THE GENTLE GAS CIRCULATION OF PRESENT-DAY STAR FORMING GALAXIES

A. Marasco - INAF, Padova observatory

(and many co-authors)

GALCROSS, Brno, 17/09/2024

gentle gas circulation in starburst dwarf galaxies

A. Marasco, F. Belfiore, G. Cresci, F. Lelli, G. Venturi, L. K. Hunt, F. Mannucci, M. Mingozzi, A. F. McLeod, N. Kumari, S. Carniani, L. Vanzi, M. Ginolfi, *A&A 670, A92, 2023*

GALCROSS, Brno, 17/09/2024

The DWALIN sample

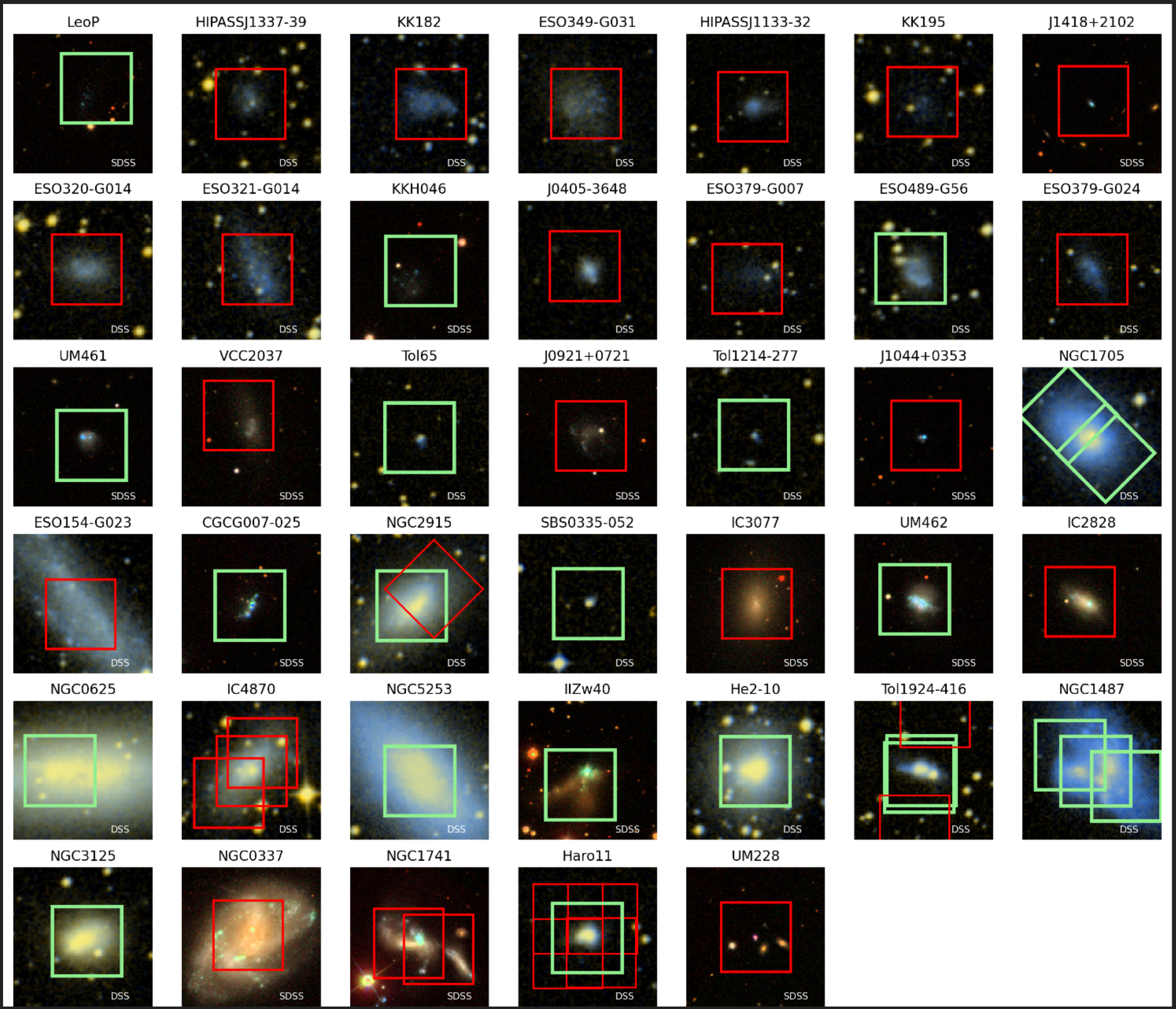
DWarf galaxies
Archival
Local survey for
Interstellar medium
investigatio**N**

From either

Herschel Dwarf Galaxy Survey
(Cormier+15)

Local volume galaxy catalogue
(D<11 Mpc, $M_\star < 10^9 M_\odot$)
(Karachentsev+13)

+ archival MUSE data



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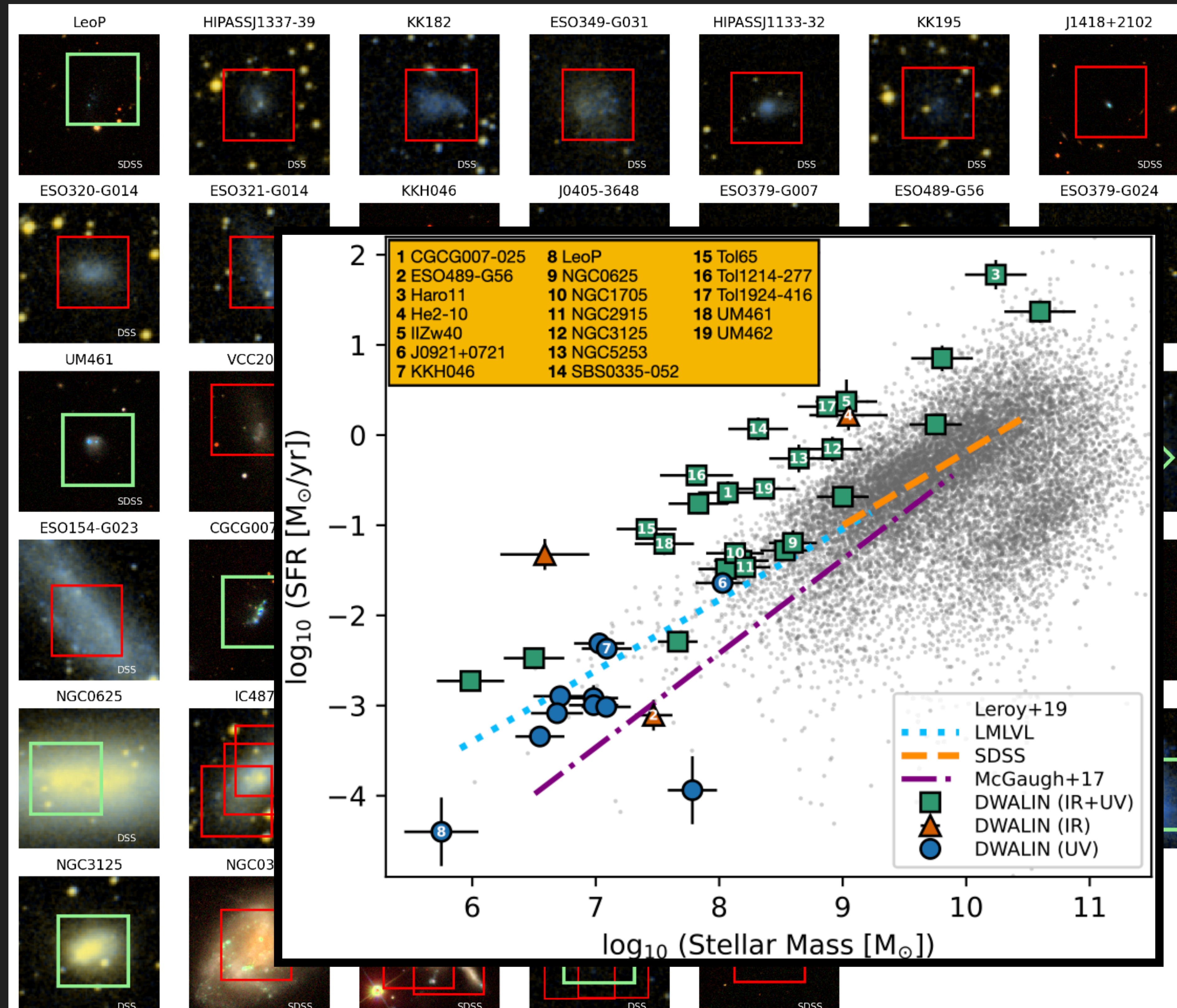
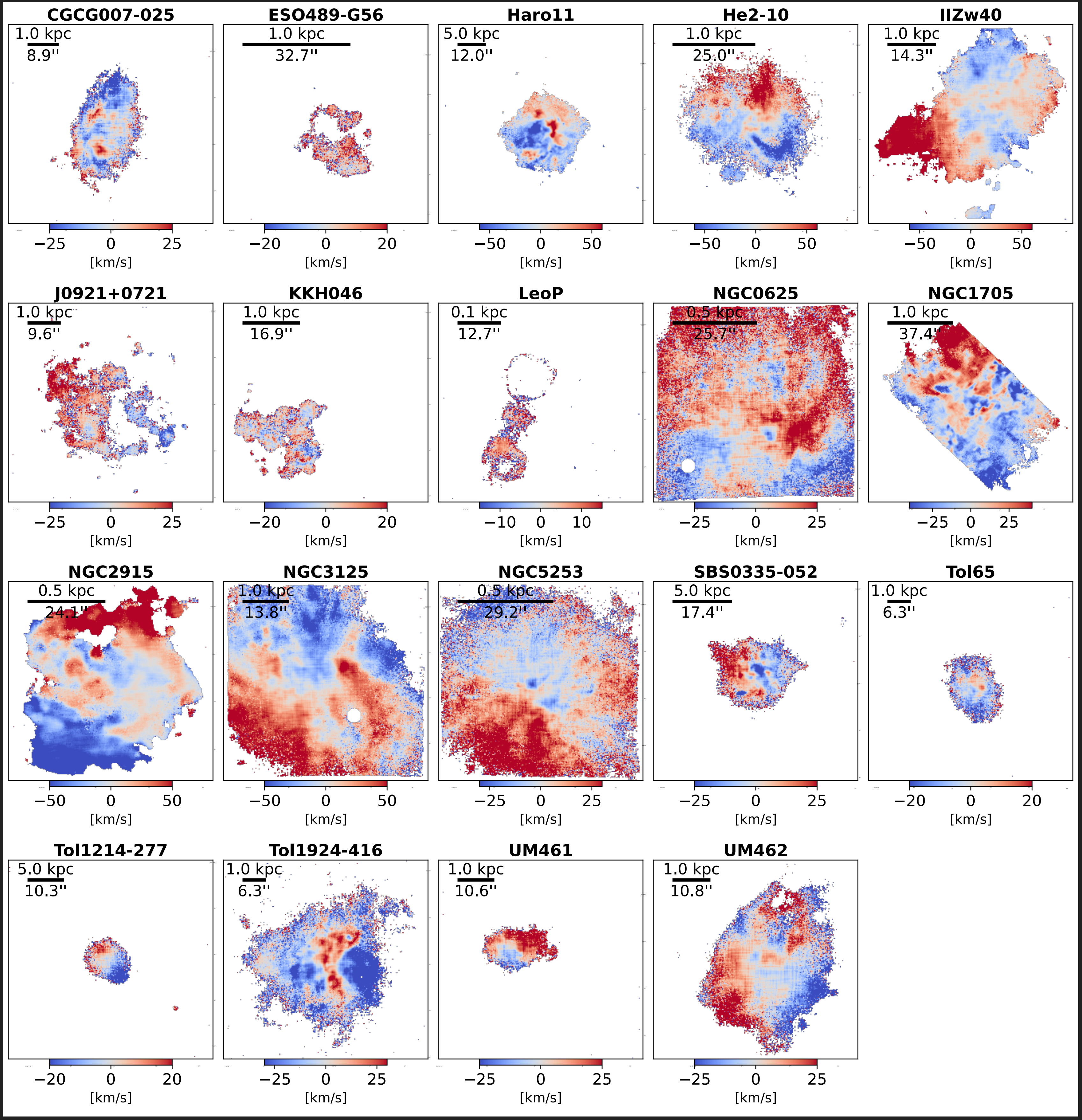


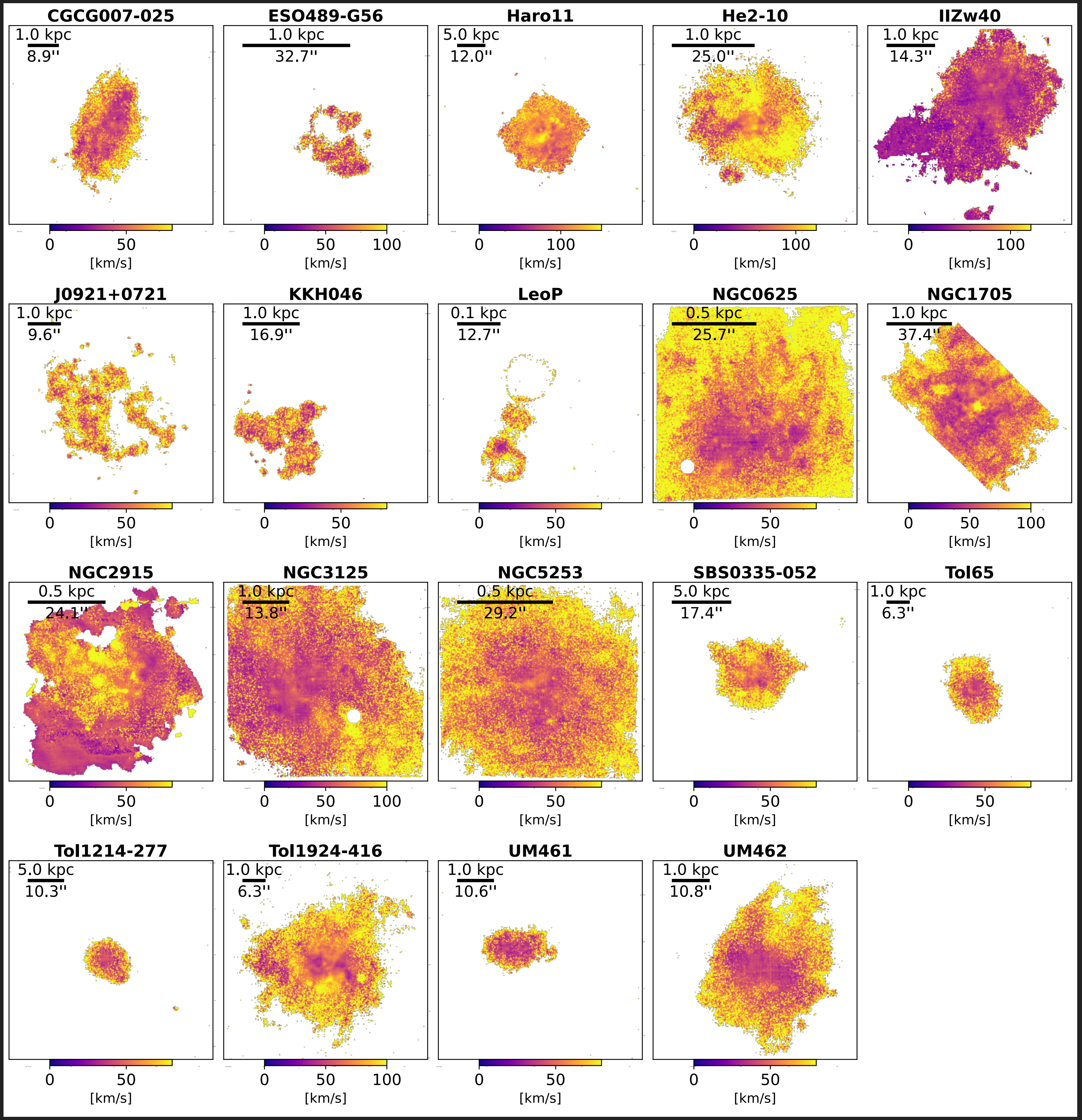
ionised gas kinematics

DWALIN - velocity fields



ionised gas kinematics

DWALIN - velocity dispersion maps



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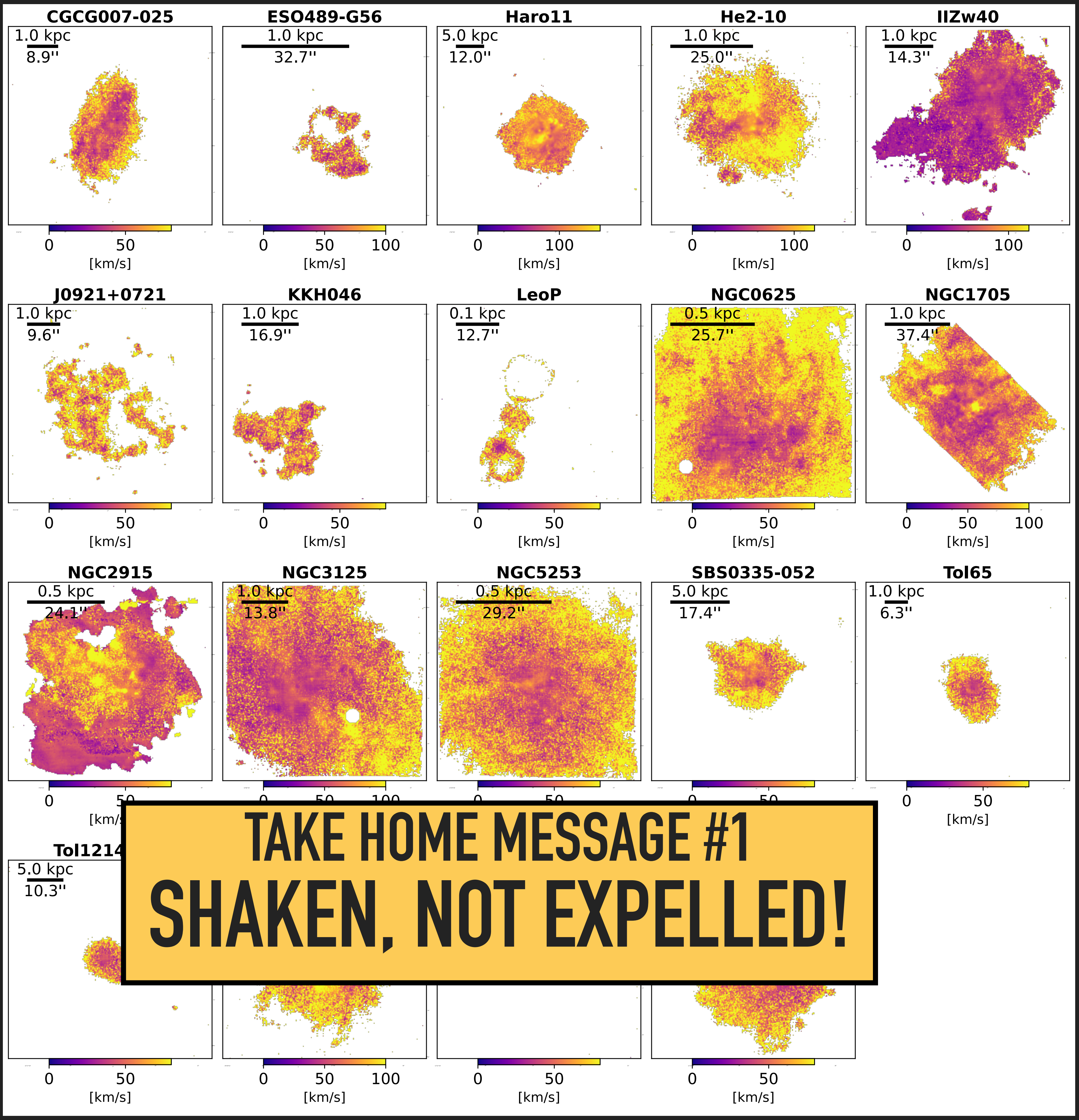


TAKE HOME MESSAGE #1

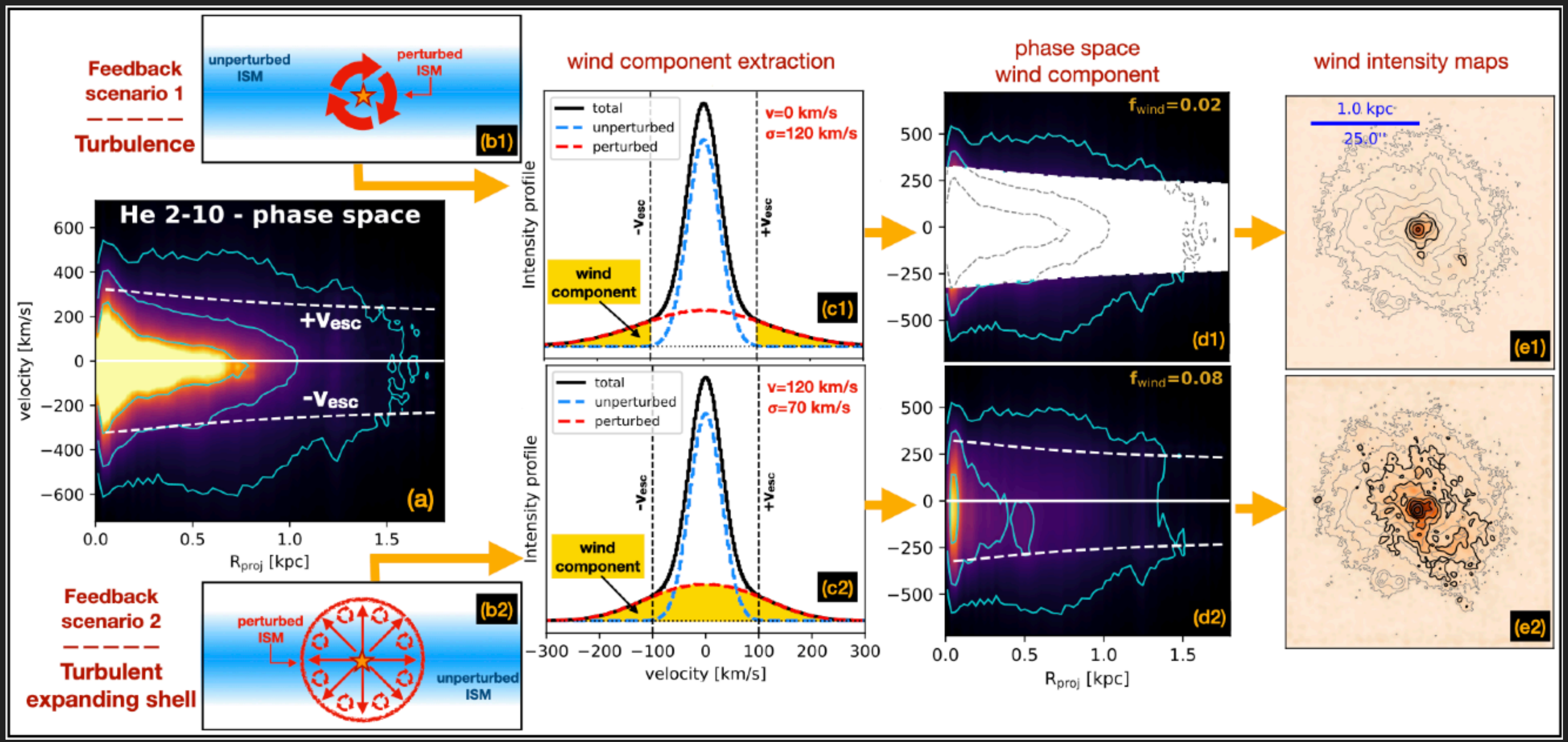
SHAKEN, NOT EXPELLED!

ionised winds

“wind”: gas at velocities ~ escape speed

ionised winds

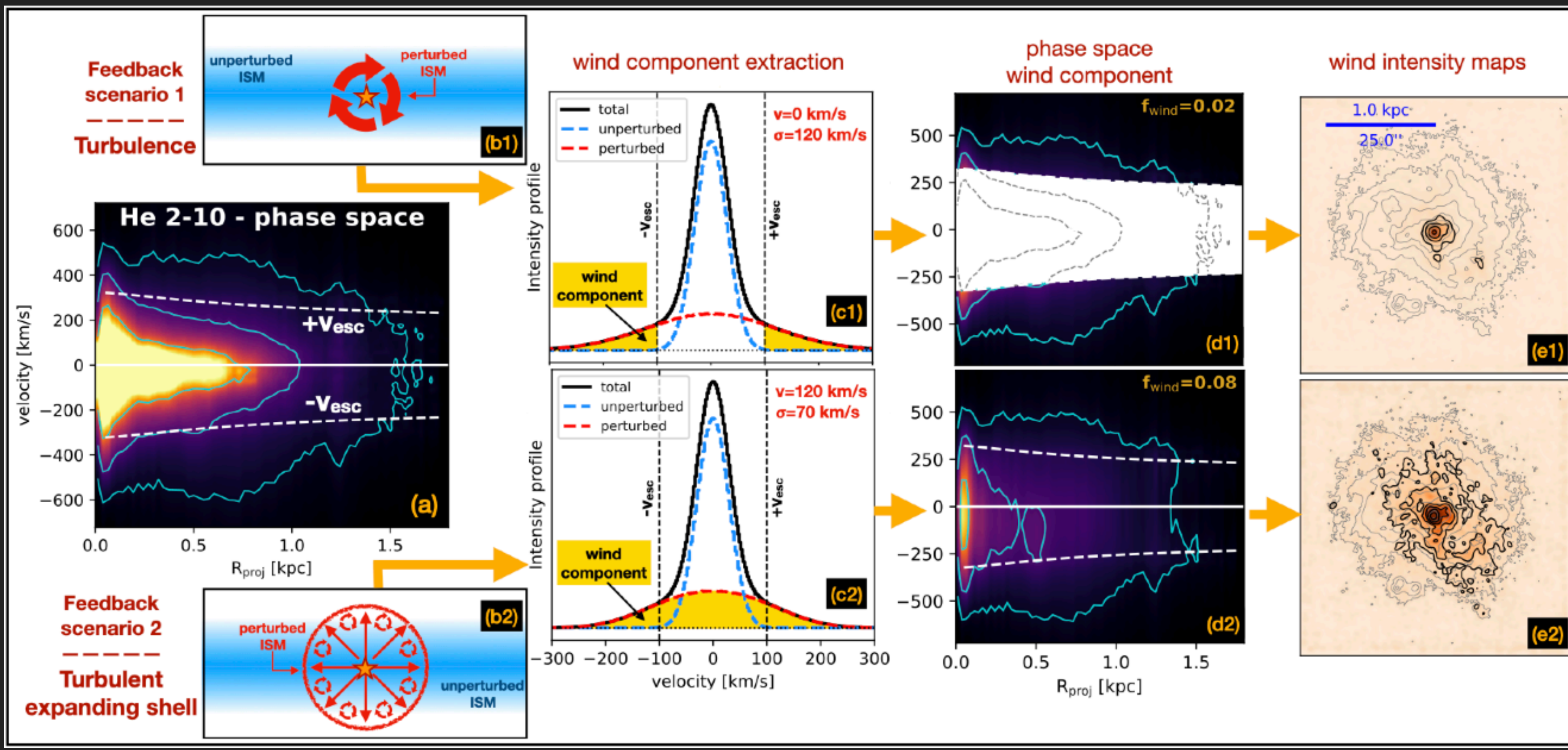
"wind": gas at velocities ~ escape speed



- Wind selected in the phase space
- v_{esc} profiles from mass model
- Wind mass from average of two methods, depending on the feedback scenario assumed

ionised winds

"wind": gas at velocities ~ escape speed



- Wind selected in the phase space
- v_{esc} profiles from mass model
- Wind mass from average of two methods, depending on the feedback scenario assumed

- Spherical or multi-cone geometry
- Constant velocity during the flow time

$$\dot{M}_{out} = \mathcal{H}\frac{M_{out}v_{out}}{R_{out}}$$

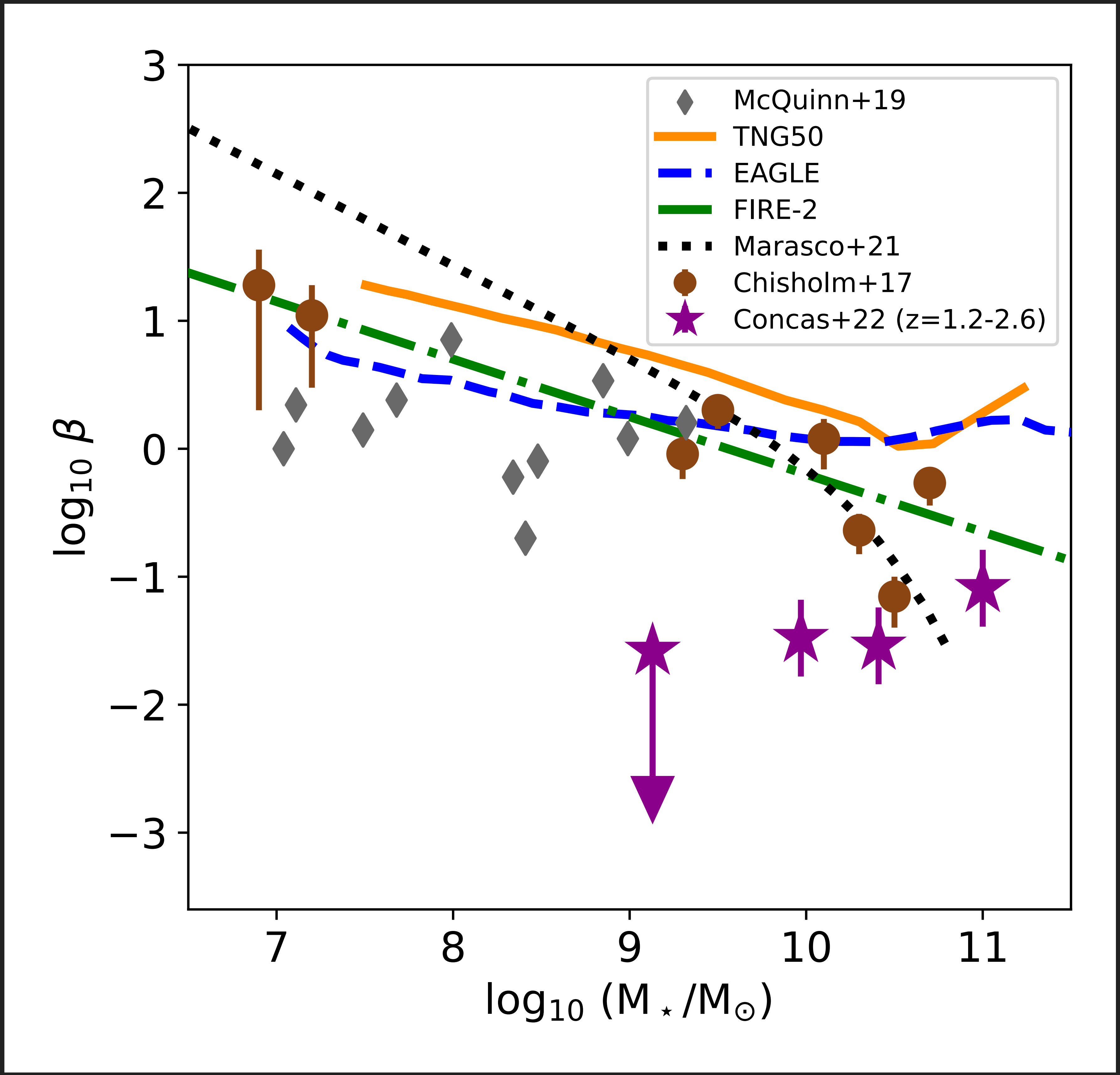
M_{out}: Depends on $\boldsymbol{n_e}$ (from [SII] ratio in wind) and on **Av** (from Balmer ratio in wind)

v_{out}: escape speed at Rout

$\mathcal{H}$: Depends on the outflow history (see Lutz+2020). We assume constant outflow rates.

R_{out}: half-light radius of wind component

Mass loading factors: theory vs observations



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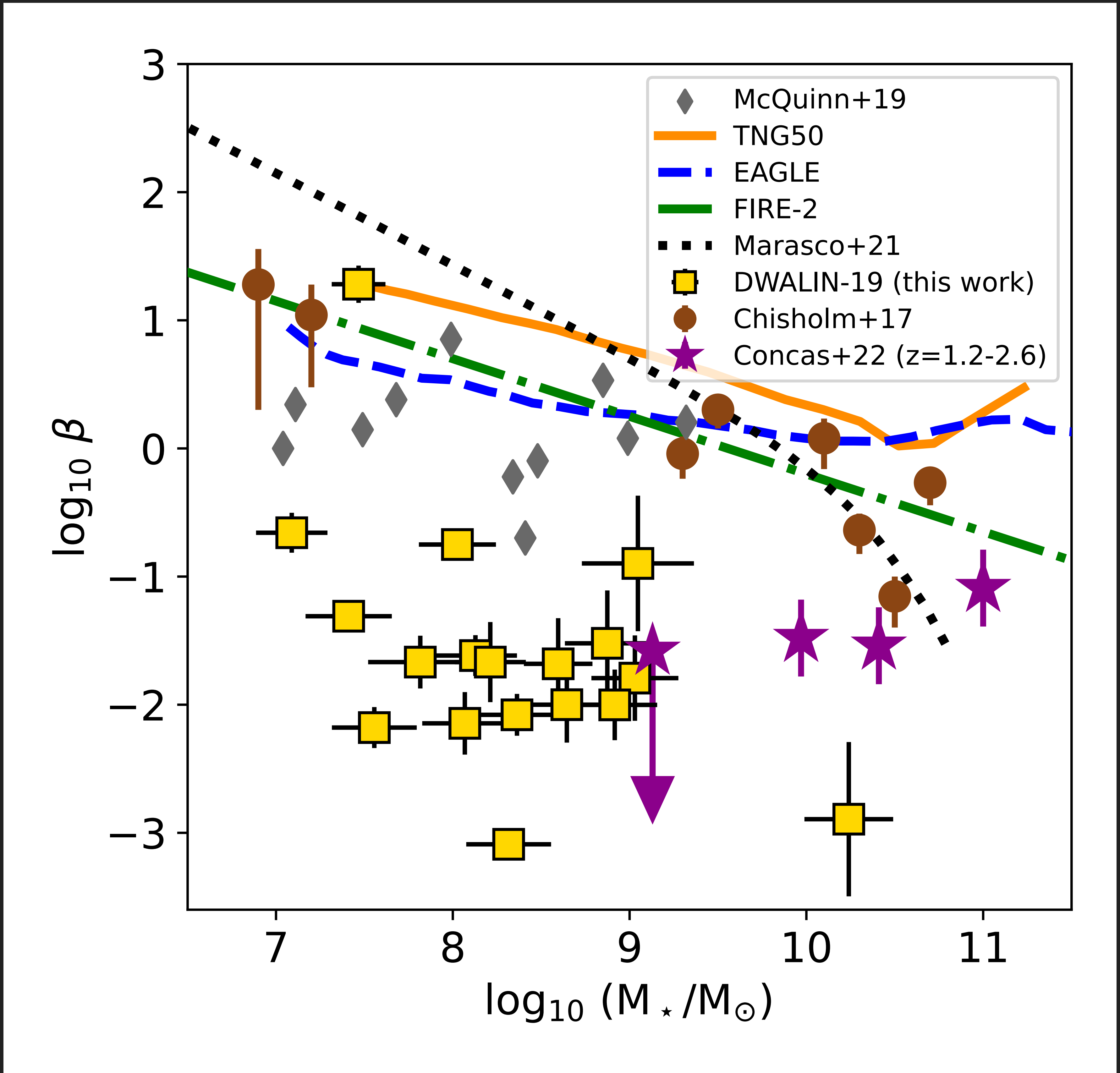

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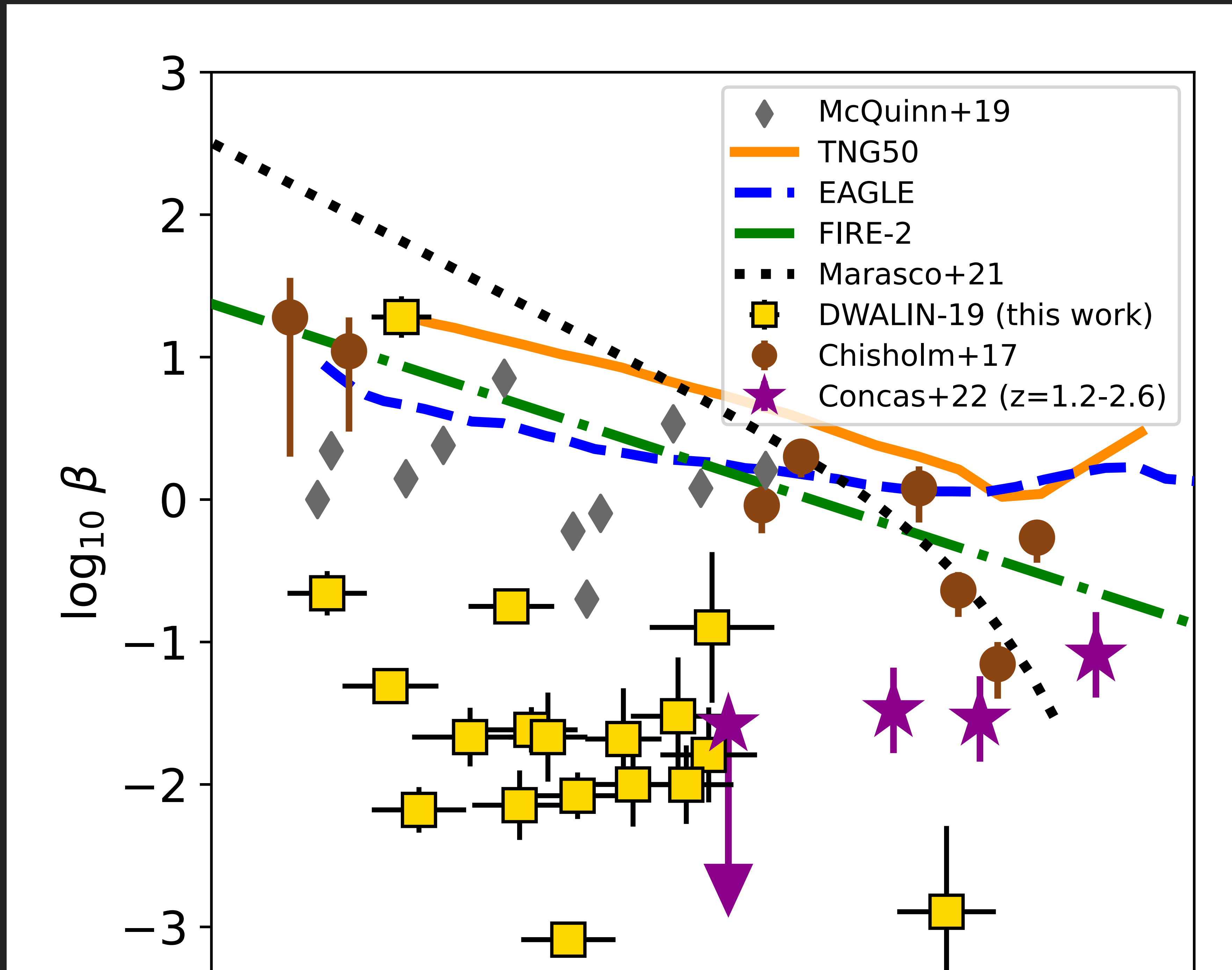


TAKE HOME MESSAGE #2

NO EVIDENCE FOR MASSIVE OUTFLOWS

MOST GAS STAYS IN THE HALO

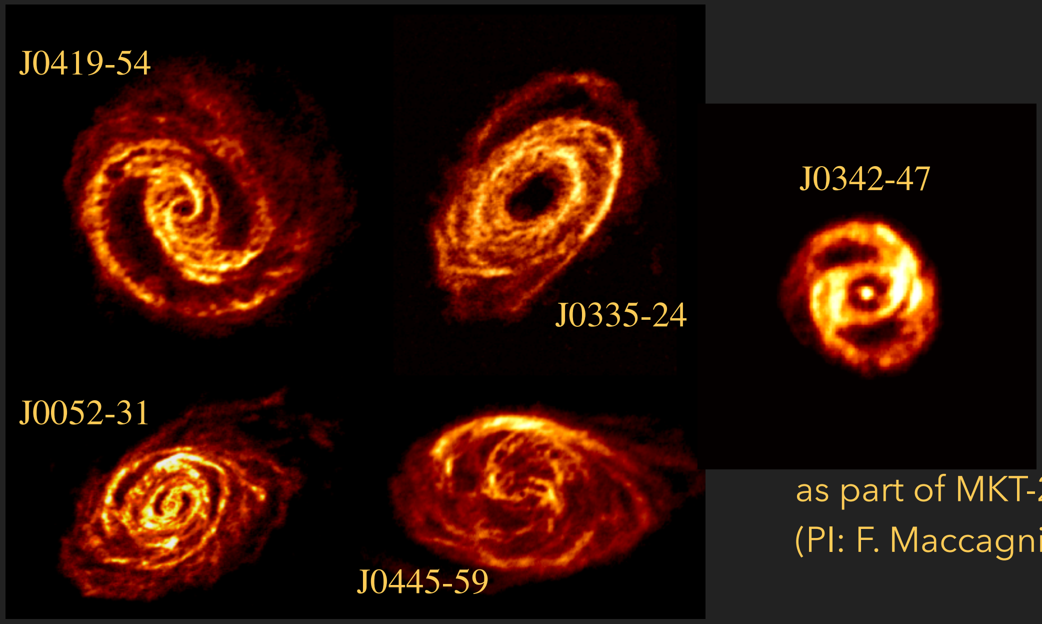
gentle gas circulation in Milky Way-like galaxies

A. Marasco, W.J.G. de Blok, F.M. Maccagni, F. Fraternali at al., in prep.

GALCROSS, Brno, 17/09/2024

HI observations with MeerKAT (n=5)

- D~20 Mpc
- FoV~1 deg -> Rmax~200 kpc
- res 20″ (HR), 60″ (LR) -> 2 and 6 kpc
- min N_{HI} ~ 5×10^{18} cm^{-2}(HR), 10^{18} cm^{-2} (LR)



MHONGOOSE
(de Blok+24)

as part of MKT-20202 project
(PI: F. Maccagni)

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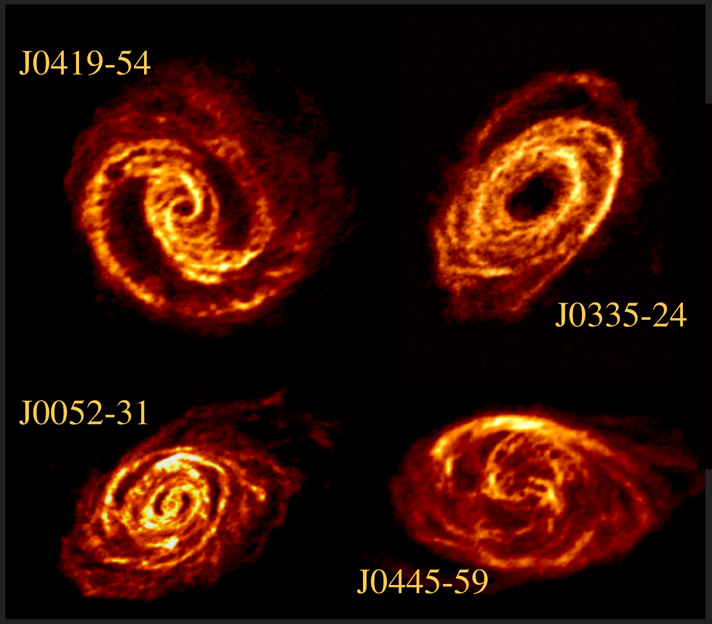

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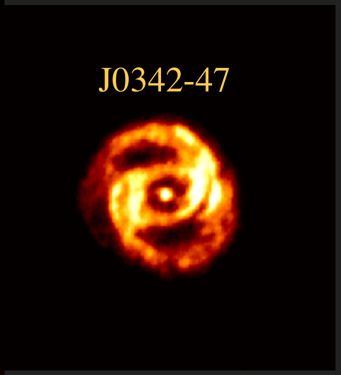

as part of MKT-20202 project
(PI: F. Maccagni)

synthetic HI observations from cosmological simulations

TNG-50 (n=15)

Pillepich+19; Nelson+19

- AREPO moving-mesh code
- $(50\ \mathrm{Mpc})^3$ box
- res ~ 70 pc, $8.5 \times 10^4\ M_\odot$
- equation of state for cold gas

FIRE-2 (n=5)

Hopkins+18; Wetzel+23

- GIZMO, meshless finite-mass
- zoom-in
- res ~ 1 pc, $7.1 \times 10^3\ M_\odot$
- No AGN physics

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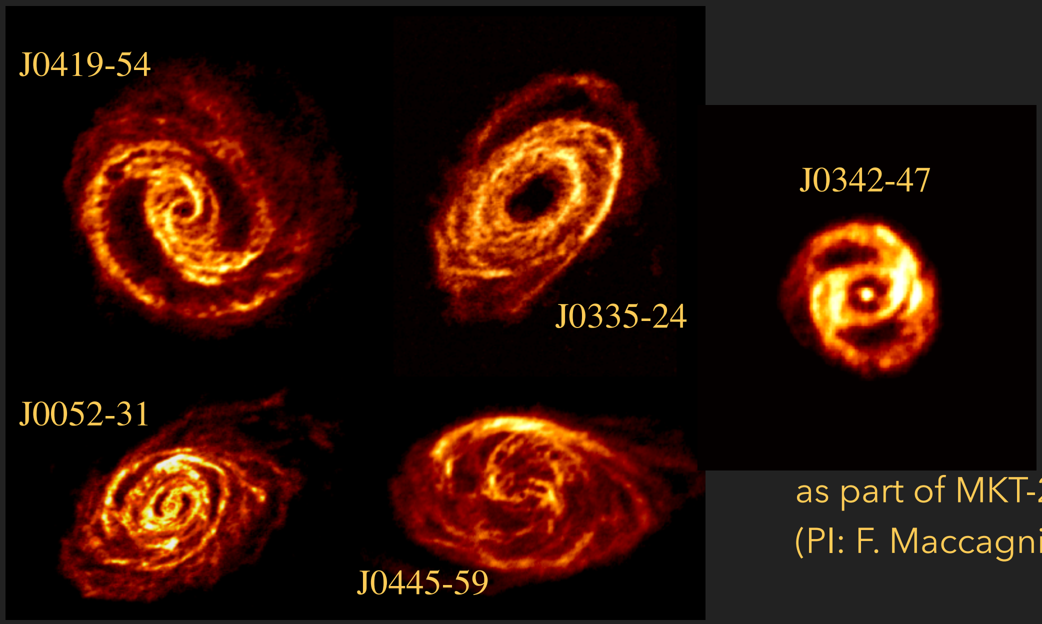

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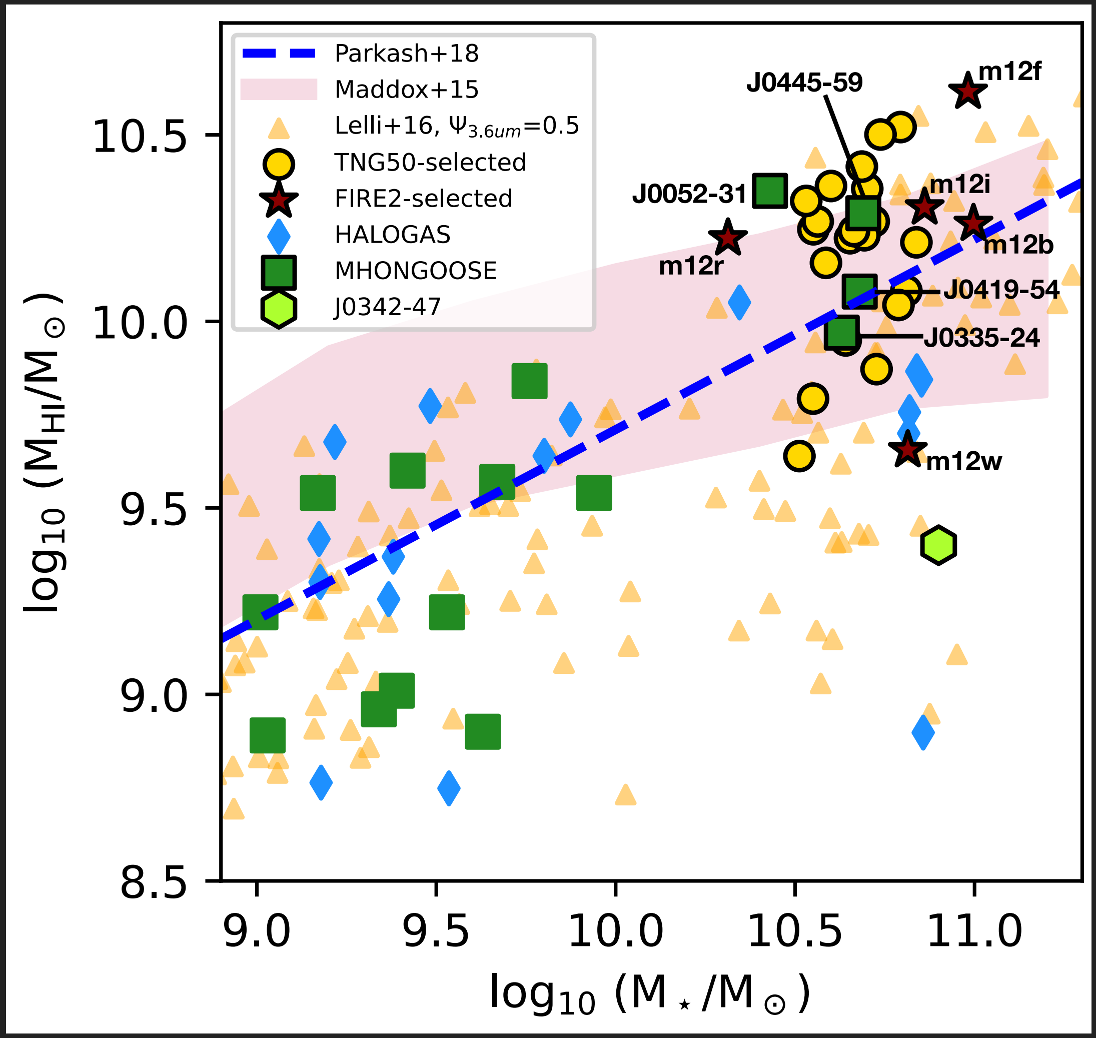
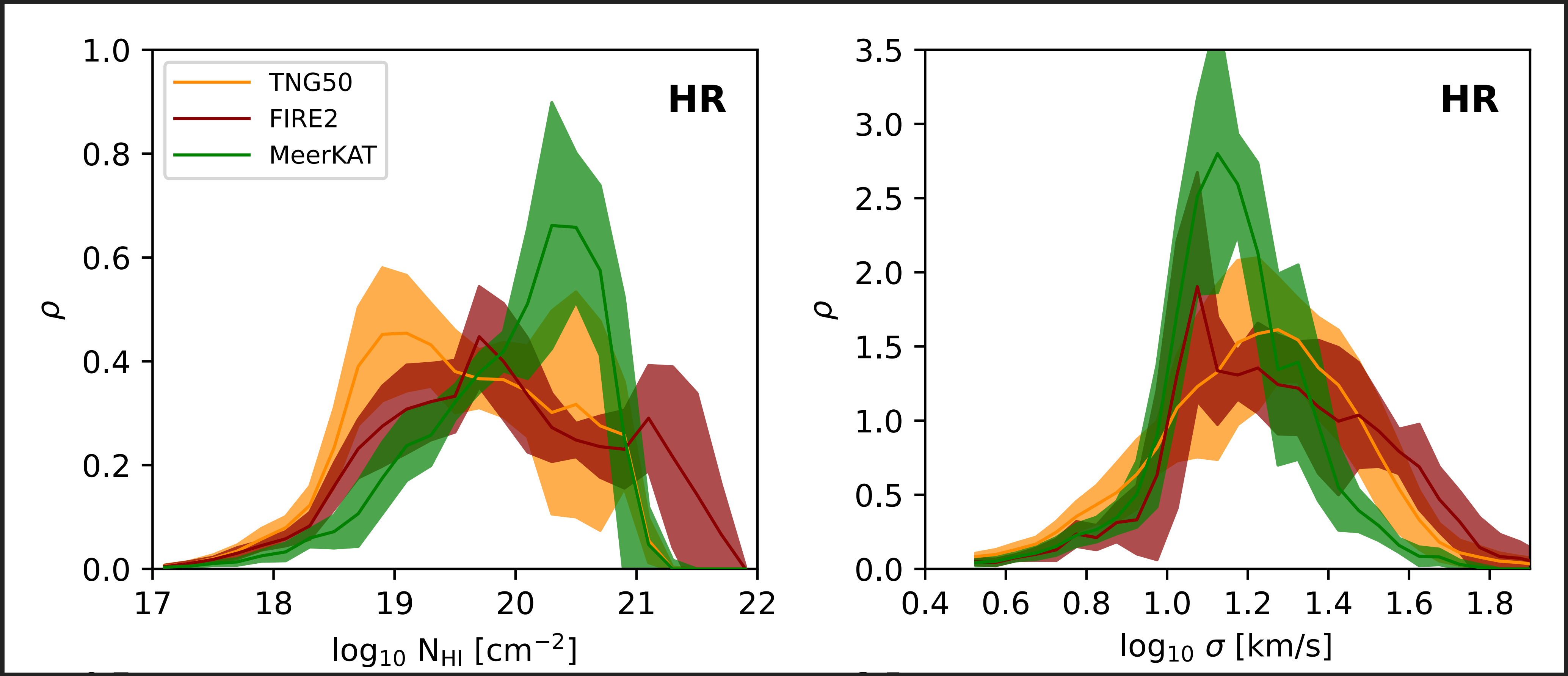


column density and velocity dispersion



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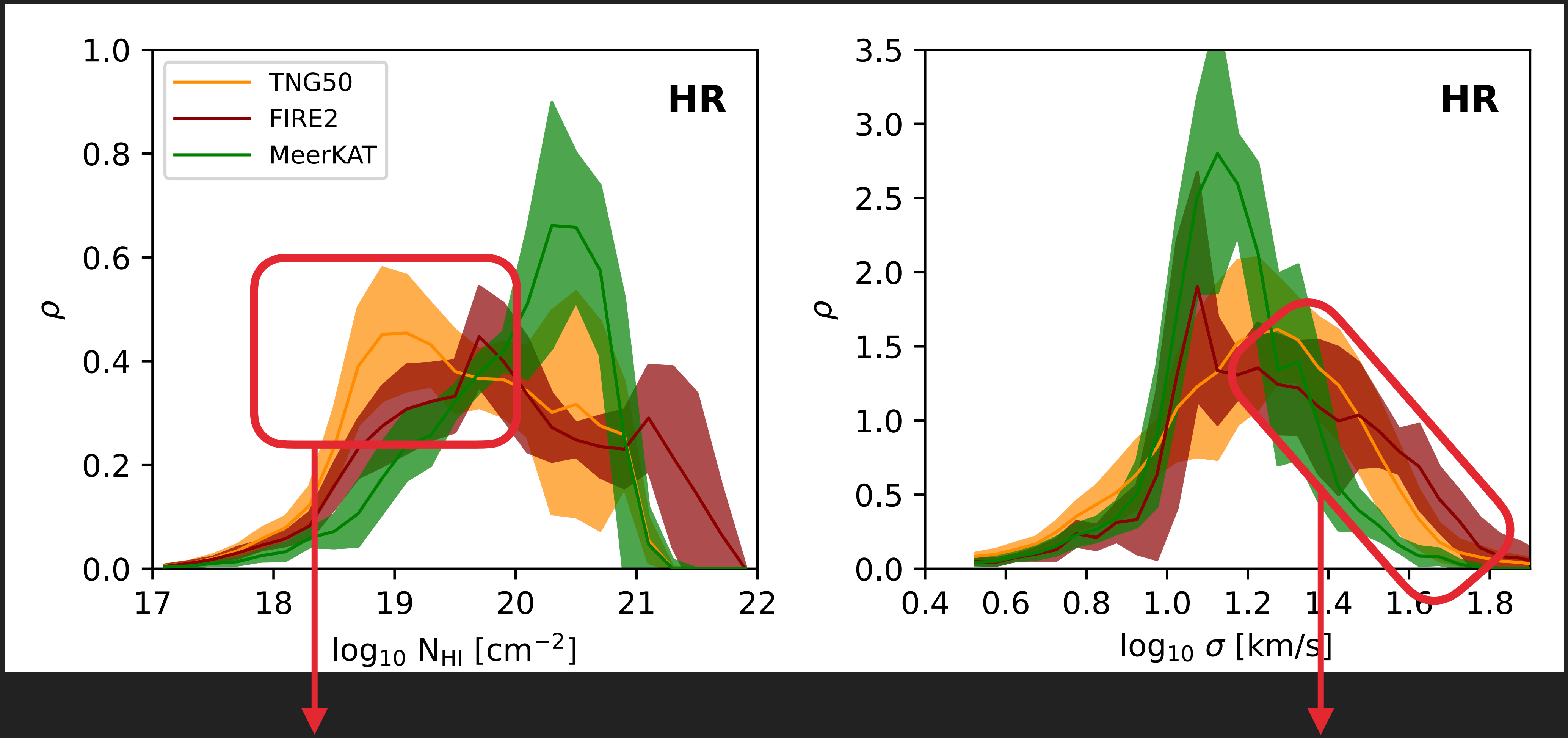


low NHI excess in the sims
(especially TNG-50)

high-σ excess in the sims
(especially FIRE-2)

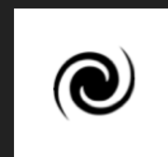
Regular and irregular systems

Galaxies dominated by high-N_{HI} spaxels ($>10^{20}$ cm^{-2})

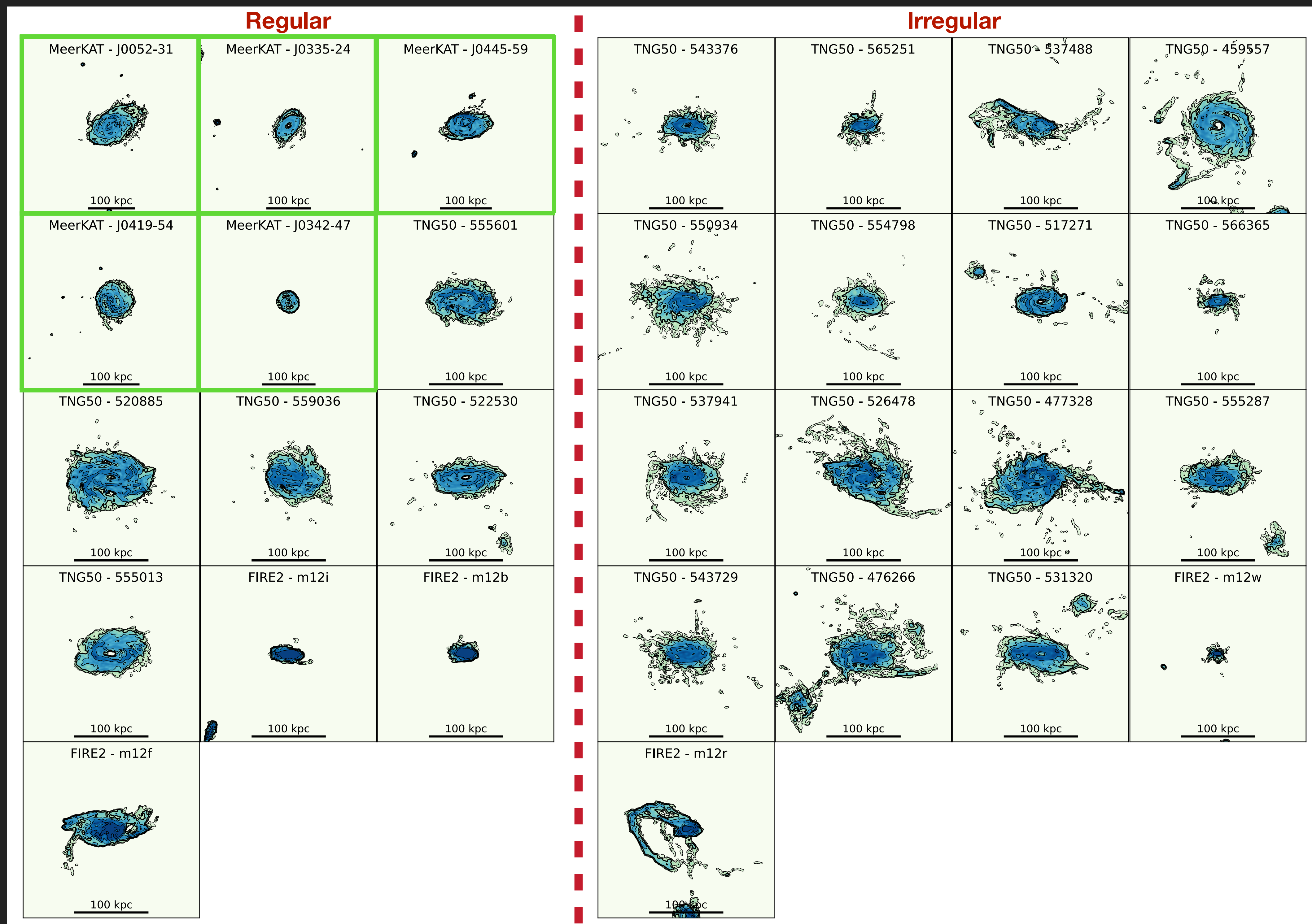
Galaxies dominated by low-N_{HI} spaxels ($<10^{20}$ cm^{-2})

Regular and irregular systems

Galaxies dominated by high-N_{HI} spaxels (>10^{20} cm^{-2})



Galaxies dominated by low-N_{HI} spaxels (<10^{20} cm^{-2})



Regular and irregular systems

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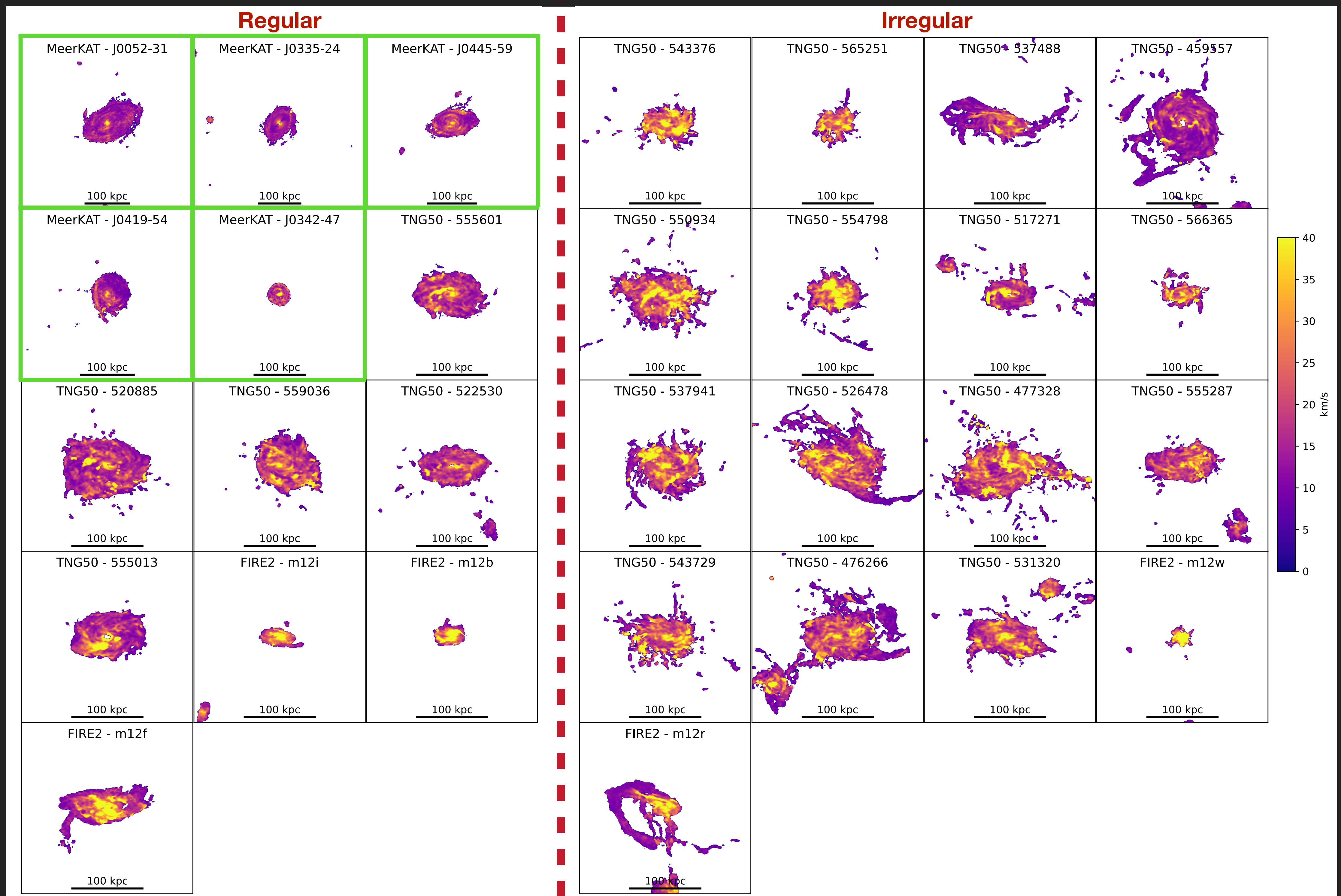

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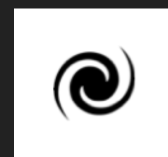

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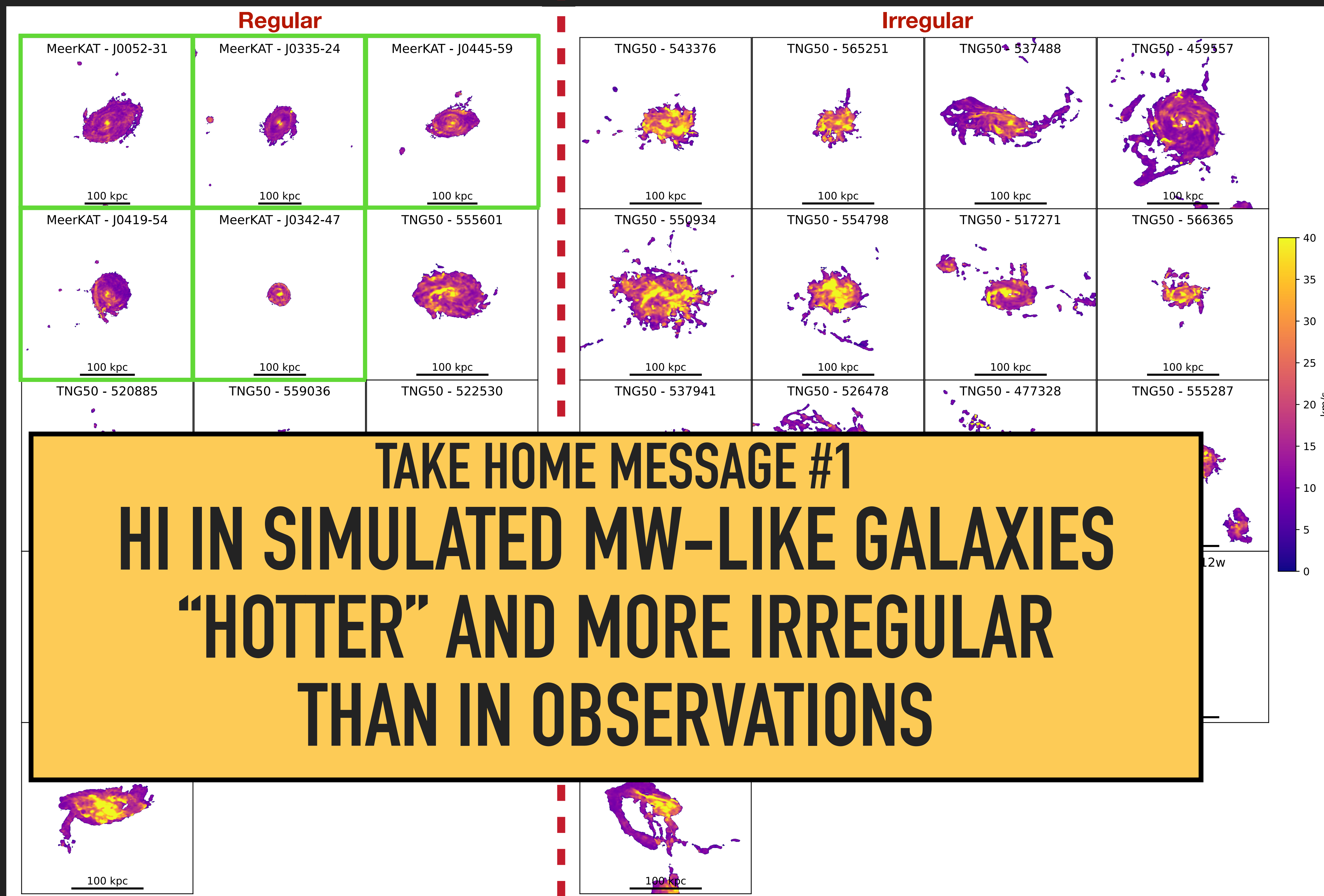


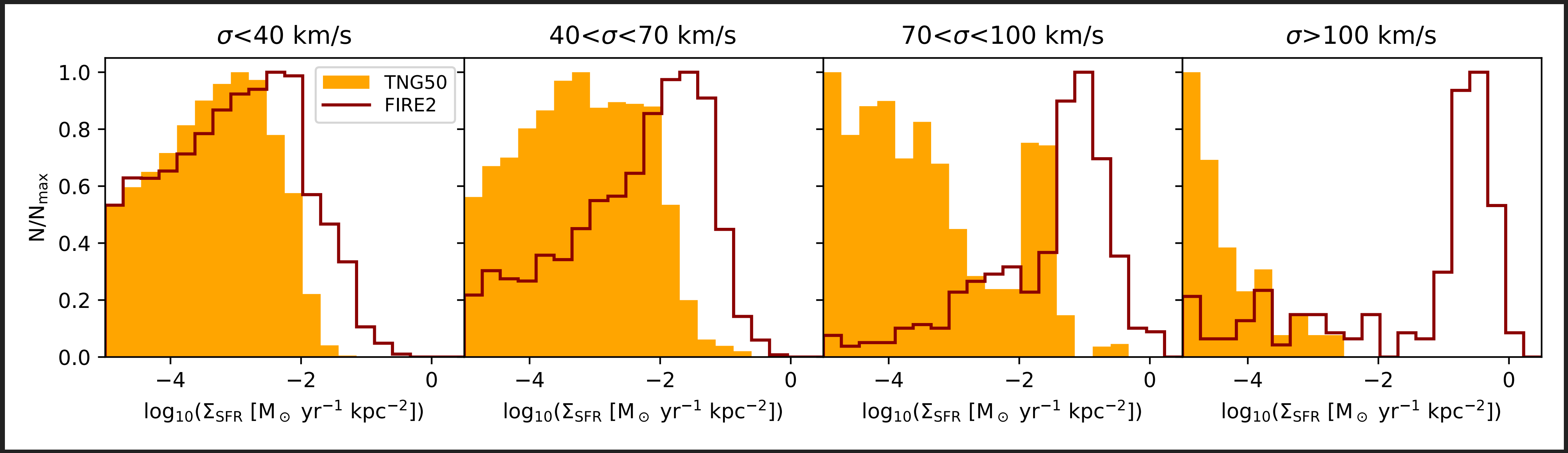
TAKE HOME MESSAGE #1

HI IN SIMULATED MW-LIKE GALAXIES "HOTTER" AND MORE IRREGULAR THAN IN OBSERVATIONS

Origin of irregular, high-σ HI

Origin of irregular, high-σ HI

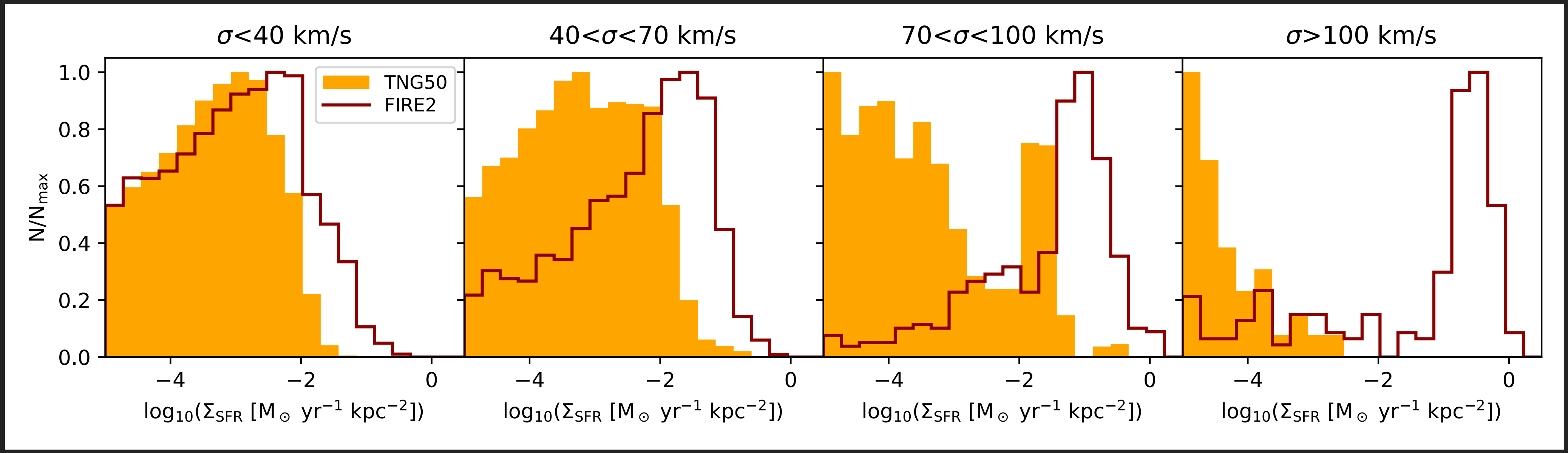
Stellar Feedback?



$\sum_{SFR}$ and σ highly correlated in FIRE2. What about TNG?

Origin of irregular, high-σ HI

Stellar Feedback?



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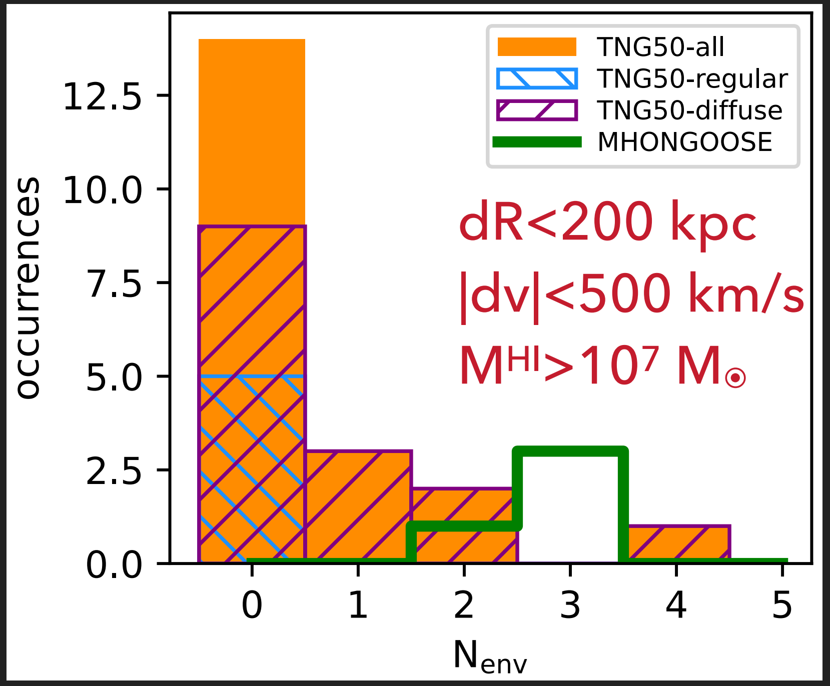

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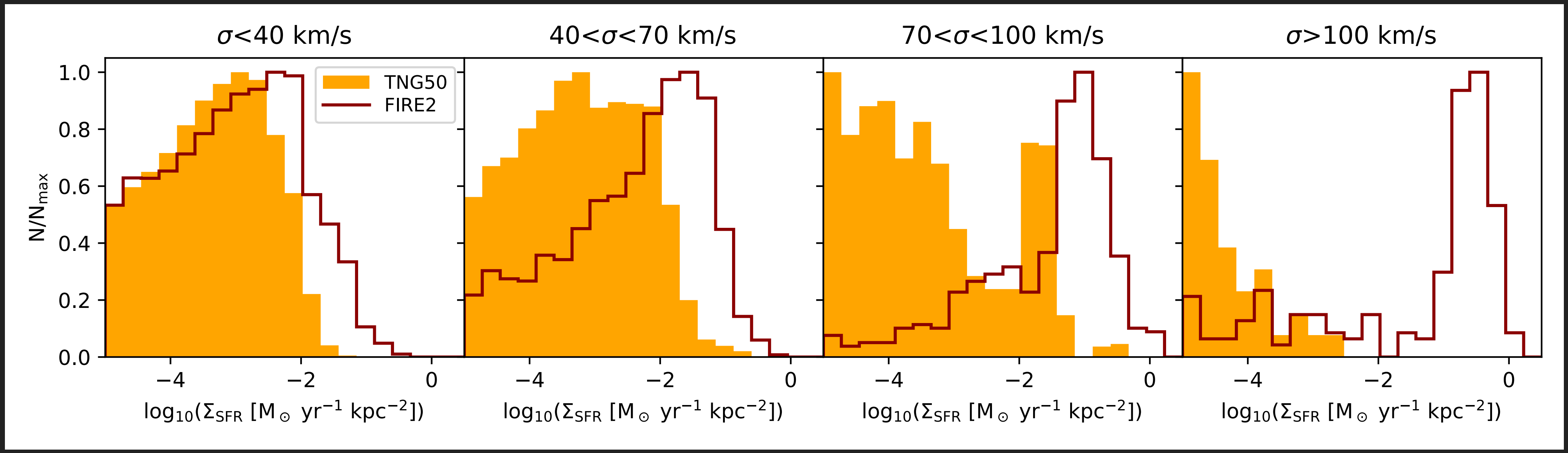

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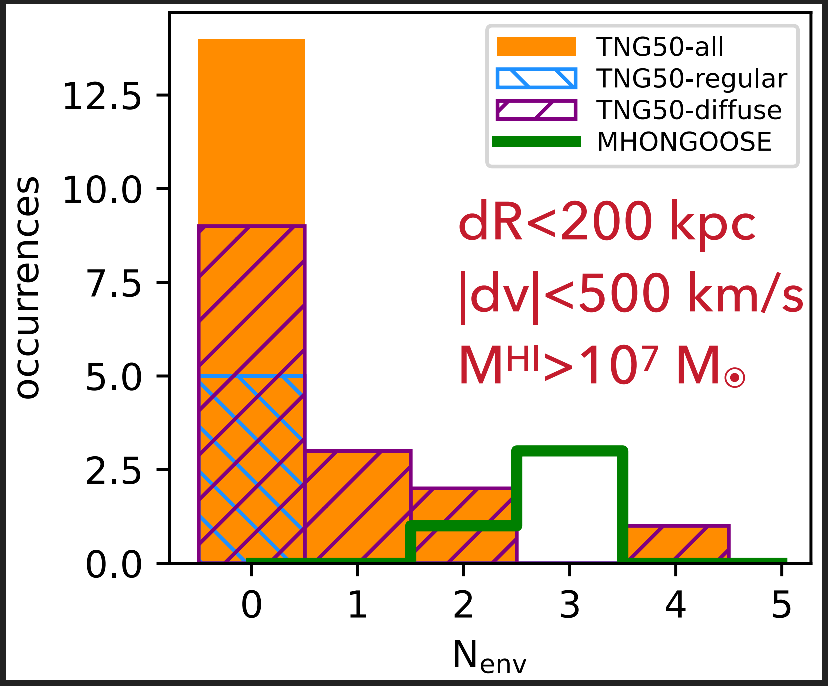

a) compared to the sims, real galaxies live in denser environments

b) compared to regular simulated galaxies, irregular galaxies live in denser environment

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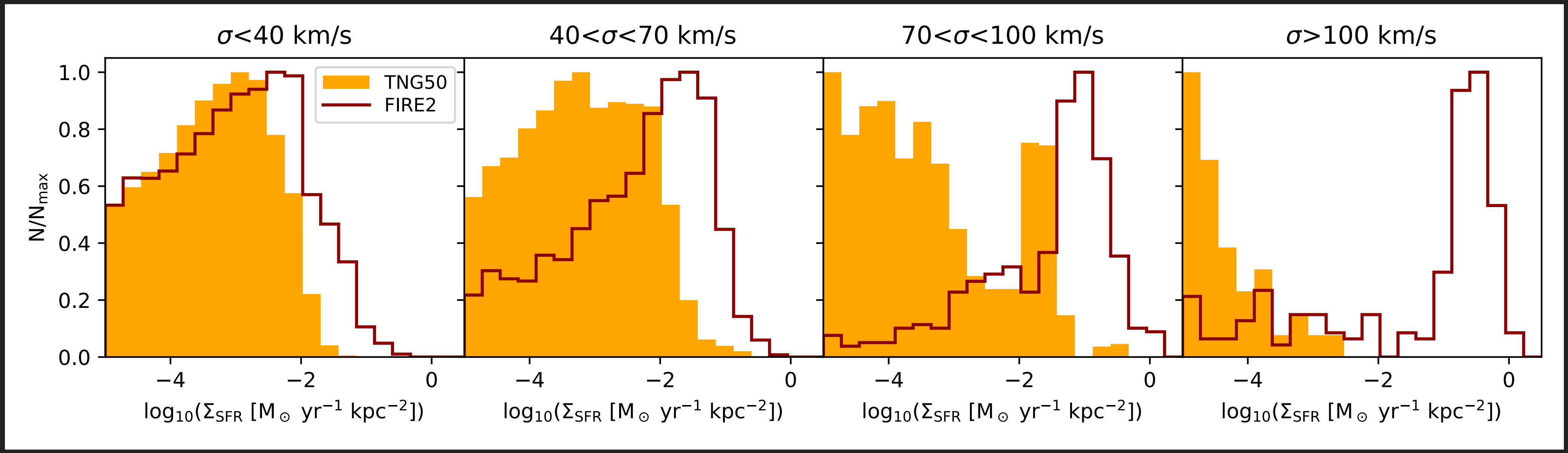

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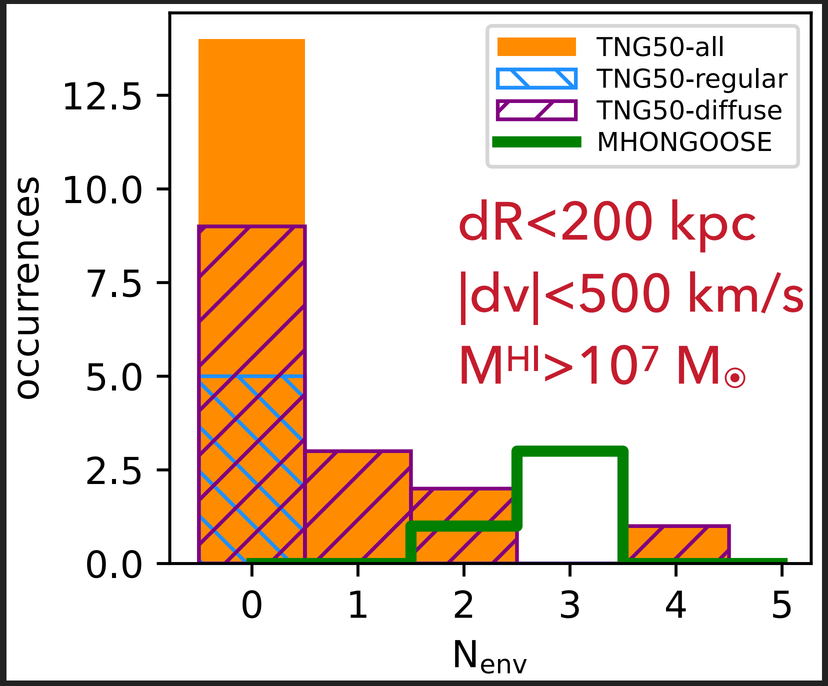

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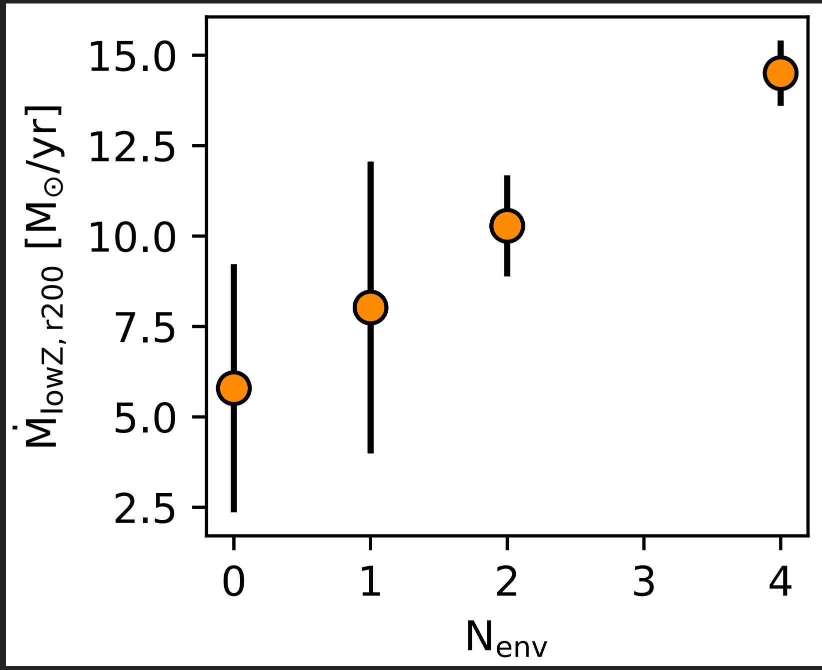
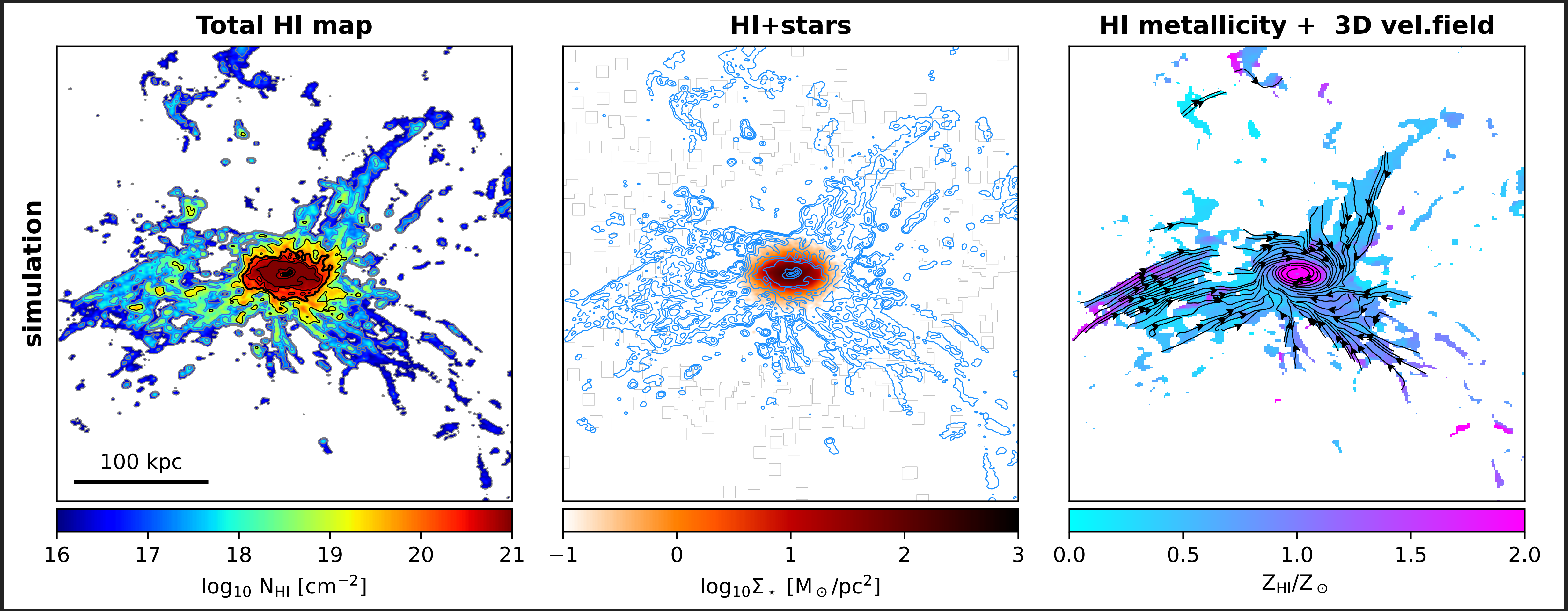


Irregular galaxies have systematically higher gas accretion onto their halo

A closer look to a simulated galaxy

TNG-50, ID 543376

mock MeerKAT HI data - 20”



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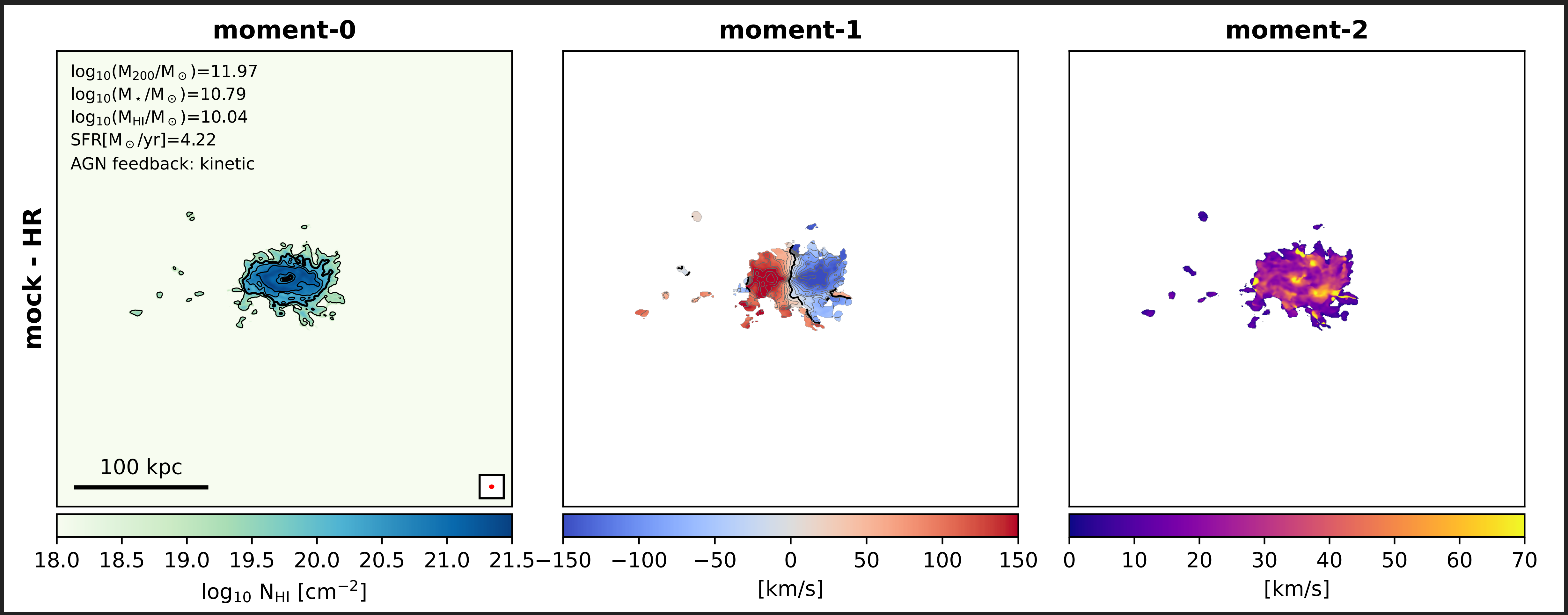

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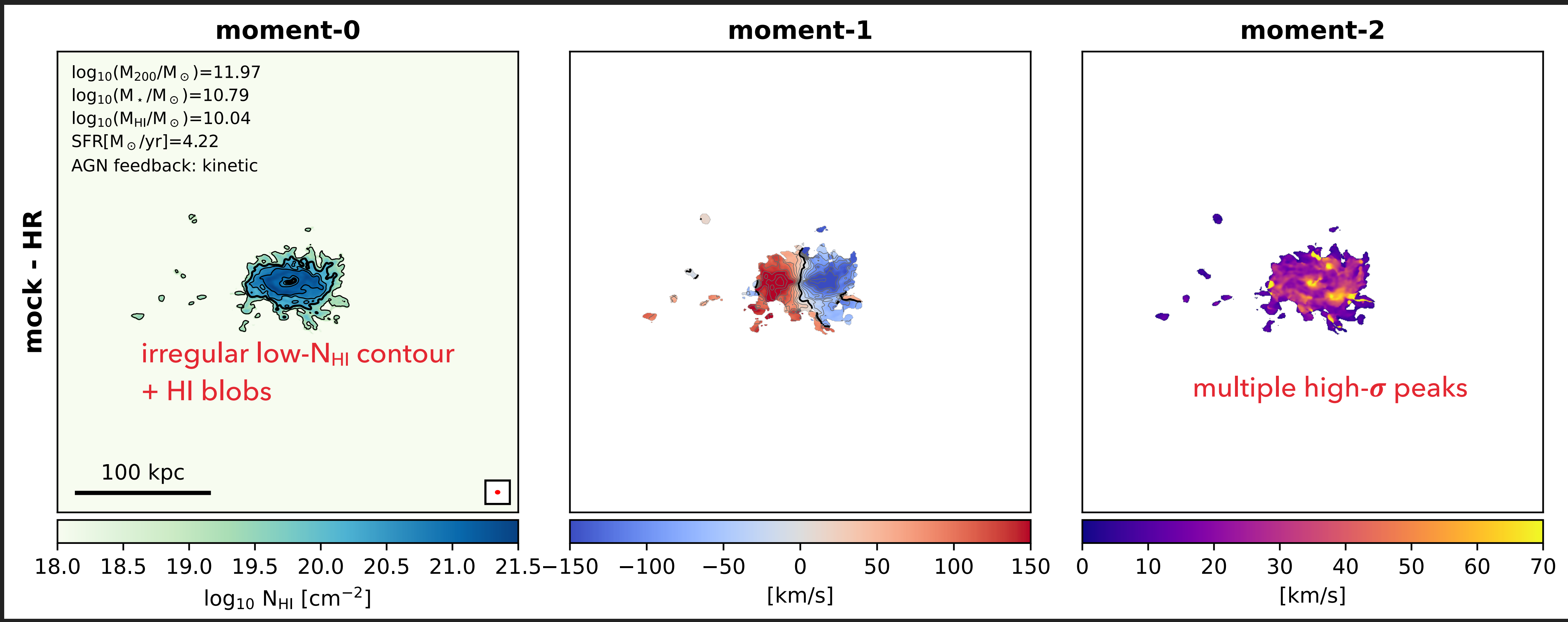

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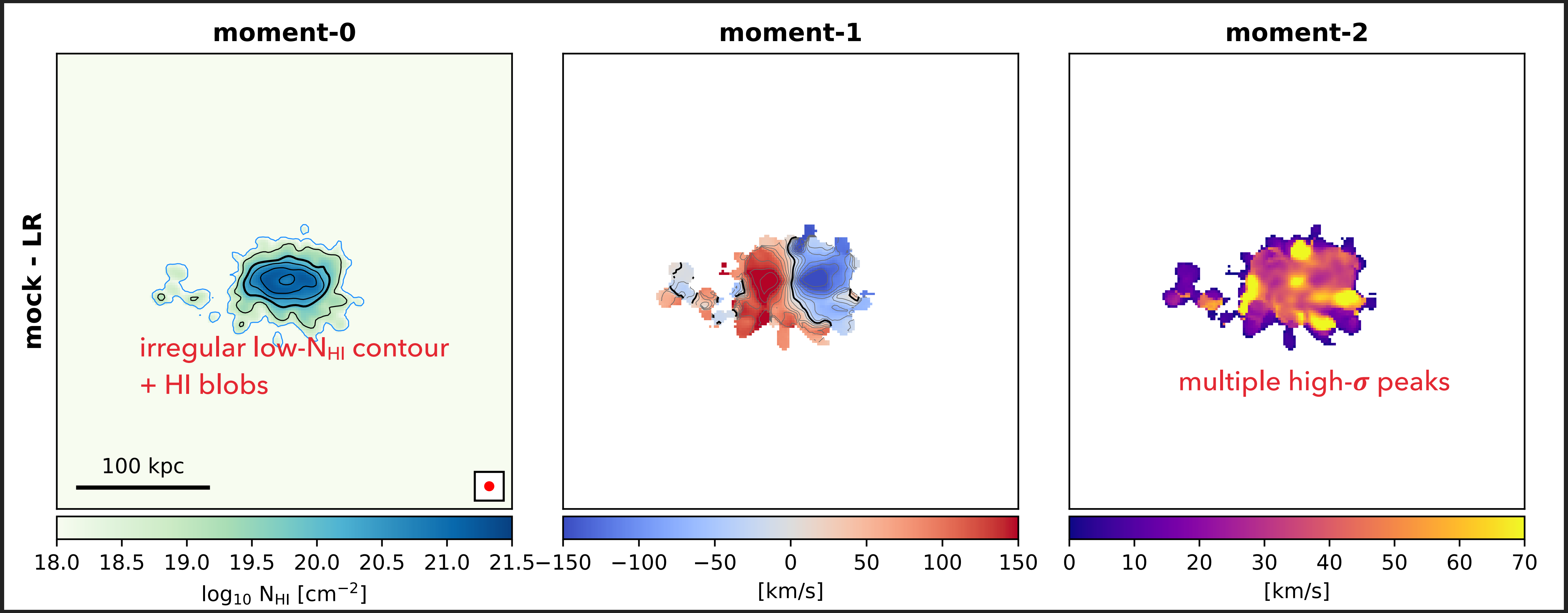
TNG-50, ID 543376
mock MeerKAT HI data - 60”



A closer look to a simulated galaxy

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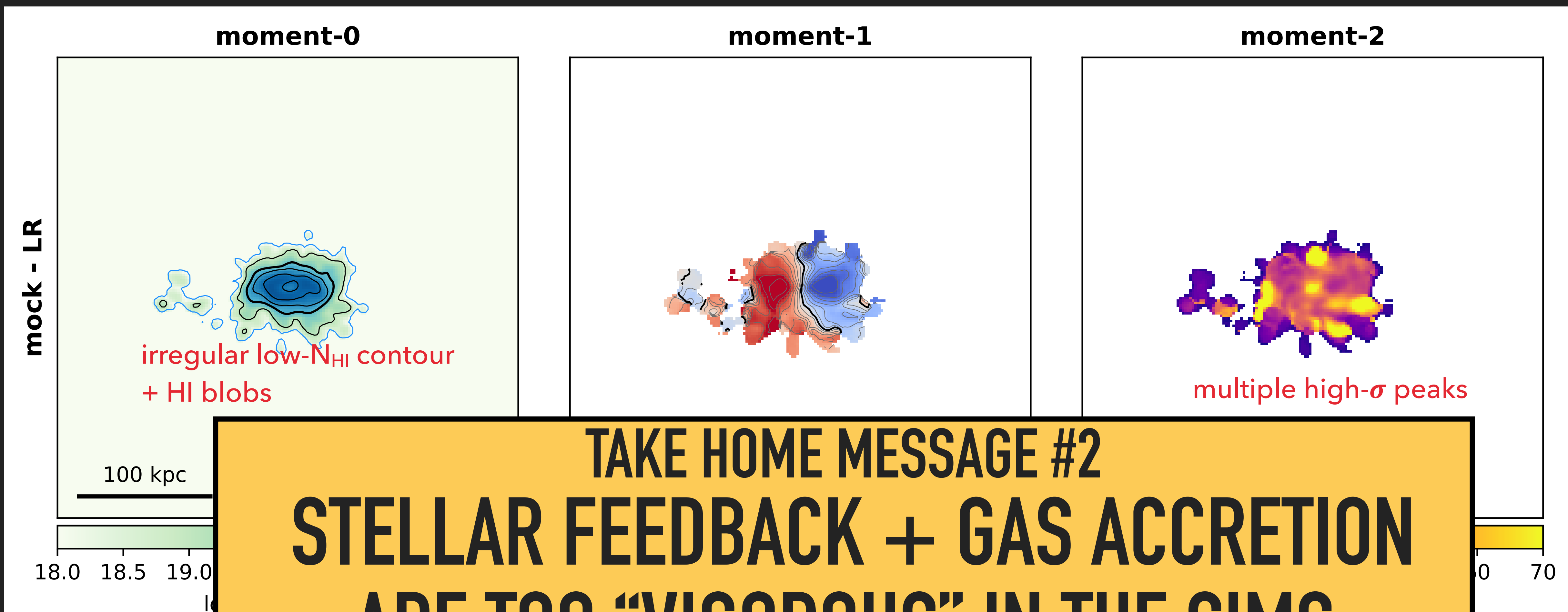
mock MeerKAT HI data - 60″



TAKE HOME MESSAGE #2

STELLAR FEEDBACK + GAS ACCRETION ARE TOO “VIGOROUS” IN THE SIMS

Conclusions

Part 1

Starburst dwarf galaxies feature mildly irregular Hα kinematics and mass-loading factors well below those predicted by theoretical models of galaxy evolution

Part 2

HI discs of simulated MW-like galaxies are more disturbed and kinematically hotter than those in real galaxies, due to feedback and accretion processes

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↓

Gaseous inflows and outflows in the observed nearby Universe are **gentler** than those predicted by evolutionary models in the ΛCDM framework.