

Establishing the Connection Between Quenching and AGN

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MGCT II

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“Downsizing”

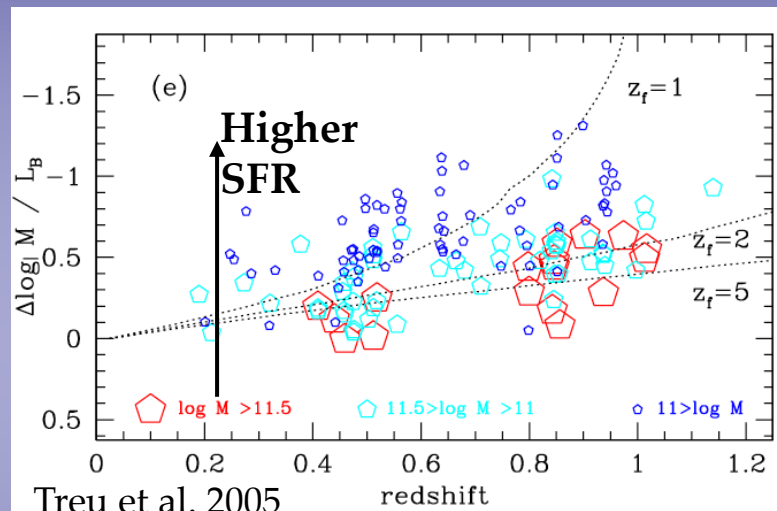
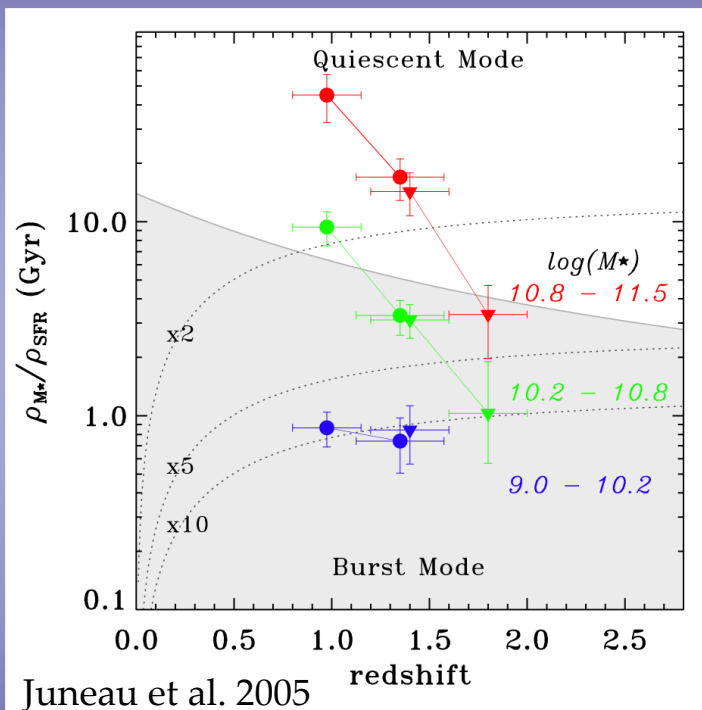
A working definition...

The sites of star formation appear to shift from including high-mass galaxies at early epochs ($z \sim 1-2$) to only lower-mass galaxies at later epochs.

Cowie et al. 1996

Downsizing, Downsizing Everywhere

Surveys to $z < 3$: Cowie et al. 1996, Brinchmann & Ellis 2000, Bell et al. 2005
COMBO17, Bauer et al. 2005, Juneau et al. 2005, Kriek et al. 2006, Papovich et al. 2006,
...



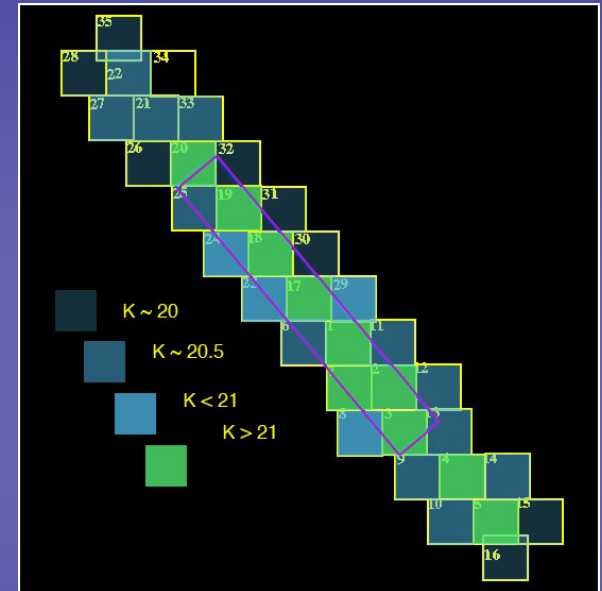
Other methods: Treu et al. 2005, van der Wel et al. 2005, Heavens et al. 2005, Jimenez et al. 2005, ...

Downsizing is a fundamental and recurring theme. How do we characterize it?



The DEEP2/AEGIS Redshift + Palomar K-band Survey

- DEEP2: 40,000 spec-z's from DEIMOS on Keck II
80 Keck nights, $z < 1.5$ over 3 deg^2 , $R < 24.1$
Spread over 4 fields, including the EGS
- Palomar K-band: 65 nights with WIRC on 200 inch
 1.5 deg^2 to $K=20$, 0.2 deg^2 to $K=21$
- Combined: 12,000 redshifts with K-band detections



EGS 14:16 +52:00

AEGIS Collaboration - Extended Groth Strip
Additionally: Chandra, VLA, Spitzer, ACS, GALEX

Key Physical Properties

1. Stellar Mass

- Palomar K-band, multi-band SED fitting

2. SFR Indicator (bimodality)

- (U-B) Restframe Color, C. Willmer

3. Environmental Density

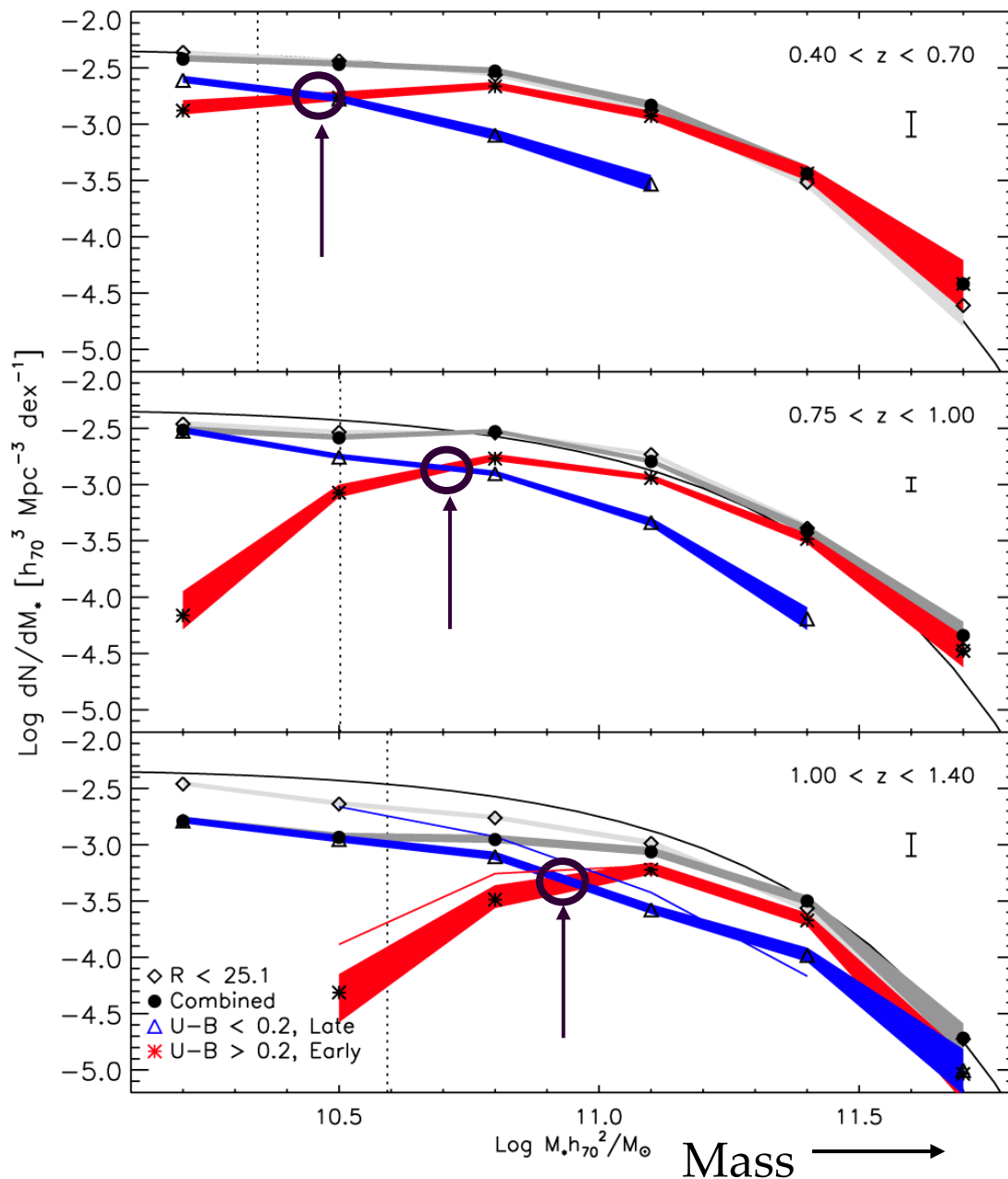
- 3rd nearest neighbor, M. Cooper

Results: Galaxy Stellar Mass Function

Partitioned by
restframe (U-B)
color into blue
(active) and red
(quiescent)
populations.

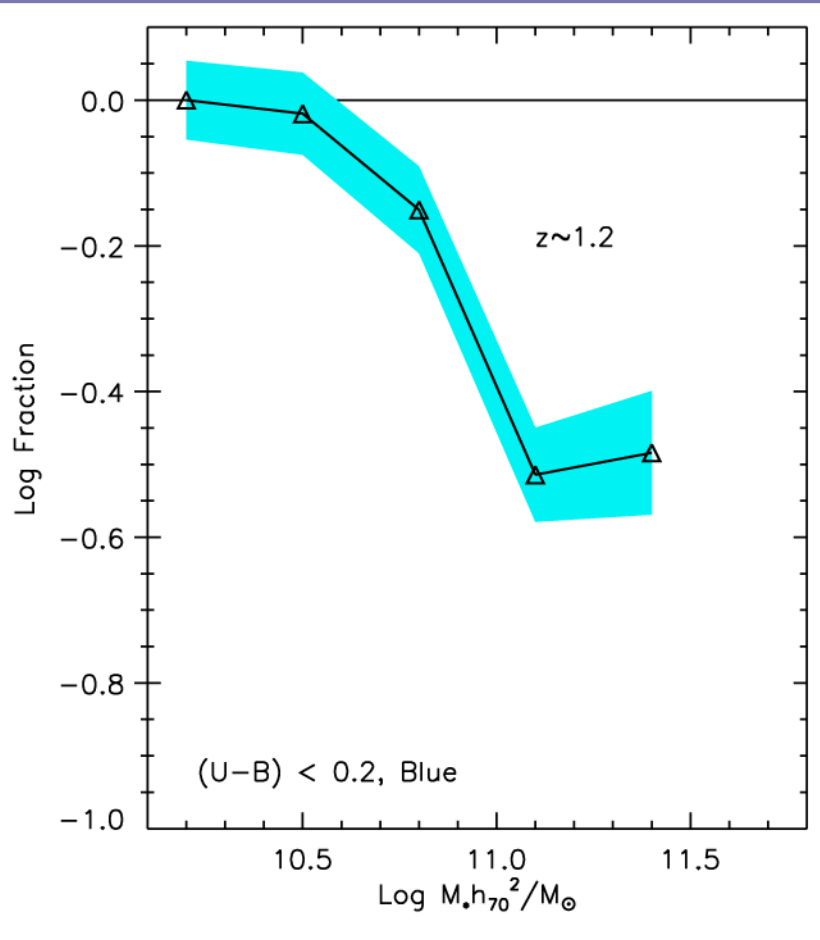
- Little total evolution
- Evolving transition
mass, M_{tr}

Number Density \uparrow



Bundy et al. 2006

Quenching of Star Formation

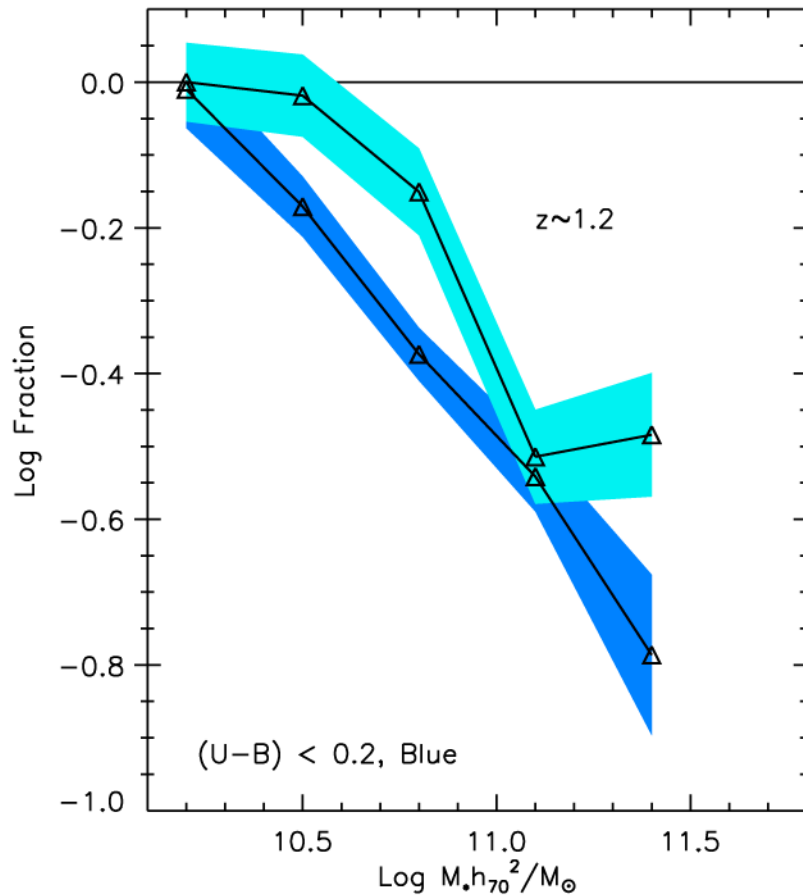


Decreasing abundance

Mass \longrightarrow

Bundy et al. 2006

Quenching of Star Formation

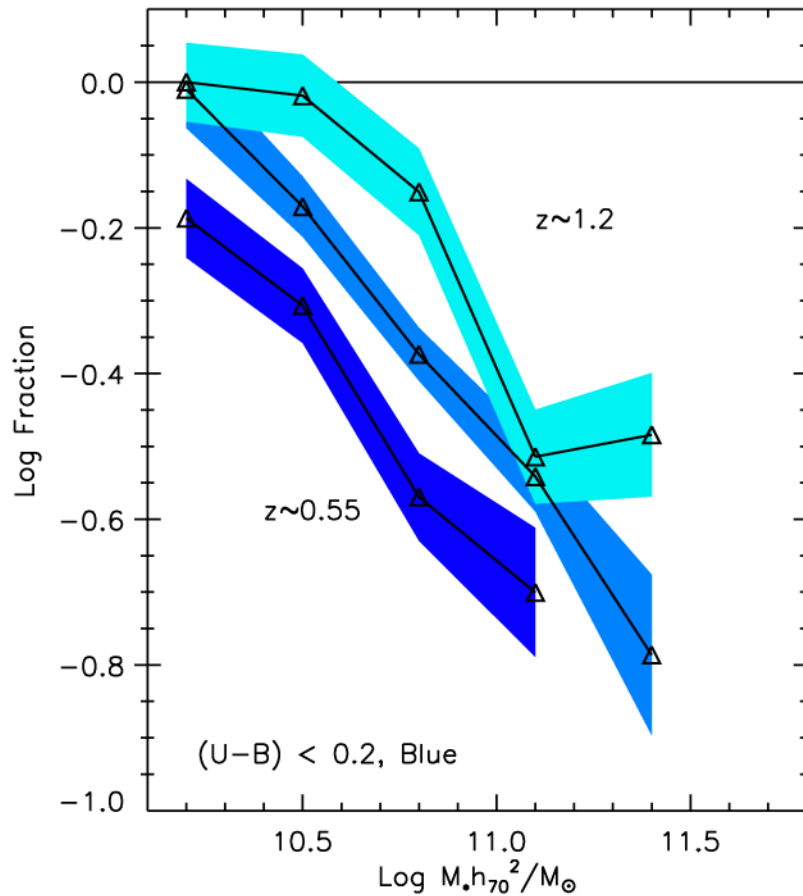


Decreasing abundance

Mass \longrightarrow

Bundy et al. 2006

Quenching of Star Formation



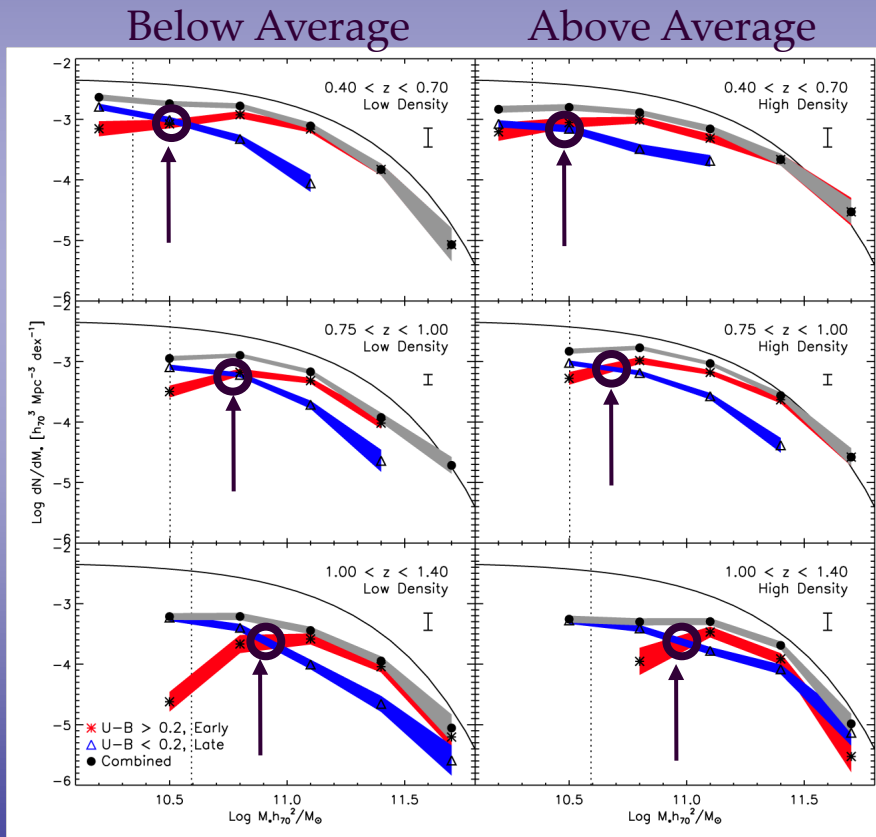
Decreasing abundance

Mass →

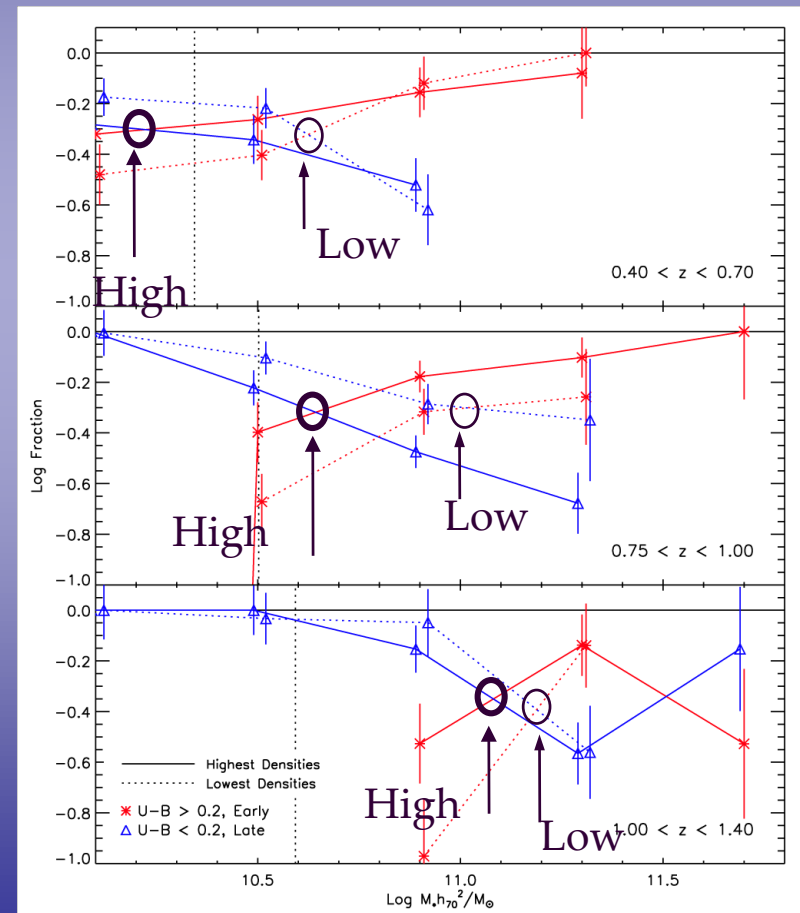
Bundy et al. 2006

Environmental Dependence of Downsizing

Average Environments
No or weak dependence



Extreme Environments
Moderate dependence



What Have We Learned?

- Quenching of SF seems to drive downsizing, transformation follows, quantify with M_{tr} and M_Q
- Weak density dependence in average environments - moderate in the extremes.
- Downsizing seems to operate in all environments.
- Quenching therefore likely caused by internal mechanism...

The Appeal of AGN

- Widely recognized presence of SM black holes.
- Physics behind the M_\bullet - σ relation?
- Large available energy without need for SF.
- Cluster cooling flows.
- Success in suppressing SF in massive galaxies at $z=0$.

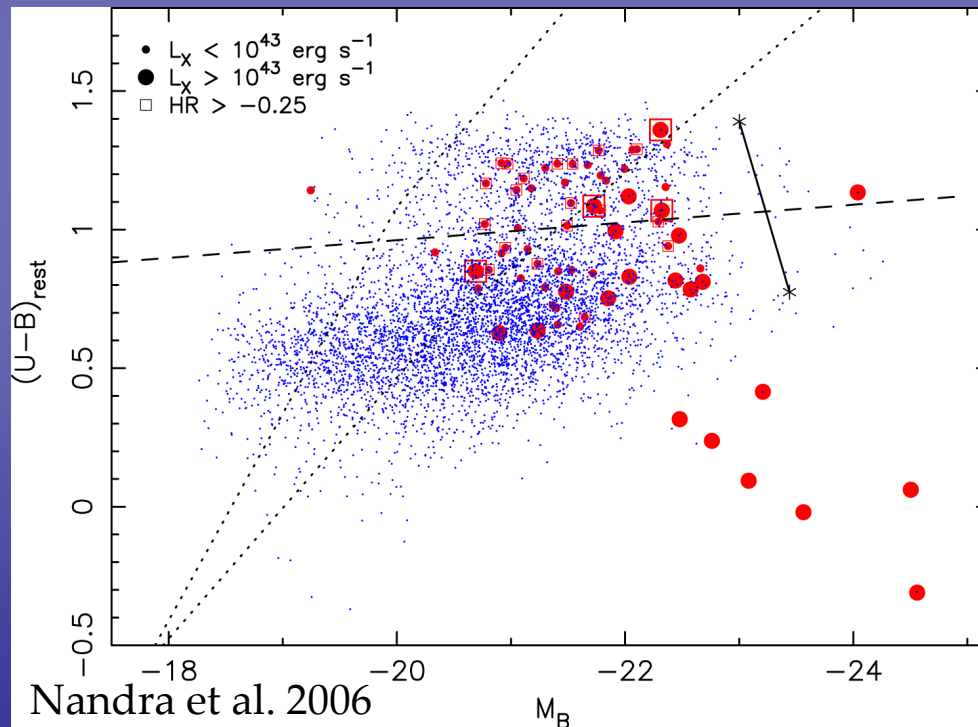
There are (at least) several pictures of how AGN feedback might work.

Come back after lunch...

Can we establish the AGN-Quenching link observationally?

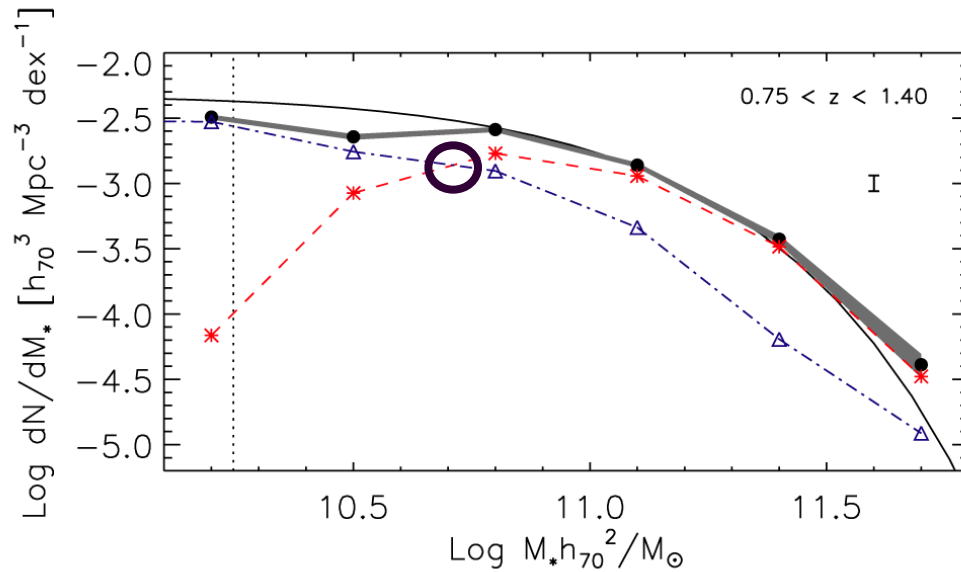
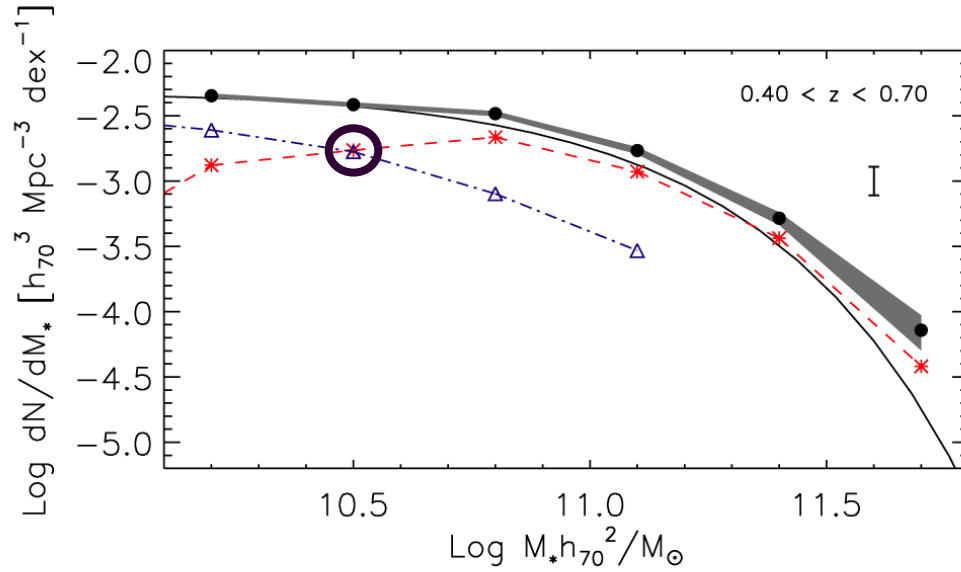
Chandra X-ray Observations from AEGIS

- 200 ks, covering the EGS, 0.5-10 keV, 1300 sources
- 165 X-ray sources with redshifts and K-band masses
- Primarily selects obscured AGN hosts, some QSOs



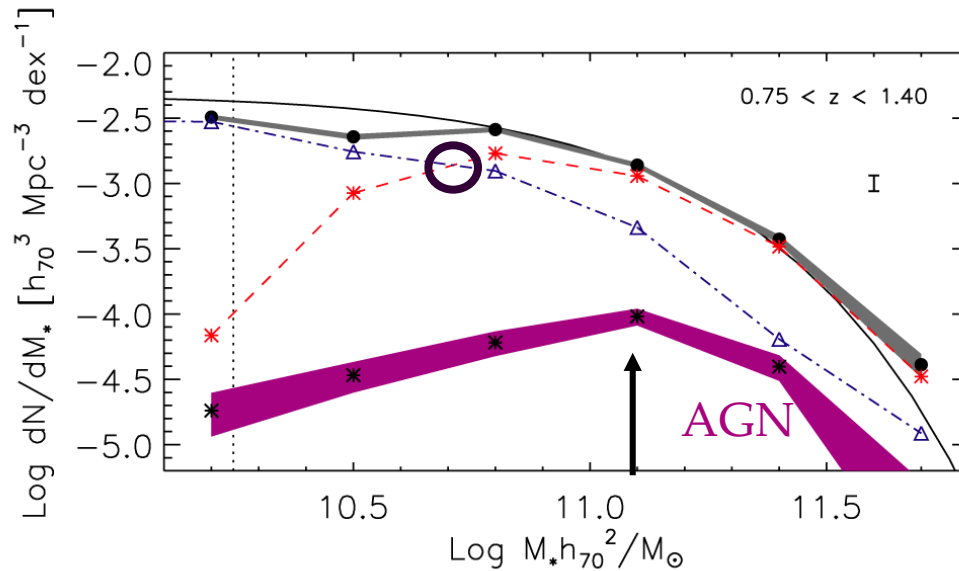
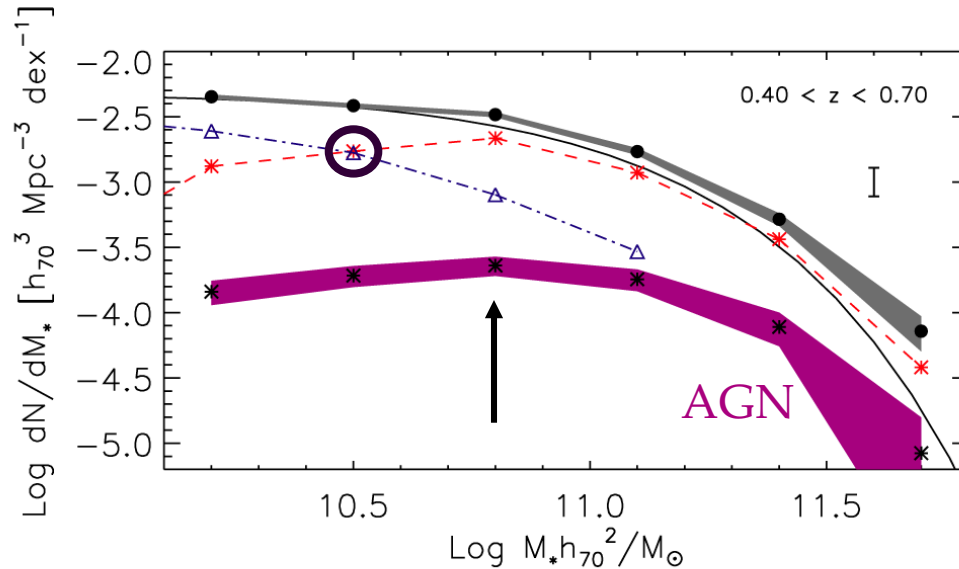
AGN Host Mass Functions

- EGS Only



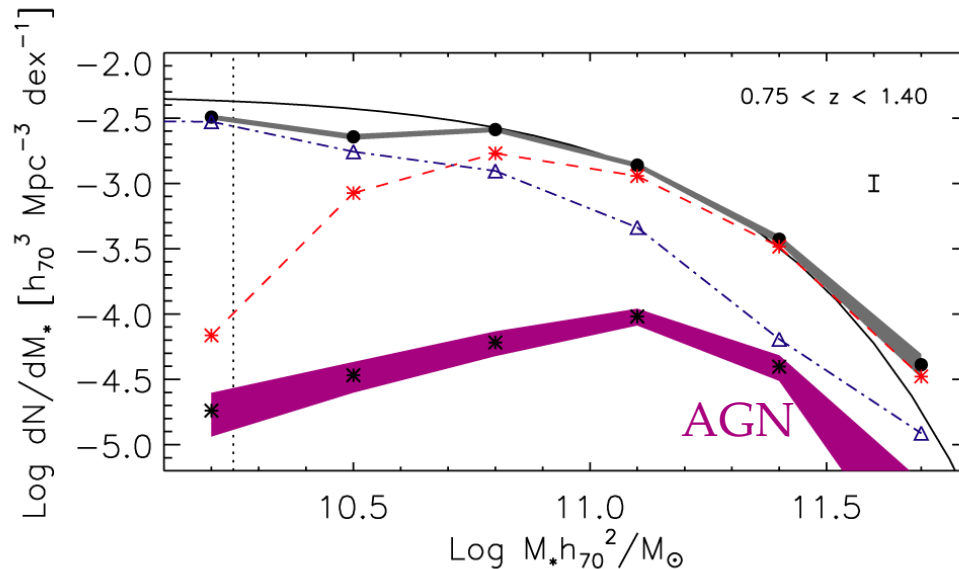
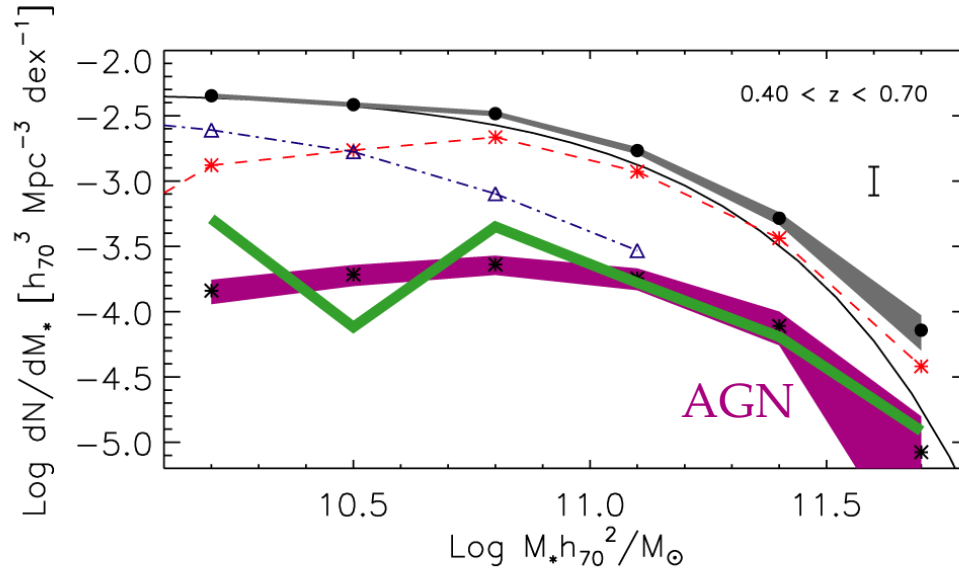
AGN Host Mass Functions

- EGS Only
- AGN host MF does not match red or blue galaxies.
- Hint of downward evolving peak



AGN Host Mass Functions

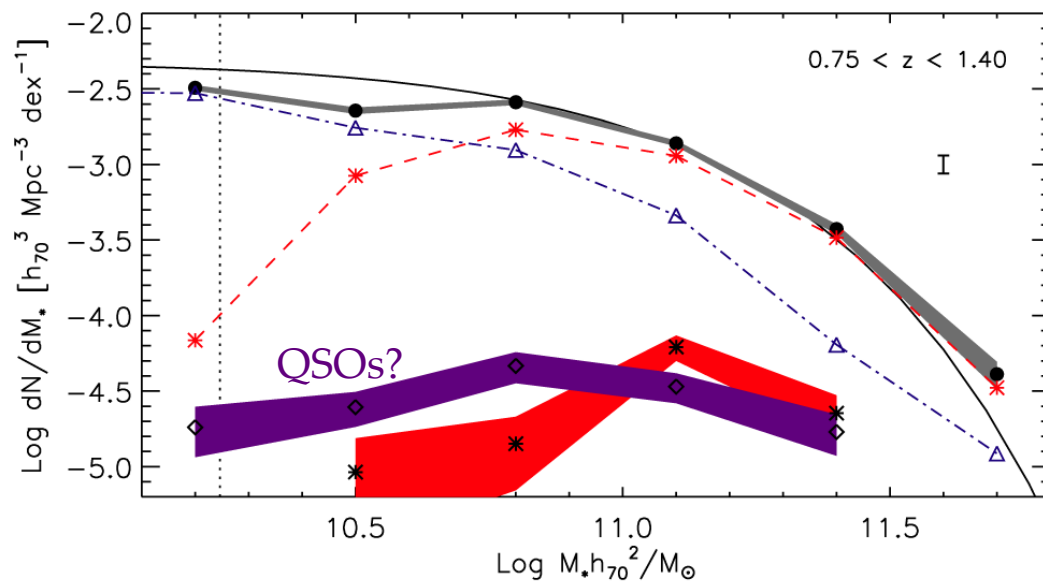
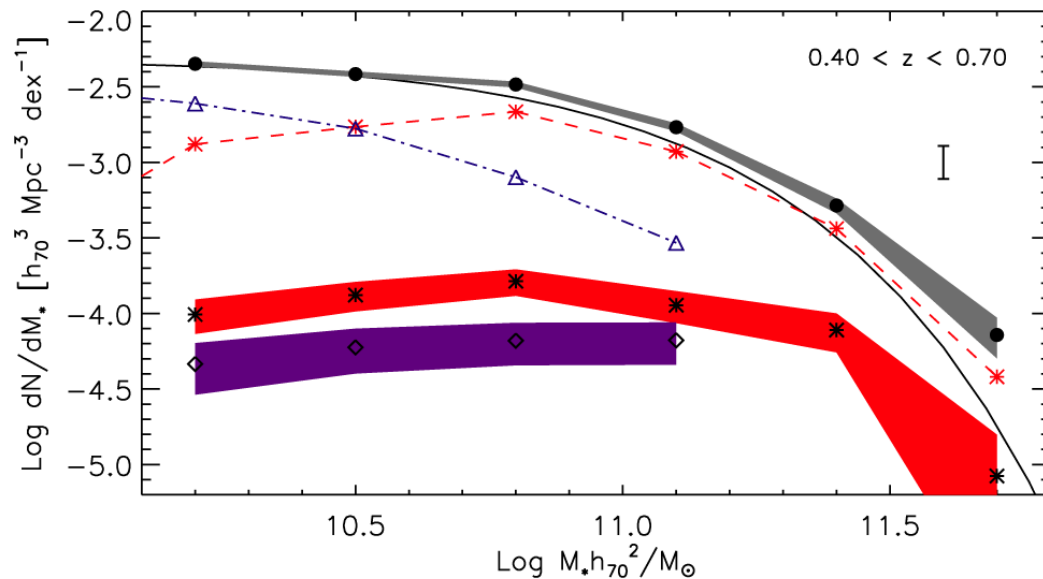
- EGS Only
- AGN host MF does not match red or blue galaxies.
- Hint of downward evolving peak
- Low- z AGN matches *differential* evolution (recently quenched systems)



Evidence for a Link

- X-ray luminous AGN are revealed in newly quenched systems over some timescale (\sim few Gyr). Consistent with AGN triggering or at least being tied to quenching.
- AGN hosts should be red and early-type
 - e.g., Nandra et al. 2006, Pierce et al. 2006, Grogin et al. 2005, Kauffmann et al. 2003

- X-ray system
- AGN
- AGN
- e.g., N



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g.

nn et al. 2003

Summary & Conclusions

- The shape of the AGN host mass function differs from the red or blue populations.
- It is consistent with the inferred mass function of newly quenched systems, circumstantial evidence of an AGN/quenching link.
- The color AGN mass function is dominated by red systems, as expected.
- Observations are consistent with a picture in which X-ray selected AGN are revealed during the quenching process.

