AGN ACCRETION HISTORY FROM HERSCHEL

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On behalf of
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Gianni Zamorani, Stefano Berta, Andrea Cimatti,
Anna Feltre, Jacopo Fritz and the PEP - Herschel team

Outline

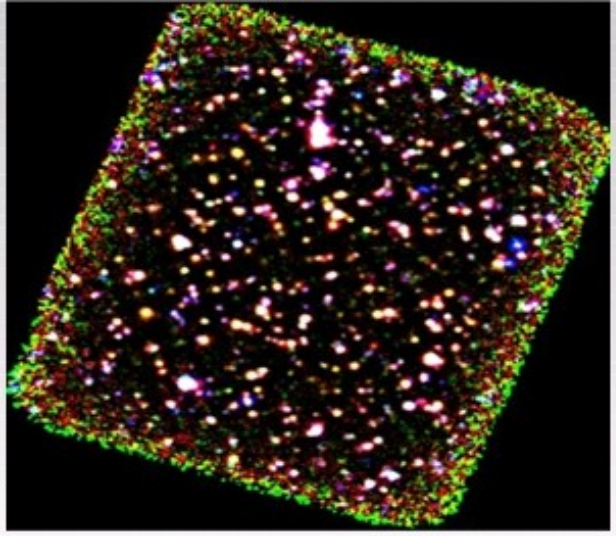
Aims:

- disentangling star formation activity from that due to AGN;
- studying the BHAD as a function of redshift in the Herschel surveys;
- comparing the BHAD derived from the IR with estimates from X-ray .

Method:

- multiband catalog from the UV up to sub-mm wavelengths;
- broad-band SED fitting analysis useful to provide an IR characterization for each source from its global SED;
- SED decomposition code to isolate the nuclear contribution.

1 **MULTI-BAND CATALOG**



GOODS - South

- Deepest PEP (Pacs Evolutionary Probe) survey (~ 300 arcmin^2);
- Detections at 70, 100 & 160 μm (PACS);
- Infrared selected catalog: 1069 objects having at least one PACS detection with 627 out of 1069 (~ 2/3) having multi-frequency coverage:

COUNTERPARTS

Sub-mm: 250 / 350 / 500 μm (Herschel)

MIR: MIPS 24 / 16 μm + IRAC 3.6 / 4.5 / 5.8 / 8.0 μm (Spitzer)

NIR: J, H, Ks (VLT)

Opt: 0.43 / 0.60 / 0.77 / 0.85 μm (HST)

UV: 0.35 / 0.38 / 0.39 μm (VLT)

GOODS-South redshift dataset

MUSIC catalog (Grazian et al. 2006; Santini et al. 2009)

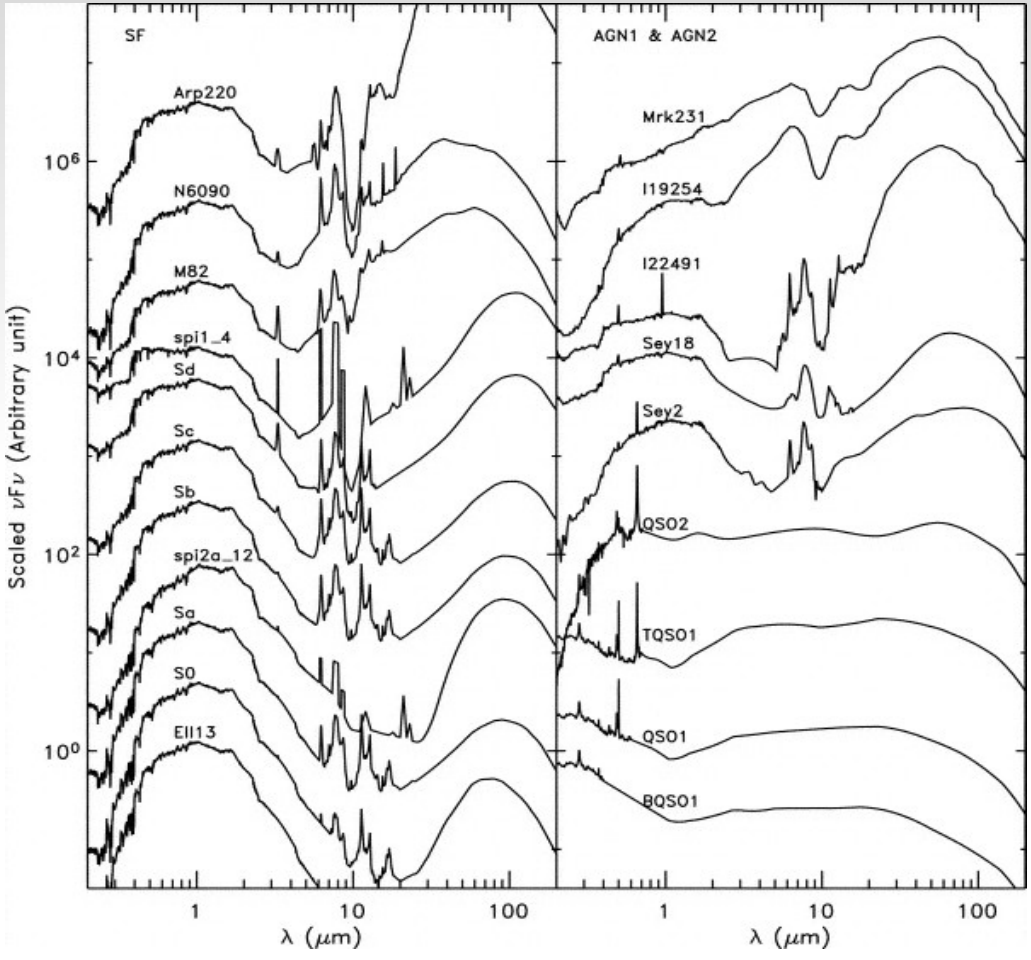
Cross correlation with further available spectroscopic and photometric data in the GOODS-S MUSIC area:

1) **Master Catalog** (GOODS / CDF-S spectroscopy, v2.0 – 12/2009);
2) **MUSYC** catalog (Cardamone et al. 2010);
3) **ACES** catalog (Cooper et al. 2012);
4) **4Ms CDF-S** catalog (Xue et al. 2011).

Z type / Catalogs	Spec	Phot	No z
MUSIC	56 %	35 %	9 %
MUSIC+other spectral datasets	68%	28 %	4 %

2

SED-FITTING ANALYSIS



LIBRARY OF TEMPLATES:

(Polletta et al. 2007; Rieke et al. 2009; Gruppioni et al. 2010)

17 GALAXIES:

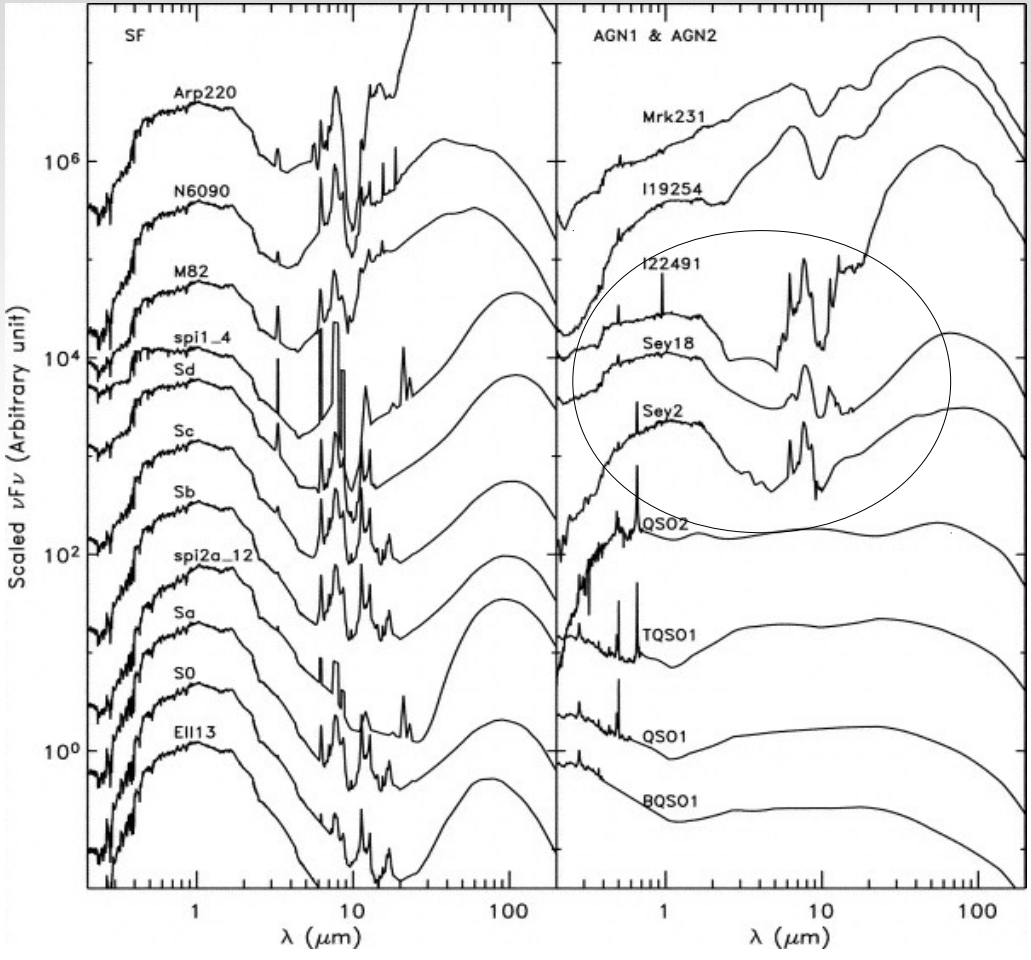
7 **Sp** + *6* **SB** + *4* **ELL/S0**

15 AGNs:

4 **AGN 1** + *4* **AGN 2** + *7* **LLAGN**

2

SED-FITTING ANALYSIS



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2

SED-FITTING ANALYSIS

DATASET OF 22 FILTERS

+

LIBRARY OF TEMPLATES:

(Polletta et al. 2007; Rieke et al. 2009; Gruppioni et al. 2010)

17 GALAXIES:

7 **Sp** + *6* **SB** + *4* **ELL/S0**

15 AGNs:

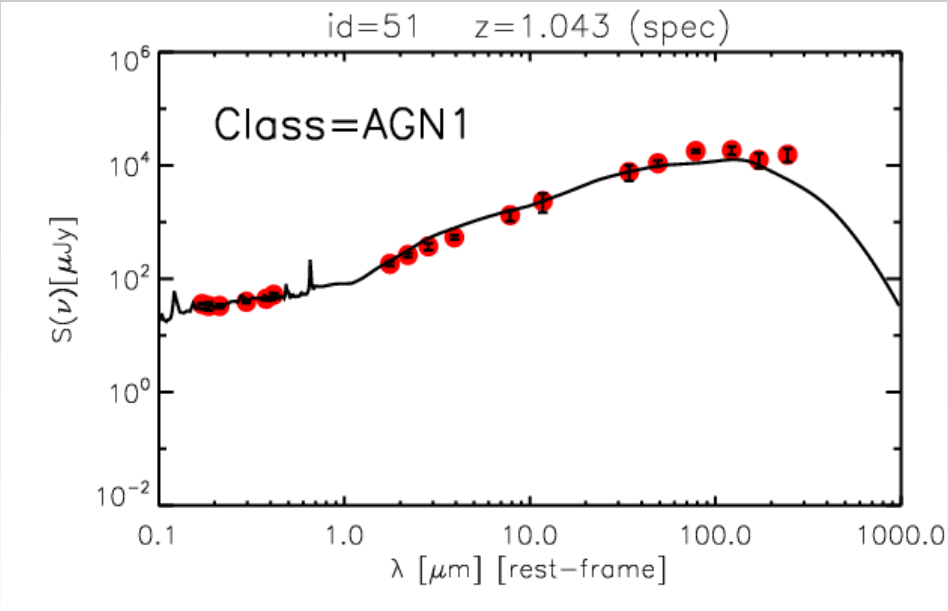
4 **AGN 1** + *4* **AGN 2** + *7* **LLAGN**

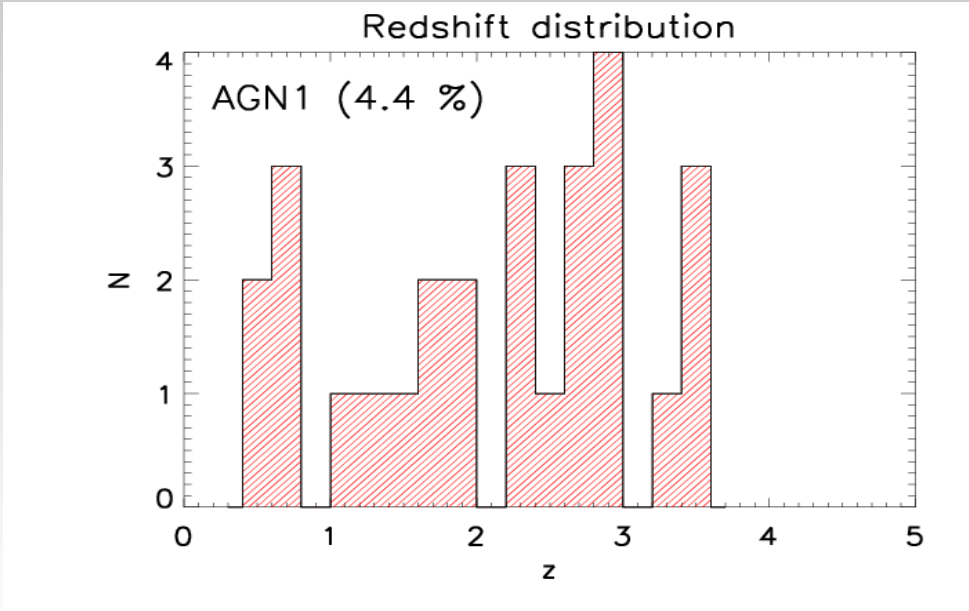
LE PHARE

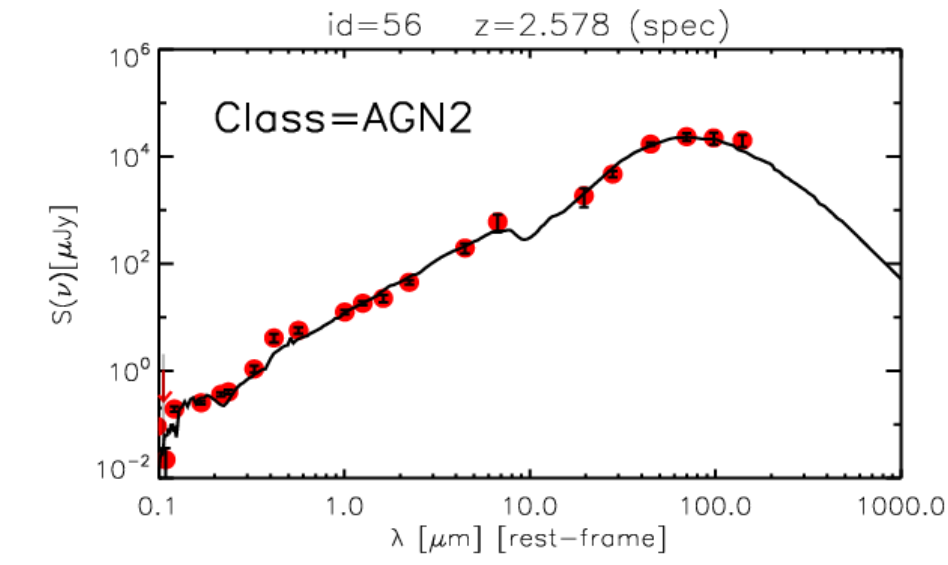
(Ilbert et al. 2006)

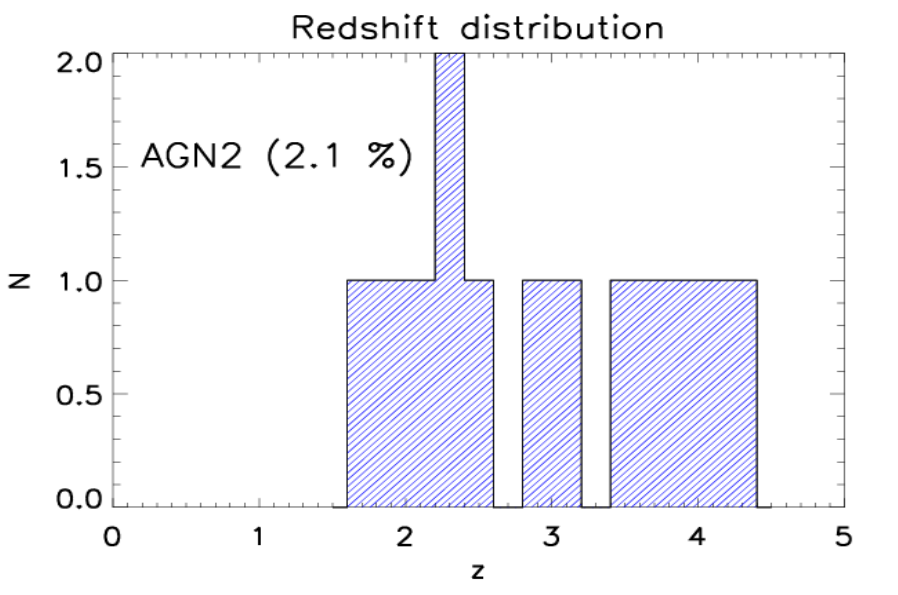
AGN 1: 4.5 %
AGN 2: 2.5 %
LLAGN: 44 %

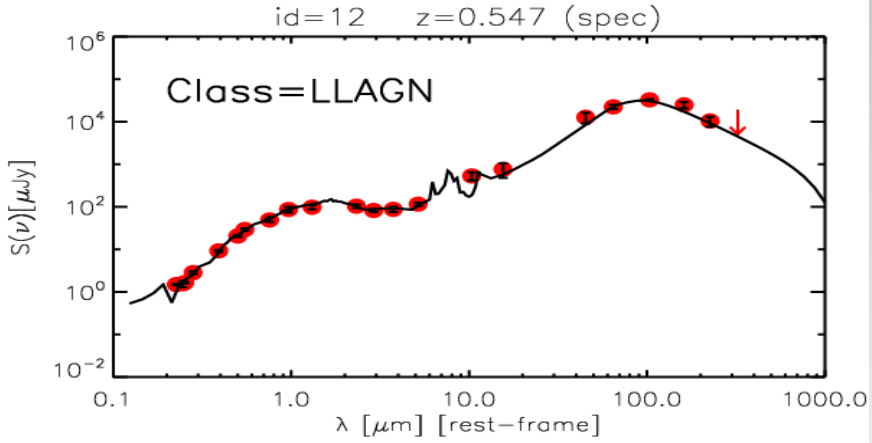
Starburst: 11 %
Spirals: 38 %

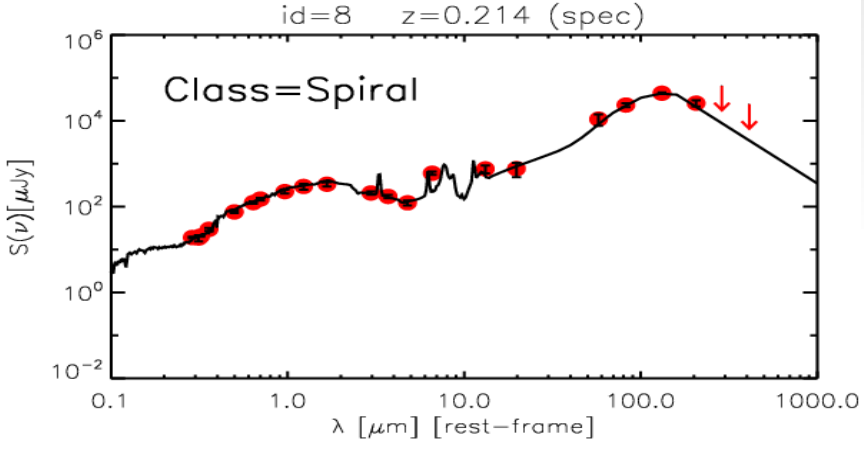

id=51 z=1.043 (spec)
Class=AGN1
S(ν)[μJy]
λ [μm] [rest-frame]

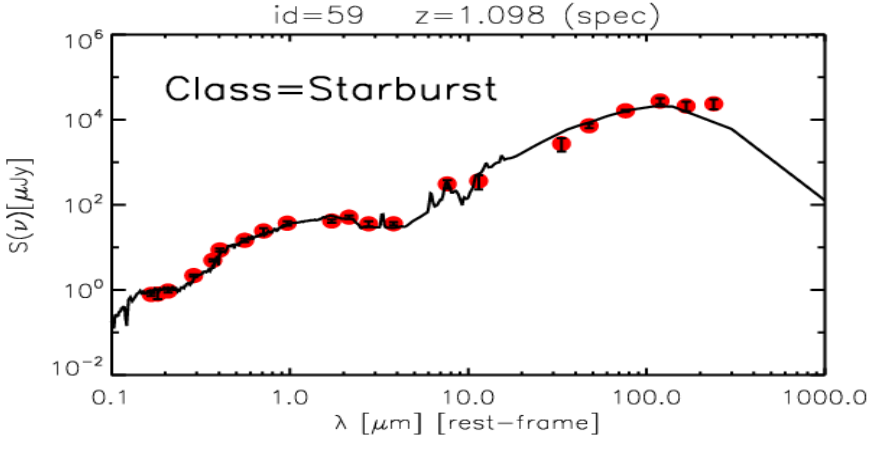

Redshift distribution
AGN1 (4.4 %)
N
z

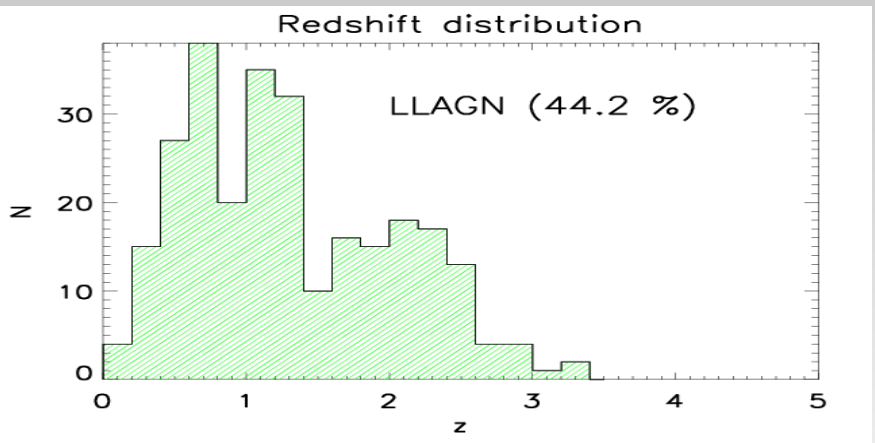

id=56 z=2.578 (spec)
Class=AGN2
S(ν)[μJy]
λ [μm] [rest-frame]

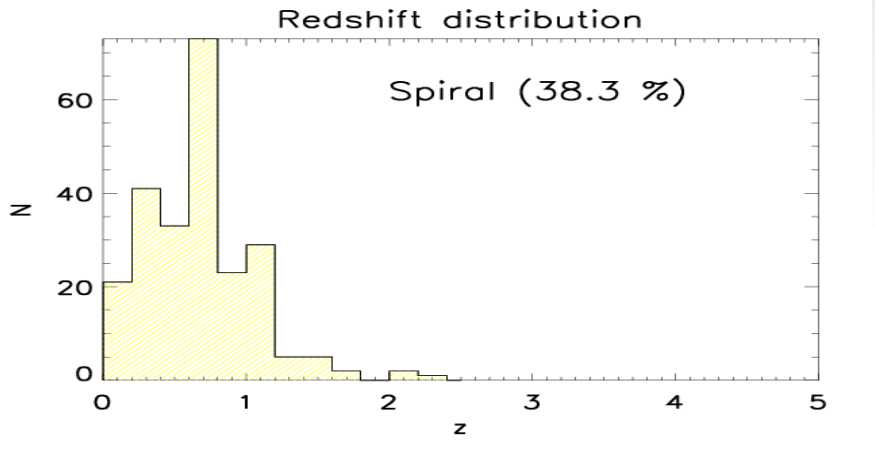

Redshift distribution
AGN2 (2.1 %)
N
z

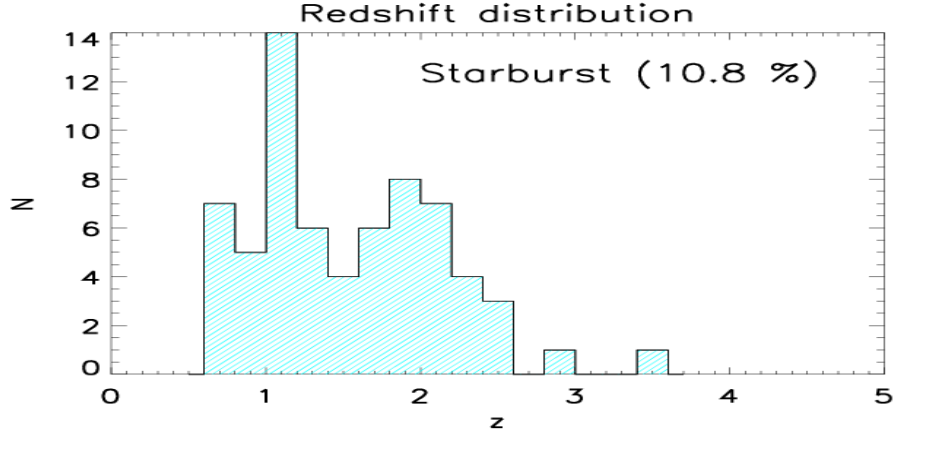

id=12 z=0.547 (spec)
Class=LLAGN
S(ν)[μJy]
λ [μm] [rest-frame]


id=8 z=0.214 (spec)
Class=Spiral
S(ν)[μJy]
λ [μm] [rest-frame]


id=59 z=1.098 (spec)
Class=Starburst
S(ν)[μJy]
λ [μm] [rest-frame]


Redshift distribution
LLAGN (44.2 %)
N
z


Redshift distribution
Spiral (38.3 %)
N
z


Redshift distribution
Starburst (10.8 %)
N
z

What can we say about PEP sources with an X-ray counterpart?

Cross correlation between PEP infrared selected sample with optical counterpart and 4Ms Chandra Deep Field South X-ray selected catalog.

➢ PEP selected X-ray counterparts: **181 / 627** (~ 29 %) of which 172 from the main X-ray catalog ($P < 0.004$) and 9 from the supplementary one ($0.004 < P < 0.01$).

➢ Matching radius [MUSIC to X-ray] = 2 arcsec .

X-ray classification

For being considered as AGN, one of the following conditions should be satisfied at least:

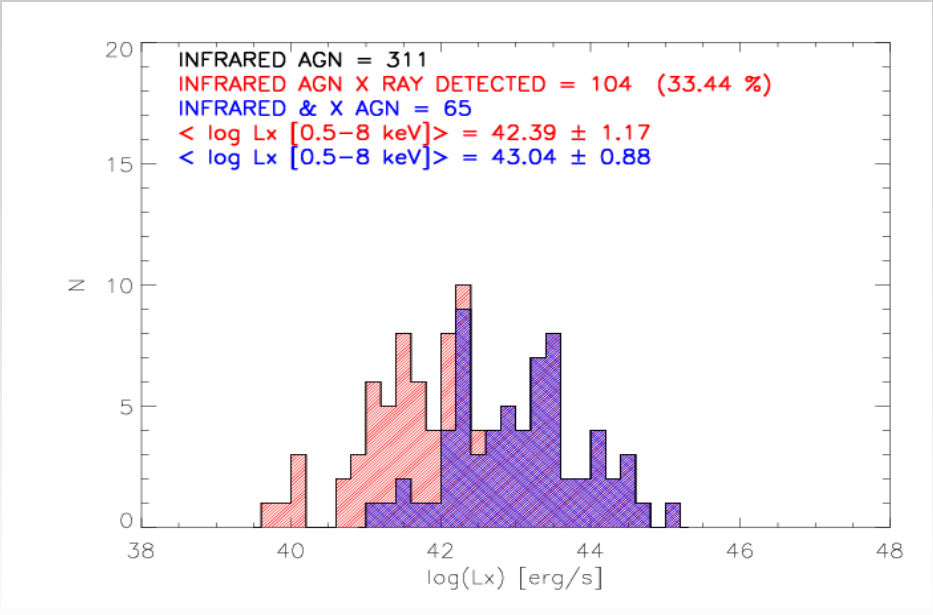
1) L_x [0.5-8 keV] $> 3 * 10^{42}$ erg/s

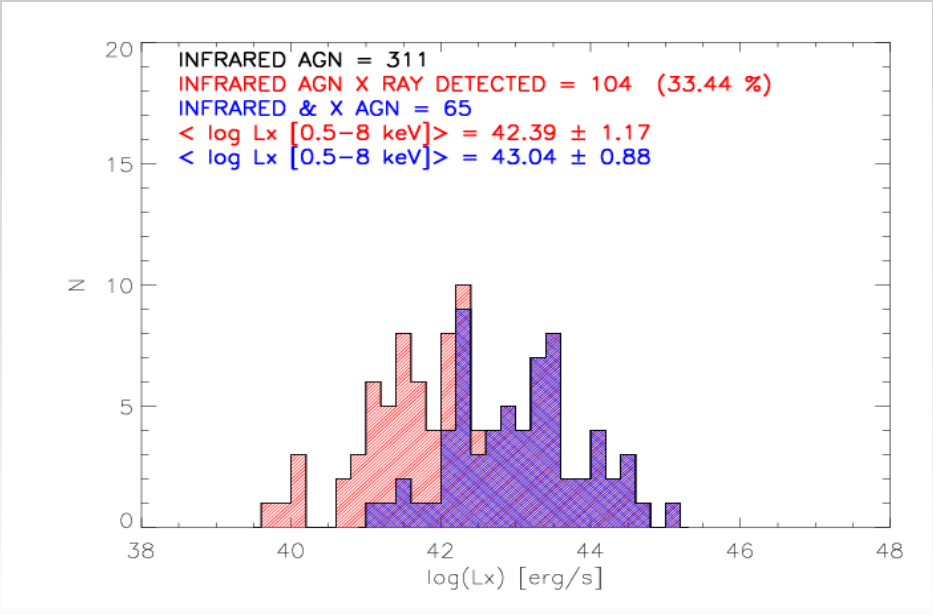
2) photon index $\Gamma < 1$

3) $F_x / F_R > 0.1$

4) L_x [0.5-8 keV] $> 3 * (8.9 * 10^{17} L_{1.4GHz})$

5) Broad Band features and/or high-excitation emission lines from optical spectroscopy.


INFRARED AGN = 311
INFRARED AGN X RAY DETECTED = 104 (33.44 %)
INFRARED & X AGN = 65
< log Lx [0.5−8 keV]> = 42.39 ± 1.17
< log Lx [0.5−8 keV]> = 43.04 ± 0.88
N
log(Lx) [erg/s]
0
5
10
15
20
38
40
42
44
46
48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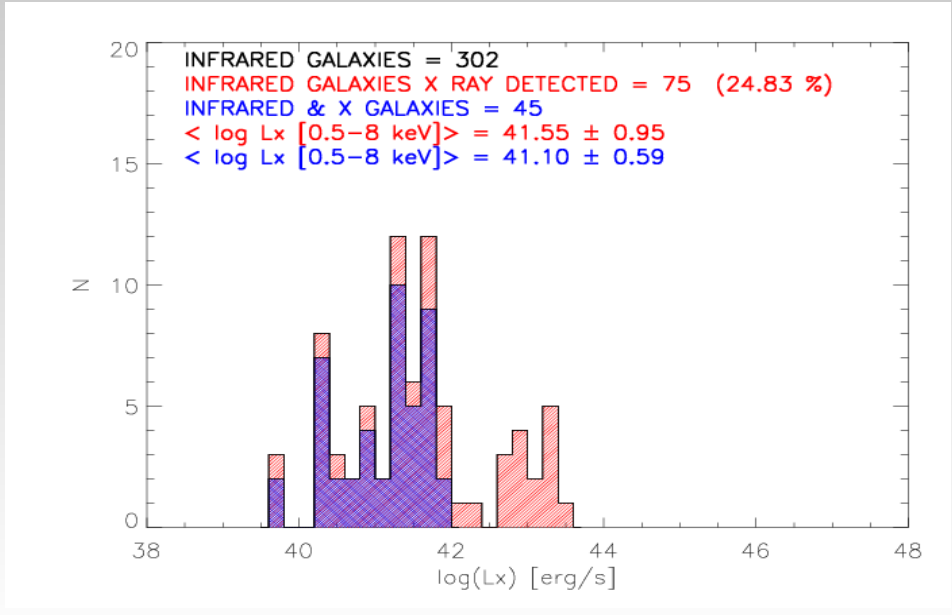
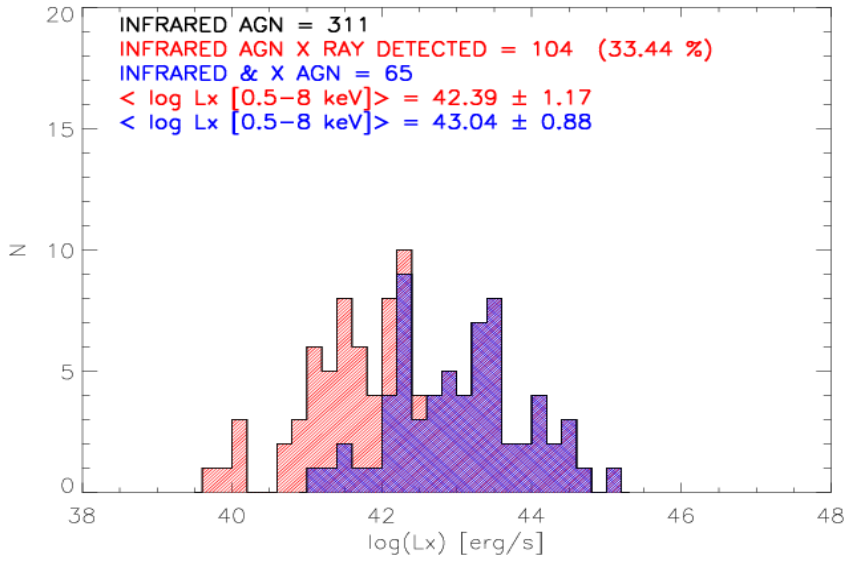

INFRARED GALAXIES = 302
INFRARED GALAXIES X RAY DETECTED = 75 (24.83 %)
INFRARED & X GALAXIES = 45
< log Lx [0.5−8 keV]> = 41.55 ± 0.95
< log Lx [0.5−8 keV]> = 41.10 ± 0.59
N
log(Lx) [erg/s]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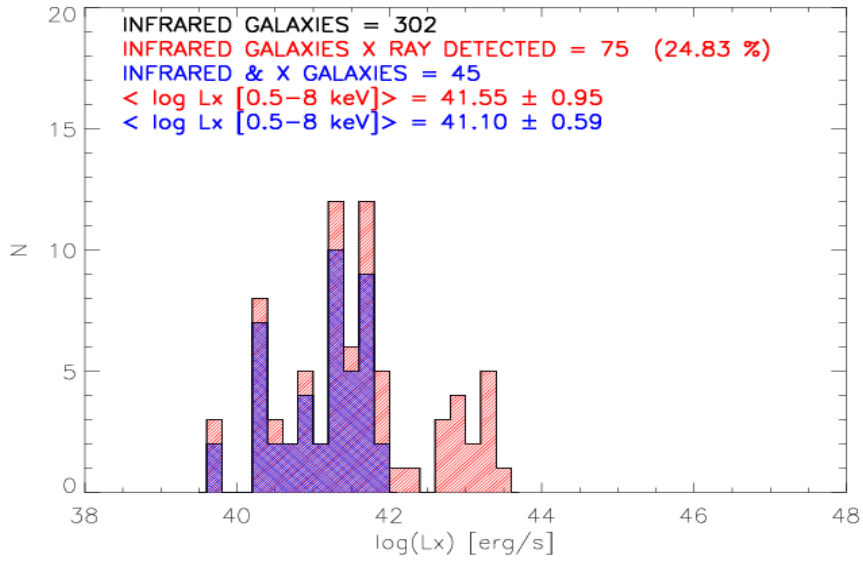
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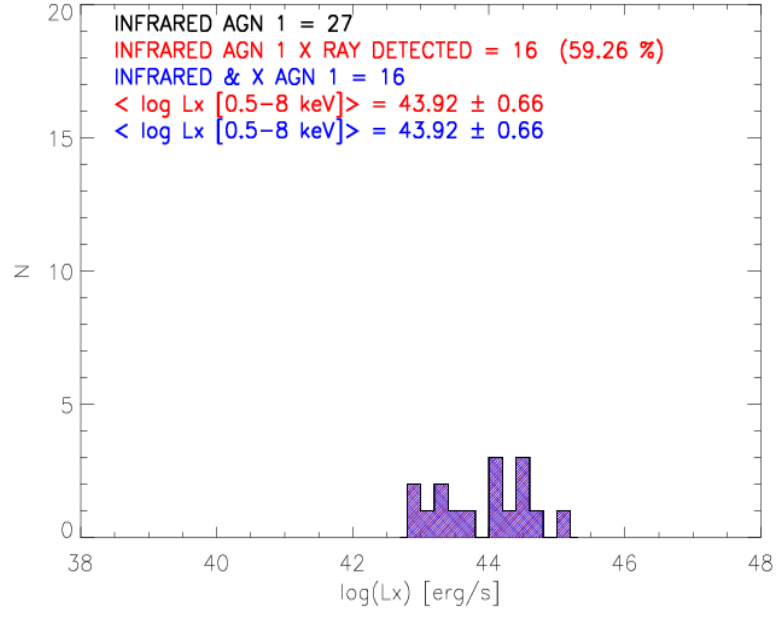
INFRARED AGN 1 = 27
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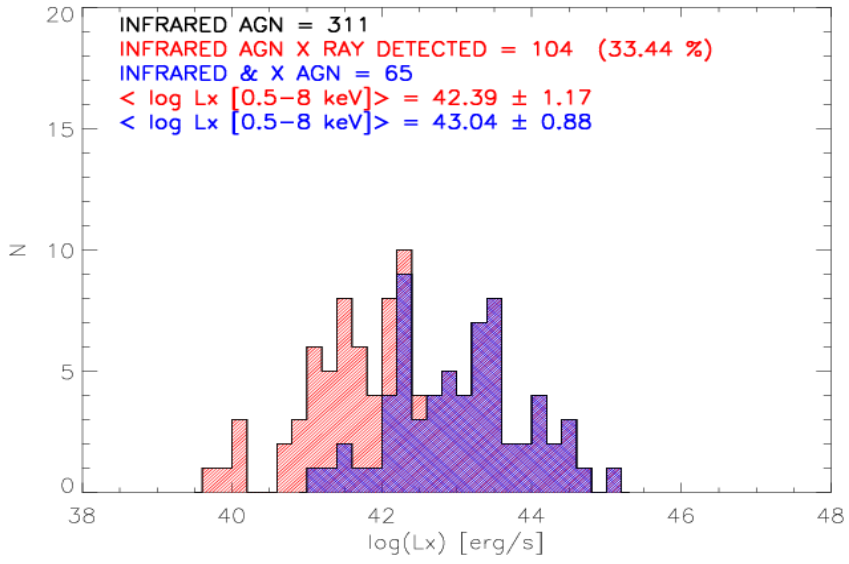
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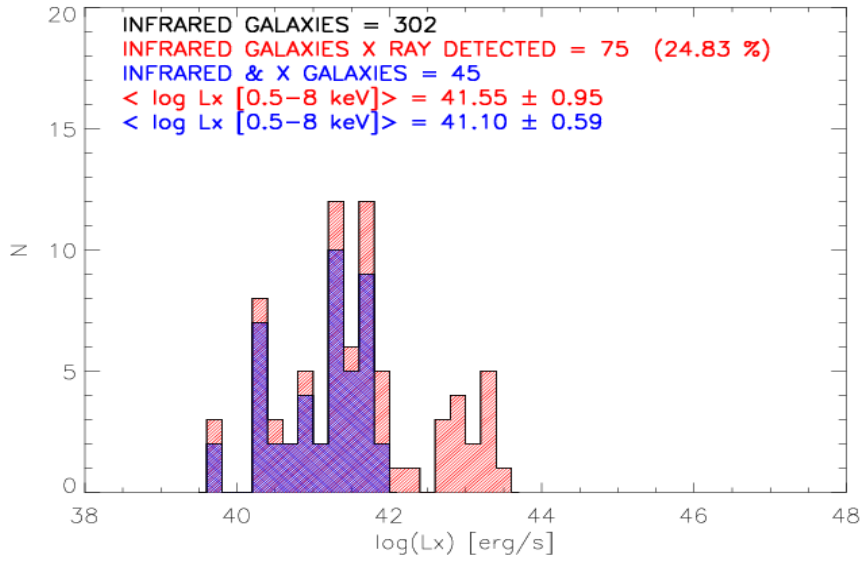
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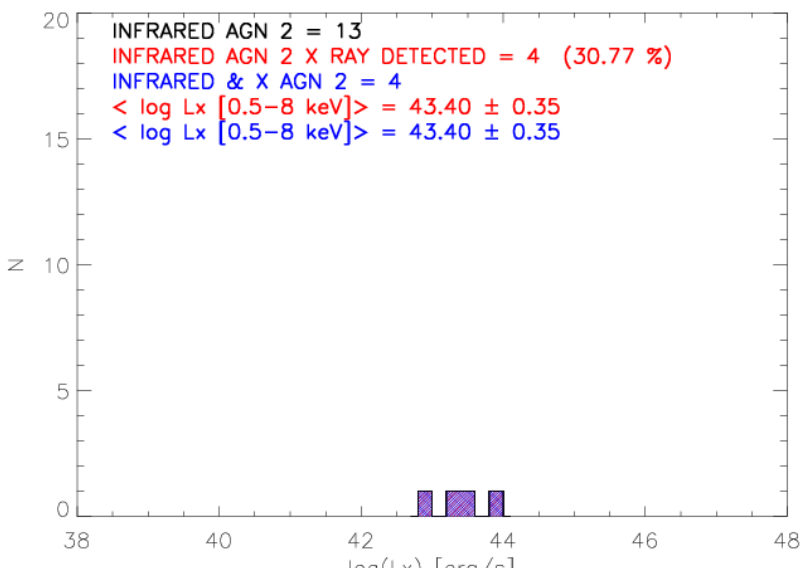
INFRARED AGN 2 = 13
INFRARED AGN 2 X RAY DETECTED = 4 (30.77 %)
INFRARED & X AGN 2 = 4
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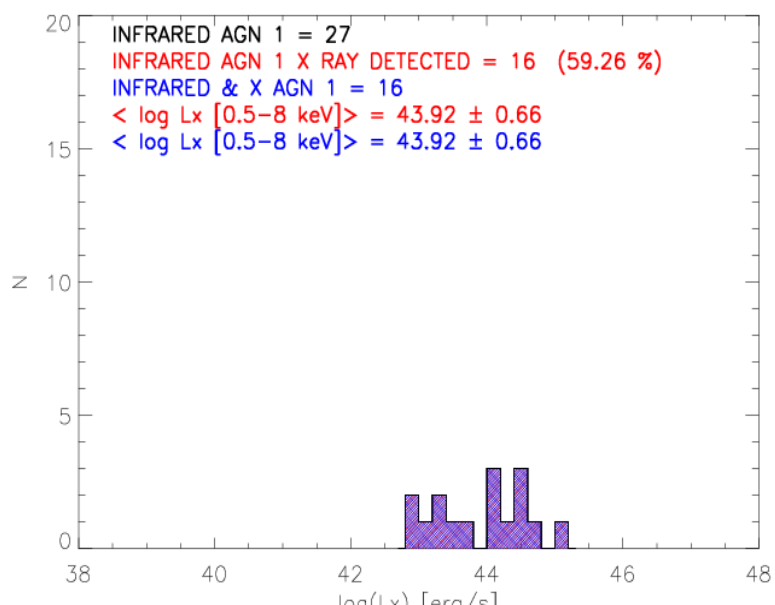
N
log(Lx) [erg/s]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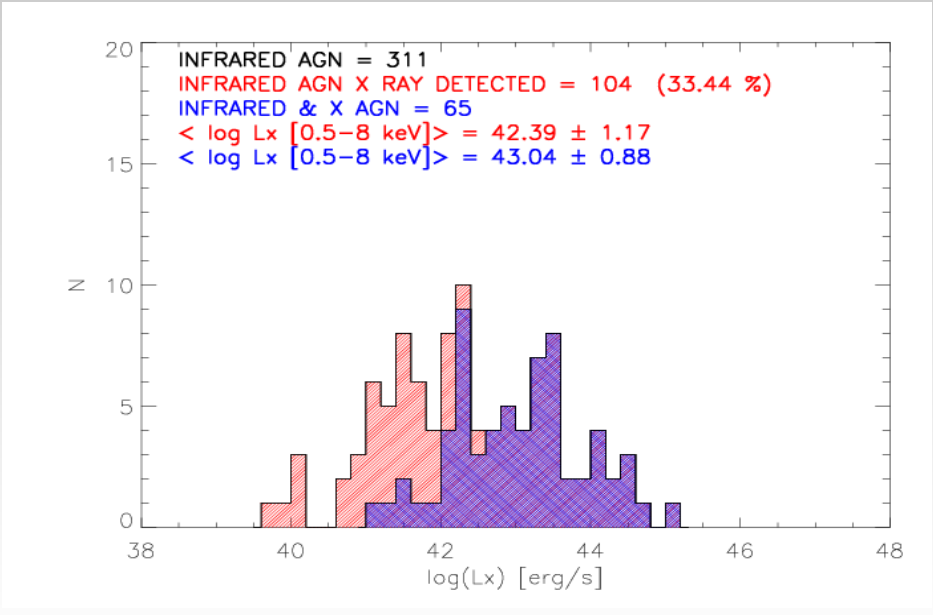
N
log(Lx) [erg/s]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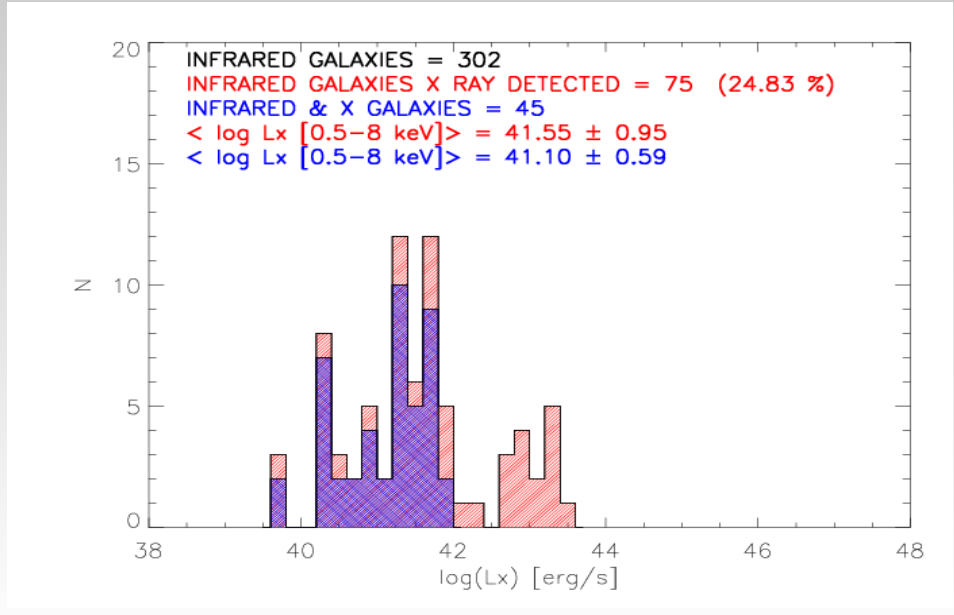
log(Lx) [erg/s]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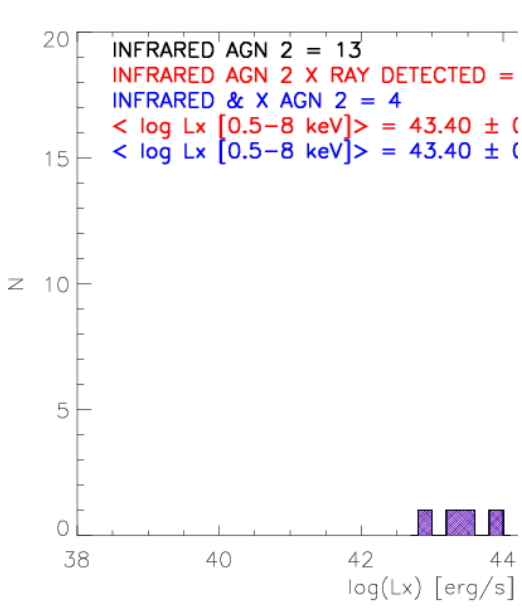
< log Lx [0.5−8 keV]> = 41.10 ± 0.59
N
log(Lx) [erg/s]


INFRARED AGN 2 = 13
INFRARED AGN 2 X RAY DETECTED =
INFRARED & X AGN 2 = 4
< log Lx [0.5−8 keV]> = 43.40 ± (
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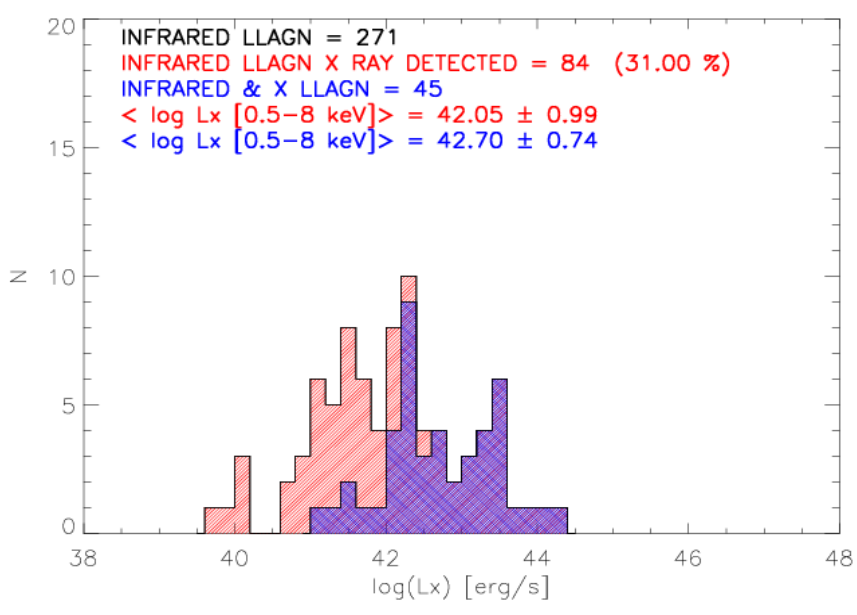
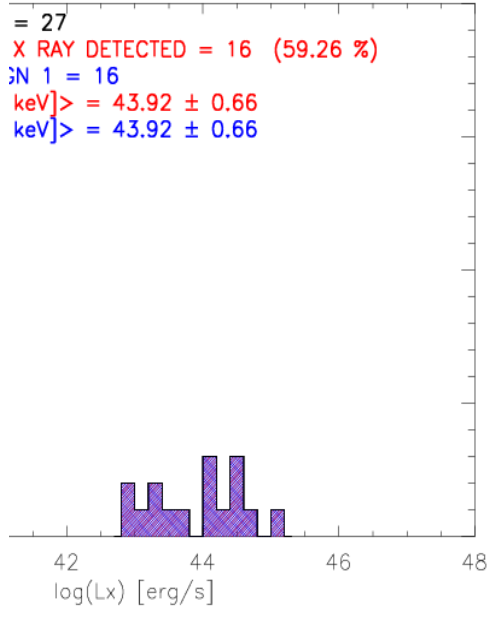
N
log(Lx) [erg/s]


INFRARED LLAGN = 271
INFRARED LLAGN X RAY DETECTED = 84 (31.00 %)
INFRARED & X LLAGN = 45
< log Lx [0.5−8 keV]> = 42.05 ± 0.99
< log Lx [0.5−8 keV]> = 42.70 ± 0.74
N
log(Lx) [erg/s]


= 27
X RAY DETECTED = 16 (59.26 %)
N 1 = 16
keV]> = 43.92 ± 0.66
keV]> = 43.92 ± 0.66
log(Lx) [erg/s]

What can we say about PEP sources with an X-ray counterpart?

Classification	IR AGNs	IR Galaxies
X-ray AGNs	*36 %*	*17 % (**)*
X-ray Galaxies	*22 % (*)*	*25 %*

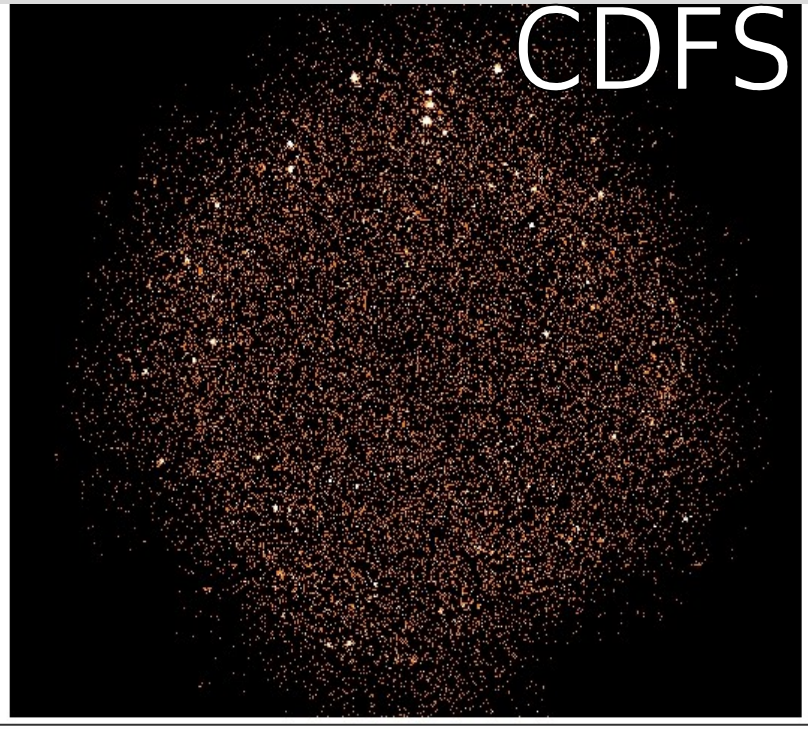
(*) All of them classified from SED fitting as “Low Luminosity AGN” ;

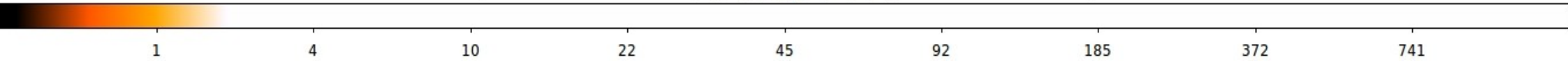
(**) 30 objects: just 13 of them having $L_x > 3*10^{42}$ erg/s .

What can we say about PEP sources without an X-ray counterpart?

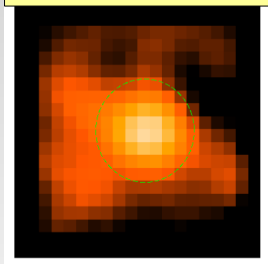
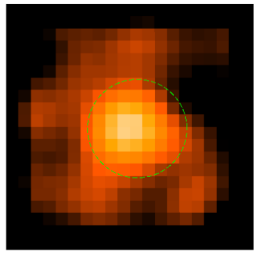
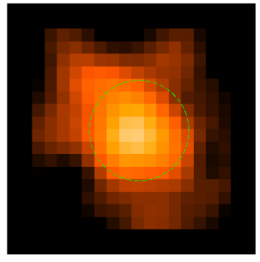
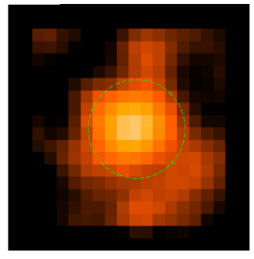
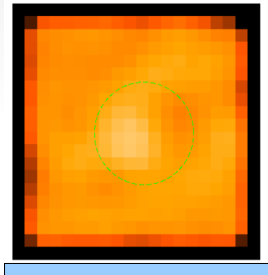
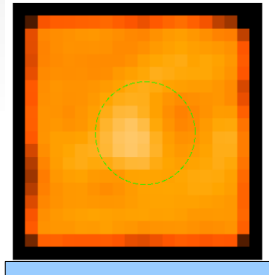
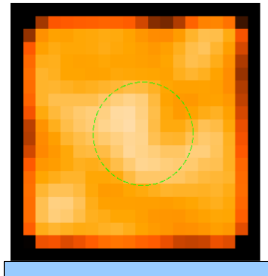
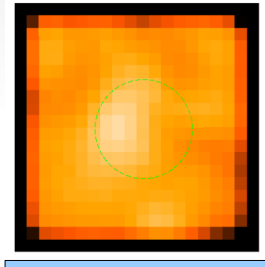
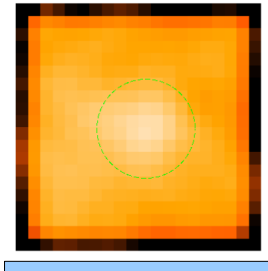
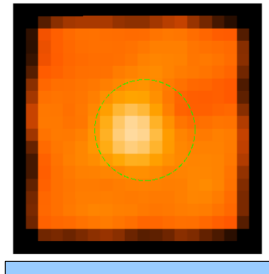
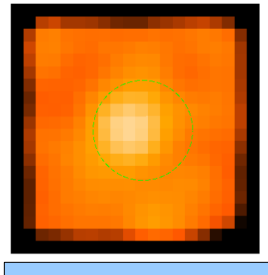
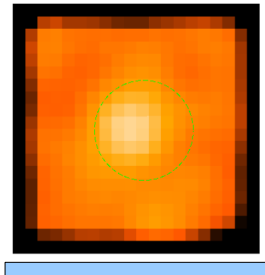
X-ray stacking analysis on

LLAGN and Galaxies without X-ray counterpart and within the MUSIC area.





#	0.3 < z < 1.0	1.0 < z < 2.5
LLAGN	63	88
Galaxies	85	56

	LLAGN	Galaxies	LLAGN	Galaxies
	0.3 < z < 1.0	0.3 < z < 1.0	1.0 < z < 2.5	1.0 < z < 2.5
SB 0.5 – 2 keV				
L_x [erg/s]	$(2.6 \pm 0.5) * 10^{40}$	$(1.7 \pm 0.4) * 10^{40}$	$(2.1 \pm 0.3) * 10^{41}$	$(1.0 \pm 0.3) * 10^{41}$
HB 2 – 8 keV				
L_x [erg/s]	No detection	No detection	$(4.7 \pm 1.8) * 10^{41}$	$(2.2 \pm 0.8) * 10^{41}$
FB 0.5 – 8 keV				
L_x [erg/s]	$(1.0 \pm 0.4) * 10^{41}$	$(4.2 \pm 1.5) * 10^{40}$	$(7.2 \pm 1.2) * 10^{41}$	$(3.0 \pm 1.1) * 10^{41}$

3 SED DECOMPOSITION

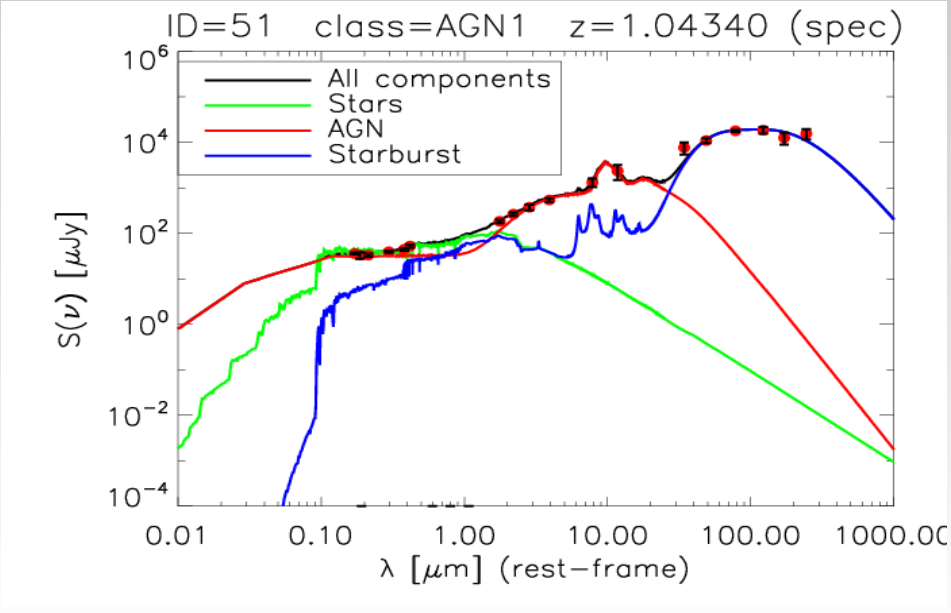
In order to disentangle the AGN contribution from that due to Star Formation, we perform a SED decomposition by means of MAGPHYS (Da Cunha+2008).

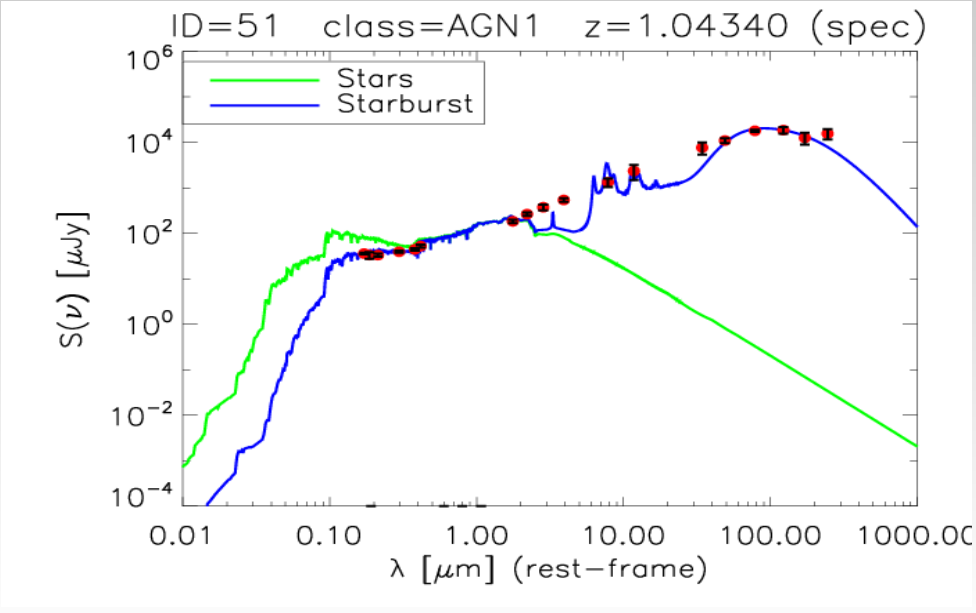
MAGPHYS

- SED fitting to reproduce the observed SEDs from the ultraviolet to sub-mm wavelenghts;
- attenuation of starlight by dust (Charlot & Fall, 2000);
- the integrated galactic MIR & FIR contribution turns to be fitted consistently with the emission shorter wavelenghts;
- marginalized likelihood distribution (PDF) of each physical parameter.

MAGPHYS + AGN *(Berta et al. 2012, in prep.)*

- Both the integrated stellar emission and galactic IR one are adopted from MAGPHYS.
- In addition to the original content, different AGN templates has been taken from Fritz et al. 2006 and Feltre et al. 2012 grid . Each of them has been achieved by solving the radiative transfer equation for a smooth dust grains distribution (details in Anna Feltre's talk).
- SED fitting with three components performed for the entire PEP-selected sample within the GOODS-S area.


ID=51 class=AGN1 z=1.04340 (spec)
All components
Stars
AGN
Starburst
S(ν) [μJy]
λ [μm] (rest−frame)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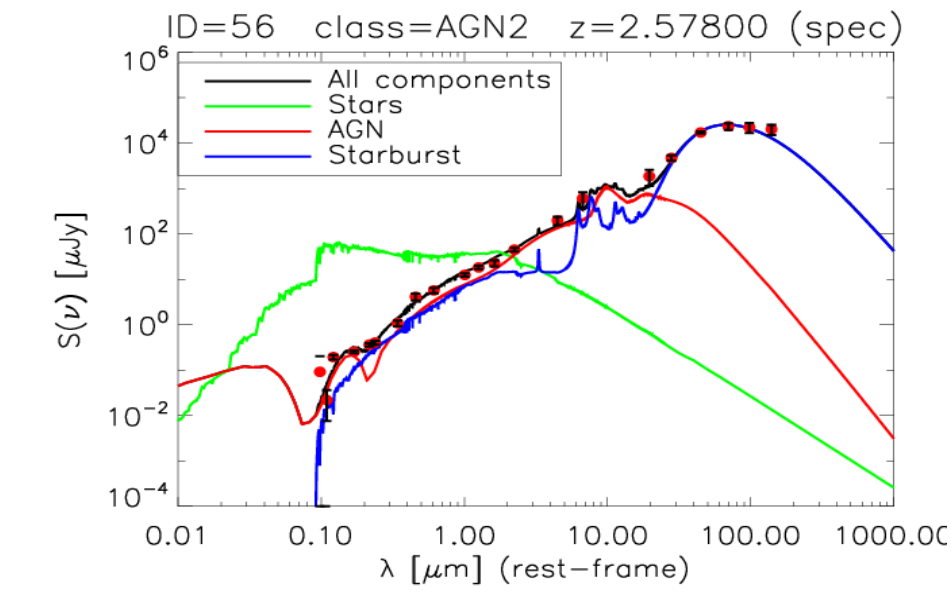
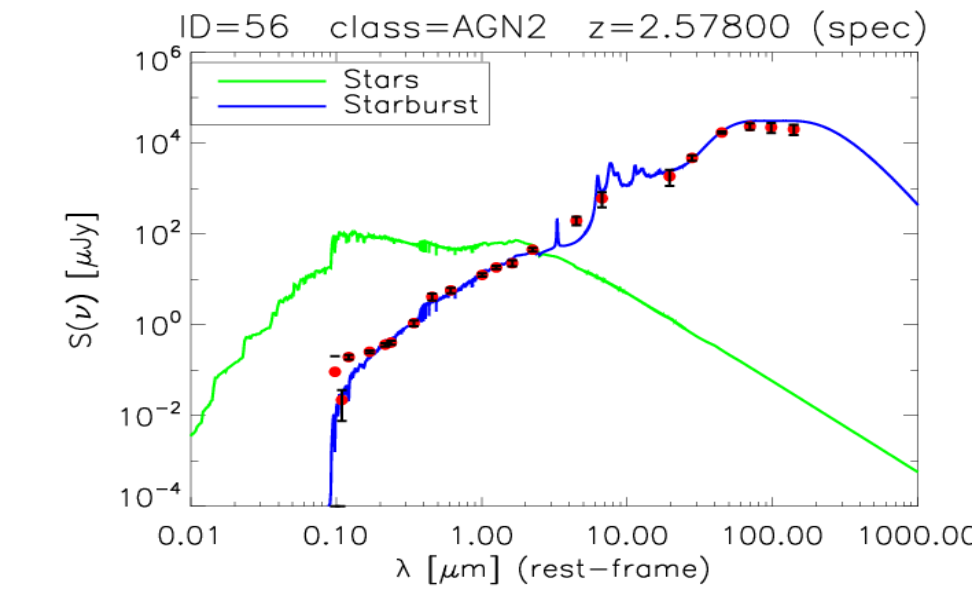
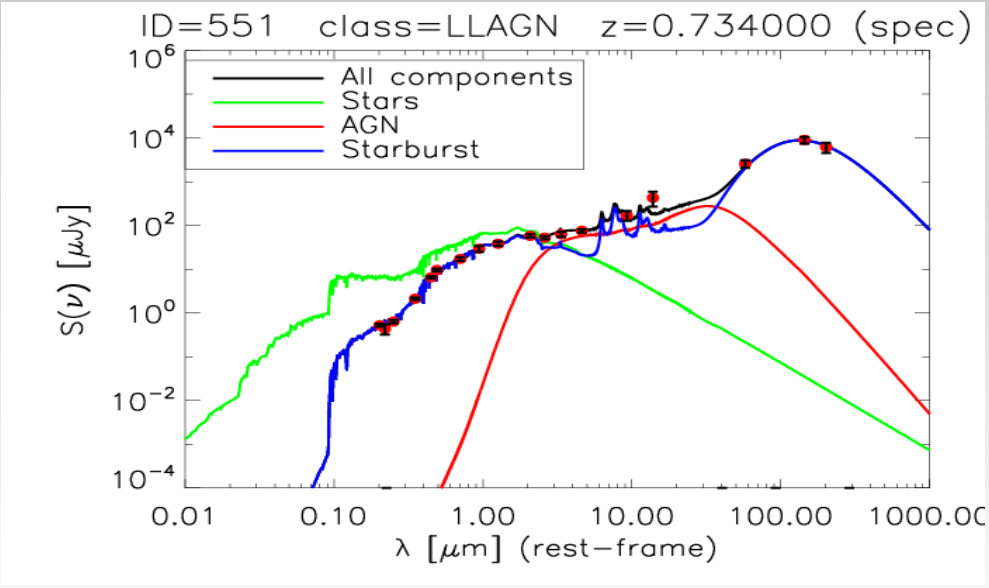
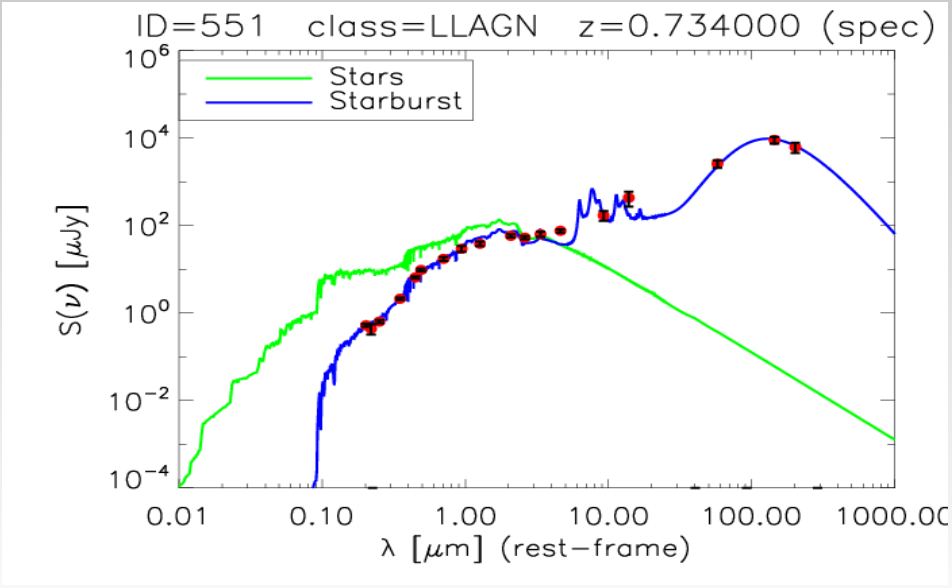
Stars
Starburst
S(ν) [μJy]
λ [μm] (rest−frame)


ID=56 class=AGN2 z=2.57800 (spec)
All components
Stars
AGN
Starburst
S(ν) [μJy]
λ [μm] (rest−frame)


ID=56 class=AGN2 z=2.57800 (spec)
Stars
Starburst
S(ν) [μJy]
λ [μm] (rest−frame)


ID=551 class=LLAGN z=0.734000 (spec)
All components
Stars
AGN
Starburst
S(ν) [μJy]
λ [μm] (rest−frame)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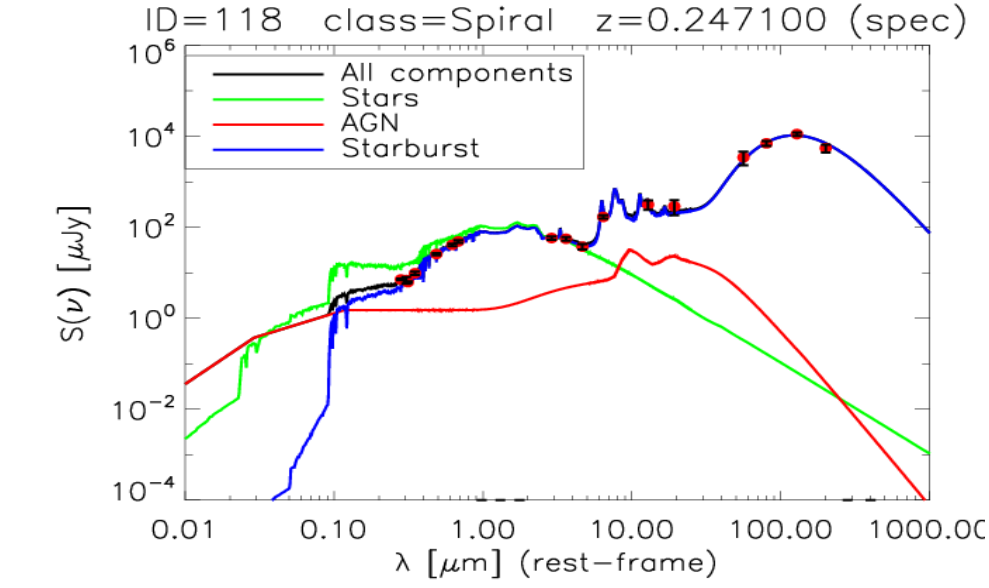
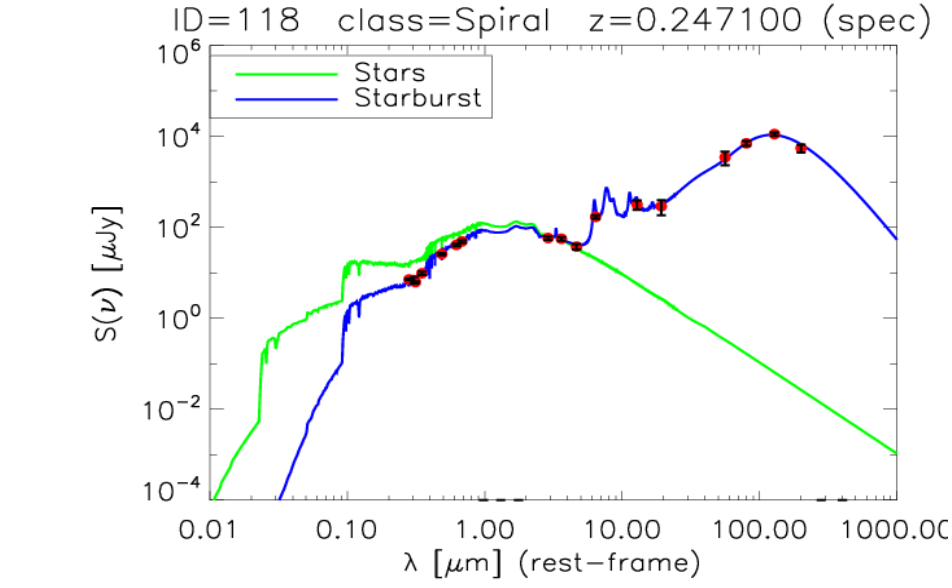
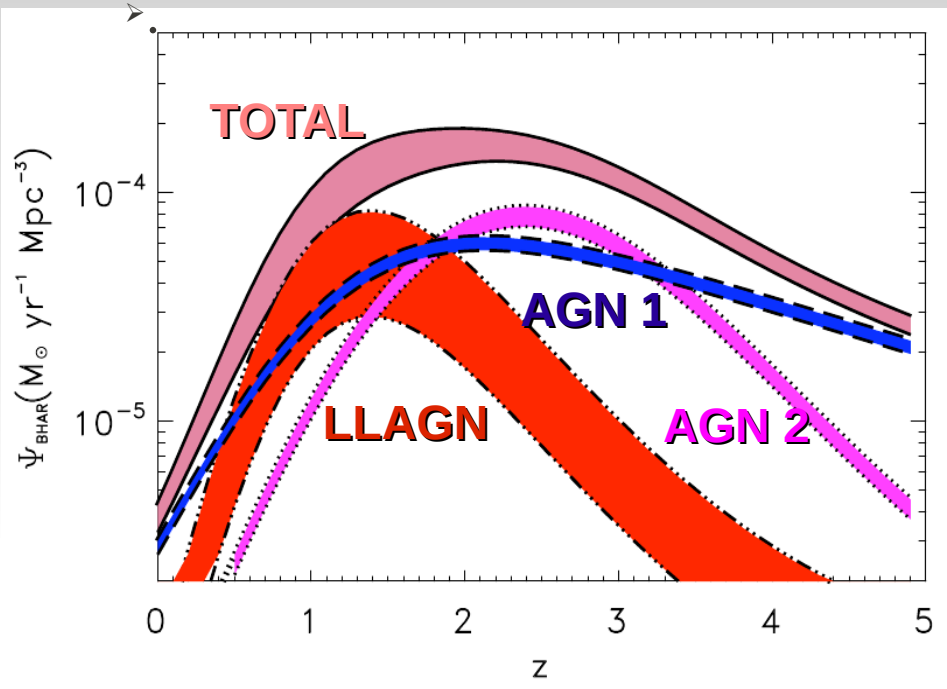
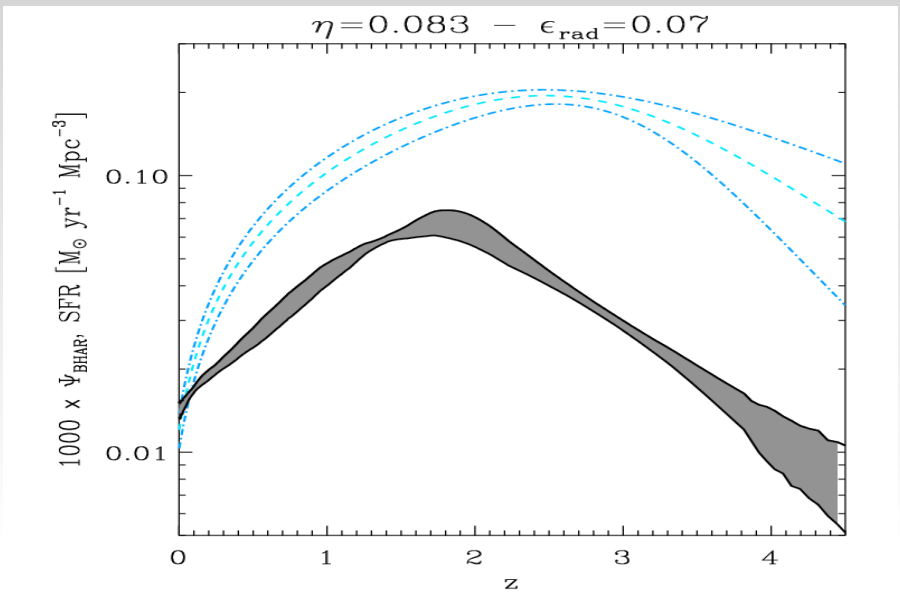
Stars
Starburst
S(ν) [μJy]
λ [μm] (rest−frame)


ID=118 class=Spiral z=0.247100 (spec)
All components
Stars
AGN
Starburst
S(ν) [μJy]
λ [μm] (rest−frame)


ID=118 class=Spiral z=0.247100 (spec)
Stars
Starburst
S(ν) [μJy]
λ [μm] (rest−frame)

BHAD: previous estimates





Top left: BHAD derived from the IR (Gruppioni et al. 2011) by decomposing 3 representative SEDs of type-1 AGN, type-2 AGN and LLAGN.

Top right: BHAD estimate from the X-rays (Merloni & Heinz, 2008) from the evolution of the observed Hard X-ray Luminosity Function.

New approach to compute the BHAD over cosmic time

$$\Psi_{BHAR}(z) = \int_0^{\infty} \frac{(1-\epsilon_{rad})\, BC\, L_{1-1000}^{AGN}}{\epsilon_{rad} c^2} \phi(L_{1-1000}) dlogL_{1-1000}$$

- Bolometric corrections from the IR will be adopted from the nuclear bestfit model chosen for **each observed SED**.

- LF will be taken from the recent PEP+HerMES evolutionary path as derived from Gruppioni et al. 2012 (in prep.) for different PEP fields.

Summary:

- We carried out a multiwavelenght analysis of a FIR selected sample in the GOODS-S field comparing X-ray VS IR classification.
- We presented a new method for constraining the BHAD as a function of redshift from the IR and for different AGN populations.

Future prospects:

- Evolution of the BHAD
- Possibility to extend the same analysis towards all the PEP fields.

Thanks a lot

for your attention!