SHARP

A big step forward:

Spatially resolved stellar population properties in passive galaxies at high-z

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Unveiling the Universe with SHARP: a Spectrograph Proposal for MORFEO@ELT
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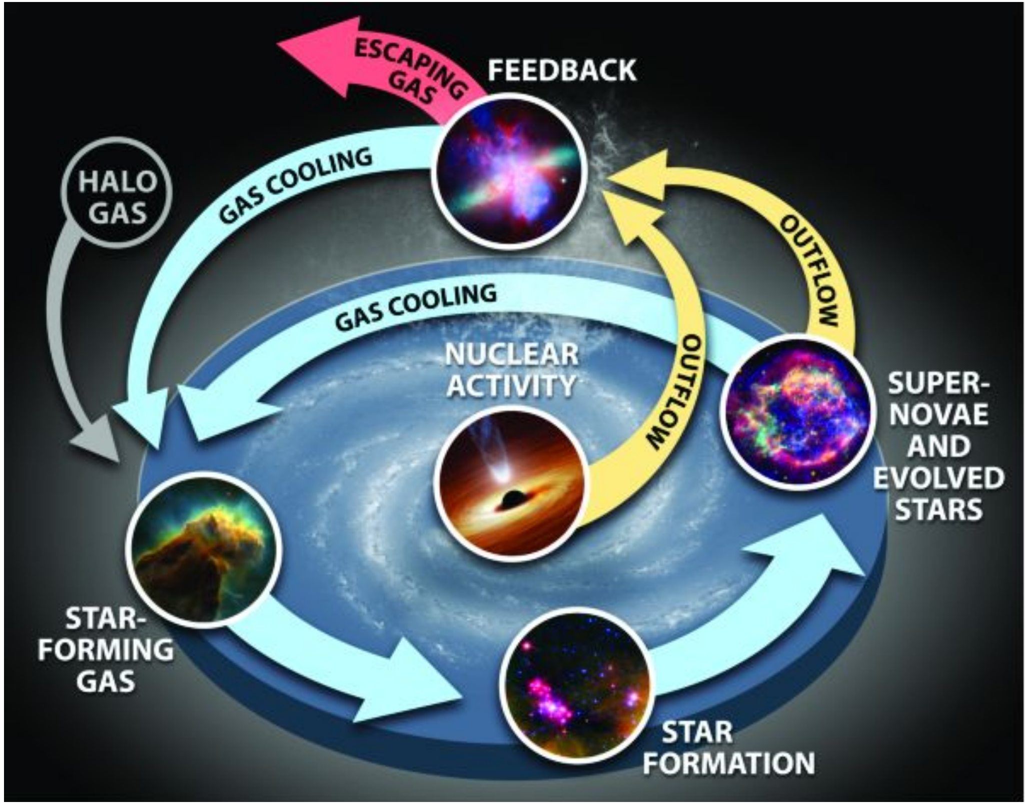
Milan

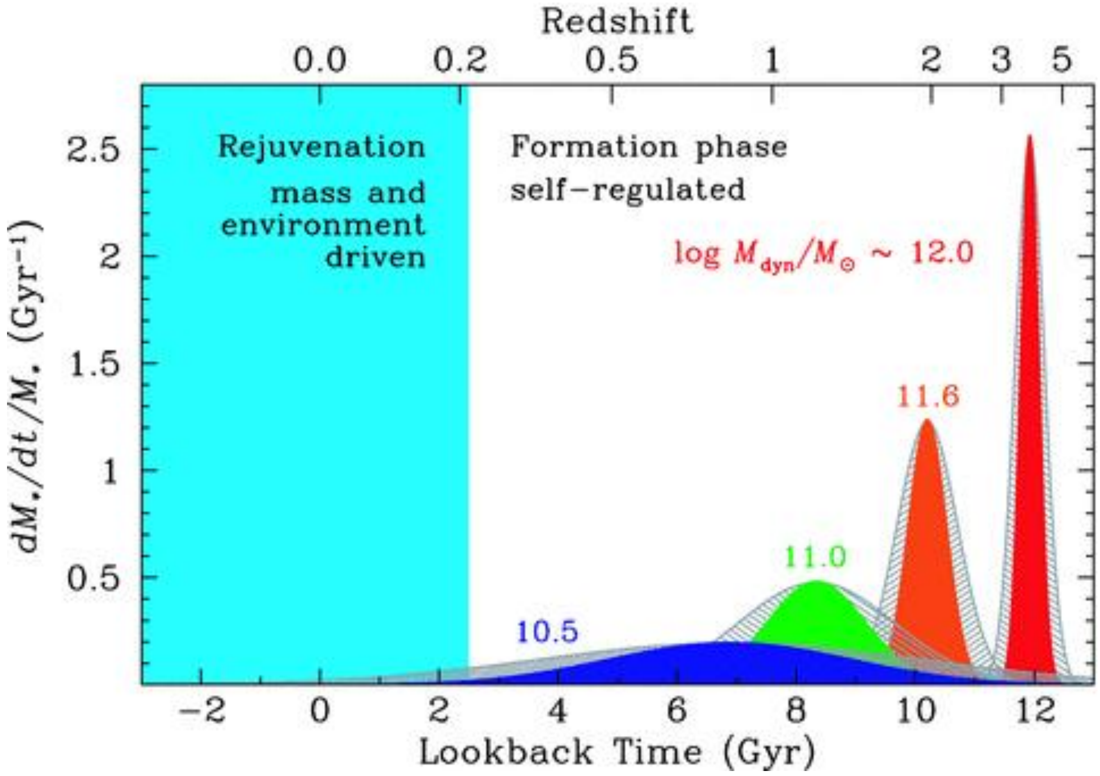
The relevance of passive galaxies (PGs)



- Most of the stellar mass in local galaxies resides in passive systems (e.g. Renzini 2006);
- Massive passive galaxies (PGs) are relevant probes for cosmological models.

However, the mechanism(s) responsible of their stellar mass assembly and star-formation quenching are still largely unknown.

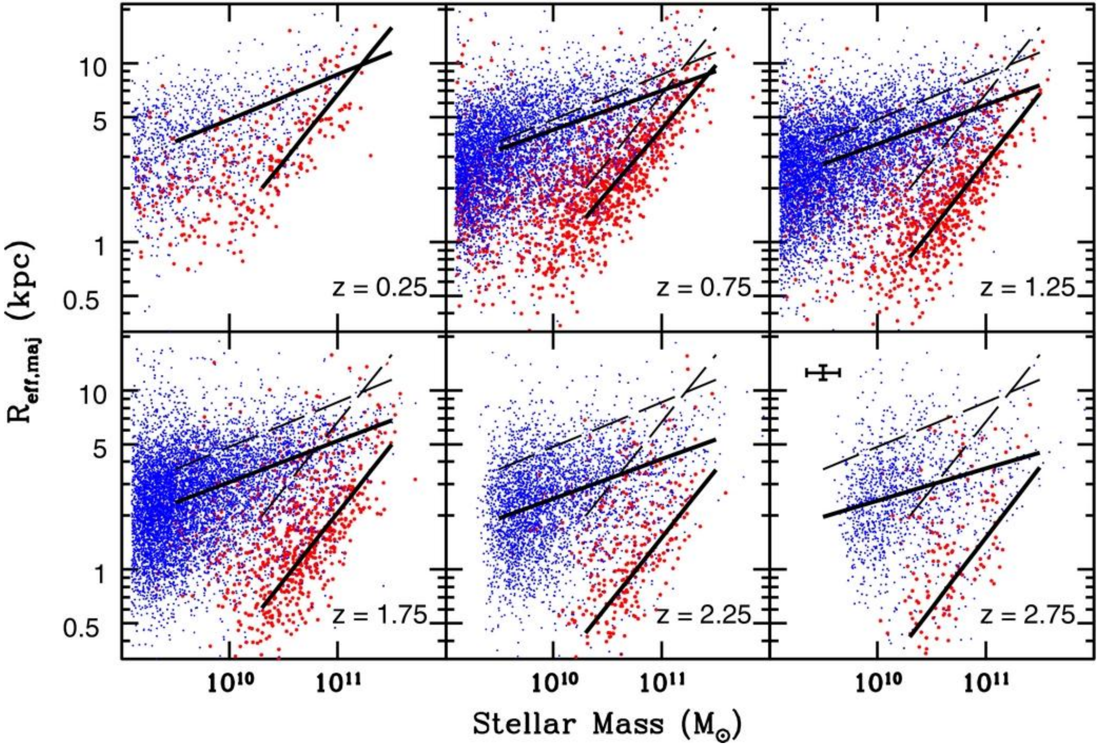
The heterogeneous properties of PGs



Thomas et al. 2010

The reconstruction of past star formation histories (SFHs) of local galaxies have revealed a anti-hierarchical assembly: massive galaxies formed earlier and over shorter timescales

The heterogeneous properties of PGs

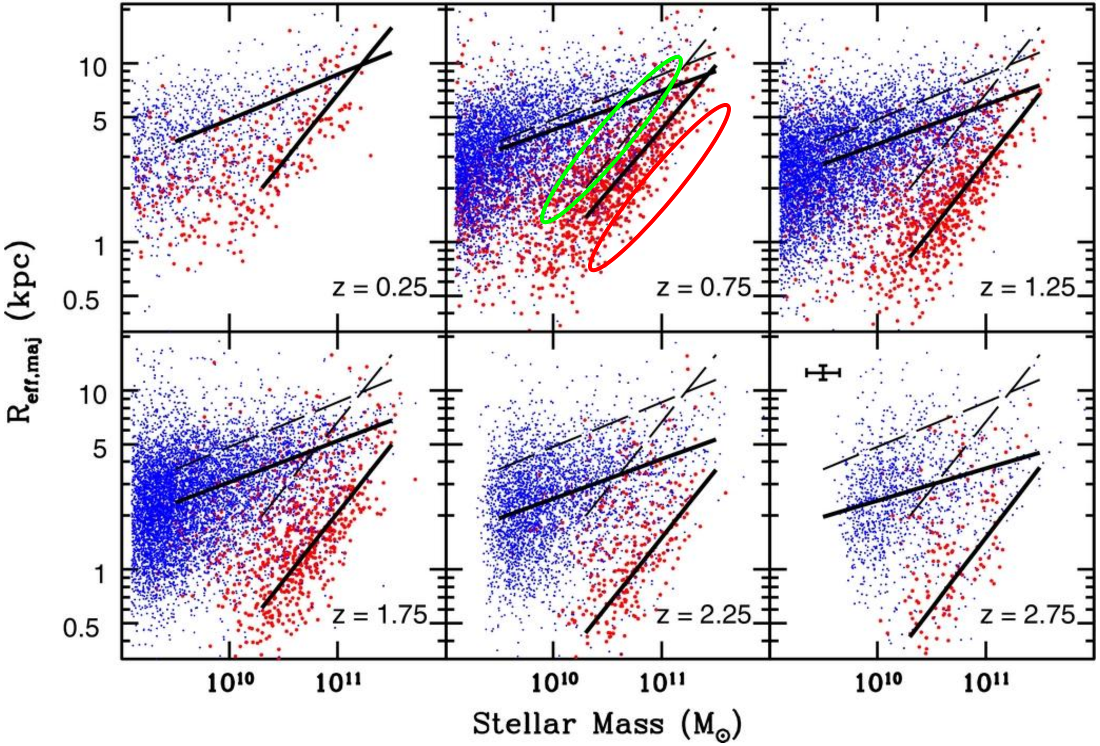


Van der Wel et al. 2014

At any z, at fixed stellar mass:

- sizes differ up to an order of magnitude;

The heterogeneous properties of PGs



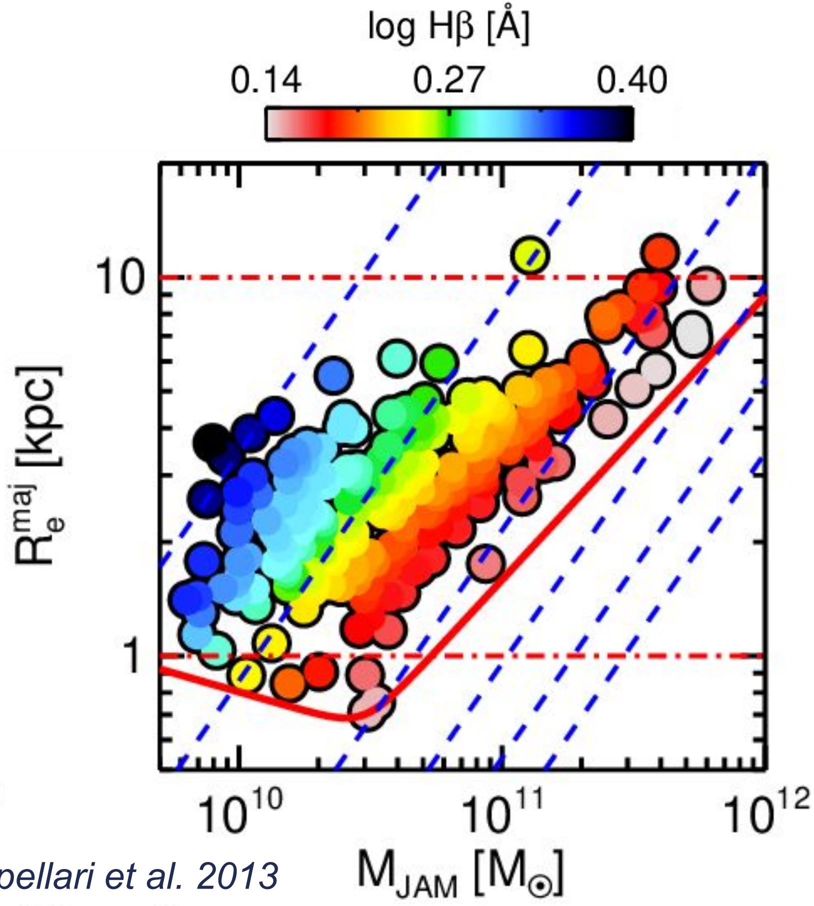
Van der Wel et al. 2014

At any z, at fixed stellar mass:

- sizes differ up to an order of magnitude;
- surface density up to 2-3 order of magnitude.
- both in cluster and field

(*Saracco, AG et al. 2017, see also Gargiulo et al. 2019*)

The heterogeneous properties of PGs

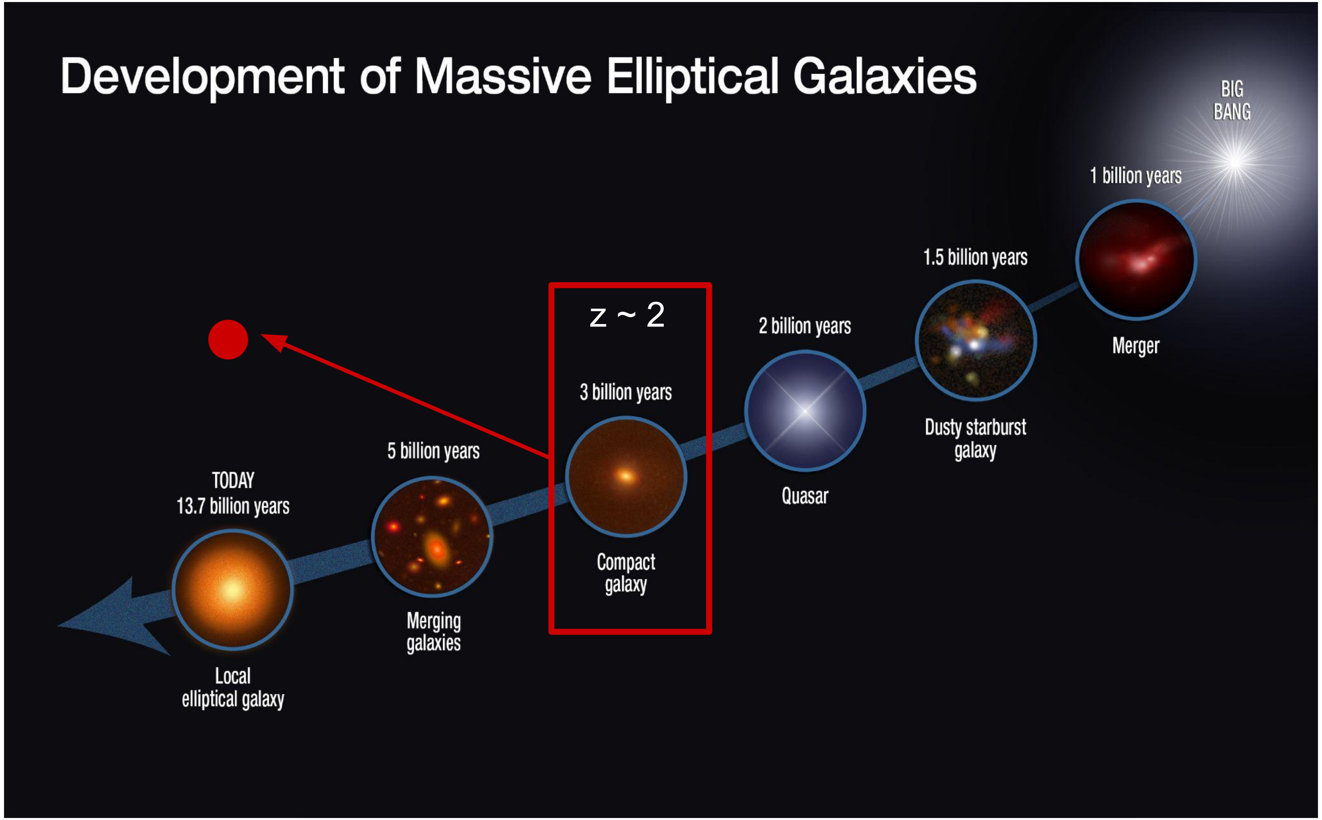


Cappellari et al. 2013

ATLAS3D - 260 local ETG
(Cappellari et al. 2013)

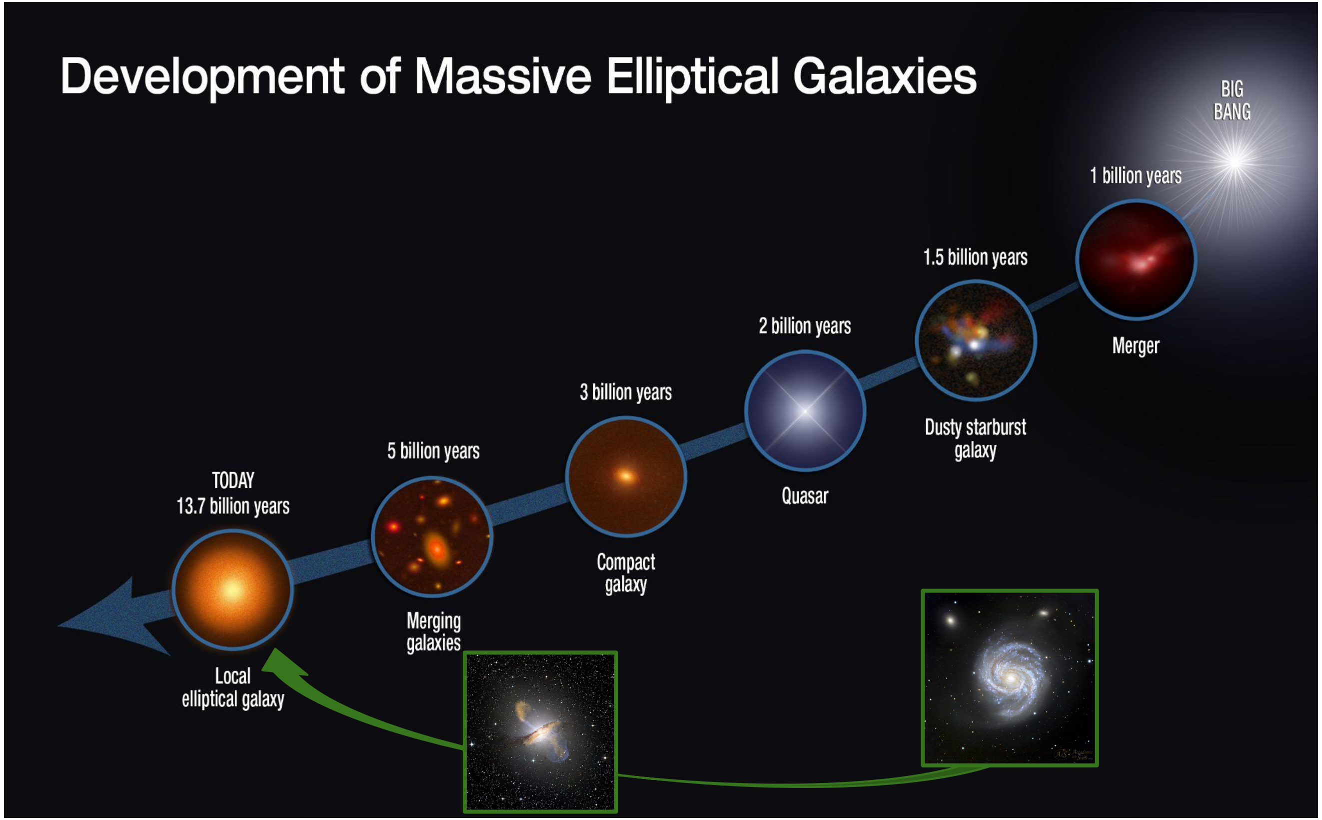
Stellar population properties (age, IMF, n, …) correlate more with velocity dispersion than with stellar mass

How PGs form and evolve: the inside-out growth

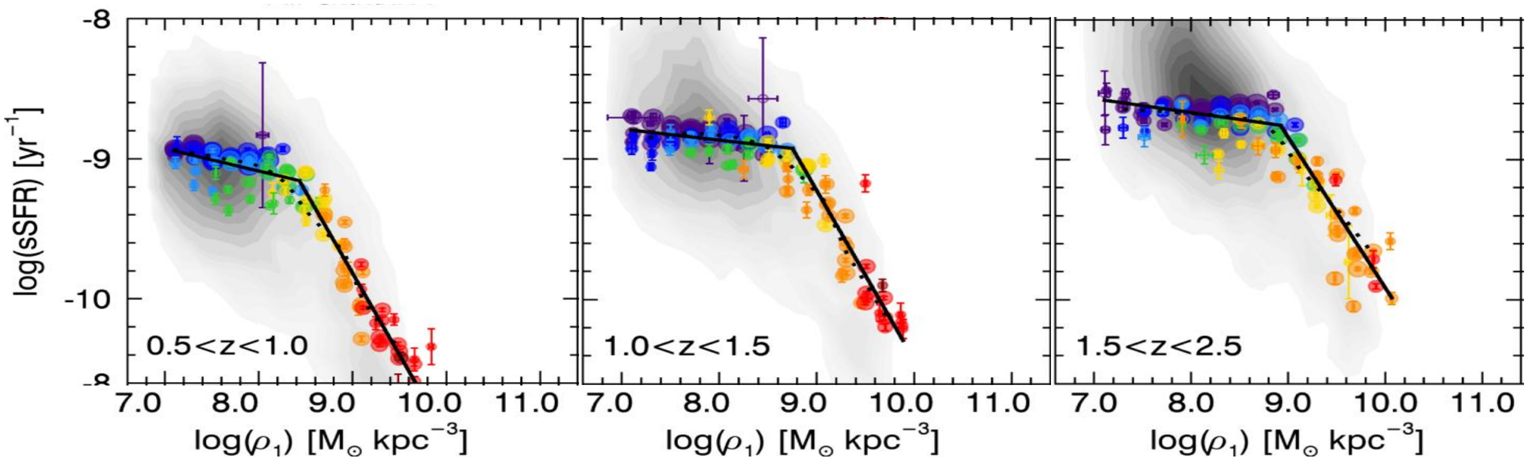


Credit:
NASA, ESA,
S. Toft and A. Feild

How PGs form and evolve: the progenitor bias



The importance of the “internal” properties: the central kpc



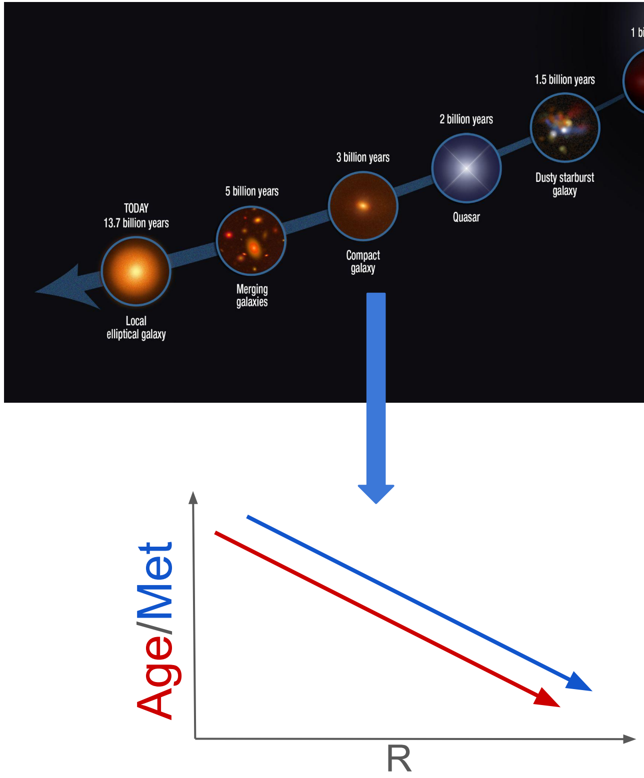
Whitaker et al. 2017, see also Saracco, AG et al. 2017

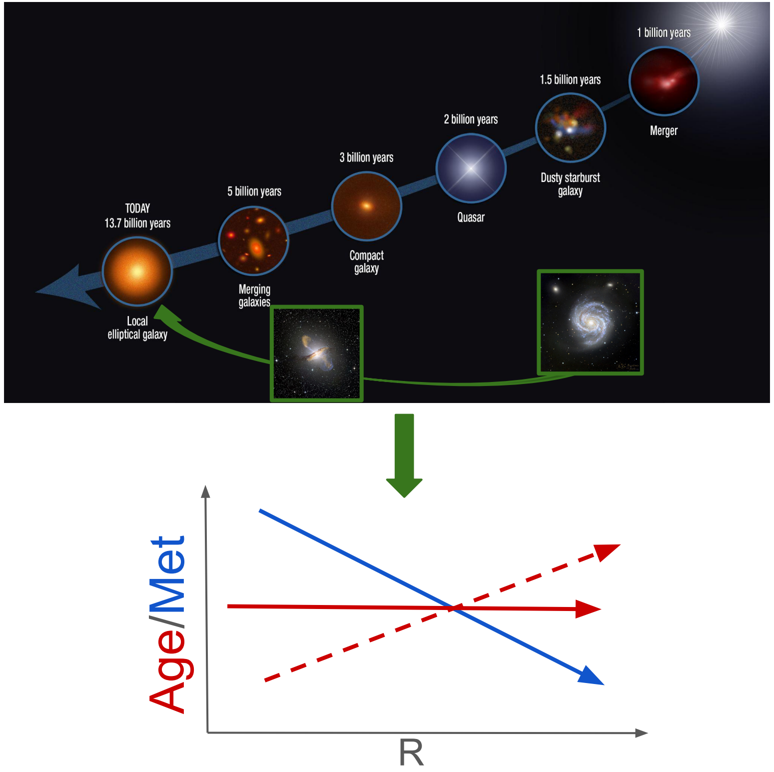
A new incoming picture:

- Independently on velocity dispersion and/or mean stellar mass density, galaxies become passive when $\rho_1 > \rho_{fixed}$
  - ρ_{fixed} quite independent on z and M_{star}

Integrated properties can tell us the *When* and the *Where* stellar mass assembly occurs, but spatially resolved information will be able to tell us the *How*

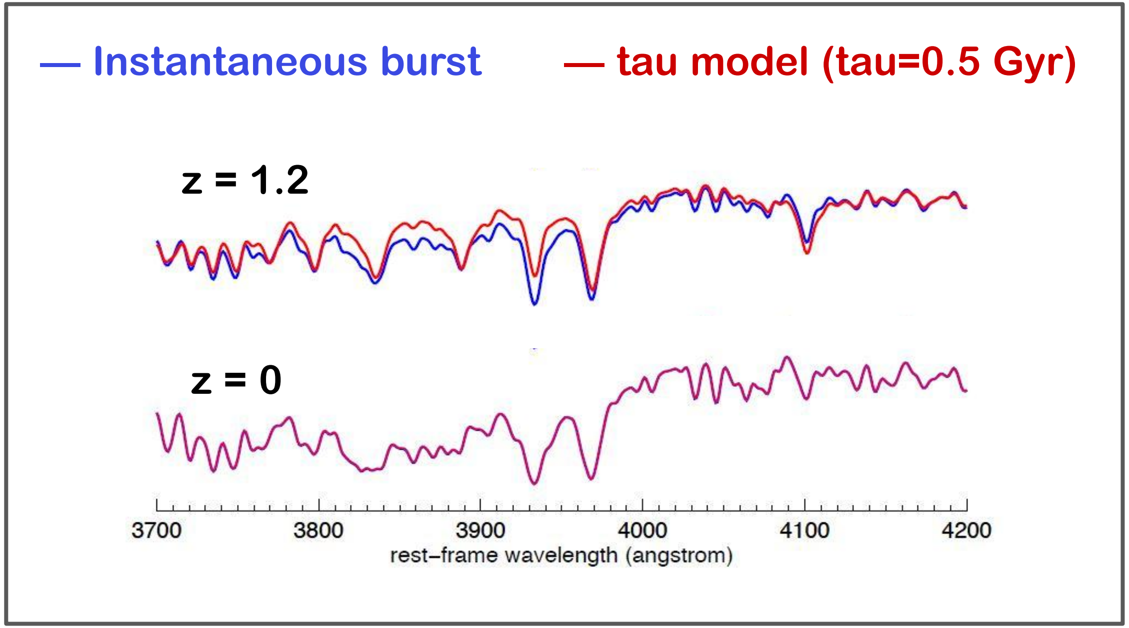
The importance of the “internal” properties: stellar pops (SPs)





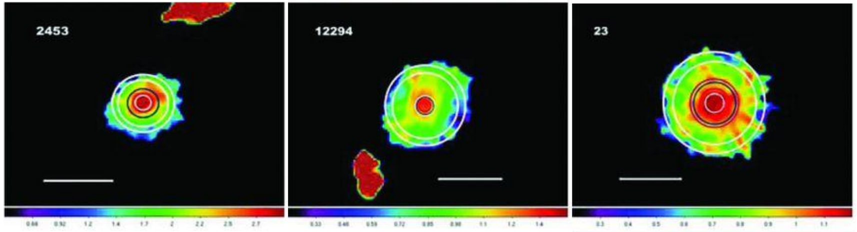
The power of high redshift information

- Quantify the impact of merging on the PGs mass assembly history;
- Discriminate the quenching mechanisms observing galaxies closer to the epochs of formation (before the majority of the merger activity occurred);
- Age/metallicity indicators rapidly evolving with age.



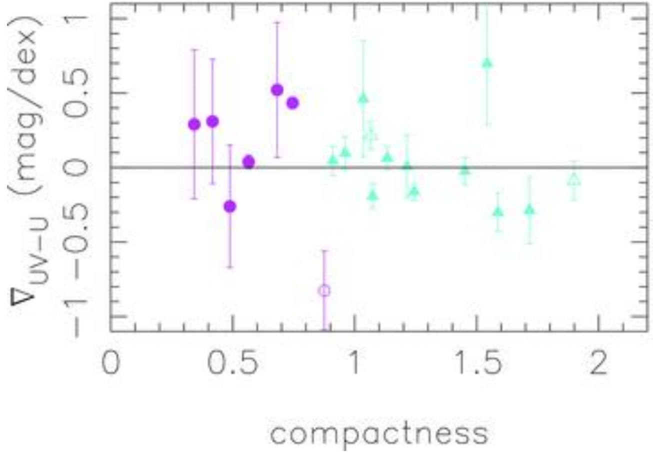
Spatially resolved SP properties at high-z: from photometry

(F606W-F850LP) and (F850LP-F160W) color gradients for individual ETGs
at 1.0 < *z* < 1.9 in GOODS- South field (*Gargiulo et al. 2011, 2012 - see also Guo et al. 2011)*



F80LP - F160W (U - R) color maps

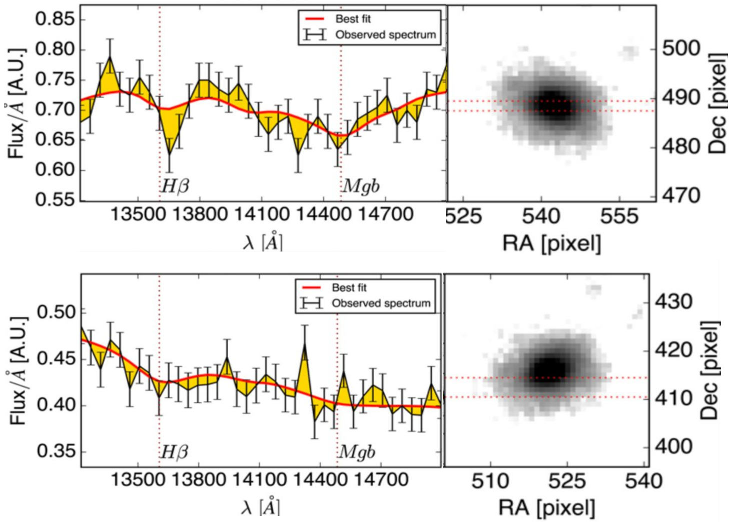
- All galaxies have negative U-R color gradients and both positive and negative UV - U color gradients

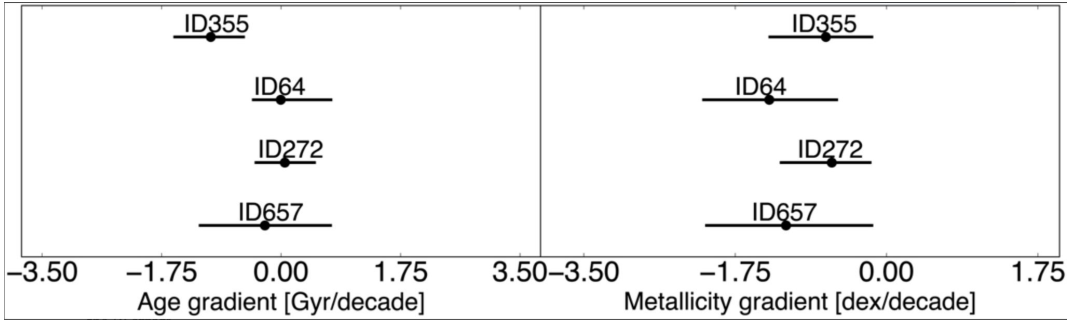


- pure metallicity radial variations do not reproduce gradients in both colors for half of the sample
- no trend with M_* and compactness → much more variegated mass assembly even in galaxies with similar density

Spatially resolved SP properties at high-z: from Slitless spectra

Age & metallicity gradients for 4 PGs at $1.6 < z < 2.4$ ($M_* > 10^{11} M_{sun}$)
from slitless HST-G141 spectra + F160W photometry *(Ditrani et al. 2022)*

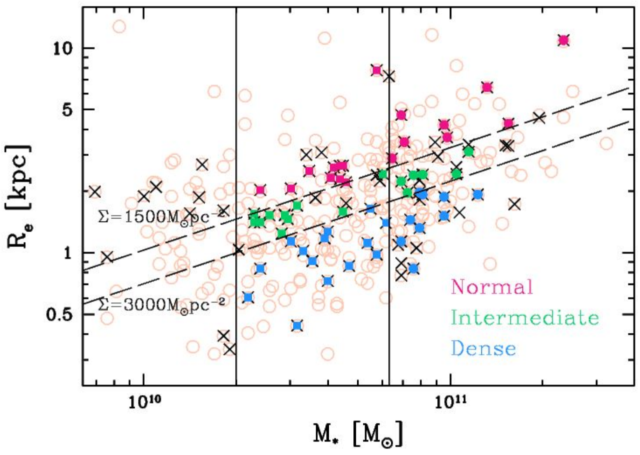


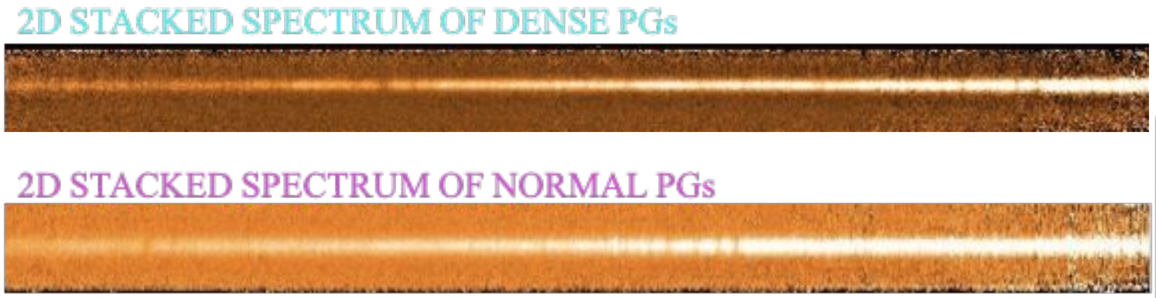


Negative metallicity gradients
fully consistent with local values

Spatially resolved SP properties at high-z: from LS spectra

Age & metallicity gradients for PGs at $1.0 < z < 1.6$ ($M_* > 2*10^{10} M_{sun}$)
from STACKED LS VANDELS deep spectra (20h-80h)
as a function of stellar mass and stellar mass density *(Gargiulo et al. in preparation)*



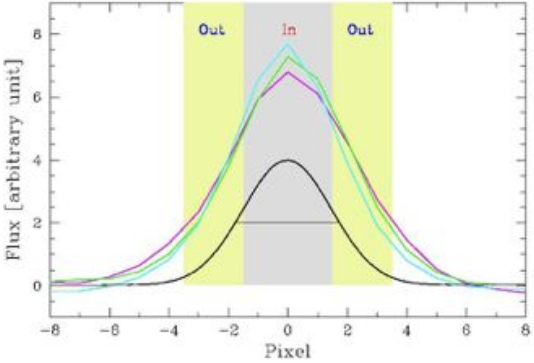


t_{exp} = [200 - 400]h

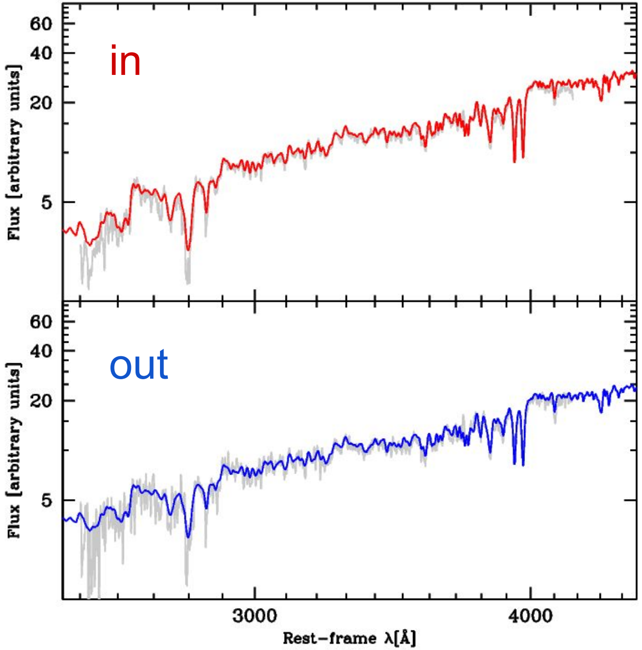
Spatially resolved SP properties at high-z: from LS spectra

preliminary results

FWHM = 0.7” → 6kpc

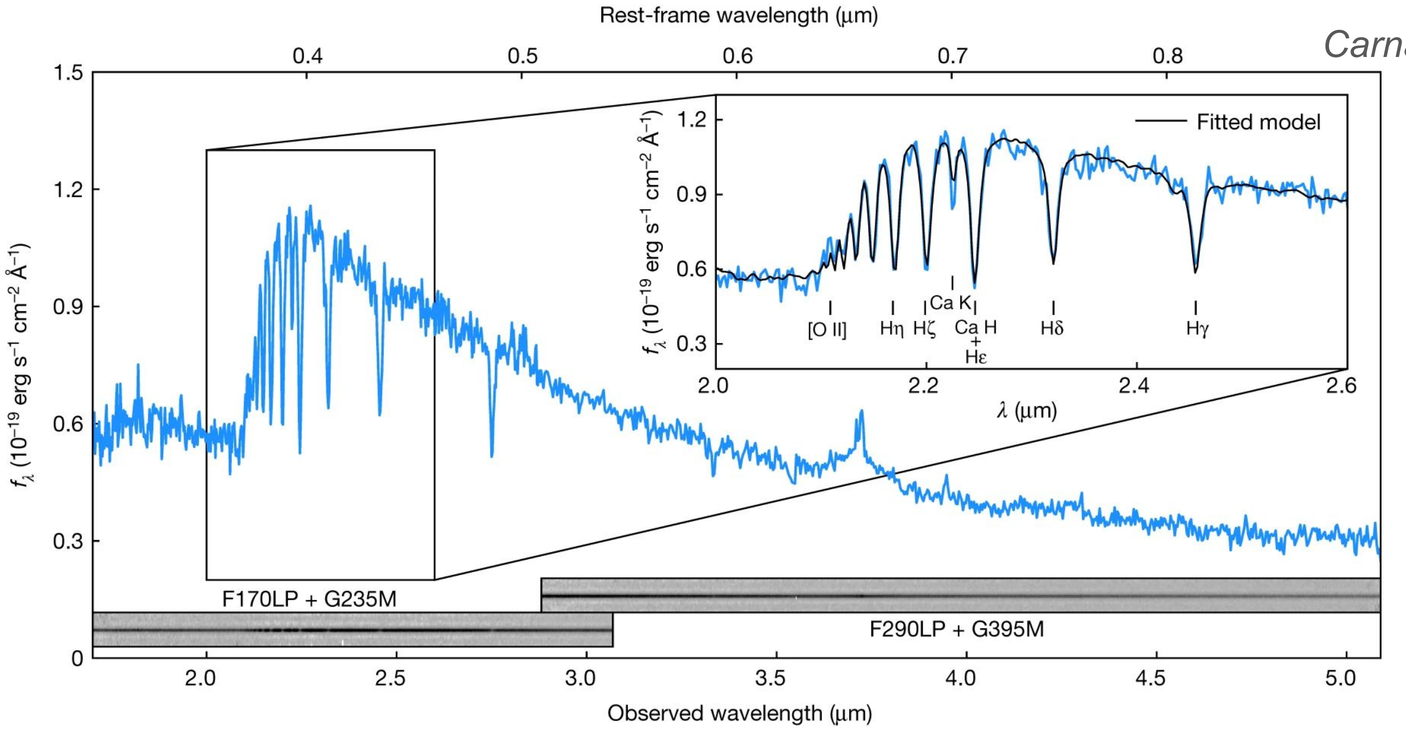


Fit of:
-UV spectra;
-photometry &
-indices to control limits of UV age/met indicators
(see e.g. Ditrani et al 2023)



The new "Universe" revealed by JWST

Carnall et al. 2023



z = 4.65

Physical Properties

K = 23.6

$M_* = 3.8 \times 10^{10} M_{sun}$

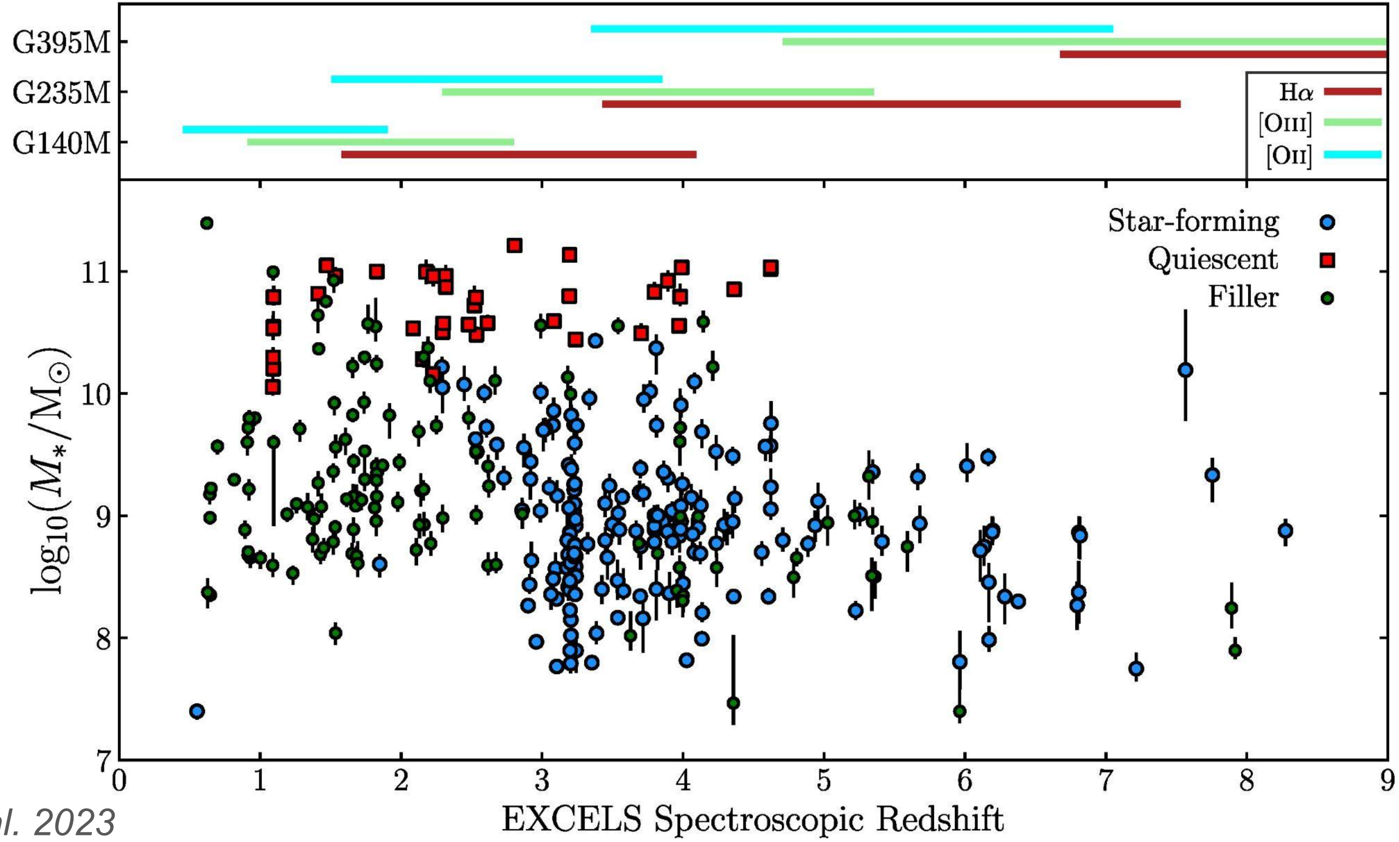
Structural Properties

R_e = 0.2kpc

n = 2.3

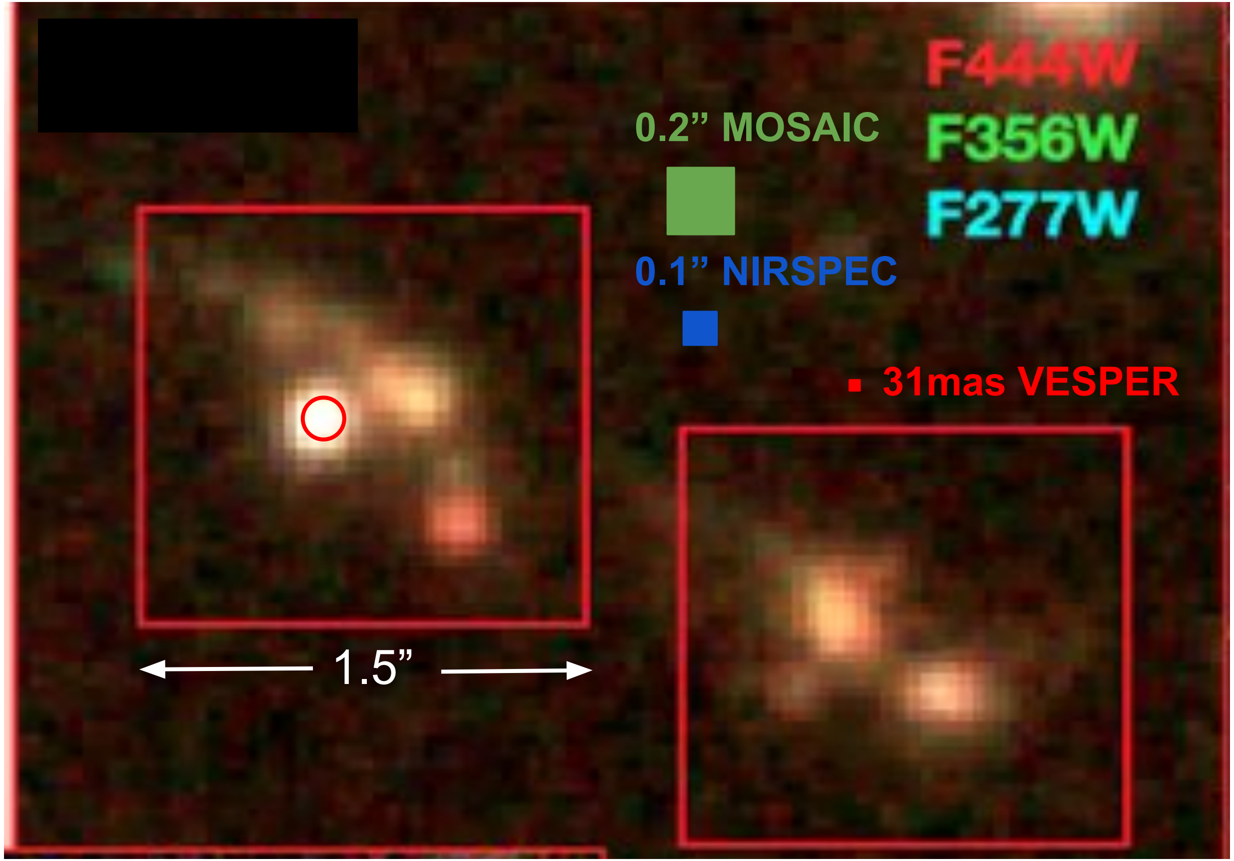
We need to push our study beyond z = 2

The new "Universe" revealed by JWST



Carnall et al. 2023

Dissecting high-z passive galaxies with SHARP

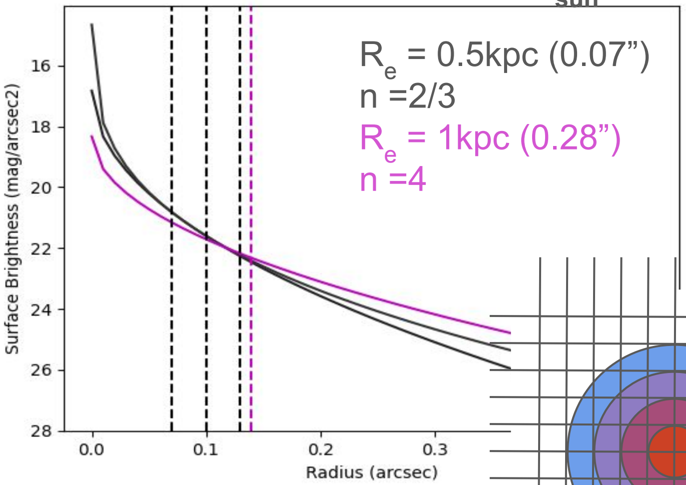


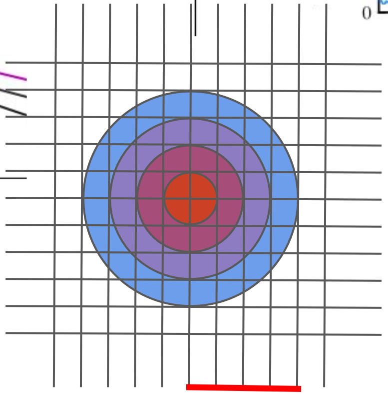
Courtesy of
Eros Vanzella

Dissecting high-z passive galaxies with SHARP

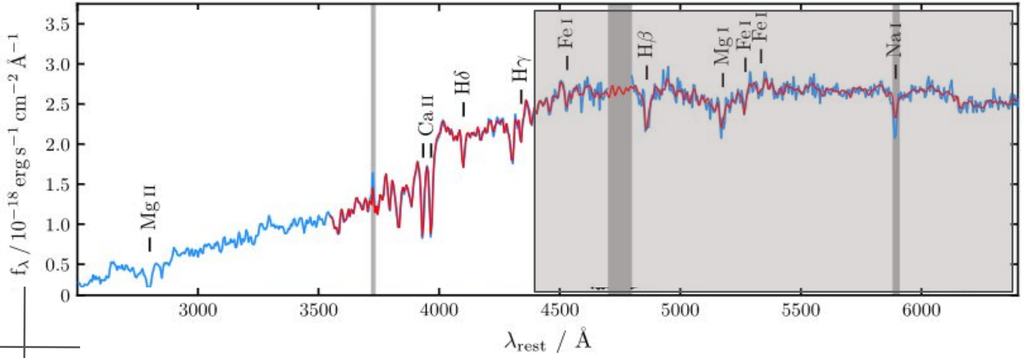
SHARP-VESPER has got the power

K = 23.6 $M_* = 3.8*10^{10} M_{sun}$





1 kpc at z = 4



- Using SHARP ETC: S/N ~ 15 in 20-30h (according to Sersic profile) in circular halo of 35mas width at 1kpc from the center.

Summary

- The synergy between MORFEO and SHARP will allow us to derive radial stellar population properties for passive galaxies down to $M_{star} \sim 5*10^{10} M_{sun}$
- Low number densities not a big problem: see Marcella’s talk, and possible synergy with Stefano and Anna science case
- The hypothetical elephant in the room: HARMONI. One single IFU could be enough for this science case, but:
  - we need of a bright star in the proximity of the high-z PG;
  - we can observe more objects in the same observation