UNIVERSITY of the WESTERN CAPE

The Nature of the MicroJy Source Population.

(Ocran et al., 2015. In prep)

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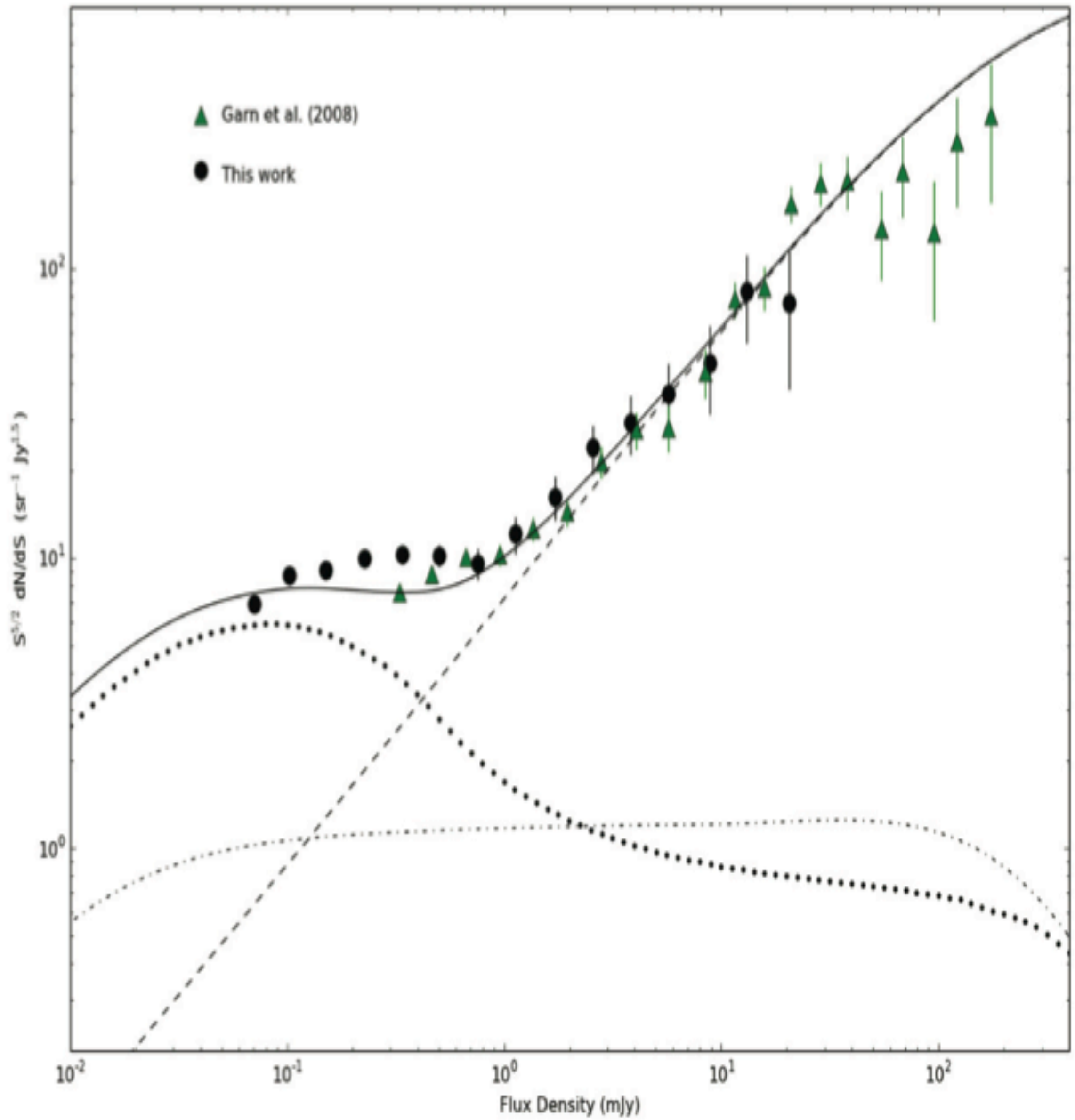
The faint radio sky

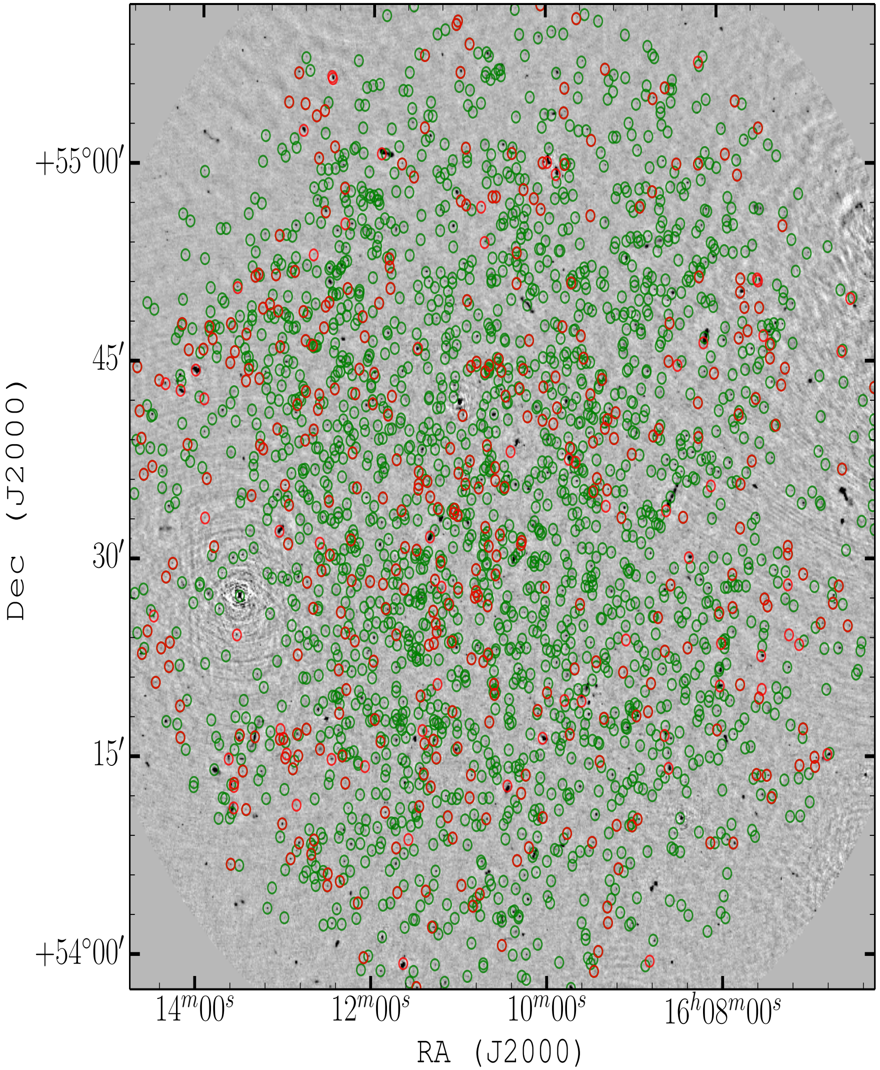
- ✓ Total intensity differential source counts at 612 MHz (Taylor et al 2014).
- ✓ Radio selected sample becomes contaminated by SFGs thereby identifying AGNs is a challenge
- ✓ A key ingredient is a multi-wavelength approach.

Our radio dataset

- ✓ **GMRT at 610 MHz** covering 1 deg ^{2} within ELAIS N 1 field down to rms of 10 μJy comprising of 2800 sources.
- ✓ Probe the radio source population at flux densities well below the regime dominated by classical radio galaxies and Active Galactic Nuclei.

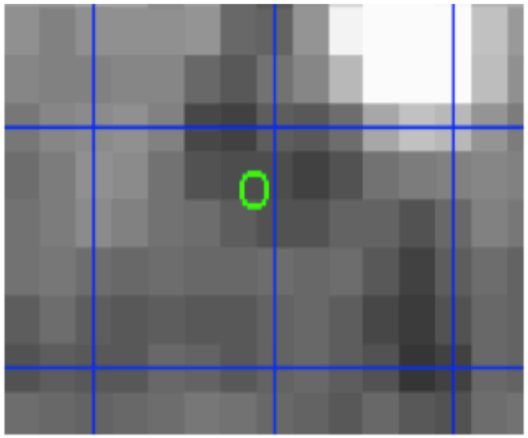


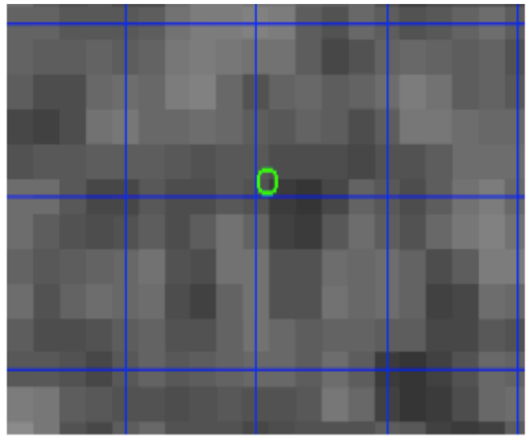
Catalog Cross - match

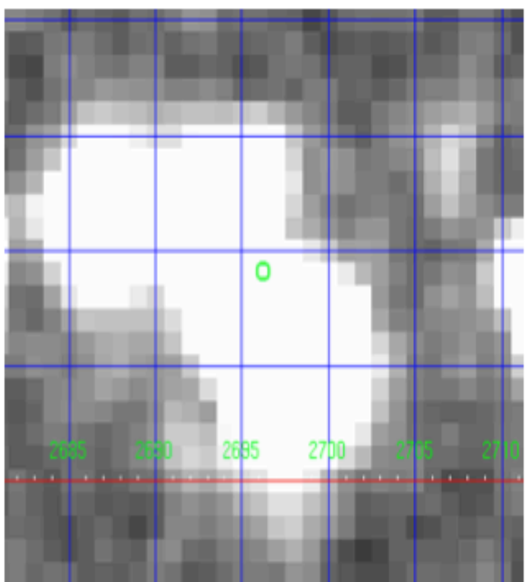


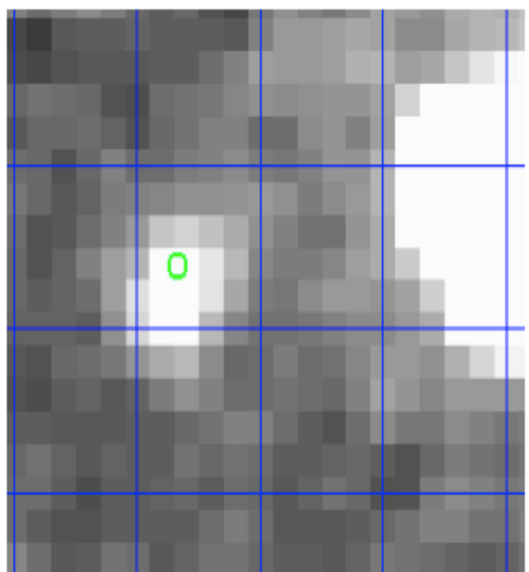
Type	Number of matches	Percentage of radio sources
Identified in both SERVS bands	2369	85%
Identified in 4 SWIRE/IRAC bands	1091	39%
Objects with spectroscopic redshift	817	29%
Objects with photometric redshift	1456	52%
Total objects with redshift	1760	63%
X-ray (Trichas et al. 2012 & Manners et al 2003)	70	2.5%
SPECZ – BOSS (GALAXY)	706	25%
SPECZ – BOSS (AGN)	96	3.4%
FIR luminosities (Rowan-Robinson et al. 2013)	1279	46%

Sources without SERVS 1 OR 2 identification



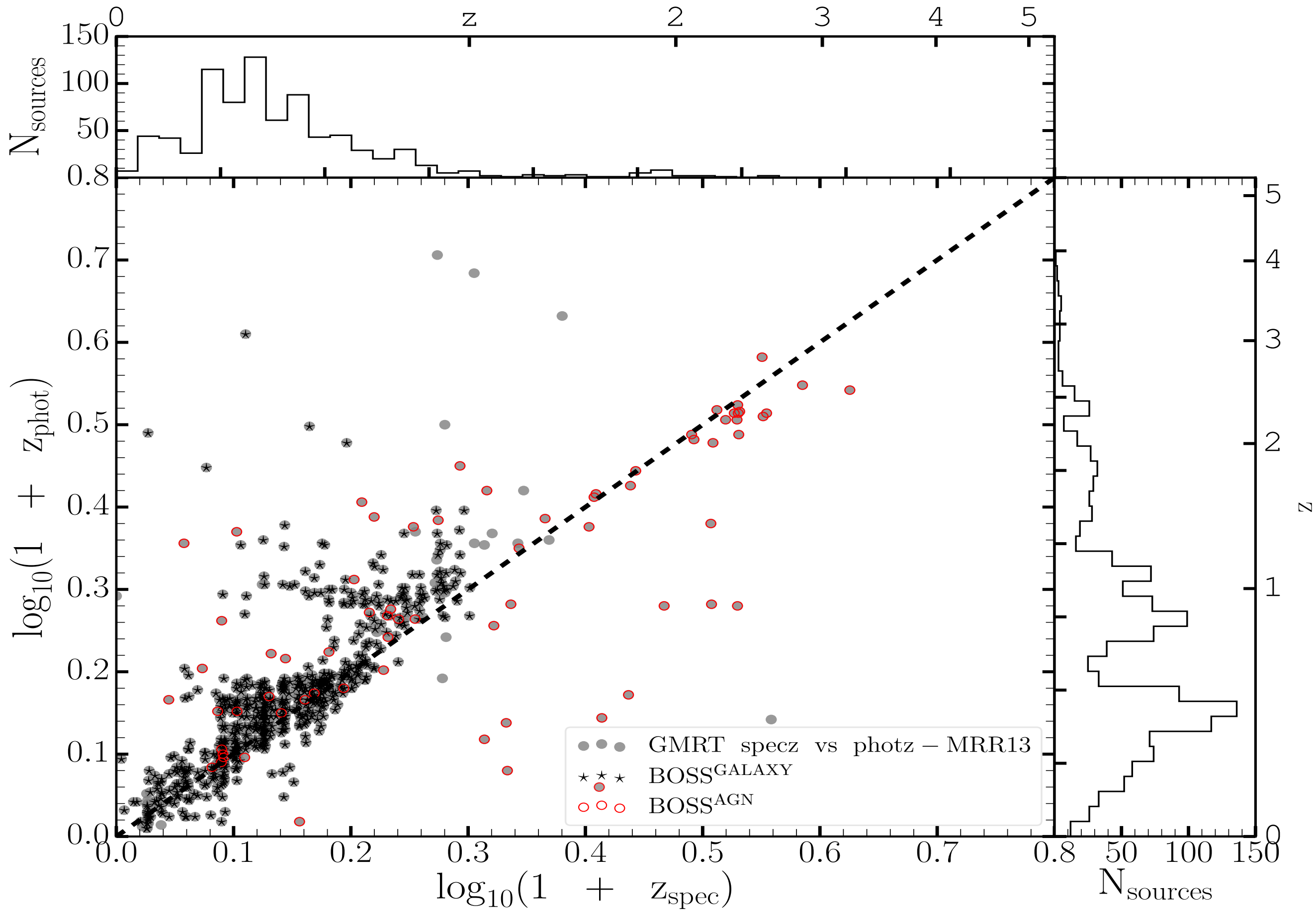






Criteria	Number	Fraction
Bright/ Confused	203	47%
Empties/ No identification	66	15%
Good identification	109	25%
Far ? Possible ID	53	12%

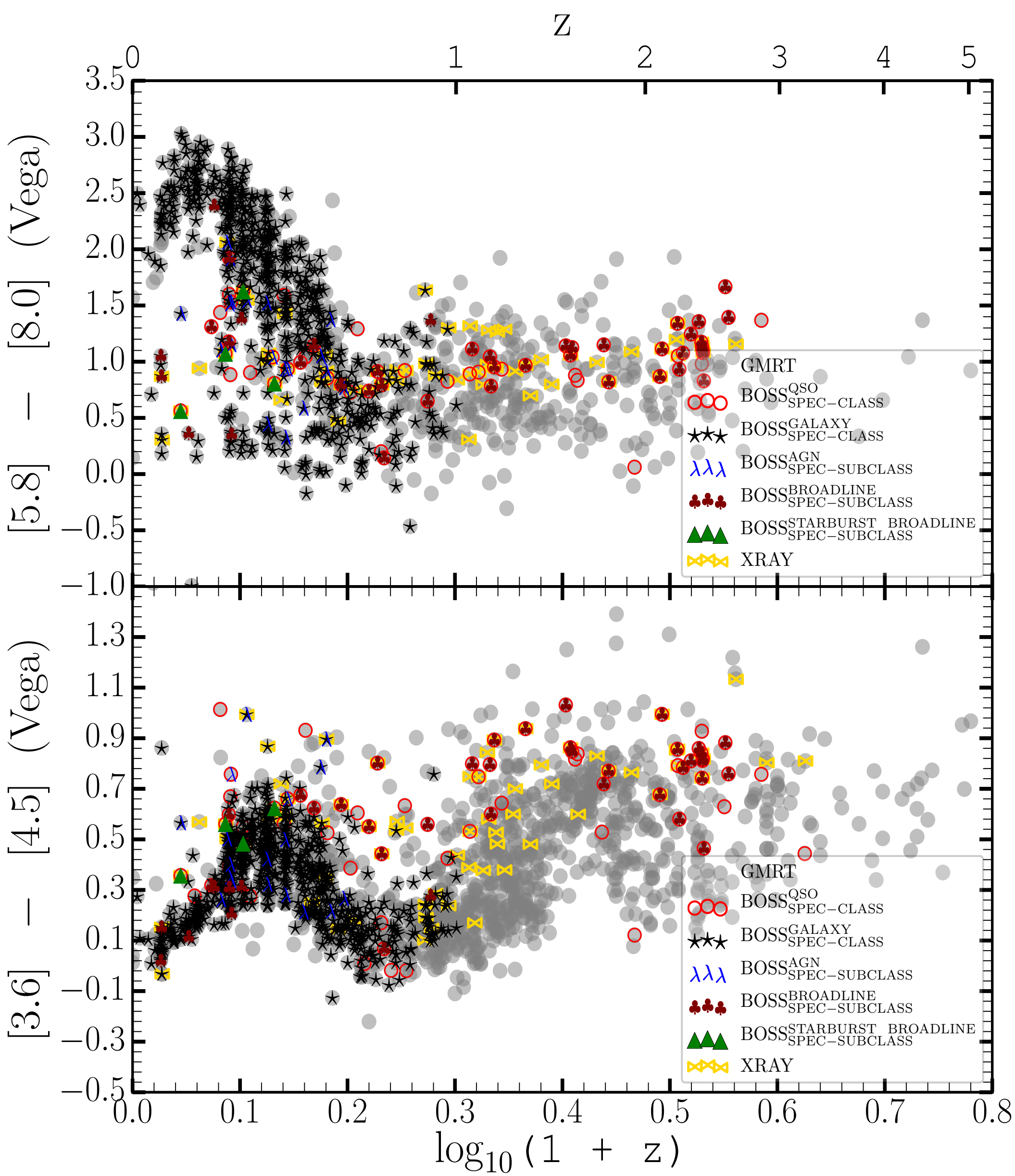
Redshift Distributions



63% of GMRT sources with redshifts, we have carried out a multi - wavelength study using Optical, X-ray, IR and Radio data

Color Evolution Galaxies

- ✓ Mid IR colors clearly separate AGNs from galaxies.
- ✓ We show the color evolution of MIR bands, [5.8] – [8.0] (Vega) and [3.6] – [4.5] (Vega) vs $\log_{10}$ (1 + z)
- ✓ Over - plotted are the various BOSS/ SDSS 'CLASS' and 'SUBCLASS' classifications and also our X-ray sources



Infrared Diagnostics

- ✓ Lacy Wedge (lacy et al., 2004, 2007):

  $\log10(S5.8/S3.6) > -0.1 \wedge \log10(S8.0/S4.5) > -0.2 \wedge \log10(S8.0/S4.5) \leq 0.8 \cdot \log10(S5.8/S3.6) + 0.5$

- ✓ Stern Wedge (Stern et al., 2005):

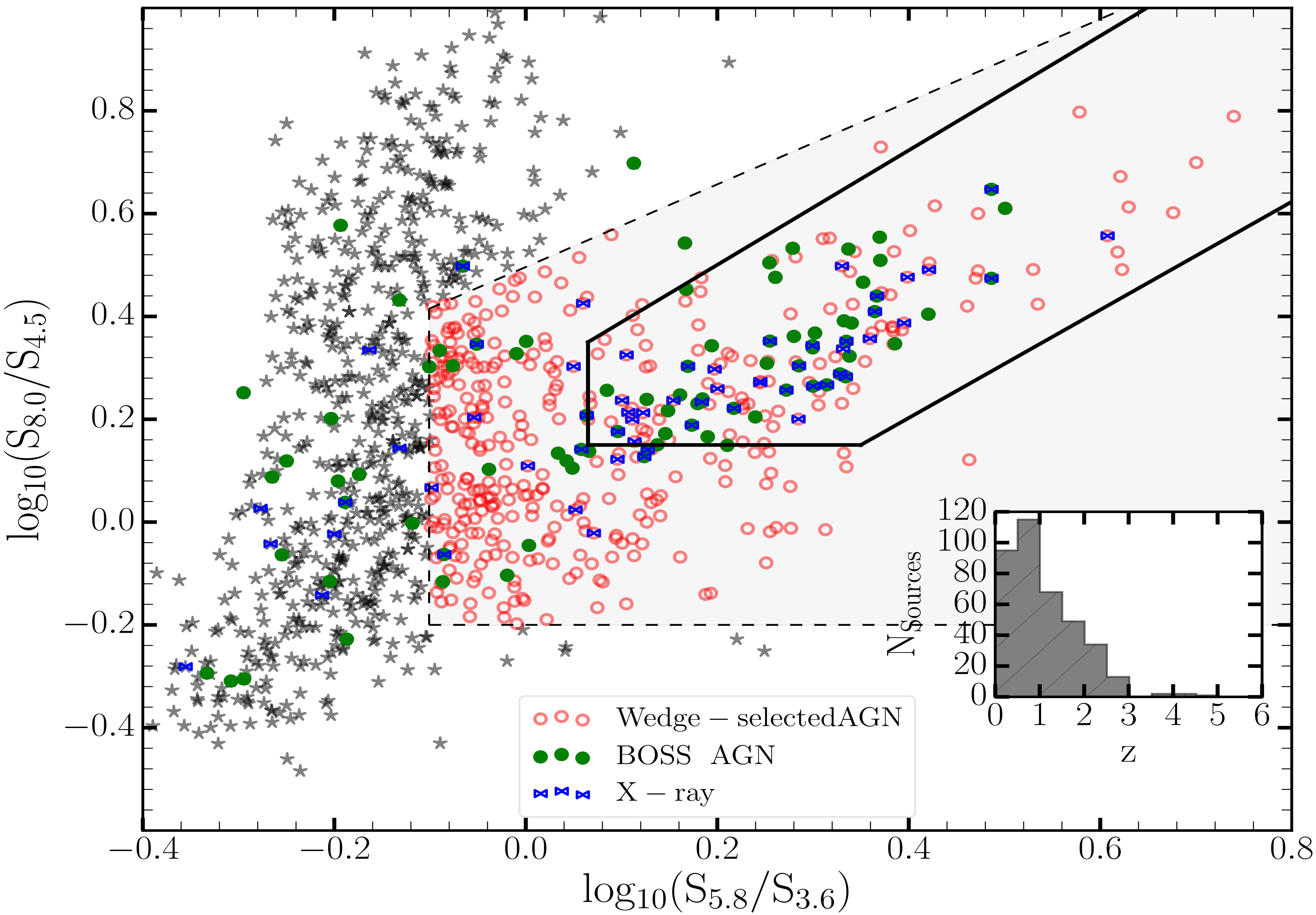
  $([5.8] - [8.0]) > 0.6 \wedge ([3.6] - [4.5]) > 0.2 \times ([5.8] - [8.0]) + 0.18 \wedge ([3.6] - [4.5]) > 2.5 \times ([5.8] - [8.0]) - 3.5$. In Vega magnitudes.

- ✓ Donley Wedge (Donley et al., 2012):

  $x = \log_{10}(f_{5.8\mu m}/f_{3.6\mu m})$, $y = \log_{10}(f_{8.0\mu m}/f4.5\mu m)$

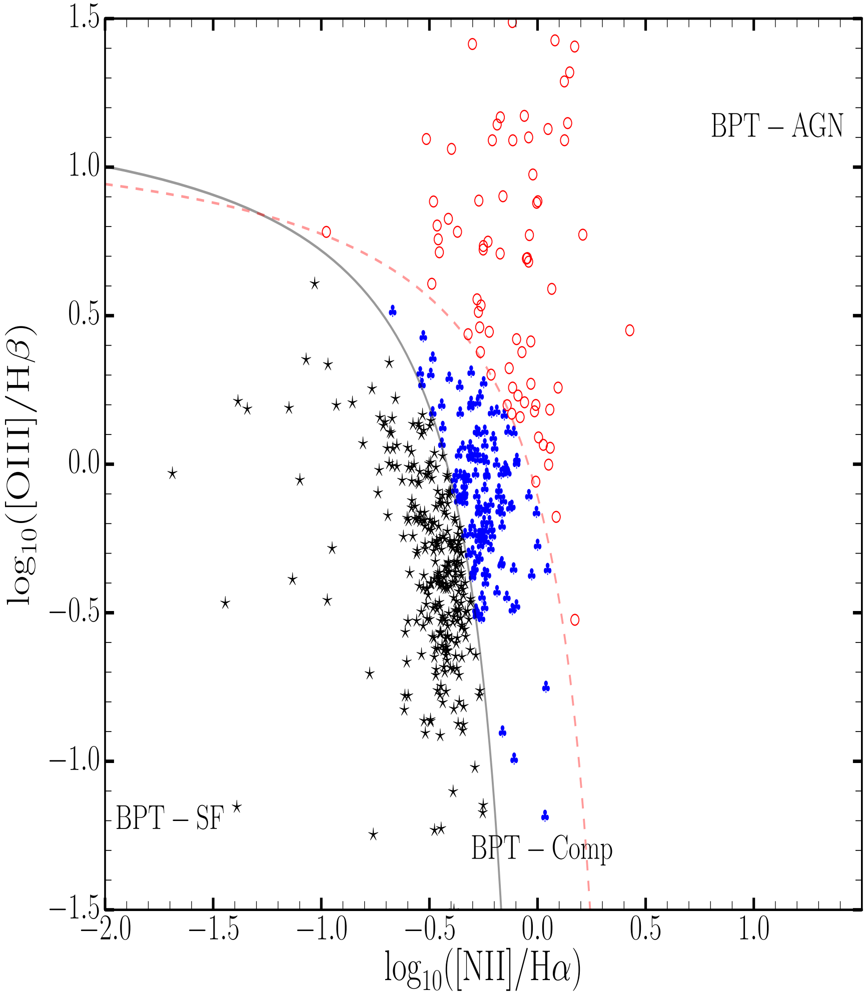
  $x \geq 0.08 \wedge y \geq 0.15 \wedge y \geq (1.21 \times x) - 0.27 \wedge y \leq (1.21 \times x) + 0.27$
  $\wedge\ f4.5\mu m > f3.6\mu m > f4.5\mu m \wedge f8.0\mu m > f5.8\mu m$

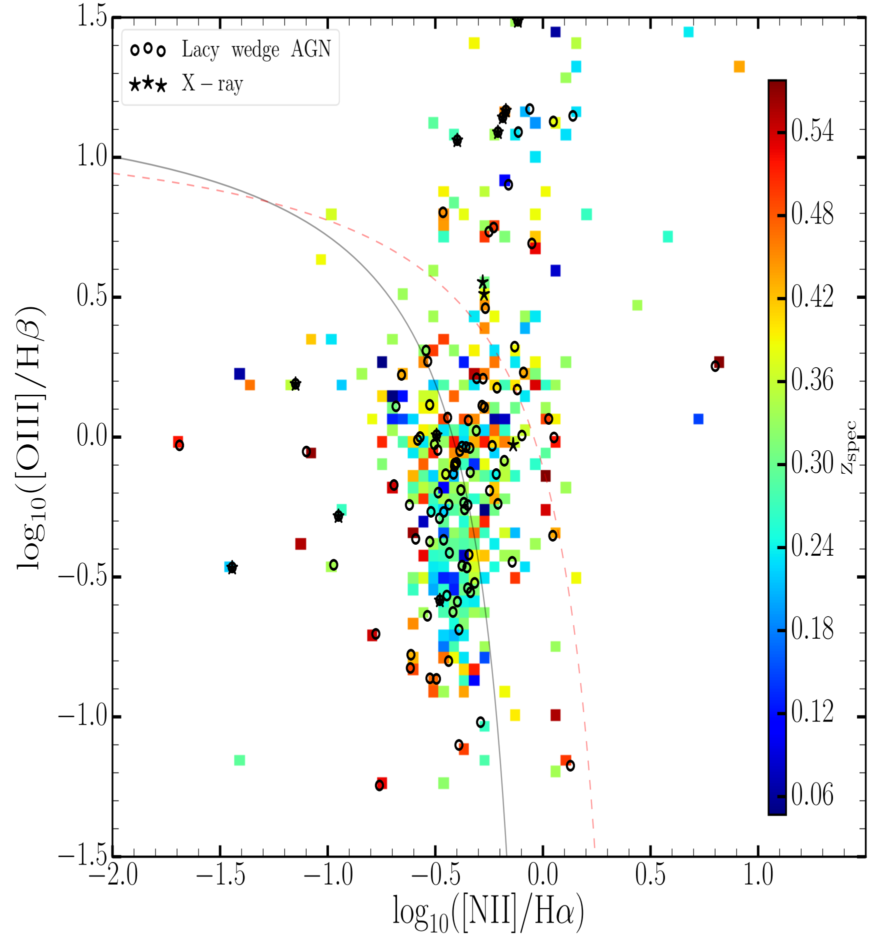
Infrared Diagnostics Contd



Optical Emission-Line Diagnostics:

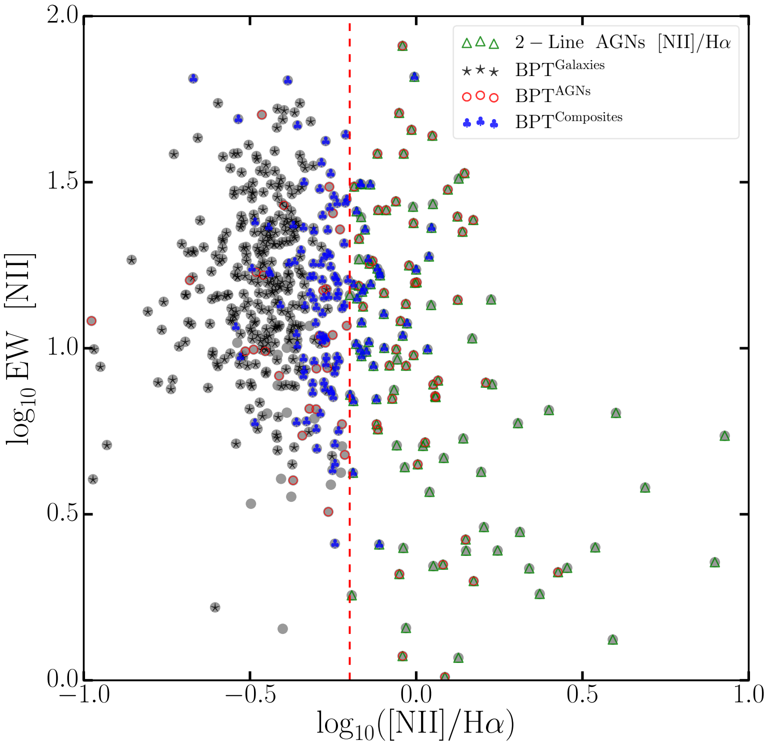
Four-line diagnostics



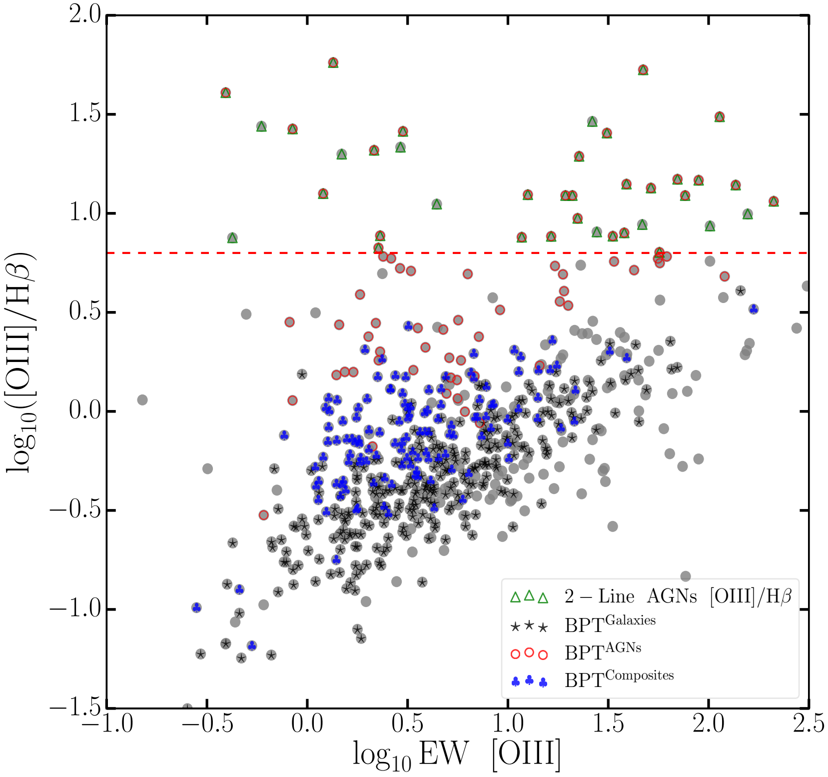


Two-Line Diagnostics

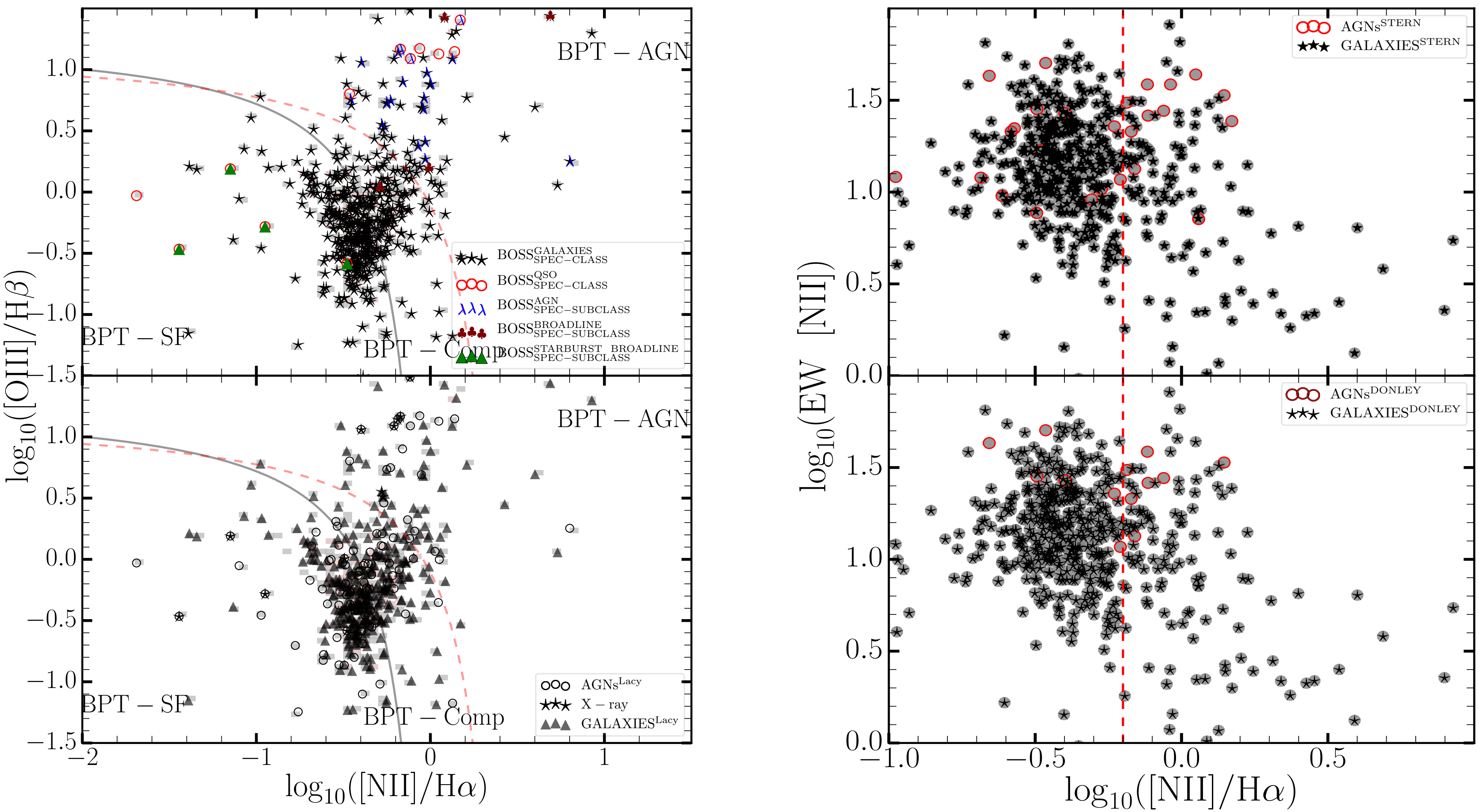
[NII]/Hα



[OIII]/Hβ



Comparison between emission-line and other diagnostics



Messages

- ✓ We compare our optical line diagnostics to the results of other AGN diagnostics techniques.
- ✓ For 19% of our X-ray classification detected in our four line diagnostics, 38% misidentified by the BPT diagram as BPT-SF
- ✓ For 23% of the Lacy AGN detected in the four line diagnostics, 56% misidentified by the BPT diagram as BPT-SF likewise 39% out of the 11% of Stern AGN identified in the four line diagnostics are misidentified as BPT-SF.
- ✓ Similar trends are observed for the various two line diagnostics.
- ✓ Applying signal-to-noise cuts (eg. SNR > 3, 5, 10), we see improvement in the agreement with other diagnostics for both the four and two-line diagnostics but we loose sources.
- ✓ This agreement is particularly evident for the Donley classification.

AGN Selection:
Radio Luminosity

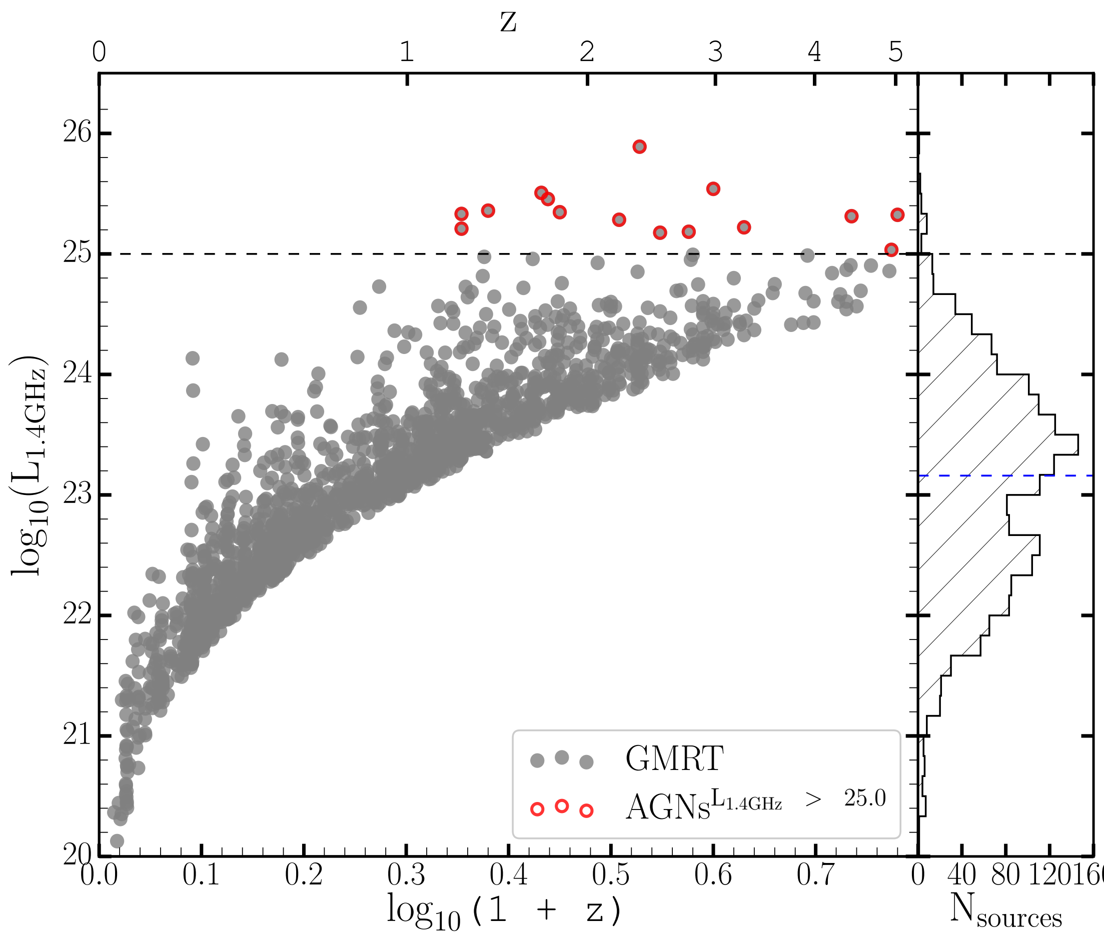
- ✓ Synchrotron emission is the dominant source of emission in the radio frequency range.
- ✓ Synchrotron emission assumed to follow a power law:

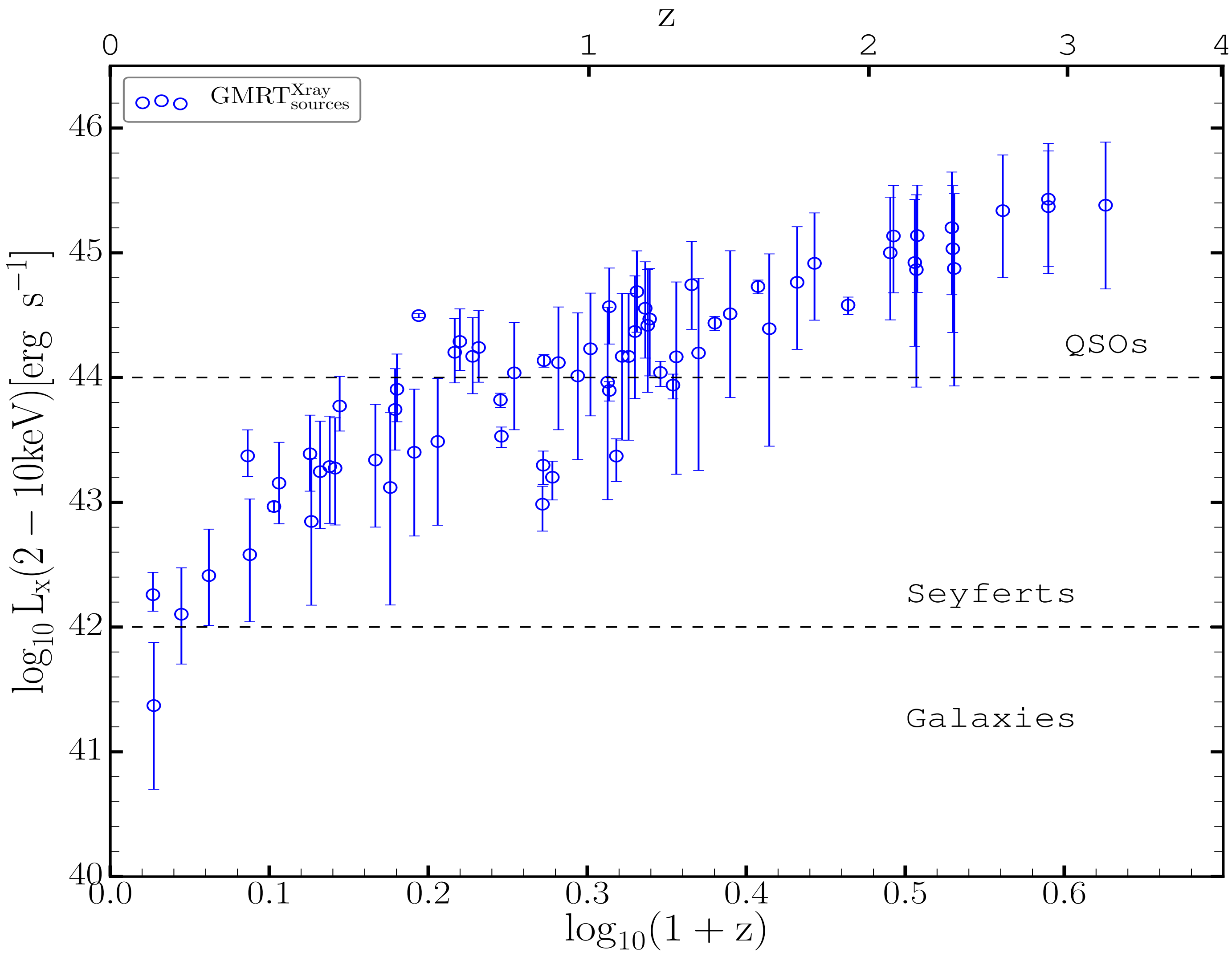
$$S_\nu = S_o \nu^\alpha$$

$$L\nu = \frac{4\pi d_L^2 S_\nu^{obs}}{(1+z)^\alpha}$$

We assumed α = -0.7 (Ibar et al., 2010)

- ✓ We adopt a radio luminosity threshold of $L_{1.4\,GHz} \geq 25$ W Hz^{-1} to classify a source as radio – loud AGN (see Jiang et al. 2007 & Sajina et al. 2008).

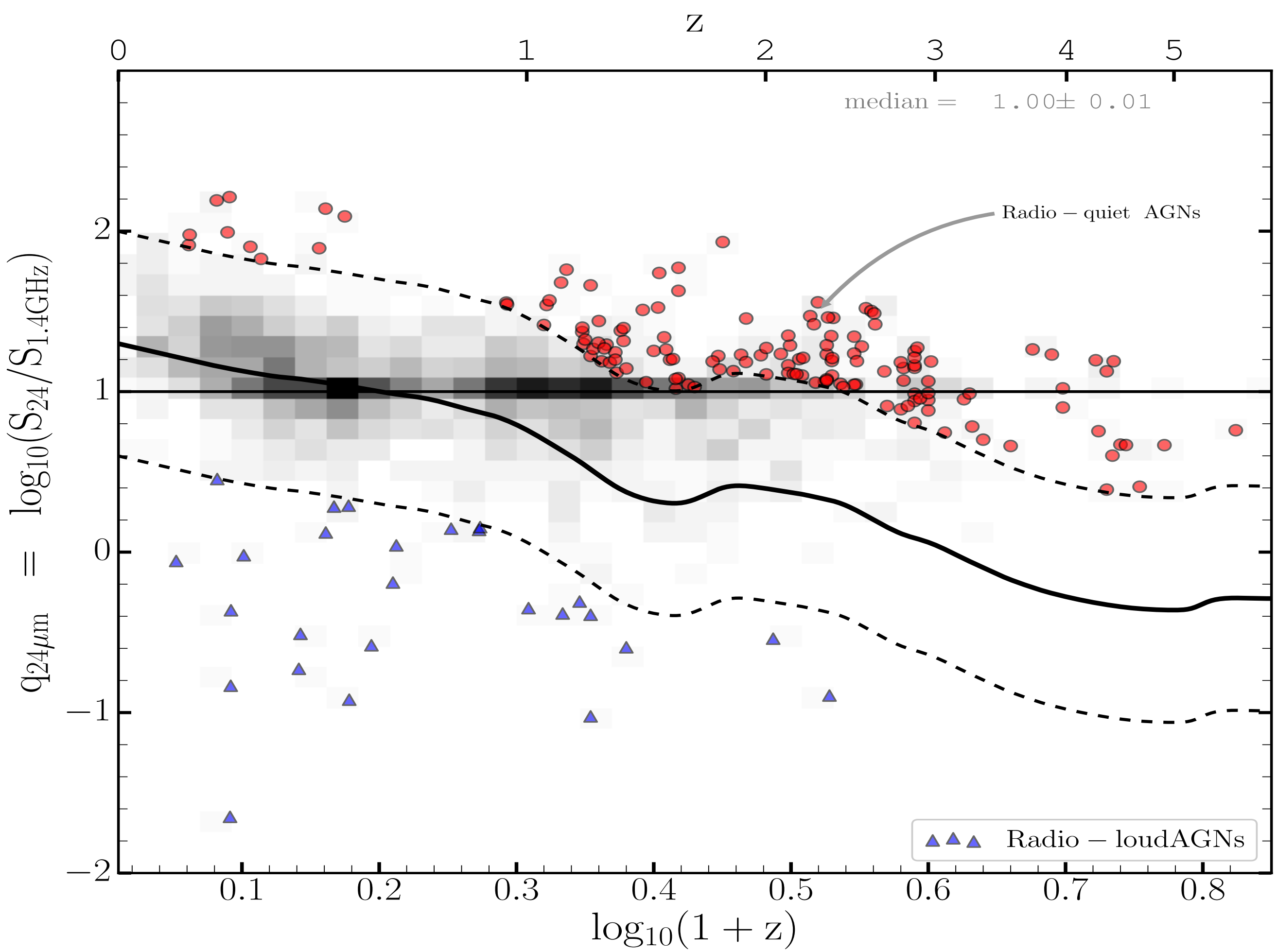




X-ray Selection of AGNs

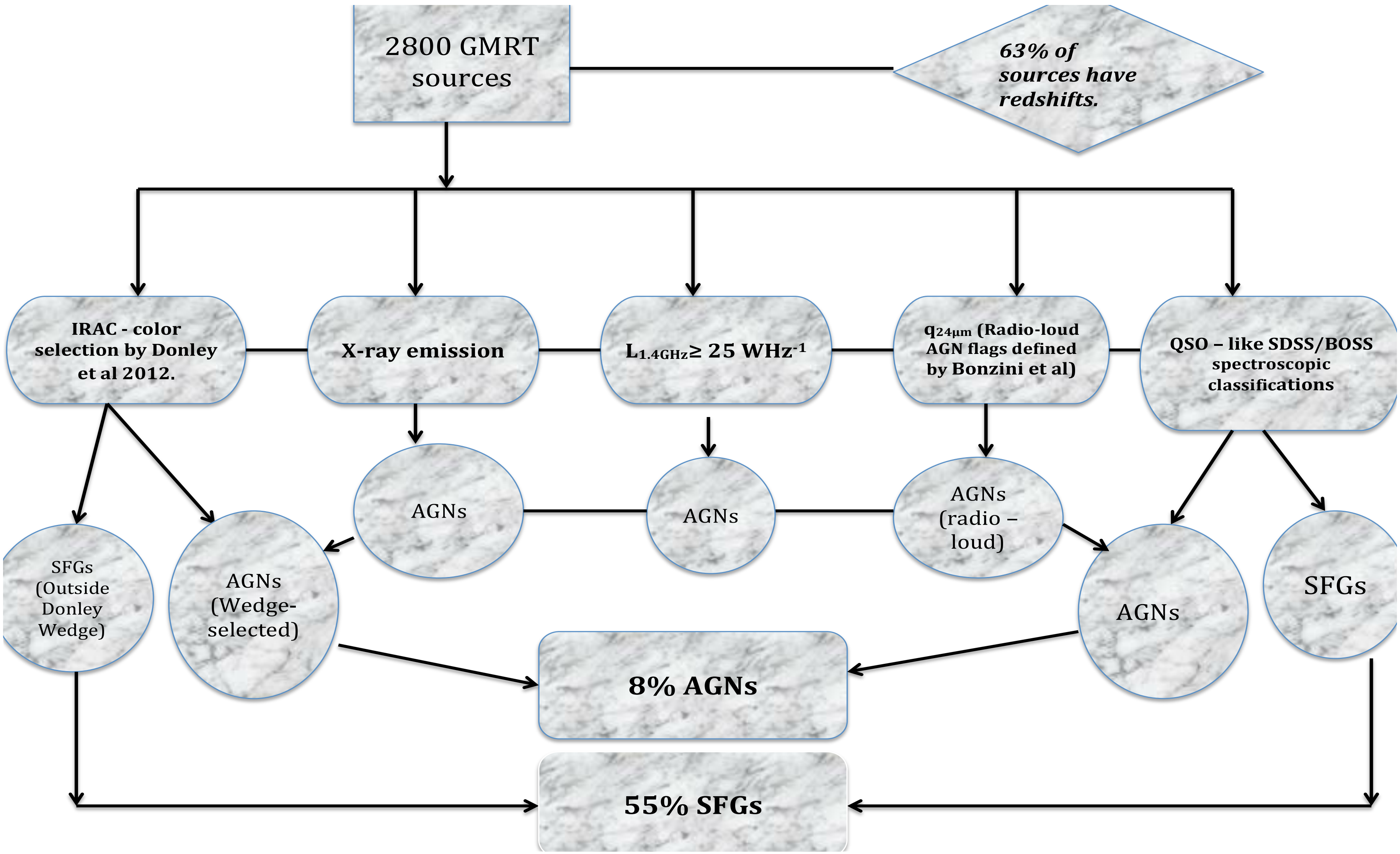
$L_X = 4\pi \times S_X \times d_L^2 (1 + z)^{2-\gamma}$, where $\gamma = 1.8$ (Vito et al., 2014).

We select an object as AGN when $L_X \geq 10^{42}$ erg s^{-1}

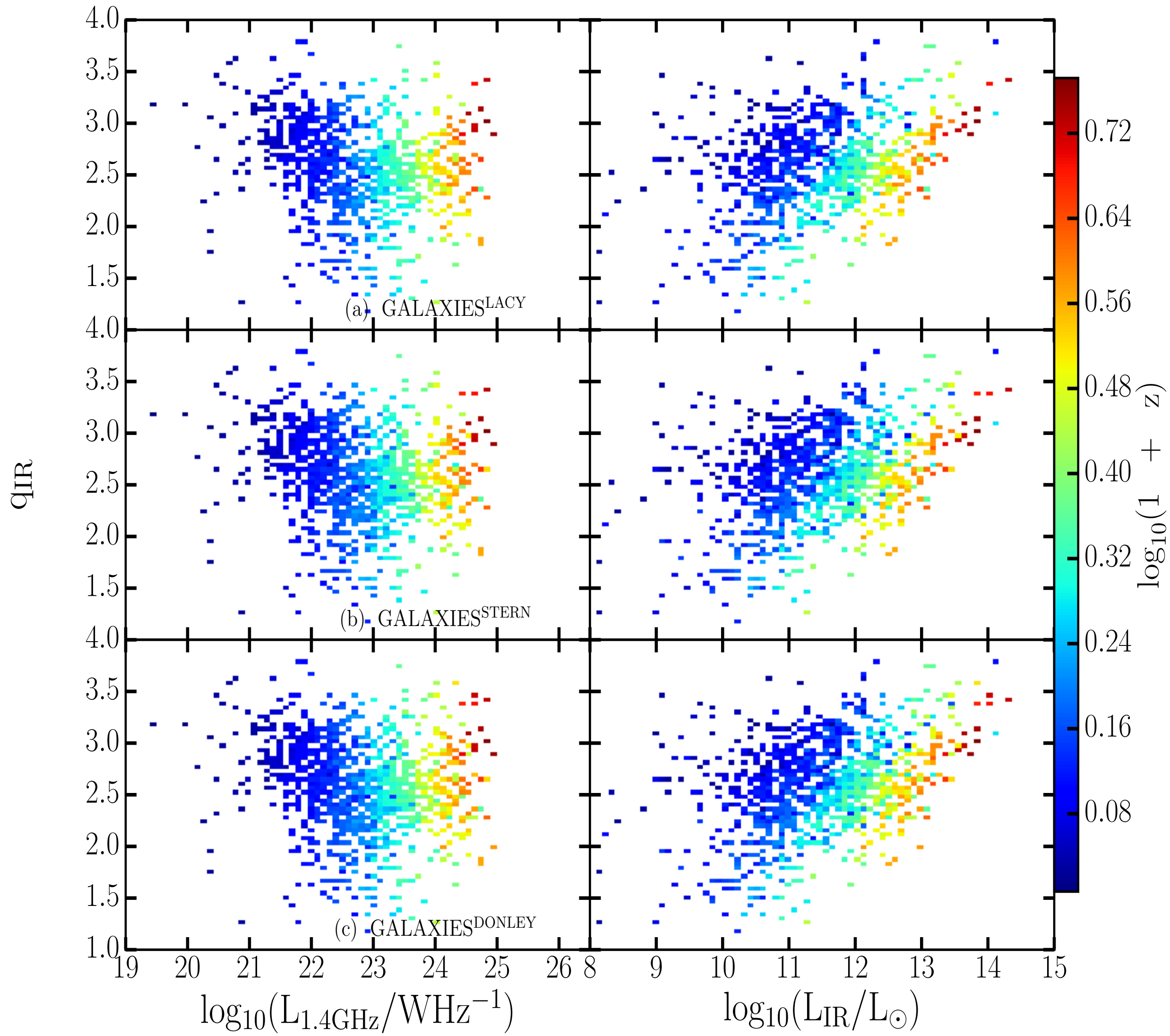


MIPS 24 micron and 1.4GHz radio flux

MIPS (Rieke et al., 2004) 24μm flux density and the effective 1.4 GHz flux density. $q_{24\mu m} = \log_{10}(S_{24\mu m} / S_{1.4\ GHz})$



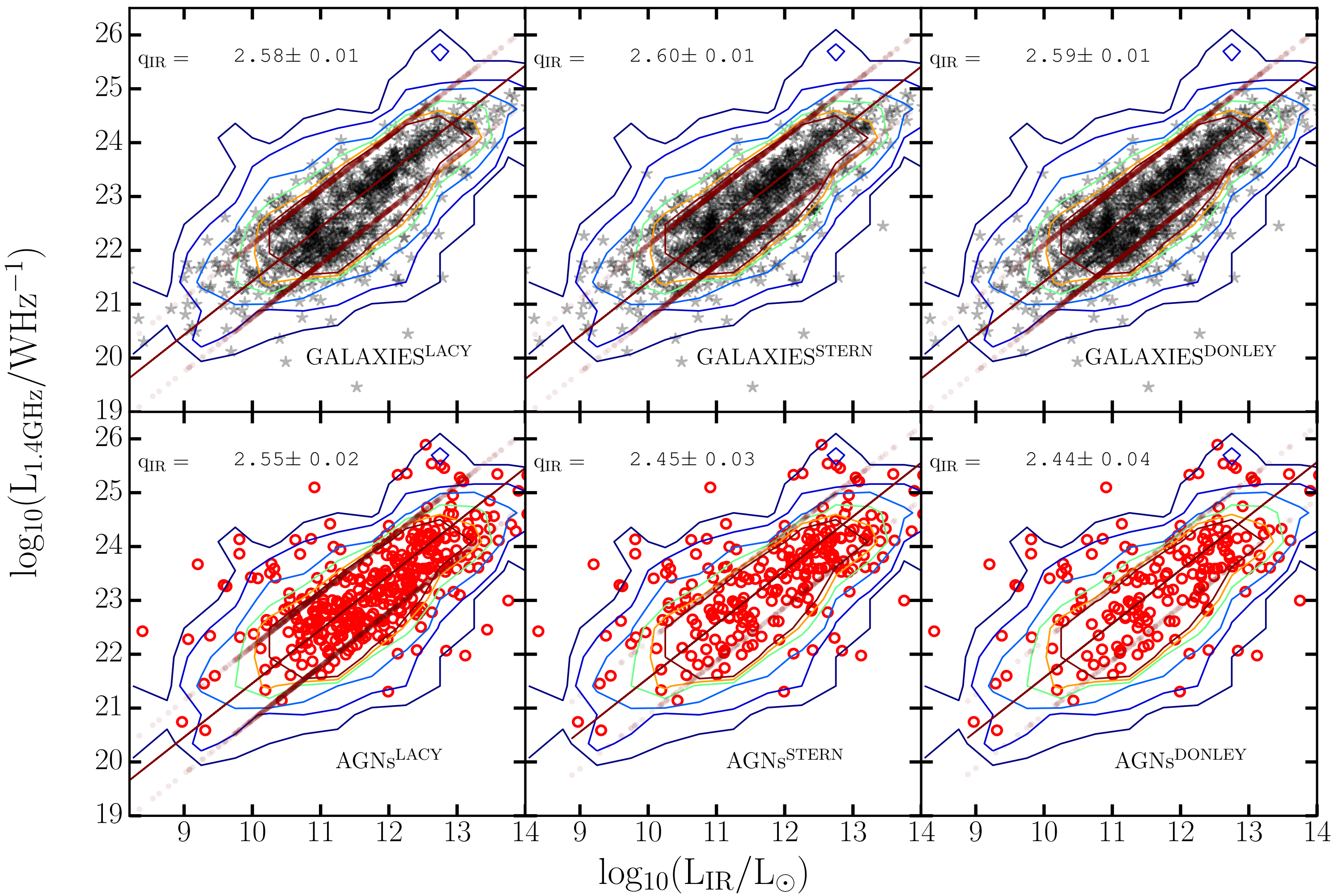
Flowchart for our AGN classification



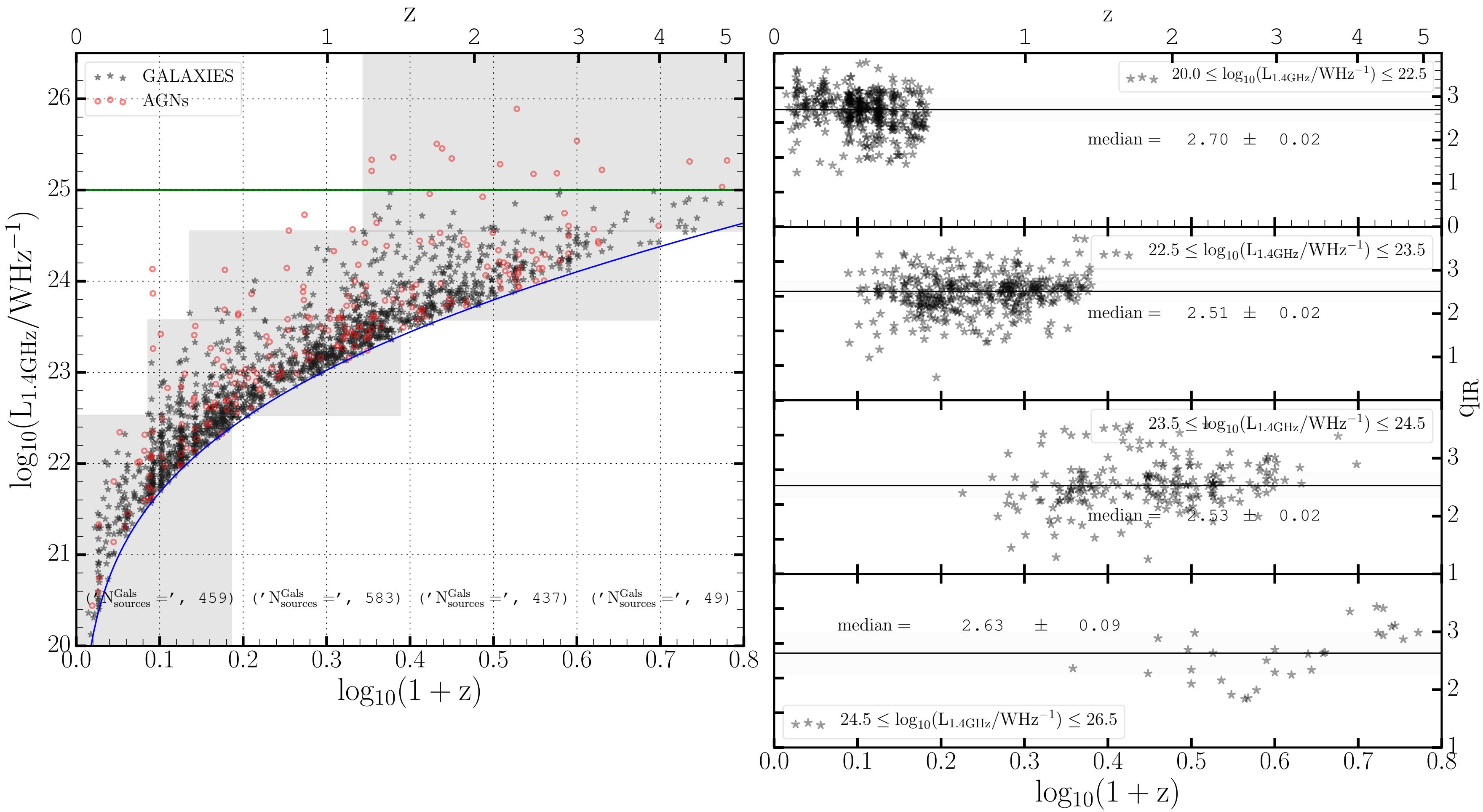
The far-infrared radio correlation (FRC)

- ✓ Tightest correlations among global parameters of observed galaxies
- ✓ Believed to be driven mostly by star formation.
- ✓ $q_{IR} = \log_{10} (L_{IR}/ 3.75\times10^{12}\ W) - \log_{10} (L_{1.4GHz}\ /\ WHz^{-1})$

(NB. the logarithmic total IR, from MRR13 catalog / radio luminosity)



1.4 GHz luminosity vs IR luminosity for Galaxies and AGNs.



Messages :

- ✓ We find that the median value of q_{IR} decrease with increasing radio luminosity from q_{IR} = 2.70 ± 0.02 for $L_{1.4GHz}$ ≤ 22.5 W Hz^{-1} to q_{IR} = 2.51 ± 0.02 for 22.5 W Hz^{-1} ≤ $L_{1.4GHz}$ ≤ 23.5 W Hz^{-1} and then increases to q_{IR} = 2.53 ± 0.02 for $L_{1.4GHz}$ ≤ 24.5 W Hz^{-1} through to q_{IR} = 2.63 ± 0.09 for 24.5 W Hz^{-1} ≤ $L_{1.4GHz}$ ≤ 26.5 W Hz^{-1} .
- ✓ From our selection scheme, we measure q_{IR} = 2.59 ± 0.01 in a sample of 1533 star-forming galaxies.

THANK YOU !