THE SOURCES RESPONSIBLE OF THE RE-IONIZATION OF THE UNIVERSE

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CONTENTS

- Introduction to the subject.
- Objectives of the project.
- The SHARDS survey.
- Our work and some results.

INTRODUCTION

- Re-ionization caused by a population of low-luminosity sources: LAEs and LBGs.
- Lyman Alpha Emitters (LAEs) show an intense Lyα emission line and barely any continuum.
- Lyman Break Galaxies (LBGs) have a prominent UV continuum to the red of Lyα, showing or not that emission line.

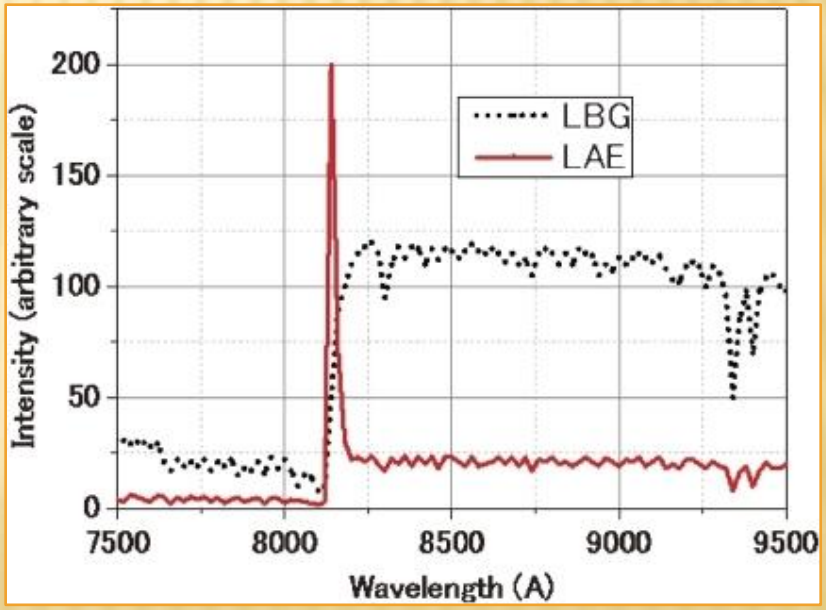


Figure 1. LAE and LBG example spectra.

INTRODUCTION

- LAEs and LBGs have different UV continuum, so the way absorption by dust and neutral hydrogen affect them is quite different.
- The ratio of LAEs to LBGs is a proxy for the ionization state of the Universe.
- Previous studies at z~2-6 got SFR too low to account for the re-ionization of the Universe.
- With SHARDS data we can probe very faint sources so we can obtain better luminosity functions and better estimations of the ionizing photon density.

OBJECTIVES

- Search for Lyman alpha sources in the GTC SHARDS survey.
- Discriminate if they are LAEs or LBGs and study their relative numbers as a function of redshift.
- Study their clustering properties.
- Calculate Star Formation Rates as a function of redshift.
- Determine the ionizing photon density at $z\sim6$
- Take spectra of the brightest sources and compute their masses, ages, metallicities and SFRs.

SHARDS

- Survey for High-z Absorption Red and Dead Sources.
- ESO/GTC Large Program that has surveyed the entire GOODS-North field. (P.I. Pablo Pérez González, UCM).
- Using GTC/OSIRIS with 24 medium band filters between 500 and 950 nm.
- Seeing conditions under 0.9 arcsec.
- Observation depth reaches 26.5 AB (3σ level) in all filters.

SHARDS

- Its original main purpose was to analyze stellar populations in massive galaxies at high redshift, specially those that are already evolving passively.

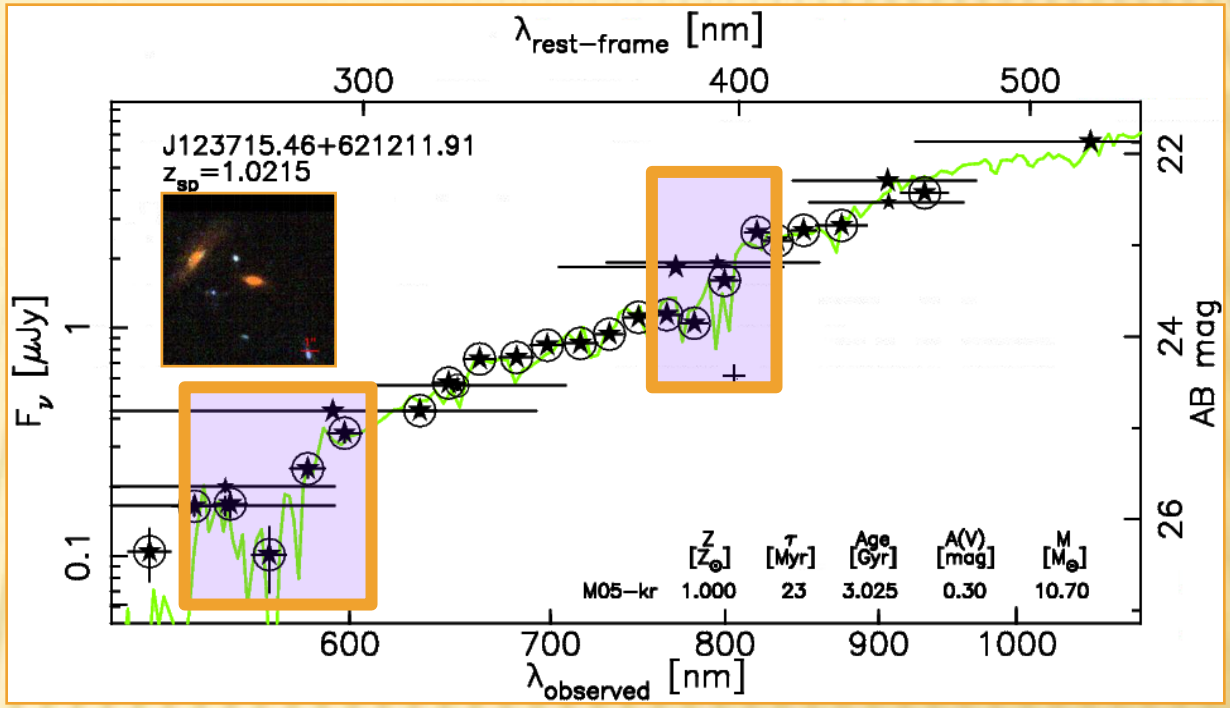
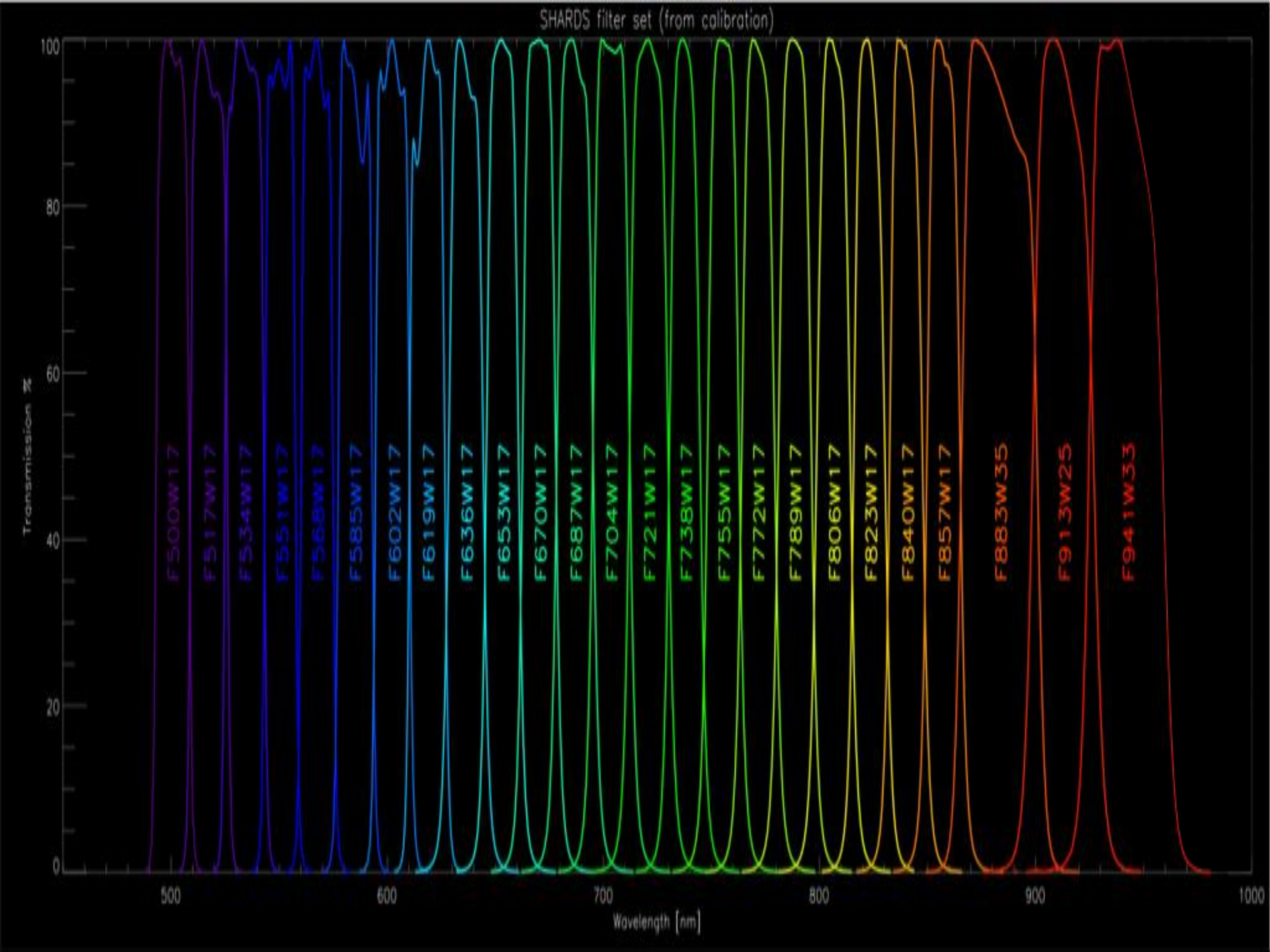


Figure 2. Old red galaxy SED. Pérez-González et al. (2013).

- Devised to be able to construct rest-frame UV/optical SEDs and measure absorption indexes.


SHARDS filter set (from calibration)
Transmission %
Wavelength [nm]
0
20
40
60
80
100
500
600
700
800
900
1000
F500W17
F517W17
F534W17
F551W17
F568W17
F585W17
F602W17
F619W17
F636W17
F653W17
F670W17
F687W17
F704W17
F721W17
F738W17
F755W17
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F883W35
F913W25
F941W33

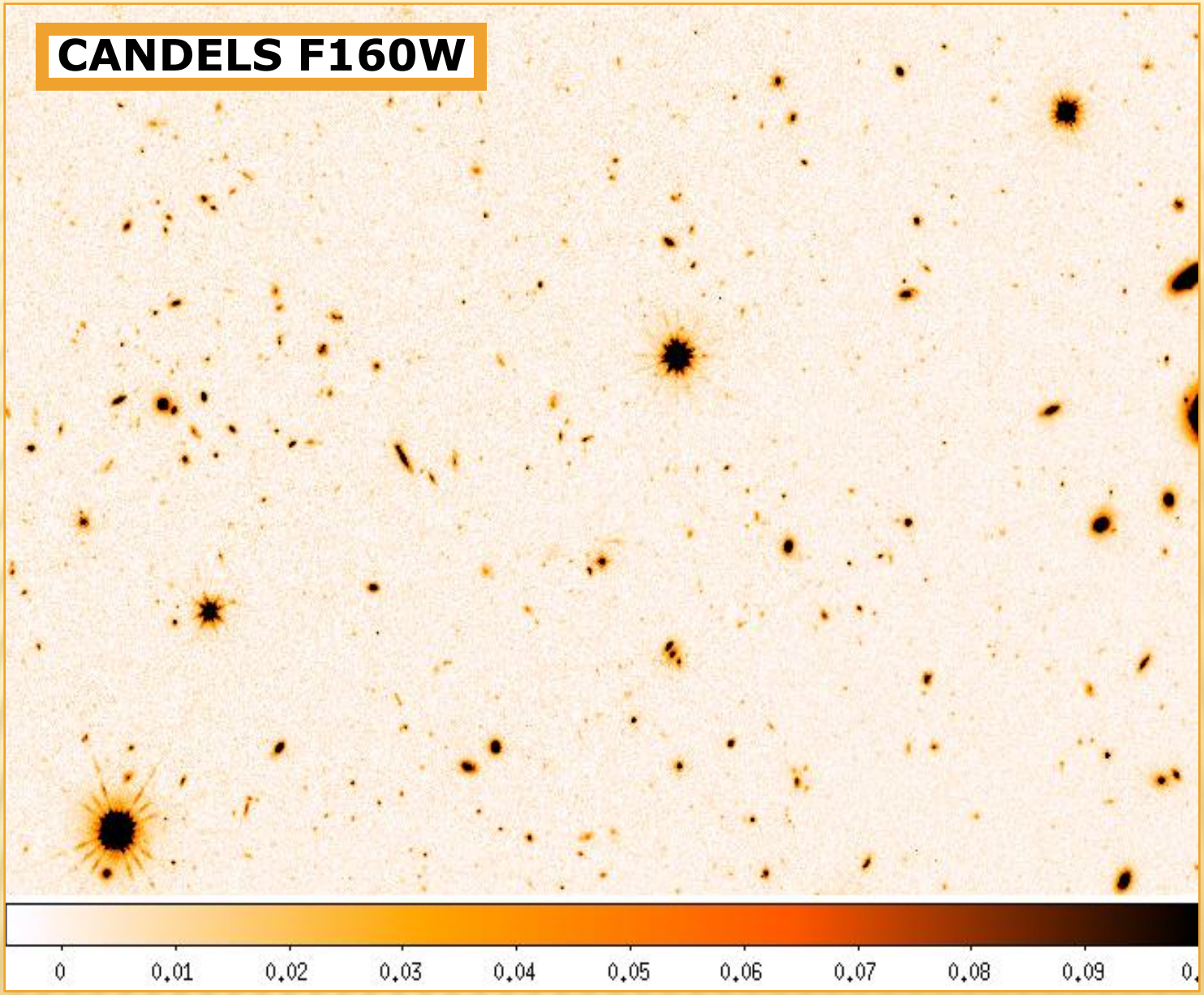

Figure 3. HST image of the GOODS-N field using the F160W filter.

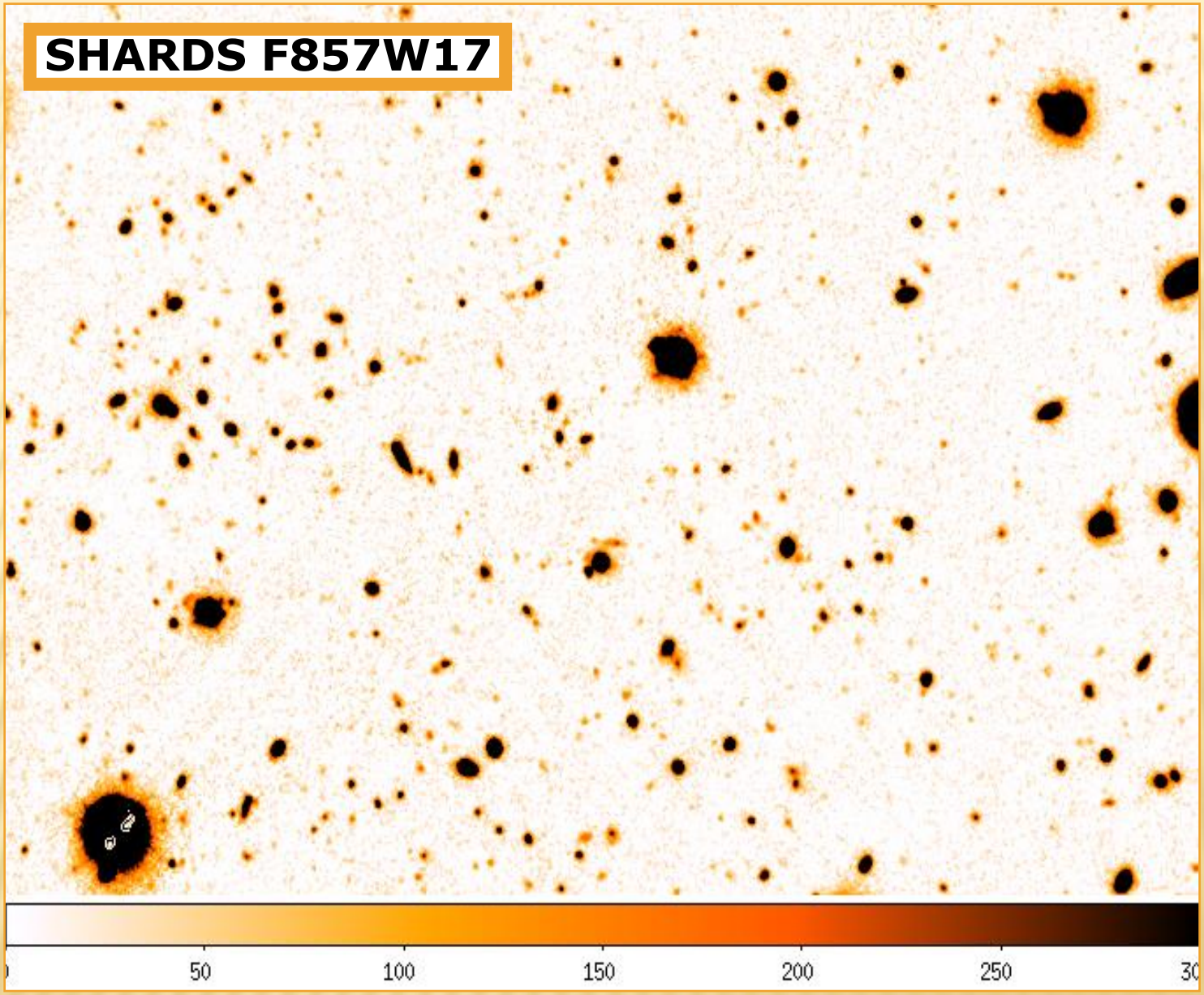

Figure 4. GTC SHARDS image of the GOODS-N field using the F857w17 filter.

OUR WORK & RESULTS

- The relative filter narrowness allows us to detect both LAEs and LBGs:
  - Higher contrast for emission lines.
  - Higher definition for drop-out sources.
- First thing was to select objects which do not have emission in some filters.
- We also made H-R diagrams combining two filters to find galaxies with emission lines in that filters.
- Then we built SEDs of the most interesting objects.
- At the moment we are designing a code to quickly identify possible emission lines in the SEDs.
- Finally, we check the real images to see what we really observe in a particular possible LAE or LBG candidate position in all filters.

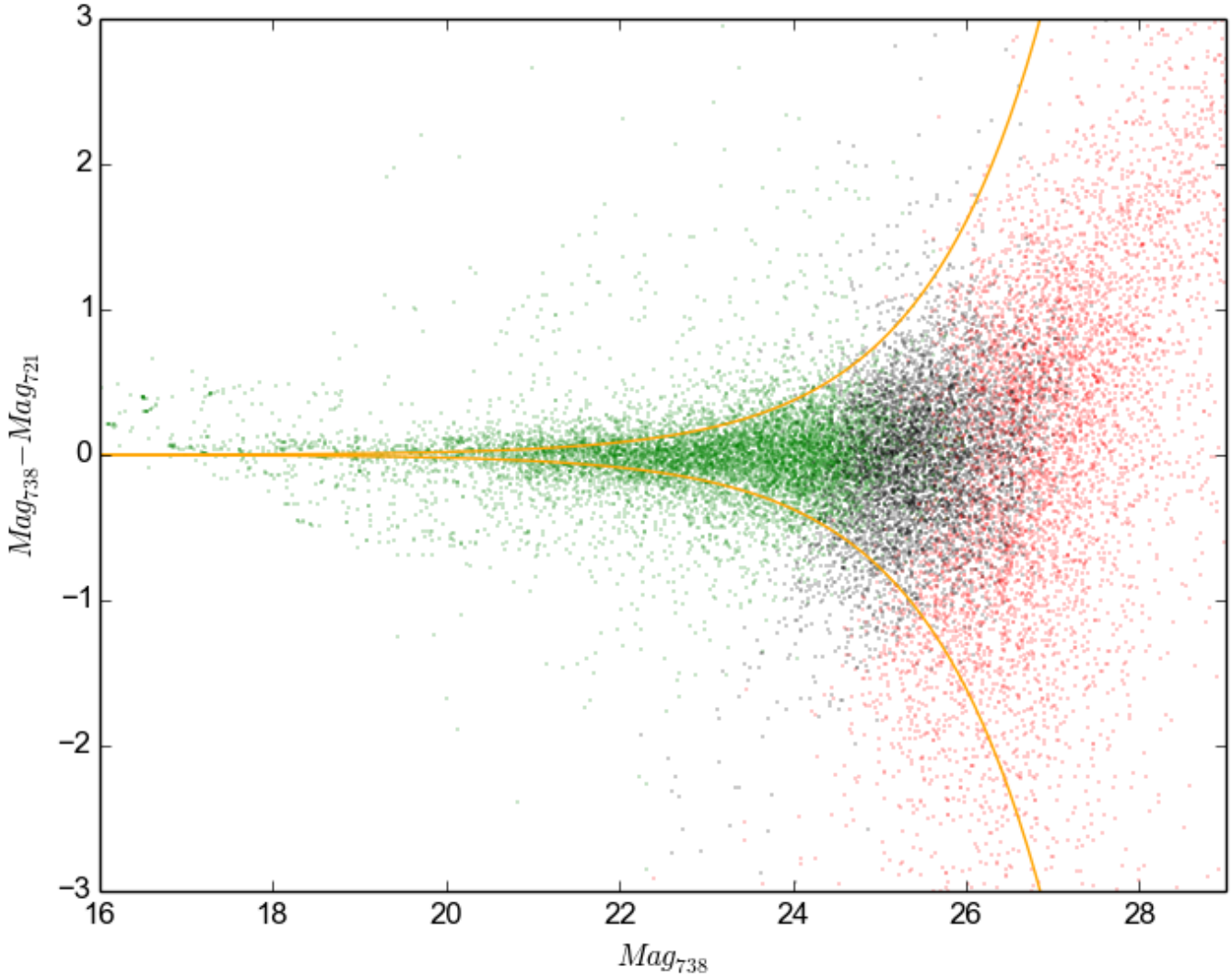

Figure 5. Color-Magnitude diagram of the SHARDS data catalog using two consecutive filters.

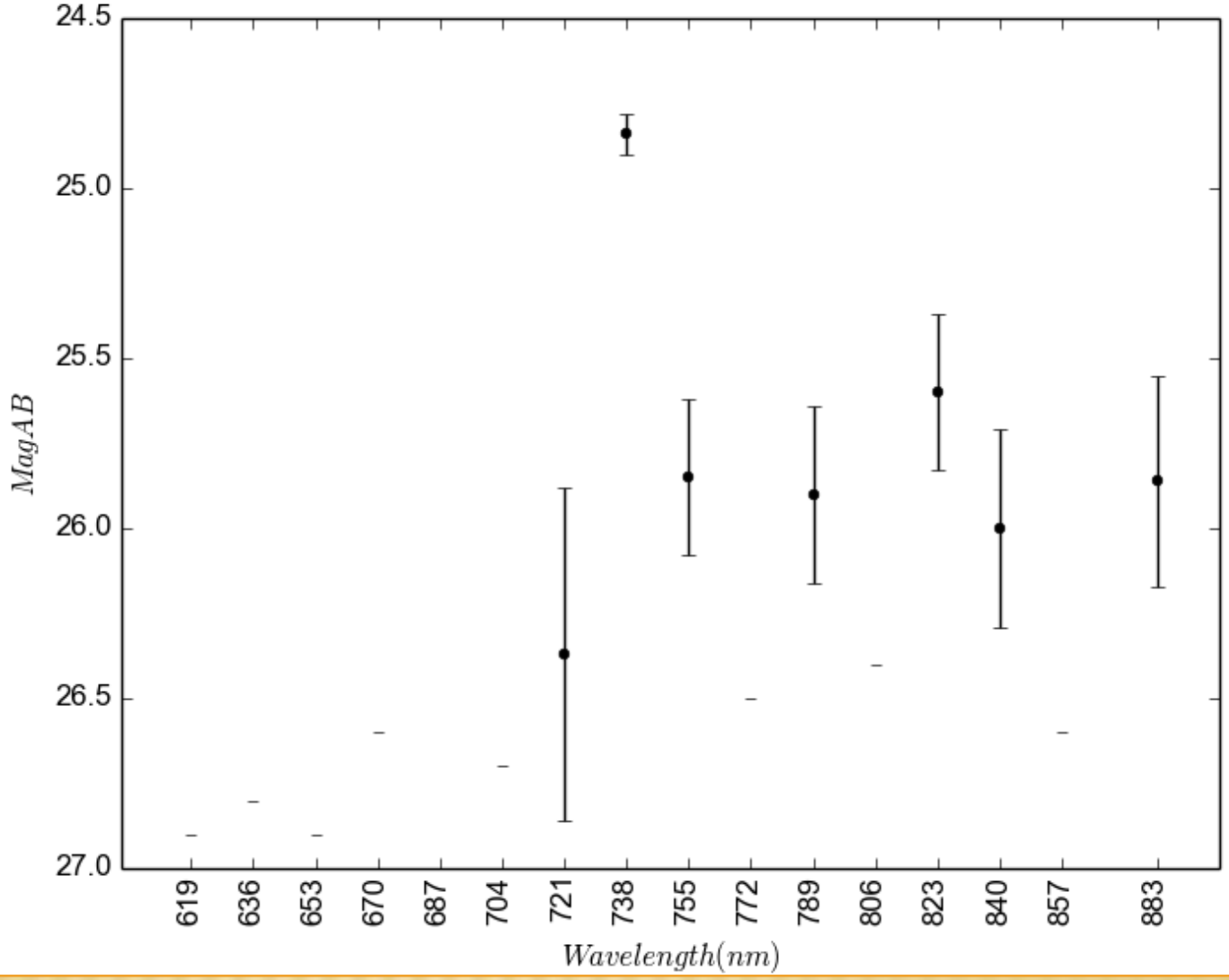

Figure 6. Possible LAE candidate SED. This particular case has been confirmed by J.M. Rodríguez et al. (2014)

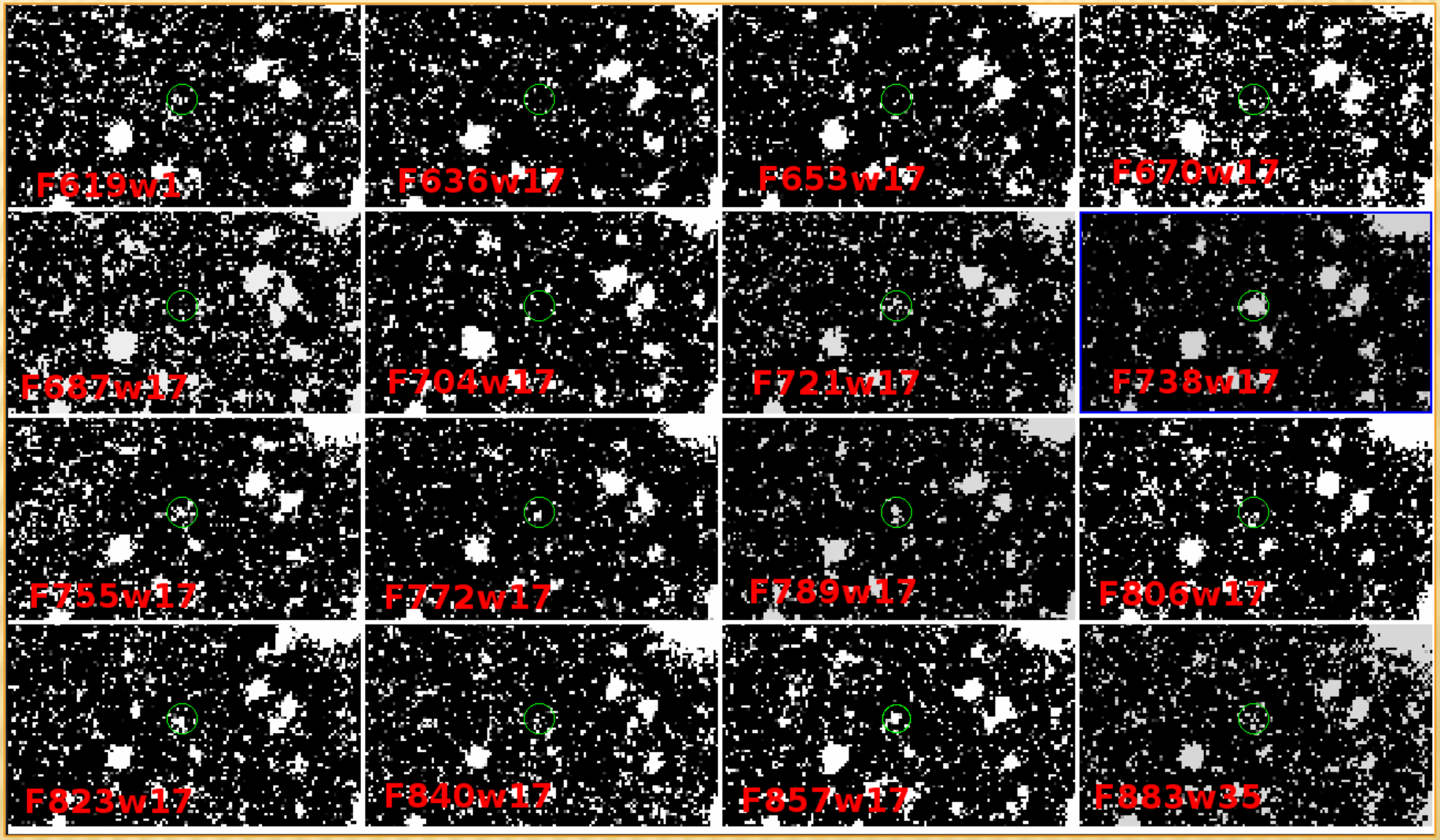

Figure 7. SHARDS image mosaic of the previous object using 16 different filters.

- [Pérez-González et al.(2013)] Pérez-González, P. G., Cava, A., Barro, G., et al. 2013, ApJ, 762, 46
- [Rodríguez Espinosa et al.(2014)] Rodríguez Espinosa, J. M., González-Martín, O., Castro Rodríguez, N., et al. 2014, Royal Astronomical Society, 444, L68
- [Pentericci et al.(2014)] Pentericci, L., Vanzella, E., Fontana, A., et al. 2014, ApJ, 793, 113
- [McLeod et al.(2014)] McLeod, D. J., McLure, R. J., Dunlop, J. S., et al. 2014, arXiv:1412.1472
- [Oesch et al.(2015)] Oesch, P. A., van Dokkum, P. G., Illingworth, G. D., et al. 2015, arXiv:1502.05399