



SIMULATIONS

AND



OBSERVATIONS

Capturing IMF variations – how far along are we ?

**Alina
Böcker**

Annalisa Pillepich (MPIA),
Dylan Nelson (ITA)

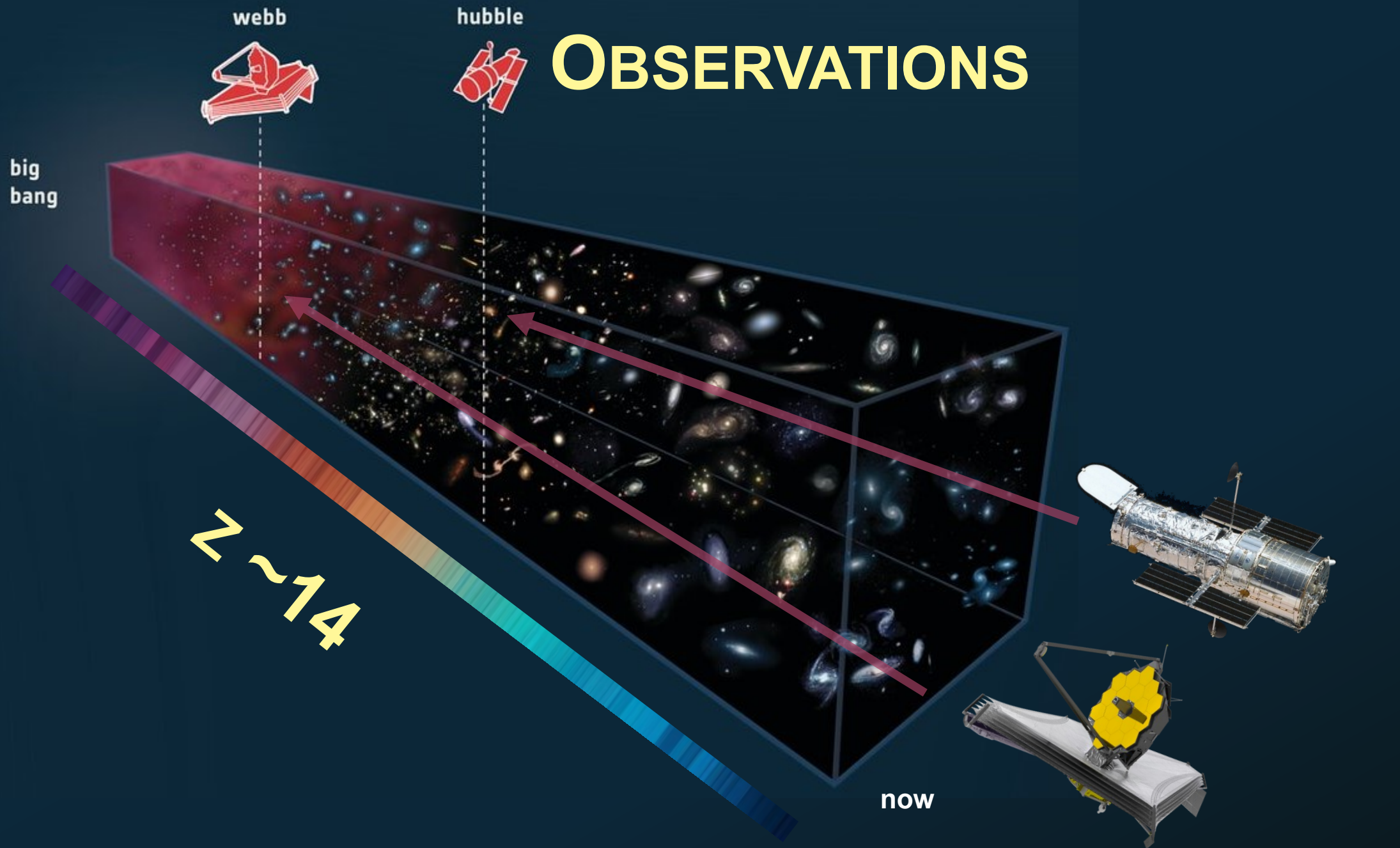


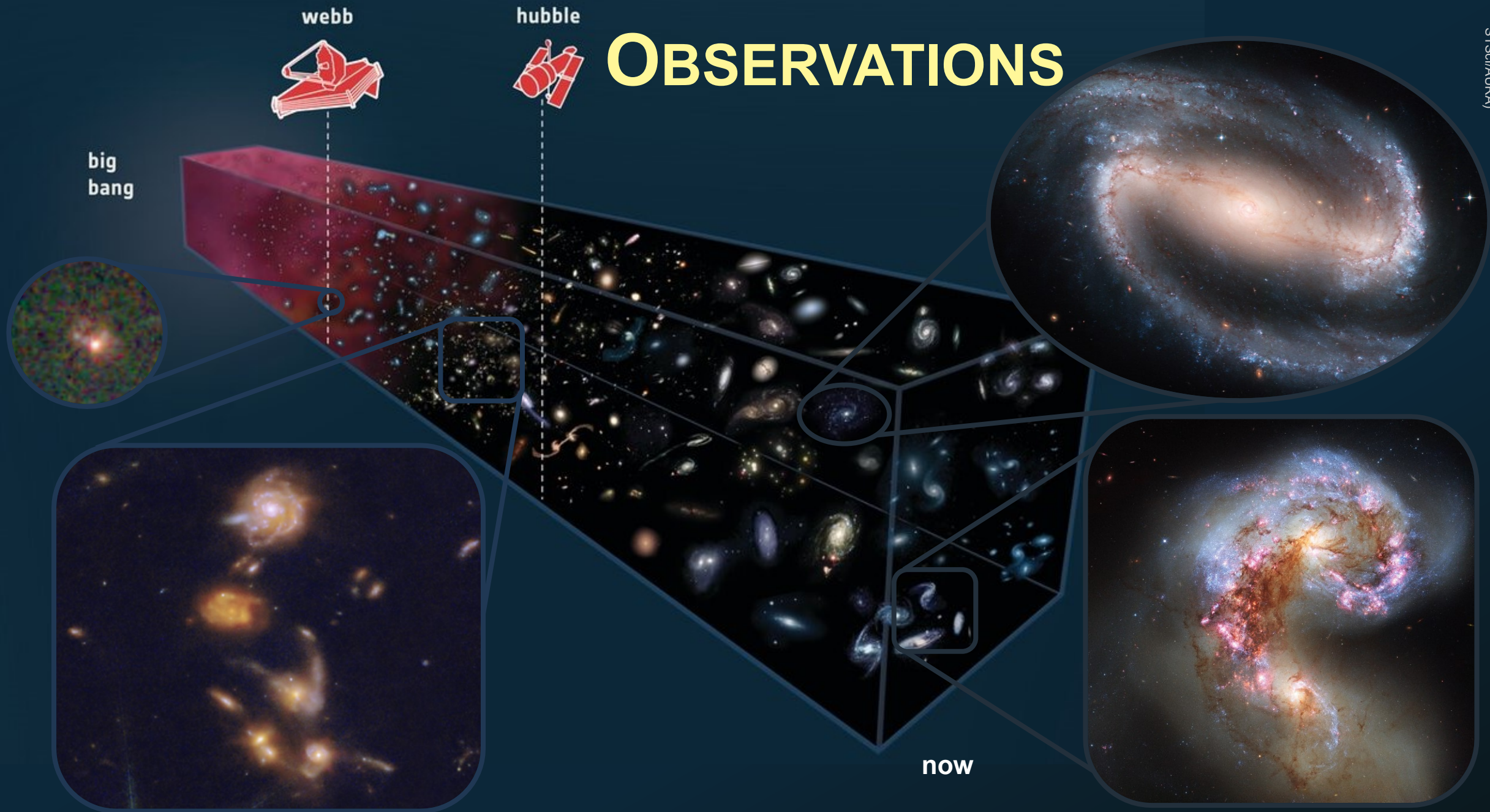
**universität
wien**

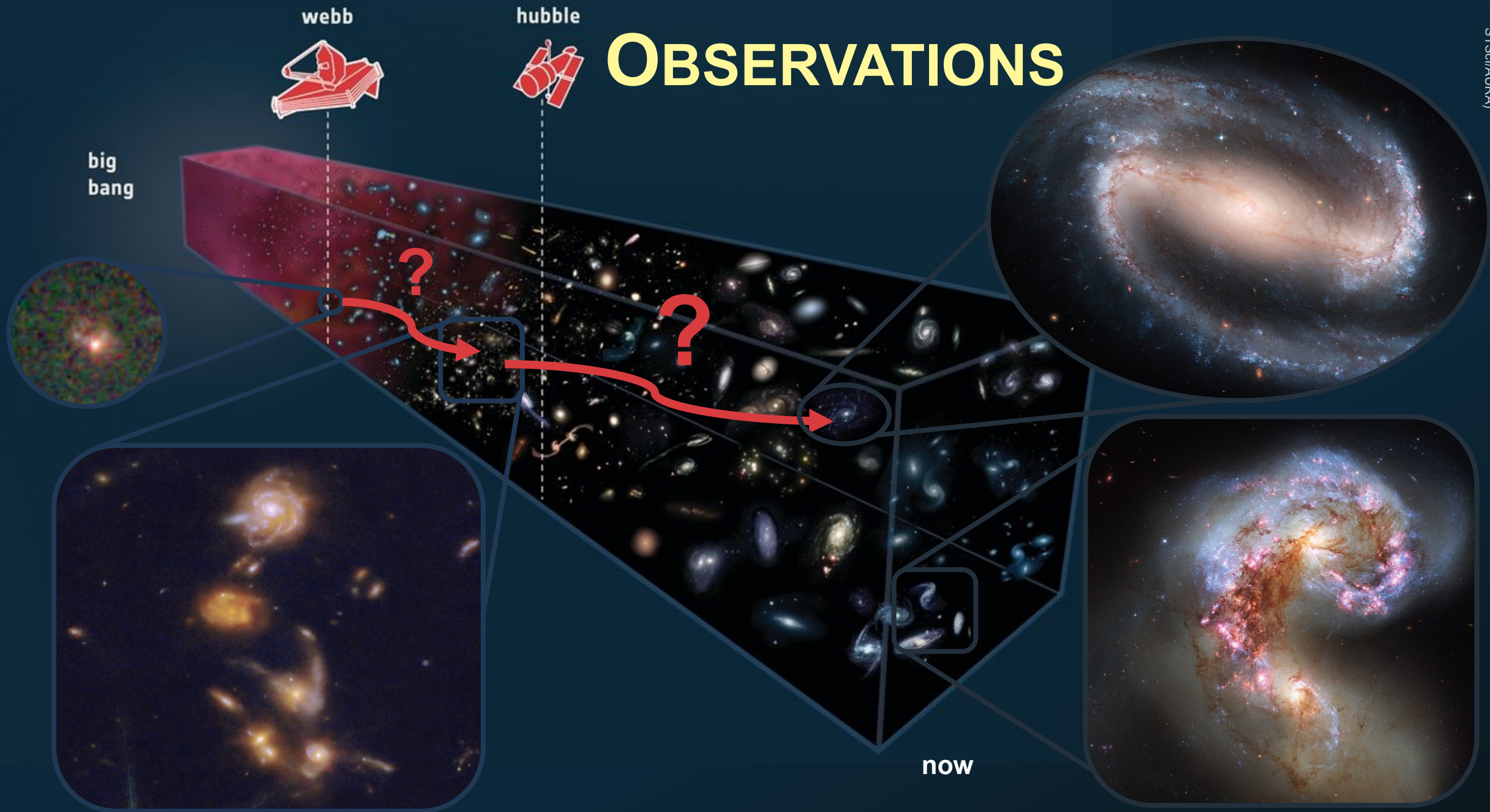
Ignacio Martín-Navarro (IAC),
Glenn van de Ven (UniVie),
Anna Gallazzi (INAF)

Hubble Deep Field

Image Credit: NASA, ESA, G. Illingworth, D. Magee, and P. Oesch, University of California, Santa Cruz; R. Bouwens, Leiden University, and the HUDF09 Team & Illustris Simulations







OBSERVATIONS

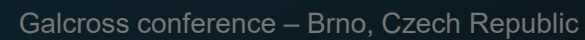
big
bang

webb

hubble

now

Image Credit: ESA ; TNG simulations



SIMULATIONS

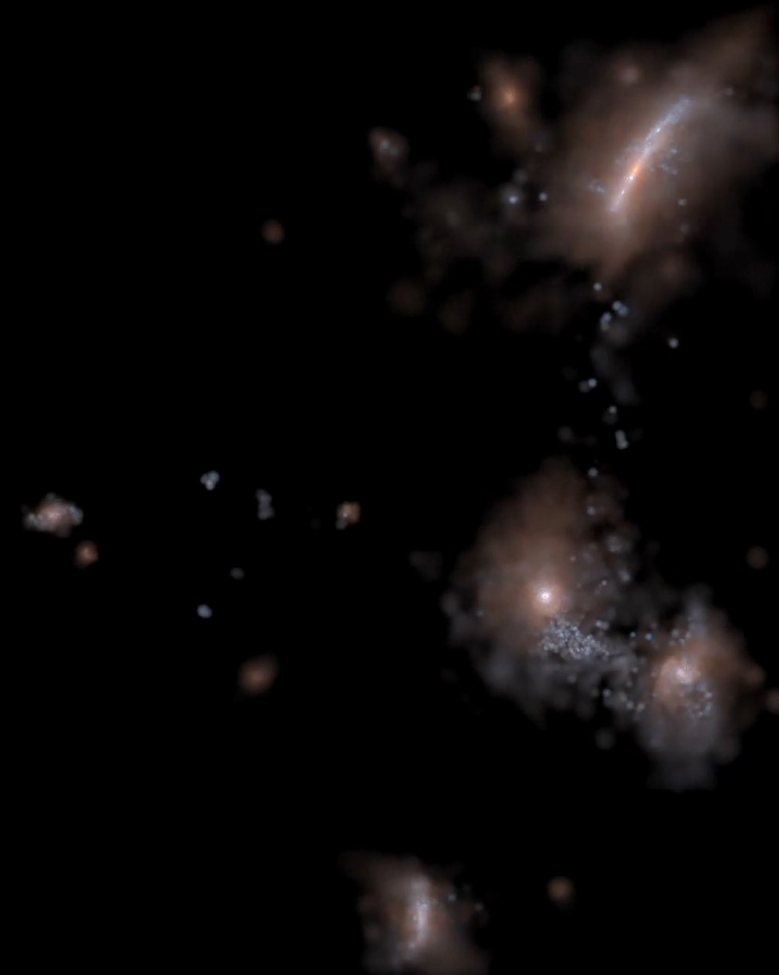
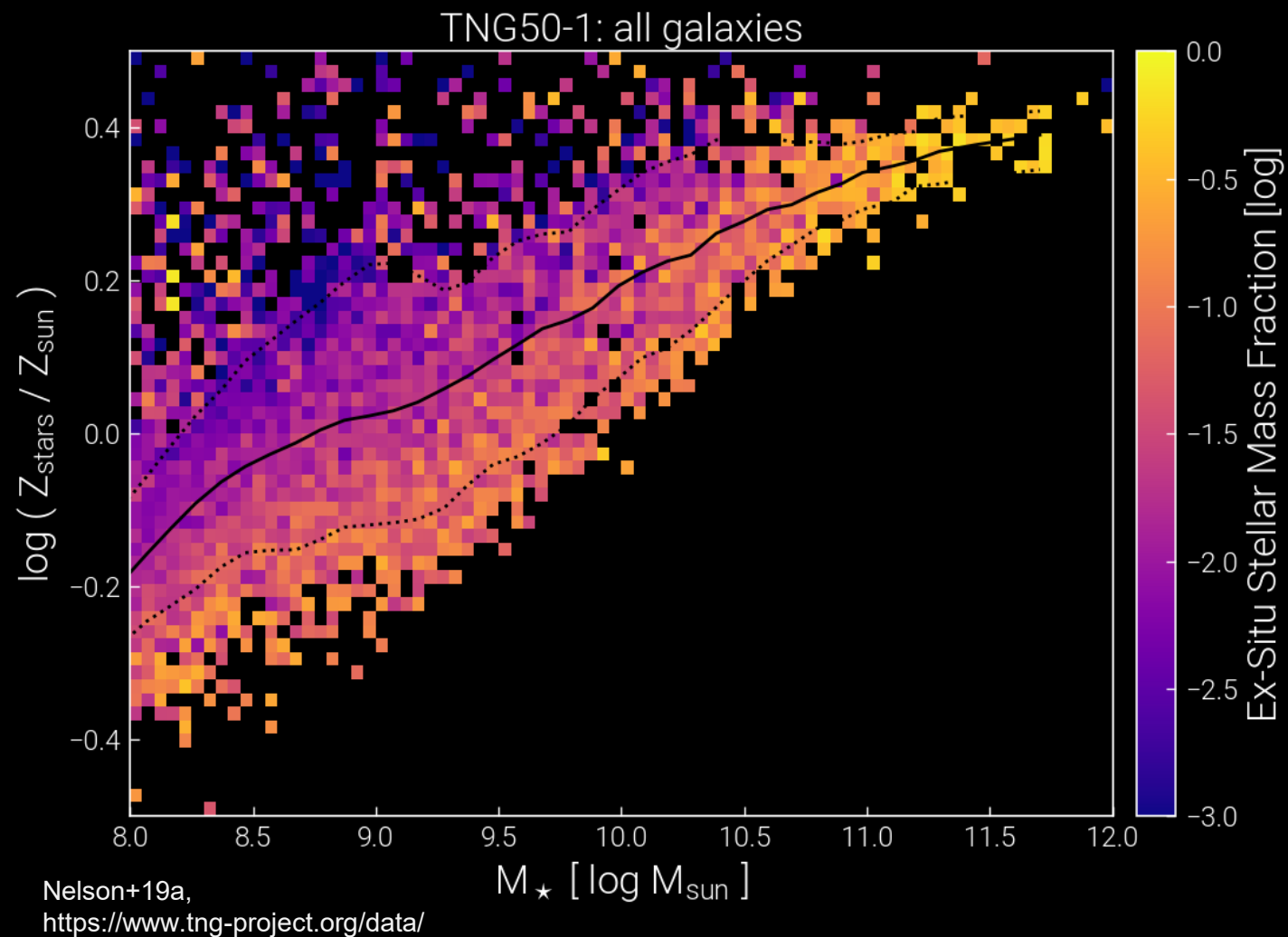
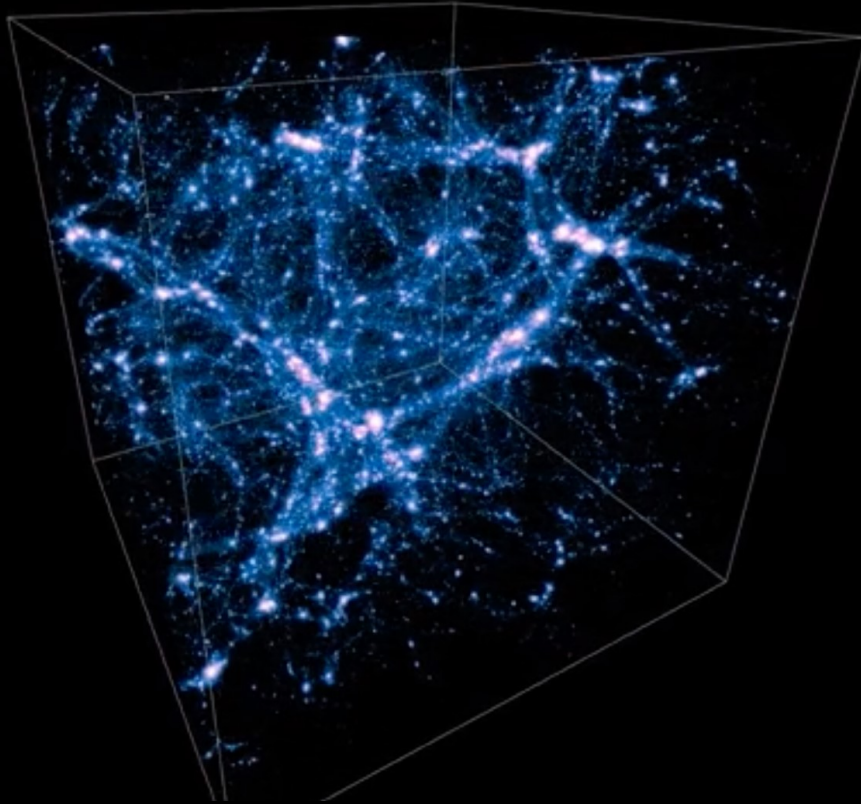


Image Credit: TNG Simulation

SIMULATIONS



18th Sep 2024

Alina Boecker (UniVie)

OBSERVATIONS

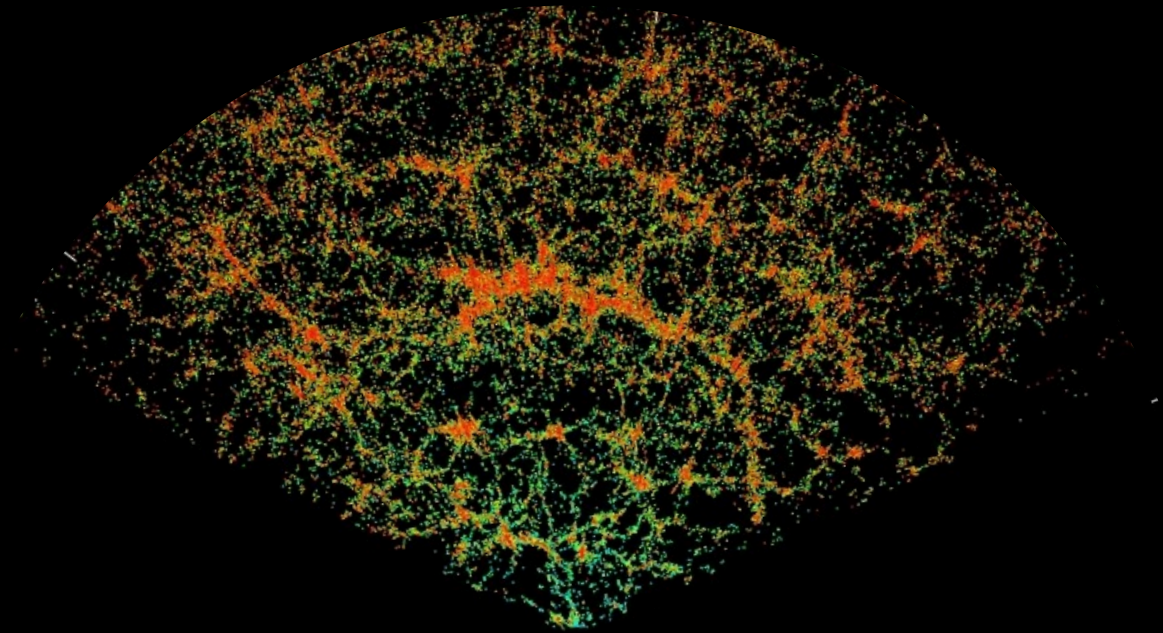
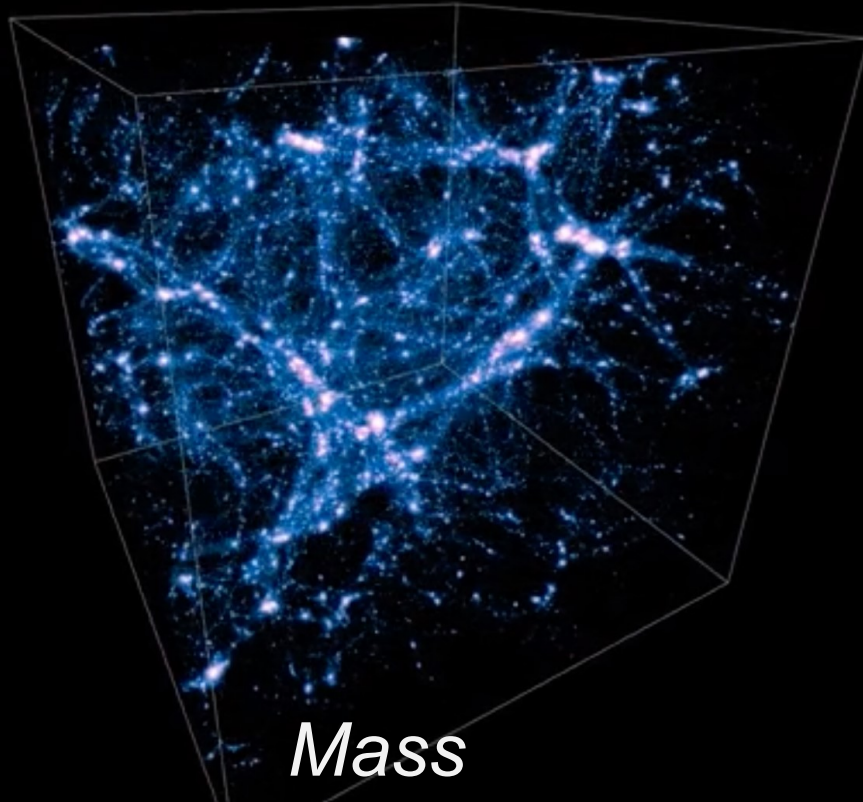


Image Credit: TNG Simulation, SDSS (M. Blanton)

Galcross conference – Brno, Czech Republic

SIMULATIONS



OBSERVATIONS

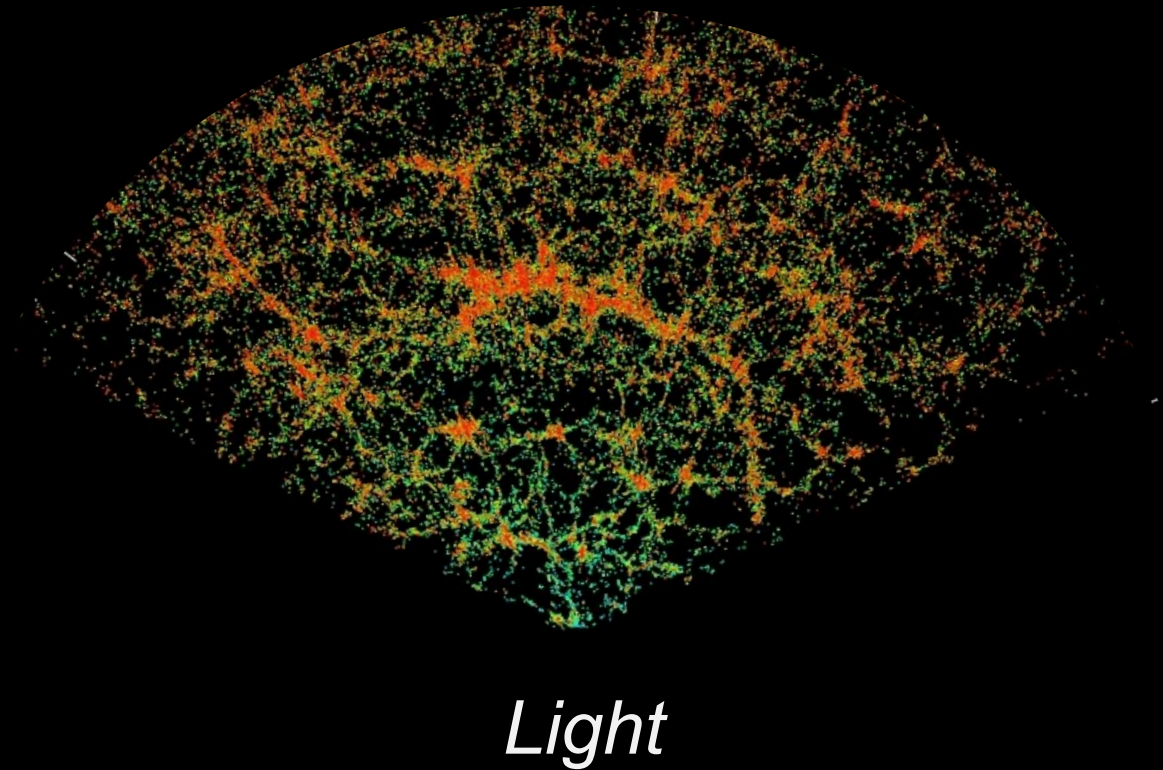
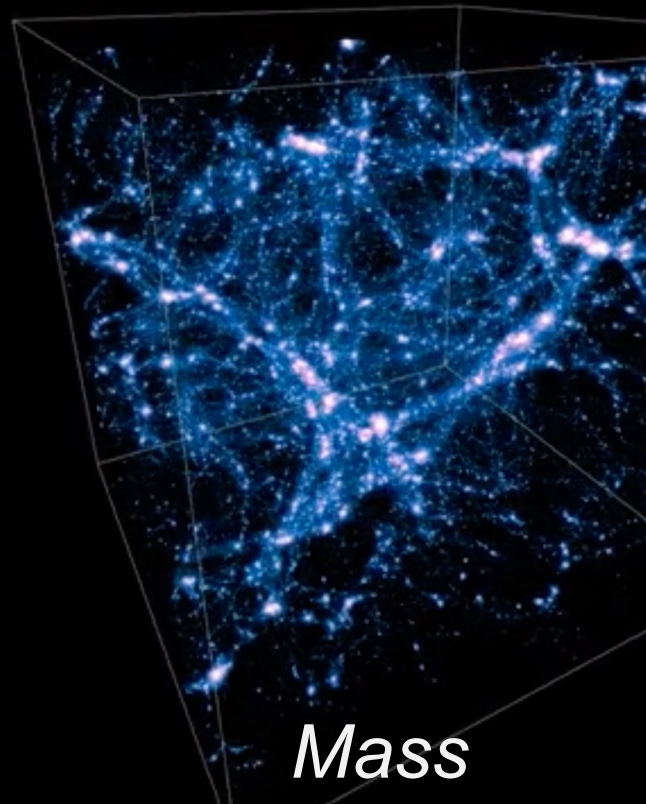


Image Credit: TNG Simulation, SDSS (M. Blanton)

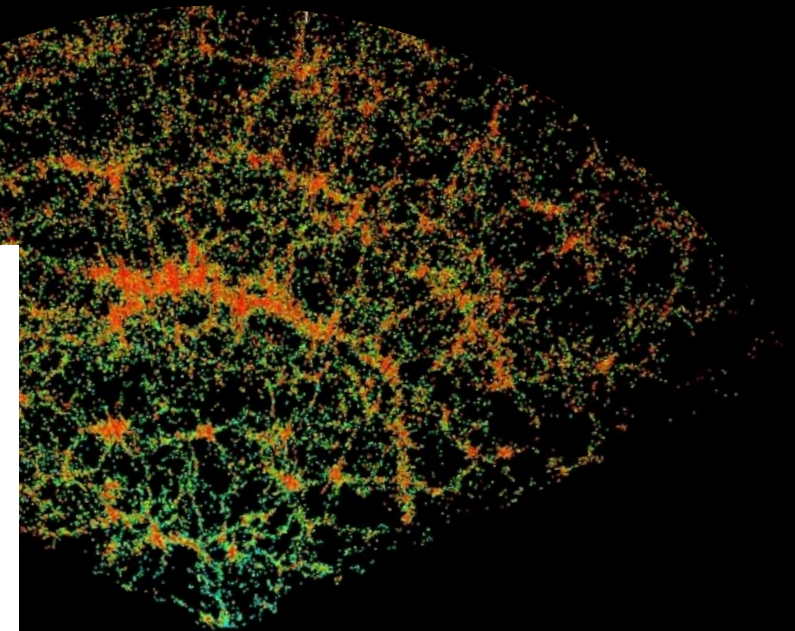
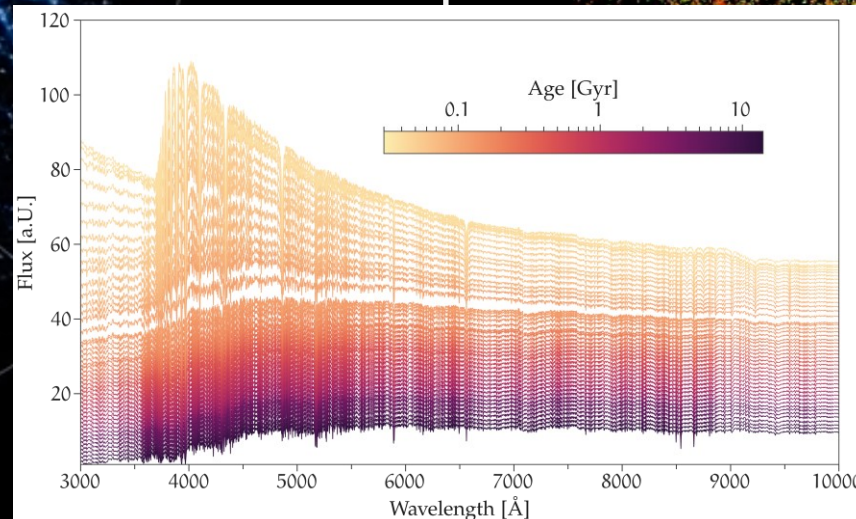
SIMULATIONS

OBSERVATIONS

SSP MODELS



Mass



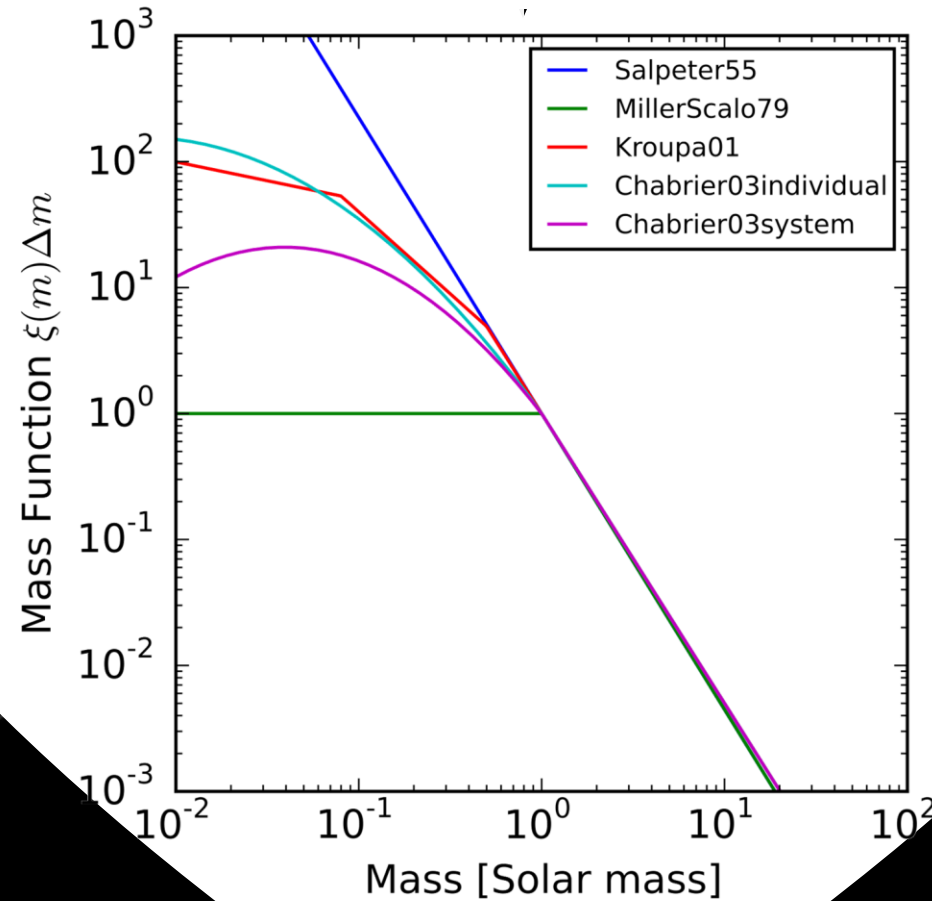
Light

Image Credit: TNG Simulation, SDSS (M. Blanton)

SIMULATIONS

OBSERVATIONS

INITIAL MASS FUNCTION



Mass

Light

Image Credit: TNG Simulation, SDSS (M. Blanton).
https://en.wikipedia.org/wiki/Initial_mass_function#/media/File:Plot_of_various_initial_mass_functions.svg

THE BARYON CYCLE

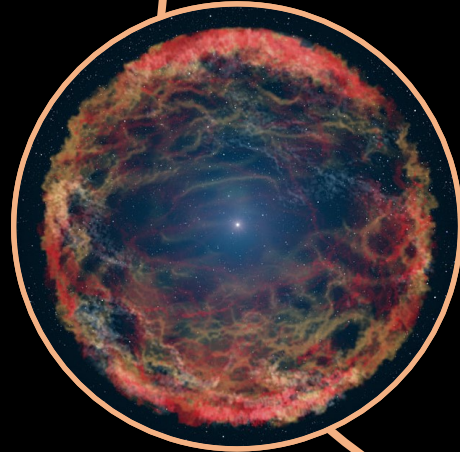
how much gas is driven out of the galaxy?

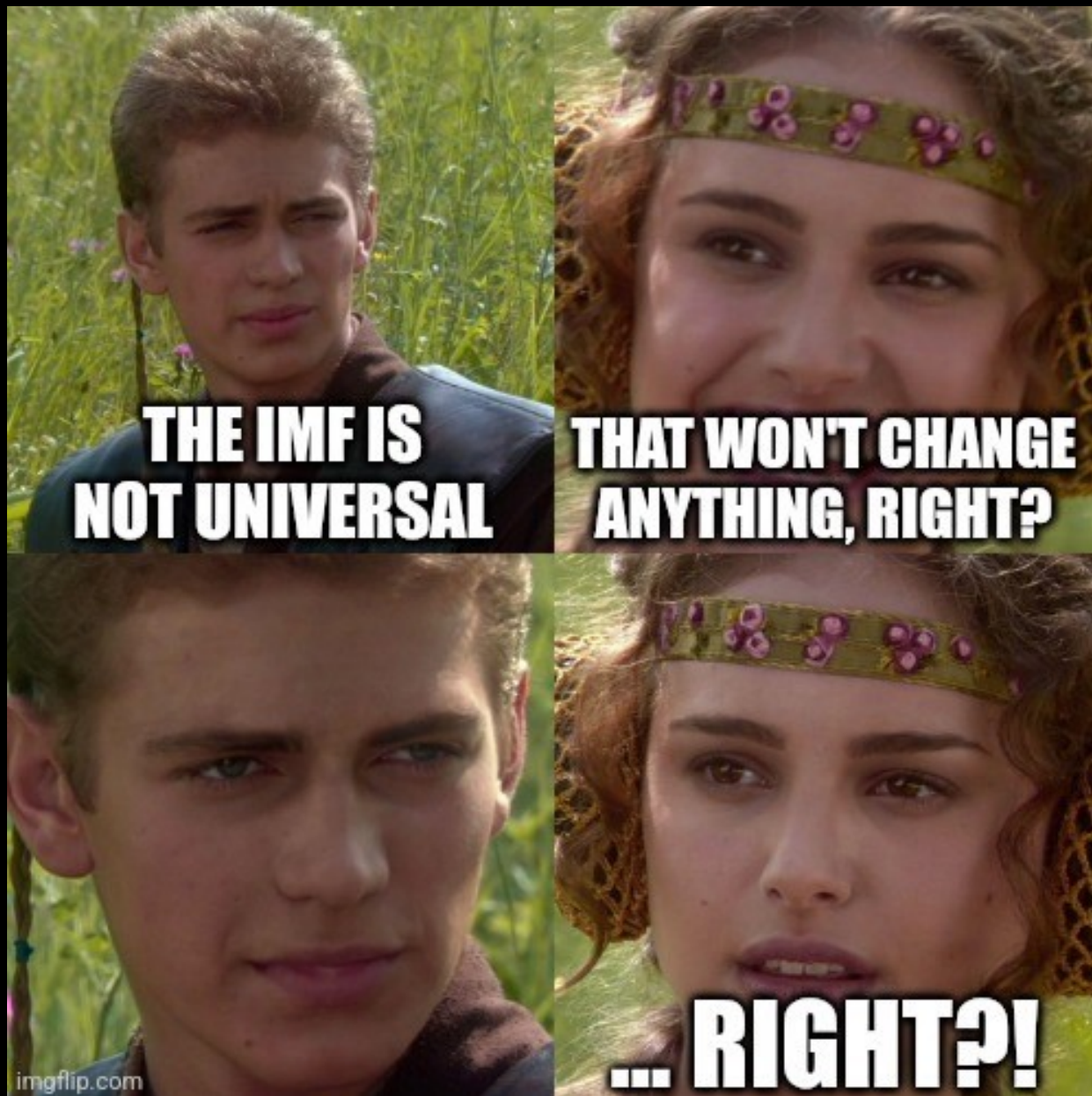


how much is the next generation of stars enriched in metals?

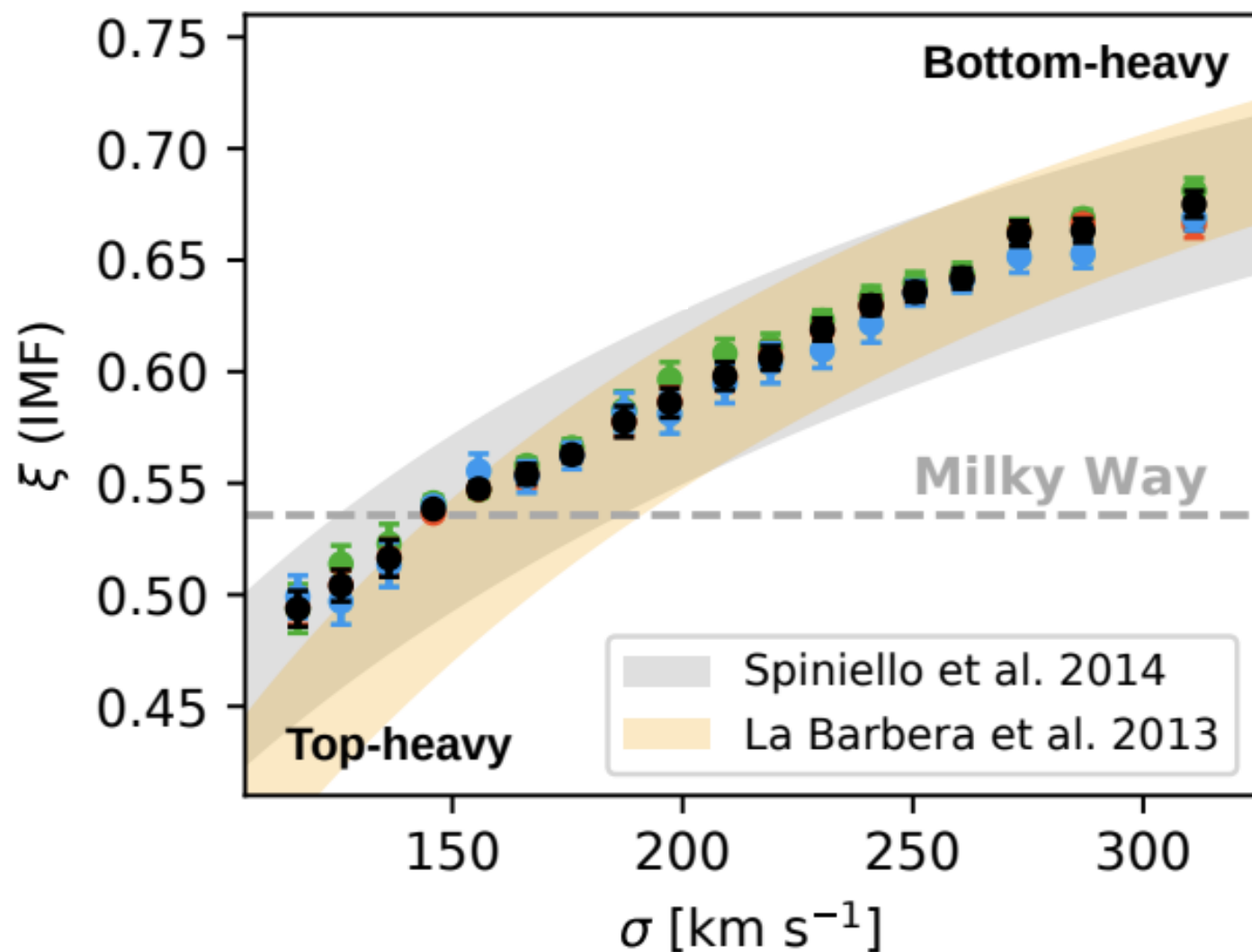


how many supernovae explode?





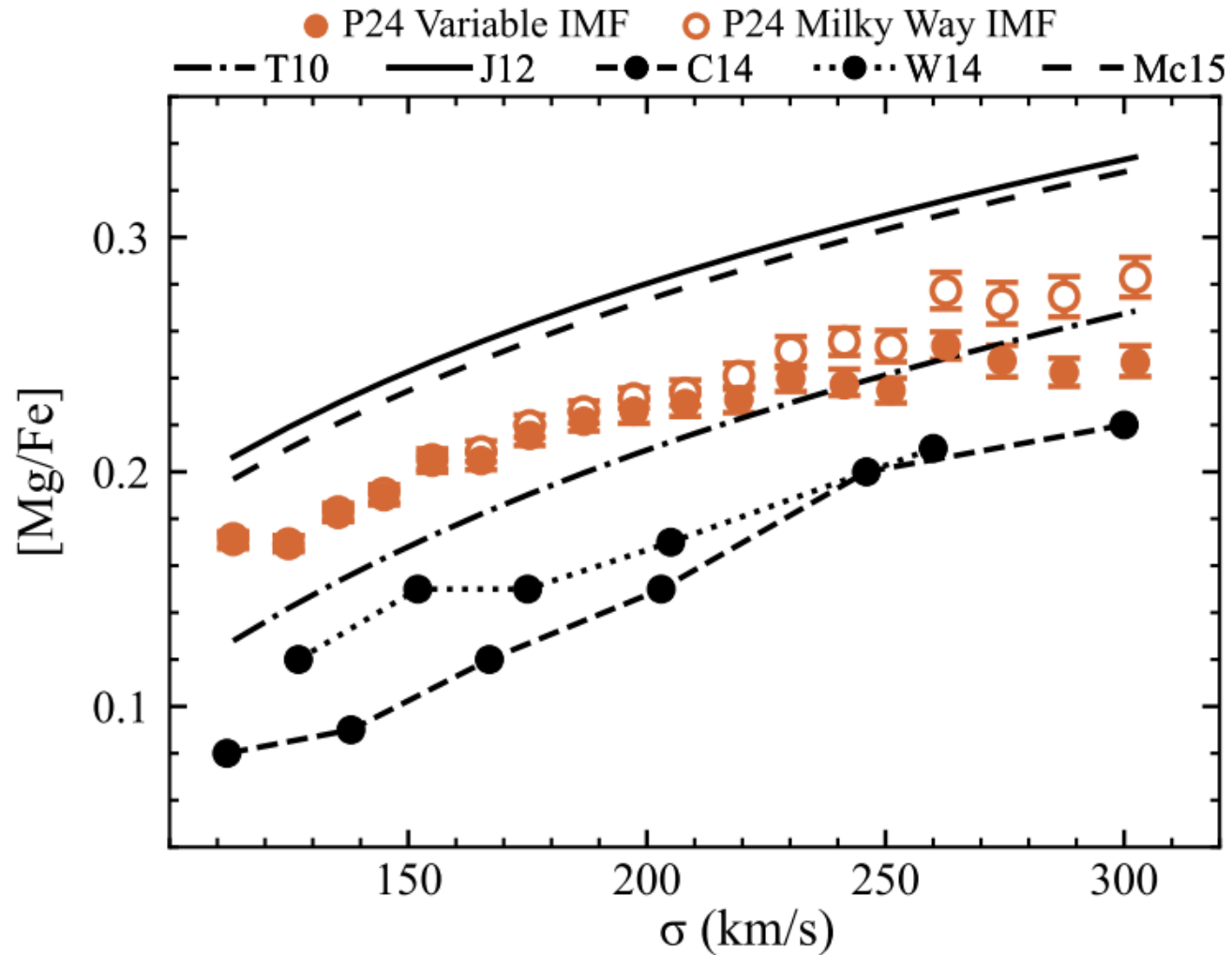
THE IMF IS NOT UNIVERSAL!



*massive ETGs, „simple“ SFH,
stacked spectra from SDSS*

Martín-Navarro+, 2019
(see also Conroy & Dokkum 2012)

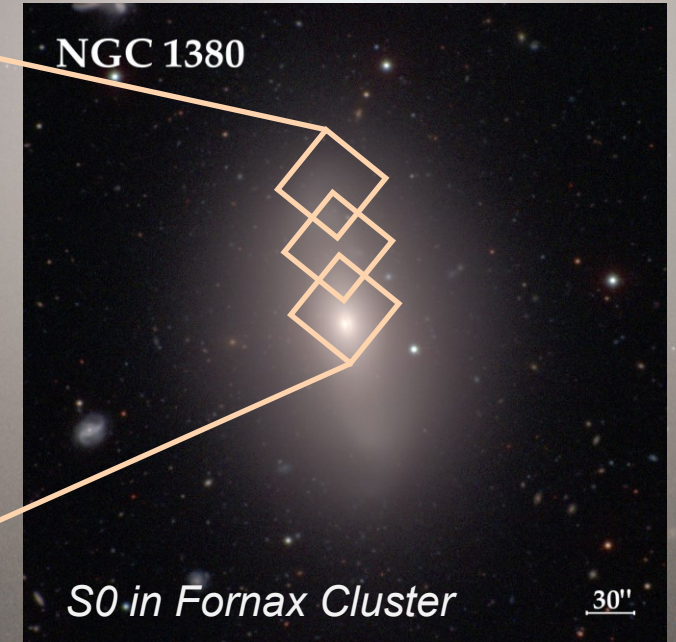
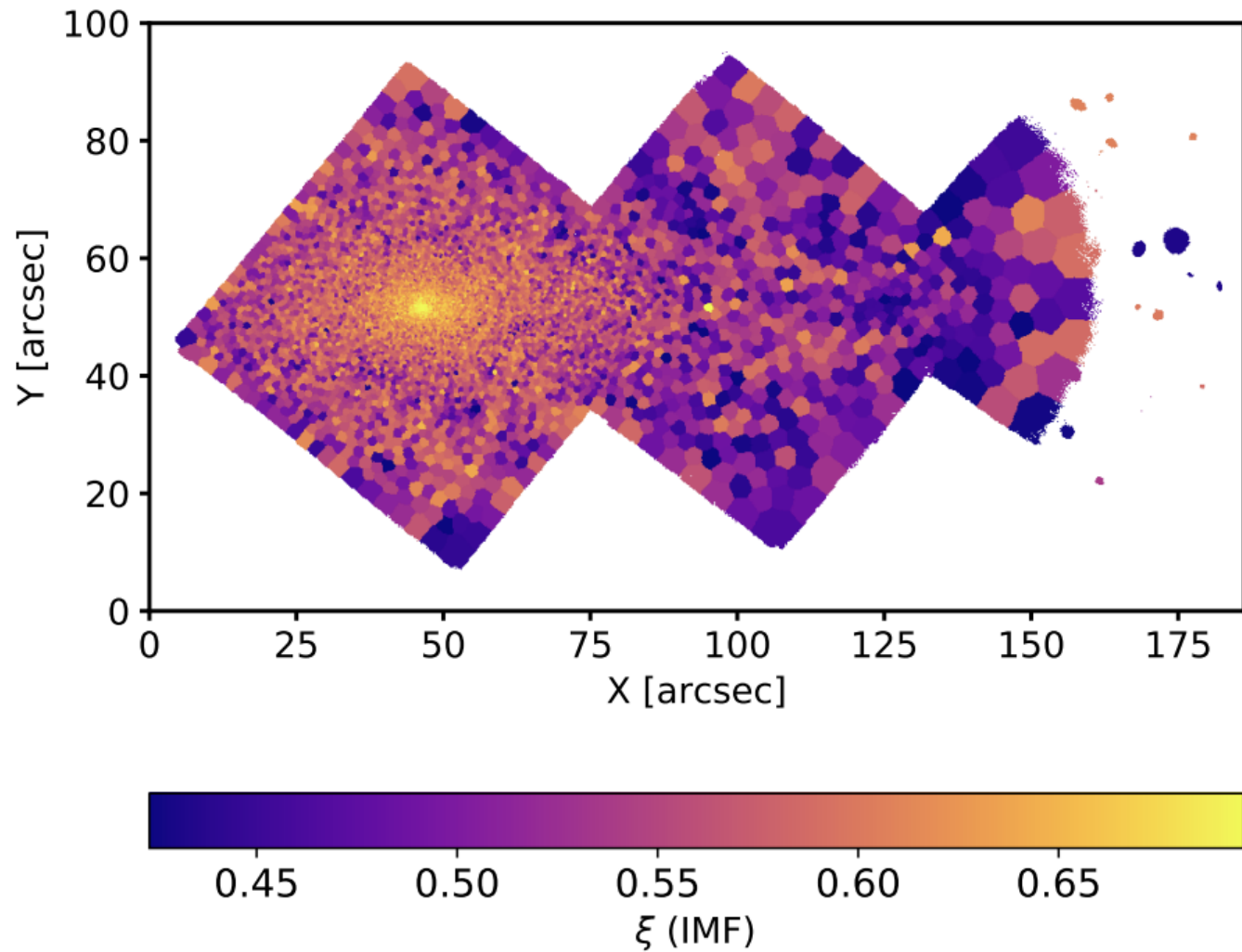
A VARYING IMF IMPACTS OTHER PARAMETERS!



*massive ETGs, „simple“ SFH,
stacked spectra from SDSS*

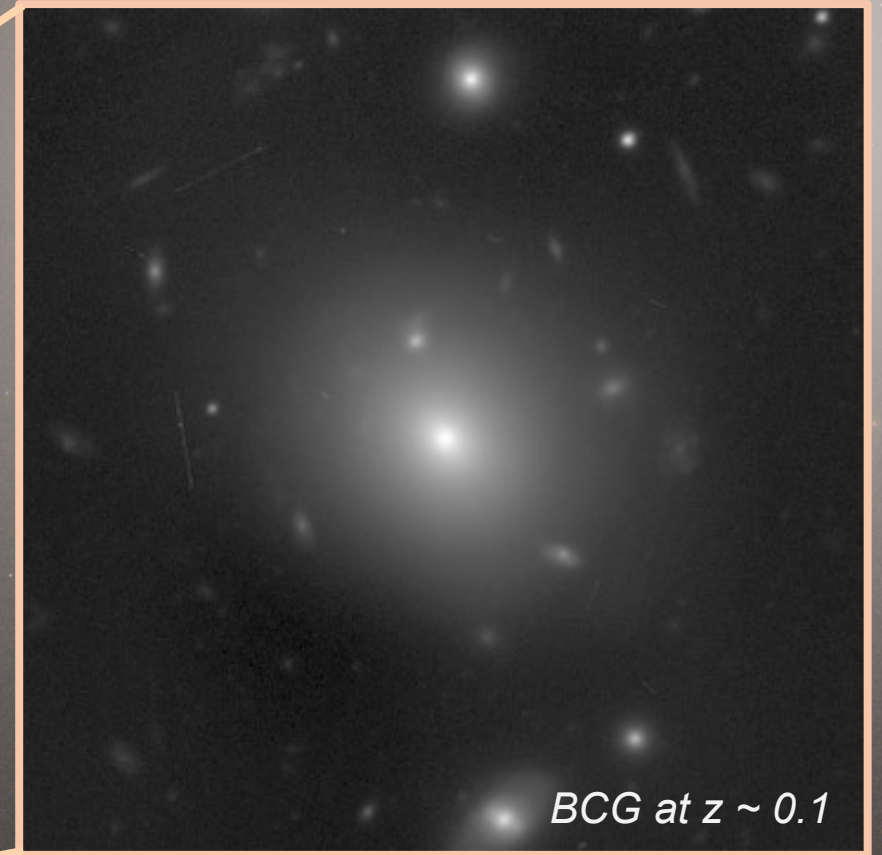
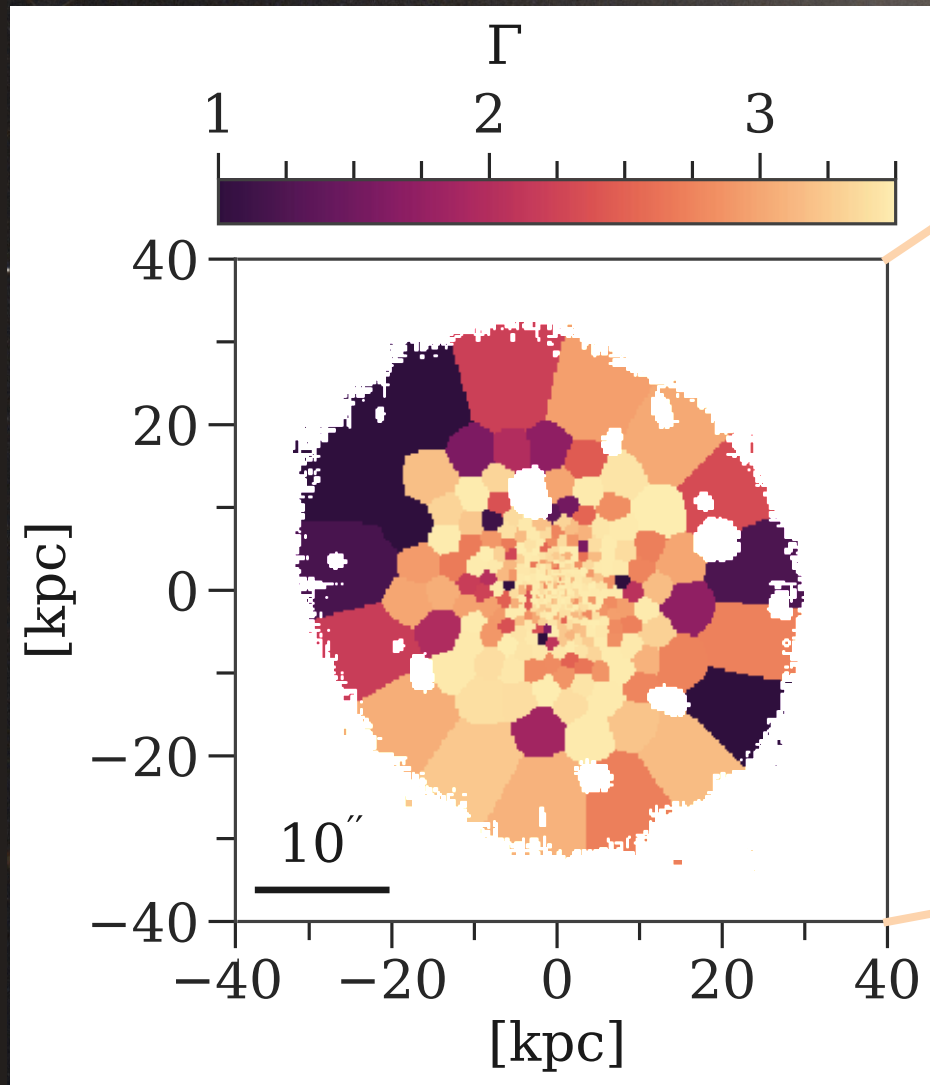
Pernet+ (incl. Boecker), 2024

THE IMF IS NOT UNIVERSAL!



Martín-Navarro+, 2021

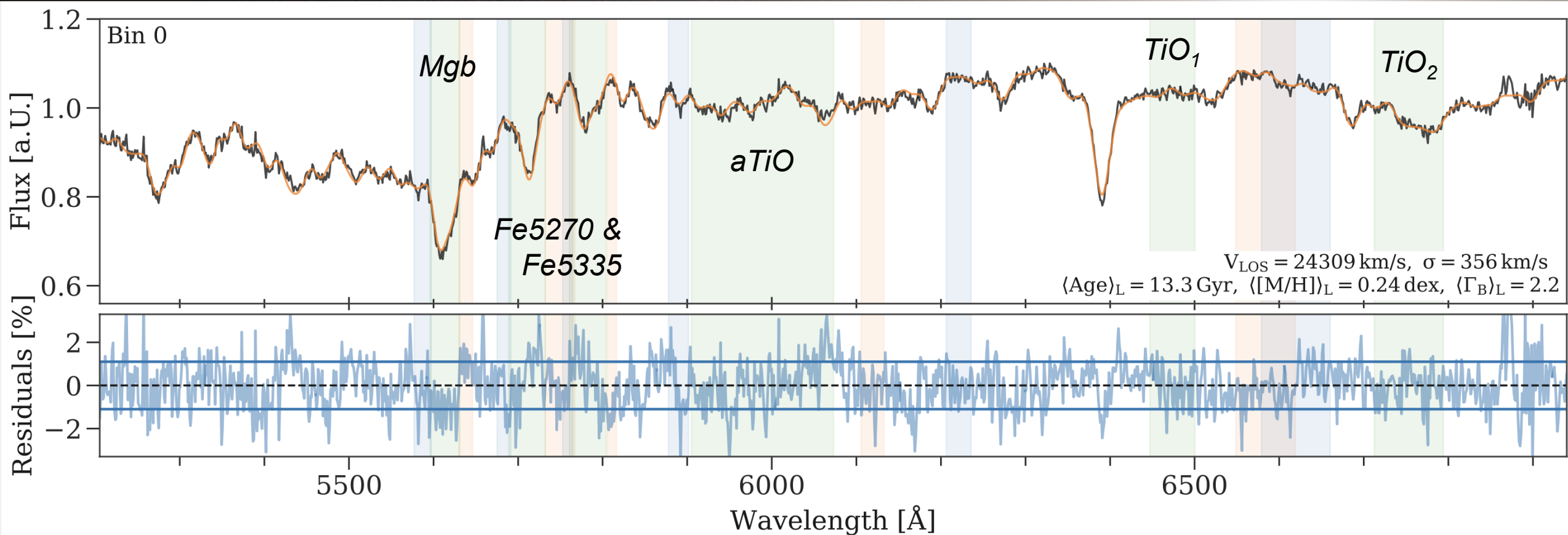
THE IMF IS NOT UNIVERSAL!



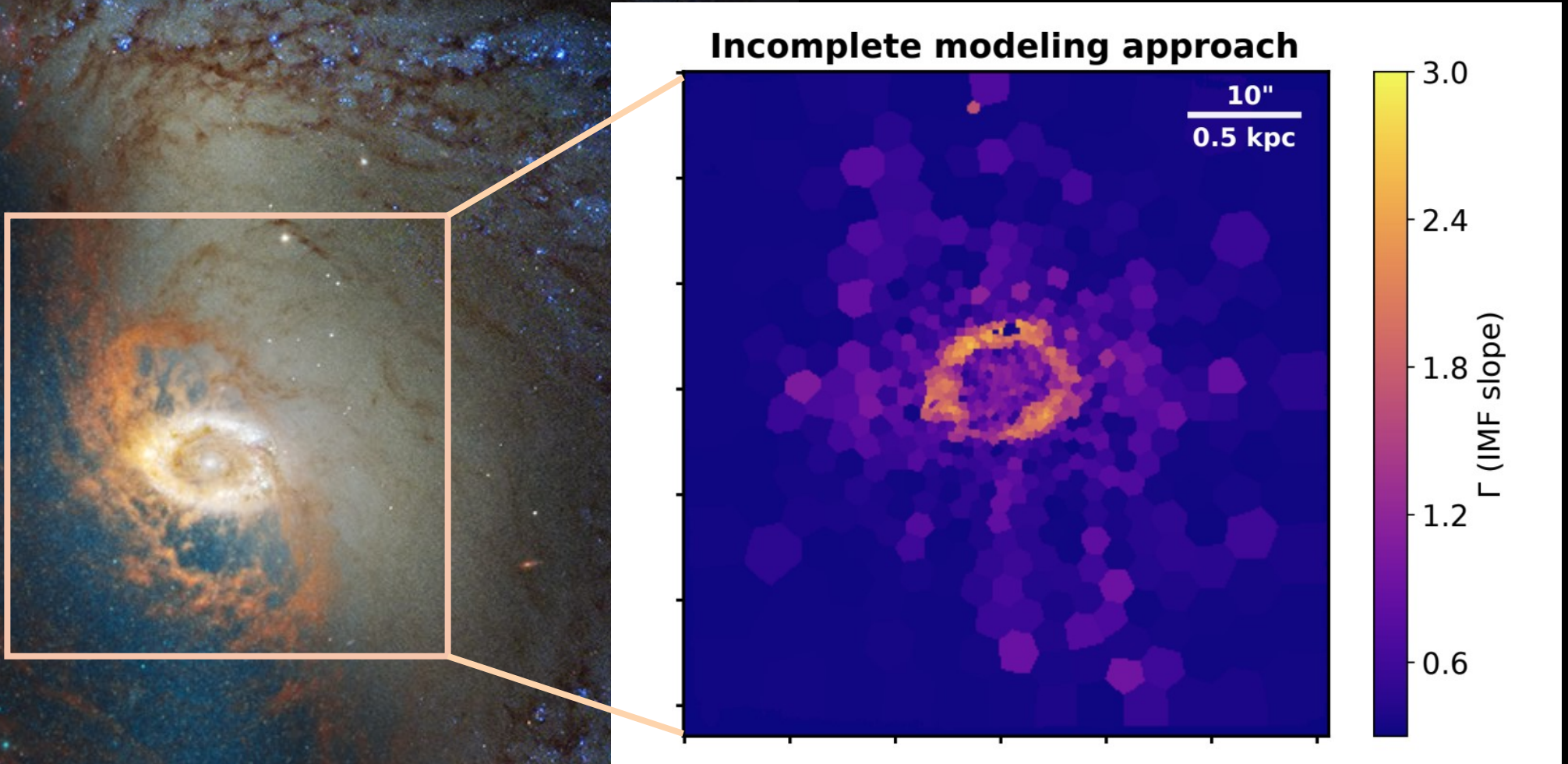
Boecker+, in prep.

IMF FROM STELLAR ABSORPTION FEATURES

ETGs are old and „SSP-equivalent“

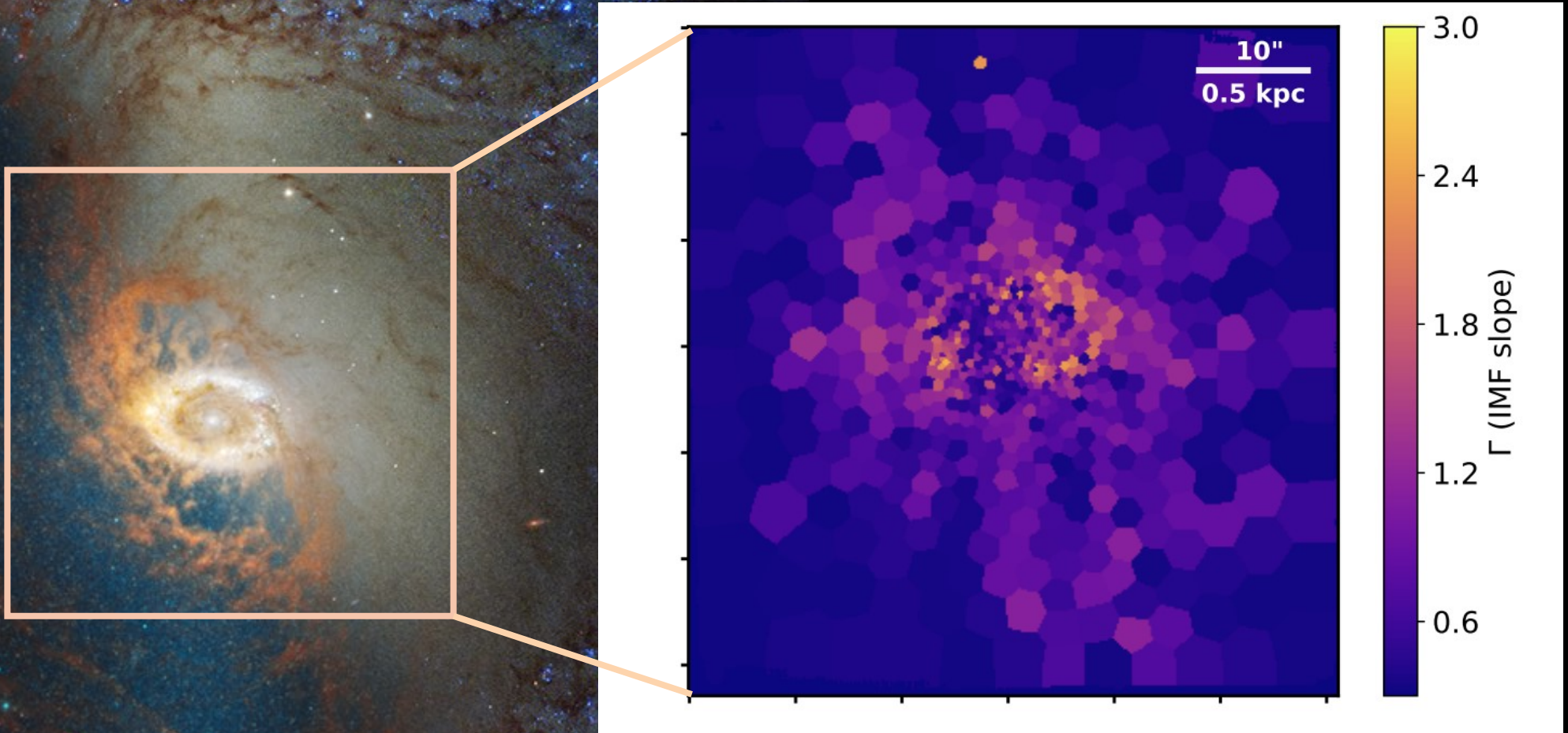


STAR FORMING GALAXIES ARE MORE COMPLICATED!



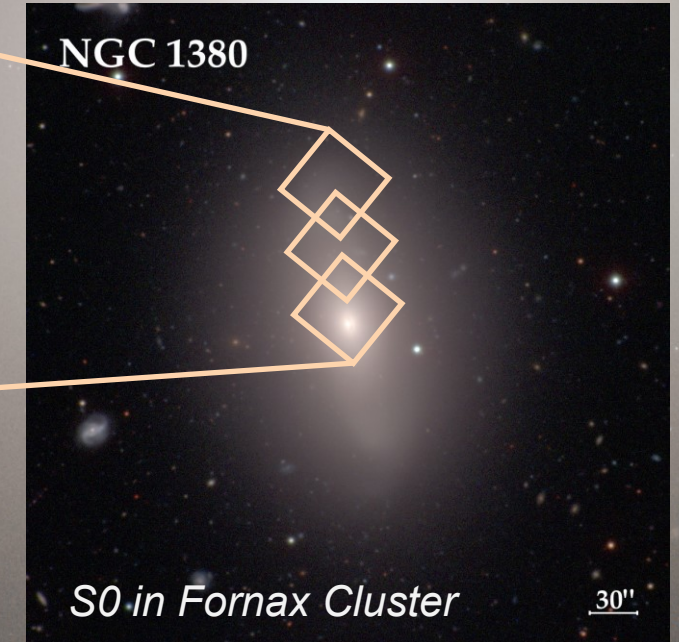
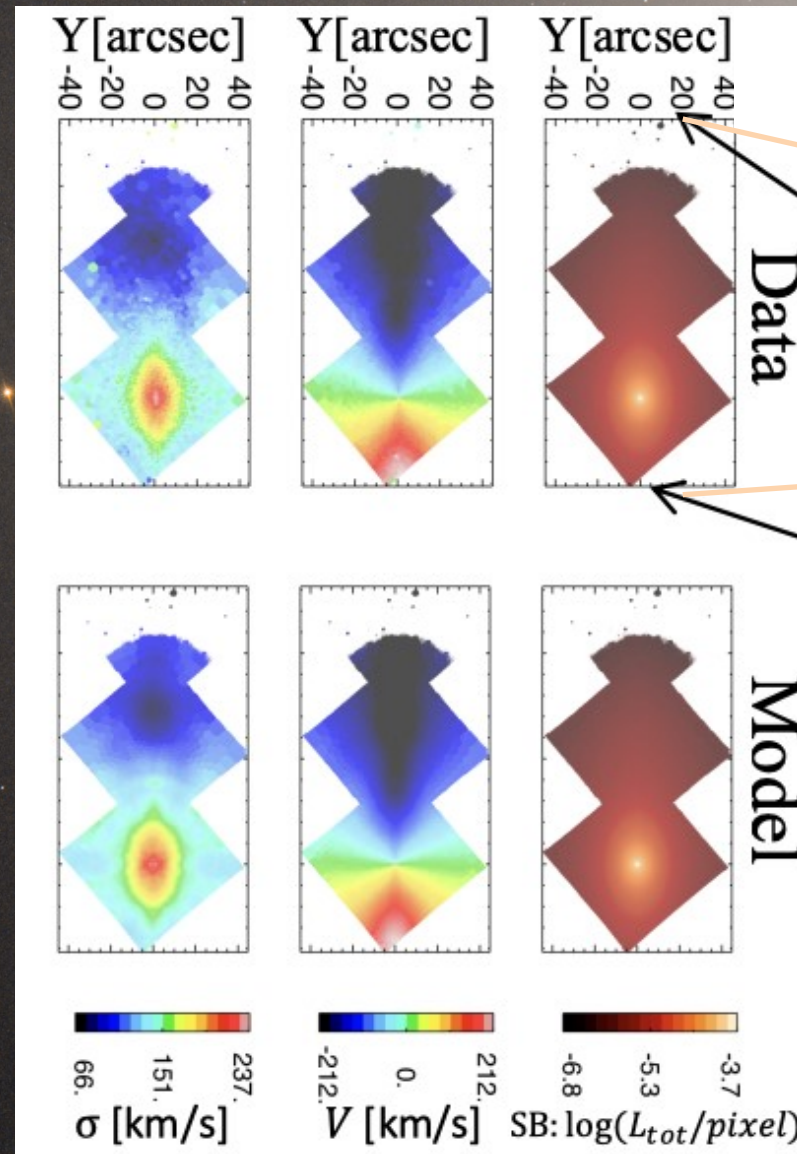
Martín-Navarro+, 2024

STAR FORMING GALAXIES ARE MORE COMPLICATED!



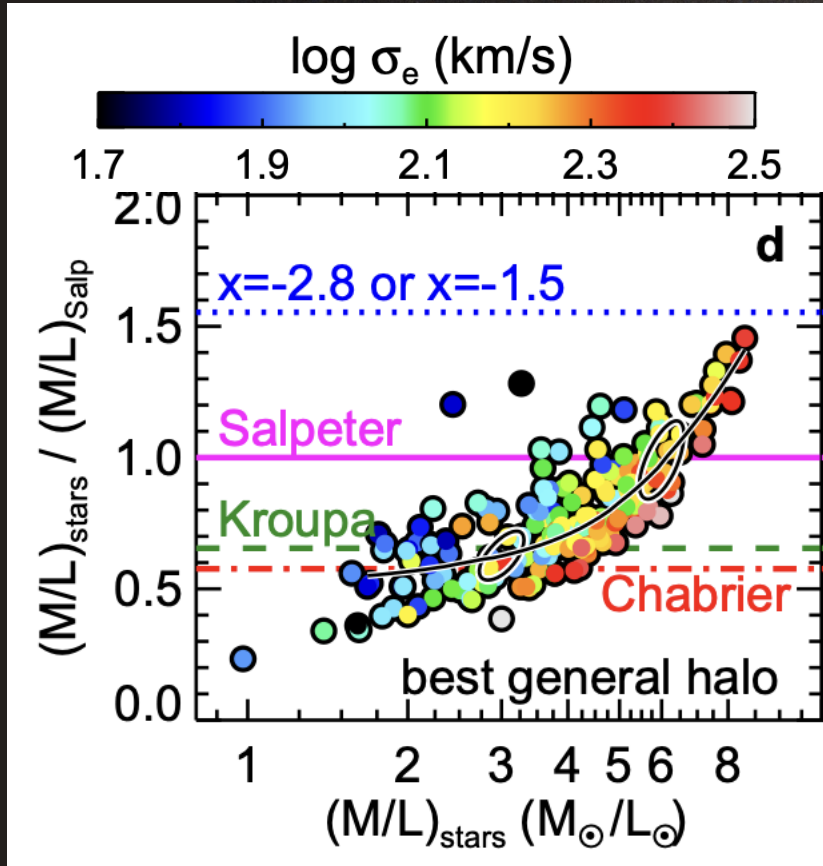
Martín-Navarro+, 2024

DYNAMICAL MODELS FIND SIMILAR M/L VARIATIONS!

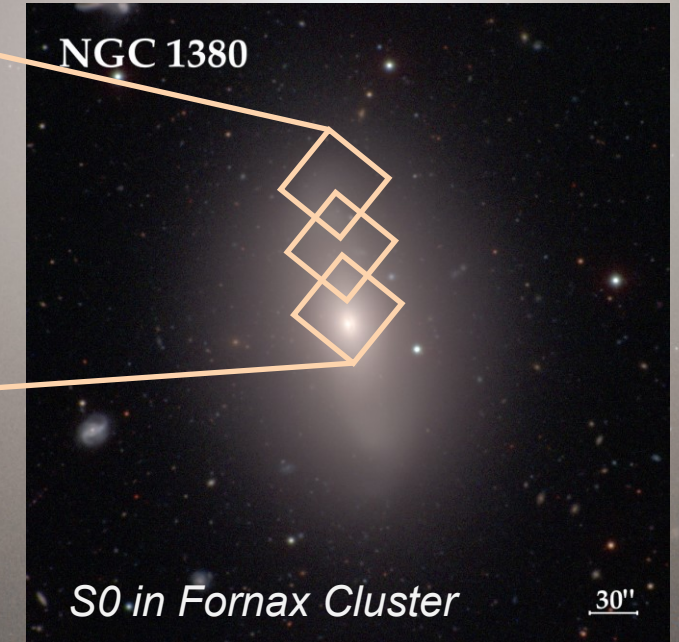
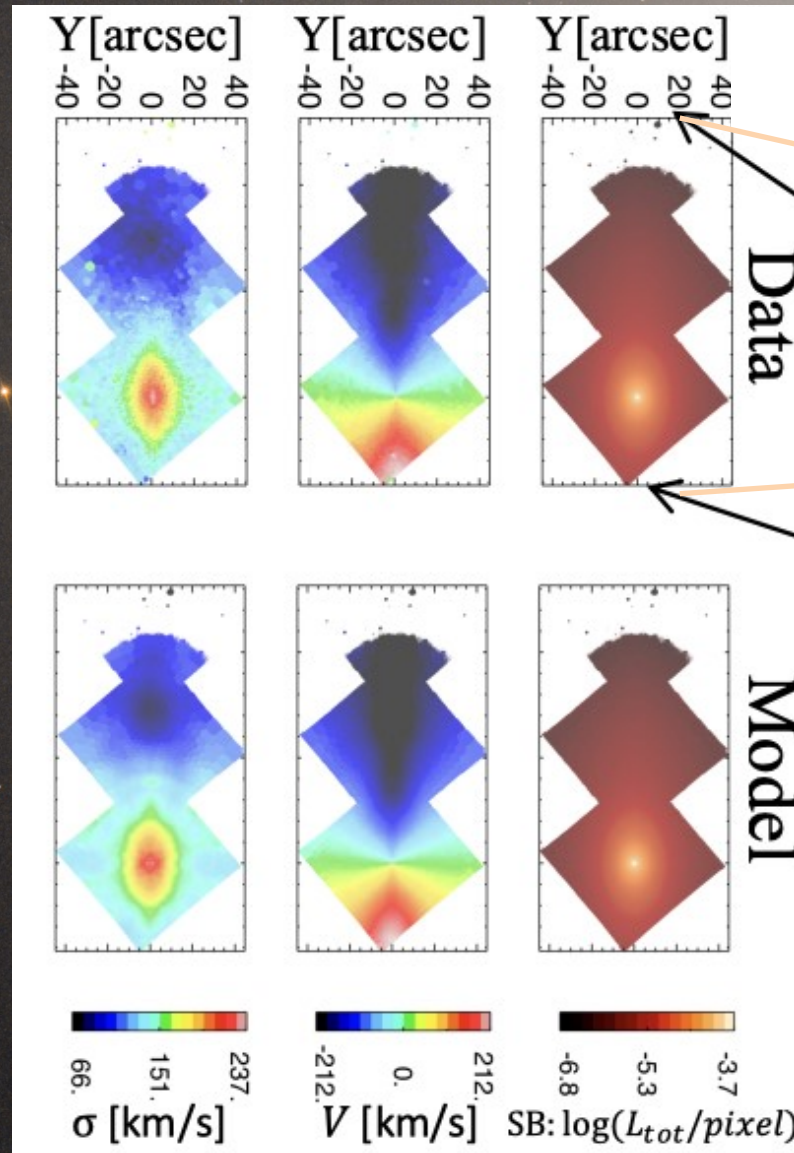


Zhu+, 2022

DYNAMICAL MODELS FIND SIMILAR M/L VARIATIONS!

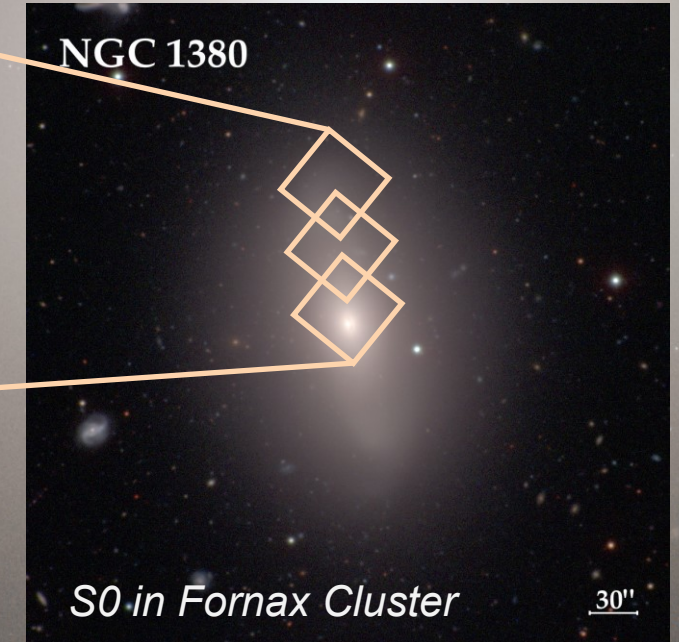
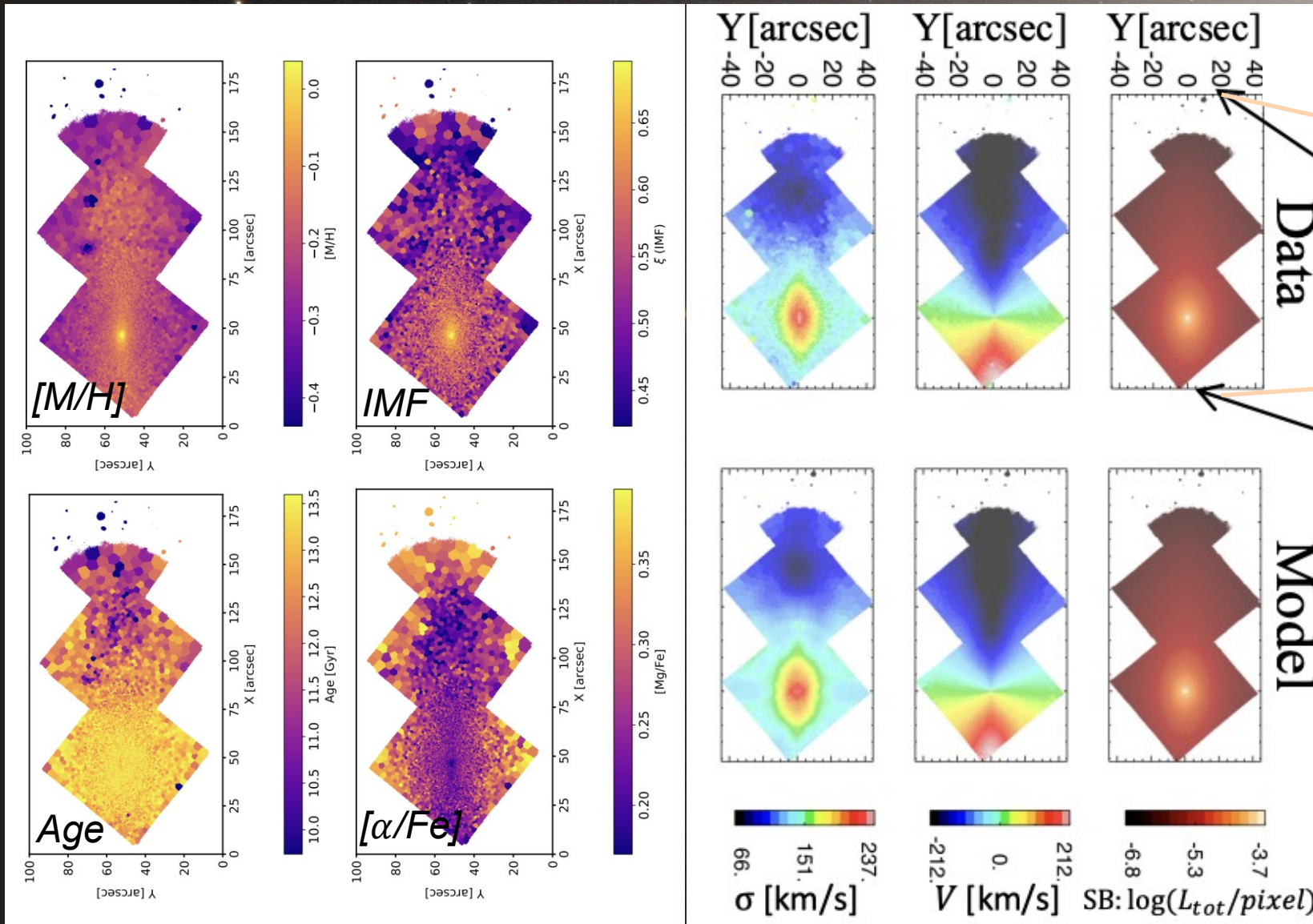


Cappellari+, 2012



Zhu+, 2022

STELLAR POPULATIONS INFORM DYNAMICAL MODELS!



Martín-Navarro+, 2021,
Zhu+, 2022;
see also Thater+ 2023

& Talk by Avinash!

Dynamics of Stellar System Group

<https://dynamics.univie.ac.at>



Glenn
van de Ven



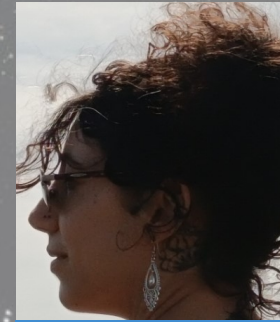
Prashin Jethwa



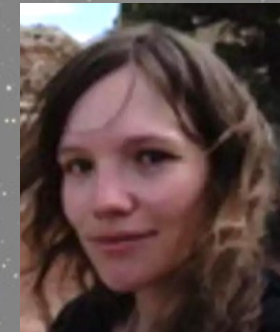
Alice Zocchi



Ryan Leaman



Iris Breda



Anja
Feldmeier-Krause



Alina Böcker



Katja Fahrion



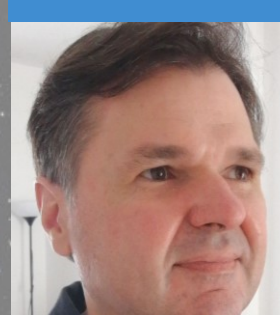
Christine Ackert



Laurane Fréour



Stefanie Reiter



Thomas Maindl



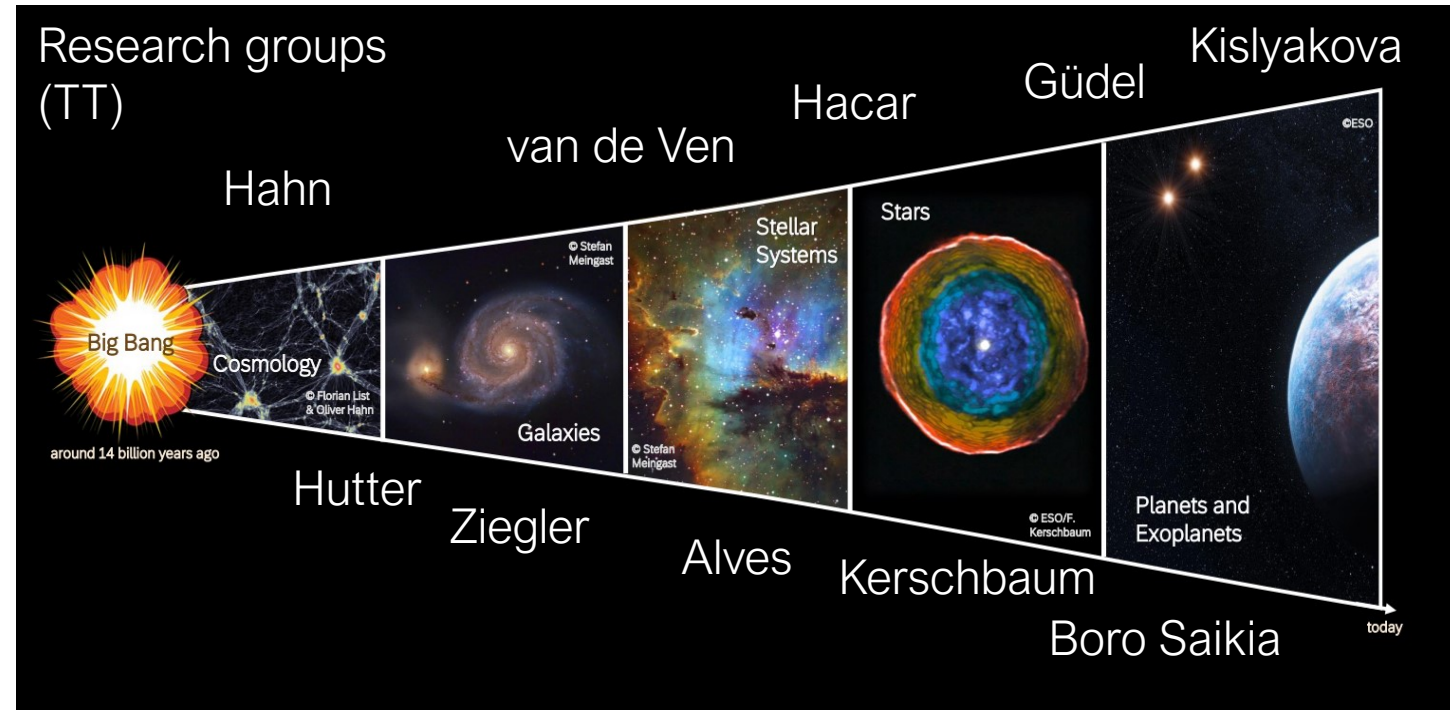
DYNAMITE code (publicly released)
https://dynamics.univie.ac.at/dynamite_docs/



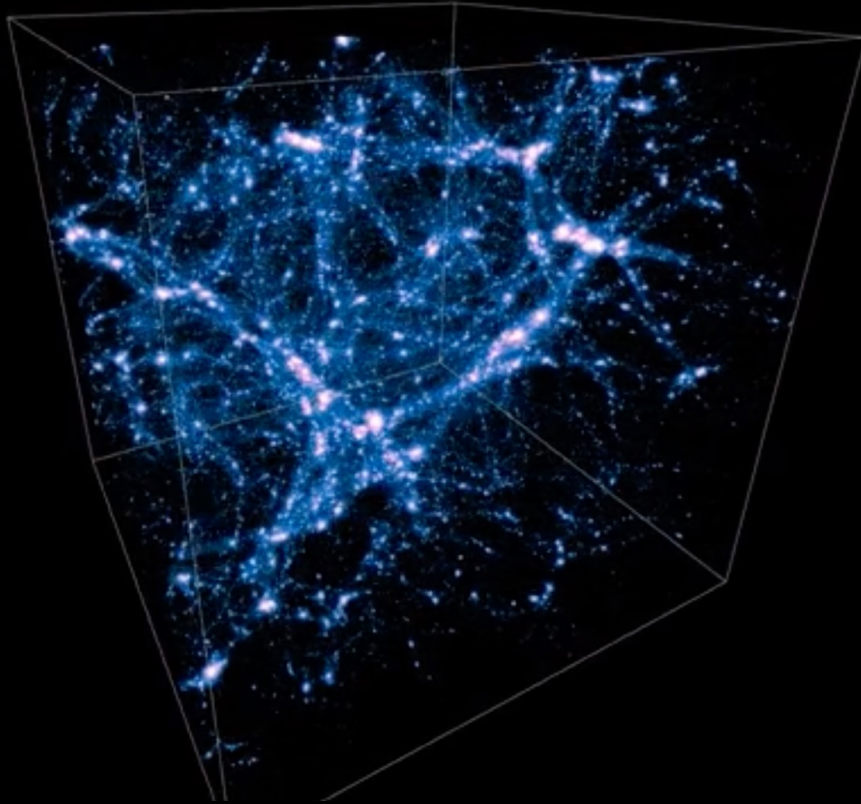
Department of Astrophysics

<https://astro.univie.ac.at/en/>

- Around ~100 members, 10 professor groups, planets, stars, galaxies to cosmology
- Strong involvement ground-based/ESO and space-based/ESA instrument software
- Astronomy BSc and MSc, English default, ~150 1st-year students
- Astronomy PhD via doctoral school VISESS internationally orientated



SIMULATIONS



18th Sep 2024

Alina Boecker (UniVie)

OBSERVATIONS

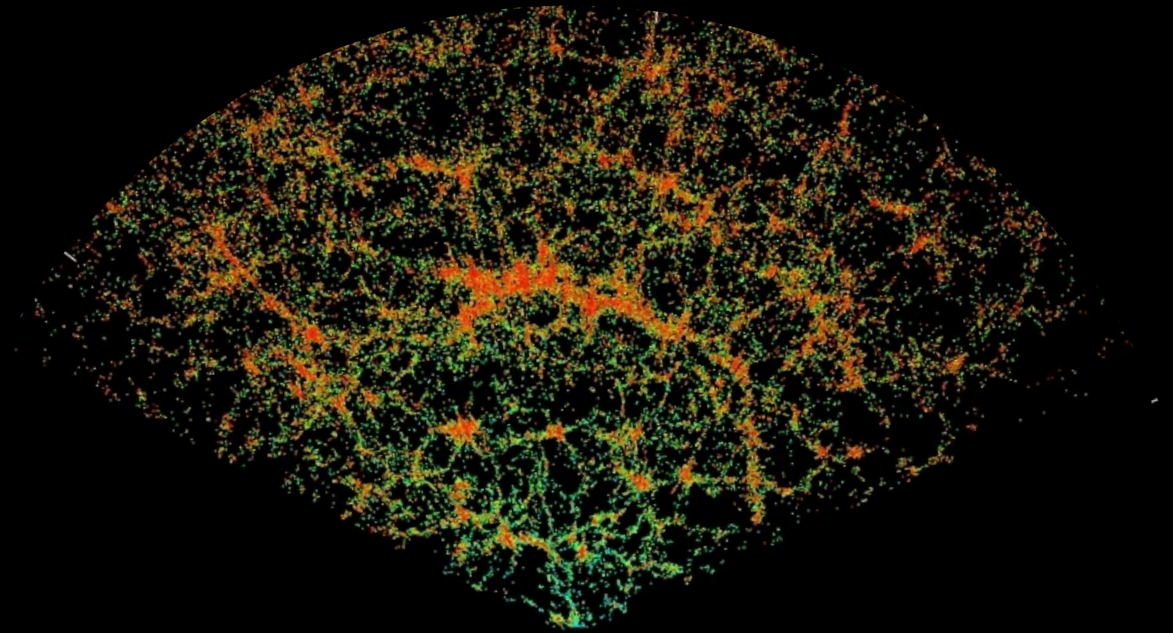
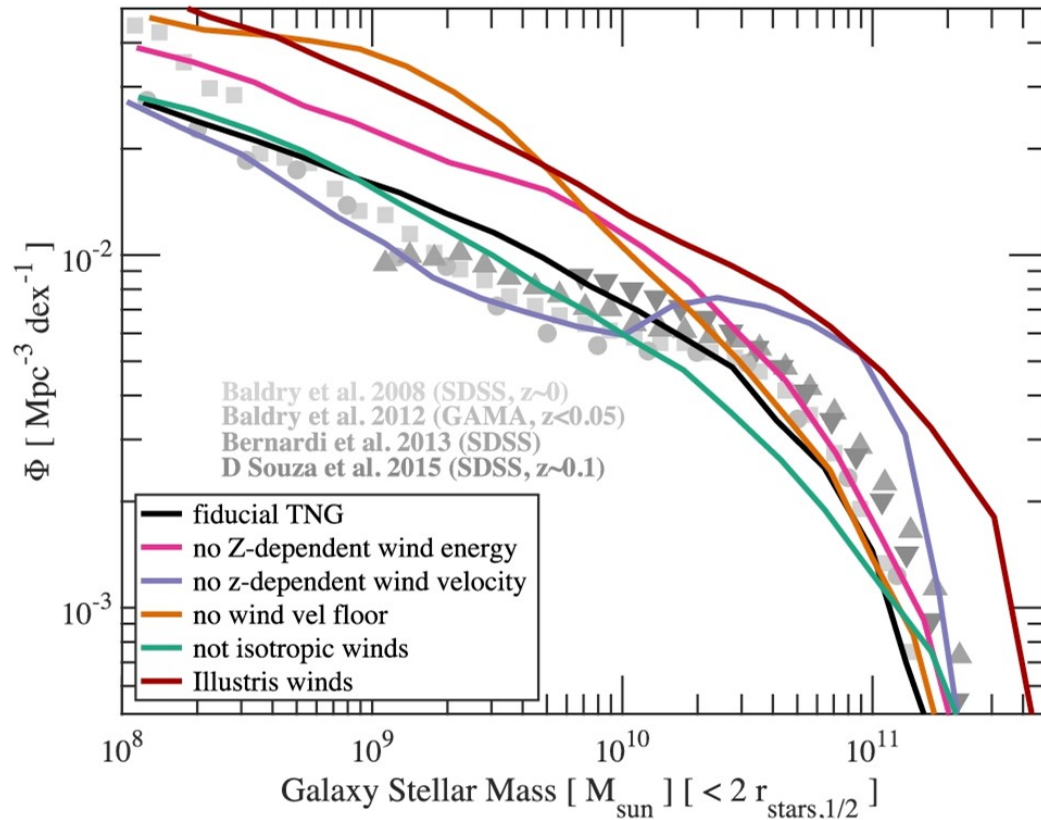


Image Credit: TNG Simulation, SDSS (M. Blanton)

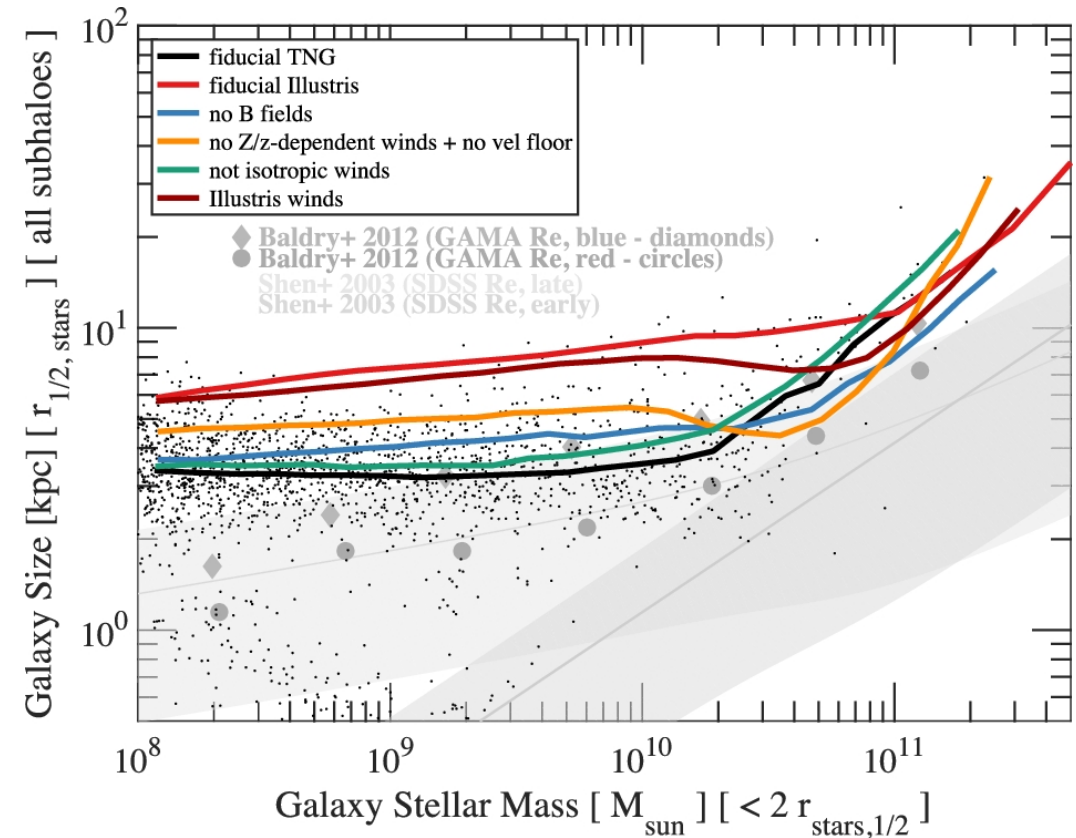
Galcross conference – Brno, Czech Republic

SUBGRID MODELS ARE CALIBRATED TO A FEW KEY OBSERVABLES

Galaxy Stellar Mass Function



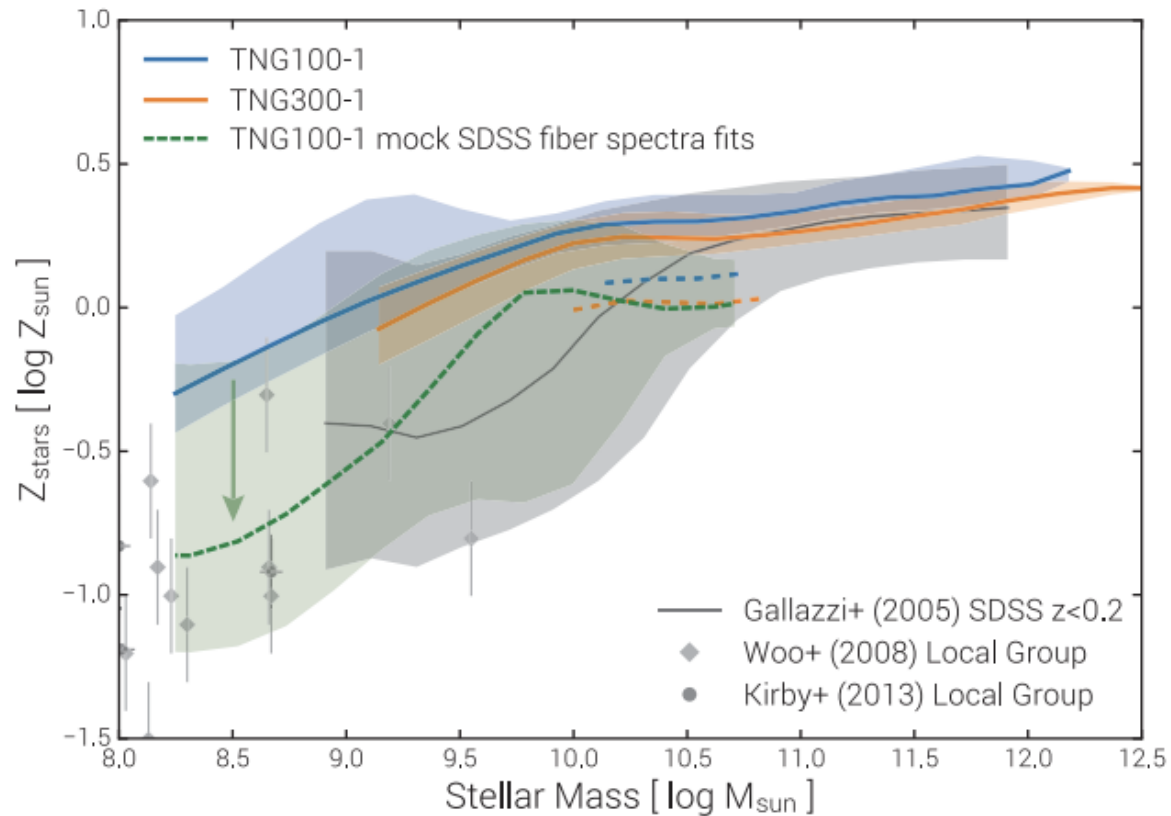
Mass-Size Relation



Pillepich+, 2018a

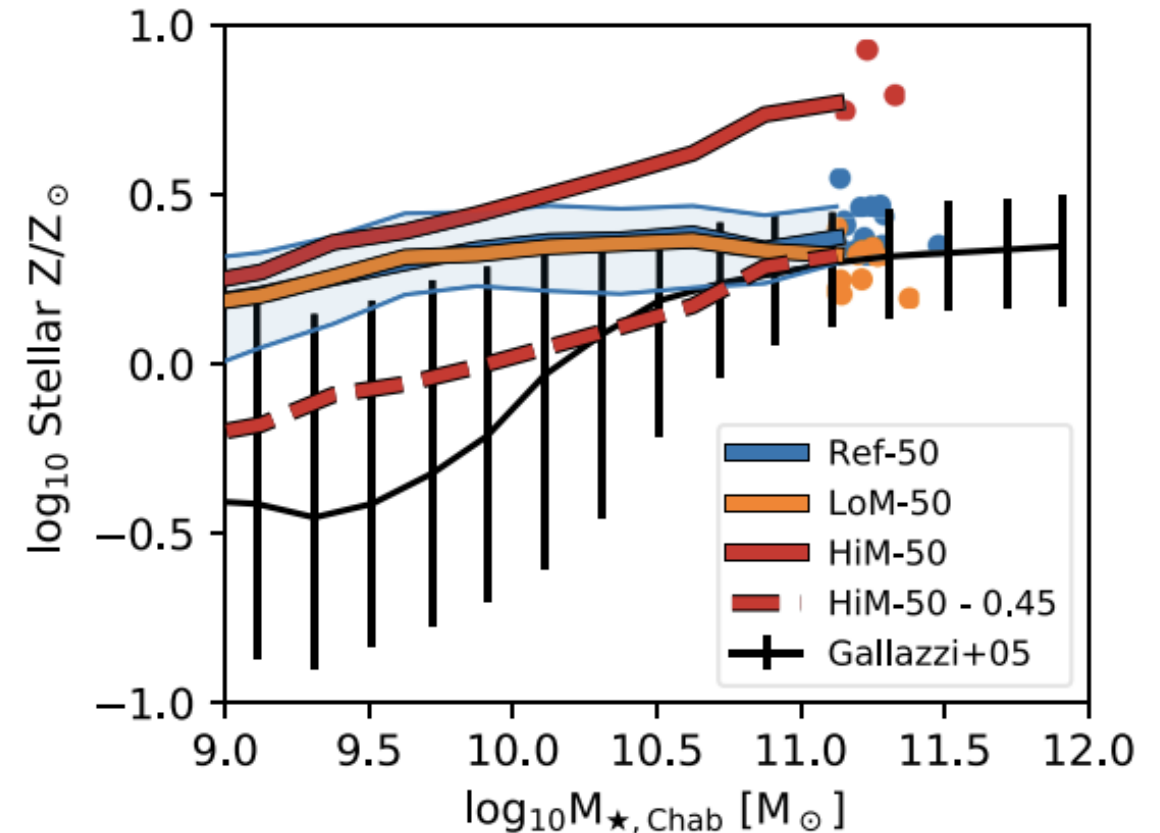
MASS METALLICITY RELATION IS NOT CALIBRATED!

TNG



Nelson+, 2018

EAGLE



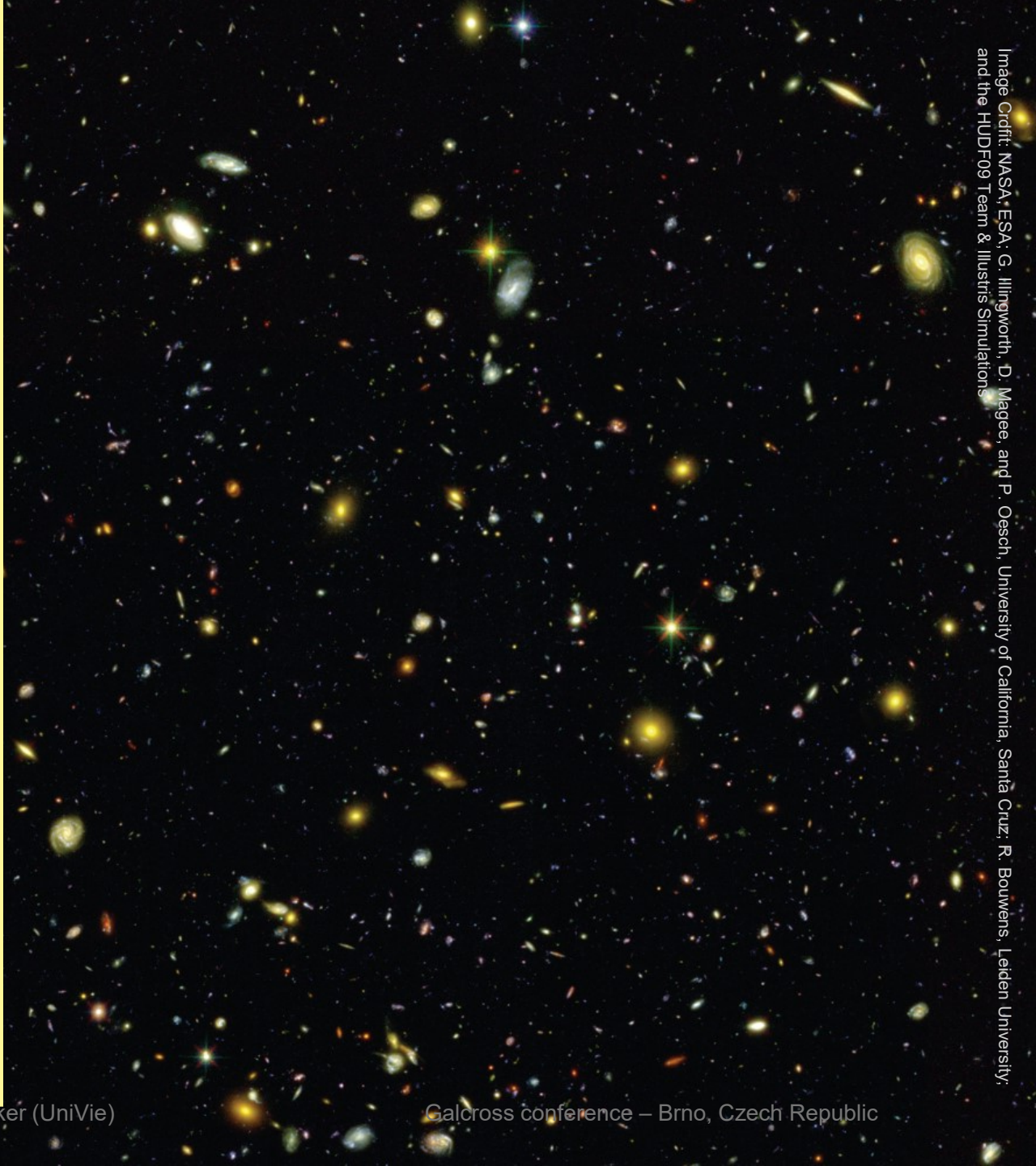
Barber+, 2018





18th Sep 2024

Alina Boecker (UniVie)

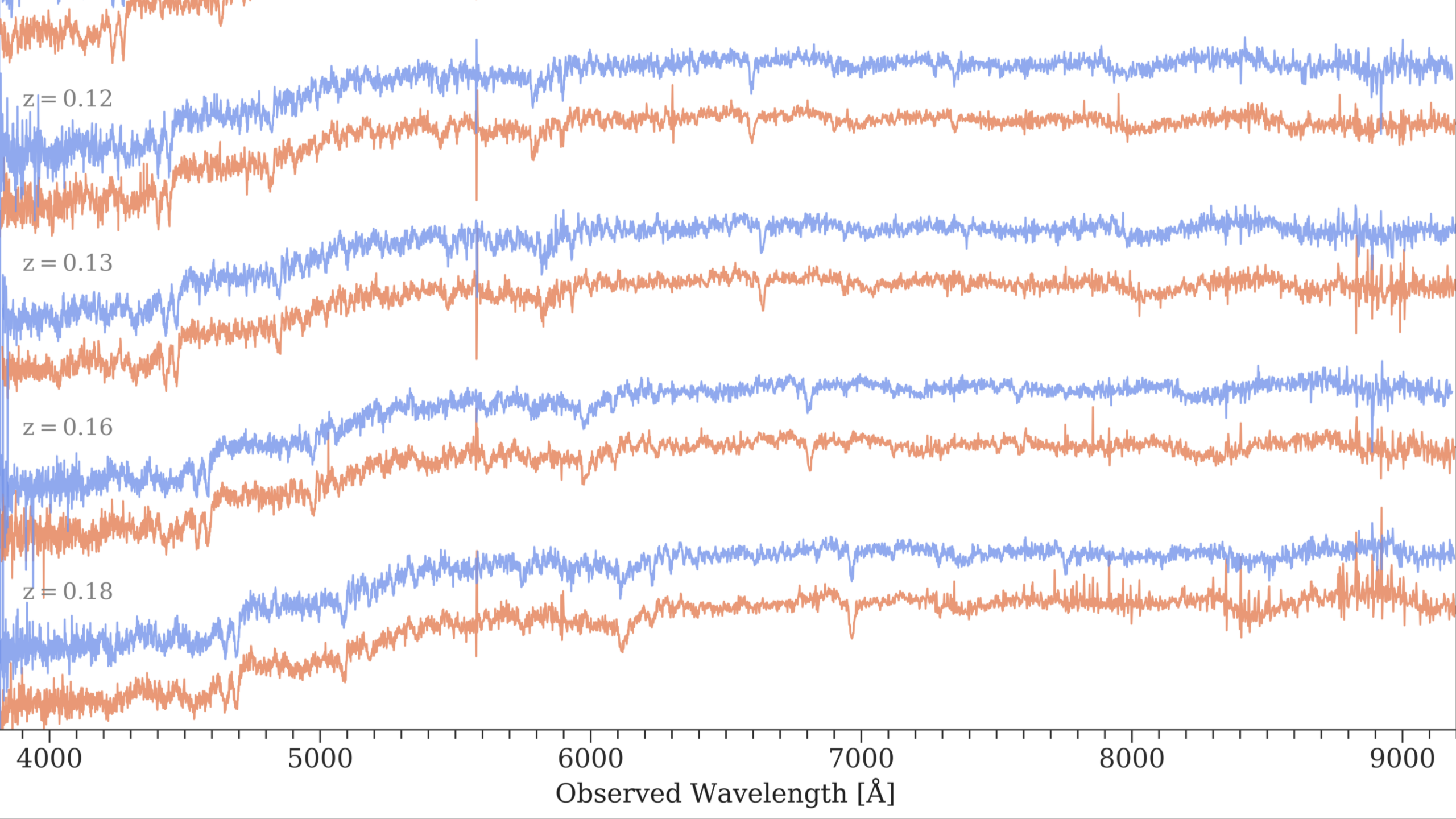


Galcross conference – Brno, Czech Republic

MOCK HUBBLE DEEP FIELD

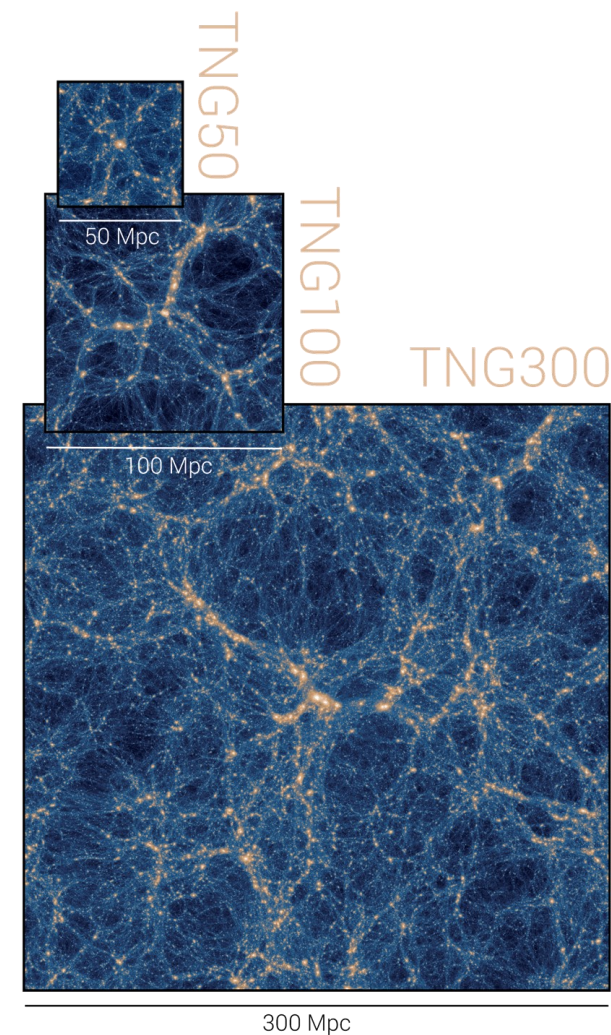
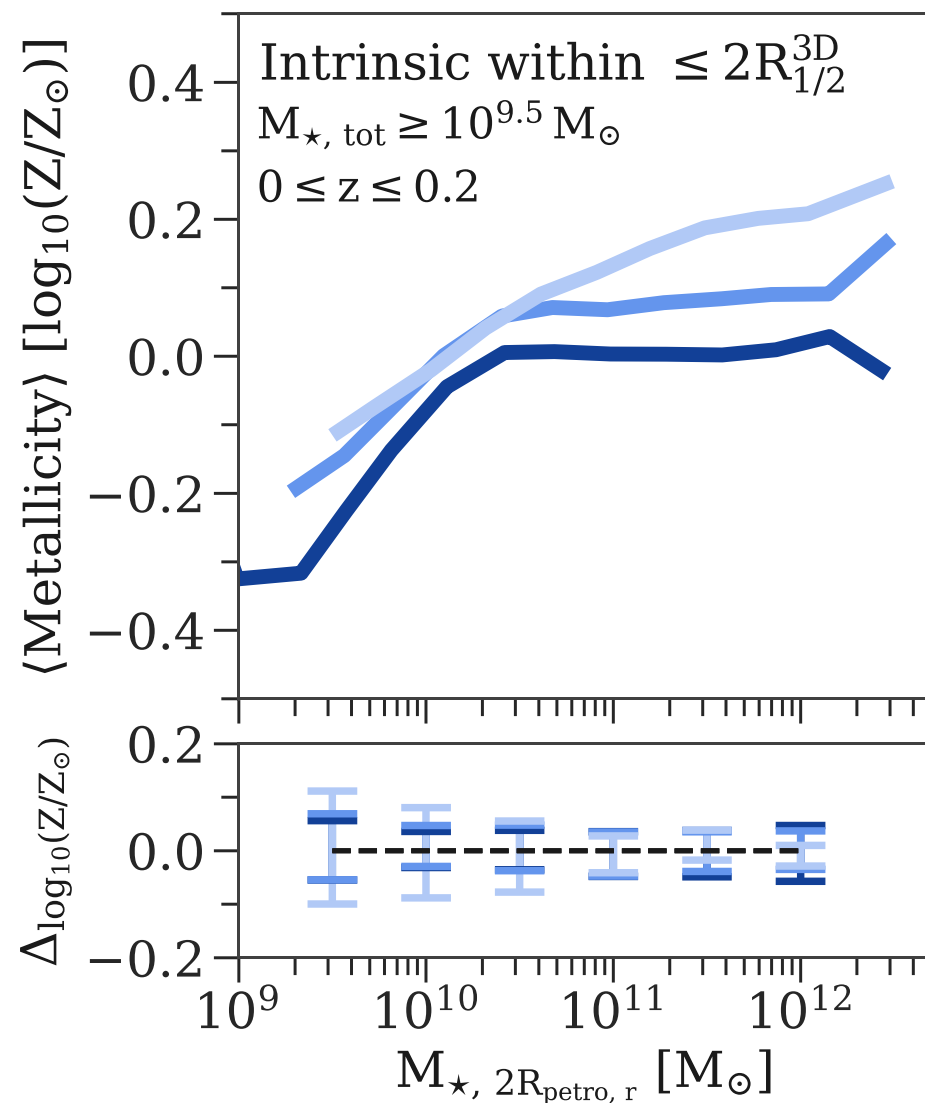
REAL HUBBLE DEEP FIELD

*Synergies between
simulations and observations
will continue to capture IMF
variations and its influence on
the baryon cycle and hence
galaxy formation*



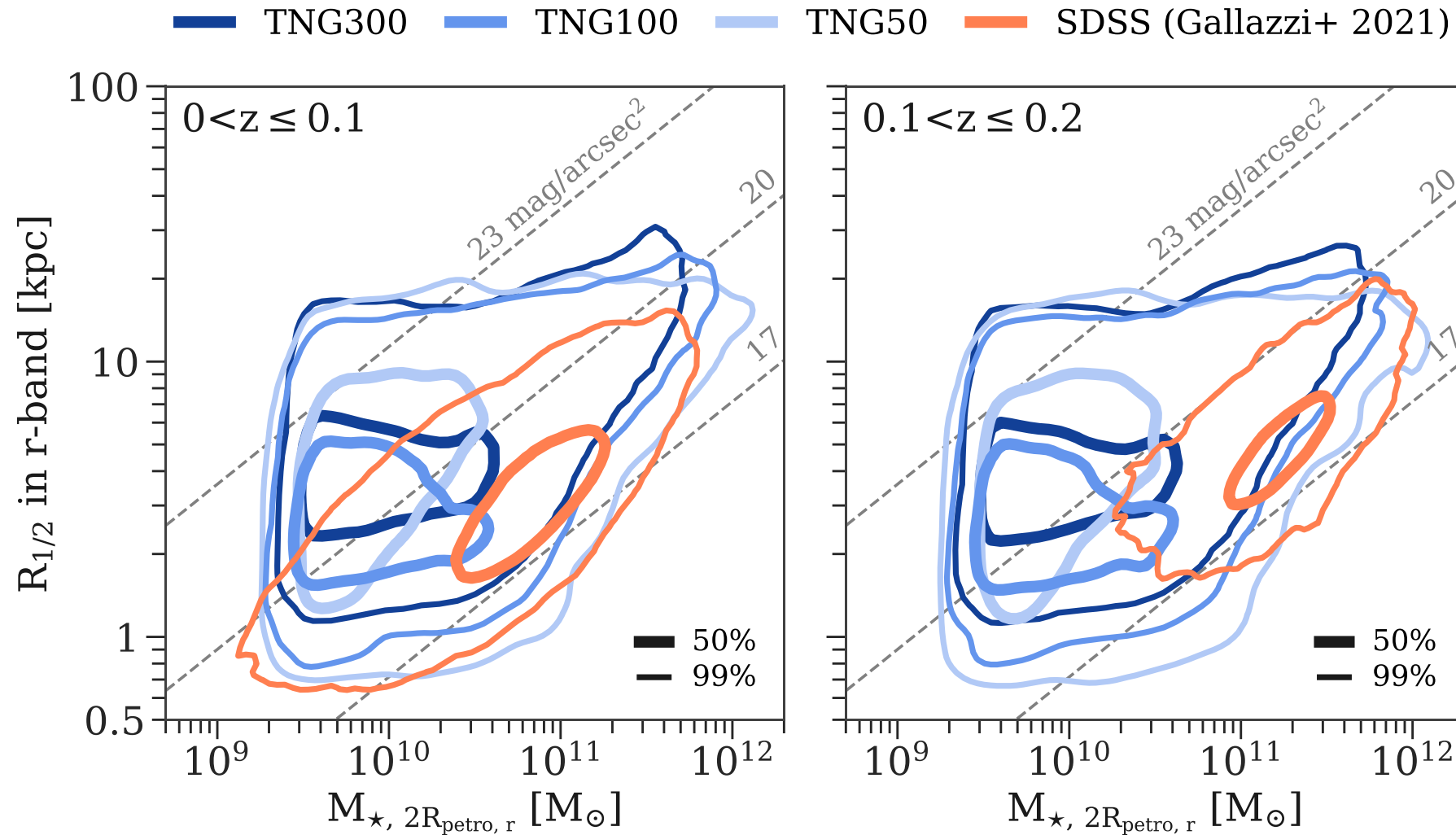
I. SIMULATION VIEW

- TNG300
- TNG100
- TNG50



Boecker+, in prep.

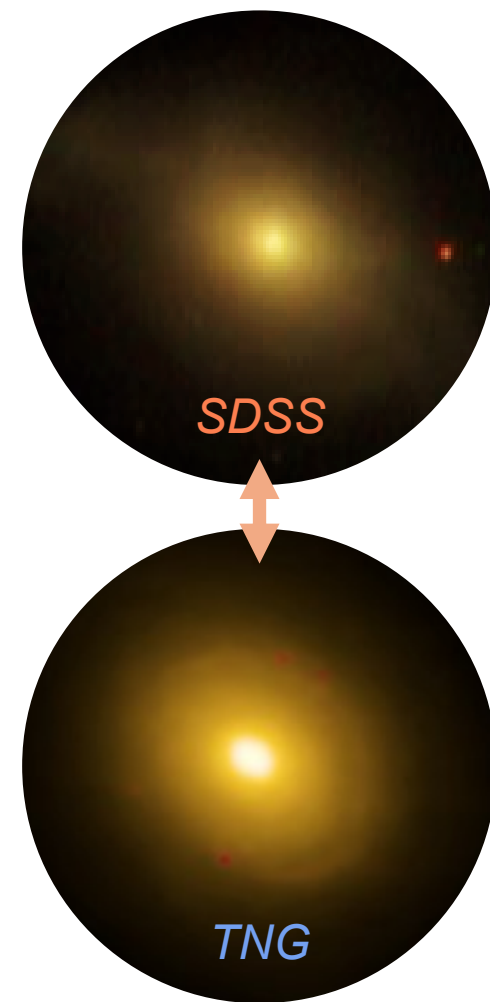
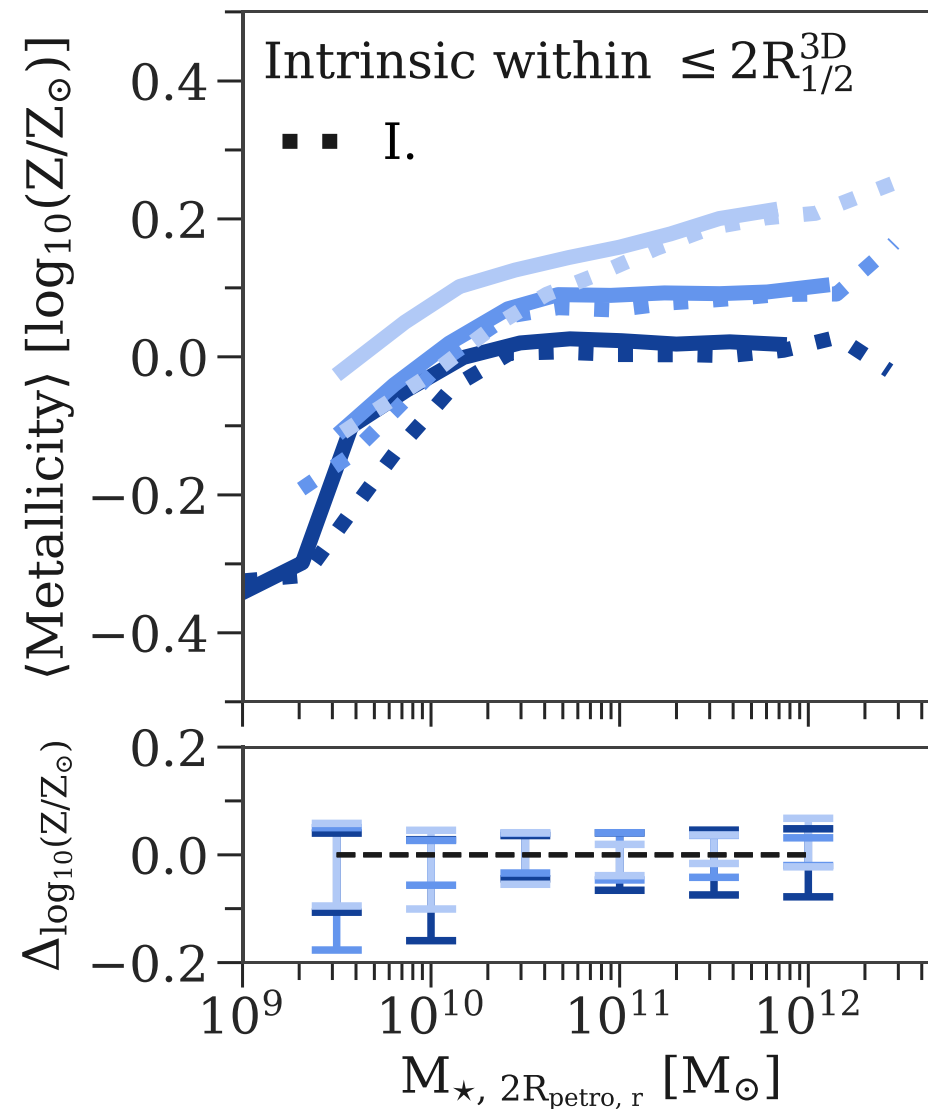
SELECTION FUNCTIONS ARE DIFFERENT!



Boecker+, in prep.

II. SAMPLE MATCHED TO SDSS

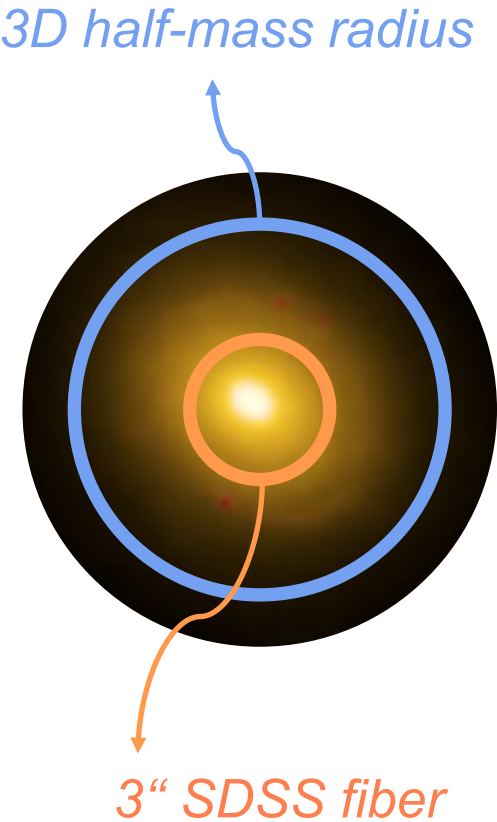
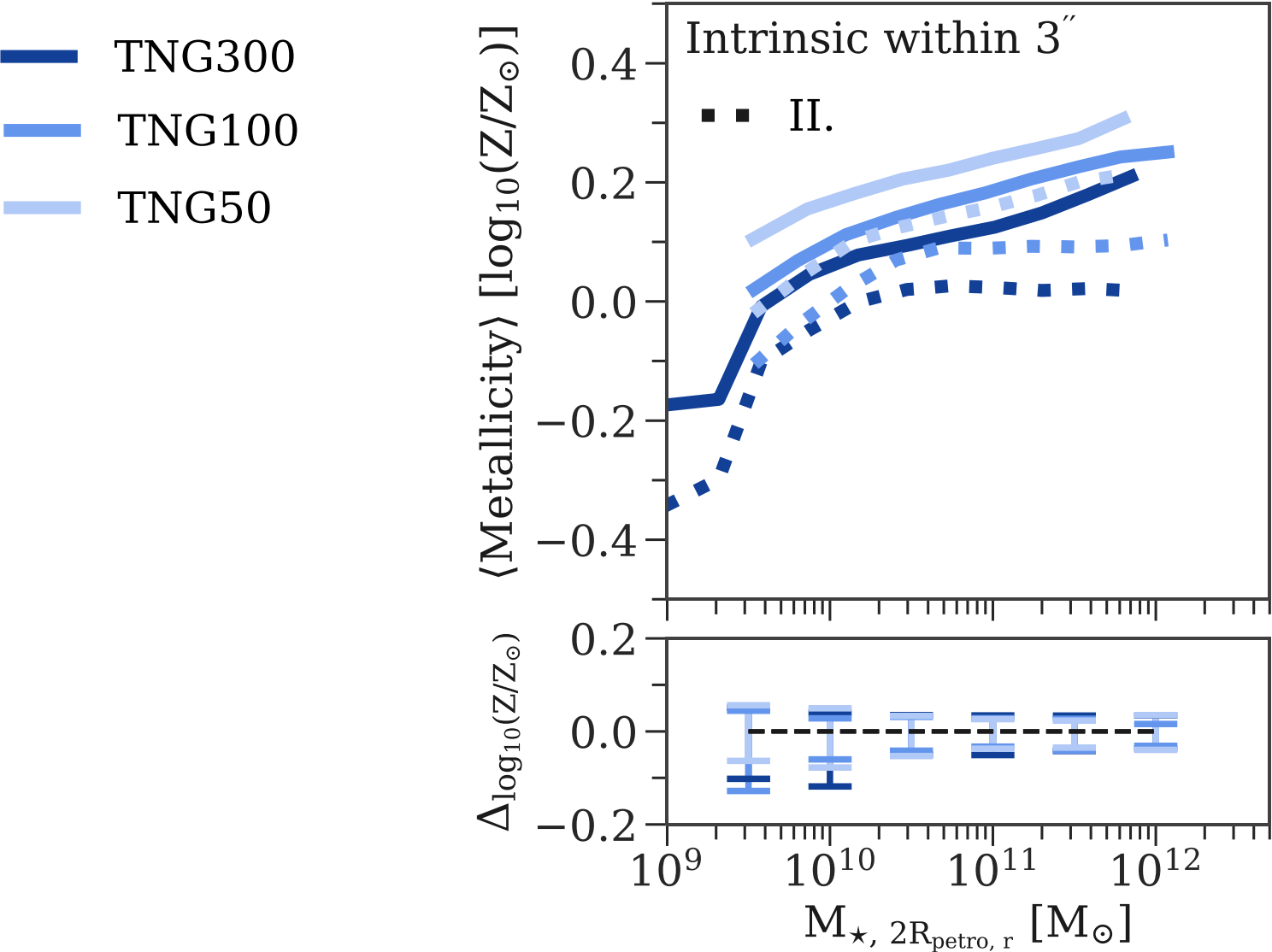
- TNG300
- TNG100
- TNG50



Boecker+, in prep.

Rodriguez-Gomez+, 2016

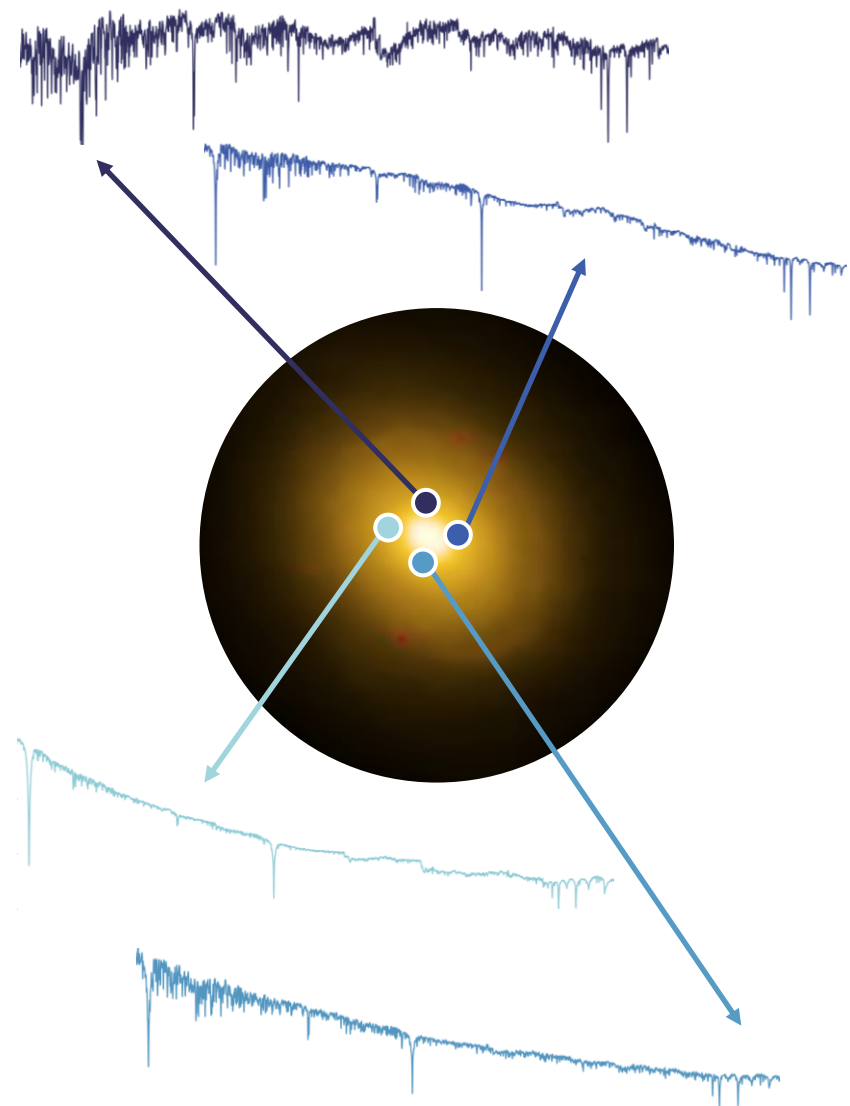
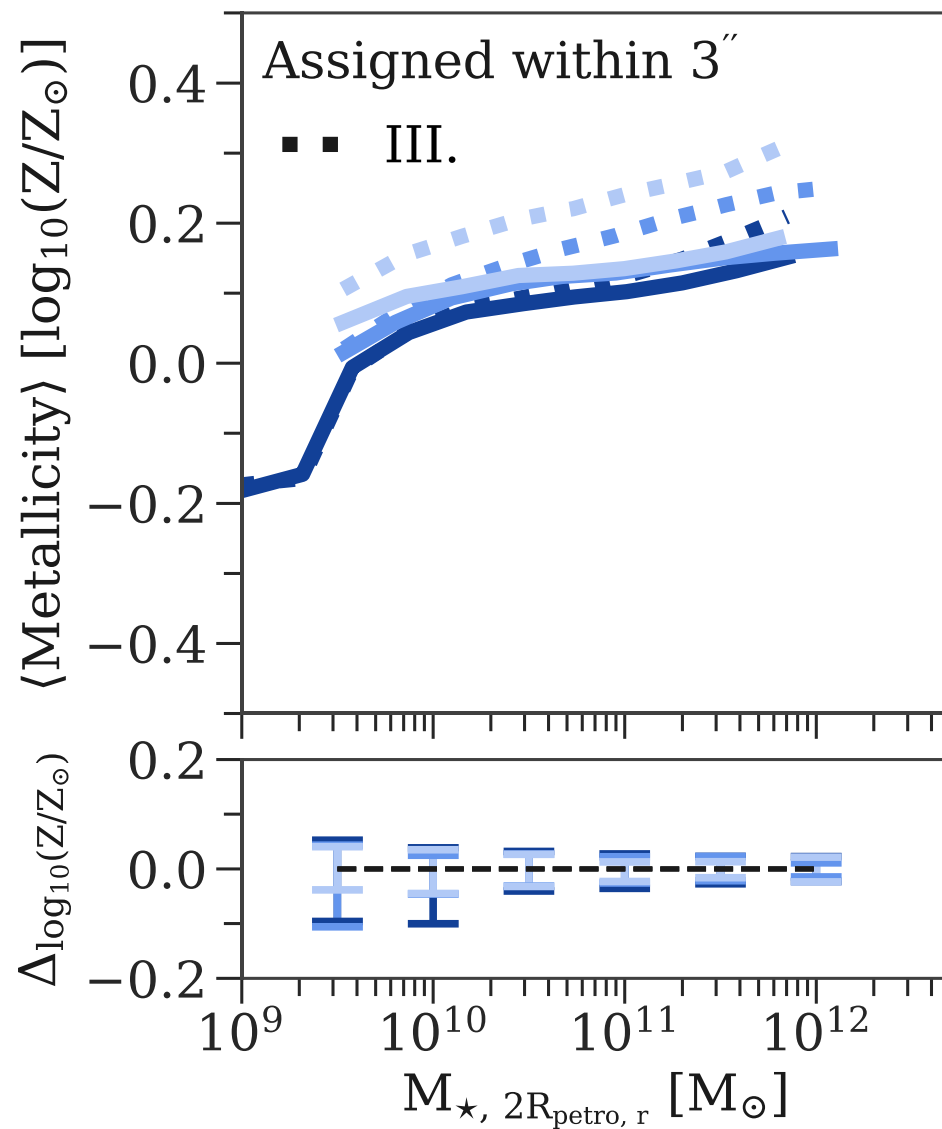
III. APERTURE MATCHED



Boecker+, in prep.

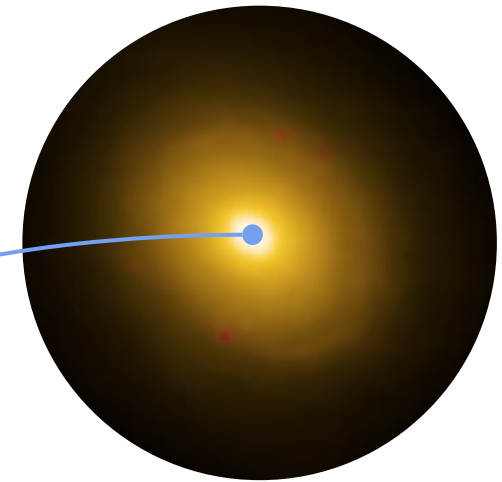
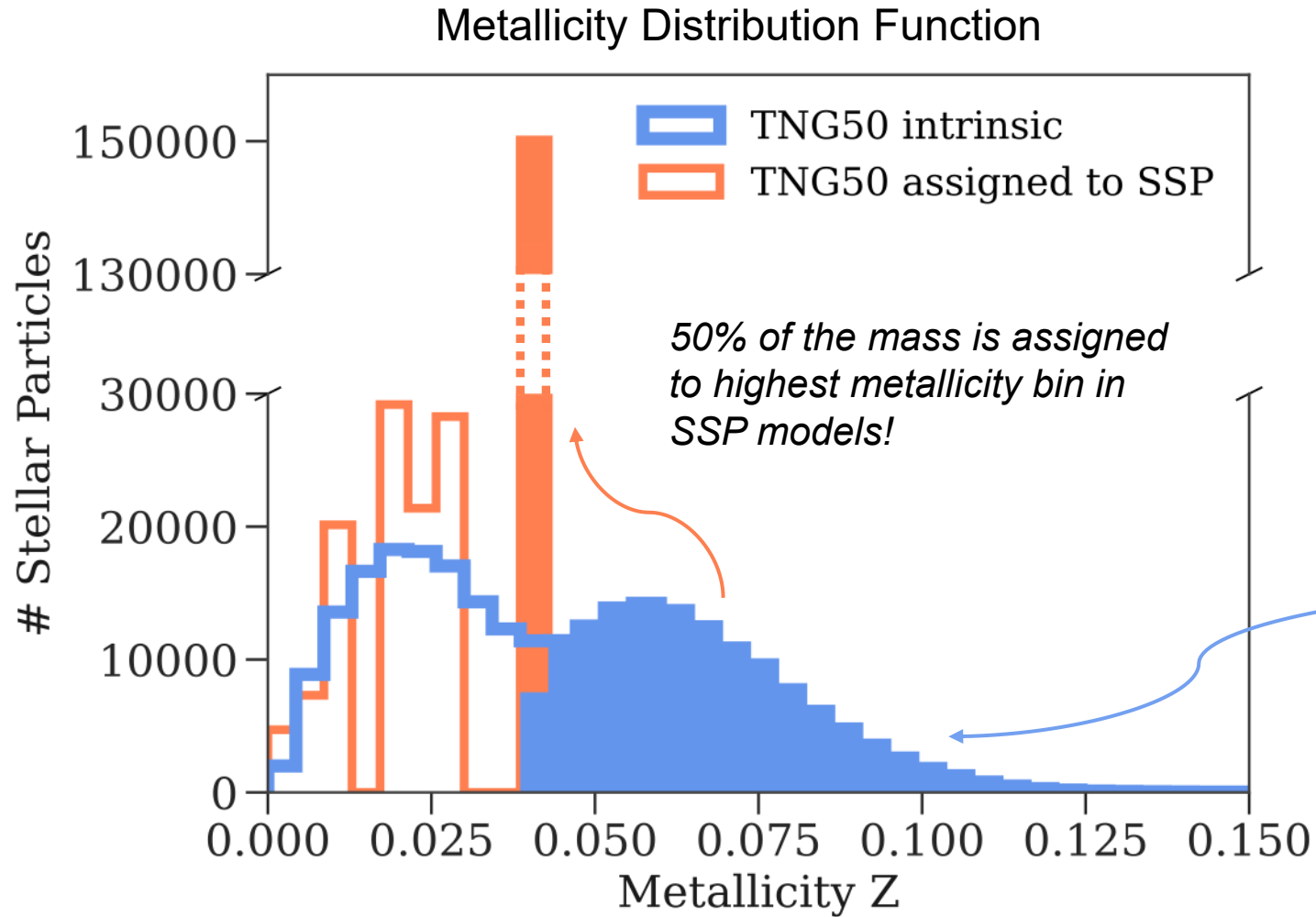
IV. SSP ASSIGNMENT

■ TNG300
■ TNG100
■ TNG50



Boecker+, in prep.

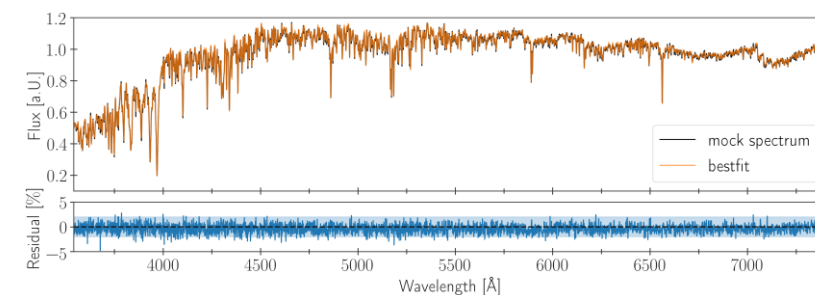
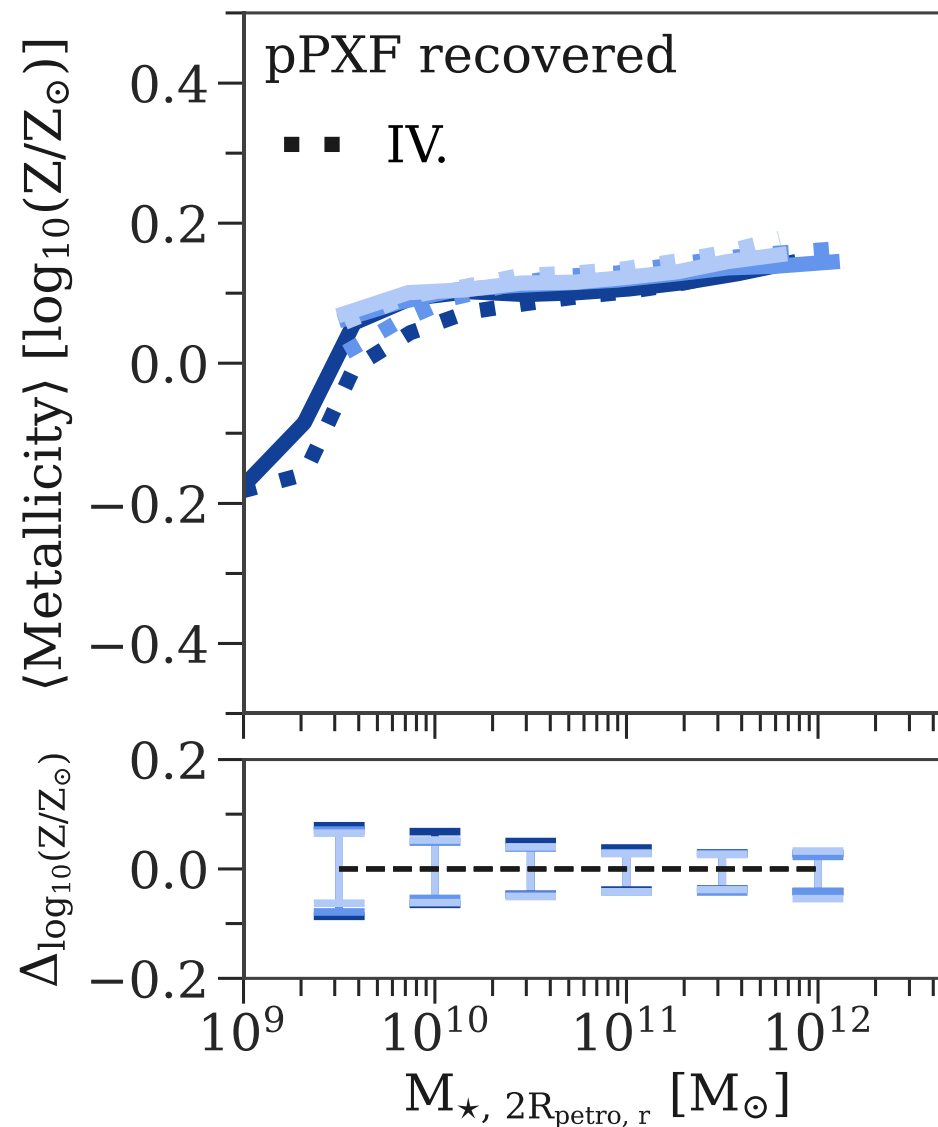
CAUTION WHEN ASSIGNING SSP MODELS!



Boecker+, in prep.

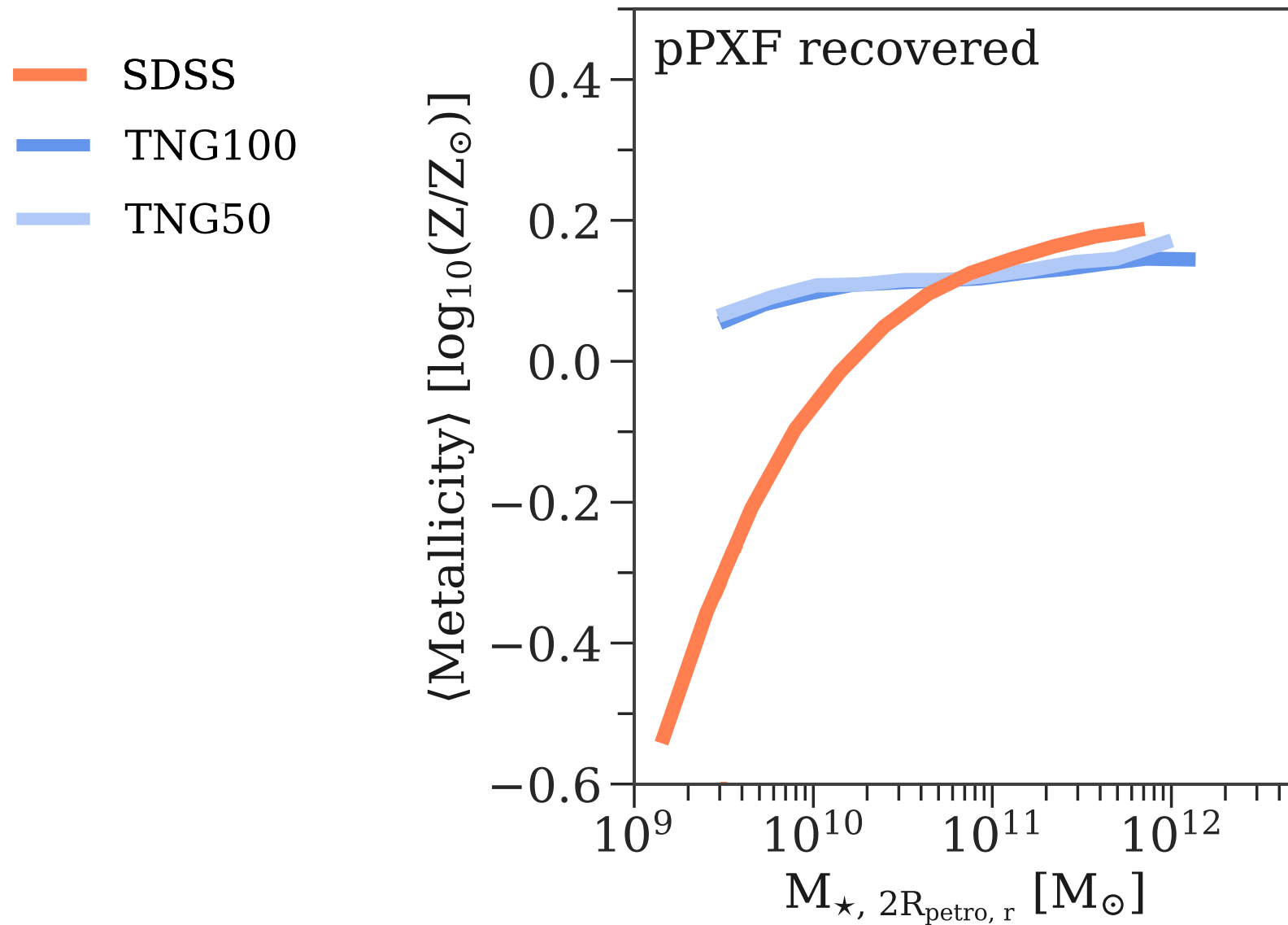
V. FULL SPECTRAL FITTING

- TNG300
- TNG100
- TNG50



Boecker+, in prep.

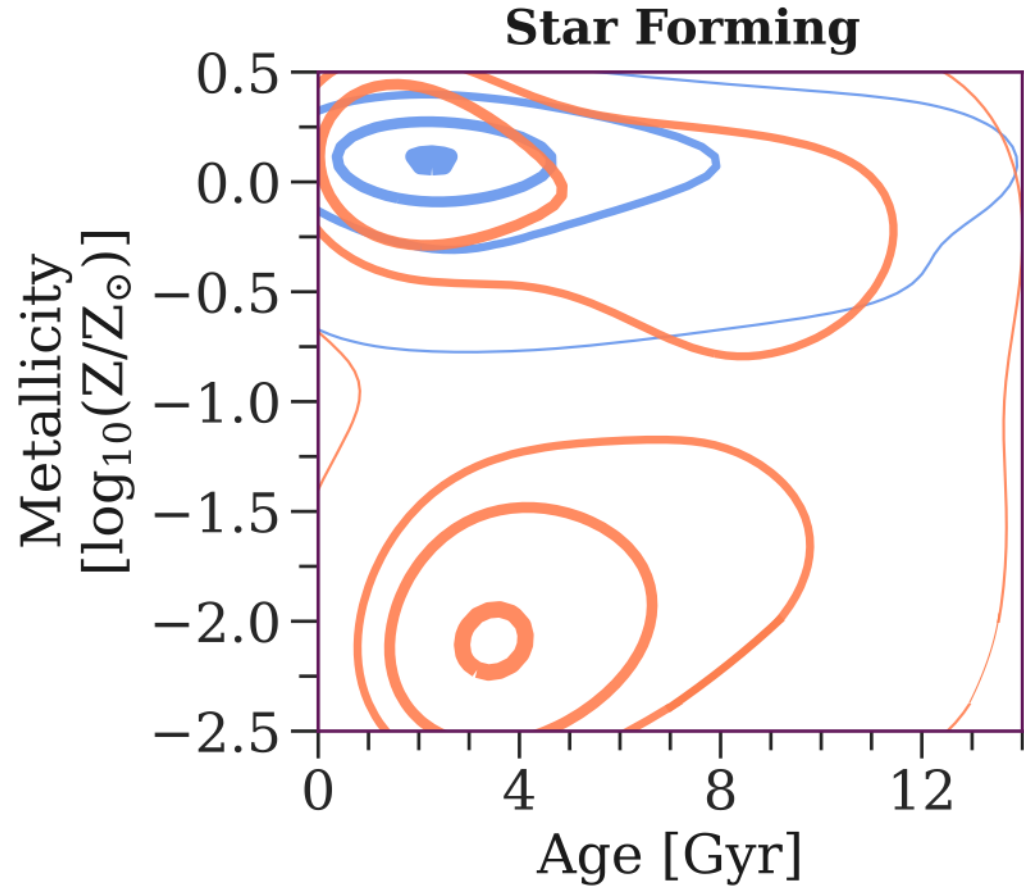
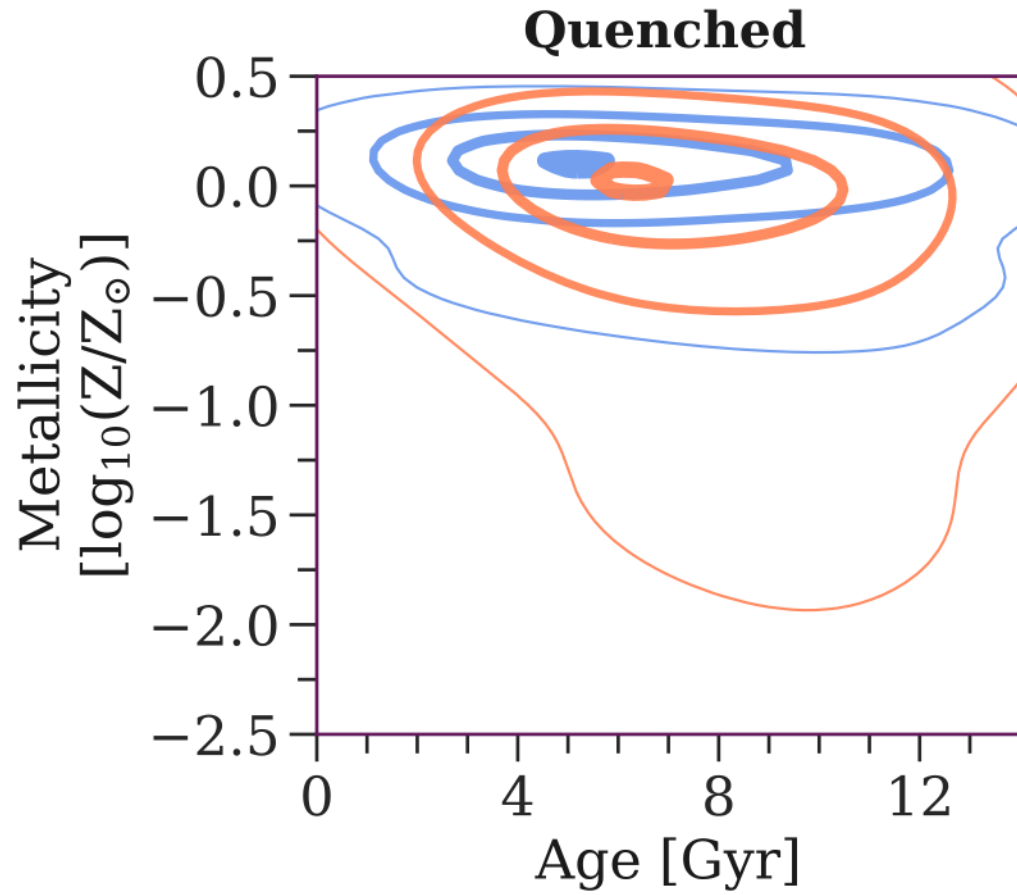
VI. COMPARISON WITH SDSS



Boecker+, in prep.

STAR FORMING GALAXIES DRIVE THE DISCREPANCY @ $\lesssim 10^{9.5} M_{\odot}$

— TNG50 Mock Recovered — SDSS

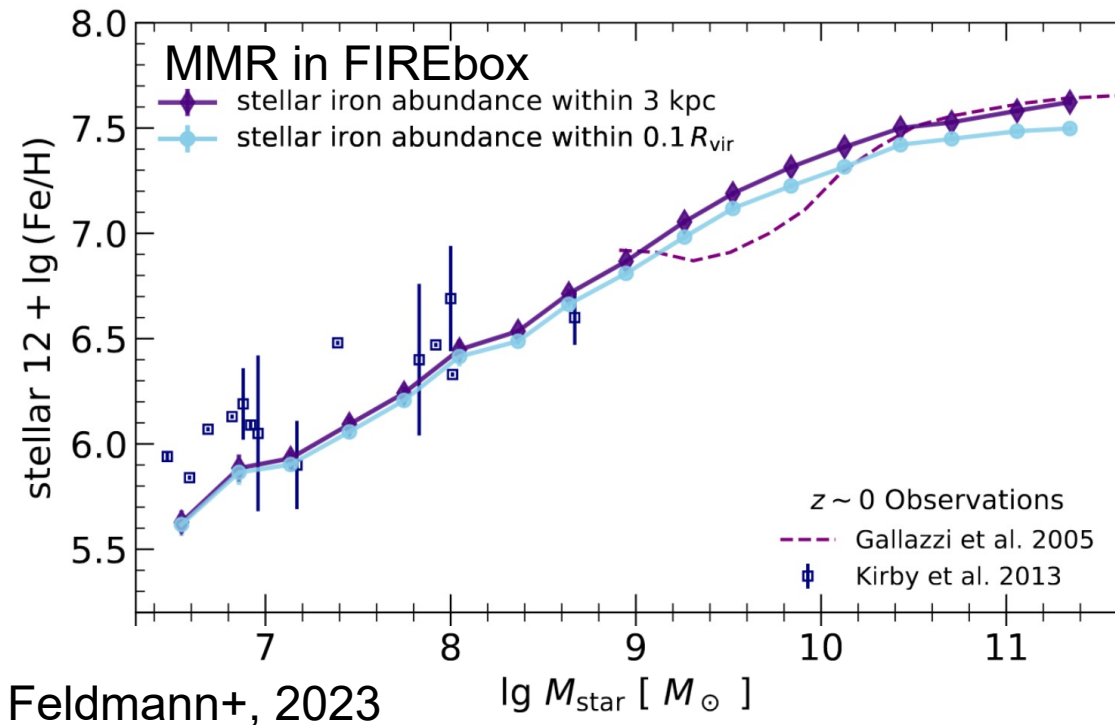


Boecker+, in prep.

POSSIBILITIES OF WHERE WE GO WRONG

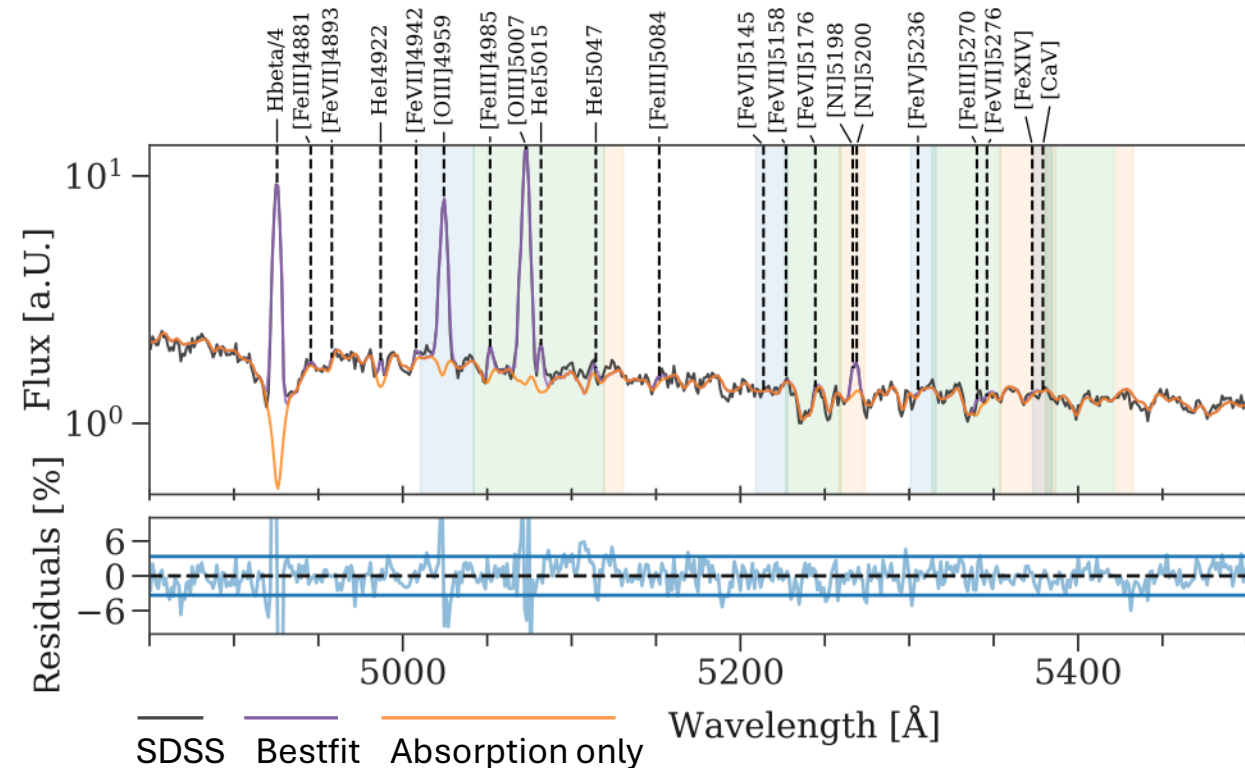
SIMULATIONS

TNG lacks multi-phase ISM
Other subgrid models (e.g. winds)



OBSERVATIONS

Emission lines are a pain
Young (< 1-10 Myr) SSP models are needed



100k SDSS Galaxies

x 3 different boxes ([TNG50](#) [TNG100](#) [TNG300](#))

x 4 different sample matching criteria

x 3 different SSP models for mock spectra construction

x 3 different assignments of SSP models

x 3 different SSP models for fitting

(6) ... coming soon?

SDSS-like mock spectra available soon!