The impact of galaxy redshift surveys on observational cosmology

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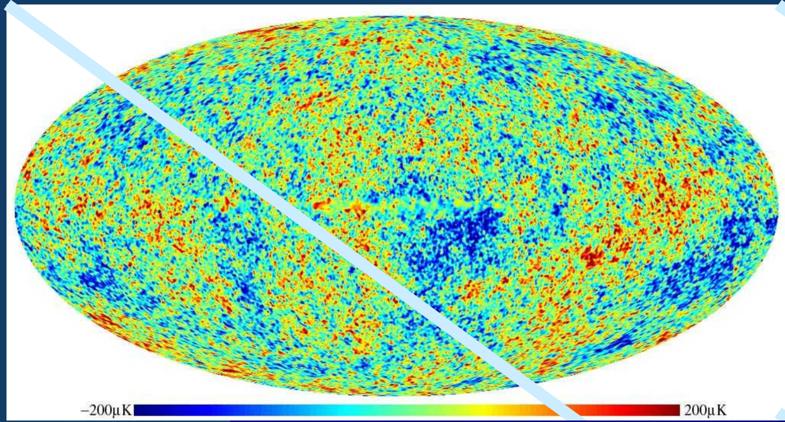
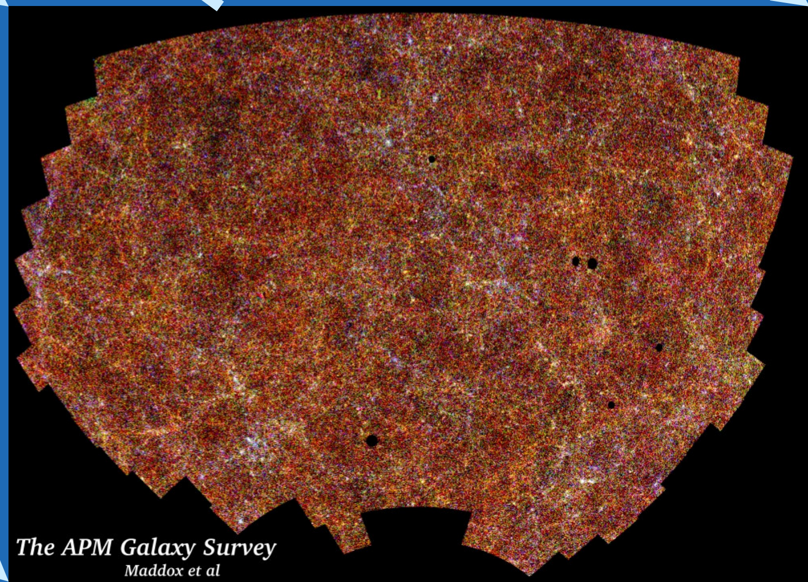
380000 years after the Big Bang



COSMOLOGY

ASTROPHYSICS



TODAY

Why

The unrepeatability of the Big Bang event requires the use of samples which are representative of the entire Universe.

The analysis of these samples allows to study the cosmic structures and their evolution.

How

Analysis of the properties of the objects in the sample using statistical tools (luminosity function, clustering analysis…)

But…

The presence of selection effects can lead to biased samples: we need complete and fair samples.

The "fair sample" problem

A sample is fair if the mean value of the quantities under study derived from the sample is equal to that of the population from which the sample has been extracted

(statistics)

A sample is fair if other samples extracted with the same criteria from other parts of the Universe give the same results

(cosmology)

Assuming the existence of a fair sample implies that the Universe is homogeneous above a certain scale

(cosmological principle)

The first surveys (late ’70s – early ’80s)

Two-dimensional catalogues

Visual inspection of photographic plates

Spectroscopic surveys

Shallow surveys

Large angular extension, modest depth

Pencil beam surveys

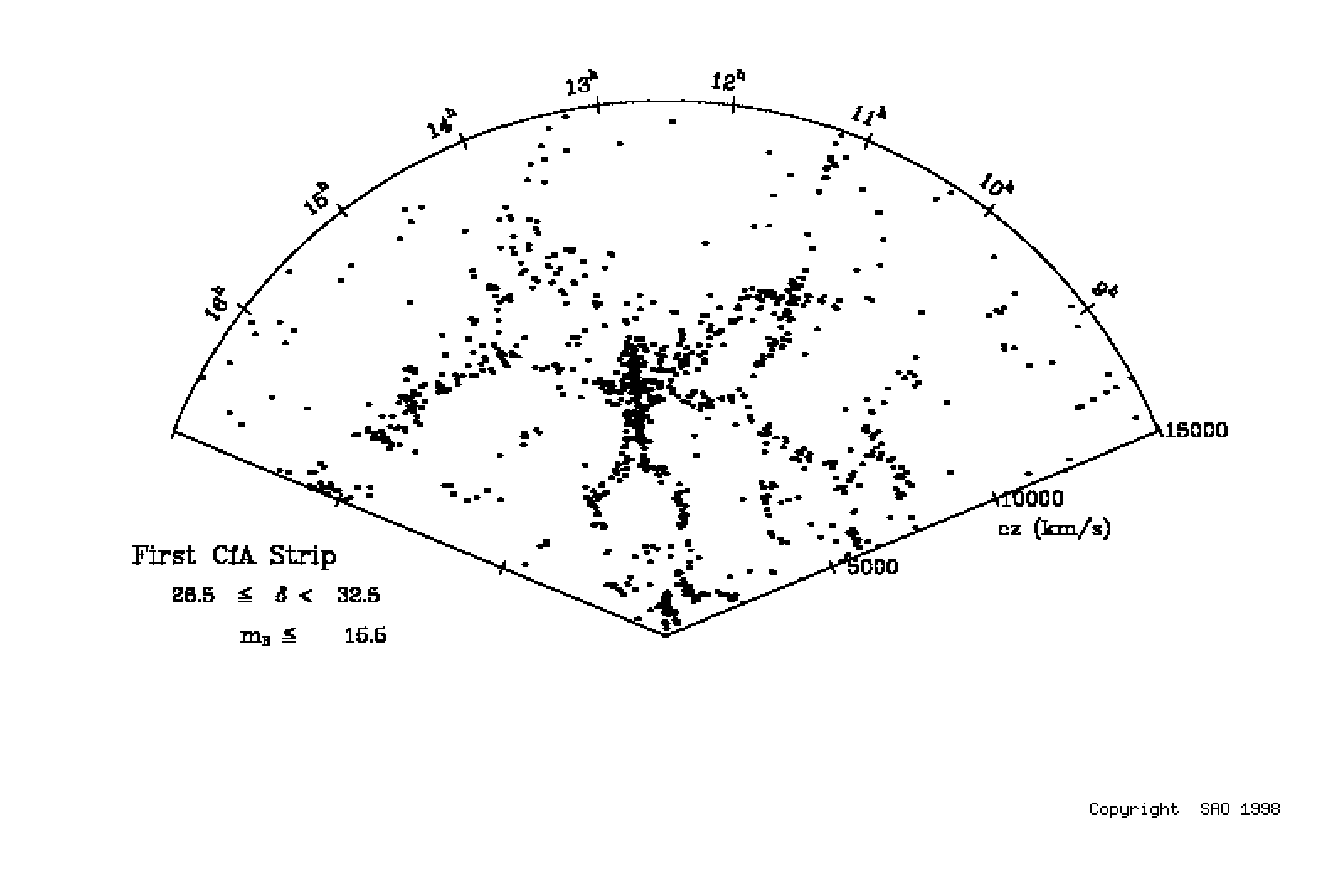
Very deep surveys, tiny angular extension

Various coverage techniques

Filled surveys, unfilled surveys, random sampling…

CfA redshift survey (Huchra, Geller et al.)

middle '80s   hundreds of spectra



The revolution of the ’90s

Digitized scans of photographic plates

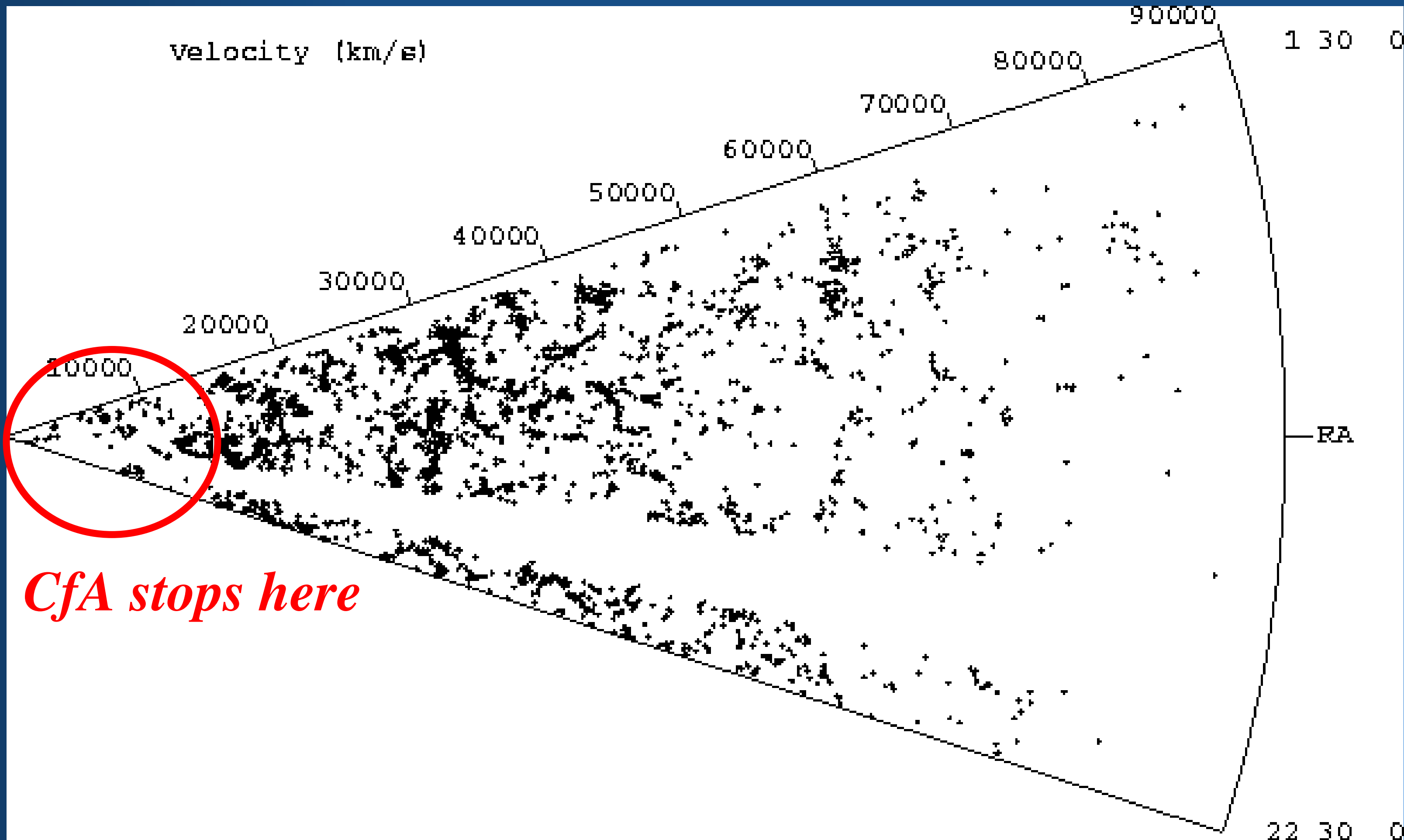
Large field CCDs

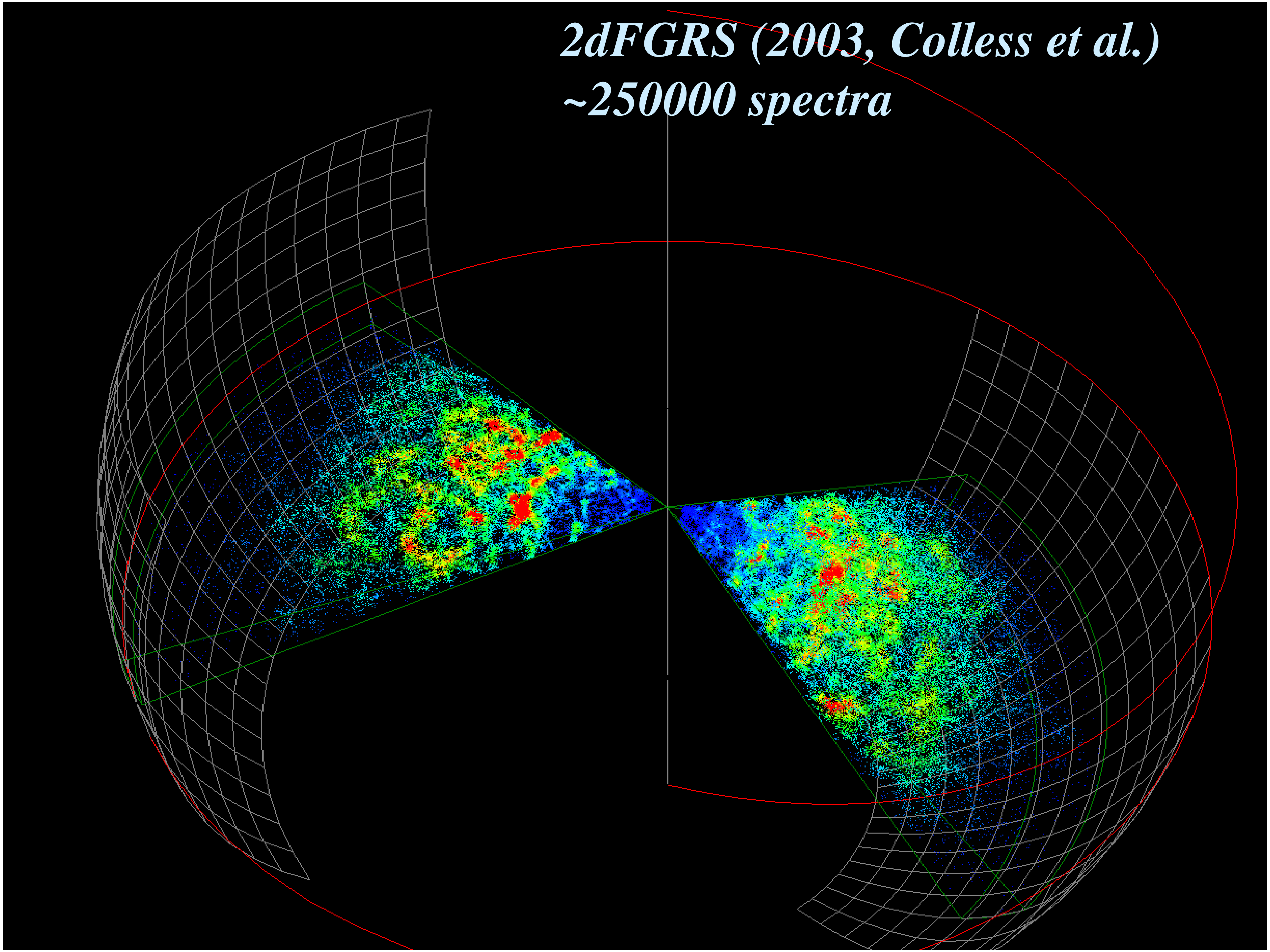
Multiobject spectroscopy

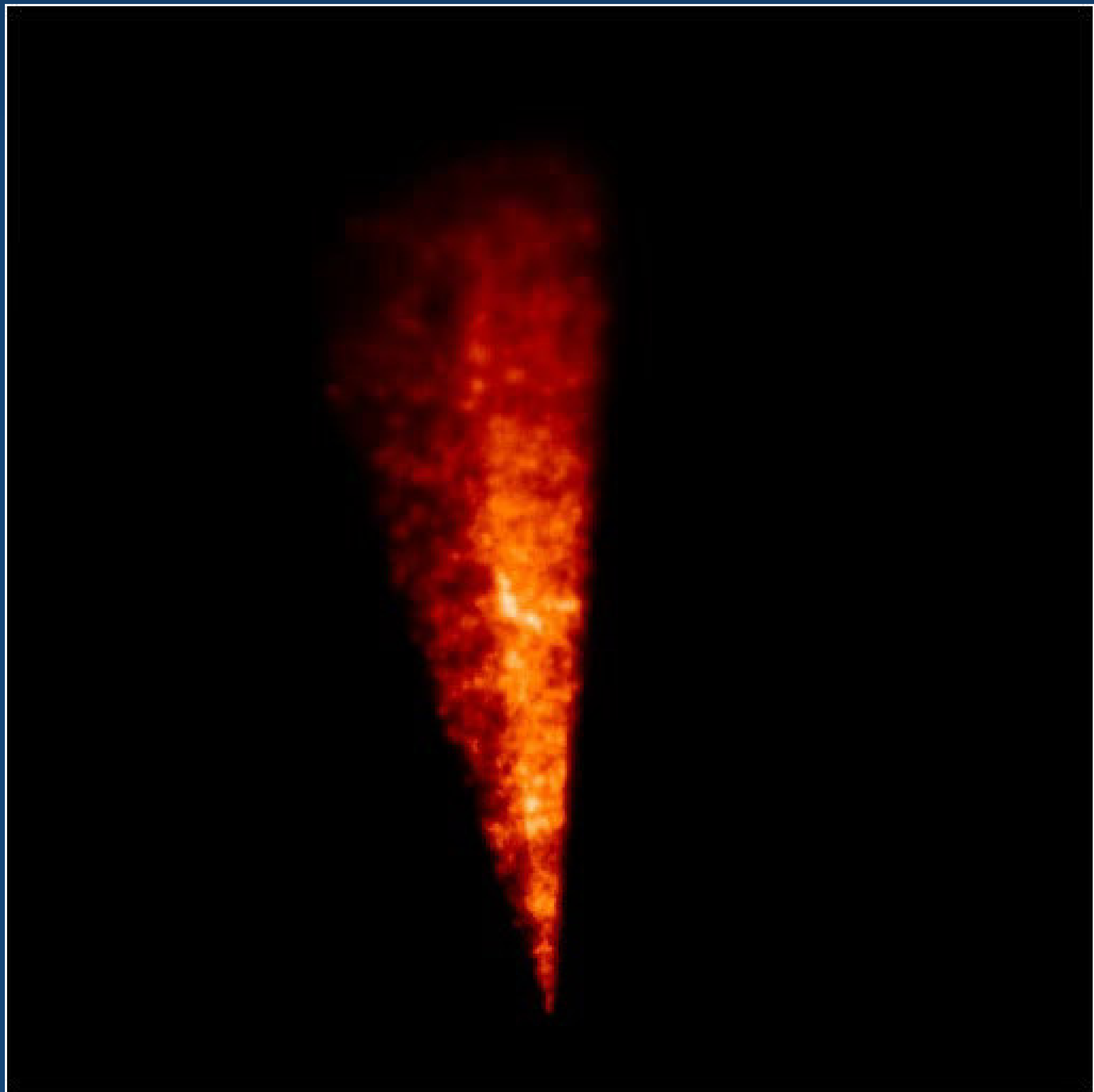
Telescopes of the 8metre class

ESO Slice Project (ESP, PI G.Vettolani)

early '90s ~3400 spectra




2dFGRS (2003, Colless et al.)
~250000 spectra



The study of the distant Universe

Which type of evolution led the Universe to be as we observe it today

(cosmology)

Who are the progenitors of the structures/galaxies that we observe today

(astrophysics)

High density of very faint objects: need of multiobject instruments on large telescopes

(tecnology)

VIMOS consortium

(P.I. O.LeFevre – CoP.I. G.Vettolani)

- **Bologna**

  INAF-Osservatorio

  INAF-IRA

  Università

- **Milano**

  INAF-Osservatorio

  INAF-IASF

- **Napoli**

  INAF-Osservatorio

- **Marseille**

  LAM

  OHP

- **Paris**

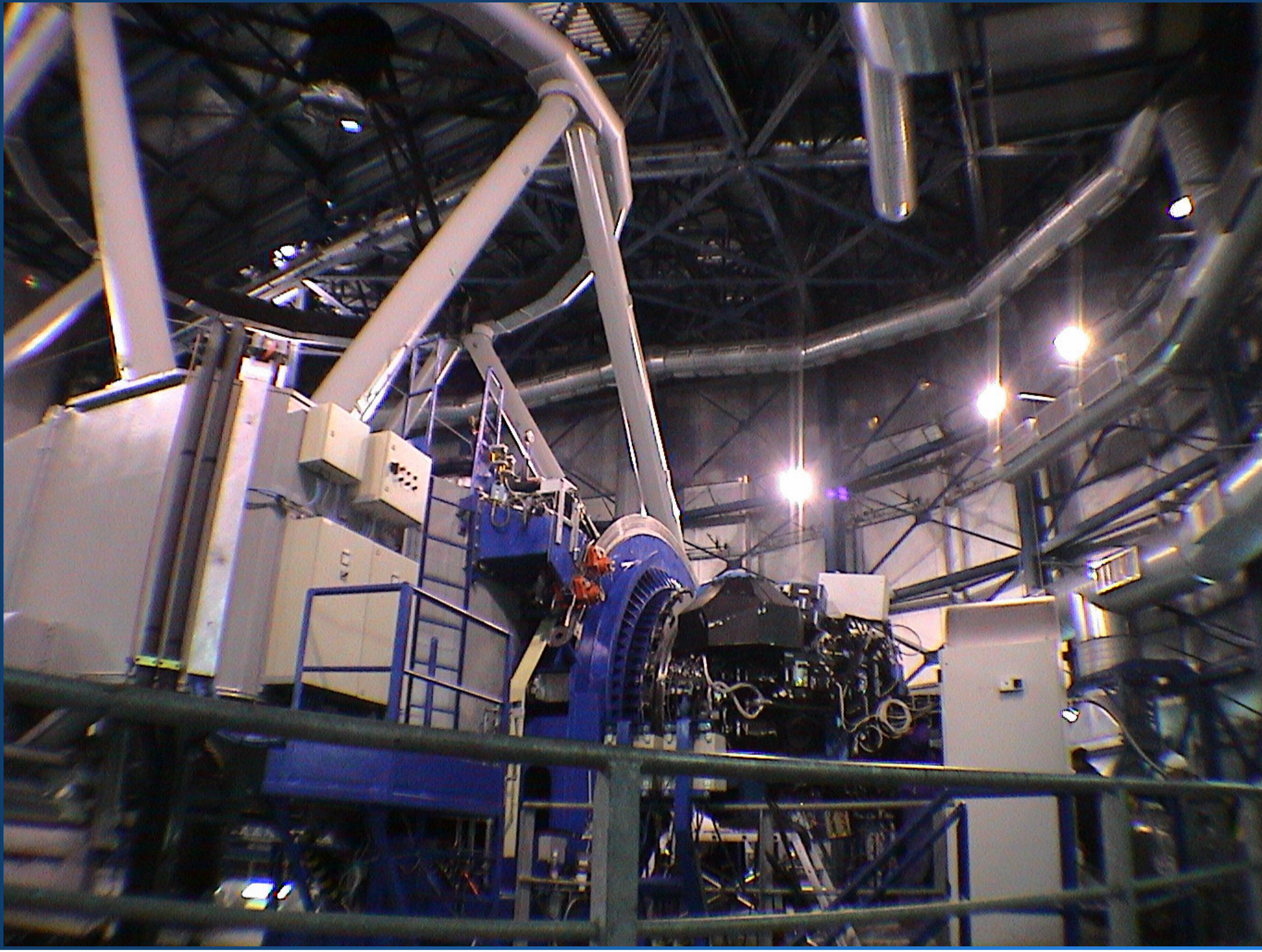
  IAP

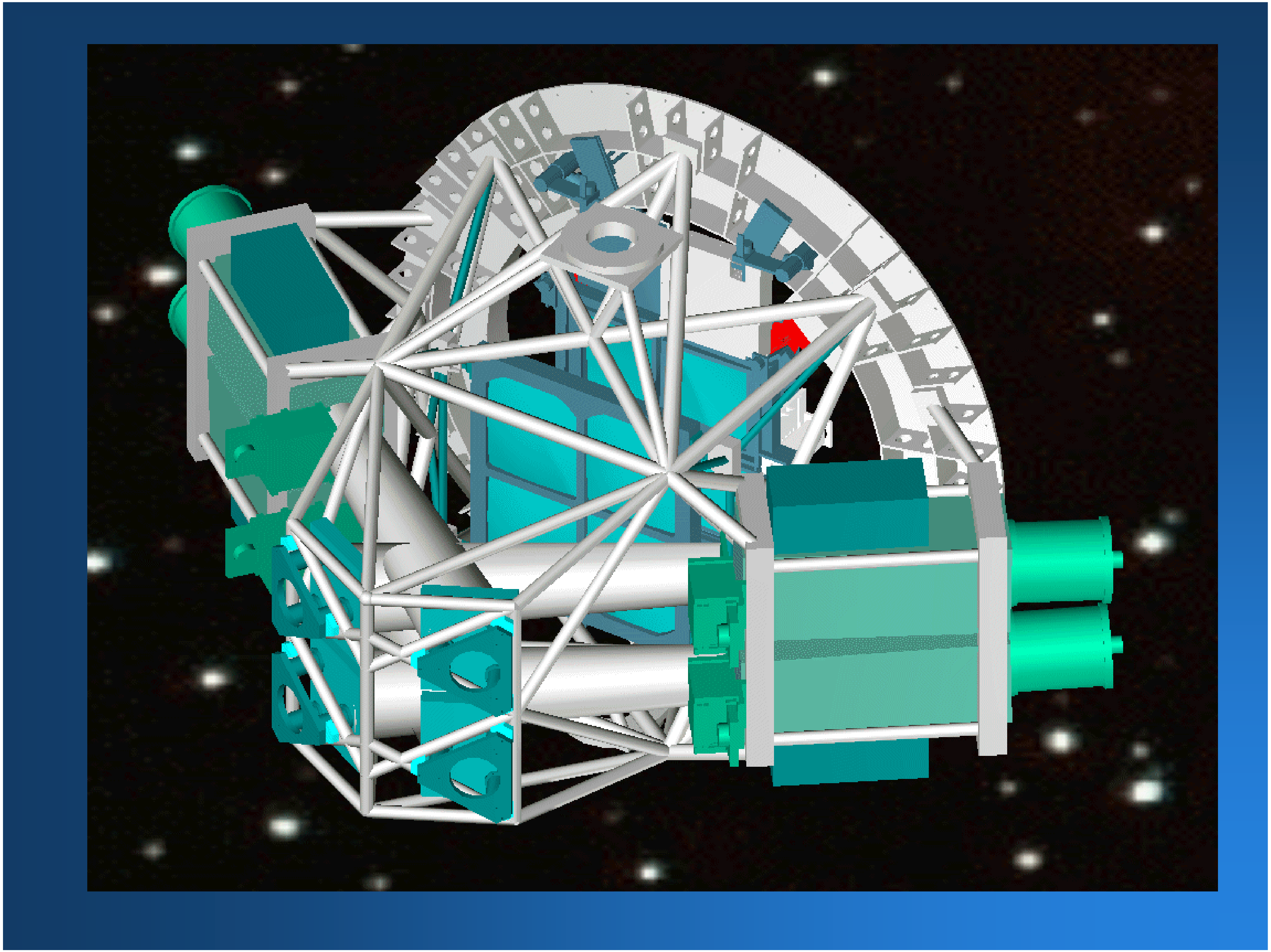
- **Toulouse**

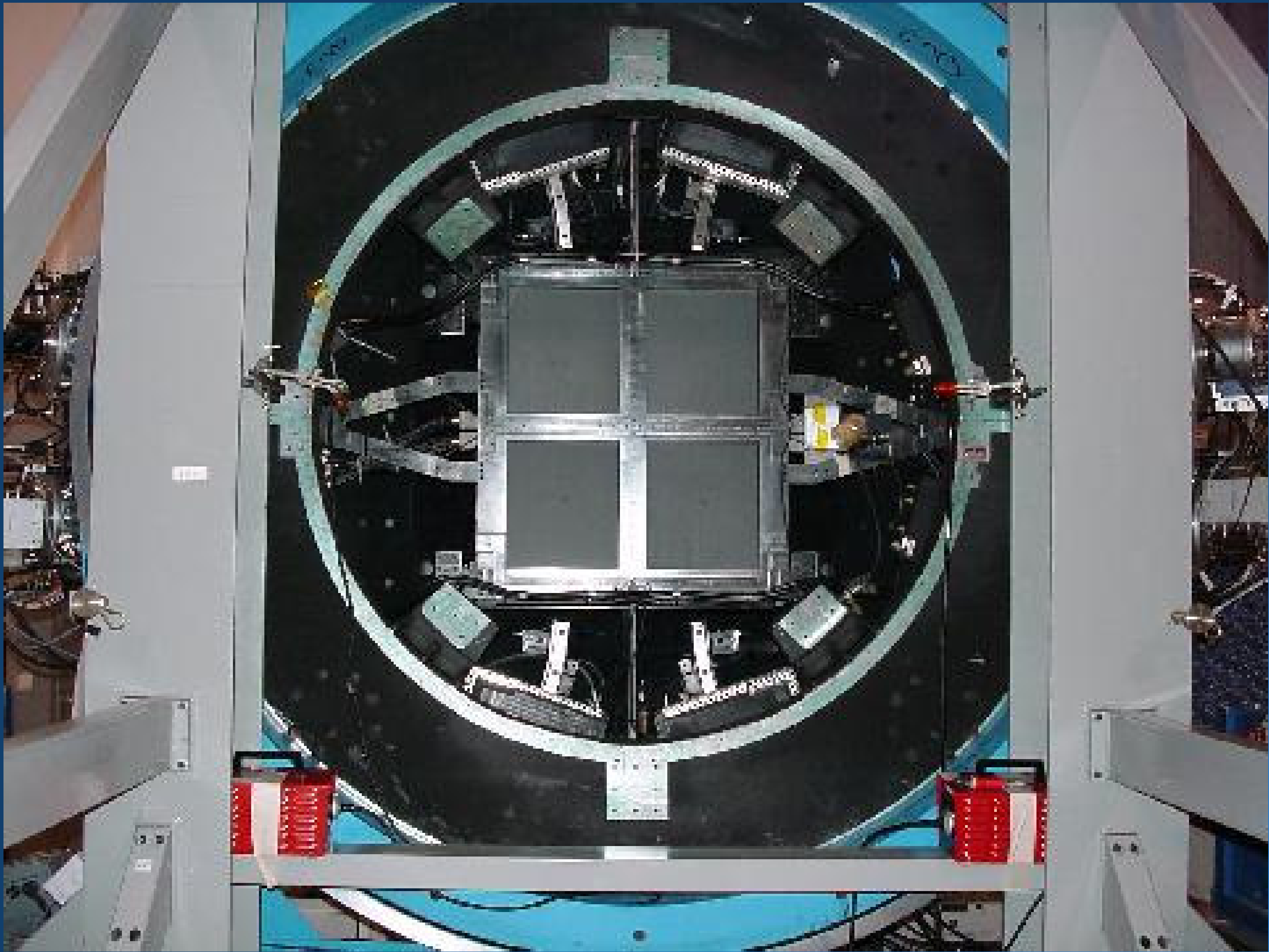
  OMP

VIMOS: characteristics

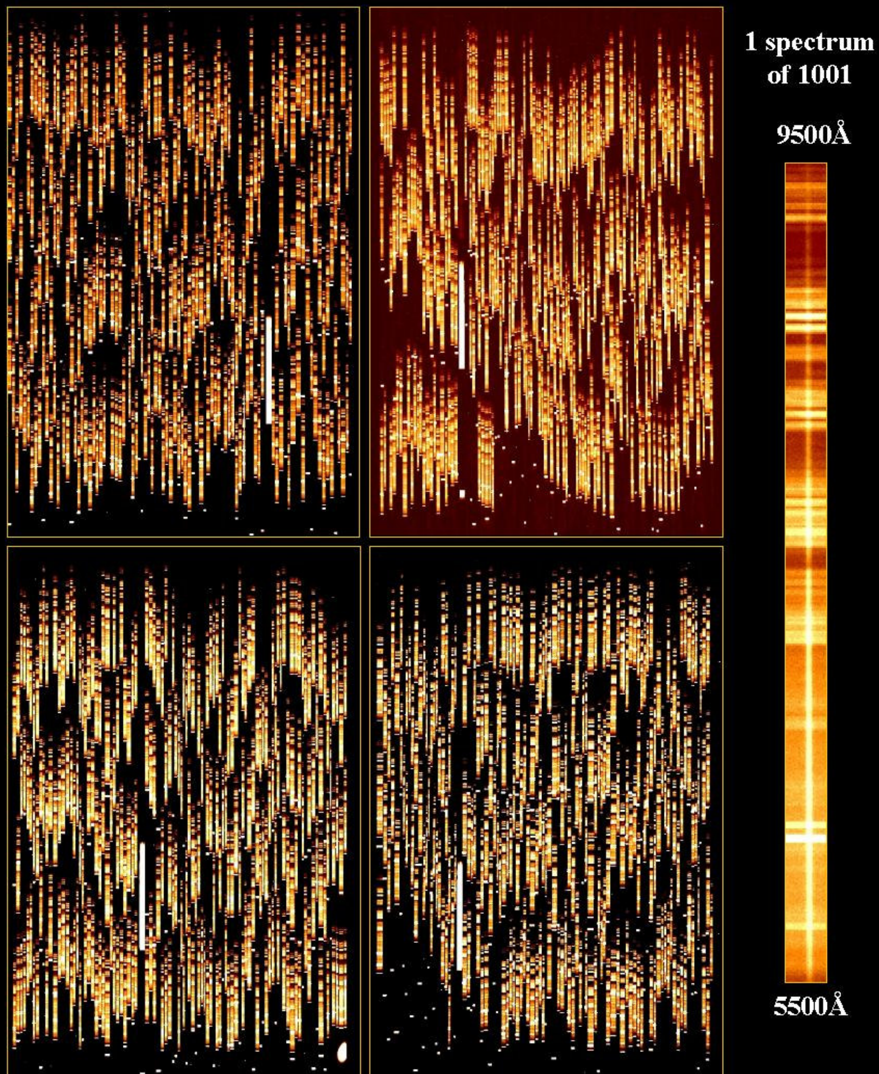
VIMOS (Visible Multiobject Spectrograph) is mounted on the Nasmyth focus of VLT/UT3



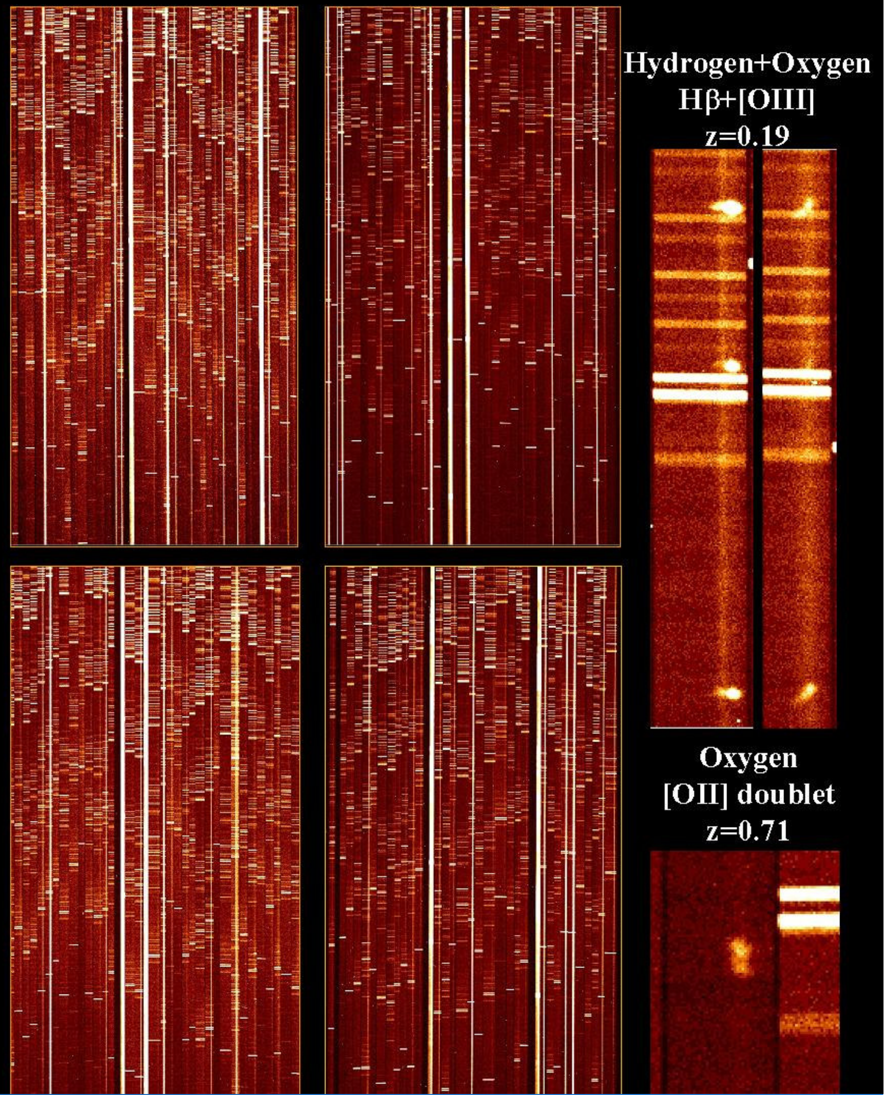


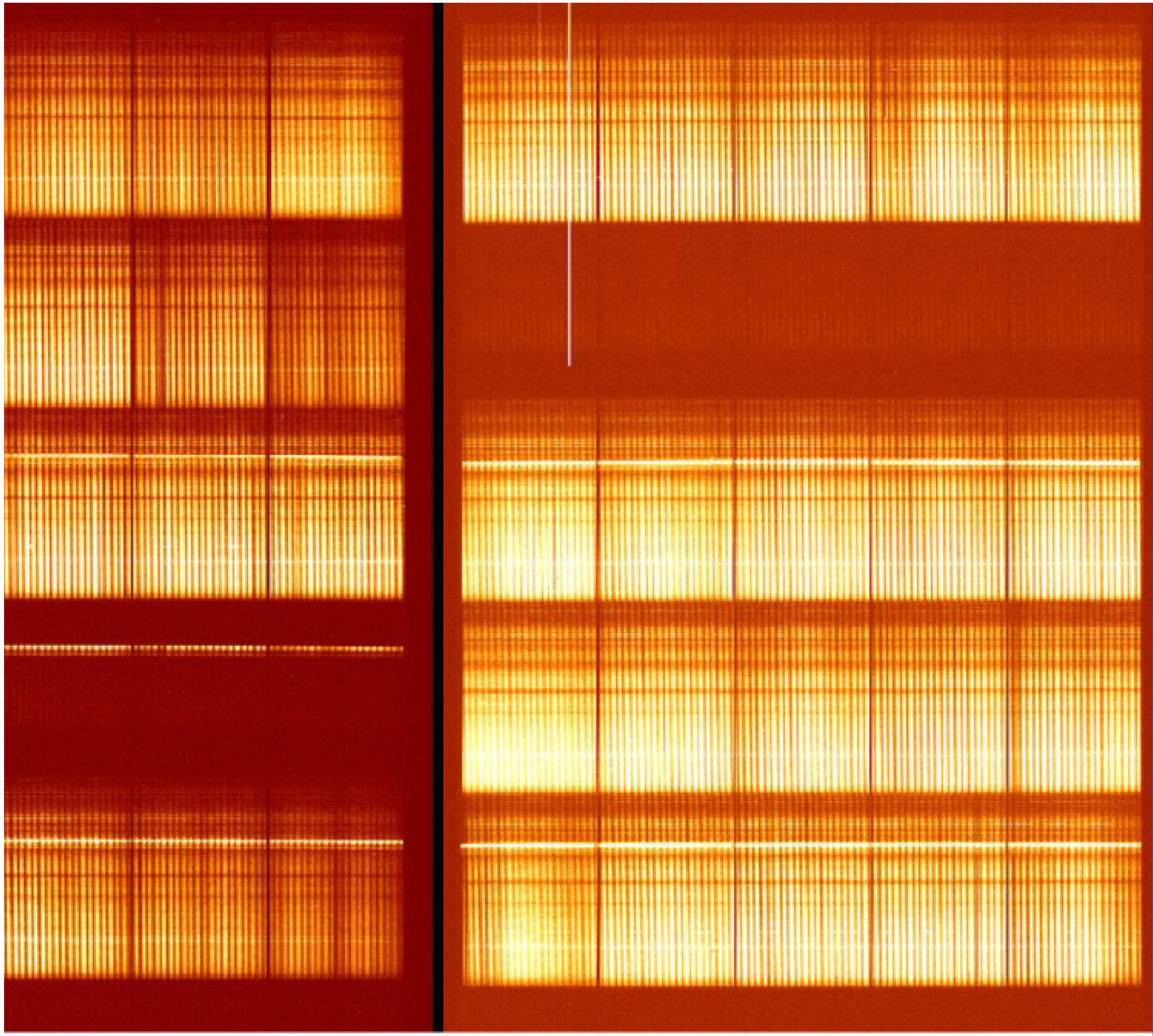


VIMOS at the ESO VLT measures the distance of 1001 distant galaxies in one single observation 28/09/2002



VIMOS at the VLT observes 150 galaxies at once at high spectral resolution (R~4000)





Integrated-Field Spectrum of the Antennae Galaxies Central Area
(VLT MELIPAL + VIMOS)

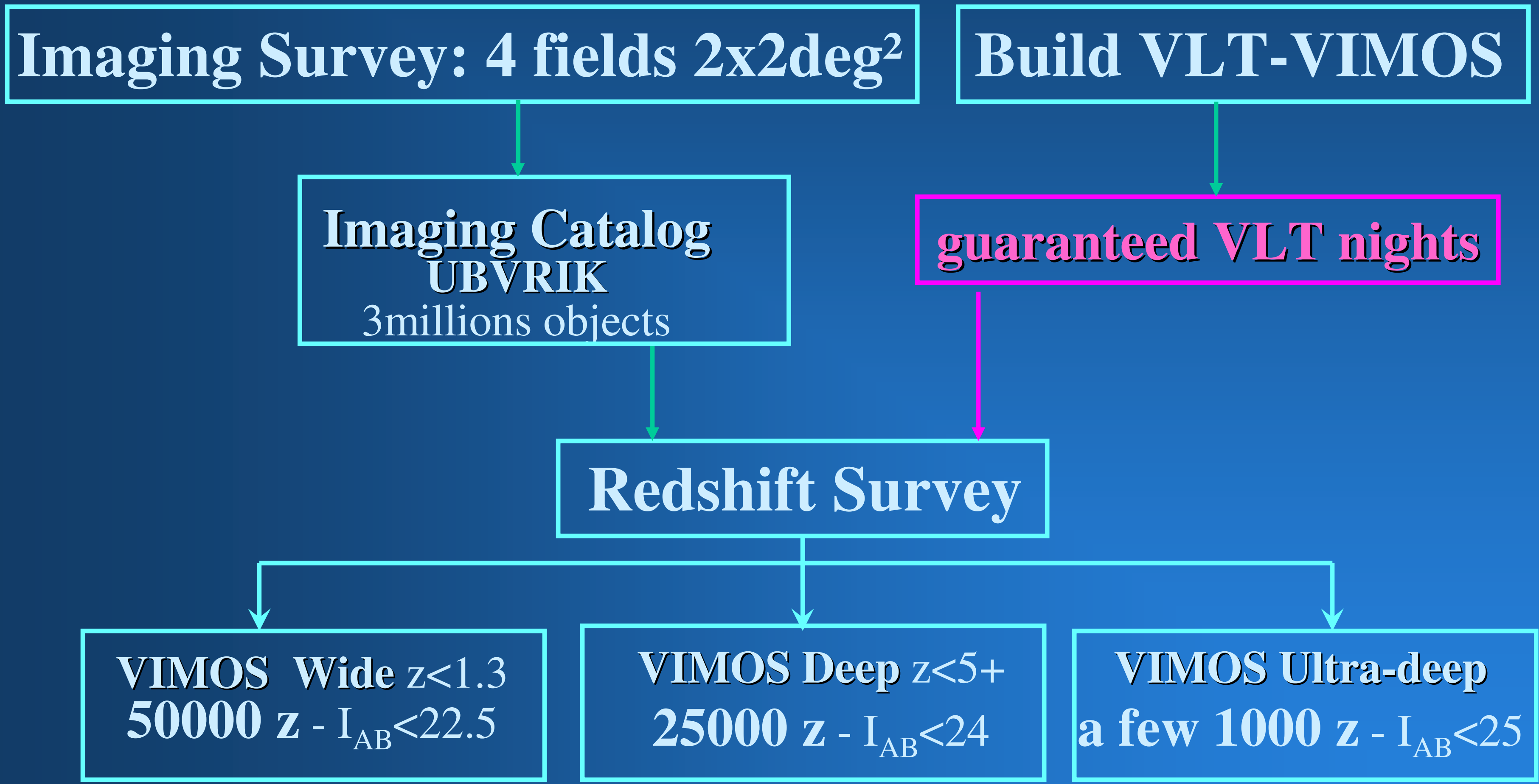
March 2002)

The VIMOS VLT Deep Survey main scientific goals

The VVDS aims to obtain a well populated sample over a large redshift range to study:

- ***Evolution of the luminosity and mass functions and of the star formation rate for galaxies of different types and in various environments.***
- ***Clustering properties and evolution over a large redshift range and search for distant clusters.***
- ***Sample of AGNs obtained without pre-selections.***
- ***Properties of "rare" objects, like EROs and LBGs.***

VVDS – strategy

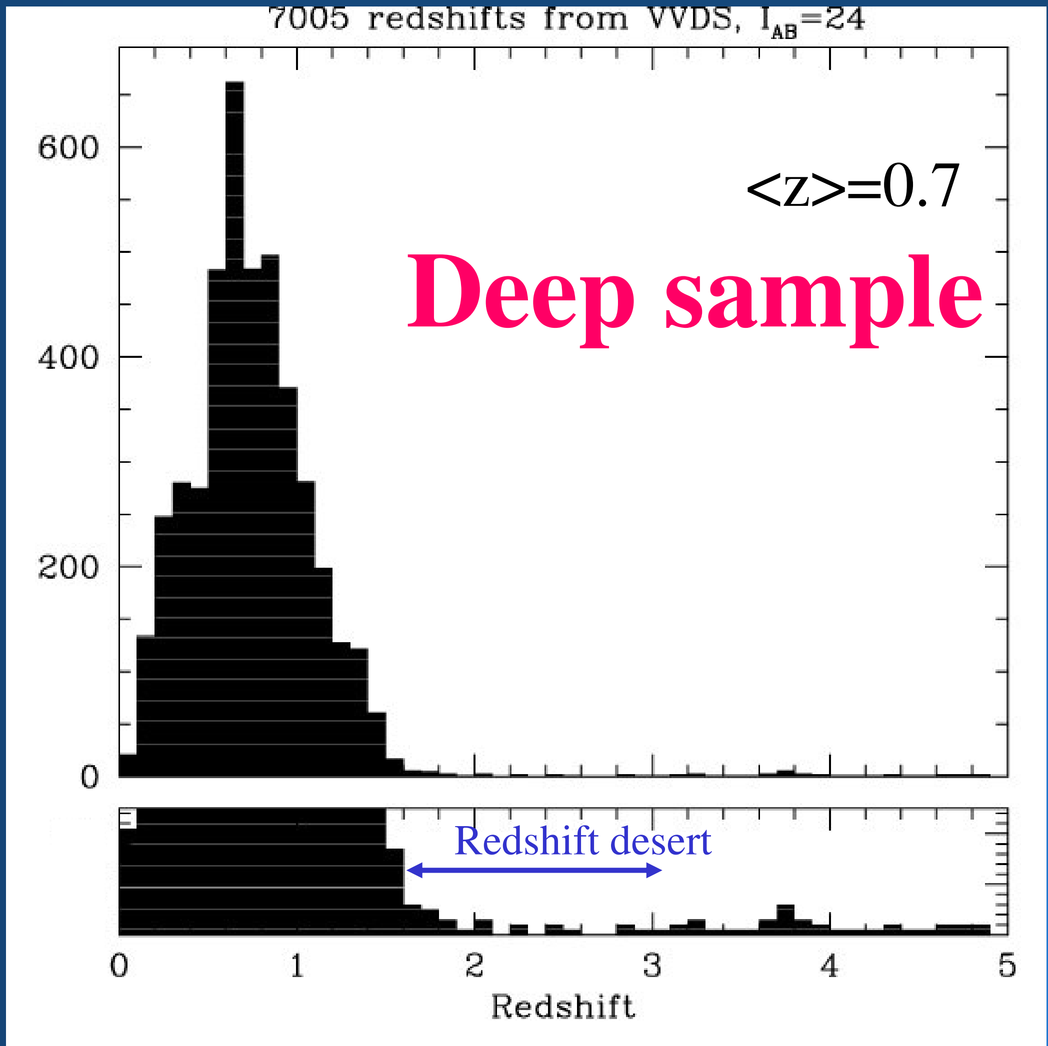


The VVDS – multiband coverage

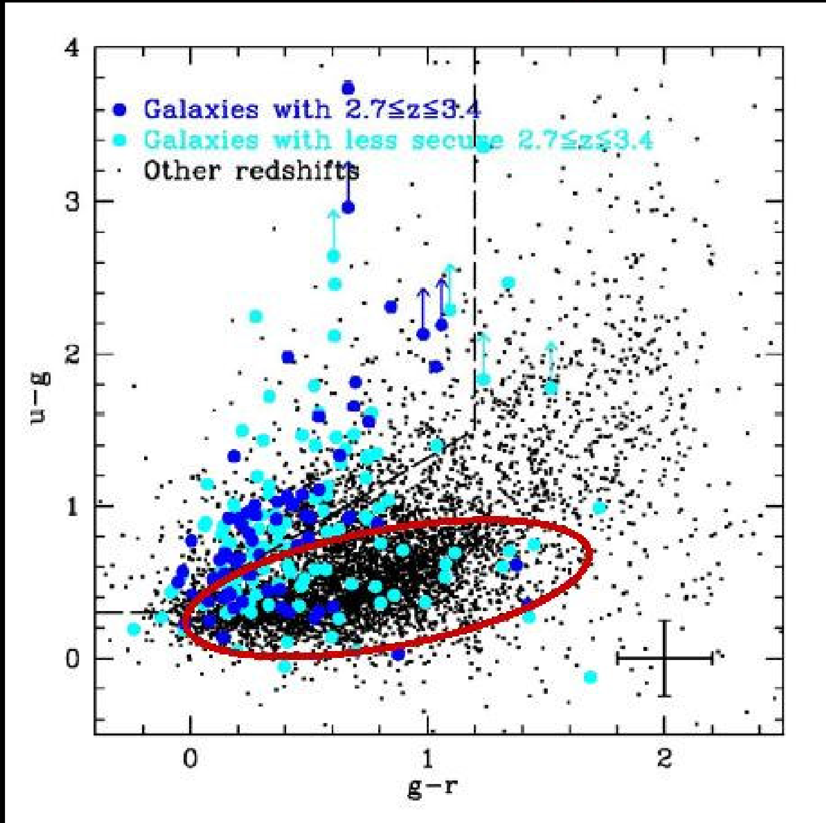
On the VVDS fields (mainly on the deep field) were completed (or are ongoing):

- *1.4 GHz survey with the VLA*
- *Narrow band (920A) imaging with CFH12K*
- *CFHT Legacy Survey observations*
- *XMM pointings*
- *HST observations (COSMOS)*
- *SIRTF observations (SWIRE)*
- *UV observations (GALEX)*

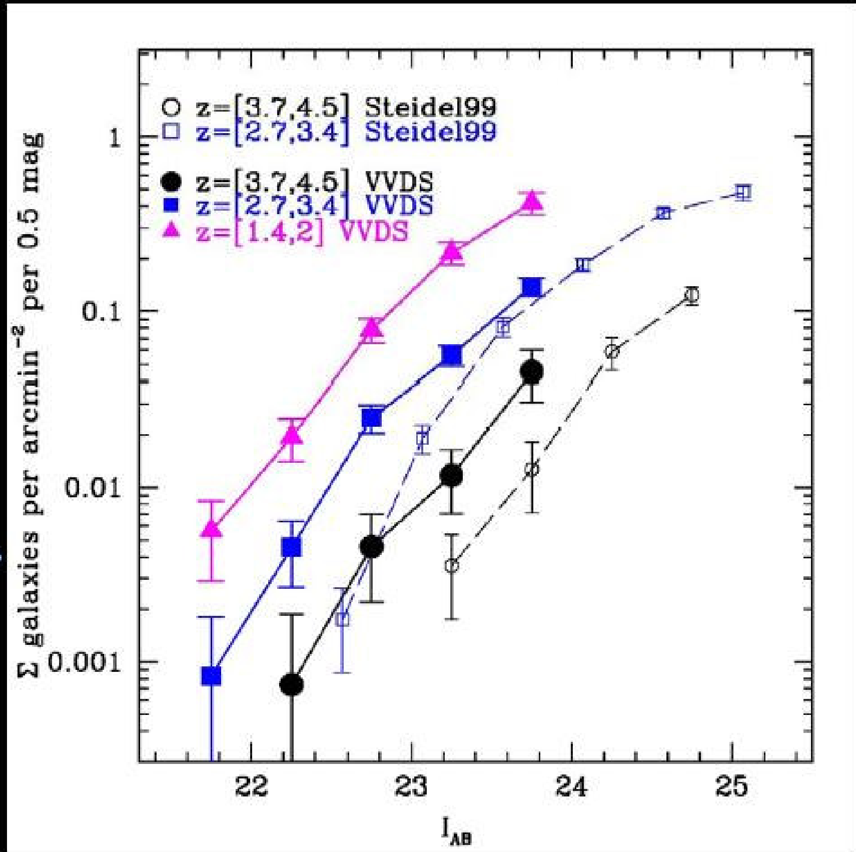
The VVDS - spatial distribution



High redshift galaxies 2.5<z<5

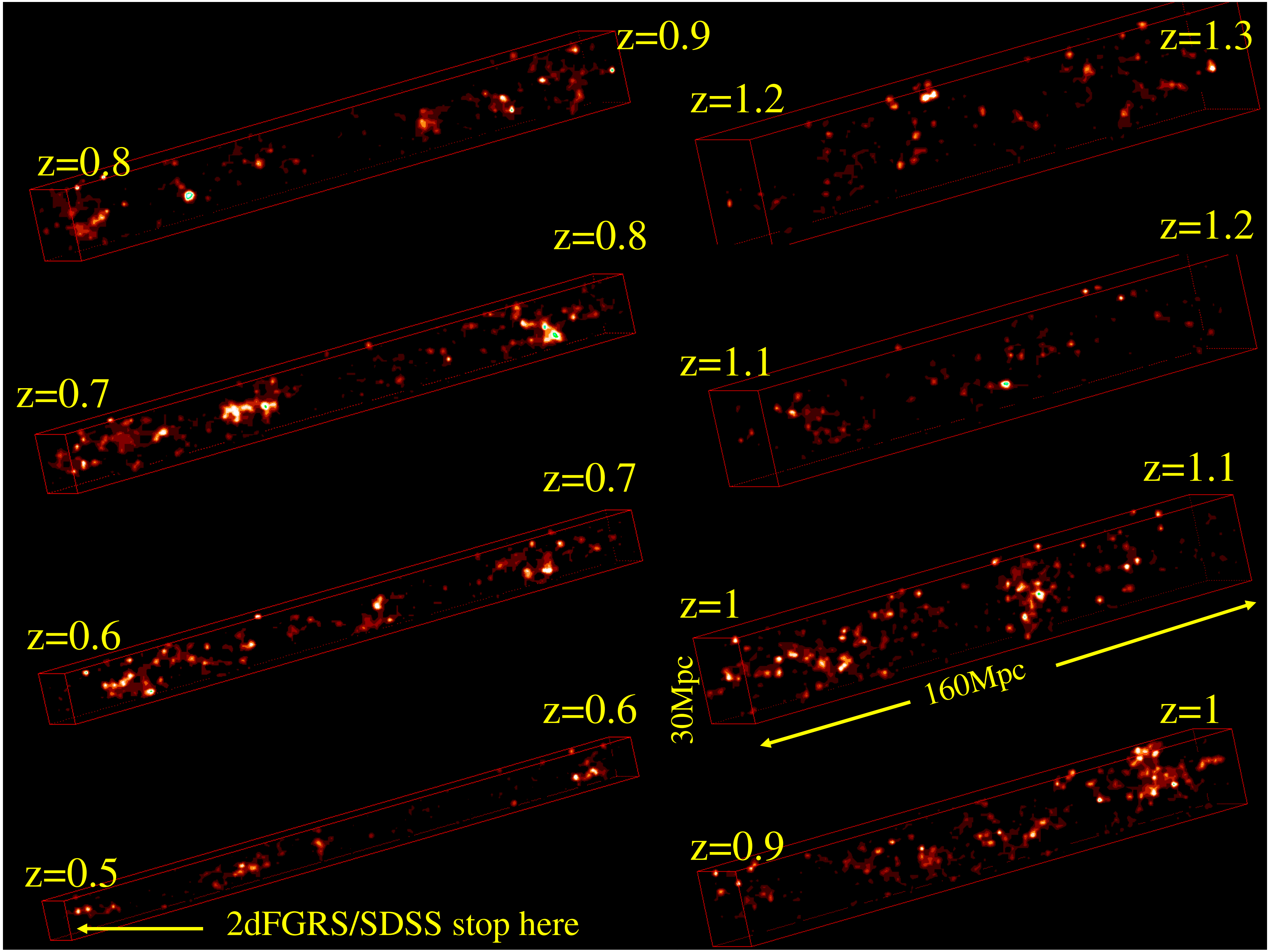


A significant fraction of high-z galaxies cannot be selected via a Lyman-break technique

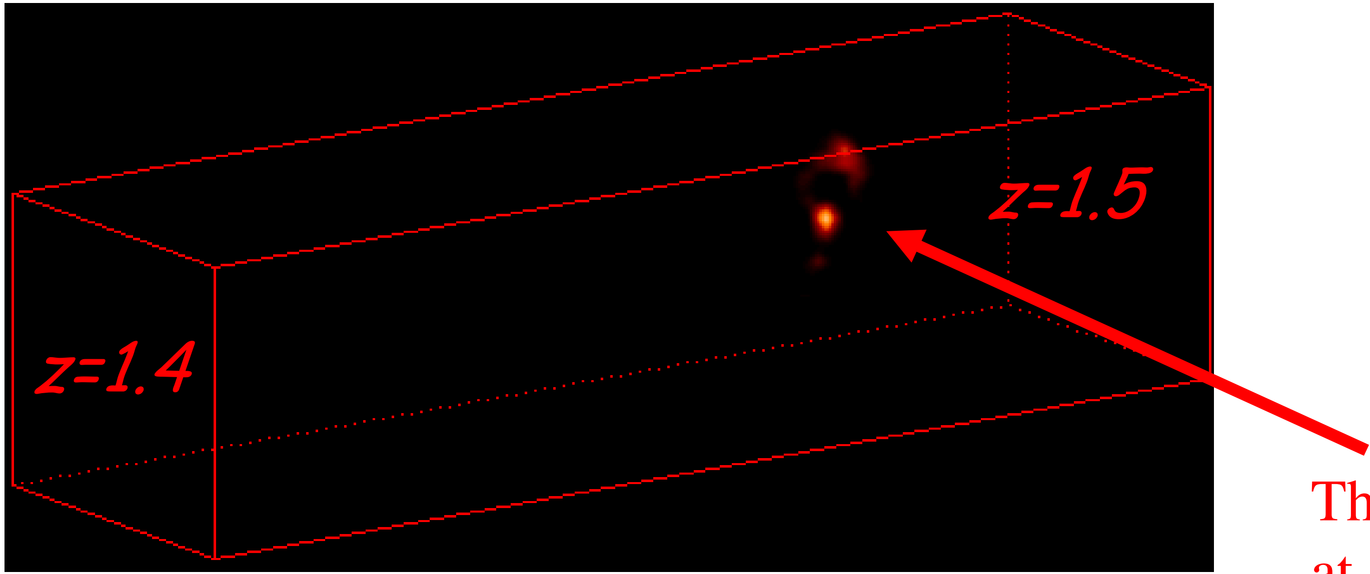


VVDS galaxies: « all in one » combining various populations seen so far ? LBGs+BzK+DRGs+…

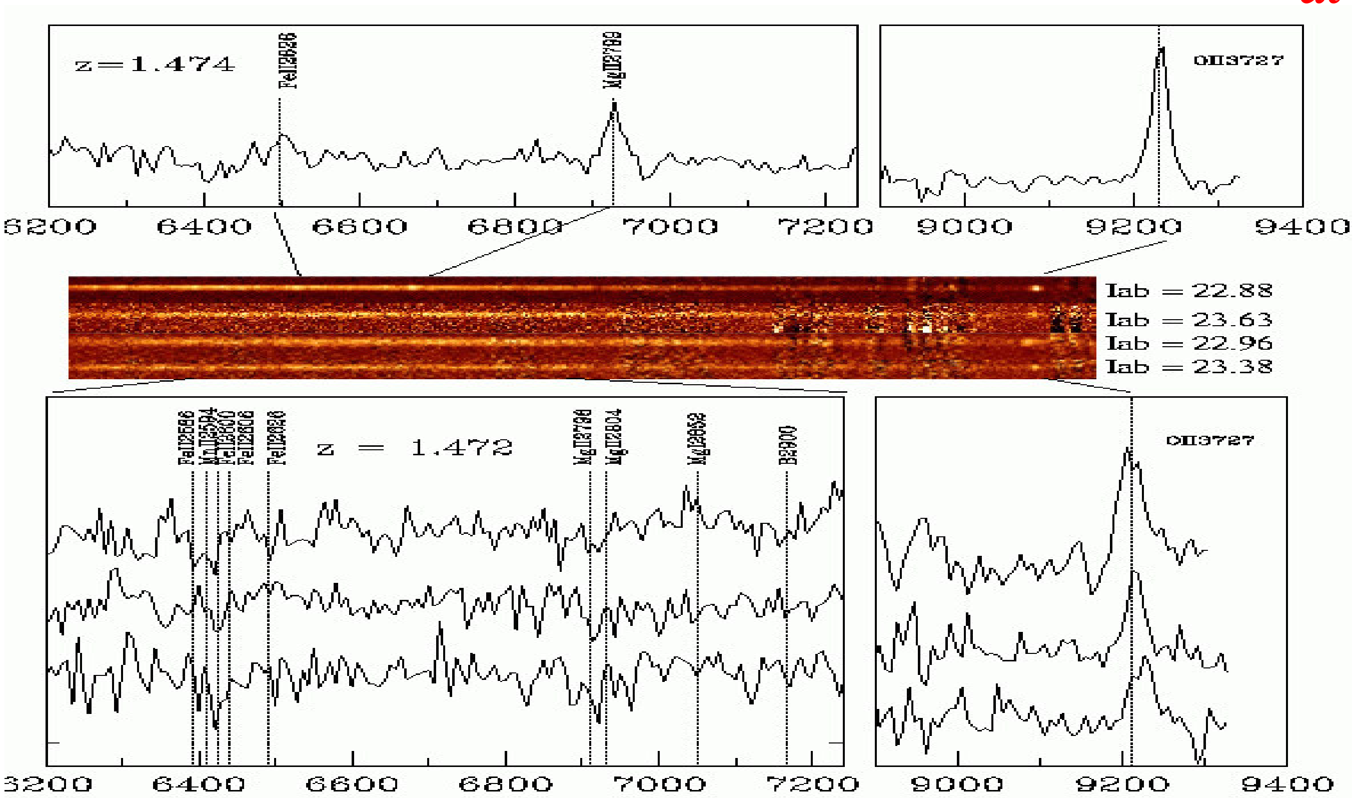
Le Fèvre et al., Nature, 437, 519



z=0.9
z=0.8
z=0.8
z=0.7
z=0.7
z=0.6
z=0.6
z=0.5
2dFGRS/SDSS stop here
z=1.3
z=1.2
z=1.2
z=1.1
z=1.1
z=1
160Mpc
30Mpc
z=1
z=0.9



The structure
at z=1.47

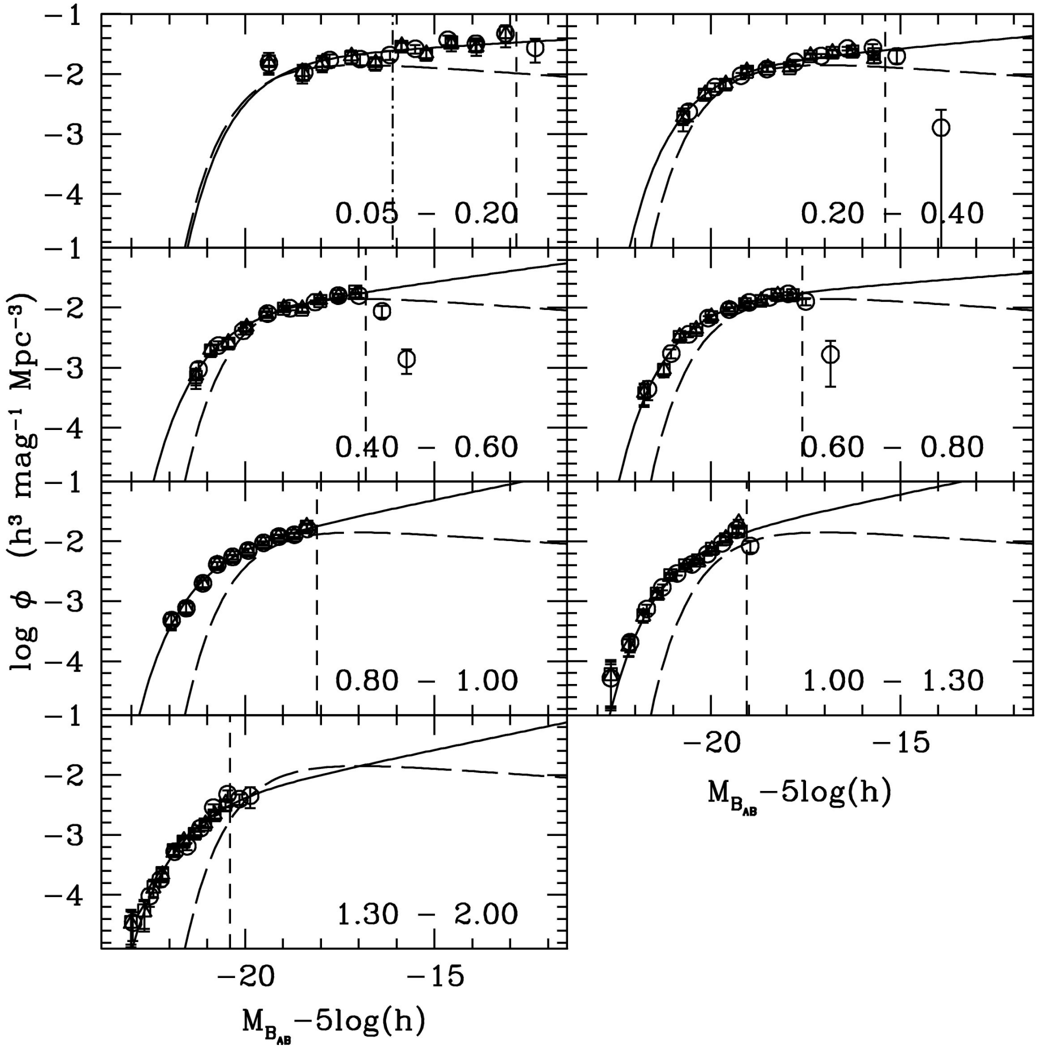


The VVDS – Global luminosity function

(Ilbert, Tresse, Zucca et al. 2005)

The VVDS data allow to determine for the first time from a single homogeneous sample, with a simple magnitude selection, the luminosity function from z~0 up to z~2, with redshift bins containing hundreds of objects.

Evolution of the LF *(Ilbert et al. 2005)*



B band rest frame

It is possible to study the LF evolution up to z~2 with a single homogeneus sample

~ 1000 galaxies with $0.8 \leq z < 1$!

The multicolour data allow to derive the LF in the U, B, V, R, I rest frame bands

$(h = 0.7, \Omega_m = 0.3, \Omega_\Lambda = 0.7)$

ΔM*

~ -2.5 mag in U

~ -2.4 mag in B

~ -1.9 mag in V

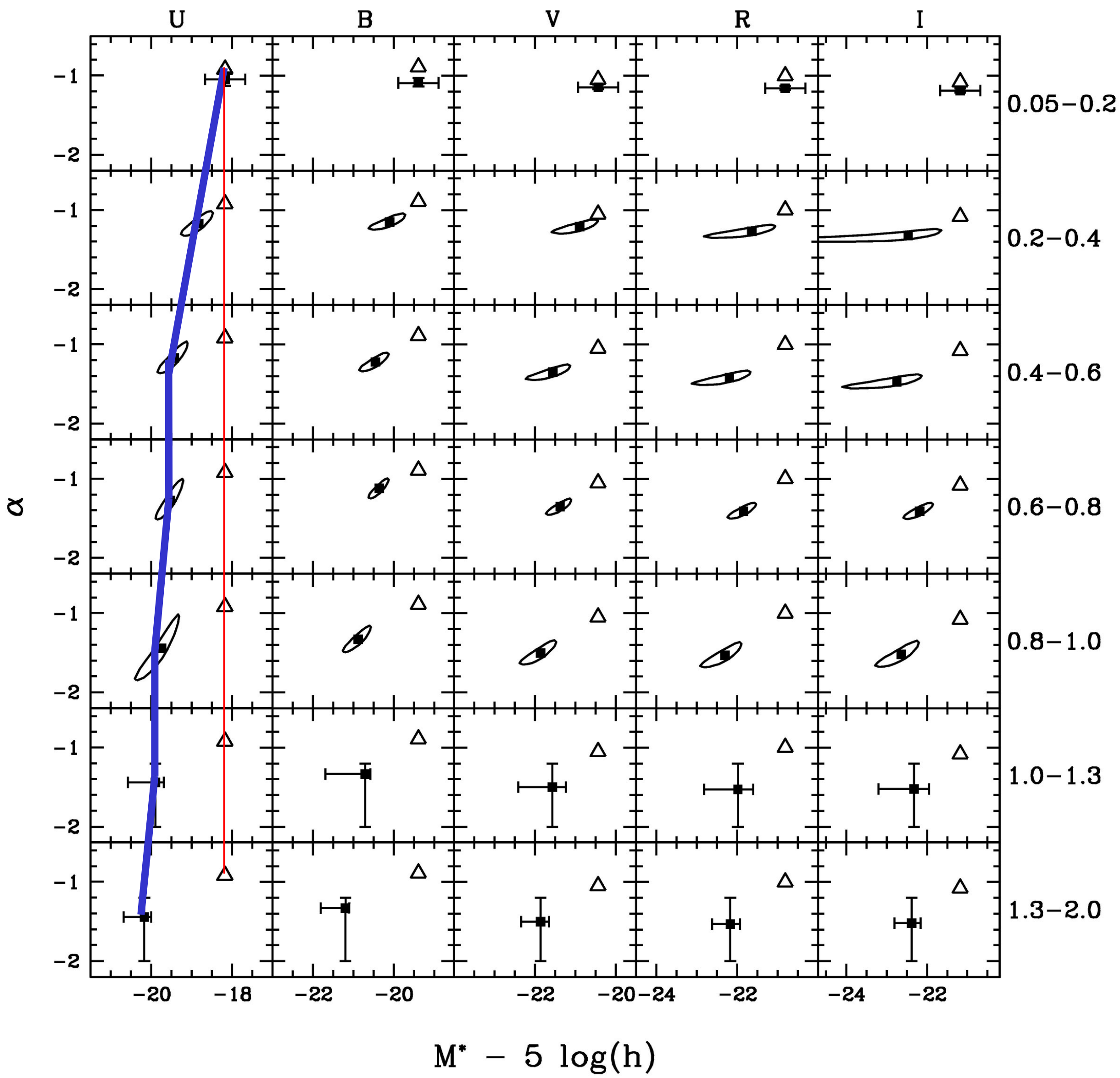
~ -1.8 mag in R

~ -1.6 mag in I

Δα

~ -0.3

in all bands



Δρ

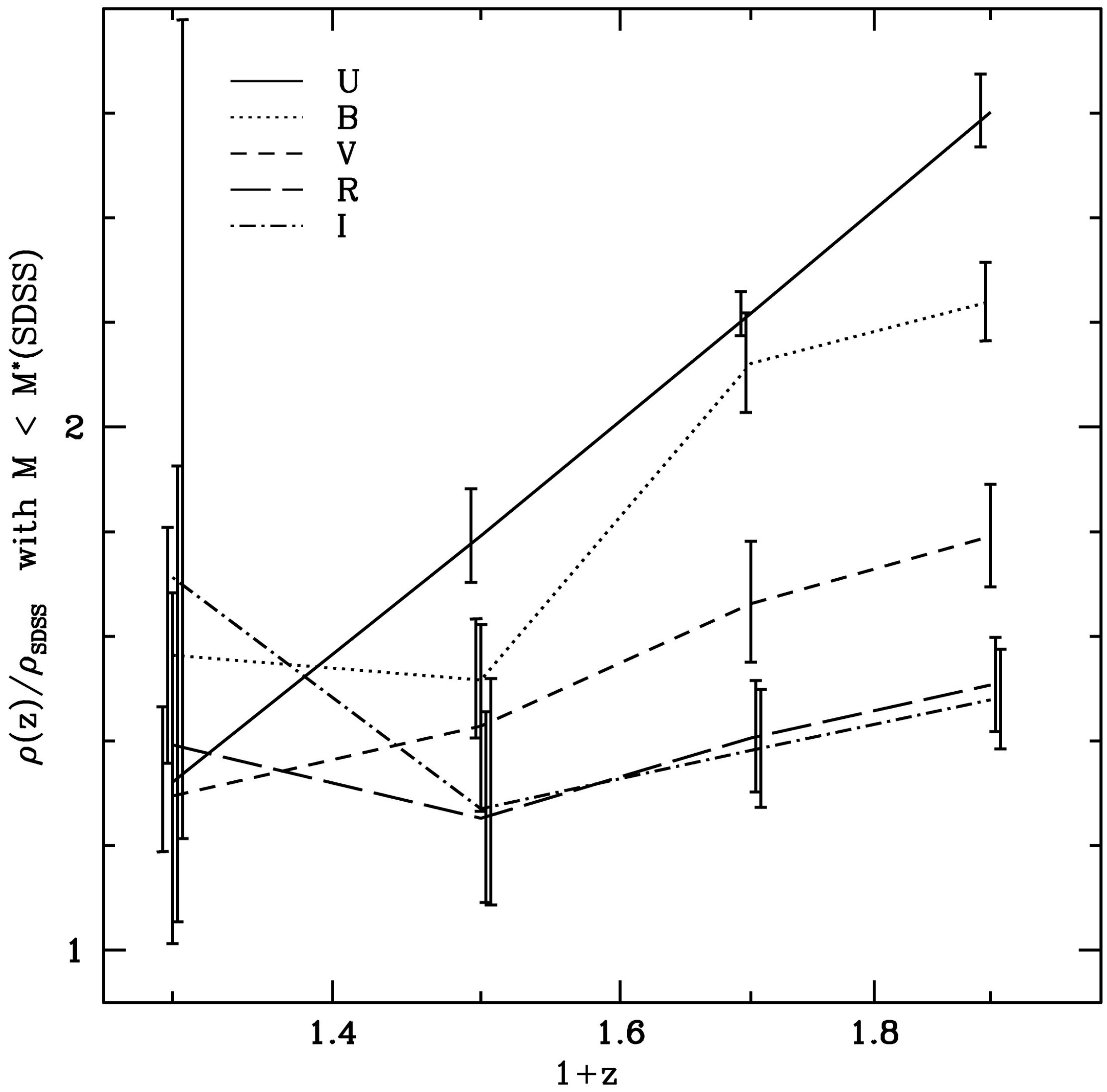
~ -2.6 in U

~ -2.2 in B

~ -1.8 in V

~ -1.5 in R

~ -1.5 in I



Strong evolution of the global LF in particular in the bluer bands

Which galaxies are responsible of this evolution?

It is important to derive the LF divided by spectral type

The VVDS – Luminosity function by spectral type

(Zucca, Ilbert, Bardelli et al., 2006)

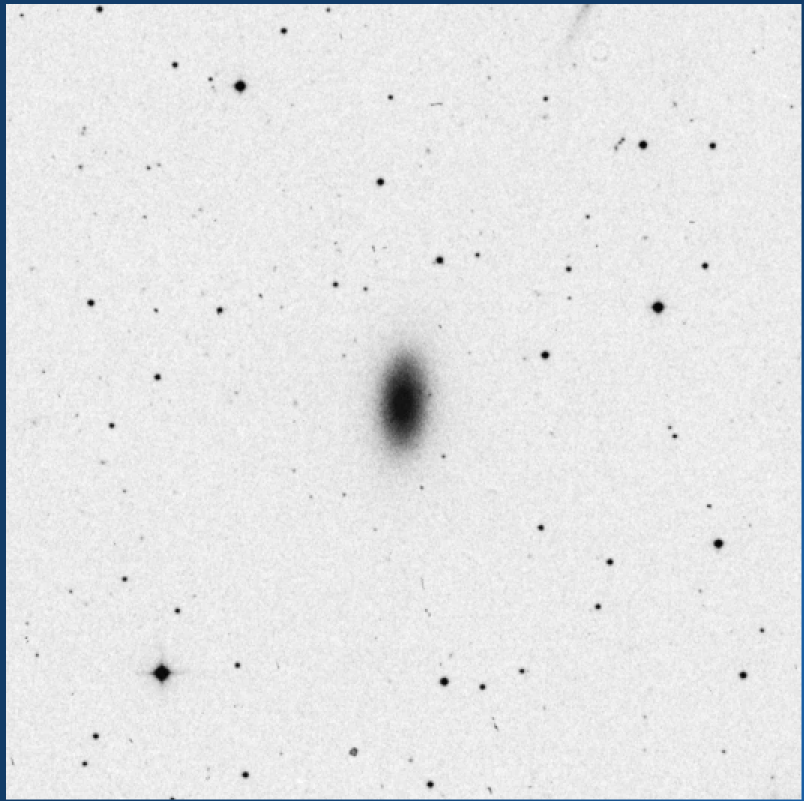
Galaxies of different types had a different star formation history

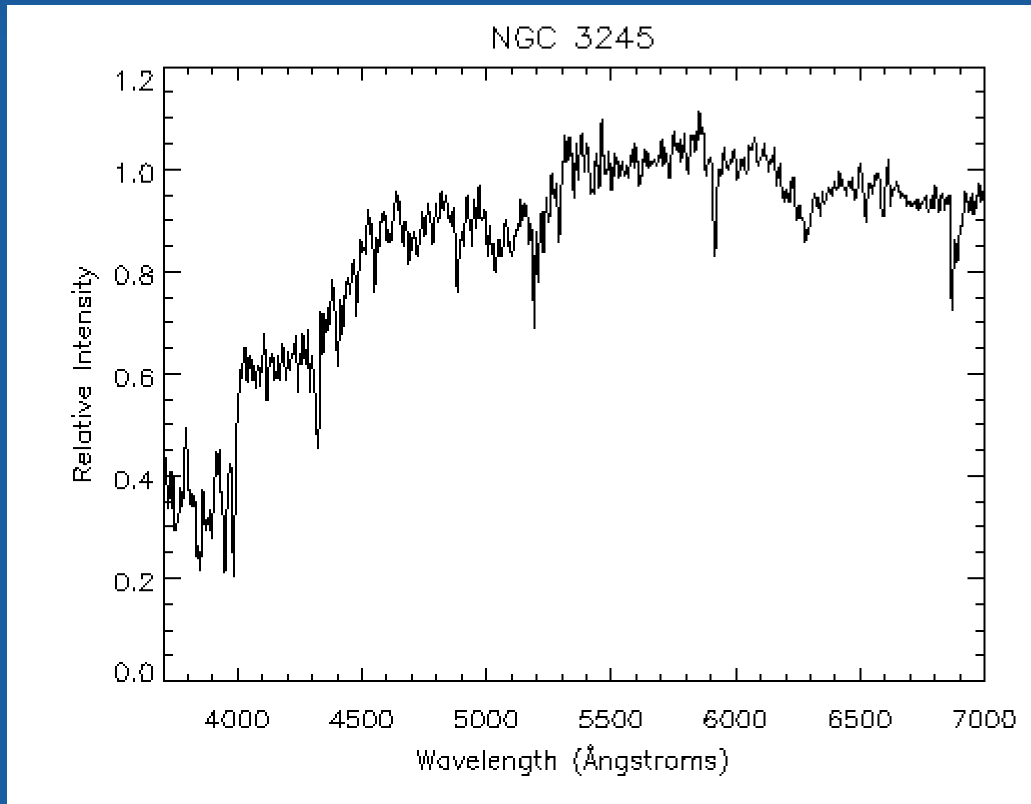
Galaxies of different types reside in different environments and therefore can be influenced by different dynamical phenomena

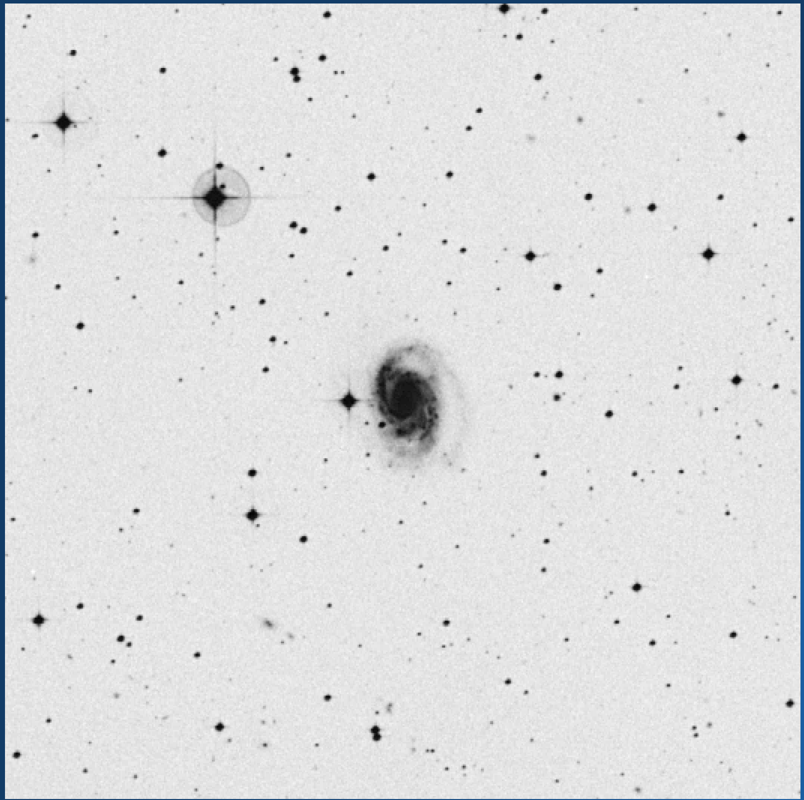
Early type galaxies

spectra dominated by red stars (on average old)

No active star formation is ongoing



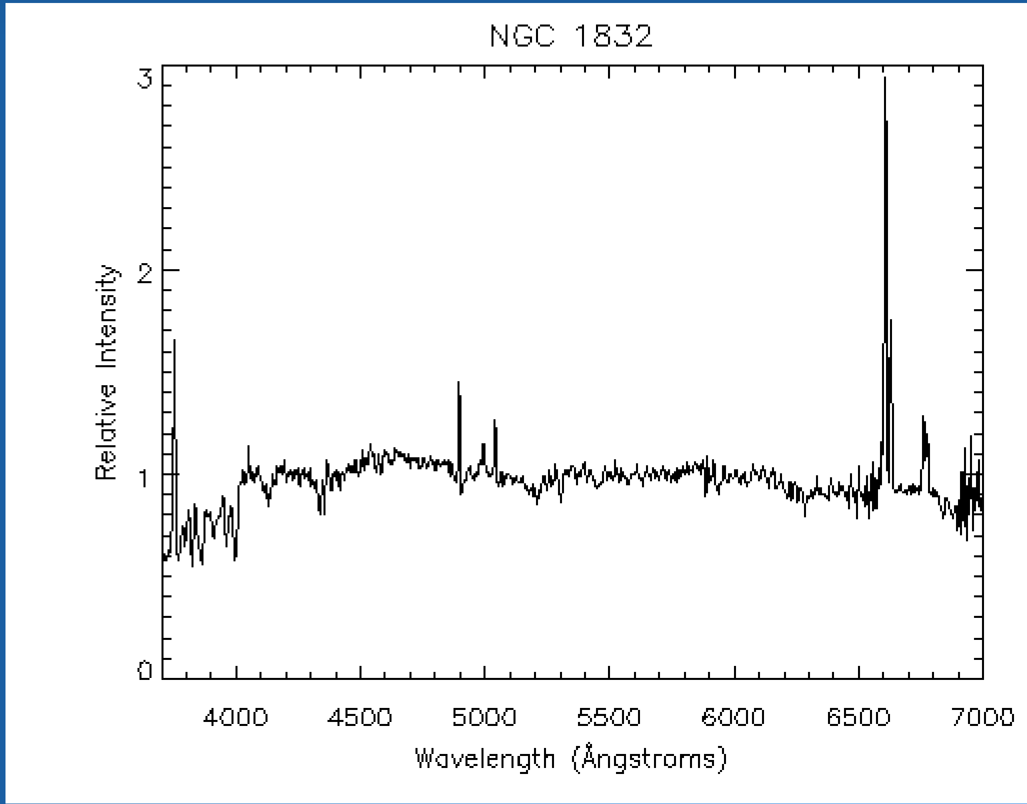


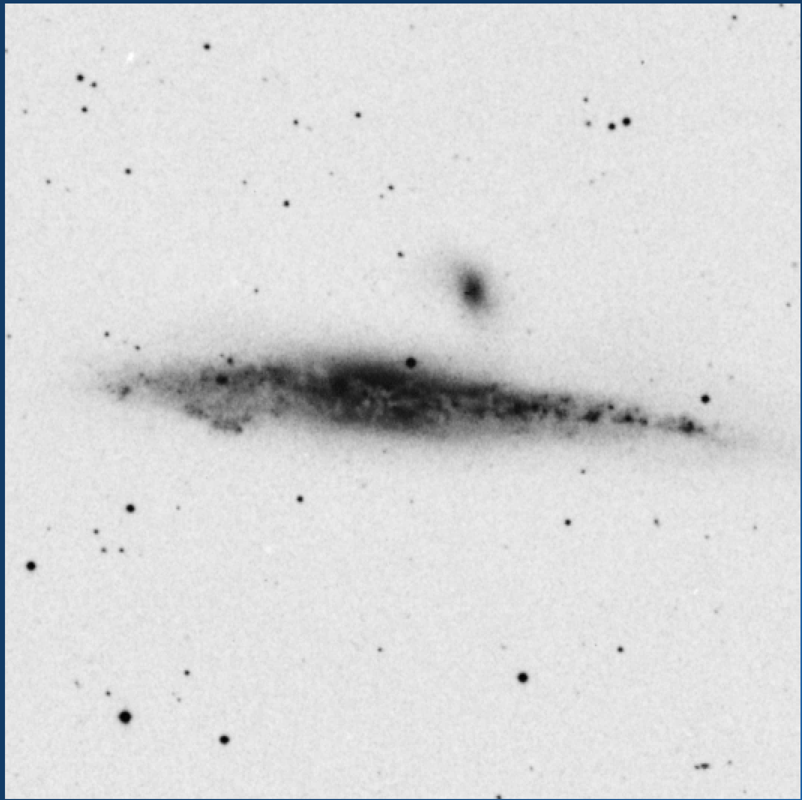


Late type galaxies

Spectra which indicate the presence of blue stars (young)

Star formation is ongoing

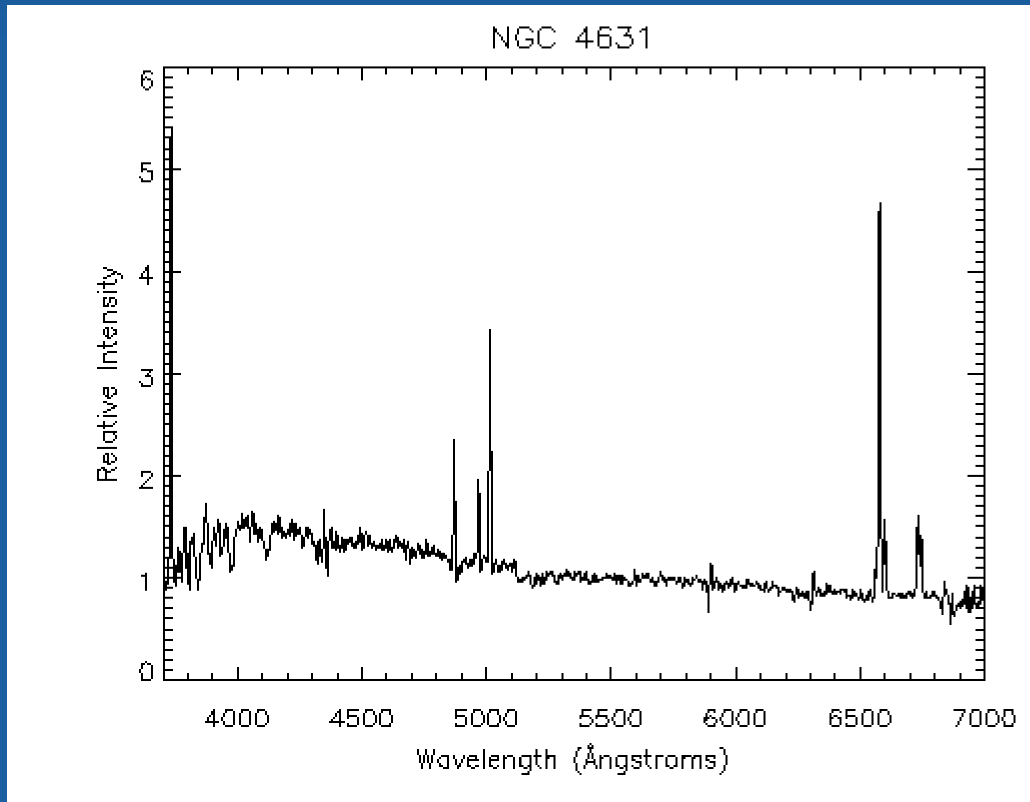




Irregular type galaxies

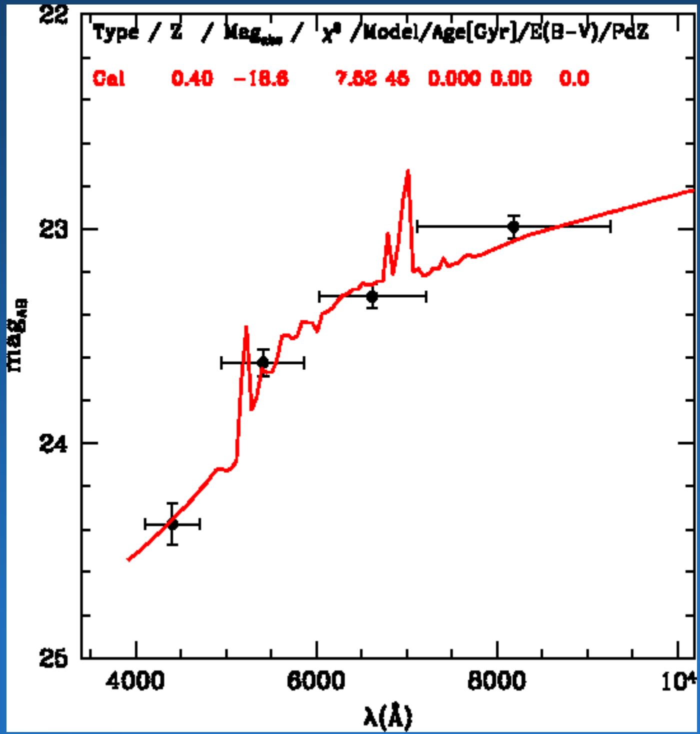
spectra dominated by blue stars (on average young)

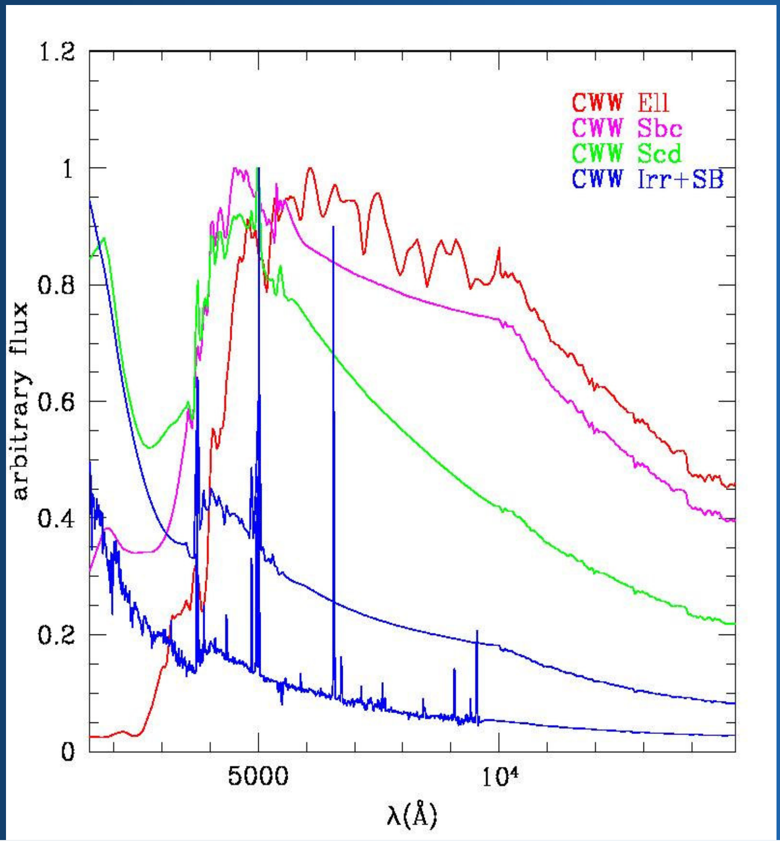
Intense star formation is ongoing



Spectral classification

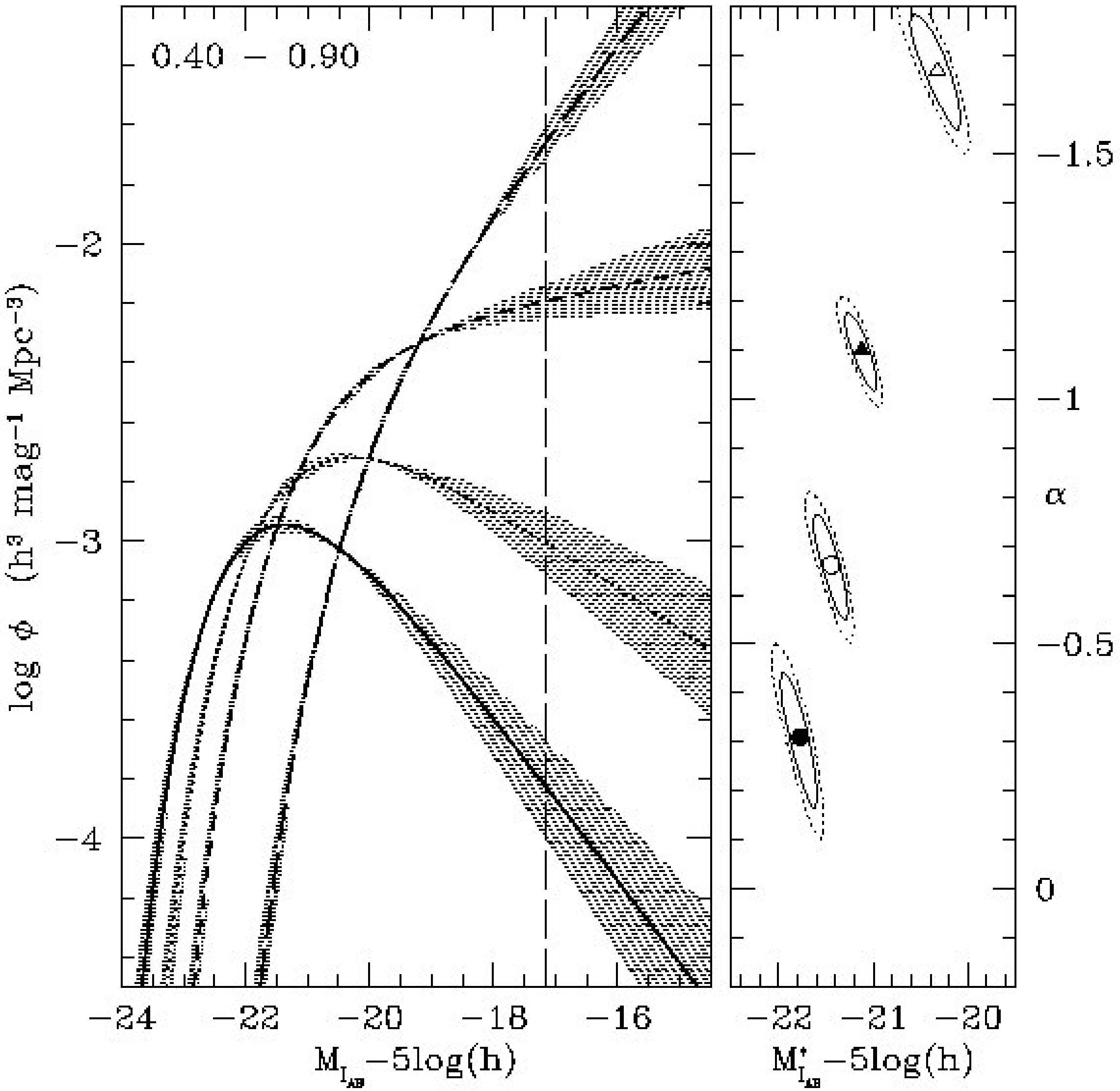
From the best fit template on the multicolor data we derive a type, used to split the sample in 4 sub-samples





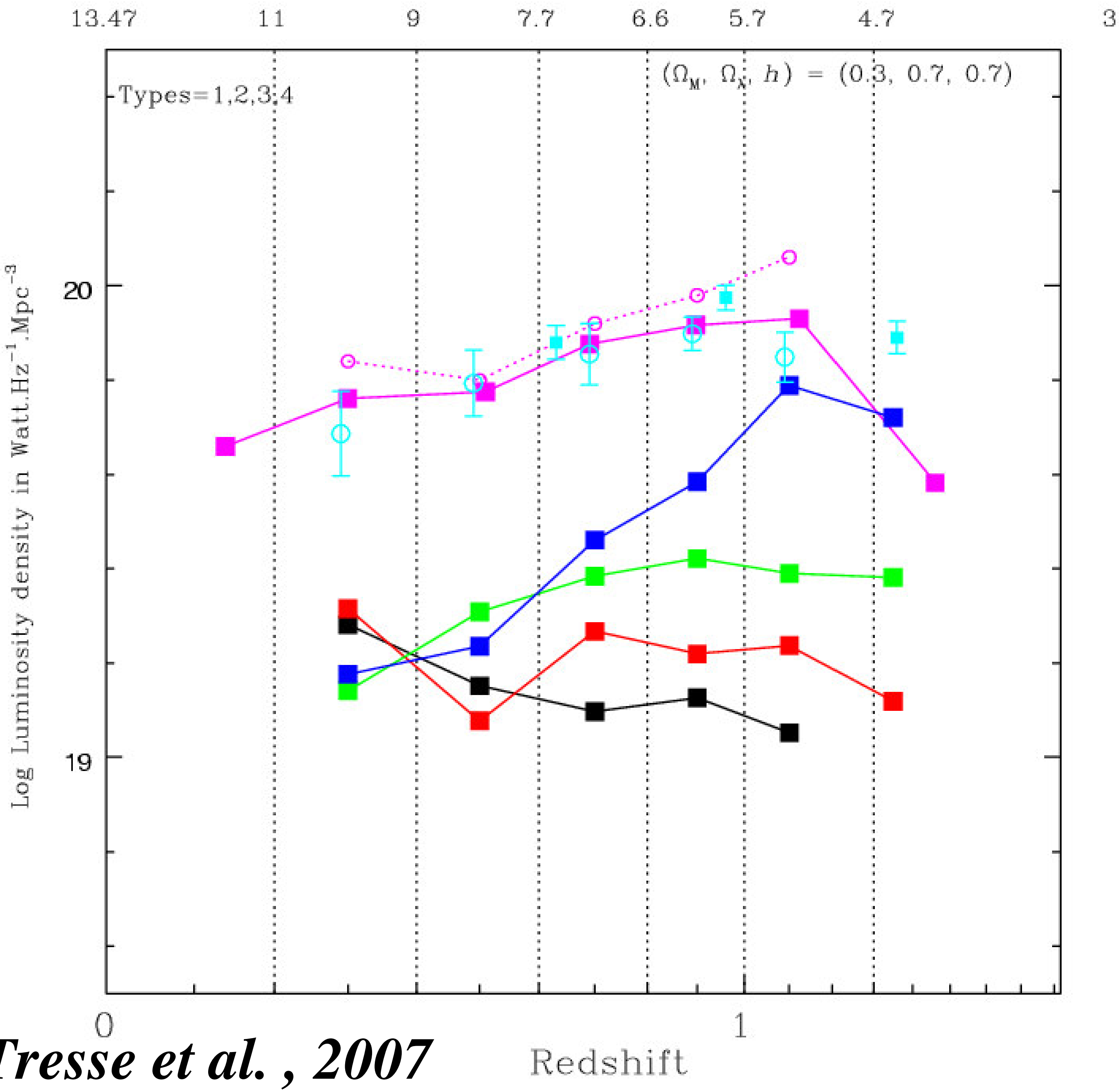
Non evolving templates to avoid to be model dependent (we verified this choice is acceptable for VVDS data)

Variations of the LF for different types



Steepening of the slope going from redder to bluer types
$\Delta\alpha \sim -1.3$ -1.5

Significant differences in M in the red bands which disappear in the blue bands*



Tresse et al. , 2007

The luminosity function of type 1 galaxies is consistent with a passive evolution up to z~1.1

Type 4 galaxies show a strong evolution in M (~1mag) and in normalization (~2x) up to z~1.3*
In particular bright (M_B<-20) type 4 galaxies increase of a factor ~6.6 from z~0.3 to z~1.3

Which is the role of the environment?

The zCOSMOS survey (P.I. S.Lilly)

zCOSMOS is a Large Program on the ESO VLT: 600 hours of observation are used to carry out a major redshift survey with the VIMOS spectrograph on the COSMOS field.

The project is divided in two parts:

The bright survey

aiming at observing ~28,000 magnitude selected galaxies with $I_{AB} < 22.5$ and $0.2 < z < 1.2$ over 1.7 sq.deg.

The deep survey

with ~12,000 galaxies selected through color-selection criteria expected to be at $1.2 < z < 3$, within the central 1 sq.deg.

COSMOS is an HST Treasury Project to survey a 2 square degree equatorial field with the Advanced Camera for Surveys (ACS). It is the largest survey that HST has ever done, utilizing 10% (640 orbits) of its observing time over the course of two years. The project also incorporates major commitments from other observatories around the world, including the VLA radio telescope, ESO's VLT in Chile, ESA's XMM X-ray satellite, and Japan's 8-meter Subaru telescope in Hawaii. The COSMOS collaboration involves almost 100 scientists in a dozen countries.

The zCOSMOS survey:
what is new?

➔ photometric coverage

the large number of bands allows a good SED fitting, for both photometric redshifts and spectrophotometric classification

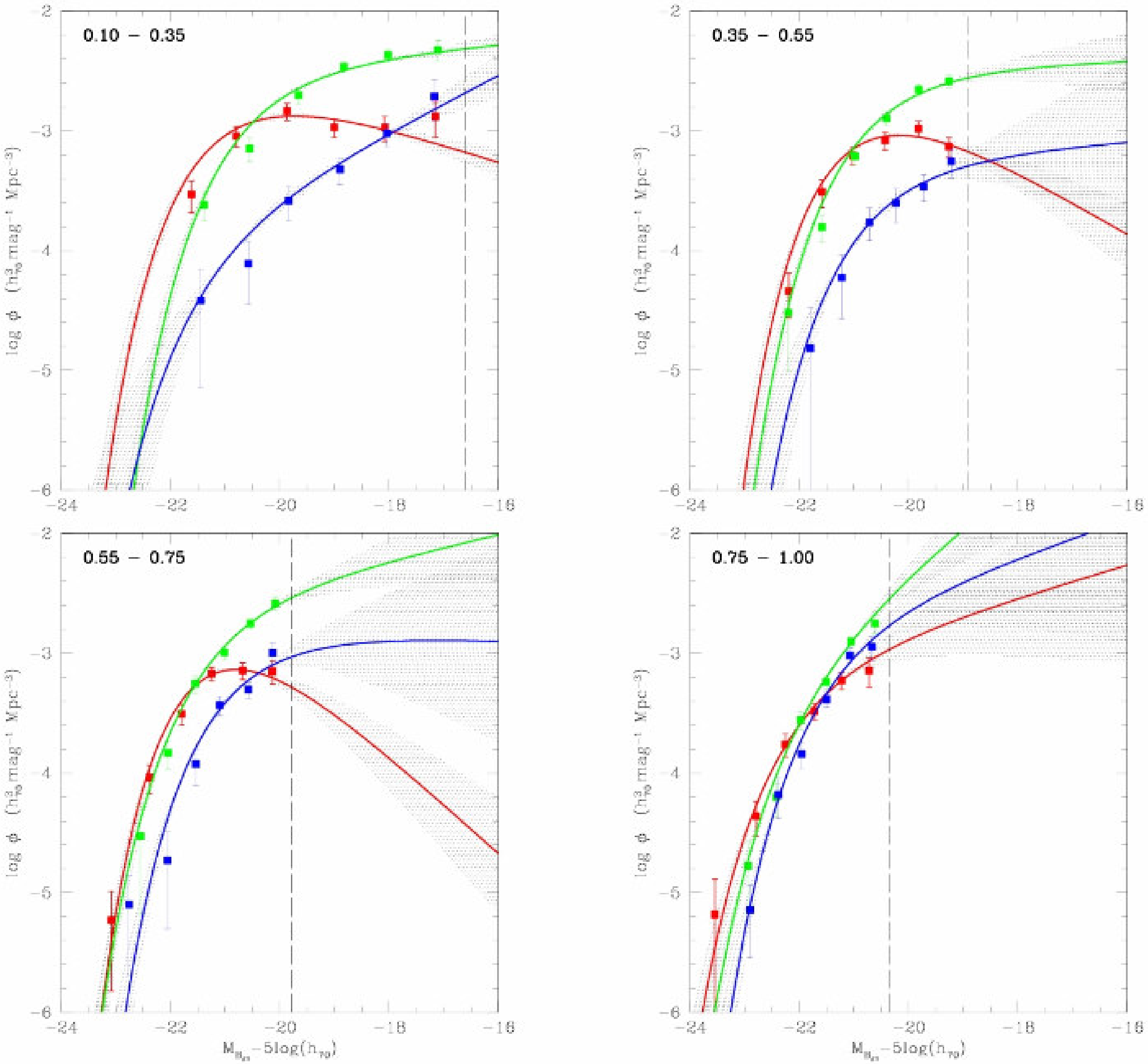
➔ HST morphologies

the ACS images allow a good morphological classification

➔ medium resolution

the medium resolution of the bright survey (R=600, corresponding to ~100 km/s) allows a good description of the environment

Which is the contribution of the different morphological types ?



Morphological classification based on HST images (Cassata et al.) (Tasca et al.)

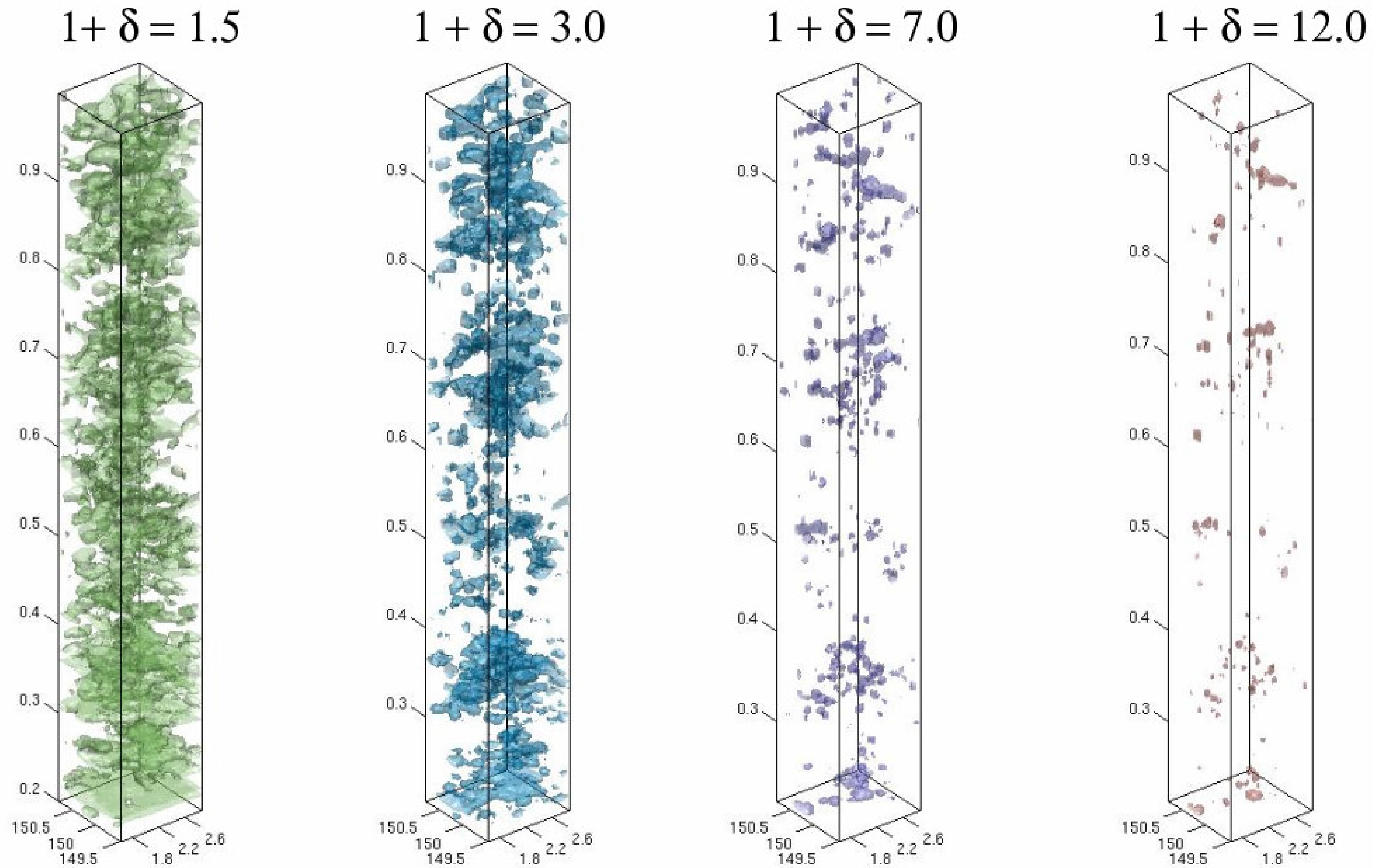
Ellipticals

Spirals

Irregulars

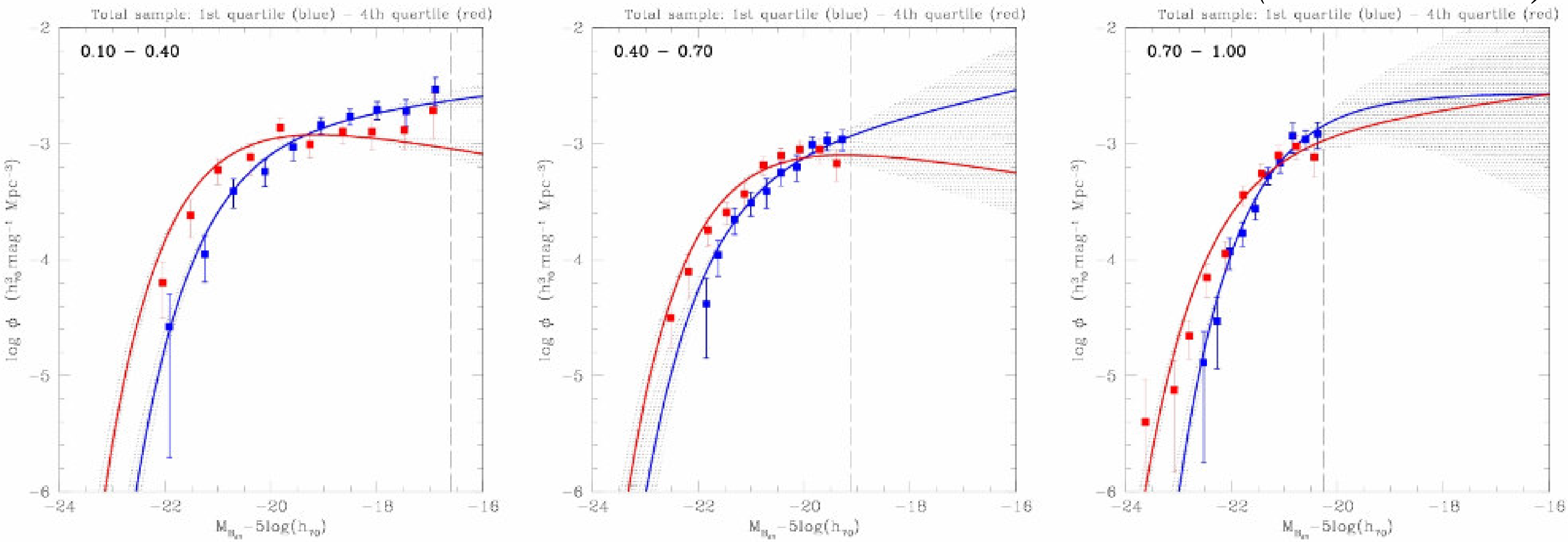
(Zucca et al. 2009)

zCOSMOS (over)density field (Kovac et al.)



Global LF as a function of the environment

(Zucca et al. 2009)



1st quartile

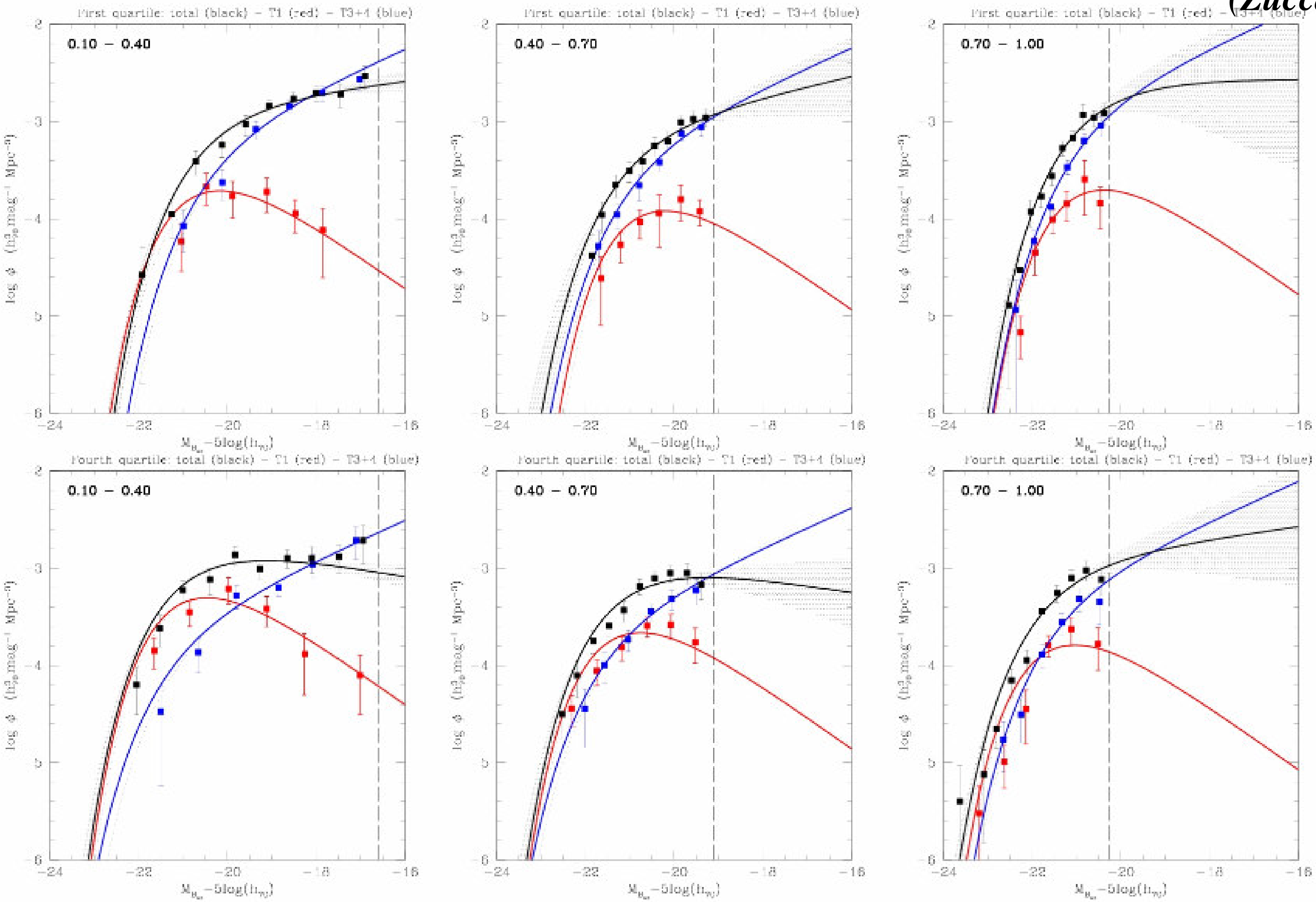
4th quartile

At all z, galaxies in underdense regions have a fainter M* and a steeper slope than those in overdense regions.

Is this trend due to the different mix of galaxy types in underdense and overdense regions?

The contribution of the different galaxy types

(Zucca et al. 2009)



underdense environments

overdense environments

Early types **Late types** **Total sample**