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Stellar Populations of Galaxy Bars & Drivers of Stellar Metallicity

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Resolved Stellar Populations in Galaxies

Project I

Stellar metallicity in nearby galaxies:

A global perspective
using a very large sample

Project II

Stellar populations in galaxy bars:

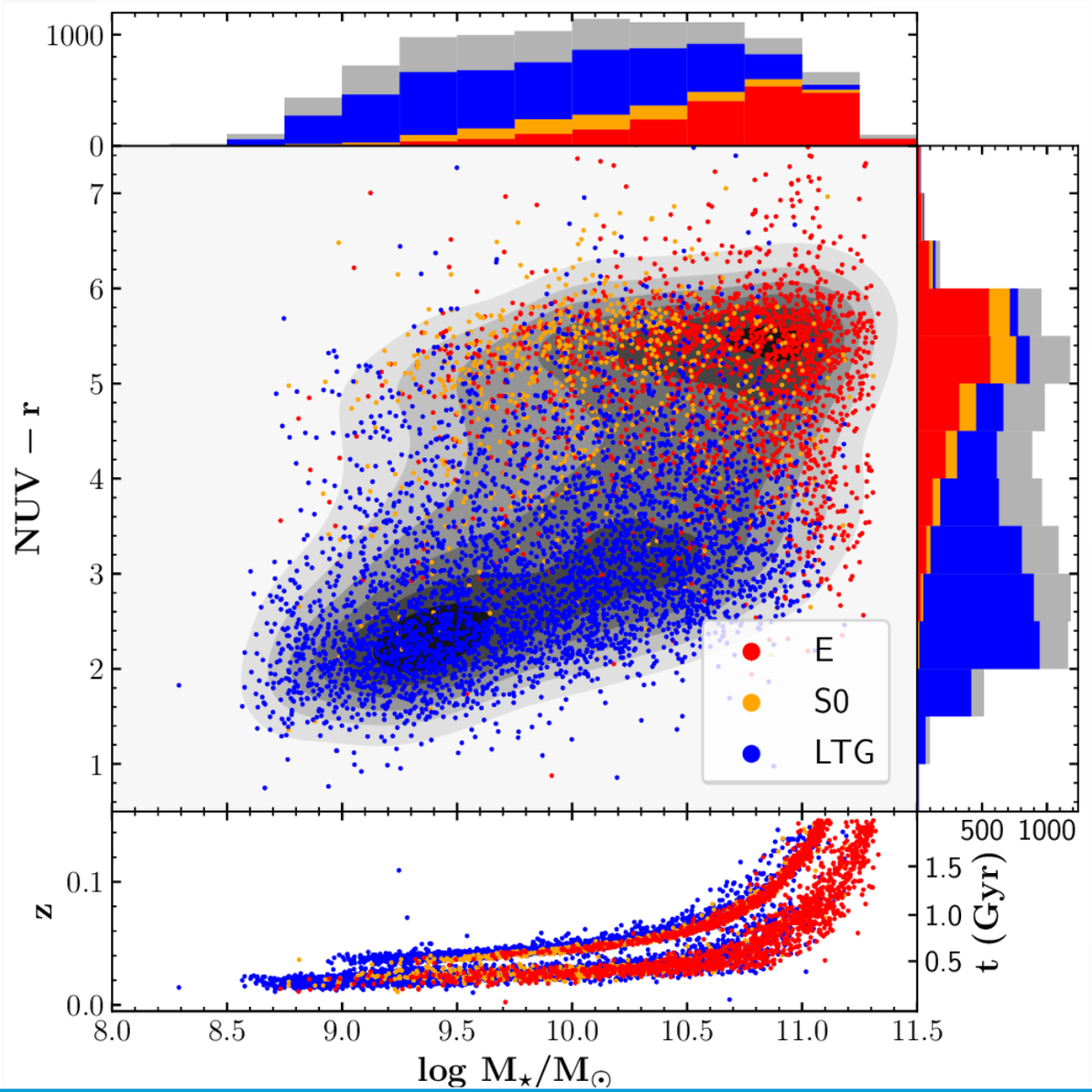
A detailed high spatial resolution study
of nine barred galaxies

Stellar Metallicity in Galaxies

- Strong global relation between mass and metallicity of galaxies (MZR)
  (e.g. Tremonti+2004, Gallazzi+2005, Peng+2015, Zahid+2017, Trussler+2020)
- Metallicity correlates locally with surface mass density
  (e.g. Sanchez+2013, Gonzalez-Delgado+2014, Barrera-Ballesteros+2016,Zibetti+2020,Sanchez+2020)
- Radial metallicity gradients in galaxies negativ (?!)
  (e.g. Belfiore+2017, Goddard+2017)

How is stellar metallicity locally connected to stellar surface mass density and galactocentric distance in the global mass - morphology plane?

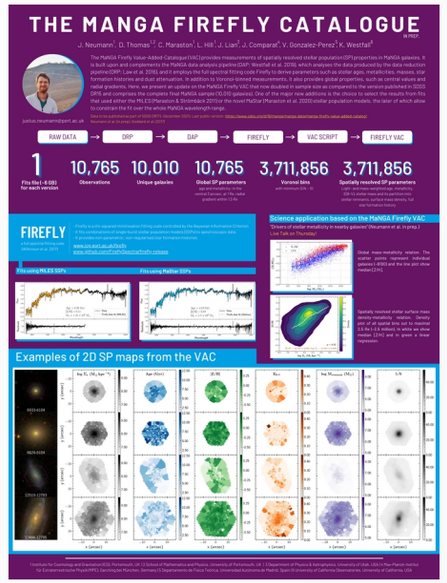
MaNGA: Data & Analysis



- Main working sample: **8109 galaxies** from MaNGA Product Launch - 10 (MPL-10)

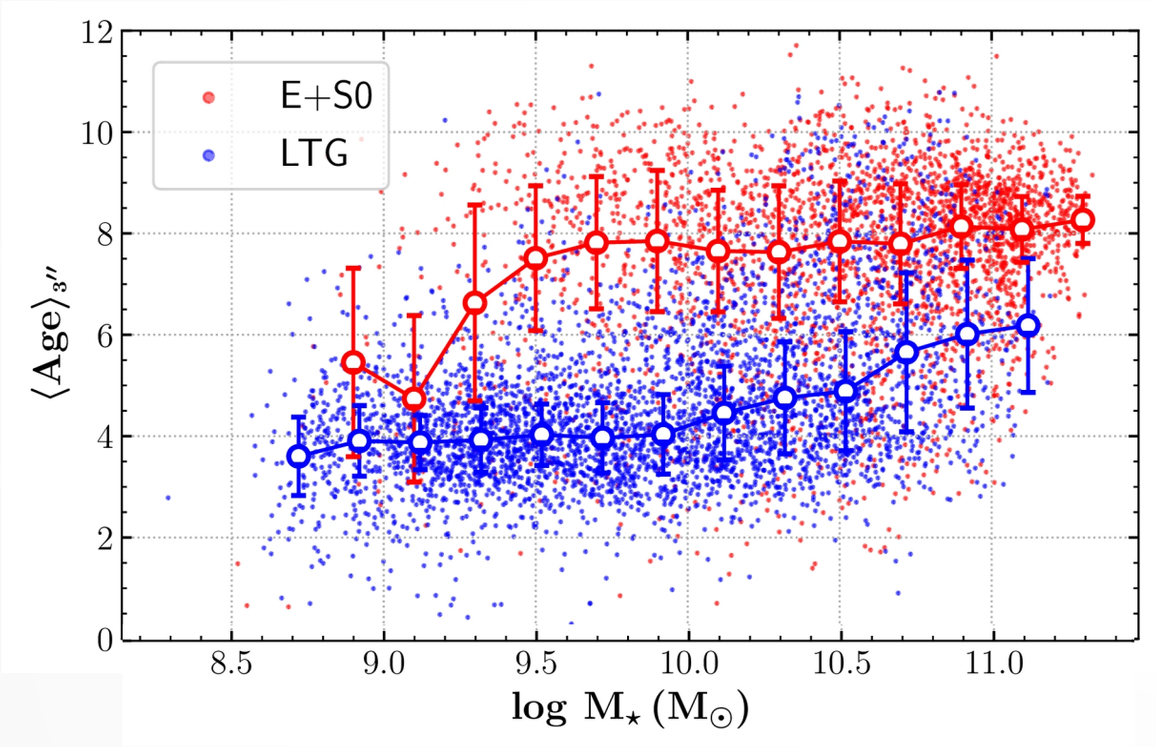
- Full spectral fitting of Voronoi binned datacubes with FIREFLY (Wilkinson+2017)
  - ➔ MaNGA Firefly Catalogue:

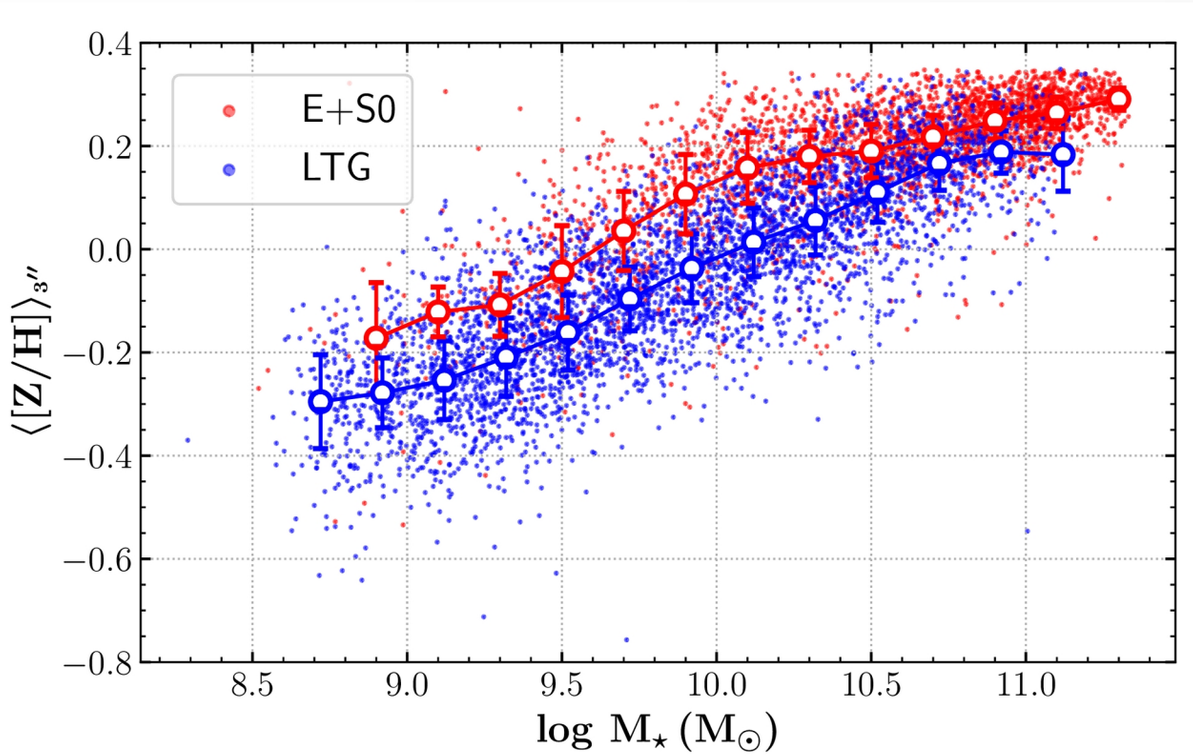
    resolved and global stellar population properties of all MaNGA galaxies



Neumann+ in prep.

Global Mass-Metallicity-Relation



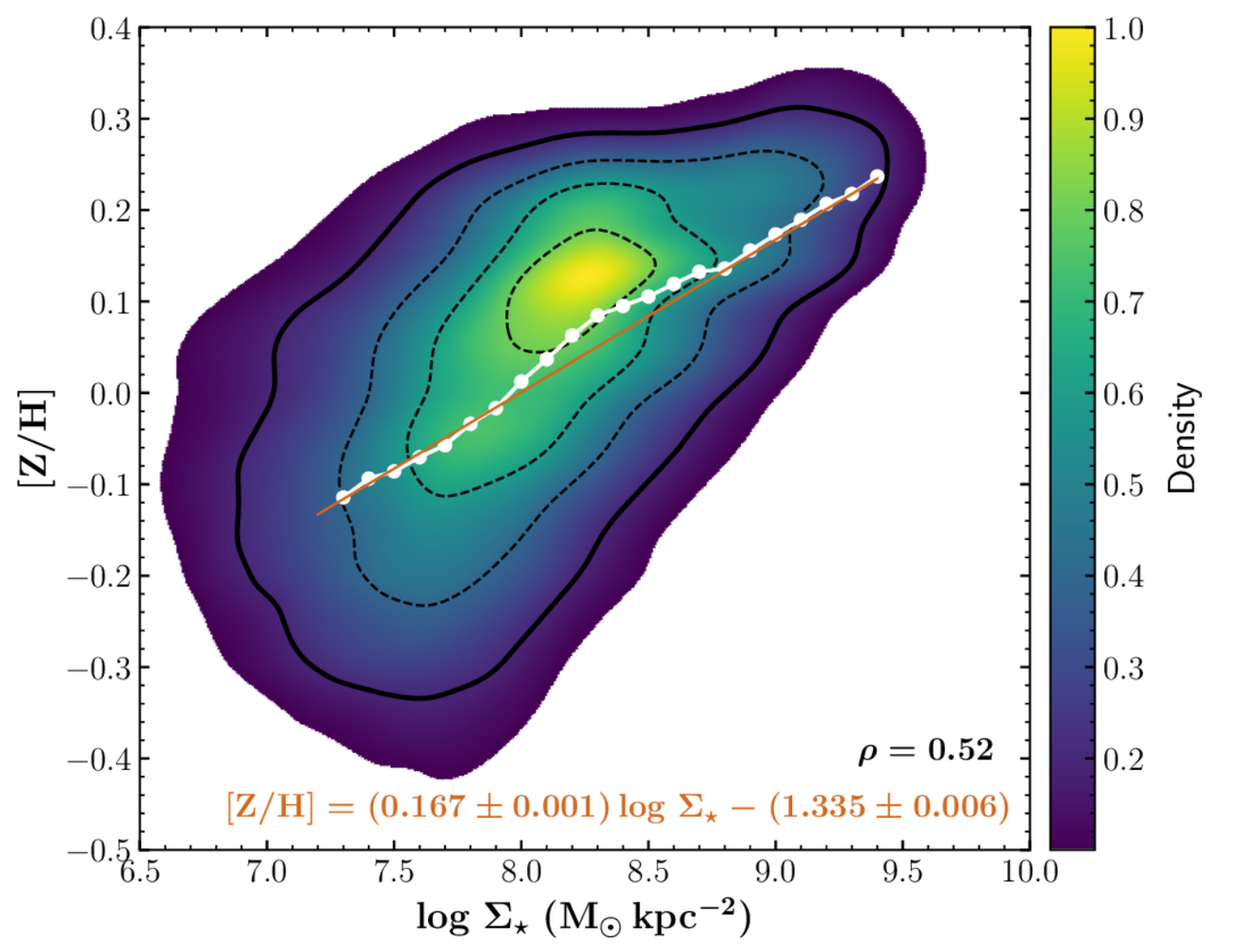


➔ At fixed mass, ETGs have higher stellar metallicities than LTGs.

Neumann+ in prep.

Trends with Stellar Surface Mass Density

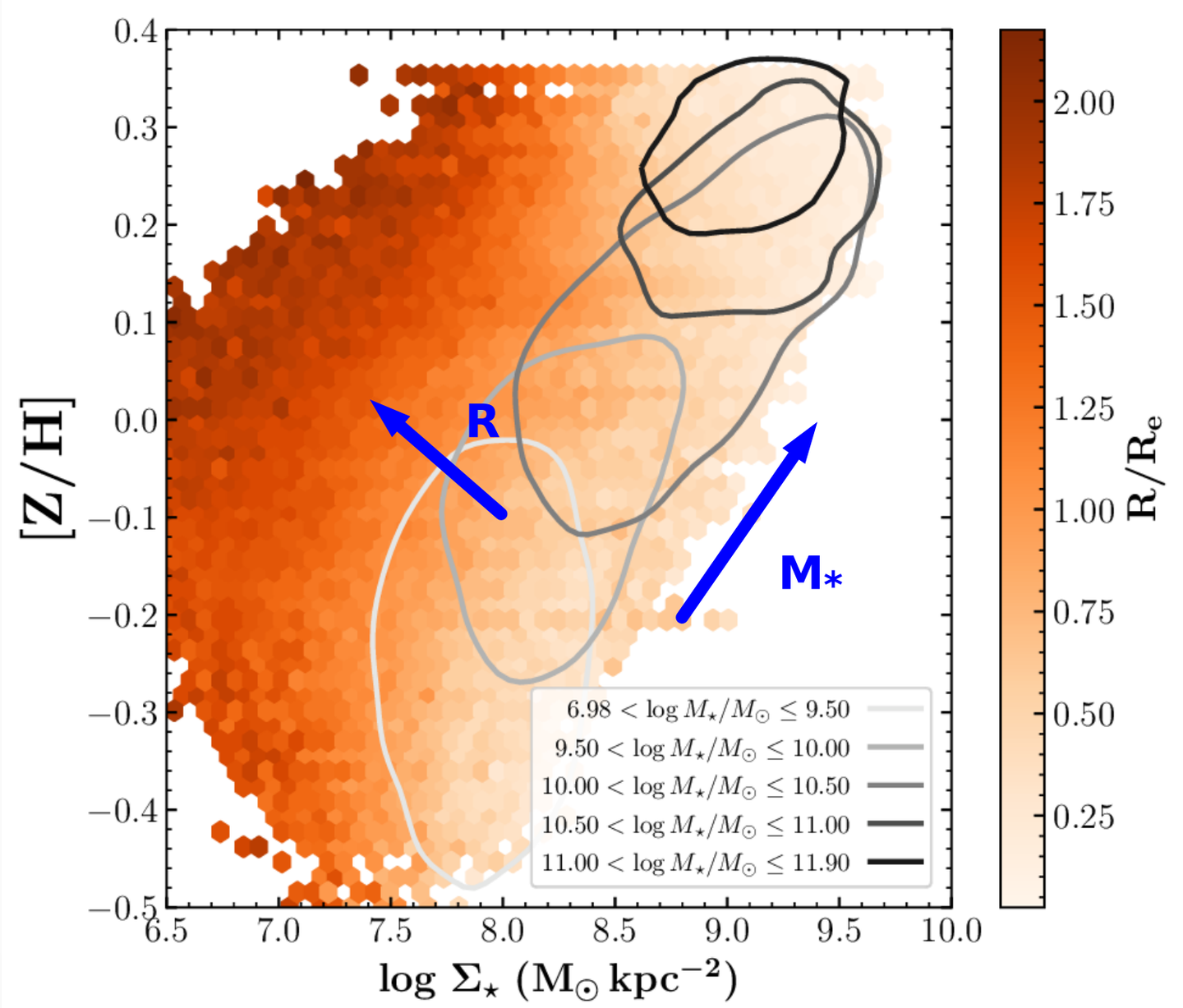
(resolved Mass-Metallicity-Relation; rMZR)



➔ Stellar metallicity is locally correlated with surface mass density.

Neumann+ in prep.

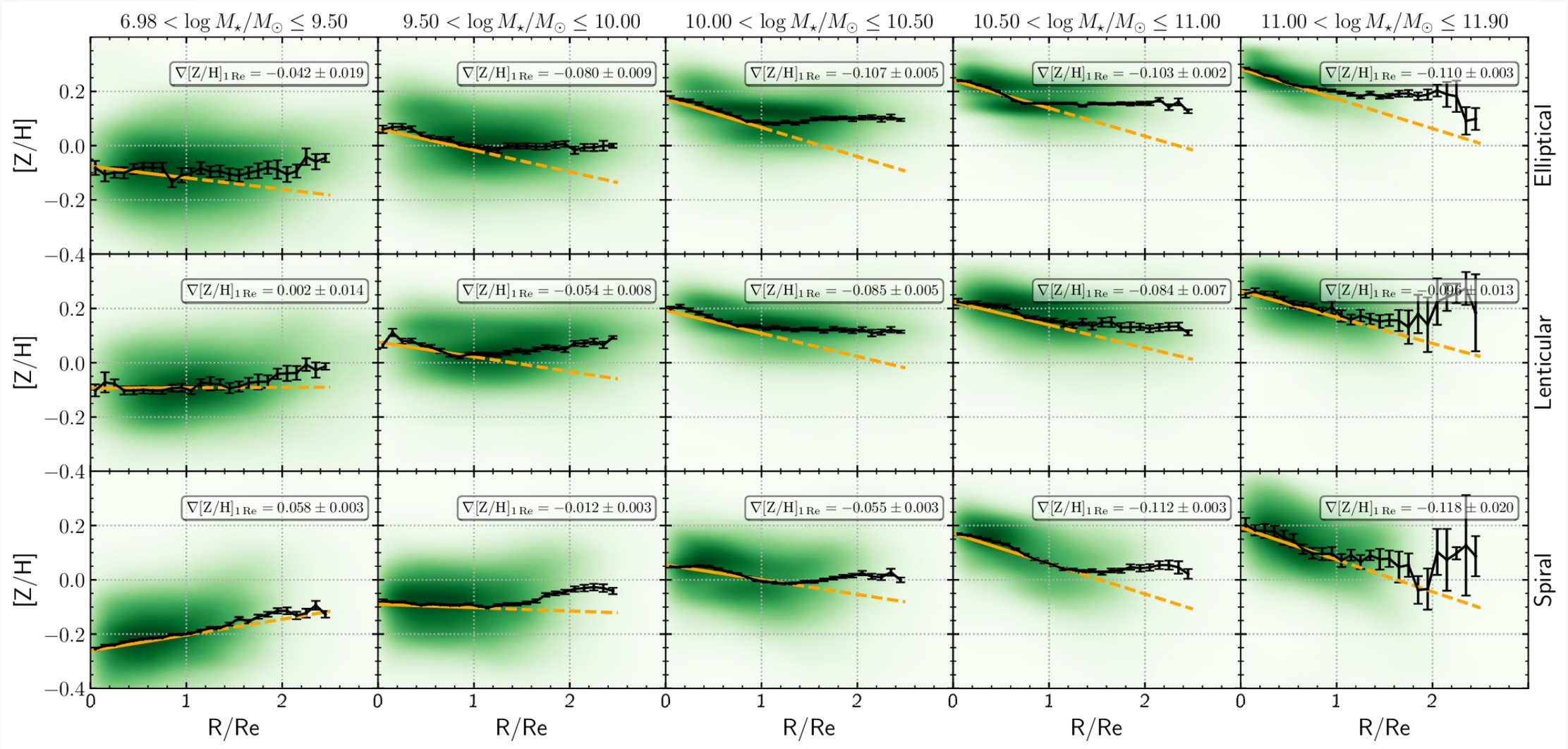
The rMZR - Dependence on Total Mass



- Higher metallicity at higher total masses, but moving “along” the relation.
- Scatter in the relation due to different radial distances.

Neumann+ in prep.

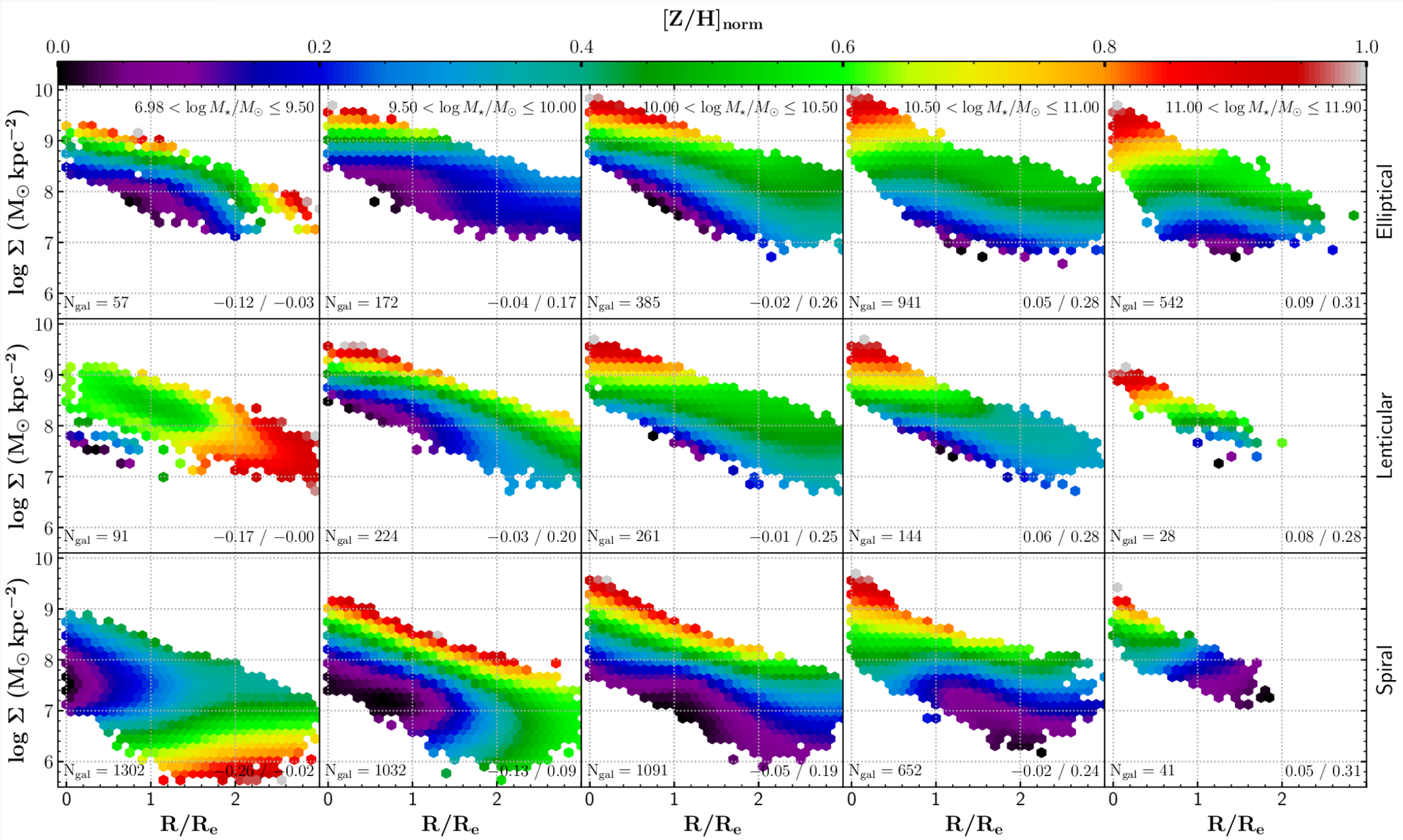
Metallicity Gradients



- Metallicity gradient negativ for massive galaxies out to ~1.5 R_e
- Positive gradient for low-mass LTGs.

Neumann+ in prep.

Radial Stellar Surface Mass Density-Metallicity Trends



Radially increasing [Z/H] at fixed Σ => additional (radial dependent) driver of [Z/H] =>

- inflows / outflows / radial migration / inside-out quenching /...

Neumann+ in prep.

Stellar Populations in Galaxy Bars

Neumann+2020

What can we learn from the stellar populations?

- Formation of the bar
- Dynamics of the stars/radial mixing
- Stellar migration
- Trapping of stars by the bar
- Star formation/quenching in the bar and surrounding disc

- Extragalactic reference for studies of the MW bulge/bar

Method:

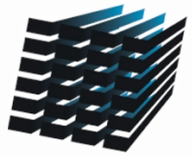
Full spectral fitting
(GANDALF, STECKMAP and PPXF)

Data:

TIMER survey (Gadotti et al. 2019)

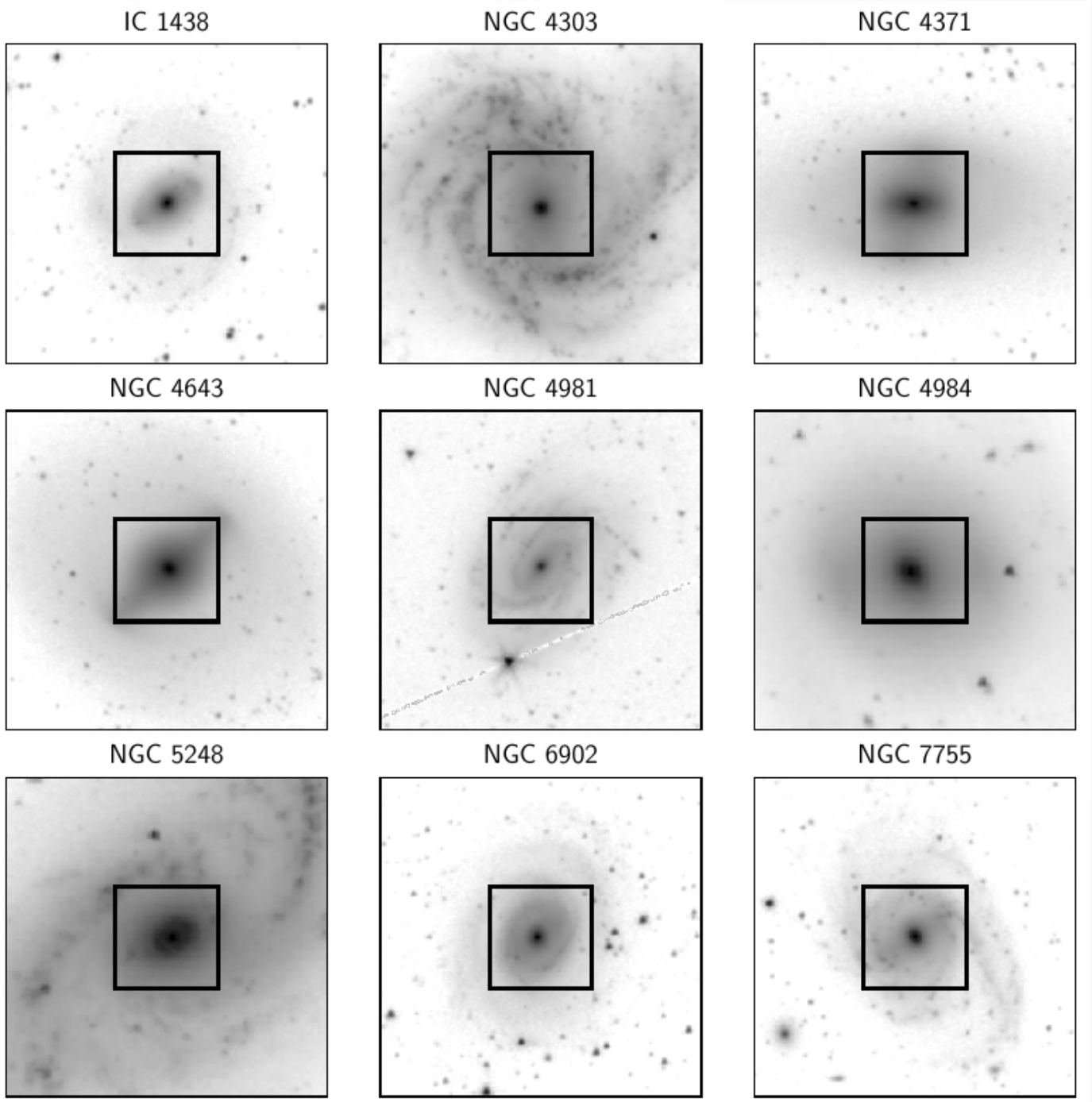
- 24 nearby (d < 40 Mpc) barred galaxies

>>> Talk by Dimitri Gadotti from Session 2 <<<



muse
multi unit spectroscopic explorer

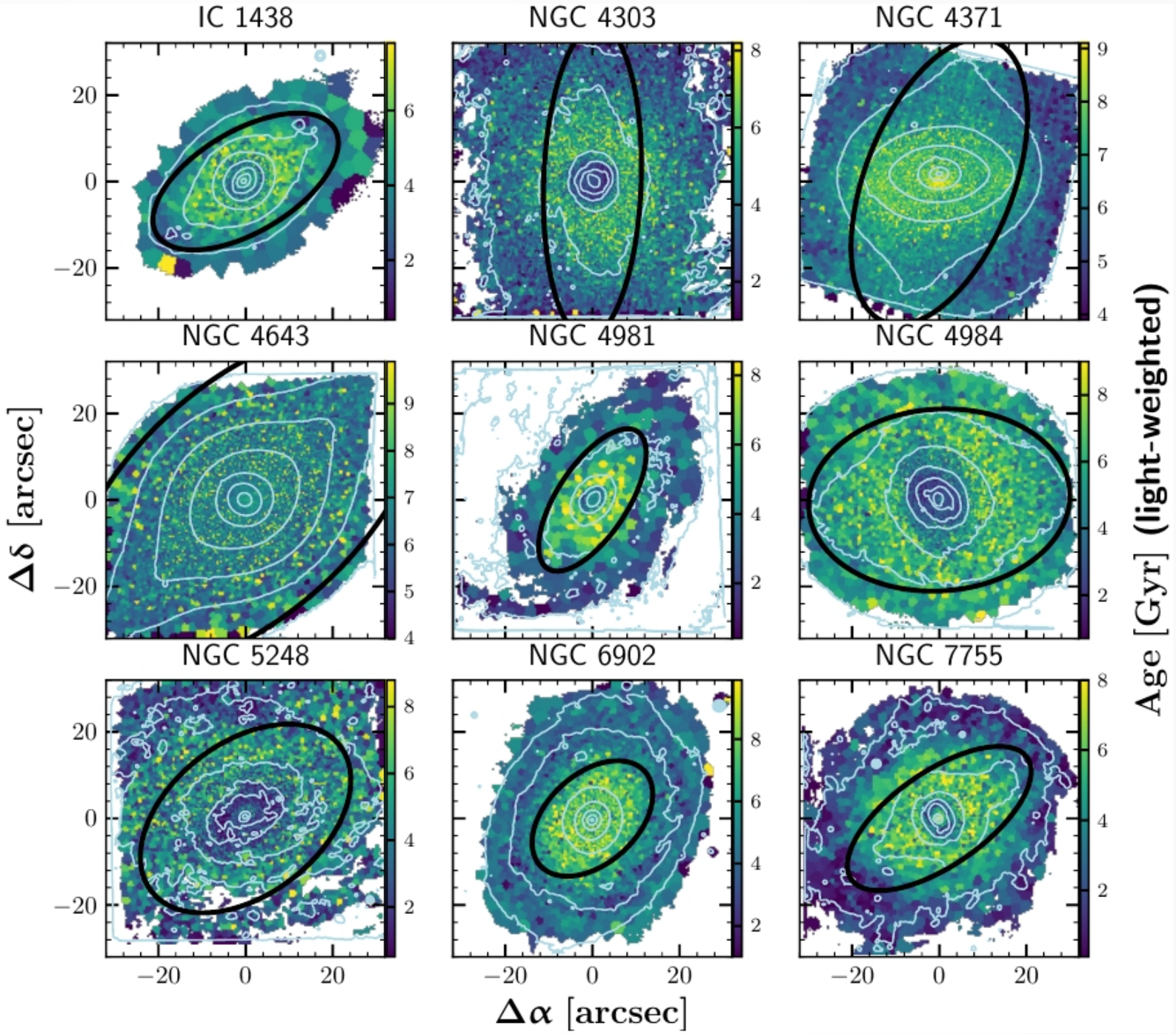
Our Subsample:



Neumann+2020

Mean Ages

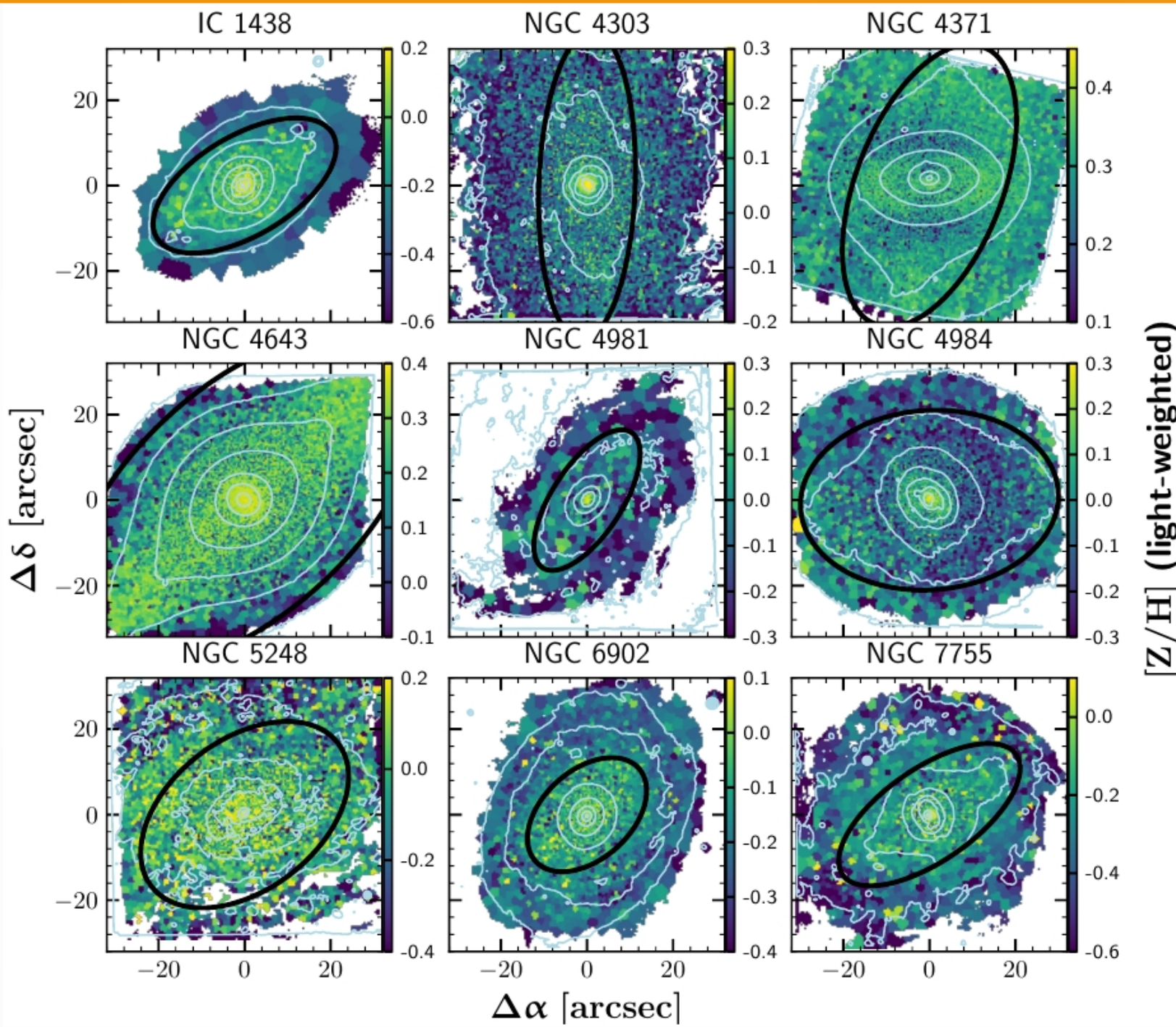
- Stellar populations of bars are **older** than (or as old as) the surroundings.



Neumann+2020

Mean [Z/H]

- Stellar populations of bars are **older** than (or as old as) the surroundings.
- Stellar bars are **more metal-rich** than (or as rich as) the surroundings.

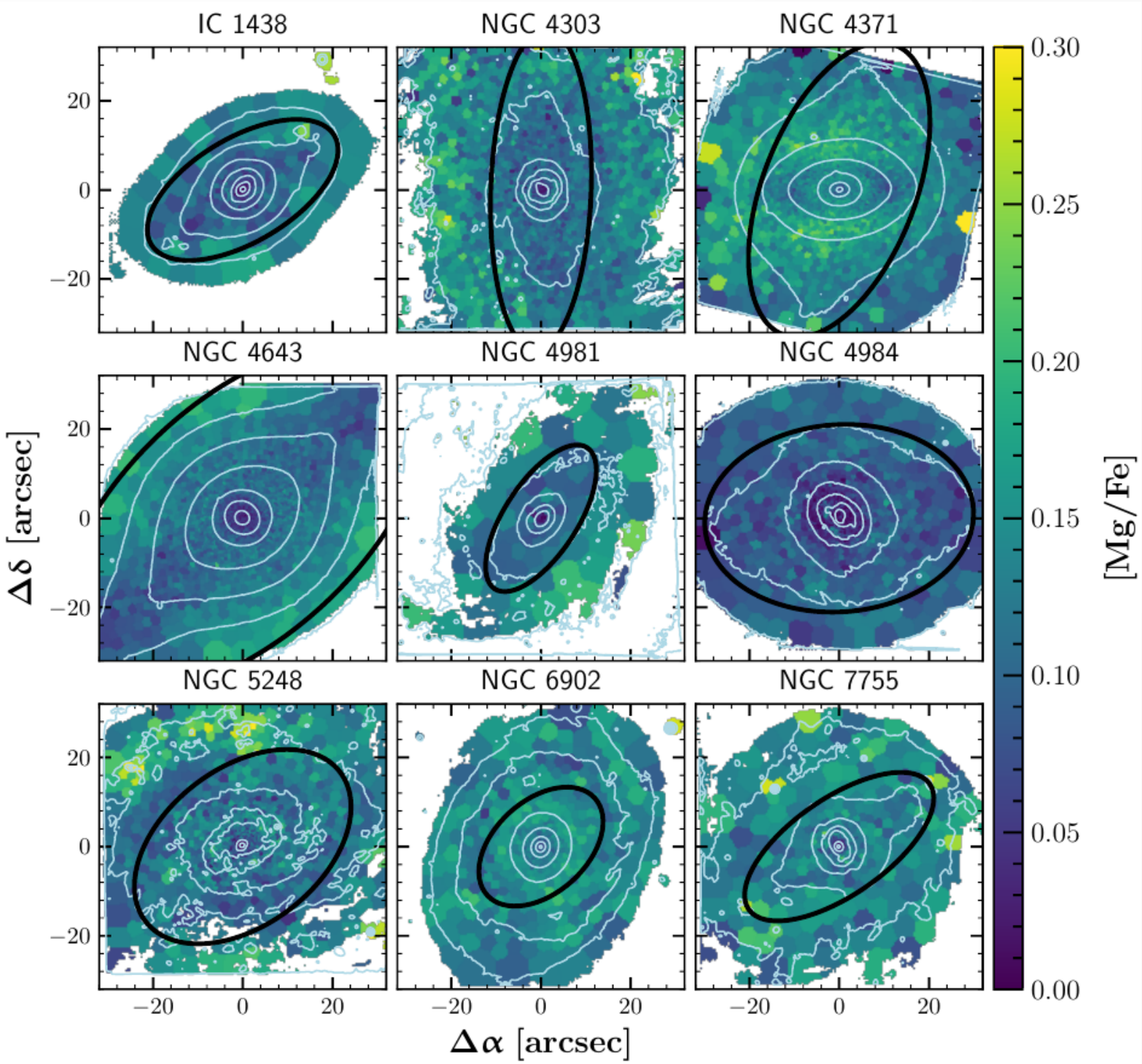


Neumann+2020

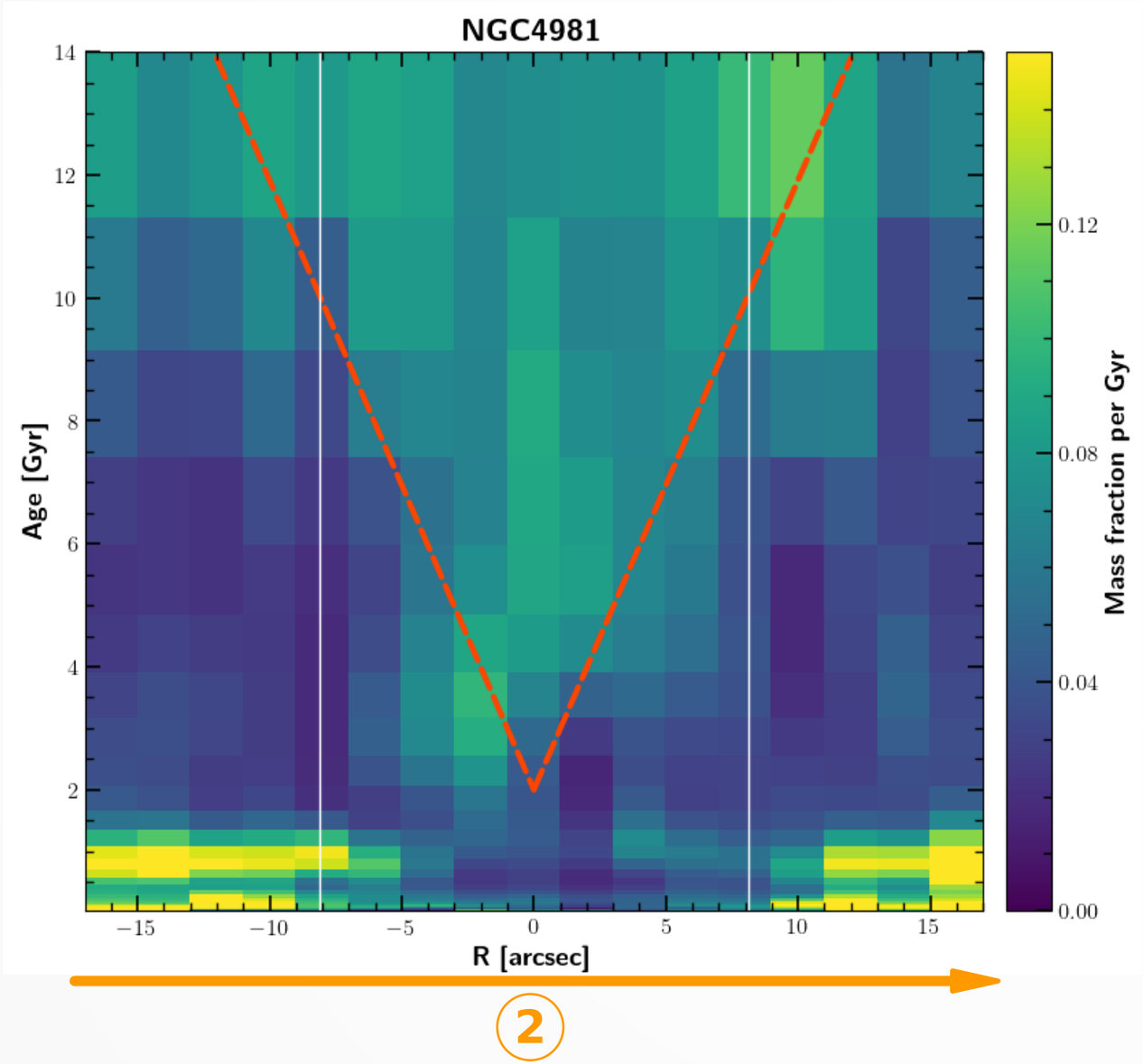
Mean [Mg/Fe]

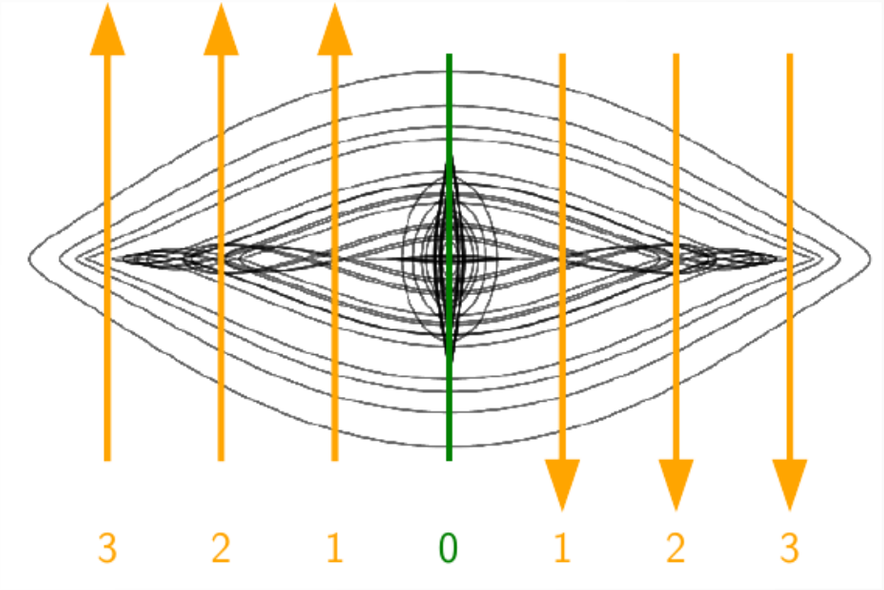
- Stellar populations of bars are **older** than (or as old as) the surroundings.
- Stellar bars are **more metal-rich** than (or as rich as) the surroundings.
- Stellar bars are **less [Mg/Fe]-enhanced** than the surroundings.

Neumann+2020



Separating stellar populations from different orbits in the bar. The case of NGC 4981.

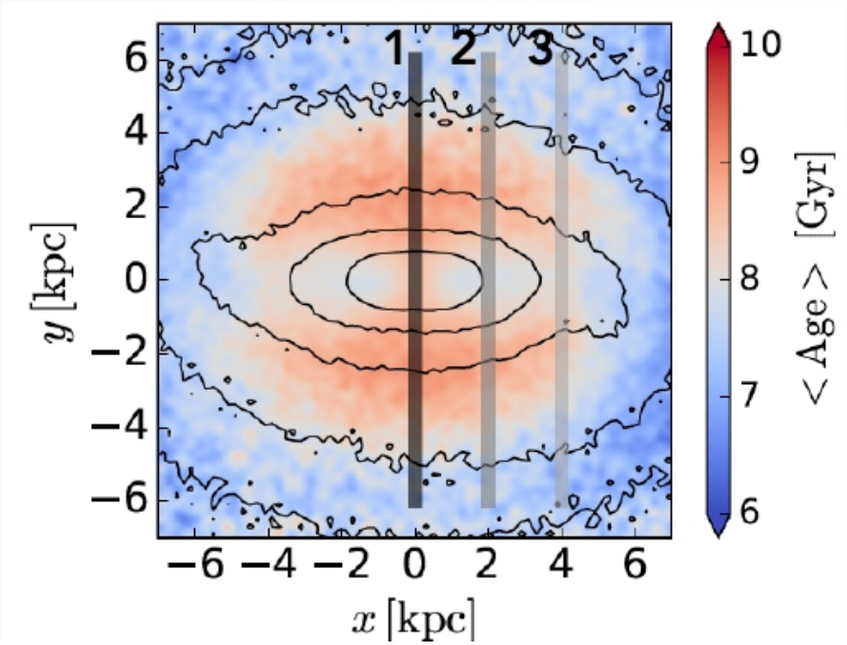


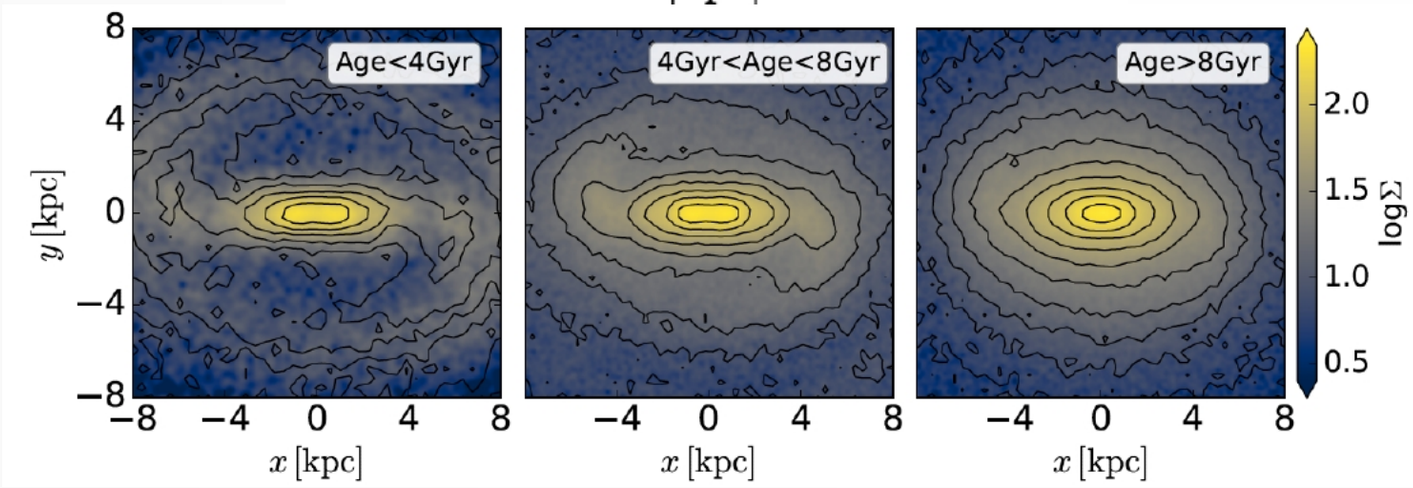


- "V-shape" in the intermediate-to-old populations.
- ➔ **Younger stars are on more elongated orbits closer to the bar major axis.**

Neumann+2020

Comparison to Auriga magneto-hydrodynamical cosmological zoom-in simulations.





- Younger populations are more clustered along the bar major axis than the oldest populations.

  kinematic fractionation

  (Debattista et al., 2017, see also Athanassoula et al. 2017, Fragkoudi et al. 2017).

First time this is seen in cosmological simulations and in observations!

Neumann+2020

Summary

Drivers of Stellar Metallicity in MaNGA Galaxies

- Stellar metallicity is driven locally by surface mass density;
  modulated by total stellar mass, morphology and radius.
- **At fixed suface mass density, metallicity is constant or increasing with radius!**
- Early-type galaxies have higher metallicities than late-types.
- Metallicty gradients are negative at high to intermediate masses and positive at low masses (in particulate LTGs).

Stellar Populations in Bars:

- MUSE observations and Auriga simulations indicate:
  - **younger stars** are trapped on more elongated orbits forming a **thinner** component of the **bar**
  - **older stars** form a **thicker** and rounder component of the **bar**.
- Bars are older, more metal-rich, less [Mg/Fe]-enhanced than the surrounding disc.