GEE-5

Galaxy Evolution & Environment :

' Observations meet simulations and theory '

Department of Physics and Astronomy, Arcetri - Firenze

15-17 November 2017

Probing AGN/galaxy co-evolution through multi-wavelength observations

F.Duras, F. La Franca, F.Fiore,
A.Bongiorno, E. Piconcelli, M. Bischetti, G. Vietri, L. Zappacosta
… and all the WISSH collaboration

ROMA TRE UNIVERSITÀ DEGLI STUDI

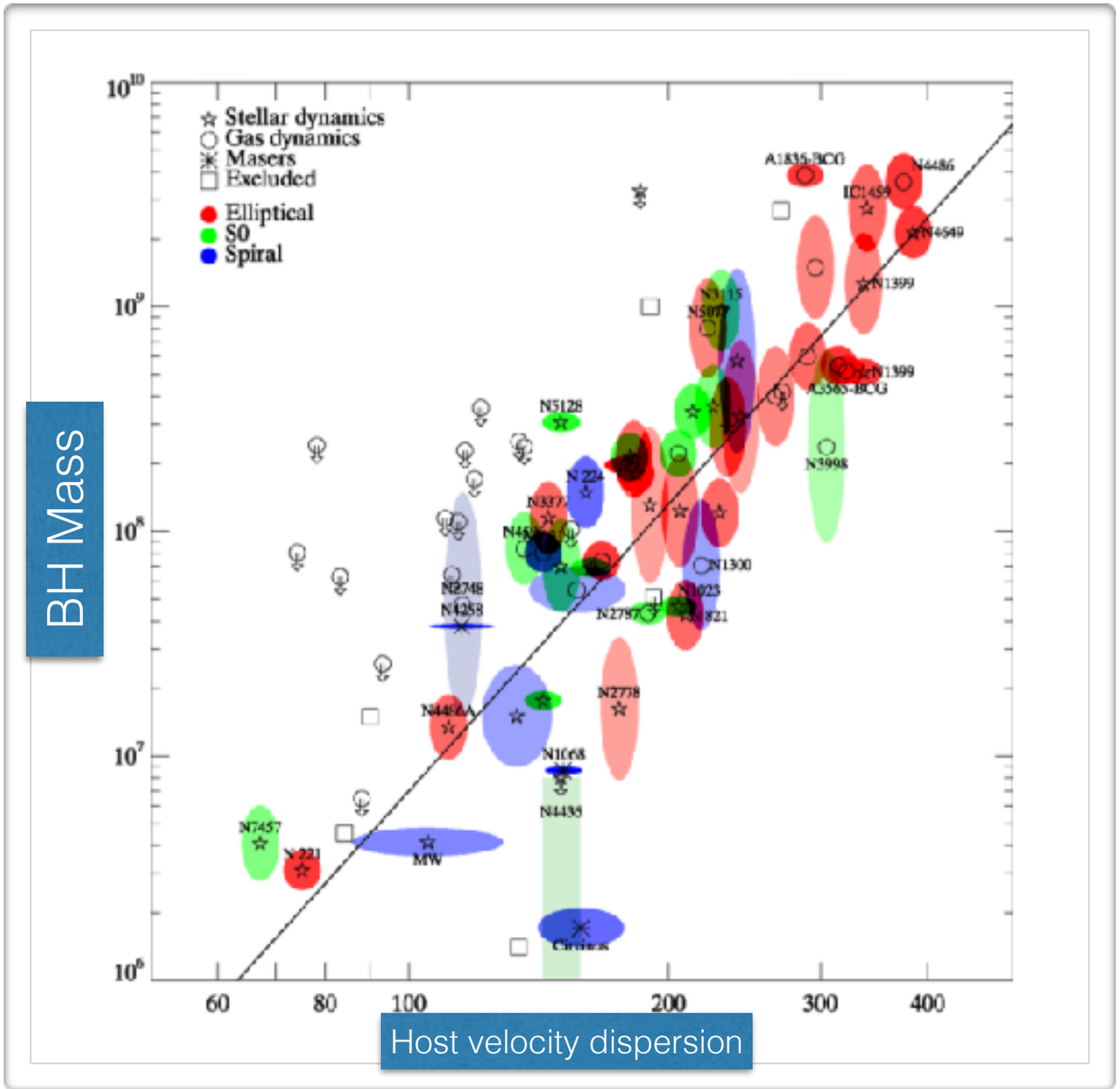
OSSERVATORIO ASTRONOMICO DI ROMA INAF ISTITUTO NAZIONALE DI ASTROFISICA

WISSH

BH-GALAXY CO-EVOLUTION

Correlation from the **smallest** to the **biggest** scales

HOW do galaxy and BH communicate ?



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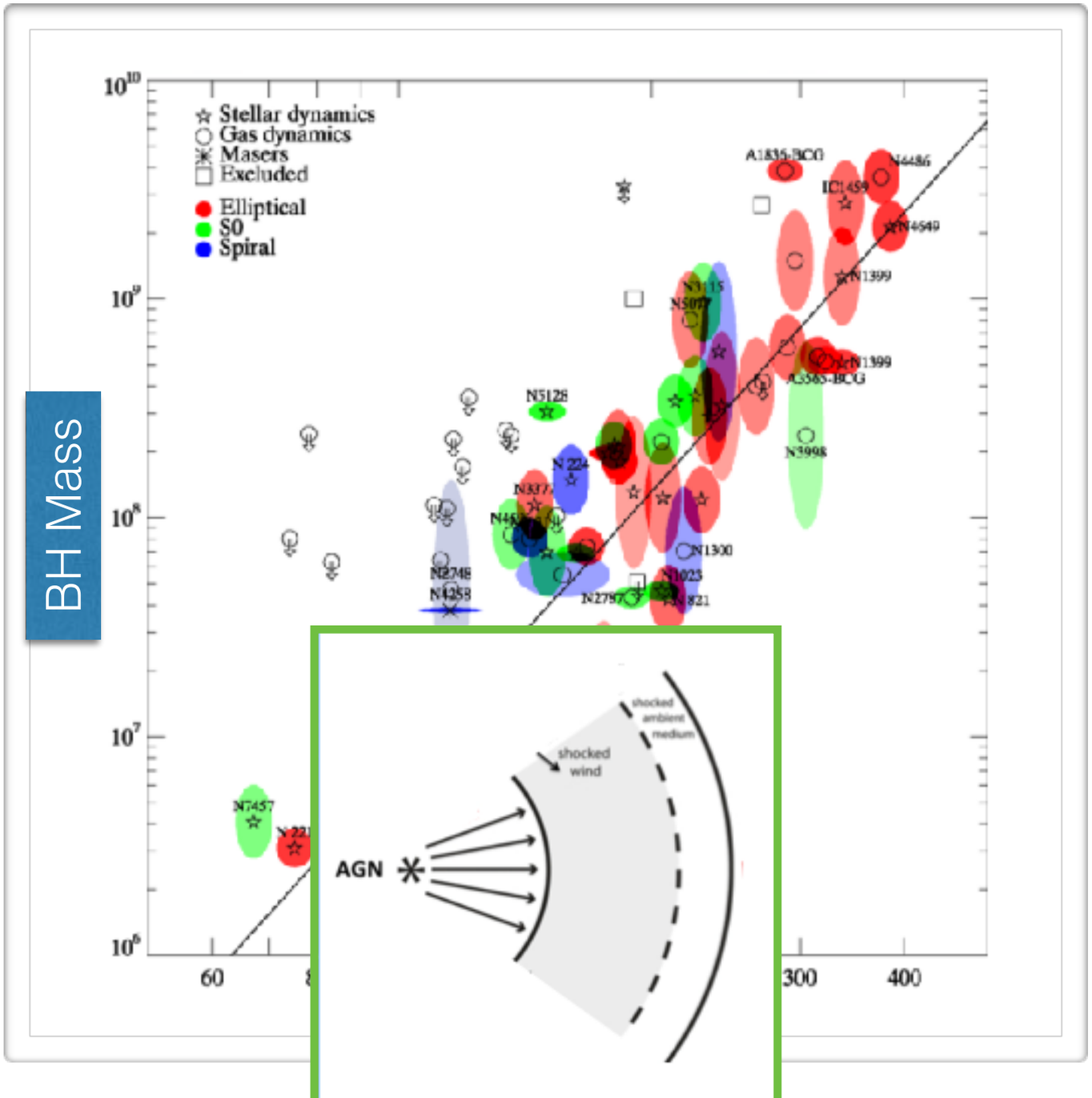

FEEDBACK process

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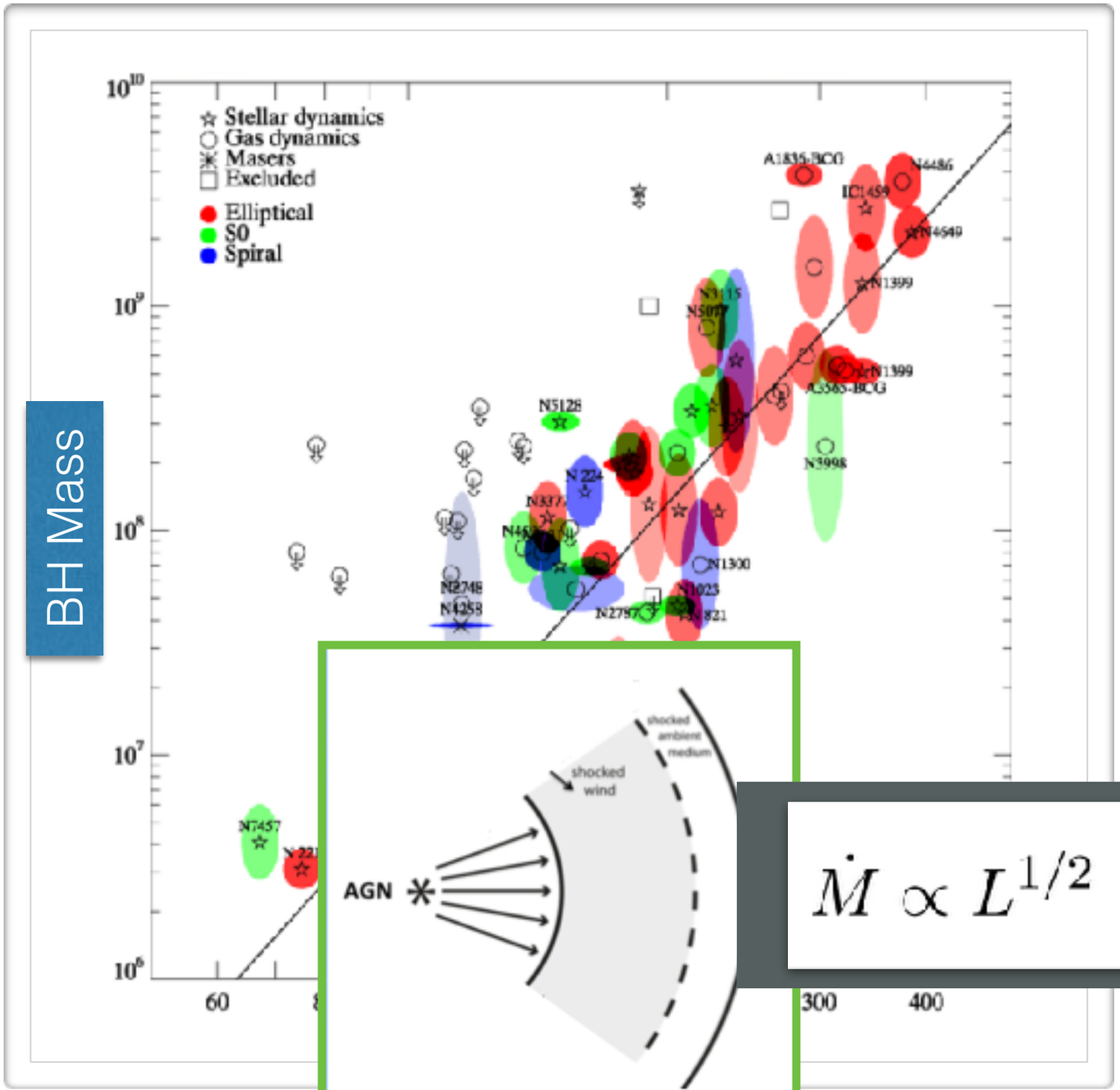


FEEDBACK process

··· Here there are the WISSH!

THE WISSH SAMPLE

Main features

Hyper-luminous objects are RARE !

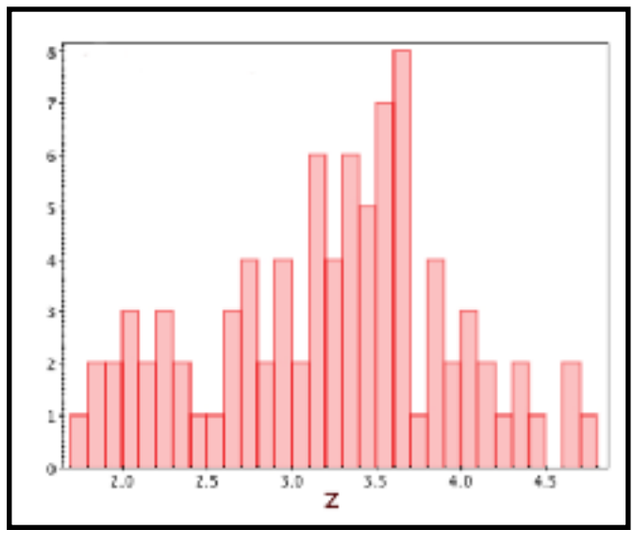
All sky surveys needed

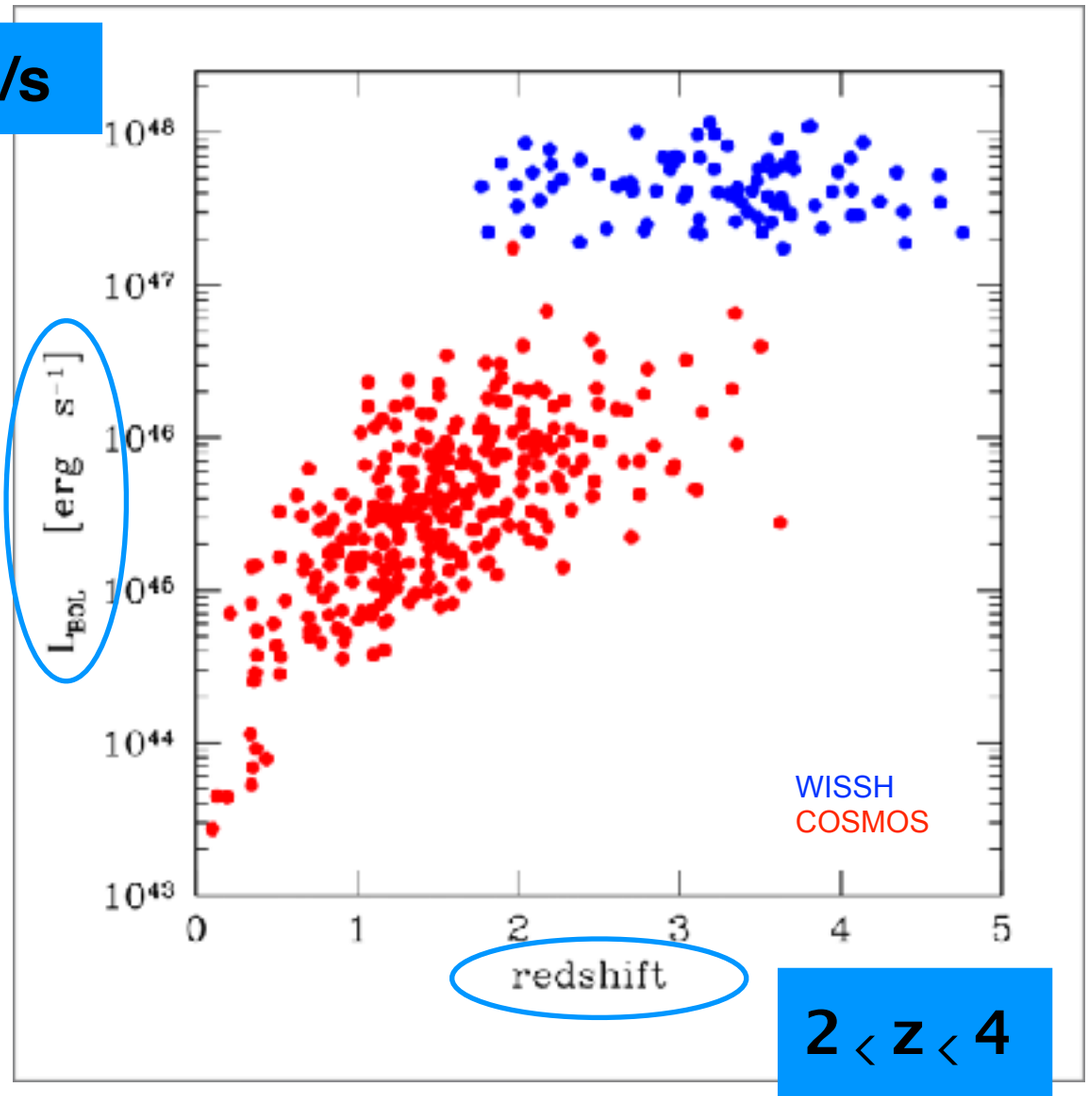
86 type-I AGN from Weedman et al. (2012) sample
Cross-correlation between the **WISE All-Sky Survey** and the **Sloan Digital Sky Survey**
(**WISE SDSS Selected Hyper-luminous**) quasars

$L_{BOL} > 10^{47}$ erg/s

Extremely high luminosities

High redshift range





$2 < z < 4$

··· Here there are the WISSH!

THE WISSH SAMPLE

Panchromatic view

We aim at investigating the **nuclear**, **winds** and **host galaxies** properties of the most luminous quasars of the Universe

SPECTRAL & PHOTOMETRIC data for a wide λ coverage

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ALMA

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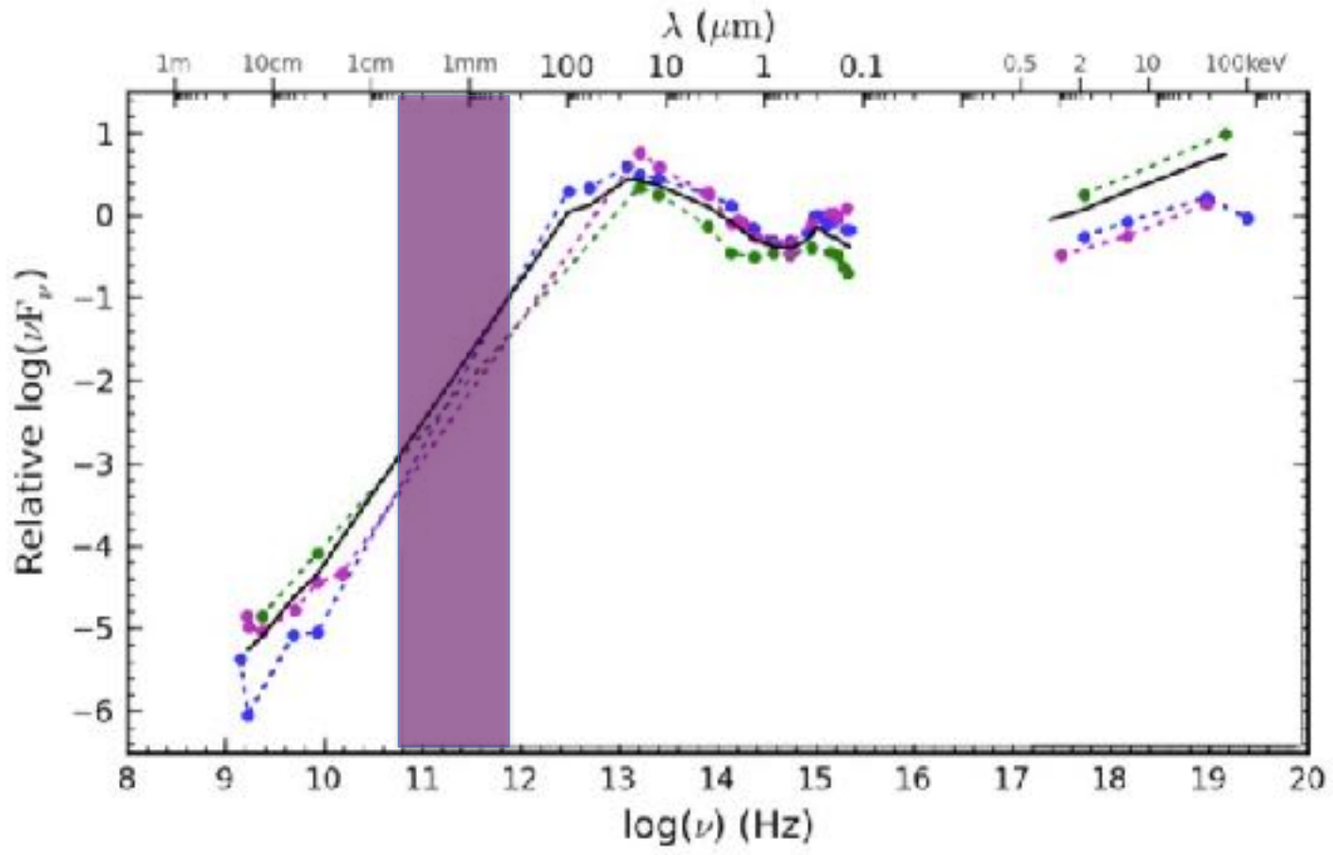

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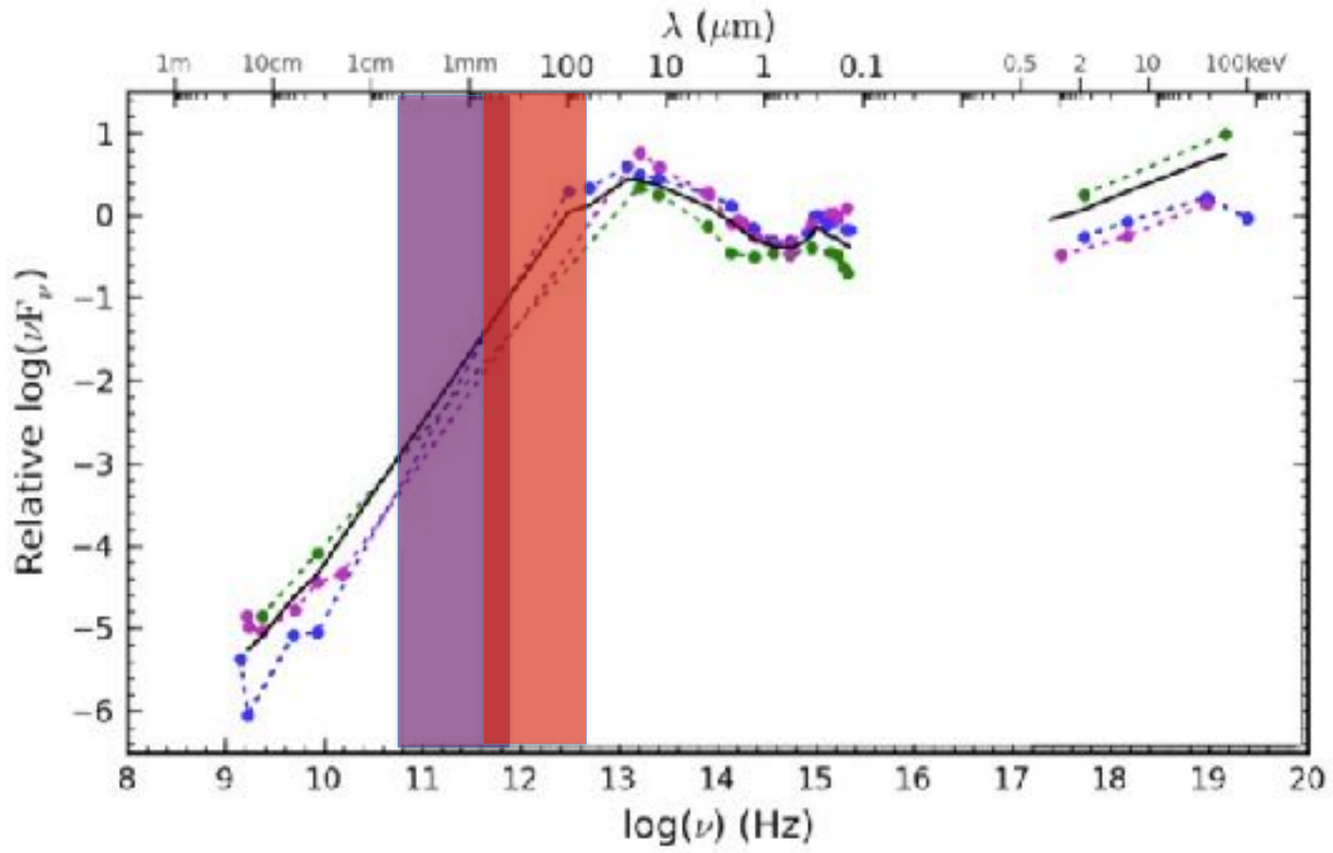

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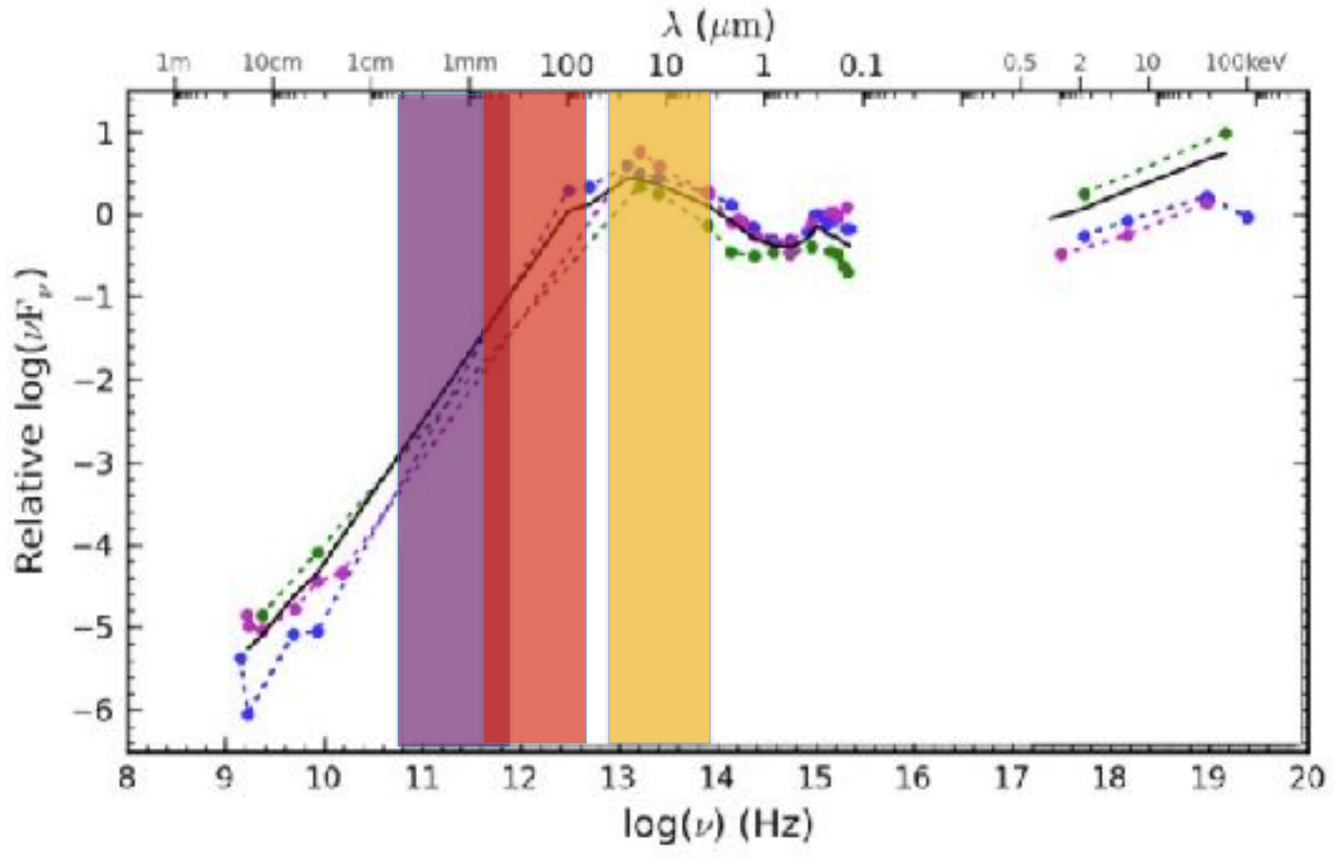

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2MASS

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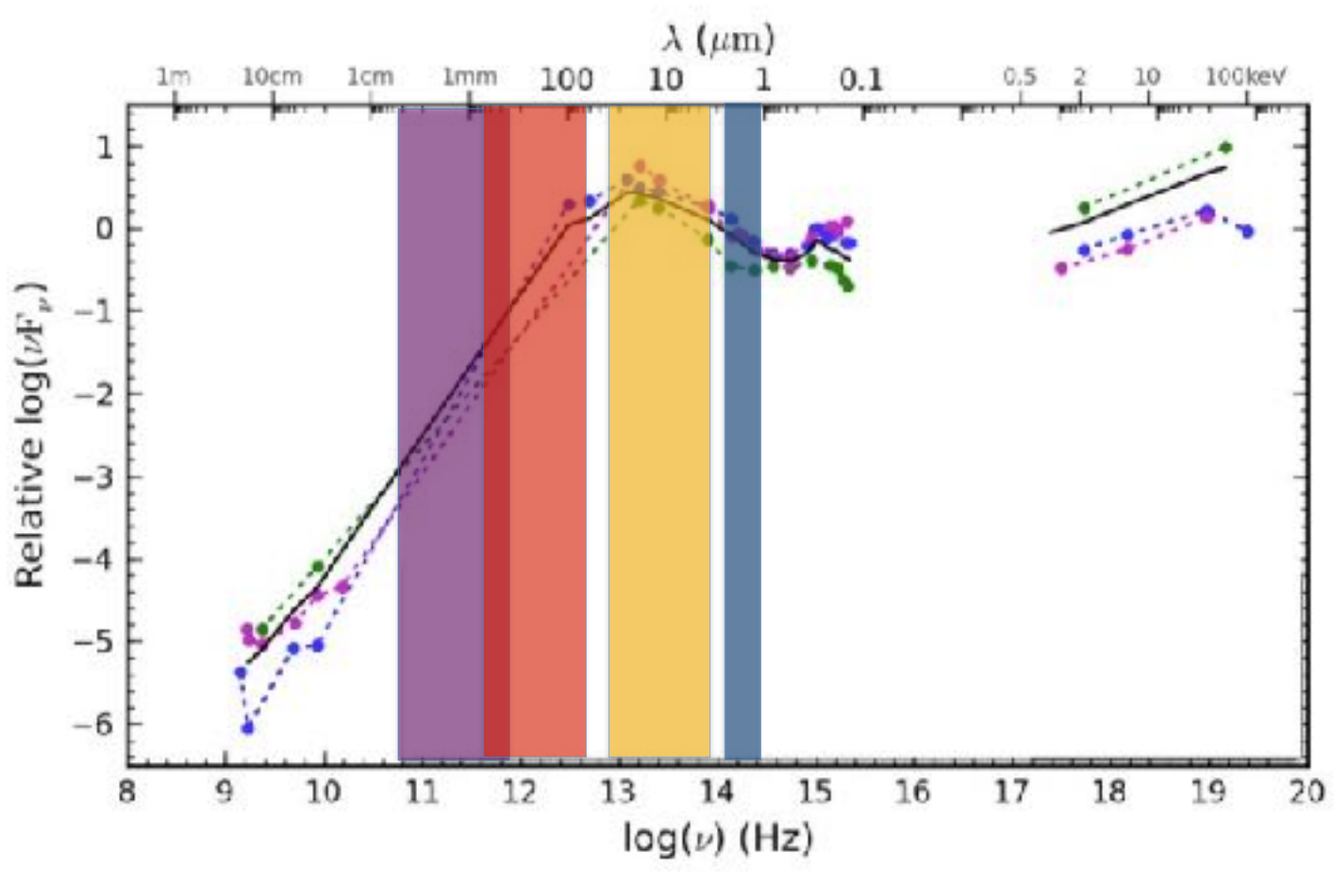

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SDSS

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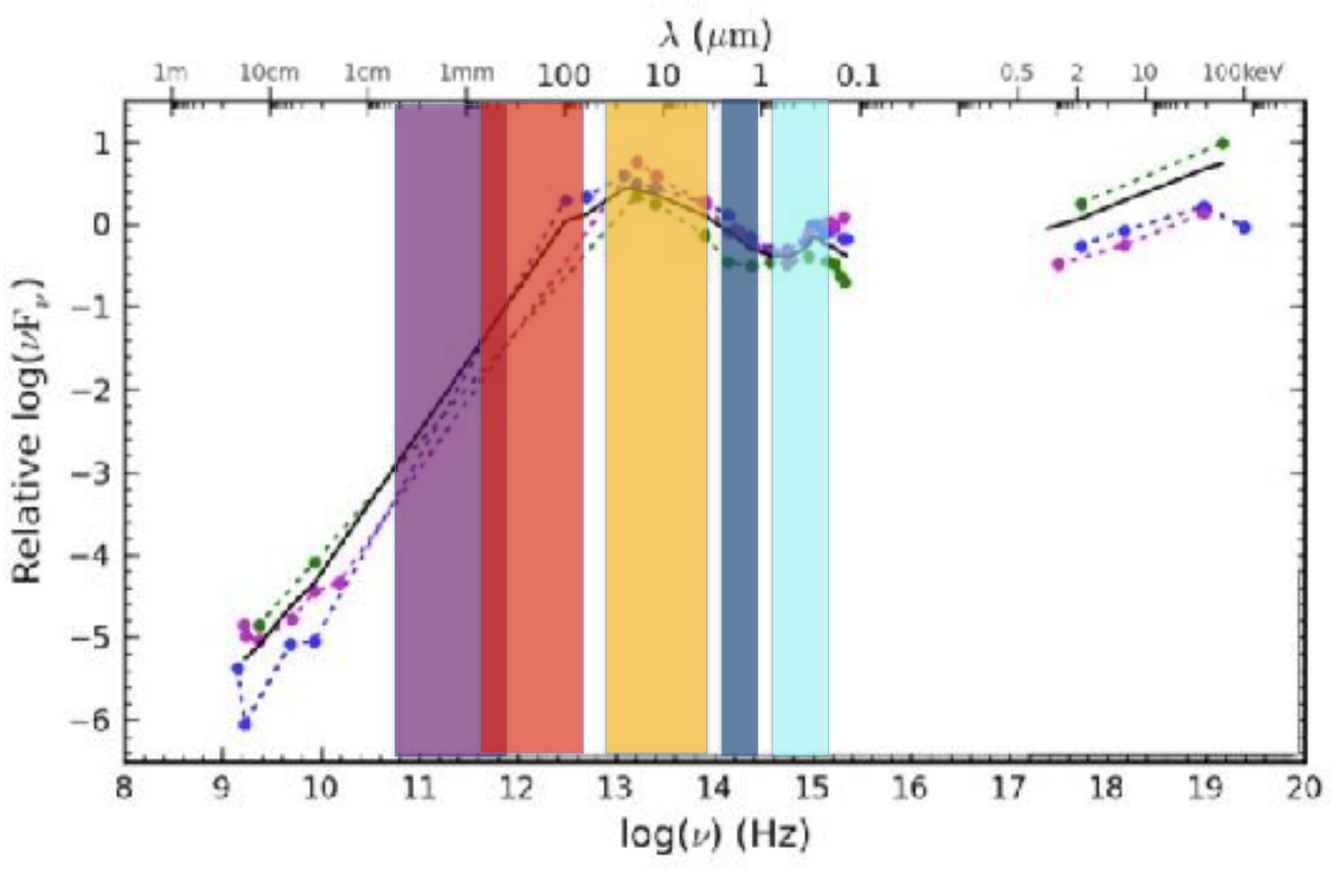

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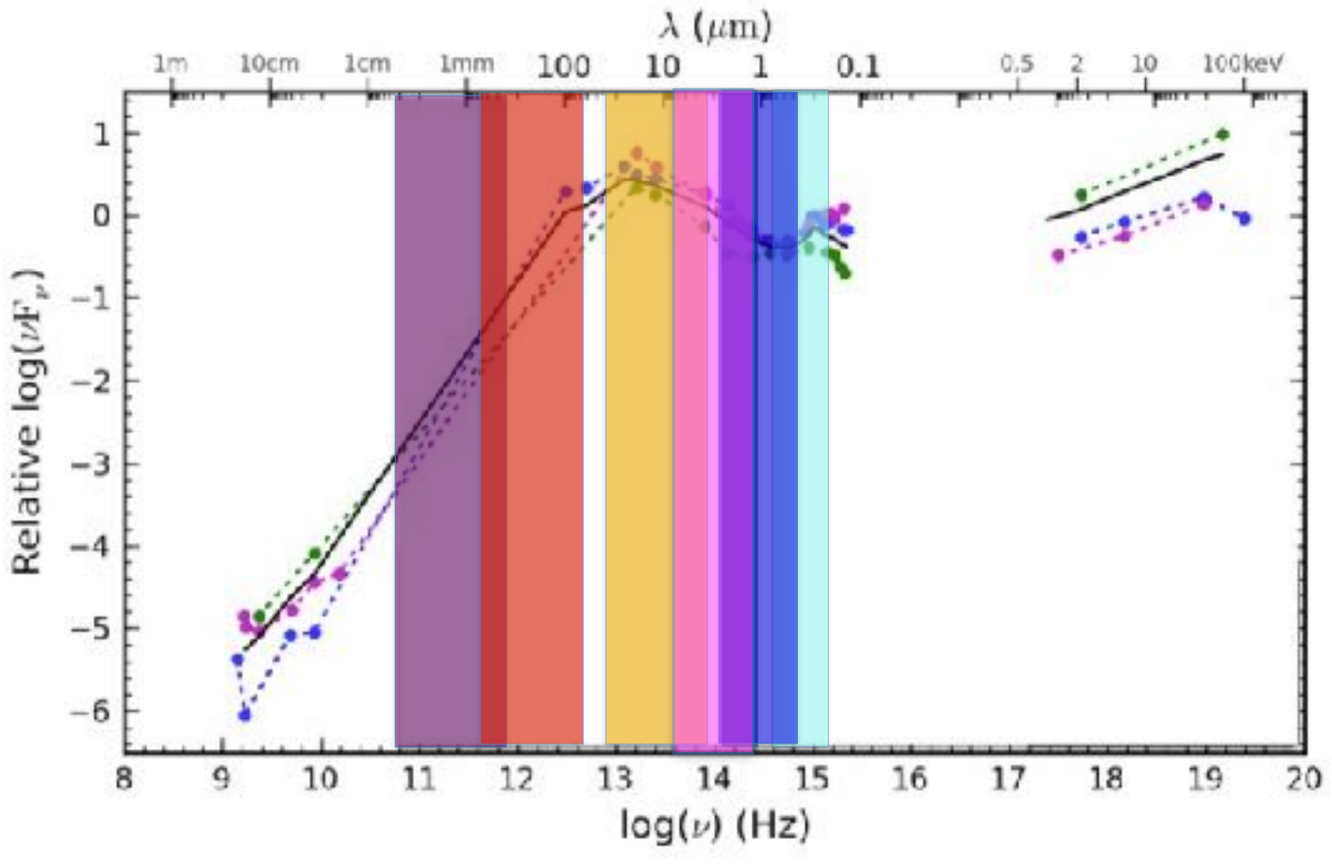

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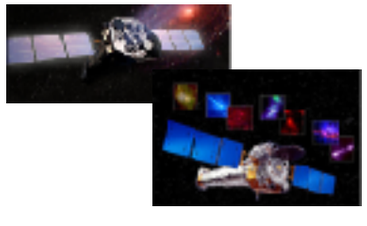
XMM & CHANDRA



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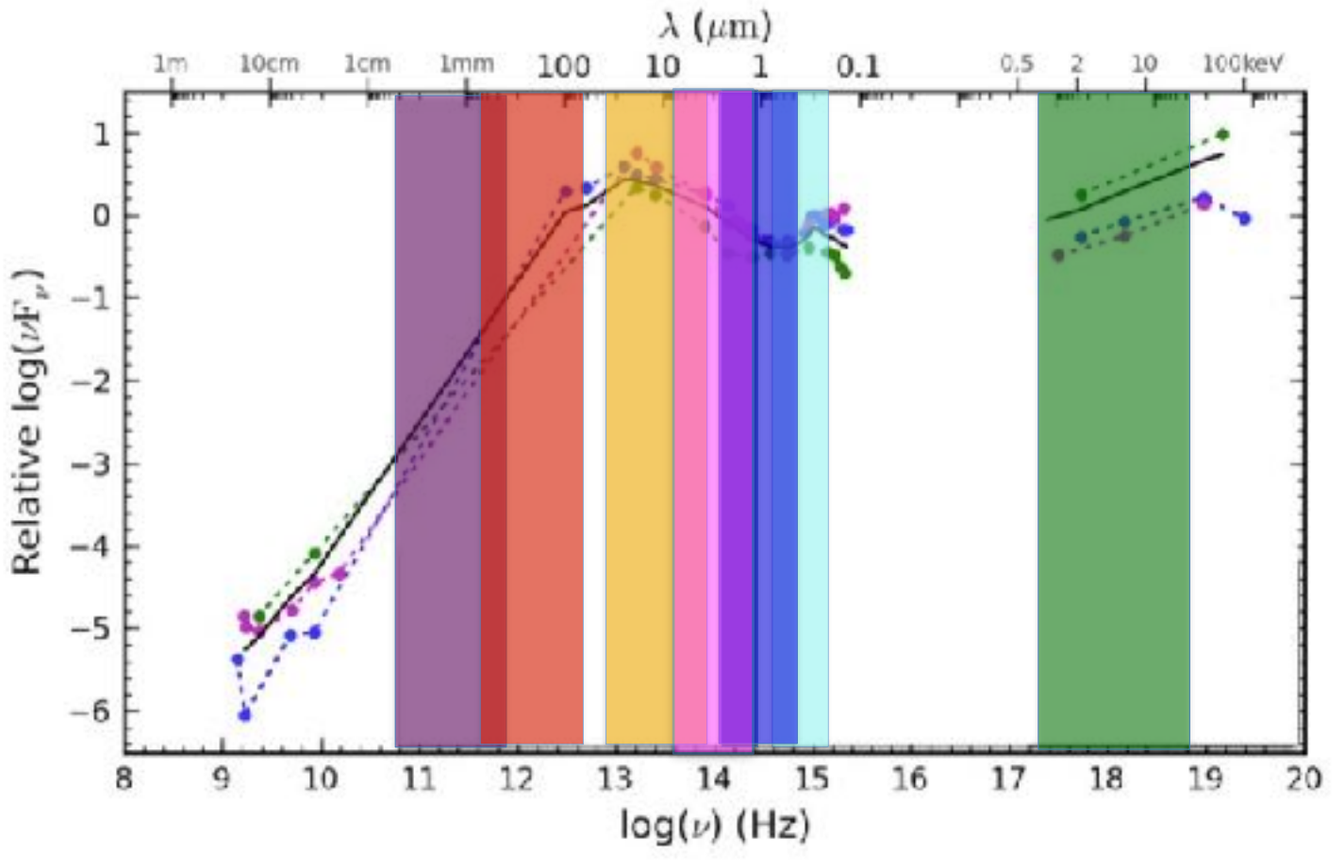


THE GOAL

This work: parallel study of

Whole sample mean properties

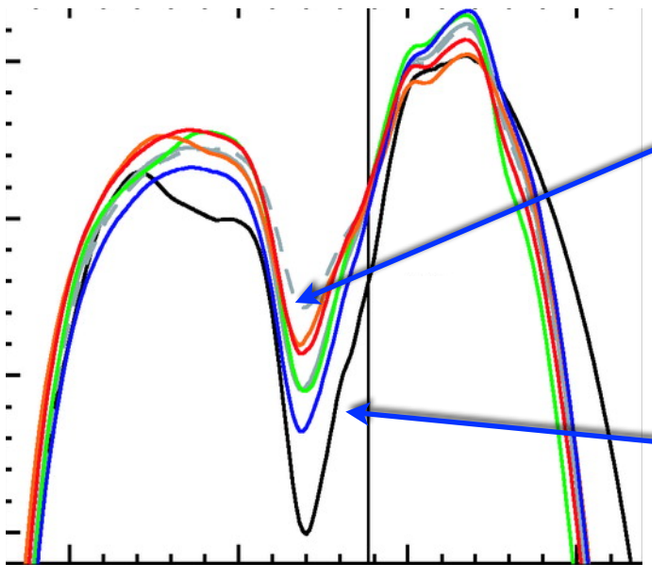
Separation of galaxy and AGN emission components through SED-fitting, with derivation of several parameters (e.g. bolometric and monochromatic luminosities, reddening, Eddington ratio...)

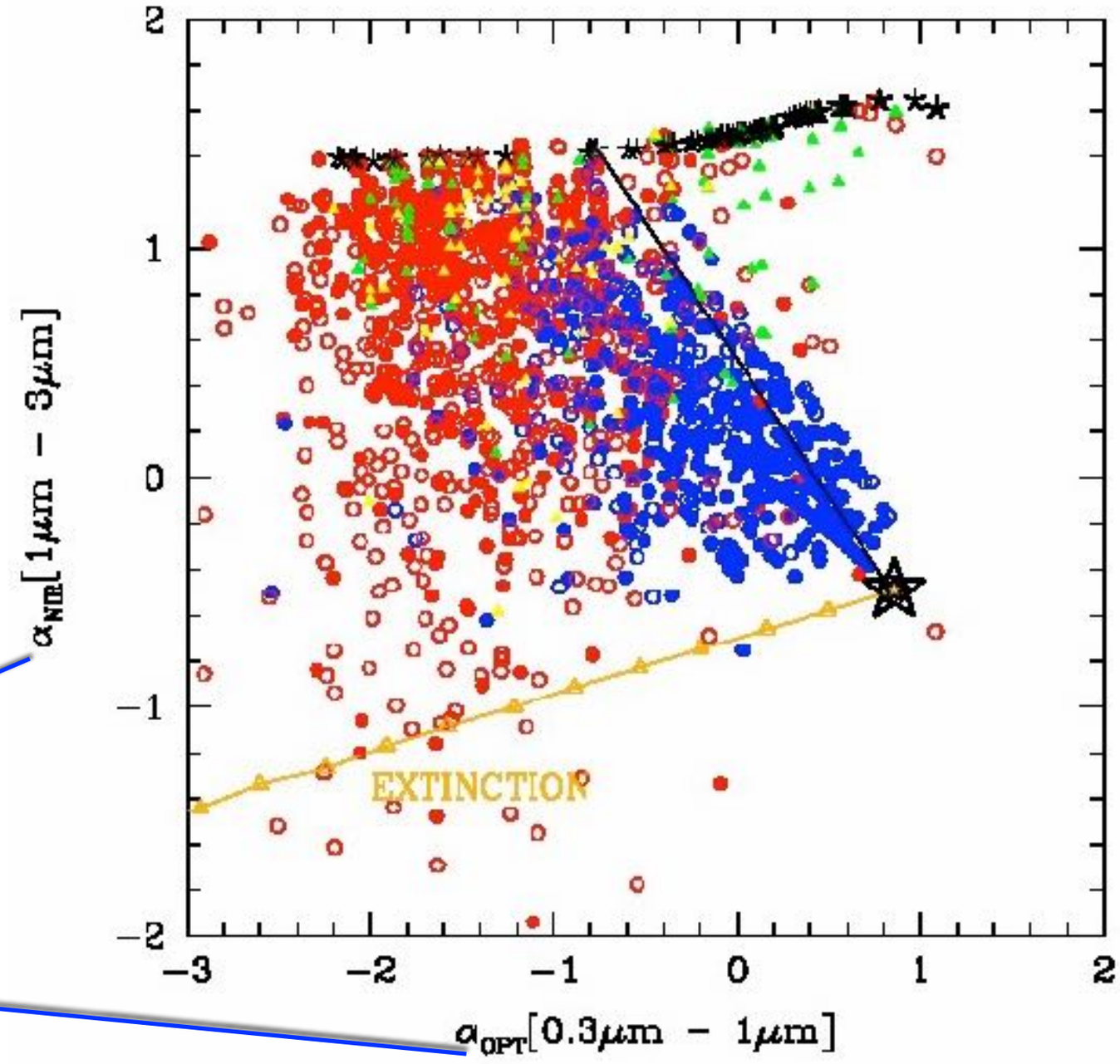
Focus on the 16 QSOs with **Herschel photometric data up to 500 μm**.

Separation of the emission components with the possibility to constrain the IR emission and to derive AGN and host parameters as IR luminosity, Star Formation Rate, ...

The Spectral Energy Distribution Fitting : WHY ?

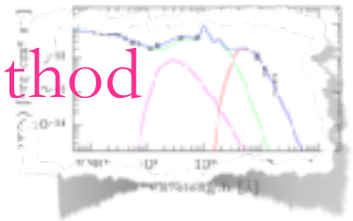
Most of the SEDs can be explained as a combination of a pure AGN eventually ABSORBED and/or contaminated by the HOST GALAXY





DISSOLVING THE TANGLE :

SED FITTING Method



INPUT:

- redshift
- cosmology
- multi-wavelength data

Strength of the method: applicable to all AGN, **independently of their luminosity**

Accuracy which depends on the number of bands of the available photometric catalogs

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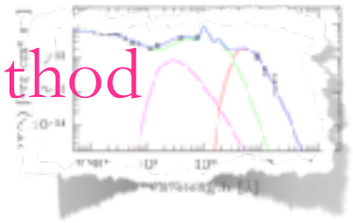

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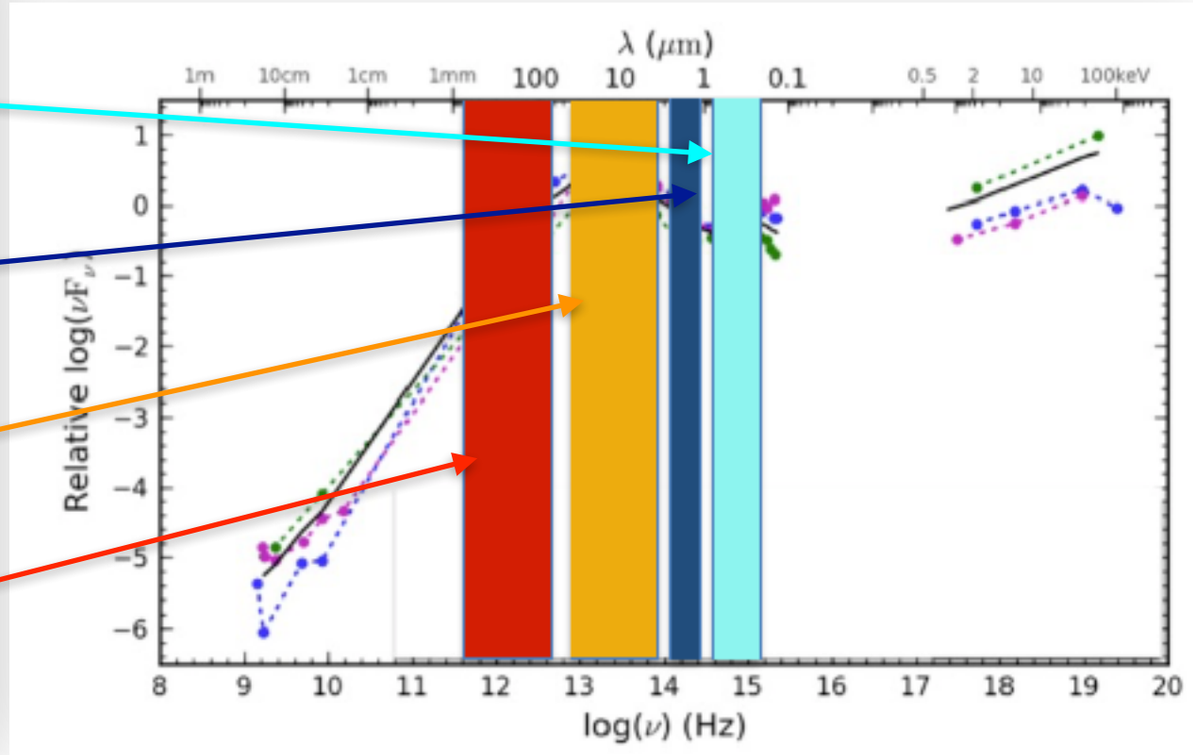
Survey	Filter	λ_{eff}
SDSS	u	3543 Å
	g	4770 Å
	r	6231 Å
	i	7625 Å
	z	9134 Å
2MASS	J	12350 Å
	H	16620 Å
	K	21590 Å
WISE	W1	3.35 μm
	W2	4.60 μm
	W3	11.56 μm
	W4	22.08 μm
Herschel	Spire1	250 μm
	Spire2	350 μm
	Spire3	500 μm



from **12** to **15 bands** of magnitude from UV to FIR

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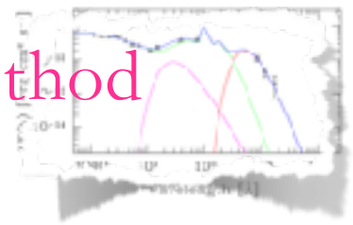

INPUT:

- redshift
- cosmology
- multi-wavelength data

OUTPUT:

- Separation of the emission components
- AGN and galaxy bolometric & monochromatic luminosities
- Eddington ratio
- SFR
- …

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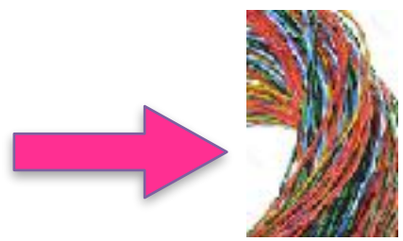


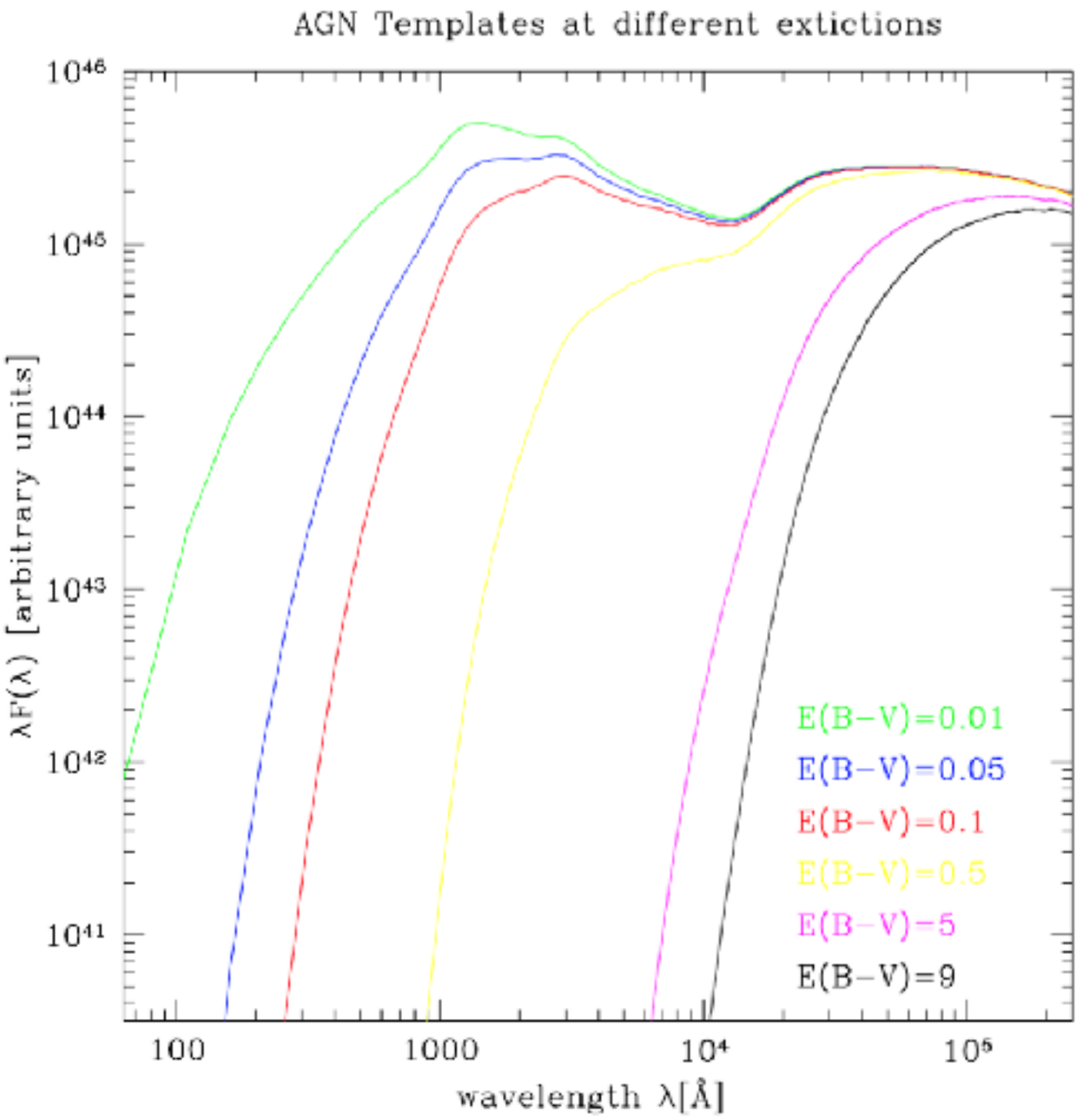
THIS WORK :

multi-component SED fitting

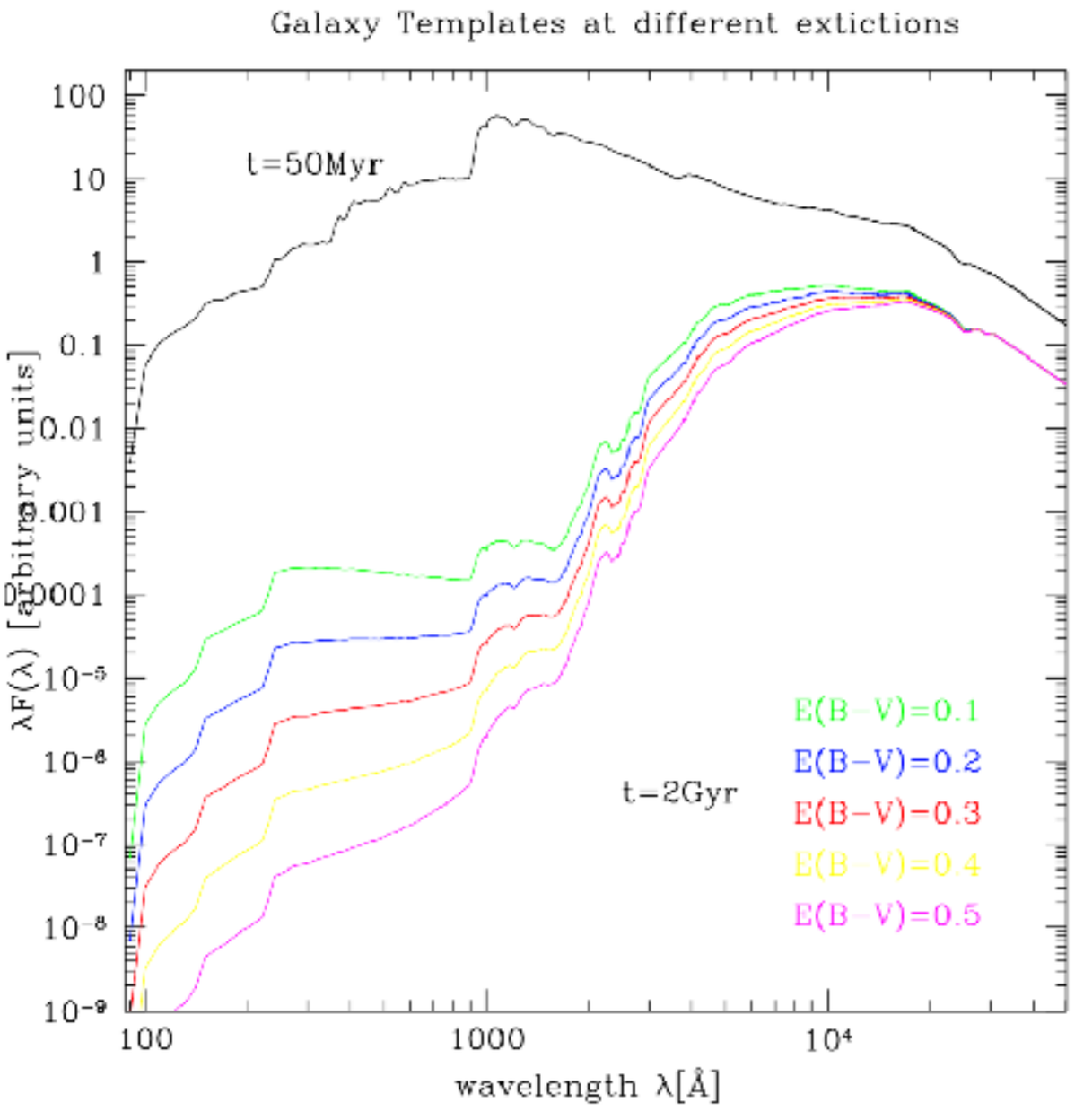
χ^2 minimization procedure

THE OVERALL SAMPLE

1. AGN templates from Richards et al (2012)
2. Galaxy templates from Bruzual & Charlot, function of age and SFR



3507 AGN templates in total

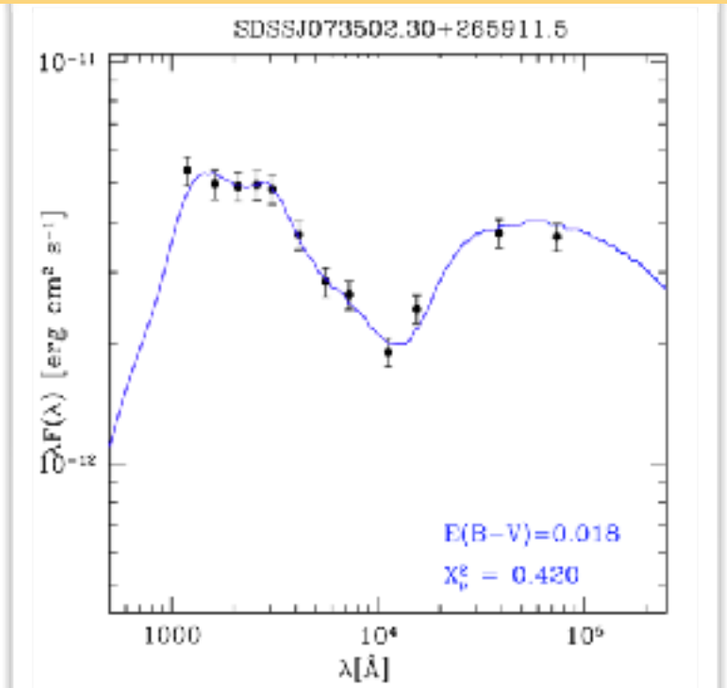


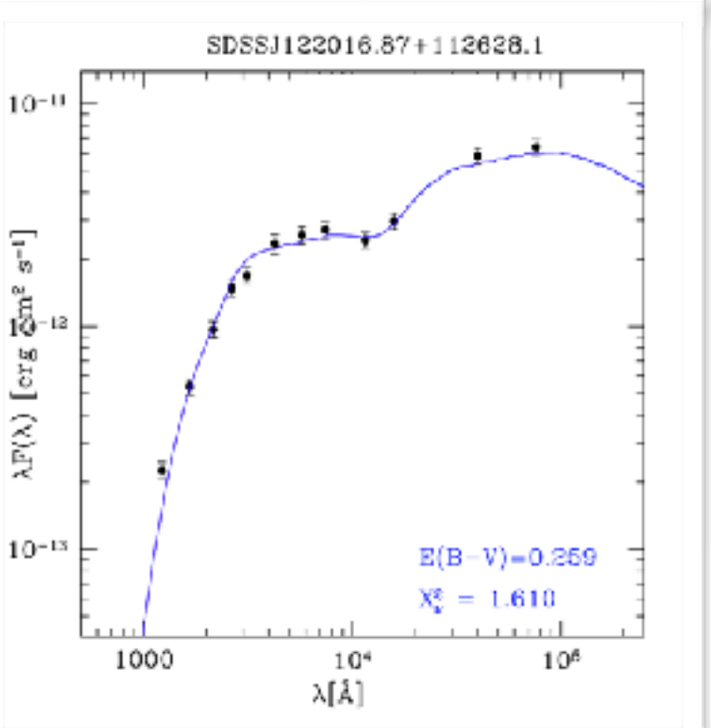
900 galaxies' templates in total

THE OVERALL SAMPLE

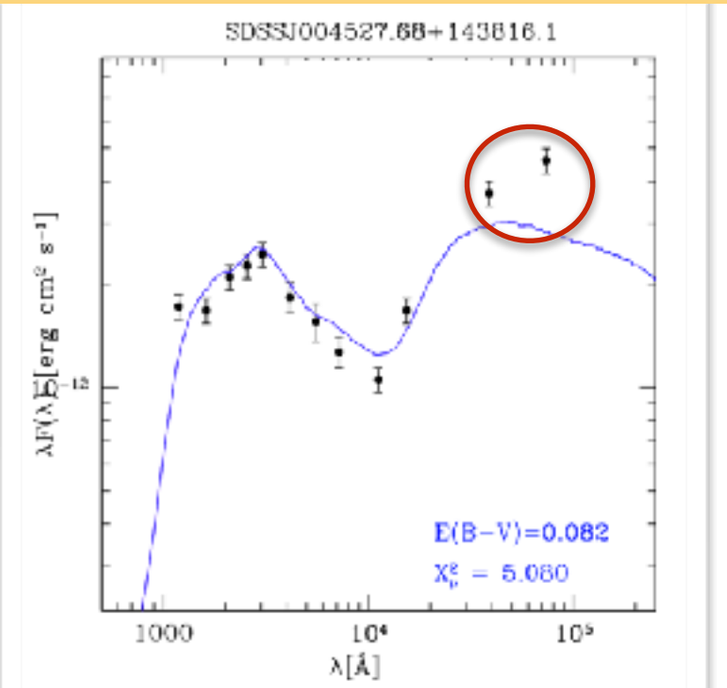
SED FITTING Results

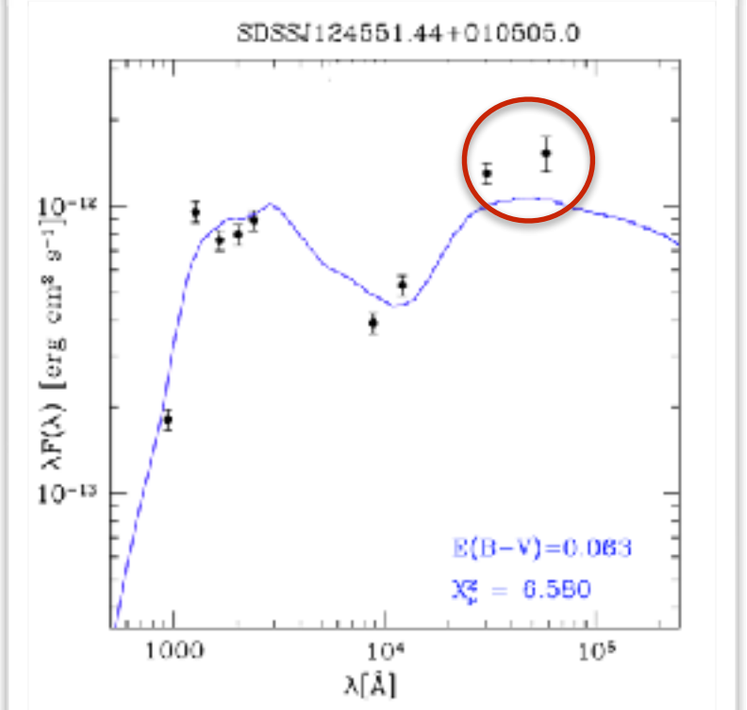
Examples of perfect matches between templates and photometric points





Examples of MIR excess of the photometric point with respect to the template

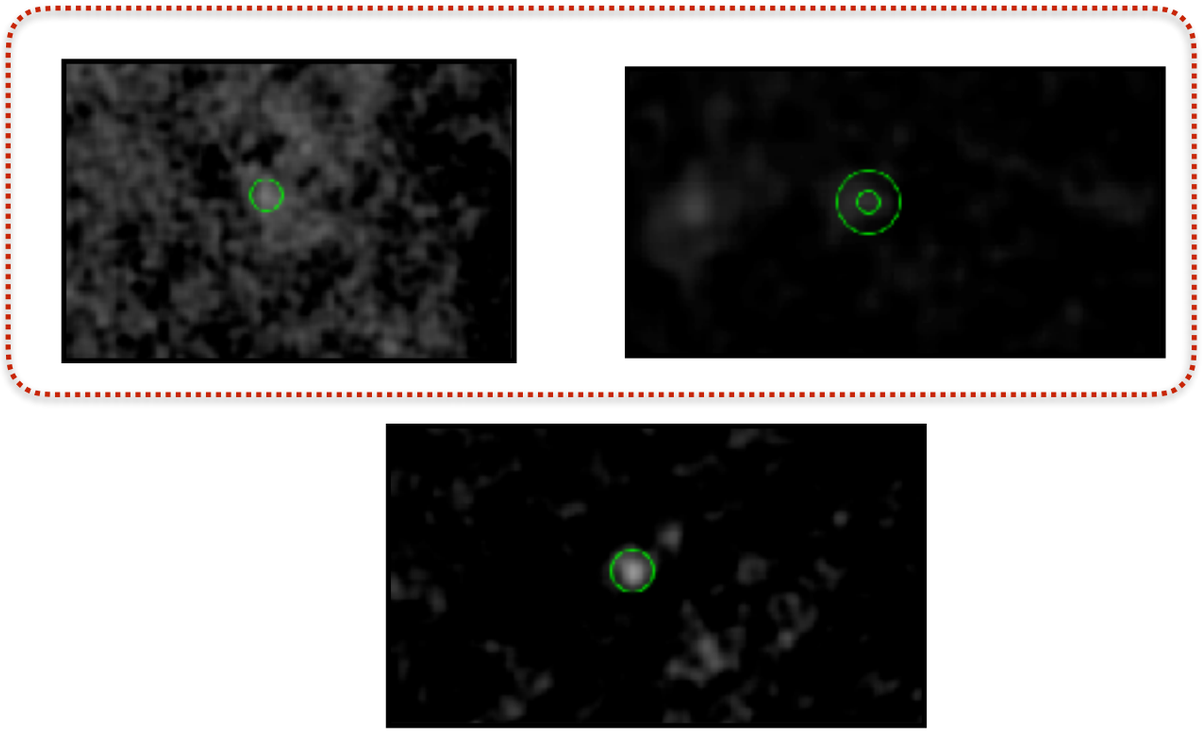




THE OVERALL SAMPLE

1. Not reliable images in the WISE All Sky Survey catalog

faint/fake images just 6% of the total



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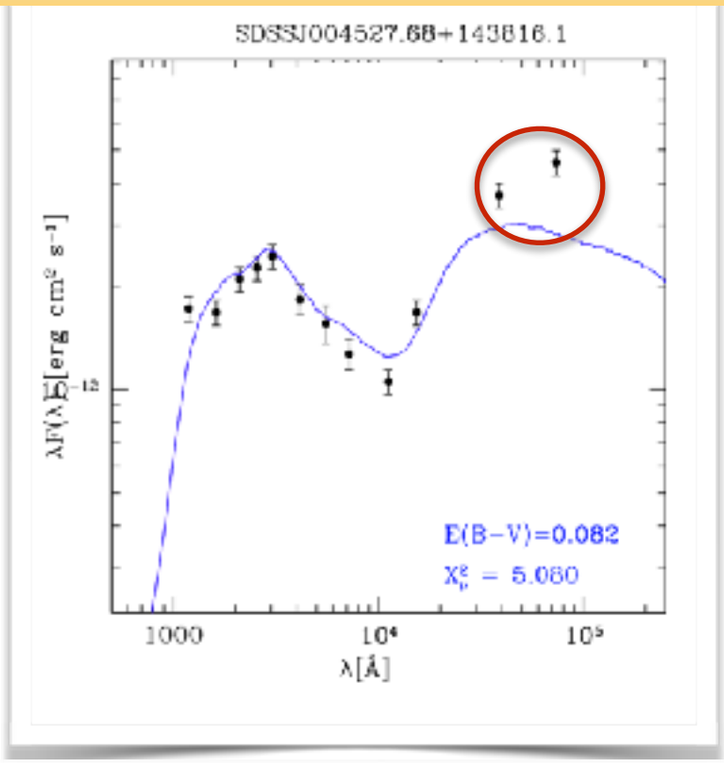
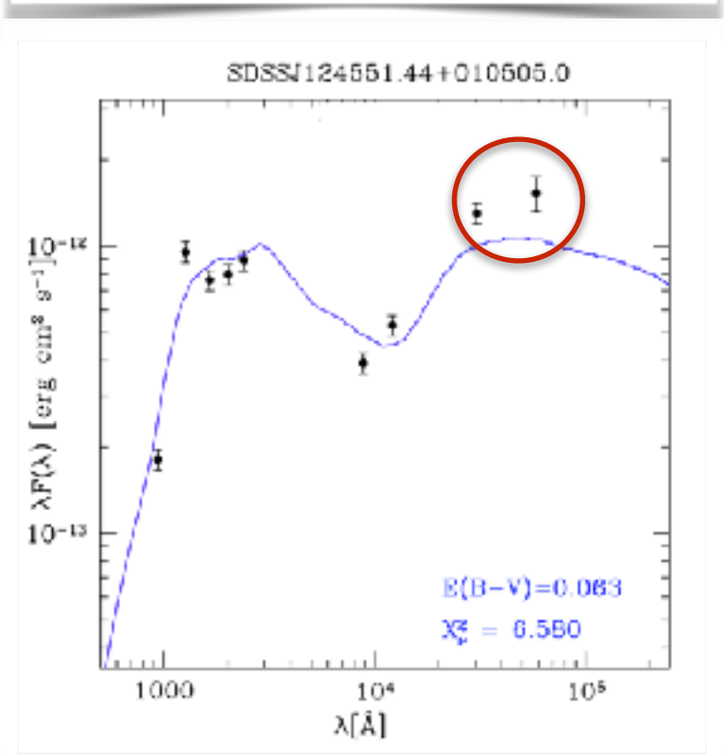


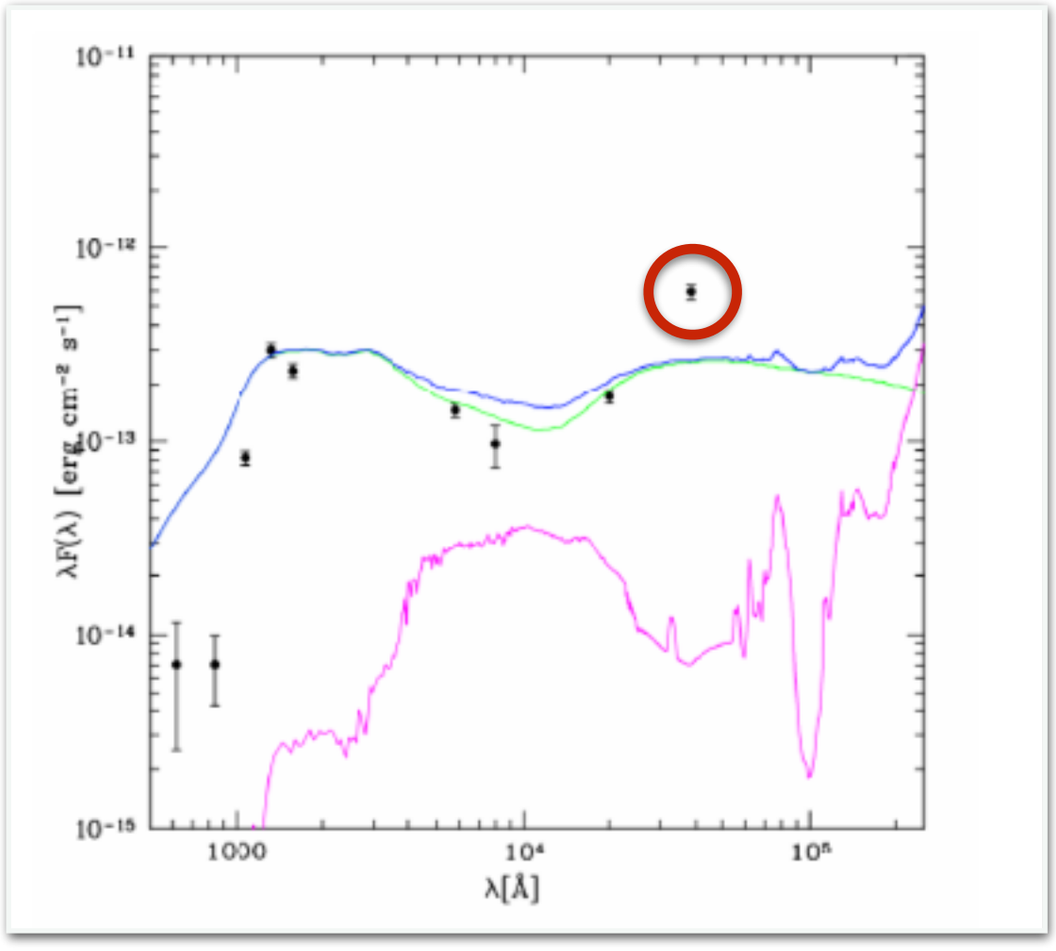


THE OVERALL SAMPLE

SED FITTING Results

2. **PAH** (Polycyclic Aromatic Hydrocarbons)
component contamination

not solving the problem



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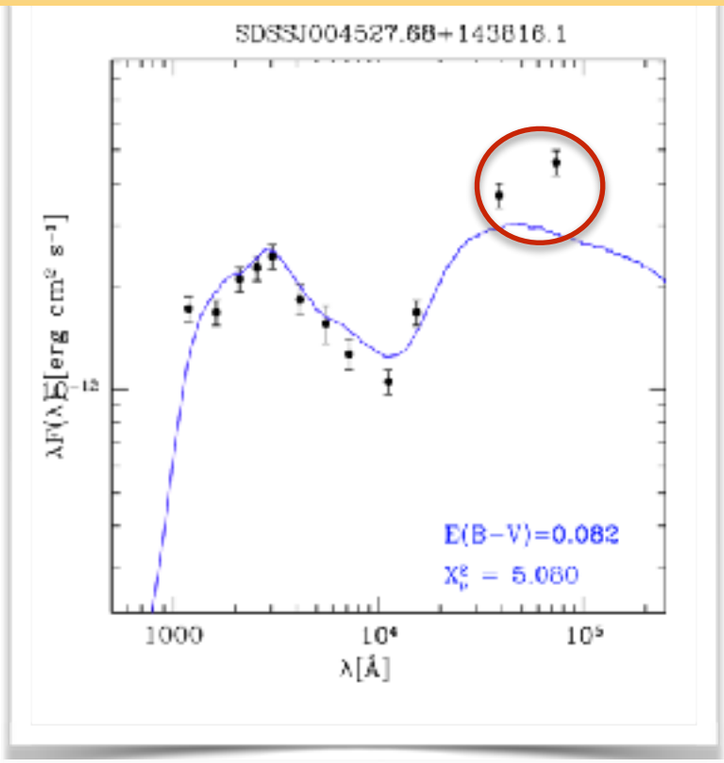

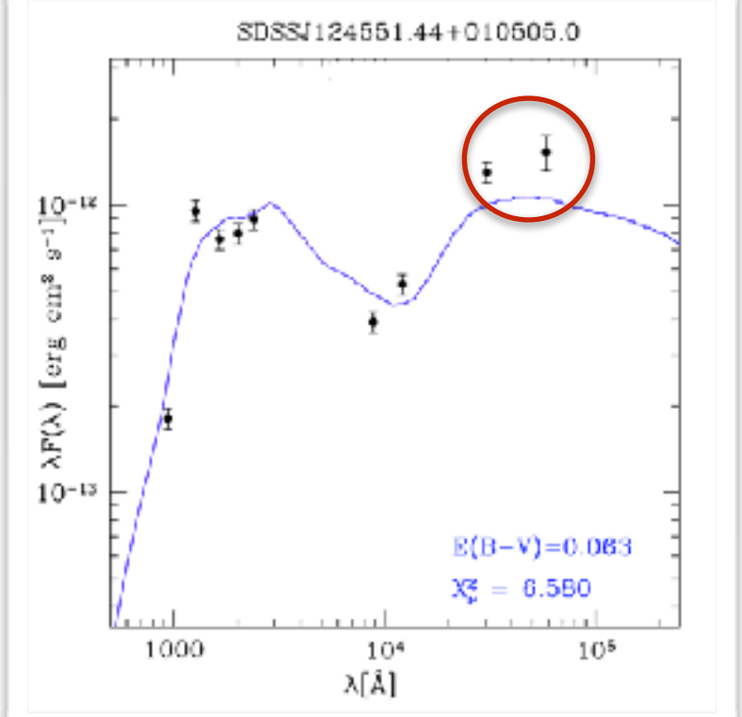

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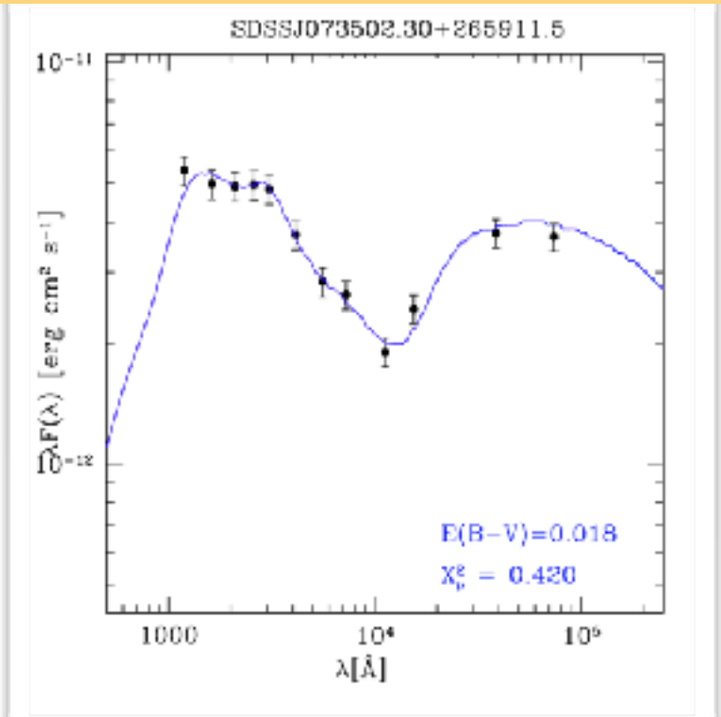

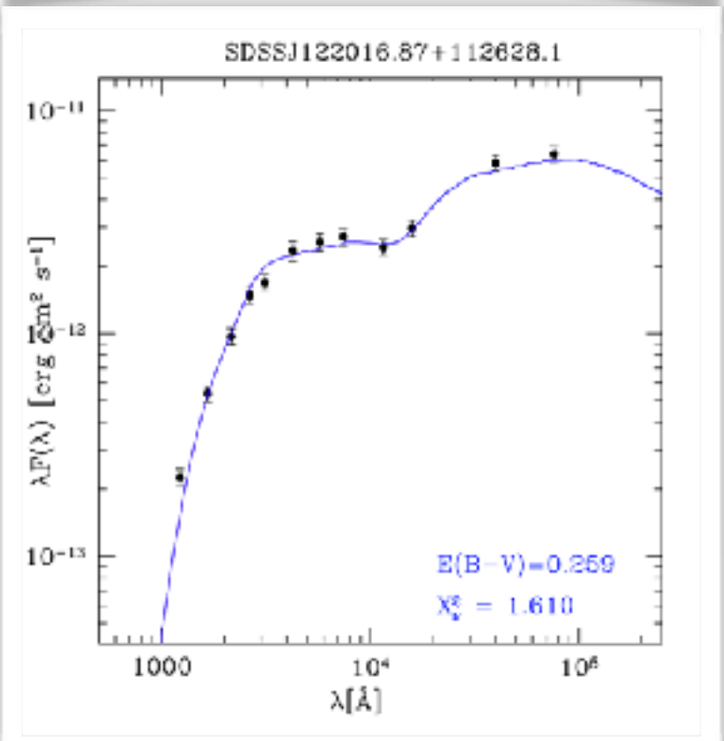

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- Reliable images in the WISE All Sky Survey catalog
- PAH emission

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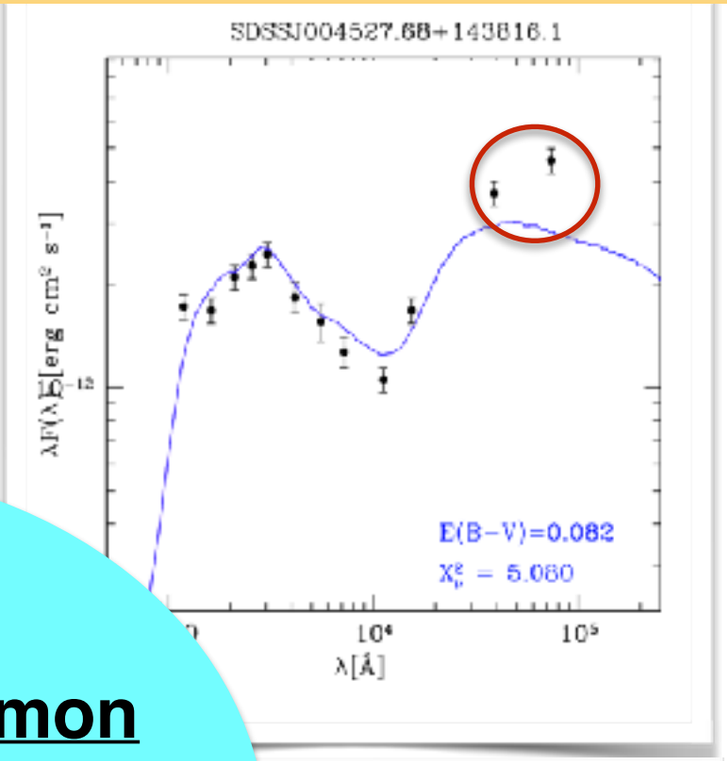

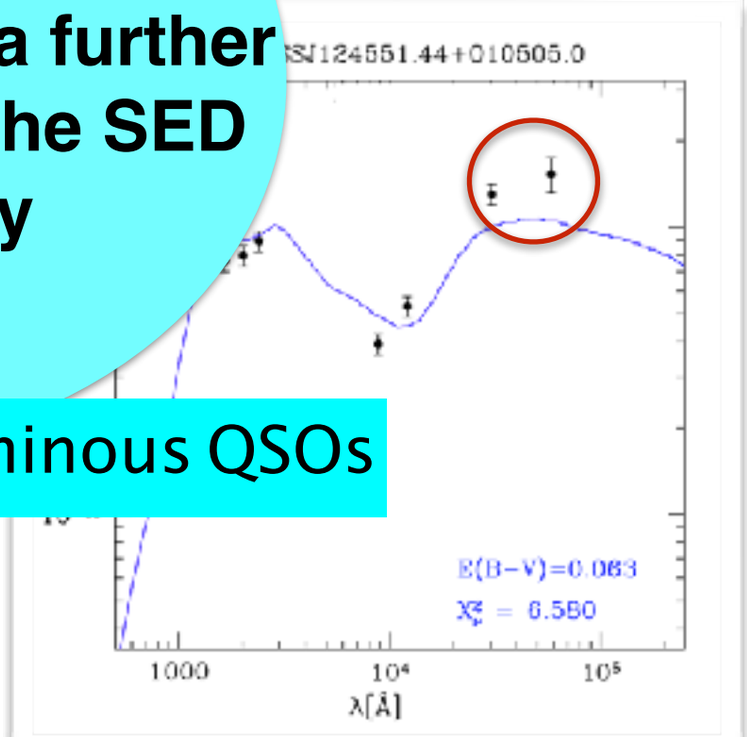

WISSH <u>not common objects</u>, for which a further detailed study of the SED is necessary

MEAN SED for hyper luminous QSOs

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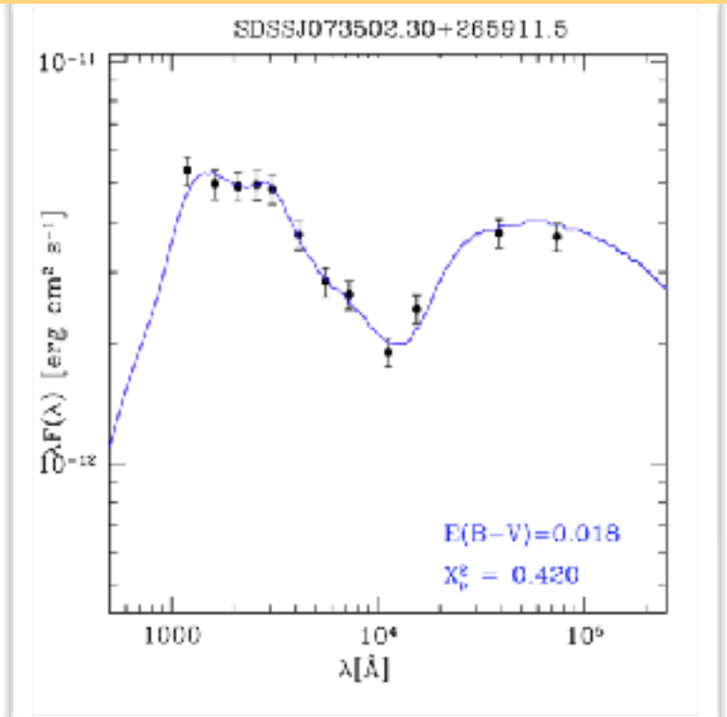

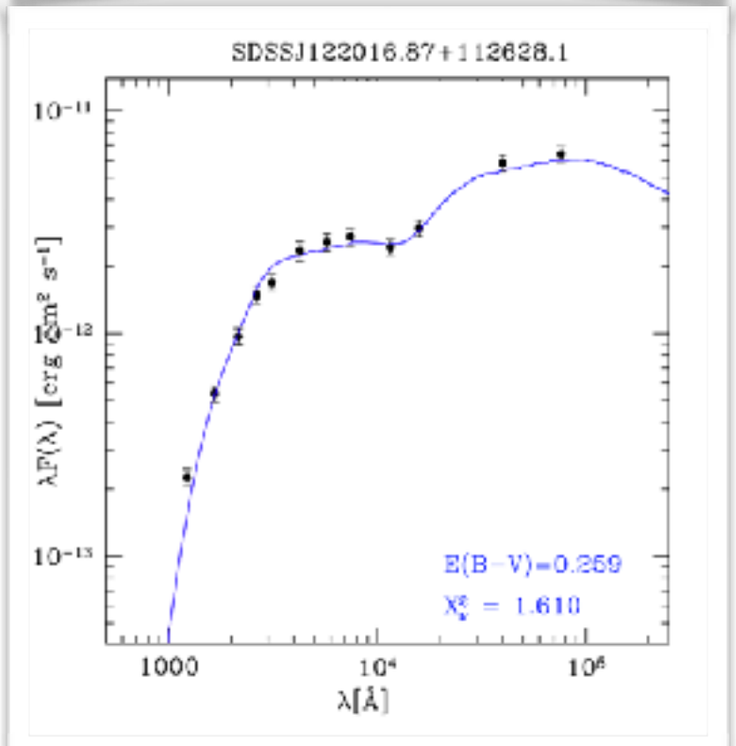

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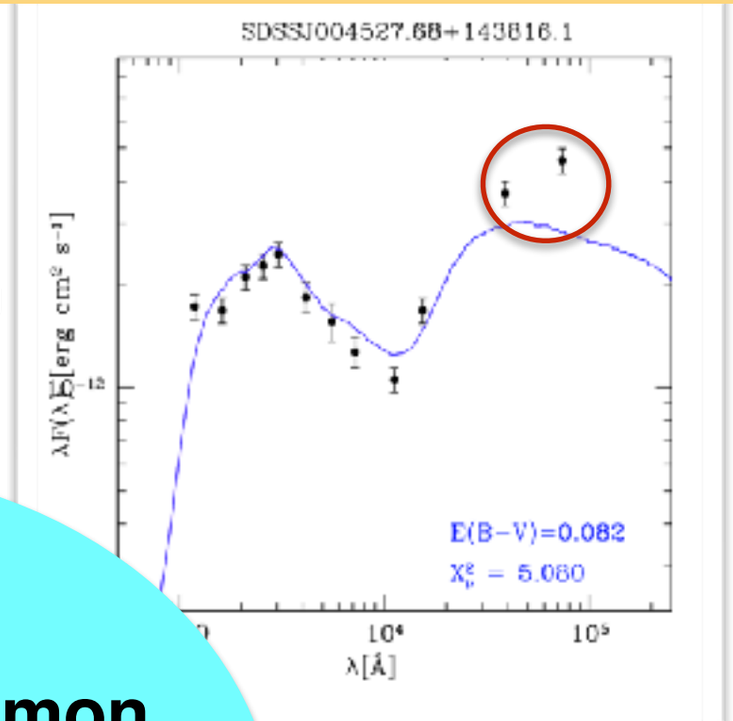

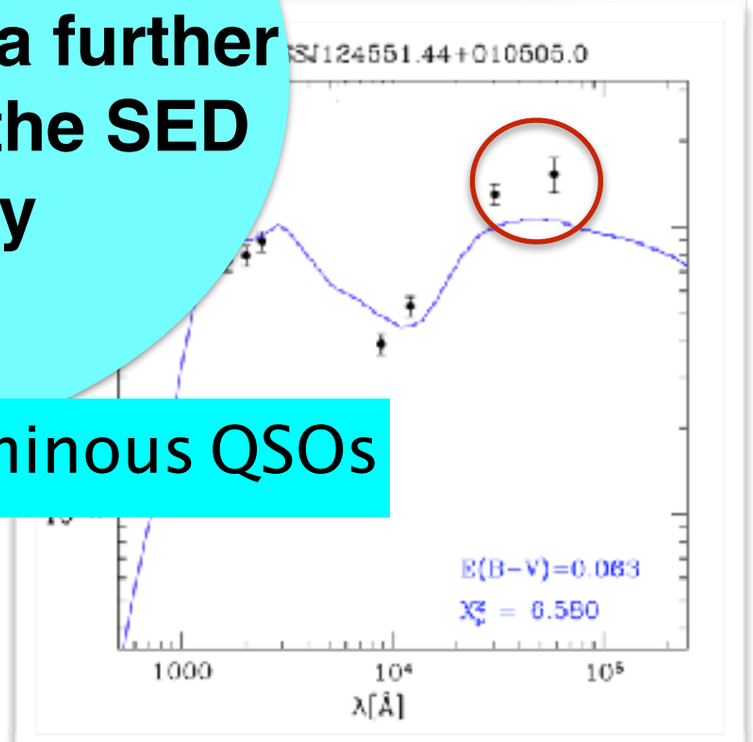

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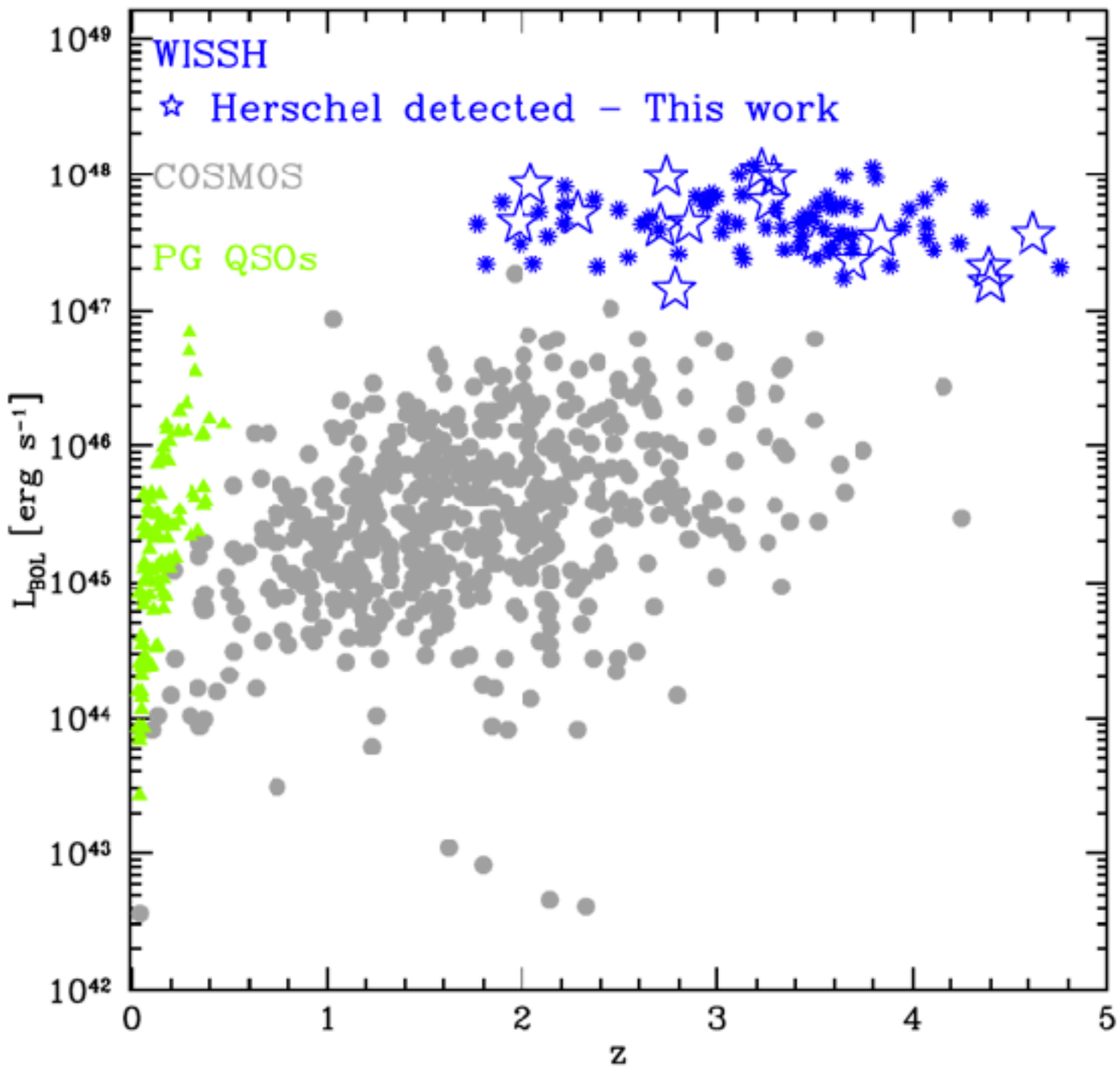
MEAN SED for hyper luminous QSOs

Galaxy's emission is OVERSHINED from the AGN!

The 16 WISSH QSOs with Herschel data coverage are representative of the entire sample, being not previously pre-selected, and being **randomly distributed** within it both in **z** and **luminosity**



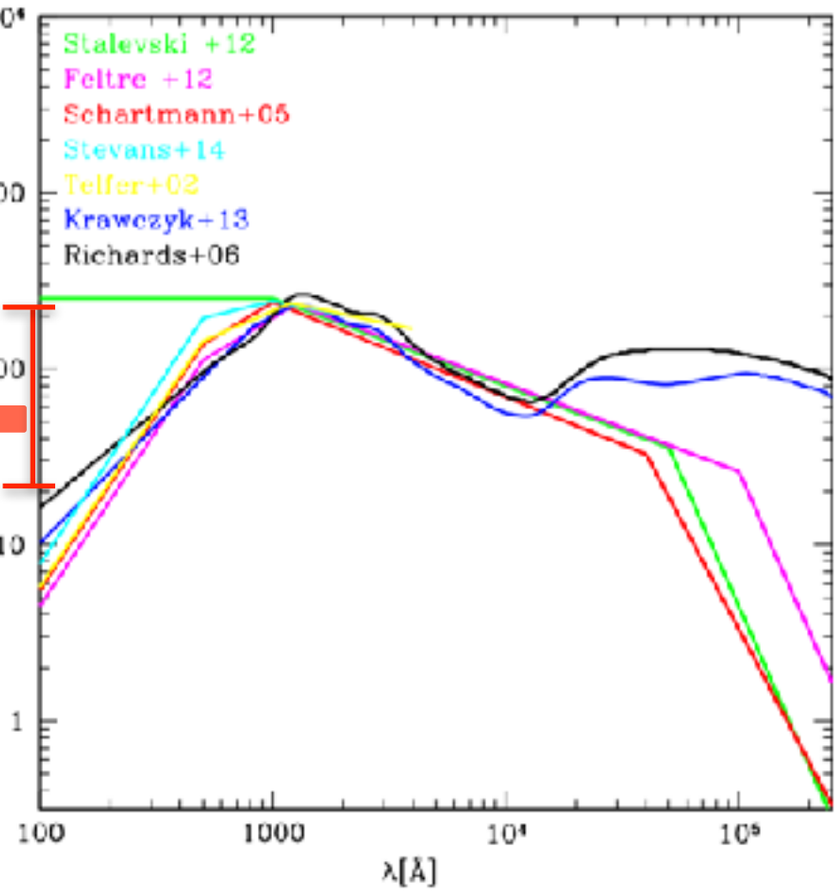
UV to FIR EMISSION

1. AGN templates from Stalevski et al. (2016) <u>with an important change</u>:
   - ★ **Accretion disk** according to Feltre et al. (2012)

$\lambda L(\lambda) \propto \lambda^{0} \quad 0.01 < \lambda \leq 0.1 \quad (\mu m)$

Stalevski et al. 2012

Overestimation of the bolometric luminosities of a factor of ~ 2 using Stalevski's AD model



Feltre et al 2012

$\lambda L(\lambda) \propto \lambda^{0.8} \quad 0.05 < \lambda \leq 0.125 \quad (\mu m)$

- ★ Smooth + Clumpy Dusty **Torus**

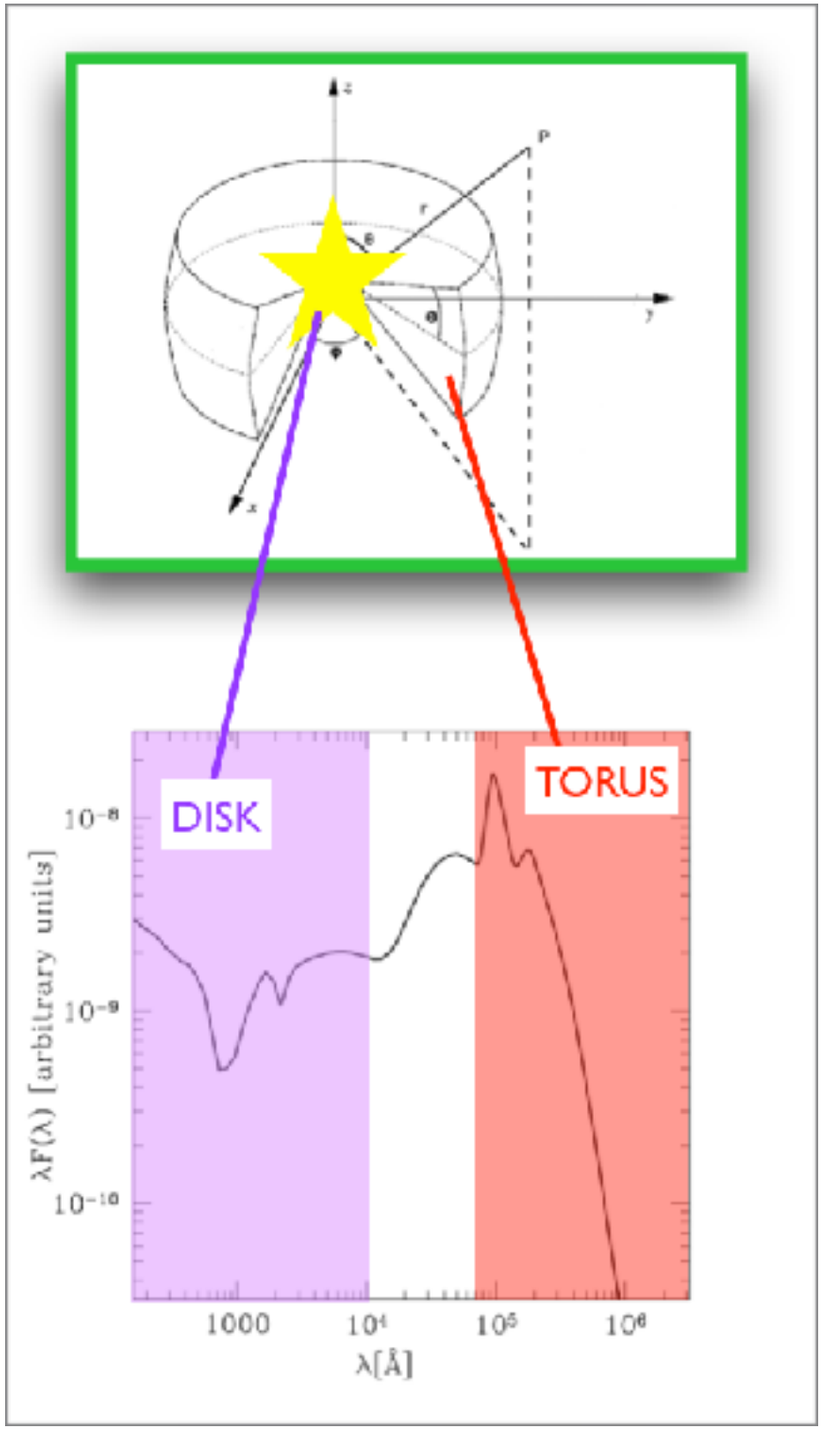
PARAMETERS OF THE MODEL :

Inclination angle i along the line of sight

Optical depth

Filling factor of the clumps

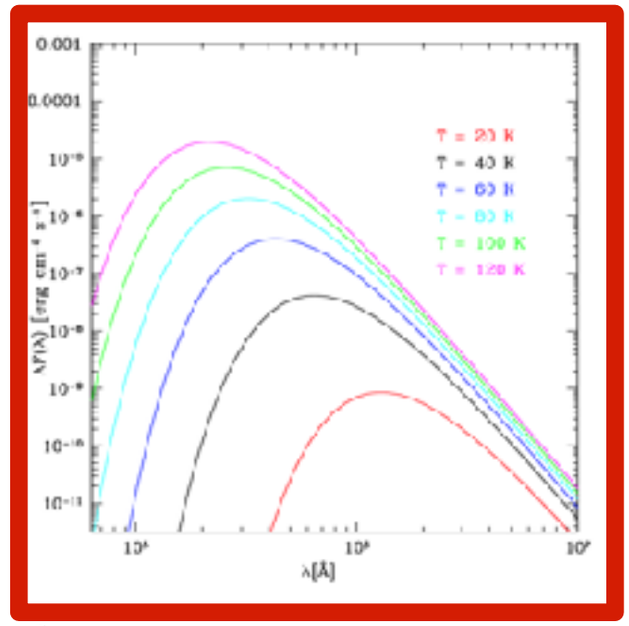
Geometry distribution of the dust



UV to FIR EMISSION

2. BB FIR: connected with SF activity

20 K < T < 120 K



3. BB MIR: additional component of dust we found to be needed to explain the excess in the mid – IR emission we observe in the WISSH Quasars

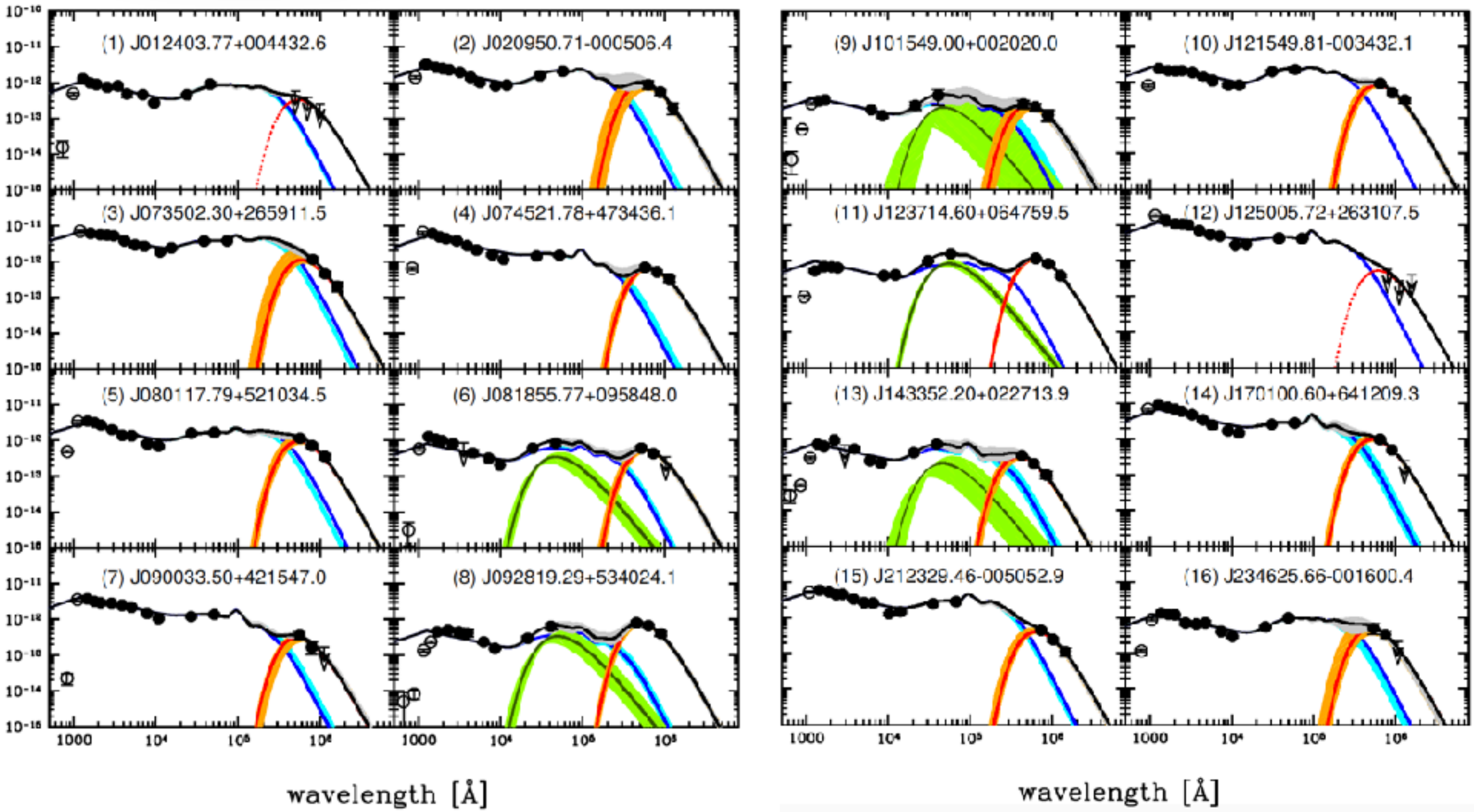
300 K < T < 1500 K

Our sources show more hot dust than that present in the torus models.

UV to FIR EMISSION

SED FITTING Results

Duras et al. +17



UV to FIR EMISSION

SED FITTING Results

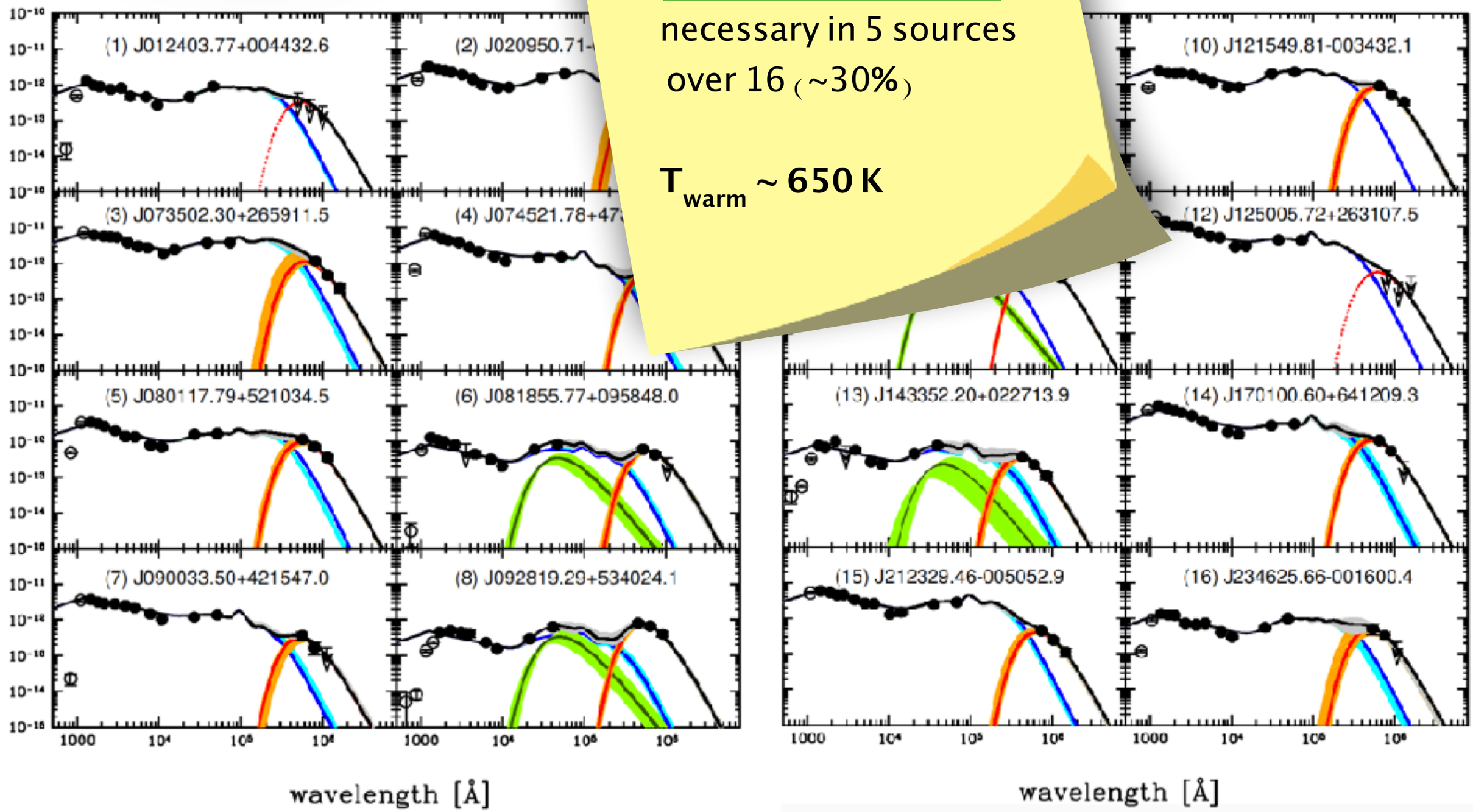
★ **Mid-IR component**

necessary in 5 sources

over 16 (~30%)

$T_{warm} \sim 650$ K

Duras et al. +17



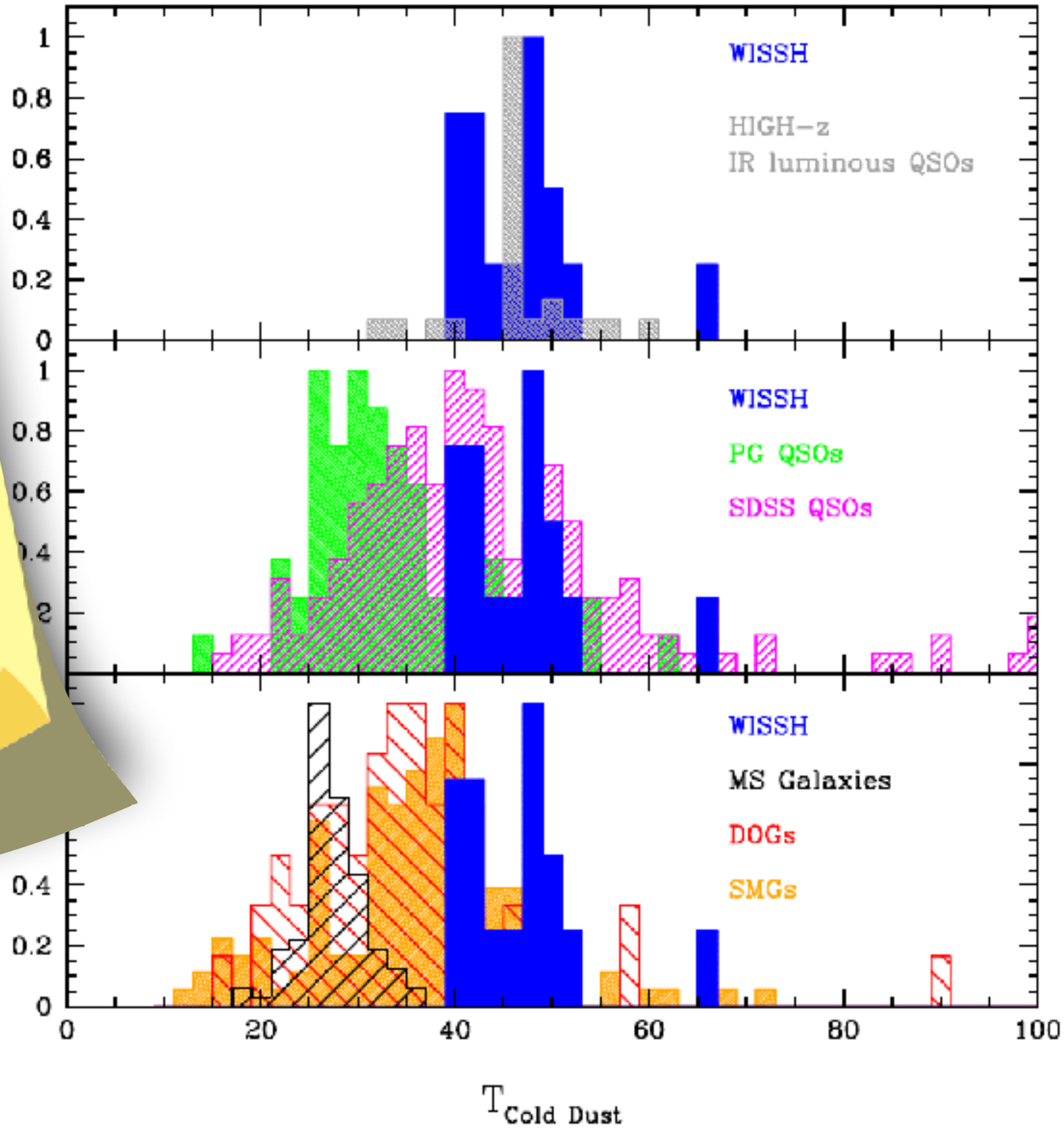
UV to FIR EMISSION

SED FITTING Results

Duras et al. +17

Cold Dust temperatures with a bulk at ~ 50 K

in accordance with high-z QSOs and hotter than MS galaxies

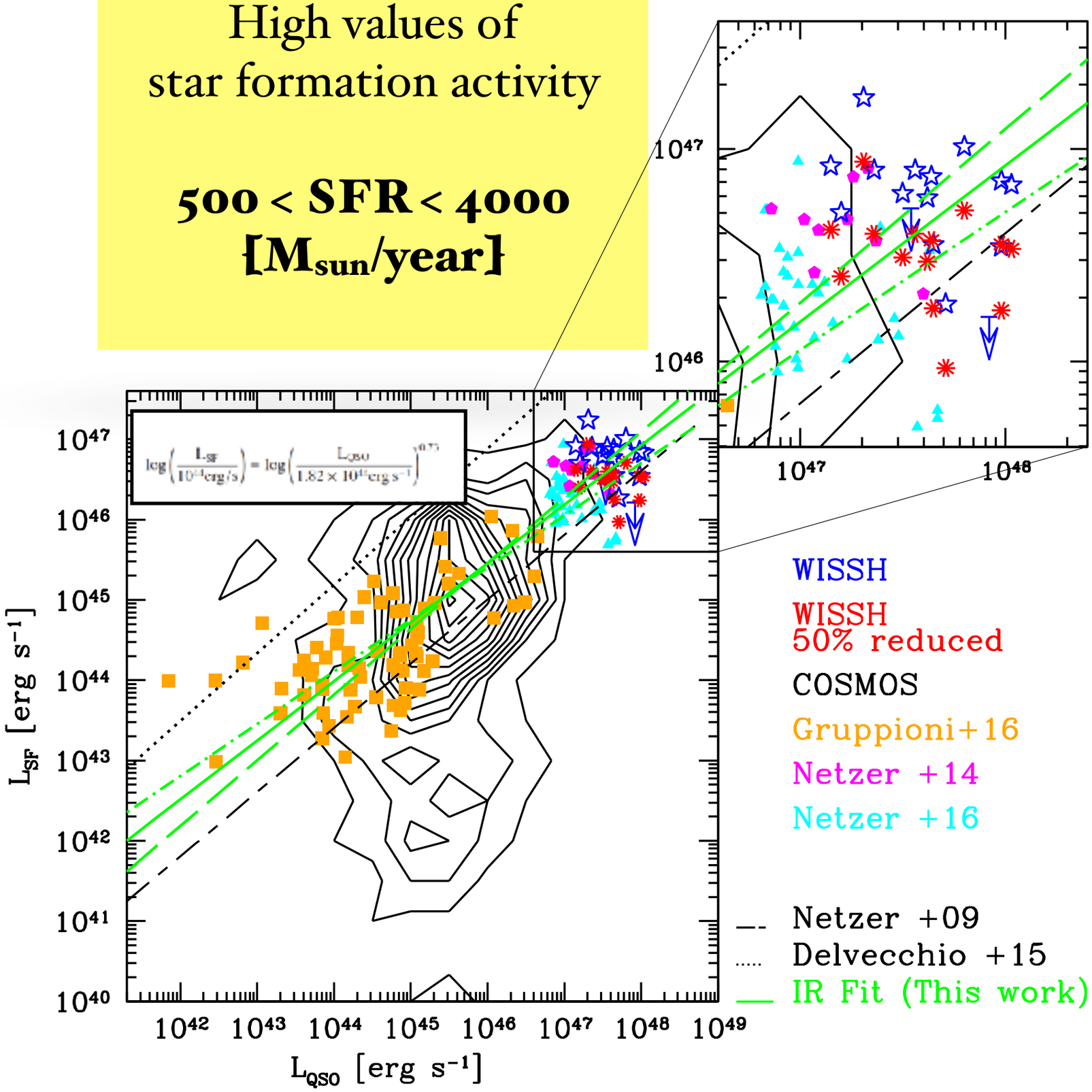


"Giant star nurseries in hyper-luminous quasars"

Duras et al. +17

High values of
star formation activity

500 < SFR < 4000
[M_{sun}/year]



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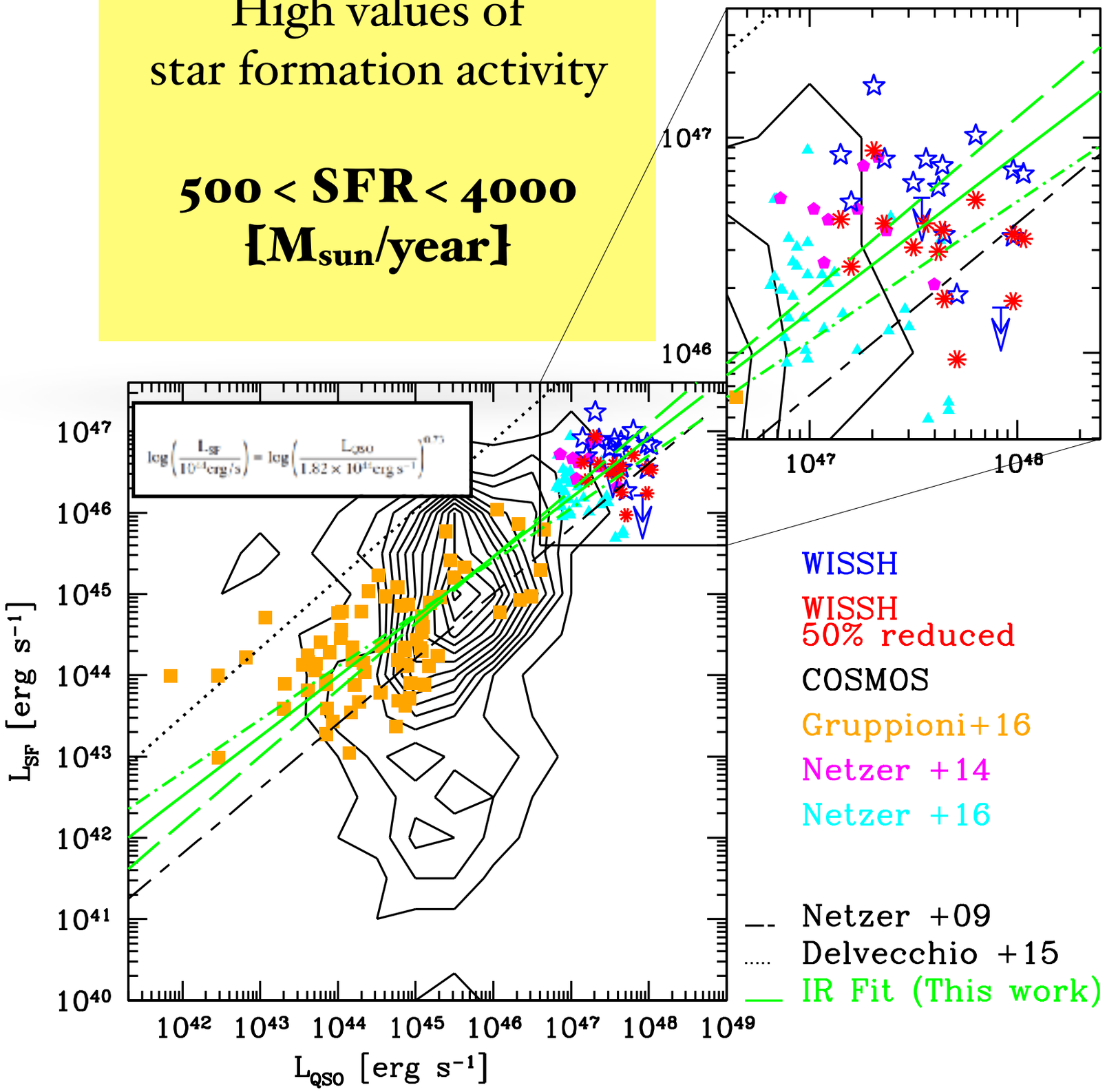

Does the AGN contribute to
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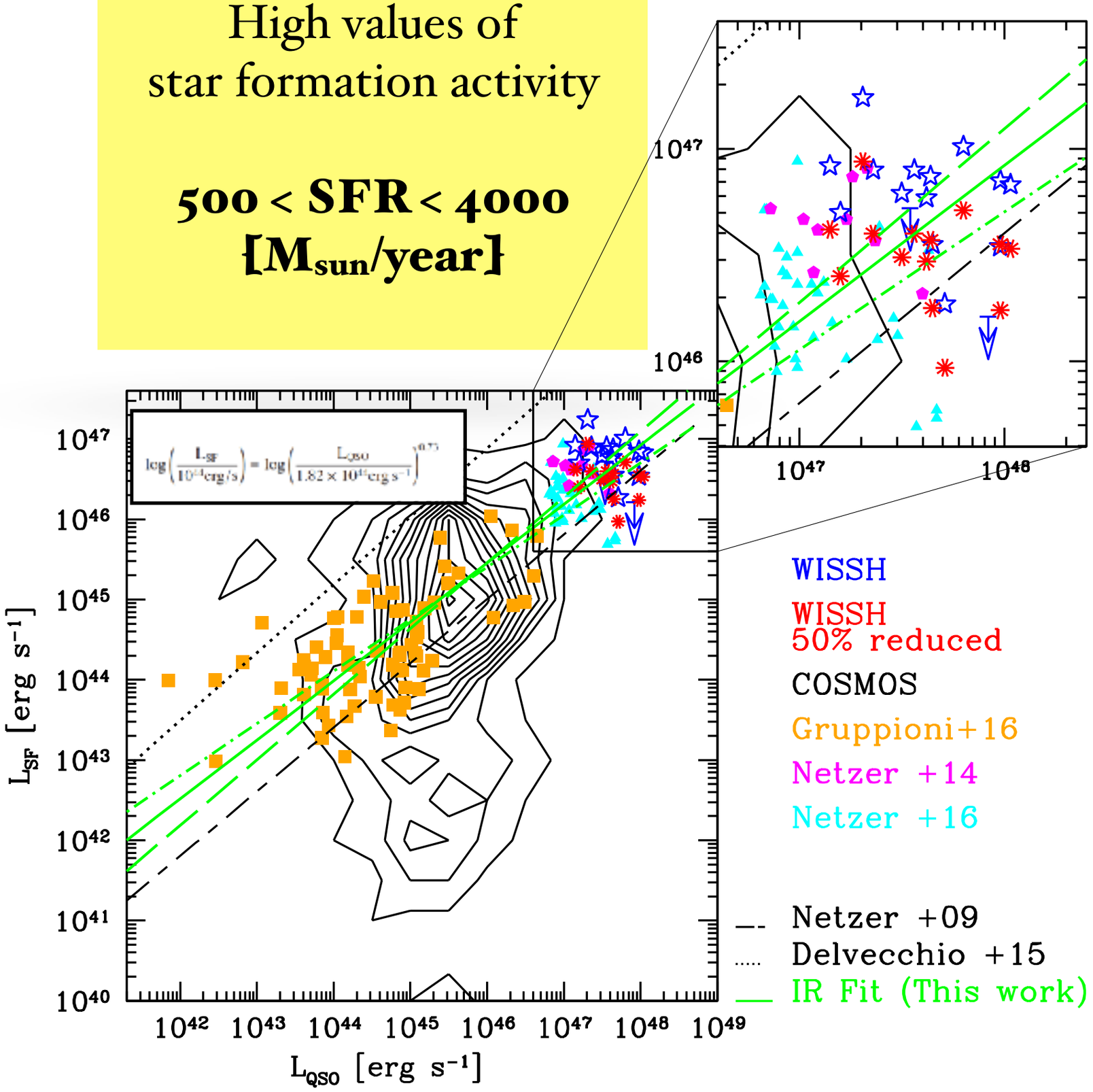

Does the AGN contribute to FIR emission?

TRADING code
(Schneider et al. +15)
applied to the **least** and the **most luminous** sources of the sample

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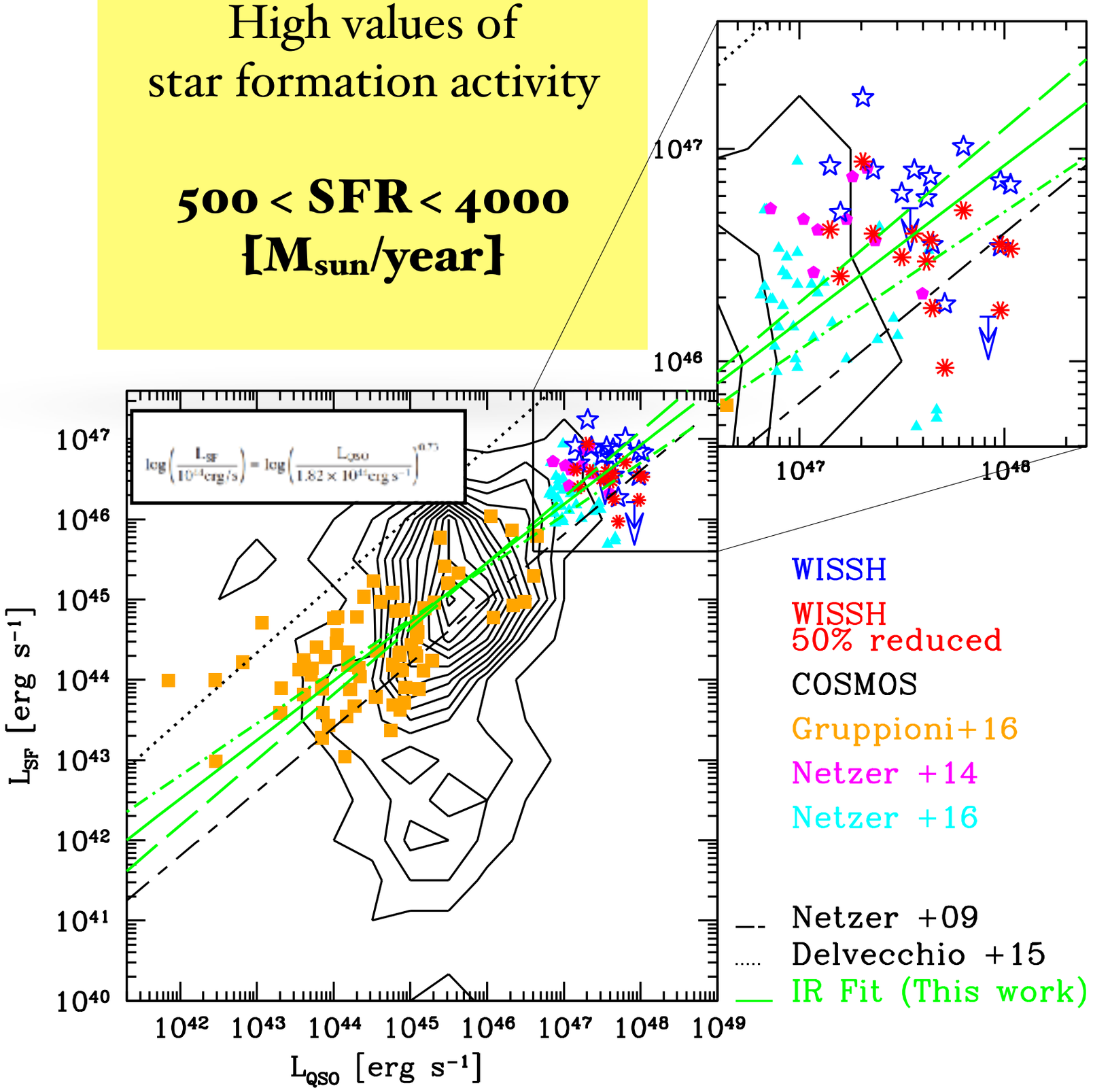

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~40 % ~60 %

AVERAGE AGN CONTRIBUTION OF ~ **50%**

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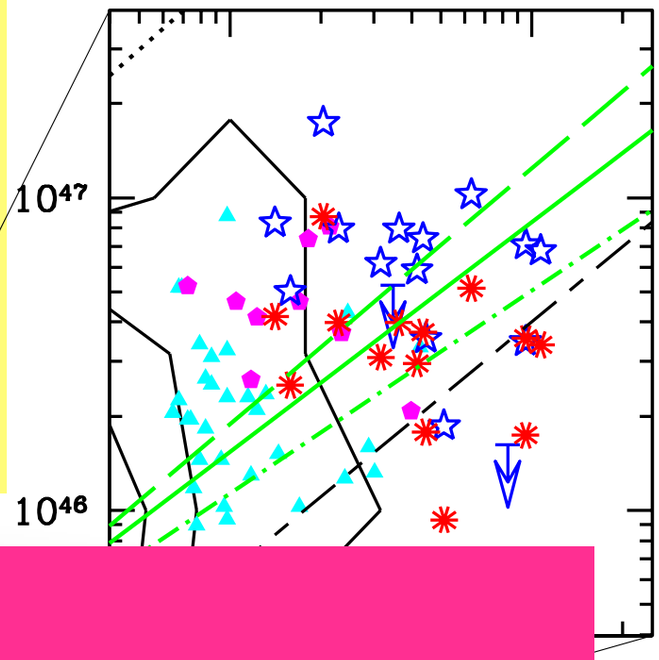

- WISSH QSOs are witnessing a precise moment of galaxy evolution, in which the dust content has not been yet swept away

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~60 %

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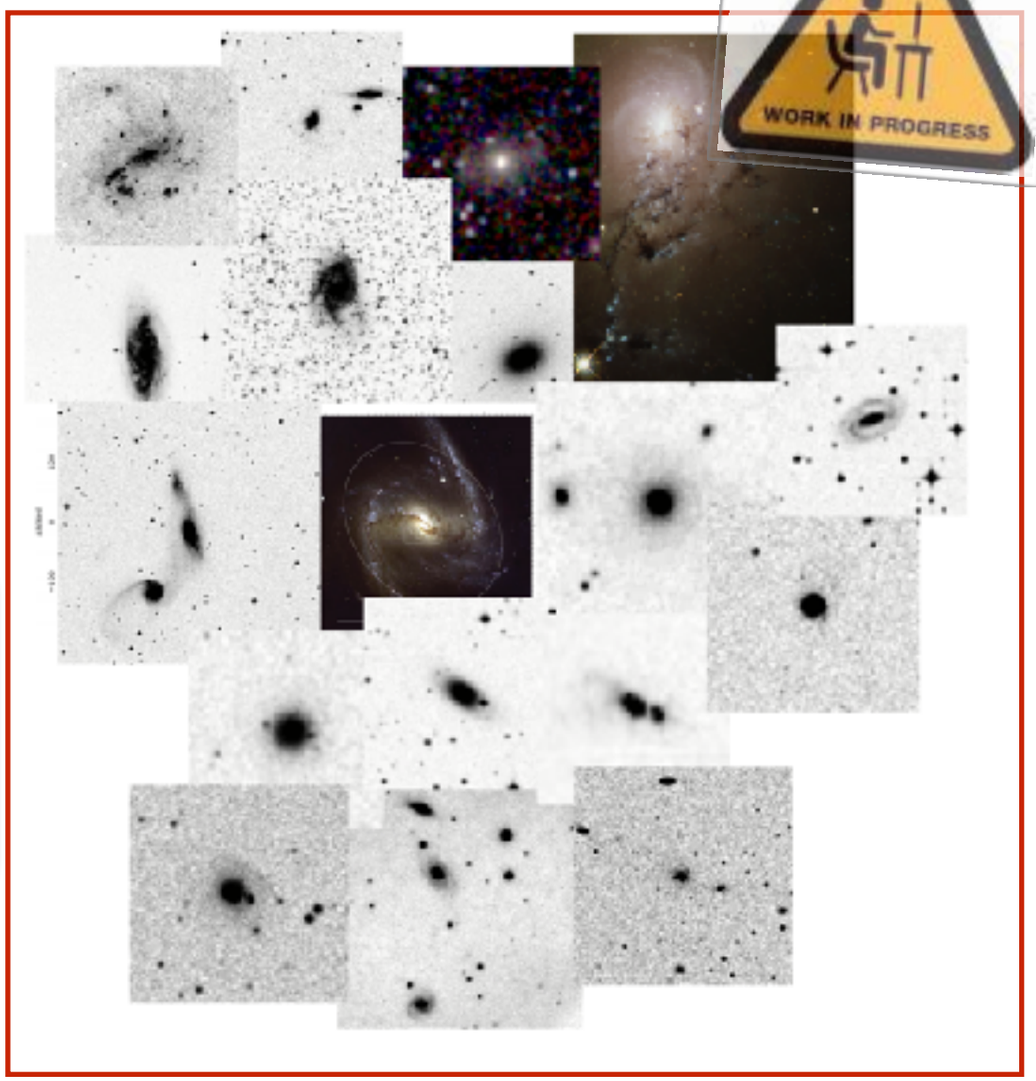
THE SWIFT-BAT SAMPLE

See Onori+17 and F. Ricci 's talk for a complete description of the sample

Local (z<0.1)
low-luminous AGN
both type I and type II



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BH mass measurements

Galaxy strongly visible

Physical parameters from SED-fitting

Luminosity
SFR (from IR and UV)
Stellar Mass
…

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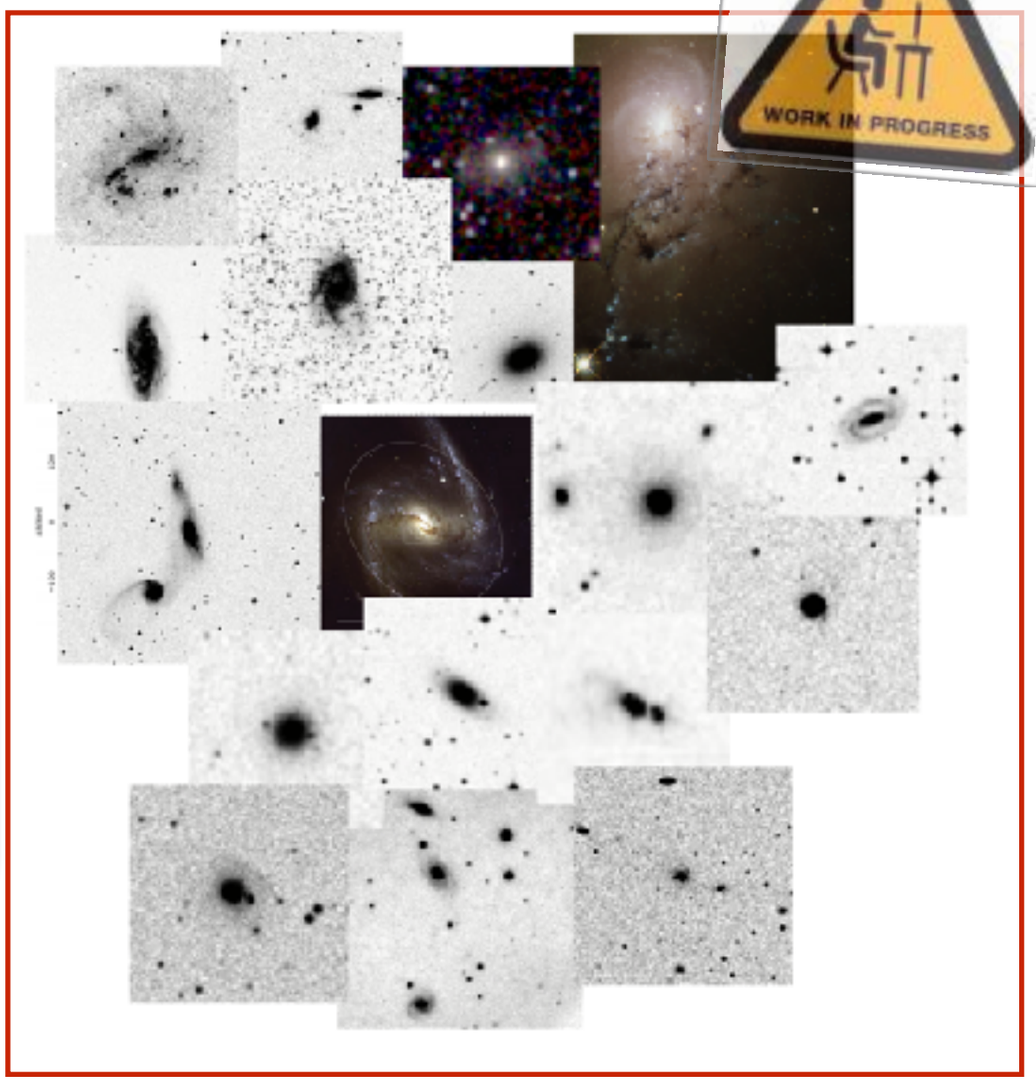

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WE ARE GOING TO POPULATE A COMPLETELY **UN-SAMPLED** REGION OF THE PLANE M_{BH}-M*, GETTING INFOS ABOUT THE BH-GALAXY EVOLUTION

I.High z
Hyper-luminous
TypeI AGN

VS

II.Low z
low-luminous AGN

- Do they talk each other?
- Is there any similarity or do they have opposite properties?
- How do they behave in the context of BH-galaxy co-evolution? Which information do we get from them?

SUMMARY AND FUTURE PERSPECTIVES

The WISSH Quasars are the most luminous QSOs in the Universe :

The best place to hunt for feedback phenomena

★ **Galaxy**'s emission **negligible** in 99% of cases

★ Not standard description of the SED

- MIR additional component required

★ High bolometric luminosities ($L_{BOL} = 10^{47} - 10^{48}$ **erg s^{-1}**)

For the 16 sources with Herschel coverage :

★ Extremely high SFR (**500 – 4000 M_{sun} / year**) even accounting for the AGN contribution : they witness a peculiar phase in the galaxy evolutionary track

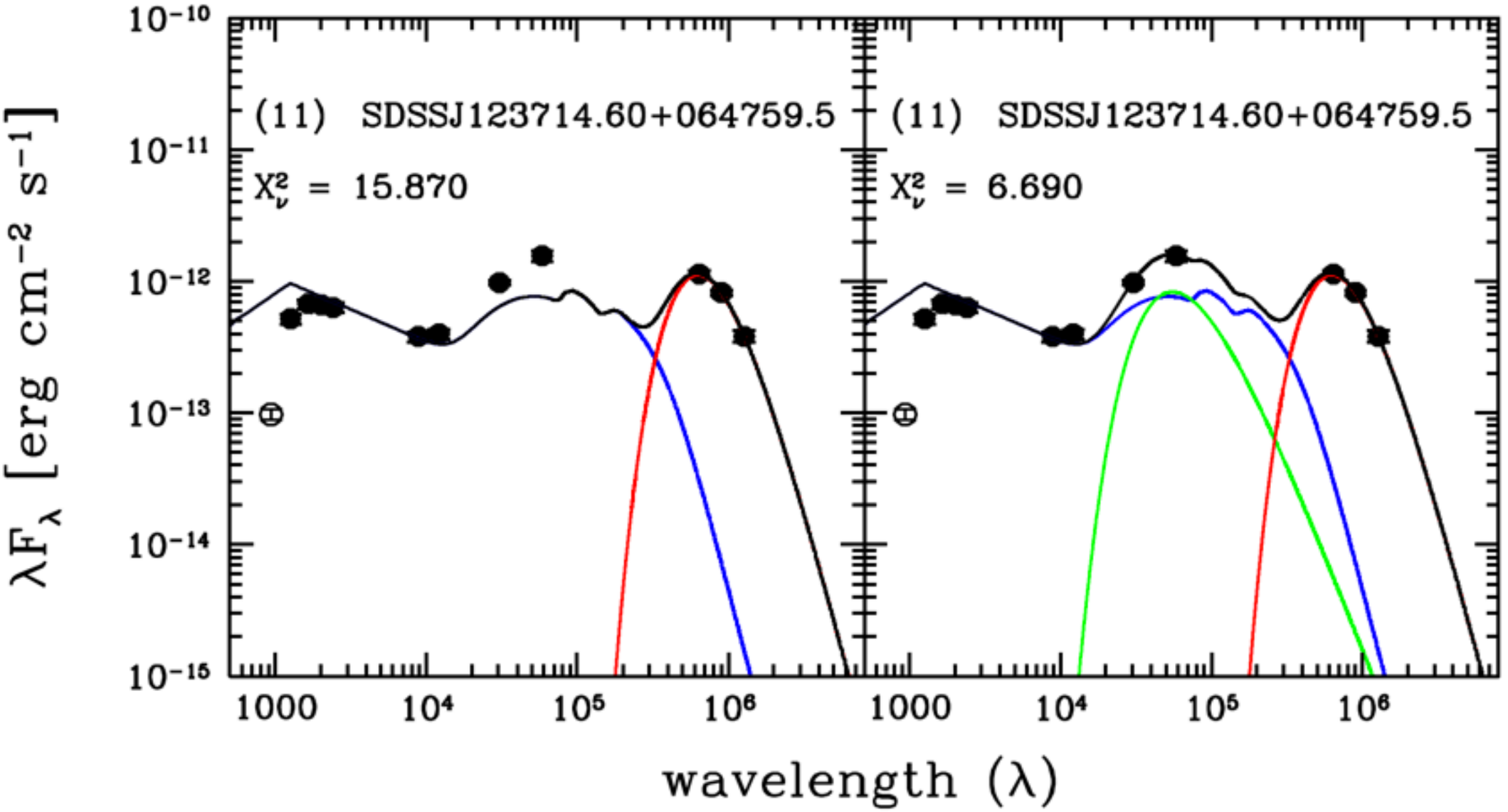
FUTURE WORK :

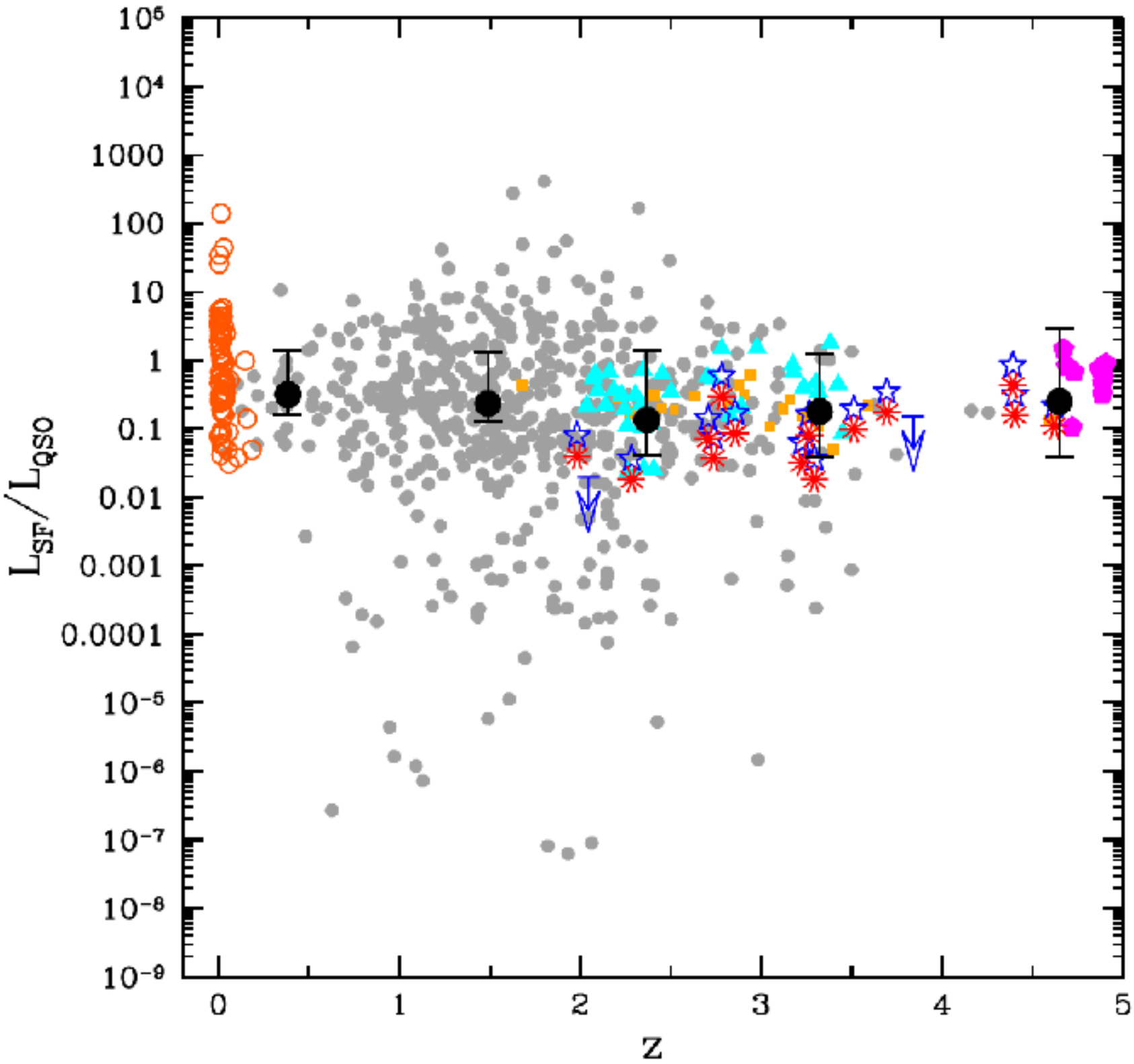
✤ Construction of the mean SED for hyper-luminous QSOs

✤ Correlation between the physical parameters and search for trends, peculiarities

✤ Comparison between high-z / luminosity QSOs and low-z / luminosity QSOs

The additional component increases the goodness of the fit for a factor ~ 5 !!!




10^5
10^4
1000
100
10
1
0.1
0.01
0.001
0.0001
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
L_{SF}/L_{QSO}
0
1
2
3
4
5
z