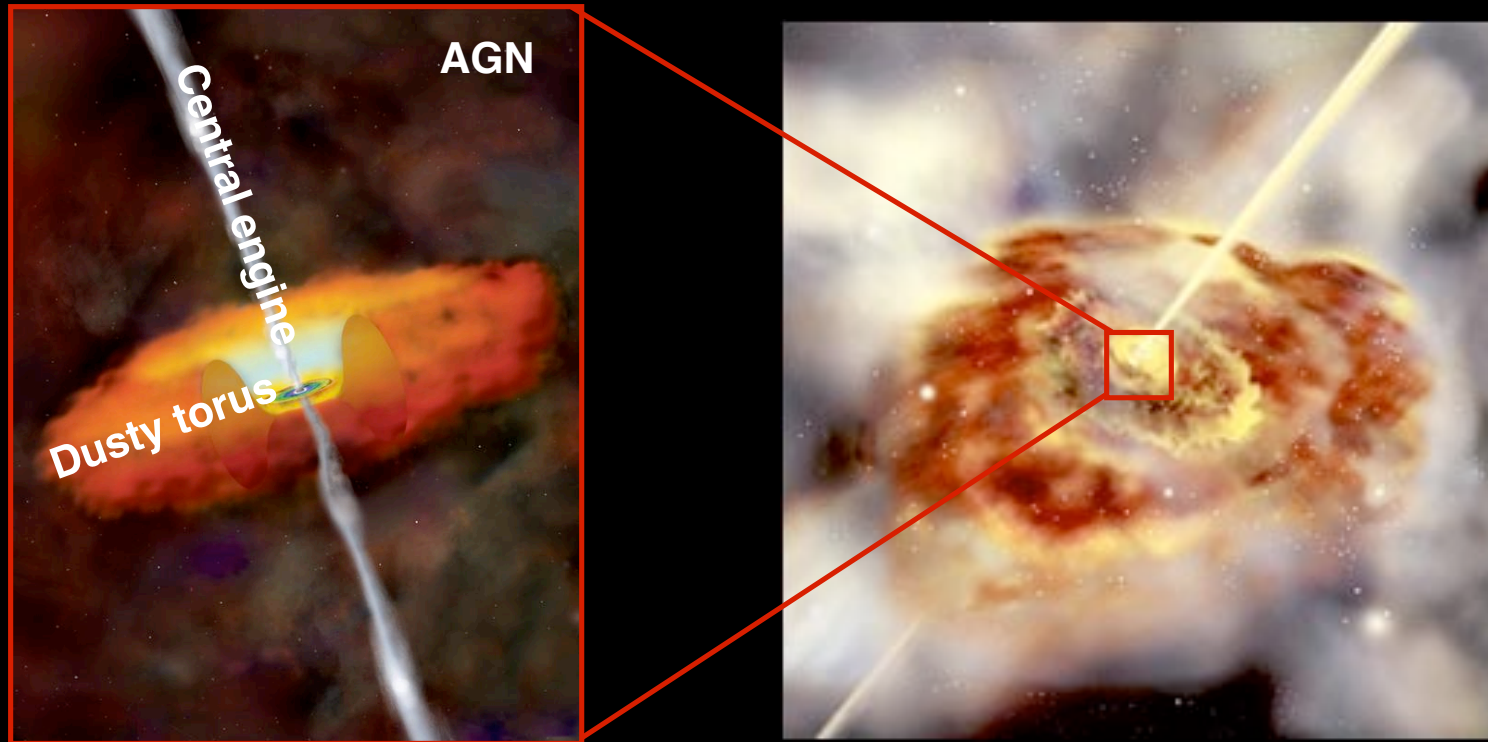


Active Galactic Nuclei in the Distant Galaxy Population



David M Alexander (Durham)

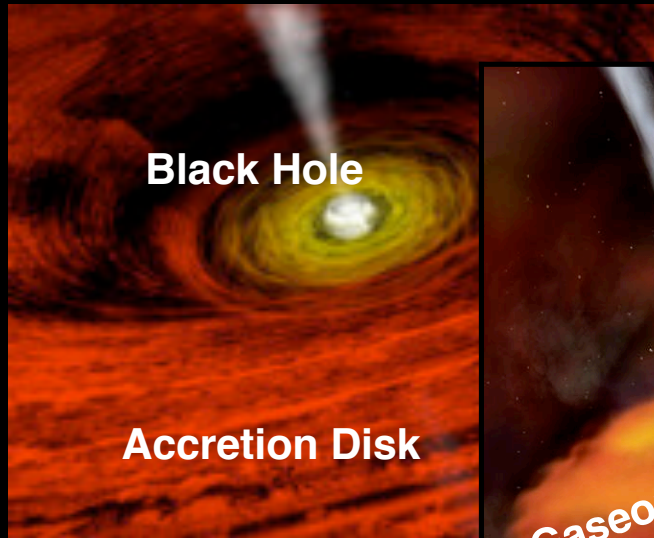
Active Galactic Nuclei in the Distant Galaxy Population

Some Key Broad Questions

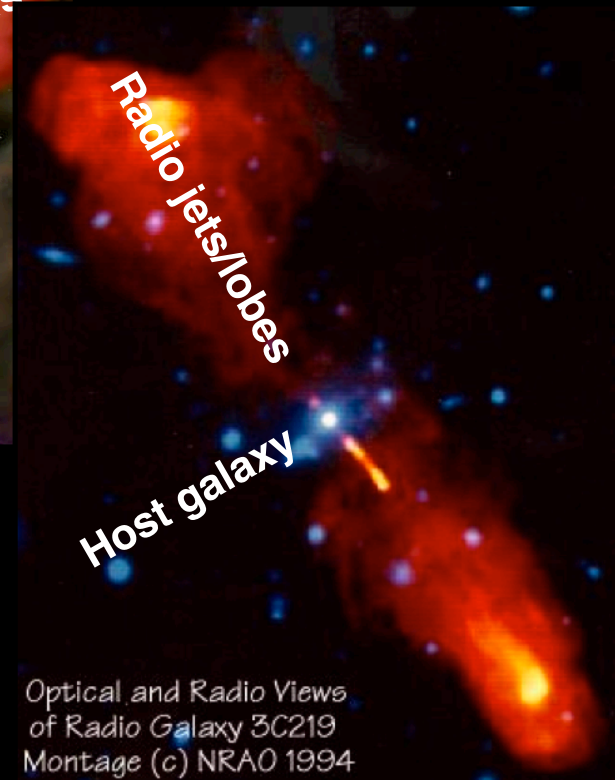
- Do we have a complete census of AGN activity and black-hole growth?
- Do we understand what drives the growth of black holes?
- Does AGN activity and star formation go hand in hand?
- Do we often see large-scale outflows, as predicted by models?

David M Alexander (Durham)

Schematic of an AGN and the power house

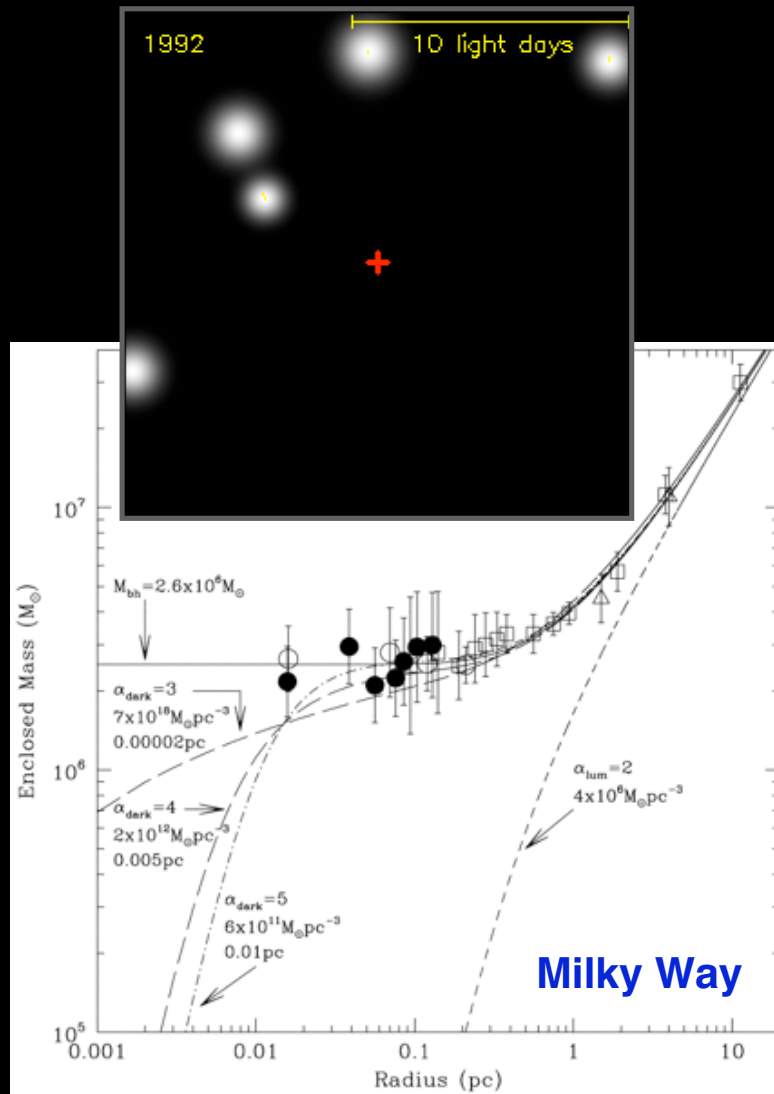


$$\Delta E \sim mc^2$$

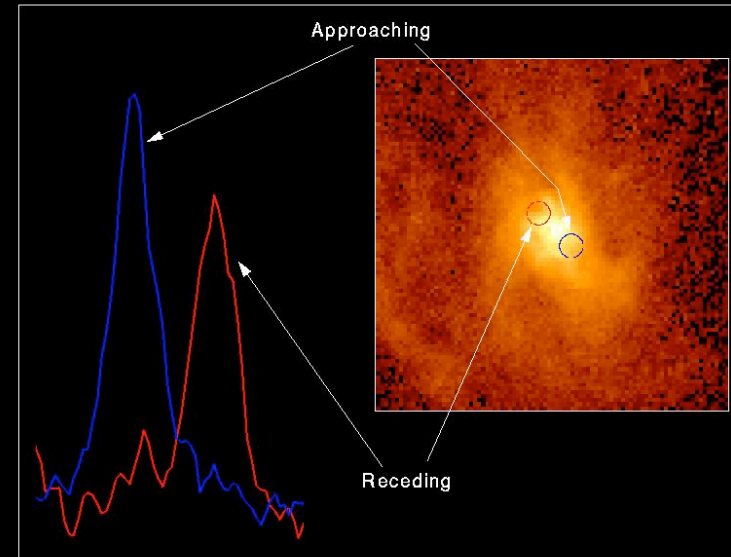


From <pc to >100 kpc

Massive galaxies host massive black holes



Spectrum of Gas Disk in Active Galaxy M87

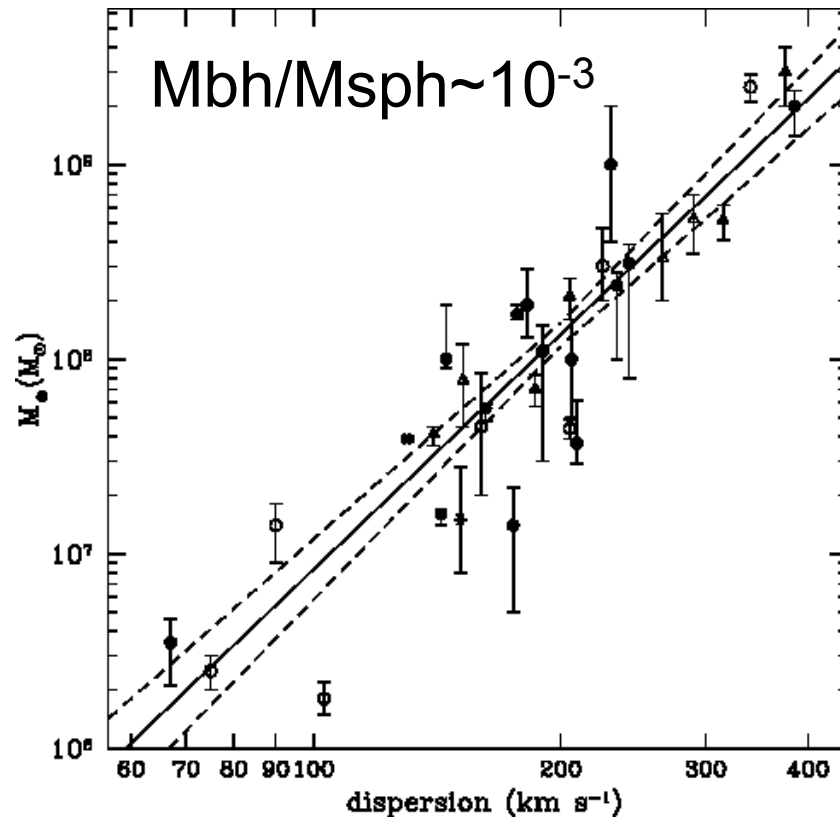


Hubble Space Telescope • Faint Object Spectrograph

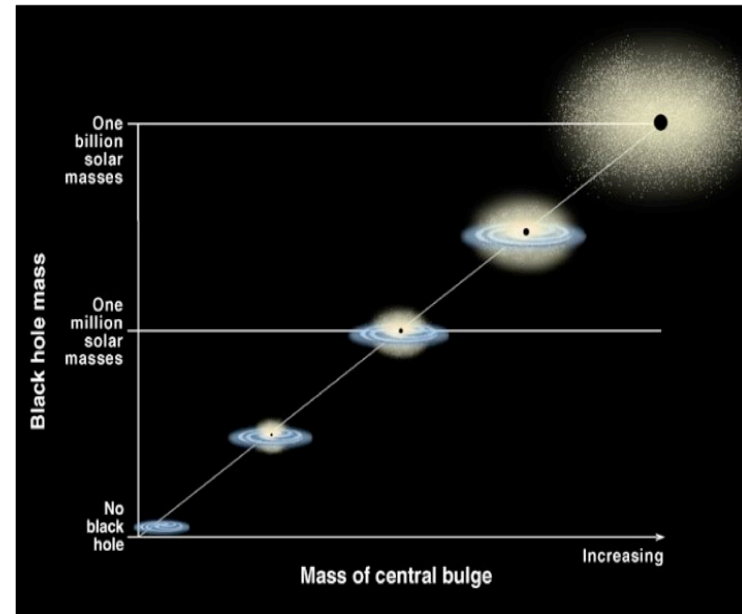


=> most (if not all) galaxies
have hosted luminous AGN
activity in the past!

Cosmological Importance of AGN activity



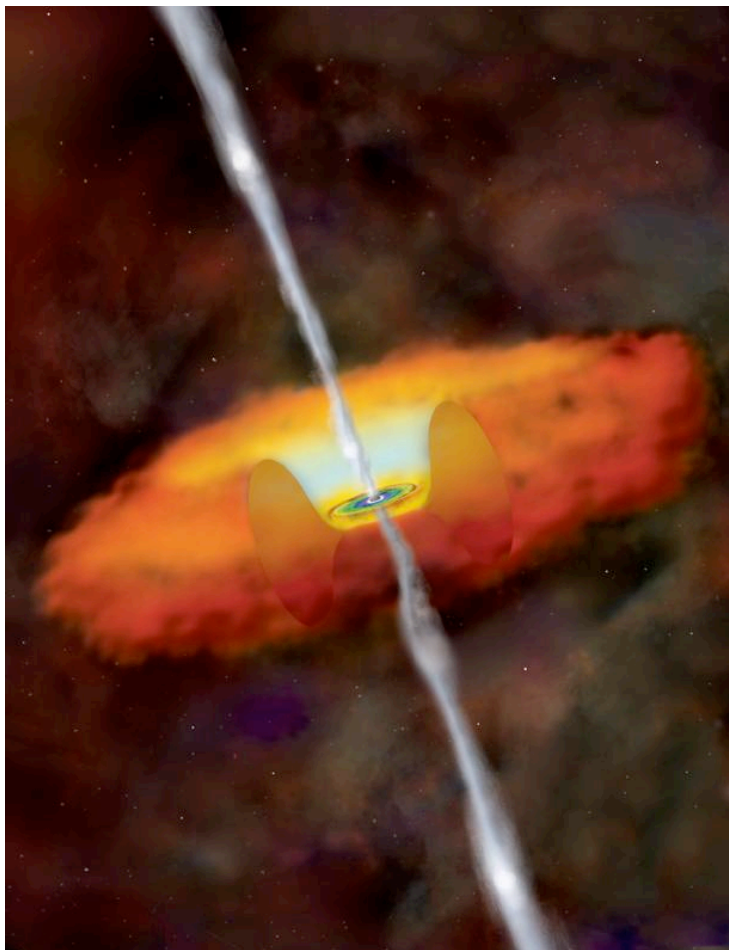
Action: AGN activity



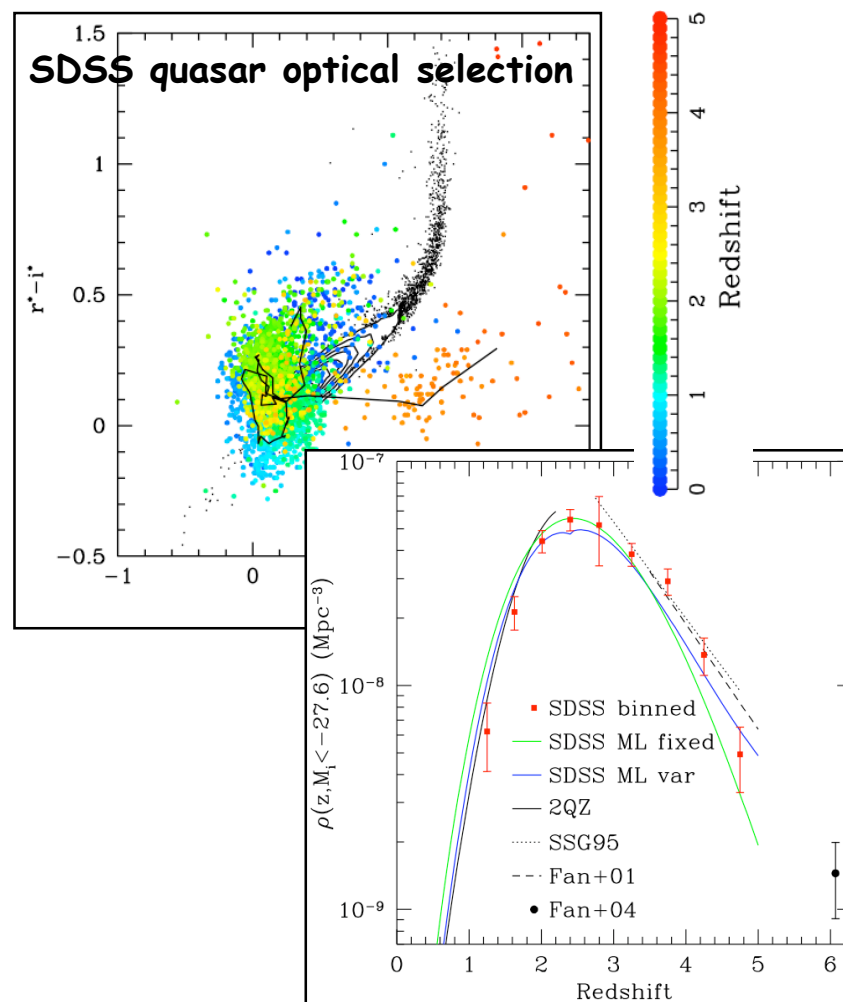
Action: Star formation

Tight connection between black hole and galaxy spheroid
Concordant growth despite a $\sim 10^9$ difference in size scale?

Difficulty in Constructing a Complete AGN Census

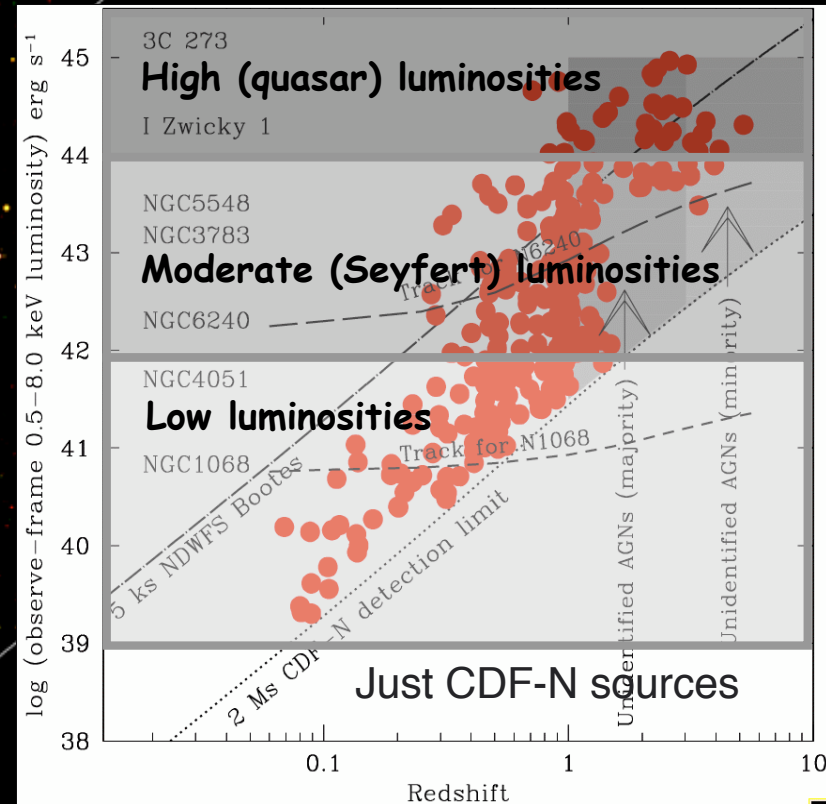
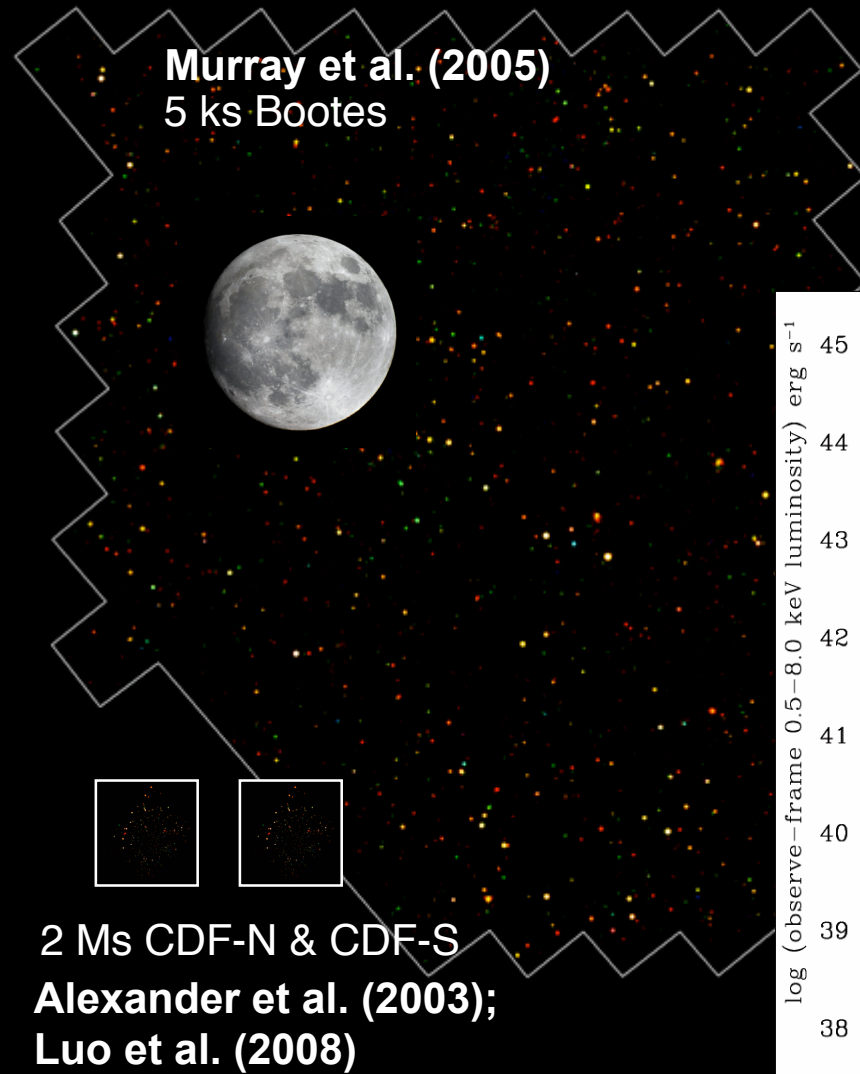


Most AGNs are hidden at optical wavelengths by dust and gas



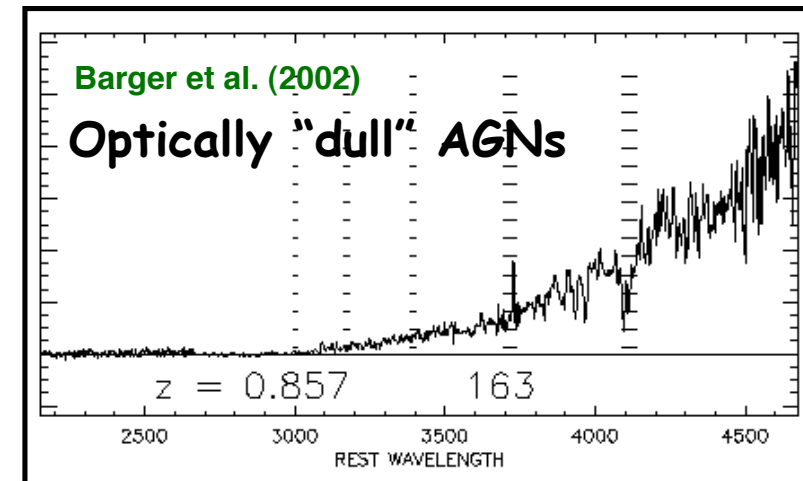
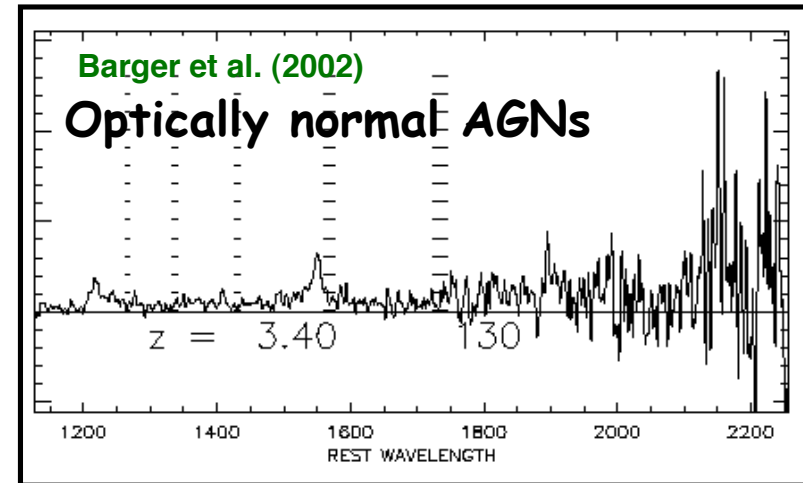
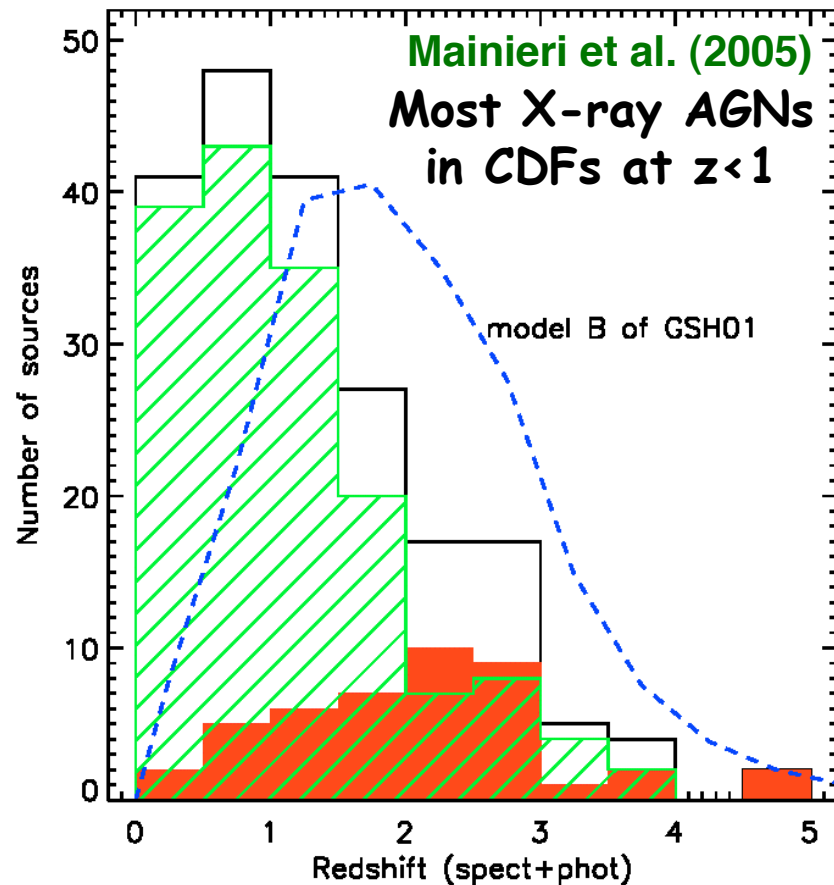
SDSS quasar surveys (optical) only find small fraction (~1-10%) of AGNs

X-ray Surveys: Penetrating Probe of AGN activity



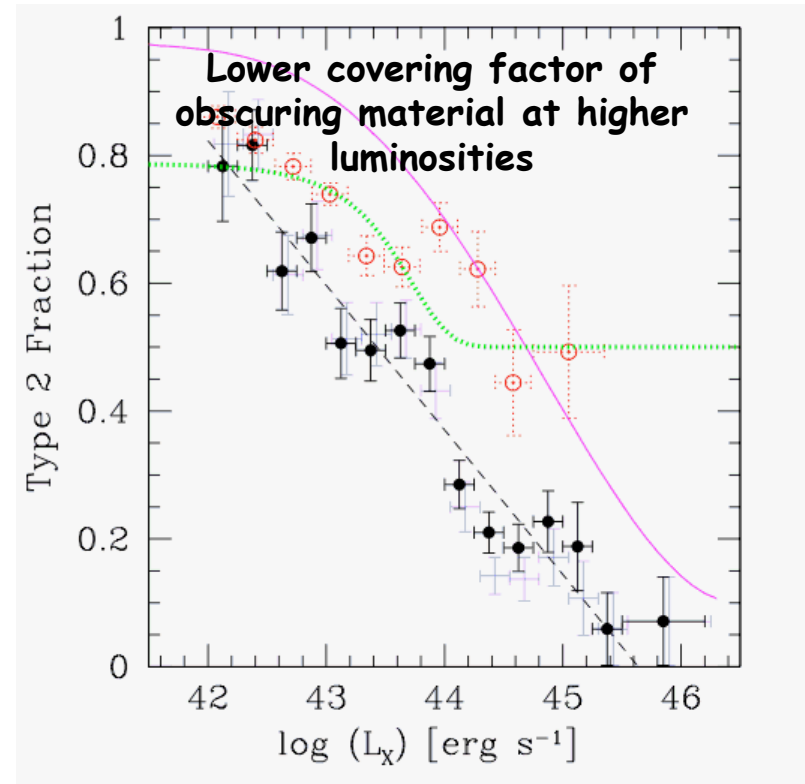
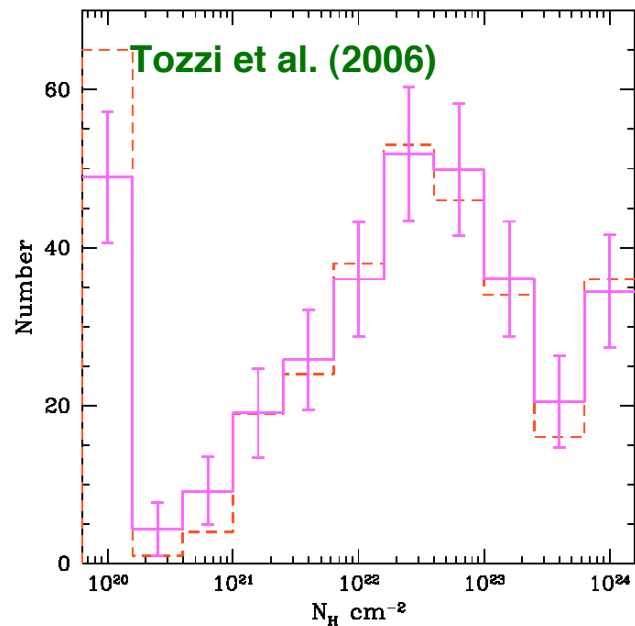
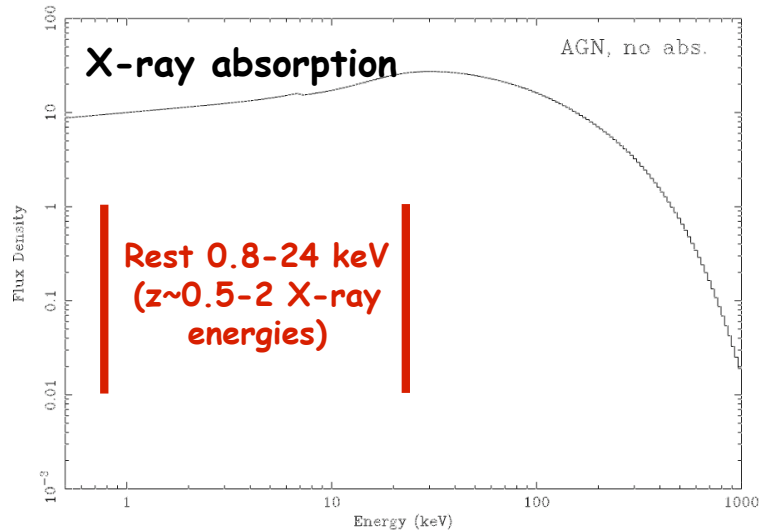
Detection of even low-luminosity AGN out to high redshift

Basic Properties of the X-ray AGNs



X-ray surveys have identified largest unambiguous AGN source density to date ($\sim 7200 \text{ deg}^{-2}$; Bauer et al. 2004): only $\sim 30\text{-}50\%$ have only photo-zs

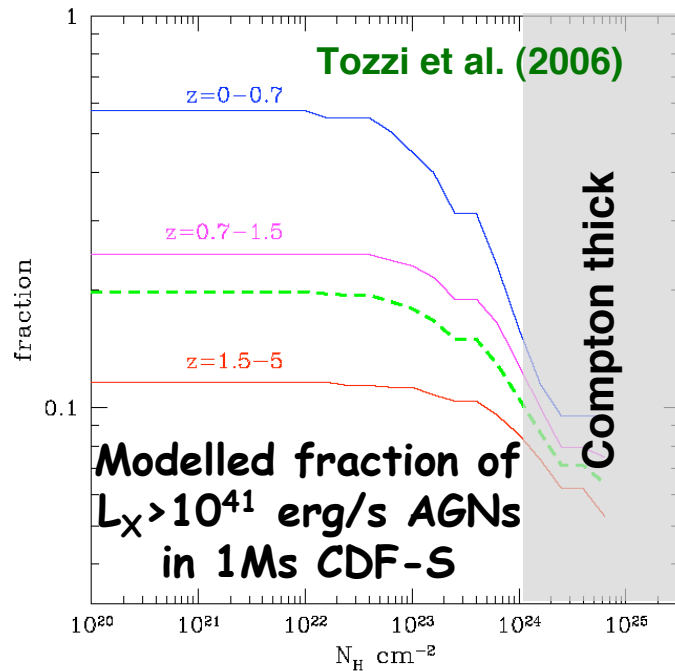
Most X-ray Identified AGNs are Obscured



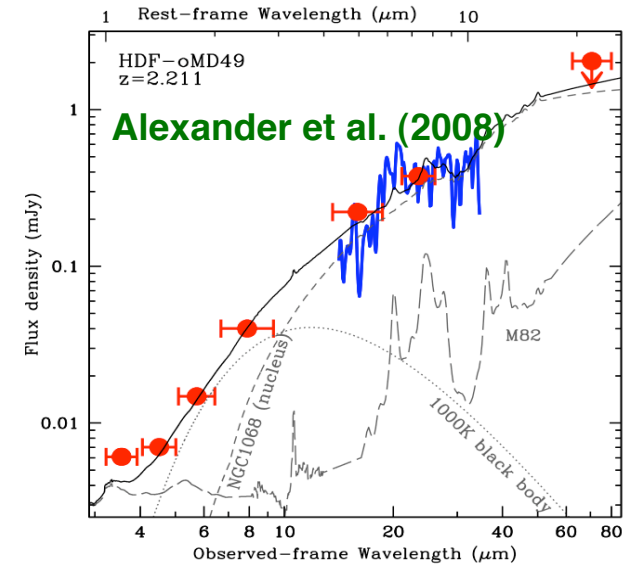
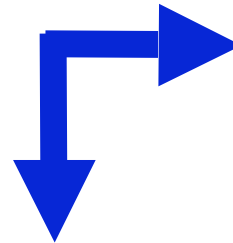
Absorption dependence with L_X and possibly redshift (e.g., Ueda et al. 2003; La Franca et al. 2005; Hasinger 2008)

See Mullaney talk for evidence of larger dust covering factor at high- z from Spitzer

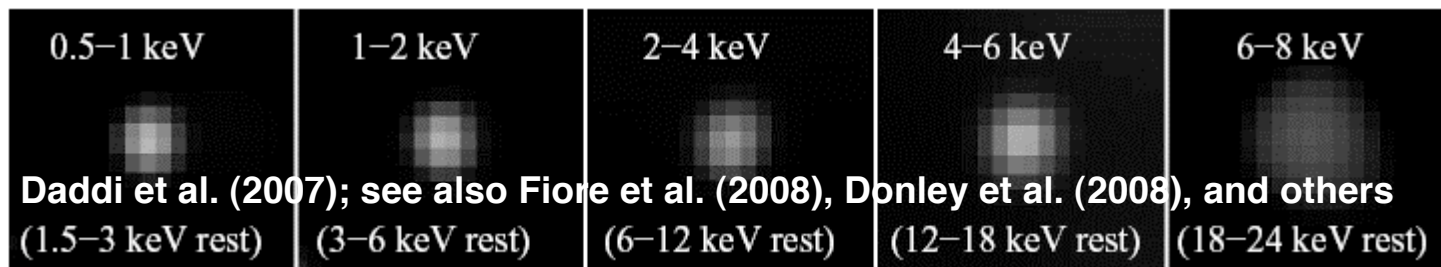
Large number of AGNs remain undetected: many can be identified at infrared wavelengths



~50% of luminous AGNs undetected: Compton thick? Many identifiable in the infrared band



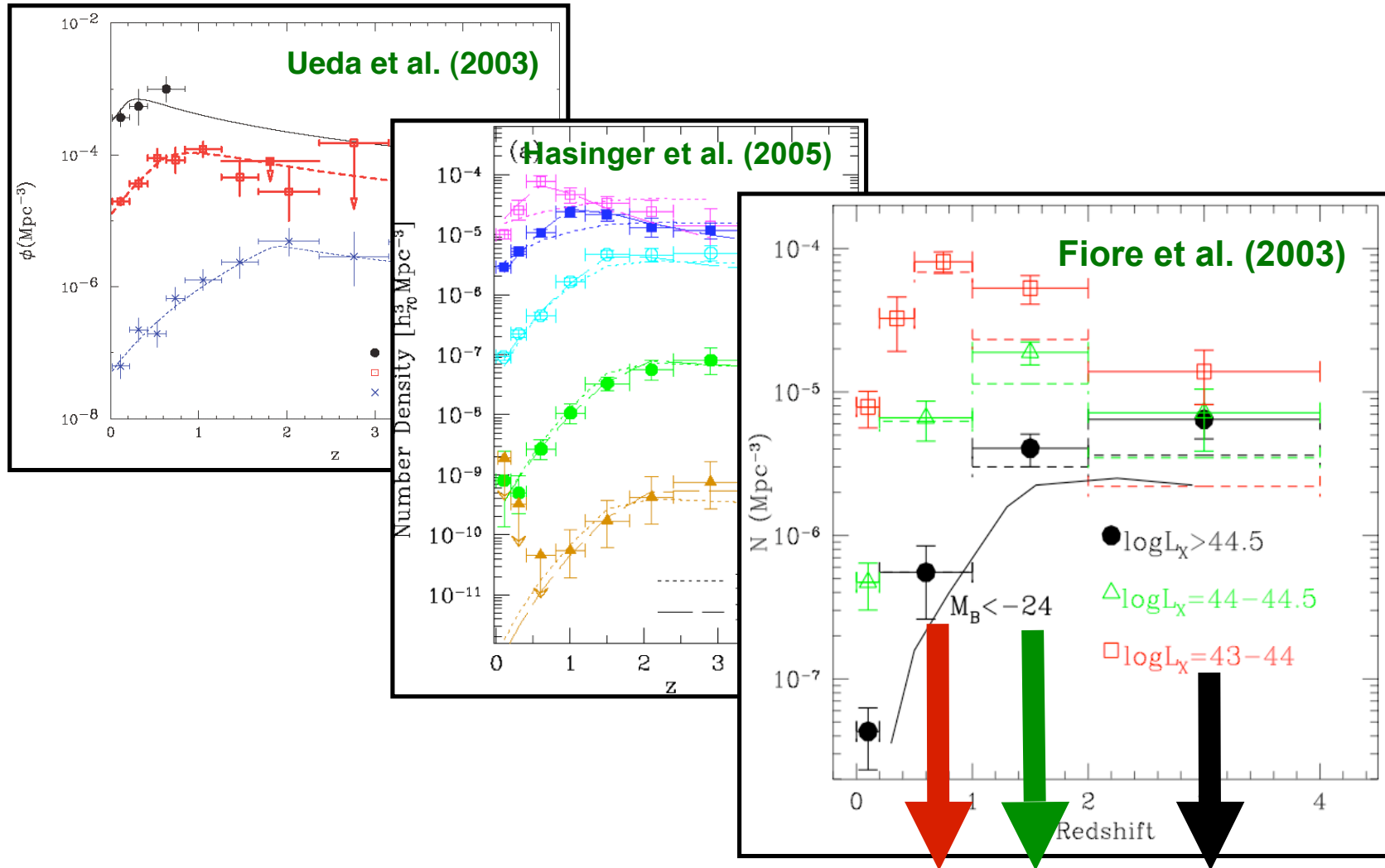
Below detection limit: stacked X-ray data of IR-bright galaxies



Very hard signal => significant fraction of obscured AGNs

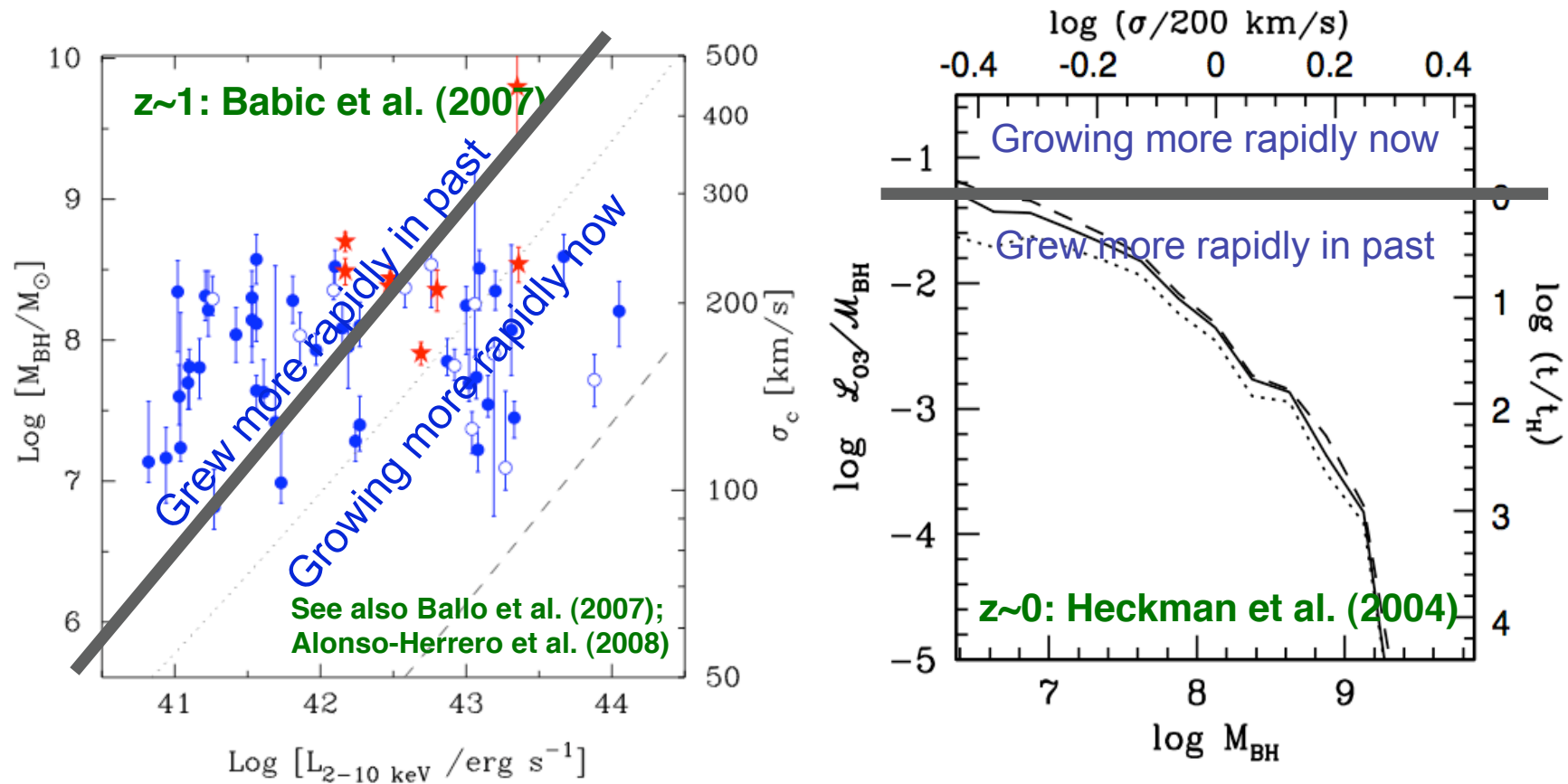
Potential for Herschel to identify many Compton-thick AGNs (see Mullaney talk)

"Cosmic Downsizing" in AGN population



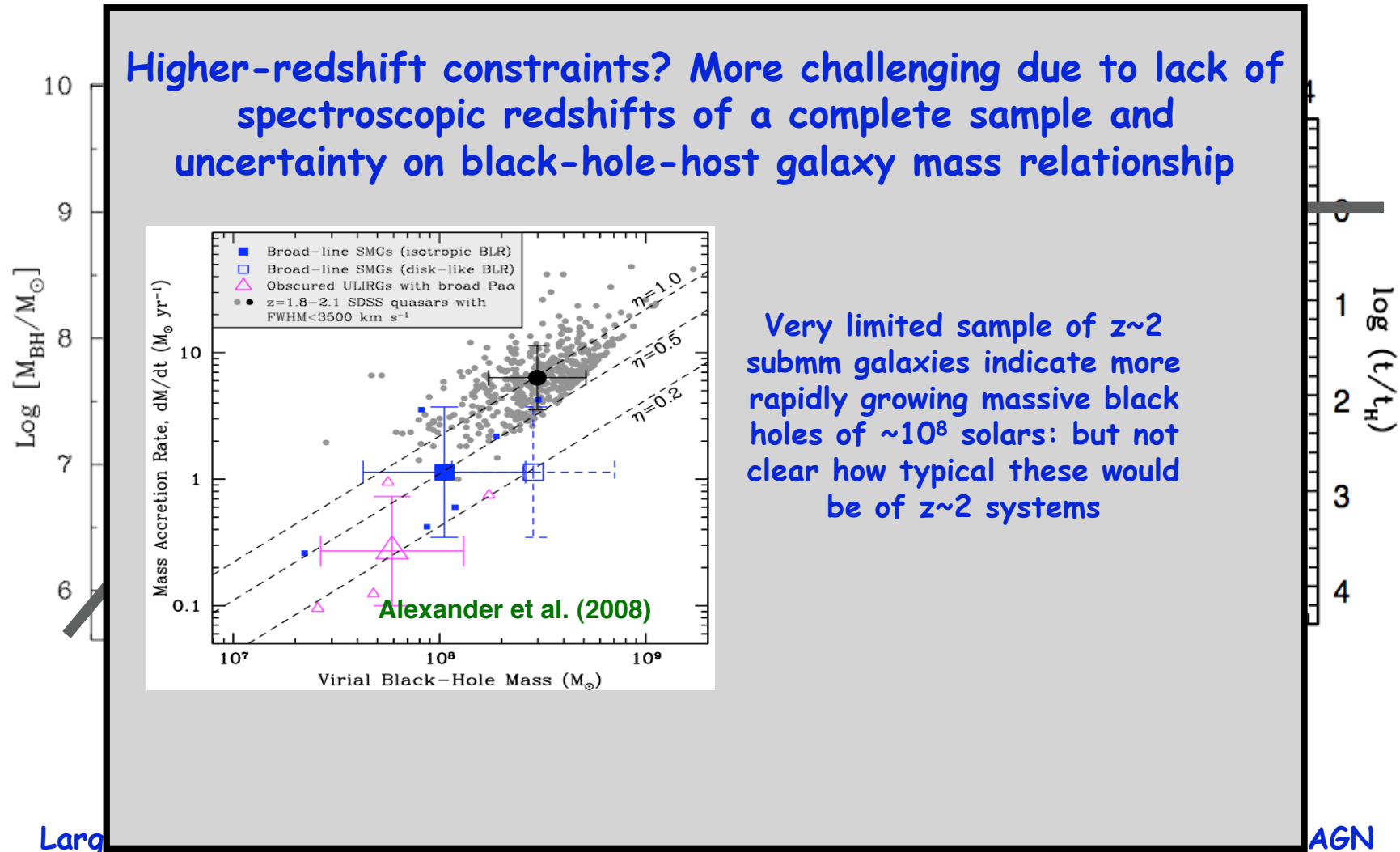
Luminosity-dependent density evolution: high-luminosity AGNs (i.e., quasars) peaked at higher redshifts than typical AGNs... note consistent refinements from Aird talk yesterday

Black-hole growth constraints on $z \sim 1$ AGNs



Larger black holes were more "active" at $z \sim 1$ than found at $z \sim 0$... appears as though AGN downsizing is similar to galaxy downsizing - the biggest things grew first... but may be missing lower-mass black holes in X-ray surveys (e.g., Shi et al. 2008)

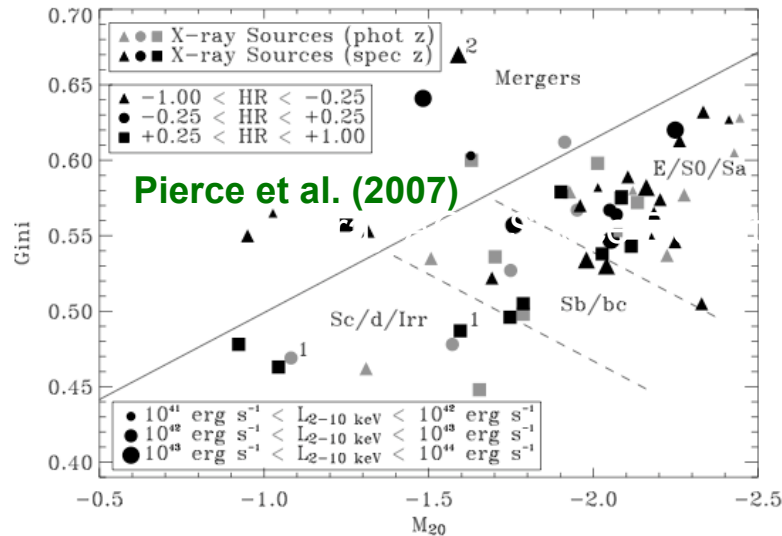
Black-hole growth constraints on $z \sim 1$ AGNs



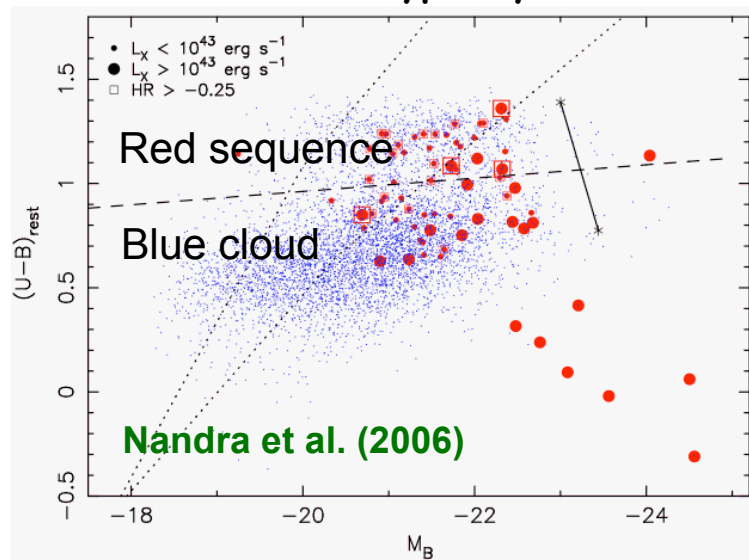
Larger AGN downsizing is similar to galaxy downsizing - the biggest things grew first... but may be missing lower-mass black holes in X-ray surveys (e.g., Shi et al. 2008)

Where is the $z < 1$ black-hole growth occurring?

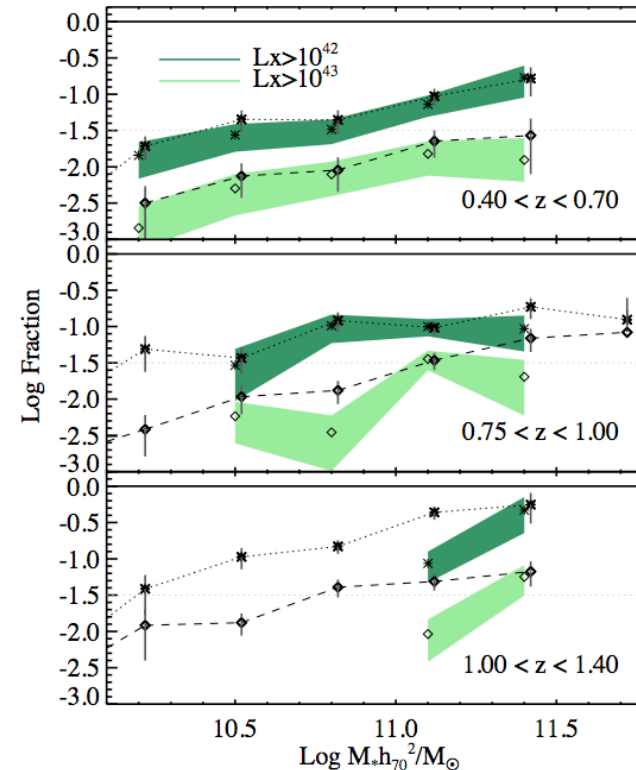
AGN activity typically not merger induced



AGN hosts are typically red



Mass-dependent AGN fraction



Most $z < 1$ black-hole growth appears to be comparatively slow and occurs over long timescales: picture at $z > 2$ is more unclear

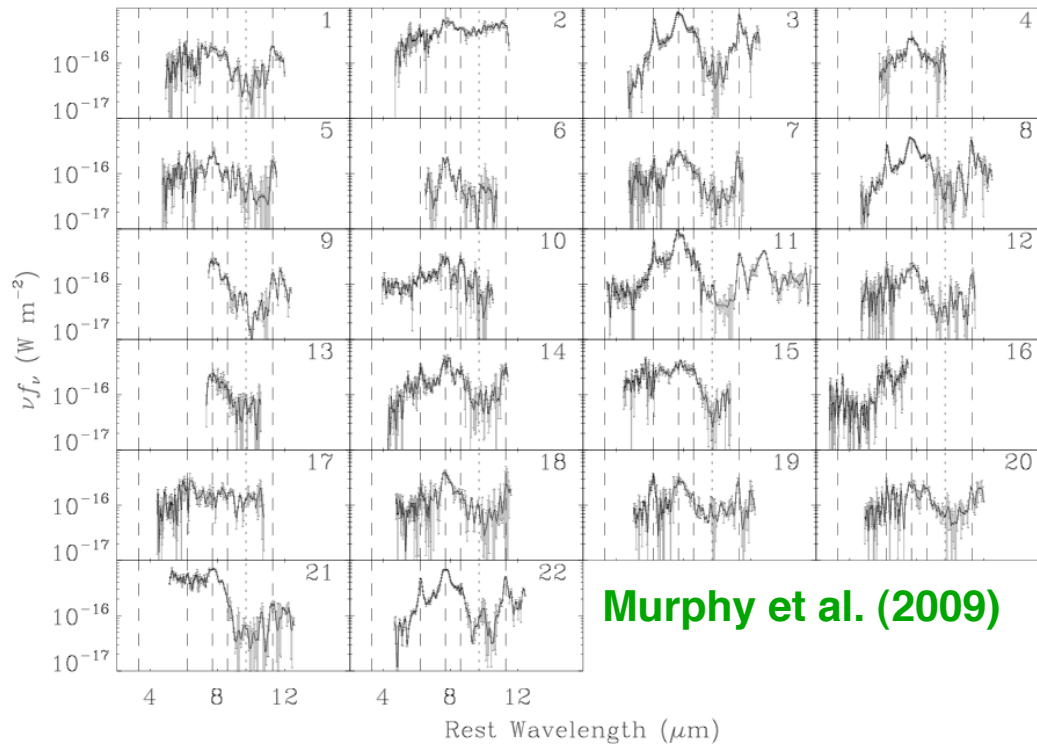
AGN activity enhanced in overdense regions (Silverman et al. 2008; Georgakakis et al. 2008): see Lehmer talk and Digby-North poster

But does star formation and AGN activity go hand in hand?

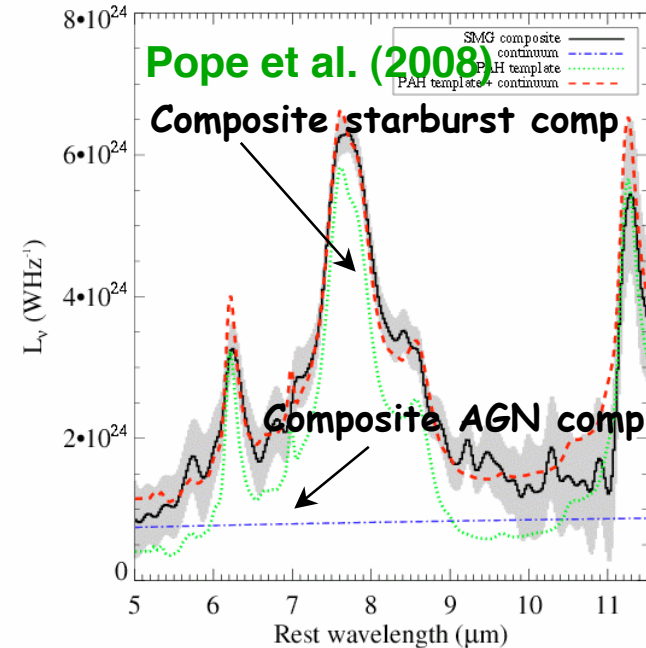
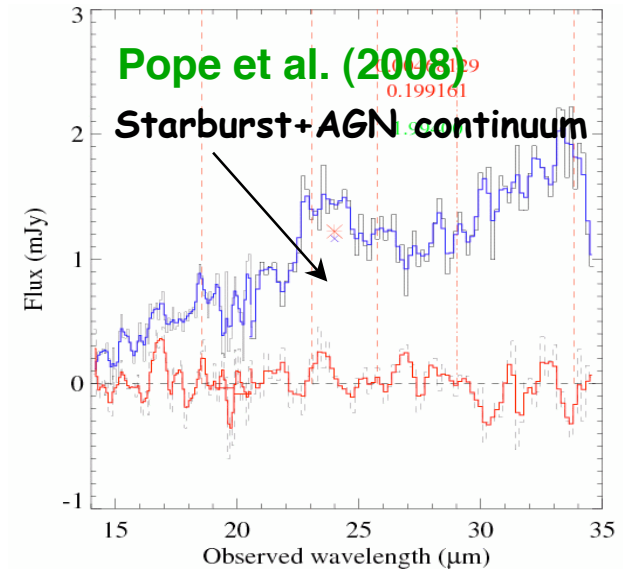
Starburst and AGN signatures often seen in individual objects



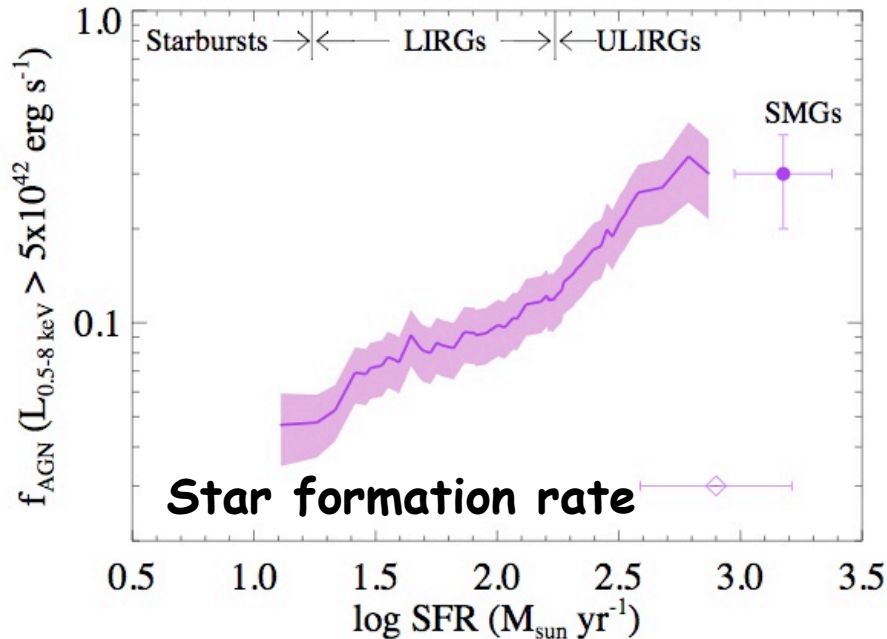
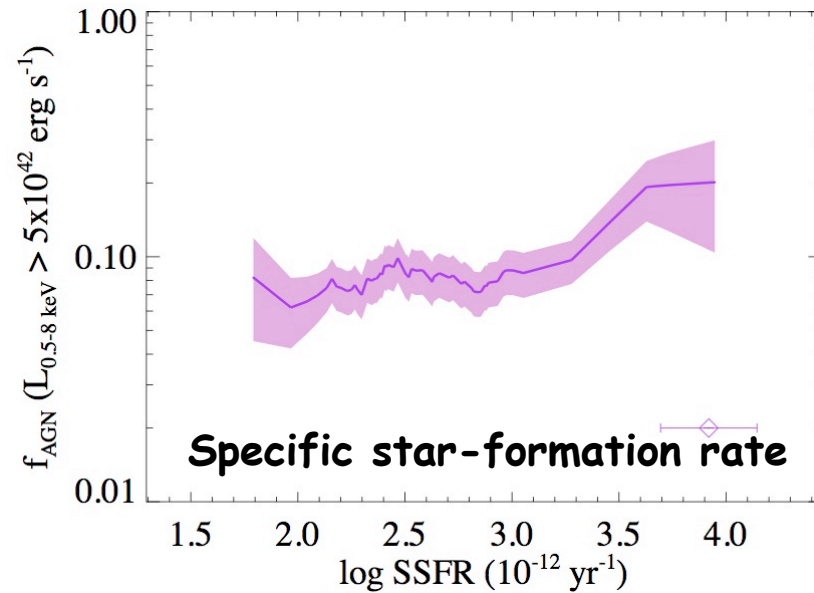
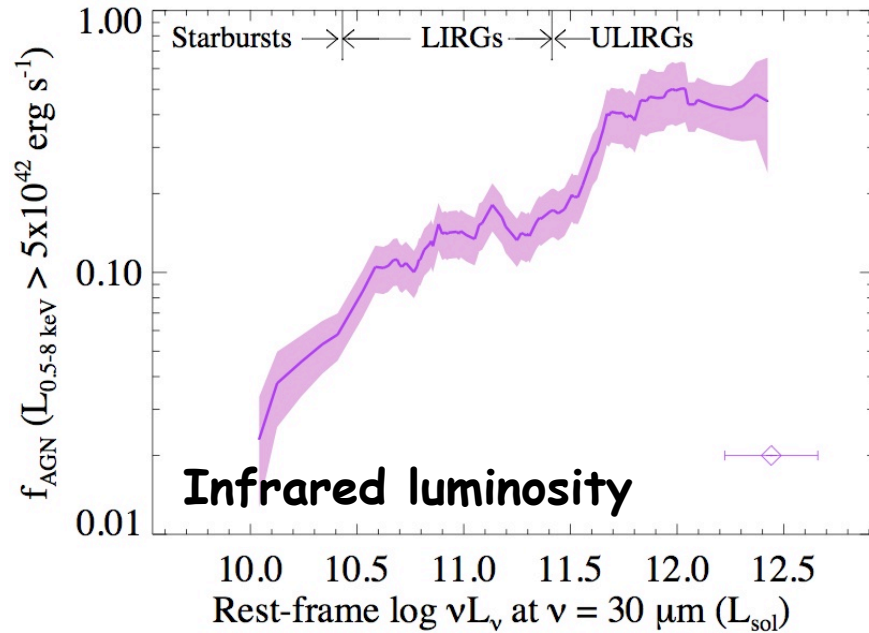
X-ray AGNs and infrared galaxies



Submm galaxies



$z < 2$ AGN fraction as function of L_{IR} and SFR



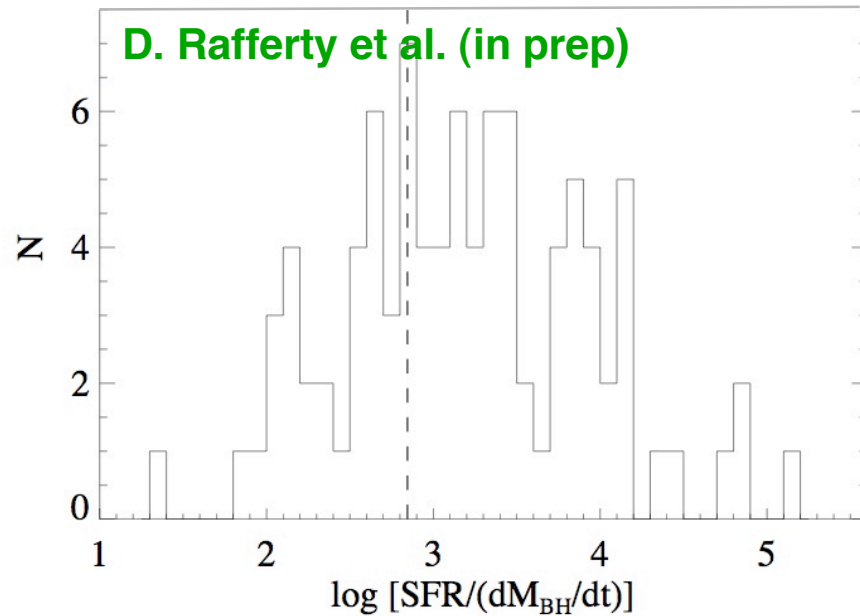
X-rays & Spitzer 24+70um

AGN fraction increases with both L_{IR} and SFR (consistent with those found for SMGs at higher z and larger L_{IR})

BUT flatter when look at SSFR: not clear what driver is

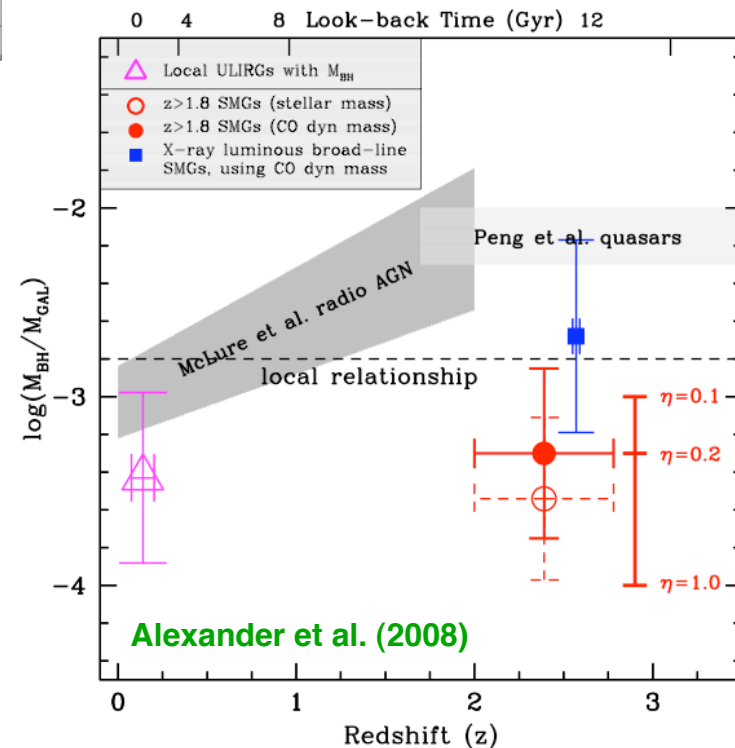
D. Rafferty et al. (in prep)

Combined black-hole stellar growth?

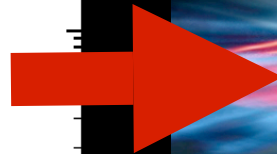
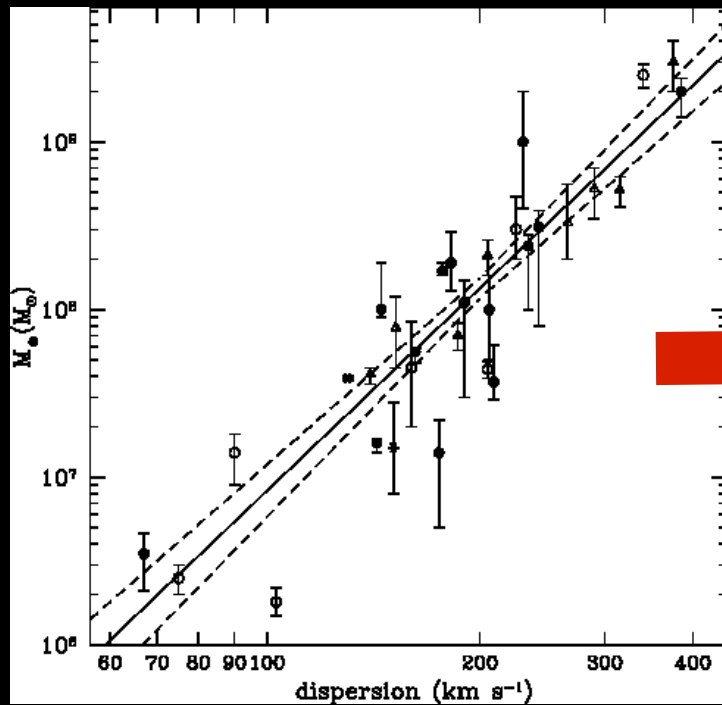


Average black hole and stellar growth rates are consistent with local black-hole-spheroid mass ratio BUT clearly large variety in individual objects (cf Silverman et al. 2008)

Even in the most rapidly evolving objects at $z \sim 2$ (submm galaxies: SMGs) we do not see a strong deviation from the local black-hole-spheroid mass ratio

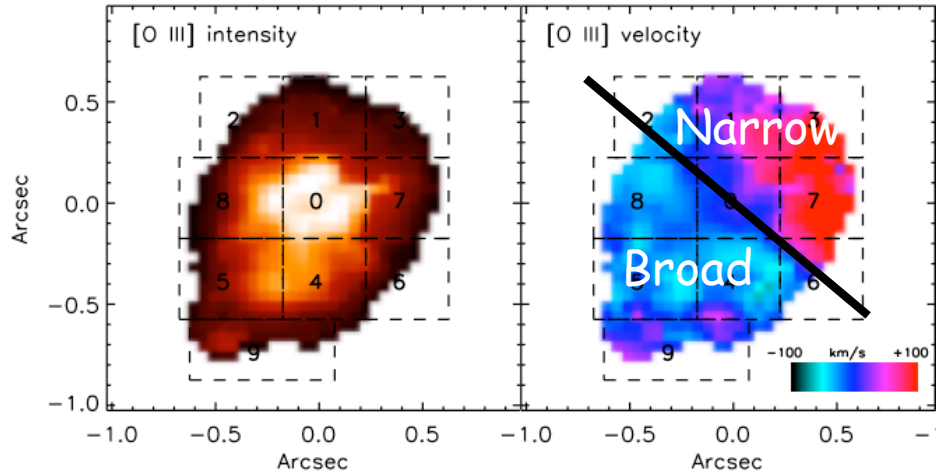


Is there evidence for large-scale outflows in the most luminous $z \sim 2$ objects, as predicted by models?

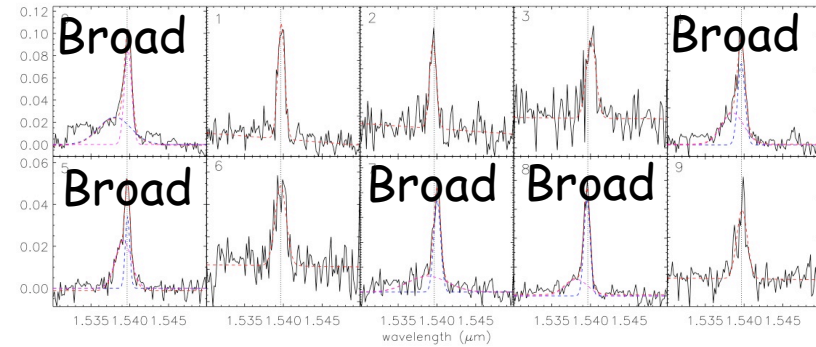


Yes we do with Gemini NIFS IFU observations

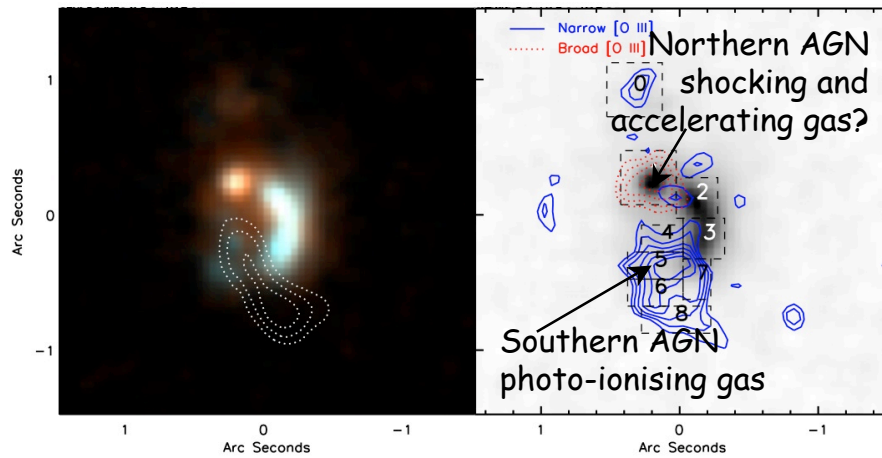
J1237+6203 ($z=2.07$)



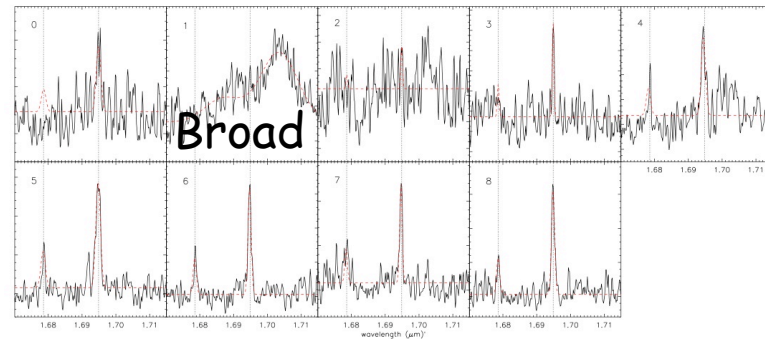
Broad over ~ 7 kpc on one side of galaxy:
 FWHM(OIII) ~ 800 km/s
 Velocity offset ~ 300 -500 km/s



J1636+4057 (ELAIS N2.4; $z=2.38$)

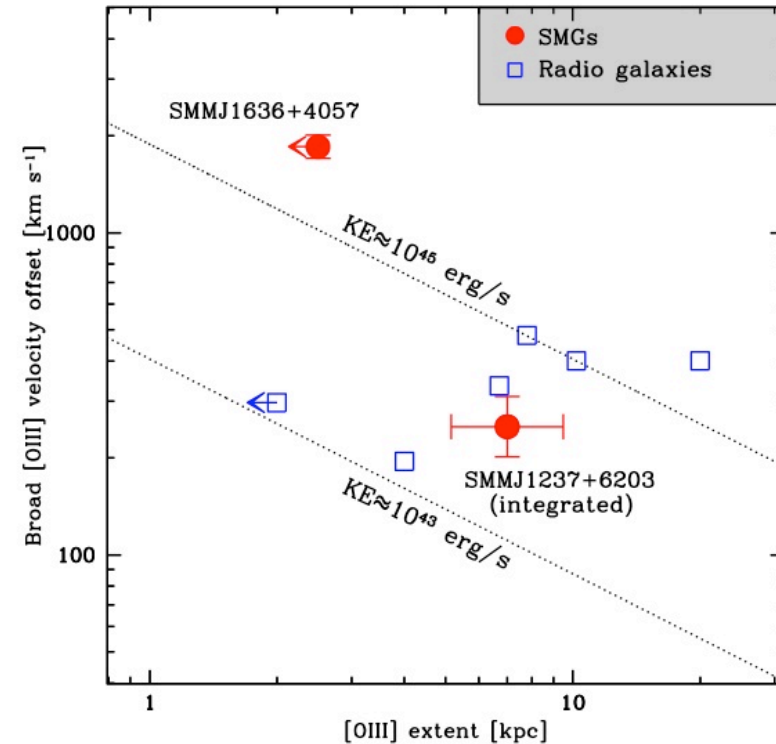
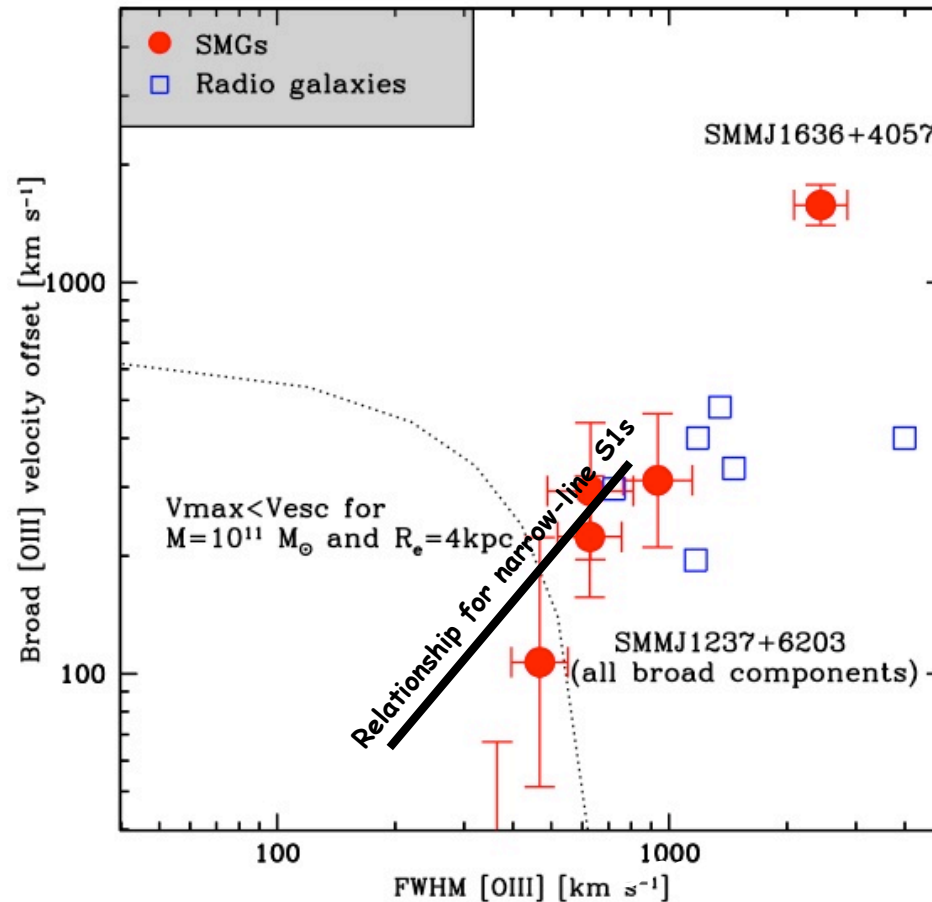


FWHM(OIII) ~ 2500 km/s!
 Velocity offset ~ 2000 km/s!
 Unresolved ($r < 2.5$ kpc)



Alexander, Swinbank et al. (in prep)

AGN outflows? Properties similar to distant radio galaxies and narrow-line Seyfert 1s



Alexander, Swinbank et al. (in prep)

But it is currently not clear what mechanism is driving the outflows in SMGs (luminous radio jets not present unlike the radio gals; Nesvadba et al. 2008)... also not clear how ubiquitous these outflows are (need more IFU observations)

Back to the Key Broad Questions

- Do we have a complete census of AGN activity and black-hole growth?

Partially: Combination of X-ray and infrared we are getting there, although also need better spectroscopic, infrared coverage, and harder energy X-ray observations

- Do we understand what drives the growth of black holes?

Starting to get there: The most detailed studies are restricted to $z < 1$ (limited information on $z > 1$ due to faintness of AGNs) but the effect of environment as a function of redshift is largely unknown

- Does AGN activity and star formation go hand in hand?

Globally apparently so (even for strongly evolving objects) although there is wide variety of properties on an object by object basis... better infrared data (Herschel; SCUBA2) will greatly help

- Do we often see large-scale outflows, as predicted by models?

Far from clear how common but outflows are certainly seen in some cases: IFU observations of more objects are required