MALT90 Unveiling its treasures

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James Jackson, Jill Rathborne, Andres Guzman, Jonathan Foster, Scott Withaker, Patricio Sanhueza, and the MALT90 team.

MALT90: Millimetre Astronomy Legacy Team 90 GHz

The primary goal of MALT90 is to characterize star-forming clumps and to study their physical and chemical evolution

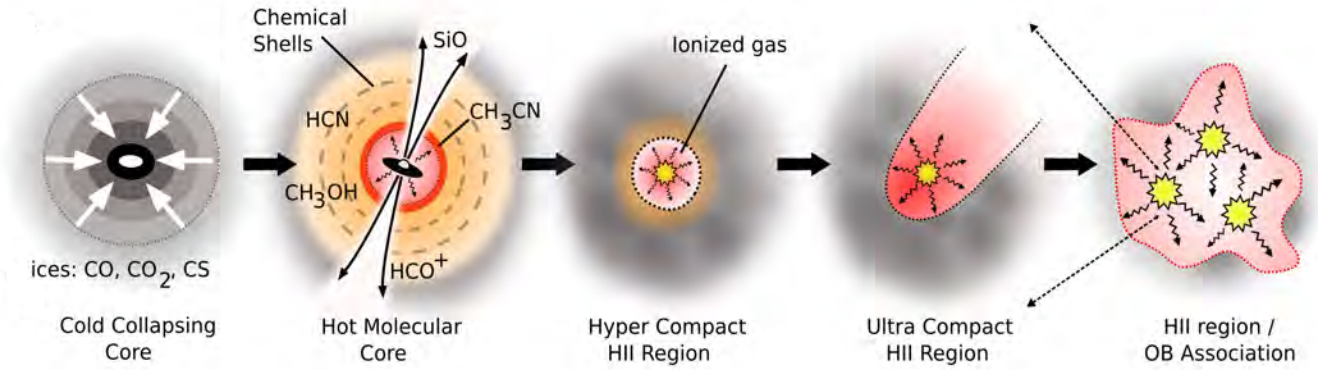
- **MALT90 Data available to everyone via the Australia Telescope Online Archive ATOA:**

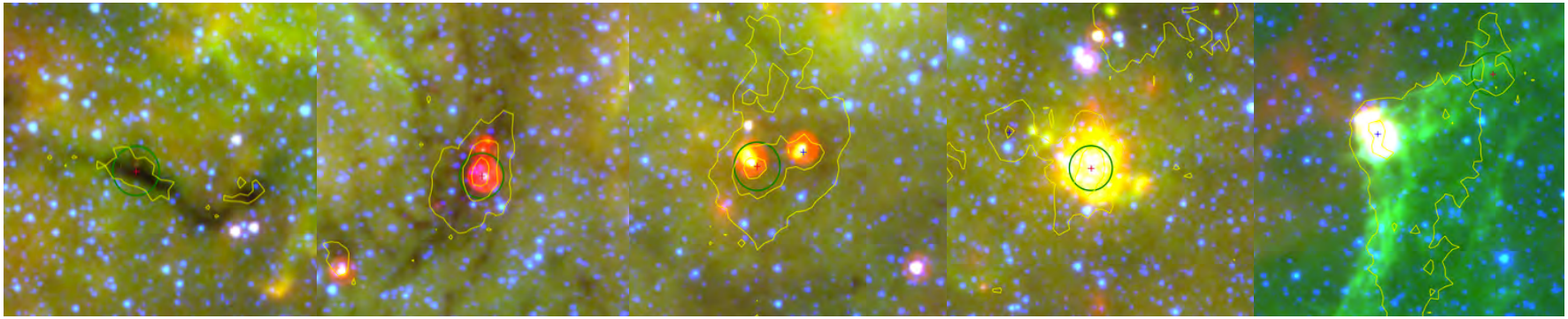
  http://atoa.atnf.csiro.au/MALT90

- **Catalog** (Rathborne et al., in prep.)**:**
  - Peak spectra, Temp, V_{LSR}, DV, 2-d Integrated emission of each of the 16 molecular lines.
- **Kinematic distances** (Jackson et al., in prep.)

- **Column densities and temperatures** (Guzman et al., in prep.)
  - Column density and temperature obtained from Hershel + ATLASGAL maps.
- **Masses and bolometric luminosities** (Contreras et al., in prep.)

Evolutionary stages

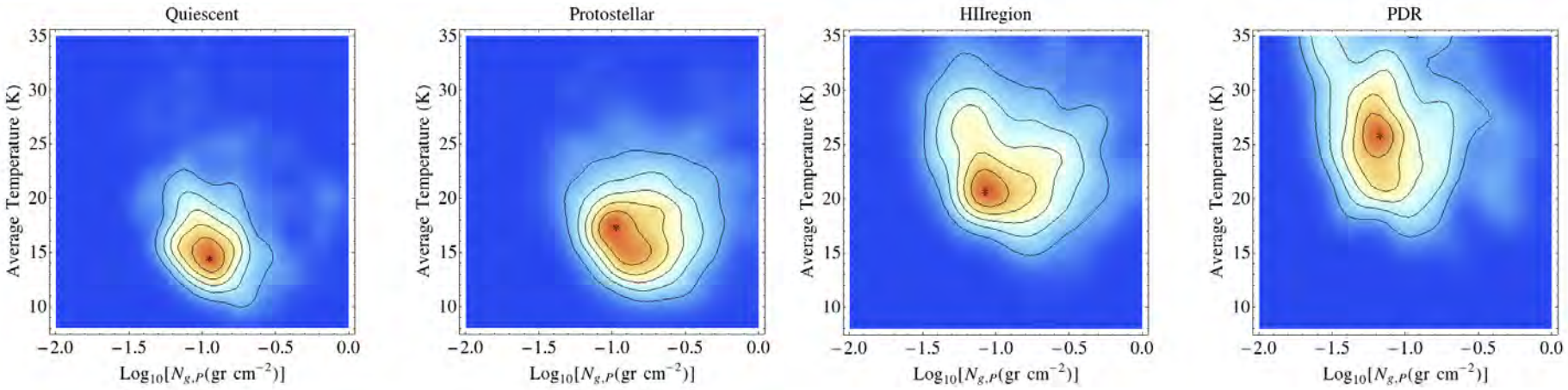




Pre-Stellar | Proto-Stellar | Compact HII Region | HII Region | PDR

Image courtesy Cormac Purcell

Column density and temperatures

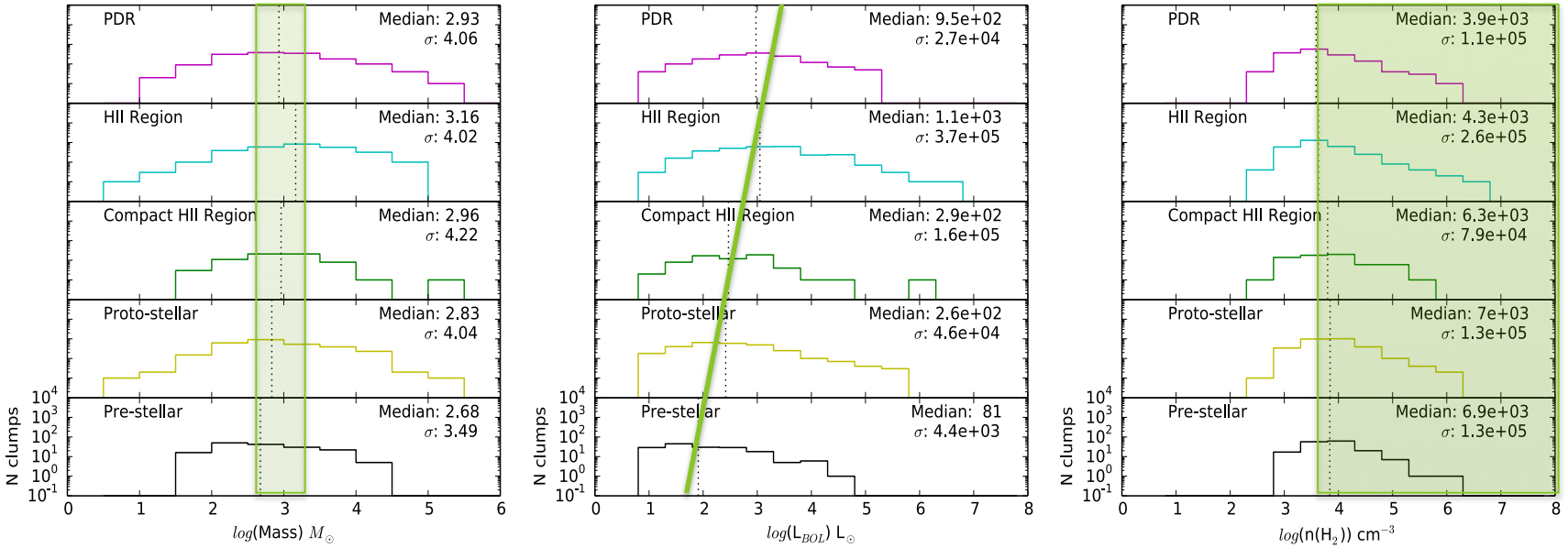


- Fit of the SED using Hershel and ATLASGAL dust continuum emission
- Monotonic increase of dust temperature with evolutionary stage of the clumps
- Column density increase and then decrease, finding the highest $N(H_2)$ associated with Proto-stellar clumps

Instrument	Band	FWHM
PACS	160	12
SPIRE	250	17
SPIRE	350	24
SPIRE	500	35
LABOCA	870	19.2

Guzman et al. In prep.

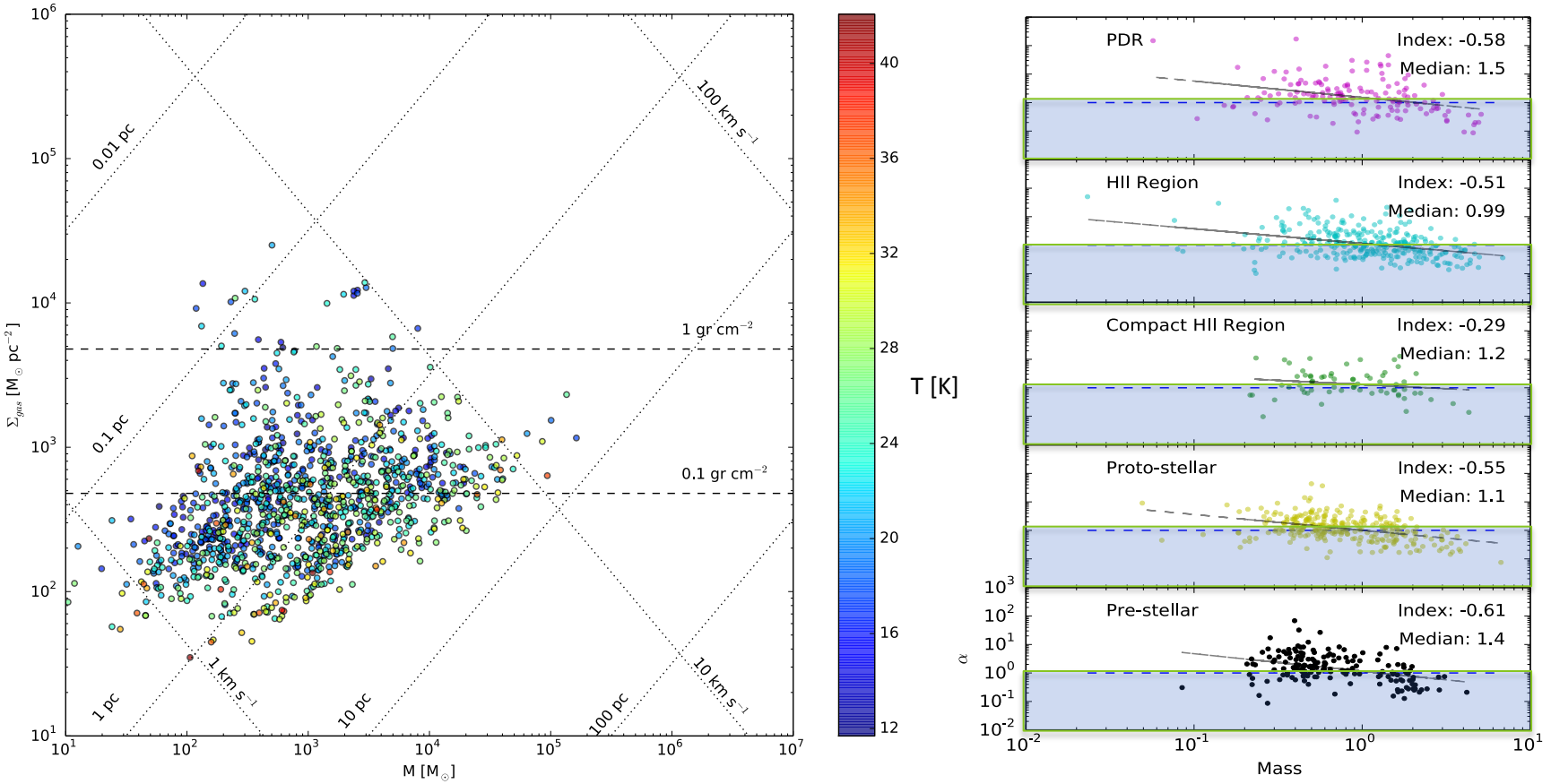
Physical properties and evolutionary stages



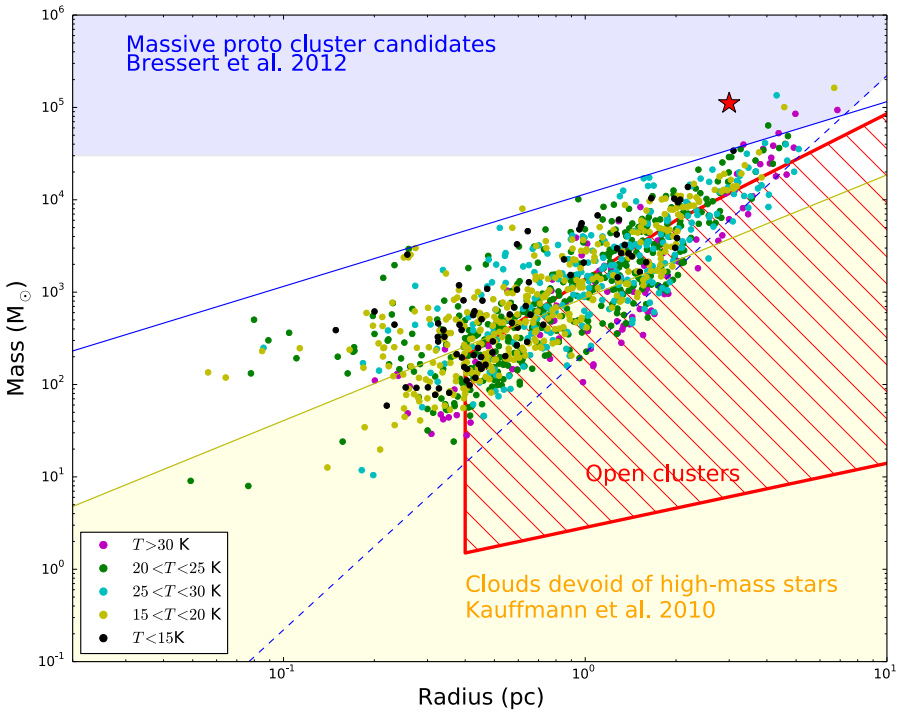
Signs of evolution in the MALT90 clumps:

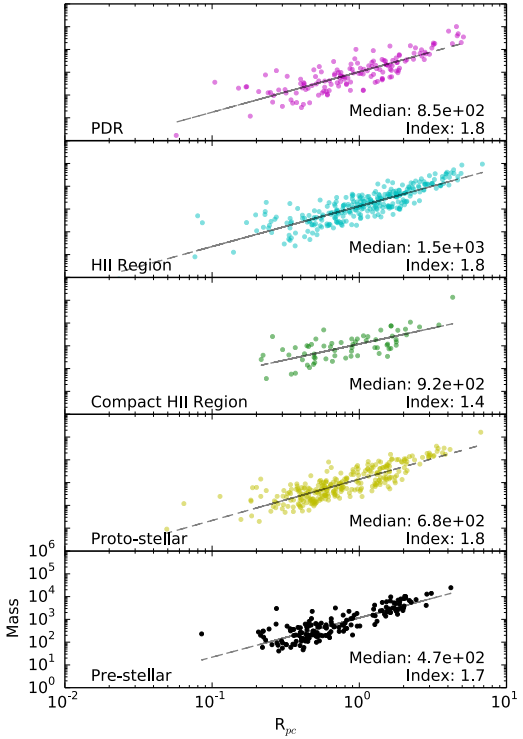
- No trend between the mass of the clumps and their evolutionary stage
- Bolometric luminosity increases with the evolutionary stage of the clumps
- Large number of clumps with volume density > 10^4 cm^{-3}

Star formation in MALT90 clumps



Star formation in MALT90 clumps

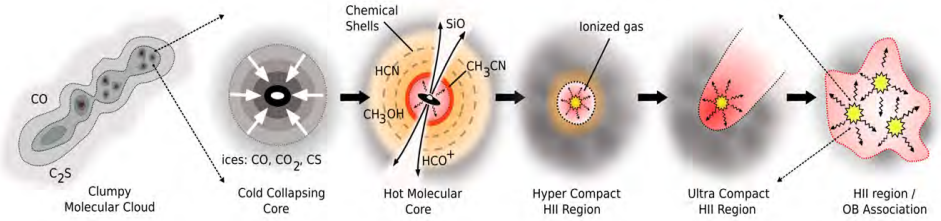


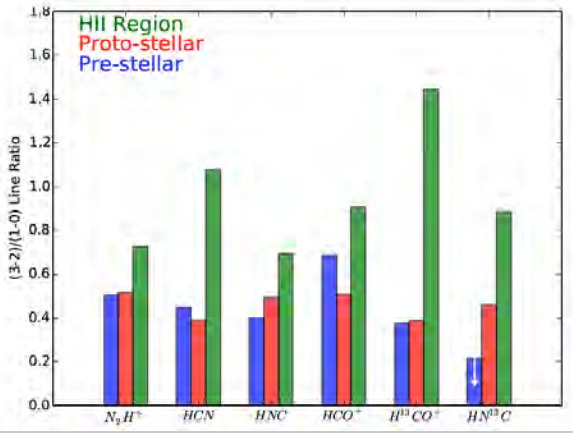


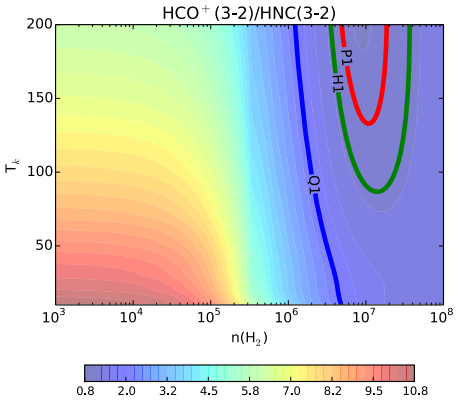
- Most clumps will potentially form high-mass stars
- Few massive proto cluster candidates
- Slope consistent with constant column density

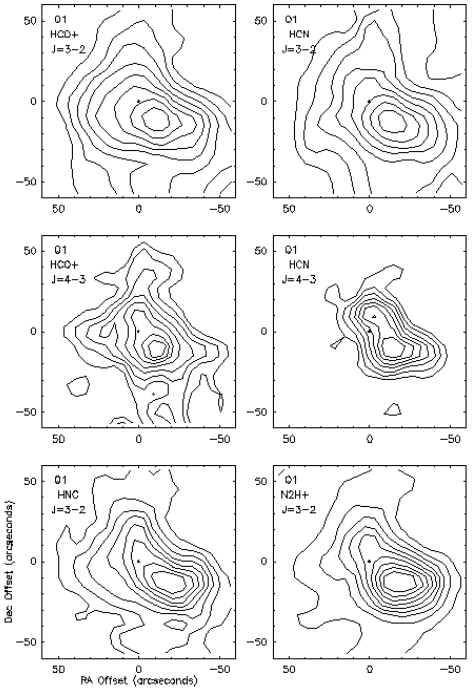
SuperMALT

- International collaboration between CASS, Chile, ESO and Germany
- Observe a sub-sample of MALT90 in high-J transitions and deuterated species: HCO^+, HCN, HNC, N_2H^+ (3-2) and (4-3); $H^{13}CO^+$(3-2); NH_2D(1-0)
- Determine accurate temperatures and column/volume densities using radiative transfer codes



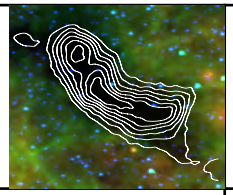
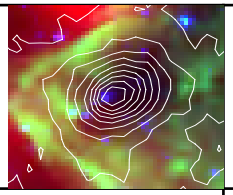
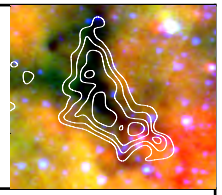


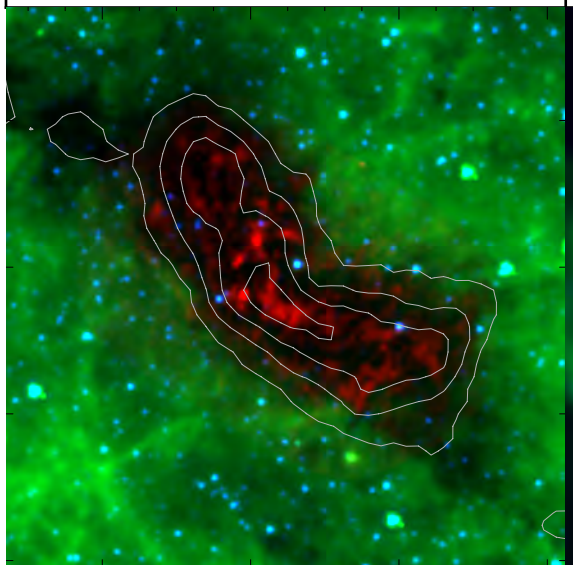


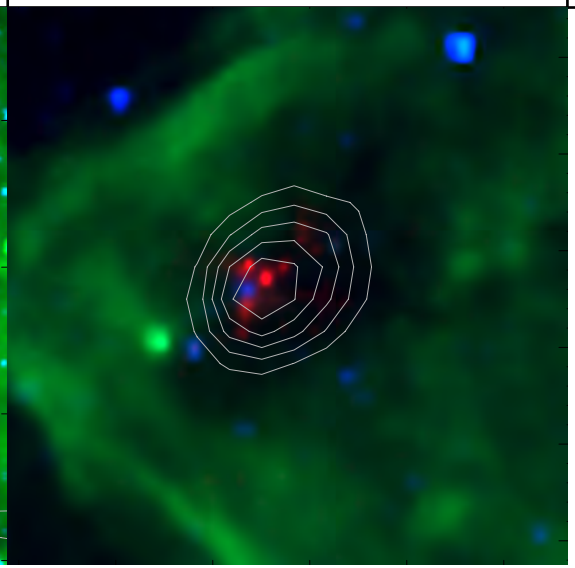


See Poster Sudeep Neupane!

Finding chart to study cluster forming clumps with ALMA

The Brick Rathborne et al. 	G305 Servajean et al. 	G331 
Mass: 10^5 $M_\odot$, n(H_2): 10^4 cm^{-2}, T<20K Galactic Center, No SF	Mass: 10^3 $M_\odot$, n(H_2): 10^4 cm^{-2}, T<20K Galactic Plane, SF	Mass: 10^4 $M_\odot$, N(H_2) 10^4 cm^{-2},T<20K Galactic Plane, No SF





Blue: *Spitzer* 3.5μm – stars; Green : *Spitzer* 8μm – diffuse Galactic background
Red : ALMA 3mm (Brick), 1mm (G305) – thermal dust; Contours : Single dish 870 μm dust emission

Summary

- Determined reliable column densities and temperatures for the 3200 MALT90 clumps
  - Increment of the dust temperature with evolution of the clumps
  - Highest column densities in proto-stellar stage
- Found increment of the bolometric luminosity consistent with evolution
- We found a large population of high-mass pre stellar clumps
- SuperMALT will further constrain the physical properties of the gas by observing high-J transition and the use of radiative transfer analysis
- MALT90 represent an excellent finding chart for follow ups with ALMA

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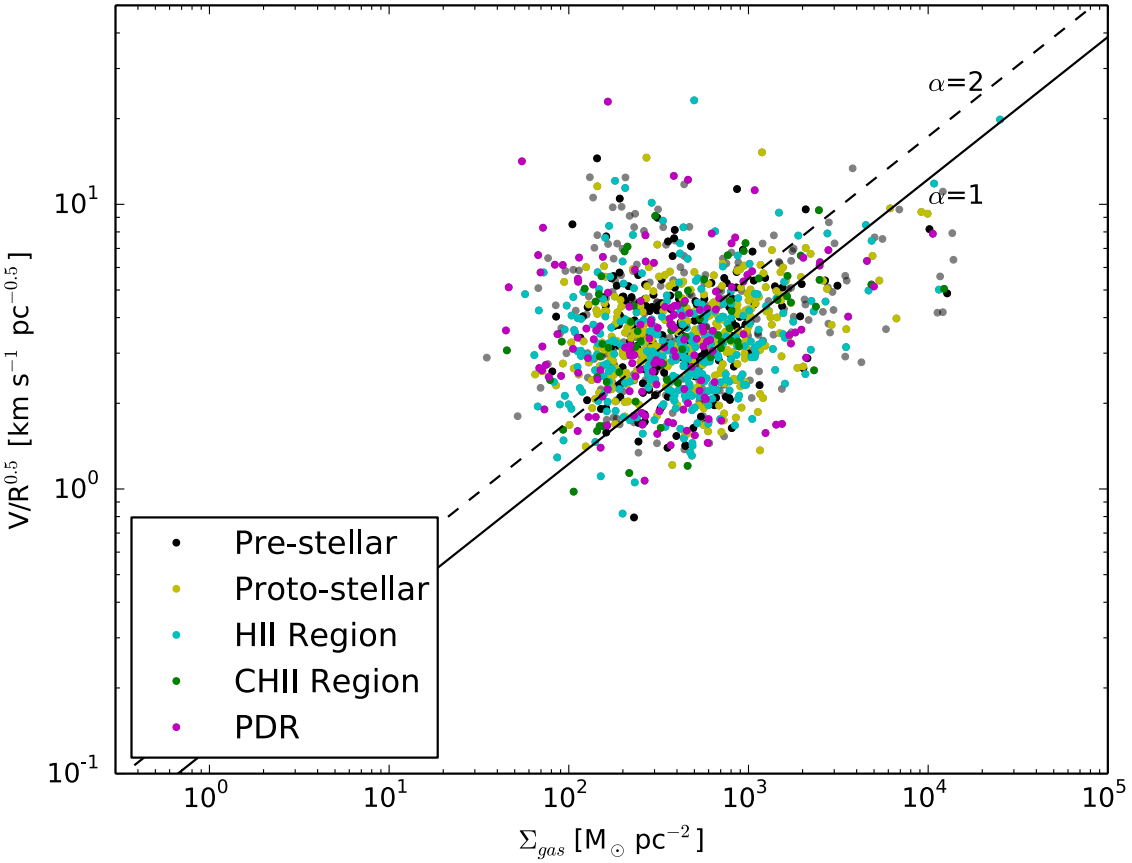
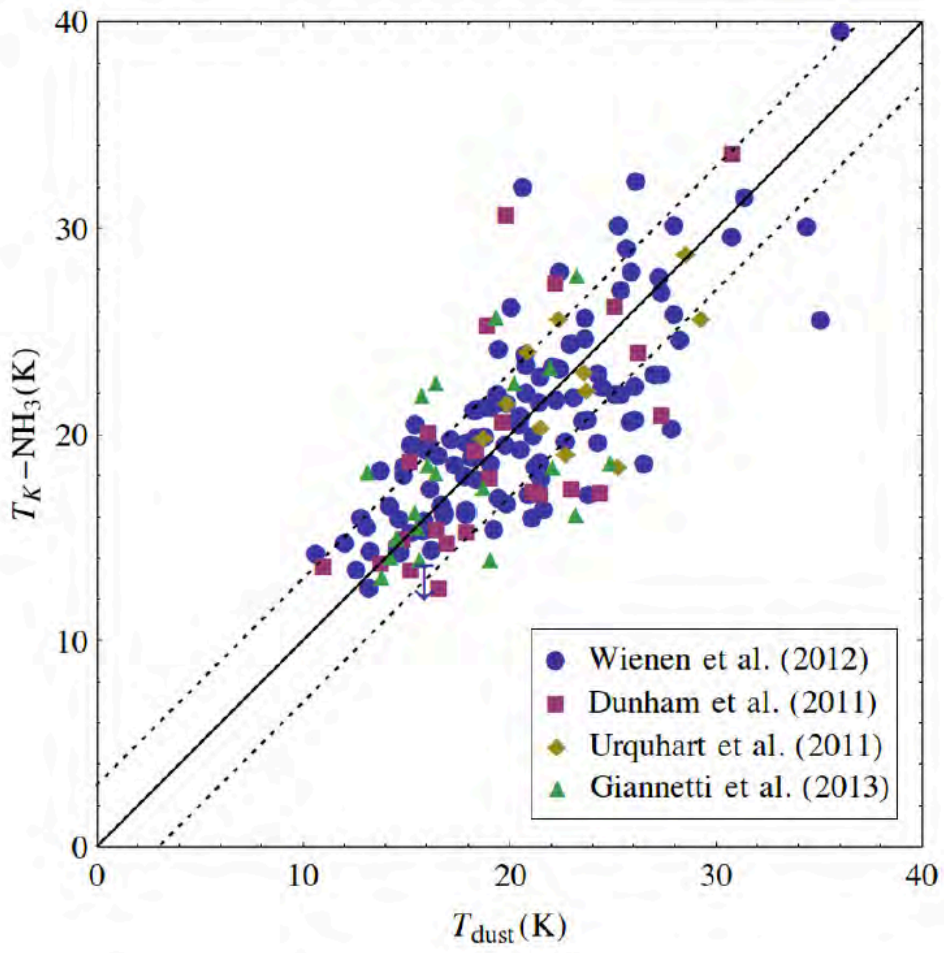
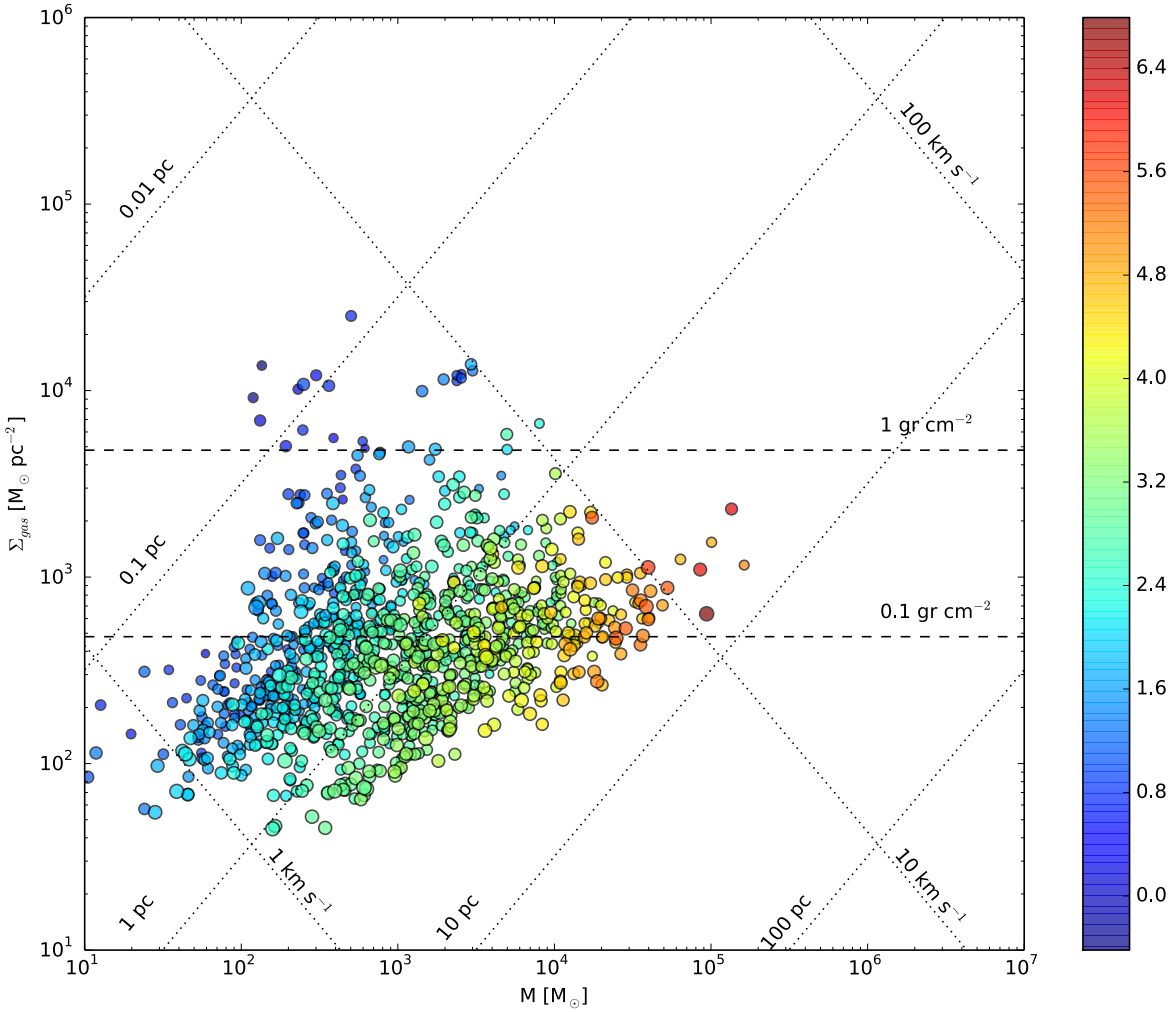
Thank you

σ – Σ plot


α=2
α=1
Pre-stellar
Proto-stellar
HII Region
CHII Region
PDR
V/R$^{0.5}$ [km s^{-1} pc$^{-0.5}$]
Σ_{gas} [M$_\odot$ pc^{-2}]
10^{-1}
10^{0}
10^{1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}

Gas vs dust temperatures




0.01 pc
0.1 pc
1 pc
10 pc
100 pc
1 km s^{-1}
10 km s^{-1}
100 km s^{-1}
1 gr cm^{-2}
0.1 gr cm^{-2}
Σ_{gas} [M$_\odot$ pc^{-2}]
M [M$_\odot$]
10^1
10^2
10^3
10^4
10^5
10^6
10^7
6.4
5.6
4.8
4.0
3.2
2.4
1.6
0.8
0.0