Vimos Ultra Deep Survey

VUDS

Initial phase of galaxy evolution 2<z<6+
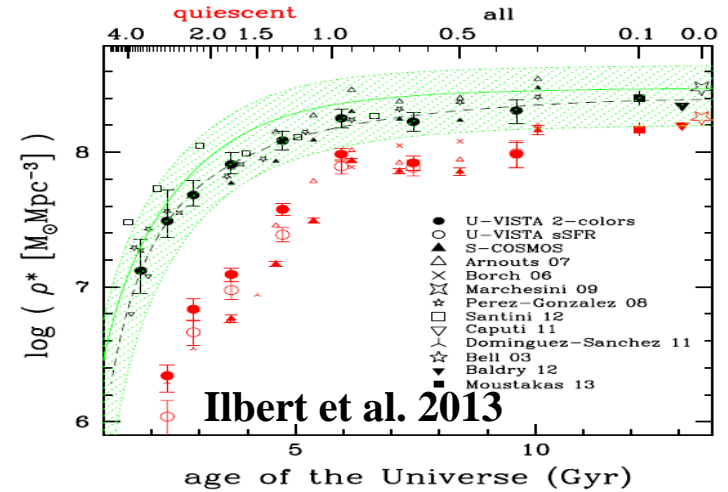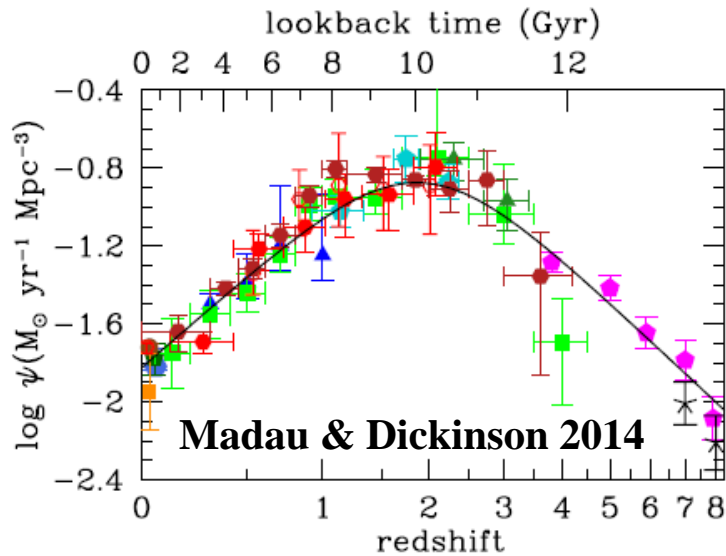
O. Le Fèvre[1], L.A.M. Tasca[1], P. Cassata[1], B. Garilli[3], V. Le Brun[1], D. Maccagni[3], L. Pentericci[4], R. Thomas[1], E. Vanzella[2], G. Zamorani[2], E. Zucca[2], R. Amorin[4], S. Bardelli[2], P. Capak[12], L. Cassarà[3], M. Castellano[4], A. Cimatti[5], J.G. Cuby[1], O. Cucciati[5,2], S. de la Torre[1], A. Durkalec[1], A. Fontana[4], M. Giavalisco[13], A. Grazian[4], N. P. Hathi[1], O. Ilbert[1], B. C. Lemaux[1], C. Moreau[1], S. Paltani[9], B. Ribeiro[1], M. Salvato[14], D. Schaerer[10,8], M. Scodeggio[3], V. Sommariva[5,4], M. Talia[5], Y. Taniguchi[15], L. Tresse[1], D. Vergani[6,2], P.W. Wang[1], S. Charlot[7], T. Contini[8], S. Fotopoulou[9], C. López-Sanjuan[11], Y. Mellier[7], and N. Scoville[12]

Lida Tasca
On behalf of the VUDS collaboration

LAM
LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE

How and when do galaxies assemble ?

Madau & Dickinson 2014

Ilbert et al. 2013

What fuels star formation?
• processes to transform gas into stars
• modulated by feedback, environment (feedback)

Effect of the environment?

What contributes to the mass increase?
• evolution of the mass in stars

MASS GROWTH

Accretion

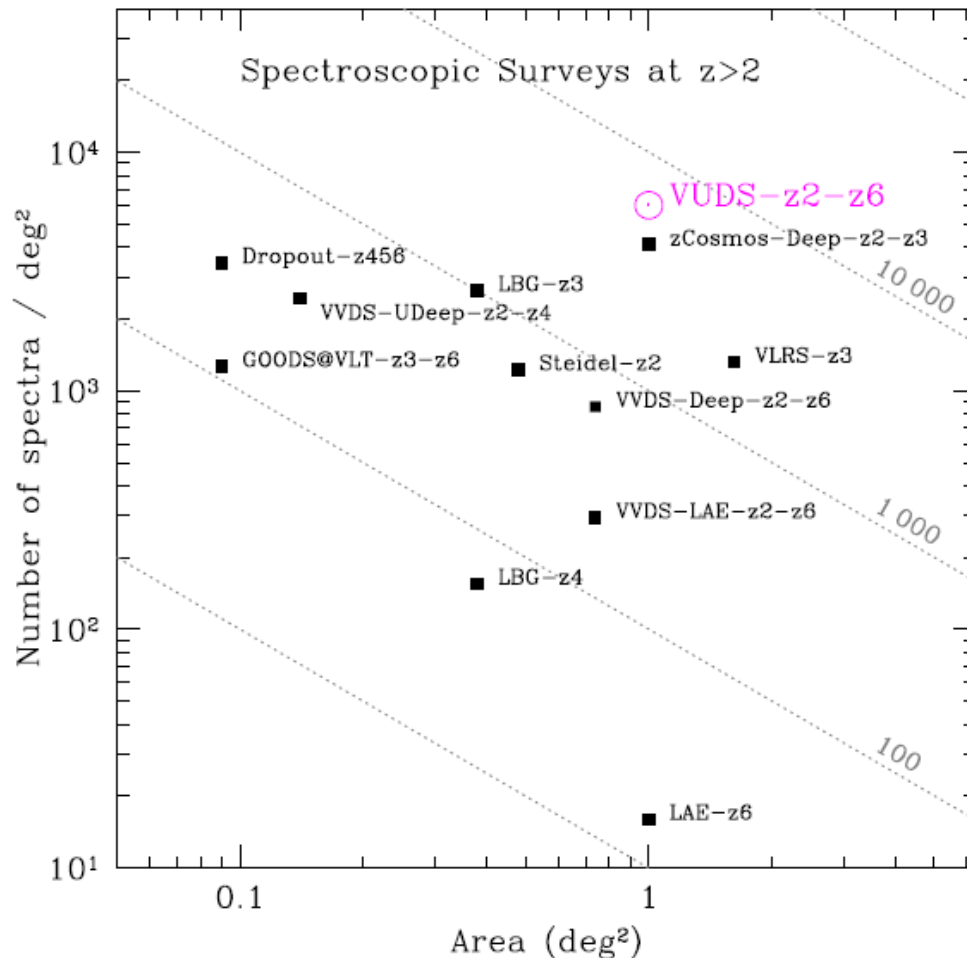**Merging**

?

Galaxy census @ z>2

- Observational picture still very incomplete and uncertain
- The census of galaxies so far relies on small fields
  - Cosmic variance (Moster+11):
    - 50% on 100 arcmin² (GOODS, CANDELS)
    - 10% on 1deg² (COSMOS)
- At z>2 most studies use photometric samples:

  only ~2000 galaxies with $z_{spec}>2$, few hundreds at $z_{spec}>3.5$

Need large and deep spectroscopic samples

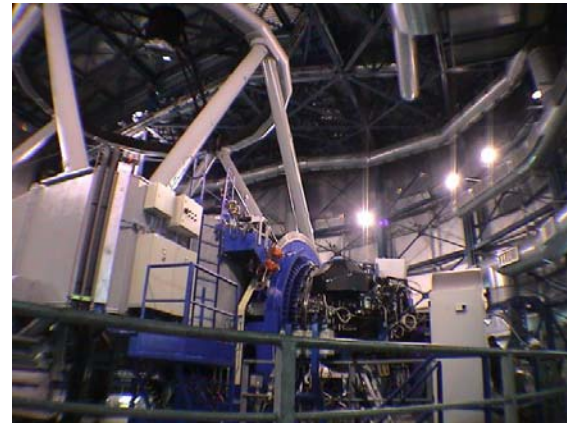# Only few spectroscopic surveys @z>2

Le Fèvre, Tasca et al. 2014

Only a few 10^3 galaxies with spectroscopic zedshifts to z~3.5

Largest is zCOSMOS-Deep with ~2000 galaxies with 2<z<3

Heterogeneous samples and selection functions
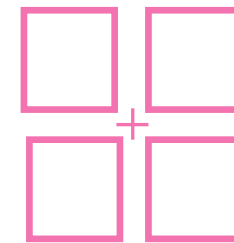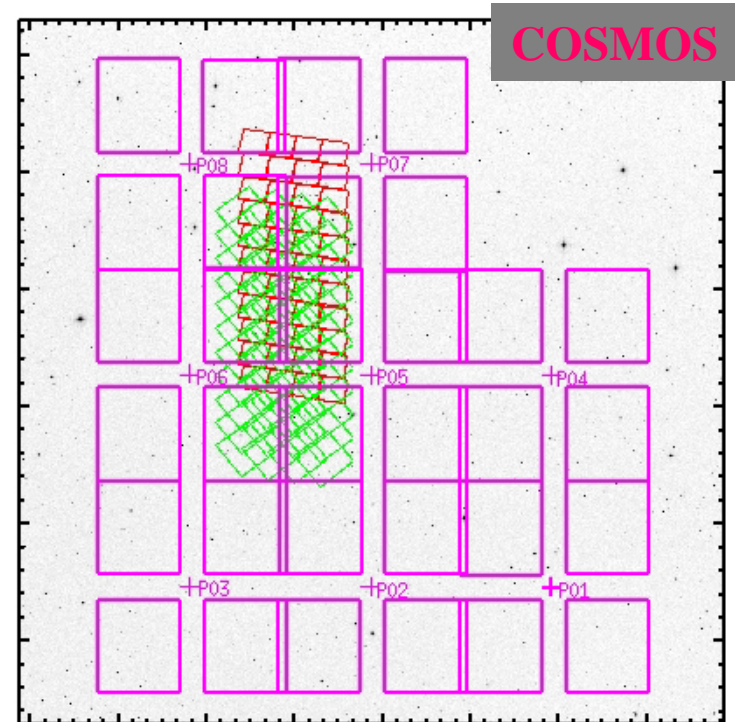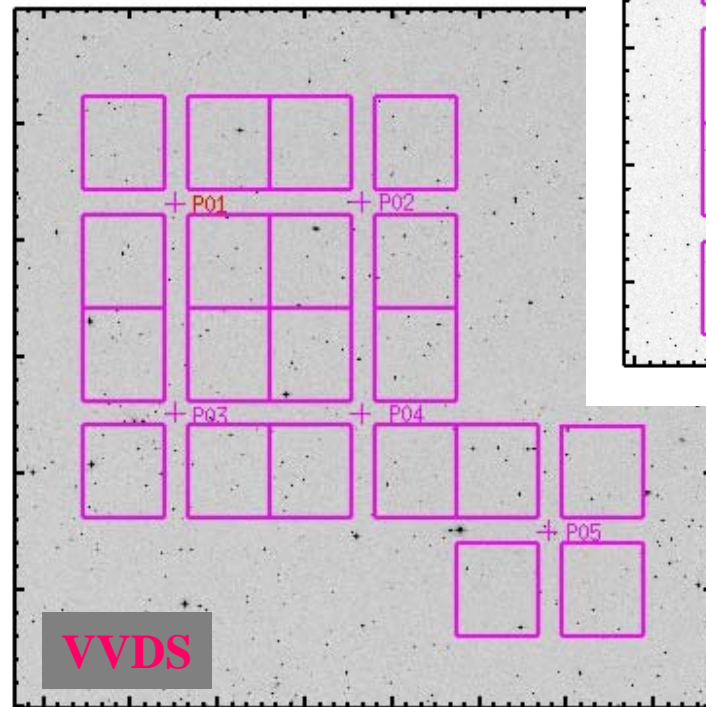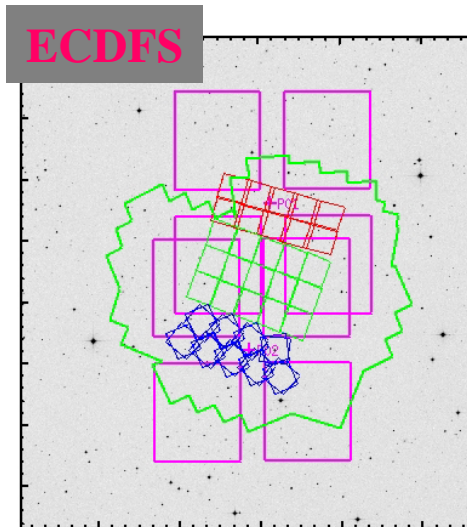
VUDS: surveying the first phases of galaxies assembly

- ESO Large Program: 640h allocated (~80 nights, clear)

- VIMOS on the VLT

- Focused on 2<z<6

- 1 deg²

- 10,000 targets

- 3 fields: mitigate cosmic variance

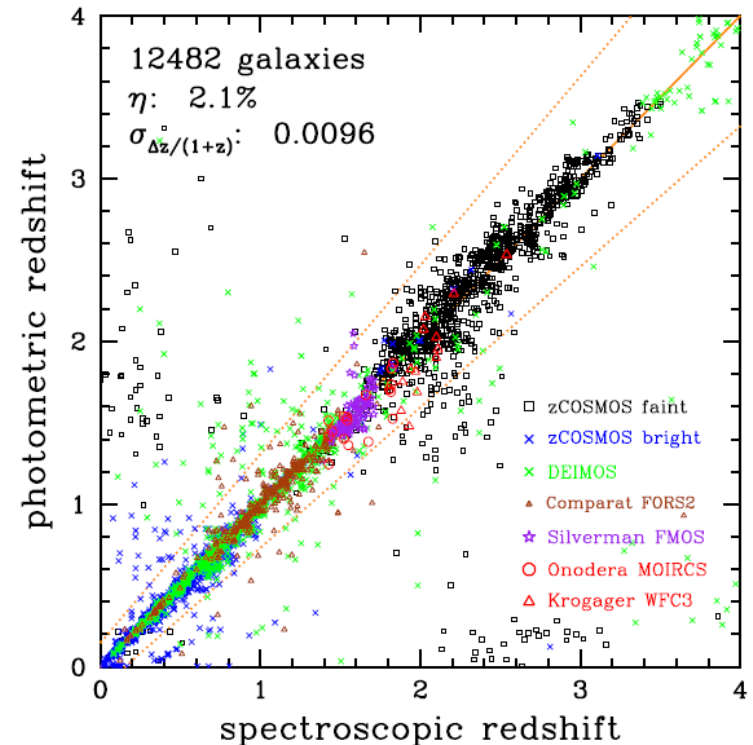| FIELD	VIMOS pointings	Area arcmin²
COSMOS	8	1800
ECDFS	2+1	675
VVDS-02	5	1125
TOTAL	**15+1**	**3600**

3 fields with a lot of existing data

• Multi-wavelength imaging from u to K bands

• Spectro-z from previous surveys: VVDS, zCOSMOS, GOODS

• Deep Spitzer data at 3.6 and 4.5 μm (24 μm)

• HST imaging

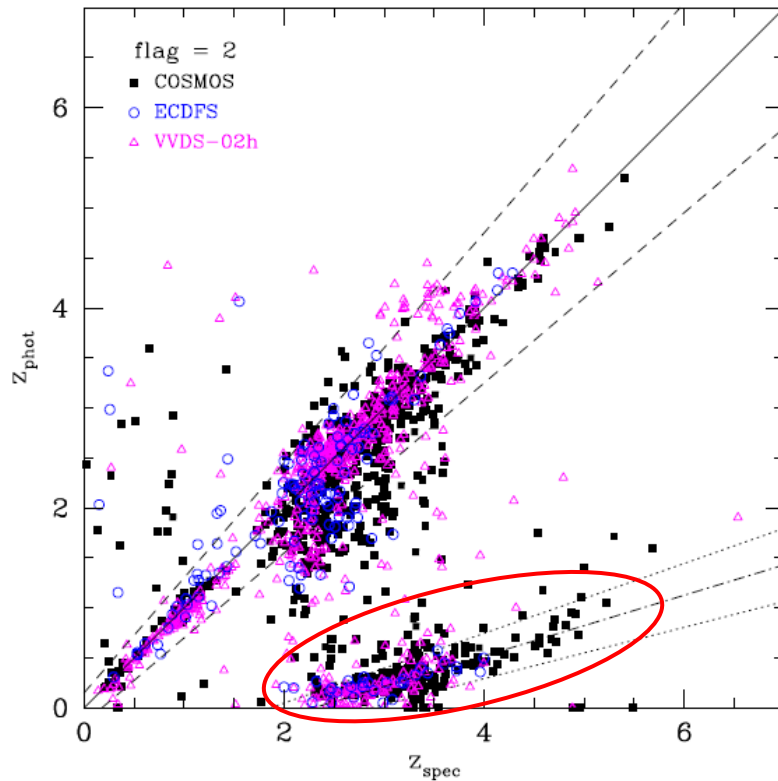
COSMOS

ECDFS

VVDS

1 VIMOS pointing

VUDS target selection

- Additive selection:
  - photometric redshifts, $z_{phot} > 2.3$ $22.5 \leq i_{AB} \leq 25$
  - First and second peak in z_{phot} PDF
  - Color-color (LBG) AND $z_{phot} > 4$ with $i_{AB} > 25$
  - Add z+NIR detected, but not detected in optical

- Large wavelength range $3600 < \lambda < 9300$ Å

- 14h integration / target with VLT/VIMOS

- ~80% redshift success rate

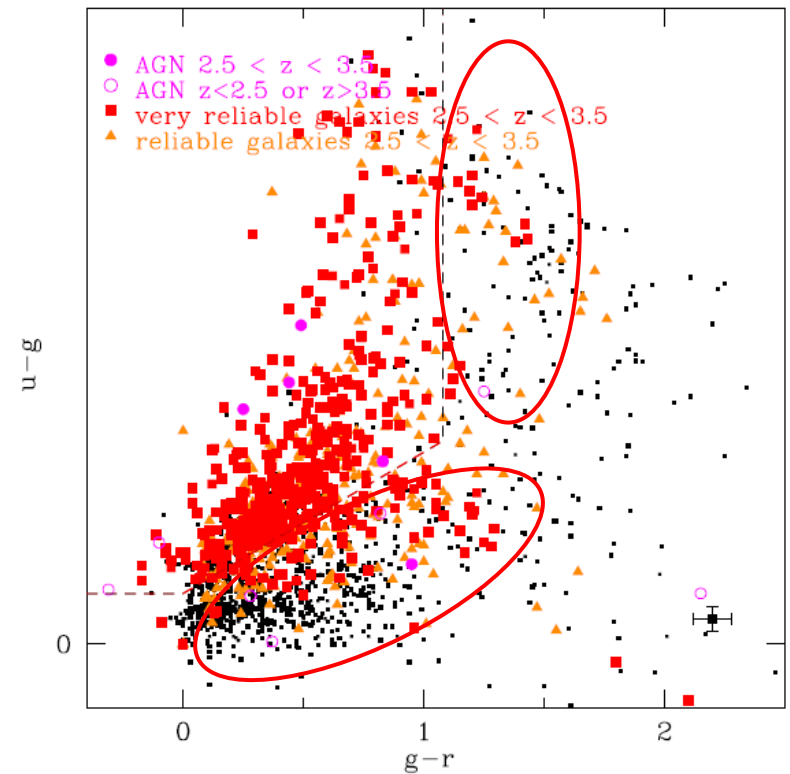12482 galaxies
η: 2.1%
$\sigma_{\Delta z/(1+z)}$:   0.0096

- ☐ zCOSMOS faint
- ✕ zCOSMOS bright
- ✕ DEIMOS
- ▲ Comparat FORS2
- ★ Silverman FMOS
- ○ Onodera MOIRCS
- △ Krogager WFC3

photometric redshift (y-axis), spectroscopic redshift (x-axis)

Ilbert et al. 2013

VUDS target selection validation

Better than a straight z_{phot} selection
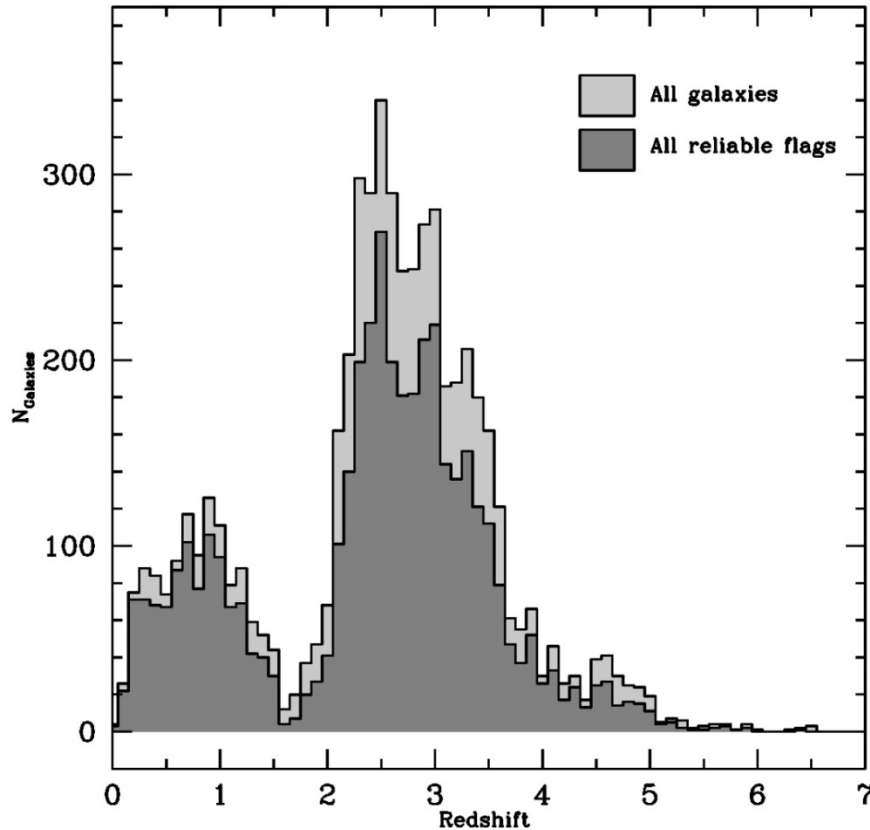
Better than a straight LBG selection

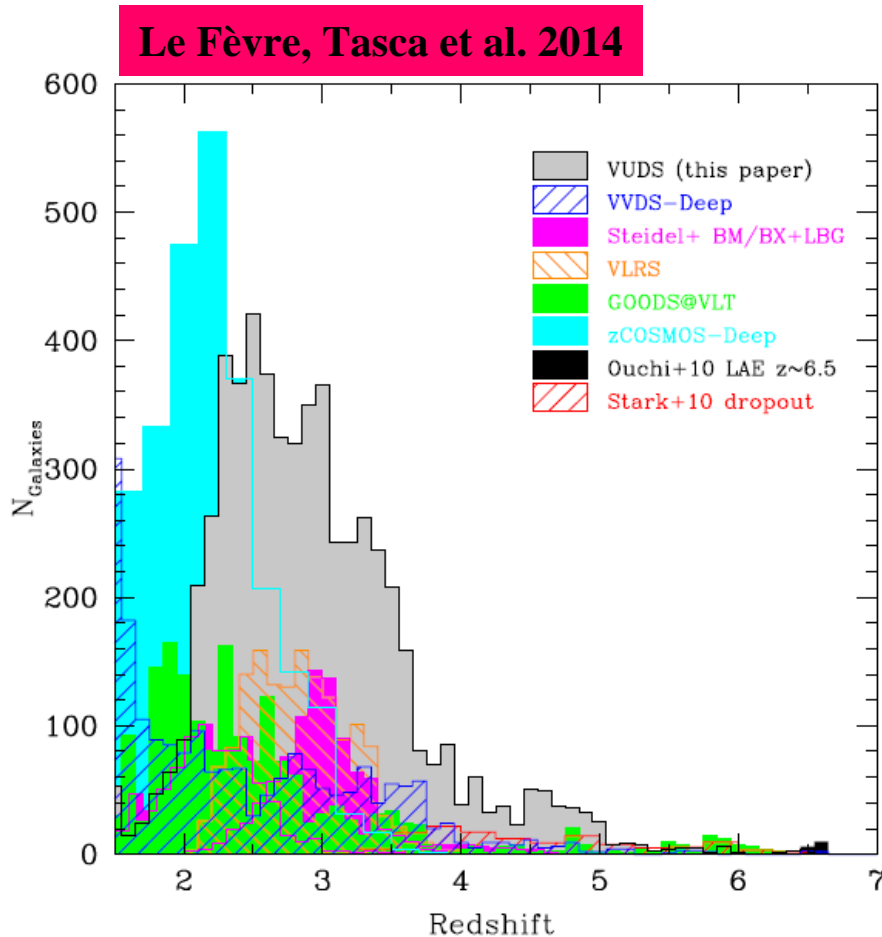# VUDS redshift distribution

Le Fèvre, Tasca et al. 2014

6045 galaxies with
measured redshifts today
Another 2000 expected from
on-going data processing

**The largest spectroscopic
sample at z>2.5**

VUDS redshift distribution

Le Fèvre, Tasca et al. 2014

6045 galaxies with
measured redshifts today
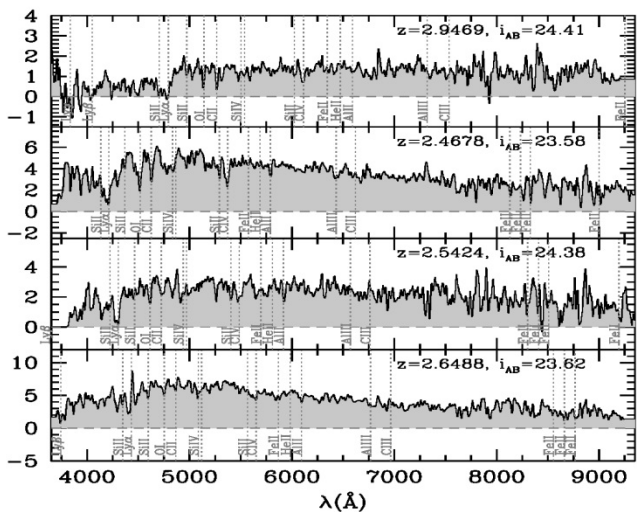Another 2000 expected from
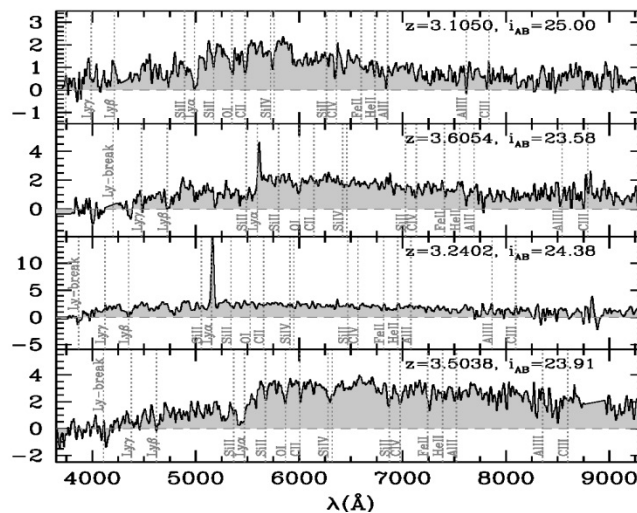on-going data processing

**The largest spectroscopic
sample at z>2.5**

Absorption & emission line galaxies to z~6

Individual spectra $i_{AB} \leq 25$, a very faint sample

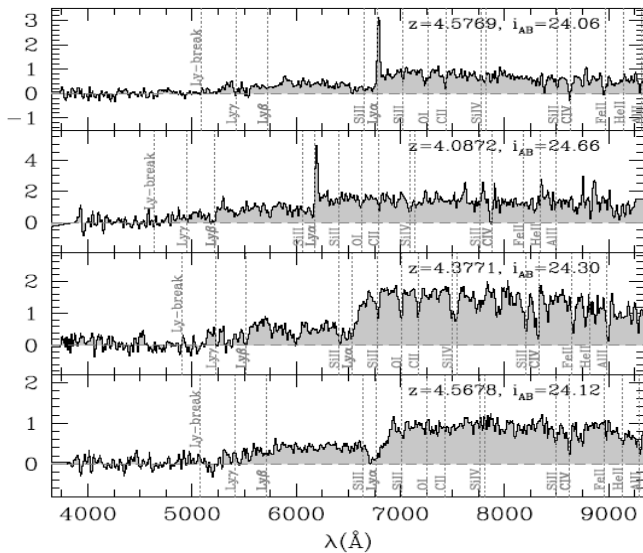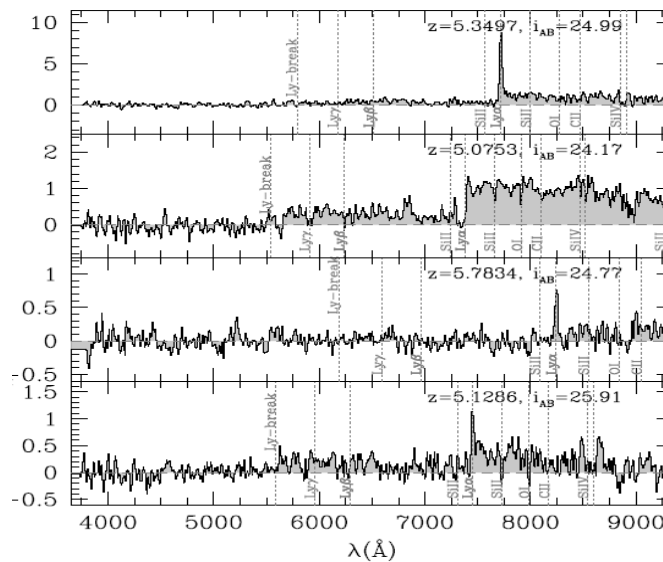# 4000 spectra: 3Gyr of evolution in one glance
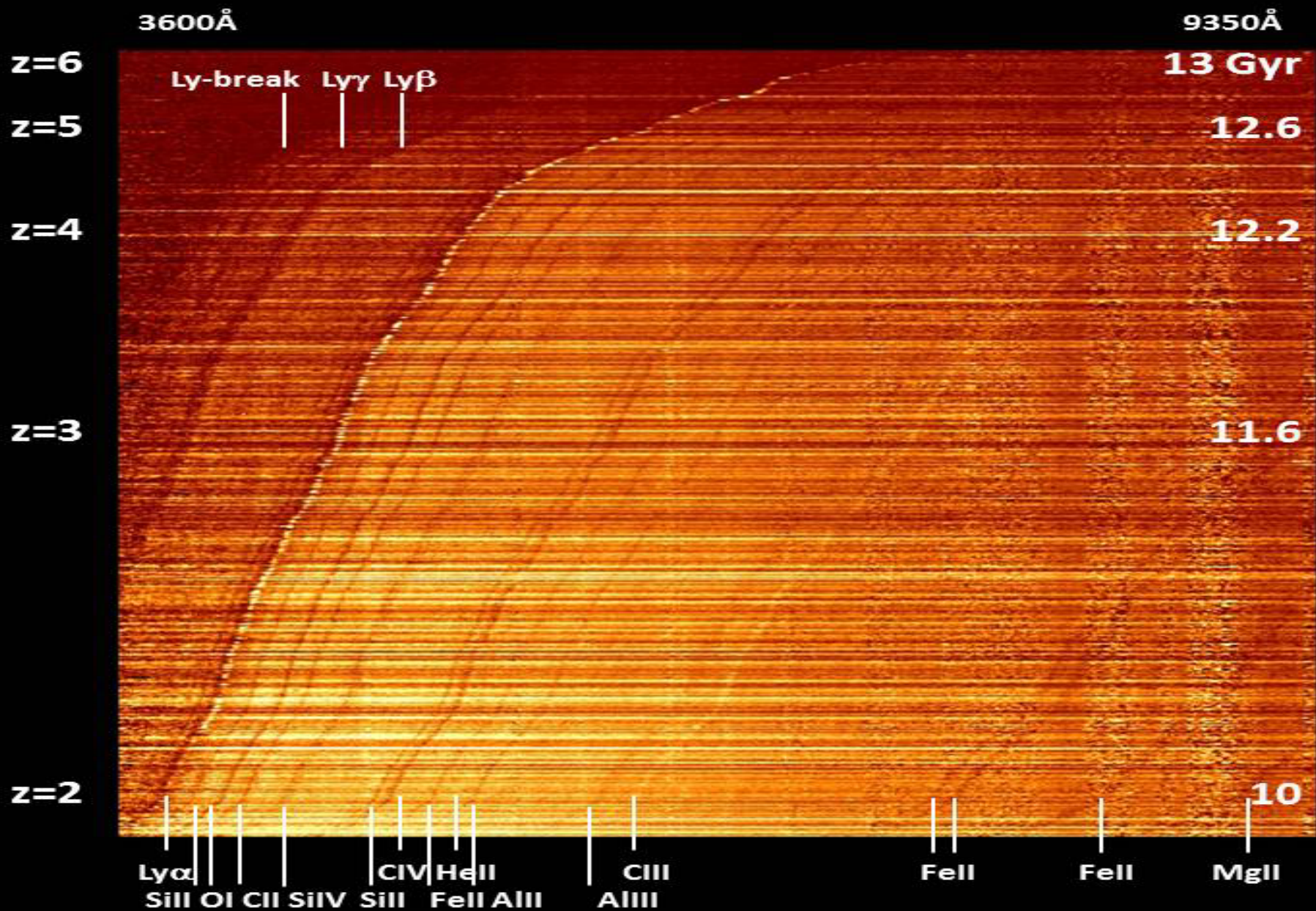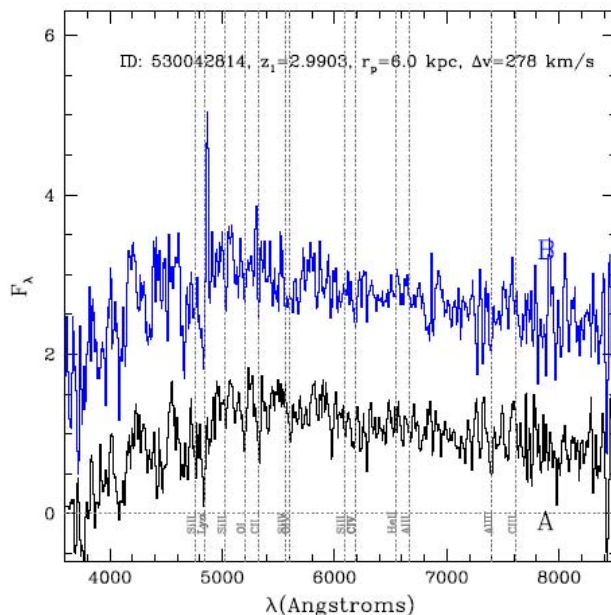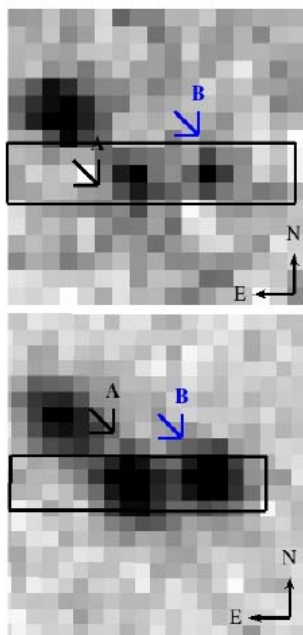
First results

1. Survey description paper (Le Fèvre, **Tasca**, et al., arXiv)
2. Merging rate z~3 (**Tasca** et al., 2014, A&A, 565, 10)
3. Lyα fraction evolution 2<z<6 (Cassata, **Tasca** et al. , in press)
4. Proto-cluster z=3.3 (Lemaux et al., in press)
5. Proto-cluster z=2.9 (Cucciati et al., 2014, A&A, 570, 16)
6. Low-M high-SFR z~1 galaxies (Amorin et al., 2014, A&A, 568, 8)
7. SFR-M and sSFR evolution up to z~6 (**Tasca** et al., arXiv)
8. IGM transmission (Thomas et al. , arXiv)
9. First clustering measurement (Durkalec et al. , arXiv)
10. Progenitors of z~2 passive galaxies (**Tasca** et al. , in prep.)
11. Epoch of galaxy formation (Thomas et al., in prep)
12. Lyα continuum escape fraction (Grazian et al., in prep)

General paper: the ESO Messenger March issue

Pairs / merger rate @z~3

Tasca+2014

- Is merging important during the first phase of mass assembly ?
- Identify true pairs: each member of a pair has a spectroscopic redshift
- Major mergers

  $M1/M2 > 1/4$
- The merger fraction is

  $f_{merg} = 20\%$

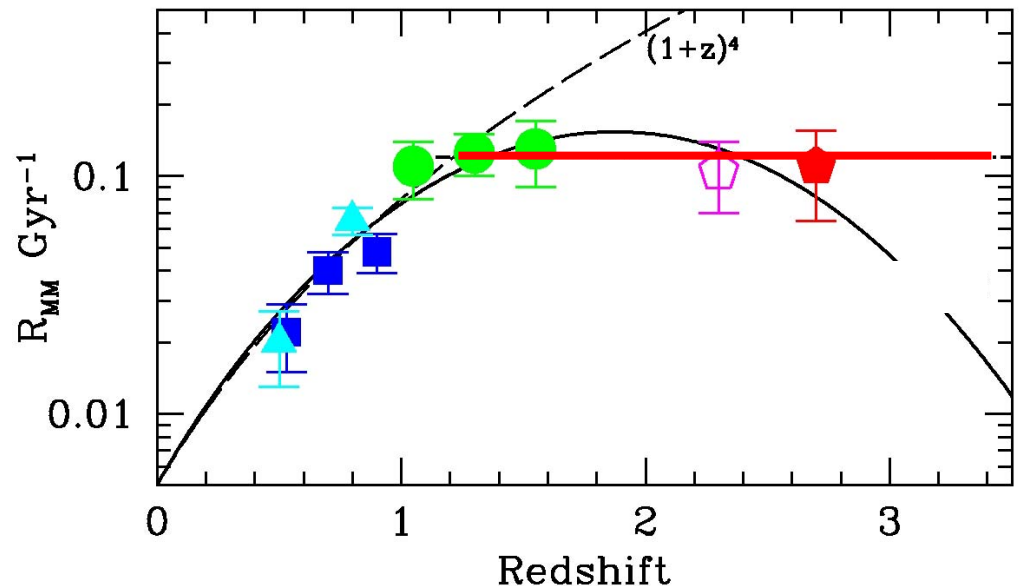**What is the merger rate history ?**

Galaxy Merger Rate History since z~3 from spectroscopic pairs

- New measurement at z~1.5 from MASSIV
- New measurement at z~2.3 from VVDS
- New measurement at z~3 from VUDS
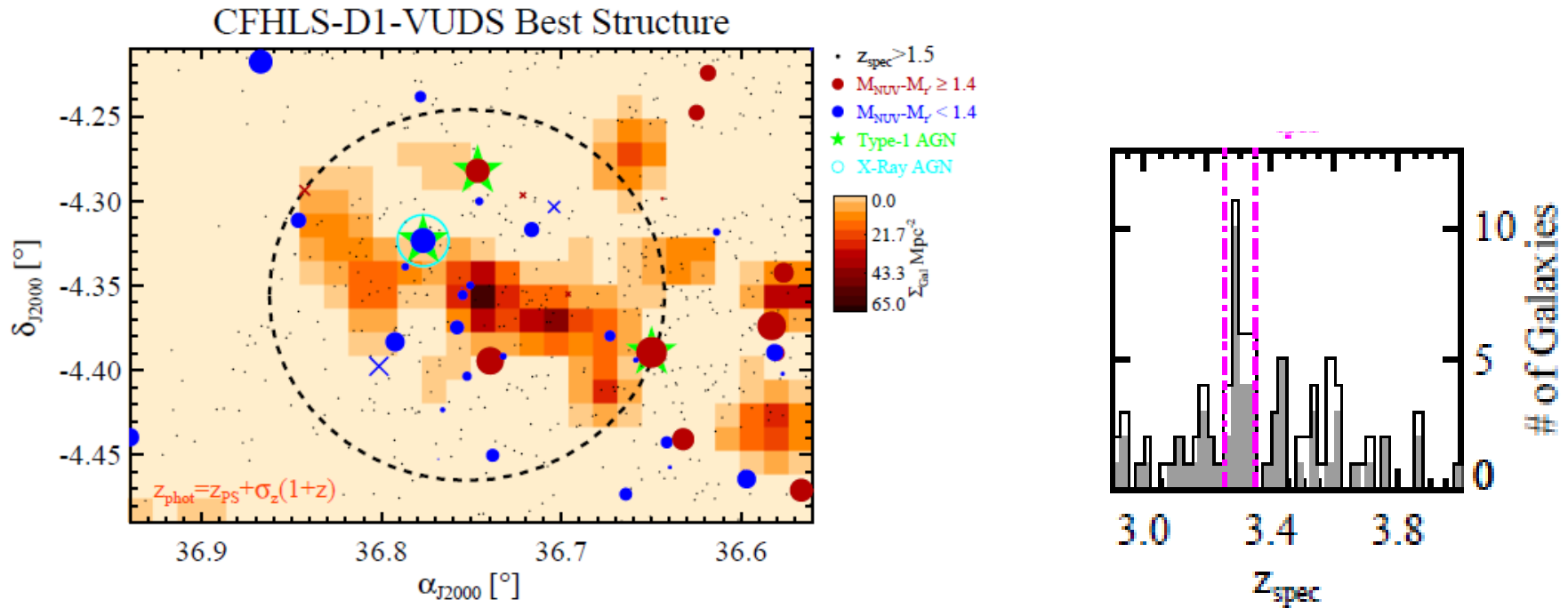
Peak in major merger rate at z~1.5-2 ?

Integrating the GMRH indicates that 60% of the mass of galaxies at z=0 has been assembled by mergers

Next: consolidate the z>2 picture with ~50 true new pairs from VUDS
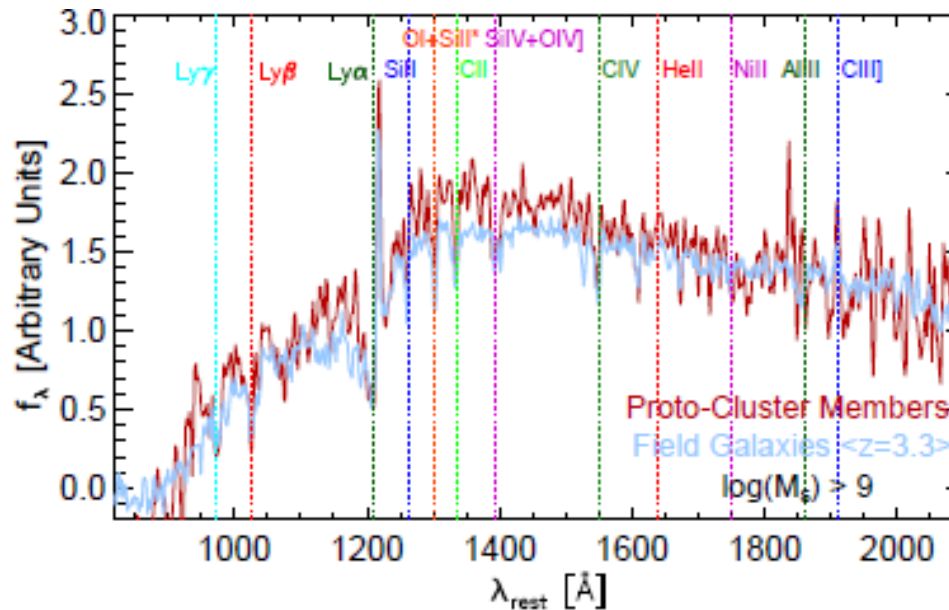
Proto-cluster at z=3.3

Lemaux, Cucciati, Tasca et al. 2014

- 19 z_{spec} confirmed members
- δ_{gal} = 10.5 ± 2.8

- Supported by photo-z analysis
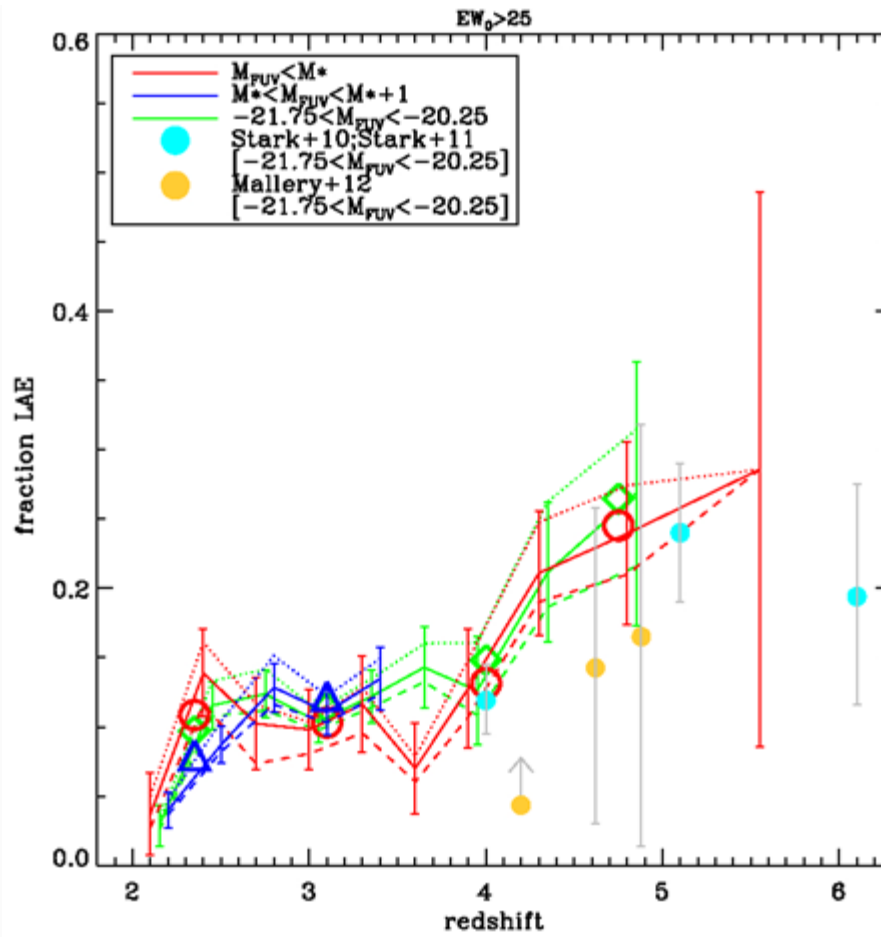- **Mass: 3×10^{14} M$_\odot$**
- As massive than Coma by z~0

Environment effects at these early times ?

Comparison of average spectrum in z=3.3 proto-cluster with field galaxies

- Steeper UV spectral slope
- Stronger Lyα, HeII, CIII
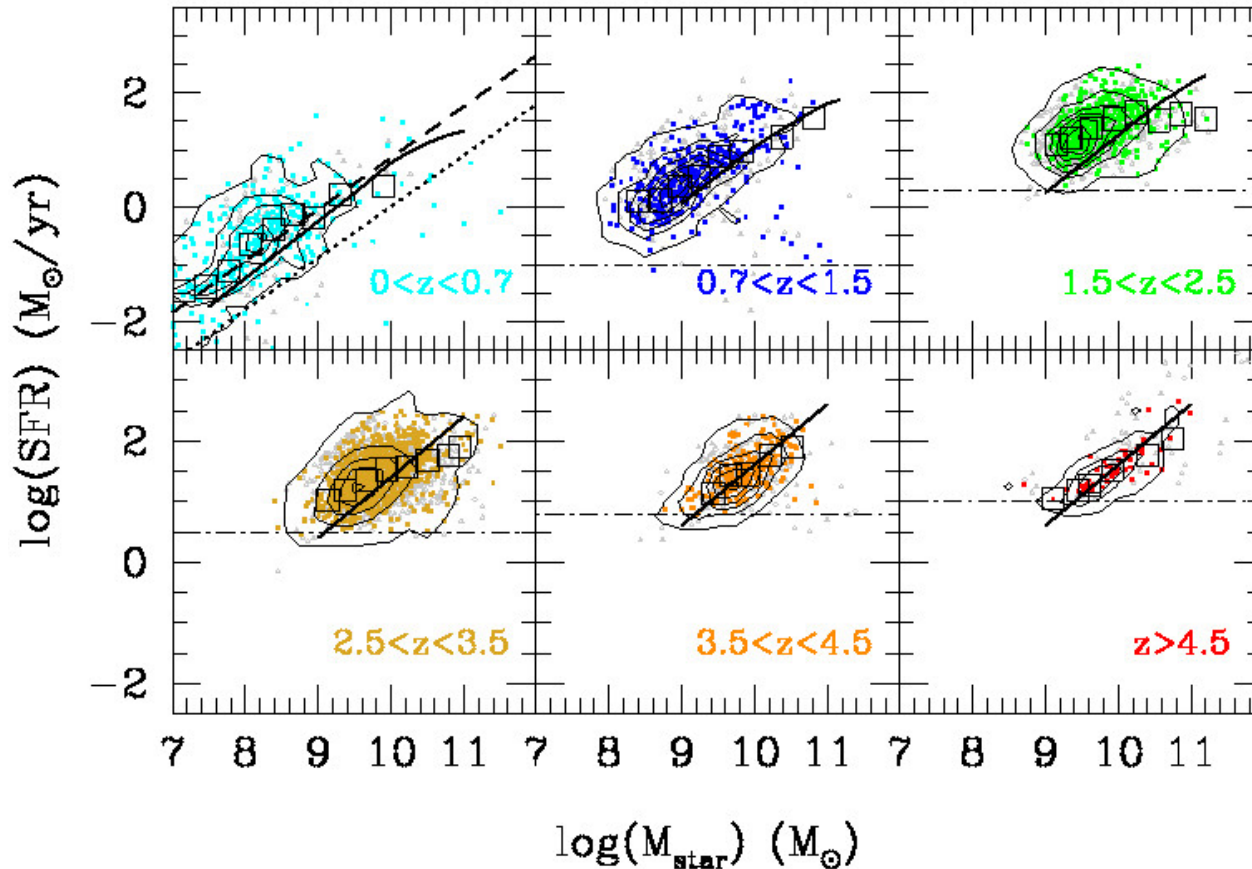- Also 3 AGN in this cluster

Activity enhanced ?

Lyα fraction evolution

The evolution of strong Lyα emitters is increasing by a factor two from z~2 to z~6
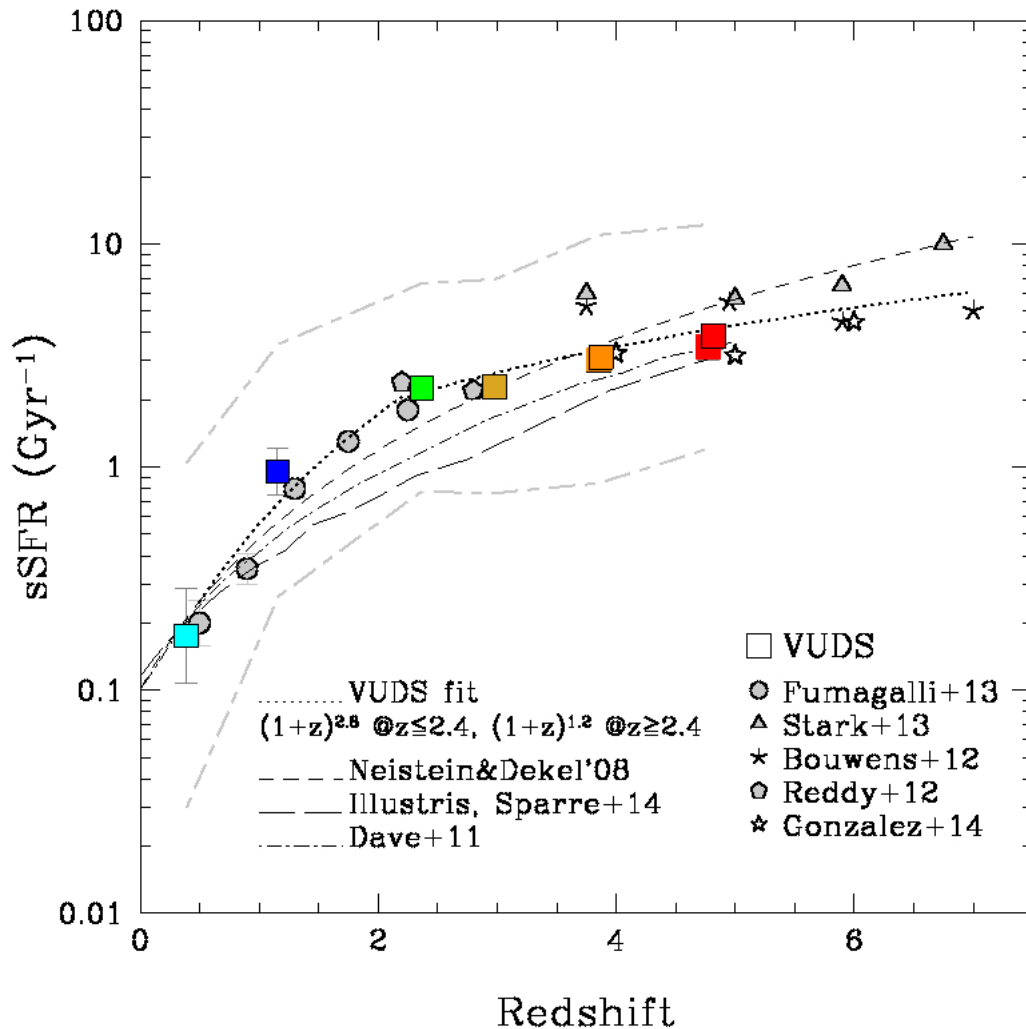
Cassata, Tasca et al. 2014

SFR-M$_*$ relation up to z~5

High-M turn-off at z<3.5. → effect of SF quenching in a downsizing pattern

Quenching processes not fully active at z>3.5

Tasca et al. arXiv

sSFR evolution since z~5

The sSFR evolution does not follow a pure accretion driven galaxy mass growth.

Need to combine with merger processes.

Summary

- VUDS is opening a window relatively un-probed with spectroscopy at 2<z<6

- It will provide ~6000 galaxies with z_{spec}>2.3

- The largest spectroscopic sample to date at these z

- On-going analysis

Stay tuned !