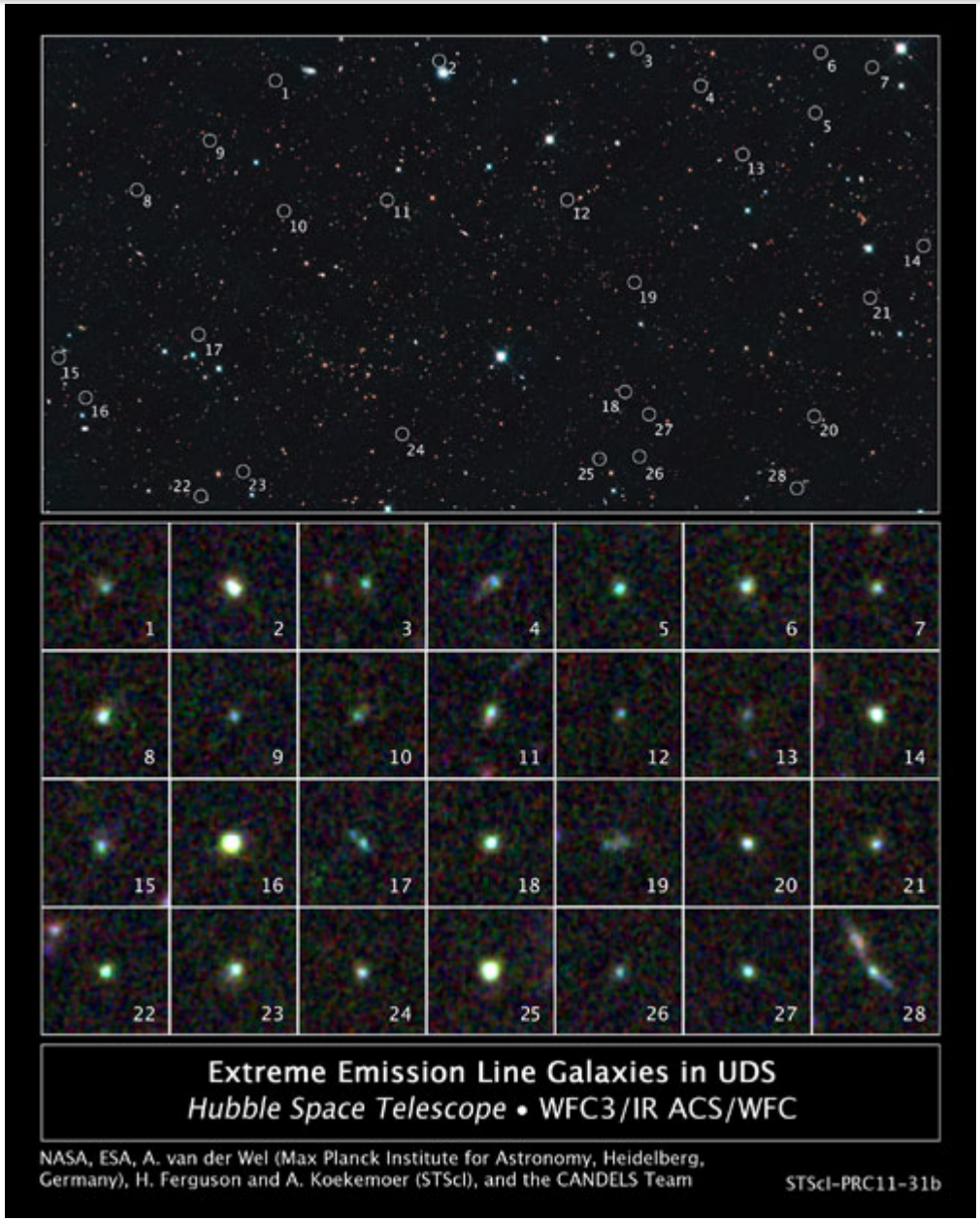
Universidad Complutense Madrid

EMIR



Good science with EMIR-2017

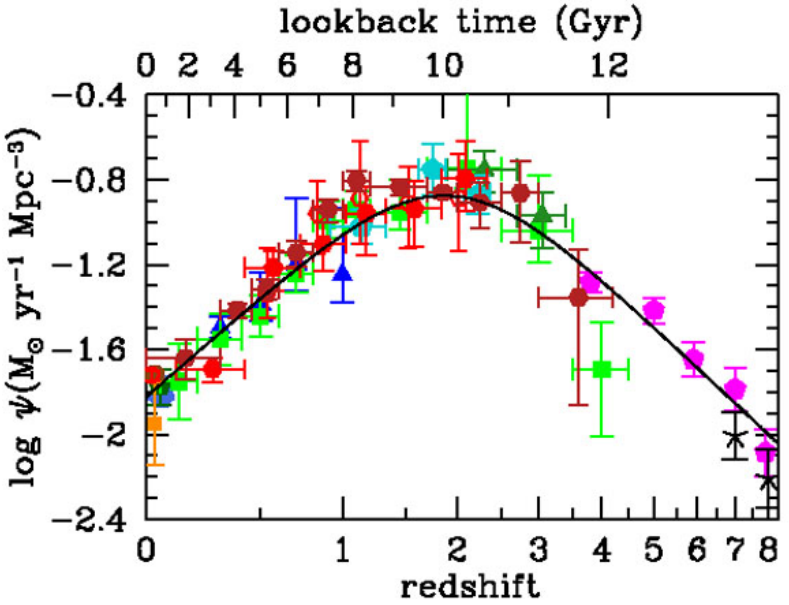
Dwarf galaxies at redshift 1-2

J. Gallego
& GOYA Dwarfs team

Goya

Classic IR-MOS Science

- Redshift desert 1.4<z<3.8
  - Cosmic SFR
  - AGN activity
  - Galaxy growth
  - Mass assembly
  - Morphological differentiation



ALL culminate at z–2

Madau & Dickinson 2014

- Very high redshift
- Massive ETGs

The standard approach 2017

- **MOSDEF** MOSFIRE Atek et al. (2014, 2017)
  1,500 objects. H(AB)<24. 1.4<z<3.8
  47 Keck nights. Flux 1e-18. 1h in J, 2h in K band.
- **FMOS-COSMOS** FMOS J,H Silvermann et al.
- **FIRE** FIRE/MAGELLAN Masters et al.
- **WISP** WFC3/HST Atek et al. (2014b)
- **FastSound** FMOS Tonegawa+2015
  4,000 obj. J, H, z=1.2-1.5 phot-z+color selec. Metallicities
- **CF-HiZELS** MOSFIRE Sobral et al. 2015
  3,500 Ha ELGs NB selected z=0.8 for Ha
- **KMOS** 5 GTO projects Wisnioski et al

IR-MOS 2017
Extreme populations

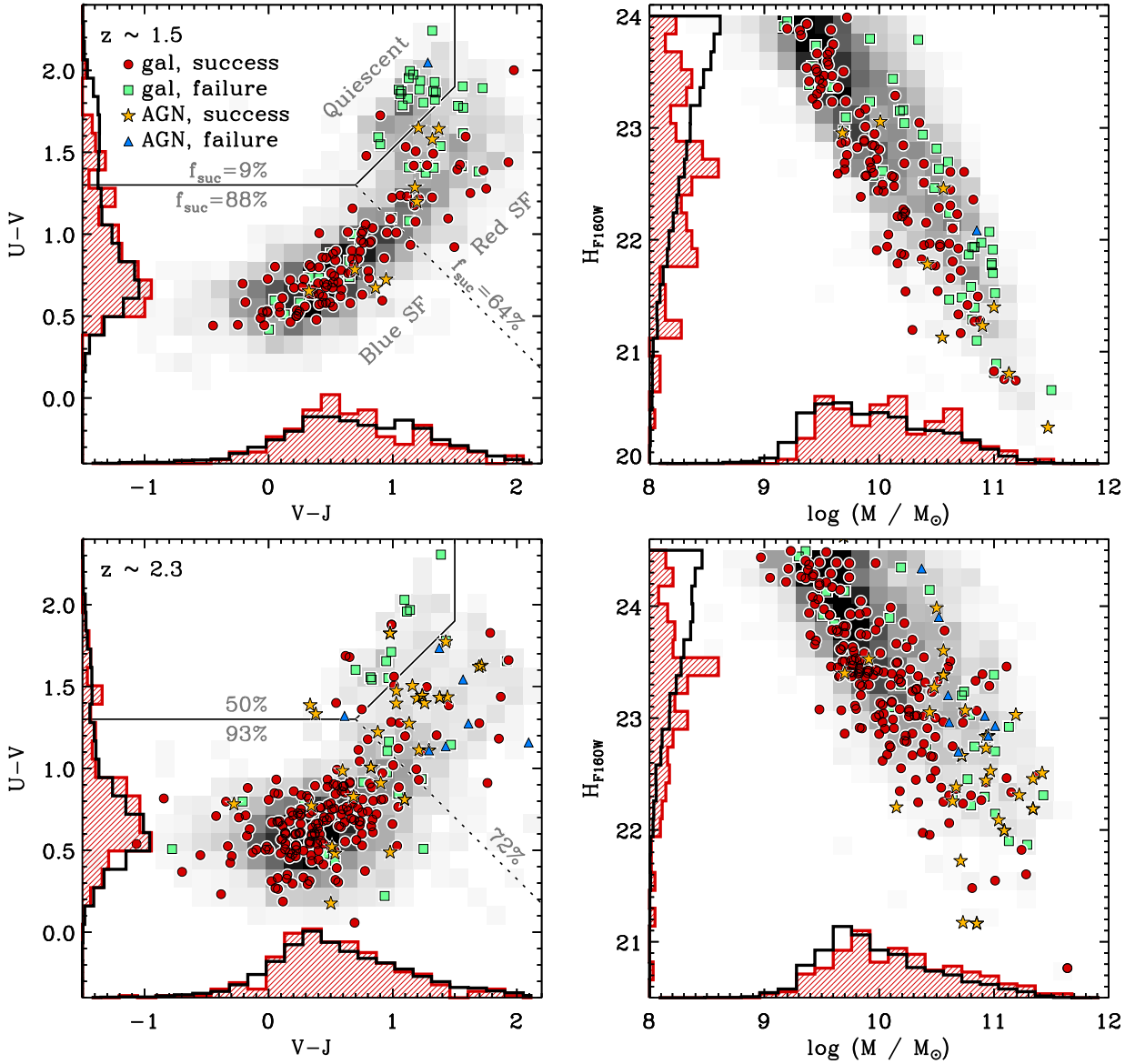
- Ultra-faint UV galaxies at z≈2 (Alavi+14)
- Very strong ELGs (Atek+11)
- Hα emitters at z≈4 (Shim+11)

- Dwarf galaxies (extreme starburts, Atek+14)
  Extreme ELGs (Van der Wel+11)

Galaxy Evolution: dwarf galaxies



EMIR-2017: How to proceed?



(U-V) (V-J) diagram

Wuyts et al (2006)

MOSDEF (Krieck et al 2014)

1,500 objects. H(AB)<24.

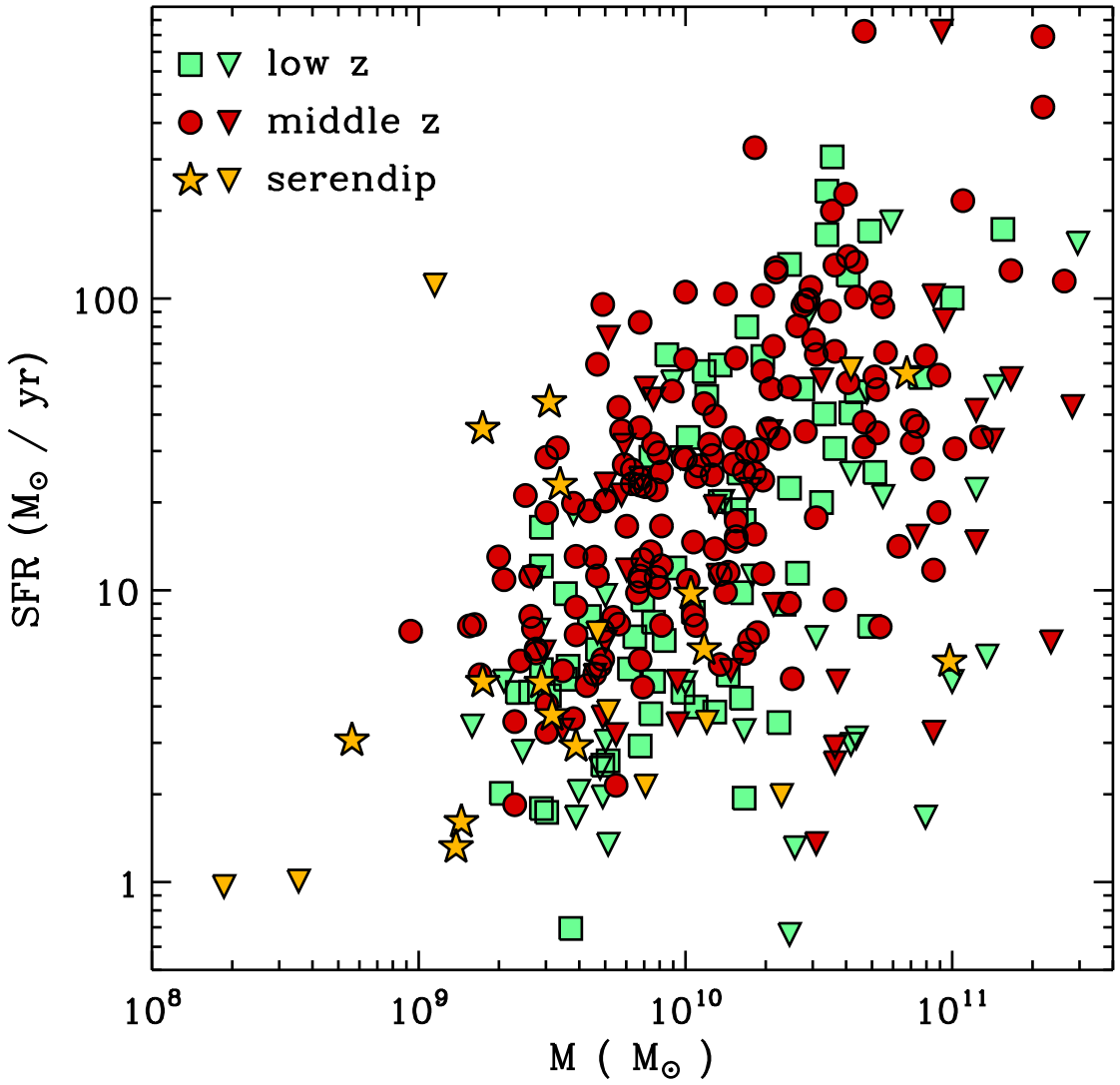
1.4<z<3.8

47 Keck nights. Flux 1e-18.

1h in J, 2h in K band.

- Go fainter
- Different selection technique
- Brand-new science

EMIR-2017: How to proceed?

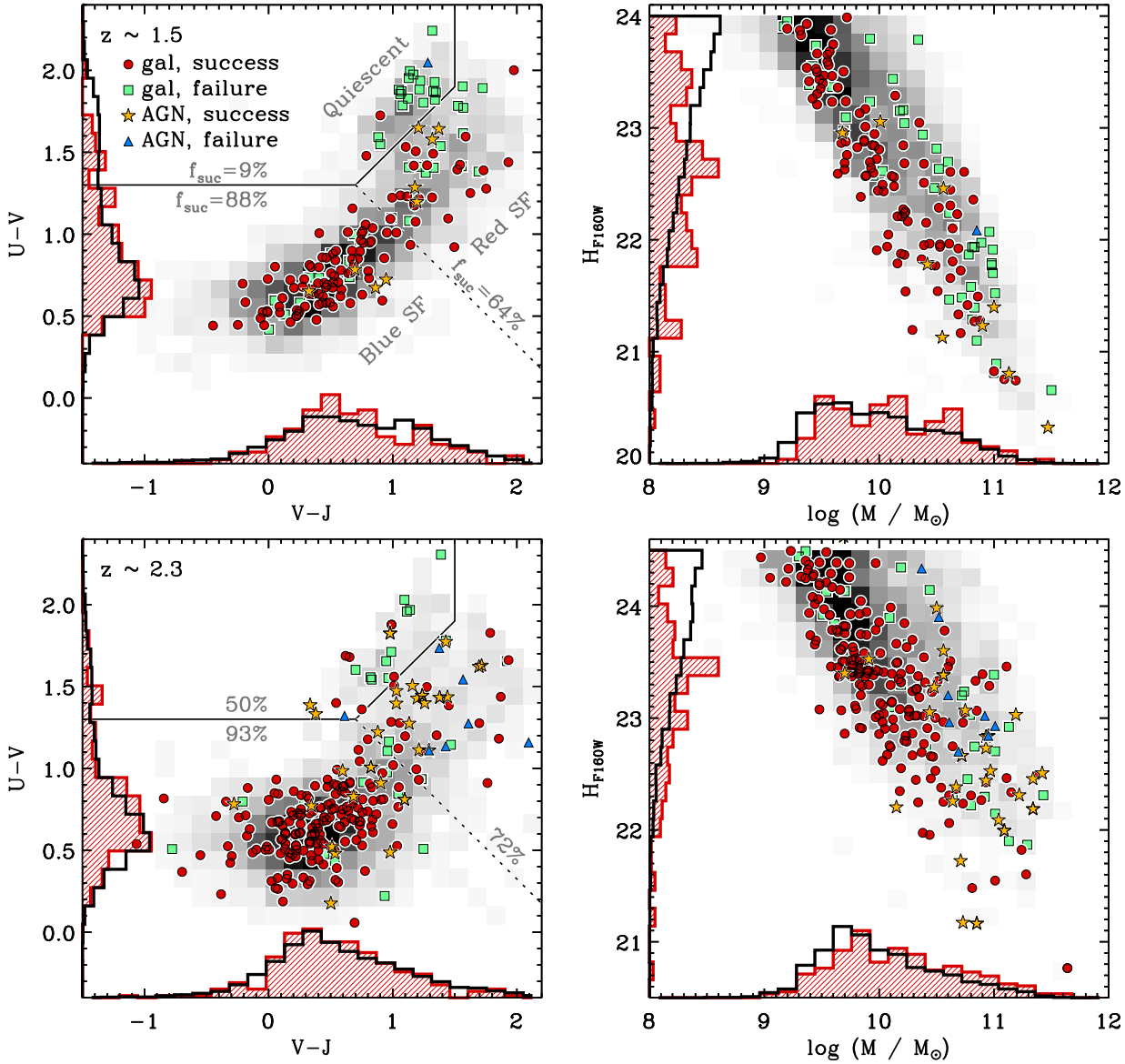


SFG Main sequence

Noeske et al (2007)
MOSDEF (Krieck et al 2014)
1,500 objects. H(AB)<24.
1.4<z<3.8
47 Keck nights. Flux 1e-18.
1h in J, 2h in K band.

- Go fainter
- Different selection technique
- Brand-new science

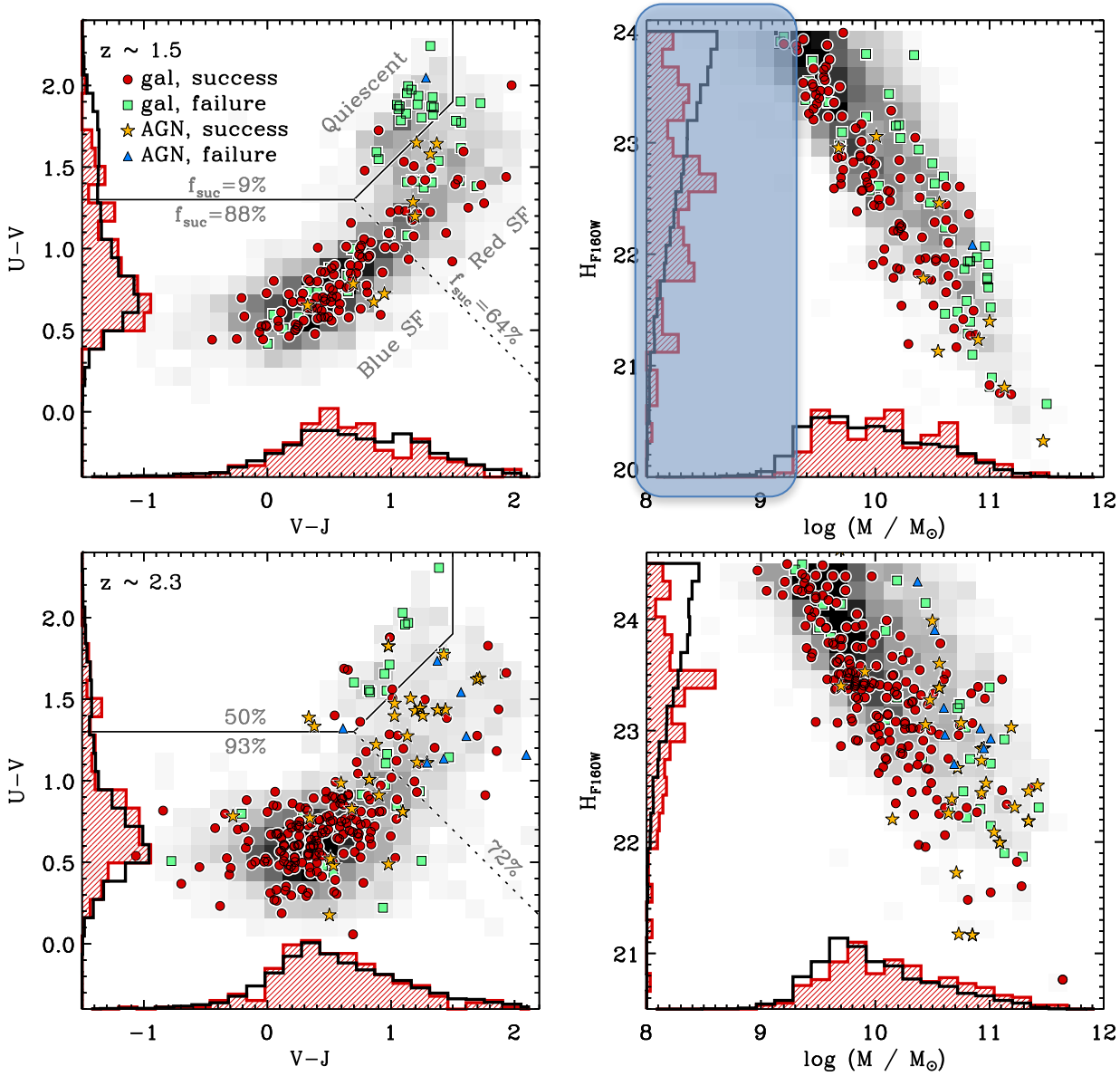
EMIR-2017: How to proceed?



MOSDEF (Krieck et al 2014)

- Go fainter
- Different selection technique
- Brand-new science

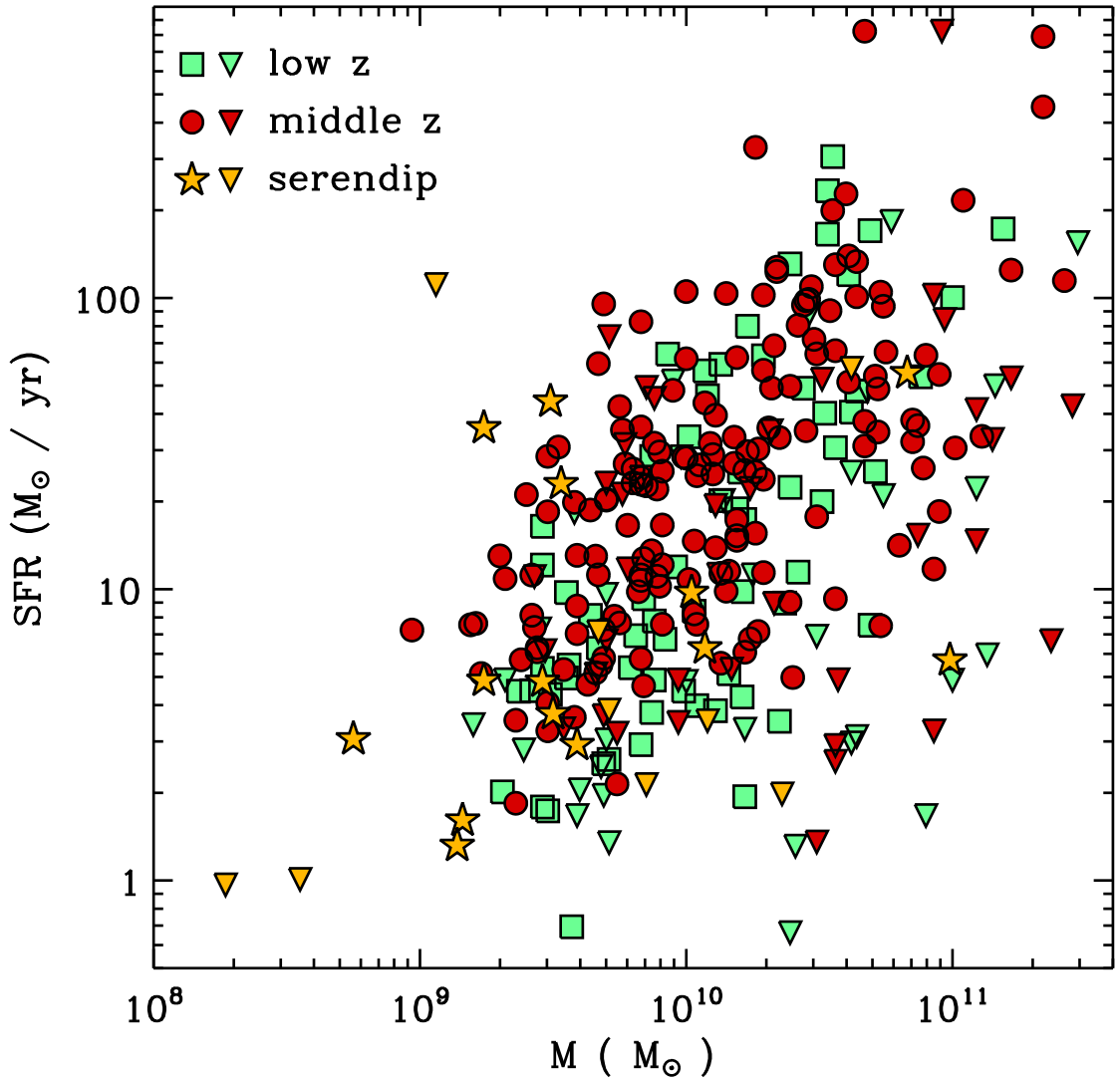
EMIR-2017: How to proceed?



MOSDEF (Krieck et al 2014)

- Go fainter
- Different selection technique
- Brand-new science

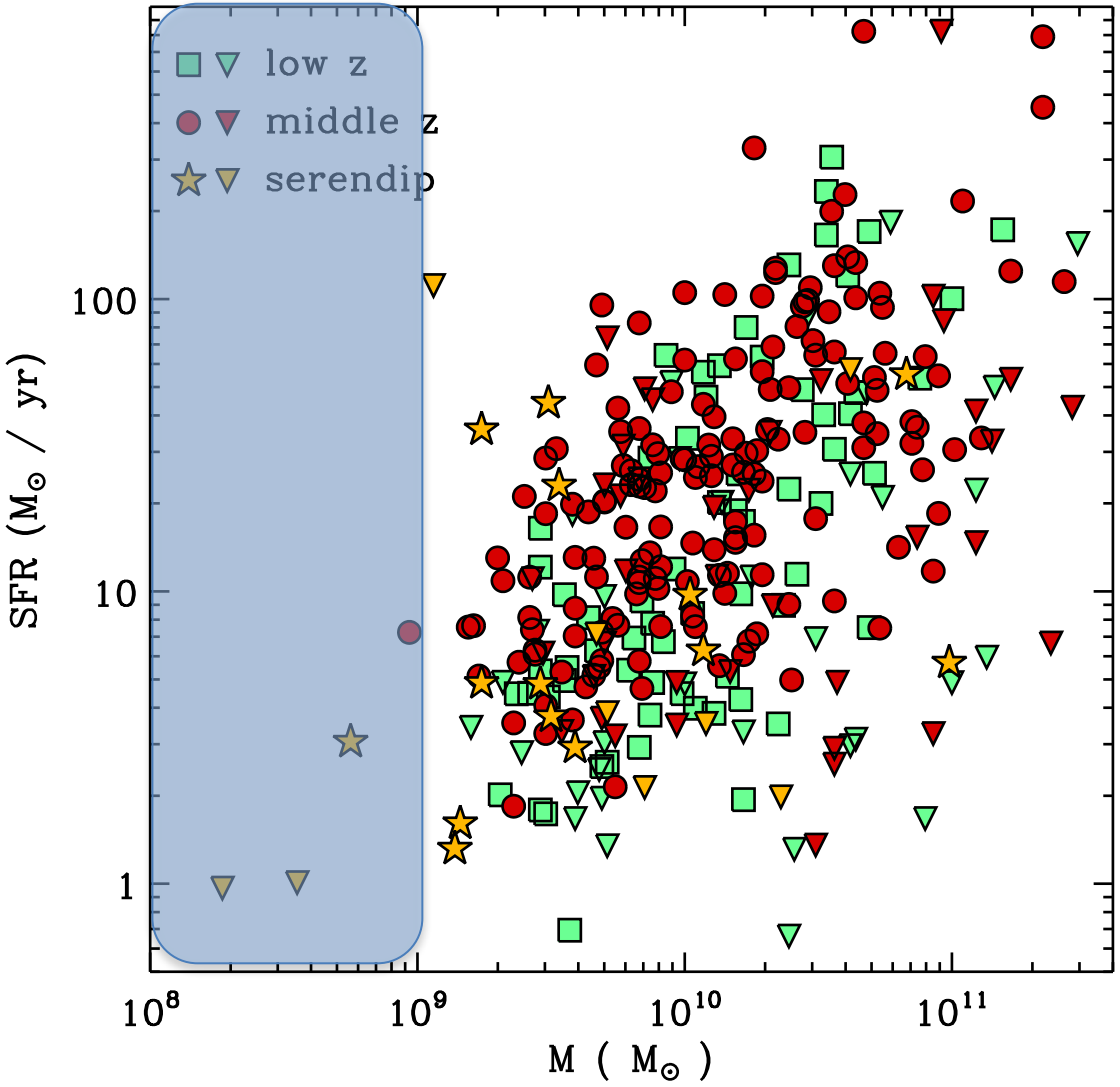
EMIR-2017: How to proceed?



MOSDEF (Krieck et al 2014)

- Go fainter
- Different selection technique
- Brand-new science

EMIR-2017: How to proceed?



MOSDEF (Krieck et al 2014)

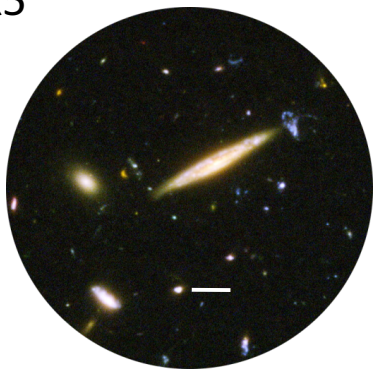
- Go fainter
- Different selection technique
- Brand-new science

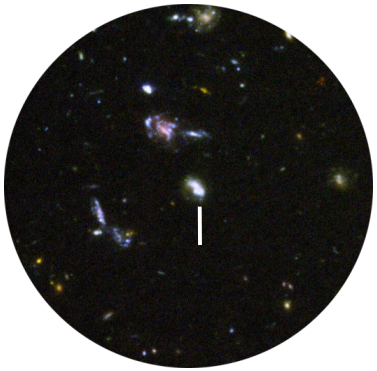
GOYA LMSFGs Summary

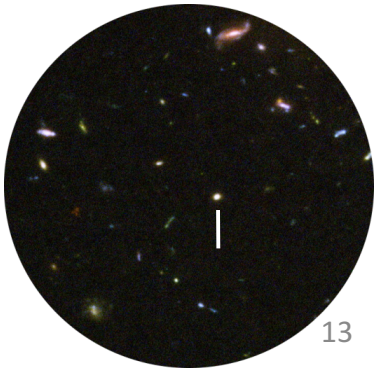
- **Goal:** Formation redshift, assembly and cosmic role of dwarfs
- **Project:** Spectroscopy of a sample of low-mass SFGs
  - nIR MOS spectroscopy of low mass (log M_* < 9) star-forming galaxies at intermediate z (0.7 < z < 1.7)
    - J band Halpha redshift 0.7 – 1.0
    - H band Halpha redshift 1.3 – 1.7
  - High spatial density: ideal for fillers
  - Ancillary data provides z, SEDs and preliminary distances and stellar masses
- **Products:** Equivalenth widths and fluxes of Ha+NII ELs
- **Results:**
  - Current dominant star-formation activity
  - Stellar mass assembly
  - Environment role on the stellar quenching of these galaxies

Low Mass SFGs: science case for EMIR-2017

HST, 5”x5”







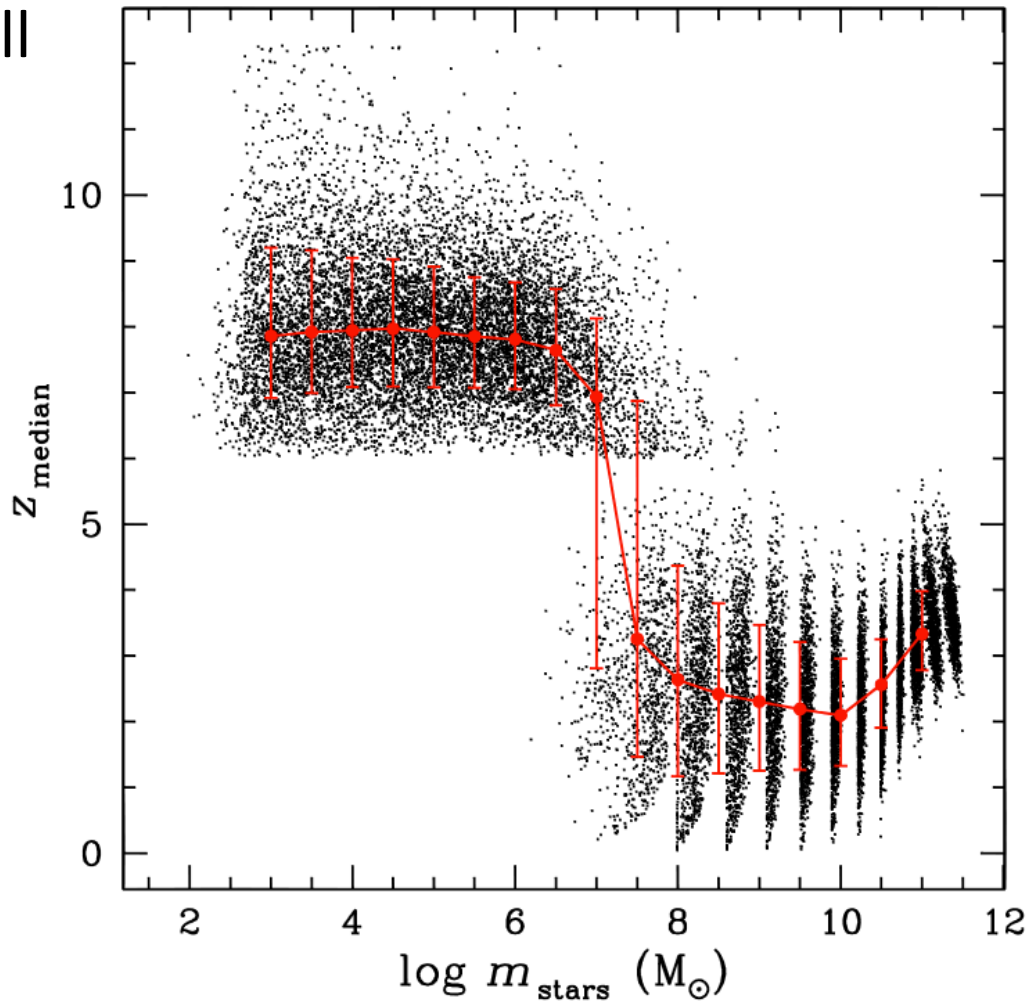
1. Low-mass galaxies are the most poorly known.
   - Very faint and small, difficult to observe
   - Studies biased to local samples

2. Similar to first galaxies. Reionization.

No unique definition of Dwarf galaxy
- Luminosity (MB> -18.5 mag) / size (~1kpc) / mass ($M^* < 10^9$-$10^{9.5}$ M^*).

Low Mass SFGs: science case for EMIR-2017

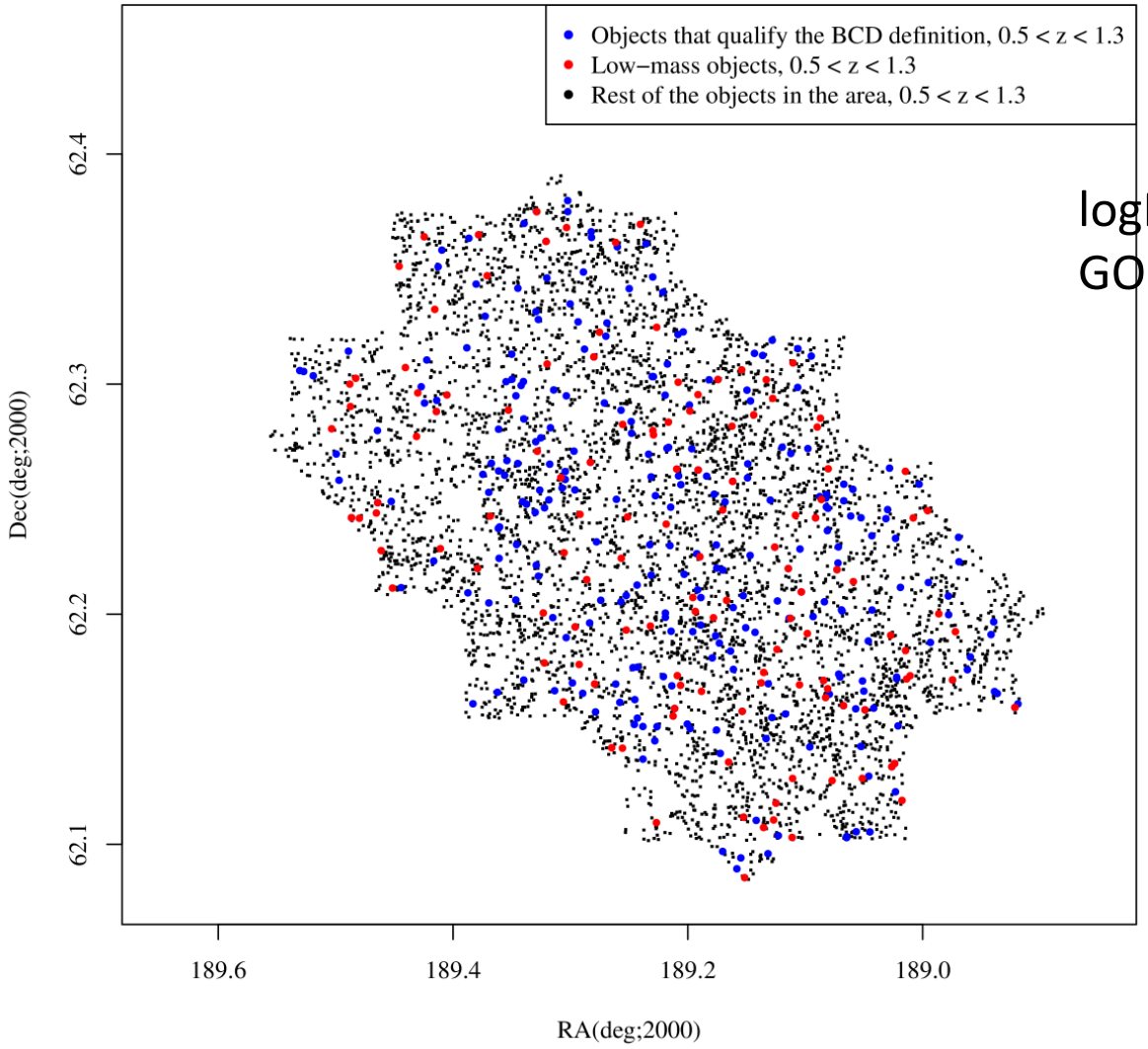
1. Mass assembly not well understood.
   - Early assembly (z=6, Dekel & Silk 1986)
   - Delayed assembly until z=1 (Kepner et al 1997)
   - Mass-dependent (Mamon et al 2012)
2. Role of environment (nature or nurture?)



Mamon et al. 2012

LMSFGs: Sample characteristics

VLT/VIMOS dwarf confirmed sample
GOODS-S, Rodriguez-Muñoz et al 2015



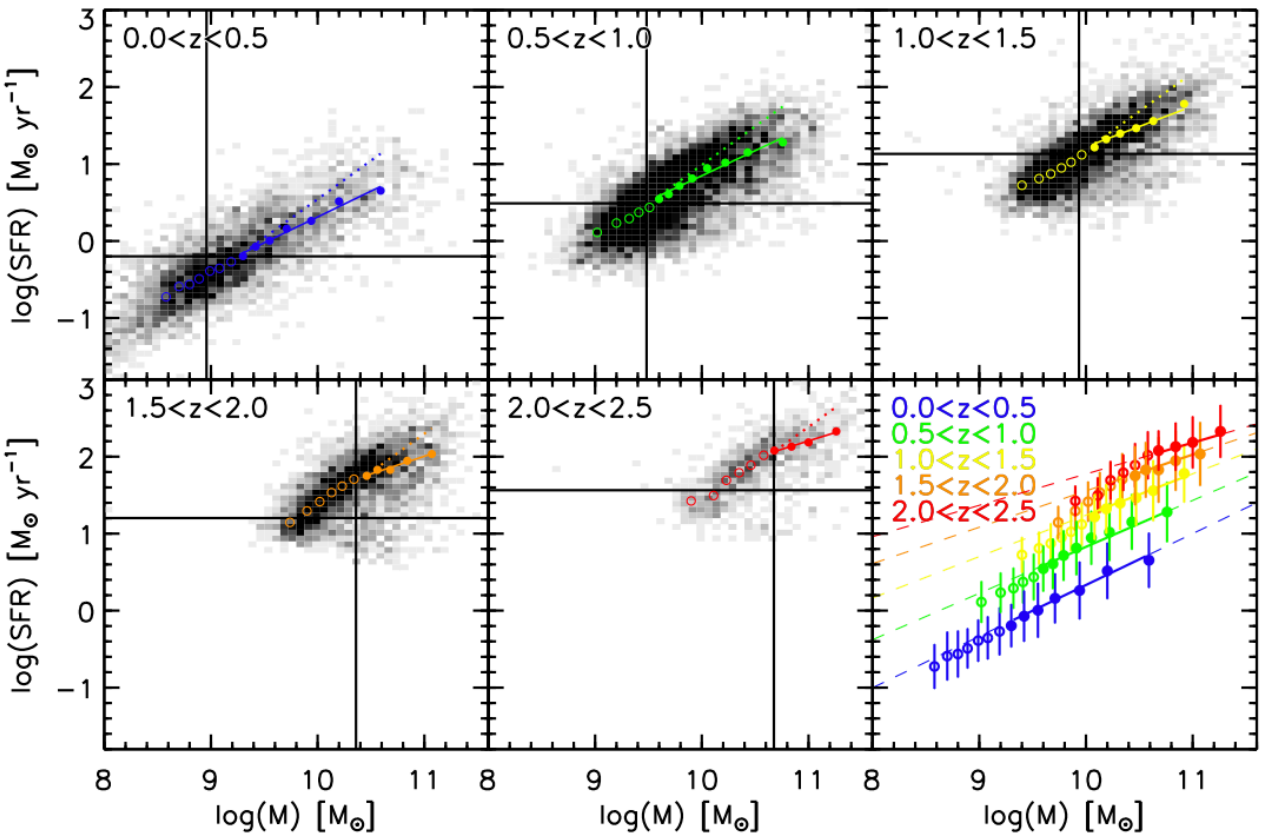
logM*<8, 0.3<phot-z<1.0; I_{AB}<26
GOODS-S 3D-HST 700 dwarfs

4,5 objects / sqr arcmin
80 targets / EMIR mask

z<1 Hα in J

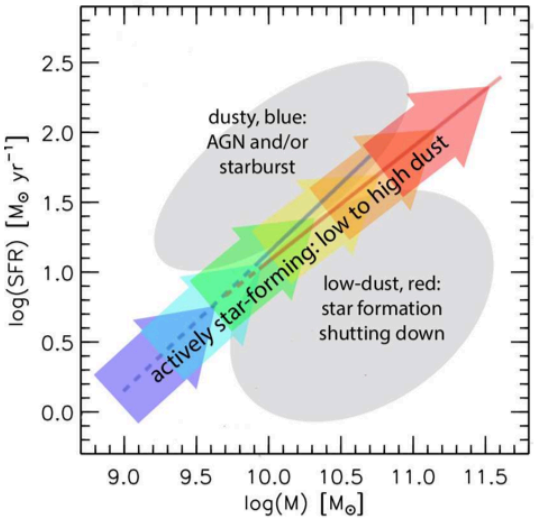
I=24.5
4h EMIR, SNR=2

LMSFGs: Sample characteristics



Noeske et al. 2007

Whitaker et al. 2012



logM*<8, 0.3<phot-z<1.0; I_{AB}<26

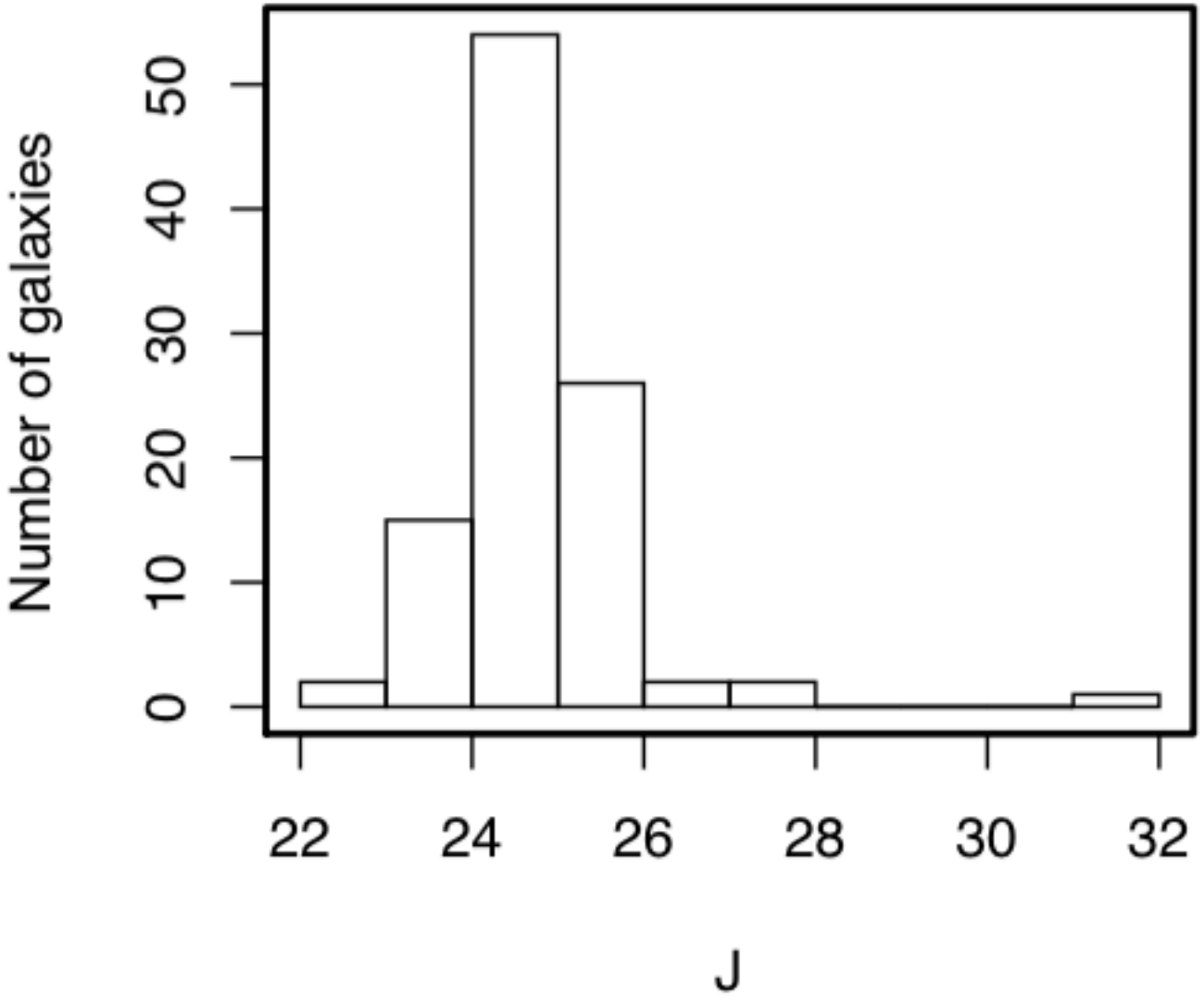
GOODS-S 3D-HST 700 dwarfs

4,5 objects / sqr arcmin

80 targets / EMIR mask

LMSFGs: Select by Stellar Mass

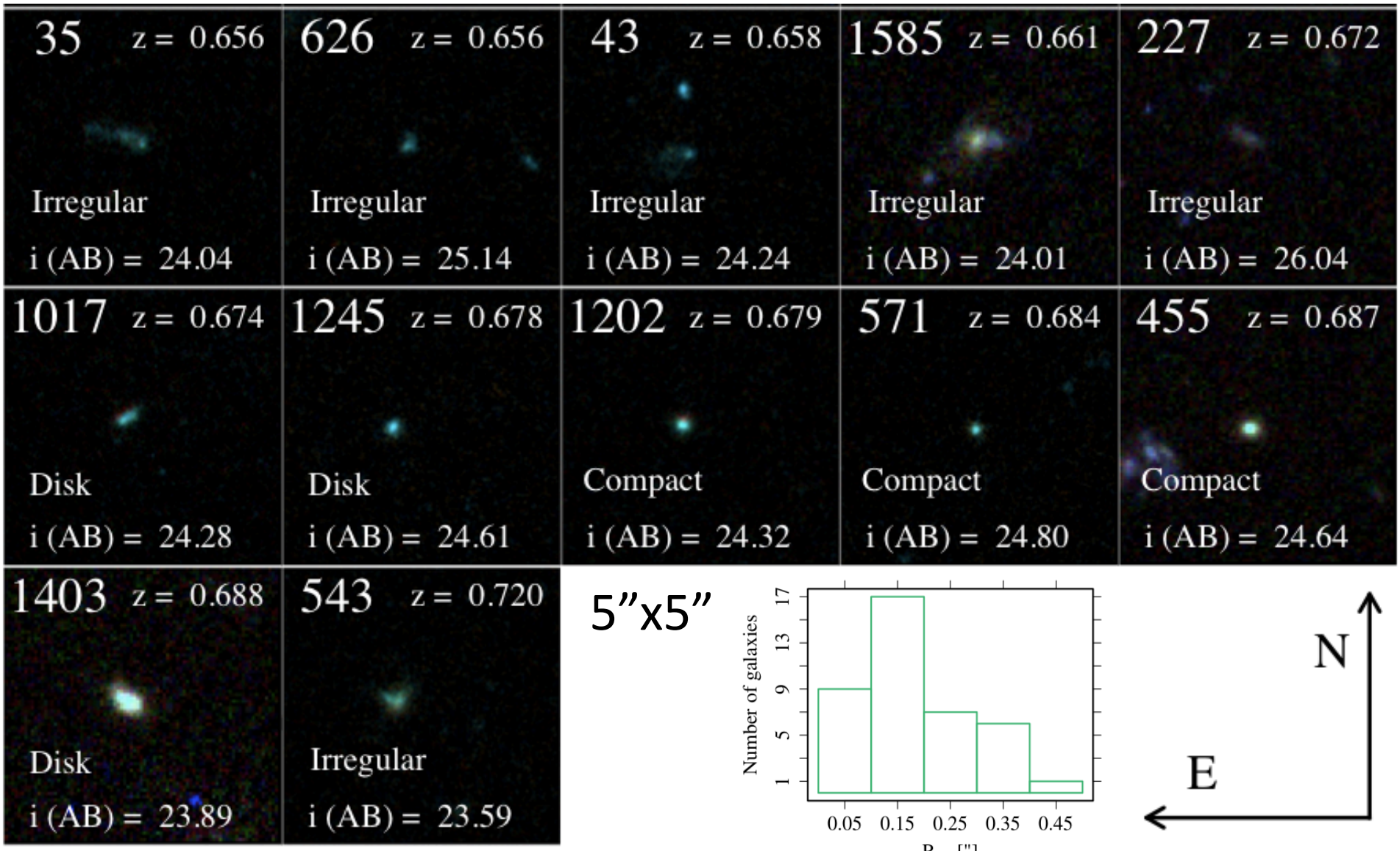
VLT/VIMOS dwarf confirmed sample
GOODS-S, Rodriguez-Muñoz et al 2015



z<1 Hα in J

I=24.5
SNR=2
4h EMIR

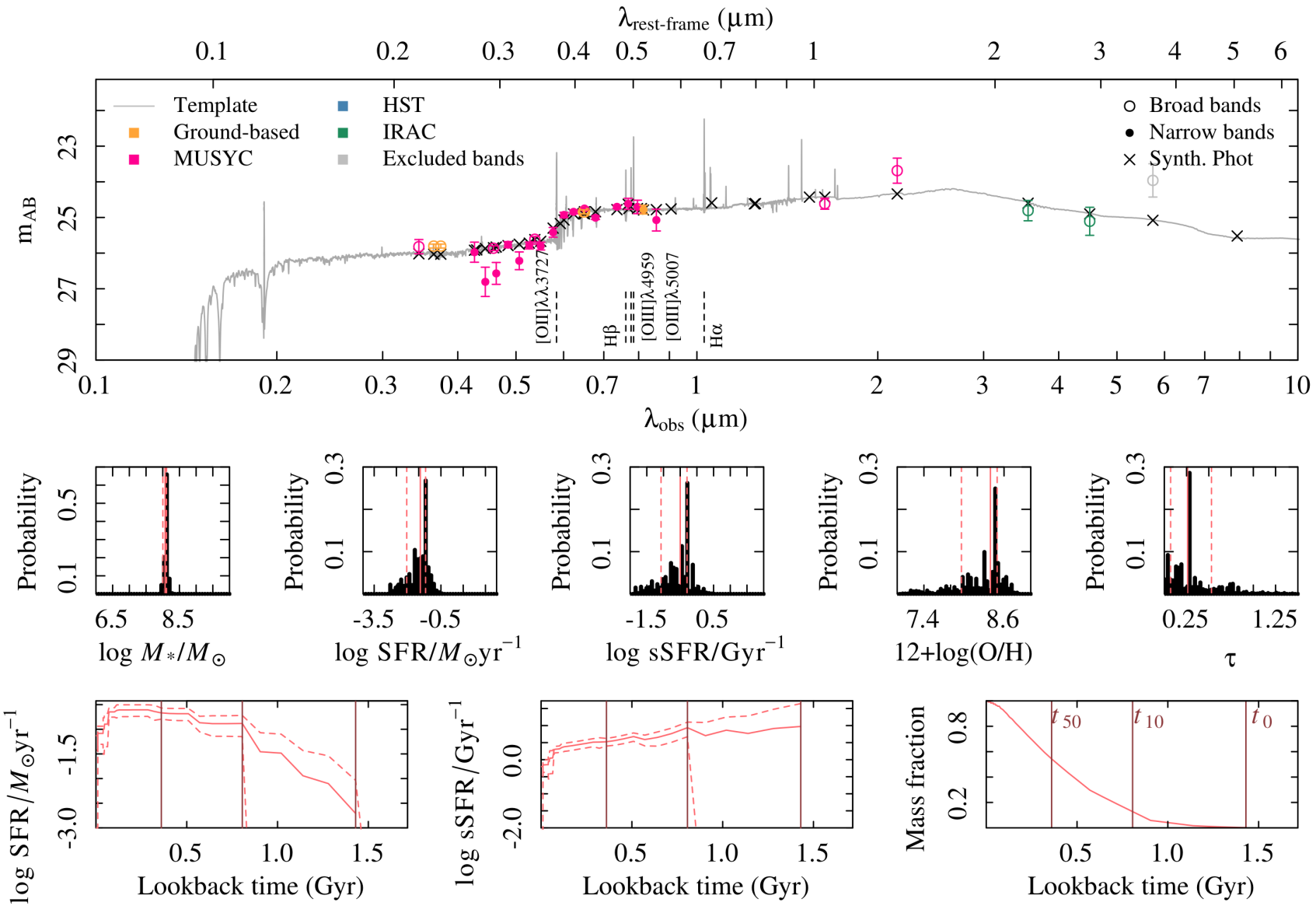
LMSFGs: Morphologies



Universidad Complutense Madrid

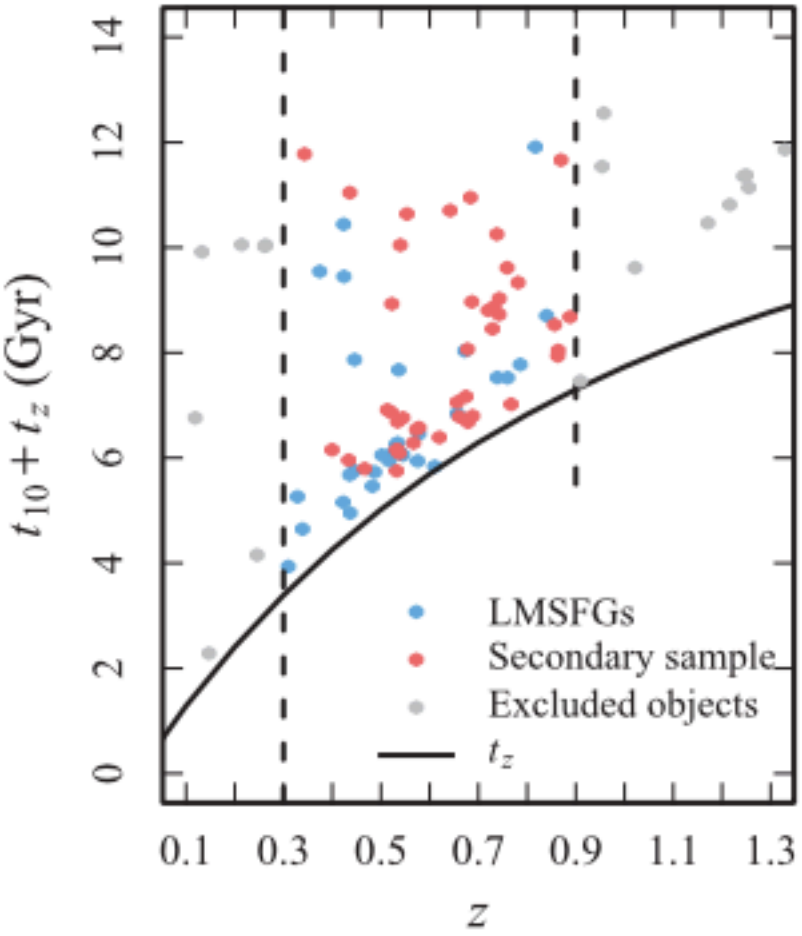
LMSFGs: Modeling

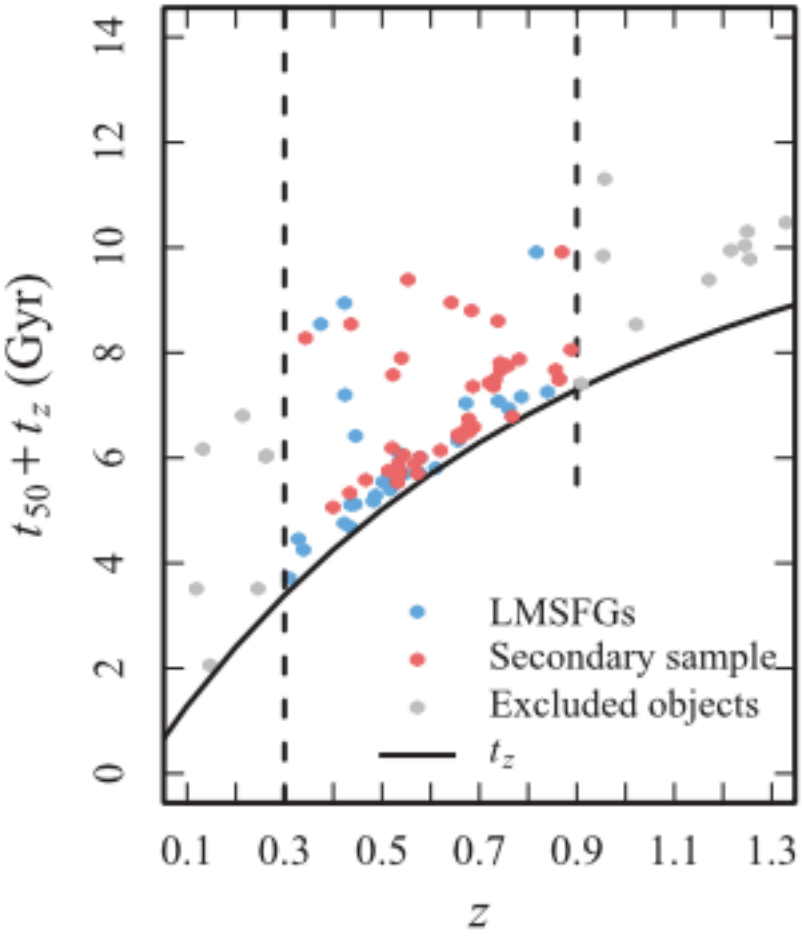
EMIR



LMSFGs: Mass assembly

VLT/VIMOS dwarf confirmed sample
GOODS-S, Rodriguez-Muñoz et al 2015





LMSFGs: Cosmic web

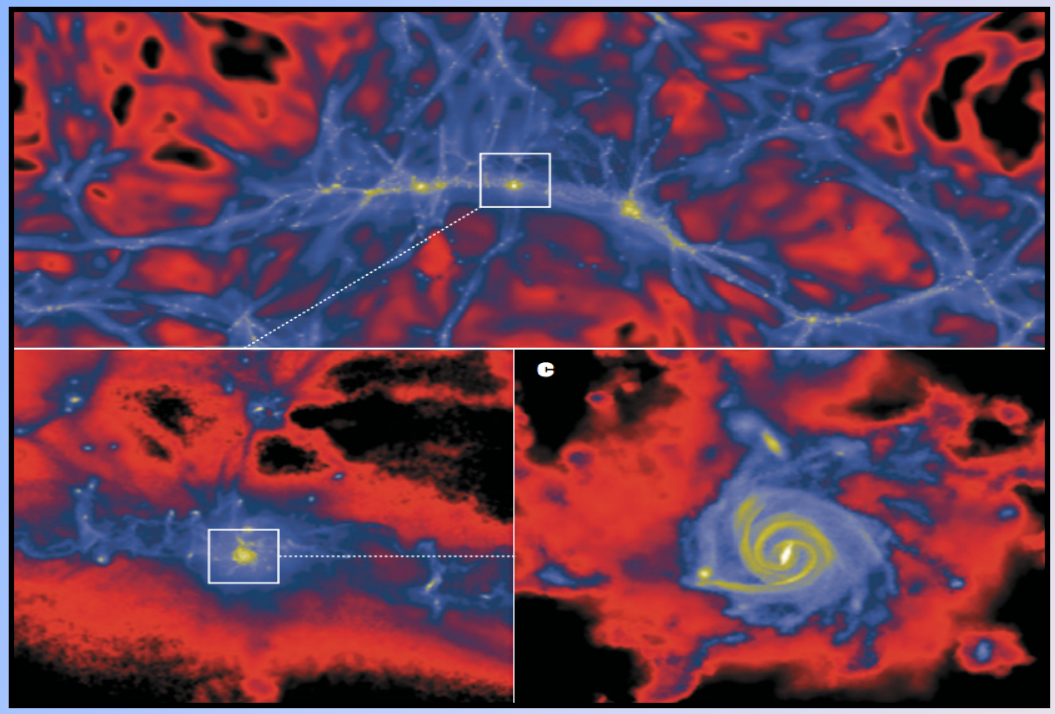
First opportunity to:

- extend previous analysis in the dwarf mass regime (7<logM<9) and

- identify their preferred locations with respect to

  the cosmic web environment (nodes, filaments and voids)

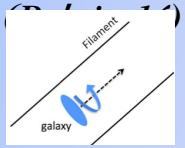
Galaxies within the Cosmic Web



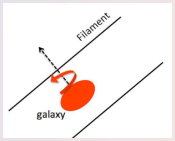
➢ **Cosmic Web : environment where galaxies form and evolve**

- **Cold streams from CW filaments** can feed high-z galaxies with 10^4 K gas disks *(Katz+03 , Keres+05,…)*
- **DM halos inherit some level of coherence from Large Scale Flows :** filamentary flows advect Angular Momentum into newly formed halos & disk of galaxies *(Hahn+07, Pichon+11, Codis+12,…..)*

- **observational evidence in SDSS with spin alignments *(Tempel+13)* and simulation** **:**



Low Mass galaxies :
spins parallel to filaments



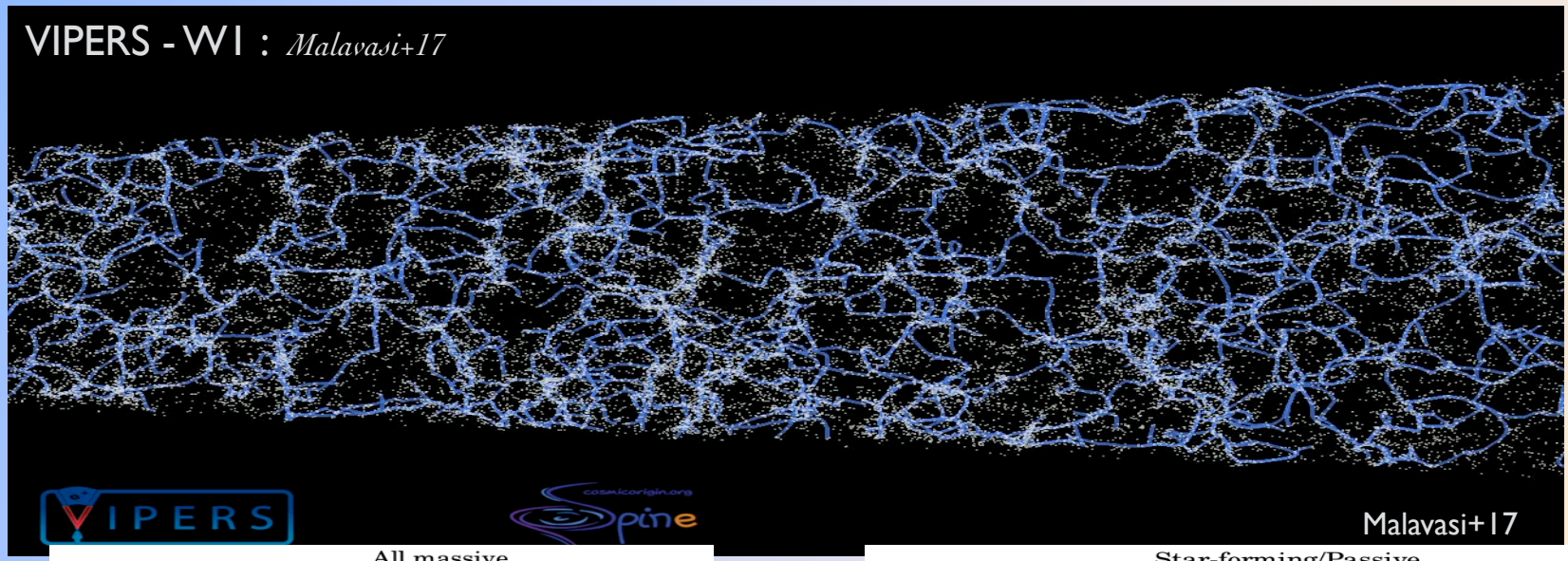
High Mass galaxies :
spins perpendicular to filaments

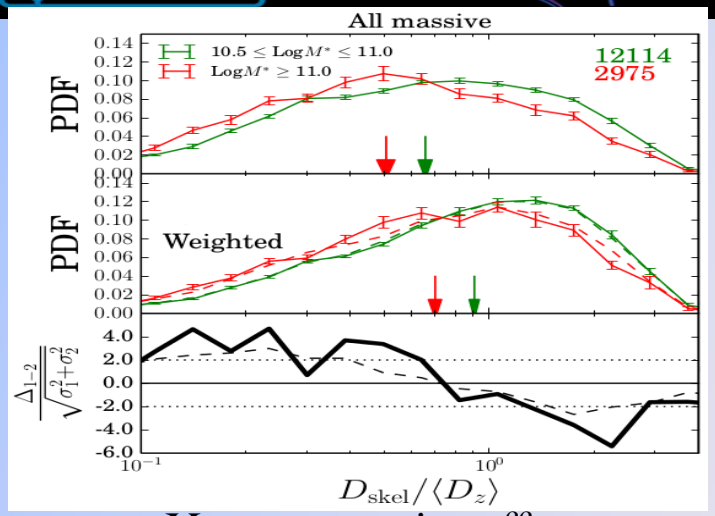
What about other properties (Mass / sSFR / …) ?

any residual effects beyond local density ?

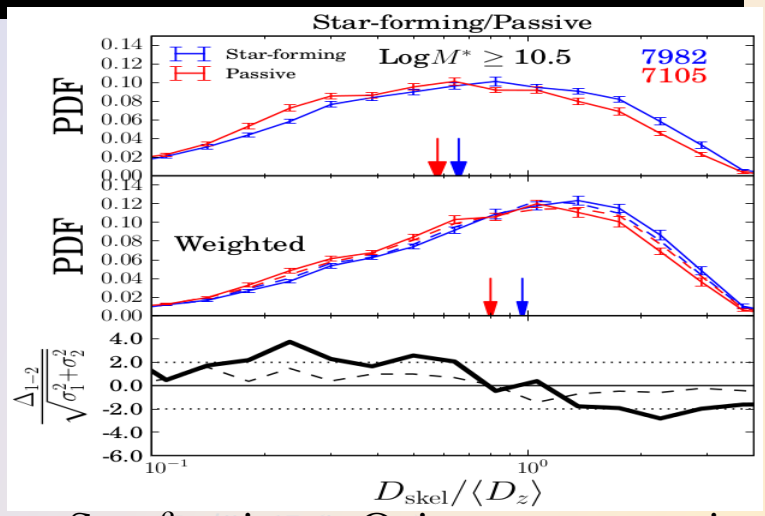
Influence of Cosmic Web : VIPERS

3D ridge Extractor extracts cosmic web features
Nodes, filaments, walls and voids *(Sousbie 2011a,b)*



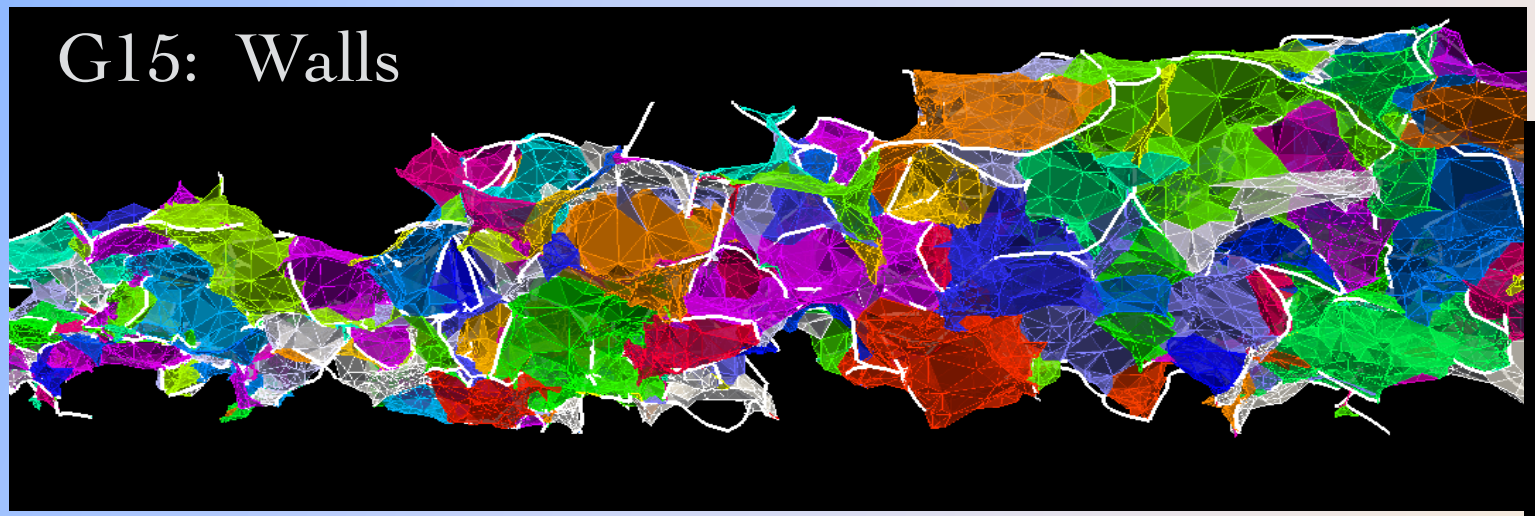


➛ Mass segregation effect

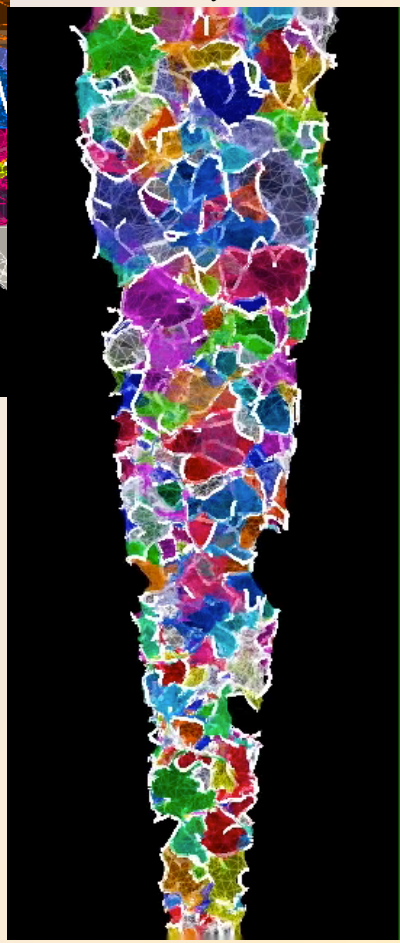


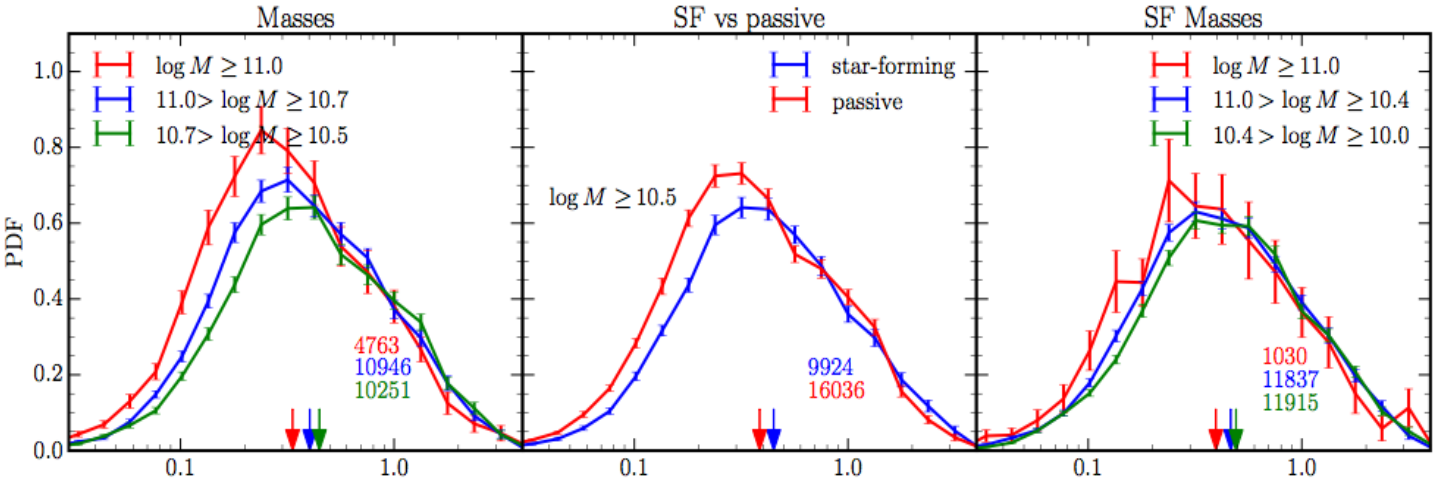
➛ Star-forming vs Quiescent segregation effect

Influence of Cosmic Web : GAMA



Kraljic +17, sub



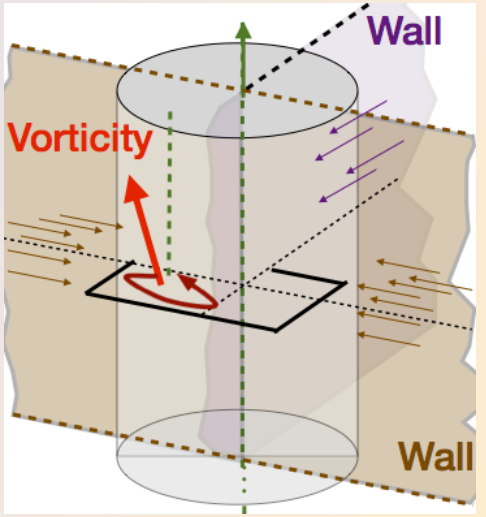


Distance to Walls

Conclusions

- **in line with current theory and hydrodynamical simulation**

(Codis+15)



Lower mass & Star-Forming galaxies prefer the outer edges of filaments

— vorticity rich regions (Pichon+99, Laigle+15)

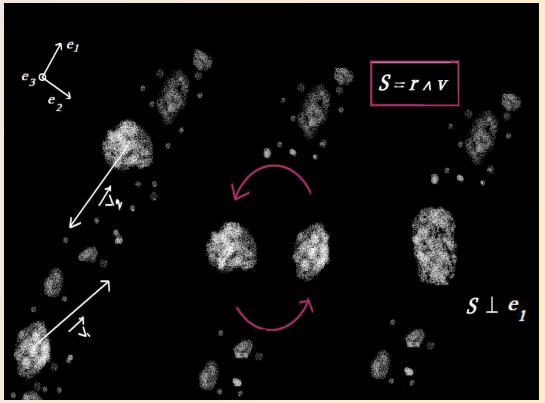
— dominated by smooth accretion (Welker+15)

Most massive or quiescent galaxies lie preferentially in the core of filaments

— where they end their stellar mass assembly

— via merging during their migrations toward nodes

(Codis+12)



- **Reveal the role of filamentary structures**

highway in which DM halos and galaxies are evolving

- **Reveal the role of large scale flows in shaping galaxy properties**

a natural framework to investigate galaxy evolution

GOYA LMSFGs Summary

- **Goal:** Formation redshift, assembly and cosmic role of dwarfs
- **Project:** Spectroscopy of a sample of low-mass SFGs
  - nIR MOS spectroscopy of low mass (log $M_* < 9$) star-forming galaxies at intermediate z ($0.7 < z < 1.7$)
    - J band Halpha redshift 0.7 – 1.0
    - H band Halpha redshift 1.3 – 1.7
  - High spatial density: ideal for fillers
  - Ancillary data provides SEDs and preliminary distances and stellar masses
- **Products:** Equivalenth widths and fluxes of ELs
- **Results:**
  - Current dominant star-formation activity
  - Stellar mass assembly
  - Environment role on the stellar quenching of these galaxies.

The standard approach EMIR-2004

GOYA: Sample limited by nIR apparent magnitude (K_vega < 22. ; M*>1e10 for z=2.5)

- Very high z
- Red objects
- AGN
- LBGs + LAEs at z=2.5
- L* Star Forming Galaxies as fillers

IR-MOS 2017: Cosmic properties evolution

- The cosmic BPT diagram (z>1.5; Kewley+13ab)
- Galaxy pairs (Morris+15)
- M* galaxy progenitors (Papovich+14)
- SF law from Ne at z≈2.5 (Shimakawa+14)

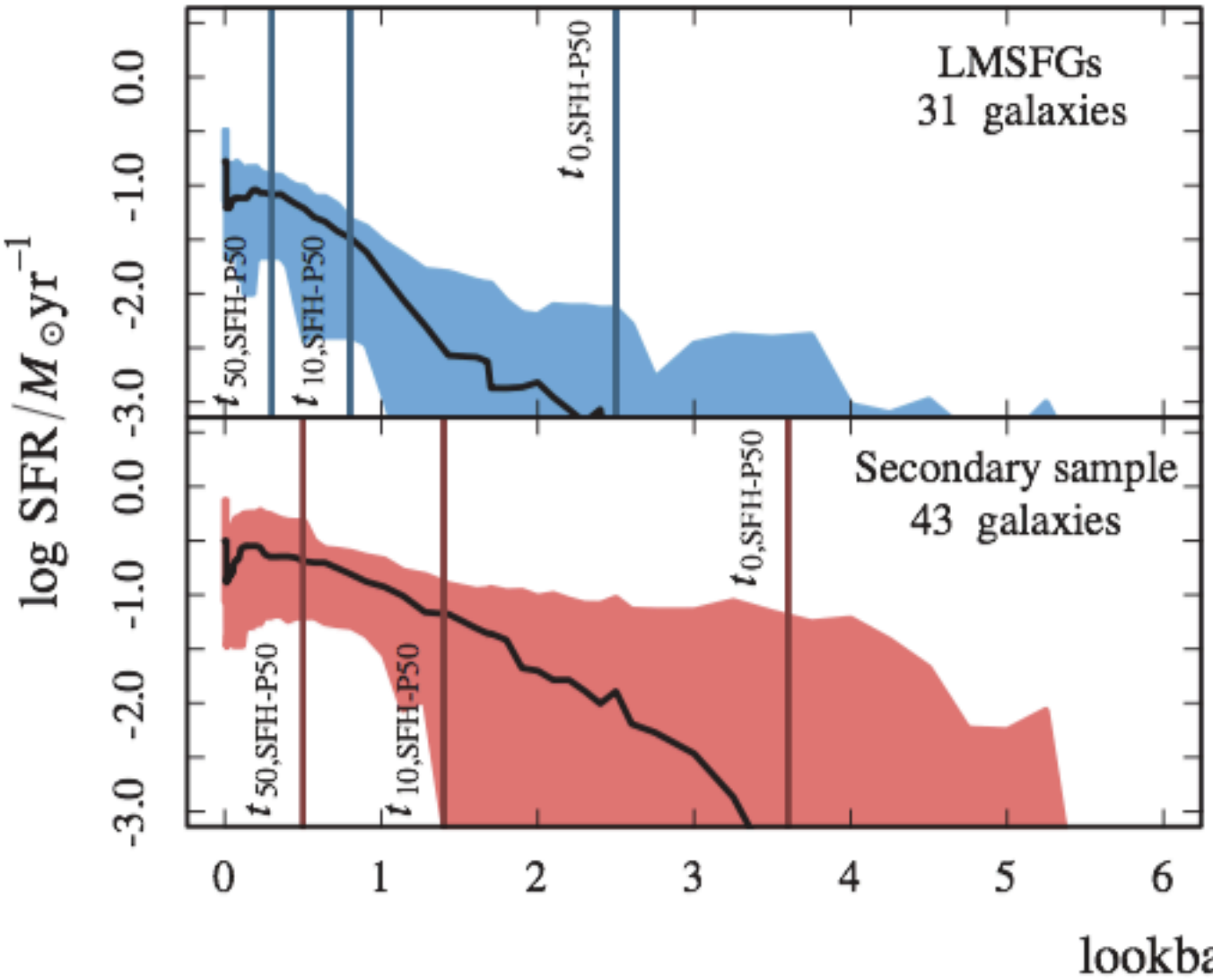
Imaging Phot-z surveys

- CANDELS — HST visible & J, H
  GOODS-N&S, UDS, EGS
  Guo et al.

- 3D-HST — HST visible & J, H
  GOODS-N&S, UDS, EGS
  Fumagalli et al.

- ZFOURGE — Magellan MediumBand-nIR
  GOODS-S, UDS, COSMOS
  Papovich et al.

LMSFGs: Mass assembly



Redshift formation of dwarf SFGs

Even further?

The Astrophysical Journal, 742:111 (10pp), 2011 December 1 doi:10.1088/0004-637X/742/2/111
© 2011. The American Astronomical Society. All rights reserved. Printed in the U.S.A.

EXTREME EMISSION-LINE GALAXIES IN CANDELS: BROADBAND-SELECTED, STARBURSTING DWARF GALAXIES AT $z > 1$

A. van der Wel[1], A. N. Straughn[2], H.-W. Rix[1], S. L. Finkelstein[3], A. M. Koekemoer[4], B. J. Weiner[5], S. Wuyts[6], E. F. Bell[7], S. M. Faber[8], J. R. Trump[8], D. C. Koo[8], H. C. Ferguson[4], C. Scarlata[9], N. P. Hathi[10], J. S. Dunlop[11], J. A. Newman[12], M. Dickinson[13], K. Jahnke[1], B. W. Salmon[3], D. F. de Mello[14,15], D. D. Kocevski[8], K. Lai[8], N. A. Grogin[4], S. A. Rodney[16], Yicheng Guo[17], E. J. McGrath[8], K.-S. Lee[18], G. Barro[8], K.-H. Huang[16], A. G. Riess[4,16], M. L. N. Ashby[19], and S. P. Willner[19]

ABSTRACT

We identify an abundant population of extreme emission-line galaxies (EELGs) at redshift $z \sim 1.7$ in the Cosmic Assembly Near-IR Deep Extragalactic Legacy Survey imaging from *Hubble Space Telescope*/Wide Field Camera 3 (*HST*/WFC3). Sixty-nine EELG candidates are selected by the large contribution of exceptionally bright emission lines to their near-infrared broadband magnitudes. Supported by spectroscopic confirmation of strong [O III] emission lines—with rest-frame equivalent widths ~1000 Å—in the four candidates that have *HST*/WFC3 grism observations, we conclude that these objects are galaxies with $\sim 10^8\ M_\odot$ in stellar mass, undergoing an enormous starburst phase with $M_*/\dot{M}_*$ of only ~15 Myr. These bursts may cause outflows that are strong enough to produce cored dark matter profiles in low-mass galaxies. The individual star formation rates and the comoving number density (3.7×10^{-4} Mpc^{-3}) can produce in ~4 Gyr much of the stellar mass density that is presently contained in 10^8–$10^9\ M_\odot$ dwarf galaxies. Therefore, our observations provide a strong indication that many or even most of the stars in present-day dwarf galaxies formed in strong, short-lived bursts, mostly at $z > 1$.

Redshift formation of dwarf SFGs

z=1.6 - 1.8 low-mass SFGs

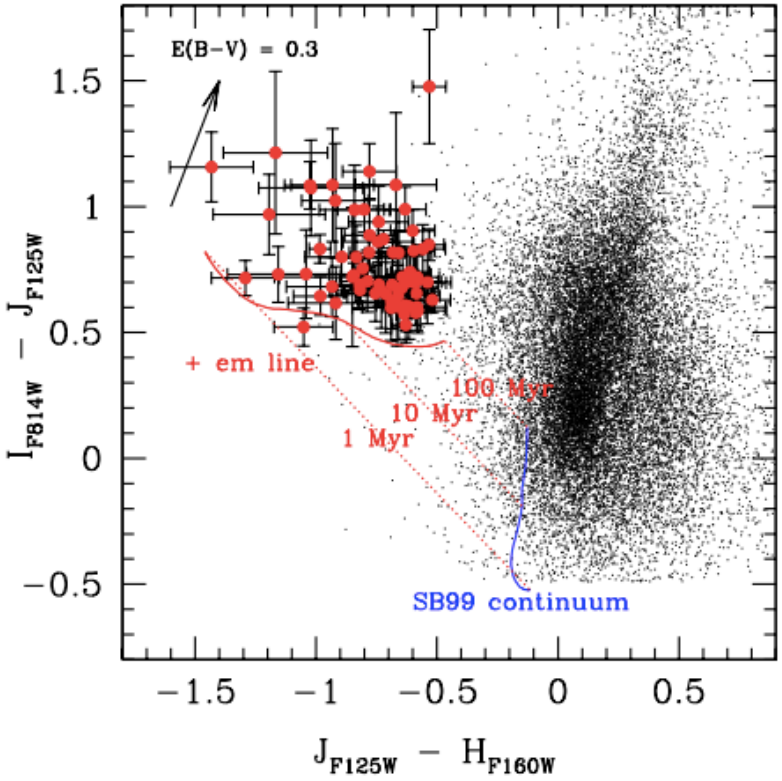


Figure 1. Observed $I - J$ vs. $J - H$ colors (in AB magnitudes) from HST/WFC3 and ACS imaging for all objects in the UDS and GSD (small black points) and the sample of emission-line dominated objects (large red points with error bars), selected by $I - J > 0.44 + \sigma(I - J)$ and $J - H < -0.44 - \sigma(J - H)$, where $\sigma(I - J)$ and $\sigma(J - H)$ are the 1σ errors on the colors. The blue line represents the redshifted ($z \sim 1.5$) continuum colors of the Starburst99 model (Leitherer et al. 1999) for continuous star for-

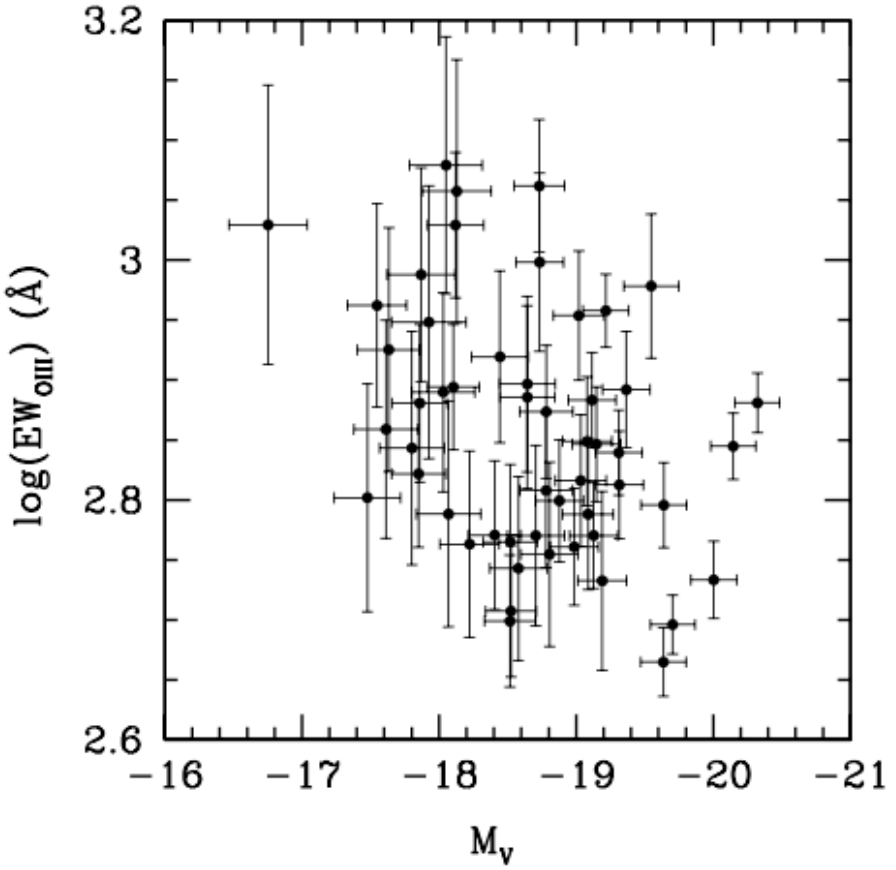


Figure 5. Rest-frame V-band luminosity vs. rest-frame equivalent width of the [OIII] emission line at 5007Å as calculated from the broad-band photometry as explained in the text and assuming that all emission-line galaxy candidates are at $z = 1.7$. They span a range in luminosity, $M_v = -17$ to $M_V = -20$, and have $EW_{[OIII],5007}$ between 500Å and 1200Å. See also Table 1.