Metallicity gradients in quiescent galaxies at z~2

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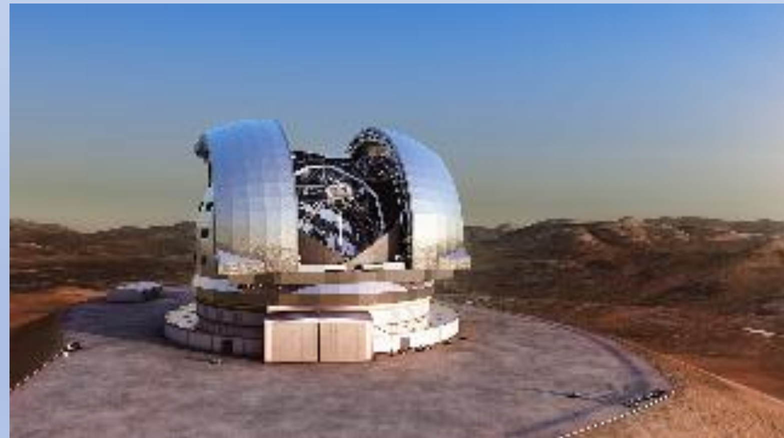


9-13 September 2019 - ROMA – *Extremely Big Eyes In The Universe*

WHY quiescent galaxies?

- ~ 70% of stars in the local universe reside in massive spheroidal systems
- at any z up to z~1.5-2 the more massive systems are spheroidal and passive systems contaning old stars (e.g. quenching of their SF at z> 2-3)

WHY gradients?

- Spatial distribution of stellar population properties are connected to the assembling path followed by the galaxies

WHY metallicity gradients

- Monolithic collapse (cold gas accretion at z > 2-3)

- Hierarchically assembly (wet mergers of disc galaxies at z>4-5)

↓

- Negative metallicity gradients
- Almost no age gradients

(Kobayashi 2004)

↓

- Almost no gradients

(Naab et al. 2009)

WHY metallicity gradients

- Monolithic collapse (cold gas accretion at z>2-3) + **minor dry mergers** (*inside-out growth*)

- Hierarchically assembly (wet mergers of disc galaxies at z>4-5)

- stochastic gradients, depending on the nature and time of satellite accretions

(Oser et al 2010; Kobayashi 2004)

- Almost no gradients (Naab et al. 2009)

WHY high redshift galaxies?

- local galaxies → negative metallicity gradients (but al large radii flatten - more stochastic gradients – Green et al. 2015)
- high redshift galaxies → age gradients? (based on broad band colours - Gargiulo et al 2012)

- **short time elapsed since their formation**

Spatially resolved spectra of high redshift quiescent galaxies

WHAT WE NEED

1. R_e [$10^{11} M_\odot$] = 1-2 kpc → 0.1" at z≳1
2. Stellar absorption lines ≃40 Å width
3. Hb, Hd, Fe, Mg….many lines better constrain Z and [α/Fe]

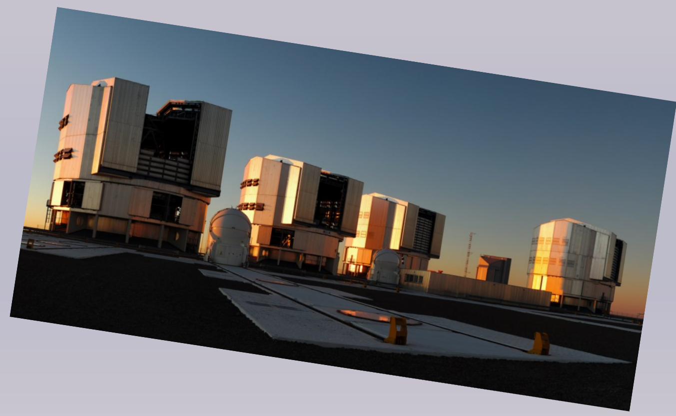
→

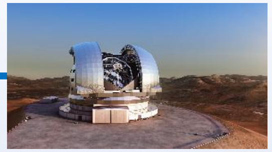
1. PSF ≲ 0.1"
2. Moderate spectral resolution (R > 120 !)
3. Large spectral window – 4000-6000 (restframe)

WHAT WE HAVE

KMOS@VLT

- IFU 1 pixel = 0.2" **PSF ≳ 0.4"**
- Moderate spectral resolution
- Large spectral window





WHAT WE NEED

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1. PSF ≲ 0.1"
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WHAT WE HAVE

SINFONI@VLT

- IFU 1 pixel = 0.1" " **PSF ≳ 0.1"**
- R=3000 (H band)
- Large spectral window

T_{exp} = **hundreds of hours**

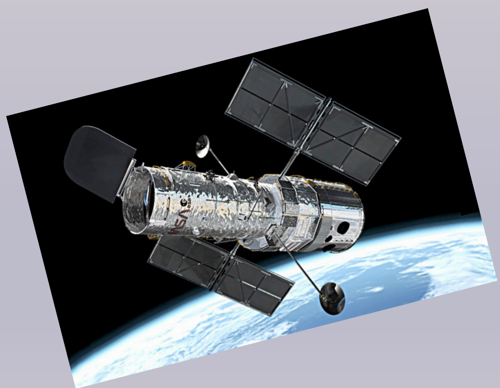
WHAT WE NEED

1. R_e [10^{11} $M_\odot$ gal] = 1 kpc → 0.1″ at z≳1
2. Stellar absorption lines ≃40 Å width
3. Hb, Hd, Fe, Mg….many lines better constrain Z and [α/Fe]

→

1. PSF ≲ 0.1″
2. Moderate spectral resolution (R > 120 !)
3. Large spectral window – 4000-6000 (restframe)

WHAT WE HAVE

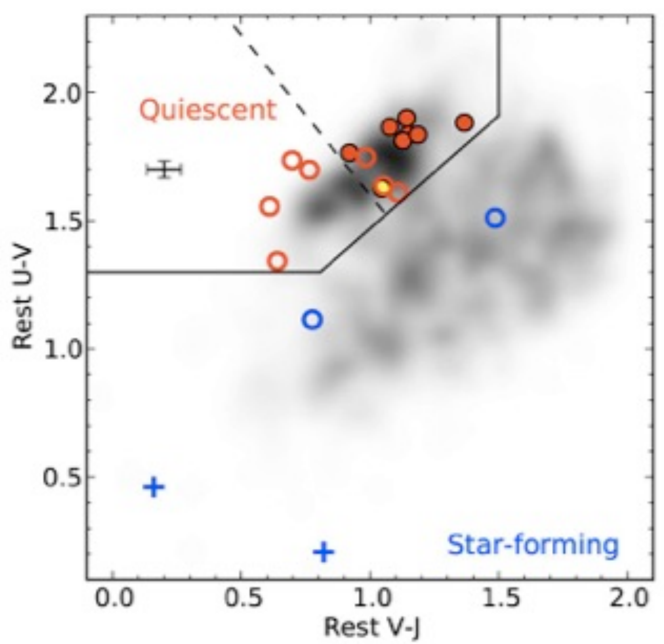


WFC3@HST:

- PSF = 0.1″
- R ≲ 130
- Minimun spectral window (G141 @ z≃2)

Andreon et al. 2009

JKCS 041



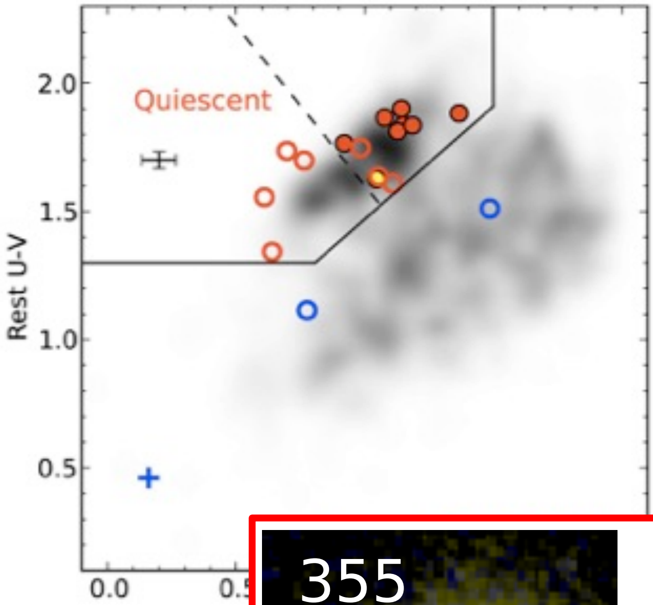
Lg(M)=14.2-14-5 $M_\odot$
(Andreon et al. 2014)

z=1.8

- WFC3@HST grism slitless spectroscopy (17 ks total exposure)
- G101 & G141
- 19 spectroscopically identified members

Andreon et al. 2009

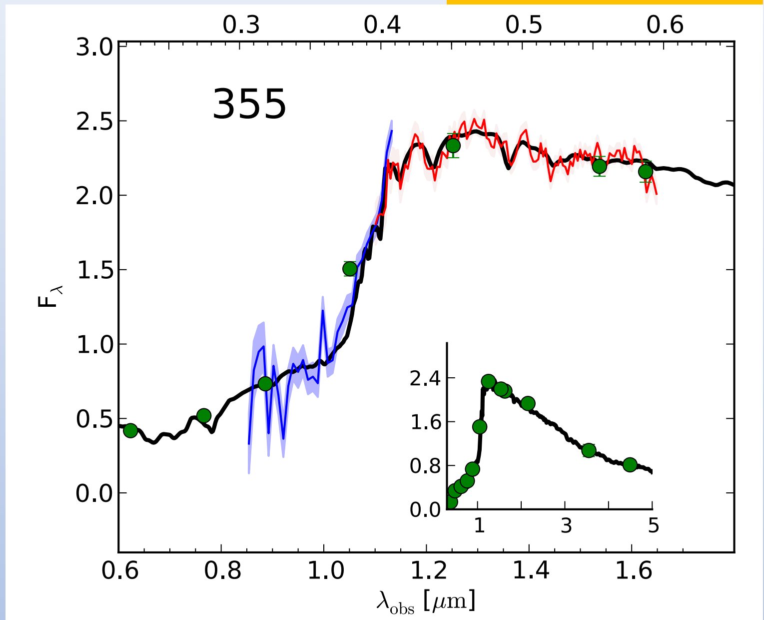
JKCS 041



Lg(M)=14.2-14-5 $M_\odot$
(Andreon et al. 2014)

z=1.8

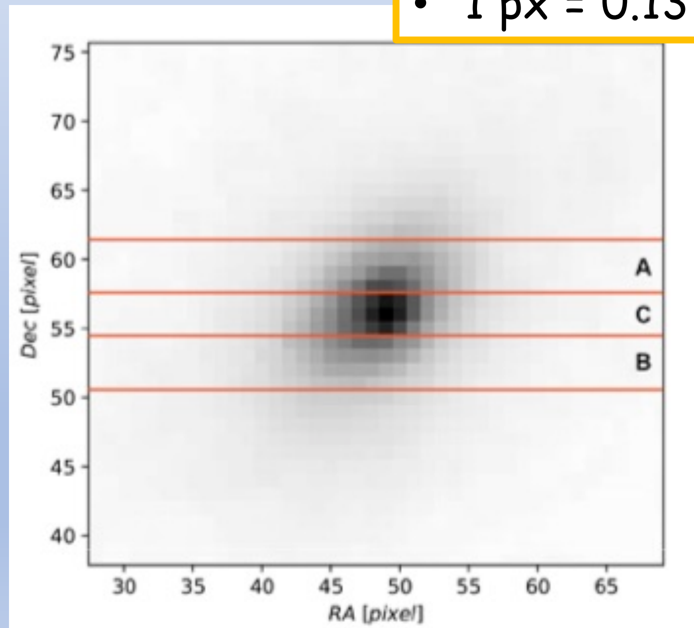
355



- z = 1.81
- H_{AB} = 20.6
- Lg(M_{gal}) = 11.52

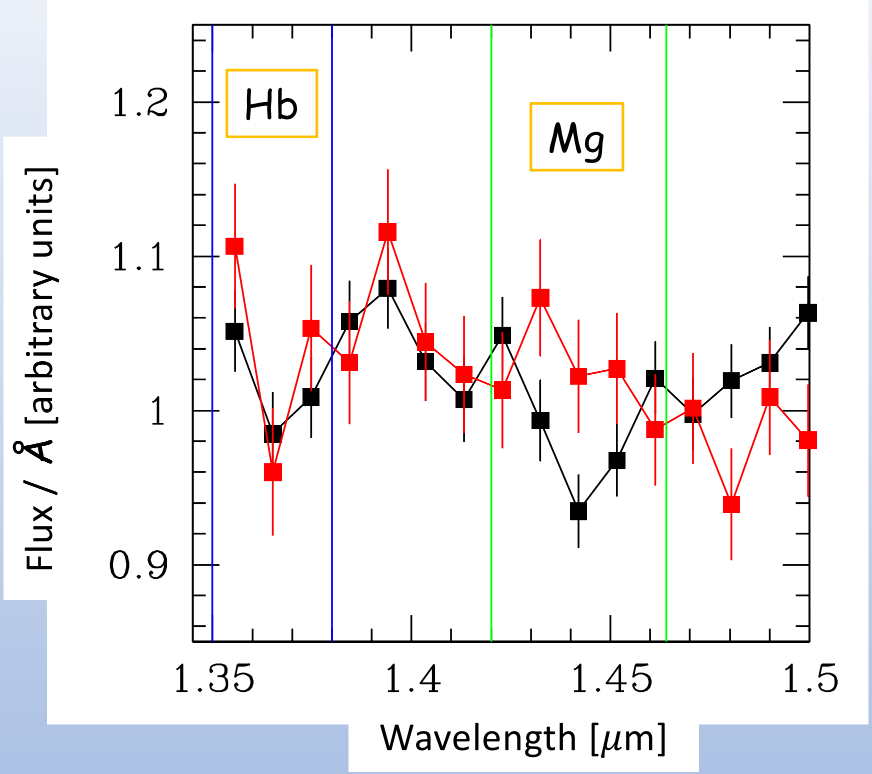
(Newman et al. 2014)

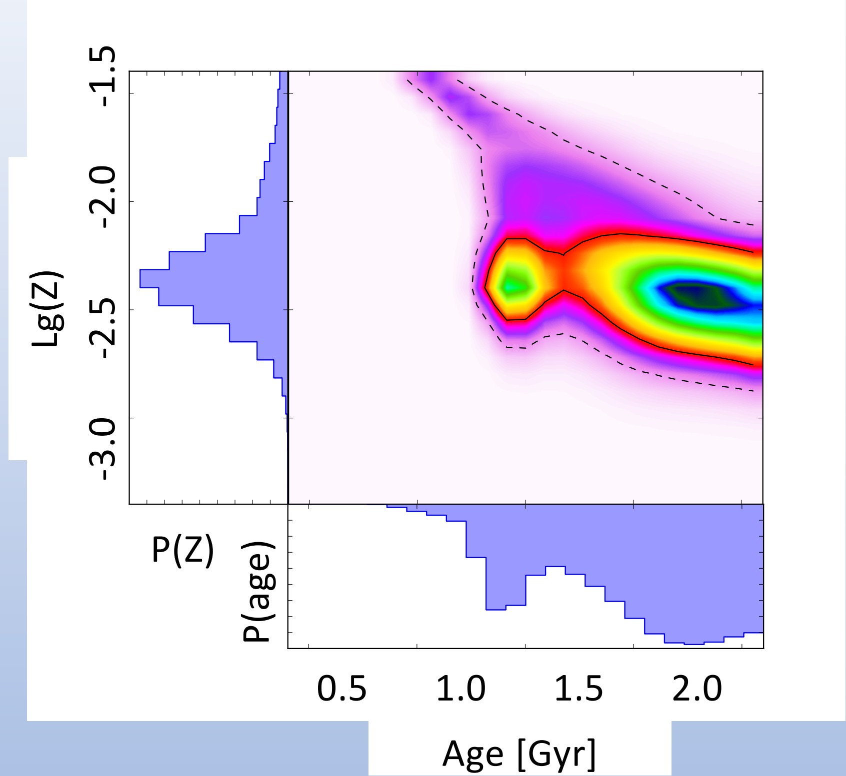
- 1 px = 0.13″



- WFC3@HST G141
- Exp time 17 ksec
- R < 130 (FWHM > 108 Å)

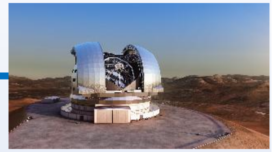
- Internal zone C = 3 px = 0.4″
- External zone A + B = 4 px = 0.5″

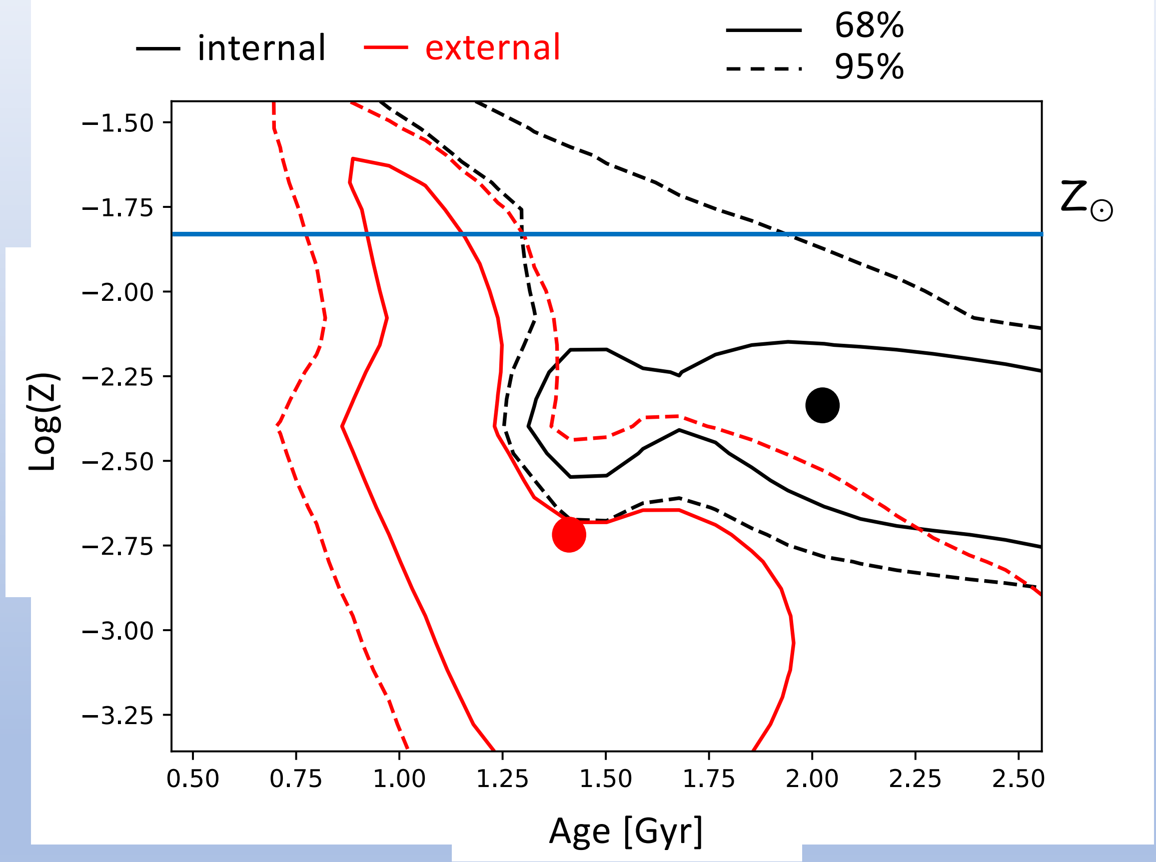




— internal — external

- BC03 (IMF Chabrier)
- SSP
- 25 x age [0.40 – 2.60 Gyrs]
- 25 x Z [0.0004 – 0.04]





<u>Inner region</u> more metal rich and older than **<u>outer region</u>**

Age = 2 Gyr Z = 0.25 $Z_\odot$

Age = 1.4 Gyr Z = 0.1 $Z_\odot$

If this is the case…. Monolithic collapse (cold gas accretion at z>2-3 – violent starburst) is favoured

<u>What we need for discriminating models of galaxy formation?</u>

FUTURE: WHAT WE NEED

With respect to HST

1. Lower mass galaxies → Larger collecting area.
2. More accurate sampling of abs lines. → Higher spectral resolution
3. 2D view of galaxies. → IFU spectra

WHAT WE HAVE

WFC3@HST:

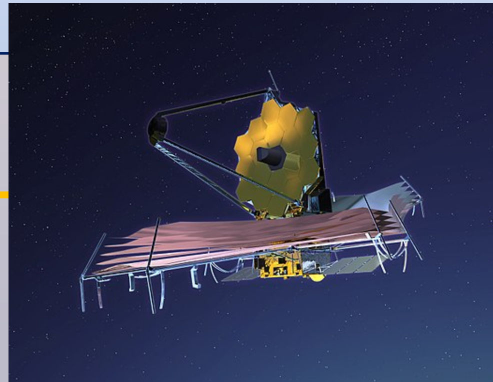
- D = 2.4 m
- t_{exp}= 17ksec (≃ 5 hours)
- S/N = 45/px → S/N = 1/ Å
- 1D spectra

FUTURE: WHAT WE NEED

With respect to HST

1. Lower mass galaxies → Larger collecting area.
2. More accurate sampling of abs lines. → Higher spectral resolution
3. 2D view of galaxies. → IFU spectra

WHAT IS COMING



NIRSPEC@JWST

1. 7 time larger collecting area (vs HST)
2. Medium spectral resolution - R≈1000
3. 1D spatial spectra

Spatial pixel size = 0.1 arcsec
Multiplexing capability (3.4′ x 3.5′ field)

FUTURE: WHAT WE NEED

With respect to HST

1. Lower mass galaxies → Larger collecting area.
2. More accurate sampling of abs lines. → Higher spectral resolution
3. 2D view of galaxies. → IFU spectra

WHAT IS COMING

MOSAIC@ELT

1. 20 time larger collecting area (vs VLT)
2. High spectral resolution - R≈5000
3. IFU (2" x 2" field)

Spatial pixel size < 0.1 arcsec
Multiplexing capability

FEASIBILITY

NIRSPEC@JWST

INPUT:

- Passive SED @z=1.8
- H_{AB} = 22 mag/arcsec^2
- R ≈ 1000

OUTPUT

- S/N = 10 per spectral resolution element (≃ 15 Å)
  per spatial resolution element (< 0.1″)

Total exp time = 5 h

(>10 targets)

FEASIBILITY

MOSAIC@E-ELT

INPUT:

- Passive SED @z=1.8
- H_{AB} = 22 mag/arcsec^2
- R ≈ 5000

OUTPUT

- S/N = 7 per spectral resolution element (≃ 3 Å)
  per spatial resolution element (< 0.1″)

  Total exp time = 20 h !!

- S/N = 10

  Total exp time = 40 h !!

(10 targets)

THANKS