# 広帯域フィルターを用いたz=2.1−2.5のHα輝線銀河の検出とその性質

(Detection of Hα emitters at z=2.1−2.5 and investigation of their properties based on broad band photometry)

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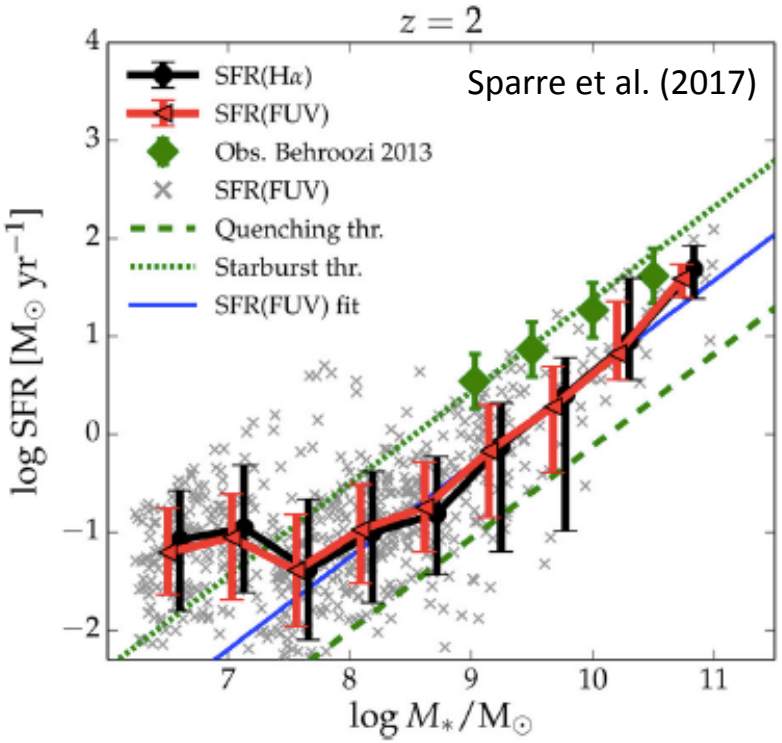
# Contents

- Introduction
  - High-z SFG identifications by narrow-band imaging
  - Advantages of the use of broad-band filters
- Data & Method
  - ZFOURGE multi-band catalog
  - Continuum estimate by SED fitting
  - Correction for dust extinction
- Results
  - Luminosity function
  - Star formation rate density
- Future prospects
  - Applying other emission lines
  - Medium-band filters of SWIMS

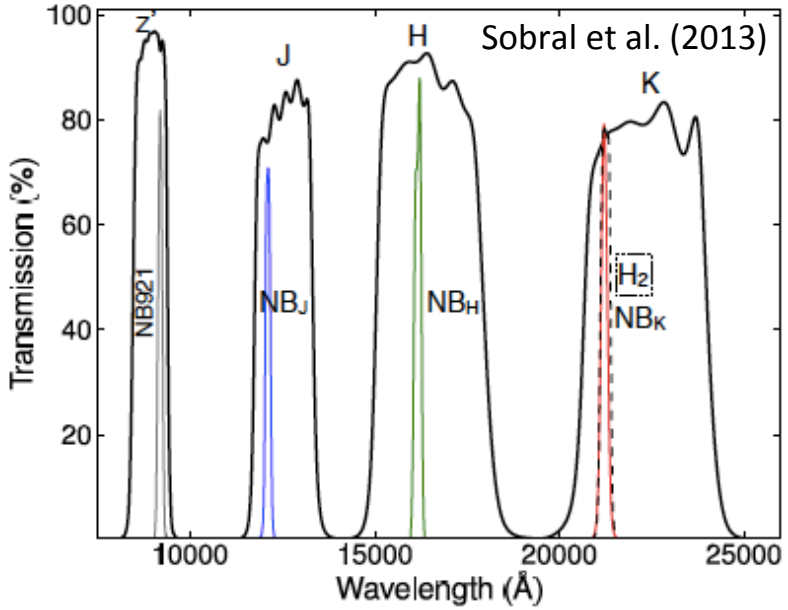
# Importance of large SFG sample

- Statistical properties of SFGs are keys to understand galaxy evolution
  - e.g., main sequence, luminosity function
- Detection of rare objects also test the models



# Narrow band (NB) imaging for high-z SFG identification

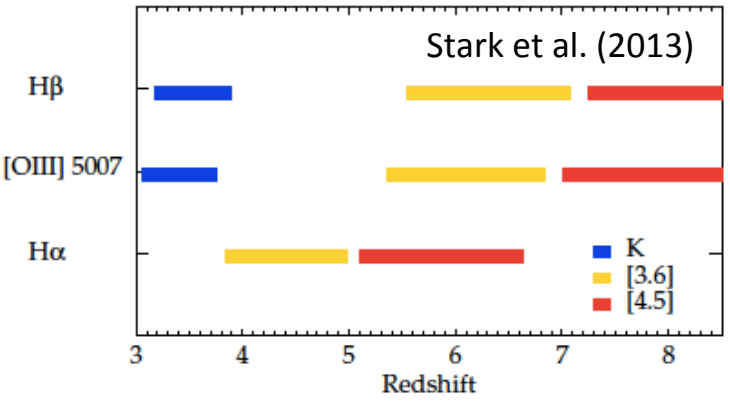
- Directly detect Hα emission lines of galaxies
  - Recovering full SFG population (Oteo+15)
- But large survey area is required to construct larg sample

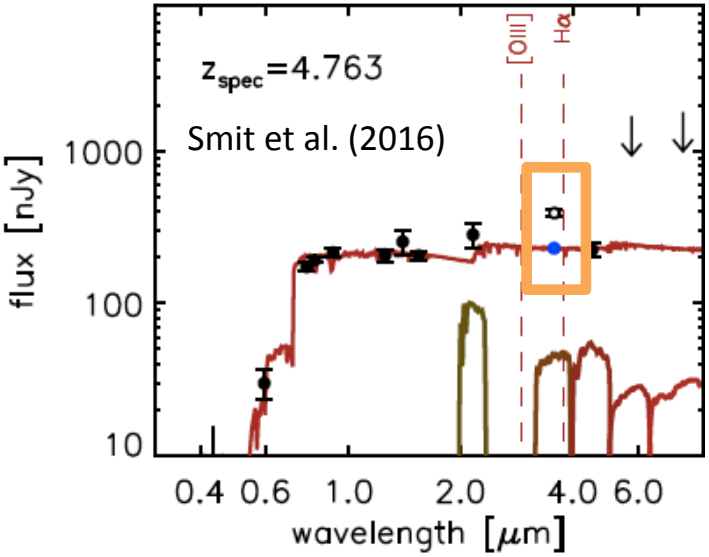



We use broad band (BB) filters to identify SFGs at z=2.1−2.5 and derive their Hα fluxes

# Advantages of Hα derivation from BB data

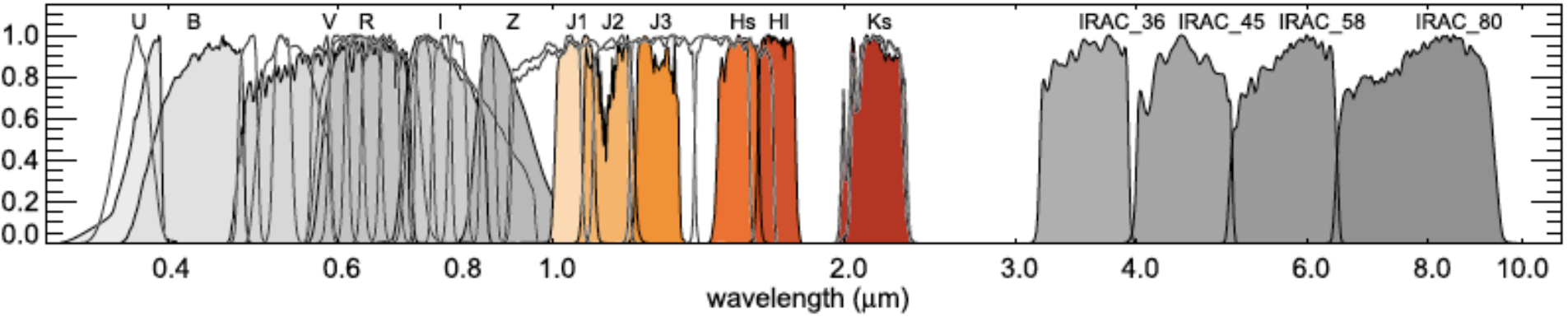
- >10 times larger survey volume than NB given a same FoV
- Possible to derive multiple lines at multiple redshifts from same filter sets
- BB data can be used for SED fitting to know other properties of galaxies
- Previous works verified the concept for SFGs at z>4



# ZFOURGE catalog (Straatman+16)

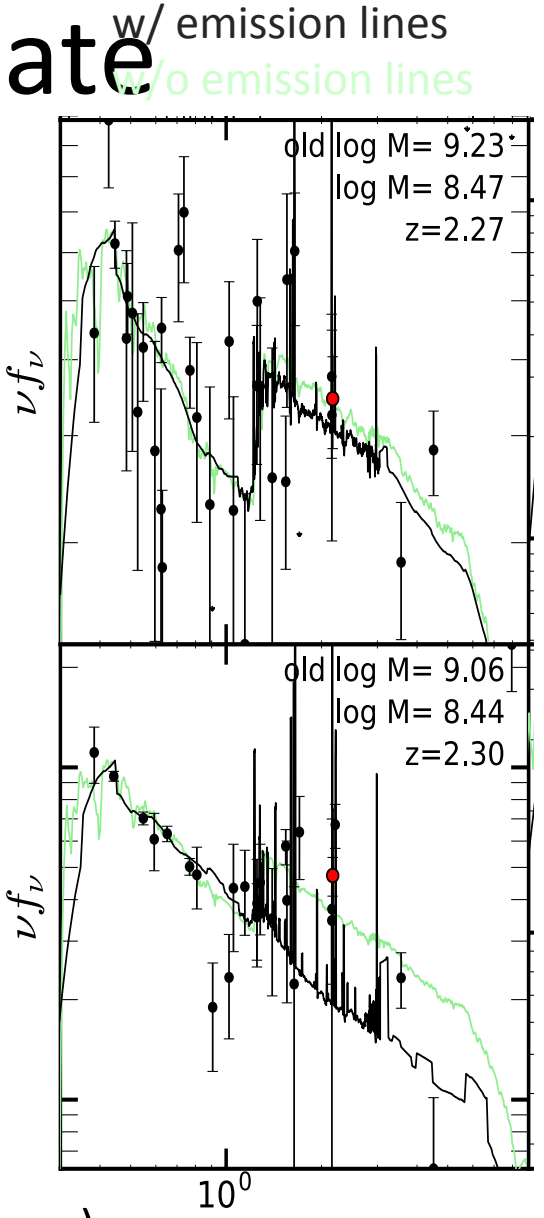
- Total ~400 arcmin$^2$ survey area
  - COSMOS, UDS, and CDFS
- Wavelength coverage of 0.3–8 um + 24 um
  - NIR data taken with Magellan/Fourstar + public catalogs
- Deep Ks photometry with limiting mag. of ~25.5 (5σ)
  - 80% complete for galaxies with logM = 9 at z~2
- Hα from galaxies at z~2.1–2.5 falls into the Ks filter
  - 3320 galaxies selected by photo-z



# Continuum estimate

- SED fitting by FAST (Kriek+09) to estimate the contribution of stellar continuum to observed fluxes
- Emission line templates the continuum

| Parameters | Values |
|---|---|
| SPS model | Bruzual & Charlot (2003) + emission lines |
| SFH | Delayed tau |
| IMF | Chabrier |
| Dust law | Kriek + Conroy (2013) |
| Metallicity | 0.02 (soloar) |




2005 emitters

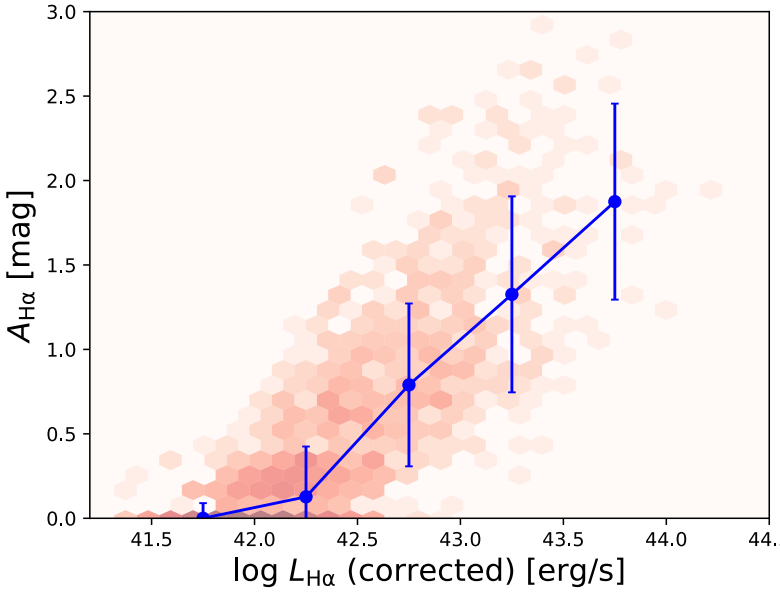
(with the excesses twice larger than photometric errors)

# Correction for dust extinction

- Attenuation at 1600 Å is calculated from the ratio of IR to UV (IRX) (Nordon+13)

$$A_{1600} = 2.5 \log\left(\frac{SFR_{\mathrm{IR}}}{SFR_{\mathrm{UV}}} + 1\right)$$

- Convert it to $A_{H\alpha}$ assuming the extinction curve of Calzetti+00
- $A_{H\alpha}$ of galaxies with no IR detection is estimated using $A_v$ from the SED fitting and the best-fit relation of both methods
  - Both result in consistent values



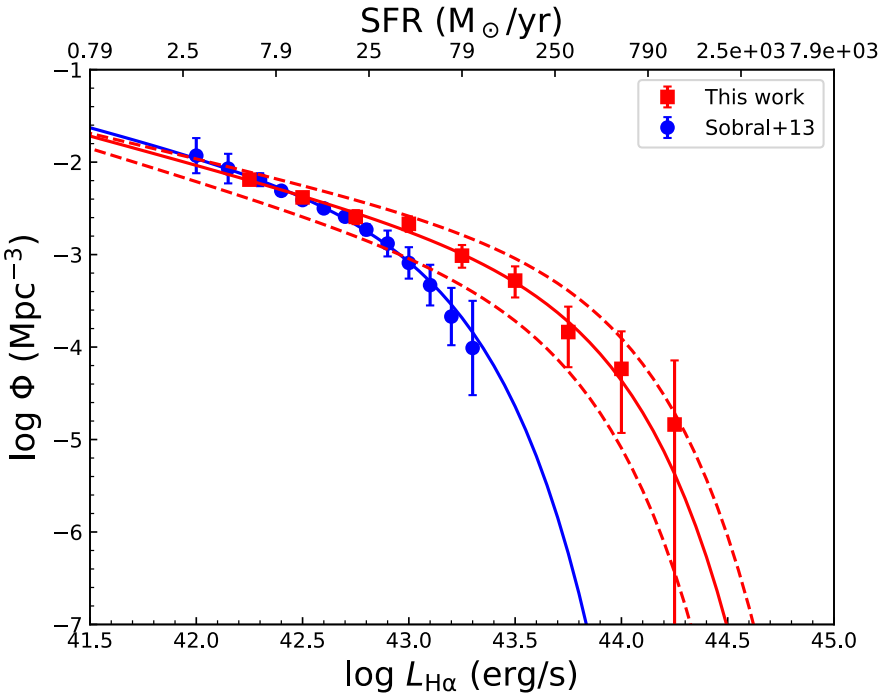
# Hα luminosity function

- Compare our LF with the result of a NB survey (HiZELS; Sobral+13)
- Our LF shows an excess in the bright end

| | Survey Area ($deg^2$) | Redshift Range | Survey Volume ($10^5$ $Mpc^3$) | HAEs |
|---|---|---|---|---|
| This work | 0.11 | 2.1—2.5 (2.3±0.2) | 5.33 | 2005 |
| Sobral +13 | 2 | 2.215—2.247 (2.31±0.016) | 7.66 | 792 |

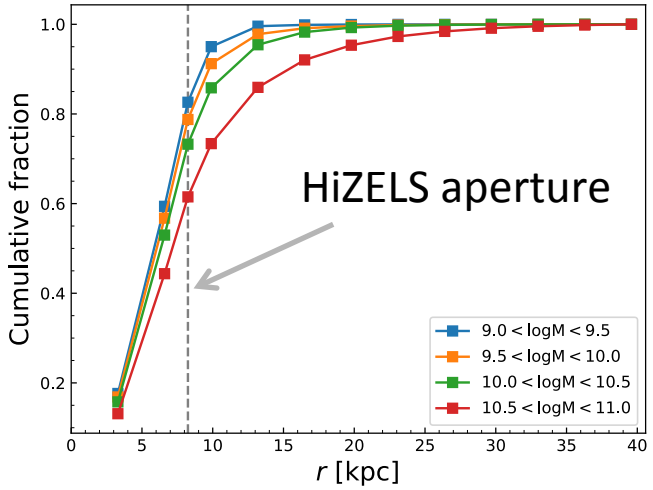
$$\phi(L)\mathrm{dL} = \ln 10\,\phi^{*}\left(\frac{L}{L^{*}}\right)^{\alpha} e^{-(L/L^{*})}\left(\frac{L}{L^{*}}\right)\mathrm{dlogL}$$

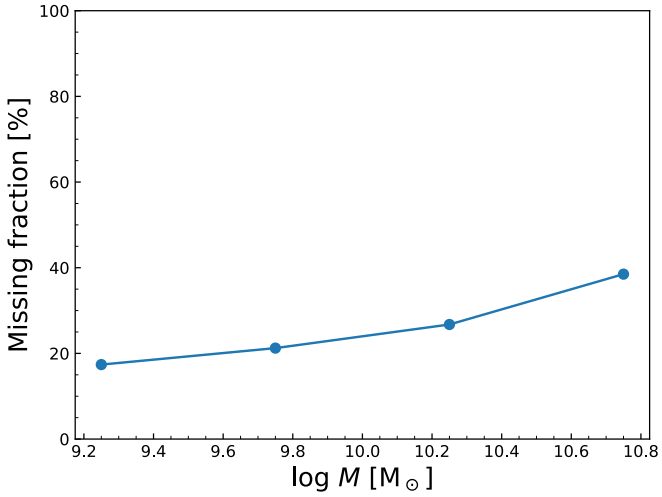
| | $\log L^{*}$ ($erg\ s^{-1}$) | $\log \phi^{*}$ ($Mpc^{-3}$) | $\alpha$ | $\rho_{SFR}$ ($M_{sun}\ yr^{-1}\ Mpc^{-3}$) |
|---|---|---|---|---|
| This work | 43.60 | −3.38 | −1.62 | 0.31 |
| Sobral+13 | 42.87 | −2.78 | −1.59 | 0.21 |



# What produces the LF excess?

- Massive galaxies tend to have extended Hα profile (Nelson+16; 0.7<z<1.5)
- Fixed 2” aperture of HiZELS may have missed at most 40% of Hα fluxes according to a simulation assuming



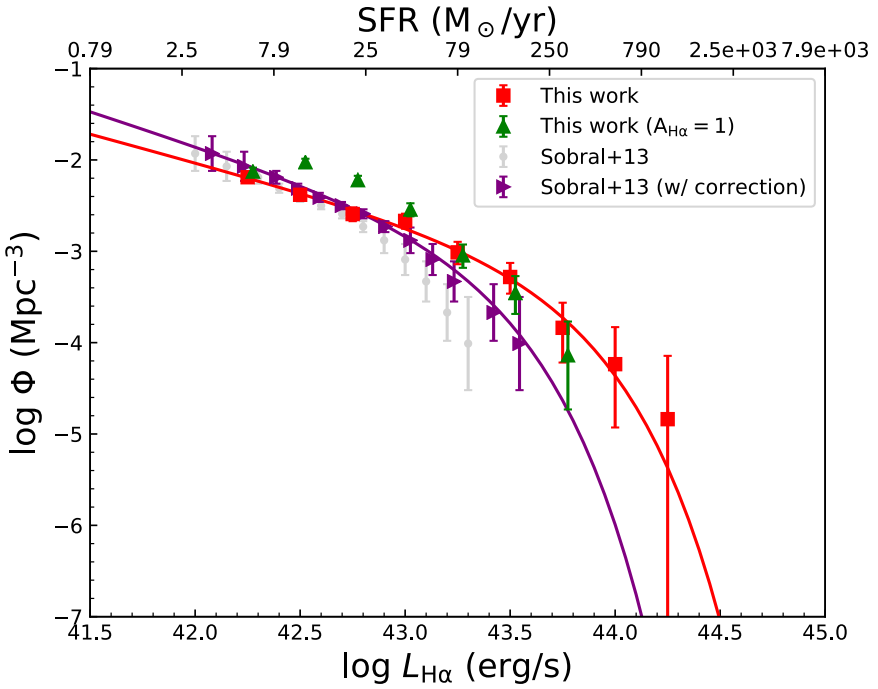




| Nelson et al. (2016) | Hα | | | $H_{F140W}$ | | |
|---|---|---|---|---|---|---|
| log(M∗) | $r_s$ | $r_e$ | n | $r_s$ | $r_e$ | n |
| $9.0 < \log(M_*) < 9.5$ | 1.0 | 1.8 | 1.9 | 1.0 | 1.8 | 1.9 |
| $9.5 < \log(M_*) < 10.0$ | 1.5 | 2.7 | 1.8 | 1.3 | 2.4 | 1.9 |
| $10.0 < \log(M_*) < 10.5$ | 1.8 | 3.2 | 1.5 | 1.6 | 3.1 | 1.7 |
| $10.5 < \log(M_*) < 11.0$ | 2.6 | 5.1 | 1.7 | 2.0 | 3.9 | 2.1 |

ions

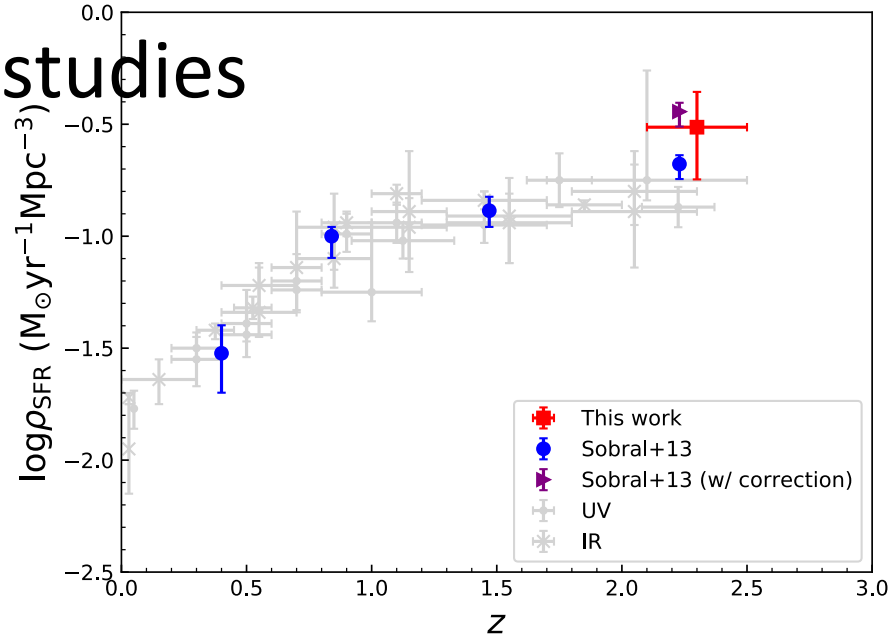
# The comparison after correction

- The offset decreases
- Another factor is the difference of the dust extinction correction between us and Sobral+13
  - Sobral+13 assumed $A_{H\alpha}$=1 for all galaxies
- Assuming $A_{H\alpha}$=1 for our sample slightly reduces the offset in bright end



# Hα star formation rate density

- Consistent with Sobral+13 within error bars
  - Contribution from the brightest galaxies is insignificant
- Higher than previous studies based on UV/IR



# Summary

- BB excess is an efficient tool to construct large emitter samples
- SED fitting with multi-band photometry is essential so that stellar continuum fluxes can be accurately estimated
- Our LF has the excess in bright end compared to HiZELS, quite amount of which can be explained by extended Hα profiles of such galaxies
- Our star formation rate density is consistent with HiZELS and higher than values from UV/IR

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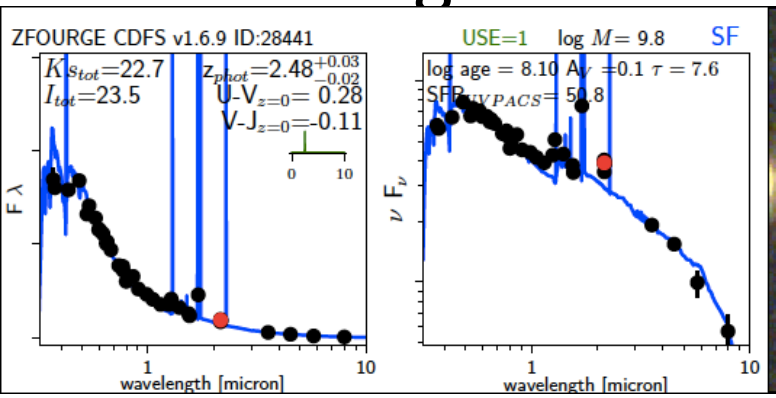
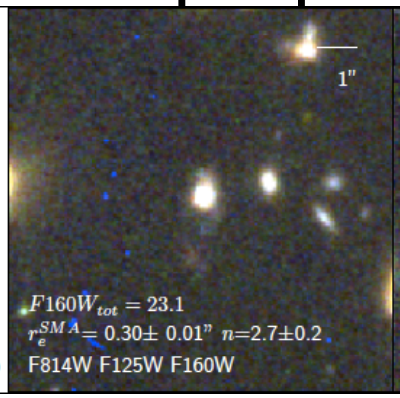
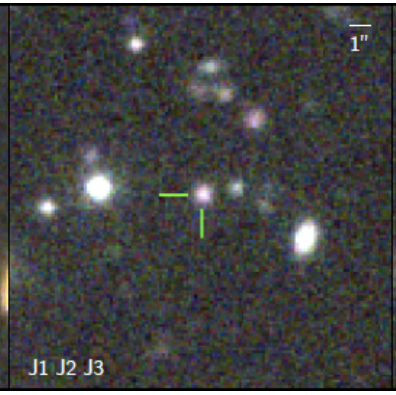
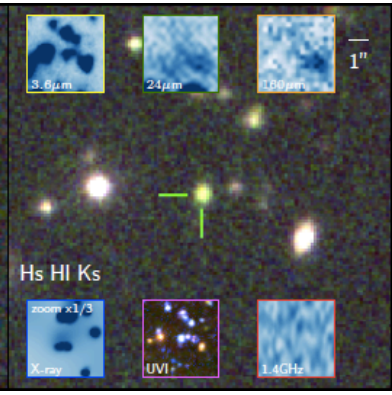
# H band excess galaxies

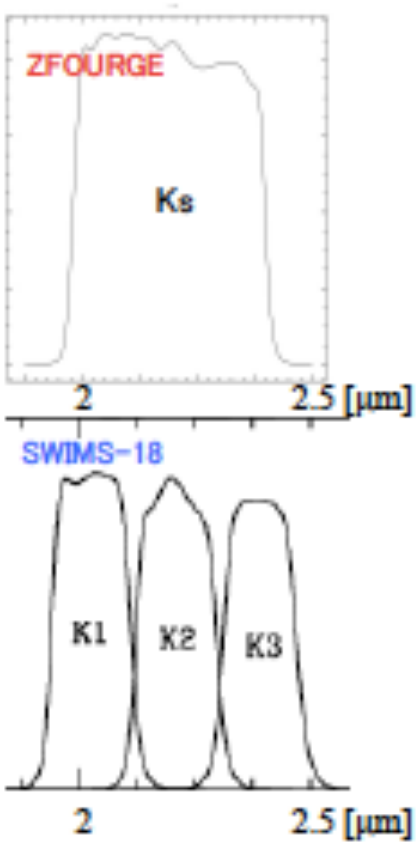
- A part of galaxies in our HAE sample show the excess even in H band, which can be caused by [OIII]+Hβ at z=2.1–2.5
- Apply our method to the H band to investigate statistical properties of



# SWIMS-18

- Medium band (MB) survey with TAO/SWIMS
- Improvement by MB filters
  - More sensitive to low-equivalent width objects
  - More accurate photo-z and stellar continuum estimate (quality of SED fitting)