# GUITARRA, a simulator for JWST NIRCam

Christopher N. A. Willmer[1], Kevin N. Hainline[1], Emma Curtis-Lake[2],
Jacopo Chevallard[3], Christina C. Williams[1], Sandro Tacchella[4],
Marcia J. Rieke[1], Karl A. Misselt[1], JADES Team

(1) Steward Observatory; (2) KICC; (3) IAP; (3) Harvard-Smithsonian CfA

## Introduction

The Joint NIRCam-NIRSpec GTO team (JADES) will observe both GOODS fields, taking initially NIRCam imaging followed a few weeks later by NIRSpec multi-object spectroscopy. This gives the team a turn-around of about 45 days between receiving the raw images and producing vetted catalogs adequate to allocate MSA slitlets on NIRSpec. To test the sequence of operations performed by the reduction and analyses pipelines we have developed the *Guitarra* simulator (*https://github.com/cnaw/guitarra*) that uses the detector footprint and catalogs of real (Skelton+ 2014; Momcheva+ 2015) and simulated sources (Williams+ 2018) to generate astronomical scenes.
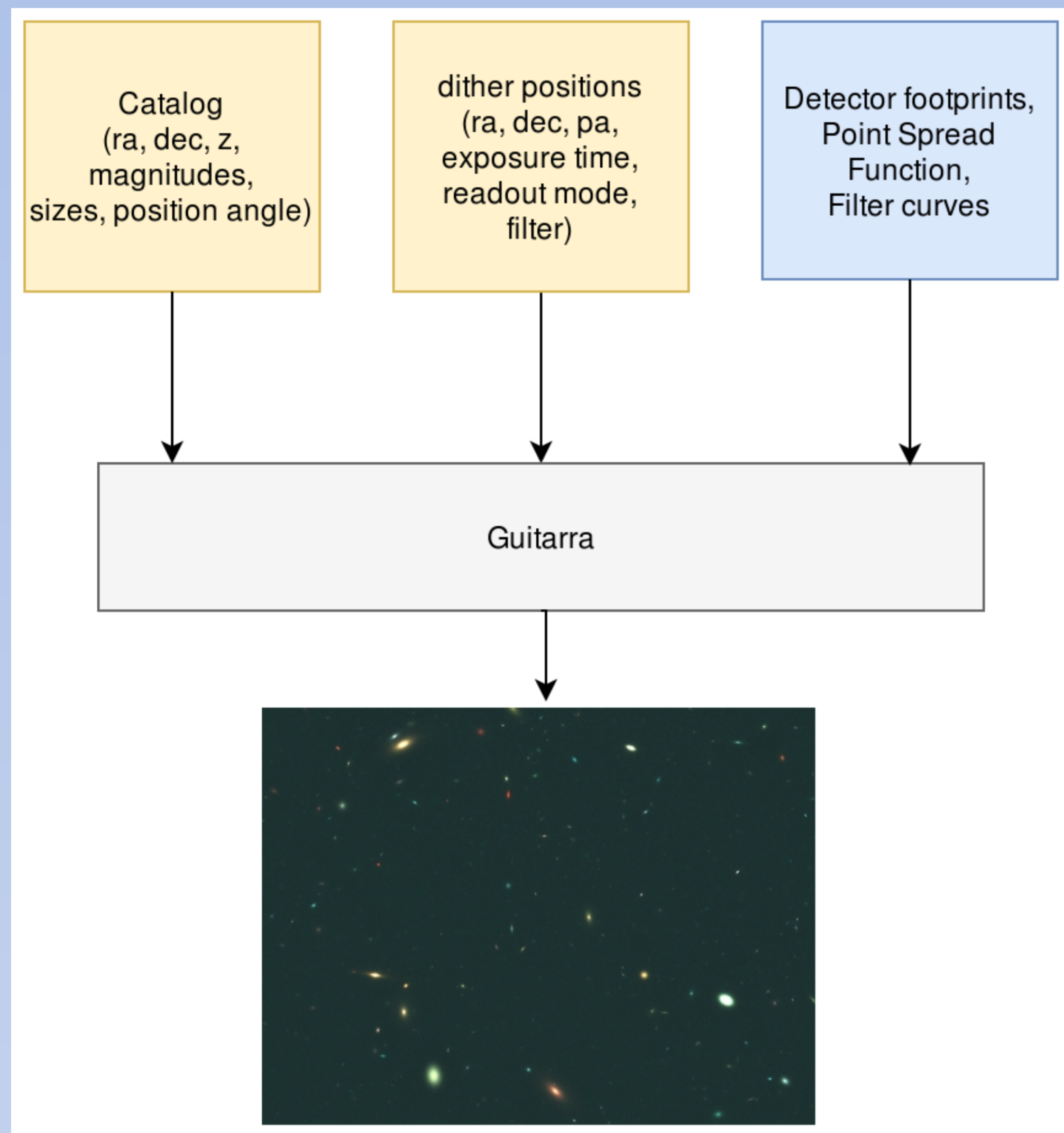
## Method



**Figure 1.** *Guitarra* generates a scene combining a catalog with the observing sequence from the JWST APT, the background estimates and point-spread functions from the JWST planning tools and ground-based engineering data for detector footprints and system throughput .
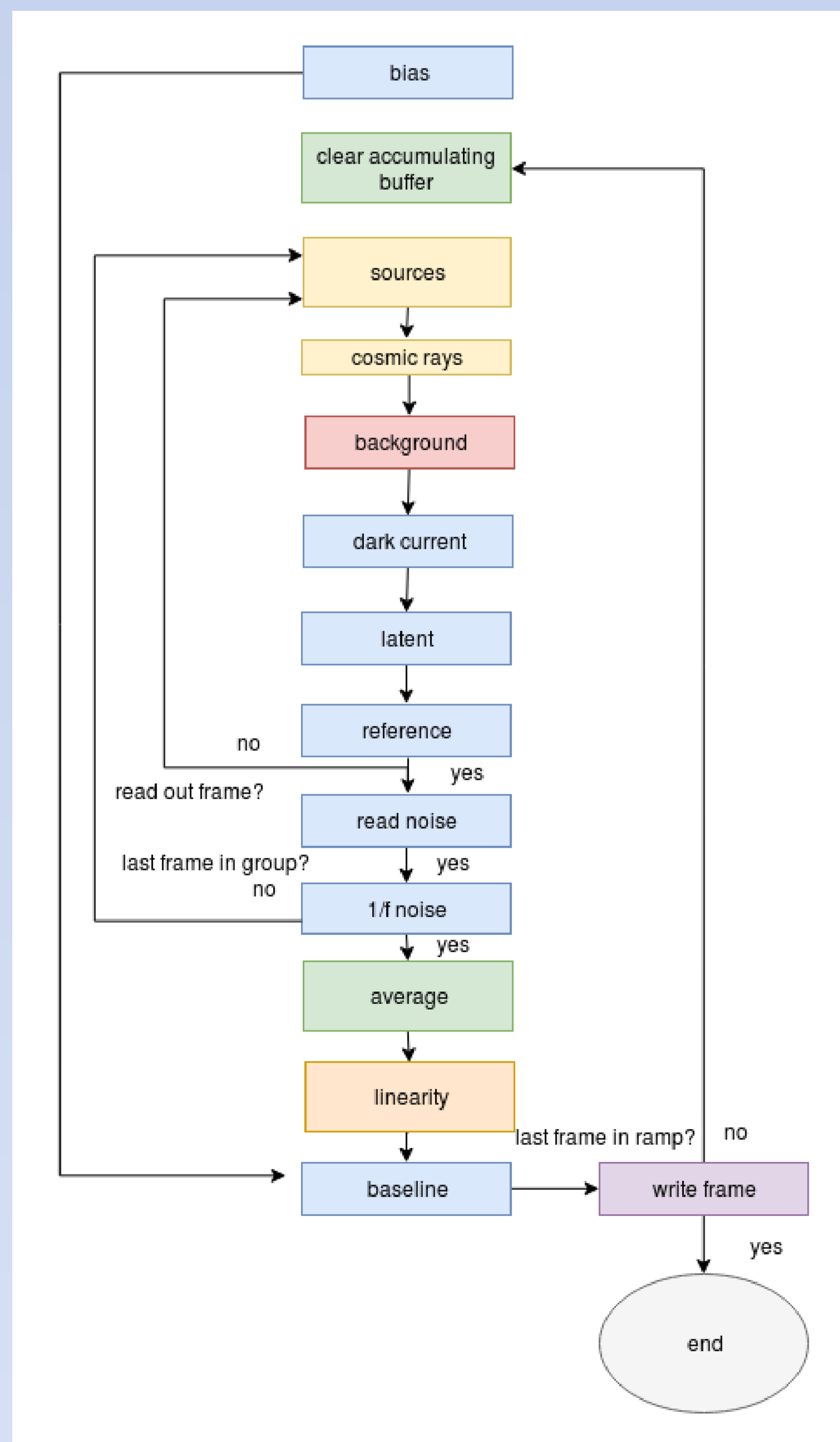


**Figure 2.** Steps followed to create an astronomical scene. Each object is simulated by ray-tracing and the process emulates the non-destructive readout used by JWST detectors. At the end of each sequence a ramp image is stored as a FITS image with format and keywords compatible with the Space Telescope Science Institute requirements for JWST data.
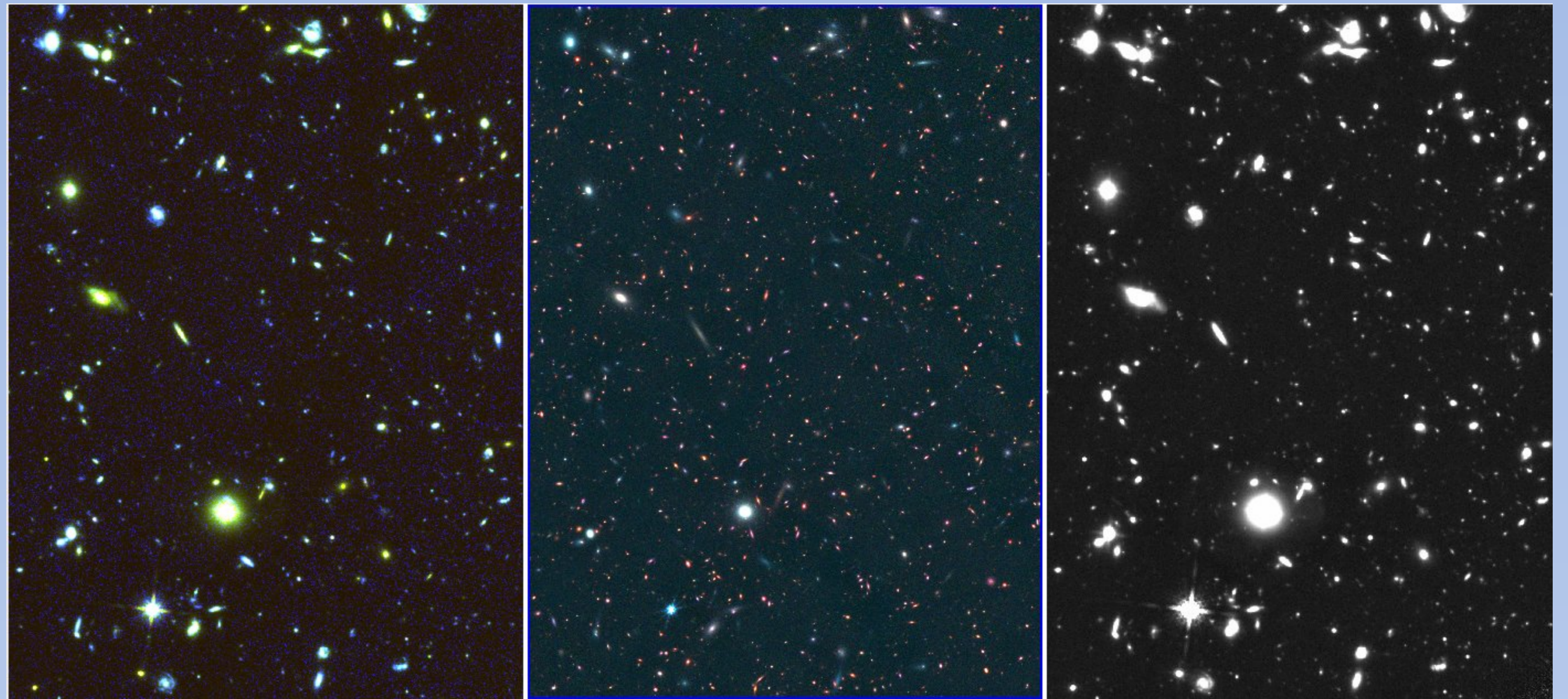
## Results



**Figure 3.** Blow-up of a region in the XDF using images processed by the 3DHST team (Momcheva+ 2016, Skelton+2014, Grogin+ 2011, Koekemoer+2011) on the left and by Illingworth+ (2013) on the right,. The center panel shows a scene generated by *Guitarra,* for a total exposure corresponding to the JADES deep survey. The simulation used the 3DHST catalogue (Skelton+2014), complemented by photometric redshifts measured using Beagle (Chevallard & Charlot 2016 ) and redshifts (spectroscopic and photometric) from 3DHST (Momcheva+ 2016). To simulate this sample the spectral energy distributions (SEDs) from Beagle or SEDs reconstructed by EAZY (Brammer+ 2008) in 3DHST (Momcheva+ 2016) were convolved with NIRCam filters. The shapes of galaxies use the structural parameters by van der Wel+ (2012) calculated with *Galfit* (Peng+ 2008; 2011). For magnitudes fainter that the 3DHST limits (estimated from H160W) we used the JAGUAR mock catalog of Williams +2018., which contains fluxes and Sersic profile parameters. As these morphologies are only approximations to the shapes of galaxies, the real and simulated galaxies look different. To overcome this limitation we will use morphologies from N-body simulations (e.g., Rodriguez-Gomez+2019) or galaxy cloning (Bouwens+ 2003), where shapes are derived from observed samples of galaxies and the SEDs measured at different resolution elements used to estimate the flux at different wavelengths.
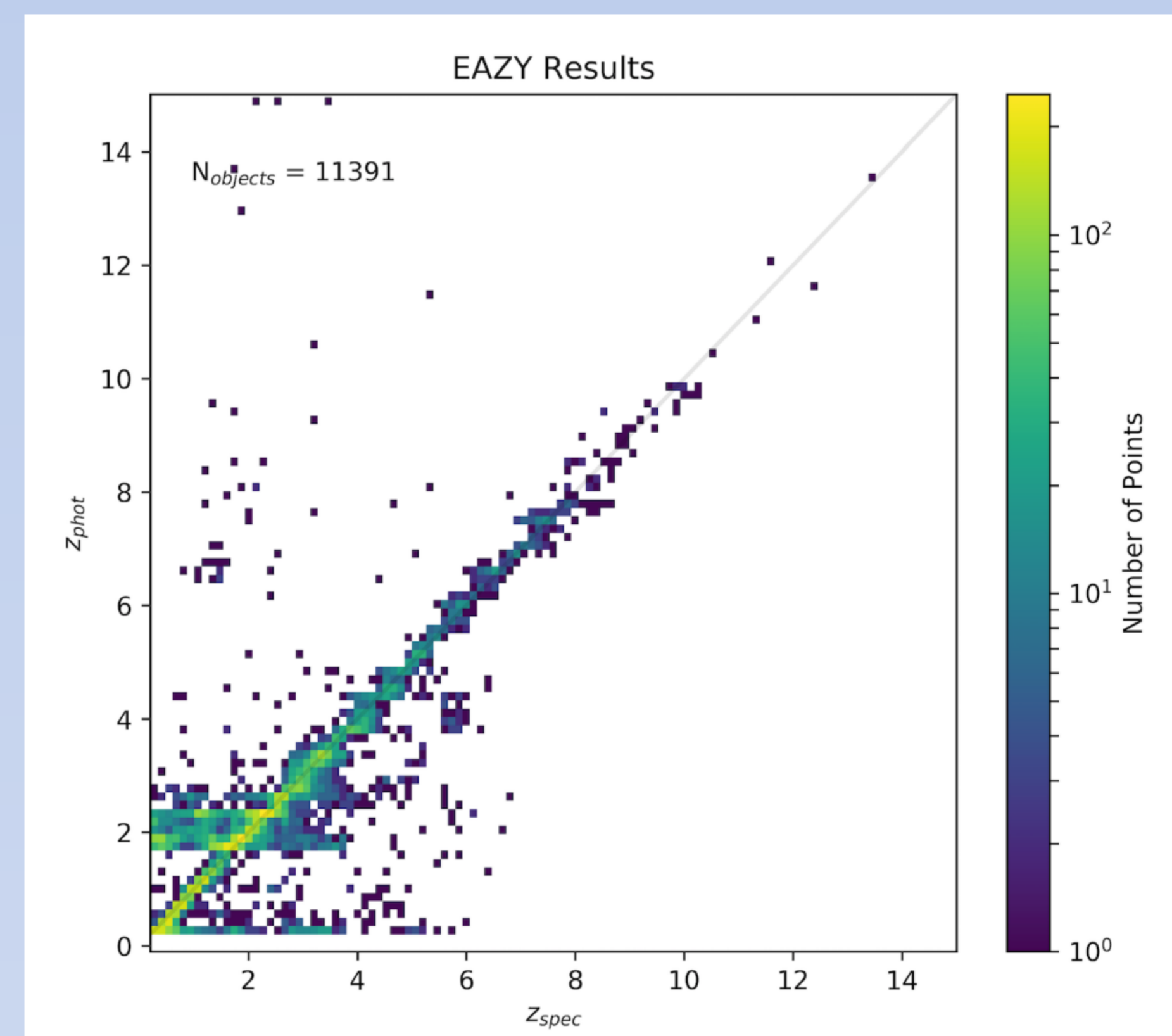


**Figure 4.** Comparison between input and calculated redshifts for a scene generated using the JAGUAR mock catalog. The field corresponds to the JADES NIRCam deep survey and uses these NIRCam filters: F090W, F115W, F150W, F200W, F277W, F335M, F356W, F410M and F444W. The catastrophic failures at redshifts < 6 are caused by the lack of filters shortward of F090W, an effect already noted by (Bisigello+ 2017).
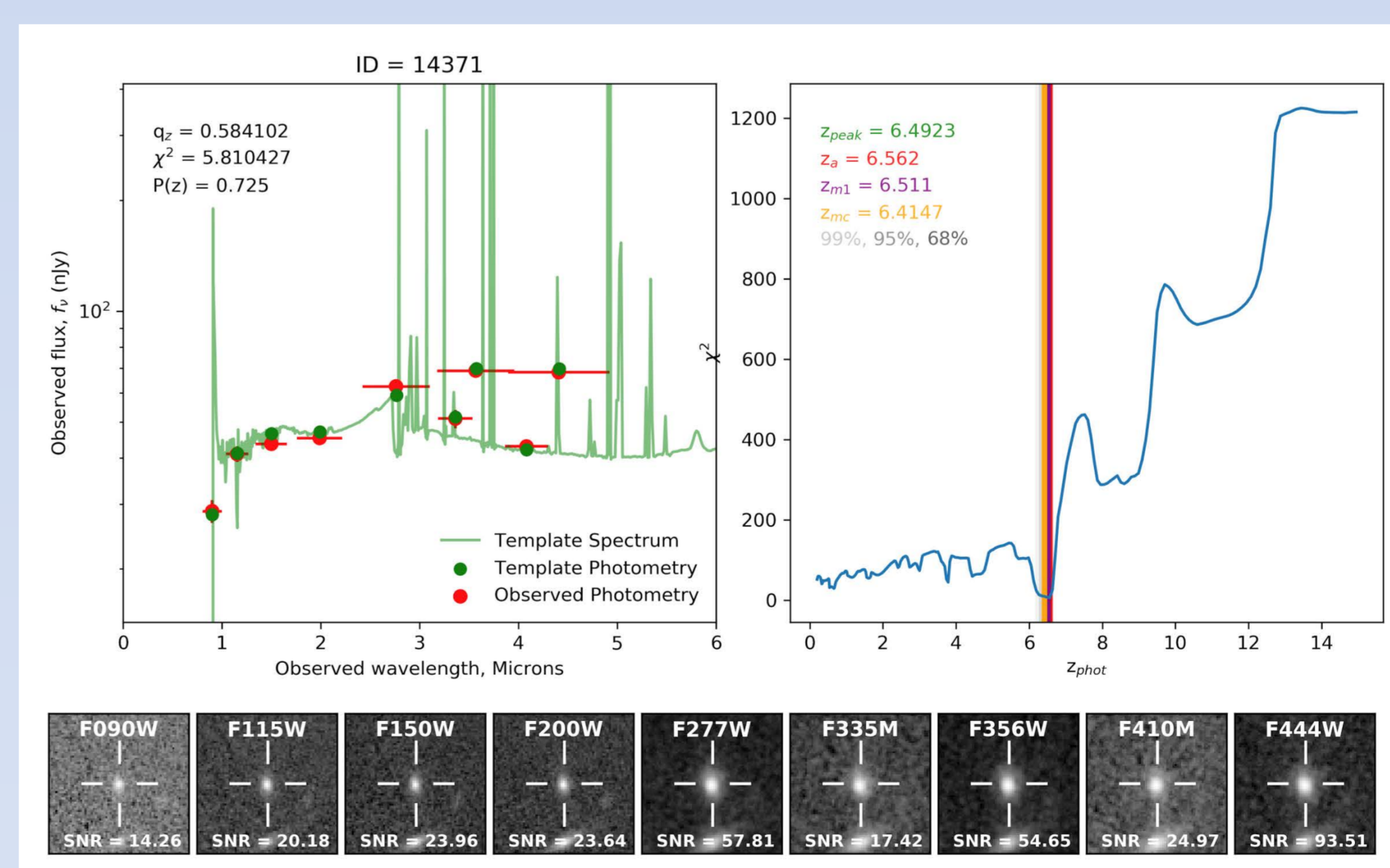


**Figure 5.** Example of simulated object and recovered redshift. The left panel shows the input spectrum and fluxes within the NIRCam filters. The red points are fluxes recovered from the simulated Image. The green SED is the best-fitting spectrum from EAZY, and green points represent the convolution between the latter and NIRCam filters. The right panel shows the $\chi^2$ as function of the recovered photometric redshift. The vertical lines indicate the recovered redshifts noted in the key. The bottom panel shows the postage stamps in the NIRCam bands.

## References

Bisigello+ 2017 ApJS, 231, 3
Bouwens+ 2003, ApJ, 593,640
Brammer+ 2008, ApJ, 686, 1503
Chevallard & Charlot 2016, MNRAS, 462, 1415
Grogin+ 2011, ApJS, 197, 35

Illingworth+ 2013, ApJS, 209, 1
Koekemoer+ 2011, ApJS, 197. 36
Momcheva+ 2016, ApJS, 225, 27
Peng+ 2002 AJ, 124,266
Peng+ 2011, ascl.soft, 04010

Rodriguez-Gomez+ 2019, MNRAS, 483, 4140
Skelton+ 2014, ApJS, 214, 24
Van der Wel+ 2012,ApJS, 203, 24
Williams+ 2018, ApJS, 236, 33