FMOS & HiZELS

(The High-z Emission Line Survey)

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Talk overview

HiZELS: the Hi-z Emission Line Survey

- What is the HiZELS survey?
- Why is it interesting / important?
- Summary of some recent results

HiZELS & FMOS

- Why is HiZELS suitable for FMOS follow-up
  - Source densities
  - Redshifts / emission lines
  - Scientific goals of FMOS observations

Hi-z Emission Line Survey

Co-PIs: P. Best (Edinburgh); I. Smail (Durham)

Narrow-band survey of SF galaxies and AGN

UKIRT "Campaign Project" (~50n allocated)

Up to 10 deg^2 in narrow-filters in the J, H, K near-IR bands to $f_{line} \sim 10^{-16}$ erg s^{-1} cm^{-2}

Primary targets: Ha emitters at z=0.84, z=1.48 and z=2.23

NB_J and NB_H also target [OII] & [OIII] at z=2.23 & Lya at z=8.9

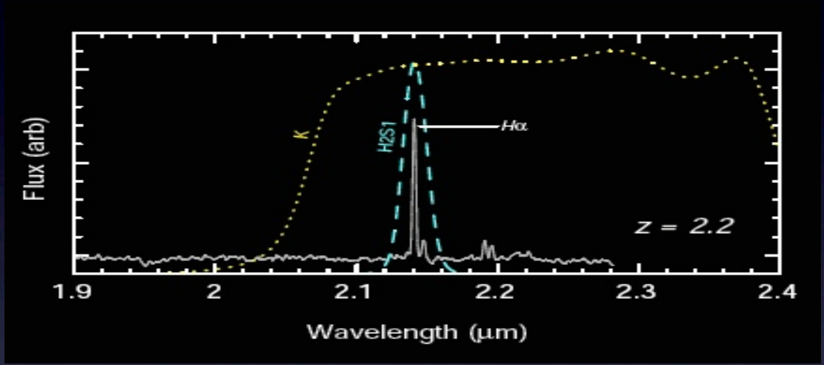
1.4 deg^2 in NB_J, 1.2 deg^2 in $NB_{H,}$ 3.2 deg^2 in NB_K to date

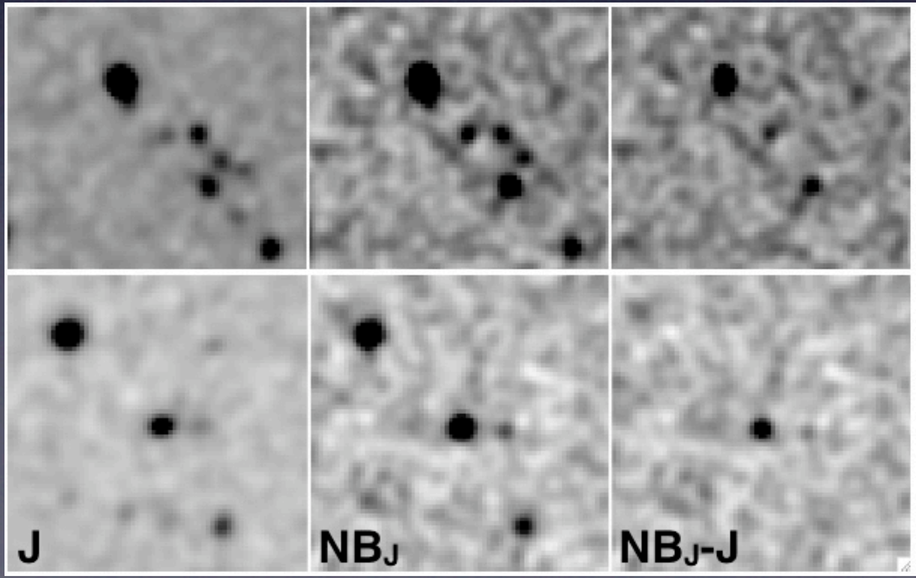
Already by far the largest survey of its kind

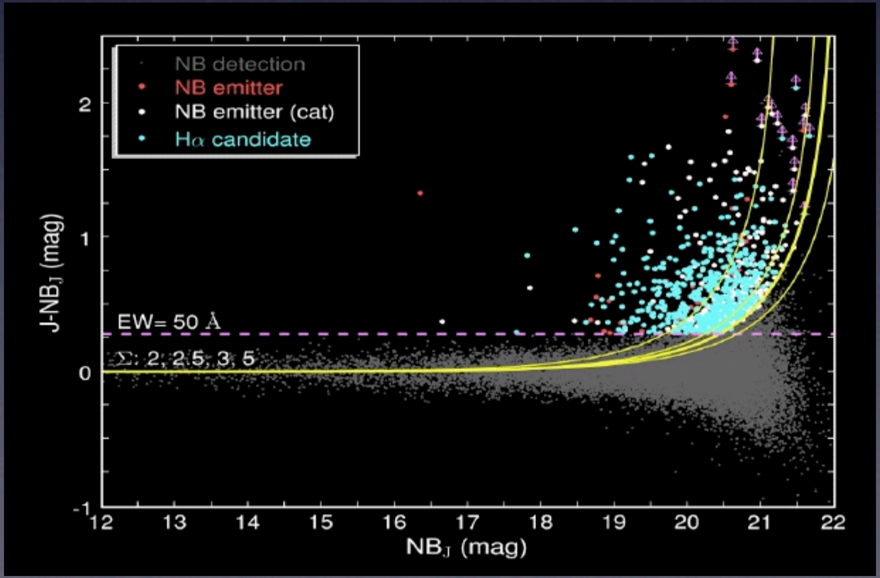
In fields with exquisite multi-wavelength data (UDS, COMSOS, Elais-N1, SSA22, ...)

Narrow-band technique

- Deep image in both broad and narrow-band filters
- Differencing picks out galaxies with emission line in NB filter
- With new near-IR detectors, large samples of hi-z emission line objects can be identified



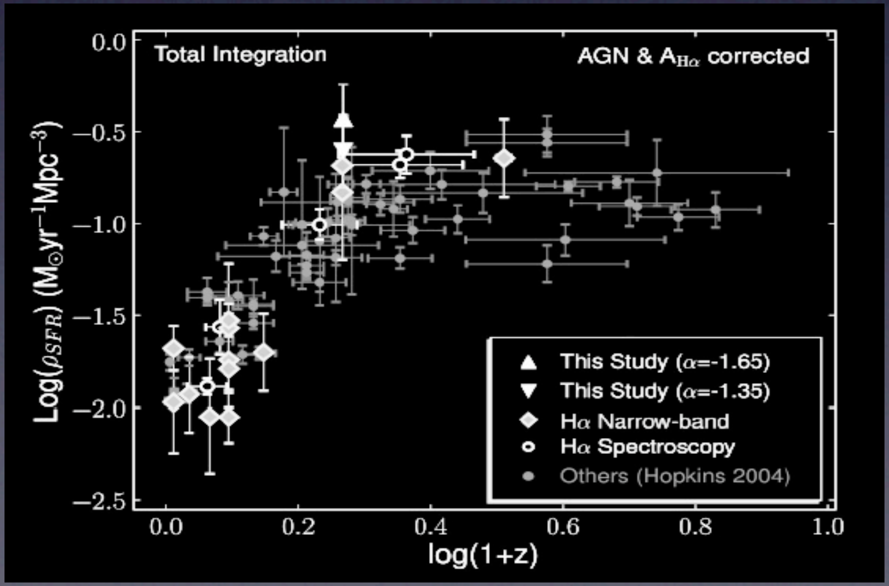




Star formation history of Universe

The primary goals of HiZELS are:

- to determine the evolution of the integrated star-formation rate density of the Universe out to z>2 using a single well-calibrated, sensitive, star-formation indicator
- to study the nature of the high-z star forming galaxies
  - masses
  - morphologies
  - environments
  - clustering
  - dust extinction, etc
- to compare with & constrain galaxy formation models

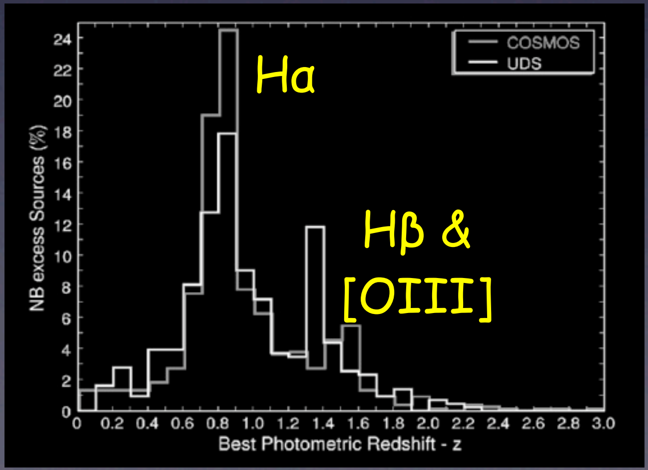


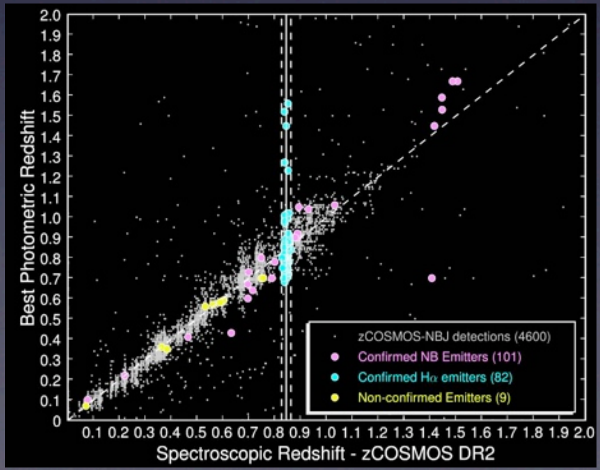
Selection of the Hα emitters

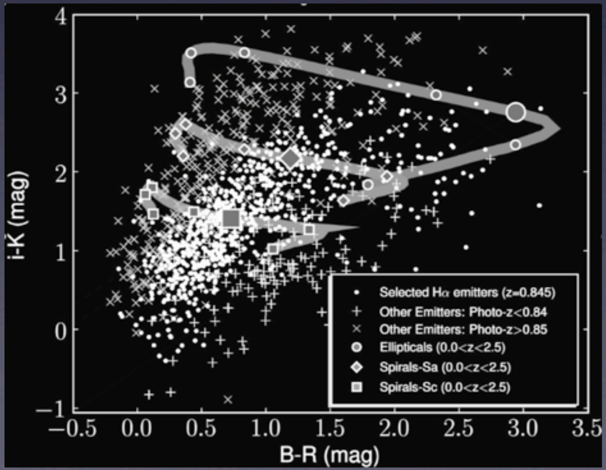
Robust line emitter selection from narrow-band excess (>3σ NB detection, >2.5σ colour excess)

Line identification from broad-band photo-z's

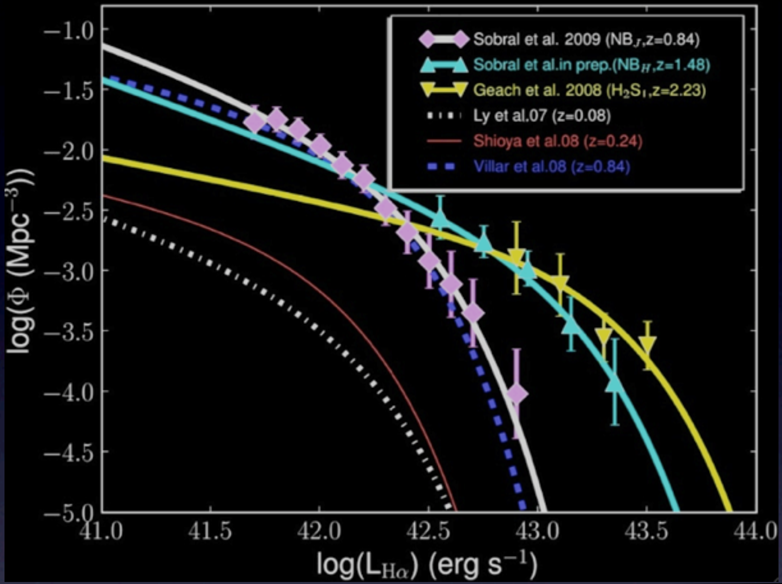
Confirmation of line identification from spectroscopy (indicates z=0.84 Hα sample 95% complete, 96% reliable).







Evolution of the Hα Luminosity Function

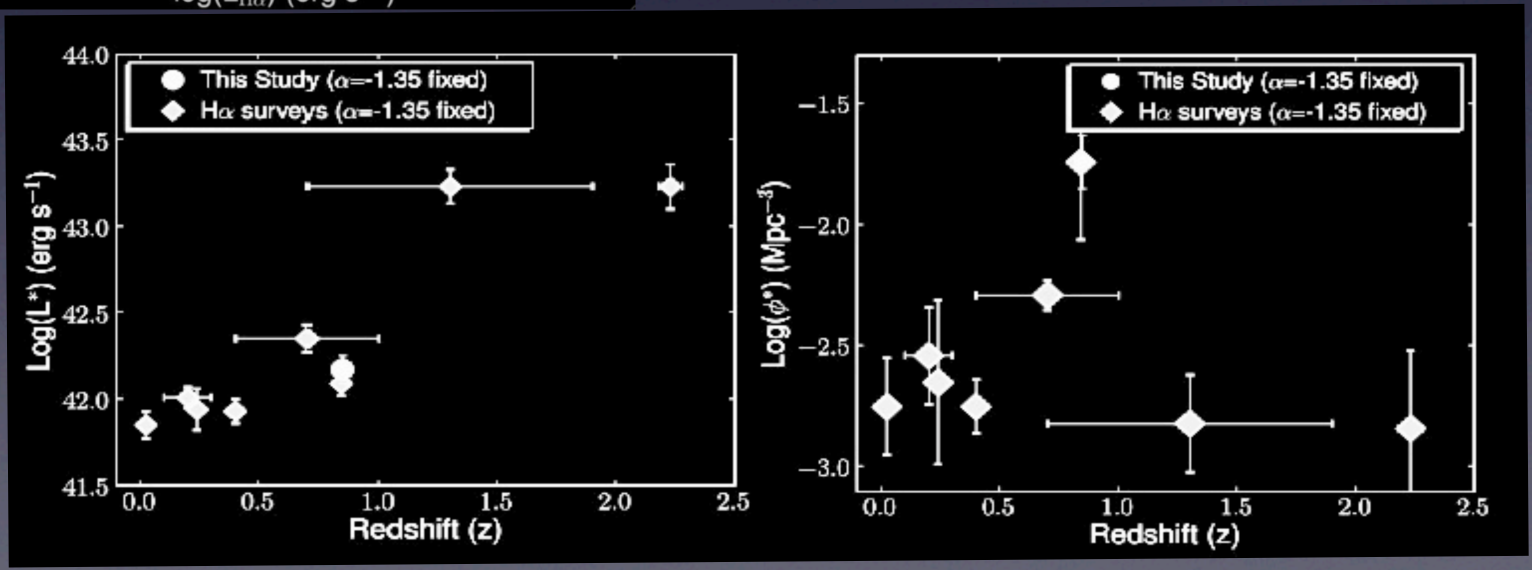


Hα LF fit with Schechter function:

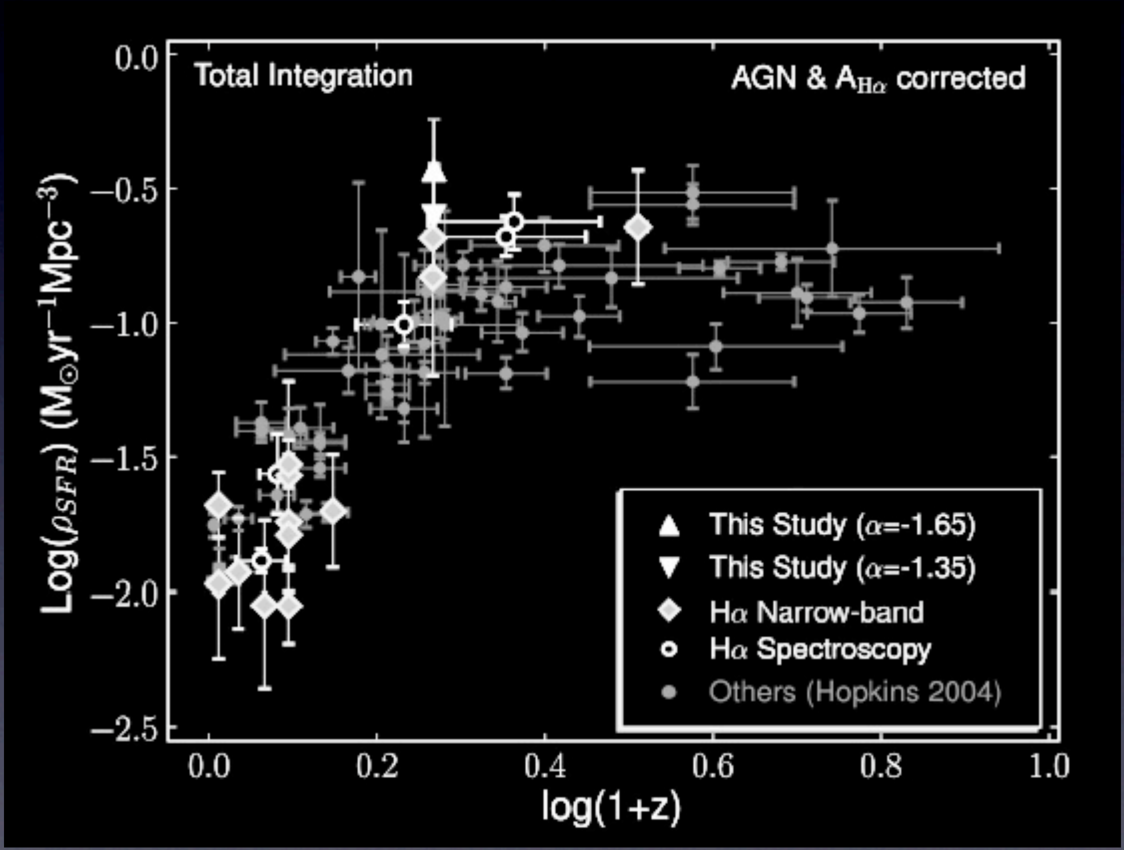
$$\varphi(L) = \varphi_* (L/L_*)^\alpha \exp(-L/L_*)$$

- Characteristic luminosity L_* increases to z>2

- φ_* increases to z~1 then decreases



Evolution of the cosmic SFRD



Integrating the Ha LF gives the evolution of the cosmic star formation rate density.

Consistent with $(1+z)^4$ evolution out to z~1 and then levelling.

On the upper envelope of other determinations at z~1 and z~2.

Morphologies of z~0.84 emitters

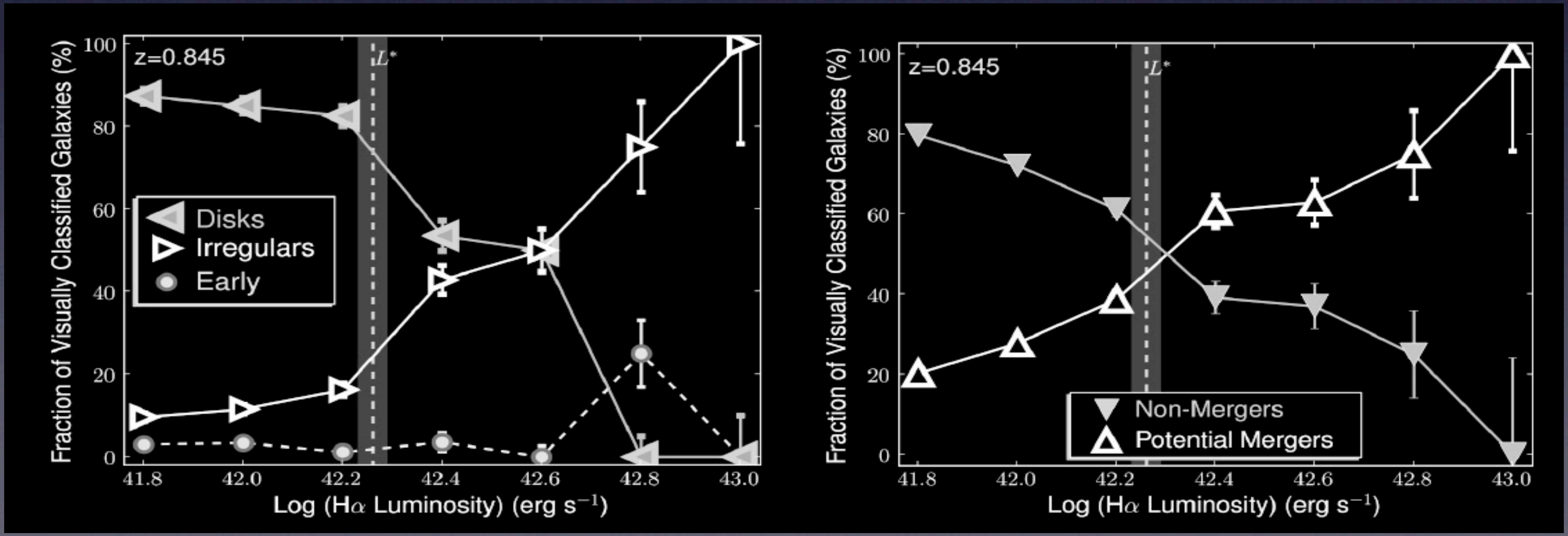
Emitters in COSMOS have HST data available
~80% disks, ~18% irregulars (mergers), 2% early-types
50-60% smaller than 1.5". ~20% larger than ~2".

Morphologies of z~0.84 emitters

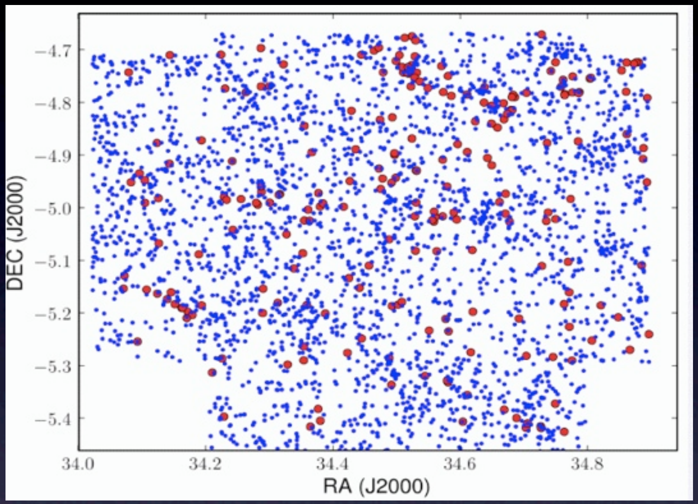
Disks dominate at lower luminosities, but morphologies switch dramatically to irregular-dominated at $L > L_*$.

30% of the sample show evidence for merging activity – again these are mostly at $L > L_*$.

Mergers account for ~25% of integrated SFR at z~1.

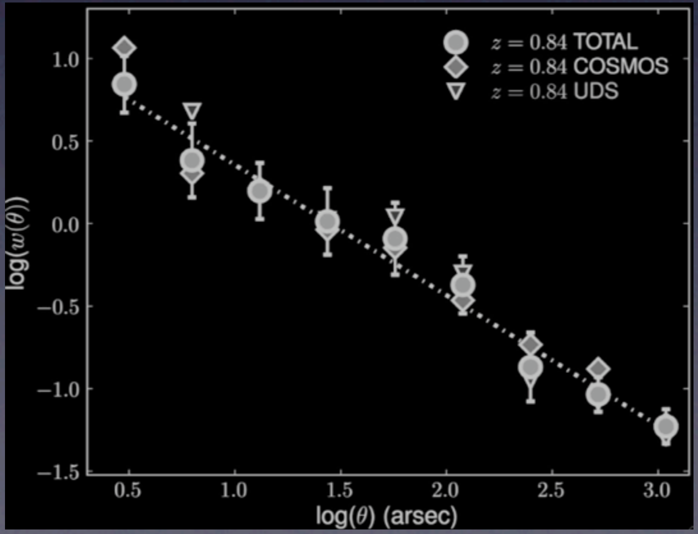


Clustering of Ha SF galaxies



Ha galaxies strongly clustered at z=0.84 and z=2.23

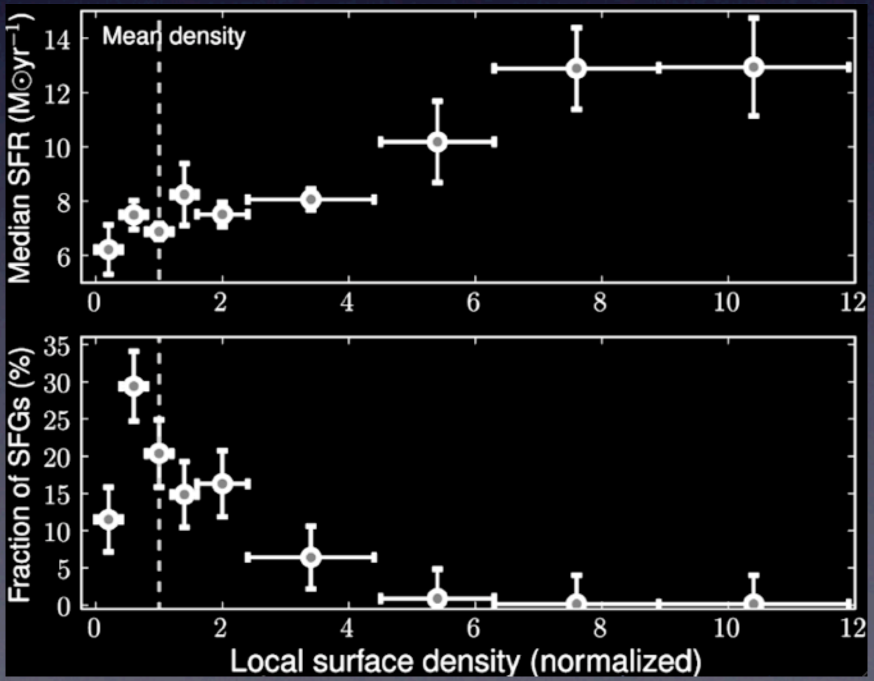
Less common in denser environments, but SFR higher there.



Top left: Ha emitters at z=0.84 (red) in UDS; all z~0.8 galaxies (blue).

Lower left: w(θ) at z=0.8

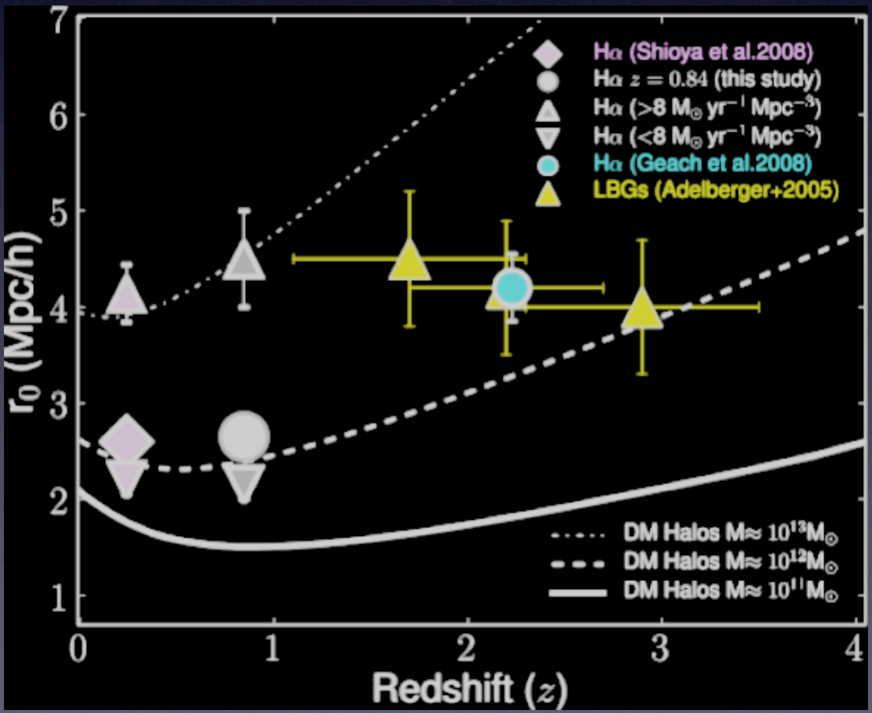
Right: SFR and fraction of SF gals versus local density

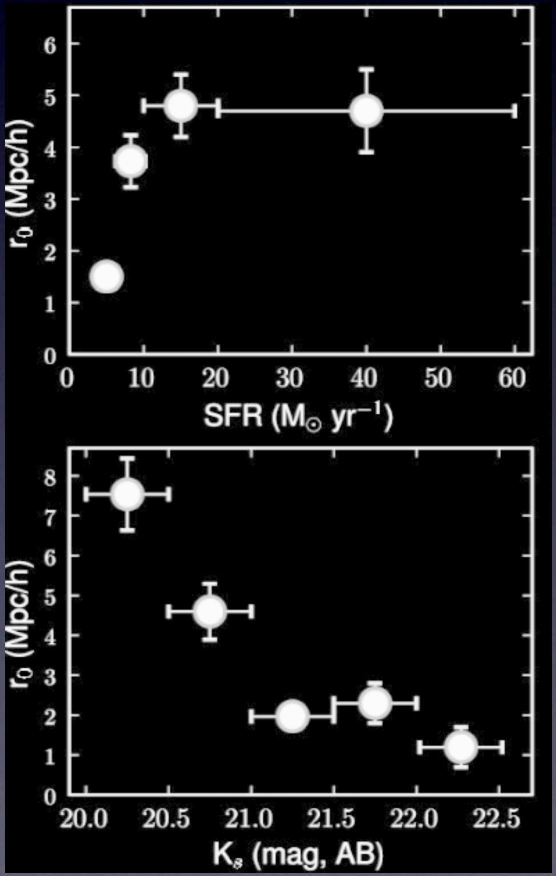


Clustering of Hα SF galaxies

Sample large enough to investigate how clustering amplitude depends on SFR, mass and morphology of galaxy - and redshift.

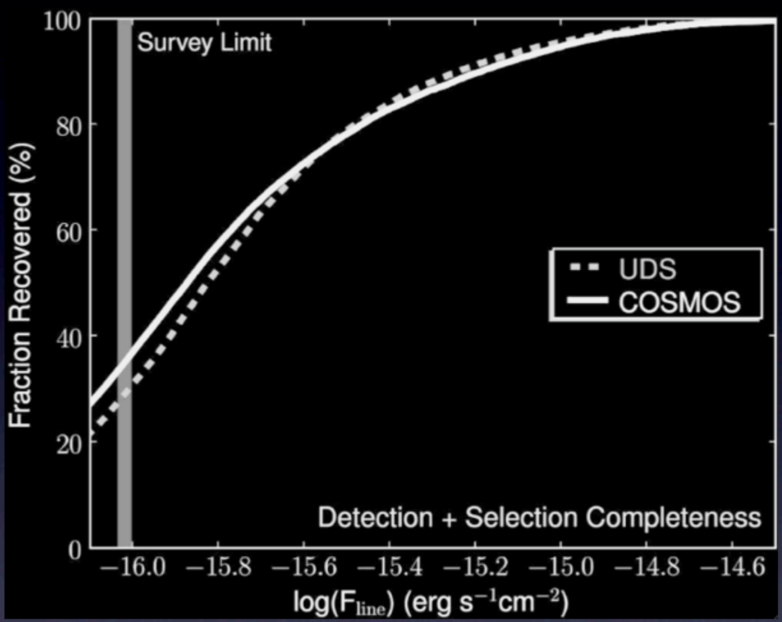
Correlation length of ~4 Mpc comparable to Lyman-break galaxies





HiZELS & FMOS

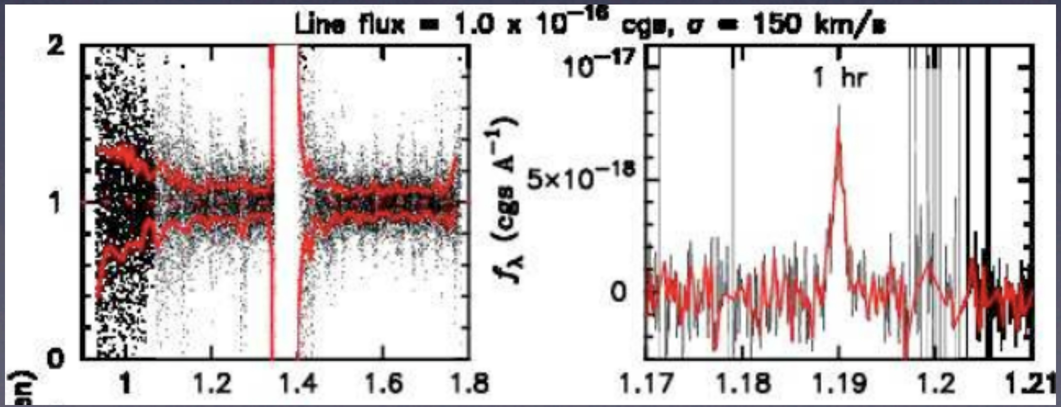
Confirmation of near-IR emission lines is a natural project for FMOS - and a great thing for FMOS to do early, as emission line locations are known.



Depth of HiZELS is

$F_{line} \sim 10^{-16}$ erg s^{-1} cm^{-2}

which is well-matched to FMOS capabilities



HiZELS source density

All filters completed on UDS field. Over 0.8 sq deg:

- NB_J: 549 narrow-band emitters; 270 selected as z=0.84 Hα
- NB_H: 354 narrow-band emitters; 158 selected as z=1.47 Hα
- NB_K: 305 narrow-band emitters; ~90 are z=2.23 Hα

Total source density of ~1500 narrow-band emitters per square degree ideally matched to FMOS fibre density (~400 fibres per 30 arcmin diameter field).

They are all emission line objects.

Each HiZELS (WFCAM) field needs 4 FMOS pointings.

Low-res FMOS observations

Main science goals need low-resolution FMOS (0.9-1.8μm)

1. Confirmation of emission lines & redshifts
   - NB_J and NB_H both have emission line in FMOS coverage
   - Wavelength range wide enough to get confirming lines
   - NB_K will rely on other lines - but e.g. [OII] 3727, [OIII] 5007 and Hβ in FMOS range for Hα at z=2.23
   - Particularly important to clean samples at z=1.47 and z=2.23
   - Also, valuable test of FMOS capabilities, to understand instrument performance at faint limits: we know where to expect emission lines!

Low-res FMOS observations

Main science goals need low-resolution FMOS (0.9-1.8μm)

2. Measurement of line fluxes and ratios
   - true line fluxes (removes issues of filter bandpass, NII, etc)
     - even for sources more extended that FMOS fibre: we have the narrow-band excess, and redshift gives location on filter profile
   - identification of AGN (clean SF samples, and study AGN)
   - determination of metallicities (cf. mass/morphology/etc)
   - dust reddening estimates (cf. comparison with mid-IR)

Requirement of project

- HiZELS will have ~8 WFCAM fields, to overcome cosmic variance, sample all environments & get large hi-z samples
  - ~2000 at z=0.84, ~1200 at z=1.47, ~700 at z=2.23
- About 1 hr per pointing needed to confirm the emission line detected in the narrow-band imaging, and probably redshift
- A few (5-10) hrs per pointing (or deeper) to get good S/N on more lines, determine reddening, metallicities, etc
- In practice, two-tier approach:
  - deep spectroscopy on a few fields (or subsample of sources in parallel with other deep projects?) for detailed study of galaxies
  - shallower spectroscopy over all HiZELS to enlarge samples, quantify cosmic variance, etc
    - can justify sky area for future deep blank-field FMOS surveys

Hi-res FMOS observations

Also scope for high-resolution FMOS observations of some smaller subsamples (few hrs times couple of pointings):

- Position 0.2μm wavelength coverage over 1.1 - 1.3μm range
  - NB_J picks up the Hα (or other) emission line
  - NB_H, for Hα at z=1.47, picks up the Hβ and [OIII] lines
  - NB_K, for Hα at z=2.23, picks up the [OII] 3727 line
- Measure line profiles
  - line FWHM -> dynamical mass estimates
  - evidence for mergers, outflows, etc

Conclusions

- HiZELS is proving to be an extremely valuable sample for a wide range of science
- It is ideal in terms of both flux limits and source density for FMOS follow-up - as well as providing ideal first FMOS faint targets where we know what to expect
- FMOS observations will greatly improve the robustness of the science currently being done with HiZELS using photo-z's, as well as offering many additional capabilities
- Valuable pilot studies can be done in 2-3 nights; whole project would also be quite modest.