Extent of the last star formation episode of Red Sequence galaxies up to z=2.5

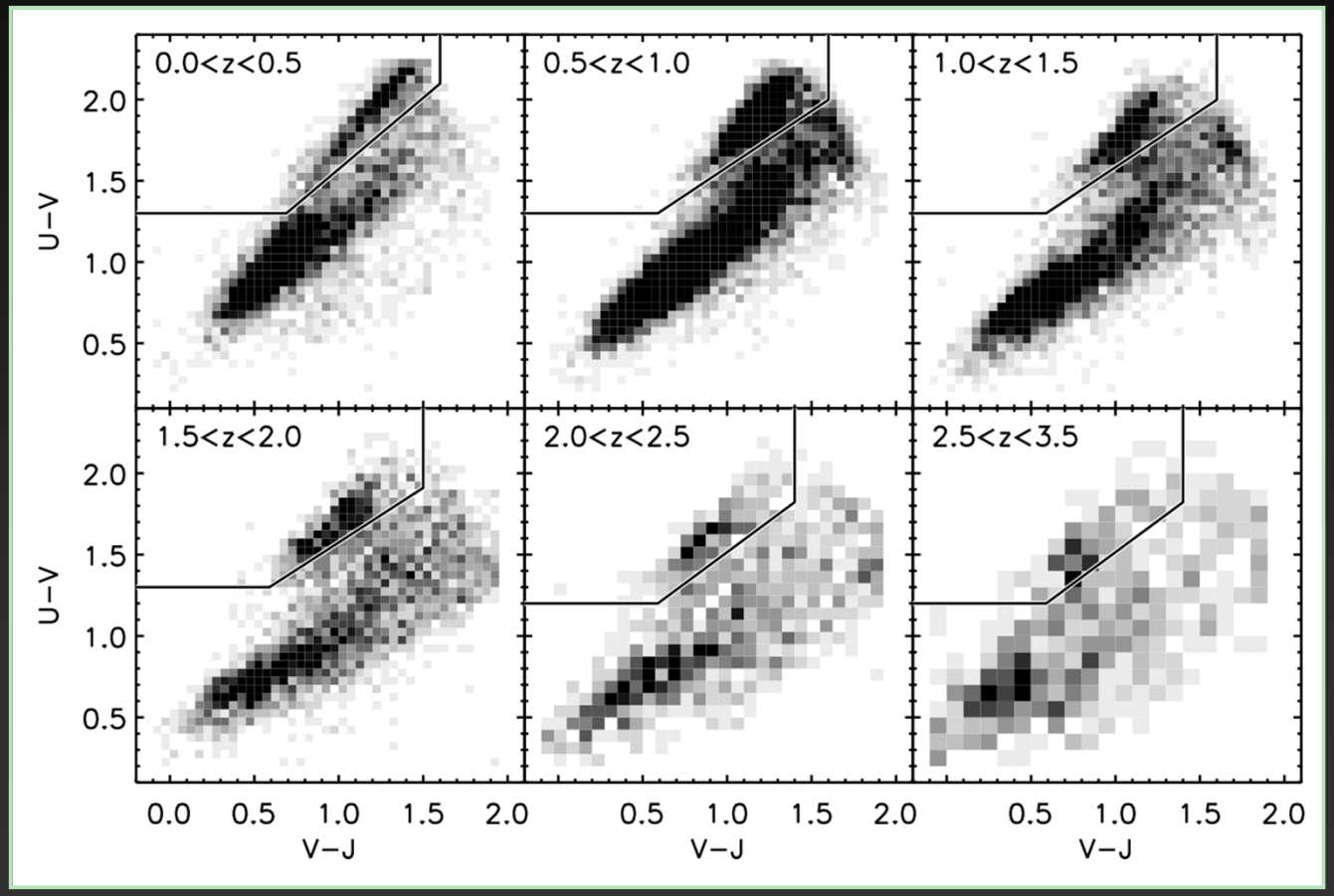
M. Carmen Eliche-Moral,
Universidad Complutense de Madrid (Spain)

Pablo G. Pérez-González, Helena Domínguez Sánchez, Pilar Esquej, Belén Alcalde Pampliega, Guillermo Barro, Antonio Cava, Néstor Espino, and the SHARDS Team

EWASS, La Laguna, June 22, 2015

Red Sequence observed since z~2

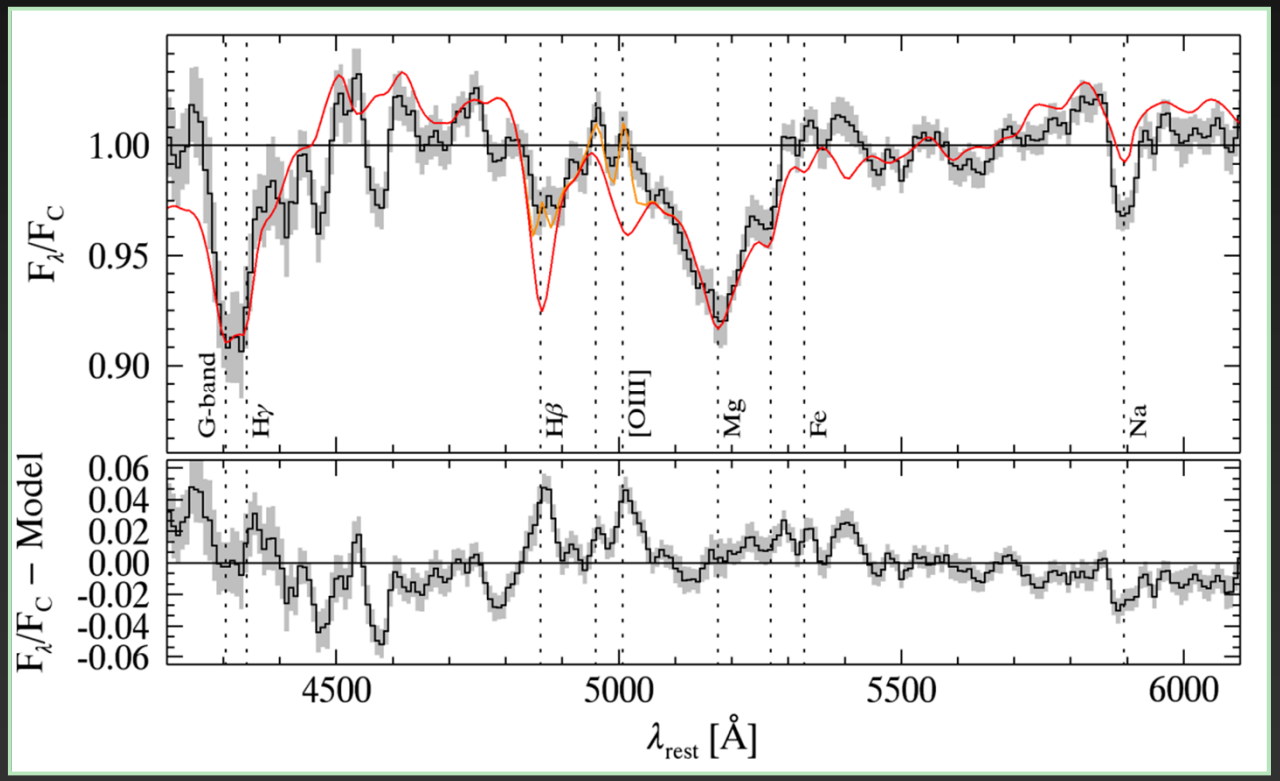
- Galaxies bimodality in CM diagrams exists up to z~2 (Williams+09, Brammer +11, Whitaker+11)
- In agreement with mass downsizing in mass (Kodama+07, Pérez-González+08) and against traditional hierarchical scenarios (De Lucia+06)



Whitaker et al. (2011)

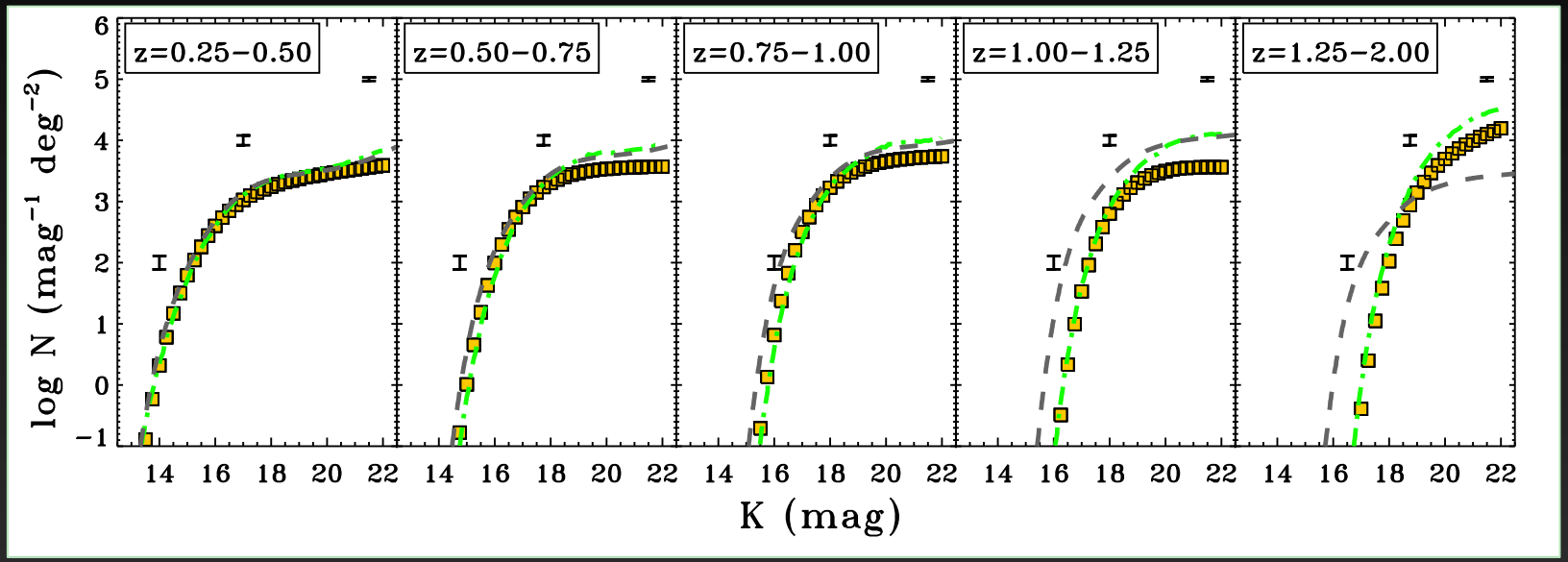
Massive quiescent galaxies at z~2

Whitaker et al. (2013)



- Few confirmed spectroscopically, basically through stacks and SSP modelling (Cimatti+08, Whitaker+13, Nastasi+14, Mendel+15)
- Concentrated morphology (Cimatti+08, Peth+15)
- Thought to be assembled at z> 2 and evolve nearly passively since then (Cimatti+08)

But the evolution of massive galaxies seems more complex…



Prieto & EM (2015)

Poster S3.34

1. Size evolution by x2-3 from z~2 to z=0 in these objects (Cimatti+08, Whitaker+12, Cassata+13)

   (…)

2. Continuous arrival to RS until z~1, also at higher masses (Daddi+05, EM+10, Moresco+10, van de Sande+12, Cassata+13, Davidzon+13, Nastasi+13, Prieto+13, Choi+14, Gallazzi+14, Marchesini+14, Belli+15, Hahn+15, Leja+15, Liu+15)

3. Significant evolution in morphology in massive galaxies down to z~1 (Huertas-Company+11, Buitrago+13, Talia+14)

Questions and aims

- **Are massive RS galaxies at z~2 really so "quiescent" and "old"?**
- **How extent was their last SF episode?**

- Estimate ages and SF timescales for individual objects and stacks using τ models for SED fitting

- **Photometry-spectroscopy in GOODS-N:**
  - **Rest-frame UV :** GTC/OSIRIS data of ESO/GTC Large Program SHARDS: Survey for High-z Absorption Red and Dead Sources (PI: P. G. Pérez-González, Pérez-González+13)
    $\Rightarrow$ old populations
  - **Rest-frame optical:** HST/WFC2 G102 and G141 grisms F105W (Y) <24, F140W (H) <25.5
    $\Rightarrow$ on-going or recent SF
  - **Broad-band data from NUV to MIR:** Rainbow Database, Barro+11a,b
    $\Rightarrow$ dust absorption + redshifts $\Delta z/z \sim 0.01$

Data selection

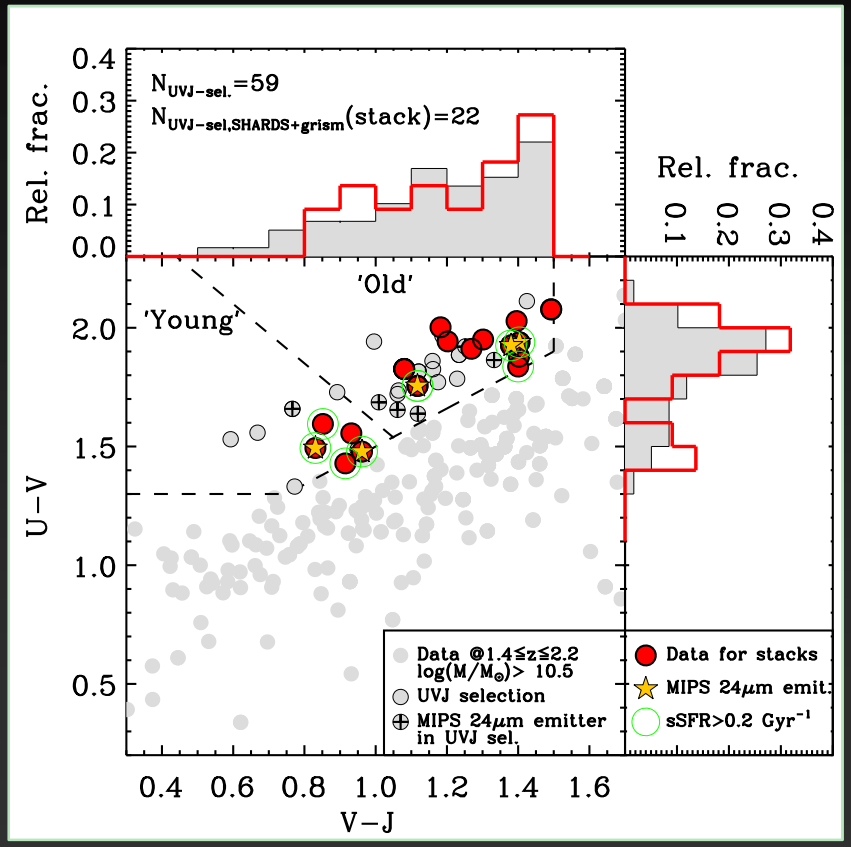
- Reproduced the selection by Whitaker+13
- Red sequence in UVJ diagram
- log (M/Msun) > 10.5
- 1.4<z<2.2

  ⇓

  N total = 59
  N G141 = 21
  N G102 = 5
  N SHARDS+grism = 22
- Fitted to delayed τ exponential models with synthesizer (Pérez-González+08):

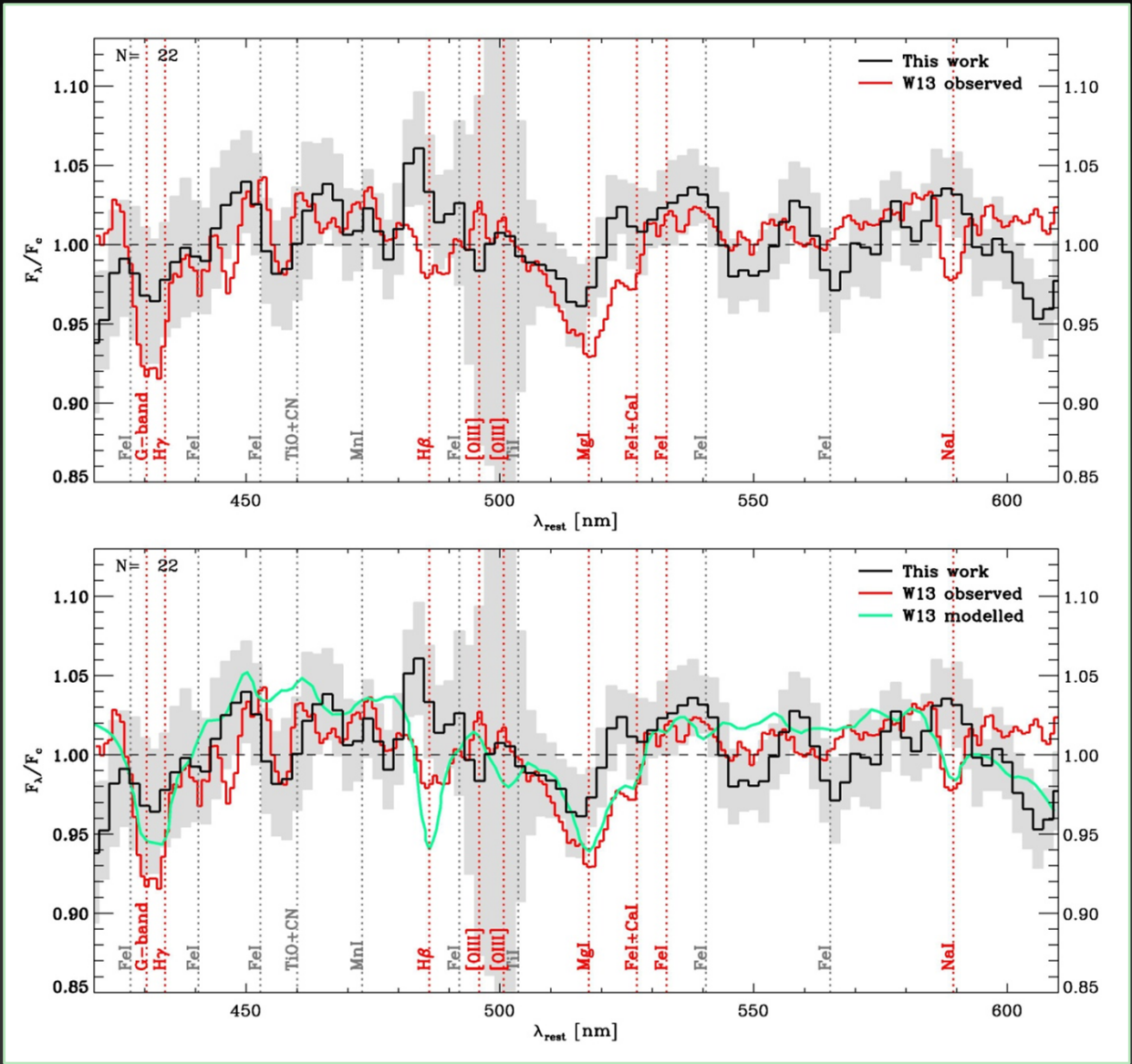
  $SFH(t) \propto [\, t / (\tau * \tau) \,] \cdot \exp(-t/\tau)$

  ⇒ **Mass, age, τ, Z, A(V)**



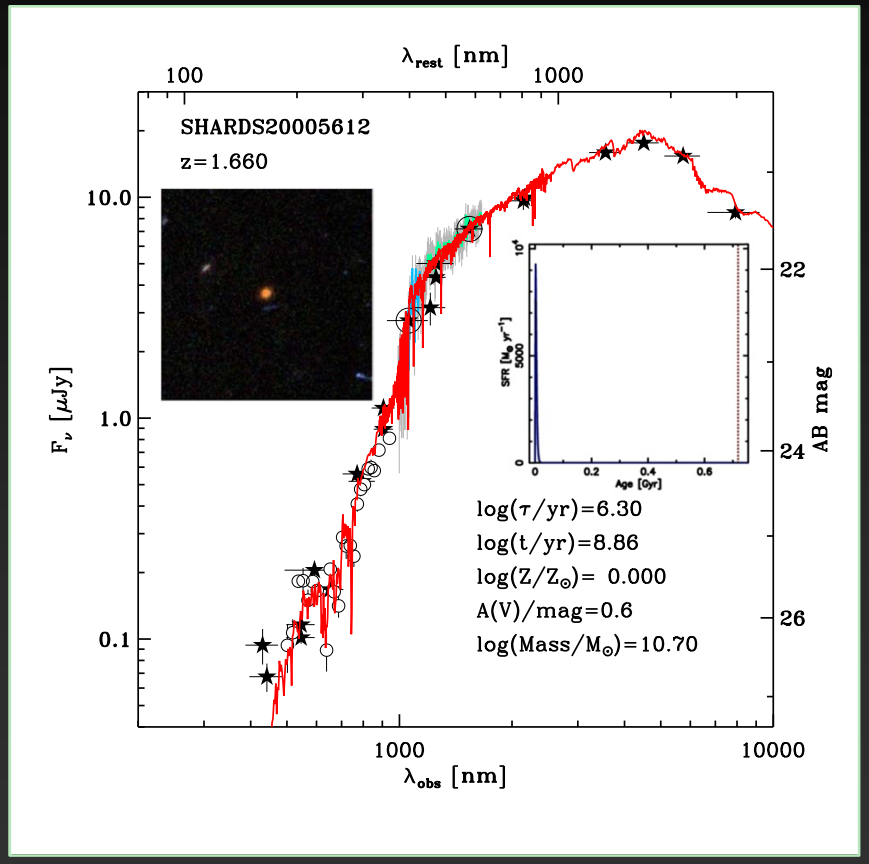
- Stellar population synthesis models by Bruzual & Charlot (2003)
- Calzetti (2000) extinction law
- Chabrier IMF, Stelib libraries

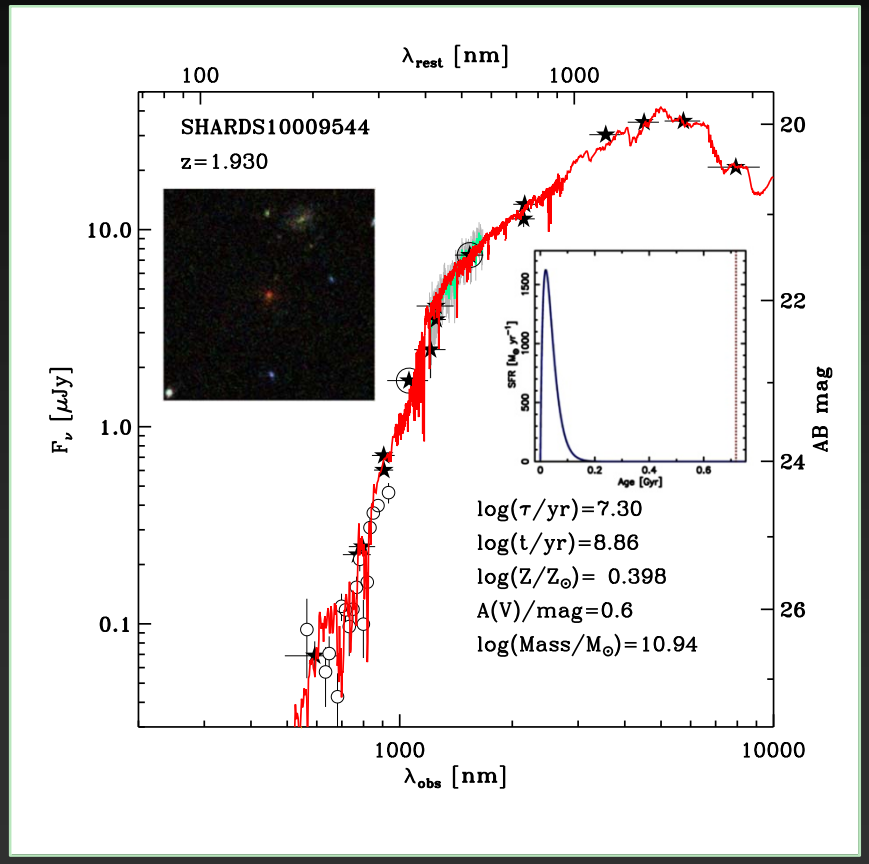
Comparison with Whitaker+13 stack



- Similar absorption features as Whitaker+13 stack
- Higher levels of residual star formation in ours, but lower statistics

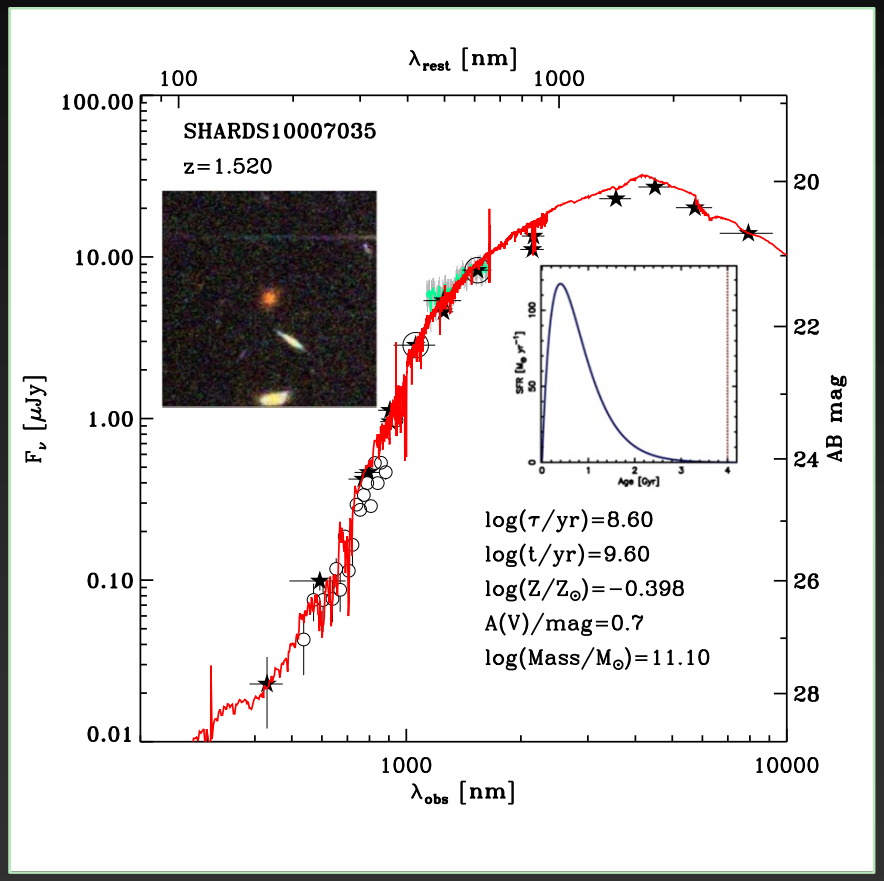
Small SFH timescales

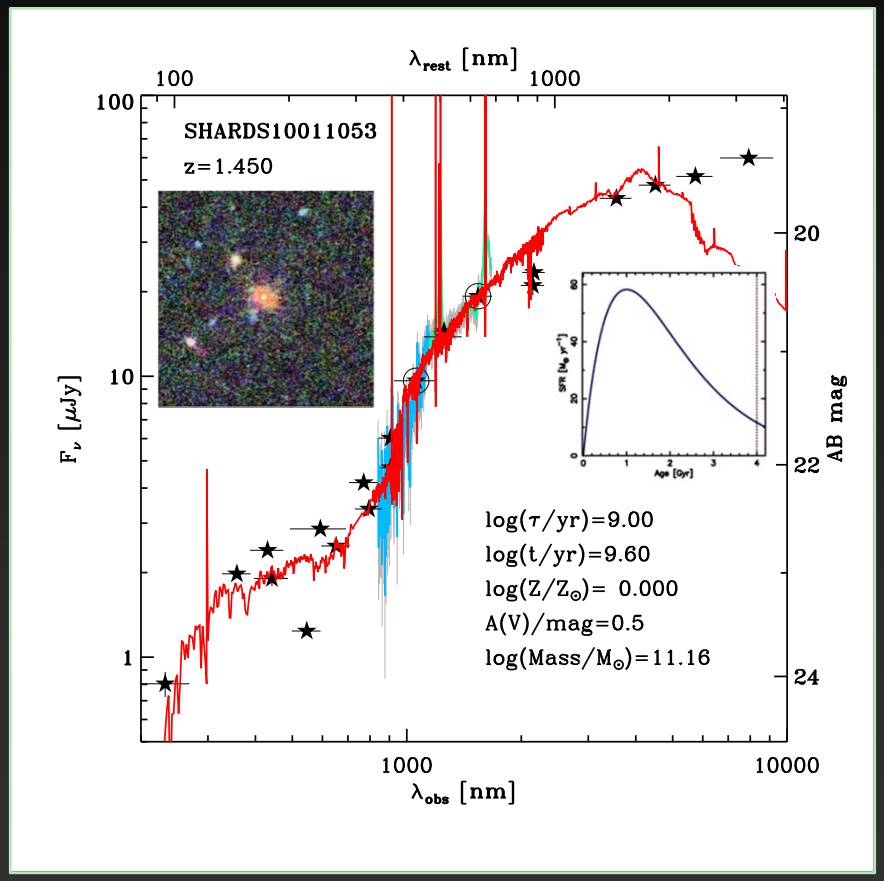




- Most galaxies have strongly peaked SFHs, with $\tau < 0.1$ Gyr at $1.4 < z < 2.2$
- Mancini+15: timescales for quenching must be < 1Gyr, attending to the low number of transition objects observed between the MS and the sub-MS

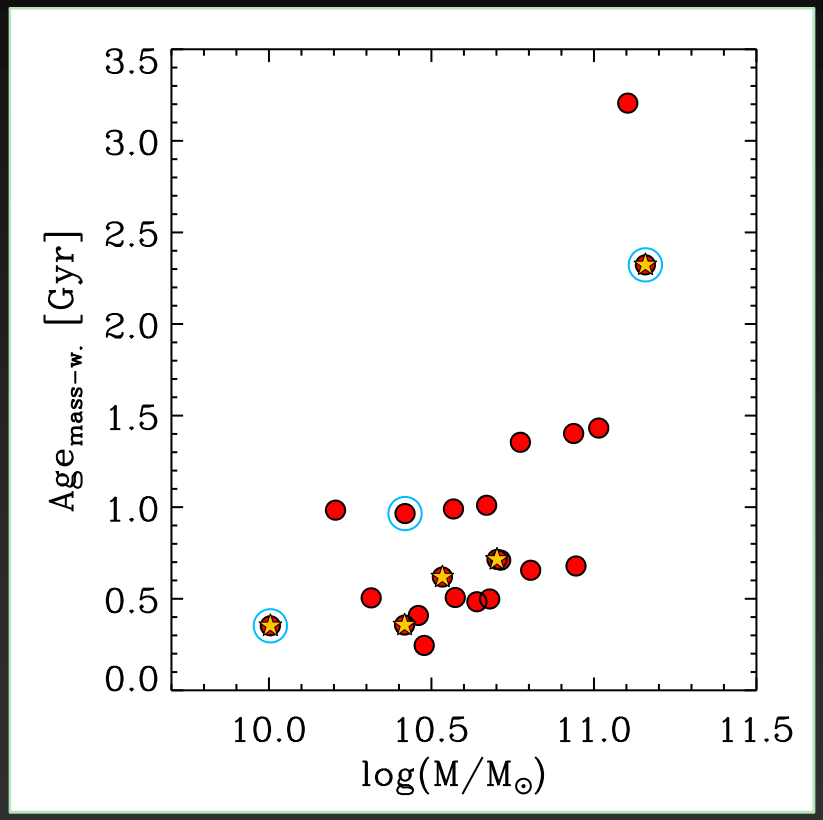
SFH timescales of ~1 Gyr only at z~1.5

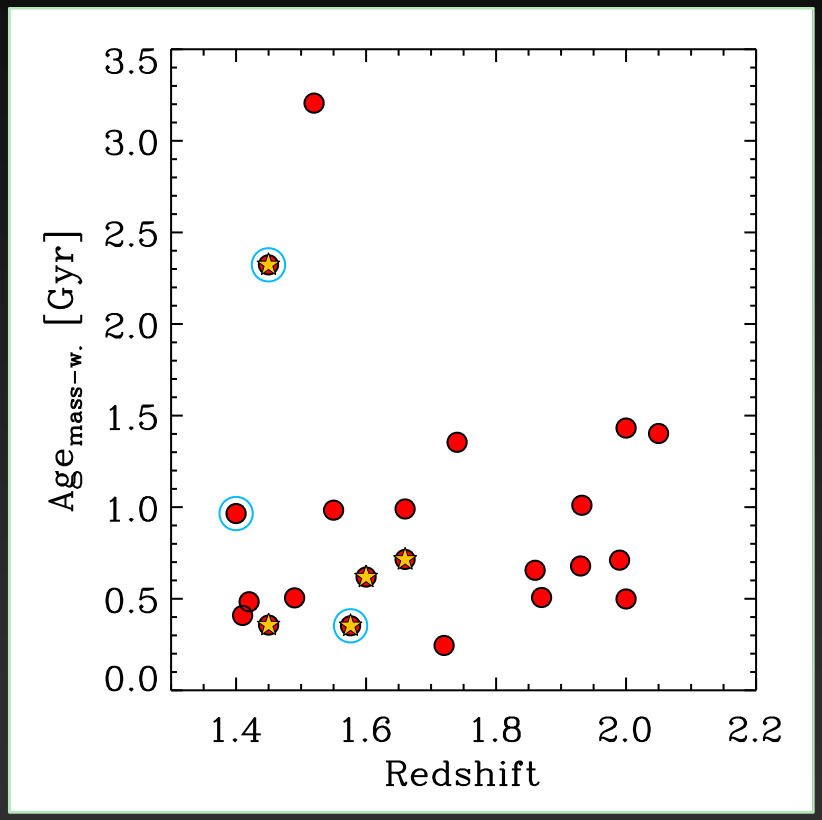




- Only 2 galaxies have extended SFHs with τ ~ 1 Gyr (one still forming stars), both at z ~ 1.5

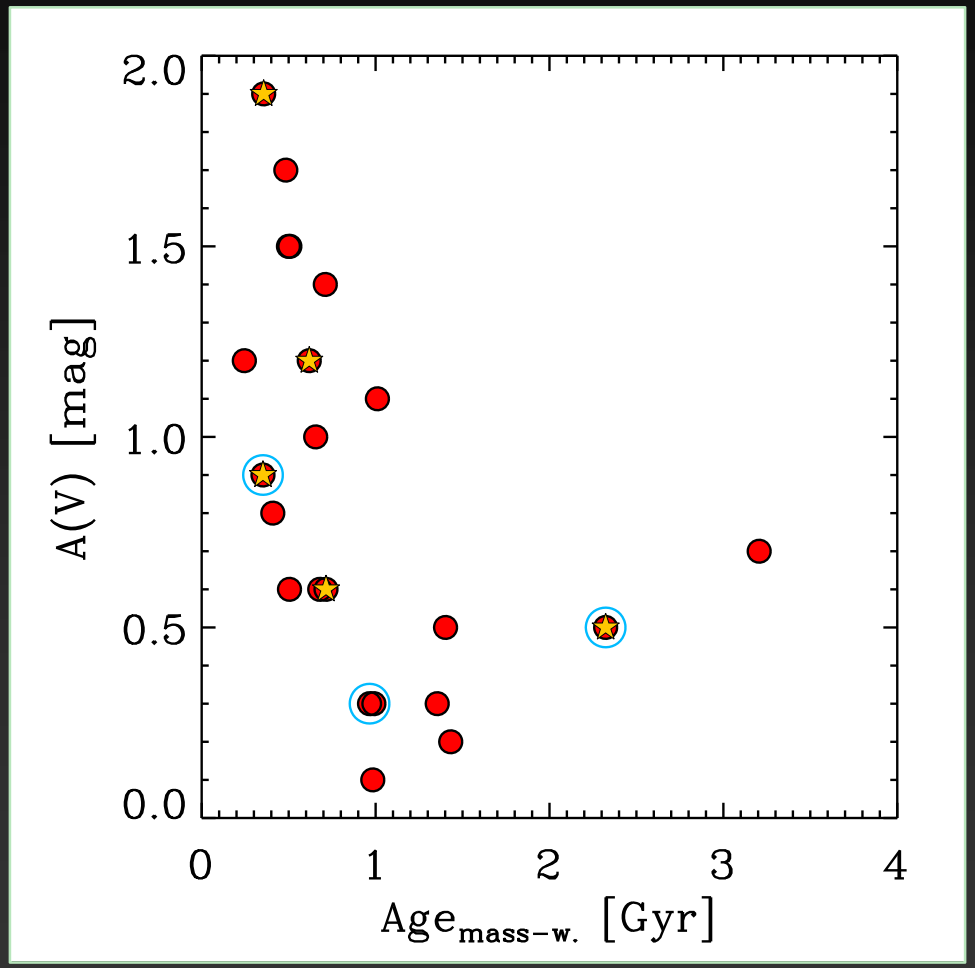
Mass-weighted ages < 1.5 Gyr





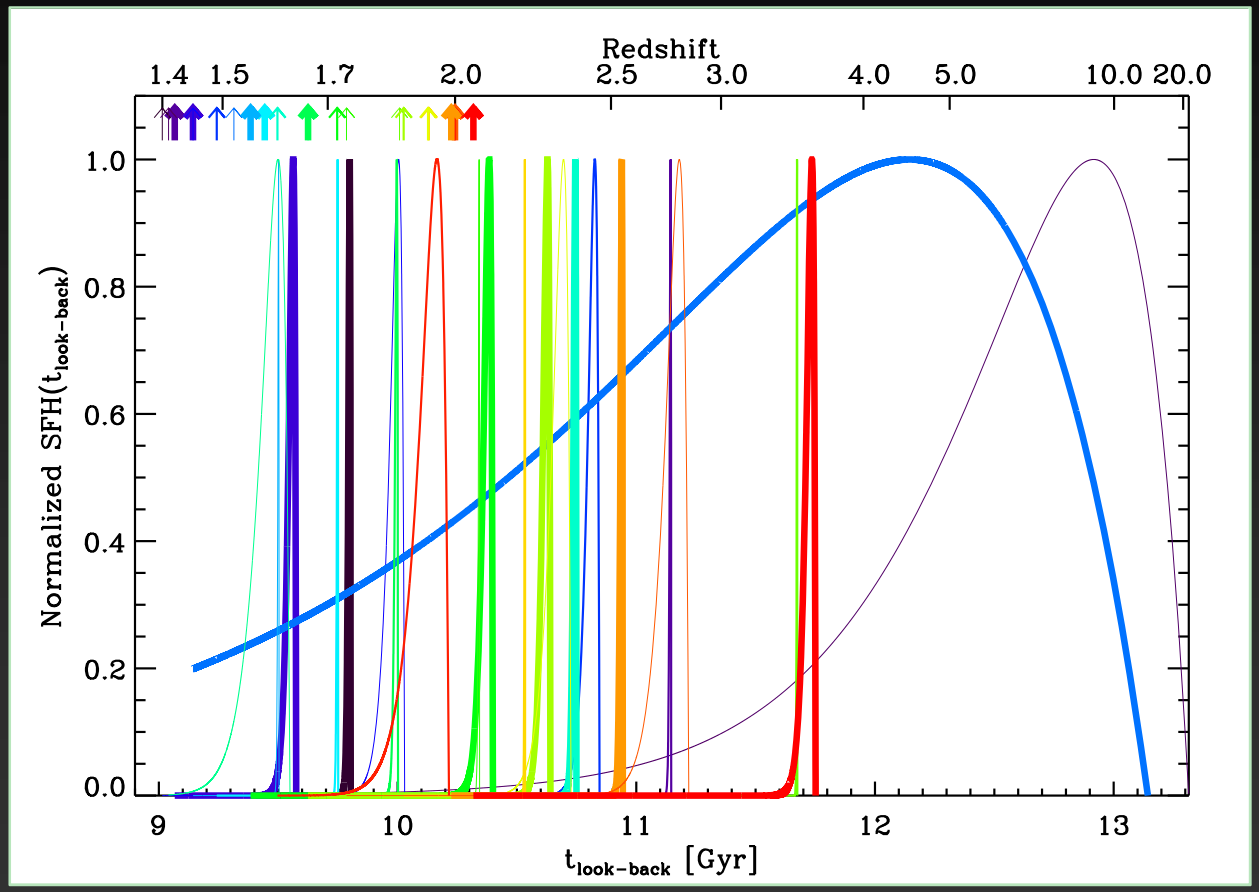
- Mass-weighted ages < 1.5 Gyr independently of mass and redshift
- Average age ~ 1 Gyr, in agreement with results from stacks of other studies (Whitaker+13, Mendel+15)

High dust extinction



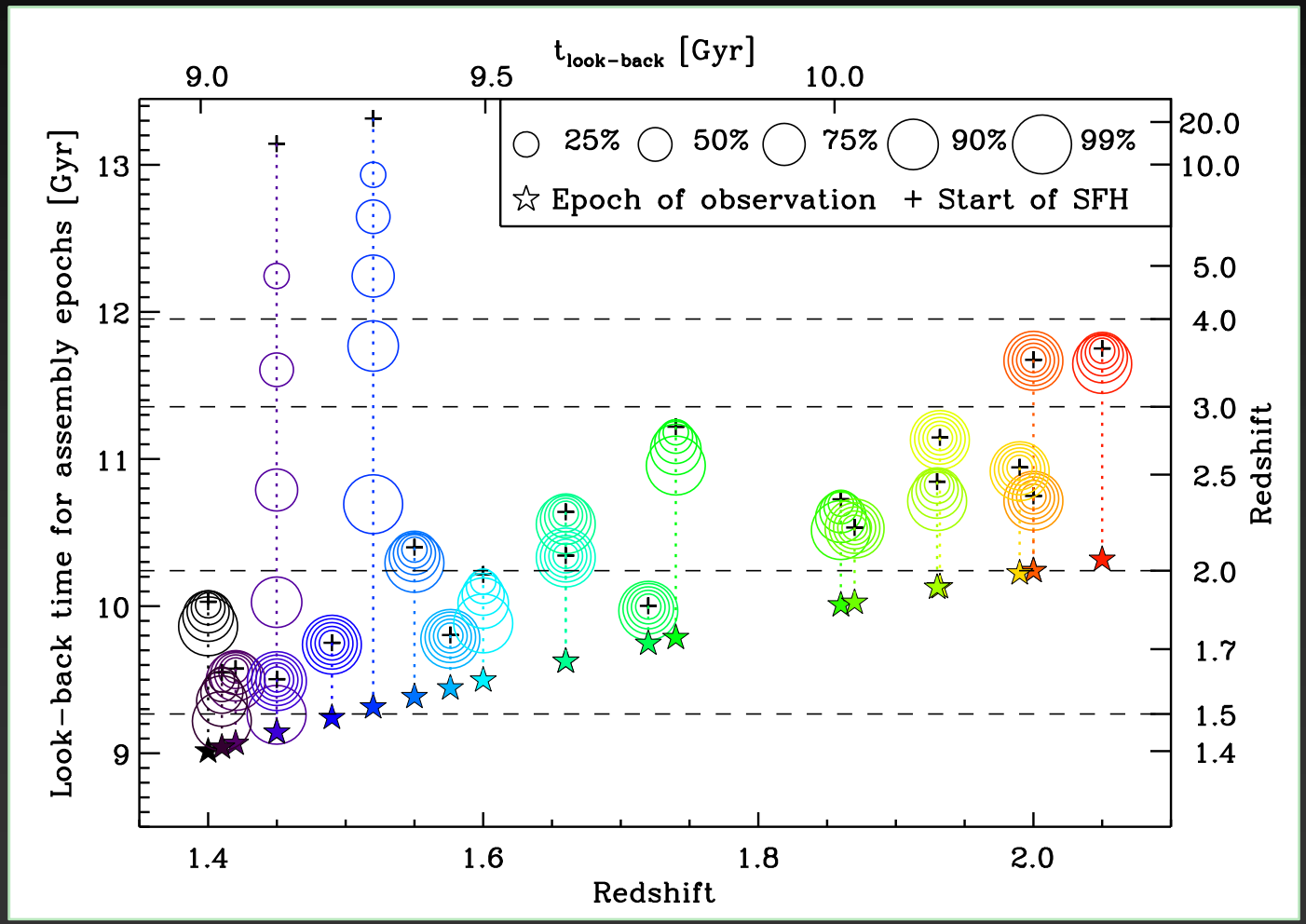
- High dust extinction in many objects, higher in younger ones (Marchesini+14)
- Analysis of clusters of solutions obtained with Montecarlo simulations

Peaked SFHs through the whole redshift interval



- ~ 2 - 3 Gyr spread in formation epoch of massive galaxies at z > 1
- Confirming results from stacks by Mendel+15

Rapid quenching of star formation



- SFH highly concentrated
- Mechanisms responsible of quenching the SF must be rapid too (τ_{quench} < 0.1 Gyr)
- Is the quenching mechanism "removing" memory of previous SFH?

More on SHARDS in this conference

1. Talk by P. G. Pérez-González, Sp 3, Wednesday 12:15h:

   Reconstructing the formation of massive galaxies from their SHARDS

2. Talk by H. Domínguez Sánchez, Sp 3, Wednesday, 12:30h:

   Living la vida loca: how to assemble a massive dead galaxy by z=1.0-1.5

   Poster S3.14 too

3. Poster S3.13 by P. Esquej:

   Galaxies in the Green Valley: are AGNs killing star formation?

4. Poster S3.2 by B. Alcalde Pampliega:

   A new population of massive galaxies at z>3 only detected in the MIR with IRAC

SHARDS homepage available at:

http://guaix.fis.ucm.es/~pgperez/SHARDS/

Ideas to take home…

1. Most massive UVJ-selected galaxies at 1.4<z<2.2 have had strongly peaked SFHs, with τ < 0.1 Gyr

2. Mass-weighted ages < 1.5 Gyr independently of mass and redshift, <age> ~ 1 Gyr

3. ~ 2 - 3 Gyr spread in formation epoch of massive galaxies at z > 1

4. Mostly quiescent and rapidly quenched, but relevant dust extinction in youngest ones

SHARDS homepage available at:

http://guaix.fis.ucm.es/~pgperez/SHARDS/