Hunting gamma-ray blazars and presenting Turin-SyCAT a new catalog of Seyfert galaxies

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2021-09-10 - Via Zoom

Credits of background image: ESO.

Outline

1. Hunting Blazars

2. The Turin-SyCAT

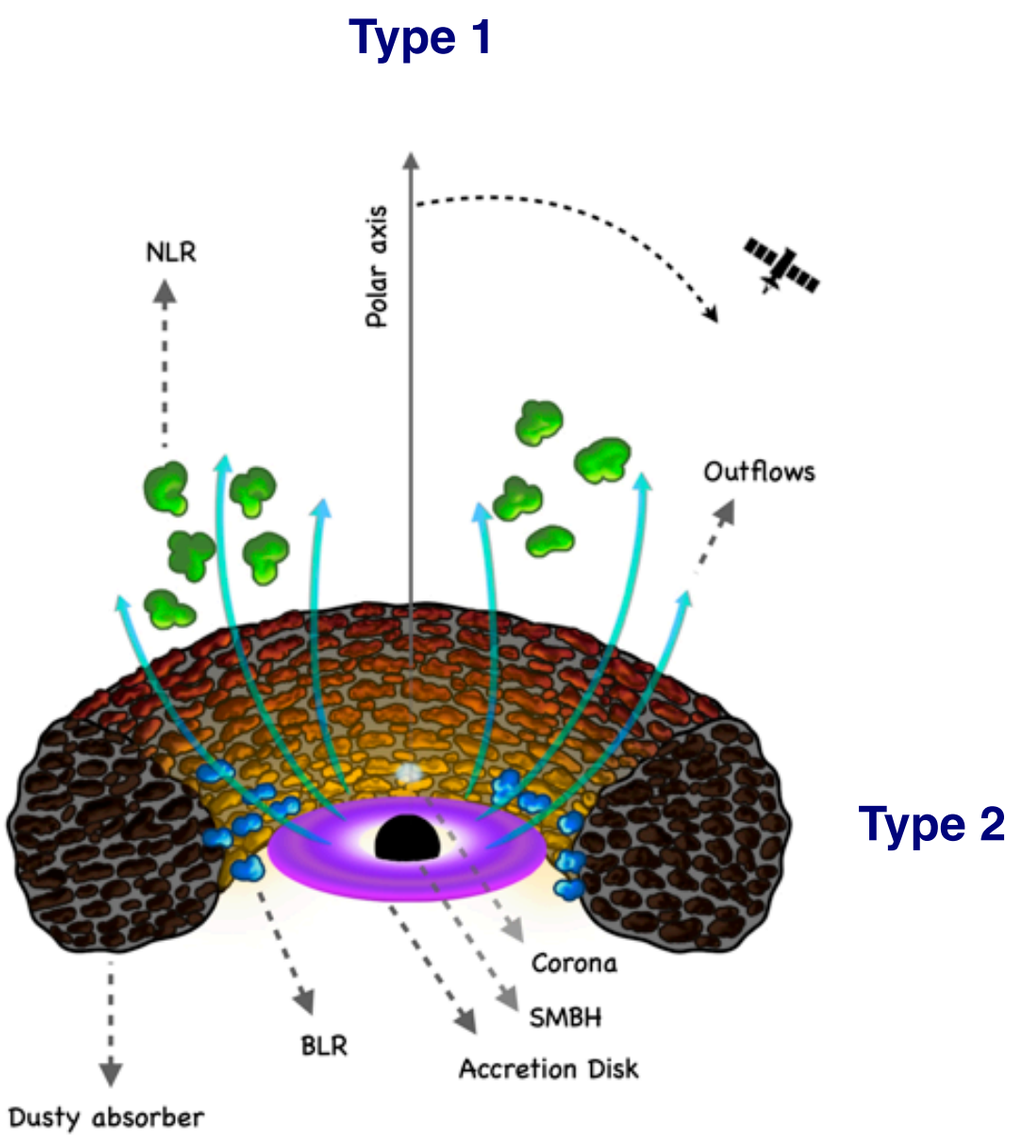
3. The Large-scale environment of Seyfert galaxies

Active Galaxies

Unification Schemes of Active Galactic Nuclei

Non-jetted or radio-quiet AGNs

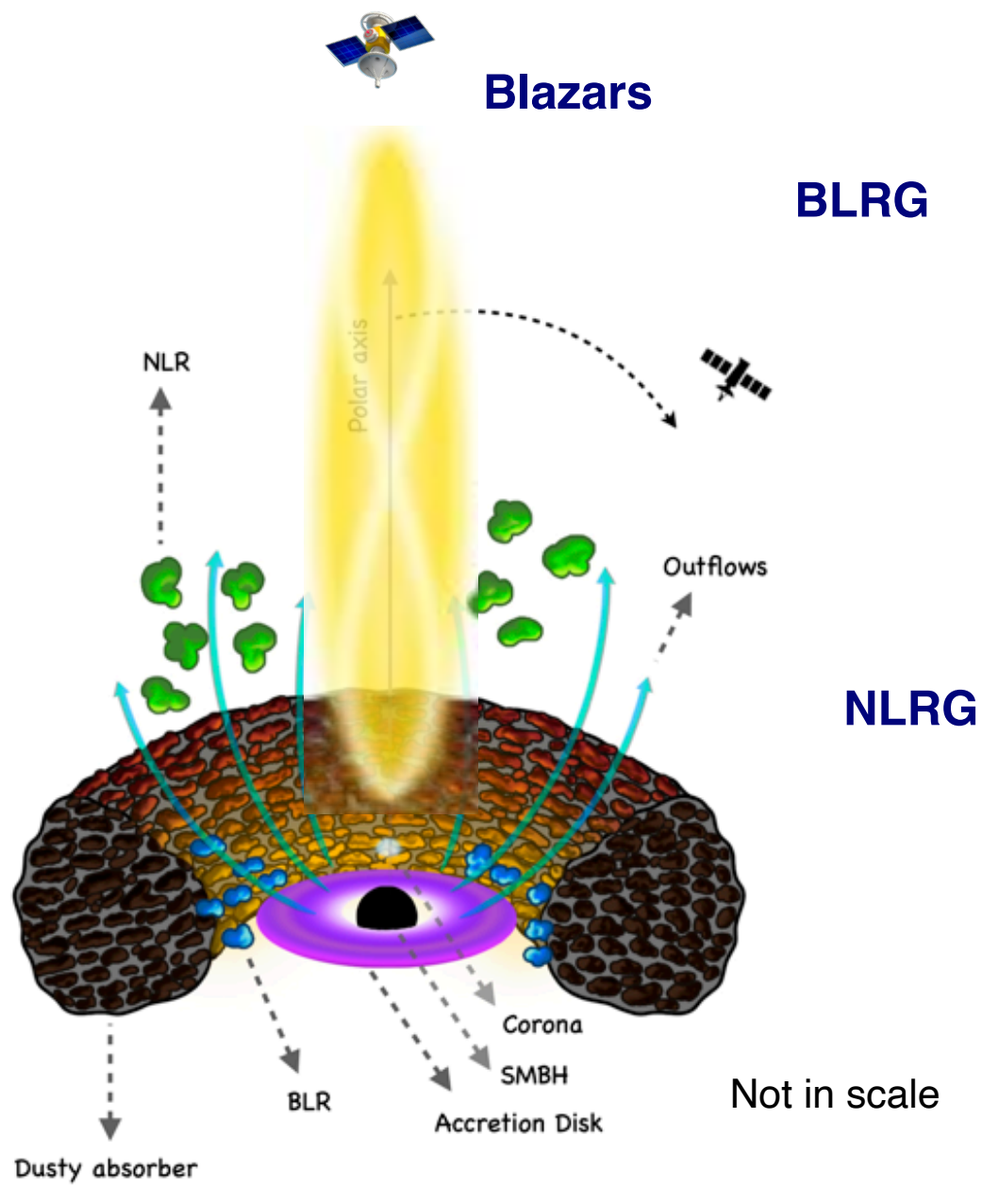
Seyfert 1 and 2



Jetted or radio-loud AGNs

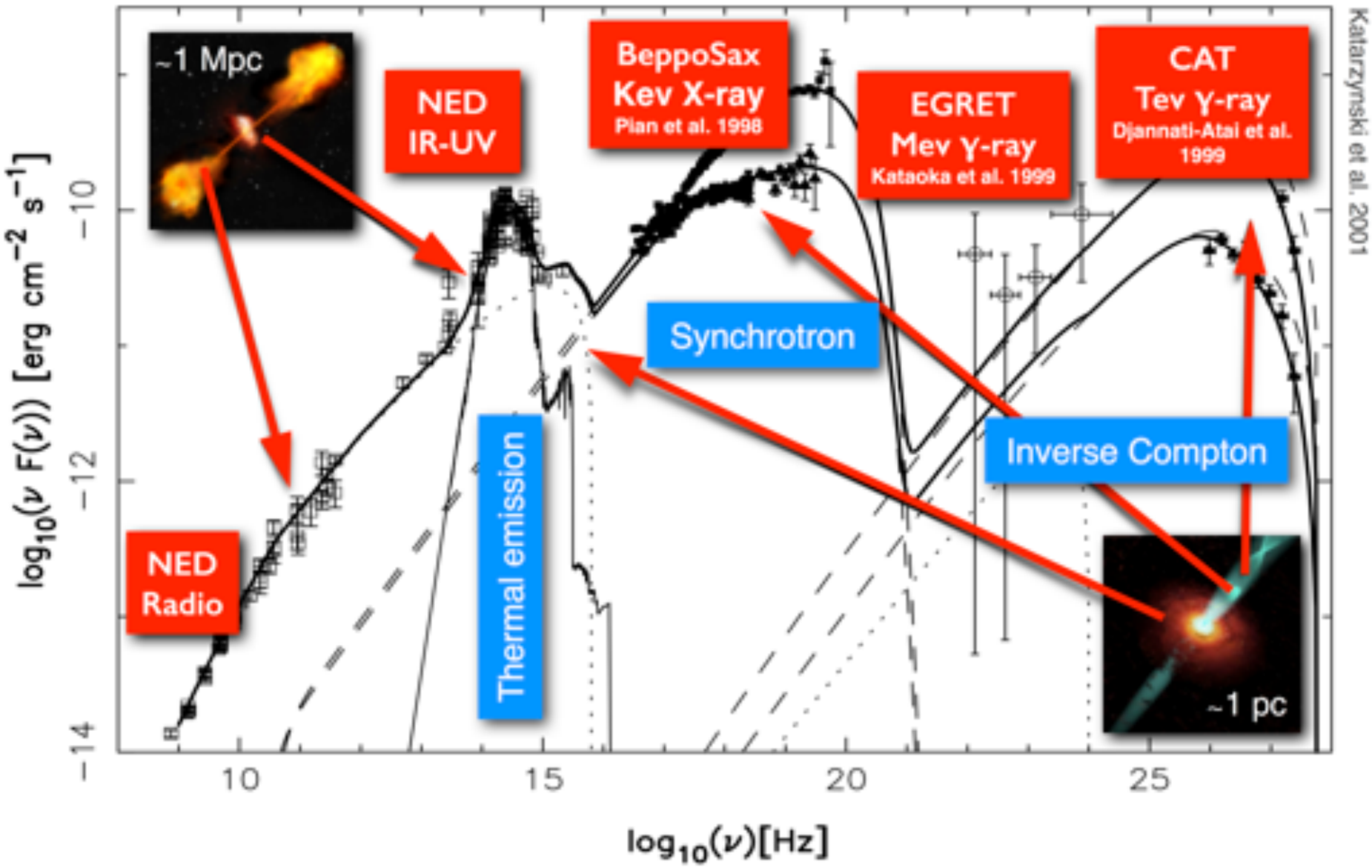
Blazars:

Small angle between the jet and LOS



Urry & Padovani, (1995)

Hunting blazars

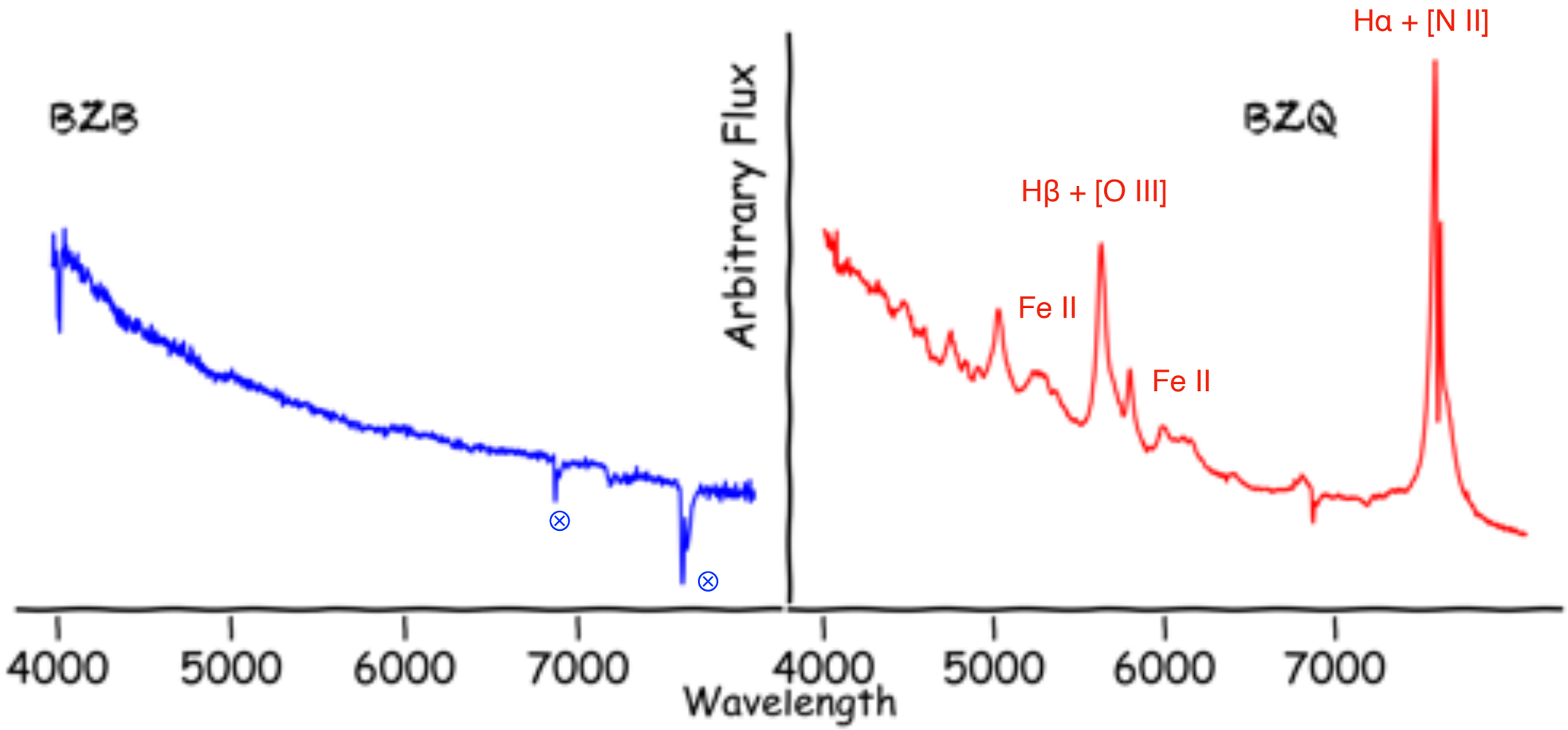


Spectral Energy Distribution (SED) of BL Lac Mrk 501.
Two bumps:

- Low-energy bumb: synchrotron emission
- High-energy bumb: inverse Compton

Hunting blazars

Blazars



BL Lac (BZB): Weak emission lines, EW<5 Å.

FSRQ (BZQ): Intense emission lines

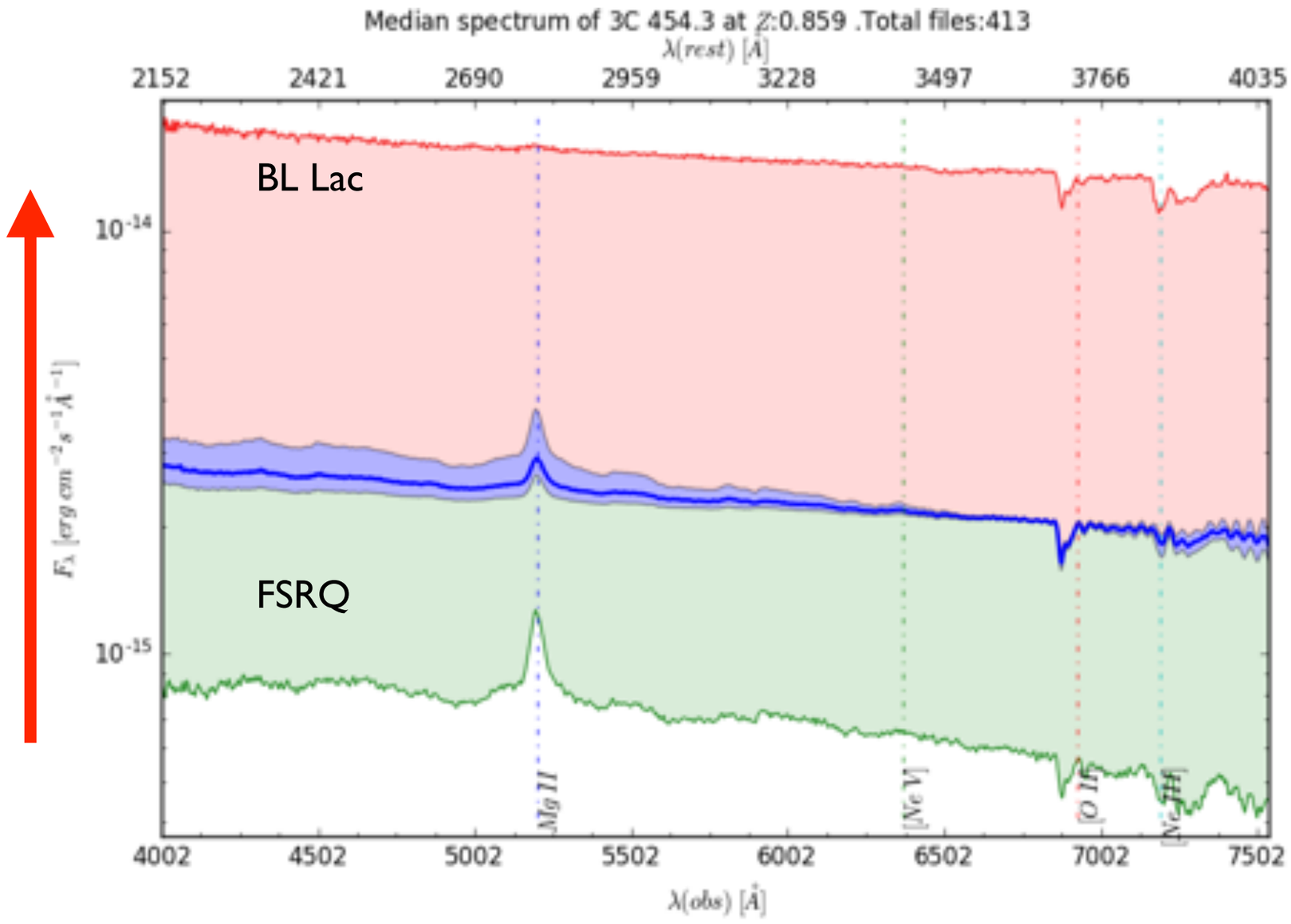
Hunting blazars

Spectral variability

- FSRQ to BL Lac

Changing look blazars!

Continuum

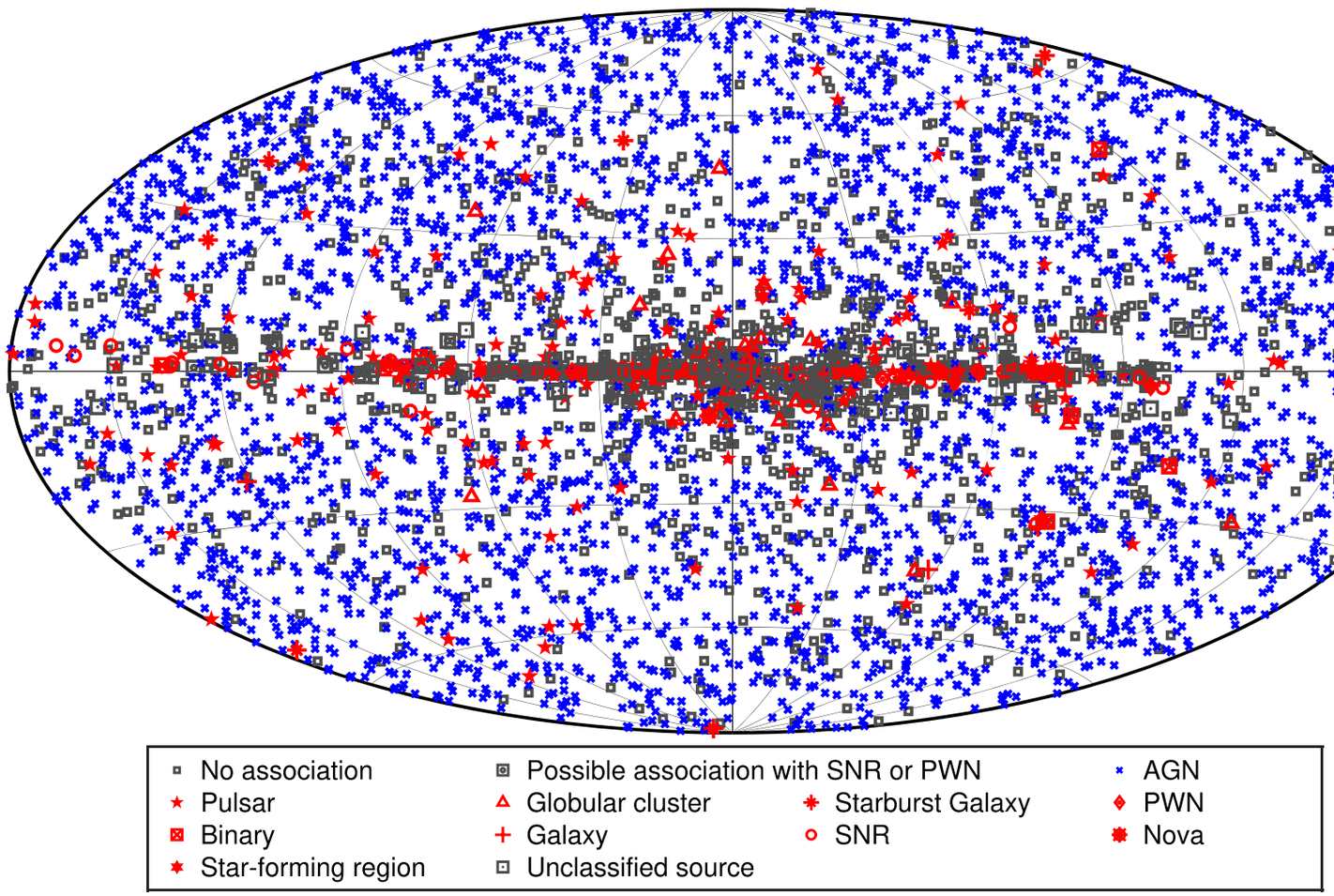


Acosta-Pulido et al. 2017

Hunting blazars

Despite of being the **rarest class** of **AGNs**, **Blazars** are the **dominant** source of the **extragalactic** gamma-rays **sky**.

In the 4FGL **Blazars** are **~91 % associated sources** (3070/3370)



Class	Identified	Associated
BL Lac	22	1109
FSRQs	43	651
BCUs	2	1310
Total 4FGL	358	3370

Abdollahi et al. 2020

Hunting blazars

In ***Fermi*-LAT** Catalogs there are sources with uncertain nature or no association**:**

- Blazar Candidates of Uncertain type (**BCU**)

Show **multifrequency behavior** similar to blazars but **lacking** optical **spectra** in the literature. Or the **quality** of such **spectra** is too low to confirm their nature.

- Unidentified/Unassociated gamma-ray sources (**UGS**):
  - **43** % of 1451 in 1FGL (Abdo et al. 2010)
  - **31** % of 1873 2FGL (Nolan et al. 2012)
  - **33** % 3033 in 3FGL (Acero et al. 2015)
  - **26** % 5064 in 4FGL (Abdollahi et al. 2020)

Total 4FGL	5064
Identified	358
Associated	3370
Unassociated	1336

My contribution: to reduce this fraction!

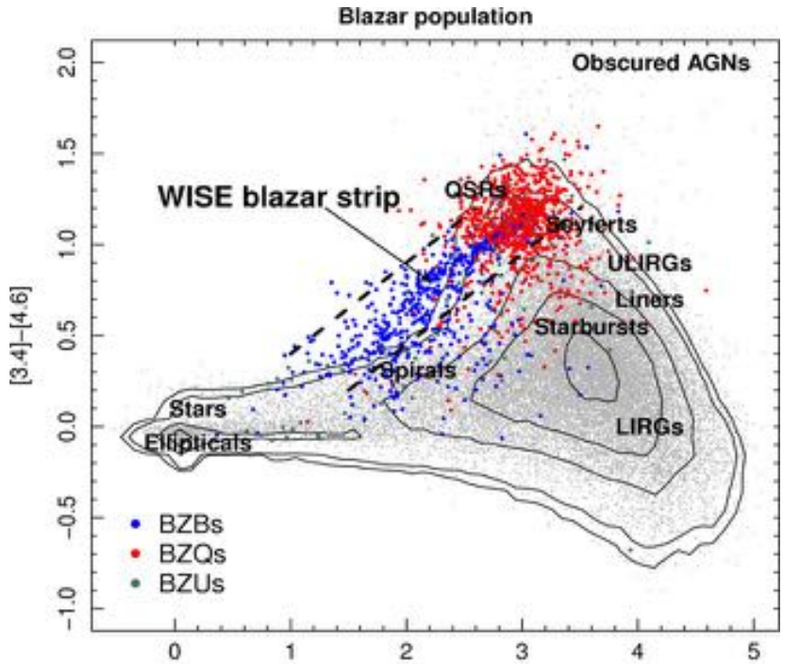
The necessity of **methods** for finding UGS counterparts.

The **number of UGSs** is still an **unresolved** issue!

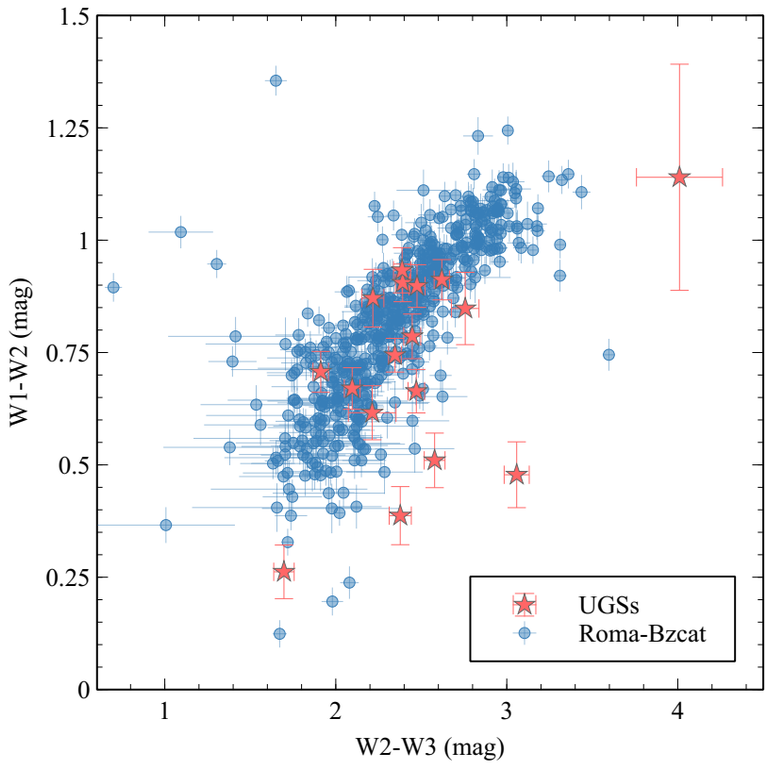
Hunting blazars

Using **Roma-BzCAT** it was discovered the WISE **blazar strip** [3.4]–[4.6]–[12] μm color–color diagram.

- This trend is not visible using other catalogs (e.g., Vèron-Cetty 2010)
- It was possible thanks to the homogeneous sources selection of Roma-BzCAT, i.e., a **clean** catalogue of blazars.



Massaro et al. 2011



Peña-Herazo et al. 2019

Hunting blazars

Finding the UGSs counterparts:

- **Surveys Compact Radio emission**, of UGSs in Fermi-LAT catalogs (Petrov et al. 2013, Schinzel et al. 2015)
- **Surveys Flat radio spectra**, surveys of 2FGL objects (Nori et al. 2014, Giroletti et al. 2016)
- Follow up with **X-rays** Swift, Suzaku, XMM-Newton, and Chandra (Paggi et al. 2013, Takeuchi et al. 2013, Acero et al. 2013, Marchesini 2020)
- **Gamma-ray blazars** locus in a distinctive **region** in the **color-color diagram** separated from other extragalactic sources. **WISE** gamma-ray **strip**.

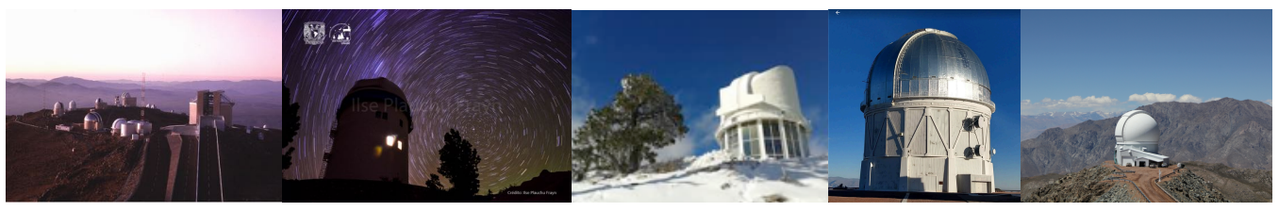
Optical Spectral Classification

To provide **unambiguous** confirmation is necessary to observe the candidates with **optical spectroscopy**.

Hunting blazars

Optical Campaign

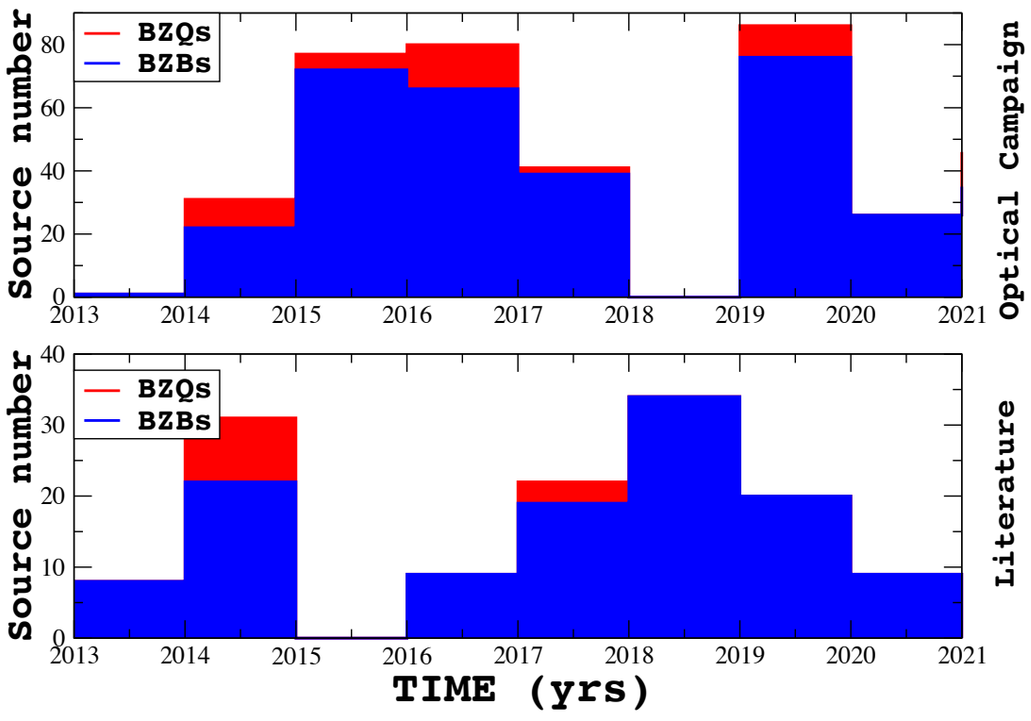
- **Unveil** the nature of Unidentified/Unassociated gamma-ray sources (**UGSs**) in Fermi/LAT catalogs;
- Confirm the **blazar** nature and find redshift estimation of **BCUs**, already associated in Fermi/LAT catalogs.
- Using 2 and 4 m class telescopes



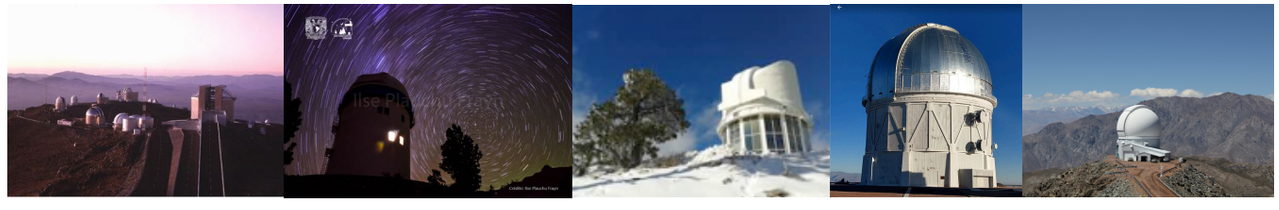
Credits: ESO, OAN-SPM,
OAGH-INAOE, OAN-SPM
Ilse Plauchu Frayn, SOAR

Hunting blazars

Optical Campaign



- In 2018 I joined a campaign we analyzed 456 unique targets confirming the blazar-like nature of 433.
- We classified 333 BL Lacs (58 with a firm redshift measurement), 51 FSRQs, and 49 BZGs.
- We collected 112 from archival observations from large spectroscopic surveys (SDSS and LAMOST).

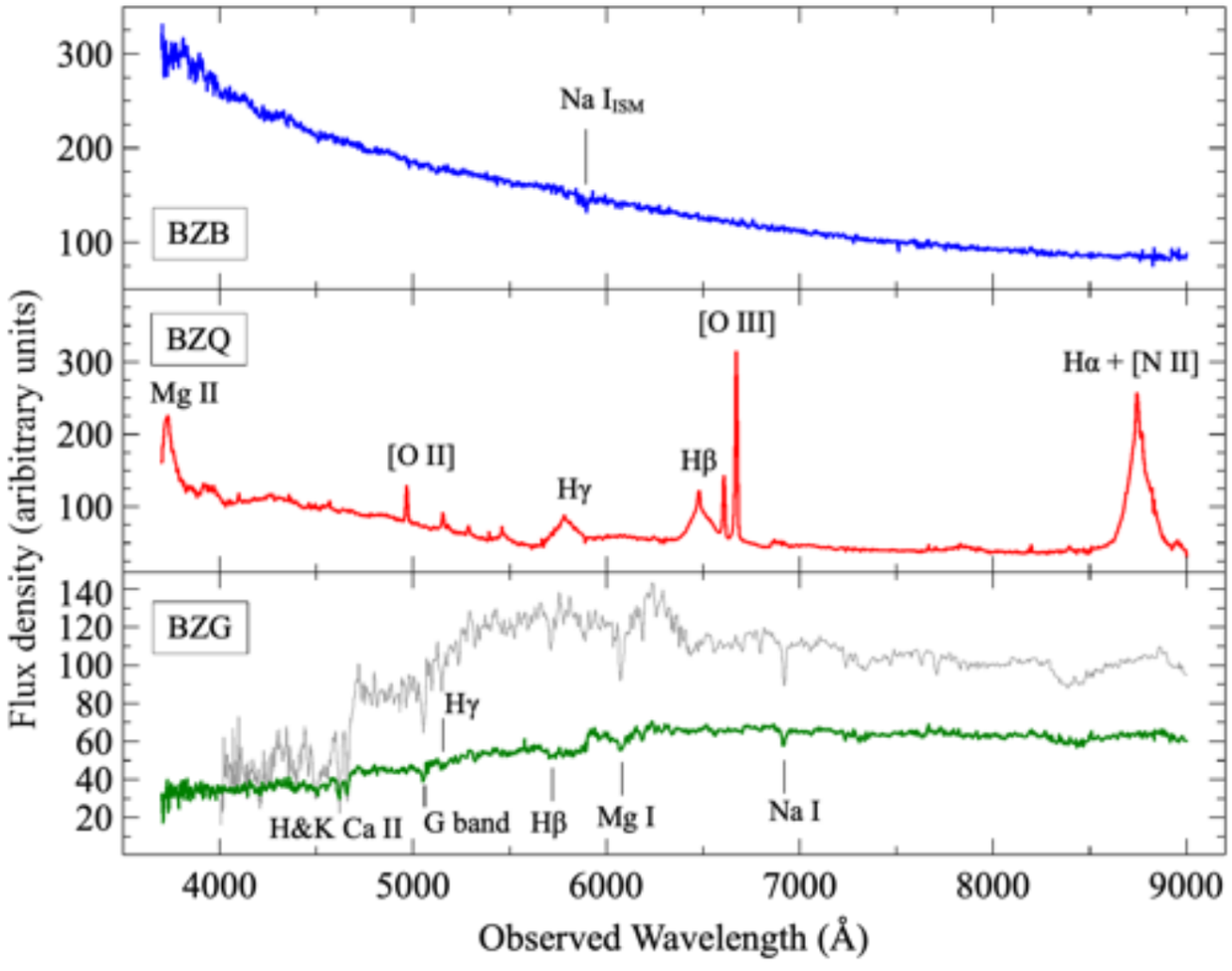


Credits: ESO, OAN-SPM, OAGH-INAOE, OAN-SPM Ilse Plauchu Frayn, SOAR

Peña-Herazo et al. 2021c

Hunting blazars

LAMOST



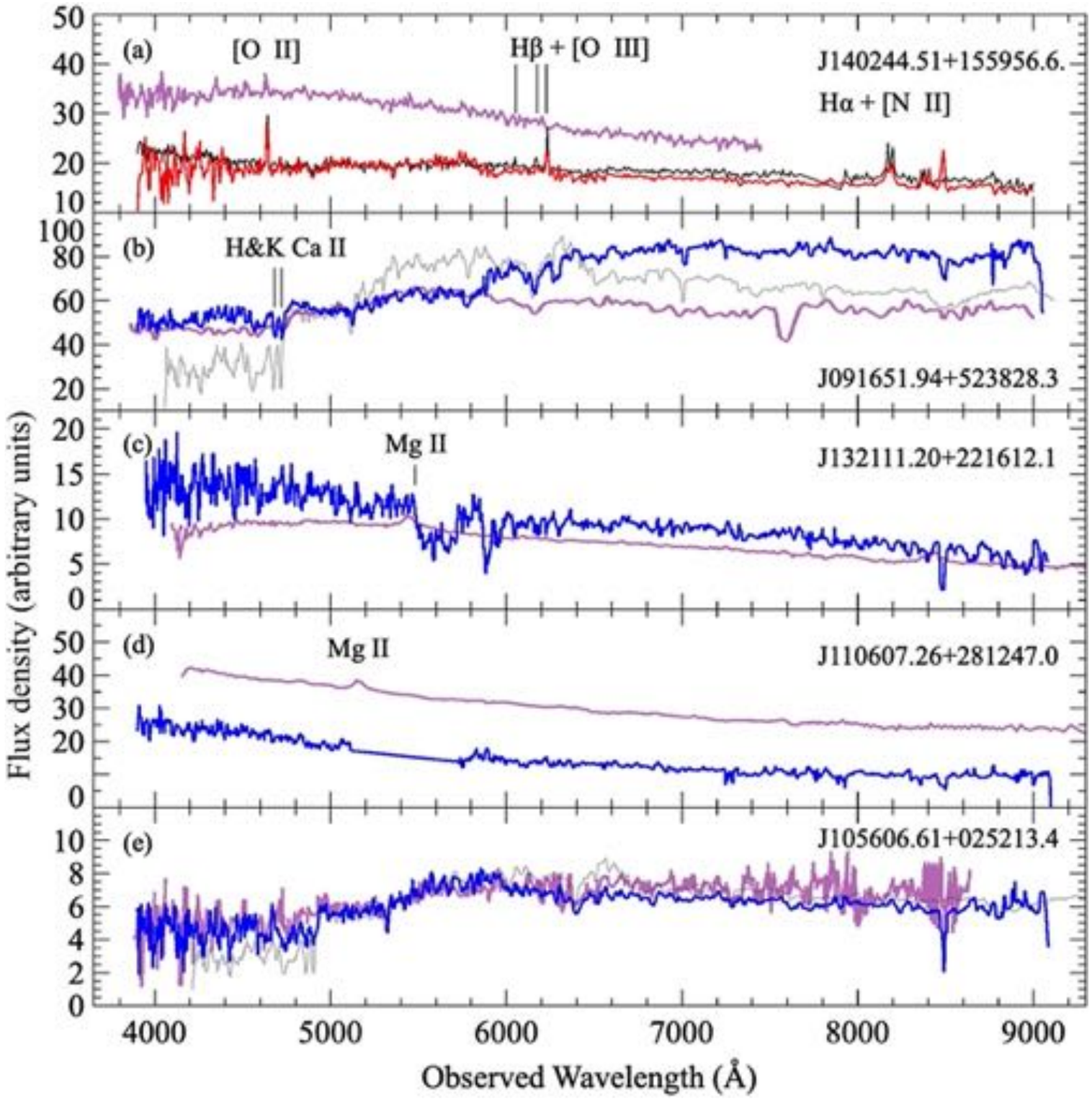
Peña-Herazo et al. 2021a, 2021b

- We confirmed the blazar nature of 24 BCUs.
- Obtained 15 new redshift measurements.
- Reported 26 sources as potential changing-look blazars.

The Large Sky Area Multi-Object Fibre Spectroscopic Telescope (LAMOST). Credit: Paul Hilscher.

Hunting blazars

Changing look blazars?

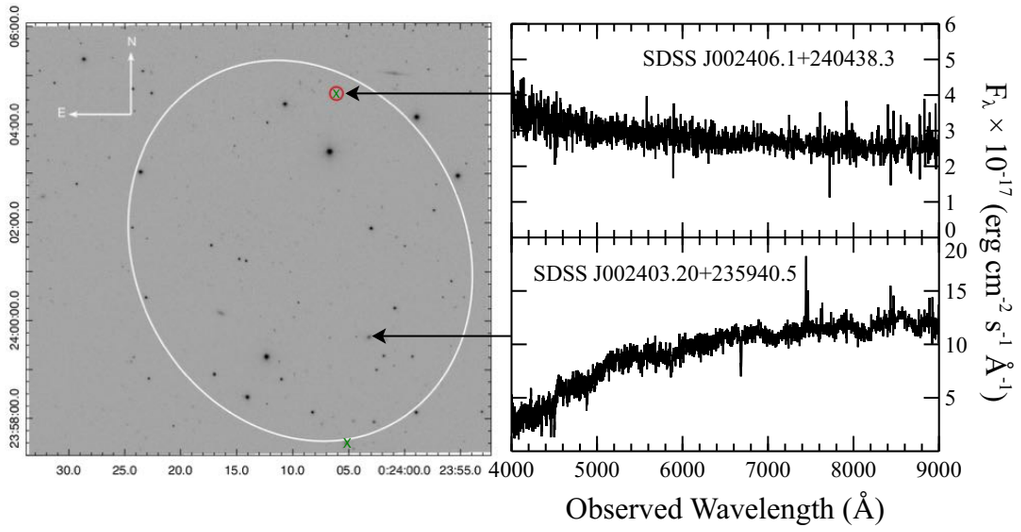


Peña-Herazo et al. 2021a

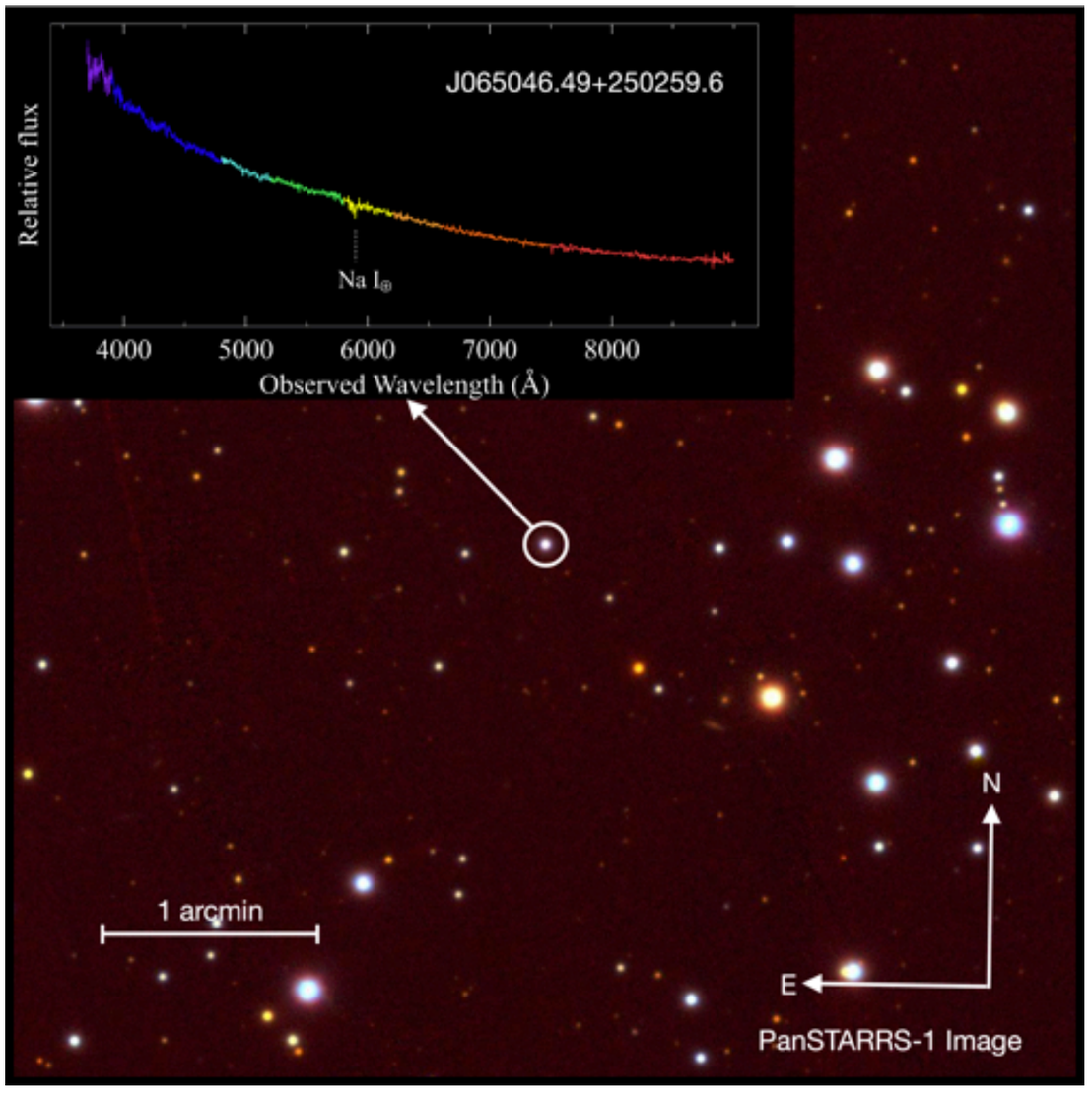
Hunting blazars

Blind search in LAMOST

Search for BL Lacs in the uncertainty ellipse of UGSs



Peña-Herazo et al. 2019



NAOC press release in preparation

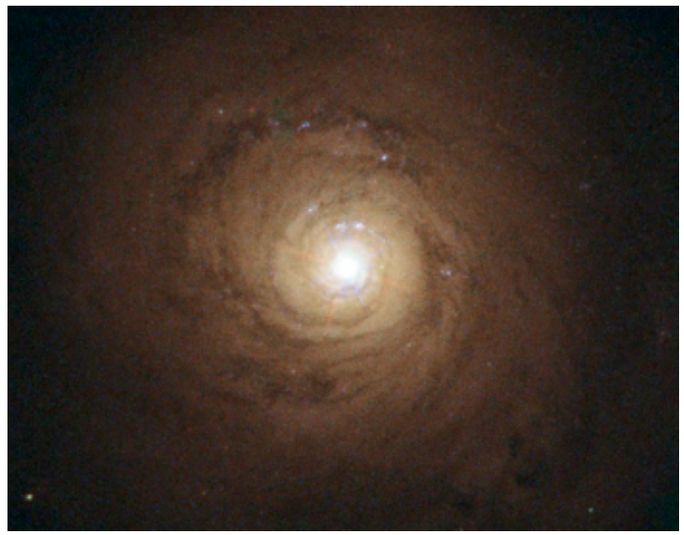
Hunting blazars

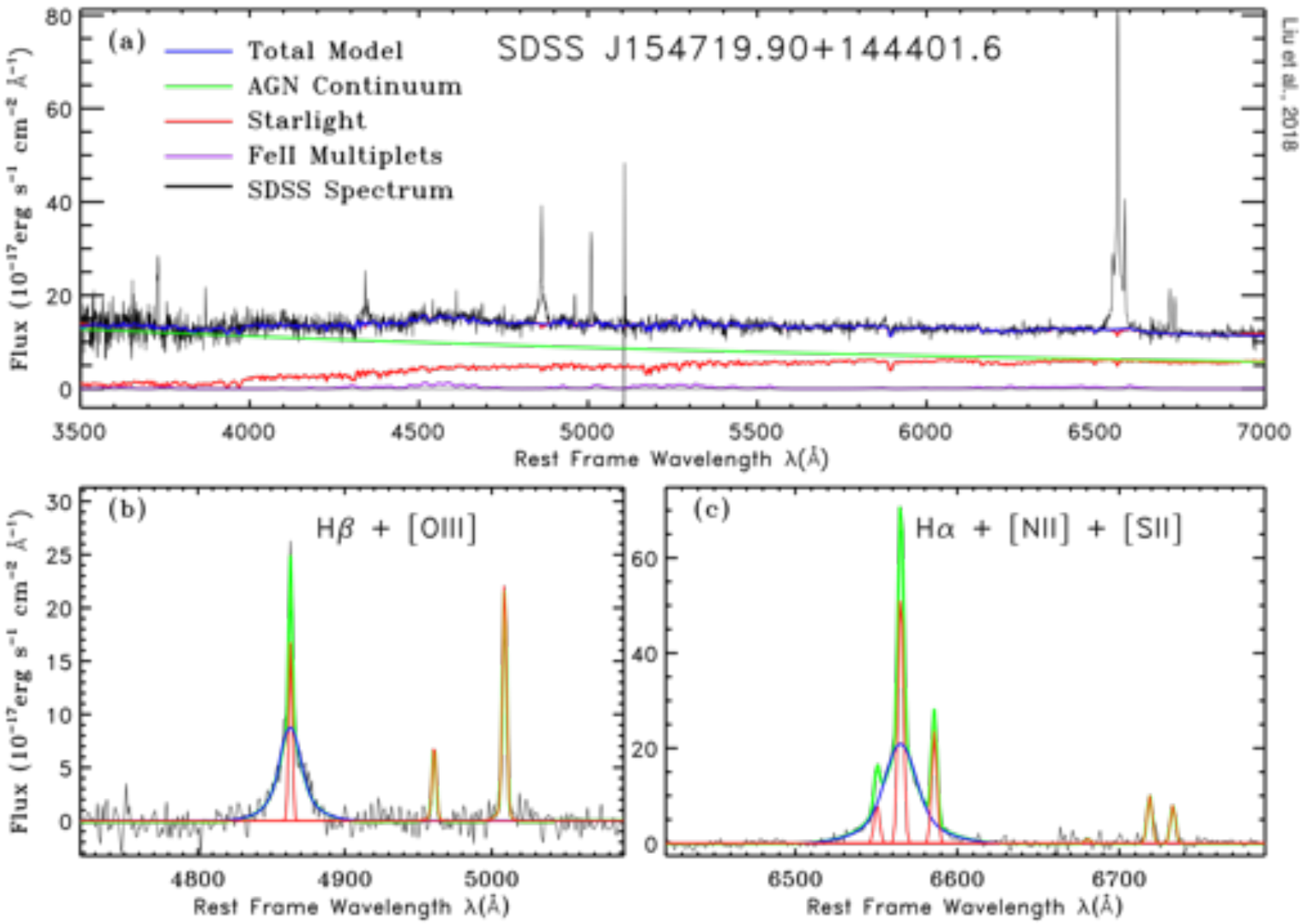
The optical spectroscopic follow up still on going.

- During 2021 I acquired new 62 spectra.
- 19 more nights, twice per year ~ **1/3** of BCUs in 4FGL. Upcoming observing nights: **OAN-SPM, SOAR, Blanco, and KPNO** thanks **Fermi-NOAO** Cooperative Agreement and **CNTAC**.
- Blind search for BL Lacs with **LAMOST.**
- Sources will be used in Roma-BzCAT v6.

Seyfert Galaxies

NGC 5548, 0.48x0.38 arcmin.
Credits: HST, NASA and ESA.

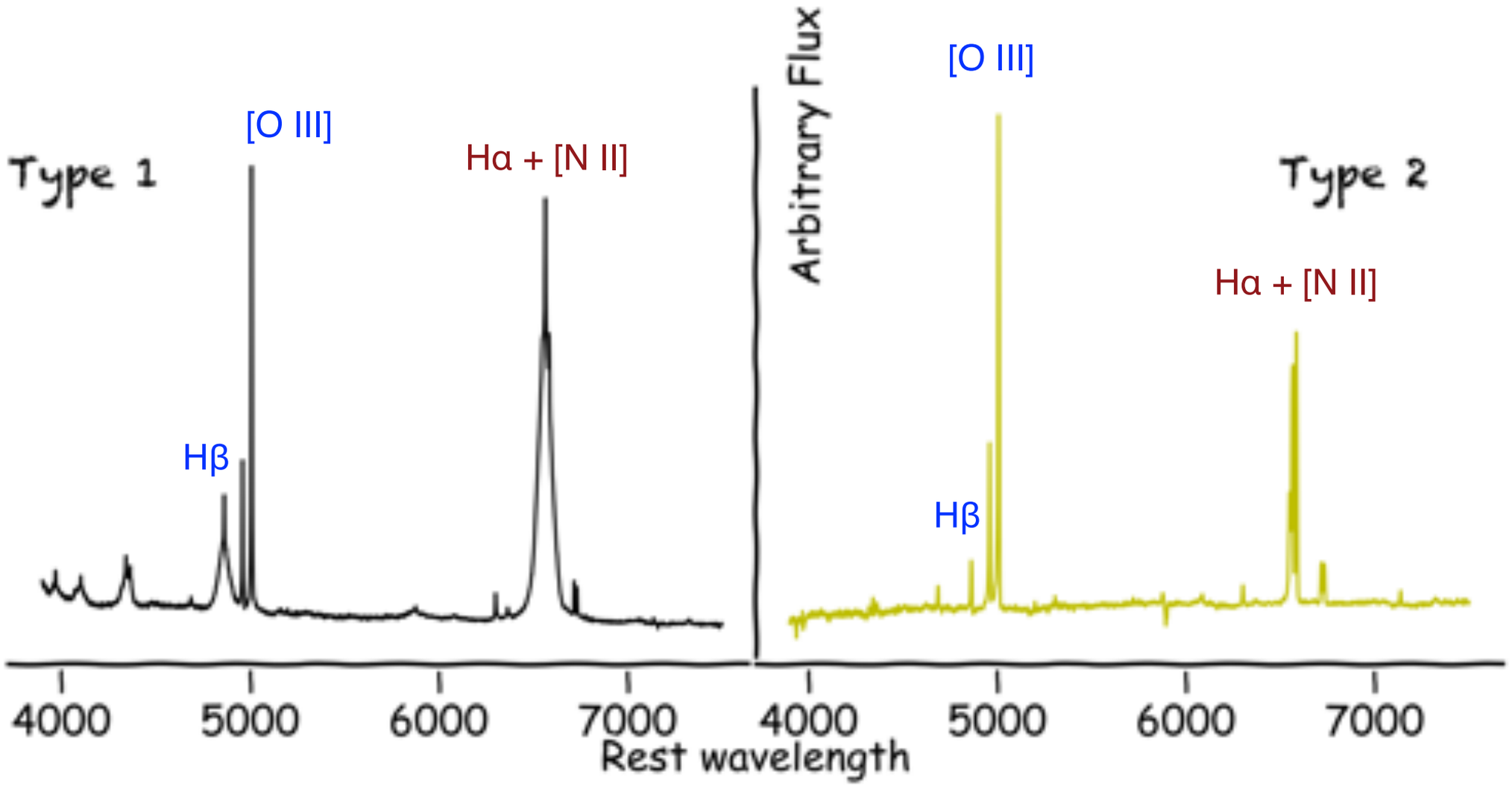




Seyfert galaxy (usually a spiral) with a high surface brightness core that reveals unusual emission lines (Seyfert 1943, Kraemer & Crenshaw 2000).

Nebular emission lines: Balmer, [O I], [O II], [O III] [N II], [S II]

By emission lines: Khachikian & Weedman (1974)



Broad Component:

FWHM ~1000 — 20000 km s^{-1}

Narrow Component:

FWHM ≲900 km s^{-1}

Detection of **broad emission lines** in **polarized** spectrum of a type 2, NGC 1068

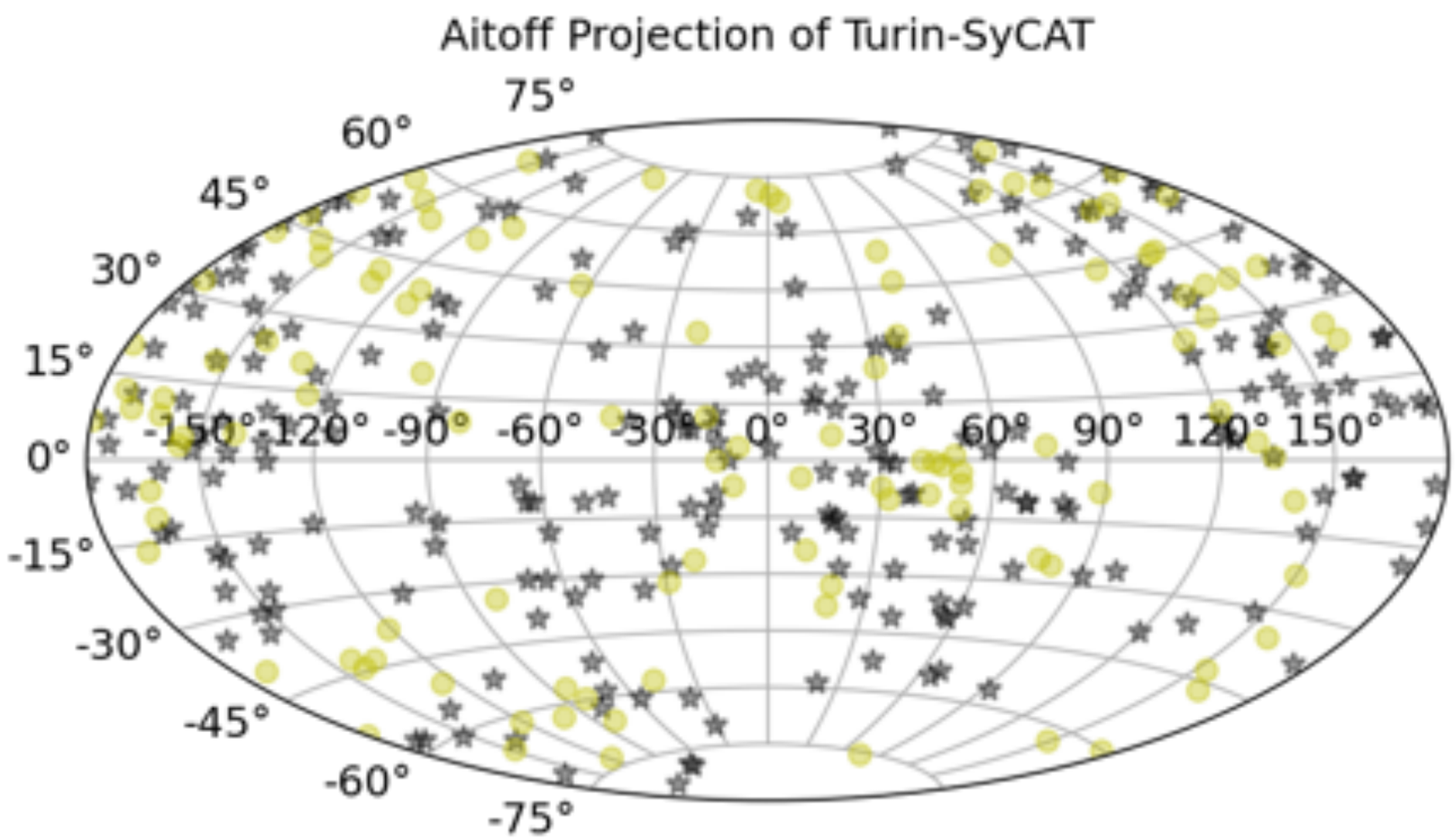
Turin-SyCAT

Based on the previous use of other clean catalogs (like Roma-BzCAT).

- Create a **clean** (i.e. with robust selection) catalog of **Seyfert** galaxies. Several other catalogs include are contaminated with other type of AGNs.
- Study **statistically** the Turin-SyCAT sample
- Study the large scale **environment** of Turin-SyCAT sample

Turin-SyCAT

- I selected **351** Seyfert galaxies fulfilling the selection criteria
- Image of their spectra
- **Counterparts** and multi-frequency properties (radio, infrared, optical, and X-rays)

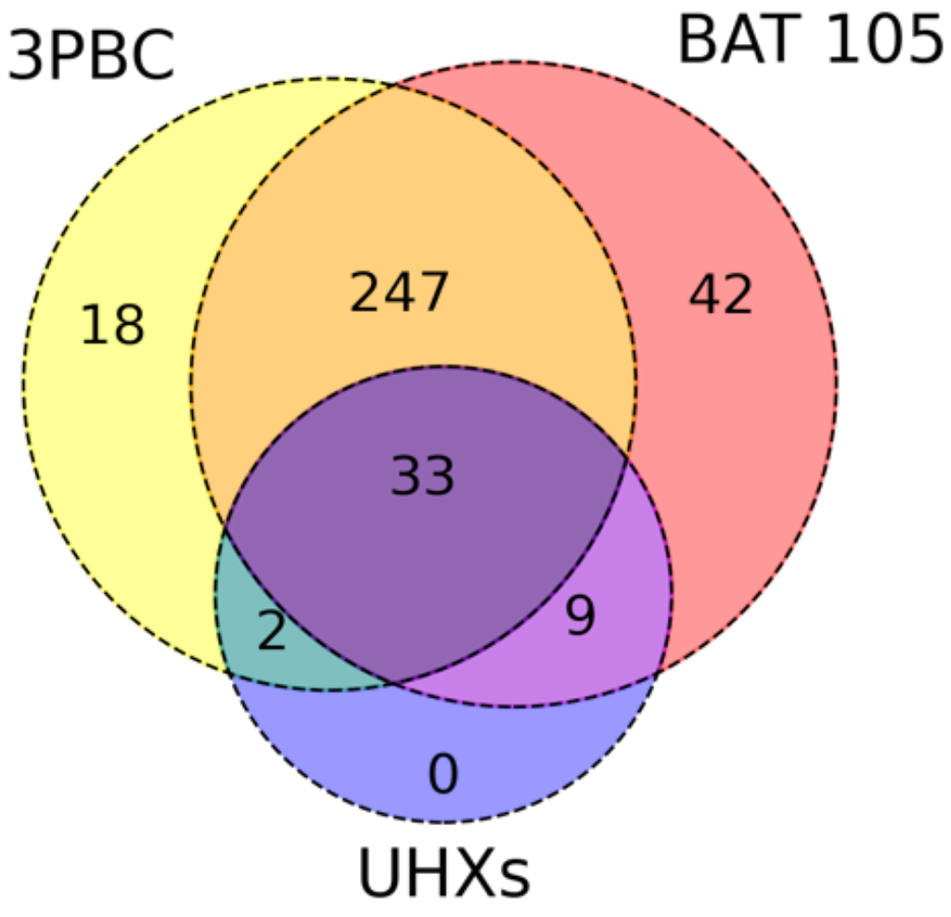


Peña-Herazo et al. 2021d accepted in A&A

Turin-SyCAT

Catalog	Total sources	Seyfert galaxies	Targets identified	+UHXs
3PBC	1593	520	265	300
BAT105	1632	827	289	331

- The 3rd release of the Palermo BAT source catalog (3PBC, Cusumano et al. 2010)
- The BAT 105 months survey (Oh et al. 2018)
- Optical spectroscopic campaign of Swift-BAT and INTEGRAL unidentified hard X-rays sources (UHXs, Masetti et al. 2004)



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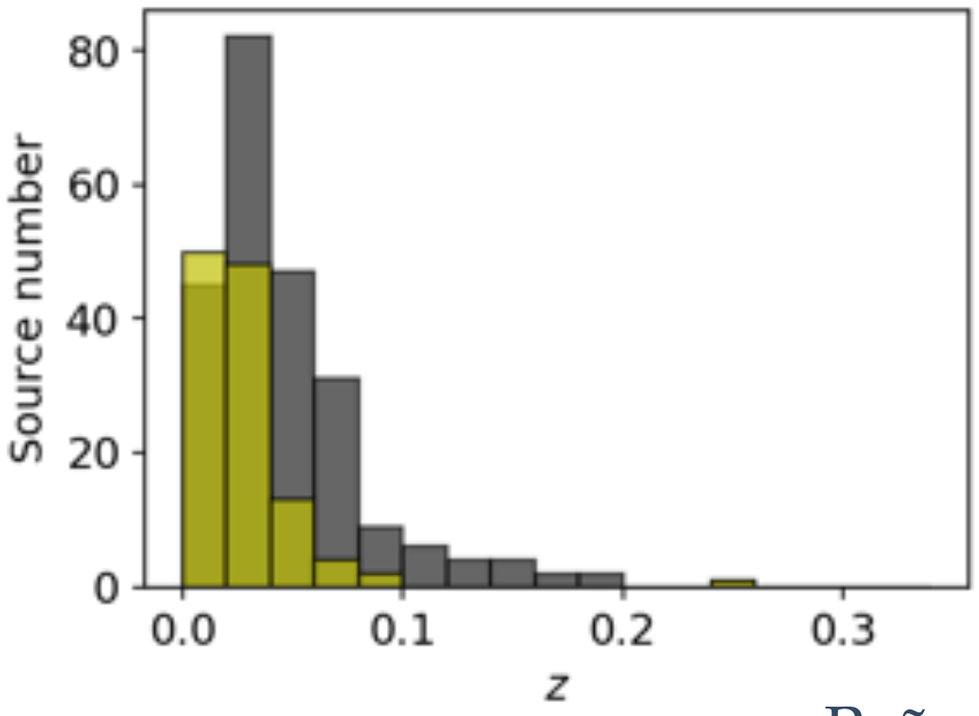
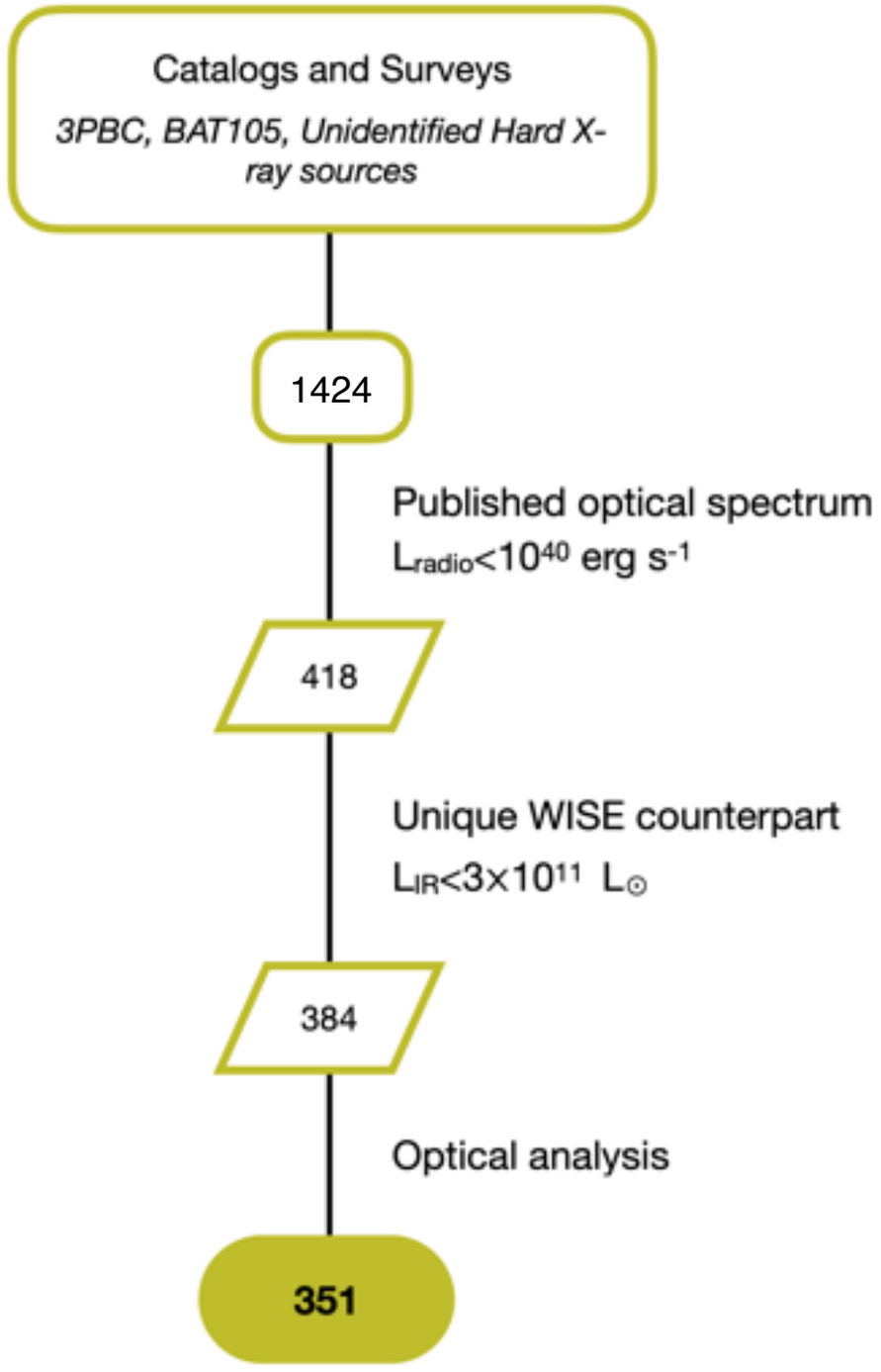
Turin-SyCAT

Using the following selection criteria:

1. **Existence** Seyfert like optical **spectrum**, in literature.
2. Radio luminosity lower than $\mathbf{10^{40}}$ erg s^{-1} whenever has a radio counterpart belonging to one of the major radio surveys, namely: NVSS, FIRST and SUMSS
3. A **mid-IR counterpart** listed in the AllWISE Source catalog.
4. Exclude nearby quasars by cutting $\mathbf{L_{3.4\mu m} < 10^{11}}$ $L_\odot$





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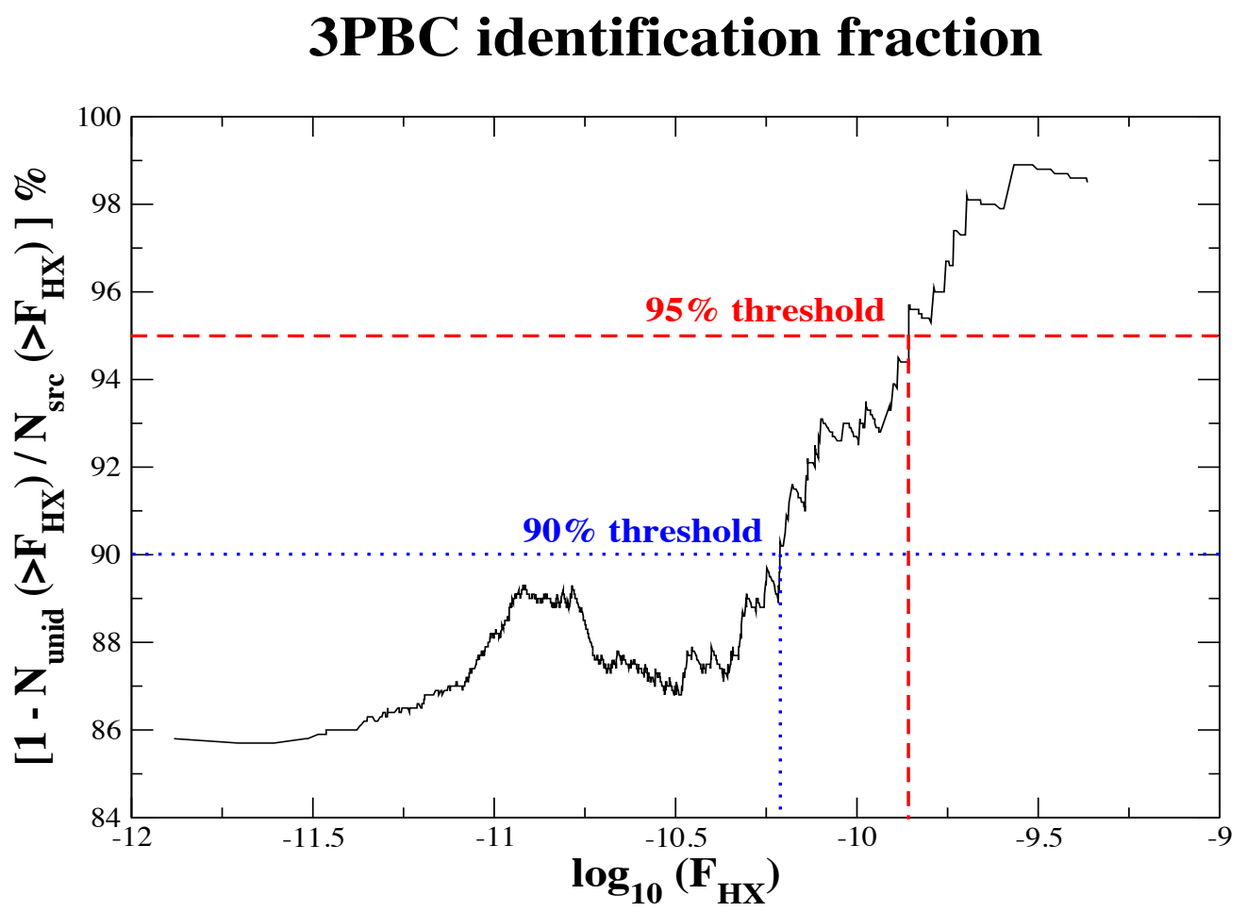
Turin-SyCAT

Flux limited samples at 90% and 95 %

identification fraction in 3PBC



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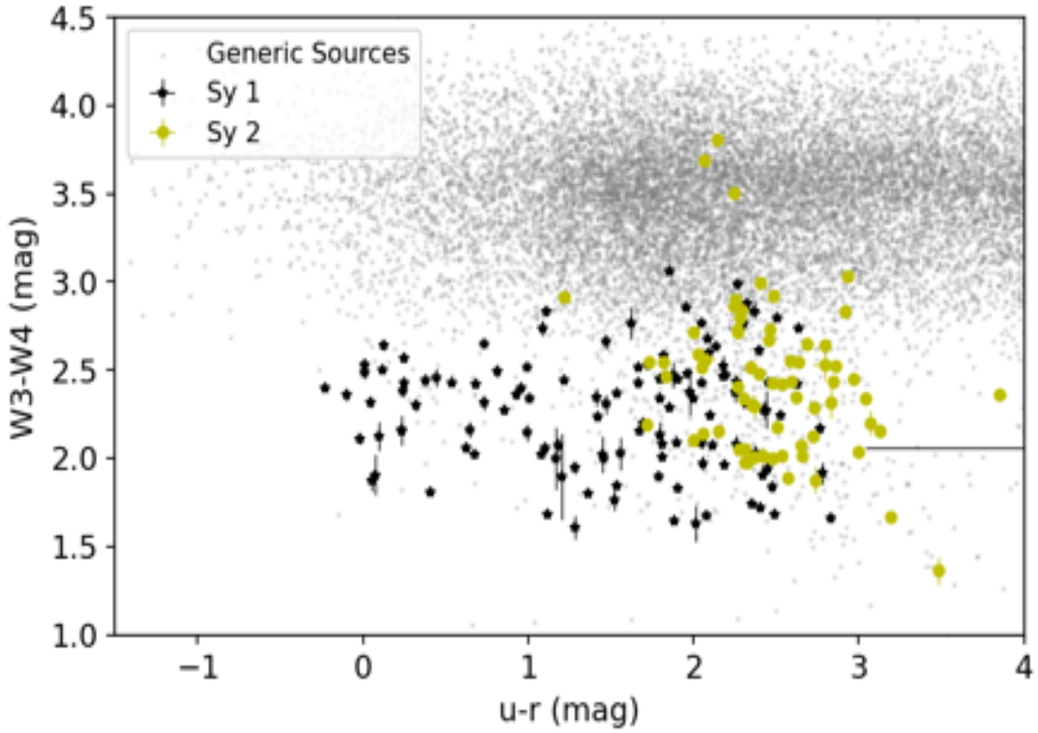
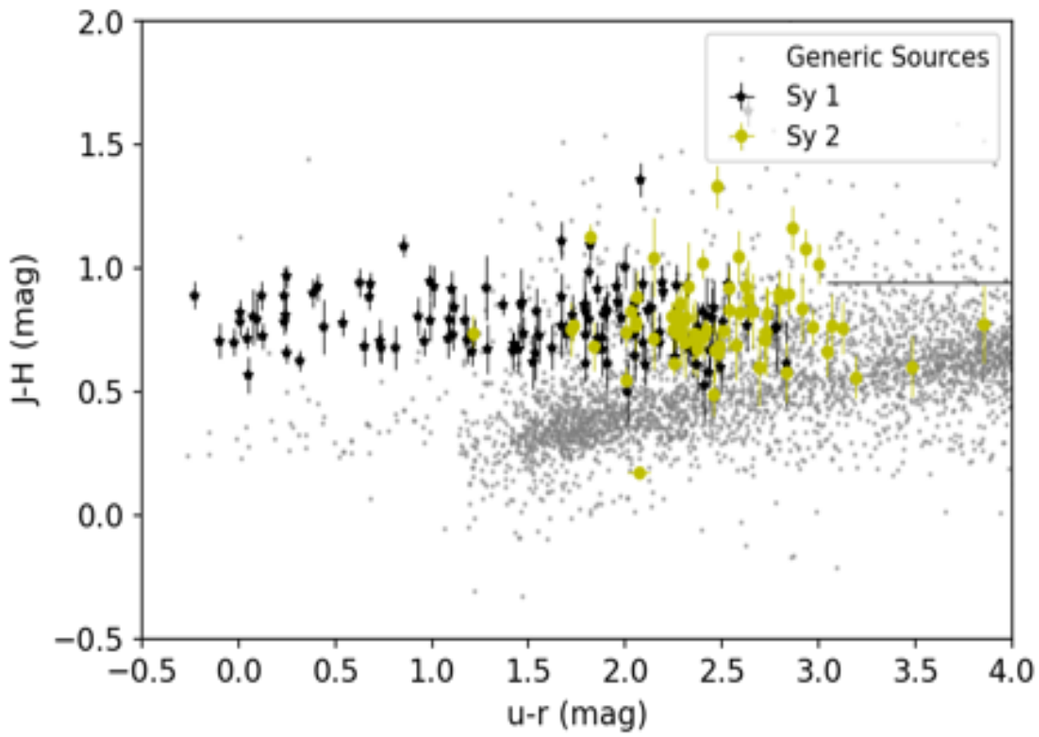
Turin-SyCAT





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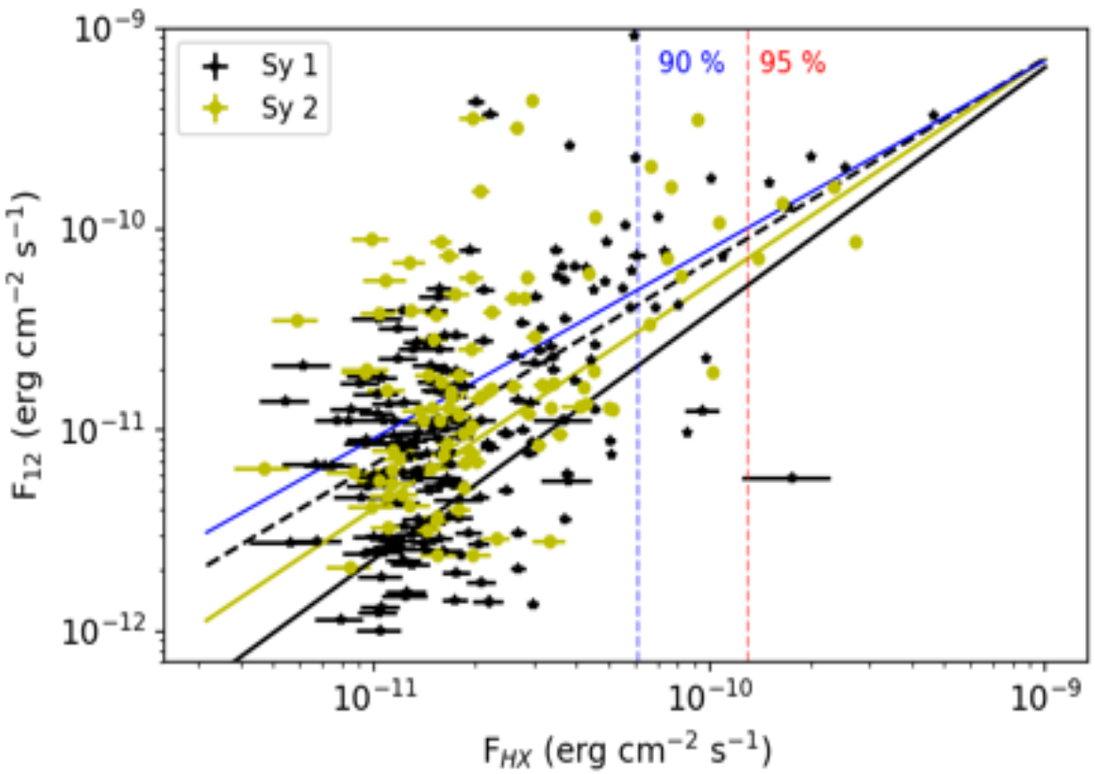
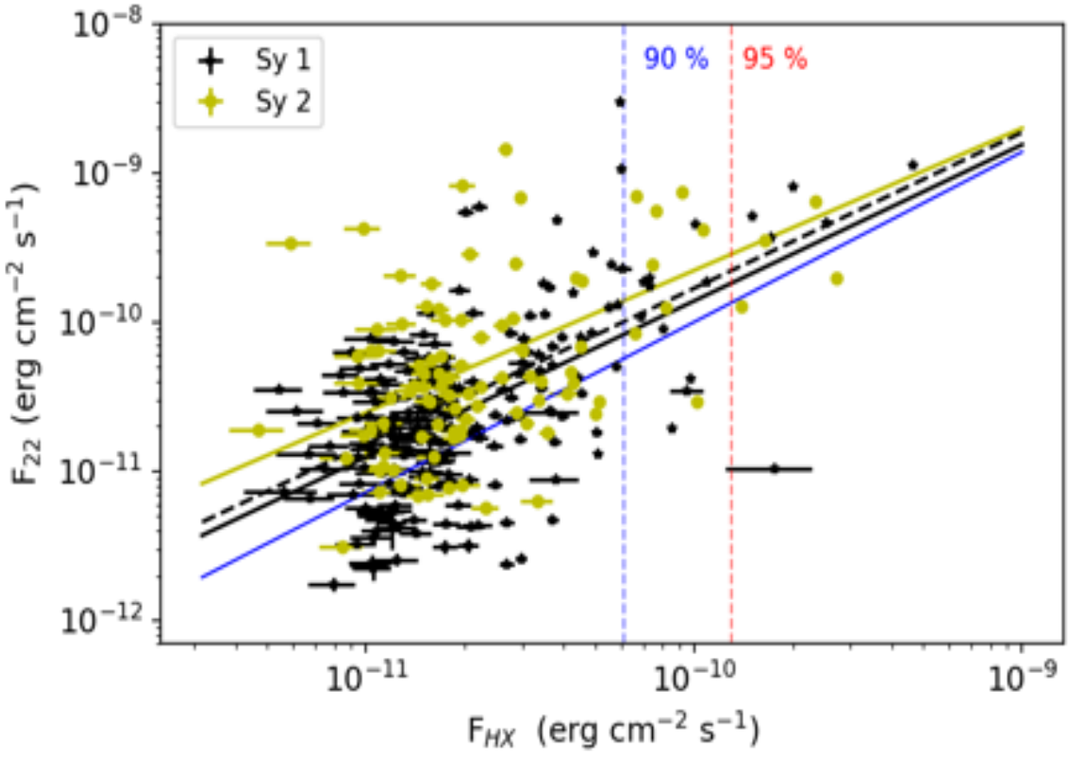
Turin-SyCAT





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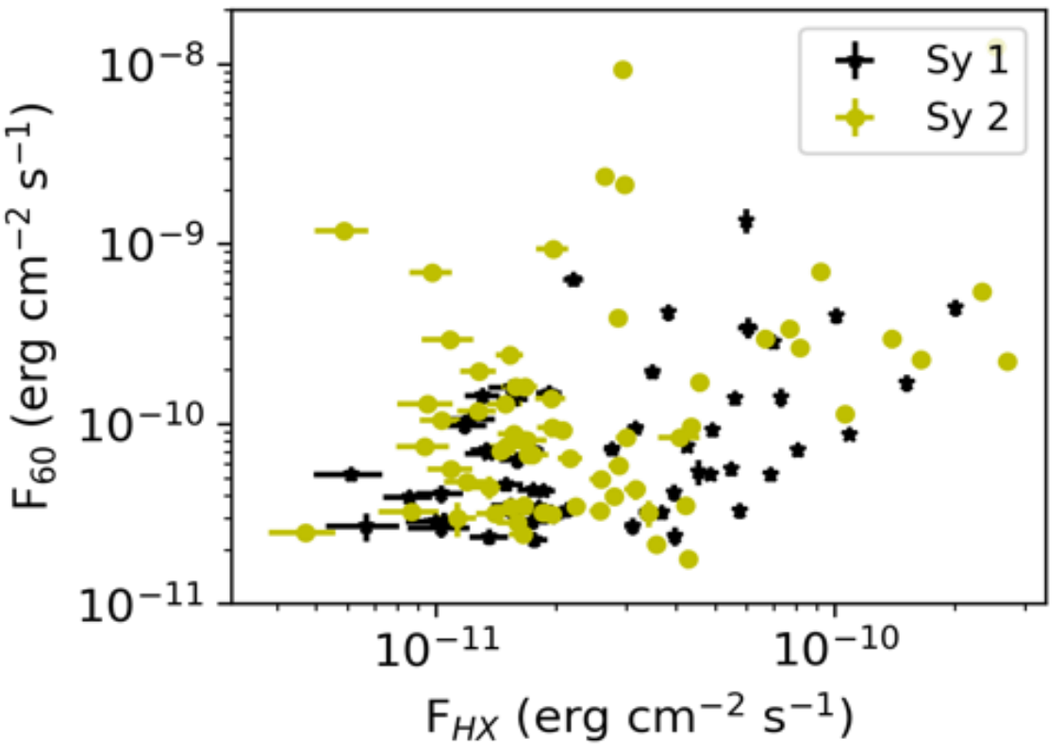
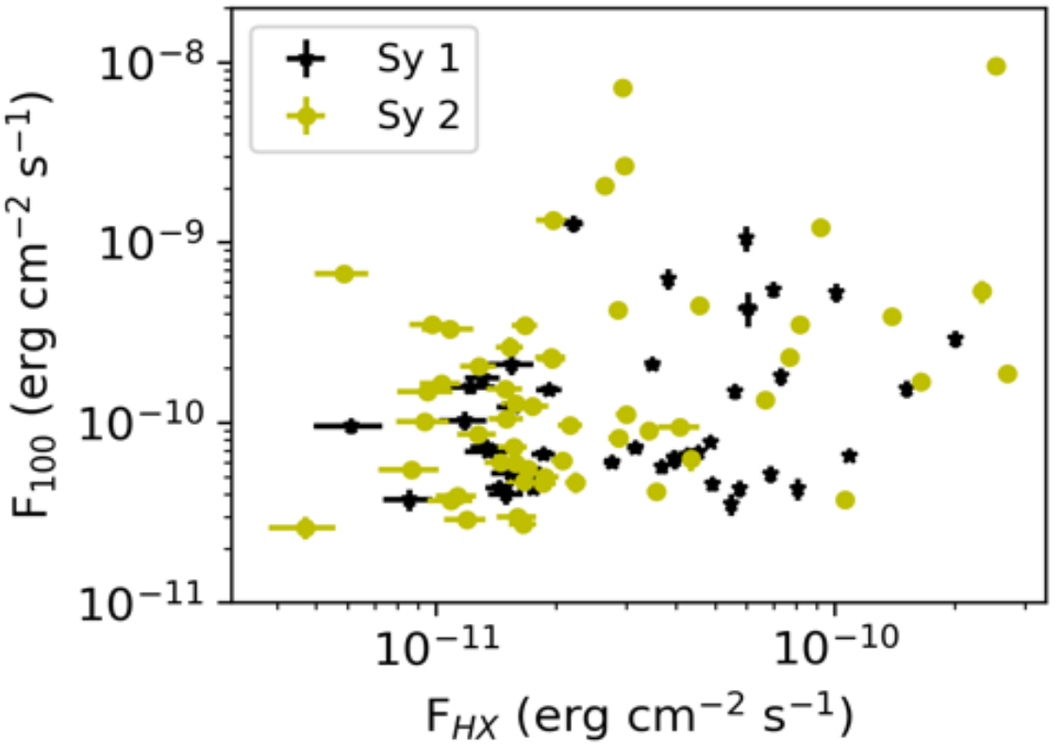
Turin-SyCAT

Point Source catalog of the Infrared Astronomical Satellite (IRAS) at 60 μm and 100 μm.

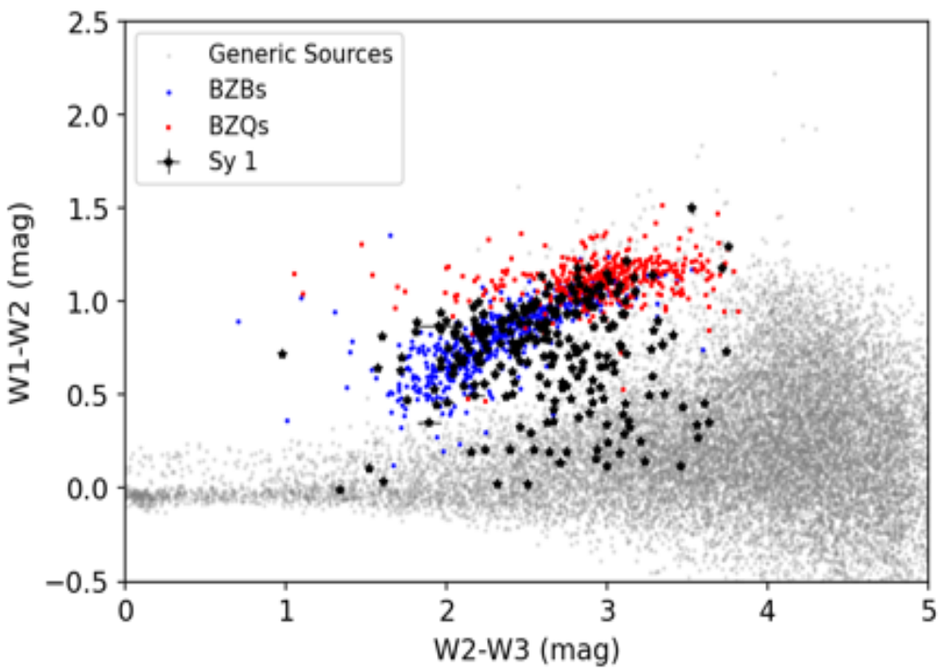


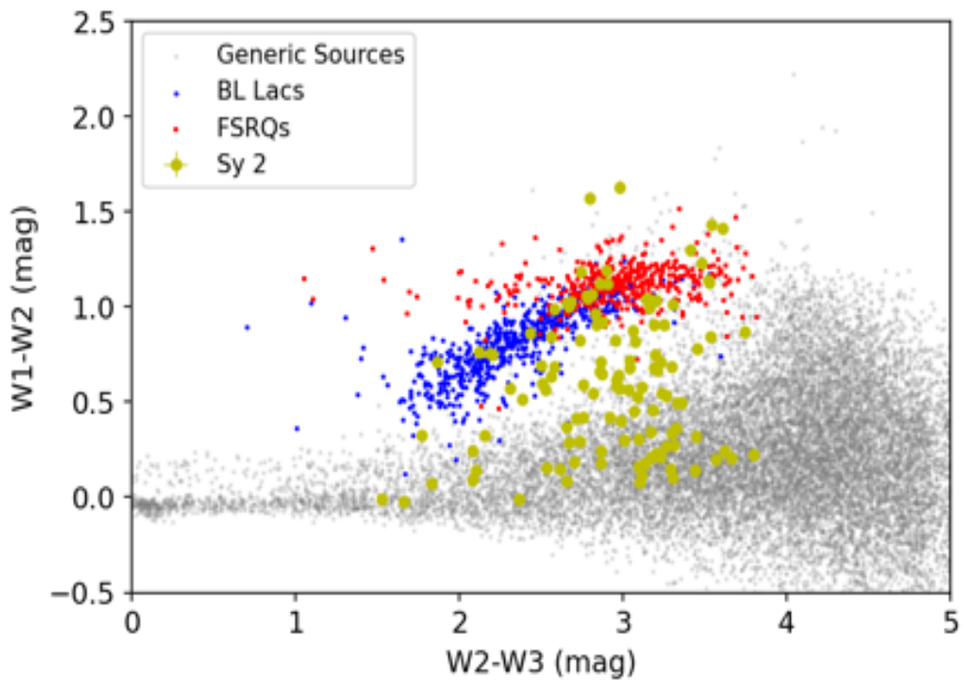


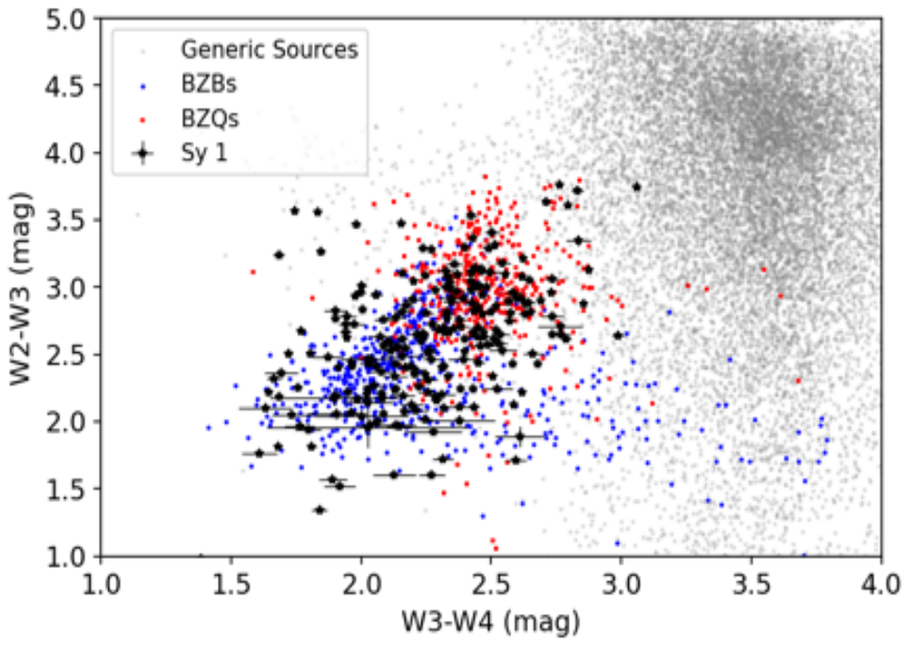
No trend. Cold dust it is not expected to be linked directly with the central AGN.

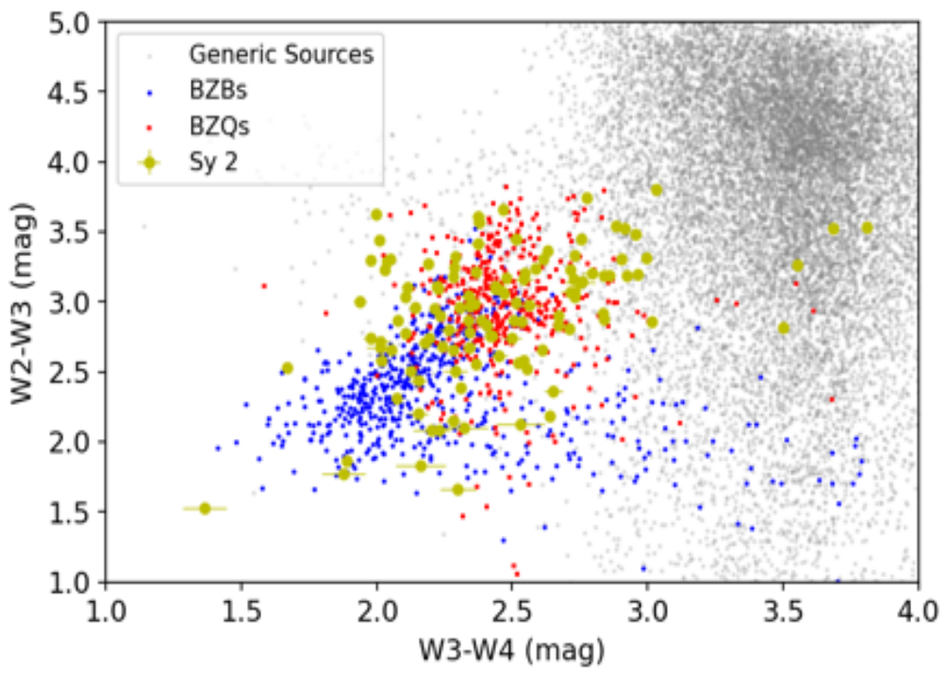
Peña-Herazo et al. 2021d accepted in A&A

Turin-SyCAT









Peña-Herazo et al. 2021d accepted in A&A

Turin-SyCAT

- I selected **351** Seyfert galaxies with homogeneous properties at radio, infrared and optical energies, 233 type 1 and 118 type 2.
- There is a tight correlation between the mid-IR flux (W3 and W4 bands) and that F_{HX}(>15 keV) for both classes of Seyfert galaxies.
- Type 1 and 2 Seyfert galaxies have a neat distinction when using the u-r color.
- We found that Seyfert galaxies contaminate the gamma-ray blazar strip

Turin-SyCAT

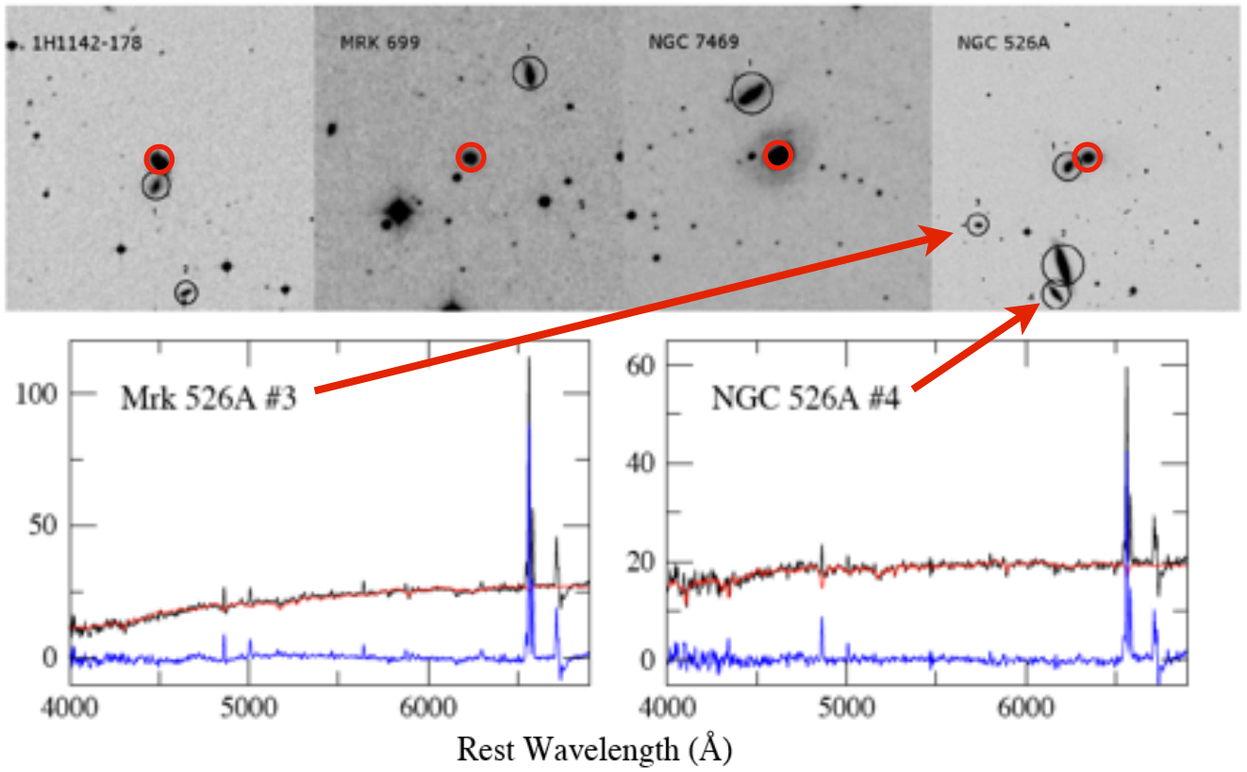
- Automatize the search to increase by factor of five the sample.
- Search for **Sy 2** at higher **redshift**. Already several Sy 2 will be added thanks to a literature and archival search (Kosiba et al. 2021 in preparation).
- Study infrared spectra of **157** sources in Spitzer archive. Spectral features compared with X-ray flux.

There is no clear consensus about the environment of Seyfert galaxies.

Different sample selections, methods, definitions of neighbors and environment.

Test the Unification Scenario!

Sy 1 and Sy 2 must lie in the same environment.



Kolouridis et al., 2013

Large-Scale Environment of Seyfert Galaxies

Samples, all limited to the **SDSS** footprint**:**

- Seyfert galaxies: Turin-SyCAT with $0.02 \leq z_{src} \leq 0.15$;
- Radio Galaxies: Low Excitation Radio Galaxies (LERGs) in FRICAT and FRIICAT with $0.02 \leq Z_{src} \leq 0.15$. Capetti et al. (2017a), Capetti et al. (2017b)
- **Mock** sources located in **random** positions of the sky.

Large-Scale Environment of Seyfert Galaxies

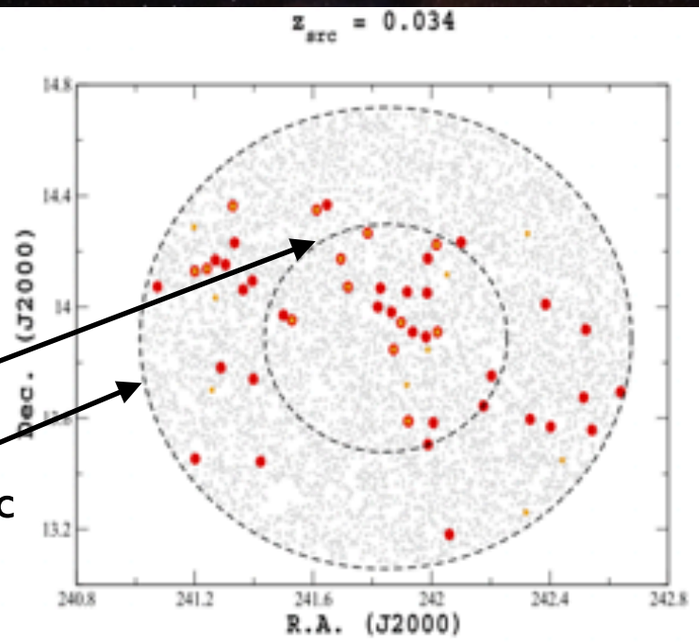
Cosmological neighbors:

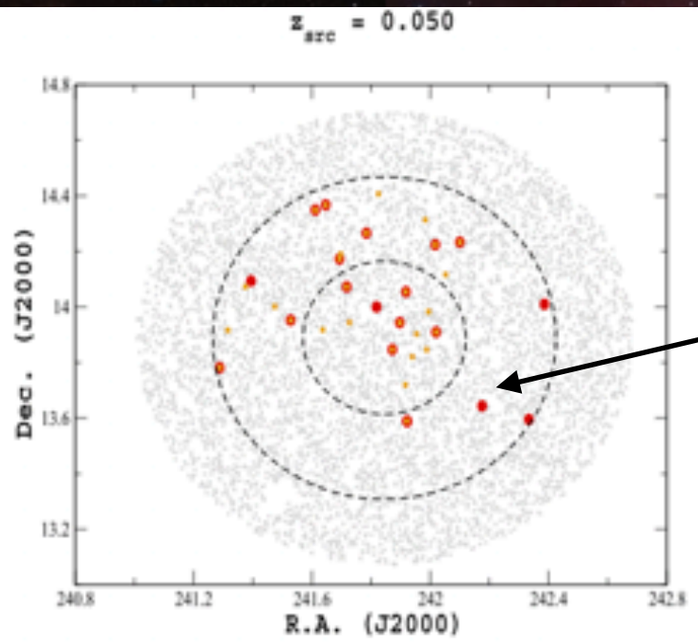
Are optical sources lying within the within **500** kpc, **1** Mpc or **2** Mpc **radius** computed at $\mathbf{z_{src}}$ of the central Seyfert galaxy with all the **SDSS** magnitude flags indicating a **galaxy-type object**, and having a spectroscopic redshift z with $\mathbf{\Delta z = |z_{src} - z| \leq 0.005}$, corresponding to the maximum velocity dispersion in groups and clusters of galaxies.

Large-Scale Environment of Seyfert Galaxies

Central Source M_R, z_{src}=0.034, N_{500}=10

Radii at 1 Mpc and 2 Mpc from the central RG.

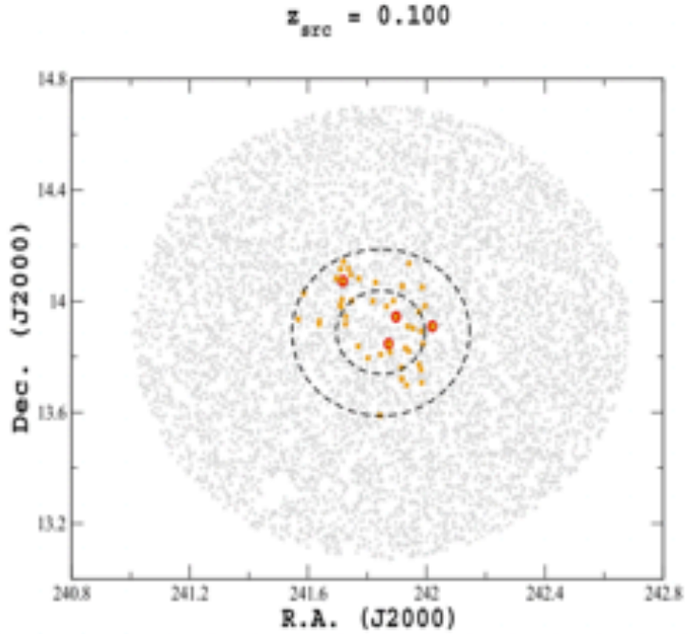


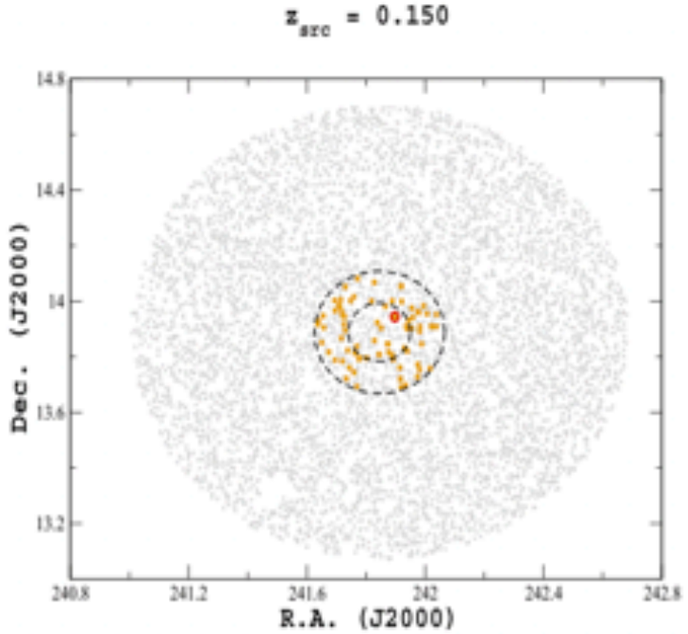


Cosmological neighbors

Same Source M_R, z_{src}=0.05 N_{500}=3

Orange squares are optical galaxies (noise)





Same Source M_R, z_{src}=0.15 N_{500}=0

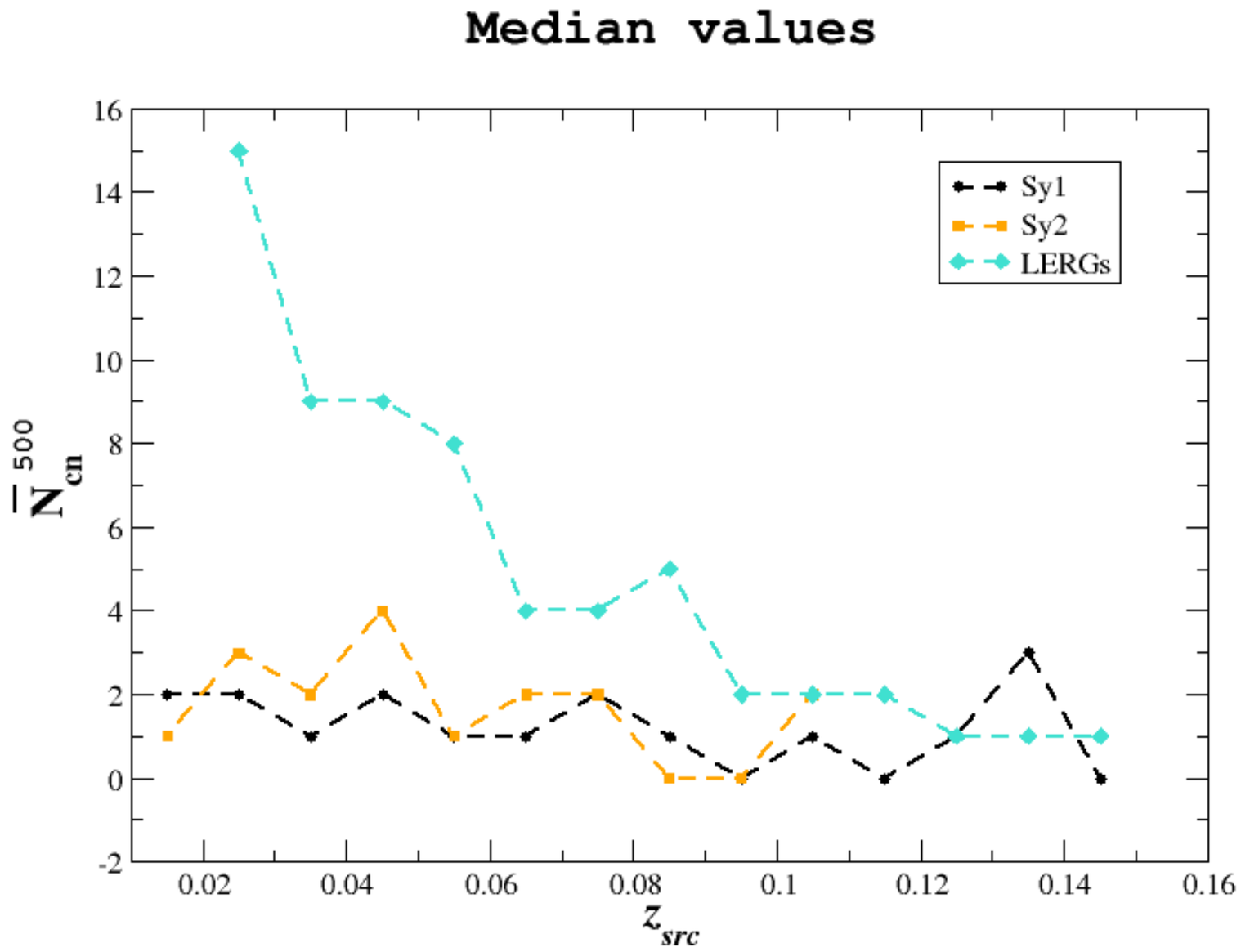
Same Source M_R, z_{src}=0.1 N_{500}=2

From Massaro et al. (2020).

Cosmological neighbors & optical galaxies if central source **would** be at z_{src} = 0.05, 0.10, and 0.15.
Re-scaling m_r to the **different z_{src}**. N_{500}=3, 2 and 0
Important to compare sources at the same redshifts

Threshold of 2 neighbors when z_{src}>0.1, as noise increases at higher redshift.

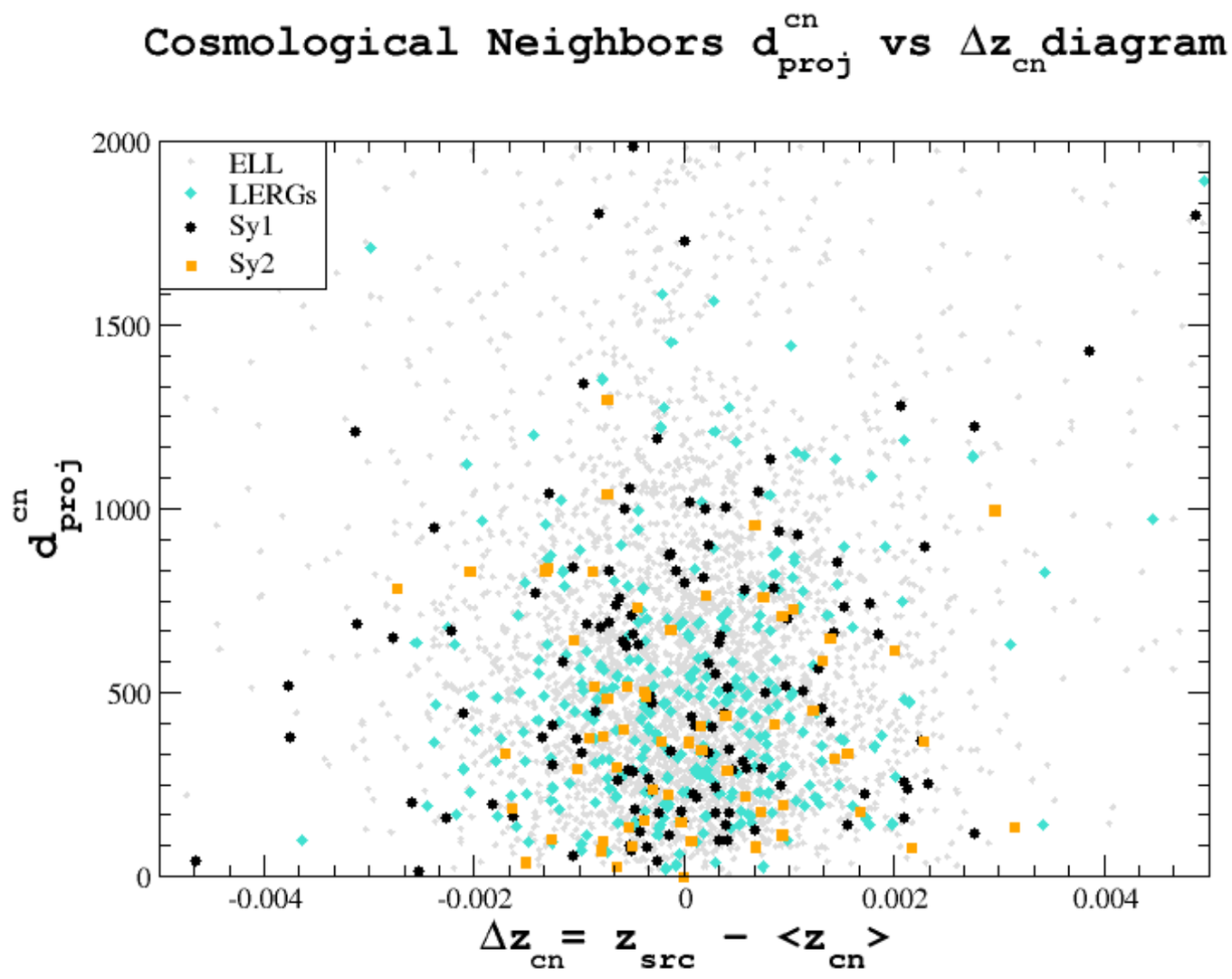
Large-Scale Environment of Seyfert Galaxies



Medians of N_{500} type 1 and type 2 Seyfert galaxies N_{cn} and **LERGs** per redshift **bins of 0.01 size**.

As shown the large-scale environment is consistent between the two types of Seyfert galaxies but appear richer in **LERGs** showing all medians distributed systematically above those of Seyfert galaxies.

Large-Scale Environment of Seyfert Galaxies

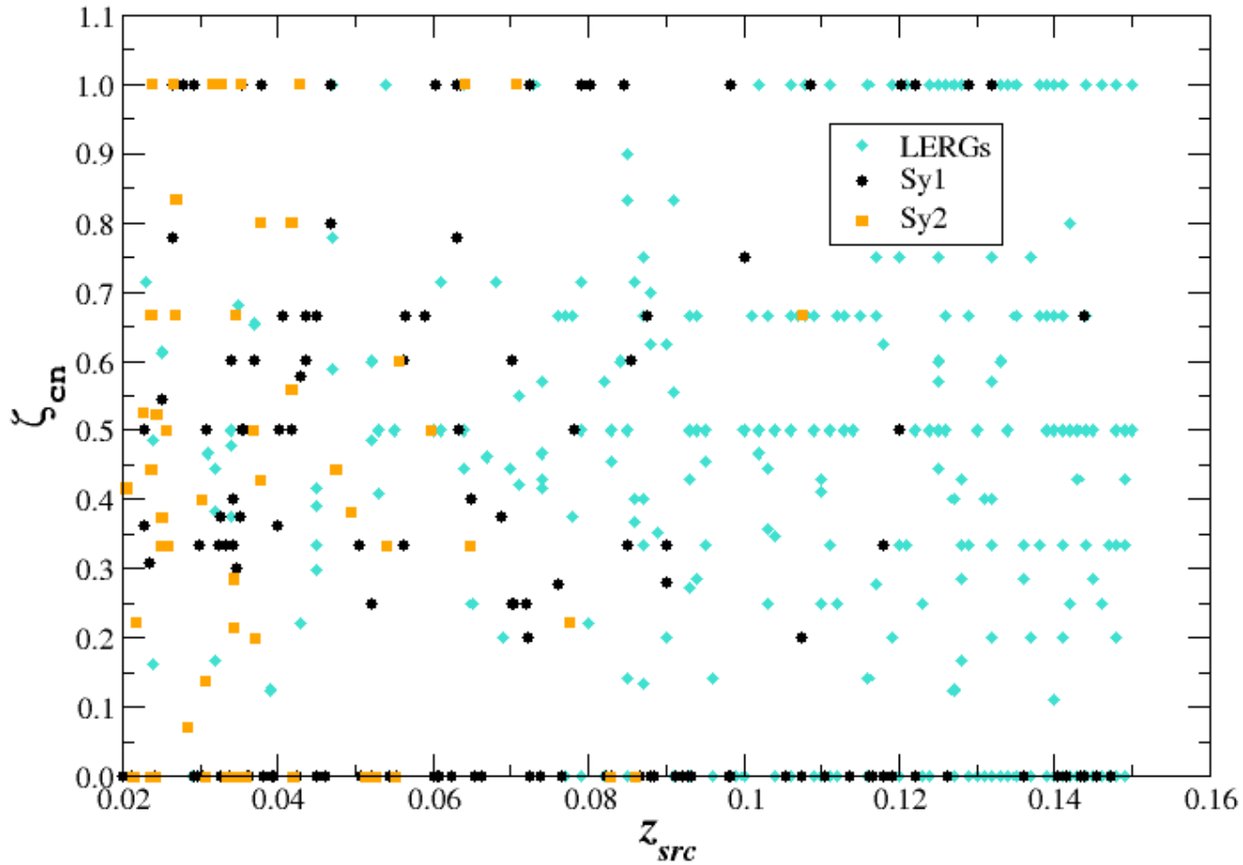


Physical distance in kpc between the central source and the average position of the N_{2000} vs z difference. This is computed at the z_{src} of the central source.

No differences in the behavior of type 1 and type 2 Seyfert galaxies between them and in comparison with radio galaxies.

Meaning that Seyfert galaxies have the **same** location in the **clusters/groups** as LERGs and ELLs

Large-Scale Environment of Seyfert Galaxies



Concentration parameter $\zeta_{cn,}$ (ratio of N_{500} / N_{1000}) as function of redshift z_{src} for both Seyfert and radio galaxies:

- No trend between these two parameters is evident, no cosmological evolution of the concentration parameter.

Large-Scale Environment of Seyfert Galaxies

- Sy 1 and 2 inhabit the **same** large-scale environments. With no differences in **spatial distribution** and **richness** of surrounding galaxies. **Supporting** the **unification scenario**!
- Radio galaxies inhabits richer environment than Seyfert galaxies.
- All other parameters related to the large-scale environments of both classes appear to be quite similar.

Large-Scale Environment of Seyfert Galaxies

- Study the colors of companions of Seyfert galaxies
- Overdensity vs Luminosity ([O III] and mid-IR)
- Study the environment with Turin-SyCAT v2.

Questions