Evolved supergiants in the Local Volume

Sumit K. Sarbadhicary
Assistant Research Scientist (JHU)

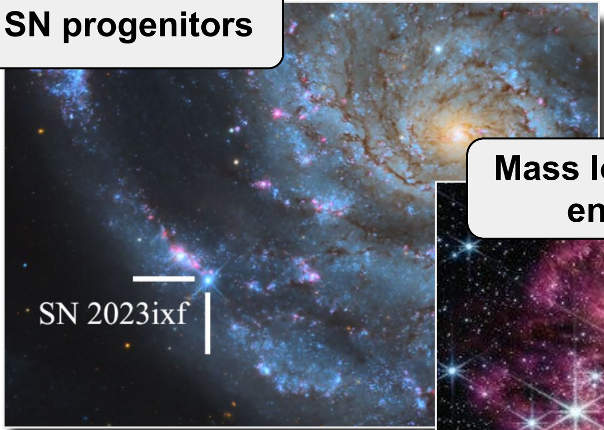
Shifting Landscapes in Astrophysics
Pasadena, CA July 13, 2026

Collaborators: David Thilker (JHU), Adam Leroy (OSU), Kirsten Larson (STSCI), Erik Rosolowsky (UA), Tim-Eric Rathjen (Cologne) + LGLBS, PHANGS

NGC 5068 (HST), PHANGS
PI: Lee, J.C.

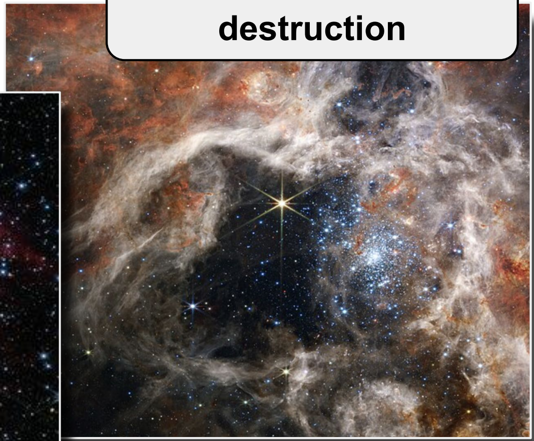
Massive stars have wide-reaching influence in the universe

SN progenitors

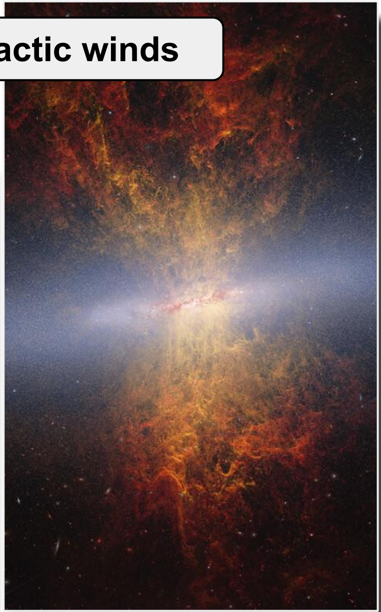


Mass loss, chemical enrichment

Molecular cloud destruction



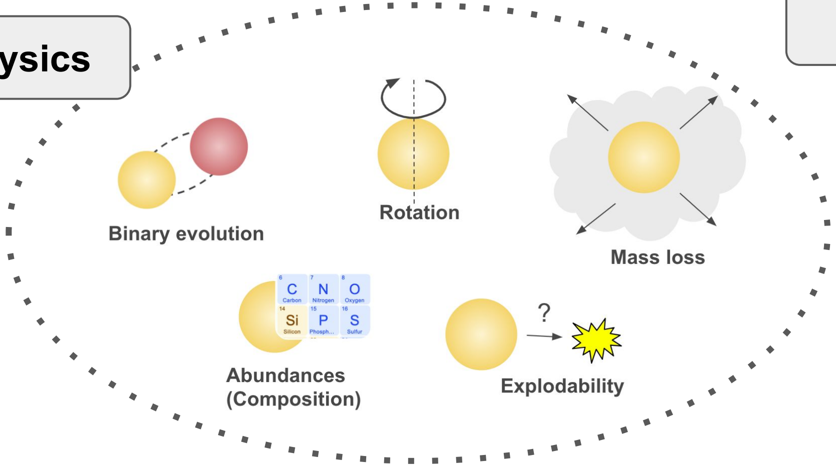
Galactic winds



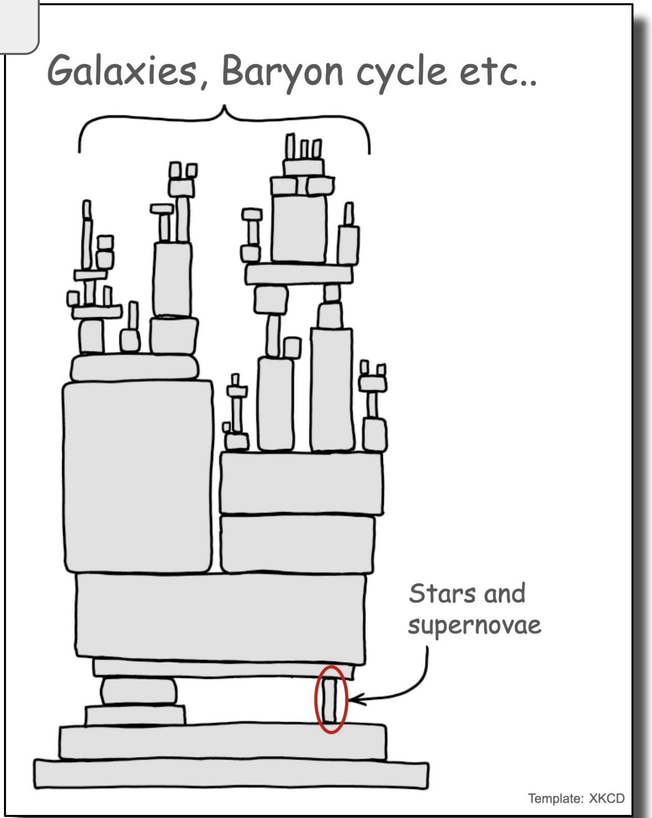
Also… Dust | Cosmic Rays | Neutrinos | Black holes | Neutron stars

Much remains to be understood about massive stars

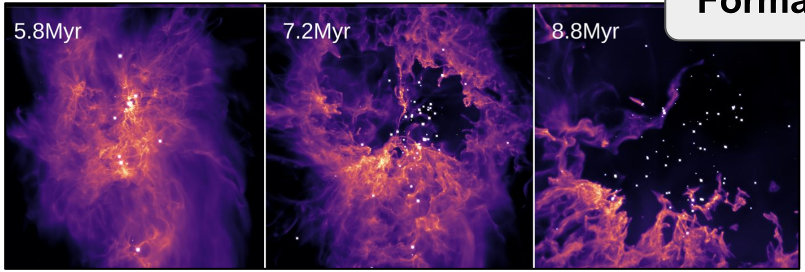
Physics



Impact



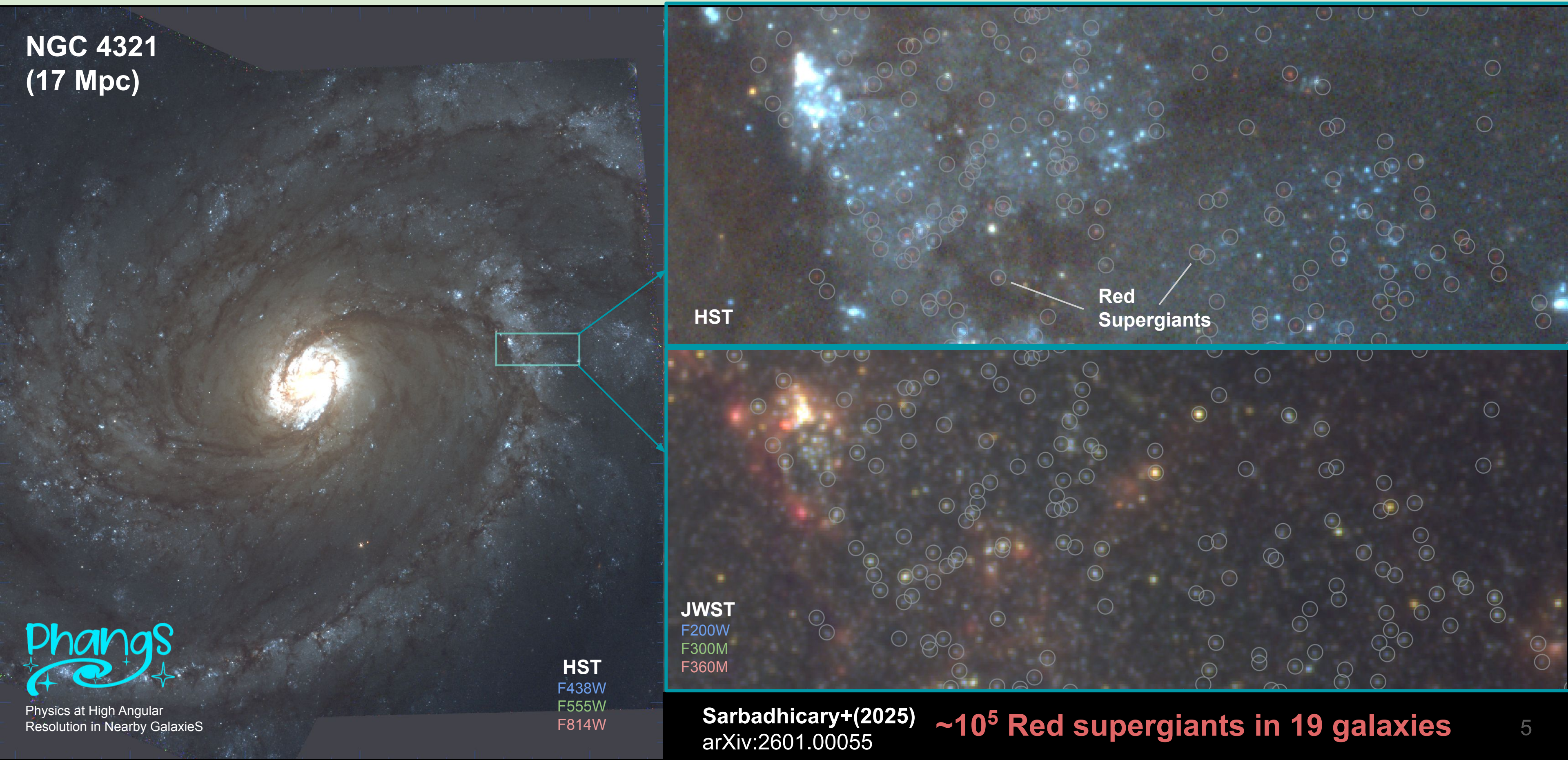
Formation



Wainer+2026


The next frontier:
Extragalactic Massive Star Surveys
NGC 5068 (HST), PHANGS
PI: Lee, J.C.

With HST+JWST ⇒ Can resolve supergiants out to ~20 Mpc



Sarbadhicary+(2025)
arXiv:2601.00055

~10^5 Red supergiants in 19 galaxies

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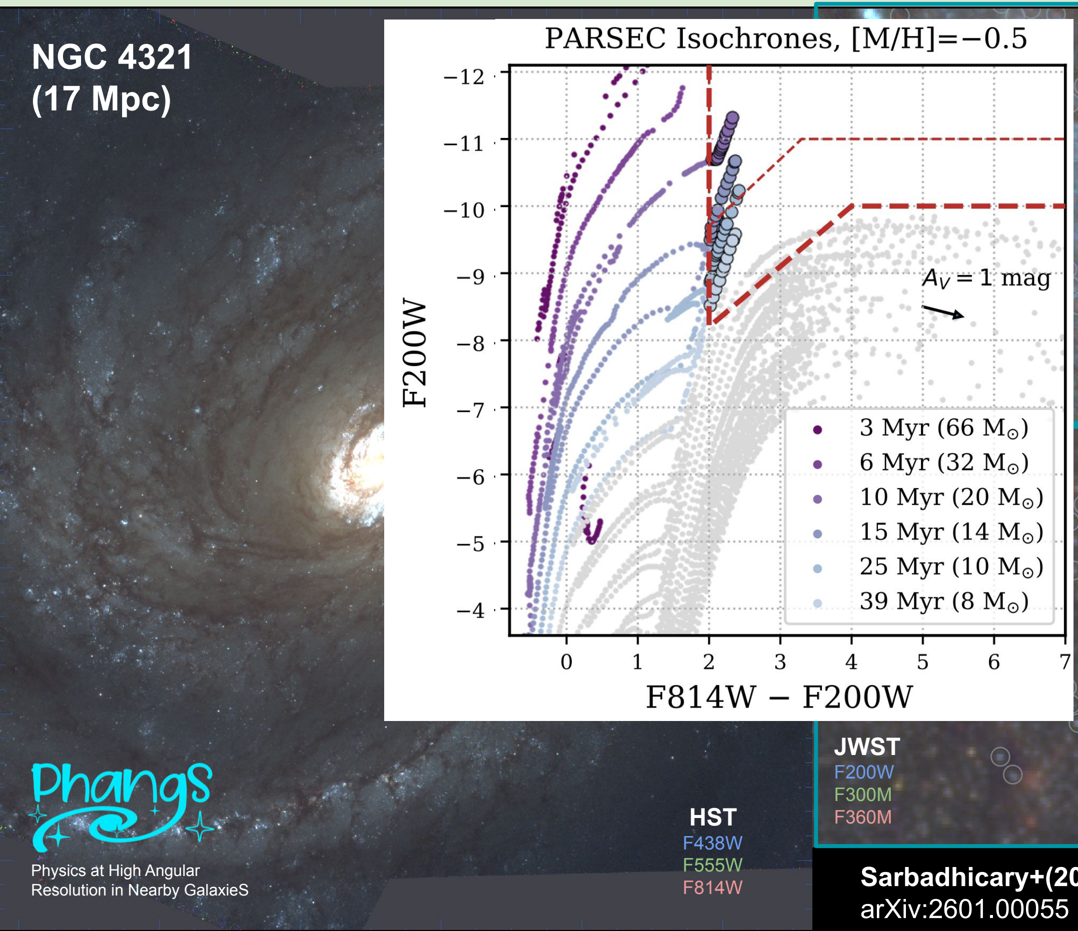

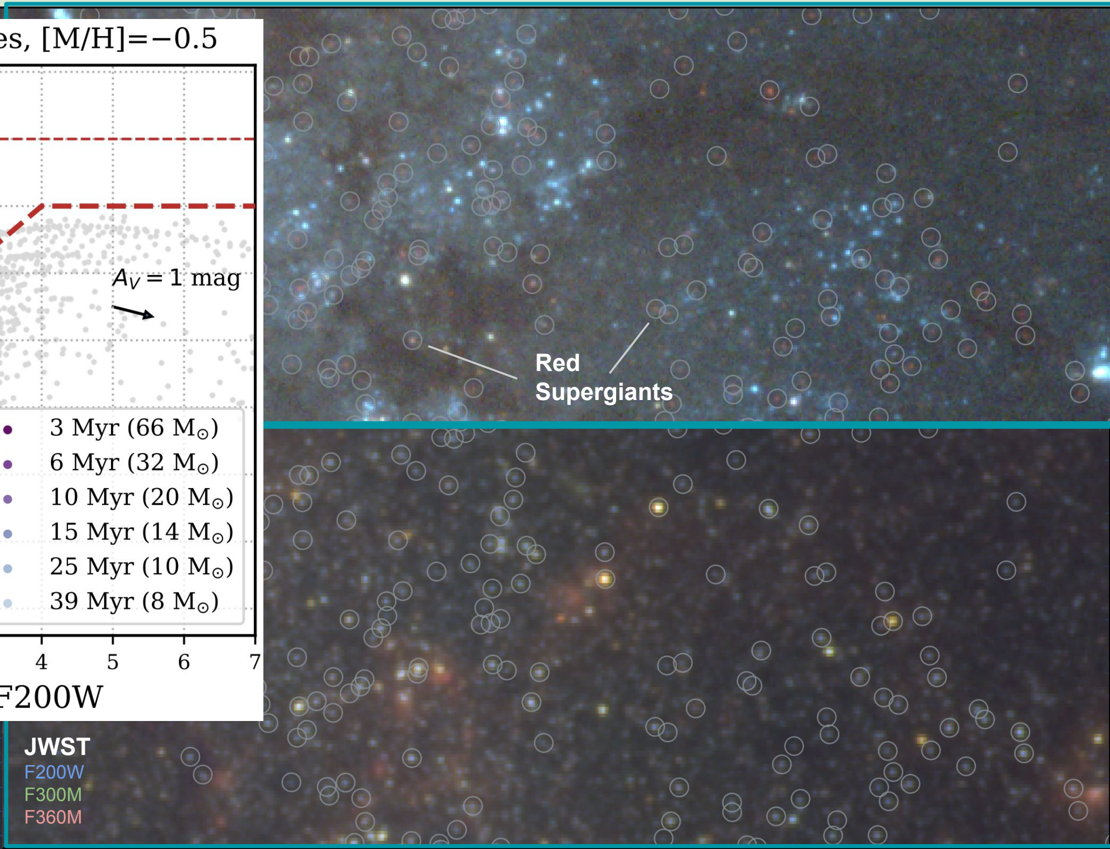

Sarbadhicary+(2025)
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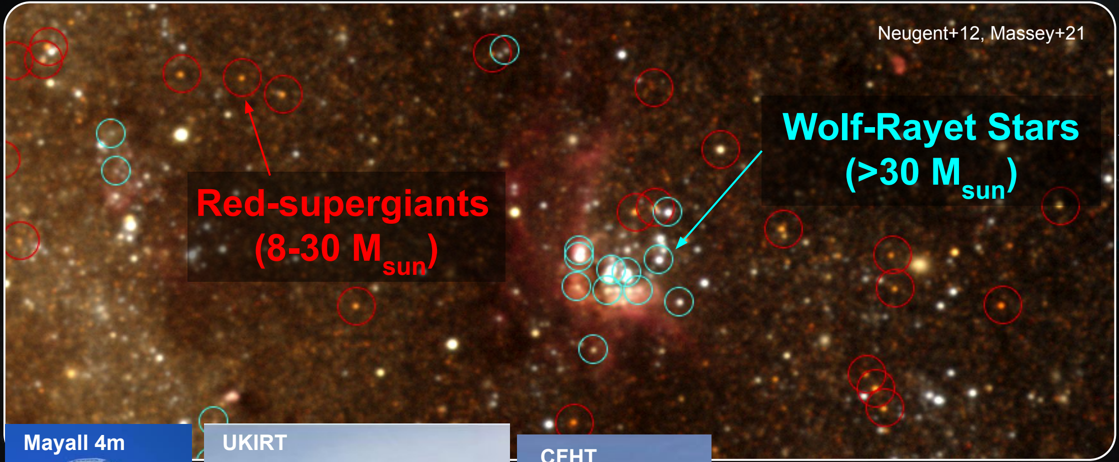
~10^5 Red supergiants in 19 galaxies

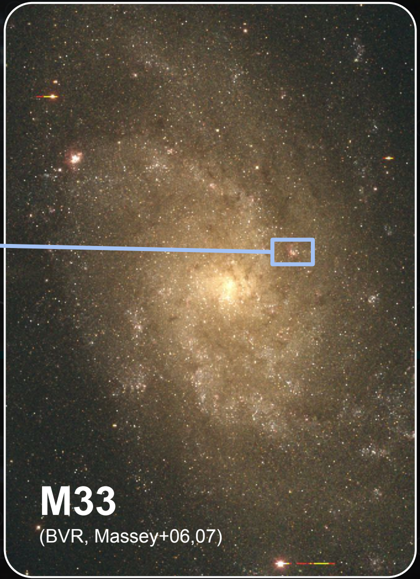
With HST+JWST ⇒ Can resolve supergiants out to ~20 Mpc

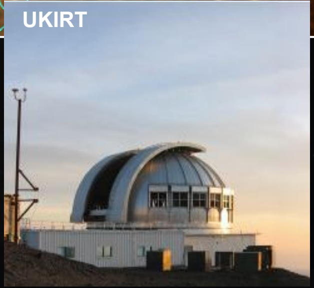
NGC 4

(17 Mp

Rich history of massive star surveys in the Local Group







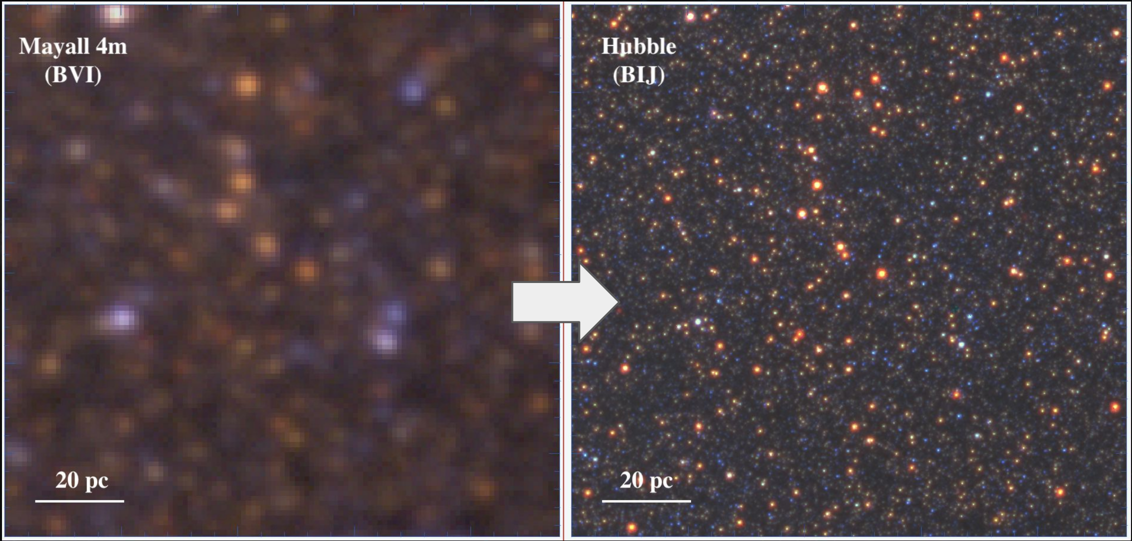
F814W

Sarbadhicary+(2025)
arXiv:2601.00055

With HST+JWST ⇒ Can resolve supergiants out to ~20 Mpc

NGC 4321
(17 Mpc)

Space-based observations will provide higher-quality photometry



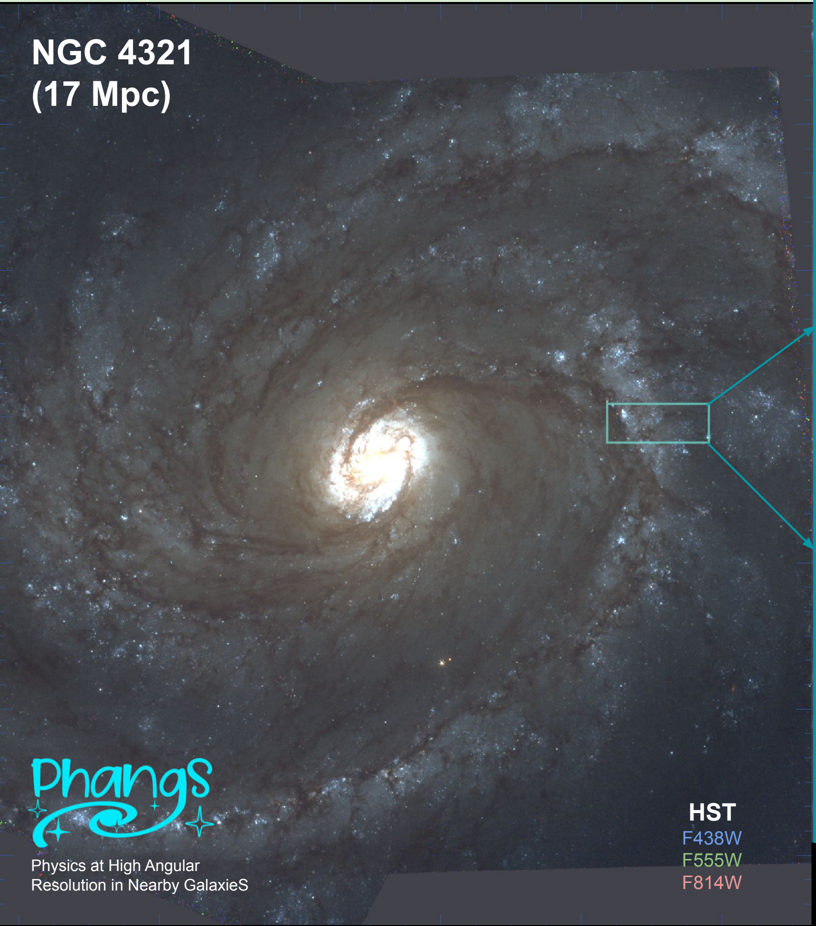
F300M
F360M

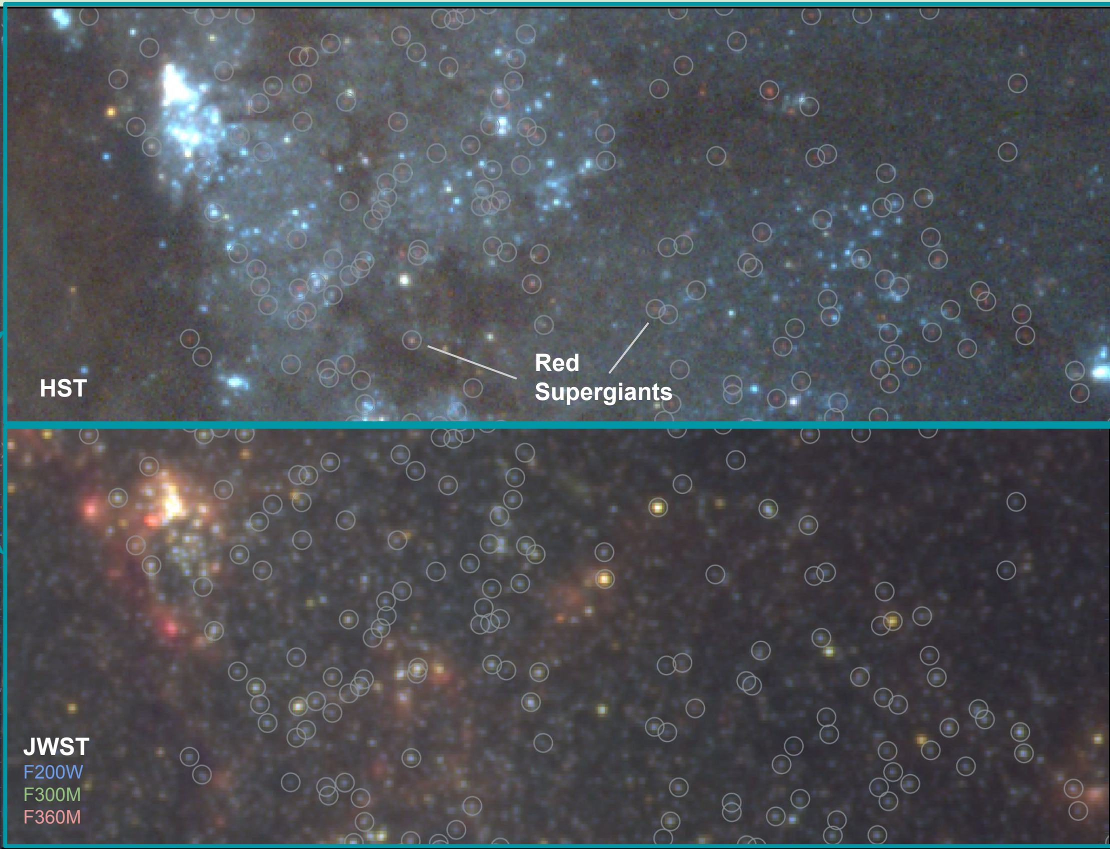
HST
F438W
F555W
F814W

Physics at High Angular Resolution in Nearby GalaxieS

Sarbadhicary+(2025)
arXiv:2601.00055

With HST+JWST ⇒ Can resolve supergiants out to ~20 Mpc





Sarbadhicary+(2025)
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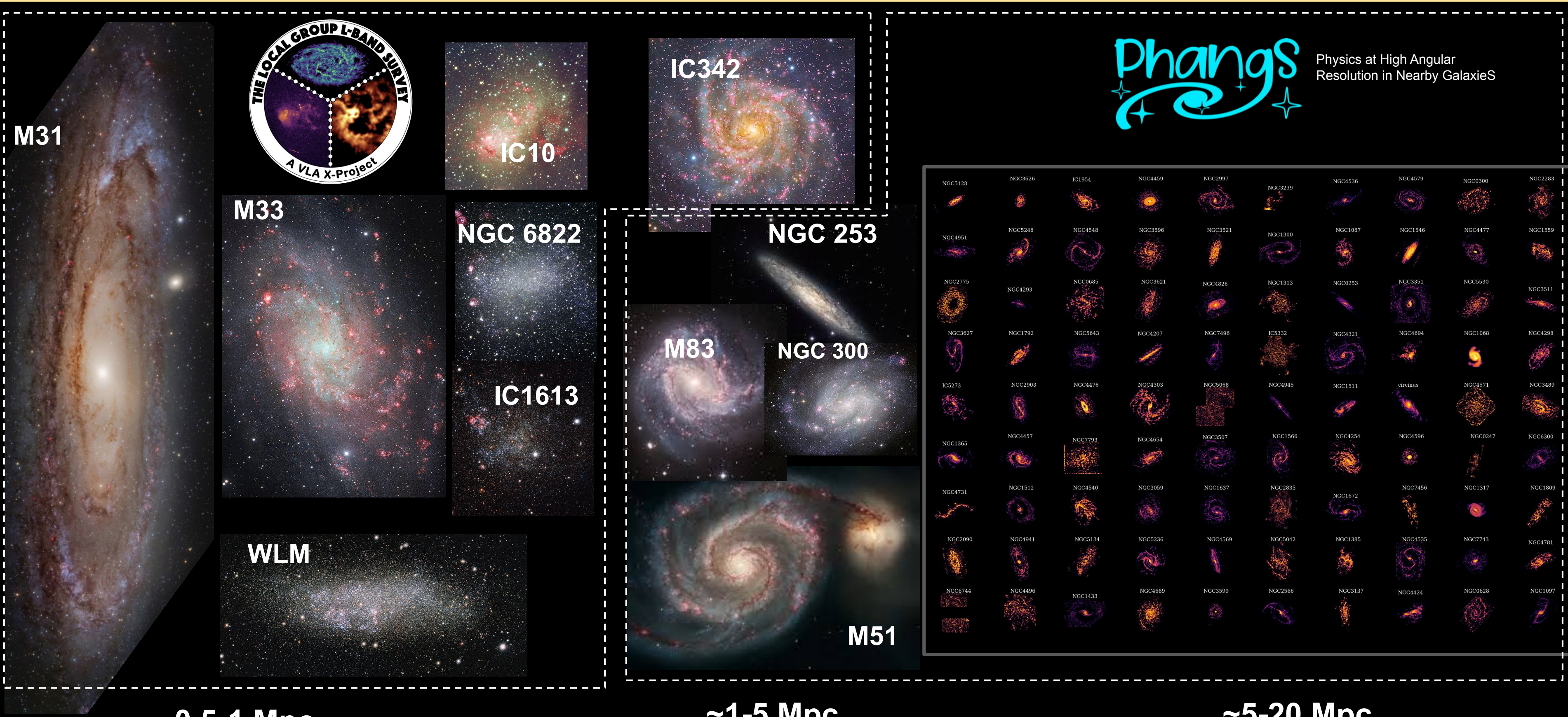
~10^5 Red supergiants in 19 galaxies

A renaissance of high-resolution nearby galaxy surveys

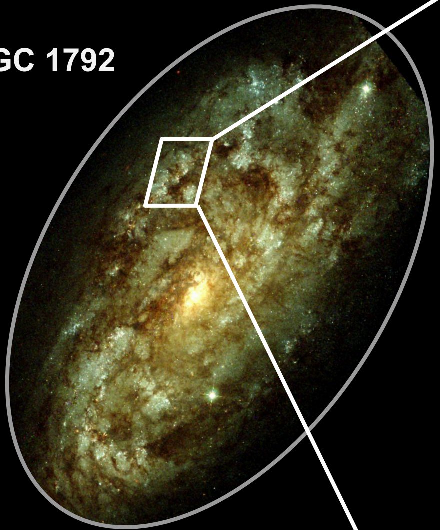


0.5-1 Mpc

~1-5 Mpc

~5-20 Mpc

NGC 1792



Chandra

AstroSAT

HST

MUSE (+WFI)

JWST

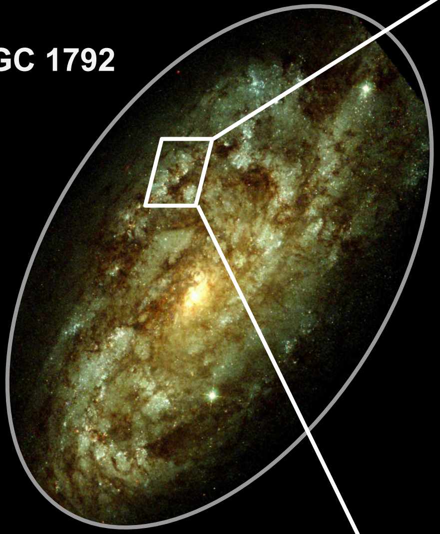
ALMA (+SMA,NOEMA)

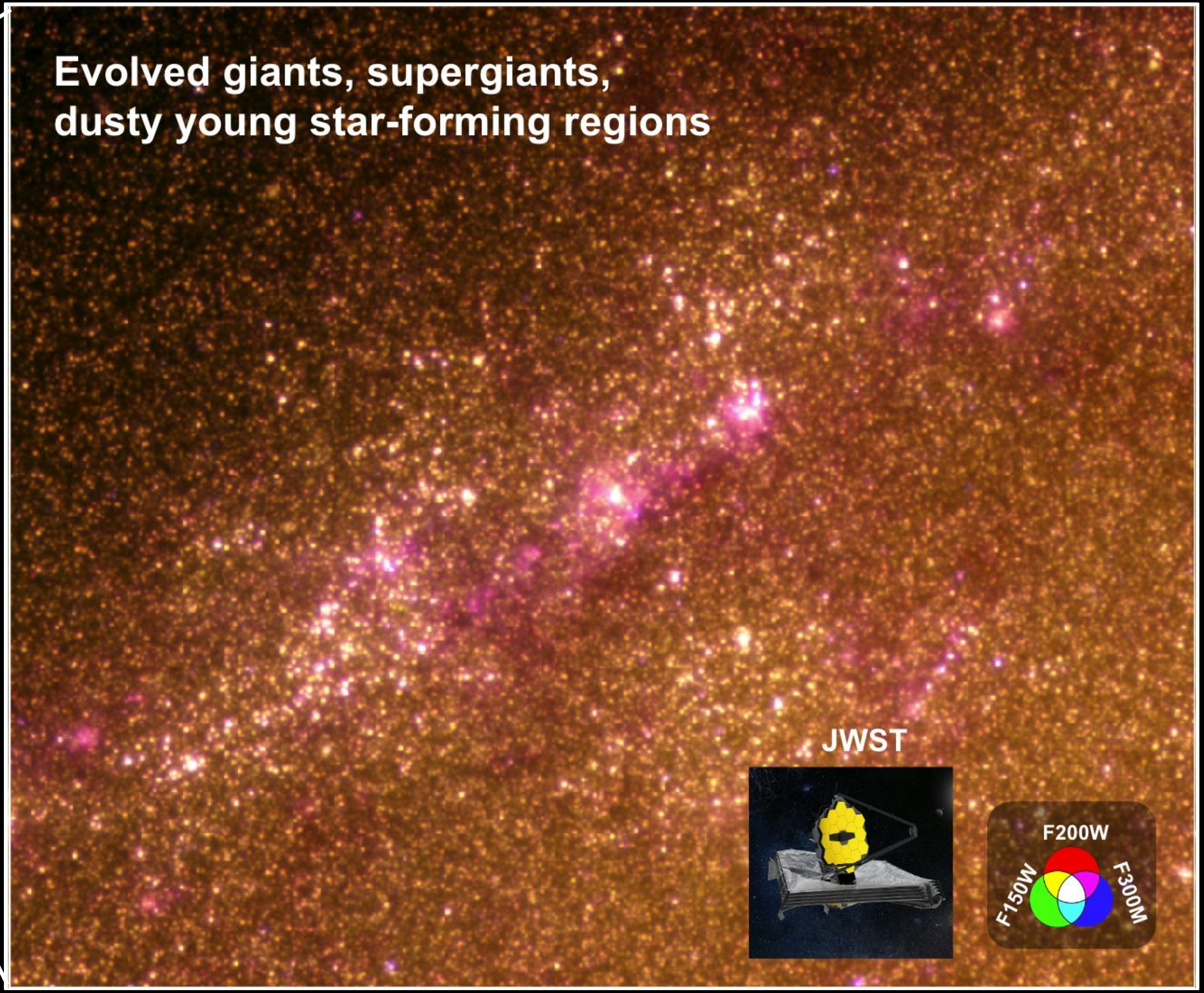
VLA (+GBT,MeerKAT)

Phangs

Physics at High Angular Resolution in Nearby GalaxieS

NGC 1792





Chandra

AstroSAT

HST

MUSE (+WFI)

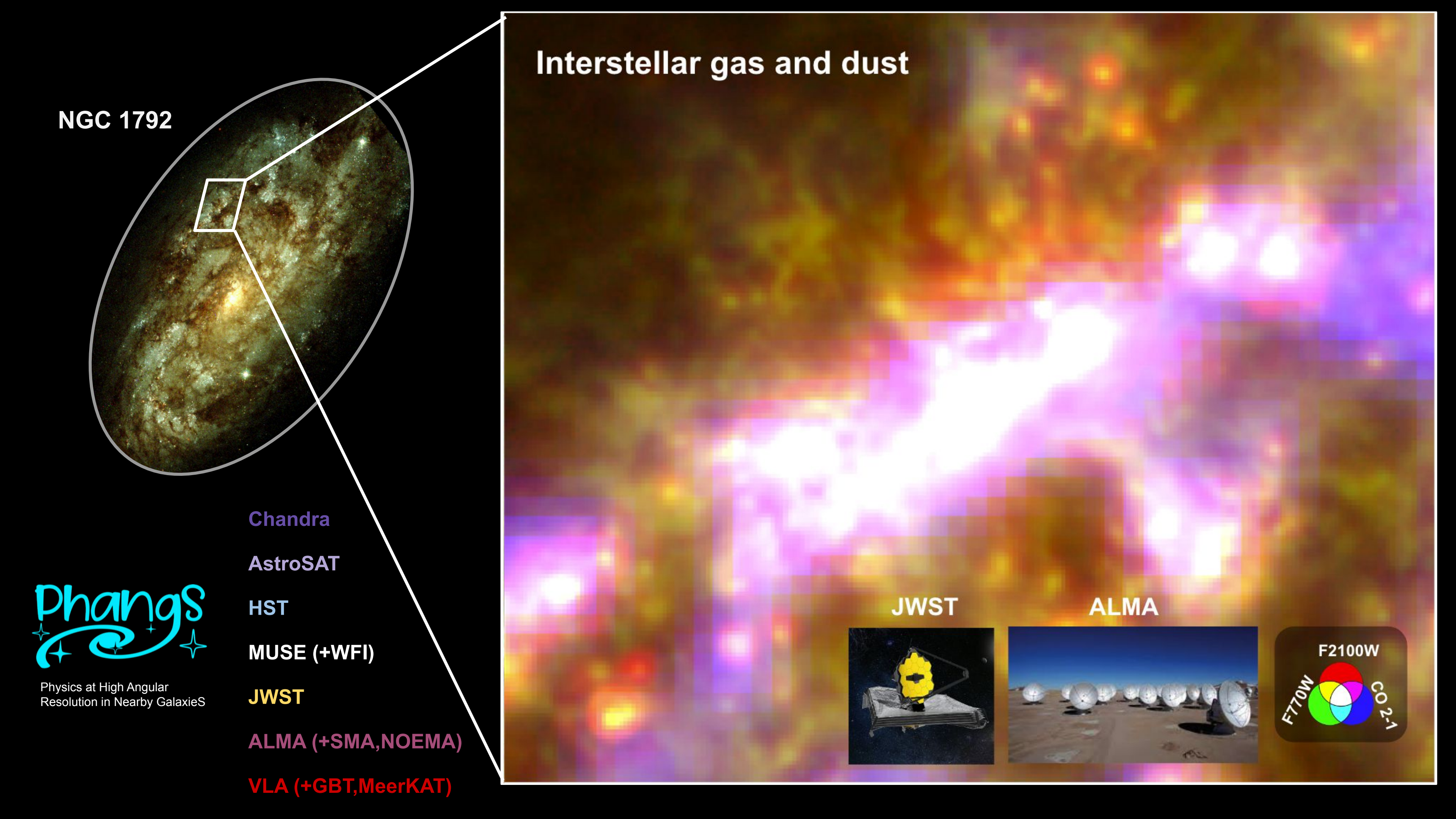
JWST

ALMA (+SMA,NOEMA)

VLA (+GBT,MeerKAT)

Phangs

Physics at High Angular Resolution in Nearby GalaxieS

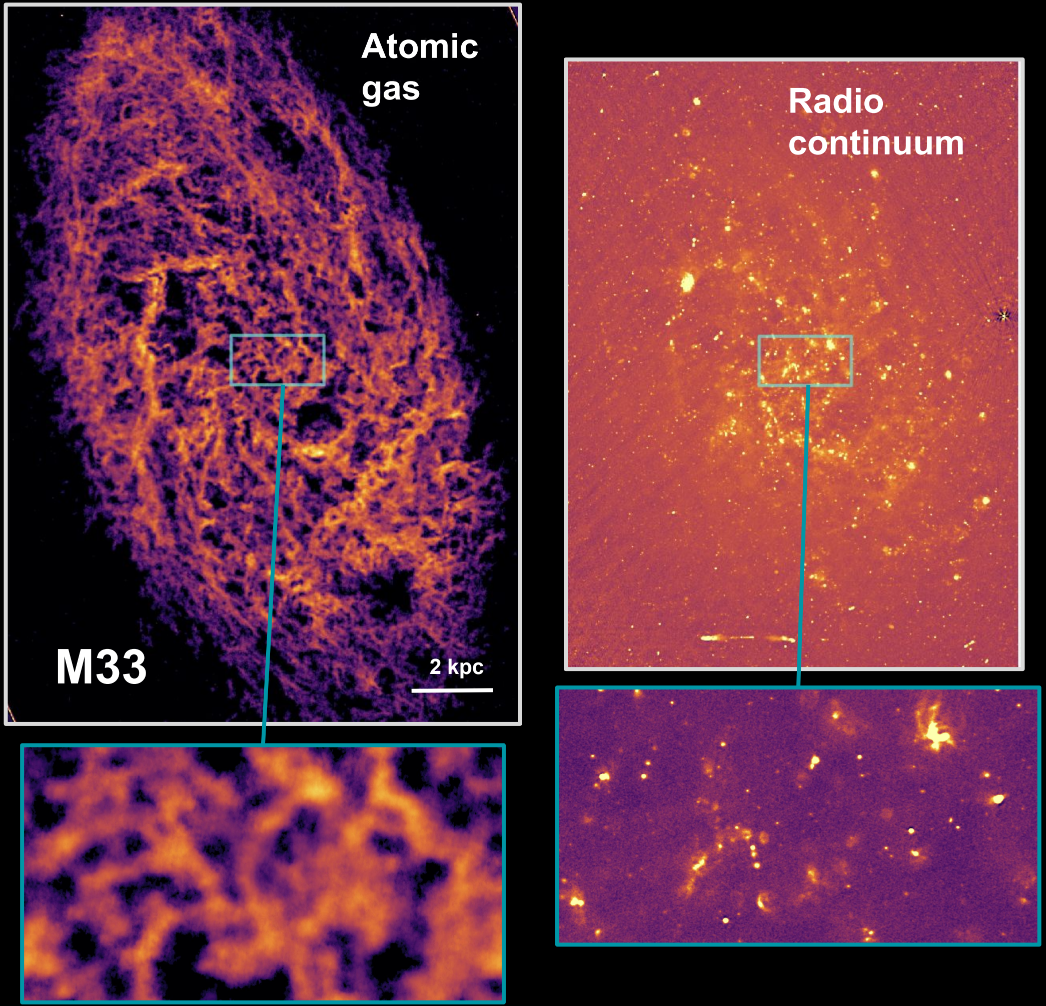

NGC 1792
Interstellar gas and dust
Chandra
AstroSAT
HST
MUSE (+WFI)
JWST
ALMA (+SMA,NOEMA)
VLA (+GBT,MeerKAT)
Phangs
Physics at High Angular Resolution in Nearby GalaxieS
JWST
ALMA
F2100W
F770W
CO 2-1

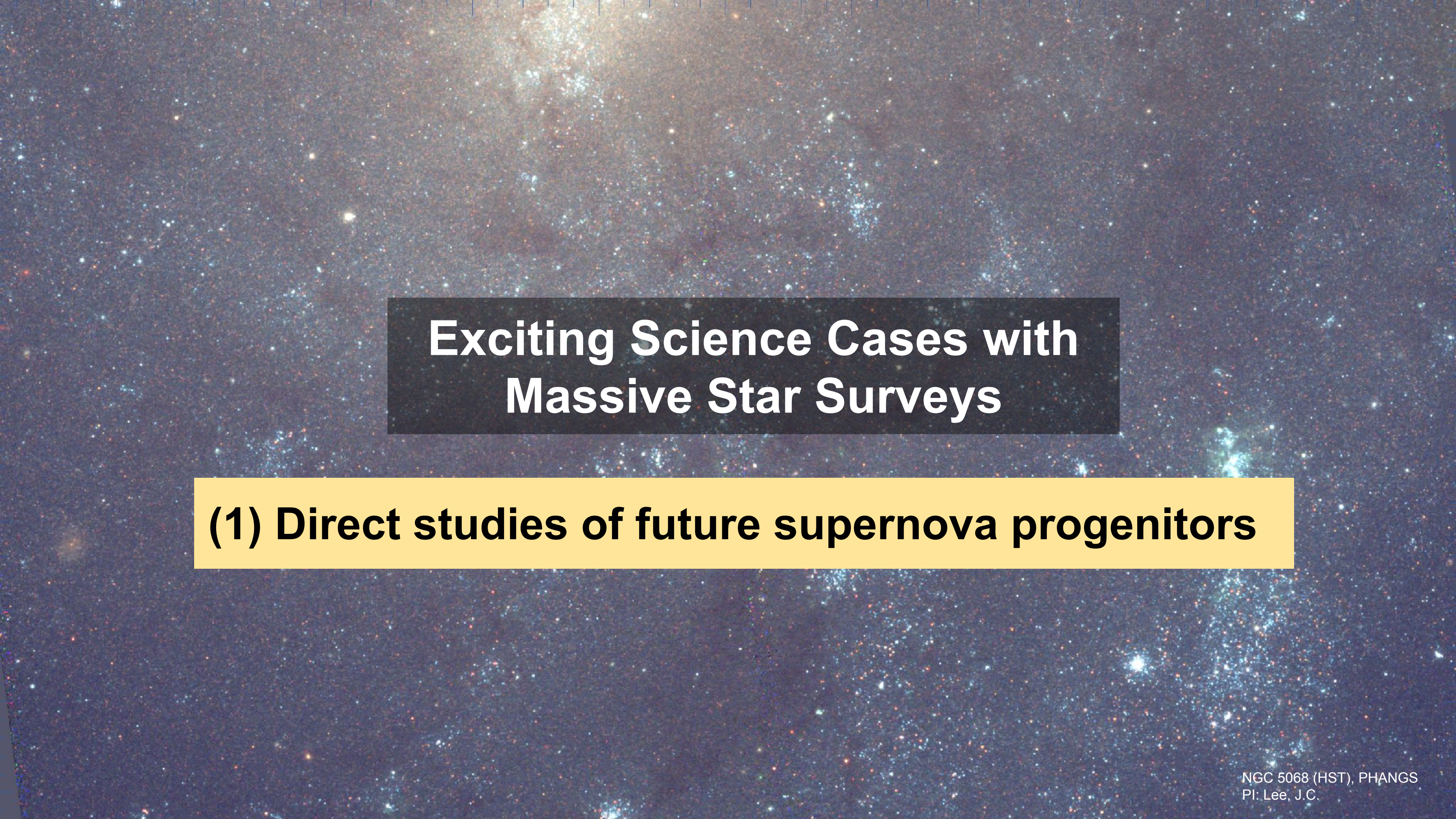
THE LOCAL GROUP L-BAND SURVEY

A VLA X-Project

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

M31	**VLA (+GBT)**
M33	**ALMA** (+SMA)
NGC 6822	**JWST** (+Spitzer,Herschel)
IC 1613	**After-Sloan V**
IC 10	**HST**
WLM	**AstroSAT/GALEX**
IC 342	**Chandra** (+XMM)
(Soon: M82, Sextans)	





Exciting Science Cases with Massive Star Surveys

(1) Direct studies of future supernova progenitors

NGC 5068 (HST), PHANGS
PI: Lee, J.C.

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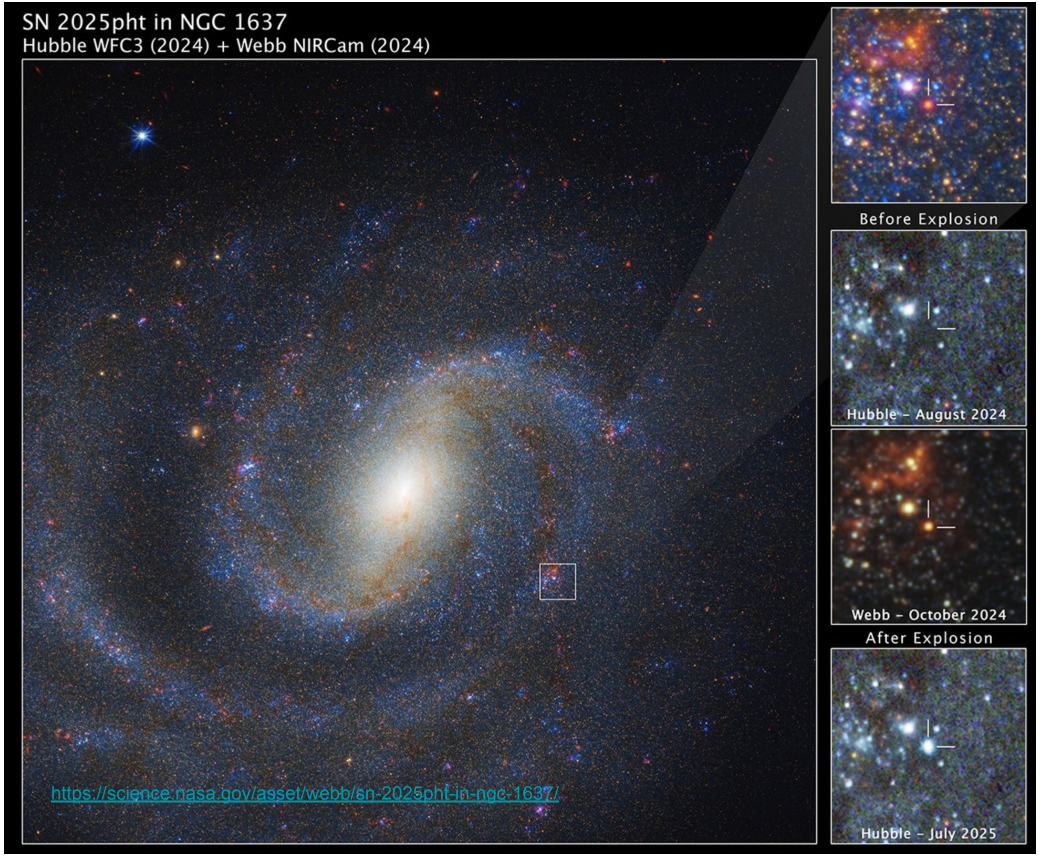
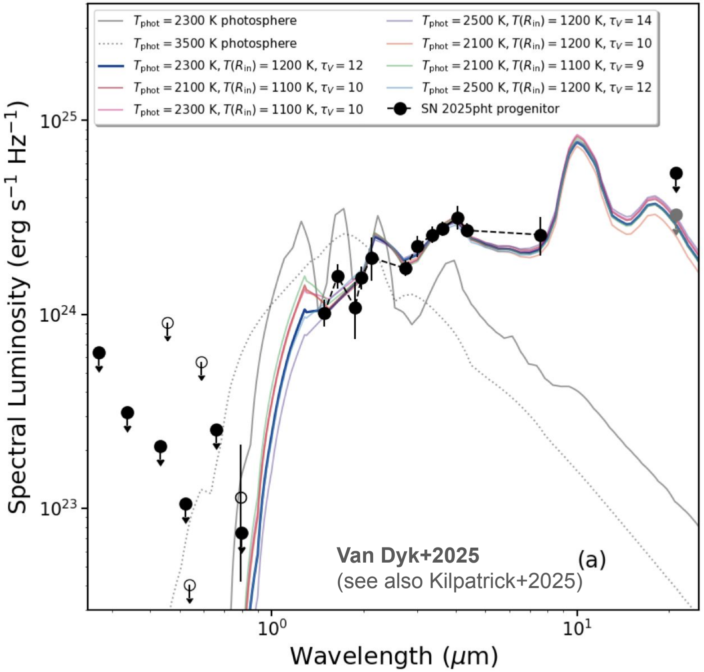
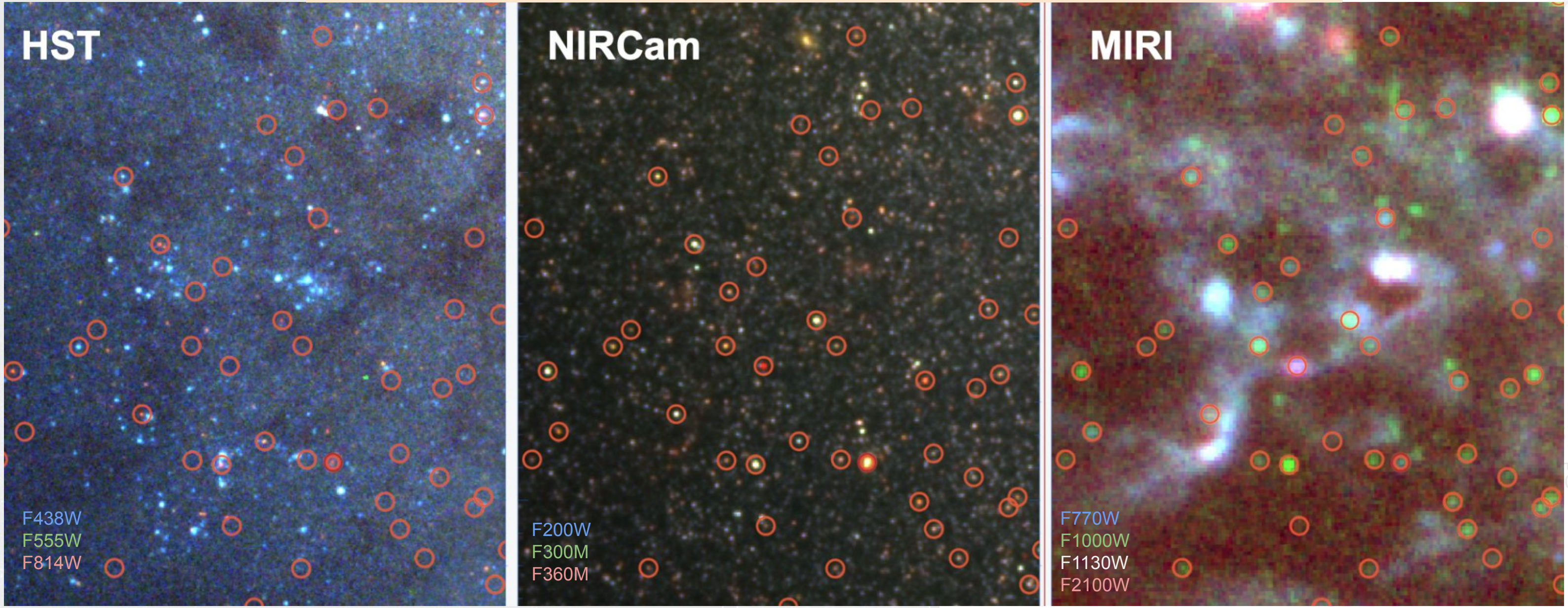




(1) Direct studies of future supernova progenitors

Ongoing survey of mid-infrared bright supergiants



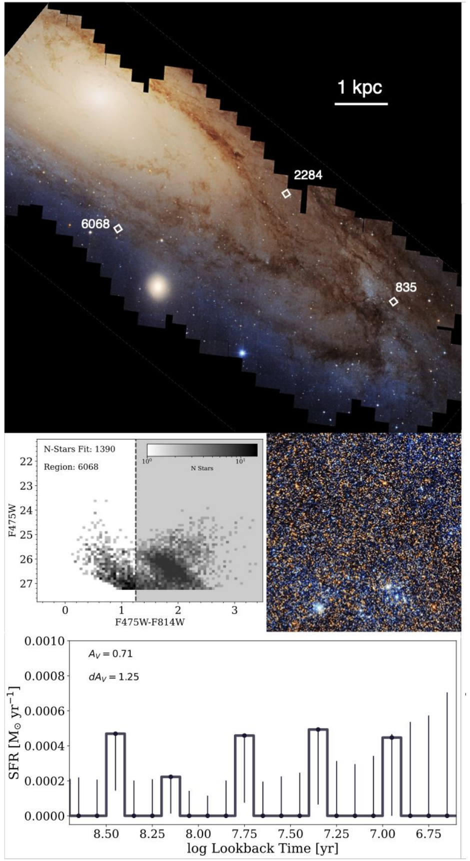
Sarbadhicary et al (in prep). See also:
Hassani et al (2026), ApJS, 284, 3
Maschmann et al (2025), arXiv 2511.20755

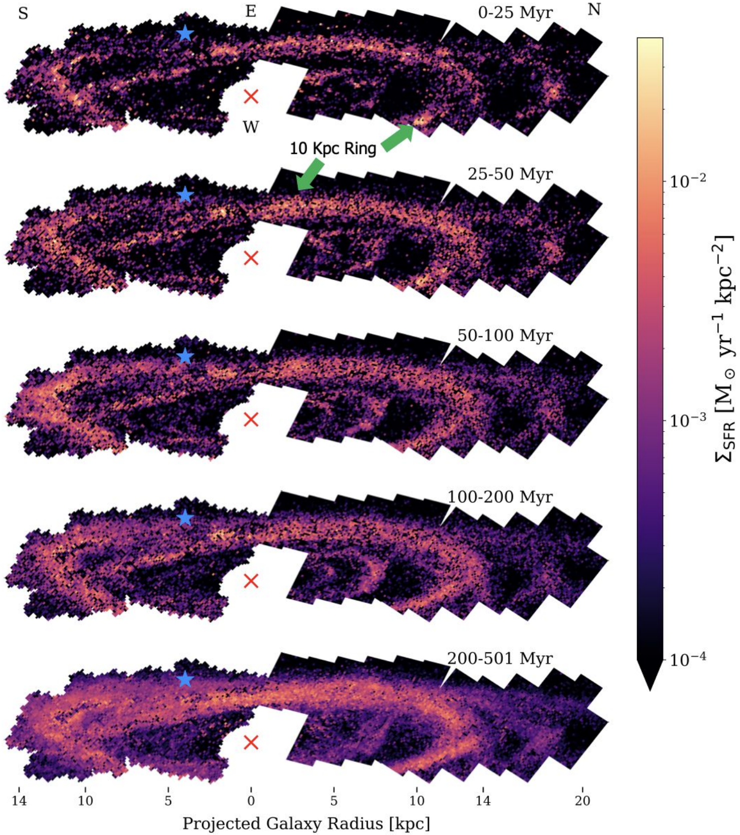
Exciting Science Cases with Massive Star Surveys

(2) Using resolved stellar populations surveys as progenitor "clocks"

NGC 5068 (HST), PHANGS
PI: Lee, J.C.

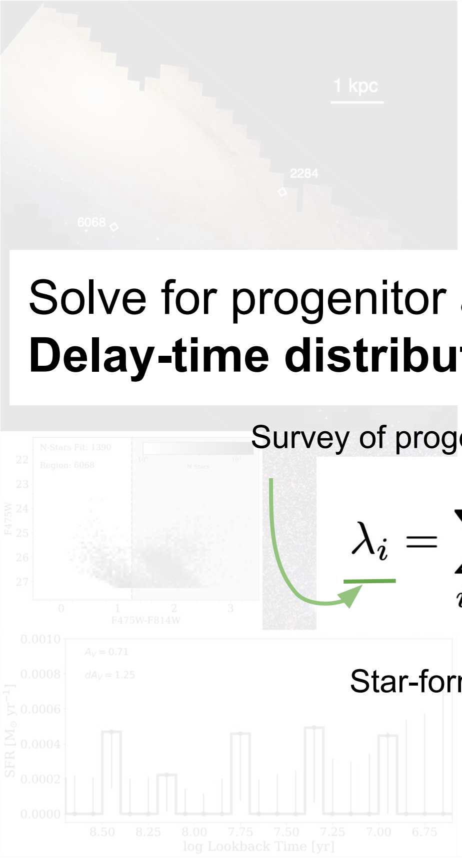
(2) Using resolved stellar populations surveys as progenitor "clocks"

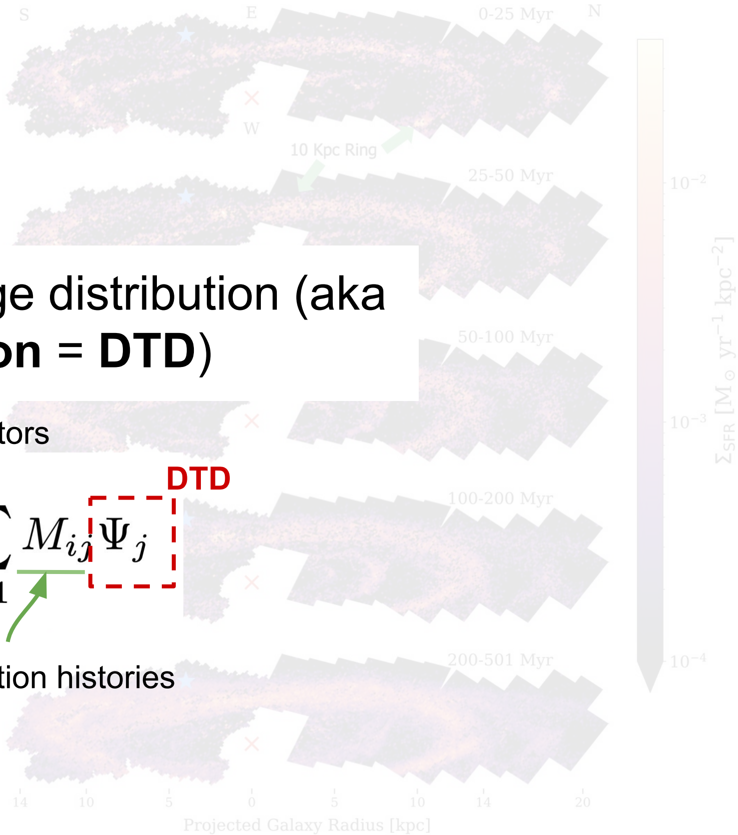




Wainer, T+(2026)

(2) Using resolved stellar populations surveys as progenitor “clocks”





Solve for progenitor age distribution (aka **Delay-time distribution = DTD**)

Survey of progenitors

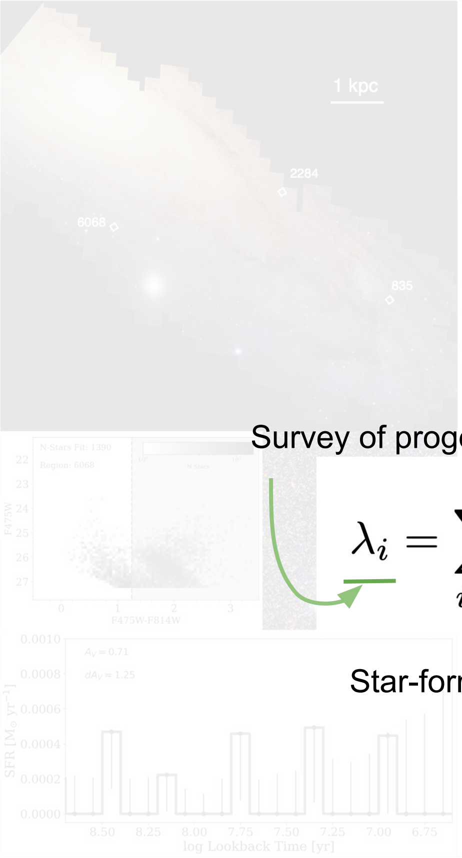
$$\lambda_i = \sum_{i=1}^{N} M_{ij} \overset{\textbf{DTD}}{\boxed{\Psi_j}}$$

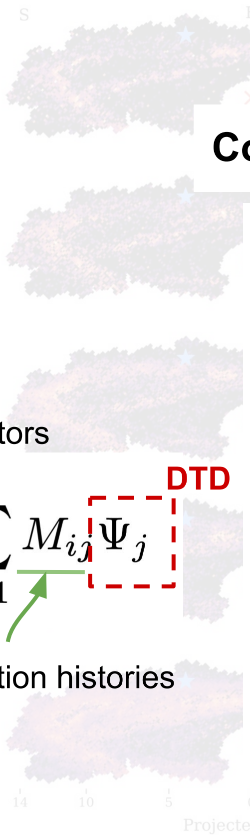
Star-formation histories

Maoz+12, 14, Badenes+15, Sarbadhicary+21, 26

Wainer, T+(2026)

(2) Using resolved stellar populations surveys as progenitor "clocks"





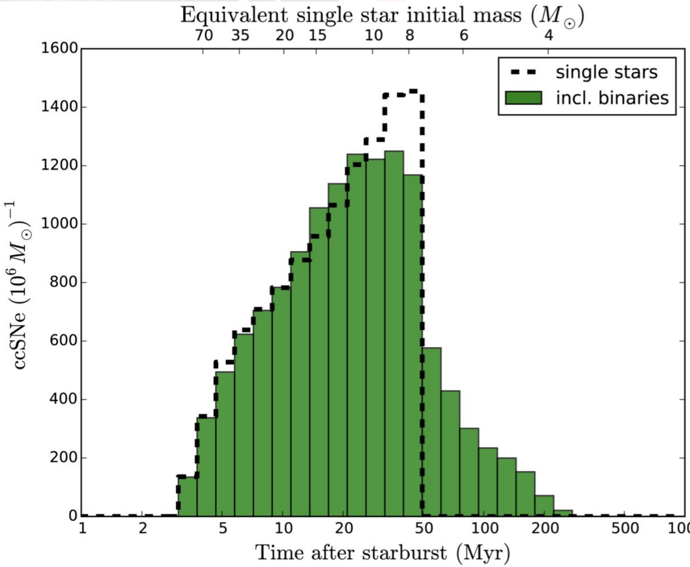
Survey of progenitors

DTD

$$\lambda_i = \sum_{i=1}^{N} M_{ij} \boxed{\Psi_j}$$

Star-formation histories

Constrain progenitor models from theory

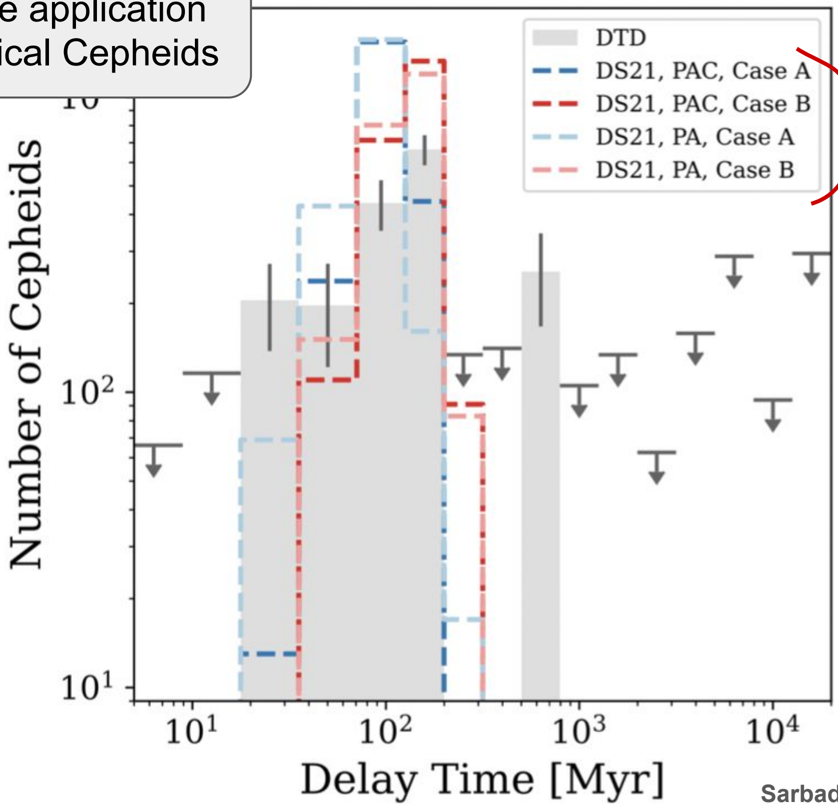


Maoz+12, 14, Badenes+15, Sarbadhicary+21, 26

Wainer, T+(2026)

(2) Using resolved stellar populations surveys as progenitor “clocks”

Example application to Classical Cepheids



Independent ages from Cepheid period-age-color relations

$$\lambda_i = \sum_{i=1}^{N} M_{ij} \Psi_j$$

Sarbadhicary (2026):
arXiv:2606.26219

(2) Using resolved stellar populations surveys as progenitor “clocks”

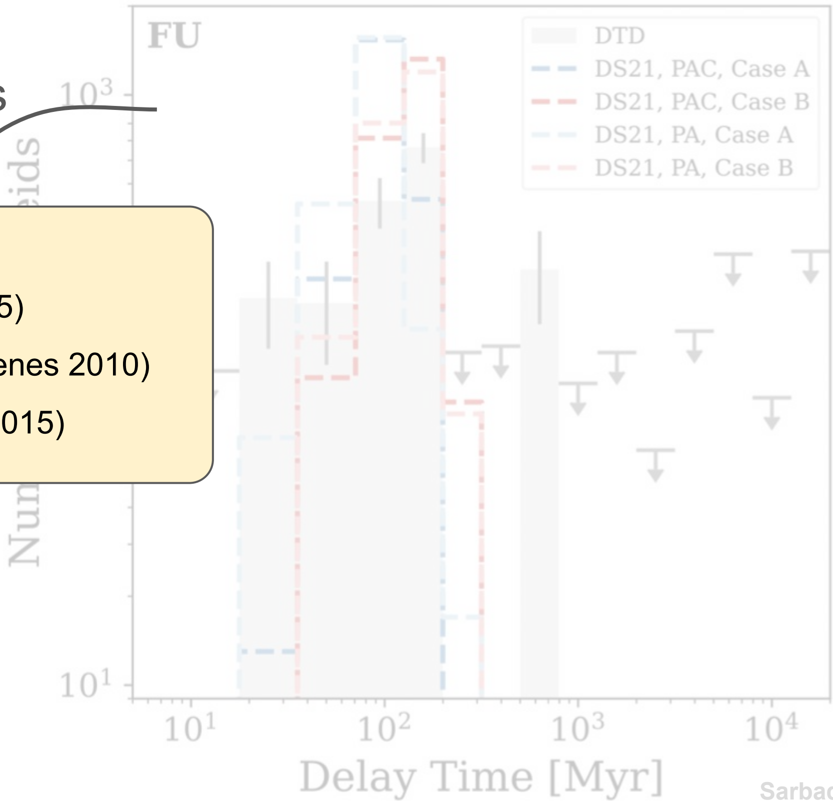
Other examples

RR Lyrae (Sarbadhicary+2021)

Classical Novae (Abelson+2025)

Local supernovae (Maoz+Badenes 2010)

Planetary nebulae (Badenes+2015)



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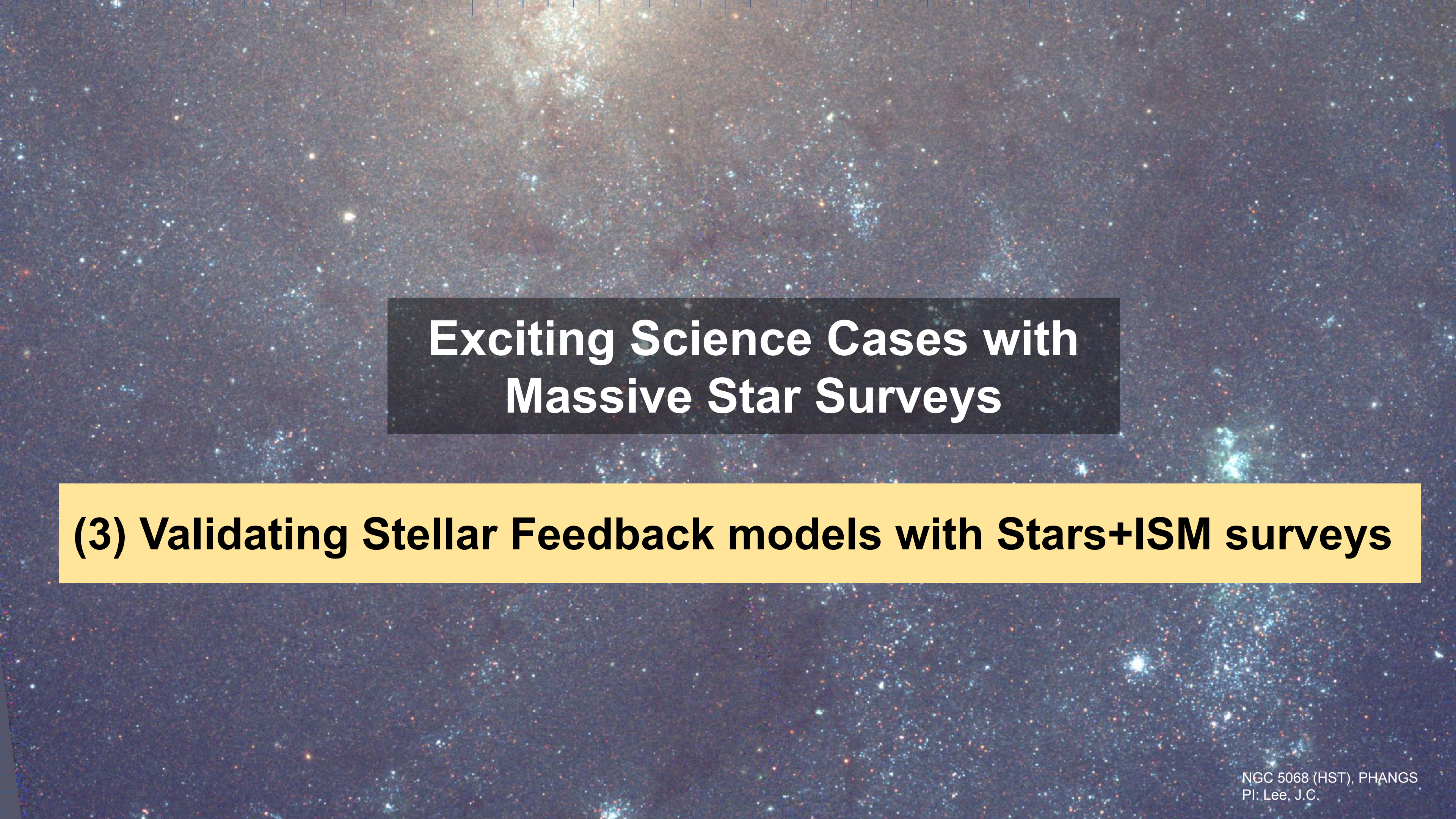

Exciting Science Cases with Massive Star Surveys

(3) Validating Stellar Feedback models with Stars+ISM surveys

NGC 5068 (HST), PHANGS
PI: Lee, J.C.

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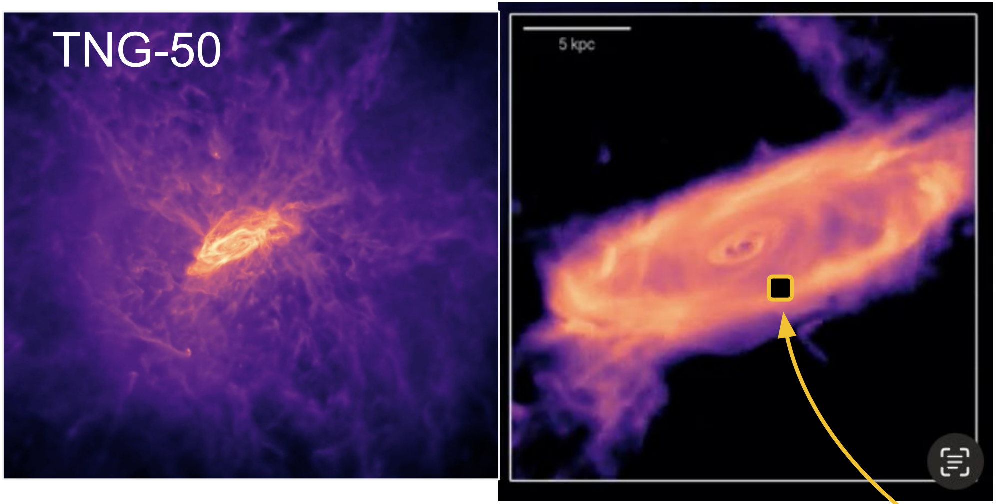
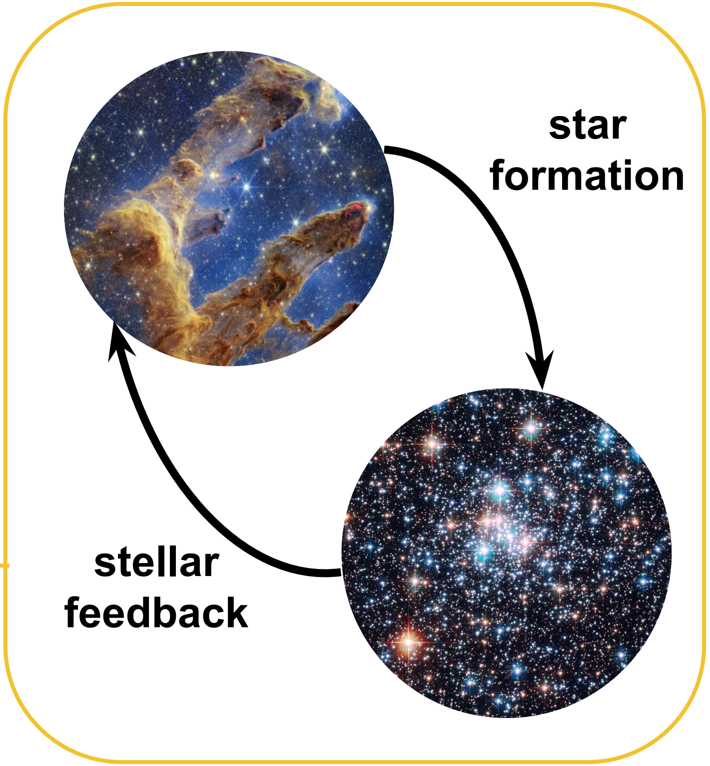
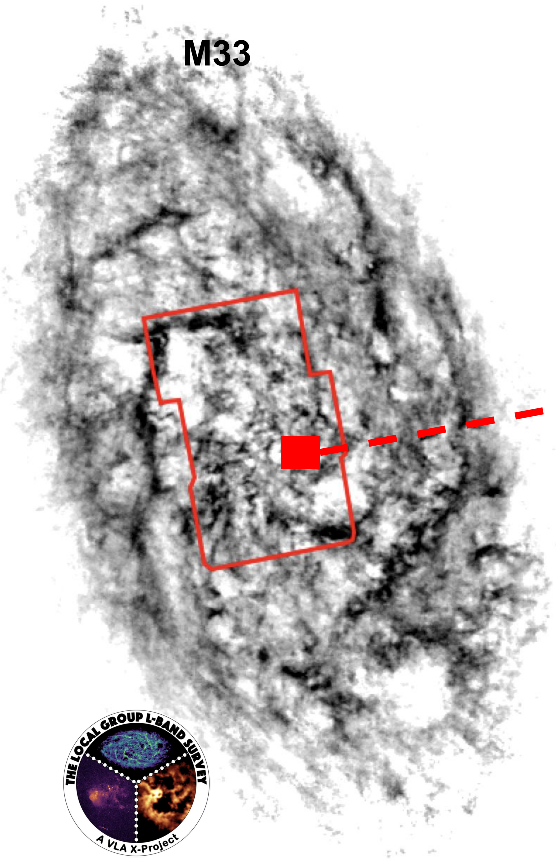
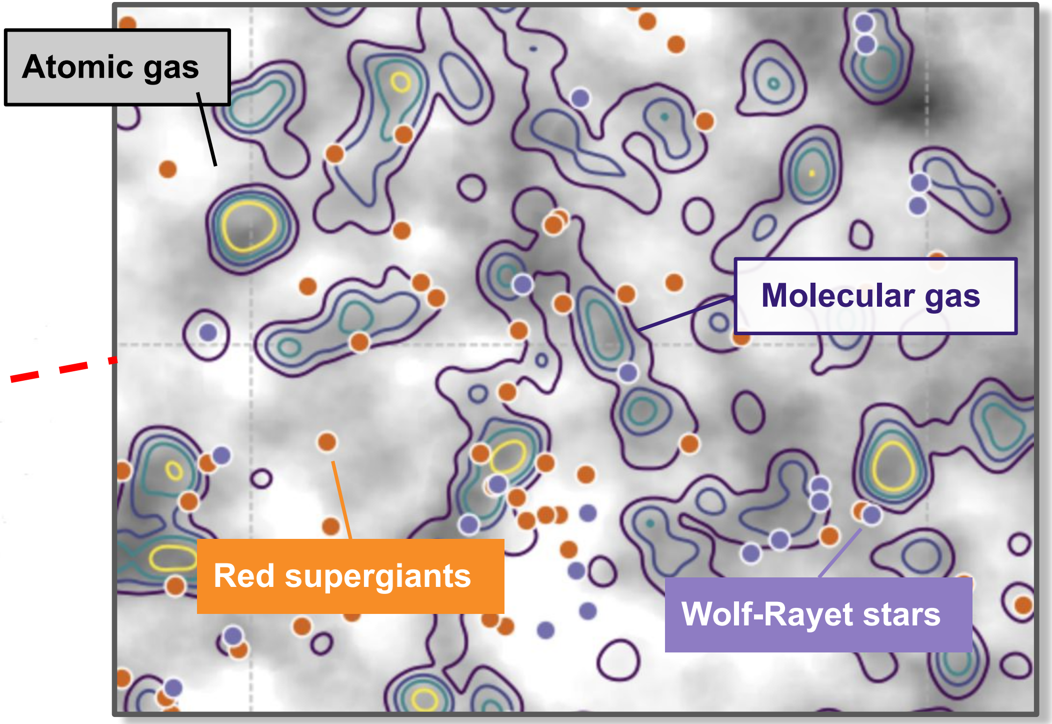


Treated with
subgrid physics



(3) Validating Stellar Feedback models with Stars+ISM surveys





Sarbadhicary+(2026), ApJ, 1000, 70

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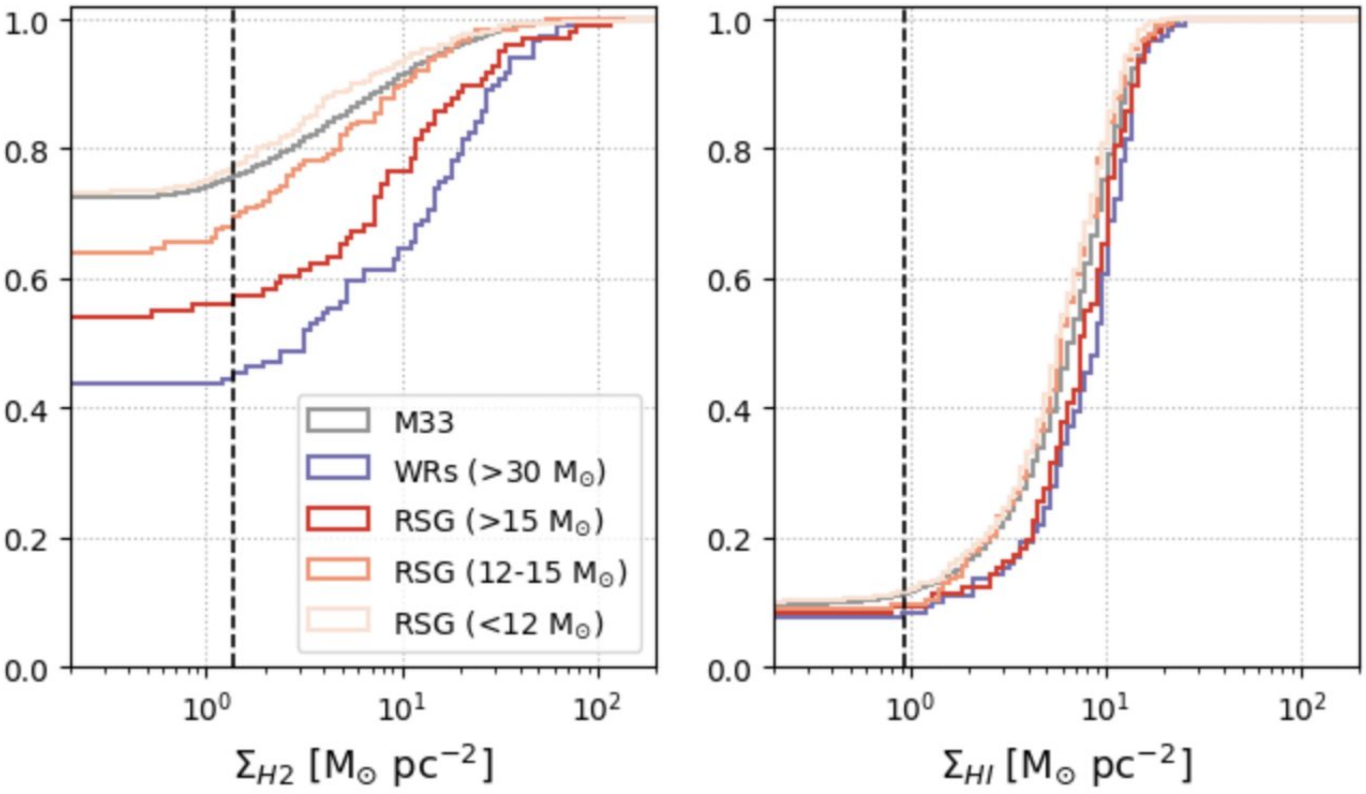
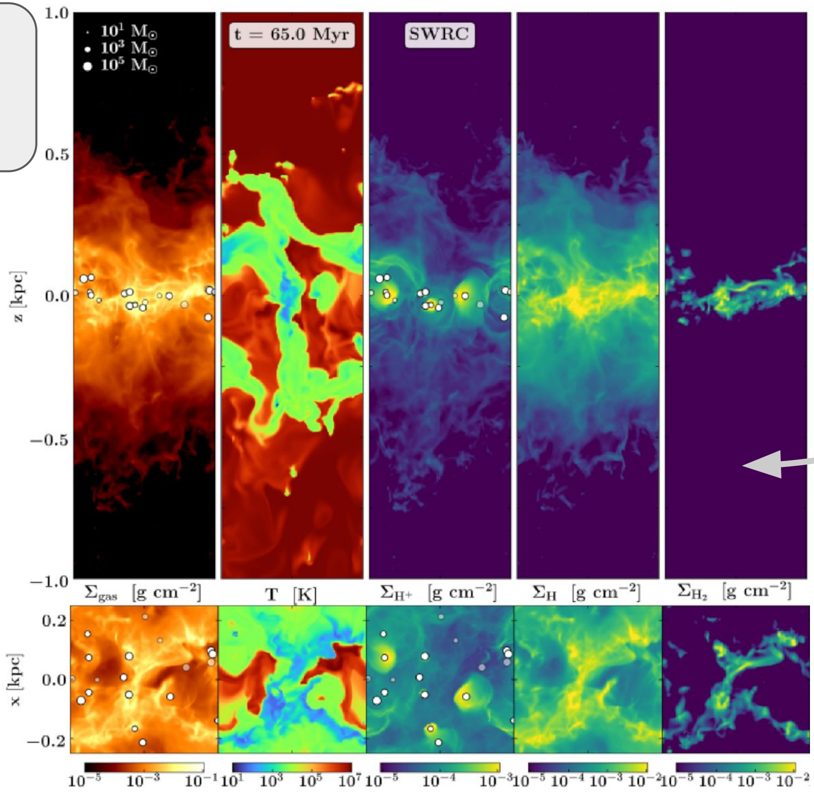


Sarbadhicary+(2026), ApJ, 1000, 70

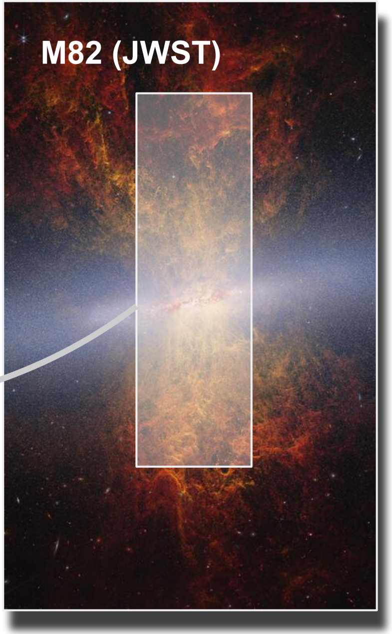
27

(3) Validating Stellar Feedback models with Stars+ISM surveys

High-resolution simulations of Galactic ISM



SILCC (Rathjen+21)



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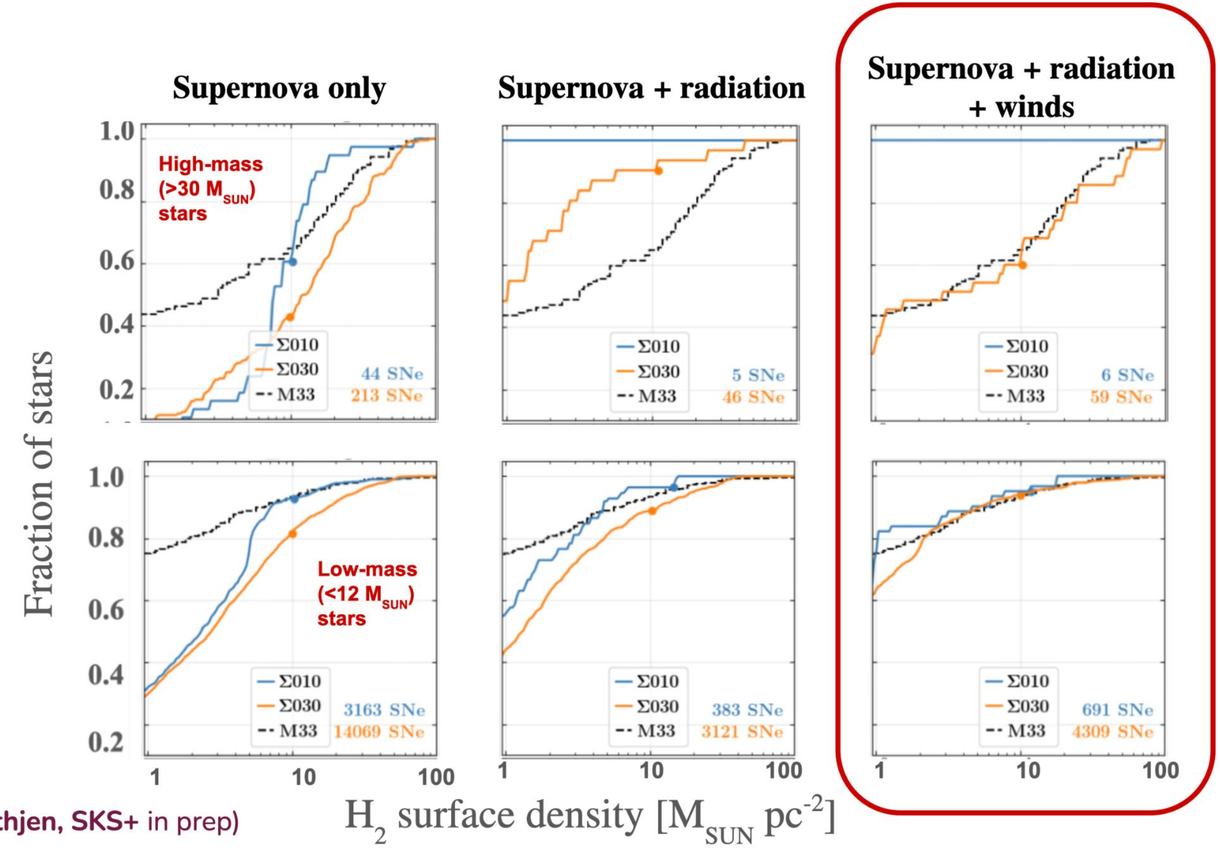
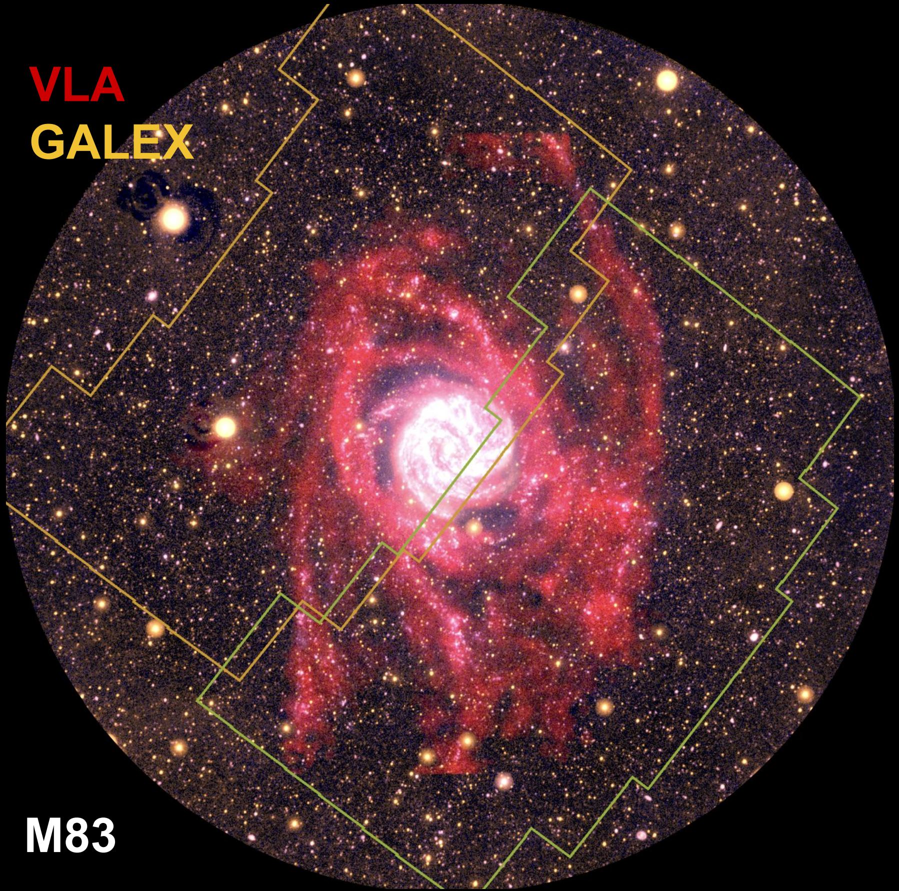
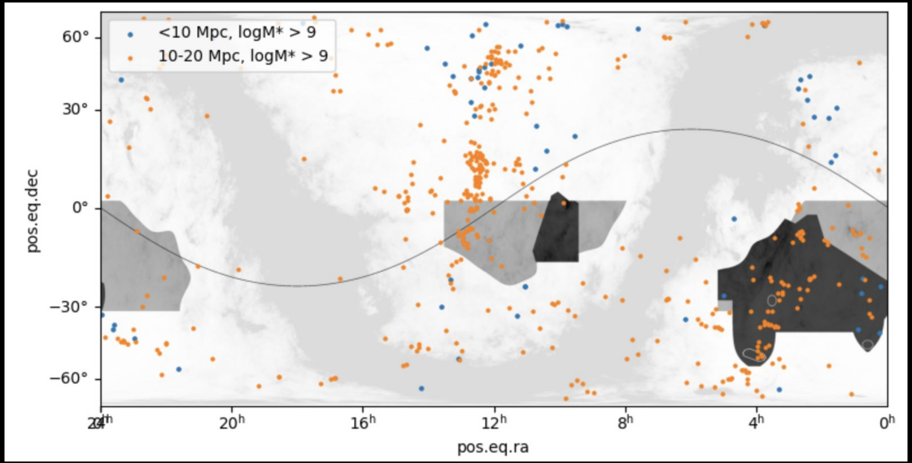


(Rathjen, SKS+ in prep)

Roman will cover star-forming disks of entire nearby galaxies





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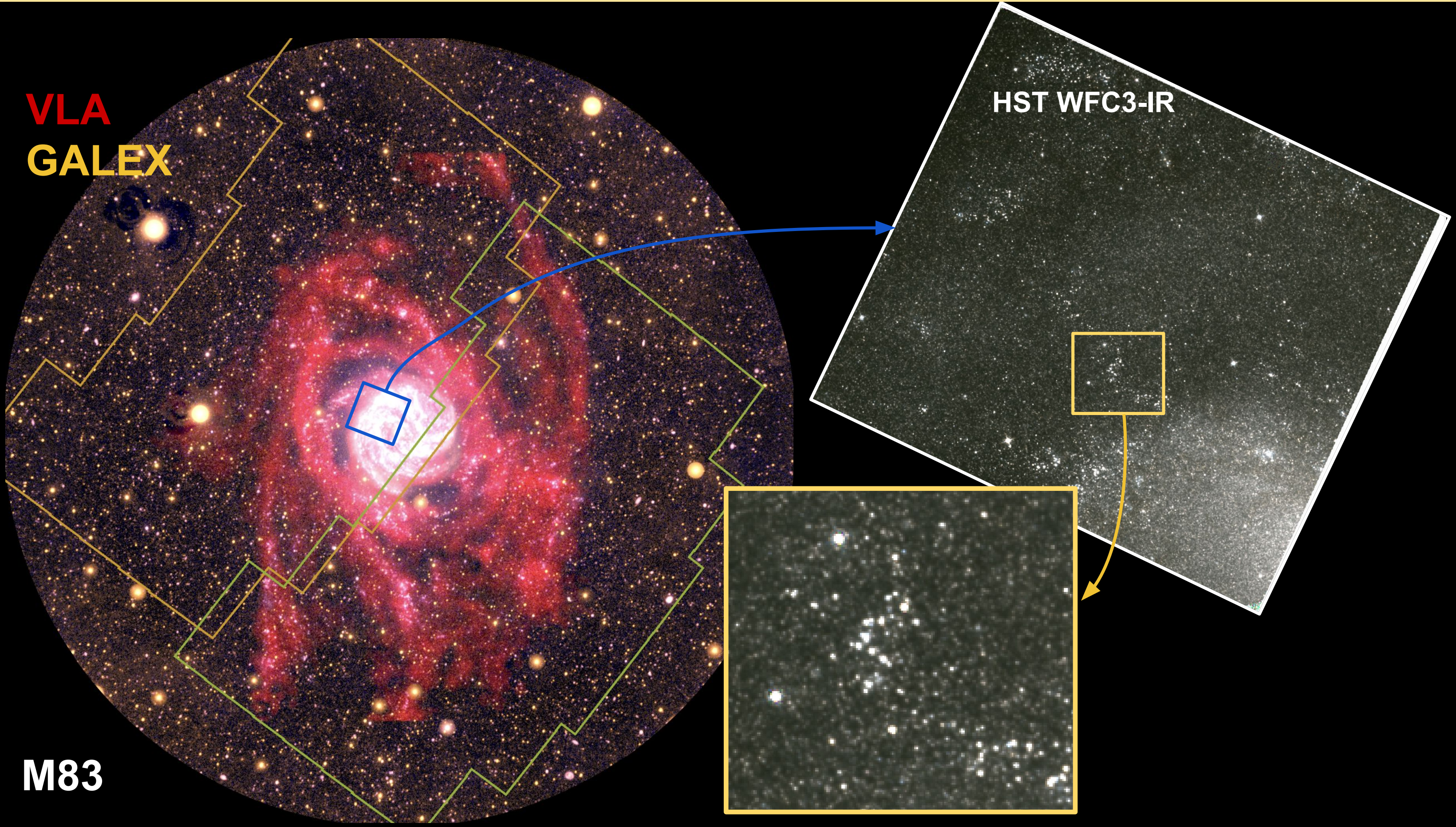

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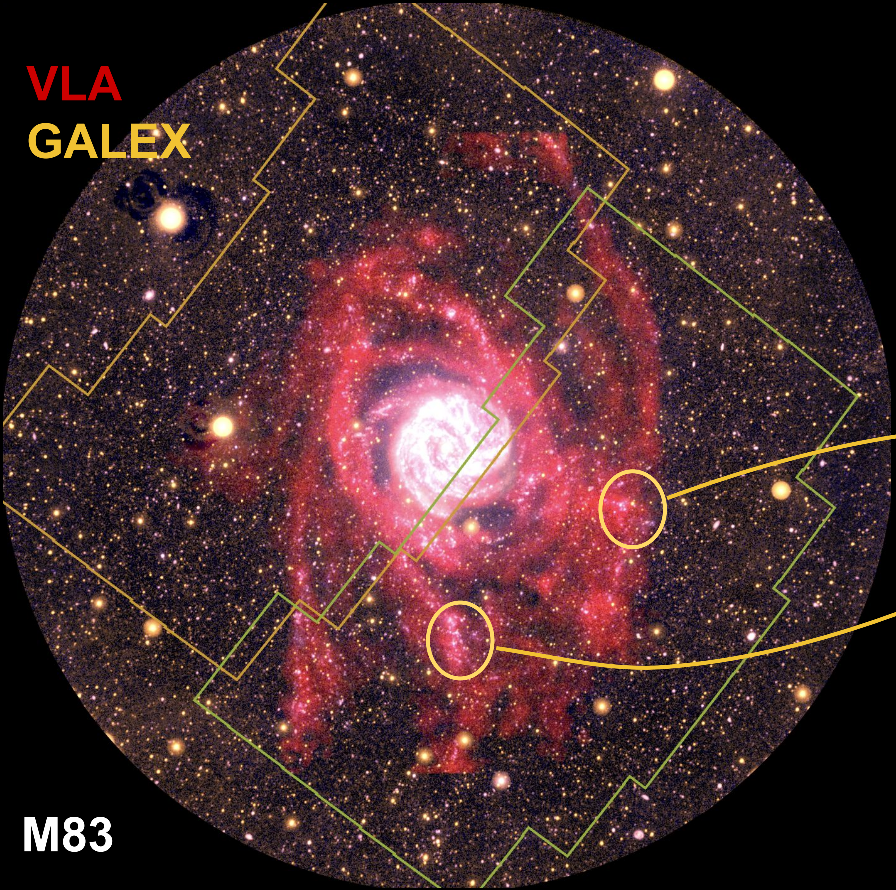
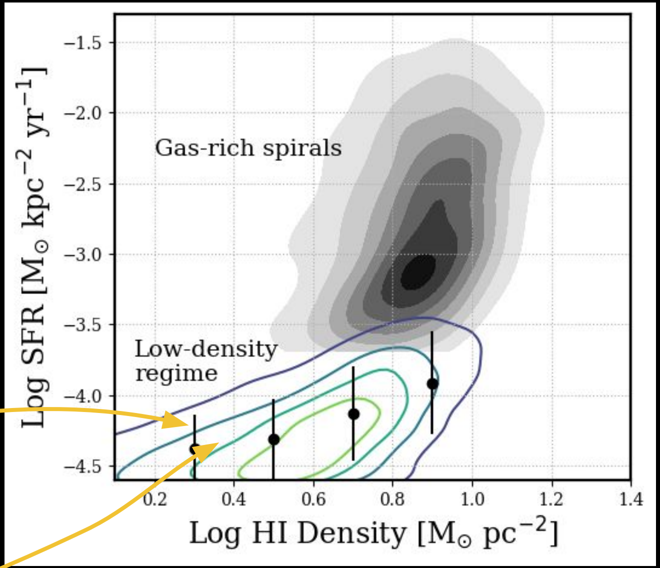
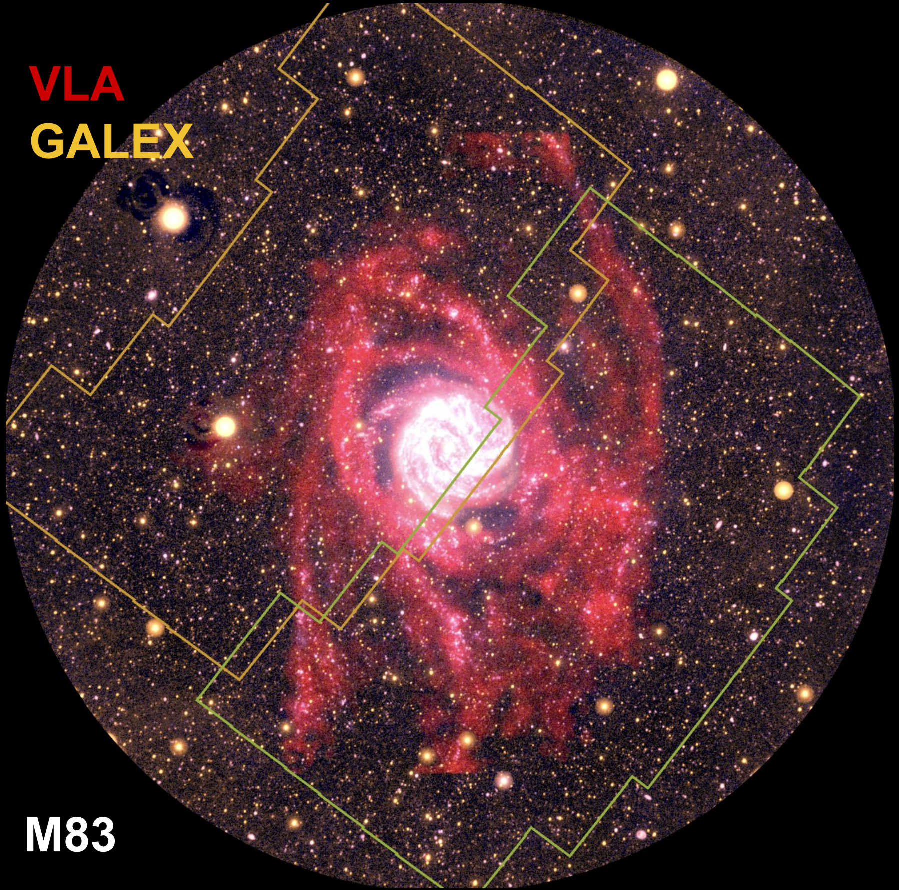




Adapted from Bigiel+08,10

SUMMARY



- Surveys of nearby galaxies is the next frontier for addressing open problems related to supernova progenitors, stellar feedback, and late-stage stellar evolution.
- Substantial efforts at other wavelengths with HST, JWST, VLA, ALMA + friends.
- Roman will systematically recover massive star populations beyond HST+JWST field of view, particularly in low density extended star-forming disks in atomic-gas dominated ISM.