# Galaxy Feedback with Young Stellar Clusters & GMCs with LEGUS


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Legacy ExtraGalactic Ultraviolet Survey

NGC 1566

@ktgrasha

# Star Formation is Hierarchical

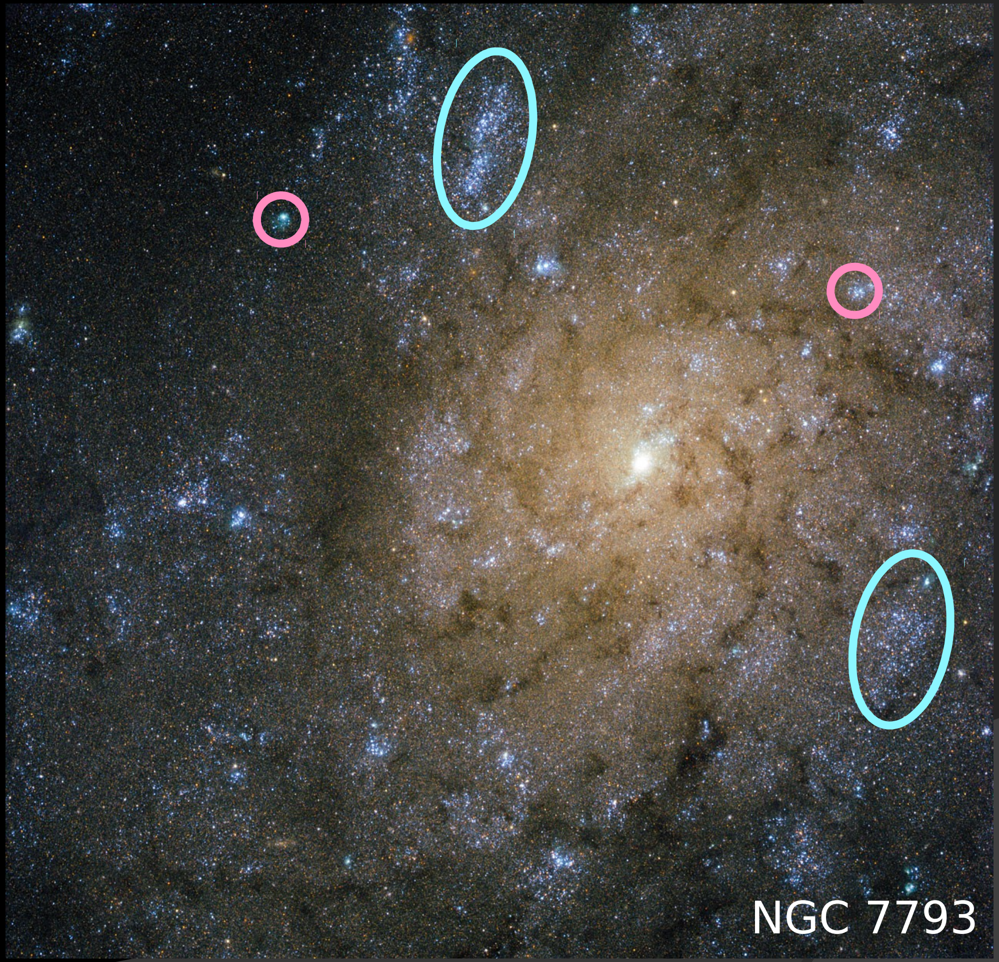
Star formation is the key process in shaping the structure, morphology, and evolution of galaxies

**Young stellar clusters**

✉ + their feedback to study star formation

Star formation is a group activity!

- → Hierarchical fashion e.g., Elmegreen+00
- → The *origins* and how they are *determined* are fundamental questions to understanding star formation



# Star Formation: The Bigger Picture

Linking local (*smooth*) star forming structures to those at high-$z$ (*clumpy*)

→ *The role of feedback in self-regulating star formation and ISM properties in galaxies and how that changes over cosmic time*

→ What are the timescales for emerging clusters?

- Can we unravel the role that cluster feedback plays in regulating the star-formation cycle?

→ What are the gas conditions of star-forming clumps?

- Map the temporal evolution of H II and photo-dissociated regions

# Legacy ExtraGalactic UV Survey

Calzetti+15

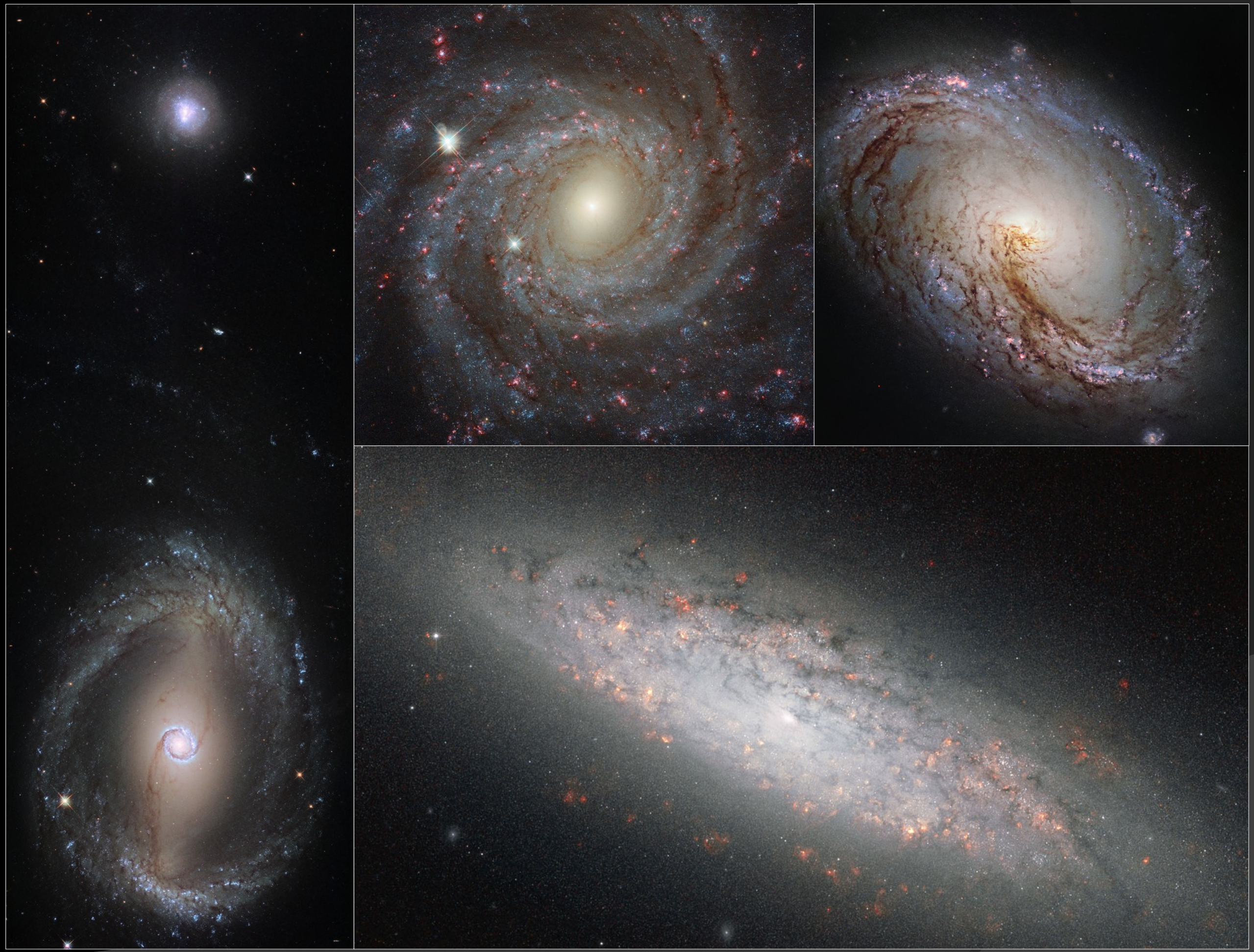
Cycle 21 *HST* Treasury Program

50 local galaxies (4-18 Mpc)

- 154 orbits
- WFC3/ NUV, U, B, V, I

Investigate star formation and its relation with the galactic environment from ~pc to ~kpc scales

LEGUS provides the gold standard for acquiring star cluster catalogs



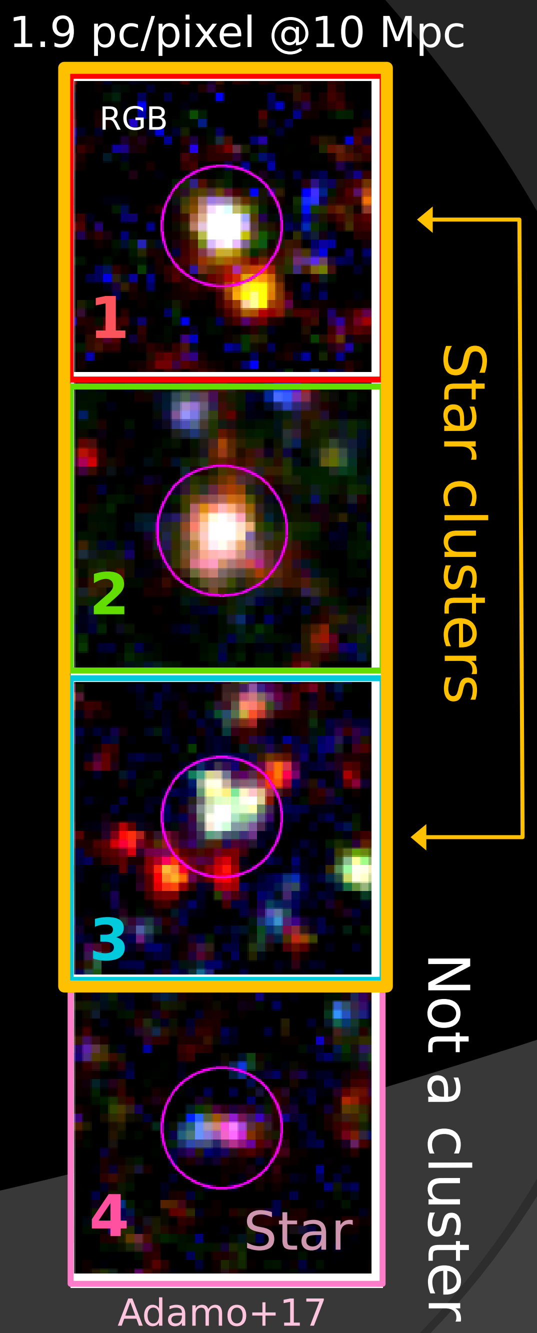
# Visual Cluster Identification

Visual identification provides robust catalogs

1 – symmetrical light profiles
2 – asymmetrical light profiles
3 – multi-peak systems
4 – not a cluster (stars, galaxies, bad pixels, etc)

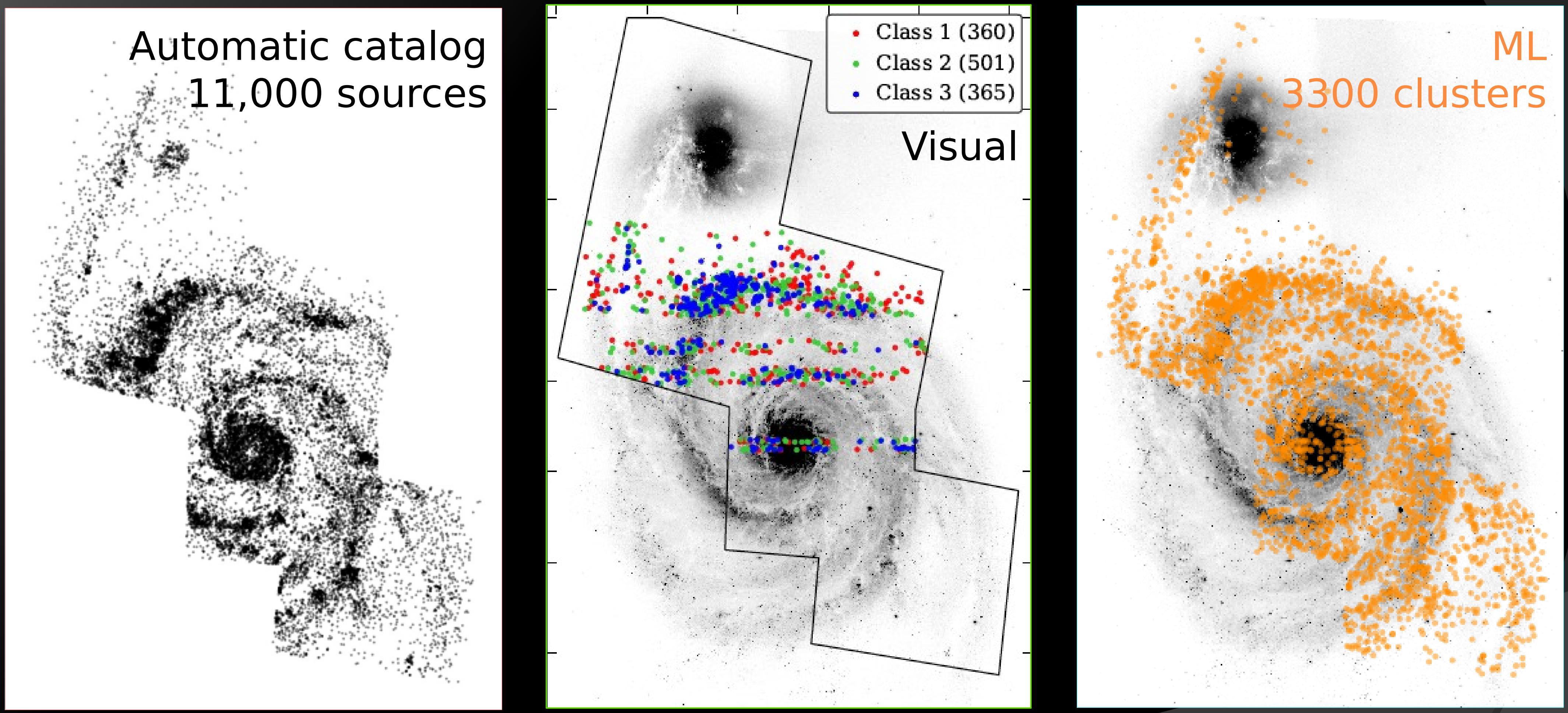
100-1000 star clusters per galaxy (-6 $M_V$ cutoff)

→ 3 inspectors for each source




Adamo+17

# Machine Learning to Classify Clusters Grasha18

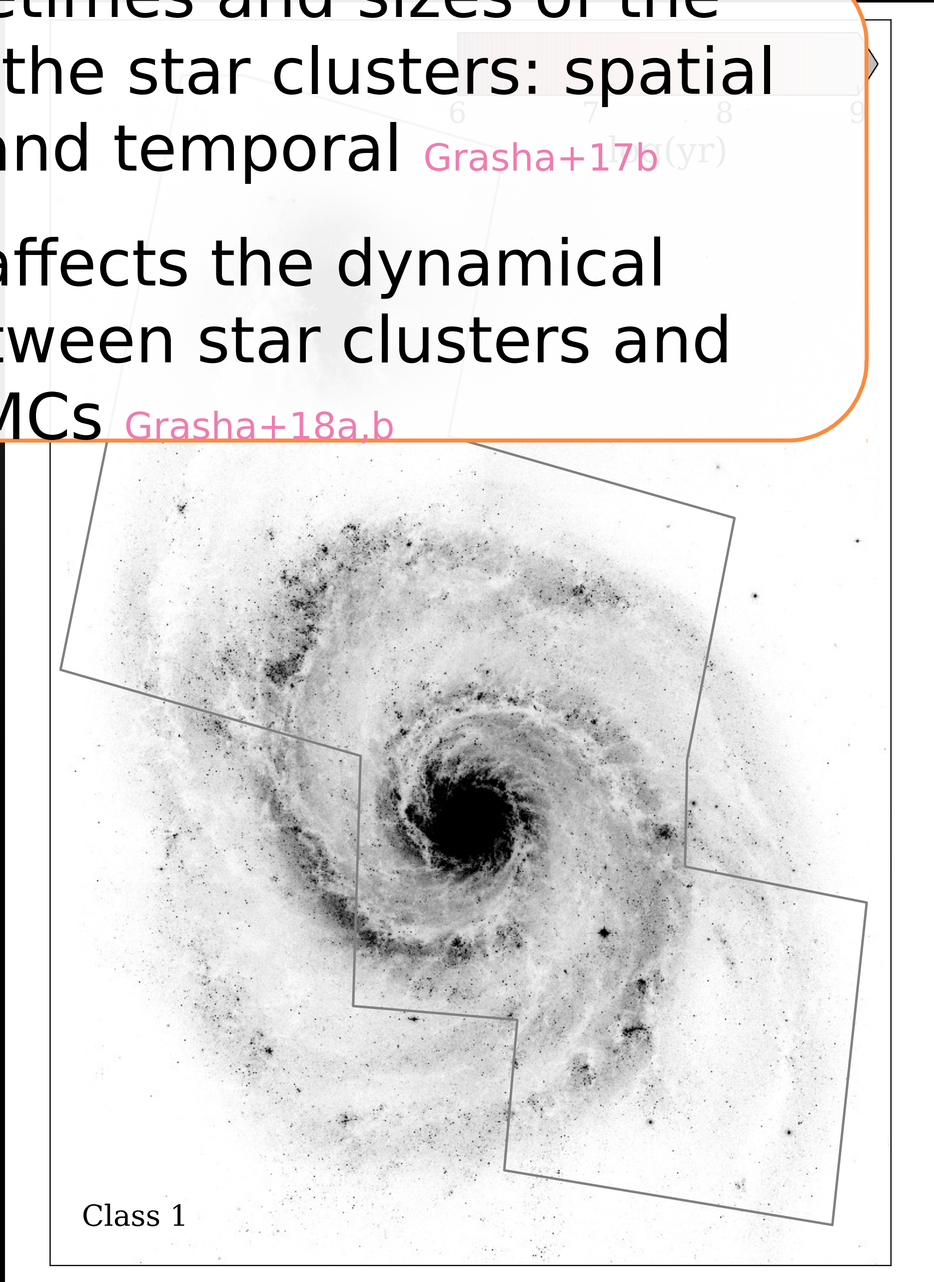


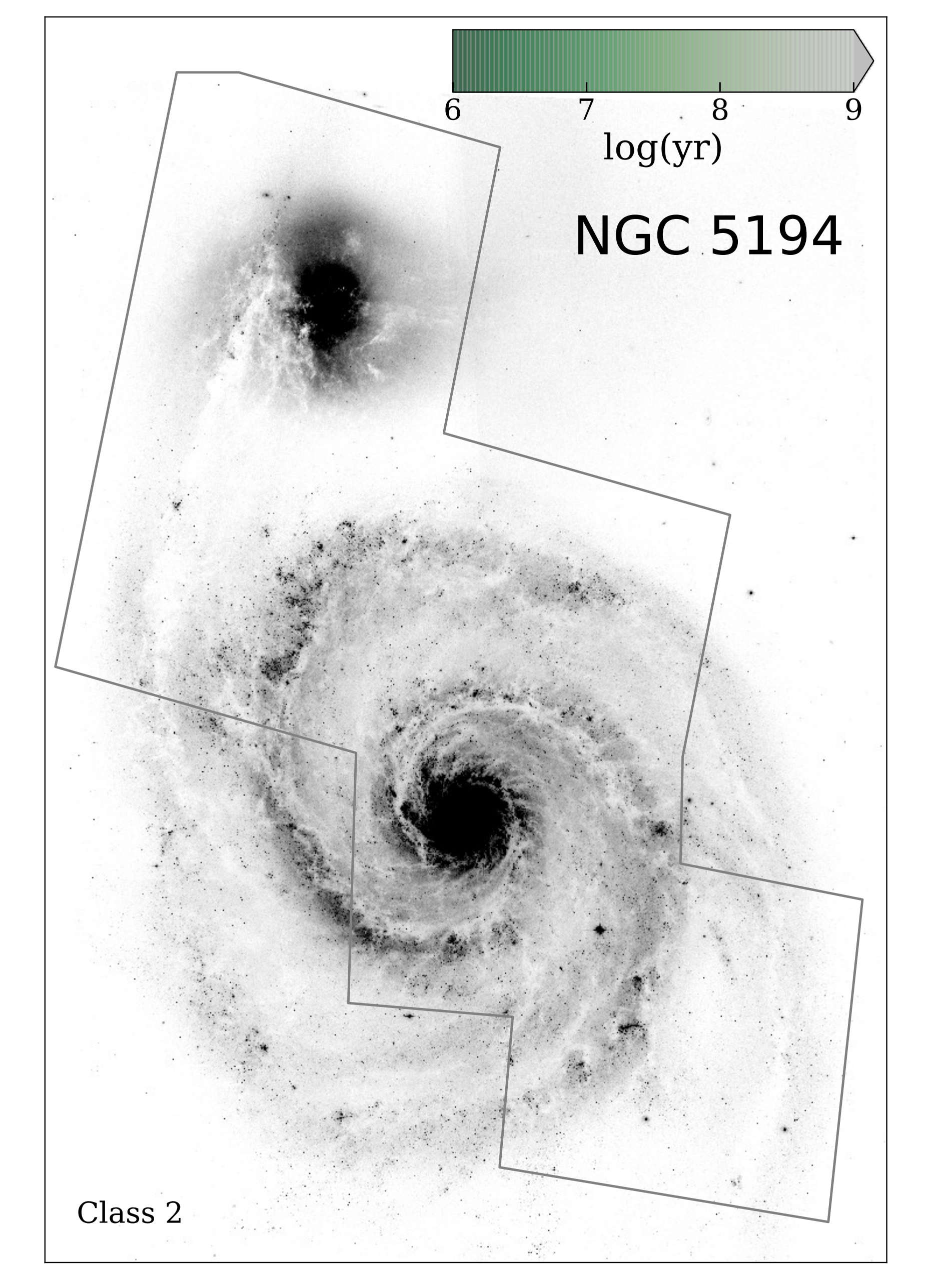
Constrain lifetimes and sizes of the clumpiness of the star clusters: spatial Grasha+15,17a and temporal Grasha+17b

Feedback affects the dynamical evolution between star clusters and GMCs Grasha+18a,b

SED fitting to get:
→ Mass
→ Age
→ E(B-V)

Calzetti+15, Adamo+17



# 1. Star-Forming Complexes: large but short lived

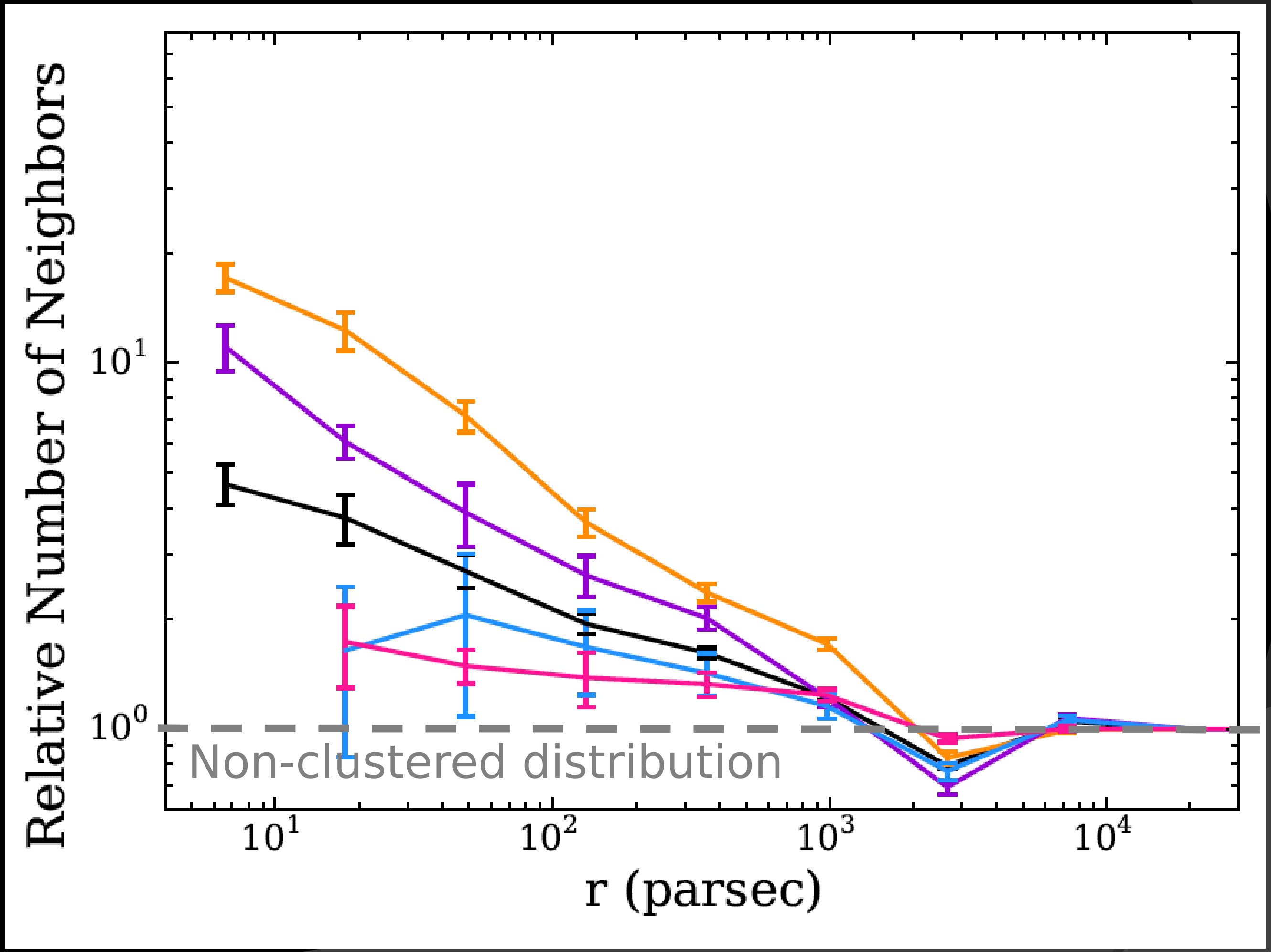
Star clusters are not random but clustered (*hierarchical*)

→ Will have many close neighbors (spatial and temporal)

The clustered distribution dissolves in a scale-free process as well

Star-forming clumps: large but short lived

- Rapid dispersal of 10’s Myr




Grasha+18b

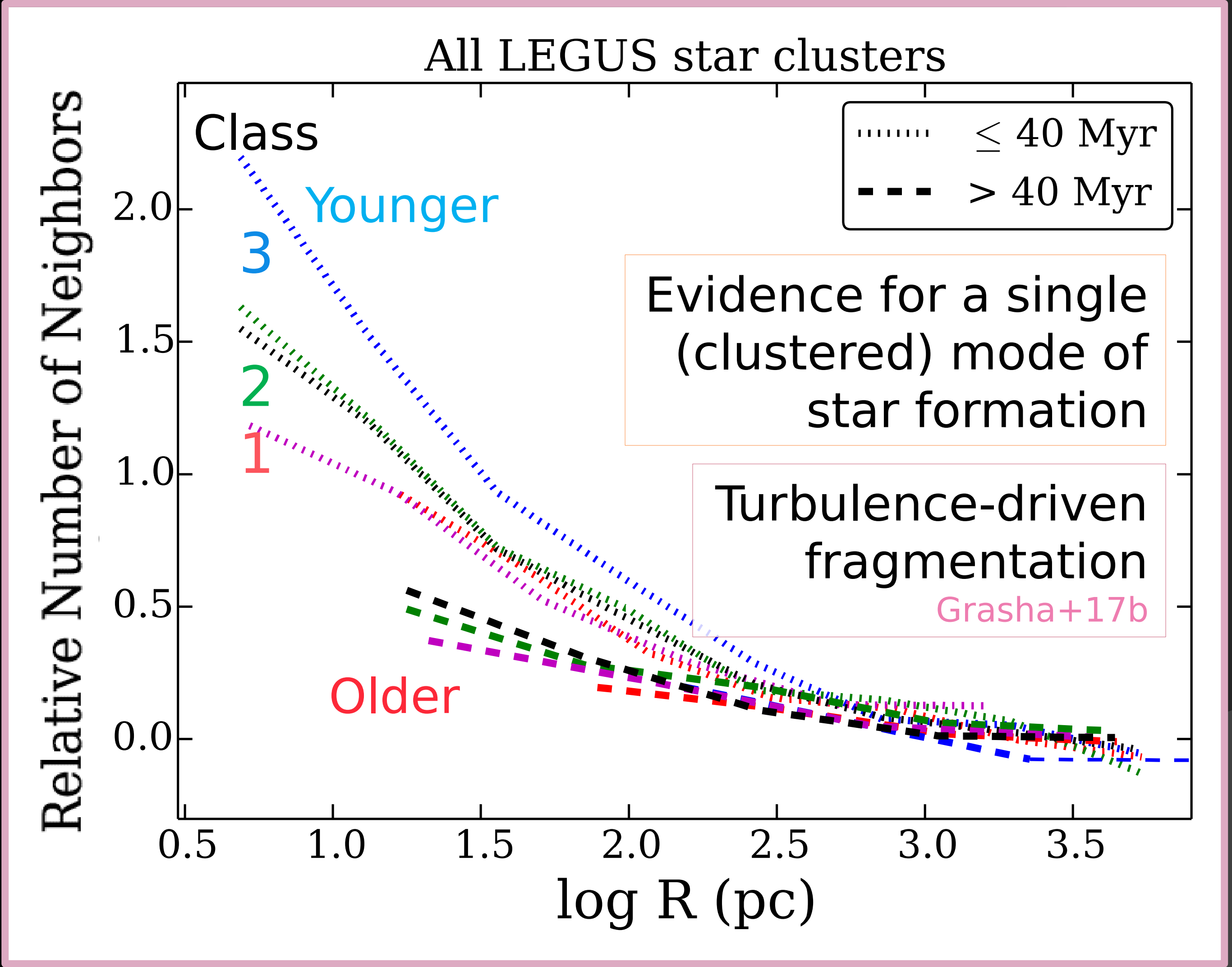
# All LEGUS galaxies show small (~50 Myr) timescales for the dissolution of structures

Size/age of typical $z$~0 star-forming clumps

Strong clustered dependency on the cluster class type

→ Age sequence

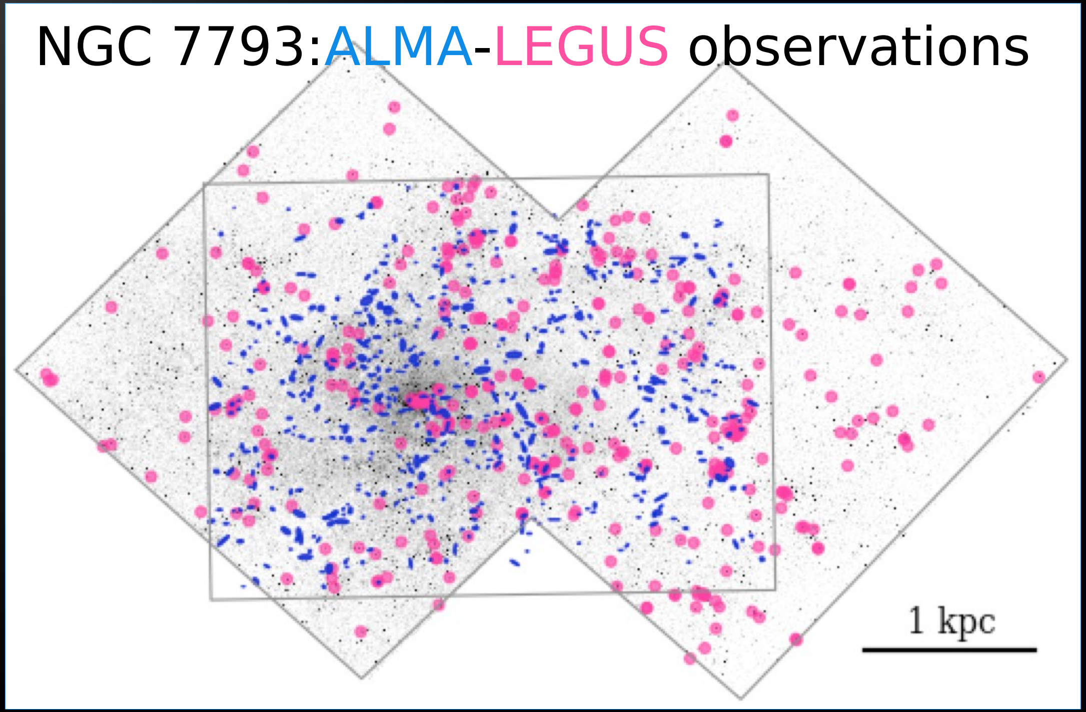
The distributions are consistent across all cluster types and across all galaxies > 40 Myr



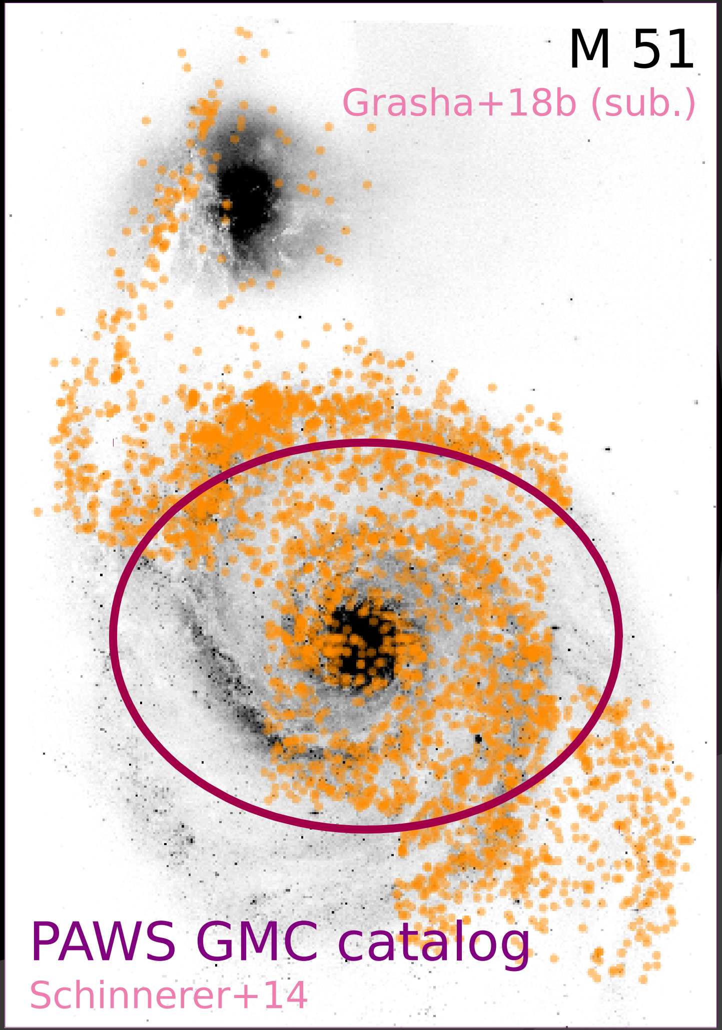

Grasha+17a

# 2. Correlate Clusters to Molecular Gas

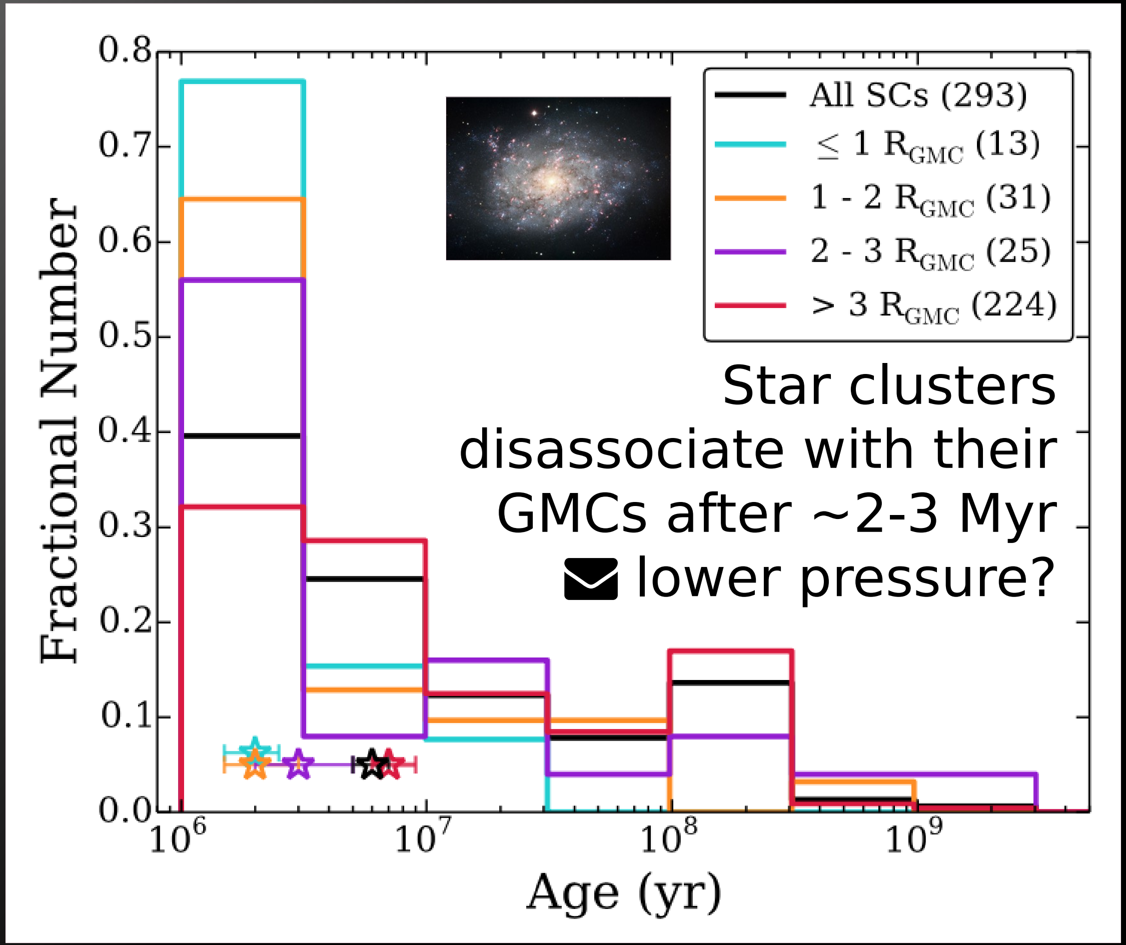
⇨ What is the timescale for emerging star clusters?
⇨ How do the properties of star clusters relate with their natal molecular clouds?



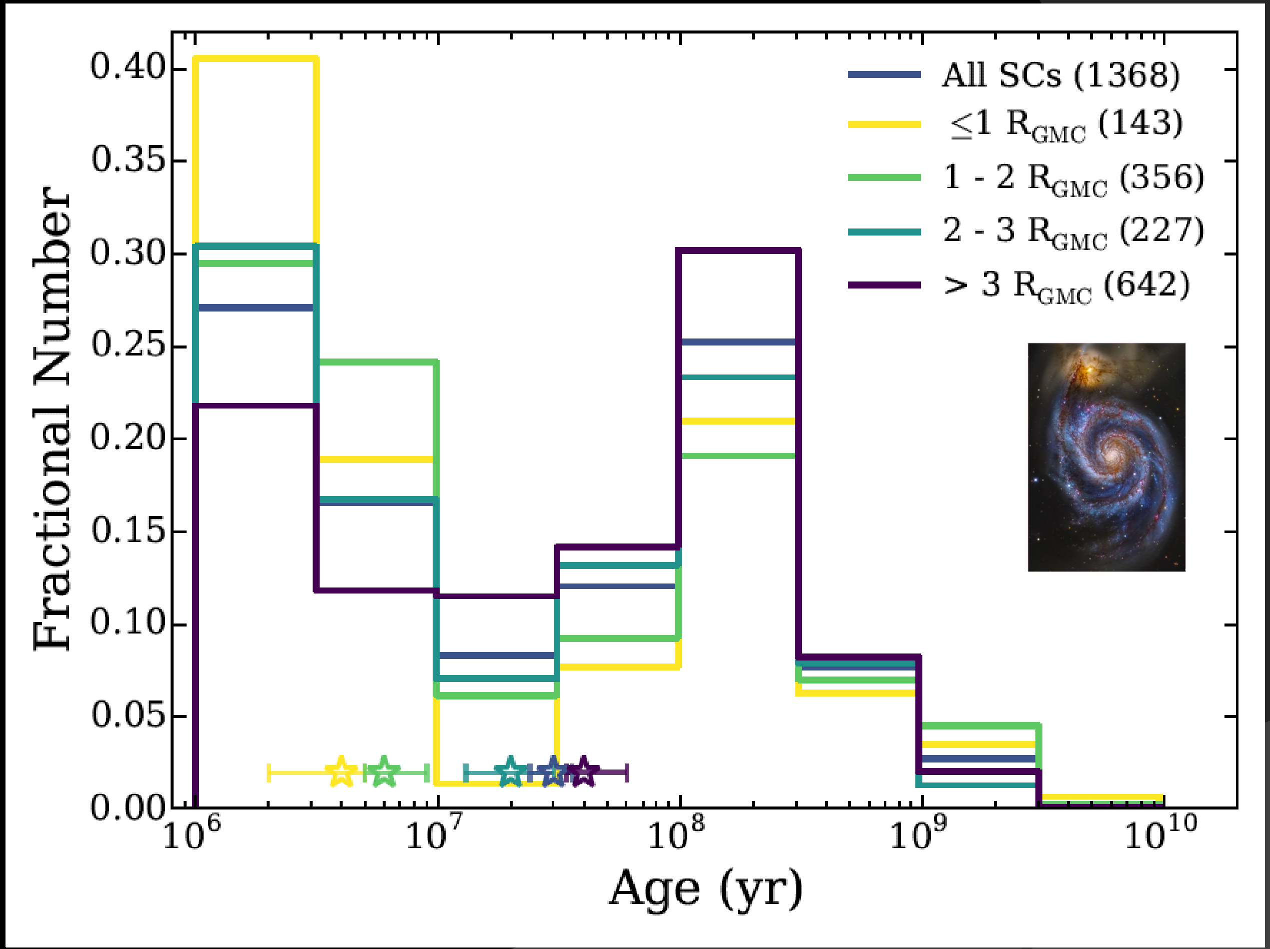

Grasha+18a, Bittle+(in prep)



# Star clusters disassociate with GMCs after ~6 Myr in M51




Grasha+18a




Grasha+18b (submitted)

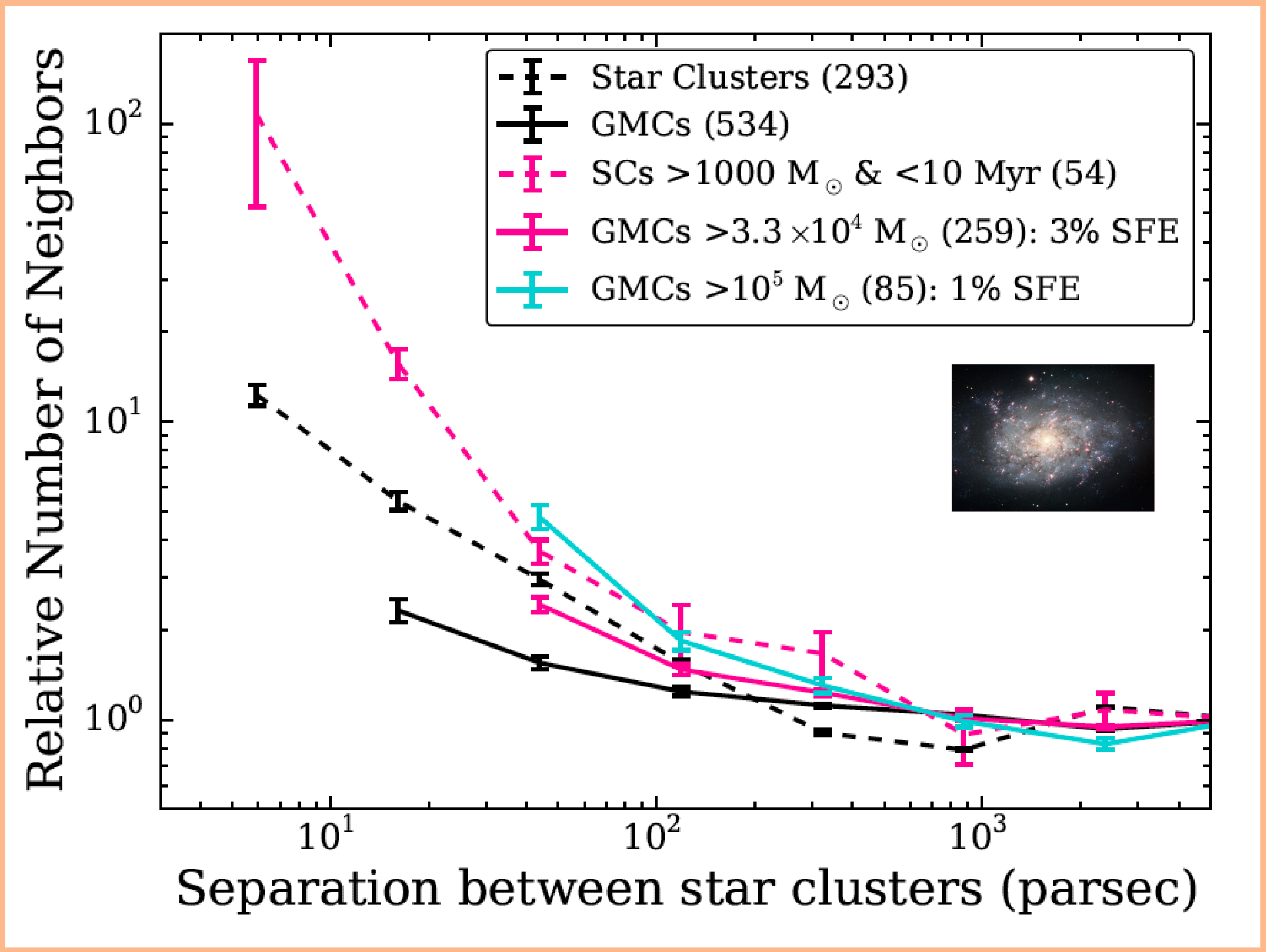
# Spatial Clustering of GMCs can reflect that of the SCs

Is the stellar hierarchy reflected in the GMCs?

The youngest, most massive SCs do trace mass-equivalent GMCs

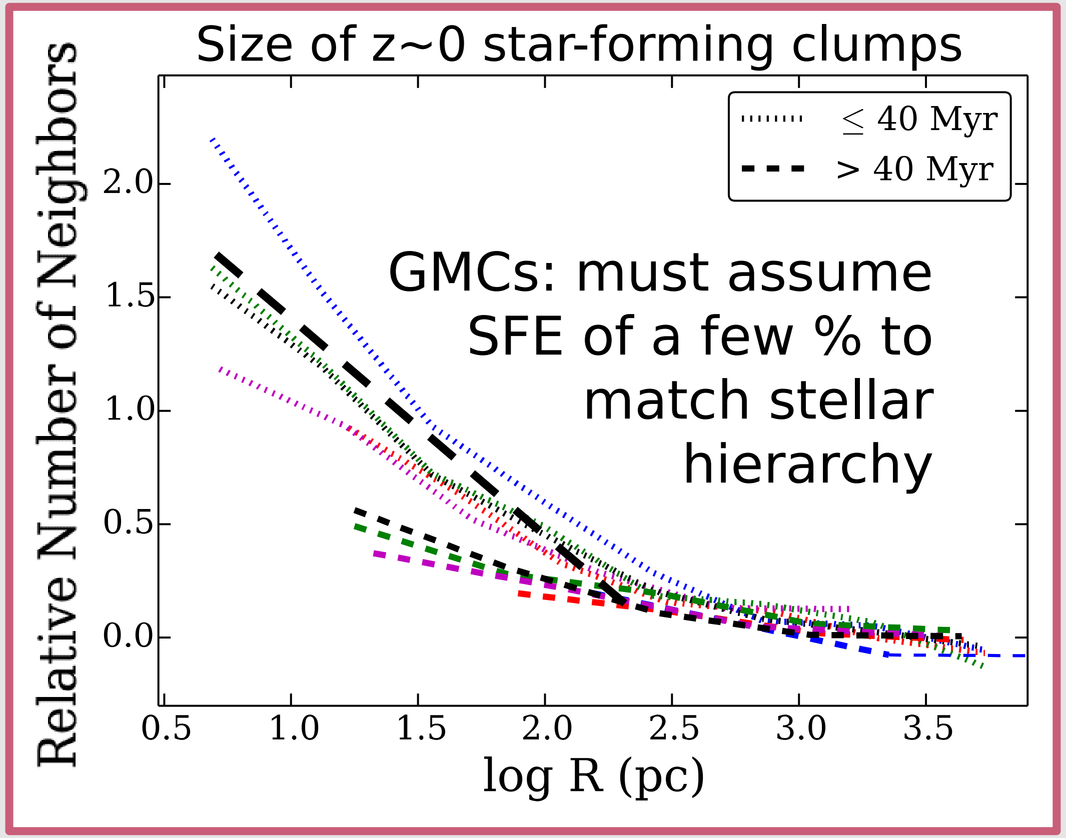
→ Must assume a SFE of a few percent!

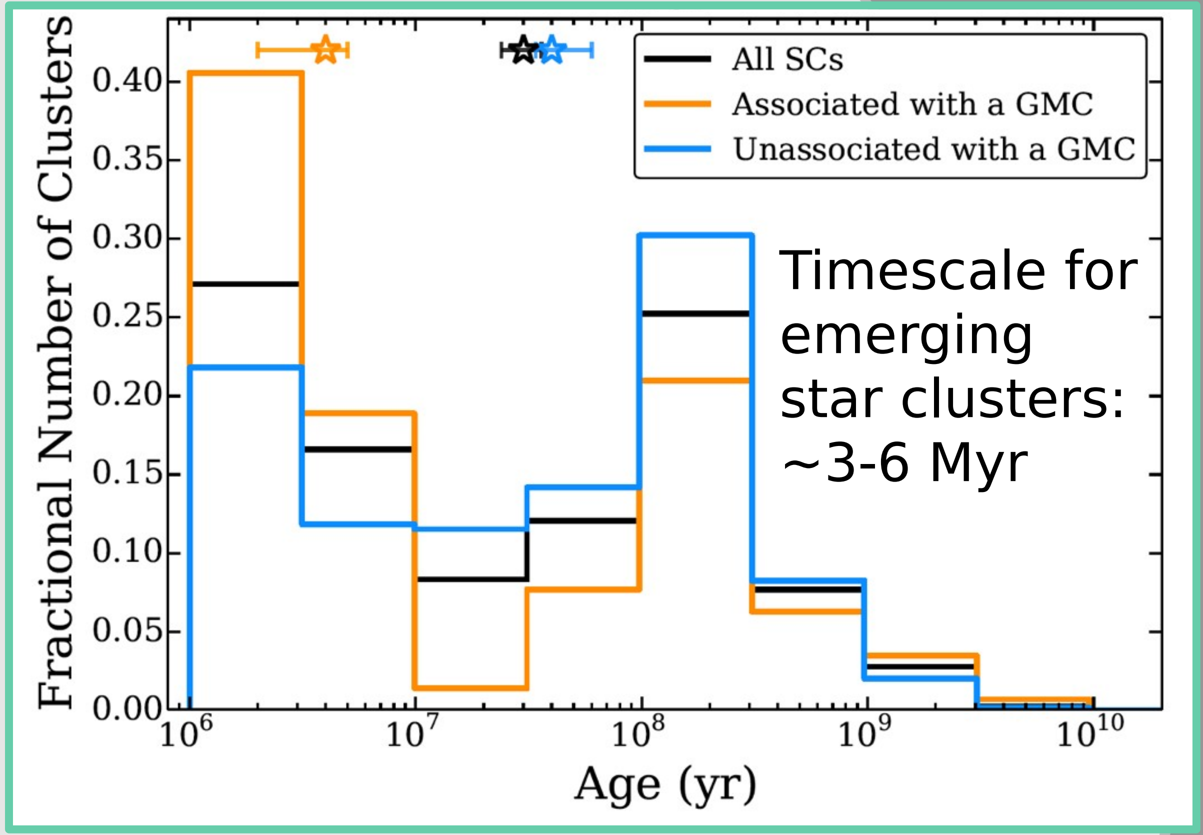
Feedback will (has to?) affect the distributions of star clusters different from GMCs




Grasha+18a

Grasha+17ab




Grasha+18a,b

*Legacy ExtraGalactic*

**LEGUS**

*Ultraviolet Survey*

Characterize the correlations of gas & star clusters: essential to place more stringent constraints on our fundamental understanding of how conditions of star formation change over time

# Future Work

The immediate surroundings is part of the star cluster too!

Star clusters in early galaxies are expected to be massive (super star clusters; $>10^5$ $M_{sun}$)

- → Huge HII regions of ionizing radiation
- → Impact/responsible for reionization of the early universe?

If we can better constrain how star clusters interact locally (resolution!), improve understanding of high-z observations of the *first galaxies* where light will be dominated by such objects

**Thank you!**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