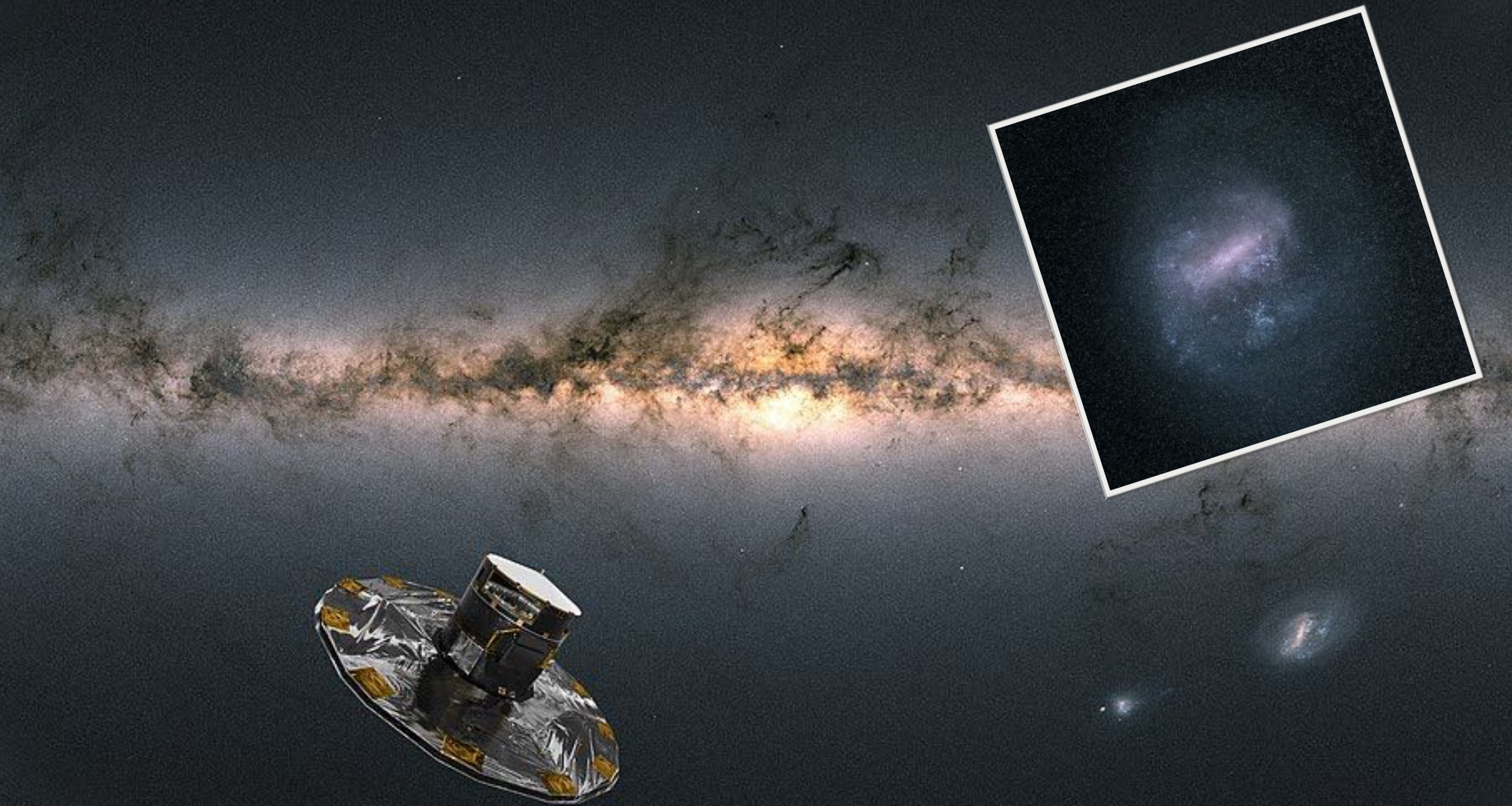


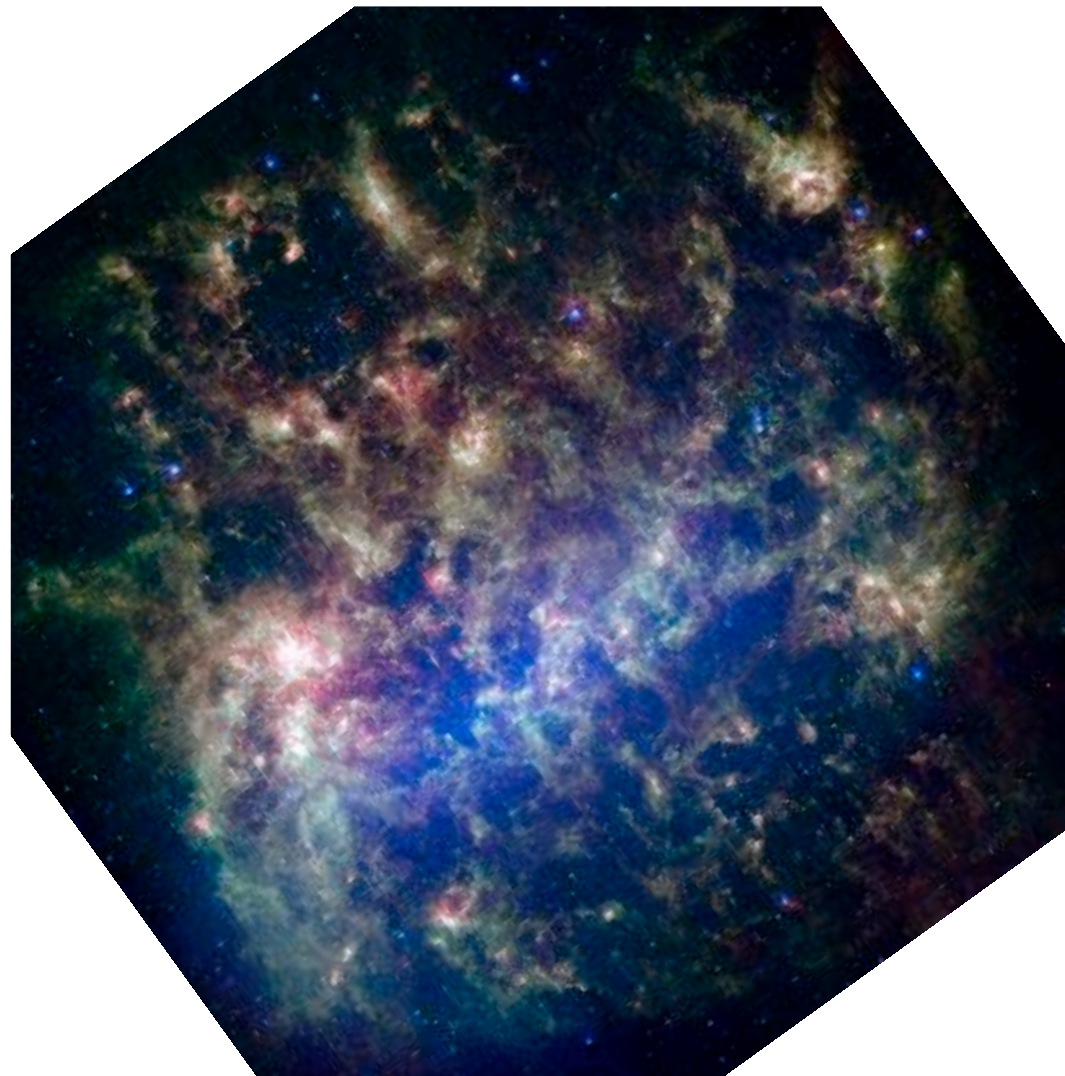
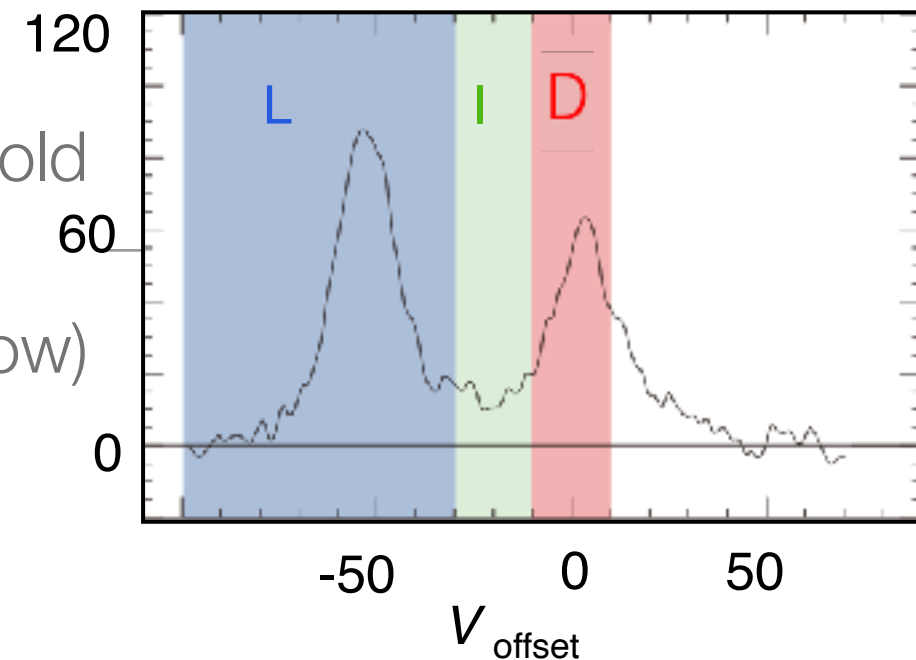
A Study of Massive Star Cluster Formation in the Large Magellanic Cloud from Their Kinematic Properties



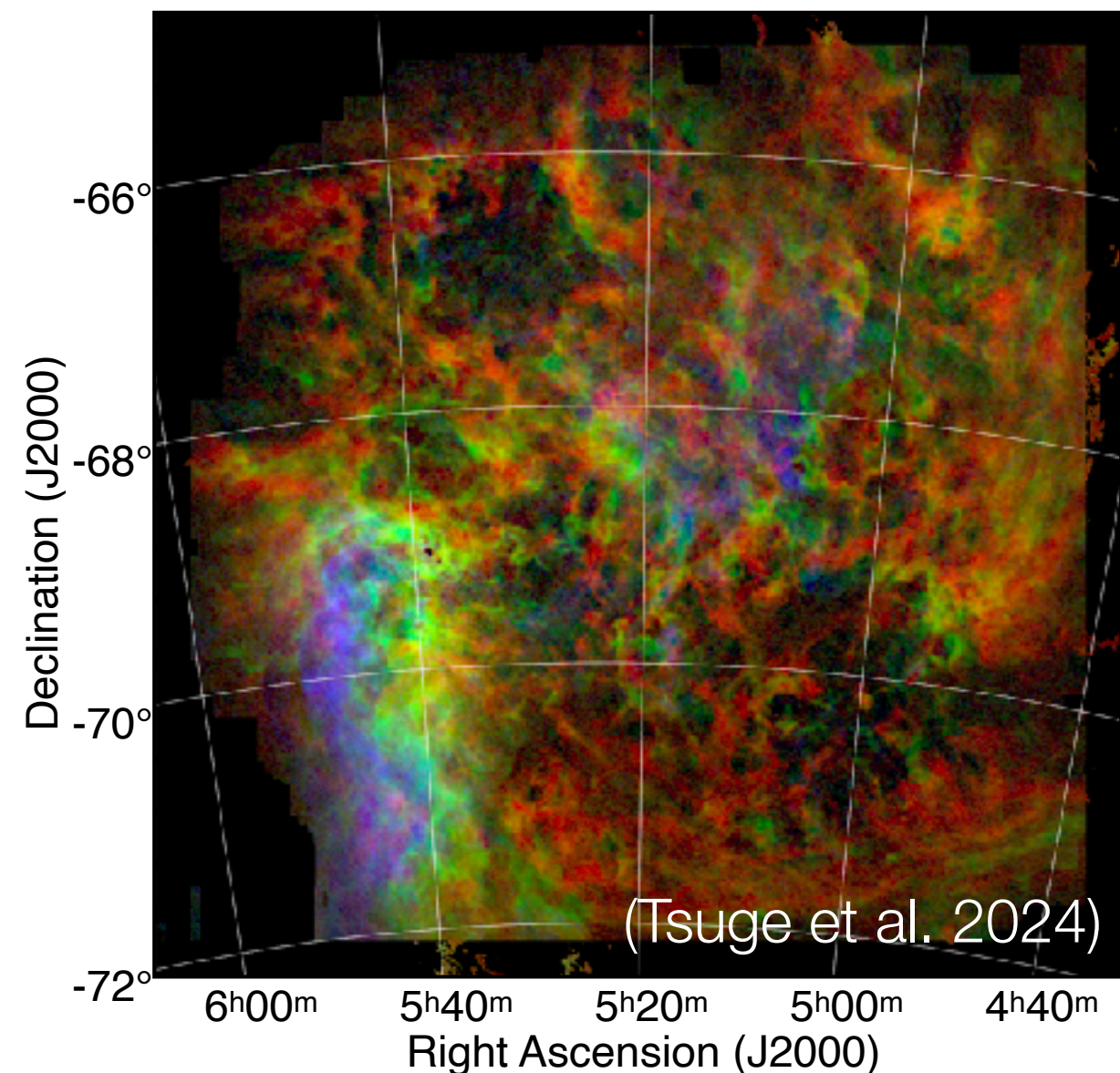
Kengo Tachihara (Nagoya University)

ISM in the Large Magellanic Cloud

- Surveyed in HI (ATCA), CO (NANTEN and Mopra), hot/cold dust (Spitzer and Herschel)
- HI has 2 velocity components (by feedback / colliding flow)
- Formations of 30 Dor and N44 have been triggered (Fukui+ 2017; Tsuge+ 2019, 2024)

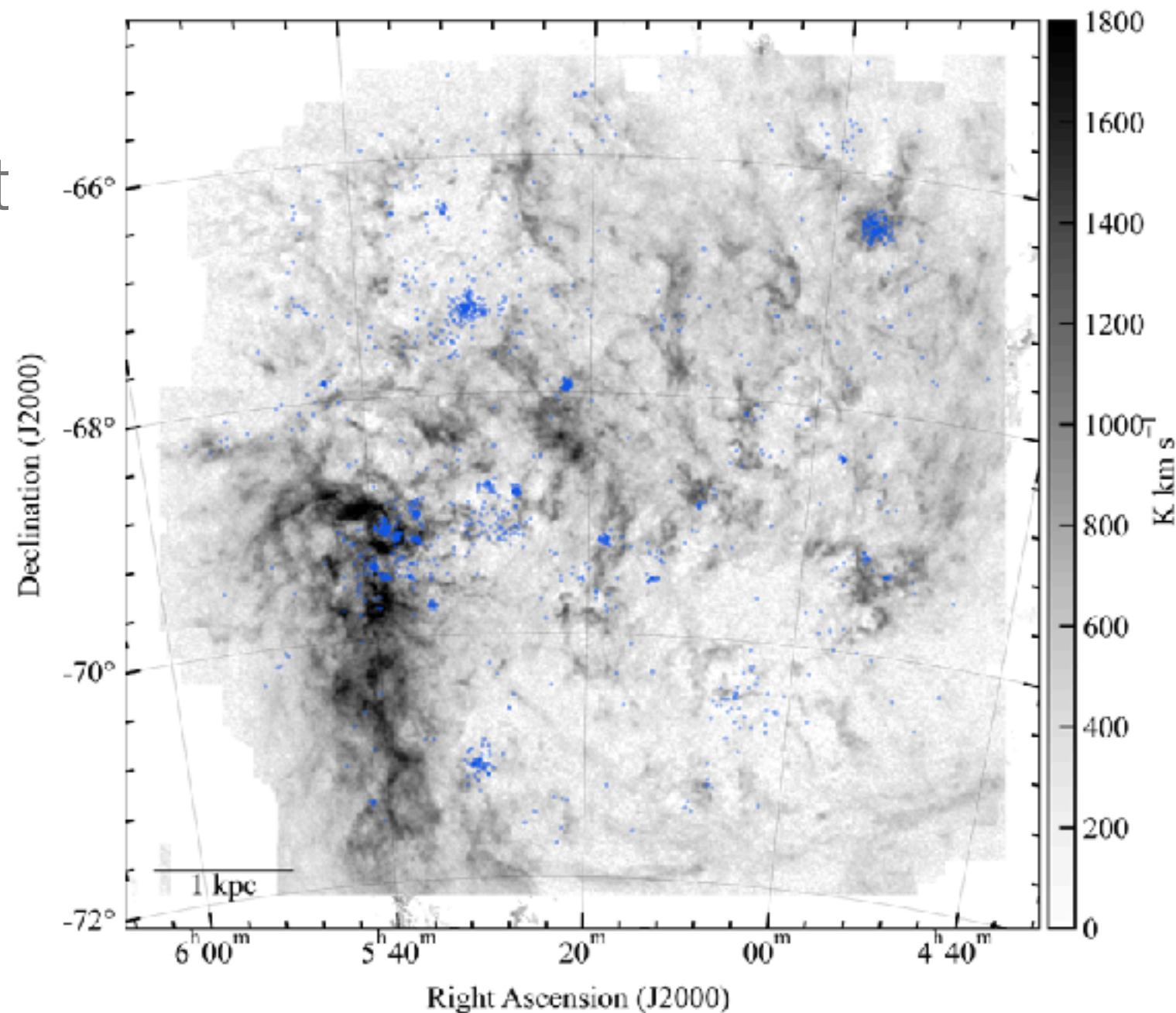


(Spitzer image: Meixner et al. 2006)



Massive stars in the Large Magellanic Cloud

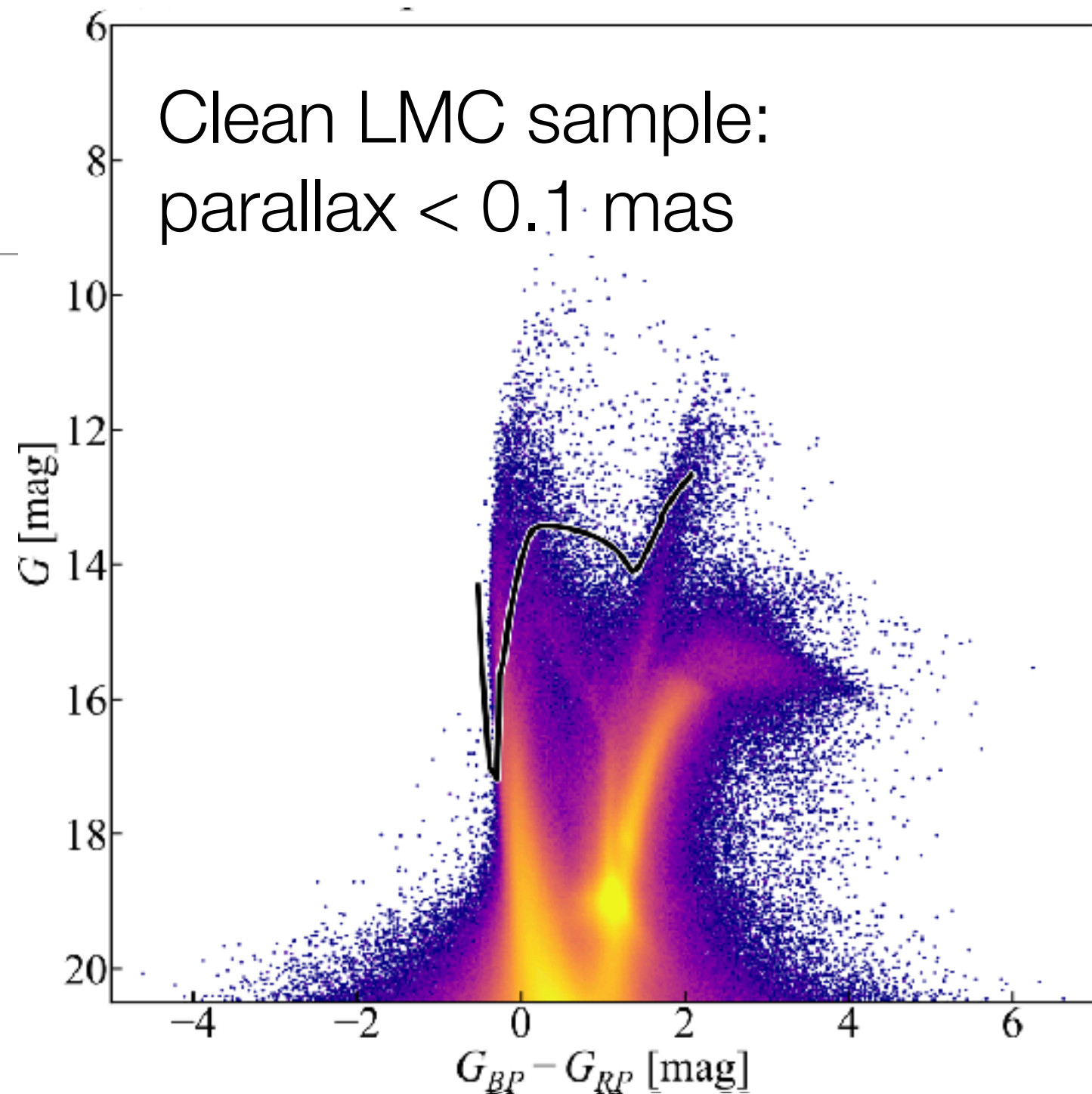
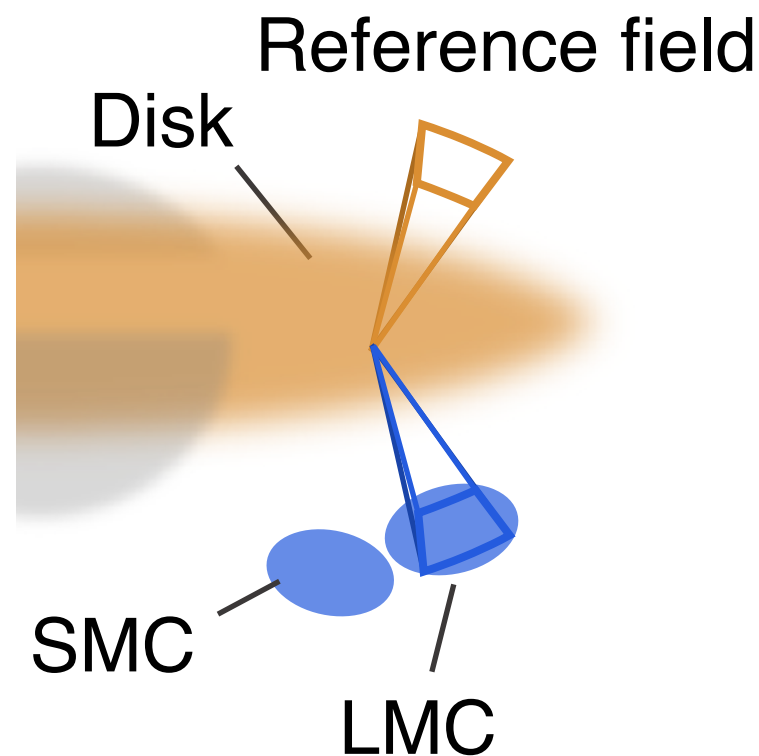
- Massive star catalog compiled by Bonanos et al. (2009)
- 1750 massive stars by spectroscopy
- Most comprehensive to date, but non-uniform
- Uniform catalog is required for statistics



(Bonanos et al. 2009)

Massive star Identification

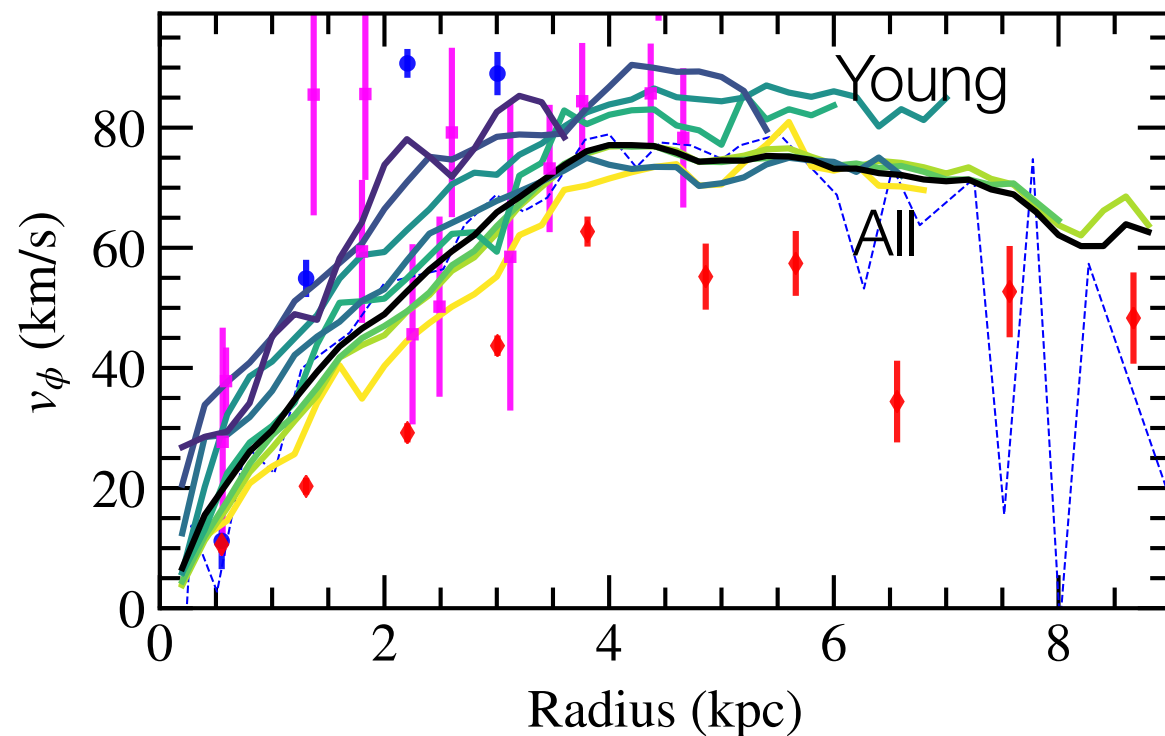
- Sample selection by CMD
 - Gaia DR3



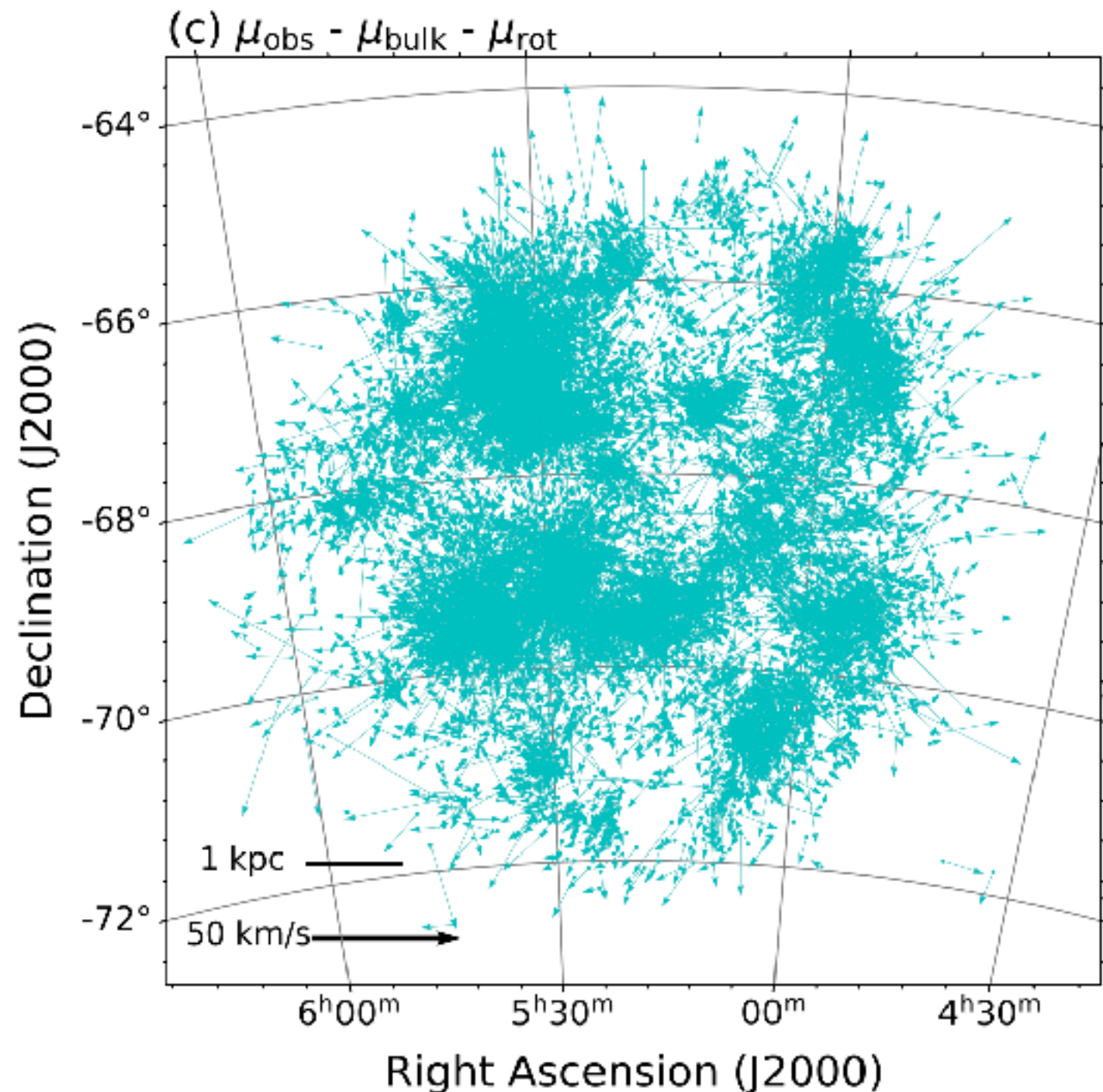
- Above the evolutionary track of $8 M_{\odot}$ star from the PARSEC model
 - Remove foreground stars
- Less than 0.4% contamination to the massive stars

Proper motions

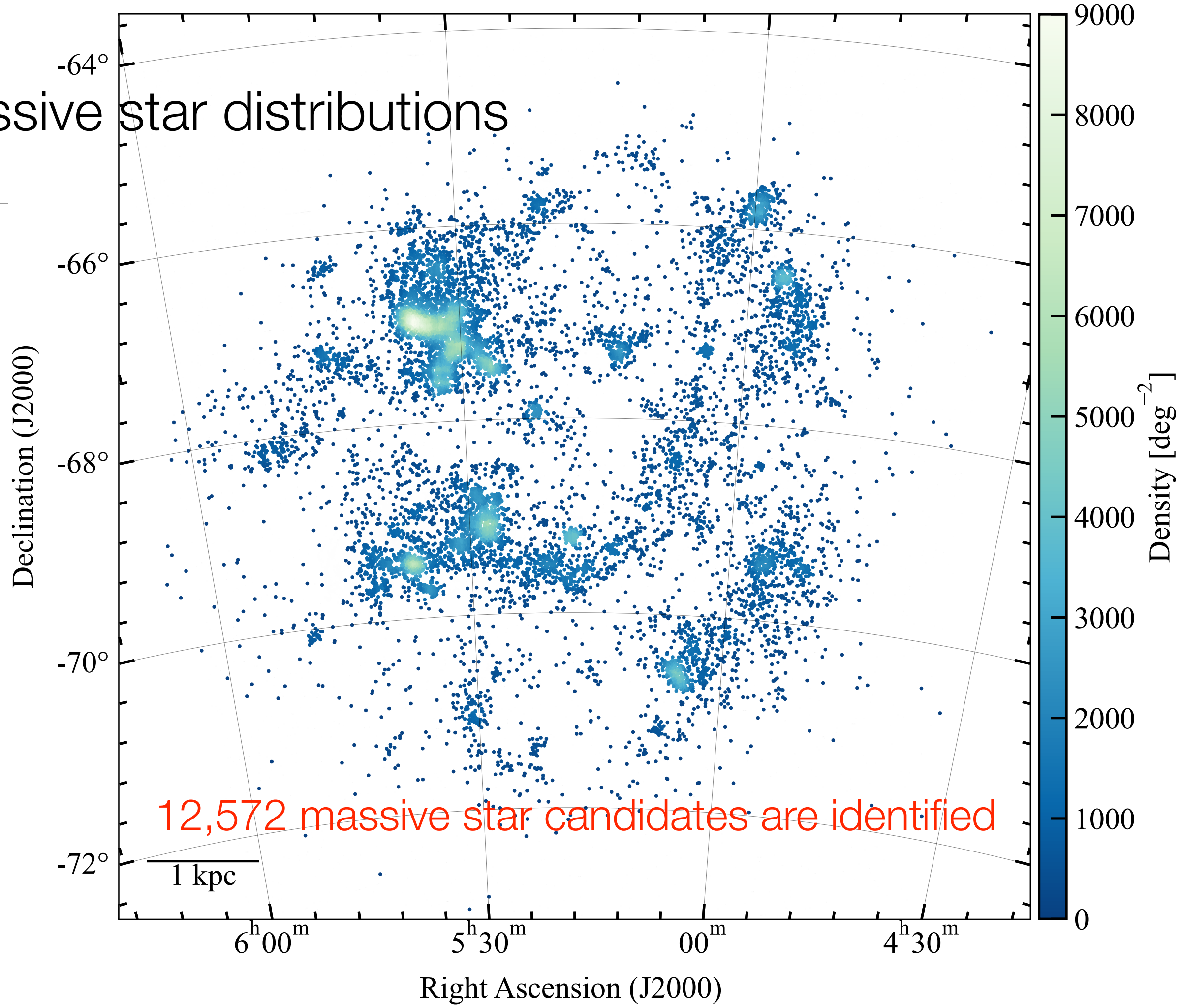
- Subtract
 - the bulk motion
 - galaxy rotation x1.3 faster than overall
- Internal PM



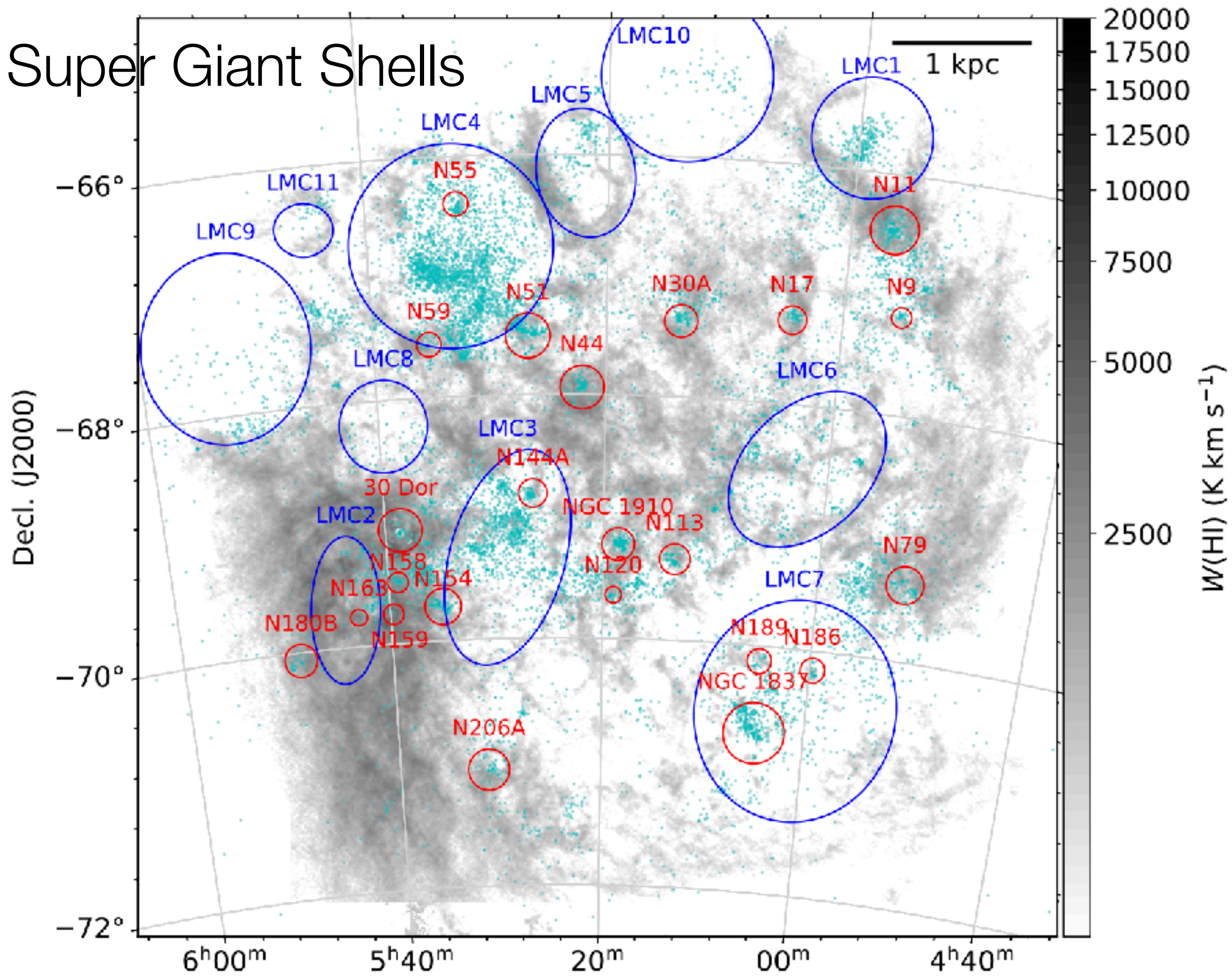
Rotation curve (Gaia collaboration 2021)



Massive star distributions

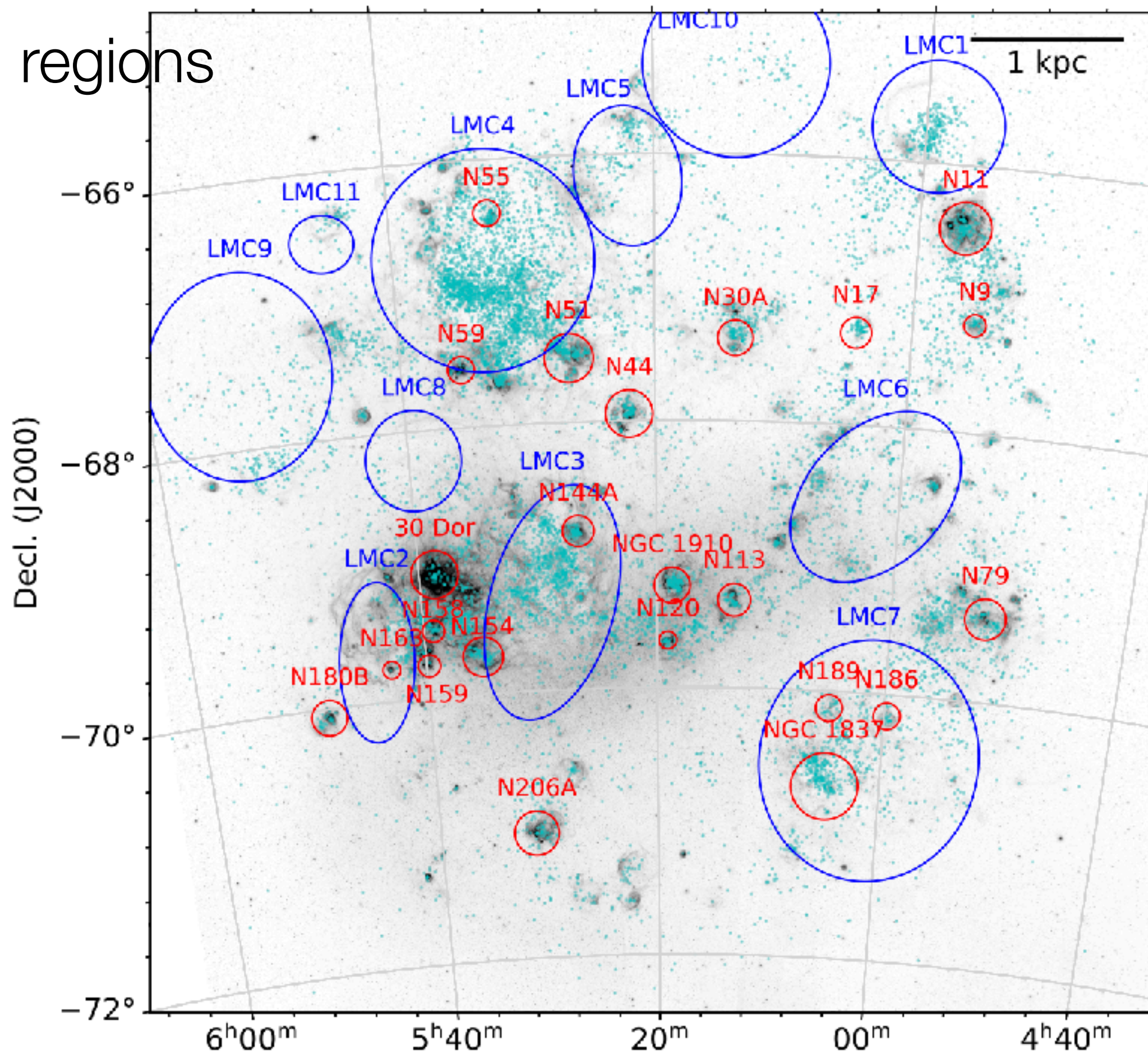


HI Super Giant Shells

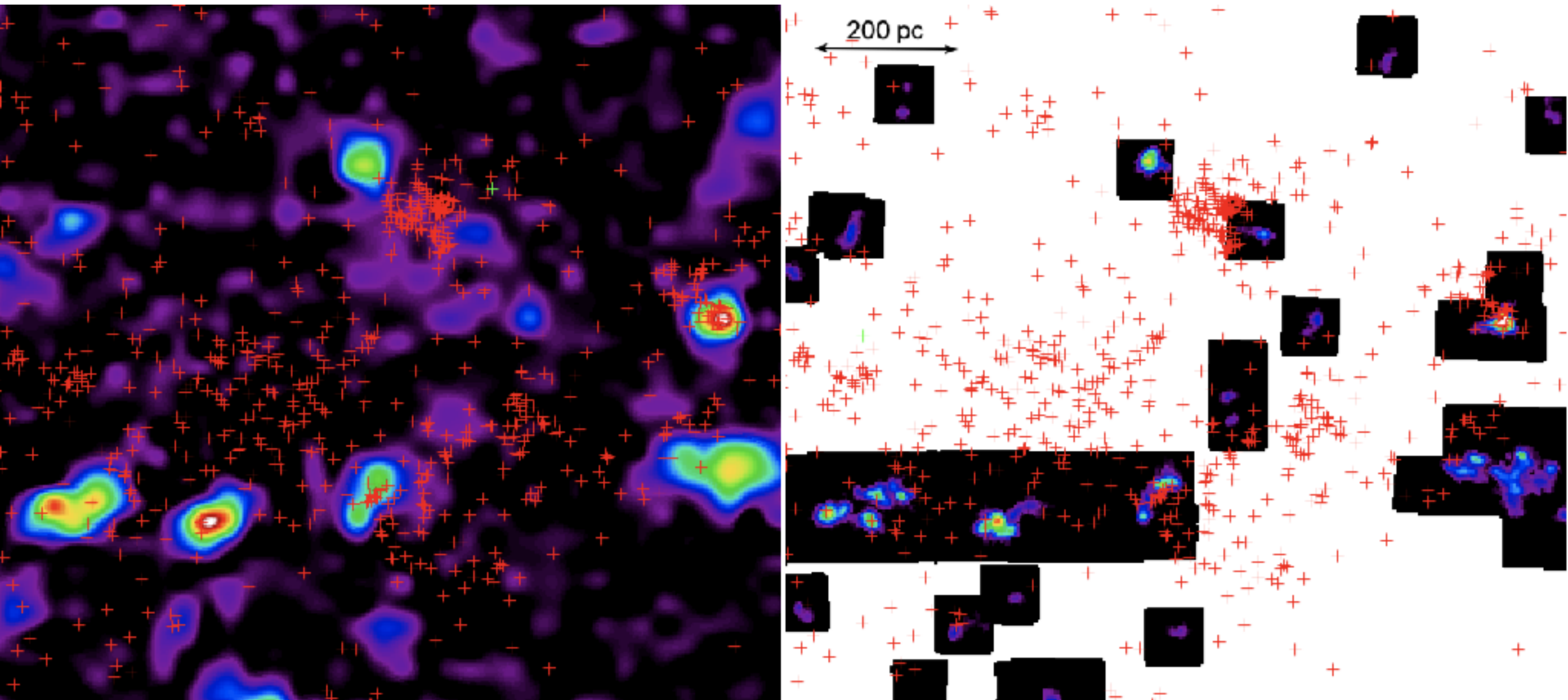


(Kim et al. 1999; Dawson et al. 2013)

HII regions



Association with CO clouds



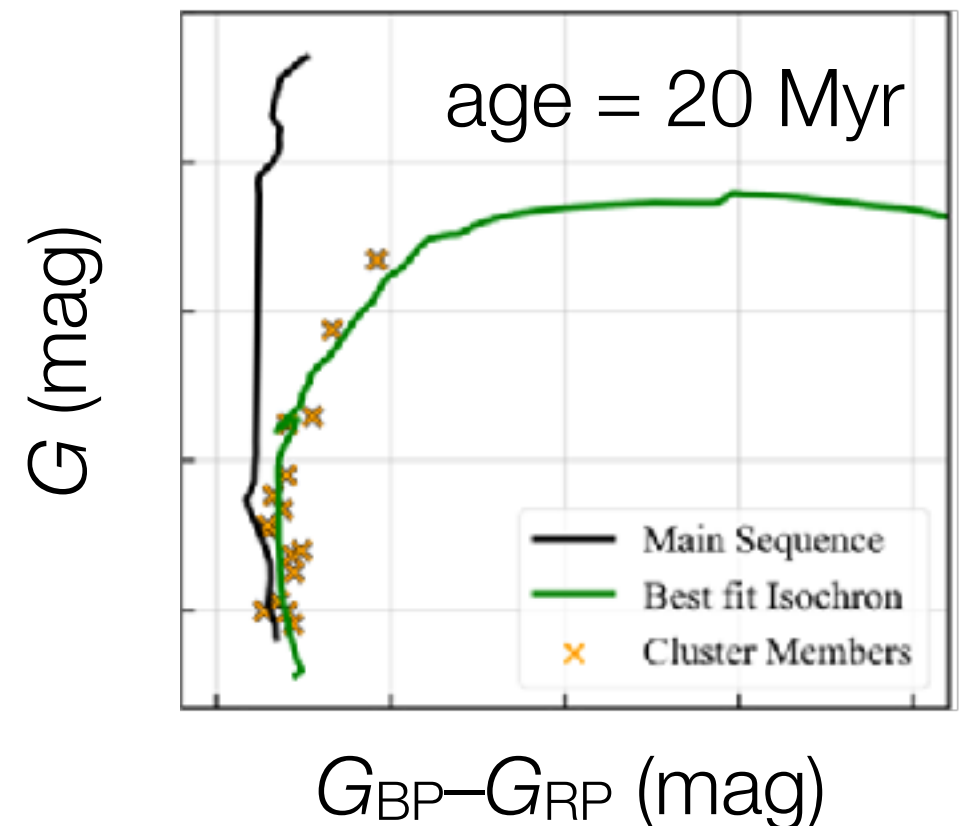
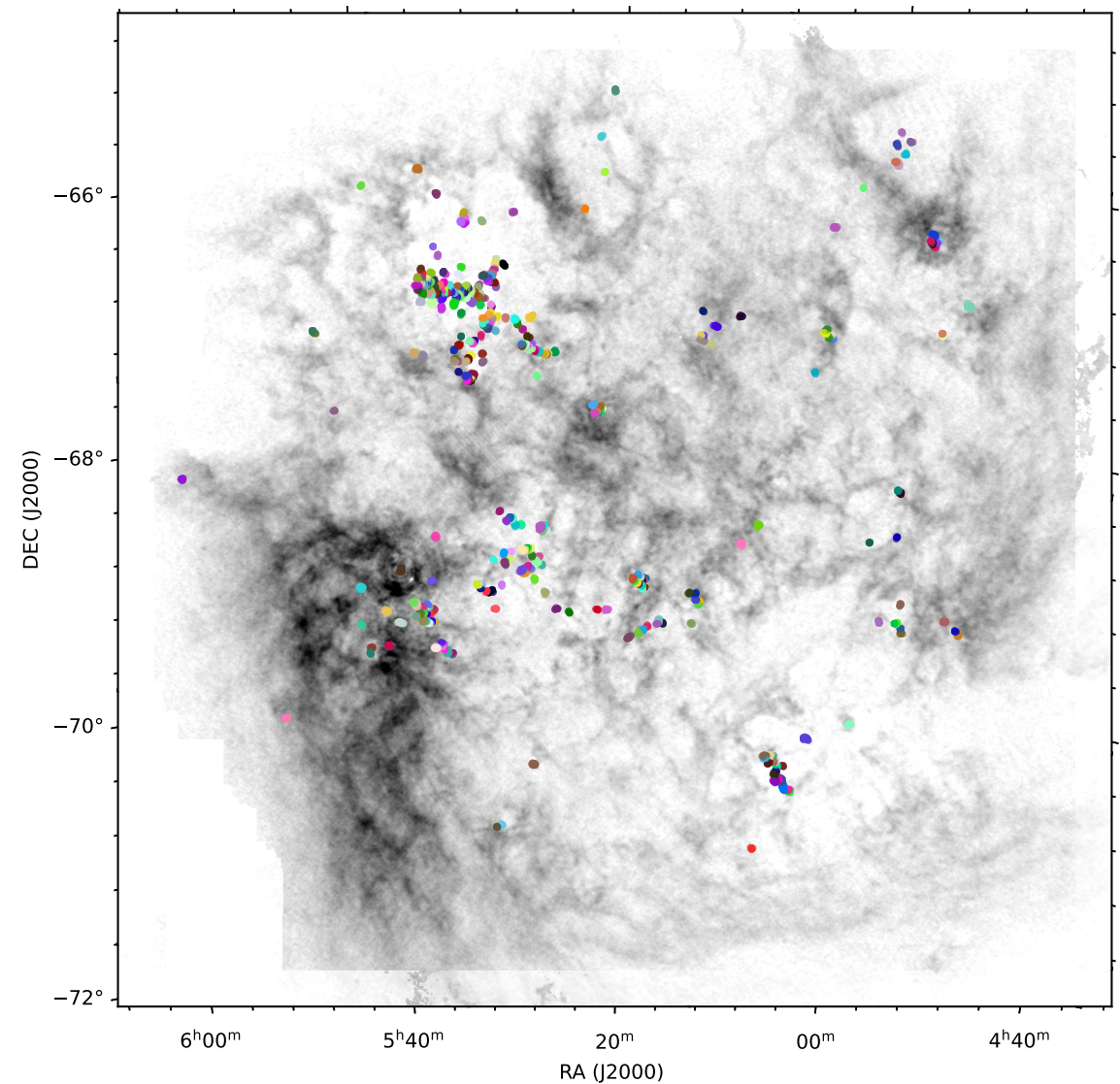
(NANTEN: Fukui et al. 1999, 2008)

(Mopra MAGMA survey: Wong et al. 2011, 2017)

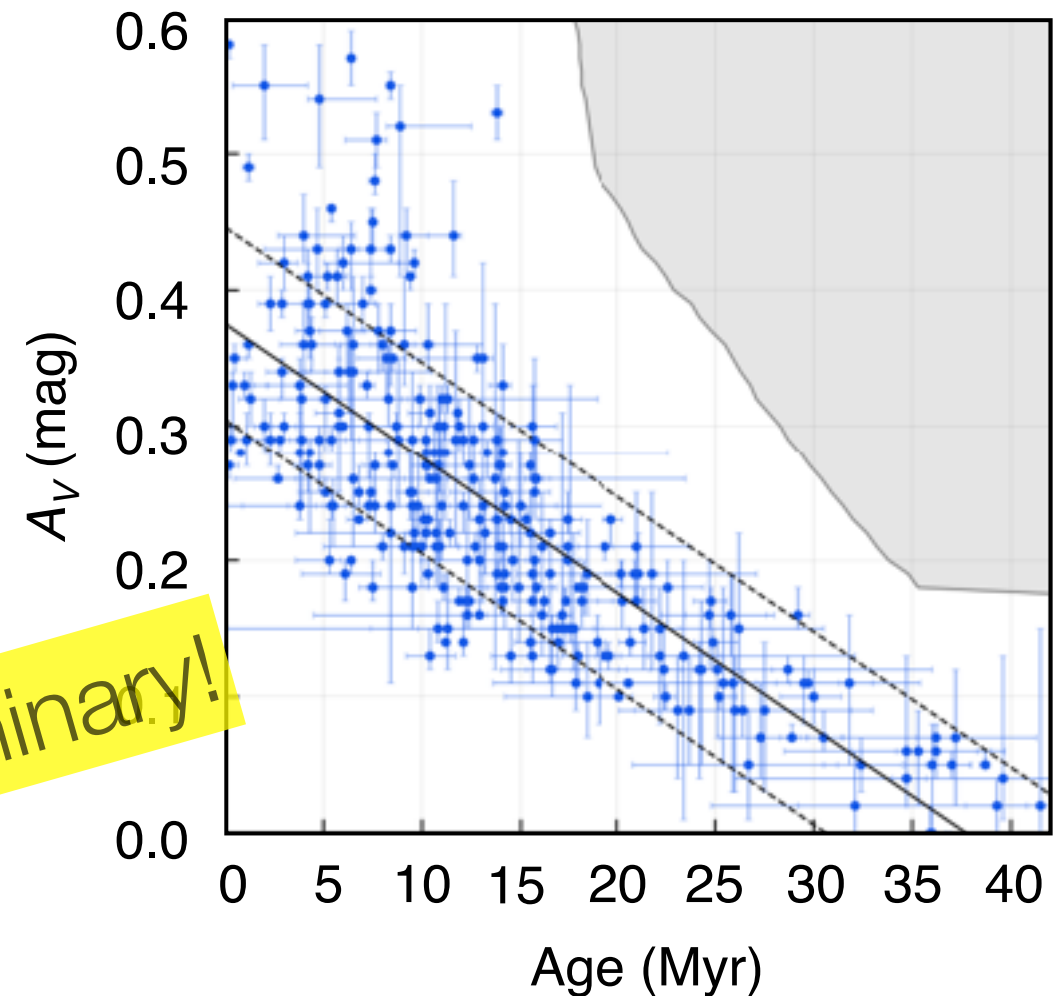
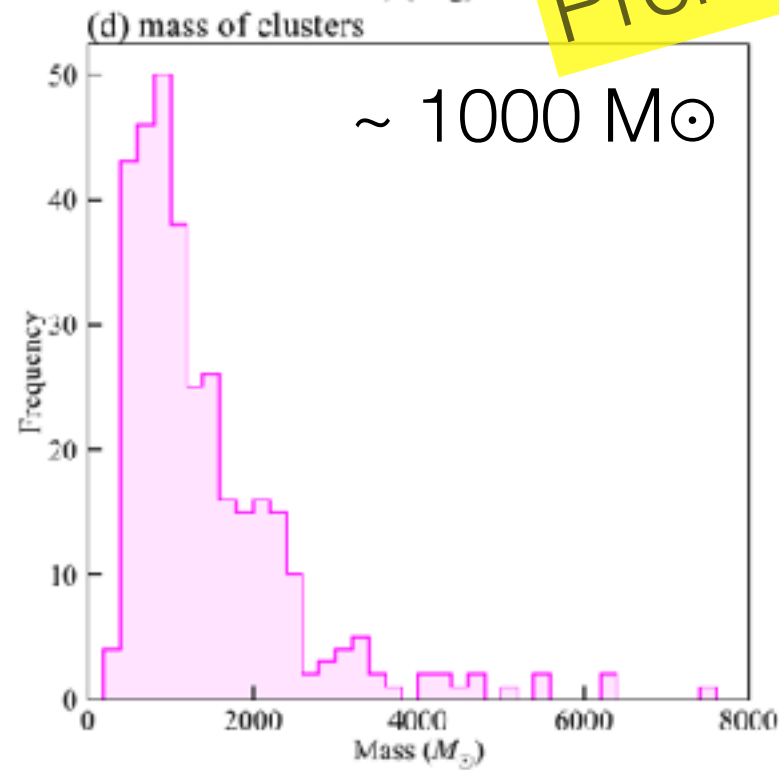
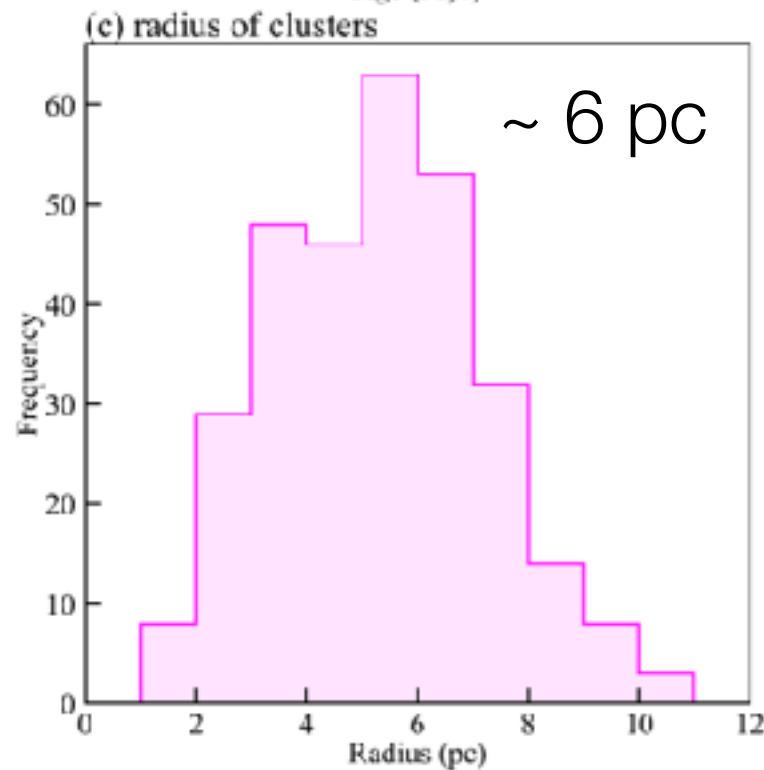
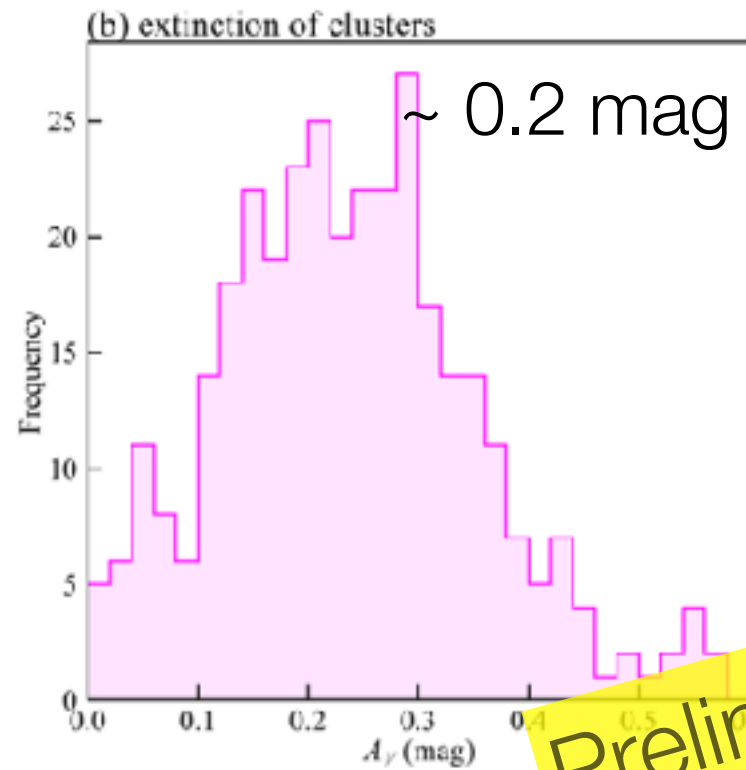
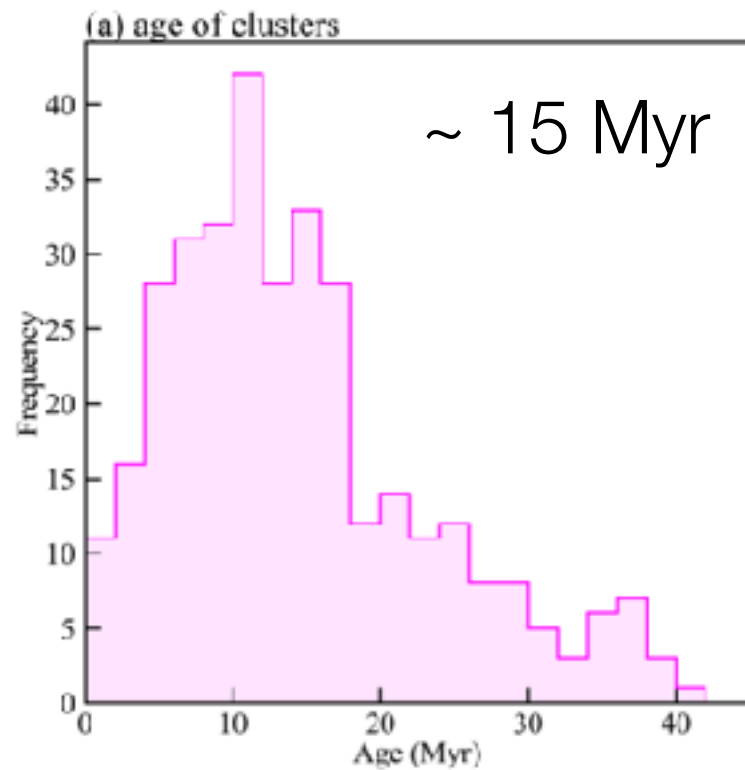
- Some are associated with CO clouds, but many others are separated.
- They are destroying molecular clouds.

Cluster identifications

- Apply the DBSCAN algorithm
- Identify 339 cluster candidates
- Apply isochrone fitting with age and A_V as free parameters
- By the χ^2 test, **304 coeval clusters**



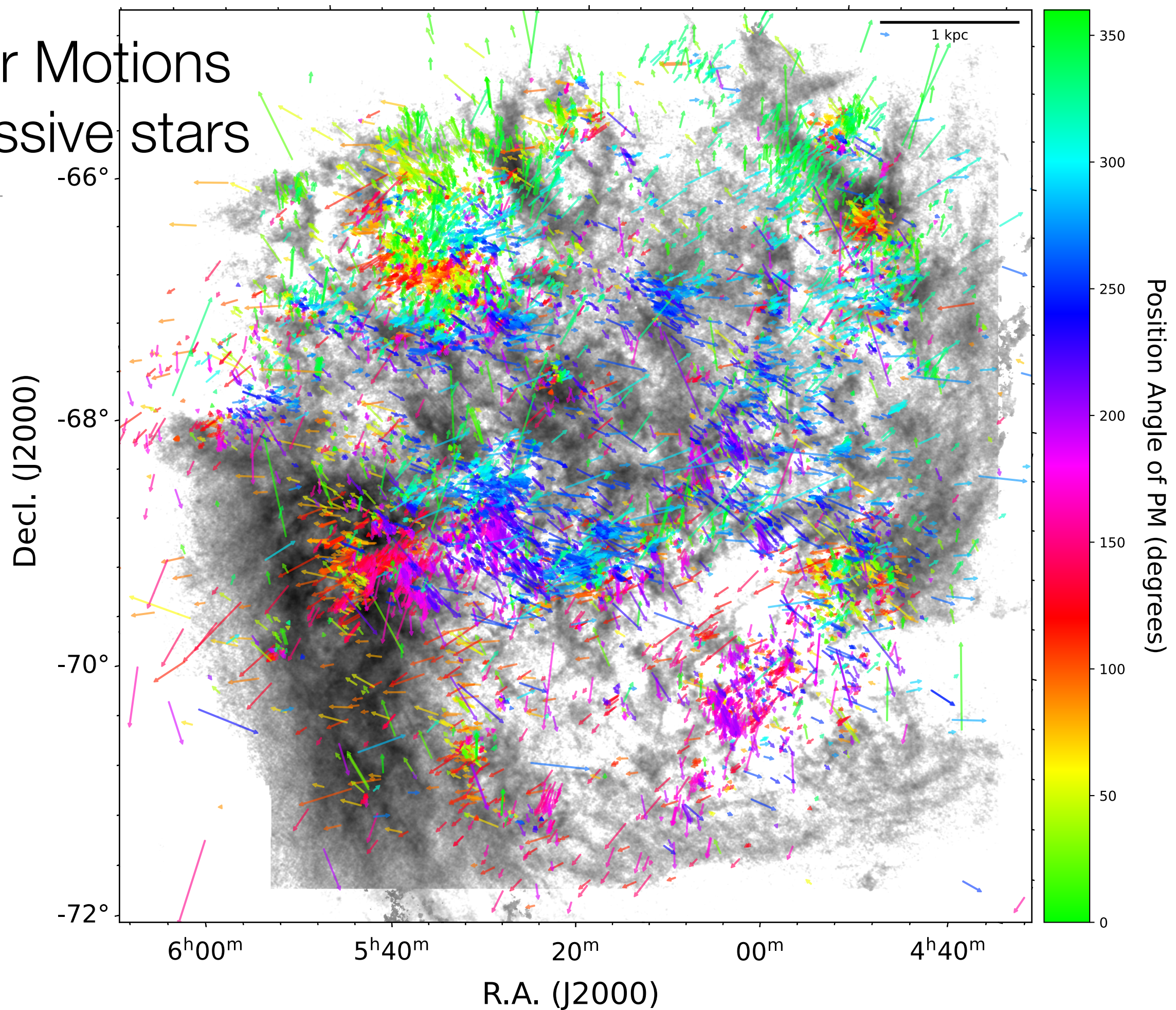
Properties of the clusters



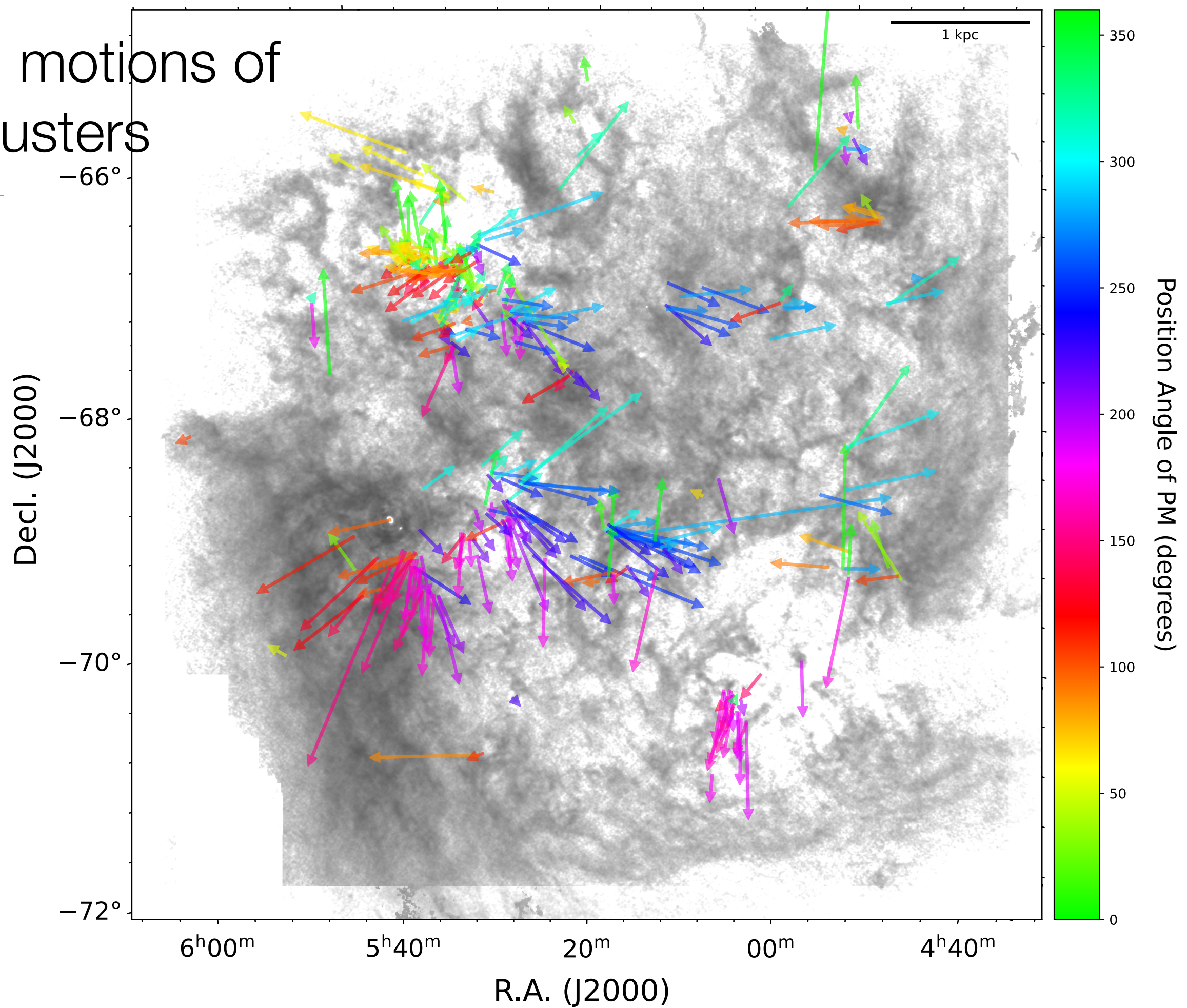
Preliminary!

Cloud dissipation timescale
~ 30 Myr

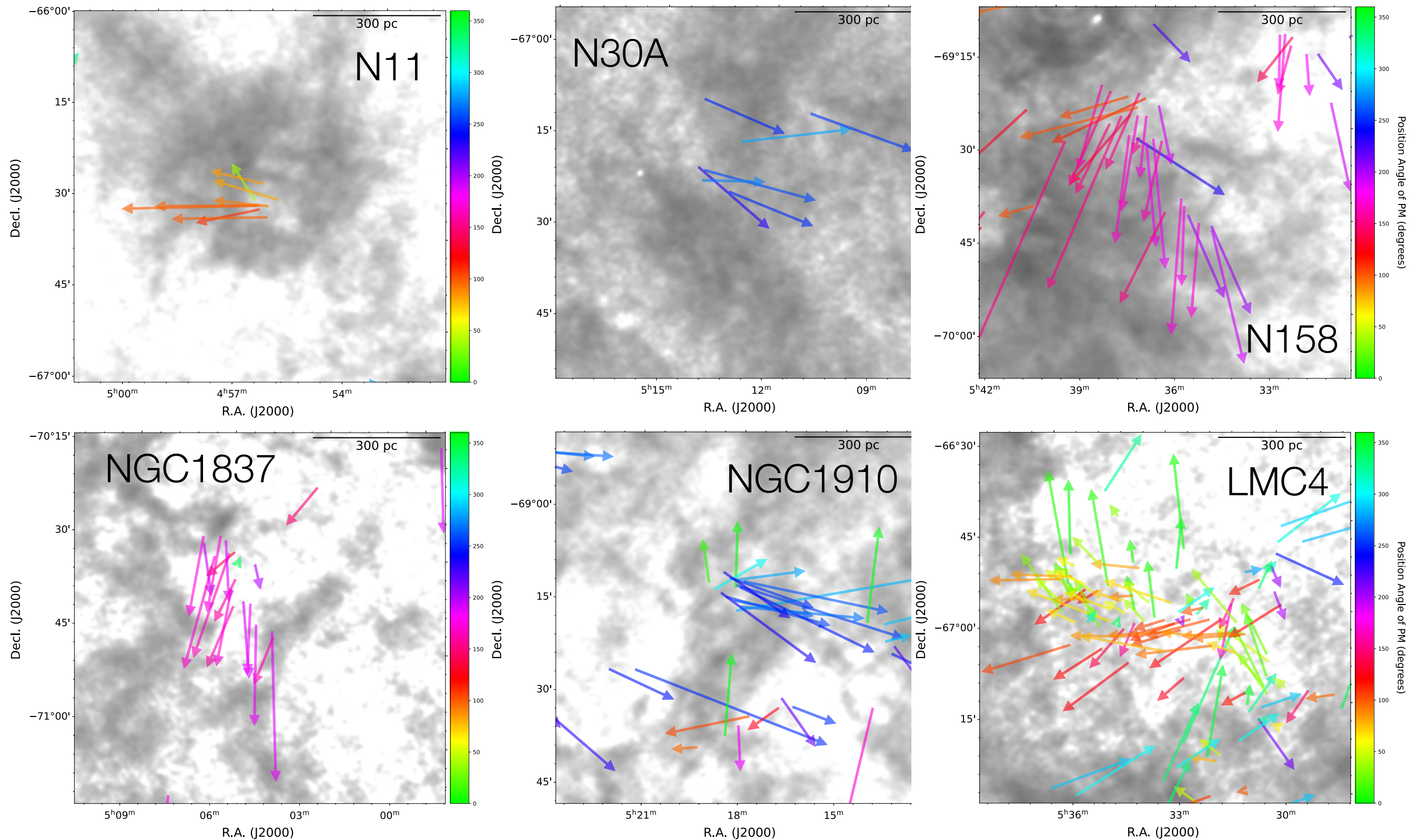
Proper Motions of Massive stars



Mean motions of the clusters

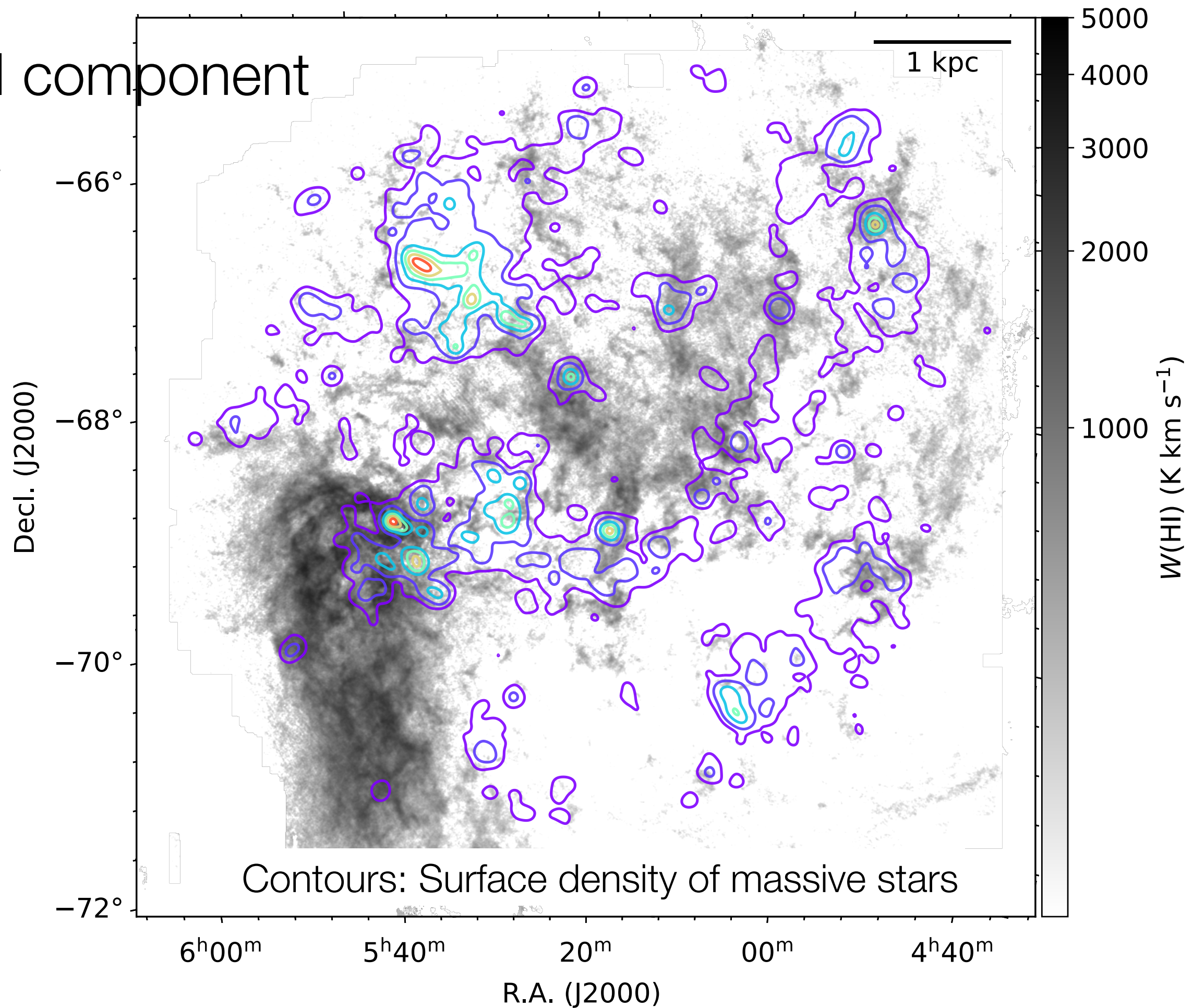


A few-100 pc scale co-moving clusters

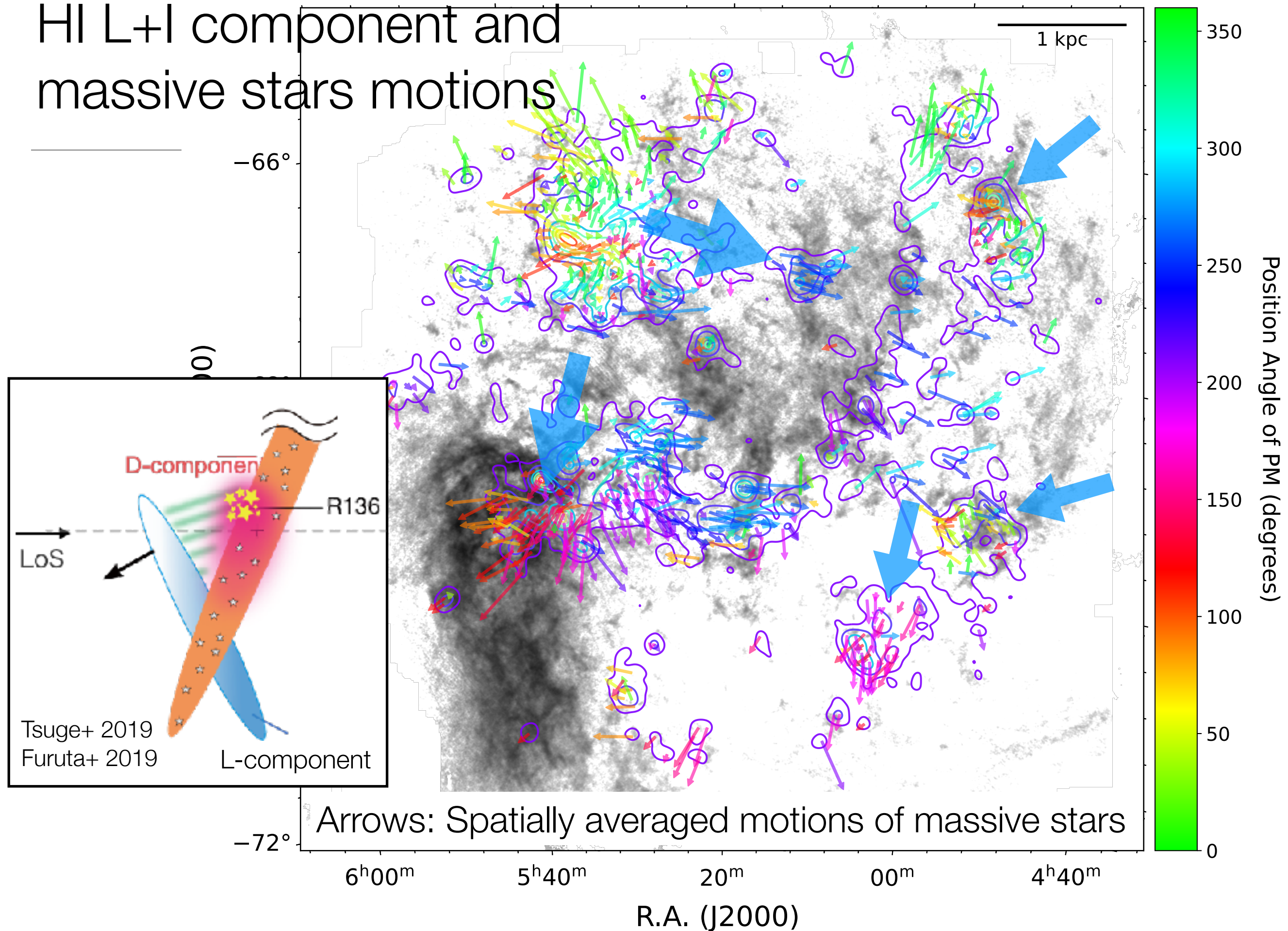


Each arrow shows mean motion of single cluster

HI L+I component

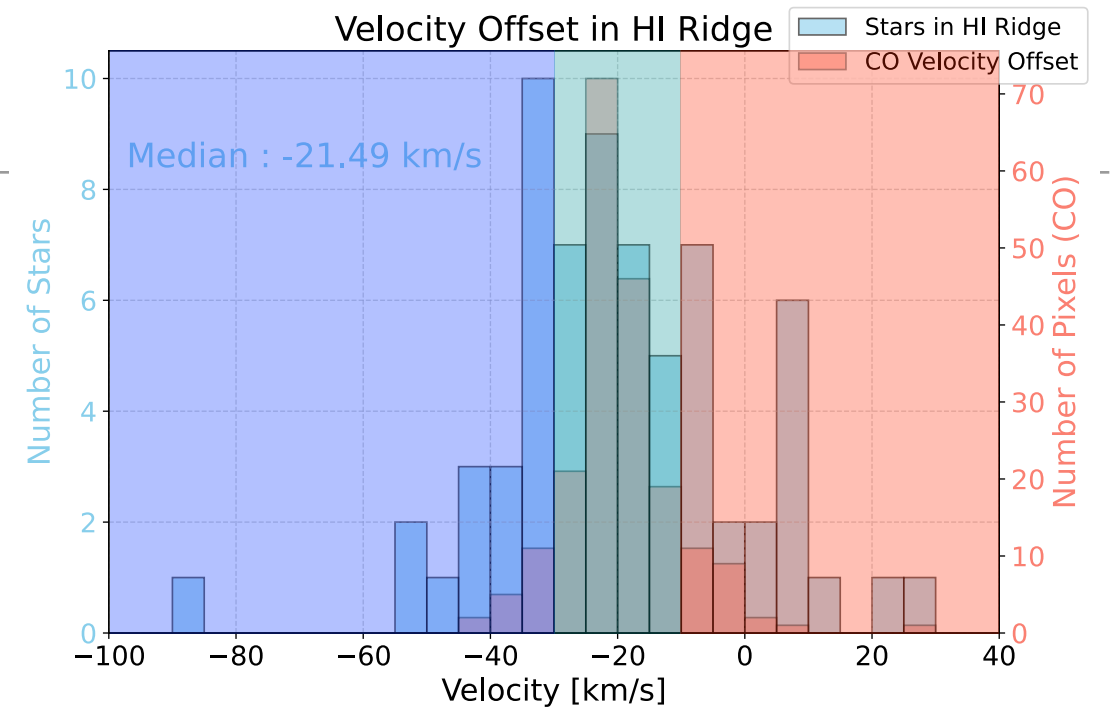


HI L+I component and massive stars motions

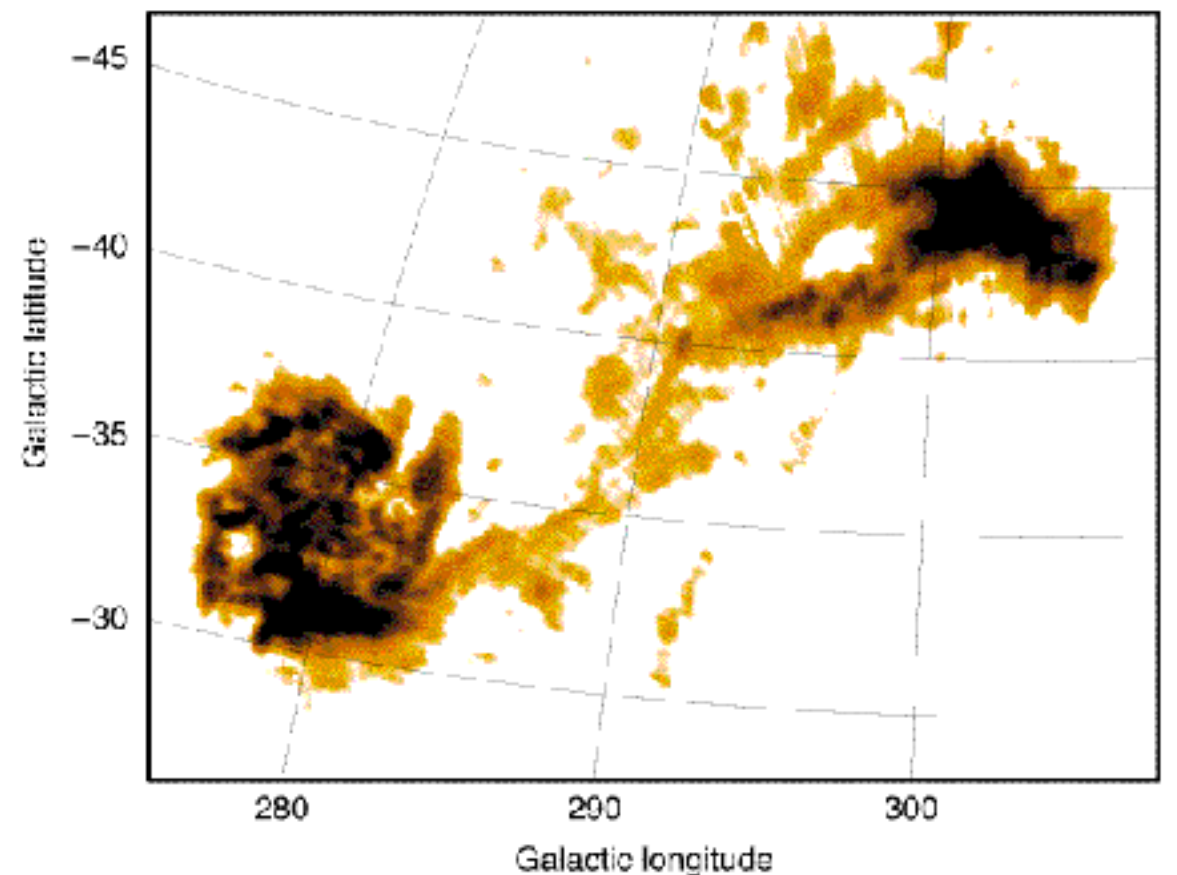


Triggered star formation by interaction with SMC

- Massive stars in LMC are
 - concentrated on the edge of the HI L+I components
 - moving away from L+I HI gas
 - have similar radial velocity to CO clouds between the HI L- and D-components
 - suggested to be **formed by triggering of accreting gas flow from the SMC.**

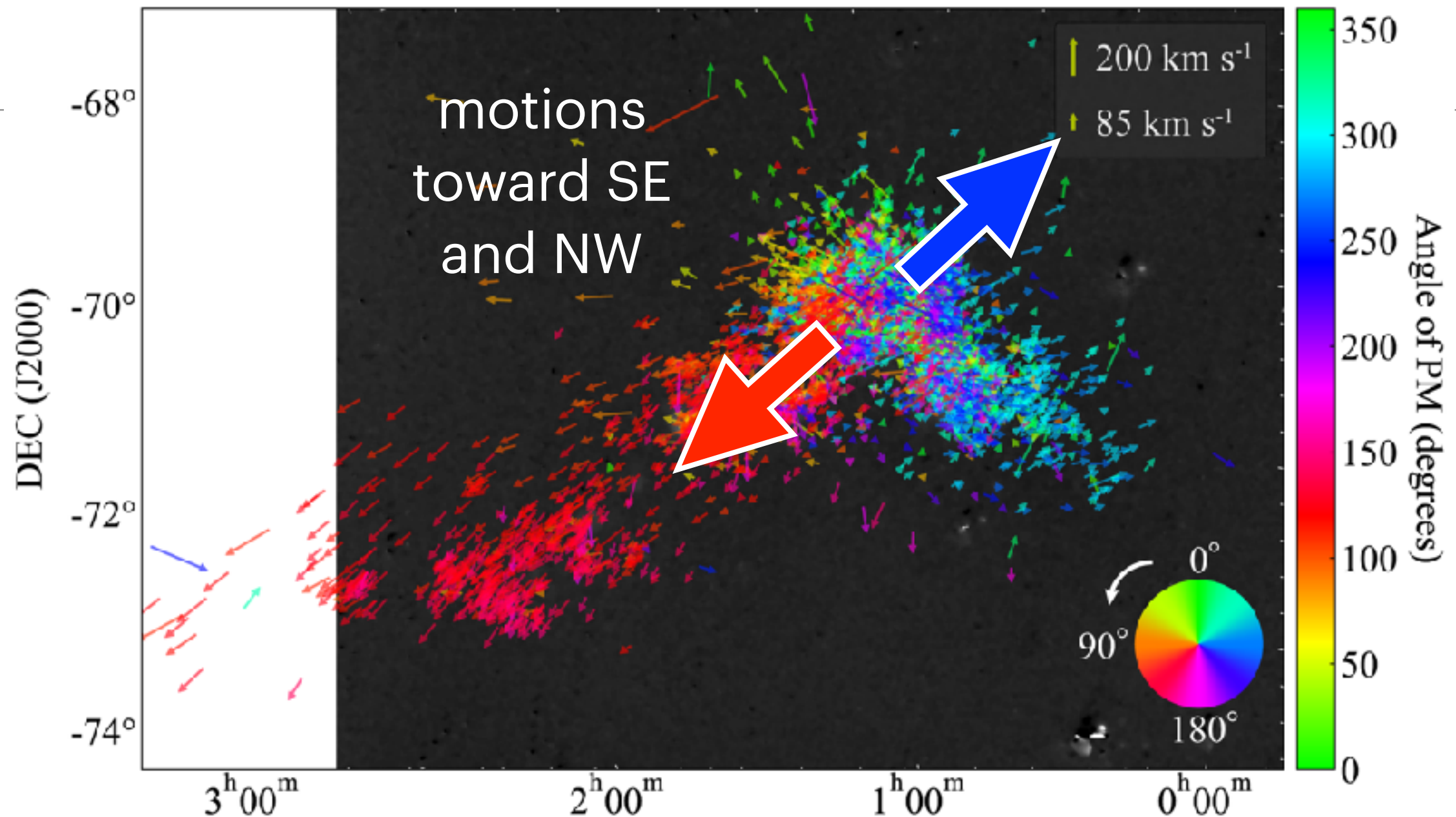


Radial velocity of CO and Gaia stars in the HI ridge



The Magellanic Bridge (Putman et al. 1998)

What about SMC?



SMC is not rotating, but being destructively stretched.
Total mass derived from the HI rotation might be wrong!

Nakano, Tamashiro & Tachihara 2025, ApJS, 277, 62

Nakano & Tachihara 2025, ApJL, 985, 5L

Summary

- Using the Gaia DR3 data, 12572 massive stars are identified in the LMC.
- ~ 300 clusters of $\sim 1000 M_{\odot}$, 15 Myr and 6 pc are identified.
- Co-moving clusters and massive stars over a size scale of a few 100 pc.
- Large-scale HI gas flow are colliding the LMC disk and triggering the massive star and cluster formation.