CLASS II 6.7 GHZ METHANOL MASERS ASSOCIATION WITH YOUNG MASSIVE PROTOSTARS REVEALED BY ALMA



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6.7 GHz class II CH3OH masers (exclusively associated with high-mass protostars)

- Codella et al. (2004)

(1) the earliest phase: maser emission present, outflow not yet developed enough to be detected,

(2) both the maser and outflow are present and detectable,

(3) maser emission disappears while the outflow remains,

(4) outflow switches off, only the UCHII region remains.

- de Villiers et al. (2015)

(1) the earliest phase: outflow develops and grows with no methanol maser present; the infall process heats the dust grains and releases methanol into the gas phase,

(2) both methanol maser and outflow are present and detectable (sufficient column density for methanol maser to turn on),

(3) methanol maser emission disappears while the outflow remains,

(4) outflow switches off, only the UCHII region remains.

ATLASGAL-MMB Viewpoint

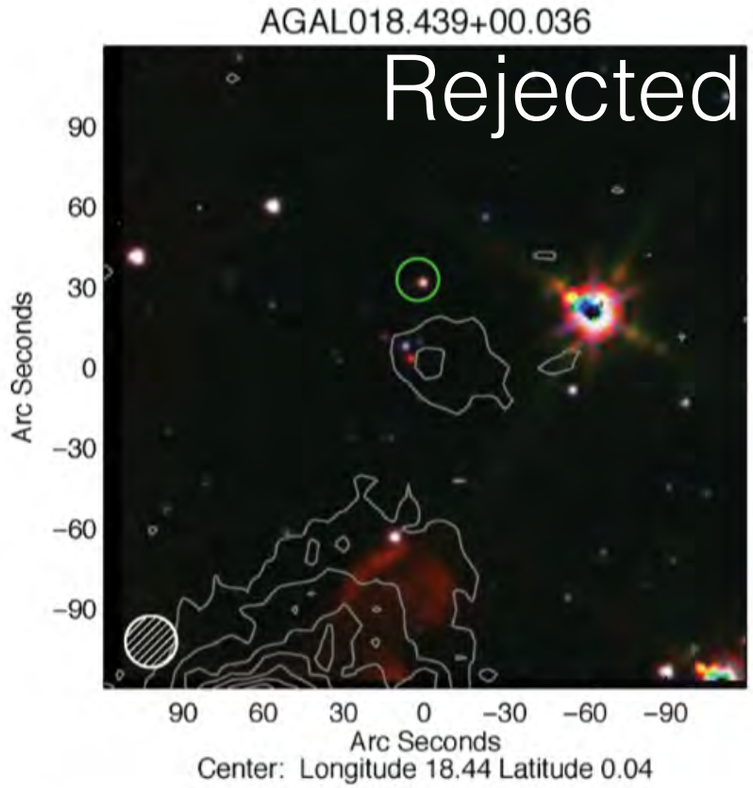
Urquhart et al. (2013) [Clump-scale]

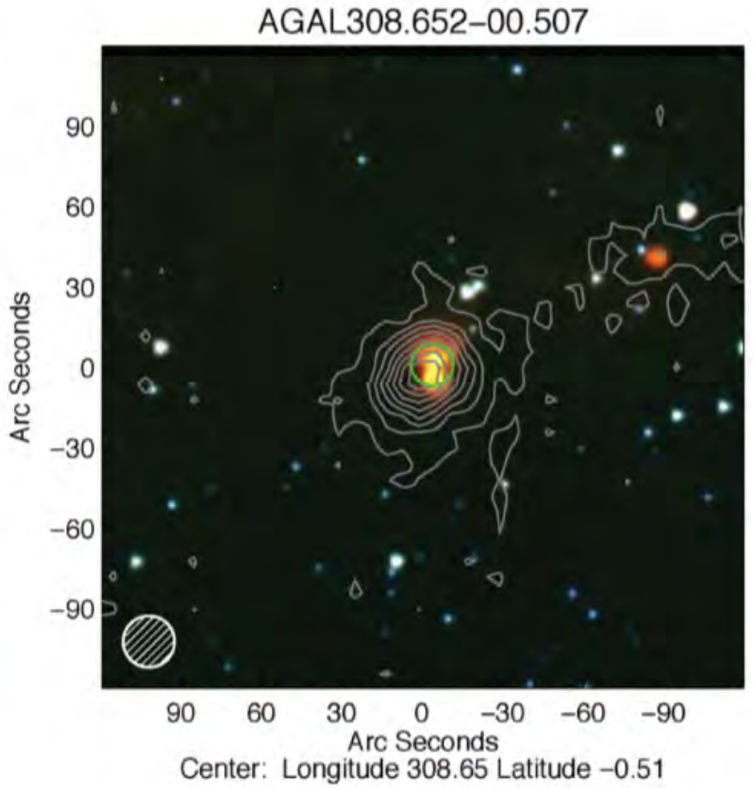
- ATLAS GAL [APEX]: 870 micron, angular resolution 19.2 arcsec, 6639 dust continuum sources.

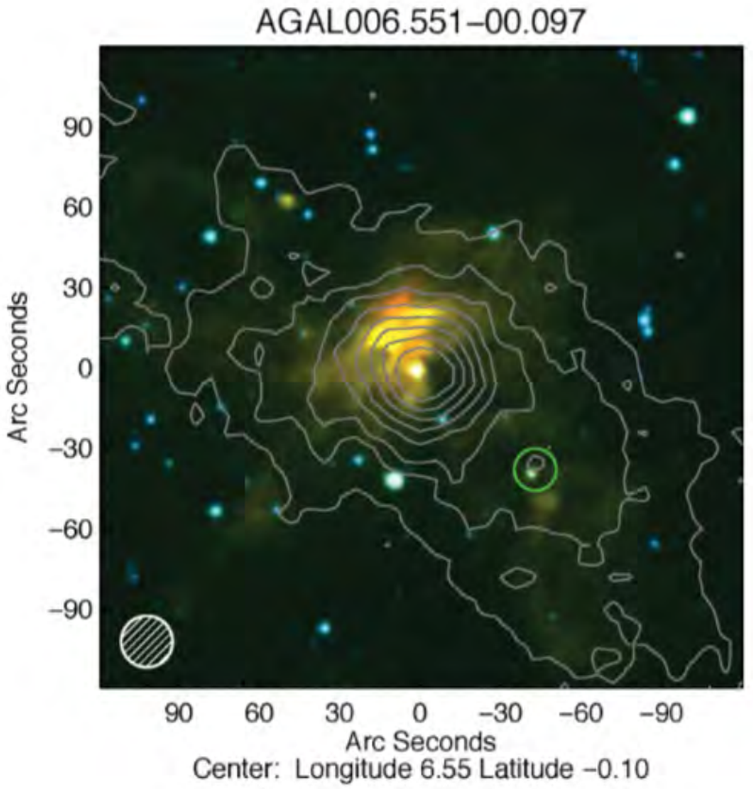
- MMB [Parkes & ATCA]: 6.7 GHz, 0.17 Jy/beam sensitivity, 0.4 arcsec positional accuracy. (707 sources reported - Caswell et al. 2010, 2011; Green et al. 2010, 2012, Breen et al. 2012)

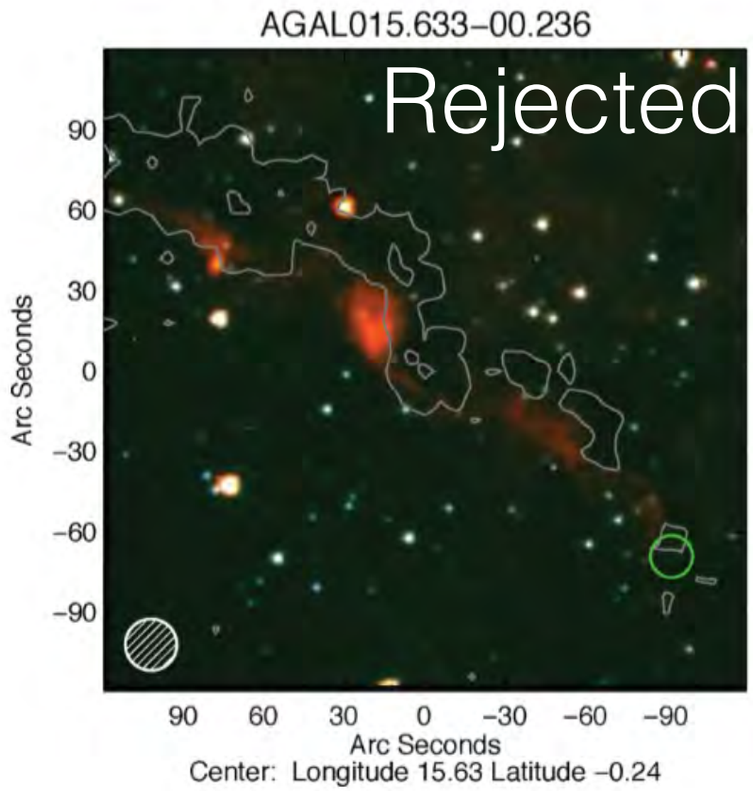
577 ATLASGAL-MMB sources

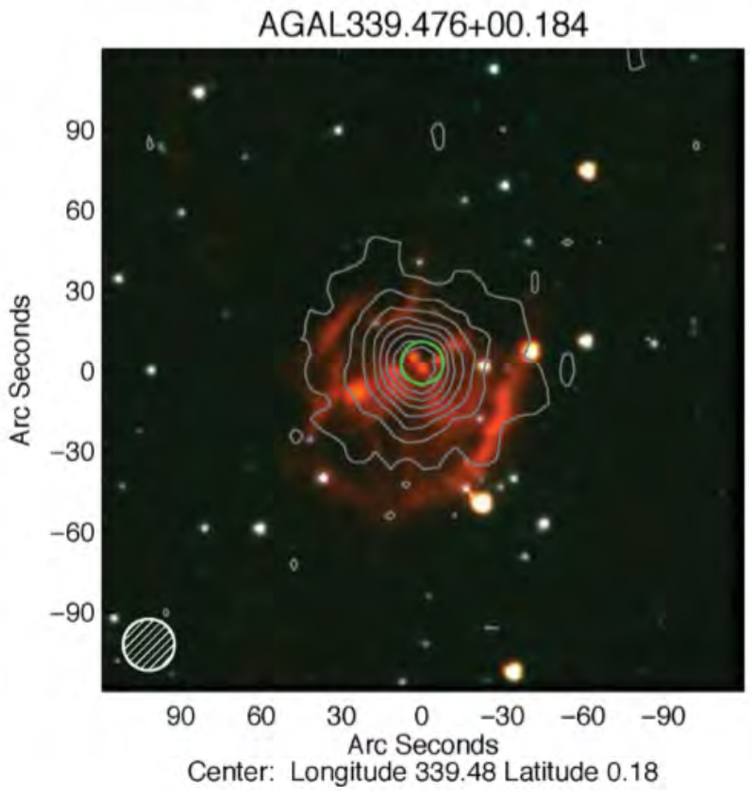
Urquhart et al. (2013)

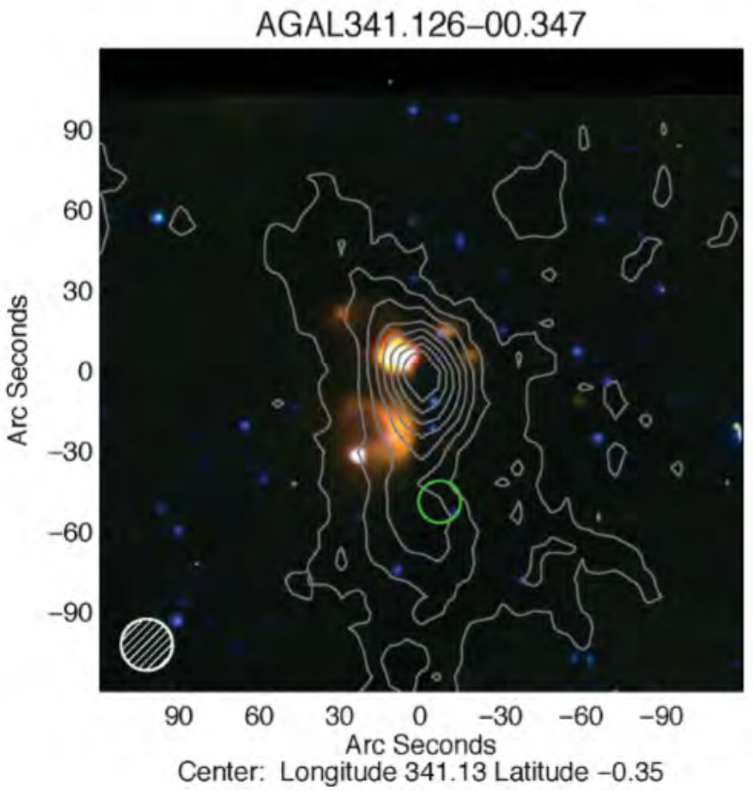


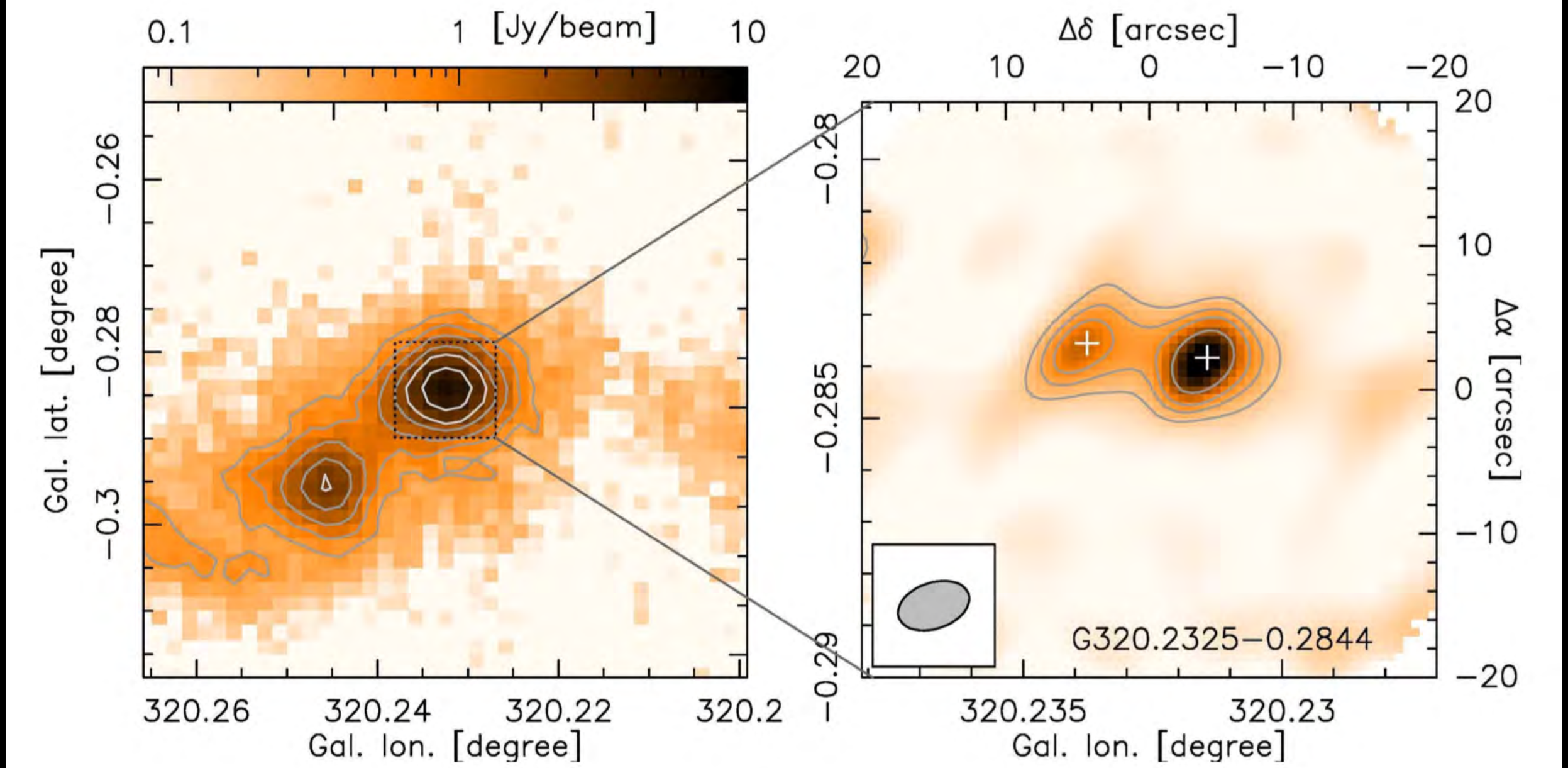












ATLASGAL and zoom in with ALMA ACA (Csengeri et al. 2017)

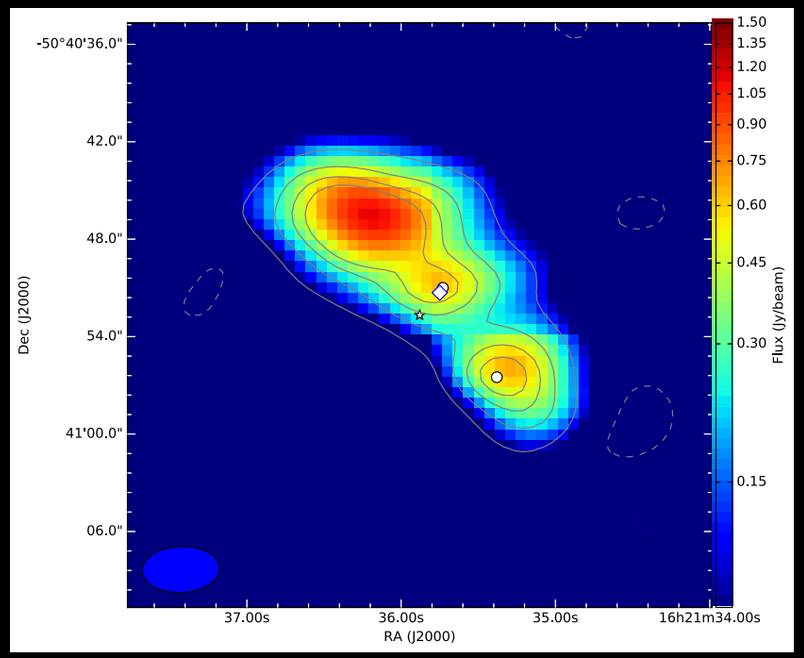
Clump-MMB vs Core-MMB Statistics
Urquhart et al. 2013 vs Chibueze et al. 2017

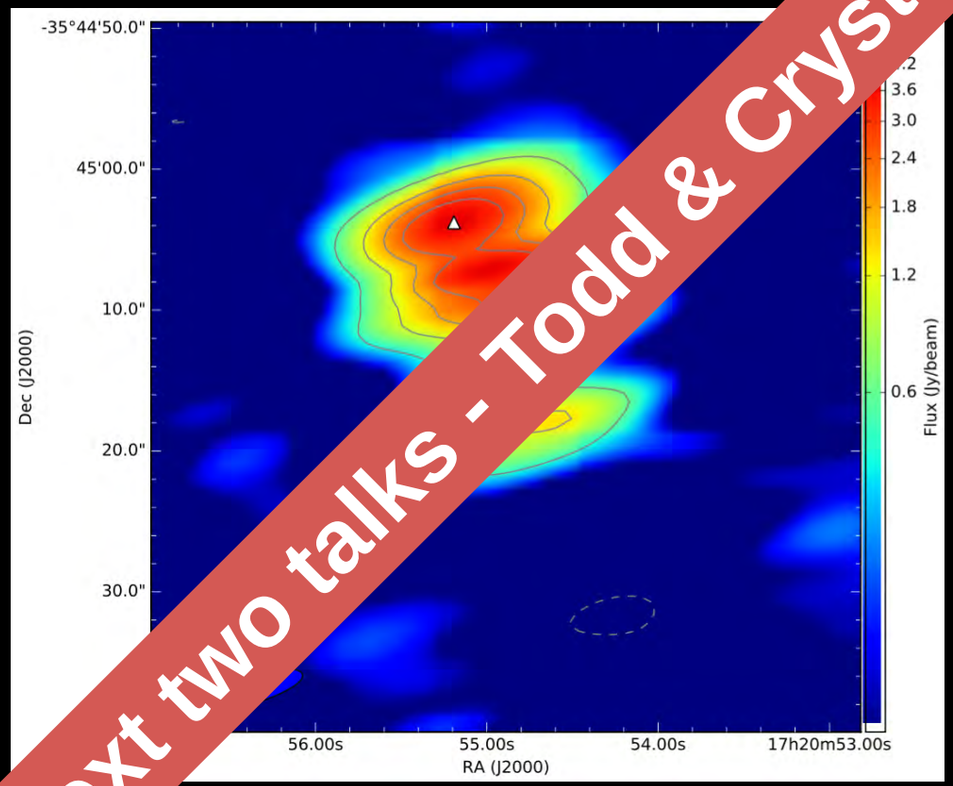
- Based on ALMA first galaxy scale survey of massive protostars (PI: Timea Csengeri)

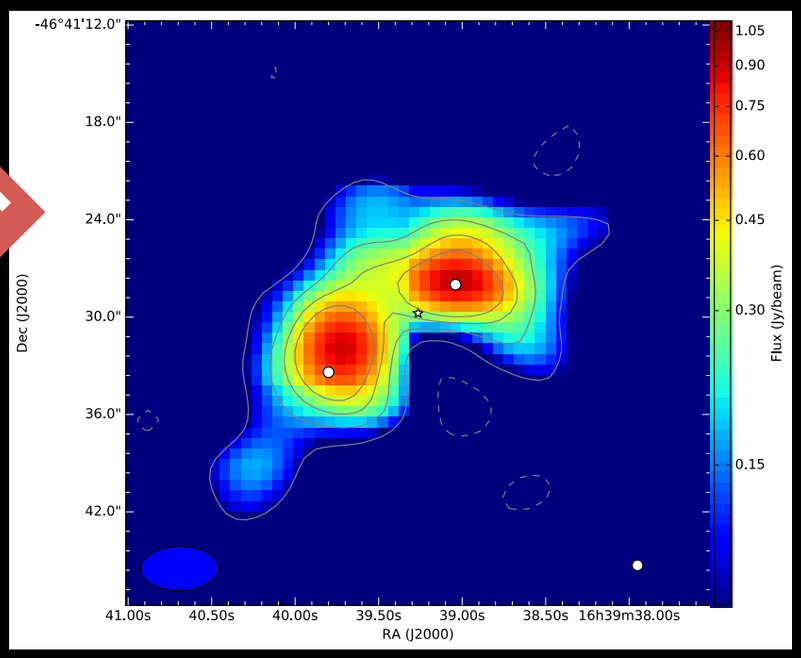
SPARKS: the Search for High-mass Protostars with ALMA up to kilo-parsec Scale

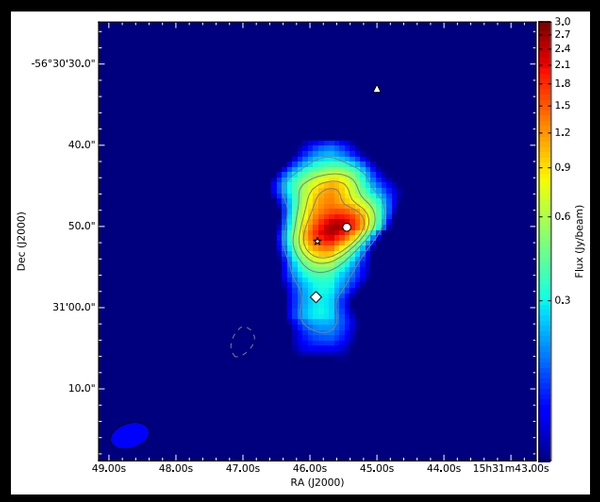
Details in Csengeri et al. (2017), also see poster 56

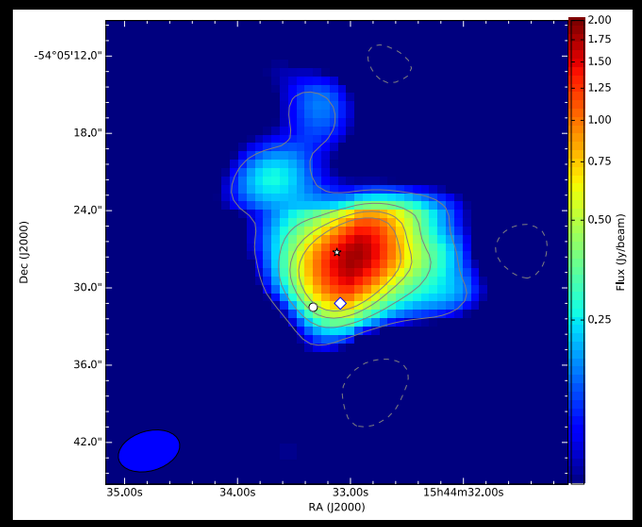
Focus on ACA cores and their association with MMB.

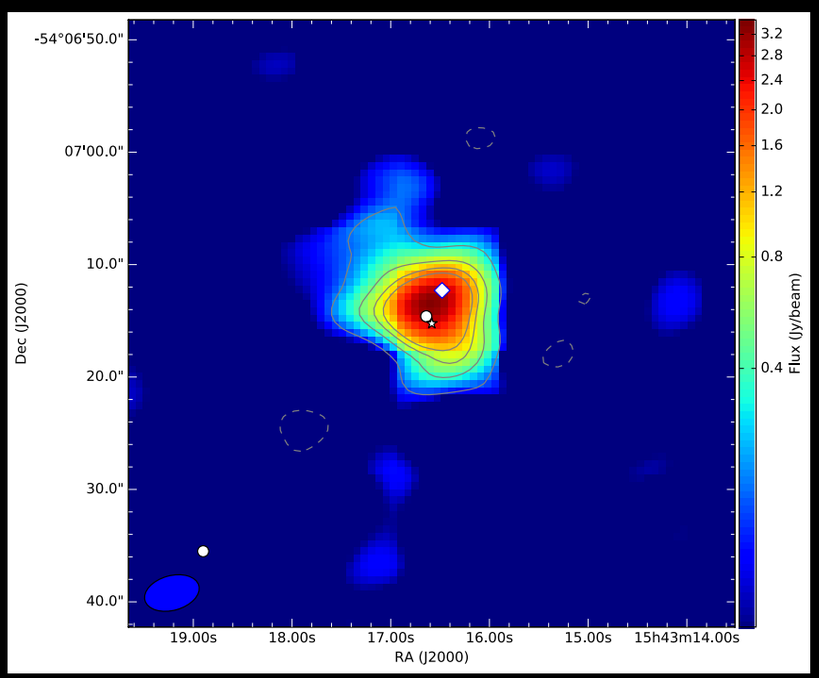


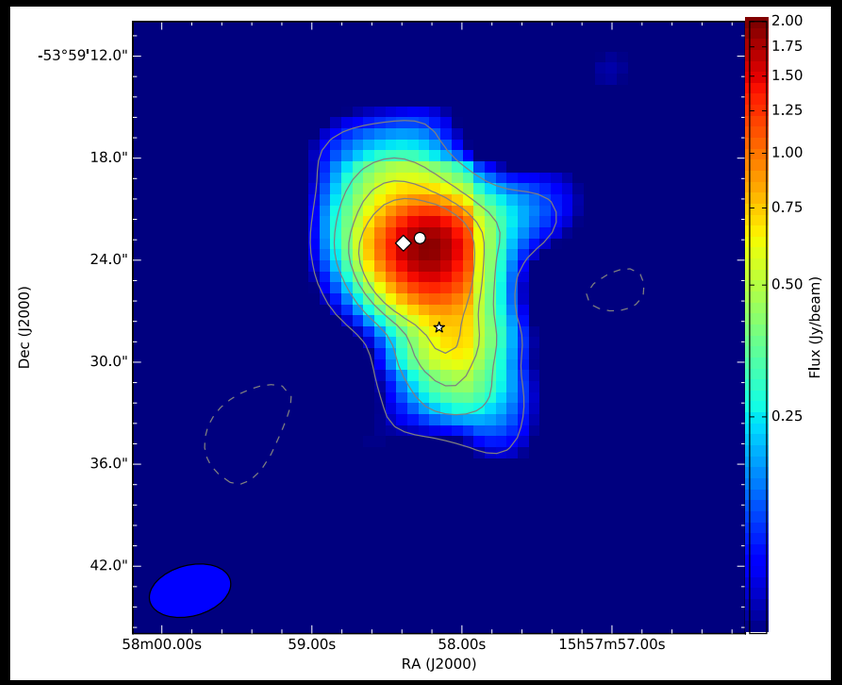


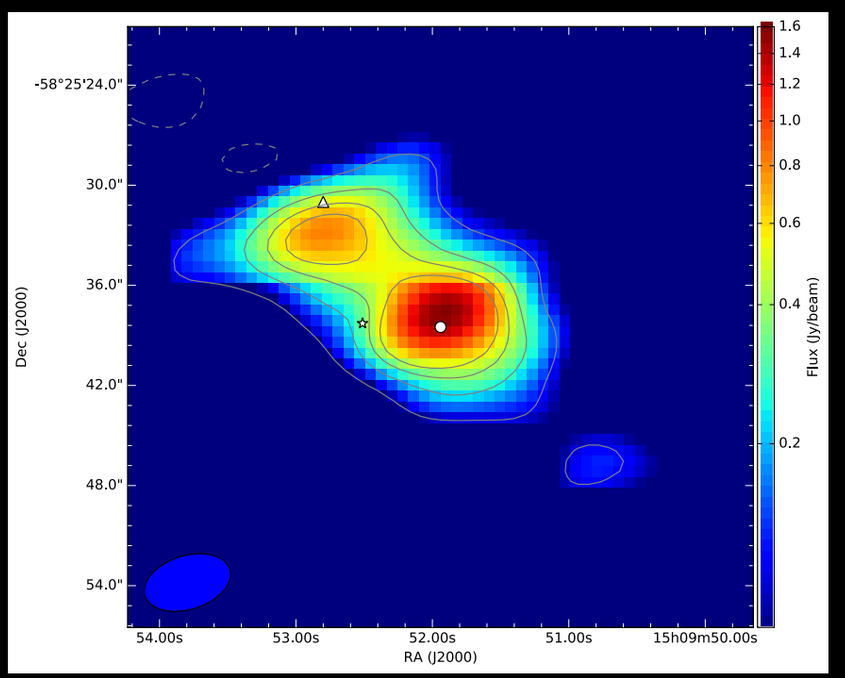










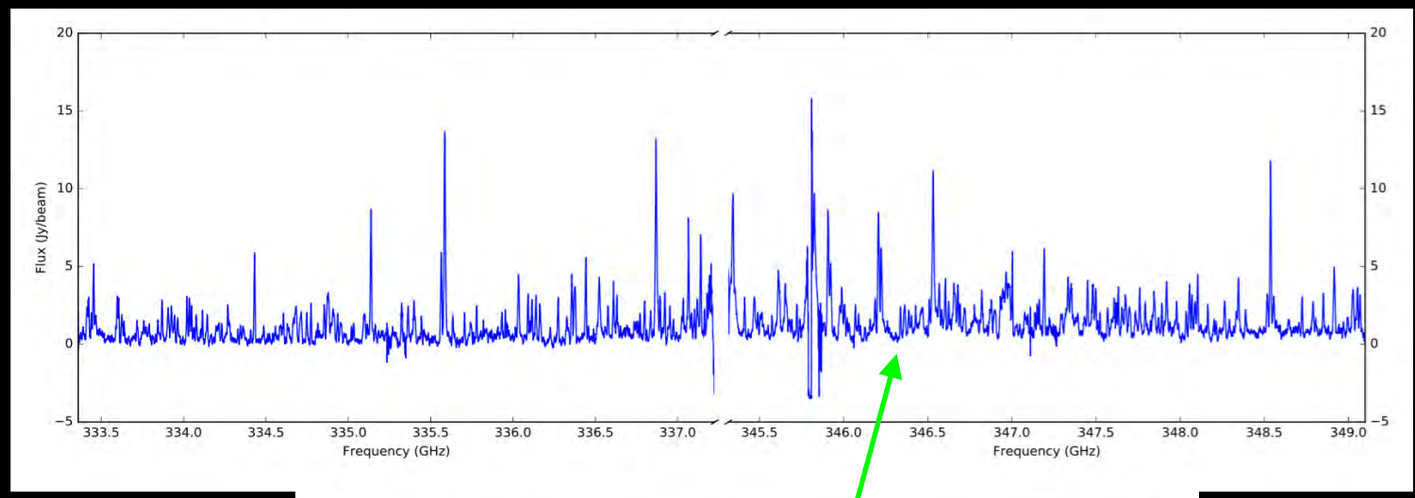


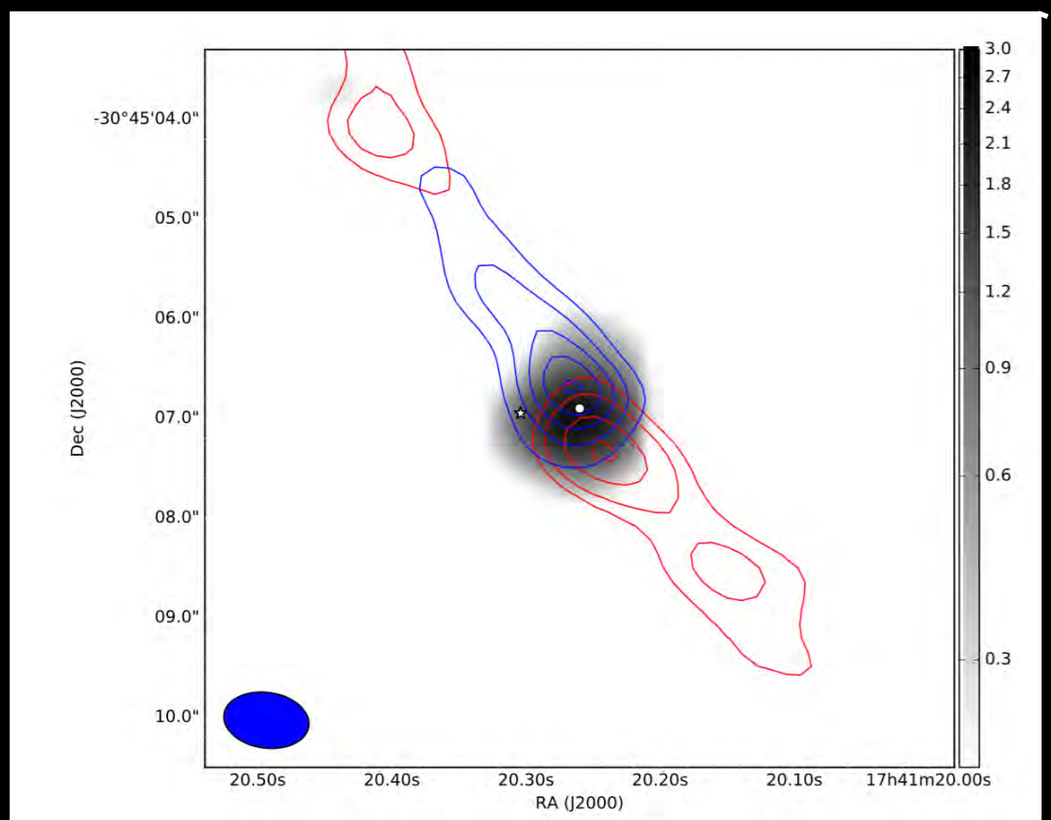
Next two talks - Todd & Crystal

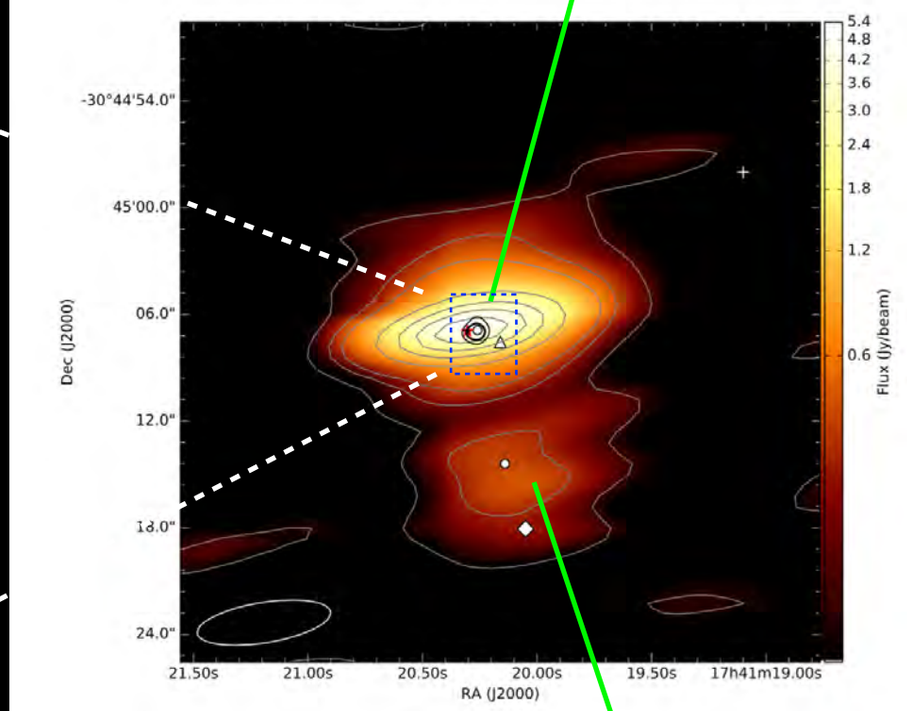
de Villiers et al. (2015) supported by ALMA survey results

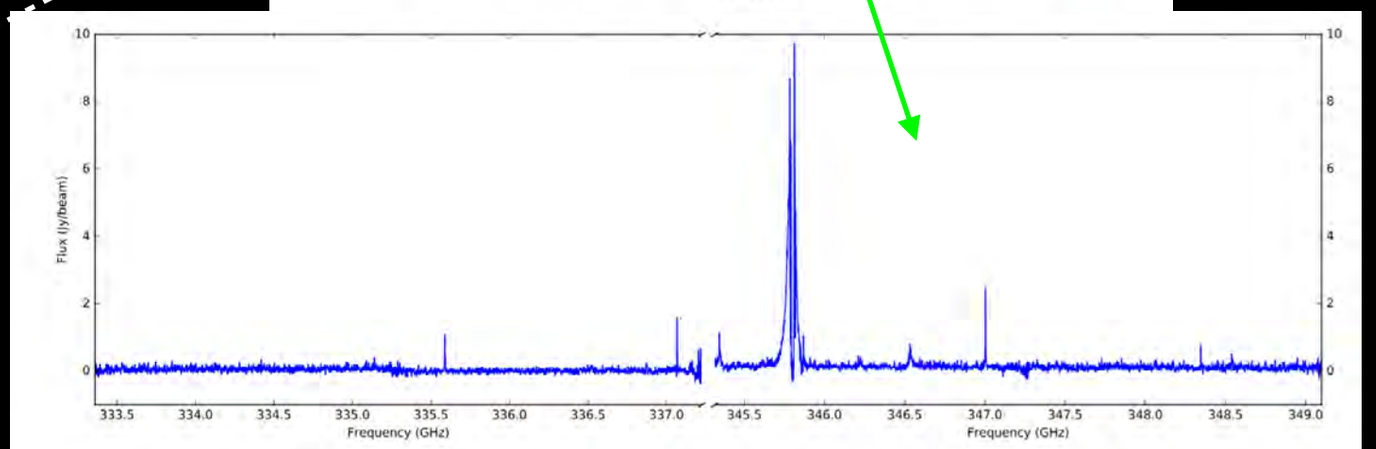
outflows seen in almost all the cores!

SiO outflow on ACA core
Chibueze et al. (in prep)









Statistical comparison

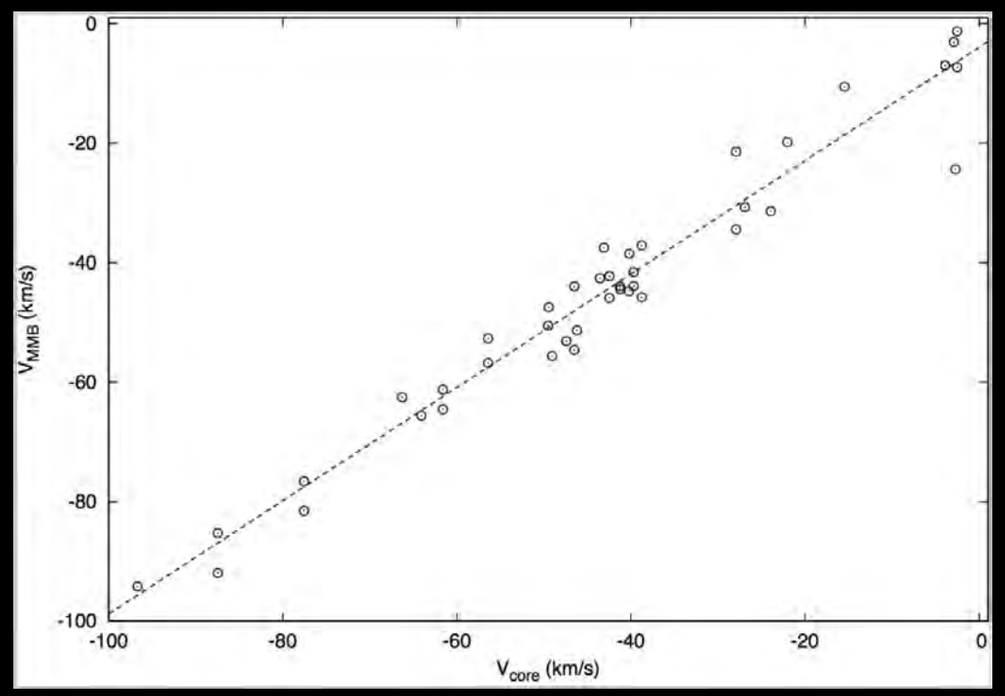
- 125 ACA cores detected in 46 ATLASGAL clumps
- 42 out of 112 (less 13 unobserved) associated with MMB.
- Distance bias: 1.7 ~ 5.0 kpc (~10 sources above 5 kpc not used in our statistics)

Association criteria

(1) the distance to the core is <5 kpc (which has better reliability than the more distant source);

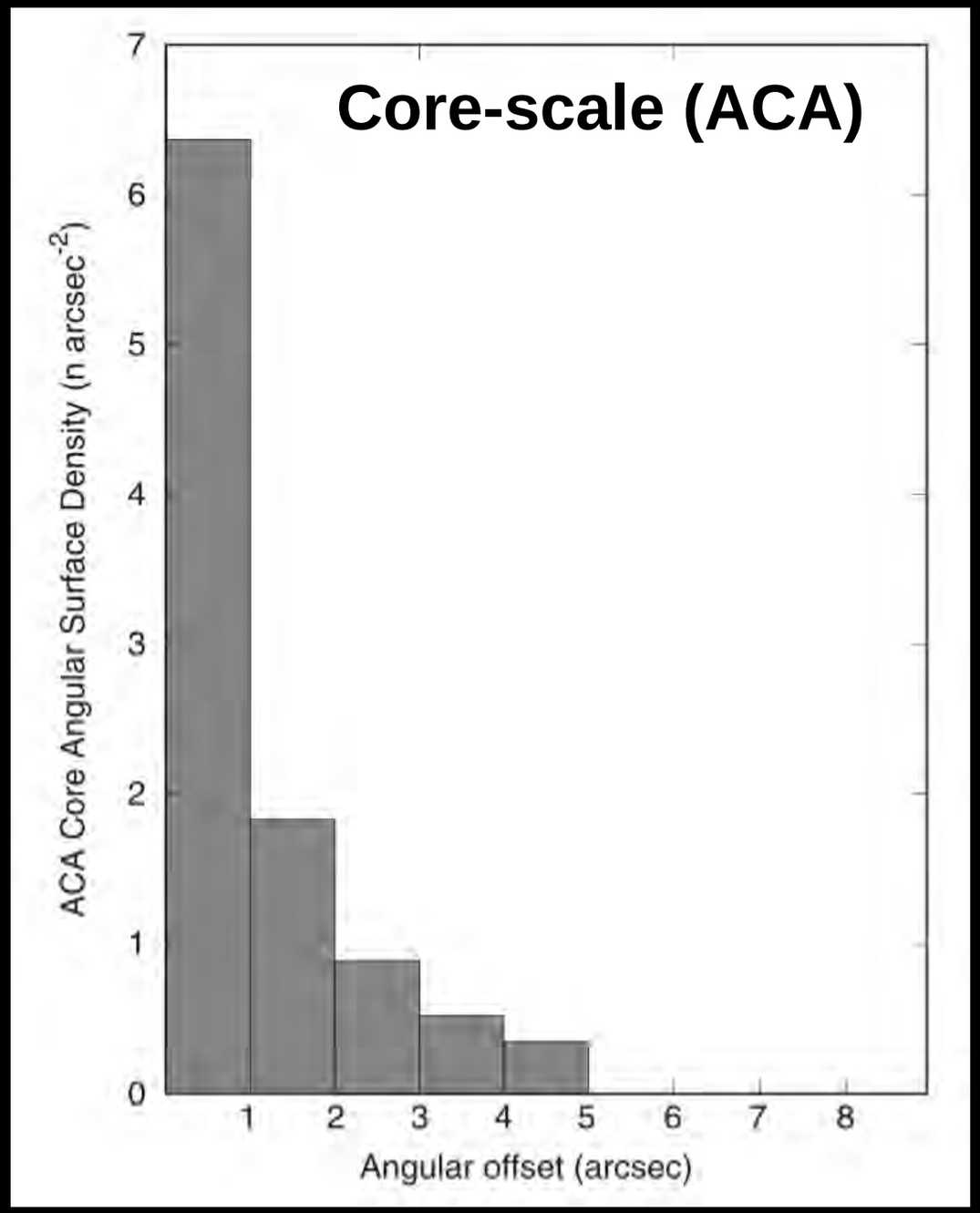
(2) the positional (angular) offset of the ACA core peak and the MMB peak is <5″.

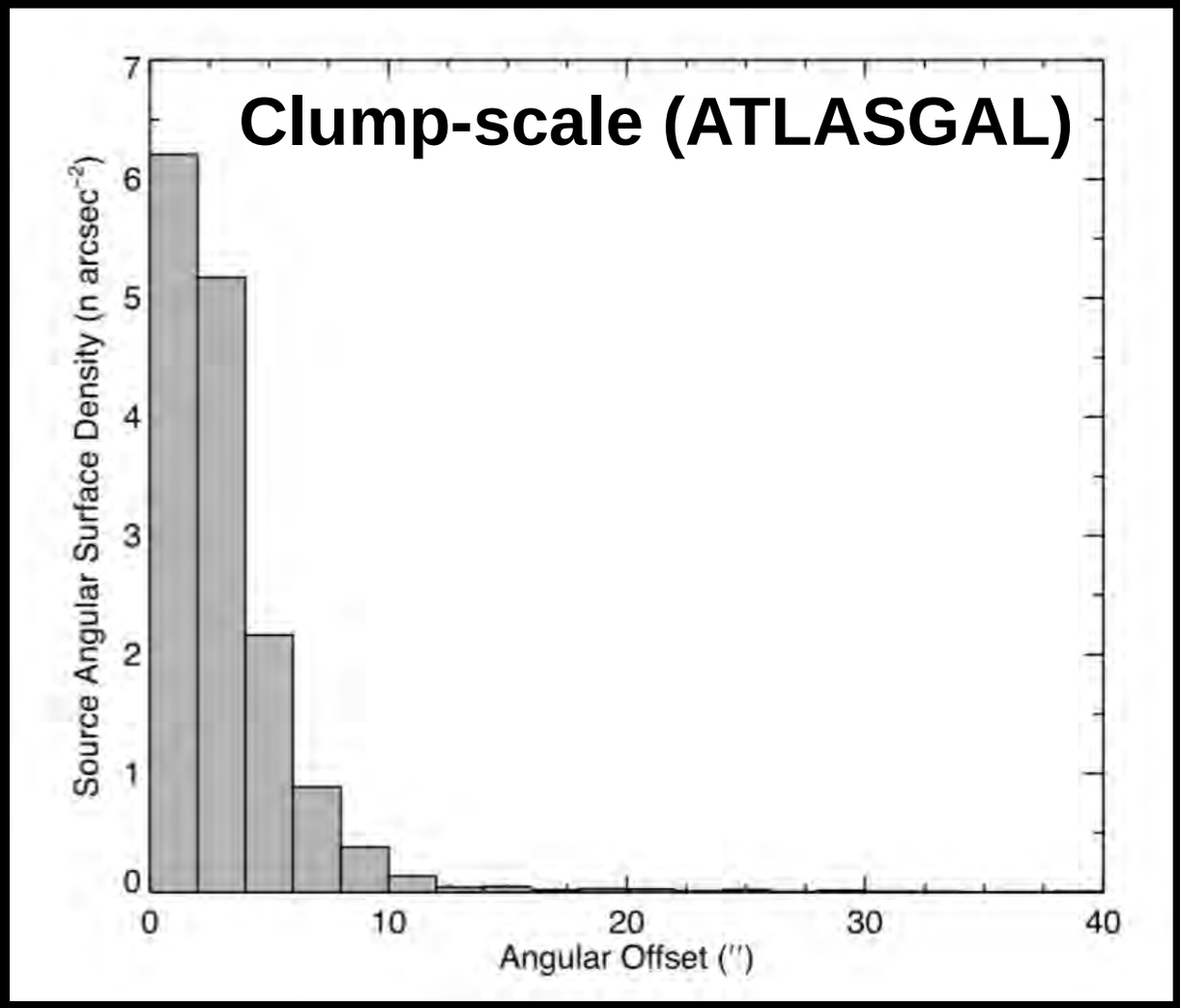
(3) the difference between the V_{LSR} of the MMB peak and that of its associated ACA core (obtained from Csengeri et al. 2017) is within ±8 km s^{-1}.



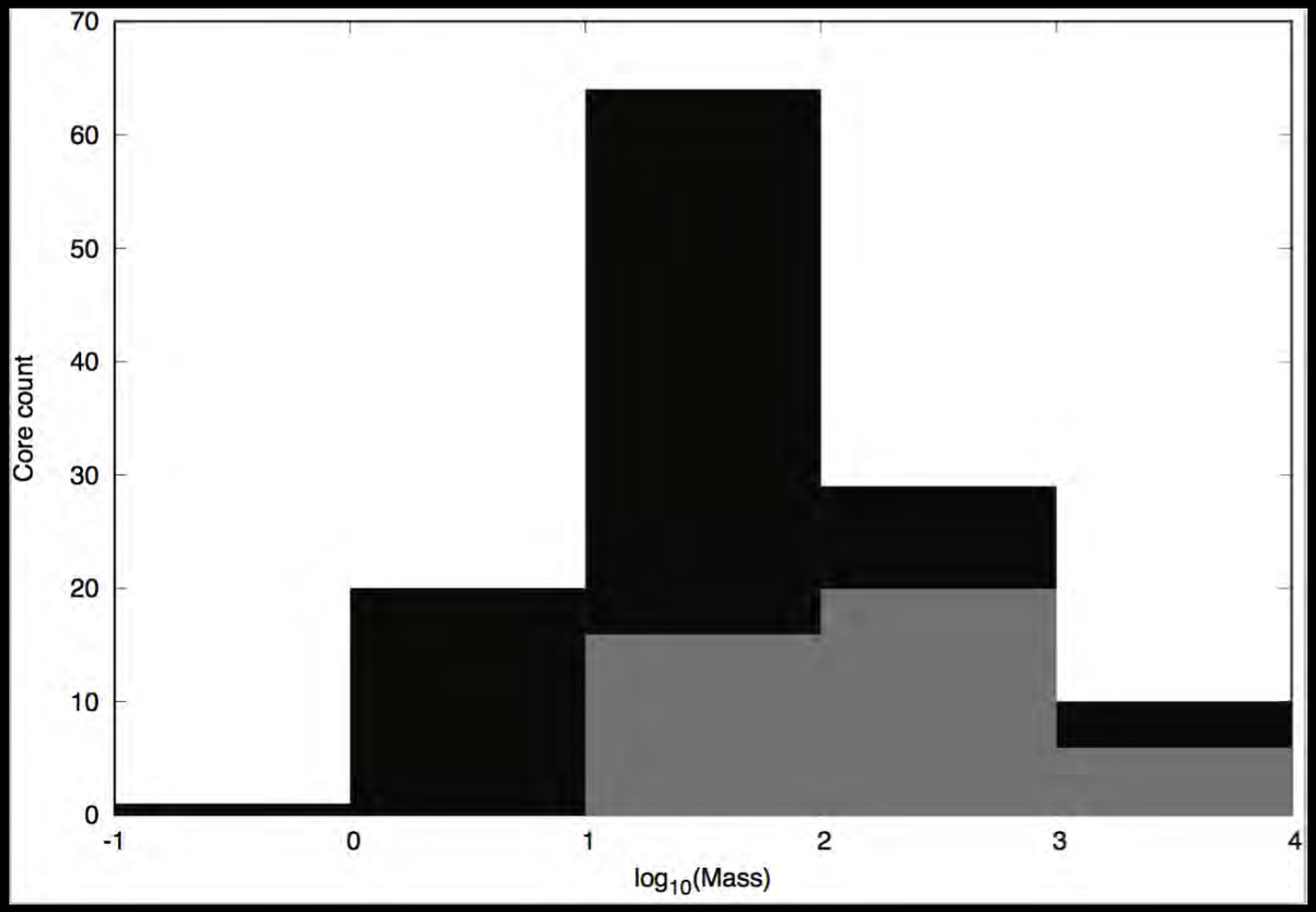
Chibueze et al. 2017

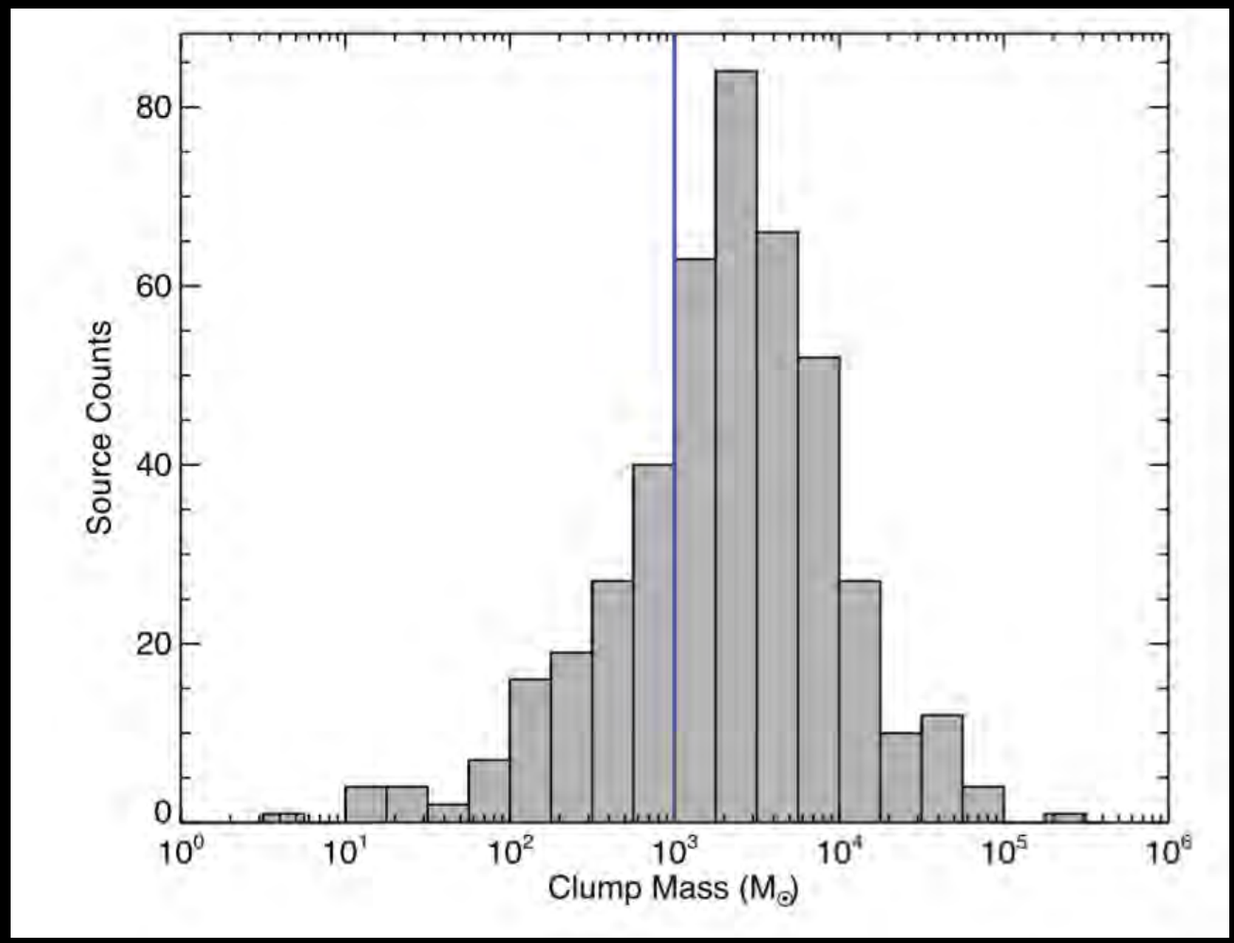
Angular offsets at core- and clump-scales





Mass distribution

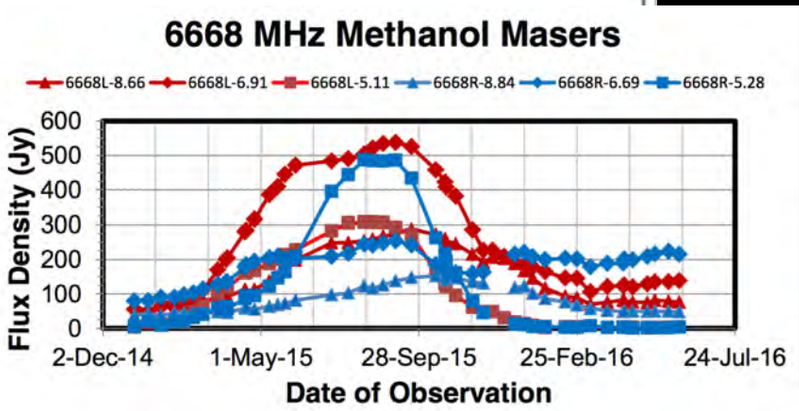


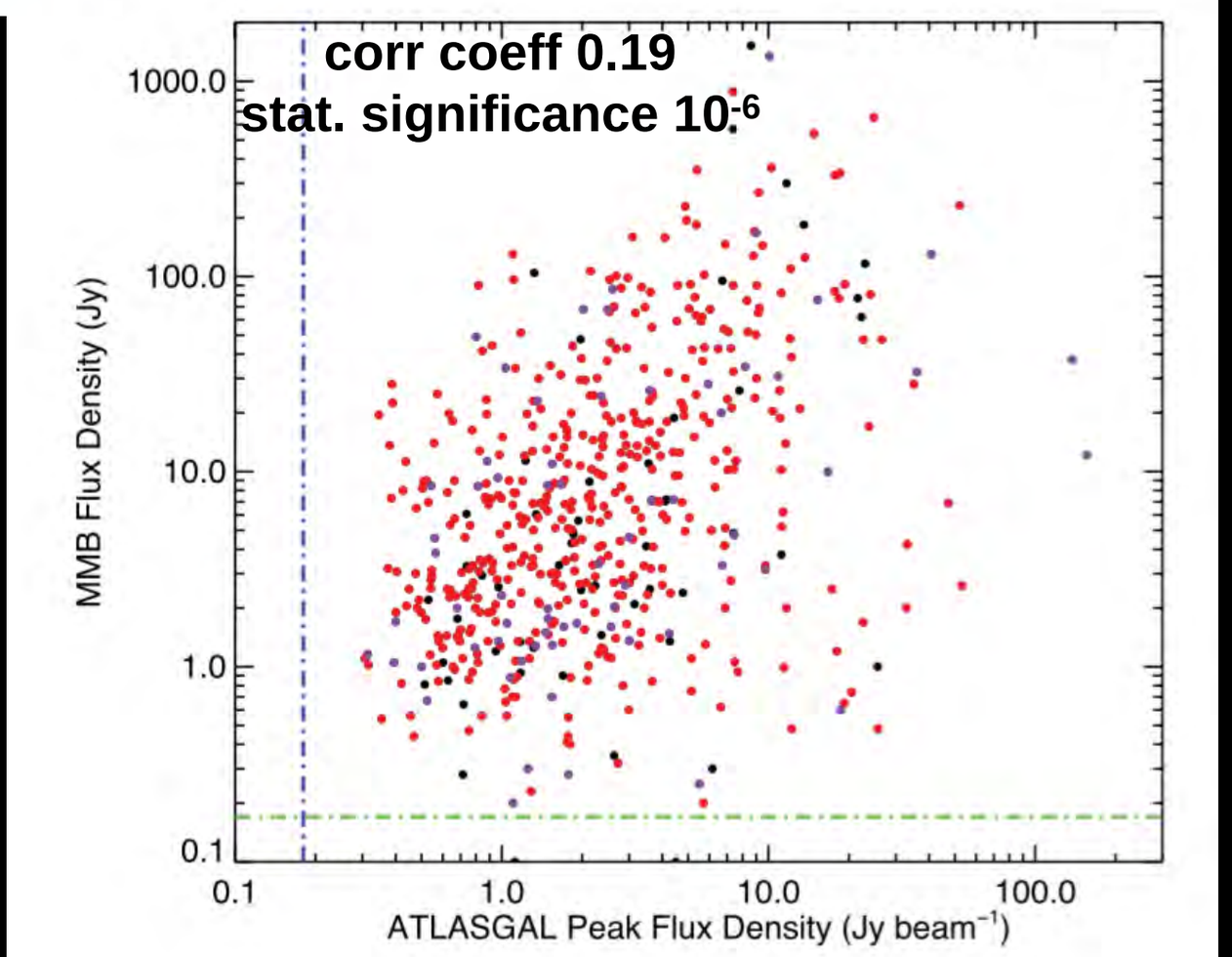


Dust temperature: 25 K (cores), 20 K (clumps)

MMB flux density comparison

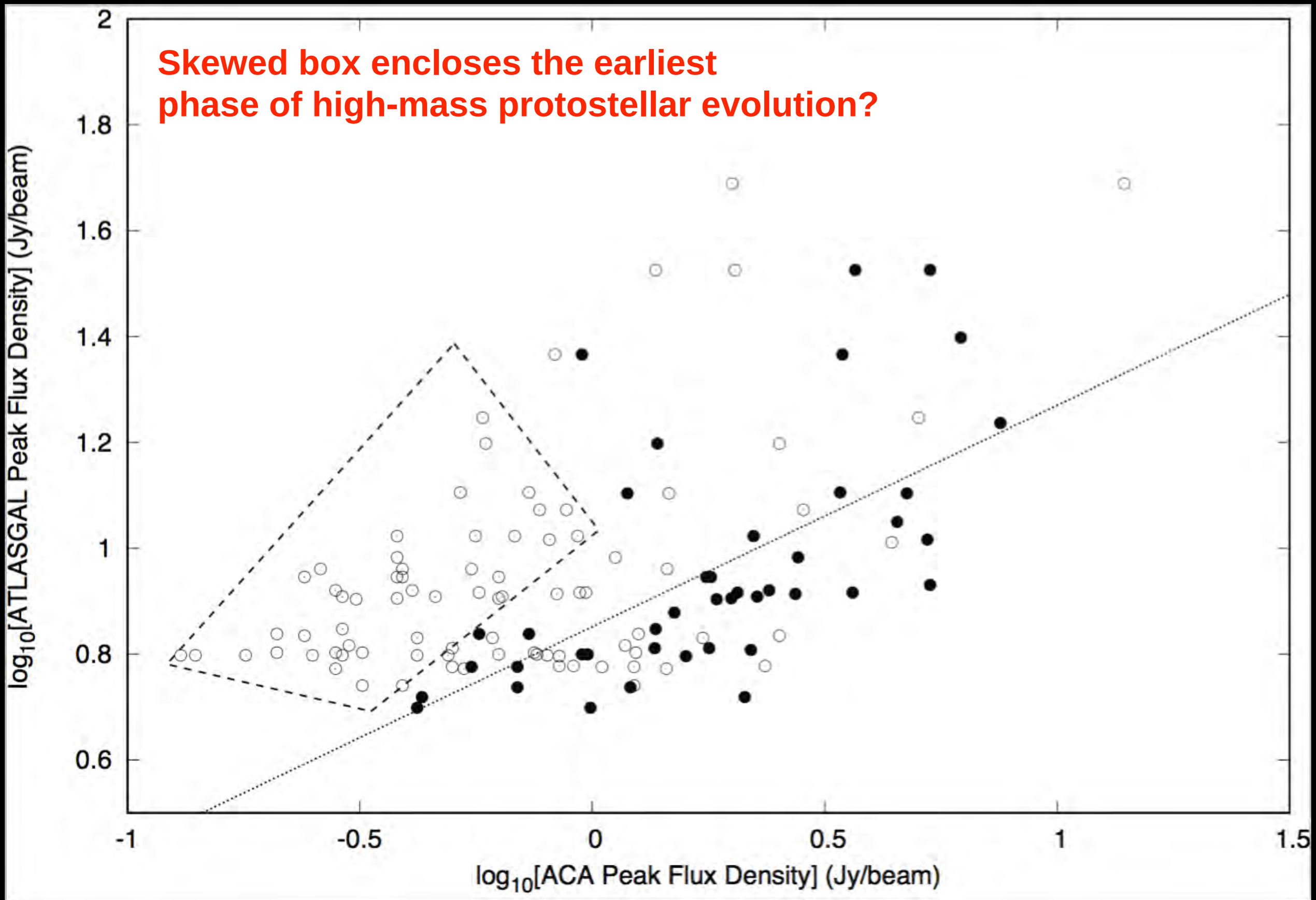
Flaring masers? Flagged





Correlation slightly varies with scale-size.

Clump-core peak flux comparison



Summary

- Presence of outflow in many cores with no 6.7 GHz CH3OH maser emission, supports de Villiers et al. proposed evolutionary sequence.
- Clump-core peak flux relation could provide a clue into the earlier evolutionary stages of massive dense core (protostellar cores).
- More survey (samples) needed to explore a robust statistical study.
- ALMA cycle 5 time to extended the survey further.