Connecting AGN and the Transition to the Red Sequence

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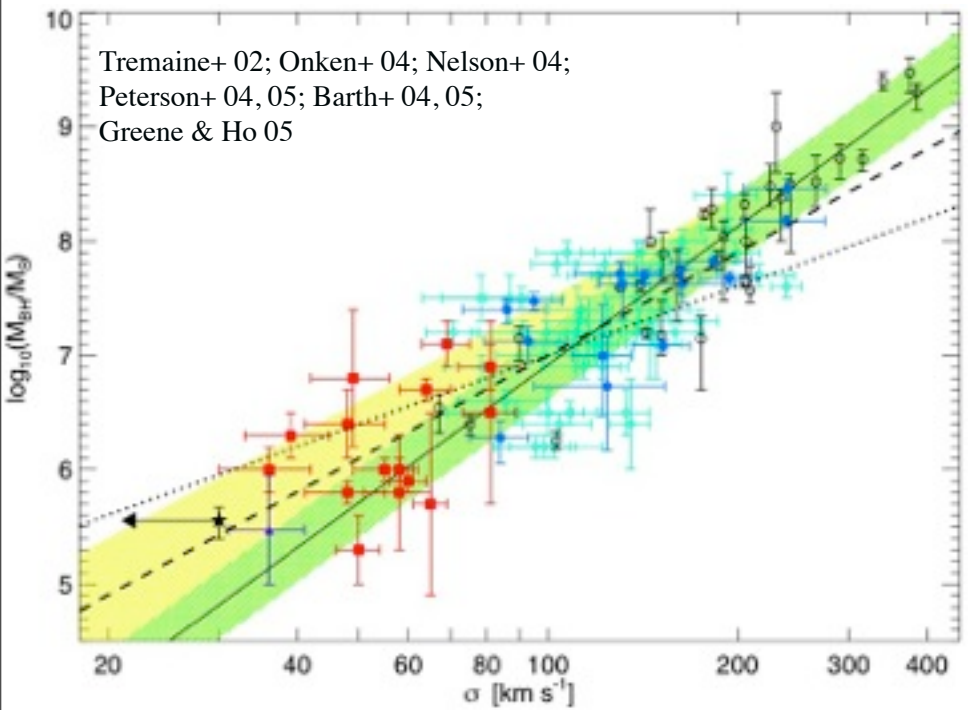
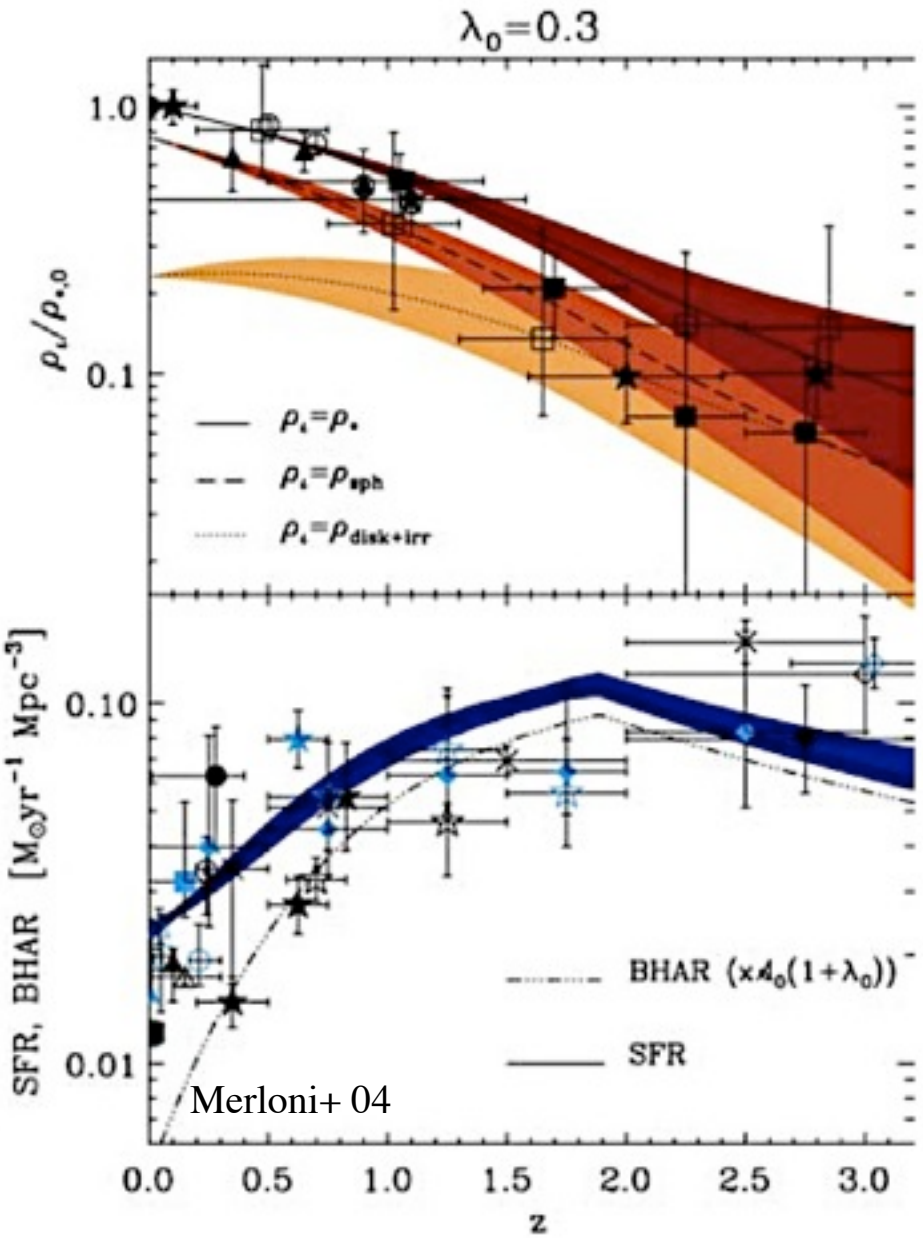
(Di Matteo, Springel, & Hernquist 2005)

Motivation

QUASARS AND SPHEROID FORMATION





Motivation

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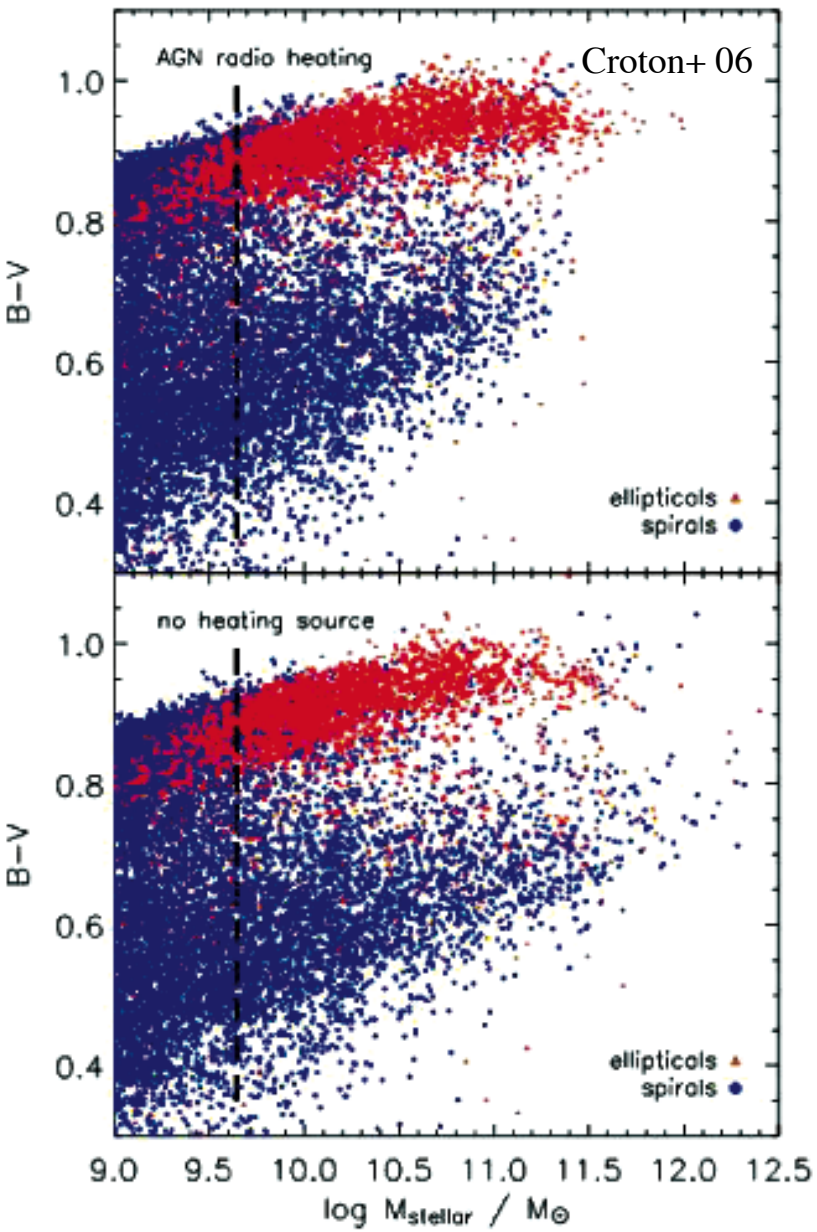
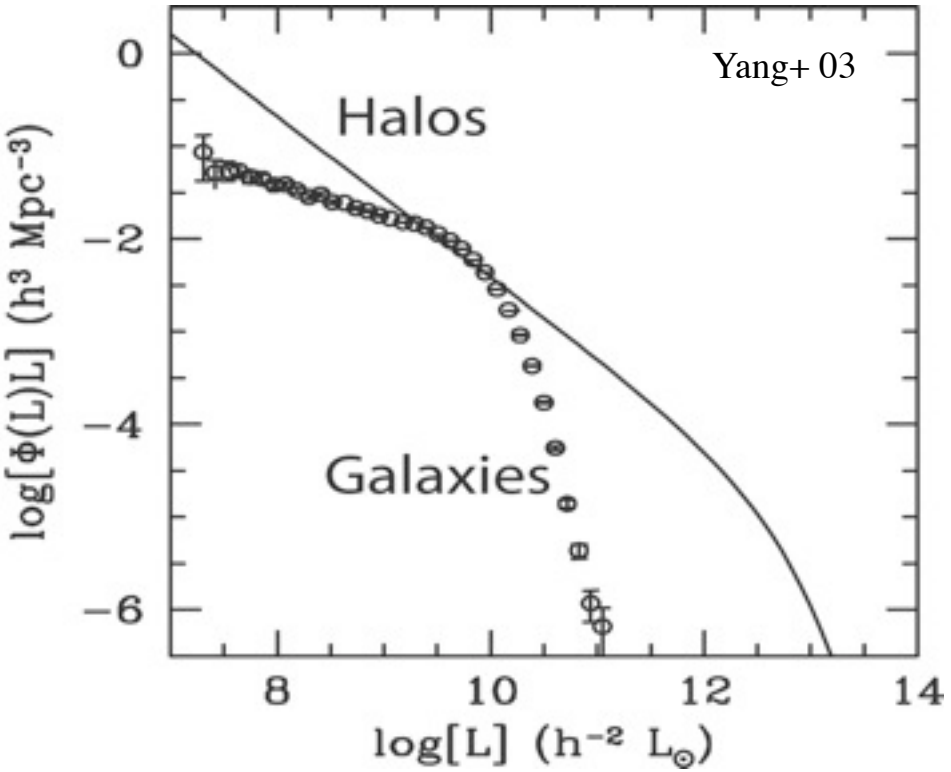
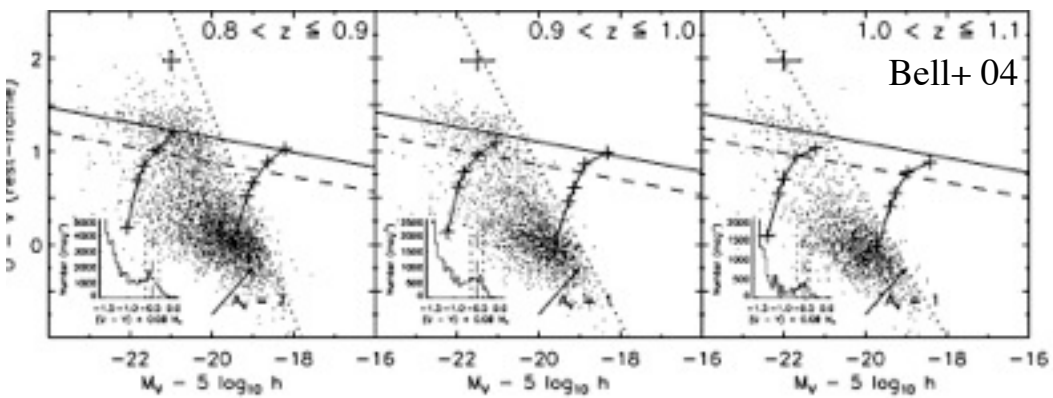


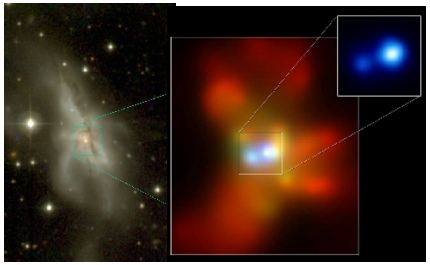




(c) Interaction/"Merger"

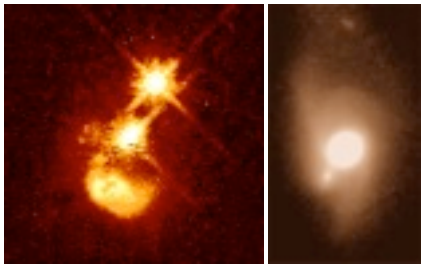
- now within one halo, galaxies interact & lose angular momentum
- SFR starts to increase
- stellar winds dominate feedback
- rarely excite QSOs (only special orbits)

(d) Coalescence/(U)LIRG



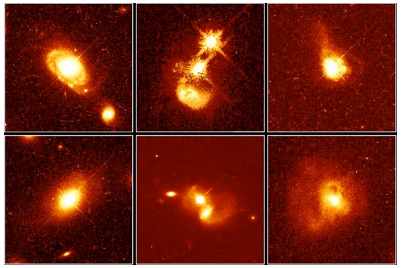
- galaxies coalesce: violent relaxation in core
- gas inflows to center: starburst & buried (X-ray) AGN
- starburst dominates luminosity/feedback, but, total stellar mass formed is small

(e) "Blowout"



- BH grows rapidly: briefly dominates luminosity/feedback
- remaining dust/gas expelled
- get reddened (but not Type II) QSO: recent/ongoing SF in host, high Eddington ratios, merger signatures still visible

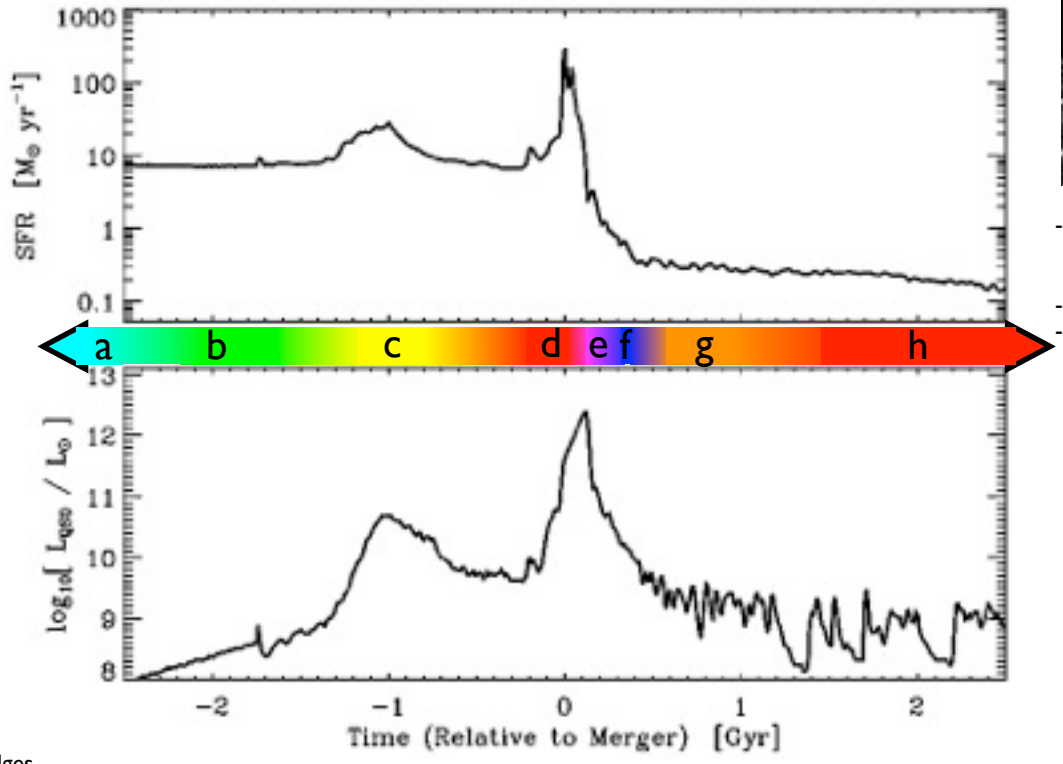
(f) Quasar



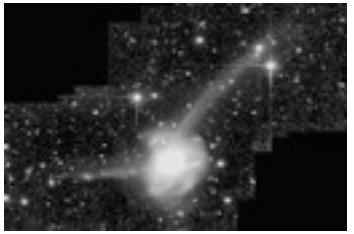
- dust removed: now a "traditional" QSO
- host morphology difficult to observe: tidal features fade rapidly
- characteristically blue/young spheroid

(b) "Small Group"

- halo accretes similar-mass companion(s)
- can occur over a wide mass range
- M_{halo} still similar to before: dynamical friction merges the subhalos efficiently

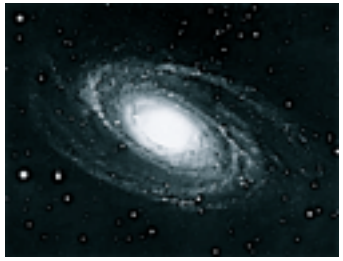


(g) Decay/K+A



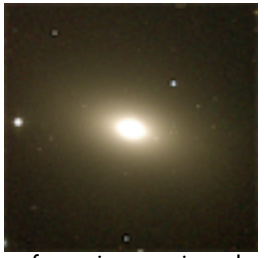
- QSO luminosity fades rapidly
  - tidal features visible only with very deep observations
- remnant reddens rapidly (E+A/K+A)
- "hot halo" from feedback
  - sets up quasi-static cooling

(a) Isolated Disk

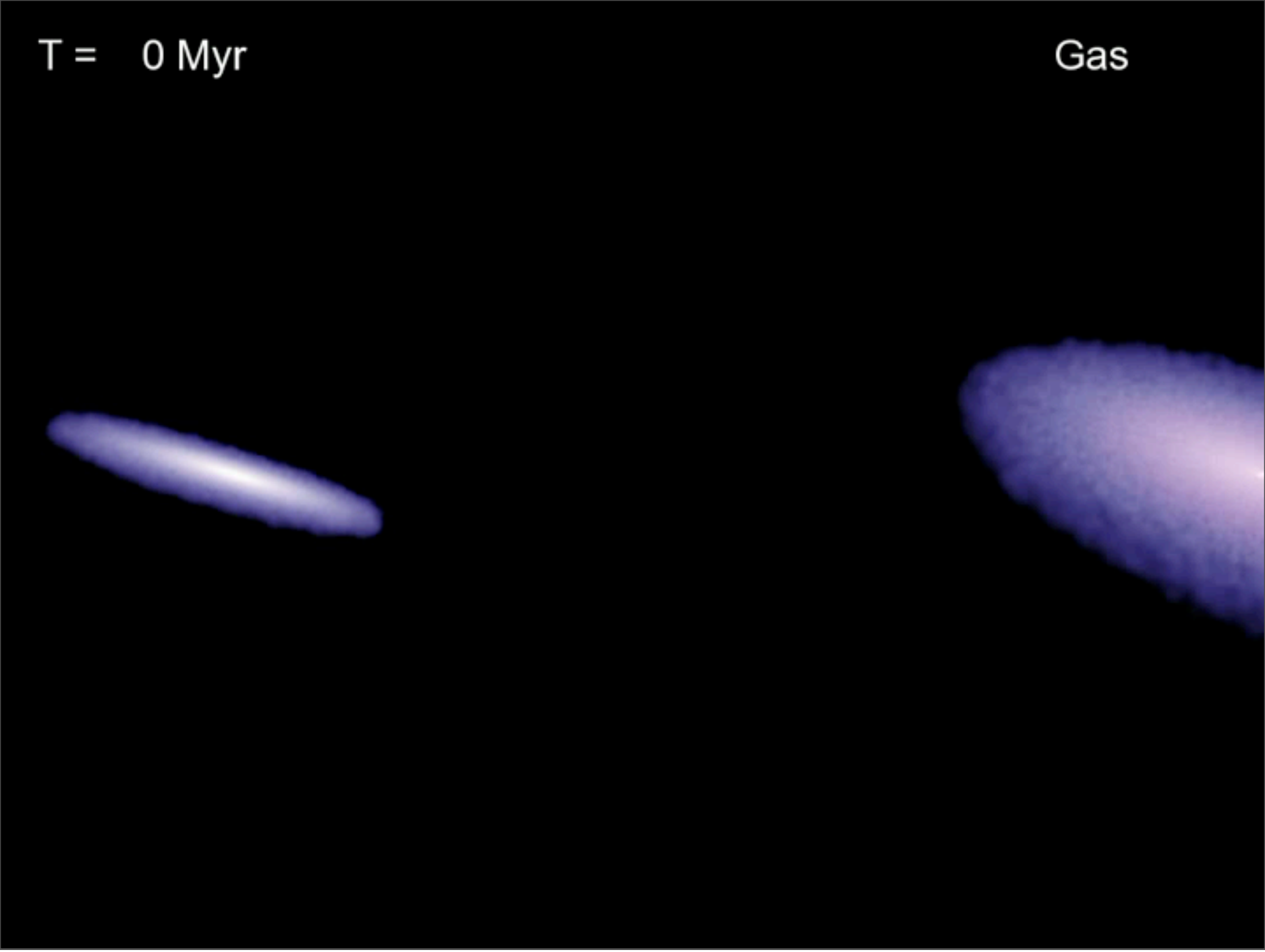


- halo & disk grow, most stars formed
- secular growth builds bars & pseudobulges
- "Seyfert" fueling (AGN with M_B>-23)
- cannot redden to the red sequence

(h) "Dead" Elliptical

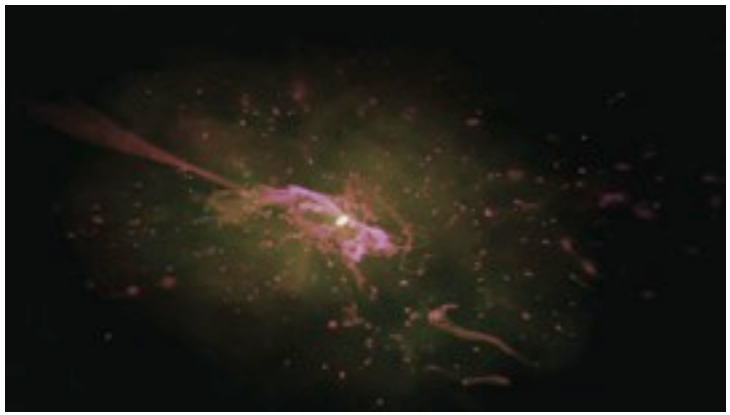


- star formation terminated
- large BH/spheroid - efficient feedback
- halo grows to "large group" scales: mergers become inefficient
- growth by "dry" mergers

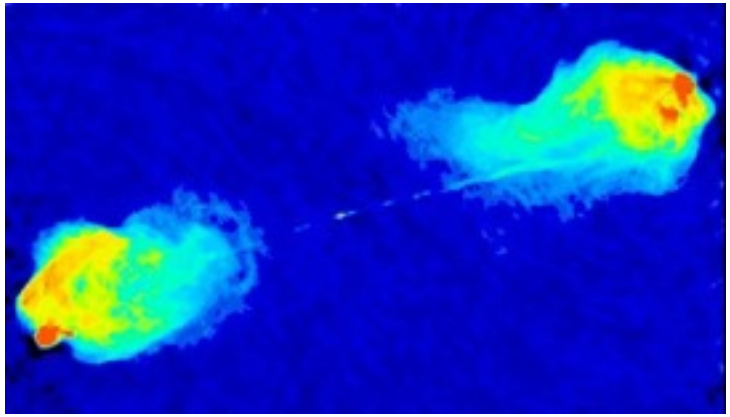

T = 0 Myr
Gas

“Transition” and “Maintenance”

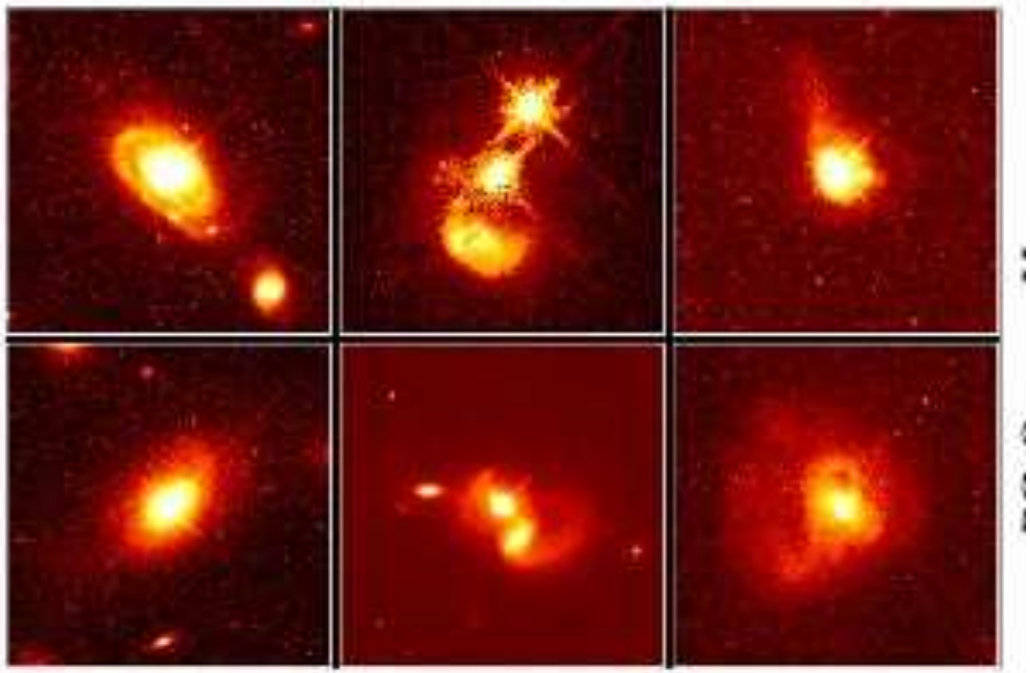
- Move mass from Blue to Red
- Rapid
- Small scales
- “Quasar” mode (high mdot)
- Morphological Transformation
- Gas-rich/Dissipational Mergers



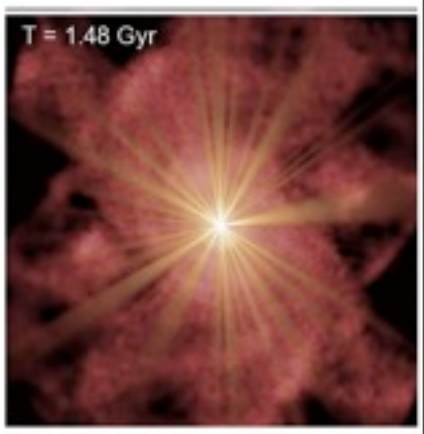
- Keep it Red
- Long-lived (~Hubble time)
- Large (~halo) scales
- “Radio” mode (low mdot)
- Subtle morphological change
- “Dry”/Dissipationless Mergers



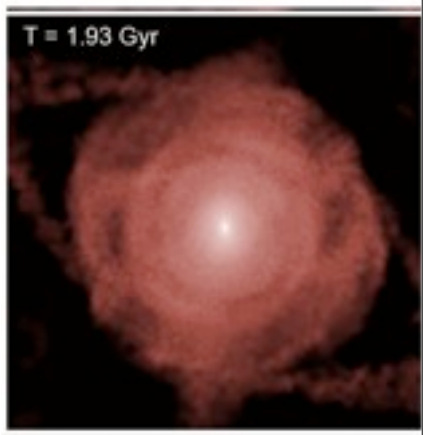
AGN Host Galaxy Morphologies



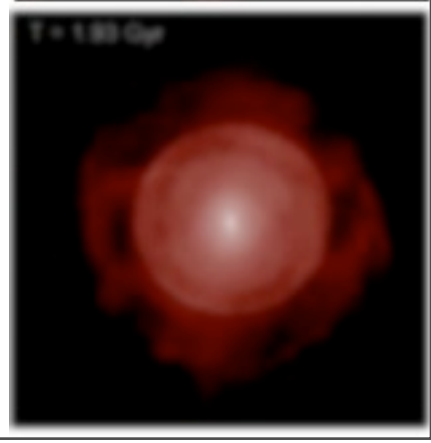
Bahcall et al.



QSO = 1000xHost



QSO = Host

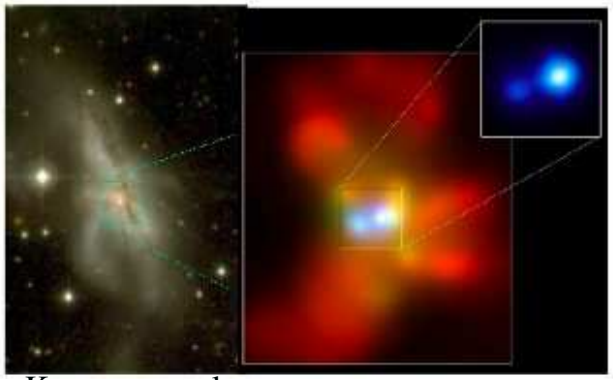


QSO = 0.1xHost

- Most “obvious” probe
  - Careful! Rapid fading, relaxation
  - Automated classifiers bad at *late stage* mergers
  - Want appropriate non-quasar comparison samples

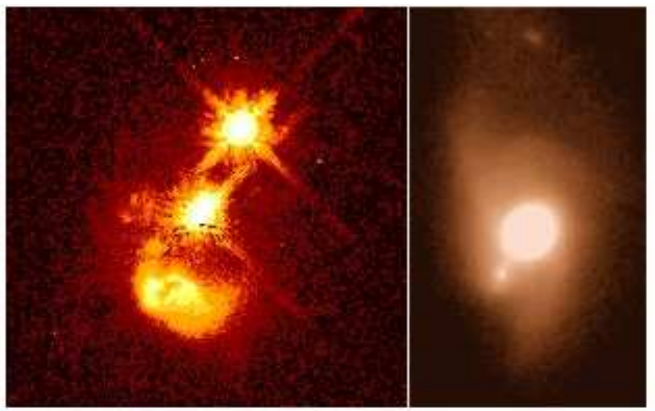
AGN Host Galaxy Morphologies

- "Secular" fueling: low M_BH in disks



Komossa et al.

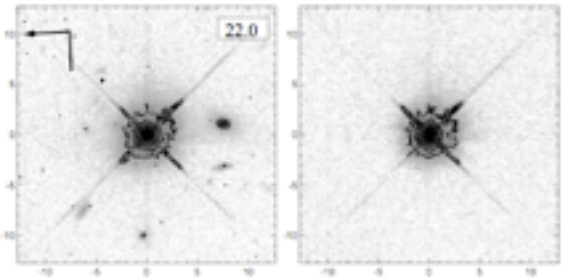
- "Buried" X-ray sources in SF-dominated ULIRGs/HLIRGs



Bahcall et al., Sanders et al.

- IR-luminous quasars in final/violent stages of mergers

Floyd et al.

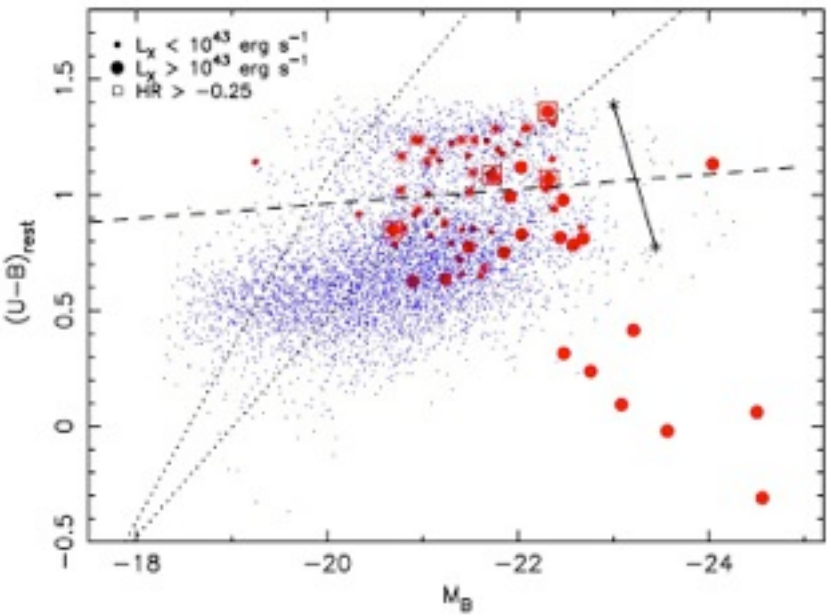


- More relaxed "traditional" optical quasars: PG-analogues

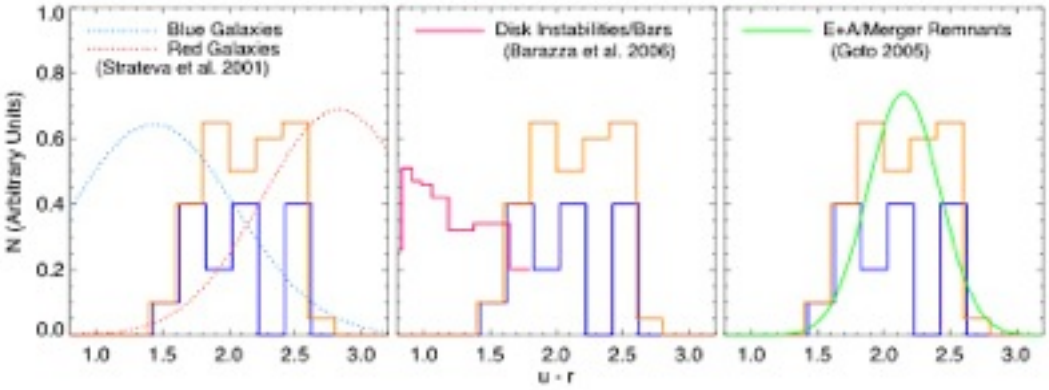
- Faint X-ray sources in "dead" hosts

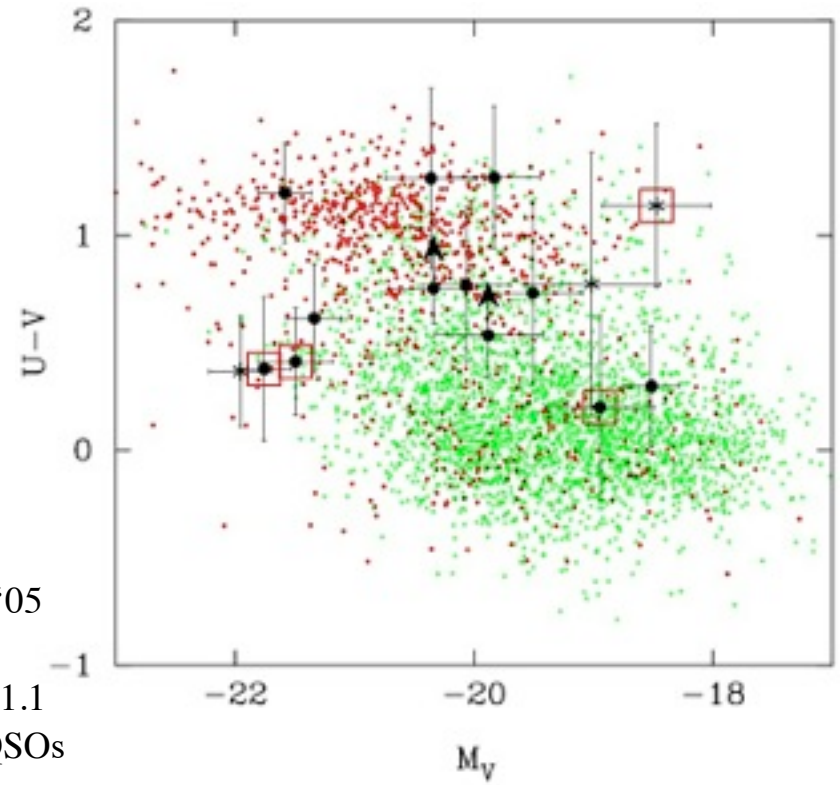
Host Colors

HOW DOES AGN ACTIVITY RELATE TO “TRANSITION”



Nandra+ ‘06
AEGIS
0.7 < z < 1.4
X-ray QSOs

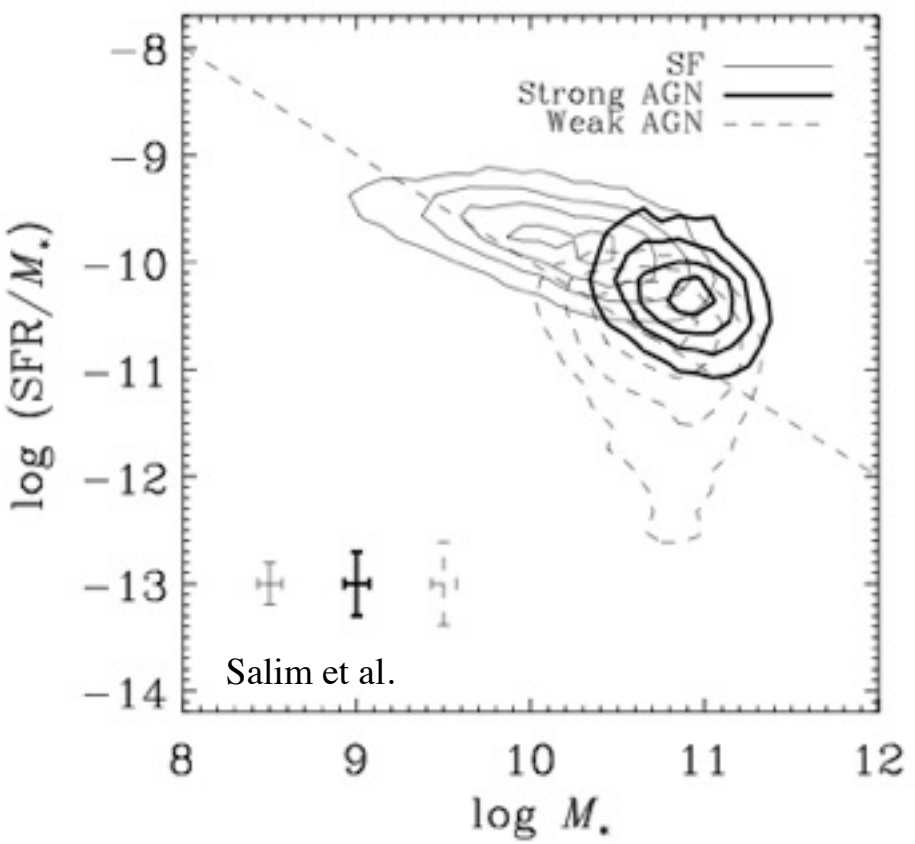




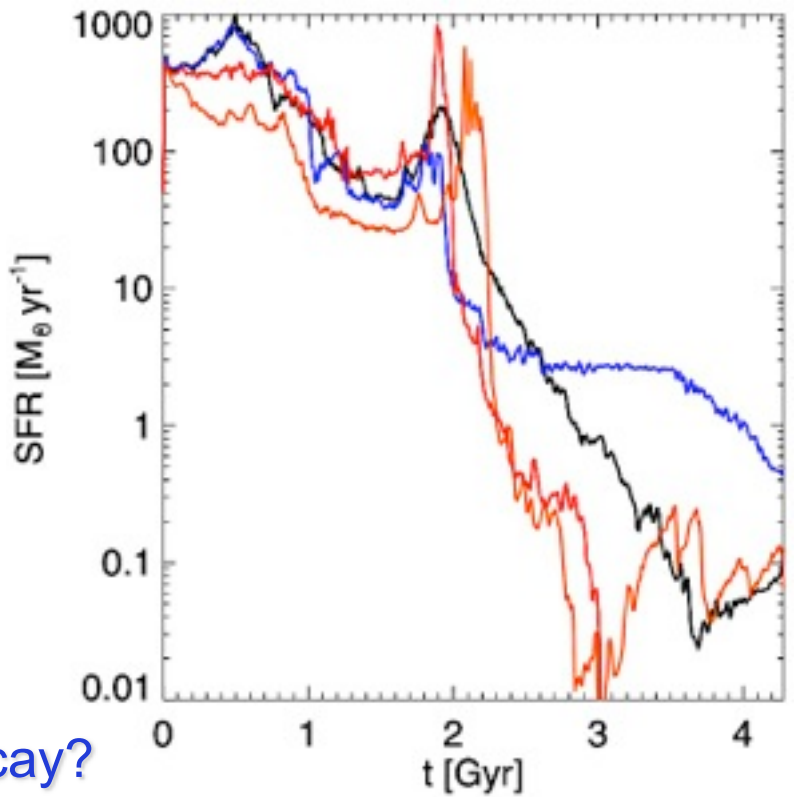
Sanchez+ ‘05
GEMS
0.5 < z < 1.1
Optical QSOs

Host Colors

DIRECTIONALITY & STAR FORMATION HISTORIES OF AGN



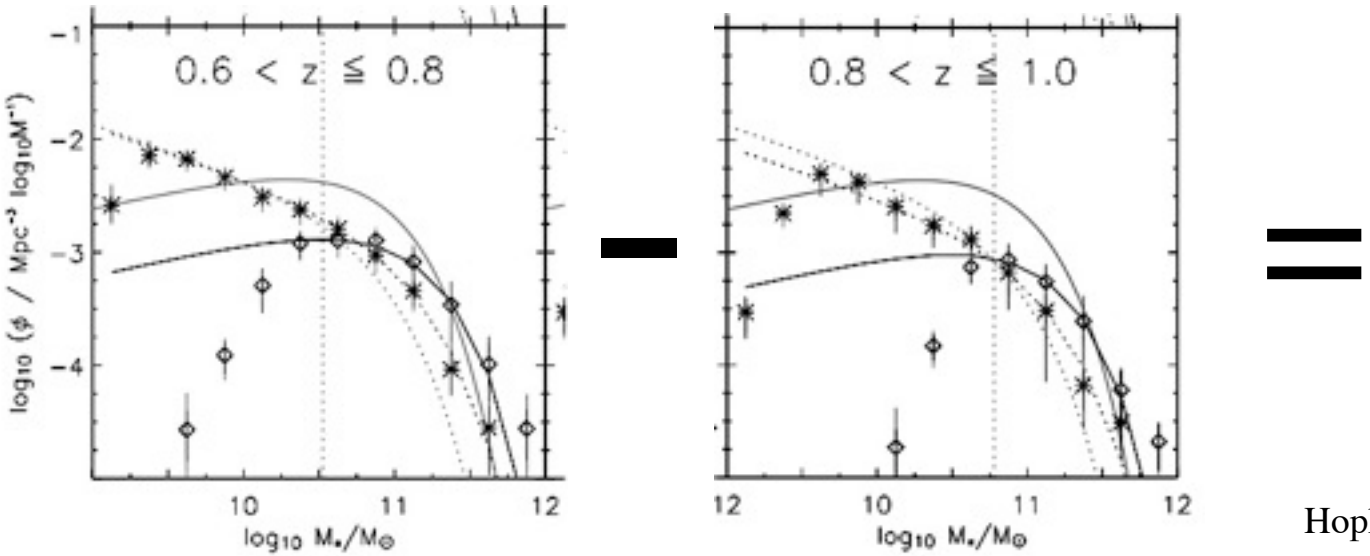
- Local AGN appear to be associated with quenching -- how does this apply to higher-redshift, more gas-rich galaxies?



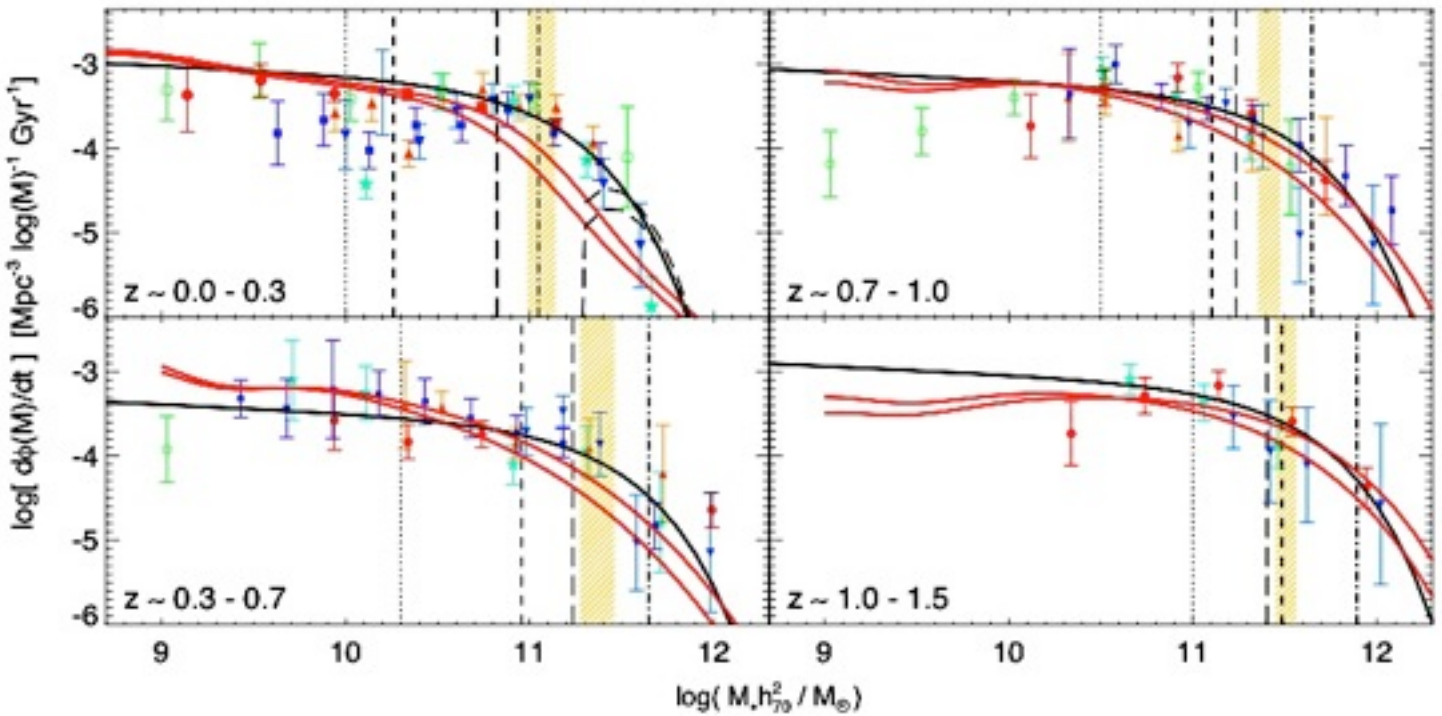
- Quasars appear to be post-starburst (e.g. Jahnke et al.)::
  - Post-starburst or just post-disk?
  - How do accretion & SF co-evolve/decay?

AGN LF versus Red Sequence "Buildup"

TEST STATISTICS OF QUASAR, RED GALAXY, & AGN POPULATIONS



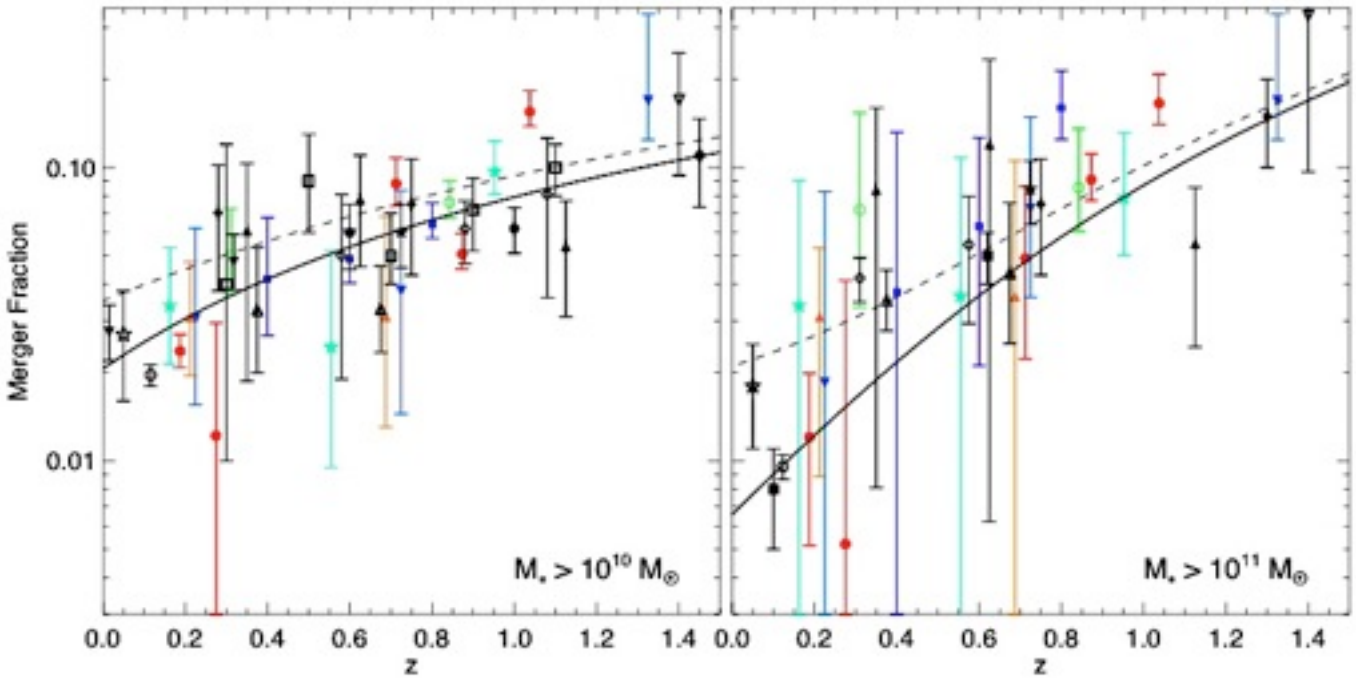
Hopkins, Bundy, Hernquist+ 06



Borch+06;
Bundy+06;
Fontana+04,06;
Pannella+06;
Franceschini+06

AGN LF versus Red Sequence "Buildup"

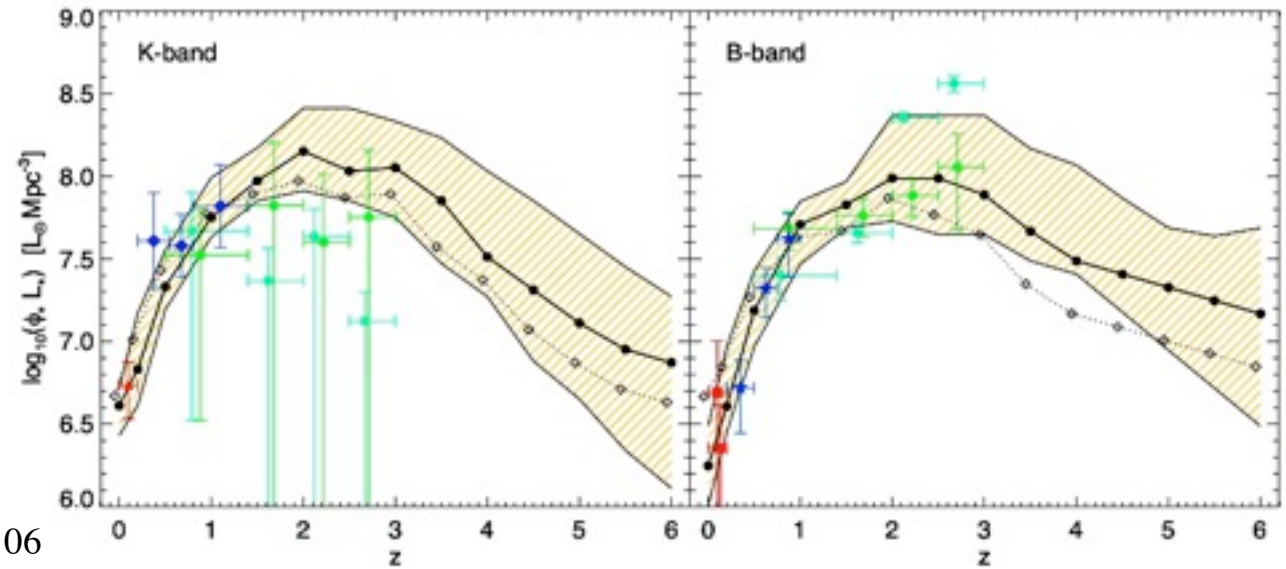
TEST STATISTICS OF QUASAR, RED GALAXY, & AGN POPULATIONS



Bell+06; Lotz+06; Lin+04; Patton+02; Conselice+03; Kartaltepe+07

Xu+;Wolf+;Brinchmann & Ellis; Conselice+; Hamilton+; Bundy+

Hopkins, Bundy+ 06

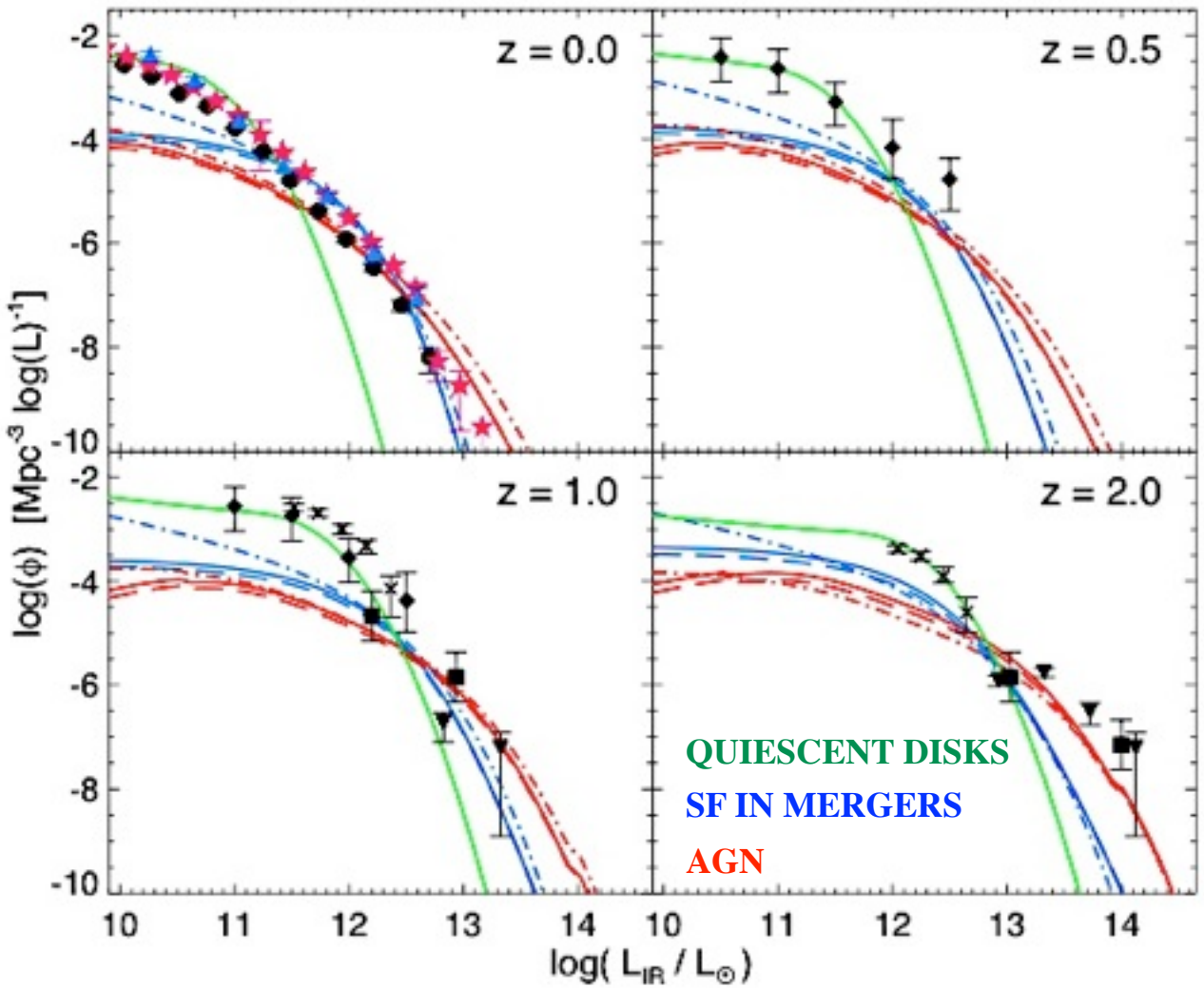


Hopkins, Somerville+ 06

IR LF versus Red Sequence "Buildup"

TEST STATISTICS OF QUASAR, IR, & AGN POPULATIONS

Sanders+; Soifer+; Perez-Gonzalez+; Chapman+; Le Floch+; Babbedge+

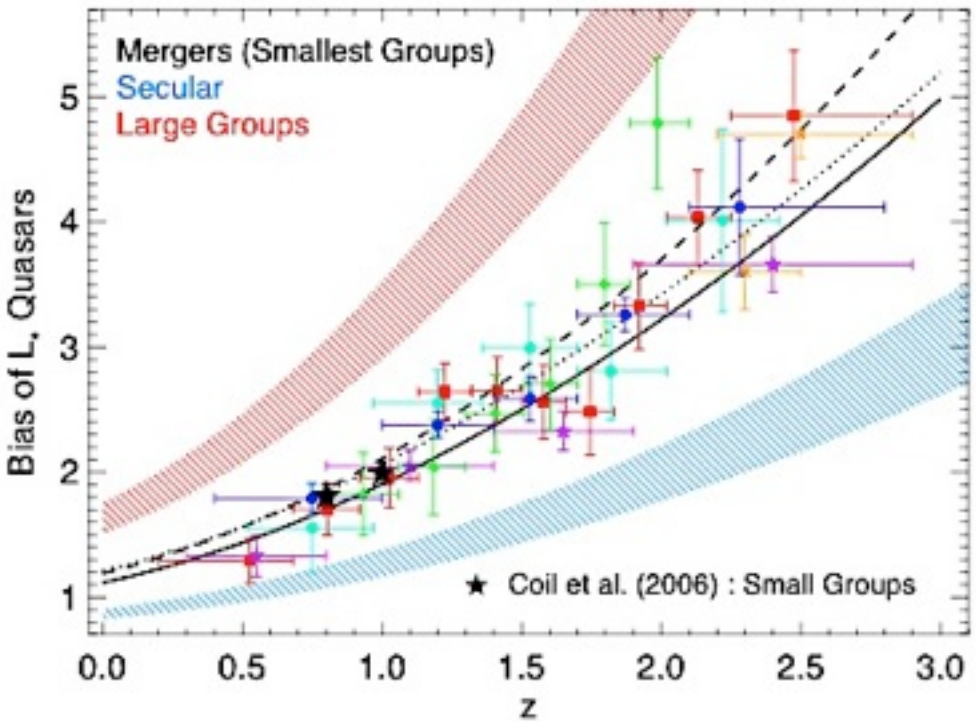


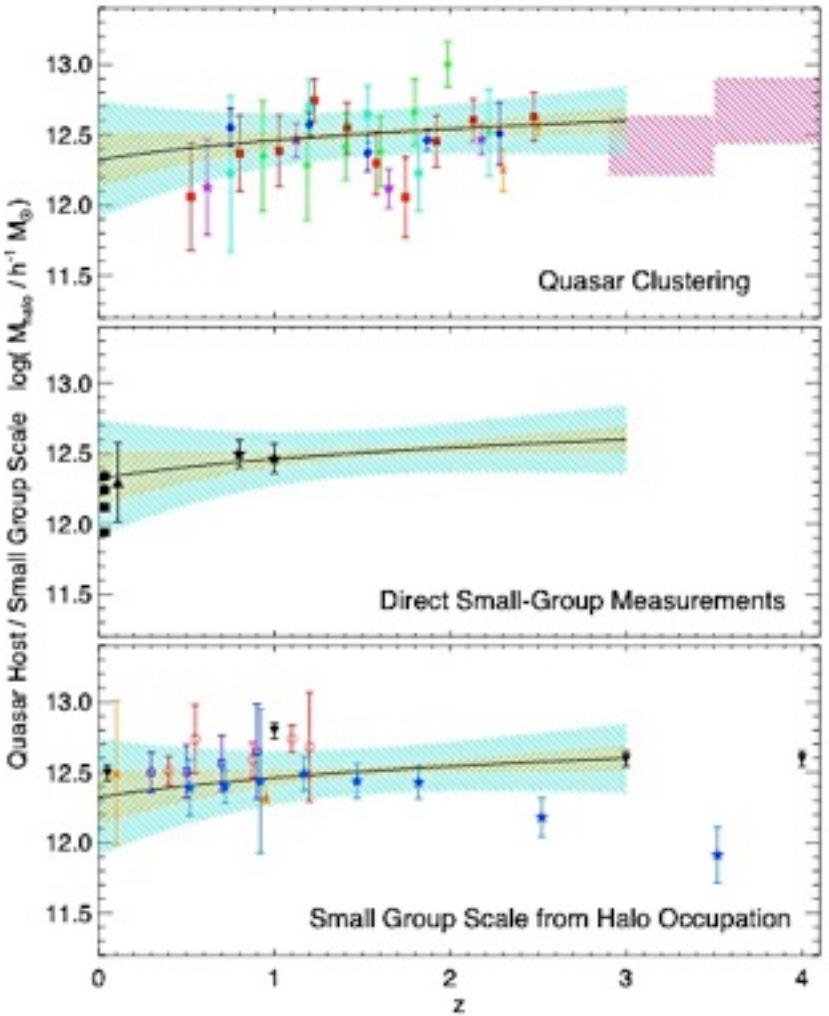
- How do AGN contribute to IR populations / how is that related to mergers/spheroid buildup?

Quasar/AGN Clustering

GLOBALLY

Hopkins, Hernquist, Keres, & Cox

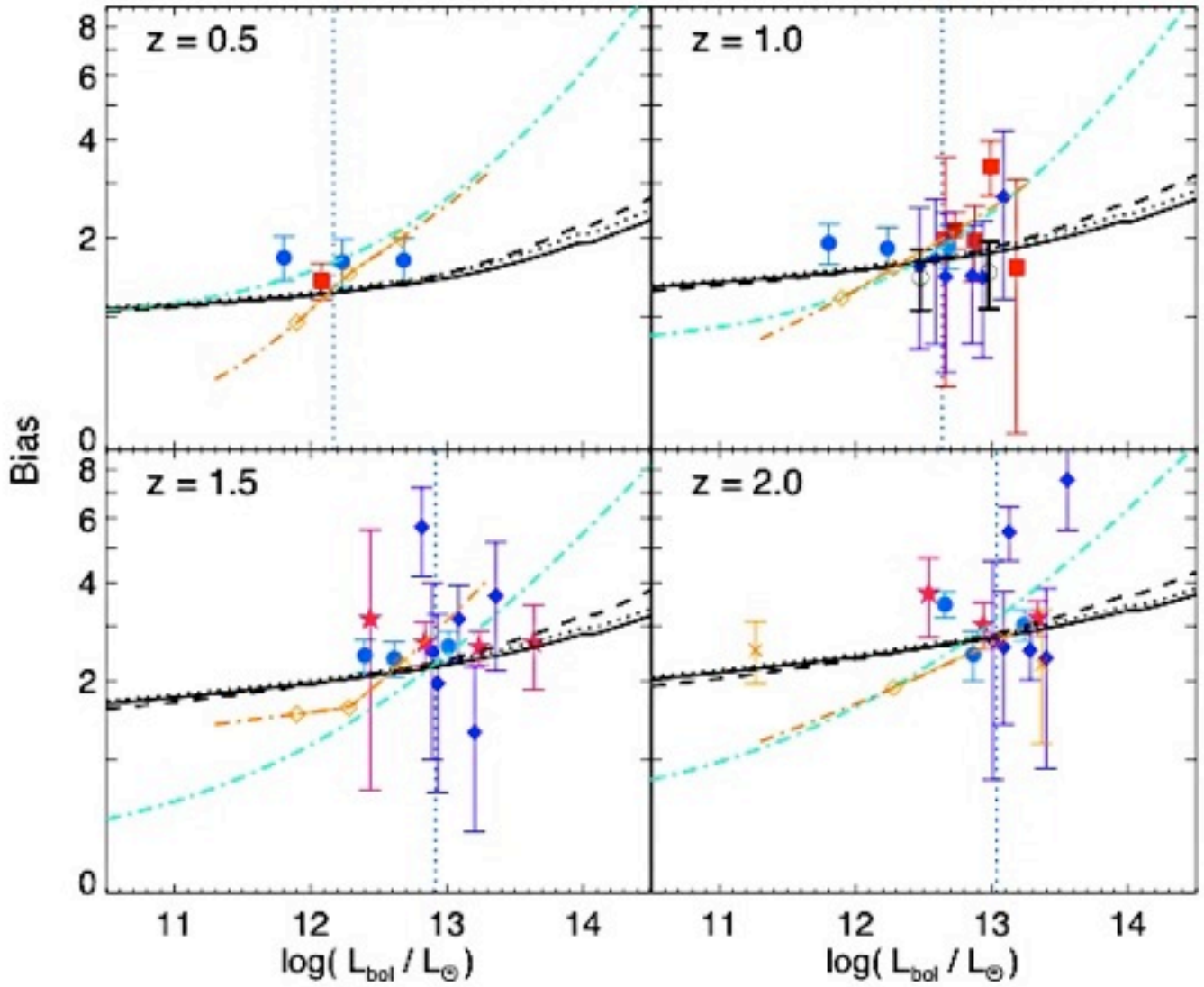




- Do AGN cluster like star-forming galaxies, small groups, or large groups/clusters?
- How does it depend on AGN selection?

Clustering

VERSUS LUMINOSITY

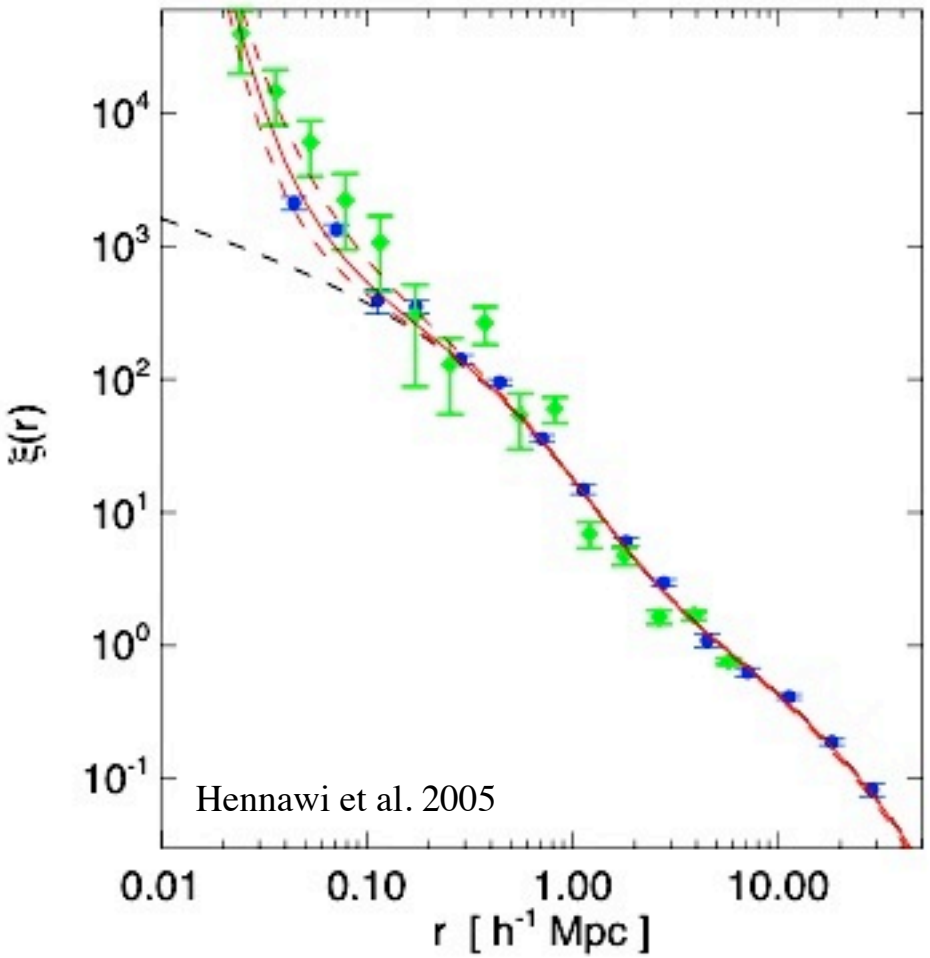


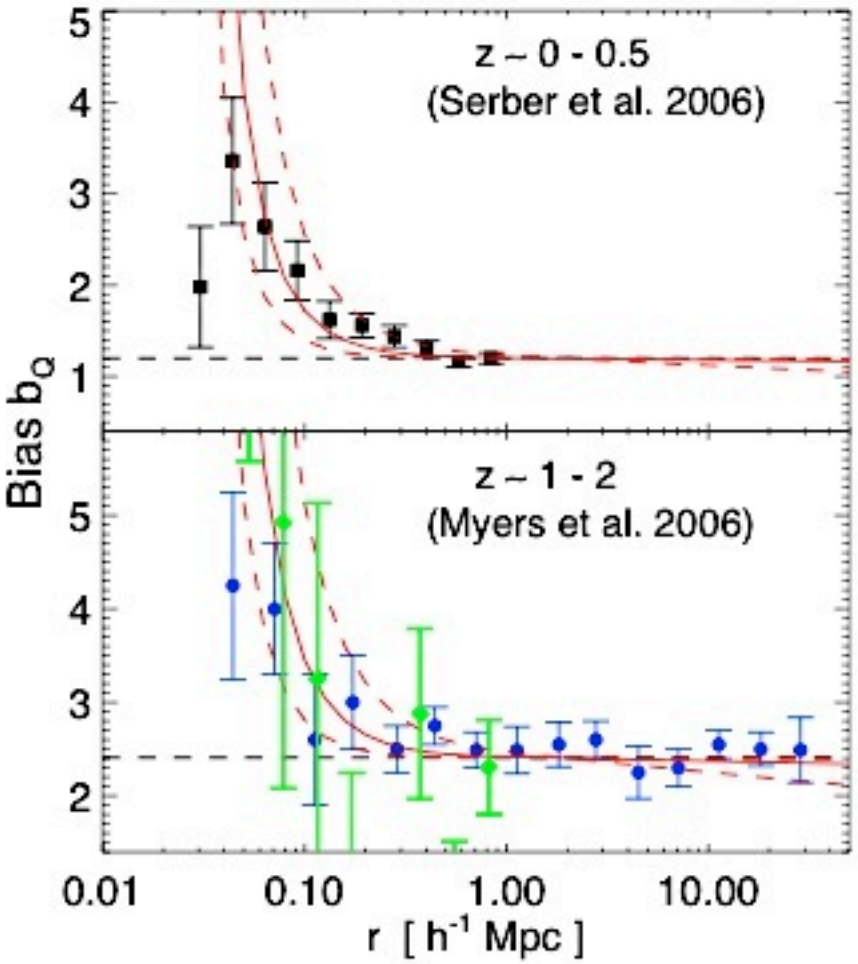
- Luminosity Dependence:
  - Strong constraints on quasar lightcurves/evolution
  - Probe different fueling mechanisms at very different L

Lidz et al.
Hopkins, Lidz et al.

Clustering

ON SMALL SCALES

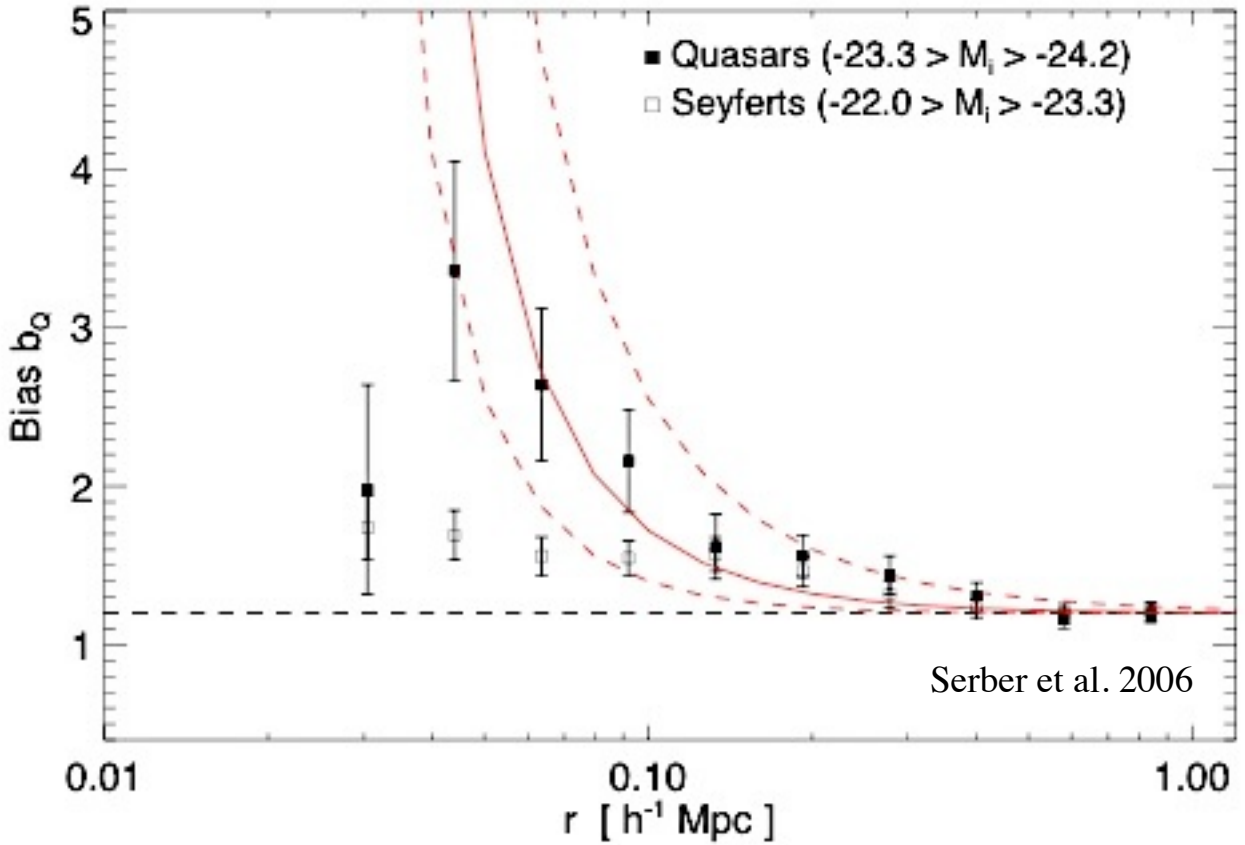




- Quasars appear to live in local overdensities
  - Enhanced merger rates/3-body interactions/pairs
  - Difficult to explain in secular/minor merger fueling models

Clustering

VERSUS SCALE AND LUMINOSITY



- Is there a transition in (dominant) fueling mechanisms near the Seyfert-Quasar divide?

Summary

- Variety of probes to test how quasars/AGN are triggered, and how they evolve in the transition to the red sequence
  - Multiwavelength surveys are critical
- Population is probably not monolithic
  - IR vs. X-ray vs. optical AGN
  - Low vs. high accretion rate
  - Low vs. high M_BH hosts (disk vs. bulge-dominated)
- Open questions:
  - Fueling
  - “Maintenance” : smooth mapping from quasar to “radio” modes?
  - How much work does the quasar/AGN do (correlation vs. causality)