IR Counterpart of the CFHTLS Deep Fields: The WIRCAM Deep Survey (WDS)

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\+ (in alphabetic order)

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- F. Ienna (LAOMP, Toulouse)
- J. P. Kneib (LAM, Marseille)
- J. Richard (LAOMP, Toulouse)
- D. Schaerer (O. Genève)
- ...

Motivation for a Deep Near-IR counterpart of the *CFHTLS Deep Survey*:

- CFHTLS Deep Survey + *WIRCAM DEEP SURVEY* (WDS):
  - ***WIRCAM DEEP FIELD (WDF, ~1 deg2)***
  - ***WIRCAM ULTRA DEEP FIELD (WUDF, ~0.11 deg2)***
- Near-IR photometry is needed
  - To consistently follow the stellar population contributing to the flux at $\lambda \geq 4000$ Å from z ~ 0 all the way to z~ 4.
  - To map the star-forming and AGN activity up to the highest redshifts (z ~6-10).

Science goals:

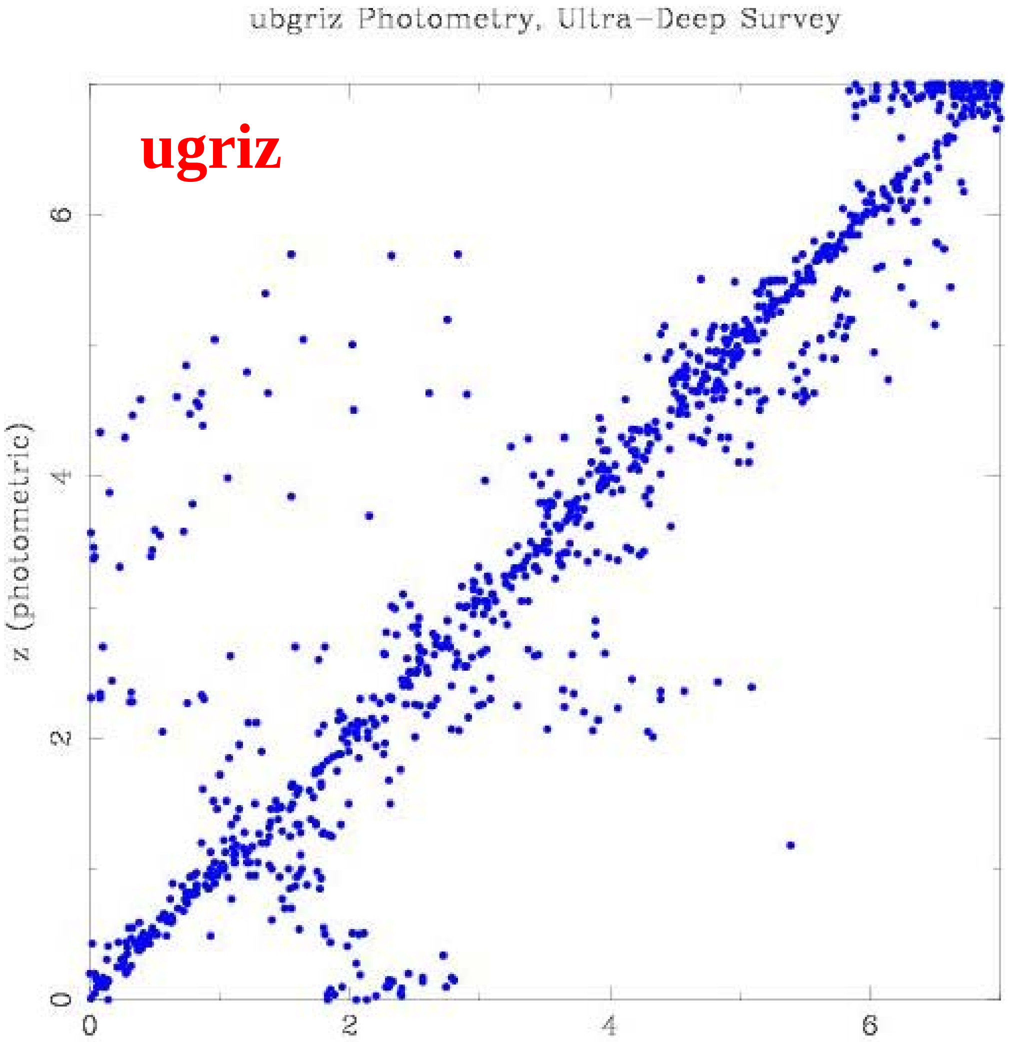
WIRCAM DEEP FIELD (WDF, ~1 deg2)

- ***Constraining the cosmological scenarios for galaxy formation & evolution: history of mass assembly.***
- ***Measuring: N(z), multi-lambda LF, stellar masses vs redshift, luminosity density (-> stellar mass density), clustering properties, cluster tomography and content, LSS.***
- ***Operational aspects: low-Res SED & photometric redshifts; spectroscopic training and control set needed.***

WIRCAM ULTRA DEEP FIELD (WUDF, ~0.11 deg2)

- ***Exploring the very high-z universe (z>~6). Constraining galaxy formation scenarios and reionisation history.***
- ***Identification of high-z candidates through broad-band photometry (optical/near-IR dropouts; photometric redshifts) or NB+broad band.***
- ***Operational aspects: photometric selection; subsequent spectroscopic follow up needed.***

Photometric Redshifts:



- **Operational point of view**
  - **CFHTLS Deep Survey low-resolution SED → z_phot accuracy:**

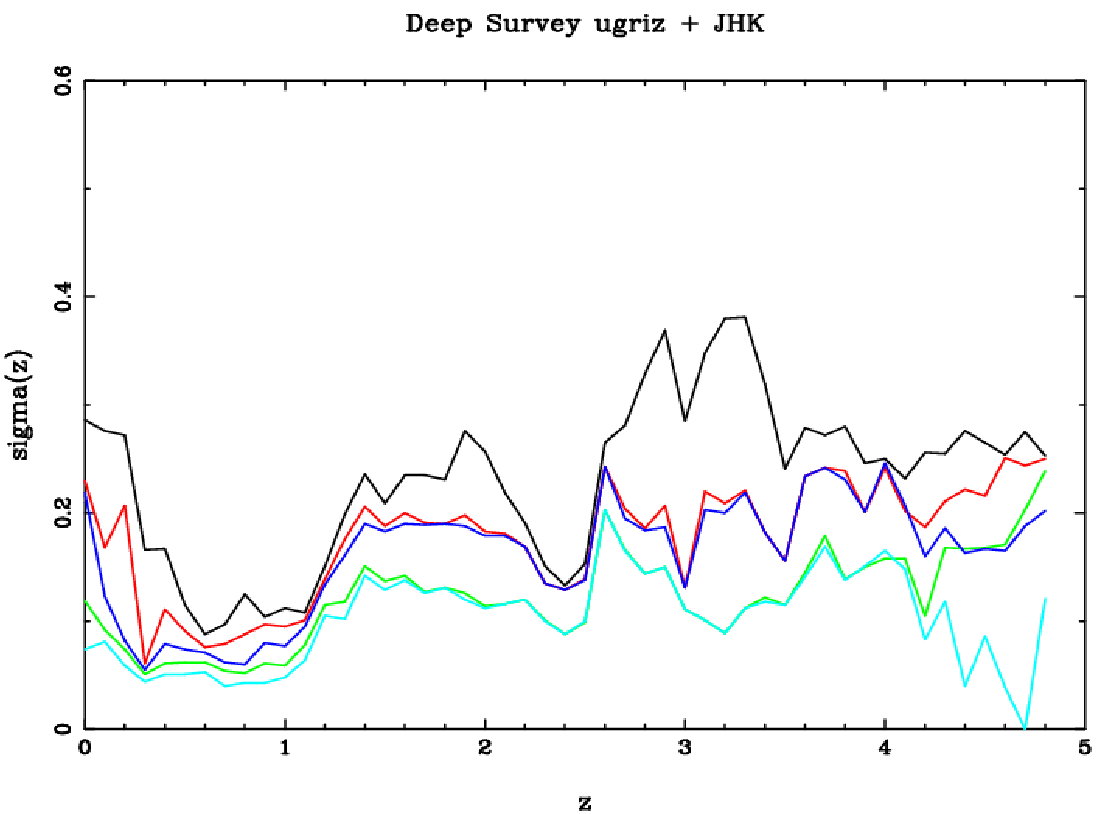
σ (z) ~ 0.1 (1+z)

  - **Without IR data, lack of strong signatures in the observed SED between 3500A and 9000A → higher errors z_phot at 1.2<z<2.2**

Filter	Expected integration time after 1 year	Limiting magnitude (AB)	Total integration time at the end of the survey	Limititing magnitude (AB)
u*	6.5 h	27.3	33h	28.2
g'	6.5 h	27.9	33h	28.8
r'	13h	27.7	66h	28.6
i'	26.5h	27.4	132h	28.3
z'	13h	26.1	66h	27.0

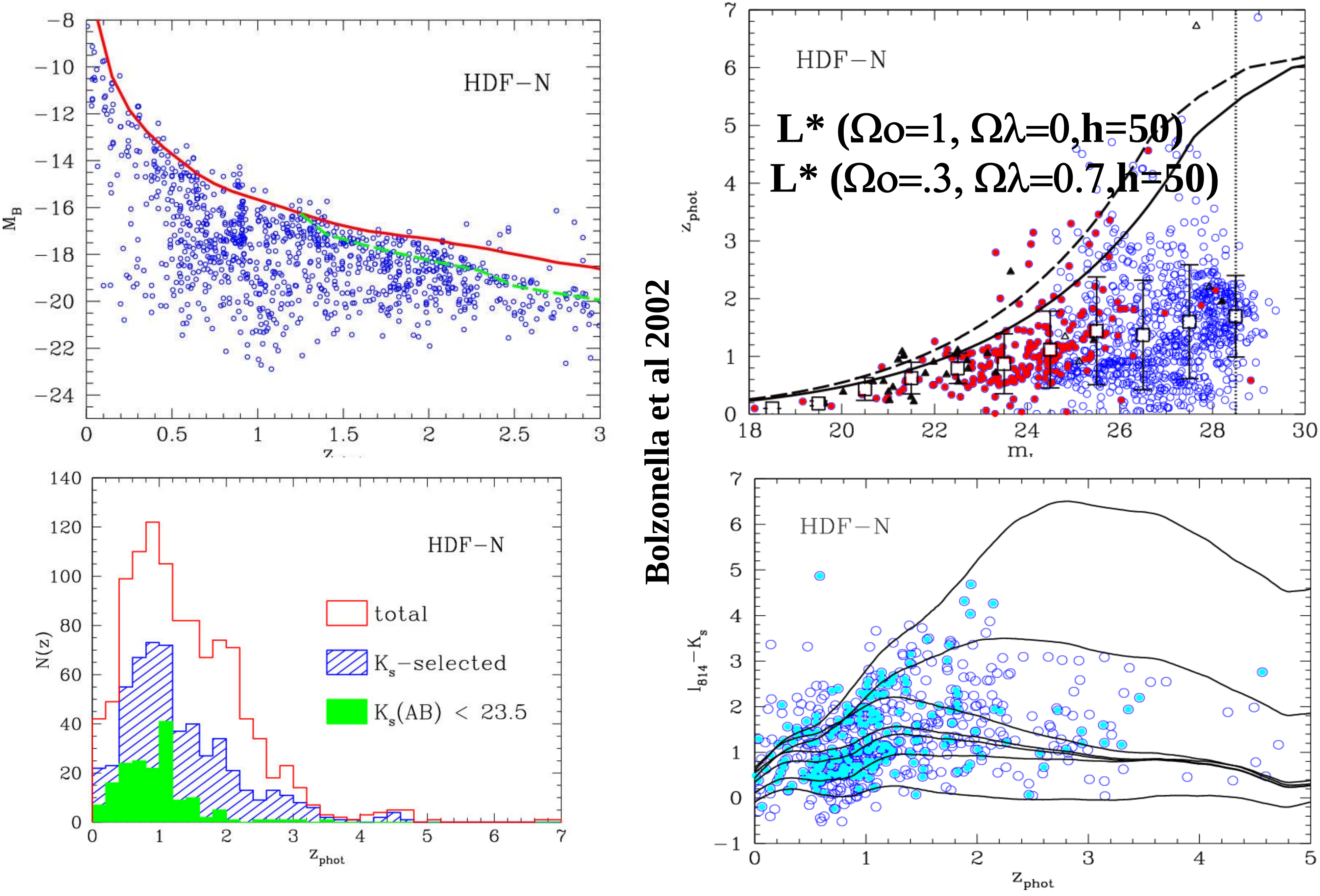
Photometric Redshifts:

ugriz + JK'

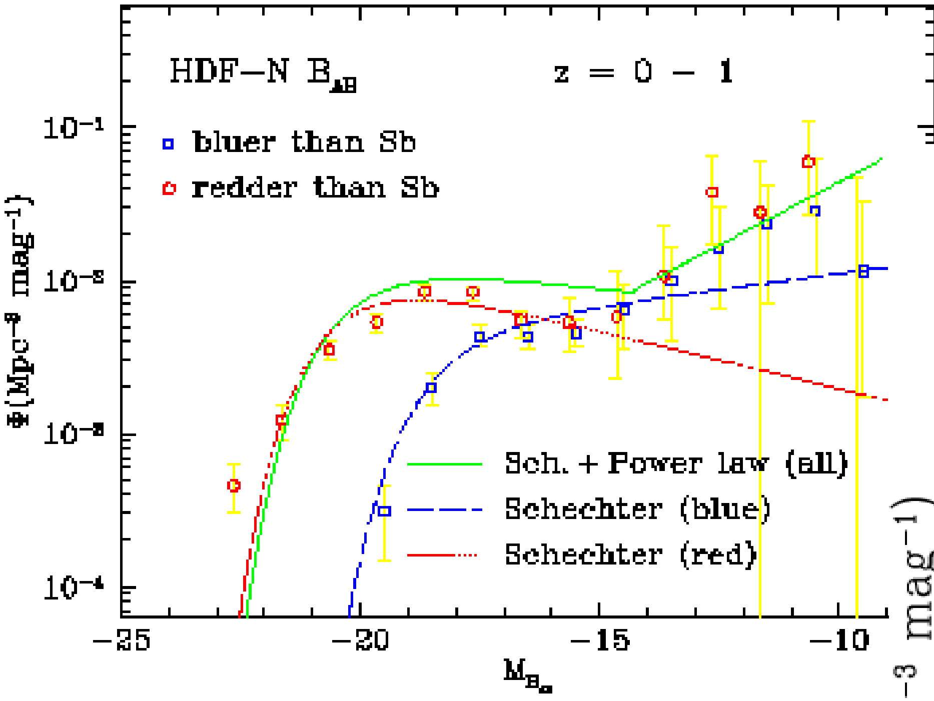


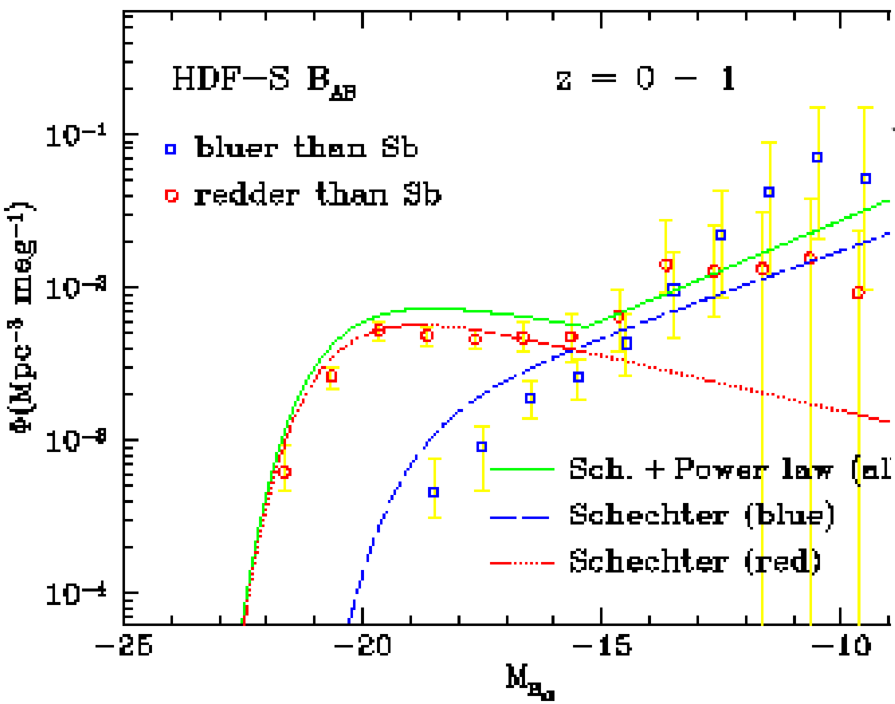
- A reasonably deep IR survey will reduce th uncertainties to better than σz ~0.2 at any redshift
- The 4000A break span the near-IR domain at redshifts between 1.2 and 4.
- The gain is also sensible for the determination of "spectral types" (early to late type galaxies, star-galaxy-qso discrimination).

N(z), Hubble diagrams, spectro_morphological types...

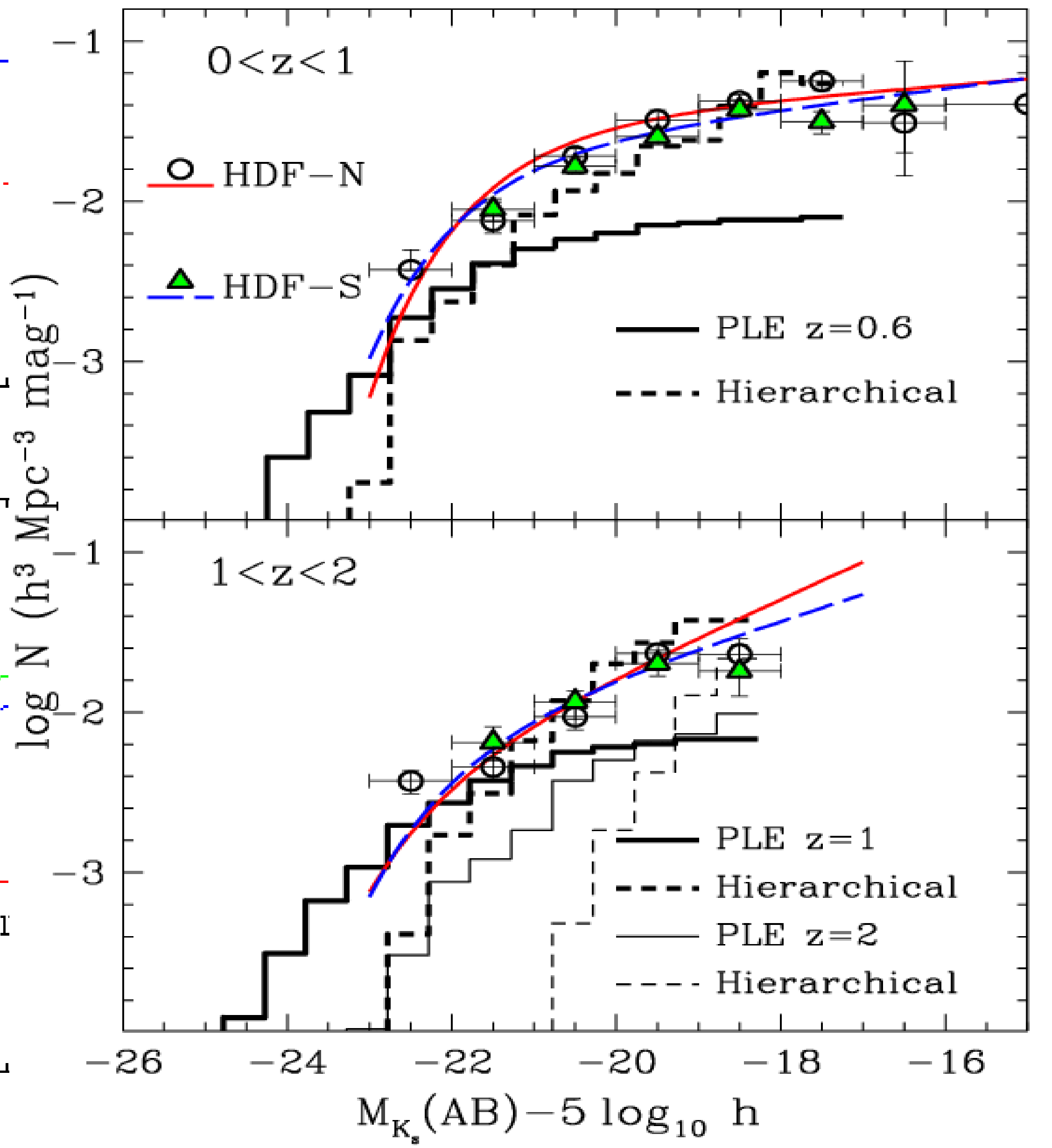


Near-IR/ multi-λ Luminosity Functions

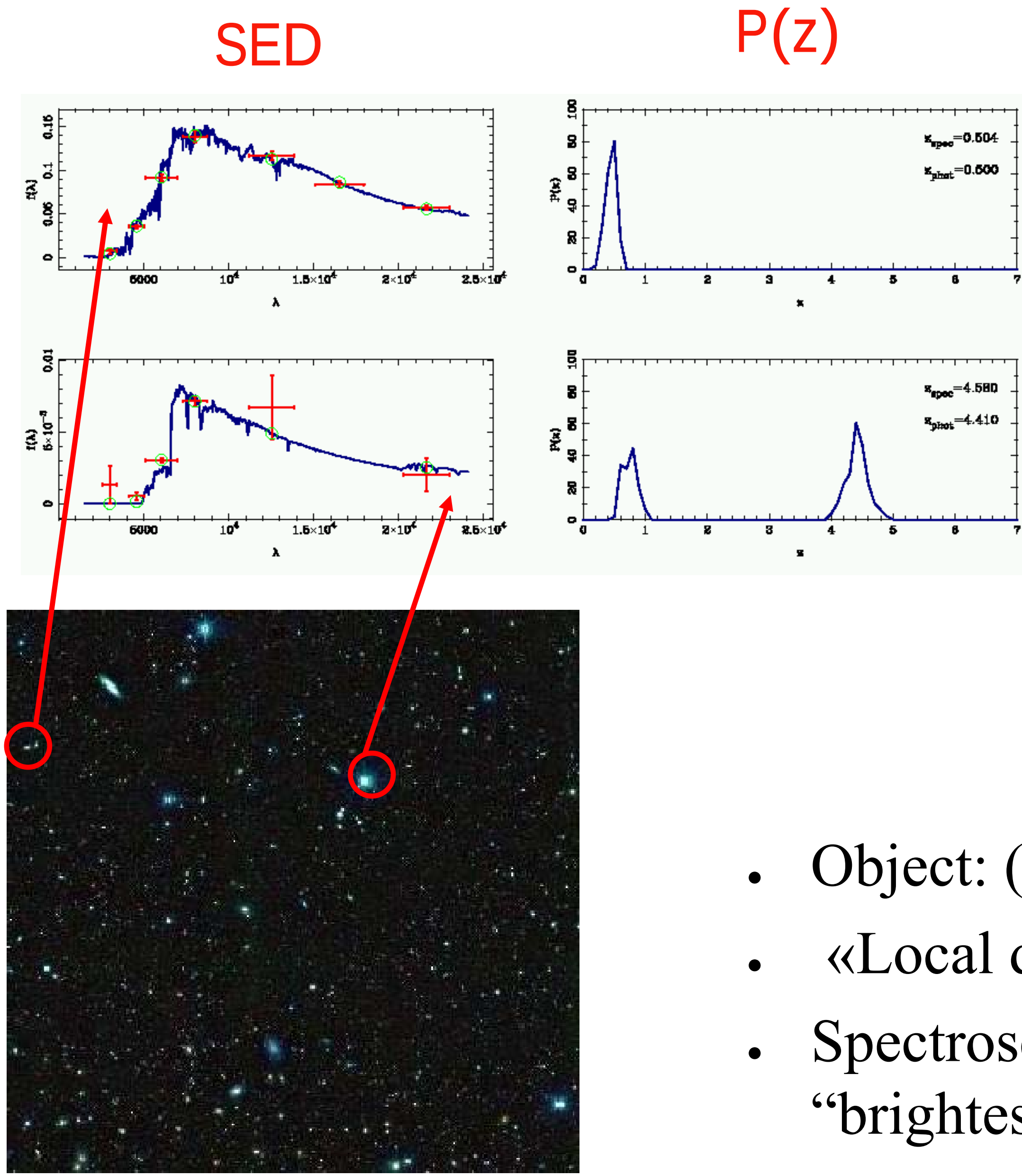


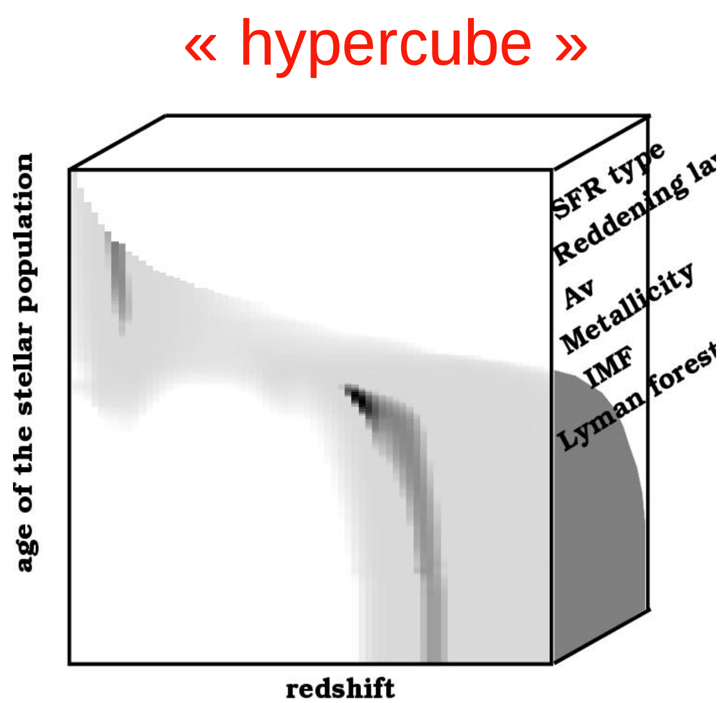


Bolzonella 2001
Bolzonella et al 2002



Properties of galaxies versus environment





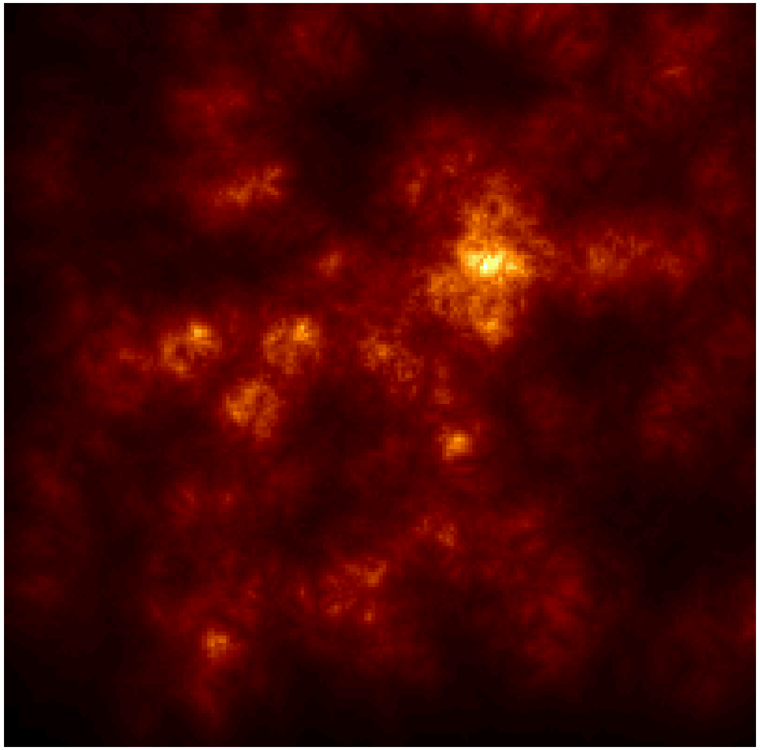
- Object: (□, □, P(z))
- «Local density » estimators
- Spectroscopic information for the "brightest" galaxies

Clusters and LSS tomography (see P. Hudelot's talk)

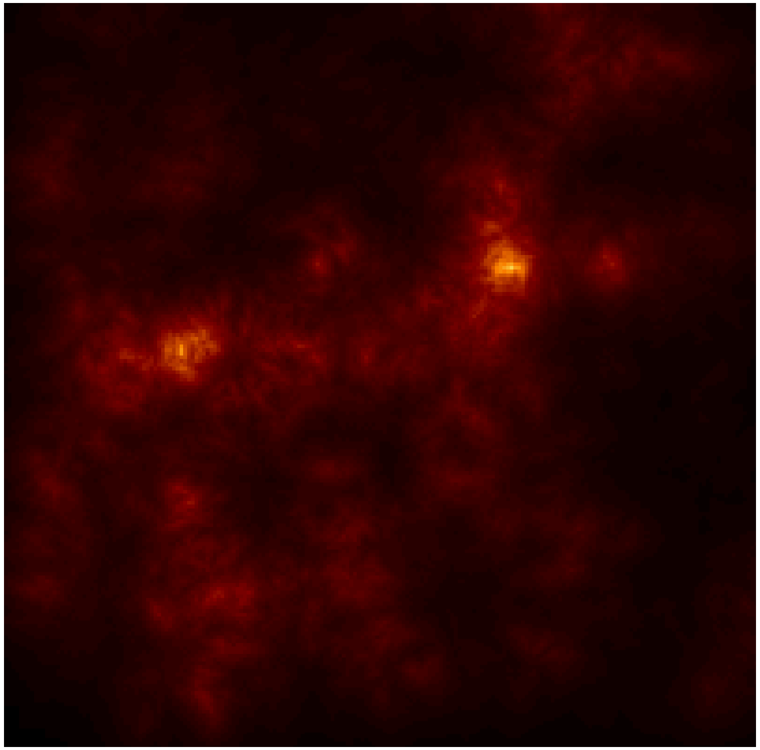
Number density maps

Z=0.694 +/- 0.03

Filters: VRIJK



Cl1054–1146 (VRIJK photometry)



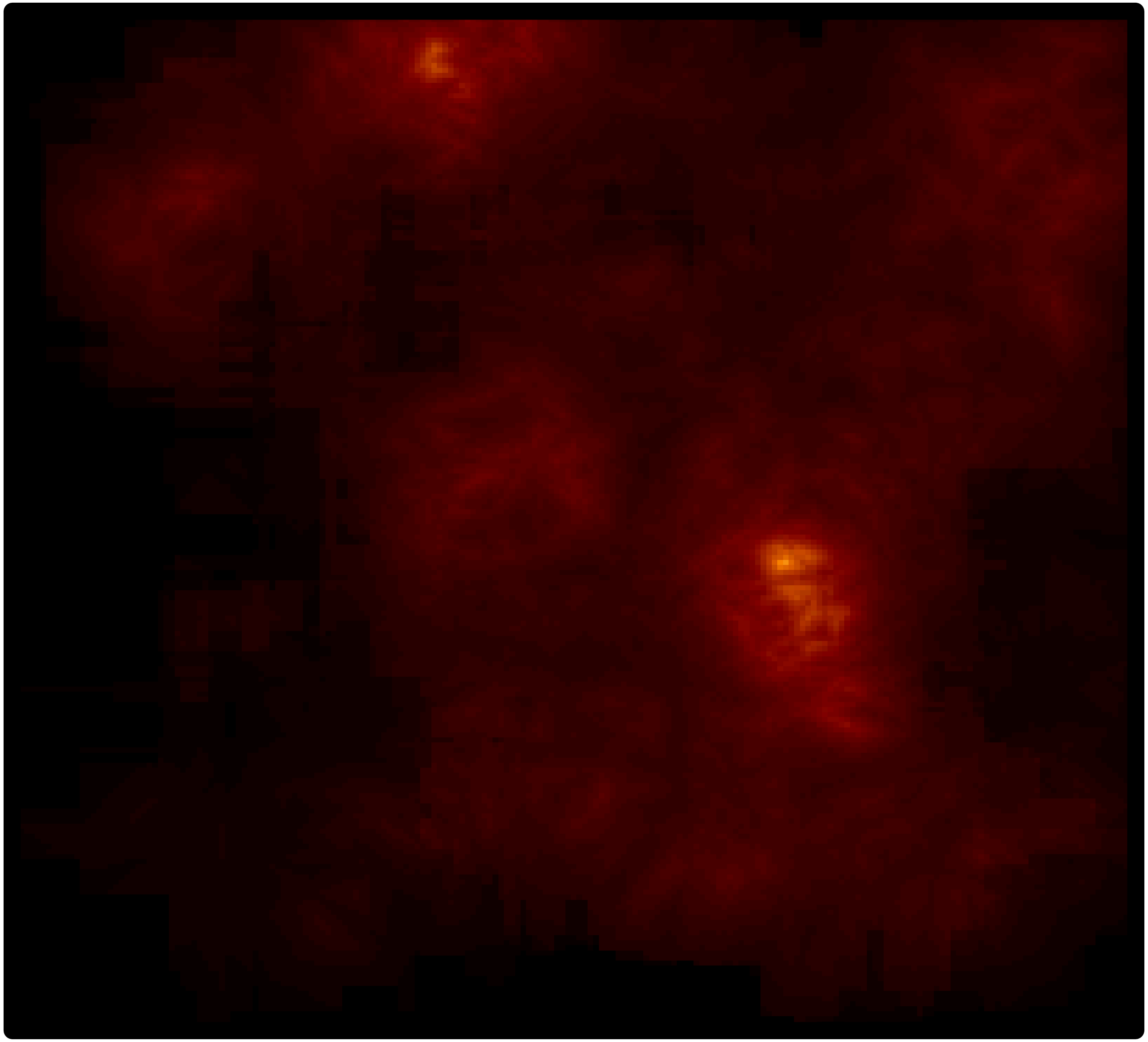
Cl1054–1146 (VRI photometry)

Clusters and LSS tomography (II)

Number density maps

Eso Distant Clusters Survey

Filters: VRIJK

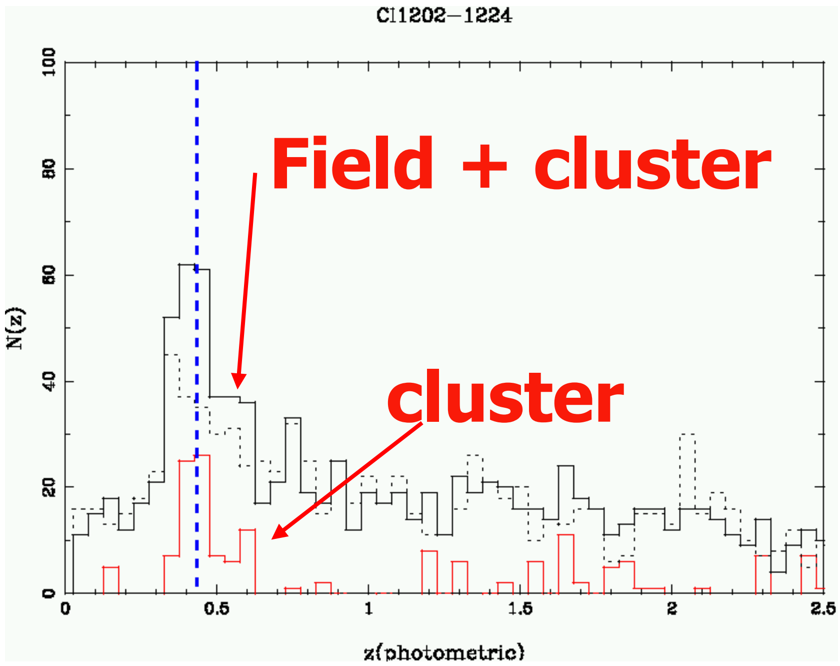


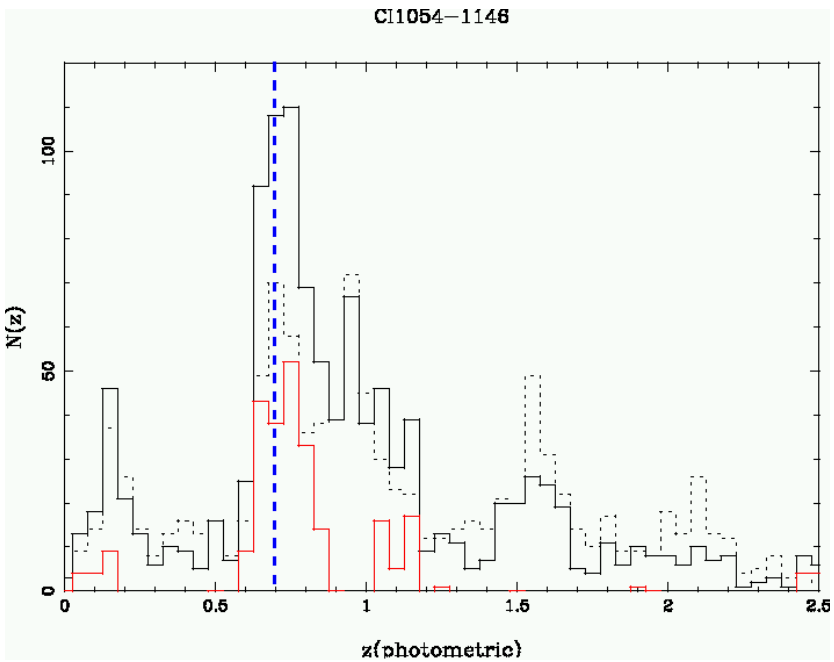
Cl1037-1243
Z(spectro)=0.62 + 0.40

Z=0.40 -> 0.90
with dz=0.1

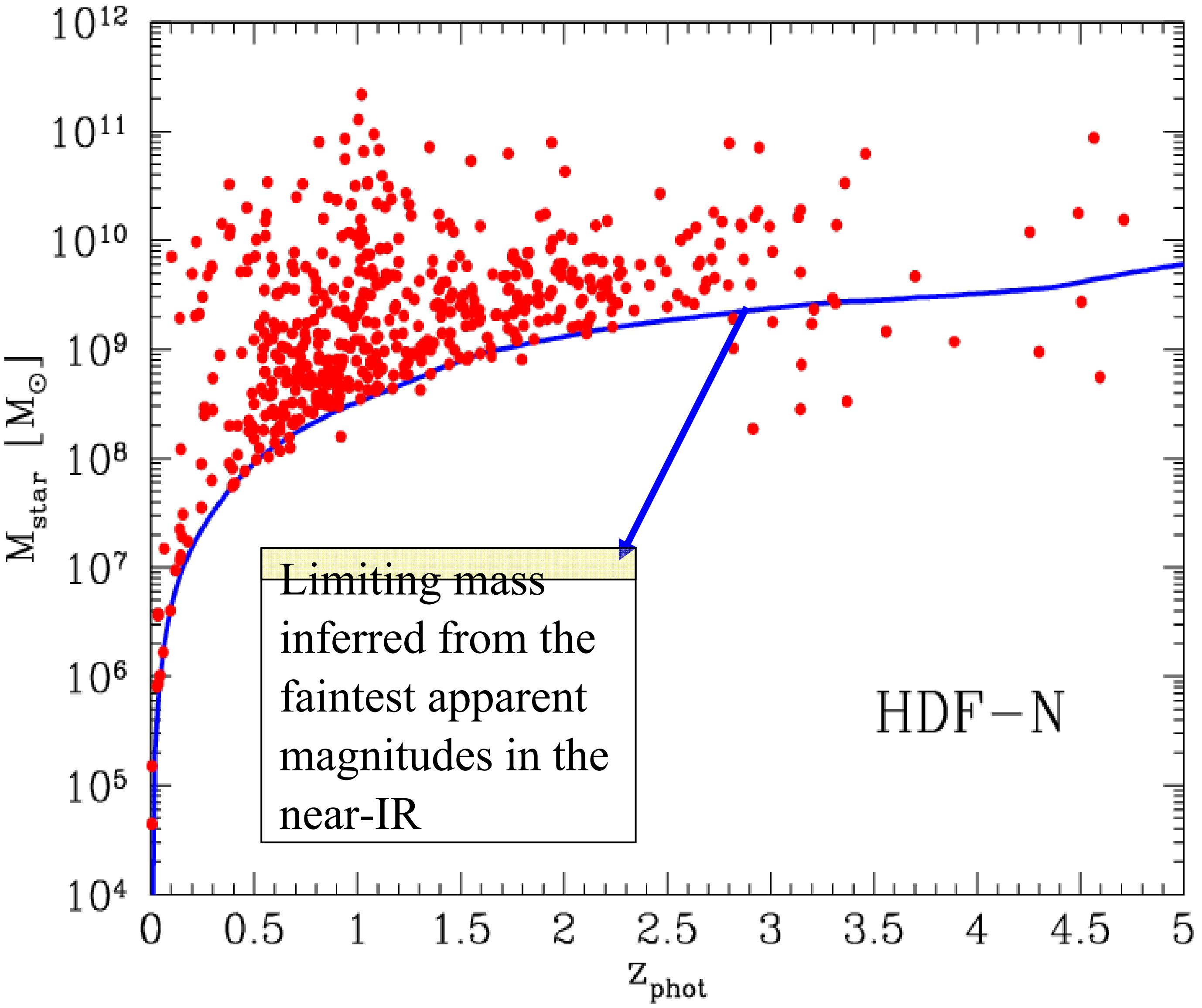
Cluster (low-z)	$z_{cluster}$ spectro	$z_{cluster}$ z_{phot}	$z_{spectro} - z_{phot}$
cl1018-1211	0.472	0.450	0.022
cl1059-1253	0.455	0.465	-0.010
cl1119-1129[1]	0.549	0.476	0.073
cl1202-1224	0.424	0.425	-0.001
cl1232-1250	0.542	0.549	-0.007
cl1238-1144[1]	0.460	0.516	-0.056
cl1301-1139	0.482	0.483	-0.001
cl1353-1137	0.589	0.540	0.049
cl1411-1148	0.520	0.491	0.029
cl1420-1236	0.497	0.510	-0.013
Mean			0.008 ± 0.021

Cluster (high-z)	$z_{cluster}$ spectro	$z_{cluster}$ z_{phot}	$z_{spectro} - z_{phot}$
cl1037-1243	0.580	0.637	-0.057
cl1040-1155	0.702	0.699	0.002
cl1054-1146	0.696	0.725	-0.029
cl1054-1245	0.750	0.732	0.017
cl1103-1245	0.703	0.766	-0.063
cl1122-1136[1]	0.640	0.797	-0.157
cl1138-1133[1]	0.479	0.650	-0.171
cl1216-1201	0.796	0.743	0.0526
cl1227-1138	0.635	0.704	-0.065
cl1354-1230	0.757	0.694	0.063
Mean			-0.010± 0.048





Mapping the stellar mass assembly



With J(Vega)<24.0; H<23.0; K<22.5:

M_halo(stars)
> n x10^9 M_solar to z<5
> n x 10^8 M_solar z<2

Bolzonella et al. 2002

WDF:

WIRCAM Deep Field

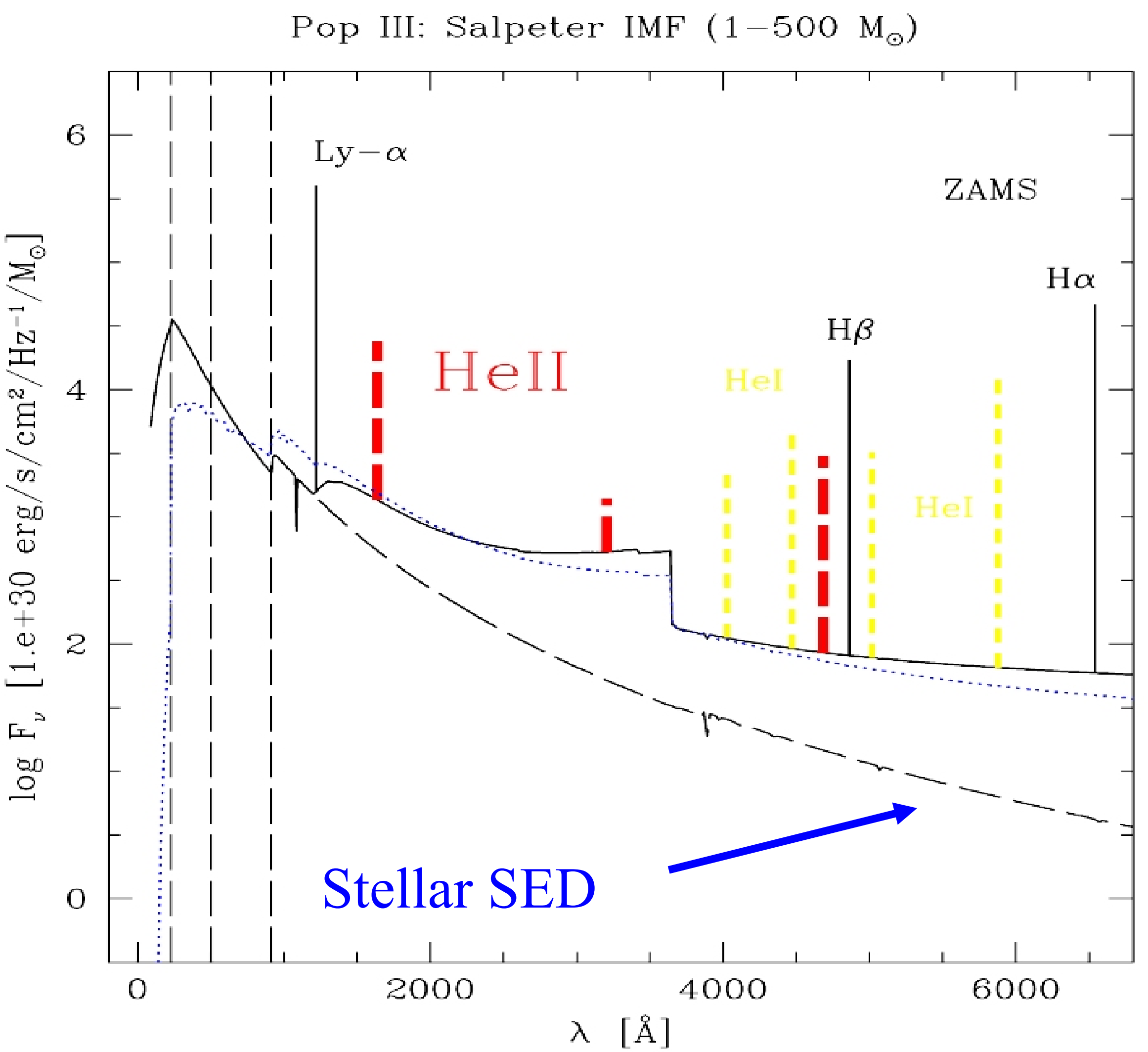
one CFHTLS deep field 1°x1°

(~10 WIRCAM fields 20'x20')

filter	AB	exp. time (h)	numb. of nights
J	25.0	7.3	7.3
H	24.5	9.5	9.5
Ks	24.5	14.0	14.0
	TOTAL	**30.8 /field**	**30.8**

Seeing: 0.6”
integration in 0.9” aperture
S/N = 5

WUDF: Looking for galaxies at z ≥ 6



Schaerer 2001,2003

- **Objects dominated by nebular continuous emission at λ> 1400 Å**

+ Strong HeII lines: <u>HeII λ1640</u>, HeII λ3203, HeII λ4686, ...

- **Unique features present for genuine PopIII starbursts;**

11/4/04

Broad-Band Color Selection of z>~ 6 galaxies

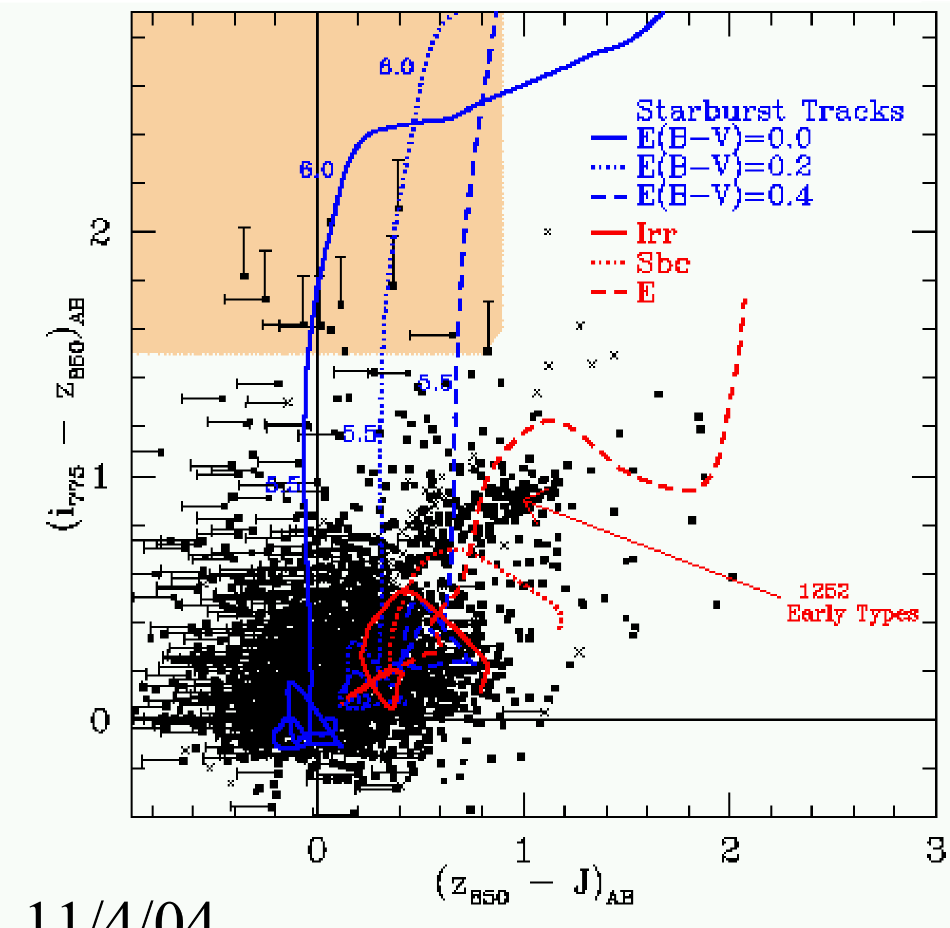
Z~6 candidates

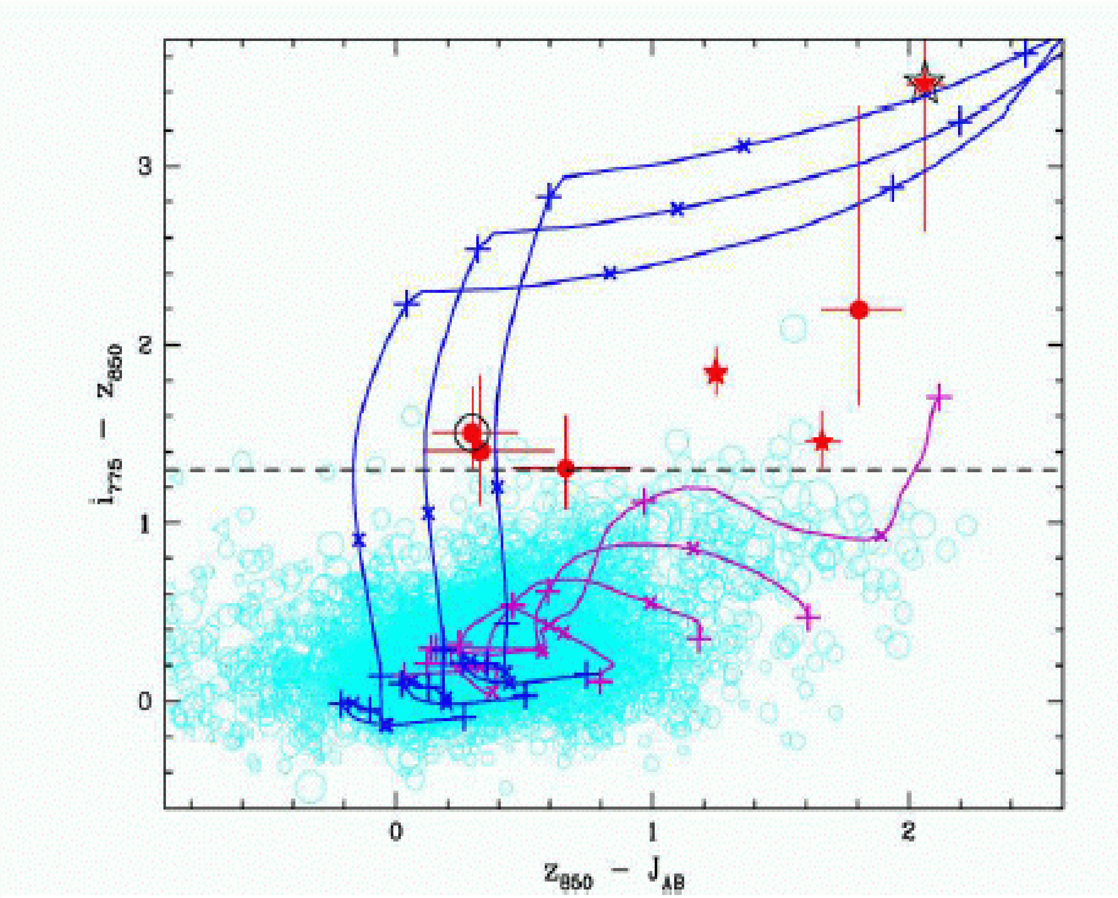
Ex: Bouwens et al. 2003, z~6

Star formation density from "I-dropouts"
- Candidates at z~6 selected on ACS/GTO HST fields

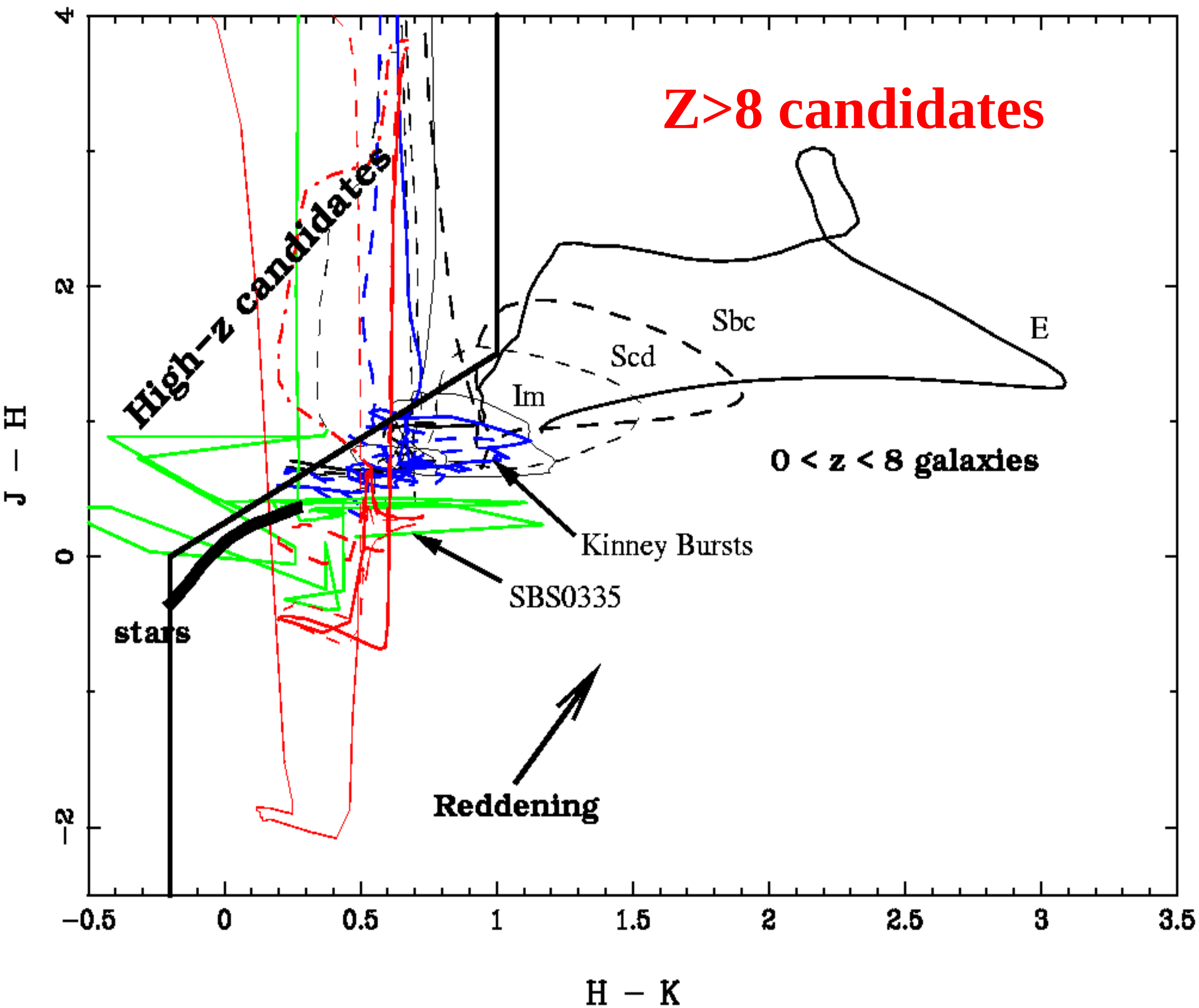
Ex: Dickinson et al. 2003, z~6 candidates in the GOODS Survey

z_850<~26.5
number density < 1 candidate/arcmin2



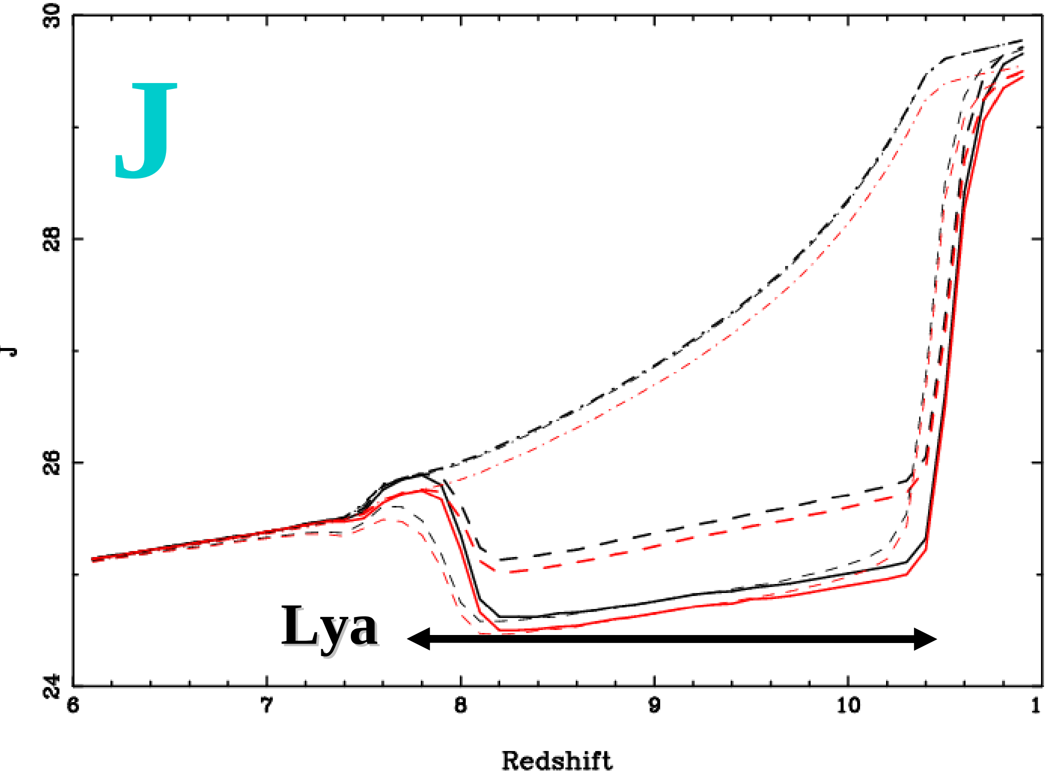


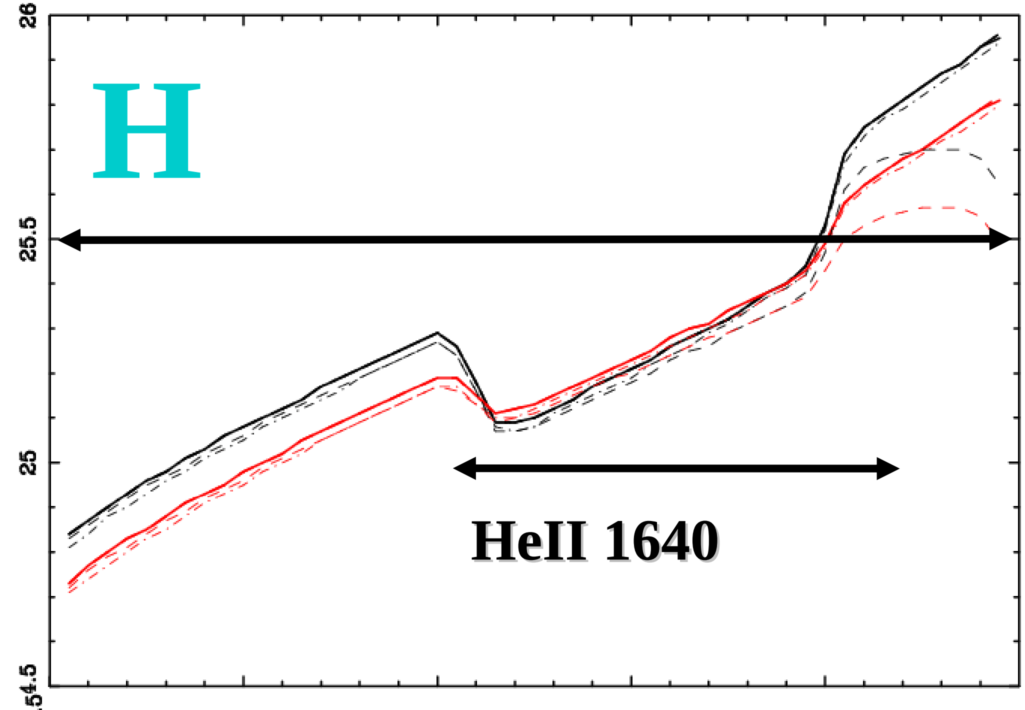
Broad-Band Color Selection of z>~ 6 galaxies

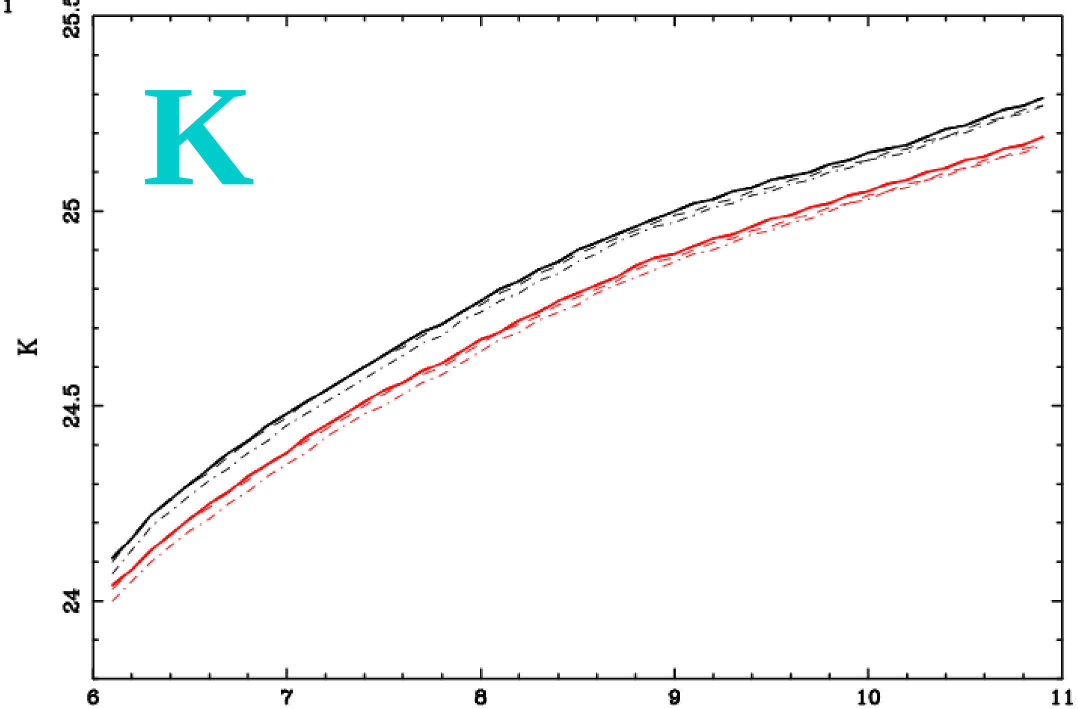


- Optical dropouts + near-IR colors
  - Z~6-7: zYJ
  - Z~7-8: YJH
  - Z > 8 : JHK

Broad-Band magnitudes







Fiducial 10^7 M_solar stellar halo

- 2.5 mags 10^8 M_solar

- 5.0 mags 10^9 M_solar

With J(Vega)<25.0; H<24.1; K<23.8:

Top heavy IMF 50-500 M_solar

M_halo(stars) >10^8 M_solar to z<10

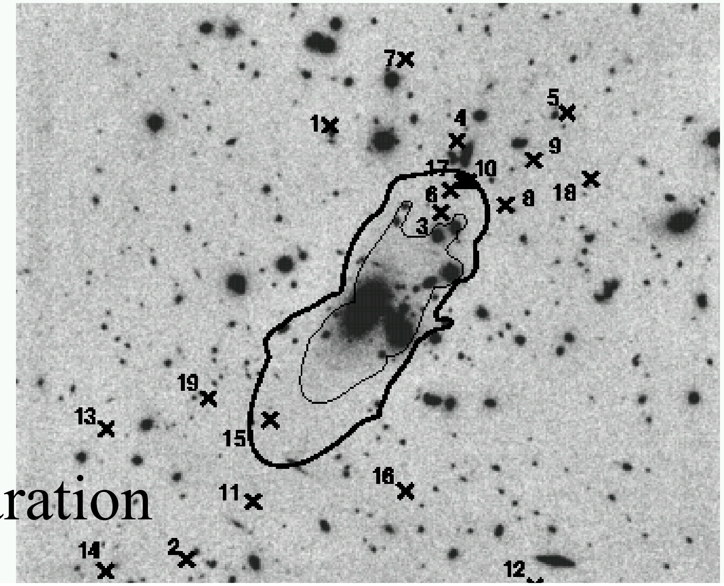
> 3-5 10^7 M_solar z<9

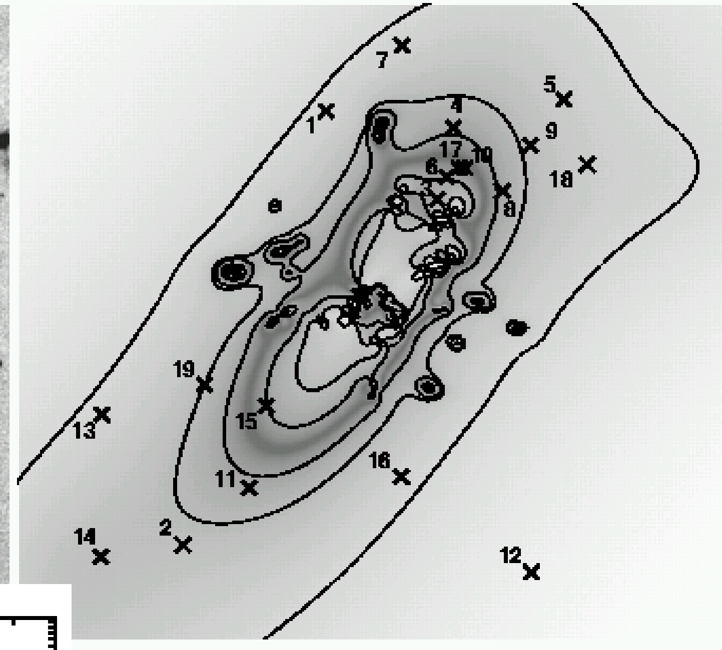
x 10 M_halo(stars) if standard Salpeter

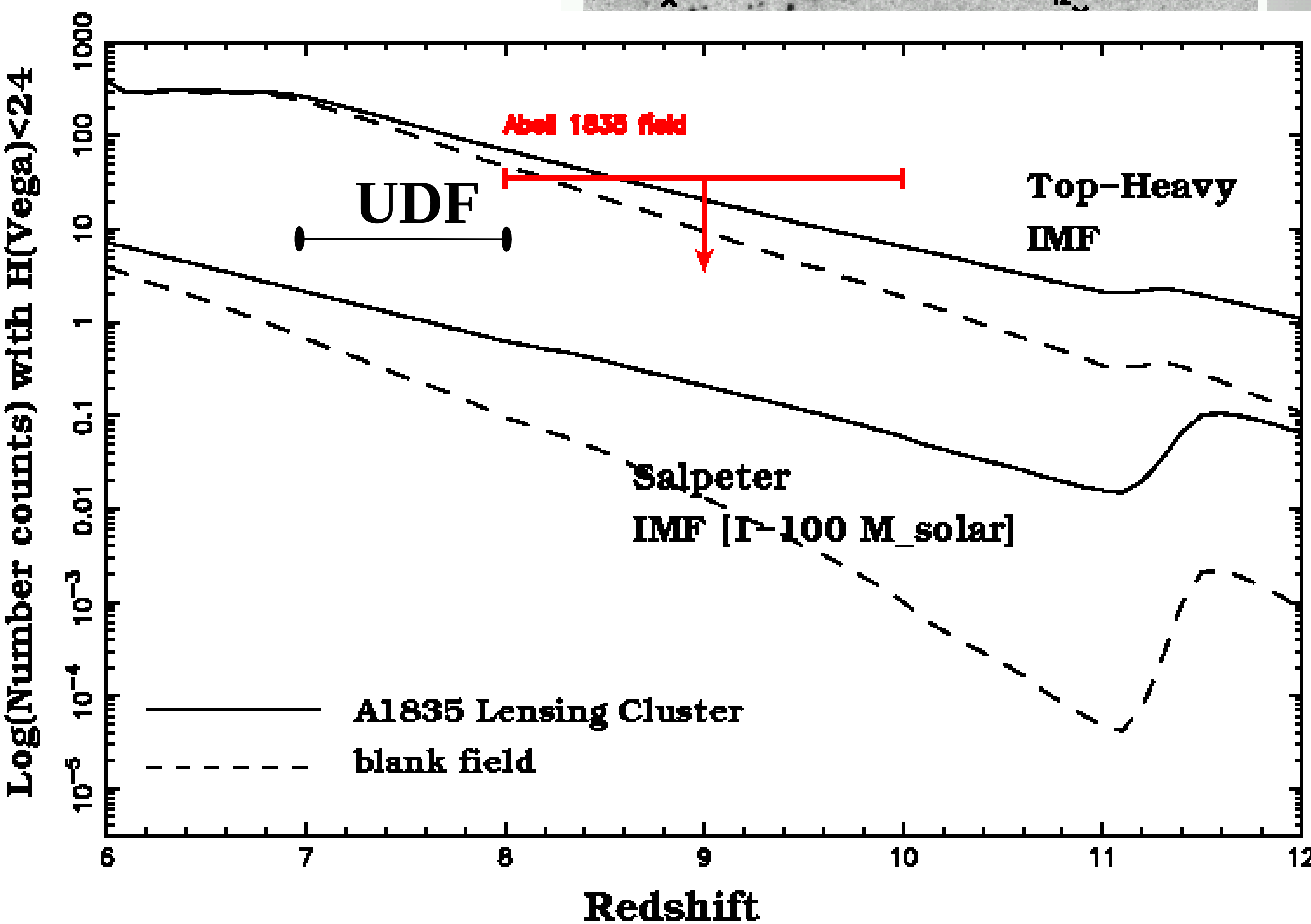
Isaac Deep Survey of lensing clusters:

Broad-band Optical + z(SZ)JHK selected z>7 candidates

Richard et al., in preparation



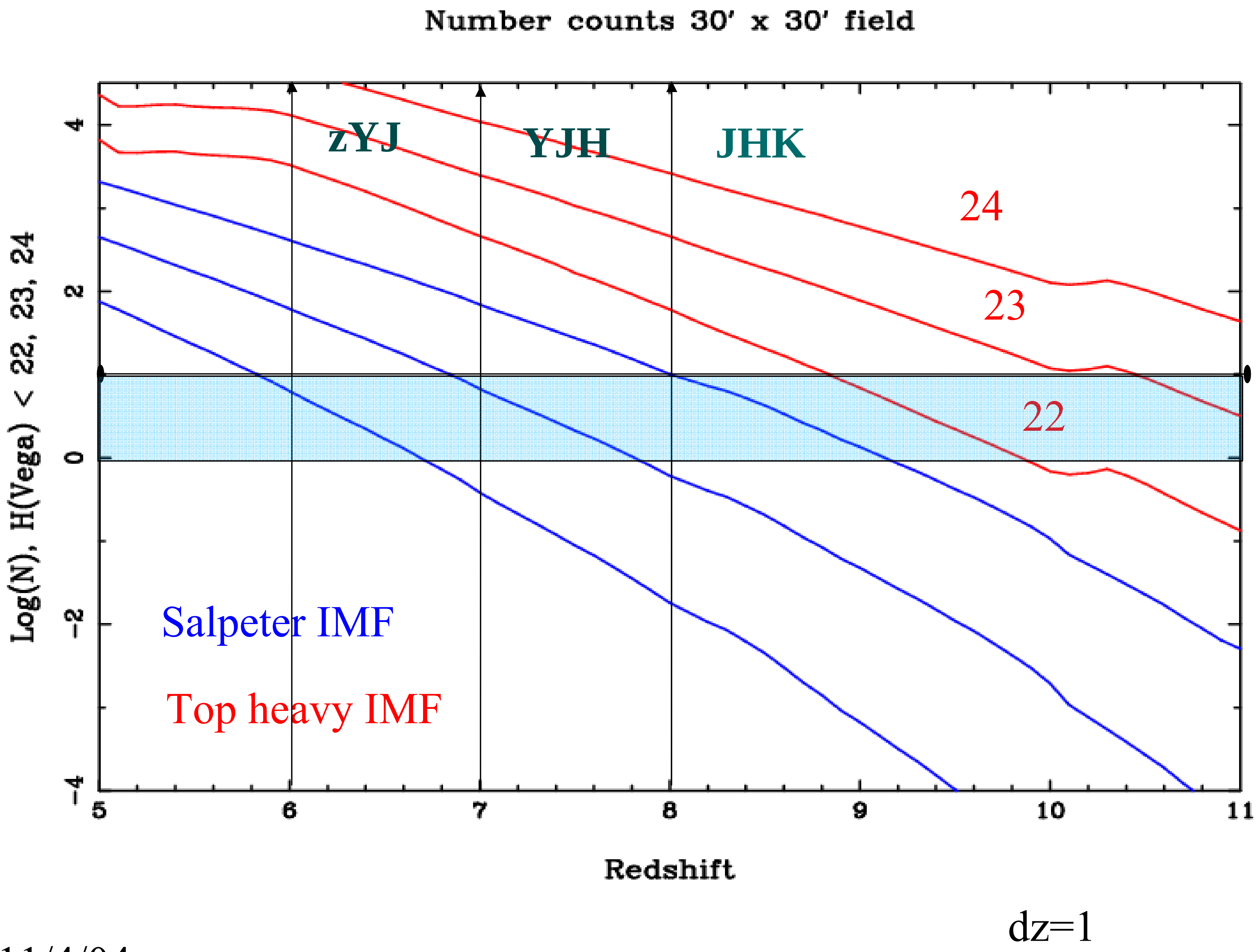


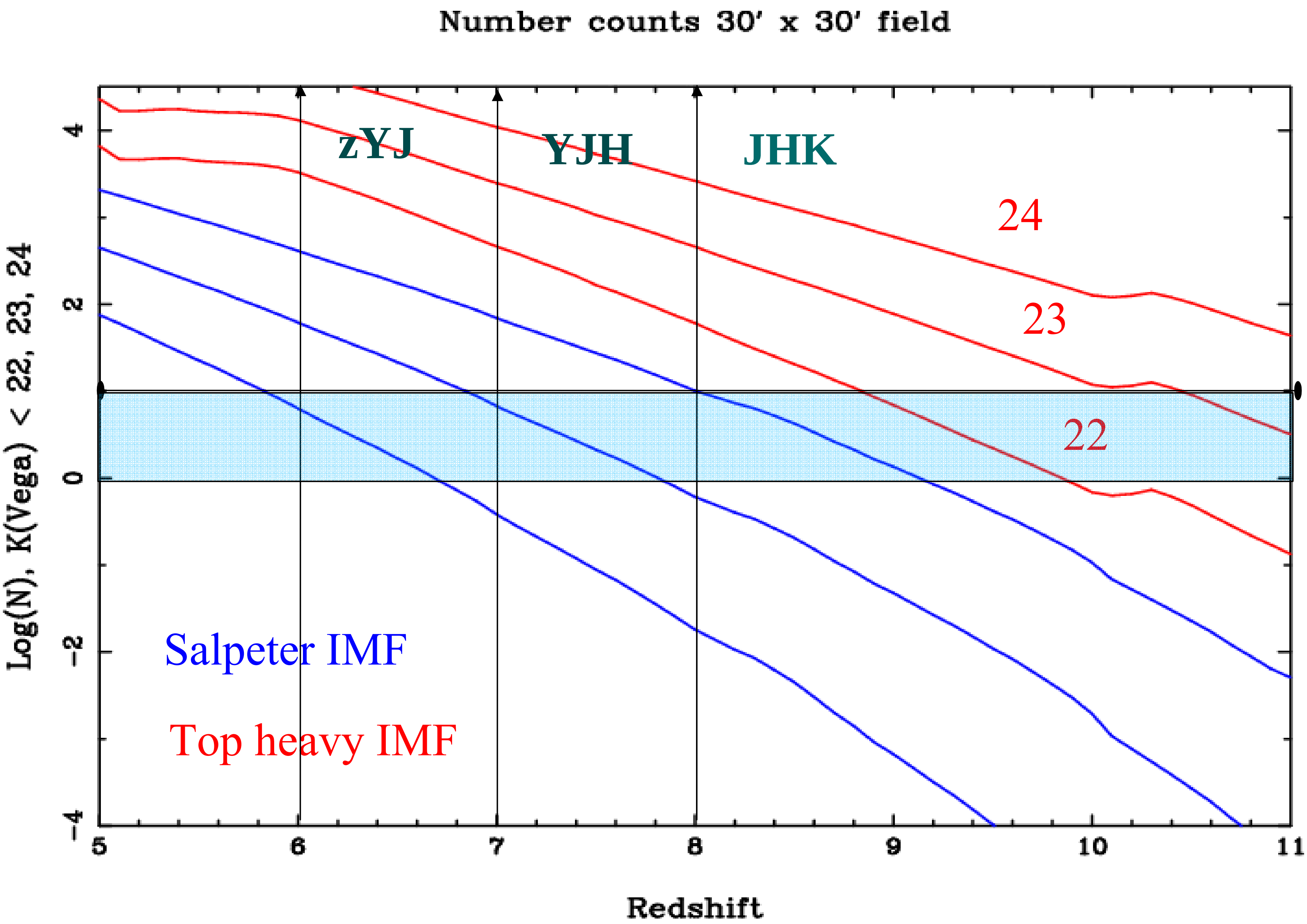


Photometric selection + spectroscopic follow up

~ 5-10 “good” candidates/cluster + secondary candidates

Efficiency to be determined.


Number counts 30′ x 30′ field
zYJ
YJH
JHK
24
23
22
Salpeter IMF
Top heavy IMF
Log(N), H(Vega) < 22, 23, 24
Redshift
4
2
0
−2
−4
5
6
7
8
9
10
11
dz=1



Number counts 30′ x 30′ field
Log(N), K(Vega) < 22, 23, 24
Redshift
zYJ
YJH
JHK
24
23
22
Salpeter IMF
Top heavy IMF
4
2
0
−2
−4
5
6
7
8
9
10
11

dz=1

11/4/04

WUDF: WIRCAM Utra Deep Field

1 WIRCAM field 20'x20'

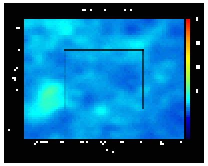
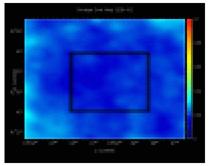
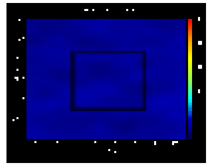
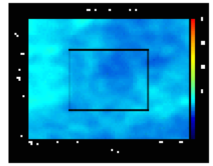
WUDF: minimum setting

filter	AB	exp. time (h)	nights
Y	25.5	14.0	1.5
J	25.5	18.3	2.0
H	25.0	23.8	2.6
Ks	25.0	35.2	3.9
TOTAL		**91.3/field**	**10.0**

WUDF: optimal setting

filter	AB	exp. time (h)	nights
Y	26.0	35.2	3.9
J	26.0	45.9	5.1
H	25.5	59.8	6.6
Ks	25.5	88.3	9.7
TOTAL		**229.2/field**	**25.3**

Seeing: 0.6”
integration in 0.9” aperture
S/N = 5

    ?

Spectroscopic redshifts needed (VVDS fields): D1, D2, D3
Multi-lambda surveys (XMM, Galex, ...) D2, D3
HST/ACS data --> morphology D3

Spectroscopic follow up in the near-IR with “new generation” spectrographs on 8-10m telescopes:

- (Stellar) mass-selected samples of galaxies at intermediate redshift (z~1-4).
- Exploring the z>6 universe.

Example:

EMIR

Goya
Galaxy Origins and Young Assembly

10m GTC/ Canarias (Spain)