First Results from CHaMP

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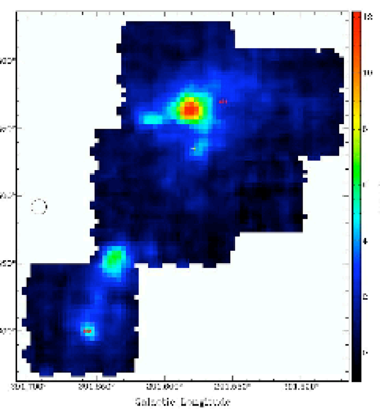
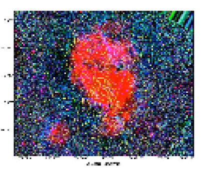
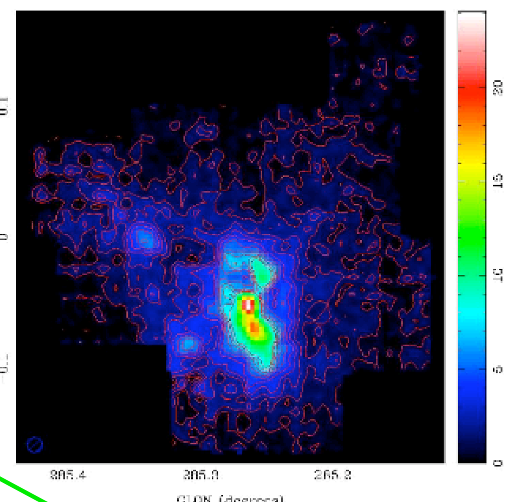
Description

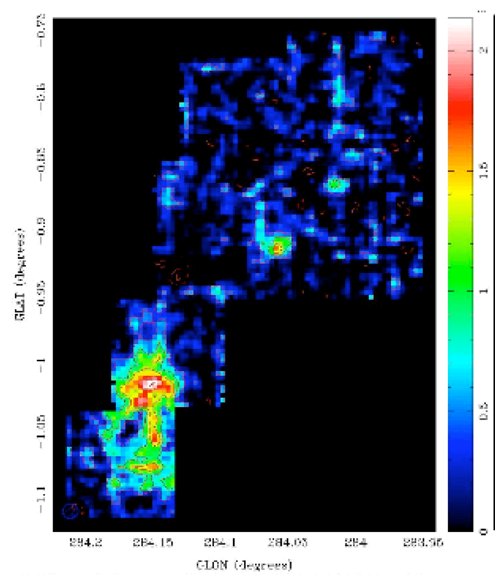
The Census of High- and Medium-mass Protostars (CHaMP) is surveying the earliest phases of massive star formation by compiling the largest, most uniform, and least biased database of such regions at multiple wavelengths. We have bootstrapped from the Nanten Galactic Plane surveys using the 128k-channel digital filterbank on the Mopra antenna of the Australia Telescope, covering a 20°x6° region in Vela, Carina, and Centaurus at 36″ and 0.1 km/s resolution. In 2005–07 we efficiently mapped 118 clumps in this region with multiple tracers, identifying all the dense gas, and we are now characterising their physical state (temperature, density, mass, luminosity, etc.). At the same time, we have begun near-IR imaging spectroscopy of these dense cores with the IRIS2 imager on the Anglo-Australian Telescope, and are also surveying the 1mm dust continuum with ASTE.

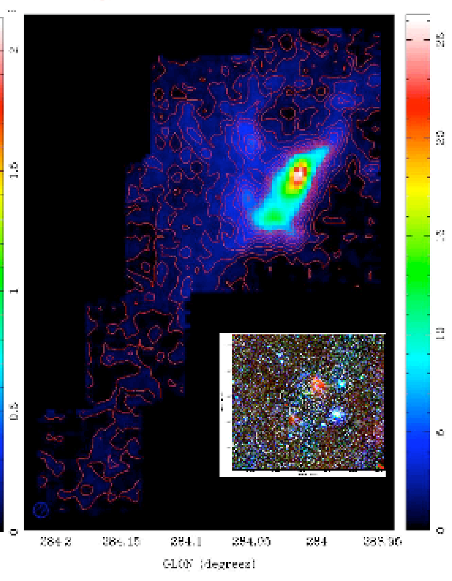
Mopra HCO^+ maps and AAT *K*-band images

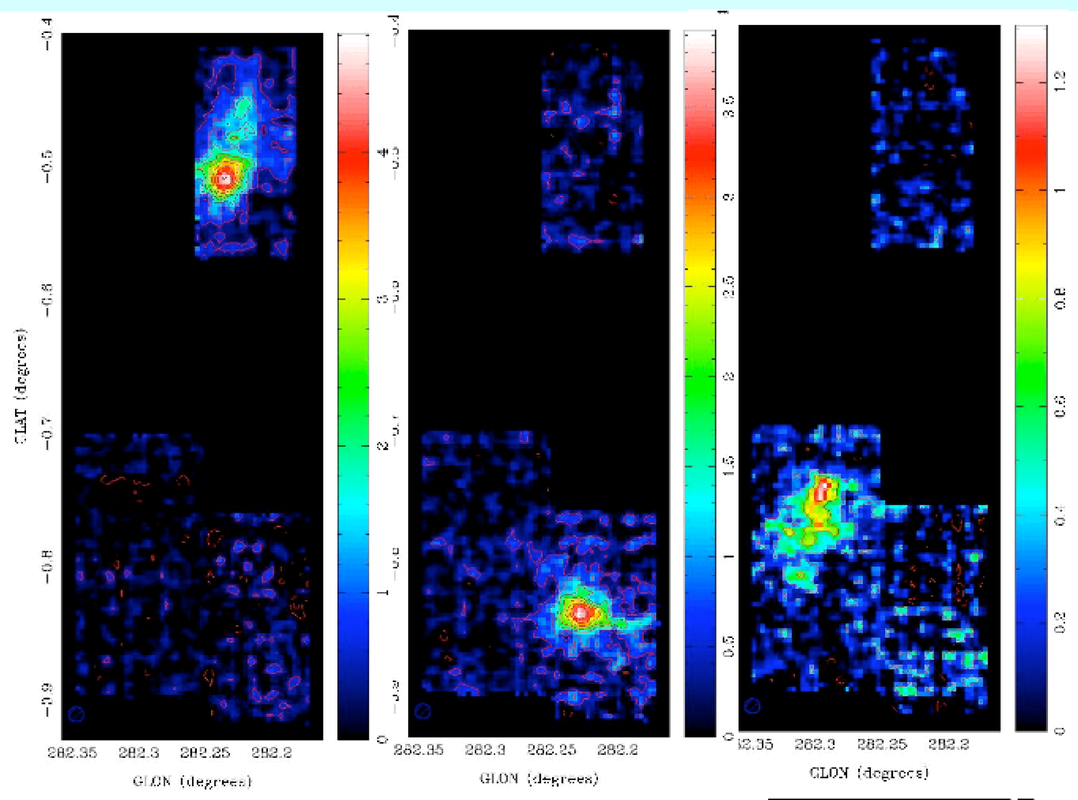


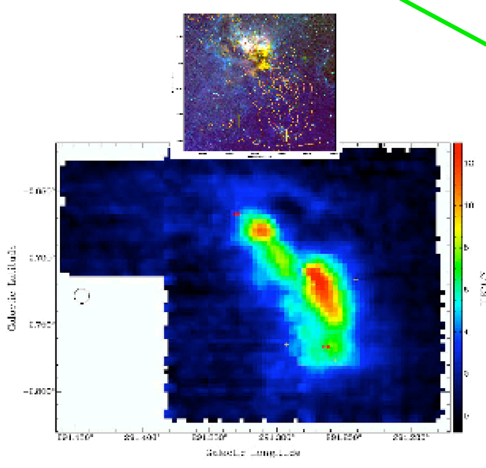




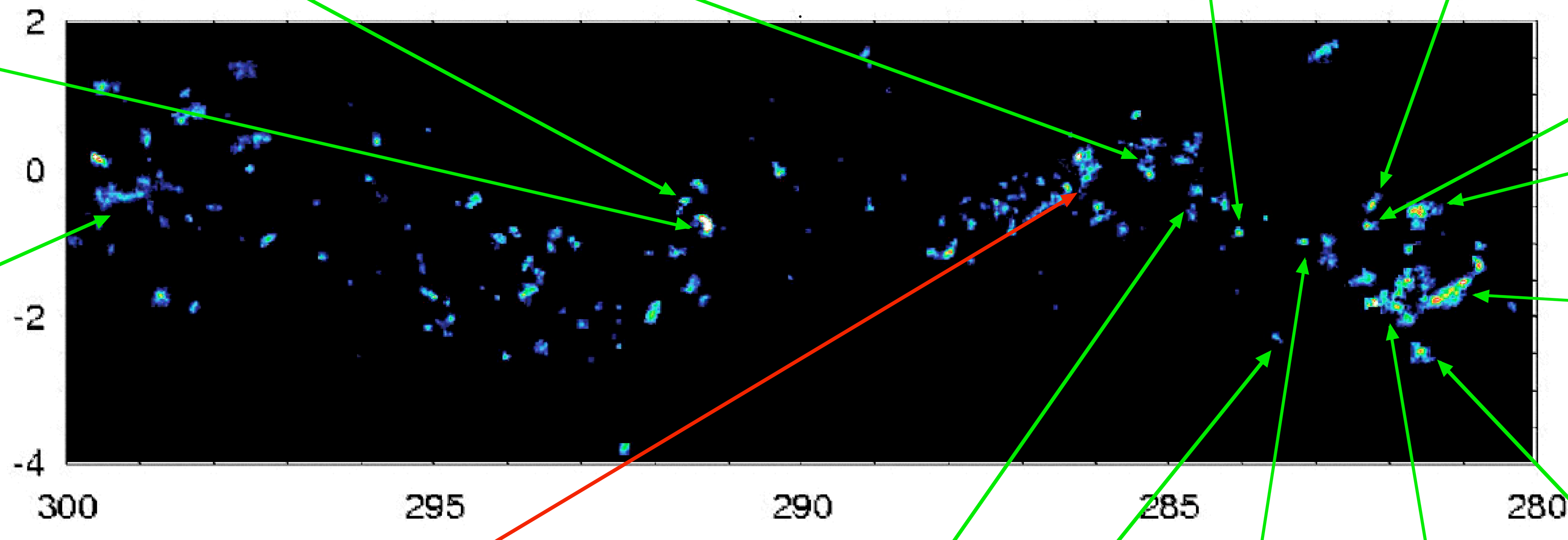


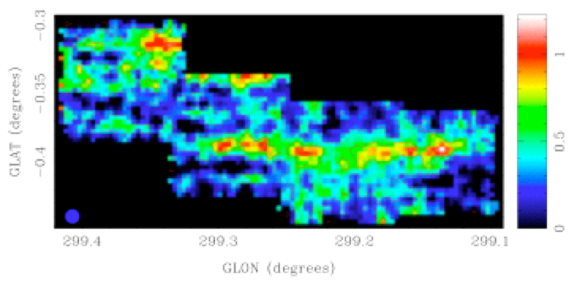


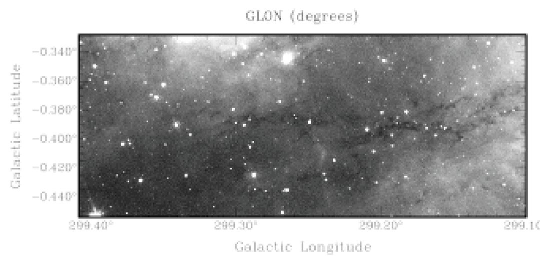




Integrated intensity of $C^{18}O$ emission from the Carina arm, mapped with Nanten. All clumps were mapped in multiple lines near 90 GHz at Mopra.

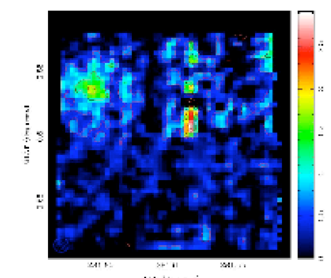


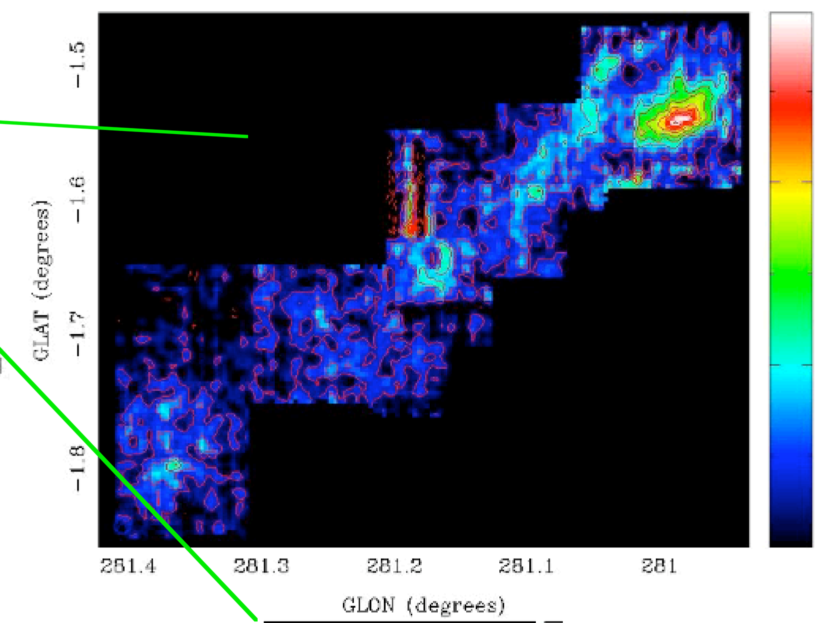


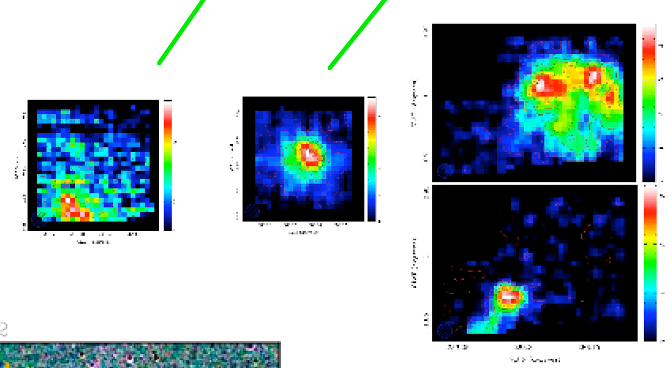


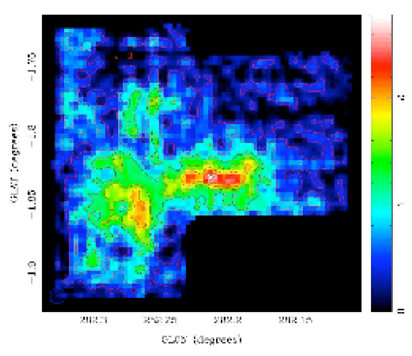
IRAC

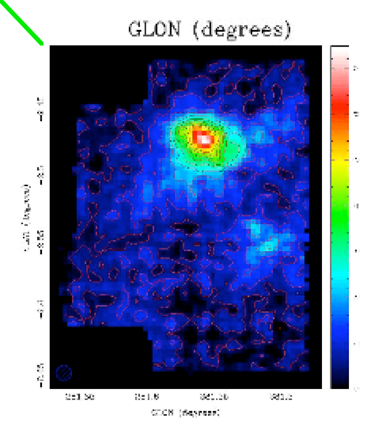
(Top) Integrated intensity in the HCO^+ 1–0 line as mapped at Mopra, units of K km/s. (Bottom) GLIMPSE IRAC 8μm image of the same region.

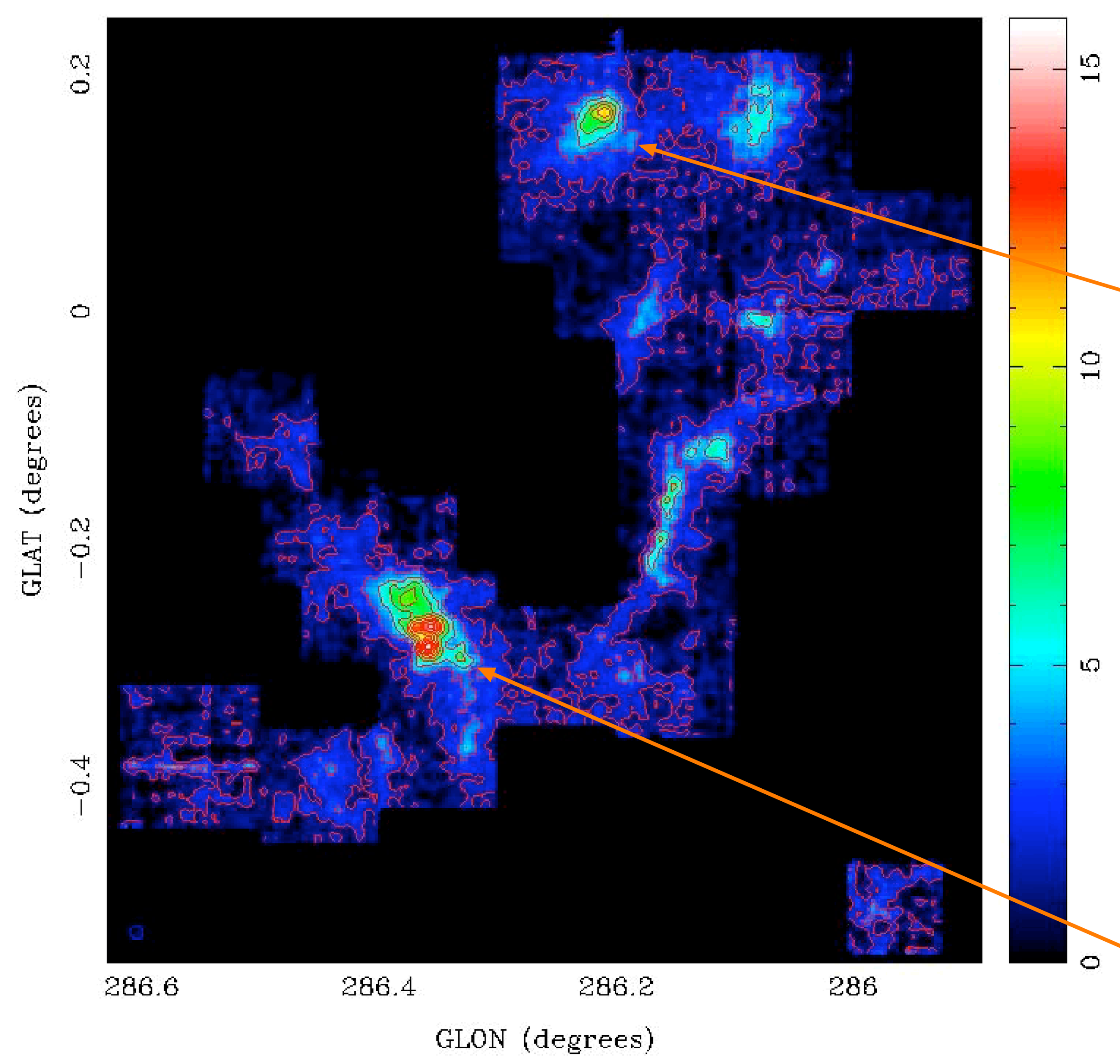




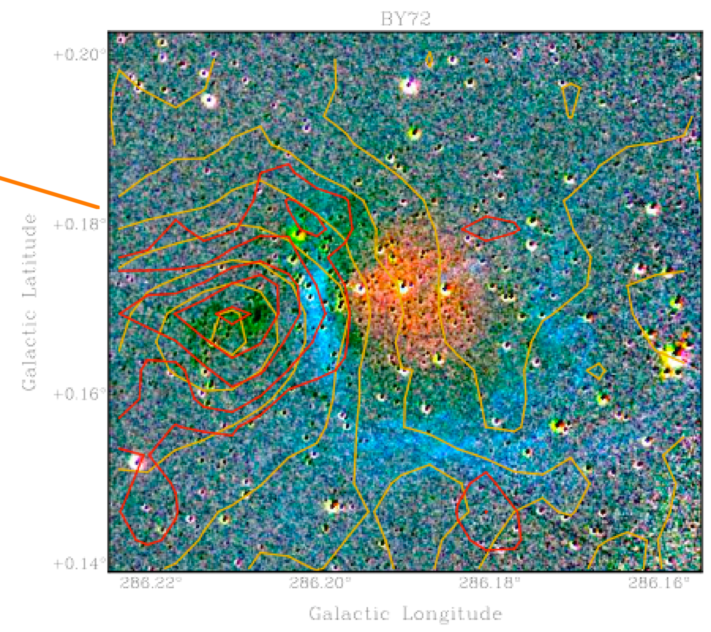




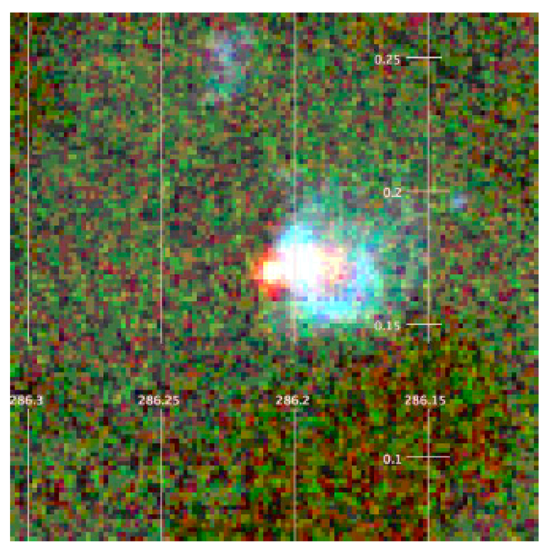




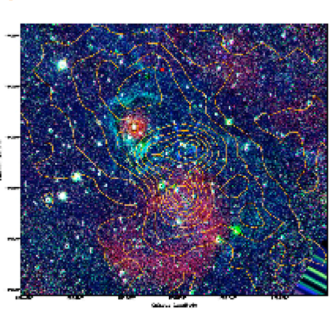
Spectacular streamers and dense clumps near η Carinae, in Mopra HCO^+ J=1–0 integrated intensity.



(Above) Overlay of a K-band pseudocolour image (red = continuum subtracted Br-γ, blue & green = continuum-subtracted H_2 S(0) v=2–1 and 1–0) with Mopra HCO^+ & $H^{13}CO^+$ contours, of a dense clump showing evidence of large-scale gravitational collapse. (Right) Pseudocolour mid-IR MSX image (8,12,21μm) of the infall: the gravitational luminosity of the infall itself contributes significantly to the bolometric luminosity.



MSX



Here and elsewhere: more continuum-subtracted Br-γ (red) and H_2 (blue & green) narrowband 2μm images from the AAT, with Mopra HCO^+ contours of the associated molecular clumps.

Conclusions

These data will allow us to take an unbiased census of all massive protostars and protostellar clusters in our 20°x6° survey region on both large and small scales, as well as identifying massive starless cloud cores, and for the first time

(a) uniformly identify the normal evolutionary stages of higher-mass star formation,

(b) characterise the physical conditions in the dense gas at each stage,

(c) directly compute the lifetimes of each stage, and

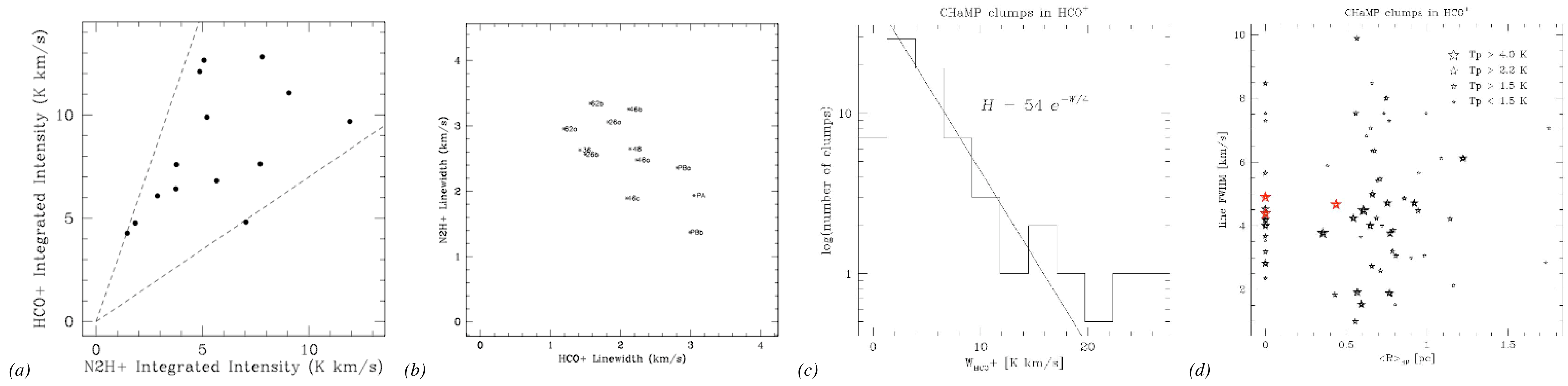
(d) compare these results with other biased surveys.

"More massive star-forming clumps than you can poke a stick at!"

Sample Results

While we see a number of bright clumps in HCO+ and other dense-gas tracers, there is an unexpectedly large population of fainter HCO+ clumps (W < 5 K km/s) which represent the majority of the clumps comprising GMCs as well. Among all clumps, the incidence of infall is so low that it must last only ~4% or less of the lifetime of a GMC. Also, bright HCO+ , HCN, and N_2H^+ emission trace different environments despite requiring similar physical conditions for excitation.

All clumps



*(a) Comparison of integrated intensities in two species from several CHaMP clumps. The HCO+ to N_2H^+ ratio varies among these clumps by a factor of 4. (b) Comparison of HCO+ and N_2H^+ linewidths in the same clumps. Note the striking anticorrelation. Both of these features suggest a strong chemical and dynamical difference in what these two species trace in the dense gas, which must be addressed by theory. (c) Source function of all HCO+ clumps, showing a strong decline in numbers with increasing brightness. This suggests that most of the mass in star-forming dense molecular clumps does **not** lie among the more commonly-studied brights clumps. (d) Very preliminary size-linewidth relation of HCO+ clumps, with symbols keyed by brightness.*