THE HI DISCS OF GALAXIES AS TRACERS OF THE BARYONIC PHYSICS OF GALAXY EVOLUTION

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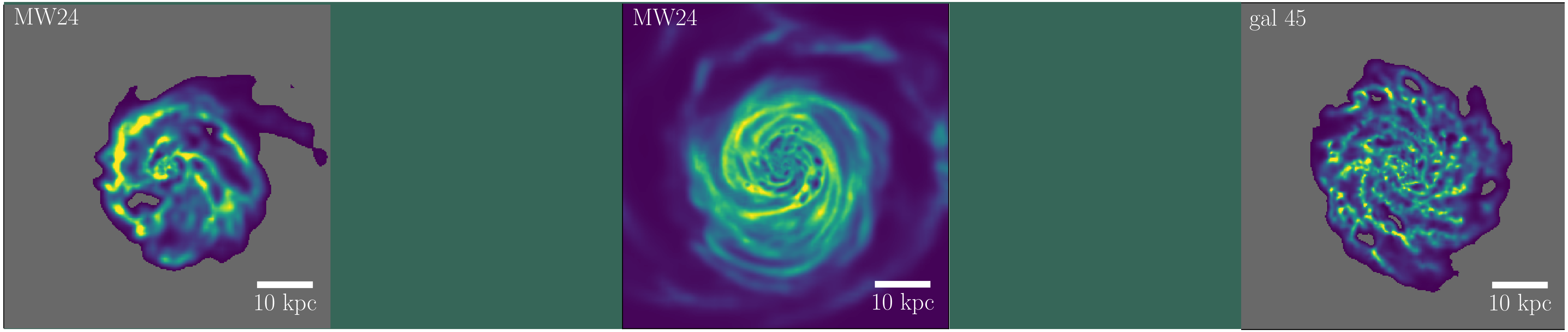
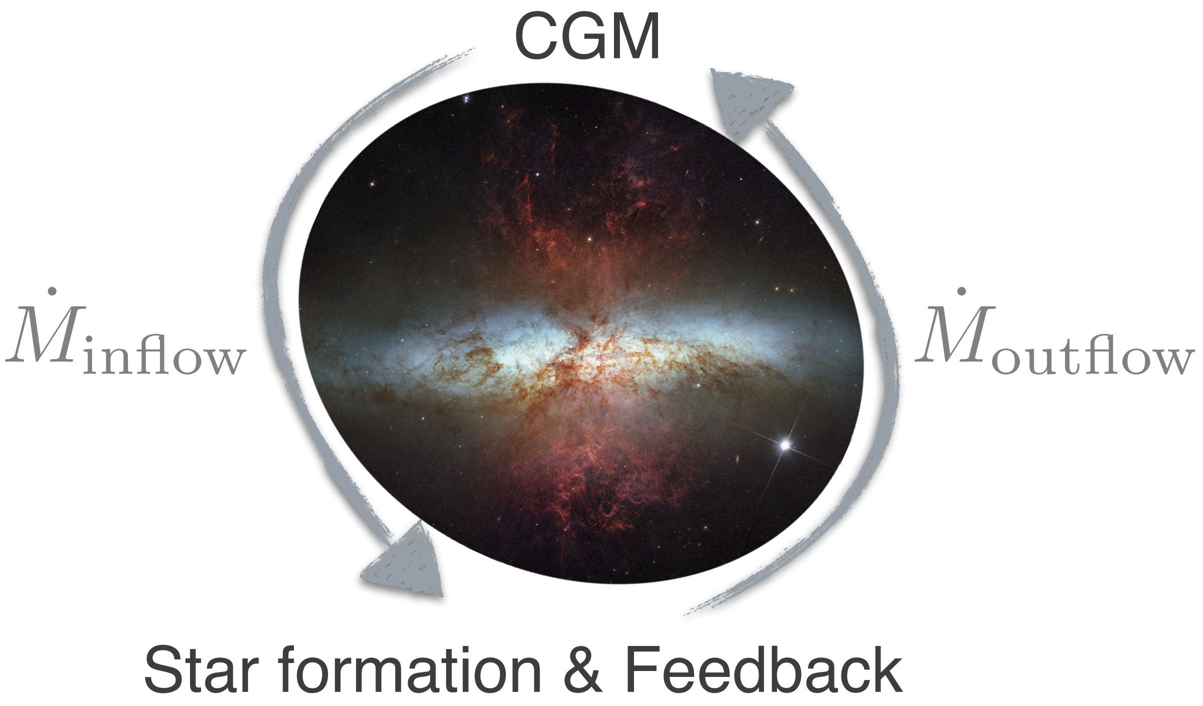
with Lucio Mayer, Robert Feldmann & the EMP team

University of Zurich[UZH]



THE BARYON CYCLE OF GALAXIES



Gas-regulator or "bathtub model"

e.g. Finlator & Davé 2008, Bouché+ 2010, Lilly+ 2013, Dekel+ 2013, Dekel & Mandelker+ 2014, Peng & Maiolino 2014, Belfiore+ 2019, Tacchella+2020

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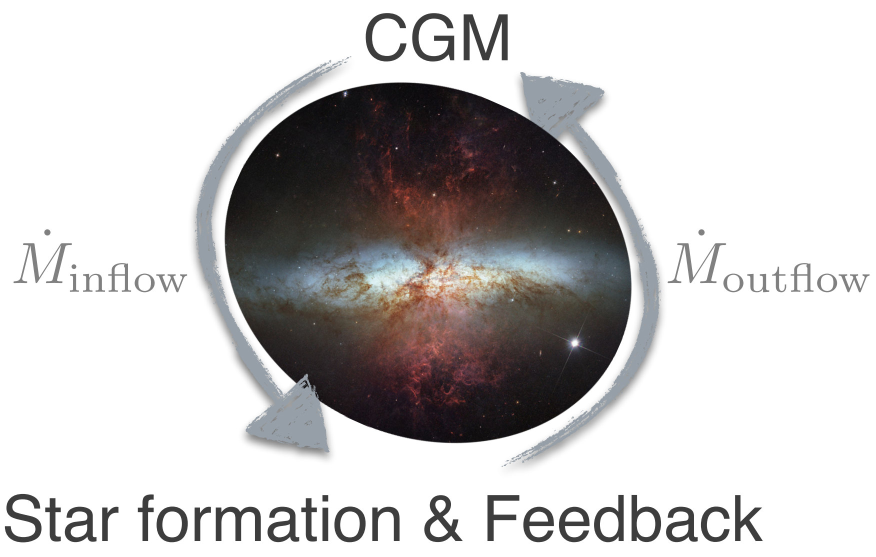

HI

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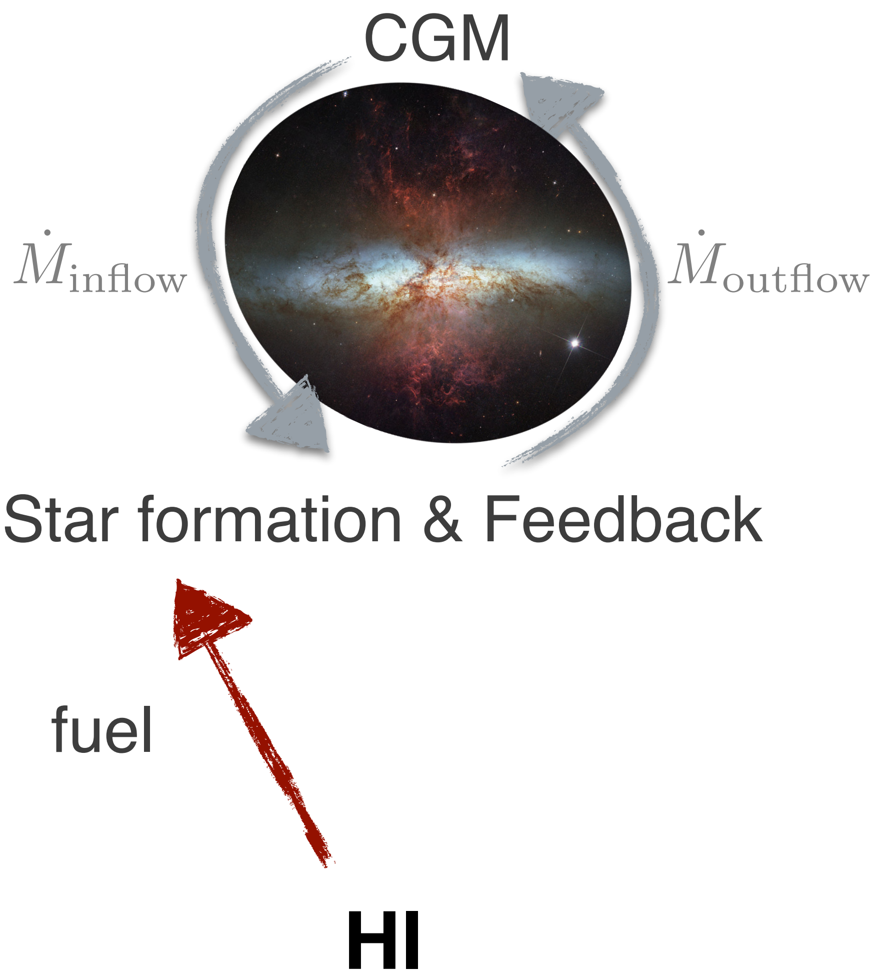

e.g. Saintonge & Catinella 2022

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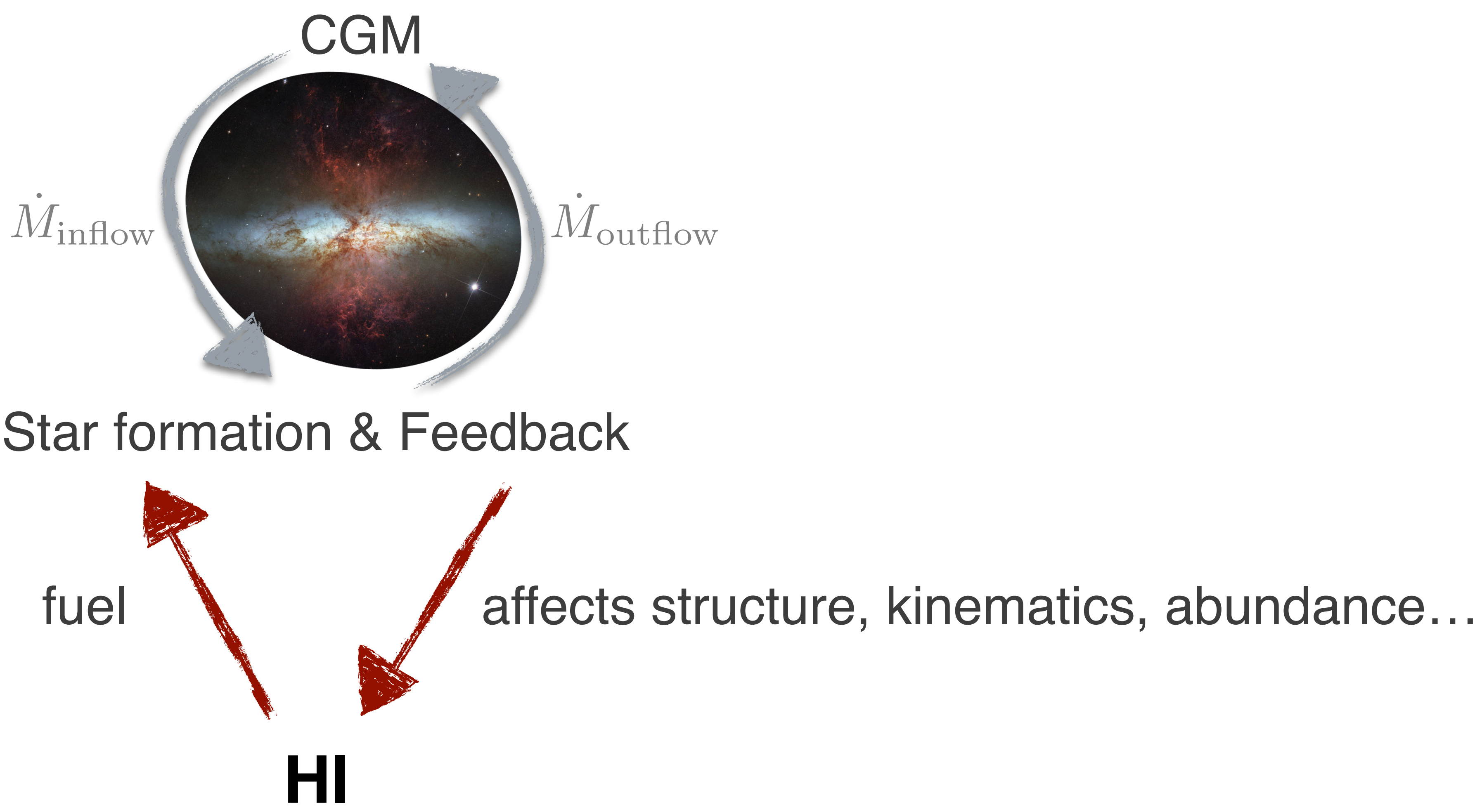

e.g. Saintonge & Catinella 2022

Can we use **HI** to learn more about **star formation** and **stellar feedback** physics?

THE SAMPLE

Galaxies selected to have Milky Way halo-mass: $11.85 < \log\left(M_{\rm halo}/{\rm M}_{\odot}\right) < 12.48$

Cosmological zooms EMP-*Pathfinder*

Reina-Campos,…,JG+ 2022

FIREbox cosmological volume

Feldmann,…,JG+ subm.

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Constant

$\epsilon_{\rm ff} = 20\%$

21 galaxies

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Multi free-fall

$$\epsilon_{\rm ff} = \frac{1}{2}\exp\left(\frac{3}{8}\sigma_{\rm s}^2\right)\left[1 + {\rm erf}\left(\frac{\sigma^2 - s_{\rm crit}}{\sqrt{2\sigma_{\rm s}^2}}\right)\right]$$

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21 galaxies	**14 galaxies**	**25 galaxies**

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Supernovae Type Ia & II + stellar winds from AGB stars

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Supernovae Type Ia & II + stellar winds from AGB stars

+ early stellar feedback

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THE SAMPLE:
GALAXIES EVOLVED SELF-CONSISTENTLY ACROSS COSMIC TIME, INCLUDING A **COLD ISM**!

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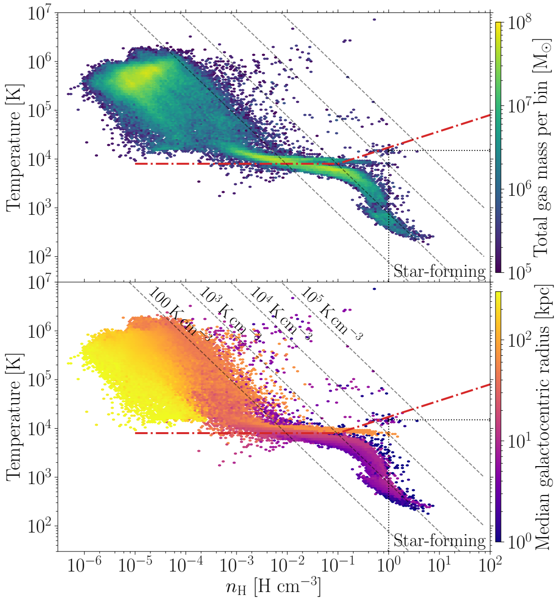

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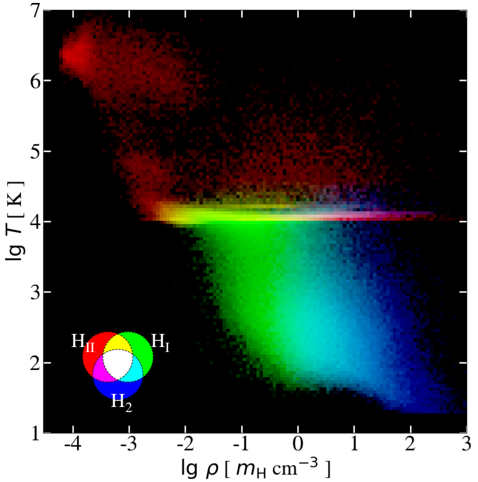

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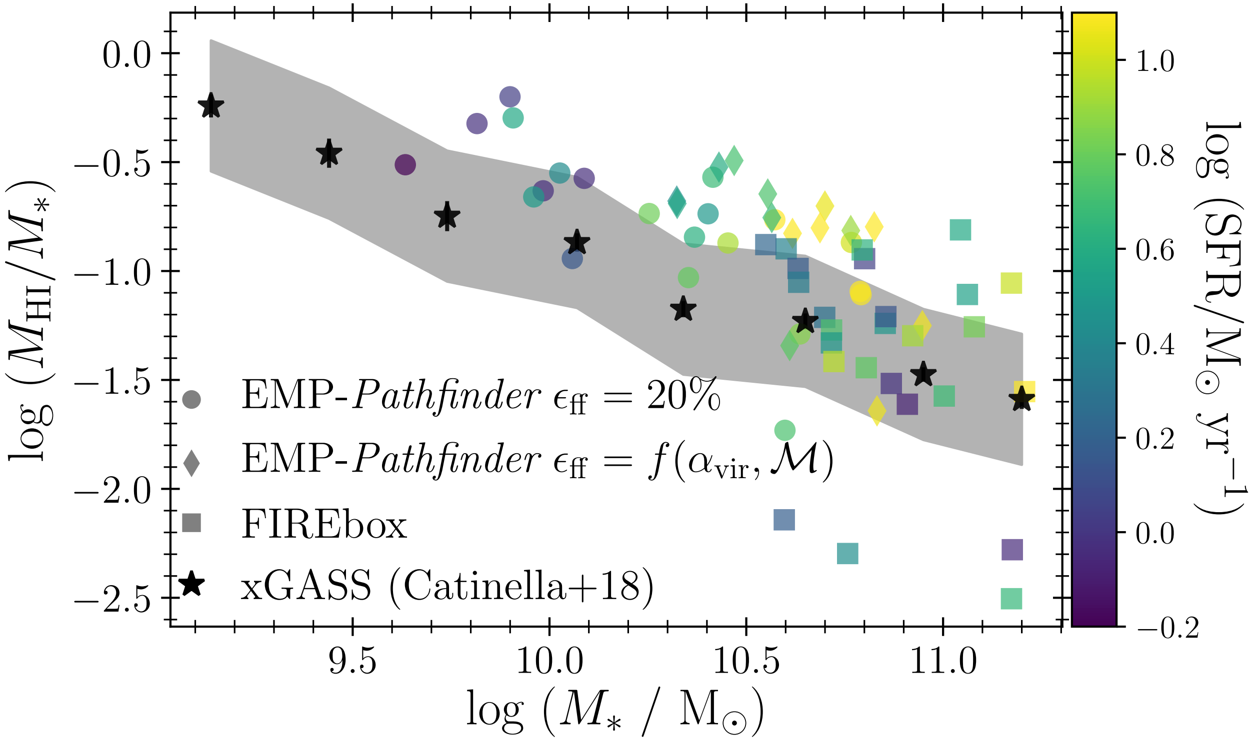
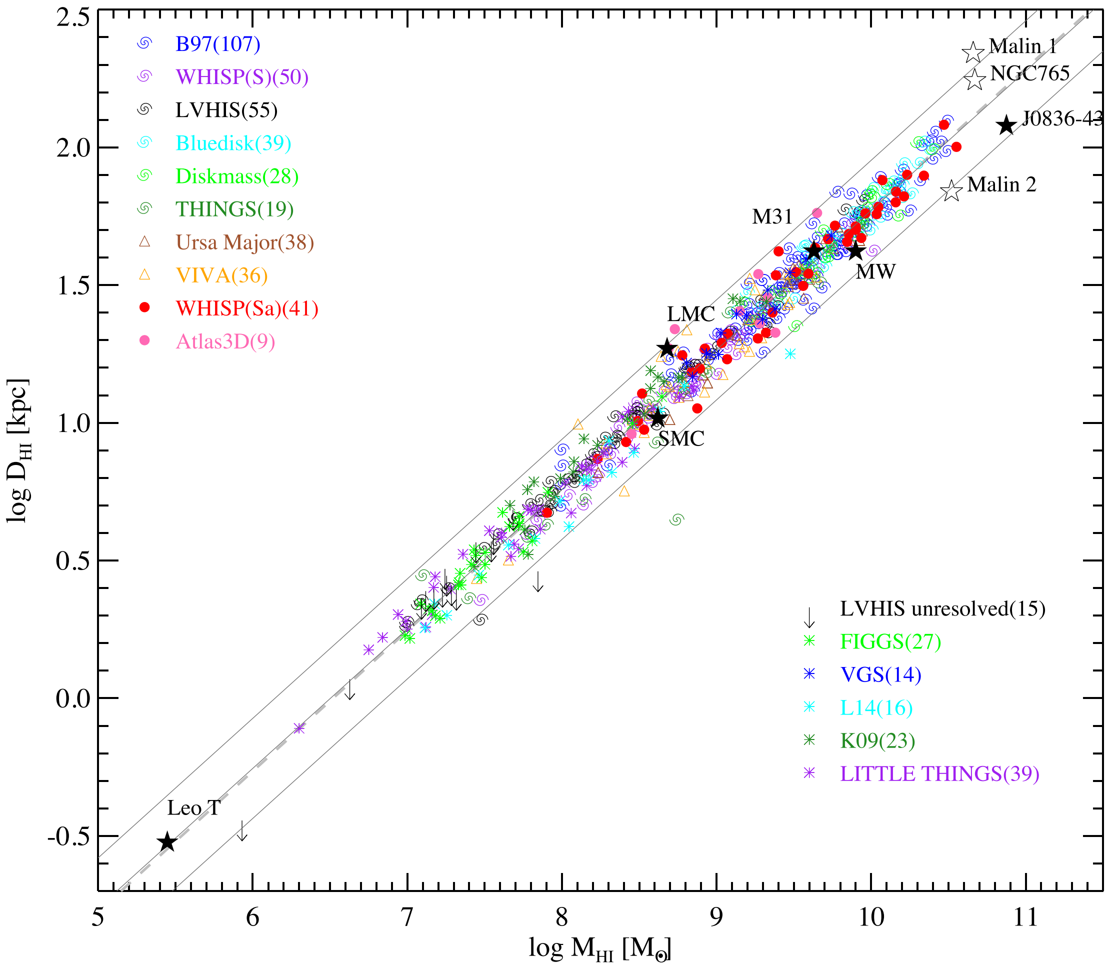
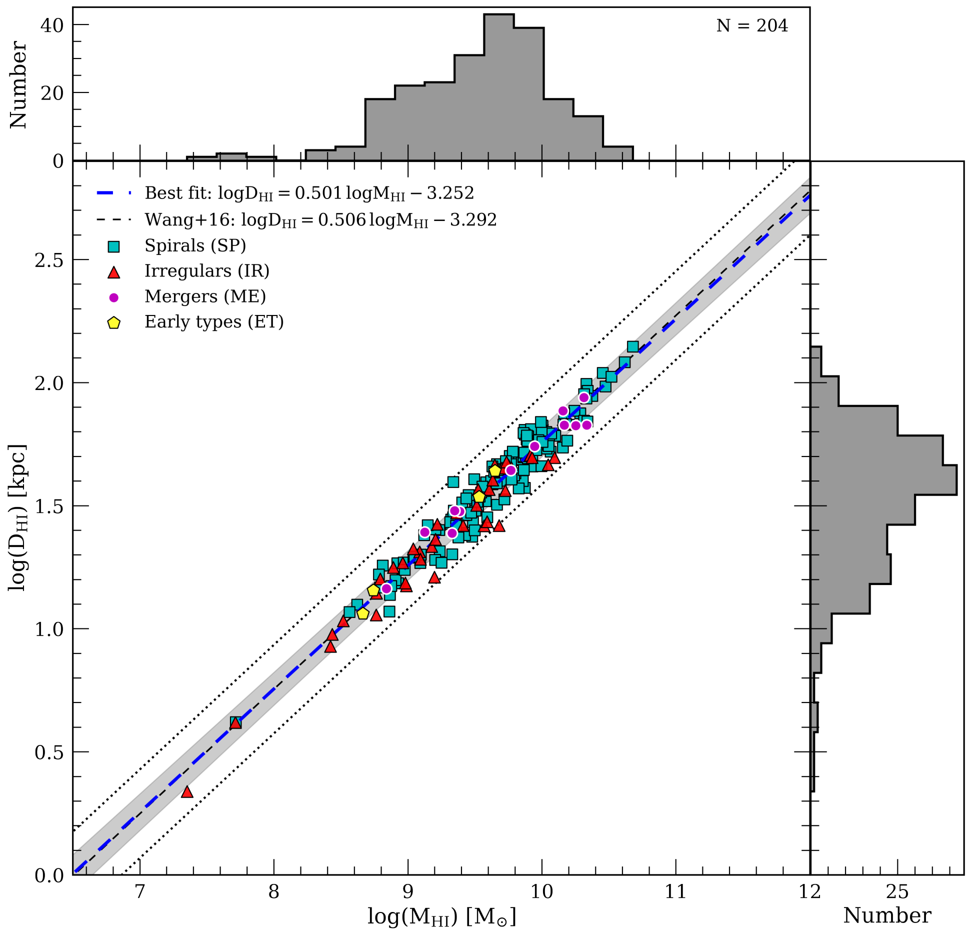


Gensior+2022b, in prep.

HI SIZE-MASS RELATION



Wang+2016



MIGHTEE (Rajohnson+2022)

See also e.g. Broils & Rhee 1997, Verheijen & Sancisi 2001, Swaters+2002, Noordermeer+2005, Begum+2008, Obreschkow+2009, Ponomareva+2016, Stevens+2019

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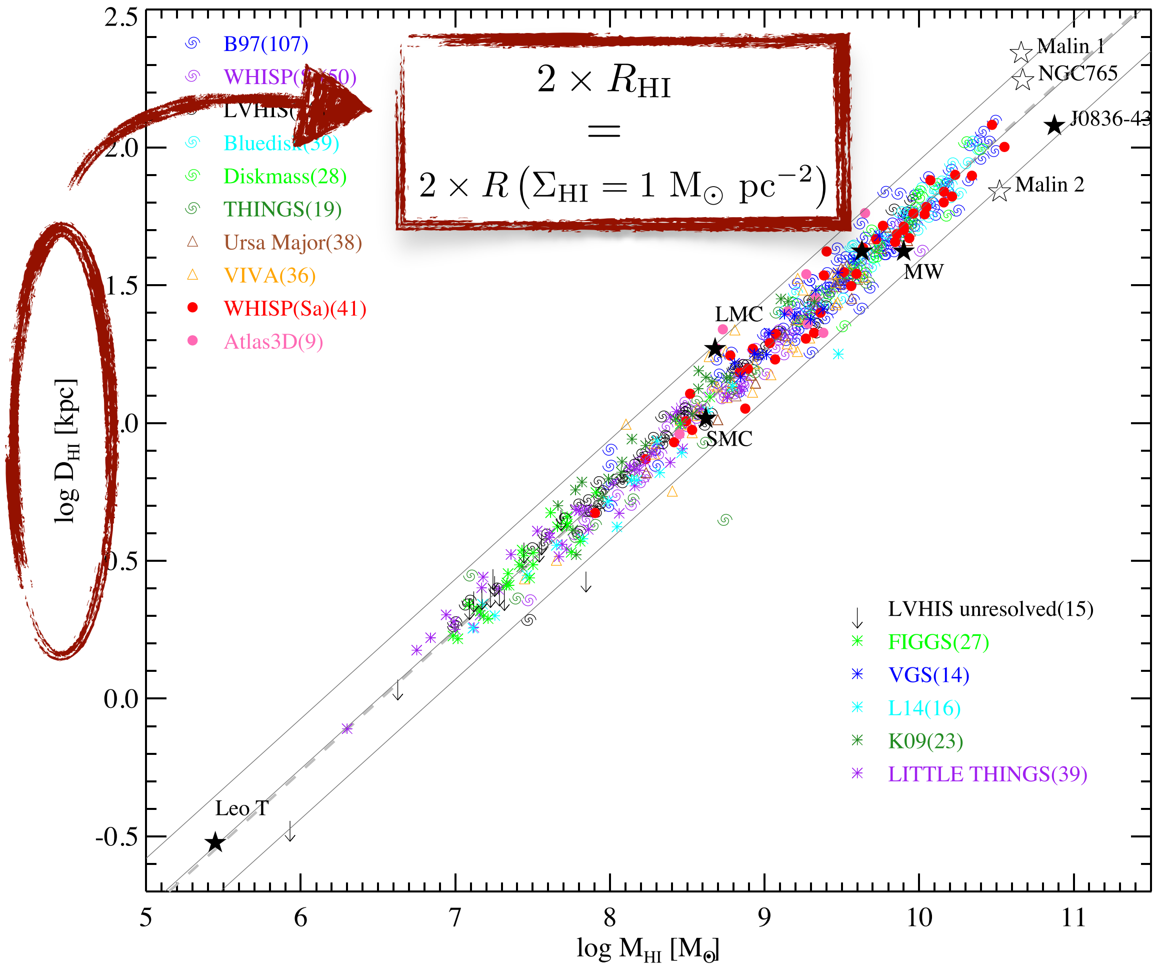

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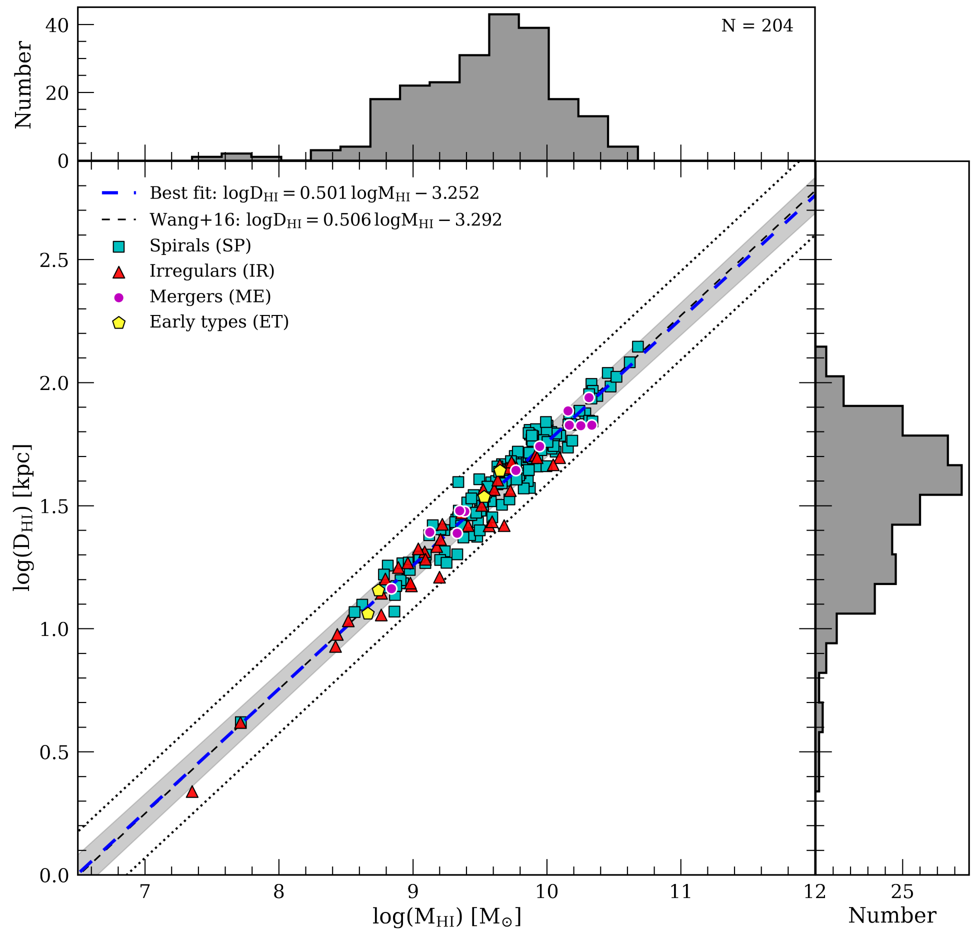

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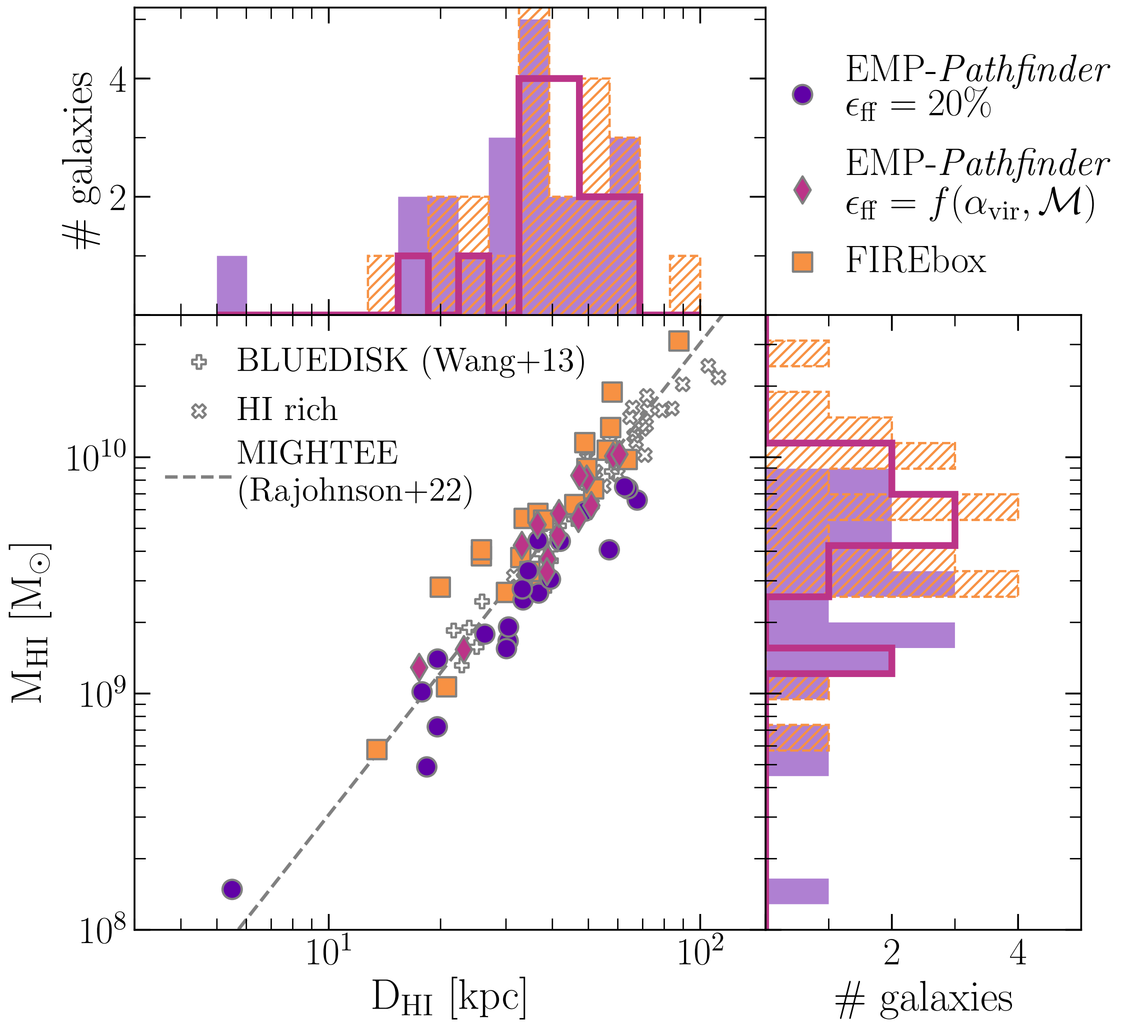

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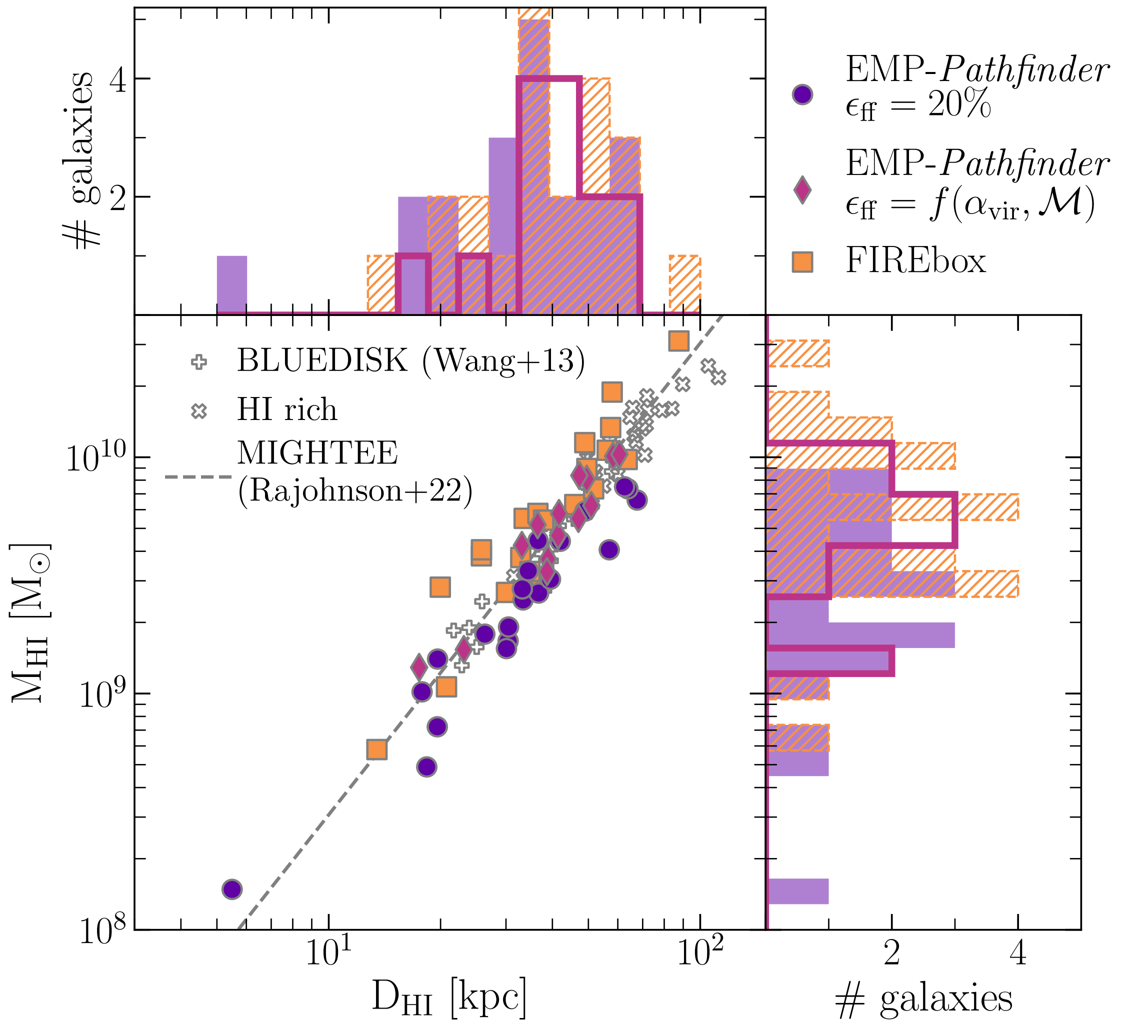
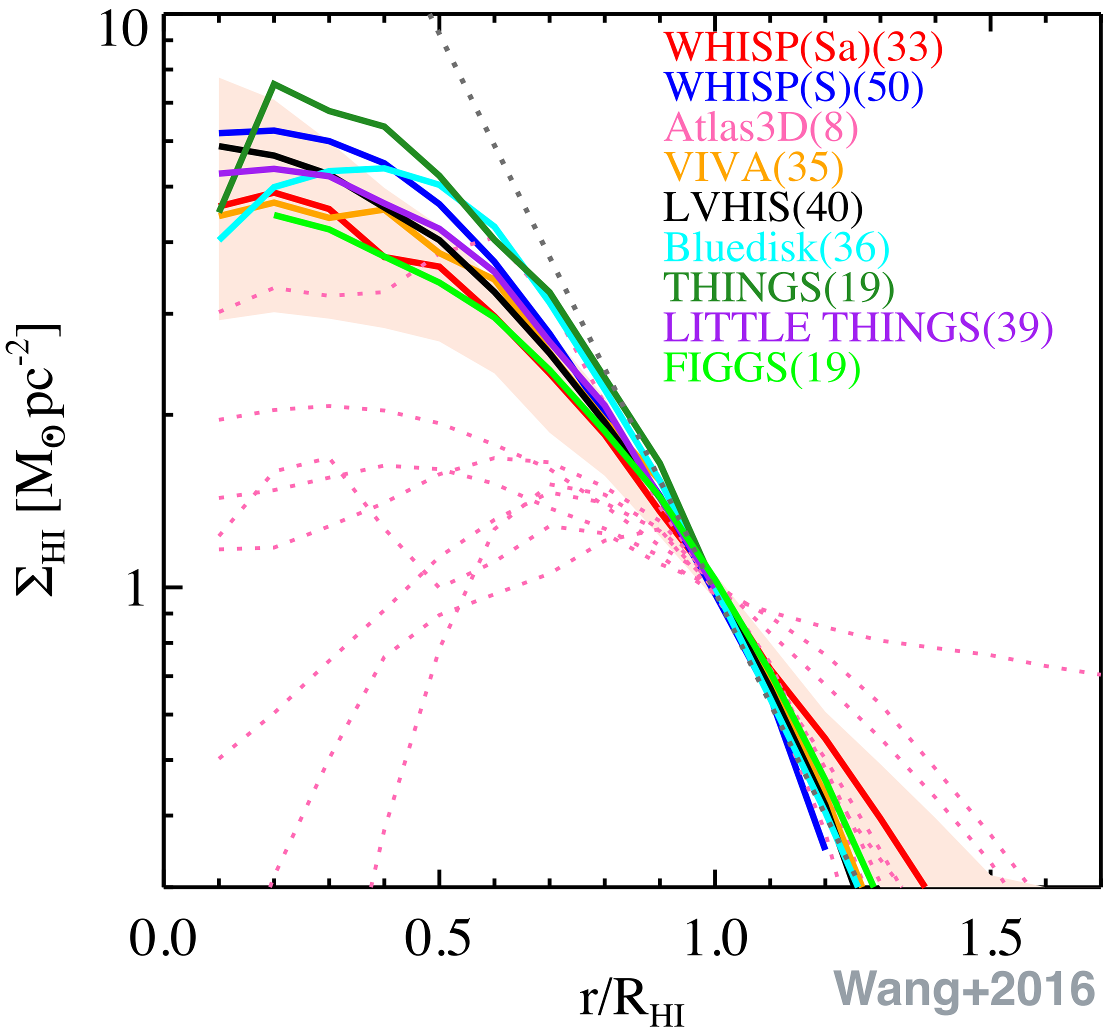


All simulations follow mass-size relation

Gensior+2022b, in prep.

MEDIAN HI SURFACE DENSITY PROFILES



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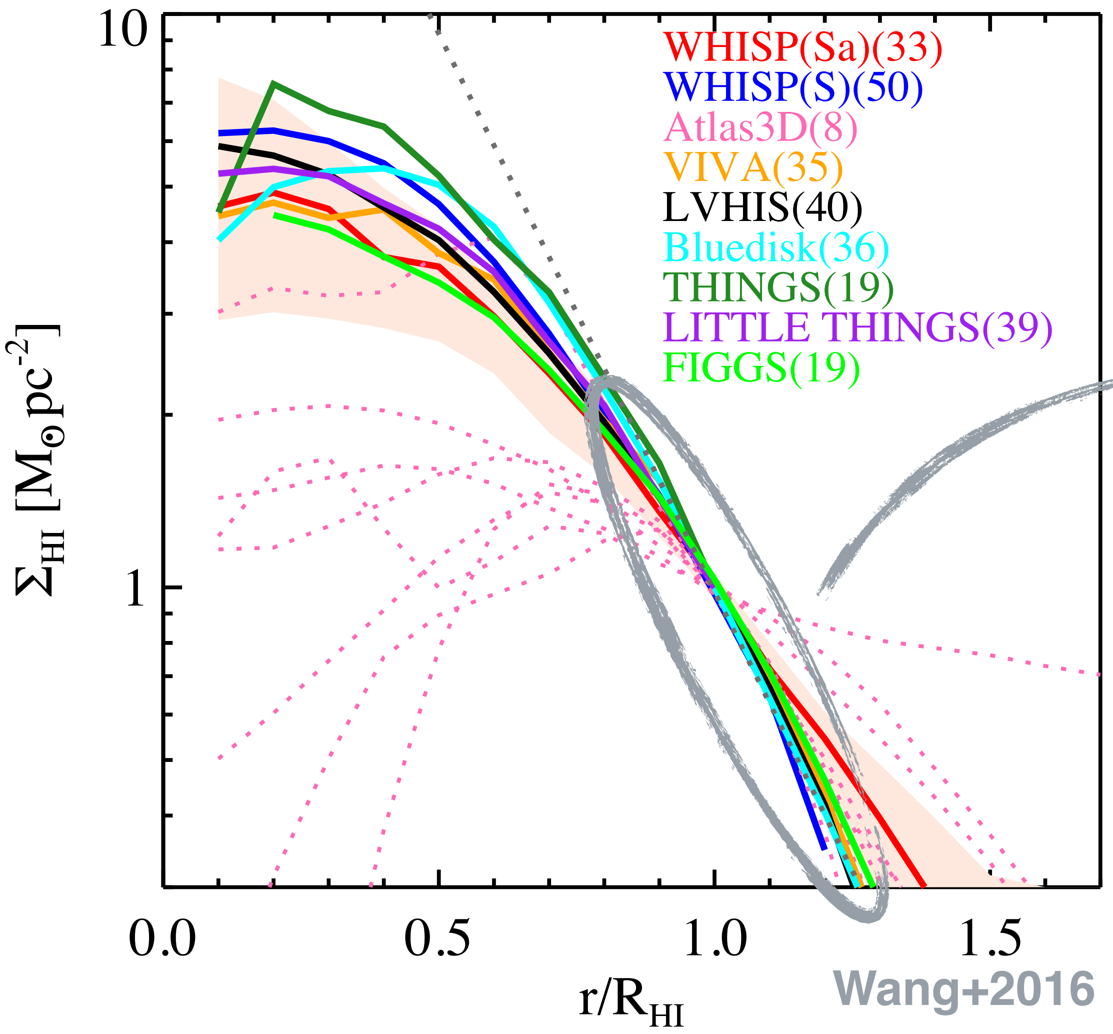
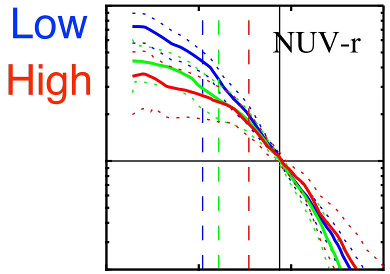


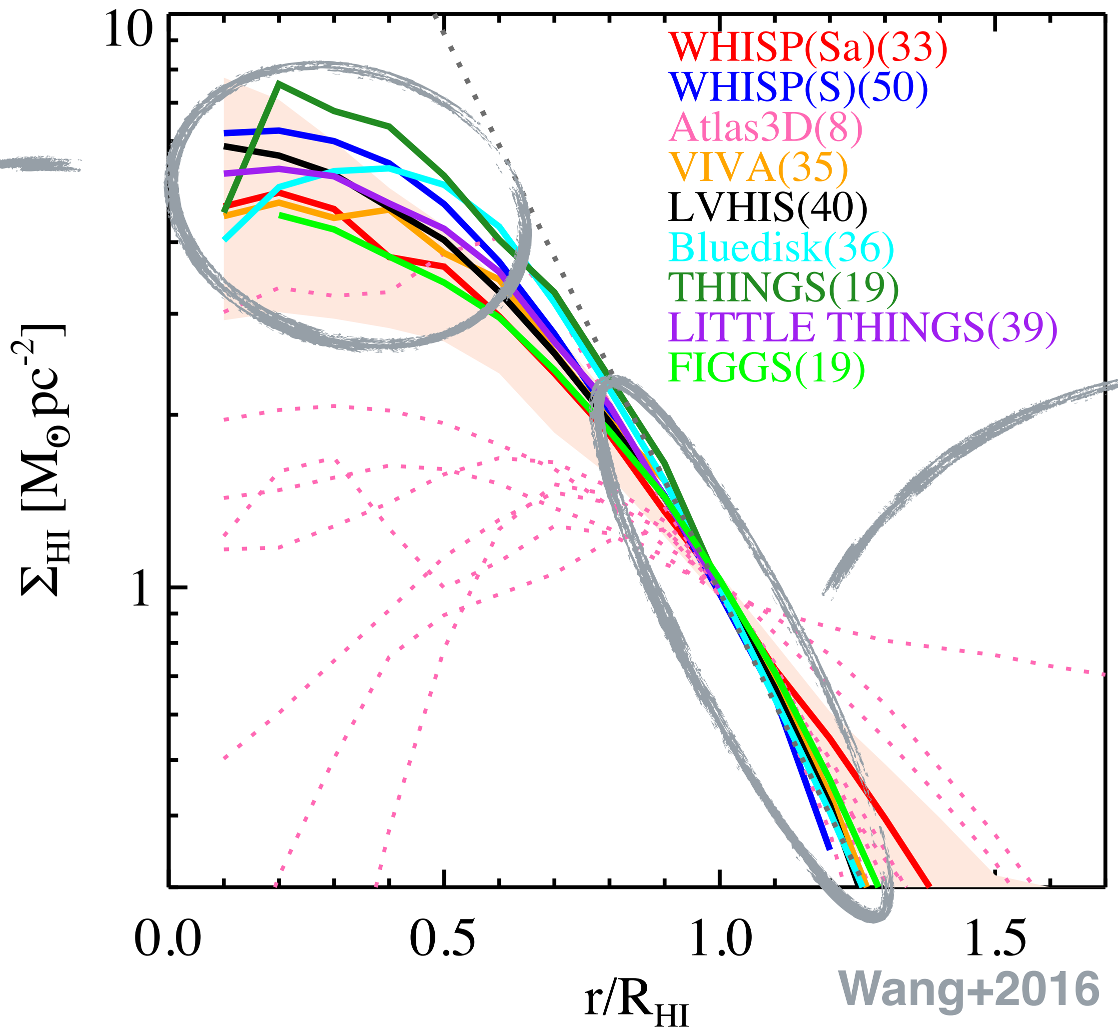
Wang+2016

exponential profile
R > 0.8 R_{HI} (e.g Swaters+2002, Bigiel & Blitz 2012, Wang+2014, Wang+2016)

MEDIAN HI SURFACE DENSITY PROFILES

Variation might be driven by SFR (Wang+2014)





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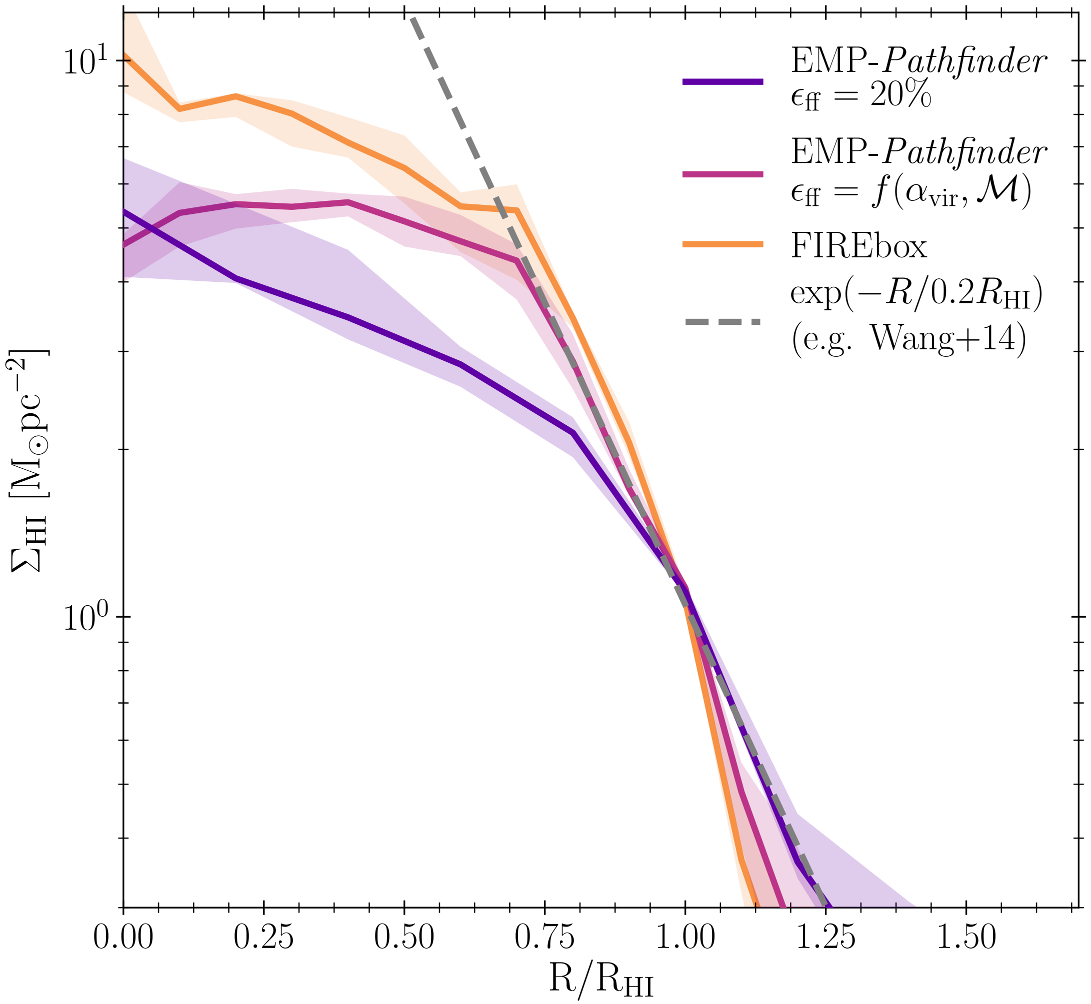

Gensior+2022b, in prep.

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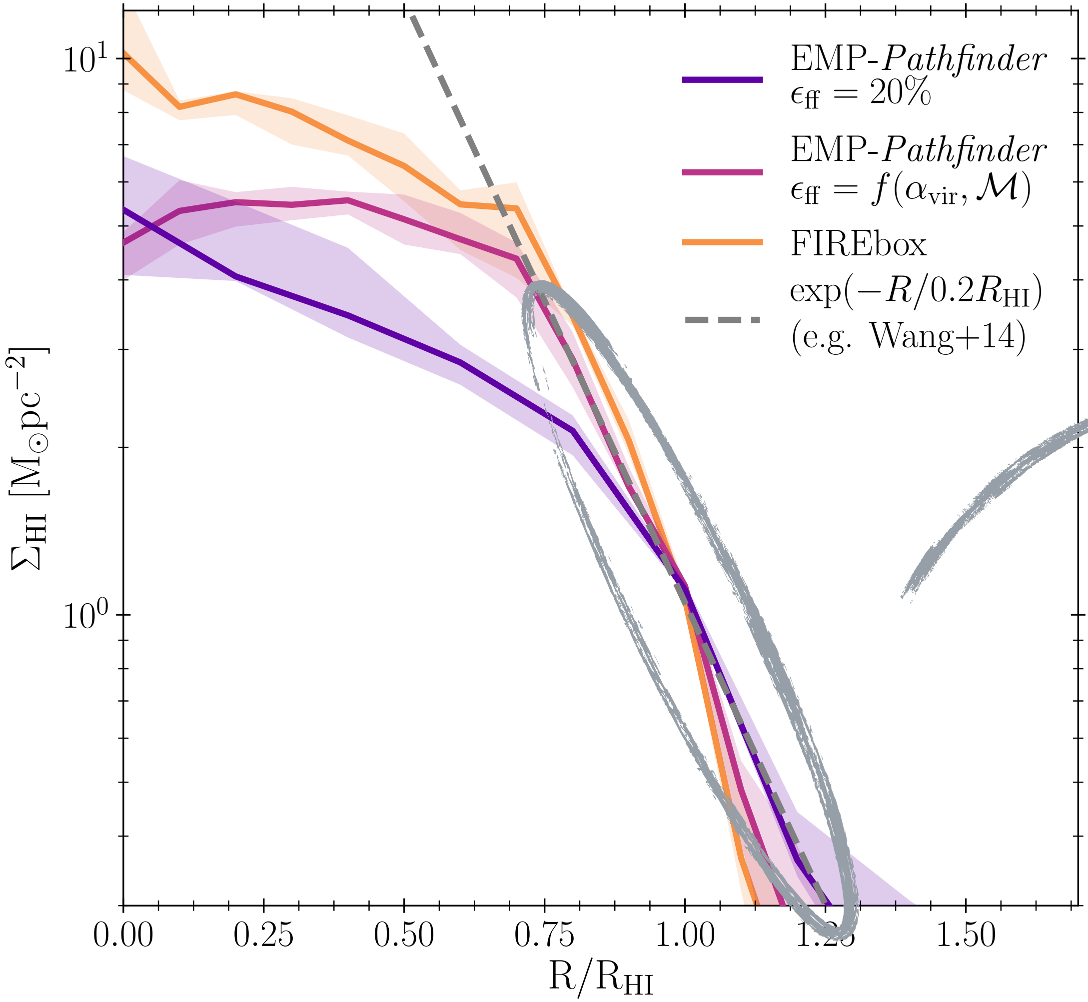


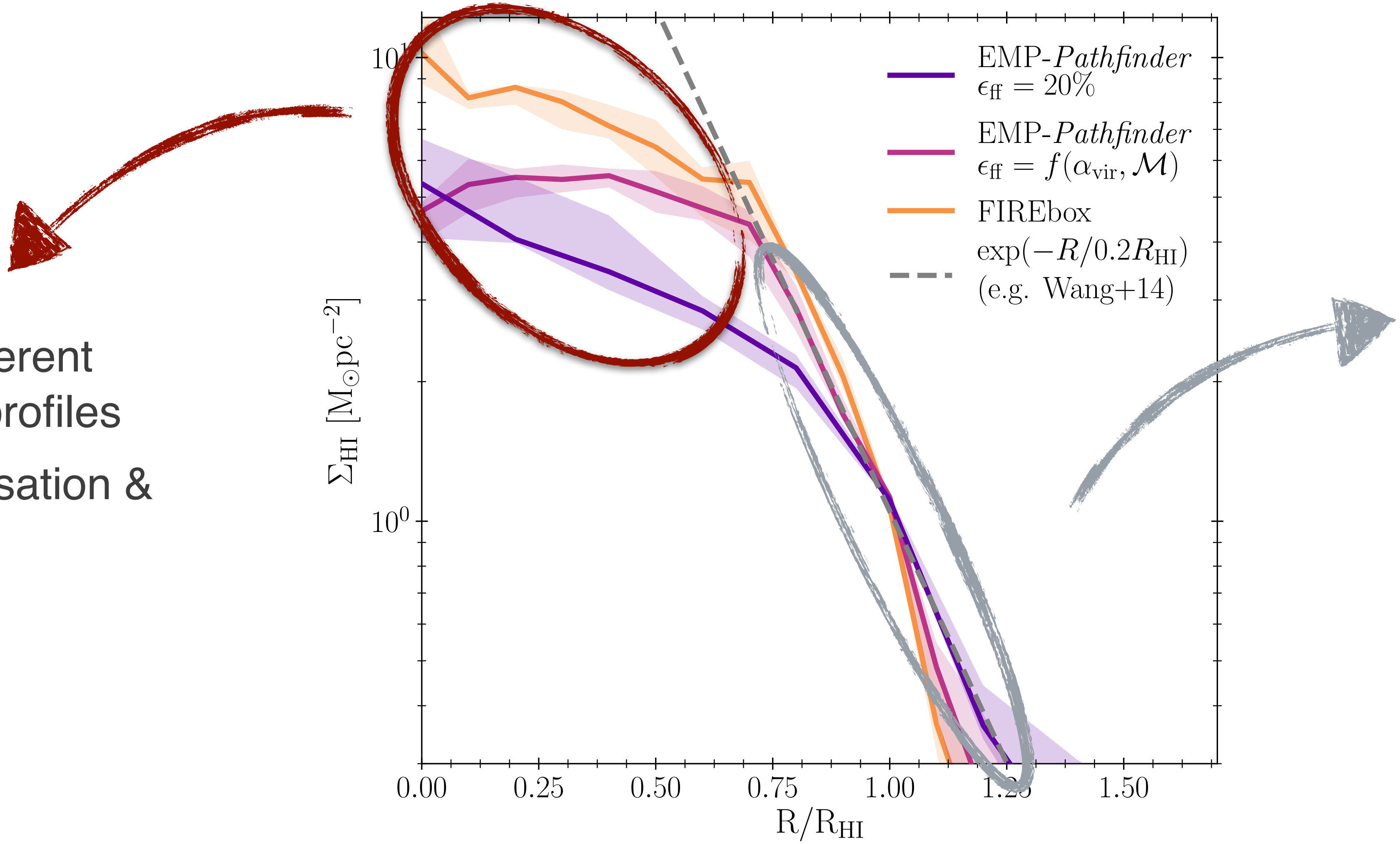
approximately follow exponential profile

Gensior+2022b, in prep.

MEDIAN HI SURFACE DENSITY PROFILES

Very different central profiles

(normalisation & shape)



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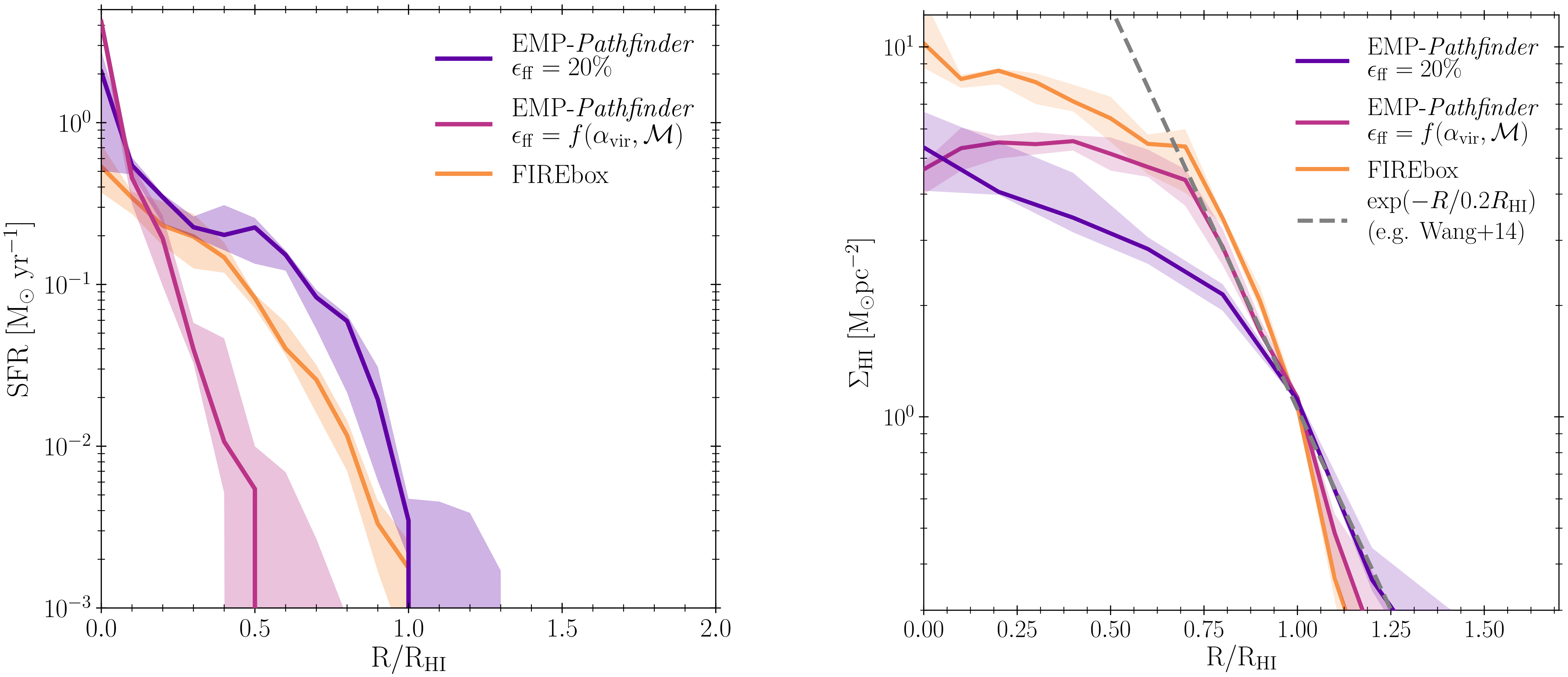

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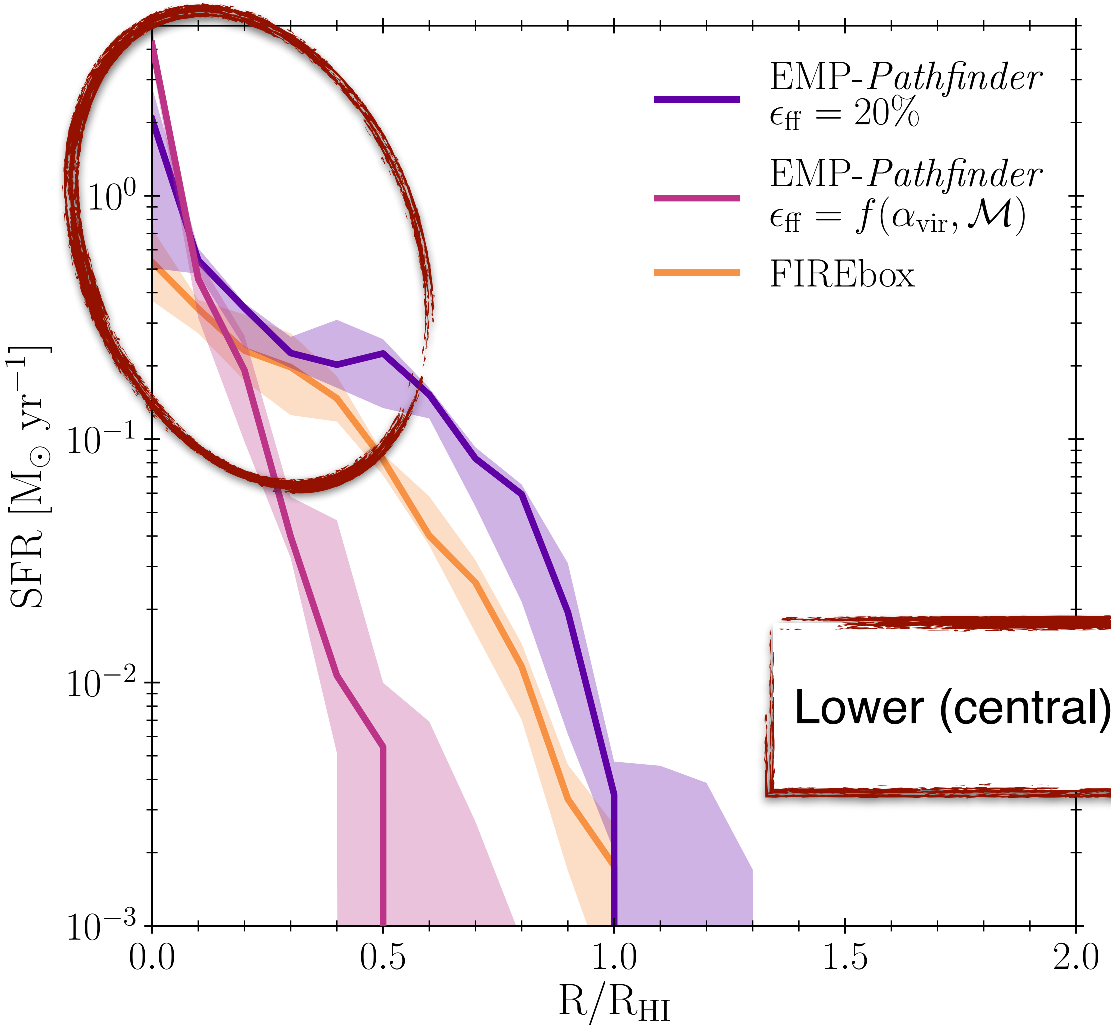
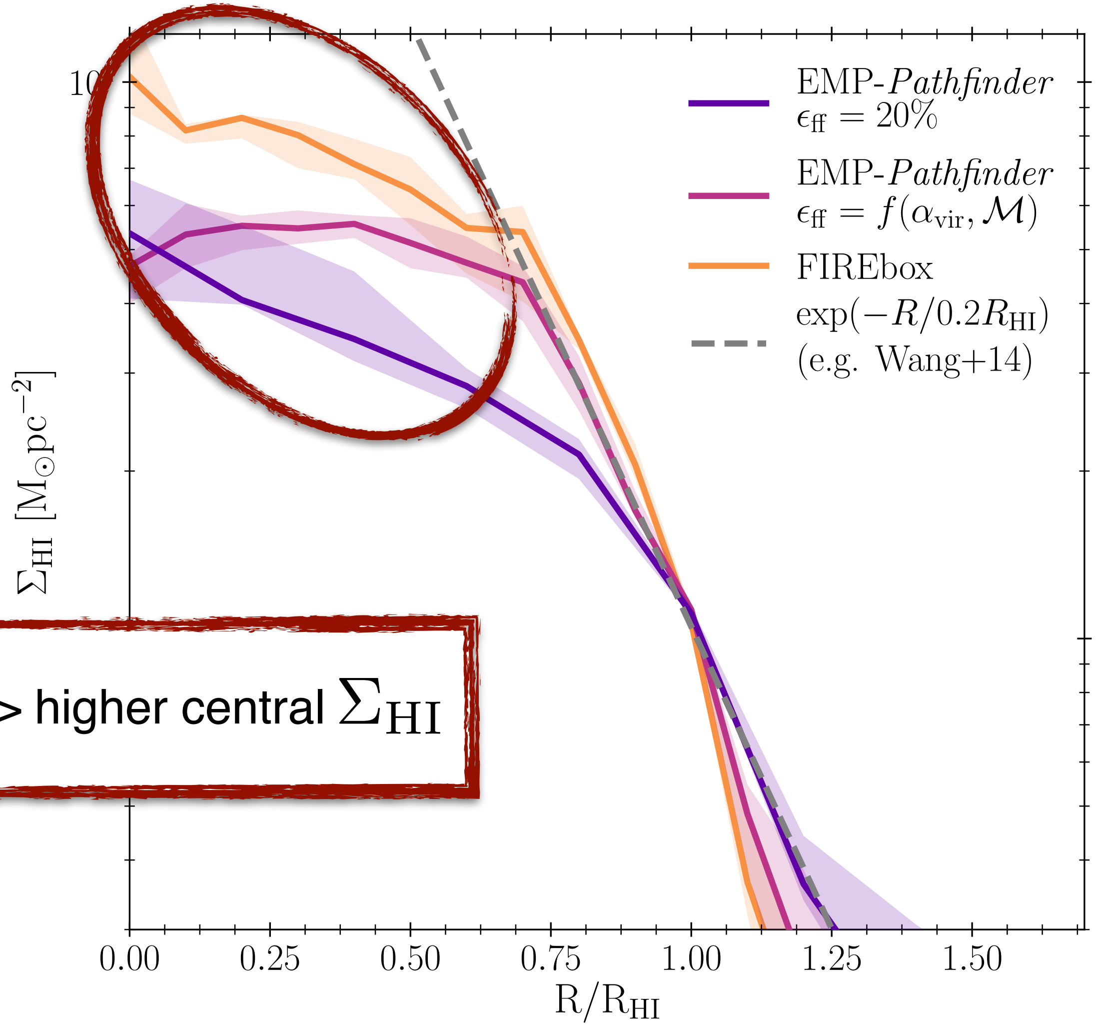
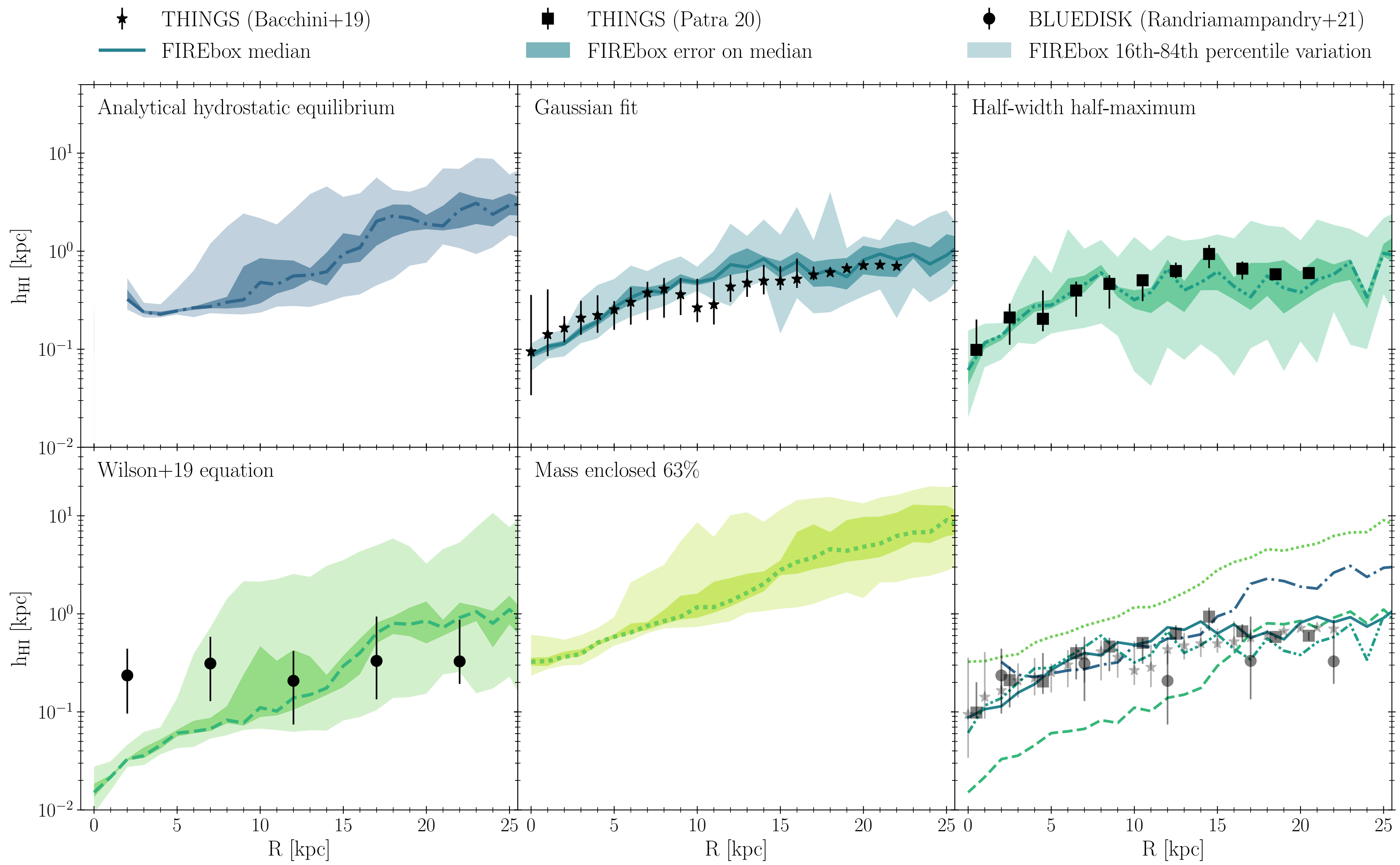


Lower (central) SFR -> higher central Σ_{HI}



Gensior+2022b, in prep.

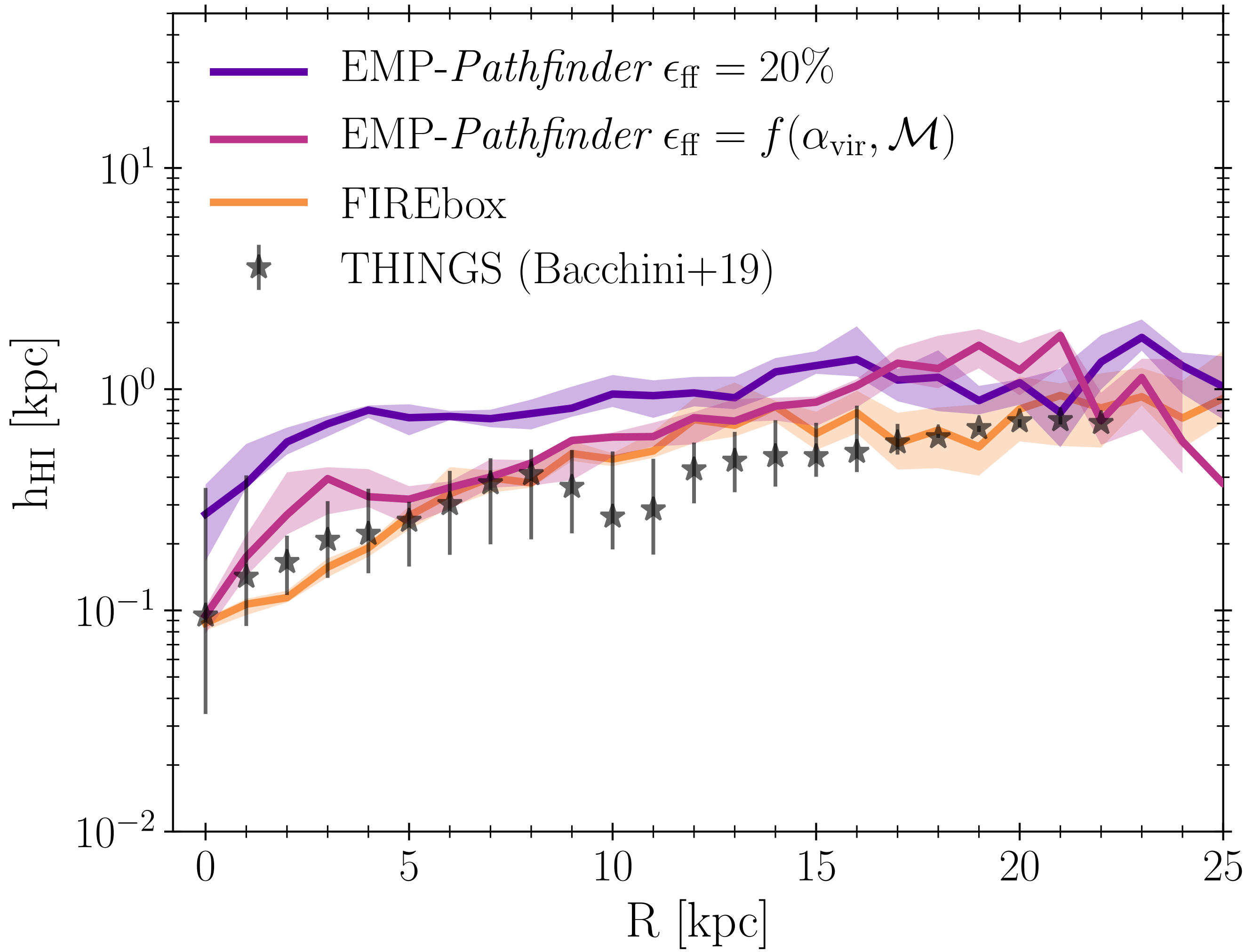
HI DISC SCALE HEIGHTS



How the scale height is measured matters

Gensior+2022a, subm.

HI DISC SCALE HEIGHTS



Gensior+2022b, in prep.

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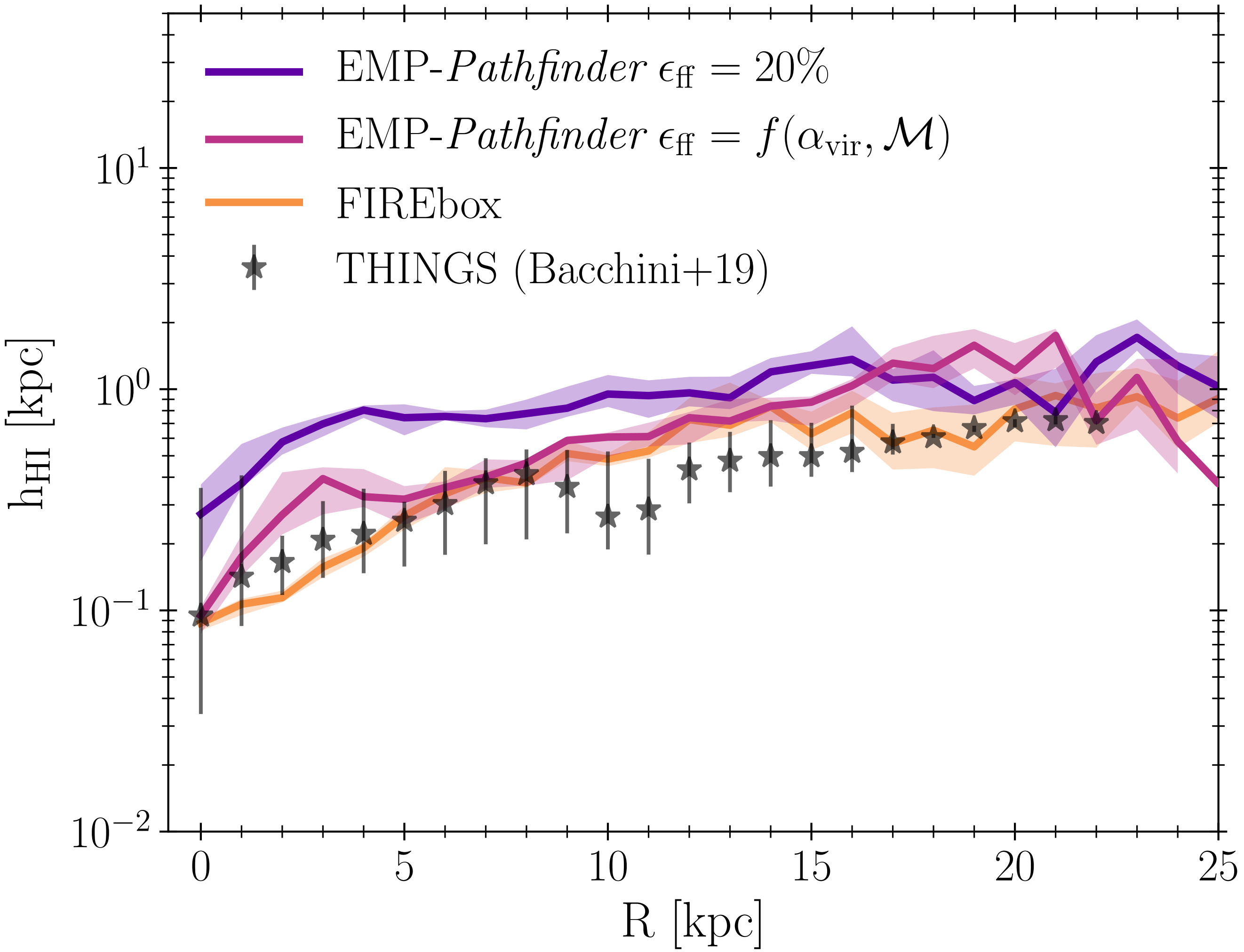

Constant SFE EMP-*Pathfinder* is too thick

Gensior+2022b, in prep.

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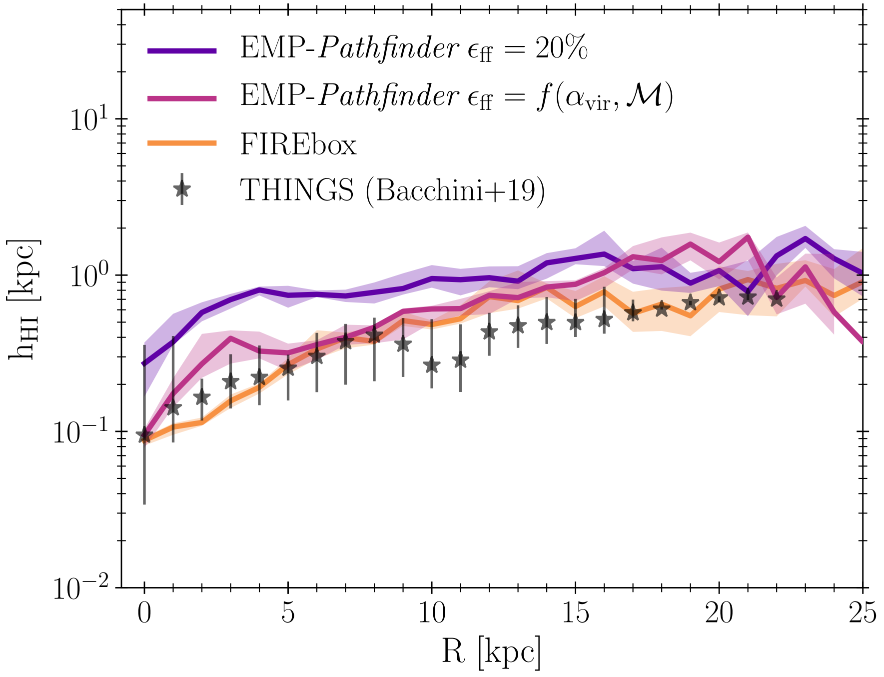
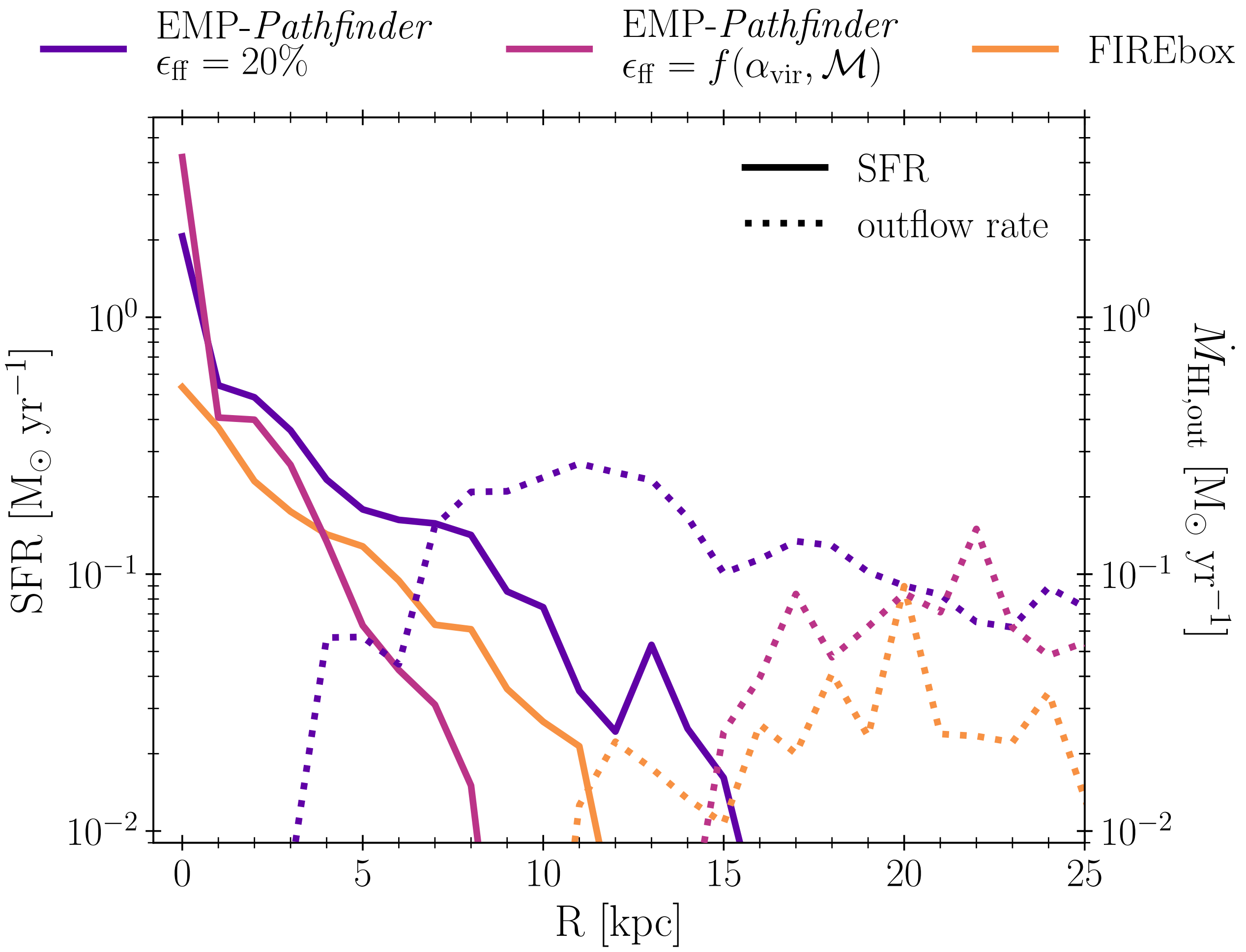


Sensitive to outflows



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HI DISC MORPHOLOGY

EMP-*Pathfinder*

$\epsilon_{\rm ff} = 20\%$

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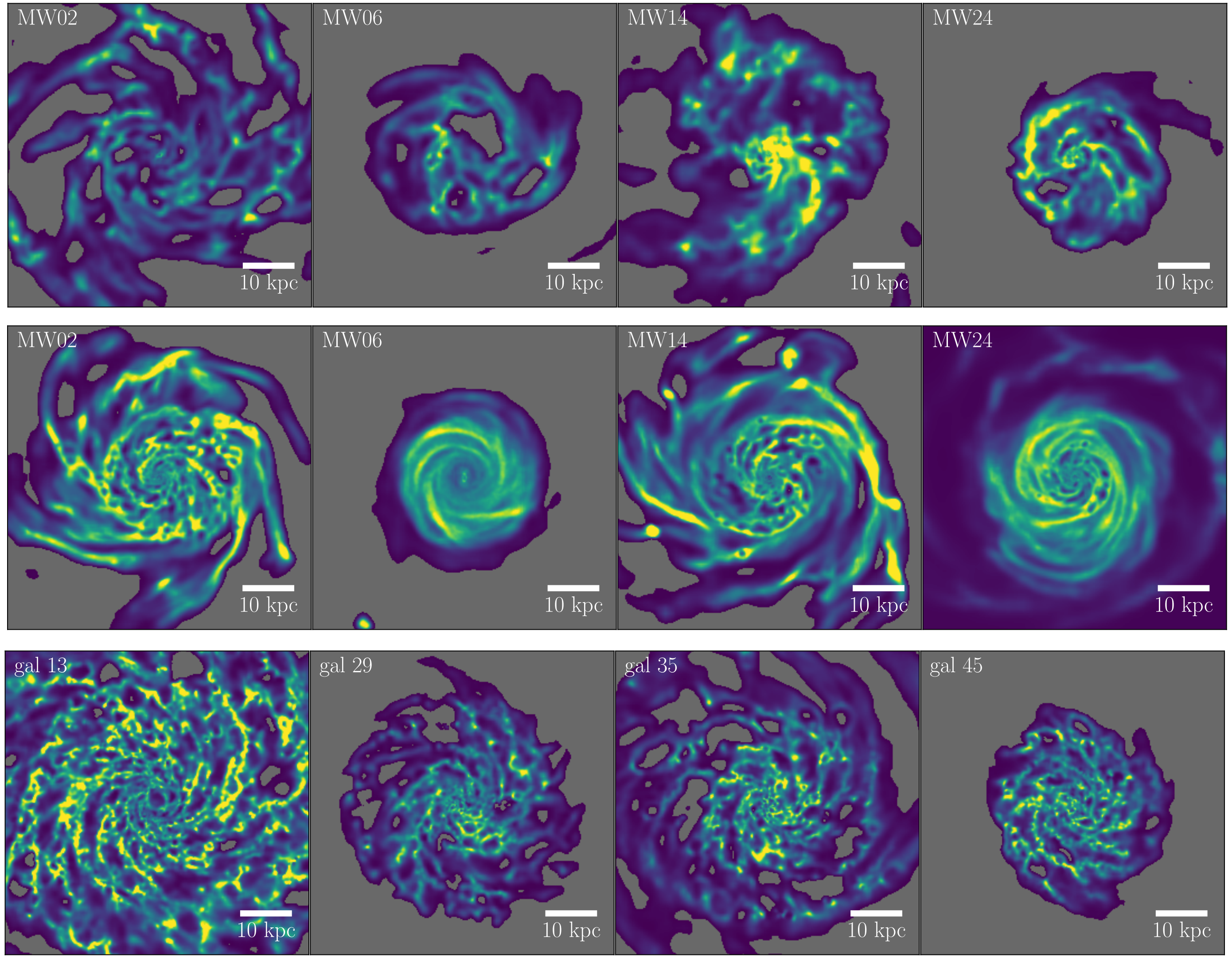
$\epsilon_{\rm ff} = f(\alpha_{\rm vir}, \mathcal{M})$

FIREbox

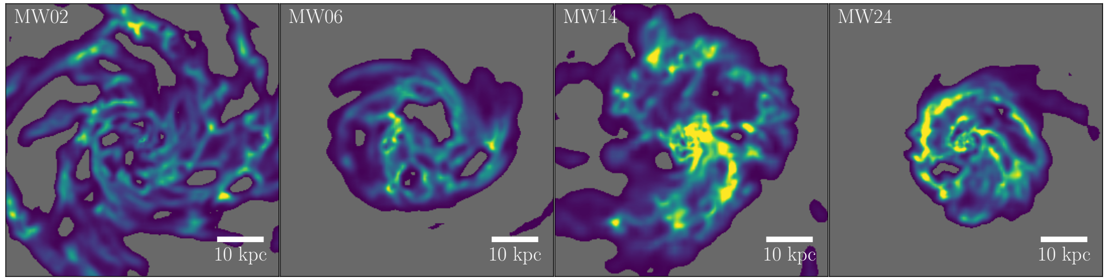


Gensior+2022b, in prep.

HI DISC MORPHOLOGY

STRONGLY AFFECTED BY BARYONIC PHYSICS

EMP-*Pathfinder* $\epsilon_{\rm ff} = 20\%$



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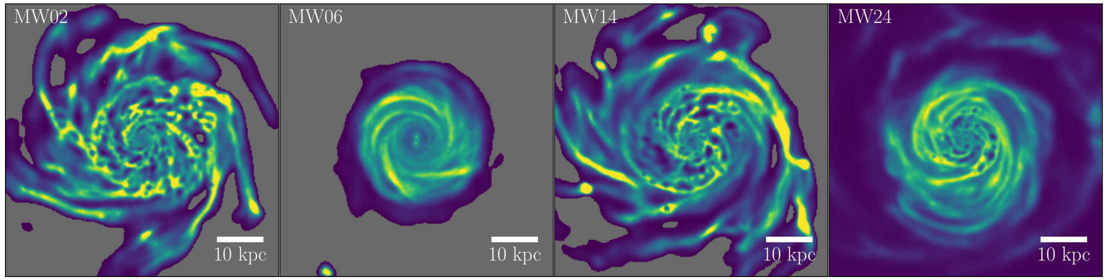

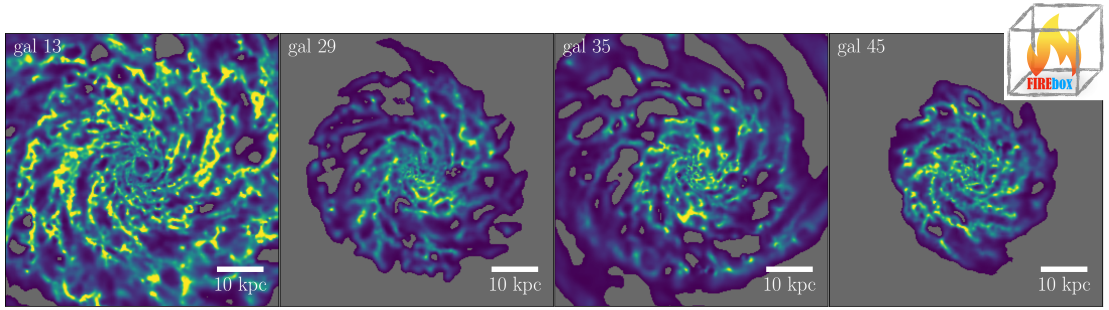

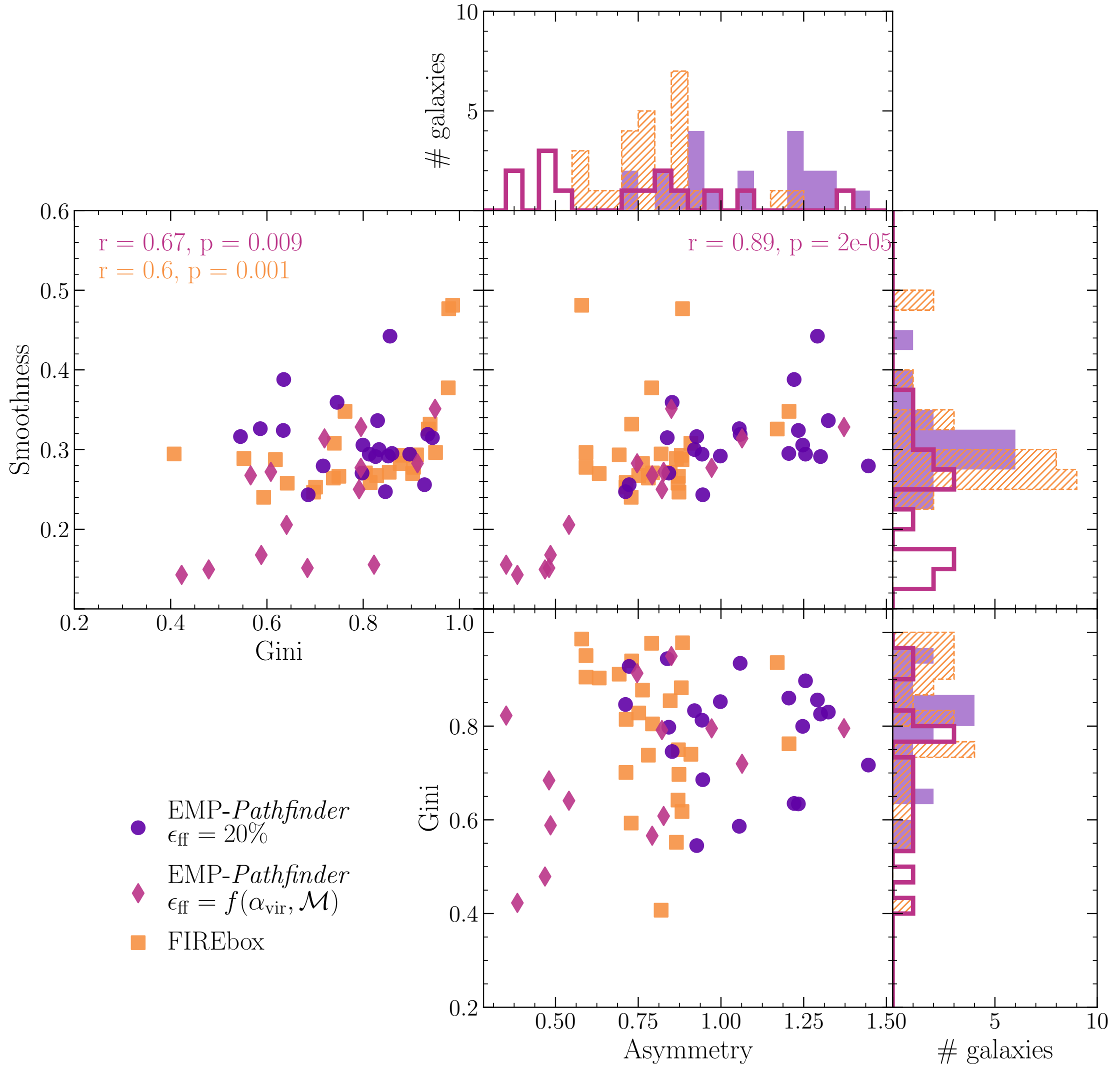

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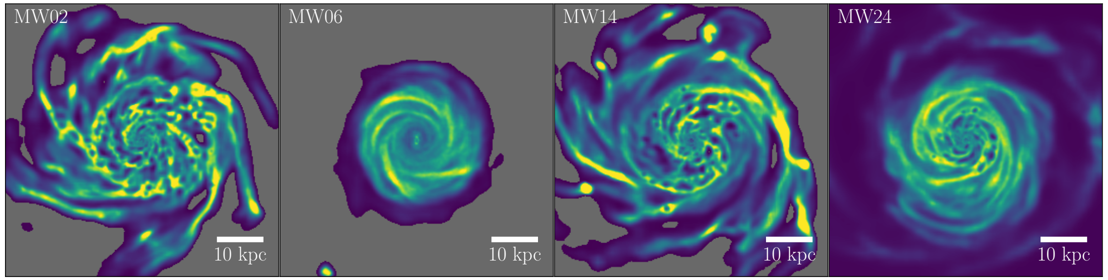

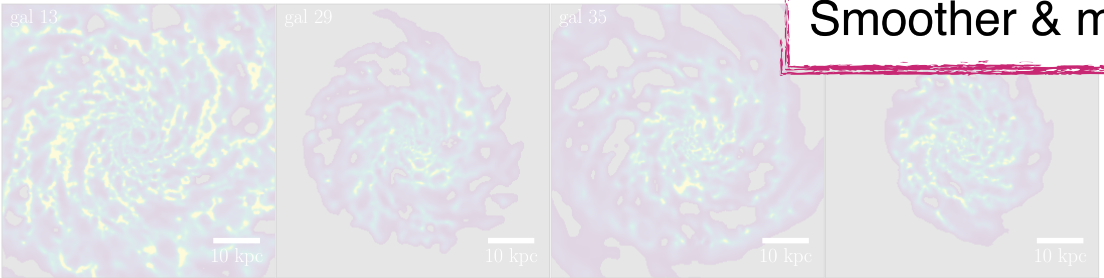

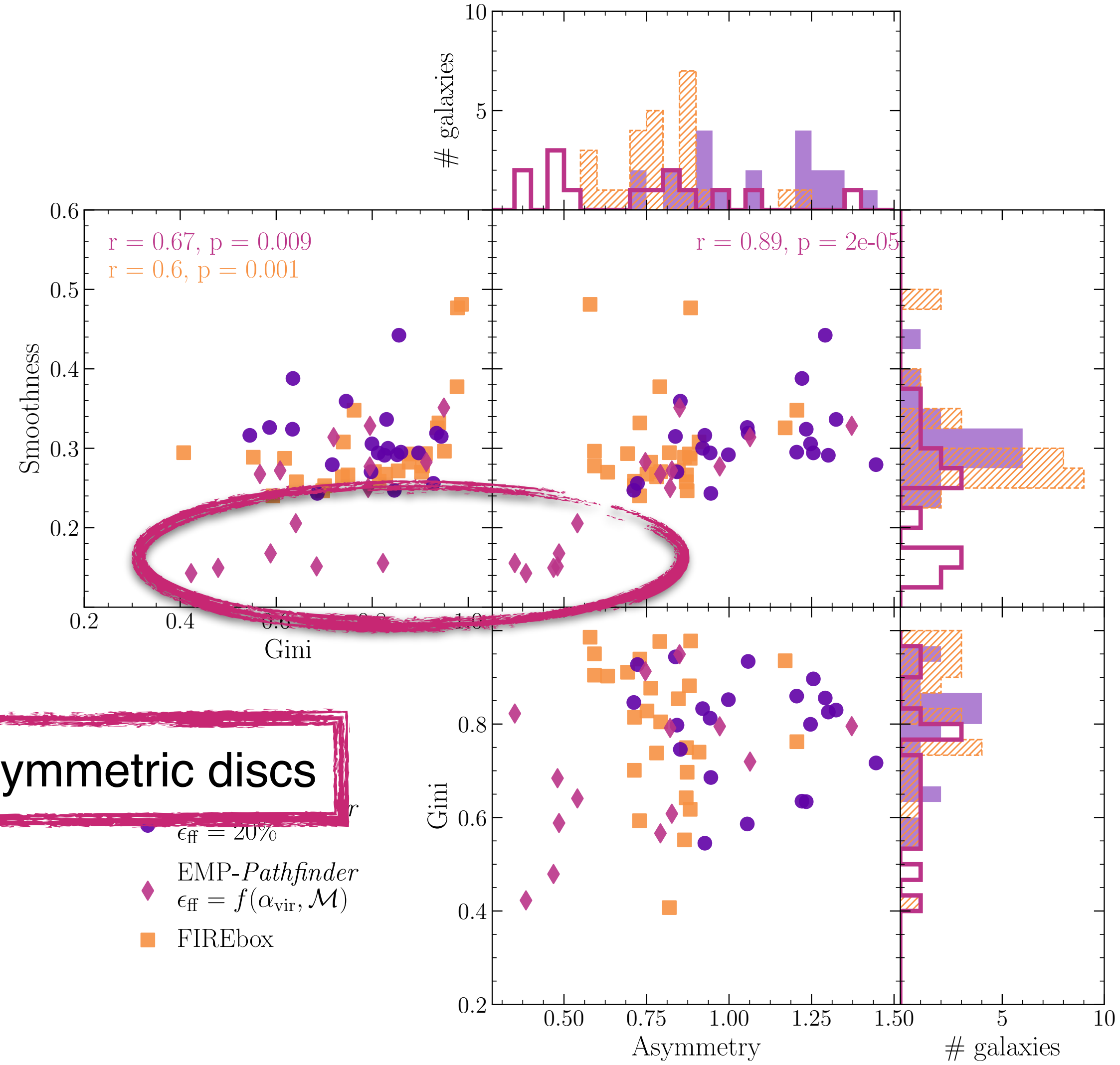

Smoother & more symmetric discs

Gensior+2022b, in prep.

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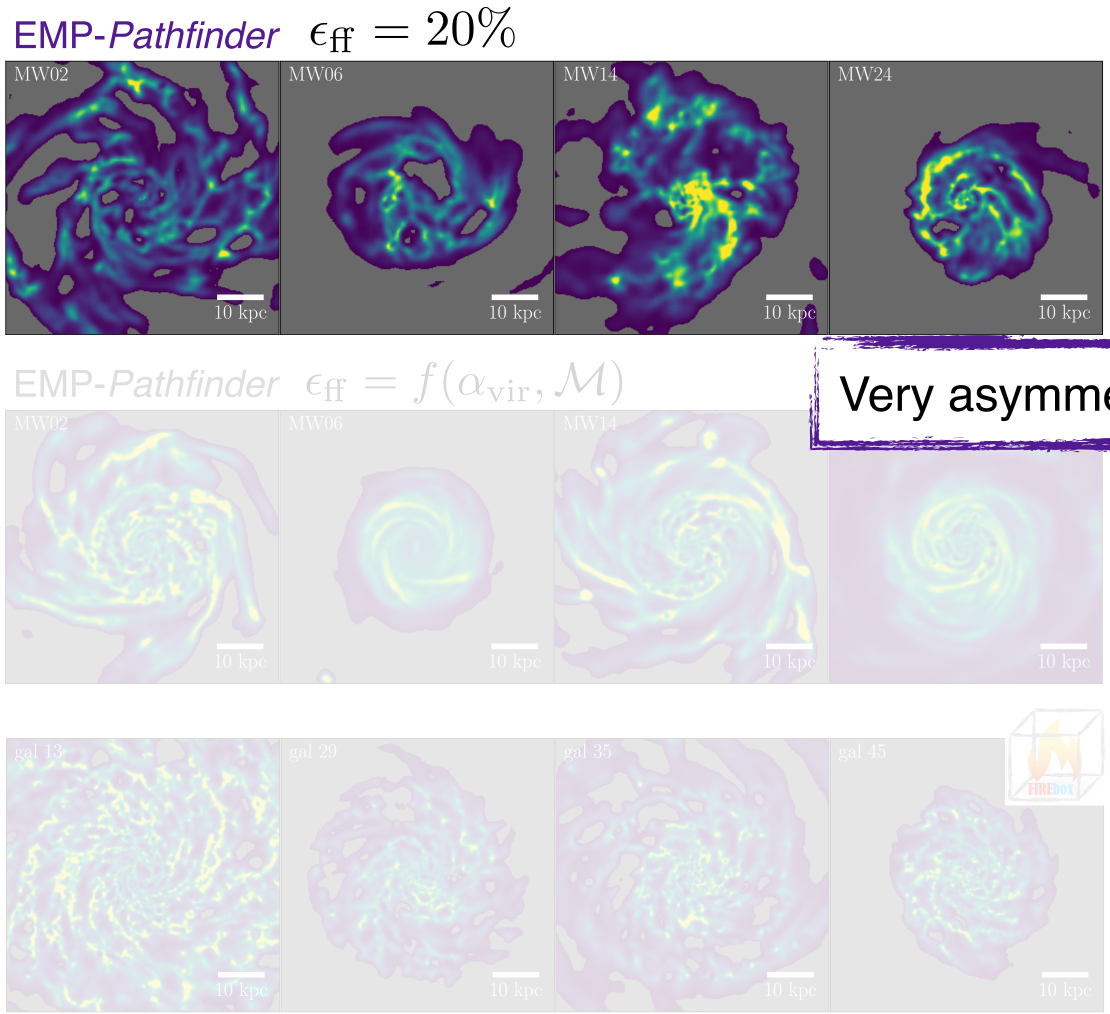
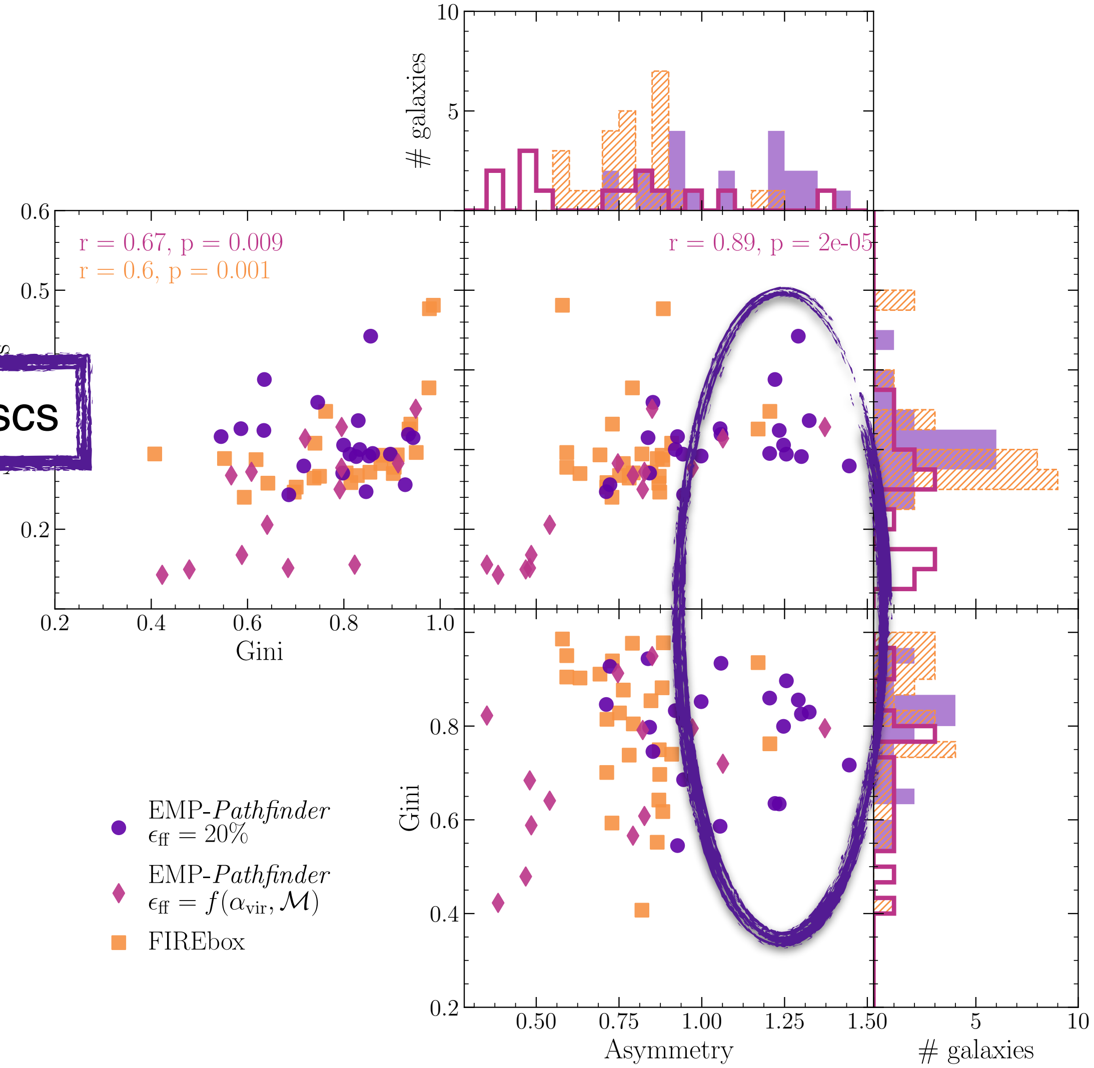


Very asymmetric discs



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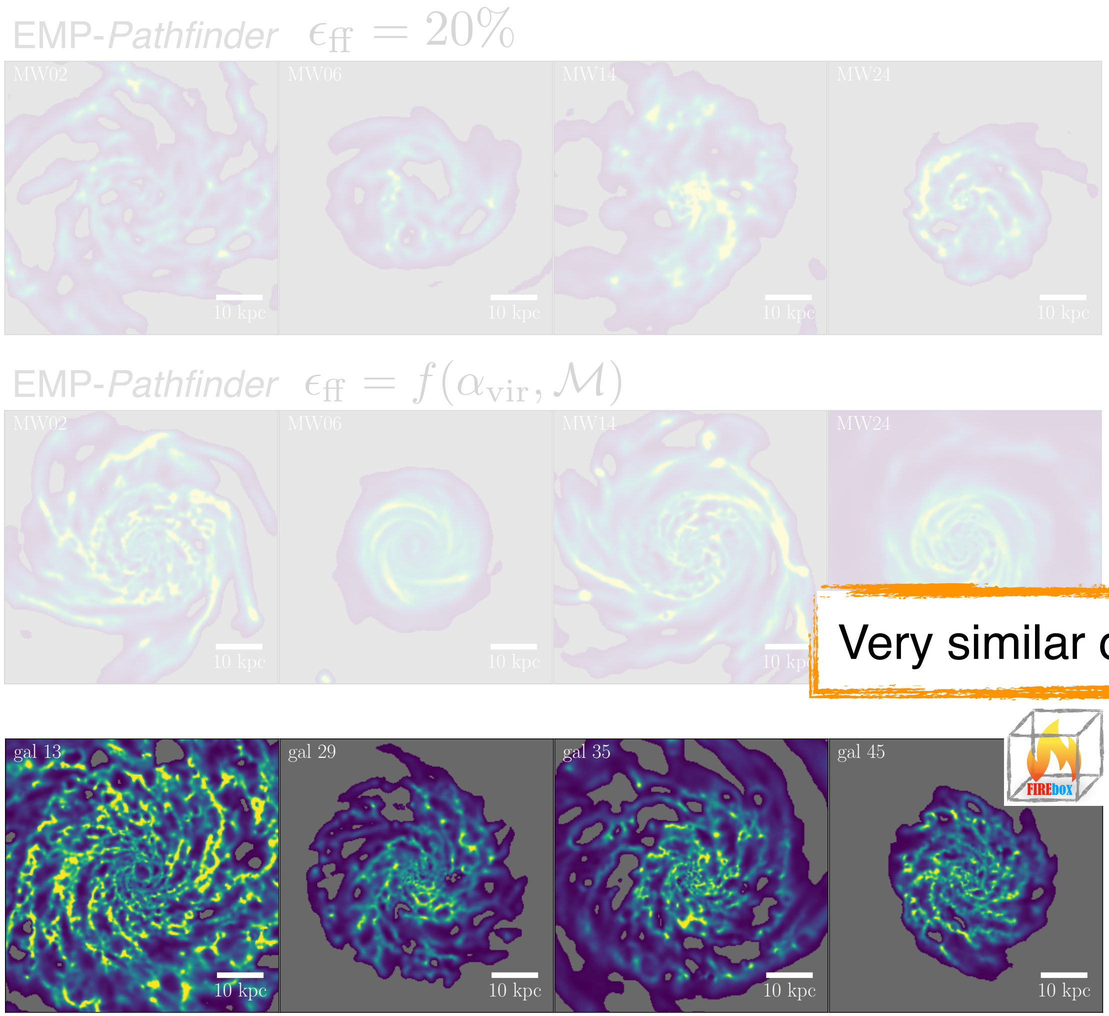
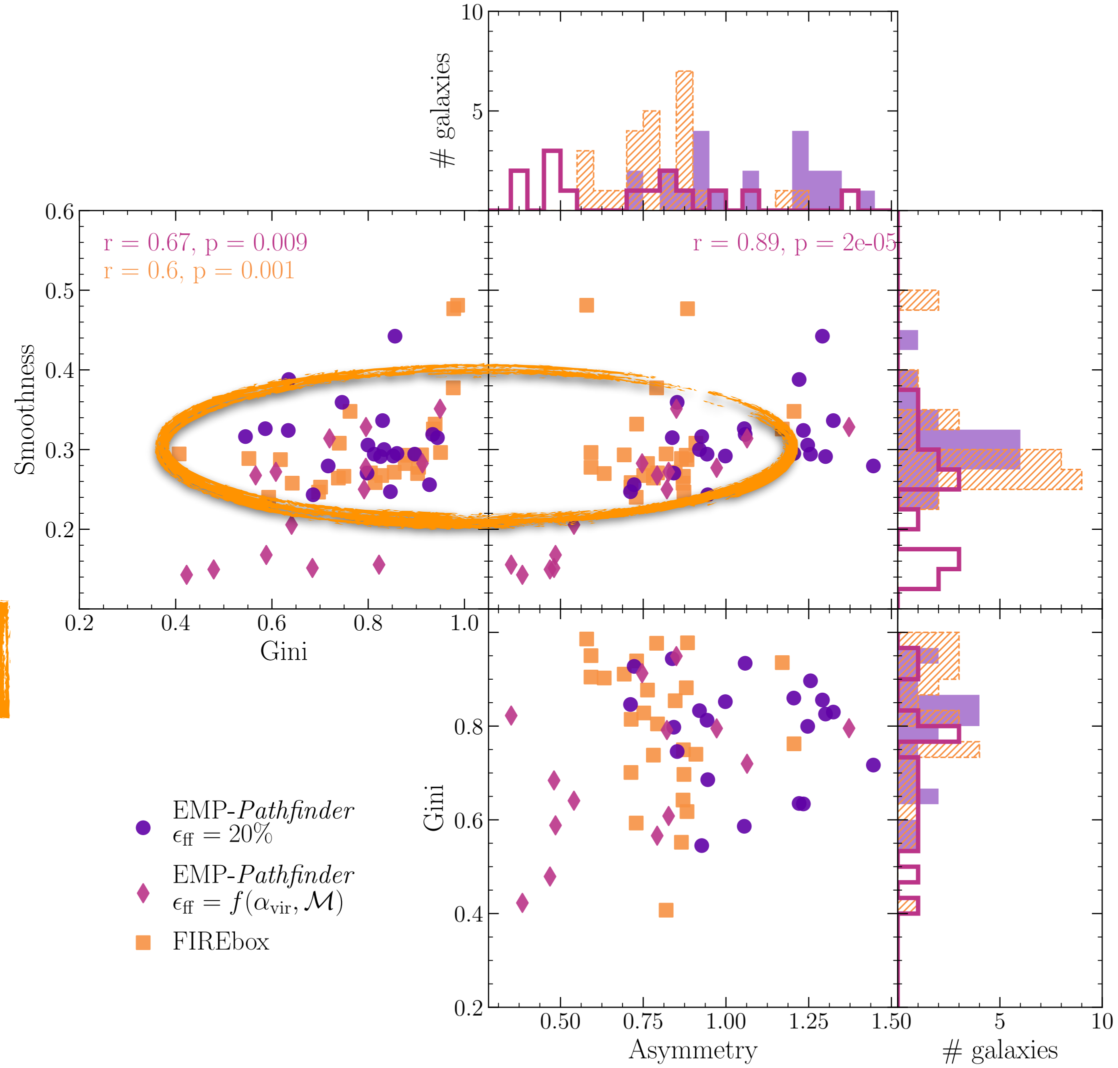
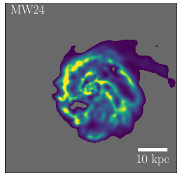


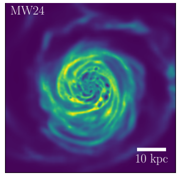
Very similar discs

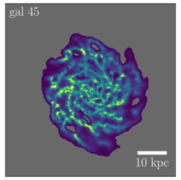


Gensior+2022b, in prep.

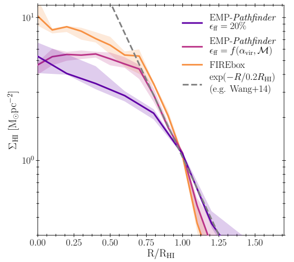
SUMMARY



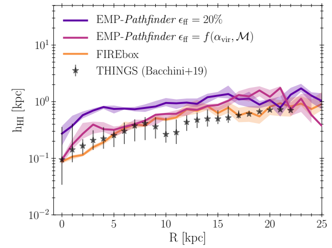




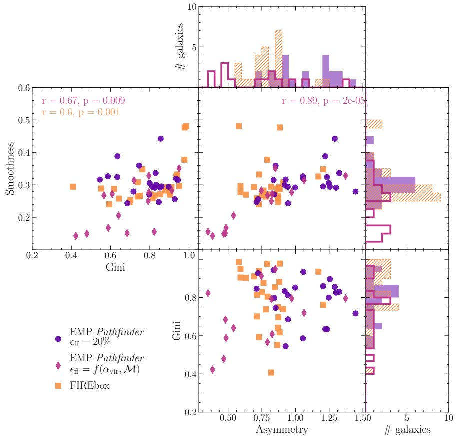
- HI discs are extremely sensitive to the physics of star formation and stellar feedback:



  - Central HI surface density profile differs depending on SFR



  - Only FIREbox & multi free-fall SFE EMP-*Pathfinder* produce thin HI discs
  - Very different HI morphologies:
    - ➡ multi free-fall SFE EMP-*Pathfinder* galaxies have very smooth & symmetric HI discs
    - ➡ FIREbox: porous & sub-structured (very similar amount of structure in all discs)
    - ➡ constant SFE EMP-*Pathfinder*: very asymmetric



- To come: in-depth investigation of the physical drivers, power spectrum analysis, predictions for higher-z