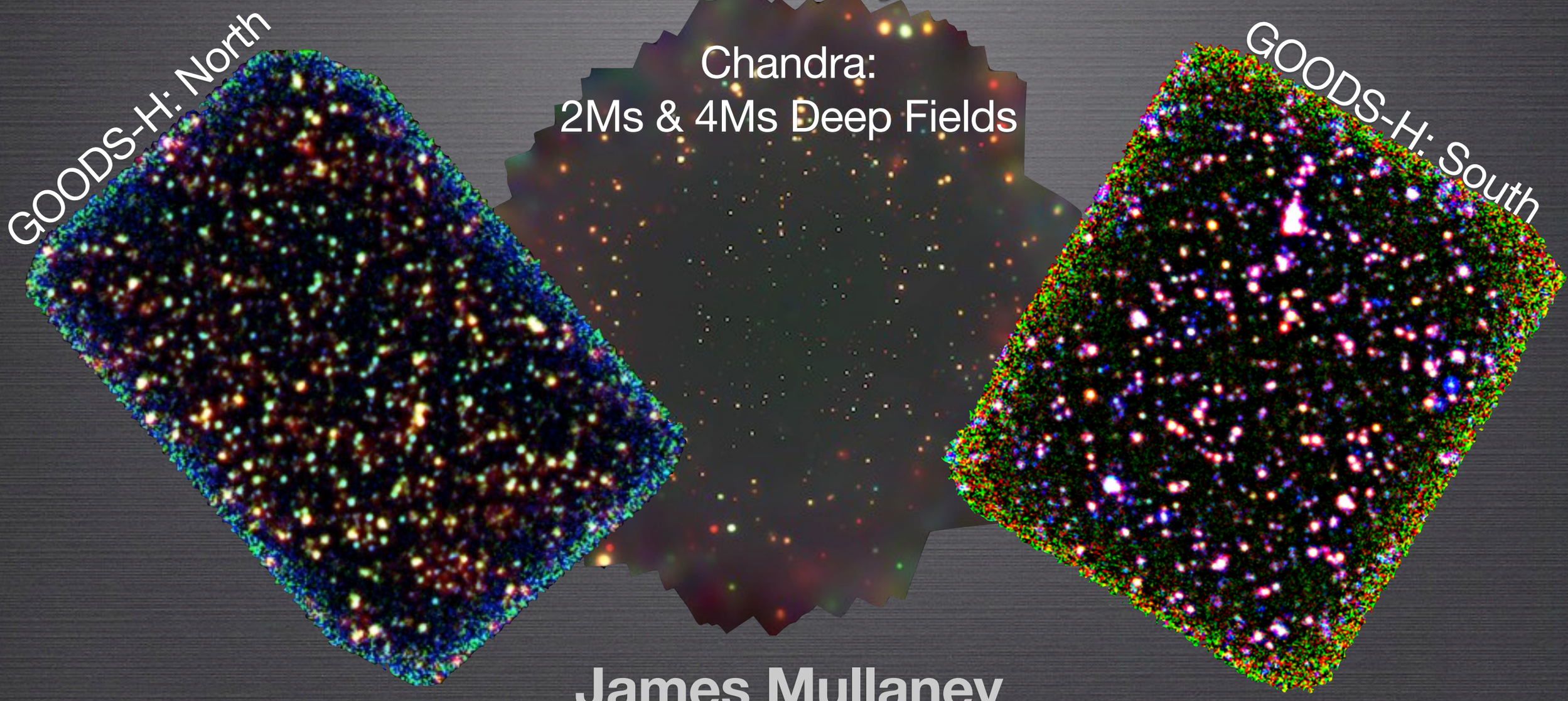
The GOODS-Herschel view of the build up of SMBH and galaxy mass since z~3.



James Mullaney

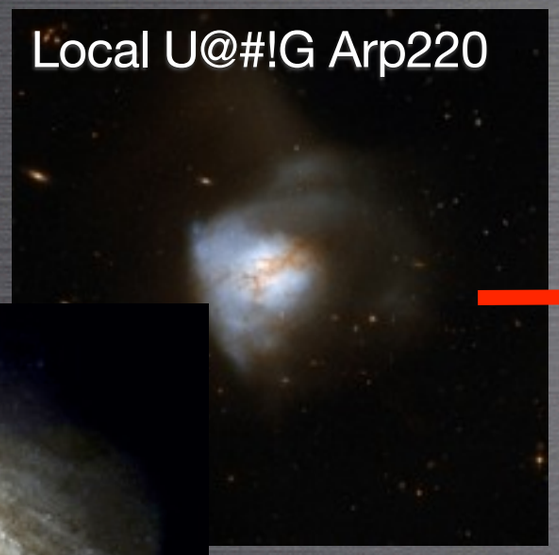
M. Panella, E. Daddi, D. Alexander, D. Elbaz, F. Bournaud

& the GOODS-Herschel team

Galaxy Formation, Durham, July 2011, arXiv: 1106.4284

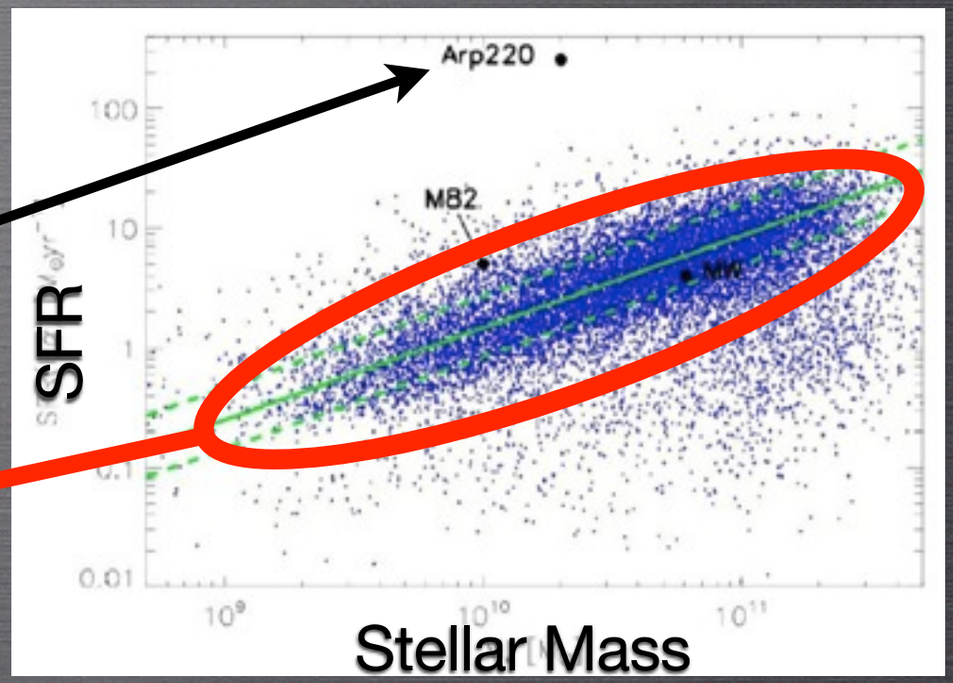
Star formation in mergers and clumps

Low z:



"Starburst" (Merger)

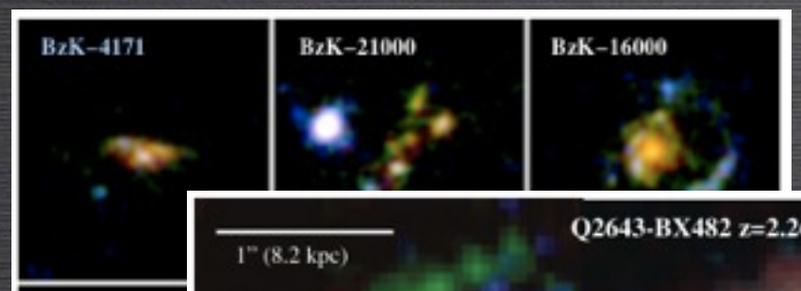
"Main Sequence"



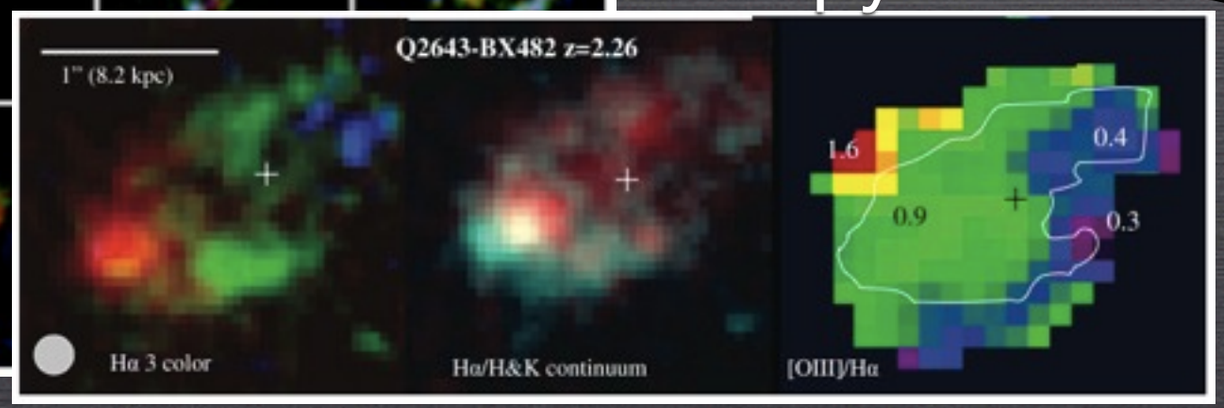
Elbaz+07

Merger (e.g., Tacconi+06)

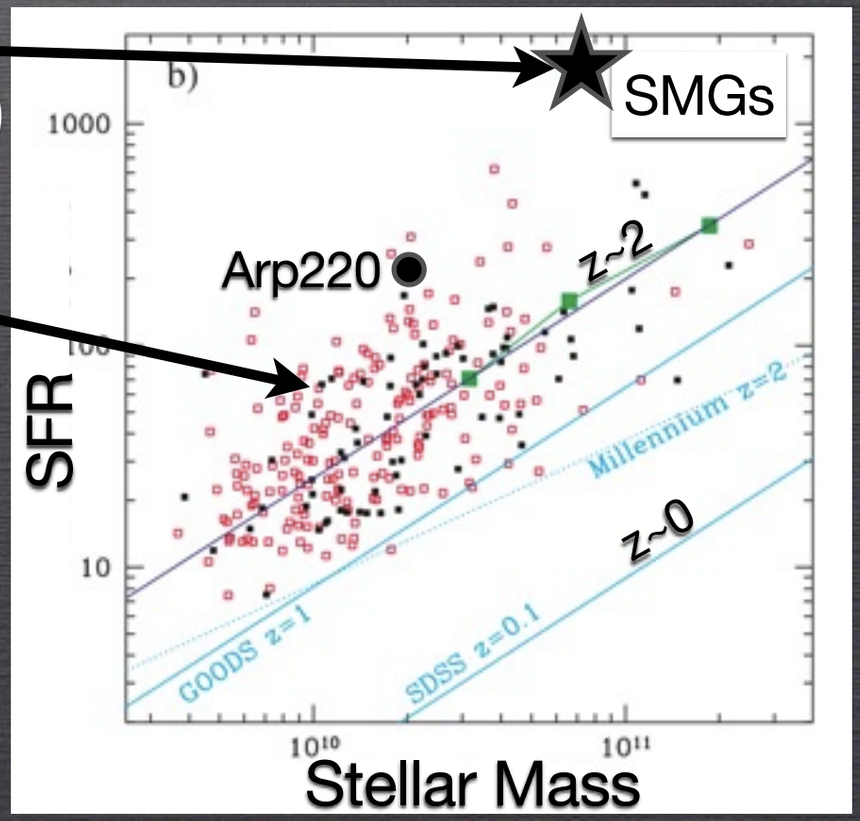
High z:



Clumpy disks



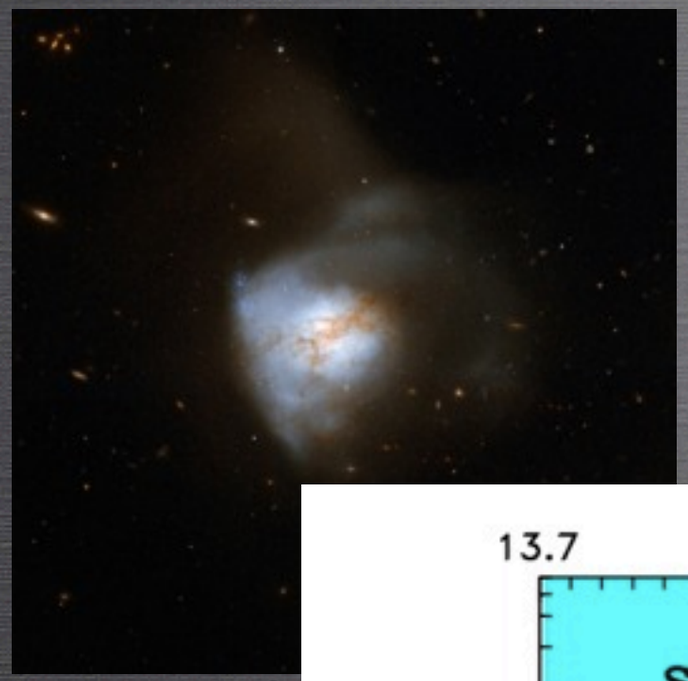
Genzel+08, Elmegreene+09, Daddi+10,



Daddi+07

Star formation in mergers and clumps

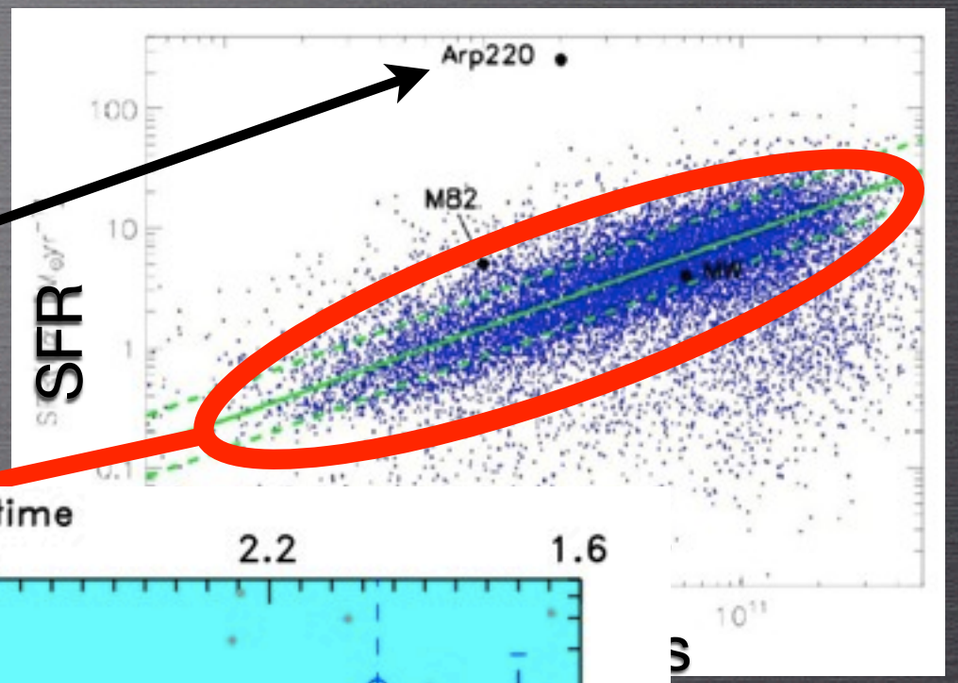
Low z:



Local ULIRG

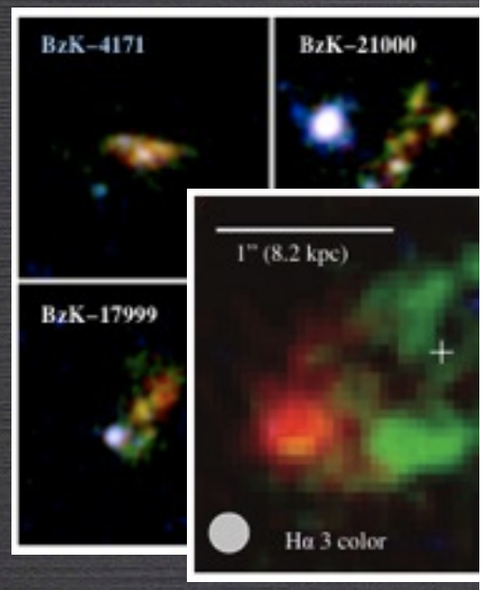
"Starburst" (Merger)

"Main

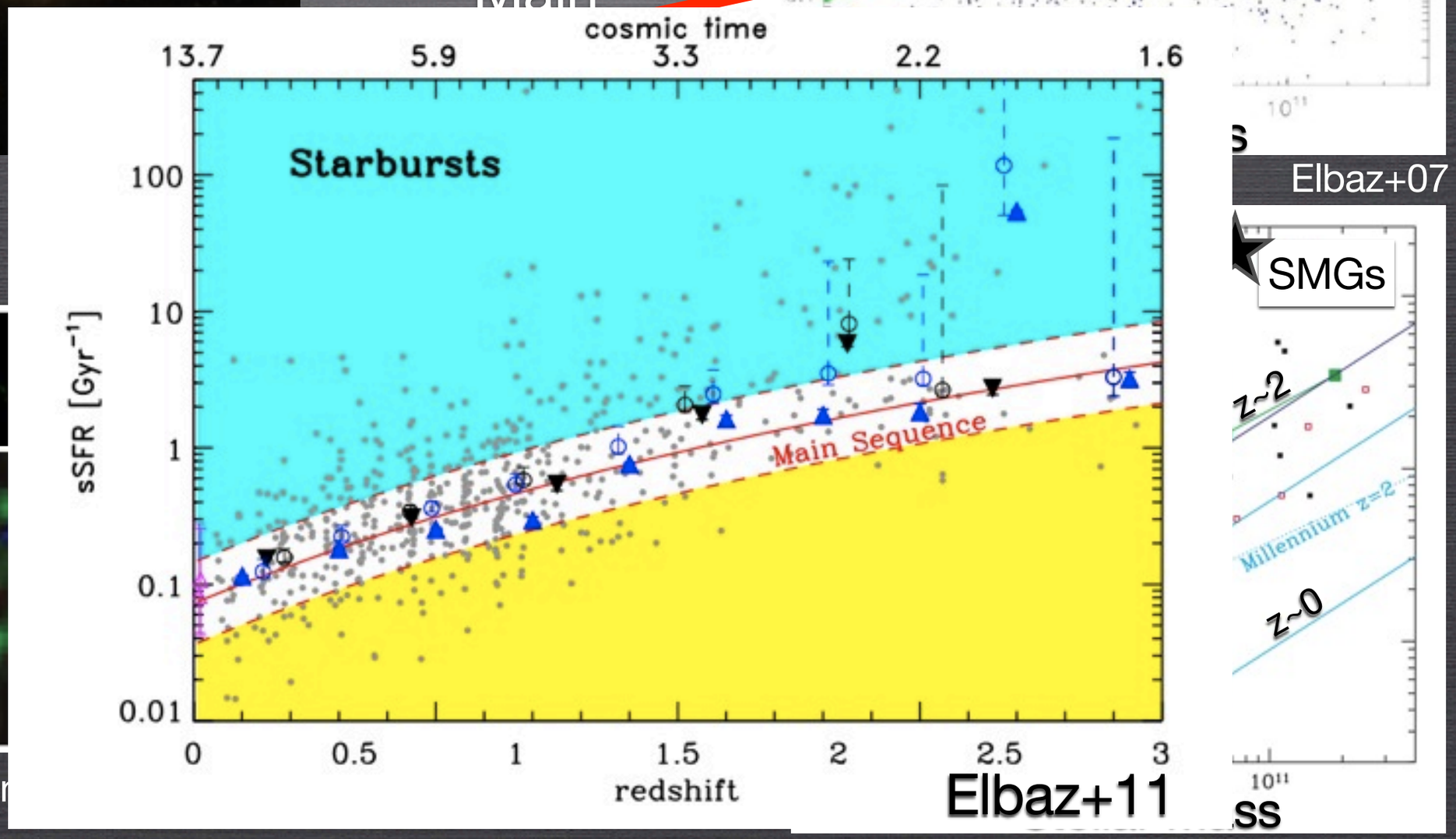


Elbaz+07

High z:



Genzel+08, Elmegreen
Daddi+10,

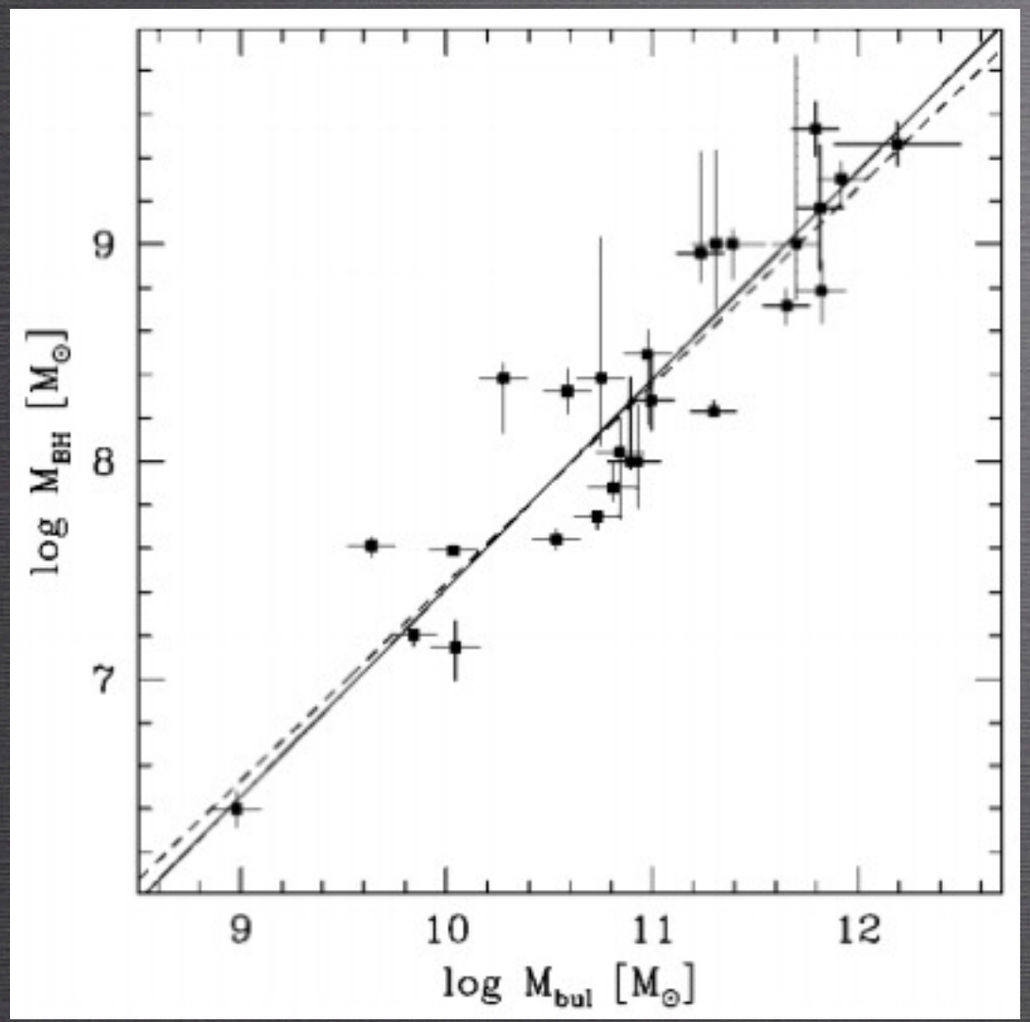


Elbaz+11

ss

Daddi+07

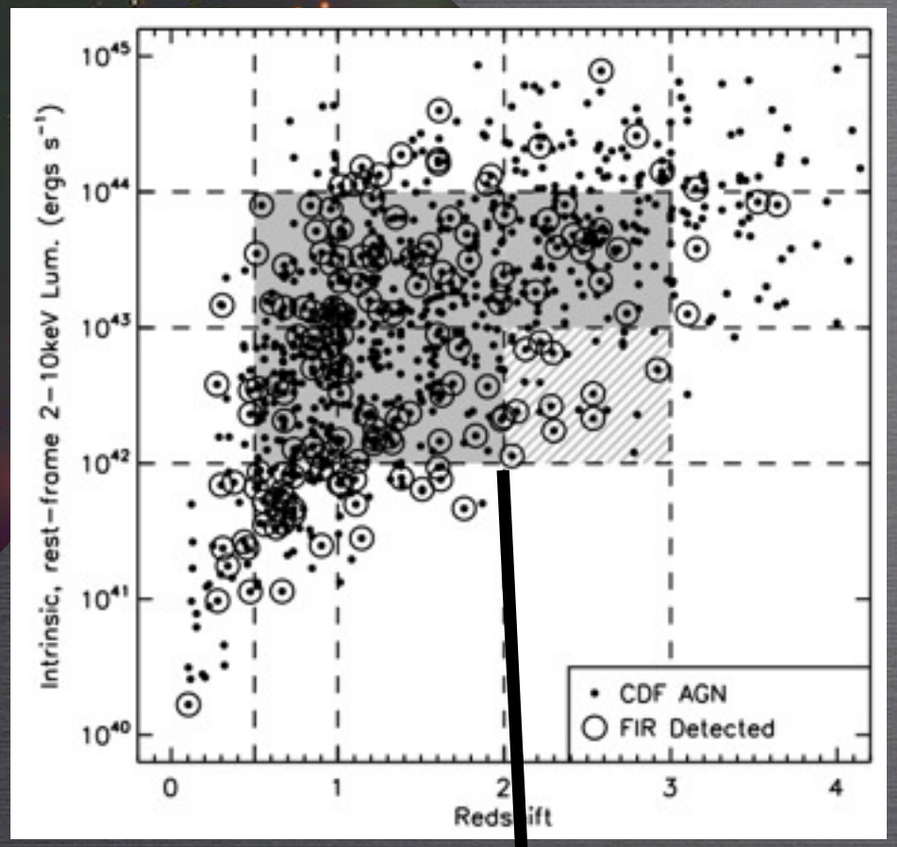
Galaxy - SMBH links



Marconi & Hunt (2003)
(also Magorrian+98, Gebhardt+00, McLure+02 etc.)

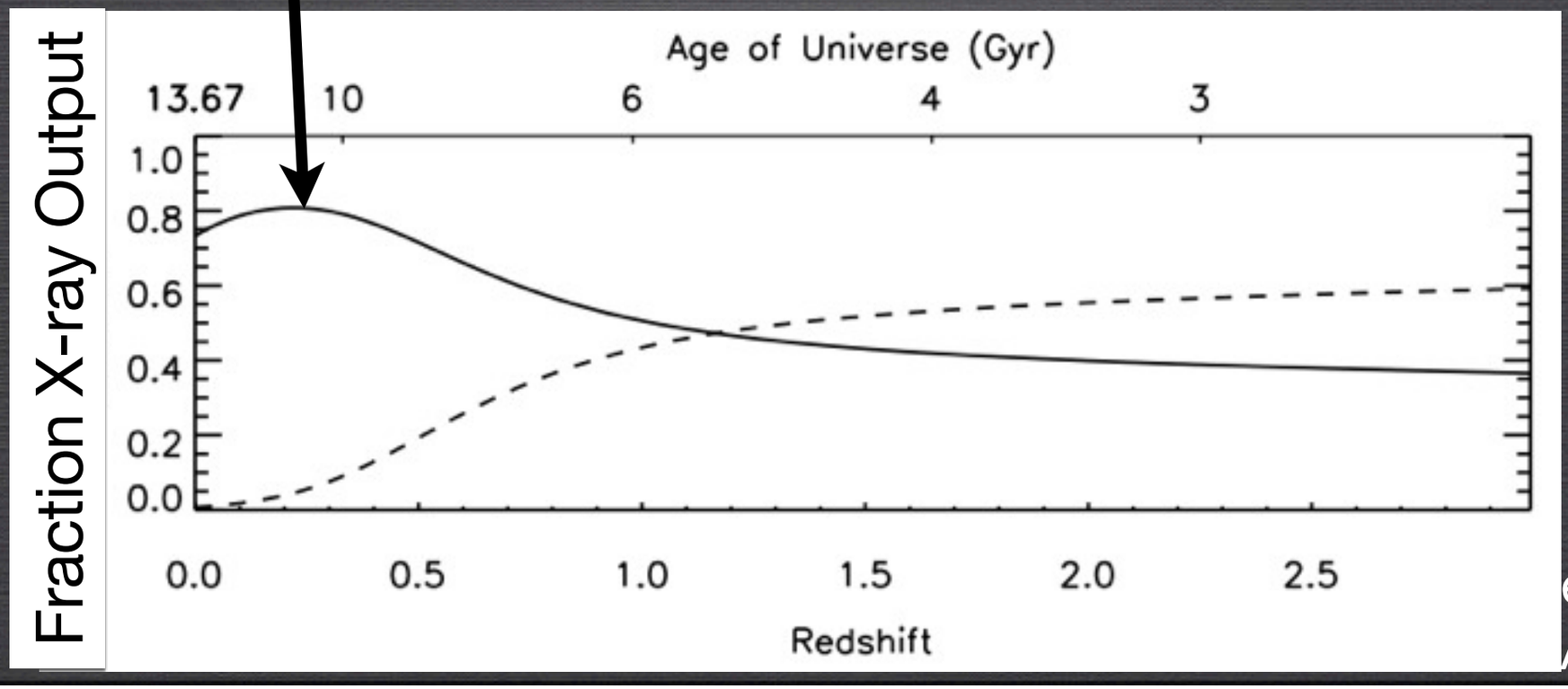
- How does black hole growth, or nuclear activity, fit in this picture?
- What type of galaxies do AGNs “live” in?

Star formation in AGN hosts



- Chandra Deep Fields
  2Ms North; 4Ms South
  (Alexander+03, Xue+11)
- Moderate Luminosity AGNs:
  Lx=10^{42} - 10^{44} ergs/s; “Sub-quasar”
- ~66% of X-ray output at z<1
  ~55% of X-ray output at z<3
- ~60% of BH growth at z<1*
  ~40% of BH growth at z<3*

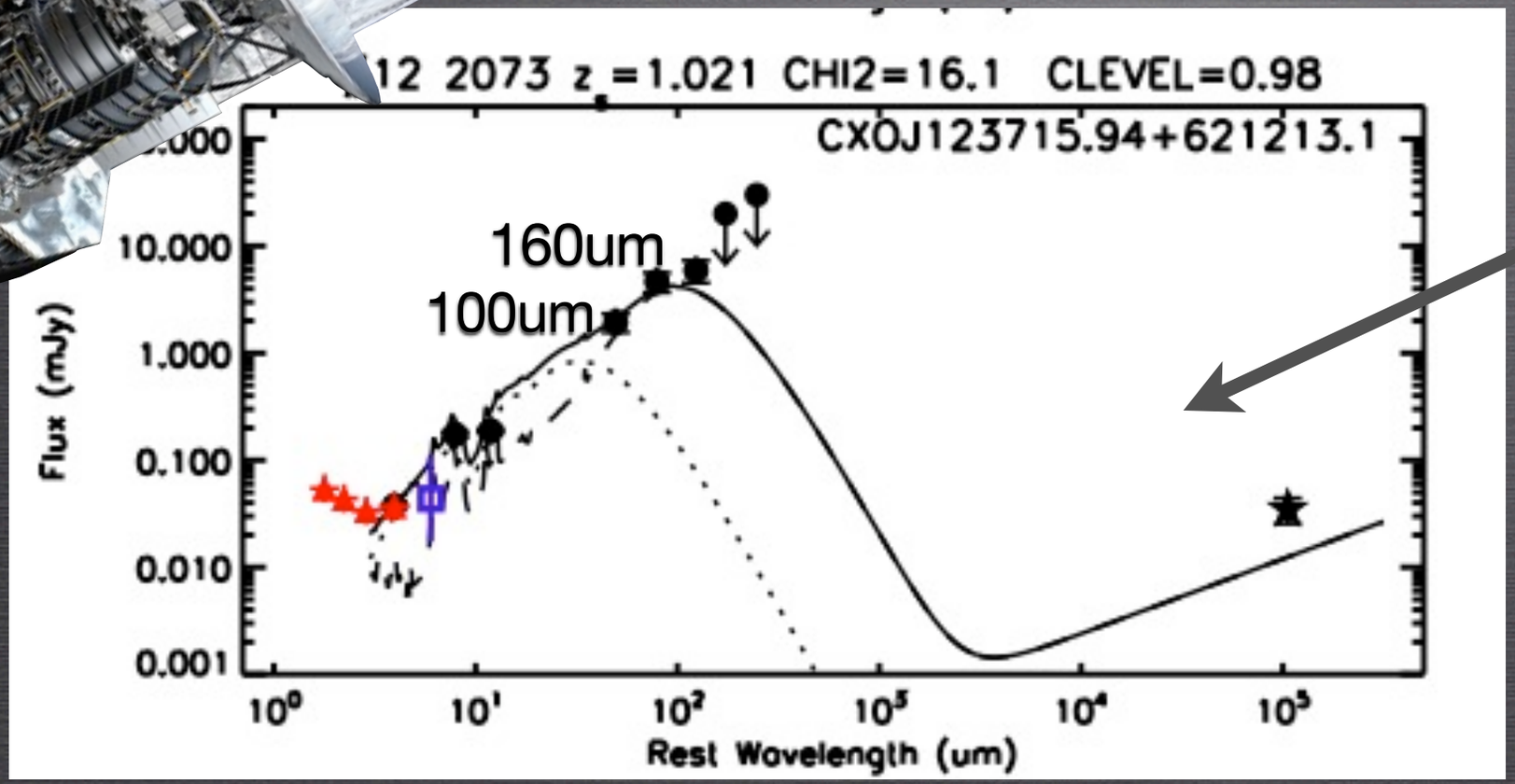
*highly dependant on bolometric correction factor



evaluated from Aird+09

FIR: Clear measure of SF

FIR from GOODS-Herschel (P.I. D. Elbaz): Deepest FIR survey yet undertaken

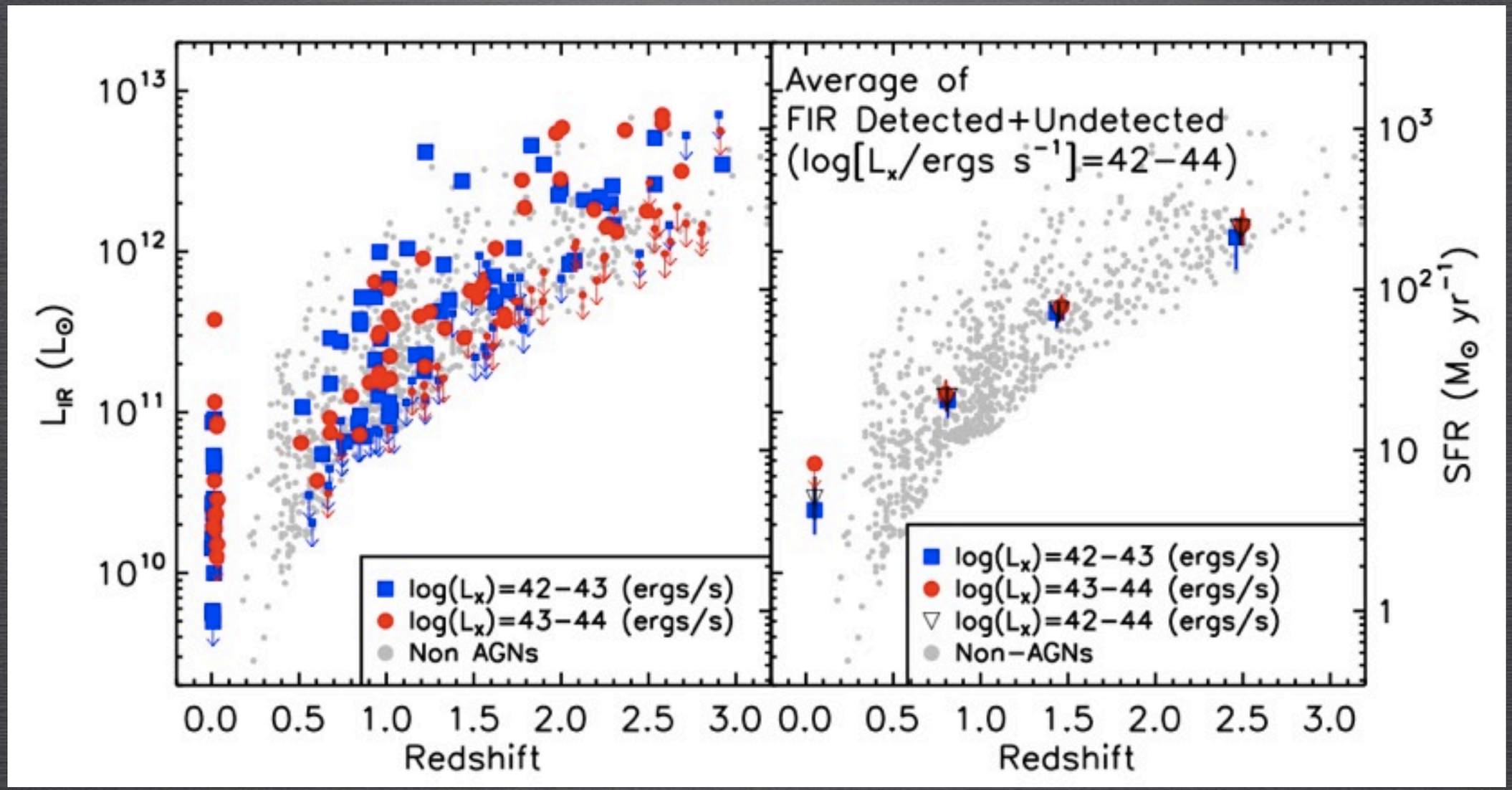


AGN & galaxy SED templates from Mullaney+11a

Courtesy of A. Del Moro+ in prep

- FIR largely uncontaminated by emission from AGN.
- ~46% of AGNs detected at 3σ at either 100um or 160um.
- ~2x better detection rate than previous FIR studies of X-ray AGNs in CDFs.
- Use FIR stacking to measure average of undetected.

Star formation in AGN hosts

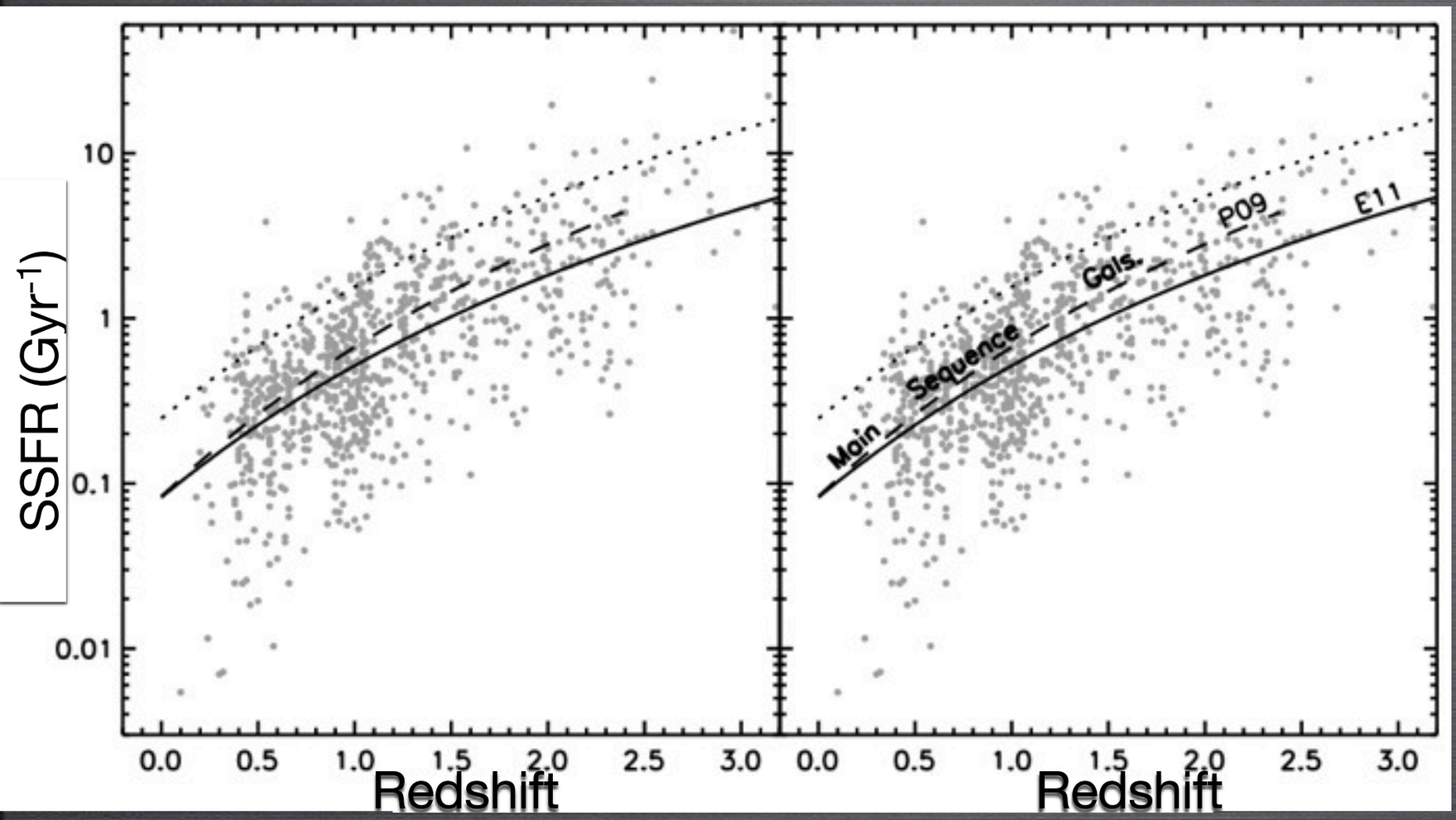


from Mullaney+11b

- Factor of ~40 increase in the average L_{IR} and SFR of AGNs with the same X-ray luminosities between z~0 to z~3.
- No significant difference in L_{IR} for different L_X bins.

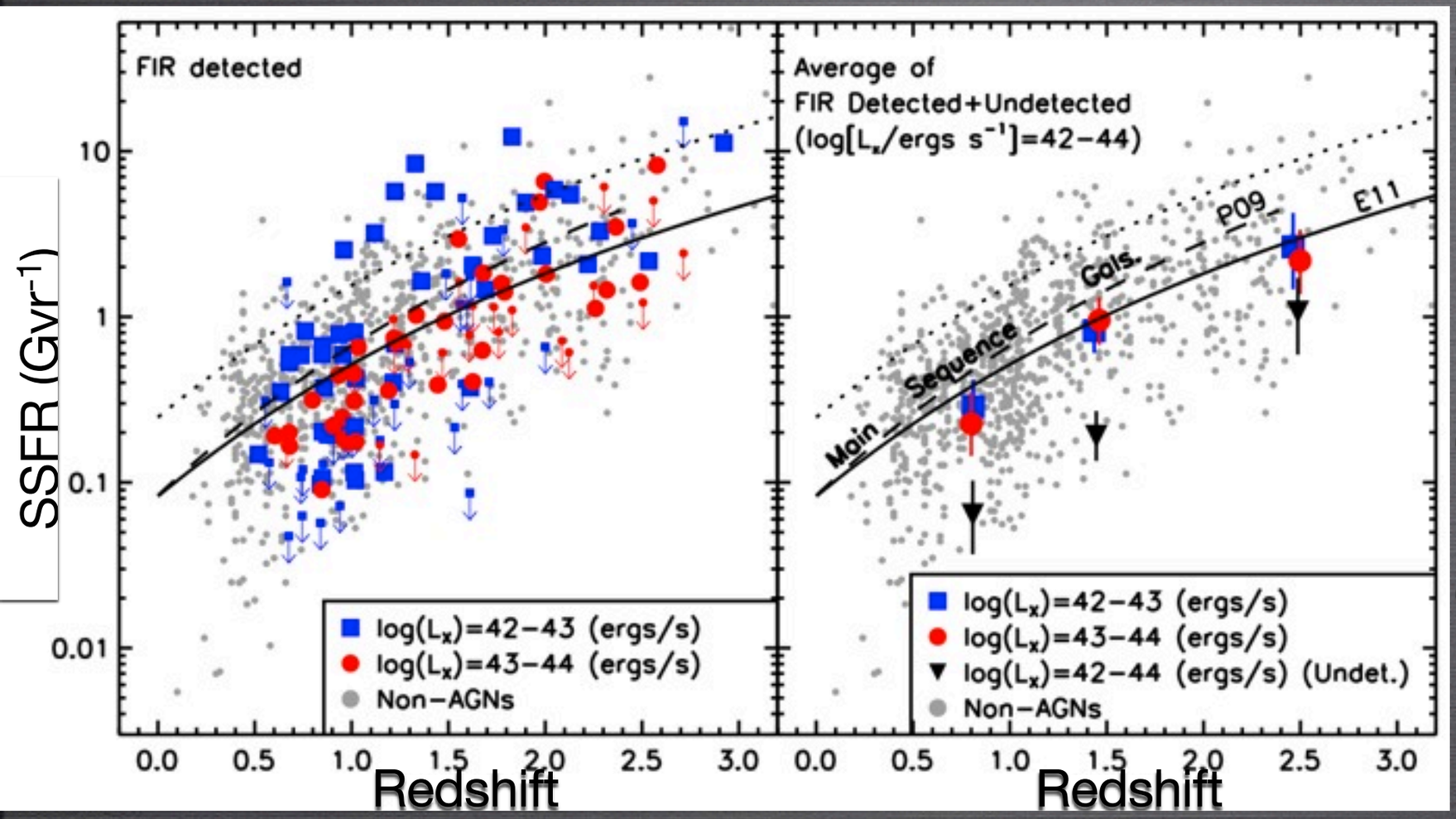
also Mullaney+'10, Shao+'10, Lutz+'10

Star formation in AGN hosts



see Elbaz+11 (from Mullaney+11b)

Star formation in AGN hosts



Mullaney+11b

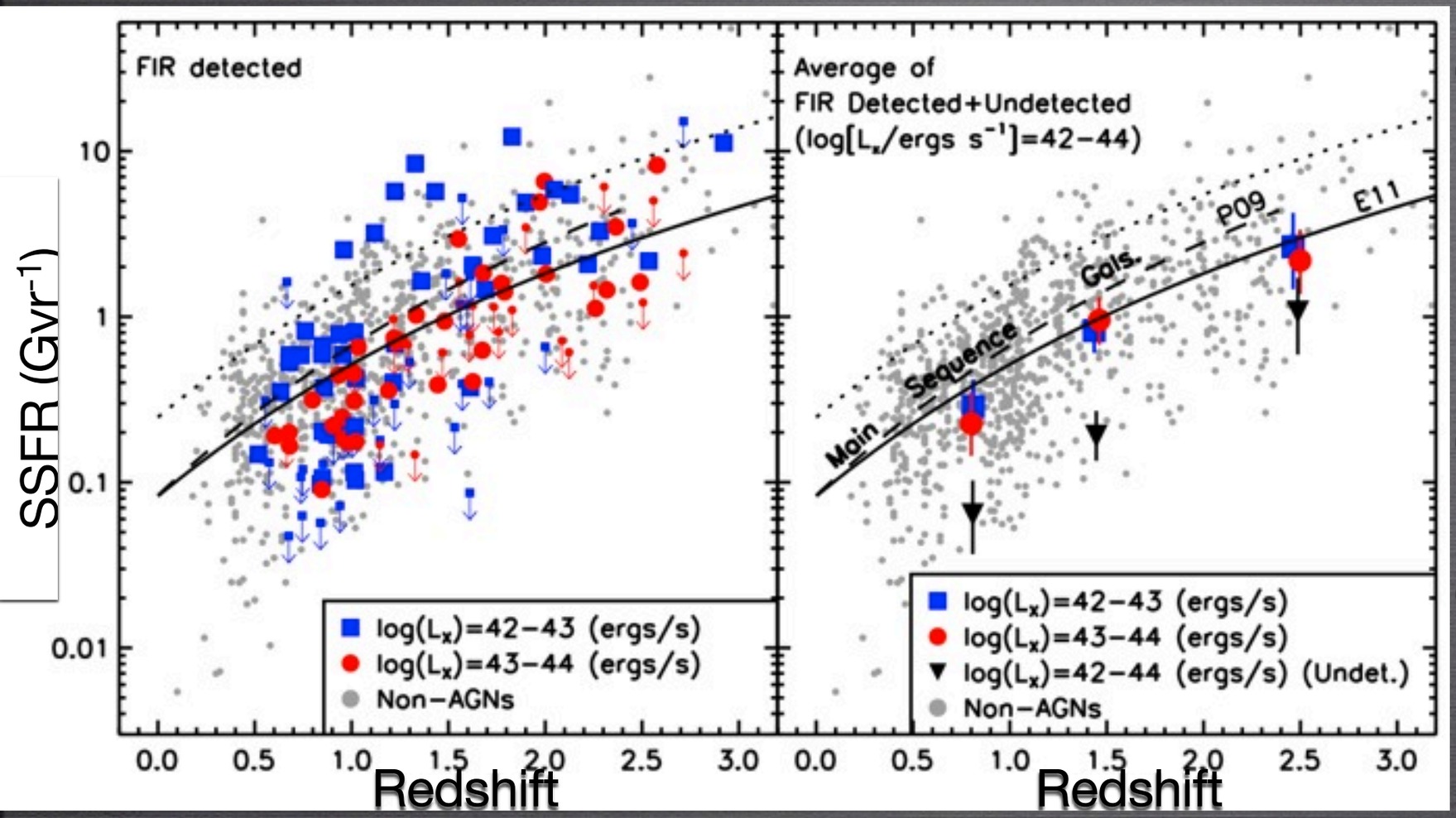
- Moderate lum. X-ray AGNs have similar SSFRs as main-seq. galaxies at all redshifts.
- Backed up by stacks.
- No difference for high/ low column densities.

"Secularly" evolving galaxies dominate moderate AGN numbers

	Moderate AGNs (Mullaney+11)
Main Sequence	79±10%
Starburst	7±2% (SSFR)
Quiesent	15±7%

Two modes for moderate and Quasar AGNs?
(e.g., Hopkins+06, Lutz+10)

Star formation in AGN hosts

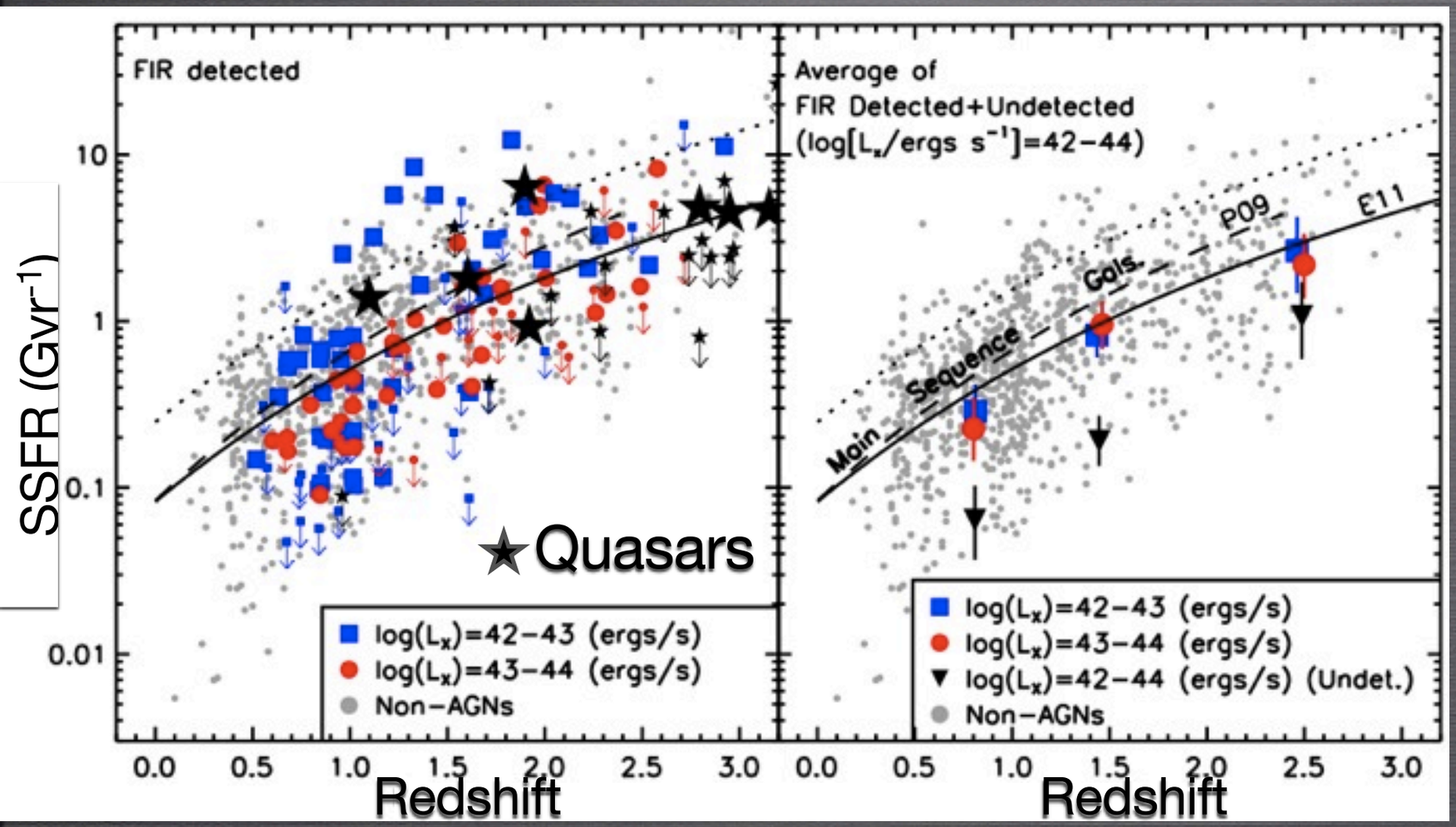


Mullaney+11b

- Moderate lum. X-ray AGNs have similar SSFRs as main-seq. galaxies at all redshifts.
- Backed up by stacks.
- No difference for high/ low column densities.

	Moderate AGNs (Mullaney+11)	Type 2 Quasars (Mainieri+11)
Main Sequence	79±10%	55%
Starburst	7±2% (SSFR)	20% (Merger morphology)
Quiesent	15±7%	~25%

Star formation in AGN hosts



Mullaney+11b

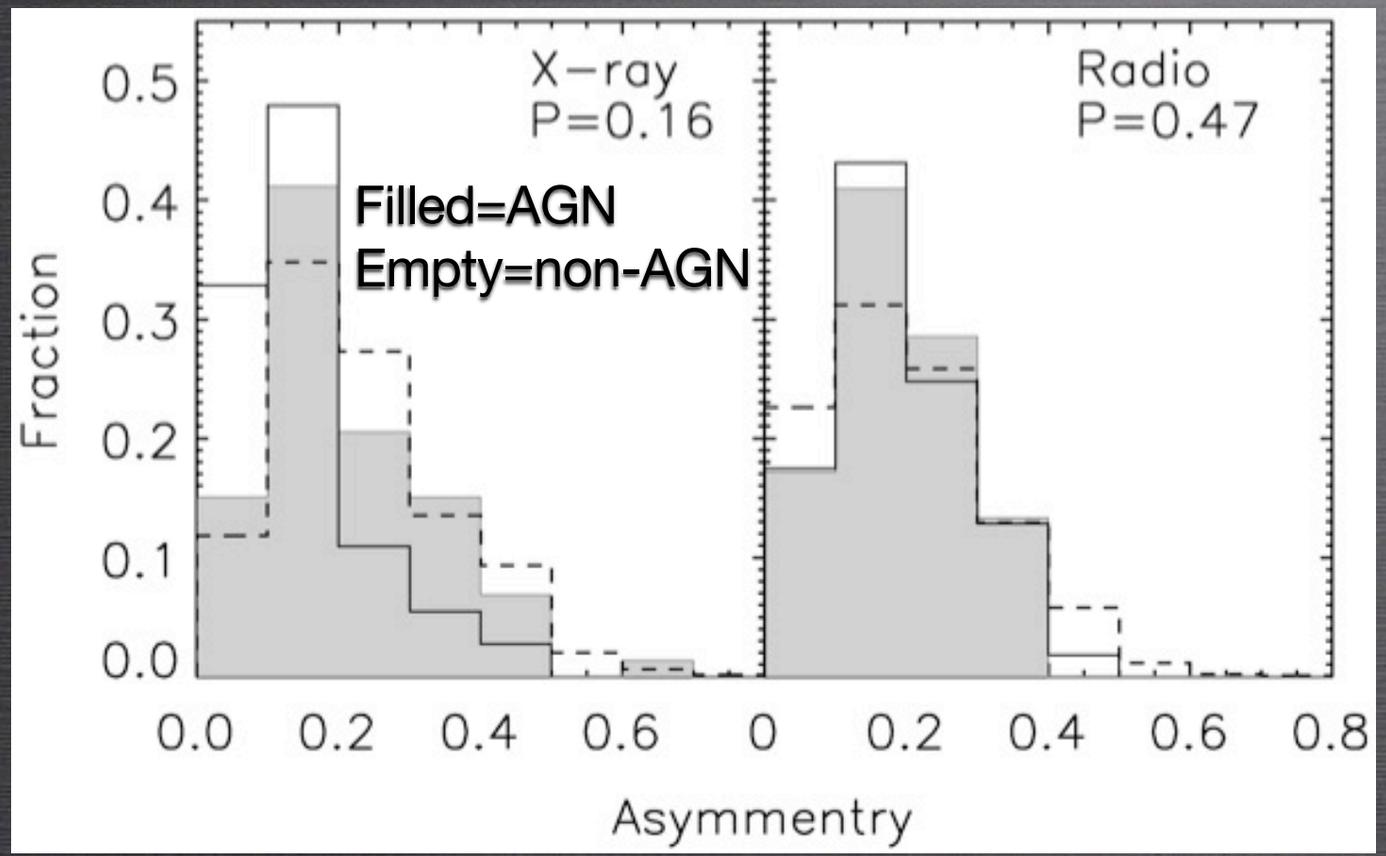
- Moderate lum. X-ray AGNs have similar SSFRs as main-seq. galaxies at all redshifts.
- Backed up by stacks.
- No difference for high/low column densities.
- Similar results for QSOs (Caution!)???

	Moderate AGNs (Mullaney+11)	Type 2 Quasars (Mainieri+11)
Main Sequence	79±10%	55%
Starburst	7±2% (SSFR)	20% (Merger morphology)
Quiesent	15±7%	~25%

(Non)Merger driver black hole growth?

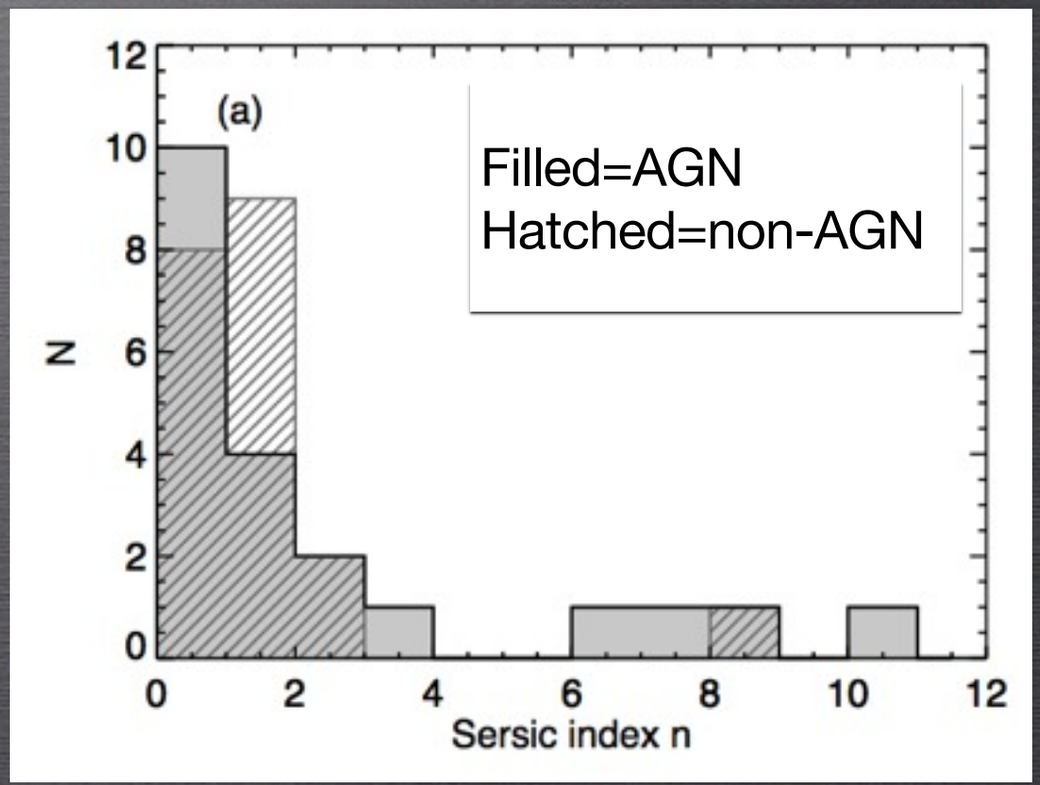
Sub-Quasars:

Redshift < 1



Gabor+09
(Cisternas+11)

Redshift ~ 2

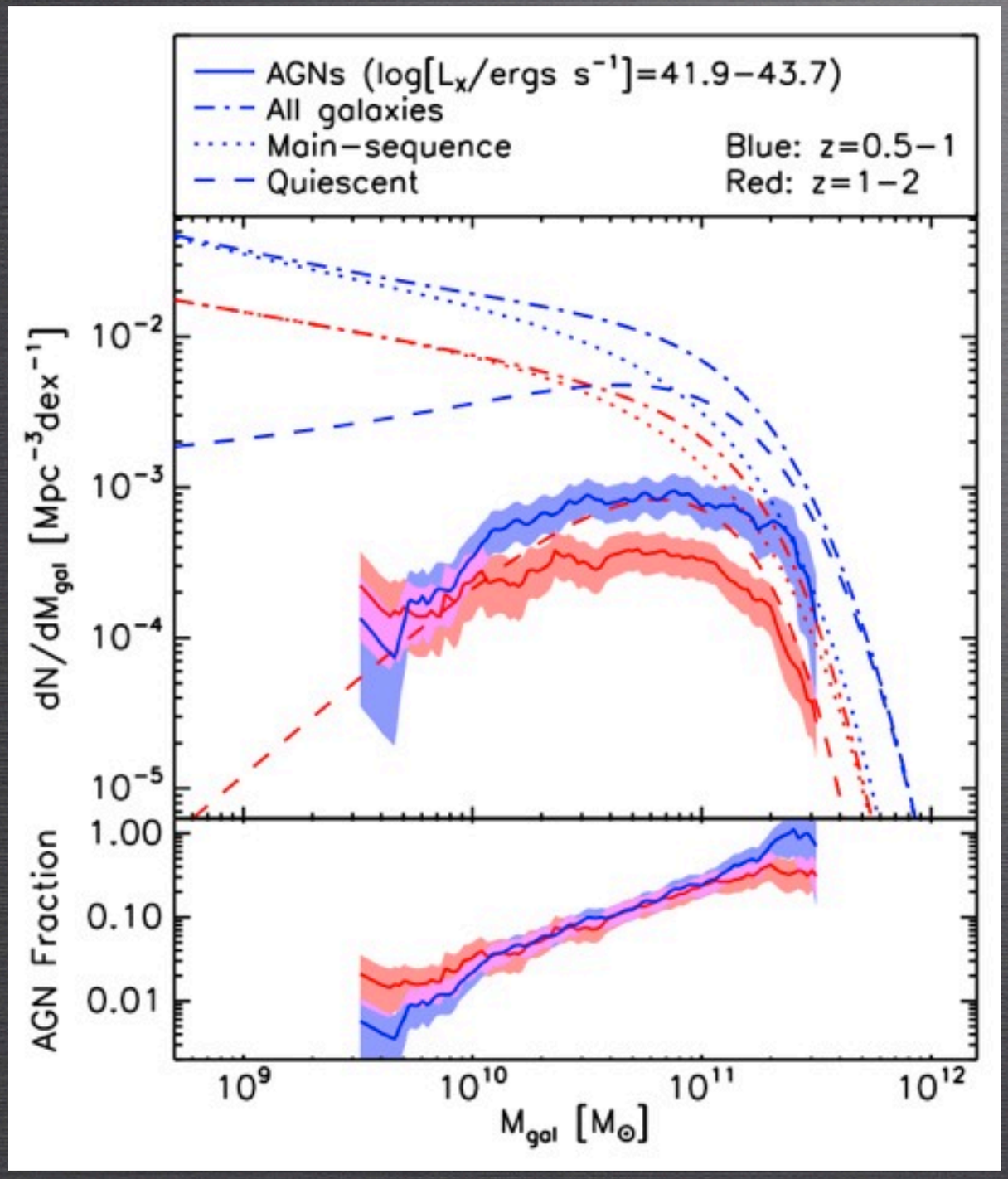


Schawinski+11

- Lack of starburst/merger activity from FIR-derived SSFRs is consistent with morphological studies.

also yesterday's presentation by Dale Kocevski

Where do AGNs live?



Xue+10, Ilbert+10
(from Mullaney+11b)

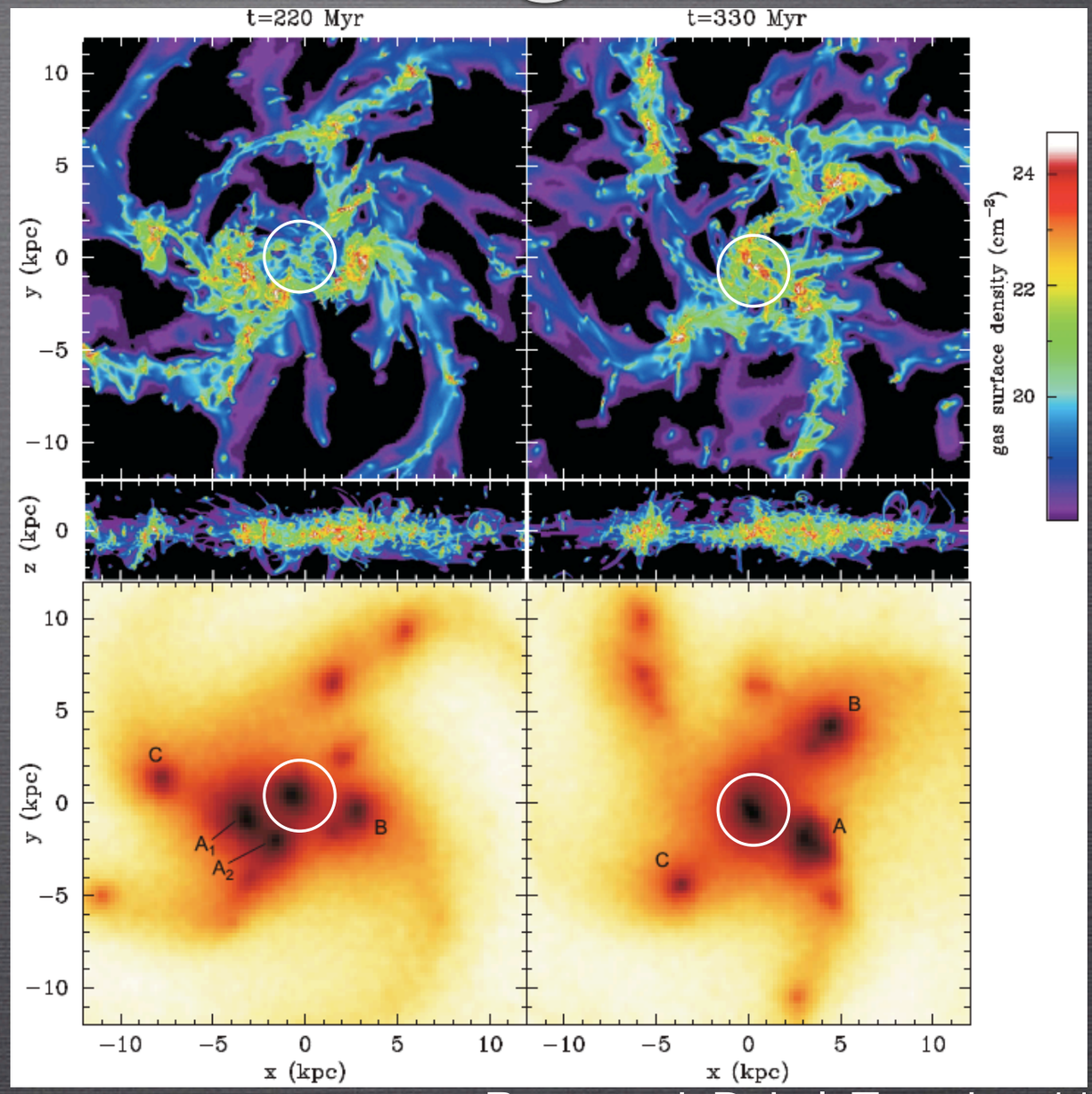
- Overall, 6-7% of main-sequence galaxies host moderate X-ray AGNs.
- But these fractions are heavily dependent on host galaxy stellar mass.

Secular feeding mode

Credit: Di Matteo+

Secular feeding mode

Credit: Di Matteo+

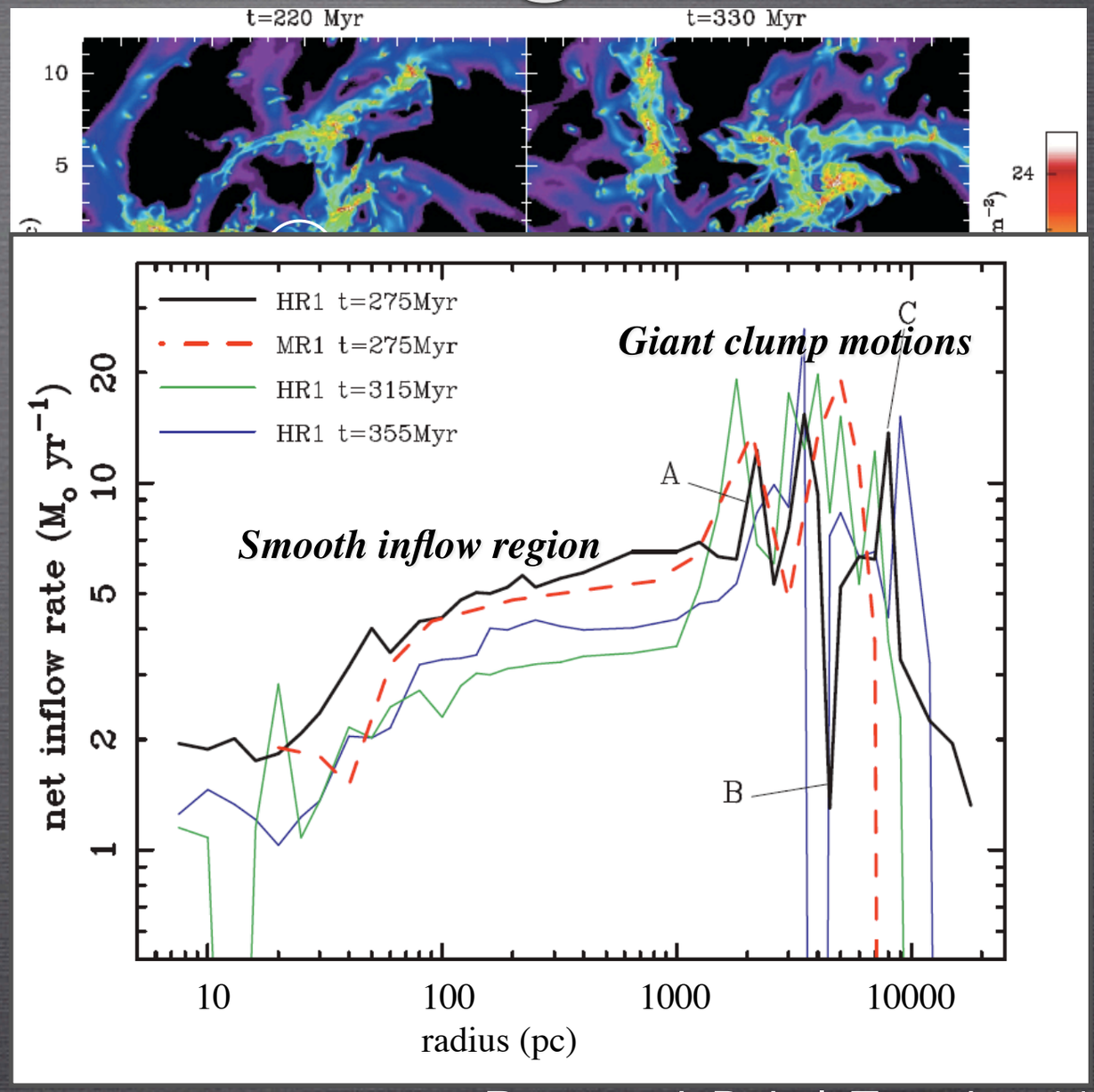


Bournaud, Dekel, Teyssier+11

- Idealised model starting with bulge + gas-rich disk
- High central surface densities of gas
- Gas torquing makes gas-rich bulge

Secular feeding mode

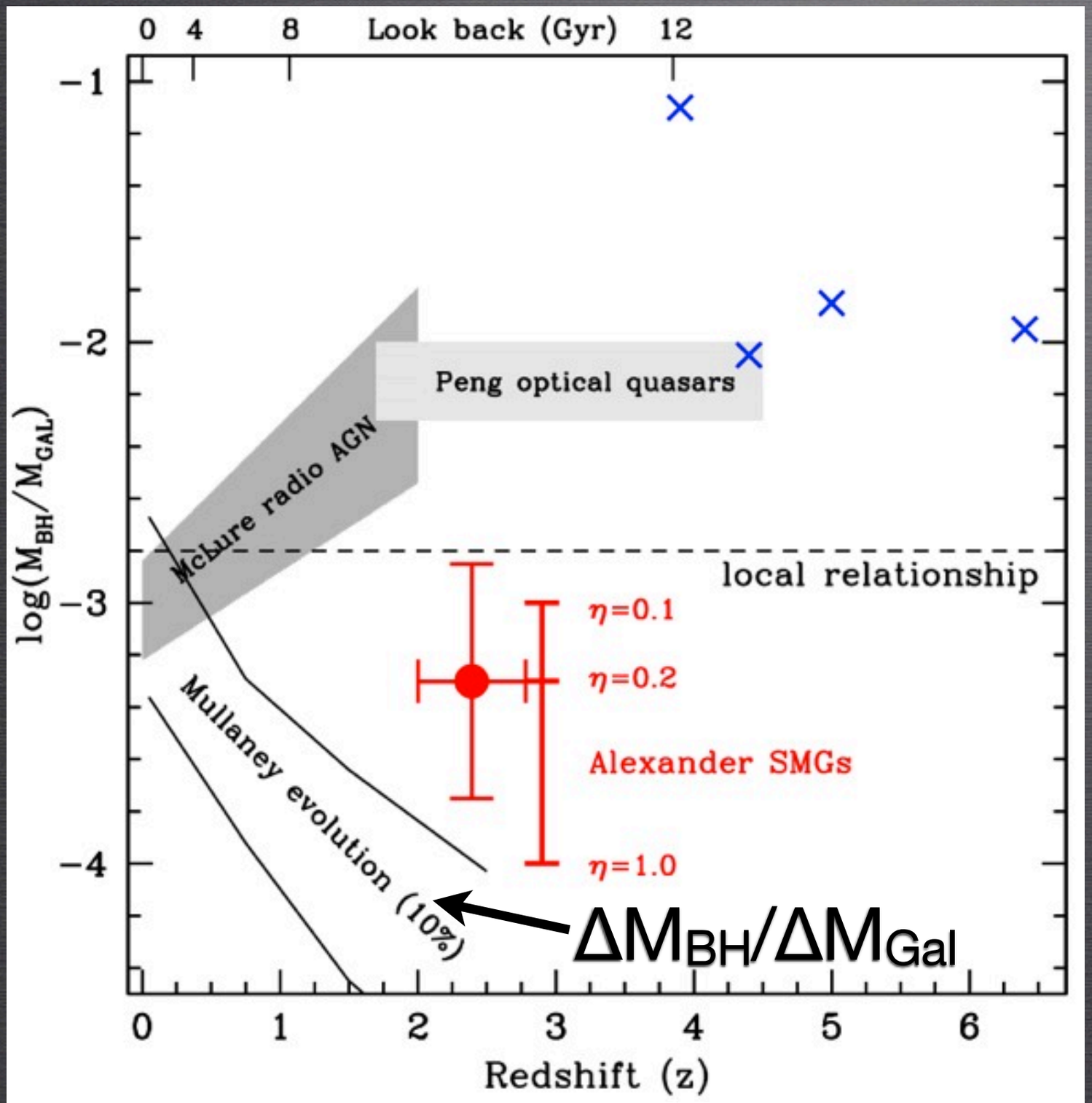
Credit: Di Matteo+



Bournaud, Dekel, Teyssier+11

- Idealised model starting with bulge + gas-rich disk
- High central surface densities of gas
- Gas torquing makes gas-rich bulge but...
- ...need very high AGN duty cycles to grow BH.

The growth of BHs and galaxies



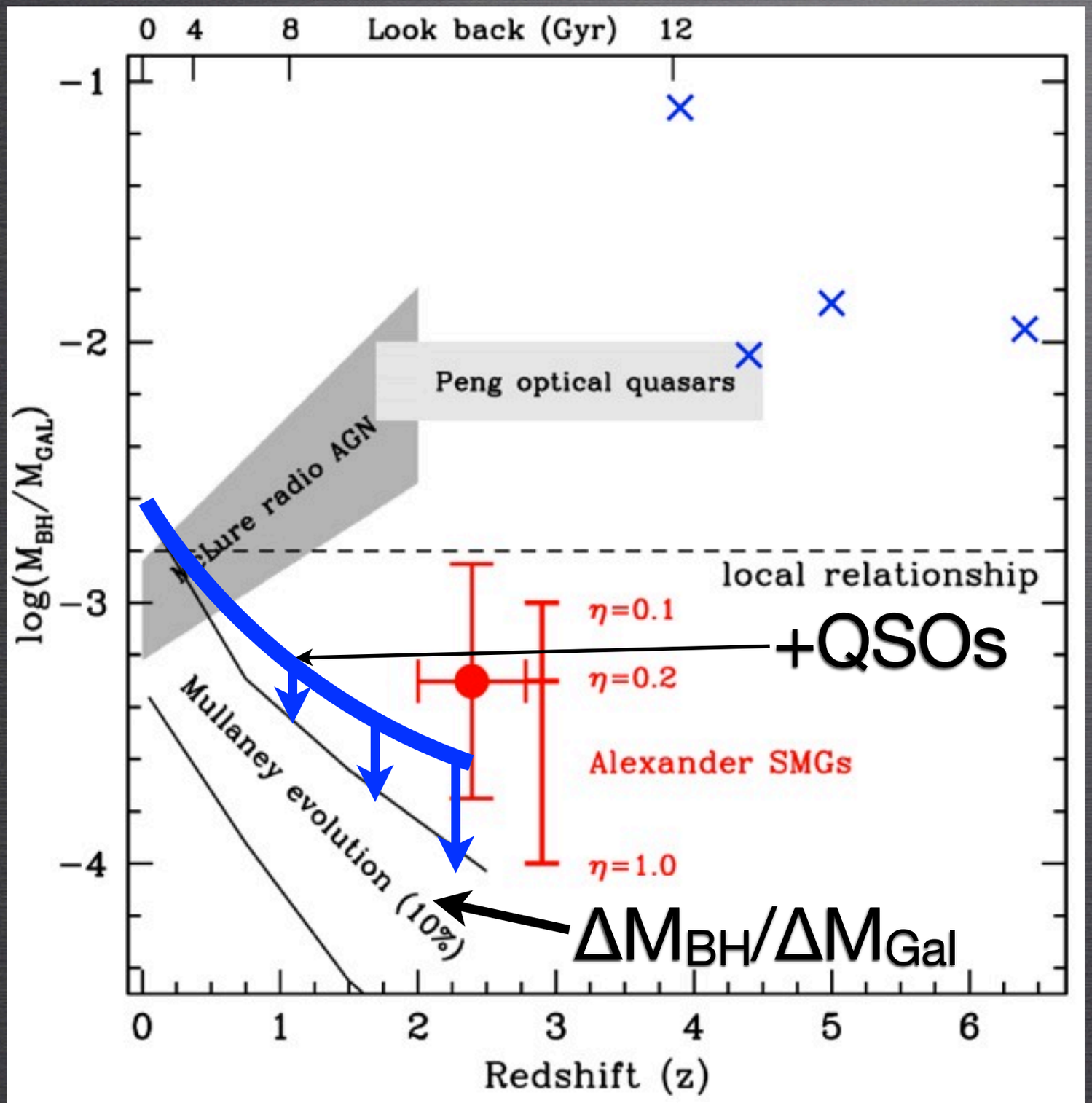
courtesy of D. Alexander

- Today's AGN and SF enough to roughly maintain M-sigma.
- Less-so in past.

1. 'Catching up to M-sigma?
2. Redshift-dependent bol. correction, duty cycle,...?
3. Obscured AGN?
4. Fraction of bulge/disk growth?
5. etc, etc...

McLure+'04,Peng+'06, Targett+11

The growth of BHs and galaxies



- Apparent mismatch between local M-sigma relationship.
- Today's AGN and SF enough to roughly maintain M-sigma.
- Less-so in past.

1. 'Catching up to M-sigma?
2. Redshift-dependent bol. correction, duty cycle,...?
3. Obscured AGN?
4. Fraction of bulge/disk growth?
5. etc, etc...

courtesy of D. Alexander

McLure+'04,Peng+'06, Targett+11

Summary

- No correlation between the global FIR output and X-ray luminosities of moderate AGNs at any redshift.
- The L_{IR} of moderate AGNs was much higher at high redshifts than it is today.
- The SSFRs of moderate luminosity AGNs are remarkably similar to main-sequence galaxies.
  - The vast majority of these AGNs ‘live’ in main-sequence galaxies.
- Suggests non-merger driven BH growth in these moderate AGNs.
- Paints an “interesting” picture of BH and galaxy growth.