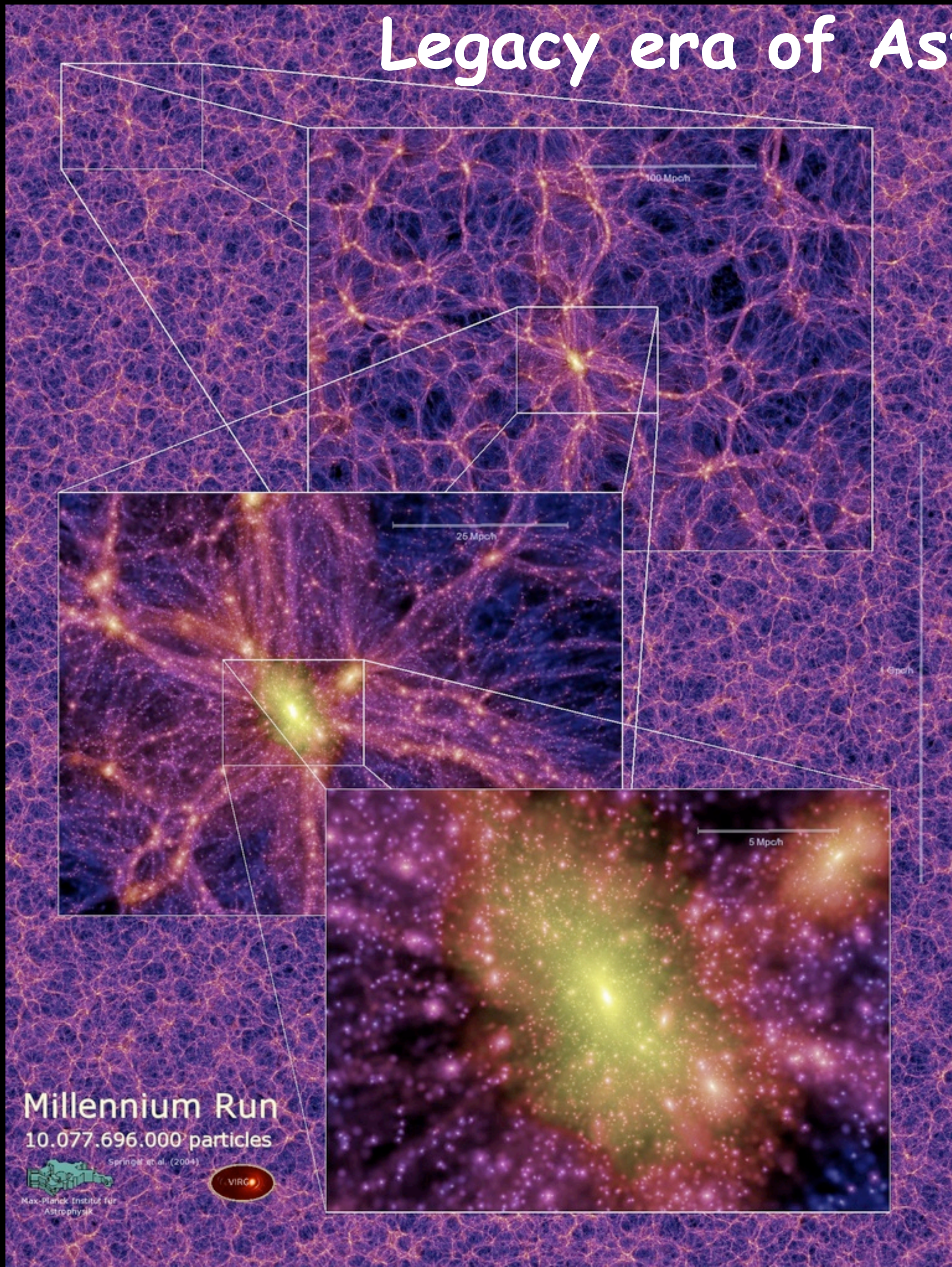
An XMM-Newton survey of infrared/submillimetre legacy fields?

Dave Alexander, Alastair Edge (Durham),
Omar Almaini, Gavin Dalton, Matt Jarvis, Paul Nandra,
Seb Oliver, Mat Page, Kathy Romer, Chris Simpson,
Ian Smail, Mike Watson

Legacy era of Astronomy



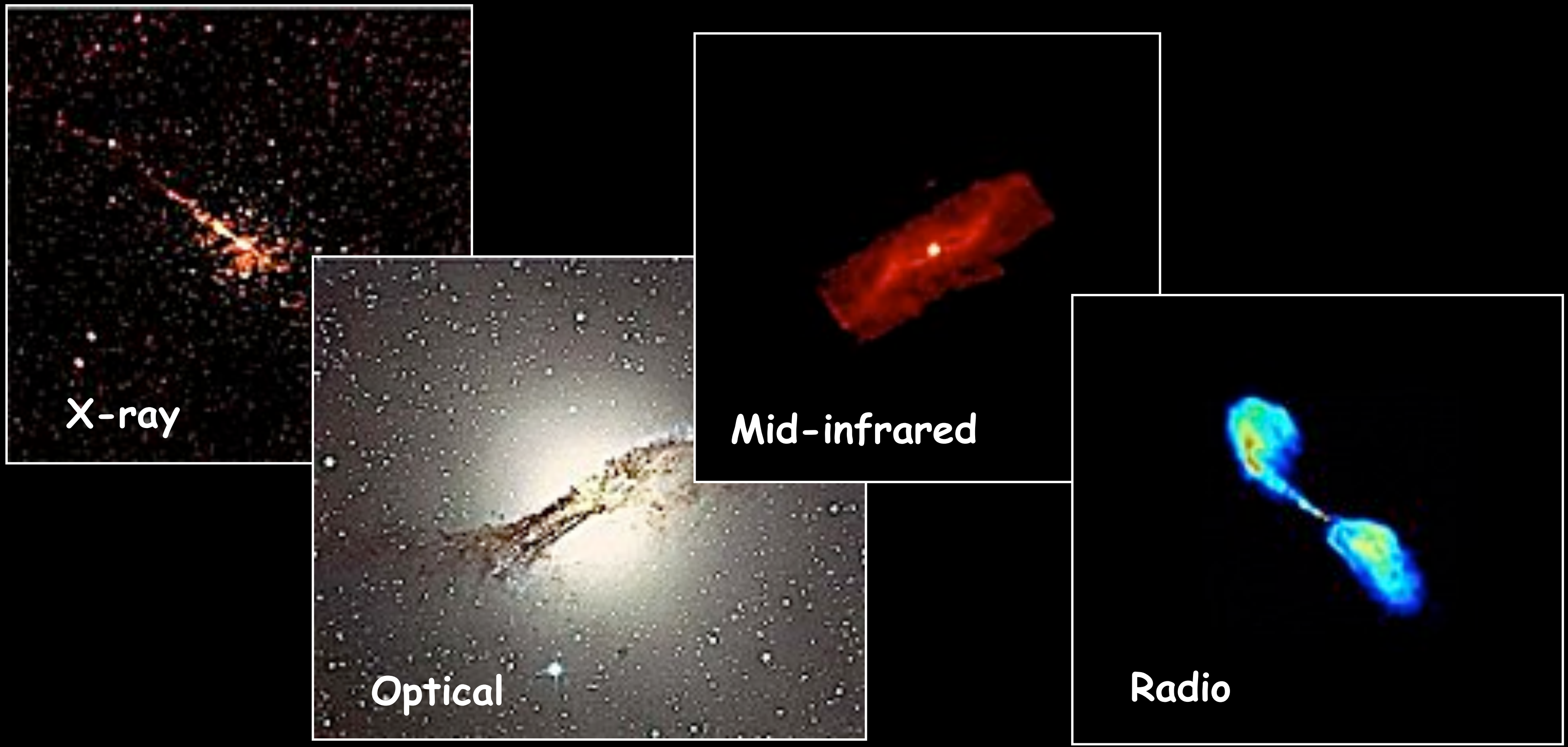
Tracing the growth of cosmic structure across the Universe:

Requires large areas (avoiding bias) or deep narrow-beam observations (tracing typical objects)

Need for large stastistical samples from ever widening selection of frequencies

Large observing allocations which require consortiums to achieve goals of project and maximise scientific impact

Need for multi-wavelength coverage



Multi-wavelength observations to distinguish in individual sources:

Starlight components
Star-formation components
AGN components

Large-area IR-submillimetre legacy surveys

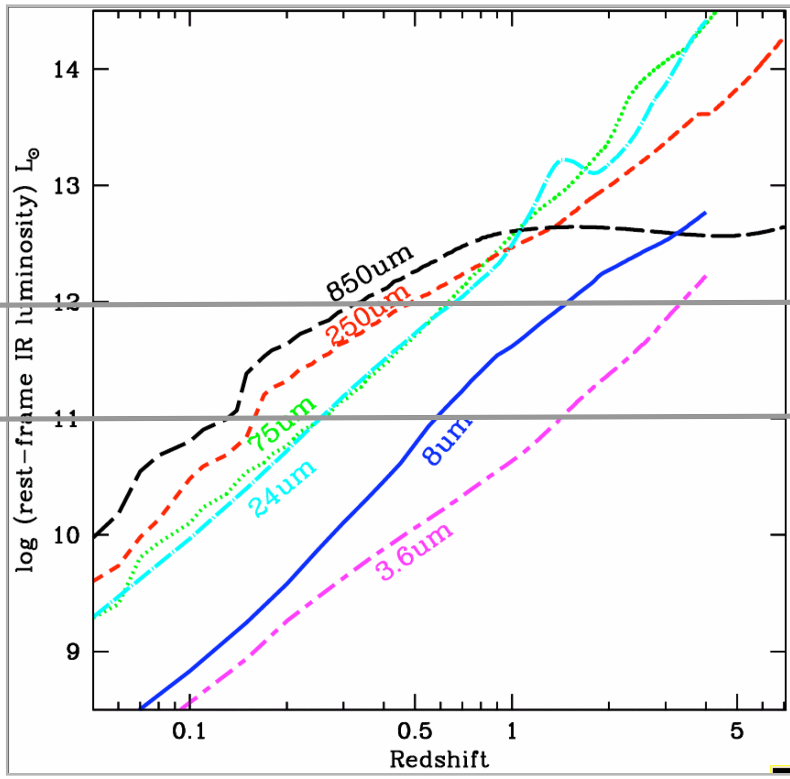
~20-50 sq deg over ~4-8 premier fields, e.g.: Full CDFS, Lockman Hole, ELAIS S1, ELAIS N1, ELAIS N2, Spitzer FLS

- 1-850um: bulk bolometric output for active objects
- equivalent volume as local SDSS (but at z~1)
- covering linear scales up to ~50-100 Mpc at z~1 (Supercluster scales)

Typically a ~3-8 Ms investment from each observatory in these surveys

Telescope	Wave (um)	Depth	Units
UKIRT	1.25	22.5	mag
	1.65	22.0	mag
	2.15	21.0	mag
VISTA	0.88	25.2	mag
	1.02	24.0	mag
	1.25	23.7	mag
	1.65	22.7	mag
	2.15	21.7	mag
Spitzer	3.6	3.7	uJy
	4.5	5.4	uJy
	5.8	48.0	uJy
	8.0	37.8	uJy
	24	230	uJy
Herschel	75	18	mJy
	170	18-120	mJy
	250	24-61	mJy
	350	29-74	mJy
	500	33-84	mJy
SCUBA2	850	3.5	mJy

Large-area IR-submillimetre legacy surveys

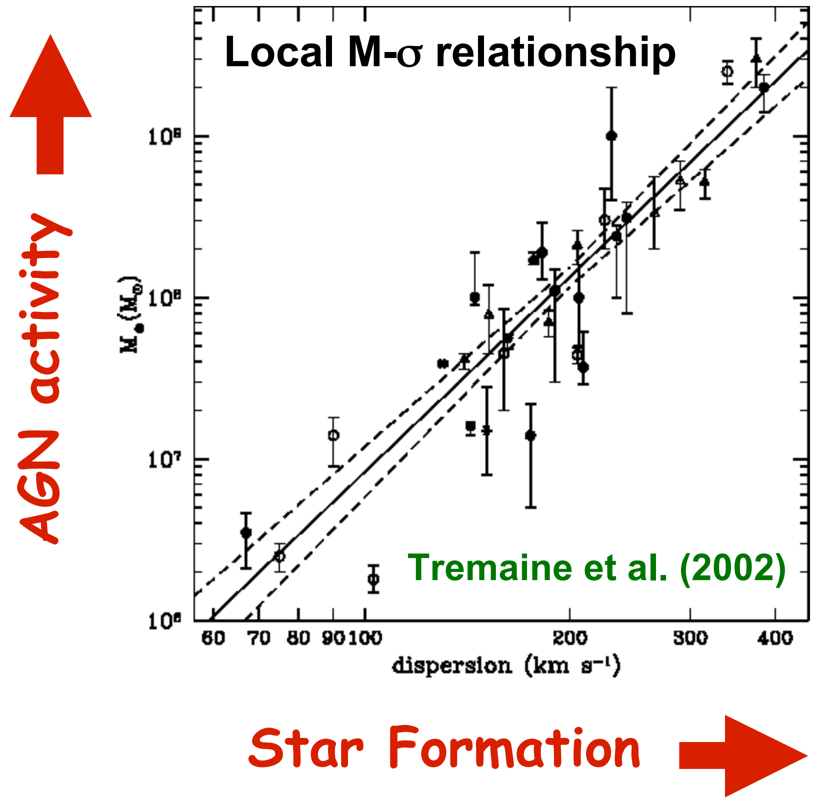


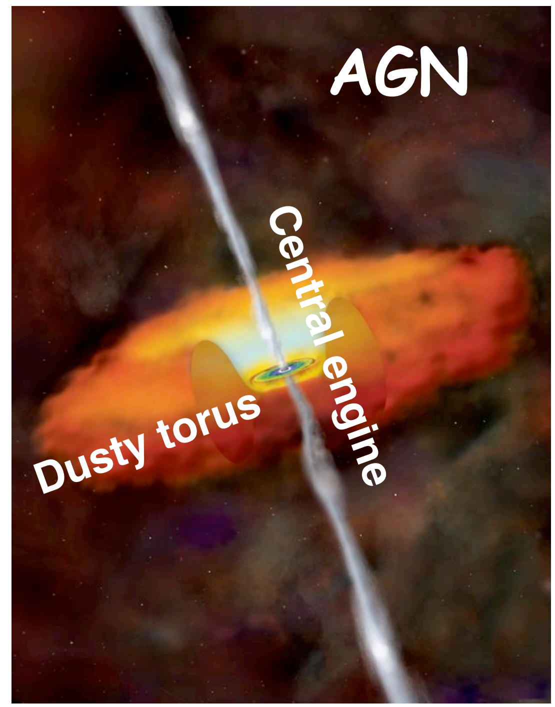
Some general goals:

- tracing star formation and AGN activity across (up to) 90% of cosmic time
- exploring if star formation/AGN activity is accelerated in high-density environments
- contribution of galaxies/AGN to cosmic backgrounds
- identifying z~6-7 galaxies/QSOs

Near-IR/mid-IR: L* galaxies out to z~2-4
Mid-IR/far-IR: LIRGs out to z~0.5 and ULIRGs out to z~3
These surveys greatly facilitated by large-area MOS spectroscopy

Need efficient AGN identification: major aspect missing in these cosmo surveys

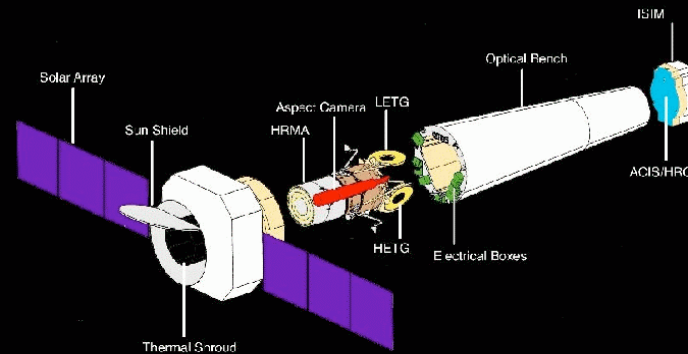




AGNs <u>WILL</u> be detected in these IR surveys but <u>identification (and very importantly energetics)</u> will be difficult to determine…

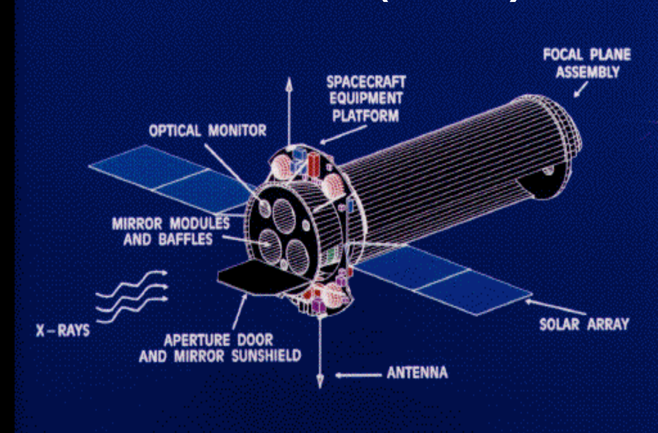
Radio data increaasing (LOFAR will provide deep coverage) but doesn't provide unambiguous energetics (when combined with X-ray, great for C.thick AGN ID)

X-rays: efficient AGN identification



Chandra (1999)

XMM-Newton (1999)



X-rays: (1) apparently a universal property of AGNs which allows AGNs to be identified irrespective of their optical/other properties, and (2) can probe heavily obscured objects

An XMM-Newton survey of infrared-submillimetre legacy fields?

Need for X-rays in these legacy surveys: X-rays provide most efficient AGN identification (even in sources lacking IR-optical signatures). X-rays efficiently locate clusters

<u>Possible strategy:</u>

• ~25 ks exposures over ~20 sq deg across ~6 fields (~10x original XMM-COSMOS) over ~5 years

• f(0.5-2keV)~10^{-15} erg/s/cm^2; f(2-10keV)~5x10^{-15} erg/s/cm^2

• XMM-Newton more efficient at covering large areas at moderate depth than Chandra: large FOV, similar sensitivity, harder X-ray band

• XMM-Newton spatial resolution provides efficient cluster detection

An XMM-Newton survey of infrared-submillimetre legacy fields?

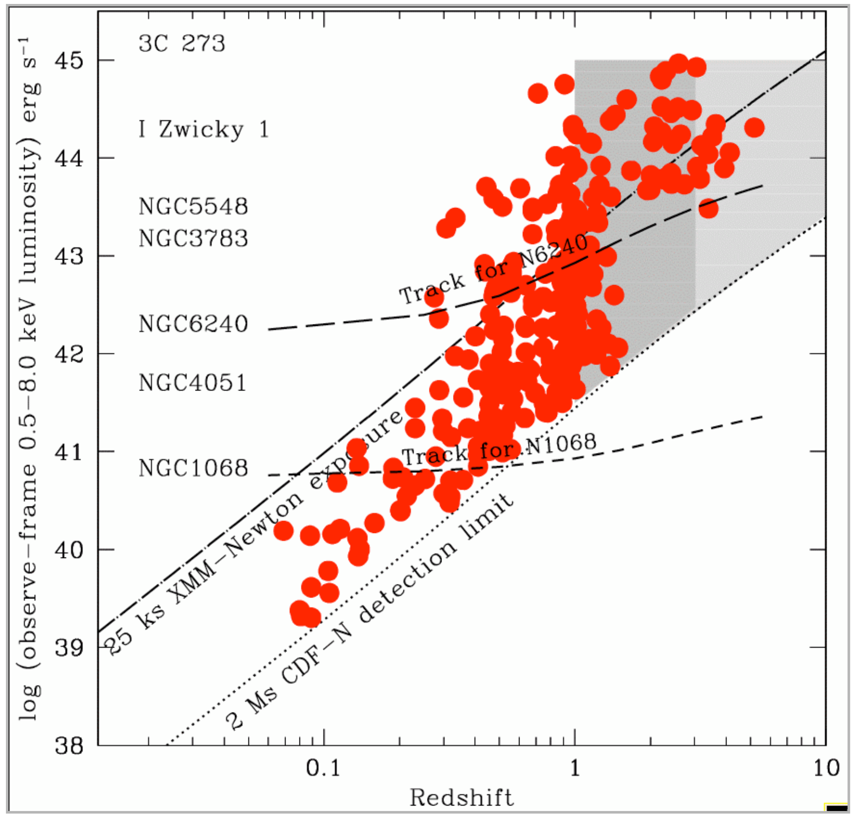
• ~15,000+ point sources (almost all AGNs; ~1000 z>3 AGN!!!): QSOs surveys exceeded only ~10,000 sources since 2001

• ~500+ clusters (up-to 100 with 10^{14} solar masses; few with 10^{15} solar masses)

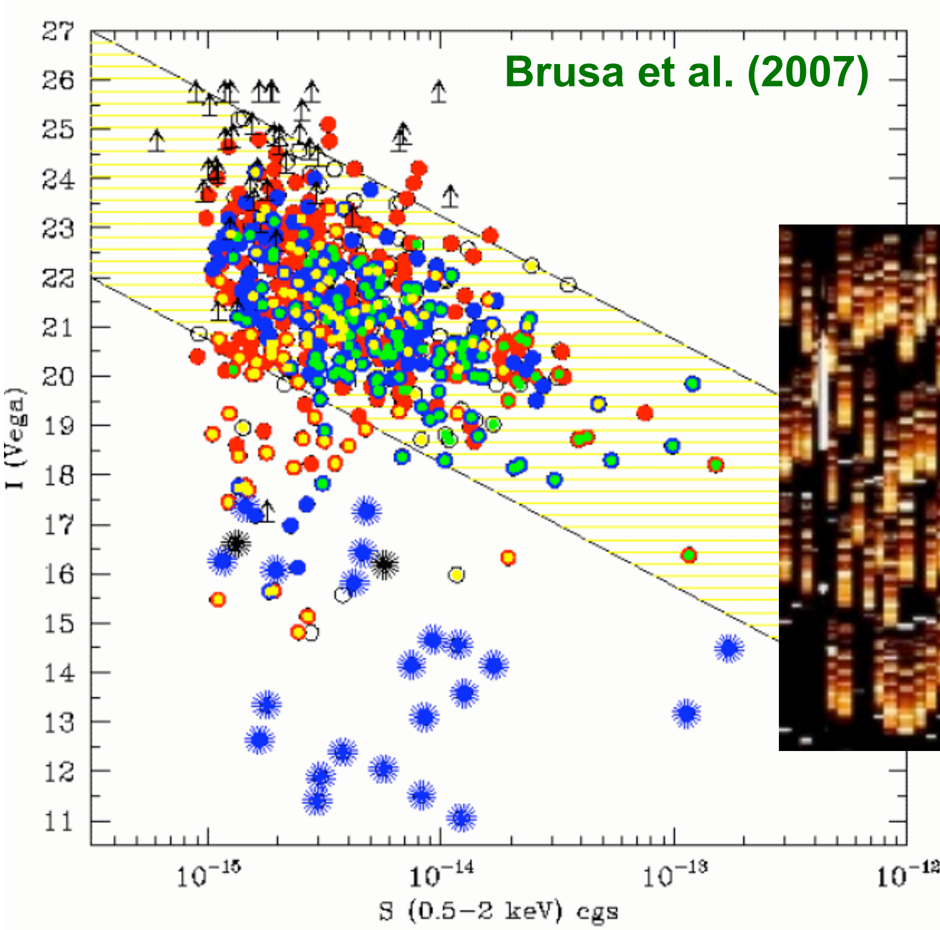
• identify AGNs where 2-10 keV lum <1% bolo IR lum

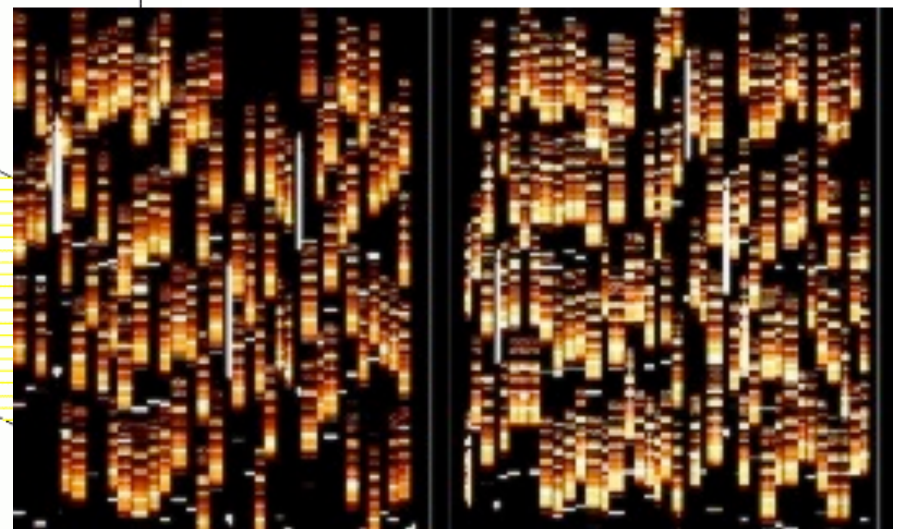
• cover linear scales of ~50-100 Mpc at z~1 (supercluser scales)

• identify galaxy cluster environments as a function of cluster mass



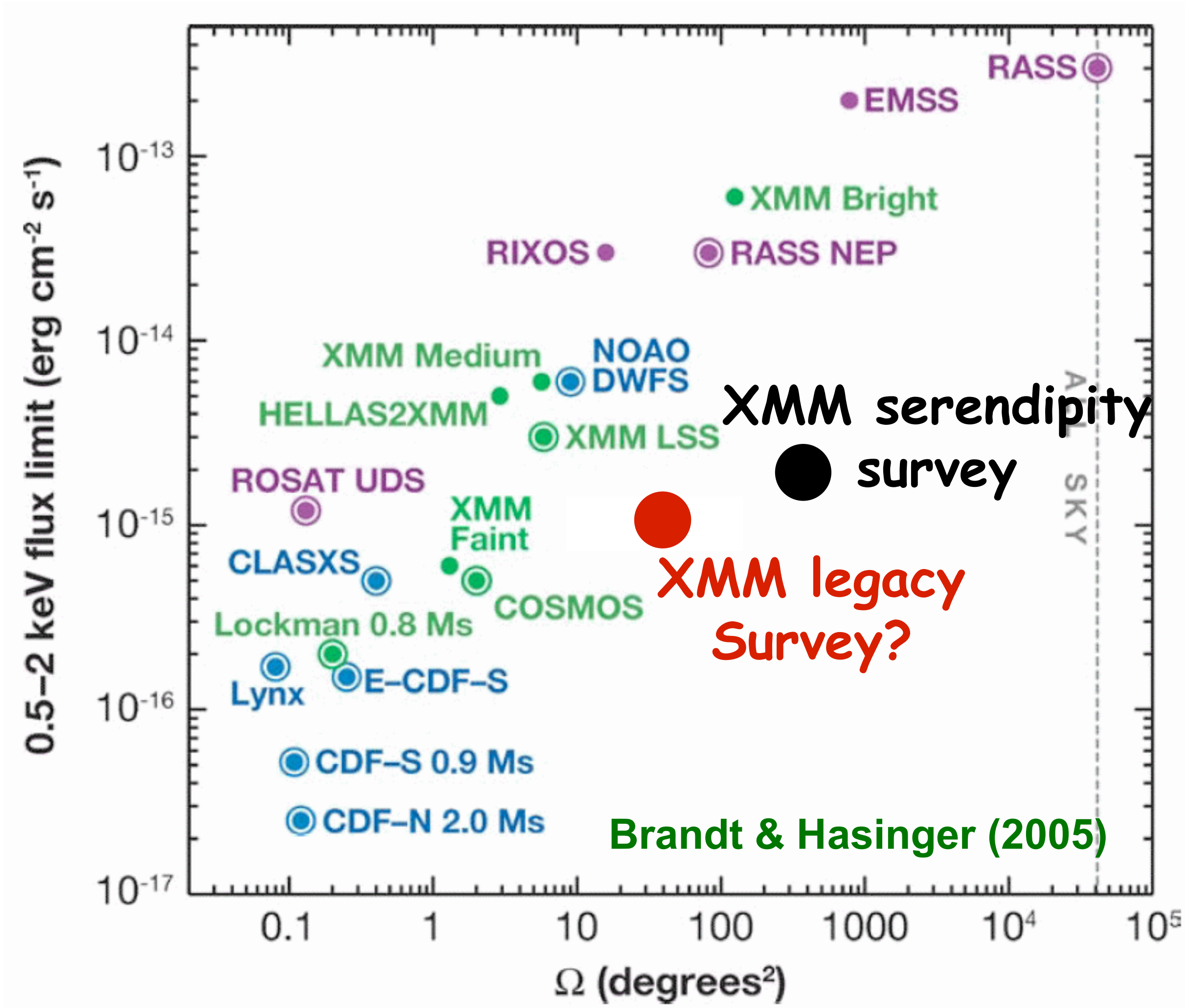
Efficient Follow-up Observations Possible with MOS





Effective spec-zs possible using large-area Mult-Object Spectroscopy (e.g., VIMOS/VLT, FMOS/Subaru, AAOmega/AAT, IMACS/Magellan, Hectospec/MMT)… but also multi-band photozs

Comparison of X-ray surveys



Would be the largest pointed survey at this depth; serendipity surveys are larger but are more challenging to follow-up sources

Pointed vs Serendipity surveys

(see M.Watson talk for fuller discussion)

Serendipity surveys: extremely efficient generation of large numbers of X-ray sources with little "expense":

Supreme for exploring variety of X-ray source population and identifying rare source types, however, it is challenging to obtain a full multi-wavelength data suite for many sources

XMM-Newton legacy survey: moderate-depth X-ray survey on fields that already have a full multi-wavelength suite (in this case ~20+Ms of ancillary data)

To date, the X-ray coverage of the IR-submillimetre legacy fields is modest, leading to:

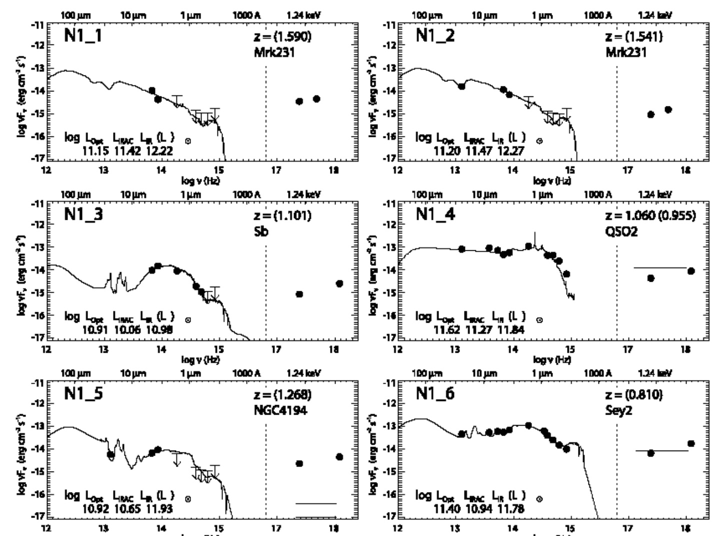
(1) a large gap in spectral energy distributions
(2) lack of efficient AGN identification and energetics
(3) decrease in effectiveness of cluster identification and masses

Total request would be ~6 Ms (~8% of time over 5 years), comparable to each of the other legacy-type observations in these fields (i.e., ~25-30% of total 20+Ms investment)

XMM-Newton legacy survey, some basic statistics: ~15,000+ AGN and ~500+ clusters:

- ~2000+ AGN with enough counts for some X-ray spectral constraints (scaled from Mainieri et al. 2007)
- ~1000 z>3 AGN (scaled from Hasinger et al. 2007)
- ~400-1000 obscured QSOs (scaled from Franceschini et al. 2005); possibly up to ~100 C-thick (Martinez-Sansigre et al. 2006)
- ~100 nearby C-thick AGN (scaled from Hasinger et al. 2007)

Efficient AGN census (BH growth; energetics) to trace AGN-star formation (largest X-ray-IR sample) across the full range of environments (field to galaxy clusters)



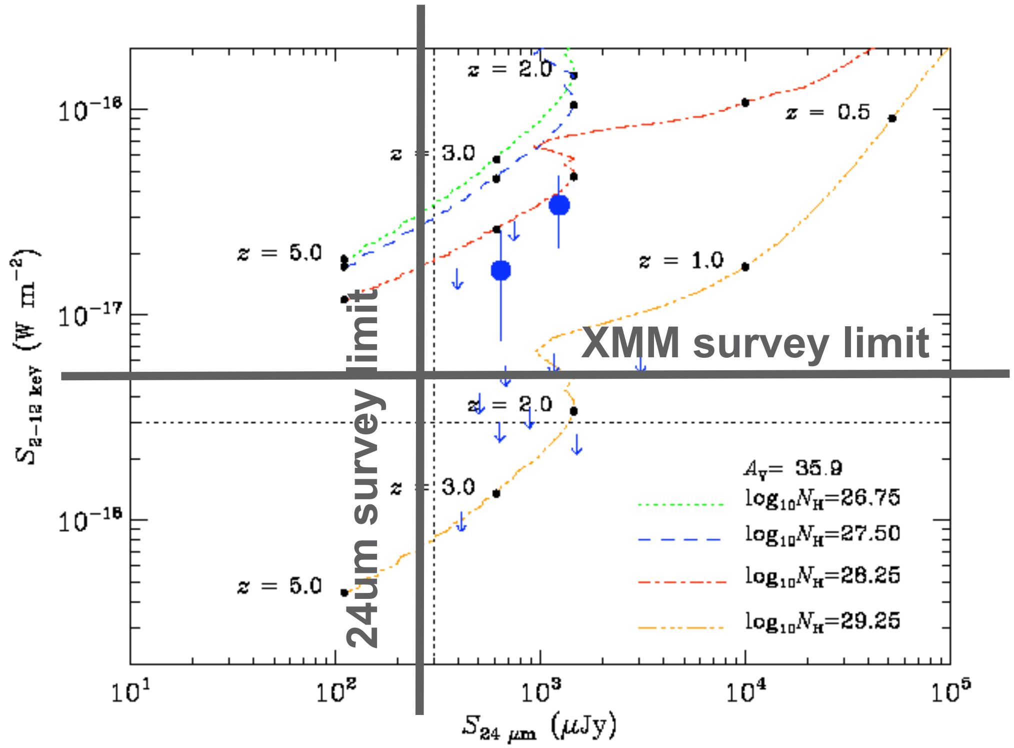
Franceschini et al. (2005)

Many possible science goals, a few explored here

Identification of Compton-thick AGN near and far

To date only ~50 C-thick AGN are known, a paltry ~10^{-8} of the entire population (Comastri 2004)! On basis of XMM-COSMOS, we expect ~100 nearby Compton-thick AGN; more than doubling known population. These sources will be easy to follow-up in great detail.

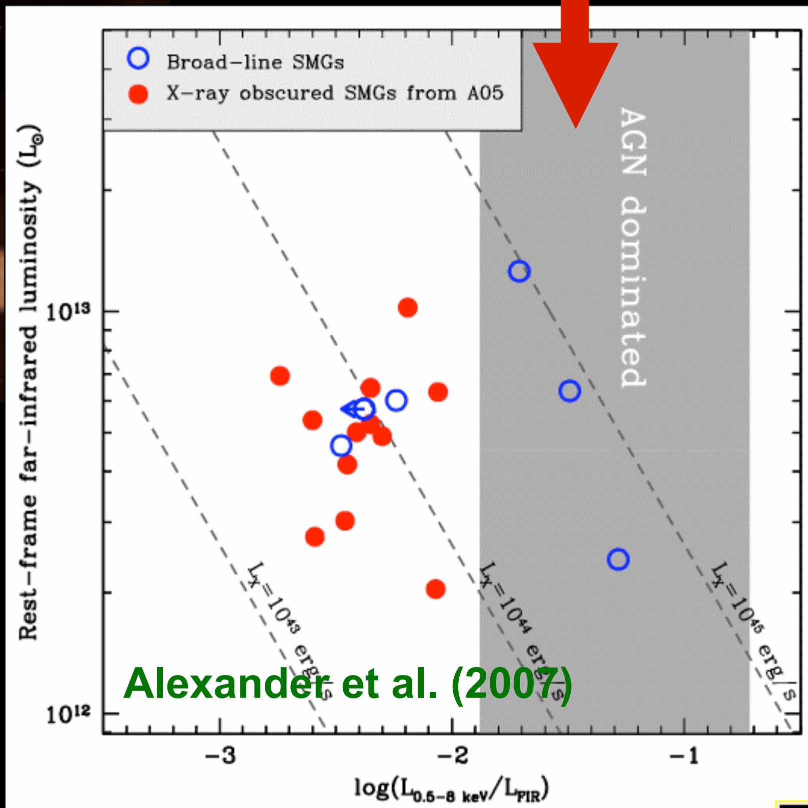
On basis of X-ray-IR-radio analyses, we might also expect up to ~300 candidate C-thick QSOs at z>1.7 (if have AGN-dominated SEDs)



Martinez-Sansigre et al. (2007)

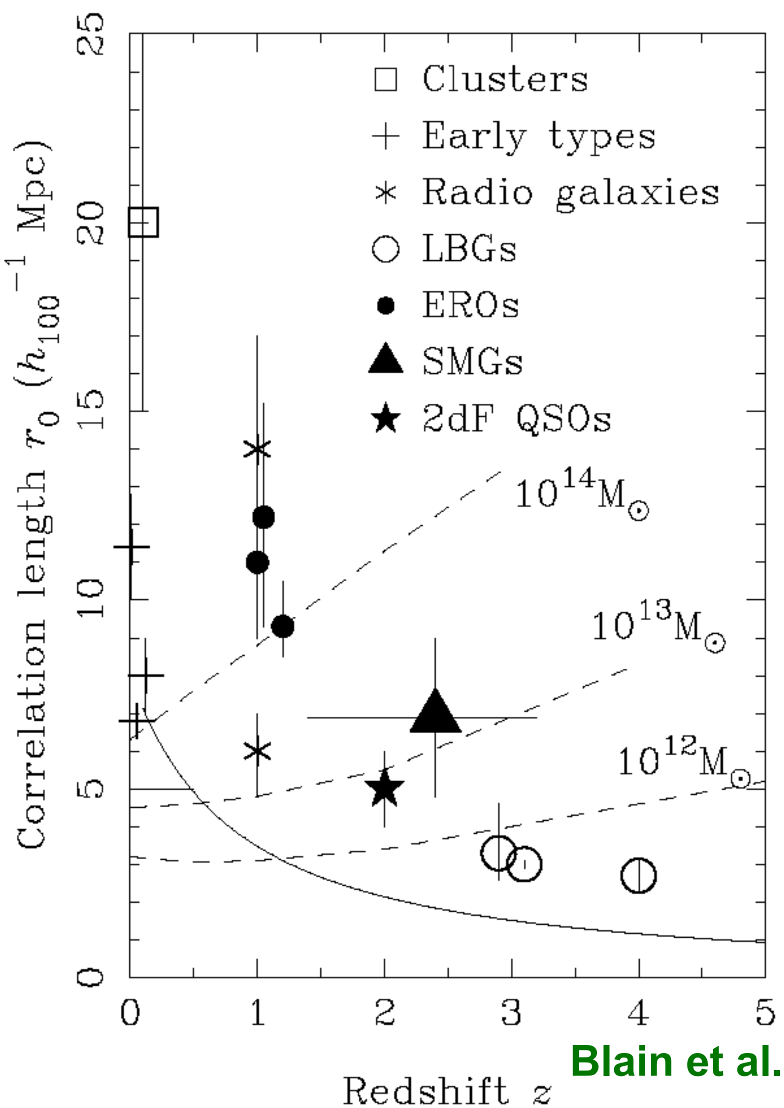
Heavily obscured QSOs in distant Starbursts

Lack of submm-identified obscured QSOs: need large area for good constraints (potentially 100+ will be found)



Models predict a crucial intense black-hole growth stage between starburst and QSO phase in major mergers, which should be found as heavily obscured submm-detected QSOs: where are they?

The Dark Matter Halos of AGNs



Blain et al. (2004)

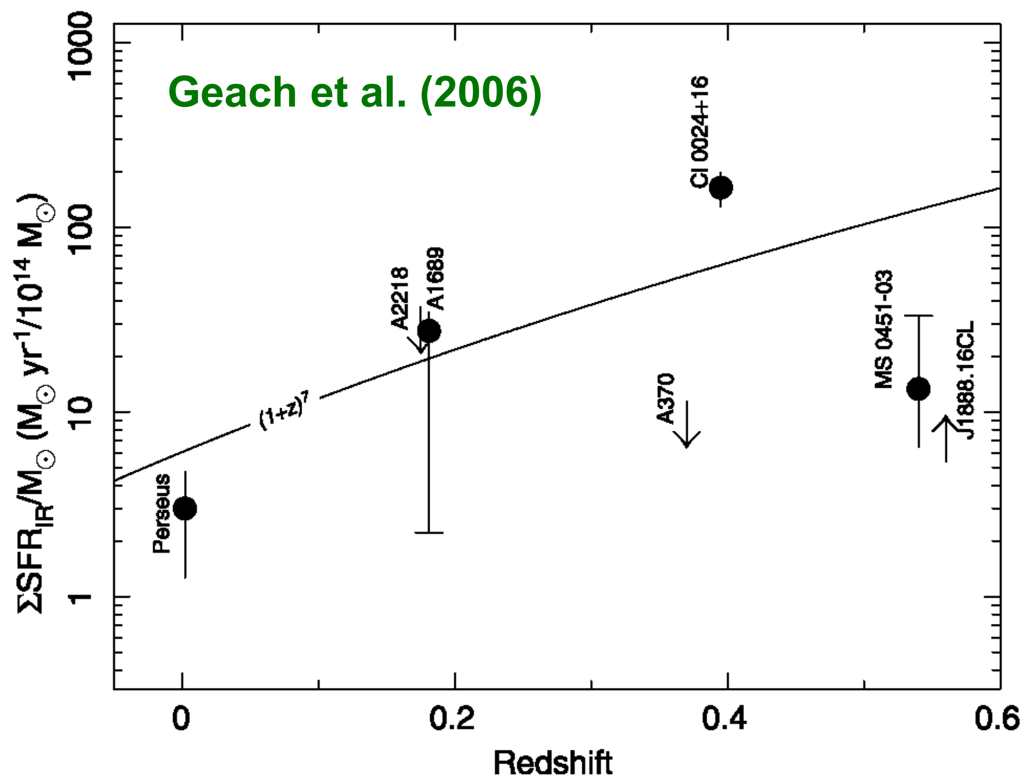
Need large AGN samples to trace the 3D clustering of AGNs as a function of redshift, luminosity, etc

Explore connections between AGN and other populations, e.g.: Is AGN activity triggered predominantly in biased regions? Is there any evolution with redshift? Do starbursts and AGNs have similar clustering properties?

Tracing Evolution of AGN and star formation activity in Galaxy Clusters

Evolution of cluster galaxy members. Star-formation in clusters appears to evolve rapidly with redshift (equivalent to evolution seen in ULIRGs) but the current statistics are poor

XMM legacy survey will provide potentially hundreds of galaxy clusters with which to trace star-formation rates and AGN activity as a function of redshift, galaxy mass, etc



Summary

• Multi-wavelength legacy surveys over large areas to required trace growth of structure across cosmic time and across all environments

• ~20-50 sq deg covered in premier fields at IR wavelengths (~3-8 Ms at each wavelength) unveiling obscured/unobscured activity. However, these surveys lack efficient AGN and cluster identification/energetics, provided by X-rays

• XMM-Newton suited to large-area legacy: ~25ks & ~20 sq deg requires ~6 Ms (~8% of time over 5 years; ~25-30% of ~20+ Ms investment in fields)

• Comparatively easy to schedule due to multiple fields

• Well matched to IR surveys (ID AGNs where 2-10 keV lum <1% bolometric)

• Expect 15,000+ AGN (~1000 z>3 AGN; ~400-1000 obscured QSOs; >100 C-thick AGN) and 500+ galaxy clusters

• Broad range of possible goals including identifying C-thick AGN, obscured QSOs in distant starbursts, tracing 3D clustering of AGNs, tracing AGN/star formation activity in galaxy clusters as function of mass, redshift, etc