Deep near-IR narrow-band imaging with CIRCE at GTC: searching for Lyα-emitters at z ~9.3

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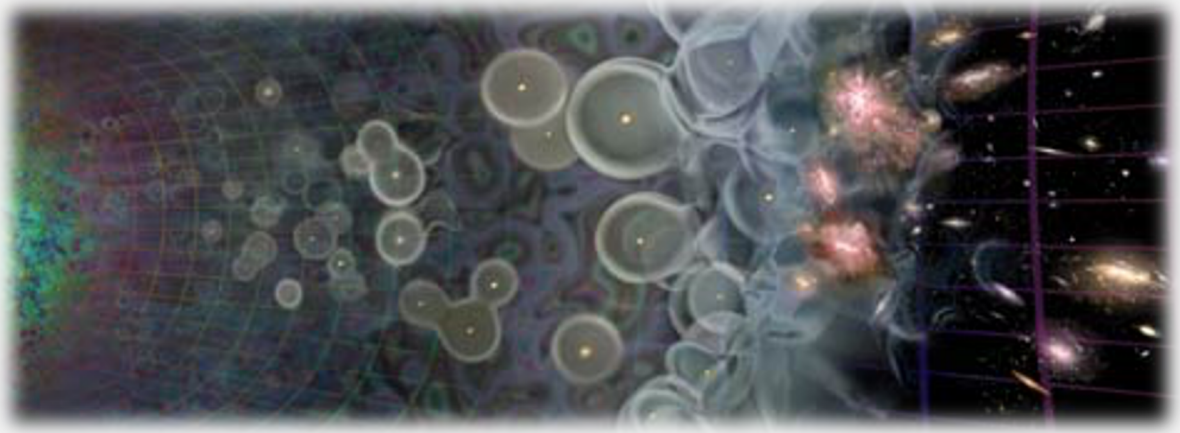

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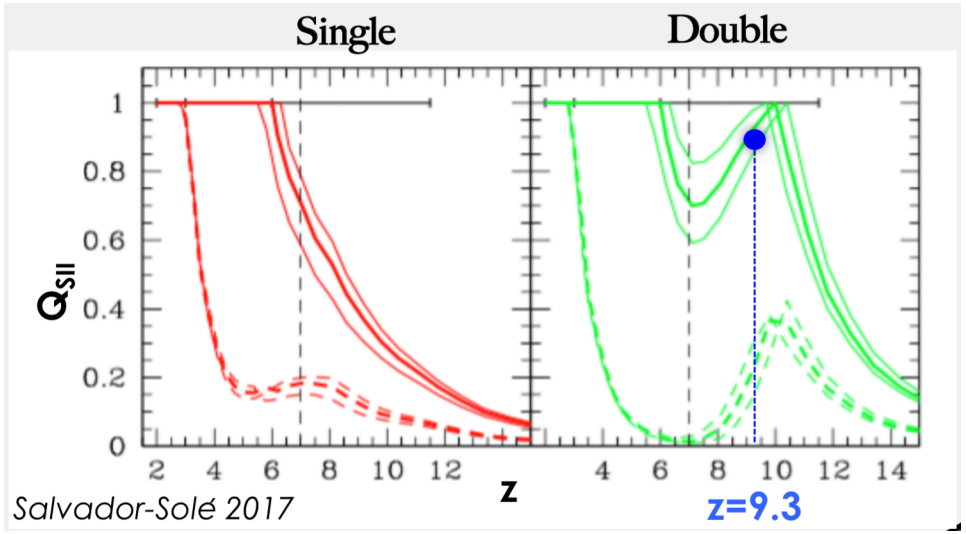
Abstract:

Identifying high redshift galaxies is crucial for understanding the formation and evolution of galaxies. The main goal of this project was to detect and quantify the double reionization predicted by the AMIGA model (Salvador-Solé et al. 2017) and the corresponding population of LAEs (Luminous Lyman-α Emitters) at z ~9.3 by the flux excess due to the Lyα emission. We present a deep image with 18.3 hours on-source integration, taken with a narrow band filter (FWHM = 11nm and central wavelength λc= 1.257 μm) designed on purpose by ourselves for the CIRCE nIR camera at GTC. We have specially designed a procedure to carry out the data reduction and to control the process step by step to generate the final deep NB image (Cabello et al. 2020 in prep.).

The deep image was obtained within the Extended Groth Strip (EGS) field, but we confirmed reaching only a limiting AB magnitude ~22 in the NB filter. With this depth we could not detect any LAE at high redshift, however, we have detected some interlopers at lower z. As a complementary result, we have performed a scientific analysis of the identified galaxies, gathering the available ancillary information from the 3D-HST and CANDELS surveys. This pioneering work will be complemented with a more spectroscopic study of low-mass star-forming galaxies at different redshifts. For this part, we will exploit the guaranteed time, spectral resolution and multiplex capabilities of both MEGARA and EMIR instruments for the GTC.

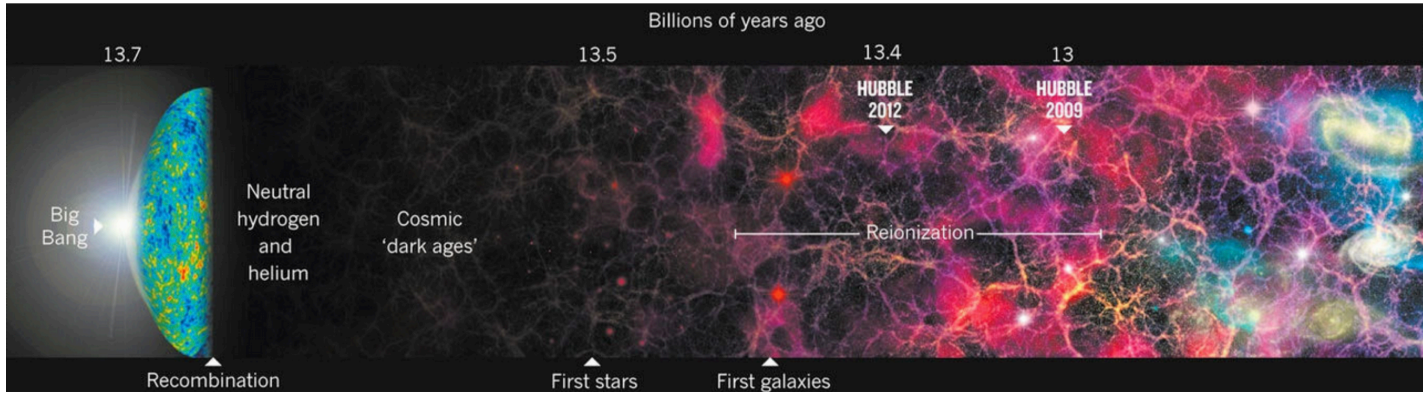
Analytic Model of Intergalactic-medium and GAlaxy (**AMIGA**)



AMIGA predictions are that it is very likely that the reionization of the intergalactic neutral hydrogen occurred in two stages separated by a short recombination period:

- A first one at z ~ 10, driven by the first generation of stars (Pop. III stars)
- A second and definitive one at z ~ 6, due to young galaxies formed at z > 6

Double reionization scenario?



At this z the Lyman-α line has been redshifted at ⇒ $\lambda_{Ly\alpha}$ = 1.25 μm

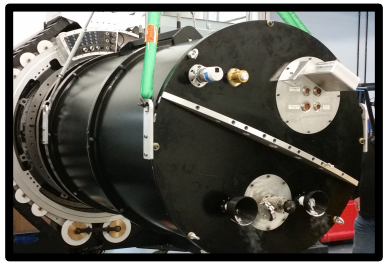
Detection of Lyman-α Emitters

Observational proofs ⇒ LAEs at z = 9.3

- Obtain an ultra-deep Narrow-Band (NB) image.
- **Selection of targets with a flux excess in the NB filter** (due to the Lyα emission) with respect to the Broad-Band filter.
- Reject lower-z contaminants and select candidates of LAEs at z=9.3 to follow-up spectroscopy confirmation.
- Analyse the results and check the reliability to the hypothetical scenario of double reionization of the Universe.

Instrumental setup

CIRCE@GTC



DETECTOR

Teledyne HAWAII-2RG controlled by a cryogenic SIDECAR ASIC.

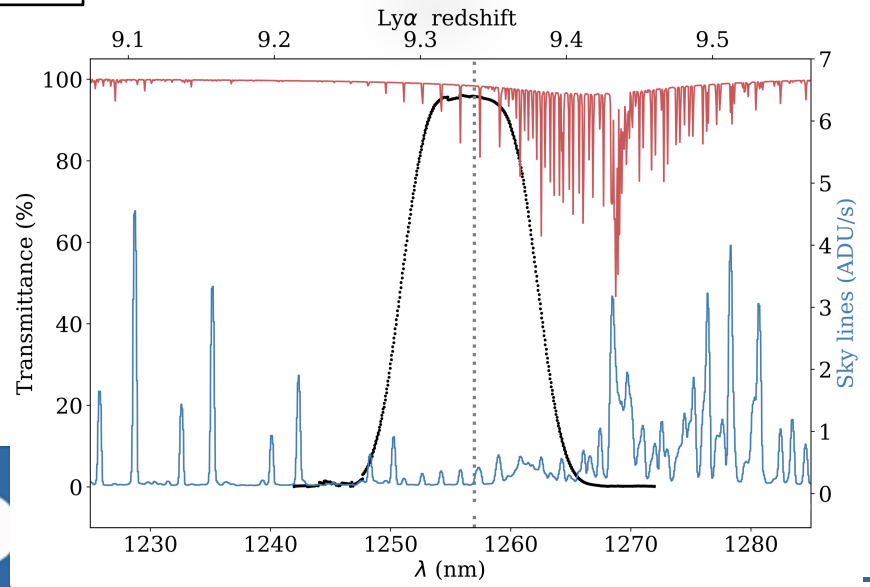
2048 x 2048 pixels
Spec. Range: 1 - 2.5 μm
FoV 3.4' x 3.4'
Plate scale: 0.1"/pix
Readout noise: 30-45 e- RMS
Gain: 5.3 ± 0.5 e-/ADU
30/32 array amplifier active

Narrow-Band 1257 filter

SCHOTT + ALBA team

NB FILTER

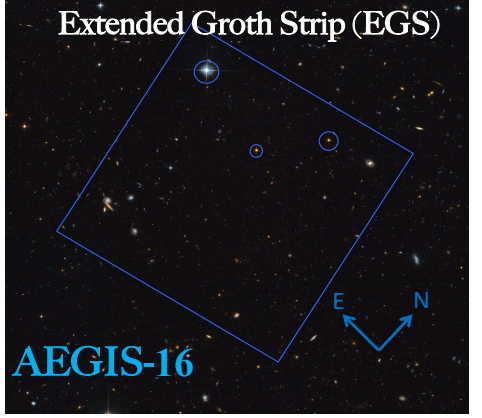
FWHM = 11 ± 0.5 nm
λ_c = 1254 ± 2 nm



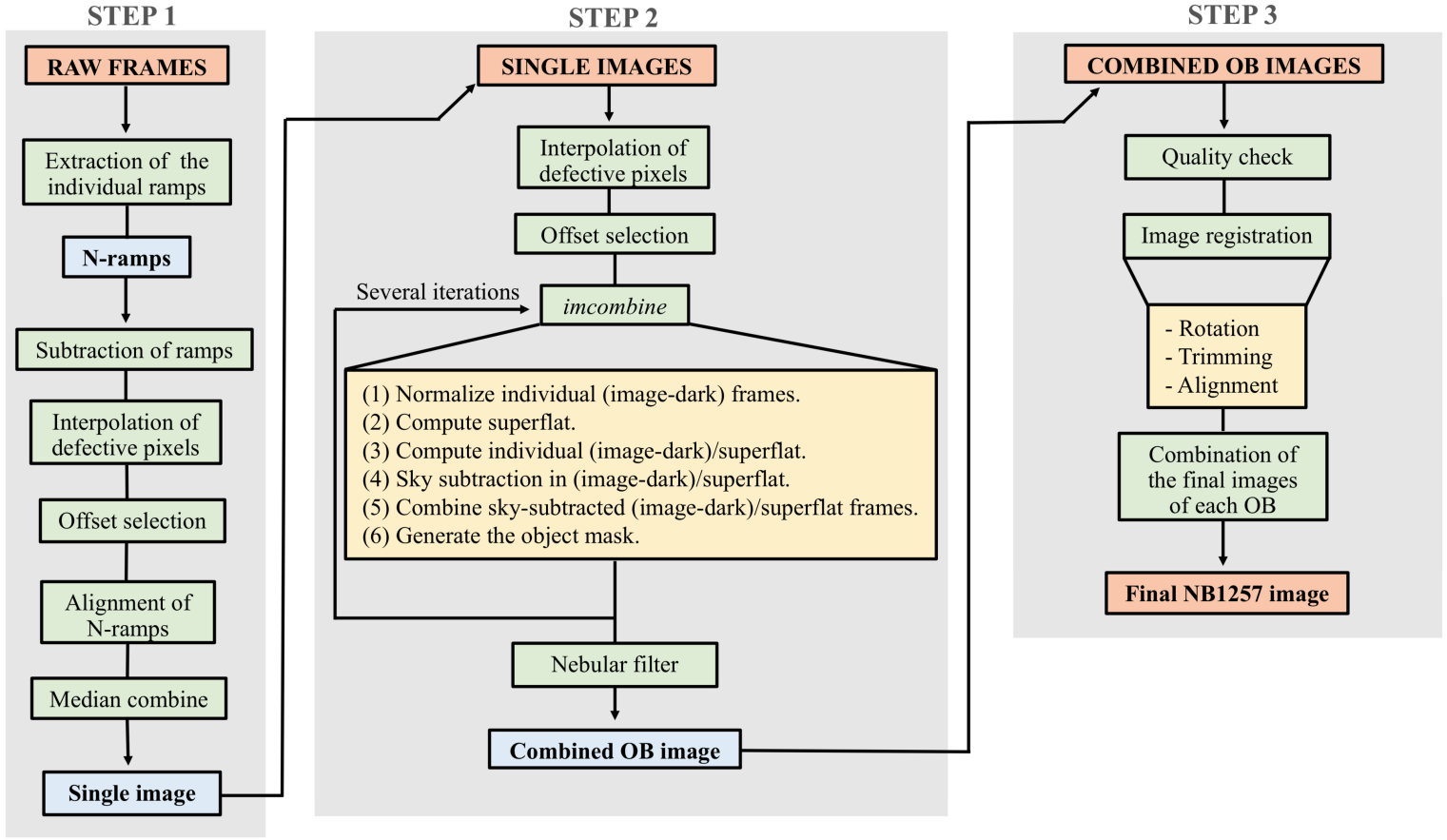
Gran Telescopio Canarias (GTC)

Obs-date:
May 2016 - July 2017

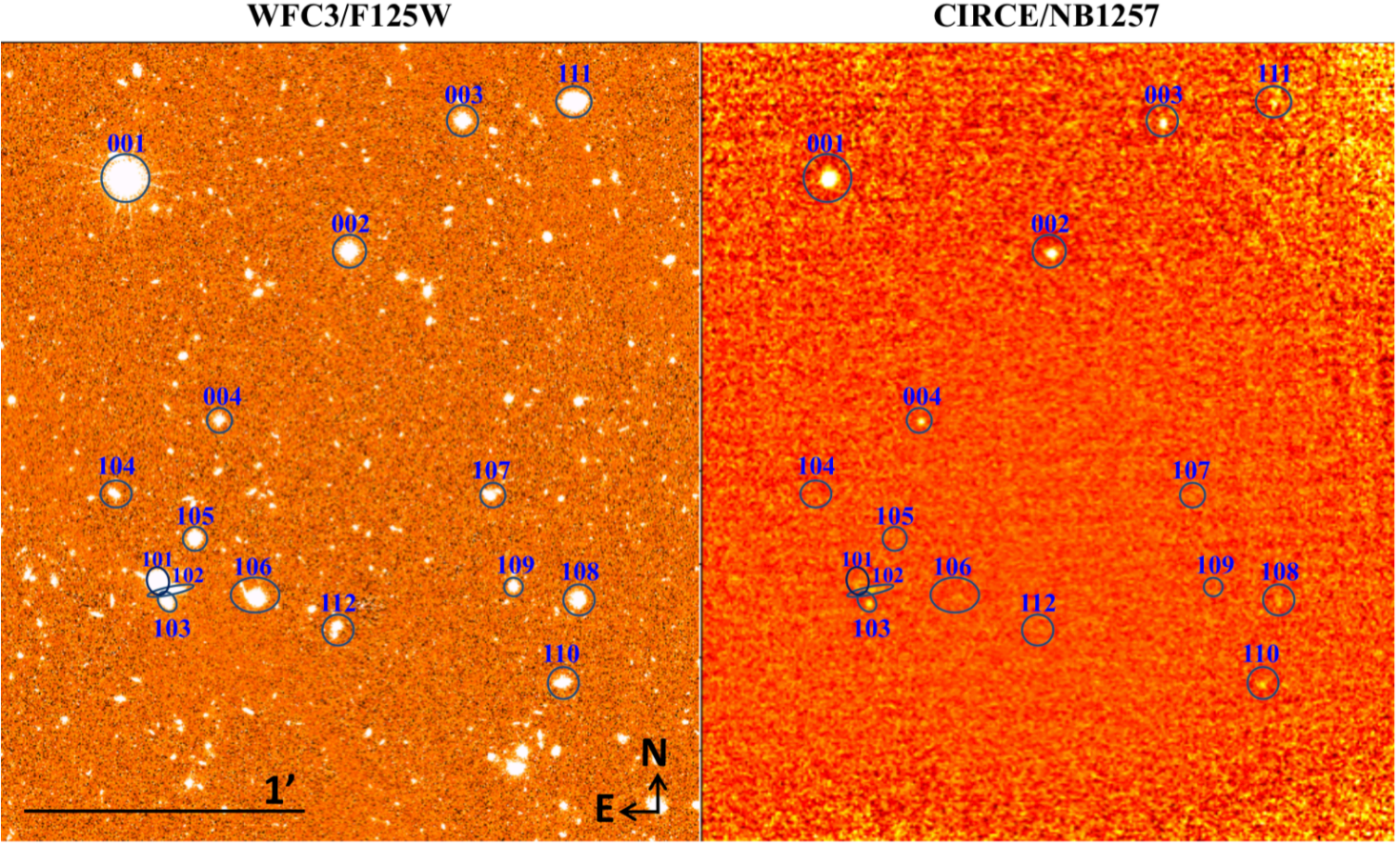
23 OBs of ~ 1h

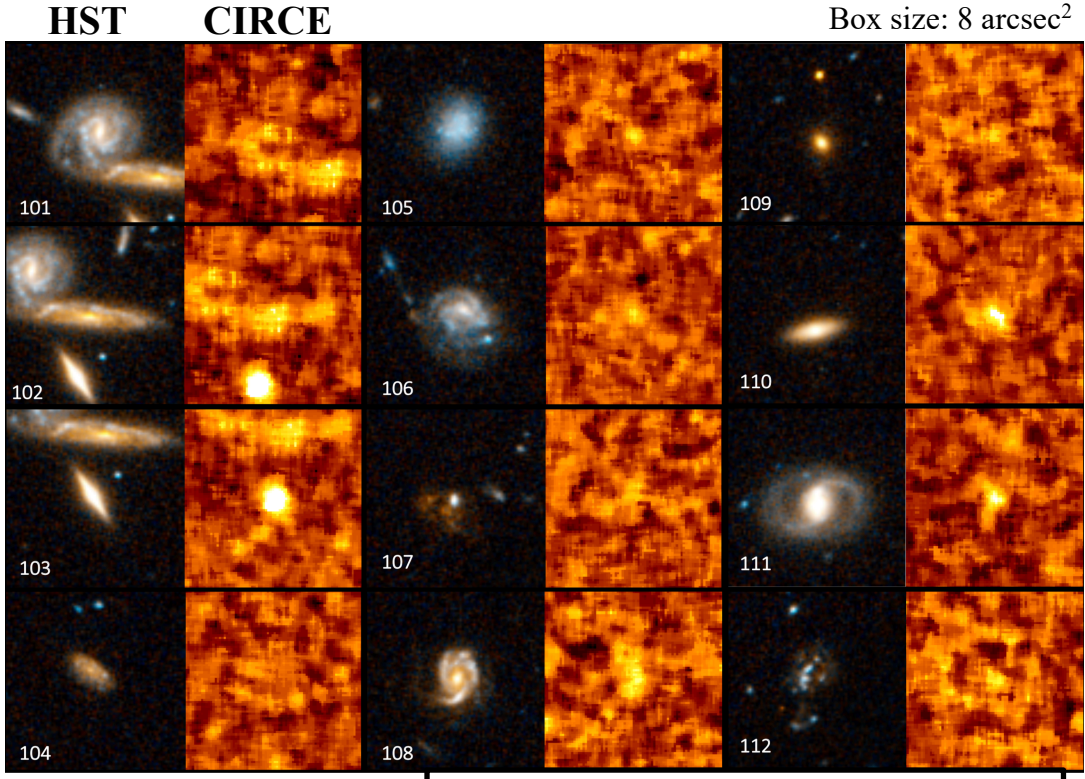


Data reduction



Final NB combined image

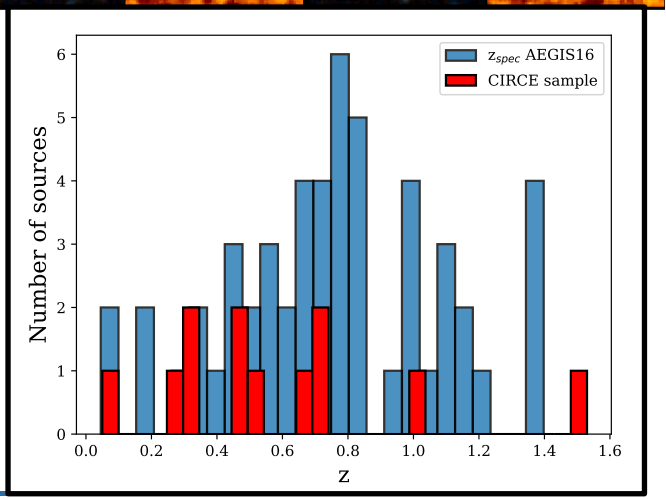




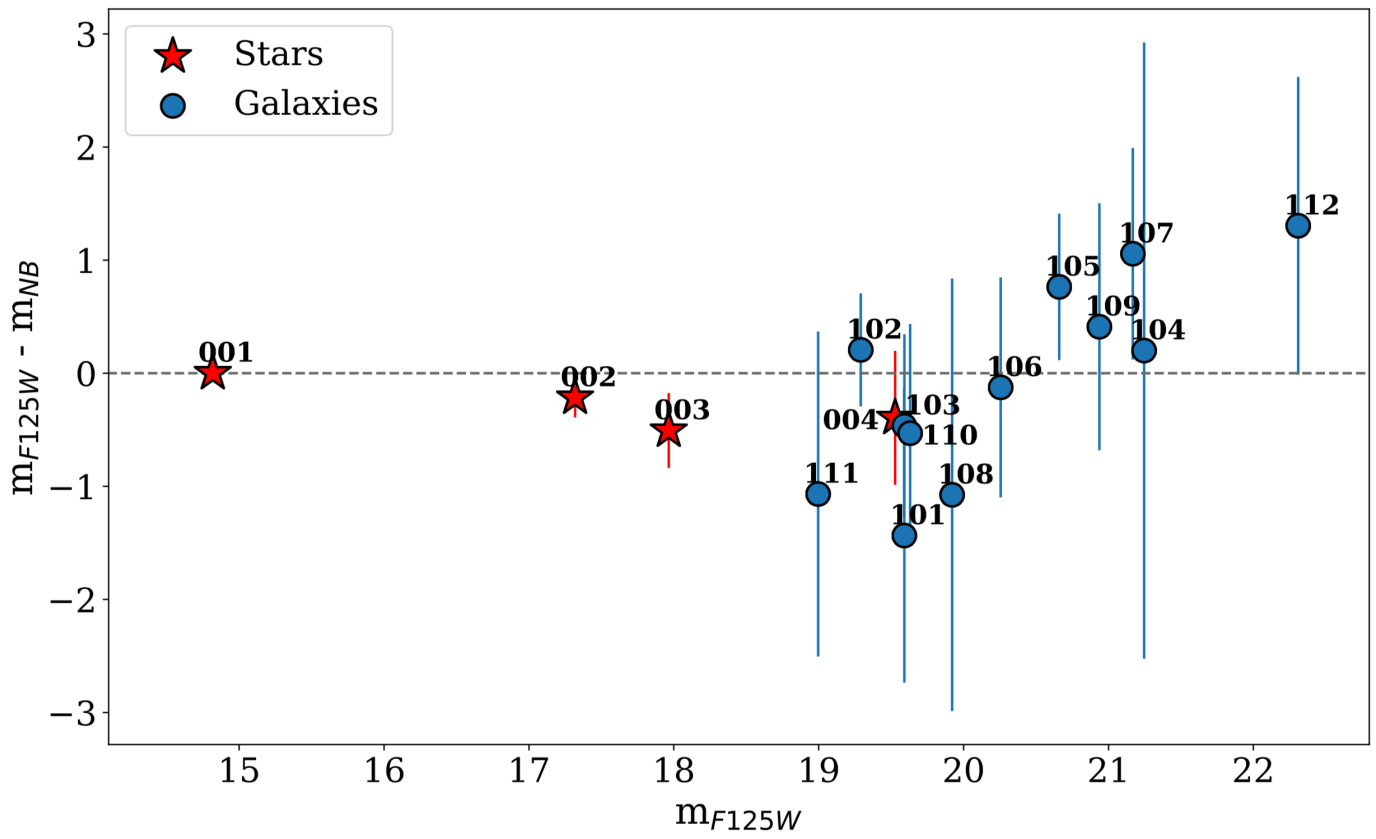
- Combination of 20 OBs.
- 18.3 h of exposure time.

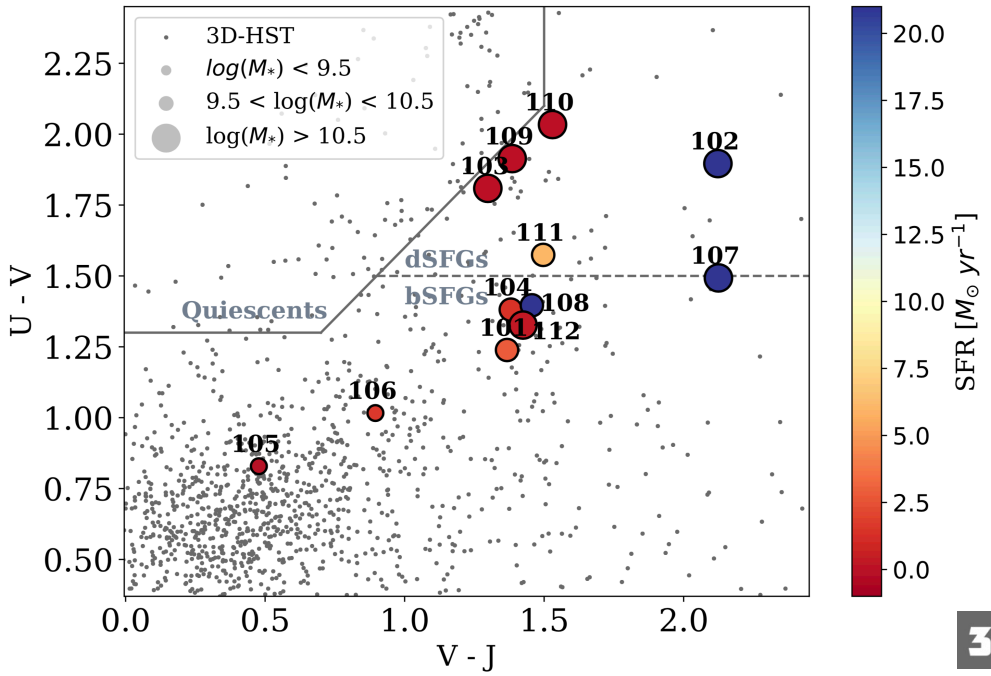
- A total of 16 identified objects, all of them already detected by HST.

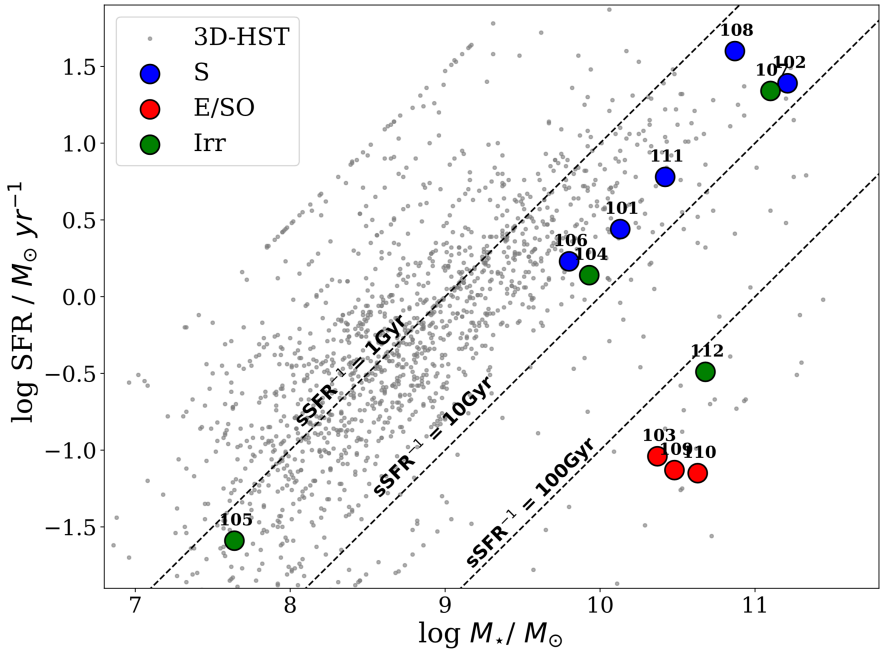
The sample lies in $0.04 < z < 1.54$



Color-Magnitude diagram

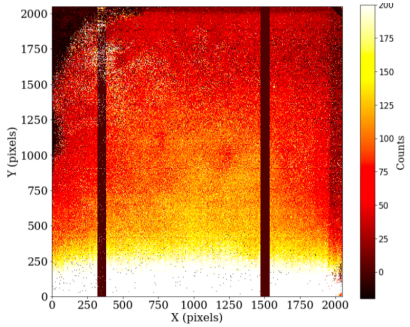






- Limiting magnitude of $m_{F125W} \sim 22.3$
- None candidate for galaxy at z = 9.3

Summary and next steps



Raw CIRCE image


ALBA NB1257 filter

1) After 18.3 h of exposure time only we reached only a limiting magnitude of $m_{F125W} \sim 22.3$ which is not enough to detect high-z galaxies. The main reasons are the bad cosmetic of the detector and the high readout noise.

2) The results obtained do not allow to impose any contour conditions of the luminosity function of LAEs at $z \sim 9$.

3) Many procedures and software tools have been developed and optimized for deep infrared narrow band filter images and they are available for future work.

4) The project will continue searching for a new nIR camera to re-use the NB filter.