

What are the physical conditions at the earliest stage of massive star and star cluster formation?

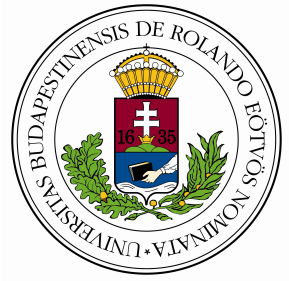
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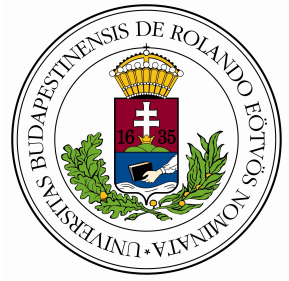
In collaboration with: Leonardo Testi, Izaskun Jimenez-Serra, Ke Wang, Viktor Toth



Overview



- Source sample:
 - ECC clumps
- Physical parameters:
 - T, N
 - D
 - M, d
- Follow-up studies



What are the ECC clumps?

Planck satellite mapped the sky at 9 wavelengths:

Sub-millimetre and radio

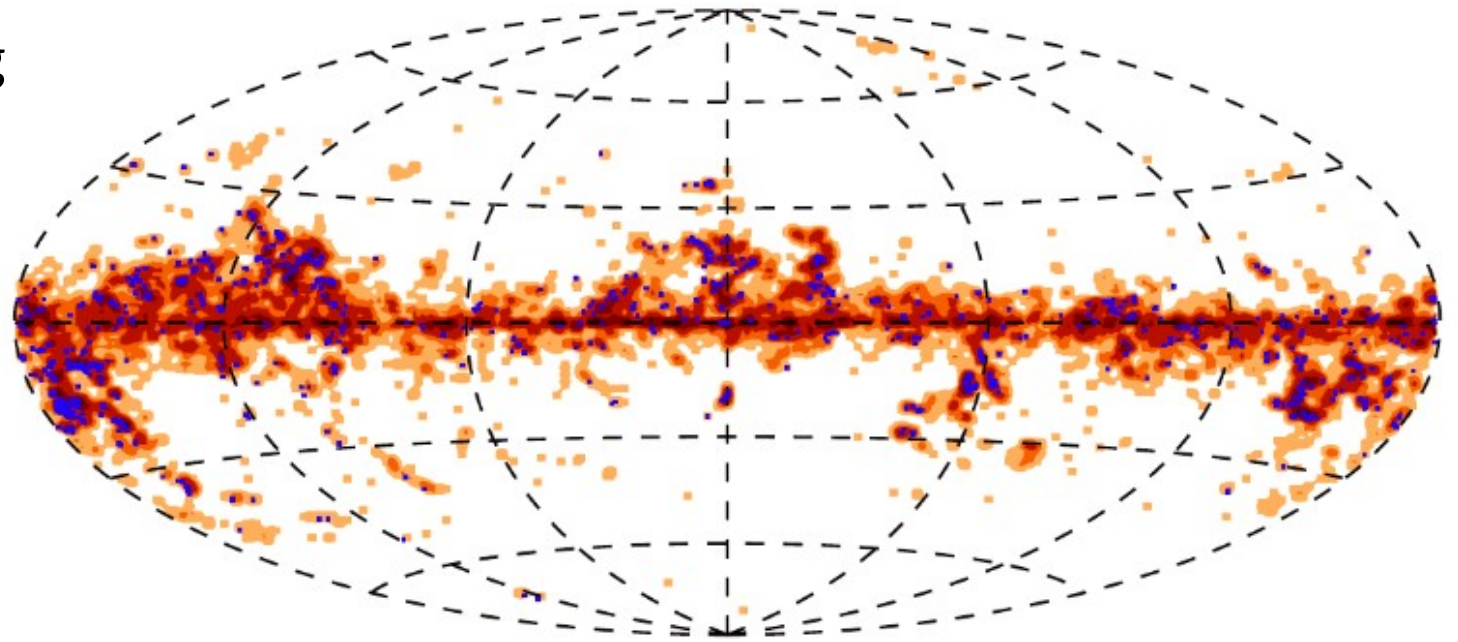
350 μm - 1cm

Preliminary catalog
~10000 sources

Most reliable
sources ~ 900
Early Cold Core
selection (ECC)

$S/N > 15$

$T < 14 \text{ K}$



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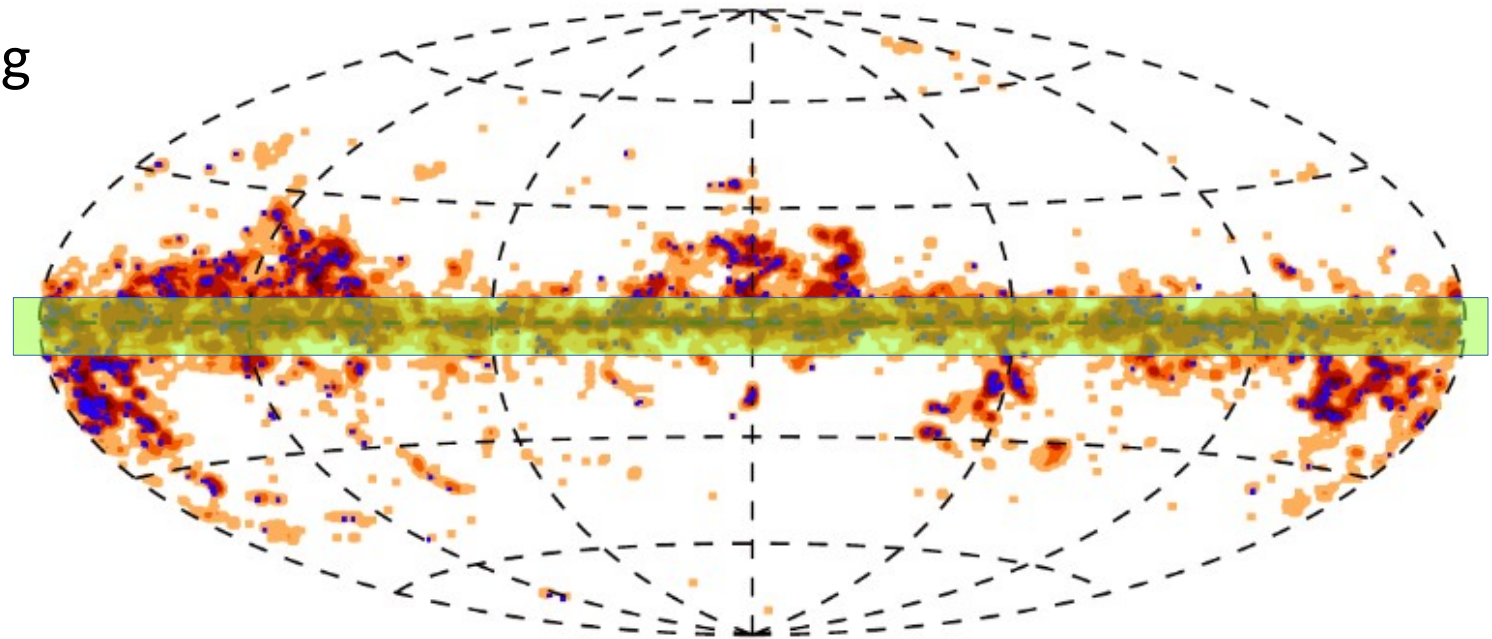
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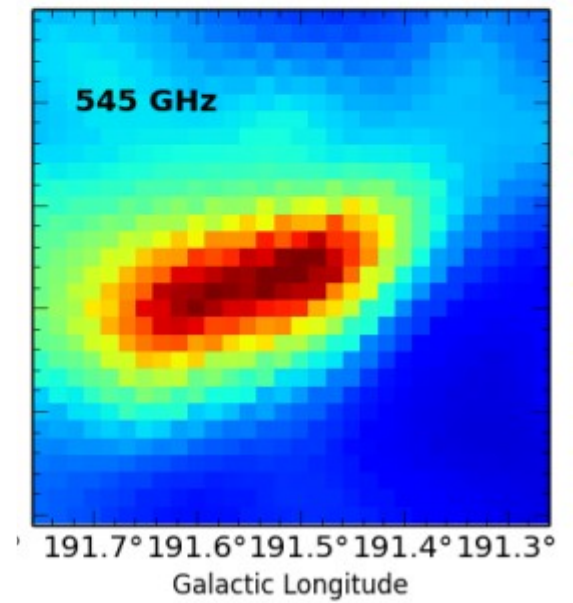
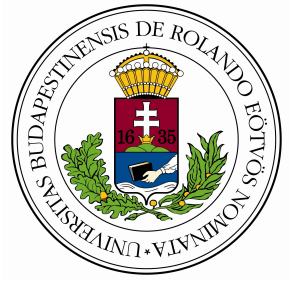
48 ECCs covered by Hi-GAL
(<https://hi-gal.ifsi-roma.inaf.it/higal/>)



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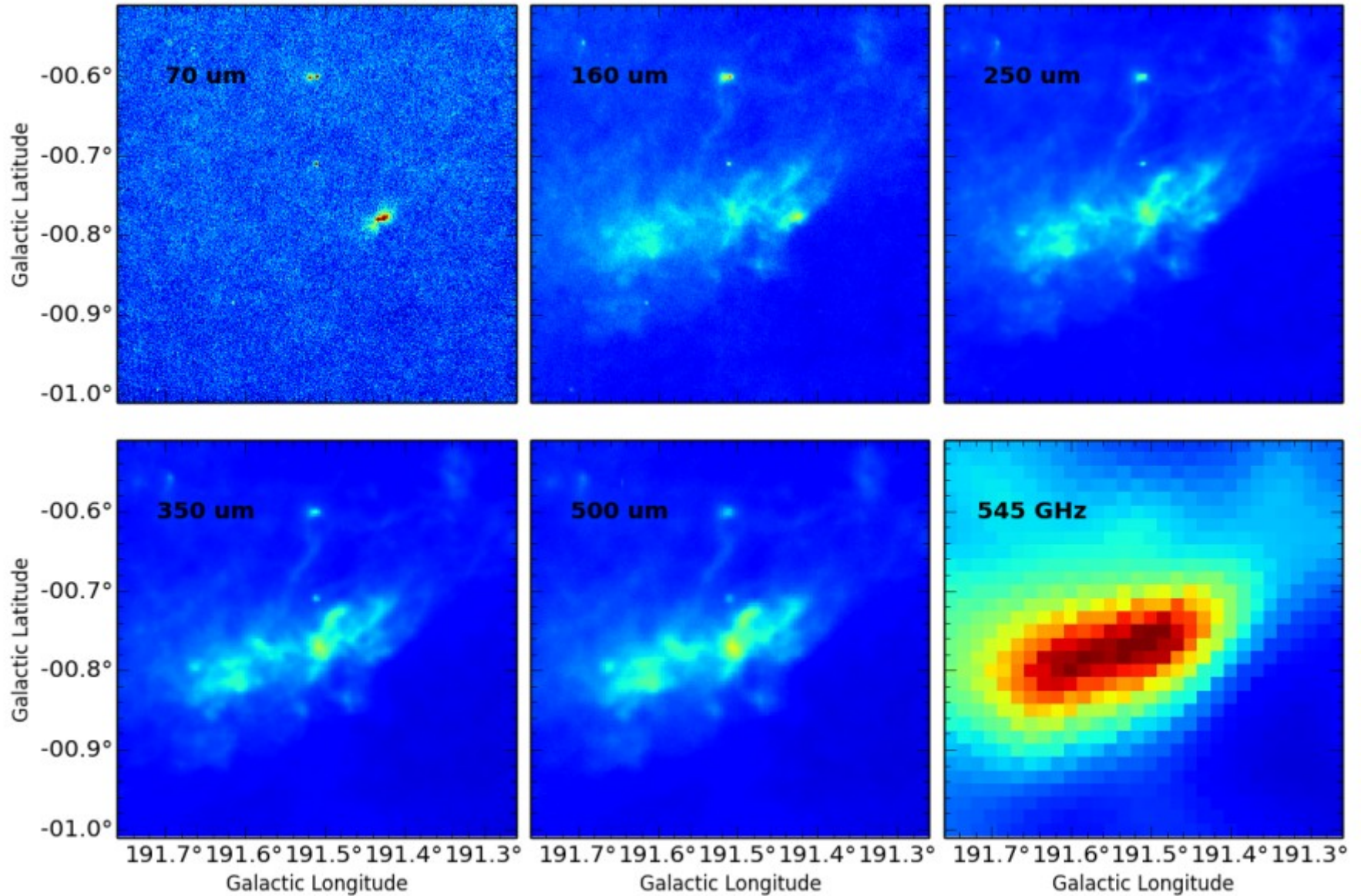
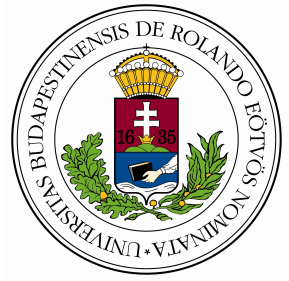


The role of Hi-GAL data



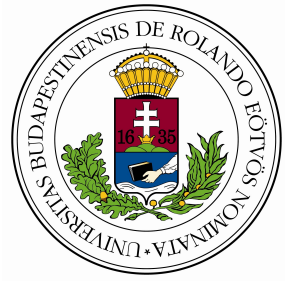


The role of Hi-GAL data

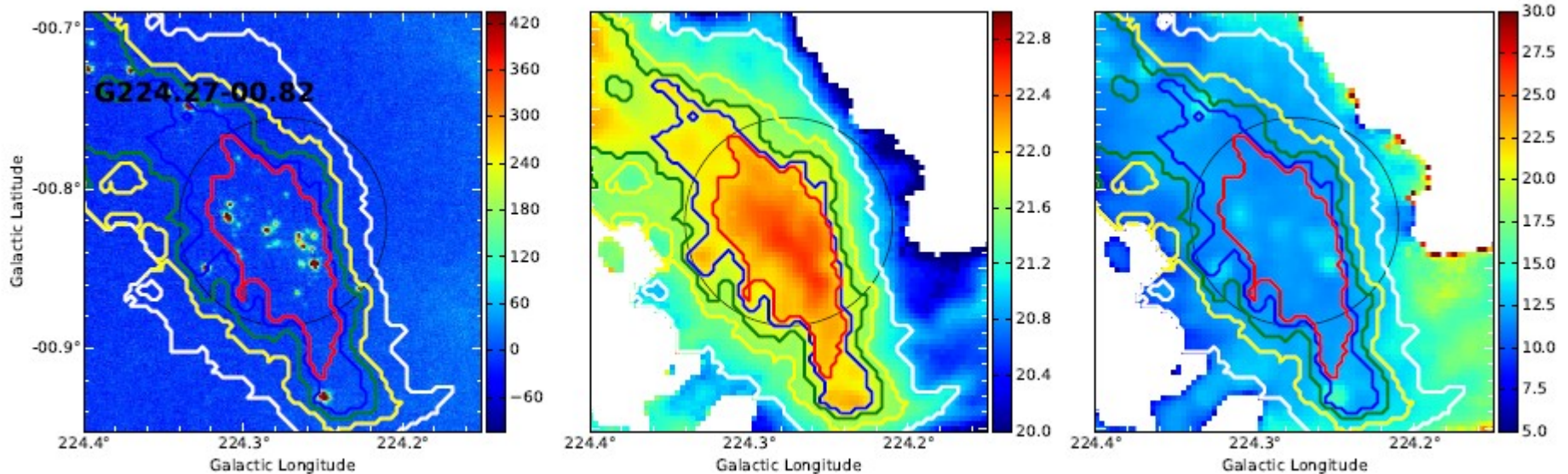




Physical properties of ECCs

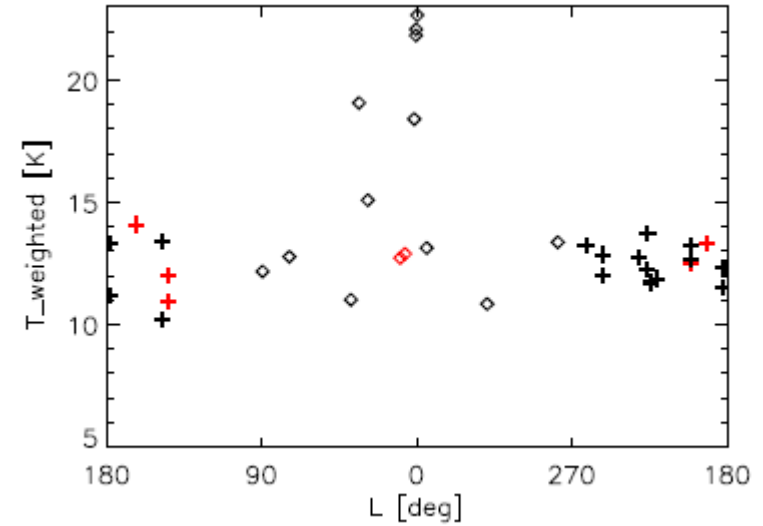
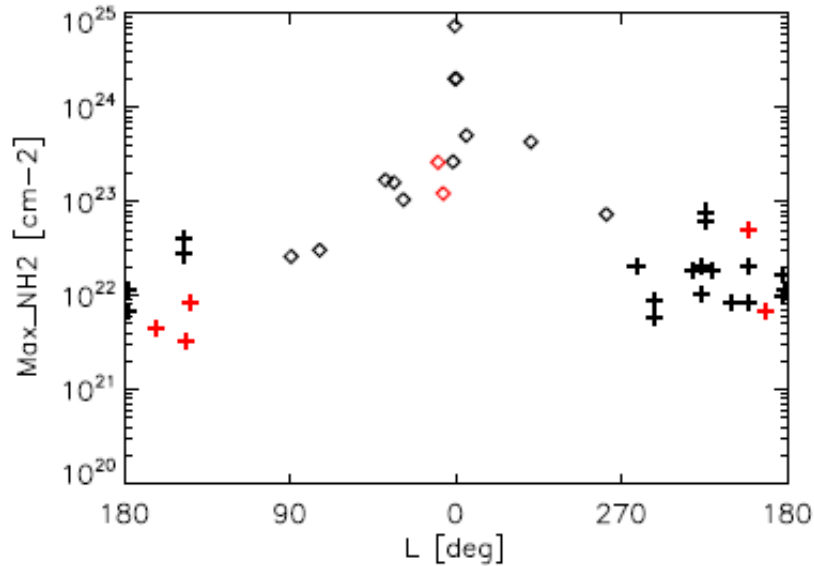


- star formation properties: 24 / 70 μm images
- T, N(H_2): 160 - 500 μm images
- size, mass: distance estimation needed (Wu et al. 2012 – Purple Mountain Obs., Galactic Plane line surveys, CfA CO survey, APEX observations, ...)



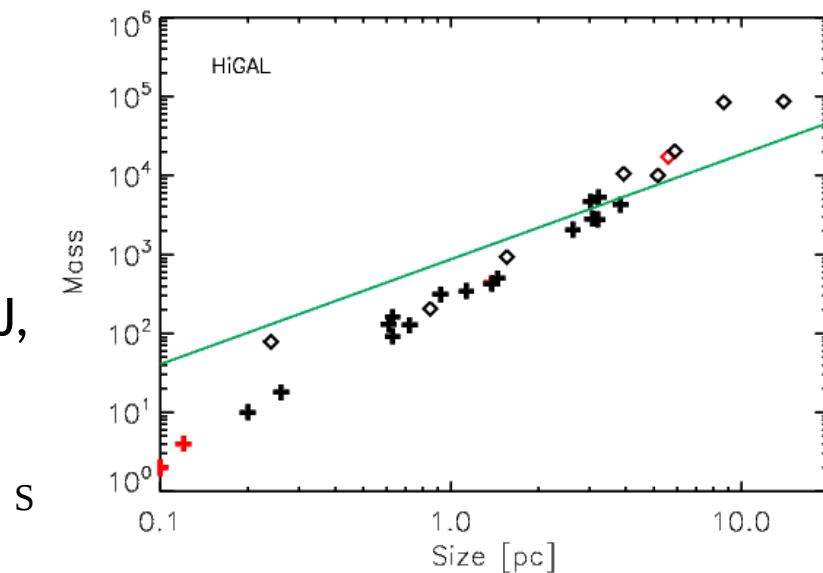


Difference in the inner and outer galaxy?



Mass - size limit for HMSF

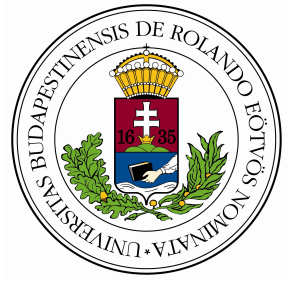
Kauffmann & Pillai, 2010, ApJ, 723, L7



S



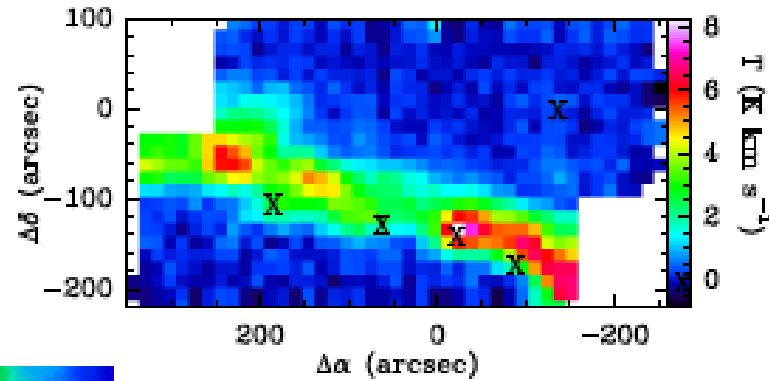
Importance of follow-up studies



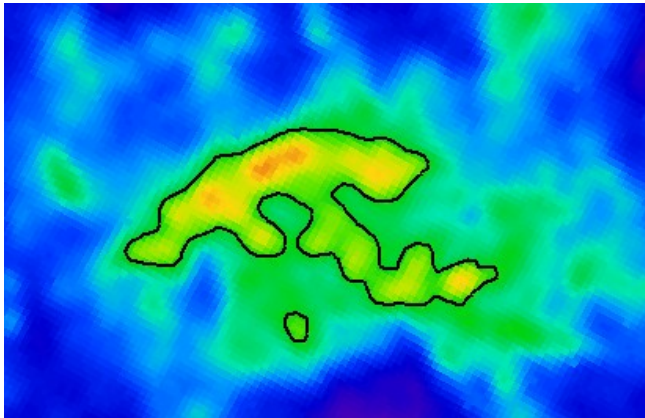
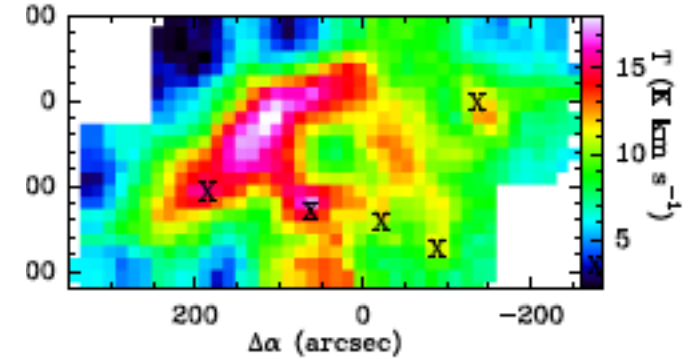
Most massive, cold sources in their early phases

Molecular line follow-up: APEX, ALMA, eVLA

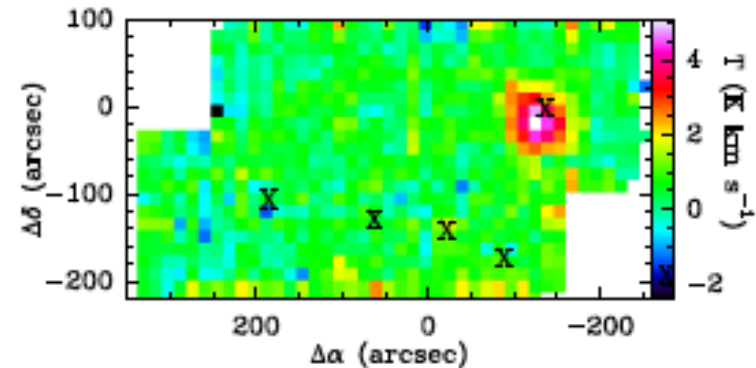
G319 13CO (2-1) integ.int. in -36 - -32 km/s



9 13CO (2-1) integ.int. in -50 - -42 km/s



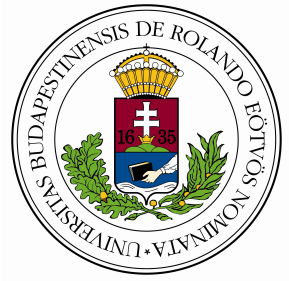
G319 C180 (2-1) integ.int. in -42 - -36 km/s



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Summary



- 48 ECCs in the Galactic plane
- $D \sim 0.5$ kpc to 8 kpc
- $M \sim \text{few } M_{\odot}$ to $10^5 M_{\odot}$
- ~ 60 % in the outer part of the Galaxy
- 23 % “starless”
- 10 objects are above the mass – size limit for massive star formation