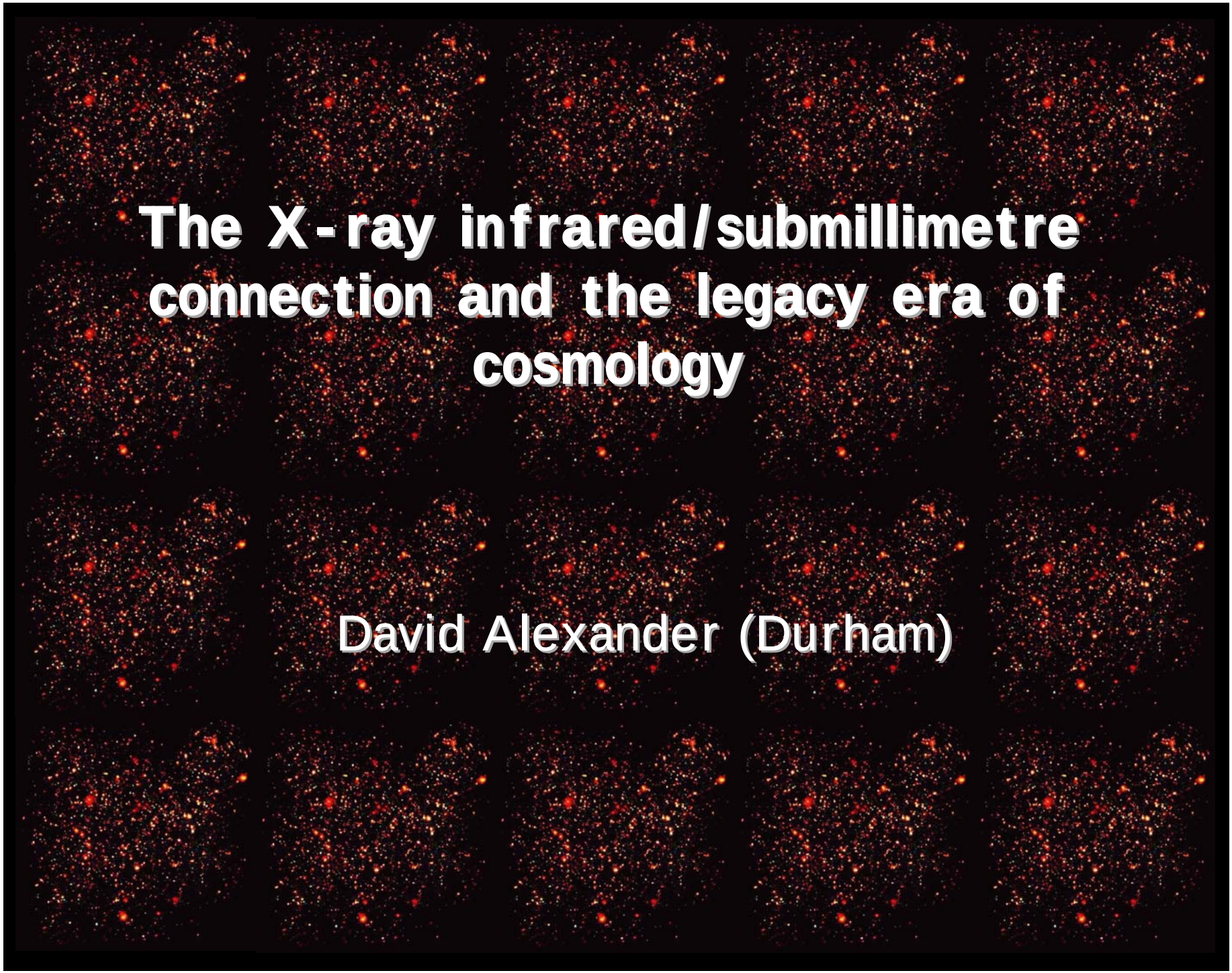
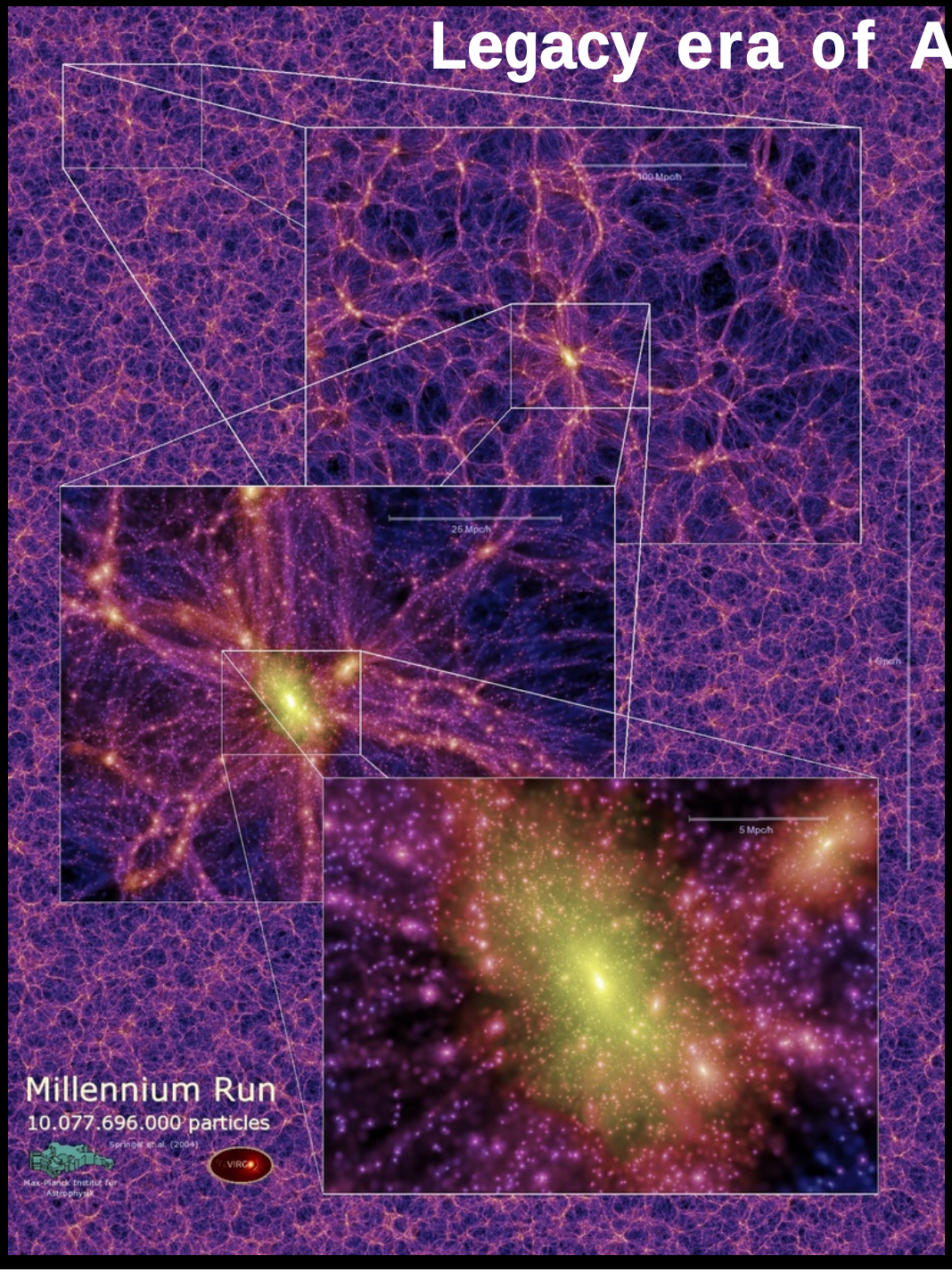

The X-ray infrared/submillimetre connection and the legacy era of cosmology
David Alexander (Durham)

Legacy era of Astronomy



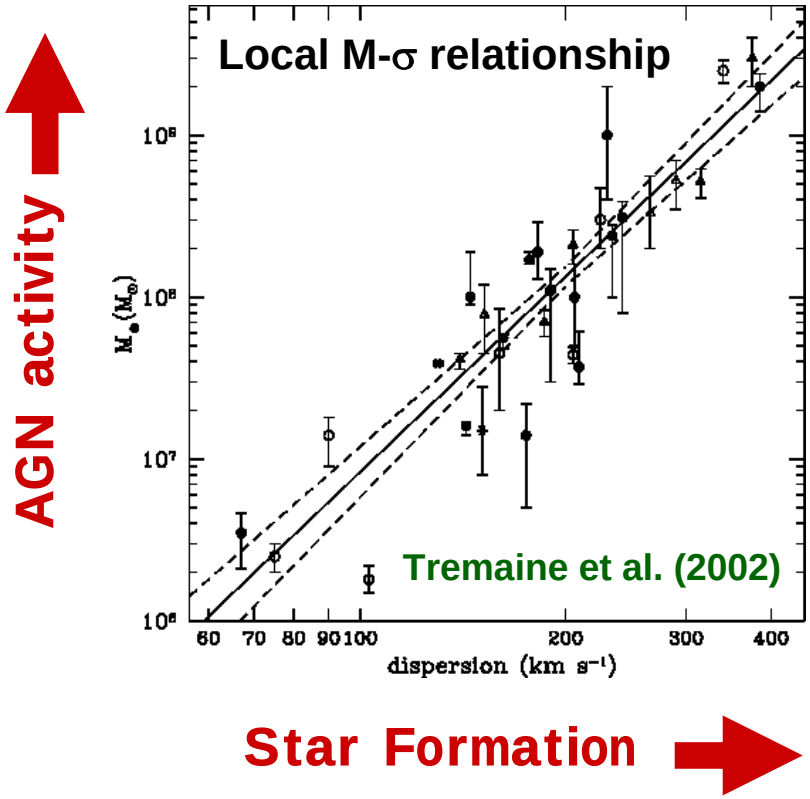
Tracing the growth of cosmic structure across the Universe:

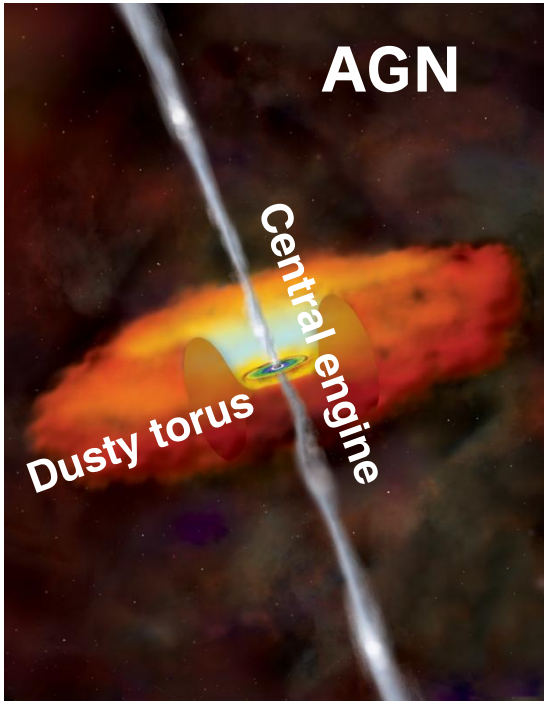
Requires large areas (avoiding bias) or deep narrow-beam observations (tracing typical objects)

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

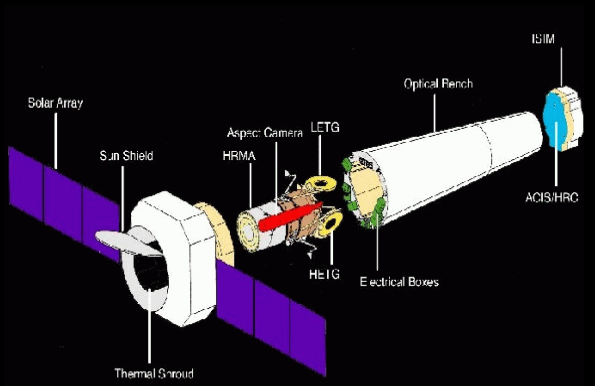
Need efficient AGN identification: major aspect often missing in these cosmo surveys



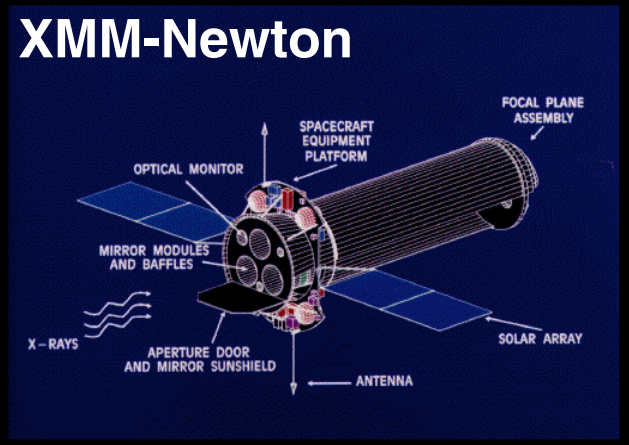


AGNs <u>WILL</u> be detected in these IR surveys but <u>identification (and very importantly energetics)</u> will be difficult to determine…

Effectiveness of X-ray Observations



Chandra



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

The XMM-Newton Wide-Deep Survey: Cosmic Accretion from Voids to Superclusters

1. Abstract

X-ray surveys have provided a sensitive view of the evolution of AGN activity and black-hole growth out to $z \approx 5$. However, these surveys have not yet had sufficient sensitivity over a large enough area to trace directly how black holes grow as a function of environment. Most simulations suggest that black holes that reside in overdense regions should grow more rapidly than those found in more typical regions of the Universe. We propose a wide-deep 50 ks survey of 7.1 deg^2 (10 deg^2 when combined with existing observations) to determine the mass-accretion history of the Universe as a function of galaxy density and cluster/supercluster environment. Our survey has sufficient sensitivity and volume to identify the environments that drive the differential evolution of moderate and high-luminosity AGNs.

Talk Topics:

- **Environment and Black-Hole Growth**
- **AGN activity in Submillimetre Galaxies**
- **Identifying Compton-thick AGNs**

The Wide-Deep XMM-Newton Survey Proposal

3 Ms Proposal Submitted Last Round: to give 10 sq deg at 50ks

Survey Parameters:

- ~50 ks exp in 5 fields (9 pointings/sq deg) with IR-submm data (7.1 sq deg but total of 10 sq deg when combined with existing data)
- Wide RA range eases stress on XMM scheduling and follow-up
- f(0.5-2keV)~5×10^{-16} erg/s/cm^2; f(2-10keV)~3×10^{-15} erg/s/cm^2
- Sensitivity limits: 1.6×10^{43} erg/s (rest-frame 4-20 keV) at z~1; about order of magnitude higher at z~3 (trace AGN "downsizing")

Source Statistics:

- ~10000 X-ray AGNs; ~1000 with >100 counts (basic X-ray spectra)
- ~500 z>3 quasars (obscured and unobscured) and ~10 at z>6
- ~100-150 Compton-thick AGNs (ID'd from SEDs)
- ~80-160 X-ray starbursts
- ~300-400 clusters (~30 with M>10^{14} solar masses; ~20-30 at z>1)

Many possible science goals, a few explored here

The Wide-Deep XMM-Newton Survey Proposal

3 Ms **50ks**

Survey

- **~50** **sq deg**
- **Wide**
- **f(0.5**
- **Sens** **about**

Source

- **~100**
- **~500**
- **~100**
- **~80-**
- **~300**

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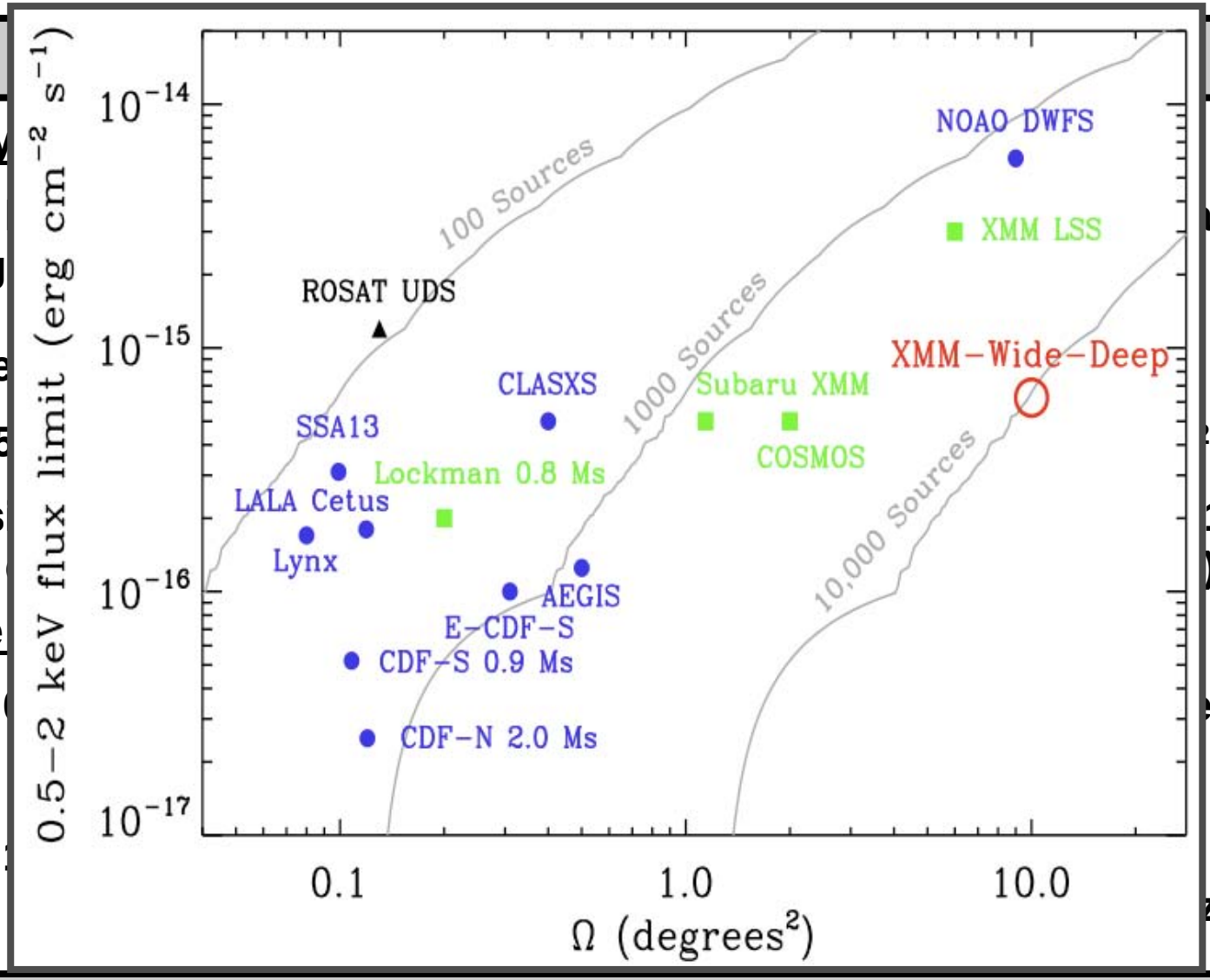
z>1)



Many possible science goals, a few explored here

Large-area IR-submillimetre legacy surveys

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

- 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

Home | Science Goals | Asteroid Threat | Design Features | Project Status | Internal Pages

Pan-STARRS
UNIVERSITY OF HAWAI'I

5-band optical data down to g~27

Dangers from space

Learn about the threat to Earth from asteroids & comets and how the Pan-STARRS project is designed to help detect these NEOs. Learn more...

1,400,000,000 pixels

Pan-STARRS has the world's largest digital cameras.

Read about them here...

The PS1 Prototype

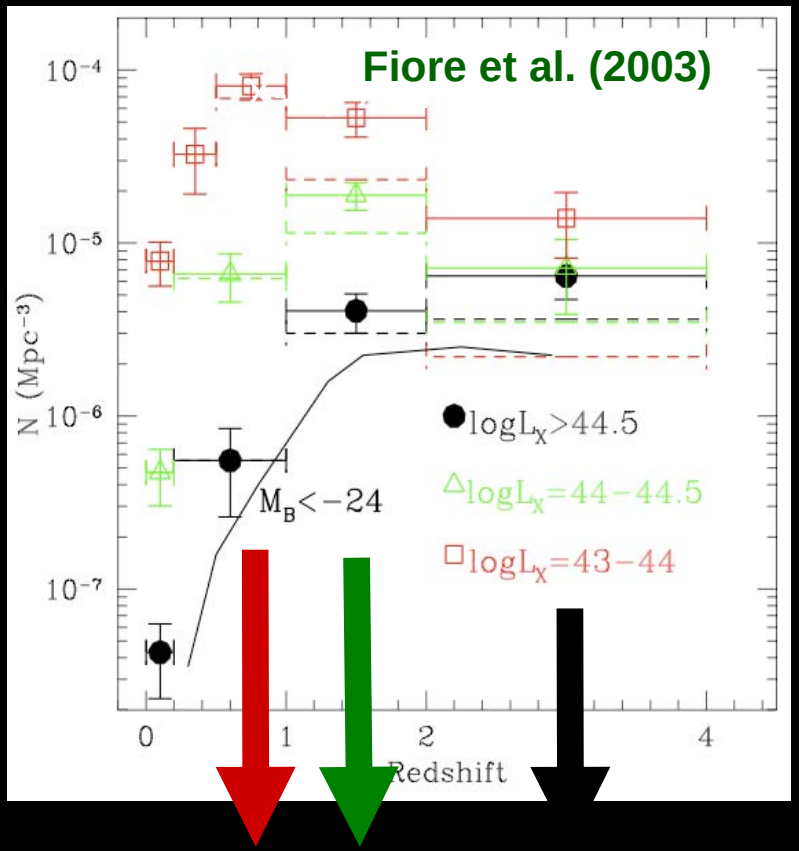
Now active on Haleakala

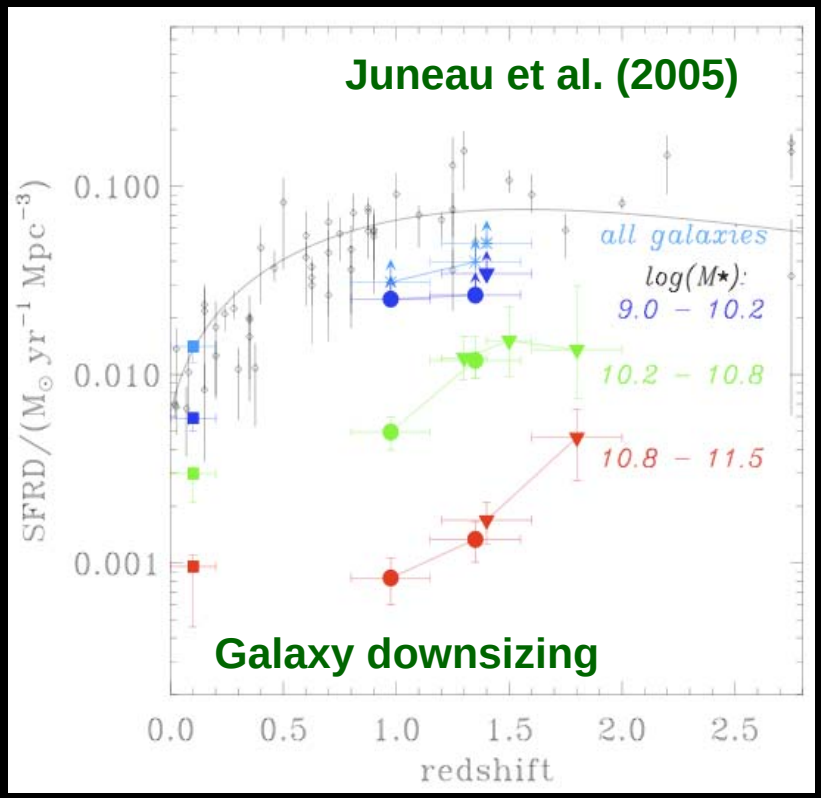
PS1 consortium formed...

More about PS1 here...

Topic 1: AGN "downsizing"

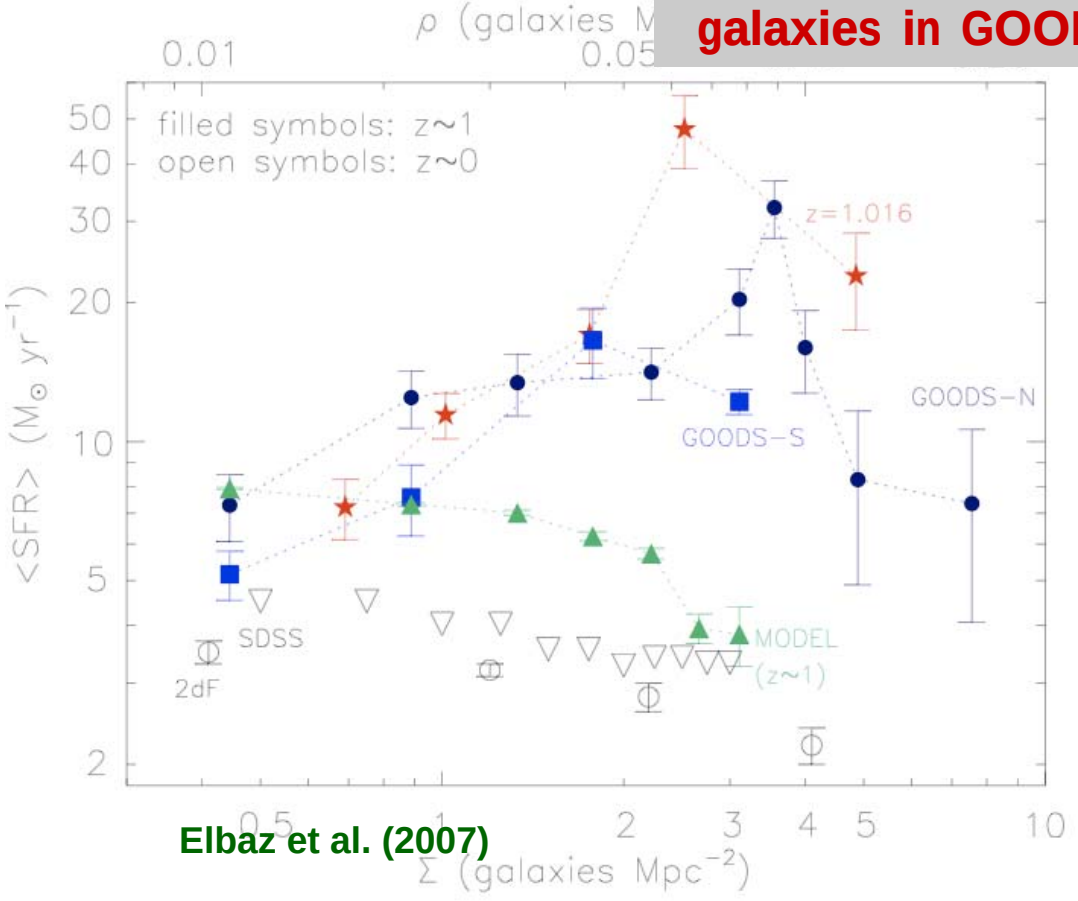
Luminosity-dependent density evolution (LDDE): high-luminosity AGNs peaked at higher redshifts than more typical AGNs (e.g., Cowie 03; Ueda 03; Hasinger 05, etc)





What is driving this evolution?

Effect of environment on star formation in galaxies

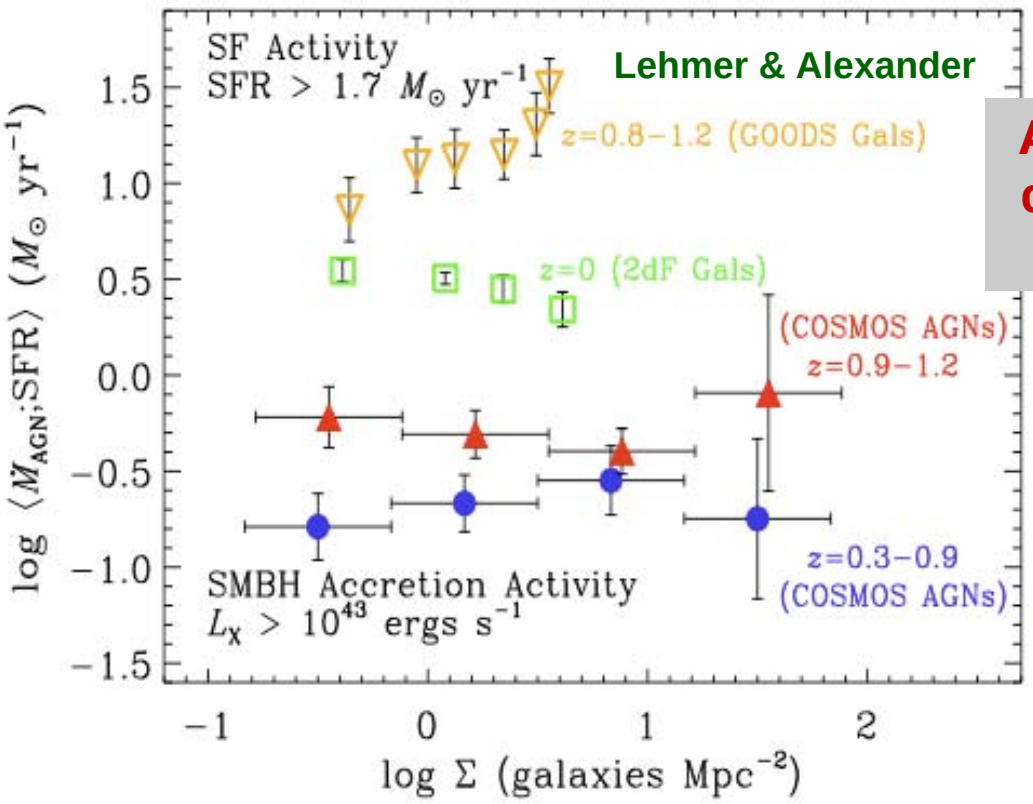


Elbaz et al. (2007)

Spitzer-identified galaxies in GOODS

At z~1 galaxies in high density regions still undergoing rapid star formation (not always obviously merger driven), in contrast to z~0 where these galaxies are red and dead

Effect of Environment on AGN activity?



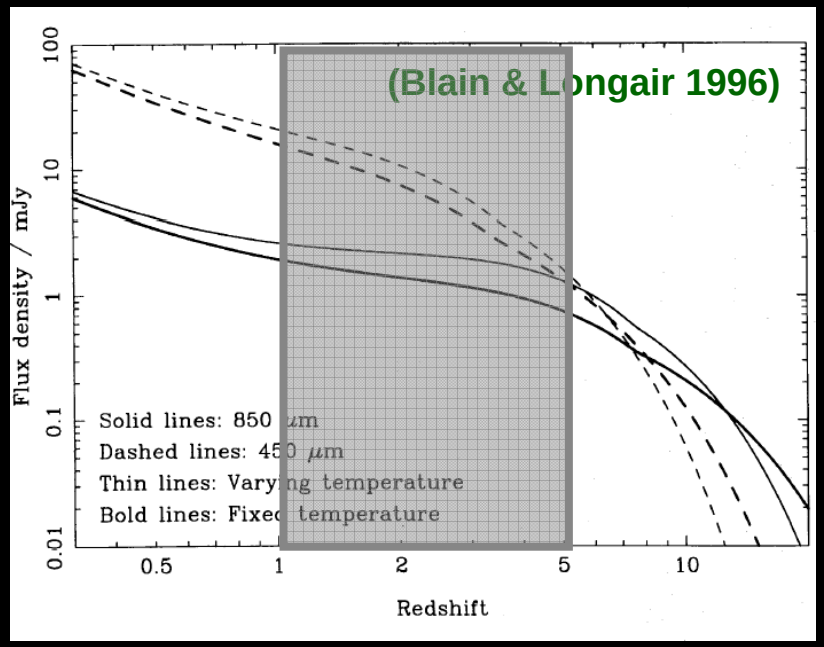
Lehmer & Alexander

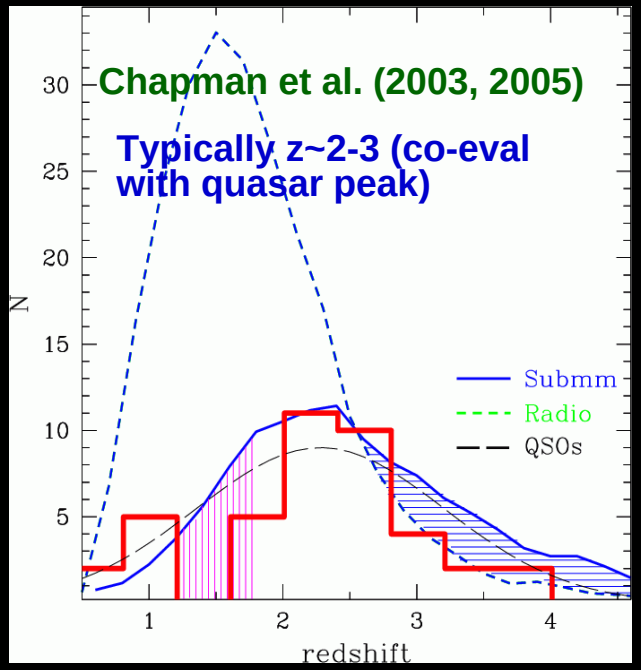
AGNs from COSMOS compared to galaxies from GOODS

Need: (1) large area (trace full range of environments), (2) large number of sources (explore the key parameters), and (3) good sensitivity (to trace dominant AGN at each epoch): e.g., 10 galaxy density bins, 5 redshift bins, 5 luminosity bins, 2 large-scale structure (clusters vs non clusters), and >10 objects/bin≥10000 AGNs

Topic (2): Submillimeter galaxies - Distant ULIRGs

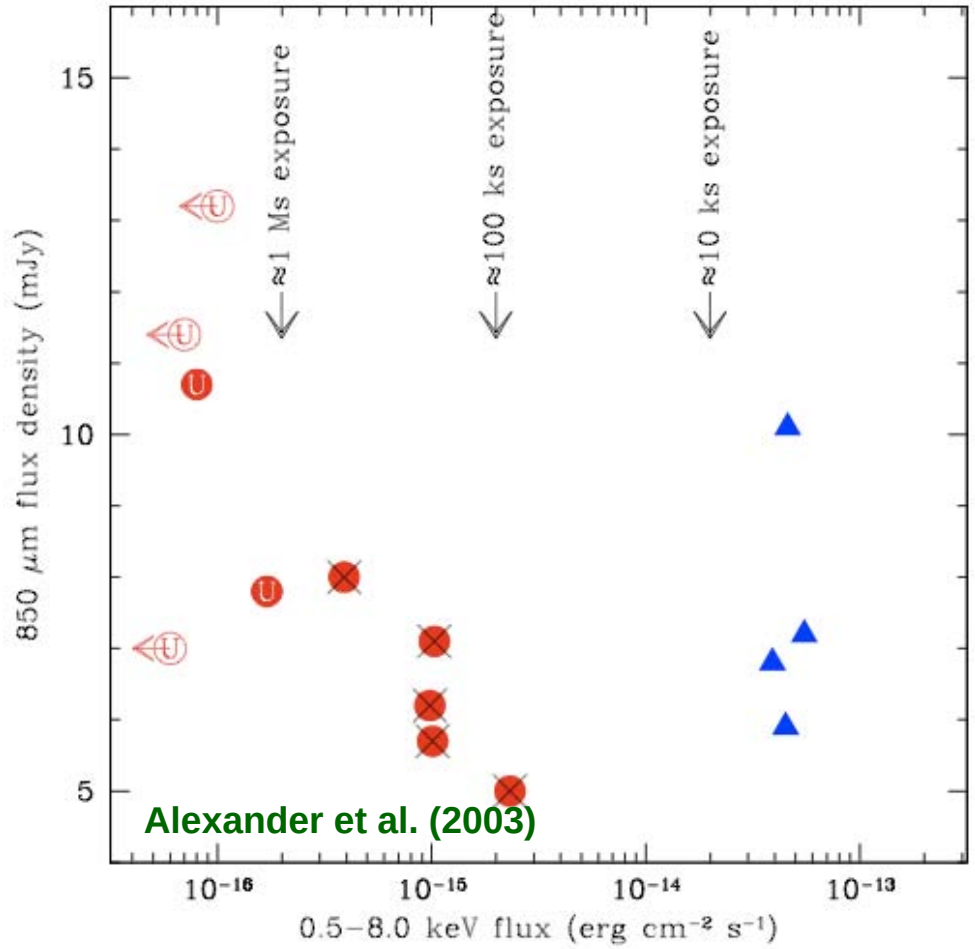
Submm Selection: Negative K correction means almost flat selection function: can detect ULIRGs out to z~5-8 almost independent of distance



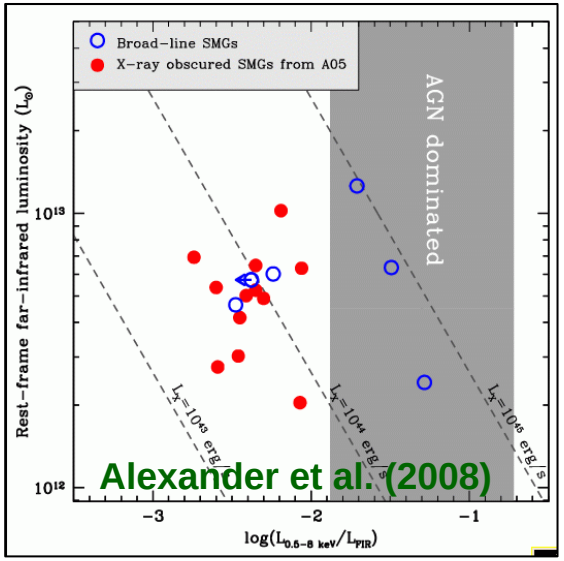


SCUBA2 legacy surveys (starting from end 2008) will cover ~20 sq deg (order of magnitude more than current surveys) in

Submm galaxies are typically X-ray faint



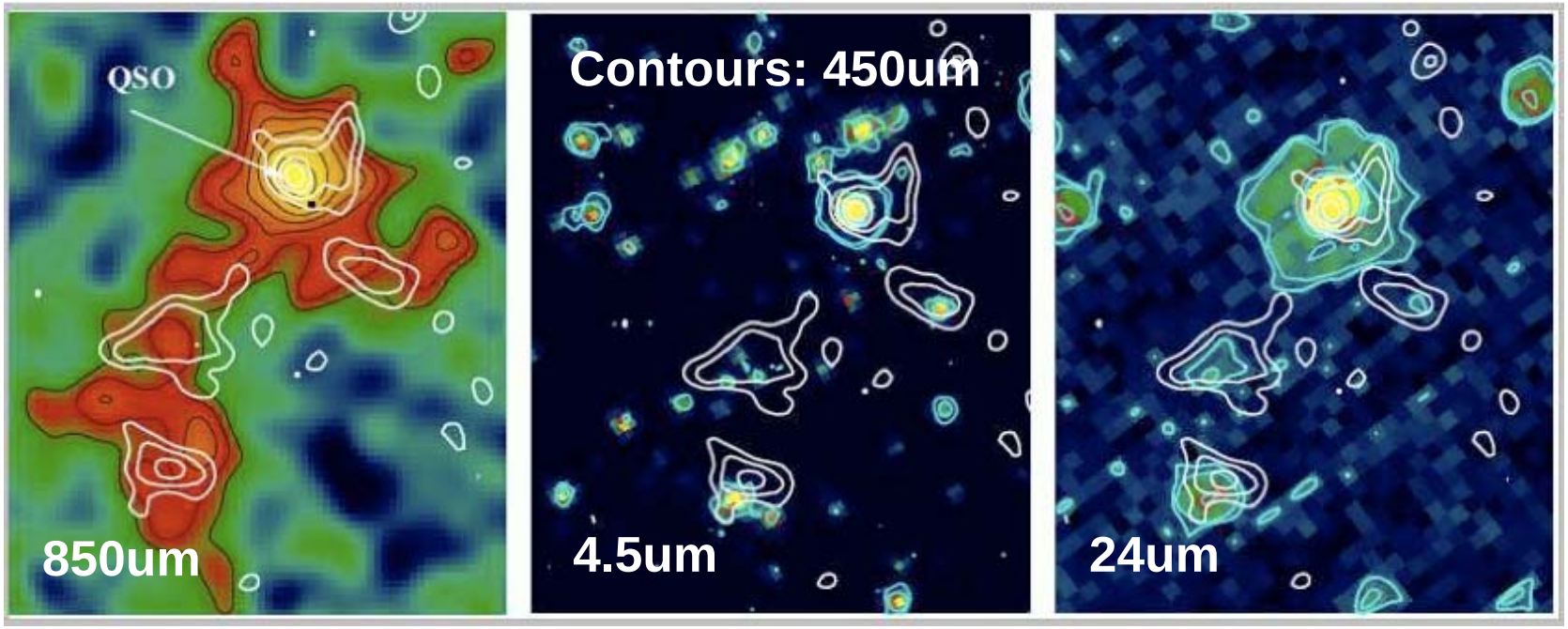
Typical submm galaxies require >100ks (red) but rare submm quasars (obscured/unobscured) need <100ks (blue)



Studying large numbers of these submm obscured/unobscured quasars will shed light on connection between typical submm galaxies and quasars

Submm Quasars: pinpoint sites of distant rapid growth

Predict ~100-200 submm quasars in 10 sq deg



Stevens et al. (2005, 2006)

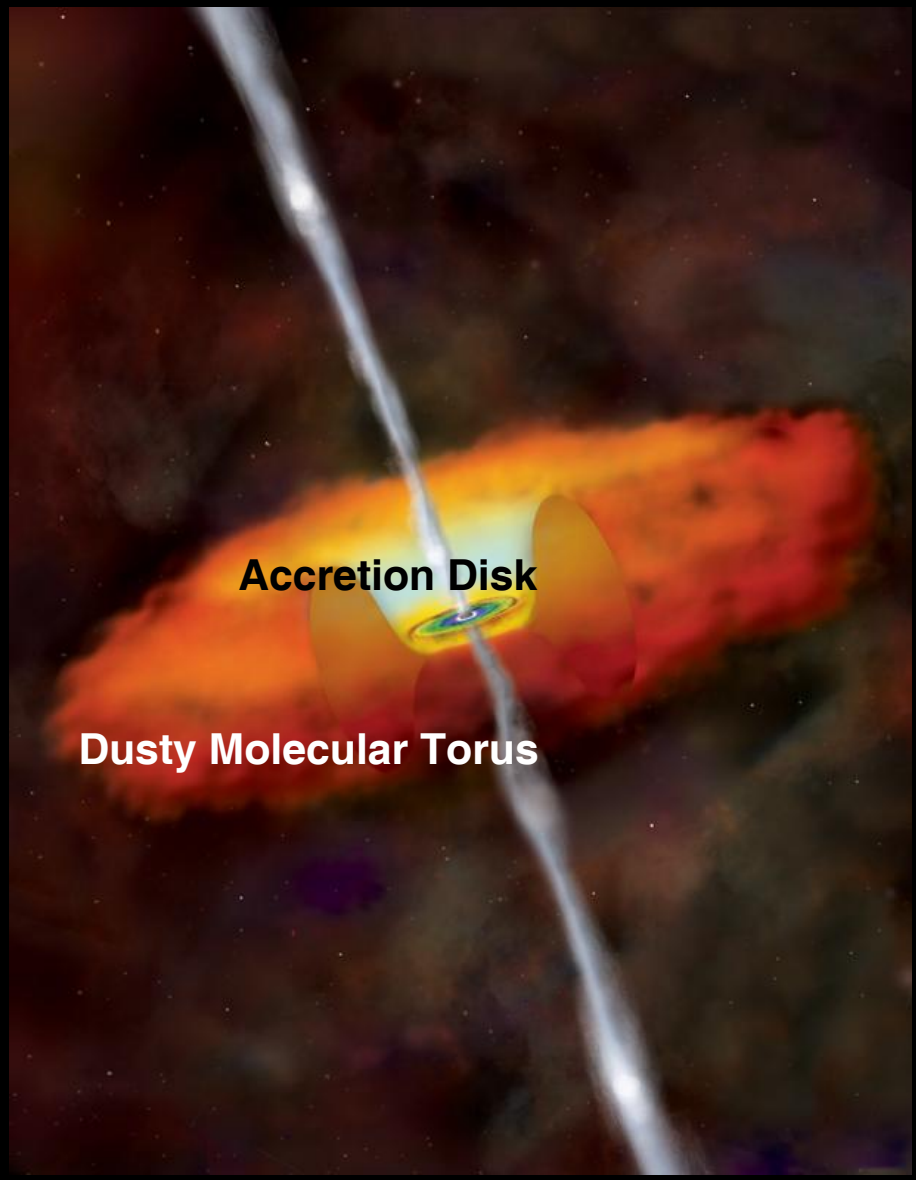
z~2 submm quasars live in overdense regions: major merger driven growth in young galaxy cluster environment (submm galaxies aligned in filaments)? X-rays plus SCUBA2 will pinpoint these overdense regions and allow for studies of X-ray properties of quasar and companions

Topic (3): Identification of Compton-thick AGNs

Perhaps ~50% of AGNs in local Universe are Compton thick (e.g., Risaliti et al. 1999; Comastri 2004)

Compton-thick AGN paradox: most conclusively identified at X-ray energies but absorption makes them X-ray weak/undetected

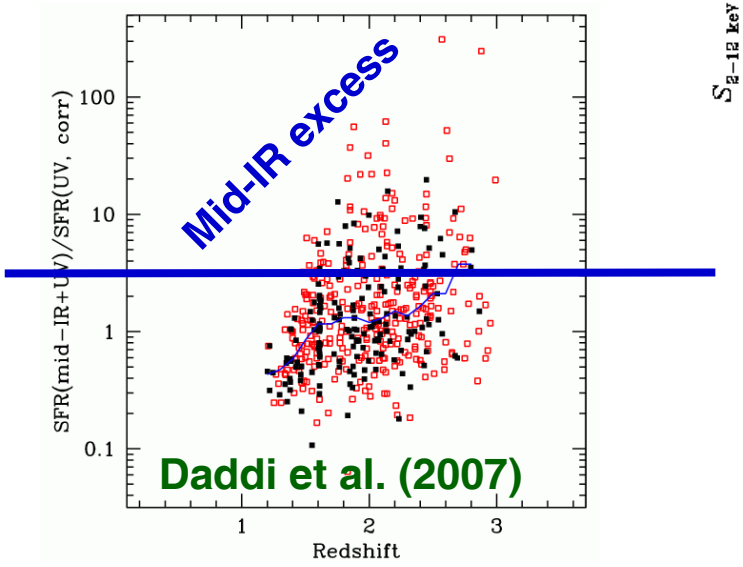
Distant Compton-thick AGNs may account for large fraction of black-hole growth and unresolved XRB



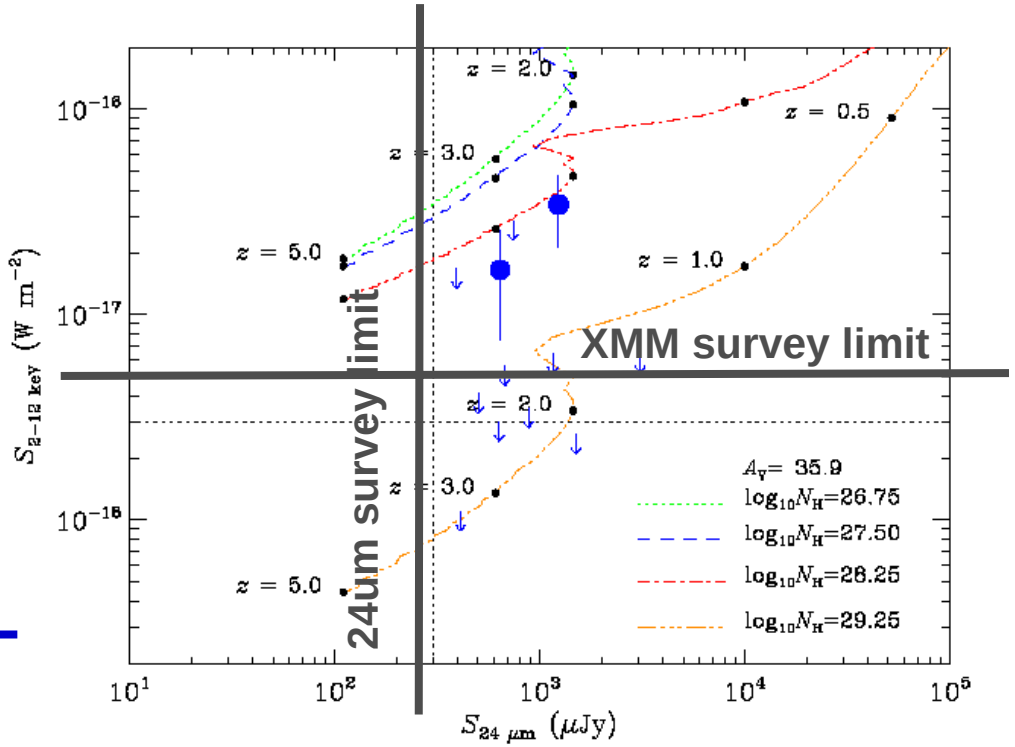
Identification of Distant Compton-thick AGNs

On basis of X-ray-Infrared SEDs, we expect ~100-150 candidate Compton-thick AGNs over 10 sq deg (basis of Polletta 06; Gilli 07)

Need multi-wavelength data to identify since will be X-ray weak/undetected (e.g., Polletta 06; Daddi 2007; Fiore 2008; Alexander 08)

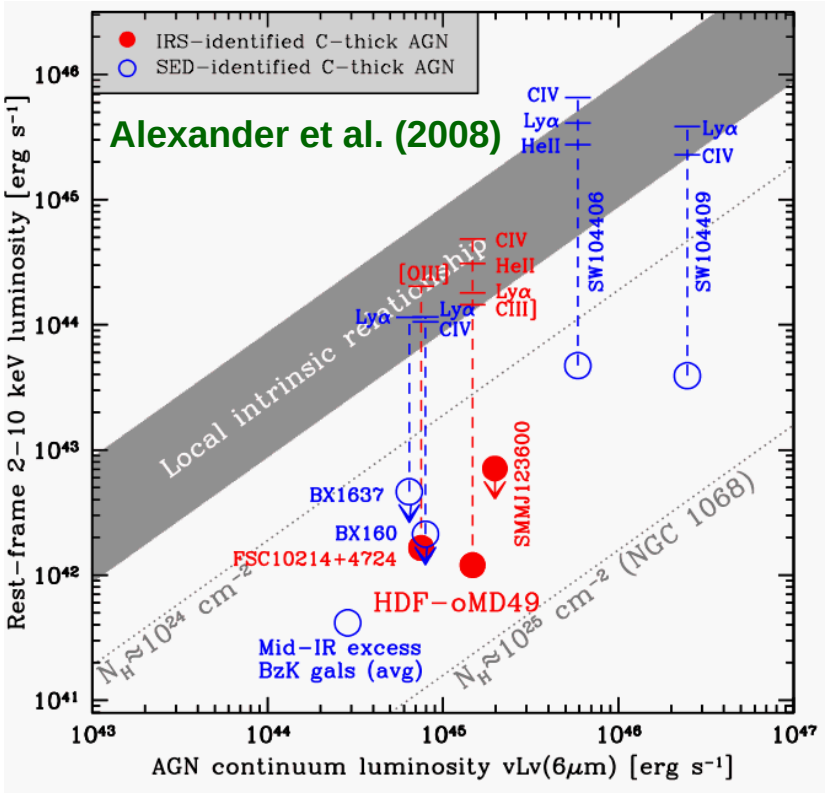


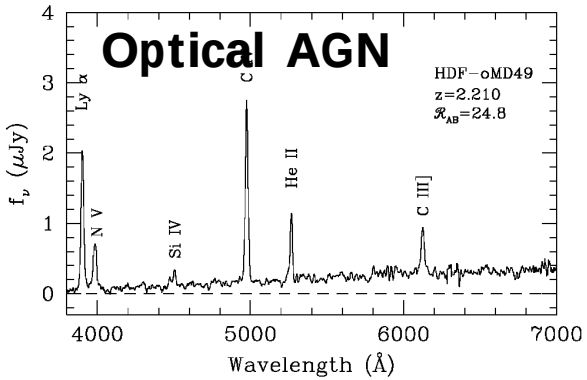
Daddi et al. (2007)

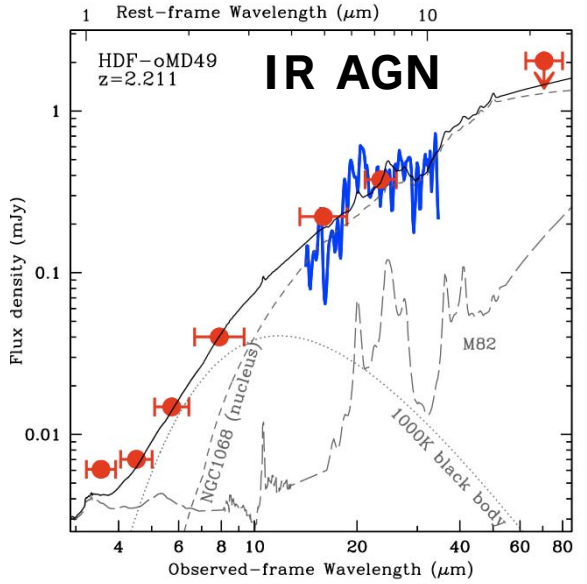


Martinez-Sansigre et al. (2007)

BUT Robust Identification Distant Compton-thick AGNs...







Need excellent multi-wavelength data to provide a strong case for Compton-thick absorption: infrared data is key

Summary

- Many wide-area (~20-50 sq deg) multi-Ms multi-wavelength surveys started to trace growth of galaxies across cosmic time across wide-range of environments: they REQUIRE sensitive wide-area X-ray survey to identify the AGNs (black-hole growth)

- 3Ms XMM proposal (50ks exposure/pointing) to provide sensitive coverage over 10 sq deg over 5 fields proposed last round: unsuccessfu!

- Comparatively easy to schedule and follow up due to wide RA range

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- Understand role of environment in triggering AGN activity (black-hole growth): are there characteristic densities at each epoch that initiate black-hole growth? ~10,000 AGNs detected in proposed survey

- SCUBA2 legacy survey (~20 sq deg) will detect ULIRGs out to z~5-8: X-ray detected quasars (both obscured and unobscured) pinpoint overdense regions (~100-200 detected in proposed survey)

- Quest to find Compton-thick AGNs: proposed survey could identify ~100-150 objects BUT require excellent multi-wavelength data for robust confirmation