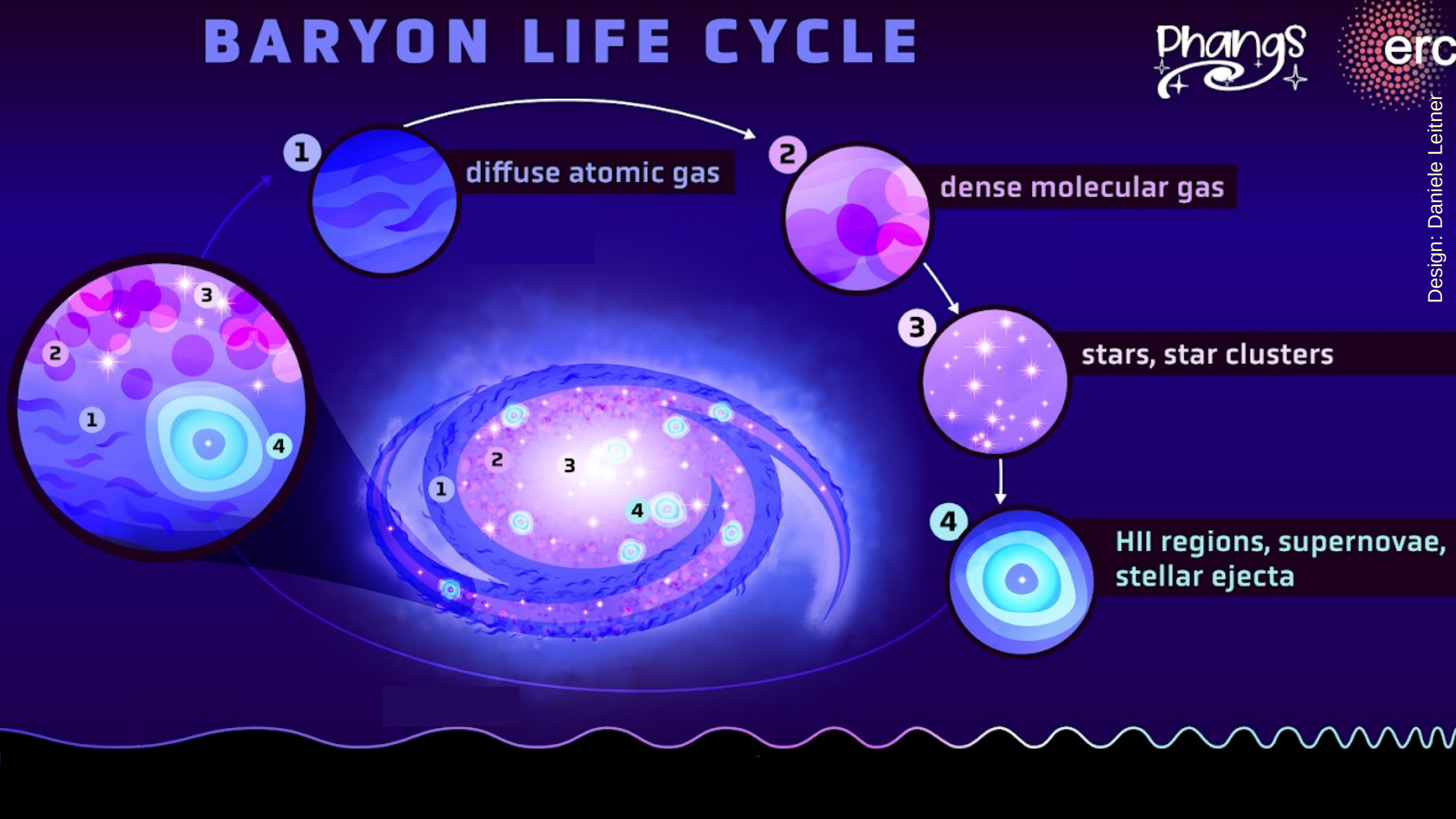
Panchromatic Surveys of the Local Galaxy Population

Eric Emsellem

With big thanks to:

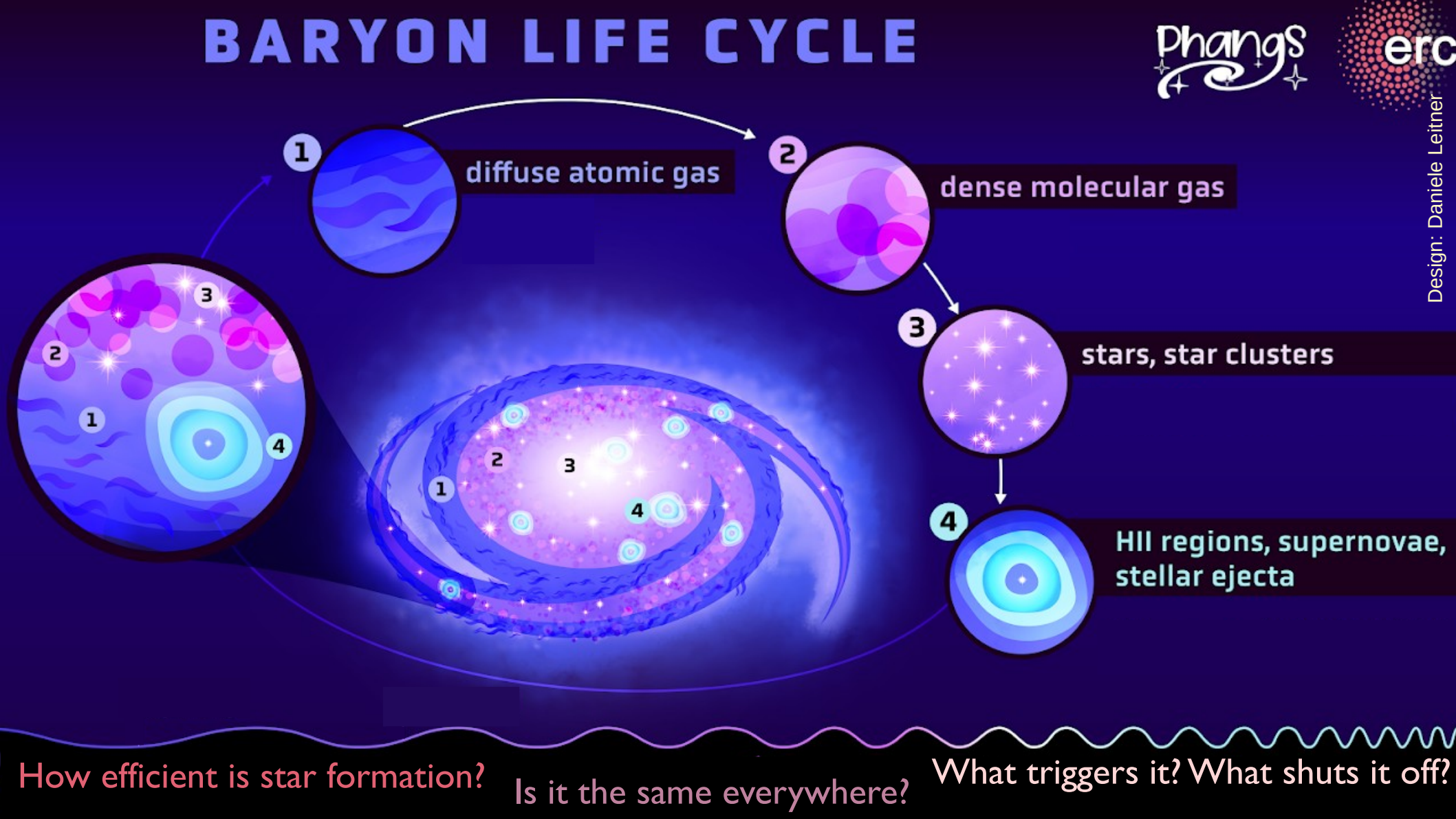
Ashley Barnes, Francesco Belfiore, Eva Schinnerer, Adam Leroy, Janice Lee

BARYON LIFE CYCLE



Design: Daniele Leitner

BARYON LIFE CYCLE



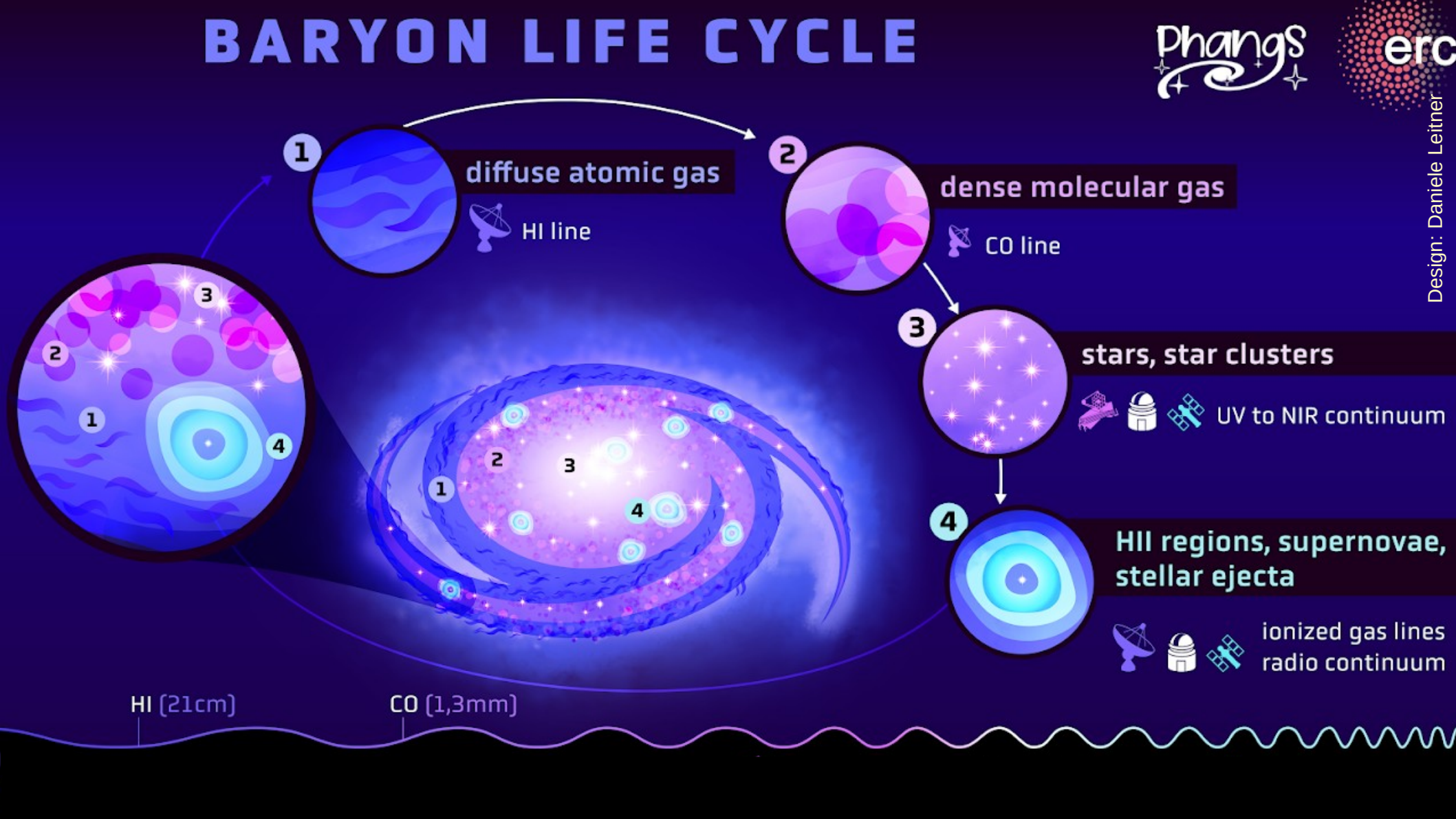
How efficient is star formation?

Is it the same everywhere?

What triggers it? What shuts it off?

Design: Daniele Leitner

BARYON LIFE CYCLE

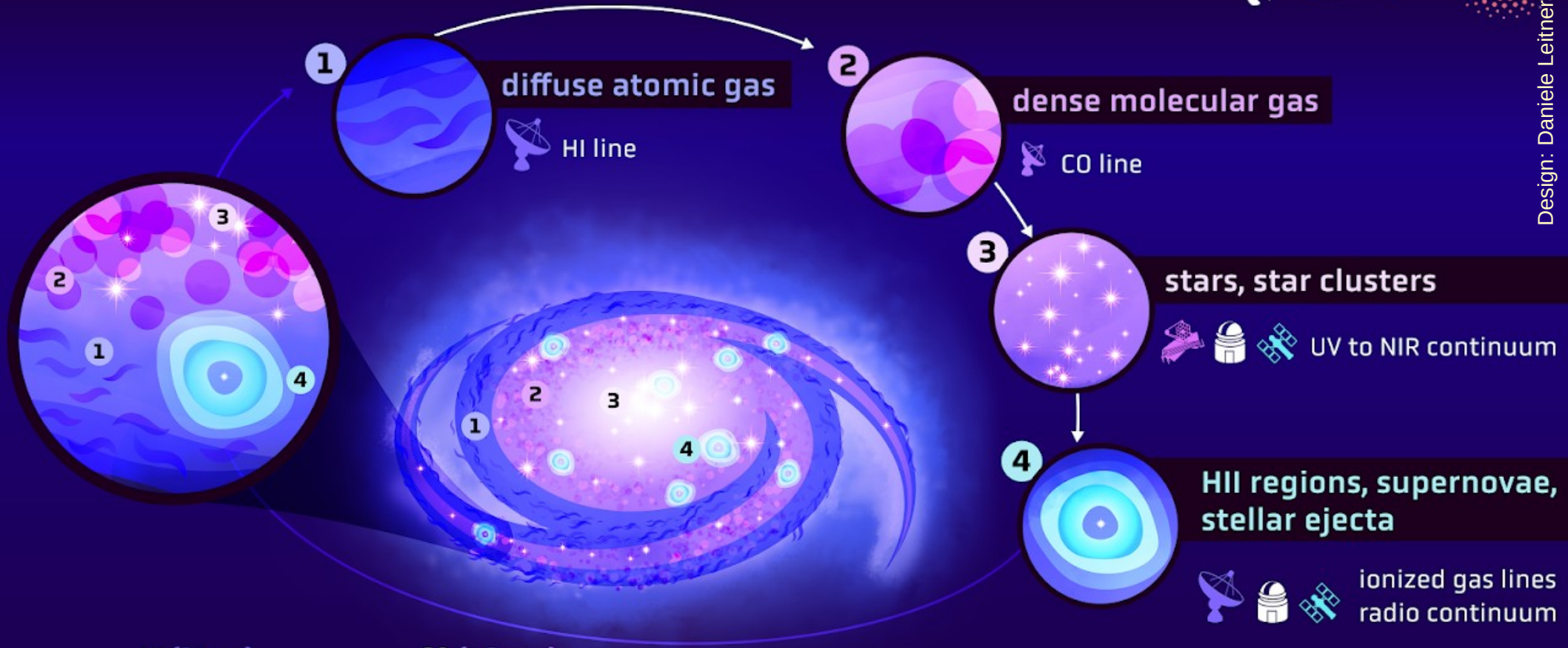


Design: Daniele Leitner

BARYON LIFE CYCLE

PHANGS

erc



Design: Daniele Leitner

HI (21cm)

CO (1,3mm)

radio waves

(sub-)millimeter

infrared

optical light

UV

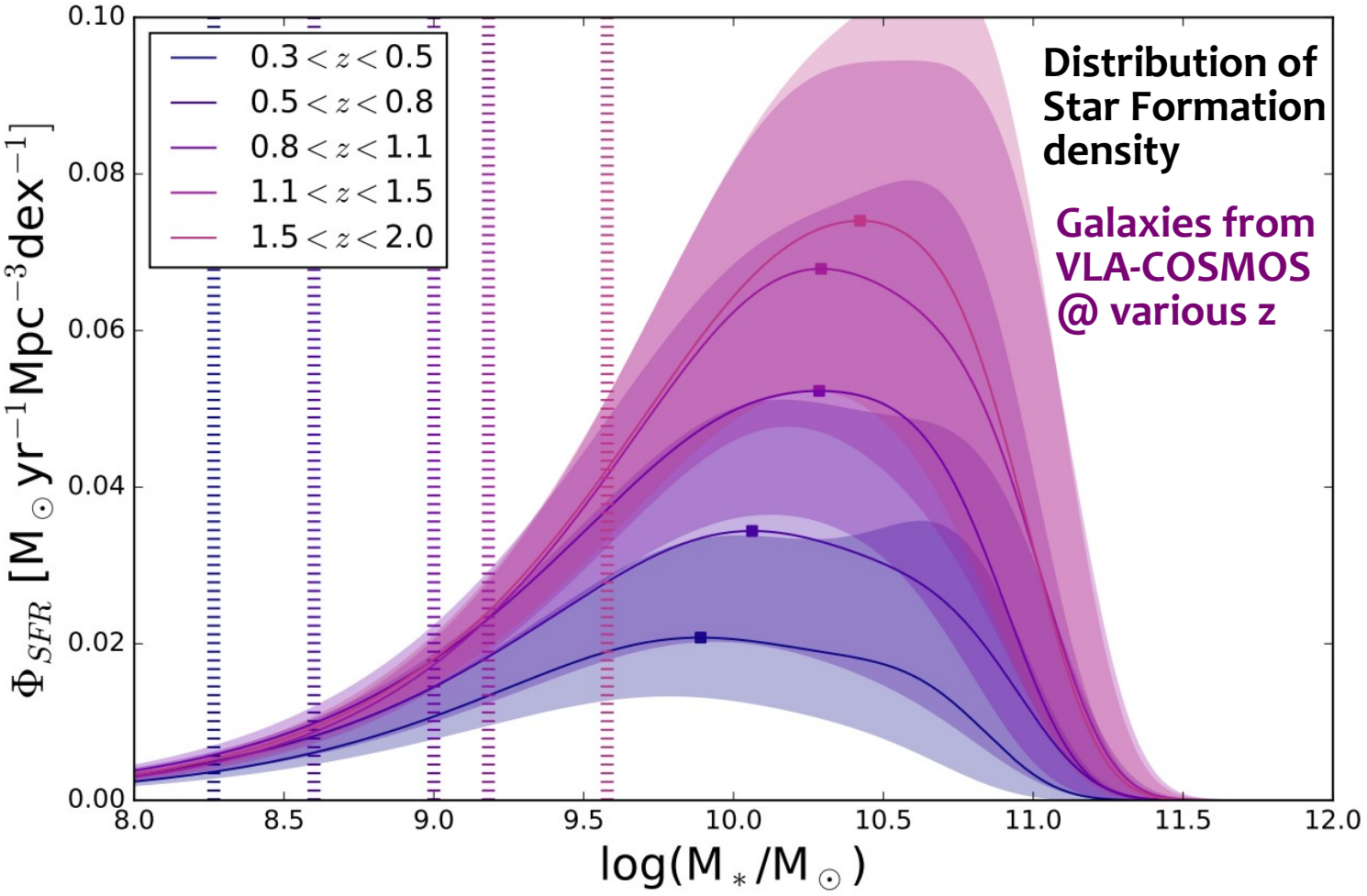
Star-forming galaxies

Leslie et al., 2020

(following Karim et al. 2011)

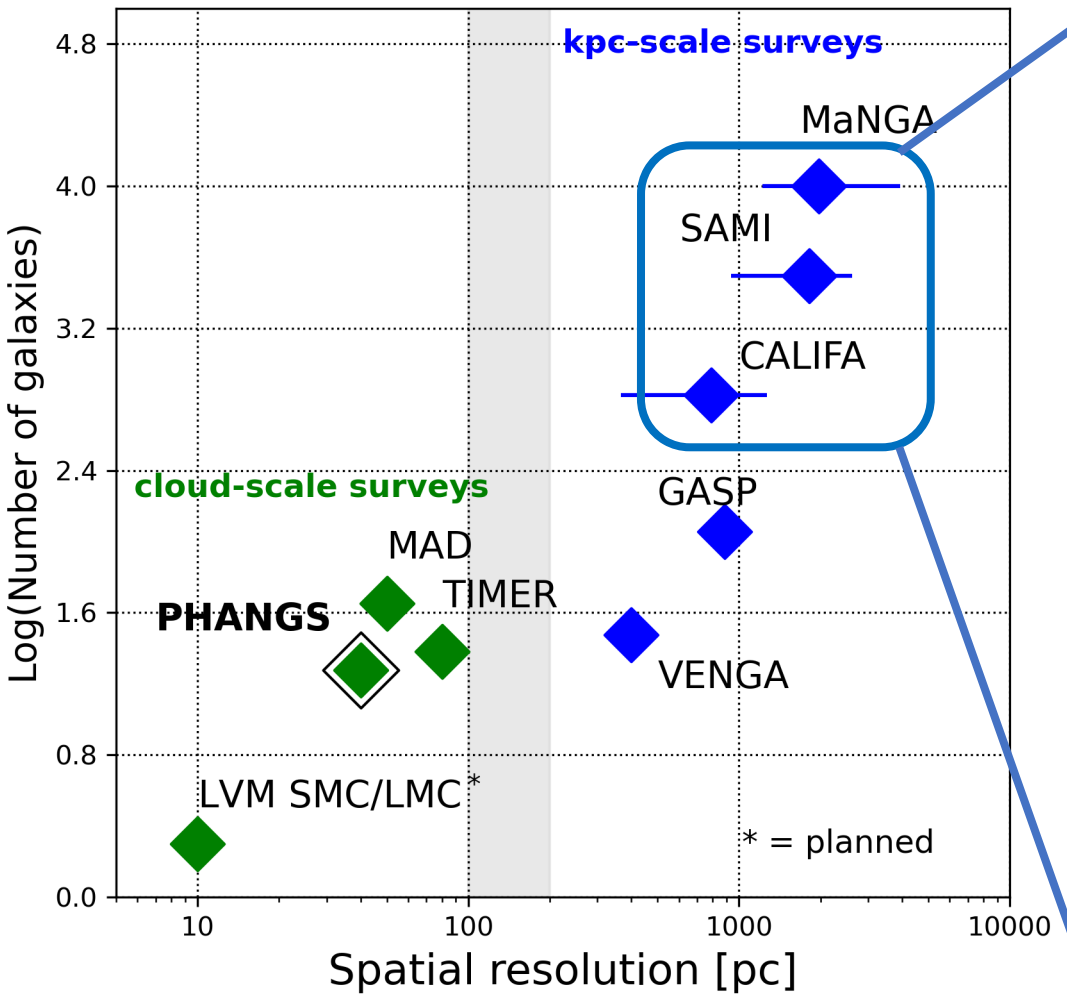
A **majority** of stars **form in discs**

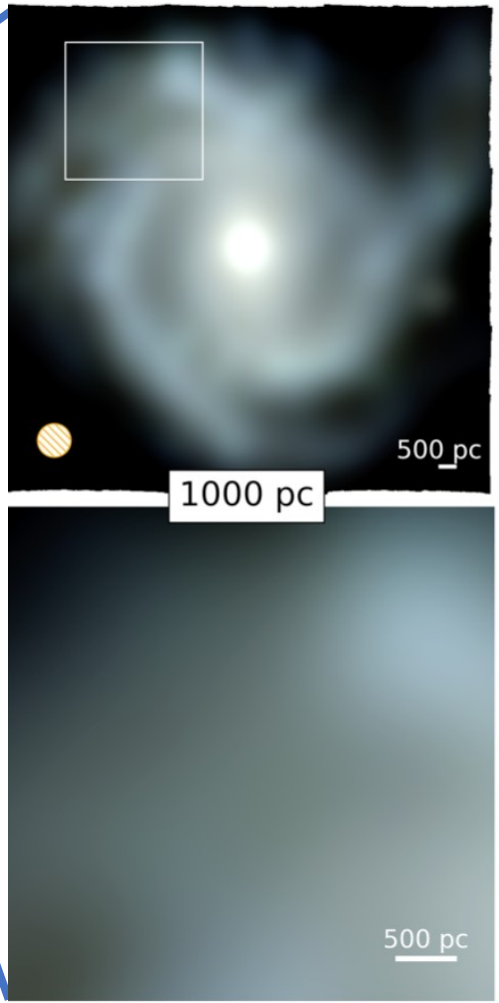
at all redshifts



The golden era of IFU surveys

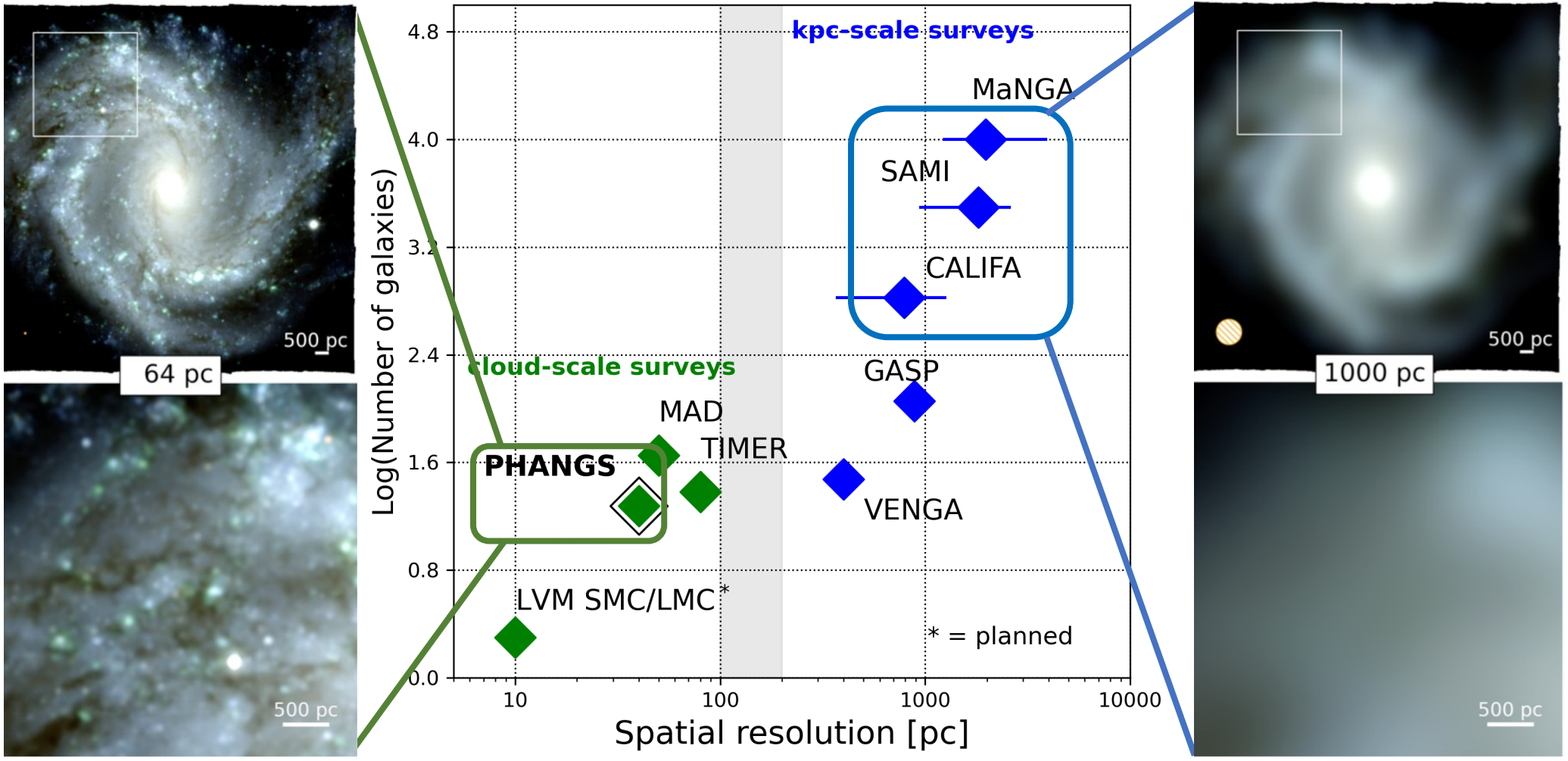
Emsellem et al., 2022





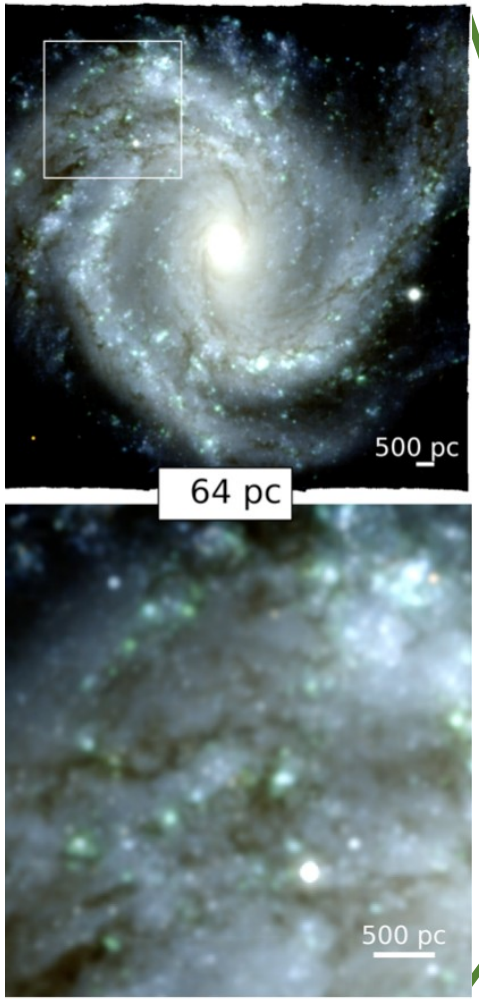
The golden era of IFU surveys

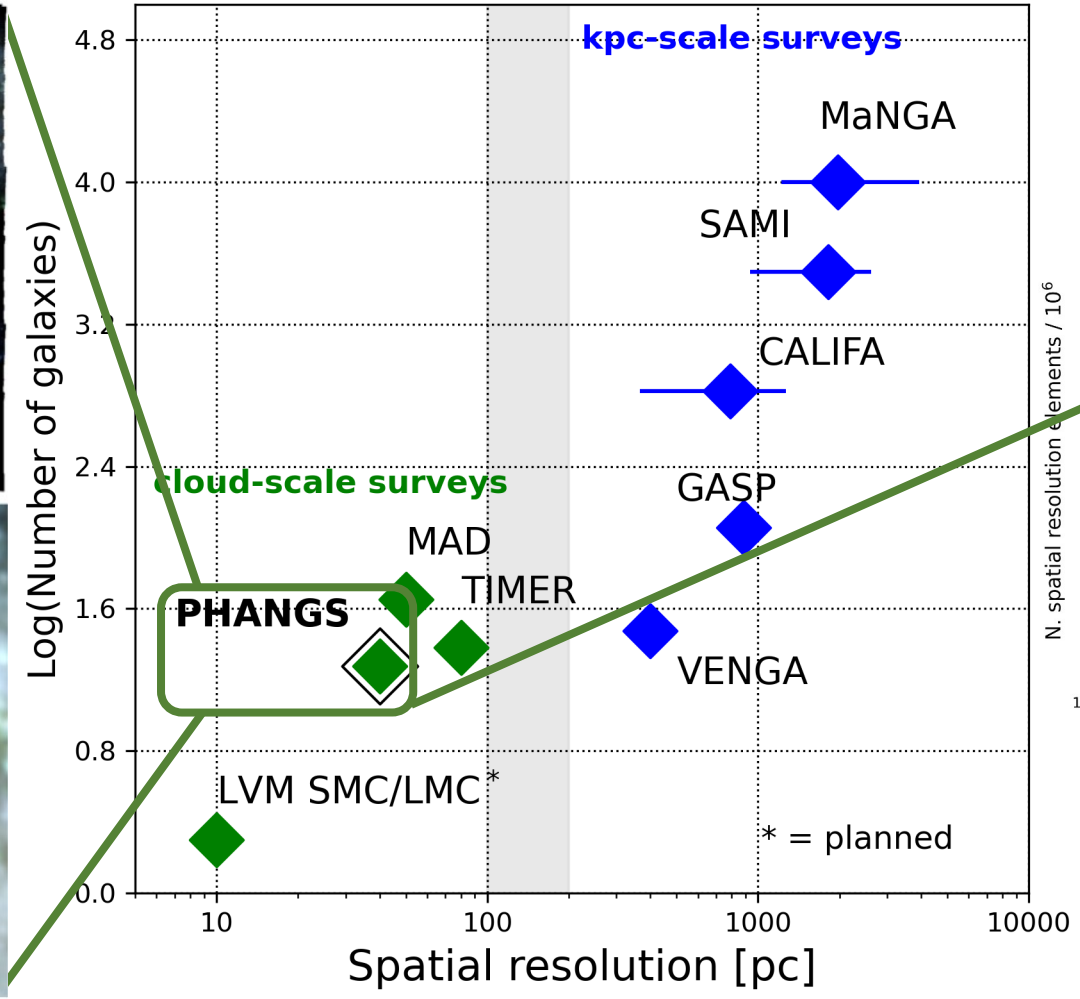
Emsellem et al., 2022

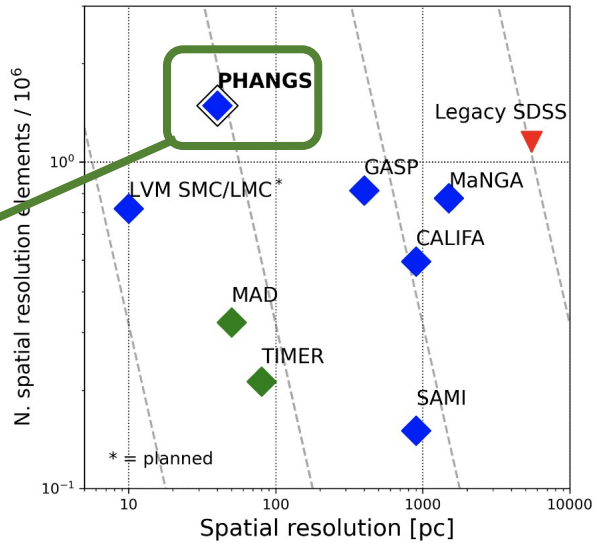


The golden era of IFU surveys

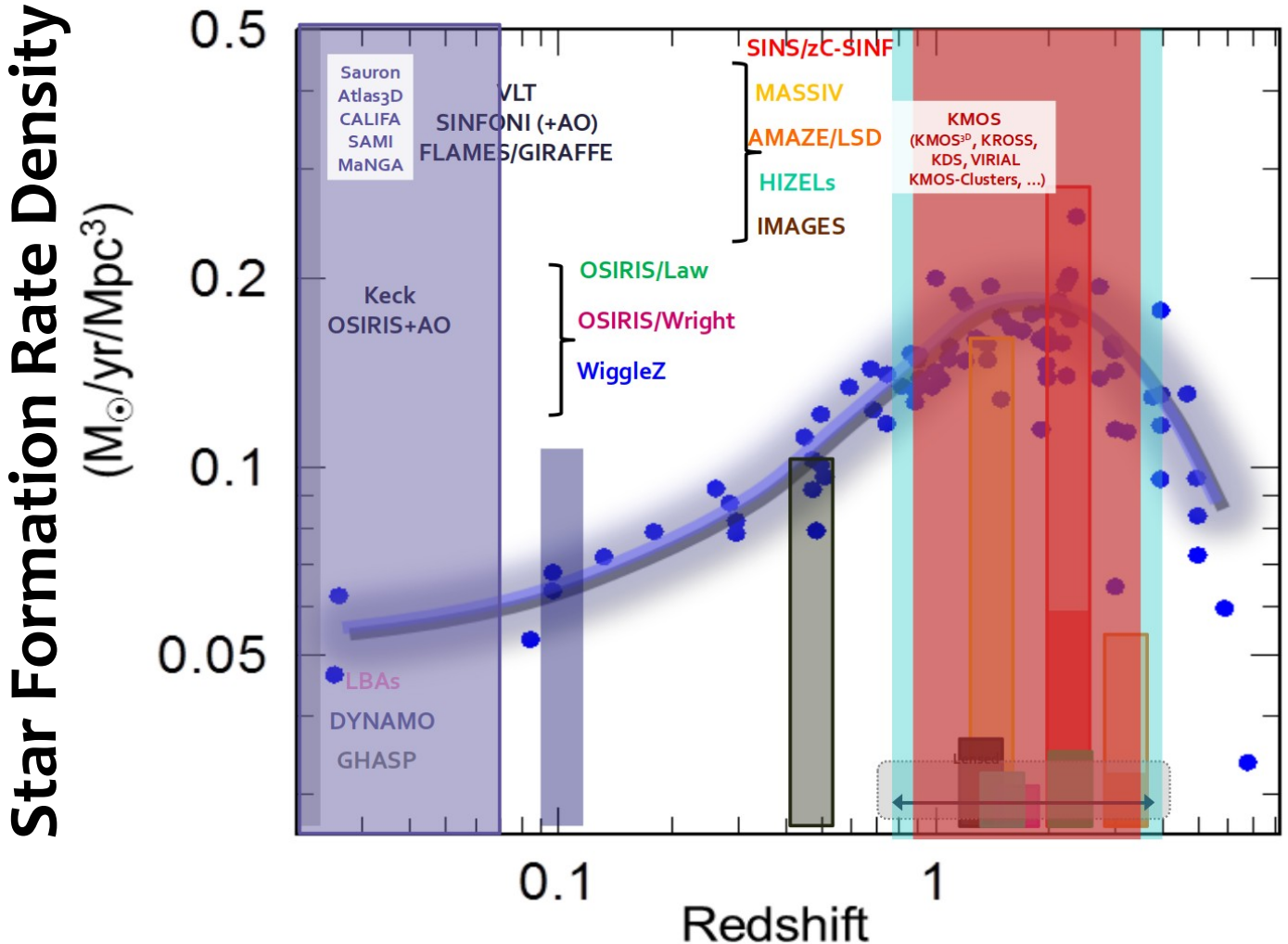
Emsellem et al., 2022

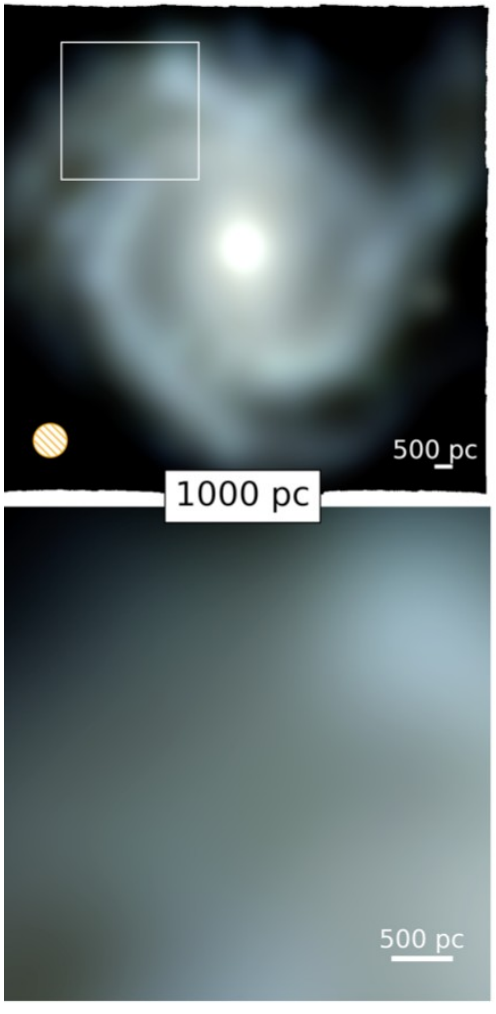




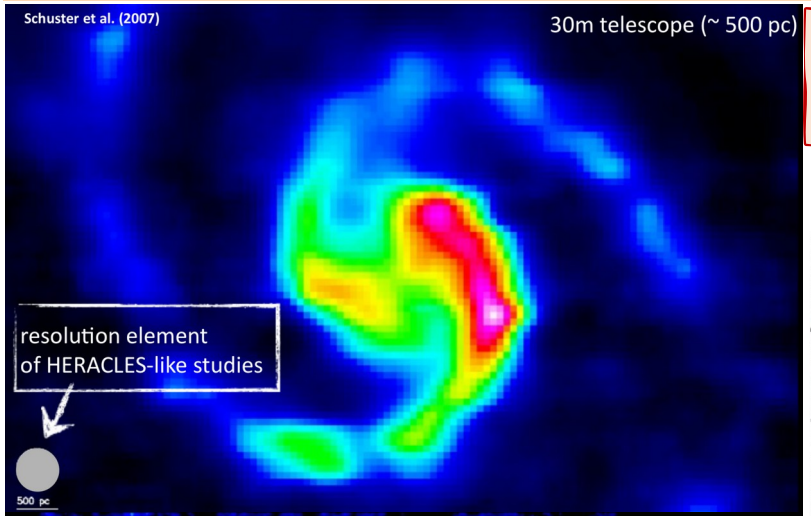


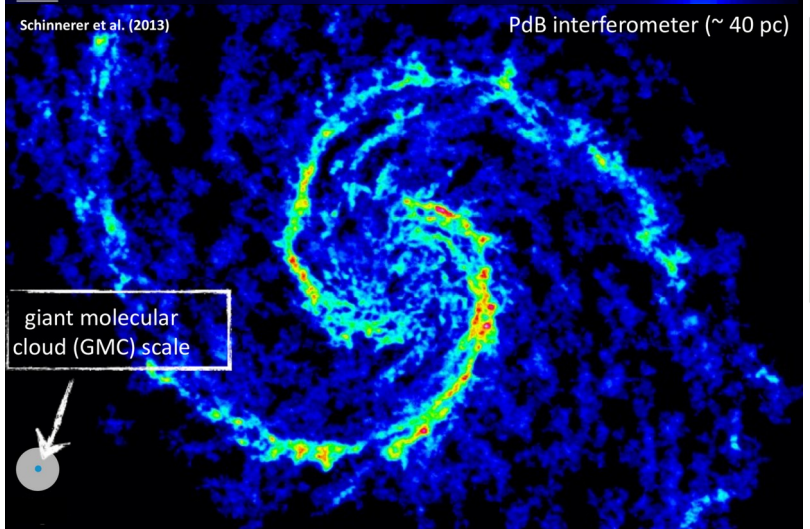
The golden era of IFU surveys





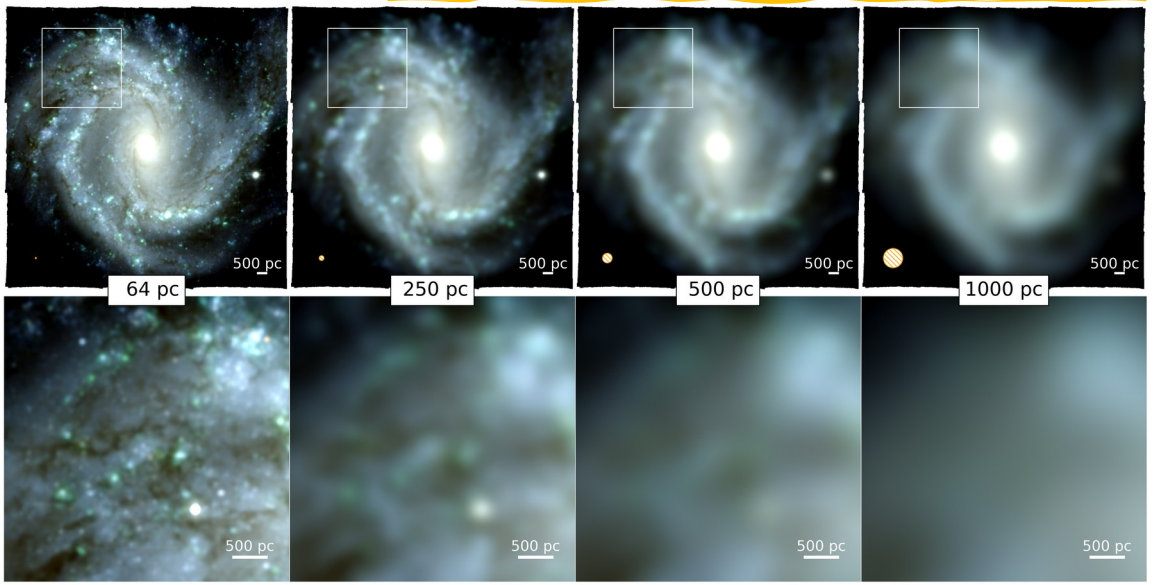
The sub-mm (ALMA) revolution





How do ionising radiation and different feedback pressure terms shape the ISM?

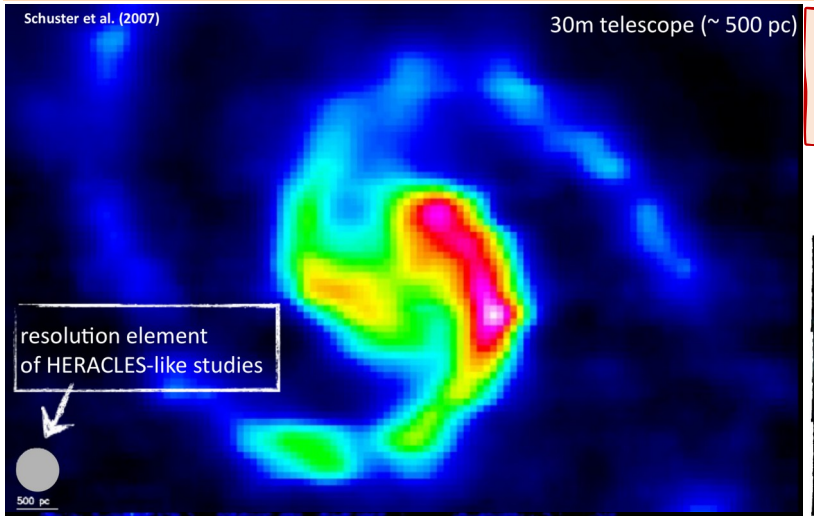
How do metals cycle in galaxy discs?

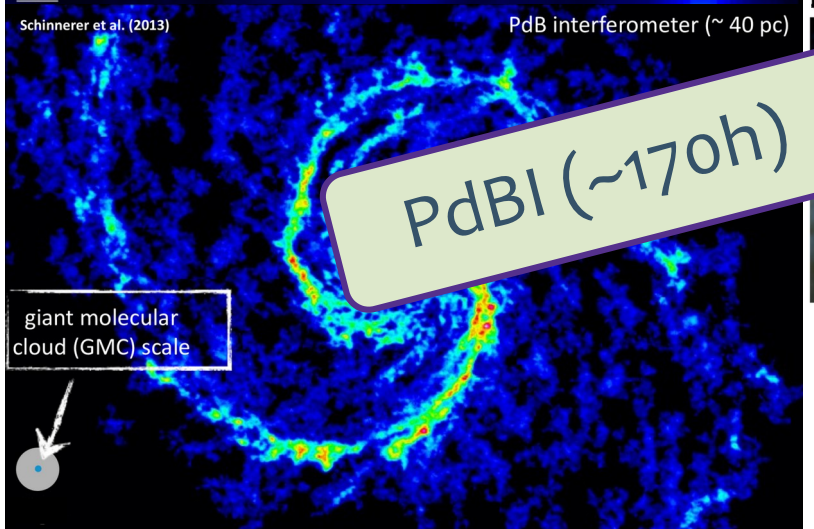


Emsellem et al. 2022

How does local (dynamical) environment affect star formation?

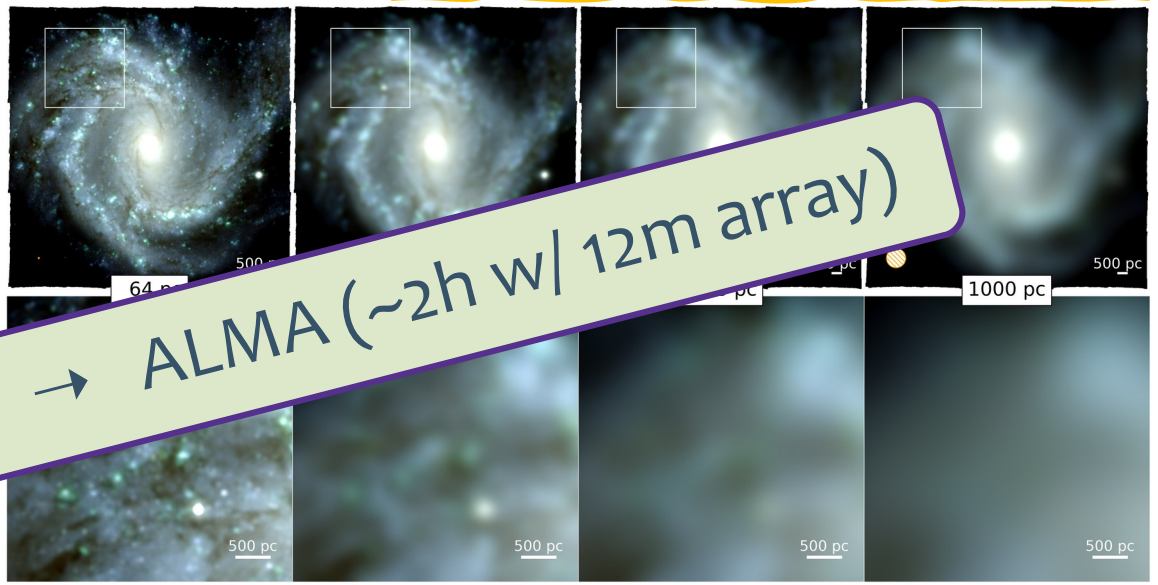
The sub-mm (ALMA) revolution





How do ionising radiation and different feedback pressure terms shape the ISM?

How do metals cycle in galaxy discs?



PdBI (~170h) → ALMA (~2h w/ 12m array)

Emsellem et al. 2022

How does local (dynamical) environment affect star formation?

PHANGS

ALMA

molecular gas probing ~100,000 clouds

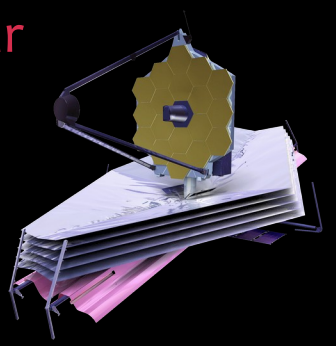
Leroy et al. (2021a)

90 galaxies

Pis Schinnerer; Blanc; Leroy; Faesi; Chevance

embedded star formation & dust heating

Lee et al. (2023)



19 galaxies

PI Lee

baryon life cycle

~80,000 stellar clusters

Lee et al. (2022)

38 galaxies

PI Lee

stellar feedback probed by ~25,000 nebulae + stellar populations

Emsellem et al. (2022)

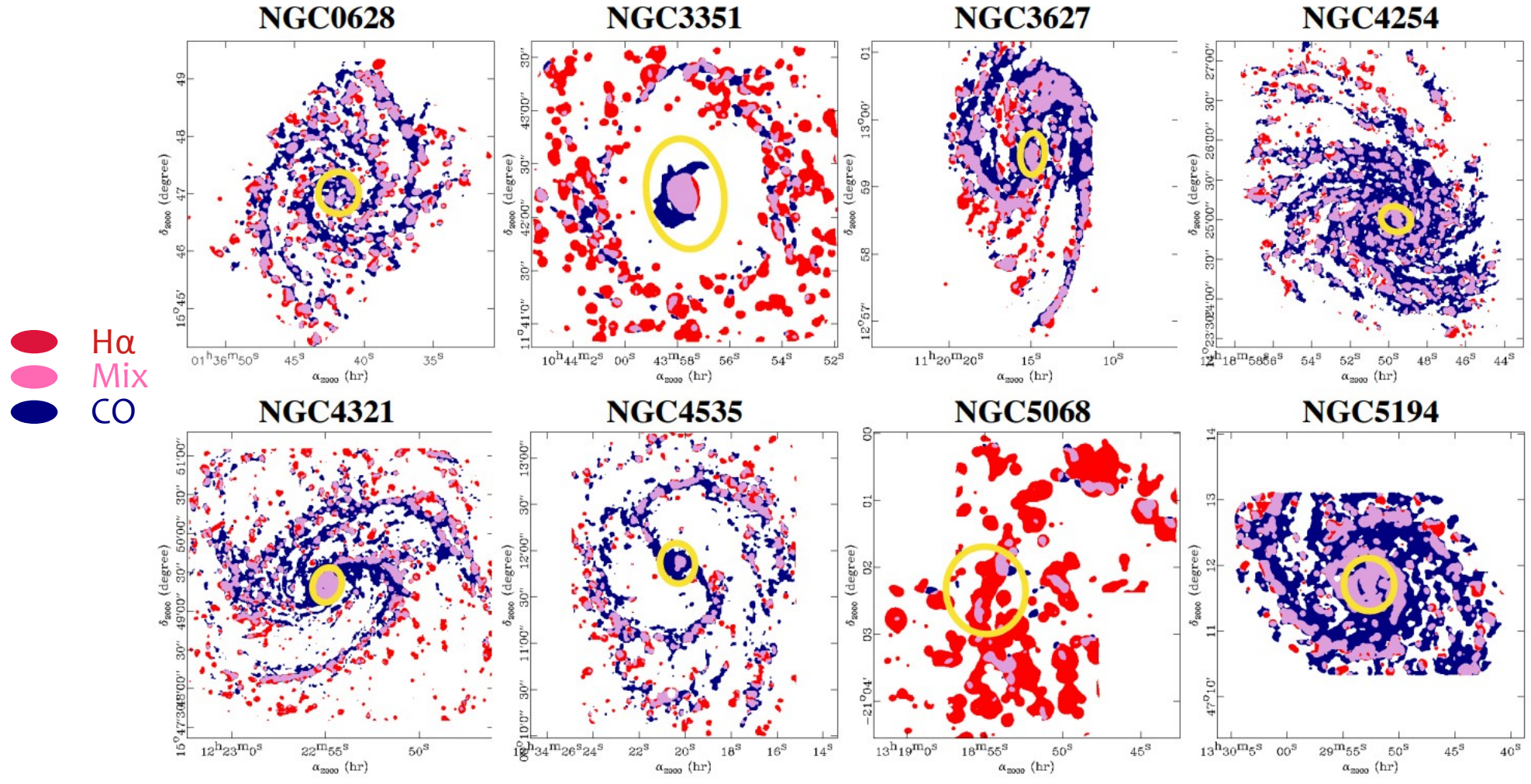
muse multi unit spectroscopic explorer

19 galaxies

PI Schinnerer

Molecular / Ionised gas

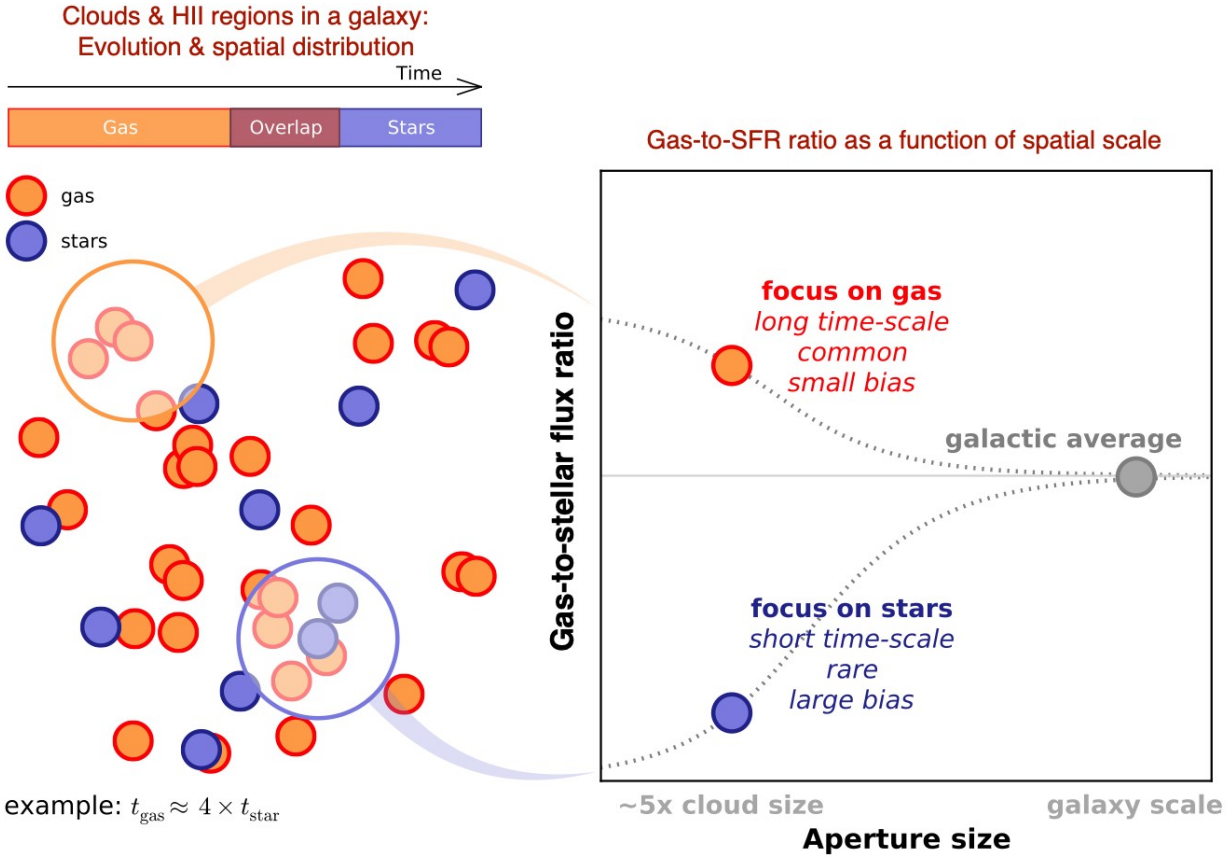
Schinnerer et al. (2019)



Molecular / Ionised gas

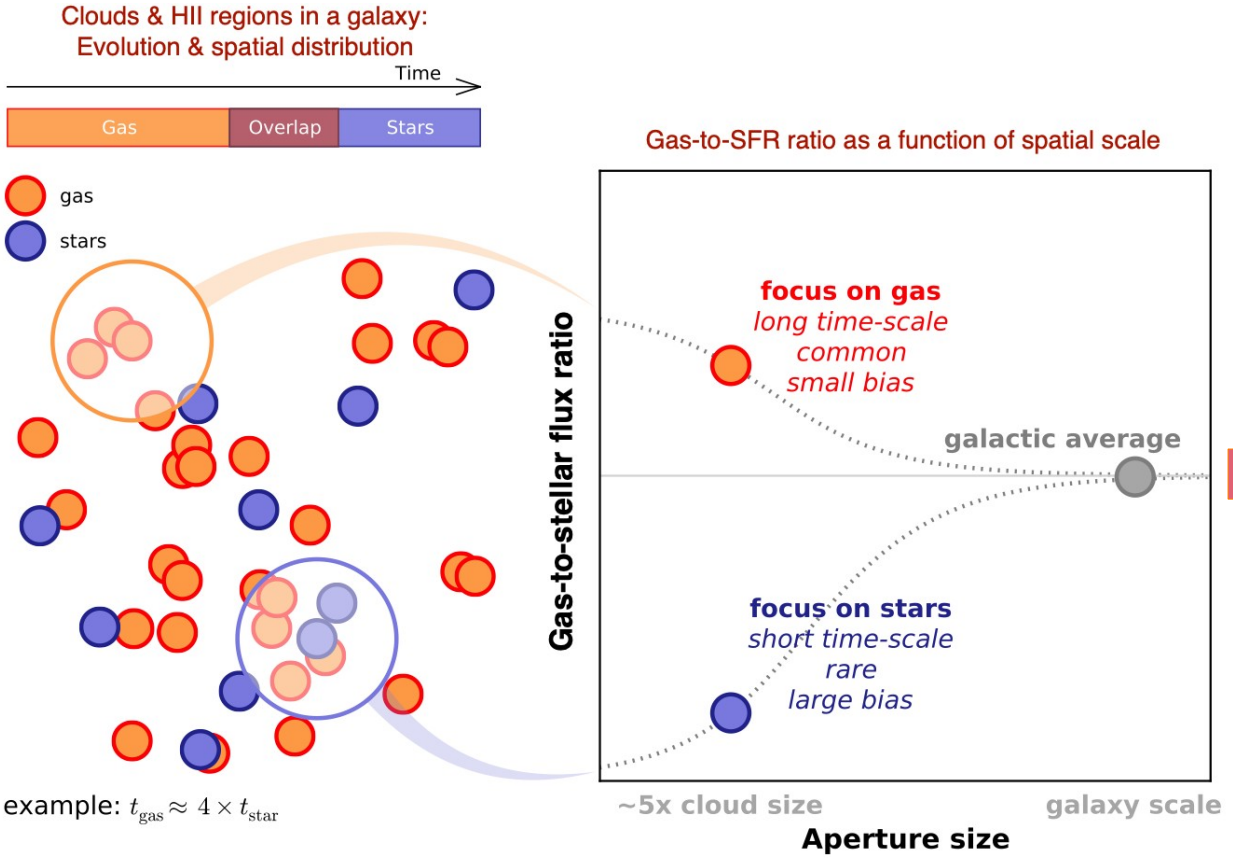
Kruijssen et al. (2014, 2018)
Chevance et al. (2020)

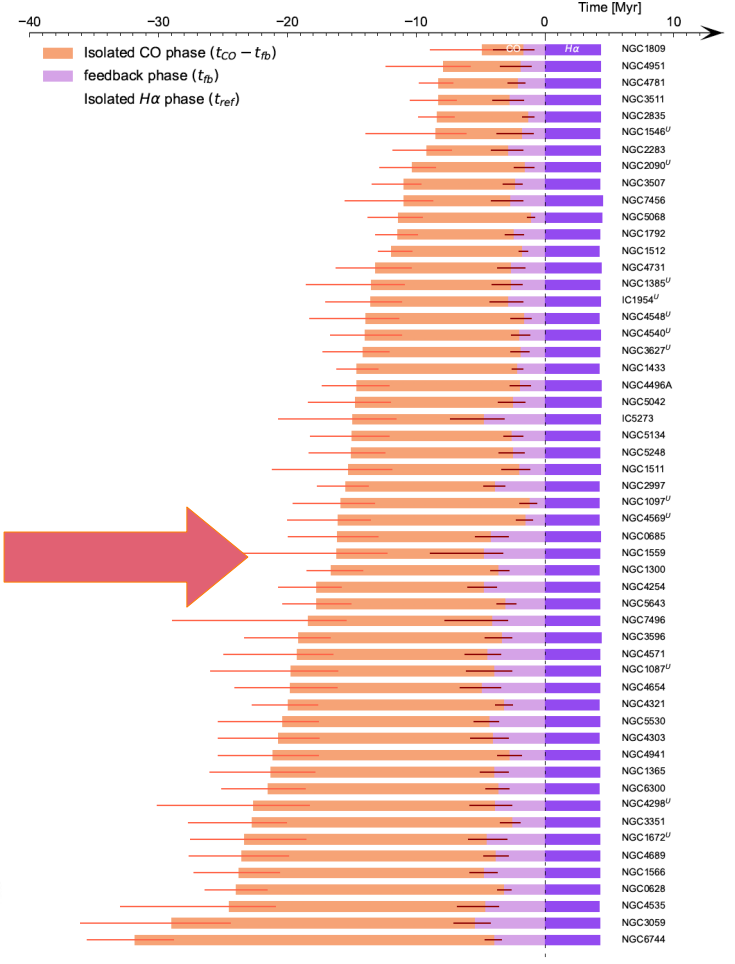
See also Kawamura et al. 2009, Schruba et al. 2010, Gratier et al. 2012, Corbelli et al. 2017

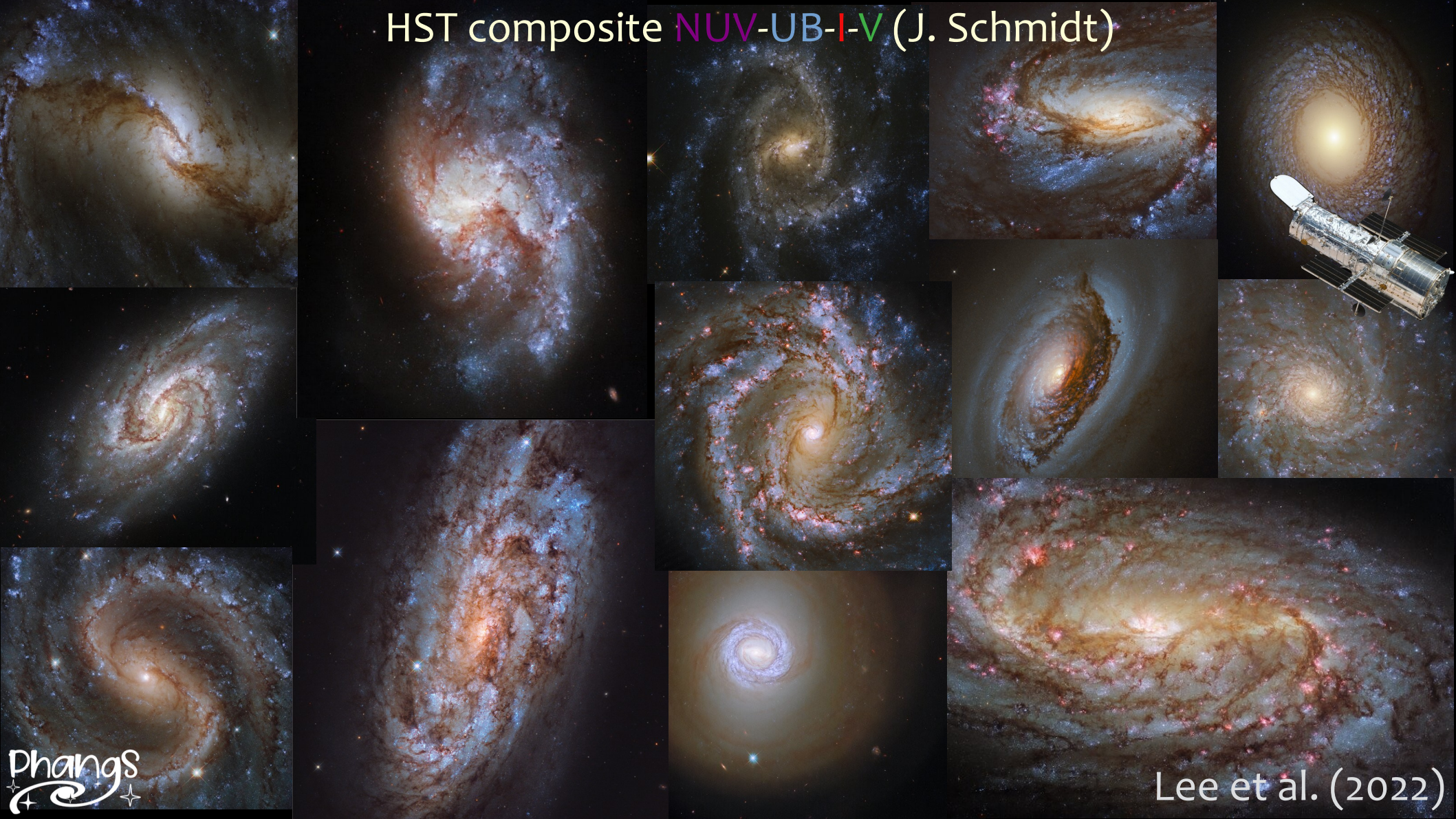


Cloud lifetime: bringing a new dimension

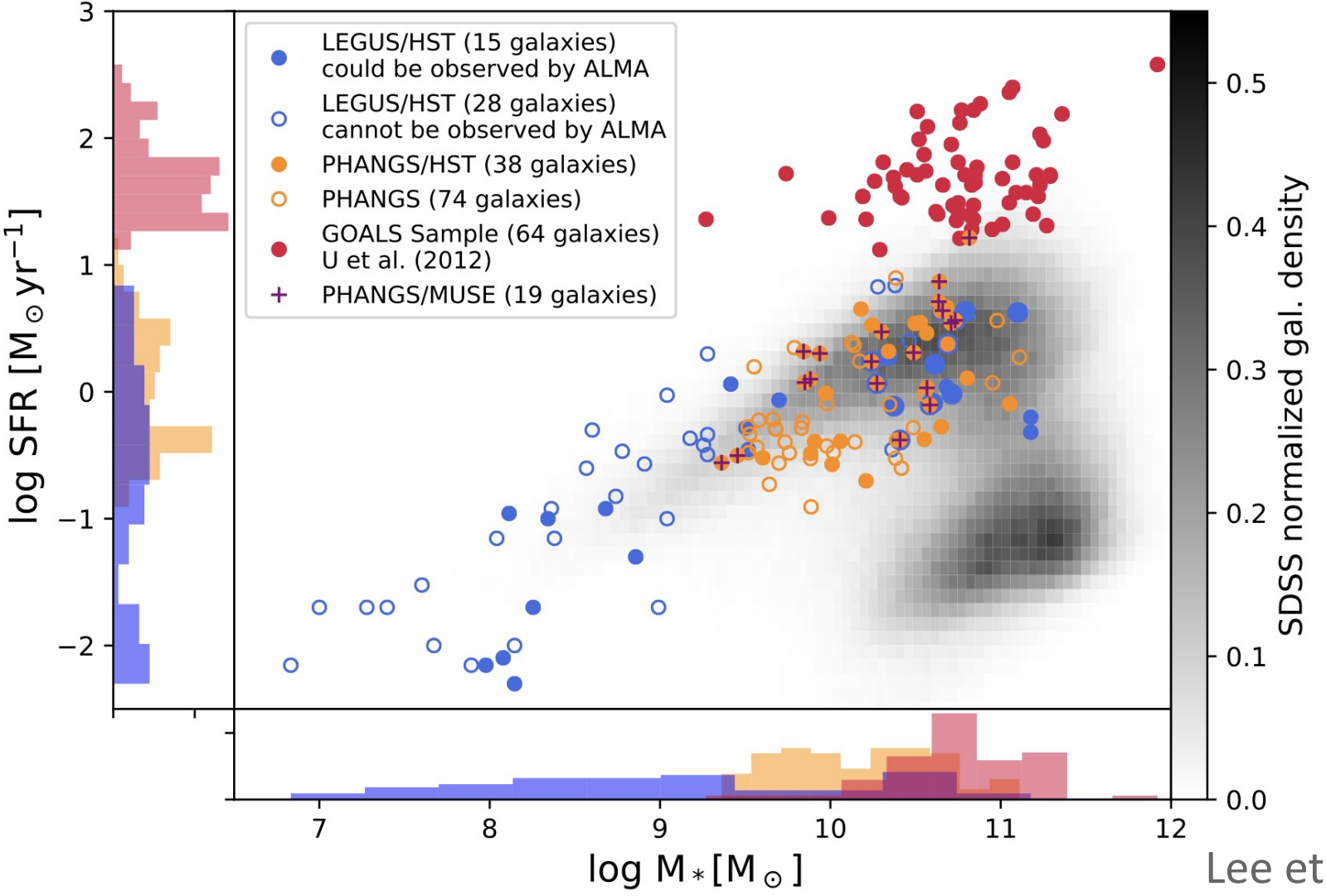
Kim et al. 2022



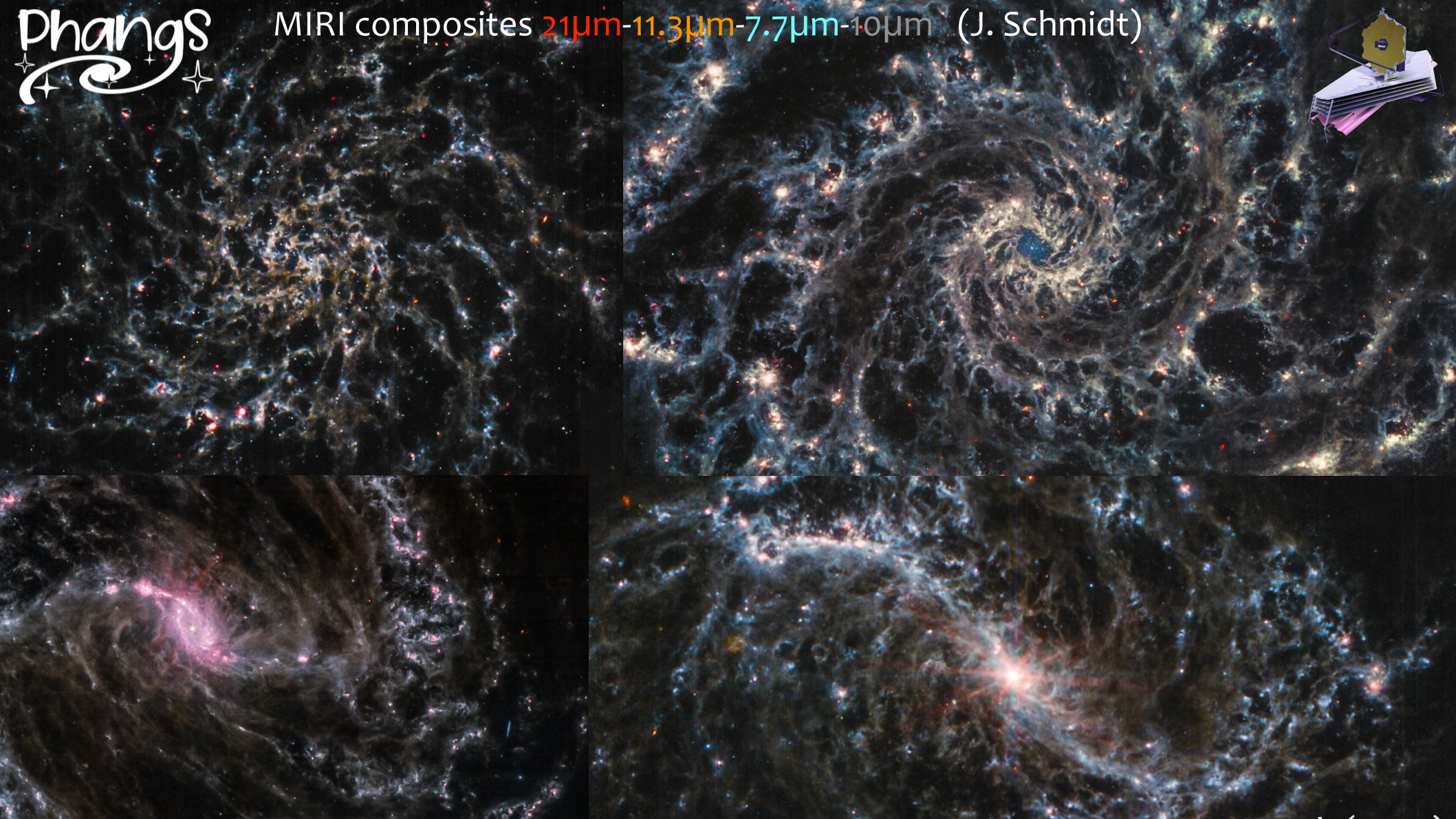



HST composite NUV-UB-I-V (J. Schmidt)
Phangs
Lee et al. (2022)

GOALS, LEGUS, & PHANGS-HST

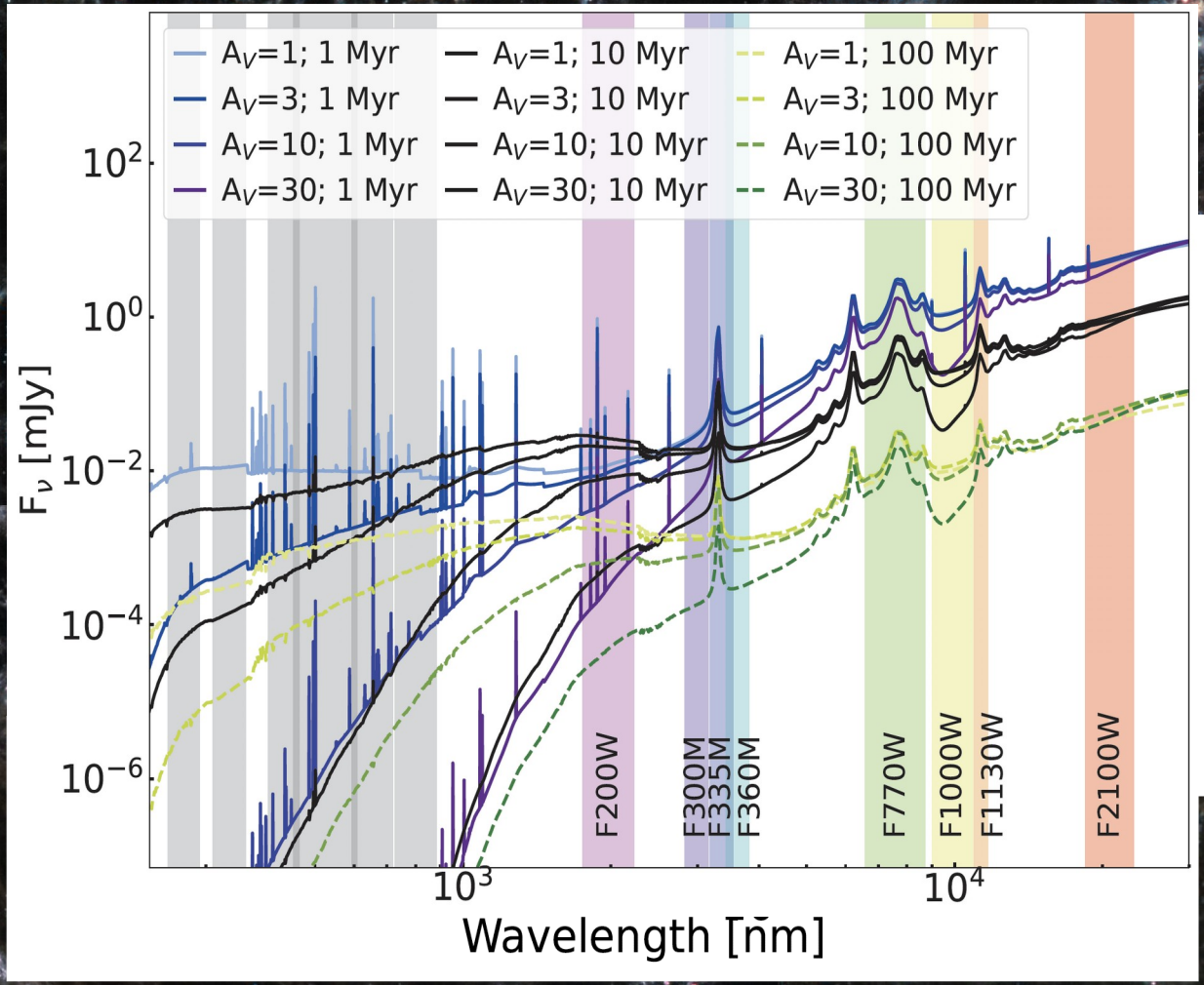


Lee et al. (2022)


Phangs
MIRI composites 21µm-11.3µm-7.7µm-10µm (J. Schmidt)

Phangs

MIRI composites 21μm-11.3μm-7.7μm-10μm (J. Schmidt)

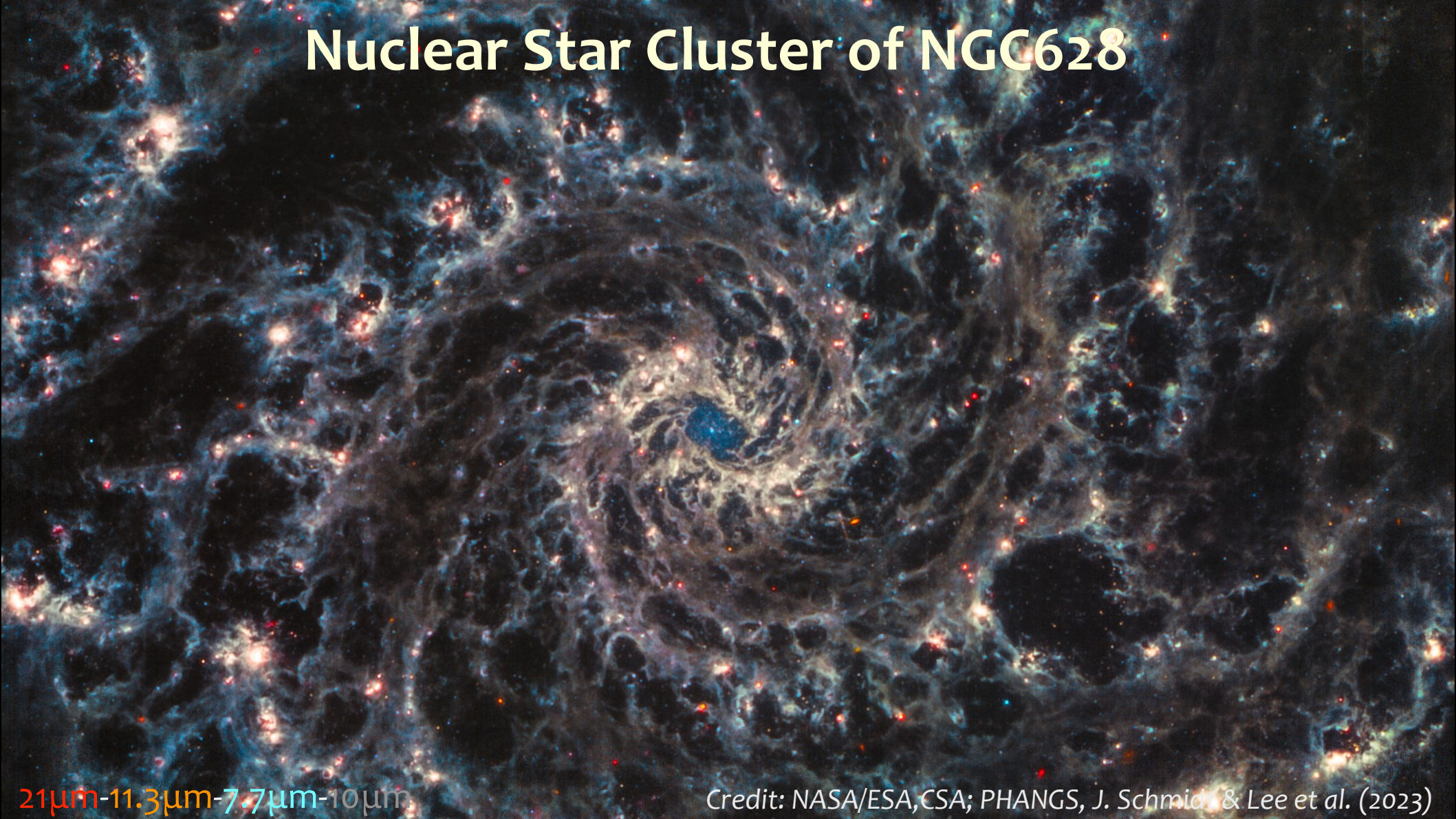


F200W F300M F360M
photospheres
(clusters, stars)

F335M F770W, F1130W
Polycyclic
Aromatic
Hydrocarbon
(size, charge)

F1000W, F2100W
dust continuum

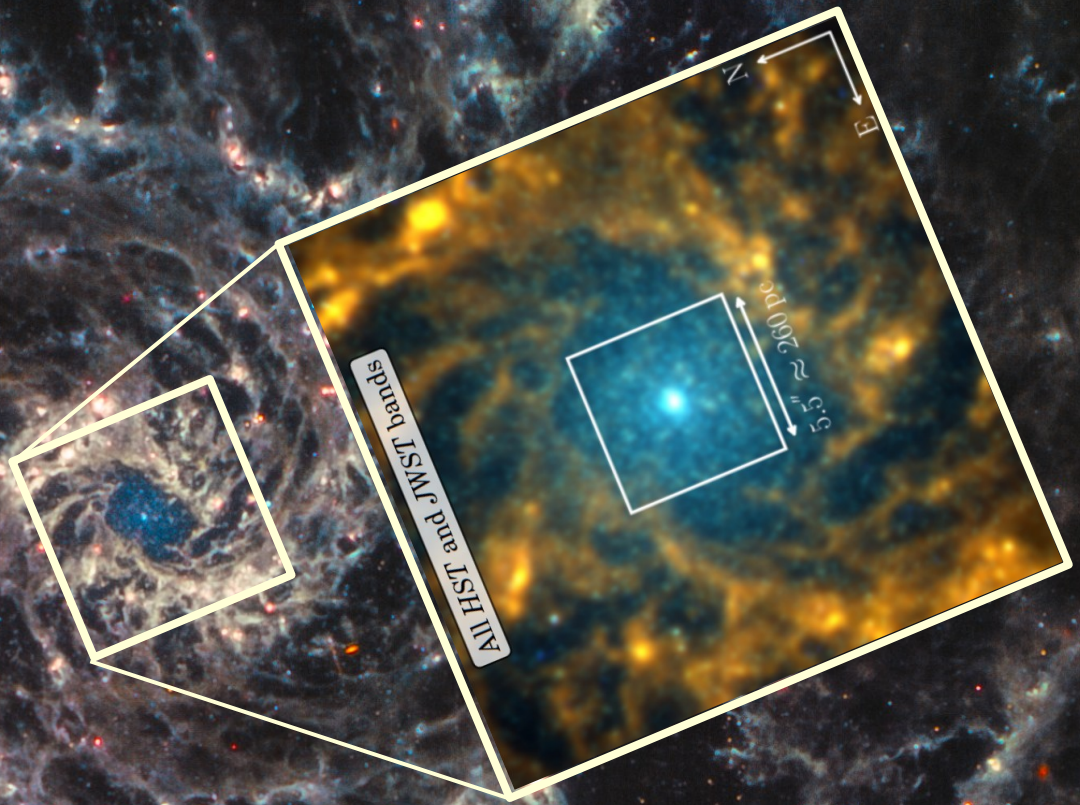
Nuclear Star Cluster of NGC628



21μm-11.3μm-7.7μm-10μm

Credit: NASA/ESA,CSA; PHANGS, J. Schmidt & Lee et al. (2023)

Nuclear Star Cluster of NGC628

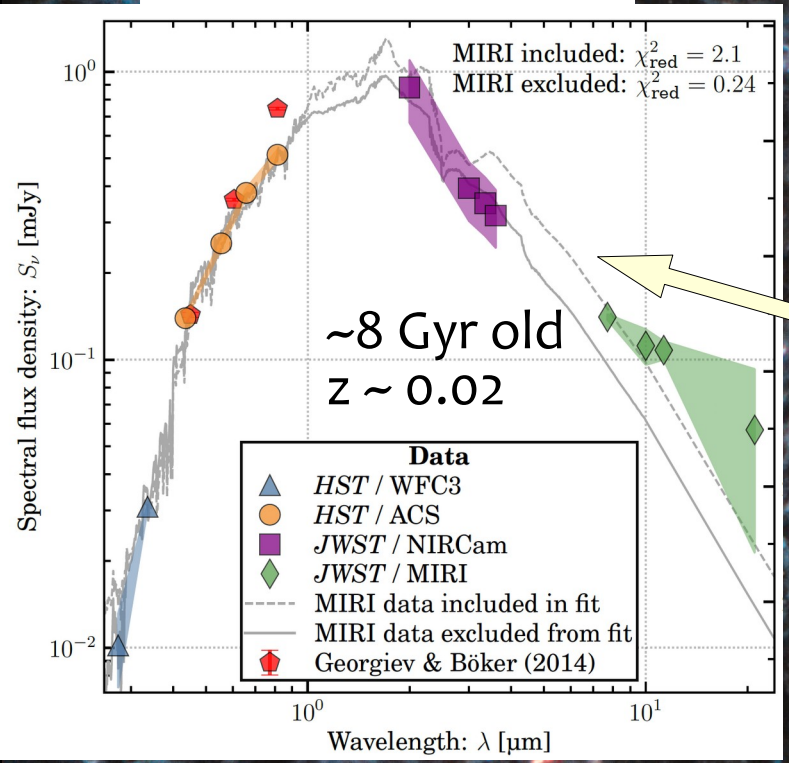


21μm-11.3μm-7.7μm-10μm

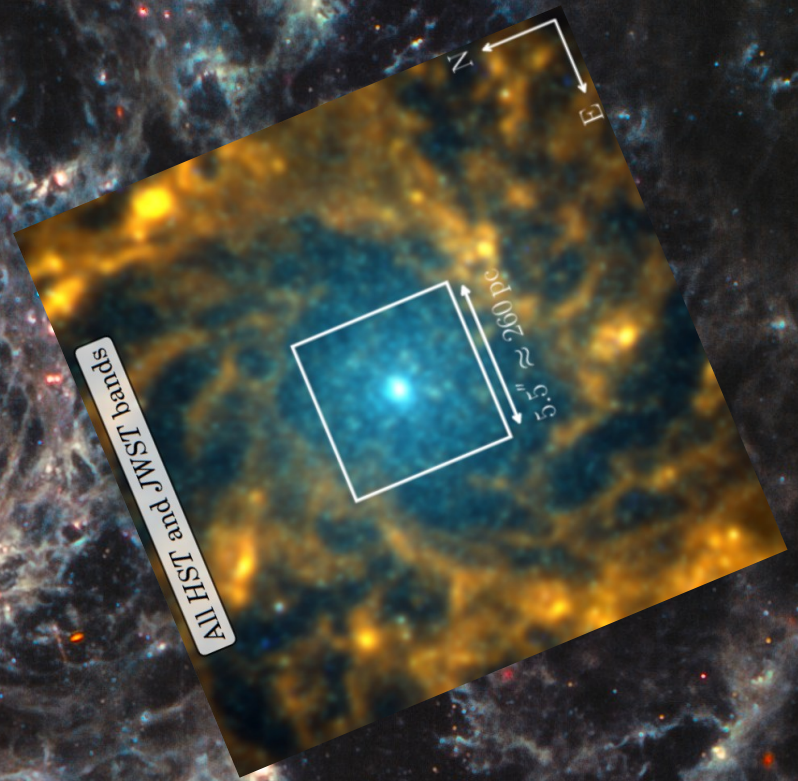
Credit: NASA/ESA,CSA; PHANGS, J. Schmidt & Lee et al. (2023)

Nuclear Star Cluster of NGC628

Nuclear cluster ***too old*** to cause cavity



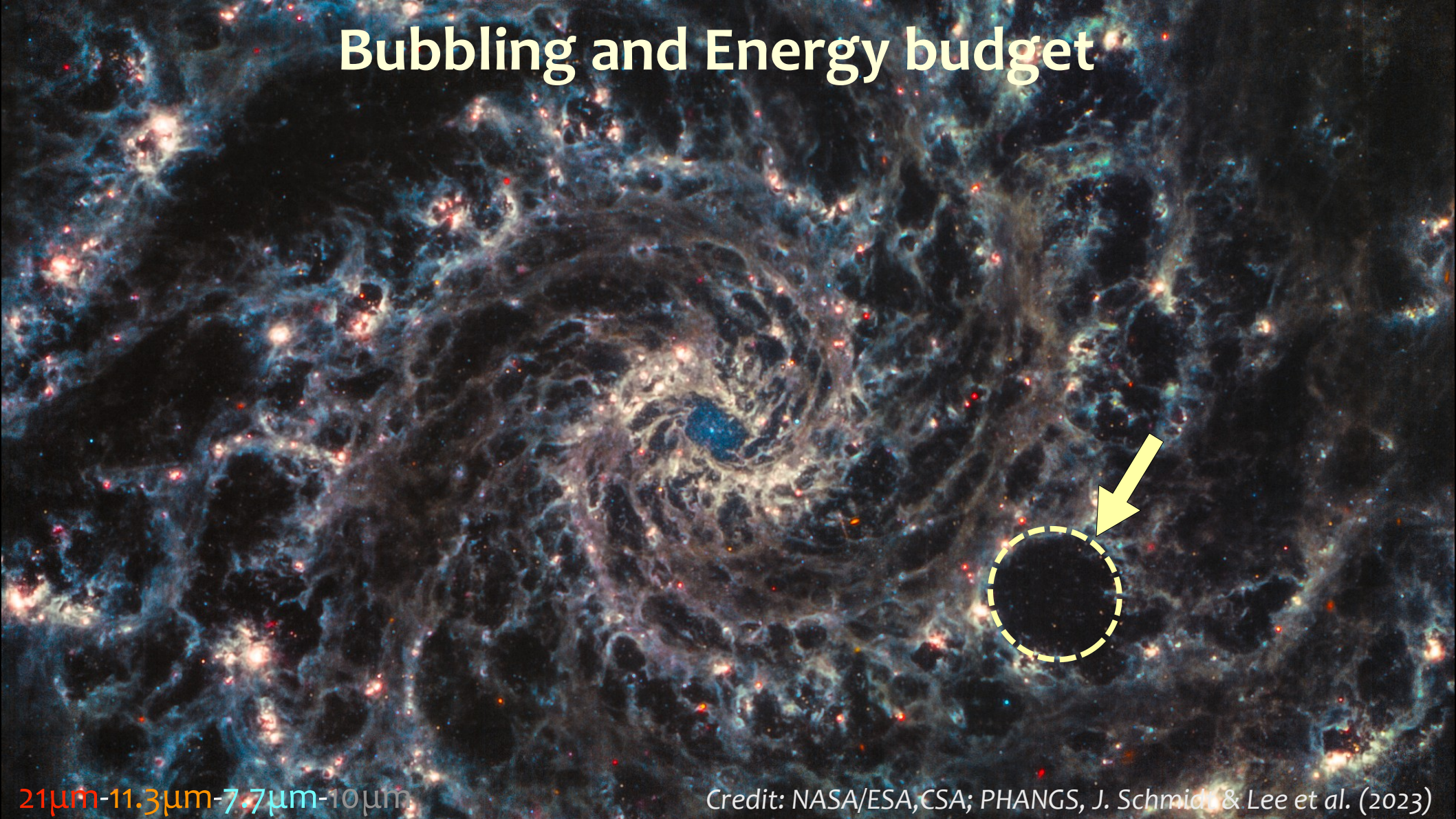
Hoyer et al. (2023)



21μm-11.3μm-7.7μm-10μm

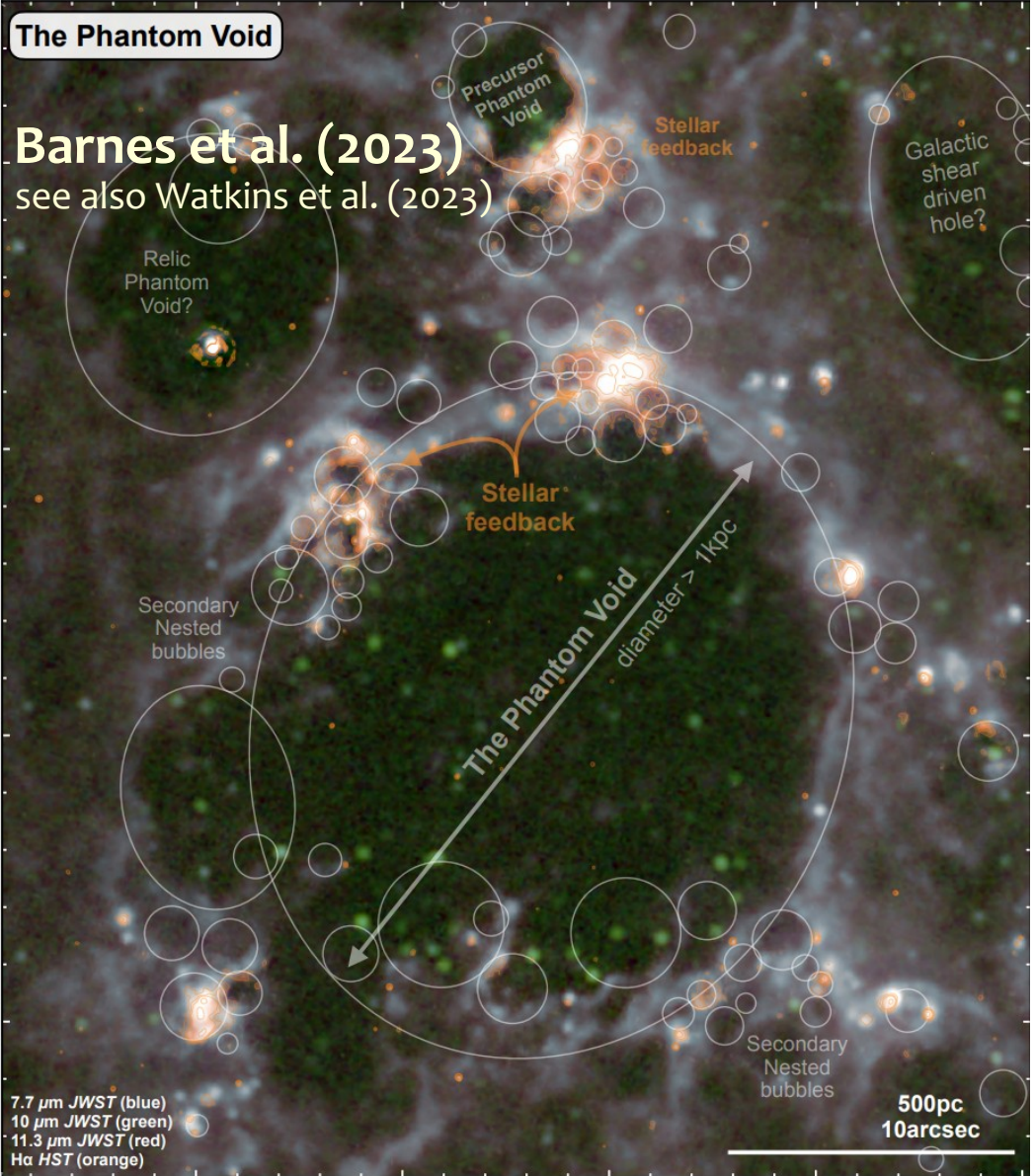
Credit: NASA/ESA,CSA; PHANGS, J. Schmidt & Lee et al. (2023)

Bubbling and Energy budget



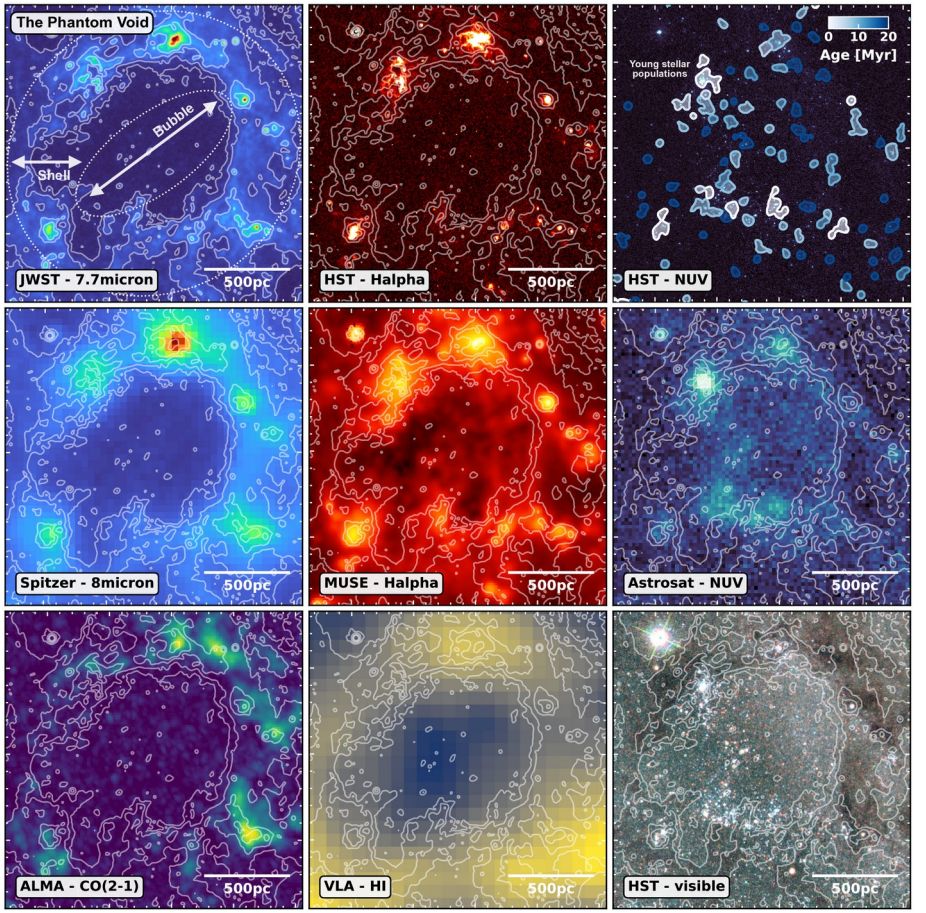
21μm-11.3μm-7.7μm-10μm

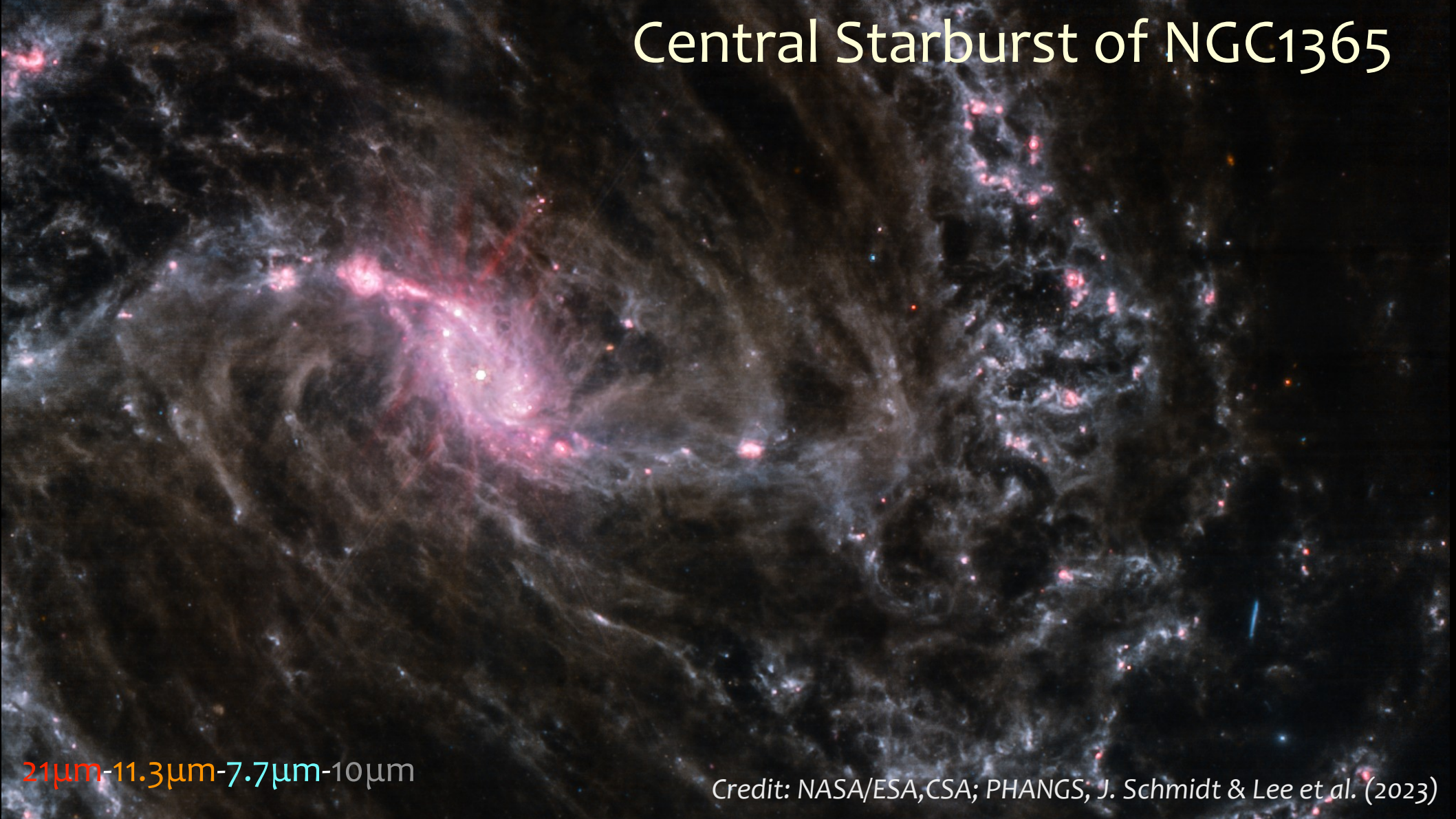
Credit: NASA/ESA,CSA; PHANGS, J. Schmidt & Lee et al. (2023)



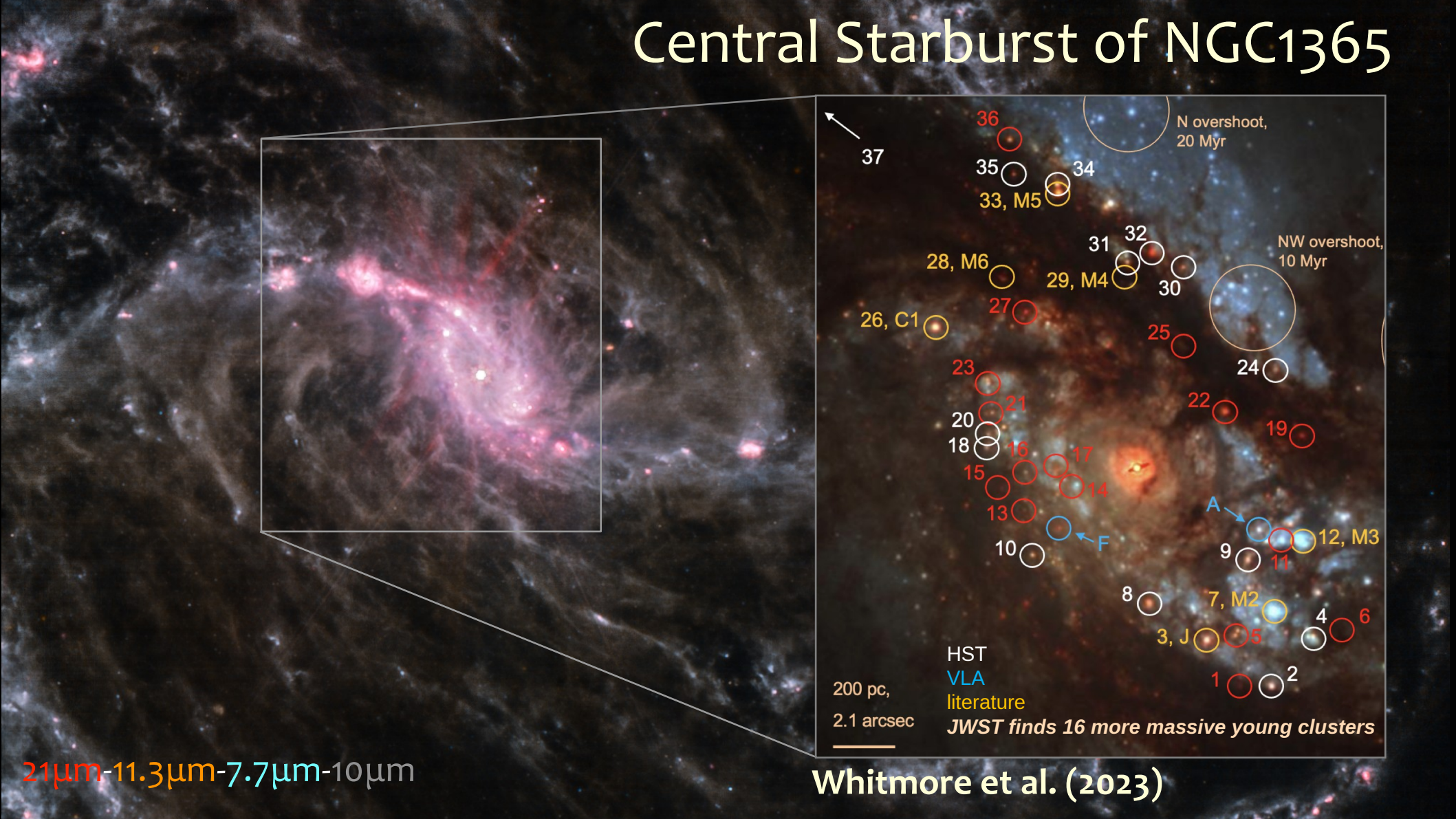
The multi-λ view

⇒ Probe Baryon Cycle
⇒ Improve theory
⇒ Guide simulations & models



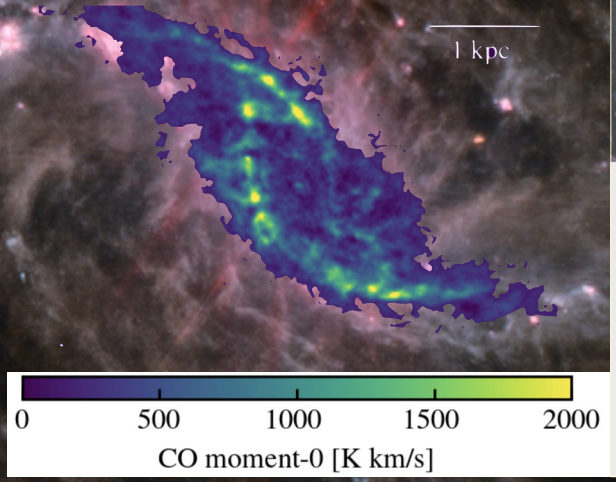

Central Starburst of NGC1365
21µm-11.3µm-7.7µm-10µm
Credit: NASA/ESA,CSA; PHANGS, J. Schmidt & Lee et al. (2023)

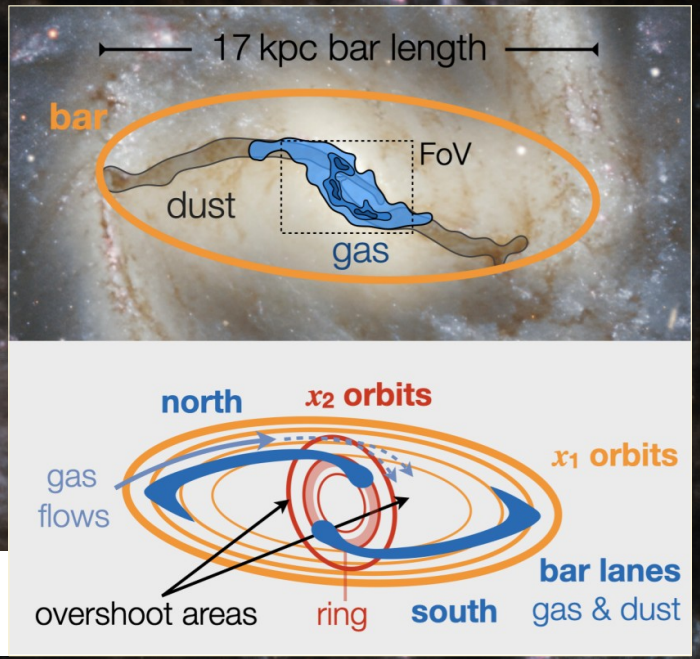
Central Starburst of NGC1365



Whitmore et al. (2023)

Central Starburst of NGC1365





Schinnerer et al. (2023)

21μm-11.3μm-7.7μm-10μm

Local Galaxy population < 20 Mpc (1" ~ 100 pc)

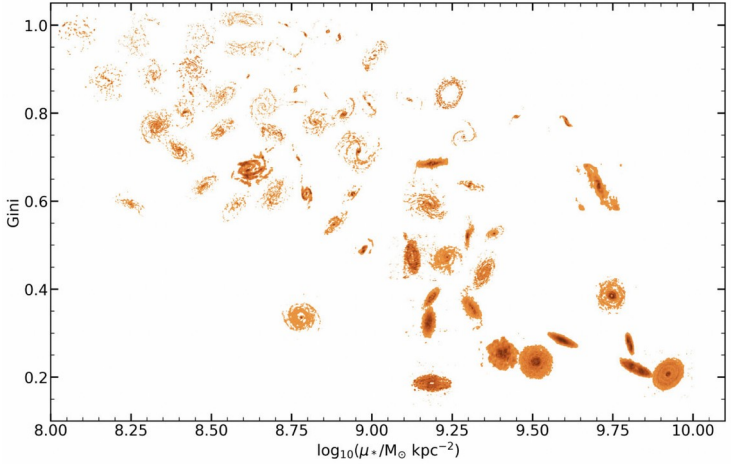
Good sample (PHANGS ≡ ~100 galaxies) but lacks some **λ-coverage** :

⇒ e.g., HI (but see e.g., THINGS, VLA ANGST, MHANGOOSE, ...)

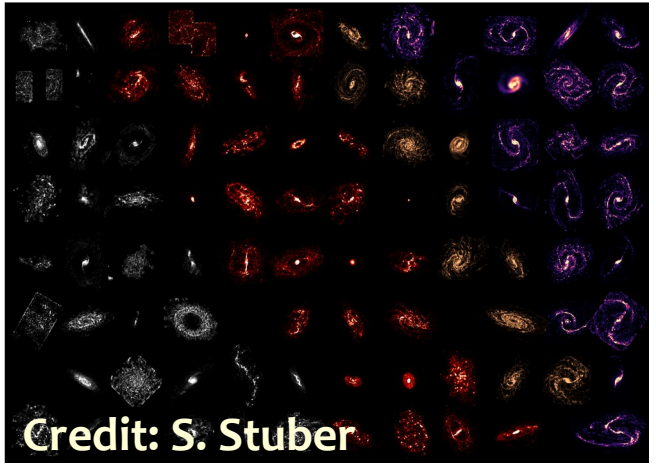
IR (but see Dwarf Galaxy Survey, S4G, SHINING, ...), X-ray, ...

How **diverse** should we go to connect with both :

resolved (e.g., Milky-Way) and unresolved (e.g., MaNGA) surveys ?



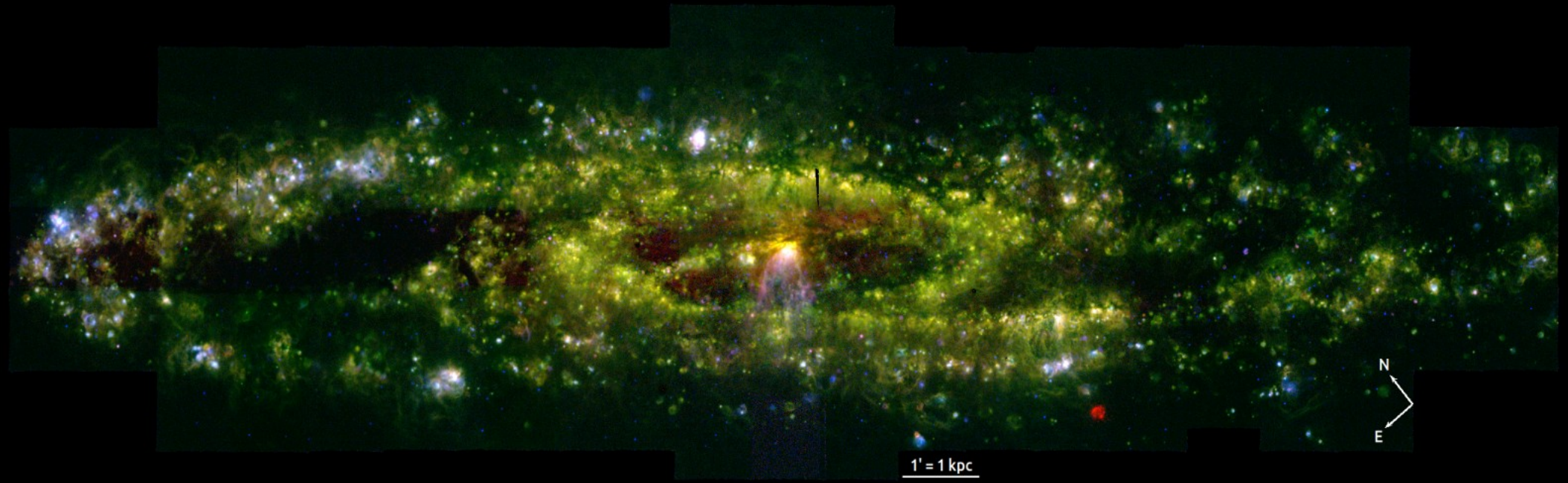
Davis et al. (2022)



Leroy et al. (2021a,b)

Nearby **large** galaxies are difficult to cover

⇒ e.g., M83 (Adamo et al.), NGC300 (McLeod et al.), NGC253 (Congiu et al.)

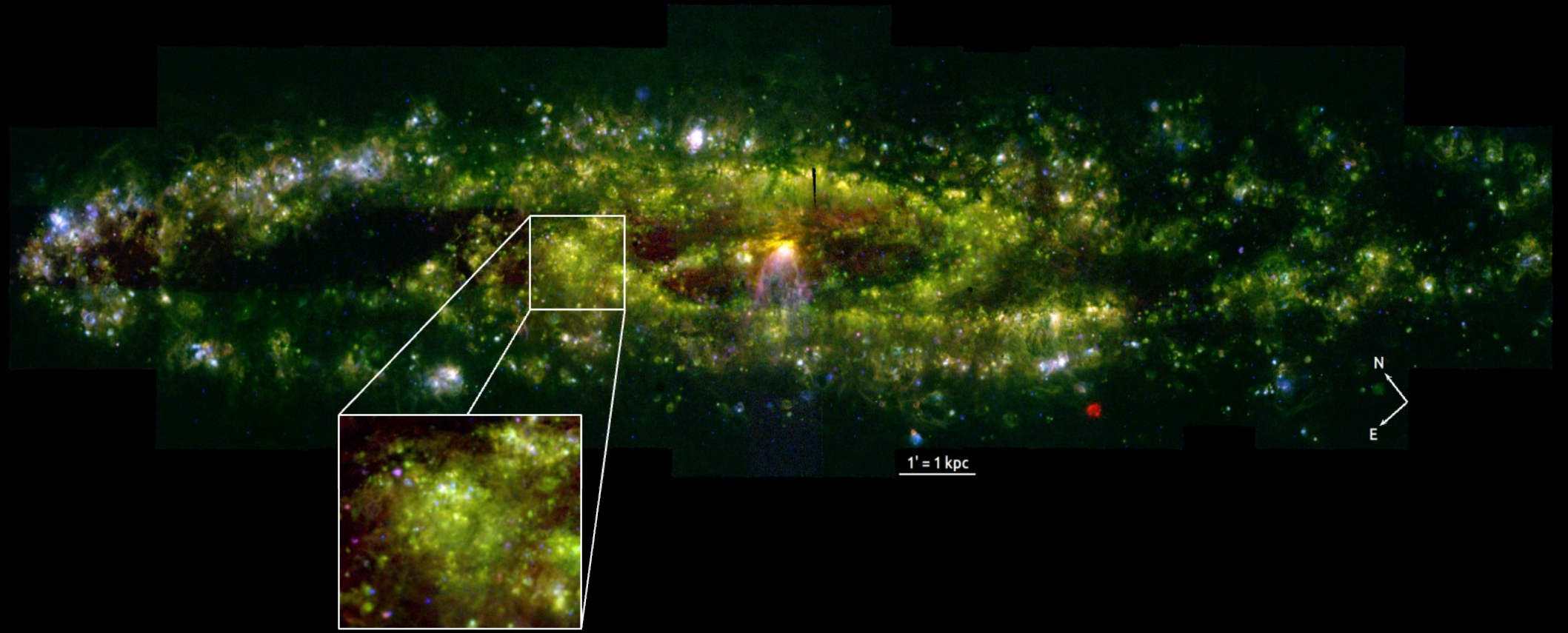


Courtesy: Enrico Congiu

NGC253

100 MUSE pointings

Hα [SII] [OIII]

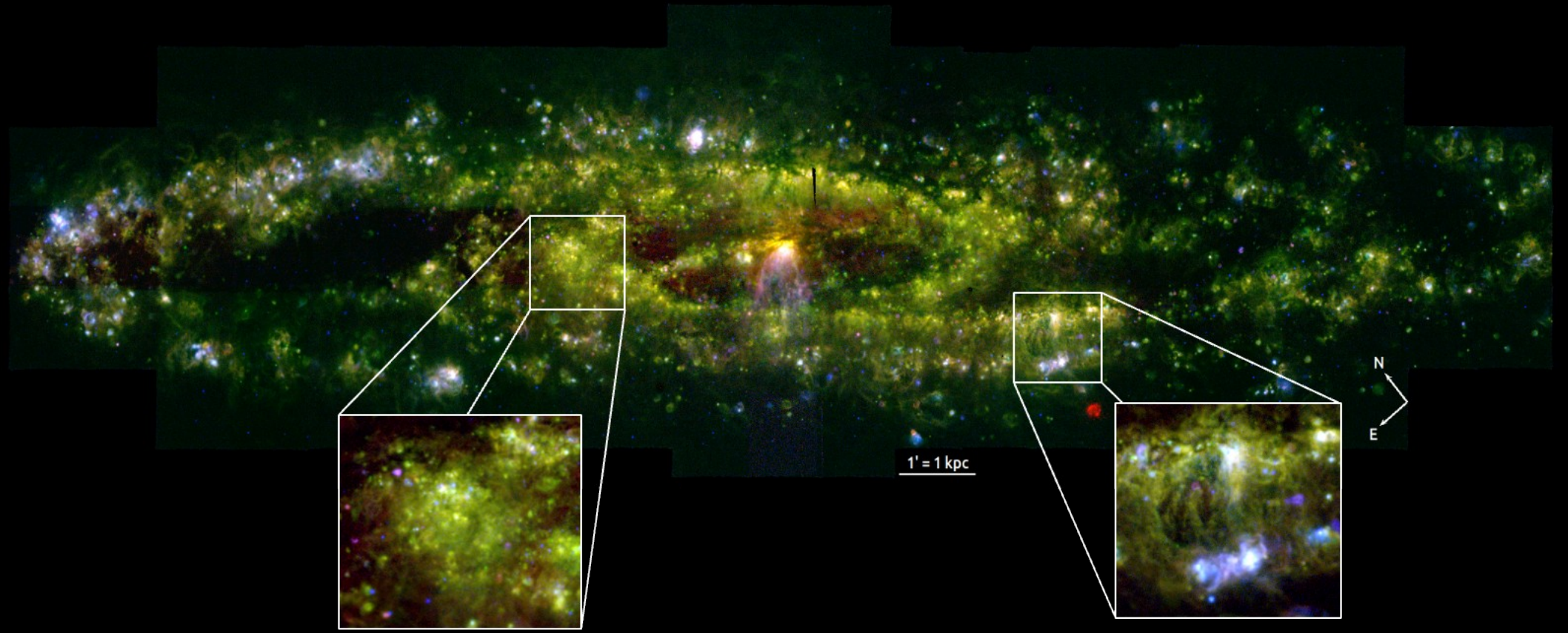


Courtesy: Enrico Congiu

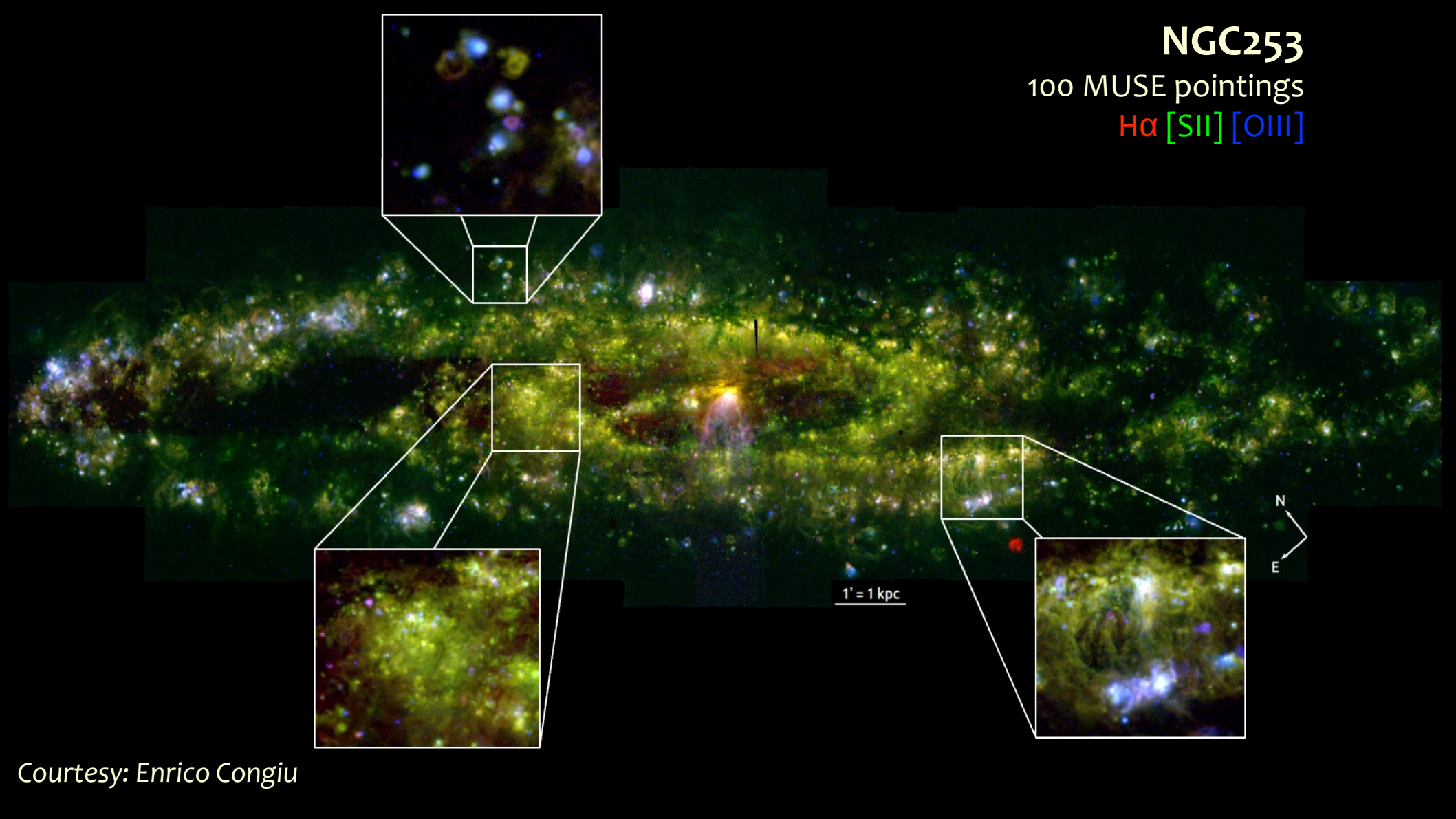
NGC253

100 MUSE pointings

Hα [SII] [OIII]



Courtesy: Enrico Congiu



Courtesy: Enrico Congiu

A Legacy "Baryon cycle" community effort

To understand star formation : where/how it proceeds

⇒ Need for a community-wide effort to conduct

- A high spatial resolution (10-100pc)
- Multi-λ « **using all eyes** » on the sky

⇒ **Survey of the local galaxy population**

⇒ ***To connect with*** resolved physics (e.g., Milky-Way) & unresolved high(-er) z surveys

⇒ ***To improve theory***
⇒ ***To guide simulations***

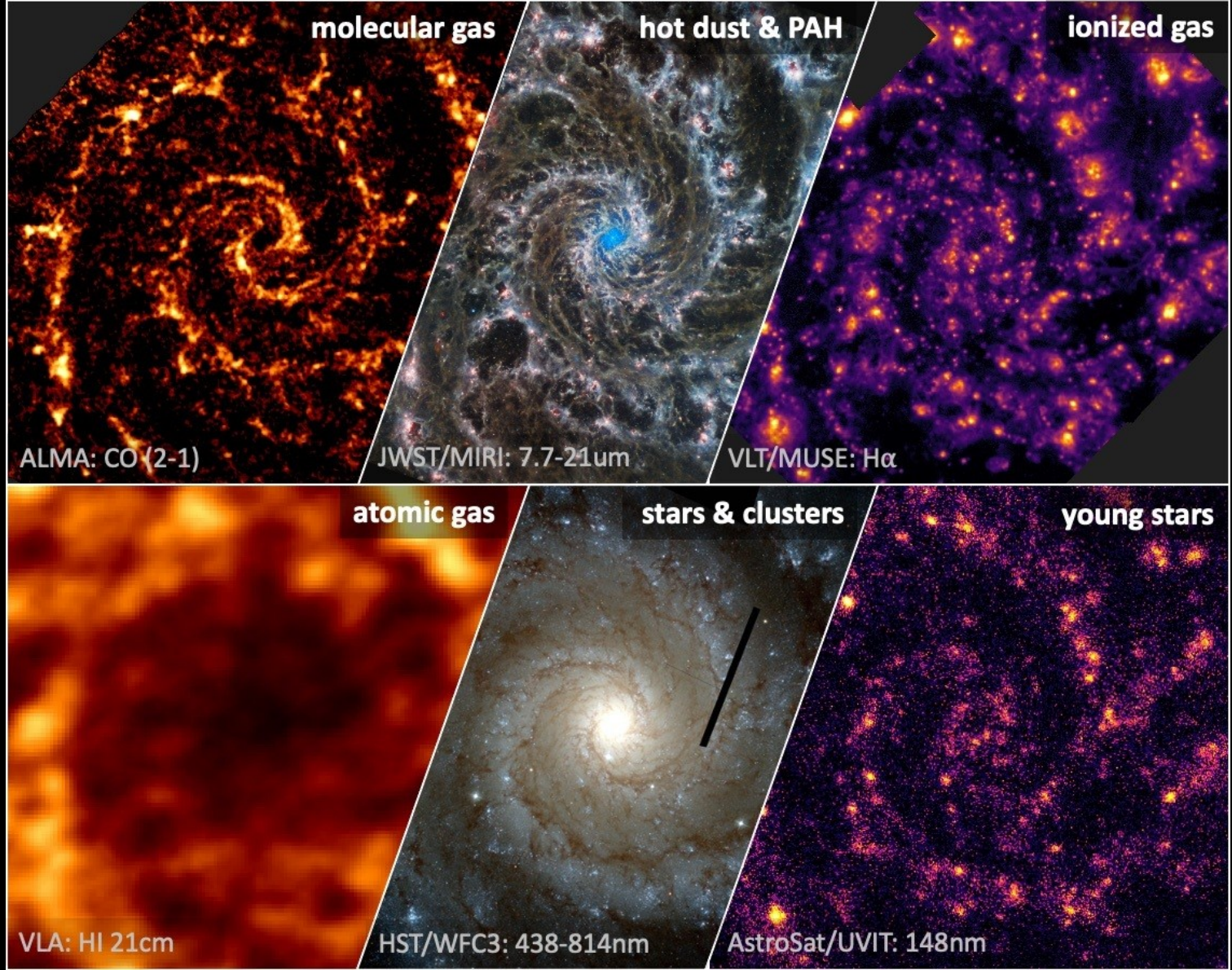
SKA : 1 arcsec atomic + radio-continuum imaging (synchrotron/thermal)

ESO instrumentation

e.g., Euclid, Roman will give imaging in optical/NIR

Waiting for WST ?

⇒ ***Can we as as community deliver the missing link ?***



Credit: Jiayi Sun