The GOODS NICMOS Survey (GNS) +POWIR/DEEP2

Christopher J. Conselice
(University of Nottingham)

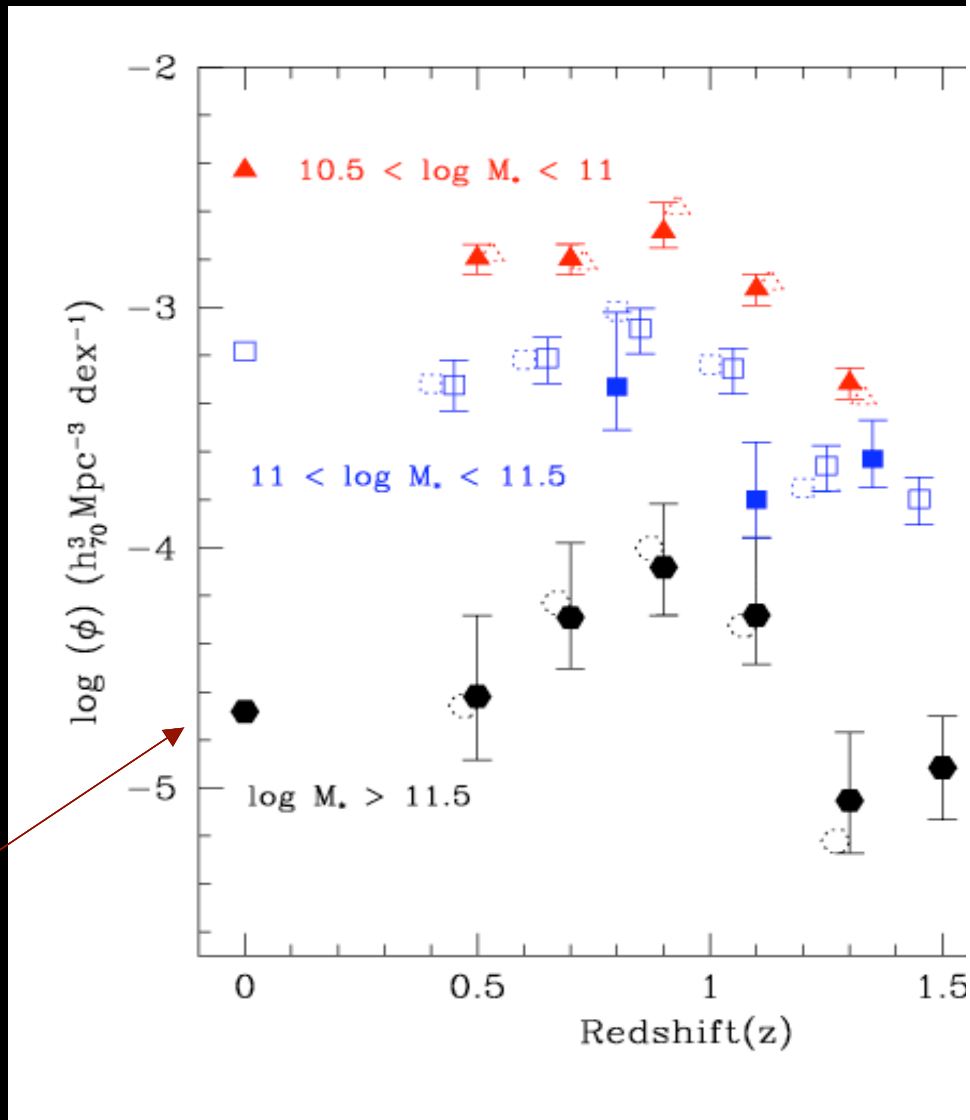
with Asa Bluck, Ruth Gruethbacher, Amanda Bauer, Fernando Buitrago (Nottingham) + others

Motivation: Nearly all massive galaxies are formed by z~

Results from Palomar Observatory Wide-Field Infrared Survey (POWIR) +DEEP2 Redshifts

(Conselice et al. 2007)

Cole et al. (2001)
z~0 comparison

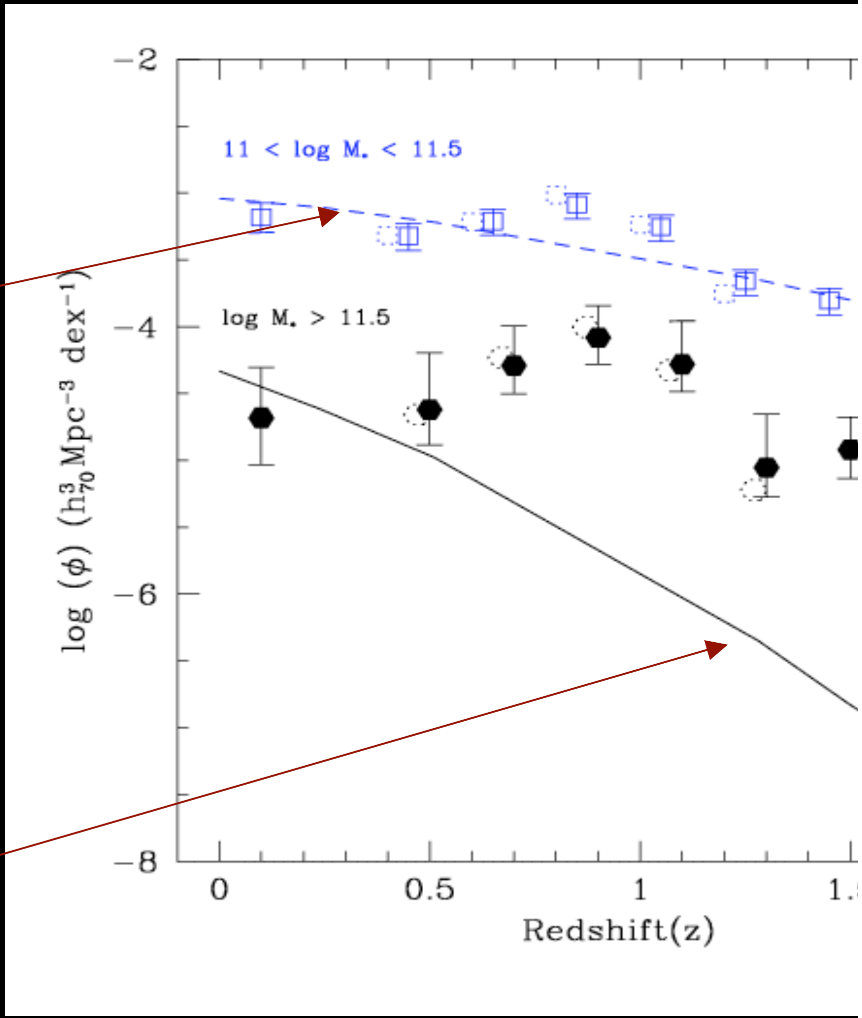


Massive galaxies must form at > 1.5

Also, there are too many massive galaxies in comparison to mo

Millennium simulation

ediction for 11 < log M < 11.5



Prediction for log M > 11.5

Conselice et al. (2007)

Vast under prediction in models compared to observations

THE GOODS NICMOS SURVEY

180 orbits HST program
NICMOS 3 camera F160W (H) band
Greatest coverage in other bands
60 pointings, 45 arcmin^2, > 8000 galaxies in total
Pixel scale 0.1”, PSF ~ 0.3”, Limiting mag. H = 26.8 (

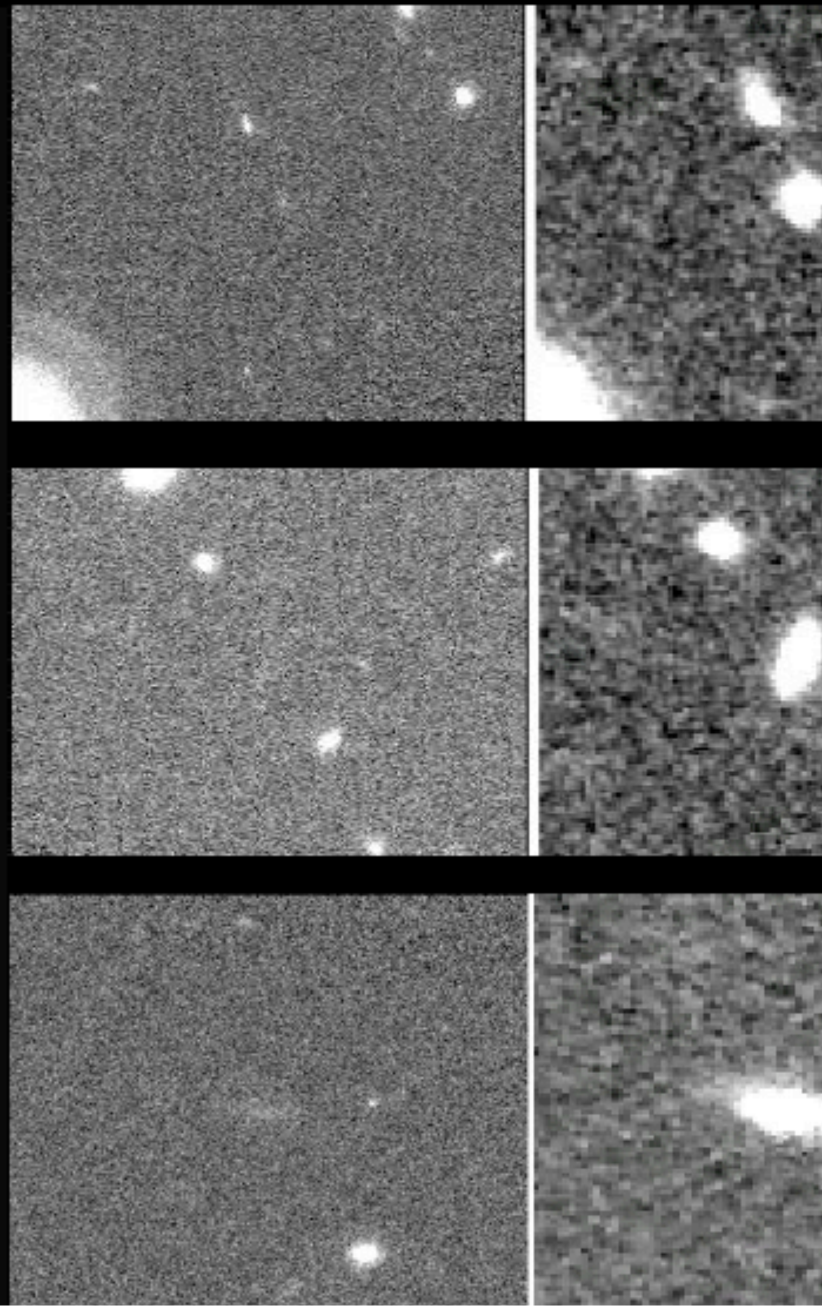
82 galaxies ≥ $10^{11} M_o$ at $1.7 \leq z \leq 3$
BzK galaxies (Daddi et al. 2007)
IRAC-selected Extremely Red Objects, IEROs (Yan et a
Distant Red Galaxies, DRGs (Papovich et al. 2006)

Can detect log M = 9.5 galaxies to z = 3

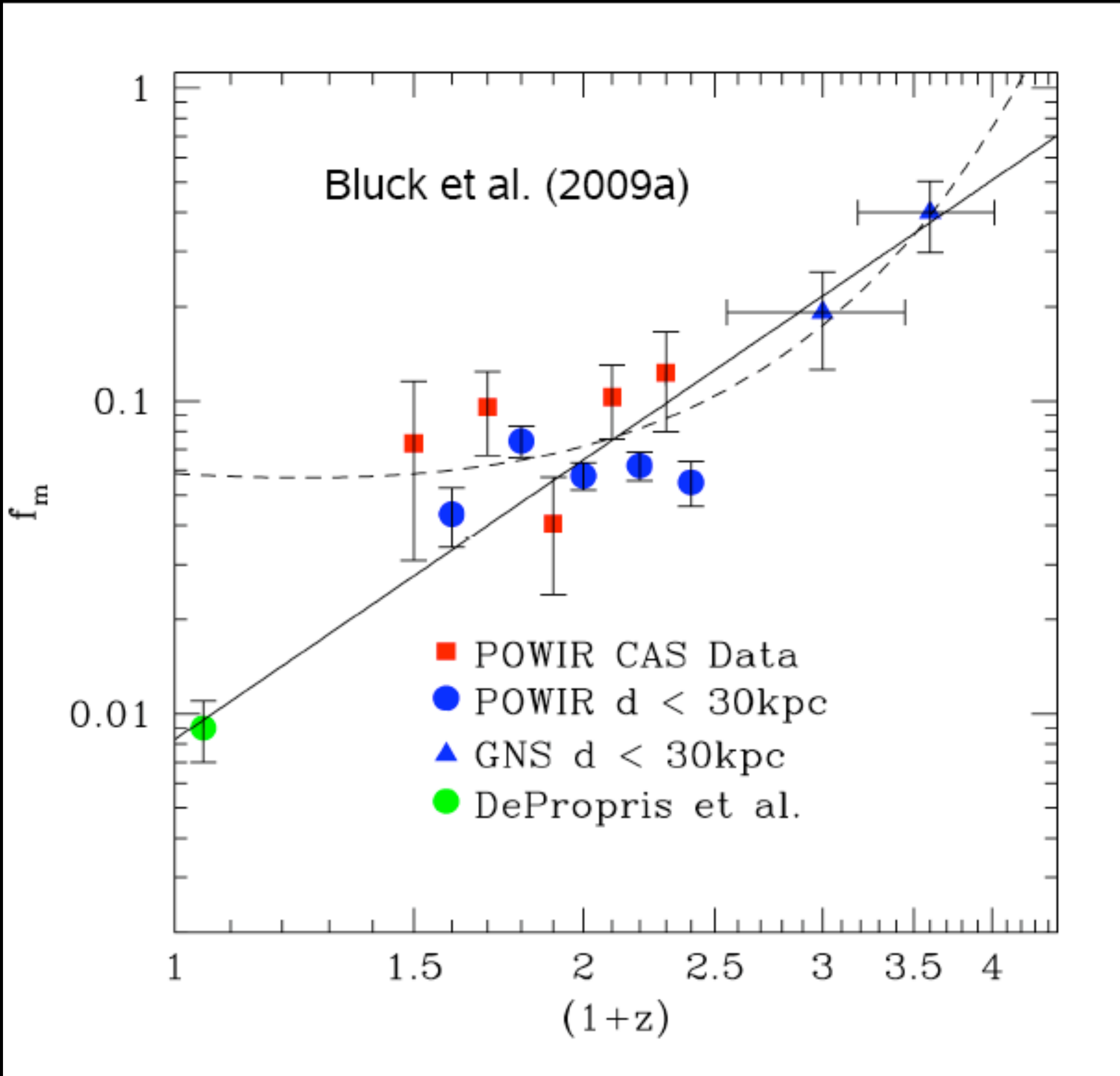
New Light

To the right is an example of three of our sample of massive galaxies viewed on the left in ACS (rest-frame UV) and on the right in NICMOS (rest-frame optical).

It is clear that many galaxies are visible in the infrared which are invisible in the optical at high z.



Results – Merger Fraction Evolution



This plot shows the red
evolution of the merger
fraction for massive ga

The solid line is a best
power law approach:

$f(z) = f(0) \times (1+z)^{\alpha}$

Dotted line is Press-
Schetchter power low e

$f(z) = f(0)(1+z)^{\alpha} \exp(\beta(1$

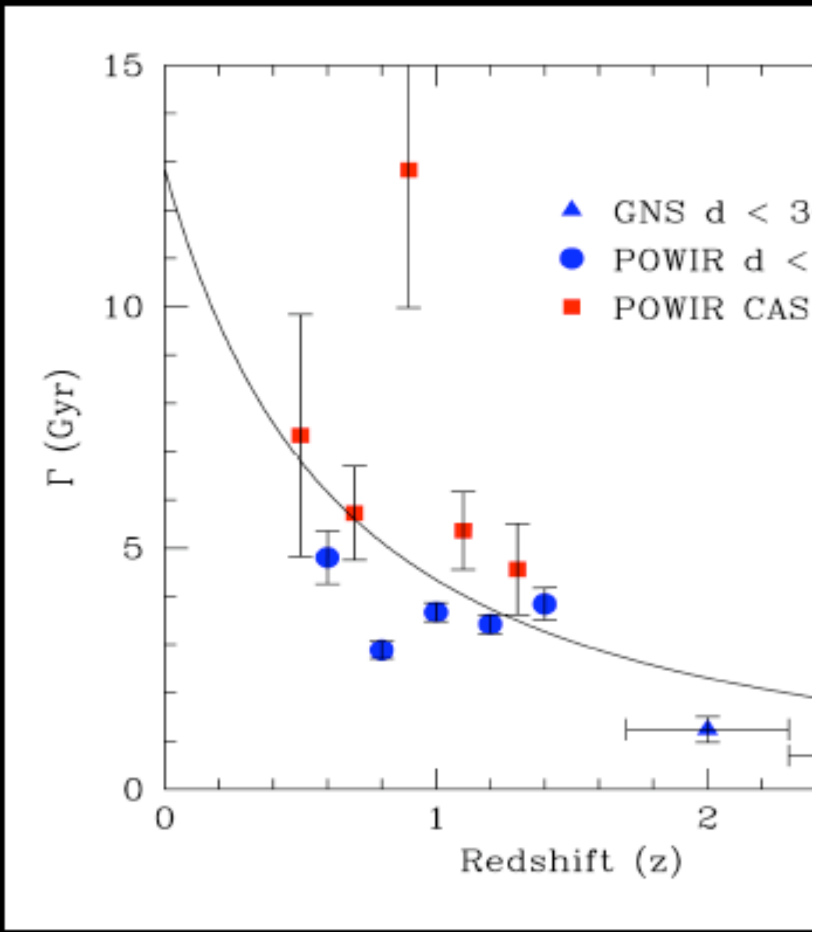
Number of Major Mergers

The number of mergers an average massive galaxy will undergo from z = 3 to z = 0 can be calculated via:

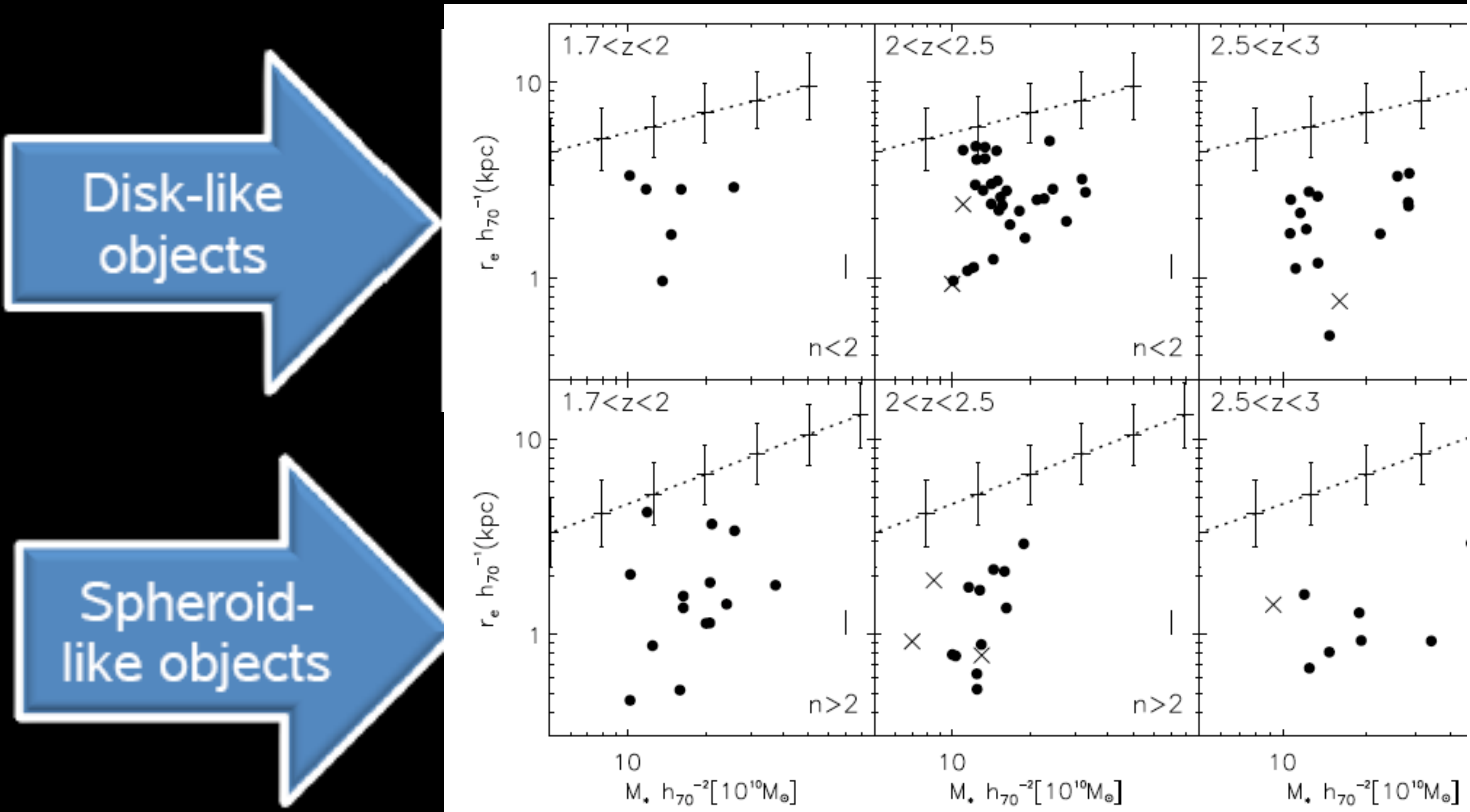
$$N_m = \int_{t_1}^{t_2} \frac{1}{\Gamma(z)} dt = \int_{z_1}^{z_2} \frac{1}{\Gamma(z)} \frac{t_H}{(1+z)} \frac{dz}{E(z)}$$

For our best fit for Γ(z), integrating over the redshift range of our galaxies we obtained:

N = 1.7 +/- 0.5
(Major mergers / Galaxy)



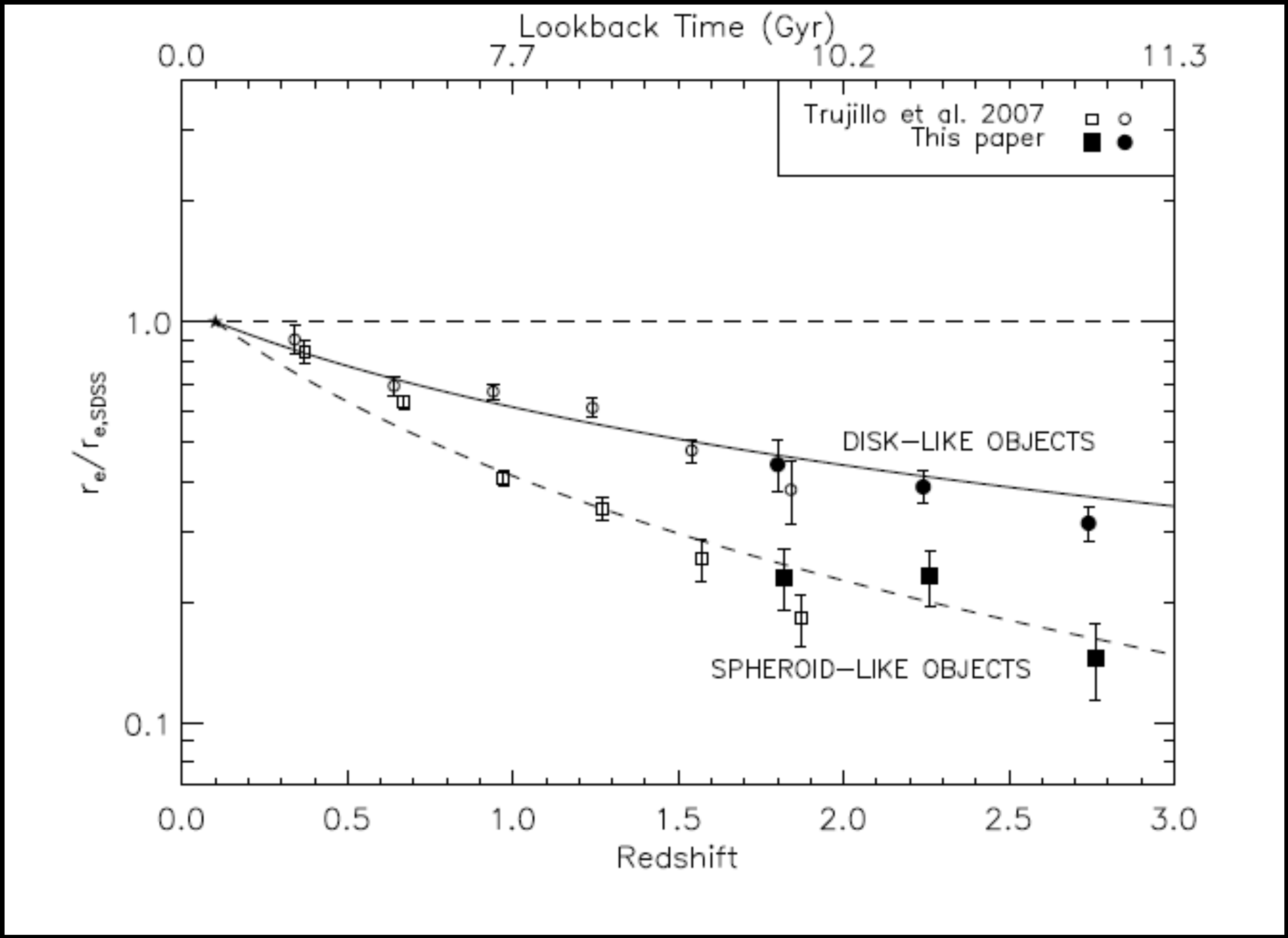
Size evolution for GNS galaxies



Buitrago et al. (2008), A

ALL massive galaxies at z > 2 are compact

Galaxy sizes continue to decrease at higher redshifts



Major mergers cannot explain

Buitrago et al.

What is the role of AGN in galaxy formation?

Can investigate with our sample using 508 X-ray selected A
At 0.4 < z < 6 within the DEEP2/Palomar and GNS fields

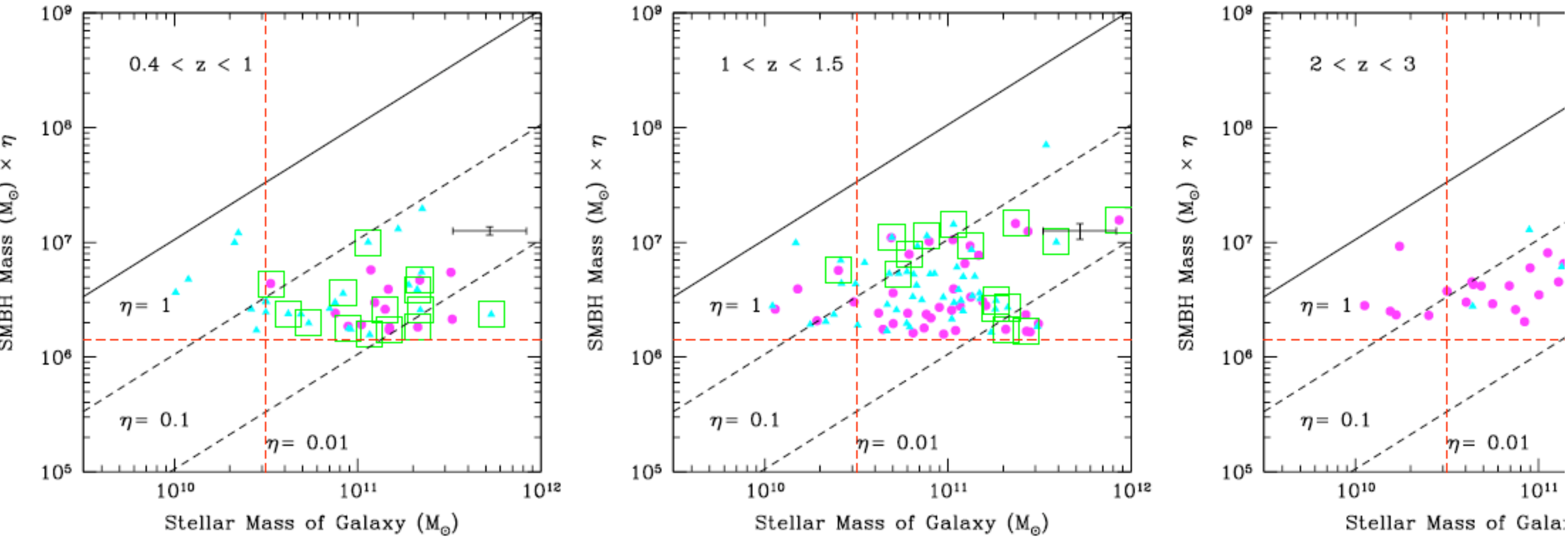
Method - find X-ray luminous AGN that are more luminous
L_X > 2.35 * 10^43 erg/s - create volume limited samples

Using X-ray luminosities to calculate the black hole mass

$$L_E = \frac{4\pi c G M \mu_e}{\sigma_T} = 1.51 \times 10^{38} \frac{M}{M_\odot} ergs^{-1}$$

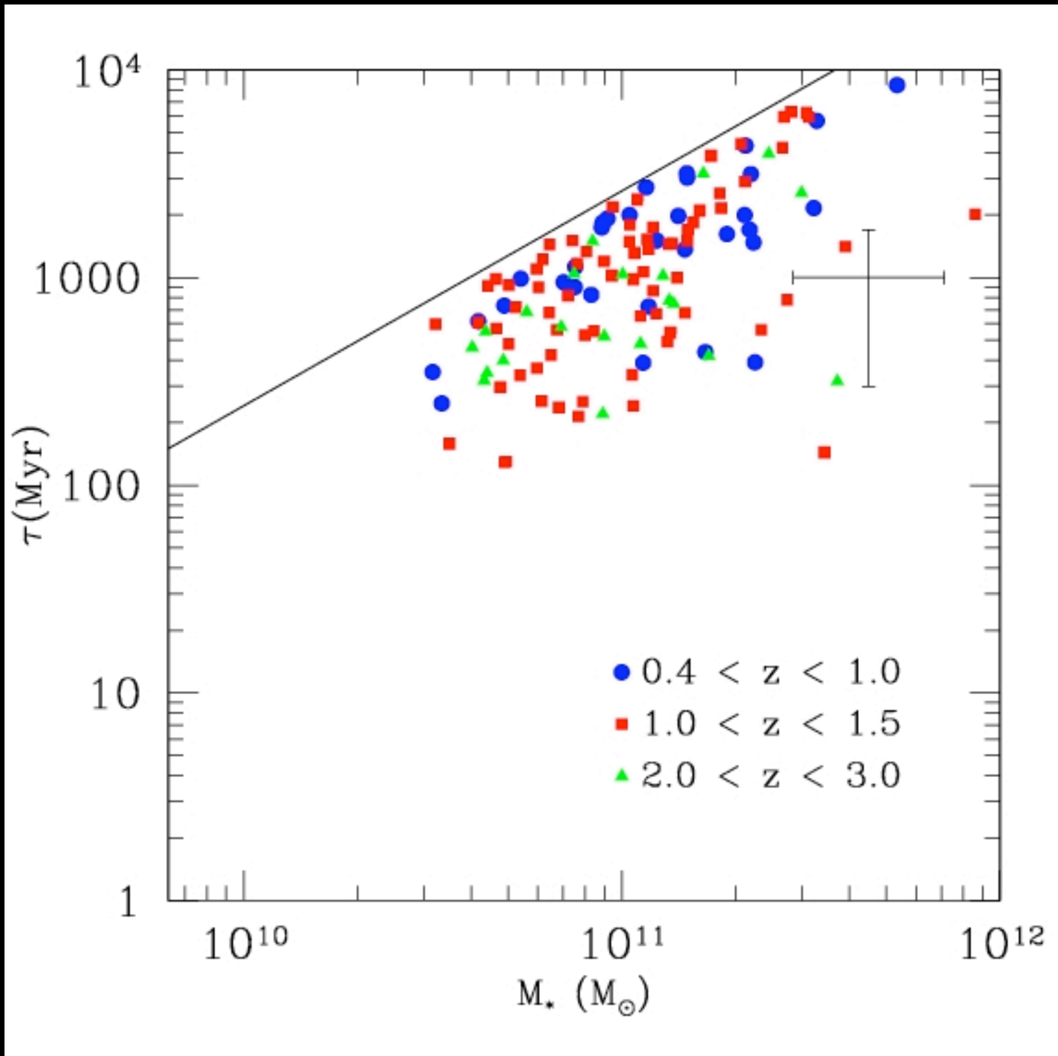
$$M = M_E / \eta$$

Co-evolution of black hole mass and galaxy mass



If assume that black hole eta efficiency same at low and hi
redshift, then black hole mass-galaxy mass relation can onl
vary by a factor of two.

Bluck et al. (2010)



Can place constrai
on time-scales for
activity based on M
M_BH relation

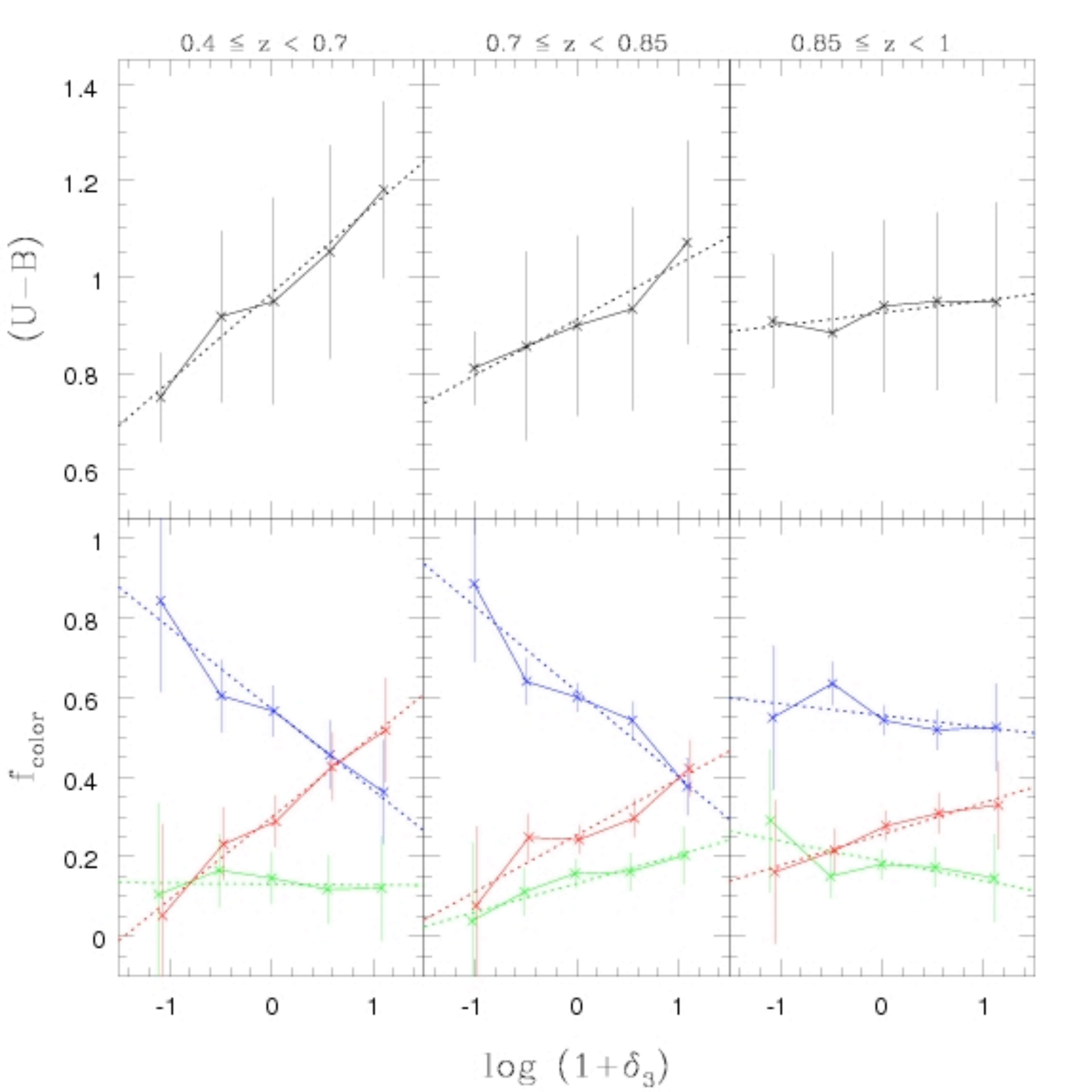
$$F_{AGN} = \int_{t1}^{t2} \Gamma^{-1}_{AGN}(z)dt = \int_{z1}^{z2} \Gamma^{-1}_{AGN}(z$$

Rate = time/f_AG

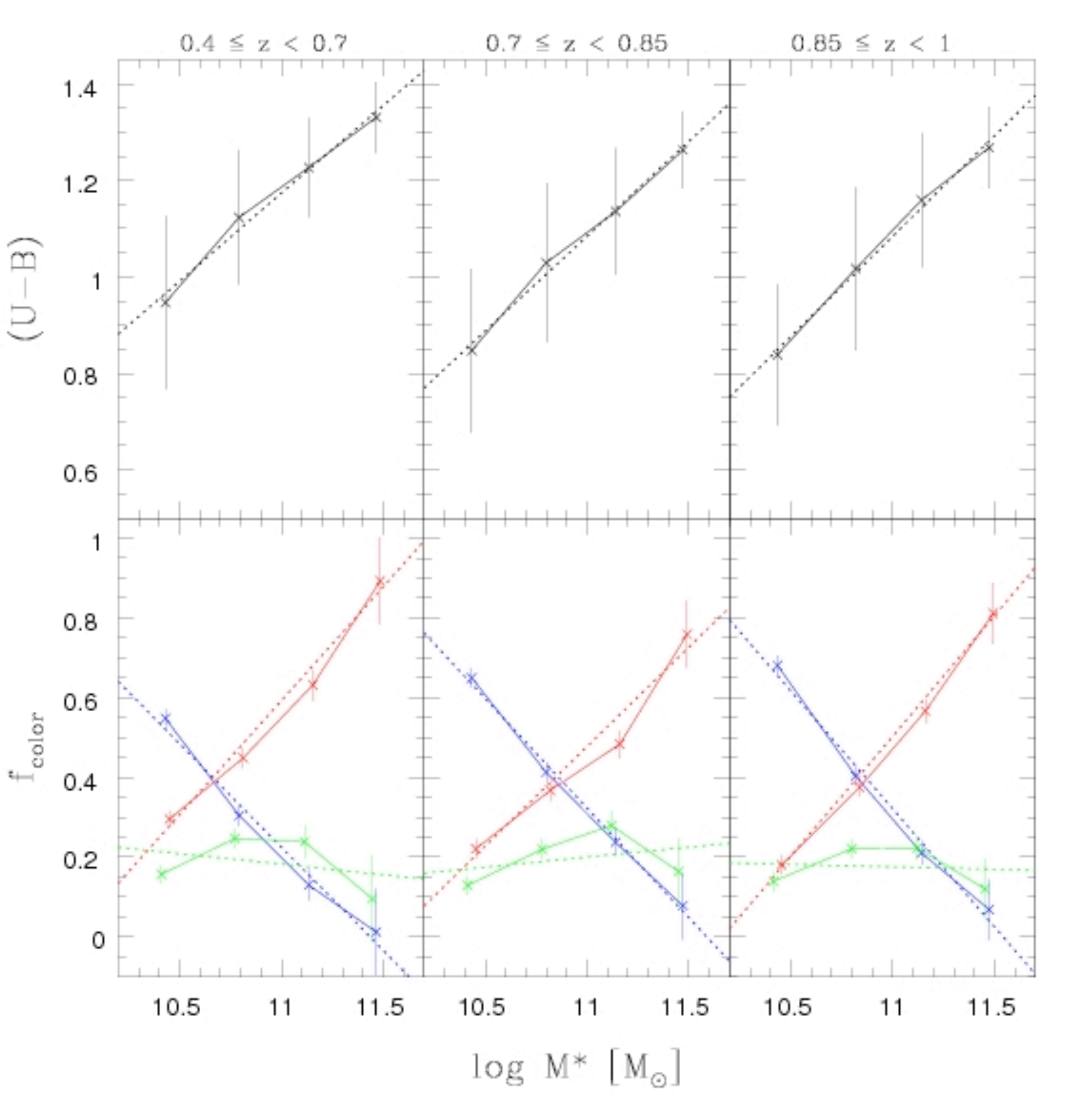
Reveals that > 1/4
Massive galaxies h
An AGN > 10^43

$$\tau_{max} = \frac{M_{BH}(z=0) - M_{BH}(z=z')}{\dot{M}} \approx \frac{M_*/1000 - M_E}{\dot{M}}$$

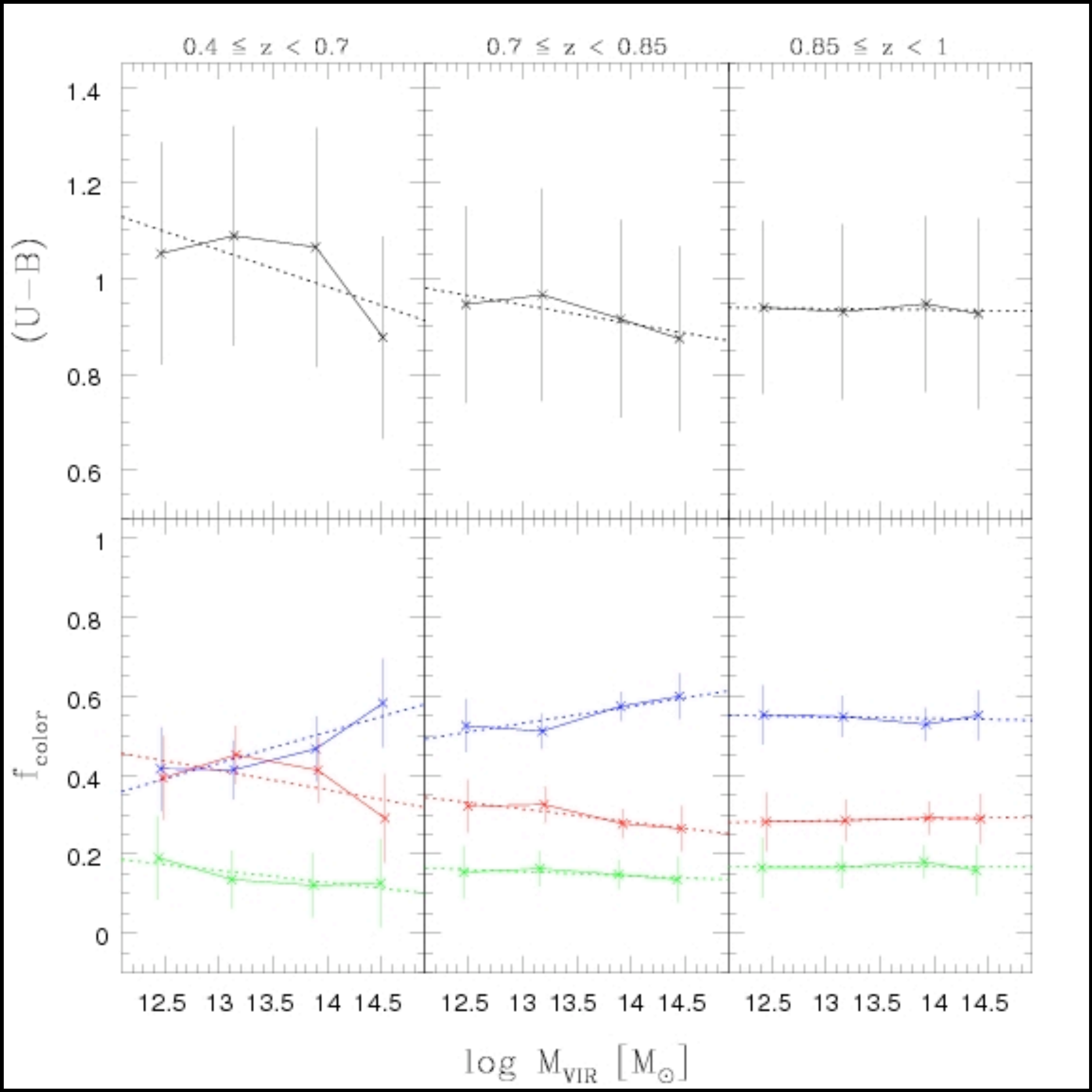
What drives the evolution of galaxies?



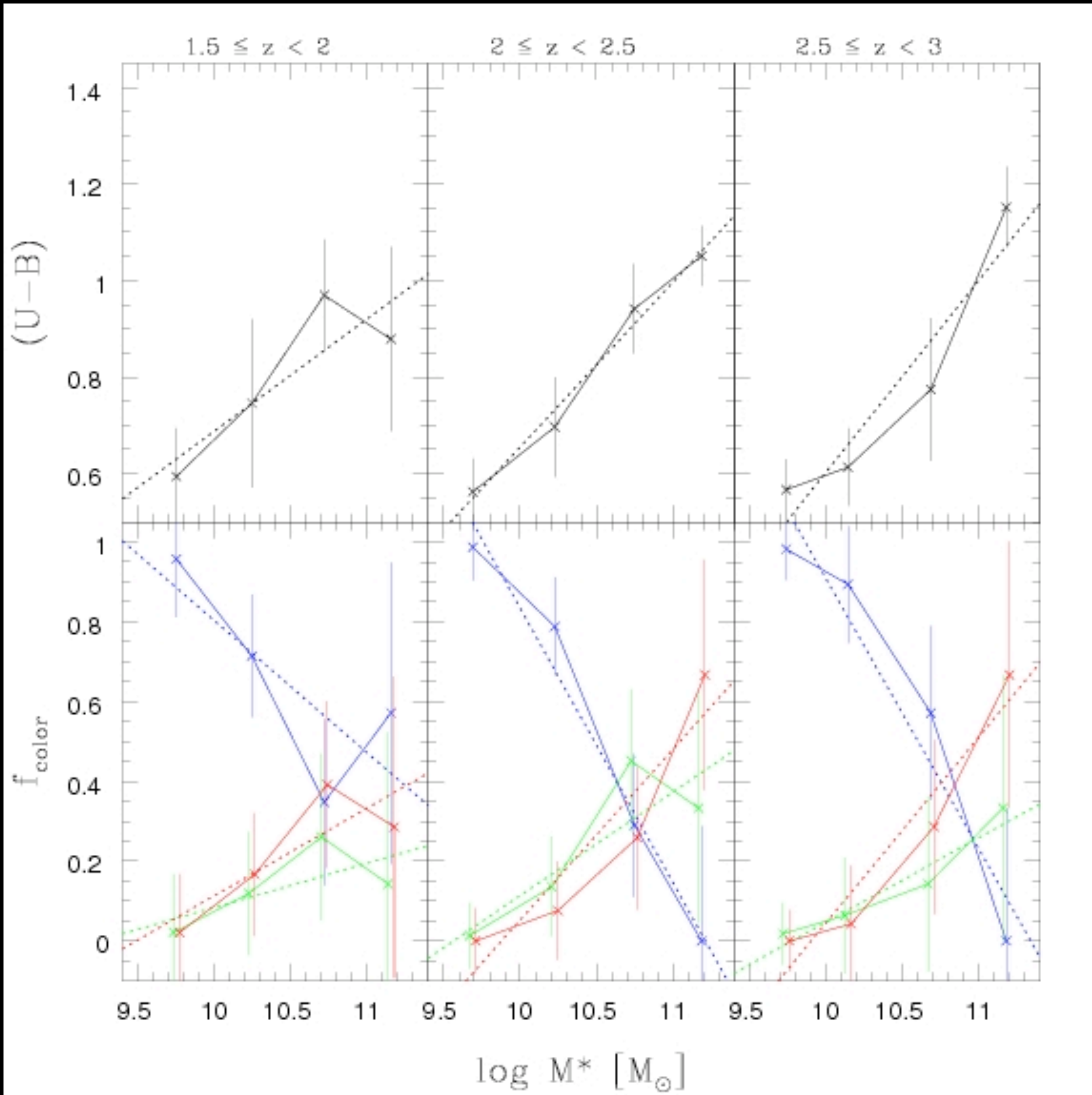
Relation b
environme
color at z
a log M >
sample



Much stronger r
between color a
stellar mass of t
galaxy



Galaxy propertie
not strongly depe
on the total envir
as measured by h
of group/cluster



See at higher
as well for gal
with log M >

Gruethbacher, Conselice et al. (2010)

Summary

1. Very deep NICMOS/HST imaging to study galaxies at $z >$
   to connect with galaxies at $z < 1.5$ with POWIR/DEEP2

2. Examination of the major merger history, the AGN history
   and how enviroment vs. mass effects the formation of gala

3. Massive galaxies become more compact at progressively hi
   redshifts and over 1/4th of massive galaxies at $z < 3$ have h
   an AGN. Galaxy stellar mass most important property for
   understanding galaxy formation