Dark Cosmology Centre

VISTA NB118 narrow-band observations: First results

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Based on Milvang-Jensen et al., in prep. (and 2013)

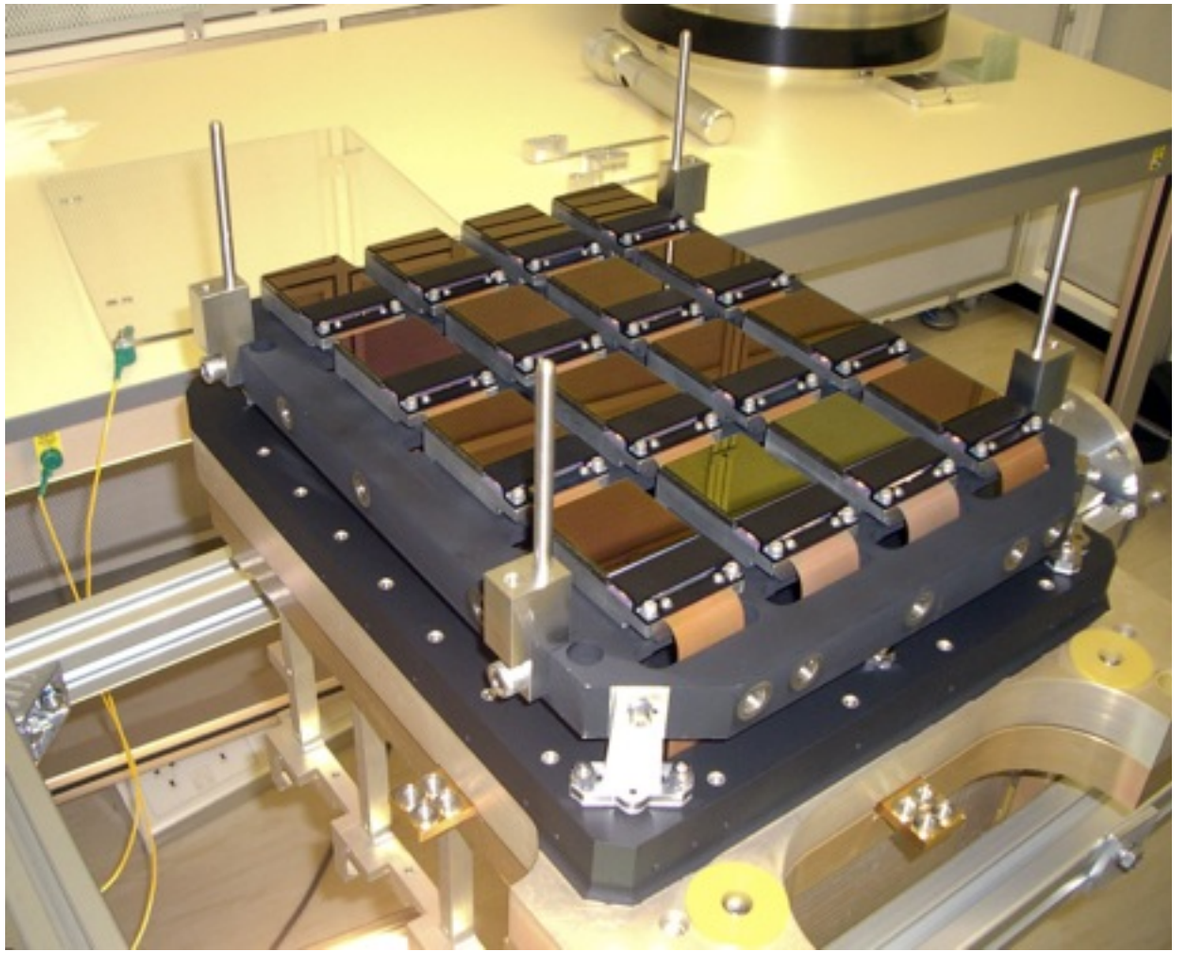
ESO Rainbows conference, 06 Oct 2015

Narrow-band imaging

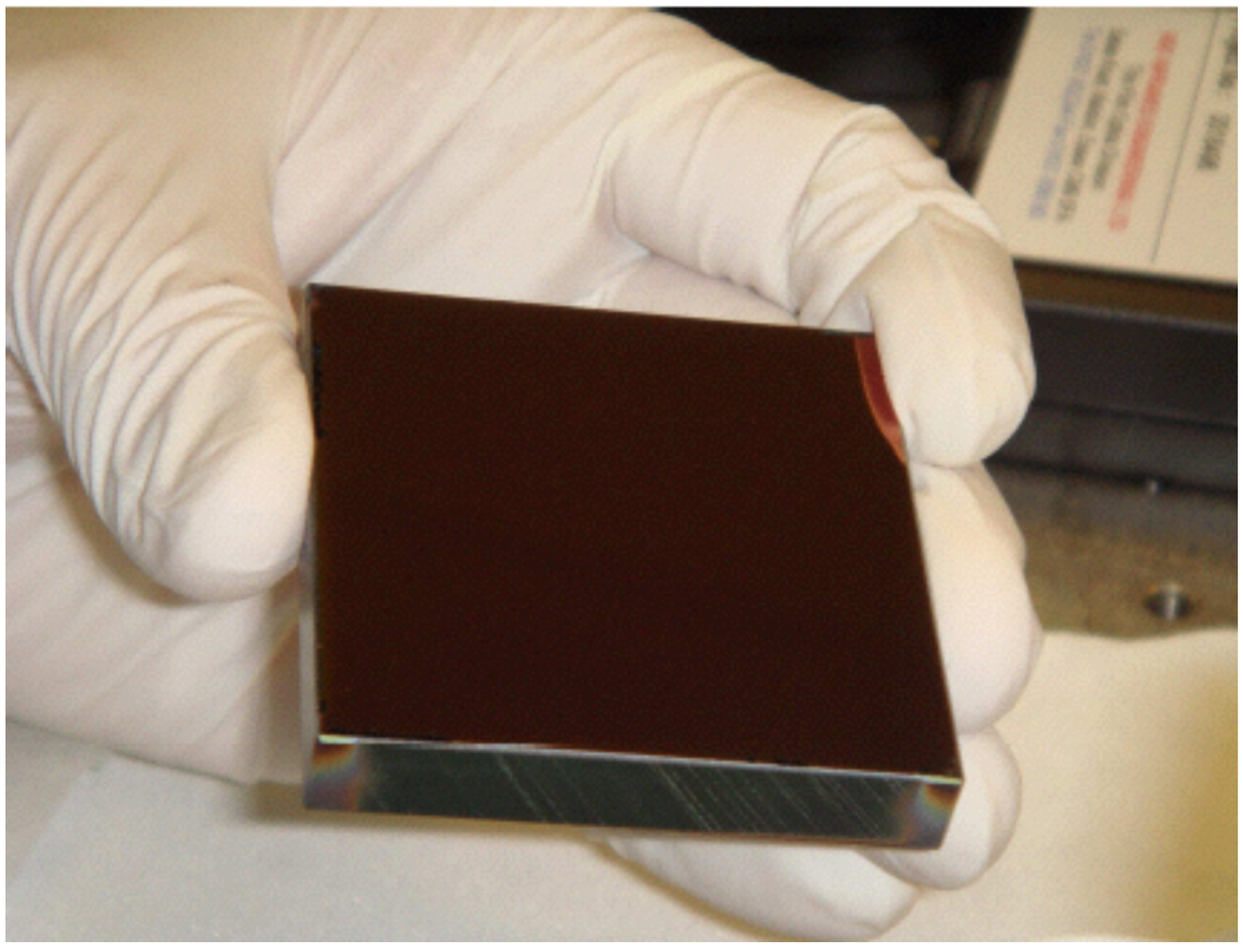
- Method to select emission-line objects (galaxies and AGN) at specific redshifts
- Choose window in the sky emission line spectrum
- 1.185 μm window (NB118) corresponds to:
  - z=0.8 Hα
  - z=1.4 [OIII], z=1.45 Hβ
  - z=2.2 [OII]
  - z=8.8 Lyα
- VISTA: opportunity for wide & deep NB118 survey

The 16 NB118 filters in VISTA/VIRCAM

The 16 detectors in VIRCAM



One of the NB118 filters



Nilsson (2007)

The 16 NB118 filters — one per detector — were bought by the Dark Cosmology Centre

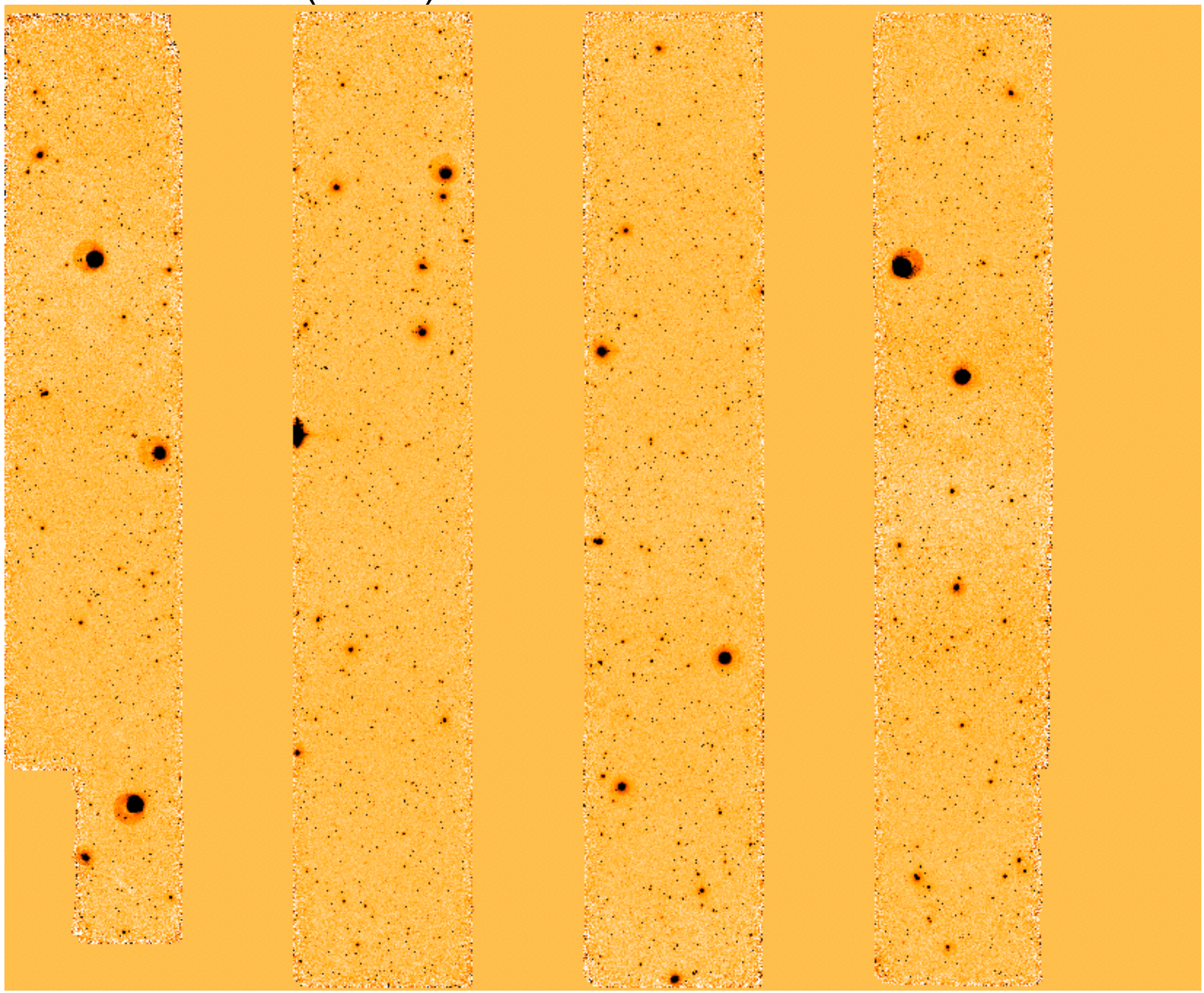
Data: VISTA imaging in COSMOS

- NB118:
  - 20 h (2'' 5σ: 23.6 AB) from GTO (Milvang-Jensen+ 2013)
  - 98 h (2'' 5σ: 24.4 AB) from UltraVISTA DR3
- Y and J: from UltraVISTA DR3
- Seeing around 0.8''

Note

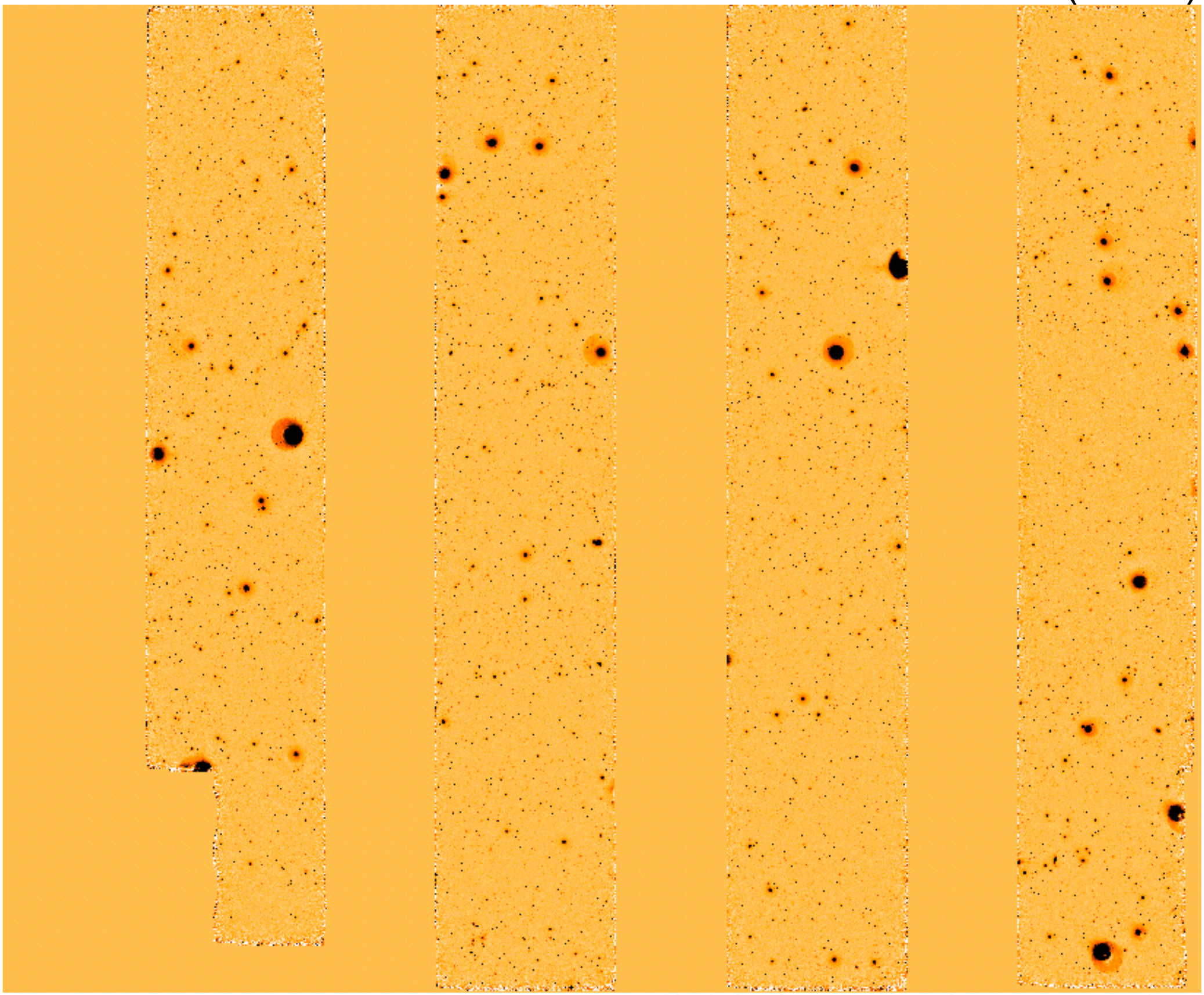
- UltraVISTA final NB118 will be 168 h (24.7 AB)
- The depth in the NB118 image varies from detector to detector = filter to filter by ±0.3 mag, so some are deeper

GTO NB118 (20 h)



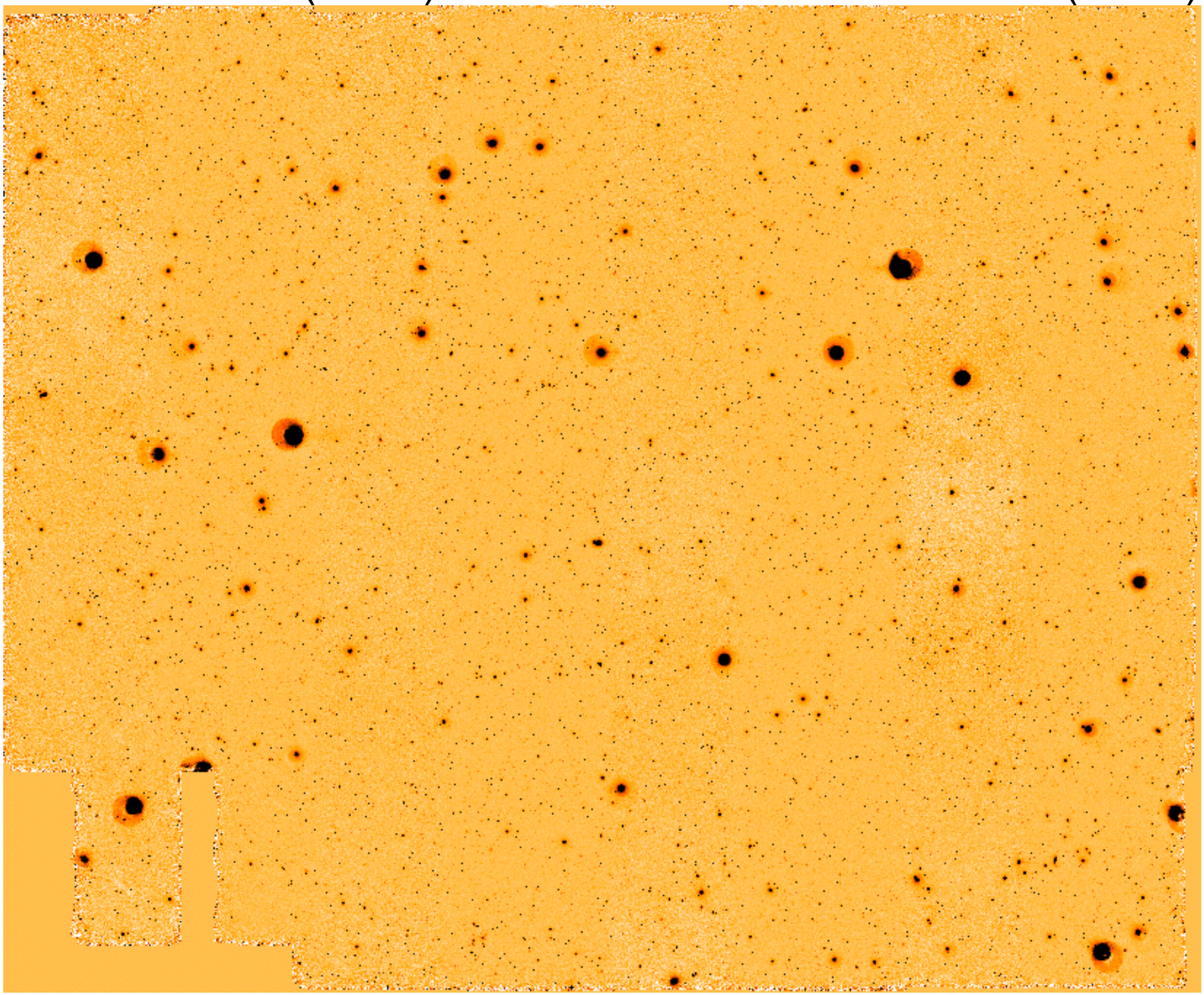
field size: 1.5 deg x 1.2 deg

UltraVISTA DR3 NB118 (98 h)



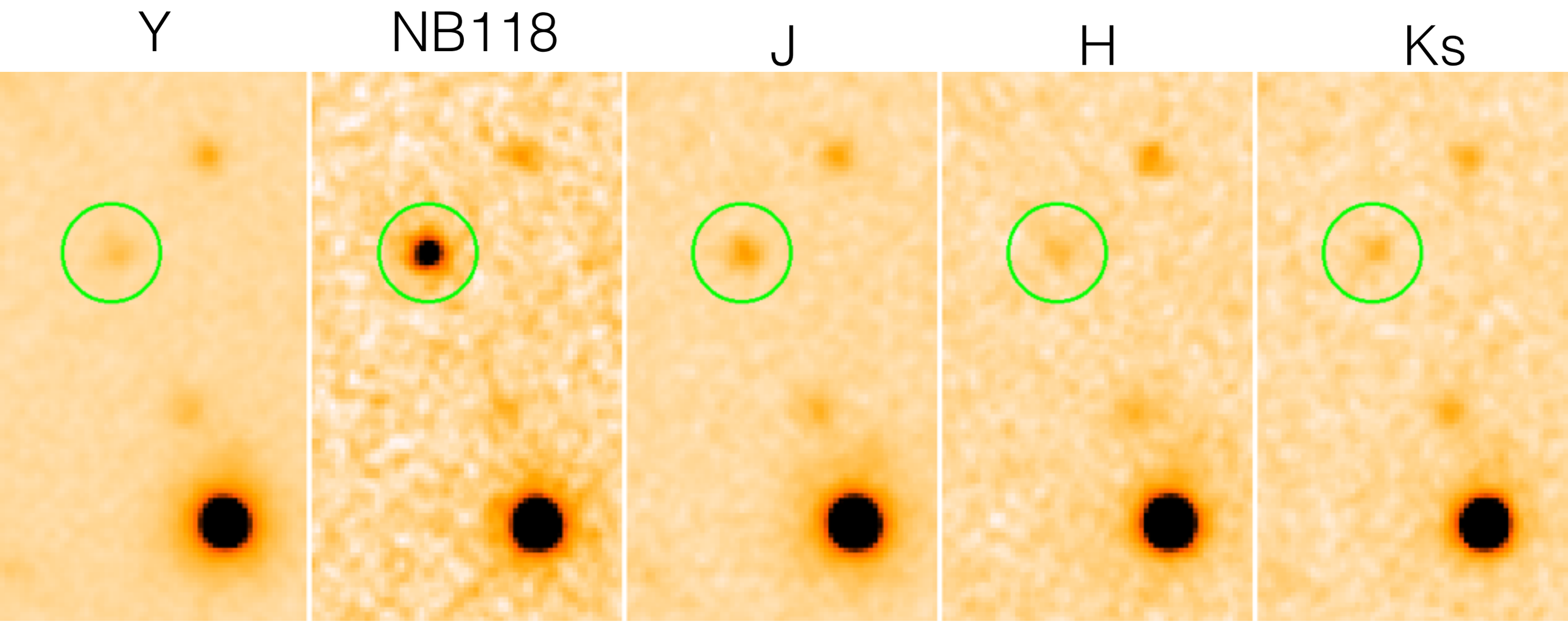
field size: 1.5 deg x 1.2 deg

GTO NB118 (20 h) + UltraVISTA DR3 NB118 (98 h)



field size: 1.5 deg x 1.2 deg

Example of a galaxy showing narrow-band excess



Green circle: 3 arcsec diameter

Just for illustration: two RGB composites, #1

blue=Y, green=NB118, red=H

blue=Y, green=J, red=H

width: 39 arcsec

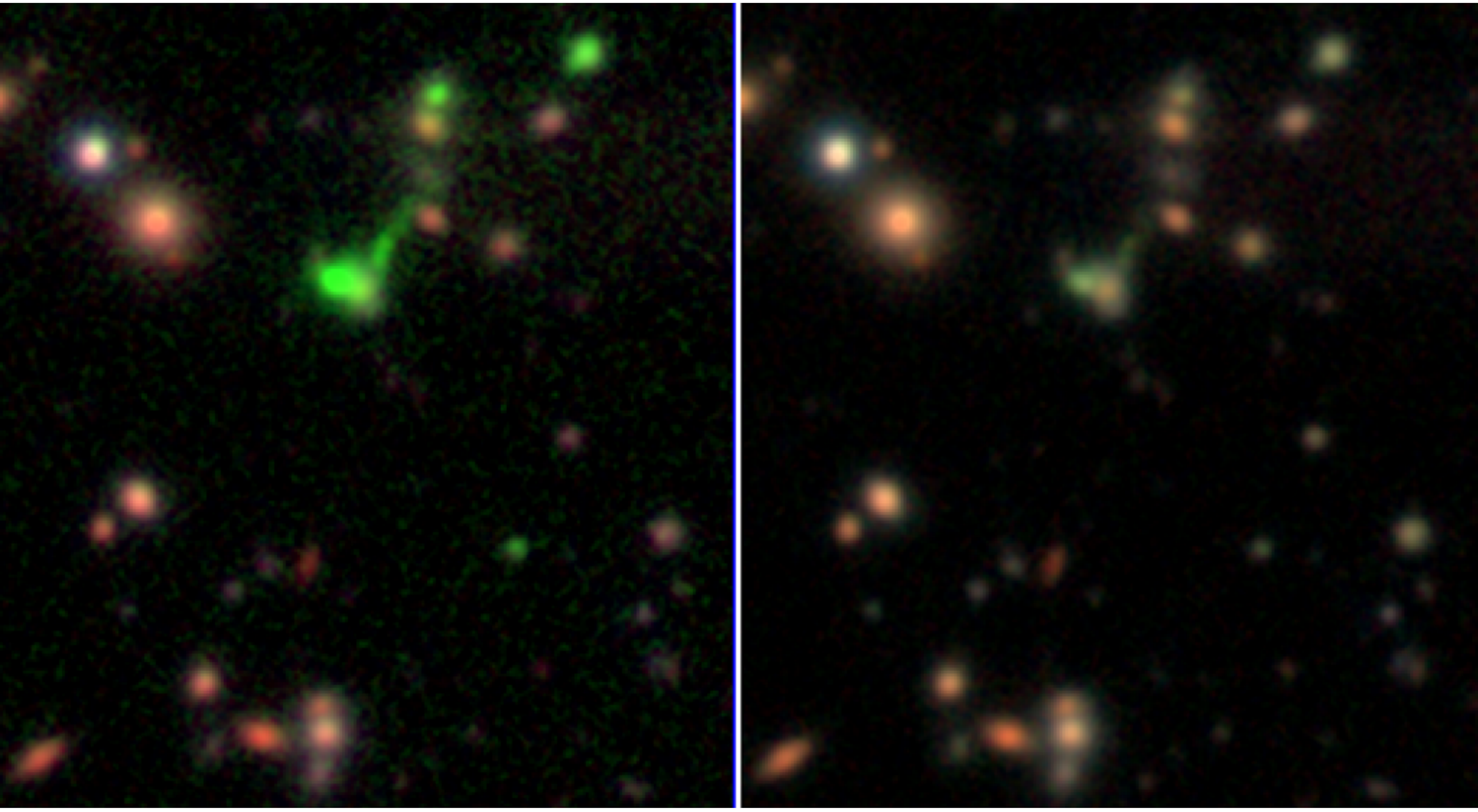
width: 39 arcsec

RGB made using the Lupton et al. (2004) method

Just for illustration: two RGB composites, #2 z=0.82

blue=Y, green=NB118, red=H

blue=Y, green=J, red=H



width: 39 arcsec

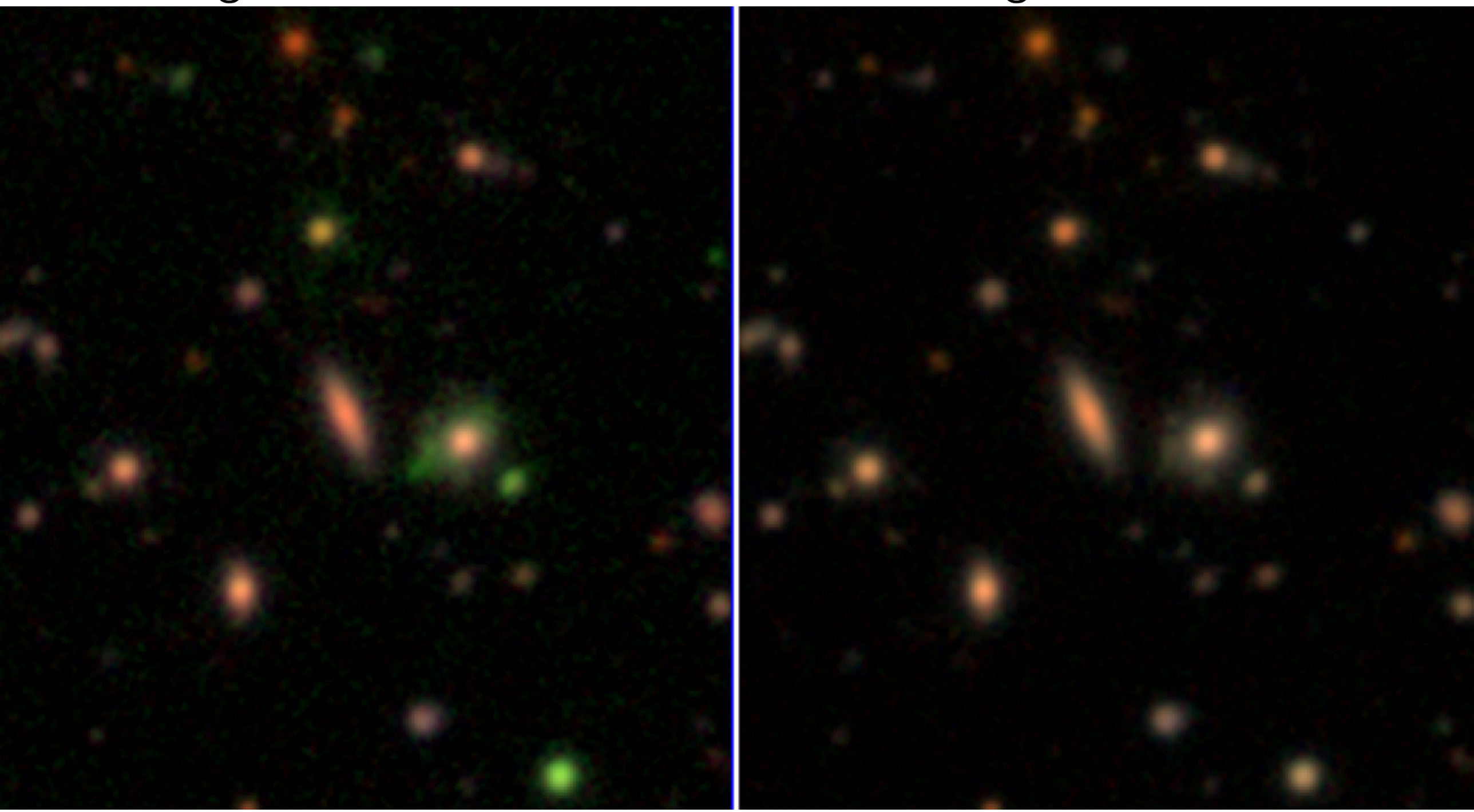
width: 39 arcsec

RGB made using the Lupton et al. (2004) method

Just for illustration: two RGB composites, #3

blue=Y, green=NB118, red=H

blue=Y, green=J, red=H

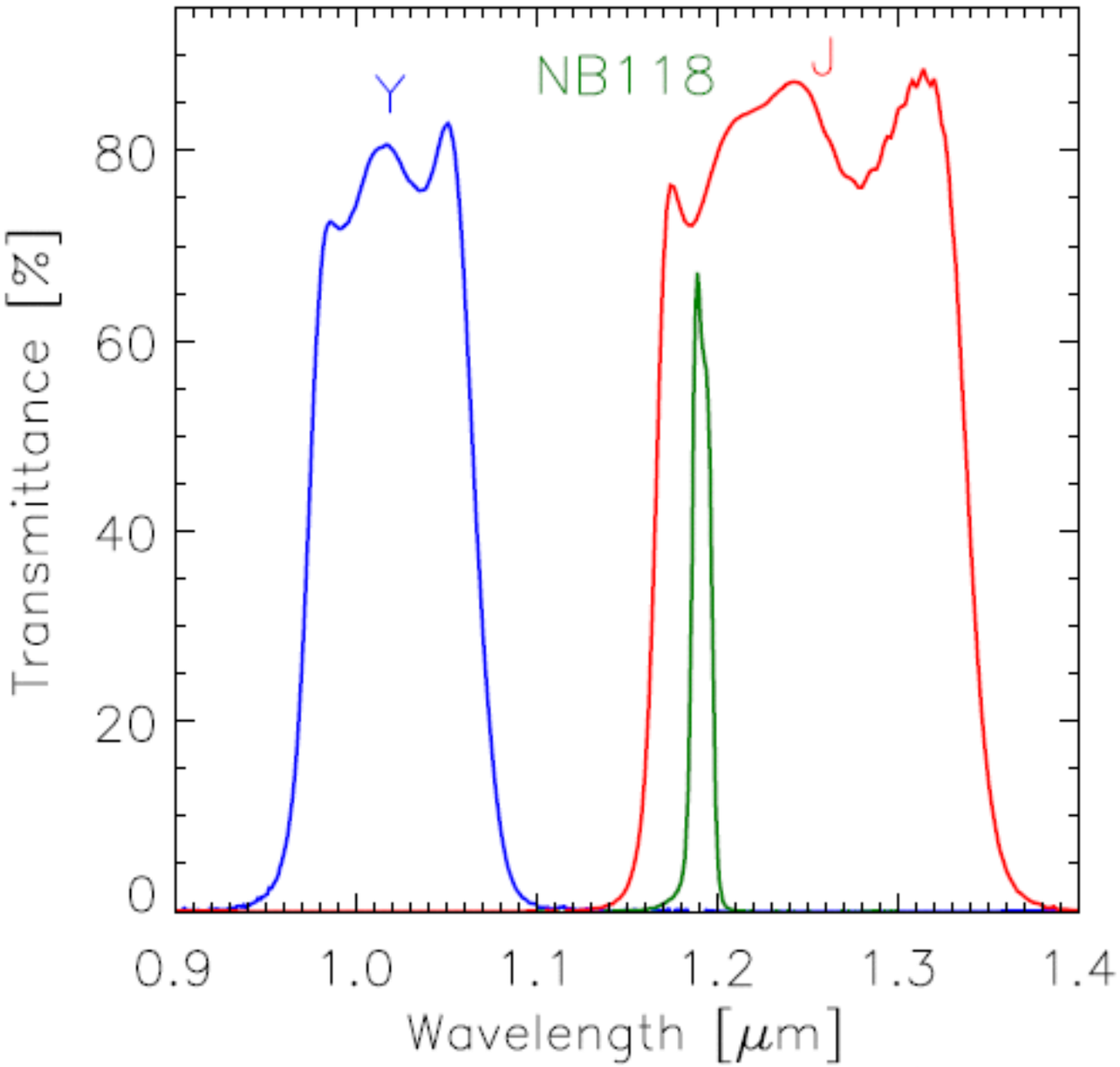


width: 39 arcsec

width: 39 arcsec

RGB made using the Lupton et al. (2004) method

Selection of objects with **narrow-band excess** using 3 filters: NB118 compared to the continuum defined by Y and J

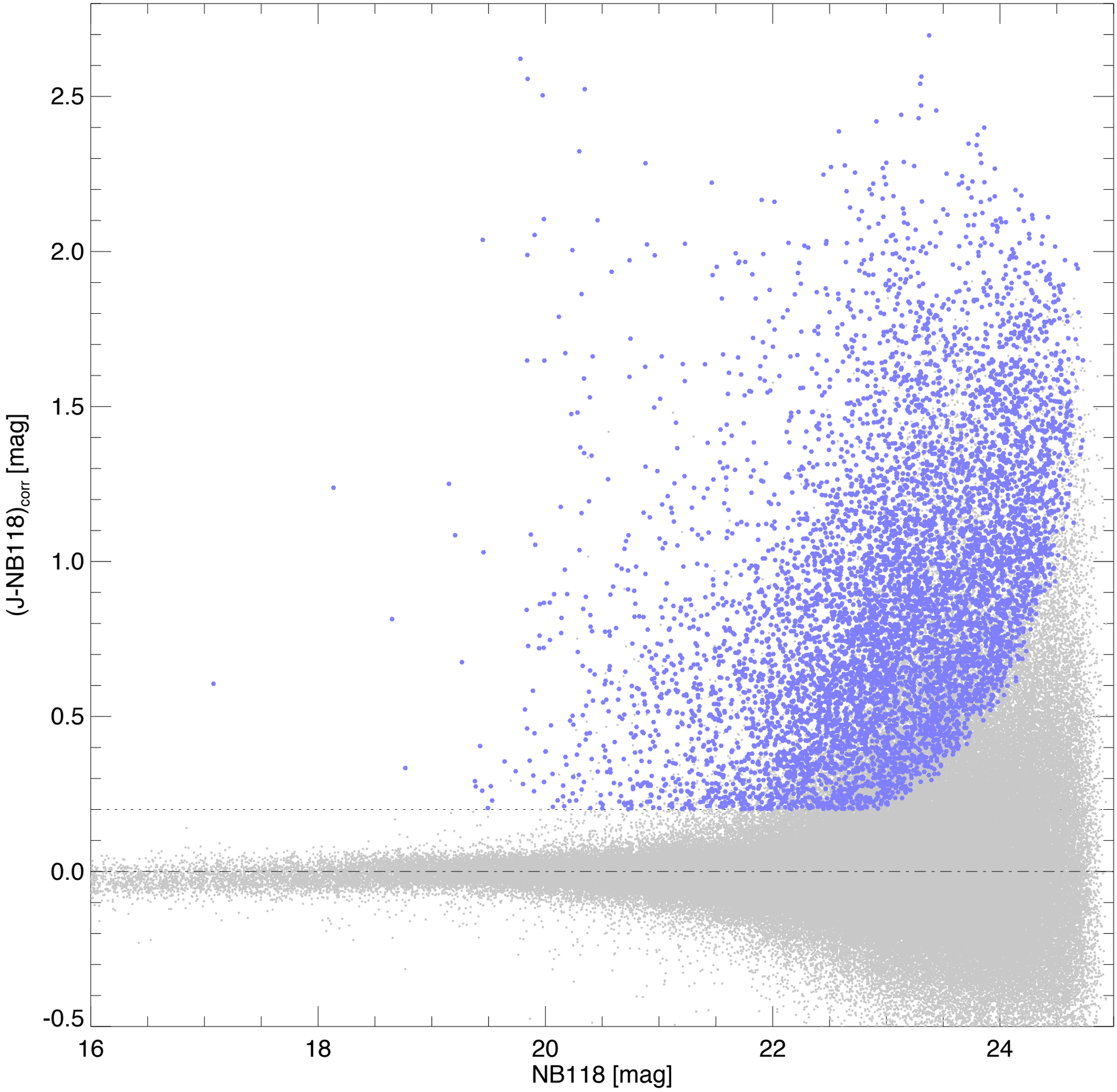


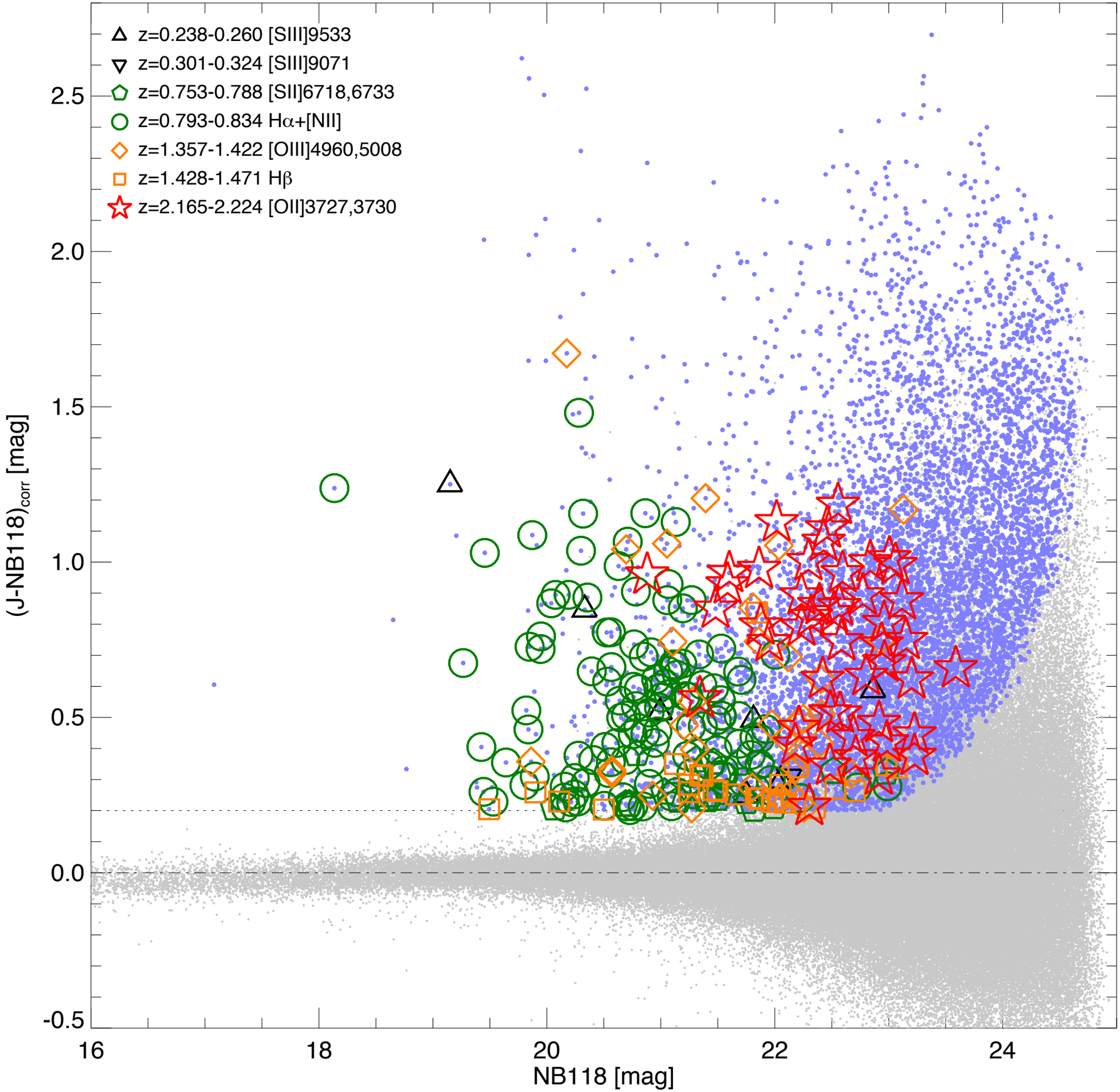
- Since the NB118 filter is not at the centre of the J filter, the slope of the continuum matters
- Here we use the (Y-J) colour to get the slope of the continuum, and we calculate $(J\text{-NB118})_{corr}$ which is corrected for the continuum slope

$$(J\text{–NB118})_{\rm corr} = \begin{cases} (J-{\rm NB118}) + 0.34(Y-J) & {\rm if}\ (Y-J) \leq 0.45 \\ (J-{\rm NB118}) + 0.153 & {\rm if}\ (Y-J) > 0.45 \\ (J-{\rm NB118}) + 0.07 & {\rm if}\ Y\ {\rm not\ detected} \end{cases} \quad (7)$$

Milvang-Jensen et al. (2013)

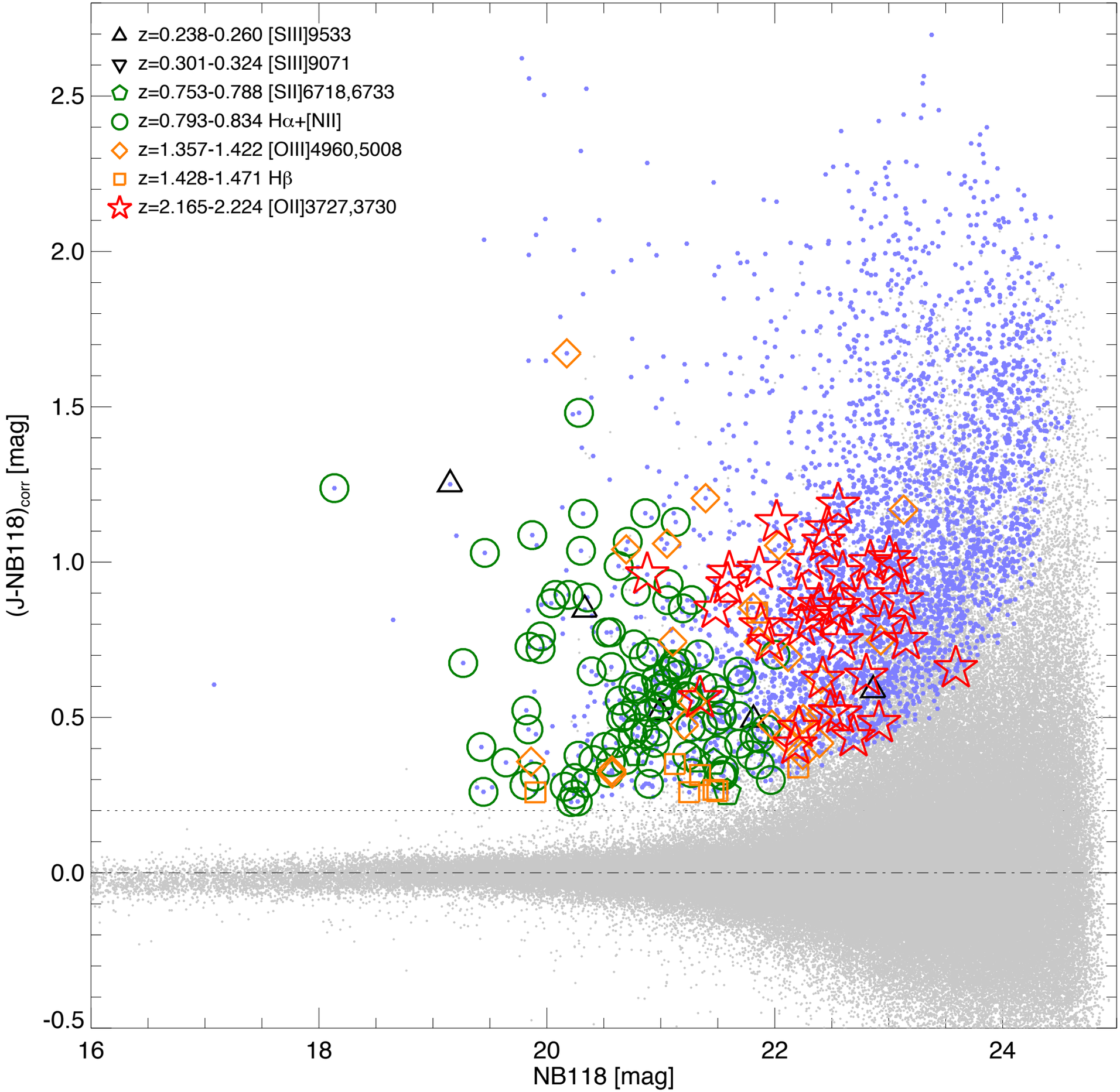
NB-excess objects: blue dots





NB-excess objects: blue dots

Spectroscopically confirmed emitters: big symbols



NB-excess objects: blue dots

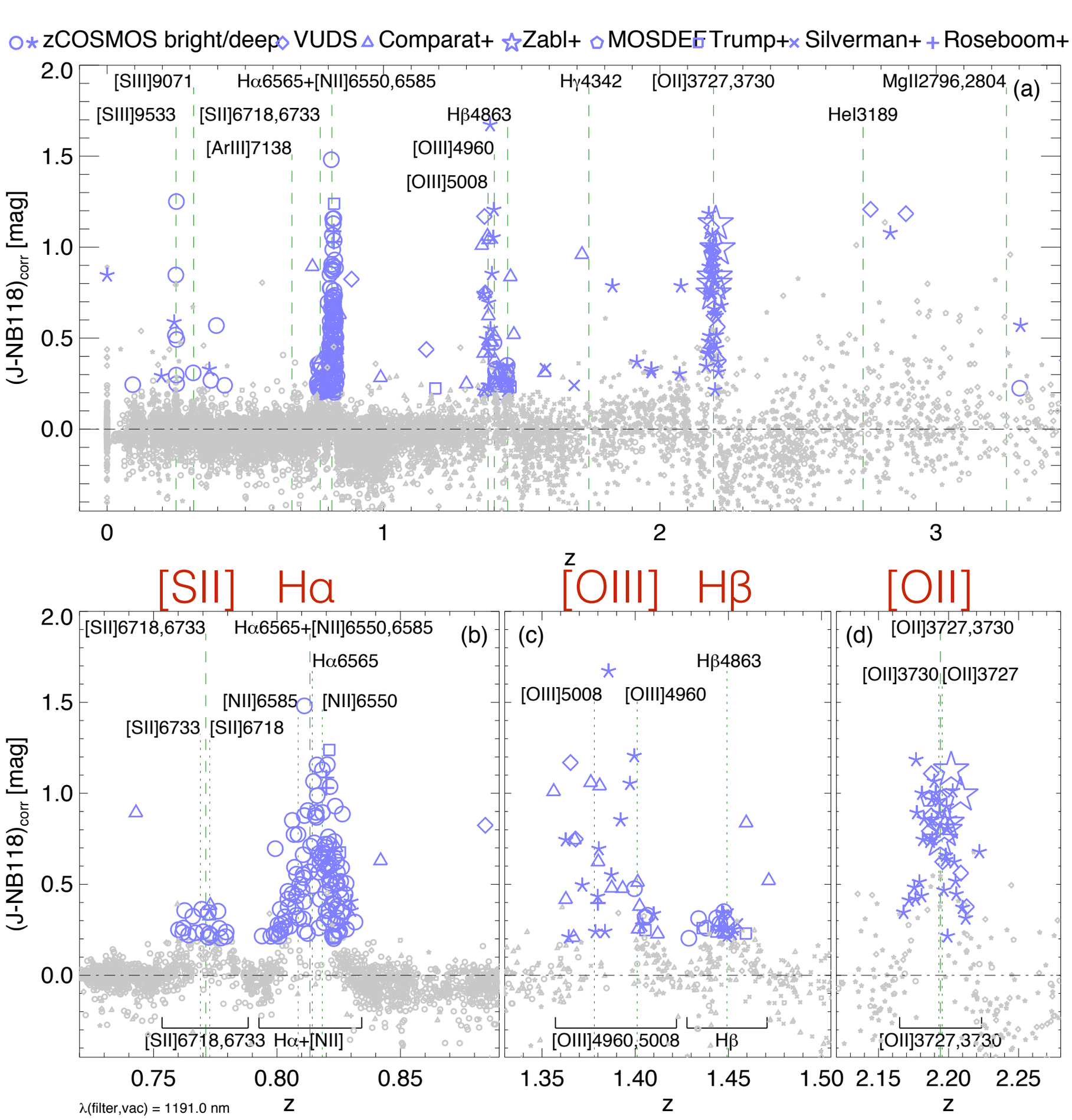
Using stricter selection

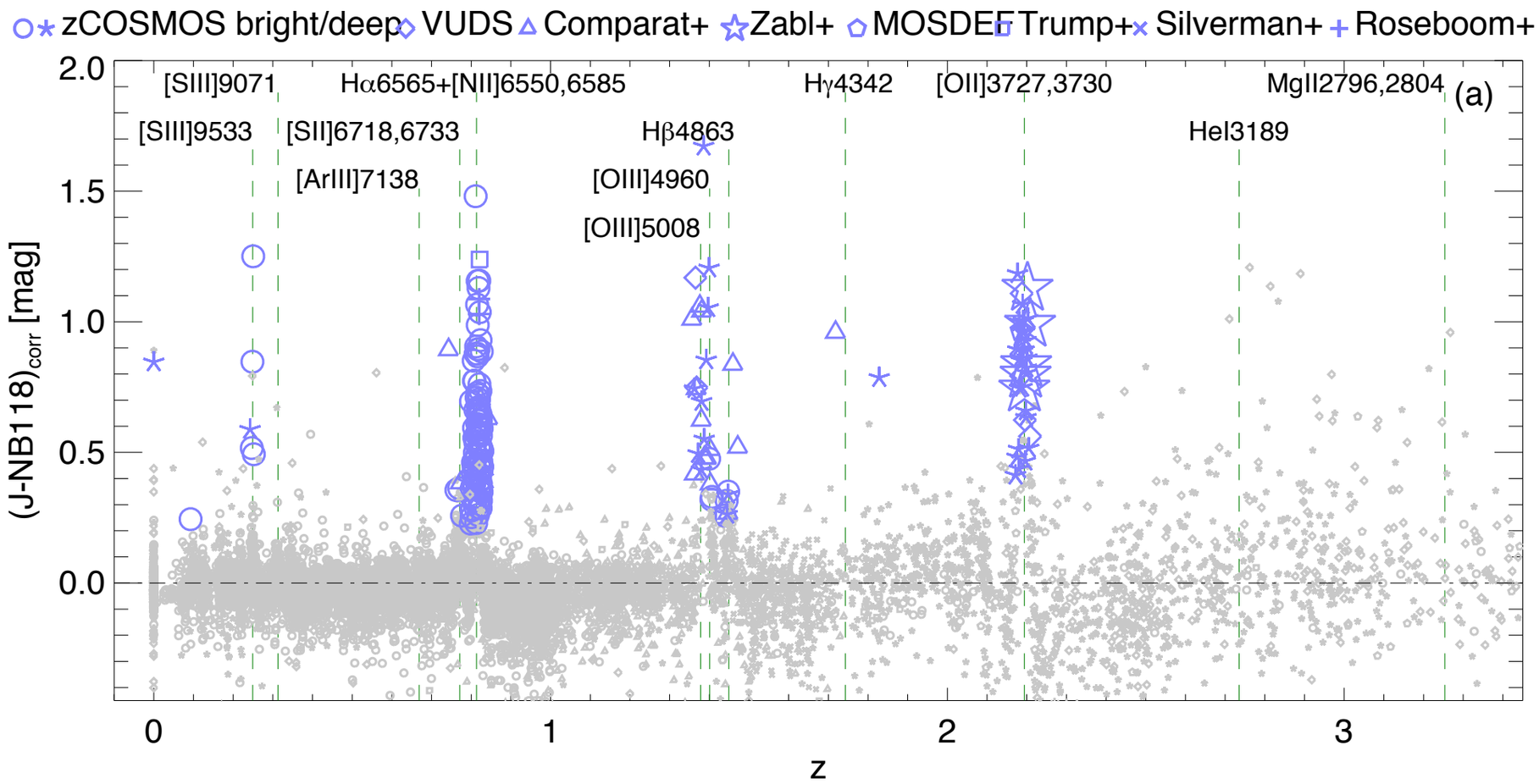
Spectroscopically confirmed emitters: big symbols

Objects with spectroscopic redshifts

NB-excess objects: blue symbols

NB-excess objects have redshifts corresponding to strong emission lines





Objects with spectroscopic redshifts

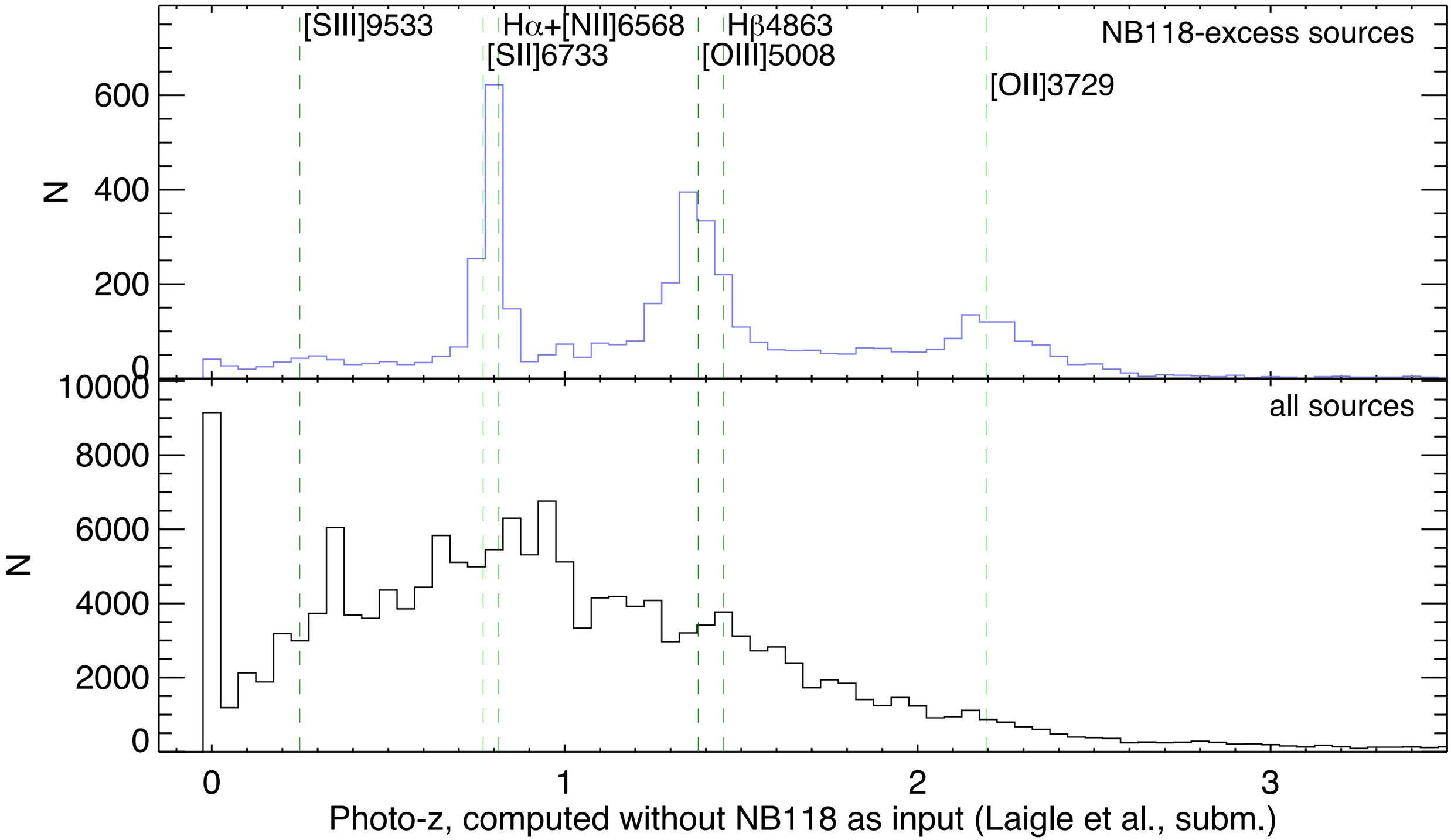
NB-excess objects: blue symbols

Using stricter selection

NB-excess objects have redshifts corresponding to strong emission lines

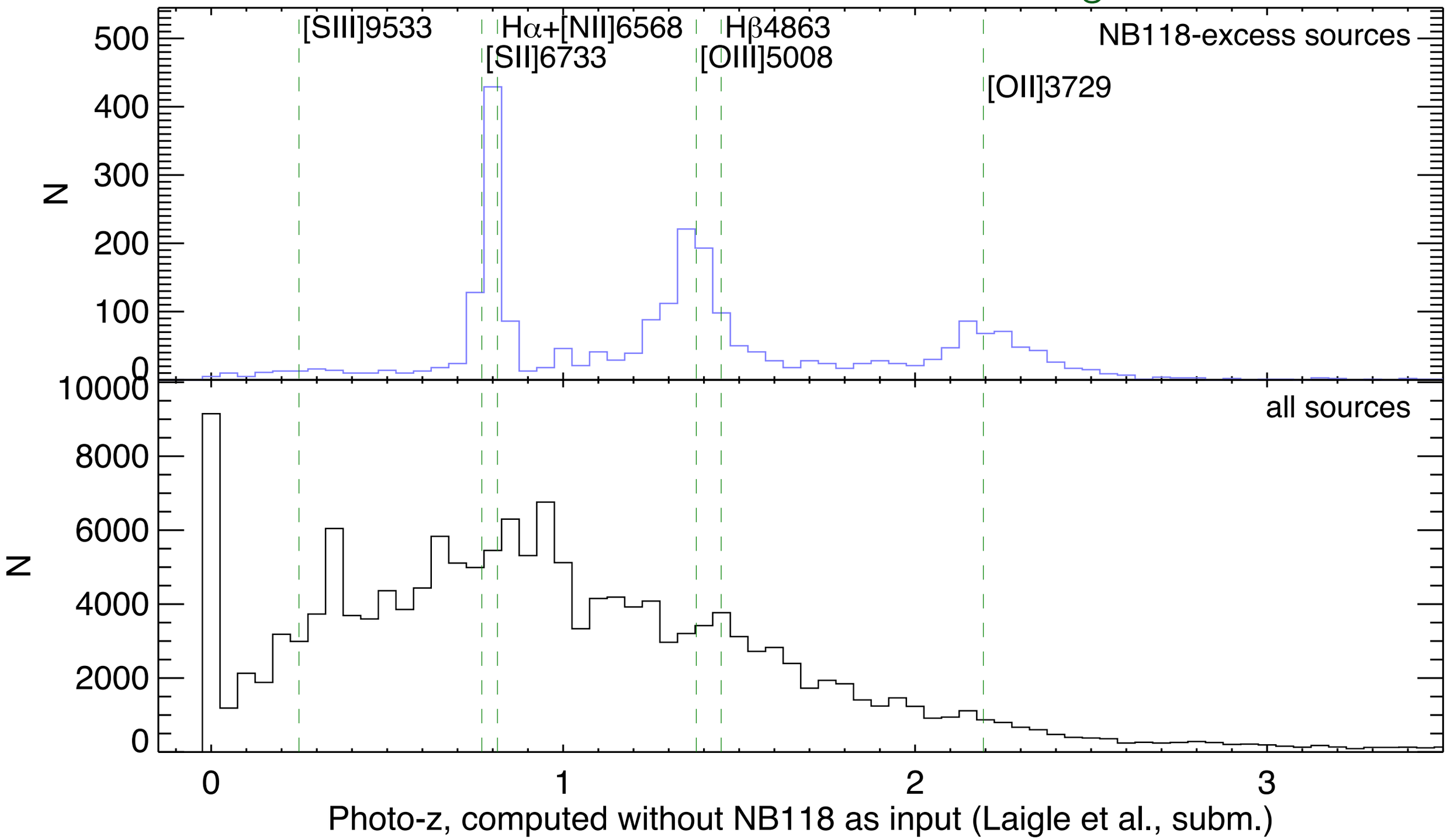
Filters ca. 3.5 nm too red, reason unknown; see M-J et al. (2013); VIRCAM still the best at 1.19μm

Using photometric redshifts to identify the emission line in the NB filter



Using photometric redshifts to identify the emission line in the NB filter

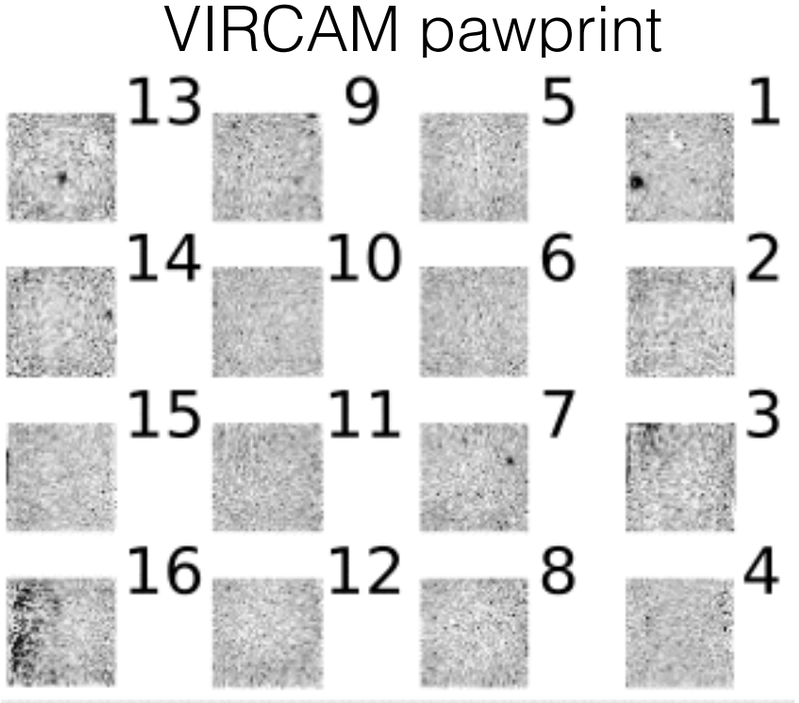
Using stricter selection



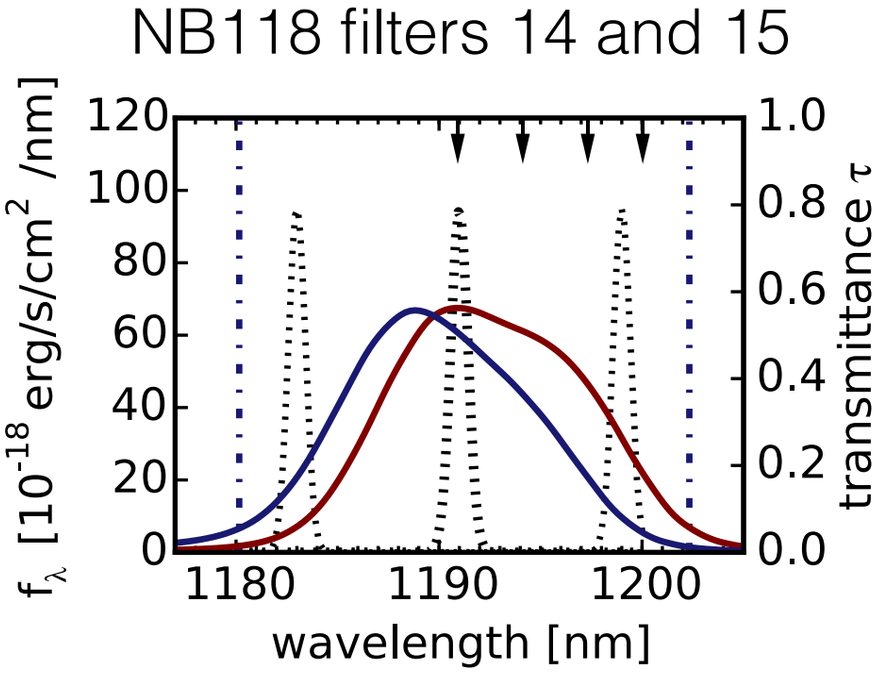
Just started: calculate LFs: Hα, [OIII]+Hβ, and [OII]

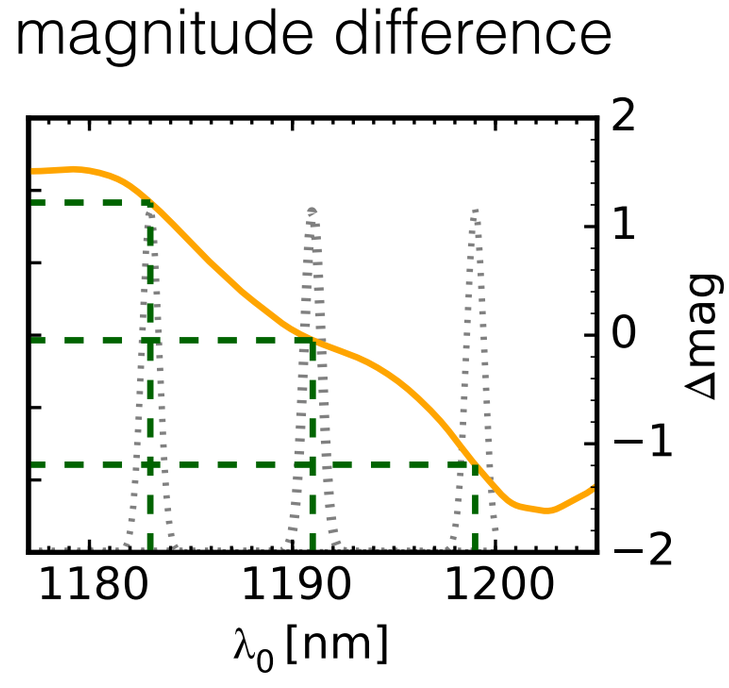
The Throughput Variation Method (Zabl et al. subm.): Idea

- Part of the sky is observed with 2 of the 16 NB118 filters
- The 16 NB118 filters are not fully identical, and some of them are sufficiently different that additional information can be obtained by analysing each detector (= filter) separately



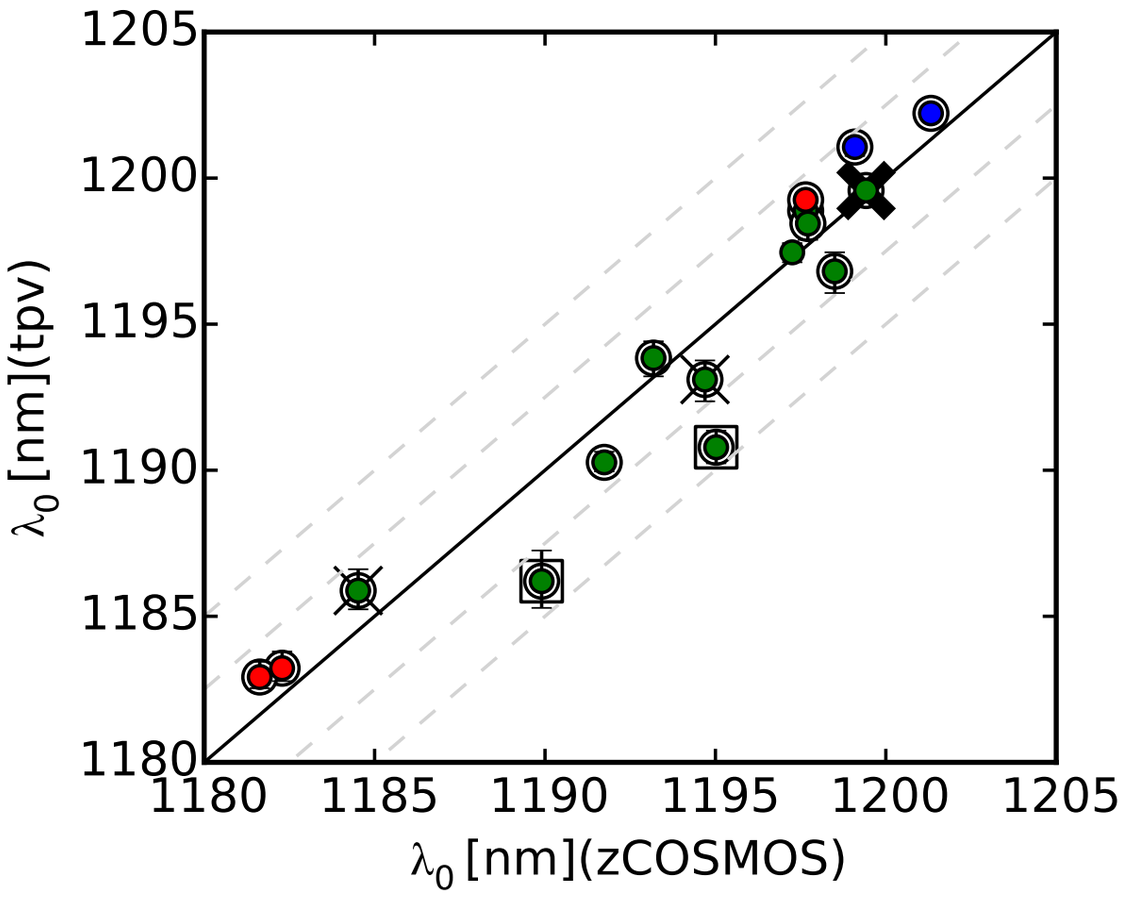
Milvang-Jensen et al. (2013)



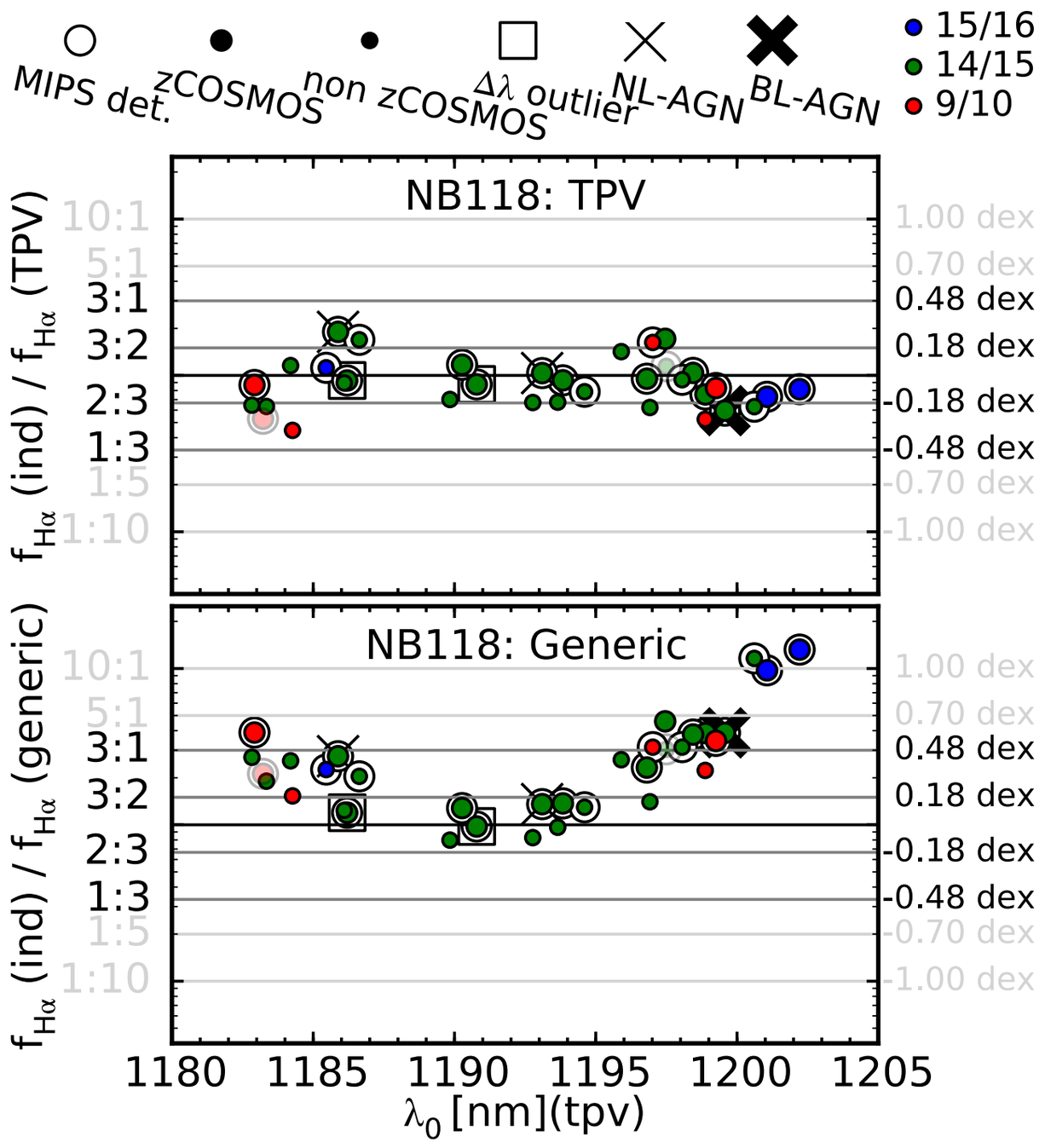


The Throughput Variation Method (Zabl et al. subm.): Results

(1) The wavelength of the emission line can be inferred accurately from photometry in 2 NB filters, plus Y, J, H



(2) The flux of the emission line can be inferred accurately from photometry in 2 NB filters, plus Y, J, H



AGN

- A minority of the NBexcess objects with spectroscopy from zCOMOS are broad-line AGN
- The time-domain of UltraVISTA should allow reverberation mapping (→black hole masses), where NB118 traces the broad-line emission and $YJHK_s$ trace the continuum

What about z=8.8 Lyα emitters?

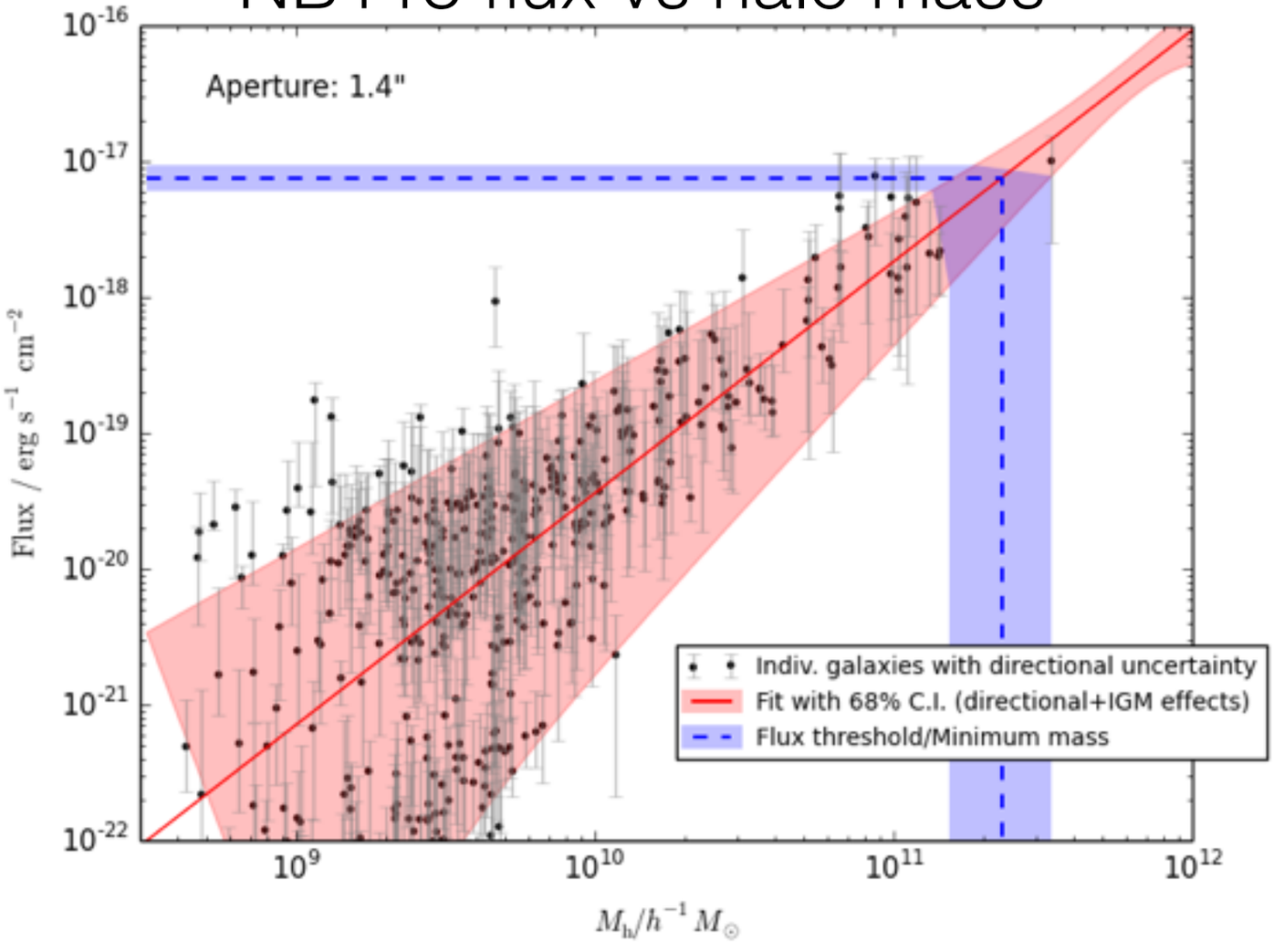
The original forecast for NB118 UltraVISTA final was 3-20 z=8.8 Lyα emitters (Nilsson+ 2007); however:

- The NB118 filters have higher sky background due to a shift to the red of 3.5 nm of unknown origin (and some filters probably have red-leak above specification)
- Even without the filter problems, the ESO ETC used to define the survey used a too optimistic sky background
- The Universe is probably more neutral at z=8.8 than previously thought

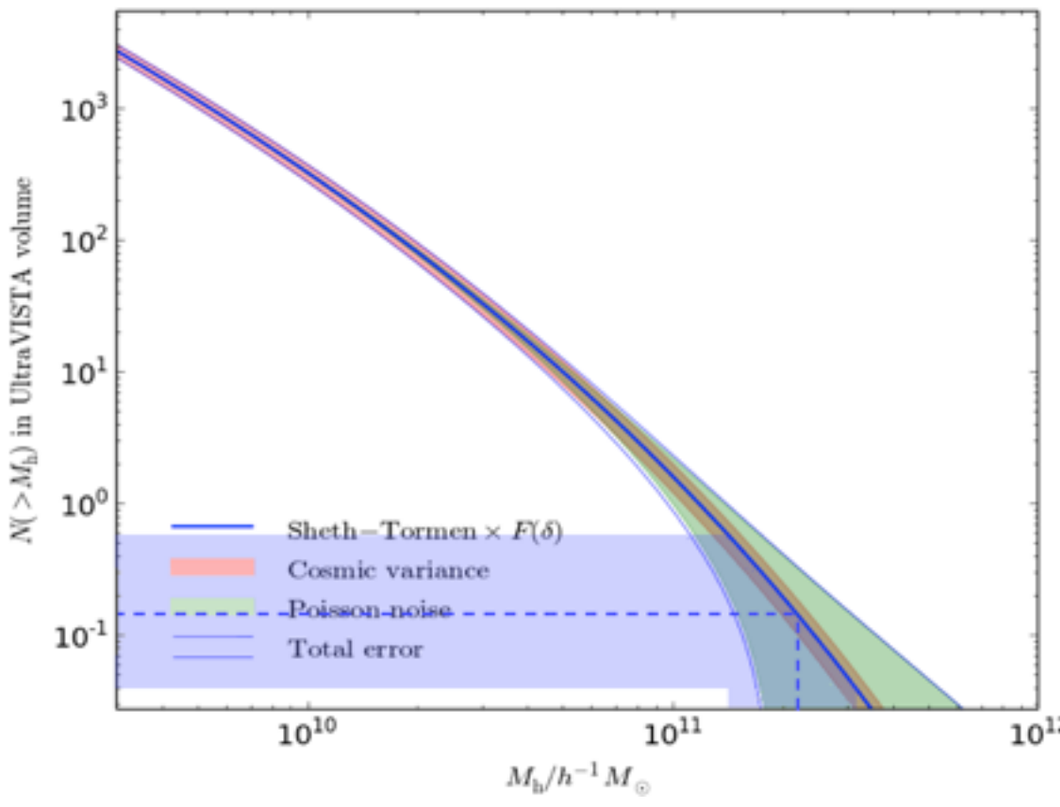
Laursen et al. in prep.: simulations of z=8.8 Lyα emitters

Dark matter + gas simulation with Lyα radiative transfer.

NB118 flux vs halo mass



No. haloes vs halo mass

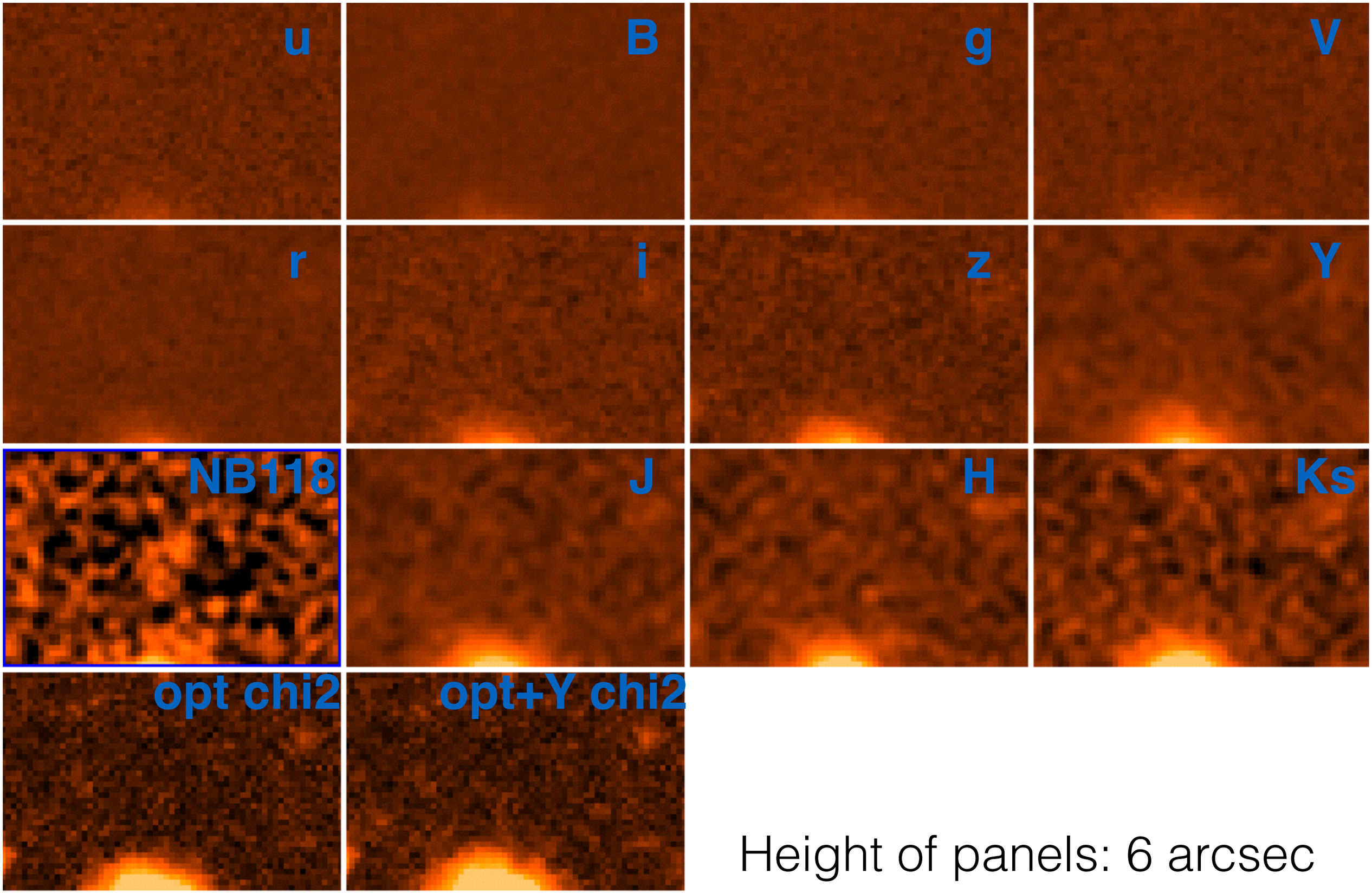


No. of Lyα emitters expected to be detected at 5σ in the final UltraVISTA NB118 image:

$$2.047^{+0.067+0.687+0.281}_{-0.070-0.711-0.281}$$

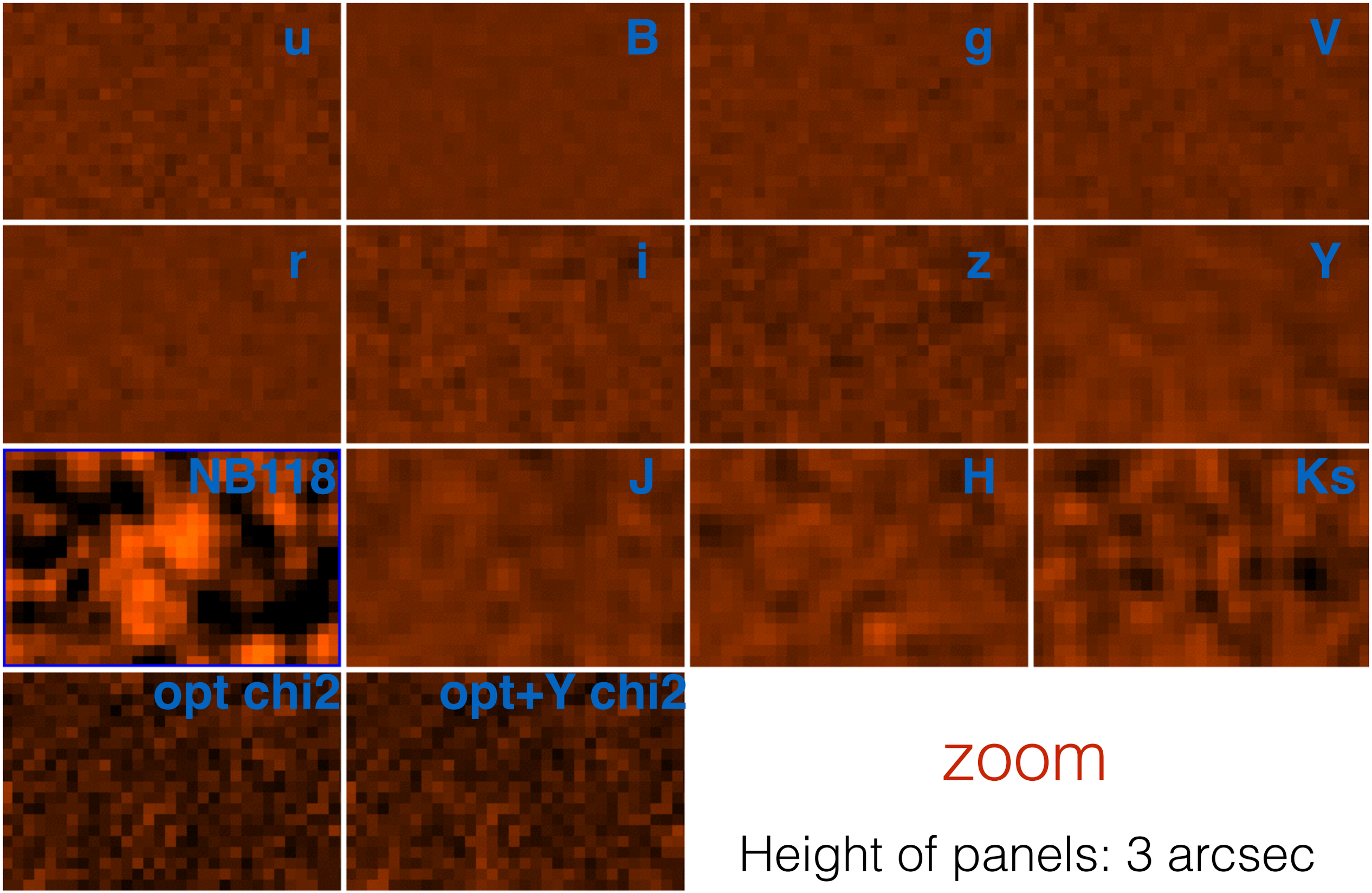
$$\sim 2.0 \pm 0.8$$

A 3.2σ NB118 detection without broad-band counterparts: Lyα?

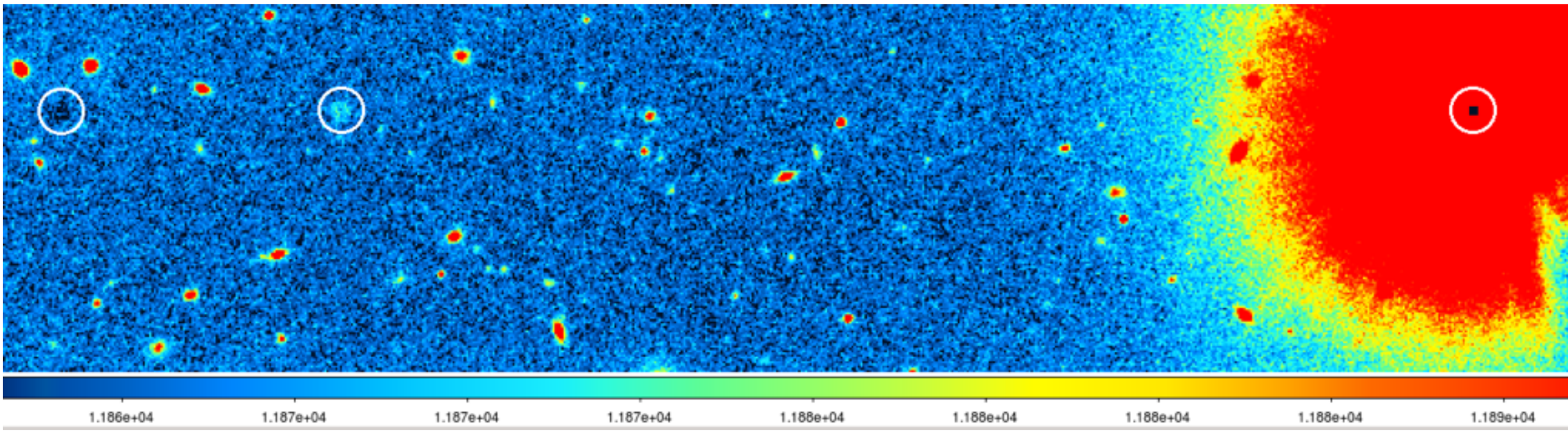


Height of panels: 6 arcsec

A 3.2σ NB118 detection without broad-band counterparts: Lyα?



Service message: VIRCAM has *some* crosstalk.
A strong example is shown here, visible in a stack of just 1 hour of exposure; the strength may vary from detector to detector



Summary

- The current VISTA NB118 data provide a large sample of z=0.8 Hα, z=1.4 [OIII]/Hβ and z=2.2 [OII] emitters
- The different emitters can be identified via colour-colour or photo-z selection, thanks to the ~30 photometric bands in COSMOS
- z=2.2 [OII] sample is great for spectroscopic follow-up: Lyα, [OII], Hβ, [OIII], Hα, [NII], plus more, accessible from the ground
- The final NB118 UltraVISTA data should contain 2.0±0.8 z=8.8 Lyα emitters