THE SFH OF RED AND DEAD GALAXIES AT z=1.0 - 1.5

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2nd SHARDS Meeting

INTRODUCTION

- **Quiescent galaxies** dominate the massive end of the local MF: **fundamental** in galaxy formation and evolution

- Existence of massive quiescent galaxies at high z (> 1) in **disagreement with theoretical expectations**

- **Challenge observations**: faint in the optical; important degeneracies using photometry (age-dust-metallicity); spectra very time consuming (~ 12 h per galaxy)

- Up to date works rely on **small samples or stacked spectra** (Cimatti + 2008, Whitaker + 2013, Mendel + 2015)

- **SHARDS data especially designed** to measure spectral features which help breaking degeneracies (MgUV, D4000)

- Wish to confirm existence of old passive population at high-z, **how were they formed** (SFH)?

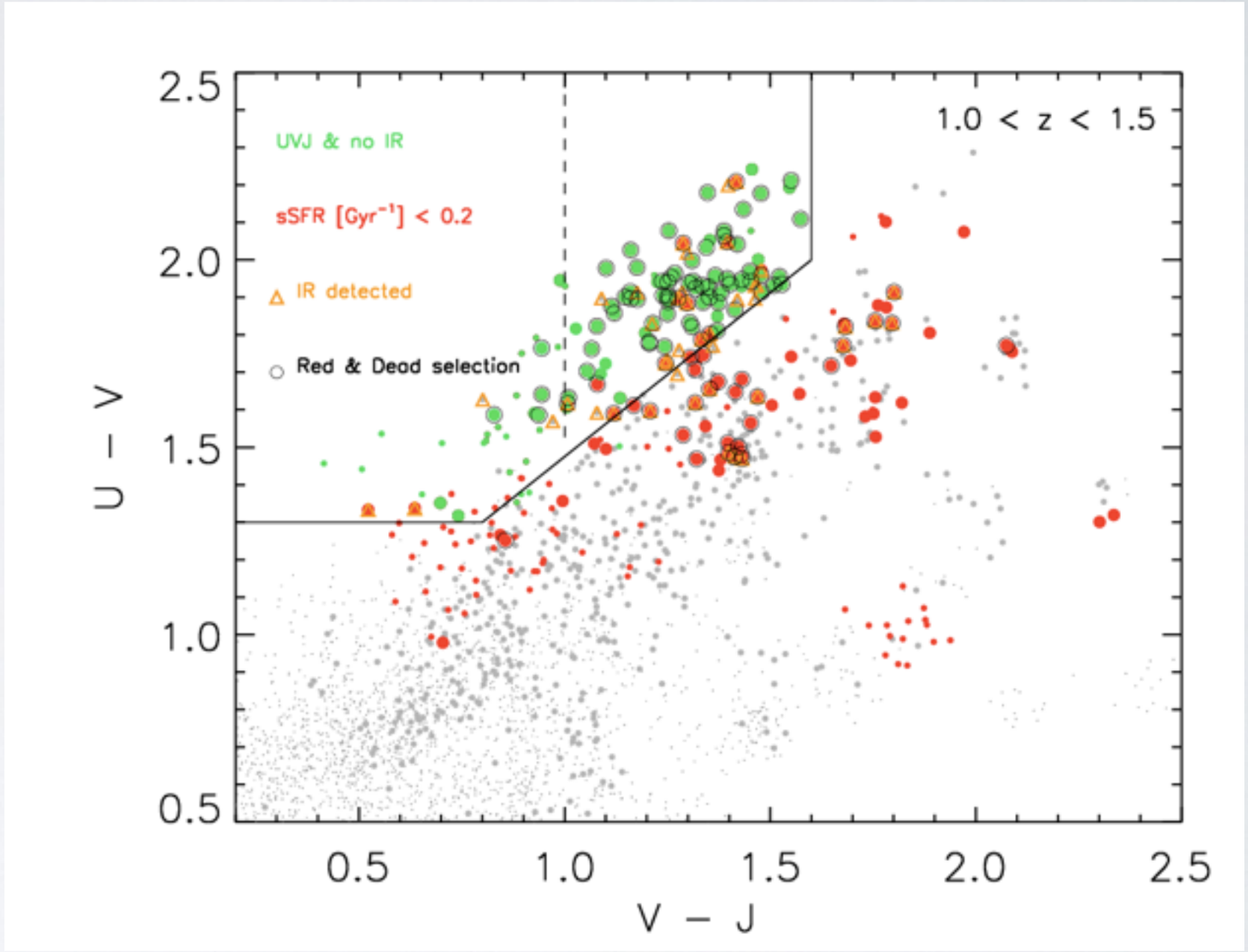
SAMPLE SELECTION

- **GOODS-N, z=1.0-1.5, log M> 10 $M_\odot$** (655 galaxies)
- **UVJ** quiescent region + **No IR** detection (85)
- **sSFR < 0.2 Gyr $^{-1}$** (152)

SFR(2800 + IR) or SFR(2800_{corr})

IRX-β relation for low IR emitters:

IRX=8.09 +3.02xβ



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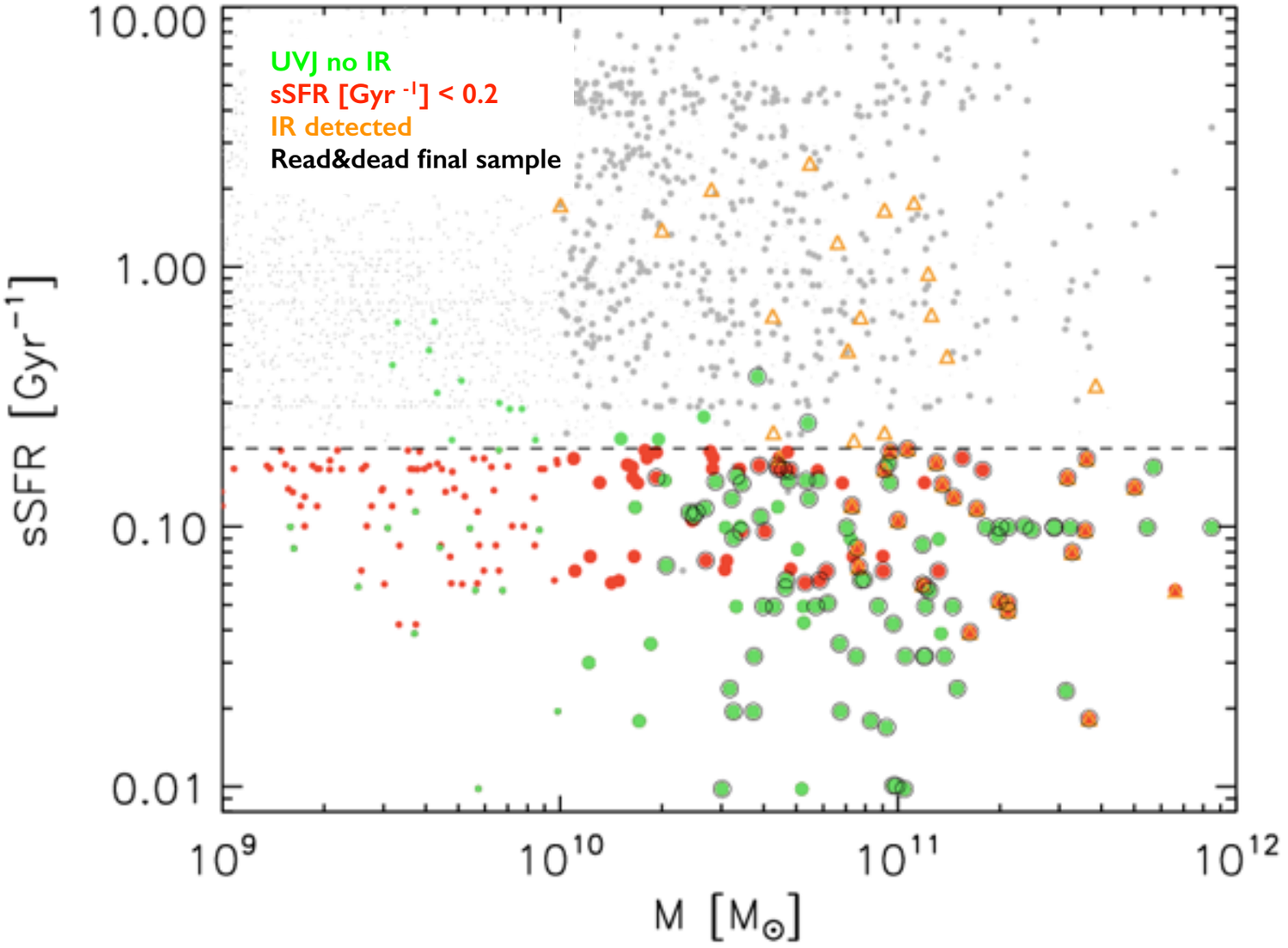


Final clean sample: **104 galaxies** (65 UVJ + 39 sSFR)

SED-FITTING

- Construct **best possible SEDs:**

  SHARDS + G102 (WFC3/HST, ~ 60%) **+ G141** (WFC3/HST, 70 %) + **Broad Band** (RB-database)

- z-spec/z-phot from RB database ($\Delta z/(1+z)=0.0035$)

- SFR(t) $\propto t\, e^{-t/\tau}$

- BC03 models, Calzetti + 2000 ext. law, Krou IMF

- **Synthesizer** code: **t (Gyr)** =[0.04 - 6.3] (steps of 0.1 dex)

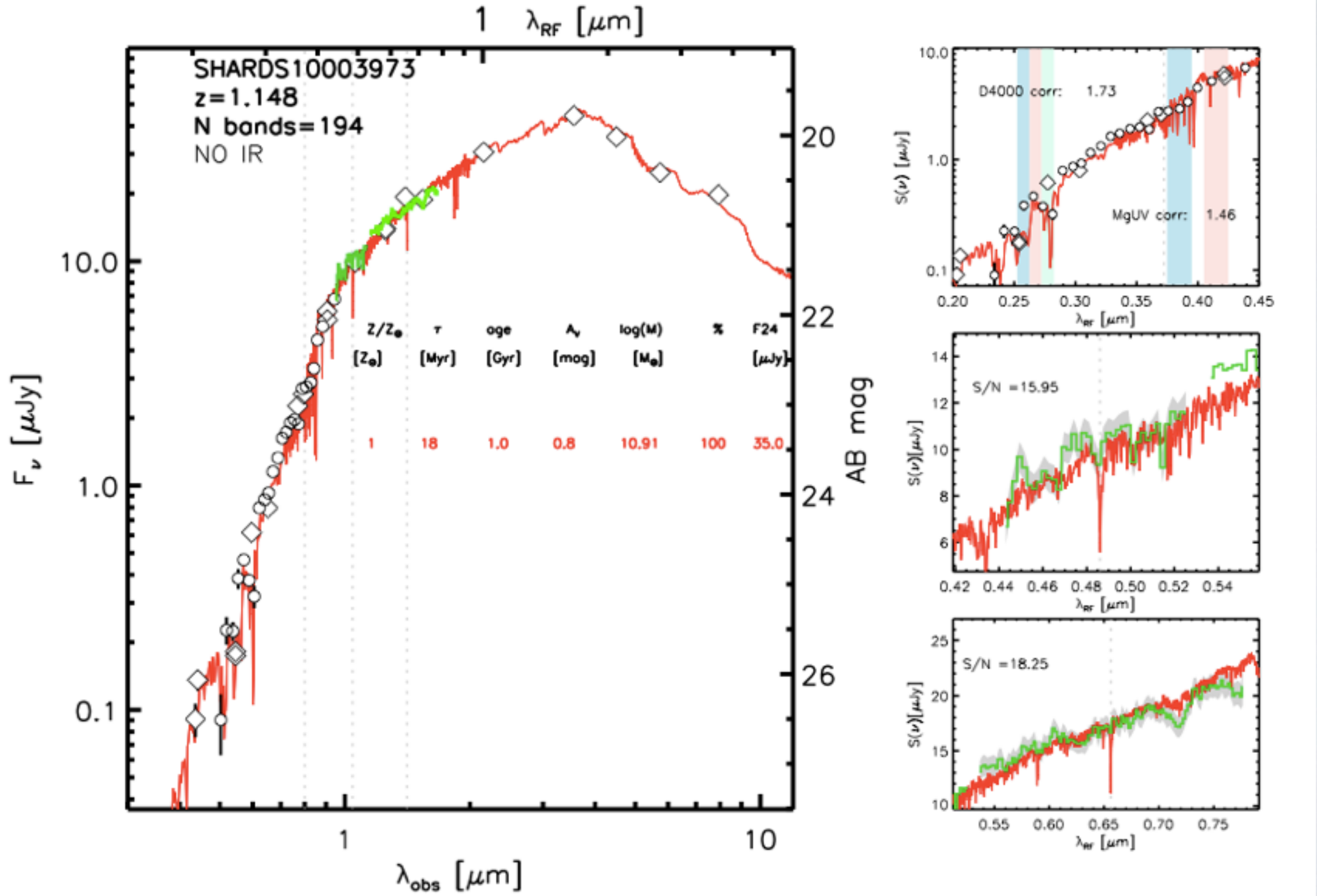
  τ (Myr) =[3 - 10000] (steps of 0.1 dex)

  AV (mag) =[0 - 1.5] (step of 0.1 mag)

  $Z/Z_\odot$ = [0.4, 1.0, 2.5]

- 1000 **Montecarlo simulations & clusters** in **t-τ** parameter space with k-means method

SED-FITTING RESULTS



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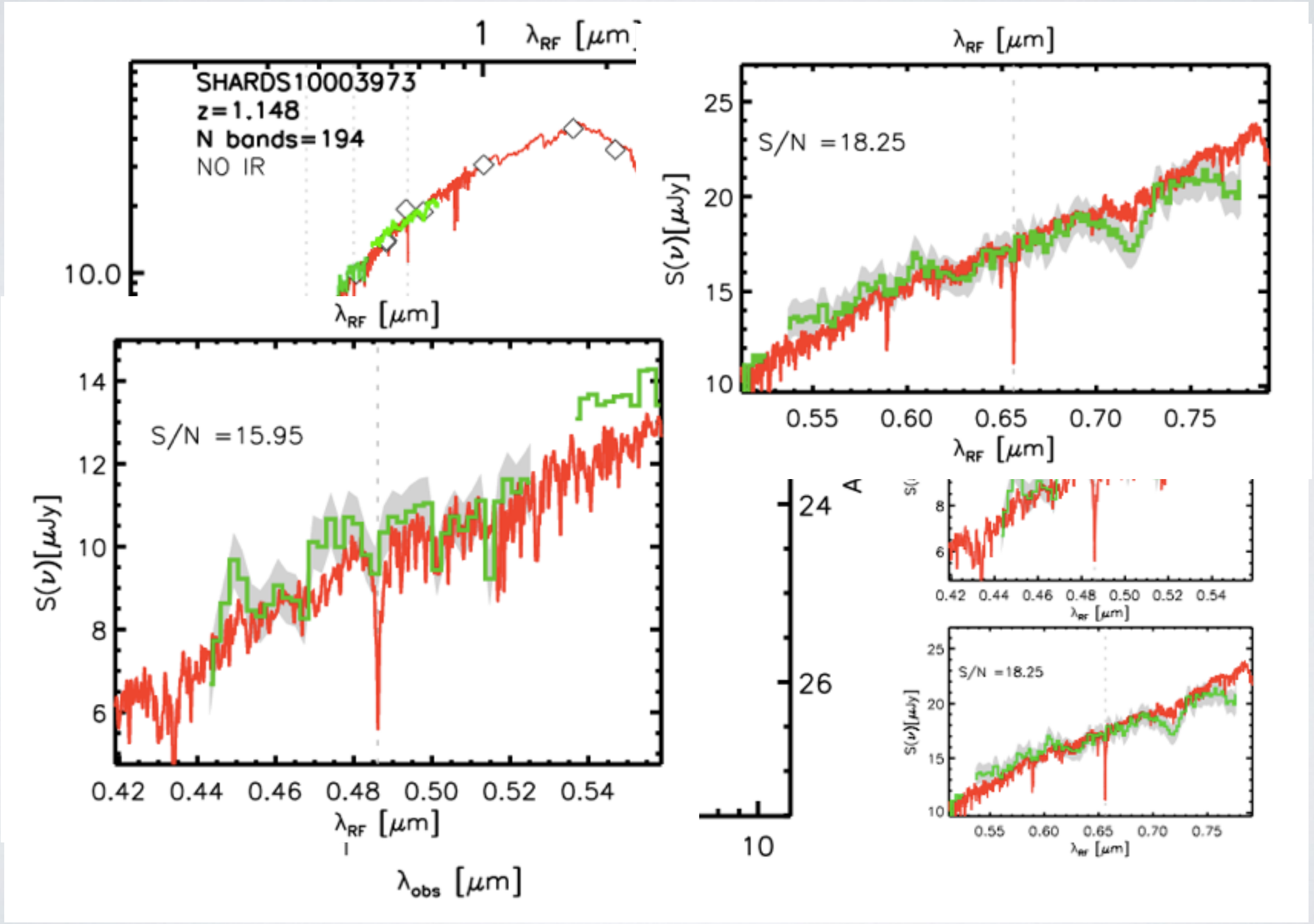

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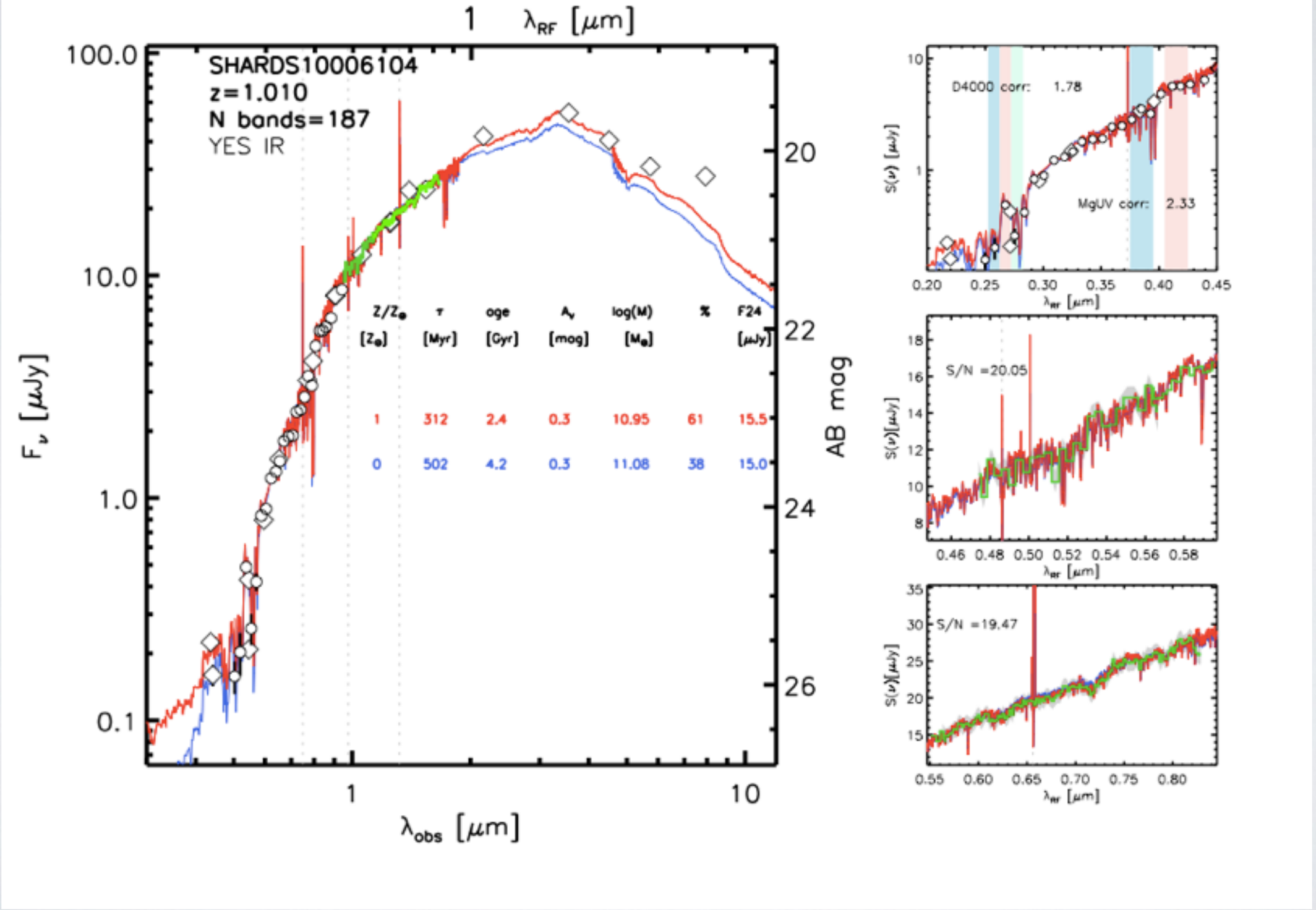
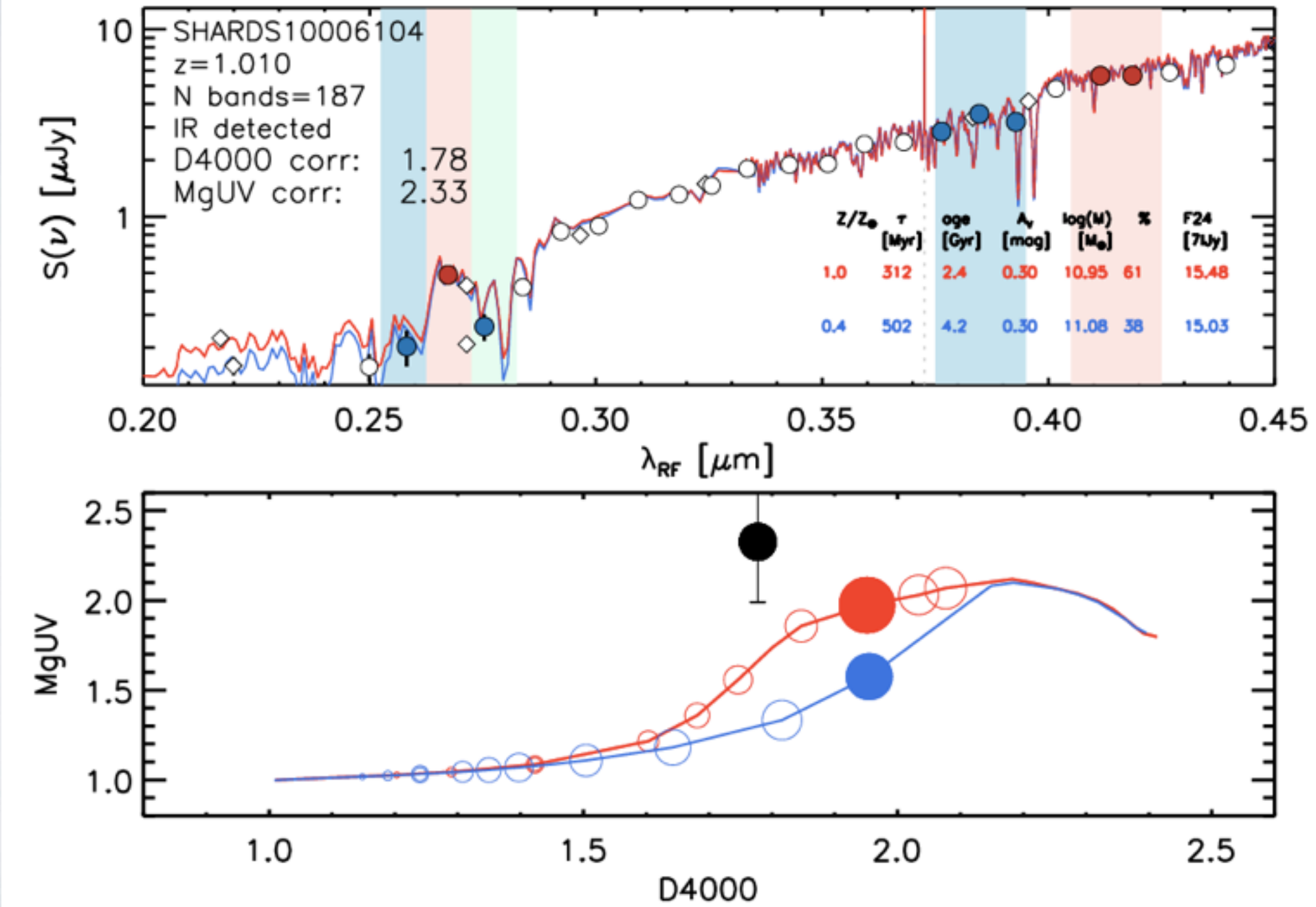
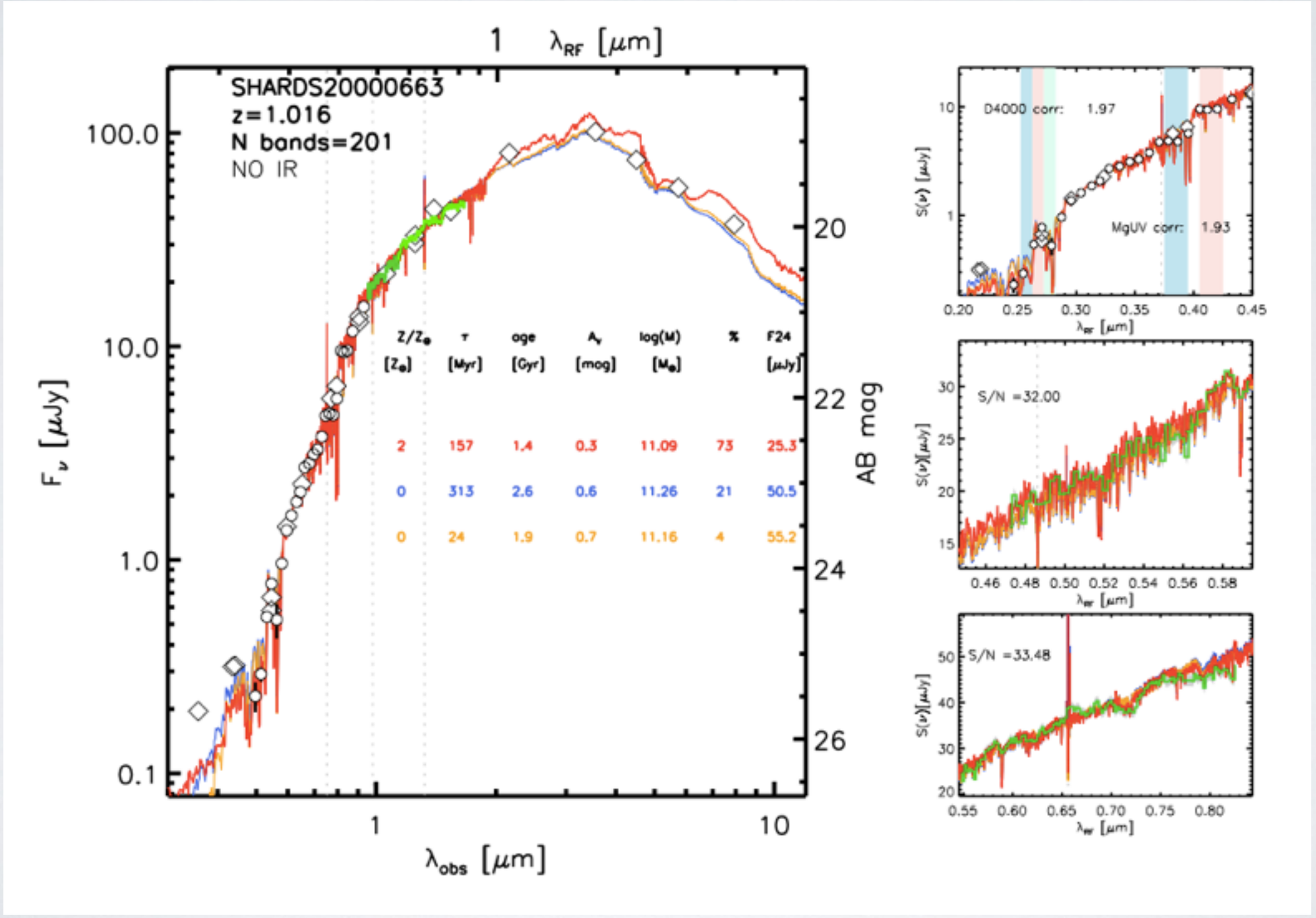


BREAKING DEGENERACIES:
D4000 & MGUV



BREAKING DEGENERACIES:
A(V) LIMIT FROM NO-IR DETECTION



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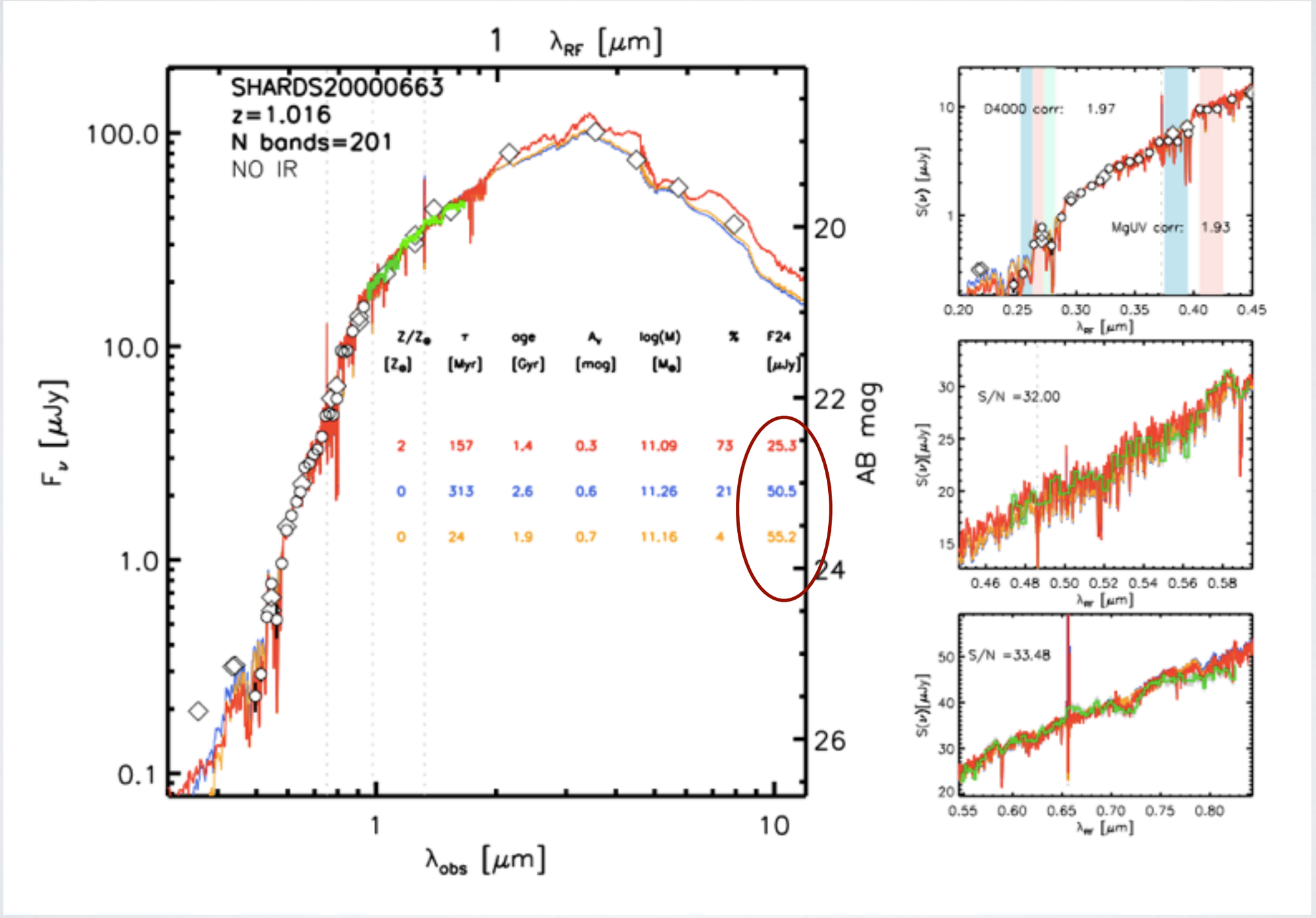
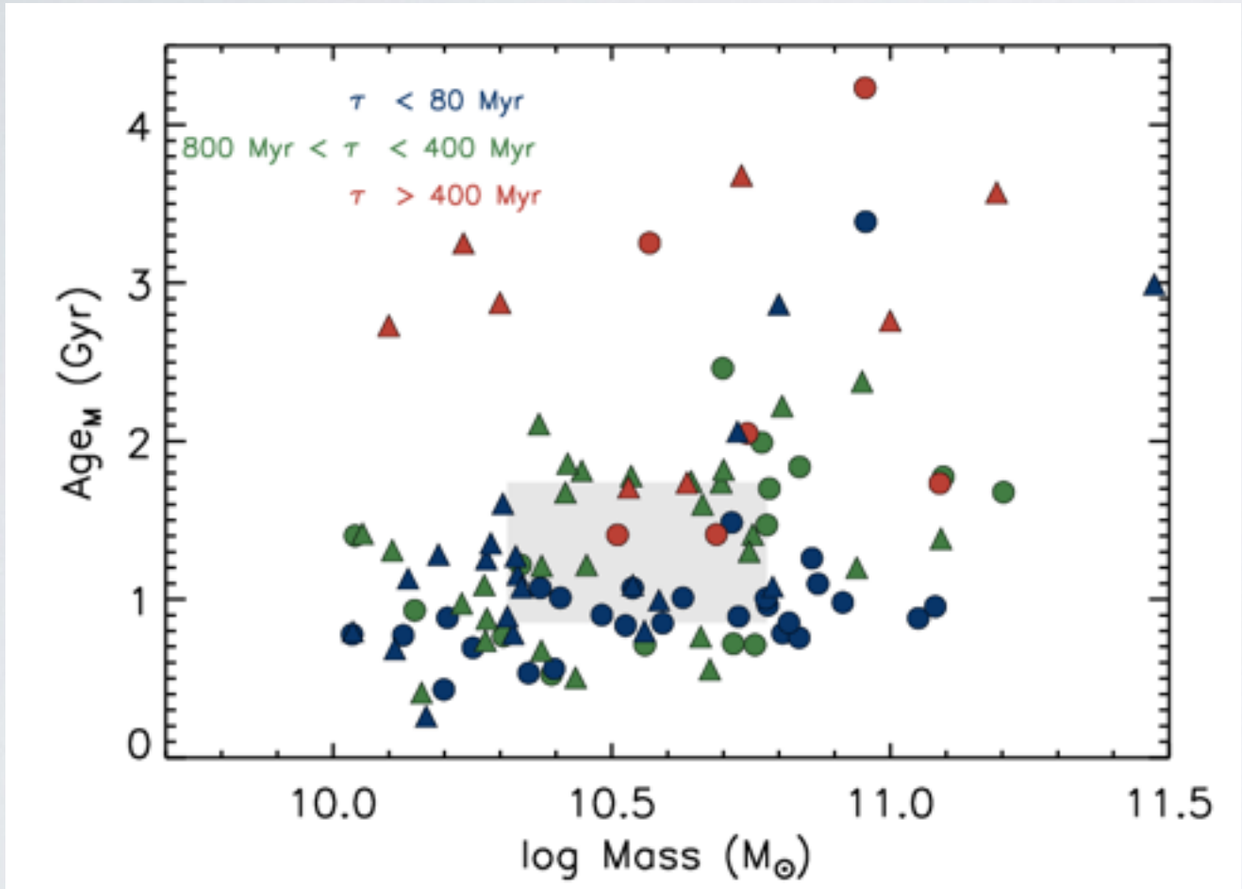
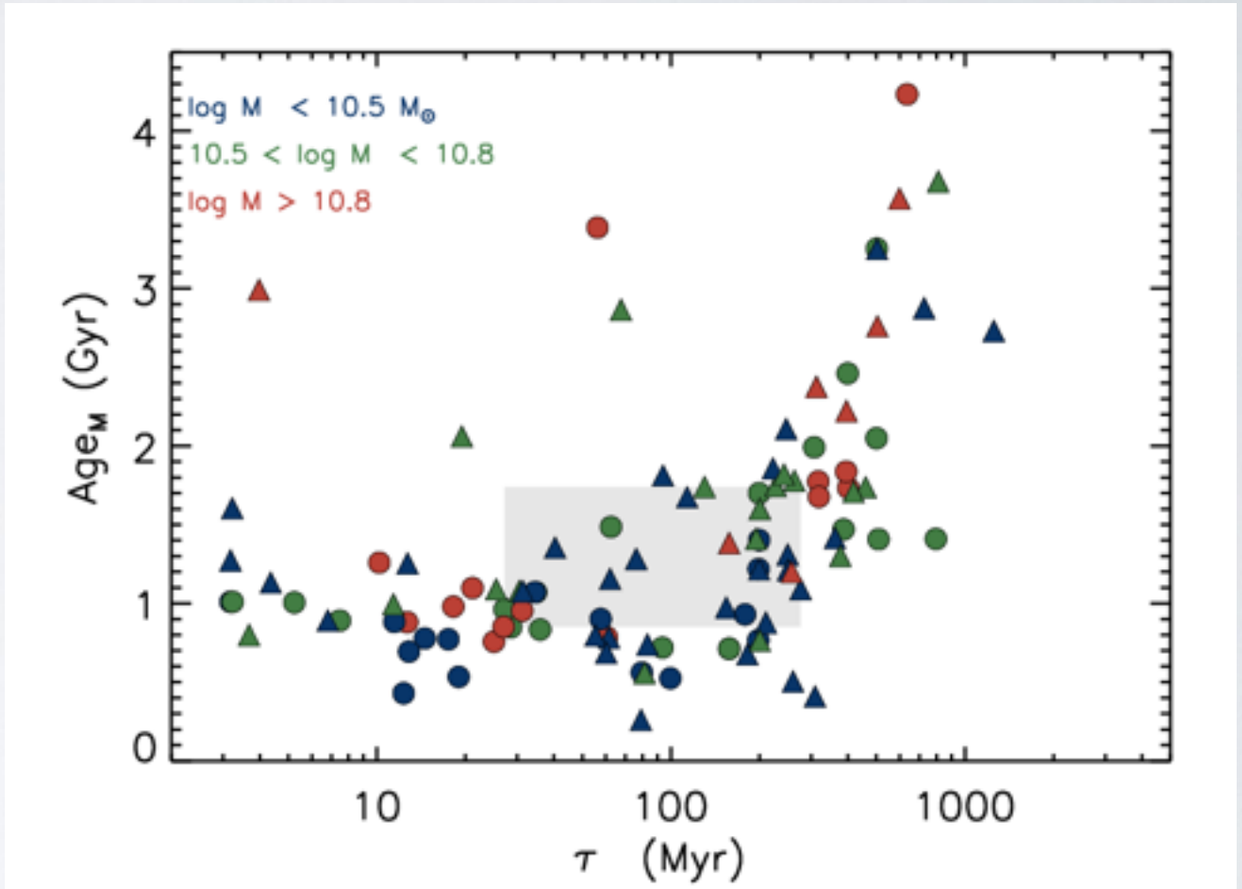


GALAXY PROPERTIES

- ▲ Degenerate solutions
- ● One cluster solution

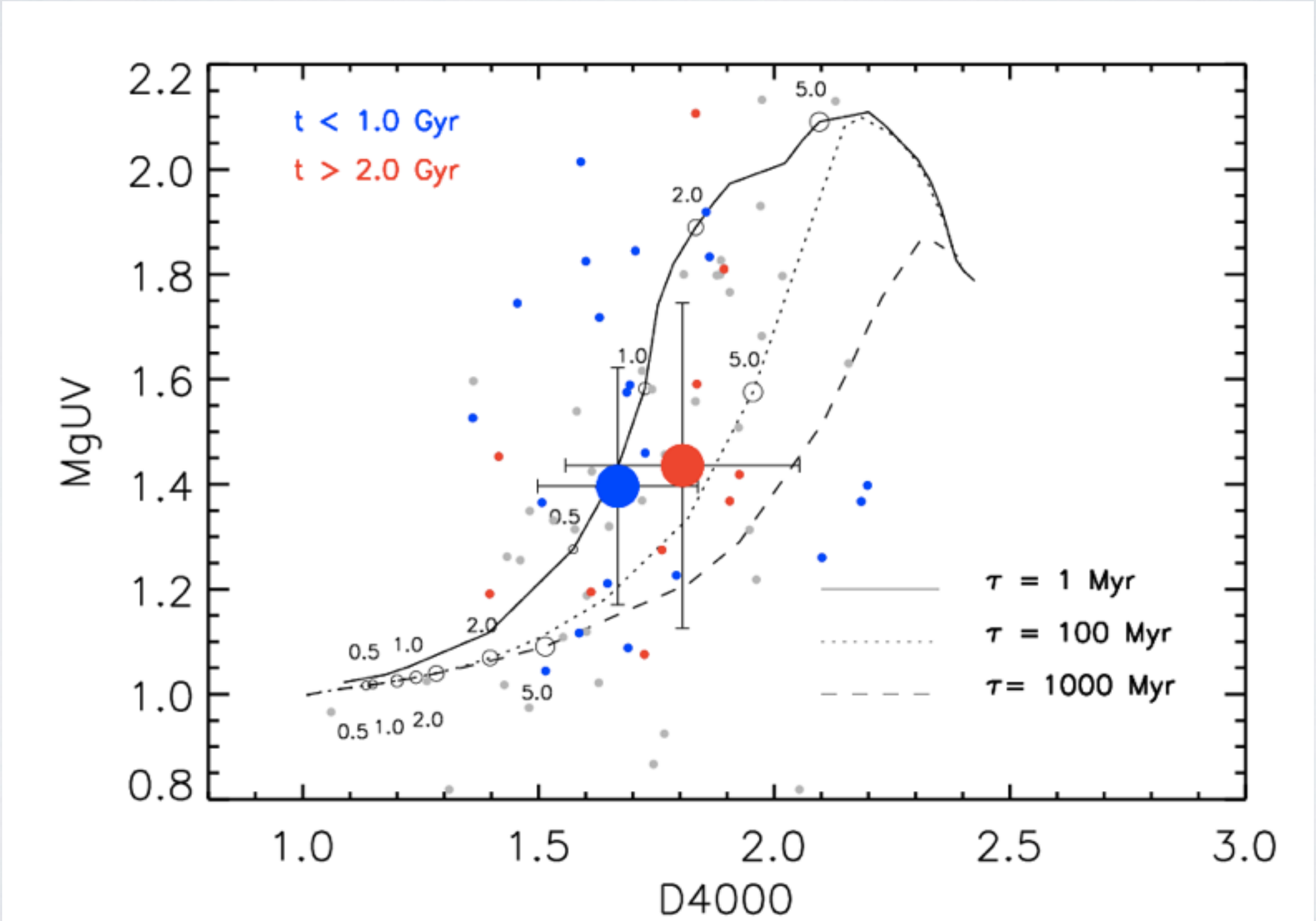




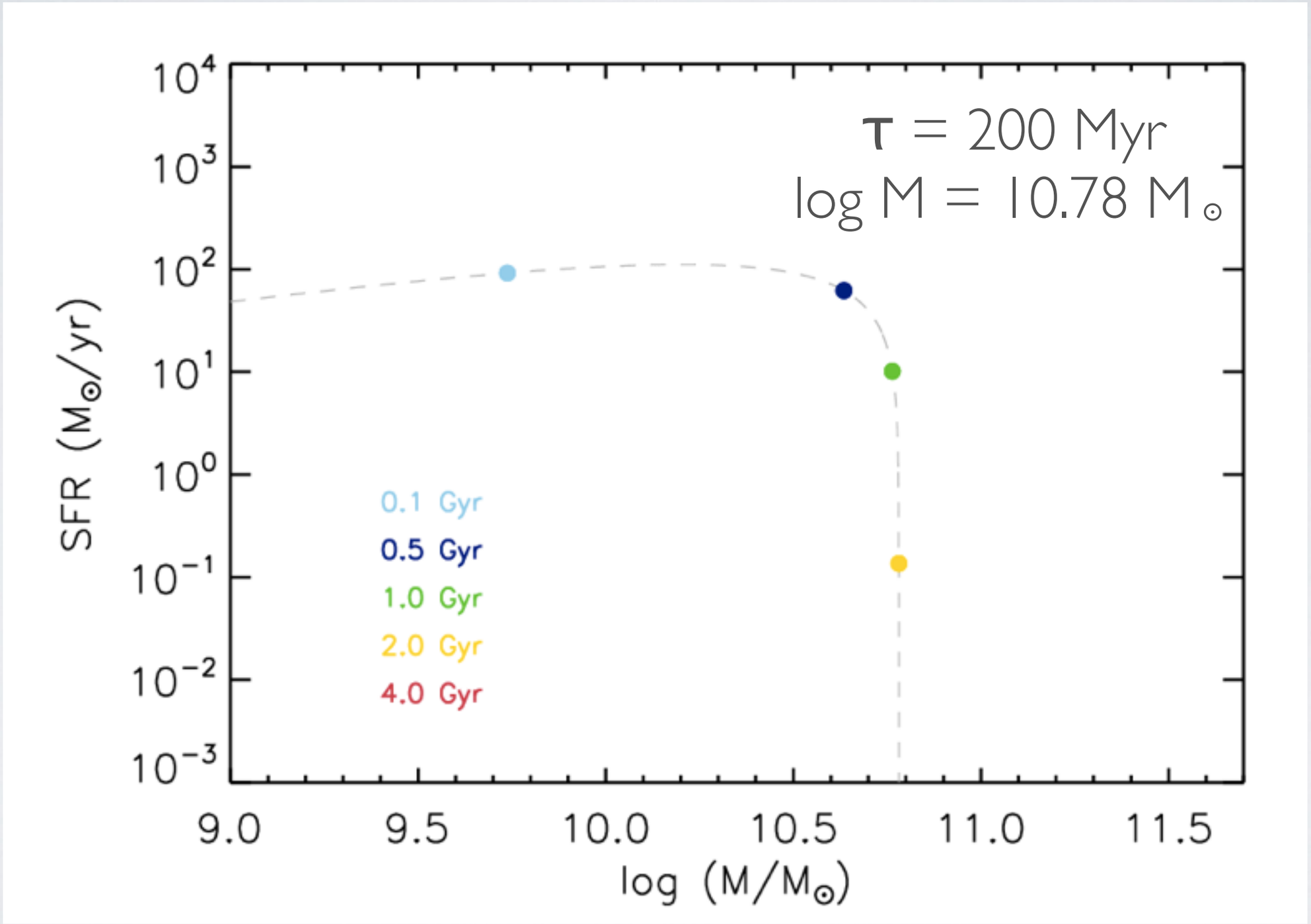
84 % galaxies **t ~ 1 Gyr,** shorter SF-timescales

17 % galaxies **t > 2 Gyr,** larger SF-timescales

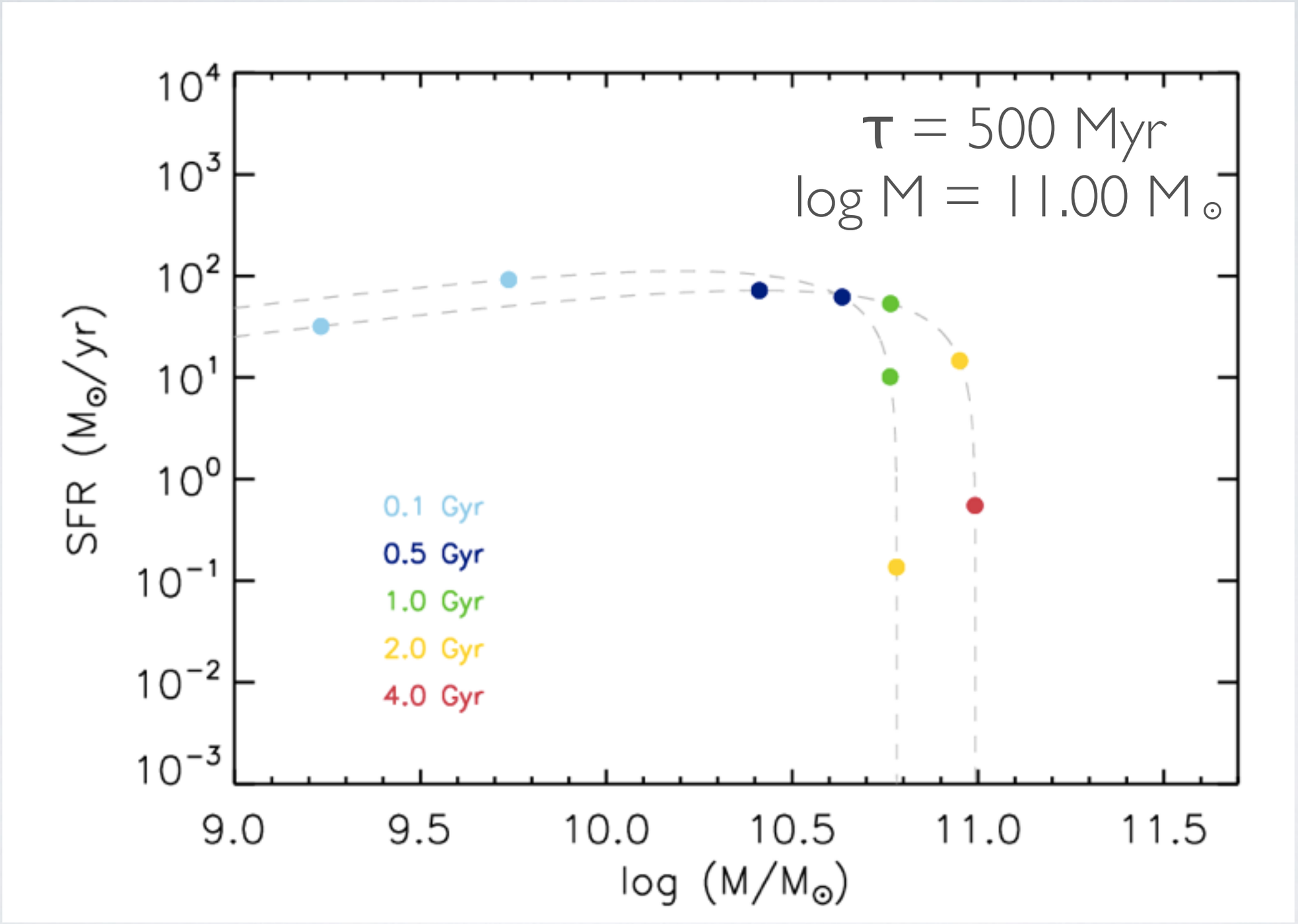
BREAKING DEGENERACIES:
D4000 & MGUV



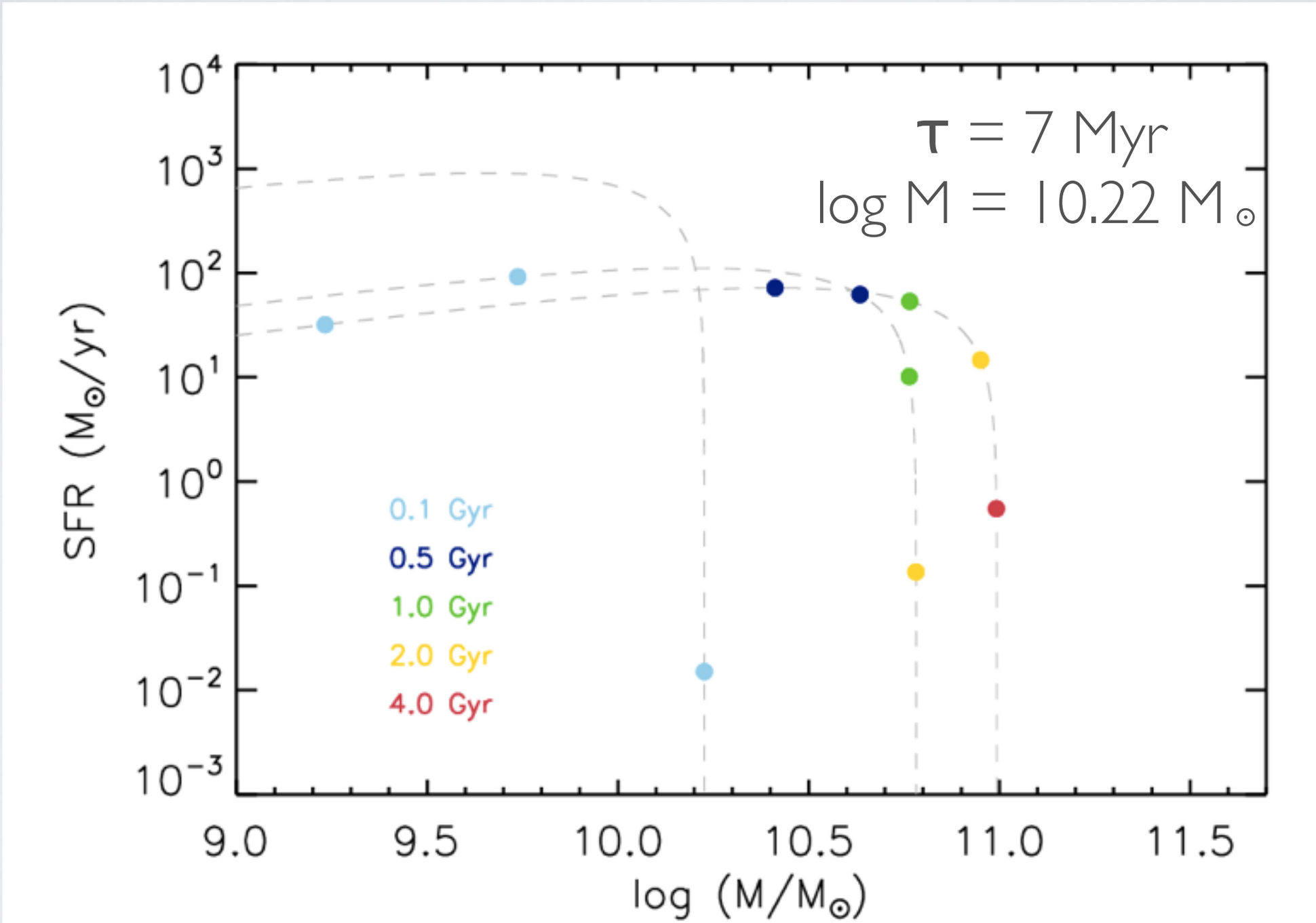
SFH TRACKS


τ = 200 Myr
log M = 10.78 M⊙
0.1 Gyr
0.5 Gyr
1.0 Gyr
2.0 Gyr
4.0 Gyr
SFR (M⊙/yr)
log (M/M⊙)
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
9.0
9.5
10.0
10.5
11.0
11.5

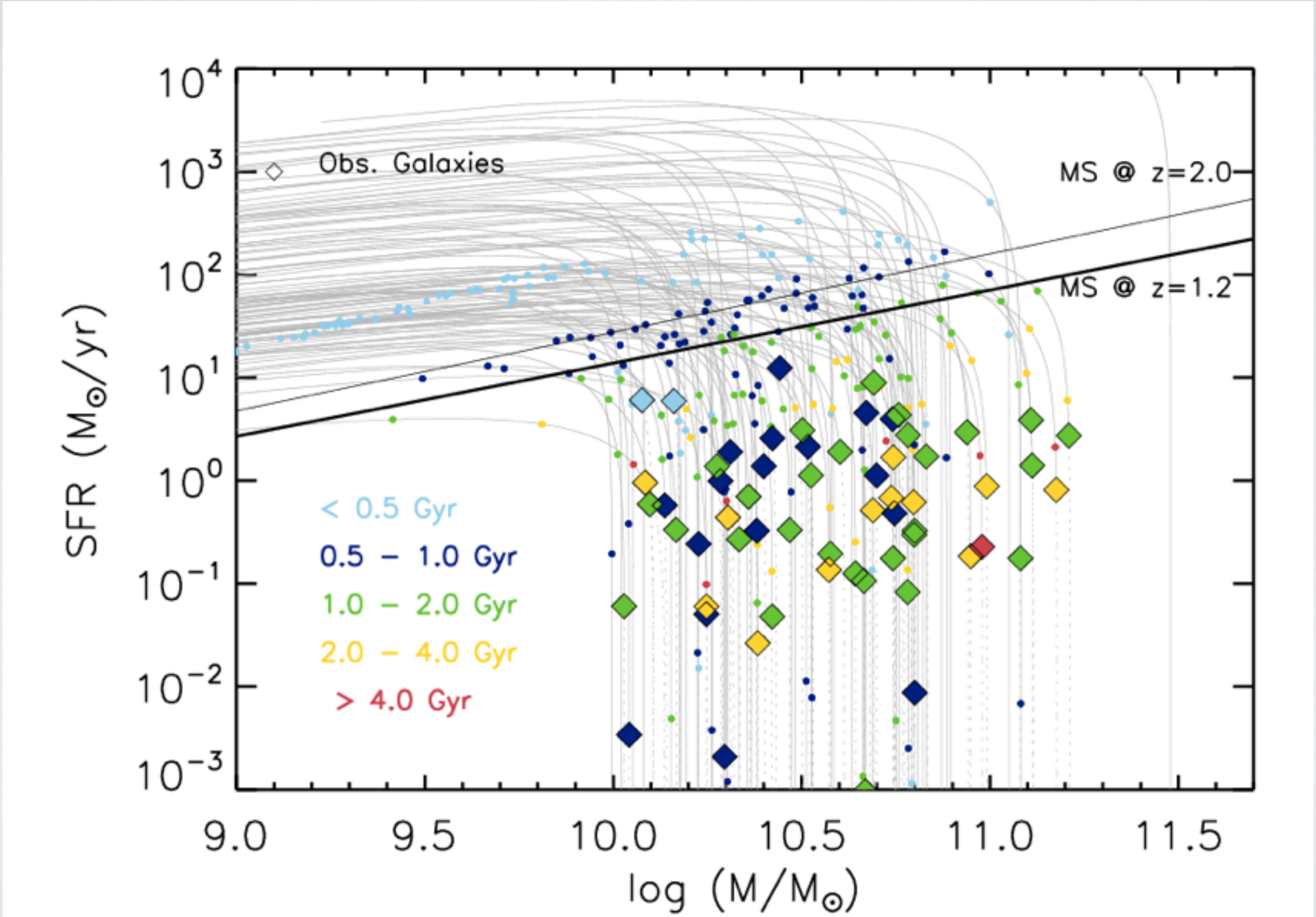
SFH TRACKS


τ = 500 Myr
log M = 11.00 M⊙
0.1 Gyr
0.5 Gyr
1.0 Gyr
2.0 Gyr
4.0 Gyr
SFR (M⊙/yr)
log (M/M⊙)
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
9.0
9.5
10.0
10.5
11.0
11.5

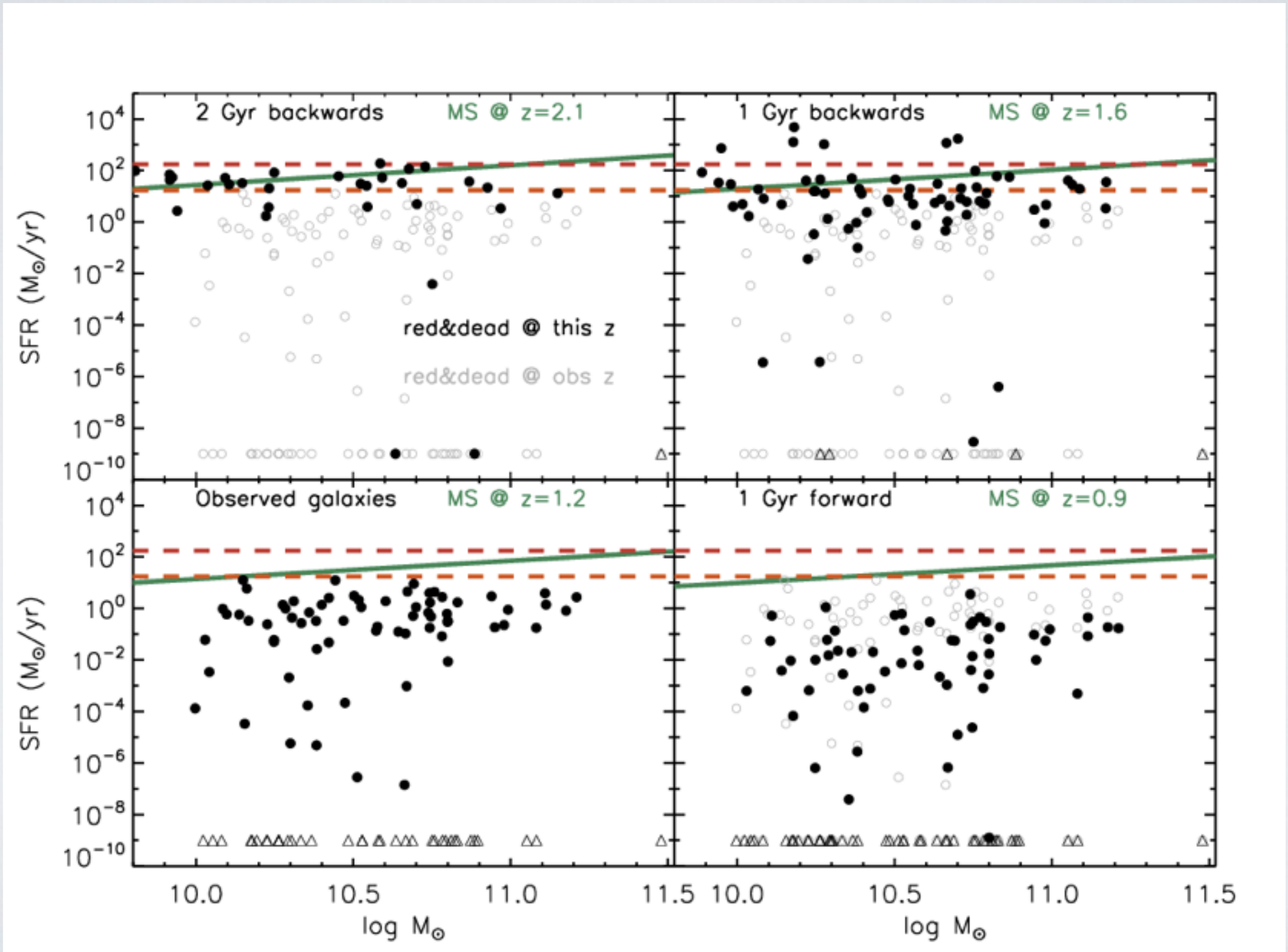
SFH TRACKS


τ = 7 Myr
log M = 10.22 M⊙
SFR (M⊙/yr)
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
0.1 Gyr
0.5 Gyr
1.0 Gyr
2.0 Gyr
4.0 Gyr
9.0
9.5
10.0
10.5
11.0
11.5
log (M/M⊙)

SFH TRACKS


Obs. Galaxies
MS @ z=2.0
MS @ z=1.2
< 0.5 Gyr
0.5 – 1.0 Gyr
1.0 – 2.0 Gyr
2.0 – 4.0 Gyr
> 4.0 Gyr
SFR (M⊙/yr)
log (M/M⊙)
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
9.0
9.5
10.0
10.5
11.0
11.5

SFR-MASS EVOLUTION



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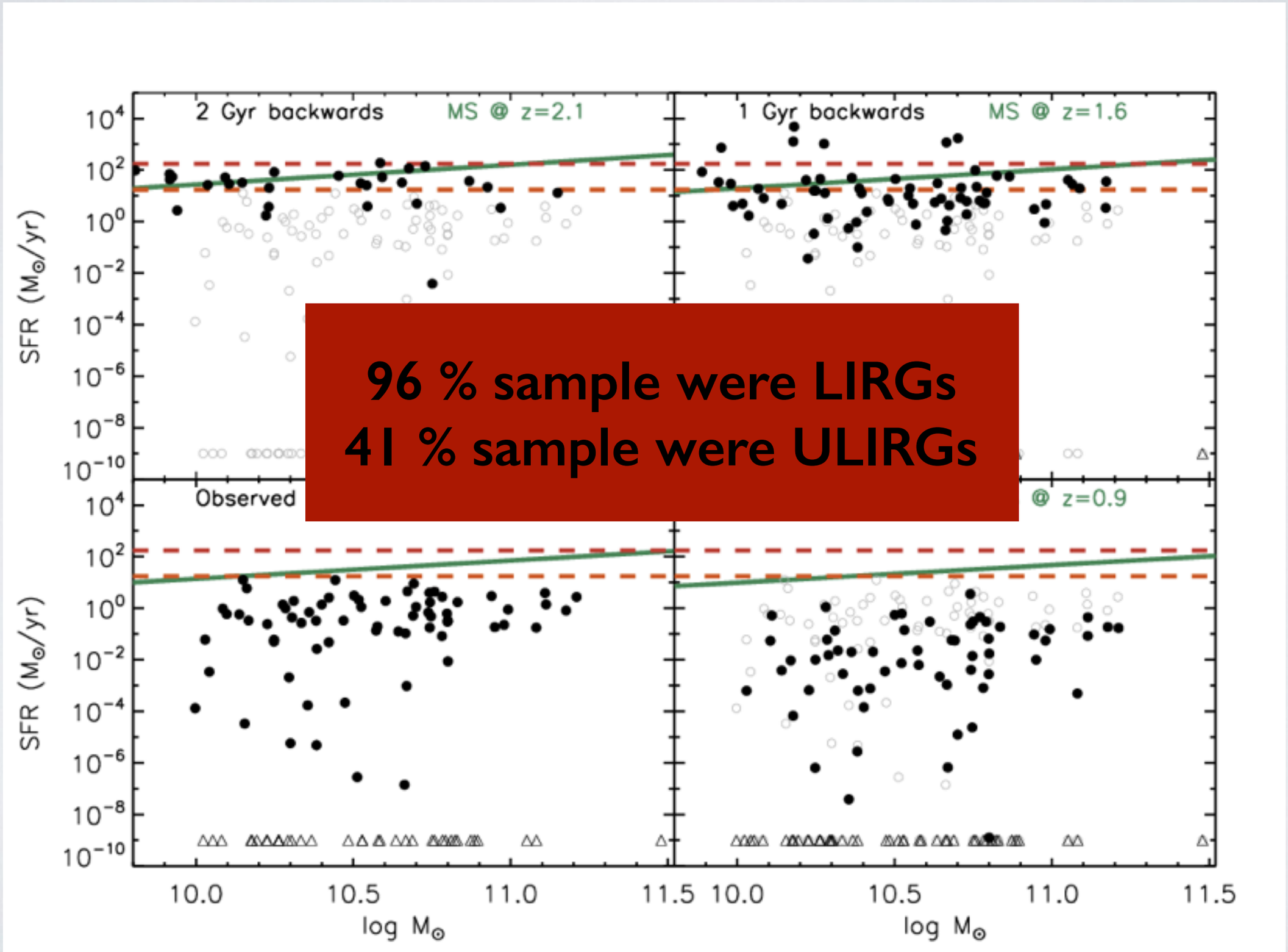
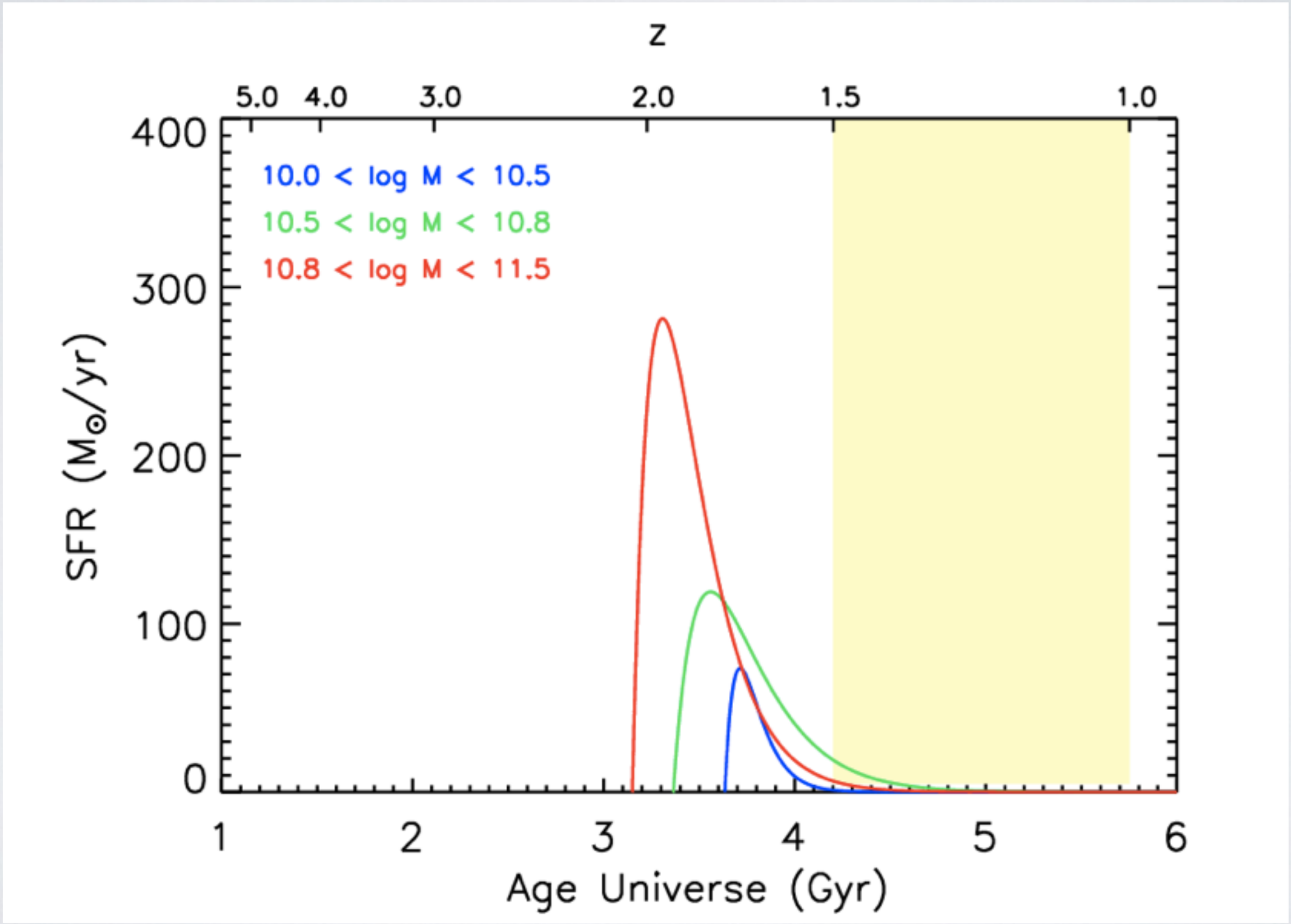
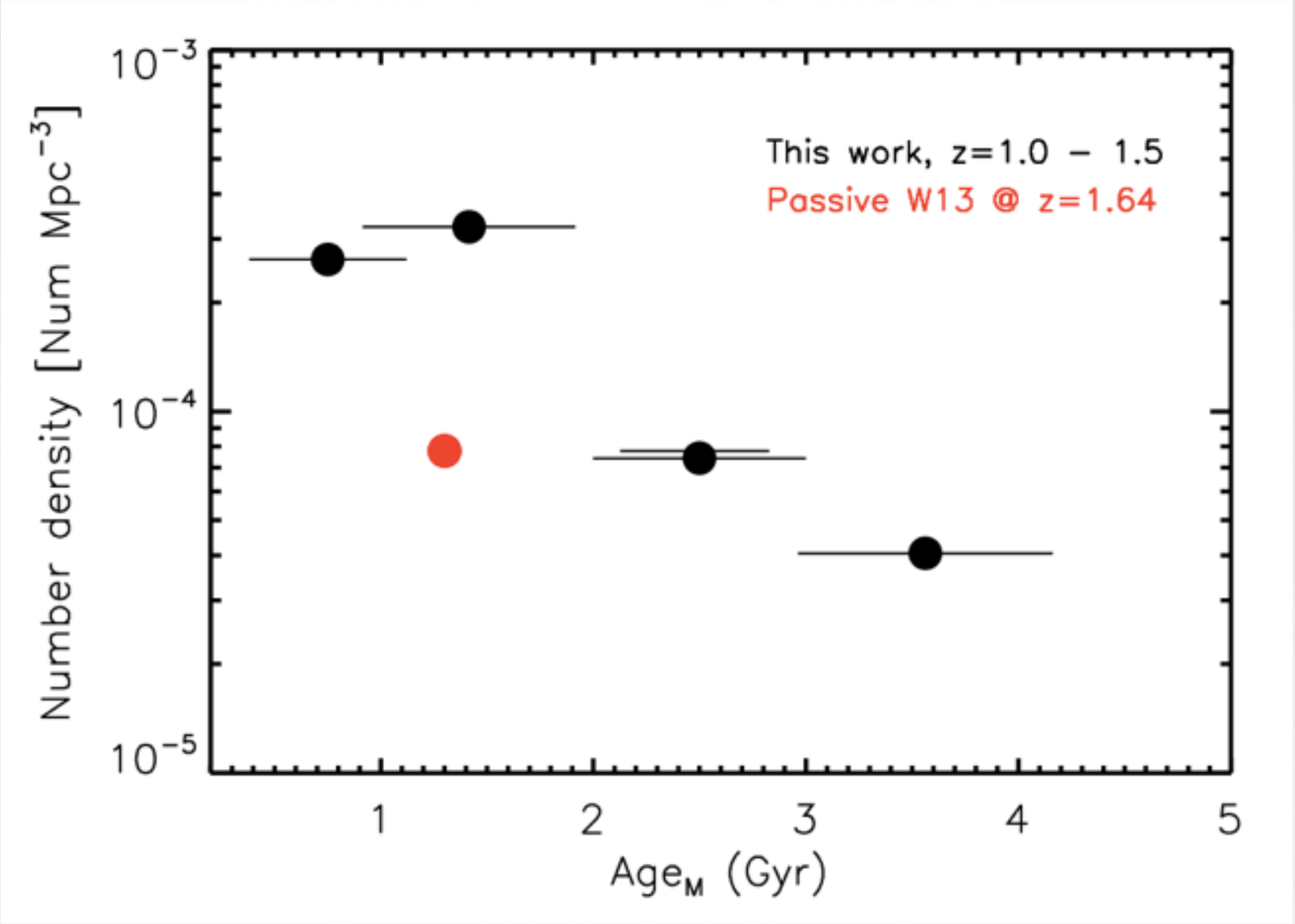


MEDIAN SFH BY MASS



NUMBER DENSITY



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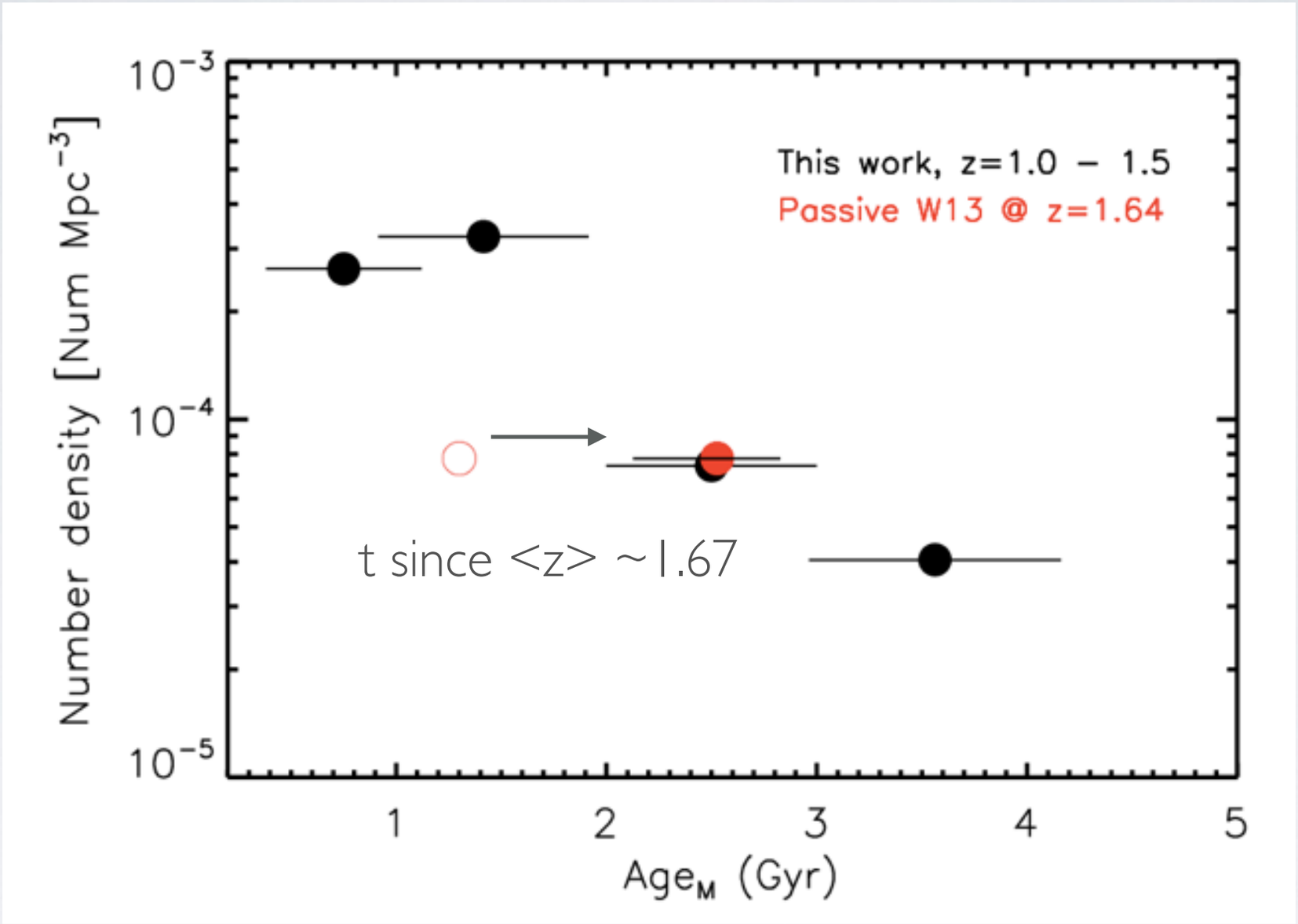

Number density of dead galaxies t ~ 2.5 Gyr consistent with Whitaker +2013 at z=1.67

CONCLUSIONS

- Combination of **SHARDS + GRISM** data fundamental for **constraining galaxy properties** of massive quiescent galaxies at z > 1.0

- Population of quiescent galaxies at z=1.0-1.5 **dominated by "new arrivals"** (~1 Gyr old galaxies).

- A **small fraction (16%) is older (2 Gyr),** so they were already dead by z~2 (cf. Whitaker+ 2013).

- The average age of a massive quiescent galaxy at 1.0<z<1.5 is **1.5 Gyr**, and the typical timescale is **100 Myr.**

- According to the SFHs we derived, massive quiescent galaxies at z=1.0-1.5 **lived on the observed main sequence at z=1.5-2.0,** following closely its slope

- The **peak SFR** in the SFHs of our sample lies **typically at the LIRG level.** The SFH for some (**43 %**) galaxies are consistent with a fraction of their lifetime time experiencing a **ULIRG phase**.

- Most massive galaxies (**log M > 10.8 $M_\odot$**) were **formed first** (downsizing) in very intense SF processes (> 100 $M_\odot$/yr)

- **TBD:** improve tests on the reliability of the older population properties (stacks), sizes & compactness