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X-ray properties of 70μm selected sources in the Chandra Deep Field South

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Outline of talk

- Introduction to infrared galaxies
- Connection between AGN and star formation
- My 70μm Sample
- Results
- Conclusions

Infrared Galaxies

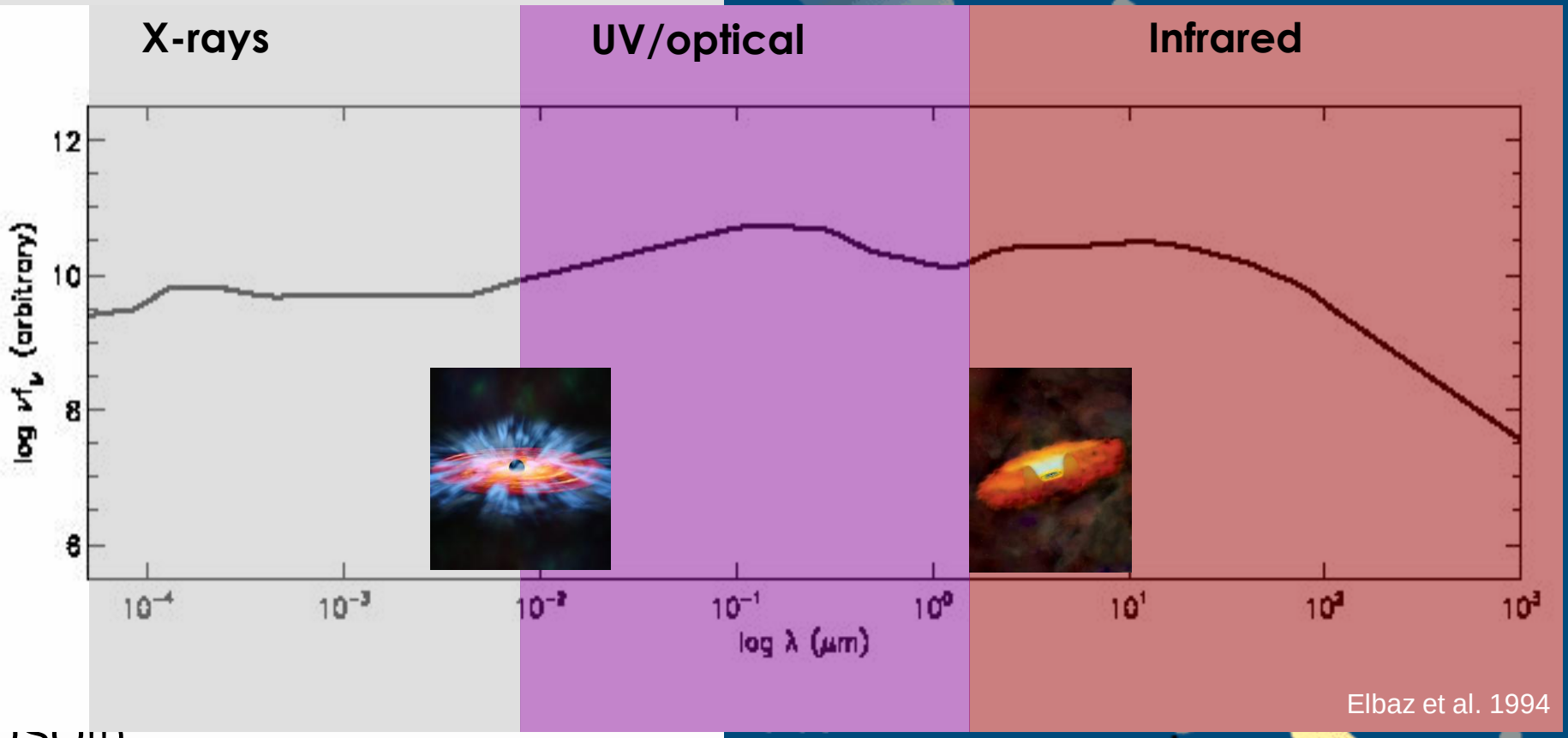
- Most of the optical and ultra-violet light emitted by stars is absorbed by dust and re-radiated at infrared wavelengths.

- IR luminous galaxies emits ≥ 90% of their radiation in the IR(8-1000μm).

- IR galaxies with $L_{IR} > 10^{11} L_{\odot}$ are the energetically dominant population of extra-galactic objects at high redshifts.

Active Galactic Nuclei

- An AGN is an accreting black hole



Elbaz et al. 1994

Credit: C.M. Urry and P. Padovani

AGN/Star Formation Connection

- Widely believed at the center of every galaxy there is a SMBH[1].

- Evidence in the local universe of the M_{BH} - M_{bulge} relationship[2].

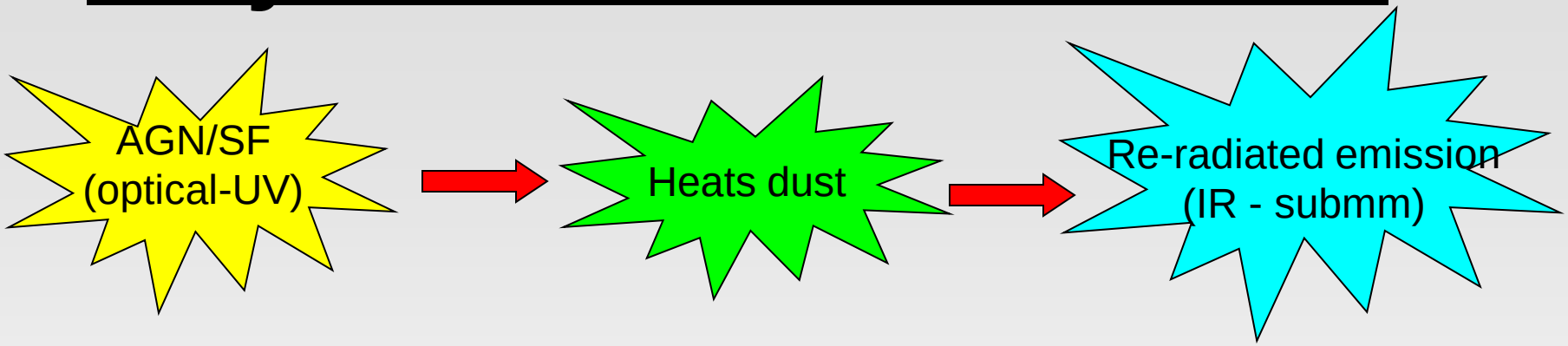
- A galaxy containing a powerful AGN will have its optical and UV SED dominated by the AGN and hence we use the FIR/sub-mm to measure the star formation rates.

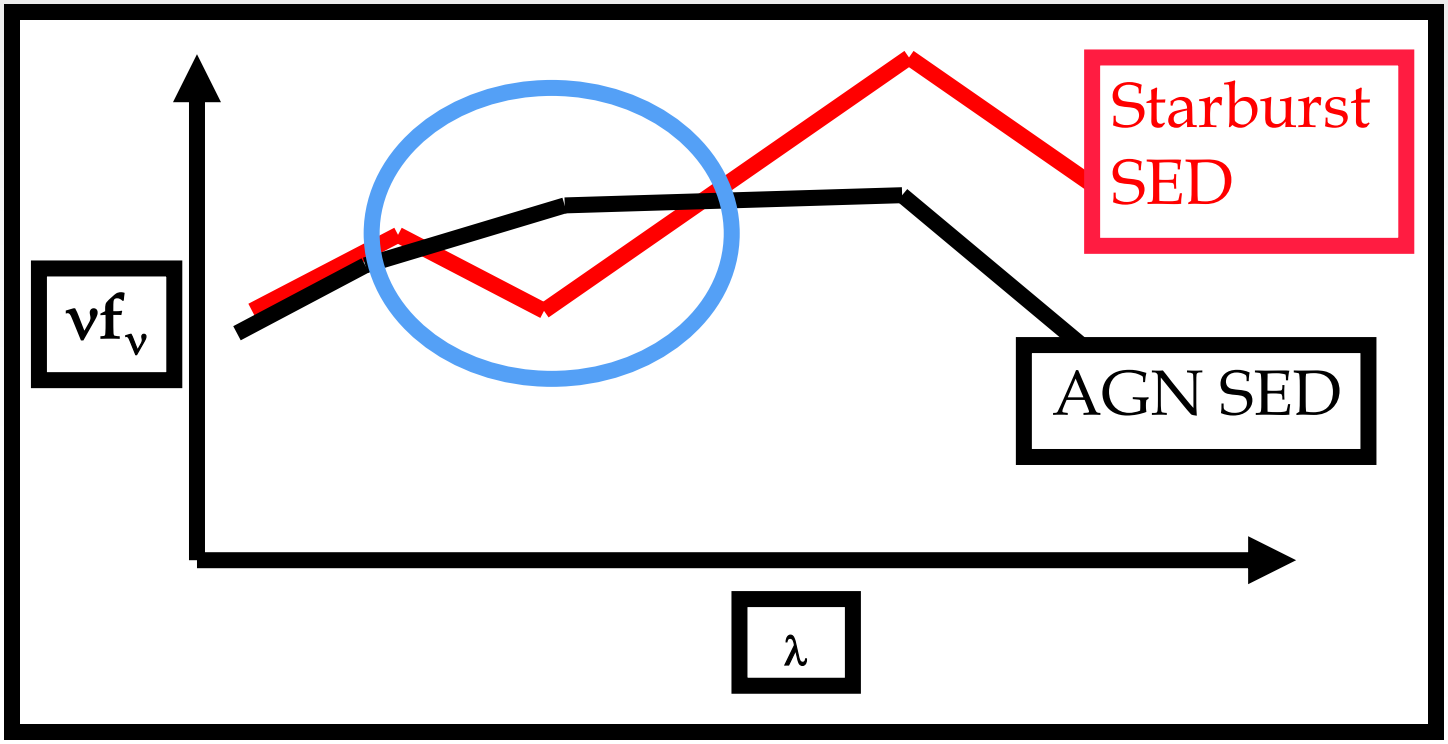
- X-ray emission can have contributions from star formation e.g. supernovae remnants or X-ray binaries[3].

References:

1. Kormendy & Gebhan 2001
2. Magorrian et al. 1998
3. Persic & Rephaeli 2002

Why select in the infrared?





Things to be investigated:

1. The luminosity distribution of the 70μm sources with and without X-ray counterparts and how this depends on redshift
2. How the total infrared luminosity and X-ray luminosity compare to the Ranalli *et al.* (2003) star formation relationship
3. Look at the AGN fraction as a function of redshift and total infrared luminosity
4. How the optical colours of the 70μm sources with and without X-ray counterparts compare to an optically selected sample

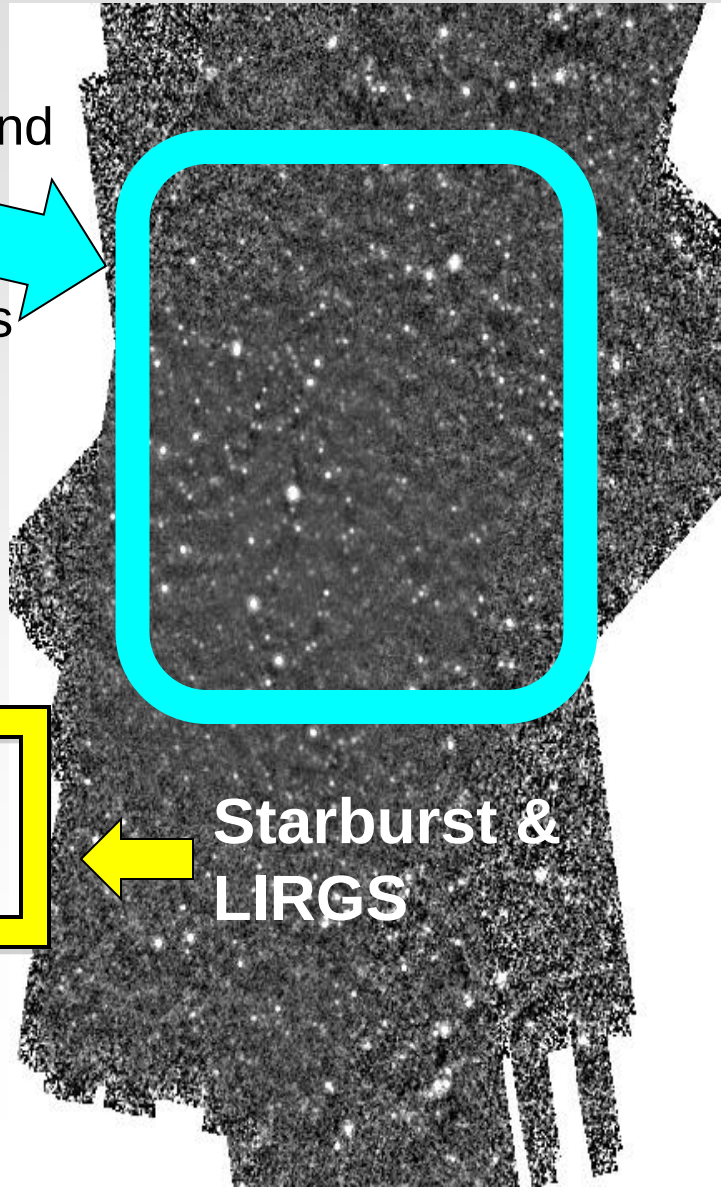
Data Reduction

Chandra Deep Field South

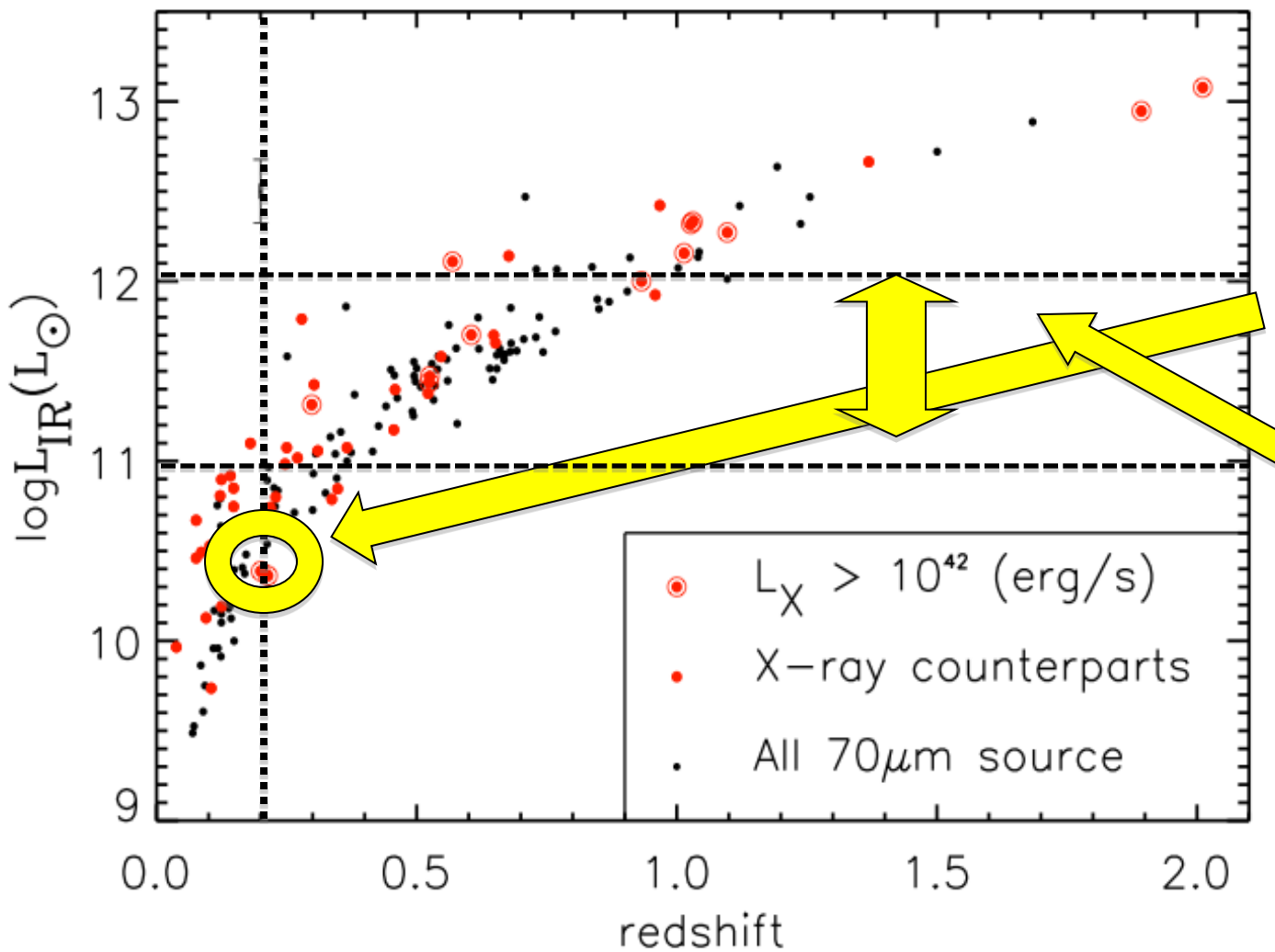
Region used (0.353deg^2) – where X-ray, 24μm and 70μm data is publicly available.

70μm catalogue contains 190 sources with fluxes > 3.5mJy @ (5σ)

Luminosity ($L_\odot$)	Fraction of 70μm sources	Number with X-ray counterpart
$10^9 < L_{IR} < 10^{10}$	11/171 **(6%)**	2/56 **(4%)**
$10^{10} < L_{IR} < 10^{11}$	62/171 **(36%)**	25/56 **(47%)**
$10^{11} < L_{IR} < 10^{12}$	73/171 **(43%)**	20/56 **(34%)**
$10^{12} < L_{IR} < 10^{13}$	24/171 **(14%)**	8/56 **(16%)**
$10^{13} < L_{IR} < 10^{14}$	1/171 **(1%)**	1/56 **(2%)**



Final Sample

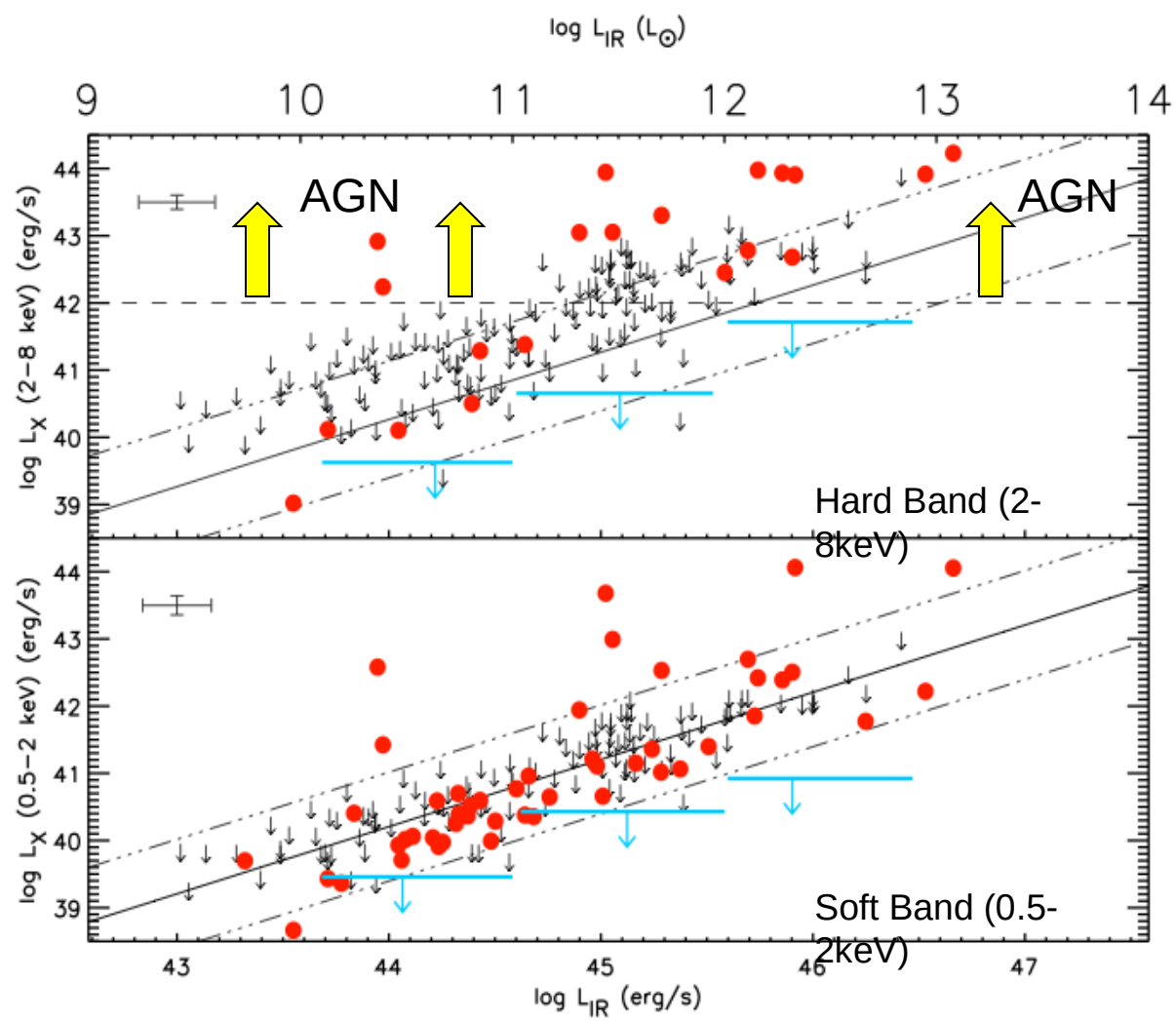


Tugwell et al. (in Prep.)

z = 0.2 is the lowest redshift for a 70μm X-ray source with $L_X > 10^{42}$ erg s^{-1}

Average total infrared luminosity for 70μm sources with and without X-ray sources classifies these sources as LIRGs.

L_{IR} Verves L_X



Tugwell et al. (in Prep.)

Sources without $L_{X(2\text{-}8keV)} > 10^{42}$ (erg s^{-1}) fall within 3σ deviations from Ranalli *et al.* (2003) star formation relationship.

Sources which appear as upper limits on the hard band graph often fall on the Ranalli *et al.* (2003) relationship on the soft band graph

AGN fraction as function of total infrared luminosity:

SB ($10^{10}<L_{IR}<10^{11}L_\odot$): 3%

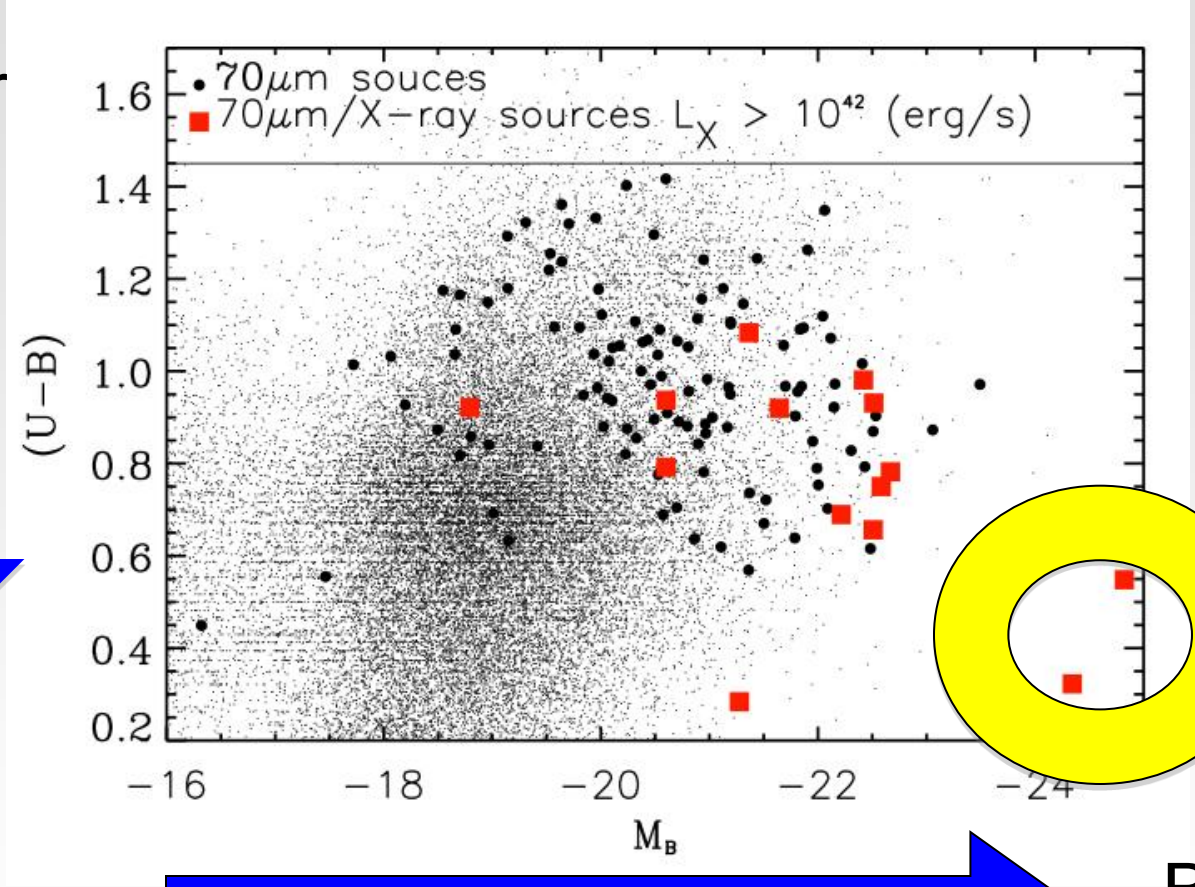
LIRG ($10^{11}< L_{IR}<10^{12}L_\odot$): 7%

ULIRGs ($10^{12}<L_{IR}<10^{13}L_\odot$):

Colour-Magnitude-Diagram

Tugwell et al. (in Prep.)

Bluer



QSO

Brighter

We find that the 70μm sources with have their X-ray dominated by AGN lie at the bluer and more massive tail of the 70μm population as

What do results mean…

- A tight correlation is seen for star forming galaxies between their total infrared luminosity and their X-rays luminosity - hence we can use X-rays to calculate the star formation rates in these galaxies

- Source with $L_{X(2\text{-}8keV)} > 10^{42}$ erg s^{-1} contain AGN, even if they fall close to the Ranalli et al. 2003 relation

- More luminous infrared galaxies are more likely to host an AGN

- AGN live in optical luminous and more massive galaxies

Summary

- We find 8% of all the 70μm sources has a X-ray detected AGN

- The fraction of sources which host an AGN increases with both increasing redshift and total infrared luminosity

- We can use $L_{X(2\text{-}8keV)} > 10^{42}$ (erg s^{-1}) is a good discriminator of AGN in ULIRGs

- Sources without AGN are found to have a correlation between their X-ray and infrared luminosities consistent with the *Ranalli et al.* 2003 relationship for star forming galaxies

- 70μm sources with $L_{X(2\text{-}8keV)} > 10^{42}$ (erg s^{-1}) tend to have very high rest frame absolute B band magnitudes.