THE STAR FORMATION HISTORY OF RED & DEAD GALAXIES at z=1.0-1.5

UNIVERSIDAD COMPLUTENSE MADRID

Helena Domínguez Sánchez

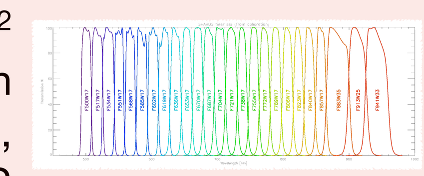
Universidad Complutense de Madrid

Pablo G. Pérez González, Pilar Esquej, Mª Carmen Eliche, Belén Alcalde + SHARDS team

ABSTRACT

We analyse the star formation histories (SFH) of M > 10^{10} M$_\odot$ read and dead galaxies at intermediate redshift (z=1-1.5). Current hierarchical models of galaxy formation predict many less massive high-z systems than observed (e.g. Ilbert et. al 2013). By combining SHARDS deep spectro-photometric optical data with WFC3 grism in the NIR (G141) and broad-band photometry (from FUV to FIR) we construct well-sampled optical SEDs with sufficient spectral resolution to obtain reliable stellar population parameters. We define a complete and uncontaminated sample of red&dead galaxies by combining the color-color UVJ selection with a cut in sSFR (SFR/Mass). We check the robustness of the results depending on different stellar population models or SED fitting-codes. Finally, the dependence of the SFH with the galaxy stellar mass will be studied, to actually measure if more massive galaxies are formed earlier and more rapidly as downsizing suggests.

1. DATA



We use a stellar mass selected sample in the 130 arcmin^2 GOODS-N region covered by the Survey for High-z Absorption Red and Dead Sources (SHARDS; Pérez González et al. 2013), an ESO/GTC Large Program carried out with the OSIRIS instrument on the 10.4m Gran Telescopio Canarias (GTC). SHARDS 25 contiguous medium-band filters at wavelengths between 500 and 950 nm reach an AB magnitude of 27 (at least at a 3σ level) in all bands. We complement the SHARDS data with the G102 and G141 GRISM operating in the IR channels of the WFC3 on board of the HST. Ancillary multiwavelenght data from UV to FIR data from the Rainbow database (https://rainbowx.fis.ucm.es/Rainbow_Database/Home.html) are also used to construct high resolution SEDs in the widest available wavelength range. The combination of these data provides spectral resolution R~50 or better from 500 nm to 1600 nm, with typically 150 independent photometric data points (instead of 20-25, the typical maximum of recent photometric studies; e.g. Ilbert et al. 2013, Skeleton et al 2014).

2. SELECTION

To construct the sample of read and dead galaxies we use a typical UVJ selection (Fig 1a), based on rest-frame UVJ colors, complemented with a cut in sSFR < 0.20 Gyr^{-1} (Fig 1b). SFRs are derived from the UV emission at 2800 Å, corrected by extinction using the UV slope. We derive an IRX (UV/IR ratio) - UV slope relation for the faint IR emitters (typically low star-forming galaxies, similar to our 'read&dead' sample). We eliminate from our sample UVJ selected galaxies with IR detection to avoid dusty star-forming galaxies. We restrict our sample to galaxies detected in at least 30 photometric bands (without considering the grism data). We recalculate photometric redshifts including the G141 data by performing an SED-fitting using EAZY (Brammer, van Dokkum & Coppi 2008). The z_{ph} accuracy is $\Delta z/(1+z)$=0.005 (better than, e.g., the 3D-HST photometric catalogs, Skeleton et al 2014). The final sample of intermediate redshift read&dead galaxies consists of 117 galaxies.

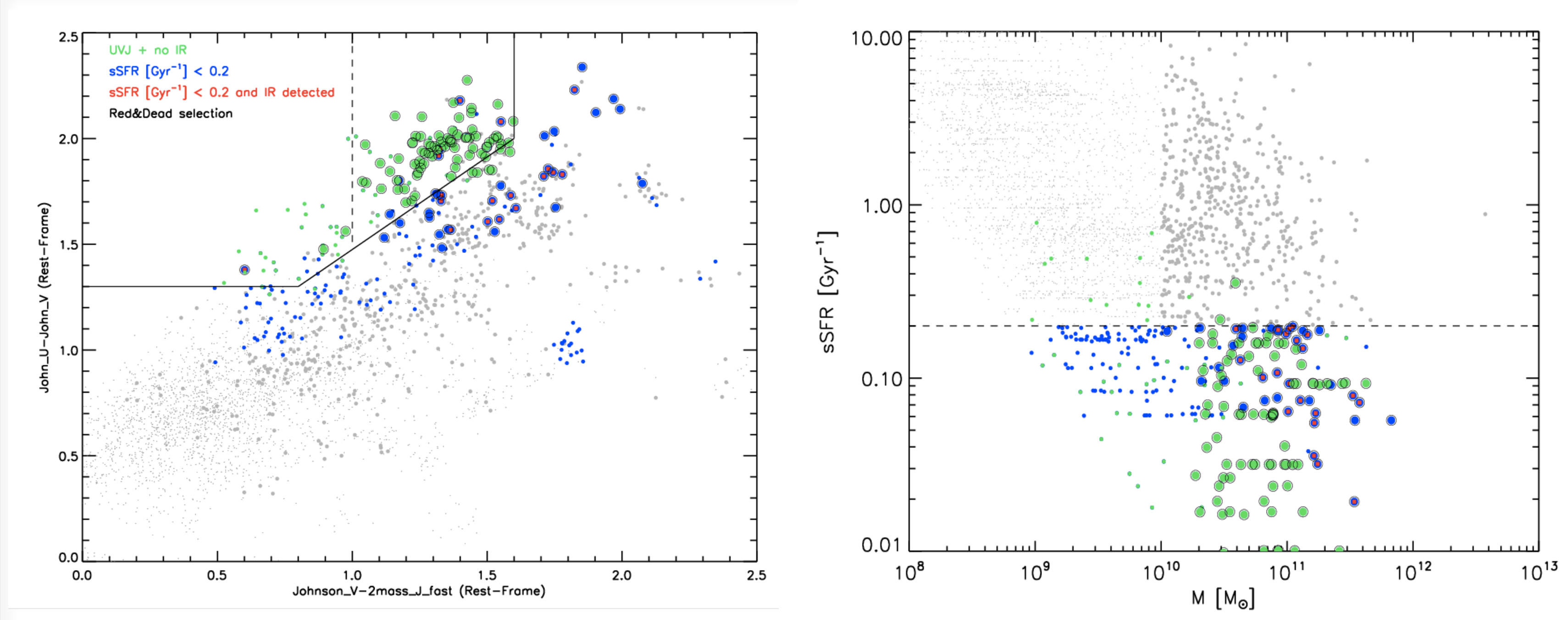


FIG 1. Sample Selection : a) UVJ color diagram for z=1.0-1.5 galaxies (grey dots). The 76 red&dead galaxies UVJ selected are plotted in green, the 41 with low sSFRs (< 0.2 Gyr^{-1}) in blue (in red those IR detected). The size of the symbols indicate the cut in mass (log M > 10^{10} M$_\odot$). 75 of the galaxies have with usable G141 spectroscopic data (64 %). b) sSFR-Mass diagram, colors as in a)

3. SED-FITTING

We perform a SED-fitting to the photometric data (with typically 40-160 filters, including nIR spectroscopic data) using two different codes: synthesizer (Pérez-Gónzalez 2003, 2008) and FAST (Kriek et al. 2009). We use Bruzual & Charlot (2003) and Maraston et al. (2005) models with (delayed) exponentially declining SFR ∝ (t)e$^{-t/\tau}$, solar metallicity, Chabrier IMF and Calzetti (2000) extinction law. We set as free parameters the masses, ages, SF timescales and extinction. An example of SED-fitting and the obtained stellar parameters can be seen in Fig 2 for both fitting-codes, with a zoom in the G141 region. The continuos coverage of the SHARDS photometry is fundamental to perform robust stellar population analysis and even interesting features such as the 4000A break or the MgUV index can be appreciated.

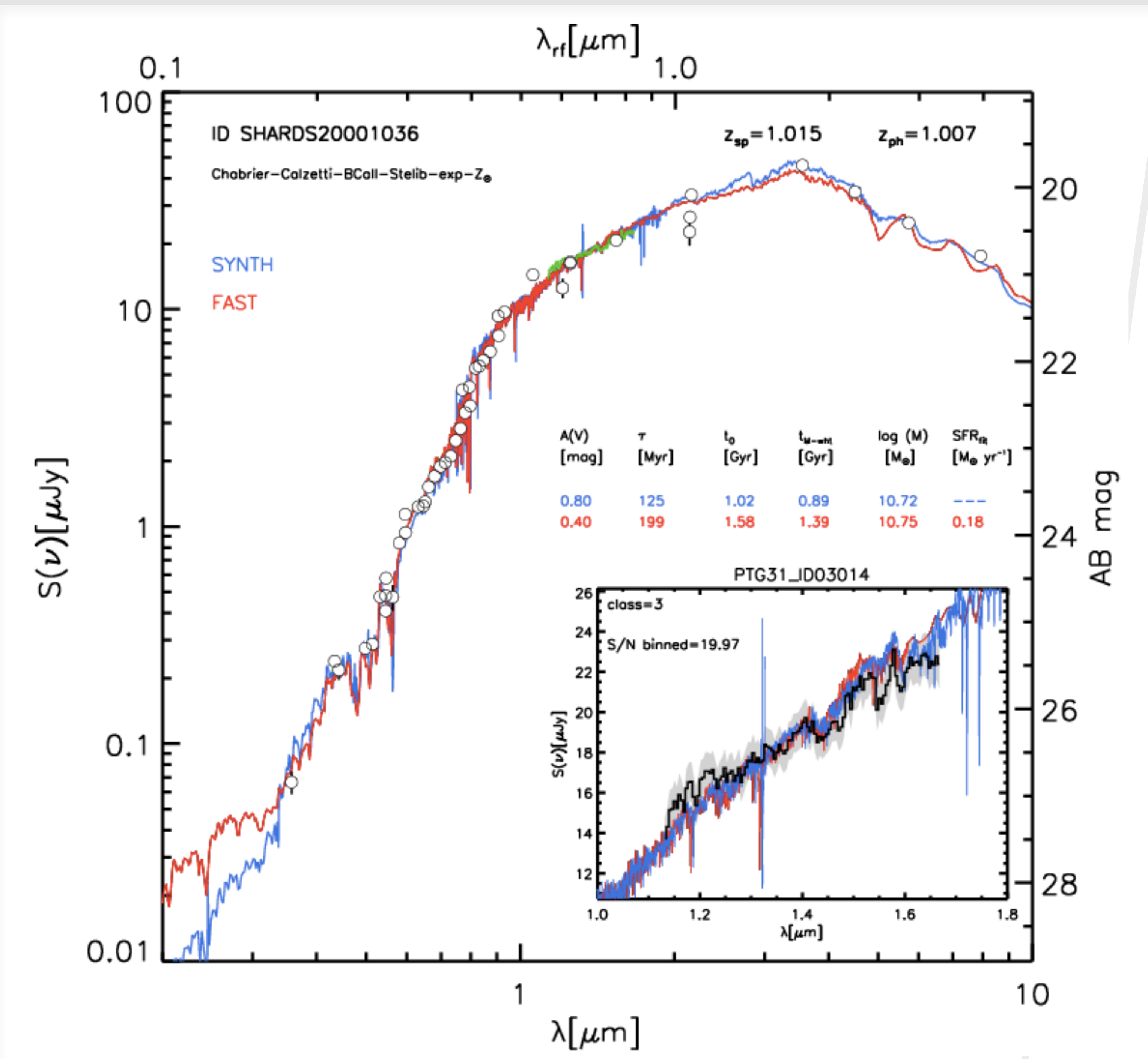


FIG 2. SED-Fitting for a red and dead z=1.01 SHARDS galaxy. Photometric data points are plotted as white circles, G141 spectra in green (zoomed in the right corner). The solutions obtained with BC03 exponentially declining models are plotted in red and blue for synthesizer and FAST codes, respectively. The resulting stellar parameters are also shown. The timescales are similar in the two cases (~150 Myr). However, FAST predicts an older stellar population with moderate extinction, while the synthesizer solution is a younger population with higher extinction. We are trying to remove these typical degeneracies by analyzing absorption indices (such as D4000 or Mg_{UV}) measured with SHARDS and HST/WFC3 grism data.

4. DEGENERACIES

Although the SEDs used in this work are one of the best sampled photometric data for high-z red and dead galaxies, results are still subject to degeneracies in the age-timescale-metallicity-extinction parameter space. To study this issue, we perform 300 Montecarlo simulations for each galaxy by allowing the photometric data to randomly vary within their photometric error and recalculating the stellar parameters with the synthesizer code. The degeneracies can be observed in Fig. 3, where we show as an example, the 300 different solutions obtained for one galaxy in the age-extinction and age-τ parameter spaces. We are trying to remove these degeneracies by analyzing absorption indices measured with SHARDS and HST/WFC3 grism data.

5. DEPENDENCES

We compare the best-fitting stellar parameters obtained by using different fitting codes (FAST vs synthesizer) or stellar population models (BC03 vs M05). The differences between the resulting stellar parameters do not present significant offsets (i.e., median Δ(param) ~ 0). They seem to be more affected by the model used rather than by the fitting-code. The most affected stellar parameter is the SF timescale. The mass, in agreement with previous studies, seems to be the most robust stellar parameter. The mass-weighted ages are compared in Fig. 4. The most massive galaxies (log M > 11.0 M$_\odot$) seem to have older ages but a wide range in SF timescales (1-1000 Myr). However, these results are only preliminary and much effort must still be done to clearly interpret these data taking into account the multiple degeneracies, selection effects and model dependencies.

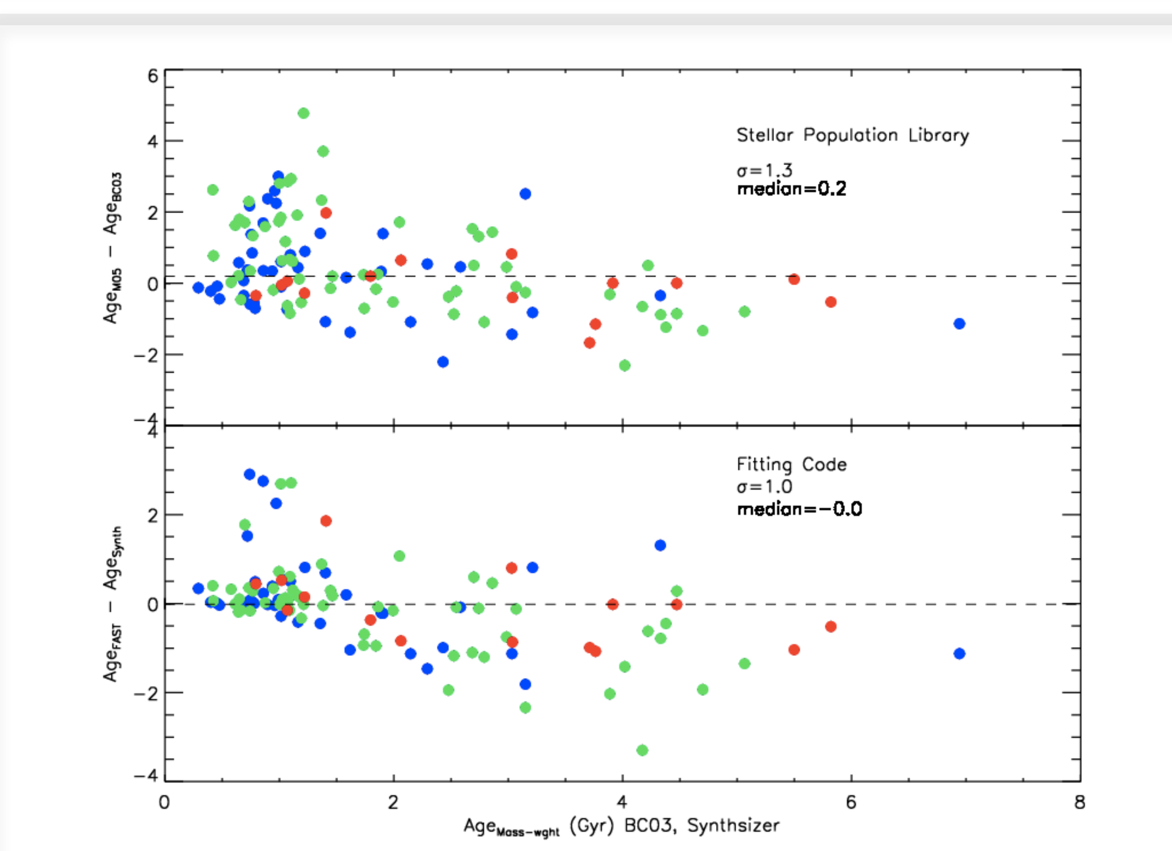
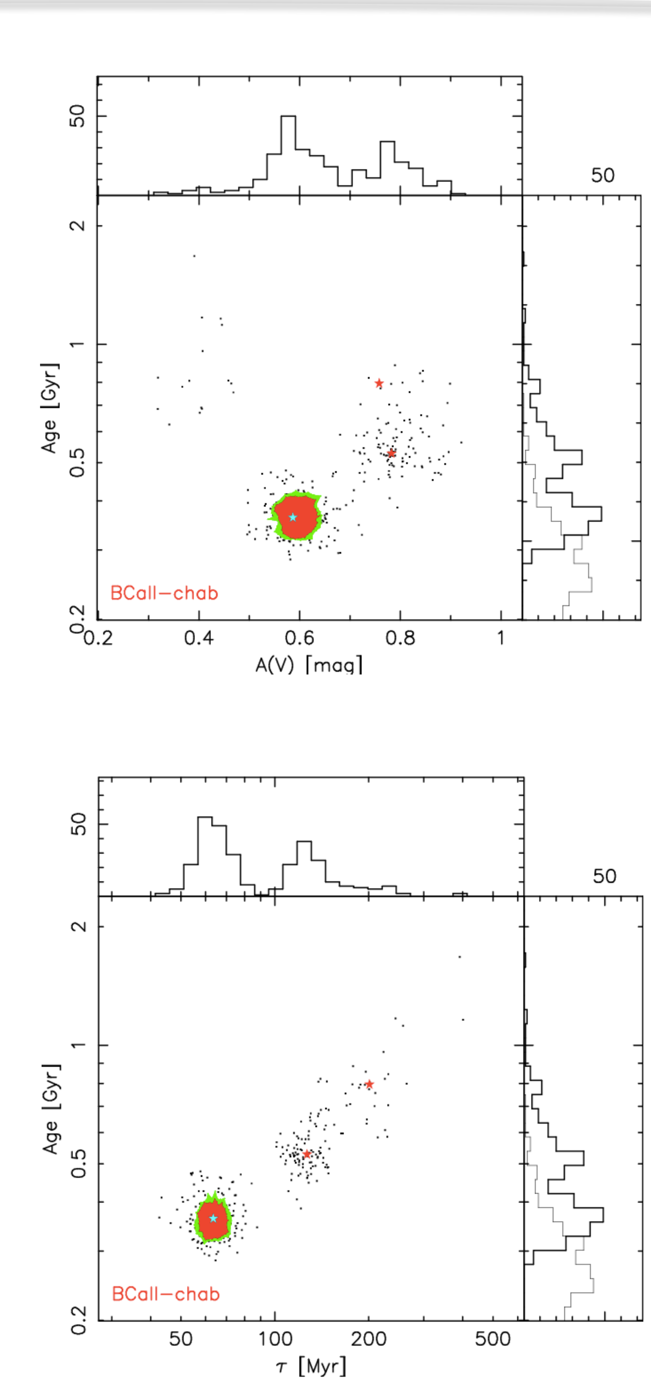


FIG 4. Comparison of the best-fitting mass-wighted age for different stellar population models (upper panels) and fitting codes (lower panels). Colors represent different bins in log mass (blue: 10.0-10.5, green 10.5-11.0, red: 11.0-11.8). We also shown the median of the difference between values and its dispersion, which is ~1 Gyr.

FIG 3. Degeneracies of the SED-fitting solutions in the age-timescale and age-extinction space parameters. The dots are the results obtained for 300 Montecarlo simulations for one galaxy with the BC03 models. The light grey histogram are the mass-weighted age distributions. In this case, we obtain 3 different solution clusters marked with red points. The most significant solution also shows 1- (red) and 2-σ (green) contours. The data is fitted with a relatively young galaxy (0.4 Gyr) with moderate extinction (0.6 mag) and short formation timescales (τ ~70 Myr) while the other two solutions imply an older stellar population (0.5-1 Gyr), higher extinction (0.8 mag) and larger star-formation timescales (τ ~150-200 Myr).



Contact: helenads@ucm.es