Correlation between the AGN and the Star Formation of the host galaxy

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Outline

- **Introduction**
- **Sample**
- **Estimating z_{phot} using TPZ**
- **SED fitting using CIGALE**
- **Summary - Conclusions**

Correlation between AGN and SFR

- **Mass** of the Supermassive black hole (**SMBH**) is **correlated** to the properties of its **bulge**, parametrised by the luminosity (Magorrian et al. 1998), or the velocity dispersion (Ferrarese & Merritt 2000).
- **Coeval growth** of **SMBH** and **host galaxy** $\rightarrow$ **causal connection between AGN and SF** properties (Alexander & Hickox 2012).
- **Models** of galaxy evolution, through mergers, assume such a connection, where **AGN feedback** plays a **catalytic role** (Hopkins et al. 2006; Di Matteo et al., 2008).

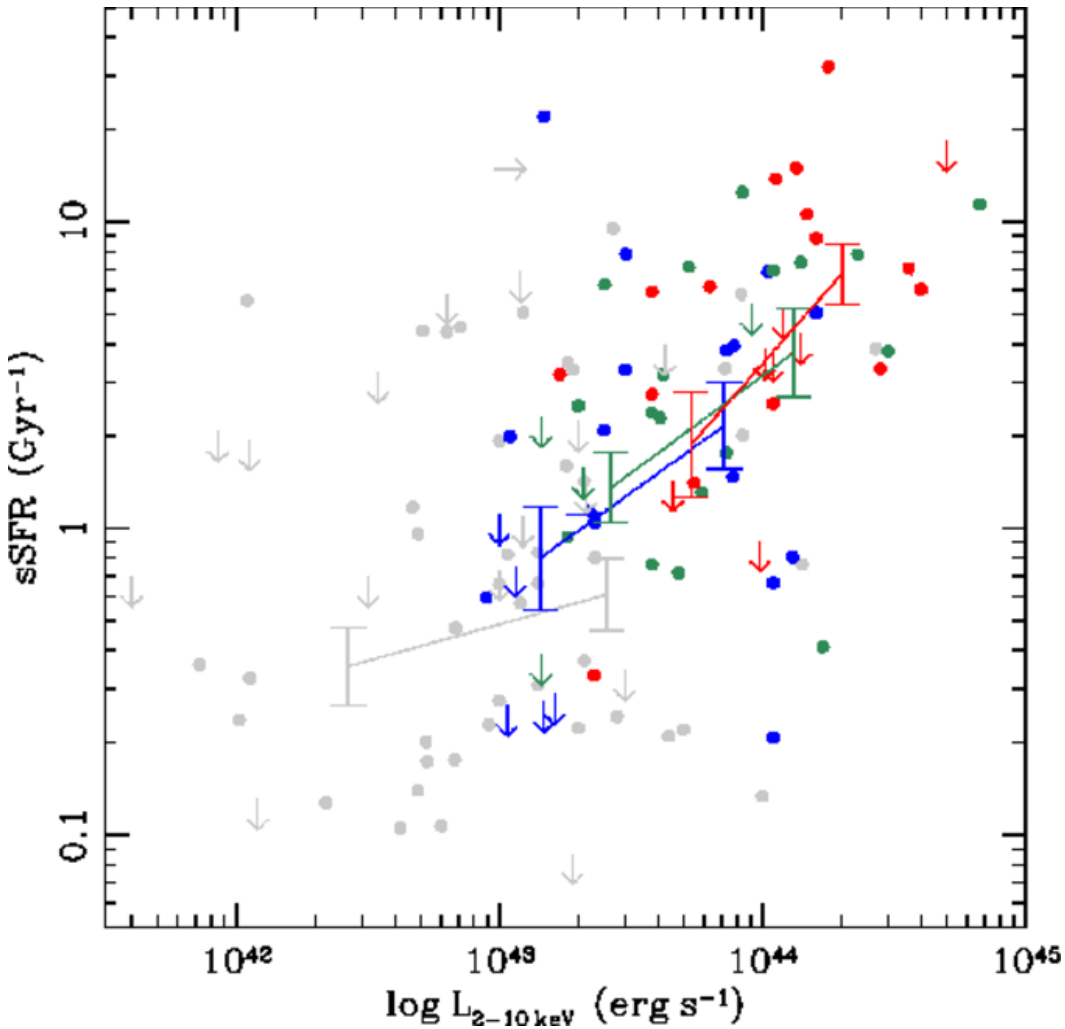
Why X-rays and Infrared?

X-rays**: Efficient way of selecting **AGN

Infrared**: Estimation of **SFR

Overview

Correlation between the sSFR and the X-ray luminosity for sources with $L_X > 10^{43}$ erg s^{-1} and at z$>$ 1 (Rovilos et al. 2012).

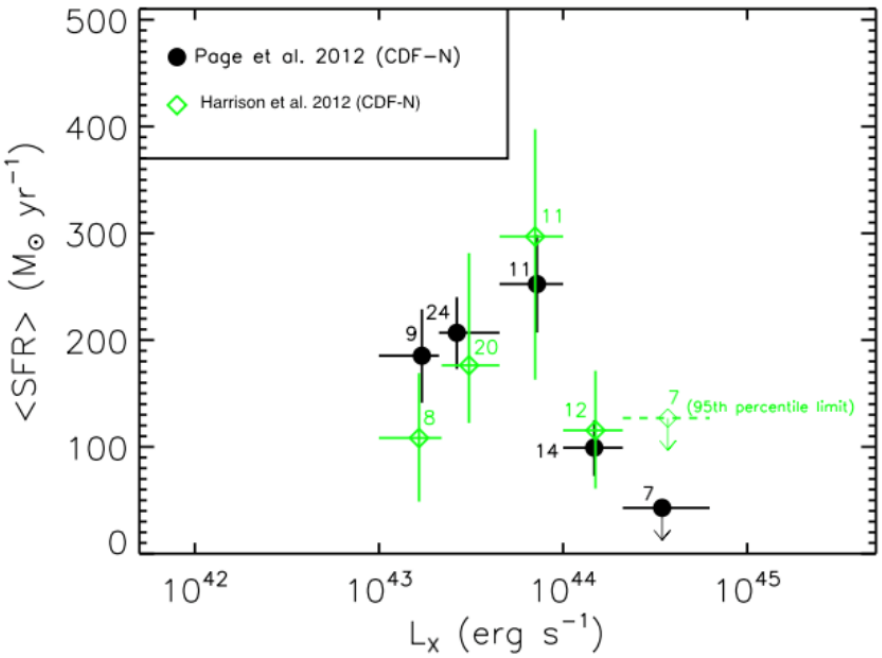


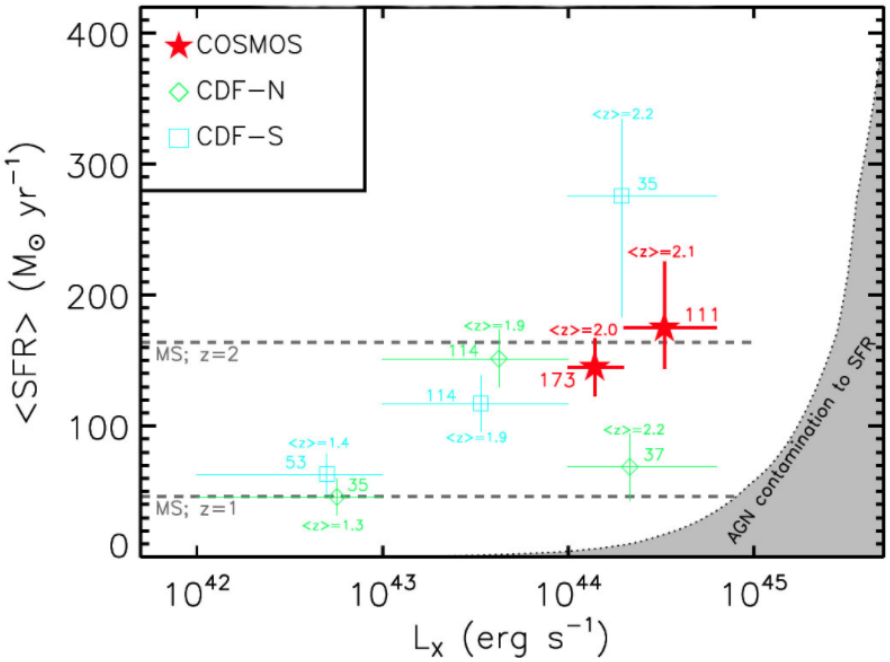
Sample: 3Ms XMM-Newton ($M_* \sim 10^{10} - 10^{11.5} M_\odot$)

z < 1.120 $1.120 <$ z < 1.615 $1.615 <$ z < 2.455 z > 2.455

Overview

- **Suppressed SF in $L_X > 10^{44}\,\mathbf{erg\,s^{-1}}$** (Page et al. 2012)
  Page et al. 2012 vs Harrison et al. 2012 (CDF-N)
- **No strong evidence for suppressed SF in $L_X > 10^{44}\,\mathbf{erg\,s^{-1}}$**
  (Harrison C. et al 2012) COSMOS CDF-N CDF-S





This Work

- **Main scientific goal** $\rightarrow$ Study the **link between AGN and SF** at **high X-ray luminosities** ($> 10^{43} - 10^{44}$ ergs^{-1}) & **low-redshifts** (z$<$ 0.5).

Our Sample

- Herschel Terahertz Large Area Survey **(H-ATLAS)**
  550 **deg^2 in five FIR and sub-mm bands** ($100, 160, 250, 350$ *and* 500 μm).

- X-ray Multi-Mirror Mission**(XMM-Newton)**
  We observed 7.1 **deg^2** (exposure time 336 ks within the H-ATLAS).
  1816 unique sources (Ranalli et al. 2015).

Photometric Estimation Methods

Why have photo-z become a necessity?

Large datasets ***Faint sources***

- ***(I) Machine learning techniques*** ***(II) Template fitting***

We apply a Machine Learning Tecnique, for the first time, to estimate photo-z for X-ray AGNs

TPZ

- ***TPZ (Trees for Photo-z)***: Fast and robust photo-z PDFs (Probability Density Functions) using machine learning algorithms (prediction trees and random forest).
- ***Main point***: **Training set**→ **Determines** a functional correlation between redshifts and colours→ **Applies** it to the photometric galaxies of interest → **Estimates their redshifts**.

Training Sample

- **XMM-XXL** $\sim 50\ deg^2$ (Liu et al. 2016).
  2,512 X-ray AGNs, reliable spectroscopy
  (SDSS-III/BOSS; Menzel et al. 2016).

- **5,157** sources with available photometry in the optical (SDSS), mid- and far-IR (WISE, VISTA-VIKING) is used for the training of the algorithm.

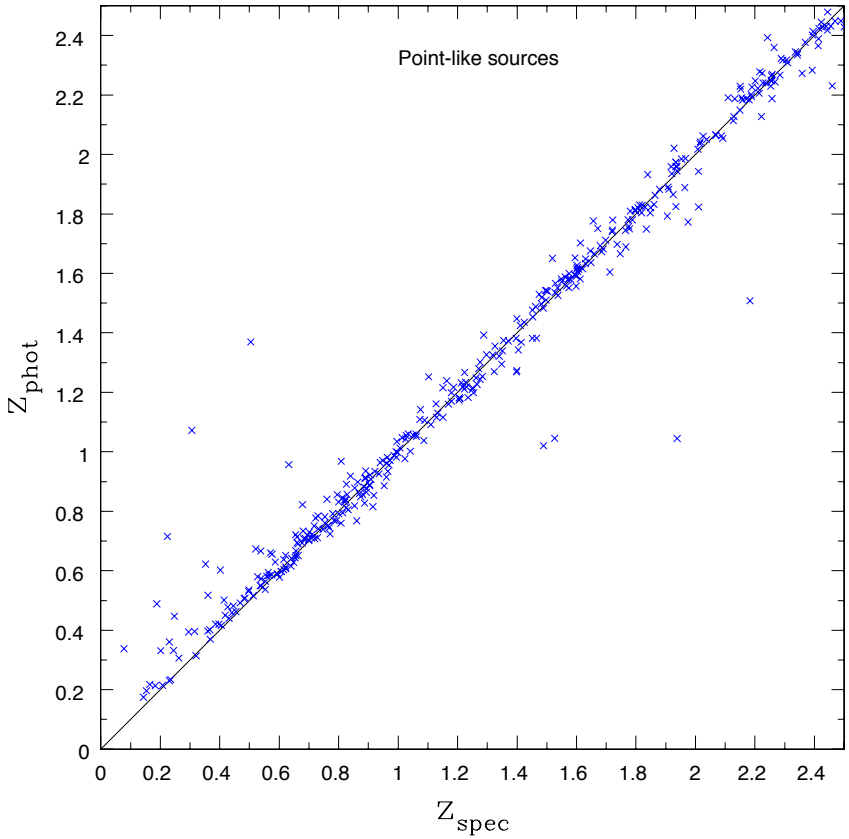
- **Split** the sources into **point-like** and **extended** based on their SDSS classification and calculate their z_{photo}.

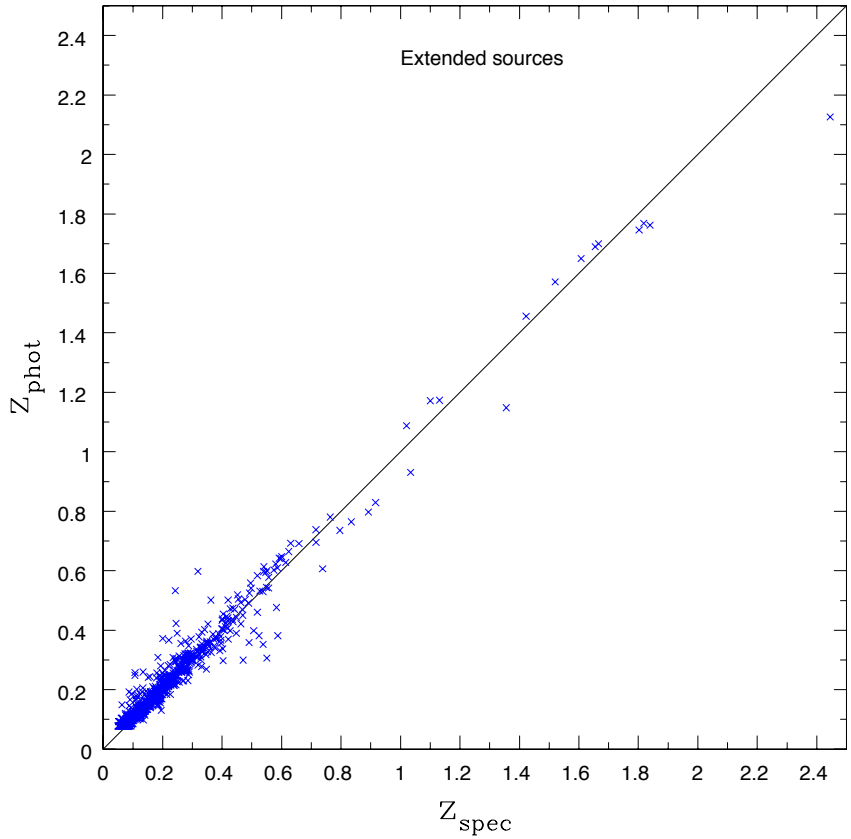
TPZ's Accuracy

(Mountrichas, Corral, Masoura, Georgantopoulos et al., in prep.)

Point-like
$\sigma = 0.07$/ outlier rate =14.2%

Extended
$\sigma = 0.05$/ outlier rate =10.2%



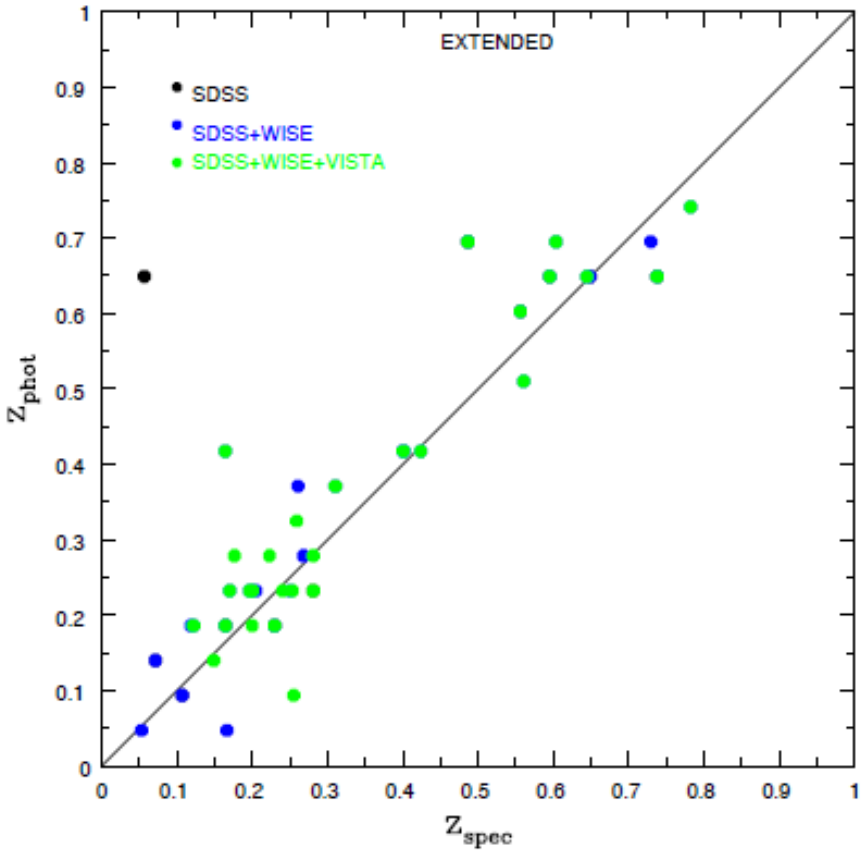


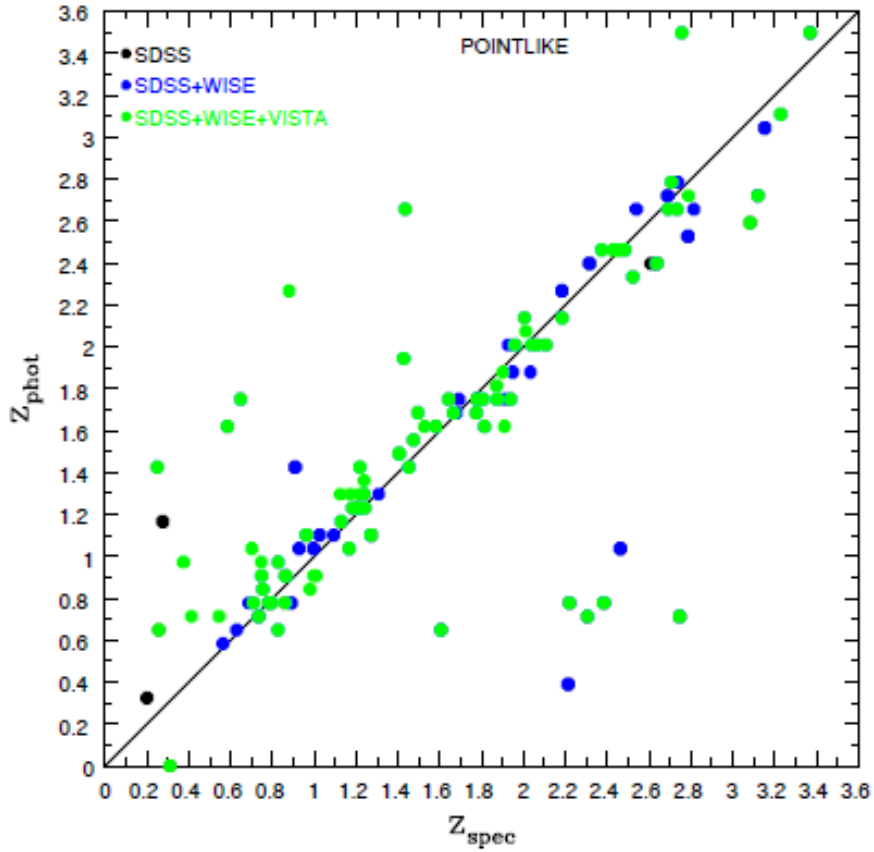
- $\Delta z_{norm} = \frac{(z_{spec} - z_{phot})}{(1 + z_{spec})}$, $\sigma \equiv 1.4826 Median|\Delta z_{norm}|, Outliers\ |\Delta z_{norm}| > 0.15$

Estimations for ATLAS

- **XMM-ATLAS cross-match SDSS,VISTA-VIKING, WISE $\rightarrow$ 1031, 848, 589** sources with optical, mid- and near IR photometry, respectively.

174/1031 sources have **spectroscopic** redshifts (SDSS or GAMA)



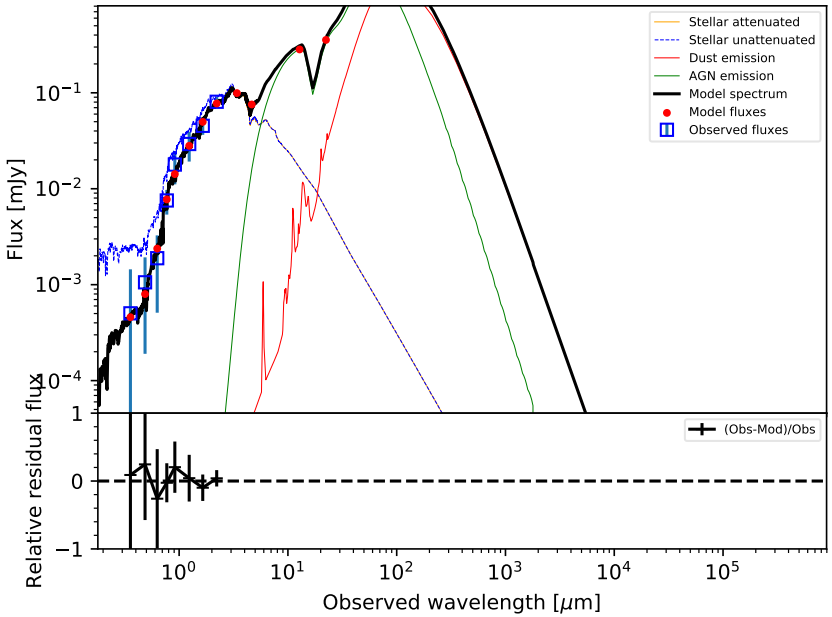


- **C**ode **I**nvestigating **GA**Laxy **E**mission.
- Estimates parameters such as SFR, M_*.

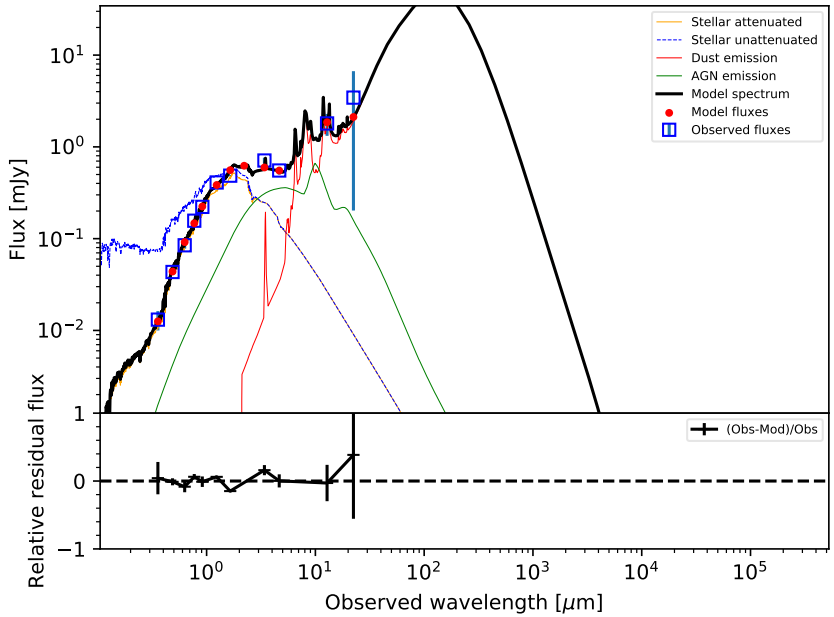
- Examples of estimations and SEDs, for two sources :

Sources	L_X (ergs^{-1})	SFR ($M_\odot$ yr^{-1})	M_* ($M_\odot$)	AGN_{frac}
7	43.9	13.95	3.4×10^{11}	0.7
26	41.1	0.41	7.1×10^{9}	0.1

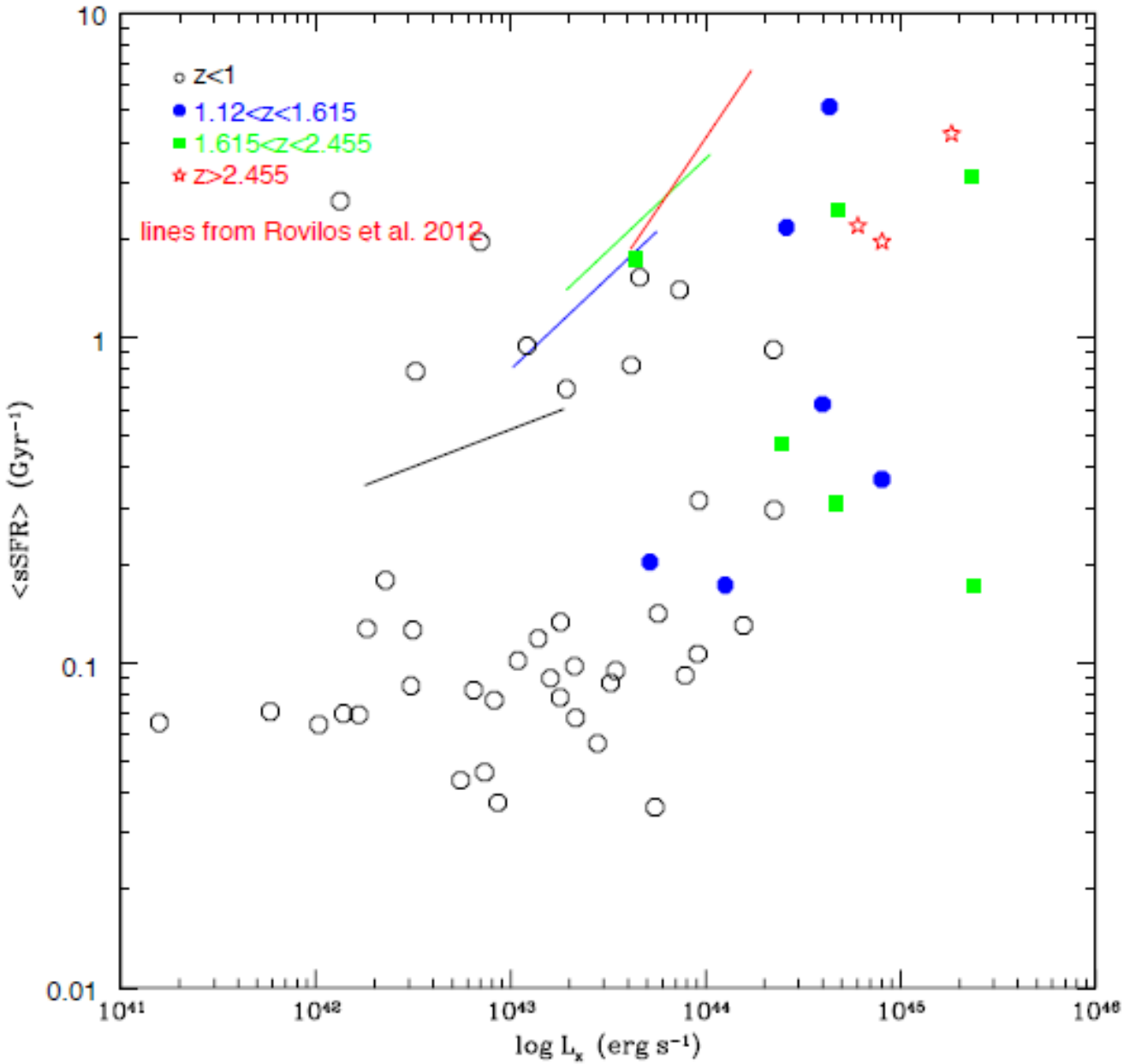
Best model for 7 at z = 0.788. Reduced χ^2=0.61



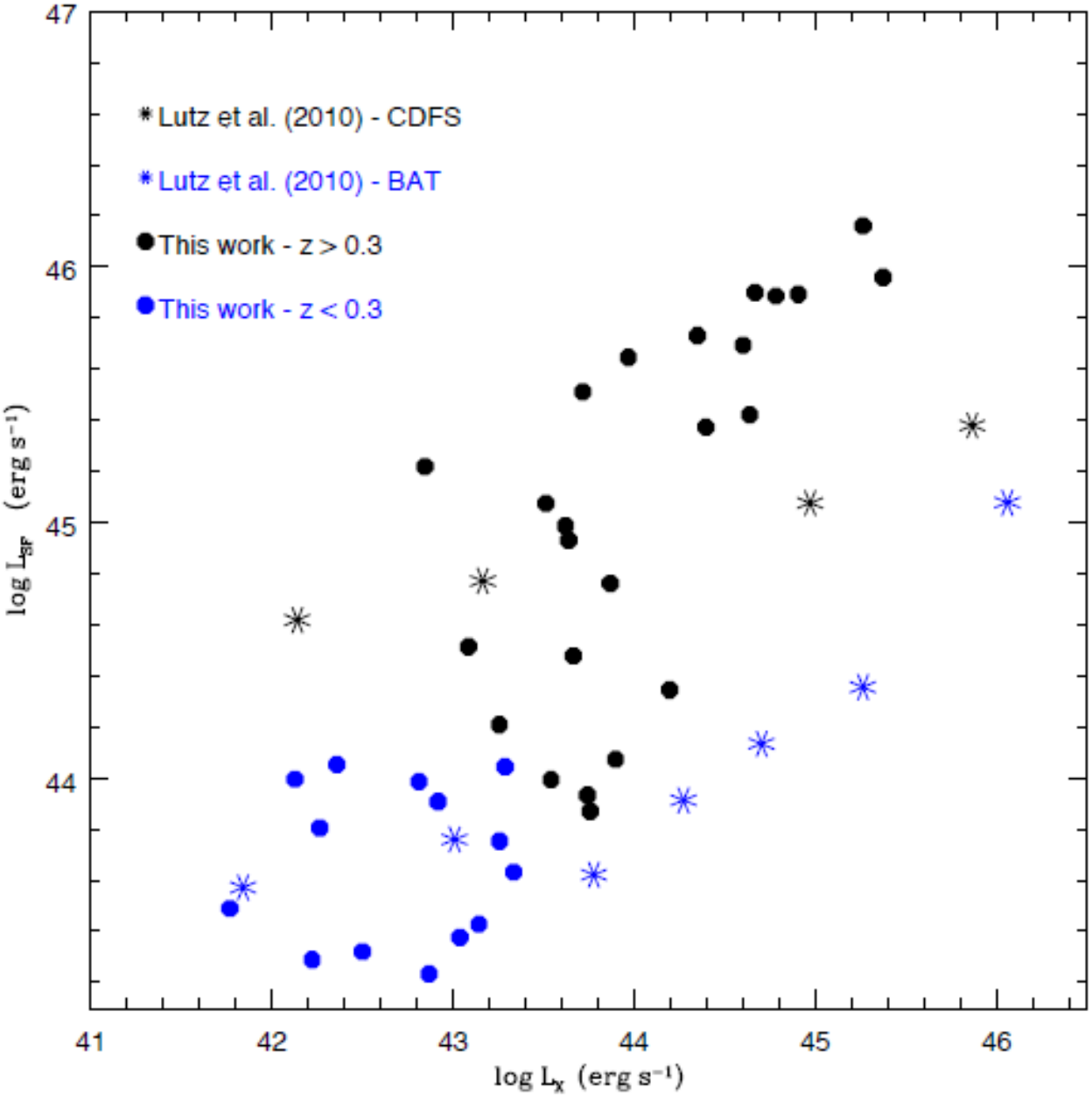
Best model for 26 at z = 0.047. Reduced χ^2=0.76



AGN - sSFR correlation



Are there two branches?



Summary - Conclusions

- We use for the **first time a Machine Learning Technique (TPZ)** to estimate z-photo for X-ray AGN (1031 sources).

- **Photometric redshifts are accurate** enough when optical photometry is combined with, at least, mid- IR photometry ($\sigma = 0.05 - 0.07$, outliers $= 10 - 14\%$ depending on whether the source is extended or pointlike).

- **Preliminary results (65/1031 sources)**

  (i) **Connection between SFR and AGN activity at high X-ray luminosities ($L_X > 10^{44}$ erg s^{-1}) at all redshifts** ($0 < z < 2.5$).

  (ii) An **indication of two different populations** (i.e. sources with the same L_X, z but sSFR that differs more than an order of magnitude).

- Future Work: This analysis will be applied on our full sample, the 1031 sources in the ATLAS field.