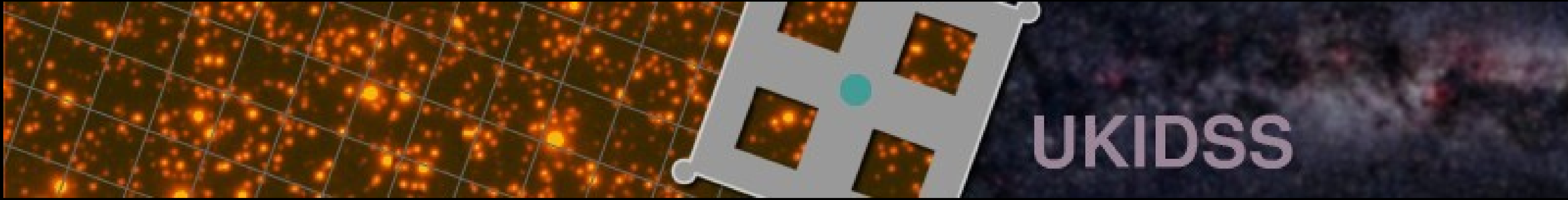


The UKIDSS Ultra-Deep Survey

First results

Sébastien Foucaud

(University of Nottingham)

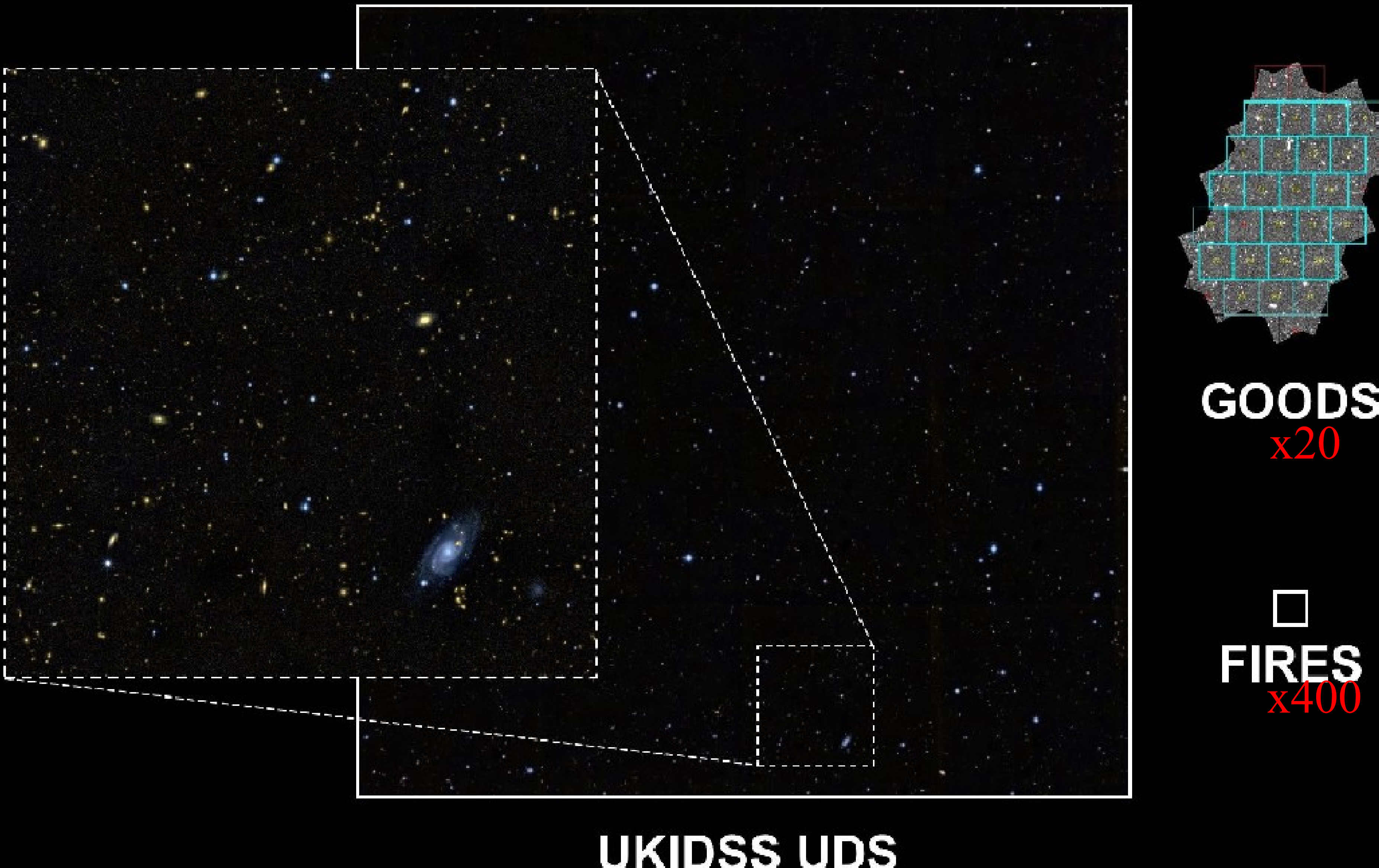
+ UKIDSS UDS Team

Omar Almaini (PI), Rob Chuter, Chris Conselice, Loretta Dunne, Will Hartley,
Kyle Lane, Steve Maddox (Nottingham), Chris Simpson (Liverpool JM),
Ross McLure, Michele Cirasuolo, Rob Ivison (Edinburgh), Jim Dunlop (UBC),
Ian Smail, Alastair Edge (Durham), Mike Watson, Paul O'Brien (Leicester),
Matt Jarvis (Hertfordshire), Steve Rawlings, Lee Clewley, Garrett Cotter,
Gavin Dalton (Oxford), Caroline van Breukelen (UCL), Mat Page (MSSL),
Kaz Sekiguchi (NAOJ), Steve Serjeant (Kent), Paul Hirst (Gemini),
Steve Eales, Simon Dye (Cardiff),
Marijn Franx (Leiden), Andrea Cimatti (Arcetri)

The University of Nottingham

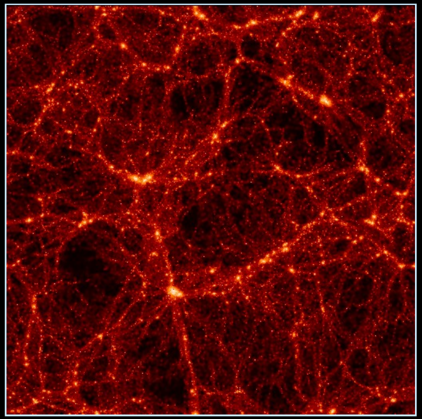
The UKIDSS Ultra-Deep Survey

http://www.nottingham.ac.uk/astronomy/UDS

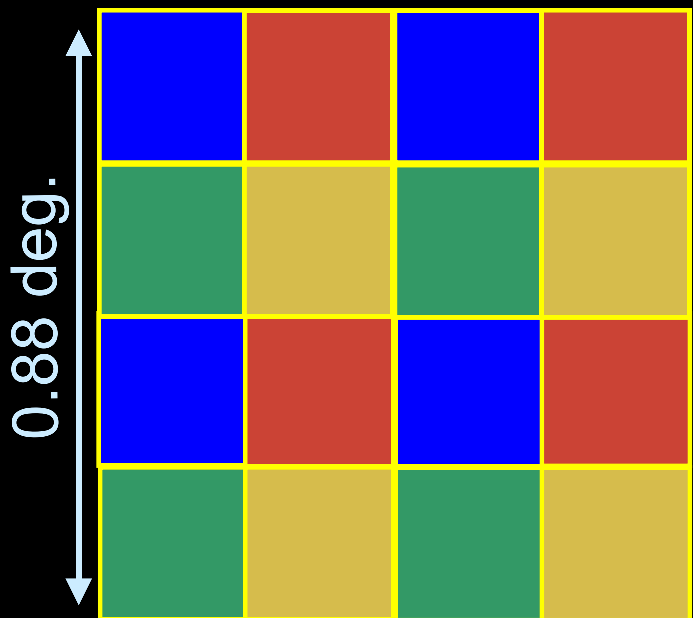


Key goals of the Ultra-Deep Survey

- When are galaxies assembled?
  - detailed luminosity functions from 1<z<6
- High-z galaxy mass function
  - Model SEDs (u,b,v,r,i',z',J,H,K + Spitzer)
- How do galaxy properties evolve with time?
  - Formation of the red sequence
  - Morphologies, prevalence of AGN etc.
- Large-scale structure
  - provides probe of dark matter halos
  - evolution of clustering & bias



The UKIDSS Ultra-Deep Survey



Depths achieved so far:

(5σ, 2" apertures, AB)

DR3: K_{AB}=23.8, H_{AB}=23.4, J_{AB}=23.5

seeing : J~0.90'' H~0.85'' K~0.75''

Almaini, Foucaud et al. (in prep.)

DR1: K_{AB}=23.6, J_{AB}=23.5

seeing : J~0.90'' K~0.75''

Warren et al. (2007)

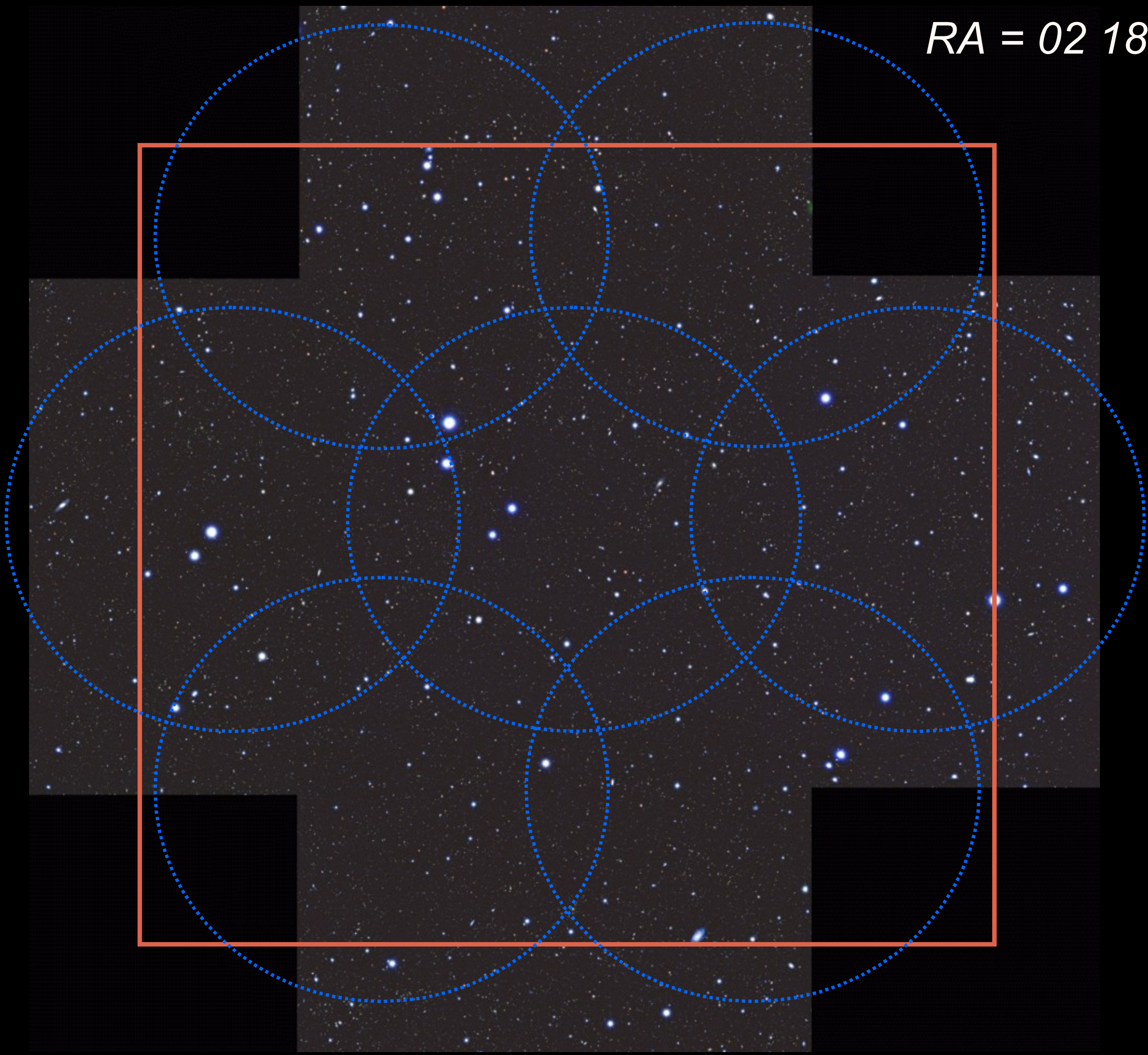
EDR: K_{AB}=22.6, J_{AB}=22.6

seeing : J~0.80'' K~0.70''

Dye et al. (2006); Foucaud et al. (2007)

Main part of the publications so far...

The Subaru/XMM Deep Field



RA = 02 18 00, Dec = -05 00 00

Optical

Far Infrared

Ultraviolet

X-ray

Radio

Submm

Spectro

Optical data

- Subaru SXDS DR1 (public 01/08)

  http://soaps.naoj.org

  B_{AB}=28.2, V_{AB}=27.6, R_{AB}=27.5, i'_{AB}=27.2, z'_{AB}=26.3

- CFHTLS Wide T0003 (public 02/07)

  http://www.cfht.hawaii.edu/Science/CFHTLS

  U^*_{AB}=24.9, g'_{AB}=25.3, r'_{AB}=24.7, i'_{AB}=25.0, z'_{AB}=23.2

- U-band (on-going)

  CFHT: 16h, PI: Almaini

  WHT: 4nights,PI: Balcells

UV/IR data

- GALEX GR2/GR3 (public 09/07)
  http://galex.stsci.edu

  NUV_{AB}=25.5, FUV_{AB}=25.5

- SWIRE DR4 (public 10/06)
  http://swire.ipac.caltech.edu/swire

  IRAC+MIPS:
  F(3.6μm)>5.0μJy, F(4.5μm)>9.0μJy, F(5.6μm)>43.0μJy, F(8.0μm)>40μJy, F(24.0μm)>311μJy

- Spitzer (on going)
  IRAC+MIPS: 292 hours, PI: Dunlop (public legacy survey)
  raw data world public immediately, processed data as soon as possible after that (early 2008)

X/Radio/Submm

- XMM-Newton 100ks + 6x50ks 2XMM (public 09/07)
  http://xmmssc-www.star.le.ac.uk

  f_X(soft)~ 3x10^{-15} erg.cm^{-2}.s^{-1}, f_X(hard)~ 1.5x10^{-14} erg.cm^{-2}.s^{-1}

- VLA 1.4Ghz (catalogue public)
  http://www.astro.livjm.ac.uk/~cjs/SXDS/radio

  12-20μJy per beam
  source list published in Simpson et al. (2006) - NED

- SHADES 850μm (catalogue public)
  http://www.roe.ac.uk/ifa/shades/

  8mJy 4.0σ at 850μm
  source lists were published in Coppin et al. (2006) - NED

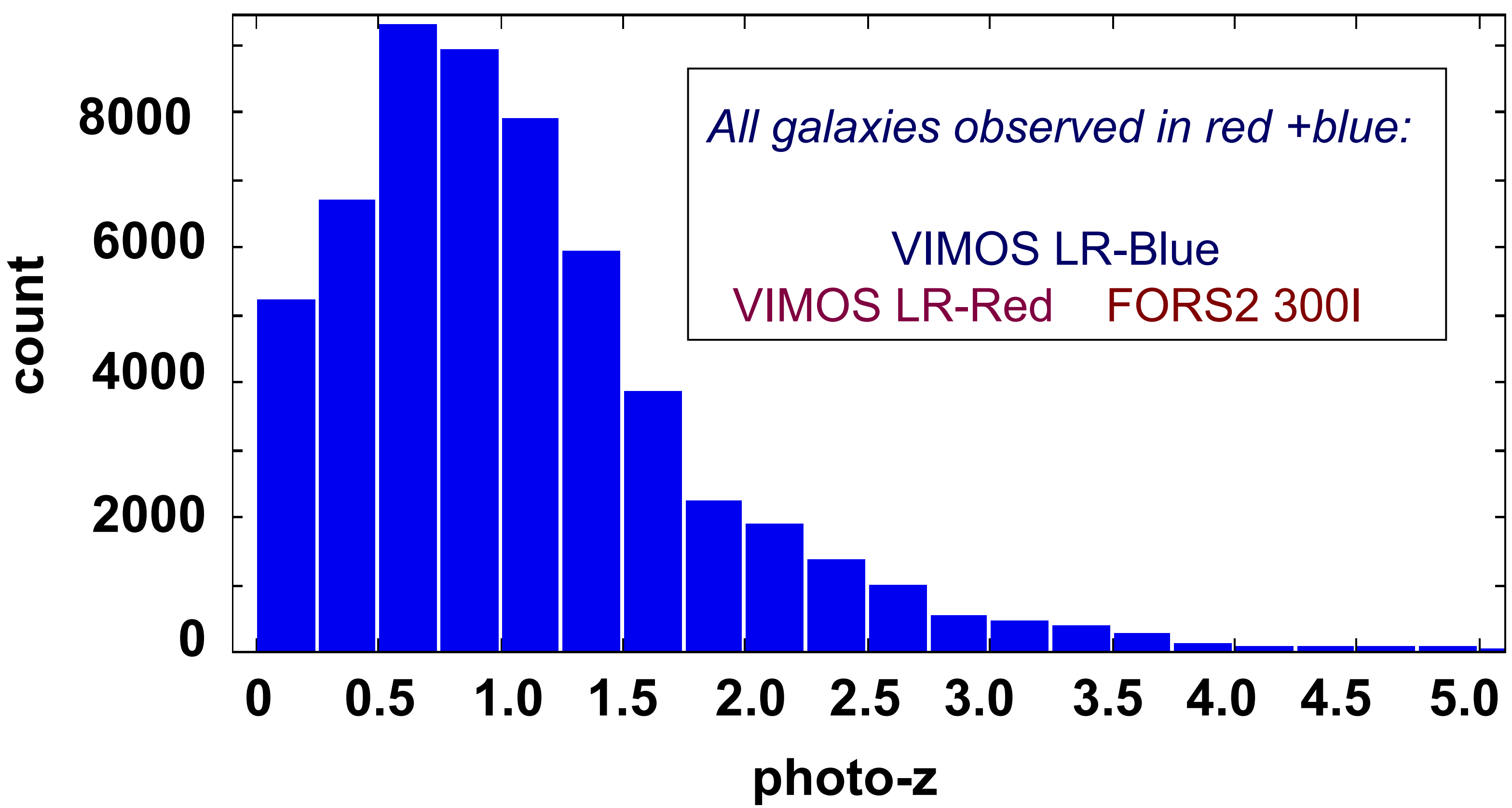
  + **SCUBA-2 Cosmology Legacy Survey**

ESO Large Programme: UDSz

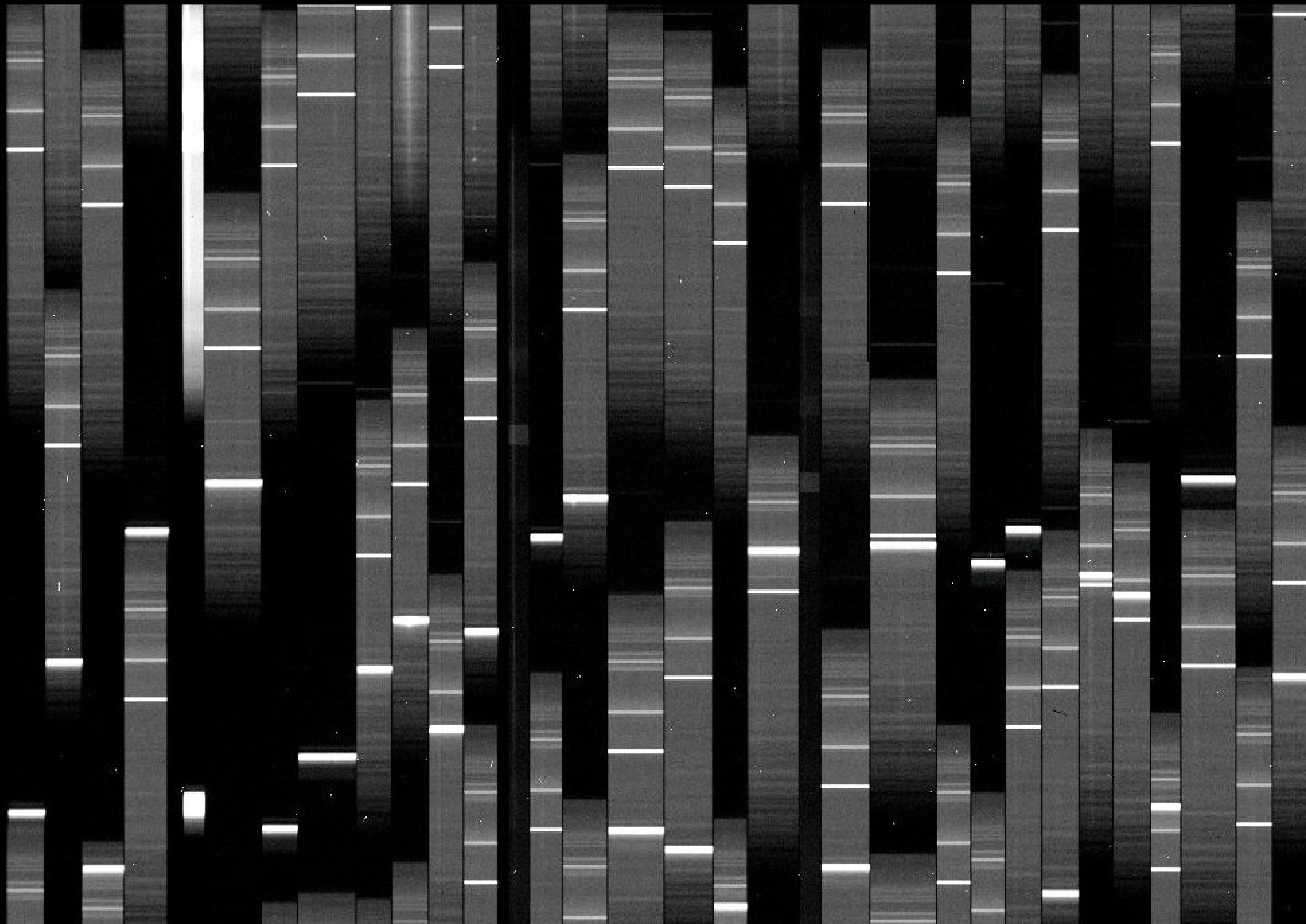
93 hours VIMOS
142 hours FORS2

ESO Large Programme: UDSz

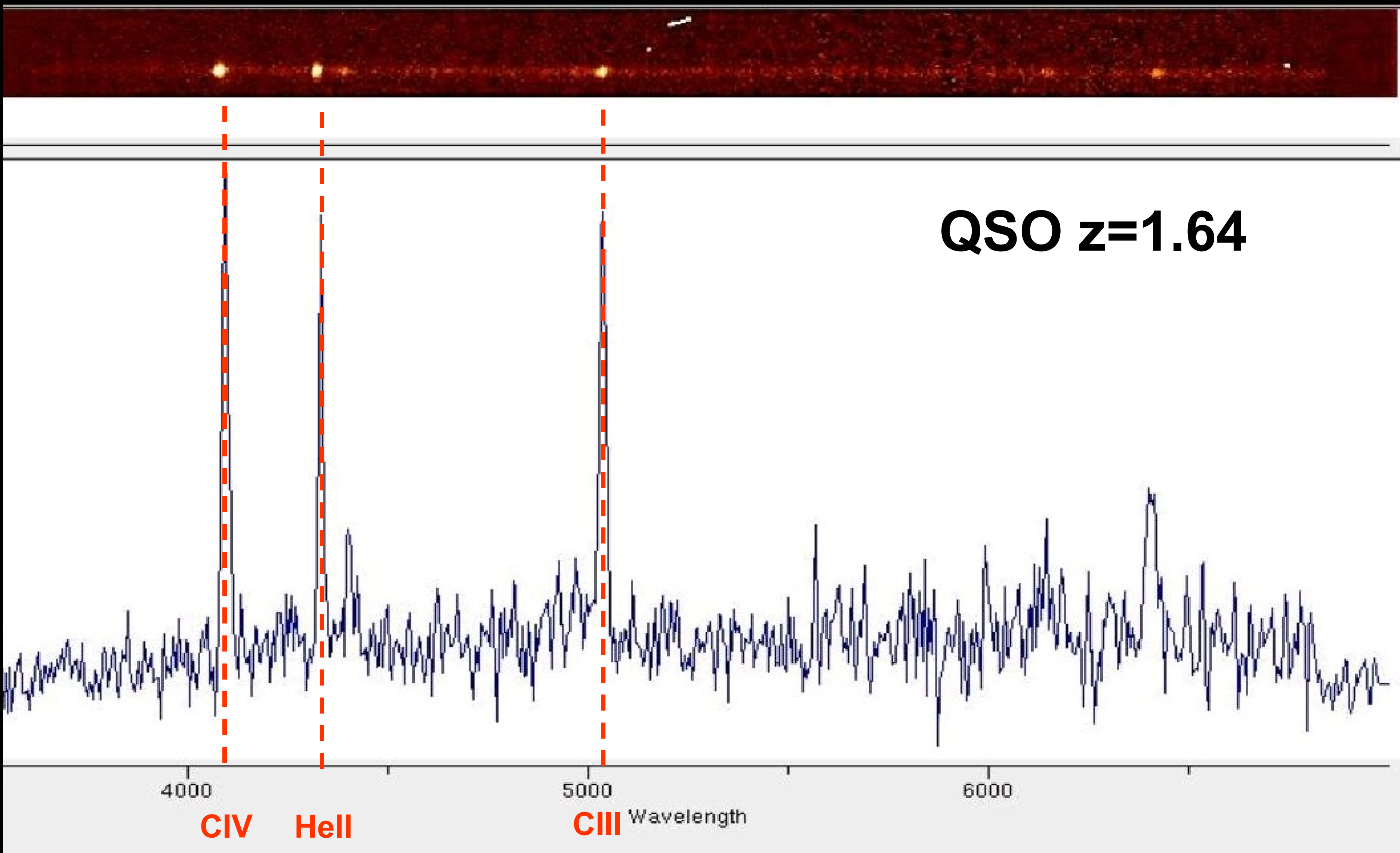
- K-selected sample to K_{AB}<23 over 0.6 sq degrees
- Pre-selected with z_{phot}>1 (plus control sample)
- Sampling 1/6 galaxies (~4000)



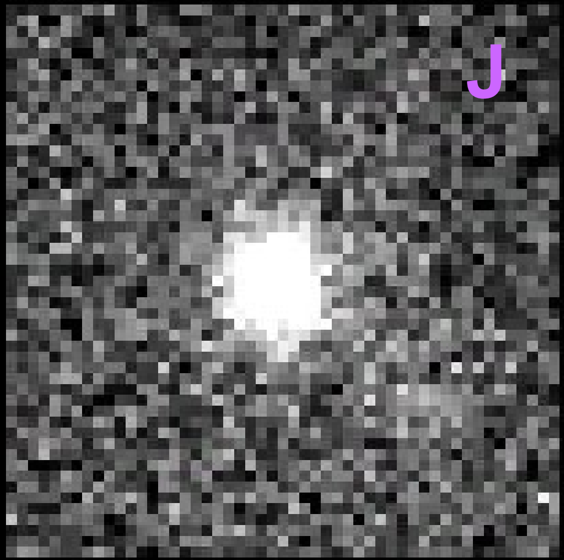
UDSz: firsts VIMOS spectra

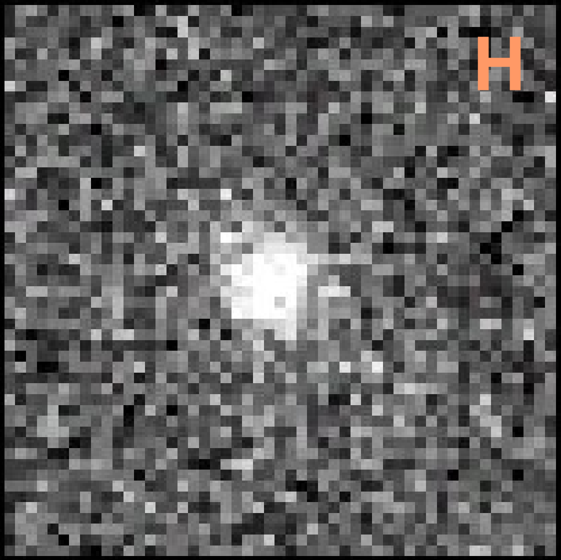


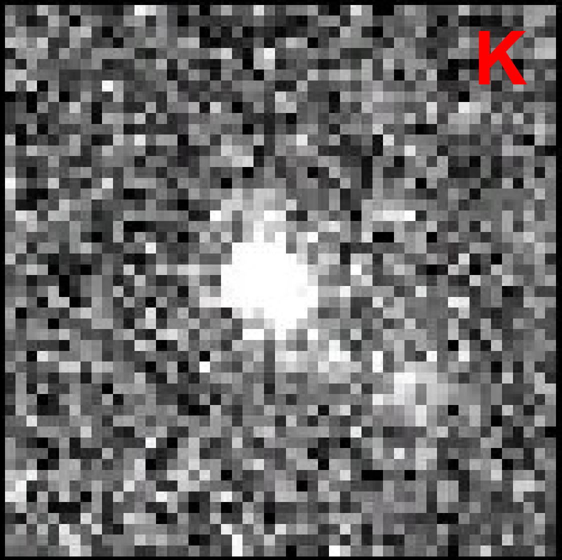
UDSz: first redshift !!!



UDSz: first redshift !!!

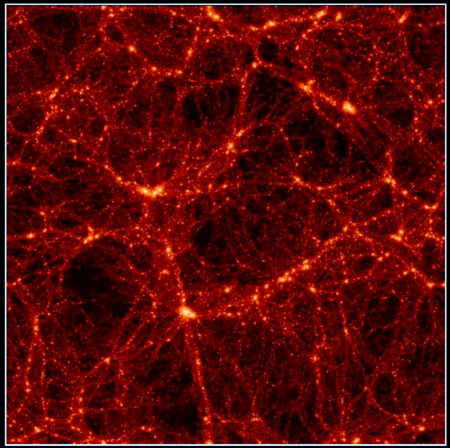




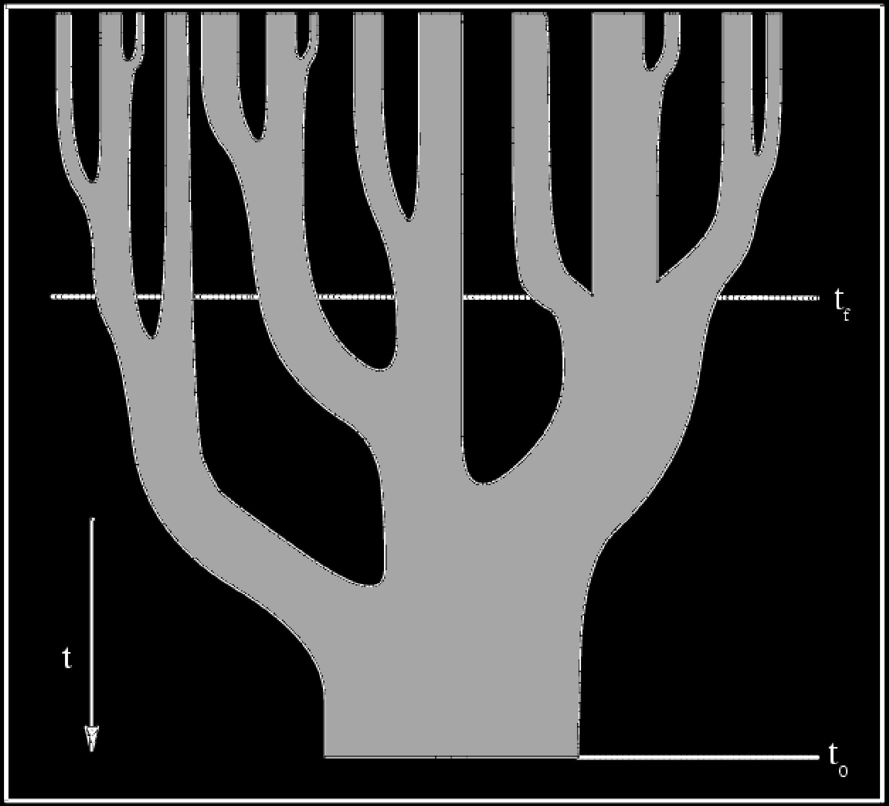


Summary of UDS scientific results

- Detection of luminous LBGs at z>5
  - McLure et al. (2006), MNRAS, 372, 357
- Study and selection of EROs
  - Simpson et al. (2006), MNRAS, 373, L21
- Selection of high-z groups and clusters
  - van Breukelen at al. (2006), MNRAS, 373, L26
- Strong clustering of bright DRGs
  - Foucaud et al. (2007), MNRAS, 376, L20
- Compton-thick quasars at high redshift
  - Martínez-Sansigre et al. (2007), MNRAS, 379, L6
- Colour selection of high-z galaxies
  - Lane et al. (2007), MNRAS, 379, L25
- K-band luminosity function to z=2
  - Cirasuolo et al. (2007), MNRAS, 380, 585
- Clustering of 24μm-selected galaxies
  - Magliocchetti et al. (2008), MNRAS, 383, 1131
- FIR/Radio correlation at high redshift
  - Ibar et al. (2008), accepted, astroph/0802.2694
- Space density and clustering of passive galaxies
  - Hartley et al. (2008), submitted
- Etc…



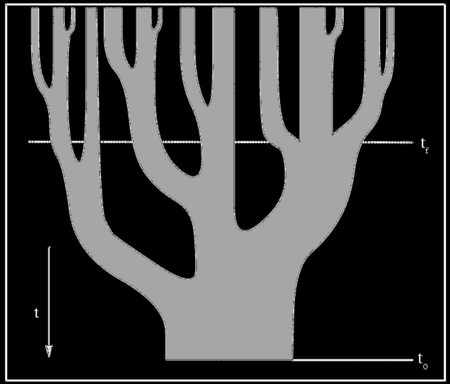
Merger Tree for the Growth of a Dark-matter Halo



- Halos built up their mass through assembly of sub-systems
- Describe well large scale properties
- Merging ubiquitous

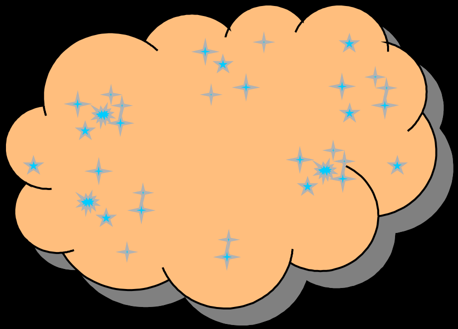
Lacey & Cole (1993)

Semi-analytic Galaxy Formation Models



N-body merger trees

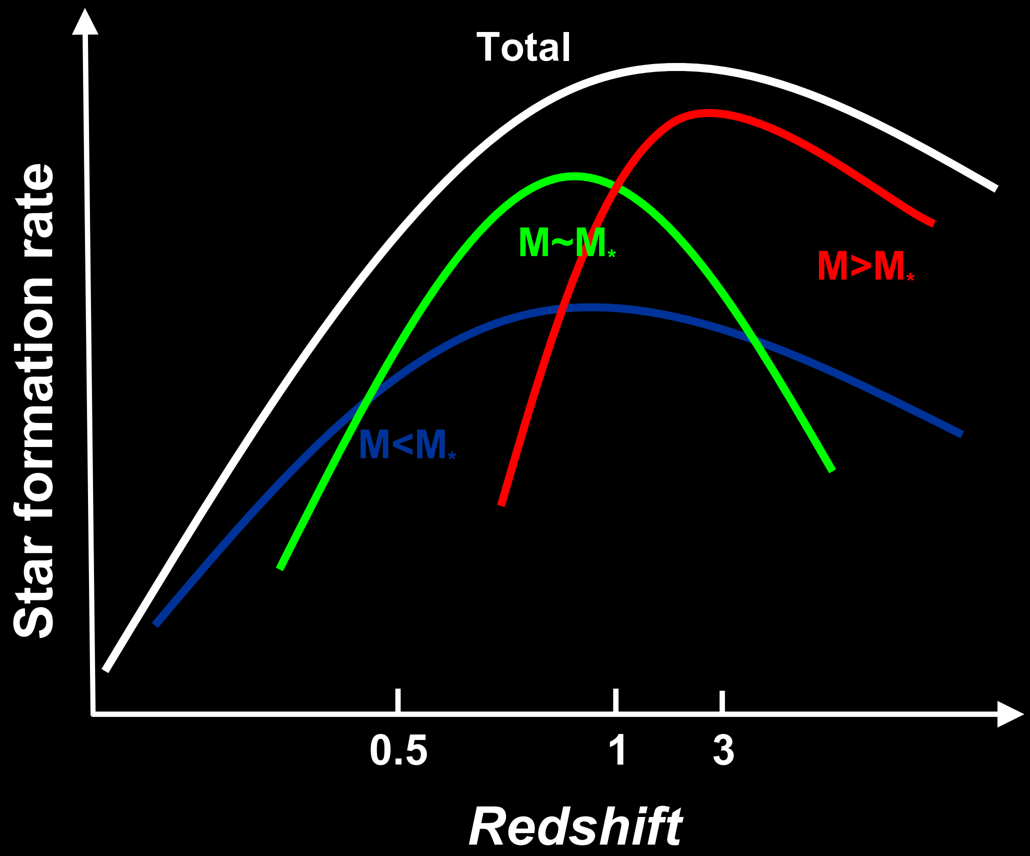
+



Messy physics
(gas cooling, star-formation,
AGN, dust, feedback etc…)

=

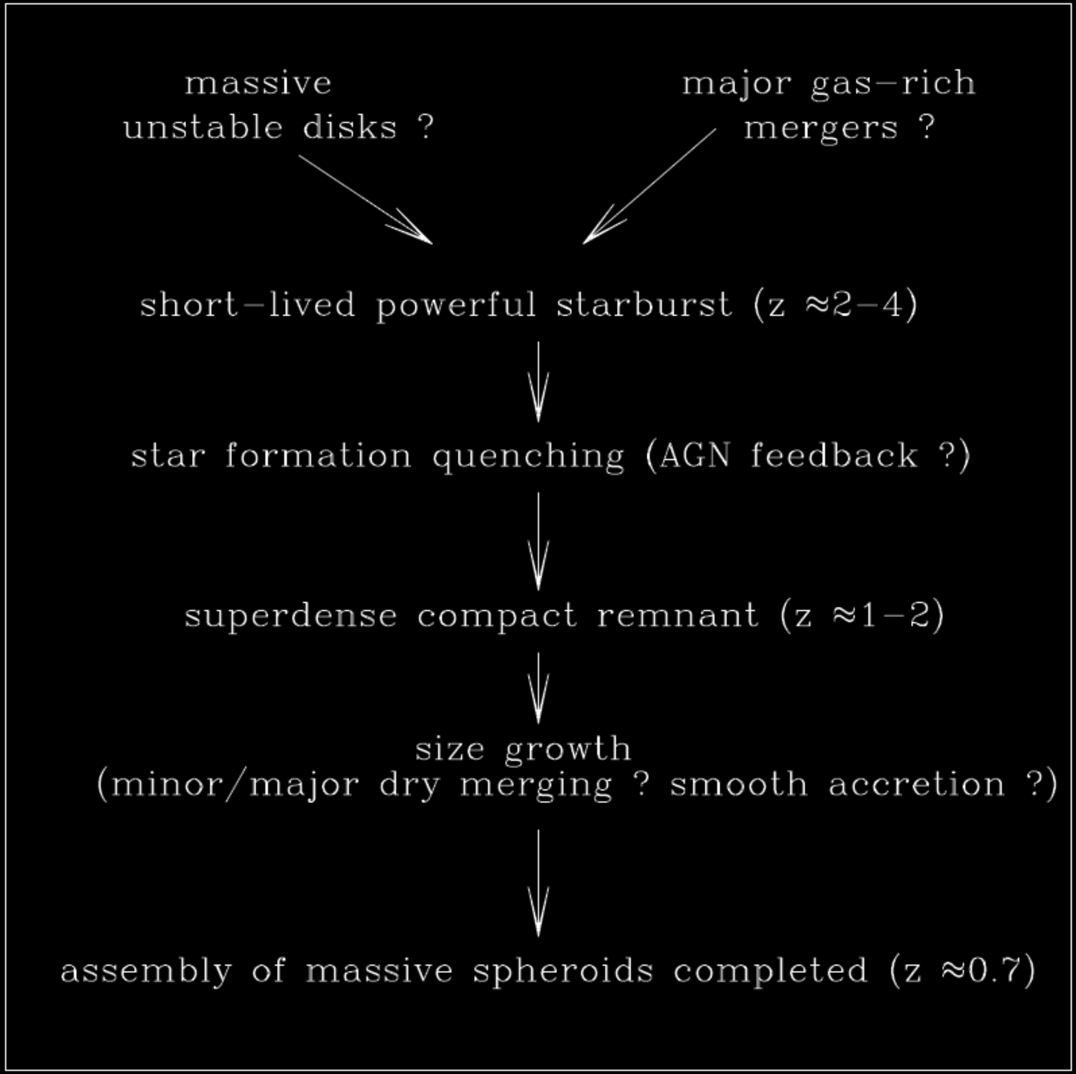
Star formation history



- Massive galaxies dominate the star formation at high-z
- Massive galaxies already in place at z~1?
- “Downsizing”: star formation migrates from more massive systems to low massive systems

Glazebrook et al. (2004)

Possible scenario for formation of massive galaxy

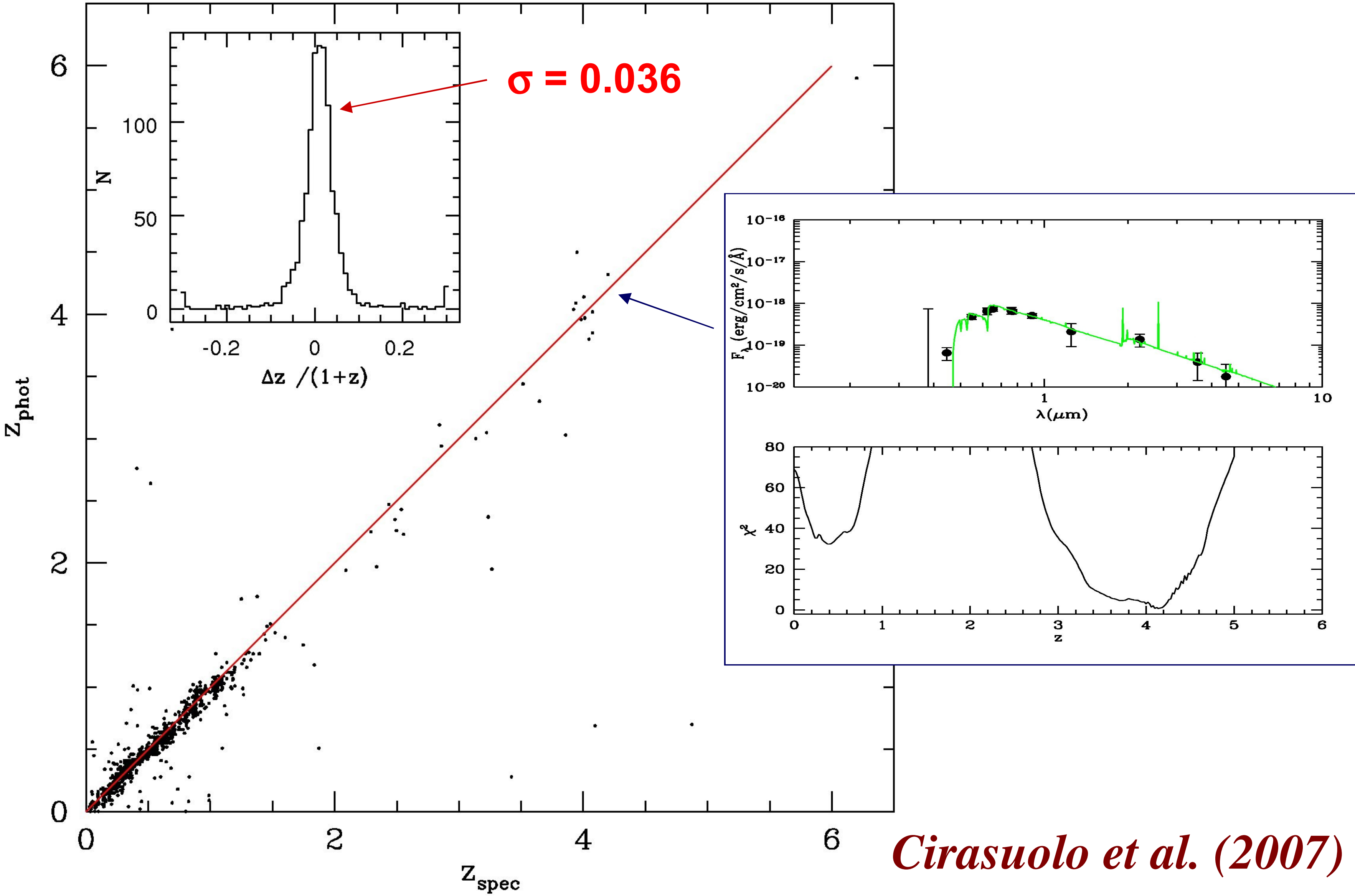


Cimatti et al. (2008)

Galaxy evolution since z=2

Photometric Redshifts

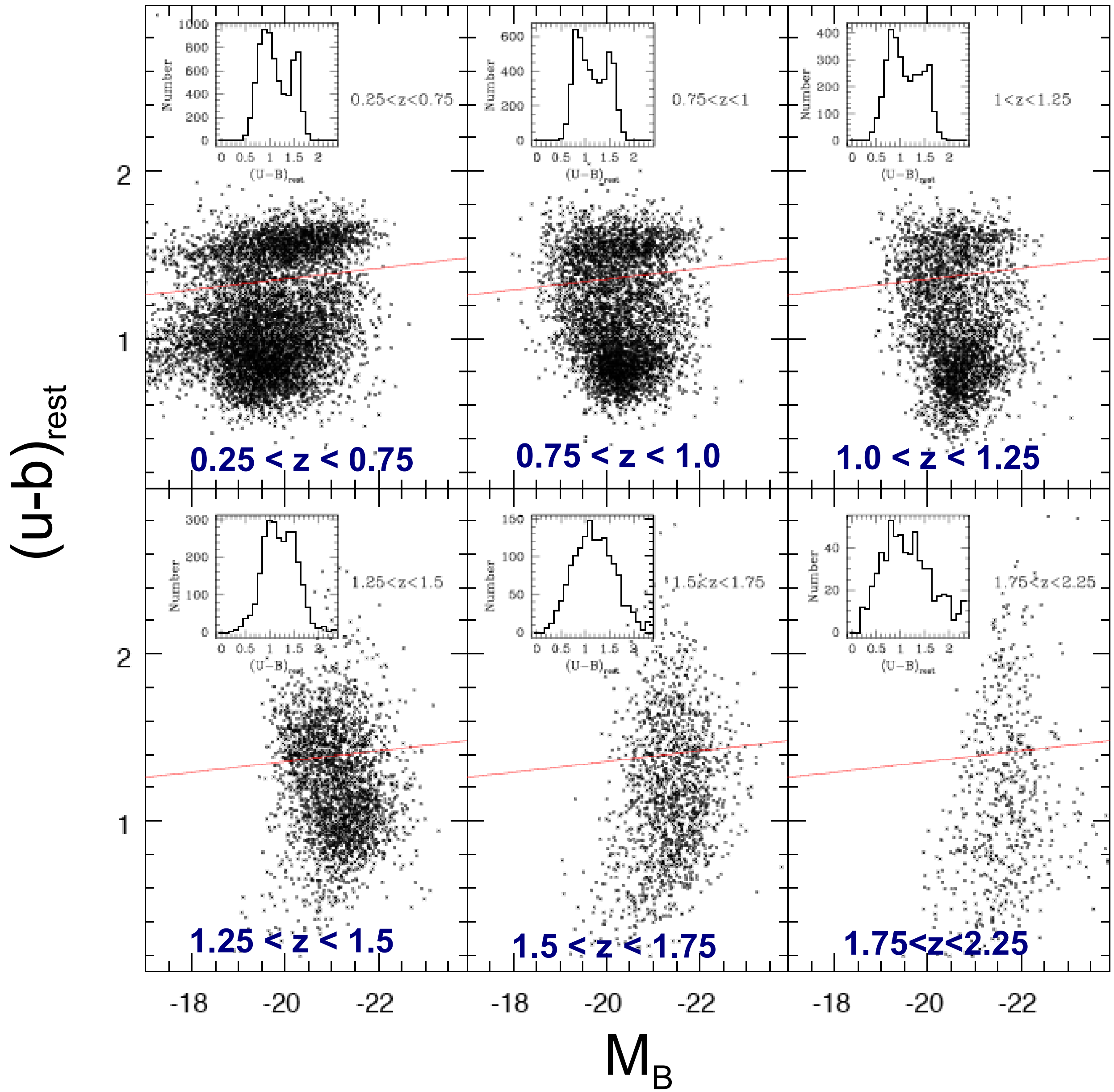
(u,b, v, r, i’, z’, J, K, 3.6, 4.5)



Cirasuolo et al. (2007)

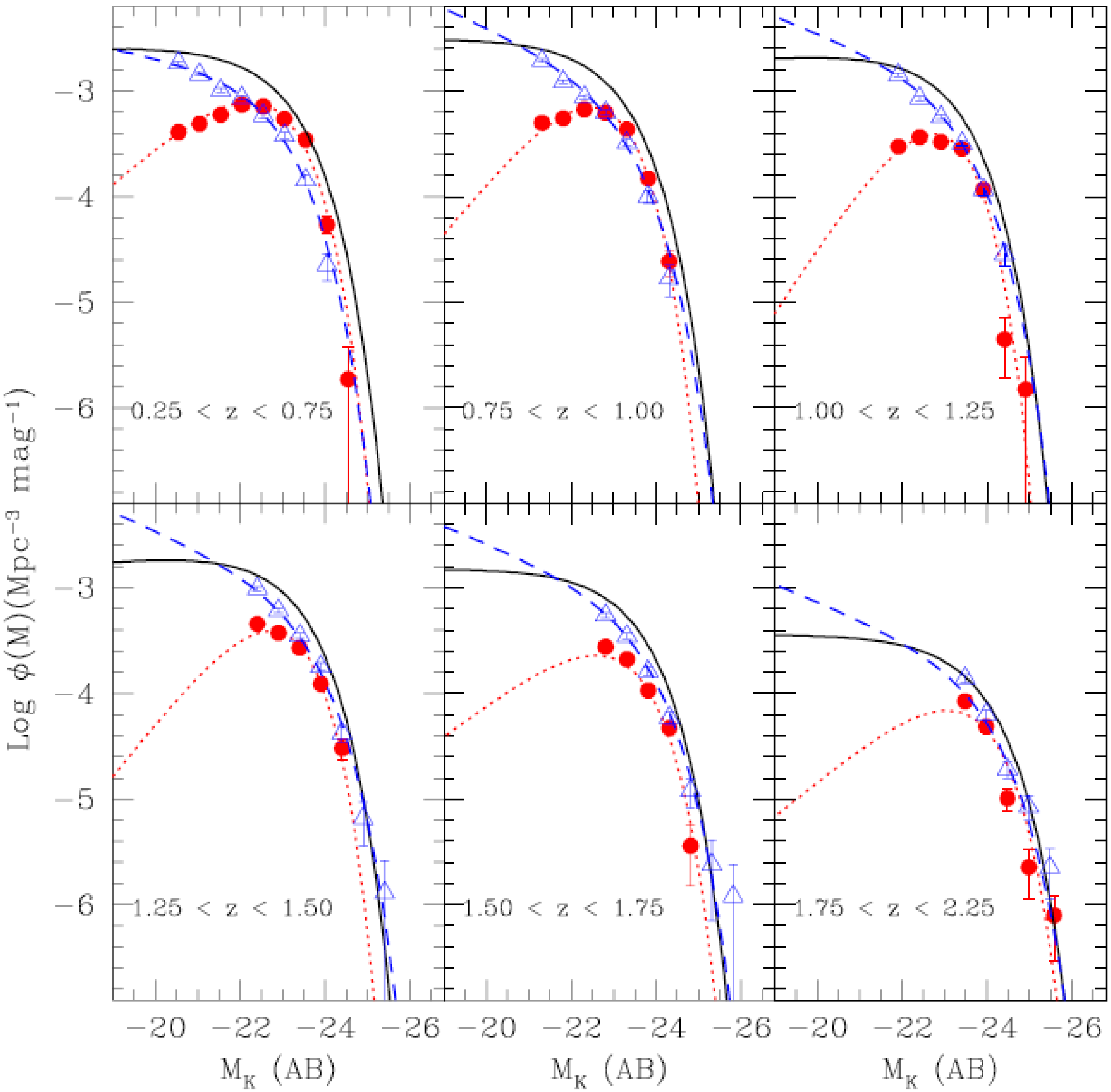
Evolution in colour bimodality

Cirasuolo et al. (2007)



K-band luminosity functions (blue vs red)

Cirasuolo et al. (2007)

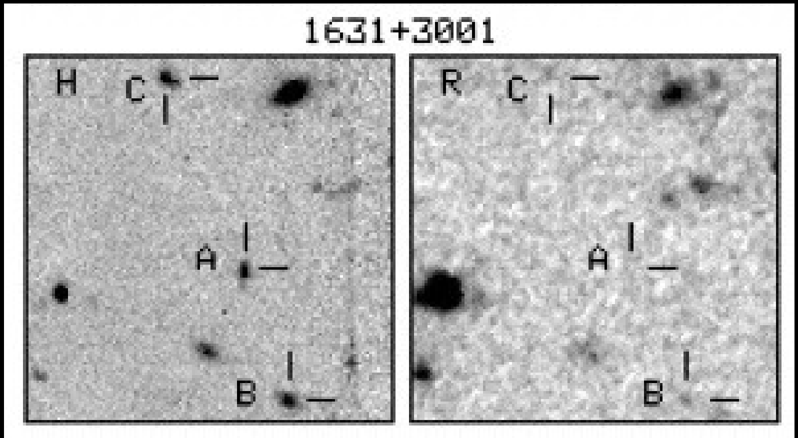


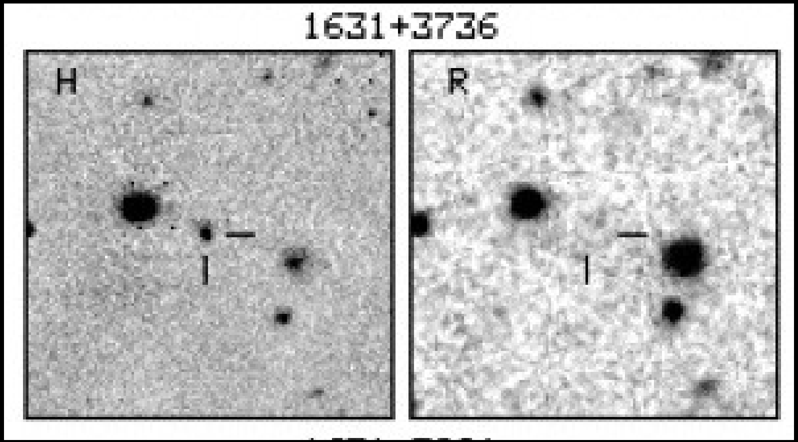
Properties of (massive) galaxies at 1<z<3

The need for deep infrared surveys

Optical surveys sample rest-frame UV at high-z

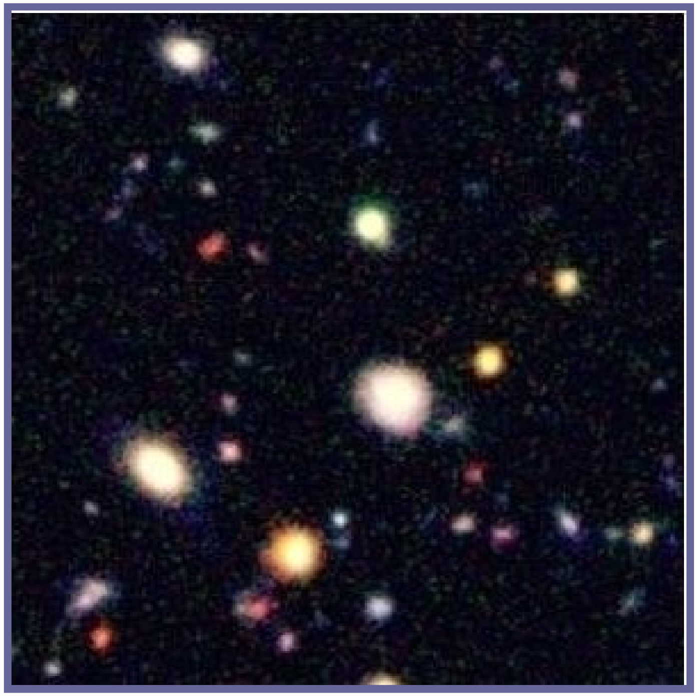
1. Biased against high-z galaxies obscured by dust
2. Bias against high-z galaxies with old stellar populations
3. Provide poor estimate of stellar mass





Deep IR surveys vital for a complete census at z>1

Distant Red Galaxies @ z>2

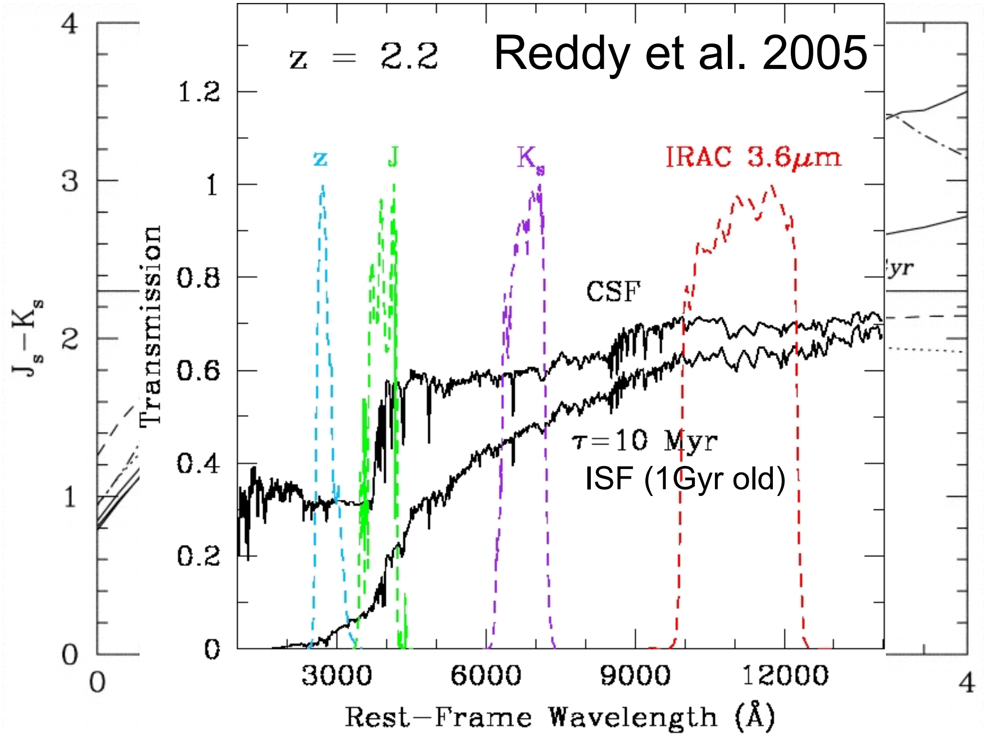


FIRES:

4.7 $arcmin^2$ to K~22.5

Using J-K>2.3 colour selection.

Find population consistent with z>2 galaxies. (FIRES: 14 objects)



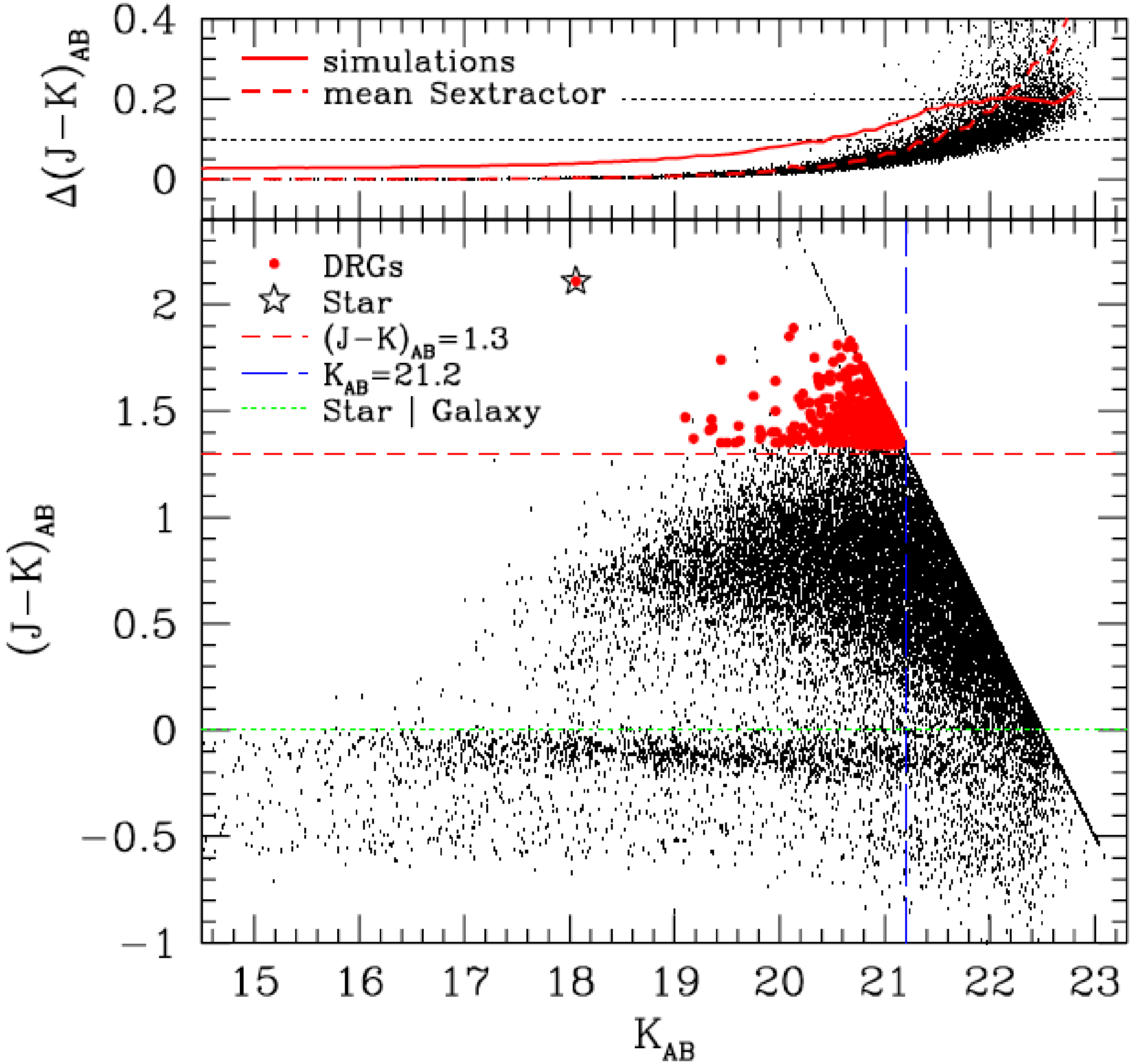
Labbe et al. 2002,
Van Dokkum et al. 2003,
Daddi et al. 2004, etc…

369 DRG candidates in UDS EDR

Foucaud et al. (2007)

Distant Red Galaxies
$(J\text{-}K)_{AB} > 1.3$

(N=239 to K=20.7)



First bright DRG correlation function

Foucaud et al. (2007)

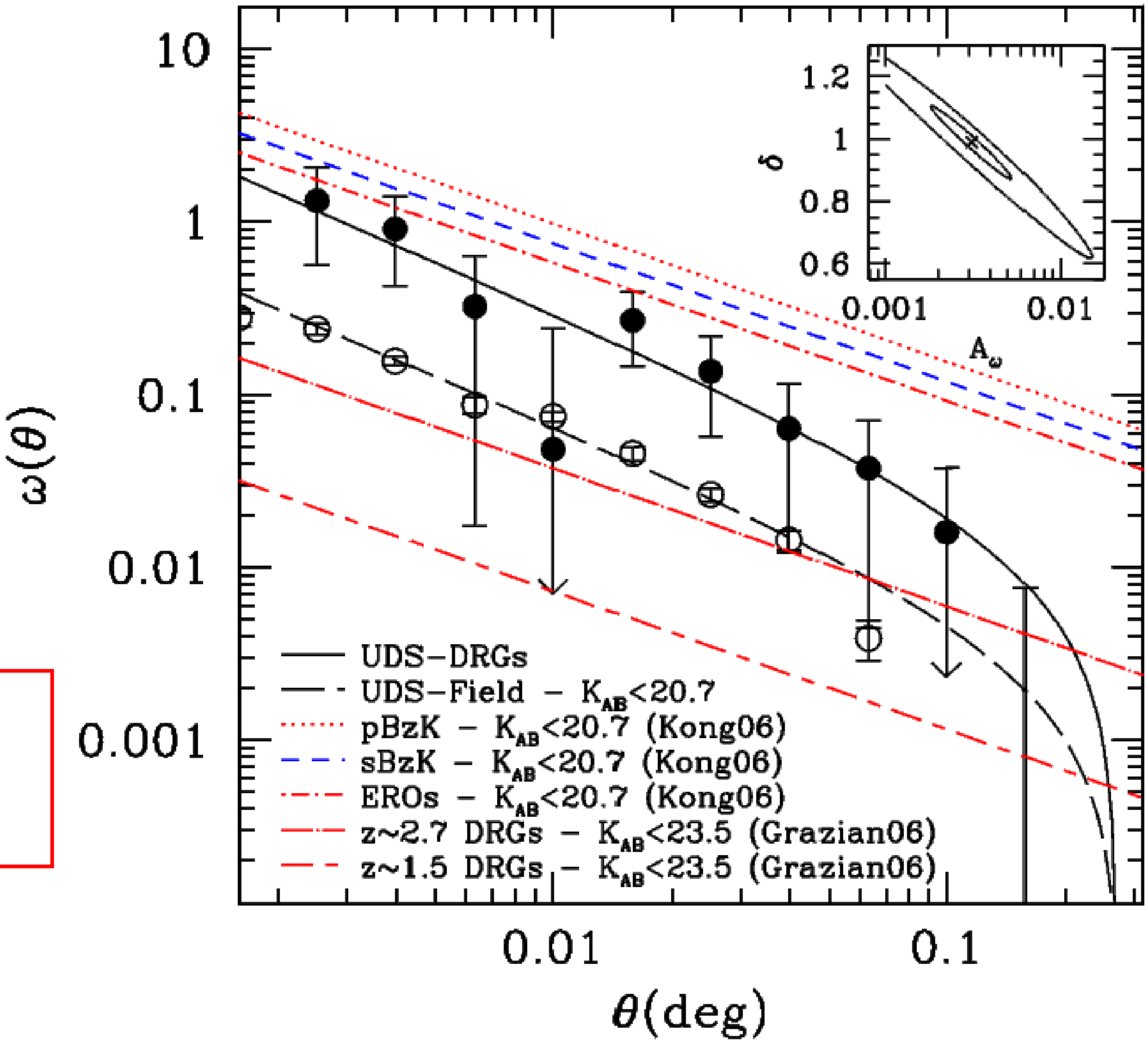
Distant Red Galaxies
$(J\text{-}K)_{AB} > 1.3$

z~1.1

(N=239 to K=20.7)

Using n(z) + Limbers:

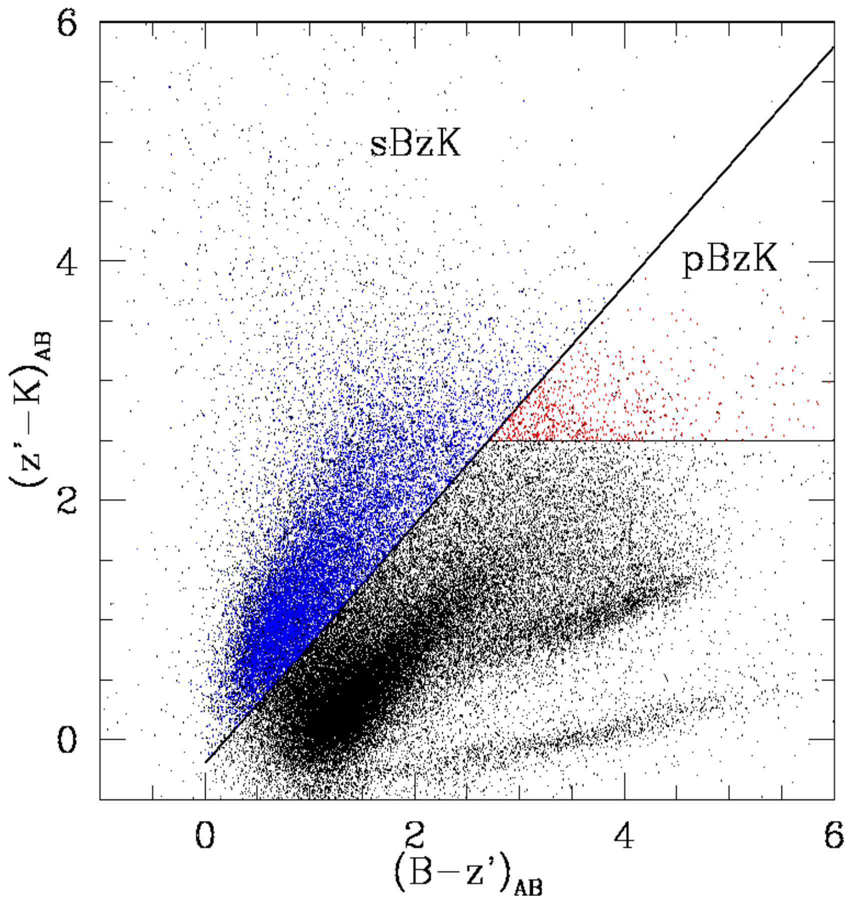
$r_0 = 11 \pm 2.0\ h^{-1}$ Mpc

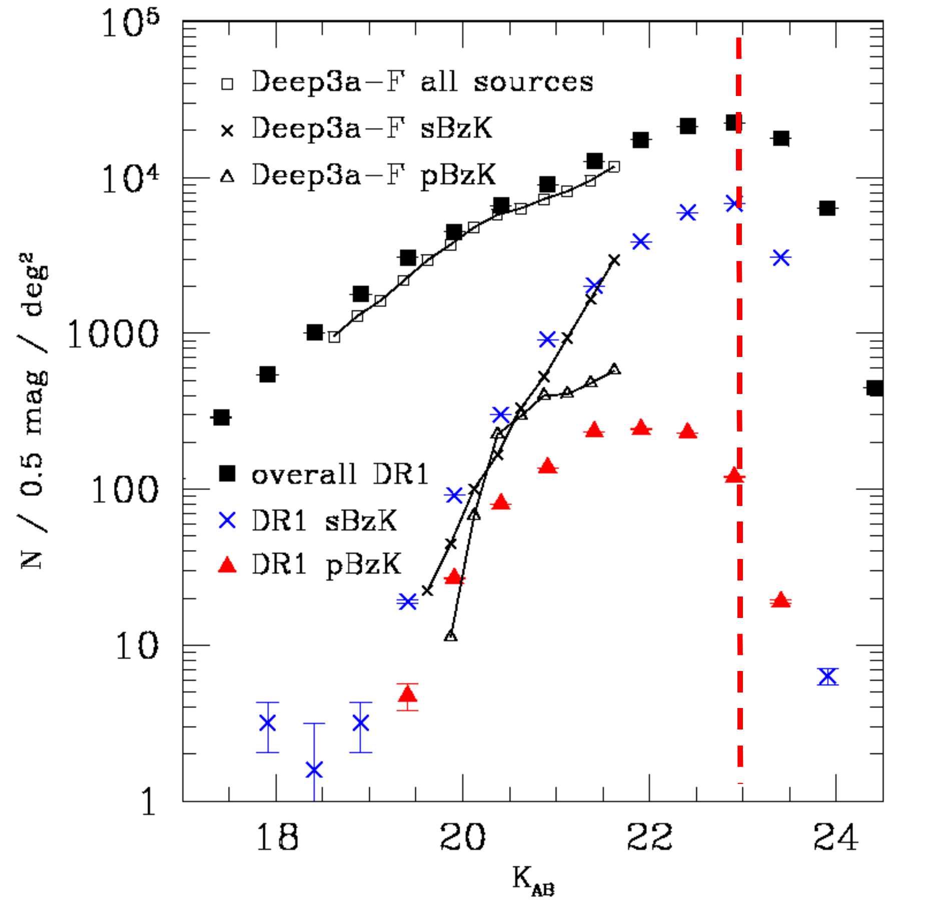


BzK selection of galaxies at z>1.4

Lane et al. 2007

Hartley et al. (submitted)





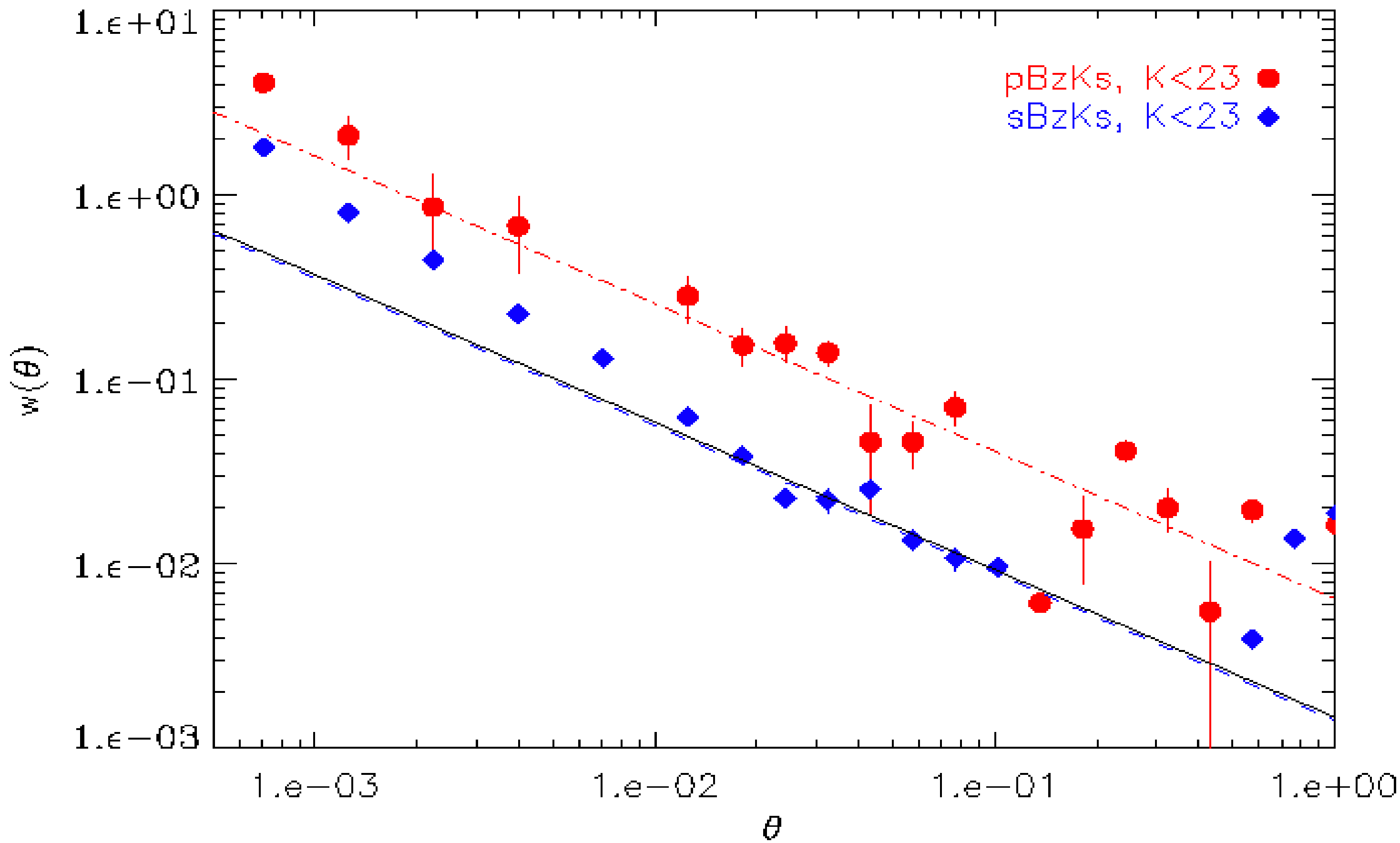
star-forming & passive galaxies
1.4 < z < 2.5

number counts show a clear turn-over

most conservative selection cannot remove the feature (including z' non-detections)

BzK correlation function

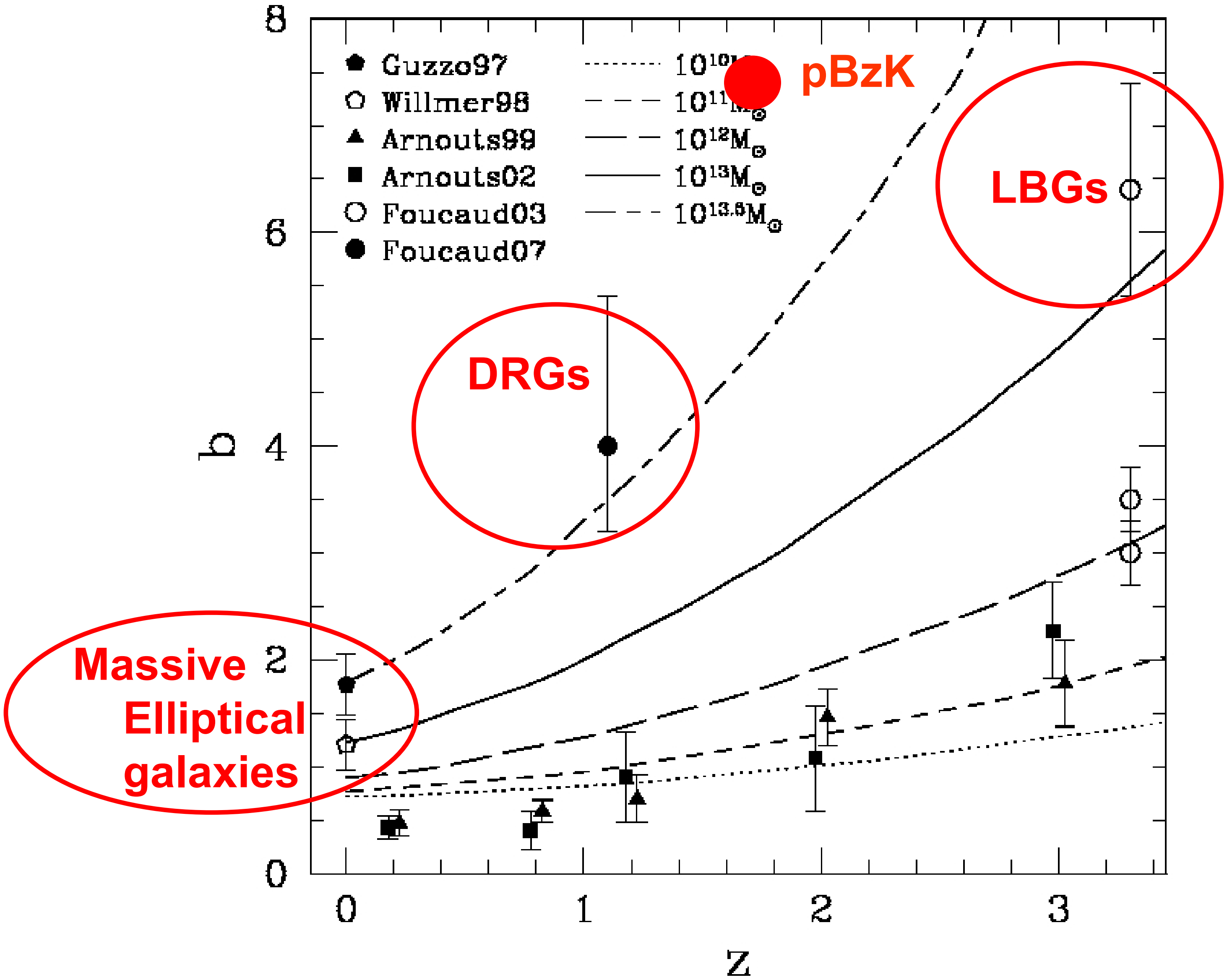
Hartley et al. (submitted)



r_0 values: pBzK – 17.5 h^{-1}Mpc; sBzK – 8.3 h^{-1}Mpc.

large excess on small scales for the sBzK's – suggests a lot of merging by z = 0.

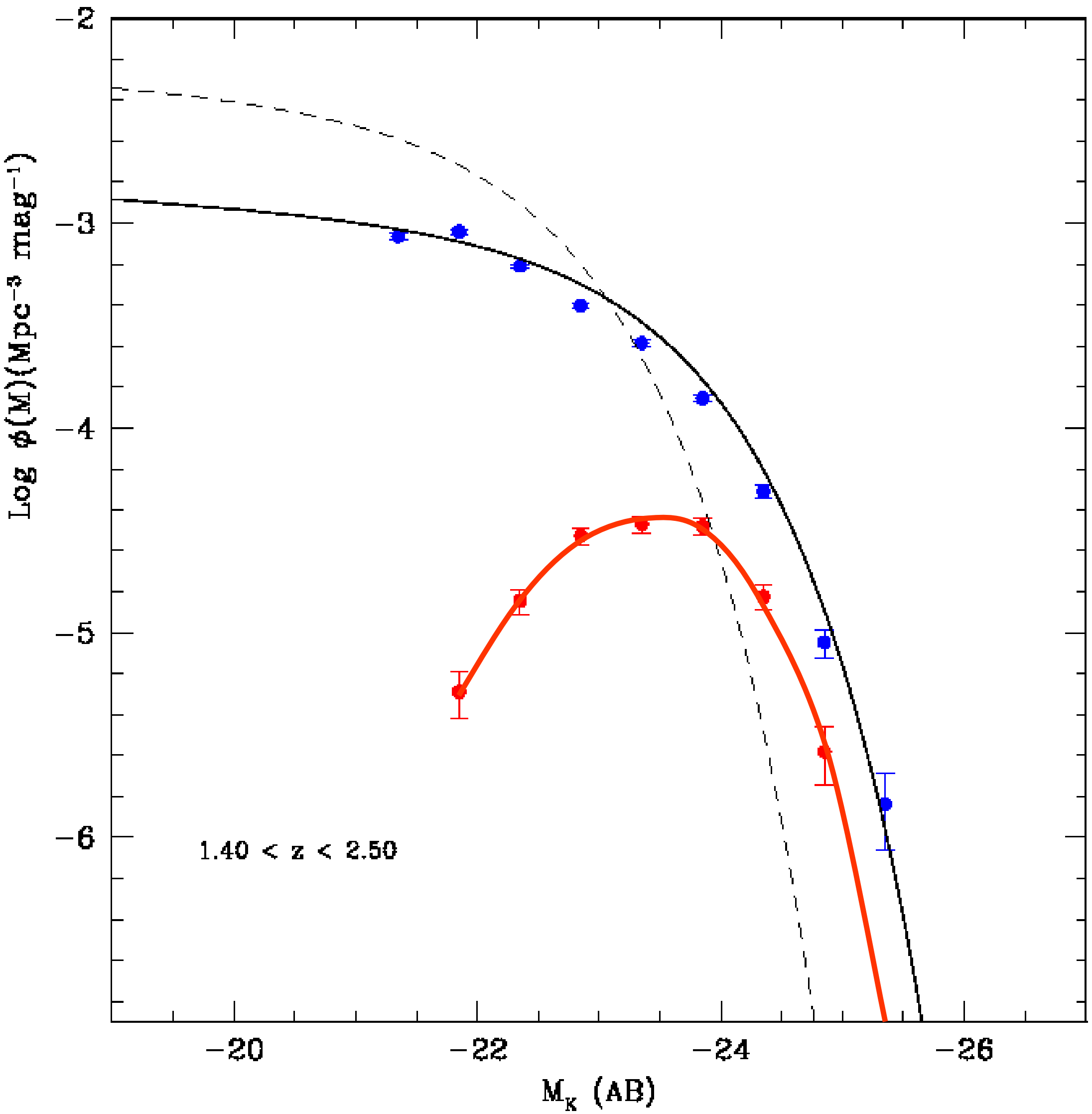
Following the evolution of massive galaxies via dark matter halos



BzK luminosity function

Hartley et al. (submitted)

pBzK's are a bright population (but not all of the brightest objects in the range are pBzK's).



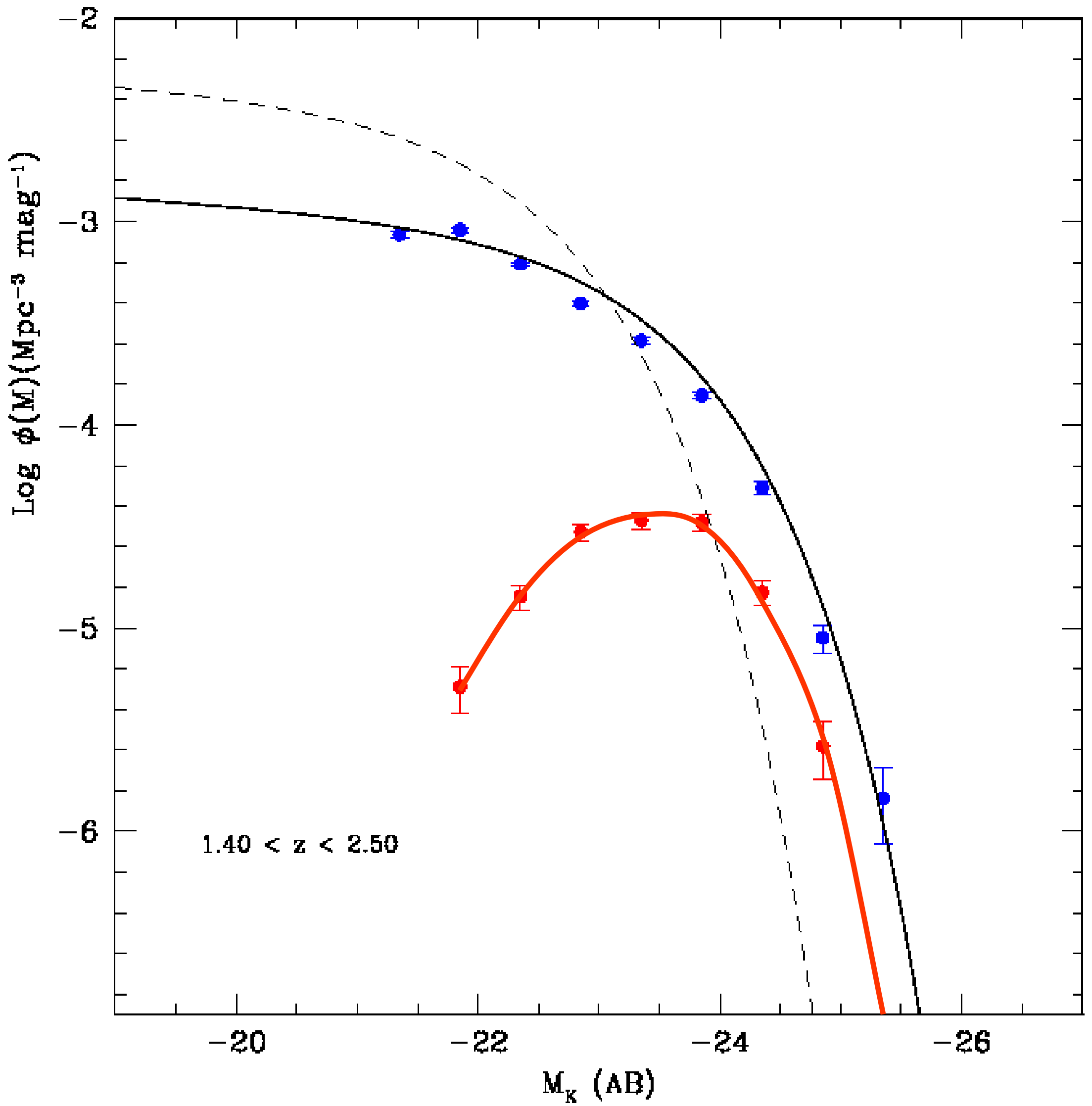
BzK luminosity function

Hartley et al. (submitted)

pBzK's are a bright population (but not all of the brightest objects in the range are pBzK's).

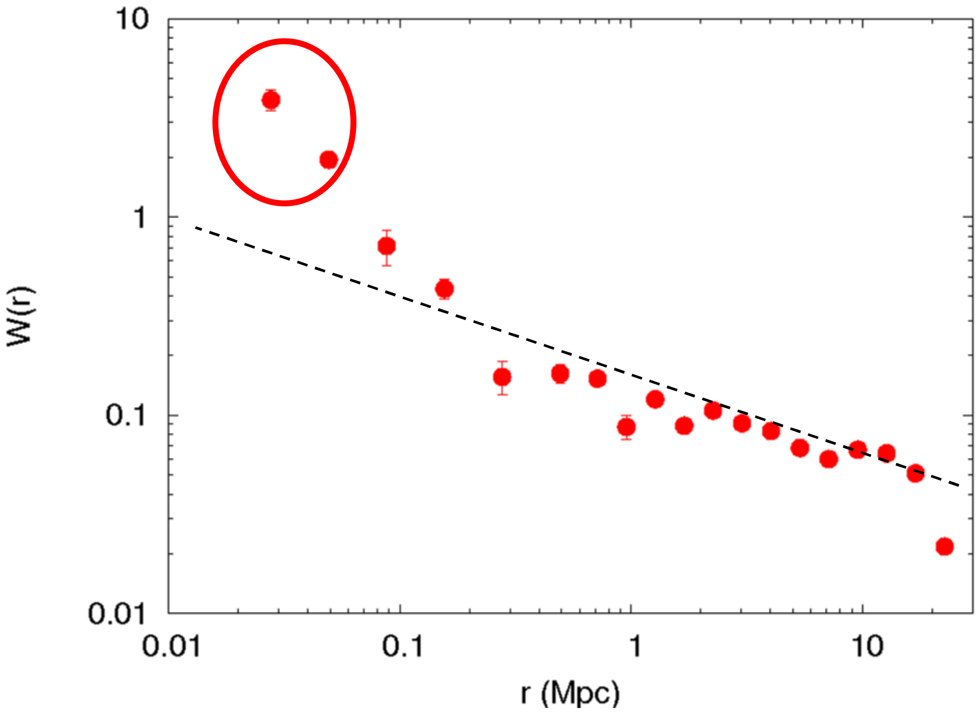
Evolution models predict they will dim by ~1 magnitude by z=0.

pBzK descendants would then make up a significant fraction of the massive ellipticals at z = 0.



Merging rate of massive galaxies

Foucaud et al. (in prep.)

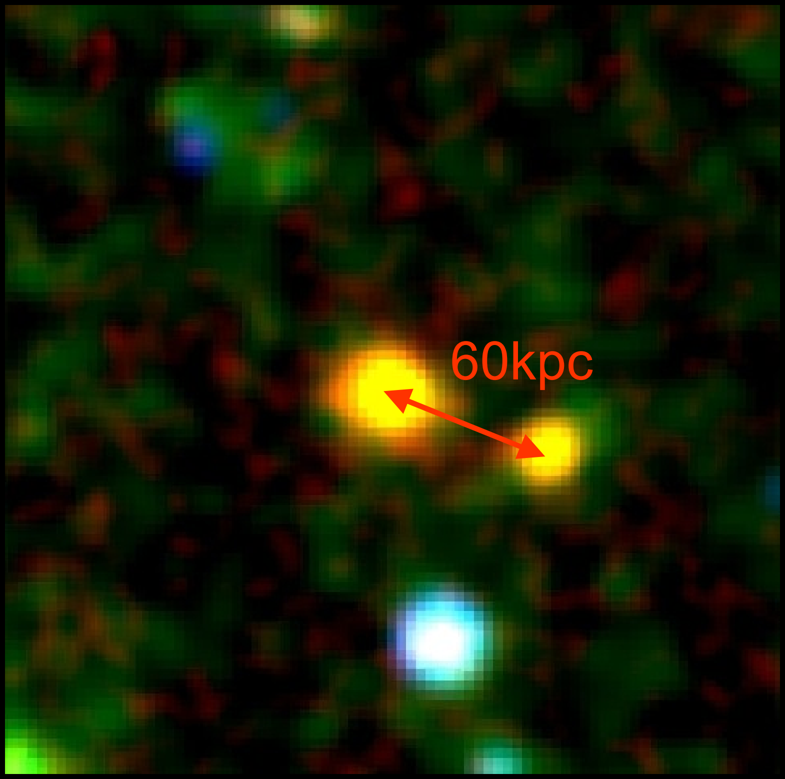


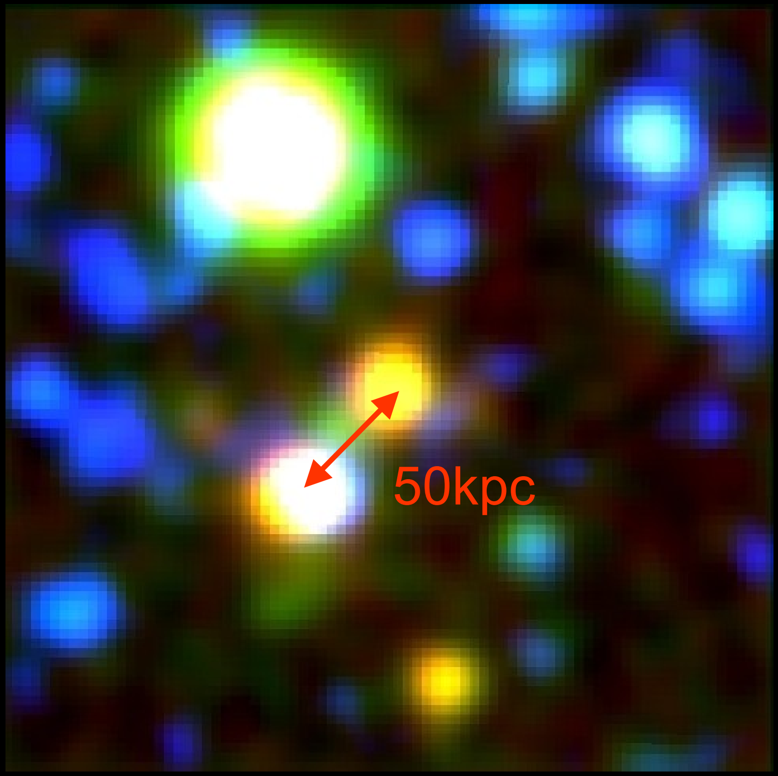
- Close pairs for massive galaxies already clear
- Solving the merging rate discrepancies @z~1
- The special case of massive passive galaxies: “dry merging” fraction?

- Selecting passive galaxies at different z and study their merging rate.

Massive passive galaxy mergers

BzK images





z=1.5 passive/passive

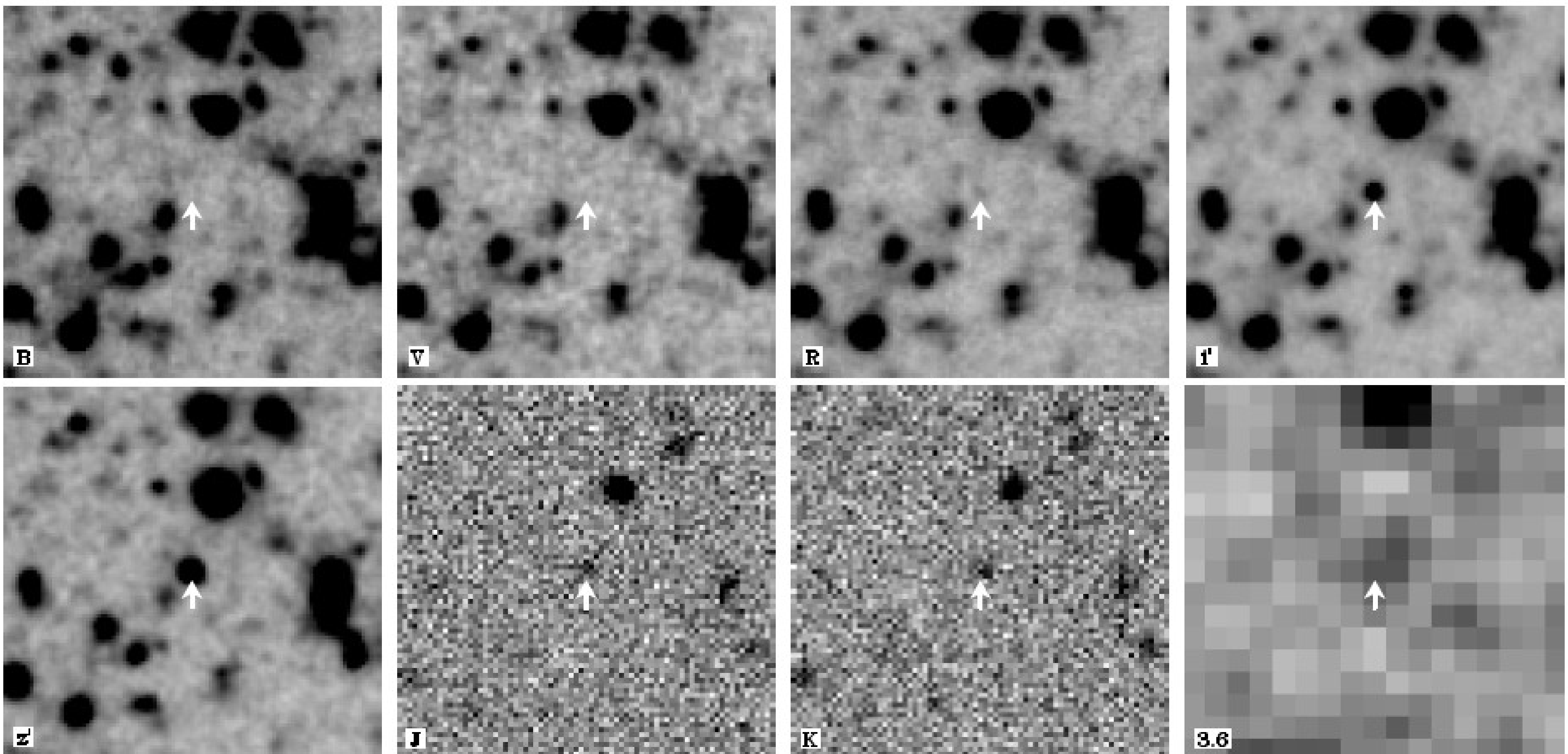
z=1.6 passive/star-forming

Galaxies at z>5

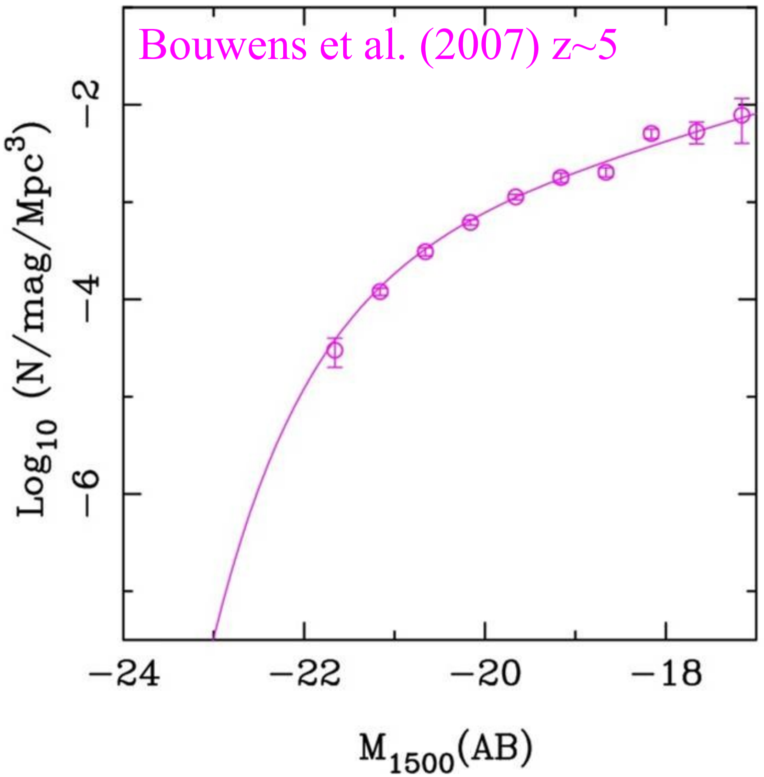
Luminous Lyman-break galaxies at 5<z<6

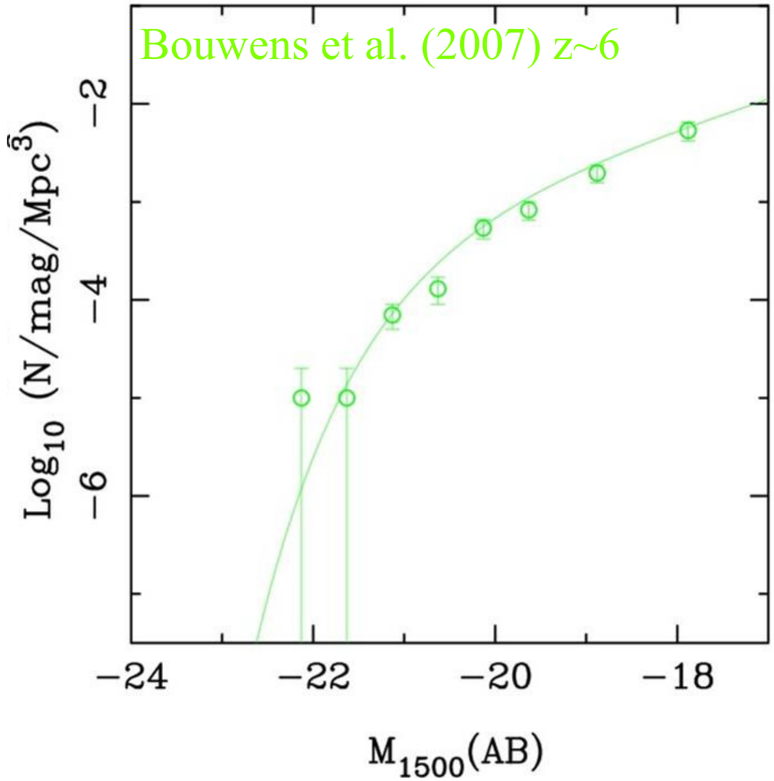
(9 candidates to $z_{AB}<25$ over 0.6 sq deg)

McLure et al. (2006)



UV selected galaxy luminosity function at high-redshift

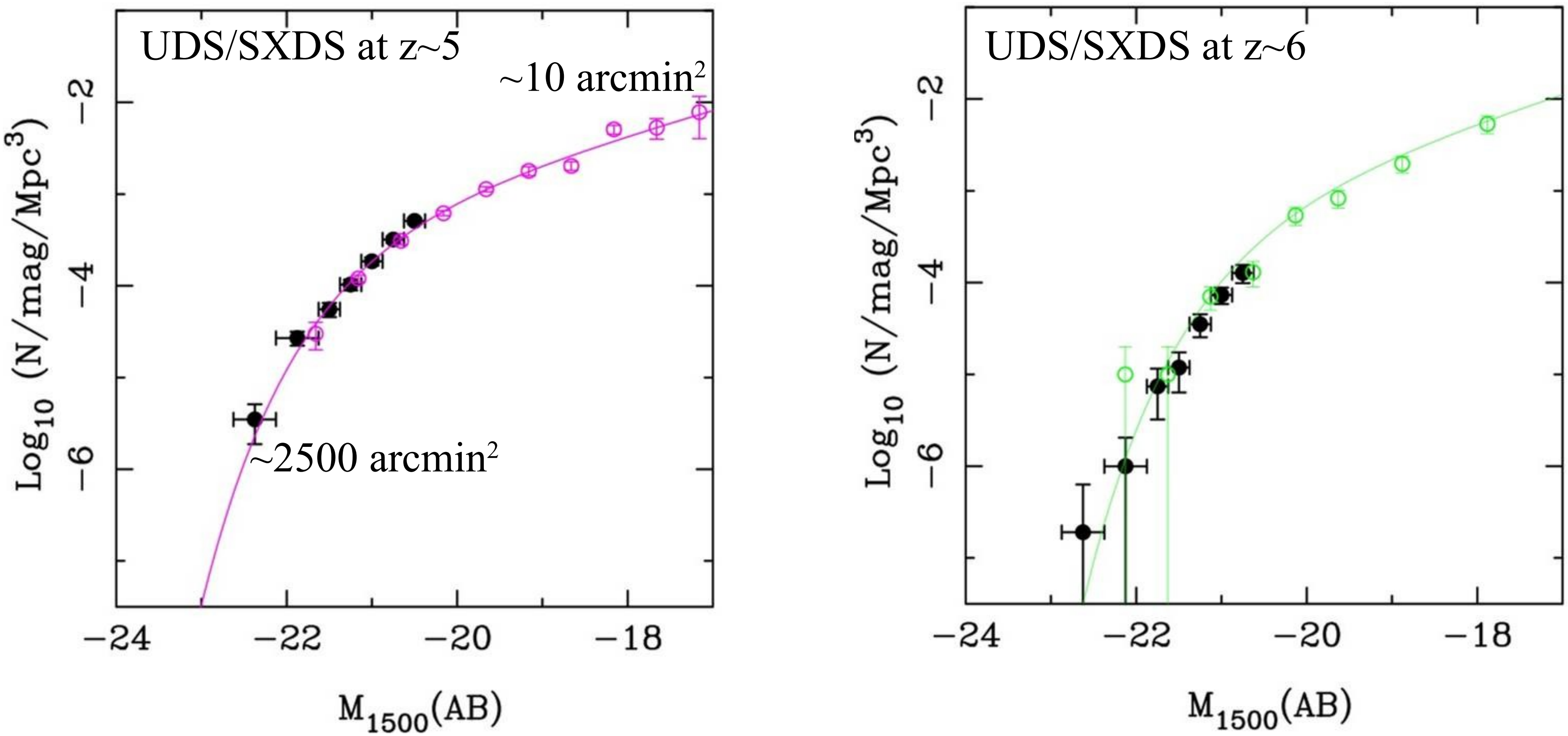




UDS: ~6000 candidates z>4.5 to z_{AB}<26 over 0.8 sq deg

McLure et al. (in prep.)

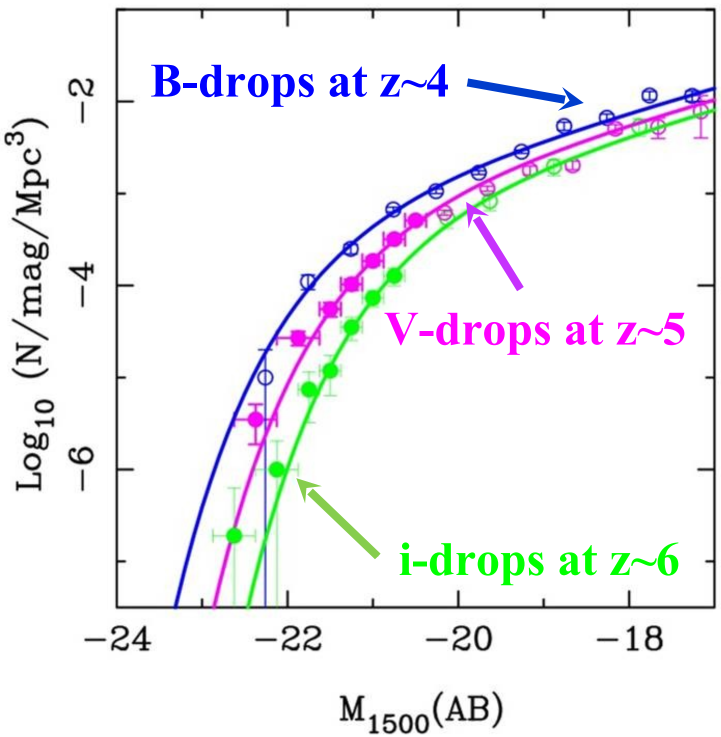
UV selected galaxy luminosity function at high-redshift



Excellent agreement with previous HST-based results in overlap region
Both LFs now extend 2 magnitudes brighter than M*

McLure et al. (in prep.)

UV selected galaxy luminosity function at high-redshift



Perfectly good statistical fit to LF in range 4<z<6 with:

$\alpha = -1.65$

$\Phi^* = 1.5 \times 10^{-3}\ \mathrm{Mpc}^{-3}$

M* evolving by 0.8+/-0.2 mags

Qualitatively consistent with expectations of hierarchical build-up at high-z

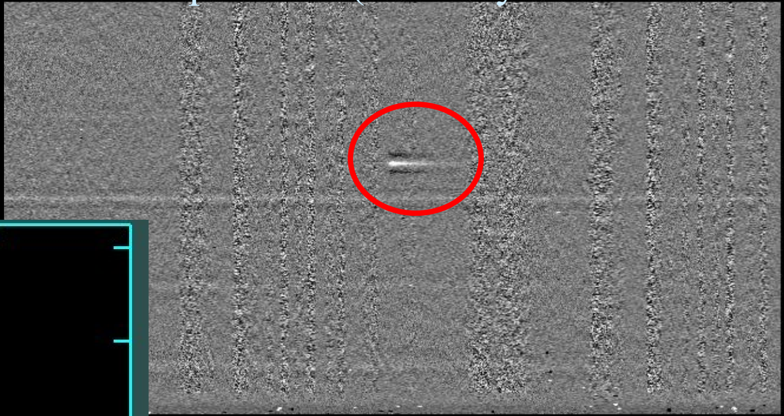
McLure et al. (in prep.)

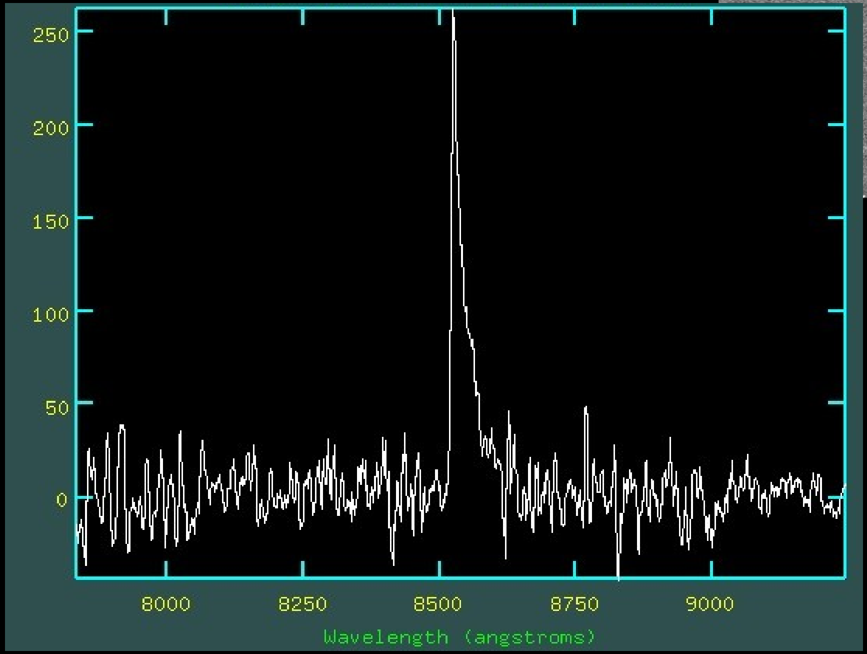
An extremely faint quasar at z=6.01

Object original identified in McLure et al. (2006) from SXDS plus UDS EDR data

Classified as massive LBG at z_{phot}=5.9+/-0.2

2D GMOS spectrum (courtesy of Chris Willott)





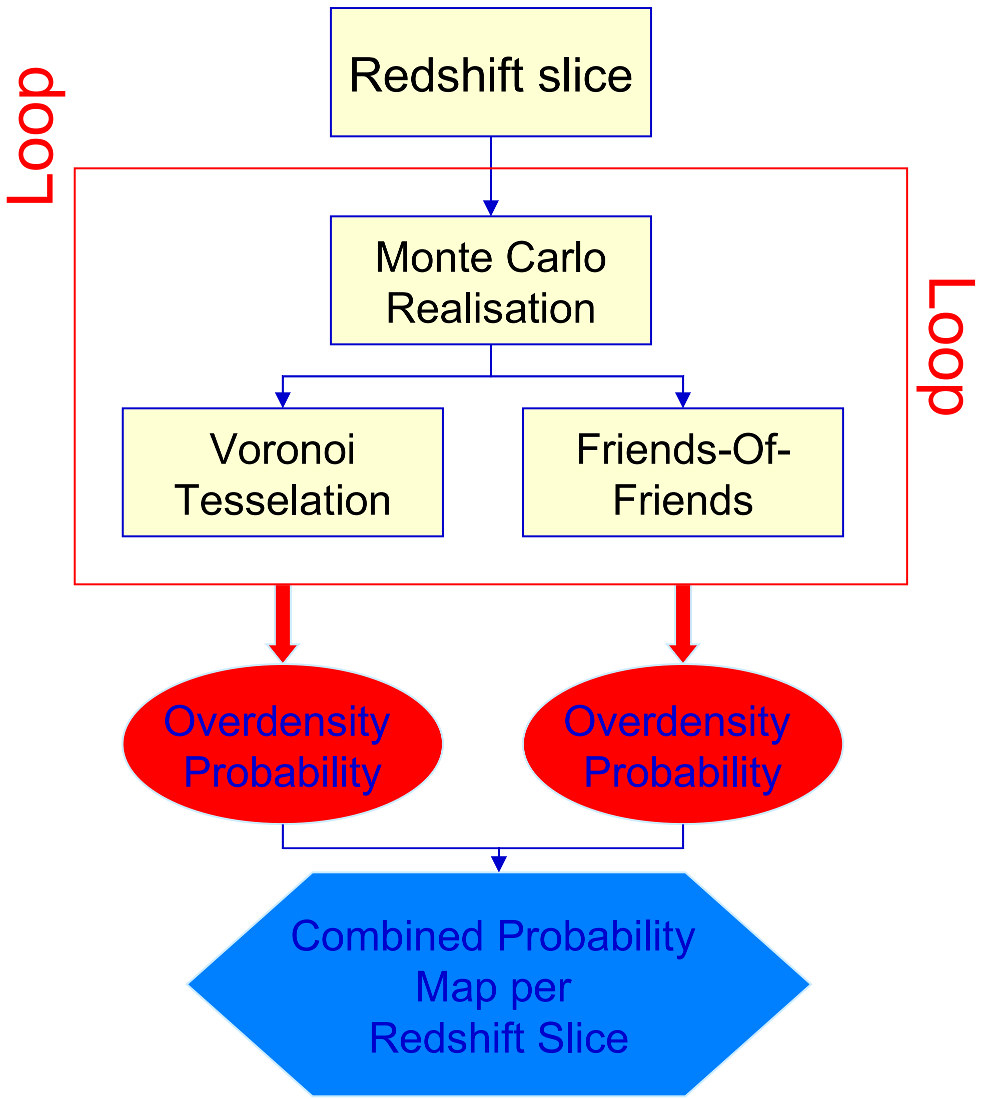
Faintest known quasar at z~6, M_{UV}~ -22 (4 magnitudes fainter than SDSS quasars)

"Seyfert galaxy" at z=6

Galaxy clusters at z<1.5

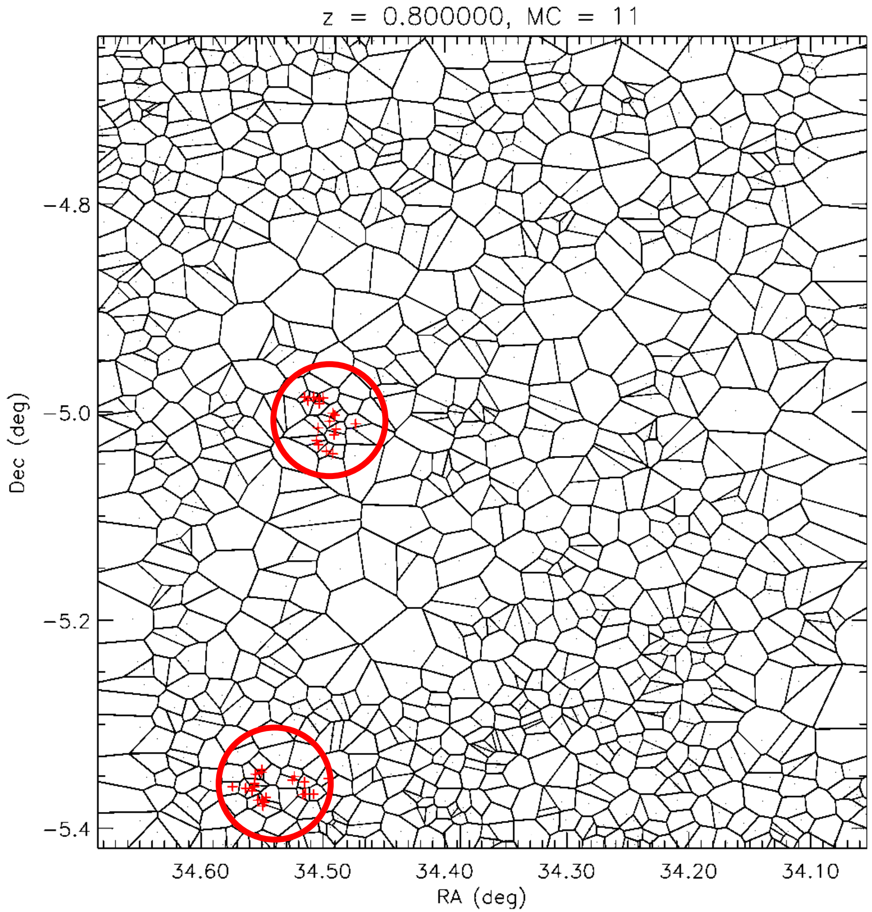
Galaxy clusters

van Breukelen et al. (2006)

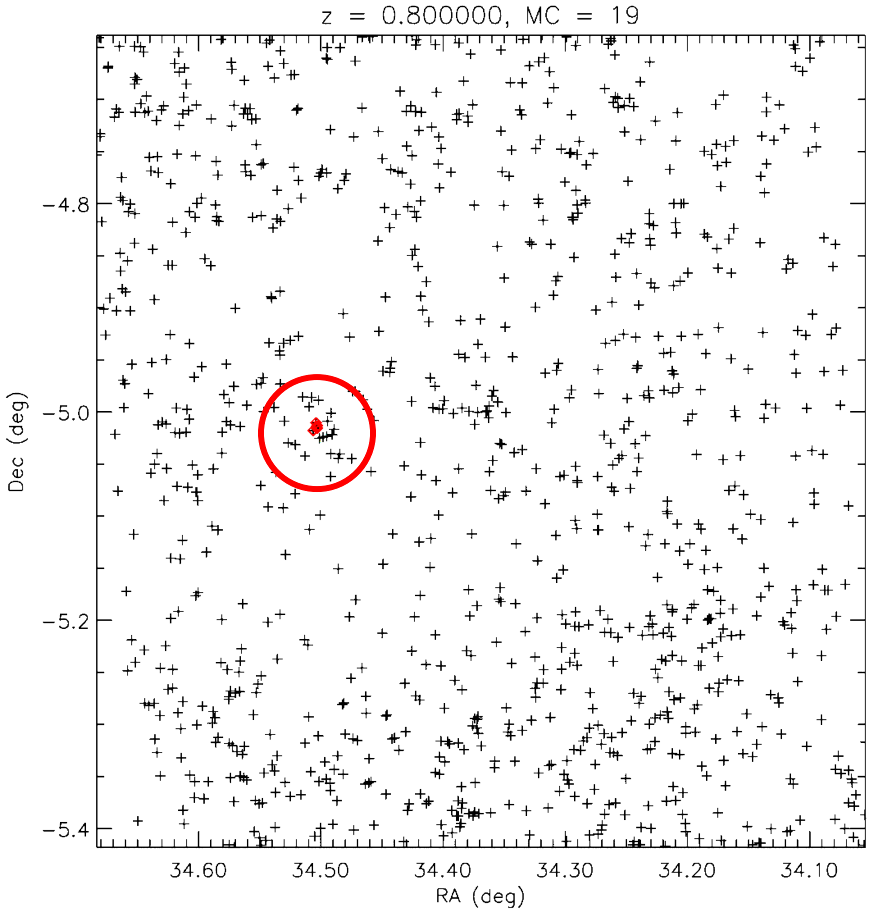


Cluster searching at z=0.8

van Breukelen et al. (2006)



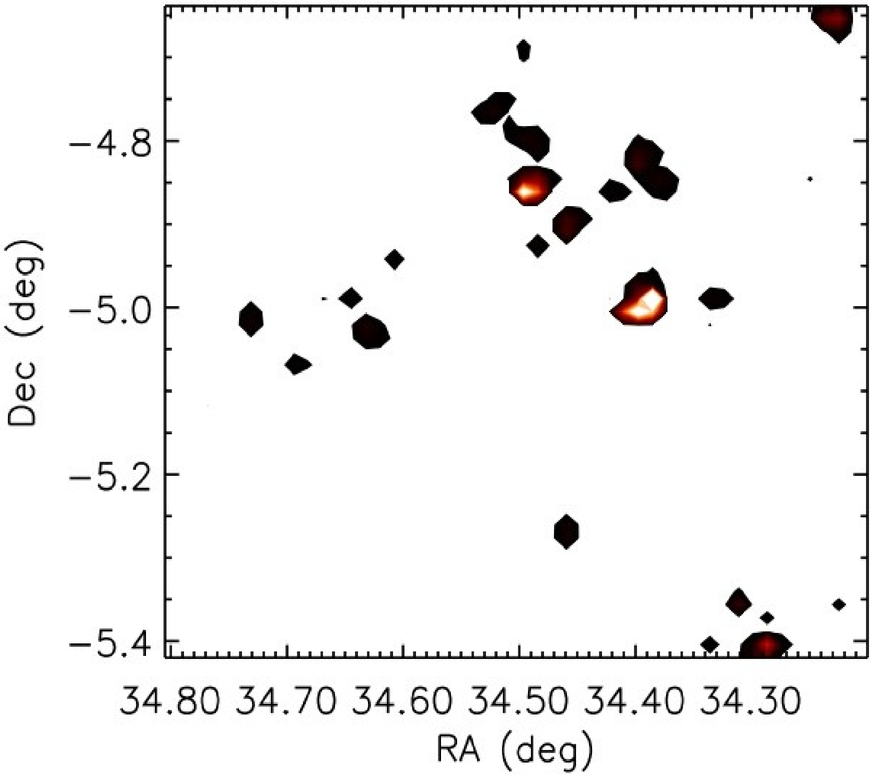
Voronoi Tesselations

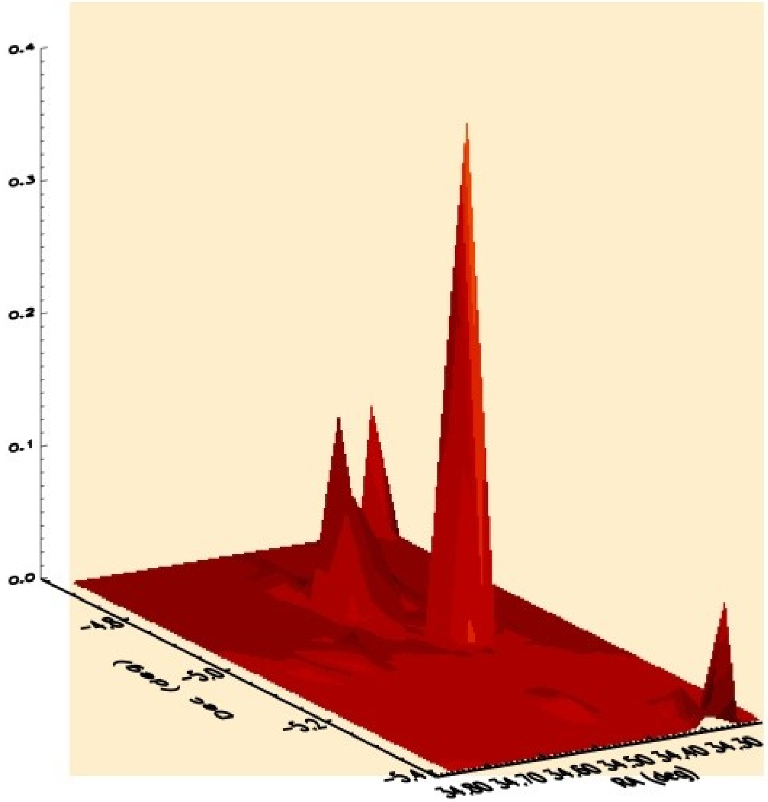


Friends-Of-Friends

Results: cluster probabilities

van Breukelen et al. (2006)

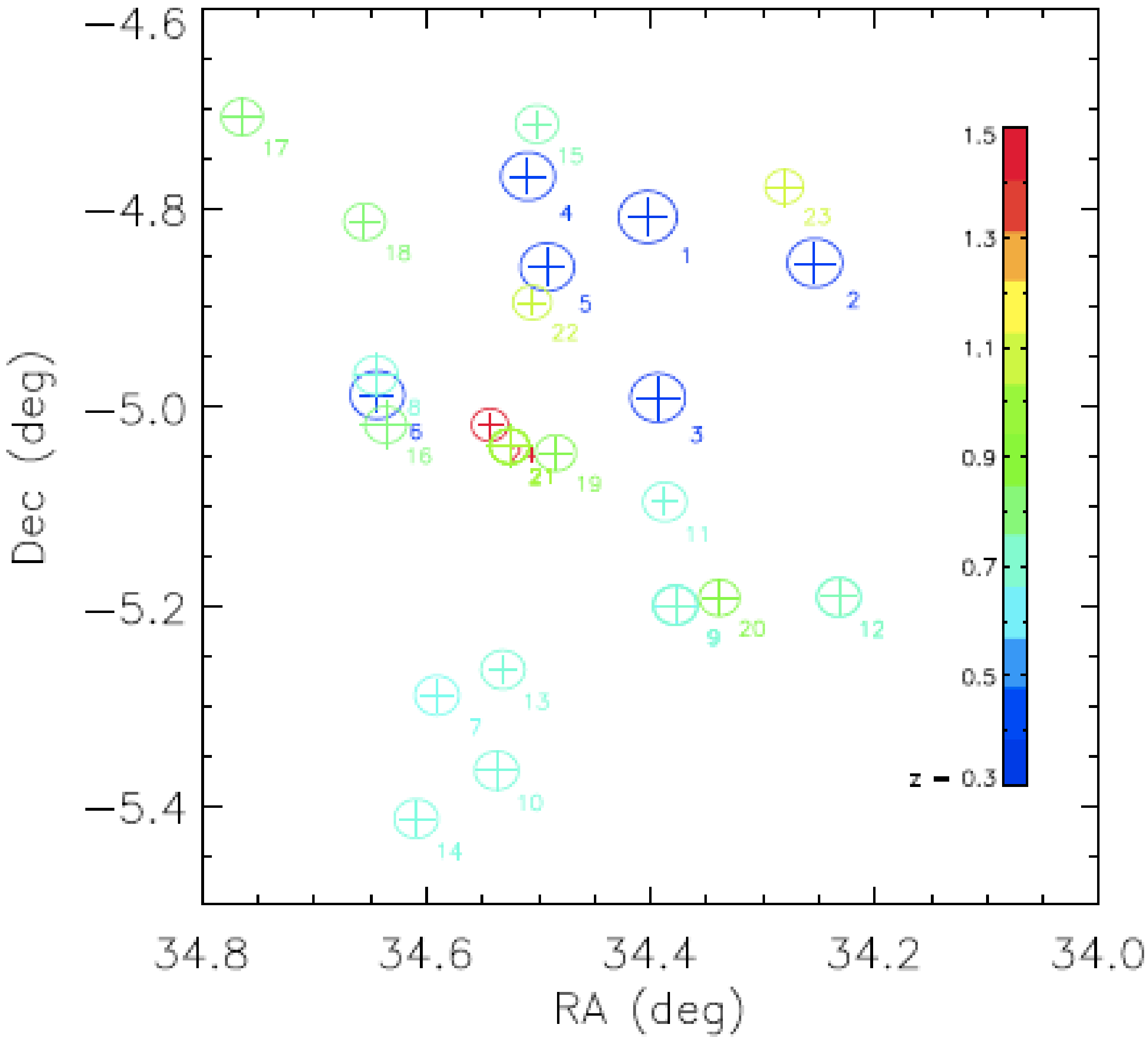




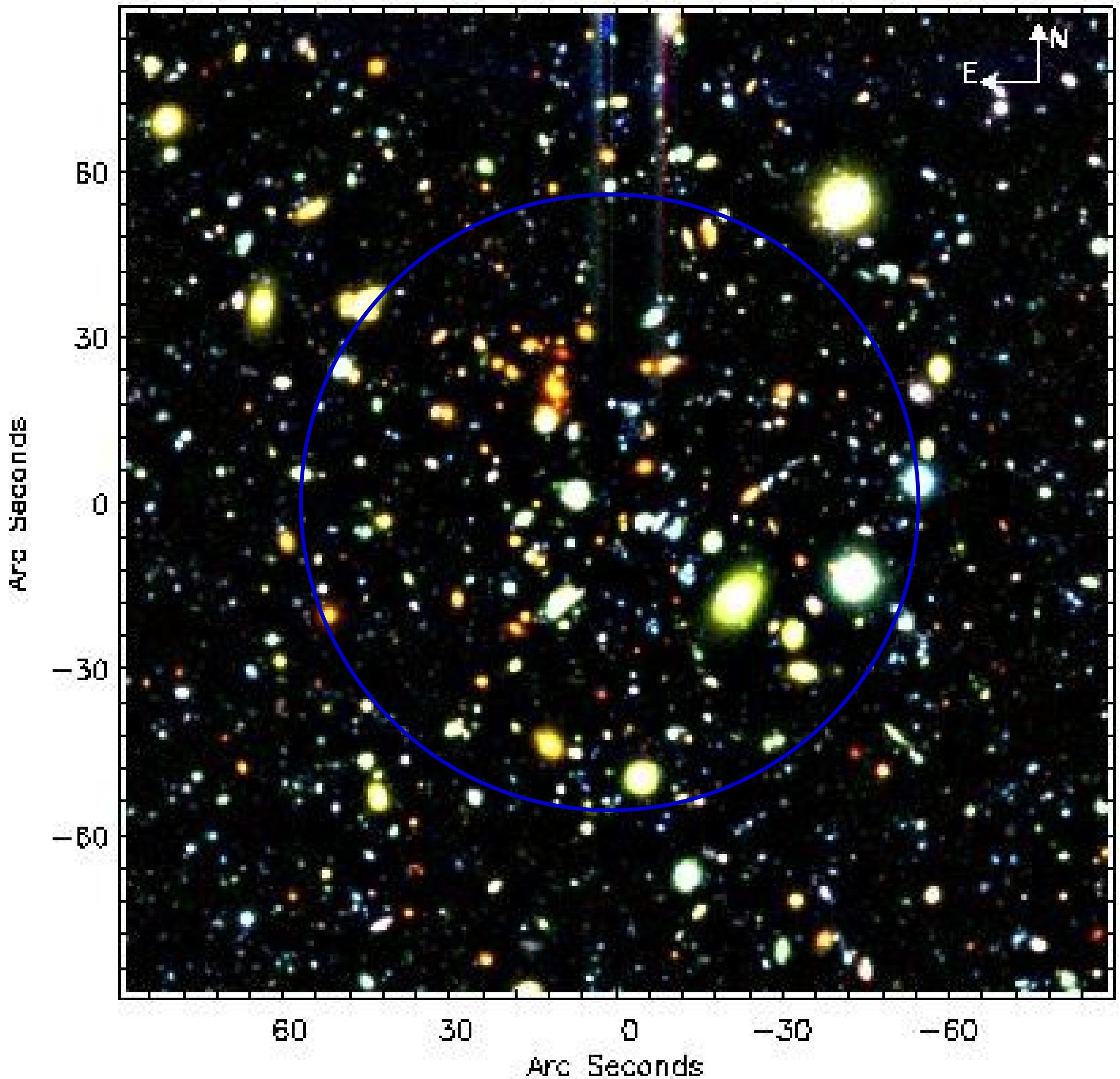
Combined Probability Map

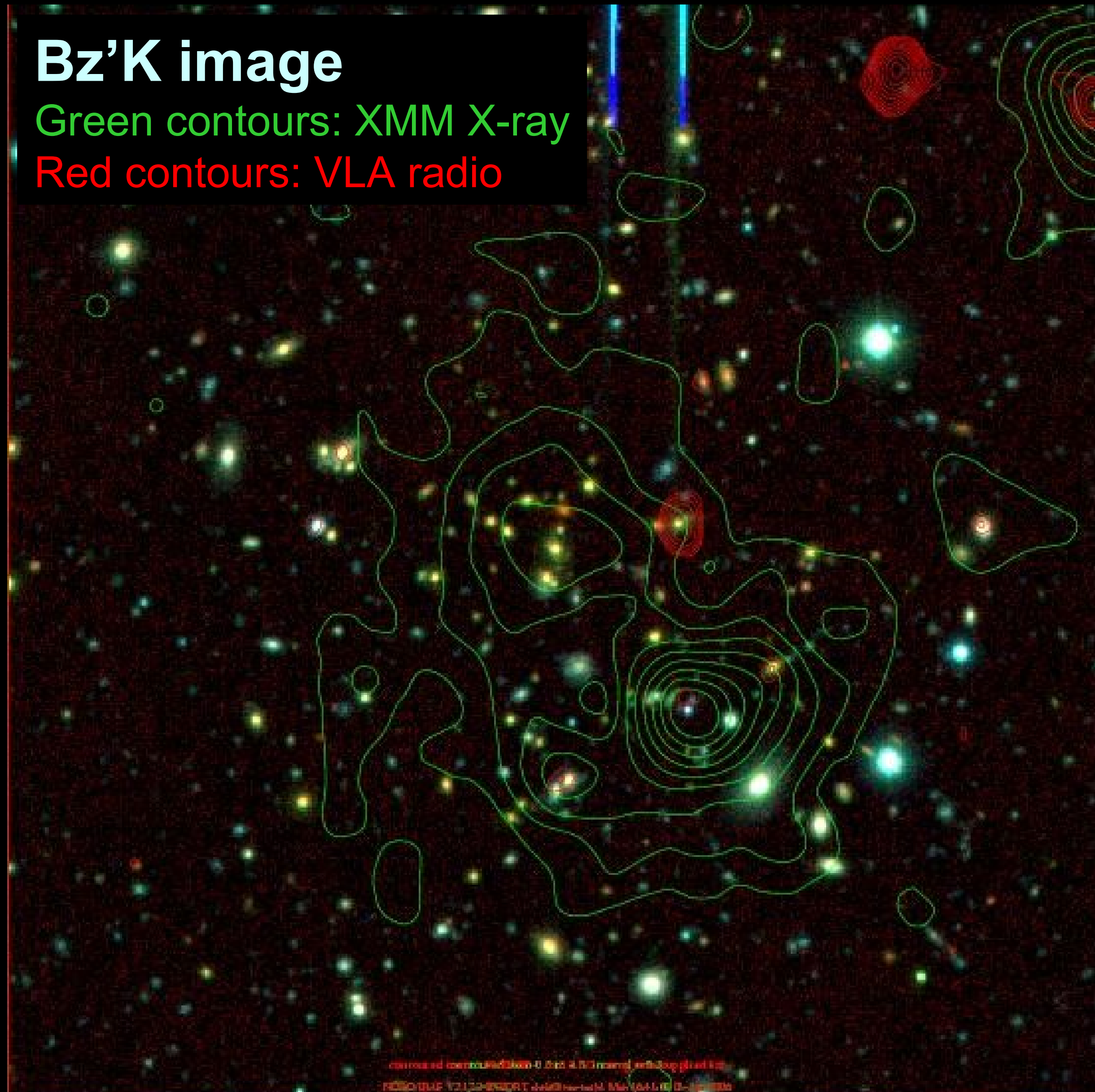
Cluster Detections

van Breukelen et al. (2006)



Confirmed galaxy cluster at z = 0.85



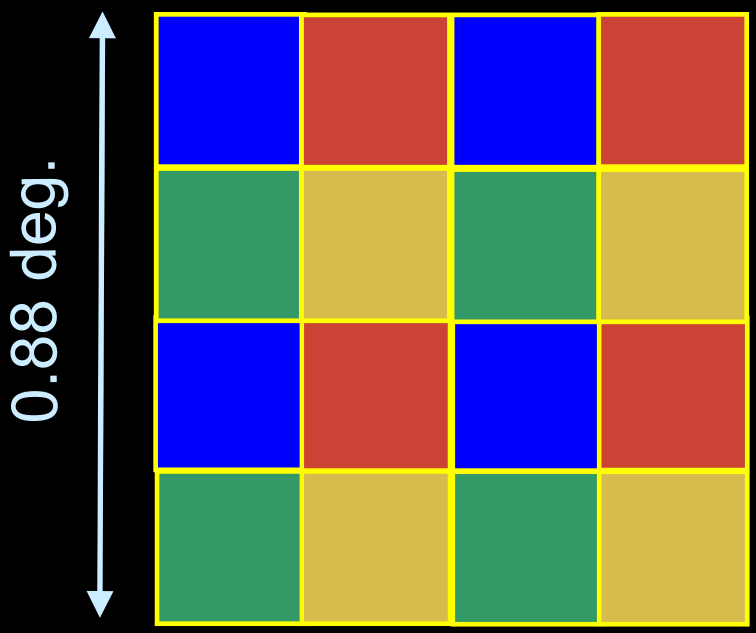


Courtesy Chris Simpson, Mike Watson

The most exciting is to come …

The UKIDSS Ultra-Deep Survey

http://www.nottingham.ac.uk/astronomy/UDS



DR1: K_{AB}=23.5, J_{AB}=23.6

(85 hours)

World-wide public in january 2008

DR3: K_{AB}=23.7, H_{AB}=23.4, J_{AB}=23.6

(120 hours)

ESO public in december 2007

Final depth: K_{AB}=25, H_{AB}=24.7, J_{AB}=24.7

(200 nights)

Another 4 years of data to come…

…plus multi-wavelength and new spectroscopic ESO survey