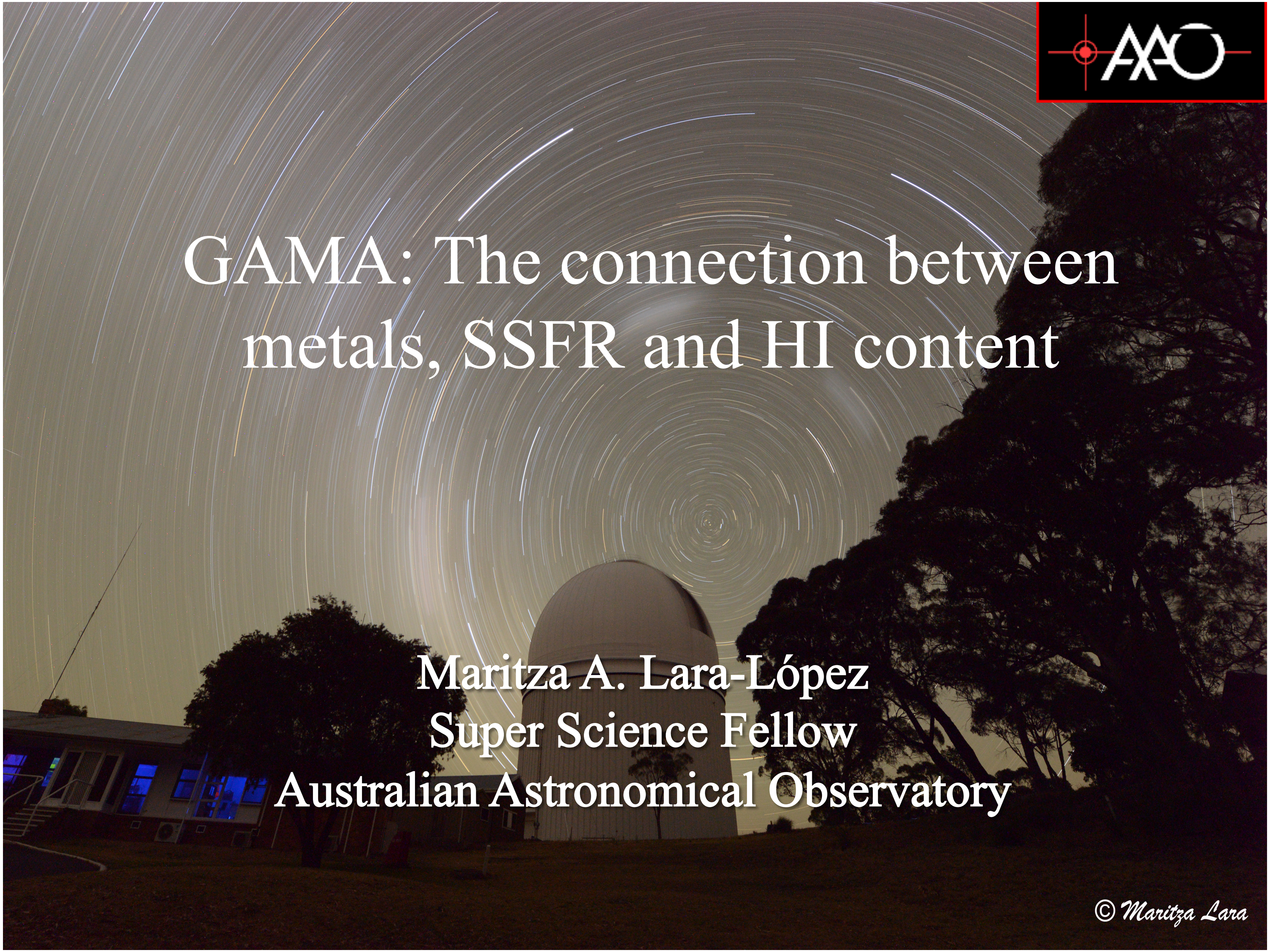
GAMA: The connection between metals, SSFR and HI content

Maritza A. Lara-López
Super Science Fellow
Australian Astronomical Observatory



METALLICITY

specific-SFR (SSFR)

HI content

- GAMA : The connection between metals, specific-SFR, and HI gas in galaxies

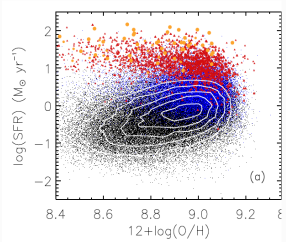
Lara-López & the GAMA team (2013c, MNRAS, 433, 35

Oxygen Yields in 3D

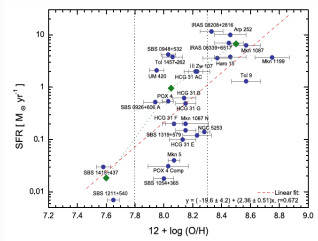
- Oxygen yields to study the impact of inflows and outflows in galaxies

Lara-López et al. in preparation

A fundamental plane for field galaxies



Lara-López et al. (2010)

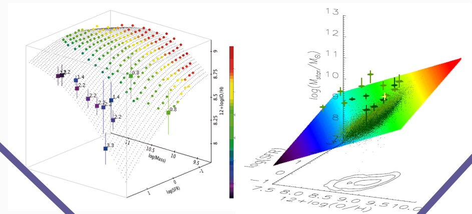


López-Sánchez (2010)

Z-SFR

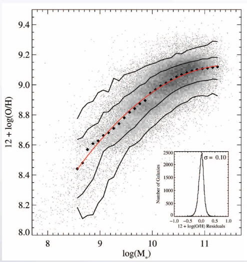
Gas Metallicity

SFR



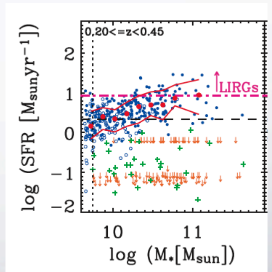
M-Z

M-SFR



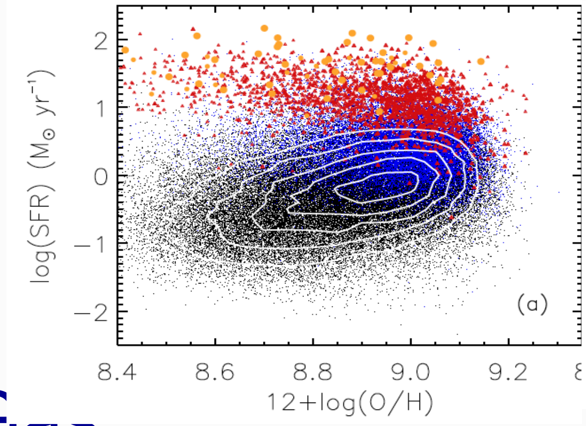
Tremonti et al. (2004)

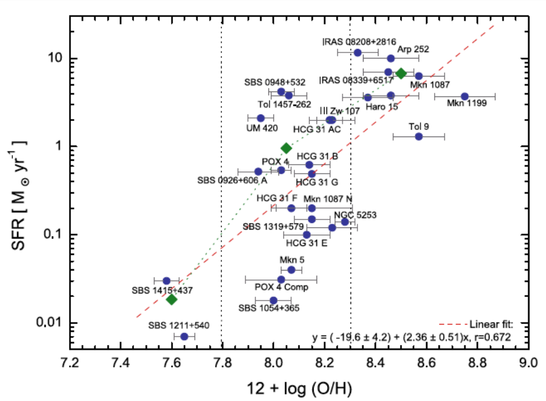
Stellar Mass



Noeske et al. (2007)

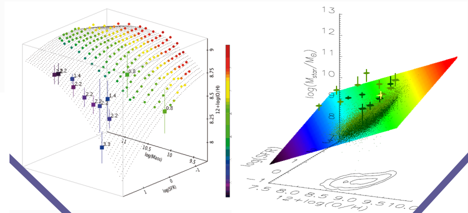
A fundamental plane for field galaxies

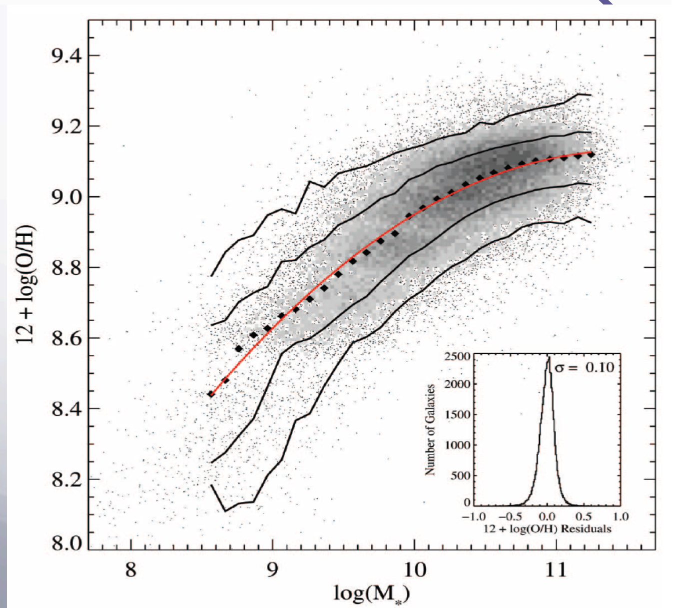




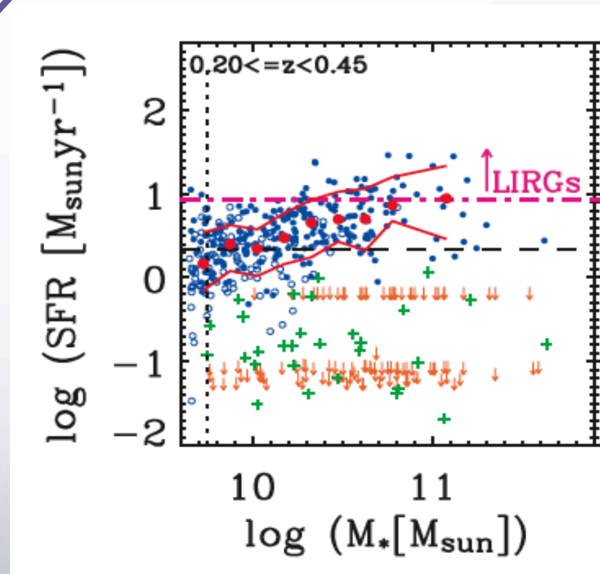
Gas Metallicity

SFR

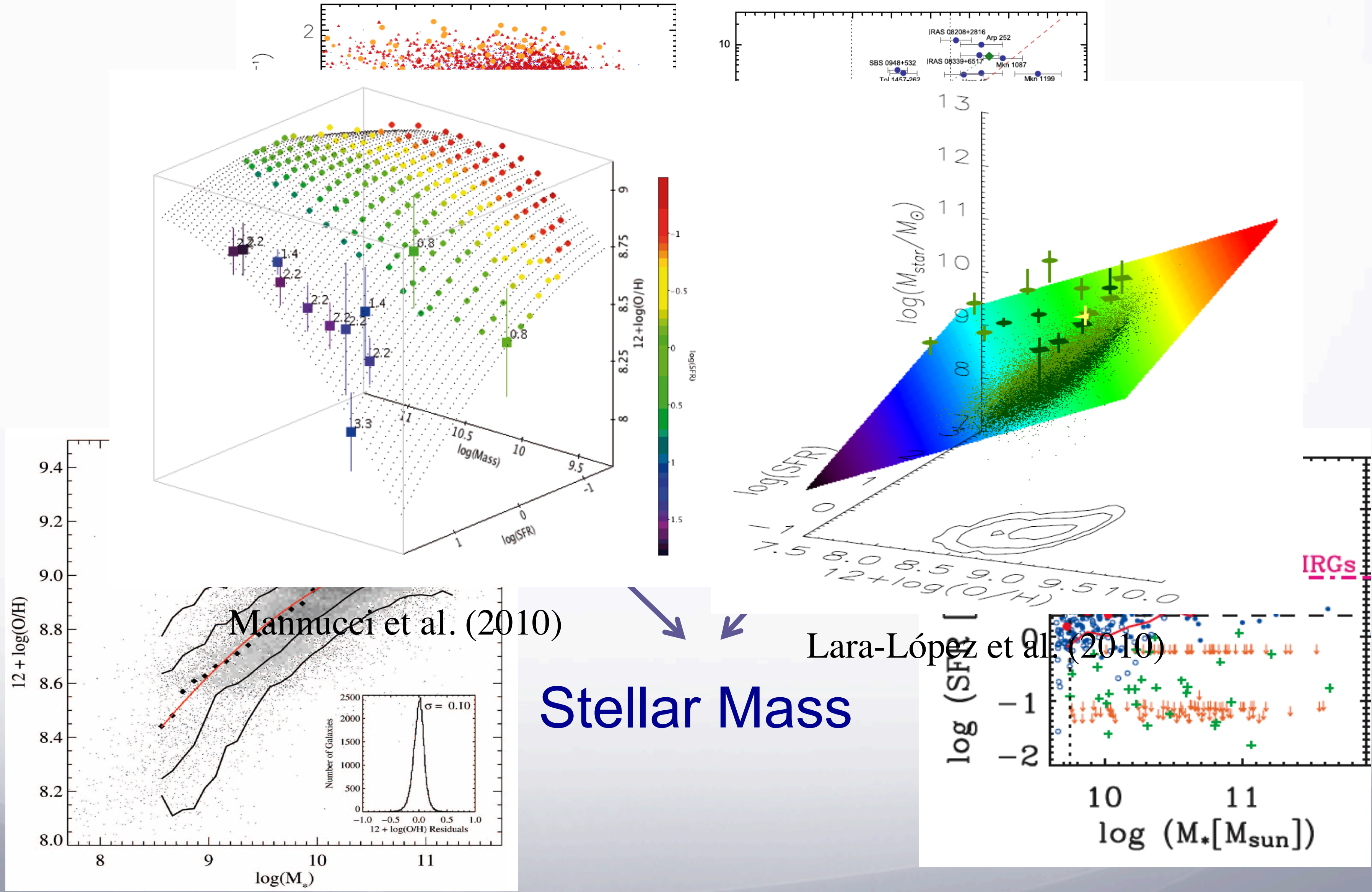




Stellar Mass



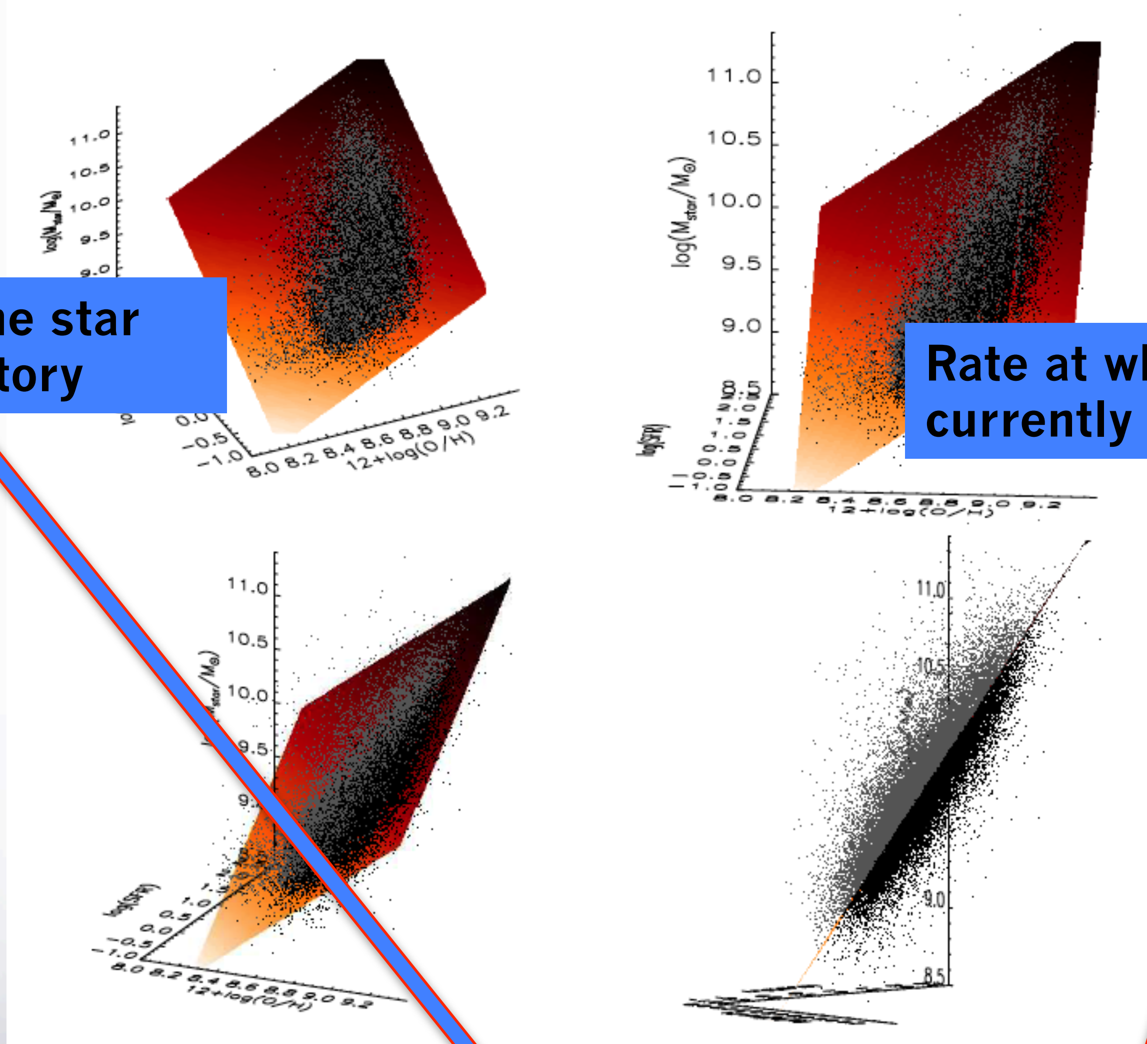
A fundamental plane for field galaxies



A FP for GAMA and SDSS

Measure of the star formation history

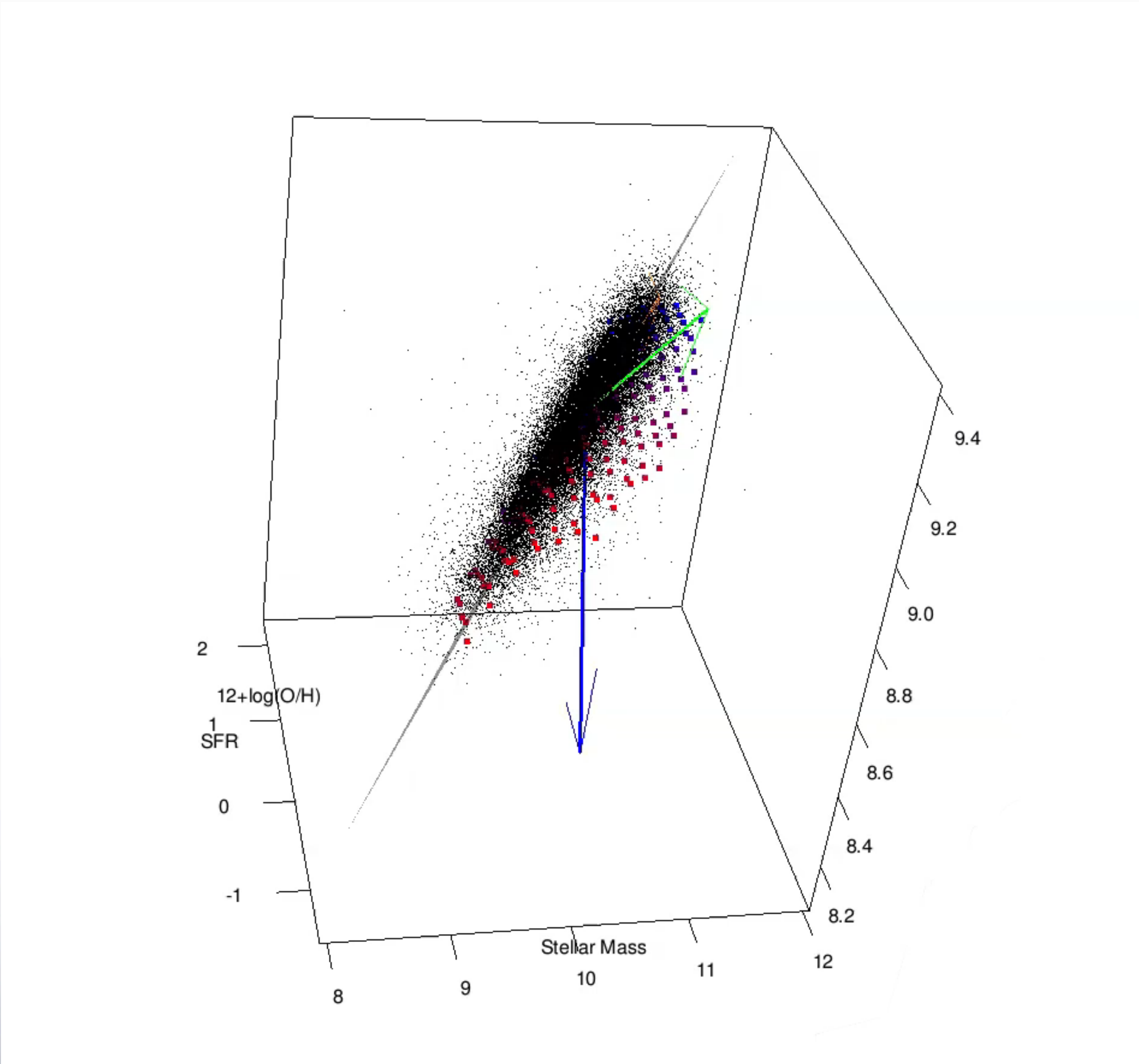
Rate at which a galaxy is currently forming stars



$$\log(M_{\star}/M_{\odot}) = \alpha\ [12 + \log(\mathrm{O/H})] + \beta\ [\log(\mathrm{SFR})]\ + \gamma,$$

Lara-López et al. 2013a, MNRAS, 434, 451

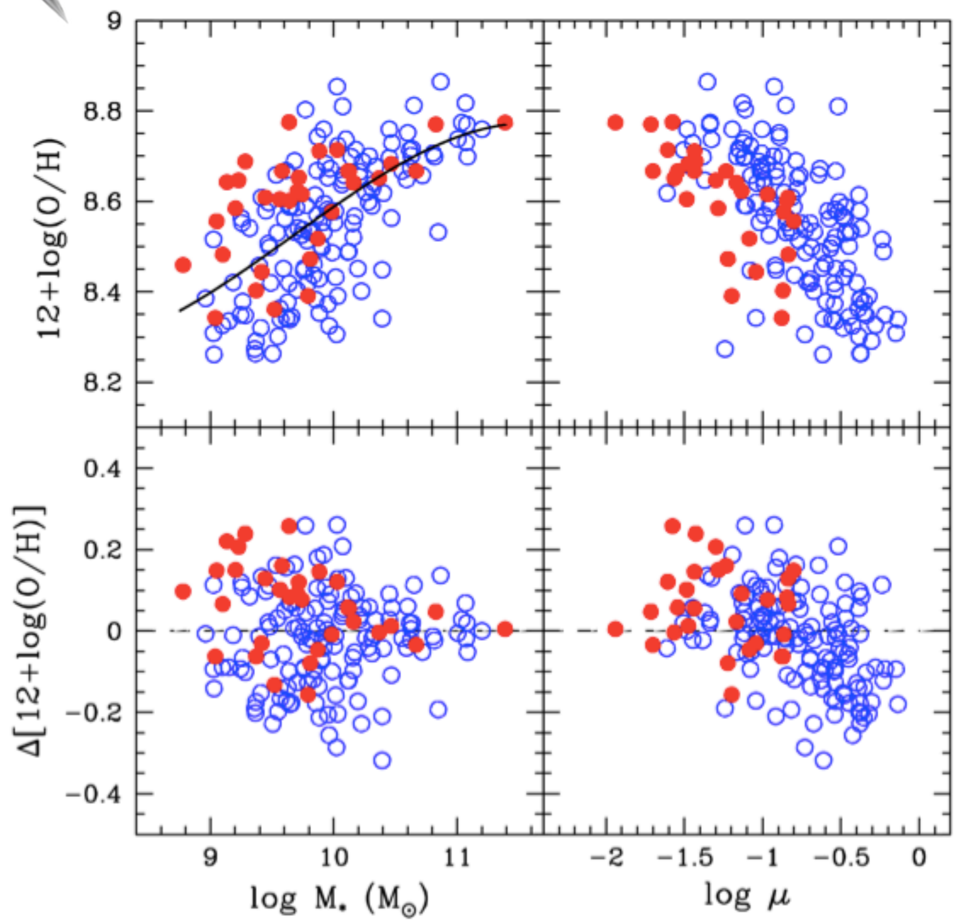
On the 3D structure of the FP



Lara-López, López-Sánchez & Hopkins (2013b, ApJ , 764, 178)

& HI content

Hughes et al. (2013) investigate the relationship between stellar mass, metallicity and gas content for a sample of 260 nearby late-type galaxies in different environments, from isolated galaxies to Virgo cluster members



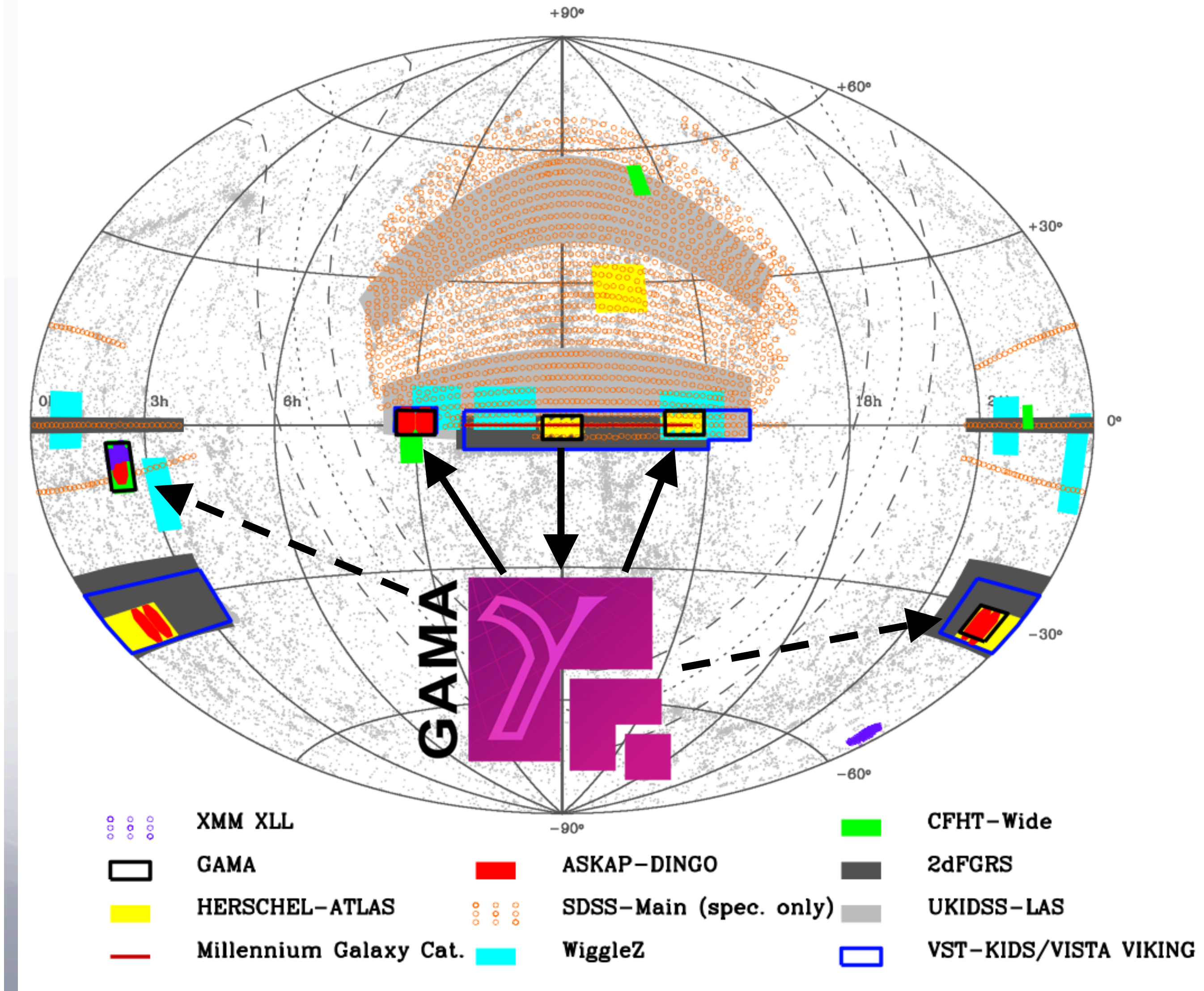
At fixed stellar mass, galaxies with lower gas fractions typically also possess higher oxygen abundances

The M-Z relation is nearly invariant to the environment

$$\mu = \frac{M_{gas}}{M_* + M_{gas}}$$

Hughes et al. (2013)

GAMA Regions

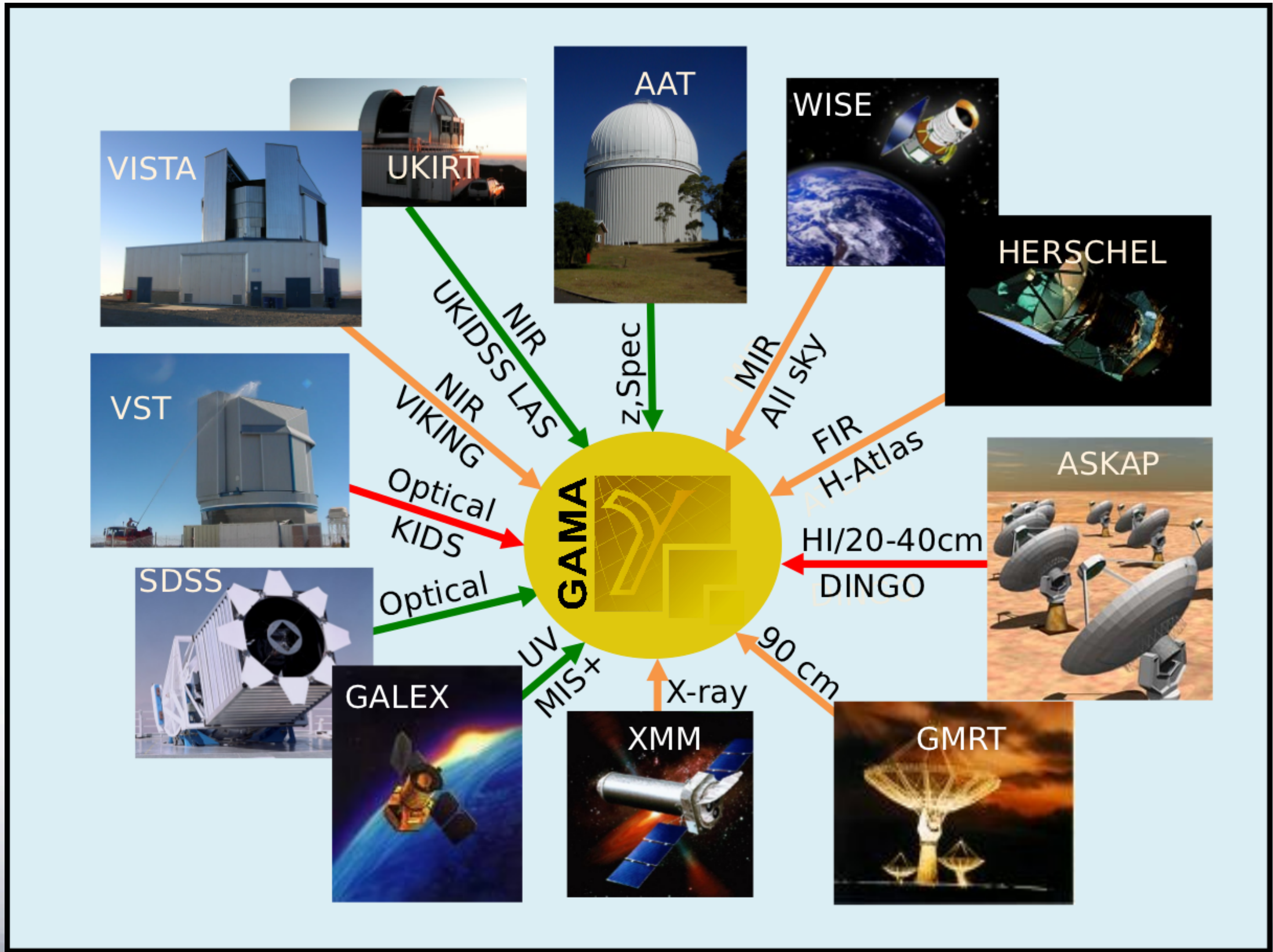


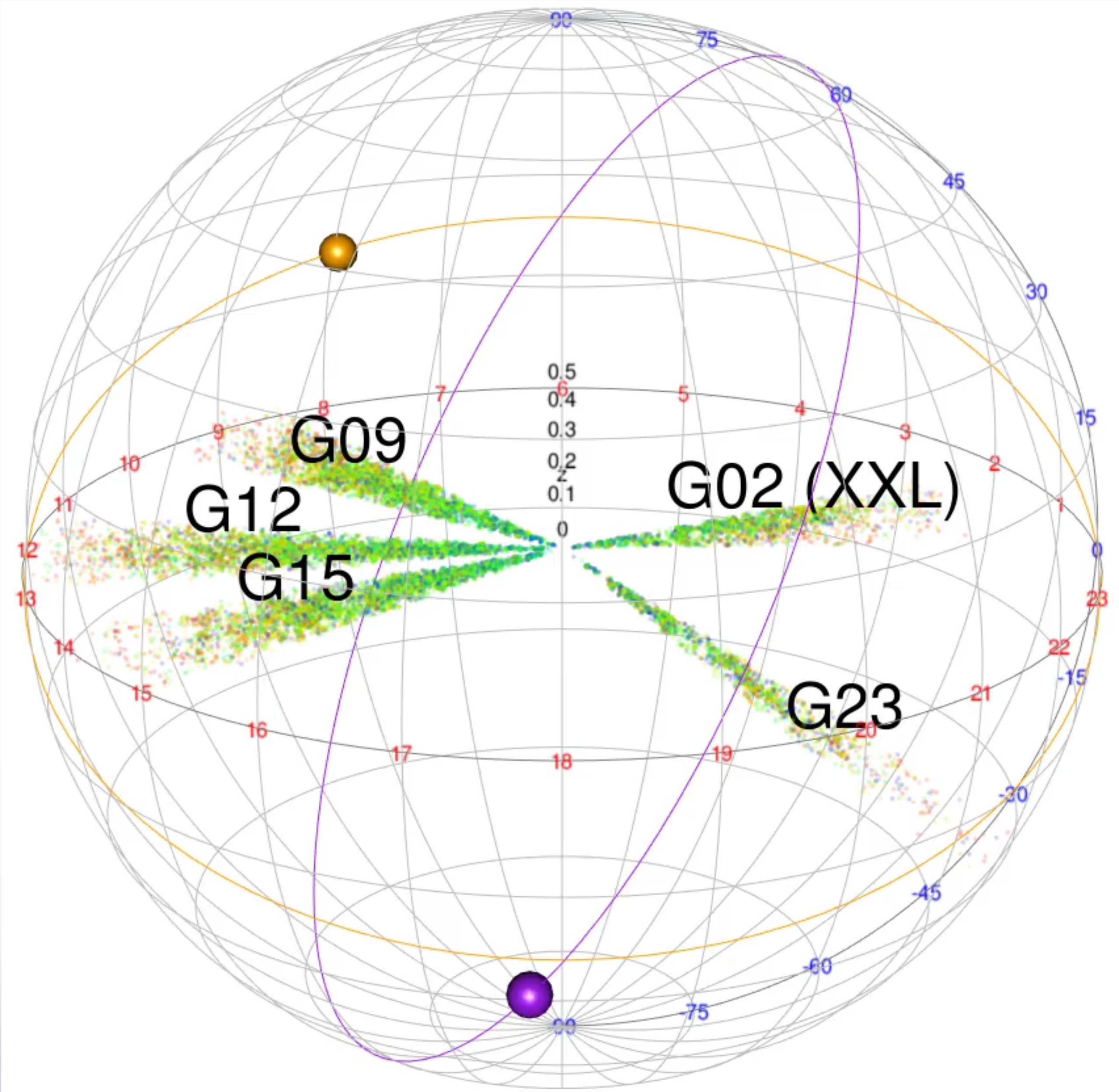
- ~340,000 gals
- r < 19.8 mag
- ~310 deg²
- 27 passbands

galaxy…

- clusters
- groups
- mergers
- structure

Galaxy and Mass Assembly





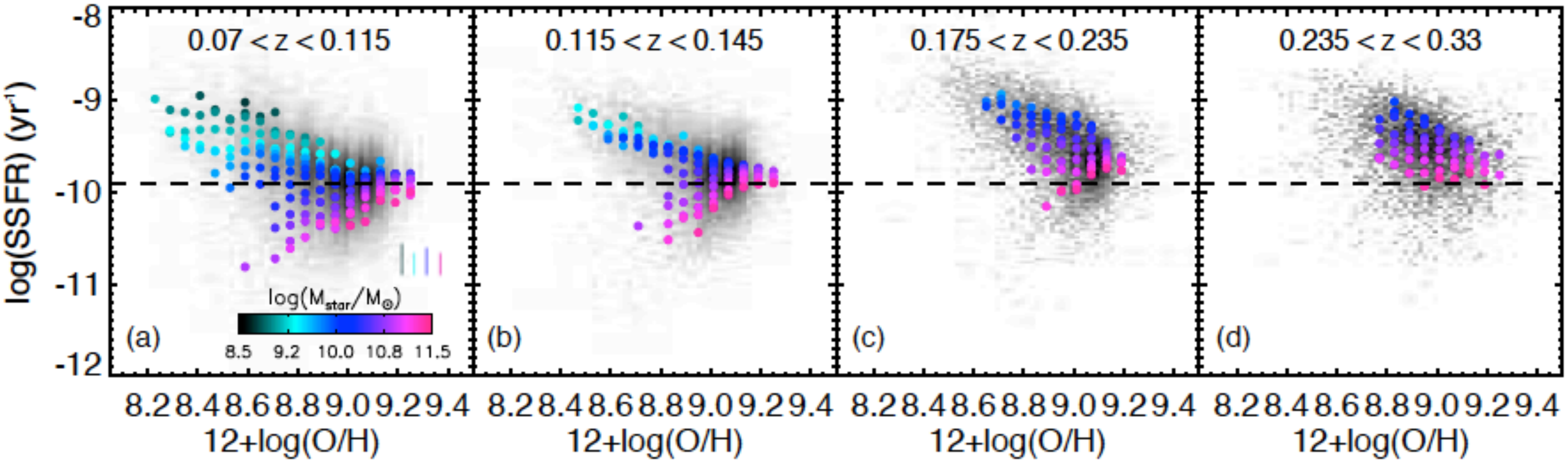
Movie credit: Aaron Robotham

The Sloan Digital Sky Survey
(SDSS)
2.5m telescope

Galaxy and Mass Assembly
(GAMA)

3.9m telescope (AAT)

The Z-SSFR relation



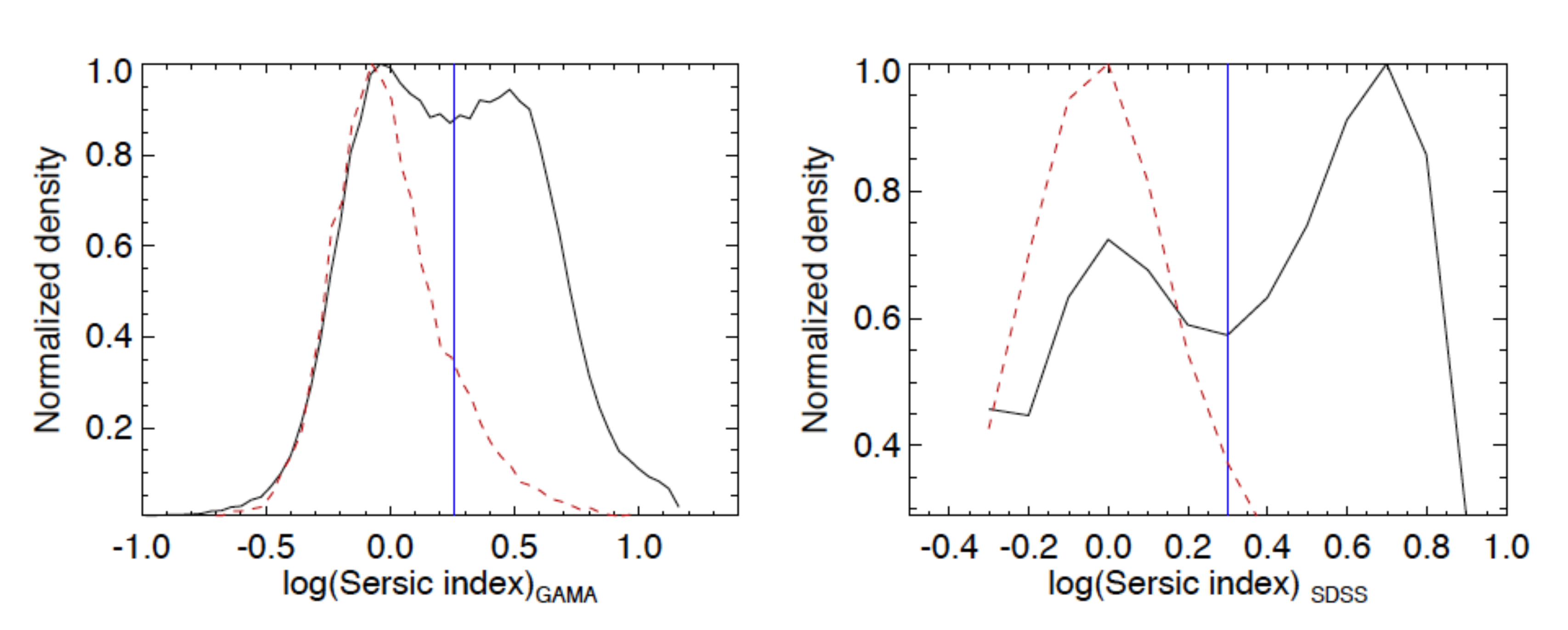
Morphology?

Lara-López et al. 2013c, MNRAS, 433, 35

It is not morphology

GAMA

SDSS

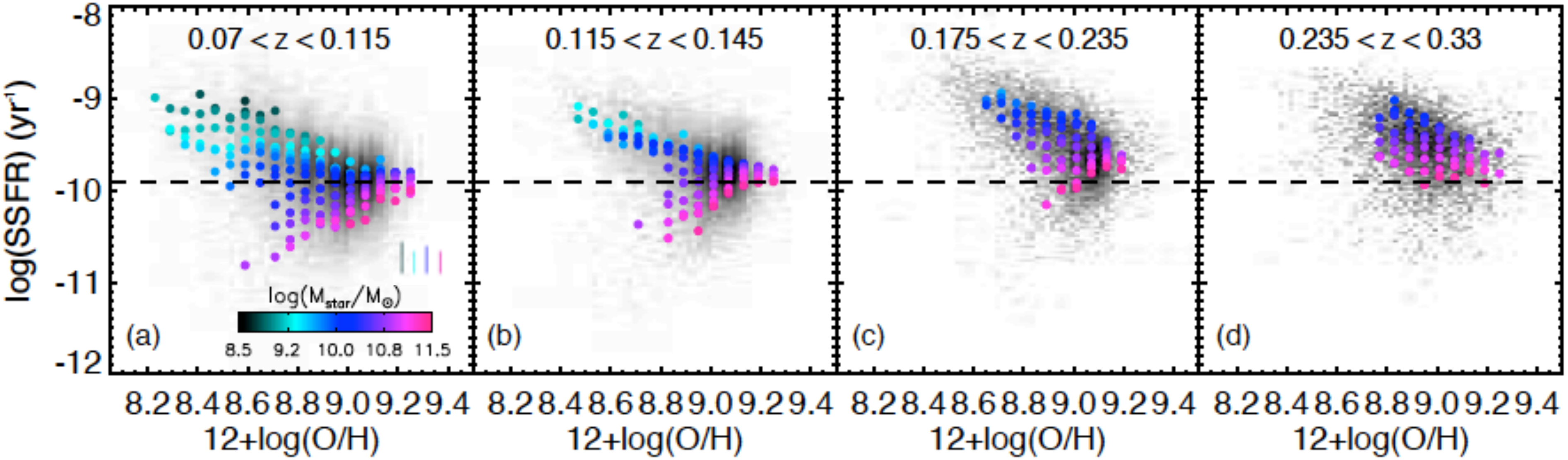


Kelvin et al. (2012)

Simard et al. (2011)

Lara-López et al. 2013c, MNRAS, 433, 35

The Z-SSFR relation



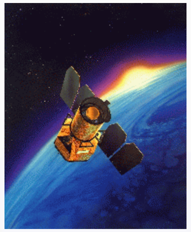
Morphology?

HI content?

Lara-López et al. 2013c, MNRAS, 433, 35

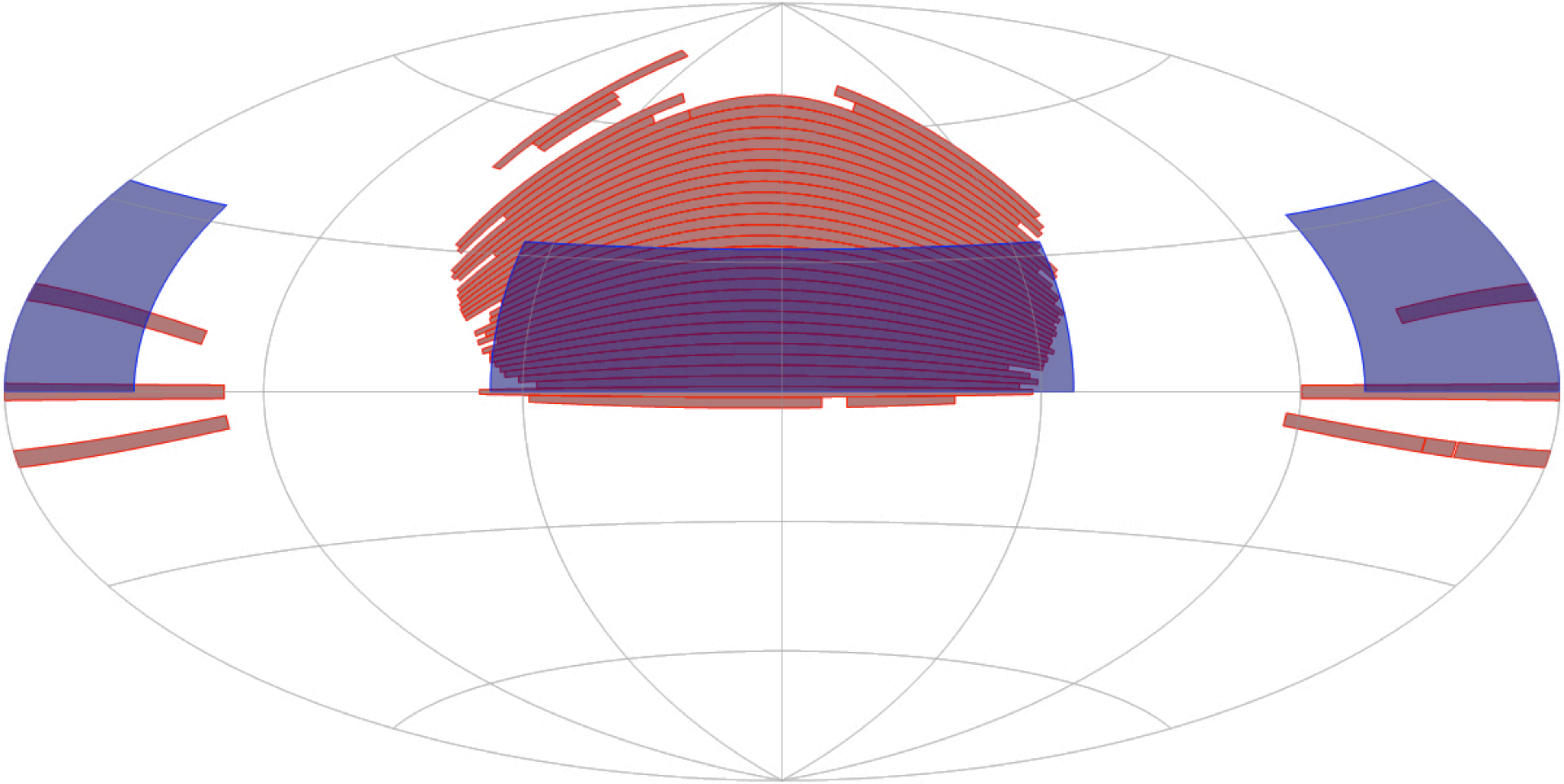
The Arecibo Legacy Fast ALFA (ALFALFA) survey is an on-going blind extragalactic HI survey of the local HI universe over a cosmologically significant volume

GASS

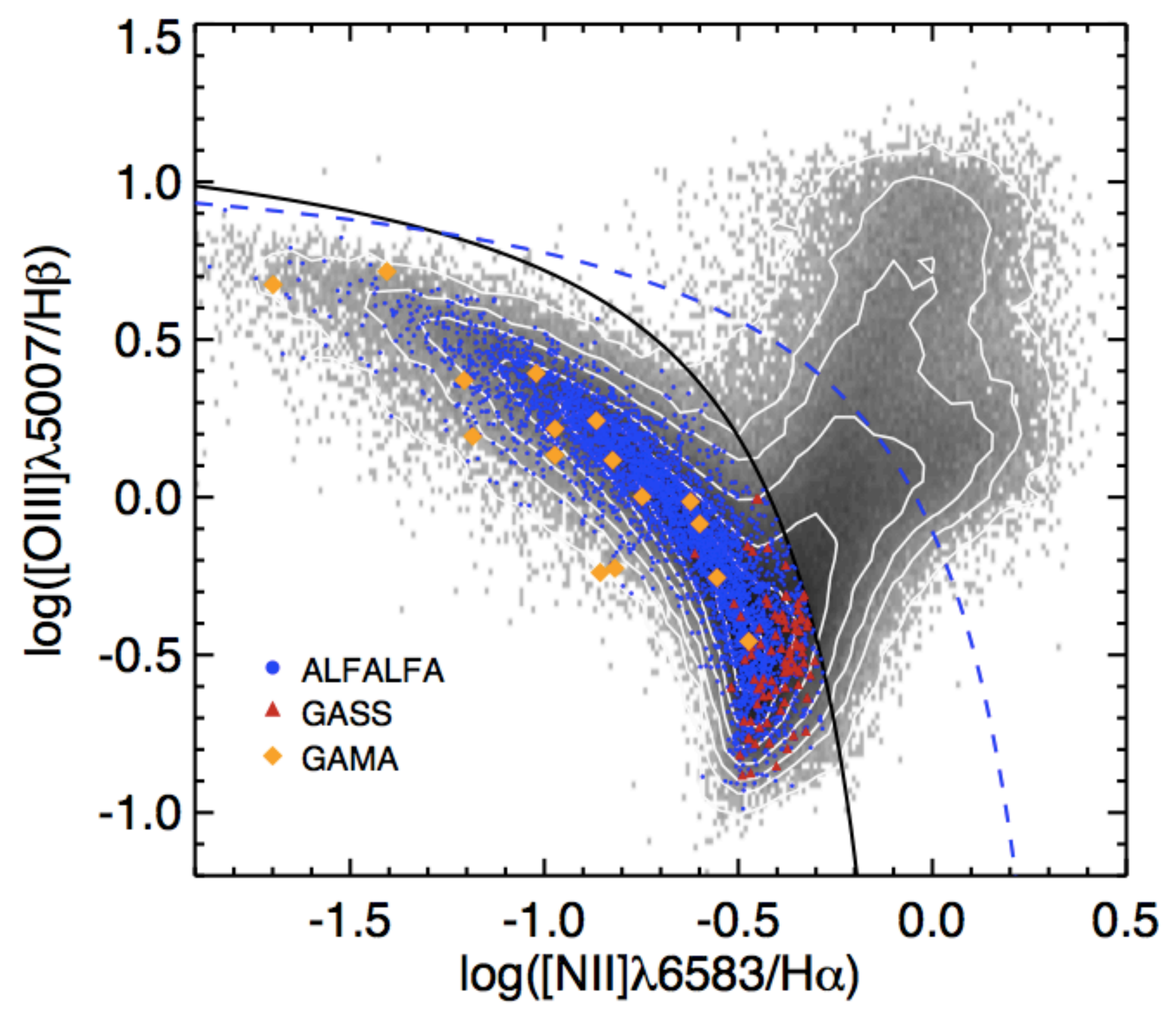


The GALEX Arecibo SDSS Survey (GASS) is an ongoing large targeted survey at Arecibo. GASS is designed to measure the neutral hydrogen content of a representative sample of ~1000 massive, galaxies, uniformly selected from the SDSS spectroscopic and GALEX imaging surveys.

SDSS + ALFALFA

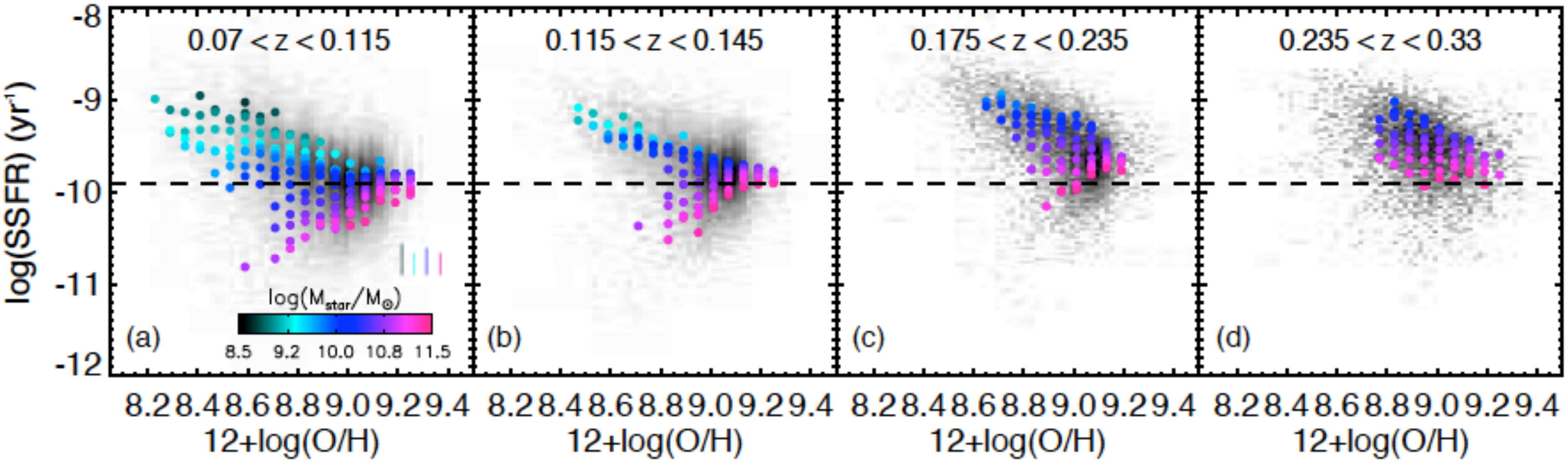


~4400 ALFALFA counterparts!, $0.025 < z < 0.05$, $10^7 < M_* < 10^{11} M_{sun}$
48 GASS counterparts



Lara-López et al., in preparation

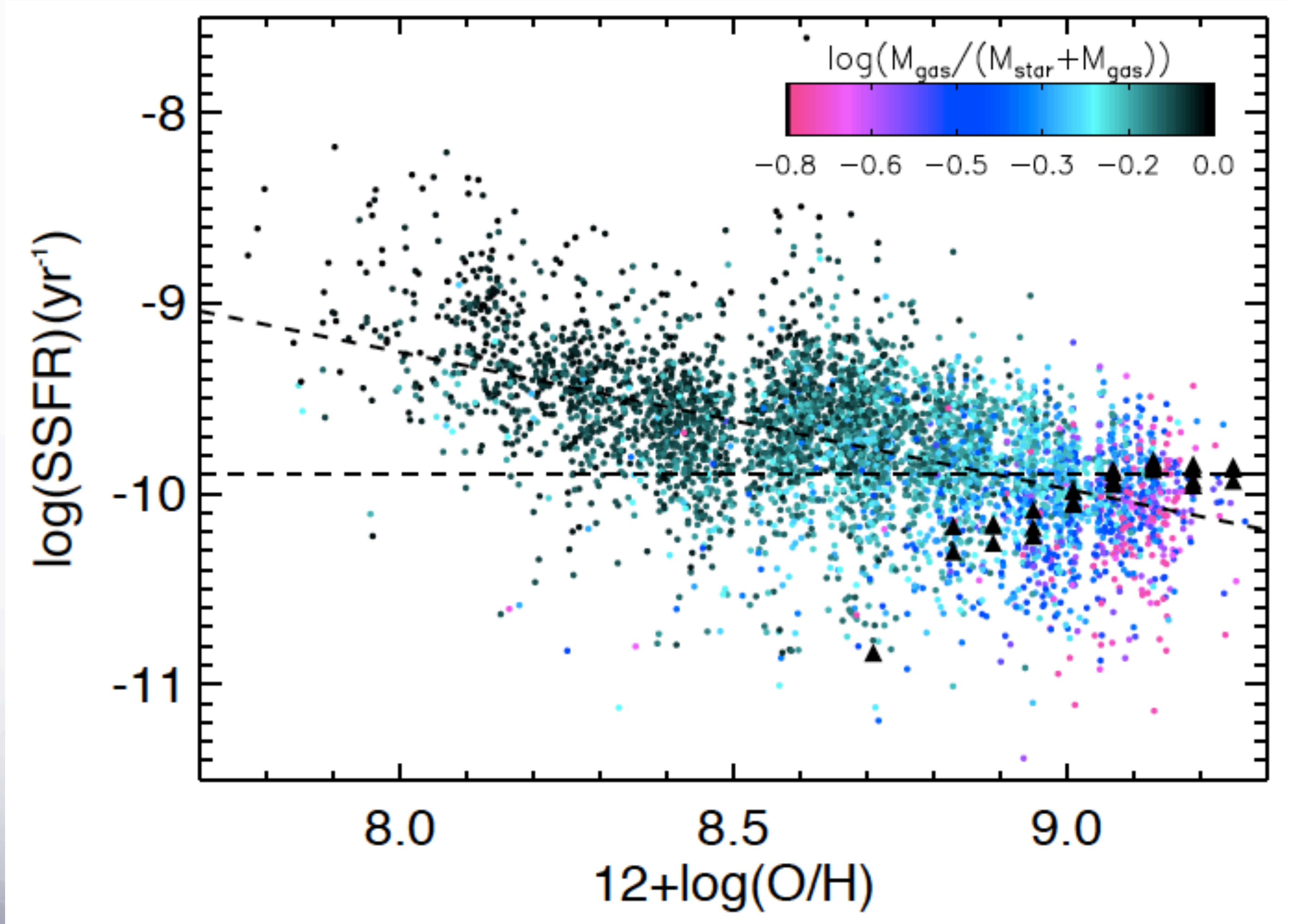
The Z-SSFR relation

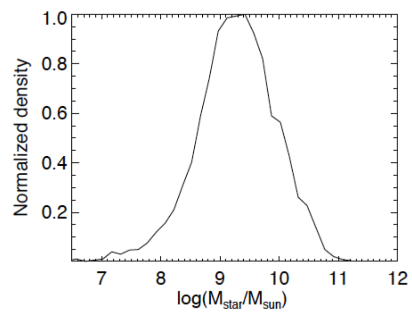


HI content!

Lara-López et al. 2013c, MNRAS, 433, 35

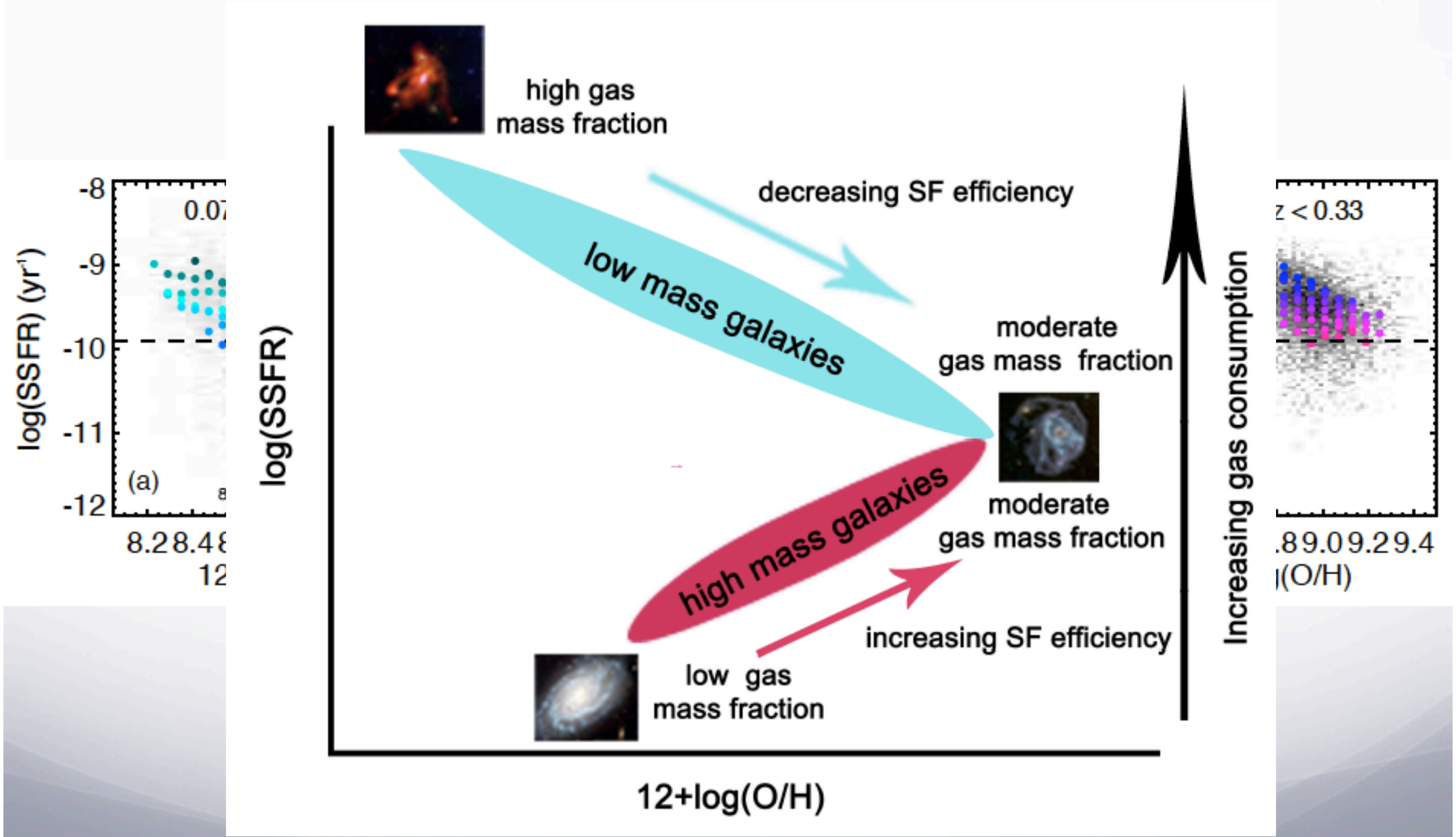
The Z-SSFR relation as a function of gas fraction





Lara-López et al. 2013c, MNRAS, 433, 35

The Z-SSFR relation

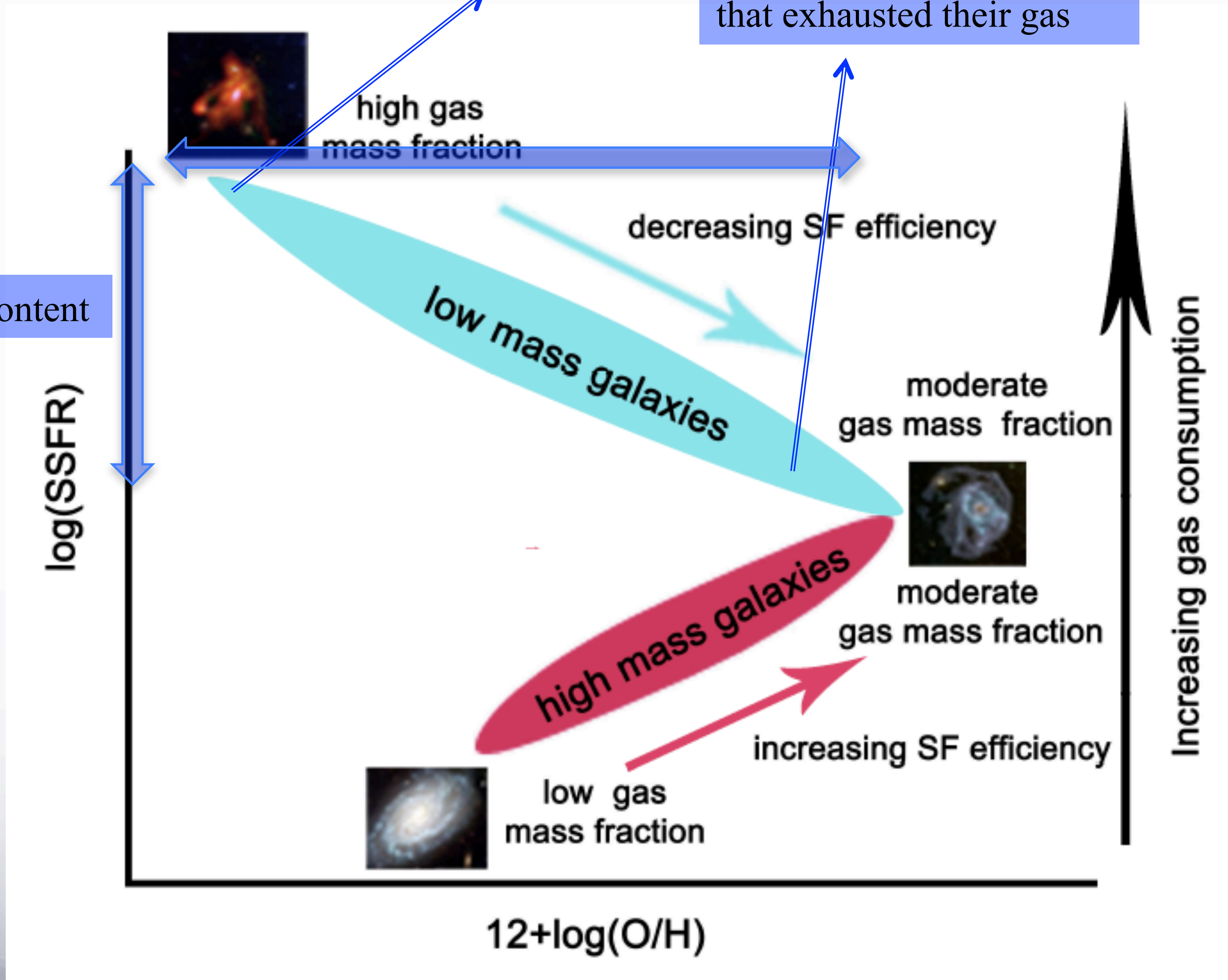


Lara-López et al. 2013c, MNRAS, 433, 35

Process their gas on longer timescales

More bursty SF in the past that exhausted their gas

HI content



Lara-López et al. 2013c, MNRAS, 433, 35

Yields & Close box model

$Z_{gas} = y_{true} \ln(1/f_{gas}),$ Where: $f_{gas} \, [\equiv M_{gas}/(M_{gas} + M_{stars})]$

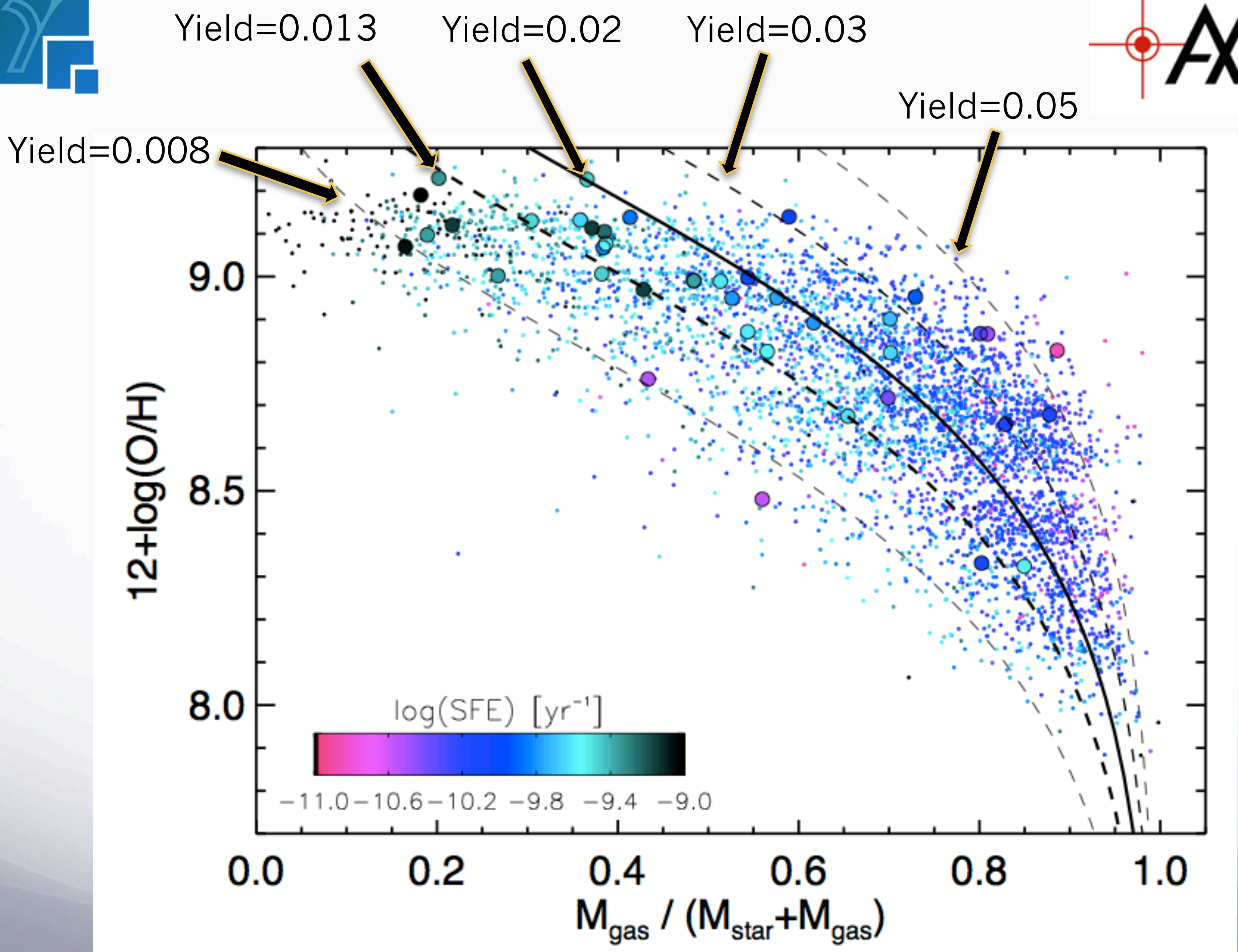
where y_{true} is the true nucleosynthetic yield, defined as the mass in primary elements freshly produced by massive stars.

$$y_{eff} \equiv \frac{Z_{gas}}{\ln(1/f_{gas})},$$

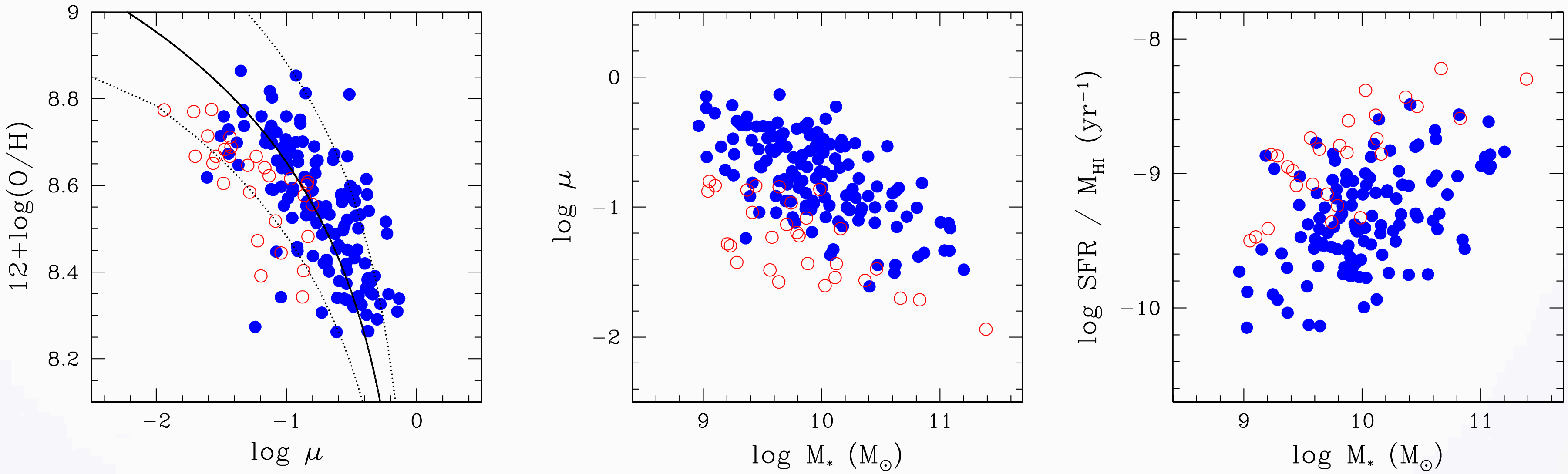
"Effective yield", which will be constant for any galaxy that has evolved as a closed box (y_{eff}=y_{true})

Close box ➔ No inflow or ouflow of gas

The effective yield is therefore an observationally determined quantity that can be used to diagnose departures from closed-box evolution.

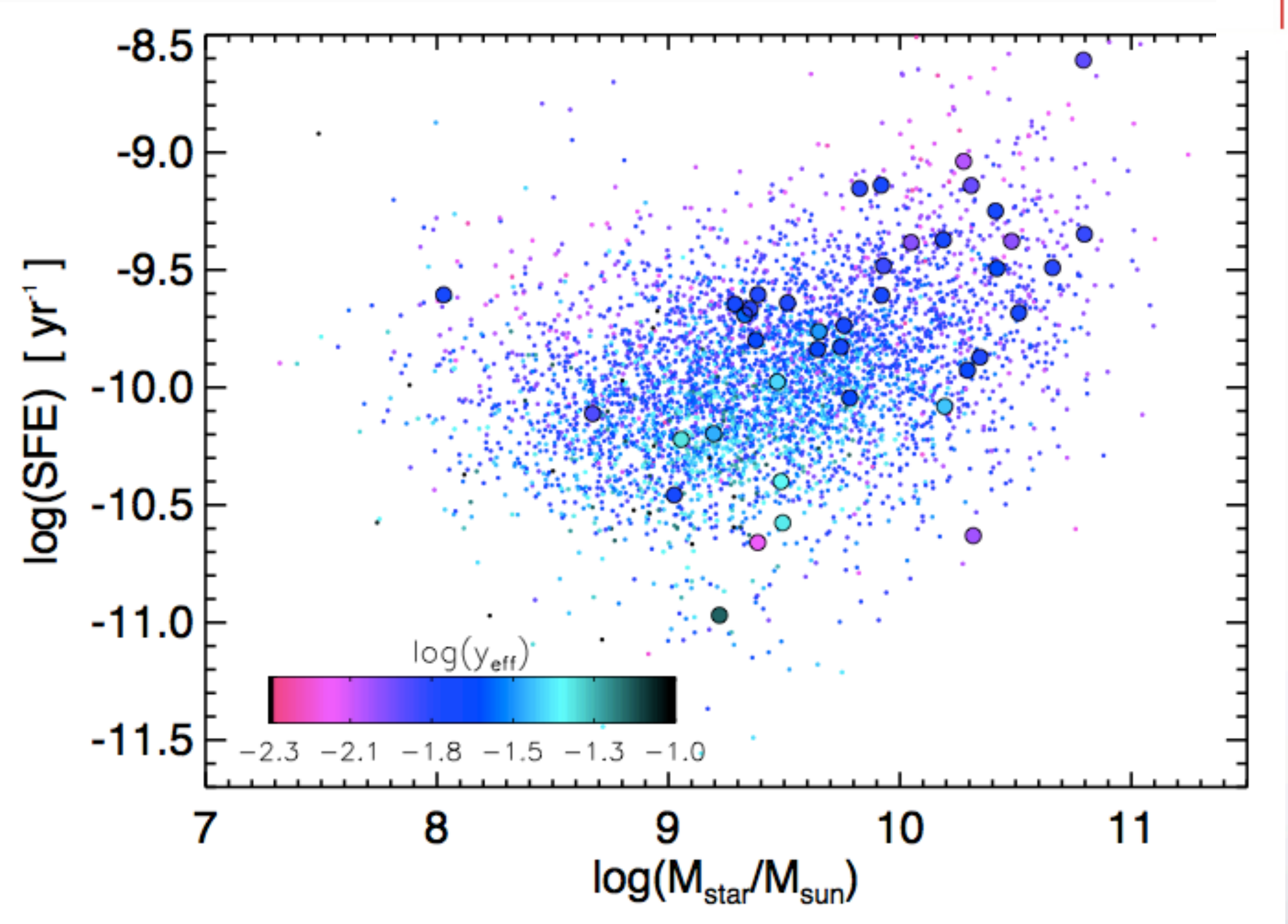


Lara-López et al., in preparation



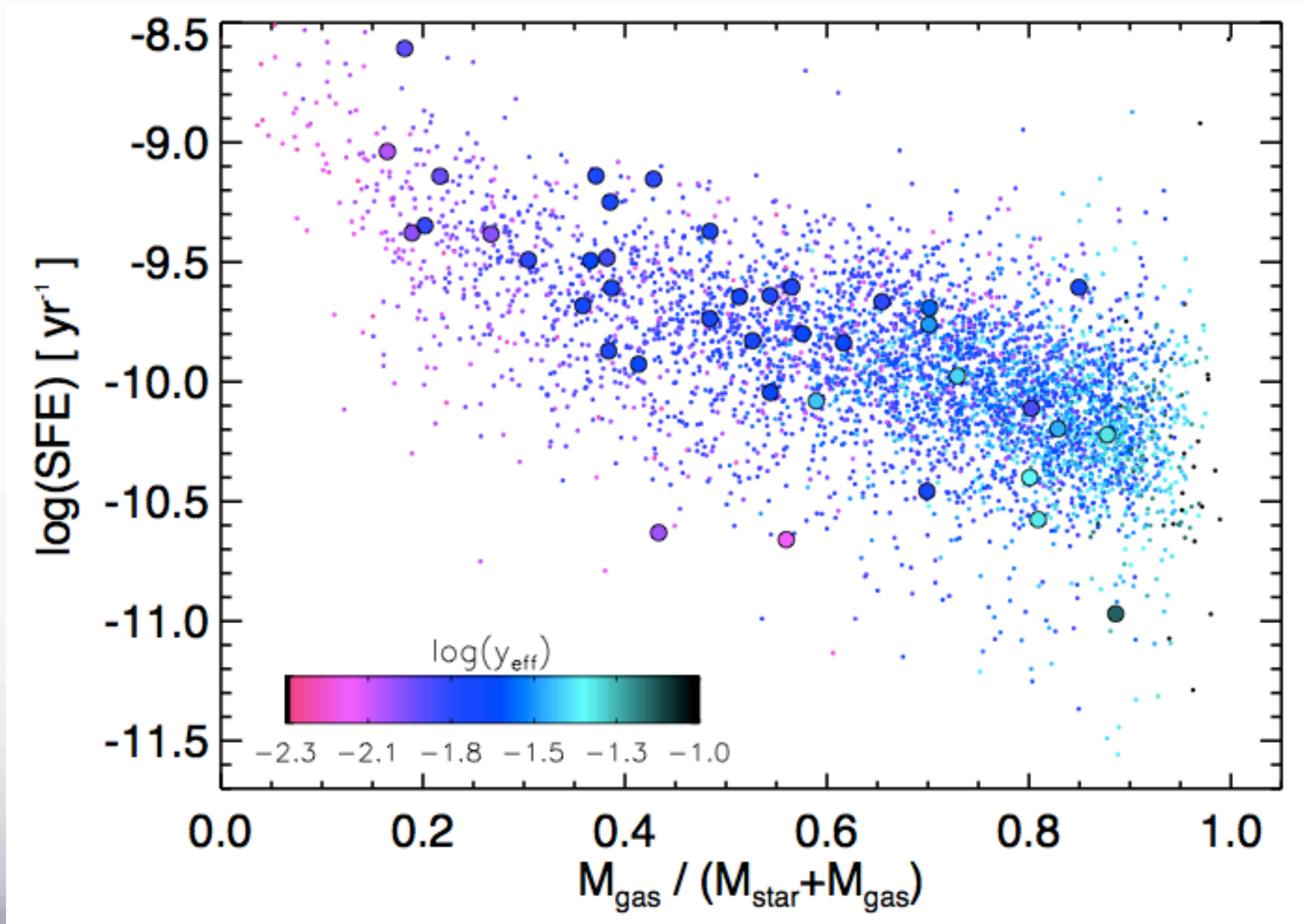
Hughes et al (2013)

The mass exchange between a galaxy and its environment can alter the relation between oxygen abundance and gas mass fraction



SFE=SFR/M_{HI}

Lara-López et al., in preparation

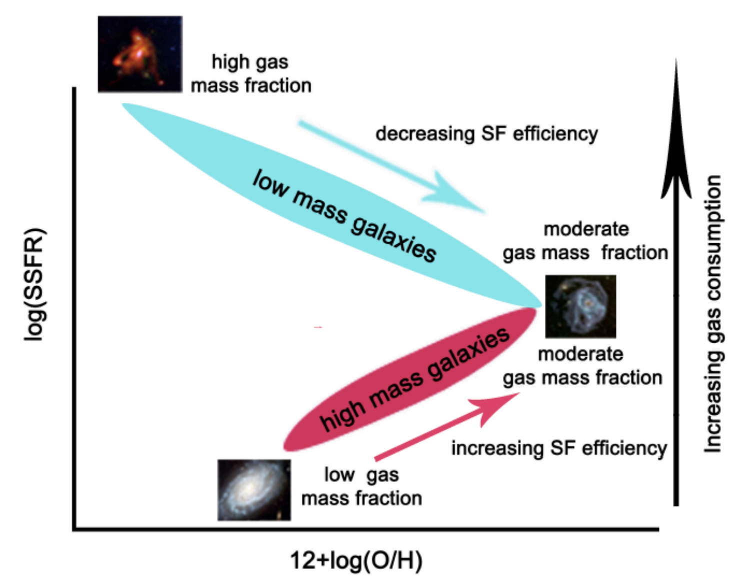


Lara-López et al., in preparation

Summary

- Different star formation efficiencies between high and low mass systems.

Higher mass systems are able to convert their gas into stars more efficiently, producing a lower gas content and higher metal content with respect to lower mass galaxies.



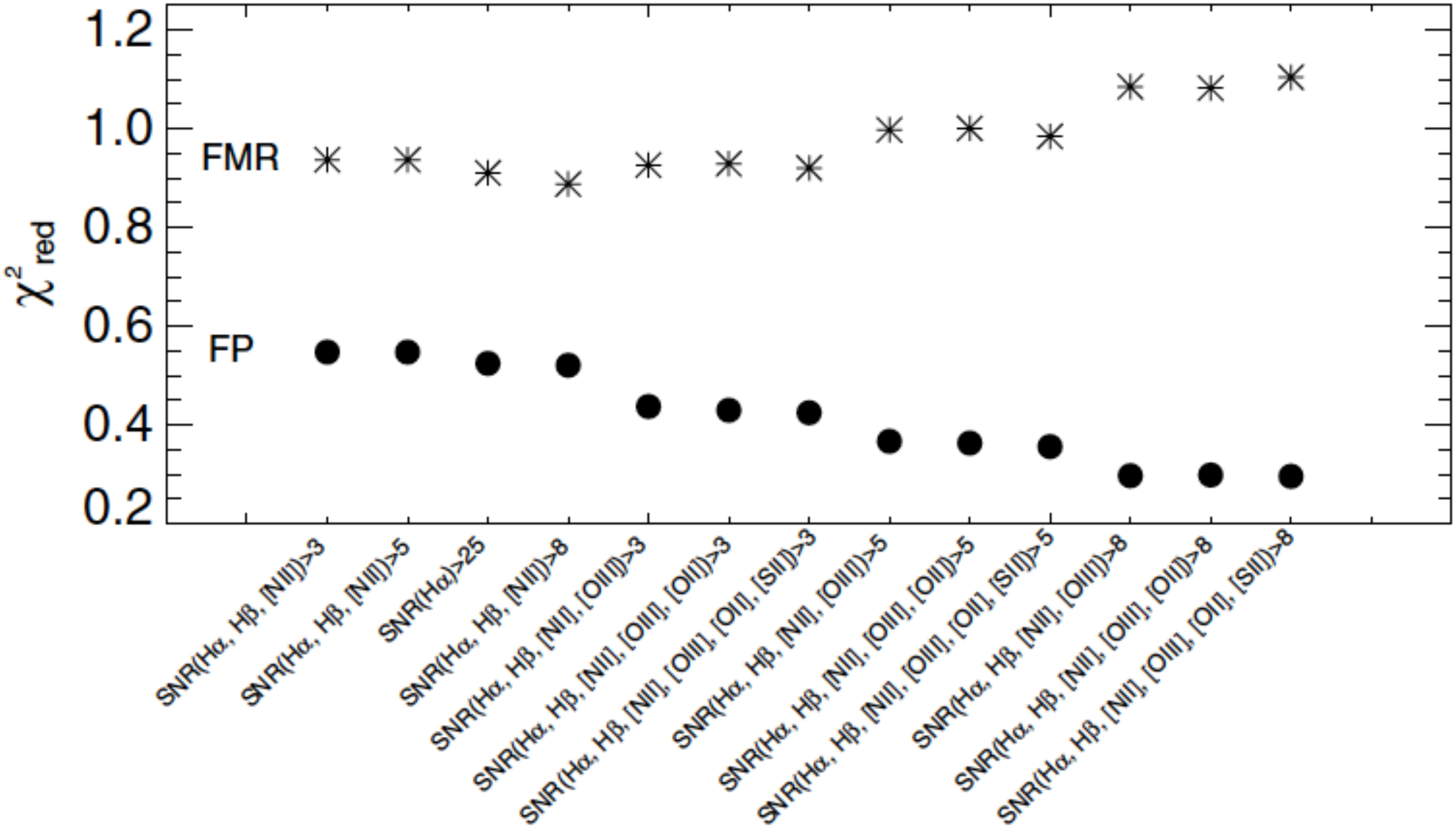
- Constant infall of gas that would have a stronger effect on low mass galaxies

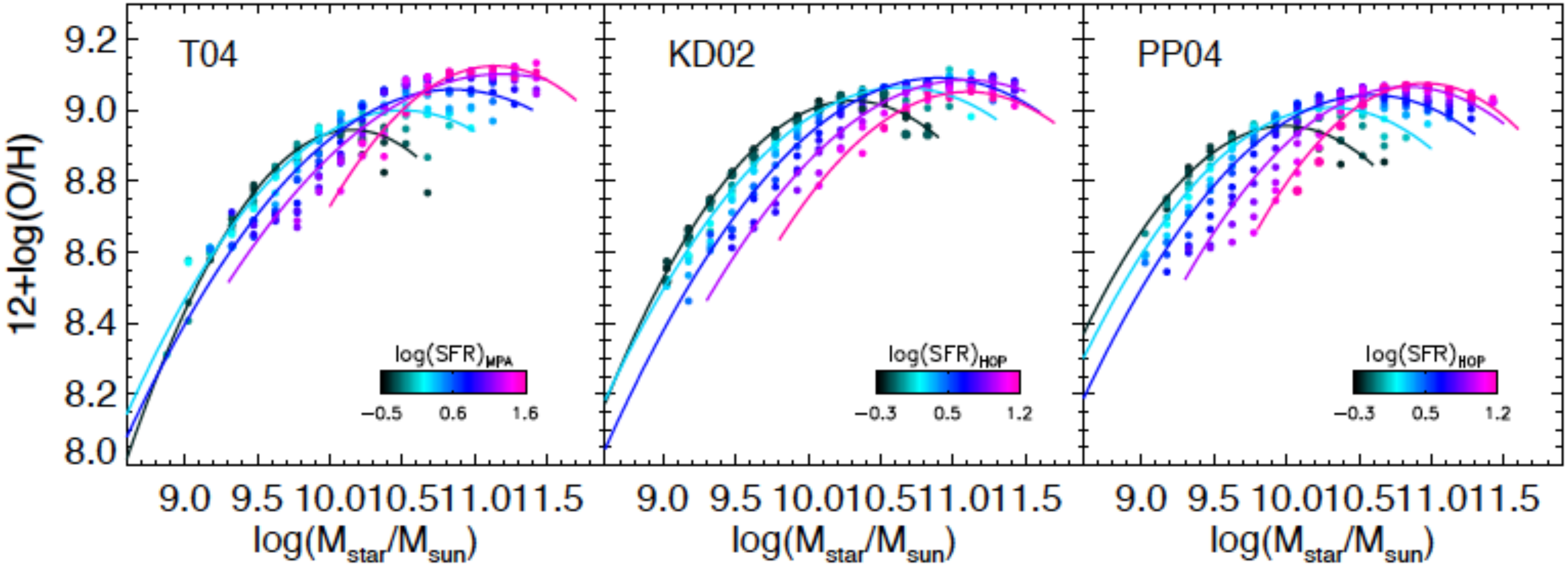
- AGN feedback could be implicated in shutting down the SFR in massive galaxies. It is likely that the effectiveness of this process varies from one massive galaxy to another, probably depending on the history of its AGN activity.

- Inflows and outflows are responsible for the scatter in our relationships
- Stay tuned for yields in 3D!

Thank you!

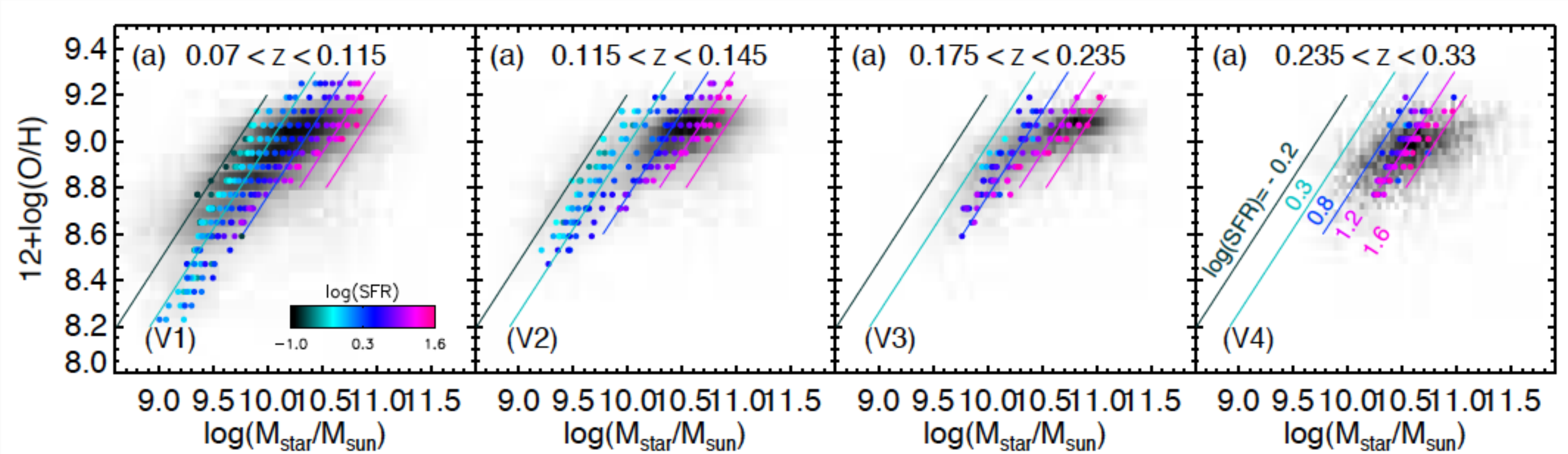
A 3D analysis of the $M_\star$, Z, & SFR space



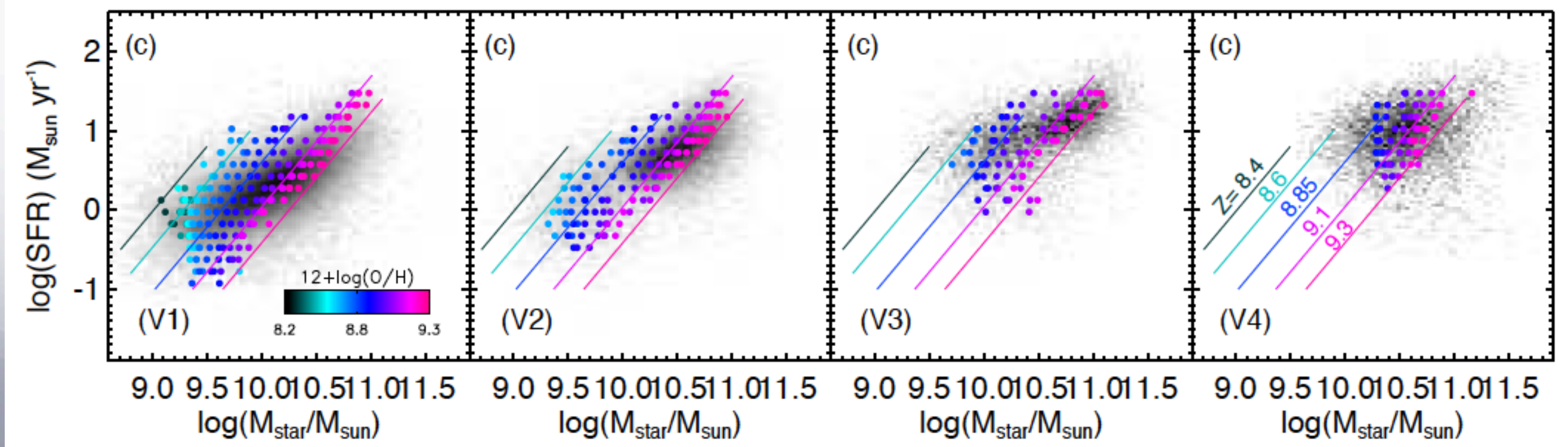


Lara-López et al. (2012, in progress)

Projections of the FP



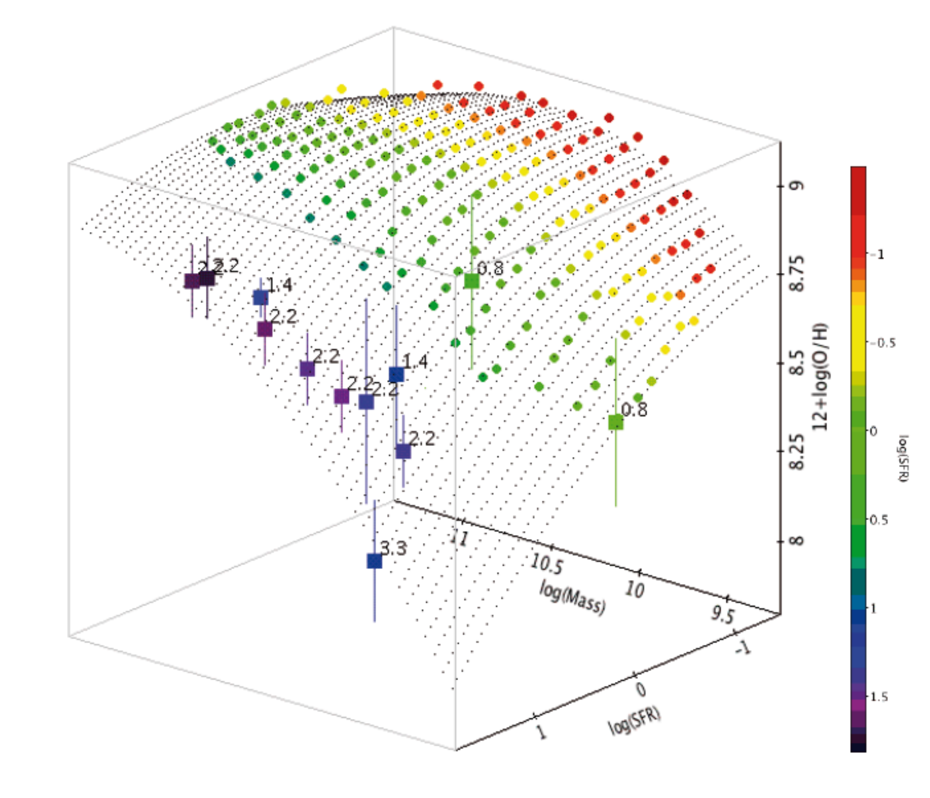
$$\log(M_\star/M_\odot) = \alpha\,[12 + \log(O/H)] + \beta\,[\log(SFR)] + \gamma,$$

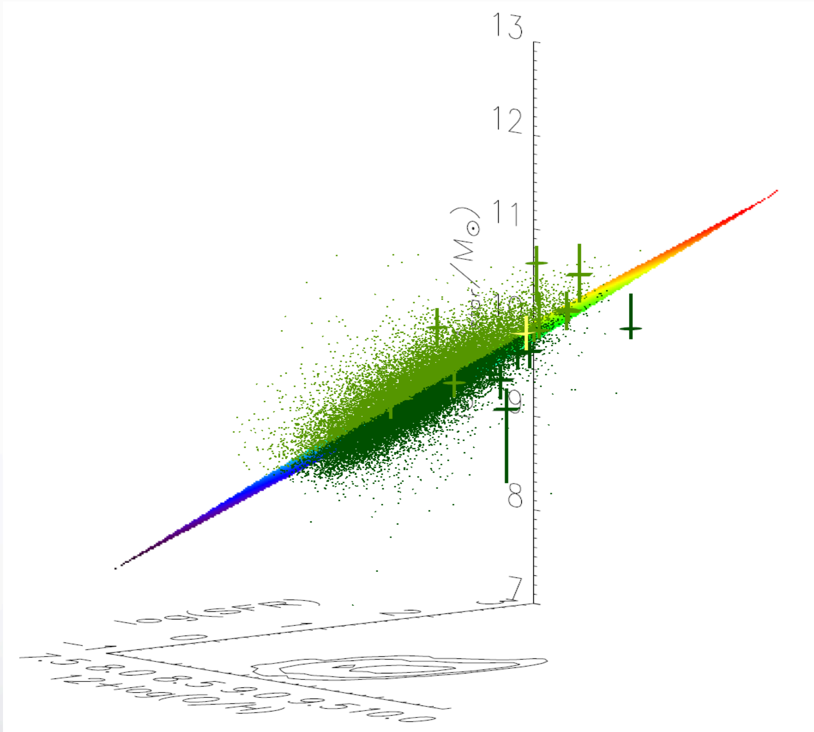


Lara-López et al. (2012, in progress)

Fundamental Metallicity Relation (FMR)

Fundamental Plane (FP)



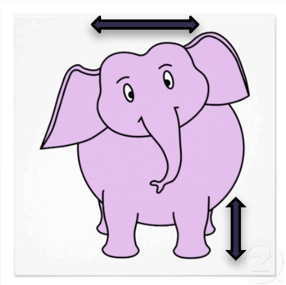


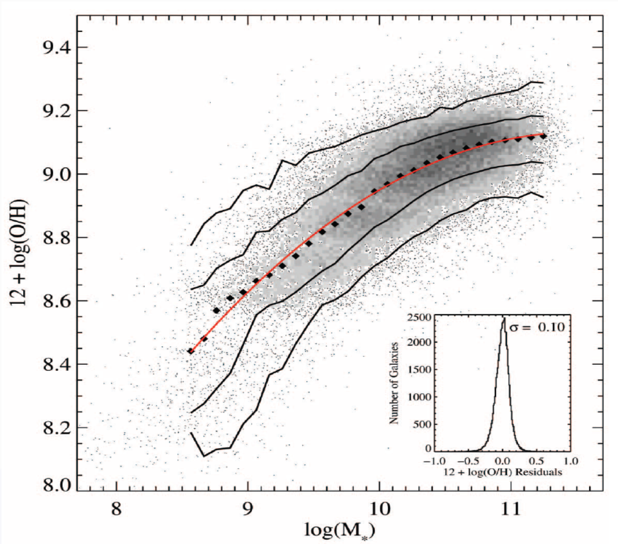
Mannucci et al. (2010)
(Dr. M.)

Lara-López et al. (2010)

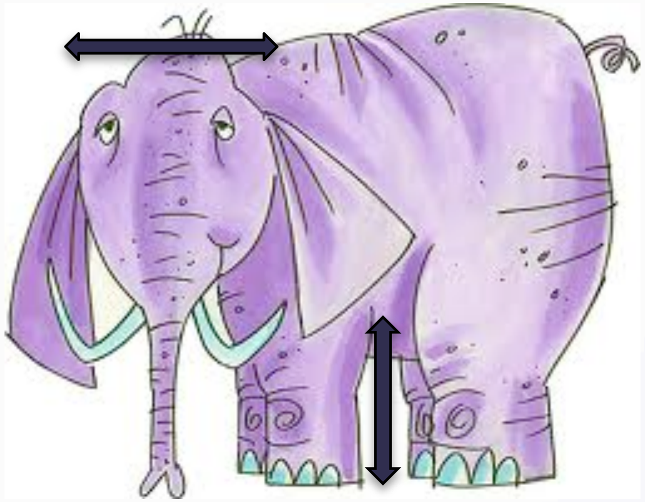
Correlation does not imply causation

Leg length vs. Skull size





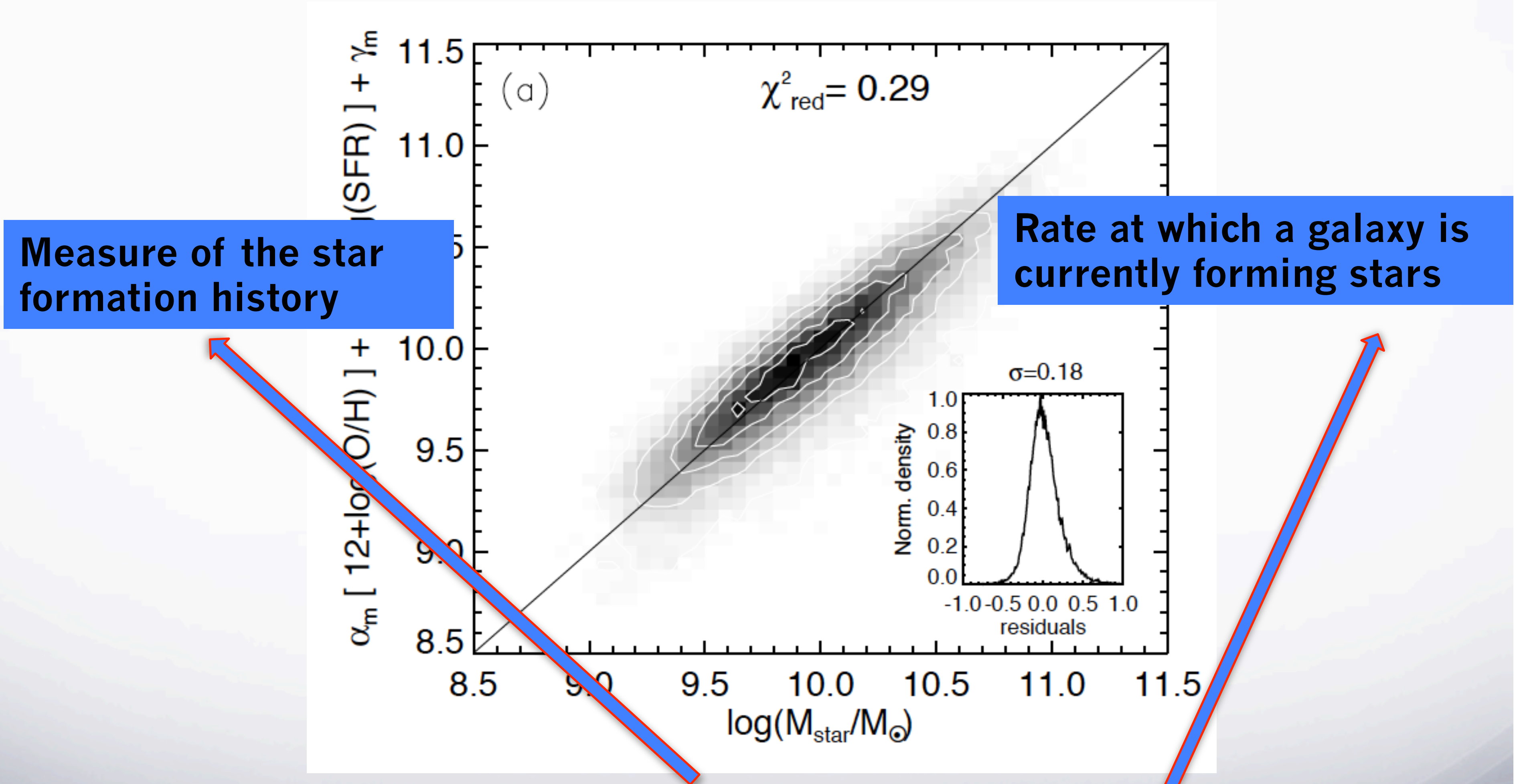
Tremonti et al. (2004)



Does an increase in skull size cause an increase in leg length?

Does a decrease in leg length cause the skull to shrink?

A FP for SDSS galaxies



$$\log(M_\star/M_\odot) = \alpha\,[12+\log(\mathrm{O/H})] + \beta\,[\log(\mathrm{SFR})] + \gamma,$$

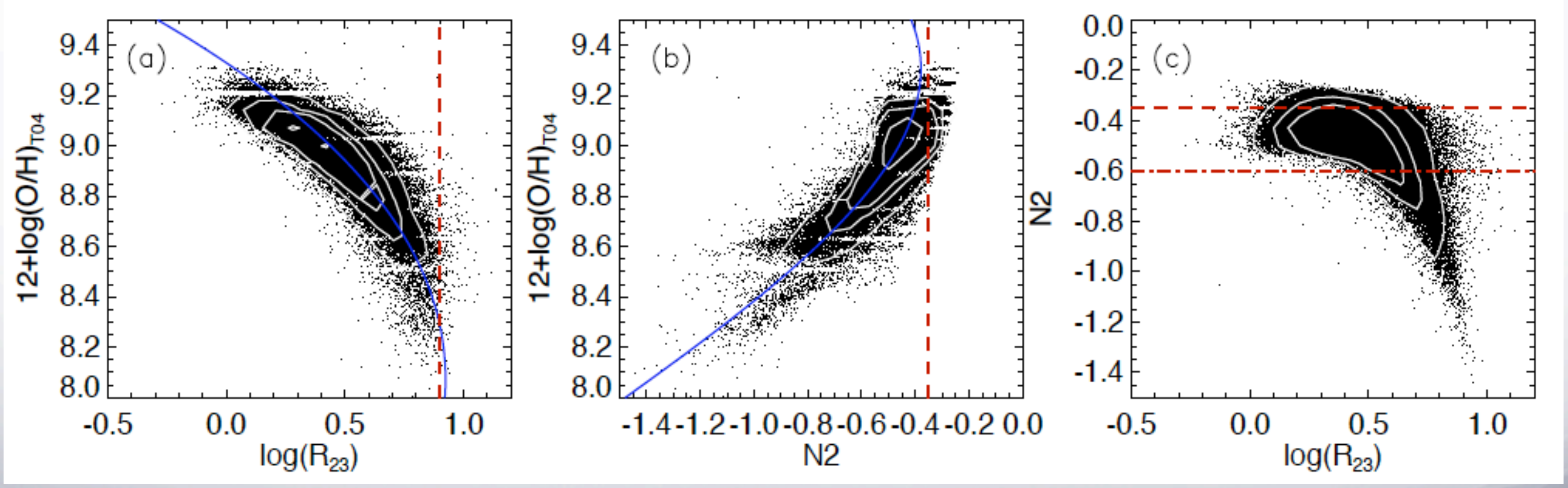
Lara-López, López-Sánchez & Hopkins (2013, ApJ , 764, 178)

Metallicities

-Limits in which this calibration is valid (saturation)
-Ionizational parameter

R_{23}=([OII] 3727+[OIII]4959,5007)/Hb

N2=log([NII]6584/Ha)



We recommend N2<-0.6 , 12=log(O/H) < 8.8

Lara-López, López-Sánchez & Hopkins (2013, ApJ accepted)

A 3D analysis of the $M_\star$, Z, & SFR space

1. Principal Component Analysis (PCA), PCA shows that the 98% of the variance can be explained by a Plane

2. Regression
   - 2. 1. Fitting to the stellar mass, $M_\star$= f (Z,SFR) (FP)
   - 2. 2. Fitting to the Z Z=f ($M_\star$,SFR)
   - 2.3 Fitting to the SFR SFR=f ($M_\star$,Z)

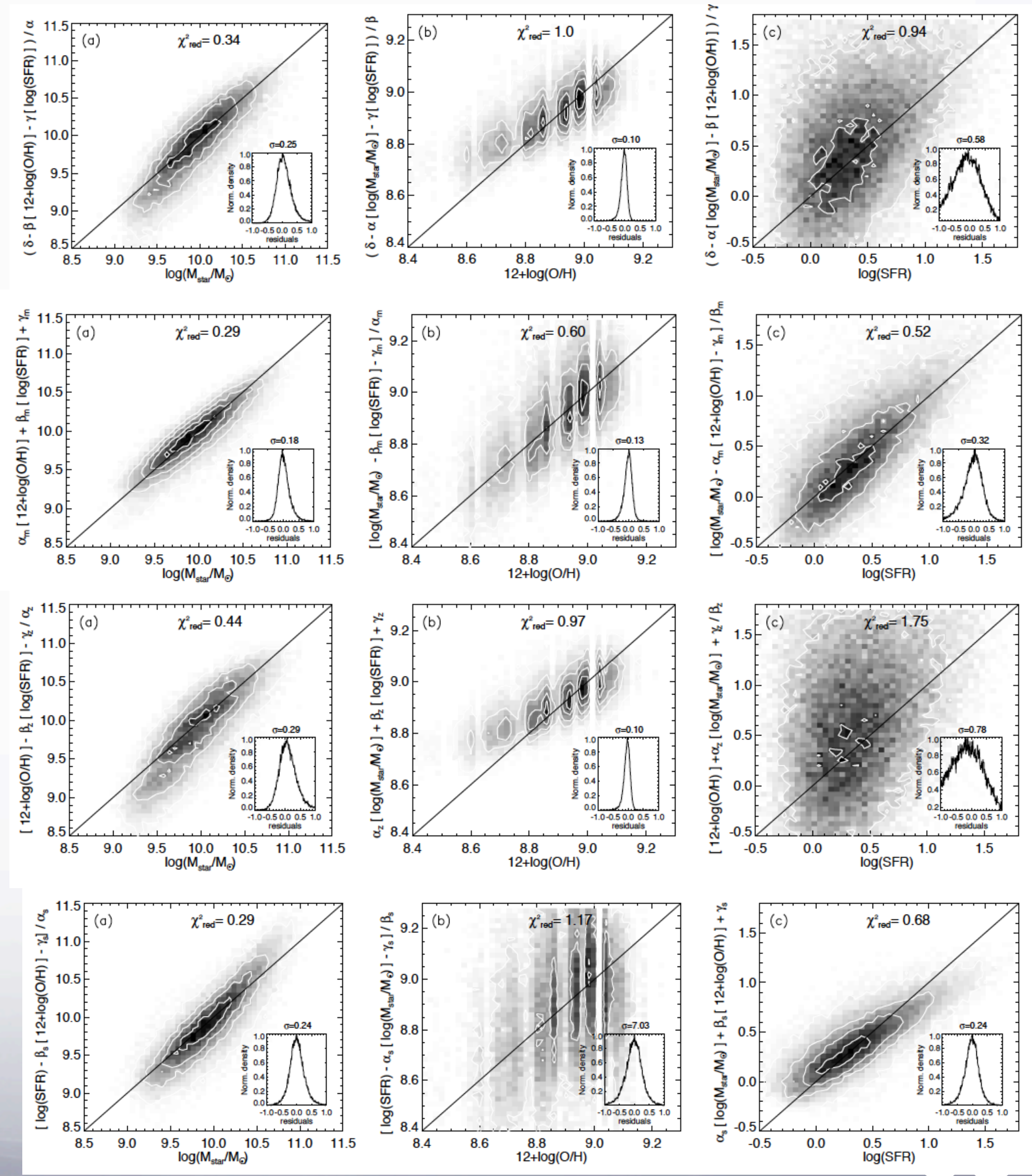
3. Binning data

PCA

Regression
$M_\star$= f (Z, SFR) (FP)

Regression
Z= f ($M_\star$, SFR)

Regression
SFR= f ($M_\star$, Z)



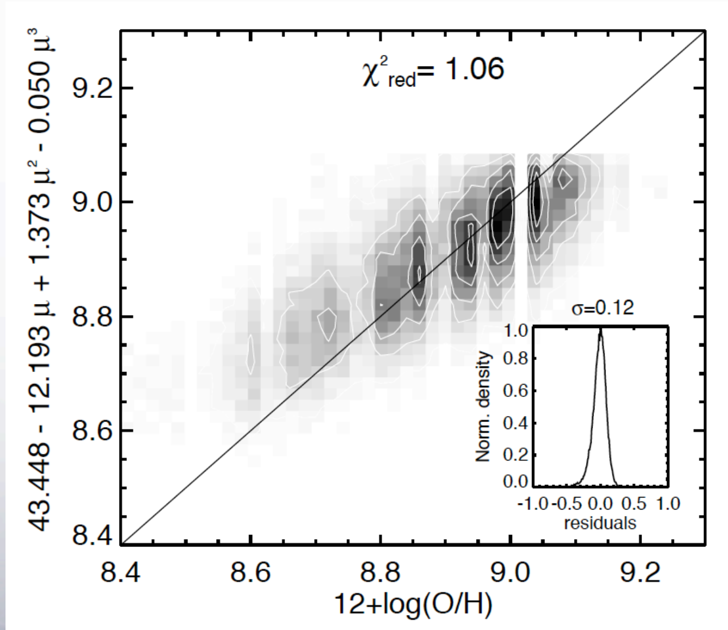
Lara-López, López-Sánchez & Hopkins (2013, ApJ accepted)

A 3D analysis of the $M_\star$, Z, & SFR space

3. Binning data

Following Mannucci et al. (2010), we generated a grid of 0.11 dex in log (SFR), and 0.15 dex in $M_\star$ and estimated the median metallicity in every square of the grid.

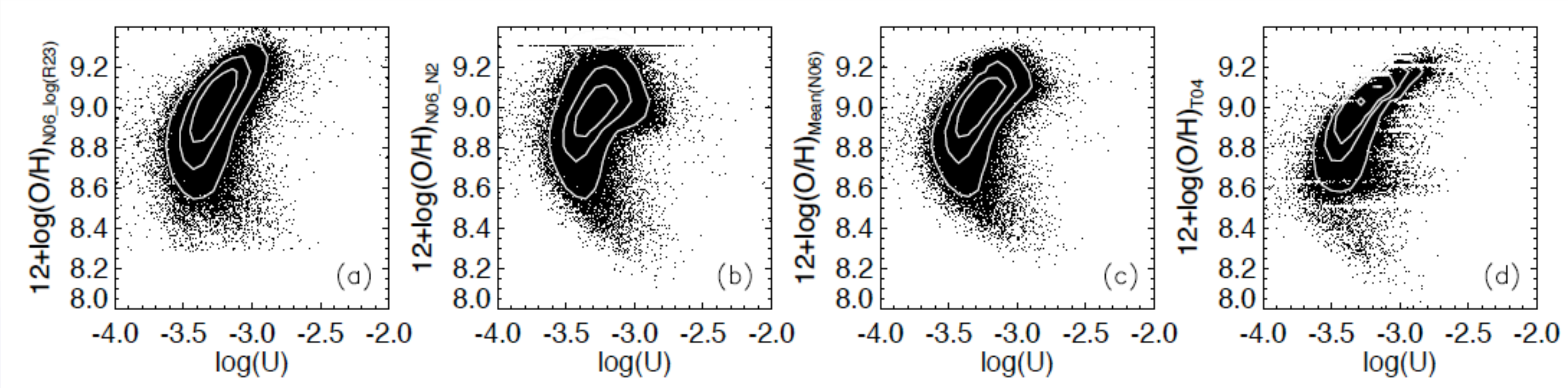
To compare how accurately the FMR can reproduce metallicity we follow Yates et al. (2012), since they use the same SDSS measurements of metallicity, SFR, and $M_\star$ as in the current work

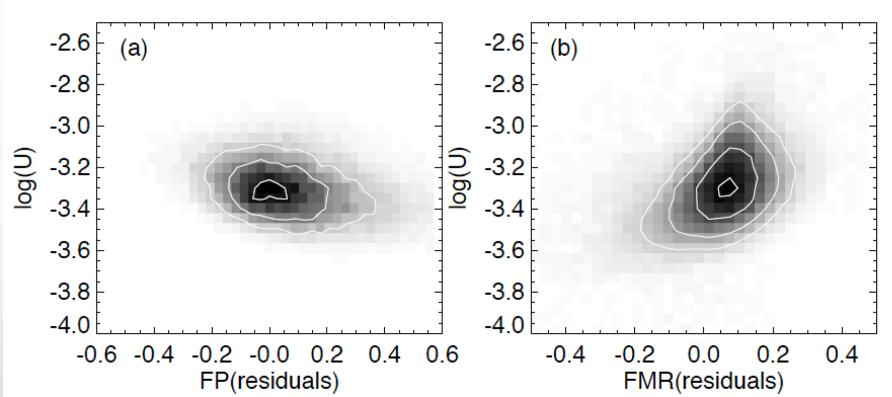


Lara-López, López-Sánchez & Hopkins (2013, ApJ accepted)

Metallicities

-Limits in which this calibration is valid (saturation)
-Ionizational parameter





A metallicity diagnostic that takes into account the ionization parameter would reduce the uncertainty in the derived metallicities and thus reduce the scatter against log(U).

Lara-López, López-Sánchez & Hopkins (2013, ApJ accepted)