)

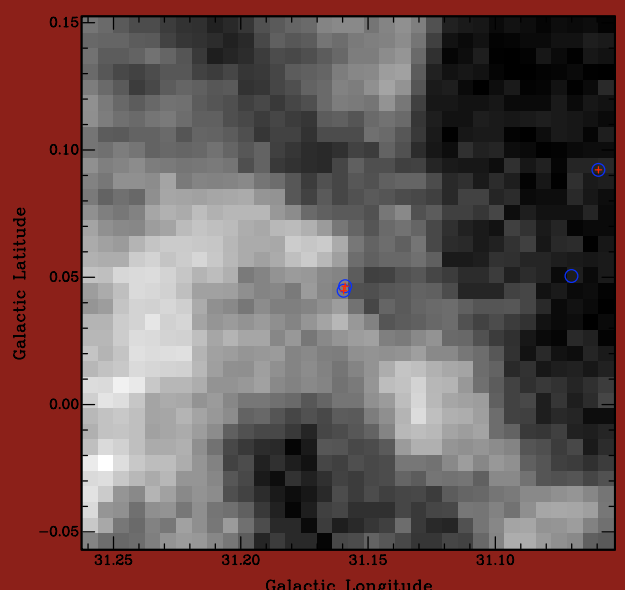
Integrated CO Maps

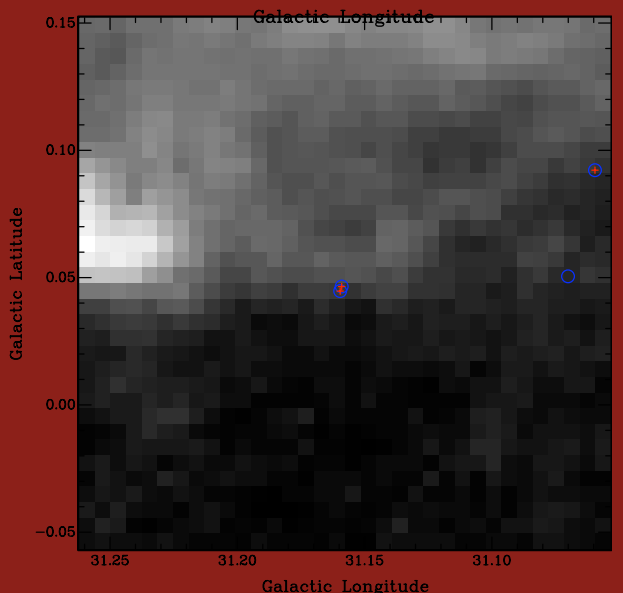
Australia Telescope National Facility











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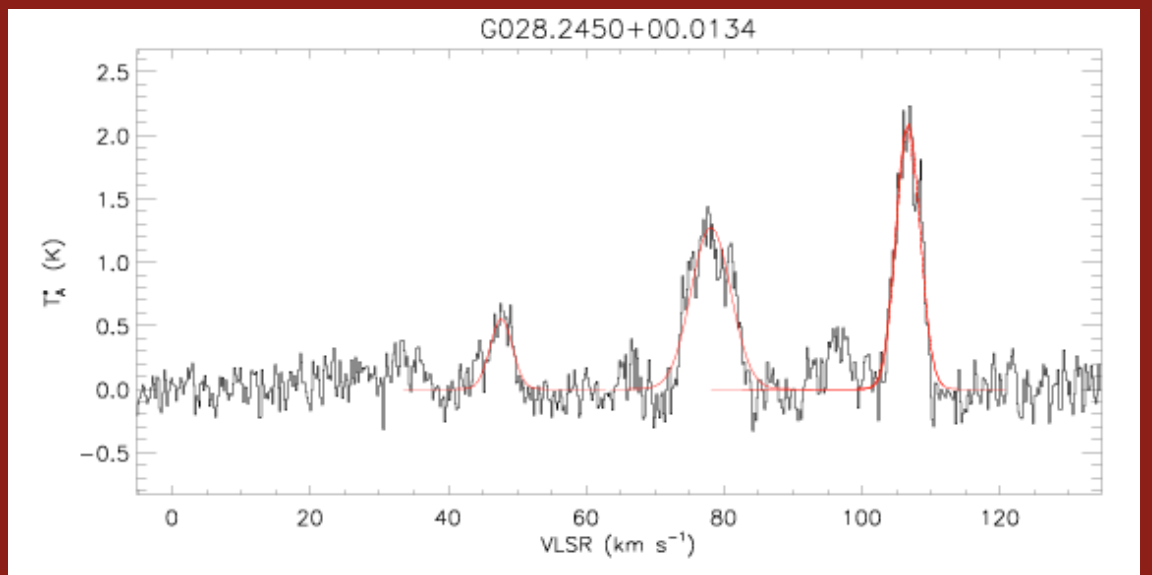

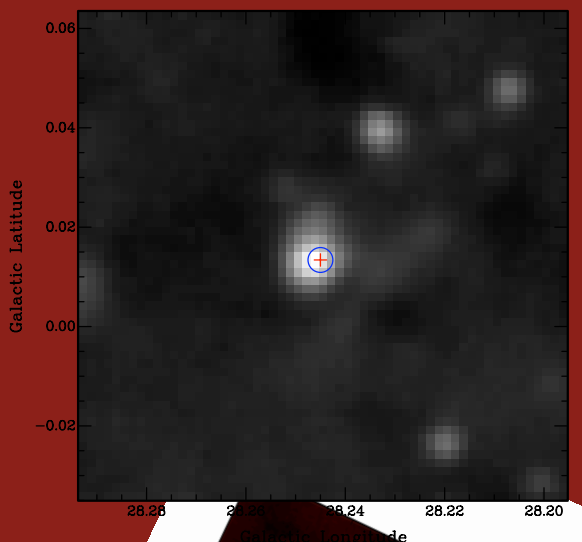

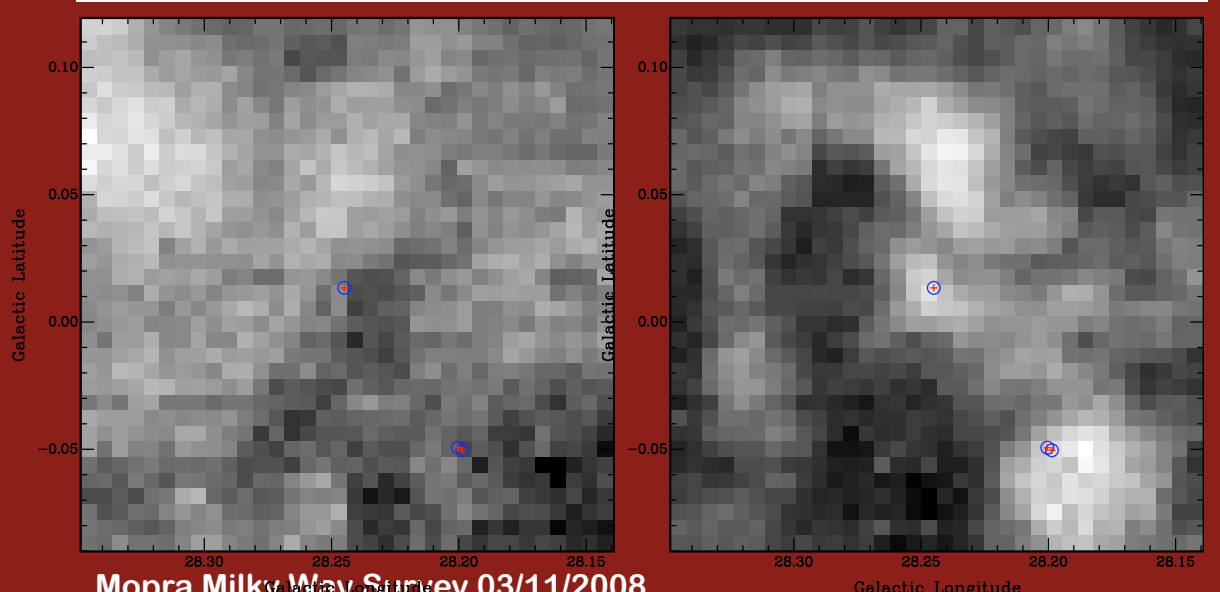

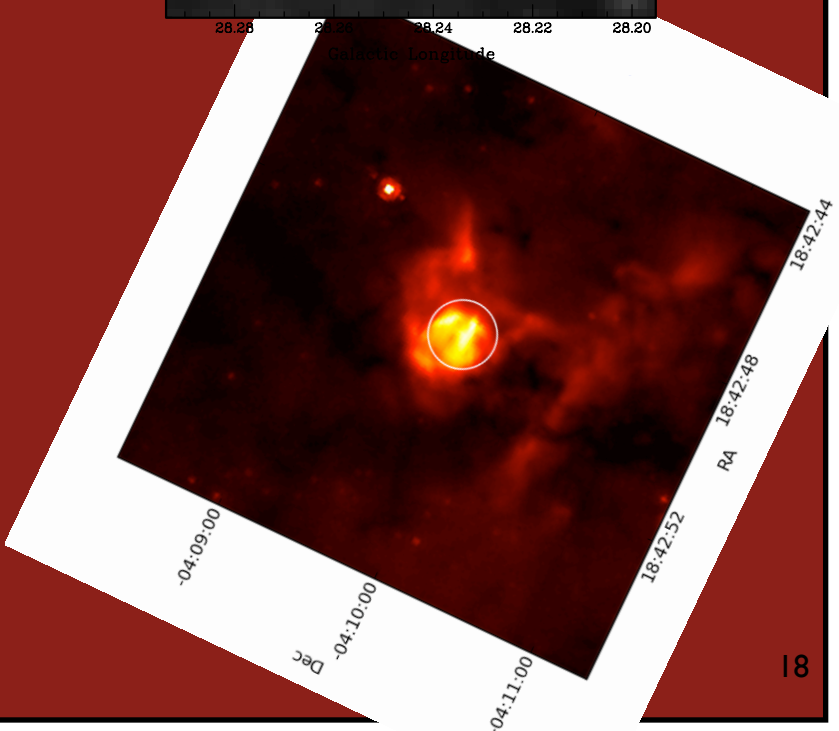

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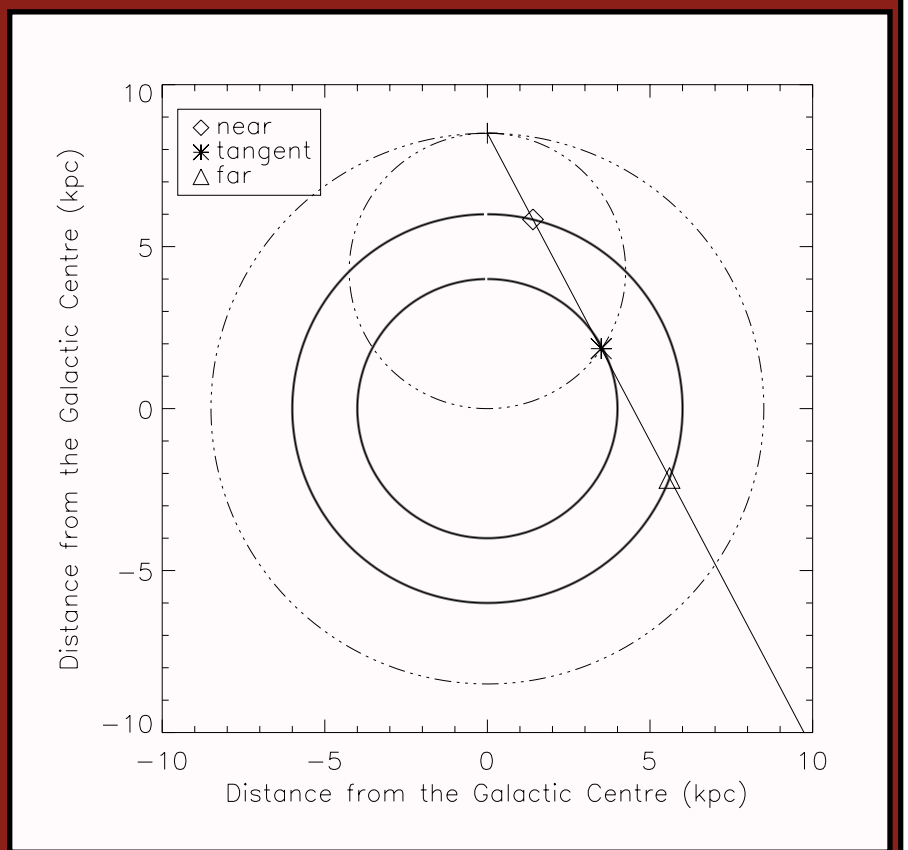
Distance Ambiguity (HI Self-Absorption)

- Once we have a unique velocity to each source we can calculate a kinematic distances using Gal. rotation curve of Brand and Blitz
- For sources in the outer Galaxy the source velocity corresponds to a single distance
- Source locate in the I and IV quadrants and inside the solar circle there are two possible distance equally spaced on either side of the tangent point
  - referred to as near and far distances
- This is know as the distance ambiguity problem
- Signficant obstacle to the determination of reliable kinematic distances



Preliminary Results

Galactic Distribution MYSOs + UCHII

Australia Telescope National Facility

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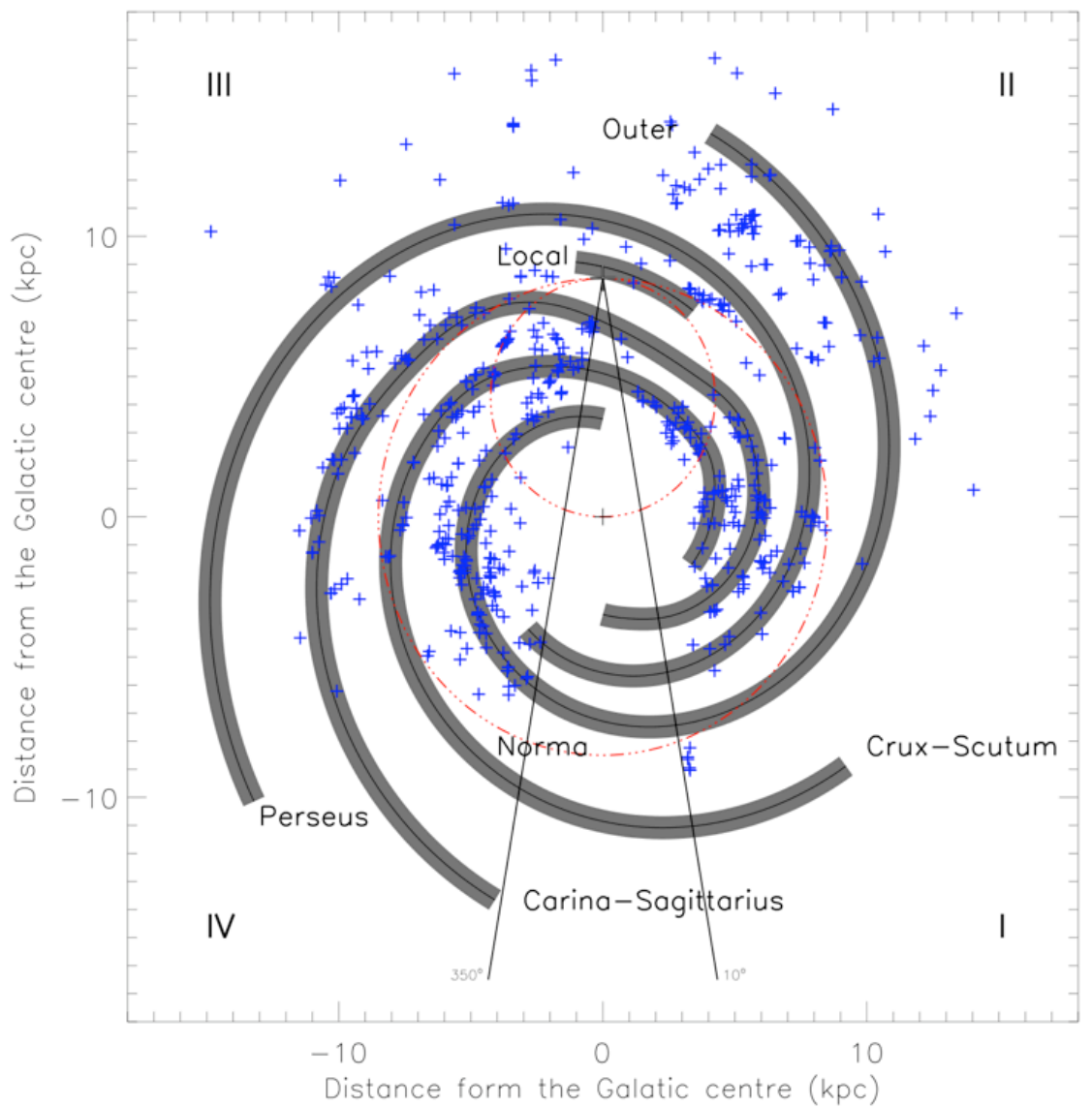

Rotation curve from Brand and Blitz 1993

Spiral arm structure from Cordes & Lazio 2004

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Preliminary Results

Source Identification

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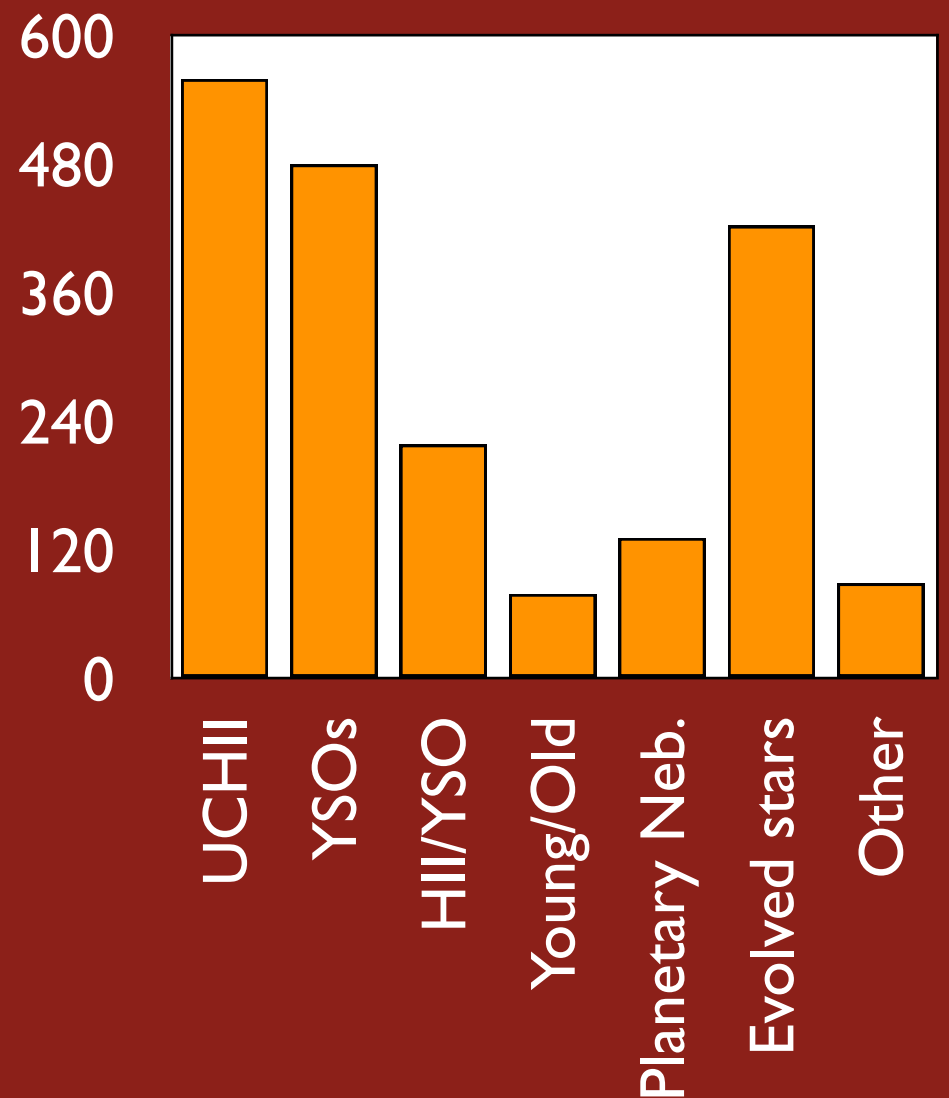

Preliminary Results

Luminosity Distribution

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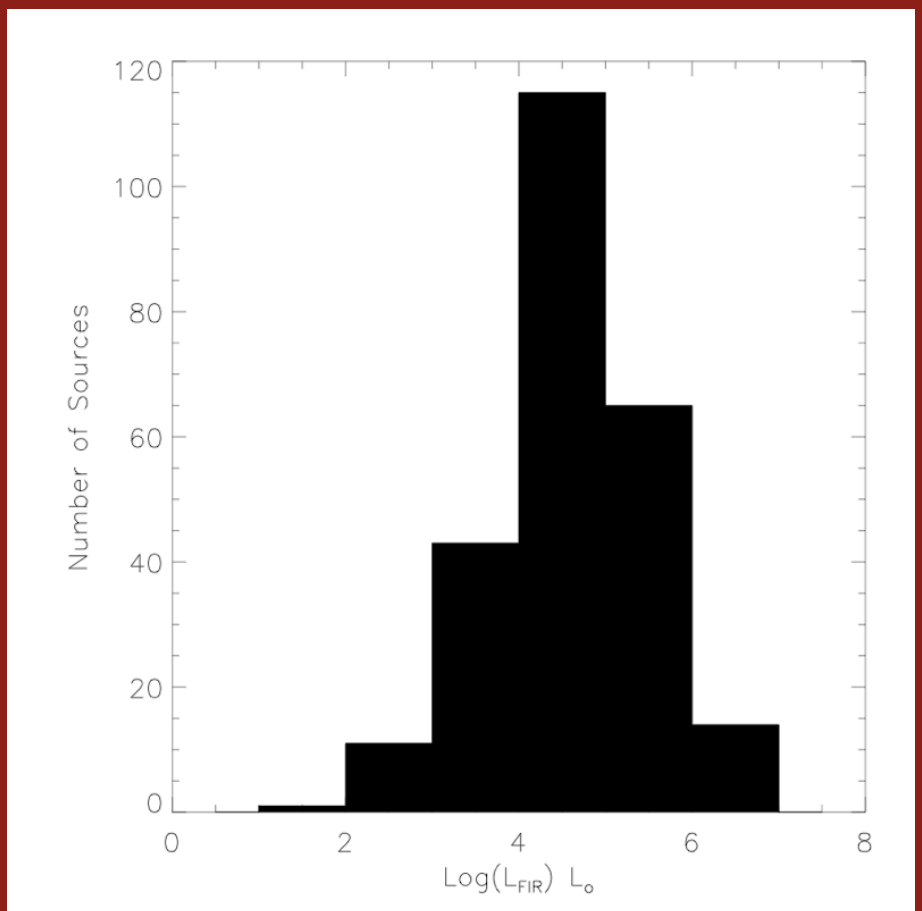
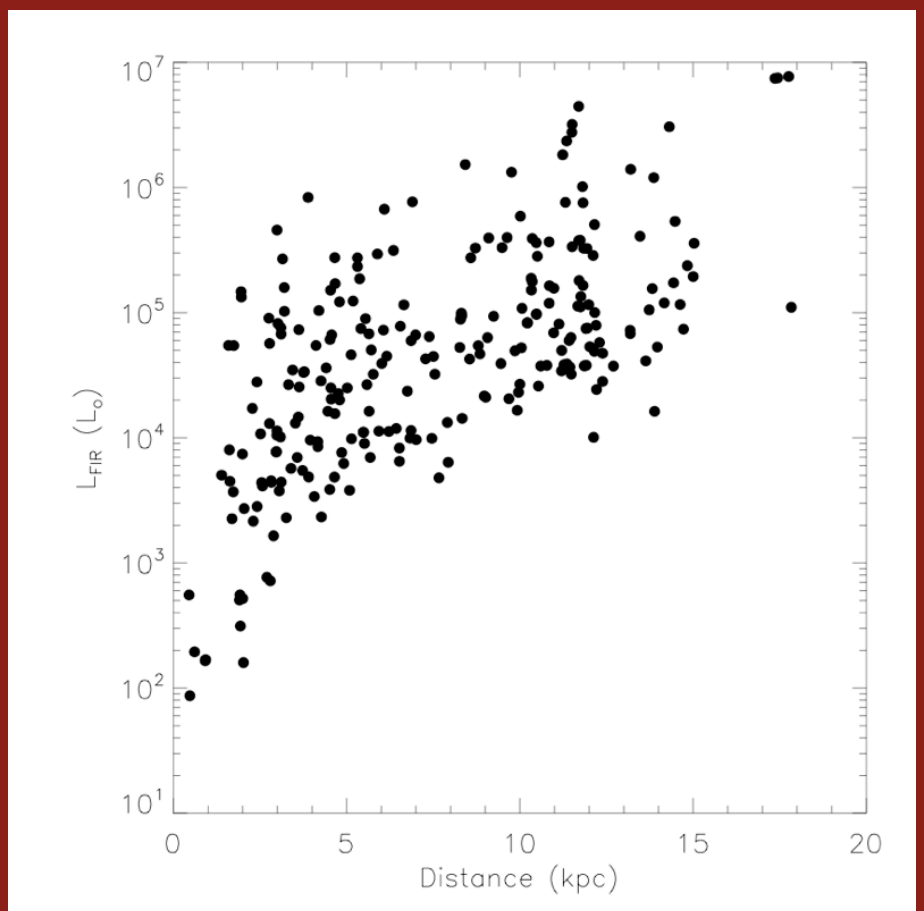
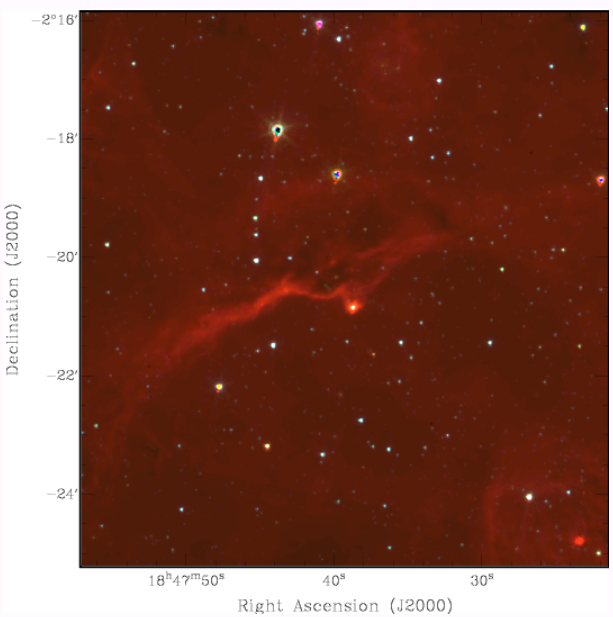


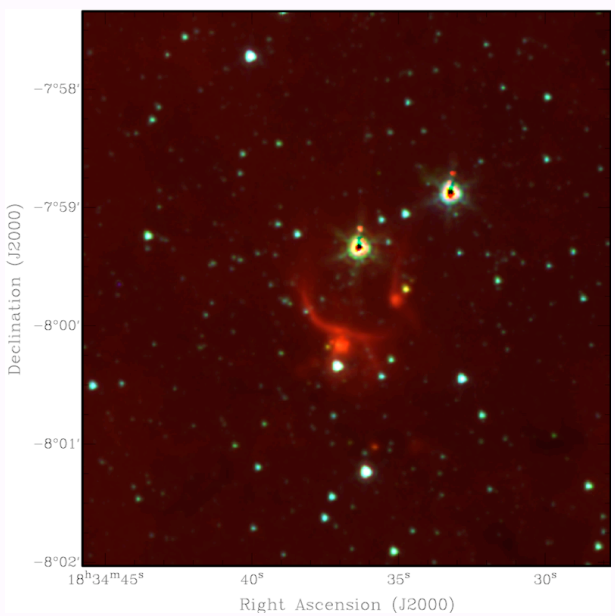


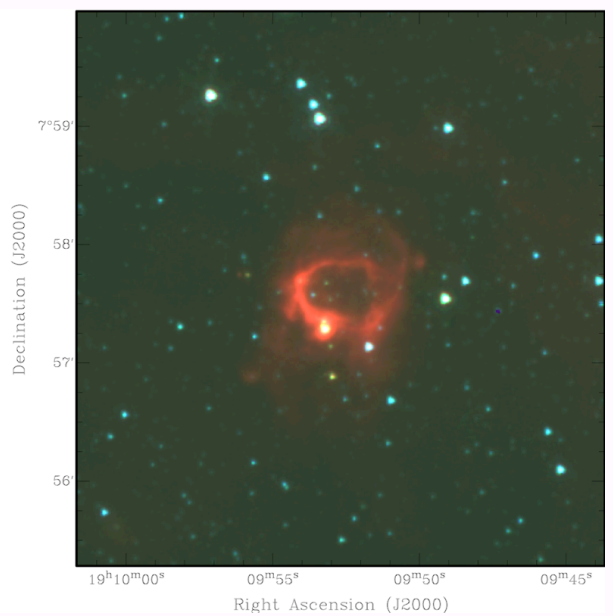
Luminosities have been estimated using the IRAS fluxes (i.e. Emerson 1988)

Further Work

- Broadband chemical study of distance limited sample of MYSO
- Outflow studies (Mopra and JCMT)
- Accretion disks (VLTI, Gemini)
- Studies of potentially triggered regions (IRAM 30m + CARMA)

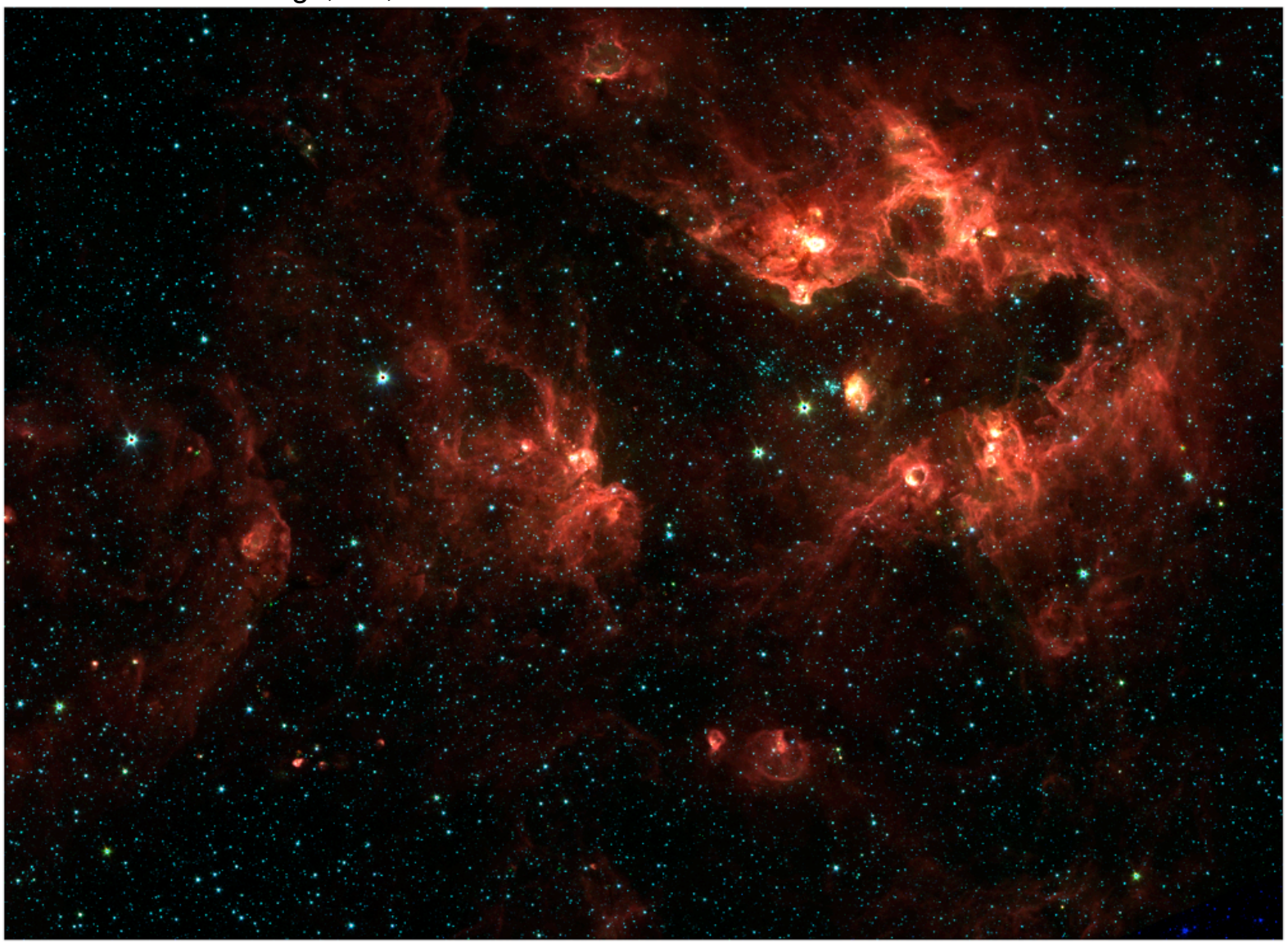






Further Work

GLIMPSE Three Colour Image, 3.6, 4.5 and 8 Micron



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Further Work

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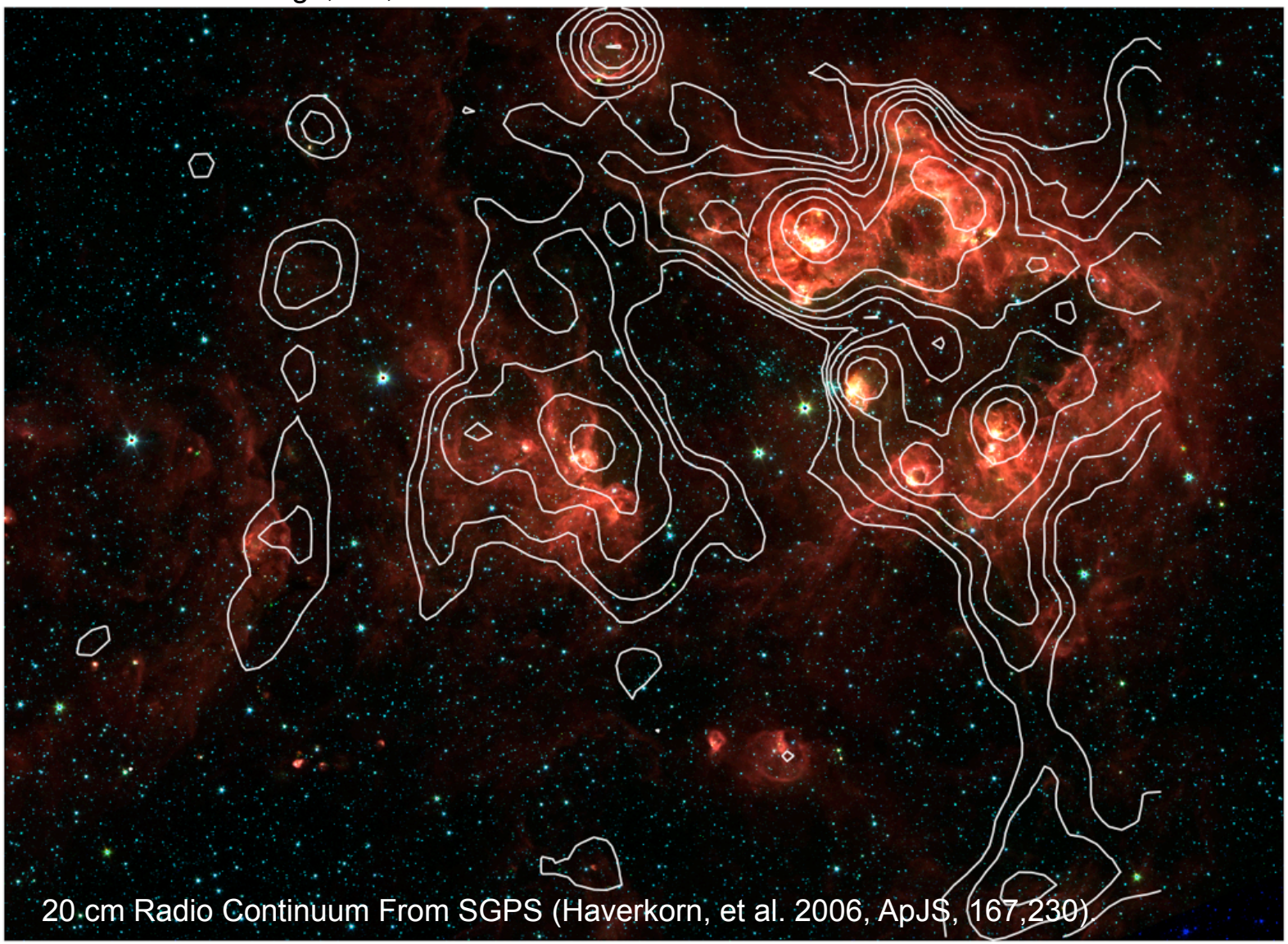

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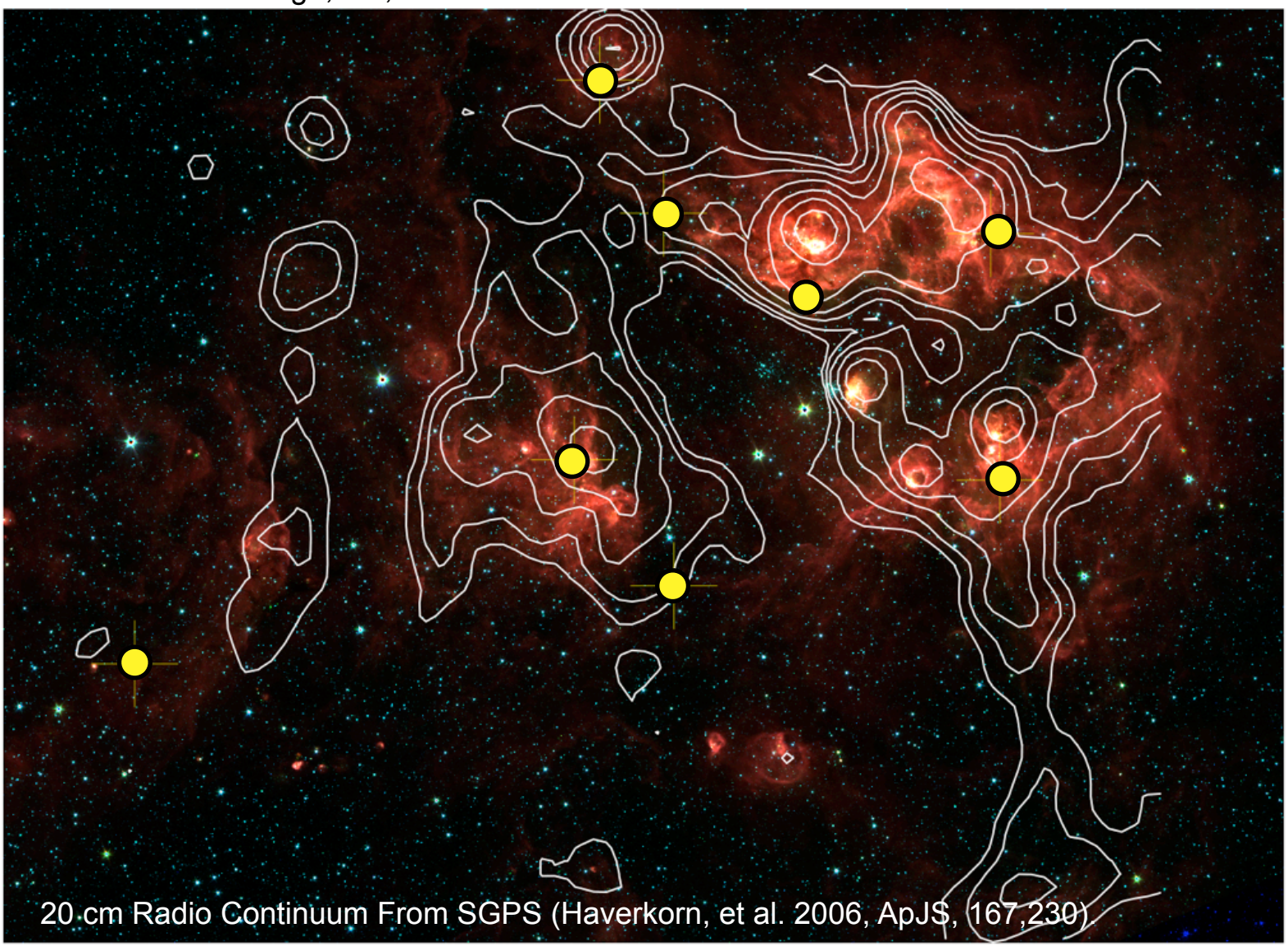

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