The sub-mJy radio population in the E-CDFS: star formation and BH accretion

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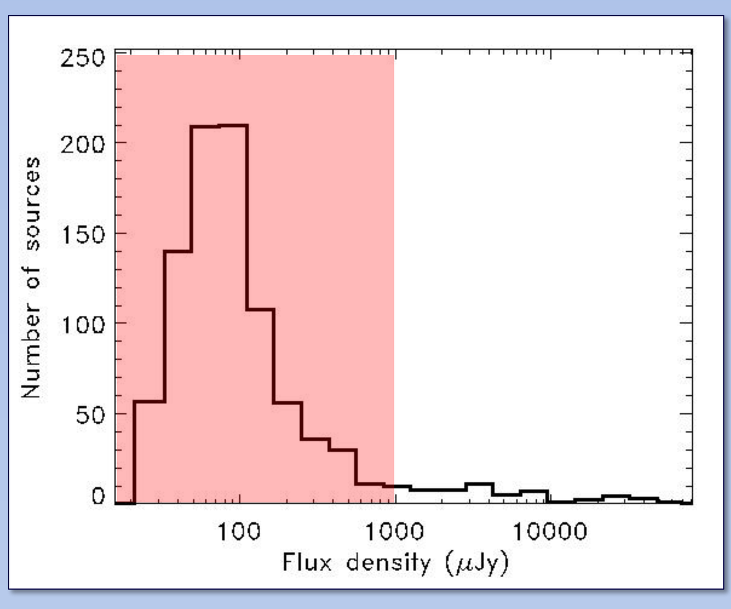
Abstract: We use a deep VLA survey at 20 cm of the Extended Chandra Deep Field South (E-CDFS) to explore the faint end of the radio population, down to the µJy level. From a sample of ~900 radio sources, we use a multi-wavelengths approach to separate AGN from star forming galaxies (SFG) looking at the ratio between their far-infrared (FIR) and radio emission, their mid- infrared colors and the level of X-ray luminosity[1]. Thanks to the µJy sensitivity of our survey, we are able to detect not only the radio loud (RL) AGN, but also significant population of radio quiet (RQ) objects according to the standard classification. We characterize the properties of the host galaxies of this radio-selected RQ AGN sample: star formation rates (SFR), stellar masses, morphological appearances and the black hole accretion level.

Deep radio observations:

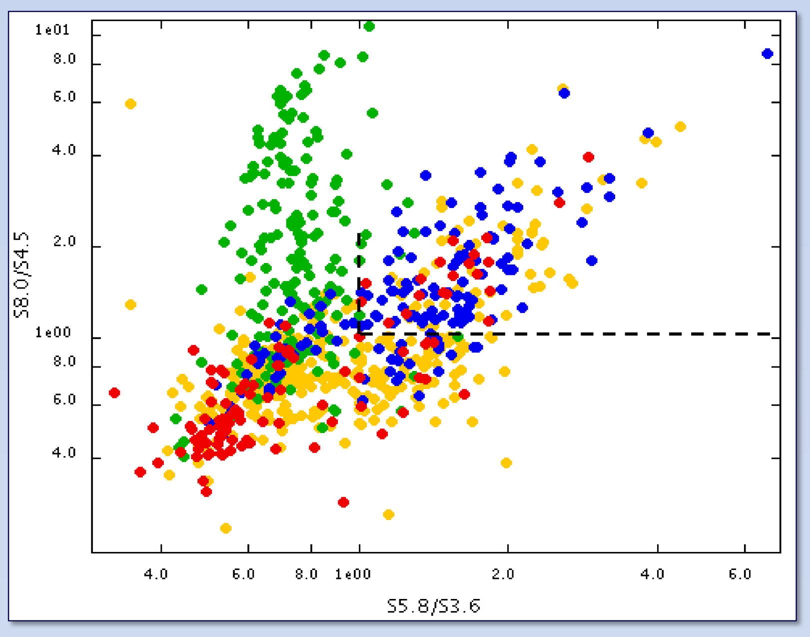


Radio flux density distribution for the 921 sources detected at 5σ with flux density limit of 43 µJy[2]. About 90% of the sources are in the sub-mJy regime (shaded region). Using a likelihood ratio technique we identified their optical-infrared counterparts. About 75% of the sources have redshift information (40% spectroscopic).

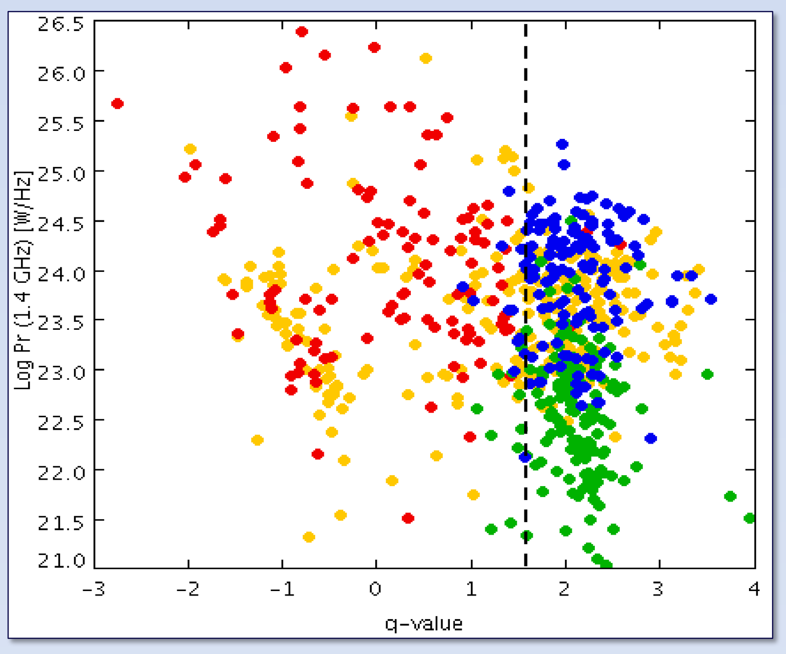
SFG or AGN?

We classified the sources with redshift as RQ AGN (blue), RL AGN (red) or SFG (green) considering:

1. their unabsorbed X-ray Luminosity[3] [2-10 keV] (AGN if $L_X > 10^{42}$ erg s^{-1})
2. their position in the IRAC color-color diagram[4] (AGN if $S_{5.8}/S_{3.6} > 1$, $S_{8.0}/S_{4.5} > 1$ and SFG if $S_{5.8}/S_{3.6} < 1$, $S_{8.0}/S_{4.5} > 2$)



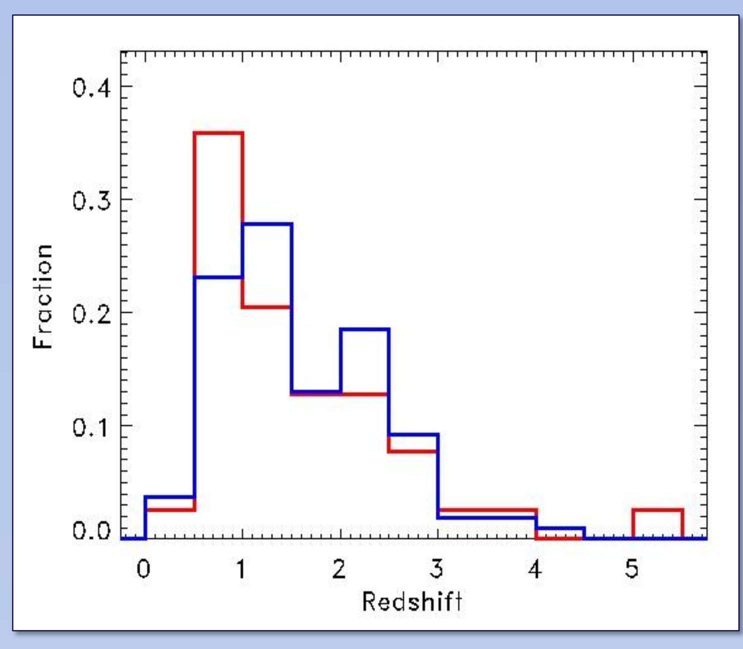
3. the FIR/radio luminosity ratio[5] (q-values) (RL AGN if q<1.7) only for sources with reliable MIR detection.



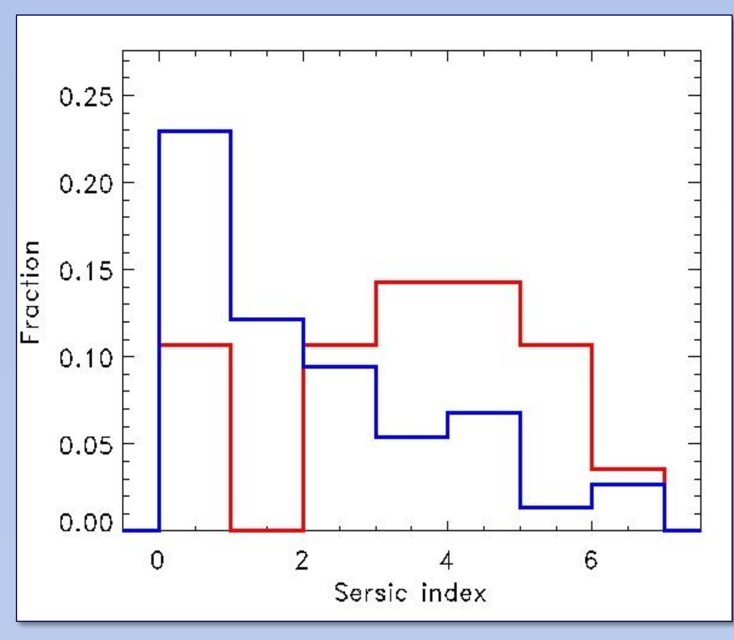
~1/3 of the sources (yellow) are still unclassified .

Host galaxy properties of radio selected radio-quiet AGN

Redshift distribution and morphology

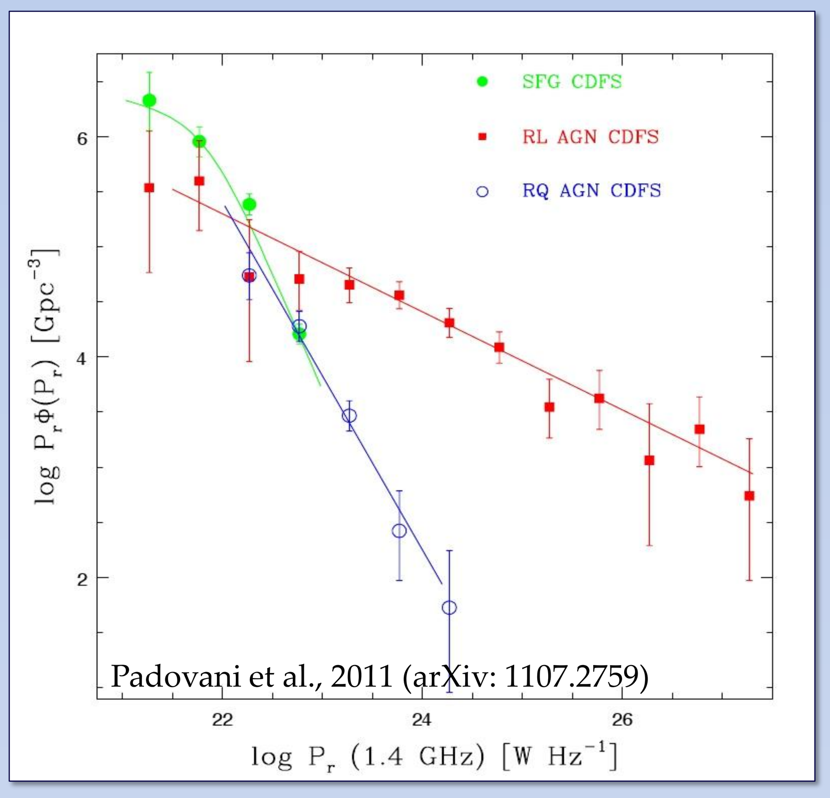


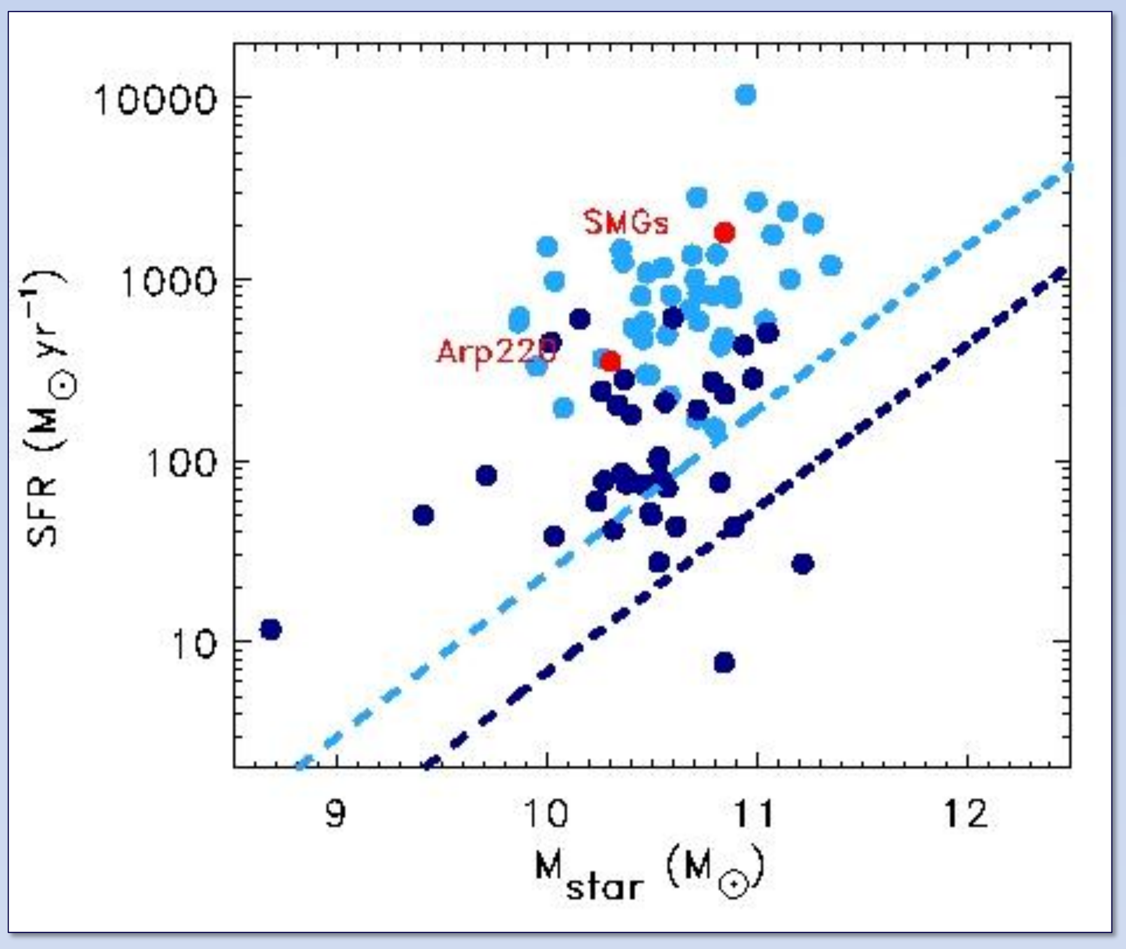
Comparison between the redshift (on the left) and Sérsic-index distribution[6] (on the right) of RQ (blue) and RL (red) AGN. The two classes show the same redshift distribution but different host galaxy morphology with an higher fraction of RQ AGN hosted in late type object (disks).



Stellar masses and star formation rates

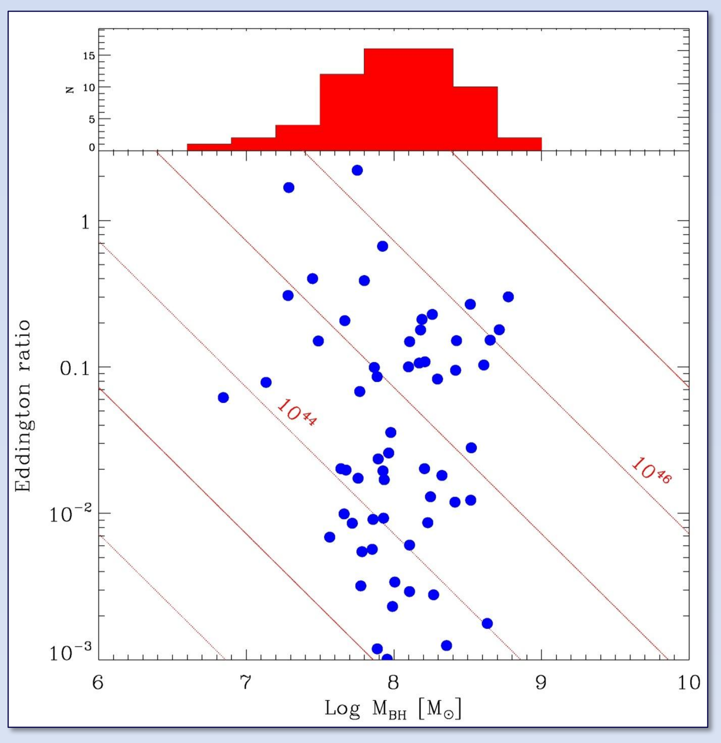
Considering the differential luminosity function (LF) obtained for the 7σ detected sources sub-sample (on the right), we observe that the RQ AGN LF appears as an extension to higher radio power of the SFG LF[7]. RQ AGN and SFG also show the same evolution[7]. We therefore formulate the hypothesis that the **radio emission in RQ AGN is due to star formation** rather than to accretion processes. Hence, we inferred the SFR from the radio luminosity[8]: $SFR = 5.9 \pm 1.8 \times 10^{22} L_{1.4GHz}$ ($M_{\odot}$ yr^{-1}).





The stellar masses (M_{star}) distribution, derived from rest-frame optical colors[9], peaks around 10^{10}-10^{11} $M_{\odot}$. The SFR as a function of M_{star} is plotted (on the left) for RQ AGN with 0.8<z<1.2 (dark blue) and with 1.4<z<2.5 (light blue) together with the correlations found for normal SFG in the same z bins[10,11] (dashed lines). Our objects lie above these correlations, in the region where starburst and sub-mm galaxies are located.

Black hole accretion



Eddington ratio (λ) and black hole (BH) masses (preliminary results). The bolometric luminosities (L_{bol}) have been derived from the unabsorbed [2-10 keV] X-ray luminosities[12] (red lines). BH masses are estimated from the host galaxy M_{star} and therefore represent upper limits[13]. Using L_{bol} and M_{BH} we computed the Eddington ratios for our sample of RQ AGN: ~1/3 of the objects have λ >10% and therefore can be considered fast accreators.

Conclusions: Our study of the sub-mJy radio population reveals the presence of a significant population of RQ AGN. We are able to set an upper limit of 60% on the contribution of SFG to the µJy radio sky . These RQ AGN are preferentially hosted in late type galaxies and the probability of finding them increases with M_{star}. The SFR is higher than in normal SFG suggesting that RQ AGN are associated with starburst processes or that there is still a non negligible contribution from the nucleus to the radio luminosity.

References: [1]Xue et al., 2011; [2]Miller et al., 2008, 2011 (in preparation); [3]Vattakunnel et al, 2011 (submitted); [4]Lacy et al., 2004; [5]Helou et al, 1985; [6]Häussler et al., 2004; [7]Padovani et al., 2011; [8]Pannella et al., 2010; [9]Bell et al., 2003; [10]Elbaz et al., 2007; [11]Daddi et al., 2007; [12]Marconi et al.,2004; [13]Marconi & Hunt,2003.