GOODS-*Herschel*: Ultra-deep *XMM-Newton* observations reveal AGN/star-formation connection

(Pending acceptance from A&A)

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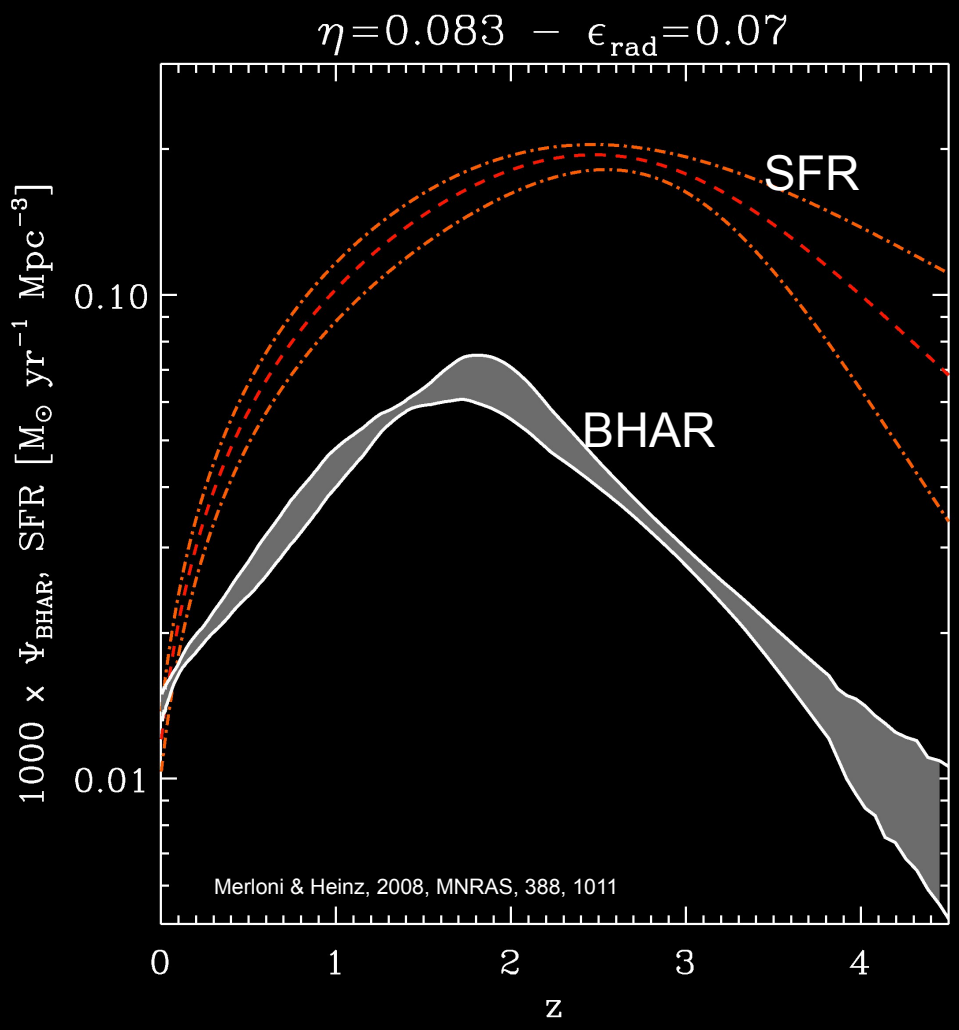
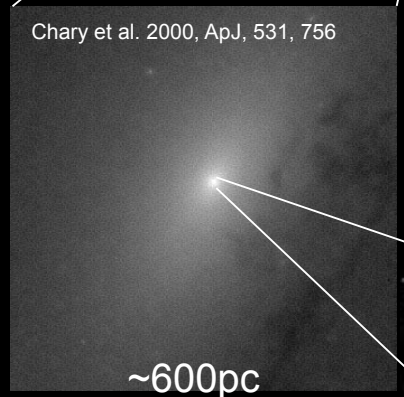
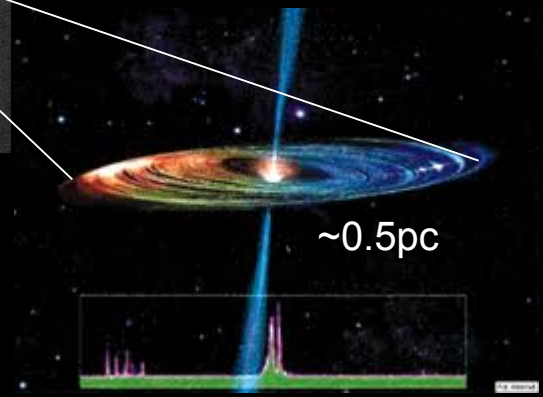
And XMM-CDFS and GOODS-Herschel teams

Coeval growth







Miyoshi et al. 1995, Nature, 373, 127

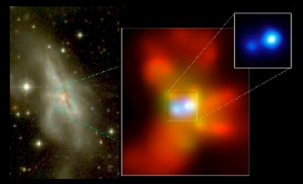
Growth of SMBH: AGN
Growth of bulge: star-formation

Evolution through mergers

(c) Interaction/"Merger"

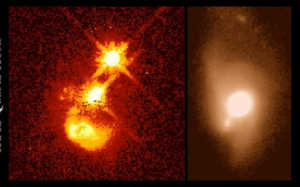
- now within one halo, galaxies interact & lose angular momentum
- SFR starts to increase
- stellar winds dominate feedback
- rarely excite QSOs (only special orbits)

(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

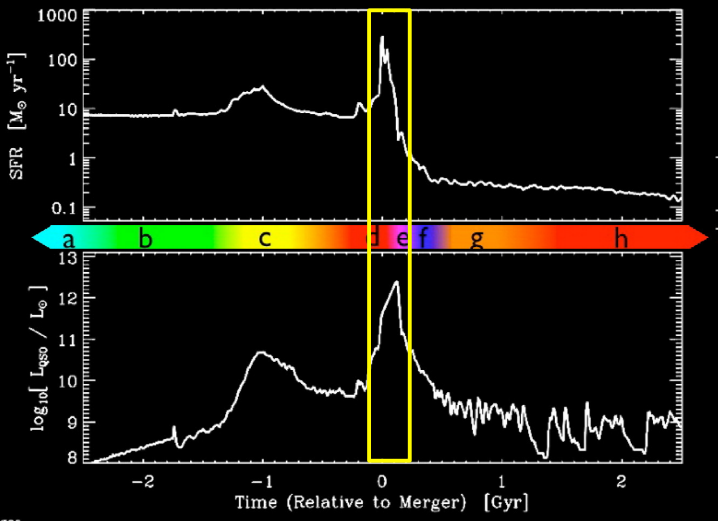
dust removed: now a "traditional" QSO
- host morphology difficult to observe: tidal features fade rapidly
- characteristically blue/young spheroid

(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

(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



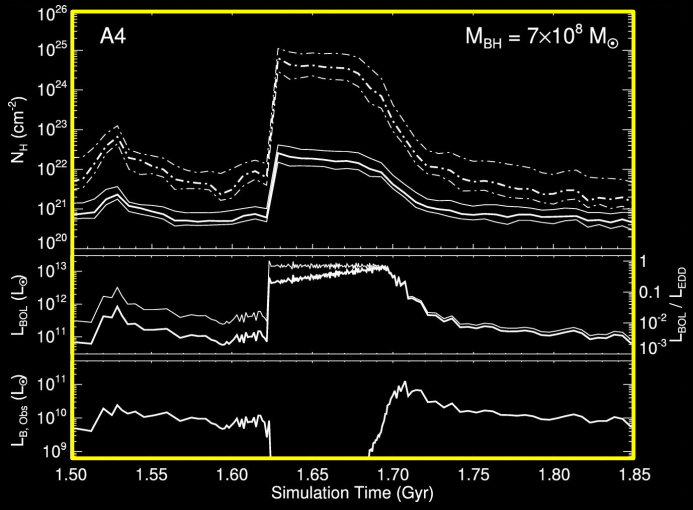
Hopkins et al. 2008, ApJ, 175, 356

(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

(h) "Dead" Elliptical

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

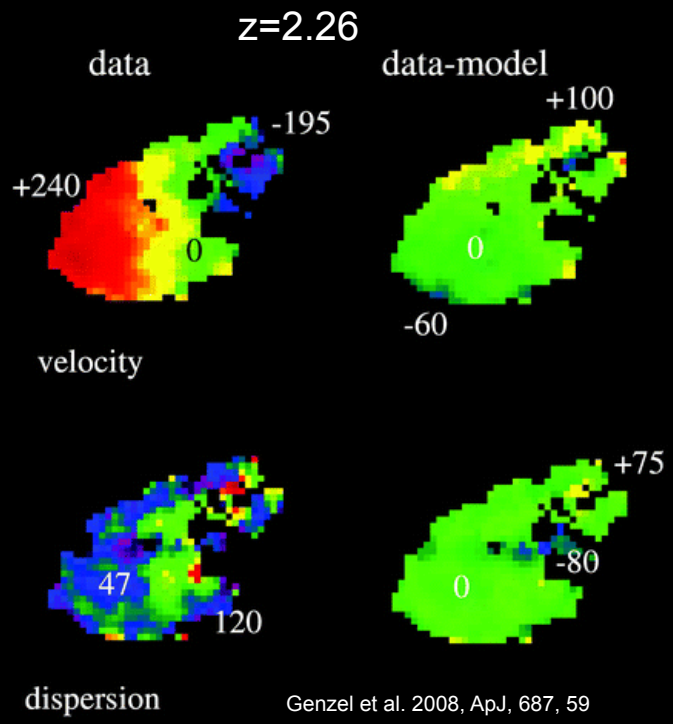


Hopkins et al. 2005, ApJ, 630, 705

(local) ULIRG Arp220

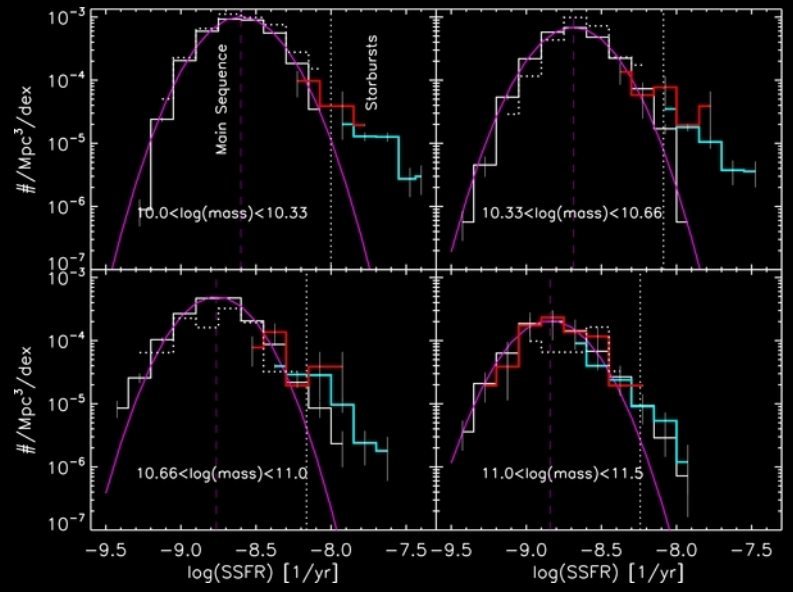
High-redshift (z > 1) ULIRGs (a.k.a. DOGs, BzKs, sub-mm galaxies, CT AGN, ...)

Secular evolution

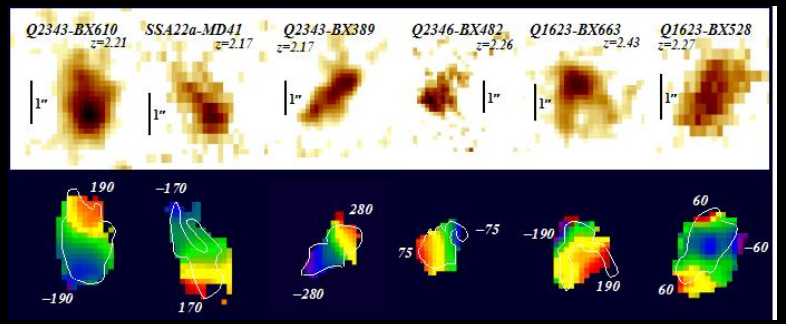


Genzel et al. 2008, ApJ, 687, 59

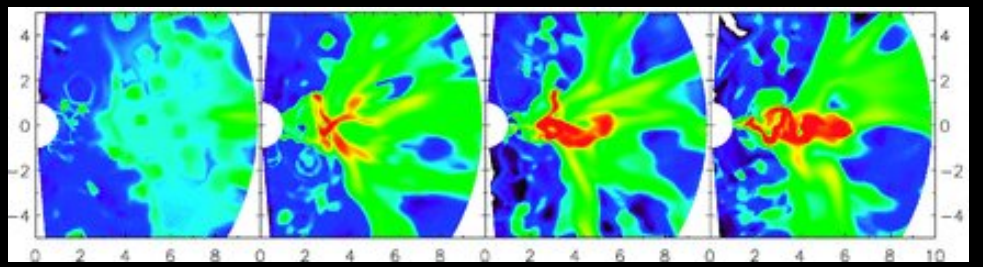
Significant number of active star-forming galaxies with no evidence of merging



Rodighiero er al., 2011, ApJ, 739, L40



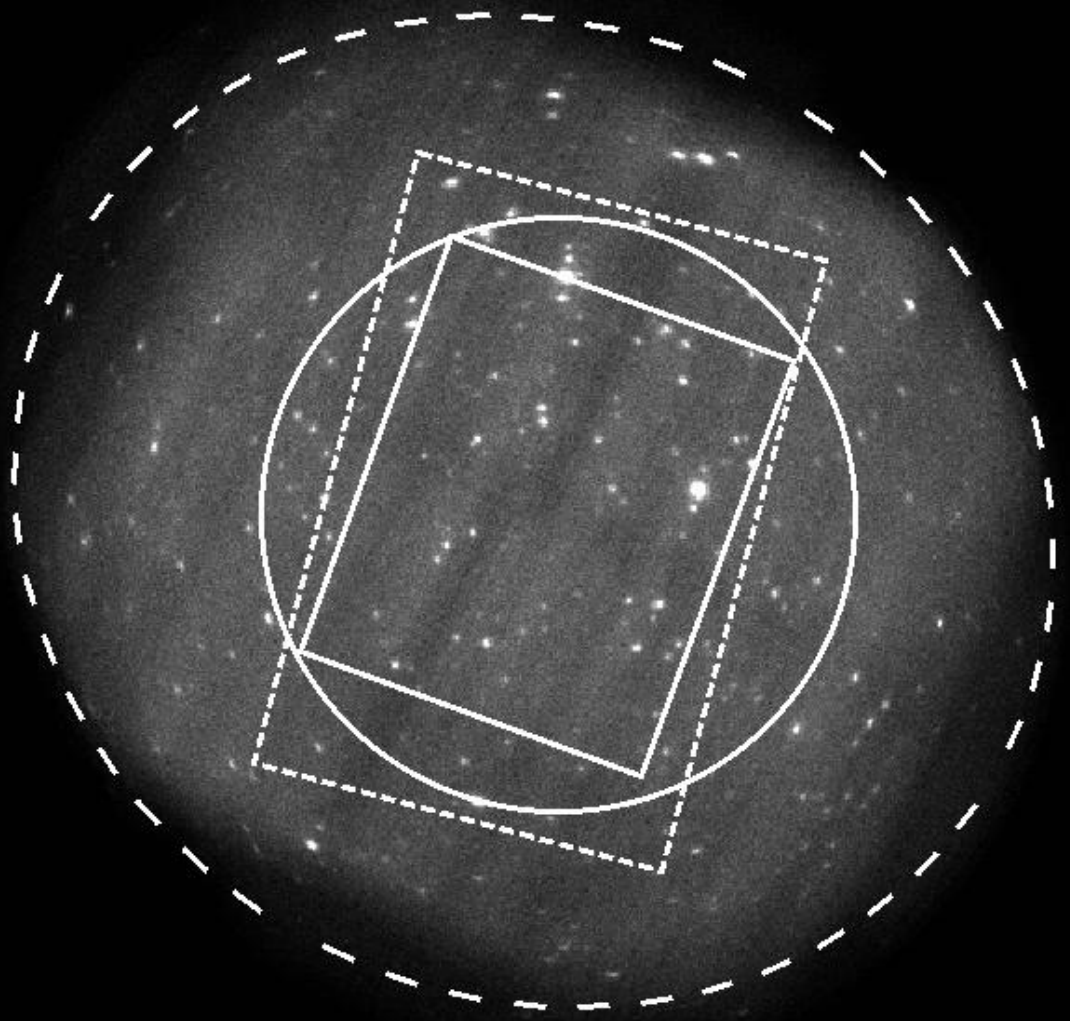
SINS survey - Förster-Schreiber et al. 2008, ApJ, 706, 1364



Schartmann er al., 2009, MNRAS, 393, 759

BH feeding through stellar winds and SN ejecta?

The data



3 Ms XMM-Newton CDFS survey

> 1 Ms XMM exposure

Herschel-GOODS

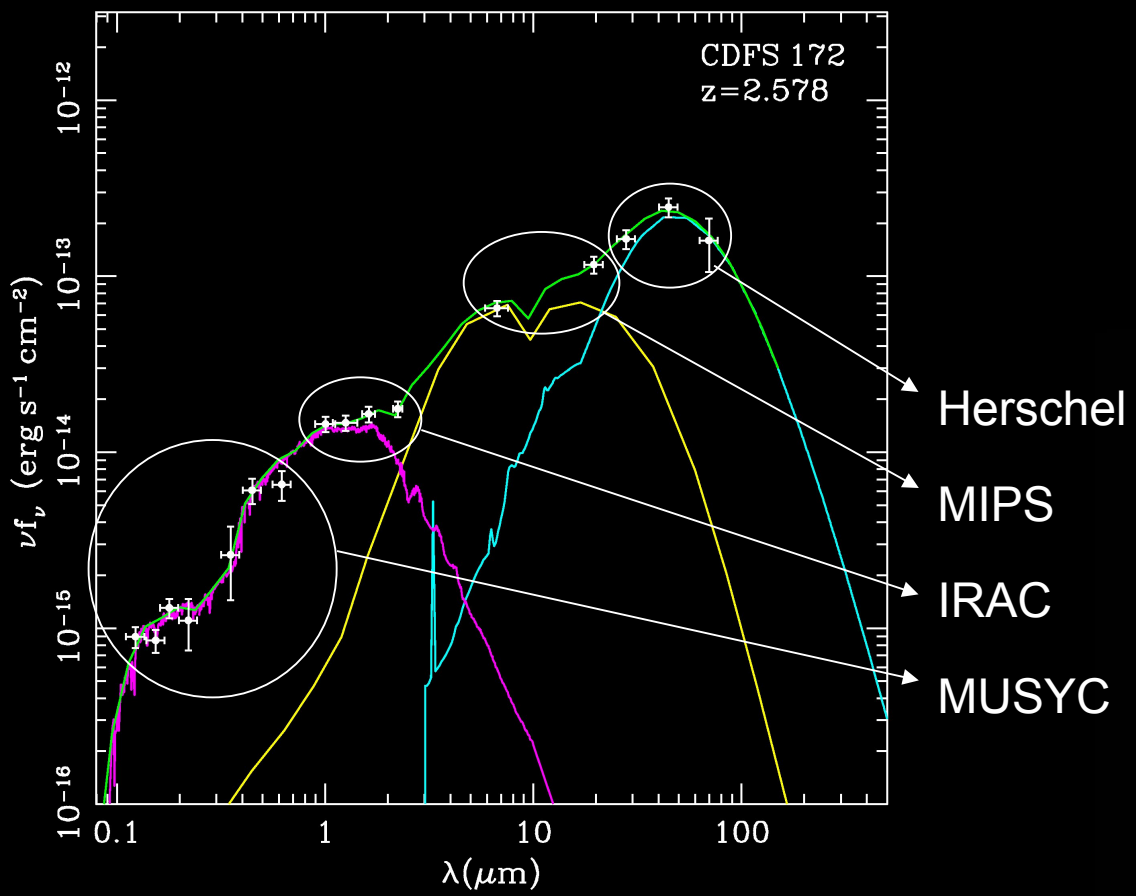
Spitzer-GOODS

VLA+VLBI radio

Ground-based optical - NIR

The sample

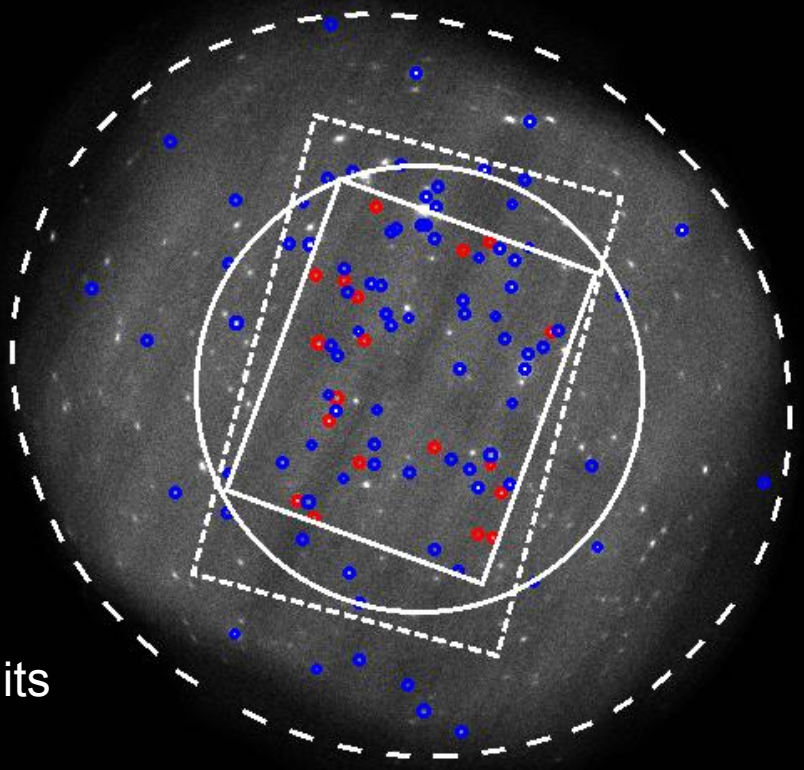
SED decomposition



Optical SED: stellar mass

FIR SED: star-formation rate

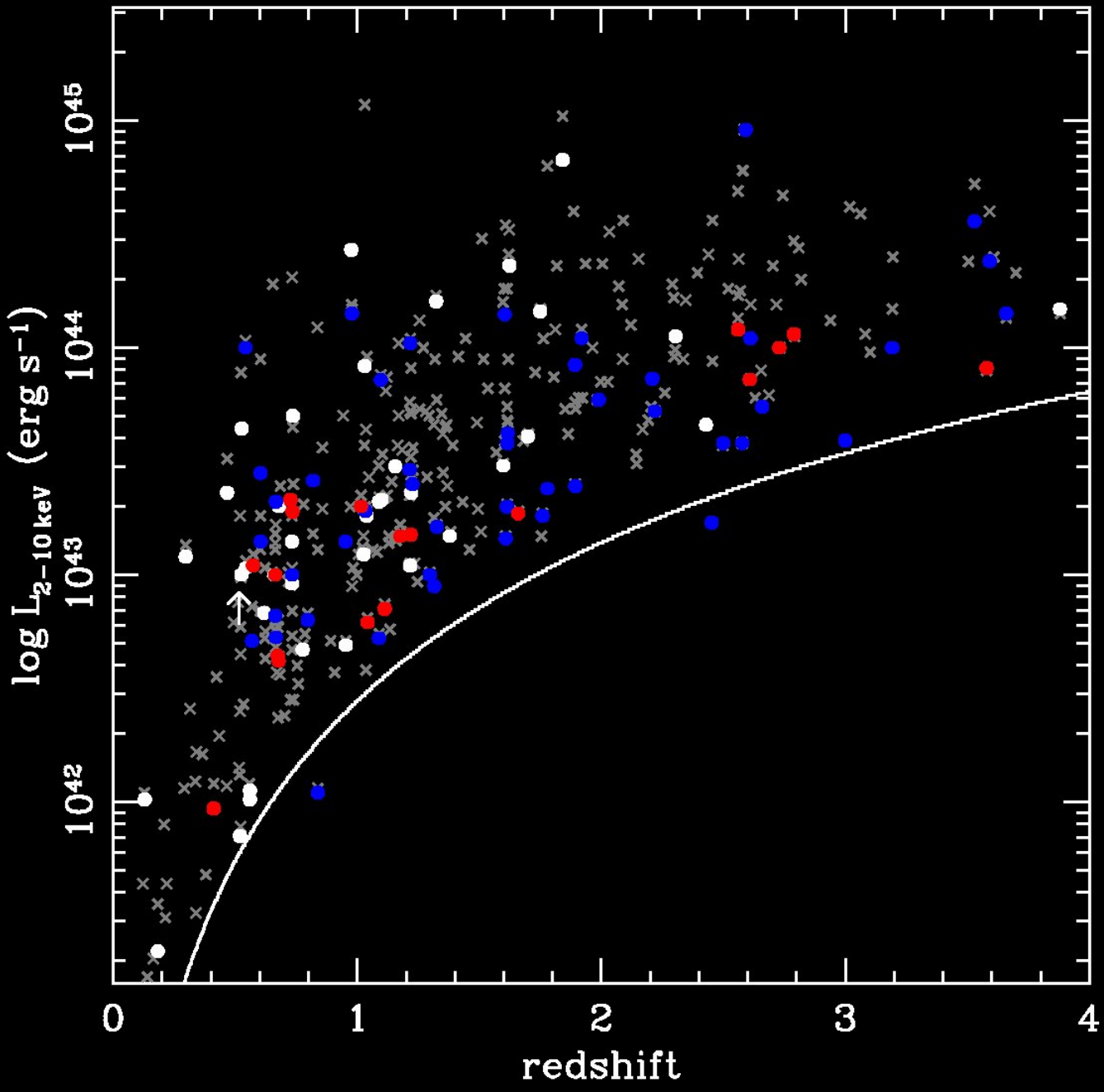
MIR: AGN contribution



Broad sample: 86 AGN with SFR and M*
66 spectroscopic z – 20 photometric

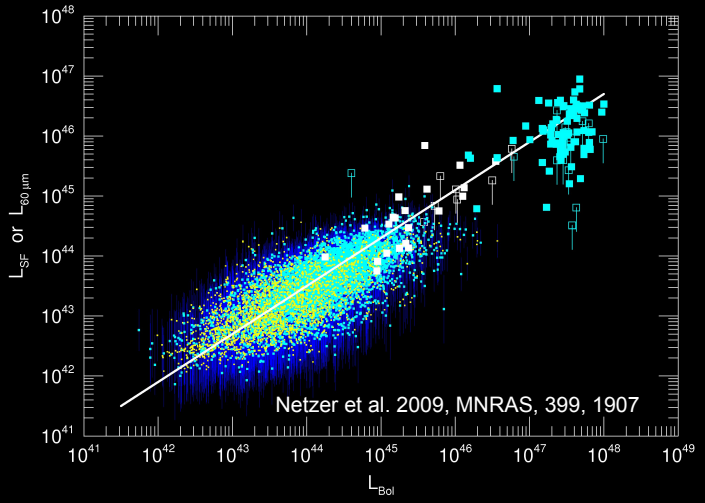
Complete sample: 47 detections and 19 upper limits
22 spectroscopic z – 14 photometric

The sample

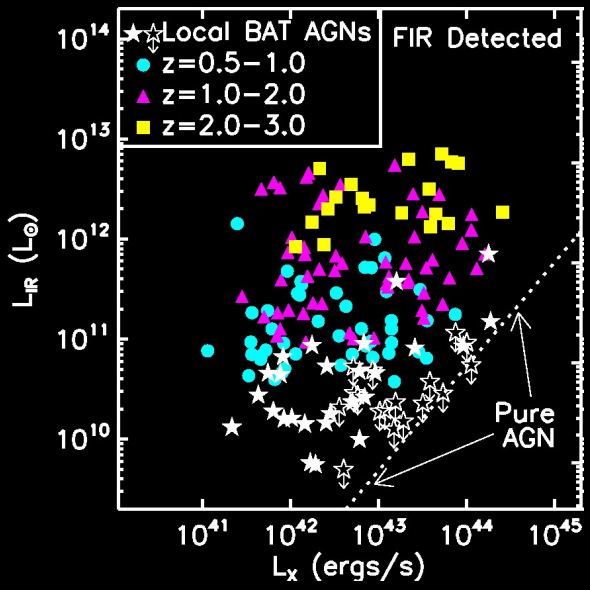


Results: AGN - SB connection

SDSS spectroscopy

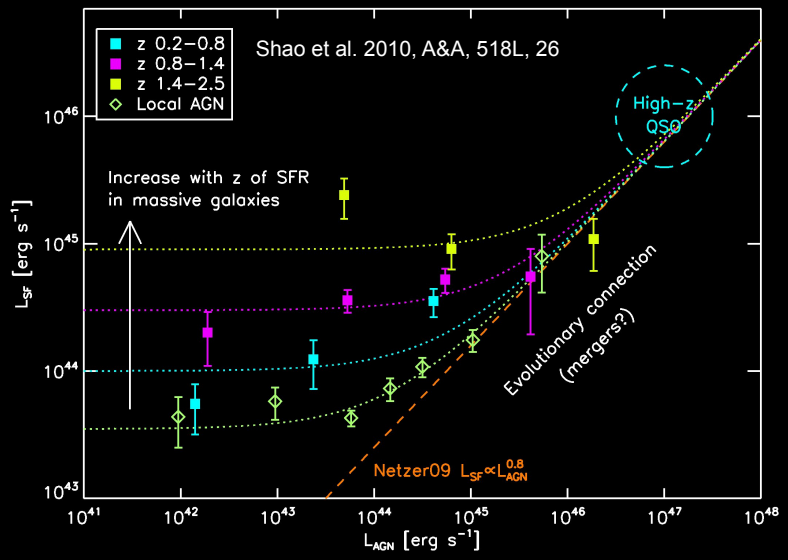


GOODS-Herschel X-ray - FIR

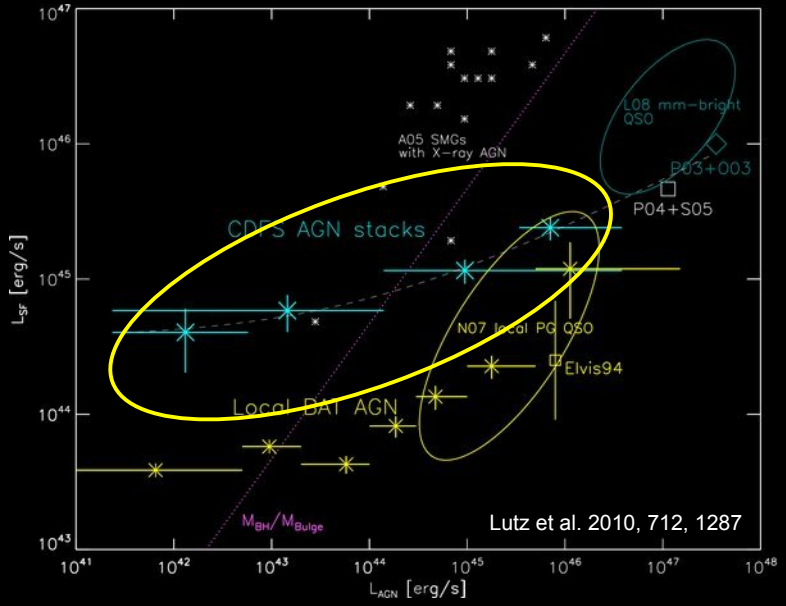


Mullaney et al. 2011, MNRAS, in press

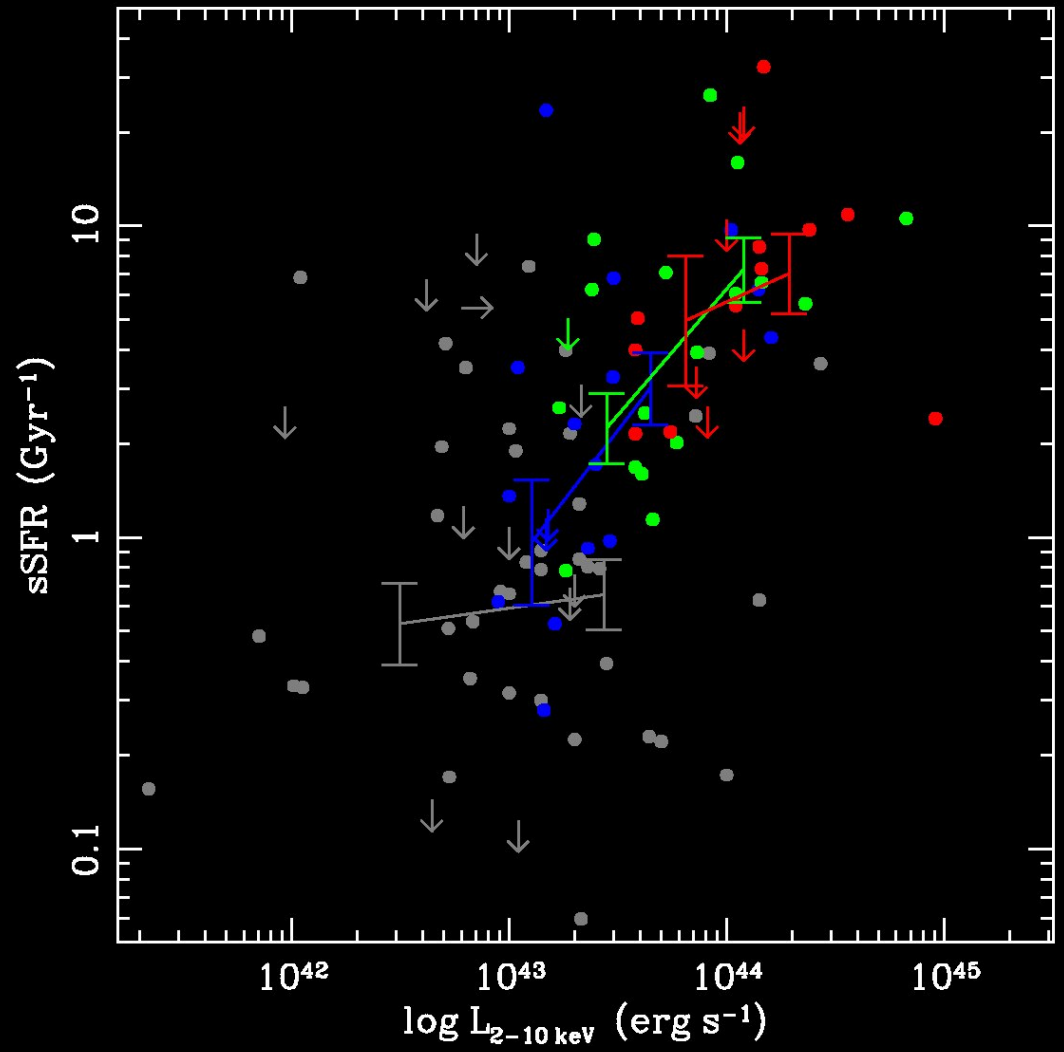
SFR-X-rays-70μm



CDFS sub-mm (LABOCA)



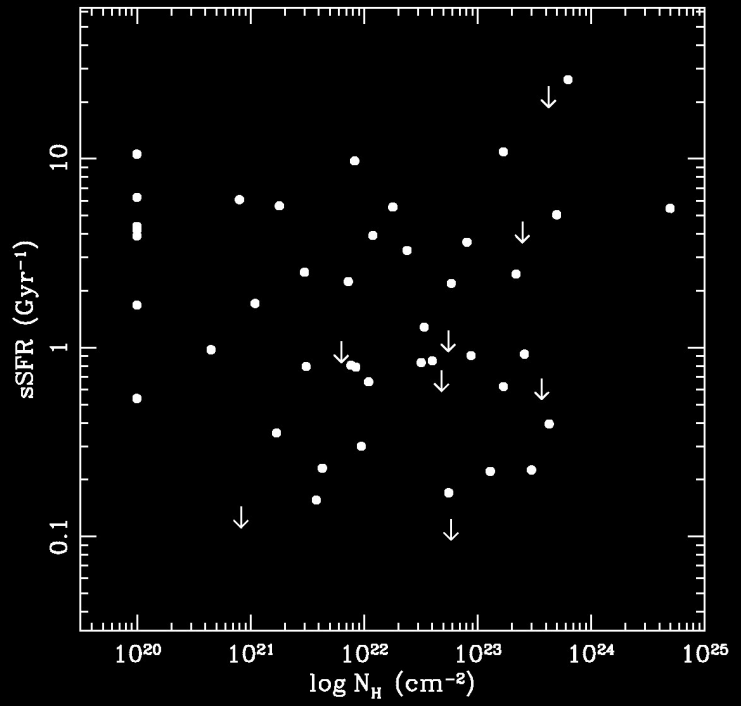
Results: AGN - SB connection



Correlation: P<0.01%

Bin	redshift range	P_{nh} (%)	P_{nh} (%)	P_{nh} (%)
1	$0.000 - 0.604$	30		
2	$0.605 - 0.777$	74	36	24
3	$0.798 - 1.113$	83	65	
4	$1.156 - 1.614$	2.3	13	2.3
5	$1.616 - 2.453$	3.0	0.02	3.0
6	> 2.460	5.9	0.58	5.9

Nuclear SF?

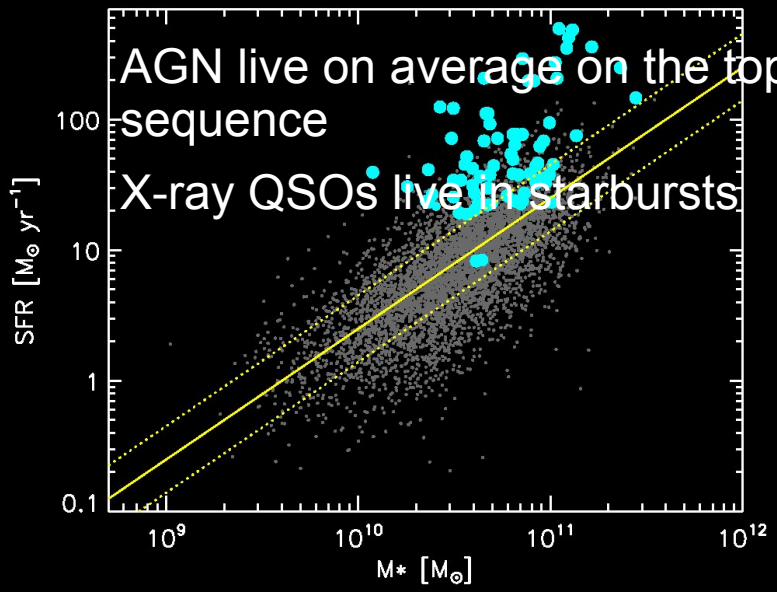


No correlation => argues against nuclear SF

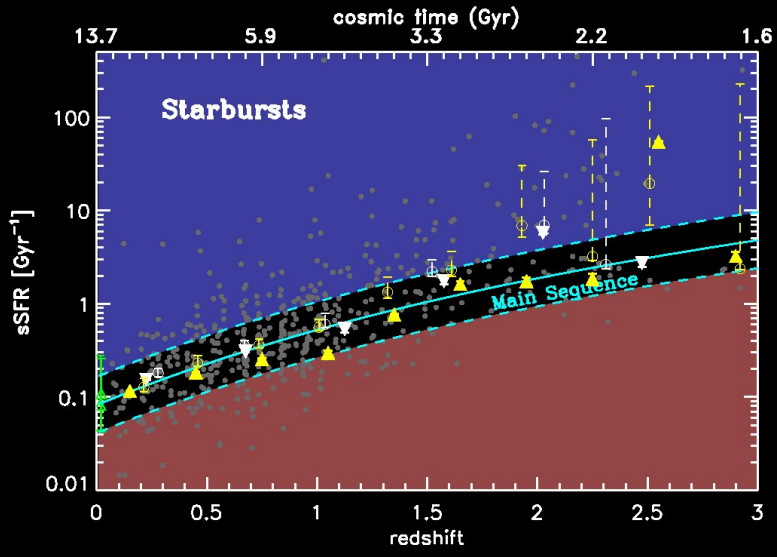
Where do AGN live?

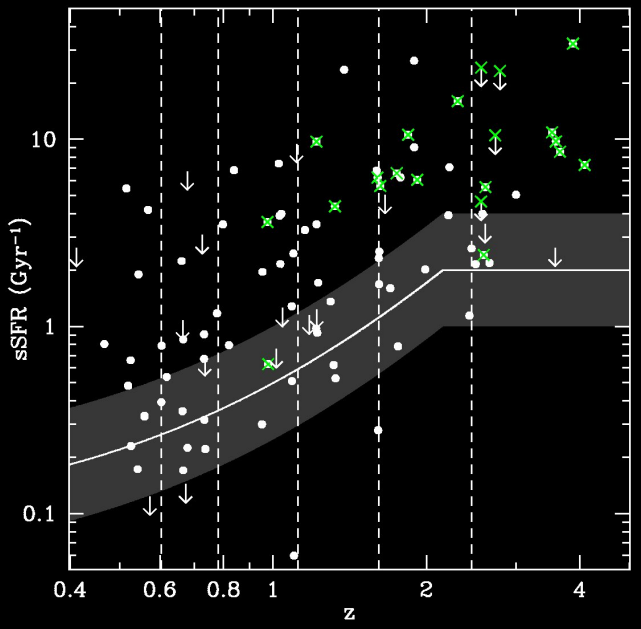
AGN live on average on the top of the main sequence

X-ray QSOs live in starbursts

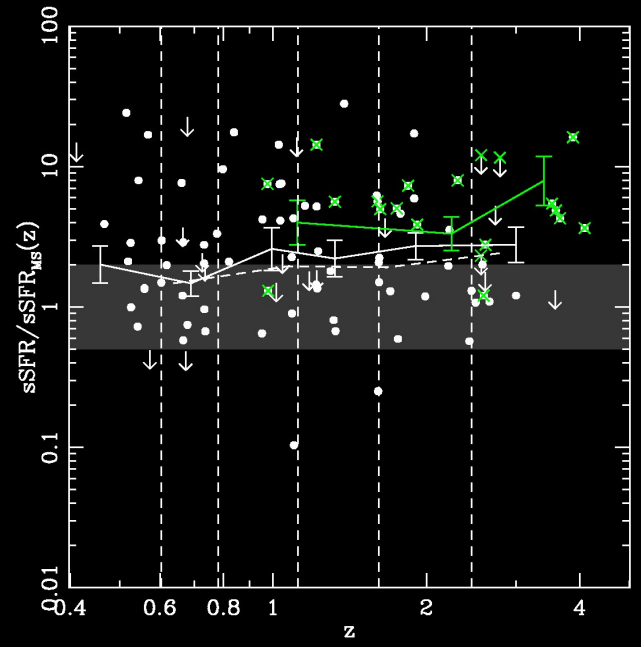


Elbaz et al. 2011, A&A, 533, 119

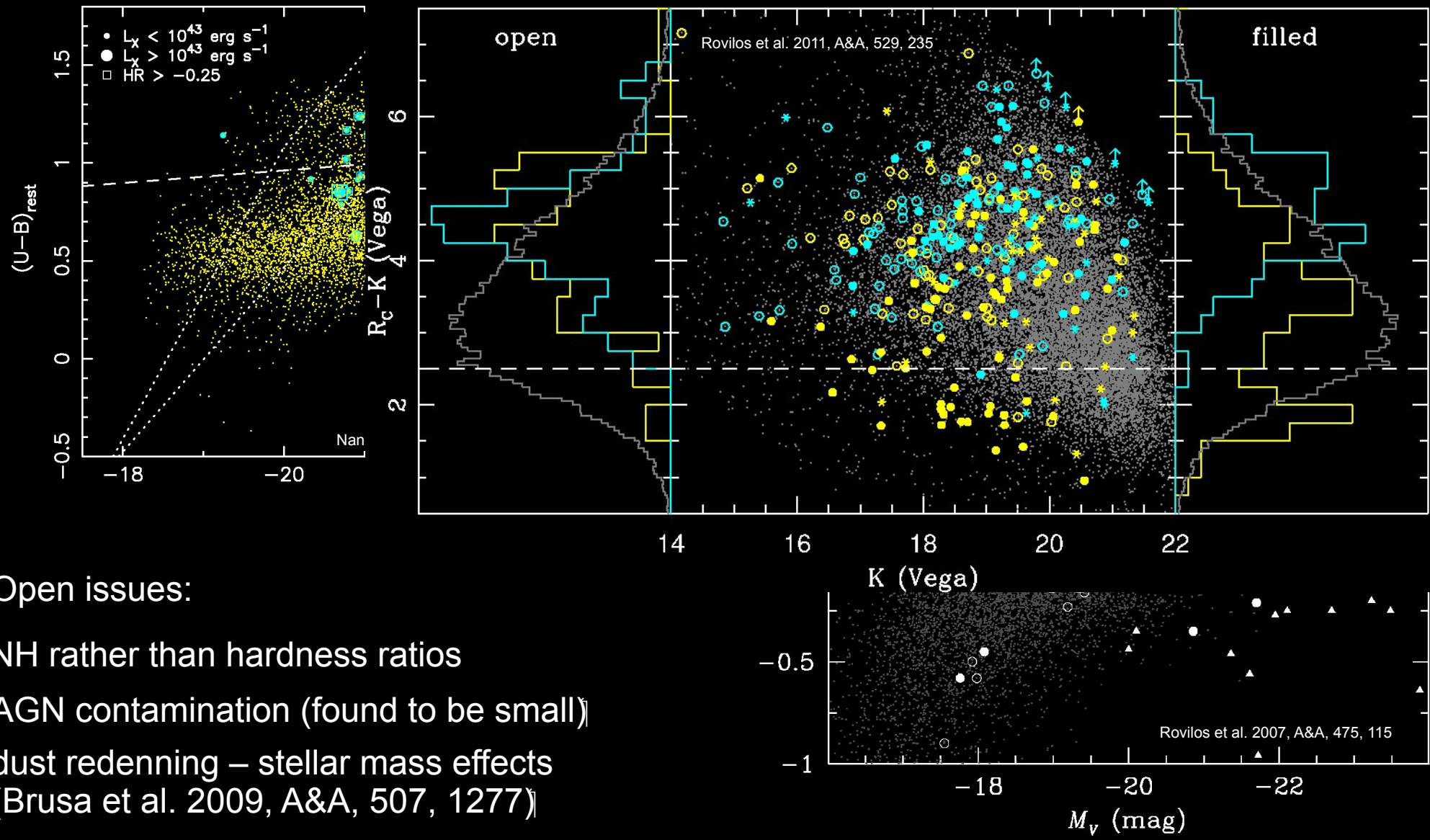




$L_x > 10^{44}$ erg/s



AGN Colour-Magnitude Diagram (story so far)



Open issues:

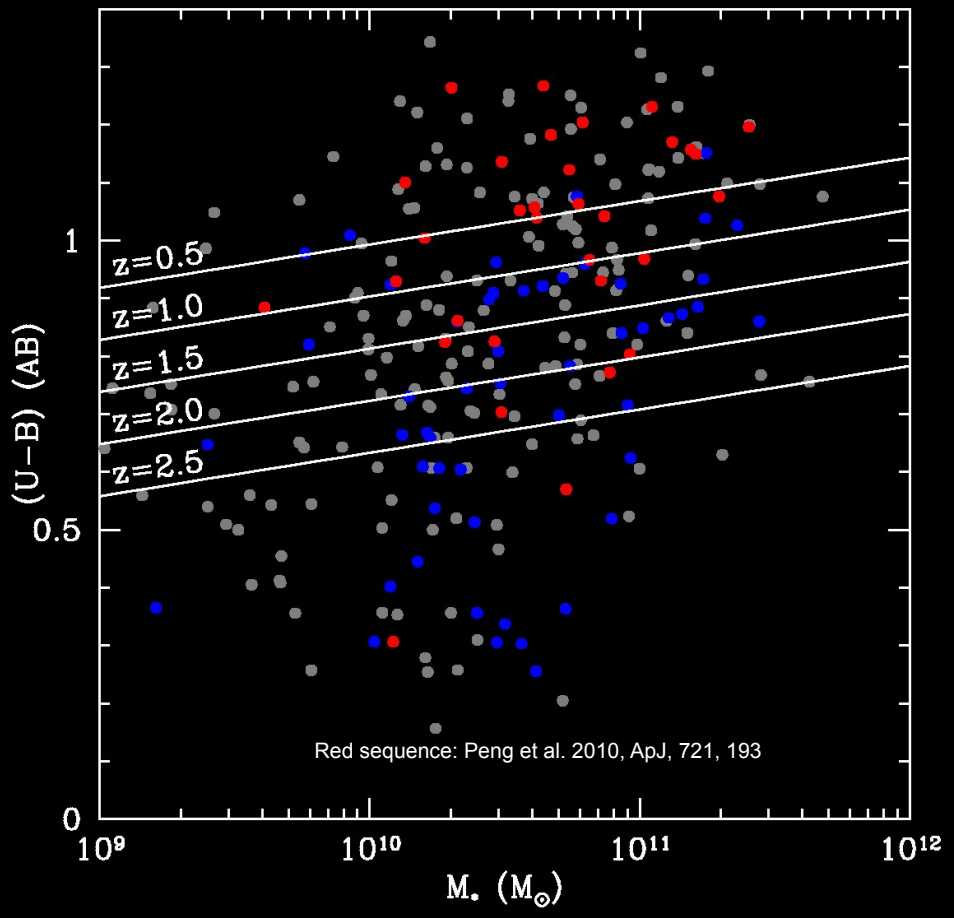
NH rather than hardness ratios

AGN contamination (found to be small)

dust redenning – stellar mass effects (Brusa et al. 2009, A&A, 507, 1277)

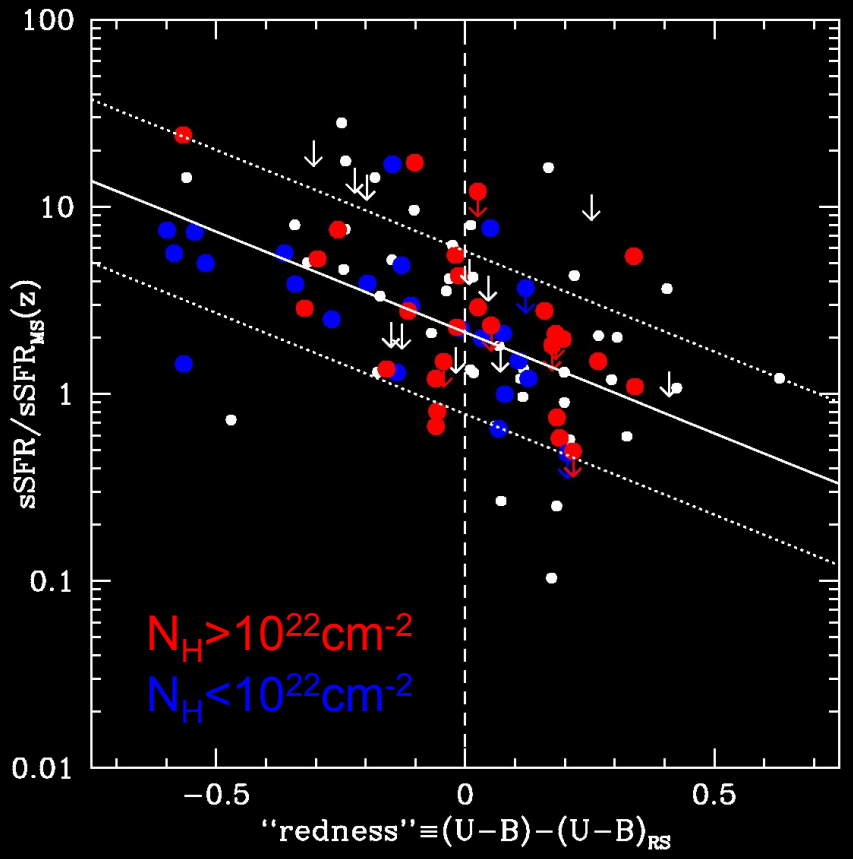
obscured AGN preferentially in “red sequence” !

Colour-Magnitude Diagram



sSFR≤1Gyr^{-1}

sSFR>1Gyr^{-1}



log(SB)=(-1.08±0.18)*redness+(0.3±0.4)

CDM is quite reliable in assessing AGN evolution

BUT: seems that obscured AGN are not in inactive hosts…

Summary

Sample of ~104 AGN with robust star-formation rate and stellar mass determinations

Correlation between sSFR and AGN activity only for $z>1$

No correlation between sSFR and AGN obscuration

AGN are found in normal star-forming galaxies with somewhat increased sSFR, but high X-ray luminosity AGN (QSOs) prefer starbursts

CMD is a cheap way to assess the host properties but not 100% reliable