THE ALMAGAL SURVEY:
Spectral line temperature catalogue

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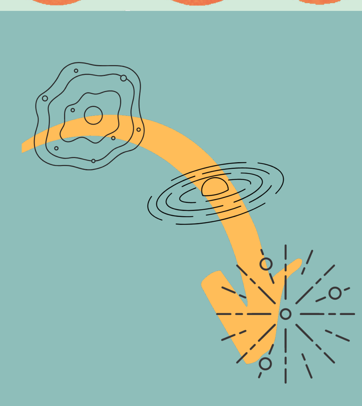
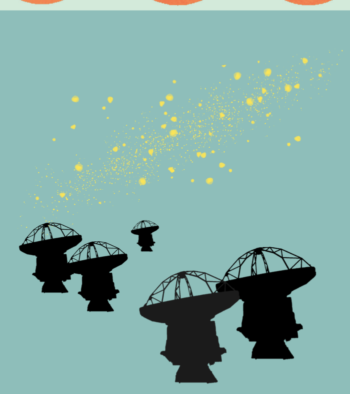
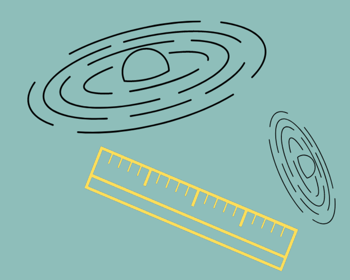
The ALMAGAL Survey

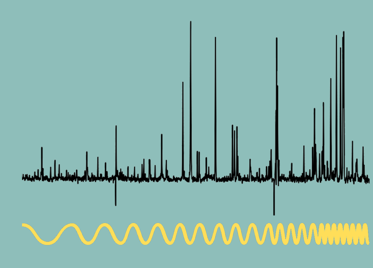

1007 high-mass star forming clumps


Luminosity-to-mass ratio from 0.05-500 $L_\odot/M_\odot$

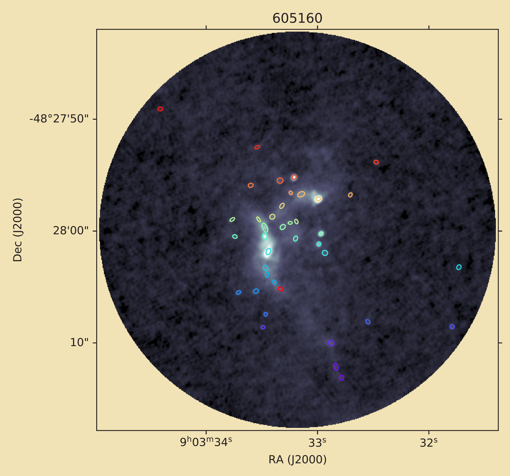

3 configurations of ALMA in band 6 (1mm)

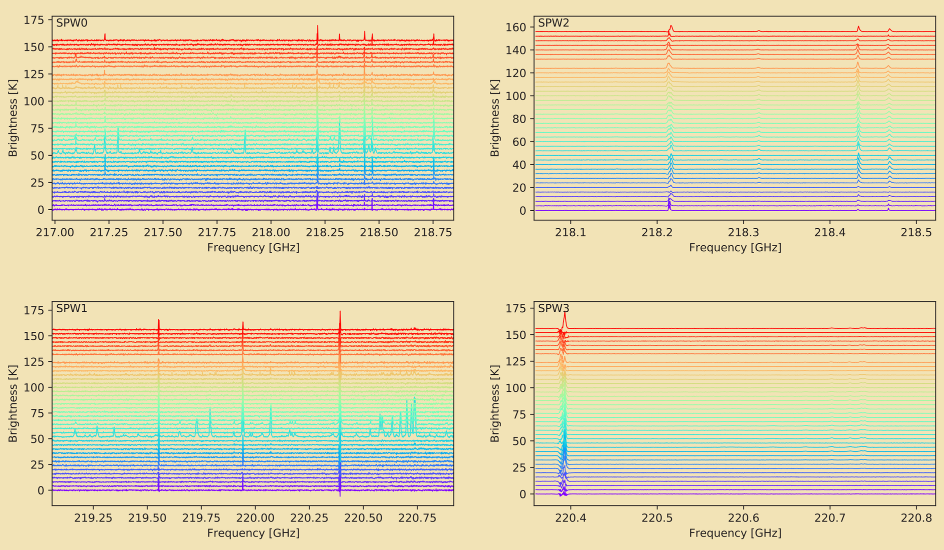

Spatial resolution of ~1000 AU


Continuum sensitivity of 0.1 mJy (0.3 $M_\odot$)


10,000 spectral channels at 1.5, 0.3 km/s resolution

Spectra and Species

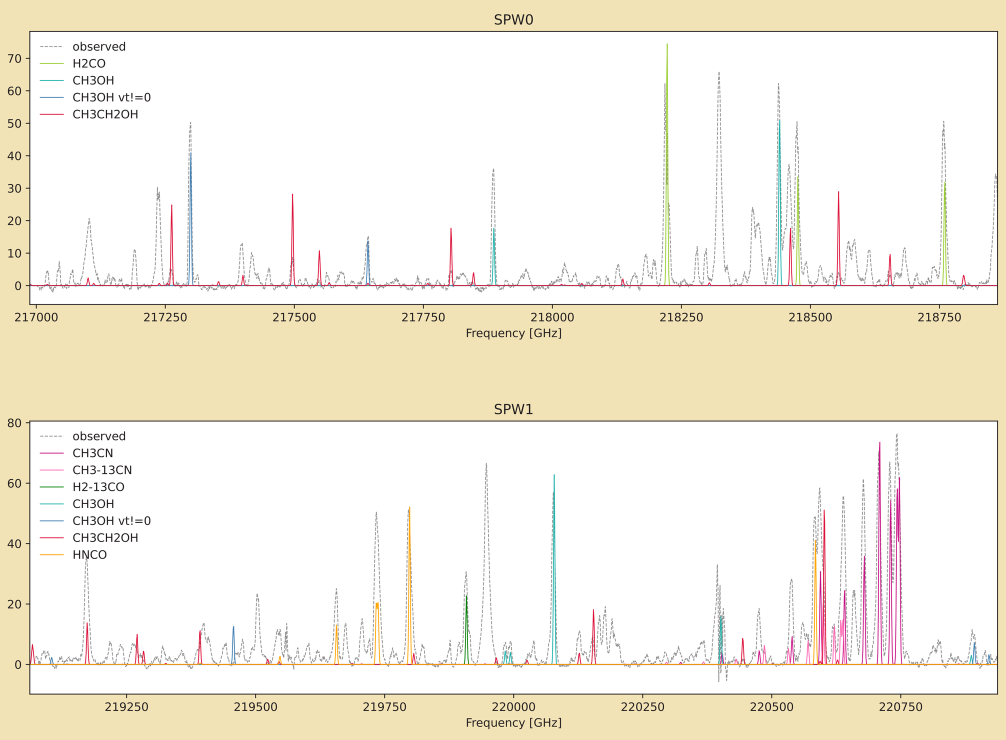




Mean spectra are extracted toward each core identified over the full-width at half-maximum ellipse of the continuum emission. For the initial temperature catalogue, only limited species are considered for temperature fitting (CH_3CN, H_2CO and CH_3OH and their isotopologues) and species necessary for line deblending (CH_3CH_2OH, HNCO).

Temperature tracers

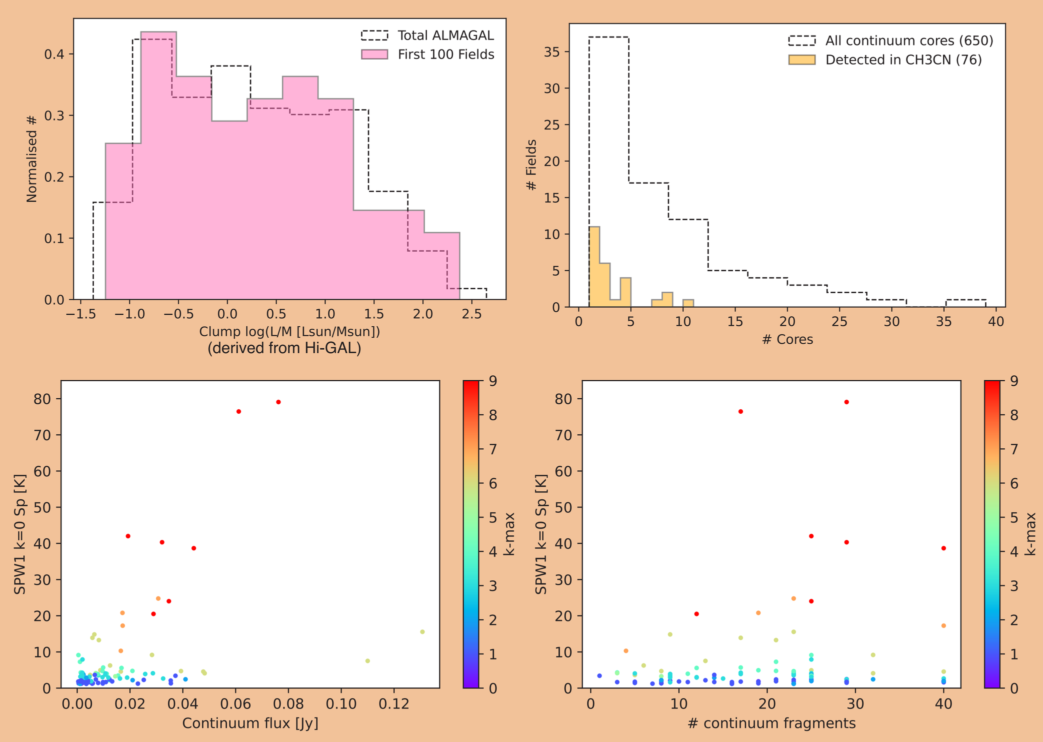
Methanol	CH_3OH	T_{ex} 35 - 735K
Formaldehyde	H_2CO, $H_2^{13}CO$	T_{ex} 10 - 70K
Methyl Cyanide	CH_3CN, $CH_3^{13}CN$	T_{ex} 60 - 920K



Blended species

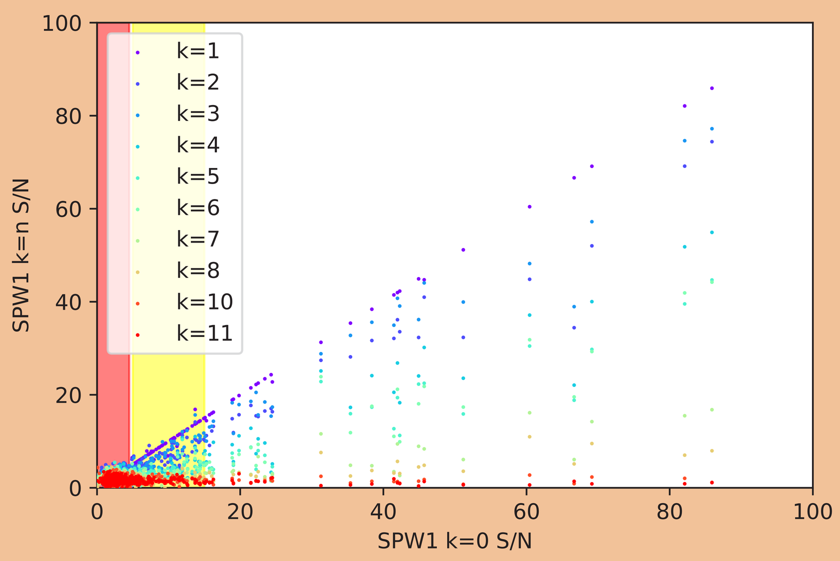
Ethanol	CH_3CH_2OH	T_{ex} 65 - 1640K
Isocyanic Acid	HNCO	T_{ex} 47 - 1000K

The First 100 Fields

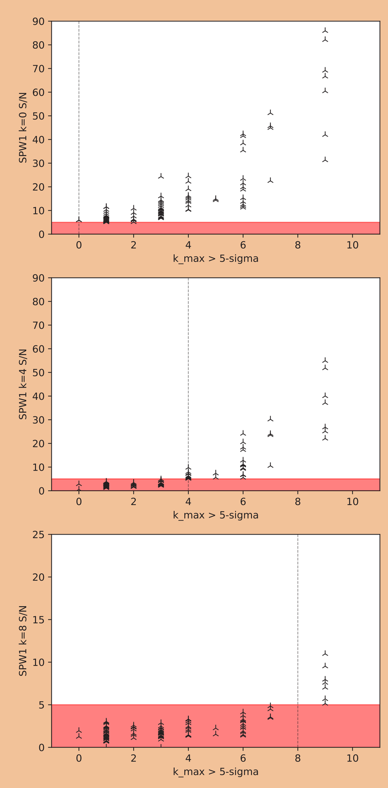


The first 100 ALMAGAL fields (near sample), containing 650 extracted cores (PI: A. Coletta[3]), are used as a mid-size test sample as data processing is ongoing within the collaboration. These sources are taken to be representative of the whole sample, containing a range of clump $L_\odot/M_\odot$ between 0.06 and 400. All fitting is currently developed on the CH_3CN (12-11) k-ladder.

Sources with CH_3CN k=0 detected above 5σ in the broad spectral window are fitted - 16% of all cores, 32% of all fields with at least one core. The 28 cores with S/N > 15 are also fitted with ethanol included for deblending - 4% of cores.

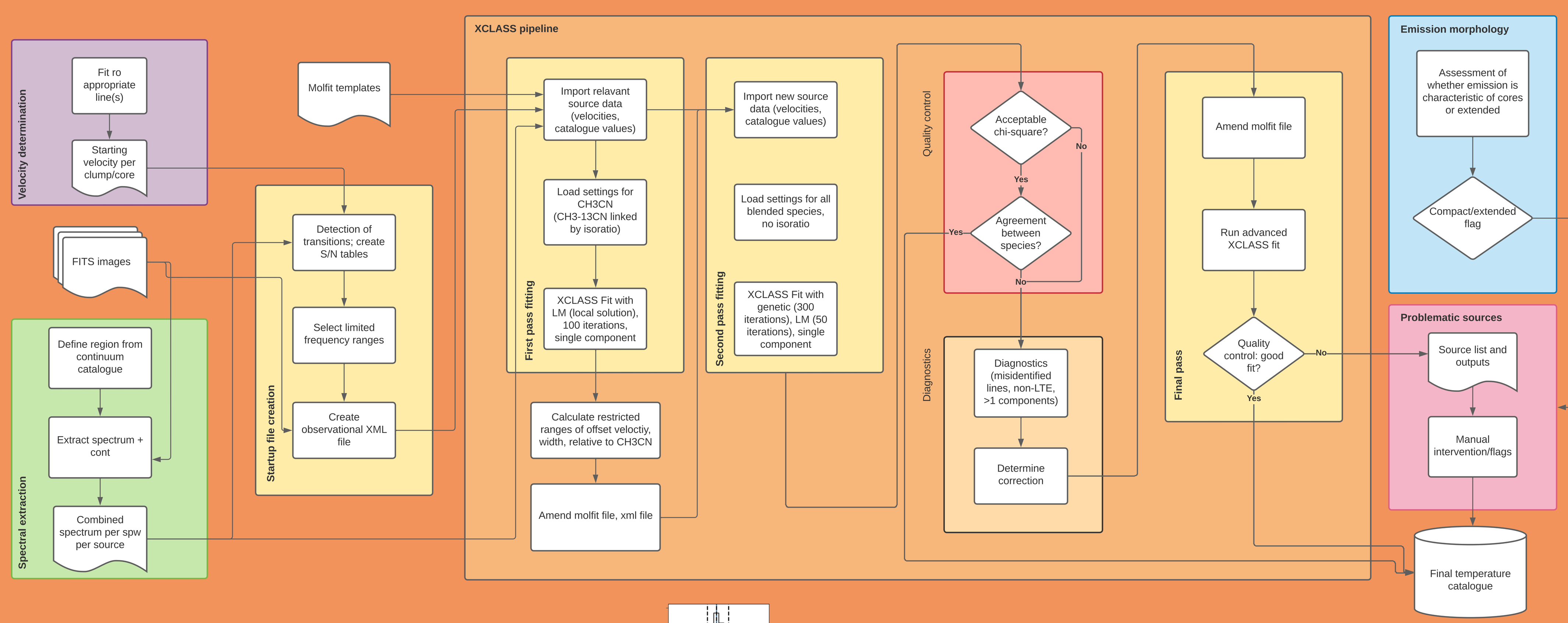


Fitting is performed over frequency ranges up to k_{max} + 2, where k_{max} is the highest k transition sequentially detected above 5σ.



The Spectral Line Temperature Catalogue

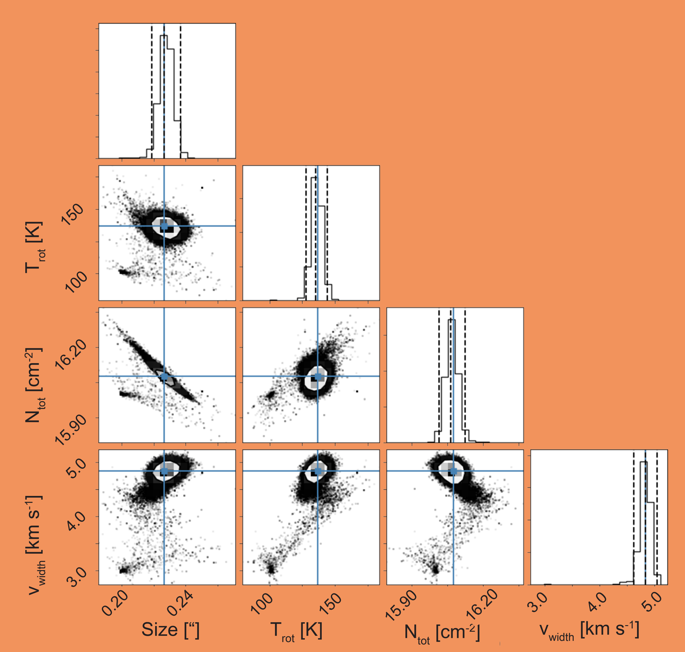
Project aim: To determine a physical temperature toward each identified continuum source through spectral lines of CH_3CN, CH_3OH, and H_2CO

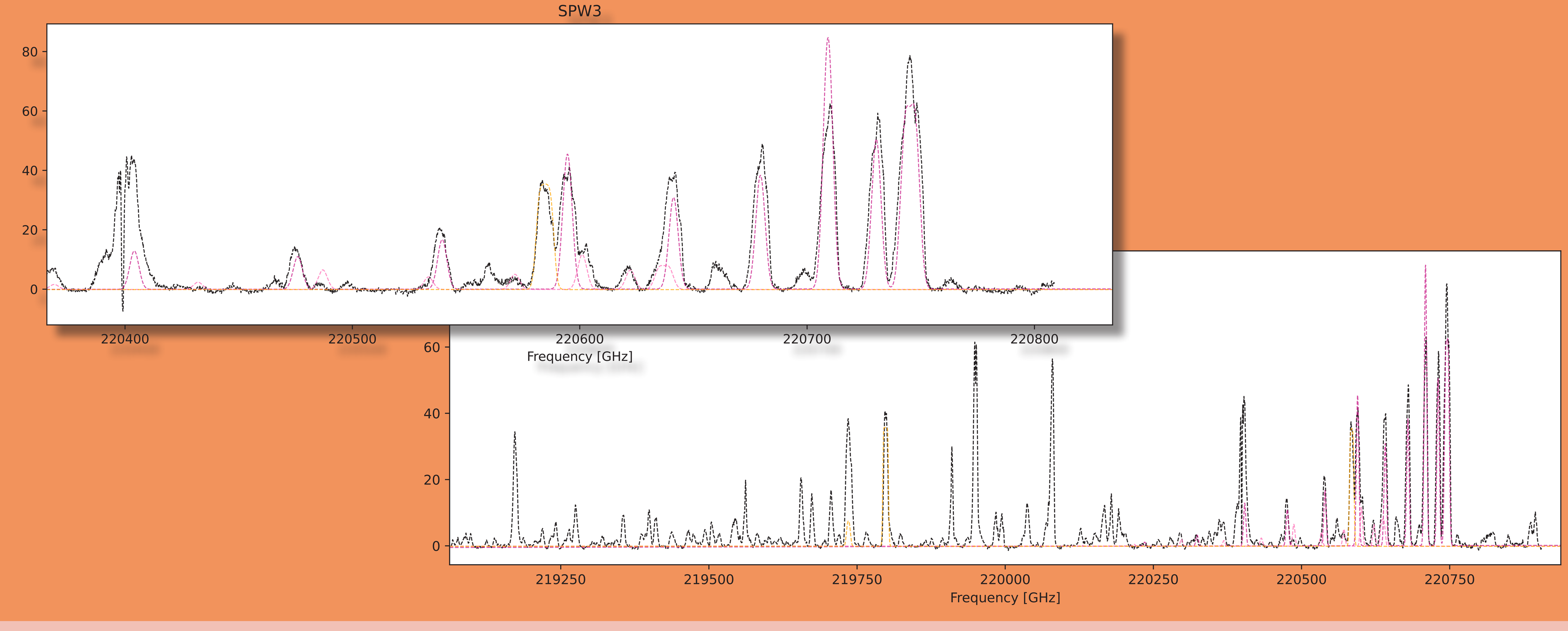


The XCLASS[5] (Möller et al. 2017) Pipeline design enables spectral fitting of all cores without manual intervention, including detection, selection of appropriate species for deblending, and quality control metrics. It relies on a chain of fitting: a first clump-scale velocity catalogue (PI: M. Benedettini[4]), a Levenberg-Marquardt fit to give initial velocity constraints, genetic algorithm fitting to explore the global parameter space, and a final Levenberg-Marquardt fit to refine the values in the global minimum.

The temperature greatly affects the mass estimate for each source and is an intrinsic requirement for accurate core mass functions in cluster-forming clumps.

The reliability of fits and uncertainties in each parameter are not simply given by measures of goodness of fit; degeneracies in the n-dimensional parameter space, sensitivity of the observations, and the limited range of temperatures probed by the observed transitions all contribute.
With XCLASS, Markov-Chain Monte Carlo realisations can be run over the high-dimensional parameter space to map the χ^2 function and provide insight into the true error estimates.





References

[2] The ALMAGAL Collaboration is an international working group formed by the PIs of ALMA Large Program 2019.1.00195.L and their extended teams:
PIs: S. Molinari (*IAPS-INAF, Rome, Italy*), P. Schilke (*PH1, Köln, Germany*), C. Battersby (*University of Connecticut, USA*), and P. Ho (*ASIAA, Taiwan, R.O.C*)
Technical Working Group Lead: Á. Sánchez-Monge (*ICE-CSIC, Barcelona, Spain*)

[3] The continuum catalogue work is led by A. Coletta (*IAPS-INAF, Rome, Italy*)
[4] The initial velocity catalogue is led by M. Benedettini *IAPS-INAF, Rome, Italy*

[5] XCLASS (eXtended CASA Line Analysis Software Suite) developed by T. Möller[1] is freely available at xclass.astro.uni-koeln.de
T. Möller, C. Endres, and P. Schilke, "eXtended CASA Line Analysis Software Suite (XCLASS)", A&A 598, A7 (2017)

[6] Header image and ALMA dish image credit: G. Stroud (*JBCA, Manchester, UK*)

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