

# Bridging **observations** and **simulations**: insights from **MAGPI** galaxies and mock data cubes

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**MAGPI**



MUSE-10 Workshop, 19 Nov 2024

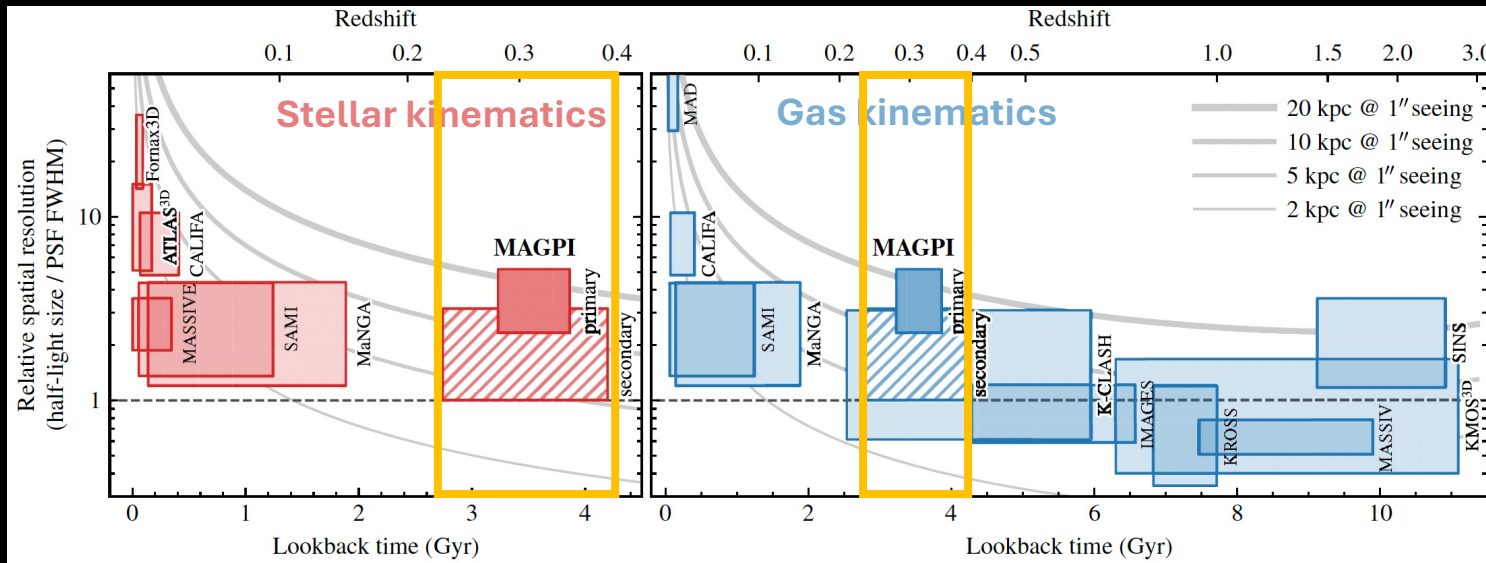
Image credits: NASA, ESA, CSA, Steve Finkelstein (UT Austin)



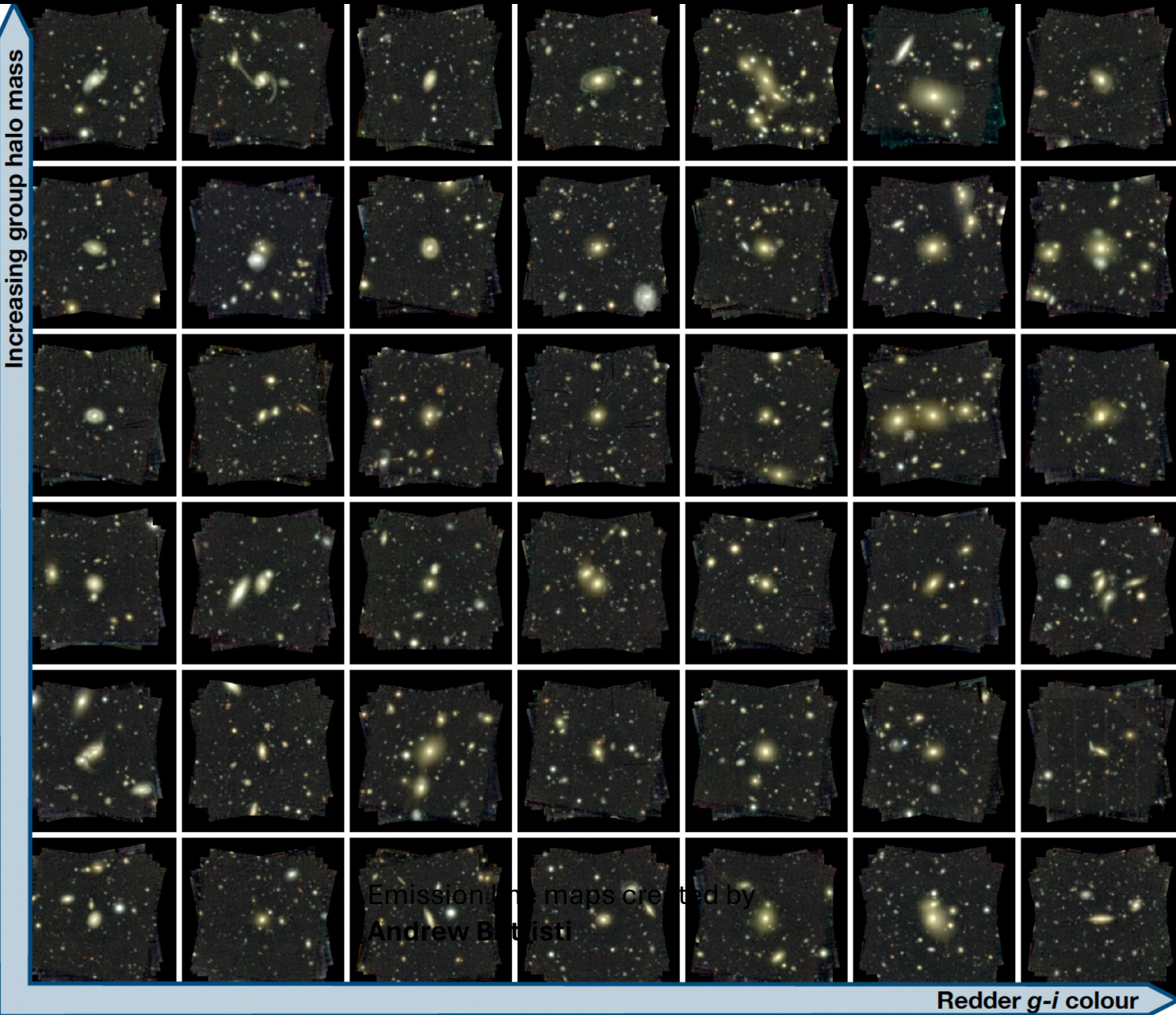
# The MAGPI survey



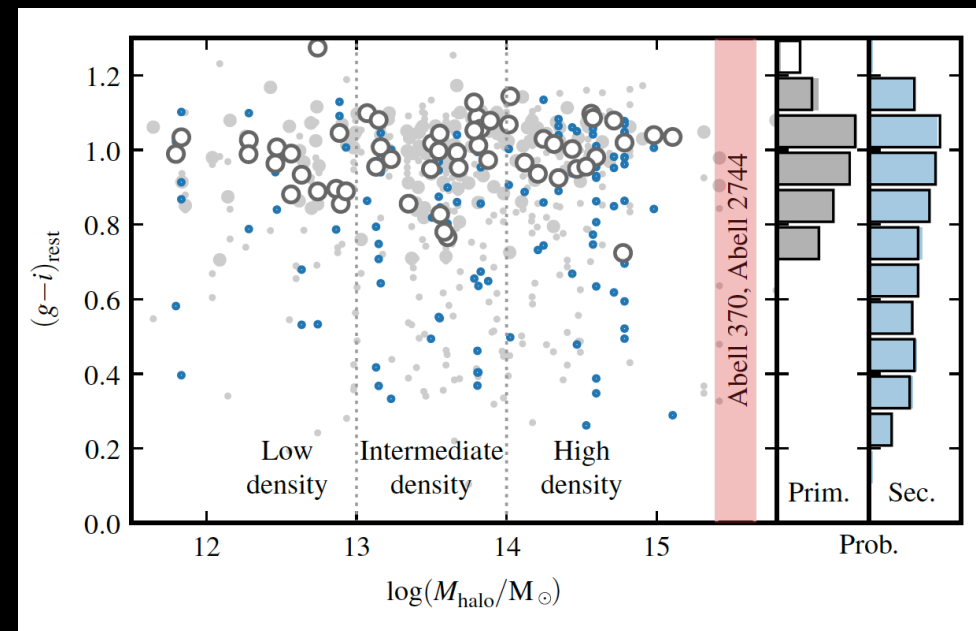
Foster+2021



- The **M**iddle **A**ges **G**alaxy **P**roperties with **I**ntegral Field Spectroscopy survey
- **ESO VLT/MUSE** Large Program

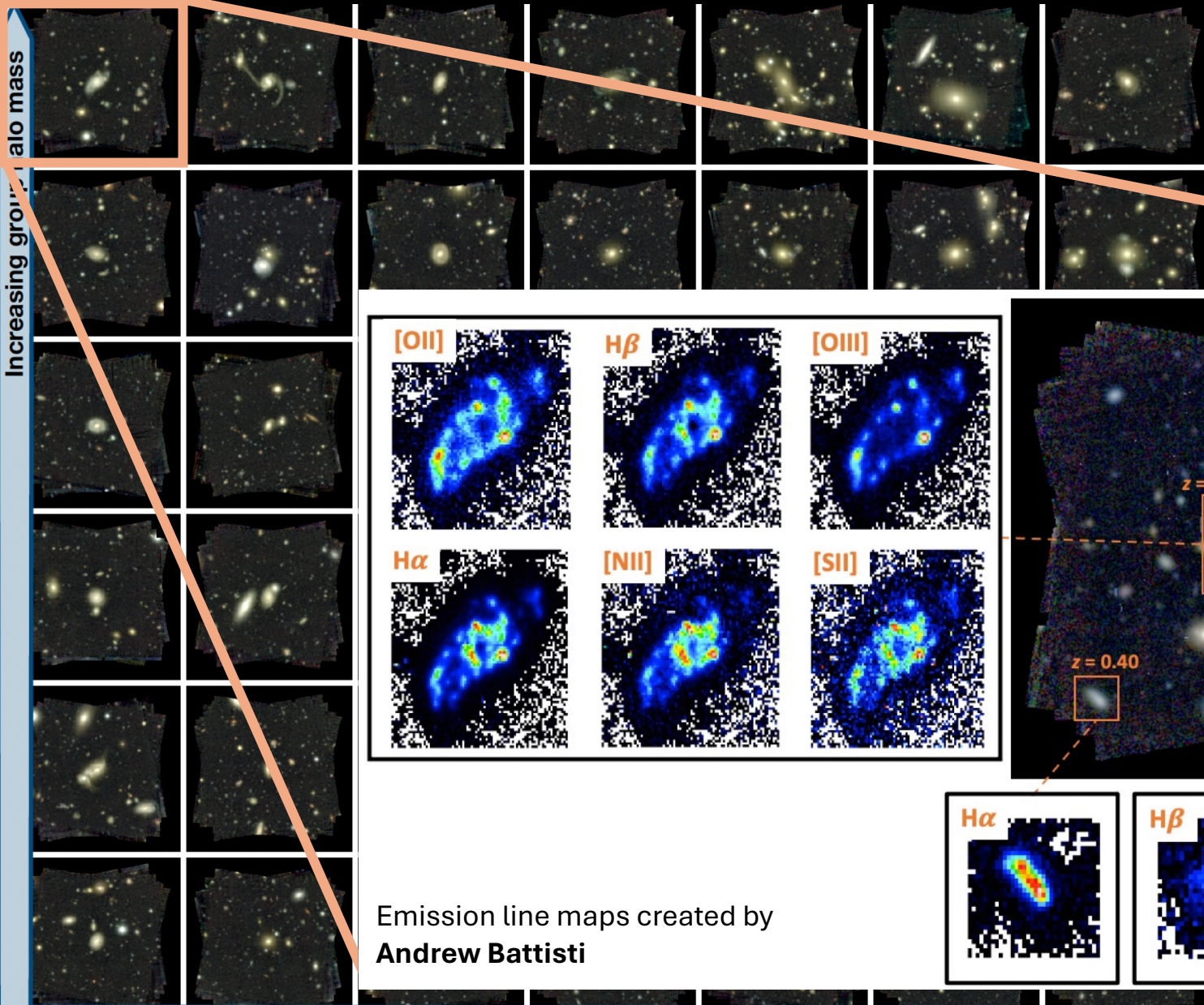


*gri* images  
created by  
**Trevor Mendel**

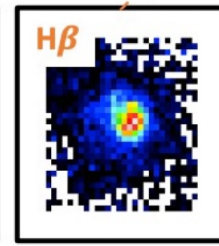
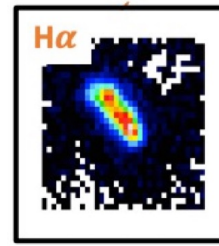
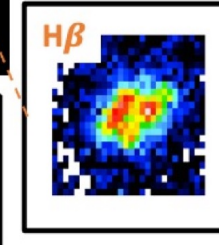
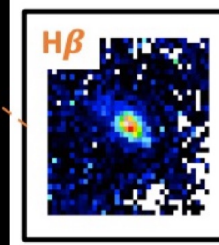
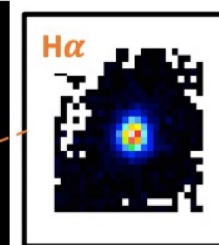
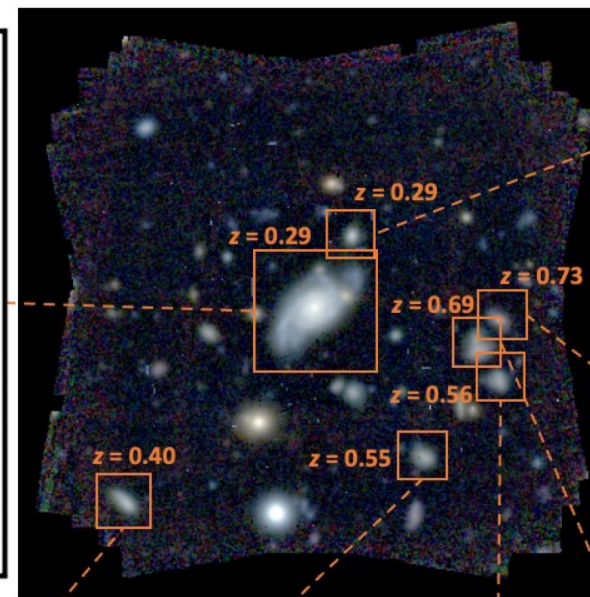
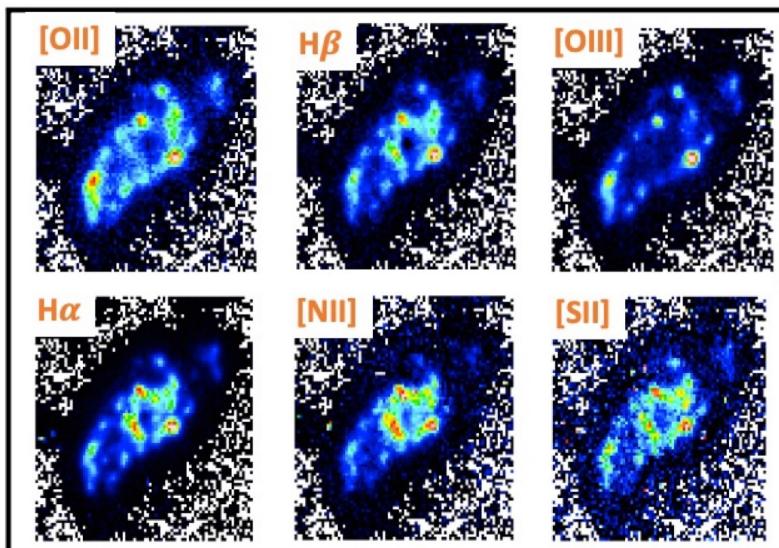


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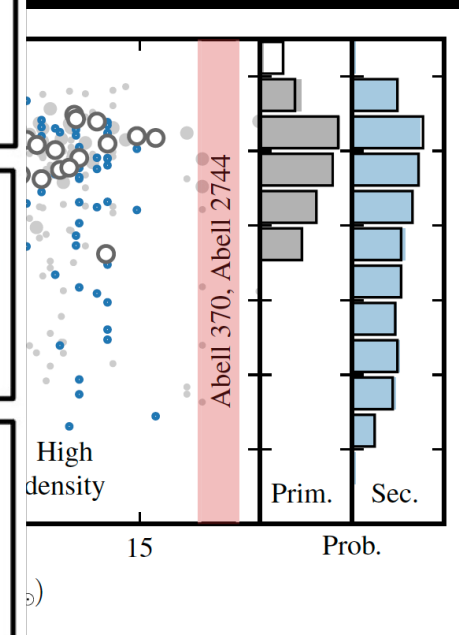




*gri* images  
created by  
**Trevor Mendel**



Emission line maps created by  
**Andrew Battisti**



Foster+2021

Redder *g-i* colour

# Bridging the low- and high- $z$ universes

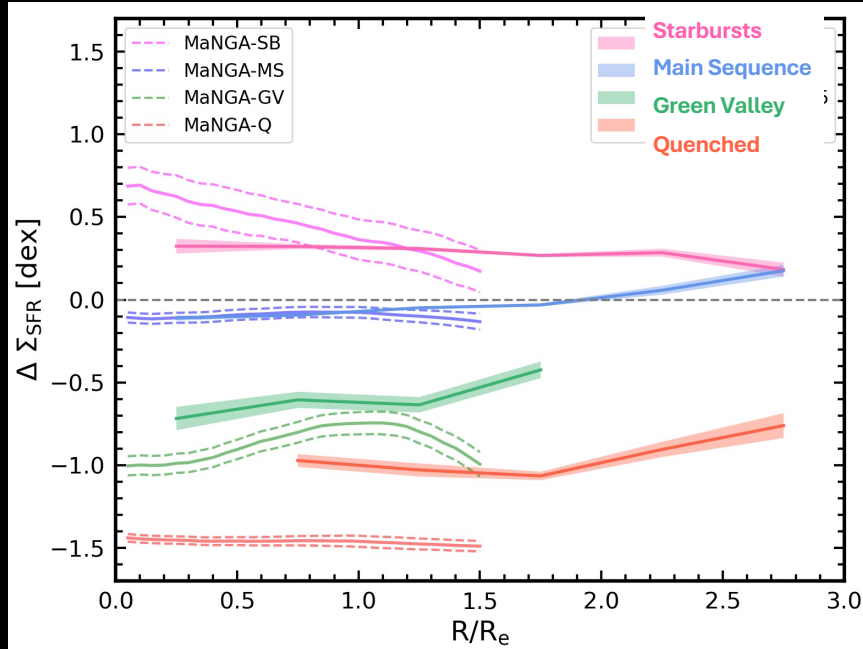


MAGPI

$z \sim 0.3$

Local Universe

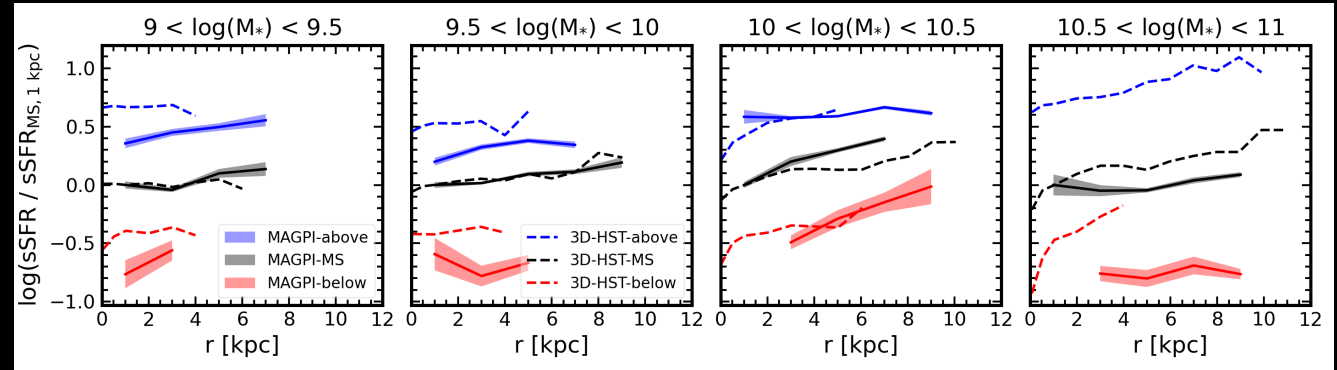
$z \sim 0$



MaNGA – Bluck+2020b

Cosmic Noon

$z \sim 1 - 2$



$$s\text{SFR} = S\text{FR} / M_*$$

3D-HST – Nelson+2016

Overall **flat profiles**, although **increasingly centrally depressed** with **increasing mass** (similar results for  $z \sim 2$ : Tacchella+2015, 2018)

**Central enhancement in starbursts**  
captured at  $z \sim 0$ , but **not at higher  $z$**

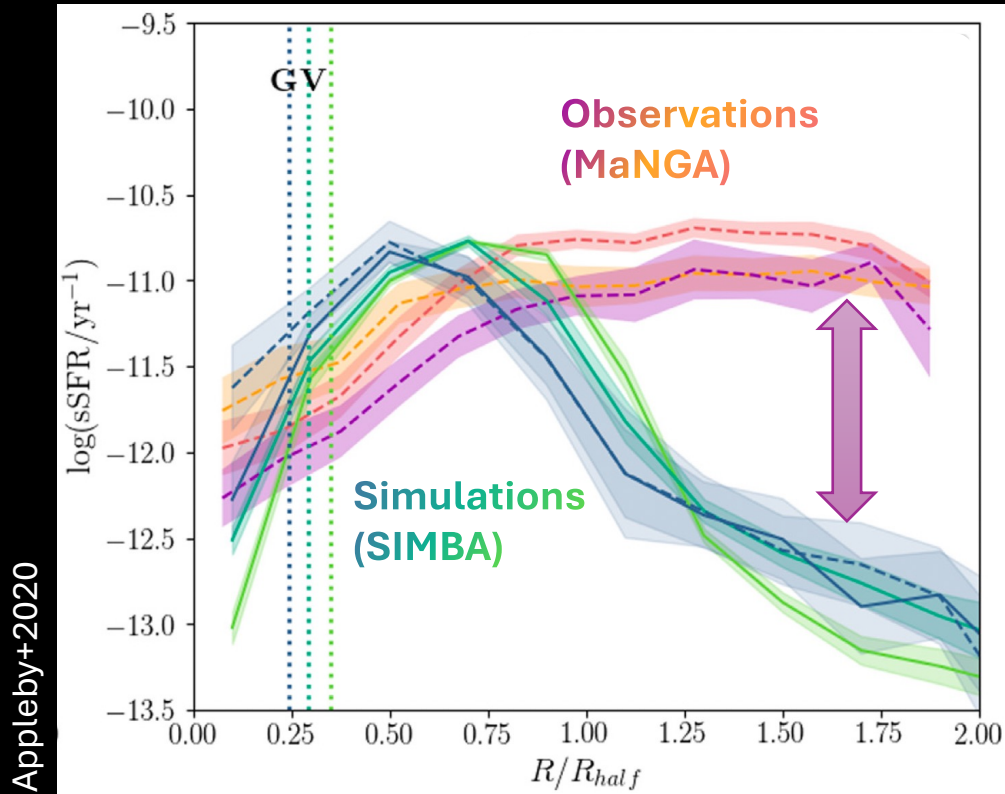


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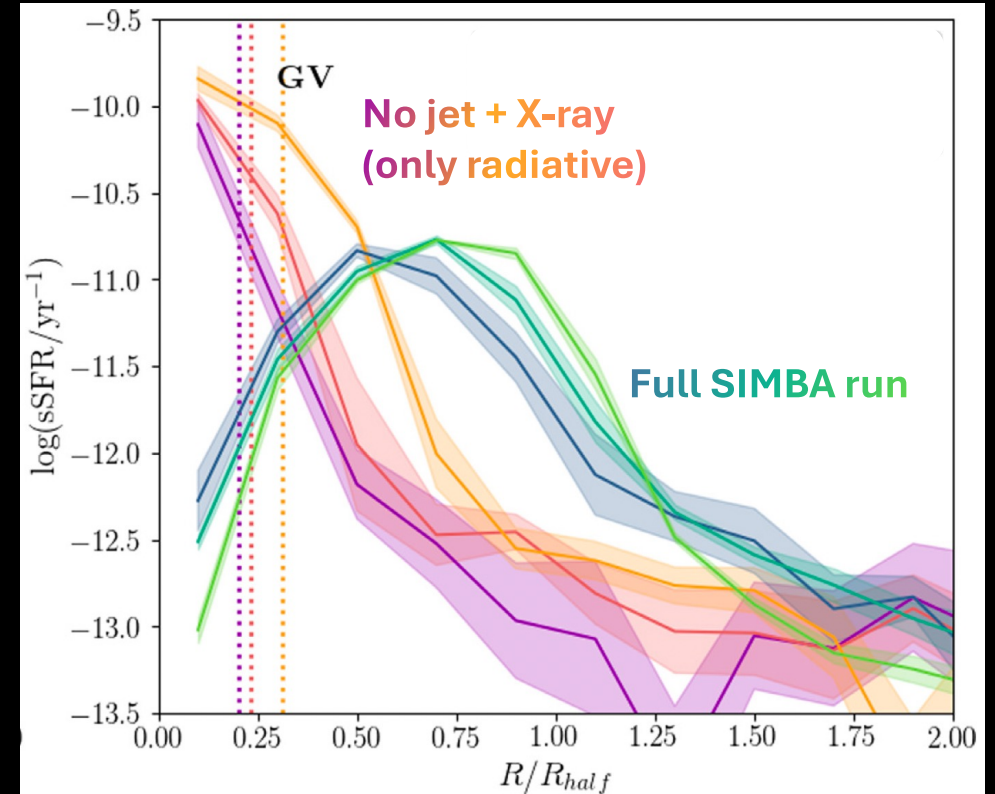


# Predictions from cosmological simulations

\*Based on  $z \sim 0$  observations of **green valley** galaxies.



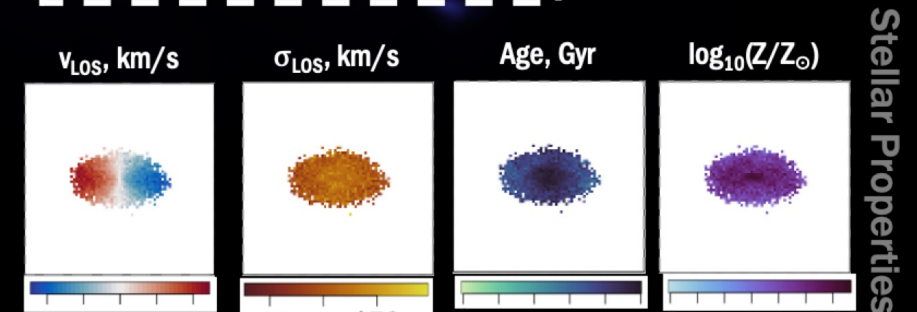
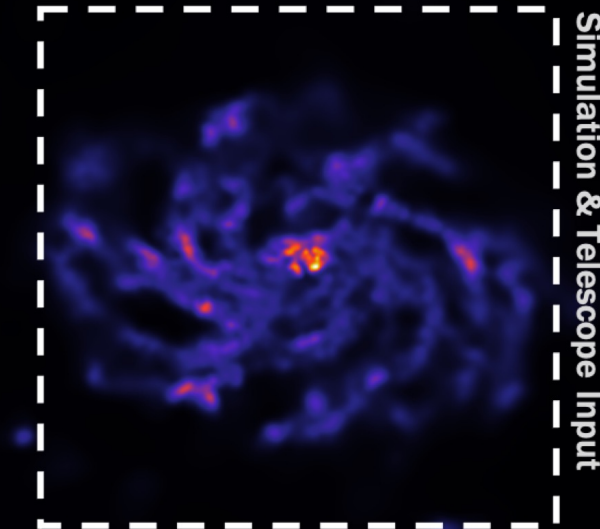
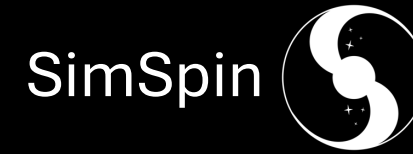
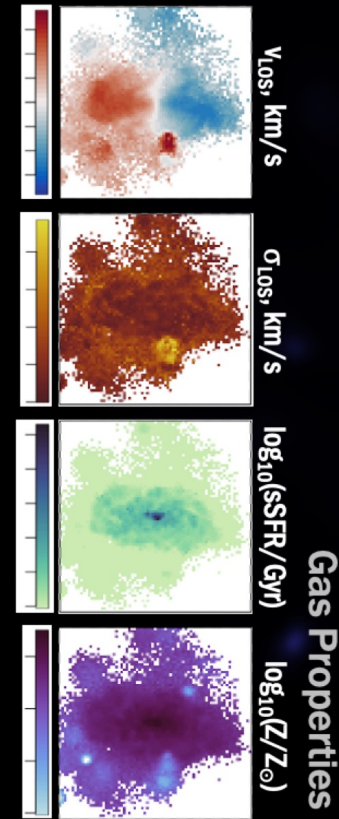
Simulated galaxies show signs of **outside-in quenching** (e.g., Starkenburg+2019), which are **not observed in real galaxies** at the **same epoch**.



But simulations can **constrain the physical processes** at play where trends agree qualitatively (**i.e., central suppression**).

# MAGPI Simulation Suite

- An **apples-to-apples comparison** between observations and simulations
  - Mock data cubes with **observing conditions applied**
    - PSF blurring, spatial resolution matching
- Agnostic to the type of simulation input, matched to the **instrument of choice (e.g., MUSE for MAGPI)**



Code developed by **Kate Harborne**  
SimSpin papers: **K.E. Harborne+2020, 2023**  
<https://kateharborne.github.io/SimSpin>

# MAGPI Simulation Suite

- Application of **SimSpin** to a **suite of large-scale cosmological simulations** with **different recipes for subgrid physics**

Simulation	Box run	Hydrodynamics	Box size (cMpc <sup>3</sup> )	z	$\langle m_{\star} \rangle$ (M <sub>⊙</sub> )
EAGLE	REF-L100N1504	SPH (GADGET3+ANARCHY)	100 <sup>3</sup>	0.271	$1.8 \times 10^6$
MAGNETICUM	BOX4-UHR	SPH (GADGET3)	68.2 <sup>3</sup>	0.293	$1.8 \times 10^6$
ILLUSTRISTNG	TNG100-1	MVM (AREPO)	110.7 <sup>3</sup>	0.298	$1.4 \times 10^6$

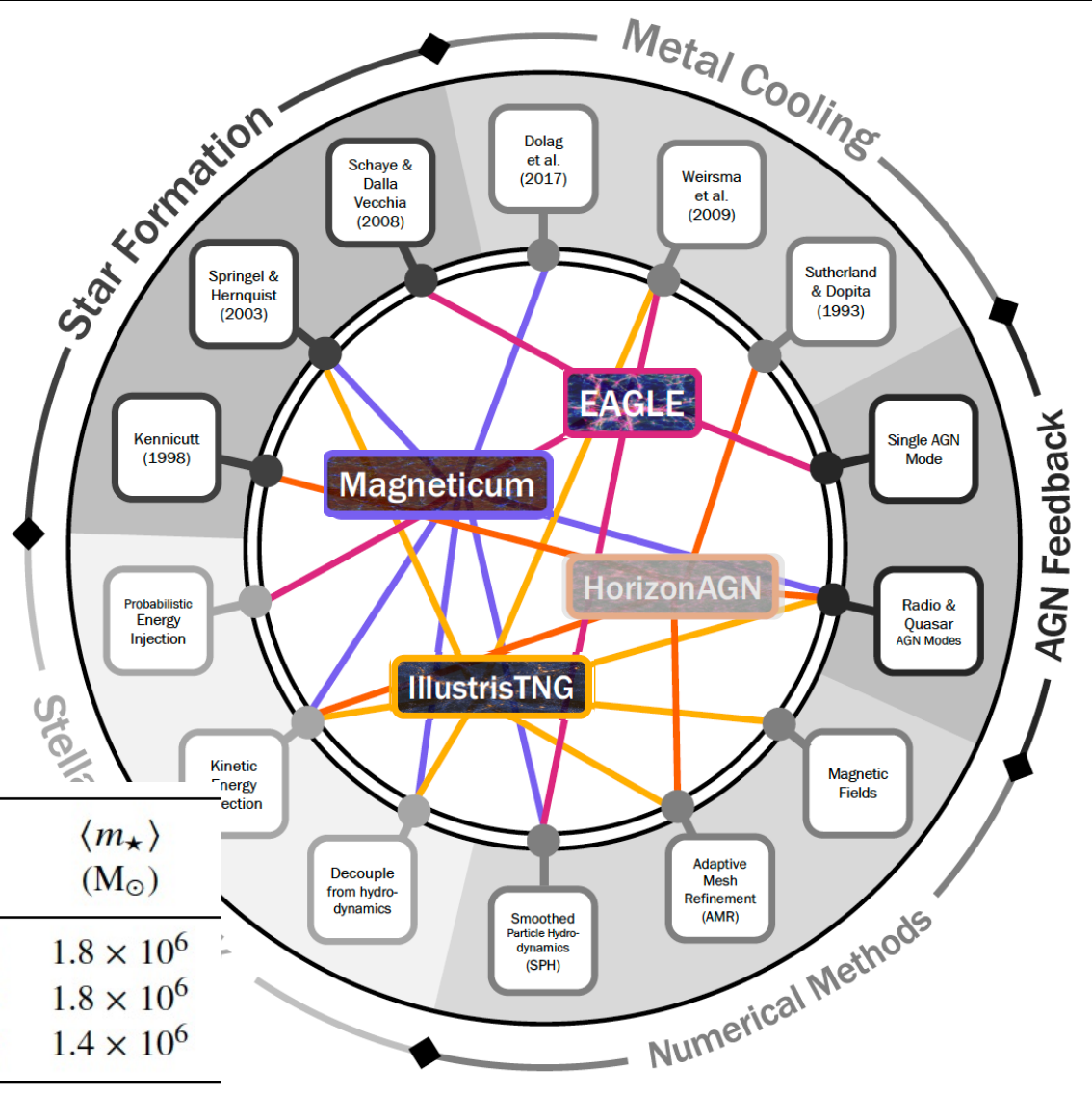
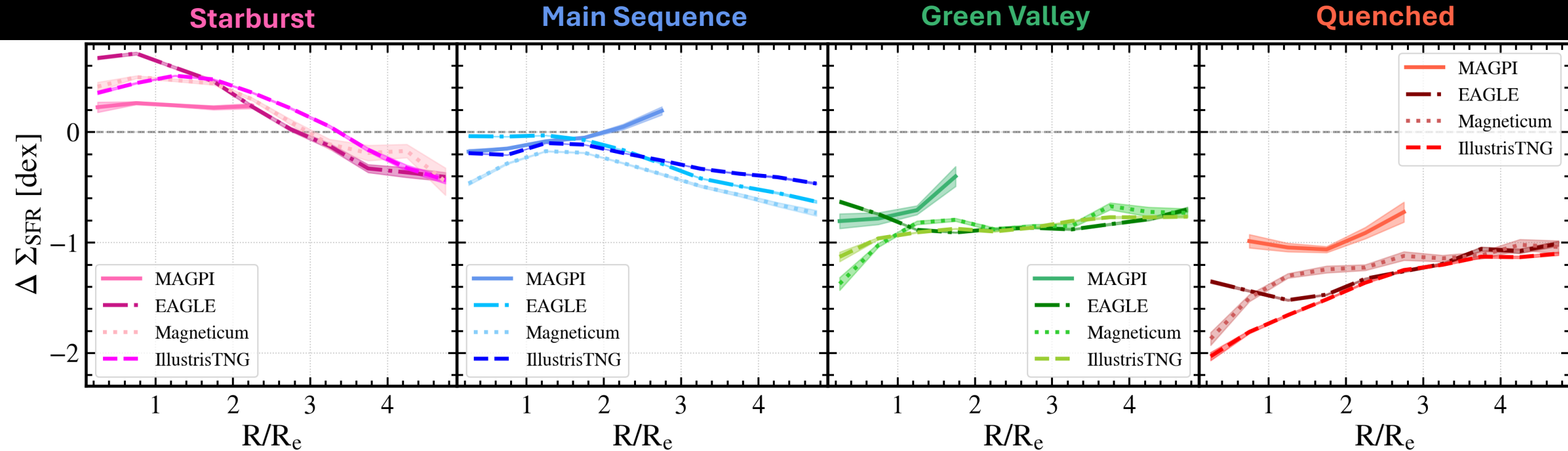


Image credit: **Kate Harborne**



# MAGPI vs. simulations

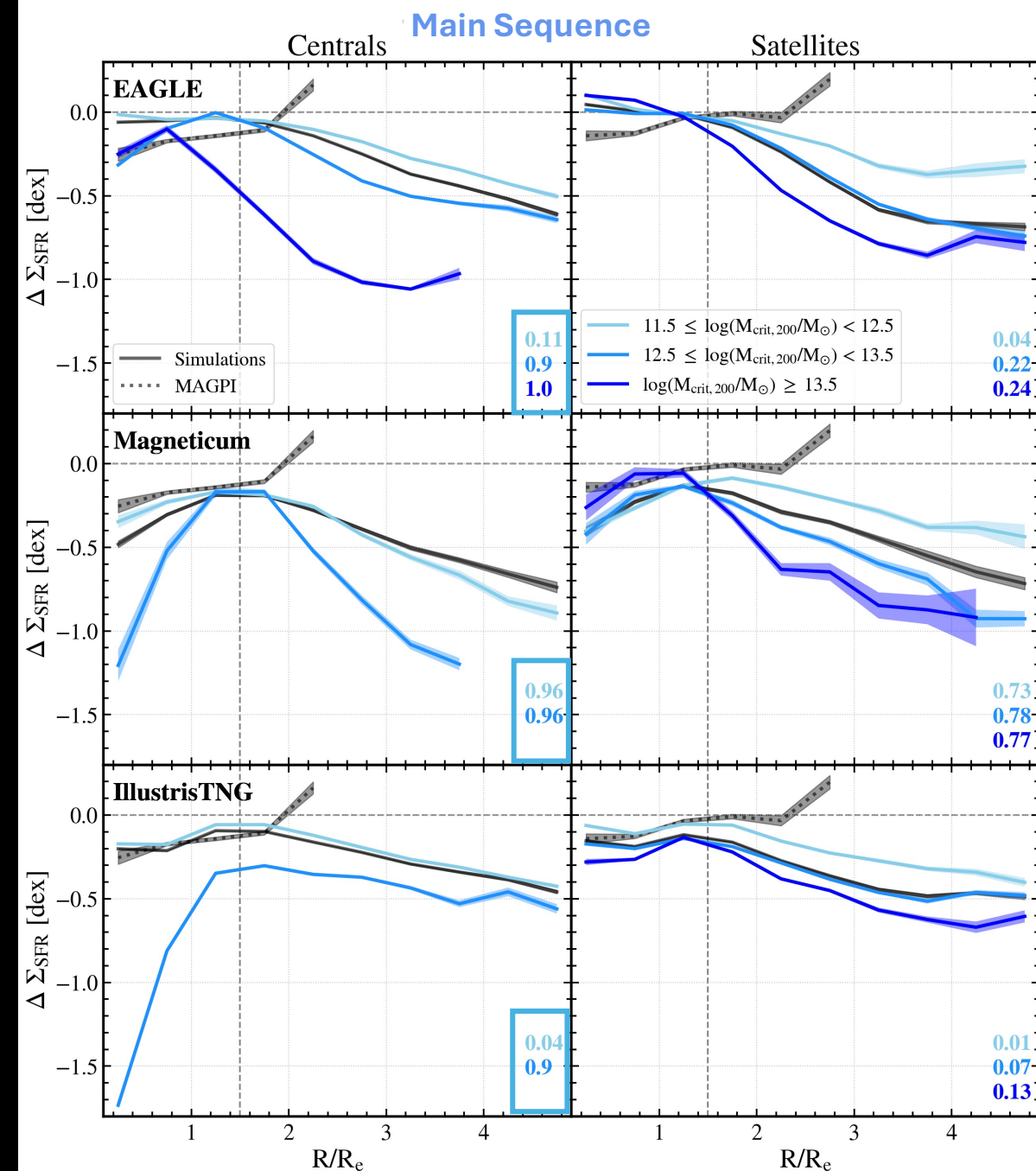
Mun+ in prep.



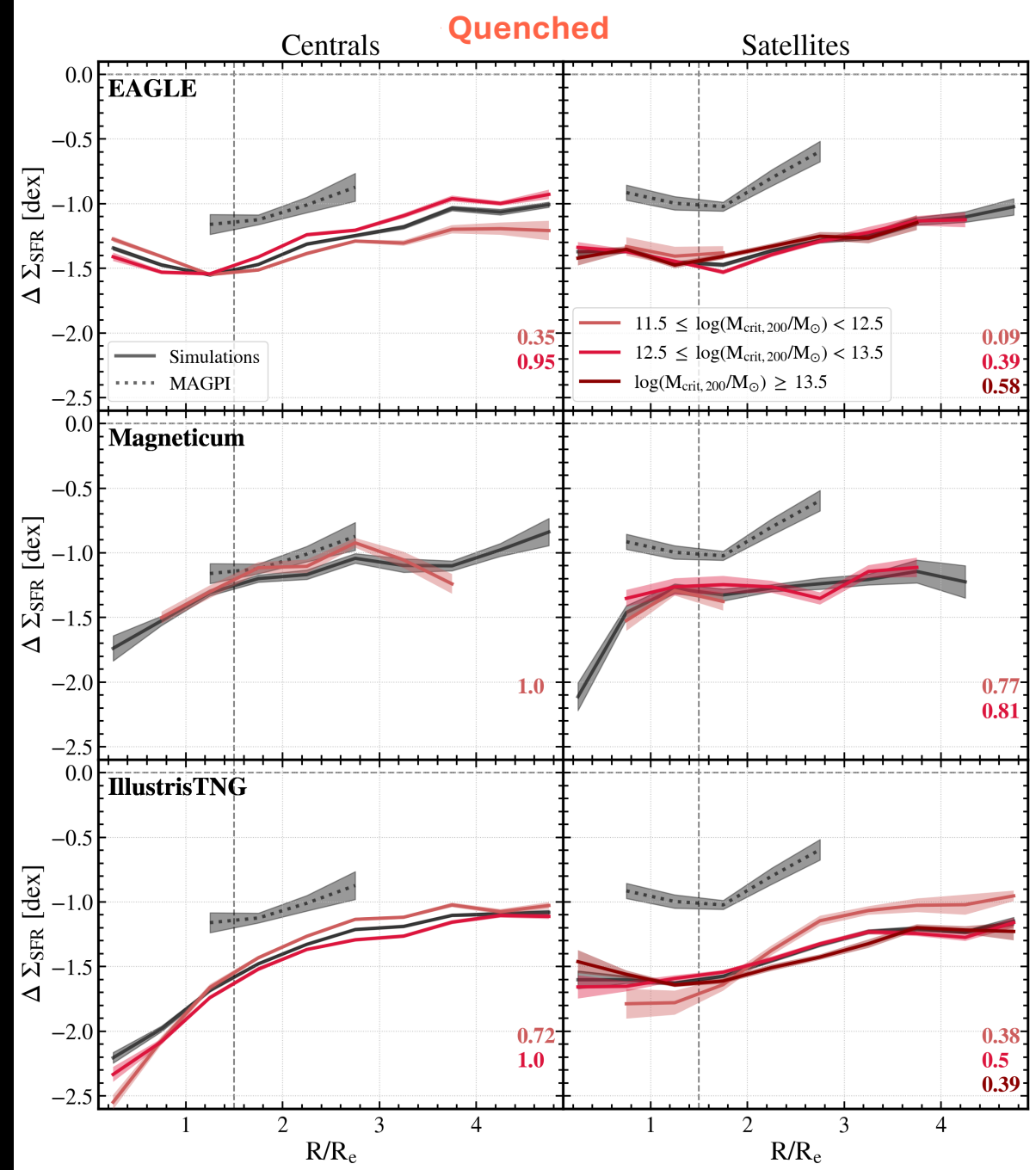
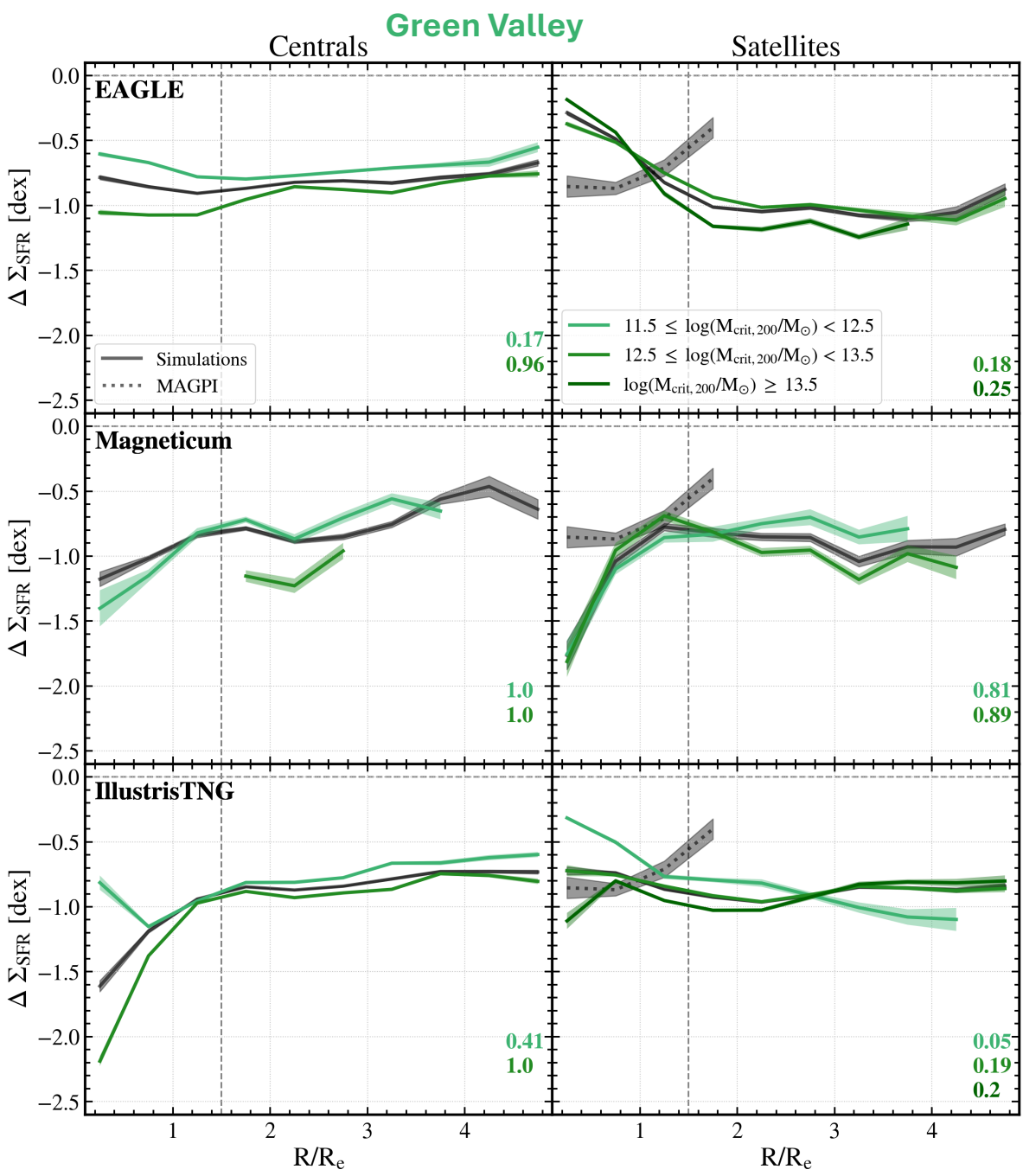
- Different **degrees of central suppression** predicted by **different simulations** ➤ likely due to **AGN feedback recipes**
- Generally, **no agreement** between MAGPI observations and simulations, **except for the quenched population**.

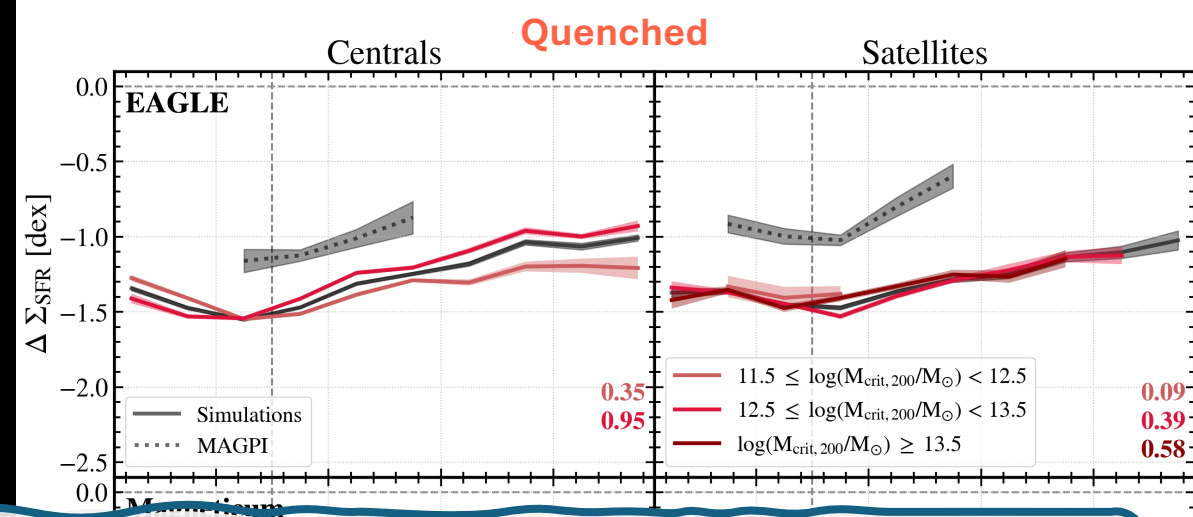
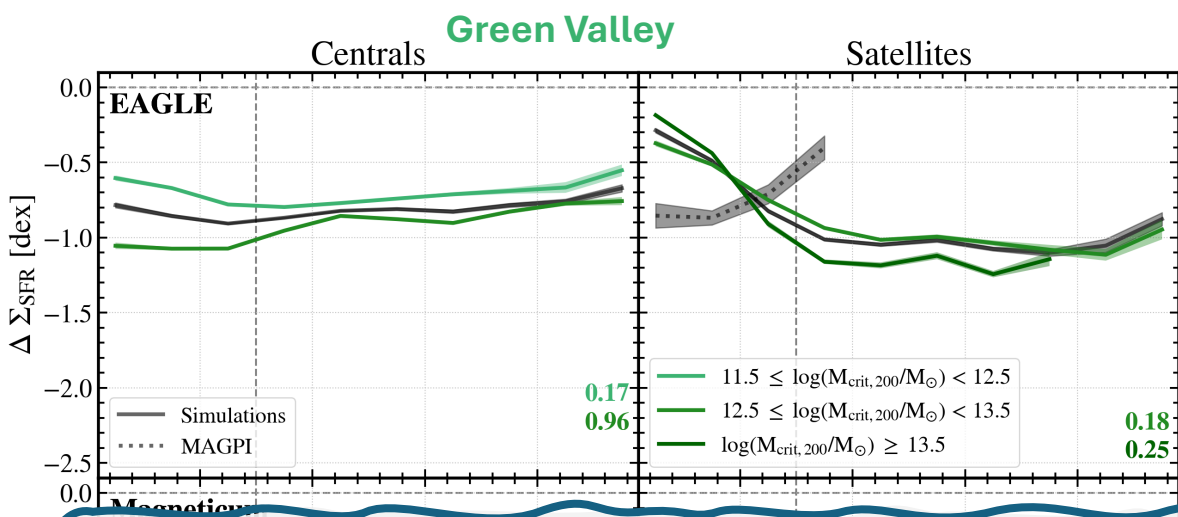
# AGN feedback & environment

- **MAGPI**: both centrals and satellites are **quenching inside-out**.
- All simulations measure **increasingly suppressed SF in the outskirts** with **increasing halo mass** ➤ environmental effects
- **Only centrals** show strong dips in SF in the centre ➤ AGN feedback
  - Fraction of galaxies with strong AGN increases with halo mass

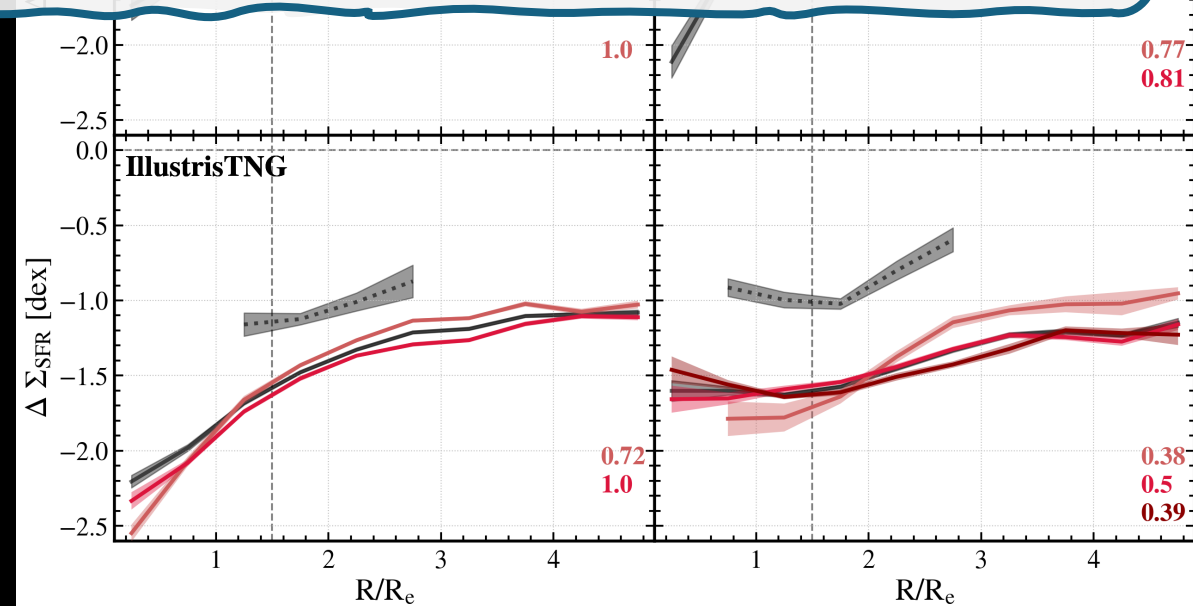
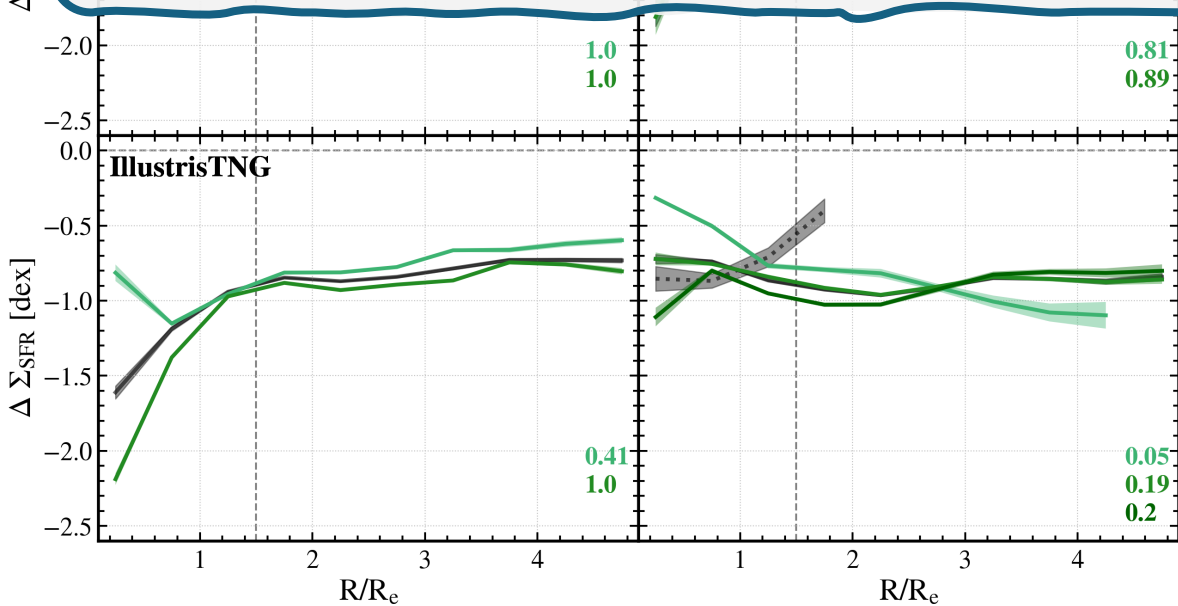








Once a galaxy has already been **quenched globally**, the environmental dependence (**central/satellite status, halo mass**) of the trends disappear.





# What we know from simulations

Nelson+2021

- Different implementations of AGN feedback at work

➤ **EAGLE**: single heating mode

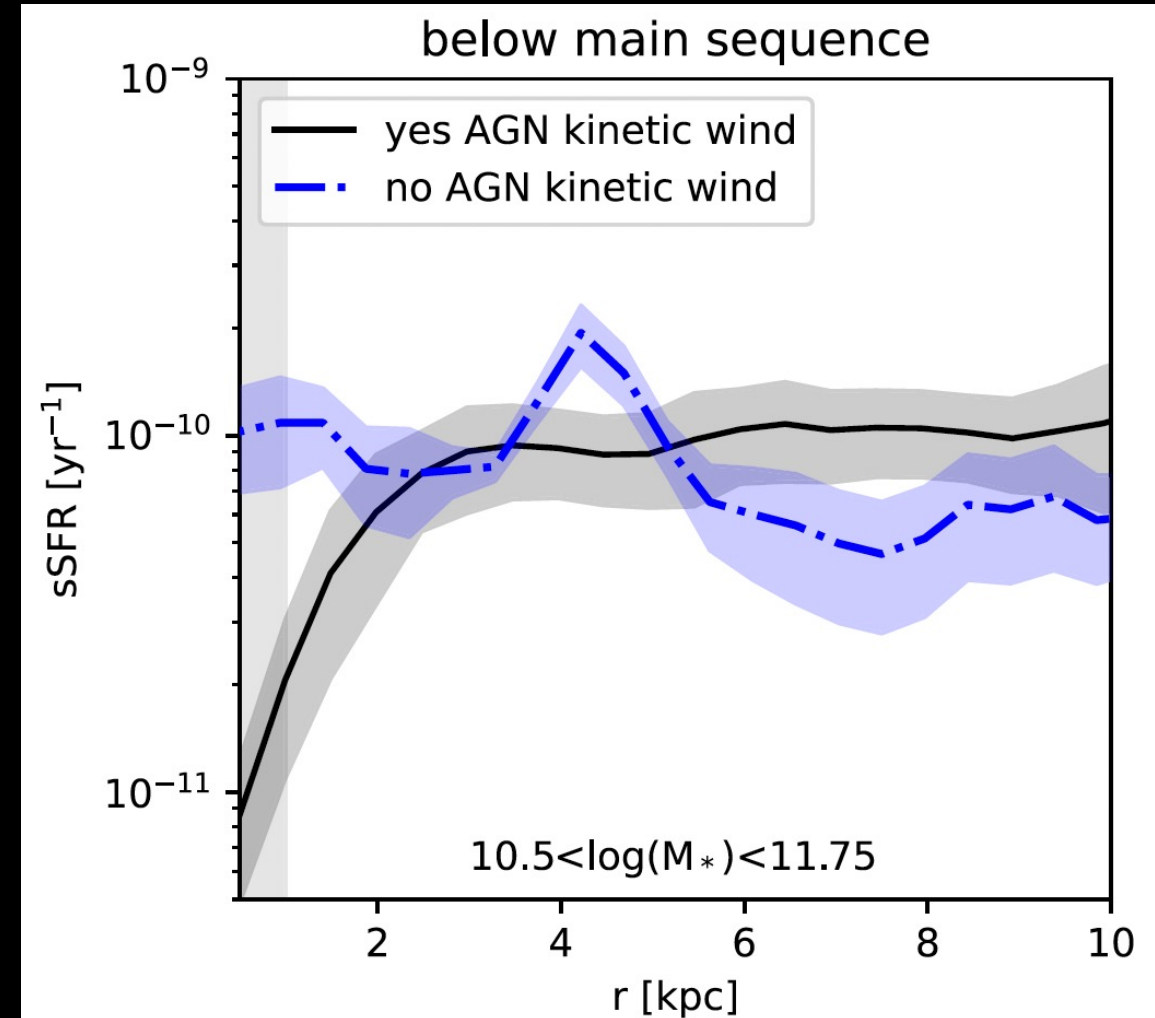
- ❖ Particularly effective for  $M_* > 3 \times 10^{10} M_{\text{sun}}$  (Bower+2017)

➤ **Magneticum**: dual mode – radio & quasar

- ❖ No known mass-dependent threshold

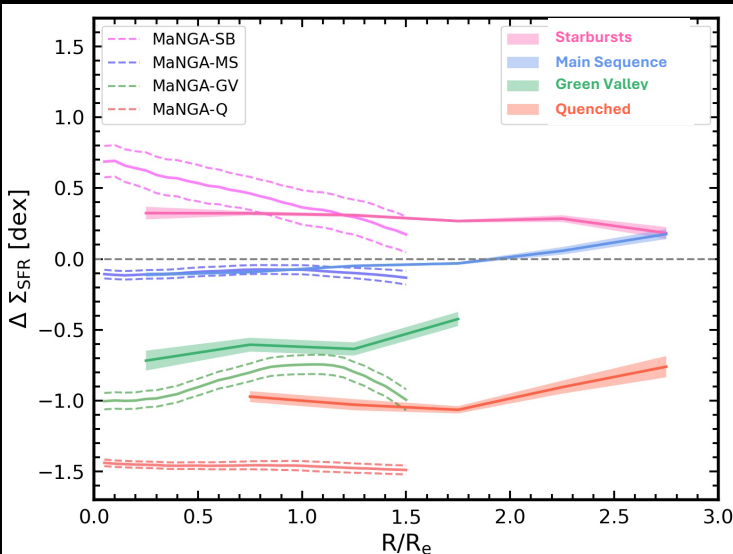
➤ **TNG**: dual mode – kinetic wind + thermal feedback

- ❖ Kinetic feedback: responsible for quenching galaxies with BH mass  $> 10^{8.2} M_{\text{sun}}$  (Terrazas+2020)

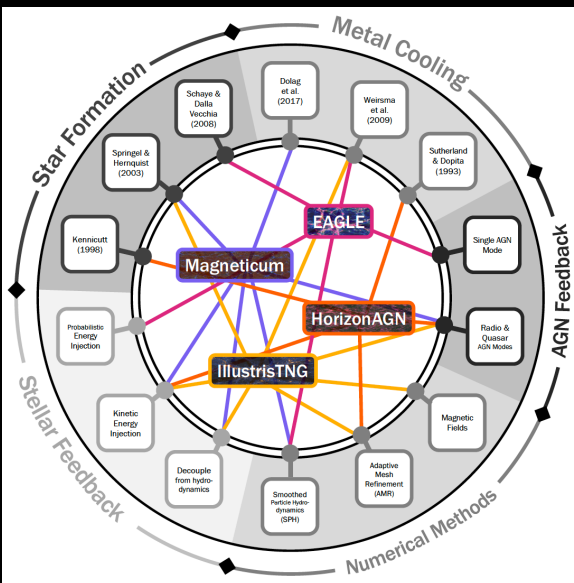


# Summary

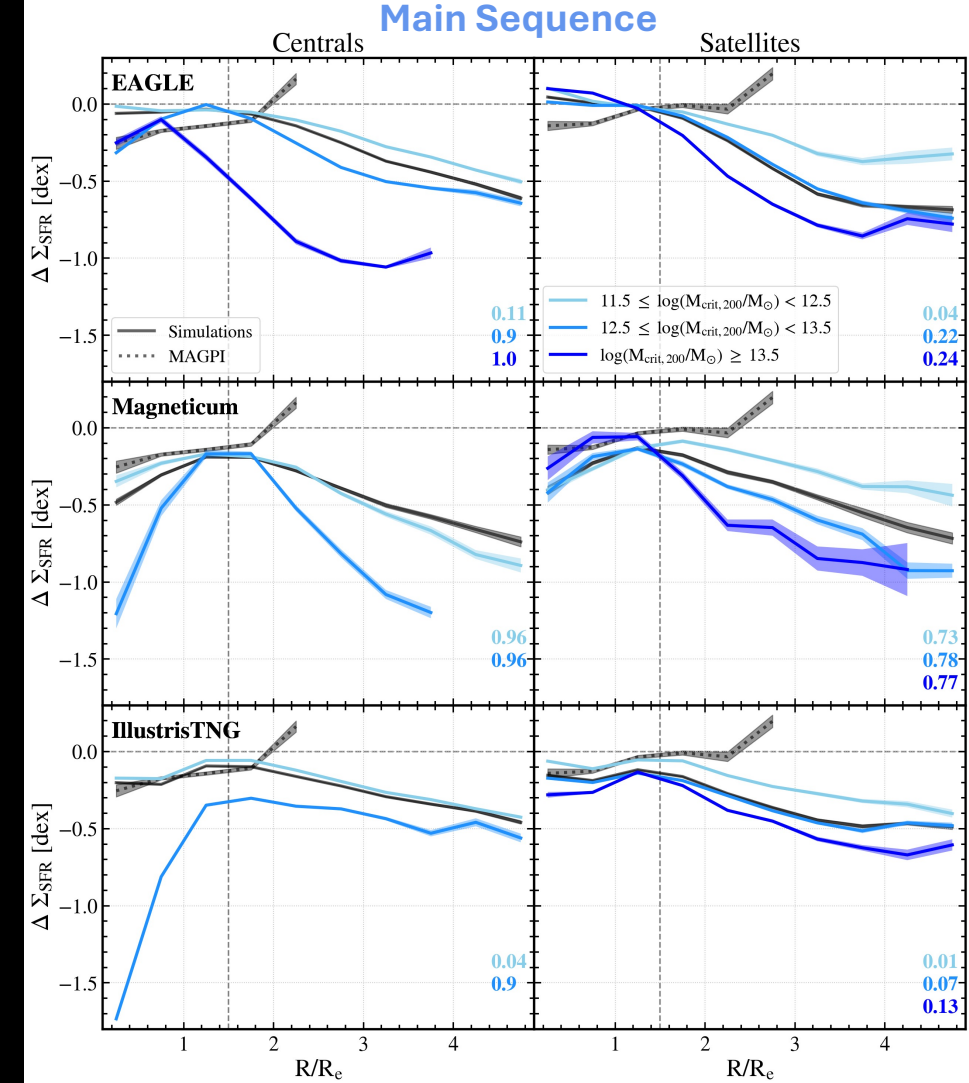
jaeyeon.mun@anu.edu.au



In Mun+2024 we captured an **evolution from flat to centrally enhanced SF for starburst galaxies** from  $z \sim 1$  to  $z \sim 0$ .



We have now extended our work towards **a suite of cosmological simulations** where we perform as much of an **apples-to-apples comparison** as possible (e.g., PSF blurring)



We capture **good agreement in qualitative trends in the simulations, but not with MAGPI**. Notable differences in the **degree of central suppression** are found, likely due to **different AGN feedback recipes**.