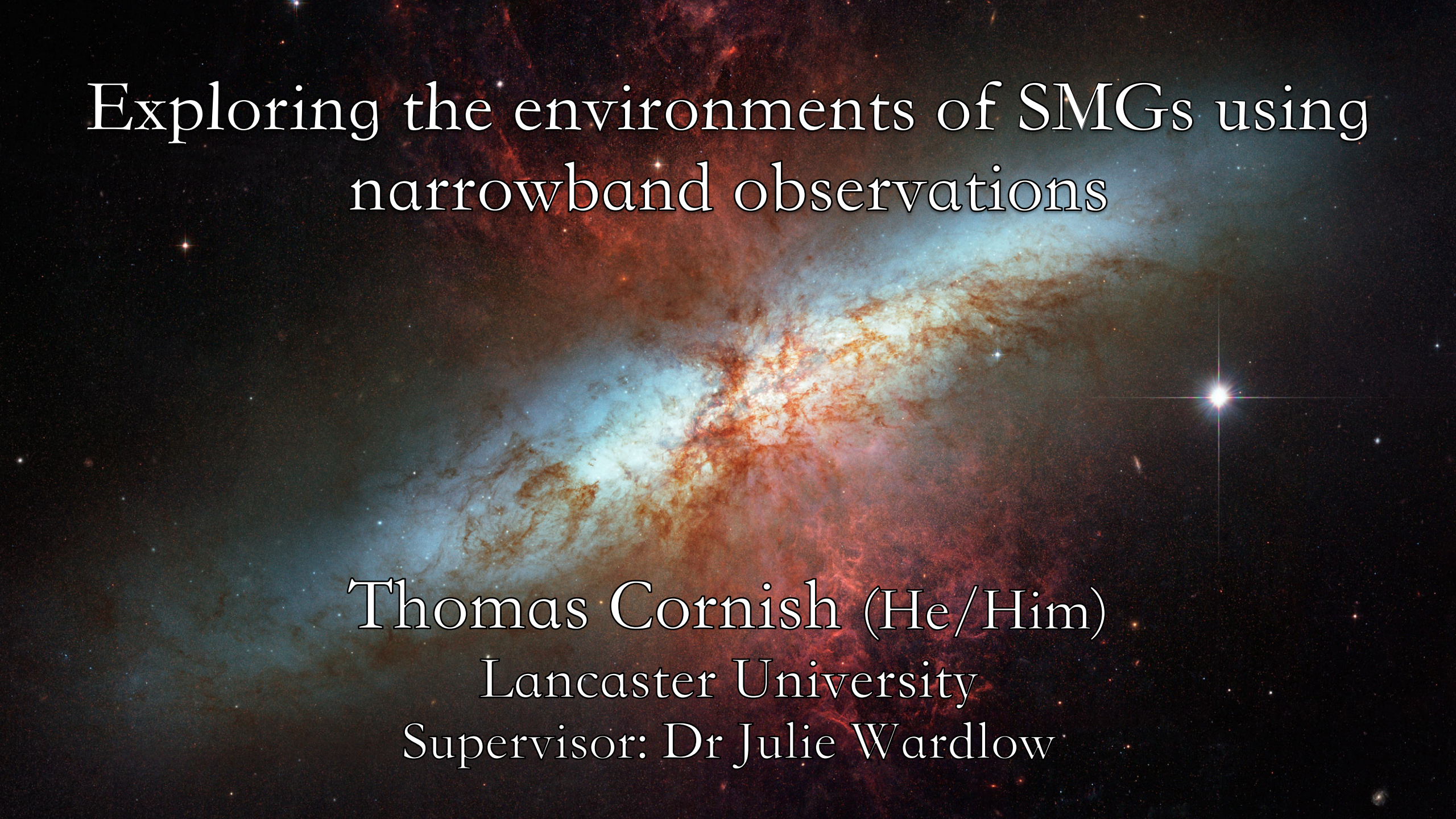
Exploring the environments of SMGs using narrowband observations



Thomas Cornish (He/Him)
Lancaster University
Supervisor: Dr Julie Wardlow

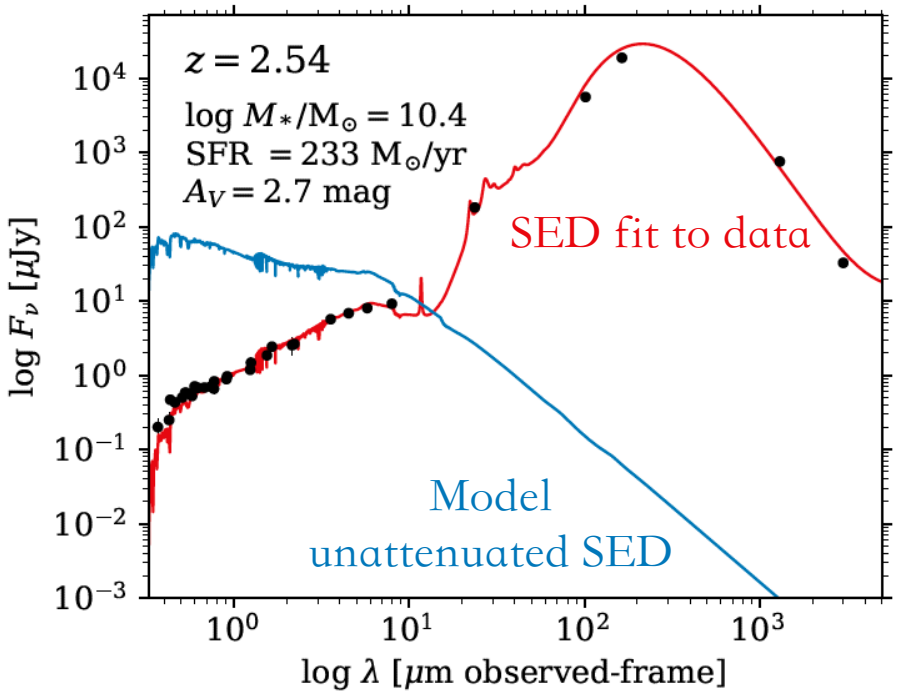
Motivation

- Submillimetre galaxies (SMGs):
  - dusty, star-forming galaxies at high-z
  - extremely high SFRs
  - extremely IR-luminous.

- Studying their environments can provide insight into their evolution.

- This study: do SMGs typically reside in protoclusters?

An example SMG SED.

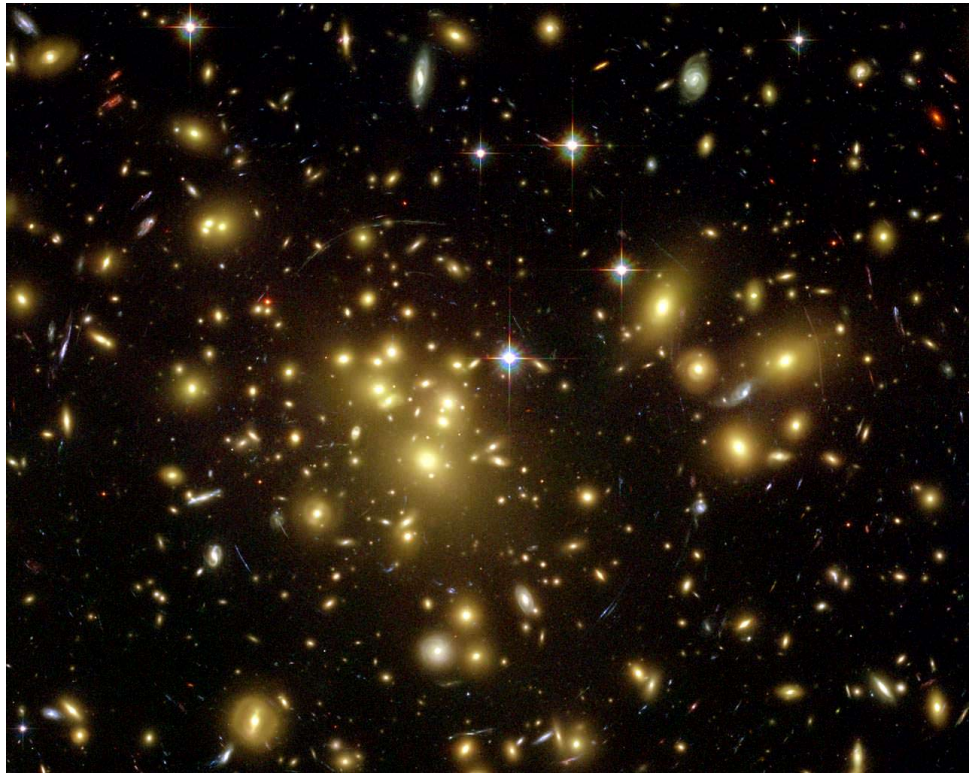


Aravena et al. (2020)

SMGs: Early-Type Galaxy Progenitors?

- Local early-type galaxies are…
  - massive
  - thought to have formed most of their stellar content in short bursts before $z \sim 2$
  - typically found in galaxy clusters.

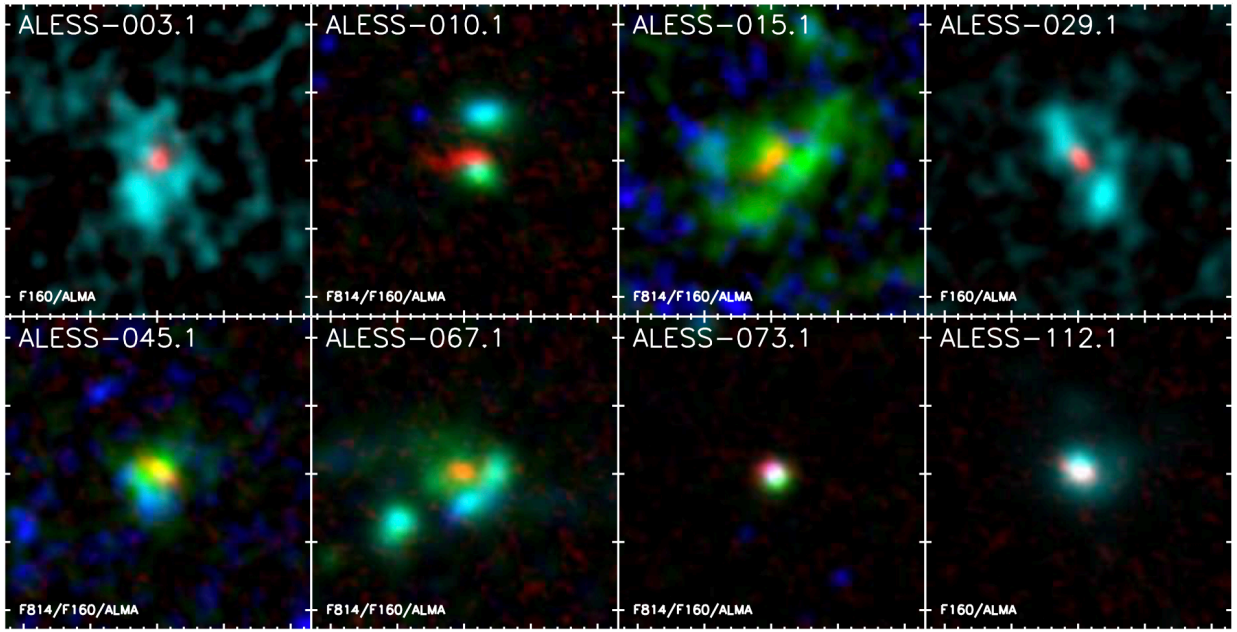
An example of a galaxy cluster.



SMGs: Early-Type Galaxy Progenitors?

- SMGs are…
  - massive
  - undergoing intense bursts of star formation at a median redshift of $z \sim 2$–2.5
  - typically found in ??? environments.

False colour images of various SMGs.



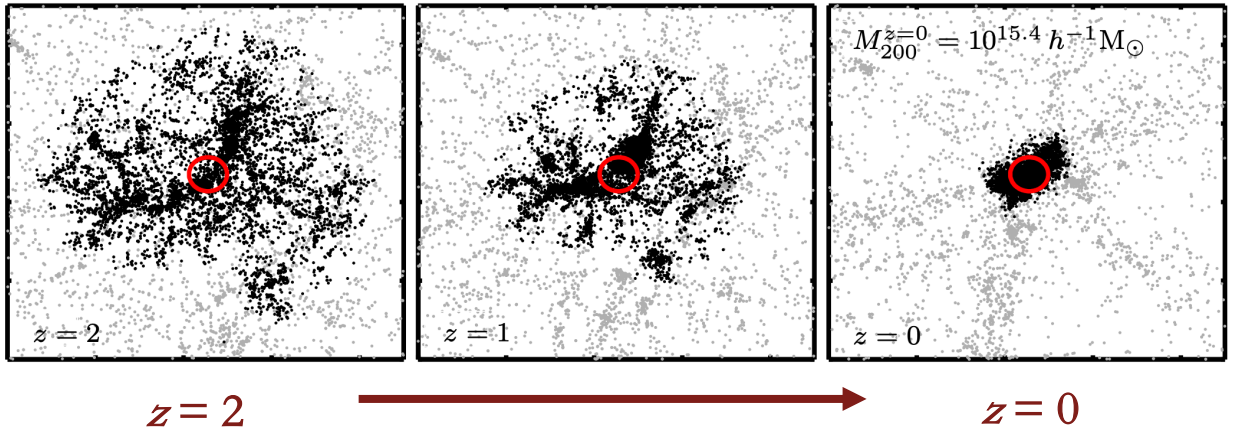
Red: ALMA Green: F160 Blue: F814 or F160

Hodge et al. (2016)

Protoclusters

- Supergalactic structures usually found at $z \gtrsim 2$.
- By $z = 0$ they expected to evolve into the galaxy clusters we see locally.
- Not usually virialized, nor containing a hot ICM.
- Characterised by an overabundance of galaxies.

Evolution of a simulated protocluster.



Muldrew et al. (2015)

SMG Environments: What Do We Know?

- Clustering measurements suggest SMGs typically reside in overdense regions, but…
  - many of these are uncertain, being largely dependent on photo-zs
  - non-uniform coverage requires complicated modelling to bridge the gaps
  - typical SMG environment not yet determinable with clustering measurements.

- SMGs have been observed in protoclusters, but…
  - existing SMG samples are inherently biased towards overdense environments.

This Study

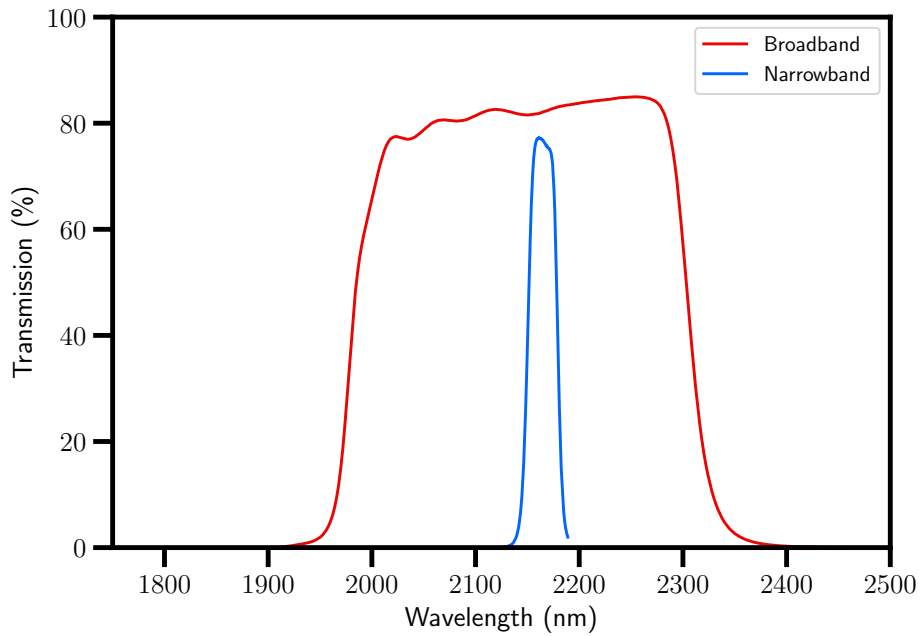
- Using VLT/HAWK-I narrowband imaging to measure ALESS SMG environments.
  - two photometric filters used: one broadband (Ks) and one narrowband (Brγ)

- No prior knowledge of these environments.

- Data covers two 7.5′×7.5′ regions within the ECDFS, containing 3 SMGs:
  - ALESS 005.1 ($z = 3.303$)
  - ALESS 075.2 ($z = 2.294$)
  - ALESS 102.1 ($z = 2.296$).

- SMGs selected because of their redshifts…

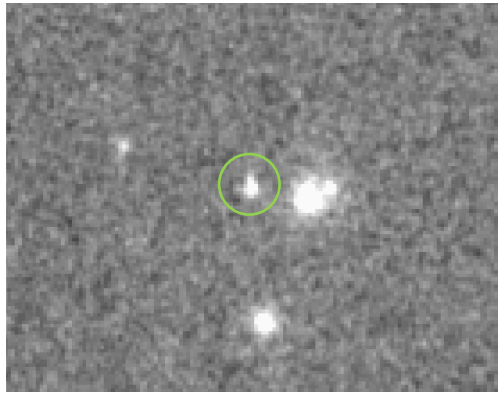
The photometric filters used for this study.

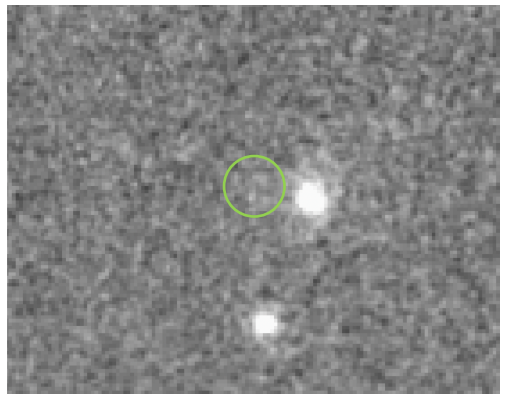


Searching for Potential Protocluster Members

- Star forming galaxies => strong emission lines.
- Emission lines redshifted into Brγ wavelength range:
  - Hα (z = 2.3)
  - [OIII] (z = 3.3).
- Expect ~15 Hα emitters per pointing, based on blank-field estimates.

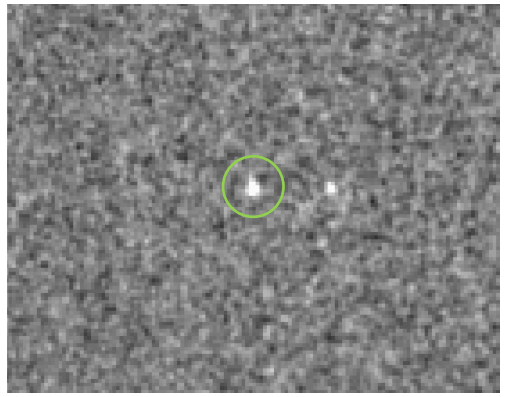
Brγ image





Ks image

(Brγ - Ks) image



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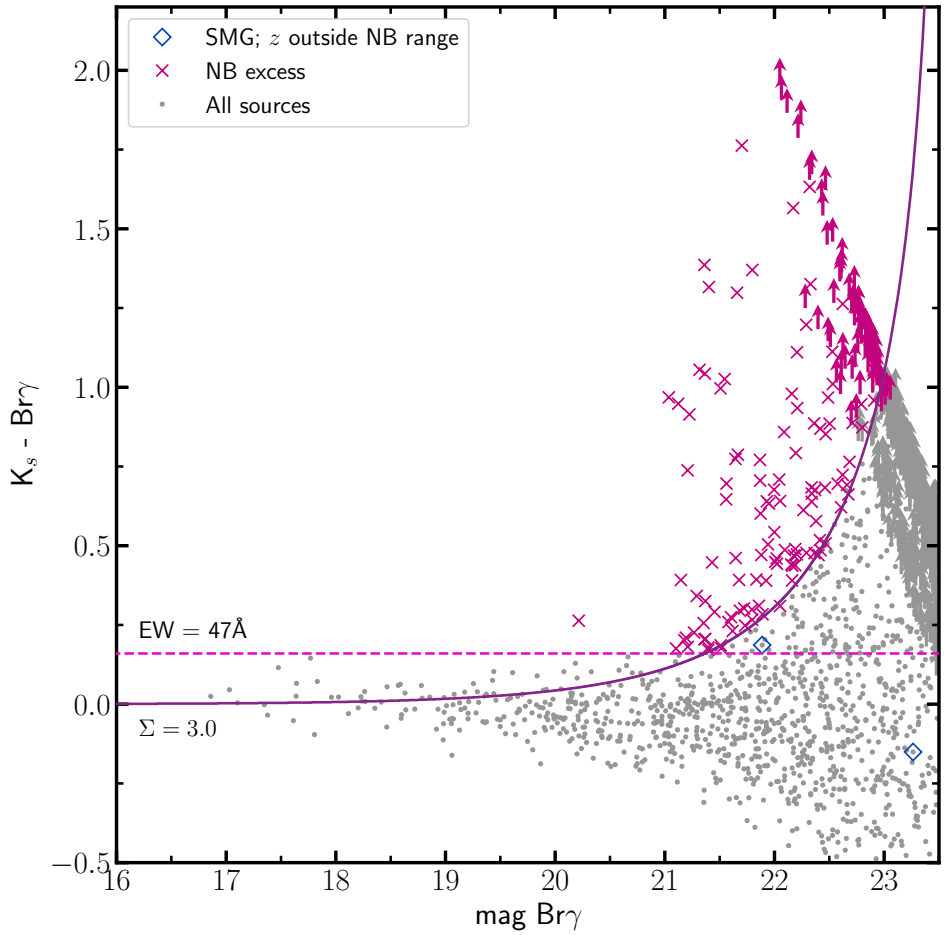
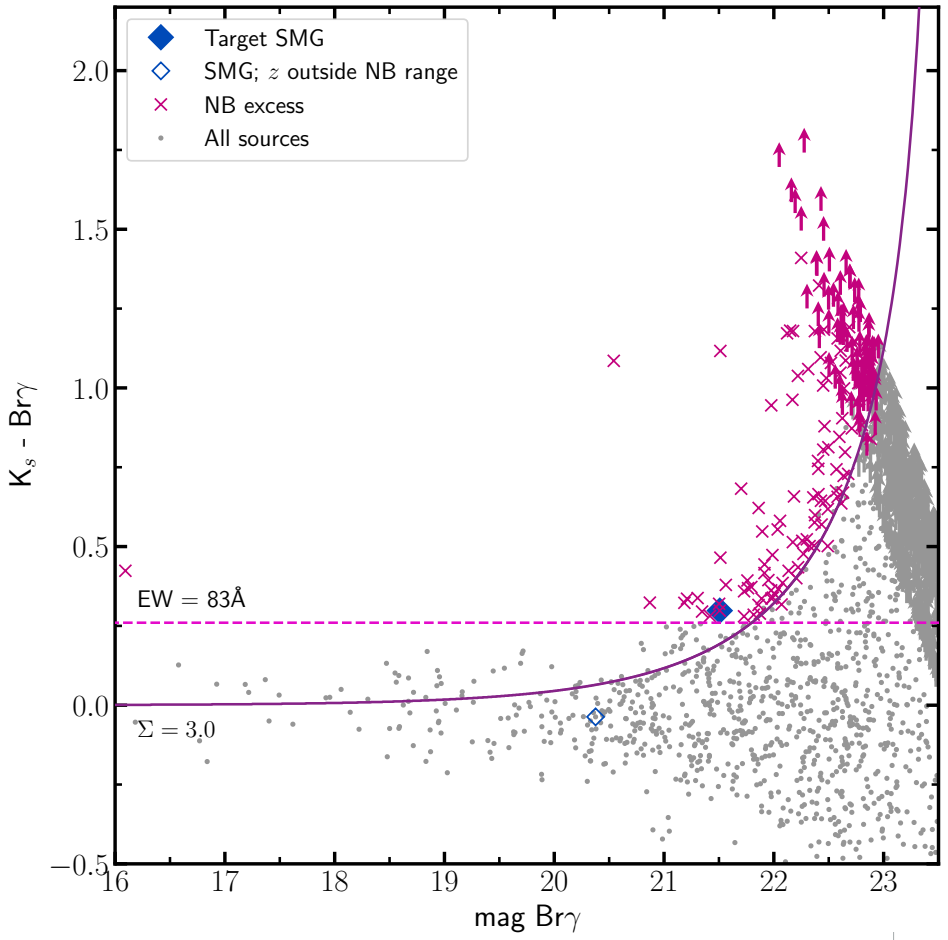
Candidate NB emitters: Colour-Magnitude Diagrams

Pointing 1



Pointing 2



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Candidate NB Emitters: Redshifts

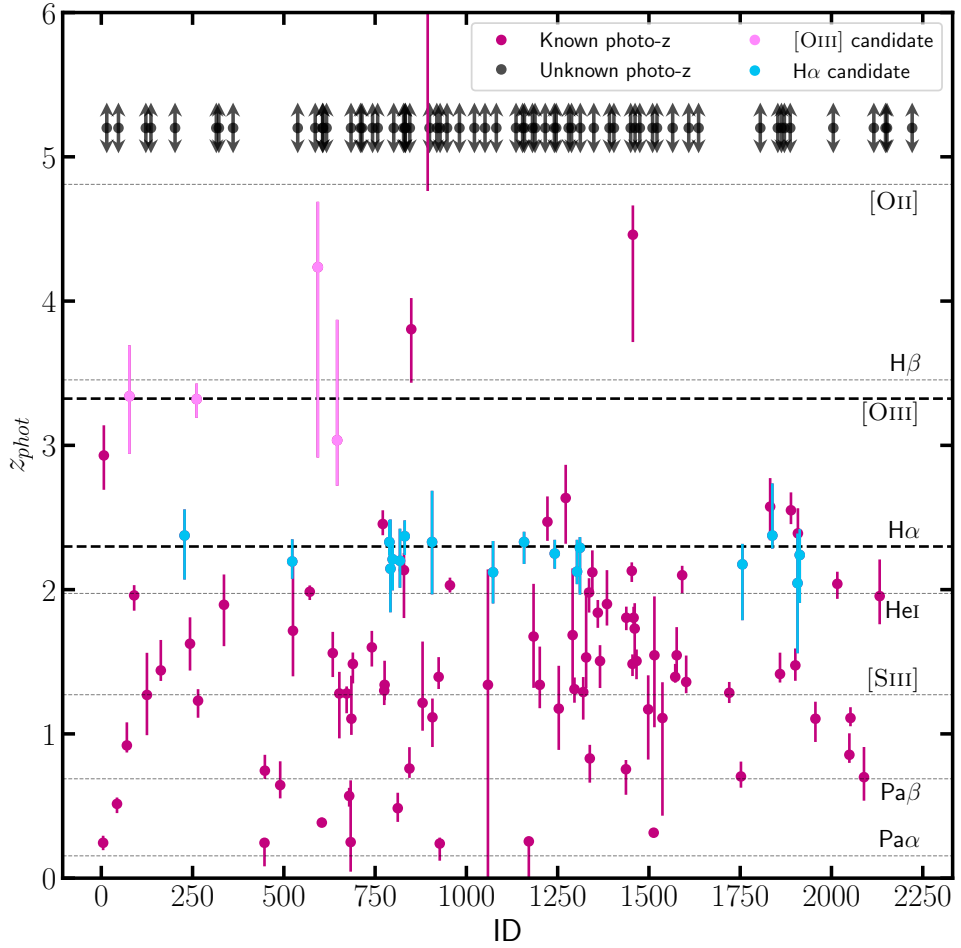
- So far, had only identified candidate line emitters in general
  - these could include several possible lines at various redshifts.

- Needed to identify any line emitters at the same redshifts as the SMGs
  - i.e. are they Hα([OIII]) emitters at $z = 2.3(3.3)$?

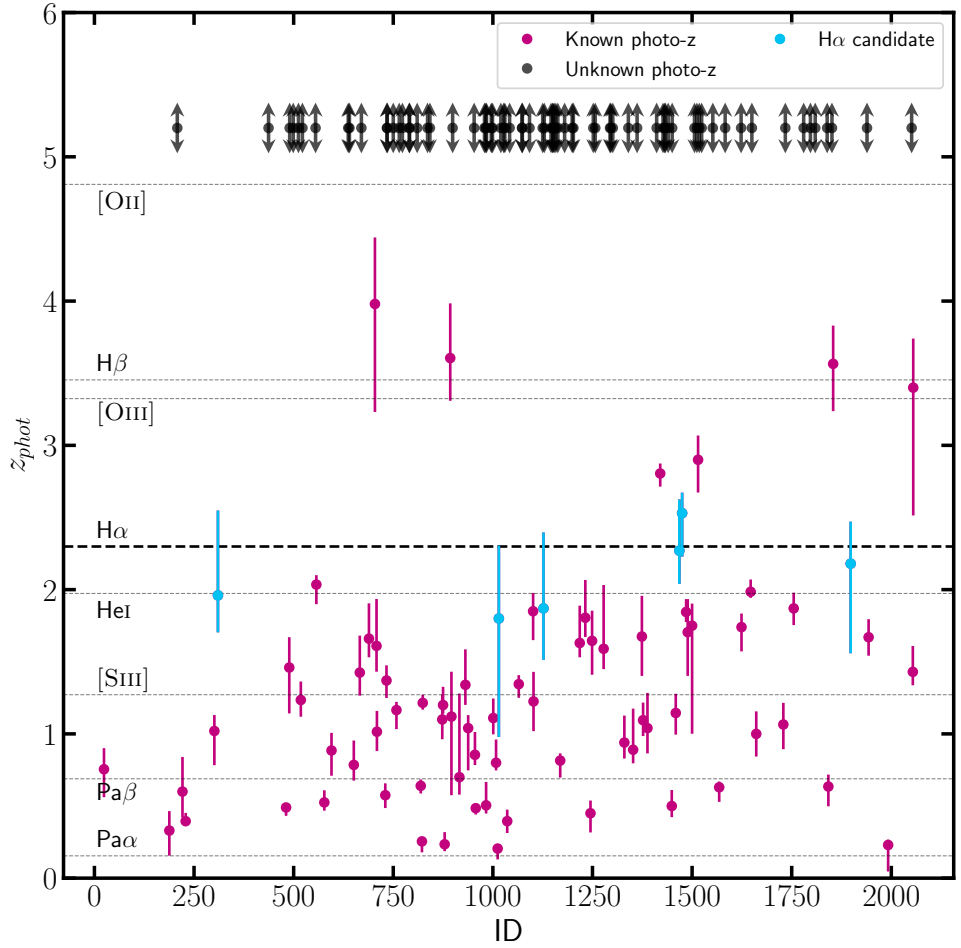
- Done by cross-matching our data with a reference catalogue which contains multiband photometry and photo-z's across the entire ECDFS.

Candidate NB Emitters: Redshifts

Pointing 1



Pointing 2



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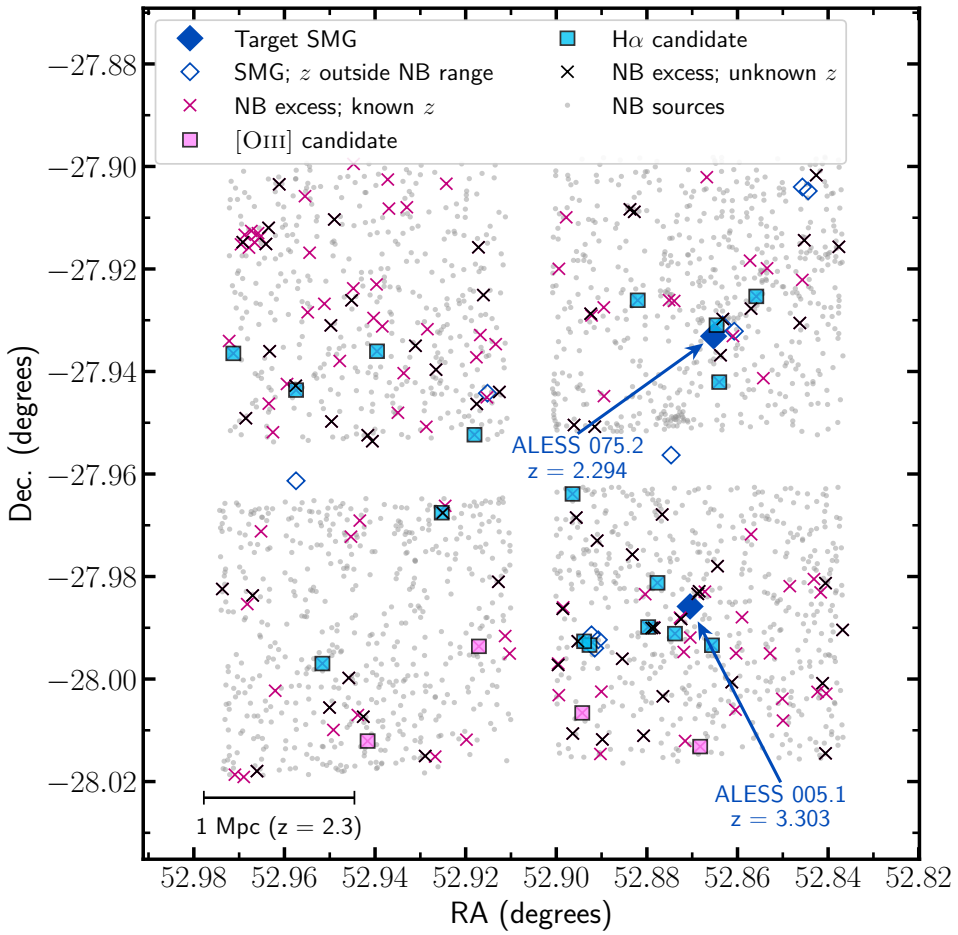
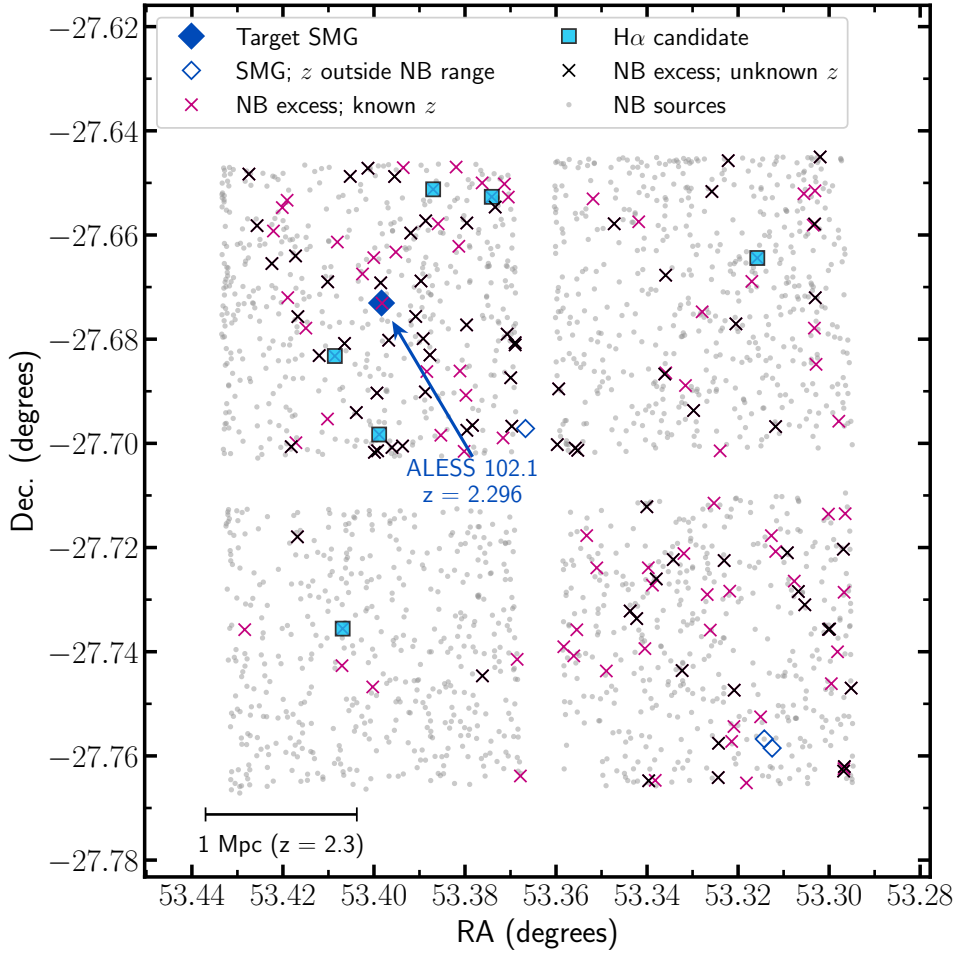
Candidate NB emitters: Positions

Pointing 1



Pointing 2



Conclusions & Future Work

- We have conducted a narrowband study in search of overdensities of star-forming galaxies around three known SMGs at $z \sim 2.3$ and $z \sim 3.3$.
- Our results hint at a substantial overdensity around at least one of the SMGs.
- Further analysis required to determine if the other two SMGs reside in significant overdensities.
- Next steps:
  - try to determine photo-zs for candidates at currently unknown redshifts,
  - analyse any significant overdensities statistically,
  - fit SEDs to NB emitters, derive SFRs and stellar masses.


Thank you

Selection of Narrowband Emitters

- Data were reduced using a custom Python-based pipeline.
- Brγ detections were used to define the aperture positions for photometry.
- Photometry was extracted from the Ks and Brγ images.
- Magnitudes in Ks and Brγ were used to compute:
  - the significance of the Ks-Brγ colour excess, Σ
  - the observed equivalent width, EW.

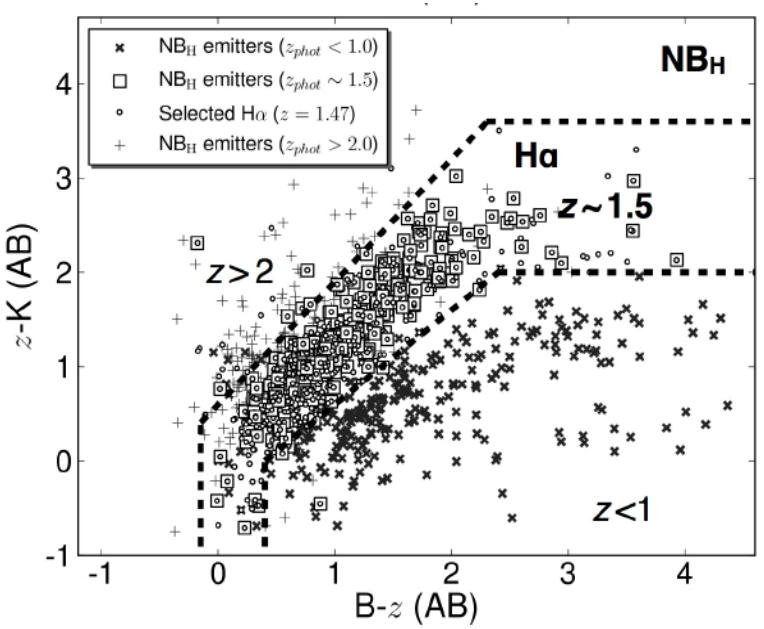
$$\Sigma = \frac{1 - 10^{-0.4(BB-NB)}}{10^{-0.4(ZP-NB)}\sqrt{\pi r_{ap}^2(\sigma_{NB}^2 + \sigma_{BB}^2)}}$$

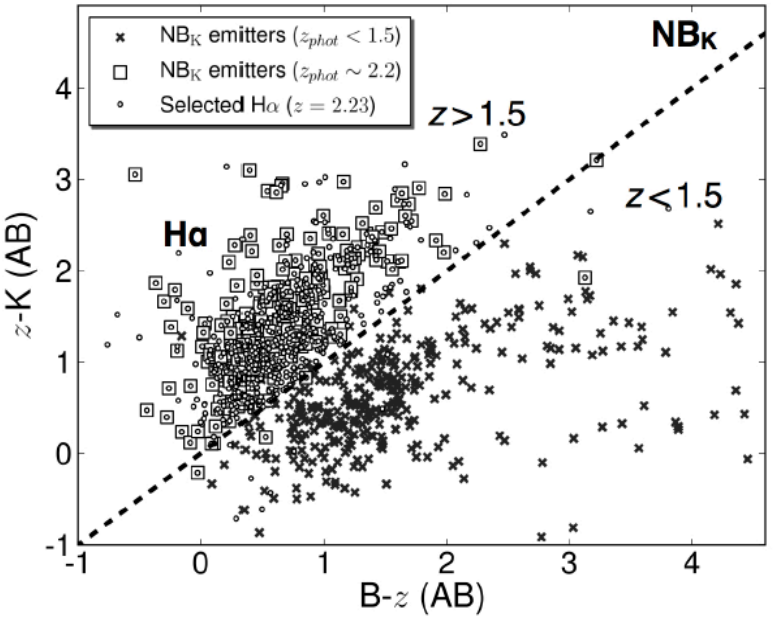
$$EW = \Delta\lambda_{NB}\frac{f_{NB} - f_{BB}}{f_{BB} - f_{NB}(\Delta\lambda_{NB}/\Delta\lambda_{BB})}$$

- Sources were identified as narrowband emitters if:
  - $\Sigma > 3$
  - EW > EW($3\sigma_{\text{Ks-Br}\gamma}$).

Colour-colour Diagrams

- Still lots of candidates with unknown z.
- Can be estimated using cuts in colour-colour space.





Sobral et al. (2013)