Morphologie des galaxies vs. Spectral Energy Distribution: Evolution depuis z~1-1.5

R. Pello, F. Ienna, ...

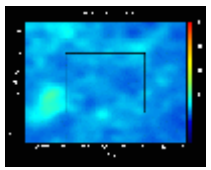
- ***Qu'est-ce qu'on peut apprendre des photo-z?***
  - **Technique de *SED fitting* et précision des mesures**
  - **Ajustement des « paramètres fondamentaux »:**
    - **Distribution spectrale en Énergie *(SED) restframe***

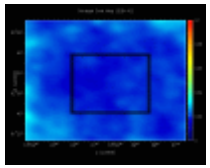
    => types spectro-photométriques
    - **Masses stellaires => Histoire d'assemblage des galaxies**
    - **Densité locale => évolution des galaxies vs. environnement**
- ***Morphologie et photo-z***
  - **Corrélation *SED restframe* et Type morphologique: évolution**
  - **Époque d'assemblage des bulbes/galaxies E-S0**
  - **« Hot spots » vs [SED intégrée, SFR, environnement, z]**
  - **Évolution des disques**

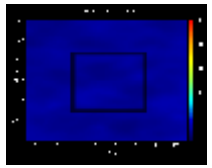
CFHTLS Deep Fields/ Data Release T0003...

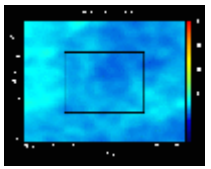
Survey	Area (deg x deg)	Filters	Depth for a point source SNR=5, 1.15"ap.,0.8"	Total integration per field	Observing strategy
Deep Synoptic: ~3 nights per run & 5 runs a year for each of the four fields					
	4	u*	28.7	33 hr (10%)	11 x 660 sec per run
		g'	28.9	33 hr (10%)	4.25 x 5 x 225 sec per run
		r'	28.5	66 hr (20%)	5.25 x 5 x 360 sec per run
		i'	28.4	132 hr (40%)	5.25 x 7 x 520 sec per run
		z'	27.0	66 hr (20%)	5.25 x 5 x 360 sec per run

Fields selection


D1


D2

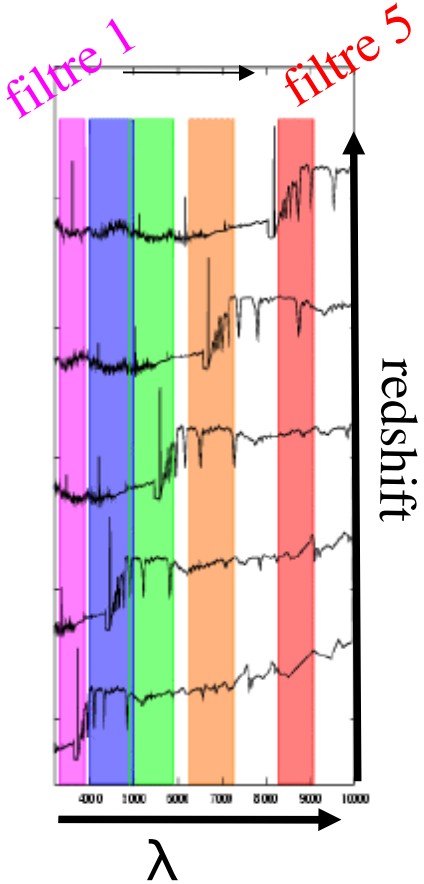

D3


D4

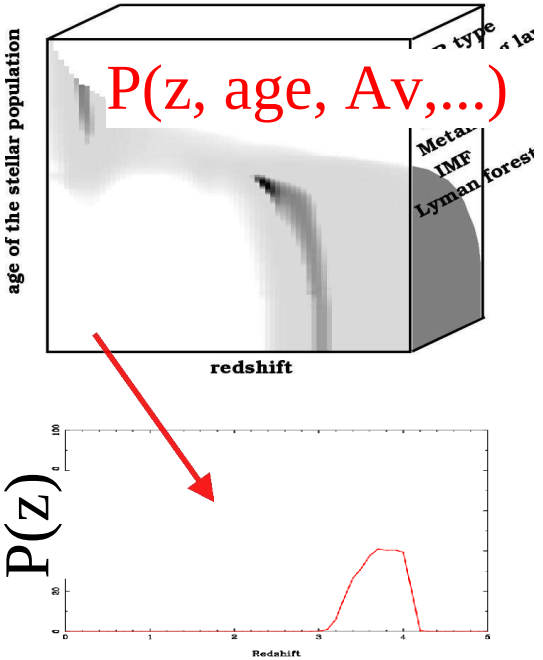
	Alpha (2000)	Dec (2000)	Comments
D1	02h 26m 00s	-04d 30m 00s	Embedded in the CFHTLS-W1 field. - Centered in the Deep area of the VLT-VIRMOS Deep Survey field, in which spectroscopic optical follow-up is taking place at the VLT with VIMOS, up to I_AB=24 at more than 80% completeness. - Located within the area covered by the XMM-LSS survey : 20 ksec XMM pointings per field. - Also a GALEX and SIRTF target
D2	10h 00m 29s	02d 12m 21s	Field selected within the area of the Cosmos/ACS project. HST data will be publicly available very rapidly. - Several multi-wavelength follow-ups on-going or planned (XMM, GALEX, SIRTF, ESO/VIMOS ...). Quick release of the data. - low extinction field
D3	14h 19m 28s	+52d 40m 41s	Embedded in the CFHTLS-W3 field. - Located within the "Groth Strip" area, with low extinction. - Redshifts available from the Deep II collaboration (I_AB<23.5), obtained with the Keck telescope. - Also a GALEX target
D4	22h 15m 31s	-17d 44m 00s	Field selected for its lowest extinction field around RA=22h. - Centered around the quasar LBQS2212-17 in the anti-Leonids area. A deep XMM-Newton exposure (250ksec) publicly available. Source positions and catalogues developped by the XMM SSC are expected to be released soon.

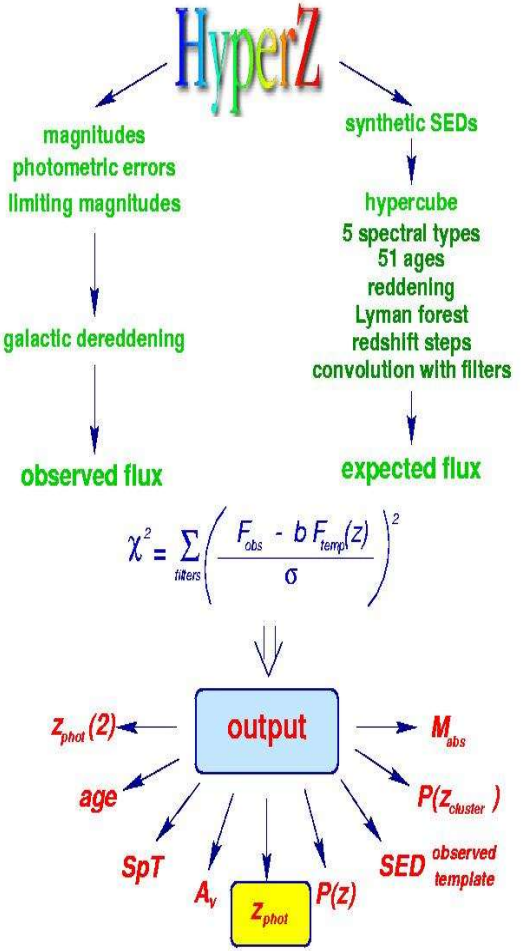
Redshift Photometrique (I)

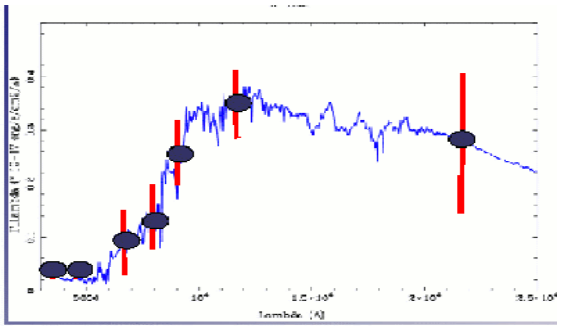
- **Calculé avec le logiciel *New_hyperZ* (*Bolzonella et al. 00*, *http://webast.ast.obs-mip.fr/hyperz* et http://www.ast.obs-mip.fr/users/roser/hyperz (nouvelle version)**



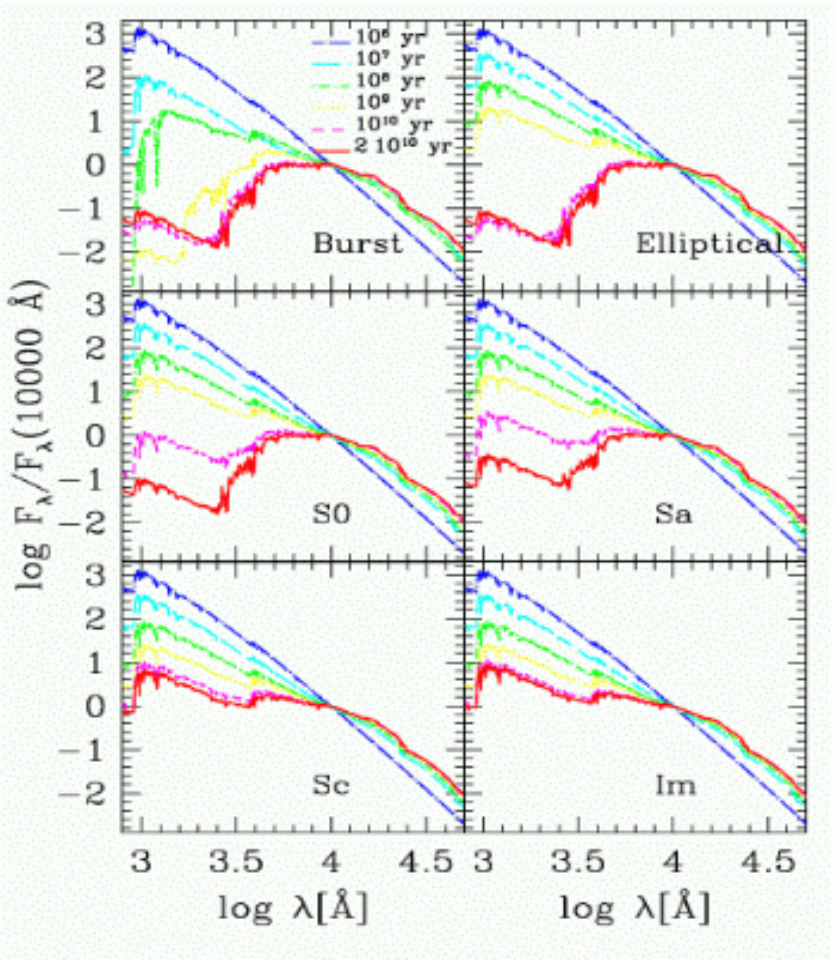
Photometric redshifts based on **standard SED fitting** with a large number of templates & parameter settings.

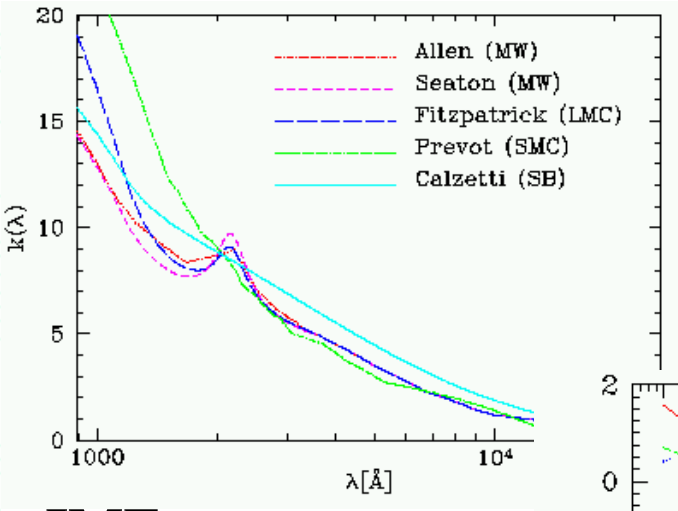






Redshift Photometrique (II)





Reddenning law

E(B-V):

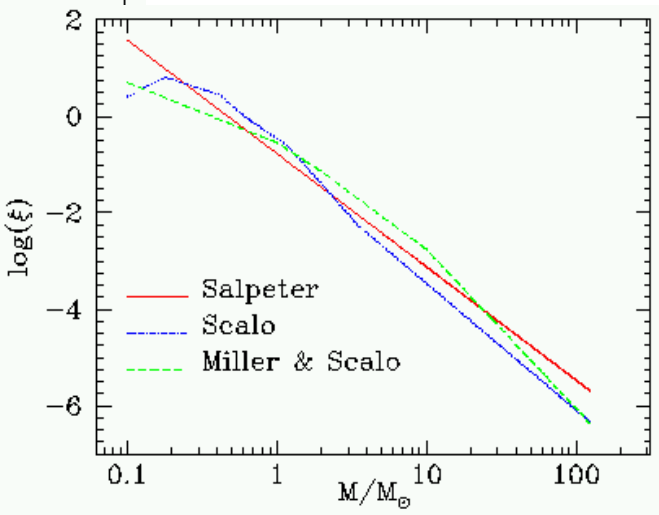
MW (global/par object)

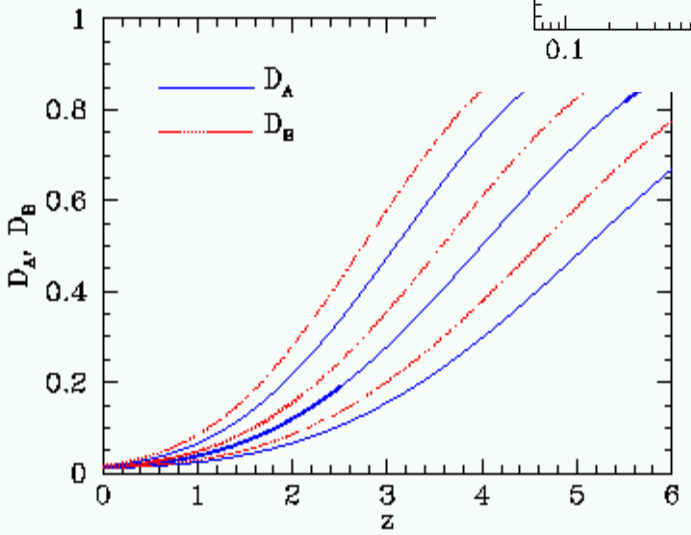
local

IMF

SFR type

Metallicity





Lyman Forest

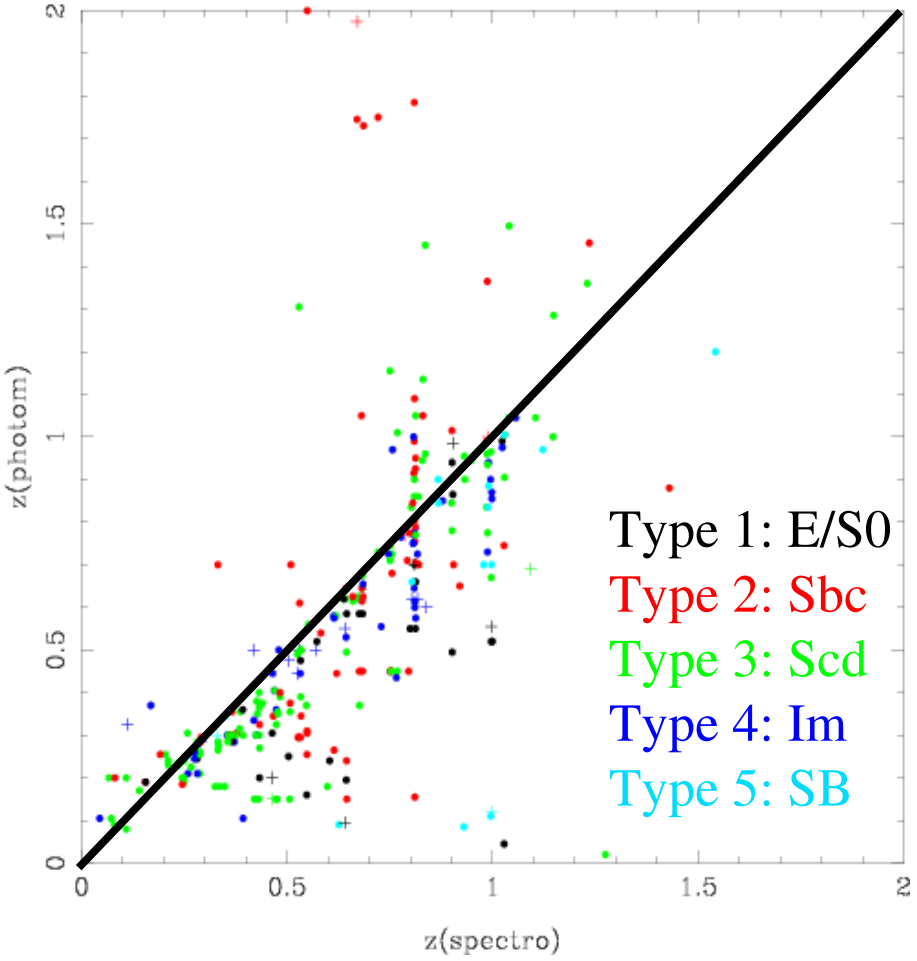
+

QSO/galaxy/*

Photoz Products: z_best + error bars, xi2, P(z), best-fit SED (template, age, Av, ...), L_λ, stellar masses

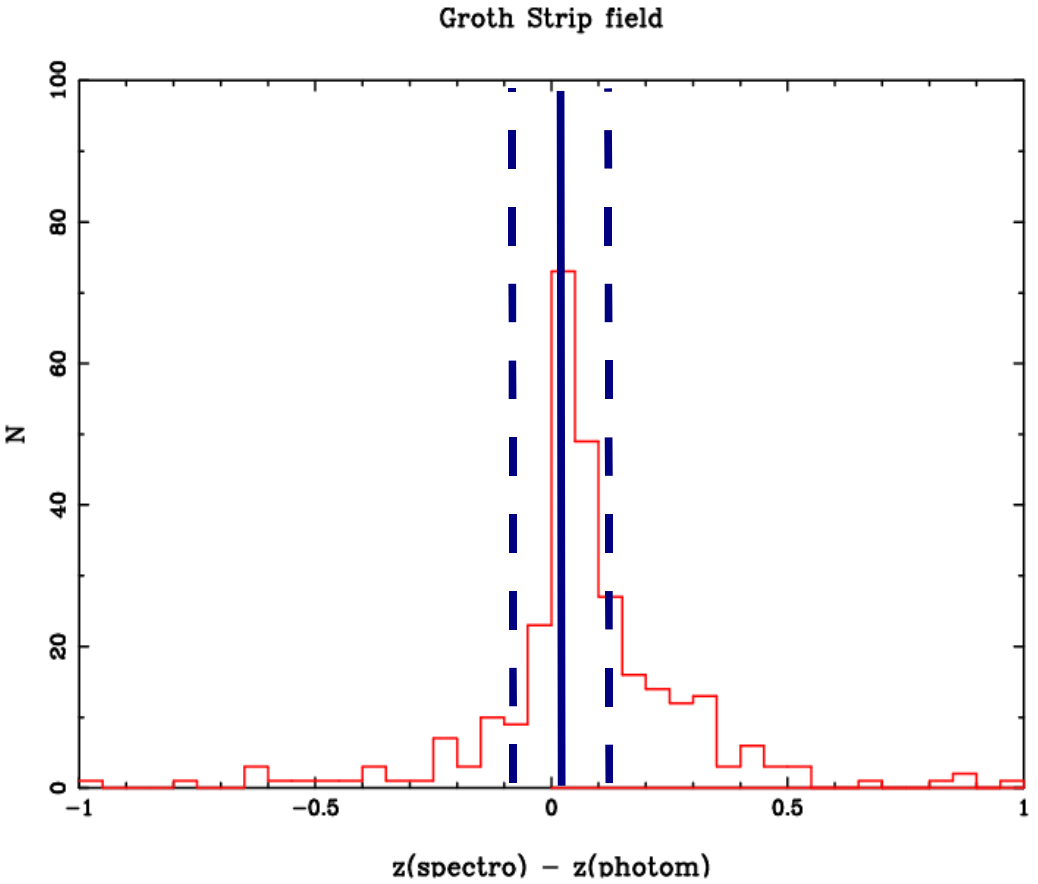
+ a rough spectral-type classification: E, Sbc, Scd, Im, SB

Photoz accuracy: blind comparison with spectroscopic samples

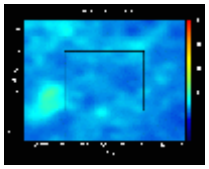


314 Objects:

dz~ 0.07 --> slight shift



Photoz accuracy: blind comparison with spectroscopic samples (D1)

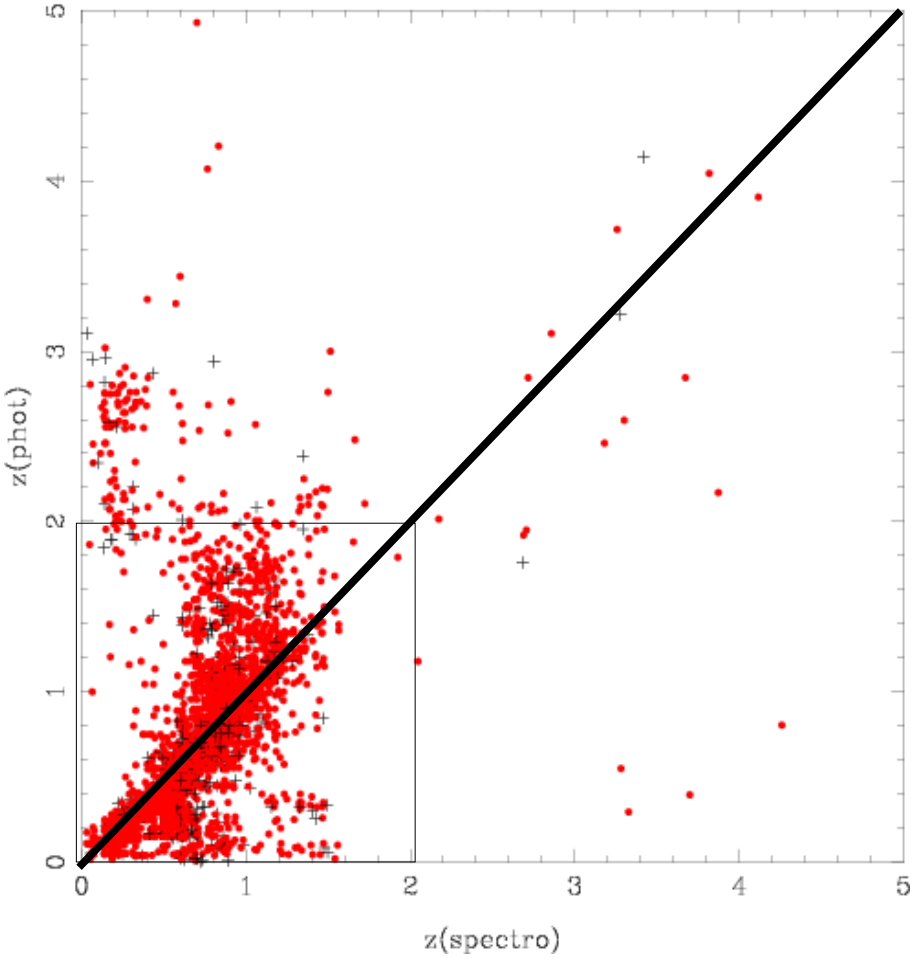


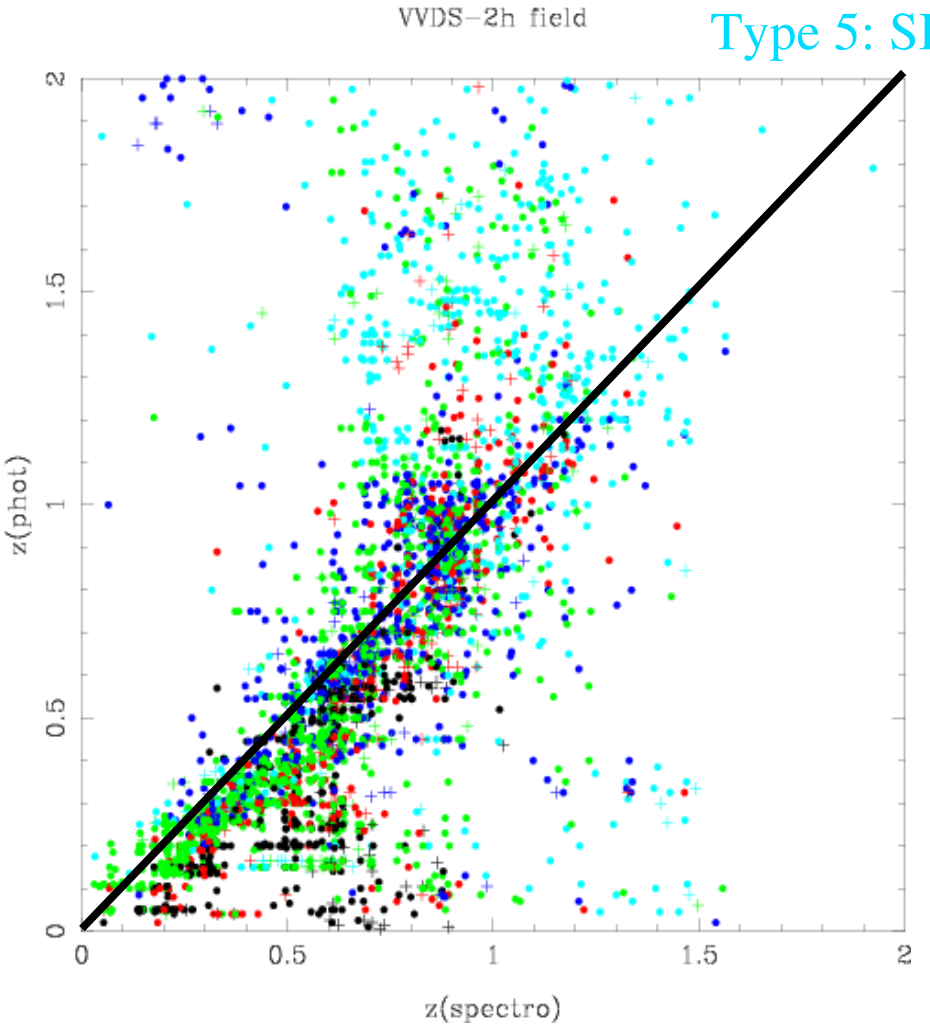
VIRMOS

VVDS−2h field

sigma(z)~0.05 a 0.1
entre z~0->1.5

Type 1: E/S0
Type 2: Sbc
Type 3: Scd
Type 4: Im
Type 5: SB





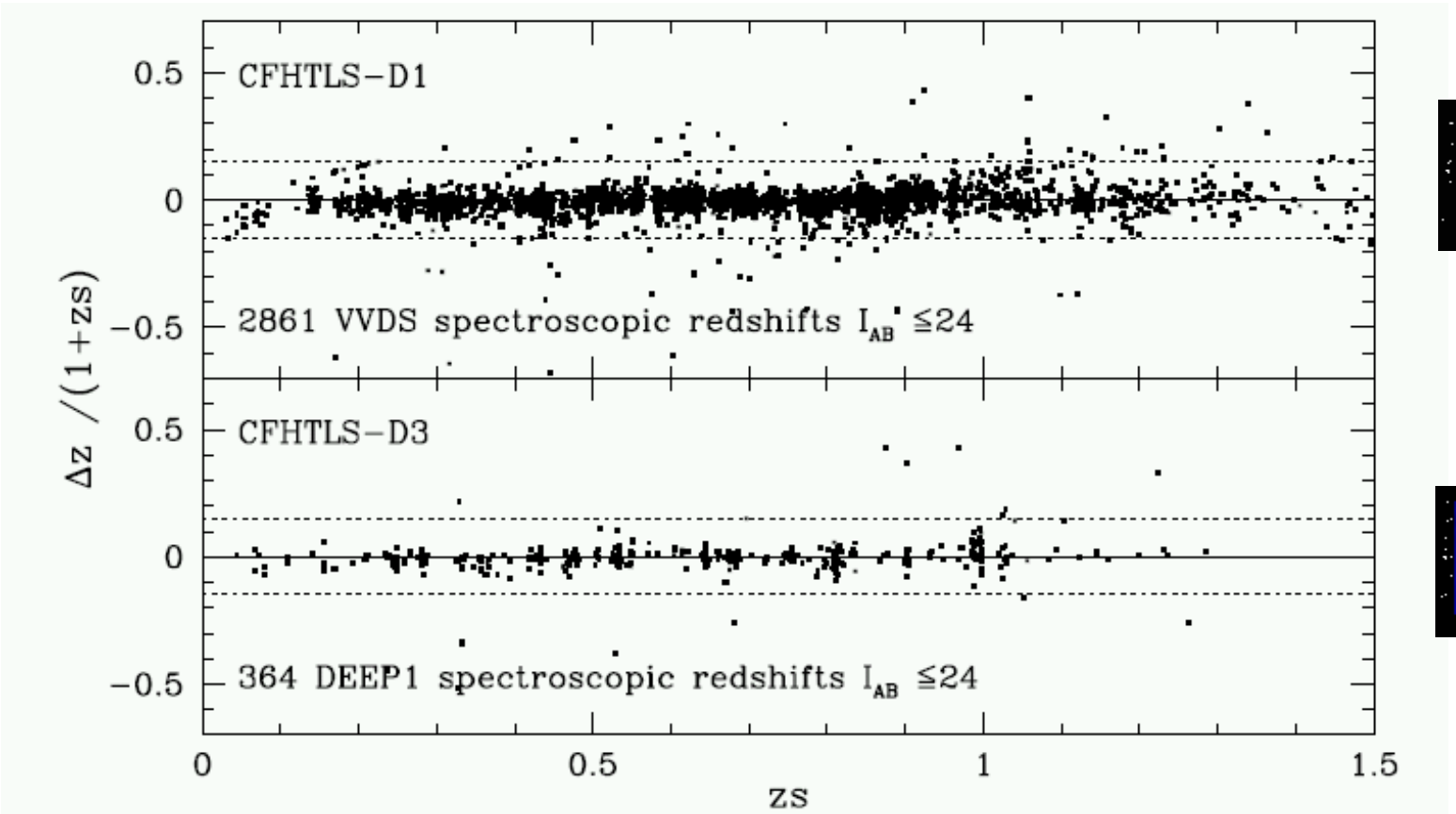
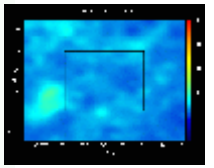
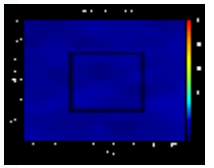


Fig. 14. Δz as a function of redshift. The photometric redshifts are computed using the CFHTLS filter set u^*, g', r', i', z'. The top and bottom panels present the photometric redshifts obtained on the CFHTLS-D1 and CFHTLS-D3 fields respectively.



D1



D3

Illbert et al. 06

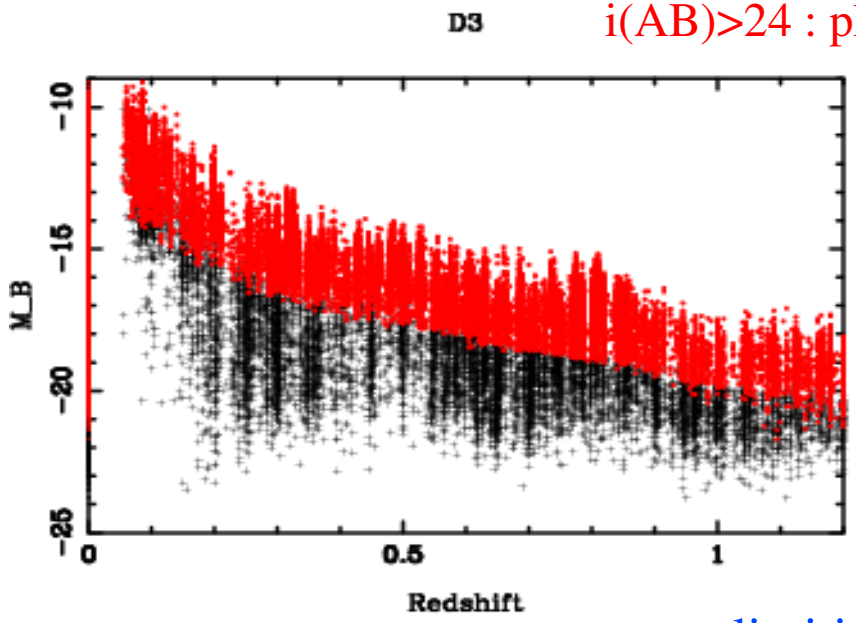
sigma(z)~0.04 a 0.7 entre z~0 et 1

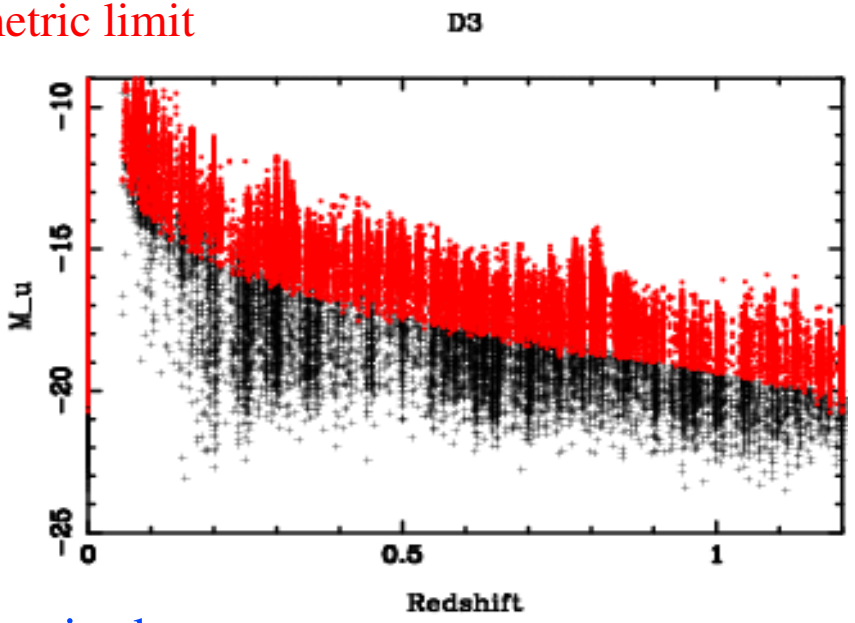
catastrophiques < 10%

N(z): Magnitude Selected samples

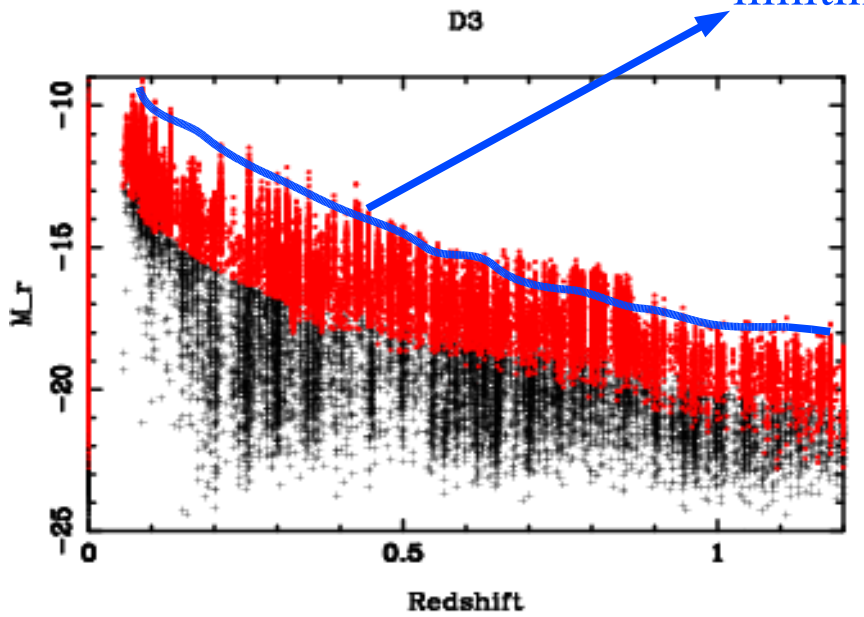
i(AB)<24 : spectroscopic limit

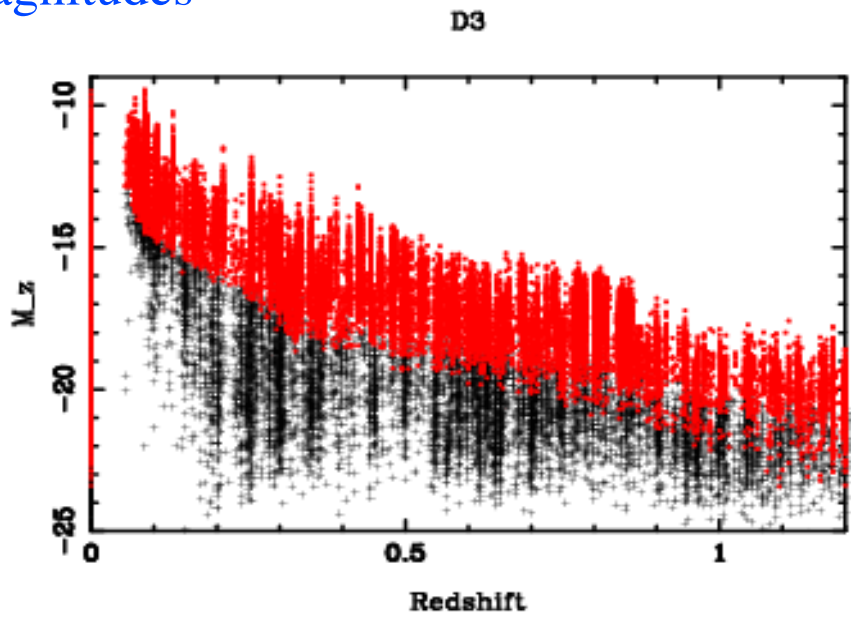
i(AB)>24 : photometric limit



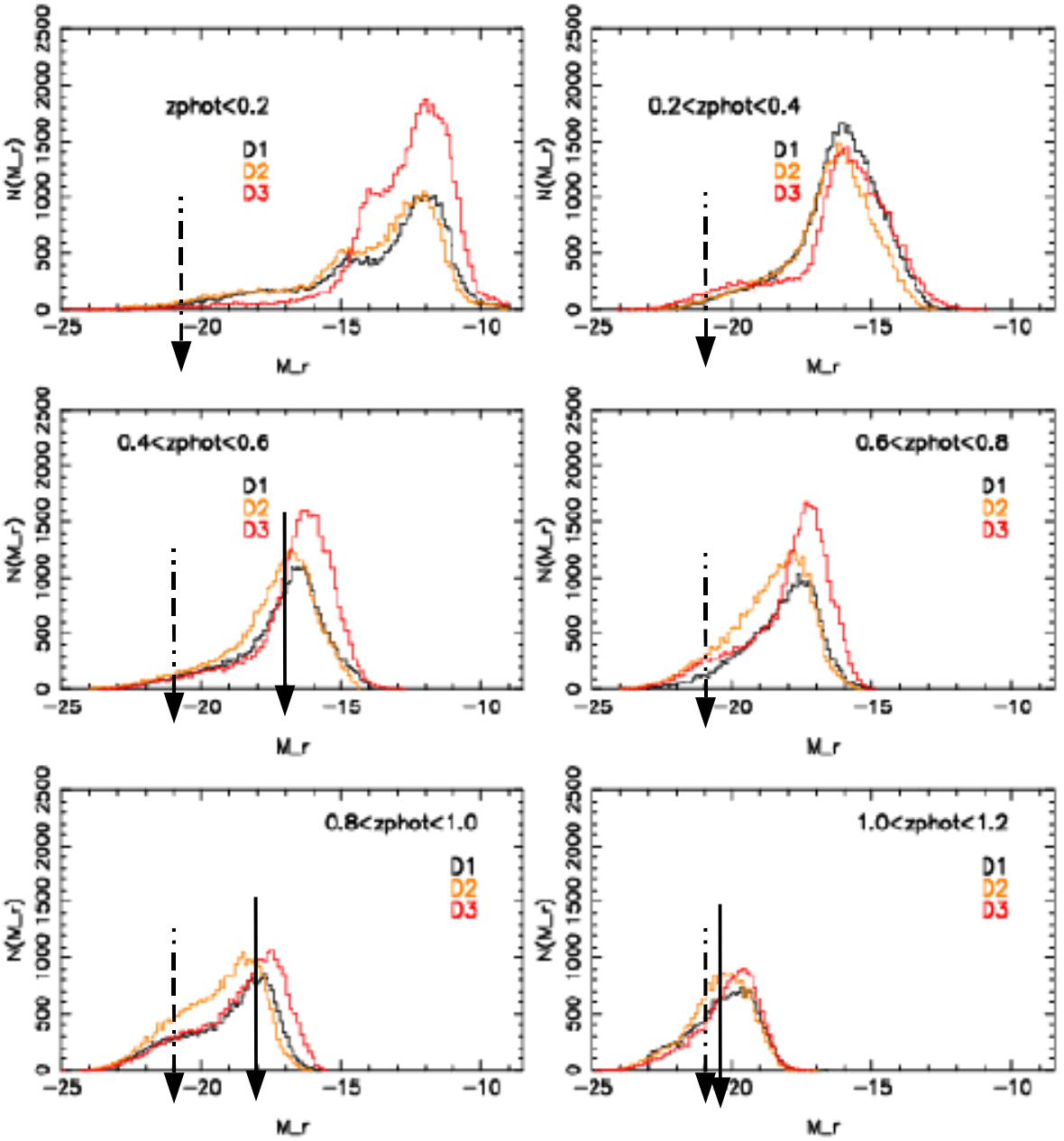


limiting magnitudes





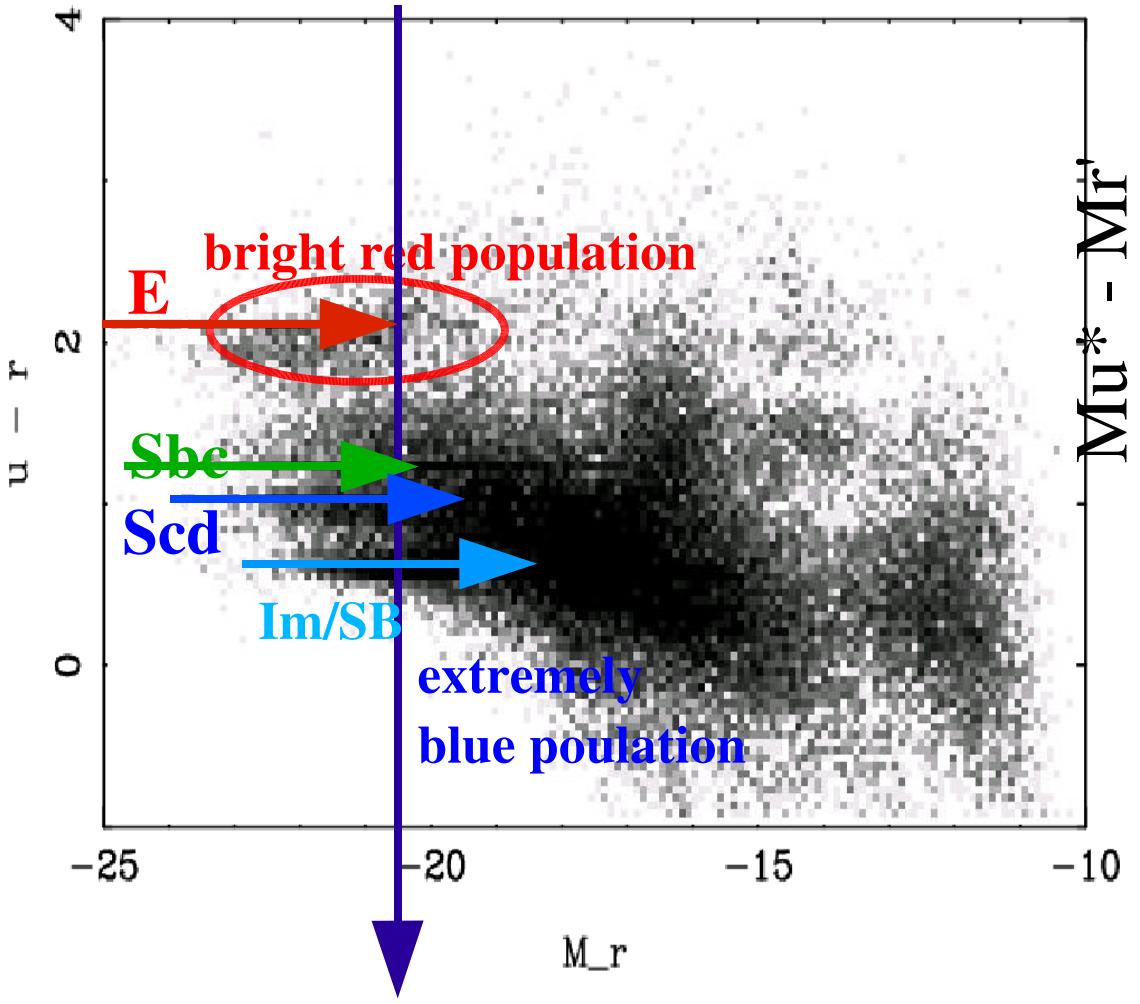
Magnitude selected samples in D1/D2/D3

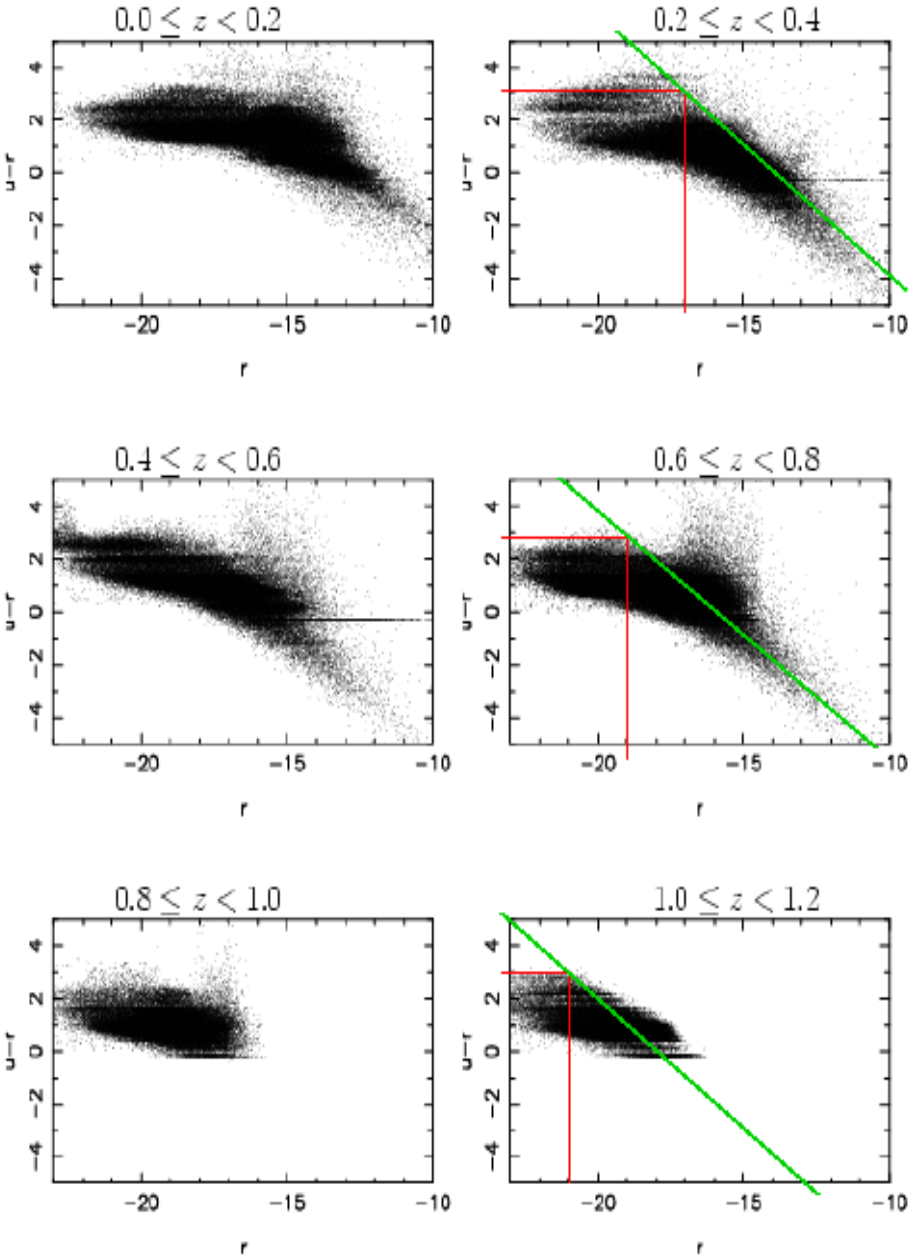


SDSS Mag limit: ·····→

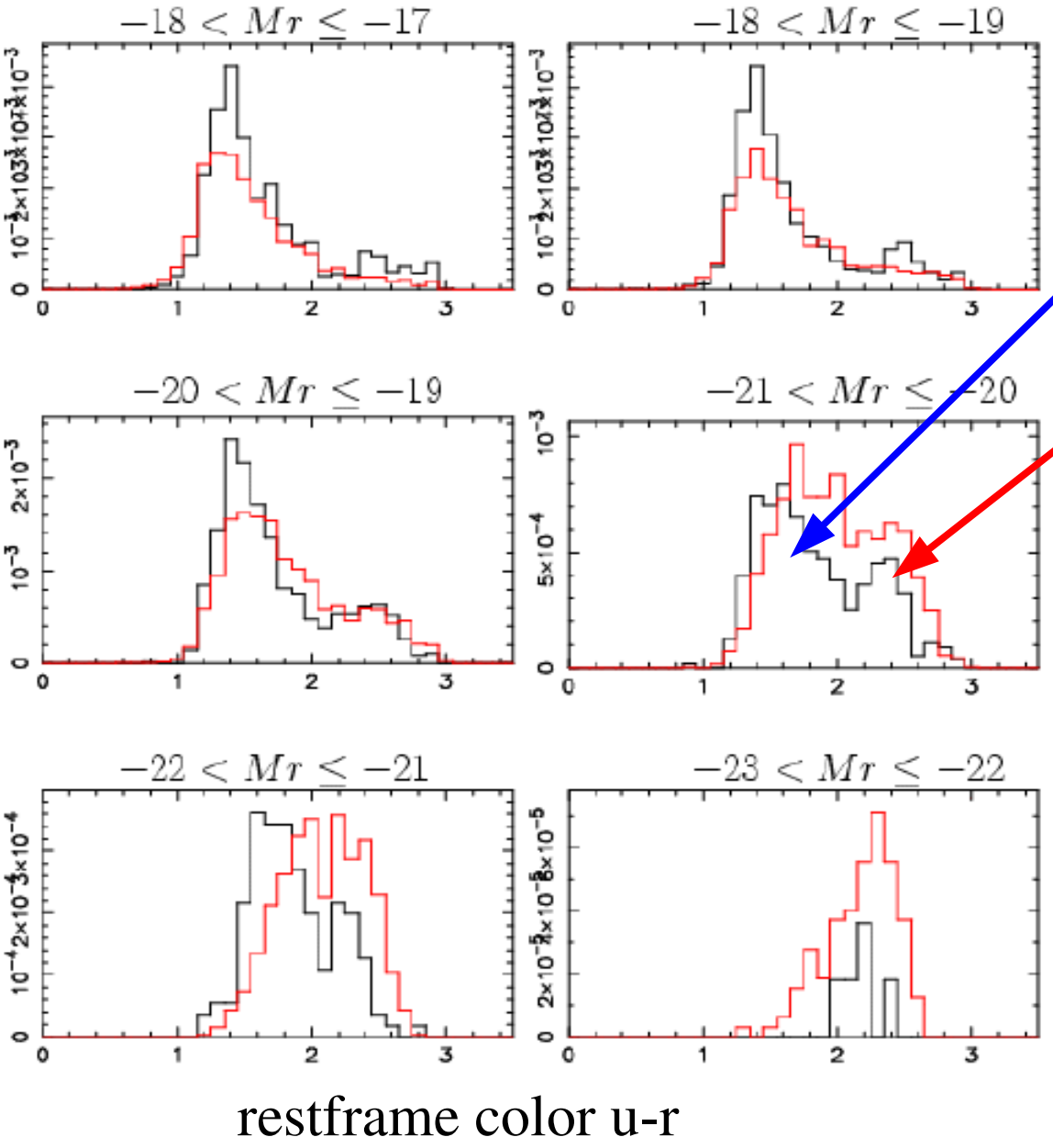
CFHTLS Mag limit: ——→

- Sample of galaxies: objects which cannot be rejected as galaxies to 90% confidence level.
- D1 + D2 + D3 *homogeneous sample:* 577.000 galaxies between $0 < z < 1.2$
- For each galaxy, we determine zphot, best-fit type (E/Sbc/Scd/Im-SB) and restframe properties (M_λ, stellar masses, etc).


bright red population
E
Sbc
Scd
Im/SB
extremely
blue poulation
u − r
M_r
Mu* - Mr'
SDSS completeness


0.0 ≤ z < 0.2
0.2 ≤ z < 0.4
0.4 ≤ z < 0.6
0.6 ≤ z < 0.8
0.8 ≤ z < 1.0
1.0 ≤ z < 1.2
u−r
r
Absolute Magnitude Mr'

Color Evolution versus Luminosity



late-types

early-types

0<z<=0.2

0.2<z<=0.4

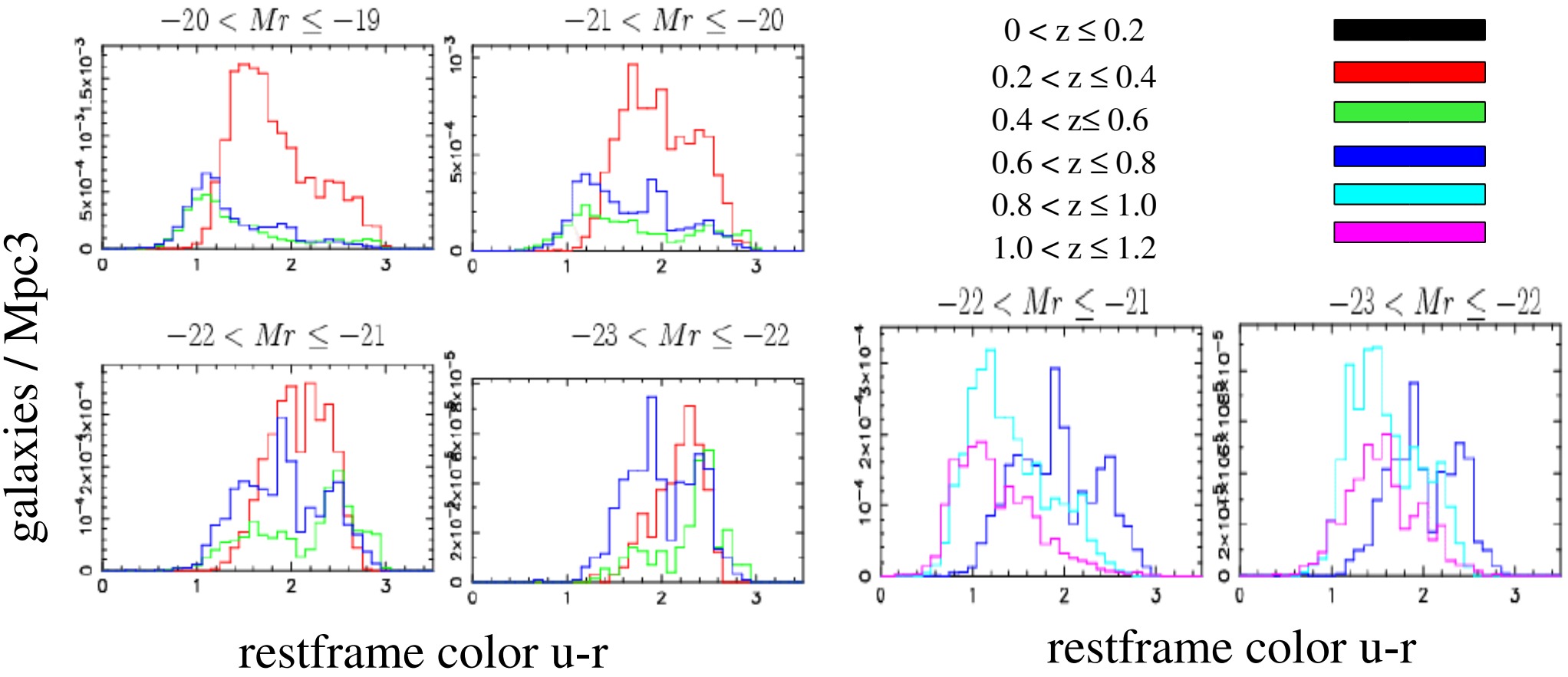
0.4<z<=0.6

0.6<z<=0.8

0.8<z<=1.0

1.0<z<=1.2

Color Evolution versus Luminosity



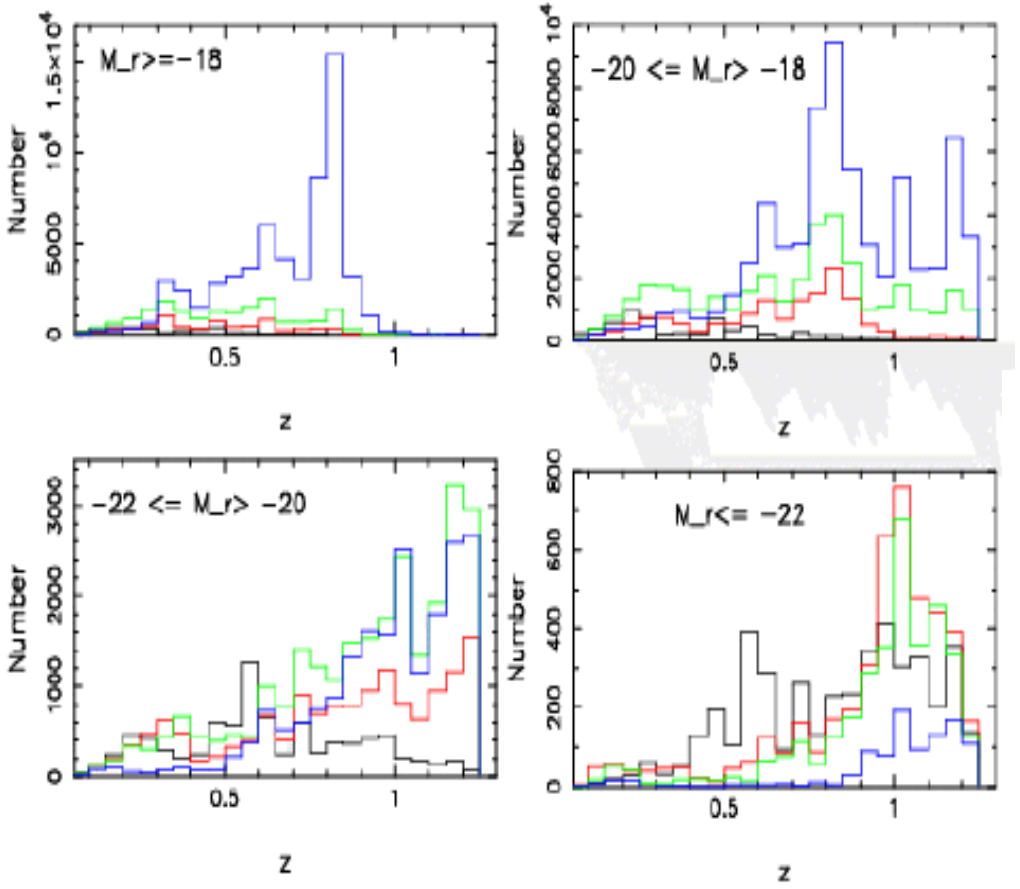
On observe une distribution bimodale en couleur:

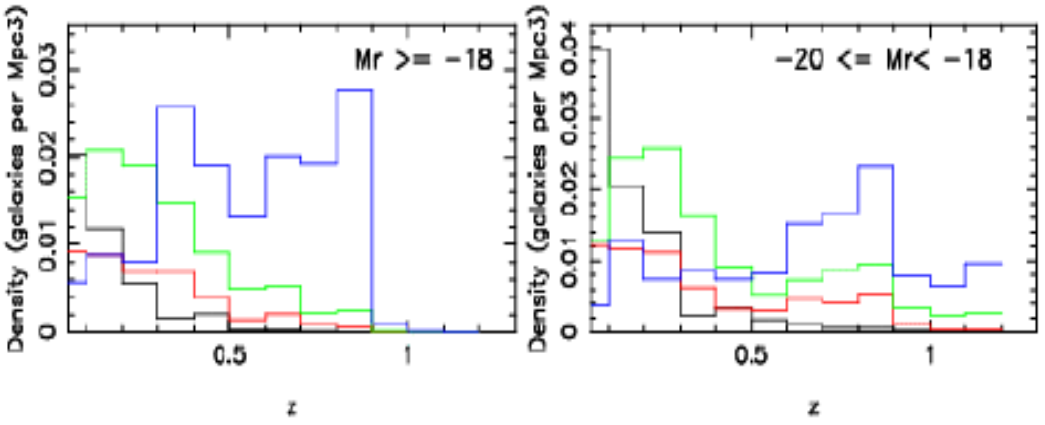
• Population bleue aux luminosités faibles jusqu'à z_phot ~0.8.

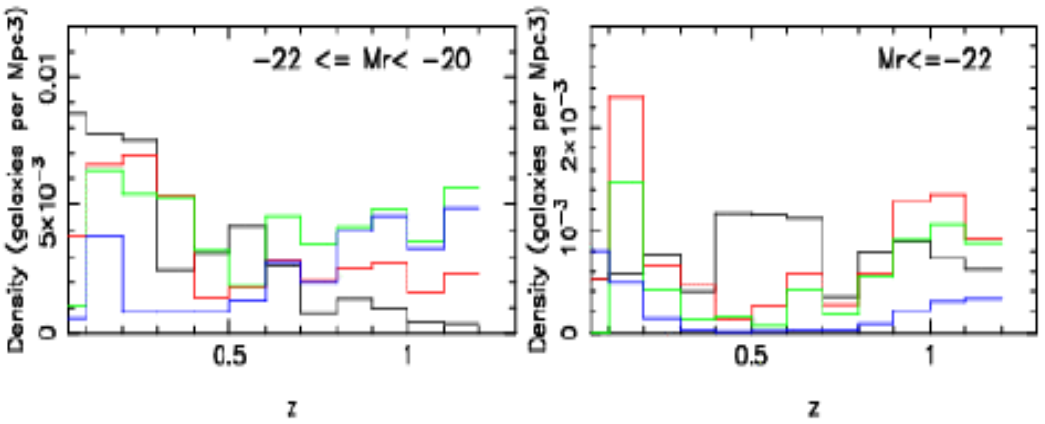
• Population rouge domine les luminosités brillantes jusqu'à z_phot ~0.8.

➔ Jusqu'à z_phot ~0.8, la couleur moyenne des galaxies bleuit quand le *redshift* augmente et quand la luminosité diminue. Au delà, une population bleue importante existe à Mr ≤ -21.

Evolution of spectral types versus Luminosity







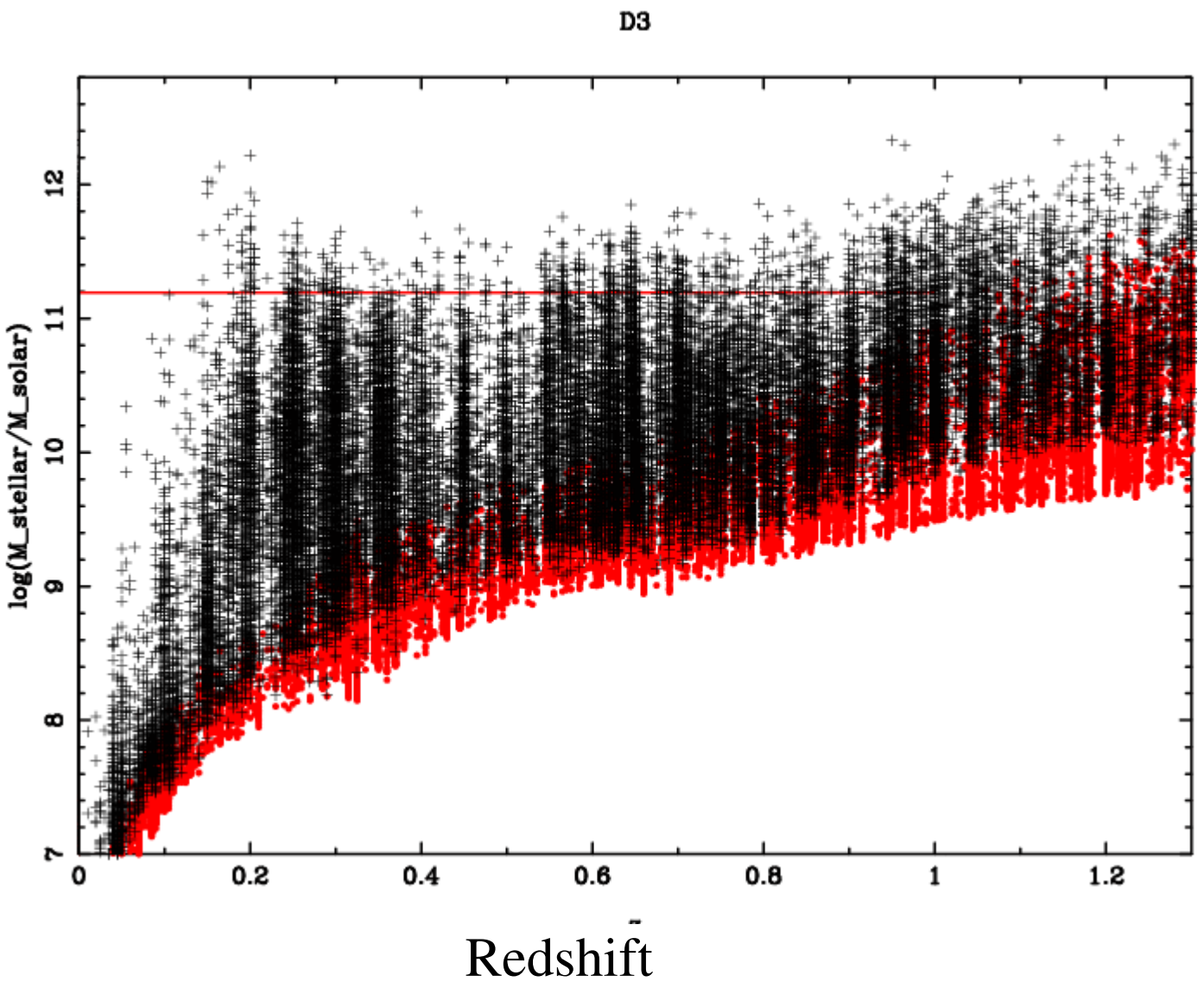
E/SO

Sbc

Scd

Im/SB

Stellar Masses



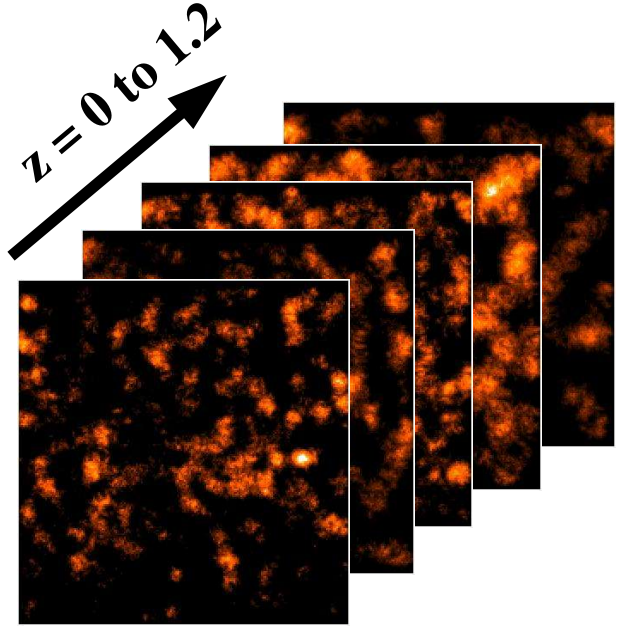
Stellar masses obtained by simple SED fitting:

- Scaling to the z-band luminosity.
- Best-fit model
- Maximum age best-fit model

Example: D3
i(AB)>24 +
i(AB)<24,
with S/N(z)>3

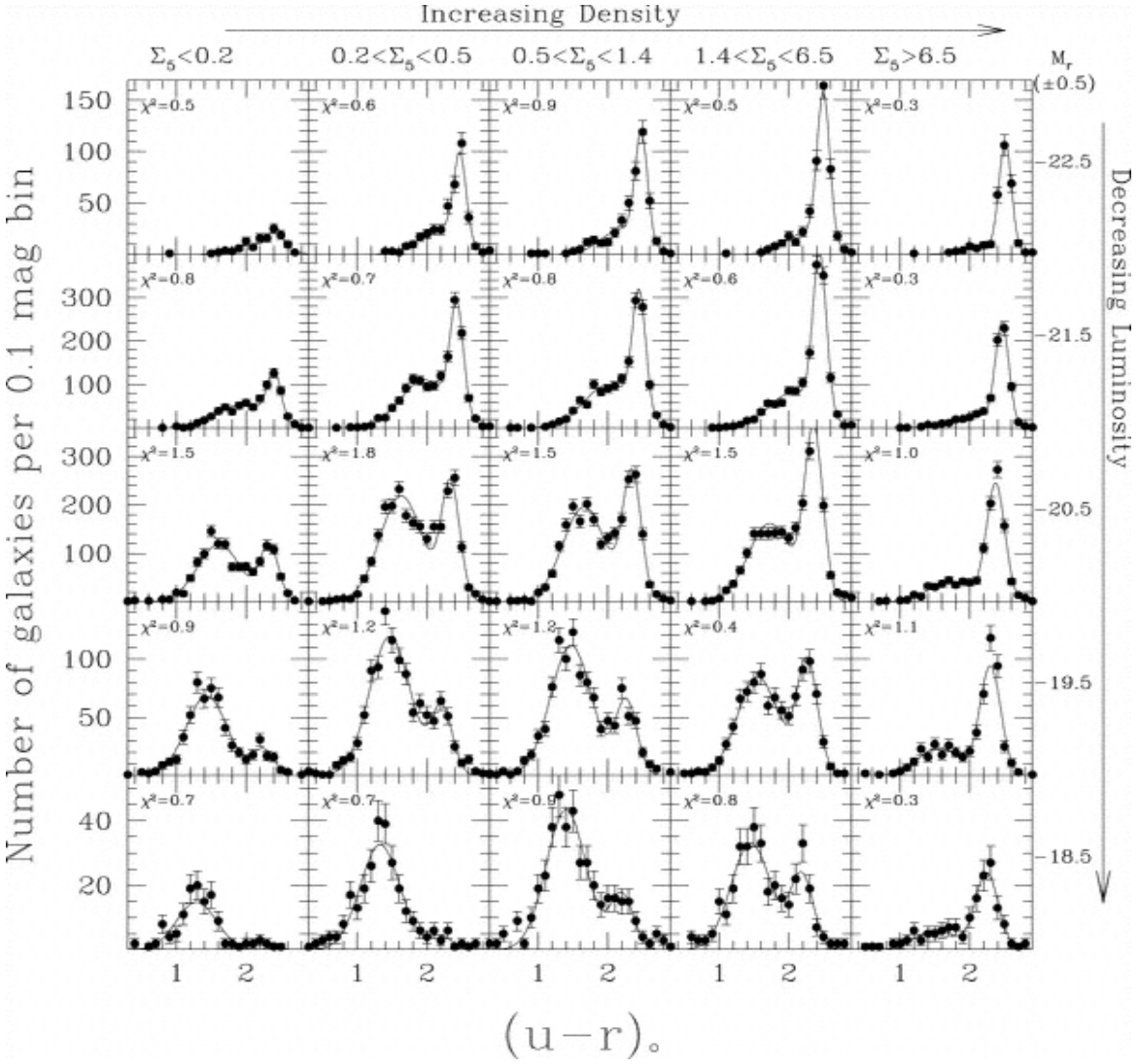
Properties of galaxies versus environment

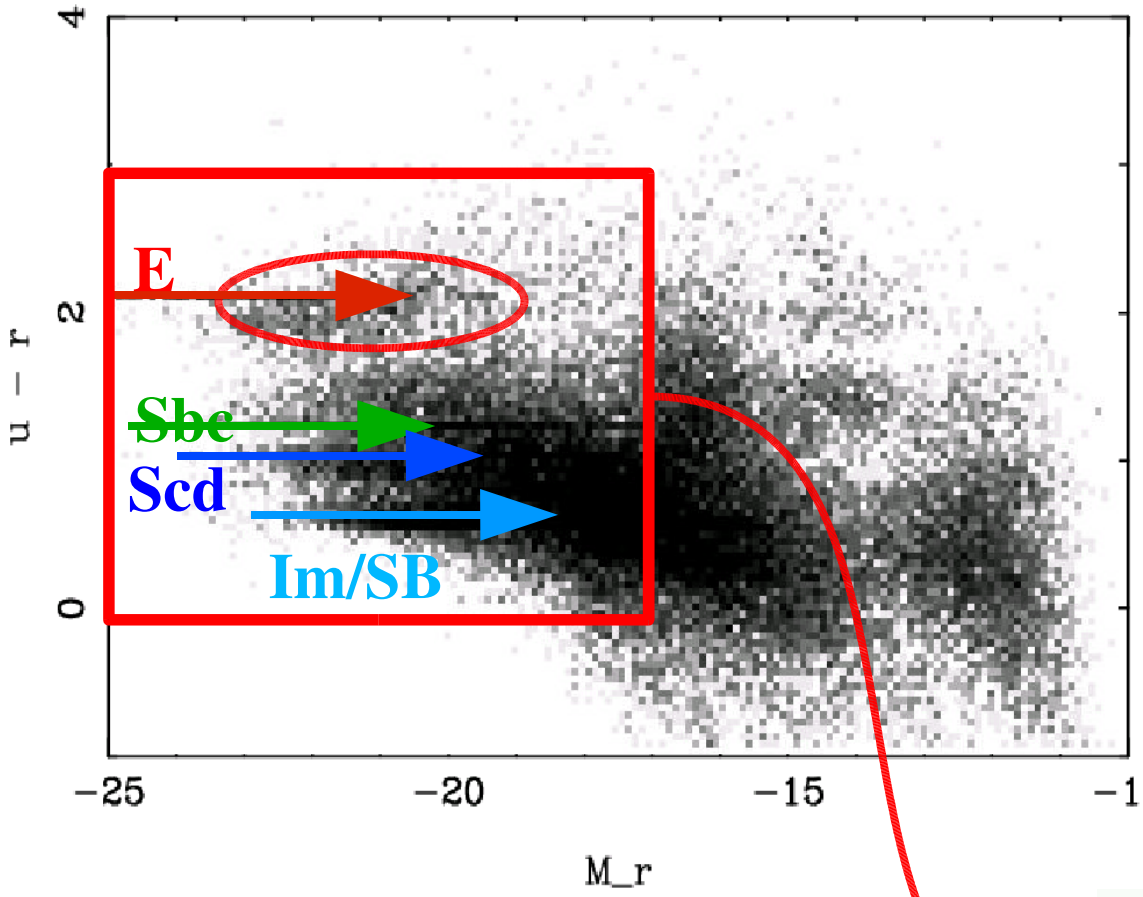
- Object: (α, δ, P(z)).
- We use the same «local density » estimators as for spectroscopic samples (SDSS).

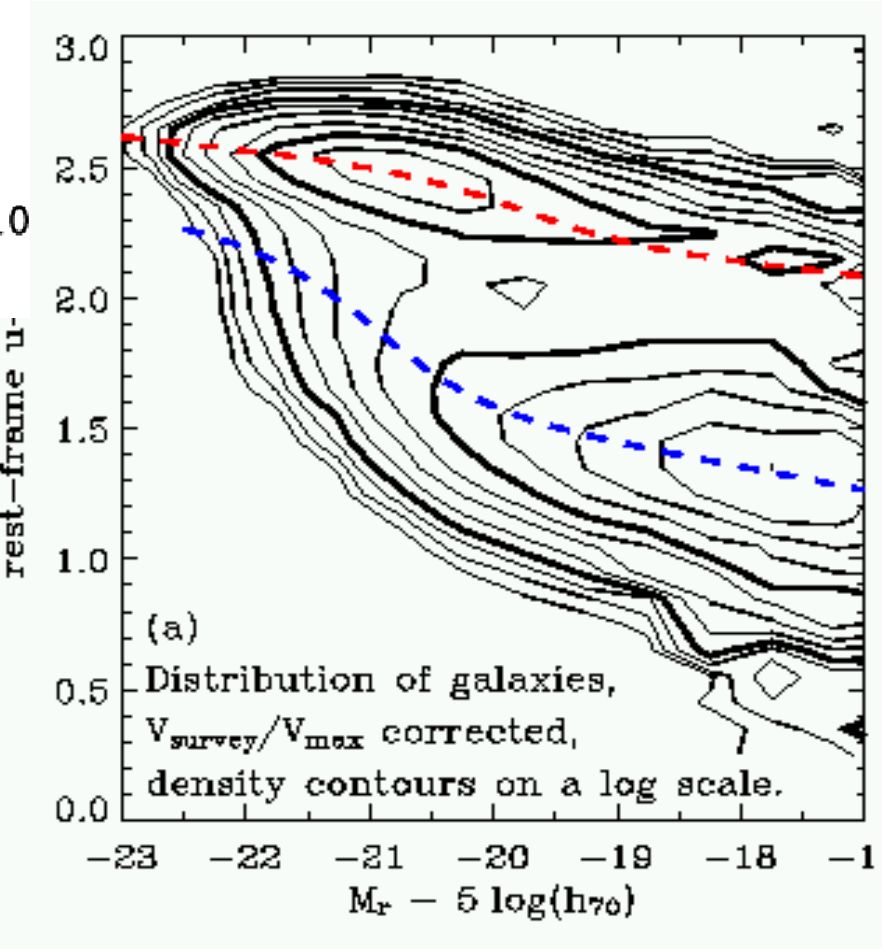


Local density estimator: Σ_5

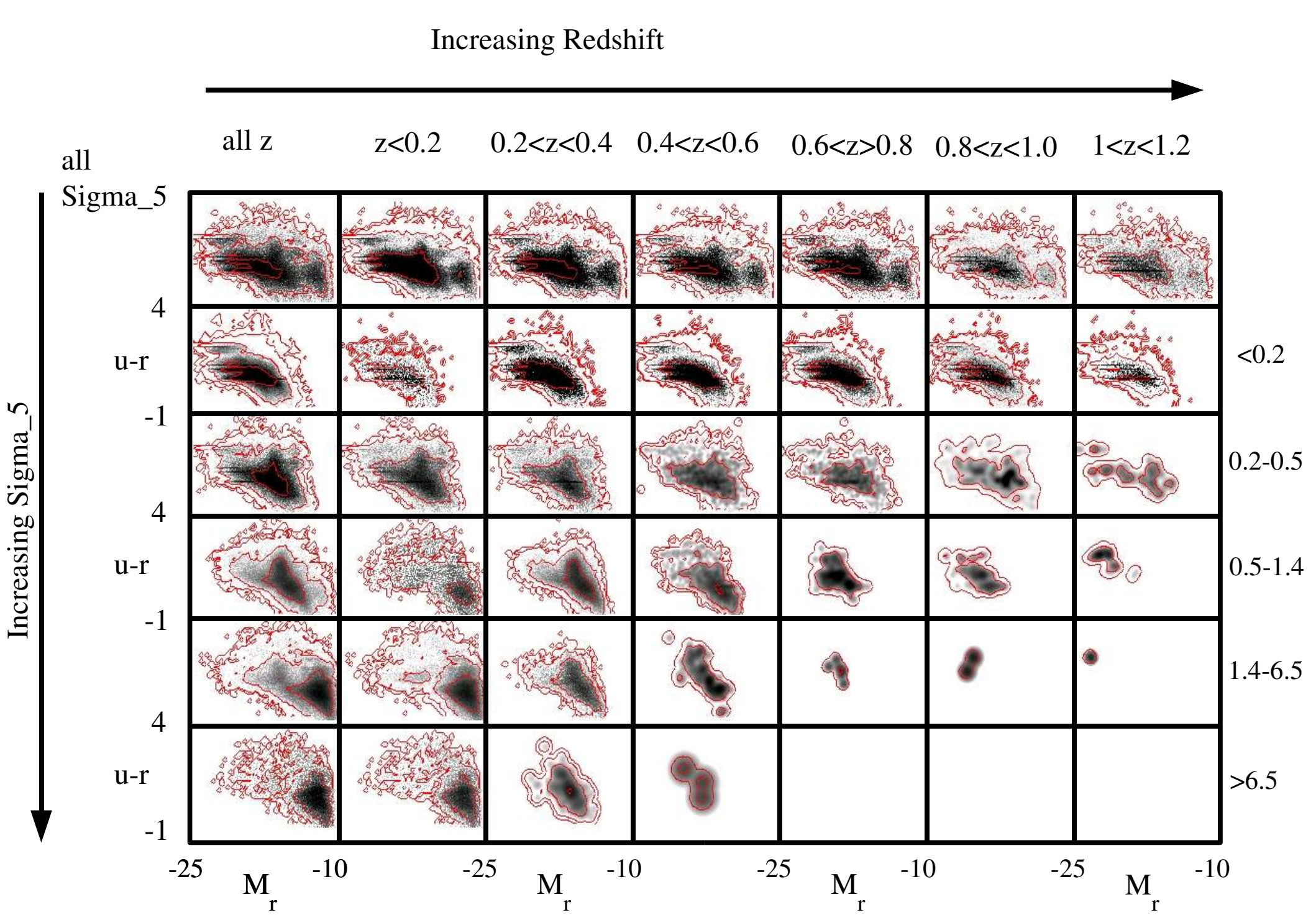
(Baldry et al. 04; Balogh et al. 04)

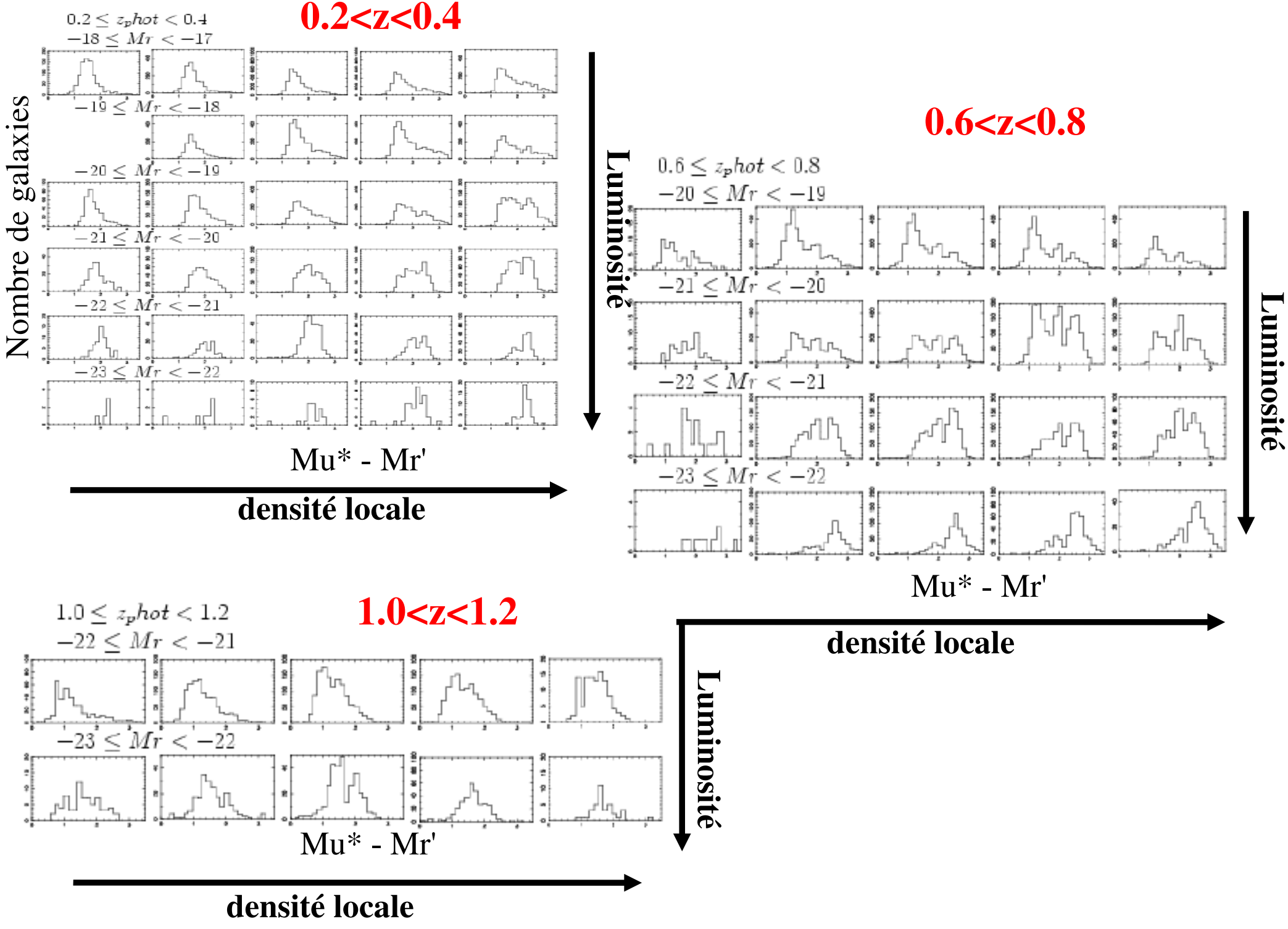




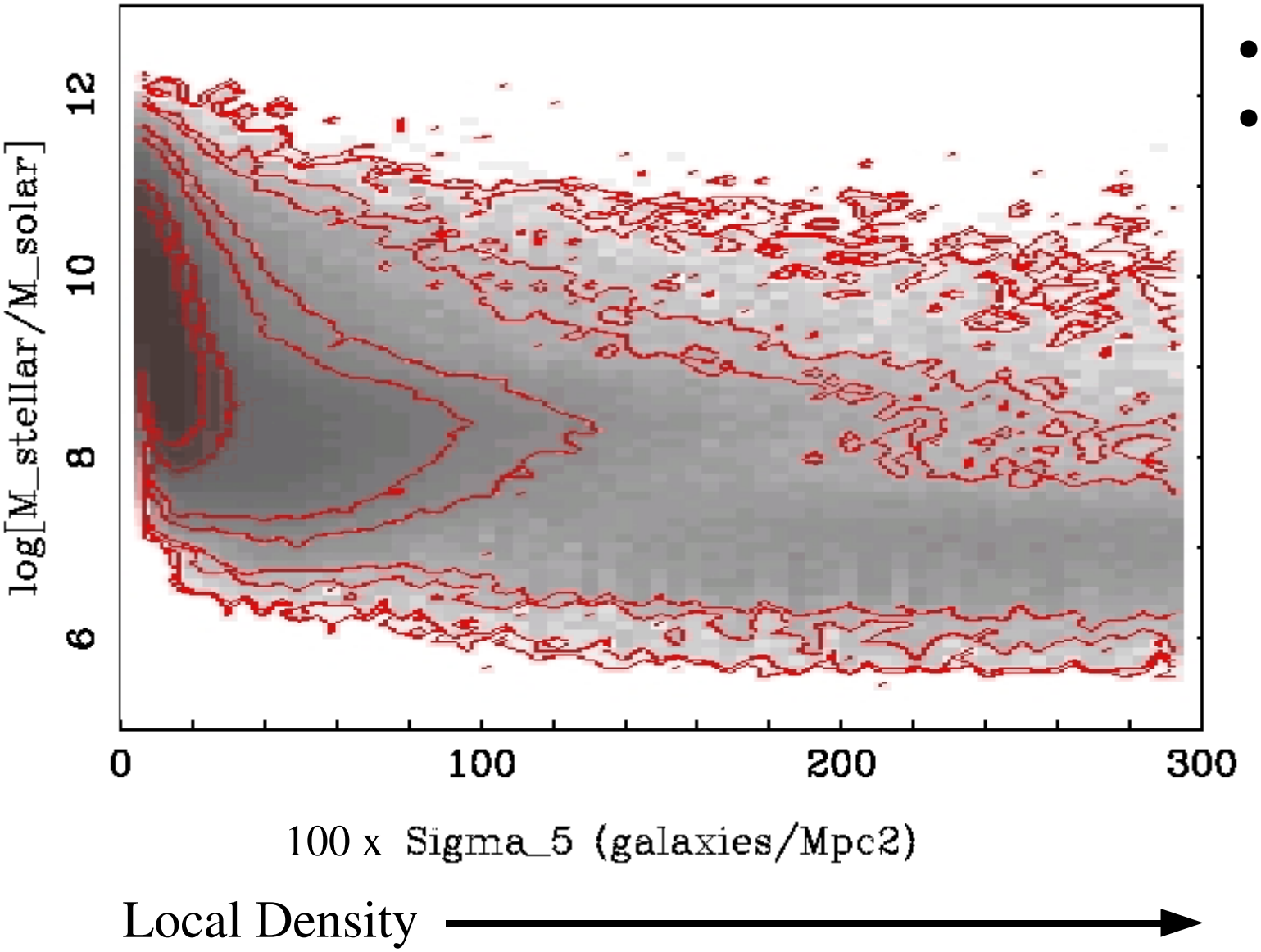


From balogh et al. 04

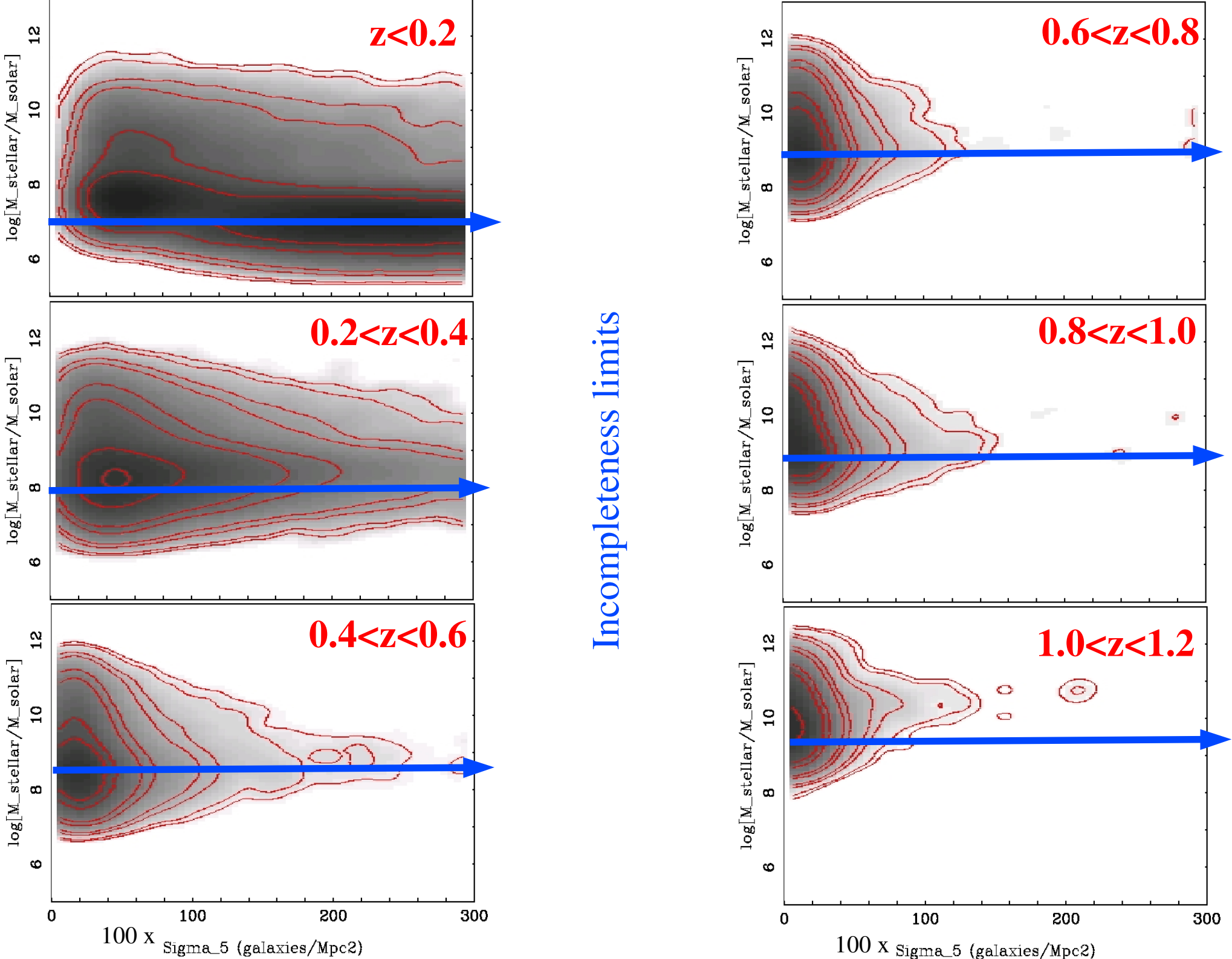

Increasing Redshift
all z
z<0.2
0.2<z<0.4
0.4<z<0.6
0.6<z>0.8
0.8<z<1.0
1<z<1.2
all
Sigma_5
Increasing Sigma_5
4
u-r
-1
<0.2
0.2-0.5
0.5-1.4
1.4-6.5
>6.5
-25
M
r
-10
See poster by Ienna et al.


0.2<z<0.4
$0.2 \leq z_phot < 0.4$
$-18 \leq Mr < -17$
$-19 \leq Mr < -18$
$-20 \leq Mr < -19$
$-21 \leq Mr < -20$
$-22 \leq Mr < -21$
$-23 \leq Mr < -22$
Nombre de galaxies
Mu* - Mr'
densité locale
0.6<z<0.8
$0.6 \leq z_phot < 0.8$
$-20 \leq Mr < -19$
$-21 \leq Mr < -20$
$-22 \leq Mr < -21$
$-23 \leq Mr < -22$
Luminosité
Mu* - Mr'
densité locale
1.0<z<1.2
$1.0 \leq z_phot < 1.2$
$-22 \leq Mr < -21$
$-23 \leq Mr < -22$
Luminosité
Mu* - Mr'
densité locale

Stellar Masses

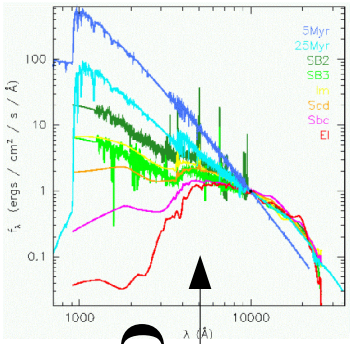


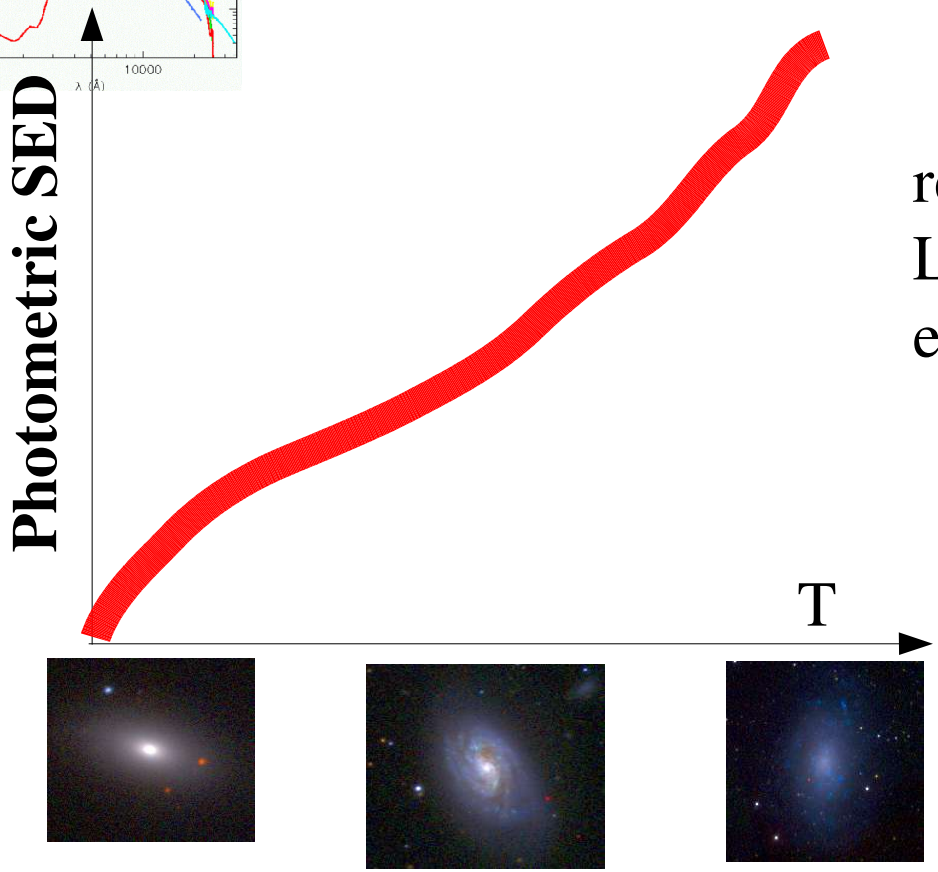
- D1+D2+D3
- All objects at 0<z<1.3


z<0.2
0.2<z<0.4
0.4<z<0.6
0.6<z<0.8
0.8<z<1.0
1.0<z<1.2
log[M_stellar/M_solar]
6
8
10
12
0
100
200
300
100 x Sigma_5 (galaxies/Mpc2)
Incompleteness limits

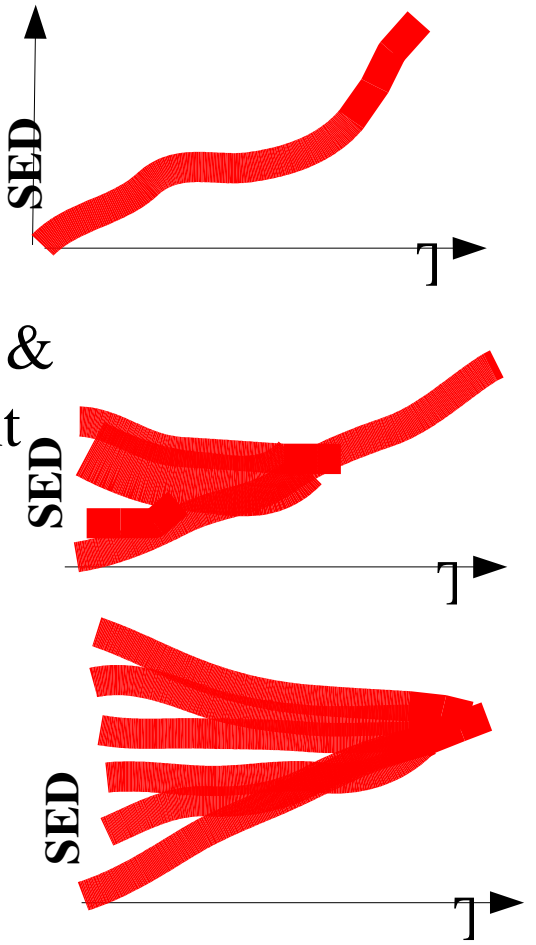
Corrélation SED rest frame et Type morphologique

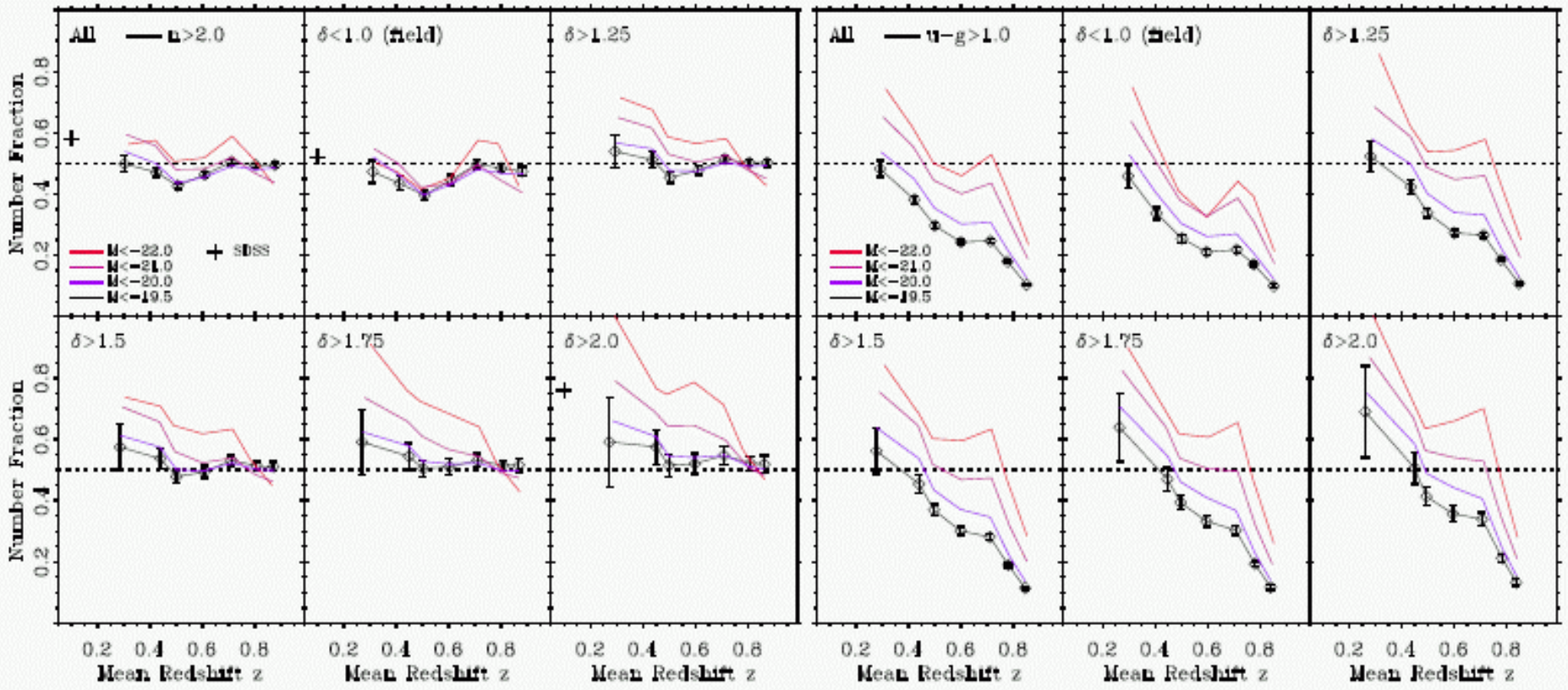
- **Corrélation *SED restframe* et Type morphologique: évolution**





redshift &
Luminosité &
environment





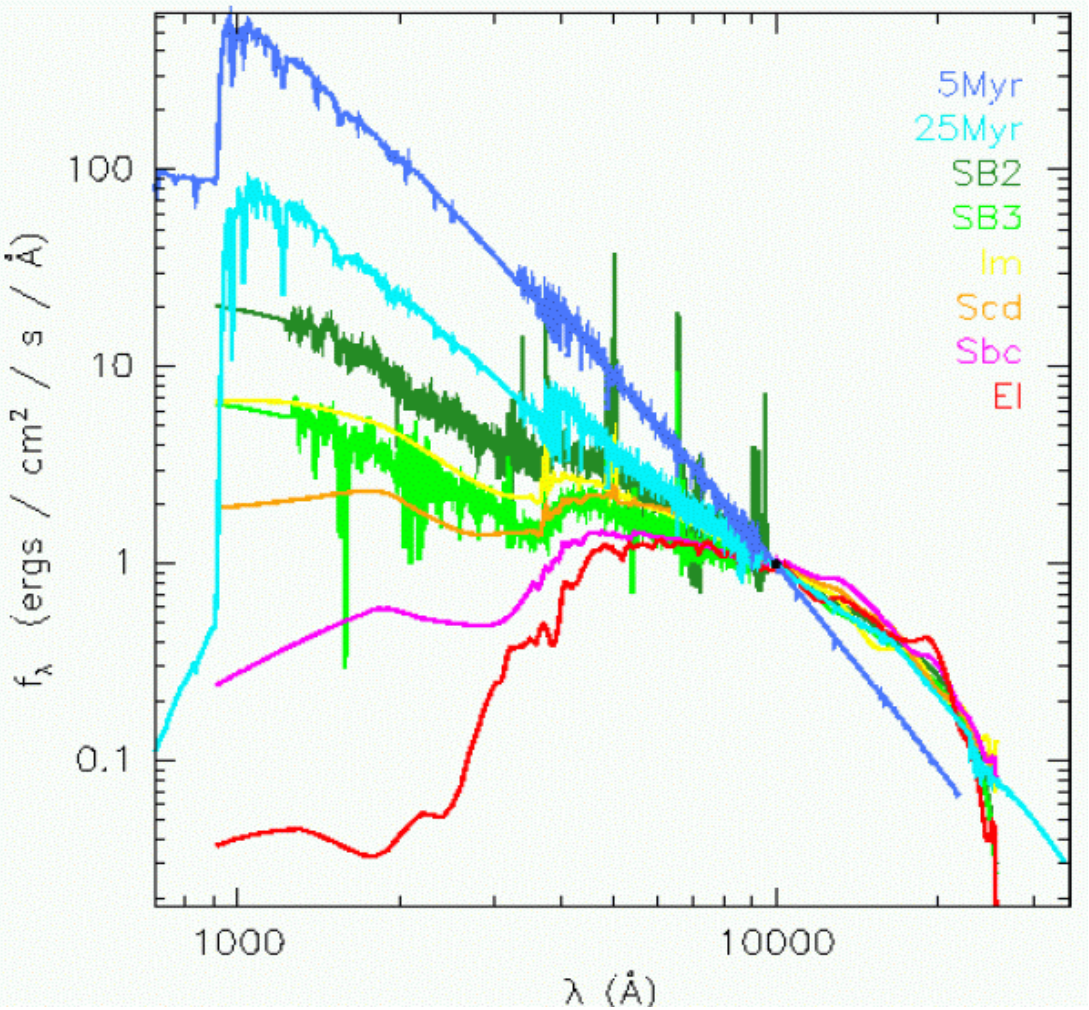
(a) Morphology (b) Color

Fig. 2.— The observed evolution of galaxies out to $z \sim 1$ in terms of galaxy number fractions for (a) morphology and (b) color as function of galaxy total luminosity $M_{g'}$ and the overdensity estimator δ_{15th}. Panel (a) shows the number fractions for $n > 2$ galaxies (Sérsic index n). The crosses are the $n > 2$ number fractions based on SDSS galaxies. Panel (b) shows the number fractions for red galaxies (rest-frame $u^* - g' > 1$). The fractions are calculated for seven redshift bins with increments of 0.1 and fixed widths of 0.2. The error bars are given by Poisson statistics only and are shown only for $M_{g'} < -19.5$ for clarity.

Nuijten et al. 2005: CFHTLS/SDSS GIM2D

Corrélation SED rest frame et Type morphologique

Ex. Coe et al. 2006: **HST/UDF; photoz + morphology (GALFIT)**



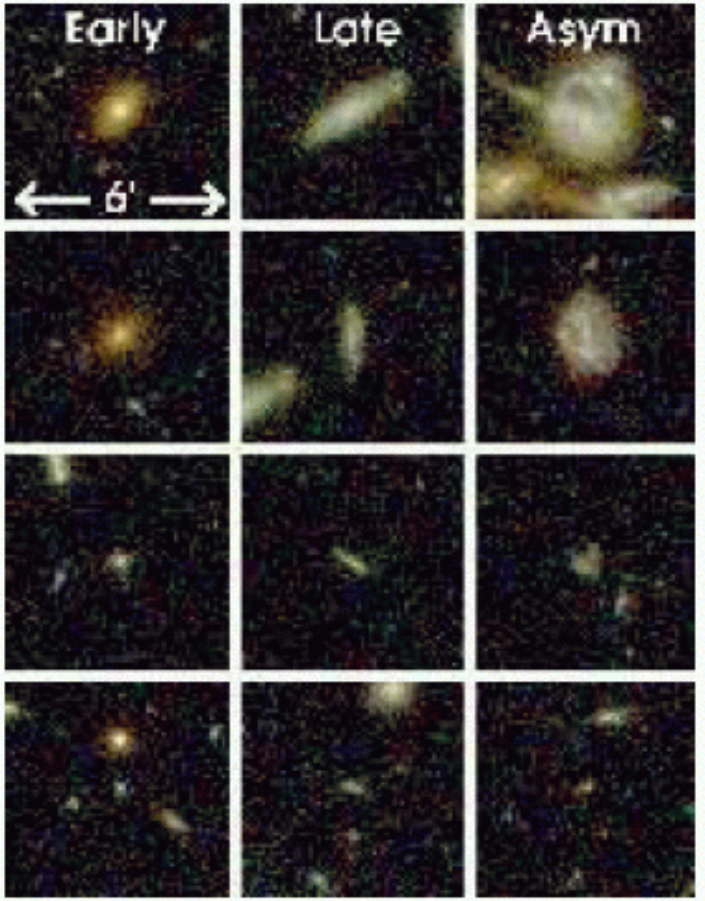
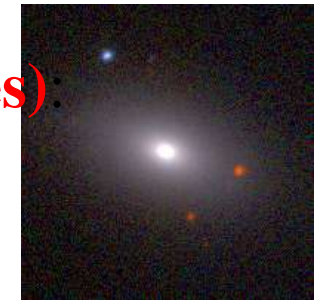


Fig. 10.— Examples of early type, late type, and highly asymmetrical galaxies. All postage stamps are 6"×6", taken from our $BVi'z'$ 4-color image. The first two columns show isolated and symmetrical galaxies with reliable measures of Sérsic index (σ_n/n <1). Galaxies in the first column are morphologically classified as early ($n > 2.5$), while those in the second are classified as late ($n < 2.5$). The third column shows galaxies with clear asymmetries ($A > 0.25$). Galaxies in this column should not be classified by Sérsic index alone. Galaxy magnitudes range here range from roughly $i' \sim 22.5$ to $i' \sim 26.5$.

Époque d'assemblage des bulbes/galaxies E-S0



- **Scénario actuel de formation des ETGs (Early Type Galaxies):**
  - Majorité de leur masse stellaire formée à z>~ 3
  - ETGs dans des environnements peu denses formées 1-2Gyr plus tard (cad vers z~1-2)

  Voir Renzini (2006), Cimatti et al. 2006, ...

- **Contraintes observationnelles récentes:**

  - **Spectroscopiques:** VVDS, Subaru-XMM-Newton Deep Survey => évolution passive pour ETGs de i<24-25, depuis z~1-1.1.

  - COMBO-17: ETGs « bleuissent » globalement entre z~0 et 1 (=> similaire aux observations sur CFHTLS)

  - Tous: a) peu d'évolution dans la partie brillante de la Fonction de Luminosité
    b) + d'évolution dans la partie de plus faible luminosité

==> besoin de comptages de ETGs à partir d'un critère morphologique bien déterminé (photo-z & morphologie)

(Voir Cimatti et al. 2006)

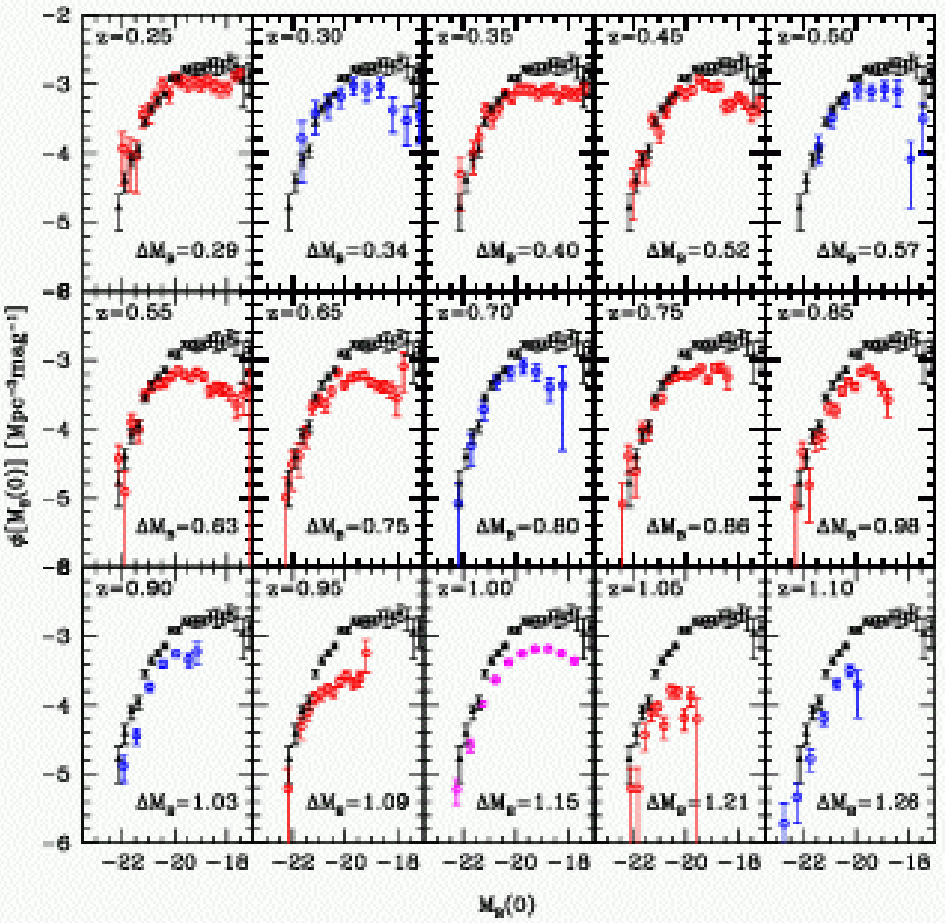


Fig. 1. The *B*-band LF of ETGs from COMBO-17 (Bell et al. 2004a, red), DEEP2 (Faber et al. 2005, blue), and SXDS (Yamada et al. 2005, magenta) "evolved" to $z = 0$ and compared to the local LF derived by Bell et al. (2004a) from SDSS data (black filled triangles). The amount of applied passive evolution (ΔM_B) is also indicated.

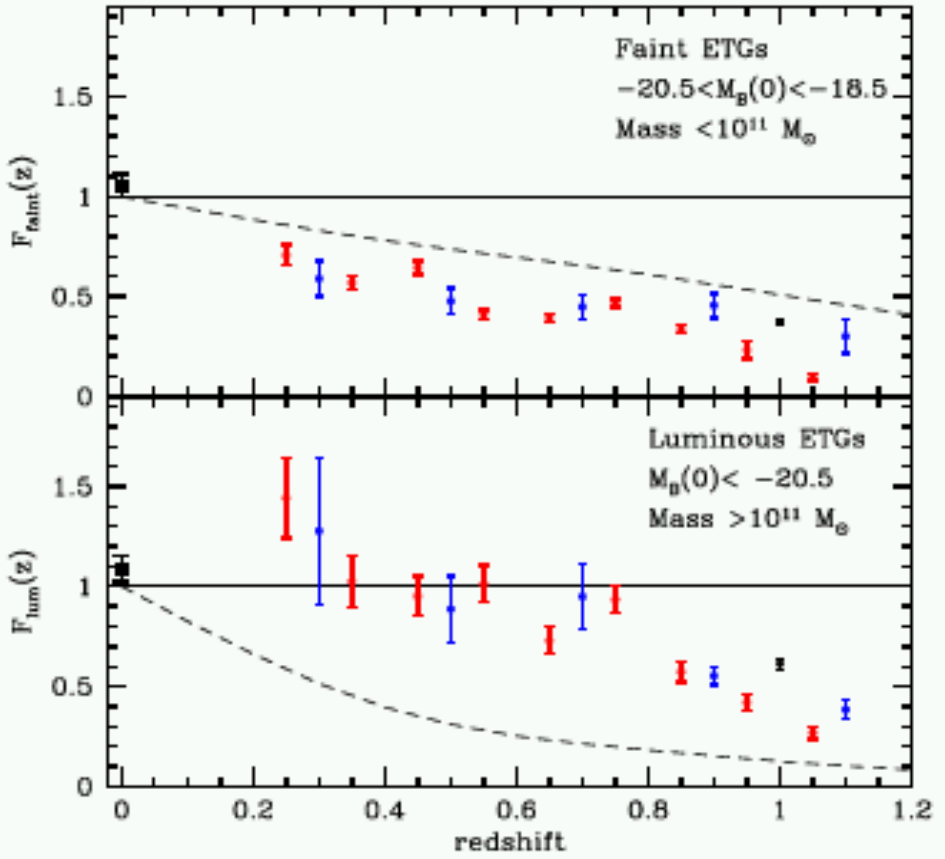
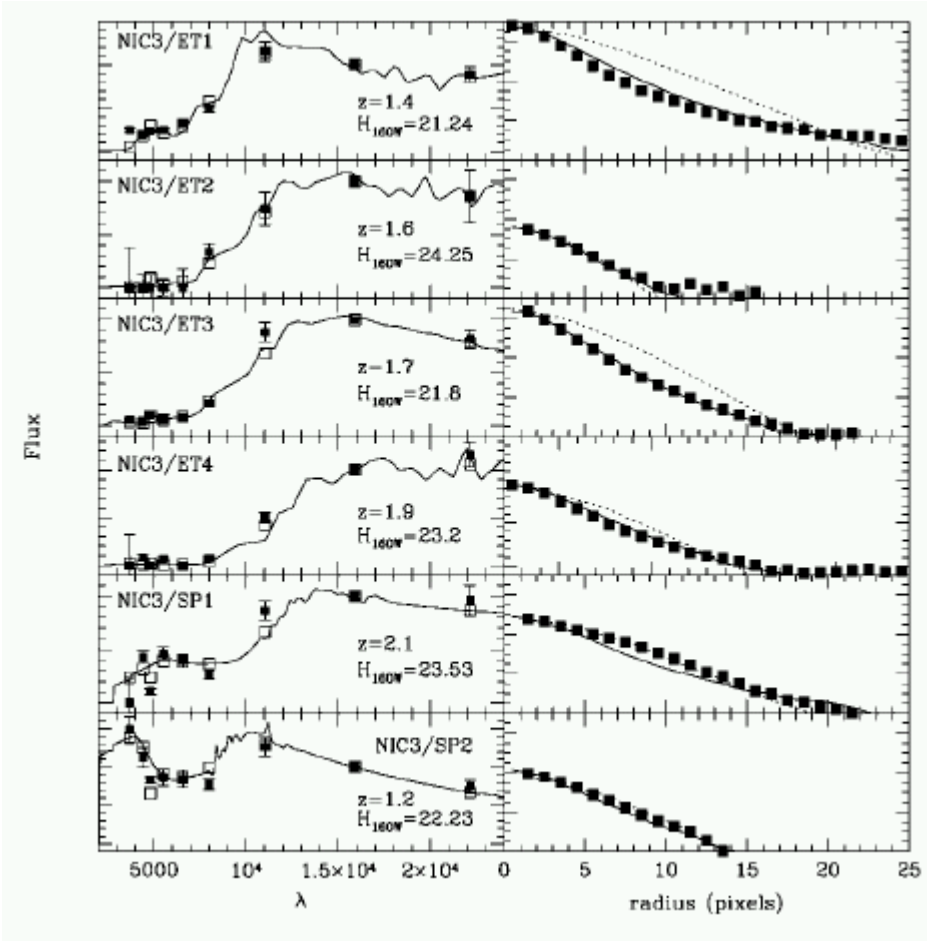
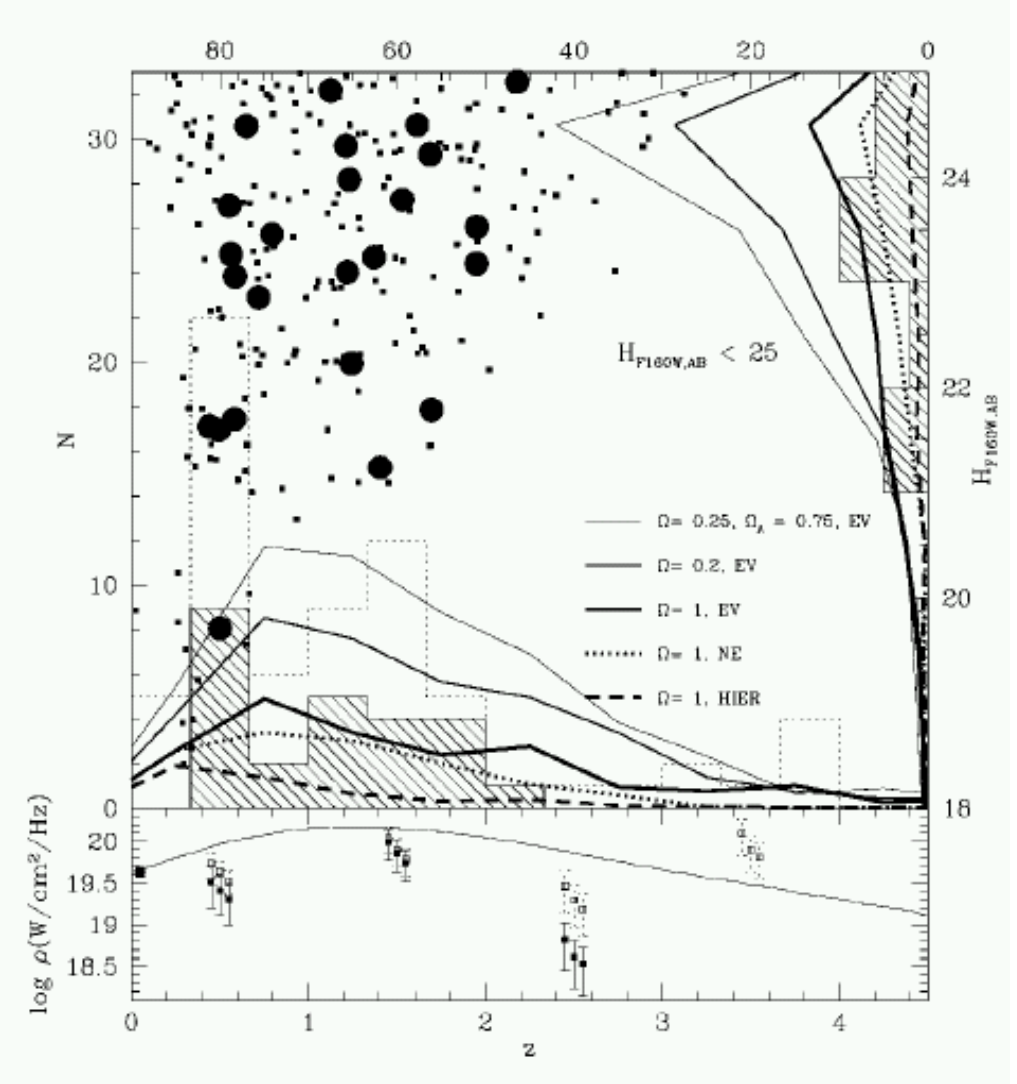


Fig. 3. The evolution of the fractional number density of low– (top) and high–luminosity (bottom) ETGs compared with the $z = 0$ best–fit Schechter function of Bell et al. (2004a). The points at $z = 0$ are not exactly equal to 1 due to the slight mismatch between the Schechter fit (Φ) and the actual SDSS data points (ϕ). Red, blue, black symbols at $z > 0$ refer to COMBO-17, DEEP2 and Yamada et al. (2005) respectively. The dashed lines correspond to the evolving fraction of the $z = 0$ ETGs which have assembled 80% of their stellar mass (from Fig. 5, bottom panel, of De Lucia et al. 2006).

Époque d'assemblage des bulbes/galaxies E-S0 (II)



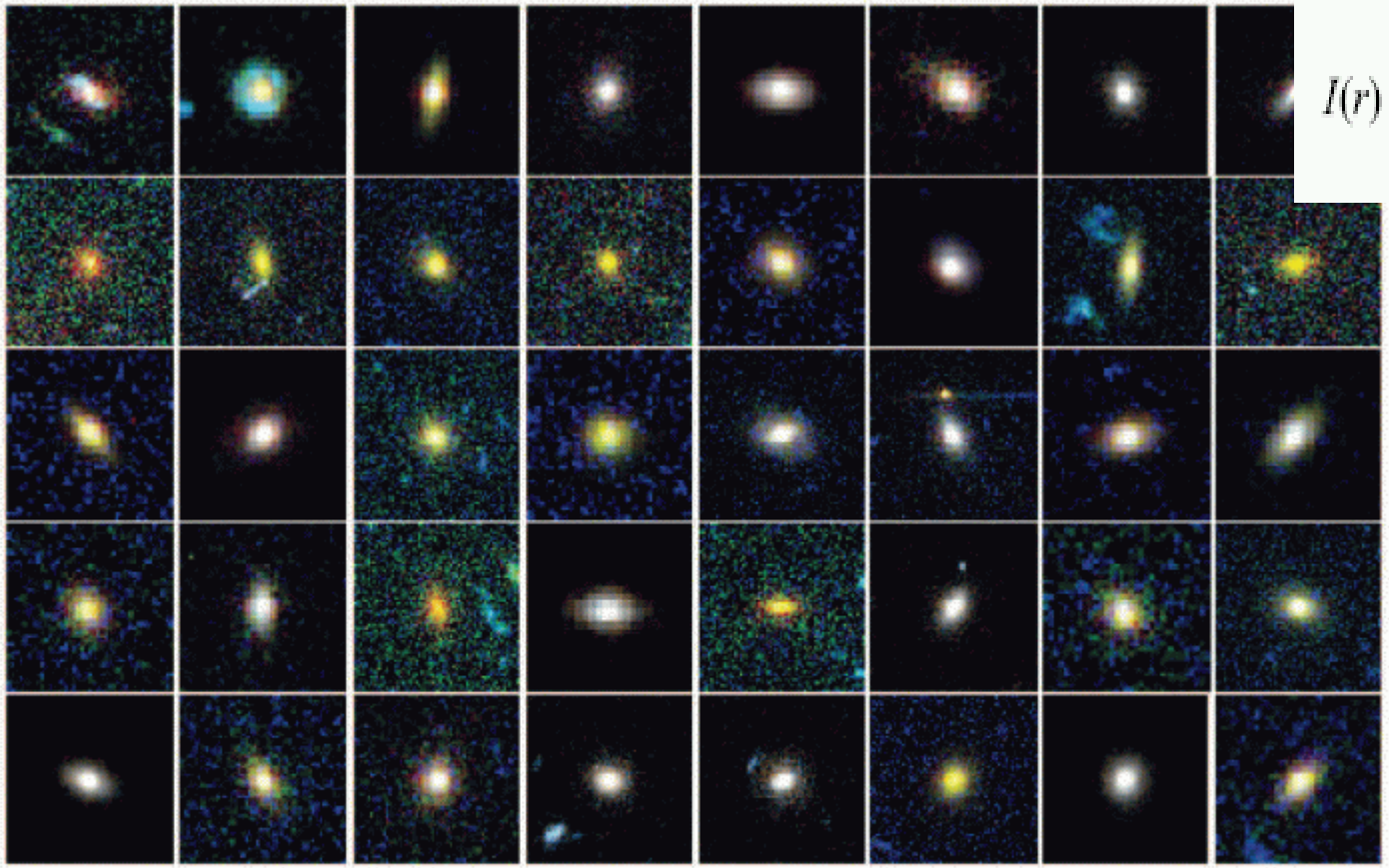


(ex. Benitez et al. 1999)

Époque d'assemblage des bulbes/galaxies E-S0 (III)

Ex. Cross et al. 2006: **Fonction de luminosité de ETGs à z~0.75**

Sélection photoz + GALFIT sur des champs HST/ACS **sans** amas



$$I(r) = I_{r_e} \exp\left\{-k\left[\left(\frac{r}{r_e}\right)^{1/\beta} - 1\right]\right\},$$

+ Treu et al. 2002

'ETGs a 0<z<0.7

FIG. 6.—Three-color postage stamps for all of our galaxies. These use an asinh stretch (Lupton et al. 2004) that preserves the colors of bright regions of the galaxy while also showing the fainter regions of these same objects. They are divided into the two redshift samples that we use throughout the analysis and then ordered by $(U - V)_0$ color, going from bluest (*top left*) to reddest (*bottom right*). This is the same order as Table 2. In the case of the HDFN, we display a combination of the ACS *i* and *z* only.

sélection morphologique

0.5<z<0.75

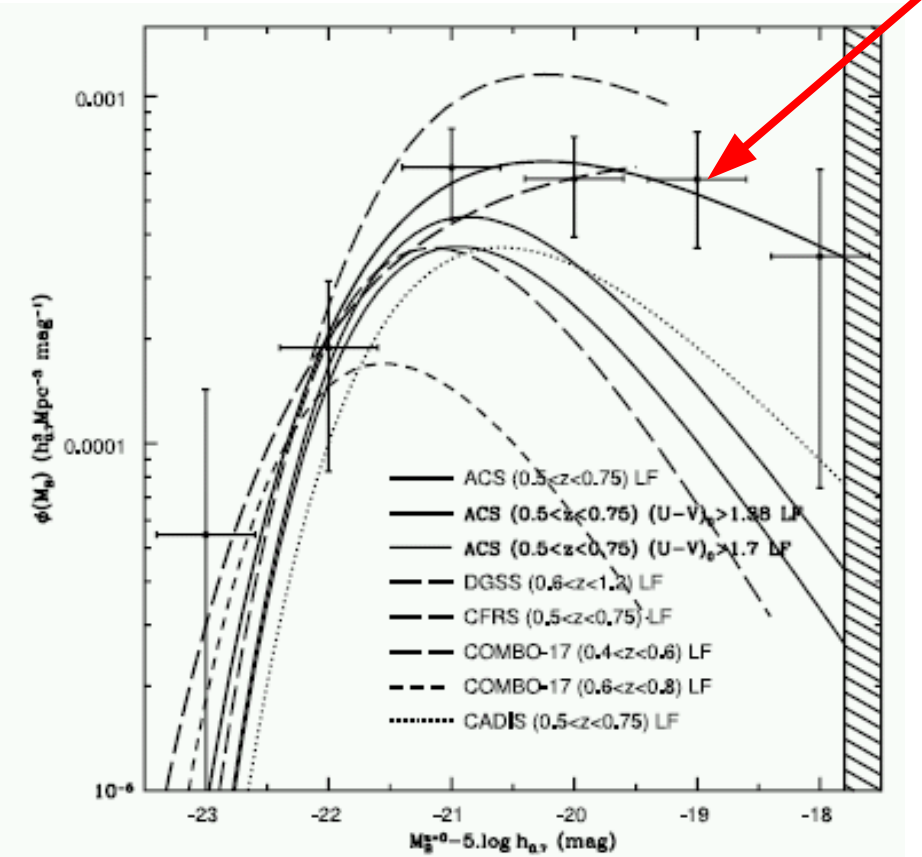


FIG. 17.—Luminosity functions of our $0.5 < z < 0.75$ early types compared to that from previous surveys. The ACS LFs are plotted with solid lines, with the thickest showing the morphologically selected LF, the medium thick showing the $(U-V)_0 > 1.38$ LF, and the thin line the $(U-V)_0 > 1.7$ LF. The points and error bars are for the morphologically selected sample. The thick dashed line shows the morphologically selected DGSS LF, the medium thick dashed line shows the $(U-V)_0 > 1.38$ selected CFRS LF, and the thin dotted or dashed lines show the SED selected COMBO-17 and CADIS LFs. All the LFs have been converted to a ΛCDM cosmology with $H_0 = 70$ km s^{-1} Mpc^{-1}.

0.75<z<1.0

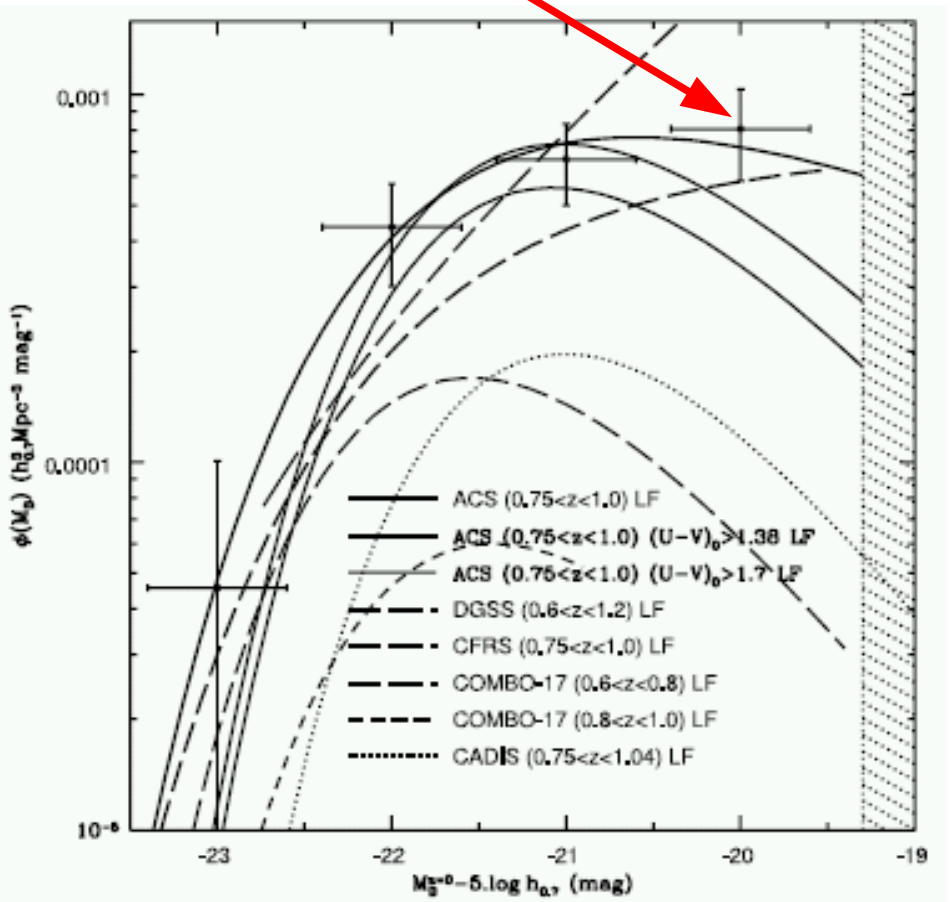
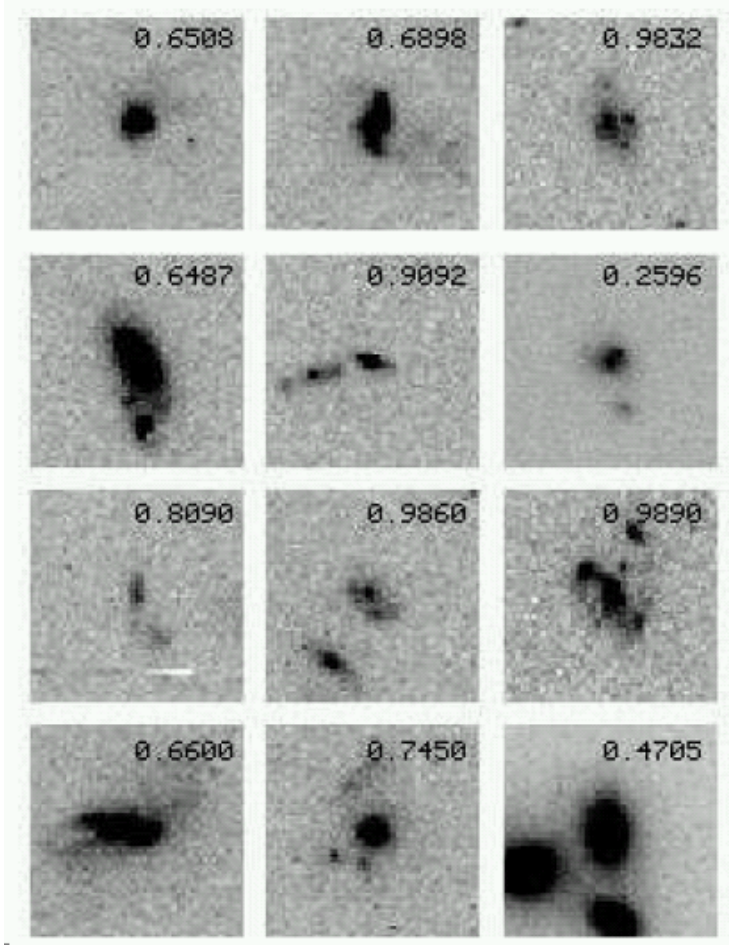


FIG. 18.—Same as Fig. 17, but for our $0.75 < z < 1.0$ early types.

Cross et al. 2006)

Hot spots vs [SED intégrée, SFR, environnement, z]

- **Hot Spots & asymétries** comme traceurs des processus de coalescence + SFR dans les différents volumes (low -> high density environments)
- **Évolution avec redshift de la densité d'objets « I » morphologiques**, en fonction de:
  - luminosité
  - SED intégré
  - masse stellaire
  - densité locale
  - présence de proches voisins
  - propriétés des galaxies environnantes



Ex: Le Fevre et al. (CFRS/LDSS Survey: Influence of mergers in the evolution of faint field galaxies up to z~1)

Évolution des galaxies à disques

Ex: Lilly et al. 1998: **HST imaging of the CFRS & LDSS redshift Surveys: Structural parameters & evolution of disk galaxies to z~1.**

Zheng et al. 2005: **HST/WFPC2 morphologies and ba structures of field galaxies at 0.4 < z < 1 (ajustement bulbe+disque et color-maps)**

+ ... etc

Évolution avec redshift de la densité d'objets « S » morphologiques, de la taille des disques (+ présence de barres?), en fonction de:

- **luminosité**
- **SED intégré**
- **masse stellaire**
- **densité locale**
- **présence de proches voisins**
- **propriétés des galaxies environnantes**