

# The Co-Evolution of Central Gas Rings and Nuclear Stellar Discs

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**Justus Neumann**

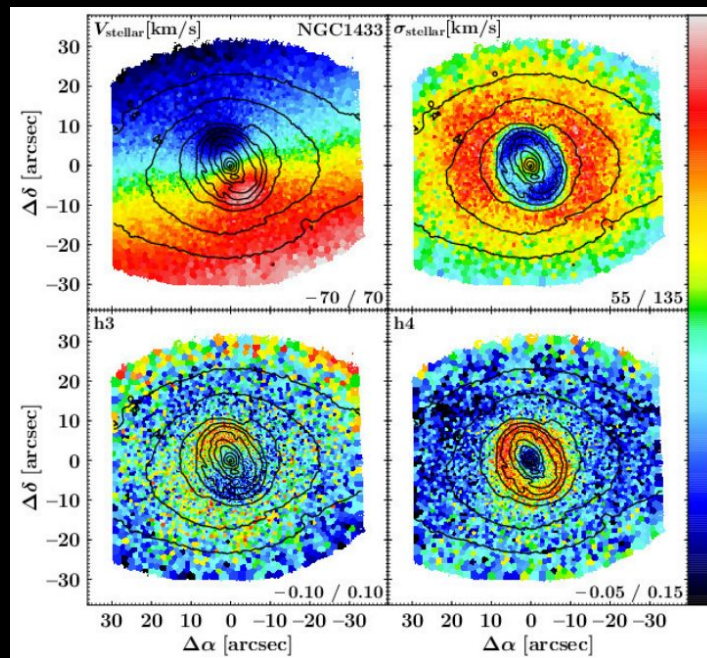
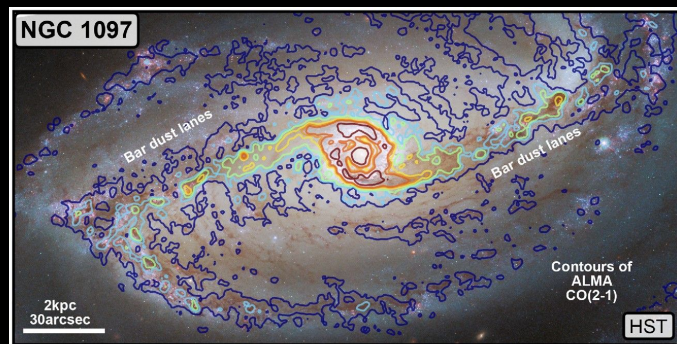
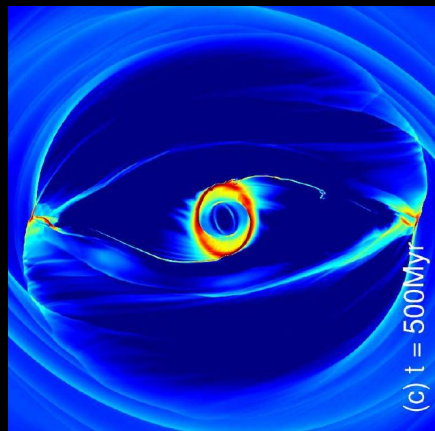
***ESO Workshop MUSE***  
**18 - 22 Nov 2024**

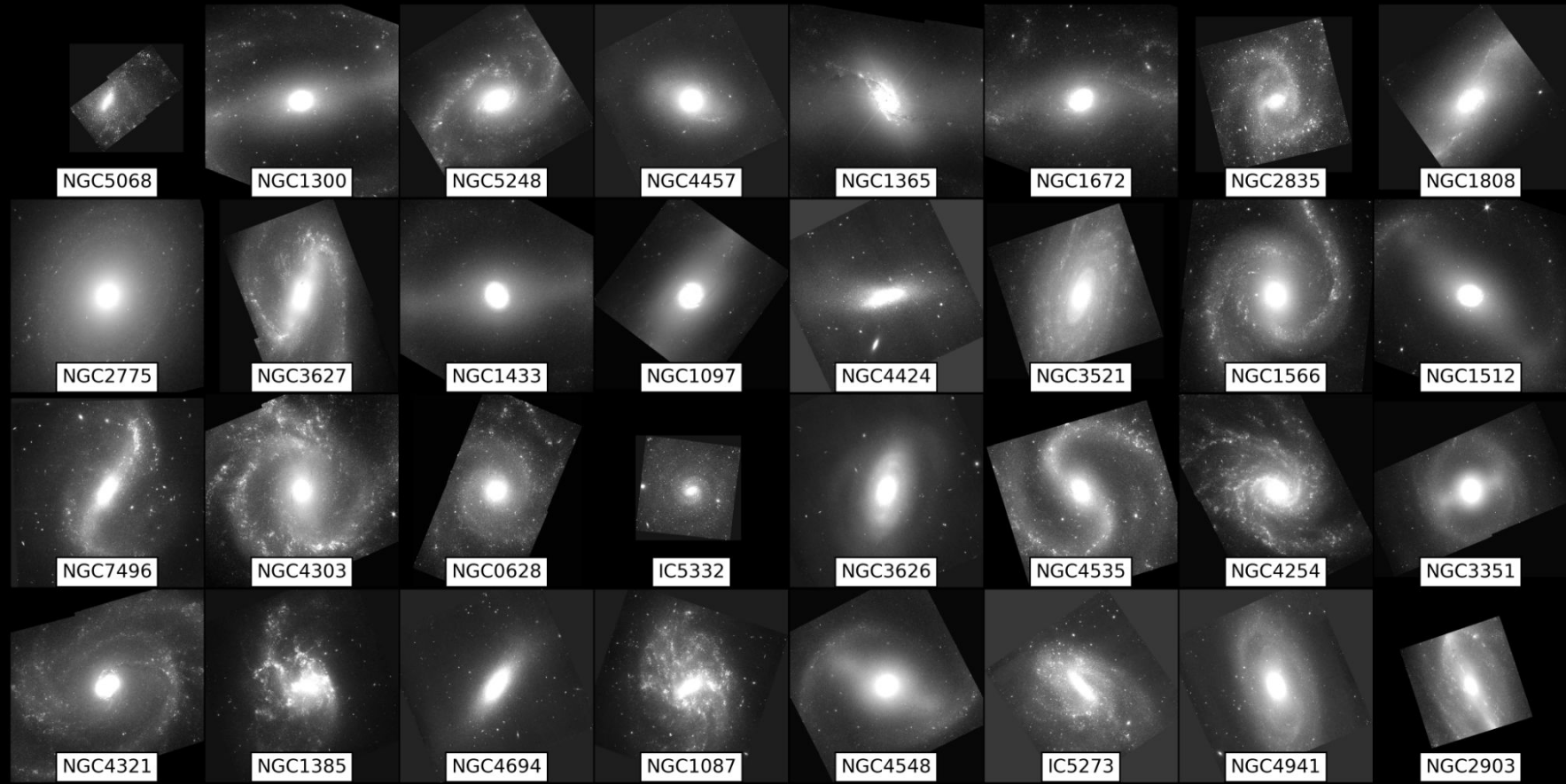


Central gas rings



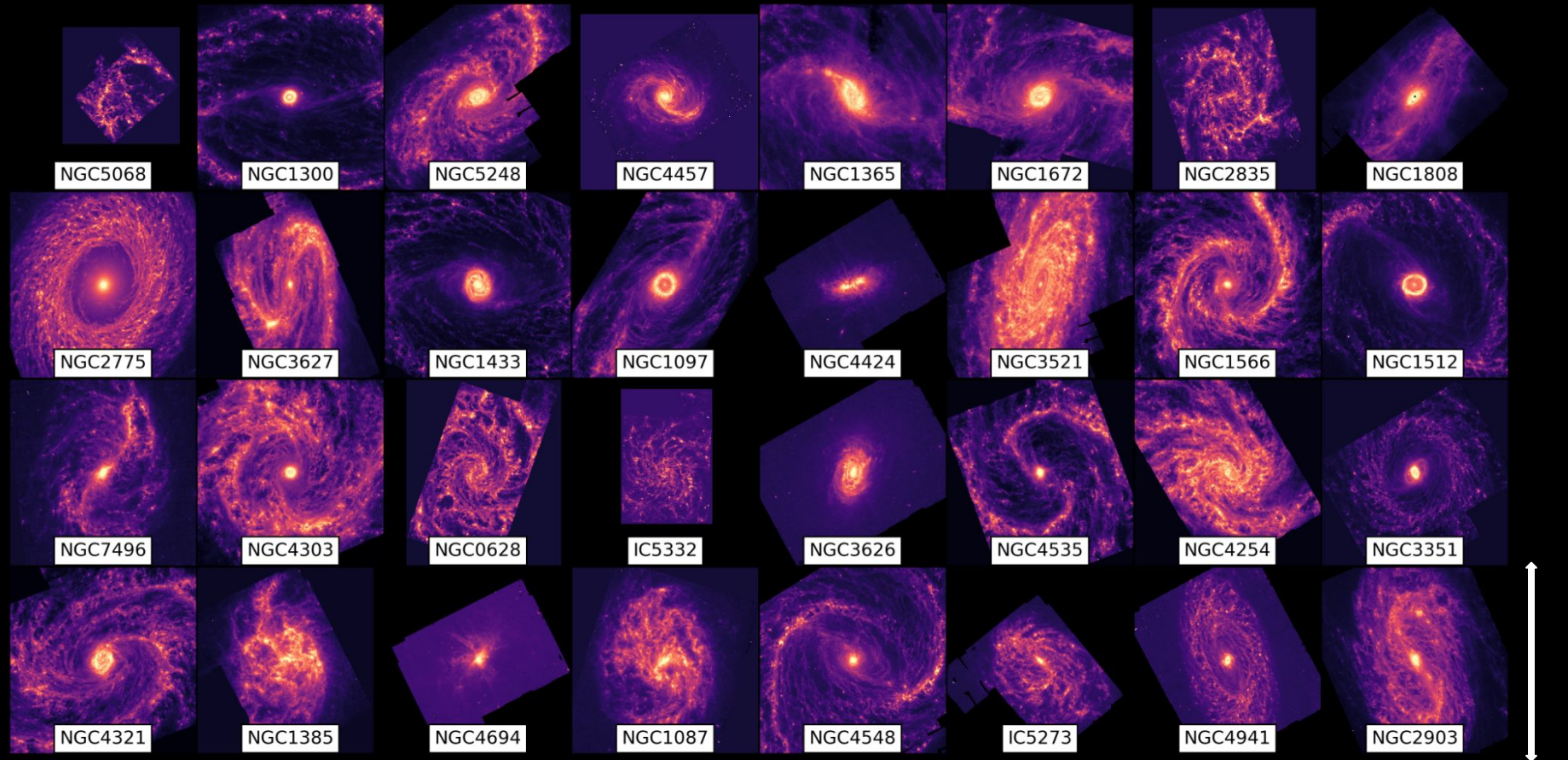
Nuclear stellar discs





12 kpc

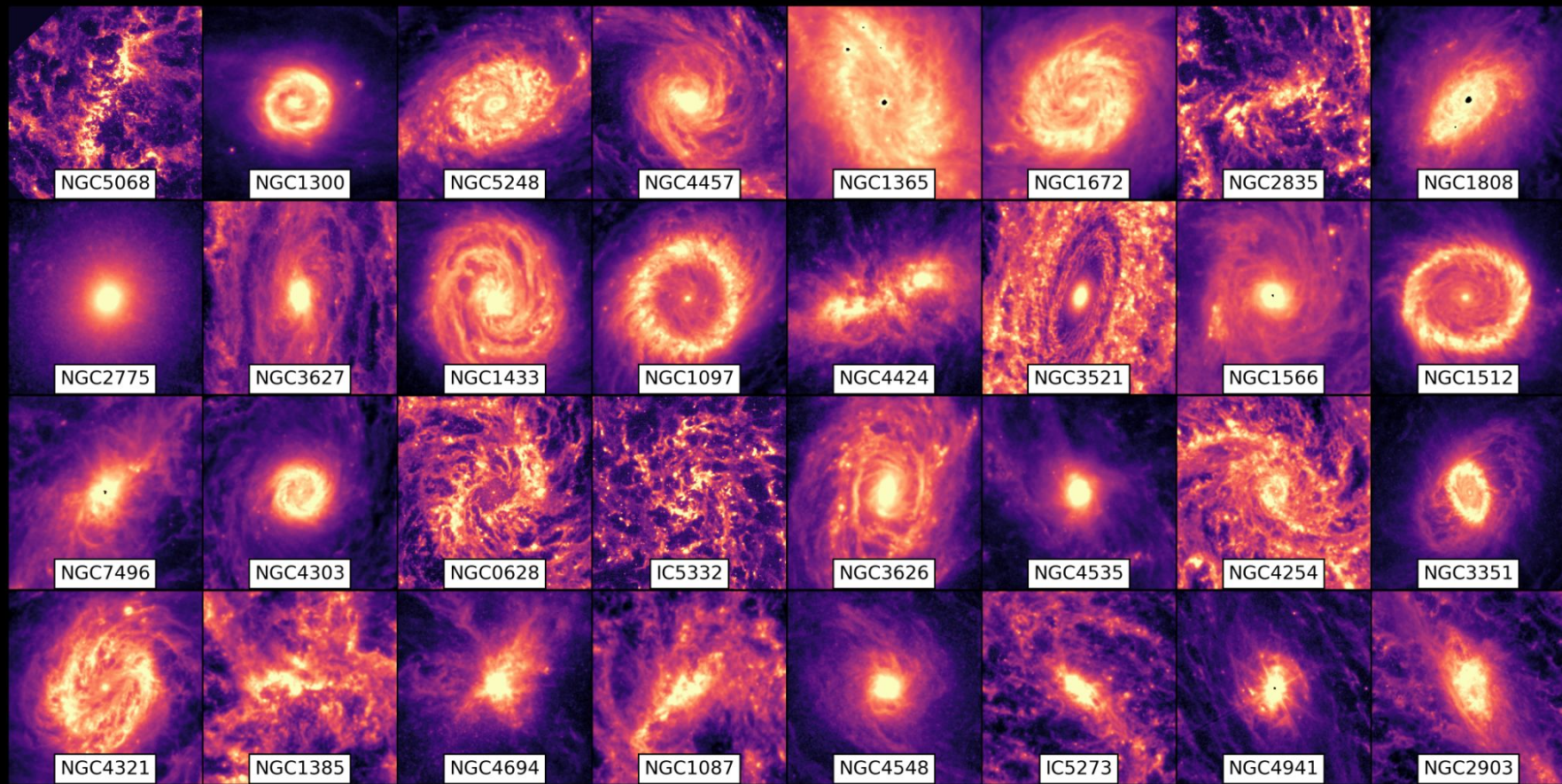




12 kpc

*JWST-MIRI - 7.7  $\mu$ m* 4

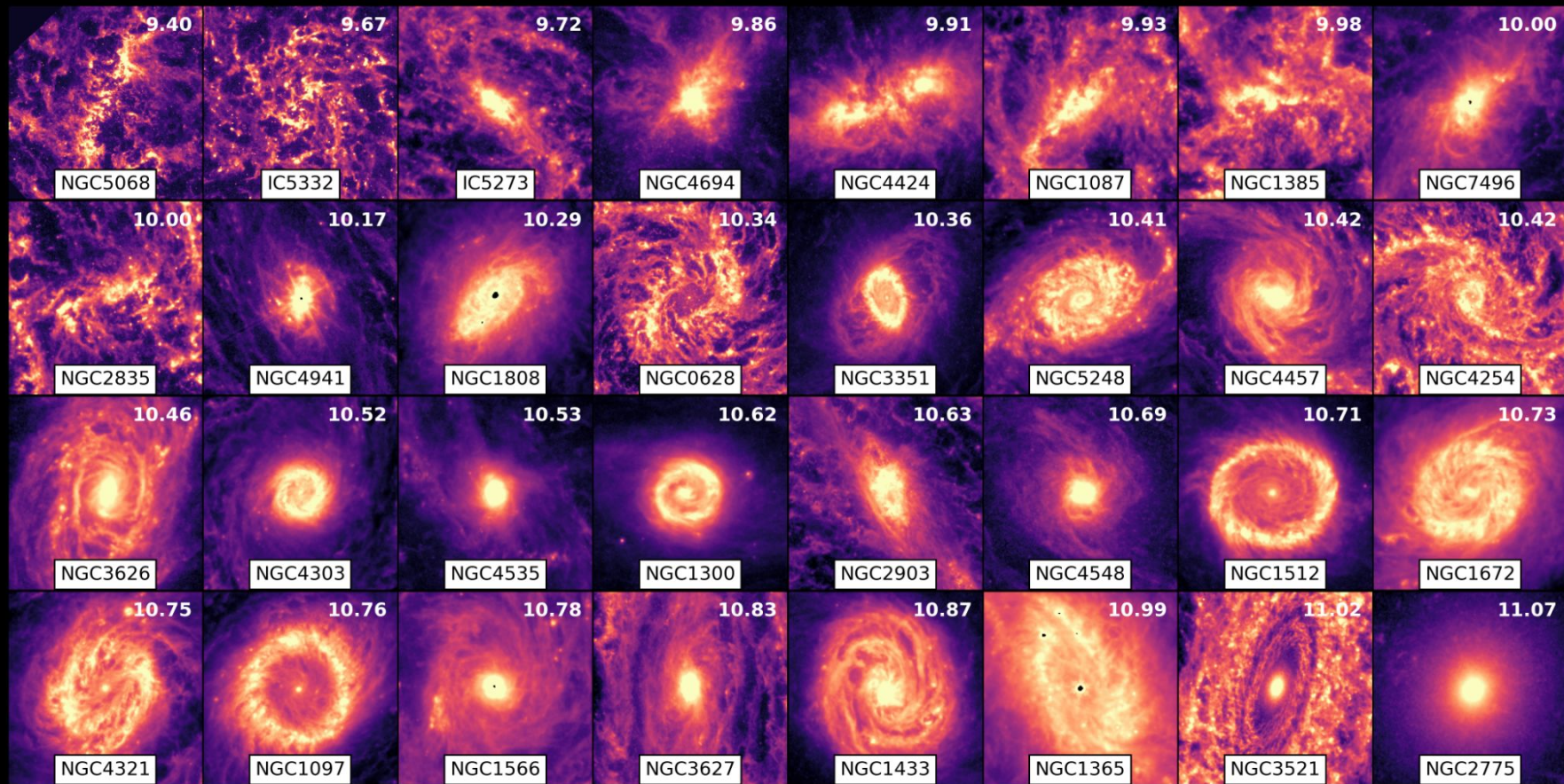




Central gas rings everywhere!

*JWST-MIRI - 7.7  $\mu$ m* 5



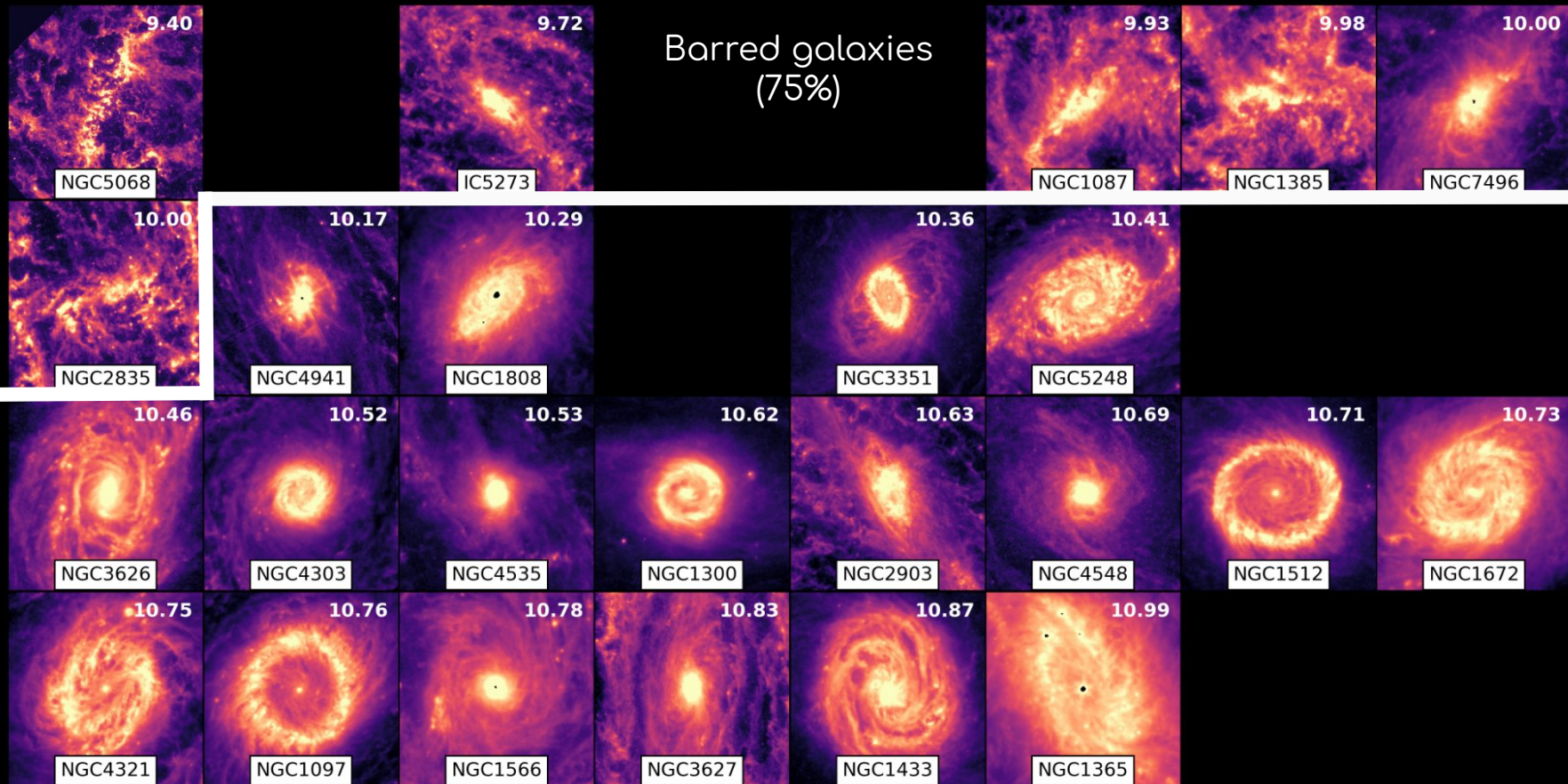


2 kpc

Rings starts to appear at high-mass galaxies

*JWST-MIRI - 7.7  $\mu$ m* 6

# Barred galaxies (75%)



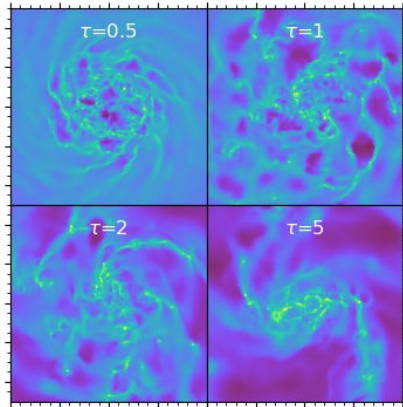
2 kpc

Change of regime at  $M_{\star} \sim 10^{10} M_{\odot}$

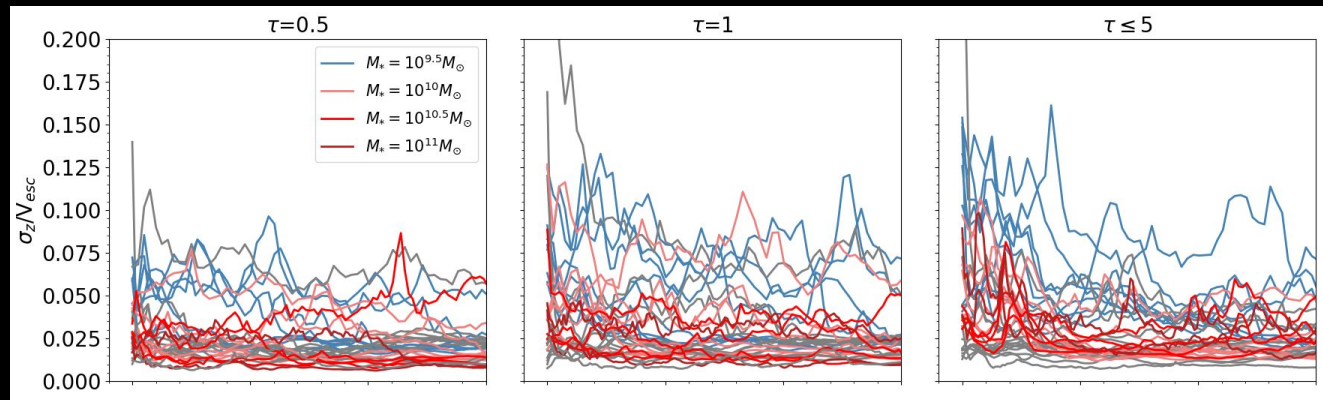
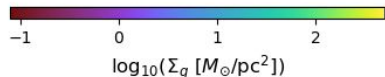
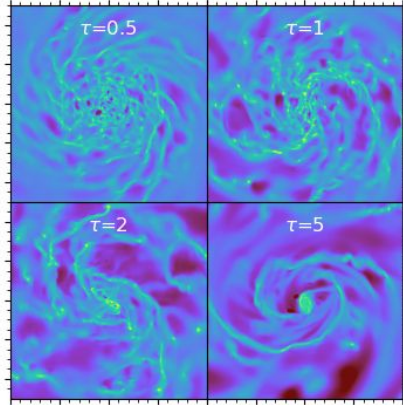
*JWST-MIRI - 7.7  $\mu$ m* 7



G025M095F40L2B00



G053M100F20L2B00



Structure change at  $M_{\star} \sim 10^{10} M_{\odot}$  also seen in simulations!

- Set of hydrodynamical simulations of 35 isolated barred galaxies matched to the PHANGS sample
- Higher-mass galaxies form a central gas concentration
- In lower-mass galaxies stellar feedback prevents the formation of such a structure

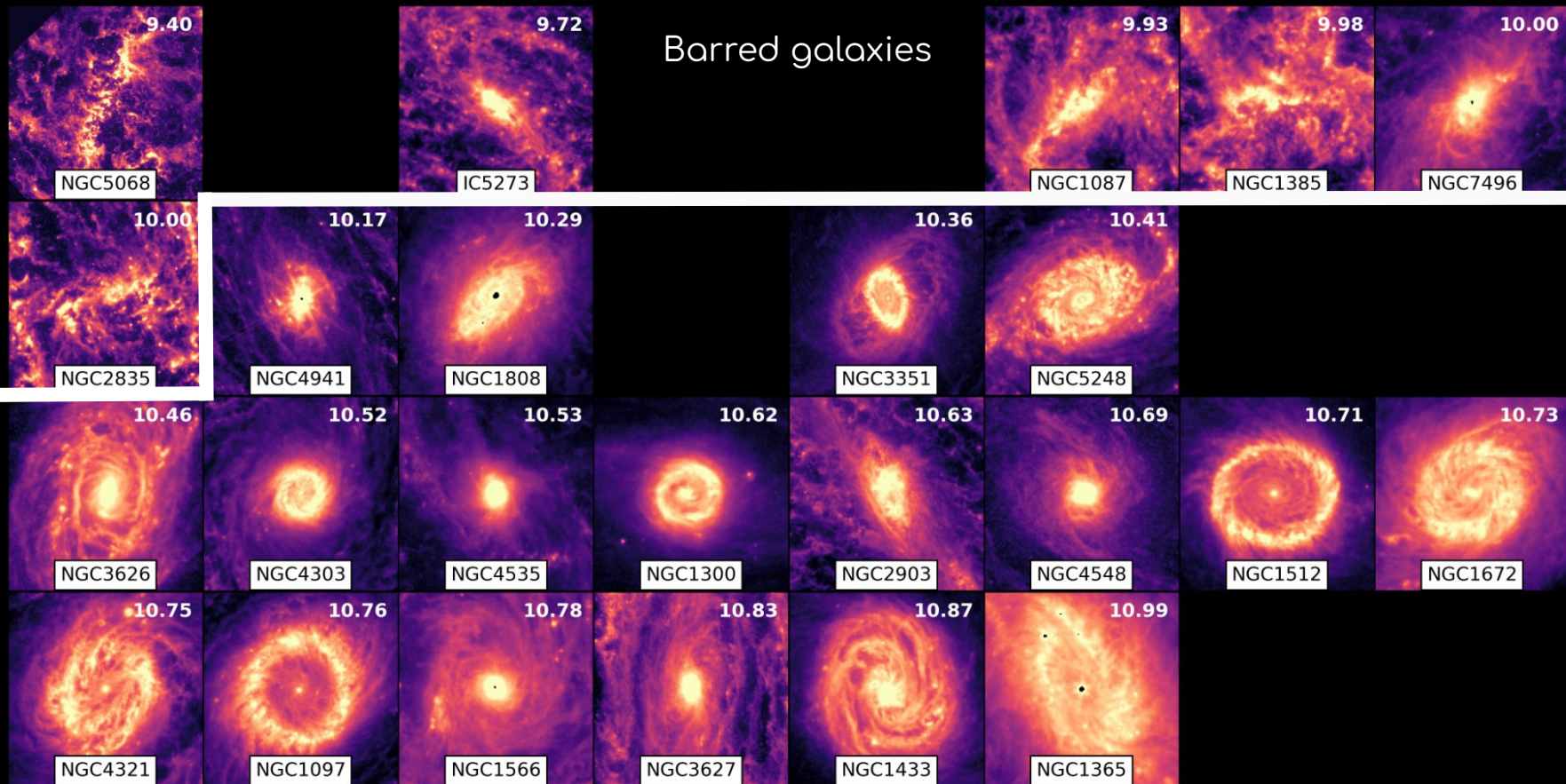
Verwilghen+2024 & in prep.: simulations  
Emsellem+ in prep.: more on obs.

Pierrick Verwilghen  
PhD student @ ESO

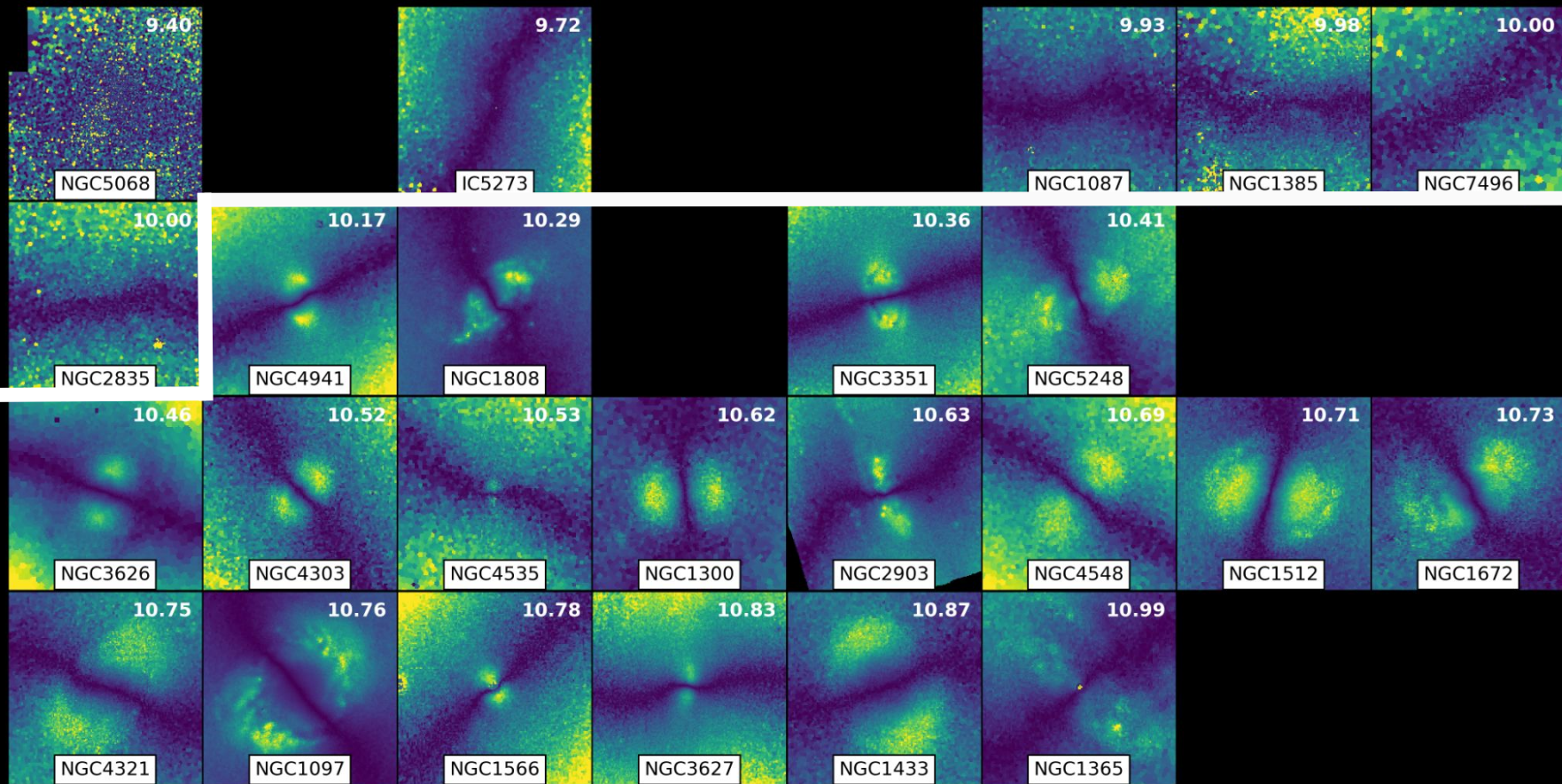




# Barred galaxies



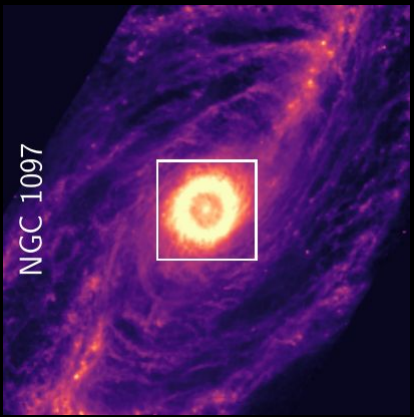
Change of regime at  $M_{\star} \sim 10^{10} M_{\odot}$

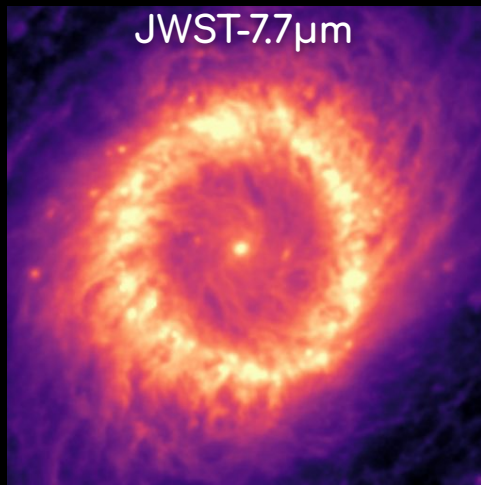
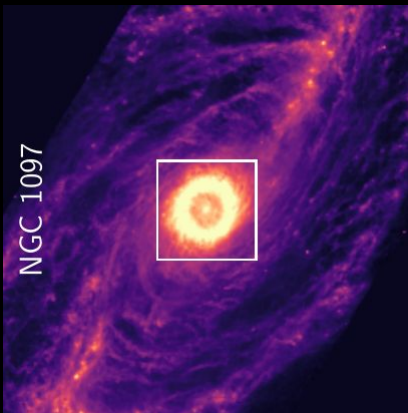


Fast rotating nuclear stellar discs “inside” gas rings

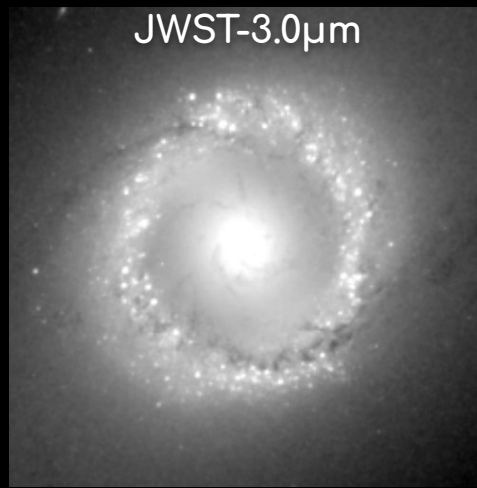
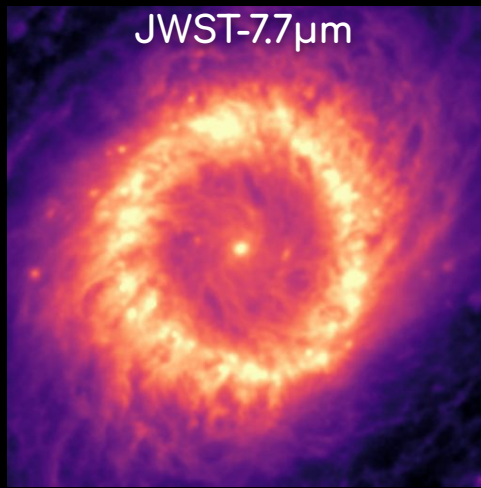
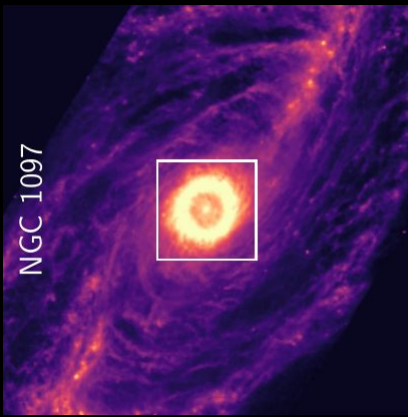
*MUSE* – Stellar  $V/\sigma$  10

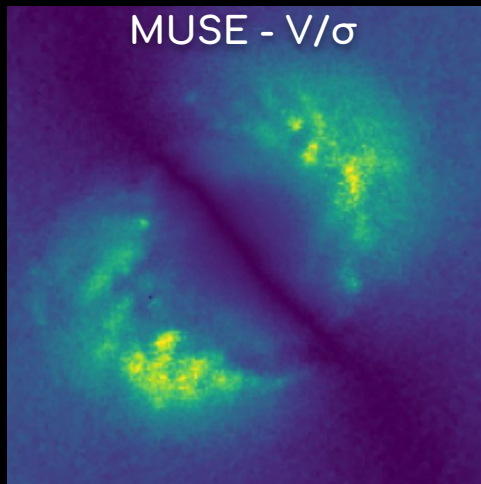
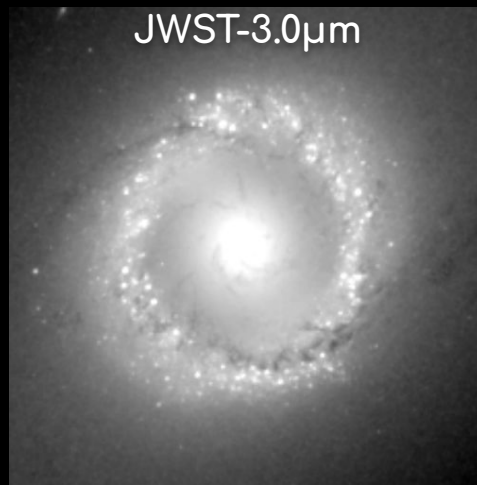
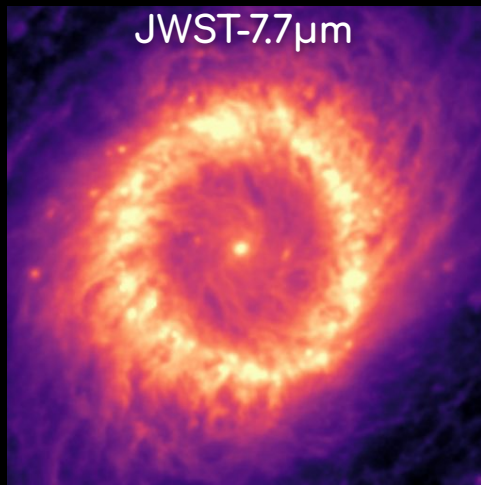
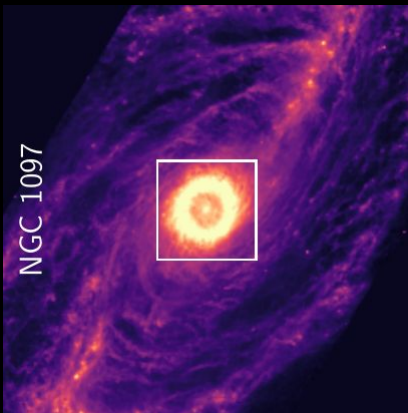




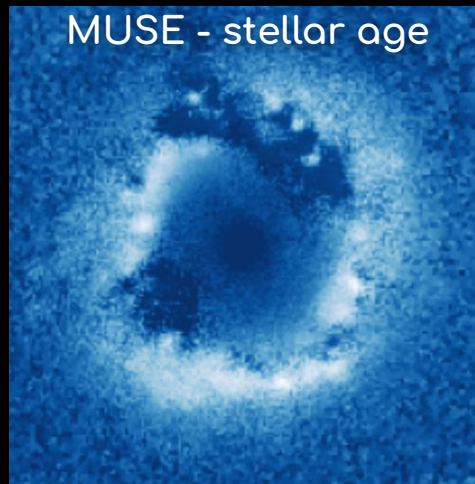
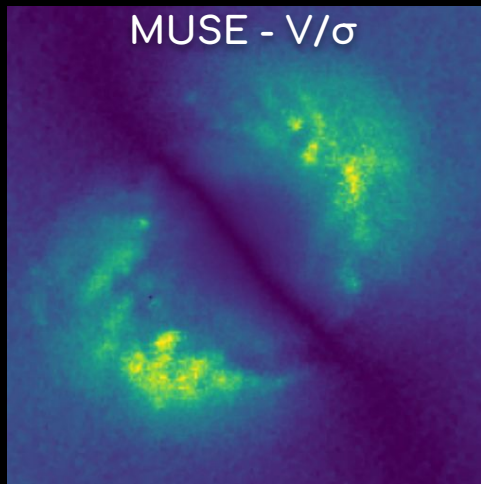
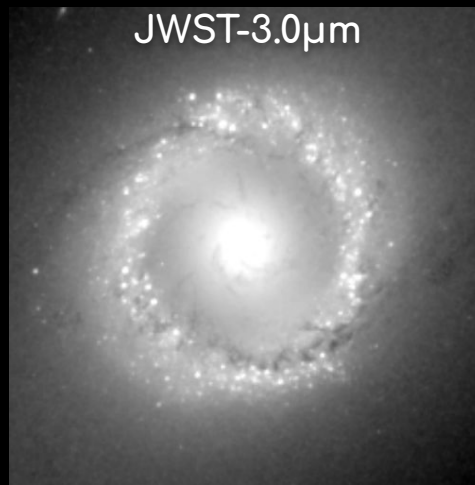
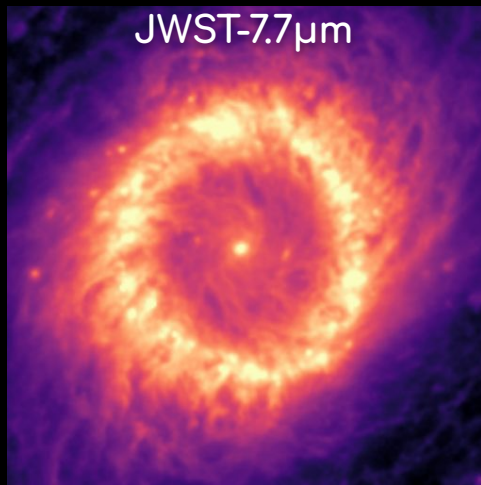
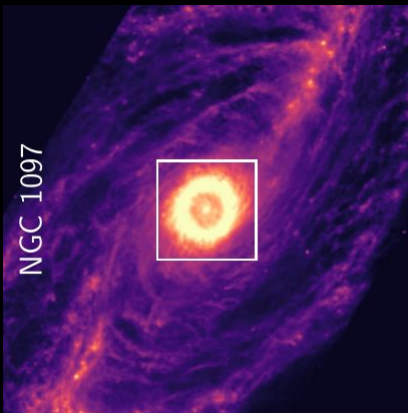


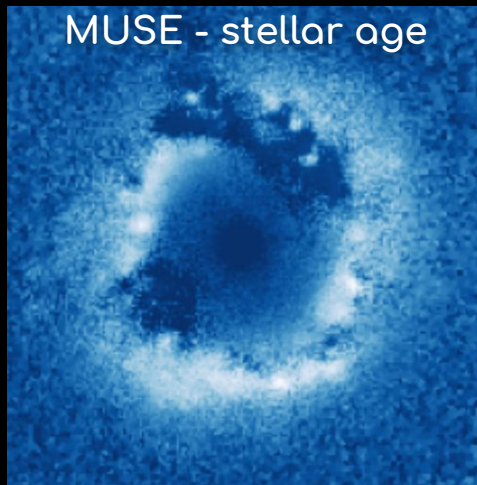
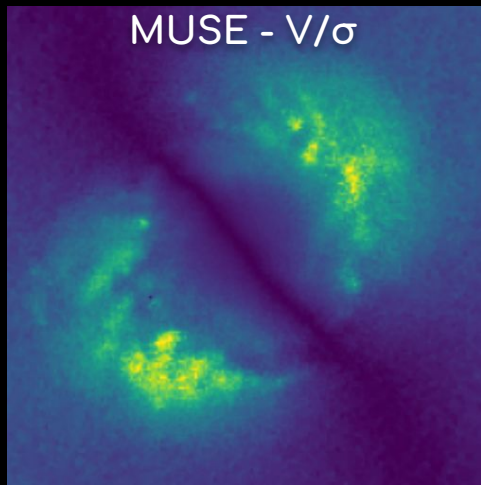
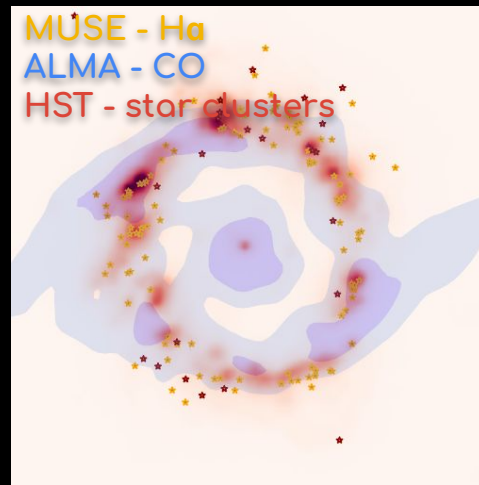
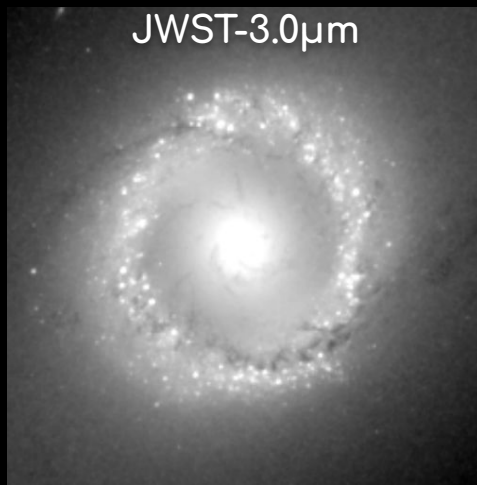
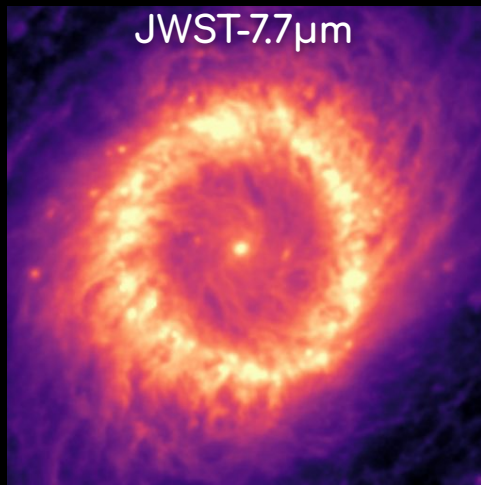
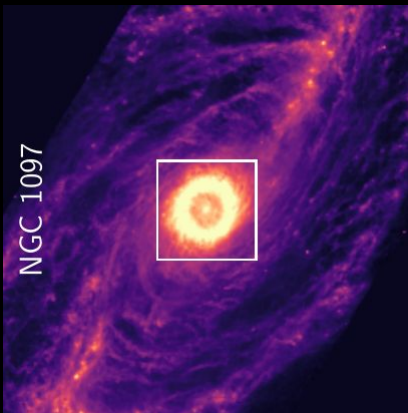




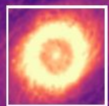




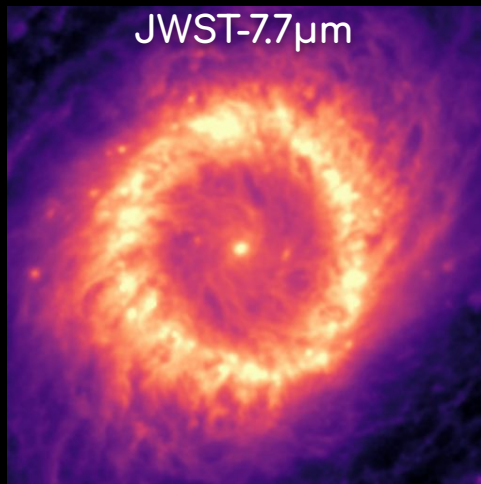




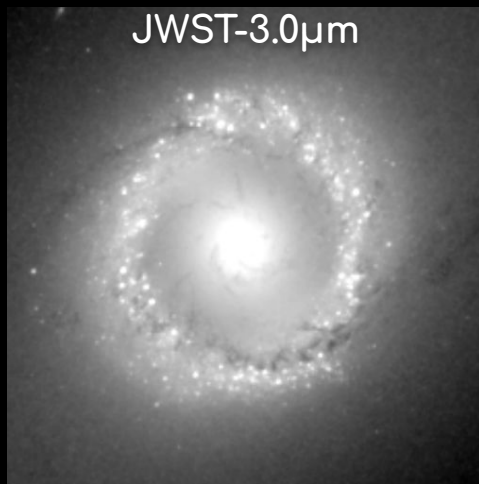
NGC 1097



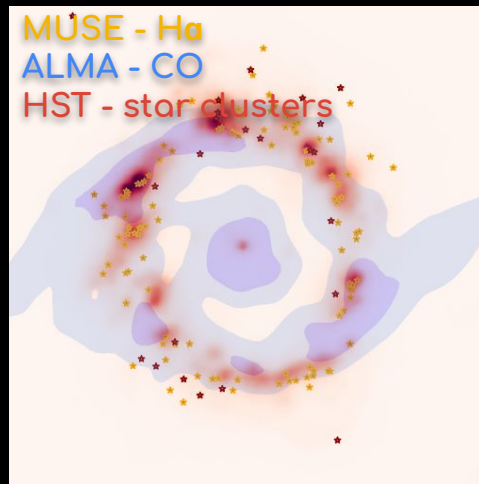
JWST-77 $\mu$ m



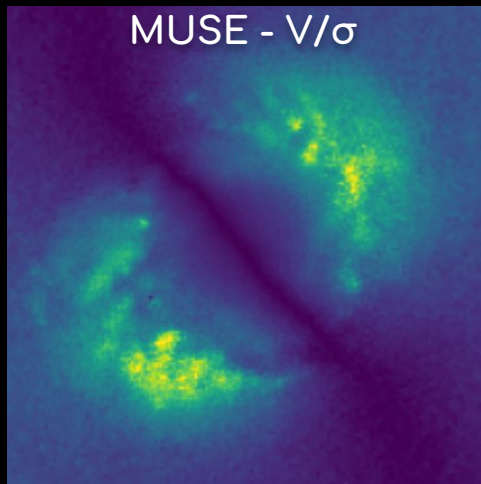
JWST-3.0 $\mu$ m



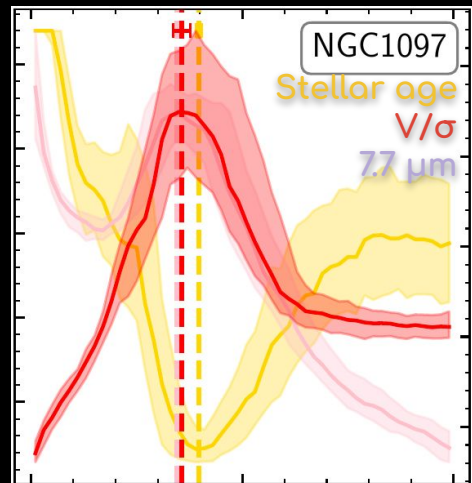
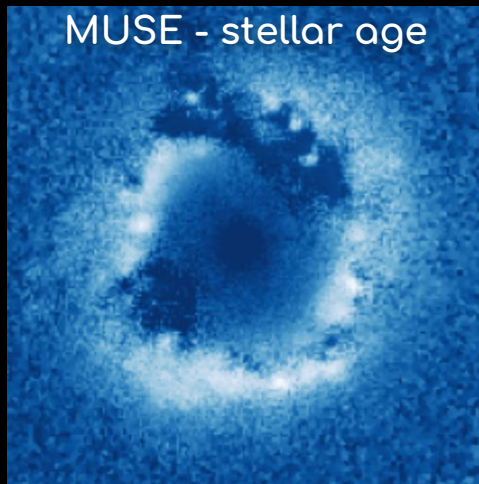
MUSE - H $\alpha$   
ALMA - CO  
HST - star clusters



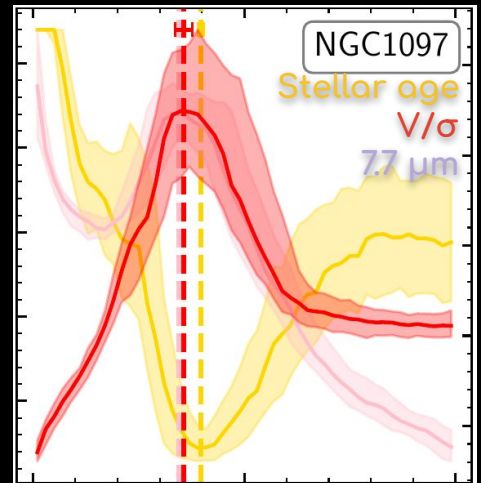
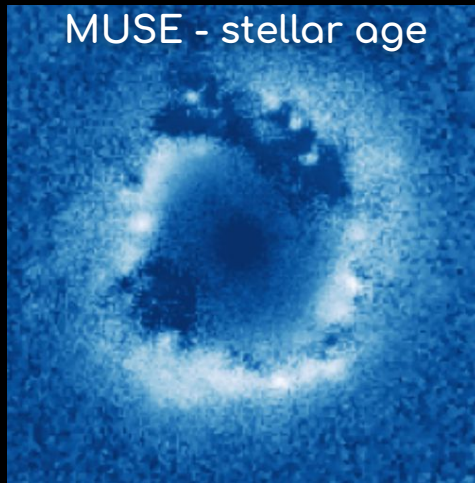
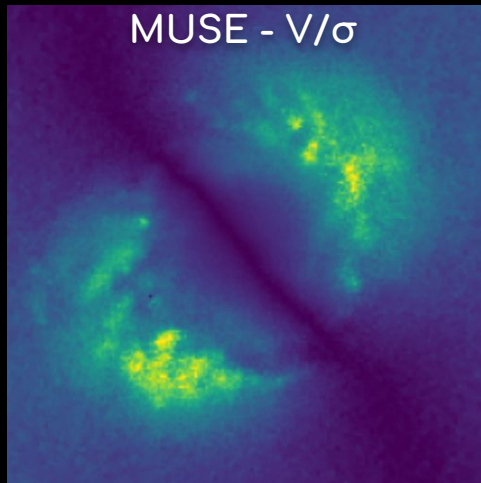
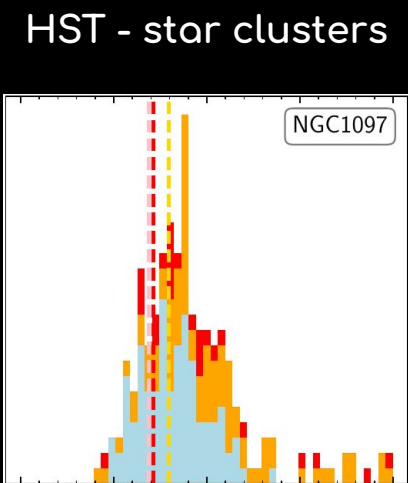
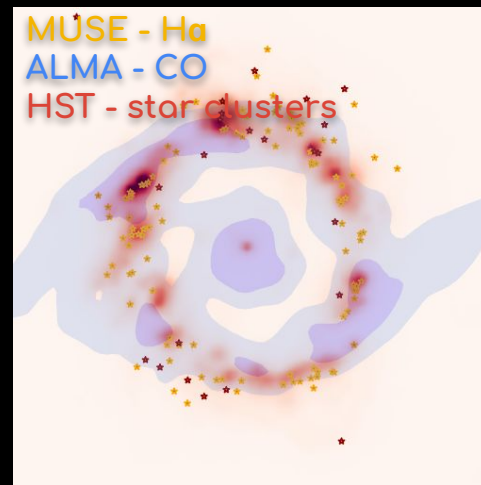
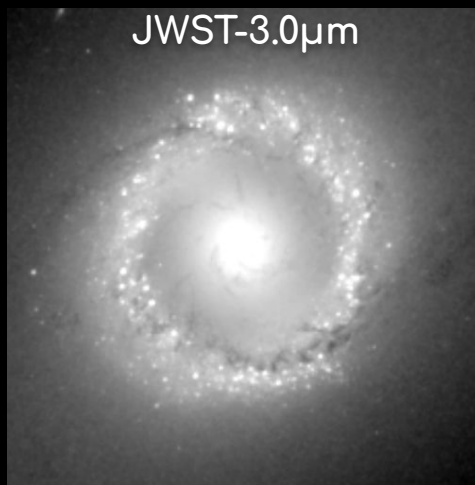
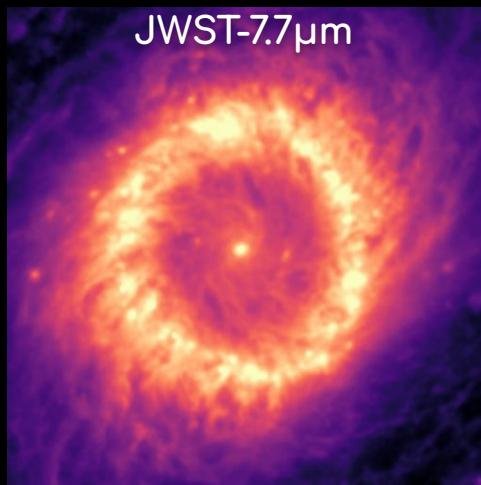
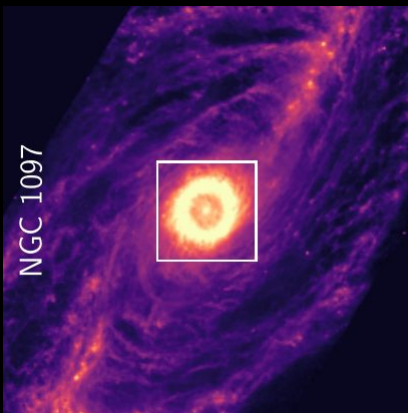
MUSE - V/ $\sigma$

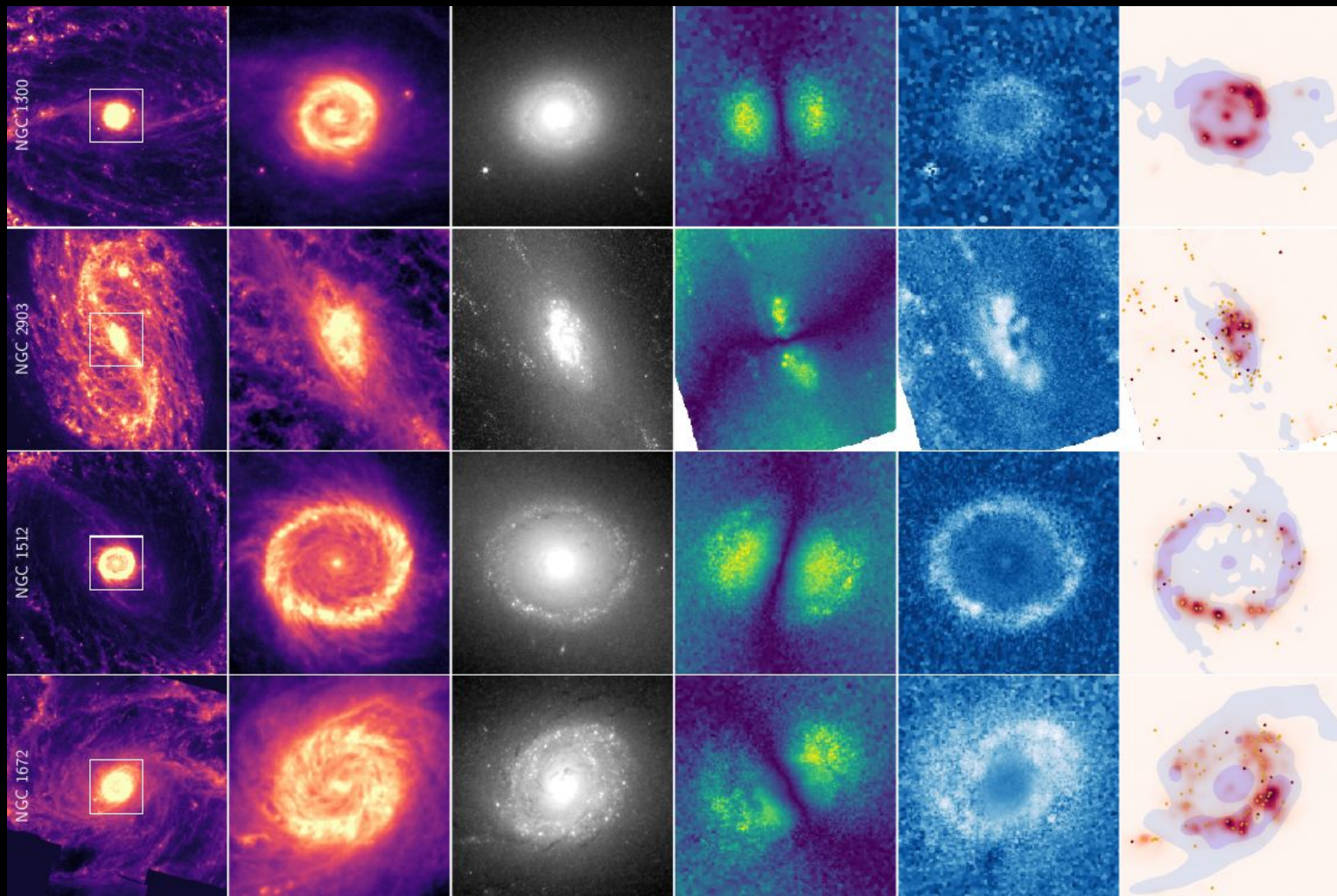


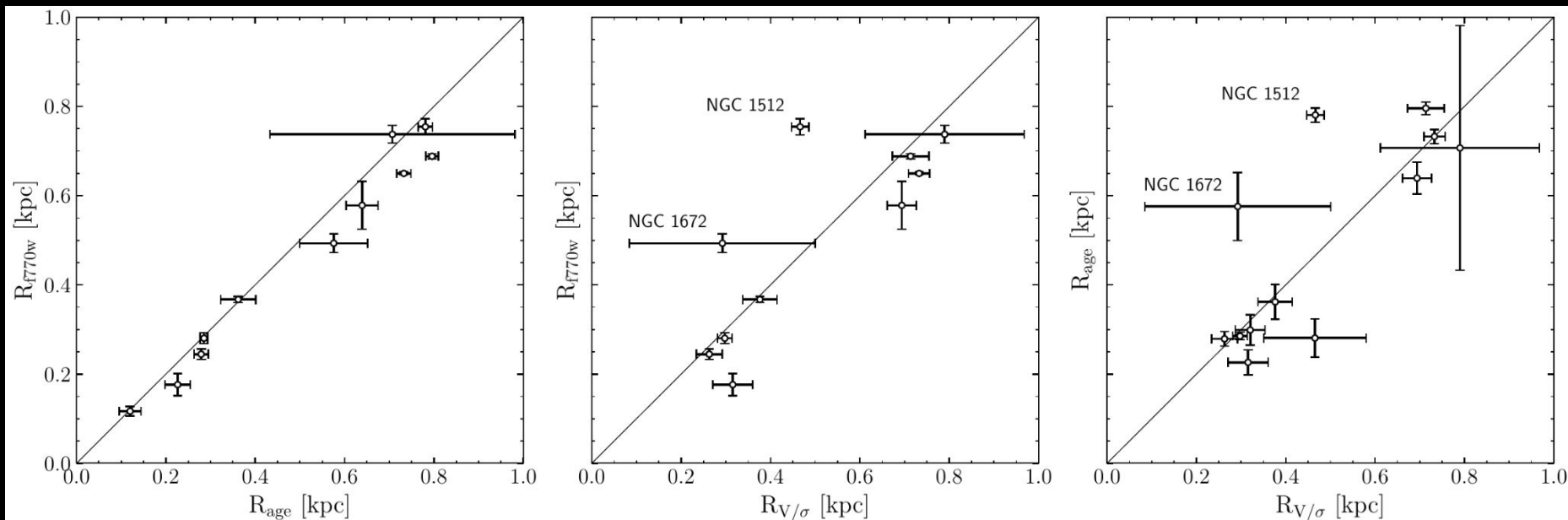
MUSE - stellar age









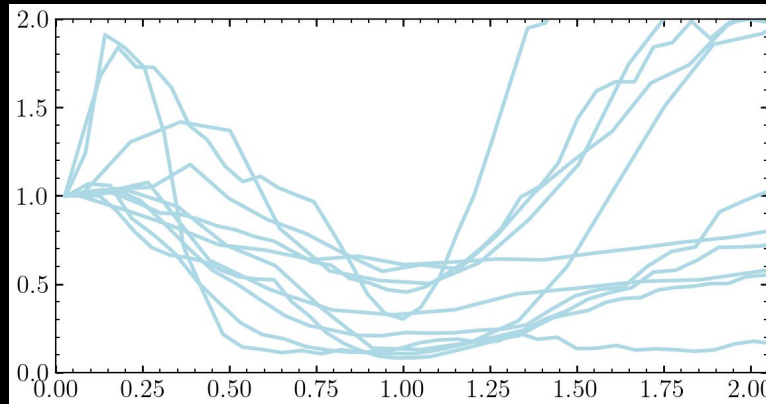


Sizes are matching: Gas rings are at the outer edge of nuclear stellar discs  
Nuclear discs form within gas rings



# Inside-out formation scenario

- Matching sizes across a sample covering bars in different evolutionary stages  
Cross-match with de Sa-Freitas+in prep. (Dimitri Gadotti's talk on Wednesday):  
7 bars of ages between 0.7 and 10.5 Gyr
- Negative age gradients inside the nuclear discs:



Neumann+in prep.  
See also Bittner+2020

- Location of gas rings is correlated with the location of an Inner Lindblad Resonance  
Radius of ILR seems to be moving outward with time (Verwilghen+in prep.)

Stars form in gas ring => ring grows with time => stellar disc grows inside-out

# Conclusions

- Dusty central gas rings are the outer edge of fast-rotating nuclear stellar discs!
  - Stars form in these rings
  - Sizes and age gradients suggest an inside-out formation:
  - As the bar evolves, the ring grows and the nuclear stellar disc grows
- All barred galaxies (in our sample) with  $M_{\star} > 10^{10} M_{\odot}$  have gas rings and nuclear stellar discs
- None of the low-mass galaxies develops neither a ring nor a disc
  - We see the same both in observations (Neumann+in prep., Emsellem+in prep.) and simulations (Verwilghen+2024 and in prep.)
- What next?
  - Can we learn more from the structure, morphology & mass of the rings?  
=> Emsellem+in prep. & Gleis+ in prep
  - What happens inside nuclear discs/rings?  
How is gas driven further inwards?

