Massive star feedback with nearby galaxy surveys

Sumit K. Sarbadhicary
Assistant Research Scientist (JHU)
Former CCAPP Fellow (2021-24)

CCAPP 20th Anniversary, June 10, 2026

CCAPP collaborators: **Adam Leroy**, Laura Lopez, Todd Thompson, Smita Mathur, Chris Kochanek, Ness Mayker Chen (former PhD), Jordan Wagner (former REU)

M33, JWST + Spitzer
(Sarbadhicary+ 25, ApJ, 989, 138)

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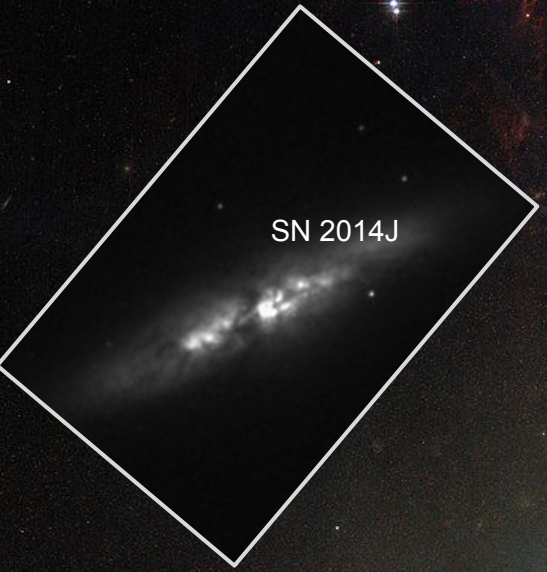
Massive stars are the main drivers of galaxy evolution



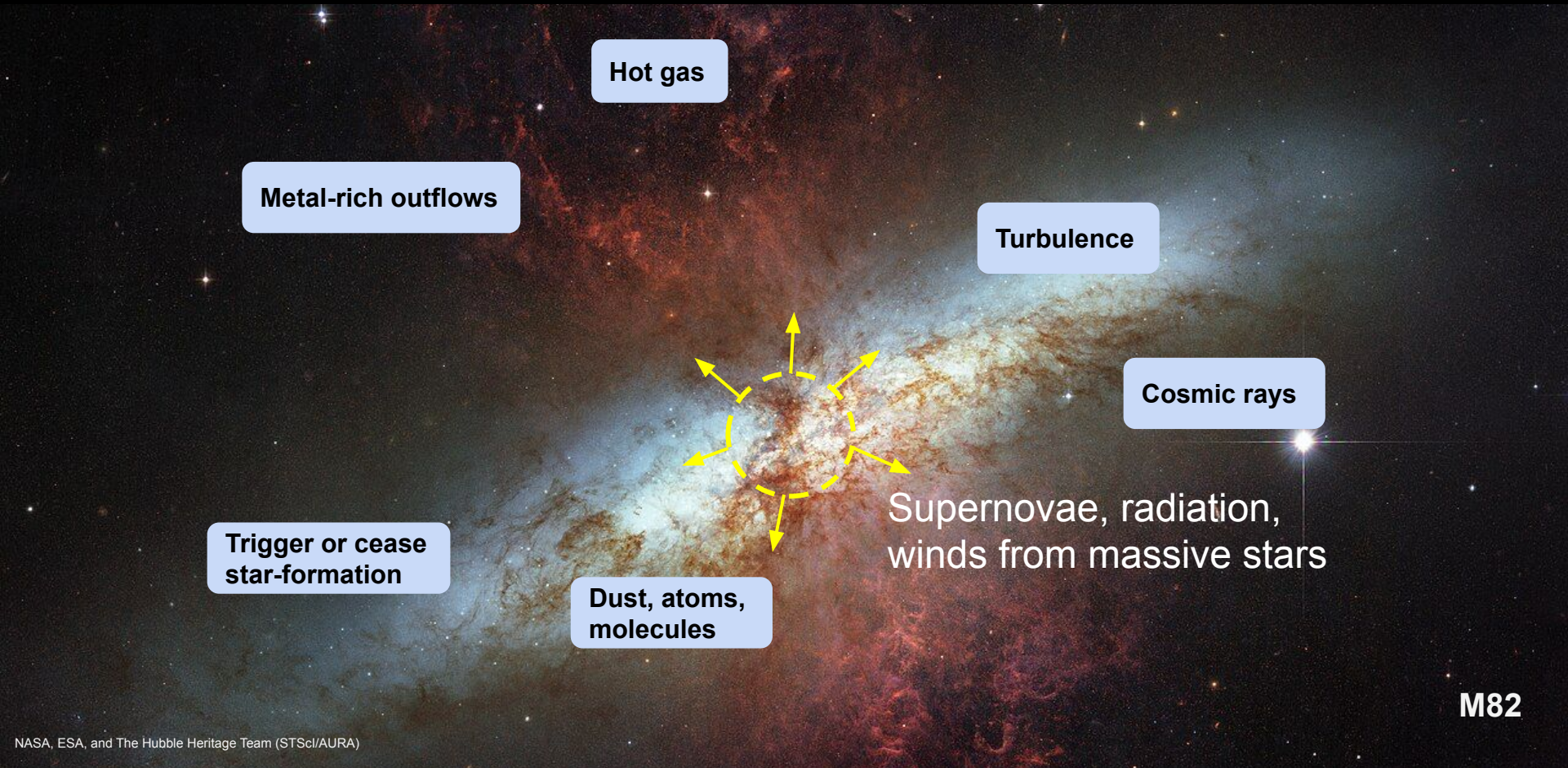
G Masi: The Virtual Telescope project

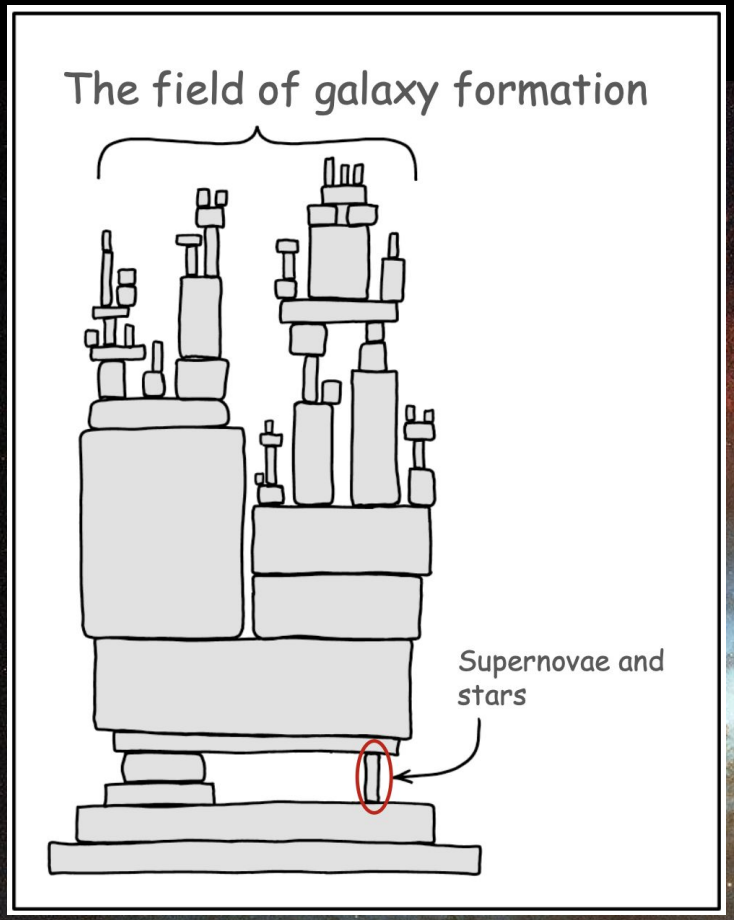
Supernovae, radiation,
winds from massive stars

M82

NASA, ESA, and The Hubble Heritage Team (STScI/AURA)

Massive stars are the main drivers of galaxy evolution





Supernovae, radiation, winds from massive stars

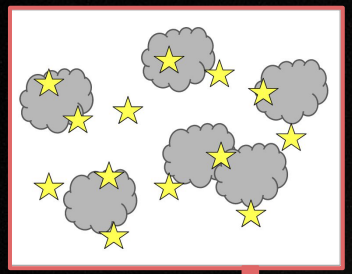
M82

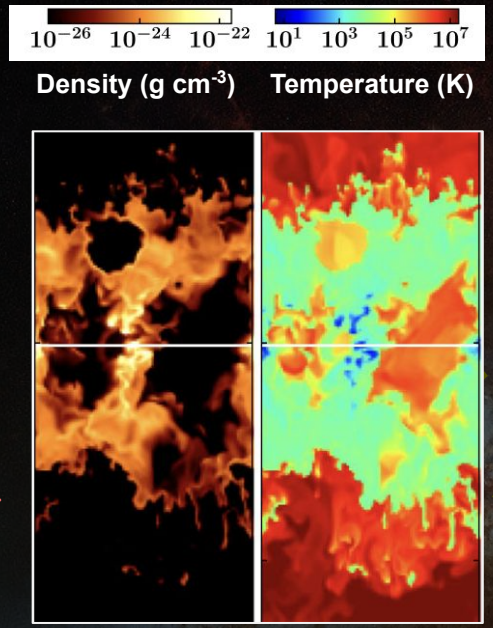
NASA, ESA, and The Hubble Heritage Team (STScI/AURA)


Where do stars explode?
M82

Predicted galaxy properties sensitive to “where” stars explode

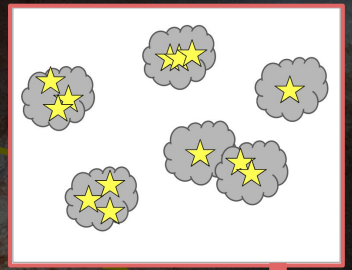
Stars exploding randomly

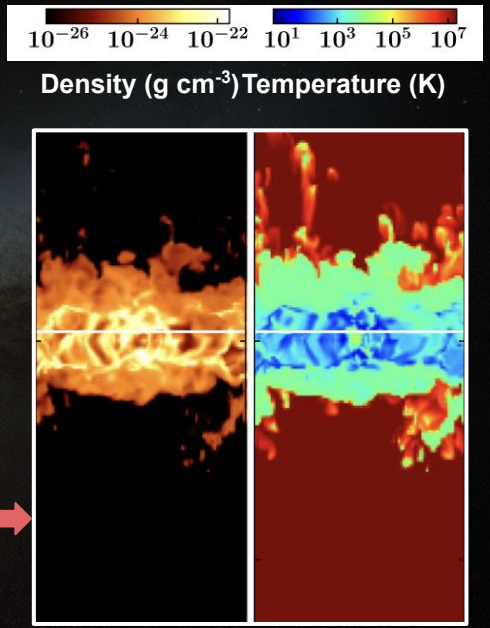




SILCC simulations
(Girichidis+ 2016)

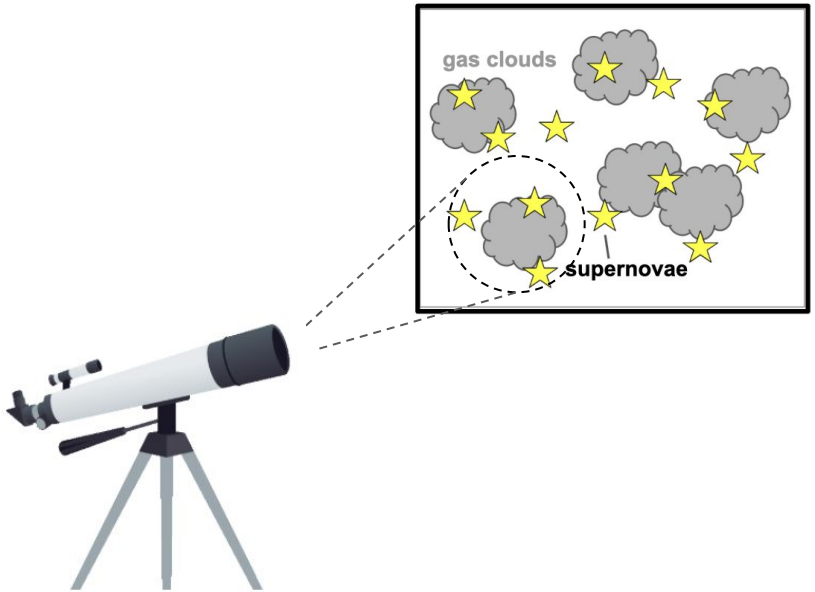
Stars exploding in dense gas





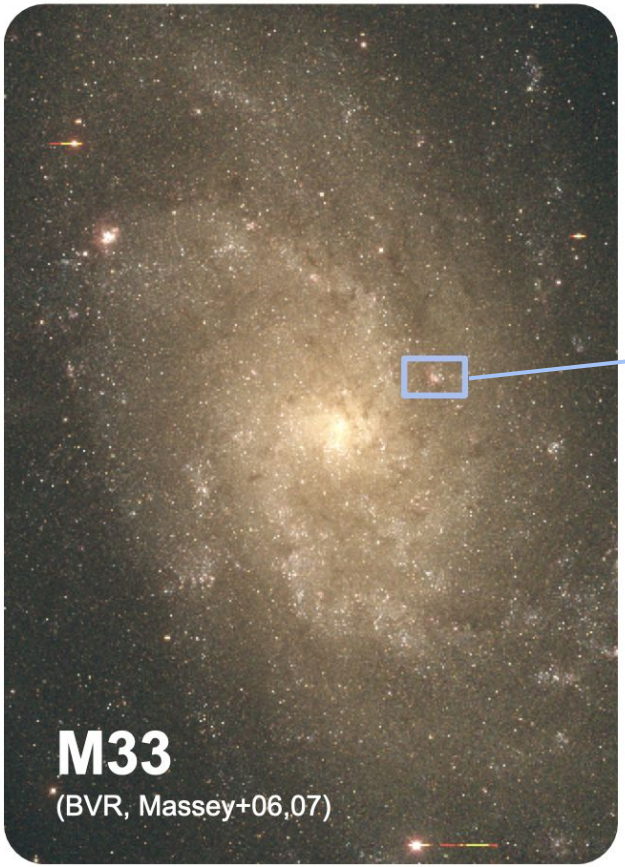
M82

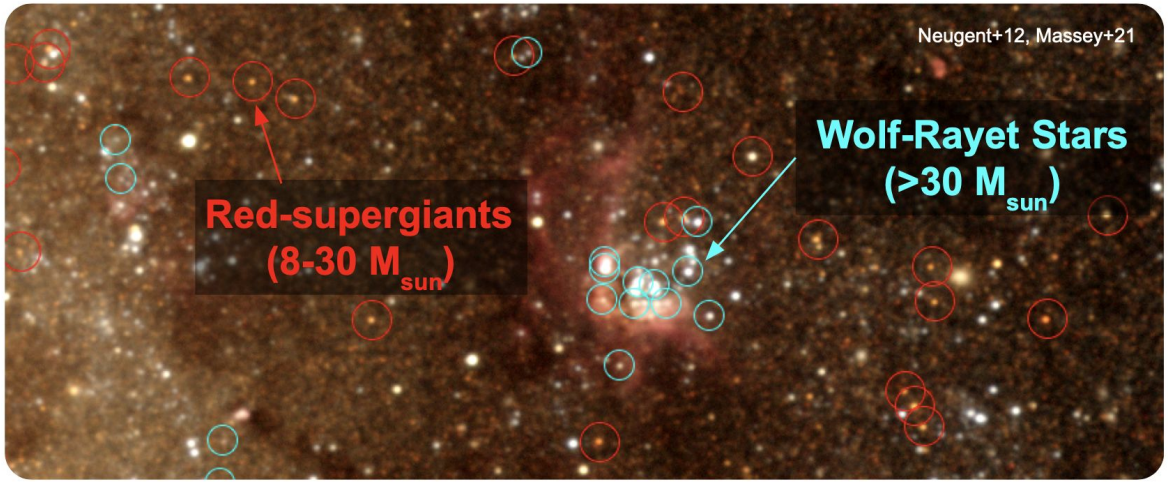
Where are stars observed to explode?



A survey of dense gas around *future* supernovae

(SKS+ 2026, ApJ, 1000, 70)





A survey of dense gas around *future* supernovae

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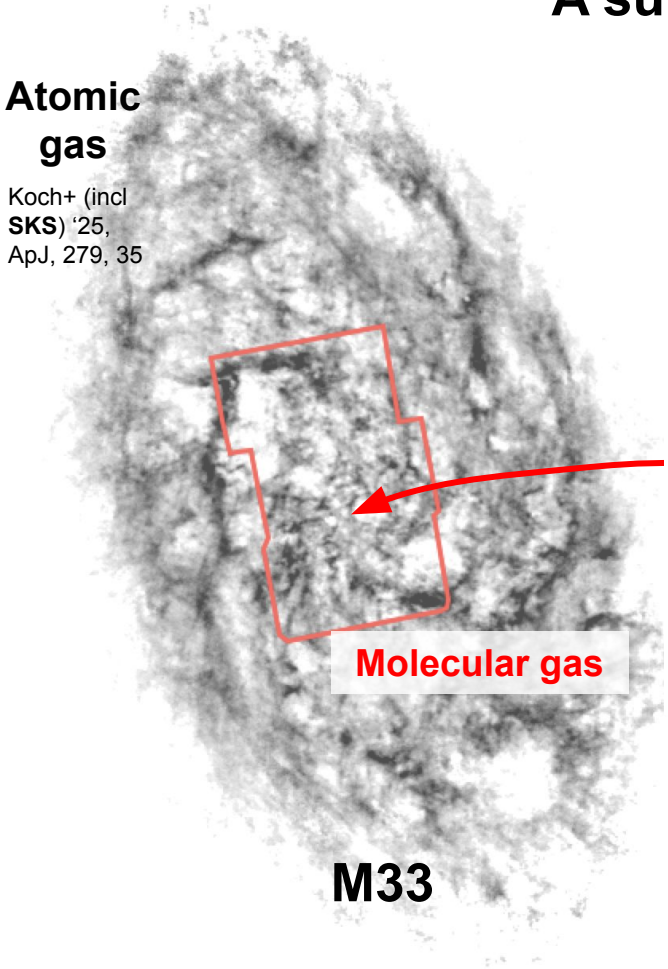
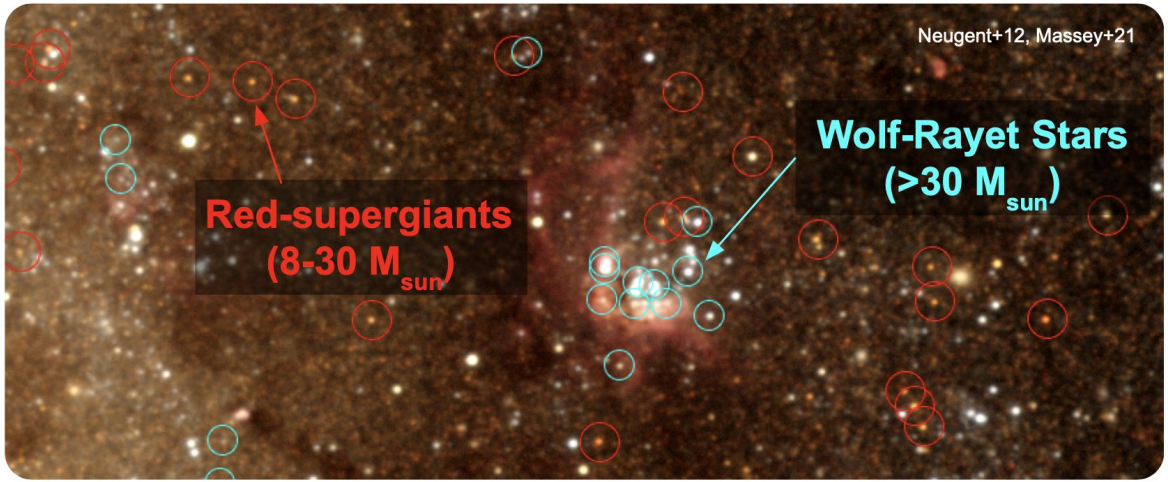
Atomic gas

Koch+ (incl **SKS**) '25, ApJ, 279, 35





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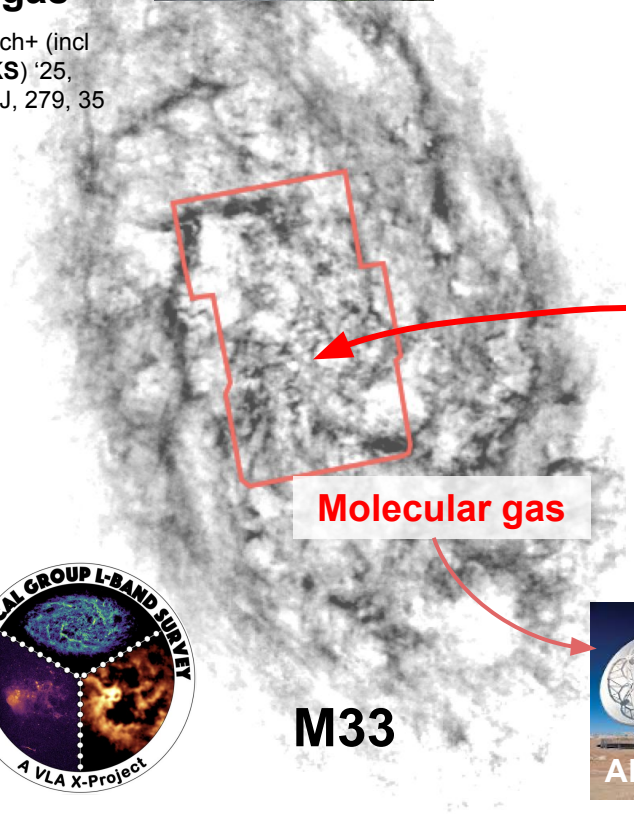
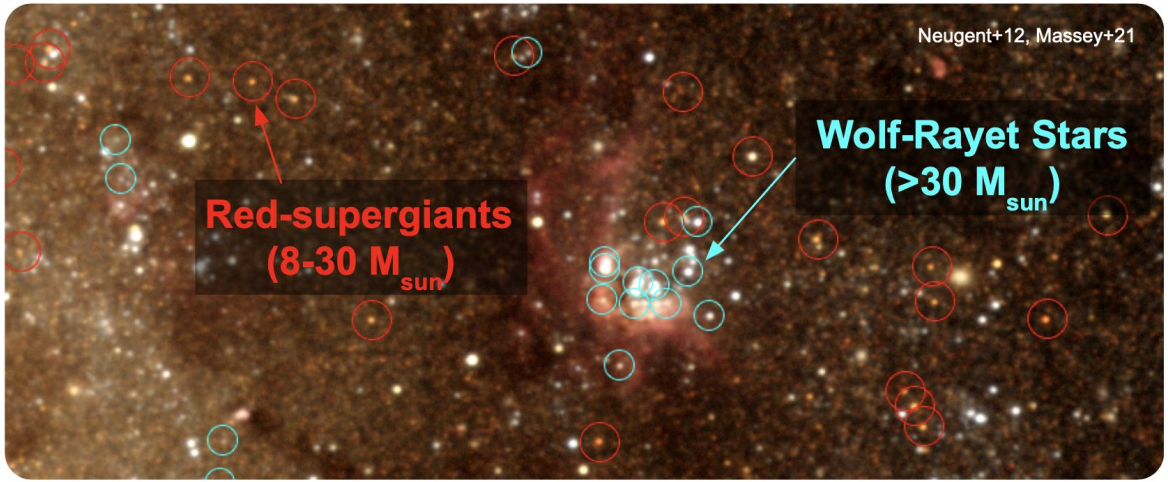
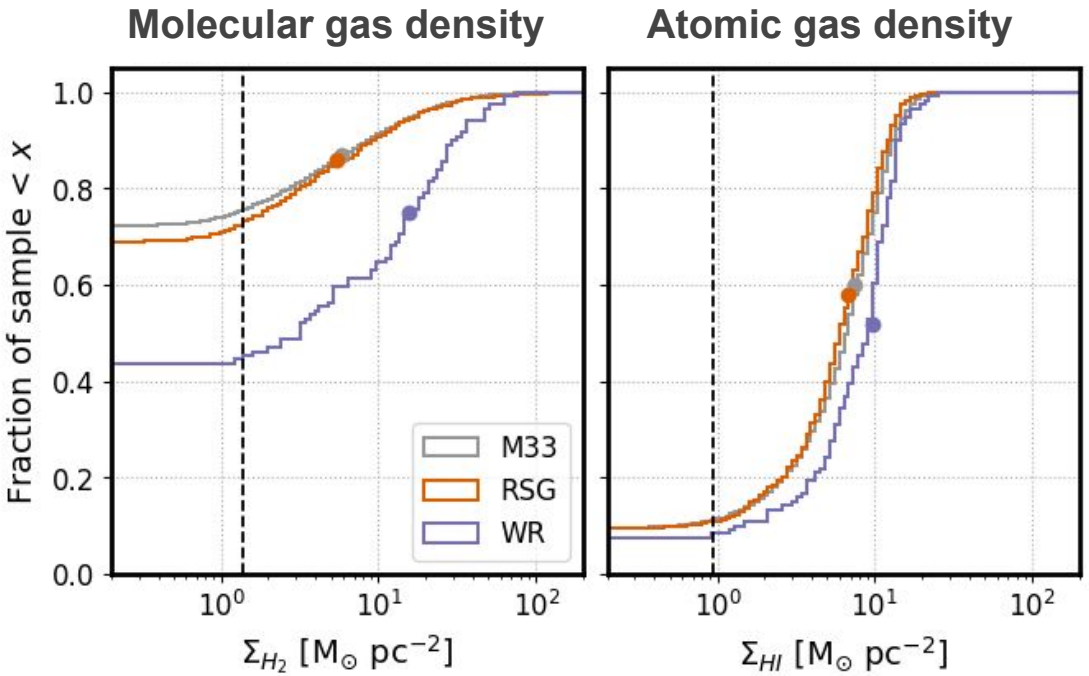




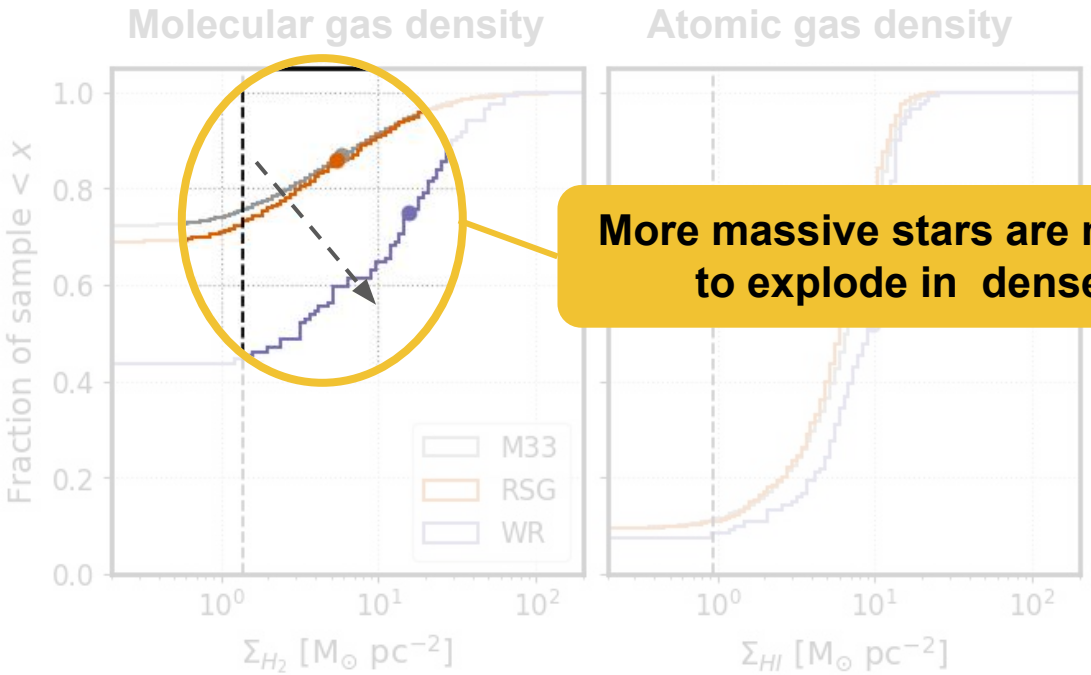
THE LOCAL GROUP L-BAND SURVEY
A VLA X-Project



RSG = Red supergiants
WR = Wolf-Rayet stars

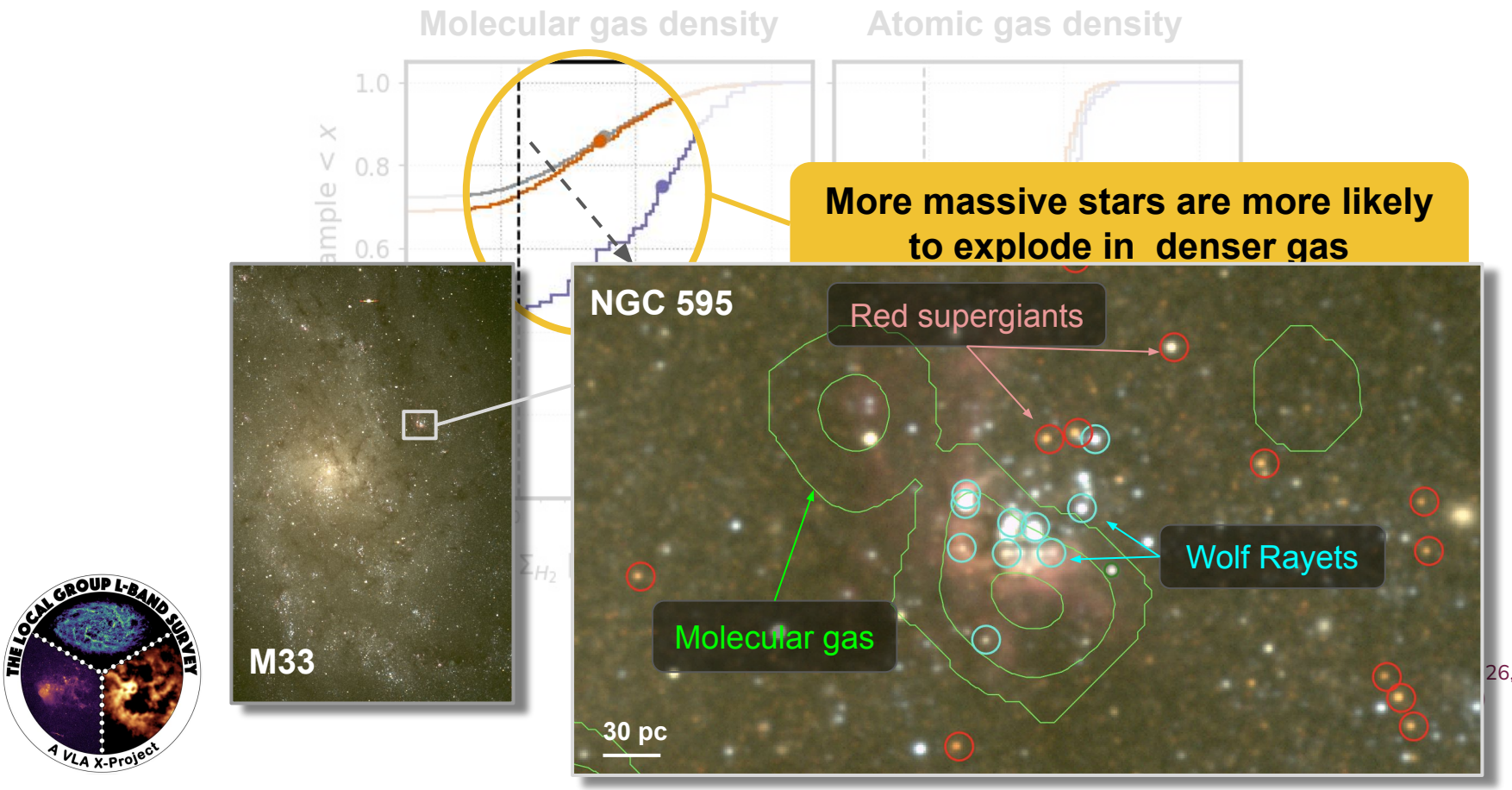
(SKS+ 2026, ApJ, 1000, 70)

SKS+ 2023, accepted to ApJ (arXiv:2310.17694)

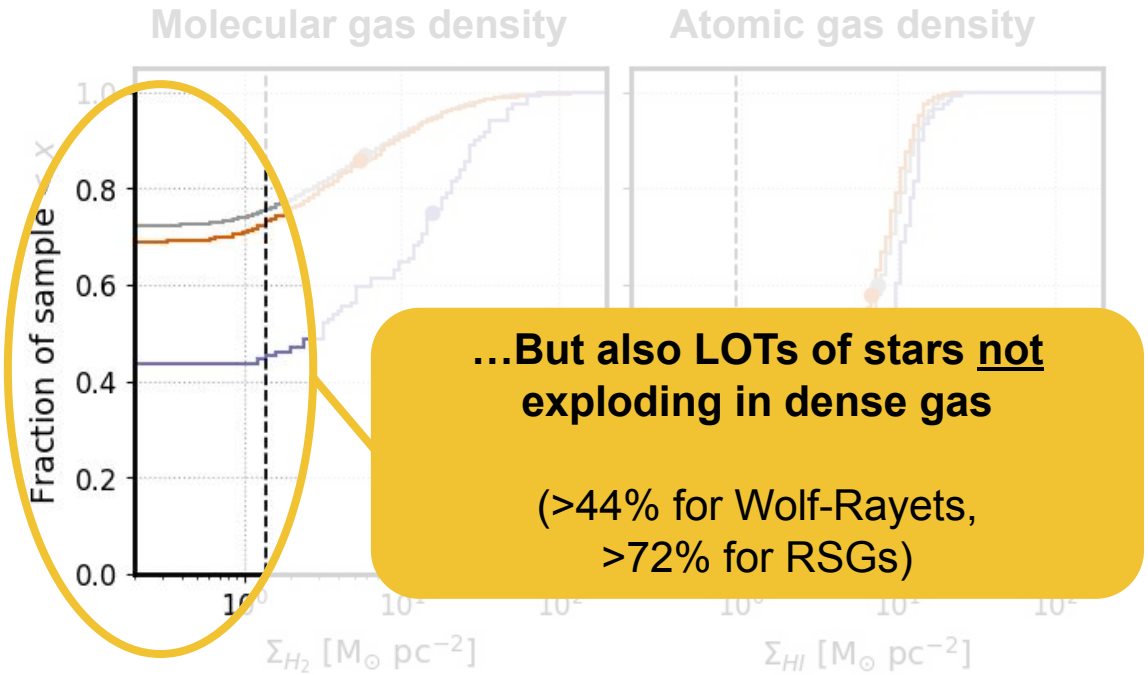


More massive stars are more likely to explode in denser gas

(**SKS+** 2026, ApJ, 1000, 70)


Molecular gas density
Atomic gas density
1.0
0.8
0.6
More massive stars are more likely to explode in denser gas
M33
NGC 595
Red supergiants
Wolf Rayets
Molecular gas
30 pc

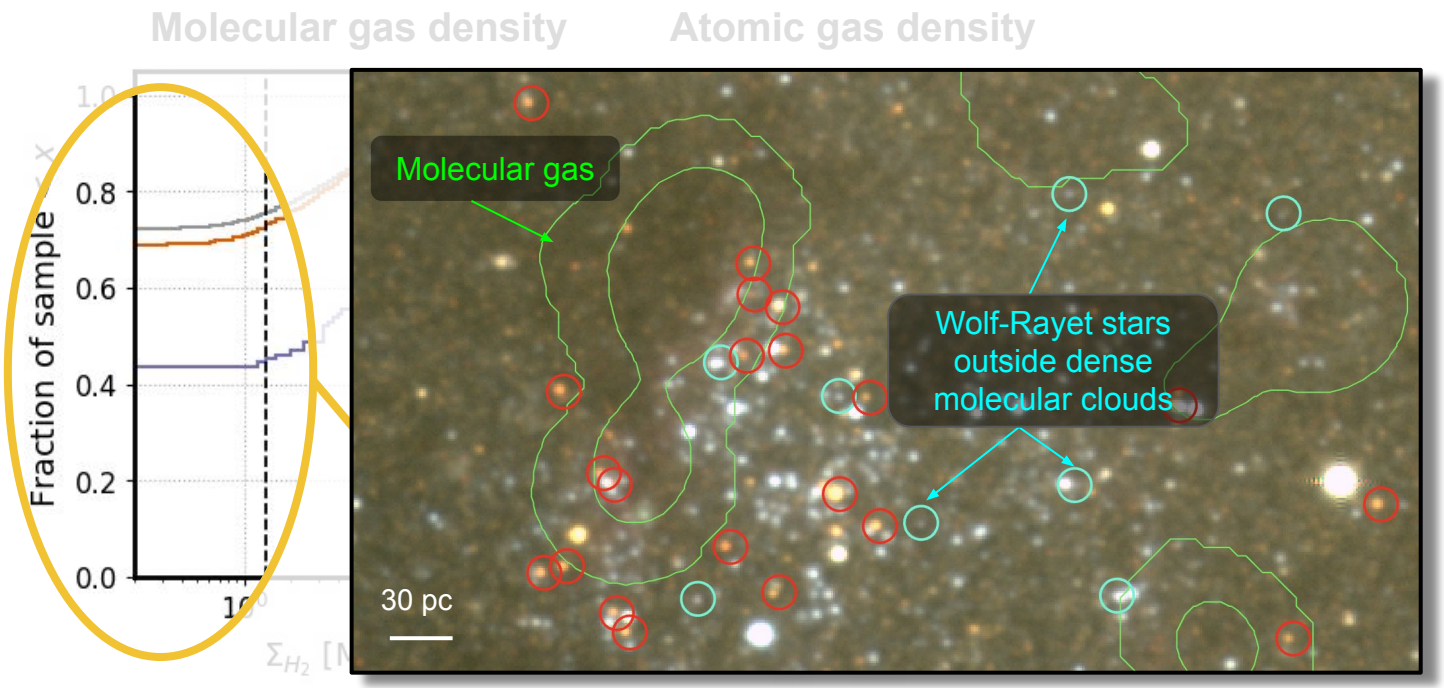
26, ApJ,



…But also LOTs of stars <u>not</u> exploding in dense gas

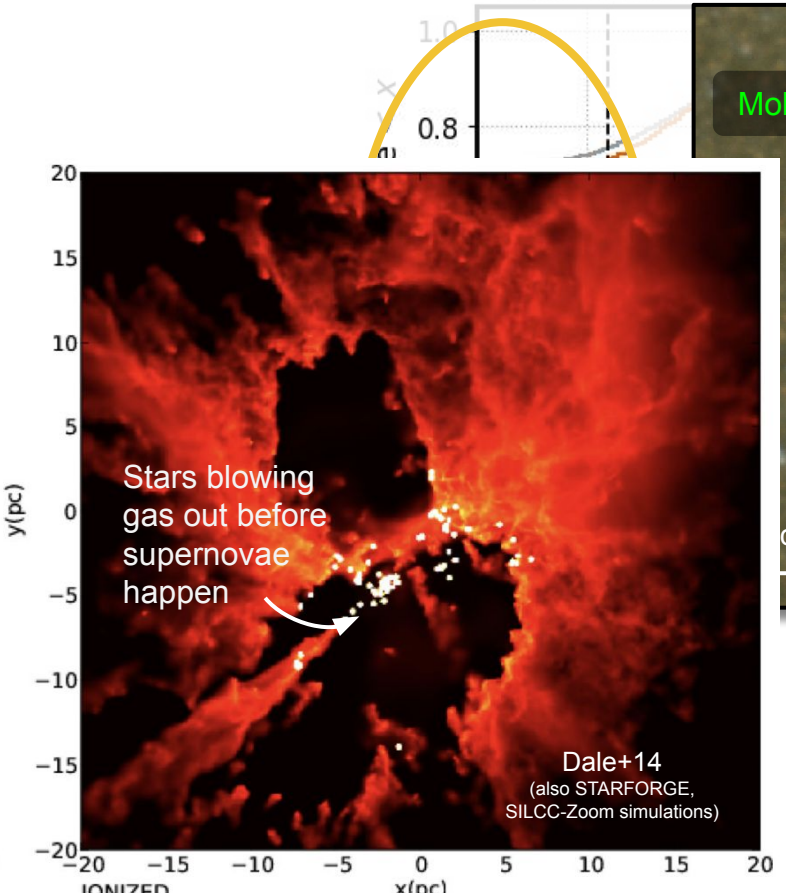
(>44% for Wolf-Rayets,
>72% for RSGs)

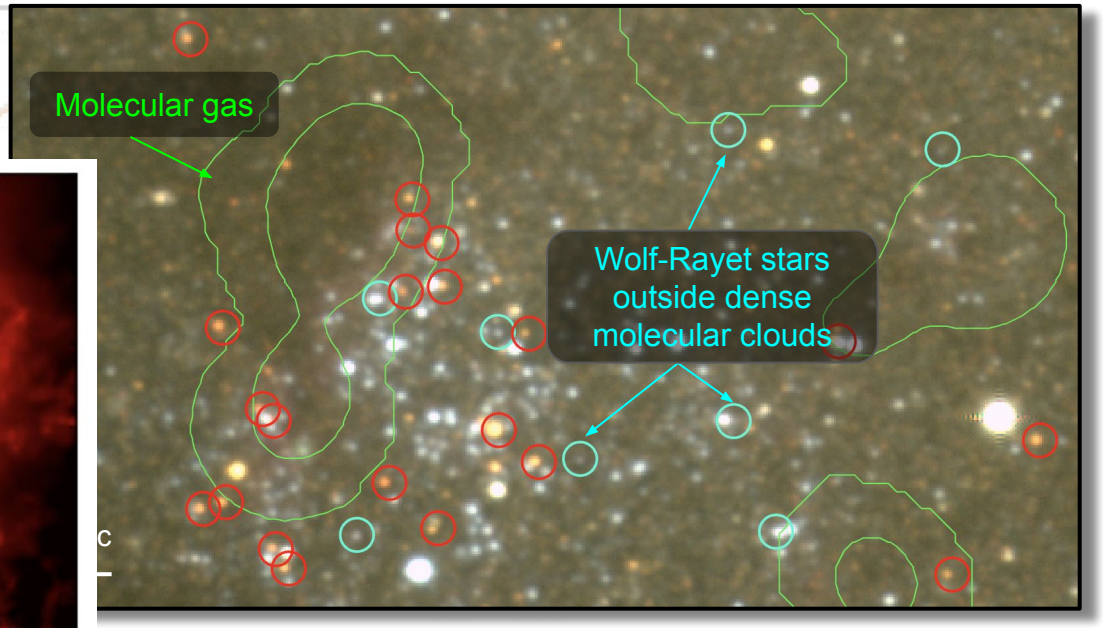
(**SKS+** 2026, ApJ, 1000, 70)



(SKS+ 2026, ApJ, 1000, 70)

Molecular gas density Atomic gas density

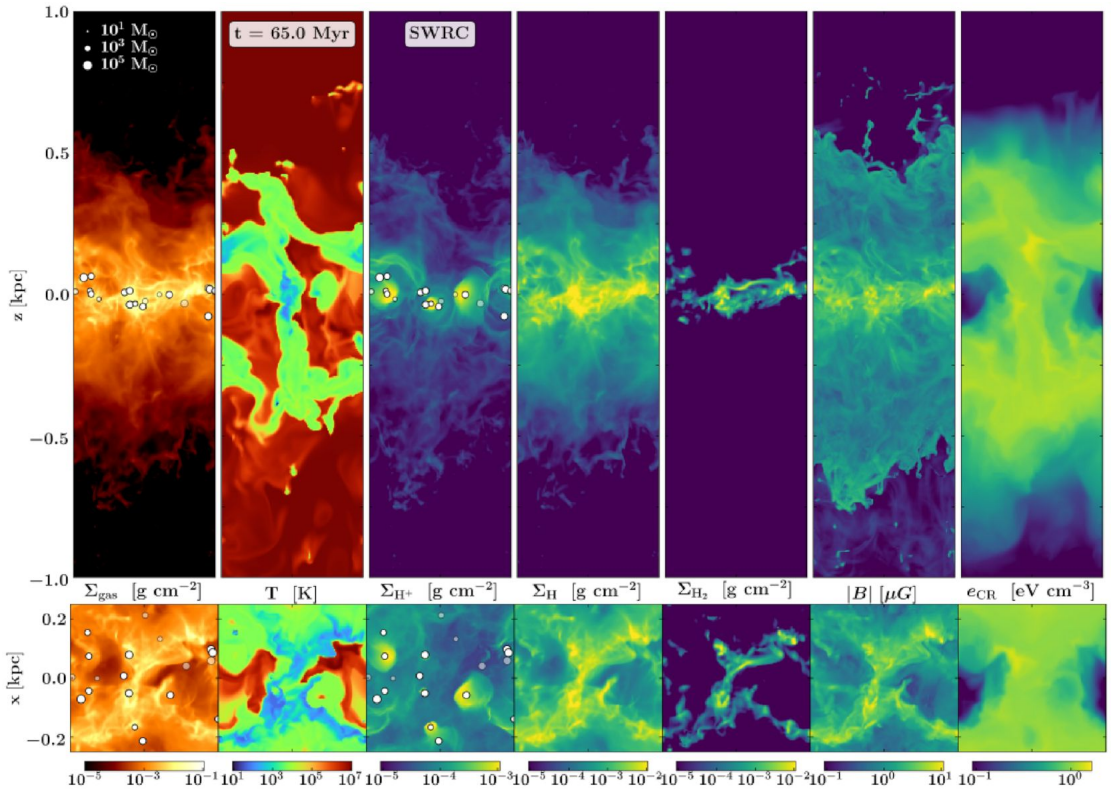


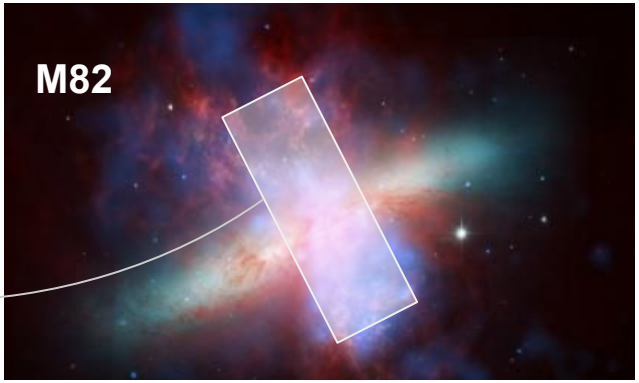


(SKS+ 2026, ApJ, 1000, 70)

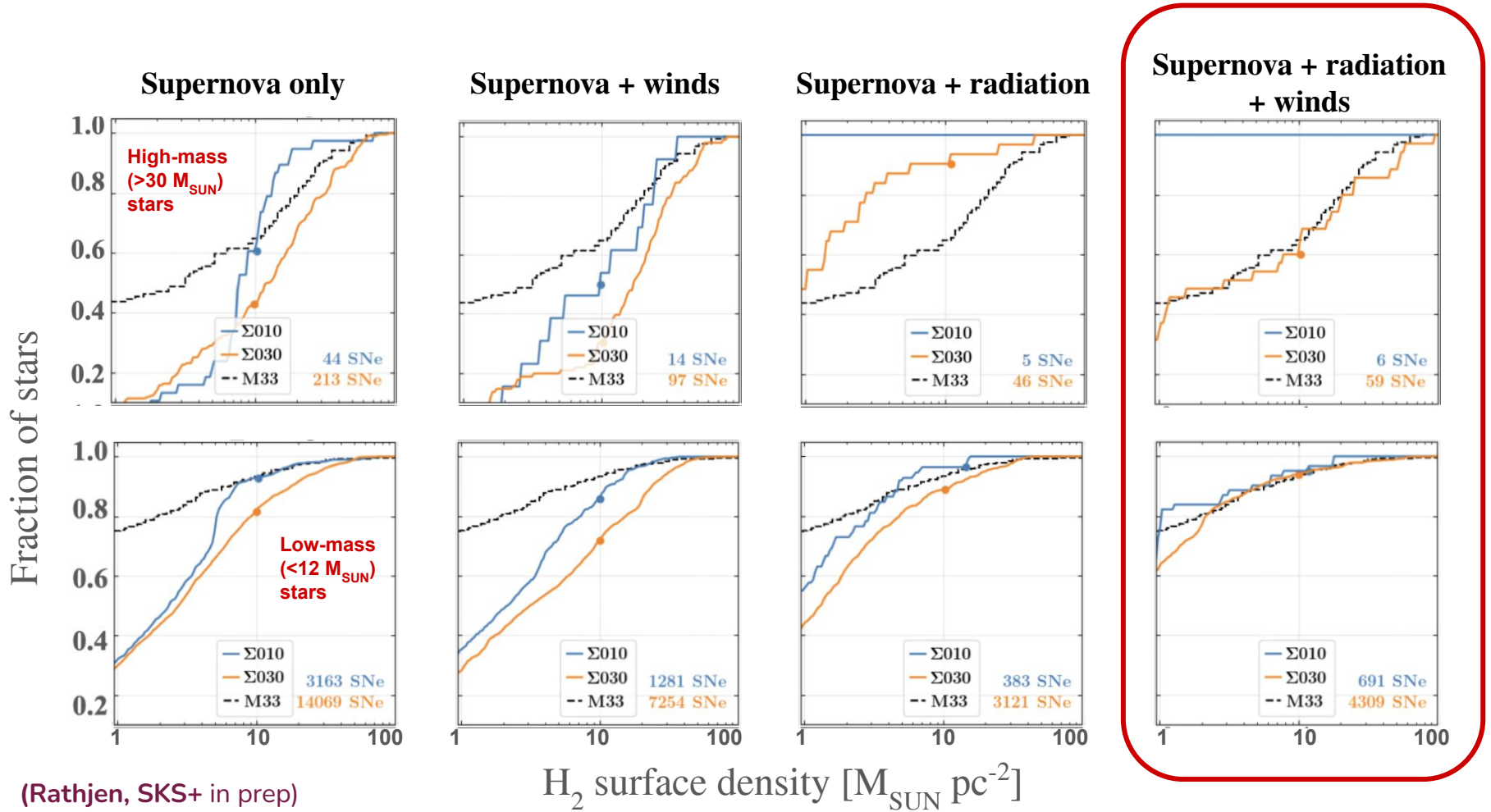
Do simulations of galaxies agree with the observations?

(Rathjen, SKS+ in prep)



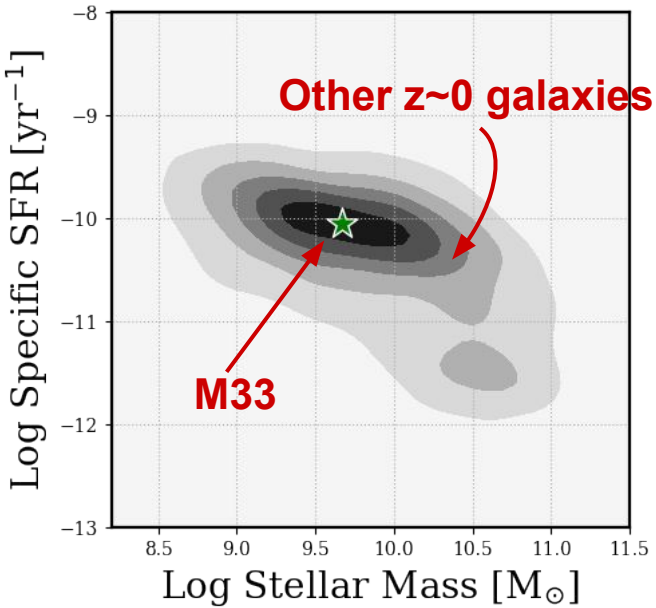


SILCC (Rathjen+21)

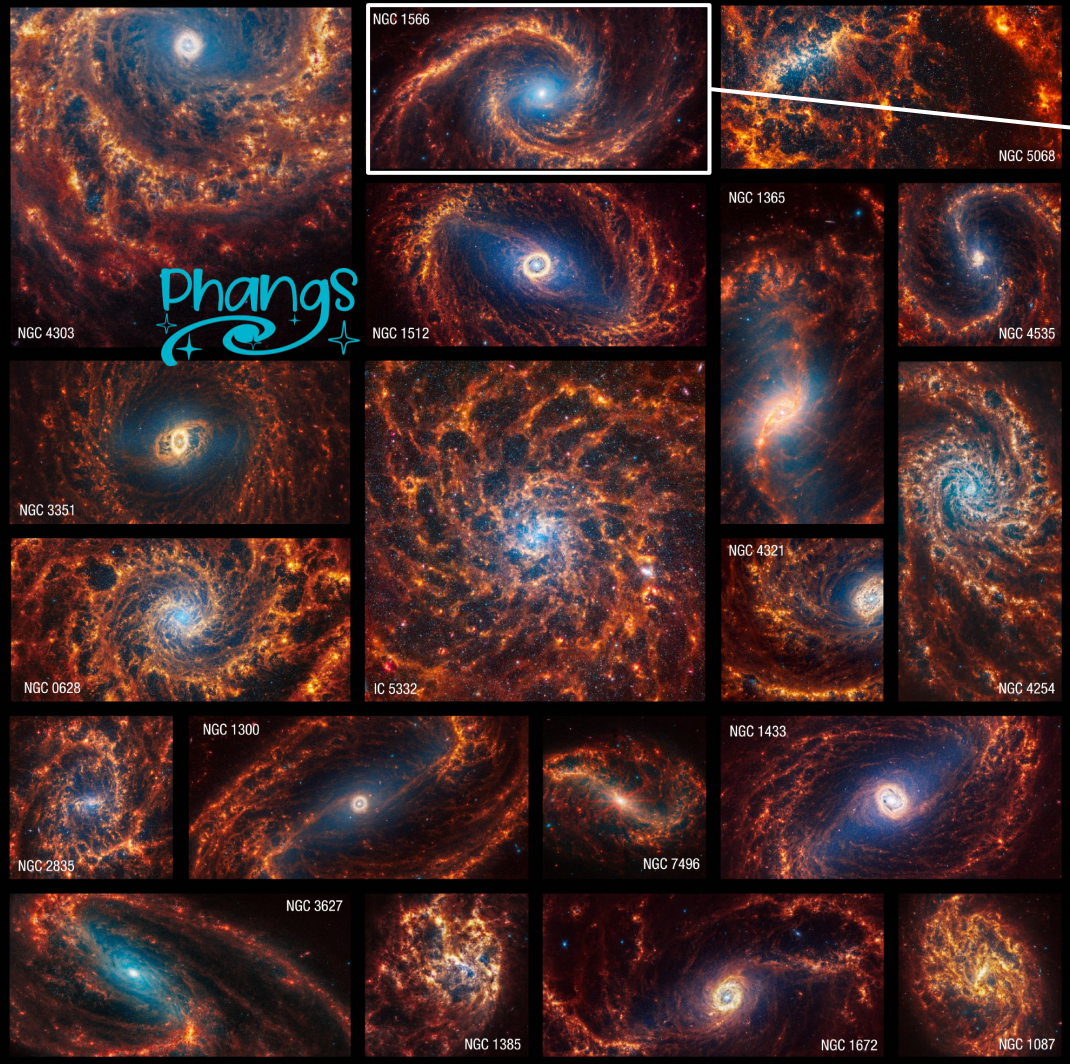


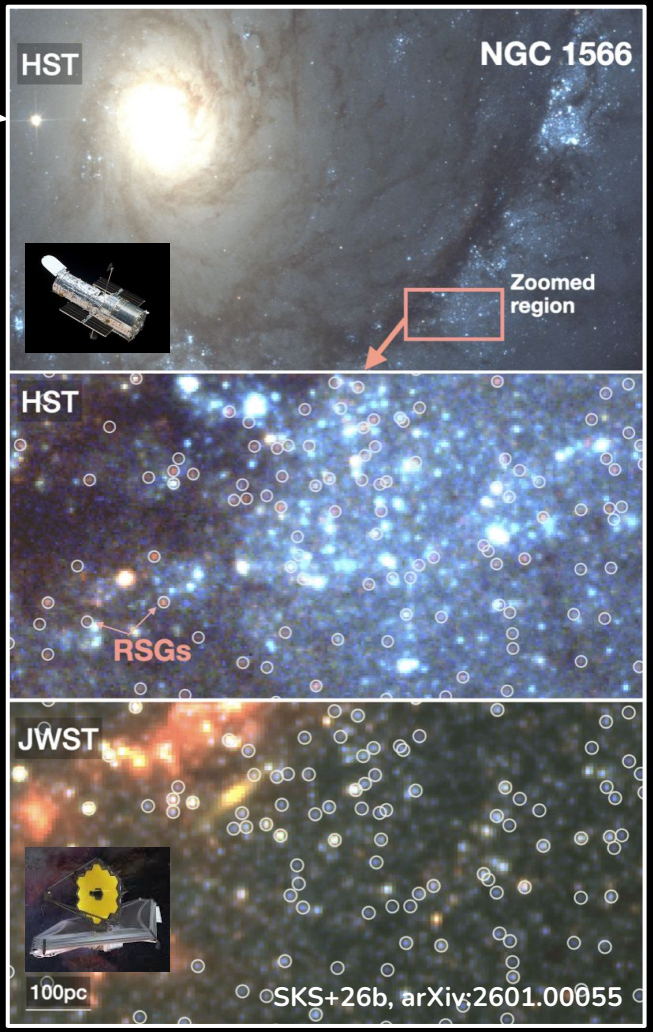
(Rathjen, SKS+ in prep)

Does this interpretation hold for other galaxies?



Adapted from z0MGS (Leroy+2019)


Phangs
NGC 4303
NGC 1566
NGC 5068
NGC 1512
NGC 1365
NGC 4535
NGC 3351
IC 5332
NGC 4321
NGC 4254
NGC 0628
NGC 2835
NGC 1300
NGC 7496
NGC 1433
NGC 3627
NGC 1385
NGC 1672
NGC 1087


HST
NGC 1566
Zoomed region
HST
RSGs
JWST
100pc
SKS+26b, arXiv:2601.00055

ROMAN

NGC 4303

NGC 3351

NGC 0628

NGC 1300

NGC 2835

NGC 3627

NGC 1385

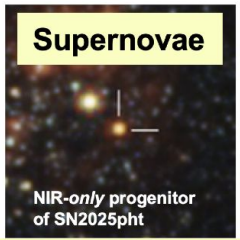
NGC 1672

NGC 1087

HST

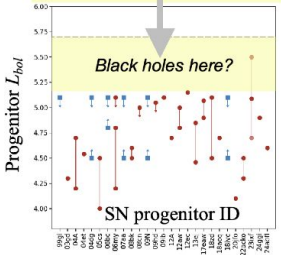
NGC 1566

Supernovae

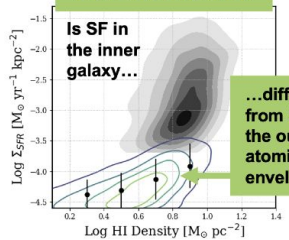


NIR-*only* progenitor of SN2025pht

Do high-mass supergiants directly collapse to black holes?



Star Formation



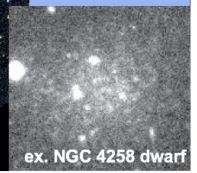
…different from SF in the outer atomic gas envelope?

GALEX+VLA

M83

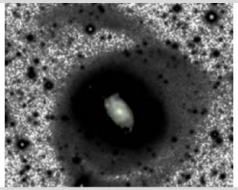
ROMAN:
White = footprint
Cyan = one dither
Multi = GAP steps

Dwarf detection and distances



ex. NGC 4258 dwarf

Galaxy Archaeology



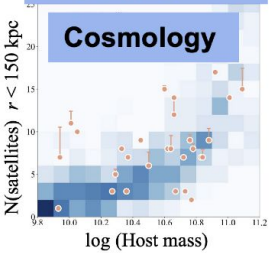
Stellar halos + streams → important mergers

Globular clusters + streams → dark matter halo masses

Simulated DM halo

How do satellites vary with halo mass and merger histories?

Cosmology



Summary

- **Locations of massive stars** in nearby galaxies can directly test stellar feedback models.
- **Many stars explode outside** dense molecular clouds in M33 (from 45% for stars > 30 M_{SUN} to 77% for stars ~ 10 M_{SUN}).
- Feedback models that include **winds + ionization** + supernovae can best reproduce observed ISM densities.
- Next step ⇒ Catalog all massive stars within 20 Mpc (HST, JWST, Roman)