The close correlations observed between supermassive black hole (SMBH) masses and properties of the galaxies that host them[1] raise the question of whether black holes play a regulatory role in galaxy evolution. Feedback[2] from active galactic nuclei (AGN) provides a mechanism for SMBHs to shape the subsequent evolution of their host galaxies. Here we investigate the global effects of SMBH growth on star formation in galaxies, motivated by studies that find SF is suppressed by the most powerful AGN[3].

Do black holes regulate the growth of massive galaxies?

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Project Goals

Using multi-wavelength data we undertake a large scale statistical analysis of galaxies hosting active galactic nuclei (AGN), to investigate the influence of black hole growth on star formation. We select AGN using Chandra X-ray sky surveys, and use SCUBA-2, Herschel and Spitzer data to probe the dust properties of their host galaxies. This enables us to study a large sample of sources at the peak of the universe's star formation (SF) and black hole accretion activities (z ~ 2).

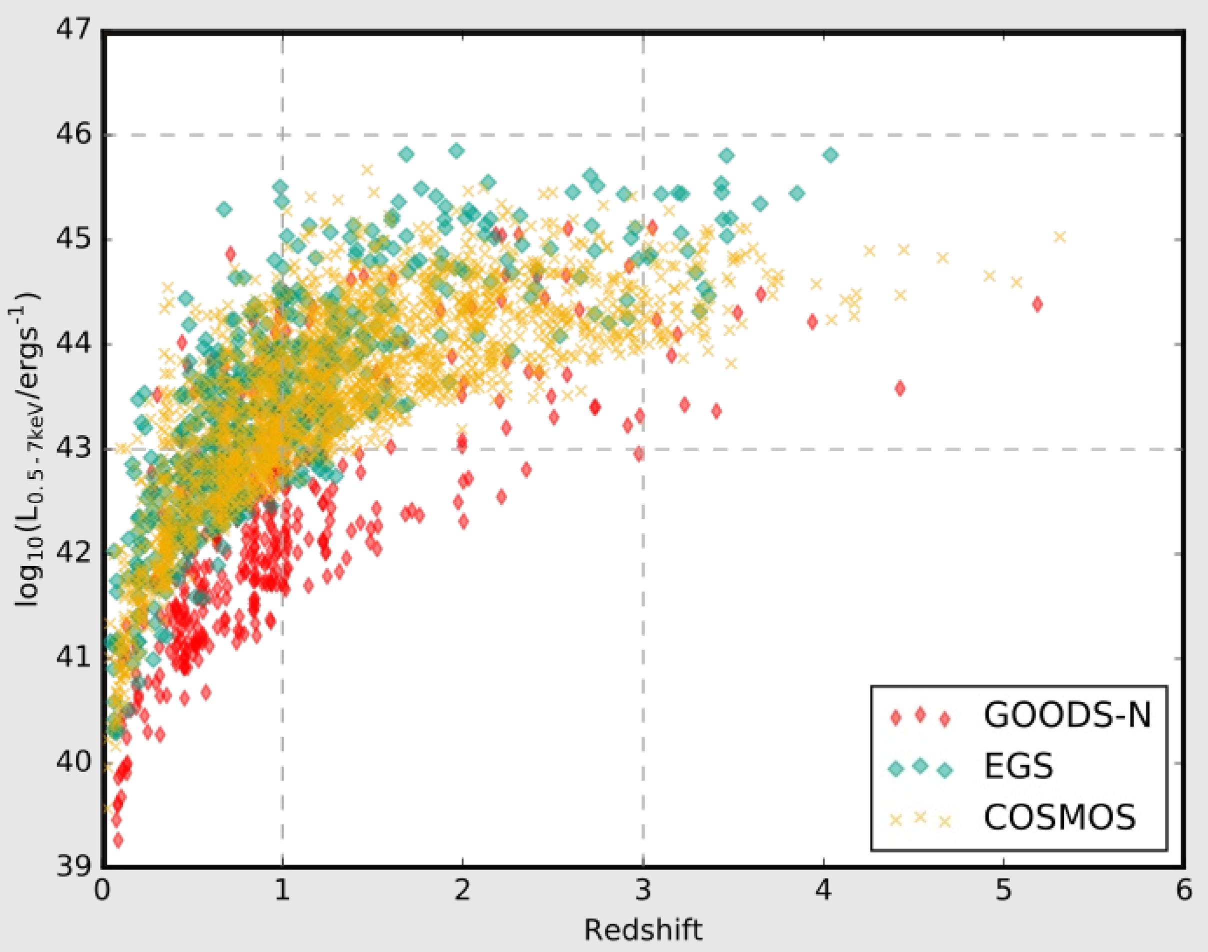


Figure 1. Redshifts and X-ray luminosities of all sources in each of the three fields used in this study. The redshift and L_X ranges of the sample are shown within the grey dashed lines.

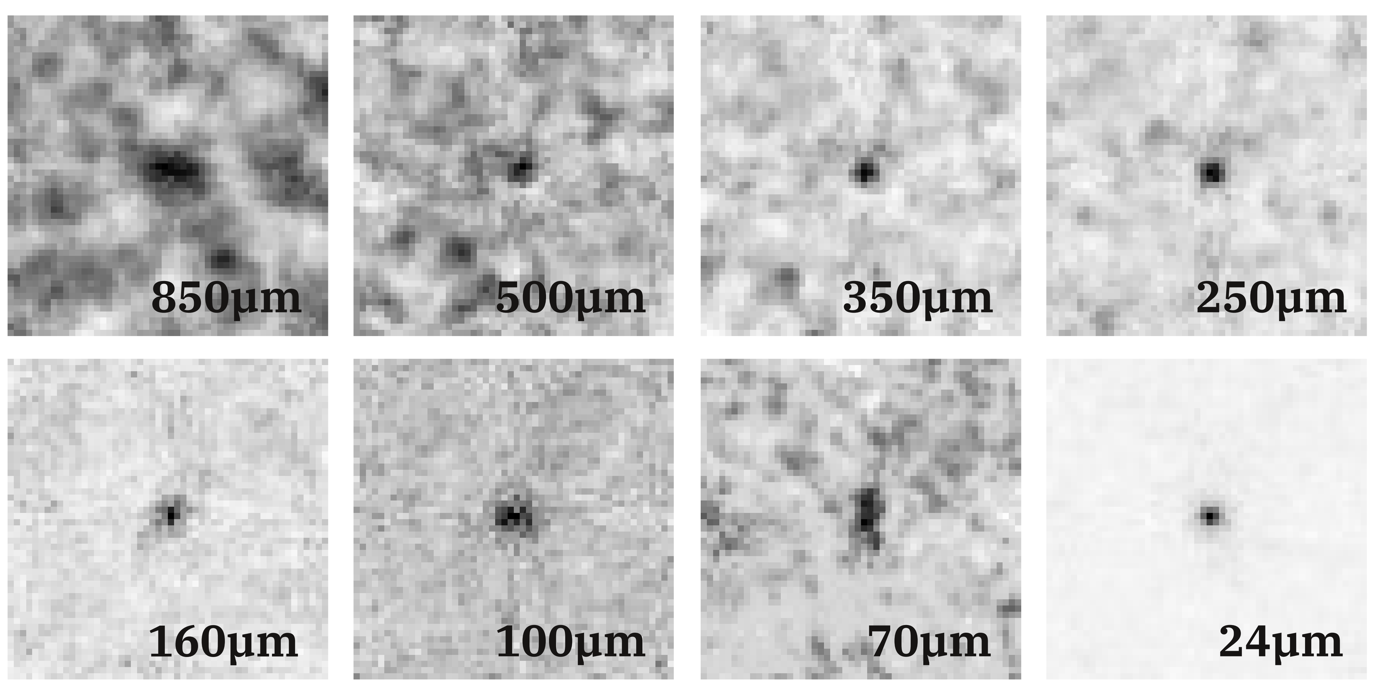
Data

The SCUBA-2 Cosmology Legacy Survey (S2-CLS)[4] provides the largest (~ 5 deg^2) sky survey at 850μm, probing to the confusion limit (~ 0.8 mJy beam^{-1}) and covering several well-studied extragalactic survey fields. The resulting catalogue includes almost 3,000 submillimetre sources. We use data from three of these fields (COSMOS, GOODS-N, and EGS). Sources are selected from Chandra X-ray surveys[5] of these fields, probing a range of X-ray luminosities down to a flux limit of 1.1×10^{-16} erg s^{-1} sq. cm^{-1} in the 0.5 – 7 keV flux range. Supporting infrared data come from Herschel SPIRE and PACS, and Spitzer MIPS, providing coverage of the dust spectrum at 8 wavelengths, from 24μm to 850μm.

Method

Using spectroscopic redshifts from the literature[6] we calculate X-ray luminosities from source count rates. We select sources in a luminosity range of $43 < \log\,(L_X/\mathrm{erg\ s}^{-1}) < 46$, the lower limit chosen to exclude starburst galaxies. We choose a redshift range $1 < z < 3$ to probe the epoch of the peak of SFR density and BH accretion rate density in the universe. The distribution of sources in z and L_X space is shown in **Figure 1.**

Figure 2. Median stacked average sources in each wavelength.



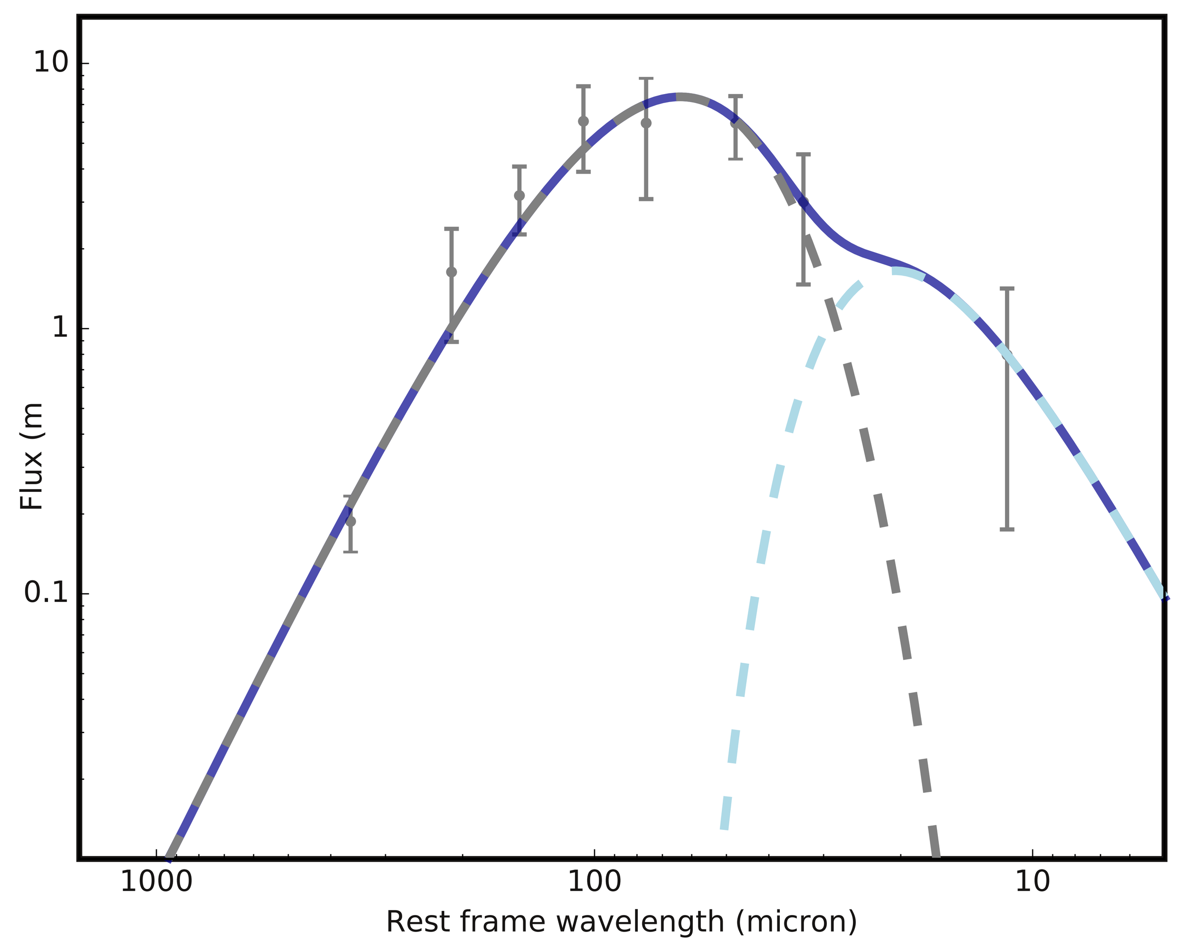


Figure 3. Example of an average SED fit. Data points show the measured average fluxes in each of the 8 wavelengths, and their 1-sigma errors. The best fit is shown with the solid blue line; the grey dashed line shows the greybody fit to the SF component and the blue dashed line shows the powerlaw fit to the AGN component.

As the majority of sources are undetected at submm wavelengths, we bin by redshift and X-ray luminosity and median stack the FIR and submm images, then measure the average fluxes from these stacked images (**Figure 2**). Using the resulting fluxes, we fit average SEDs to decompose the contributions to the FIR from the AGN and from SF. We fit a greybody to model the SF dust and a power law to model the AGN contribution (**Figure 3**) and calculate the luminosity due to SF for each average source and convert to a SFR.

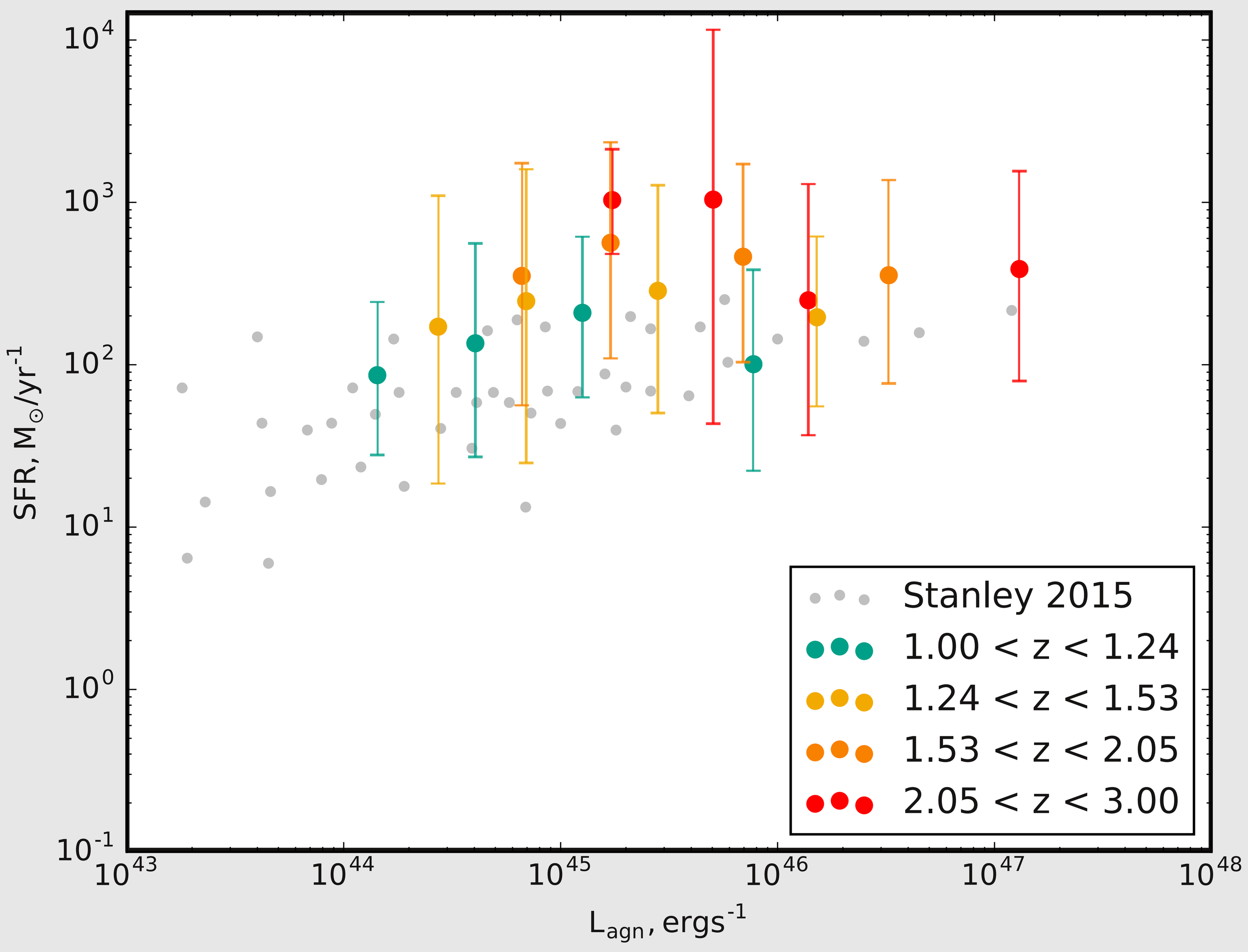


Figure 4. SFR as a function of AGN luminosity. Colours correspond to redshift bins, each subdivided into four AGN luminosity bins. Plotted in grey are data from Stanley et al. (2015). Our results are consistent with these, showing no sign of decreasing SFR with AGN luminosity.

Results

The resulting star formation rates as a function of AGN luminosity are shown in **Figure 4**. We find no evidence of SF being suppressed in the host galaxies of the most powerful AGN, instead finding a flat trend across each of the redshift bins. Our result supports that of Stanley et al.[7], also plotted, who conclude that the SFRs of galaxies hosting AGN are consistent with the normal starforming galaxy population. However, measuring instantaneous AGN luminosity does not take into account AGN variability over timescales much shorter than SF timescales[8]. This may be the reason we do not observe a signature of SF quenching.

Conclusion: No sign of star formation quenching by powerful AGN

References: [1]Ferrarese & Merritt 2000, ApJ 539. [2]Fabian 2012, ARAA 50. [3]Page et al. 2012, Nature 485. [4]Geach et al. 2016, MNRAS 465. [5]Civano et al. 2016, ApJ 819; Nandra et al. 2015, ApJS 220; Xue et al. 2016, ApJS 224. [6]Marchesi et al. 2016, ApJ 817. [7]Stanley et al. 2015, MNRAS 453, Stanley et al. 2017, MNRAS 472. [8]Hickox et al. 2014, ApJ 782.