Environmental Dependence of AGN activity in the present-day universe

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Why some galaxies have AGN?

- if most galaxies have a supermassive black hole at the center
  (Kormendy & Gebhardt 2001; Ferrarese & Ford 2005)
- how to trigger AGN activity (fuel supply to the center)?

Triggering AGN activity in different scales

- galaxy merging/interaction (Sanders et al. 1988; Hopkins et al. 2006)
- galaxy internal process (e.g. bar driven gas inflow: Combes 2003)
- local activity near BH
  (stellar wind: Ciotti & Ostriker 2007; turbulence; Wada 2004)

Are AGN host galaxies different?

1) Excess of bar or local density? (Combes 2003; Maia et al. 2003)
2) No difference in the fundamental plane relation
   (Bettoni et al. 2001; Barth et al. 2003; Woo et al. 2004, 2005)
3) Molecular gas & young stellar population in early-type AGN hosts
   (Scoville et al. 2003; Tadhunter et al. 2005)

Previous studies

- Before SDSS, limited to small sample (~several hundreds)
  (Ho et al. 1997; Hunt & Malkan 2004)
- With SDSS, studies with a large sample available
  (Kauffmann et al. 2003; Heckman et al. 2004; Schawinski et al. 2007; Graves et al. 2007)

Dependence of AGN activity on galaxy properties in the present-day universe

Collaborators: Yun-Young Choi (Sejong Univ.) &
Changbum Park (Korea Institute of Advanced Study)

By comparing AGN host galaxies with non-AGN galaxies

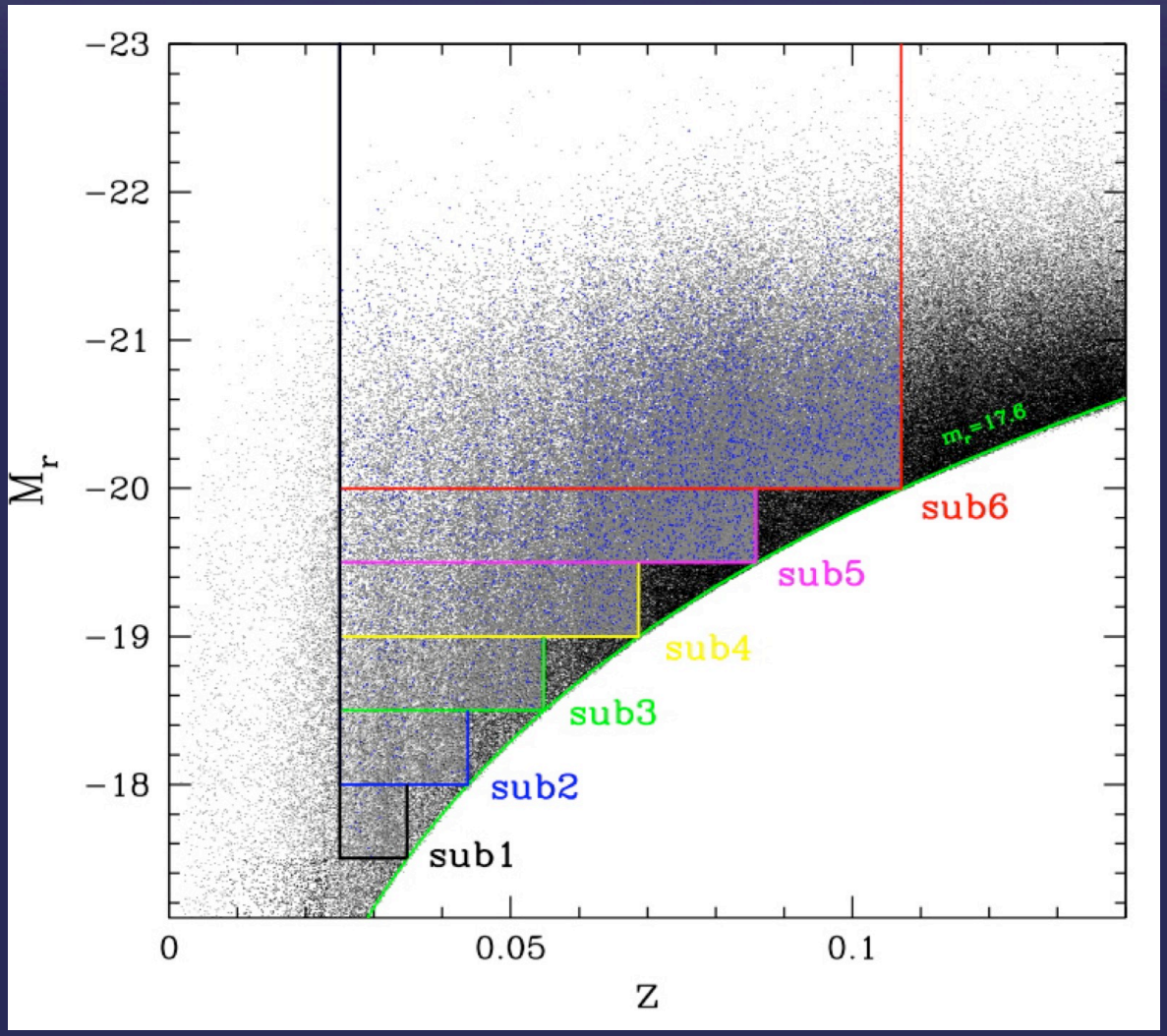
1) how the fraction of AGN changes
   fAGN = (# of AGN / # of all galaxies) at fixed galaxy property
2) how AGN power changes
   $P_{AGN} = L_{[OIII]} / M_{BH}$ (Eddington ratio indicator)

Sample Selection

Volume limited sample of 144,940 galaxies in the present-day universe ($z < 0.1$)

Using SDSS DR5.

Each subsample with different luminosity limit is corrected for the volume difference.

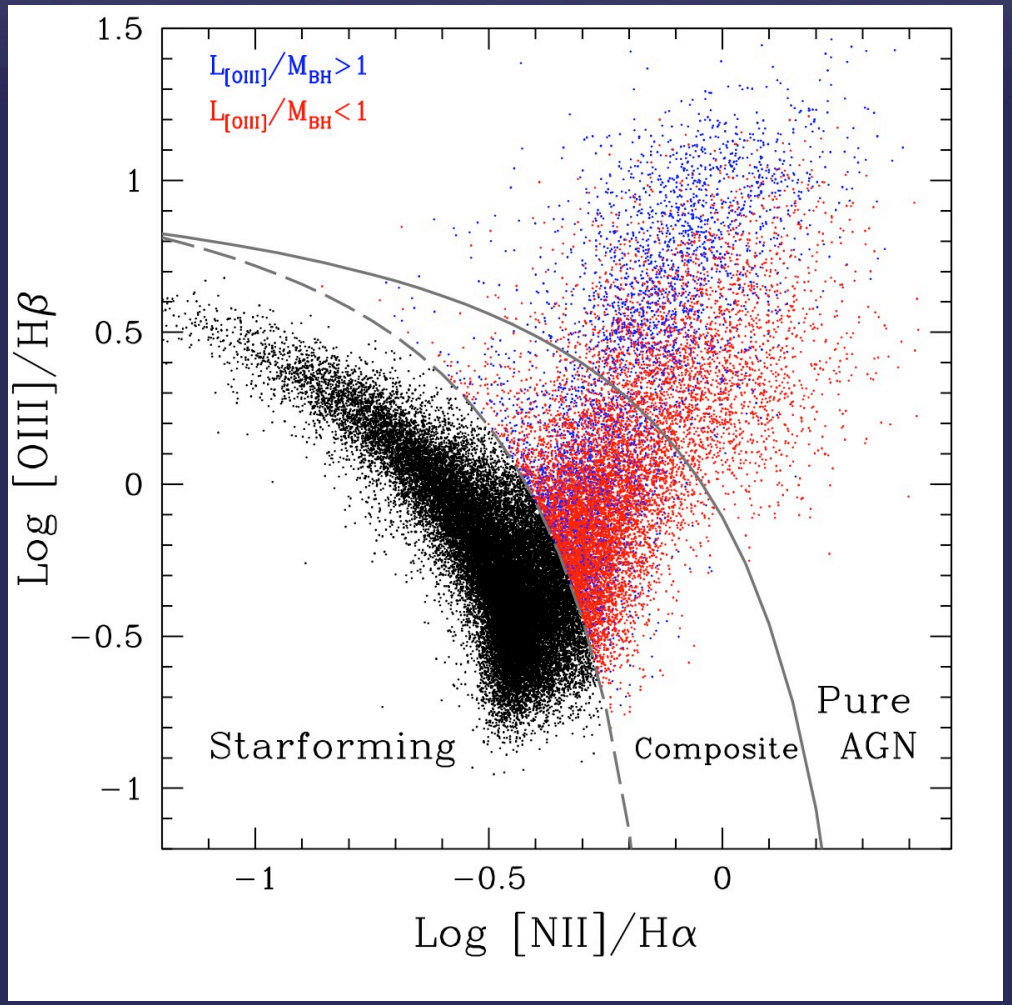


AGN Sample

Selecting Type II AGNs based on emission line ratios

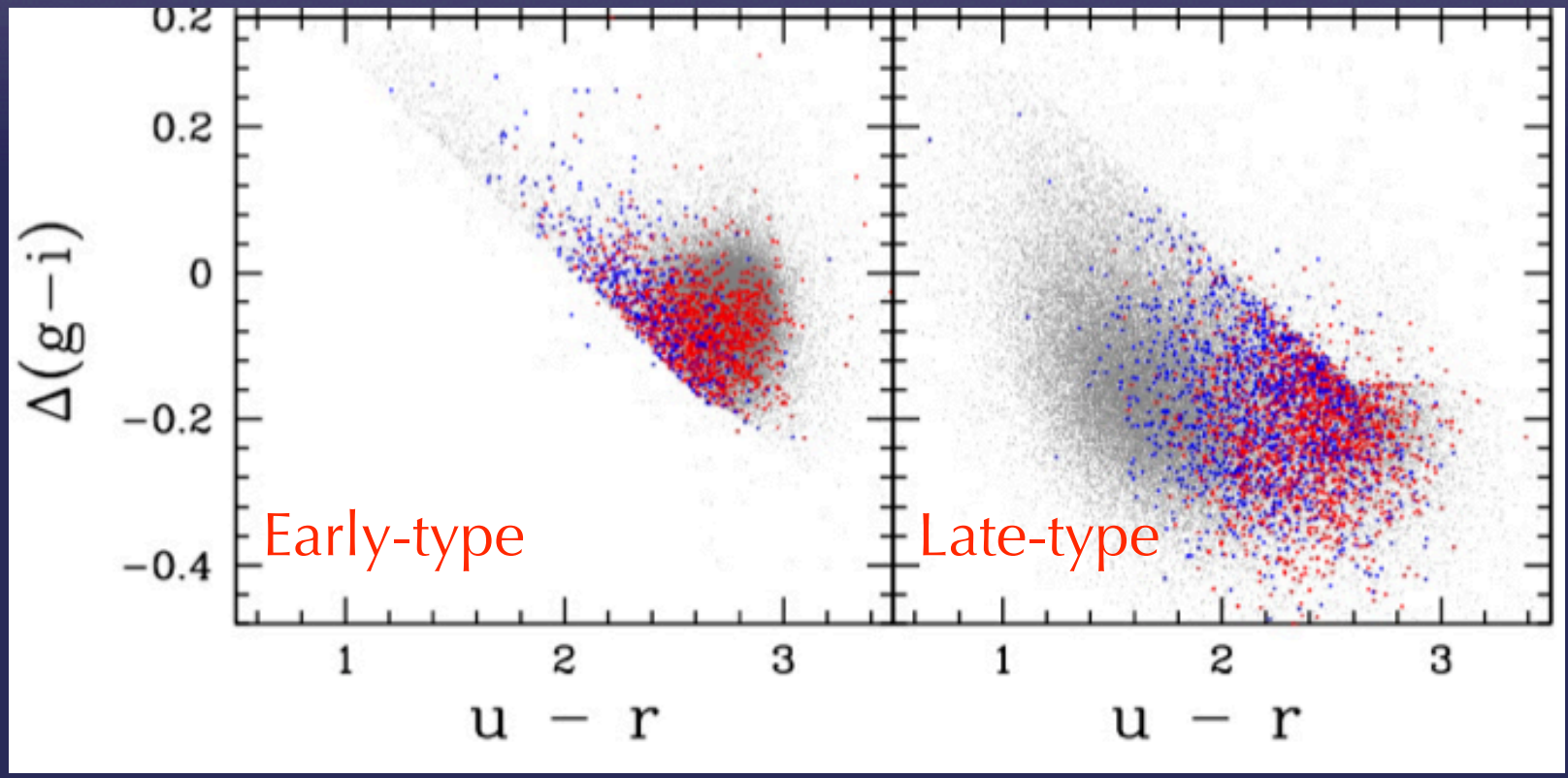
Among 46,520 emission-line galaxies (with S/N > 6),
pure AGN ~2,605
Composite objects ~ 8,913

Total AGN sample = 11,518
(AGN fraction ~8%, lower limit)



Morphology classification

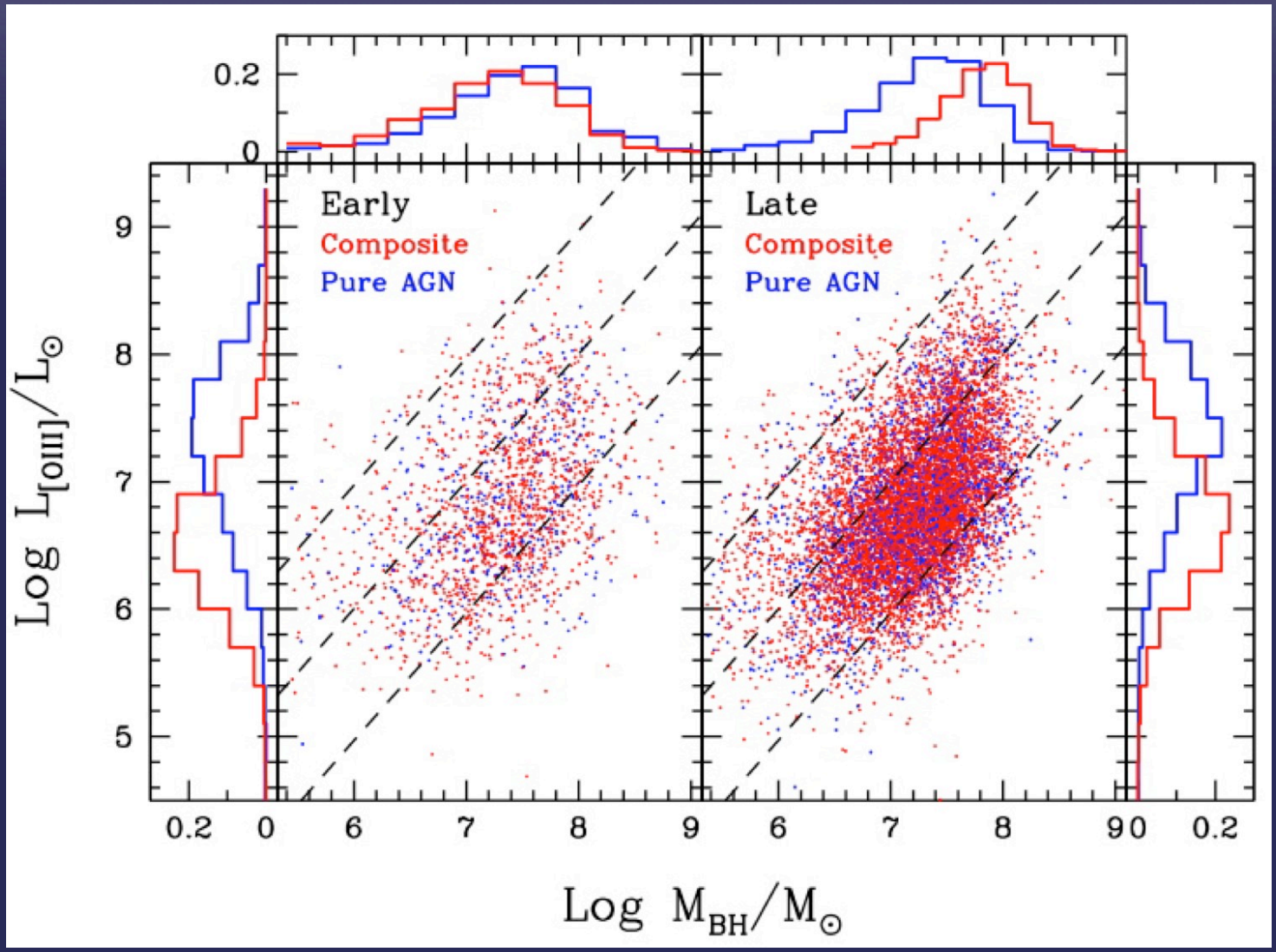
based on color and color gradient (see Park & Choi (2005) for details)



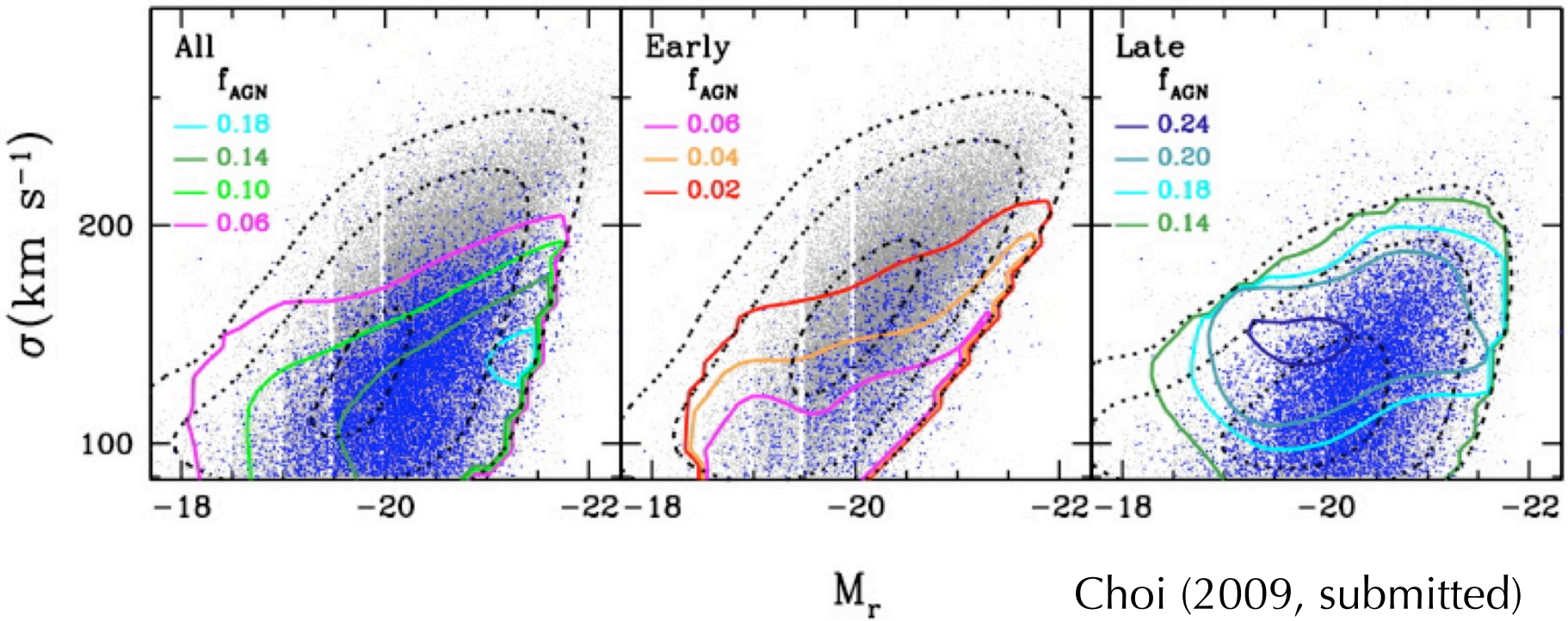
Total sample: 41% early-type vs. 59% late-type

AGN sample: 17% early-type vs. 83% late-type

AGN properties



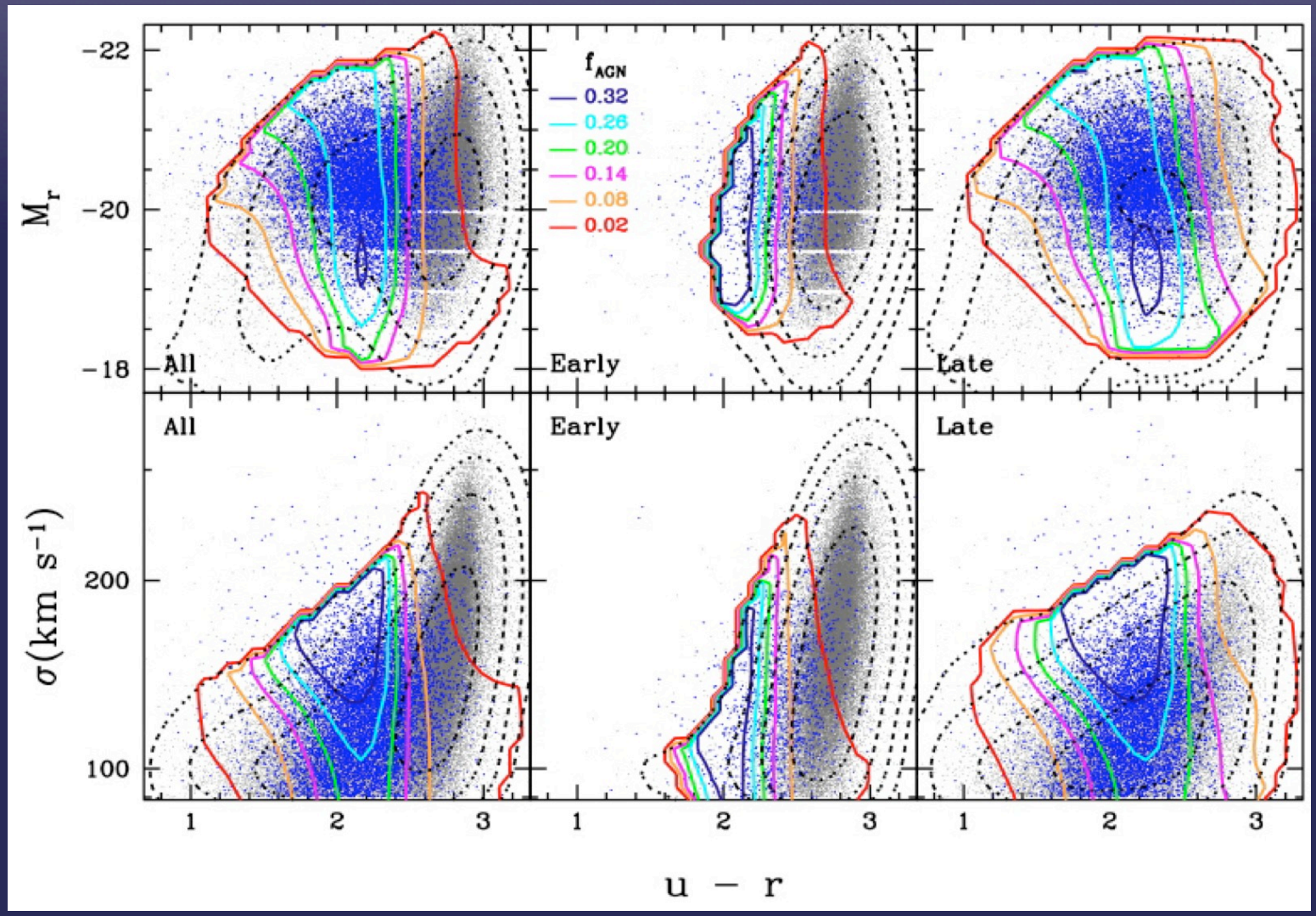
f_{AGN} dependency on luminosity & velocity dispersion



Choi (2009, submitted)

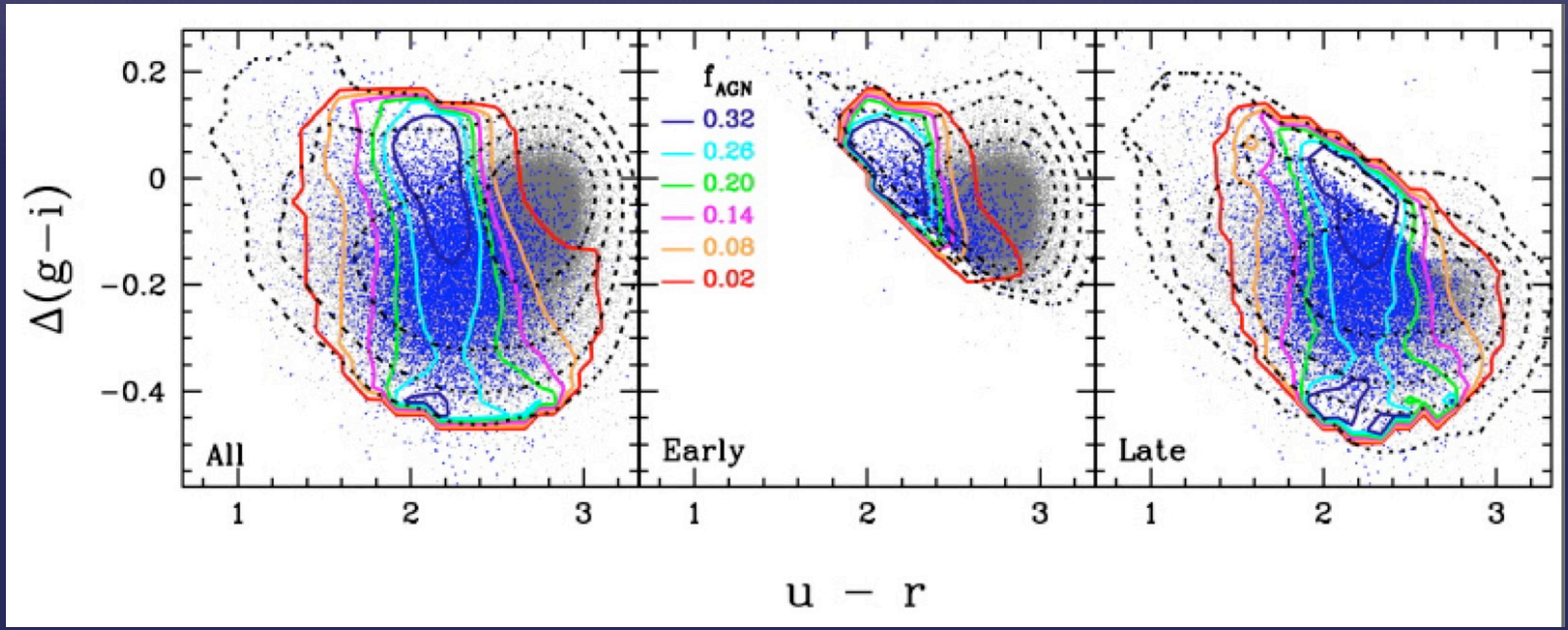
- f_{AGN} increases with luminosity
  More luminous galaxies are more likely to host AGN
- f_{AGN} in early-types decreases with velocity dispersion
  More massive galaxies are harder to host AGN
- f_{AGN} in late-type peaks at intermediate velocity dispersion (~130km/s)

f_{AGN} dependency on u-r color



- f_{AGN} peaks at intermediate color (e.g. Nandra et al. 2007, Schawinsky et al. 2007)
  AGN activity is related with recent star formation in early-type galaxies

f_{AGN} dependency on color gradient

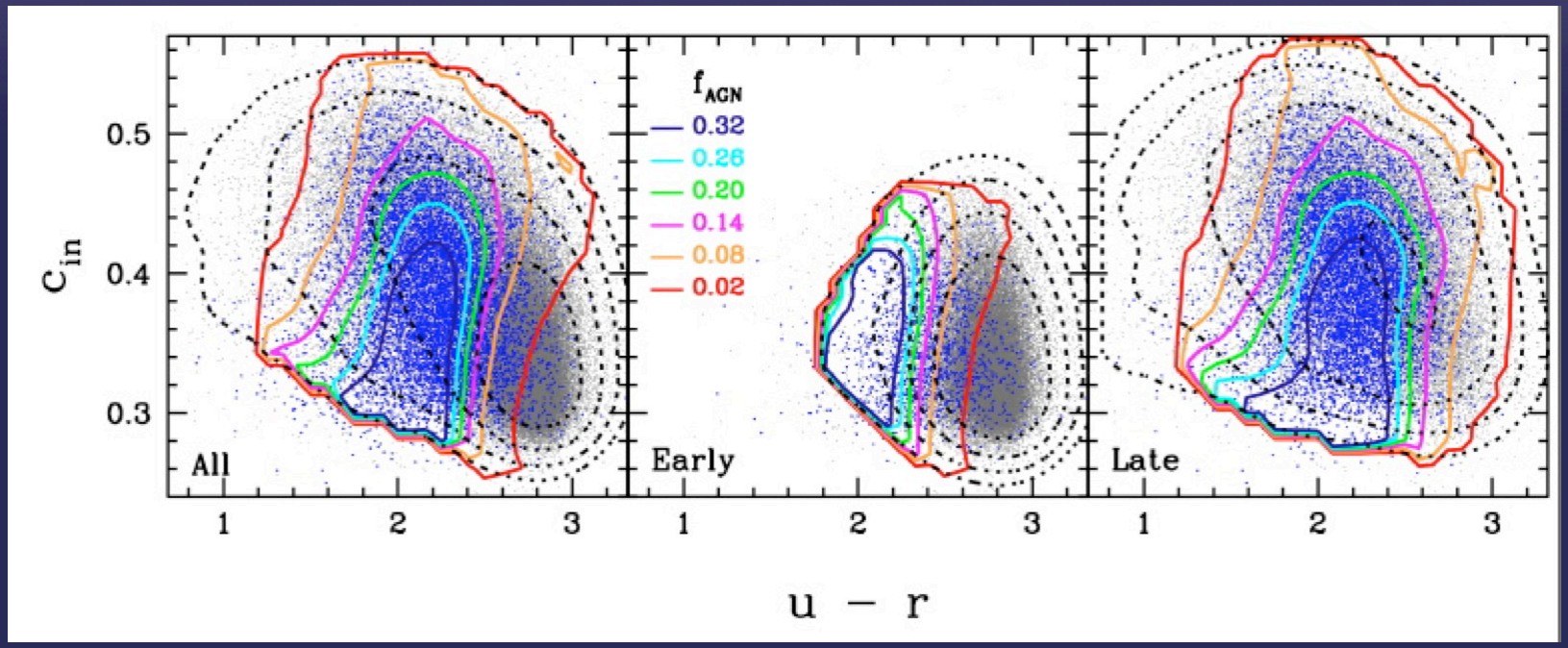


Δ (g-i) = (g-i) outer part – (g-i) inner part

- f_{AGN} does not strongly depend on color gradient

f_{AGN} dependency on concentration index

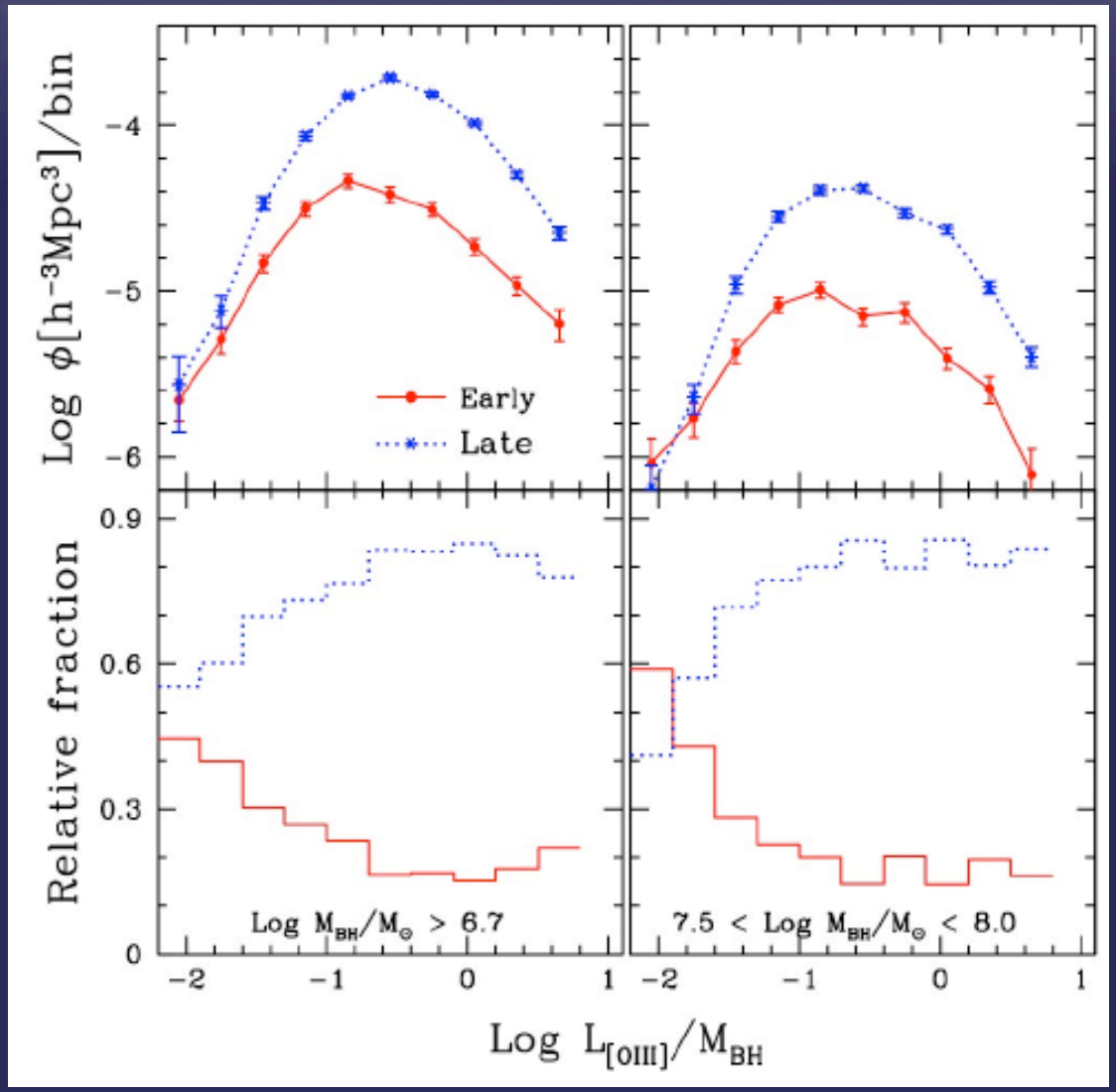
($C_{in}=R_{50}/R_{90}$)



- f_{AGN} in early-type does not strongly depend on C_{in}, similar to vel. disp.
- f_{AGN} in late-types is higher for more concentrated galaxies
  More massive galaxies (and black holes) are more likely to host AGN

AGN power dependency

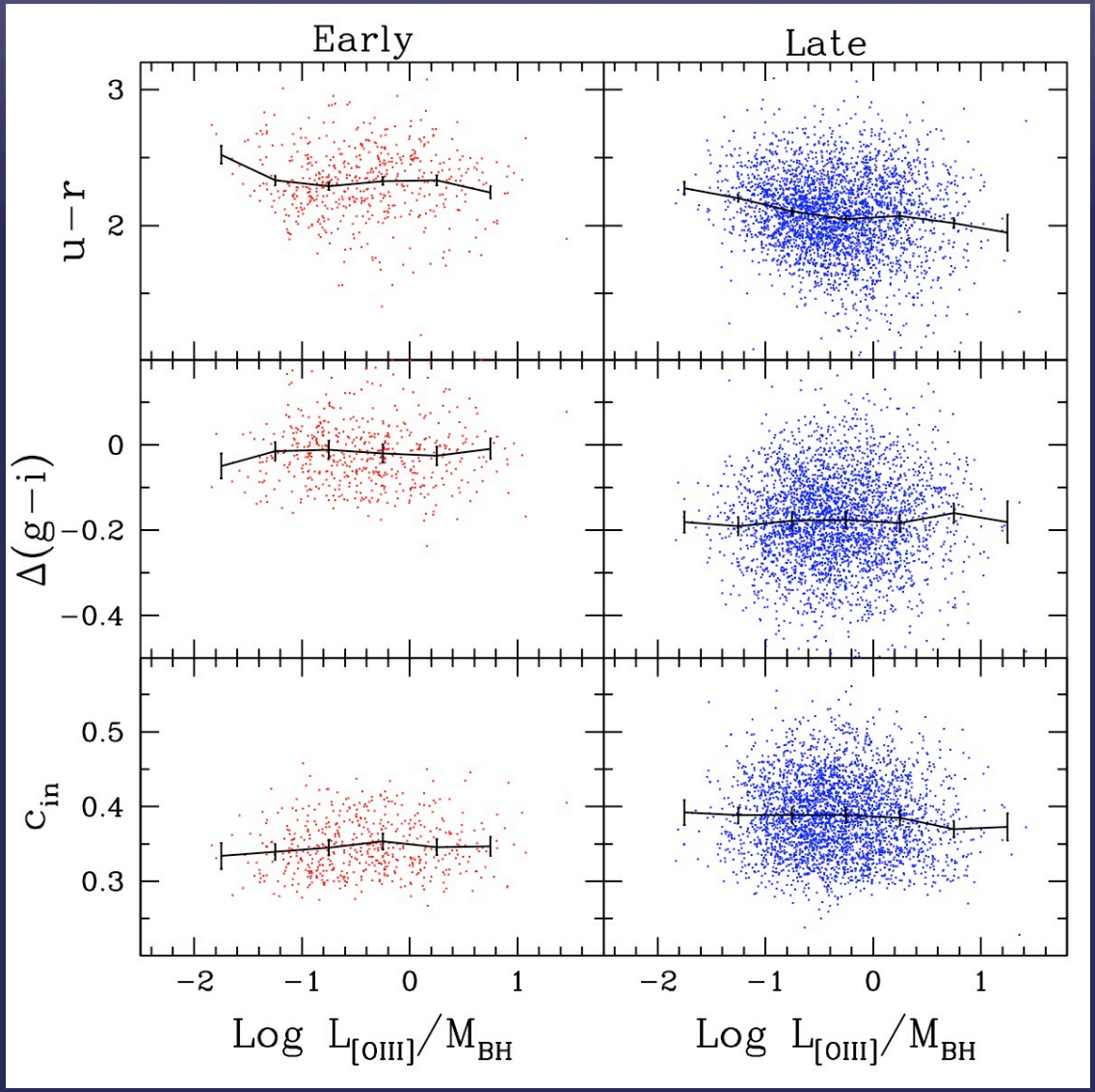
- Late-types are dominant host for all AGN power.
- The fraction of early-type host increases at low AGN power (< 1% of Eddington)



AGN power dependency

- AGN power slightly increases for bluer color host galaxies

- color gradient and concentration index do not strongly affect AGN power)



Summary and Conclusions

- f_{AGN} is lower than ~20-30% (lower limit) at any combination of galaxy properties, indicating global galaxy properties are not sufficient condition to trigger AGN activity.
- AGNs in the present-day universe are dominantly hosted by intermediate-mass late-type galaxies.
- Color is the dominant parameter of $f_{AGN.}$ In particular for early-types, f_{AGN} does not depend on luminosity or velocity dispersion at fixed color and there seems to be a connection between recent star formation and AGN activity.
- High power AGNs are dominantly hosted by late-type galaxies. For both morphological types, Eddington ratio ranges over 3 orders of magnitude, indicating various levels of accretion for given M_{BH}.