

# UKIDSS Ultra-Deep Survey

Will Hartley

Working group members:

Omar Almaini, Sebastien Foucaud, WH, Rob Chuter

Chris Conselice, Steve Maddox, Emma Bradshaw (**Nottingham**)

Jim Dunlop, Ross McLure, Michele Cirasuolo, Rob Ivison,  
Andy Lawrence (**Edinburgh**)

Ian Smail, Alastair Edge (**Durham**), Chris Simpson (**LVJM**),

Mat Jarvis (**Herts**), Paul Hirst (**Gemini**), Steve Serjeant (**Kent**)

Mike Watson, Paul O'Brien (**Leicester**), Mat Jarvis, Steve Rawlings,  
Caroline van Breukelen, Lee Clewley, Garrett Cotter, Gavin Dalton (**Oxford**),

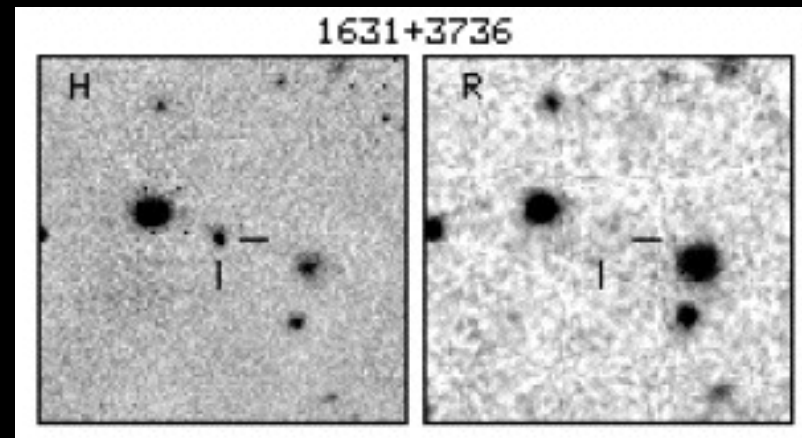
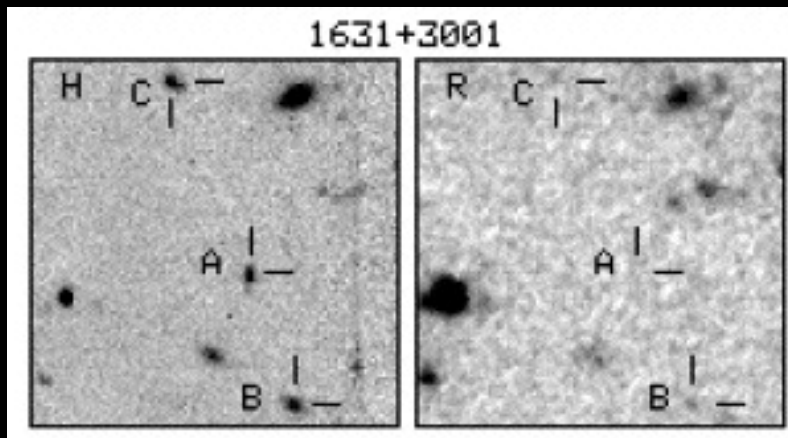
Steve Serjeant (**Kent**), Steve Eales, Simon Dye (**Cardiff**),

Mat Page (**MSSL**), Kaz Sekiguchi (**NAOJ**),

# The need for deep infrared surveys

## Optical surveys sample rest-frame UV at high-z

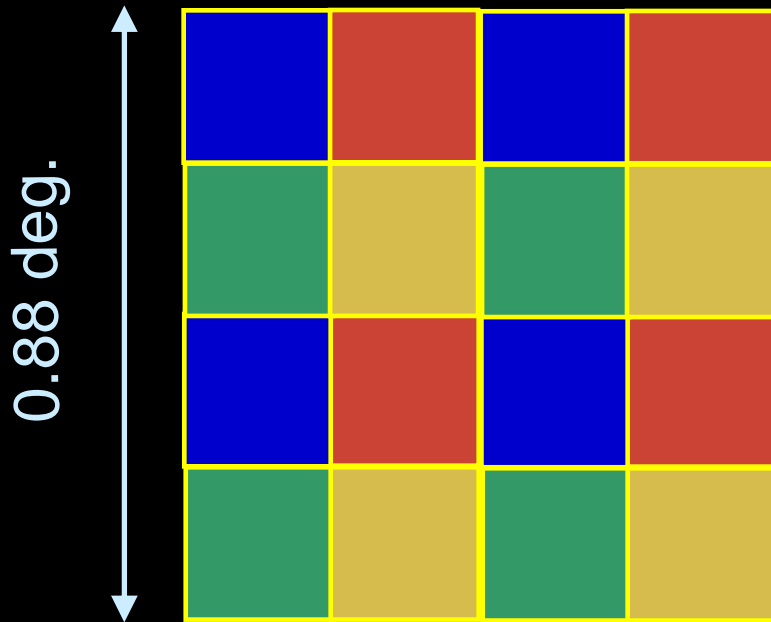
1. Will miss high-z galaxies obscured by **dust**
2. Will miss high-z galaxies with **old stellar populations**
3. Provide poor estimate of stellar mass



Deep IR survey vital for a complete census

# The UKIDSS Ultra-Deep Survey

Depths achieved so far:  
(Vega,  $5\sigma$ , 2" apertures)



*DR5*: K=22.0, H=22.3, J=23.1  
(~200 hours, ~15% complete)

*2012*: K=22.8., H=23.3, J=24.4  
(~1000 hours)

(revised goals)

***Already deepest IR survey over this area...***

# The Nottingham UDS pipeline

*Almaini et al. (in prep.)*



Reprocessing

Quality control

Mask borders and bad regions

WeightWatcher

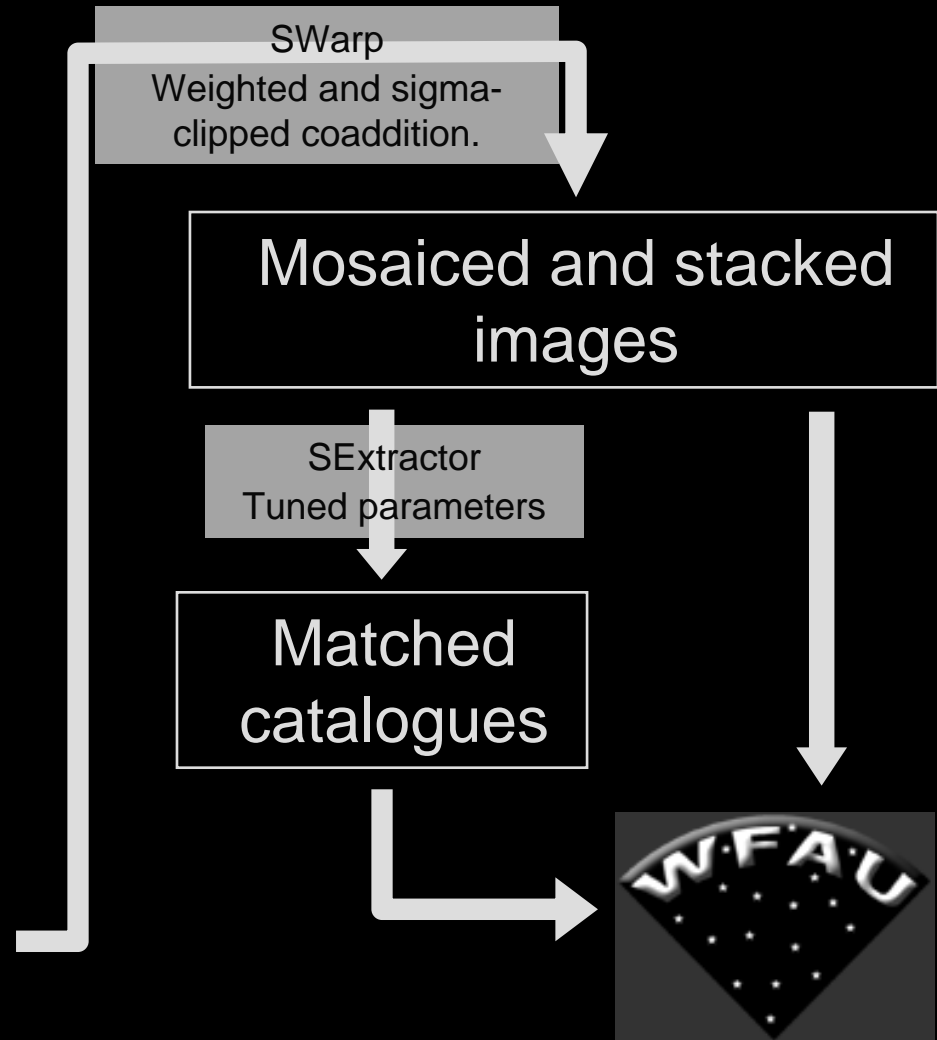
Weight images by sky variance

SWarp  
Weighted and sigma-clipped coaddition.

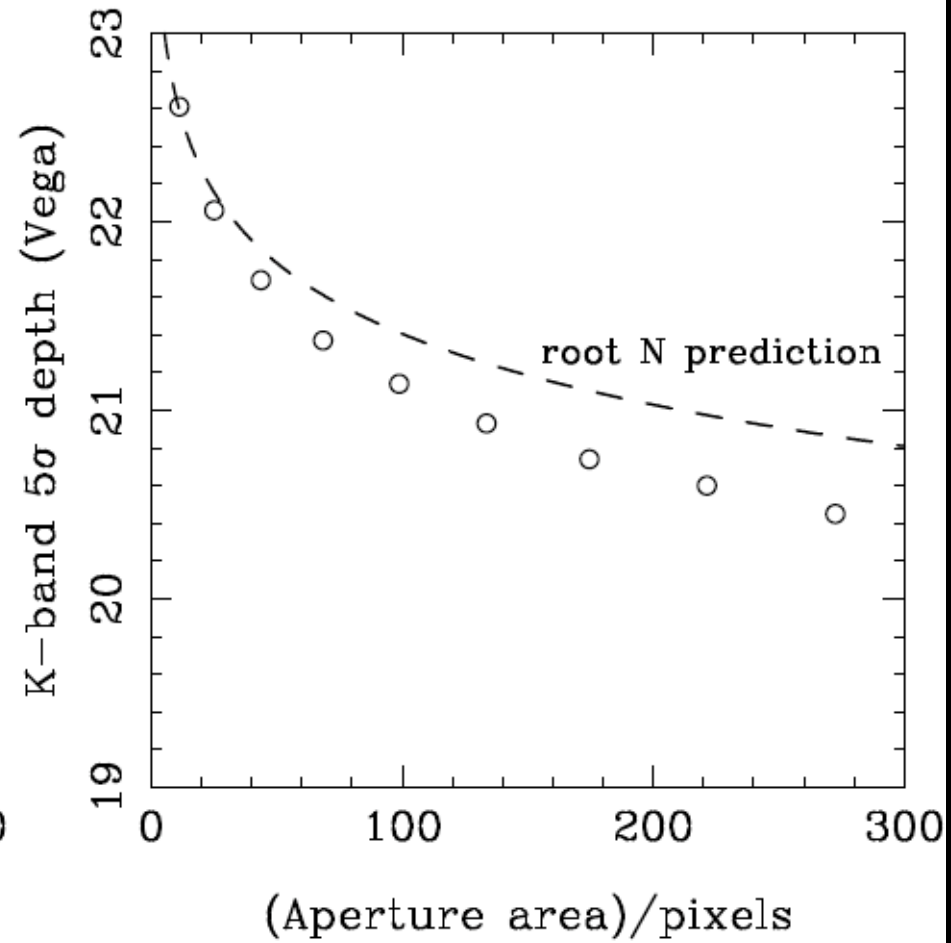
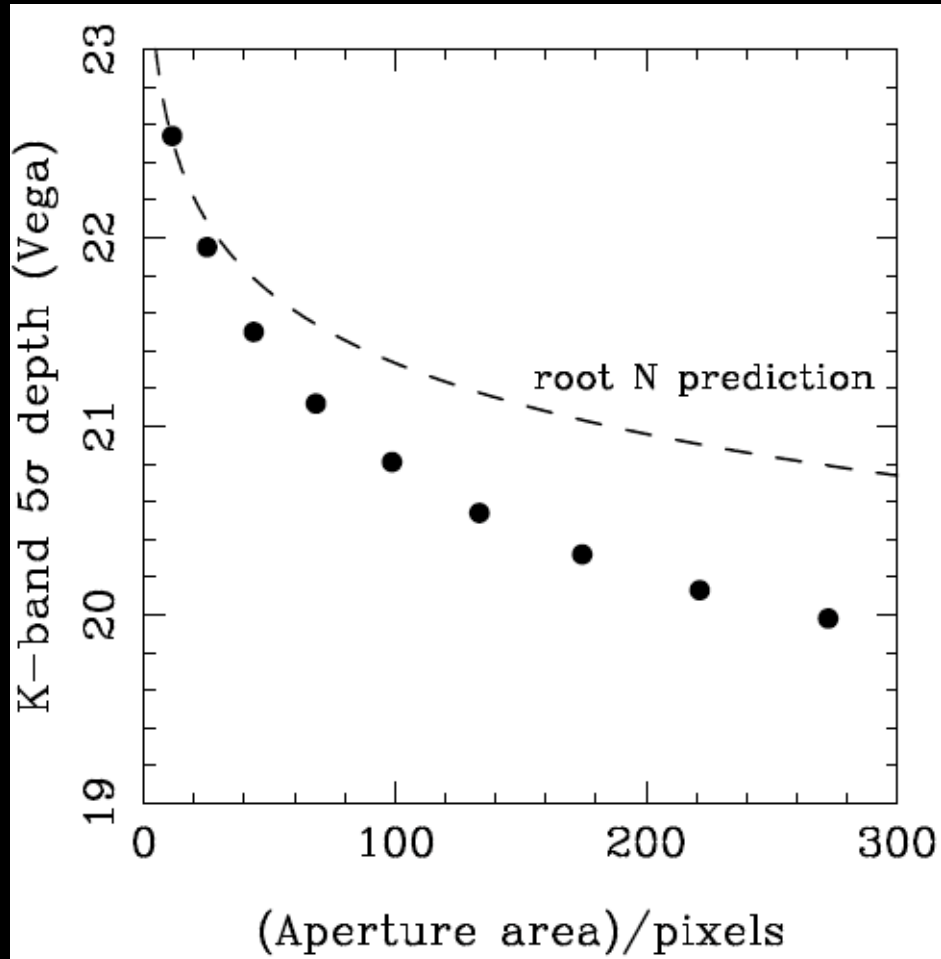
Mosaiced and stacked images

SExtractor  
Tuned parameters

Matched catalogues



# Large-scale correlated noise



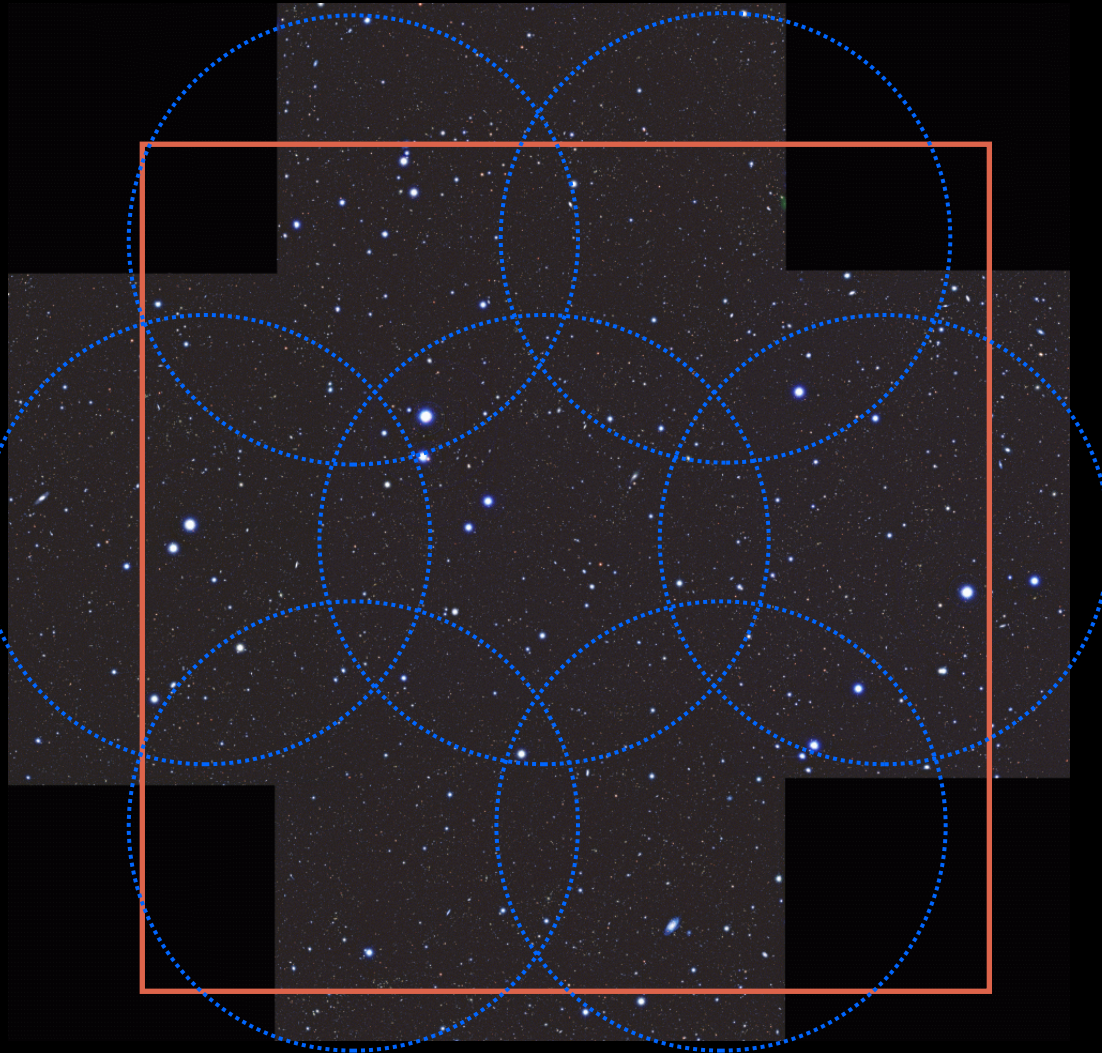
# Poor sky-subtraction



Noisy detector edges



# The Subaru/XMM Deep Field



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

## Optical:

B=28.2, V=27.6, R=27.5,  
i'=27.2, z'=26.5, U=27.0

## X-ray:

XMM-Newton 100ks + 6x50ks

## Radio:

VLA 12  $\mu$  Jy rms 1.4Ghz

## Spitzer:

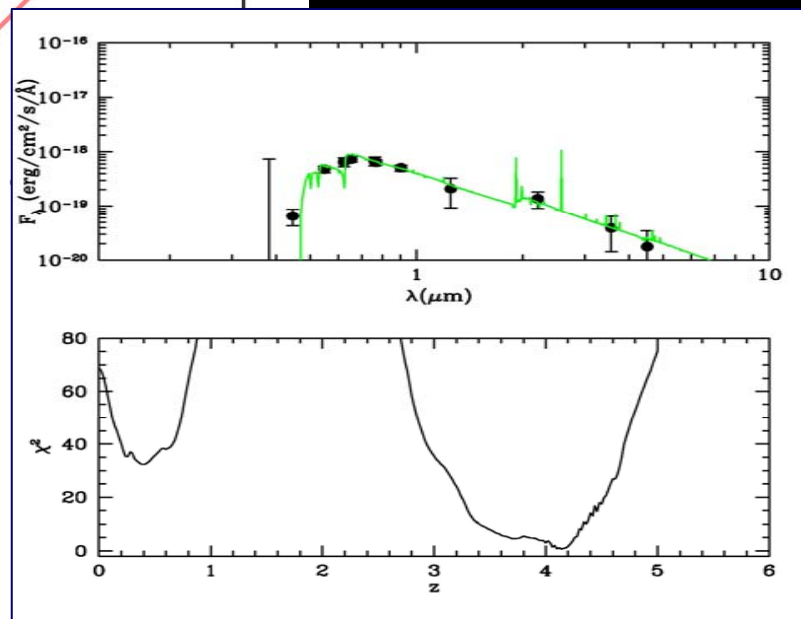
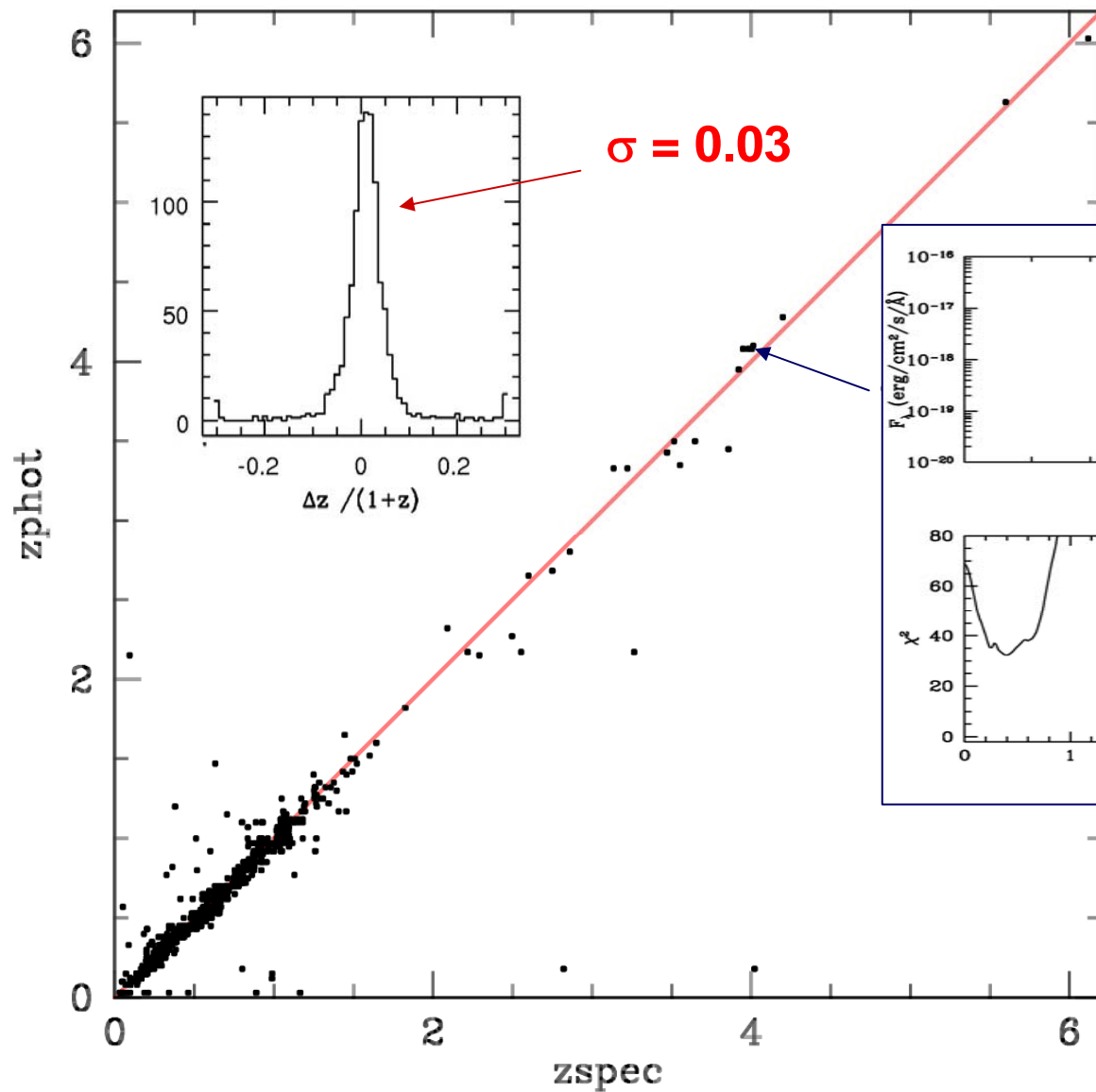
Spitzer SWIRE 3.6-160 $\mu$ m  
(**NEW**: Legacy survey to  
~24 AB at 3.6, 4.5 $\mu$ m)

## Submm:

SHADES 8mJy (850 $\mu$ m)  
+ SCUBA2 from 2009

# Photometric redshifts

(U, B, V, R, i', z', J, H, K, 3.6, 4.5)



*Cirasuolo et al. (2007)*



Science goals (2001):

Number density of  $z=3$ ,  $2xL^*$  elliptical galaxies

Clustering of high  $z$  galaxies

High  $z$  Kormendy relation

Sub-mm, X-ray link (SF, AGN)

L, T dwarfs

31 papers to date (~5 astro-ph):

UK – 19

Europe – 7

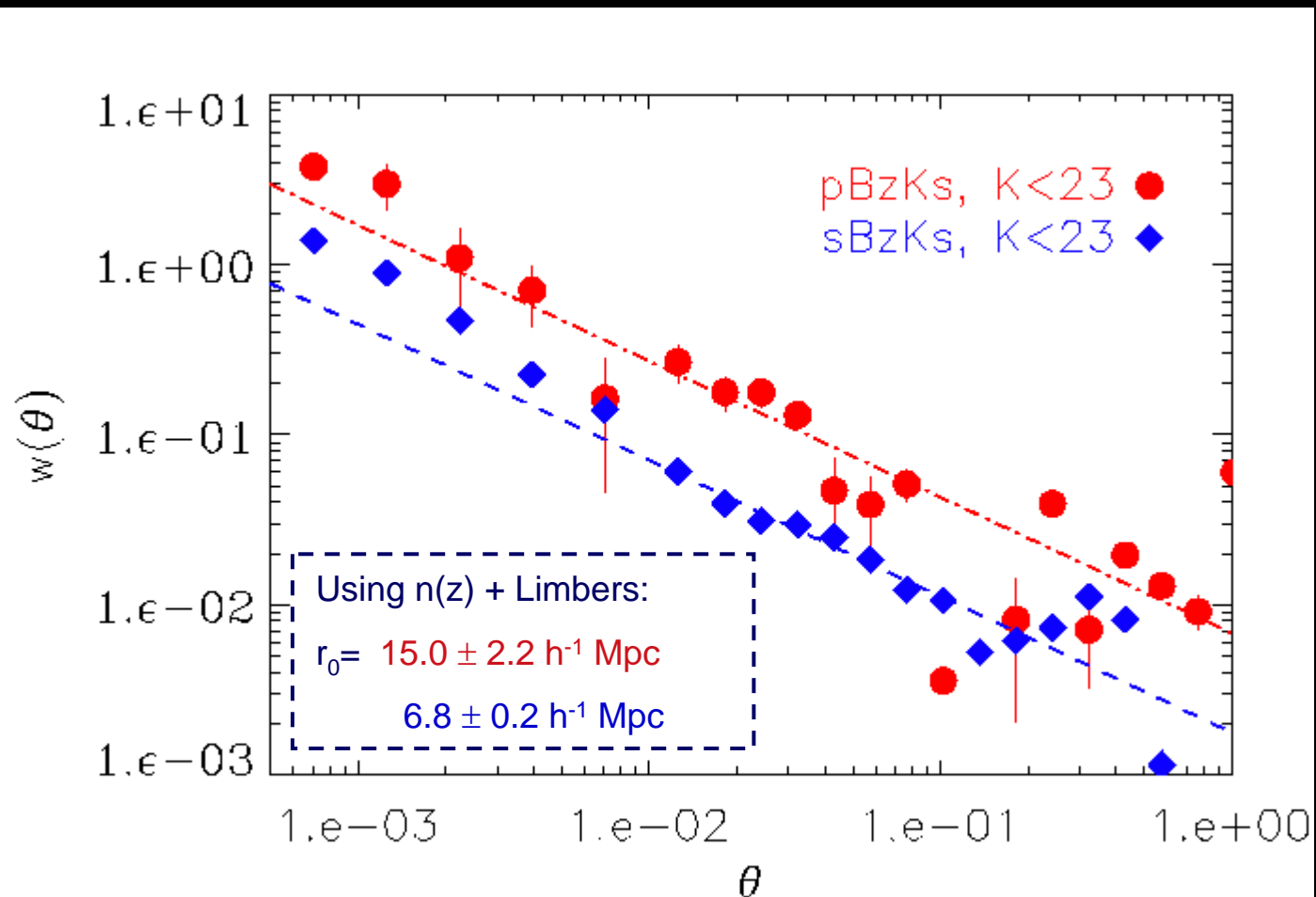
World – 5

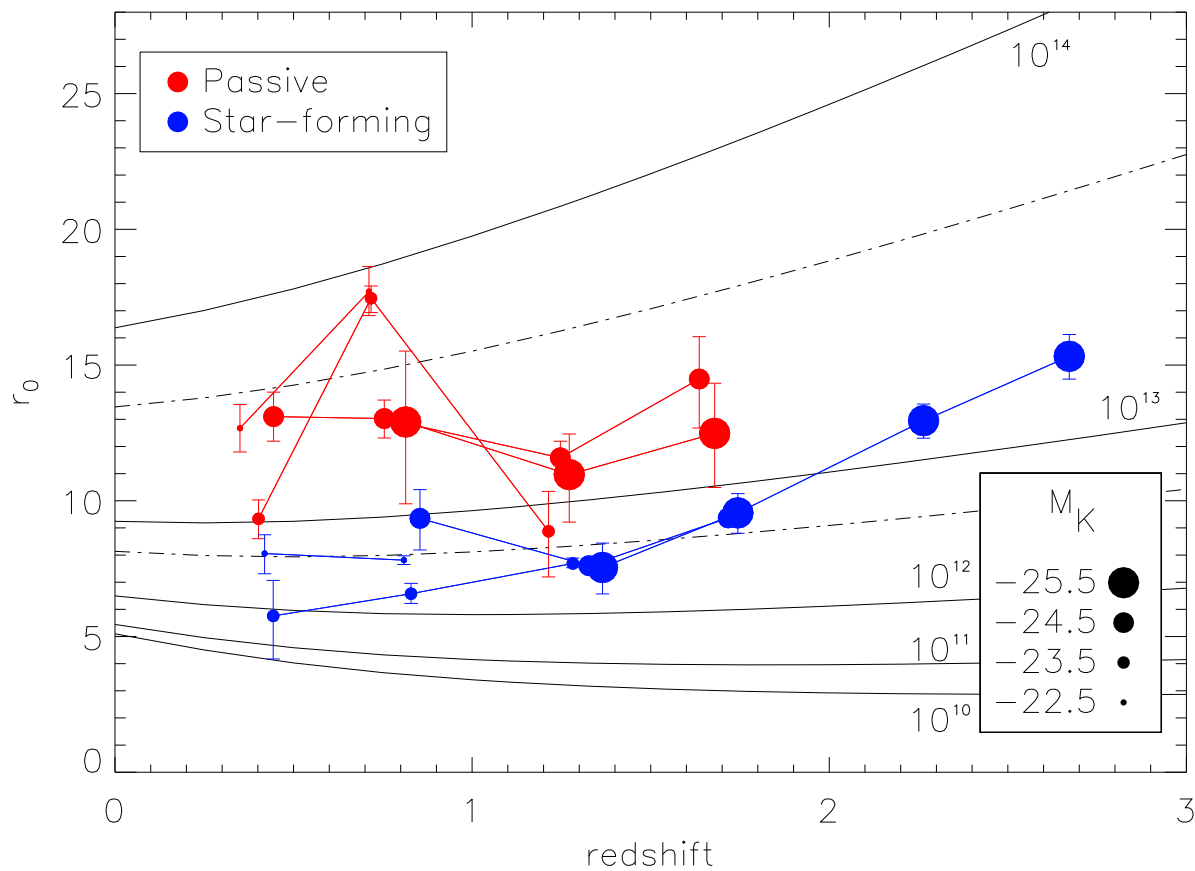
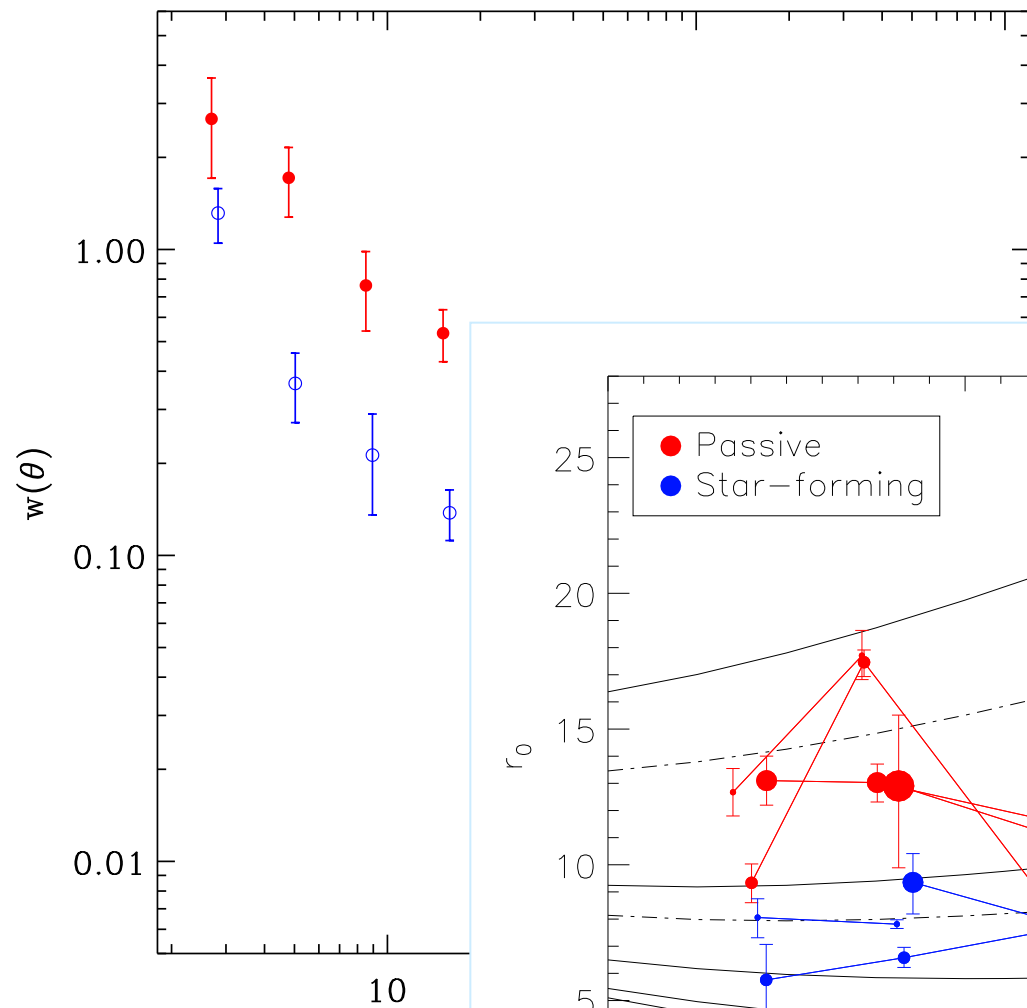
Highest science paper citation count:

56 (Cirasuolo et al., 2007)

# 1. Passive galaxies cluster far more strongly at $z \sim 2$

*Hartley et al. (2008)*

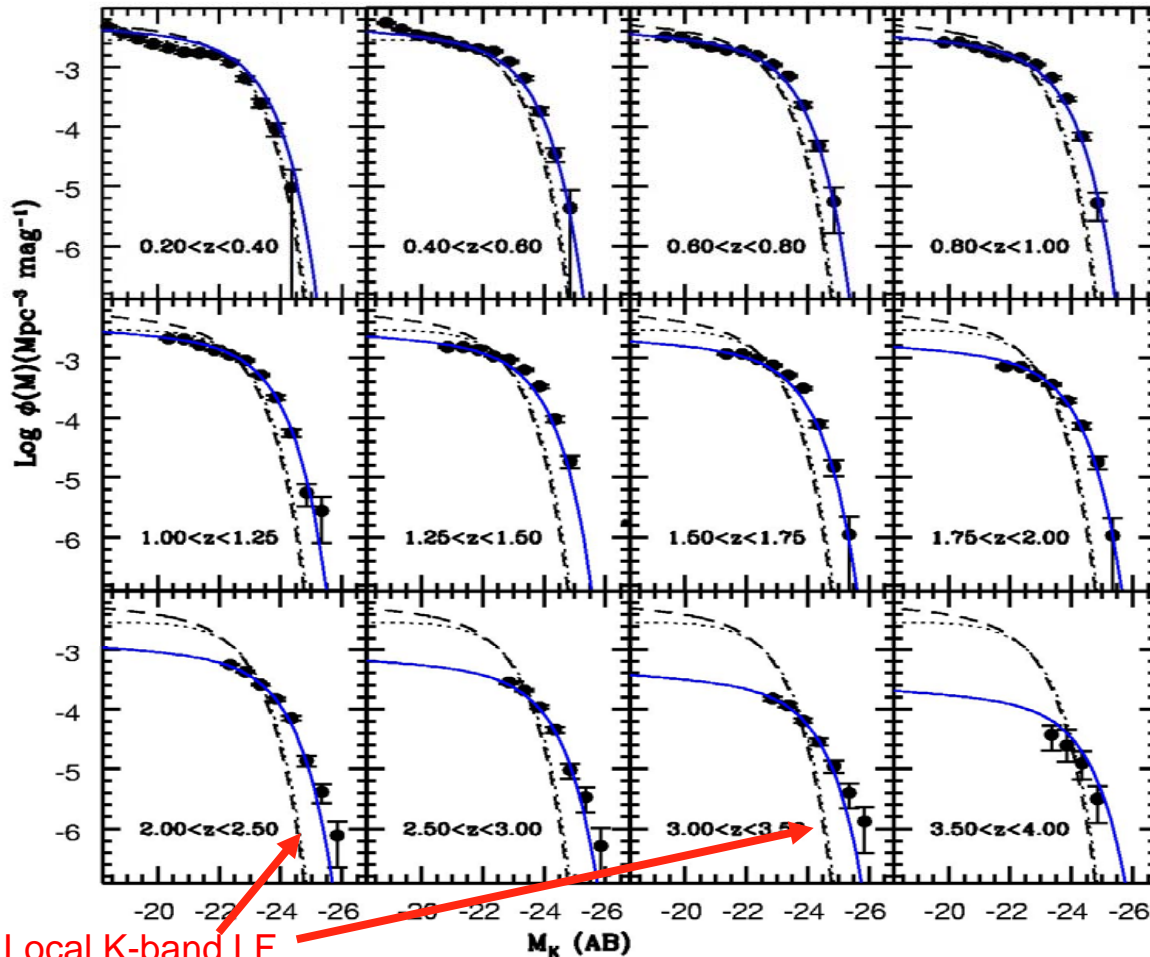




# 2. Evolution of the near-IR galaxy LF

Cirasuolo et al. (2008)

>50,000 galaxies with  $K_{AB} \leq 23$



Local K-band LF

Schechter function  
with

Luminosity evolution

$$M^*(z) = M^*(0) - \left( \frac{z}{z_M} \right)^{k_M}$$

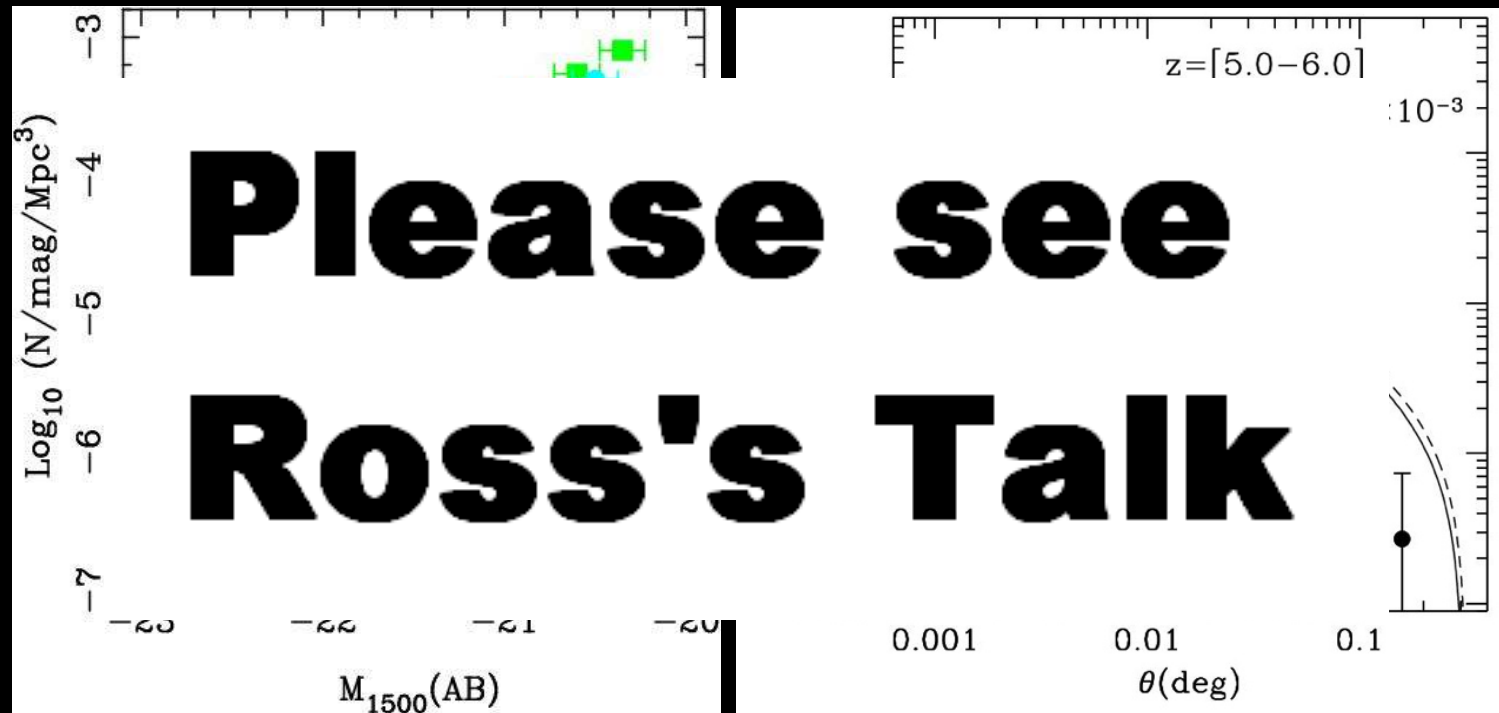
+

Density evolution

$$\phi_0(z) = \phi_0(0) \times \exp \left[ - \left( \frac{z}{z_\phi} \right)^{k_\phi} \right]$$

# 3. Massive galaxies at $4.5 < z < 6.5$

McLure et al. (2008)



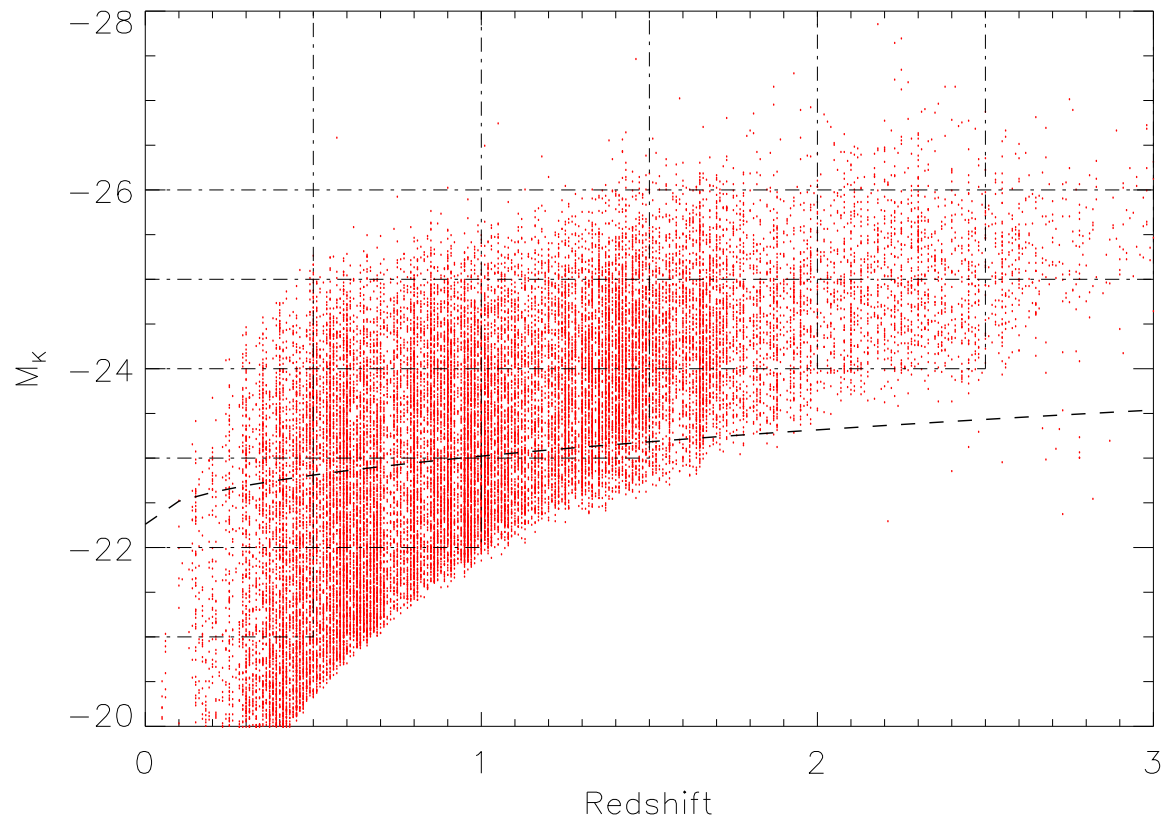
## Future plans:

- Extend to higher  $z$  and lower luminosities

## Future plans:

- Extend to high

Hope to  
probe  $L^*$  at  
 $z=5$





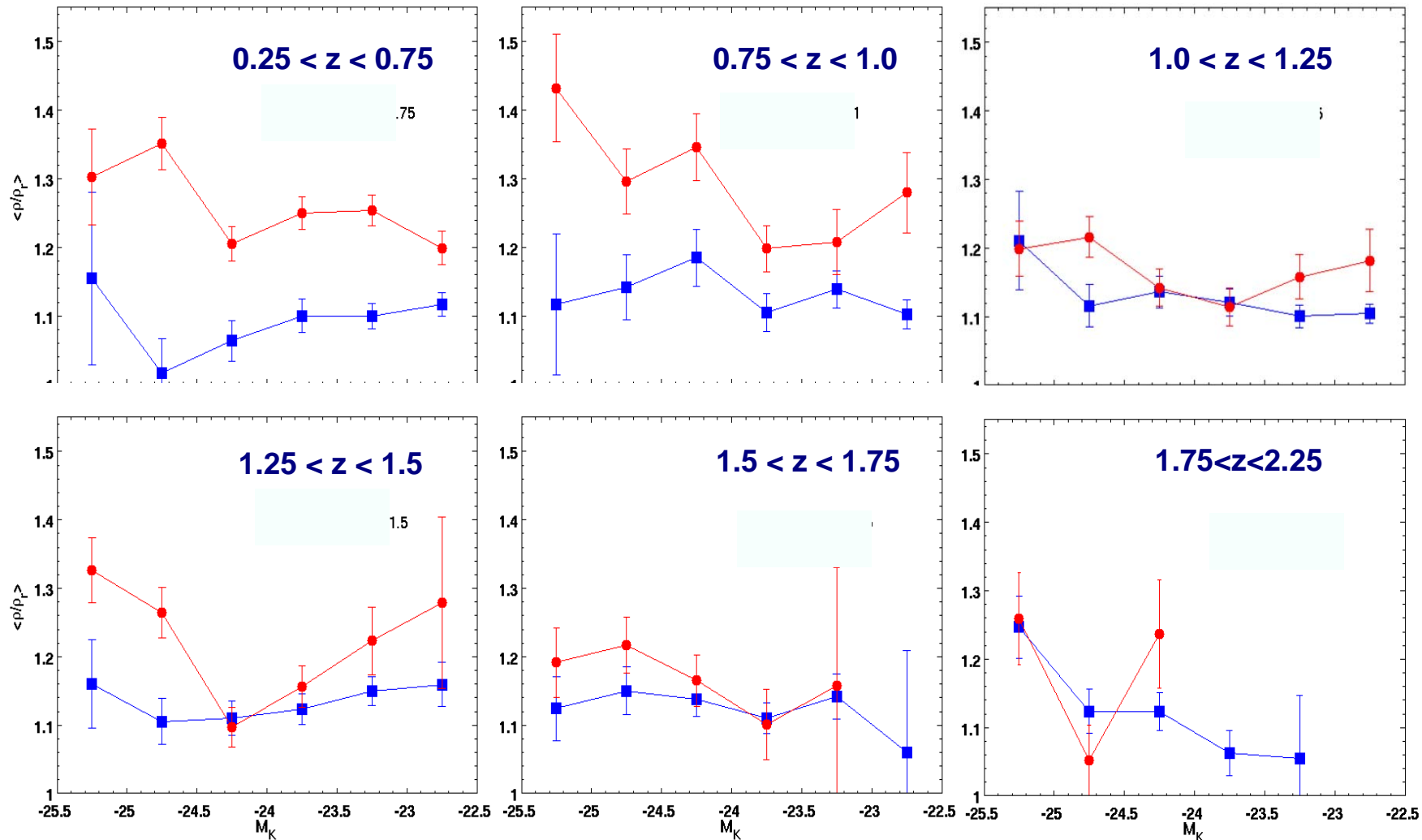
## Future plans:

- Extend to higher  $z$  and lower luminosities
- Rest frame optical properties of  $\sim 1000$   $z > 6$  galaxies and their LSS.
- Evolution of galaxies and environment at  $1 < z < 3$

# High-z galaxy environments depends on colour

*Chuter et al. (in prep)*

$\langle \rho / \bar{\rho}_r \rangle$



Bright ← → Faint

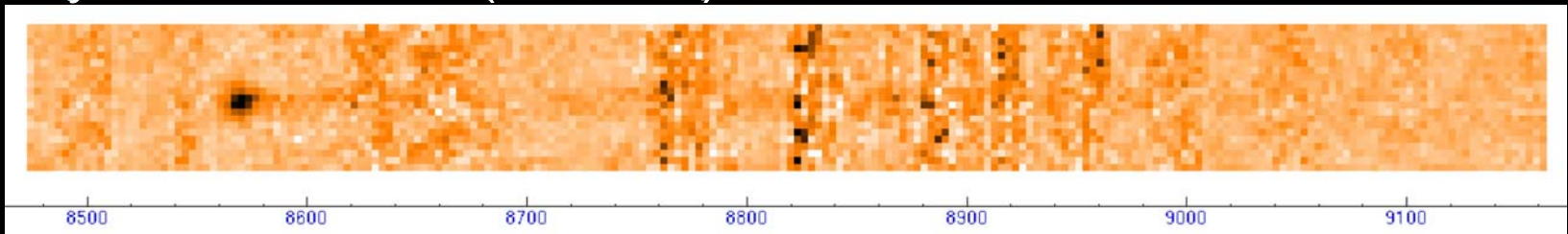
$M_K$

## Future plans:

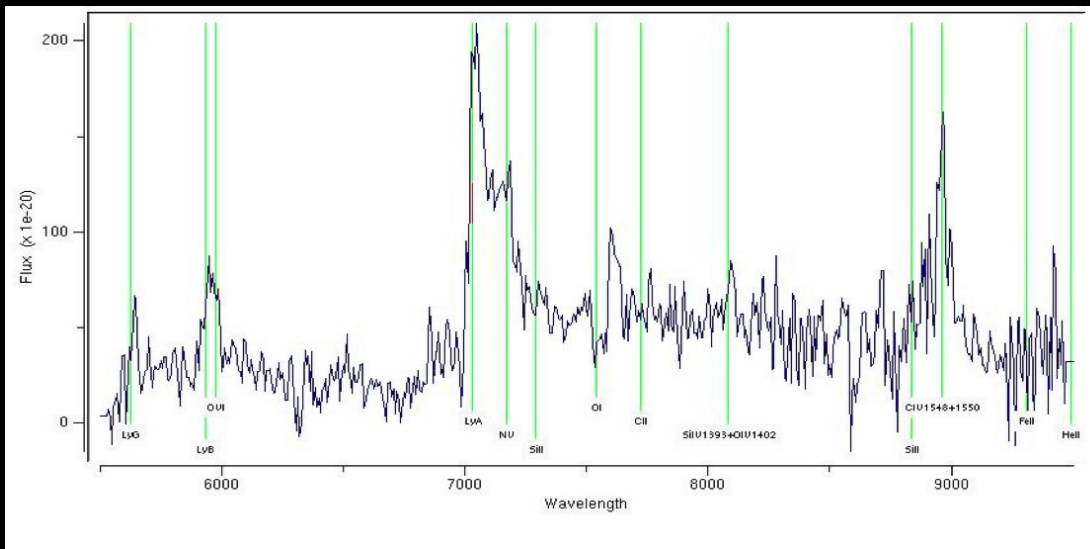
- Extend to higher  $z$  and lower lum.
- Rest frame optical properties of  $\sim 1000$   $z > 6$  galaxies and their LSS.
- Co-evolution of galaxies and environment at  $1 < z < 3$
- Recent + new data:
  - SpUDS, UDSz, SCUBA-2, deeper  $z'$ -band (Subaru), DIEMOS

# High redshift galaxies

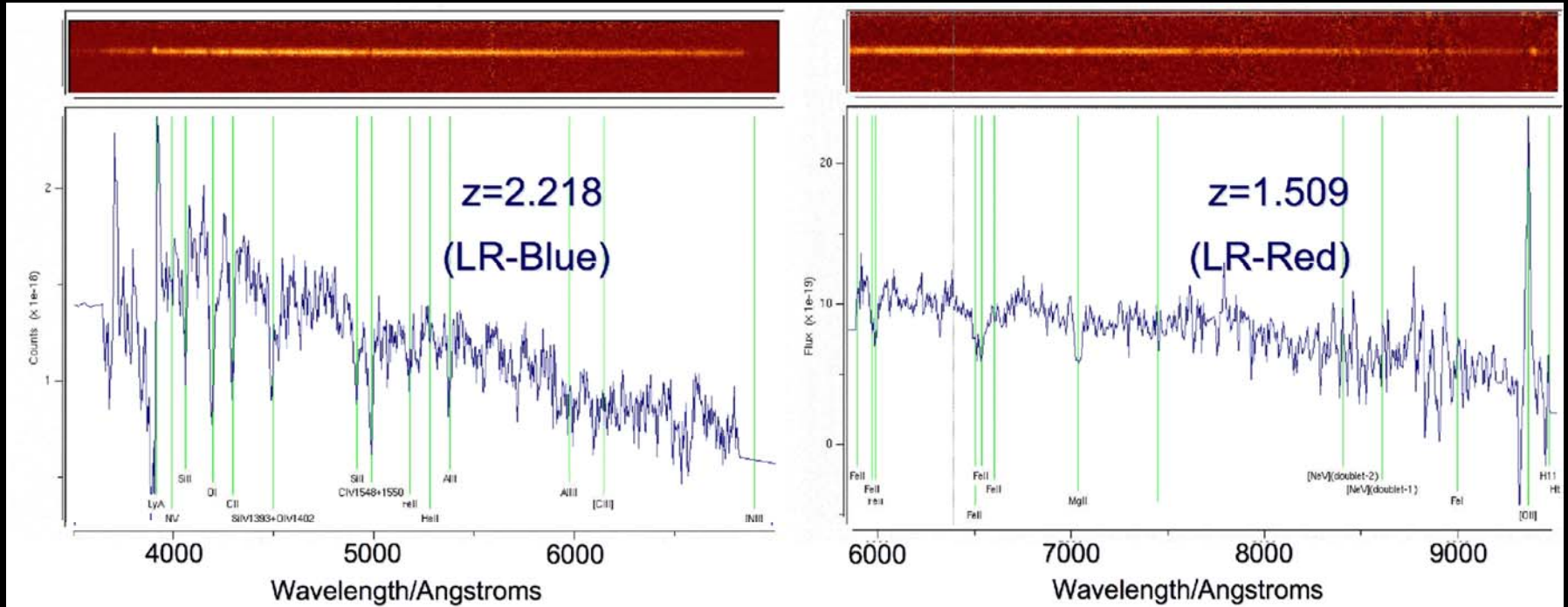
## Ly- $\alpha$ at $z=6.05$ (FORS2)



## Quasar at $z=4.8$ (VIMOS)



# Early VIMOS spectra of BzK galaxies

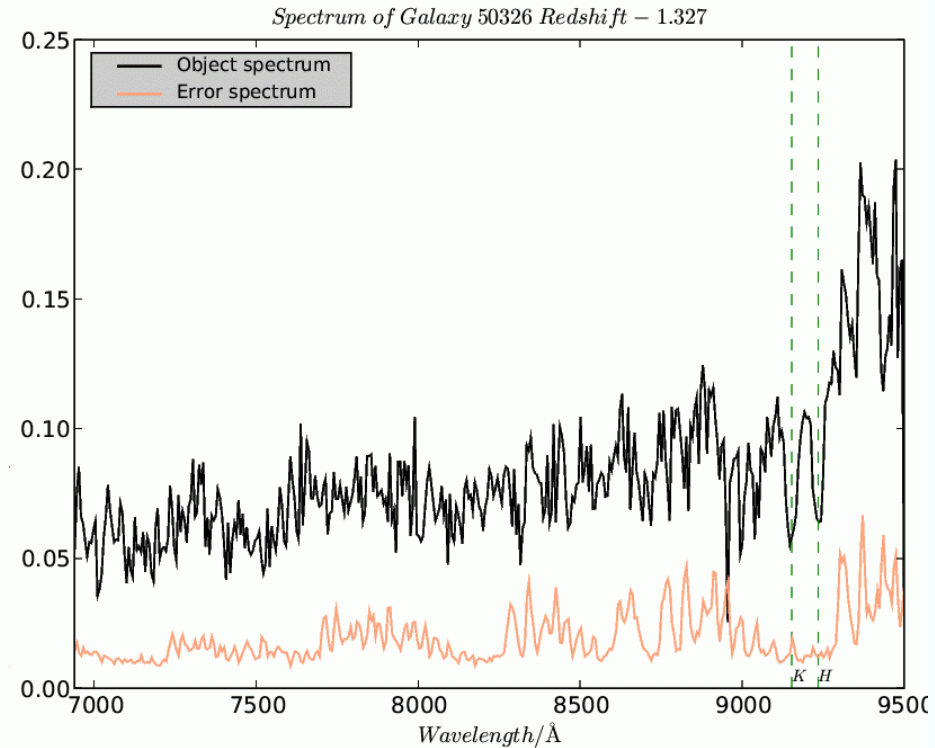
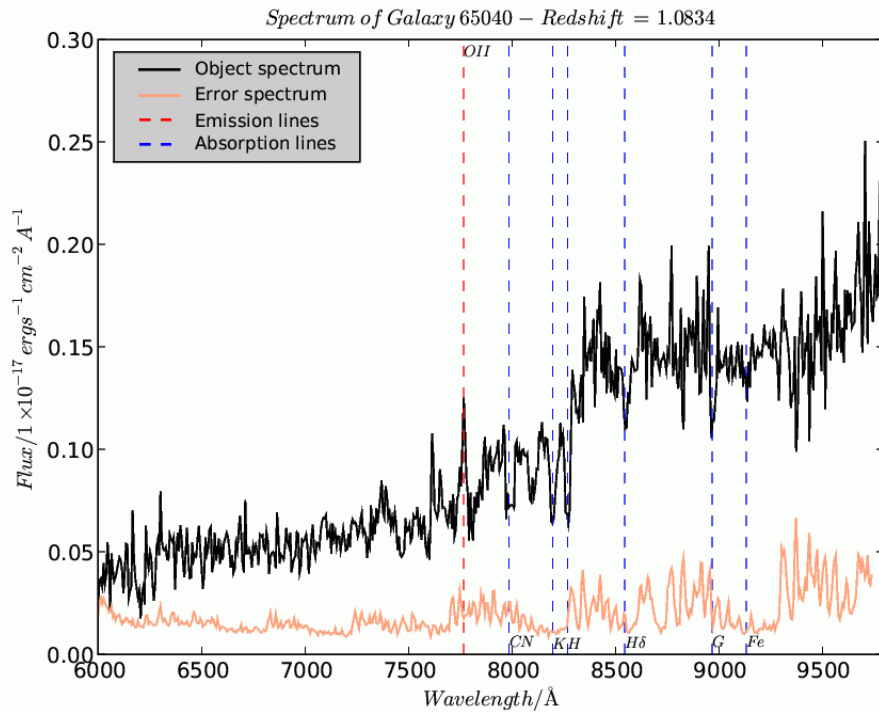


# Thanks

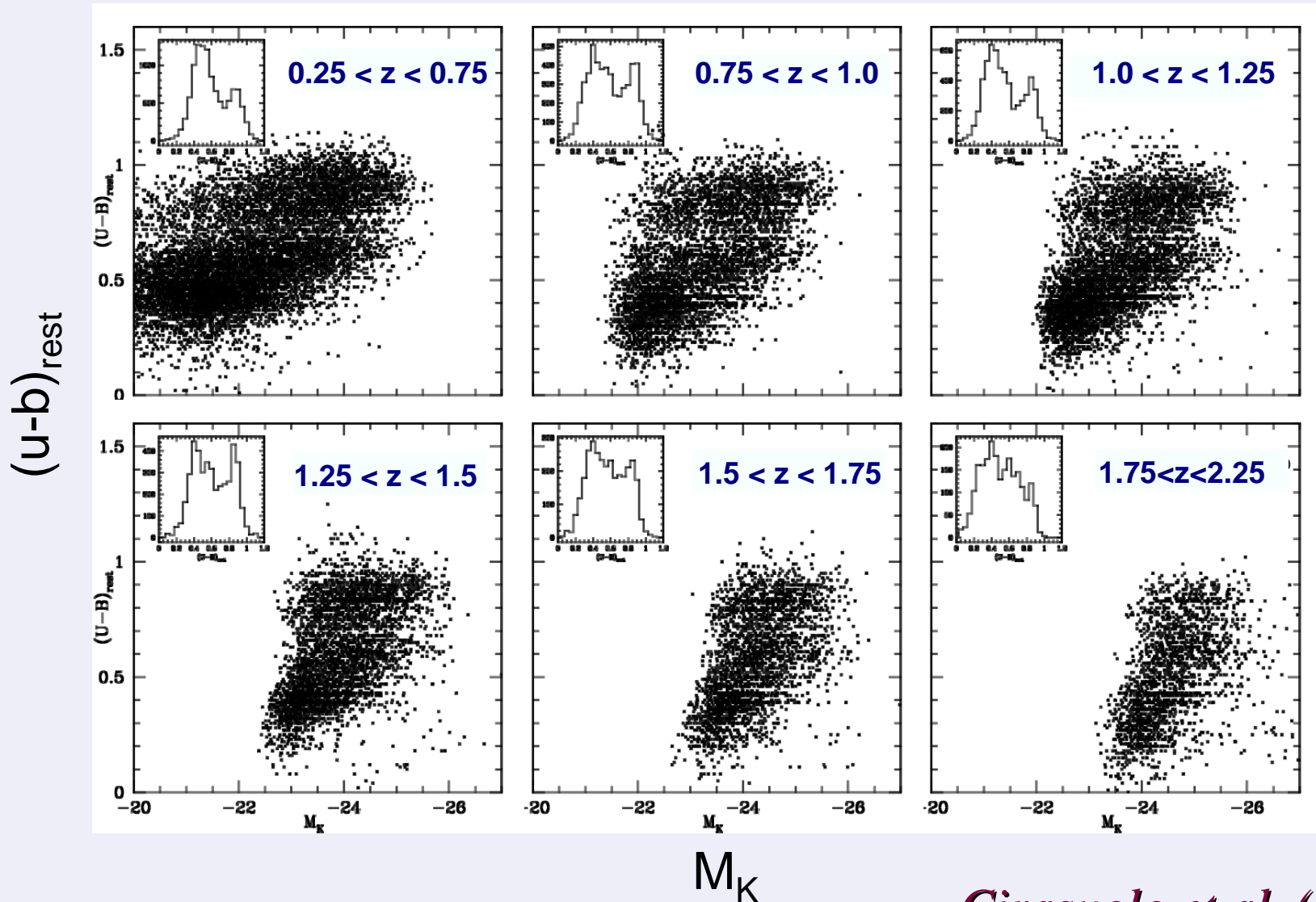
To those responsible for building the telescope and instruments;  
For the ongoing running of UKIRT;  
To everyone that is fighting to keep UKIRT open;  
All involved in the data reduction and archiving.

Hopefully UKRT has enough time to launch a couple more careers in astronomy...

# The elusive faint, red galaxy population



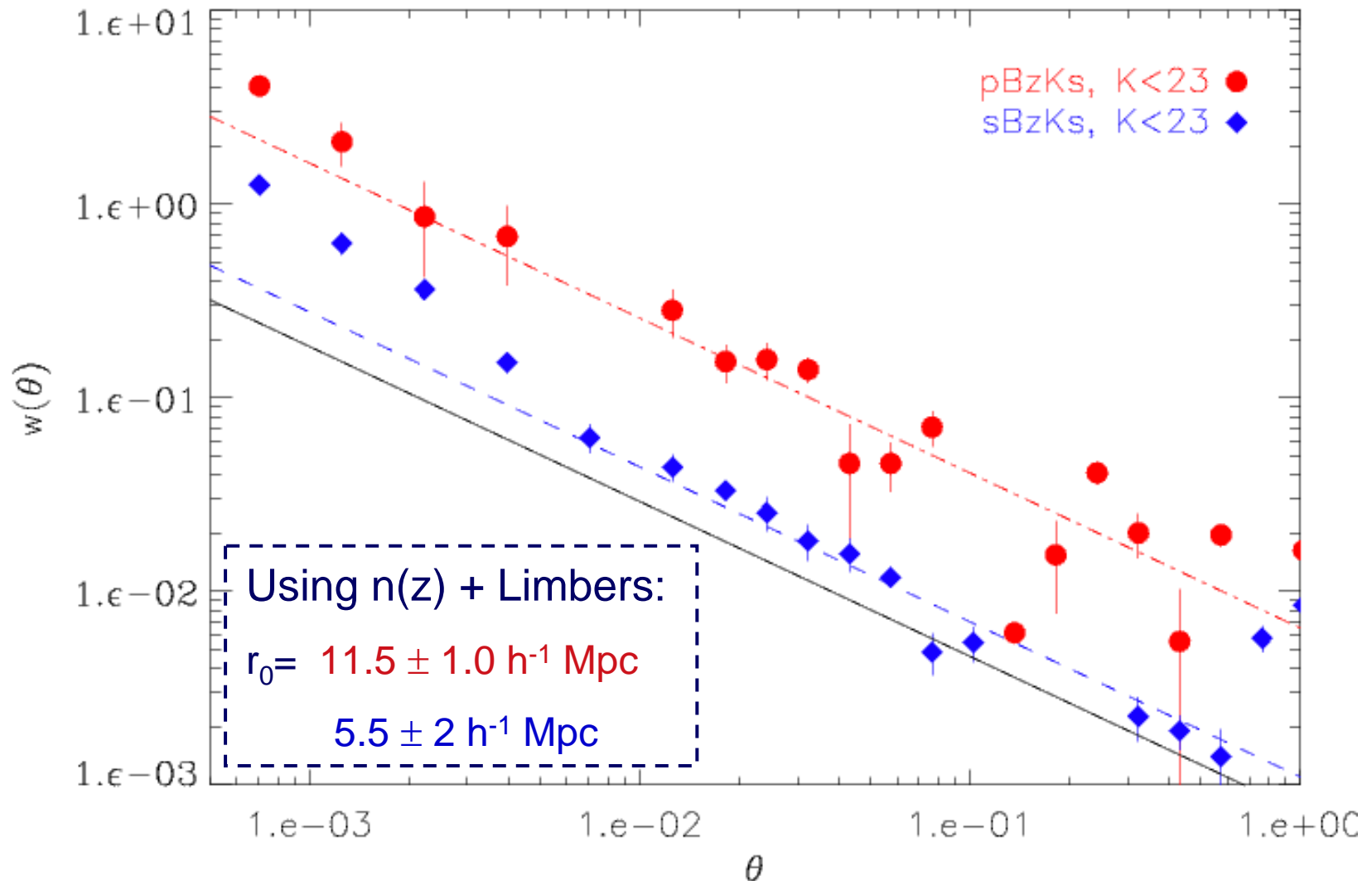
# Evolution in colour bimodality to $K_{AB}=23$





# Passive galaxies cluster most strongly in the range $1.4 < z < 2.5$

*Hartley et al. (2008)*



# What next?

ESO Large Programme: UDSz

~4000  $z > 1$  galaxies to  $K < 23$

*93 hours VIMOS*

*142 hours FORS2*



# BzK selection of galaxies at $z > 1.4$

*Lane et al. (2007)*

