Investigating the AGN-Merger Connection at z~2 with CANDELS

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with

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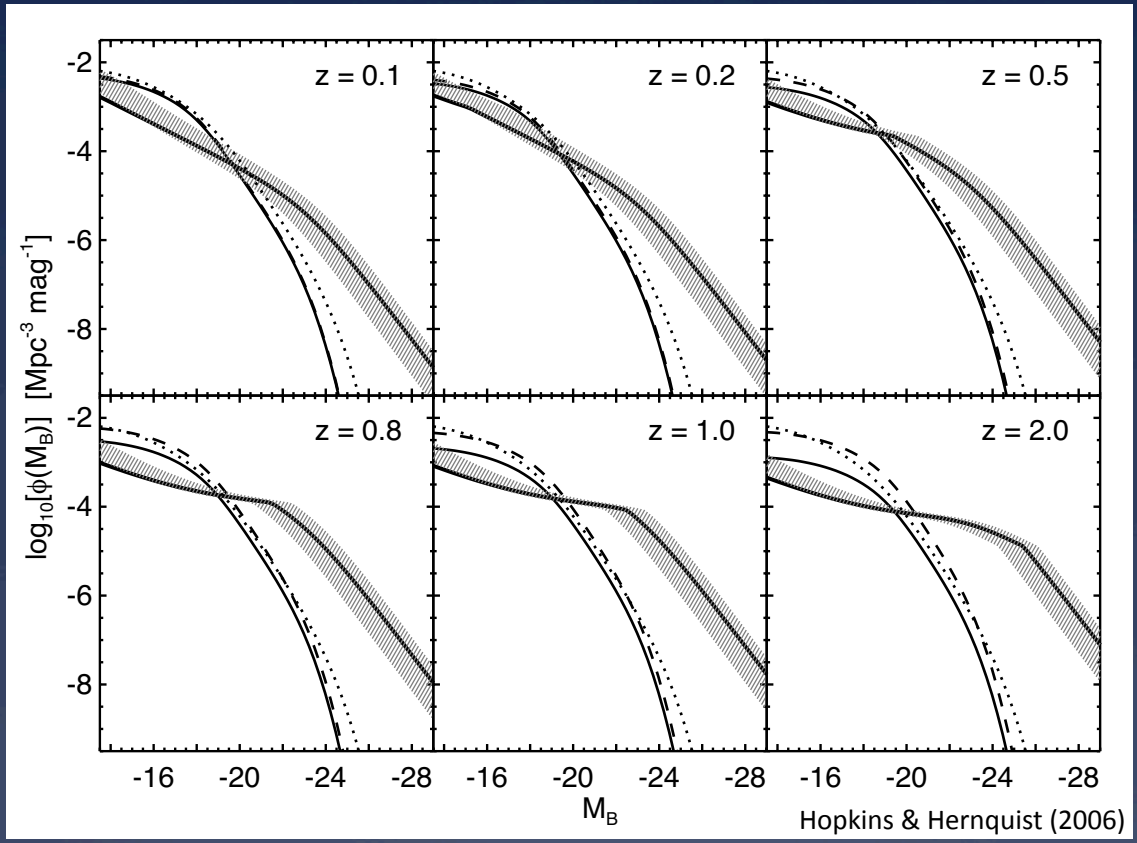
+

The CANDELS Team

Background

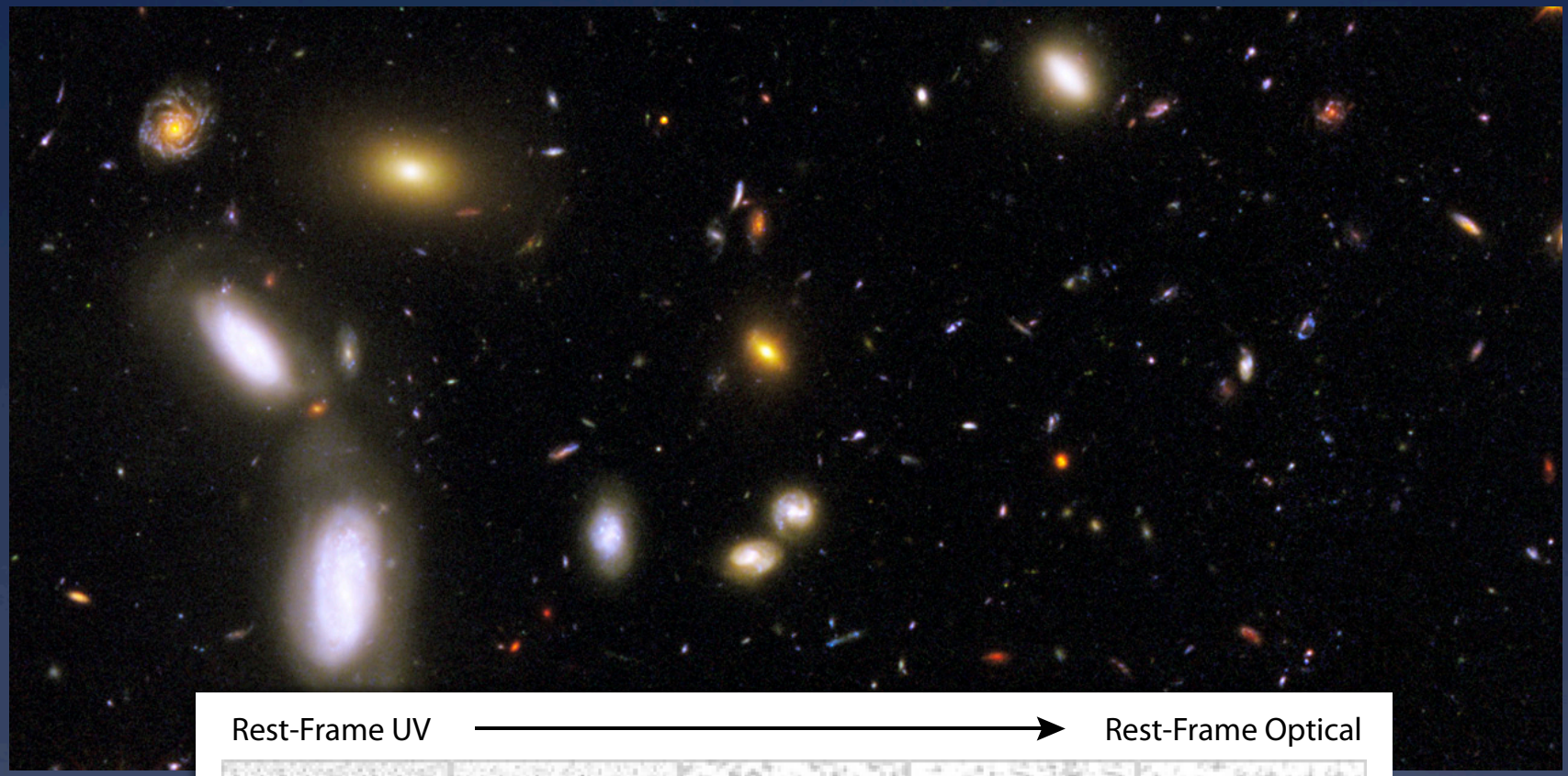
* Mergers have long been an attractive AGN fueling mechanism.
* Would help explain scaling relations between BH mass and bulge mass and velocity dispersion.
* Previous searches failed to find a convincing AGN-merger connection out to z~1.
* Especially true for moderate-luminosity AGN, many of which are found in normal spirals.

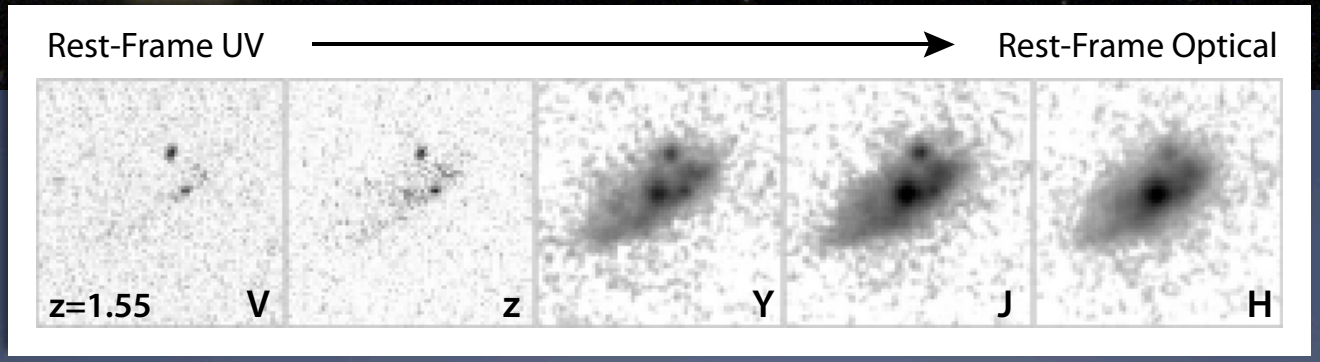
Evolution of AGN Fueling Modes



- Two fueling modes: merger-driven accretion & stochastic accretion
- Frequency of merger-driven accretion evolves rapidly with redshift. At z~2, mergers expected to be dominant fueling mode.

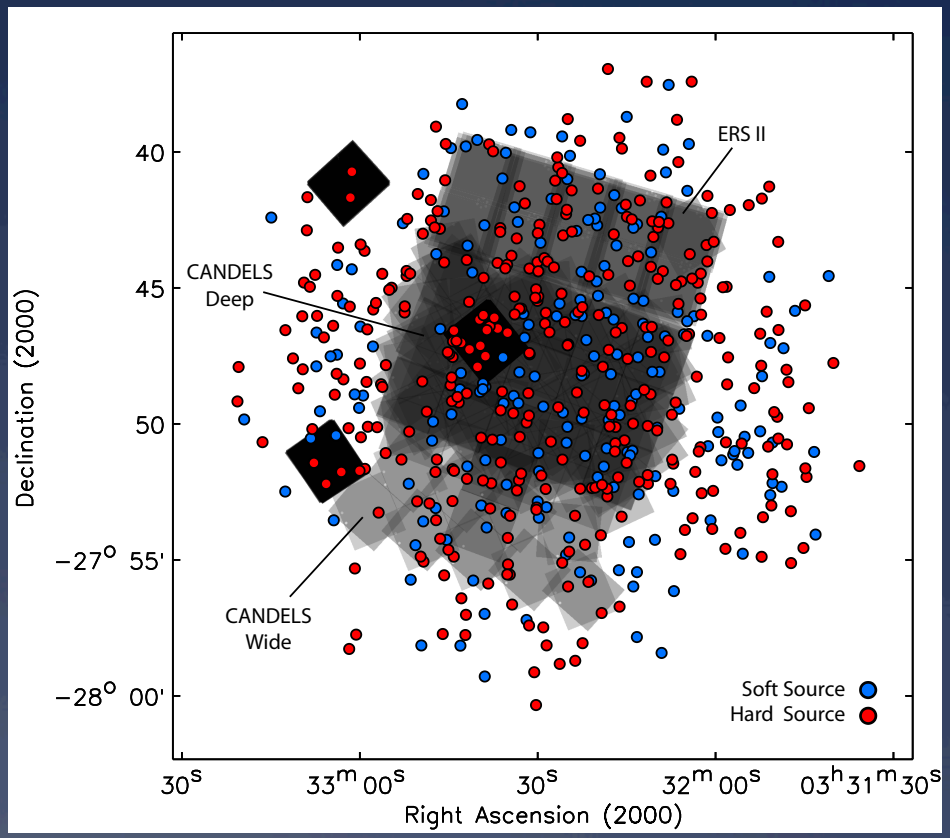
Wide Field Camera 3



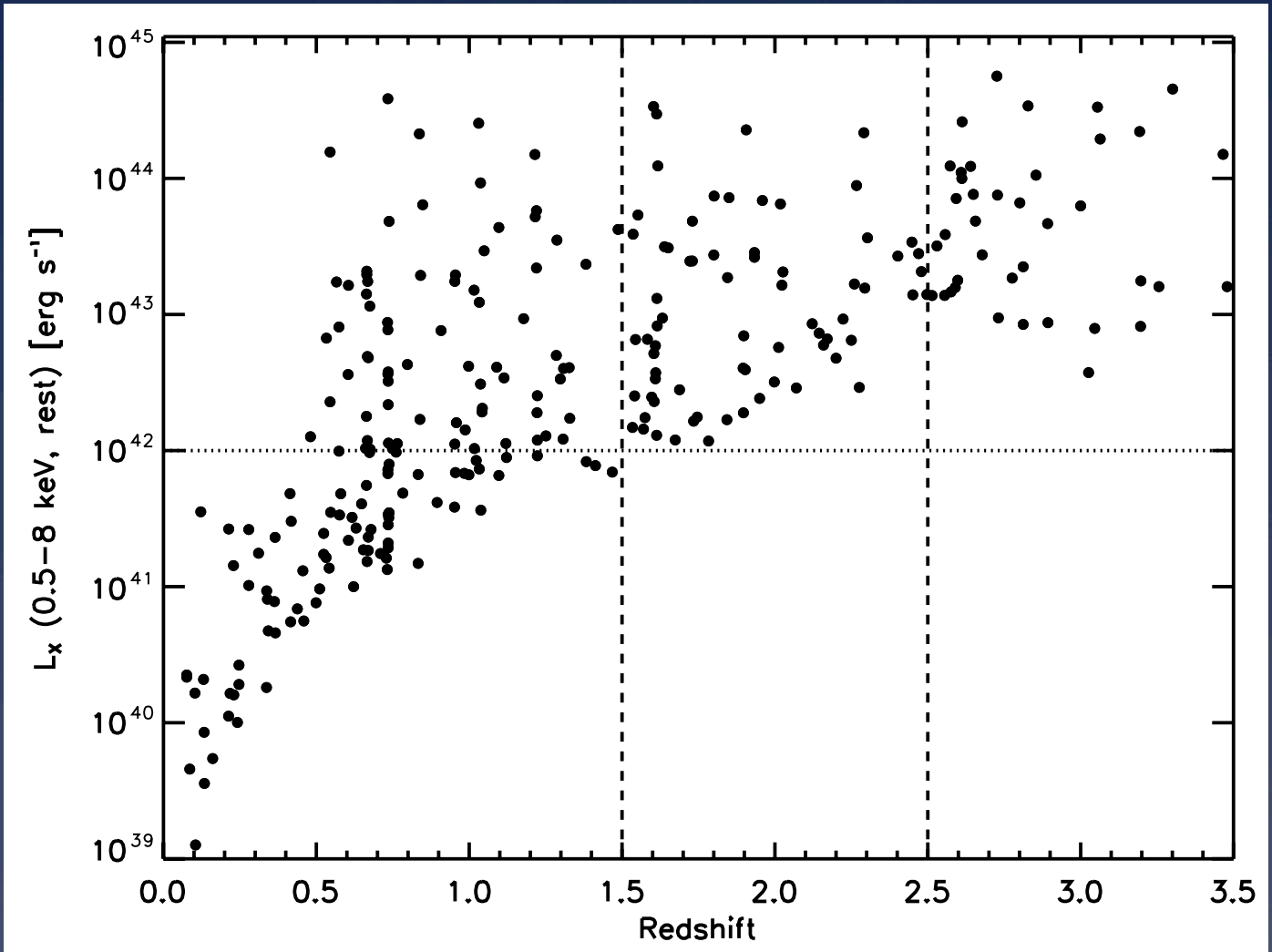


X-ray AGN in GOODS-S

- Selected z~2 AGN using:
  - CANDELS WFC3 H-band imaging.
  - Chandra 4 Msec dataset in CDFS. Deepest X-ray data available.
- Nandra et al. 4Ms source catalog contains 569 sources in CDFS.
- Likelihood Matched to WFC3 H-band catalogs.
- Redshift Determination:
  - Silverman et al. (2010) – Spect-z
  - Wuyts et al. (2010) – Photo-z
- Results in 72 AGN at 1.5 > z > 2.5.

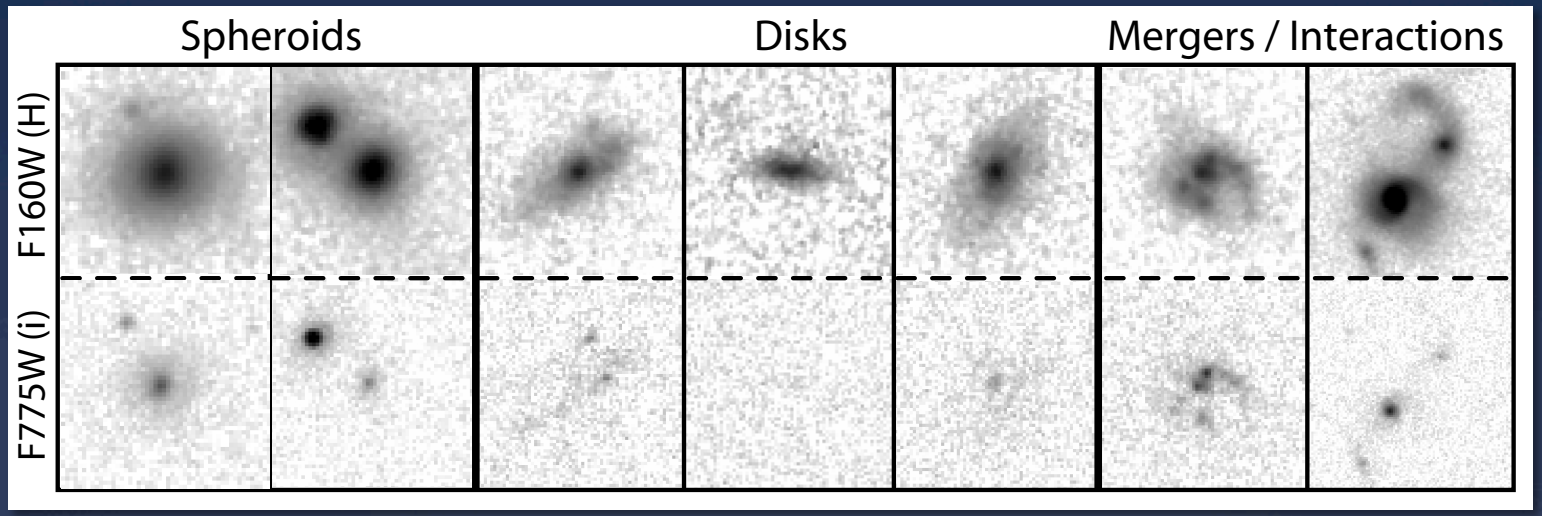


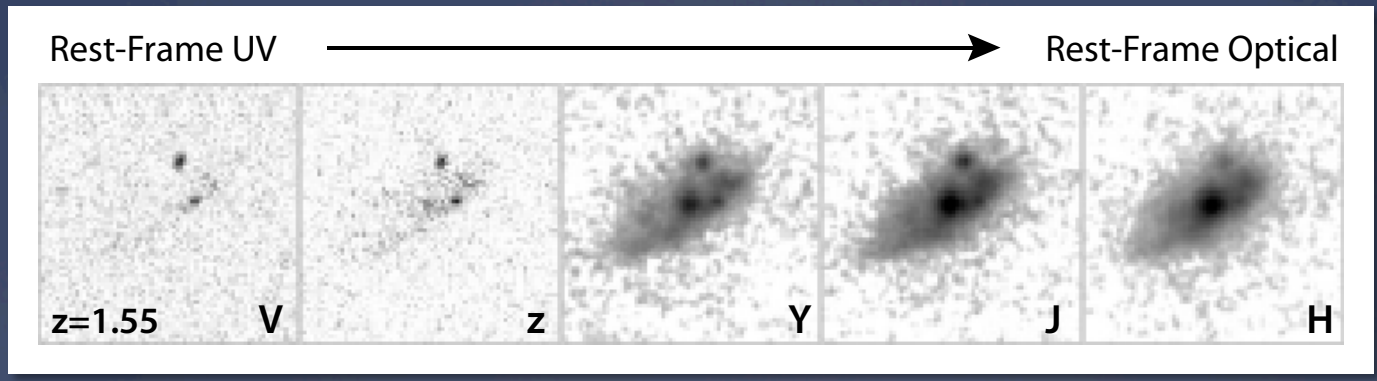
X-ray Luminosity Distribution



Luminosity limit at z~2: $L_X \sim 10^{42}$ erg/s

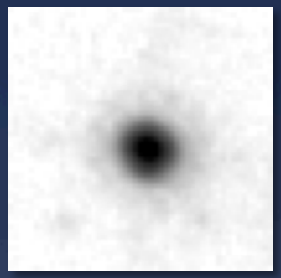
Host Morphologies





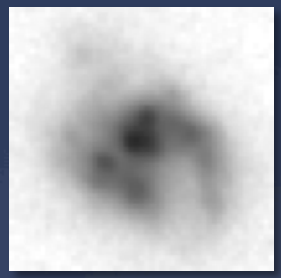
Visual Classifications


Disk


Spheroid


Irr / Pec

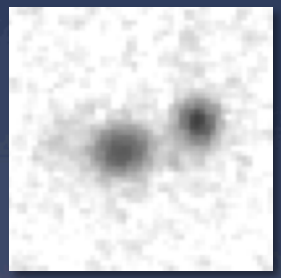

Compact


Merger


Interaction


Disturbed

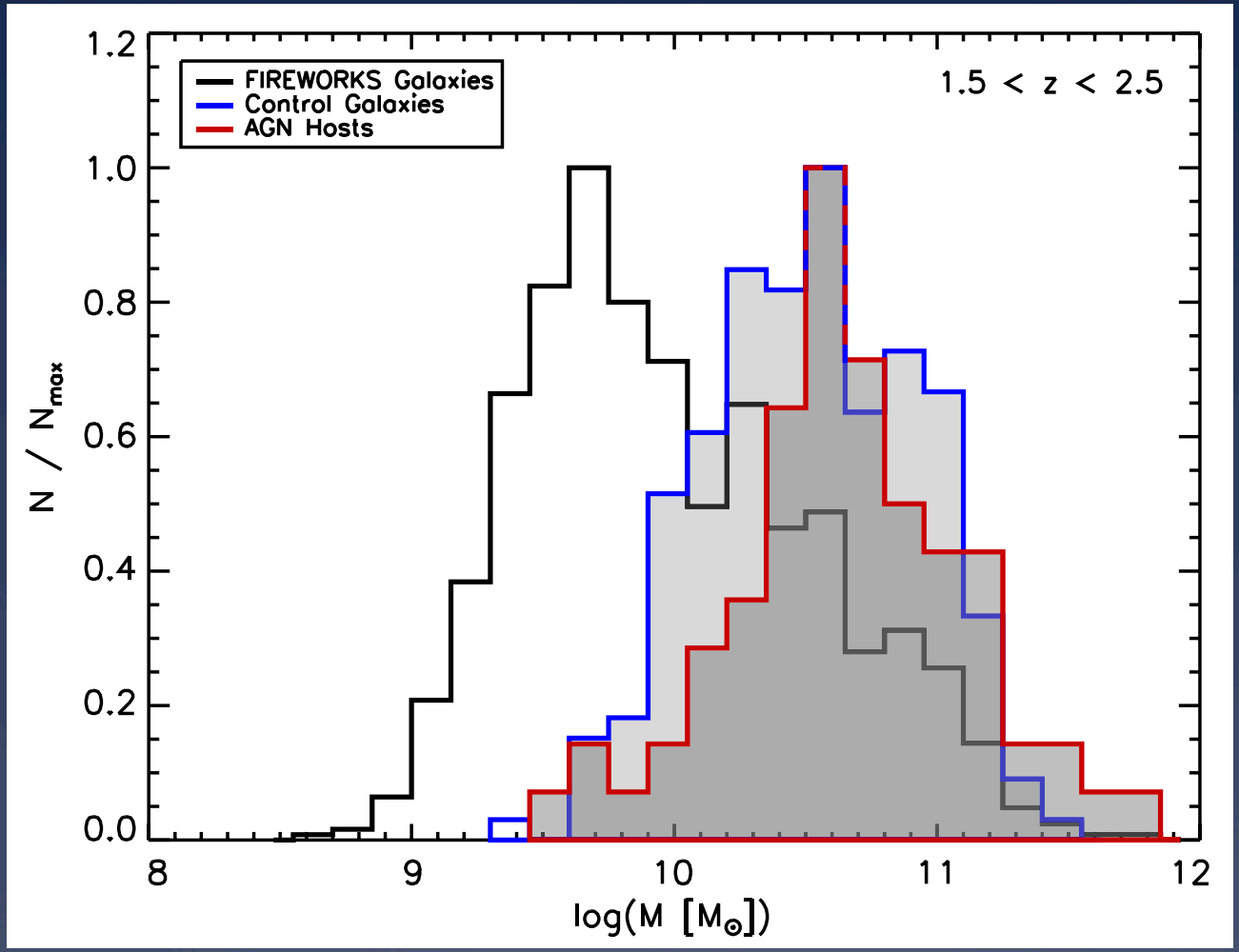

2x Nuclei


Close Pair

Classifiers:

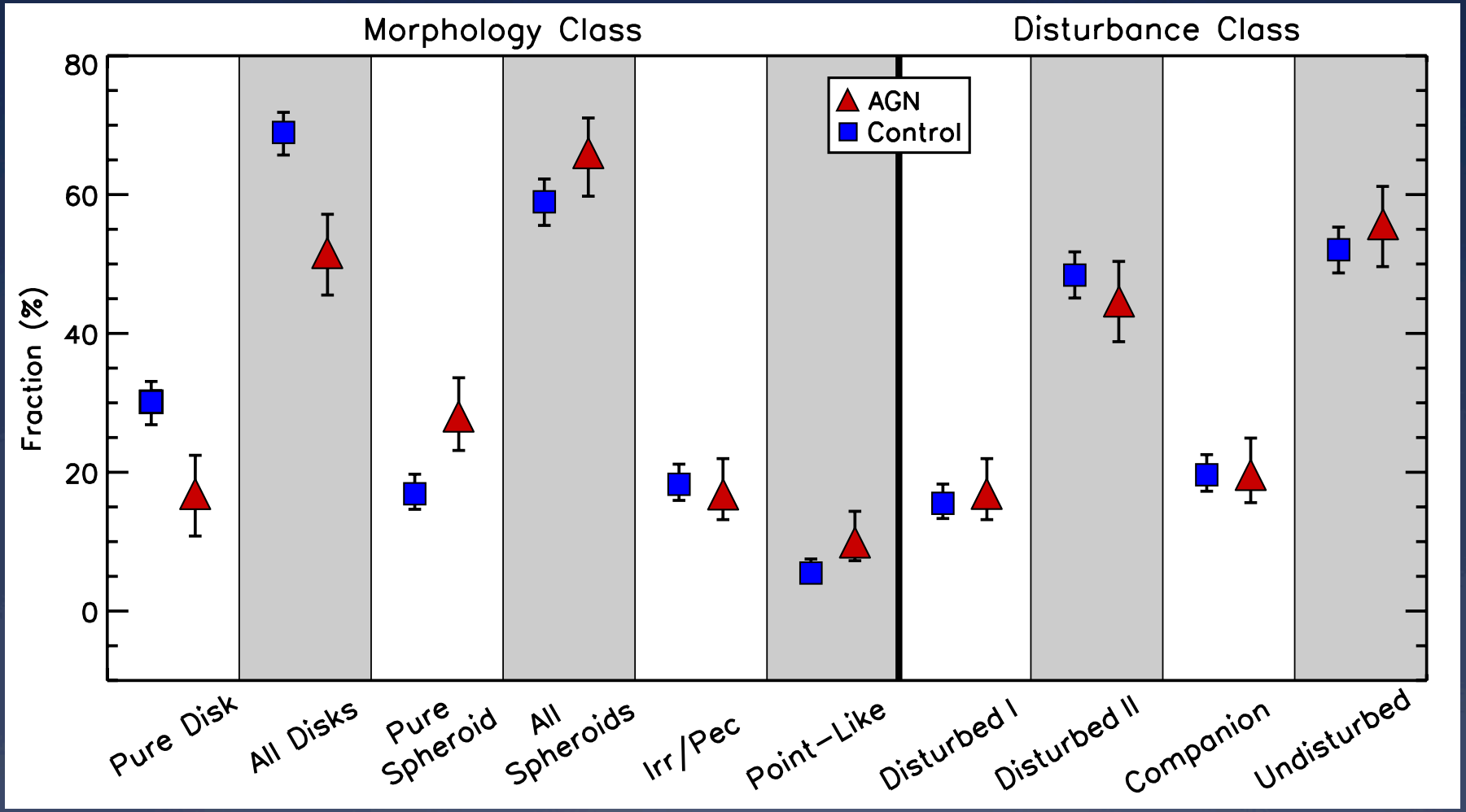
Sandy Faber, Jon Trump, Mark Mozena, Liz McGrath, Jeyhan Kartaltepe, Chris Conselice, Jenn Donley, Amber Straughn, Ray Lucas, Caroline Villforth, Stephanie Juneau, Kamson Lai, Aday Robaina, Anton Koekemoer, Norm Grogin.

Mass-Matched Control Sample



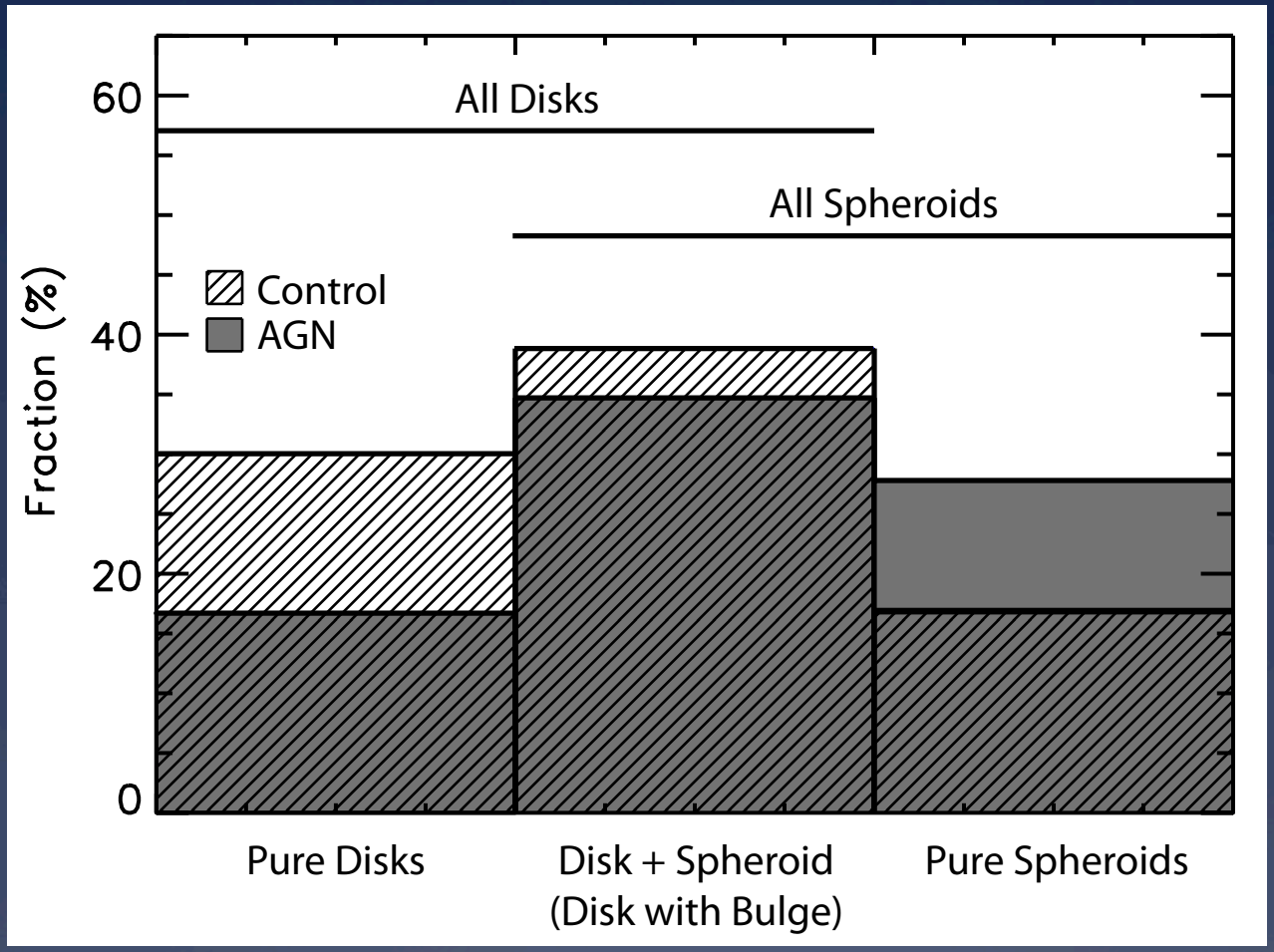
* Compared against 216 mass-matched control galaxies: ($M_{Host}/2 < M_{Gal} < 2M_{Host}$).

Classification Results



- No excess of disturbed morphs among AGN hosts vs control.
- Majority of hosts undisturbed.
- Disk most common single morphology for AGN hosts.
- AGN associated with spheroids more often control galaxies.

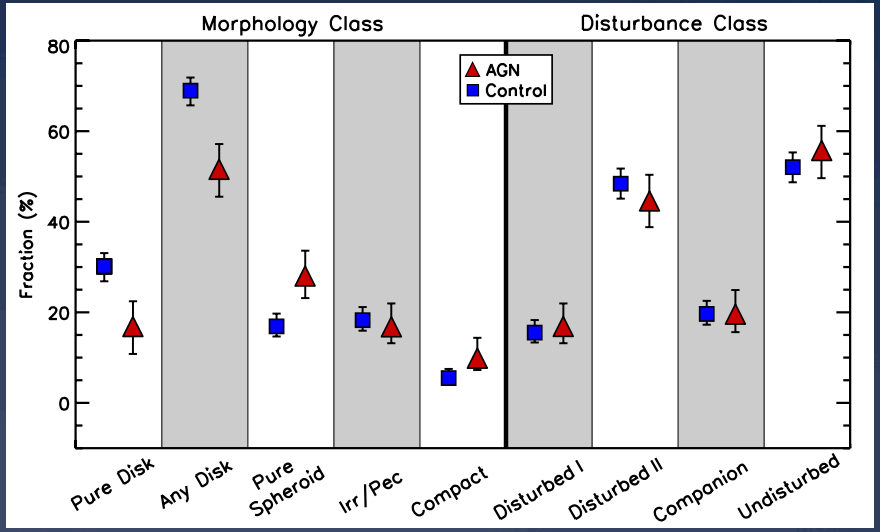
AGN Still Favor Spheroids

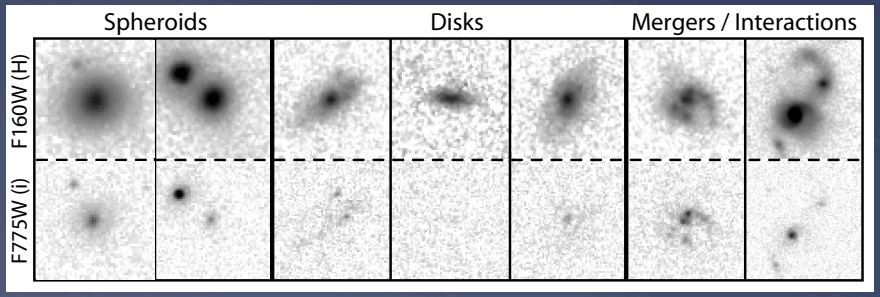


* Even in an era where the mass-morphology relationship appears to break down, AGN still preferentially found in spheroidal systems.

Standard Caveats

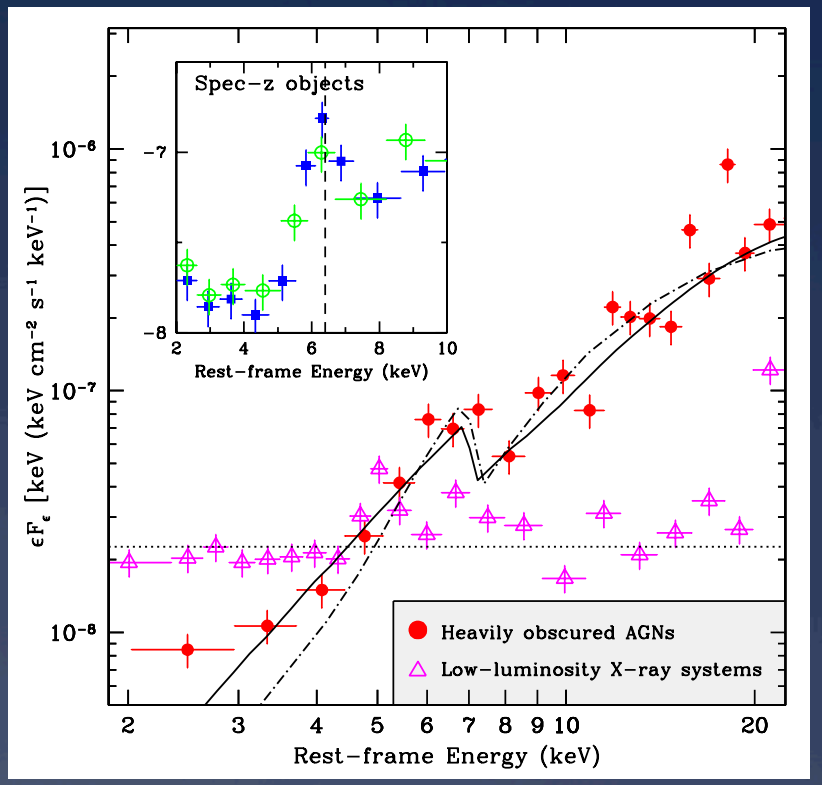
* May miss AGN-merger connection because:
  * Obscuration
  * Time delay between merger and AGN activity
* Alternative Triggering Mech:
  * Violent disk instabilities (i.e. clumpy disks)
  * Secular processes
  * Minor Mergers
* It appears stochastic accretion plays a larger role in triggering AGN activity at z~2 than previously thought.

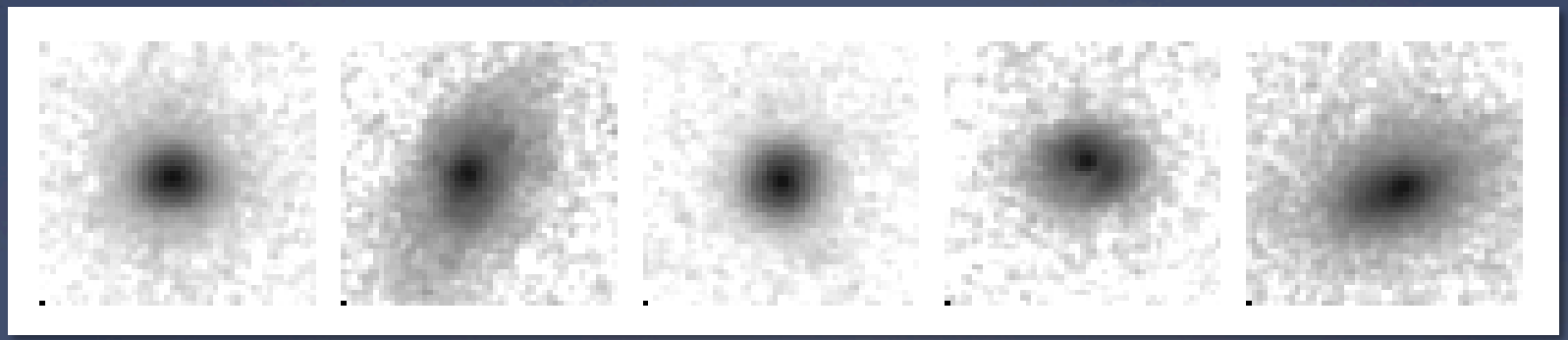




Morphologies of Compton Thick AGN

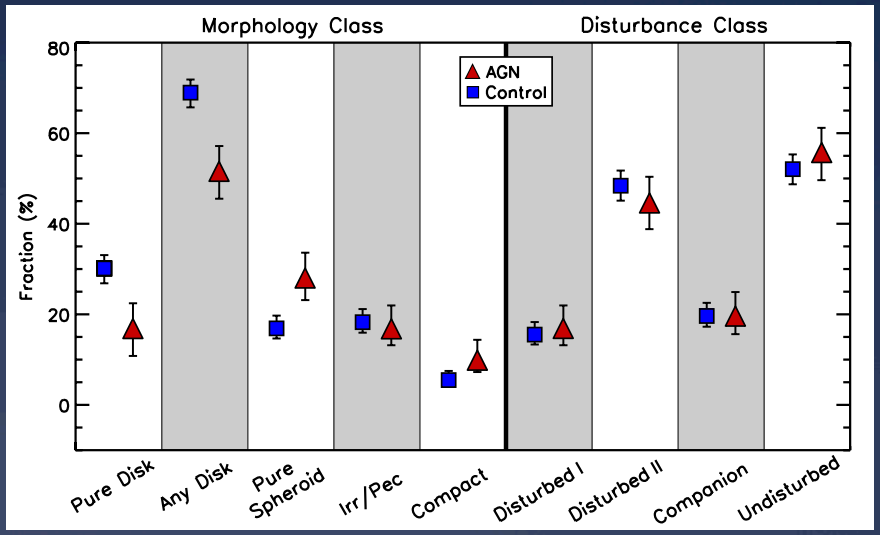
* Can test obscuration bias by examining morphs of Compton thick sources.
* Alexander et al. (2011) find 11 sources in CDFS at z~2 with reflection dominated X-ray spectra, suggesting extreme column densities ($N_H > 10^{24}$ cm^{-2}).
* Morphology of these sources do not appear considerably different than entire sample.

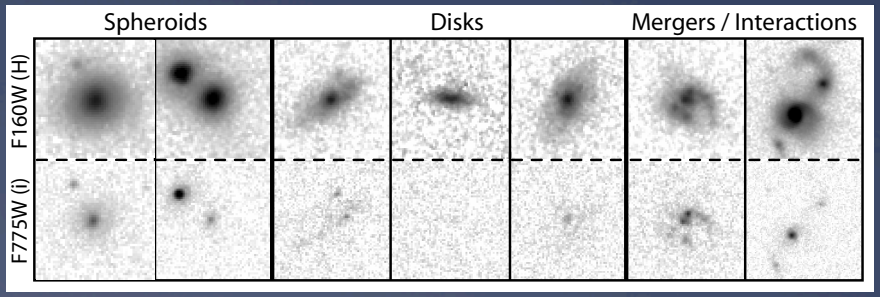




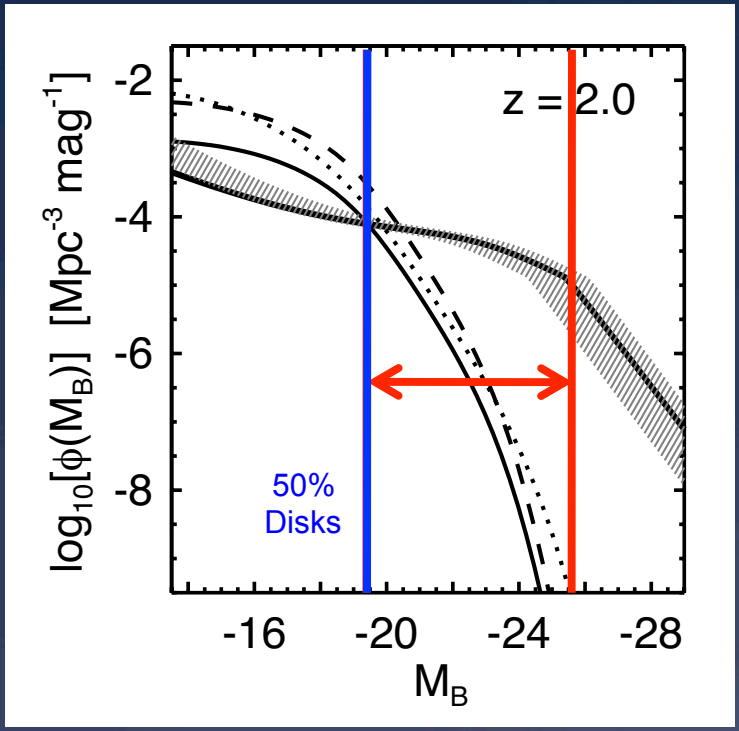
Constraints on Time Delay Caveat

* May miss AGN-merger connection because:
  * Time delay between merger and AGN activity
* Morphologies:
  * 51% found in Disks (17% bulgeless)
  * 28% found in Spheroids
  * 17% have irregular morphs
  * More bulge-dominated than non-active, massive galaxies.
* Disks may survive major mergers, when gas rich, but unlikely (Bournaud et al. 2011).
* If spheroids = triggered by past major mergers, disks = fed by secular processes, then we find far too little merger activity.

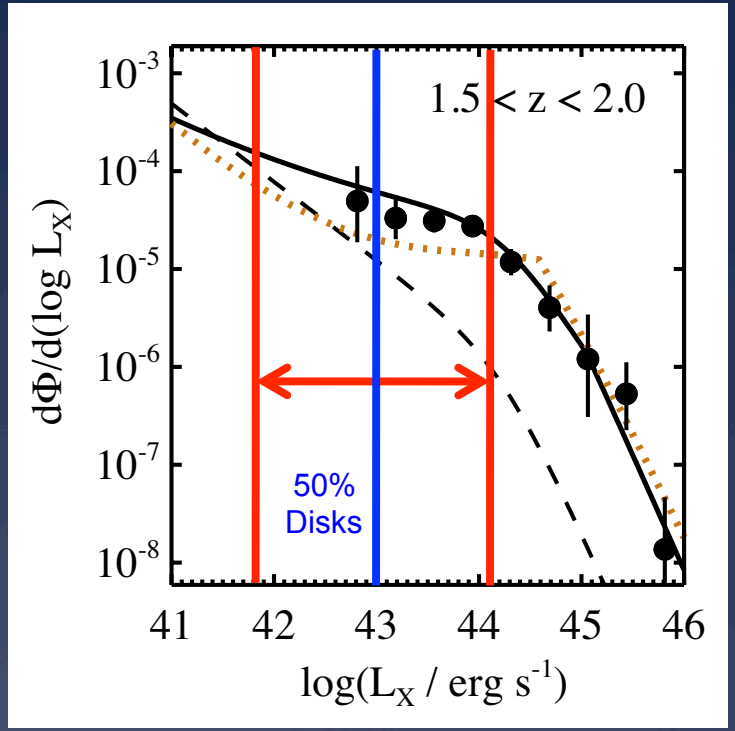




Implications for AGN Fueling Models



Hopkins & Hernquist (2006)

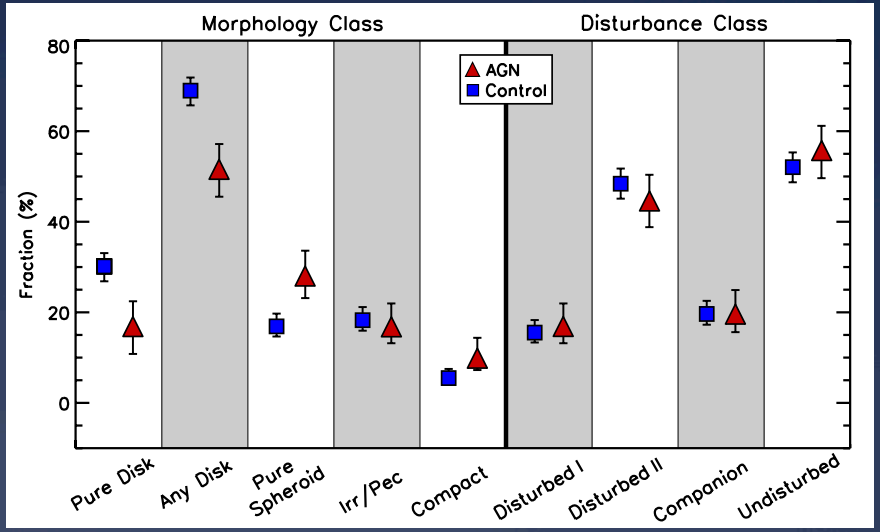


Aird et al (2010)

- Number density of stochastically fed AGN rival merger-triggered AGN roughly 2 orders of mag below knee.
- Knee in XLF: Lx ~10^44 erg/s (2-10 keV)
- We find 50% disk-like fraction at Lx~10^43 erg/s
- Implies stochastic accretion plays a larger role in triggering AGN activity at z~2 than prev thought.

Alternatives to Mergers

* May miss AGN-merger connection because:
  * Obscuration
  * Time delay between merger and AGN activity
* Alternative Triggering Mech:
  * Violent disk instabilities (i.e. clumpy disks)
  * Secular processes
  * Minor Mergers



BLACK HOLE GROWTH AND AGN OBSCURATION BY INSTABILITY-DRIVEN INFLOWS IN HIGH-REDSHIFT DISK GALAXIES FED BY COLD STREAMS

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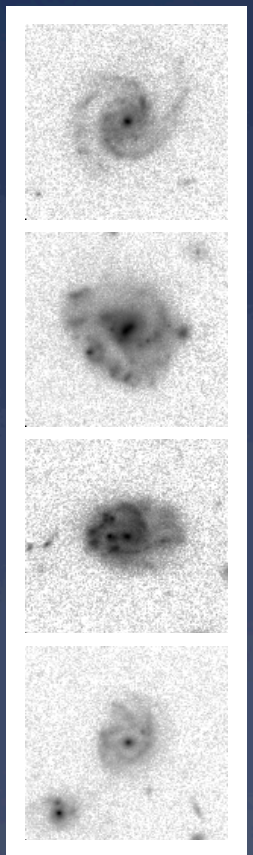
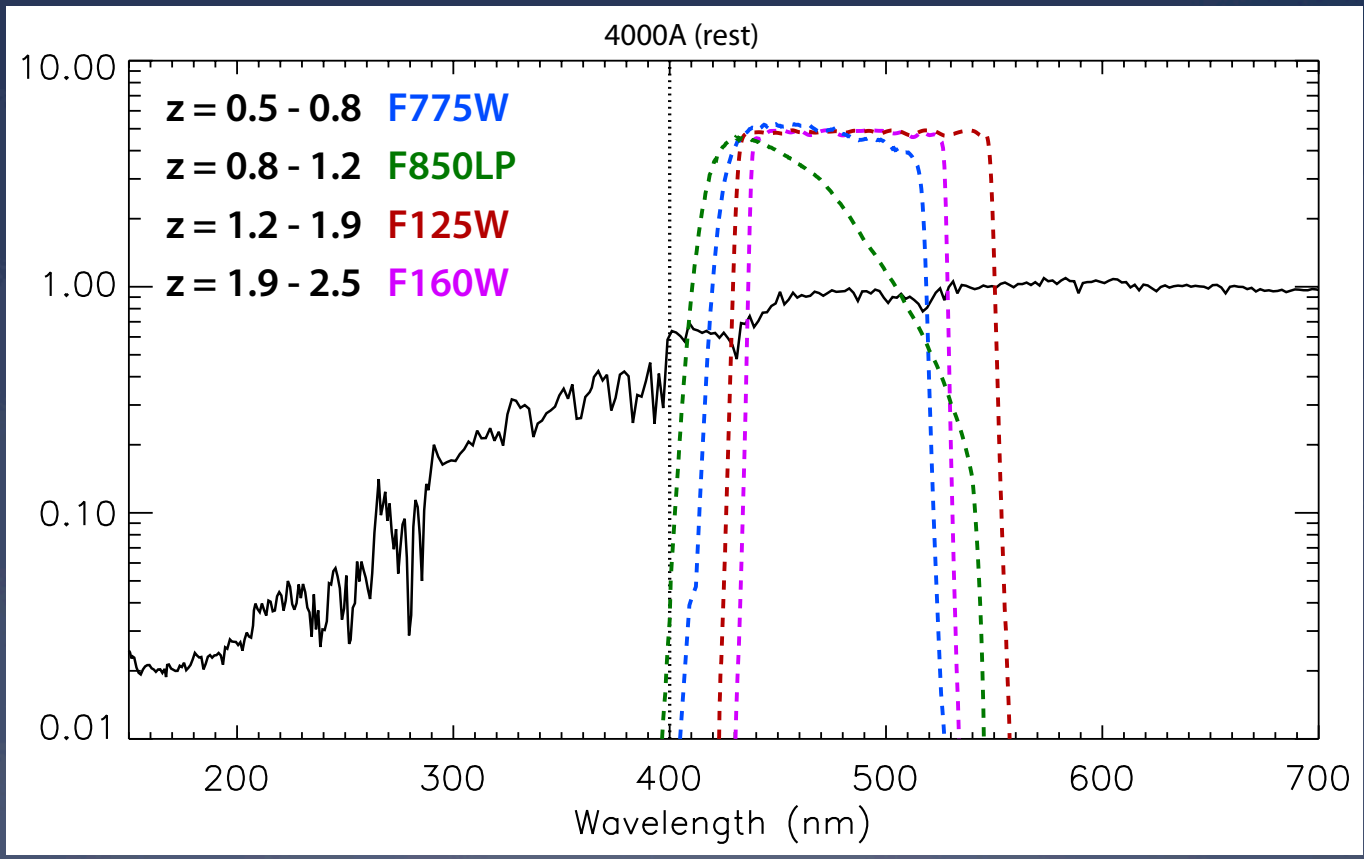
Clumpy Disks Among AGN Hosts

* Visually classified the "clumpiness" of AGN hosts from z=0.5-2.5.
  * Classifications done at same rest wavelength using **i z J H** bands.
  * ACS imaging smoothed to match WFC3 resolution





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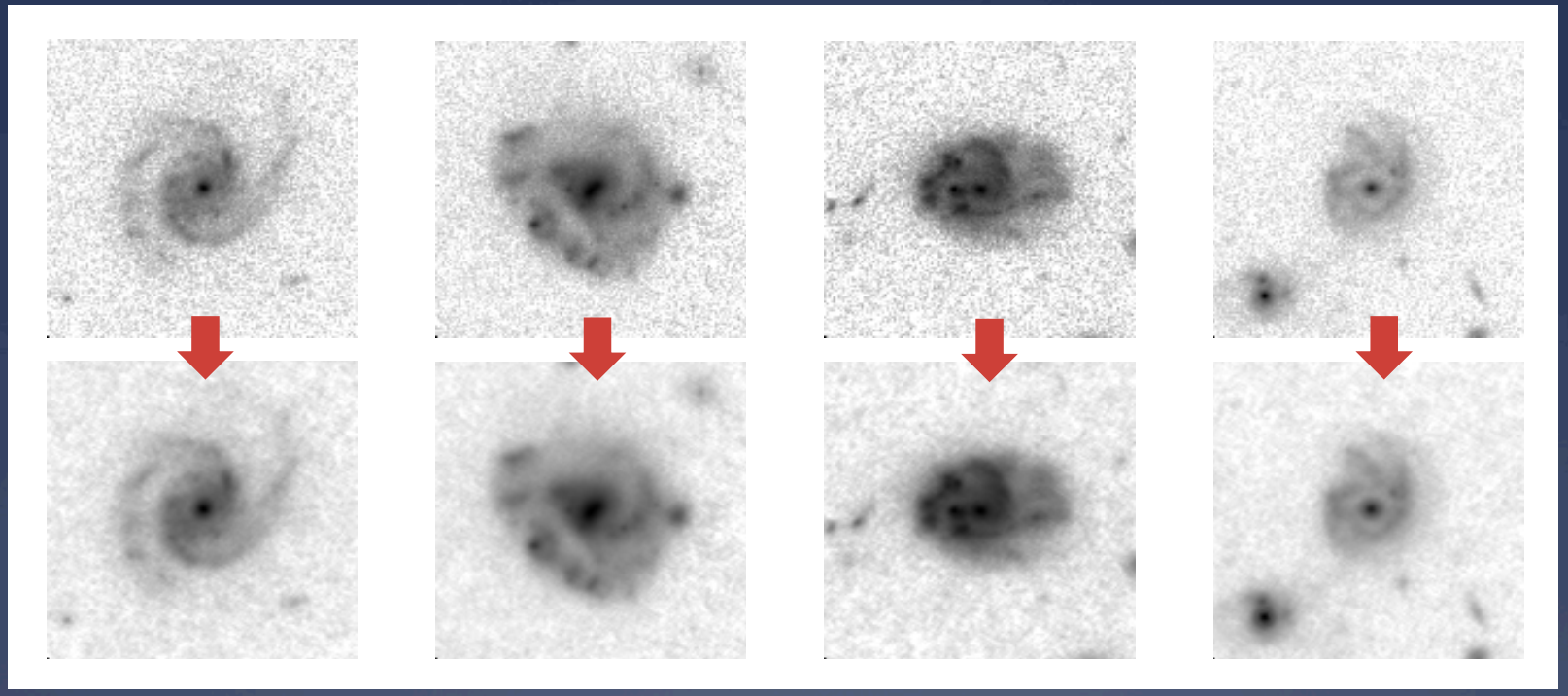
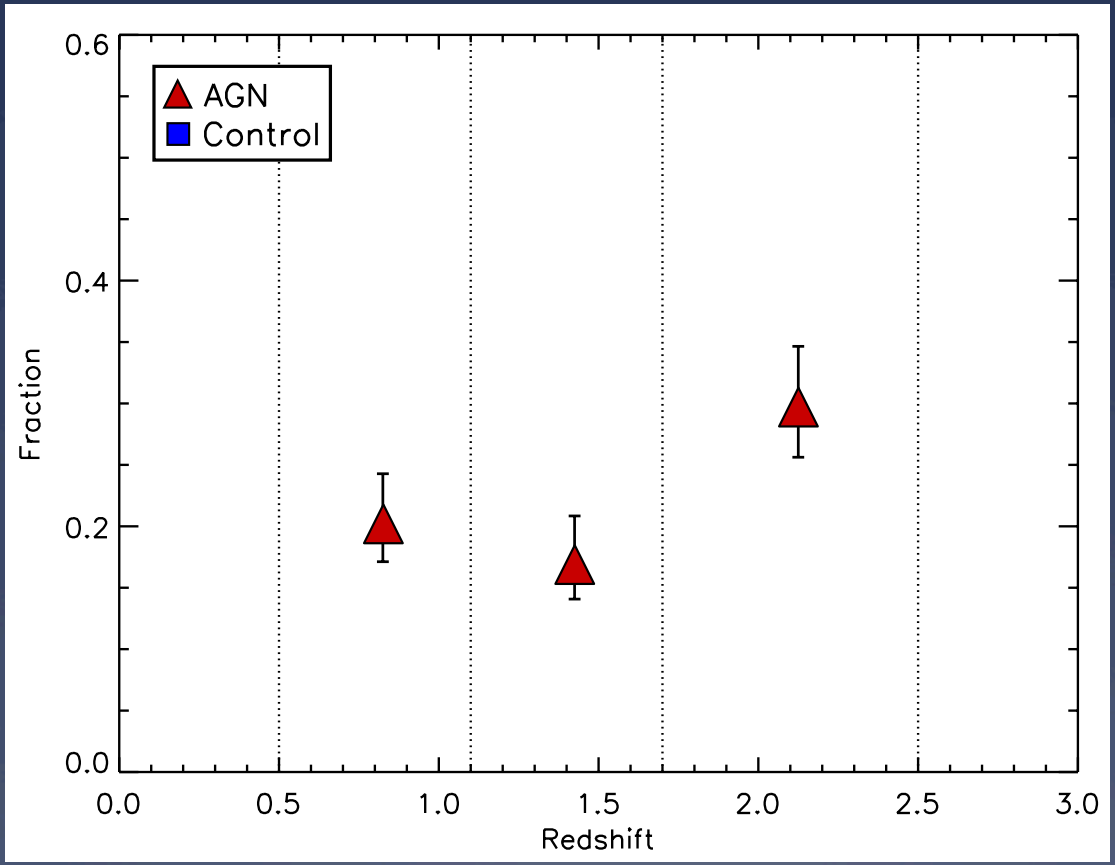


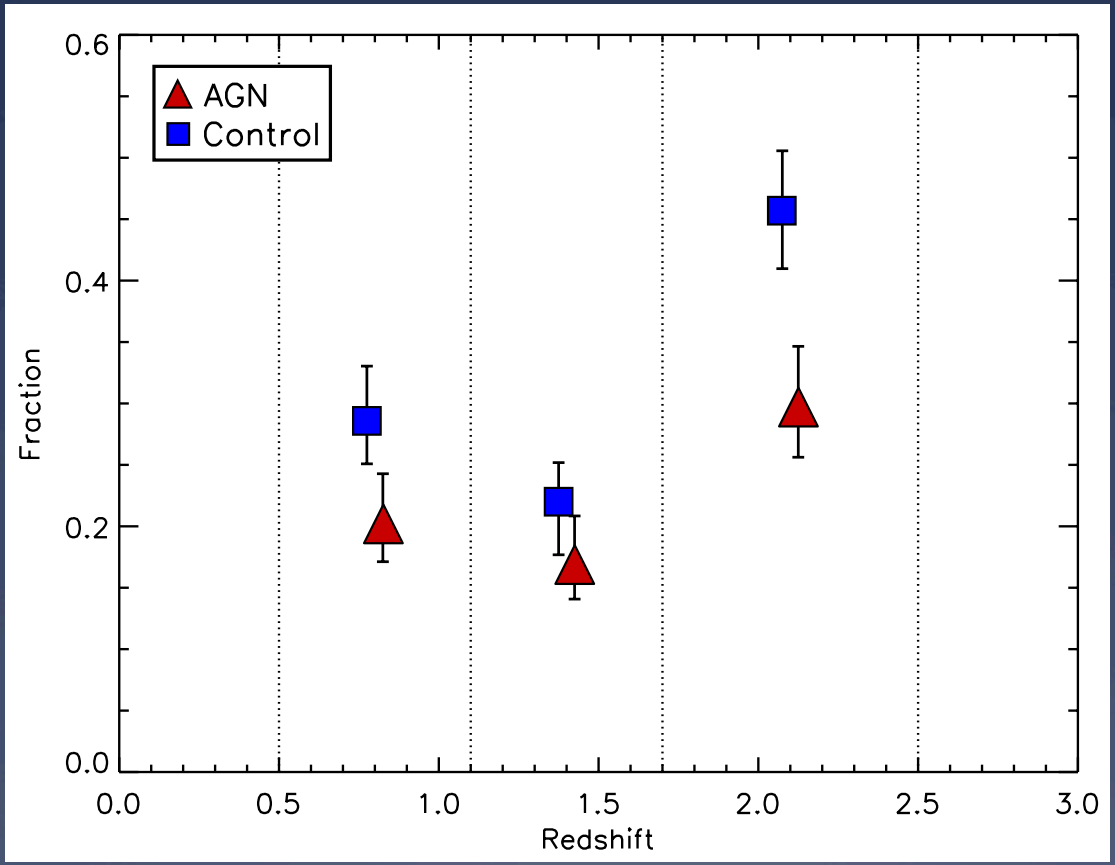
Clumpy Disks Among AGN Hosts

* Mild increase in frequency of clumpy AGN hosts at z~2.



Clumpy Disks Among AGN Hosts

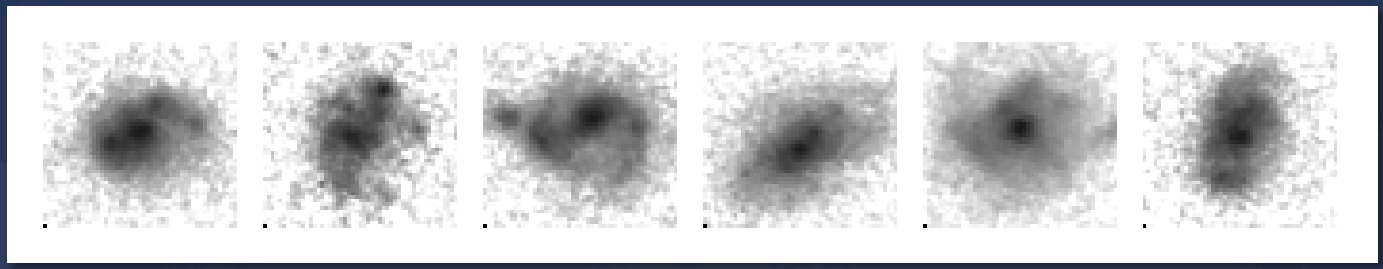
* Mild increase in frequency of clumpy AGN hosts at z~2.
* Greater increase in clumpy fraction among control population.

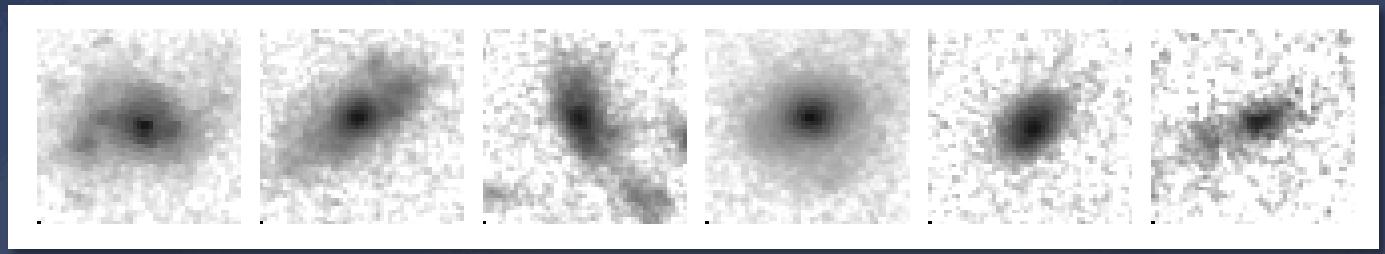


Clumpy Disks Among AGN Hosts

* Violent disk instabilities should be visible as clumpy disk morphs.

Control Galaxies





AGN Hosts

* Some evidence clumpy disks more prevalent among non-active galaxies.

Alternatives to Mergers

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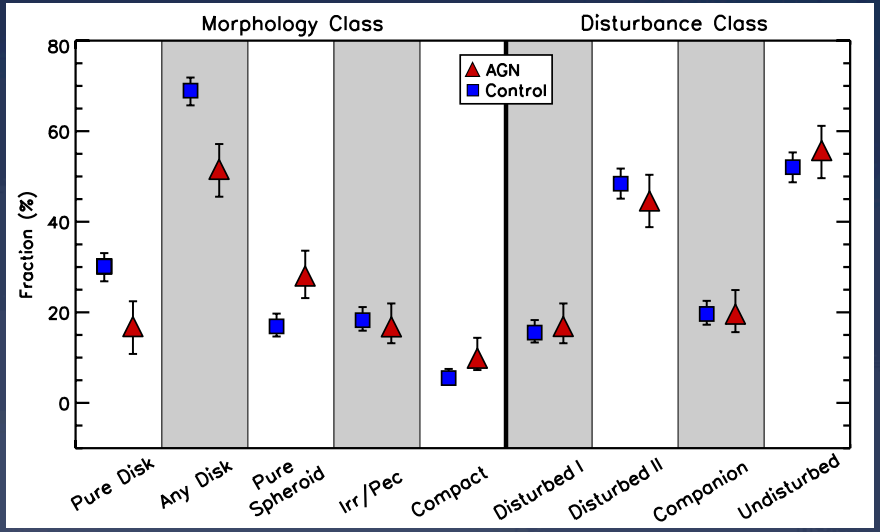
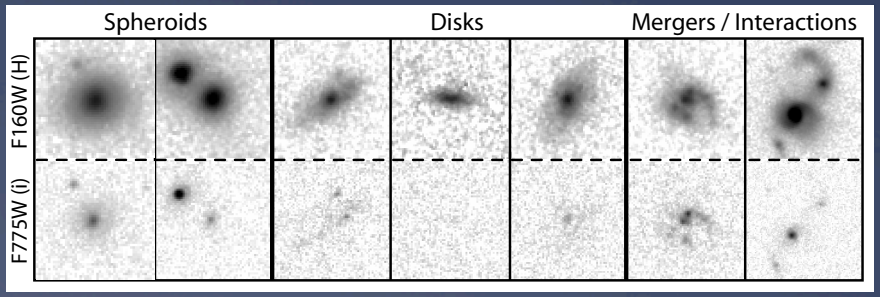
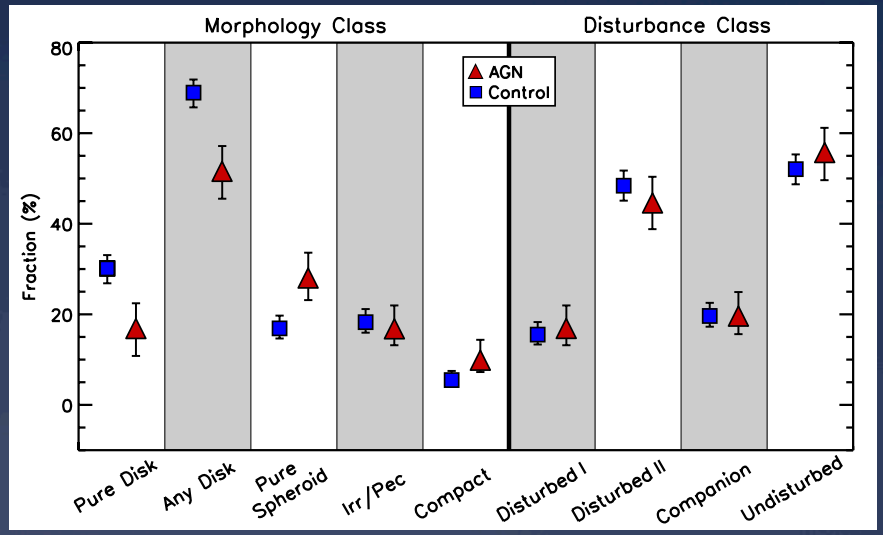
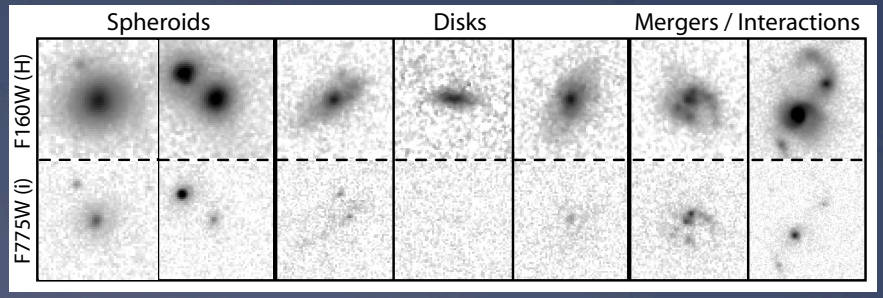




Conclusions

- AGN hosts at z~2 do not show irregular morphs more often than mass-matched non-active control galaxies.
- Undisturbed disks most common morphology
- If disks have not experienced major merger in recent past: **stochastic accretion must play a greater role in fueling AGN activity at z~2 than expected.**
- Cannot rule out minor mergers.
- Kocevski et al. (2011) – Submitted





CANDELS: THE AGN-MERGER CONNECTION AT $Z \sim 2$

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ABSTRACT

Using HST/WFC3 imaging taken as part of the Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS), we examine the role that major galaxy mergers play in triggering active galactic nuclei (AGN) activity at $z \sim 2$; the first such analysis at this redshift. Employing visual classifications, we have analyzed the the rest-frame optical morphologies of 72 galaxies at $1.5 < z < 2.5$ which host moderate-luminosity ($L_X \sim 10^{42-44}$ erg s^{-1}), X-ray selected AGN in the Chandra Deep Field South. To determine if the AGN host galaxies show merger signatures more often than similar non-active galaxies, we compare their morphologies to a sample of 216 mass-matched control galaxies at the same redshift. We find that a majority of the AGN reside in late-type galaxies (51.4%), while a smaller percentage are found in early-type hosts (27.8%) and systems with irregular morphologies (16.7%). Despite the high disk fraction, the AGN hosts are more often associated with spheroids than non-active galaxies of similar mass. Roughly 16.7% of the AGN hosts have highly disturbed morphologies and appear to be involved in a major merger or interaction, while the majority of hosts (55.6%) instead appear relatively relaxed and undisturbed. These fractions are statistically consistent with the fraction of control galaxies that show similar morphological disturbances. Our results suggest that the hosts of moderate-luminosity AGN are no more likely to be involved in an ongoing merger or interaction relative to non-active galaxies of similar mass at $z \sim 2$. Furthermore, the high disk fraction observed among the AGN hosts appears to be at odds with predictions that merger-driven accretion should be the dominant AGN fueling mode at $z \sim 2$, even at moderate X-ray luminosities. The presence of a large population of relatively undisturbed late-type hosts suggests that secular evolution and the stochastic accretion of gas plays a greater role in triggering AGN activity at these redshifts than previously thought.

Subject headings: galaxies: active — galaxies: evolution — X-rays: galaxies

Kocevski et al. (2011)

Submitted – on astro-ph soon