BLACK OUT

A project funded by PRIN MIUR (2017PH3WAT)
blackholewinds.inaf.it

Task 4.1
BH nuclear winds

Andrea Marinucci

ASI
Agenzia Spaziale Italiana

Task 4.1 BH nuclear wind models [Lead: RomaTRE, participants: INAF, UniBo]

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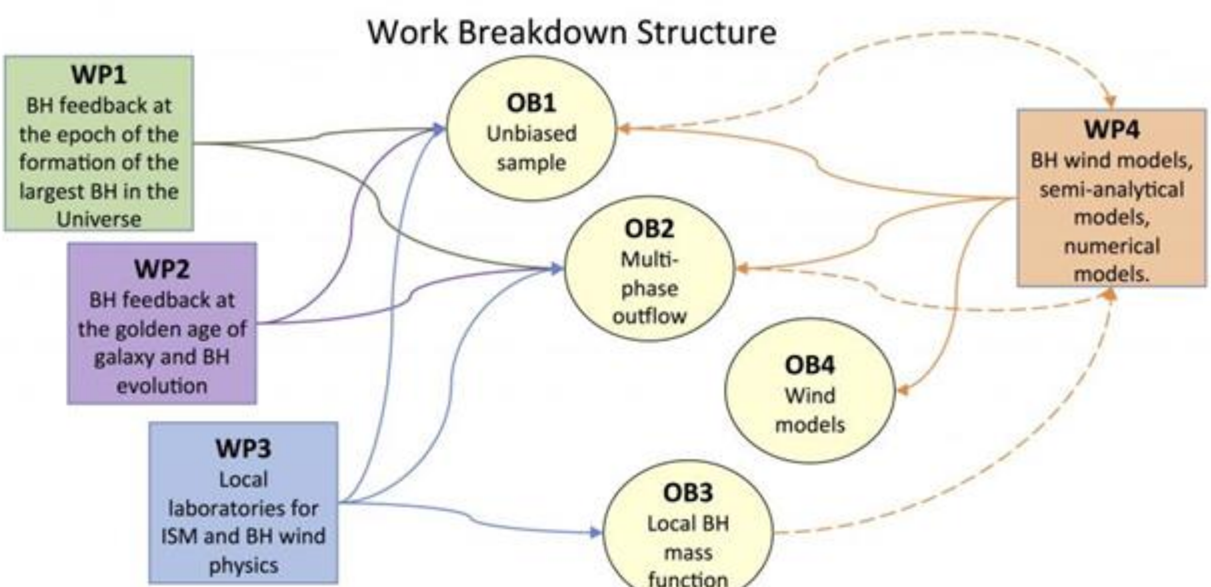

All WPs will work independently and in parallel to achieve the objectives. All observational WPs will contribute to reach 2 or 3 objectives (OB1, OB2, and/or OB3); the theoretical WP will provide the physical models (OB4) but will also enable a comparison between the observational results and the models.

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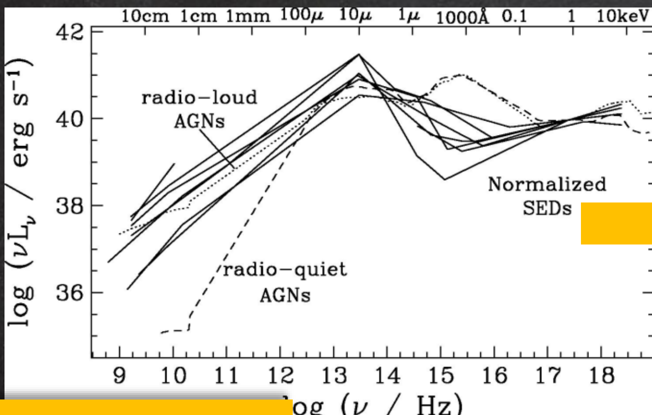
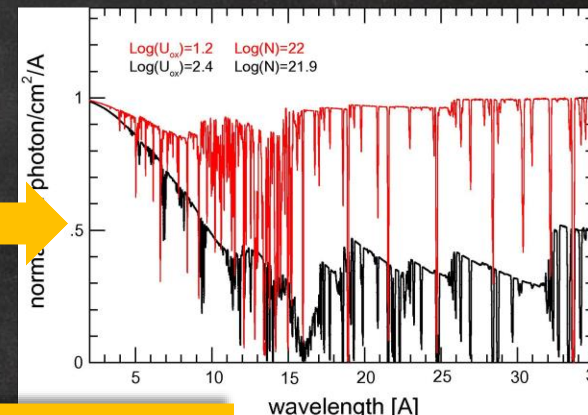
Cloudy Nuclear Wind Models



Netzer et al. 2008

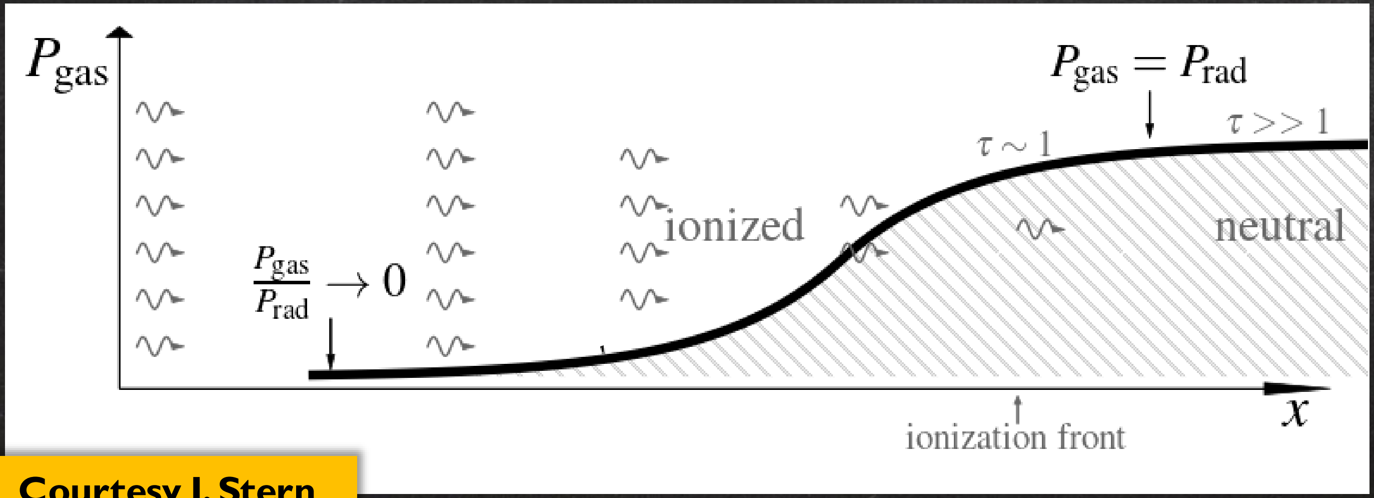


Netzer et al. 2008

The most straightforward approach is to assume only one type of clouds
Given the gas chemical abundances, the resulting spectrum is then specified by the source luminosity and SED, the distance, density and column density of the cloud, together with its total covering factor (of course distinguishing the special line of sight which actually intercepts the cloud)

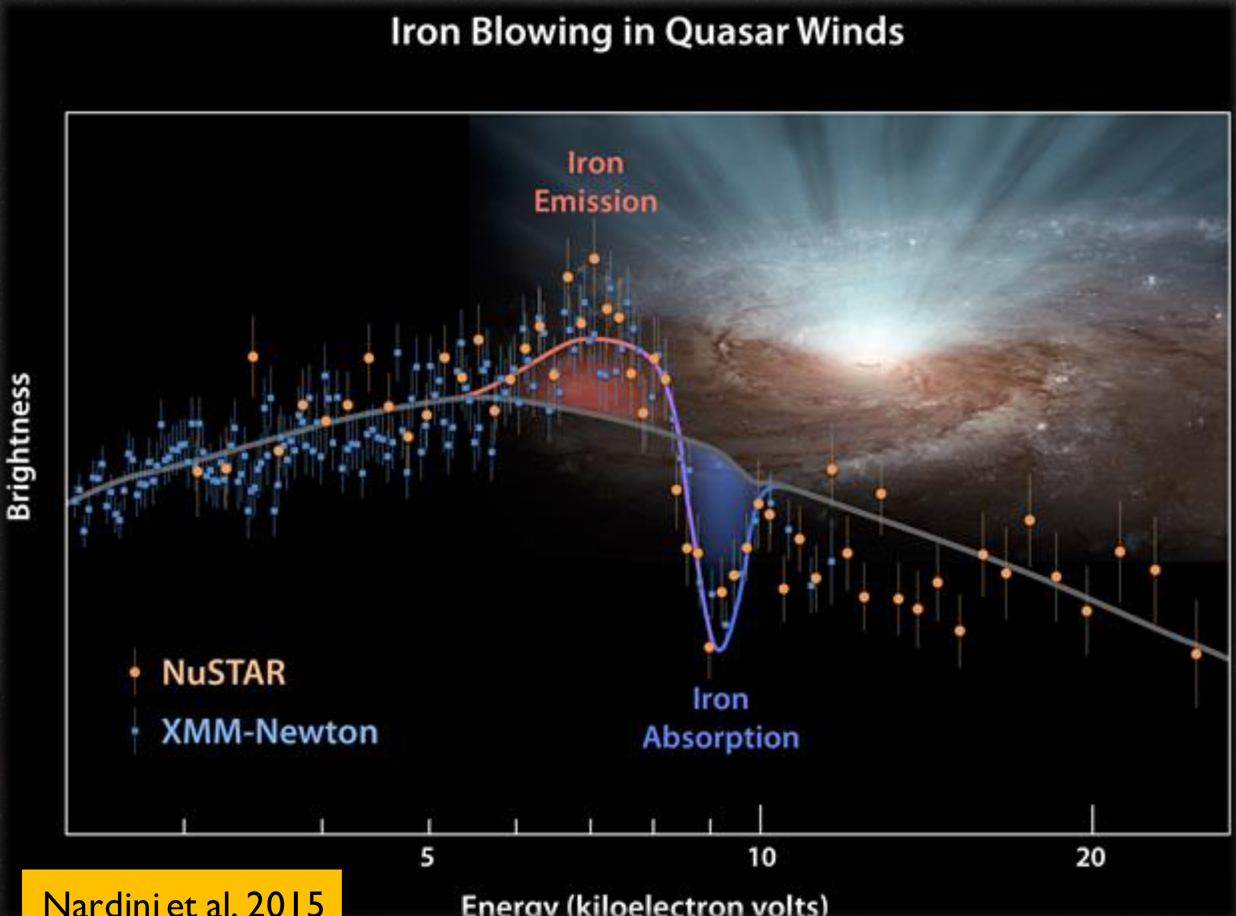
More sophisticated, alternative approaches include the locally optimally emitting cloud (LOC) model (Baldwin, Korista and Ferland 1997), which invokes a large range of cloud properties at any given location, thus producing lines from high and low ionization species at all radii. The LOC model needs the different clouds to exist side-by-side via some confinement mechanism, which can be magnetic or thermal

A universal density and ionization distribution naturally arises when radiation pressure compression (RPC) is correctly taken into account (Dopita et al. 2002; Draine 2011; Stern, Laor & Baskin 2014). Indeed, X-ray outflows can be described as RPC media (Goosmann et al. 2016, Bianchi et al. 2019).



Courtesy J. Stern

Single clouds can be a very rough representation of a continuous wind: the line photons are Doppler shifted, so that absorption and emission from the same transition are observed at different energies, which crucially depend on the geometry of the outflowing matter. The resulting P-Cygni line profile may be difficult to model, but contains a wealth of information on the kinematics and covering factor of the wind



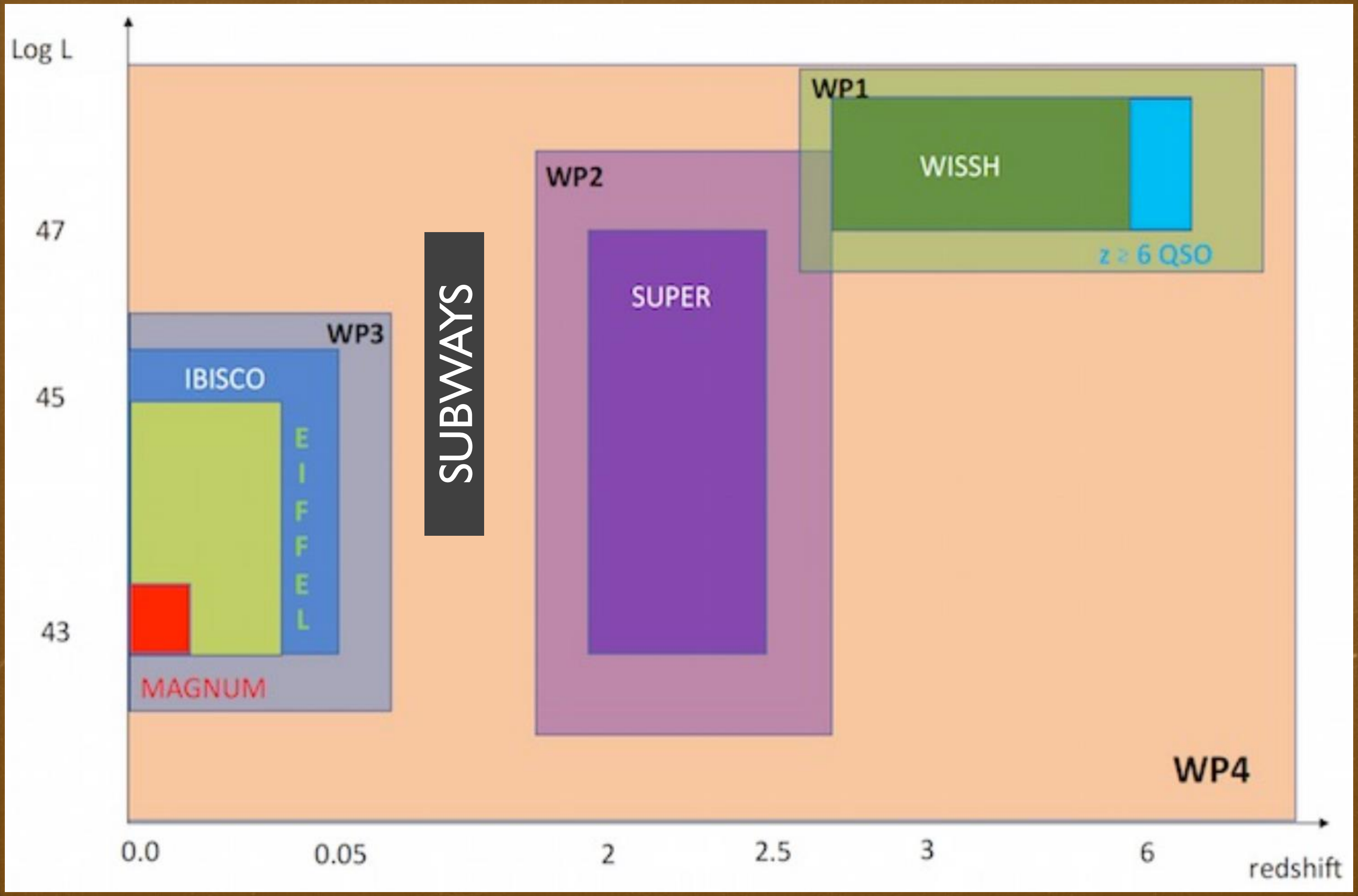
Nardini et al. 2015

The iron absorption feature (in blue) is due to the component of the gas along the line of sight: its blueshift allows a direct measure of the gas velocity

The red emission feature is produced by all the outflowing gas: its strength depends on the total solid angle covered by the wind

We plan to analyse the best available X-ray data of AGN with self-consistent models of the absorption and emission features expected from winds

The SEDs will be a fundamental input for the photoionization code CLOUDY, in order to produce synthetic spectra to be fit (via XSPEC tables) to the corresponding sources



At first we will adopt a 'single cloud' approach, to extract from the observed X-ray features the physical, geometrical and dynamical properties of the gas

For example, we will derive an estimate of the wind inner radius, to be compared to the predictions made by the different launching mechanisms, and we will check if the solutions are thermally stable (e.g. Chakravorty et al. 2013; Bianchi et al 2017)

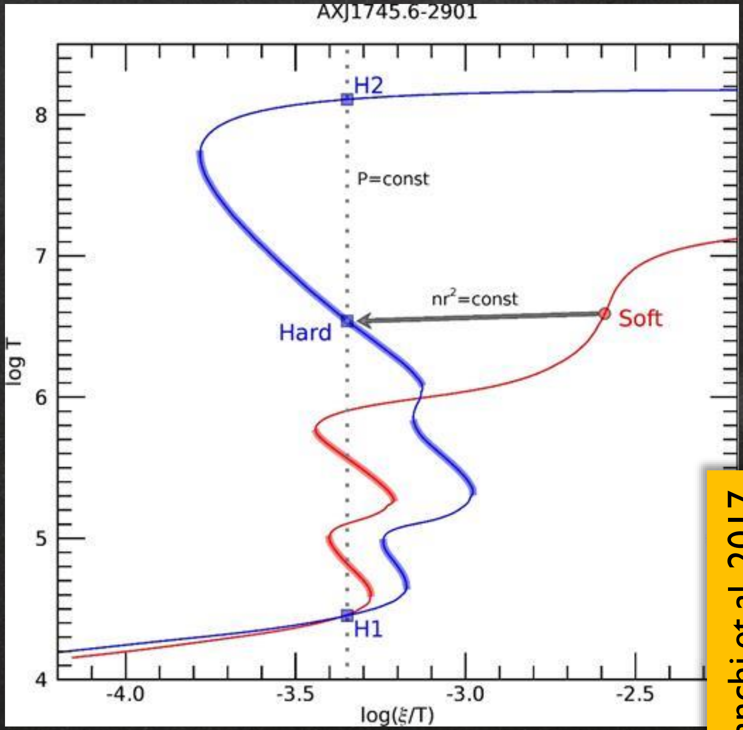
This will allow us to picture a comprehensive scenario for a sizable number of sources

$$R_{in} = 2GM_{BH}\bar{v}^2 \qquad R_{in} = \sqrt{L/(\xi n_e)}$$

$$\dot{M}_{out} = \Omega \mu m_p N_H R_{in} v$$

$$\dot{E}_k = \frac{1}{2}\dot{M}_{out} v^2$$

$$\dot{p}_{out} = \dot{M}_{out} v$$

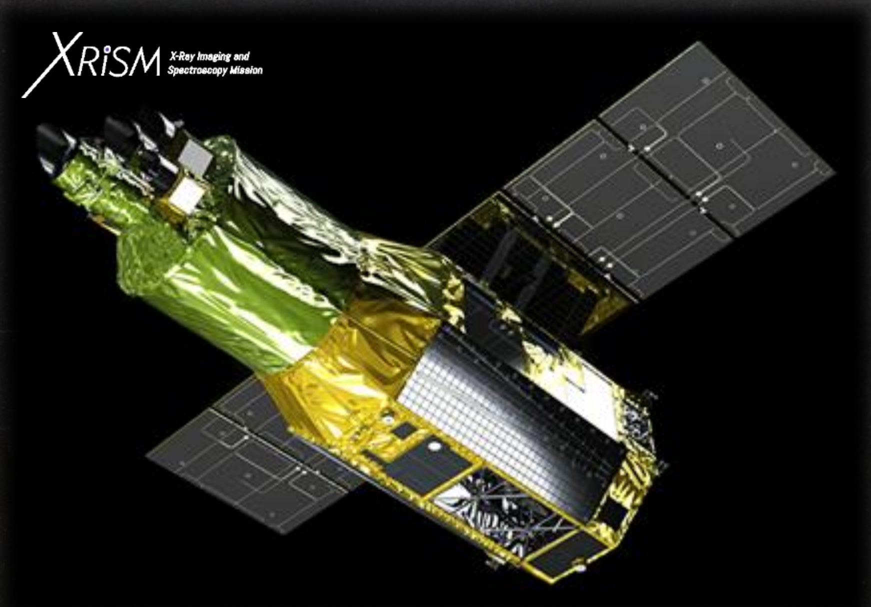


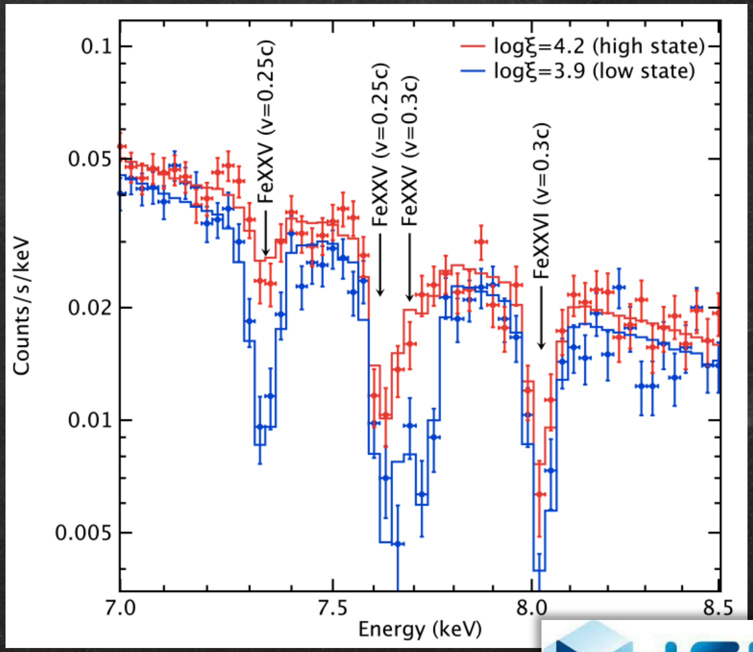
Bianchi et al. 2017

A further step will be to compute synthetic spectra built on a self-consistent accretion-ejection model in synergy with the results from other WPs

A comprehensive picture of the properties of the accretion flow, the launching mechanism of the outflow, its physical properties and geometry, will be used as quantitative inputs for CLOUDY. Different line of sights, intercepting various components of the outflow, will be integrated, producing detailed line profiles.

In order to fully exploit their potential, these self-consistent synthetic spectra will be prepared for high resolution micro-calorimeter data, and will be tested also on the first XRISM spectra, when/if available, and used for Athena science studies





ATHENA X-ray Integral Field Unit

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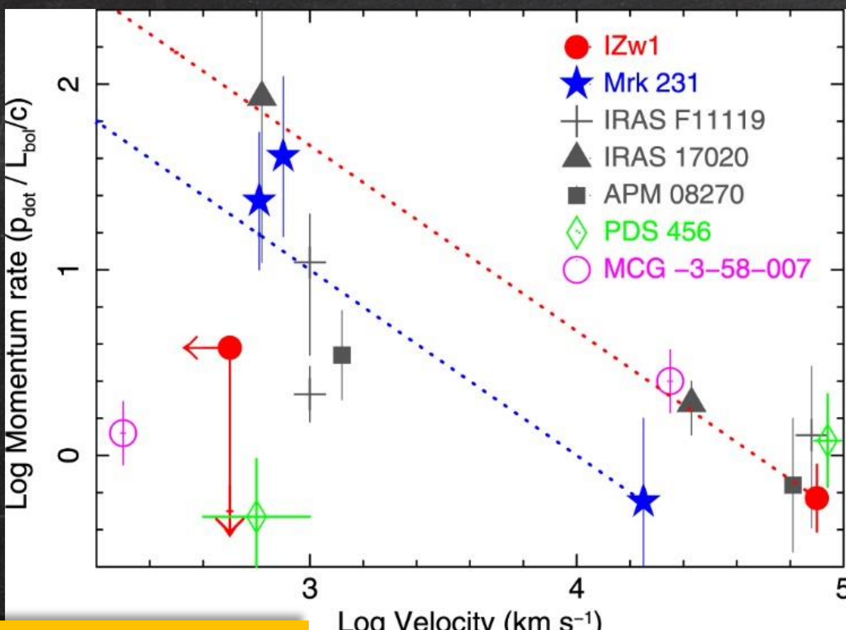
Comparison with the Molecular Gas Outflows



Reeves & Braito 2019

The energetics for the X-ray winds will be compared to observations of the molecular gas in the same sources, to determine the mechanical effect of the wind on the large-scale ISM gas

The comparison between the momentum rates at inner and outer scales provides crucial constraints on the feedback mechanism (e.g. momentum or energy conserving scenarios)

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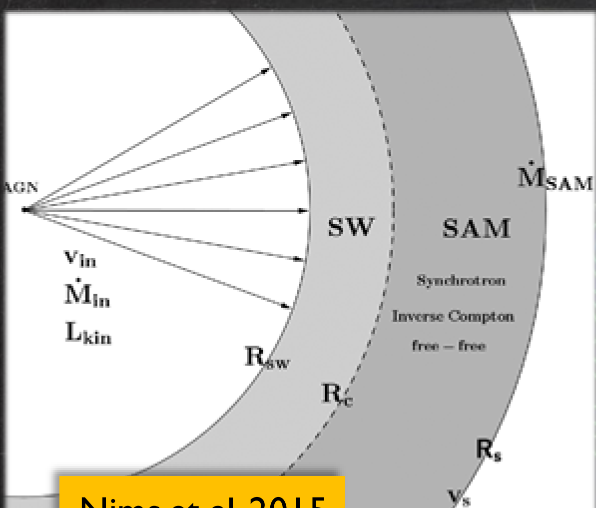
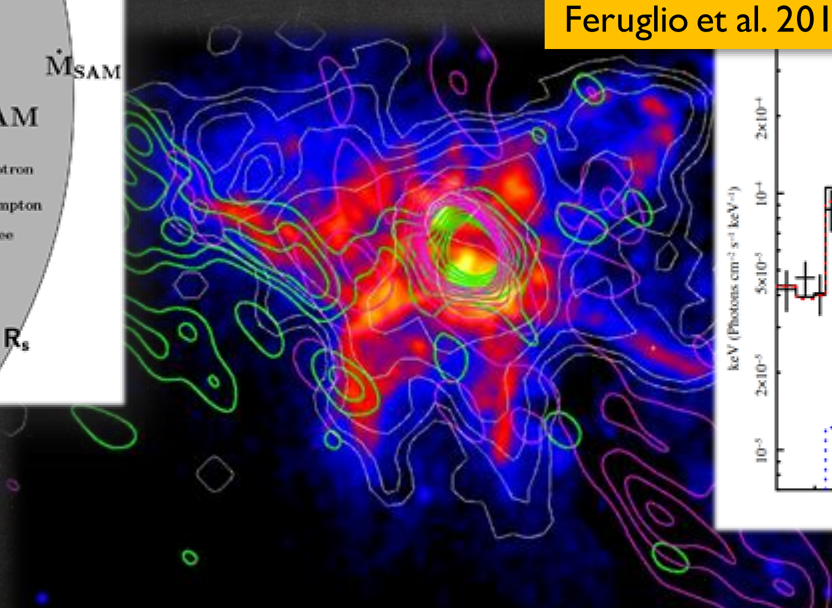
Extended soft X-ray emission

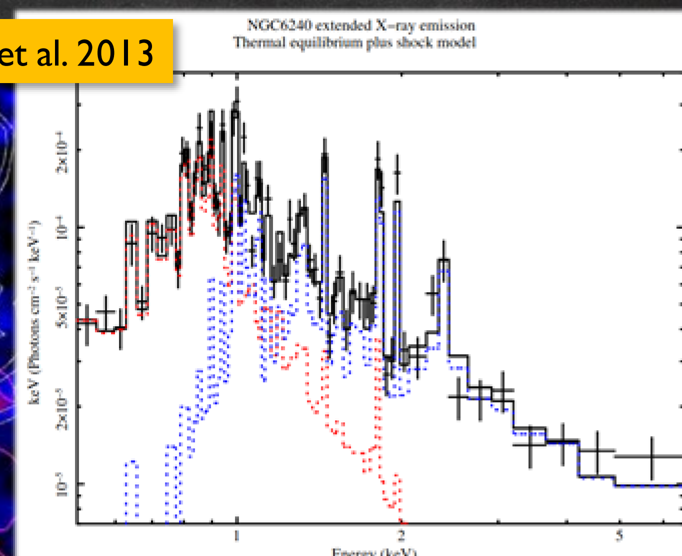
BH winds should produce thermal X-ray emission on $0.1 - 3$ kpc scale. The characterization of this component is crucial because this emission is a direct measure of the interaction of the AGN outflow with the ISM. Intriguingly, extended X-ray emission has been actually detected, in association to molecular and ionized winds, in the local AGN/LIRG NGC6240



Nims et al. 2015



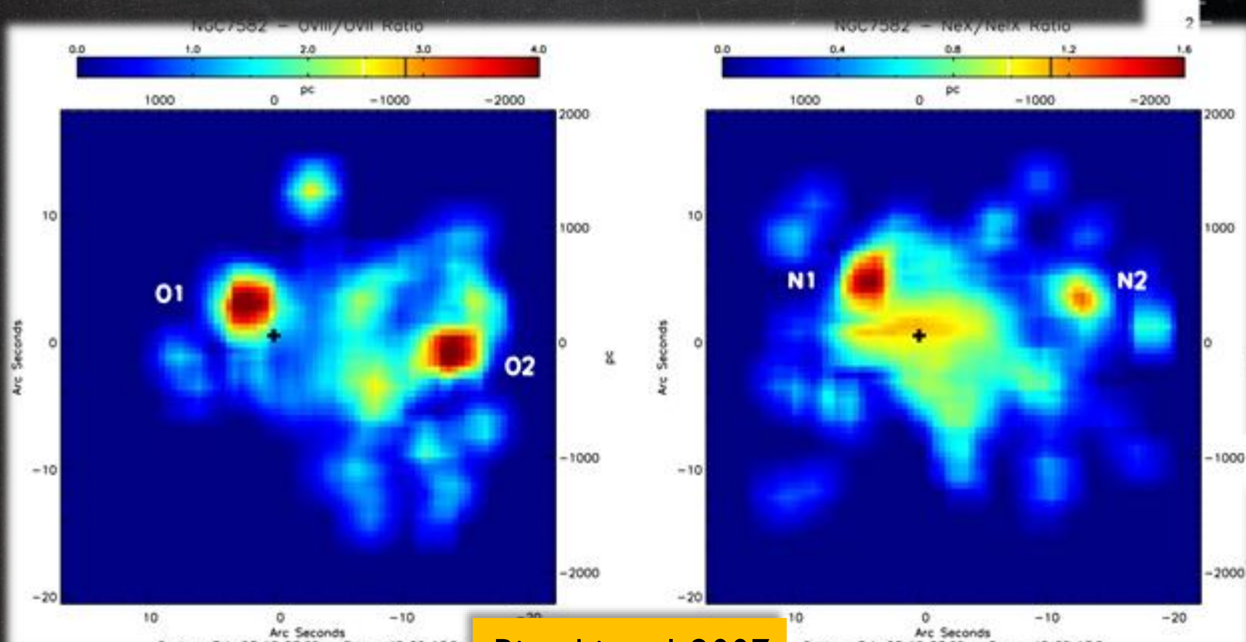
Feruglio et al. 2013



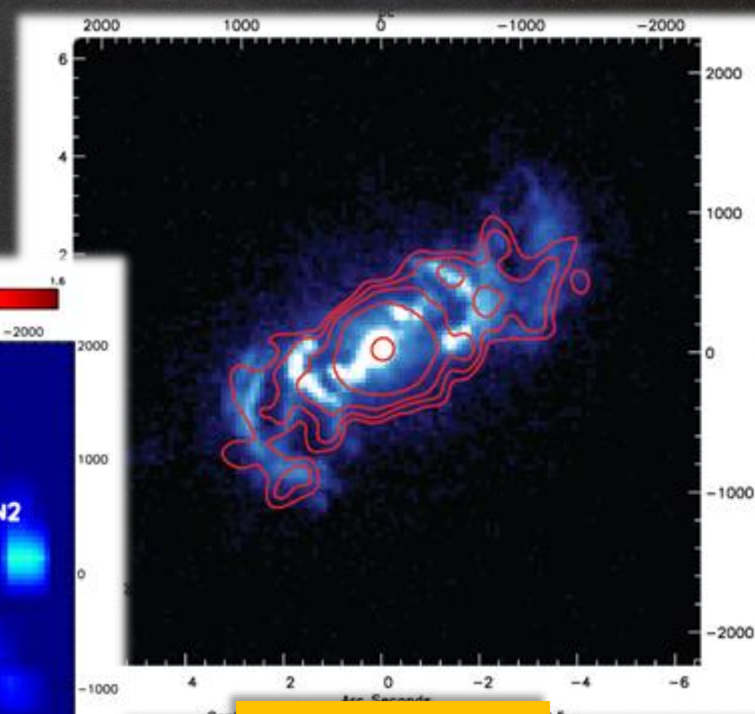
It is certainly worth it to look for soft X-ray structures correlated to large scale structures observed in other wavelengths

However, it is uncommon to see extended X-ray emission in unobscured AGN (too bright nucleus, geometrical effects). On the other hand, obscured AGN invariably present photoionized gas correlated with the NLR.

It is very difficult to disentangle any shocked-induced emission



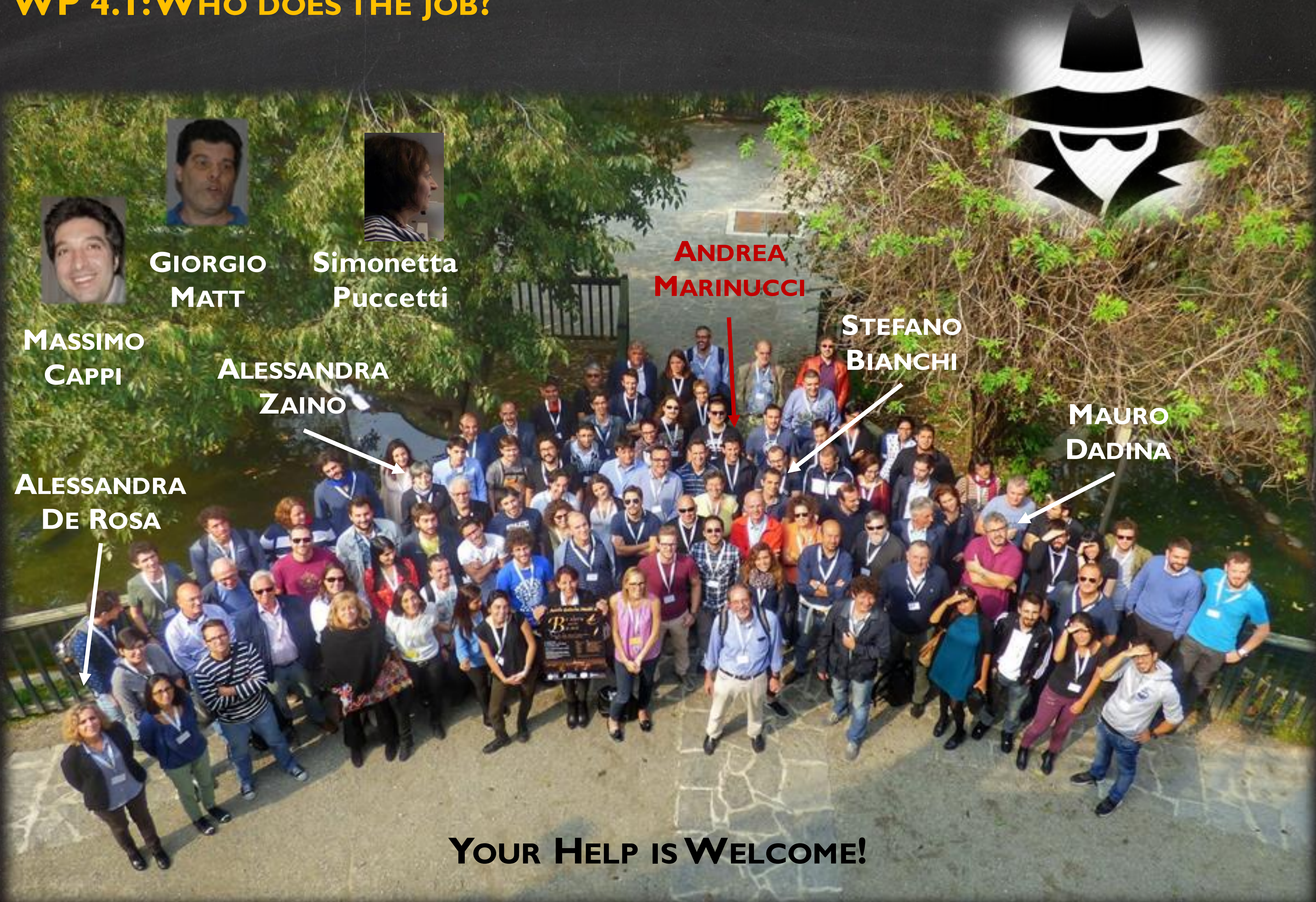
Bianchi et al. 2007



Bianchi et al. 2010

WP 4.1: Who does the job?

Post-Doc
(to be hired!)



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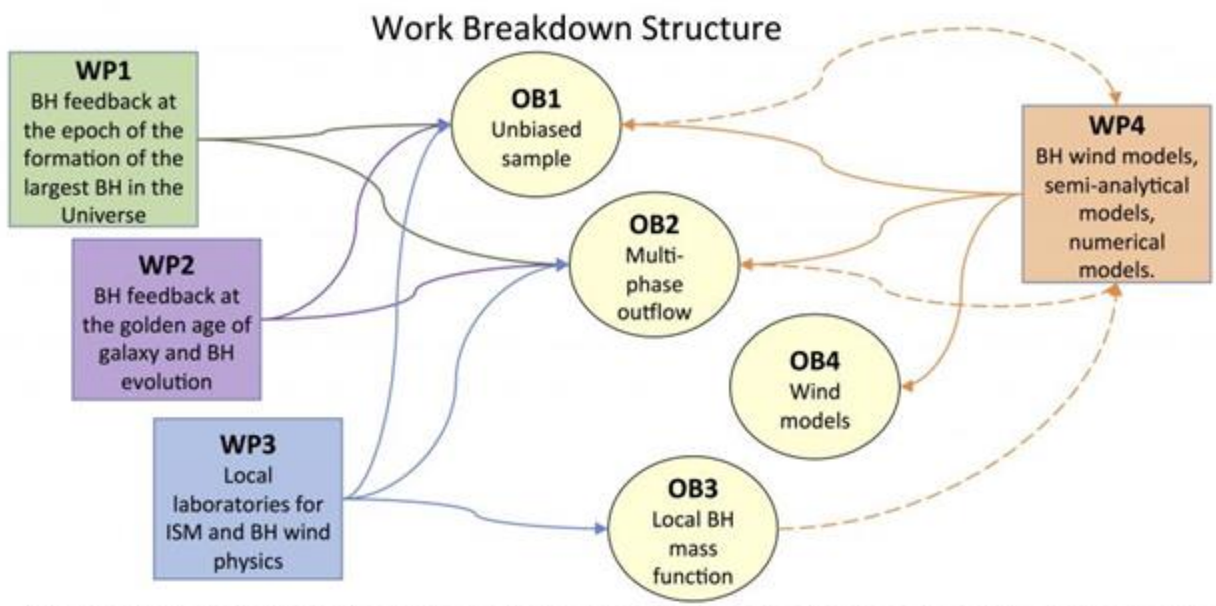
Task 3.4
BH mass functions

Task3.4 Local AGN physical quantities [Lead: RomaTRE, participants: INAF, UniFi, UniBo]

We will measure BH masses and the accreting host galaxy properties (Lbol, SFR, M*) of an unbiased (flux limited) sample of 50 local hard-X ray selected AGN, using deep NIR spectroscopy, building on our successful pilot program[40,41,42]. We will measure for the first time the local BH mass function, AGN BH-mass/bulge scaling relations and the accretion/SF properties of local AGN, to be compared with high-z samples (WP1,2) and to guide models (WP4).



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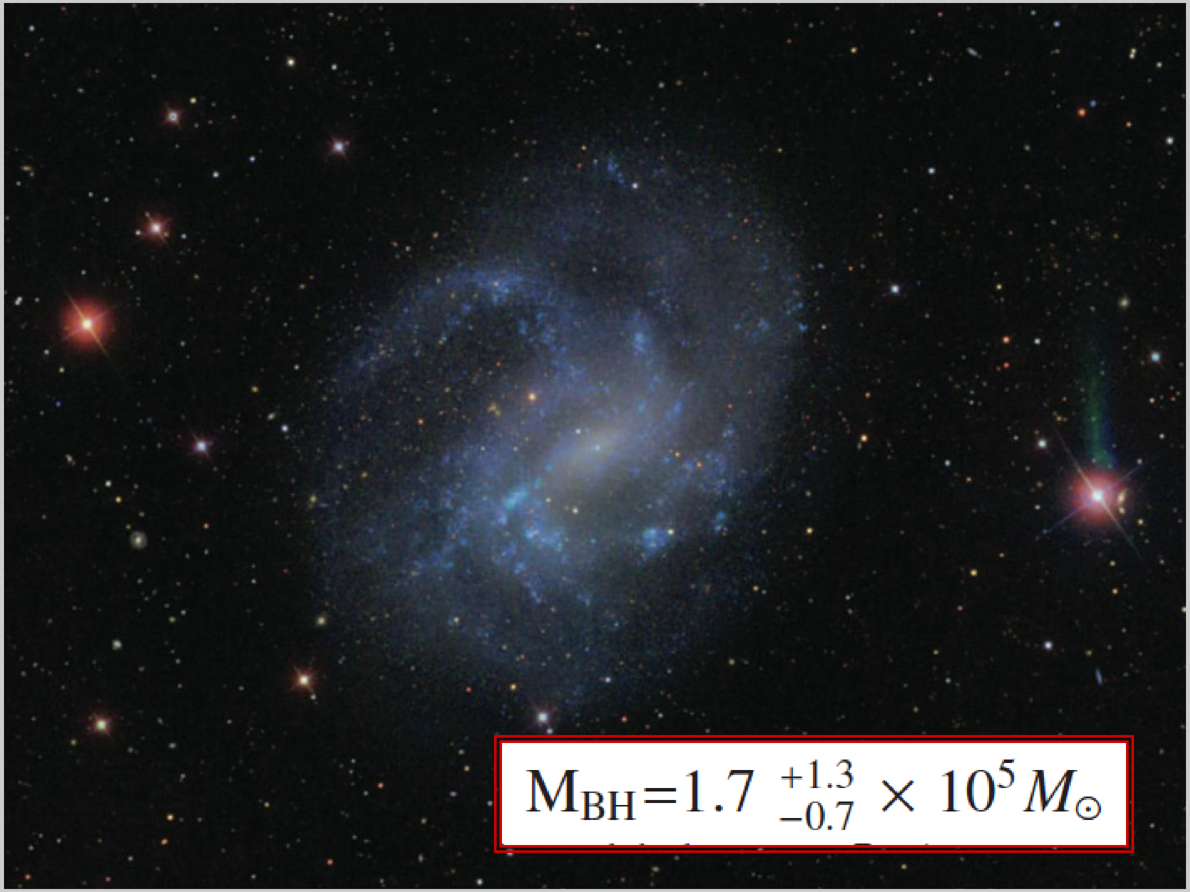
The role of the Intermediate Super Massive Black Holes

Fabio La Franca, Federica Duras, Angela Bongiorno, Federica Ricci, Enrico Piconcelli e molti di noi

Misura della MBH in AGN2 in galassie di piccola massa

NGC 4395 has no bulge but…



How many of such objects do exist?

We have calibrated new Single Epoch relations which allow to use the NIR Paschen lines to measure the BH mass in both type 1 and (**for the first time**) **type 2 AGN**s.

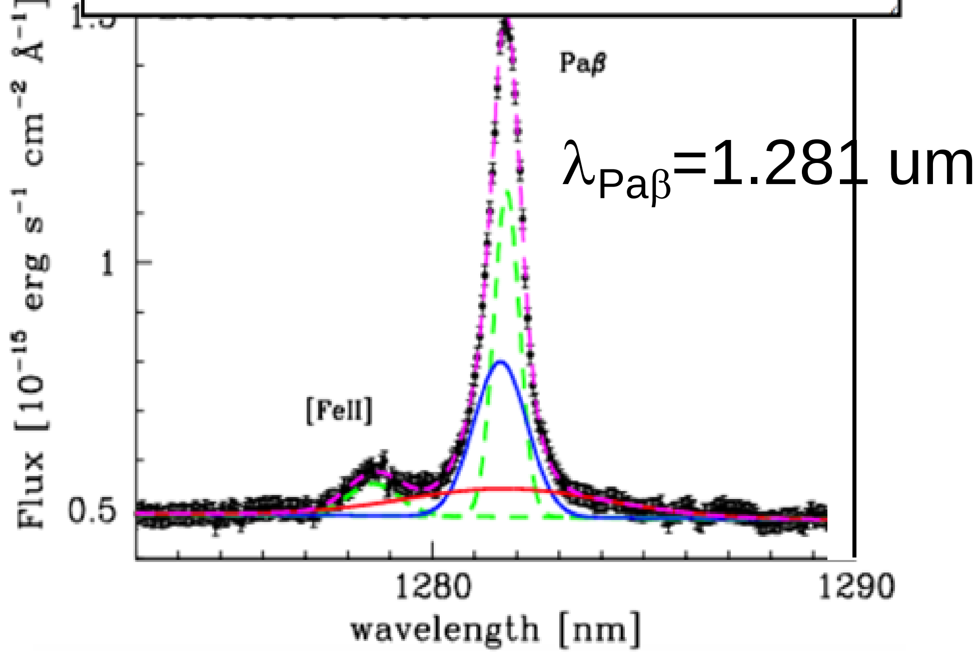
BUT :

faint broad
(800 < FWHM < 3500 km/s)
components found in **15** type2 AGN through deep NIR spectroscopy

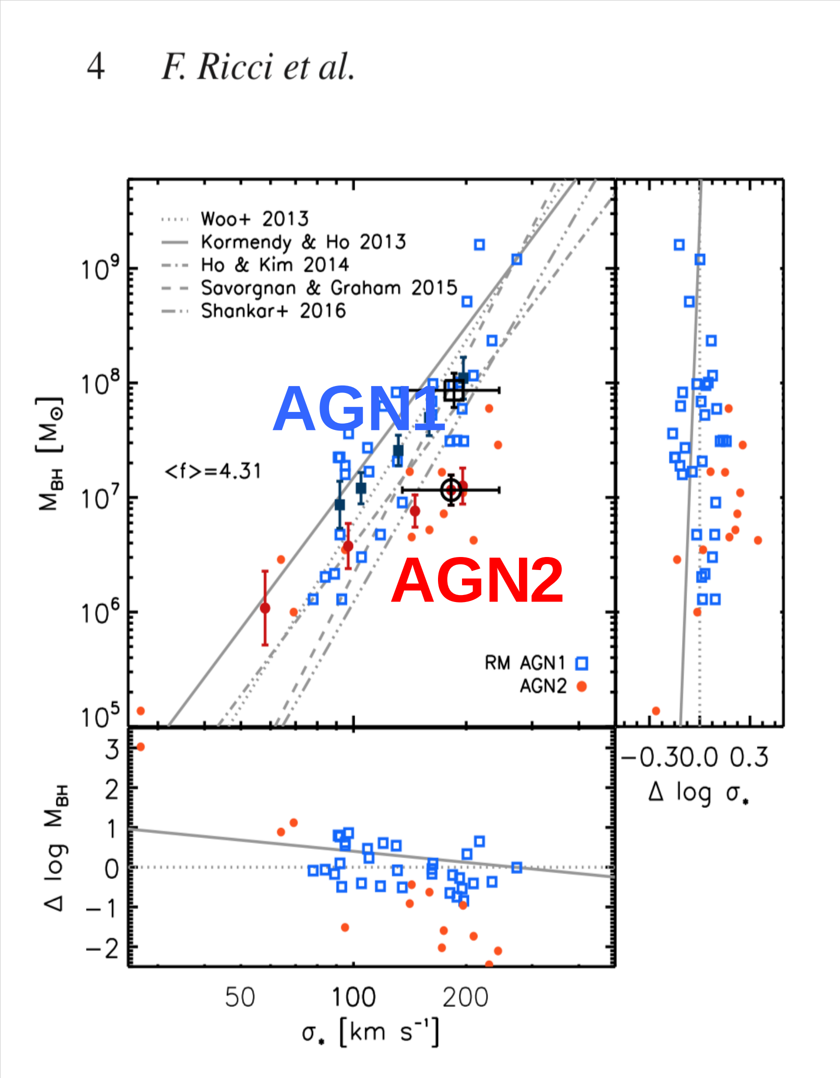
BH mass estimation

see Onori+17 and Ricci,F.+17

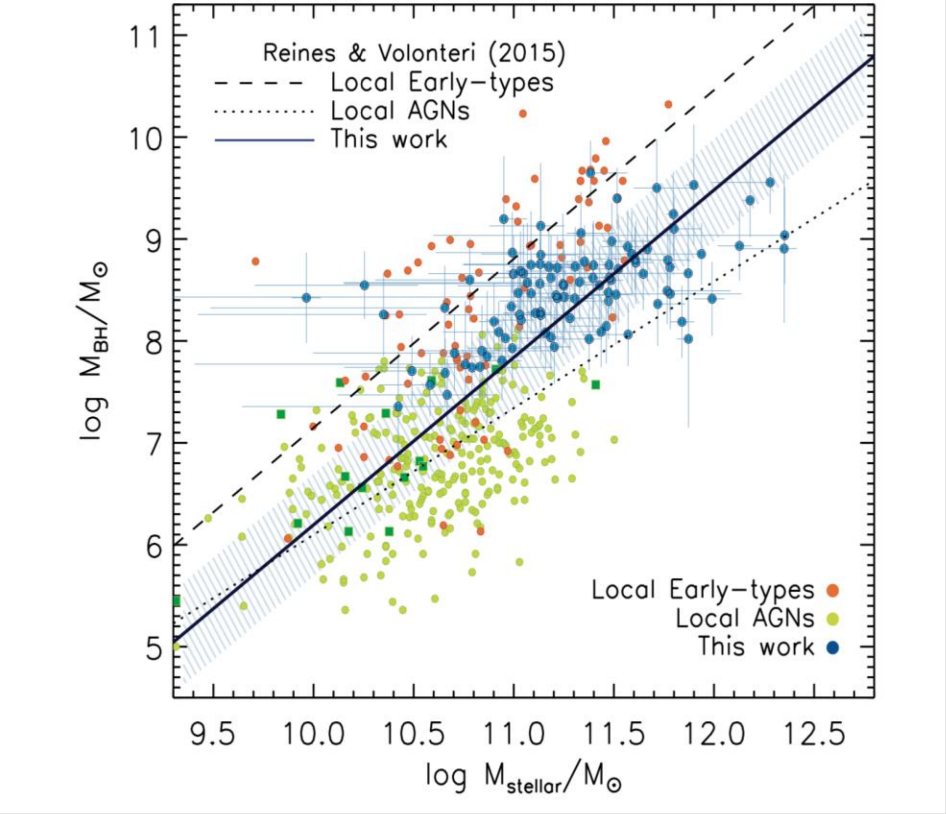
$$\log\left(\frac{M_{BH}}{M_\odot}\right) = 7.75 + \log\left[\left(\frac{\mathrm{FWHM_{NIR}}}{10^4\ \mathrm{km\,s^{-1}}}\right)^2\left(\frac{L_{14-195\,\mathrm{keV}}}{10^{42}\ \mathrm{erg\,s^{-1}}}\right)^{0.5}\right]$$



Una larga frazione di AGN2 mostra avere masse dei BH inferiori agli AGN1 a parità di L_X, $\sigma_\star$, $M_\star$



Suh, Civano, Trakhenbrot+19



Sani+18, Ricci+17a,b, Onori+17a,b

4 *F.Duras et al.*

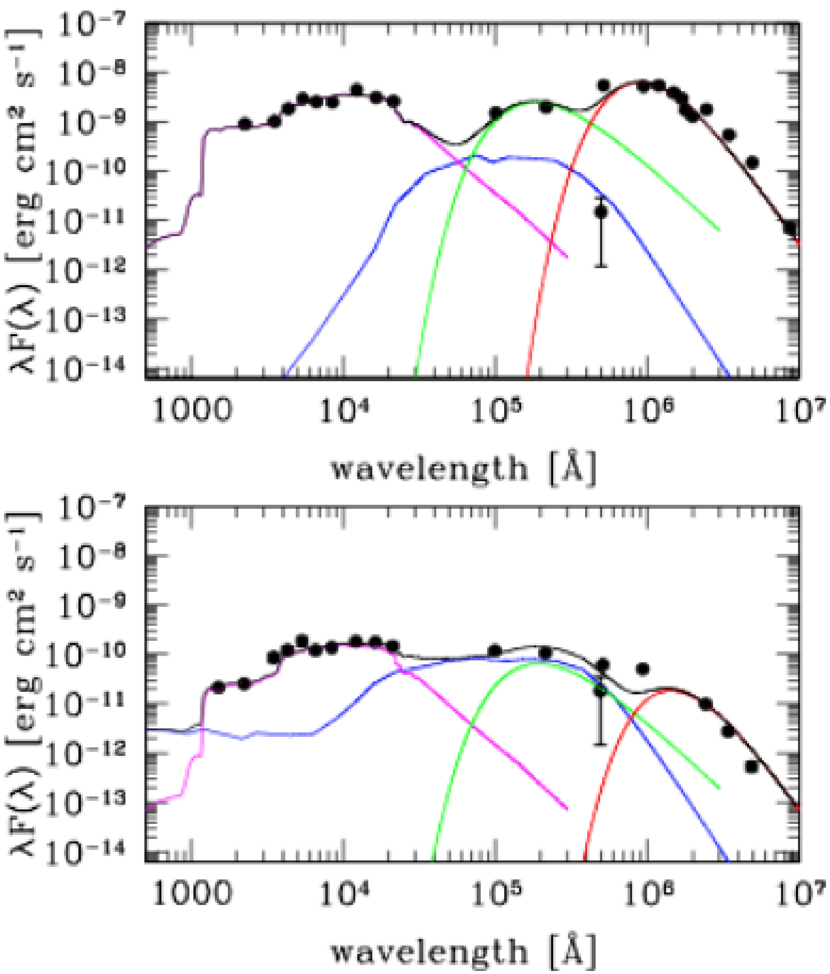


Figure 1. Examples of SED fitting results for a type 2 (upper panel) and a type 1 (lower panel) source

Dalla spettroscopia NIR è stata ricavata la:

MBH

Attraverso SED fits, ed una nuova stima della K-correction in X, sono state derivate:

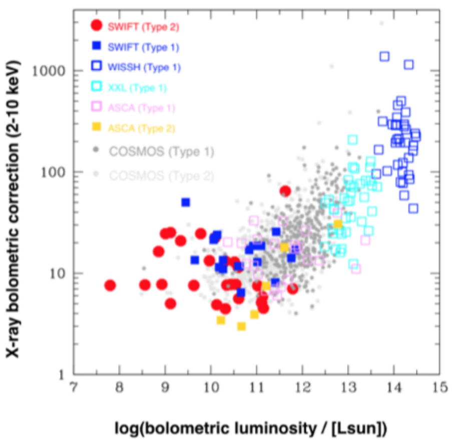
M$_*$
SFR
Lbol (AGN)

Duras+20, A&A

Il campione (unito ad altri samples) ha permesso di estendere a basse Lbol la stima della K-correction (X e ottica)

STEP BY STEP : THE SAMPLE(S)

Five AGN (both type 1 and type 2) samples selected to cover a wide range of luminosity



380 TYPE1 and 540 TYPE2 AGN
from the COSMOS sample by *Lusso+12*
0.1 < z < 4

23 TYPE1 and 6 TYPE2 AGN
from the ASCA sample by *Akiyama+03*
Photometric information by cross-correlating SDSS, 2MASS and WISE

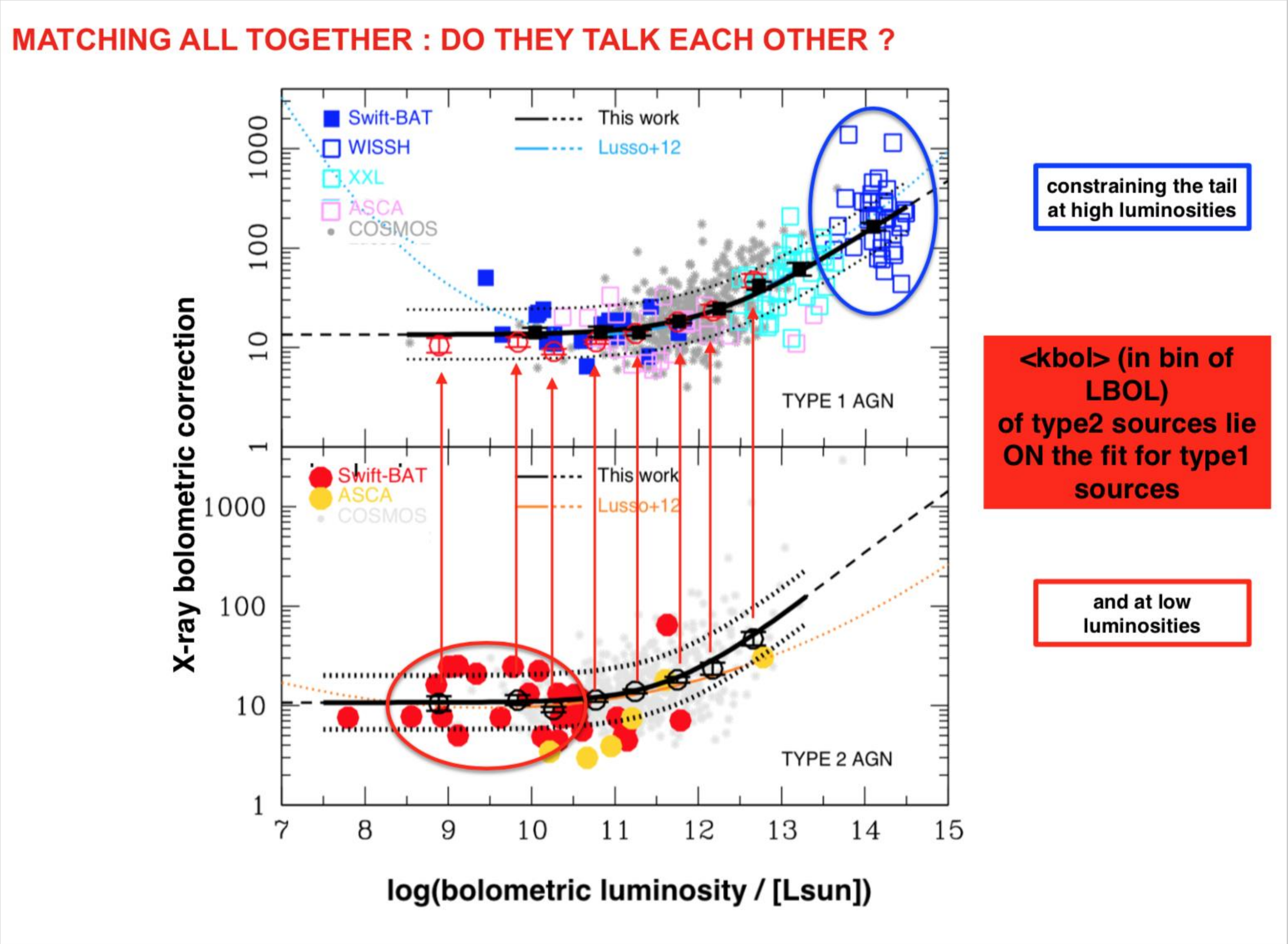
35 TYPE 1 AGN
from the XXL-N survey
Starting from the paper by *Liu+16*, selection of the objects with the highest L_{BOL} (>46.5)

21 TYPE1 and 27 TYPE2 AGN
from the SWIFT/BAT 70-month catalog (*Baumgartner+13*)
Mass measurements for all type 1 and for a fraction of 30% type 2 (through deep NIR spectroscopy —> see *Onori+17*)

35 TYPE 1 AGN
from the WISSH sample (X-ray analysis performed by *Martocchia+17*)

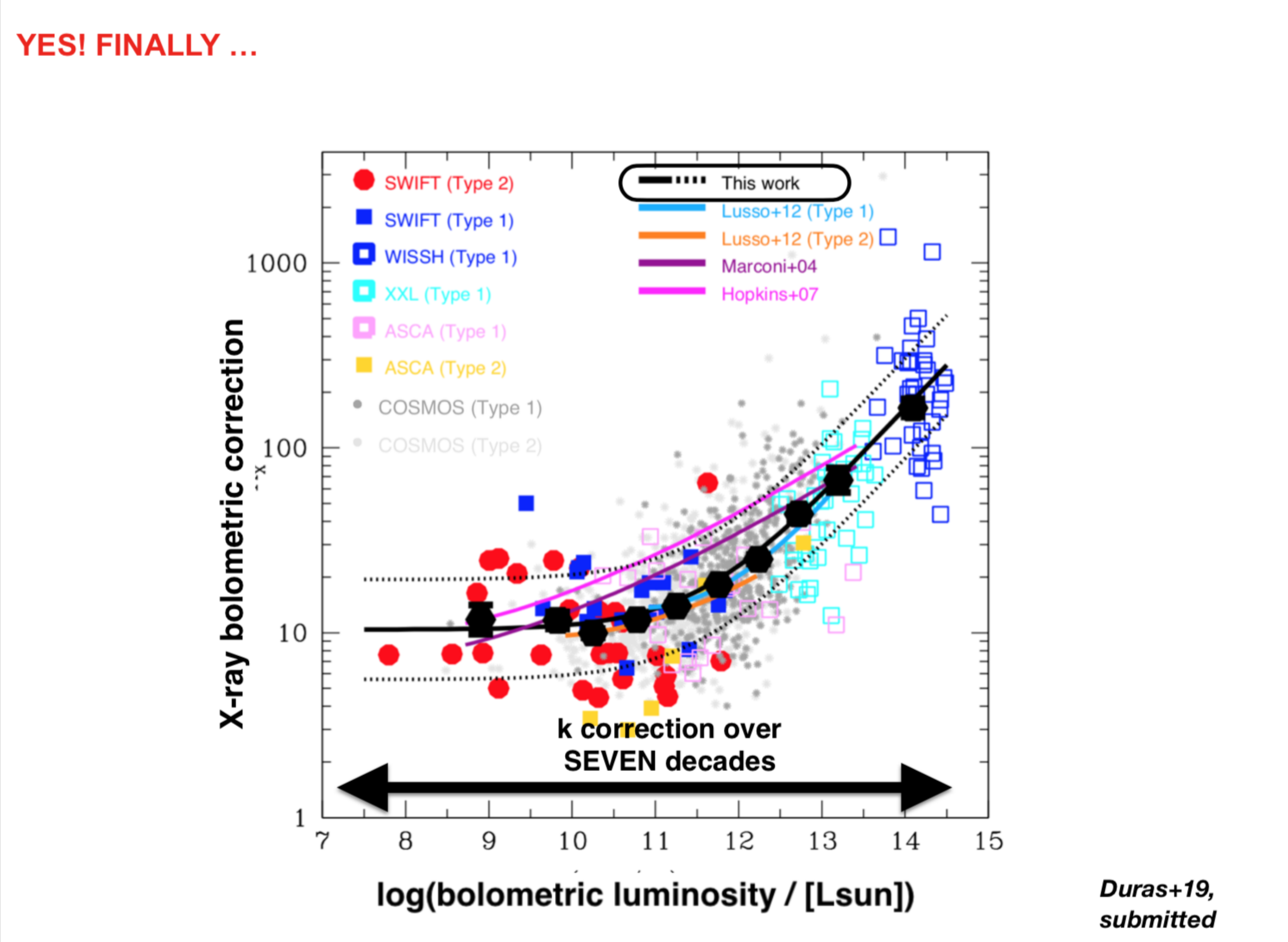
Duras+20, A&A

AGN1 e AGN2 condividono la stessa K-correction X ed ottica



Duras+20, A&A

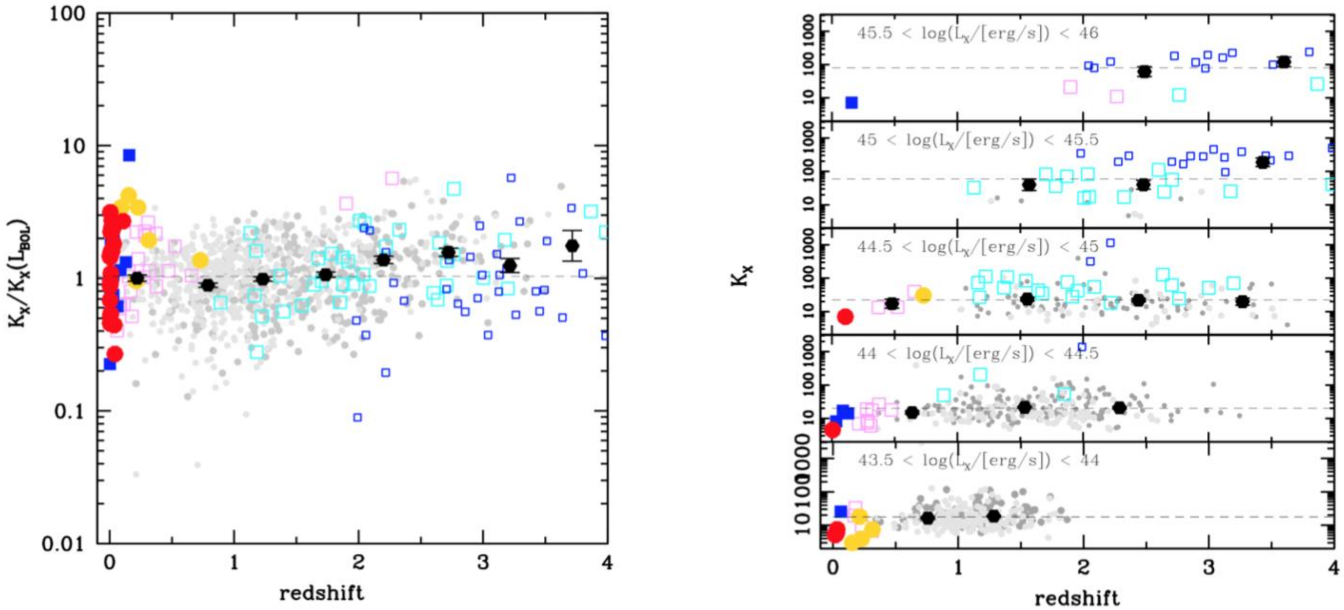
AGN1 e AGN2 condividono la stessa K-correction X ed ottica estesa su 7 decadi



Duras+20, A&A

AGN1 e AGN2 condividono la stessa K-correction X ed ottica

e senza cambiamenti con z



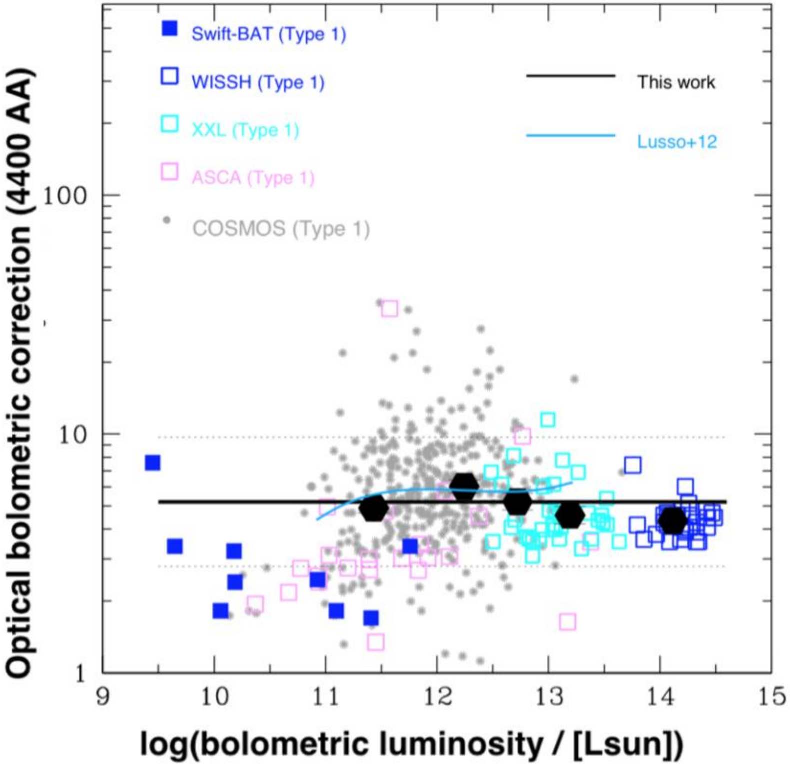
No hint for redshift dependence!

Duras+19, submitted

Duras+20, A&A

La K-correction ottica è costante (K_O~5)

THE OPTICAL BOLOMETRIC CORRECTION

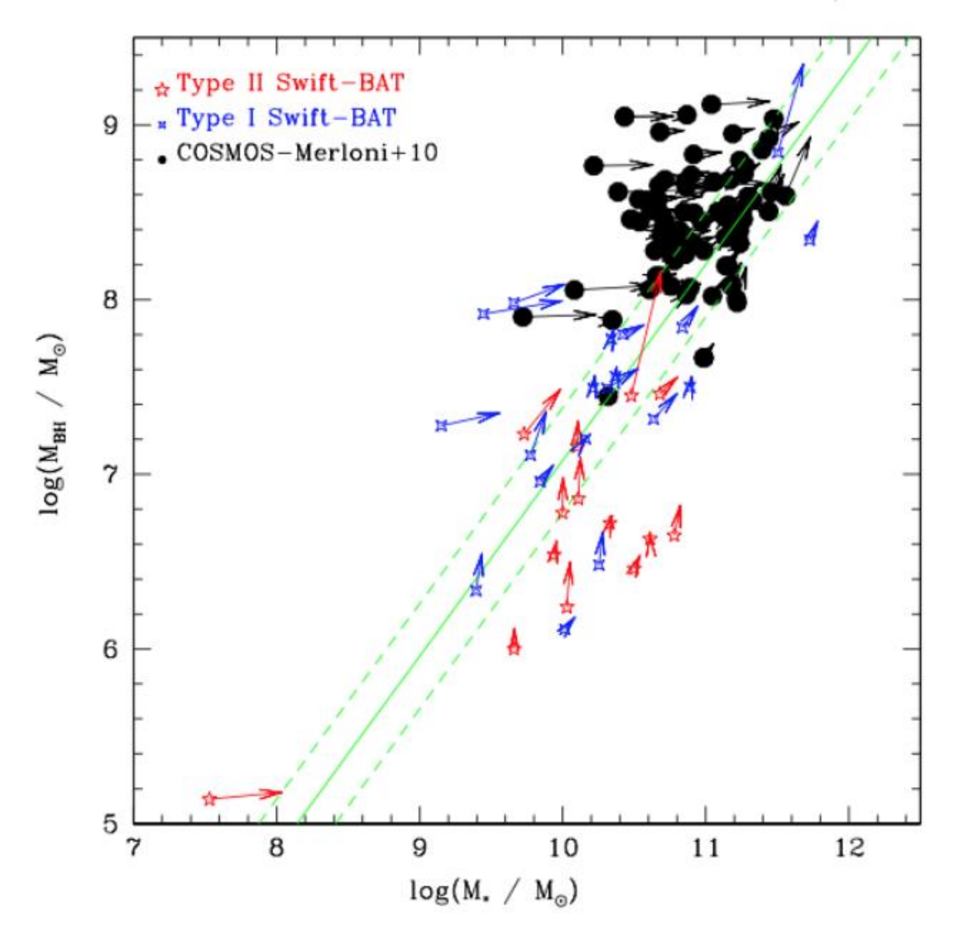


Consistent to be **flat** (K_O ~ 5) in agreement with previous findings (e.g. Lusso+12, same value of the K_O)

Duras+19, submitted

Duras+20, A&A

Grazie alle stime di $\mathbf{M_{BH}}$, $\mathbf{L_{Bol}}$(AGN), $\mathbf{M_{\ast}}$ e **SFR** siamo per la prima volta in grado di descrivere il moto sulla relazione di scala degli AGN (1 e 2) locali



Federica Duras et al., in prep

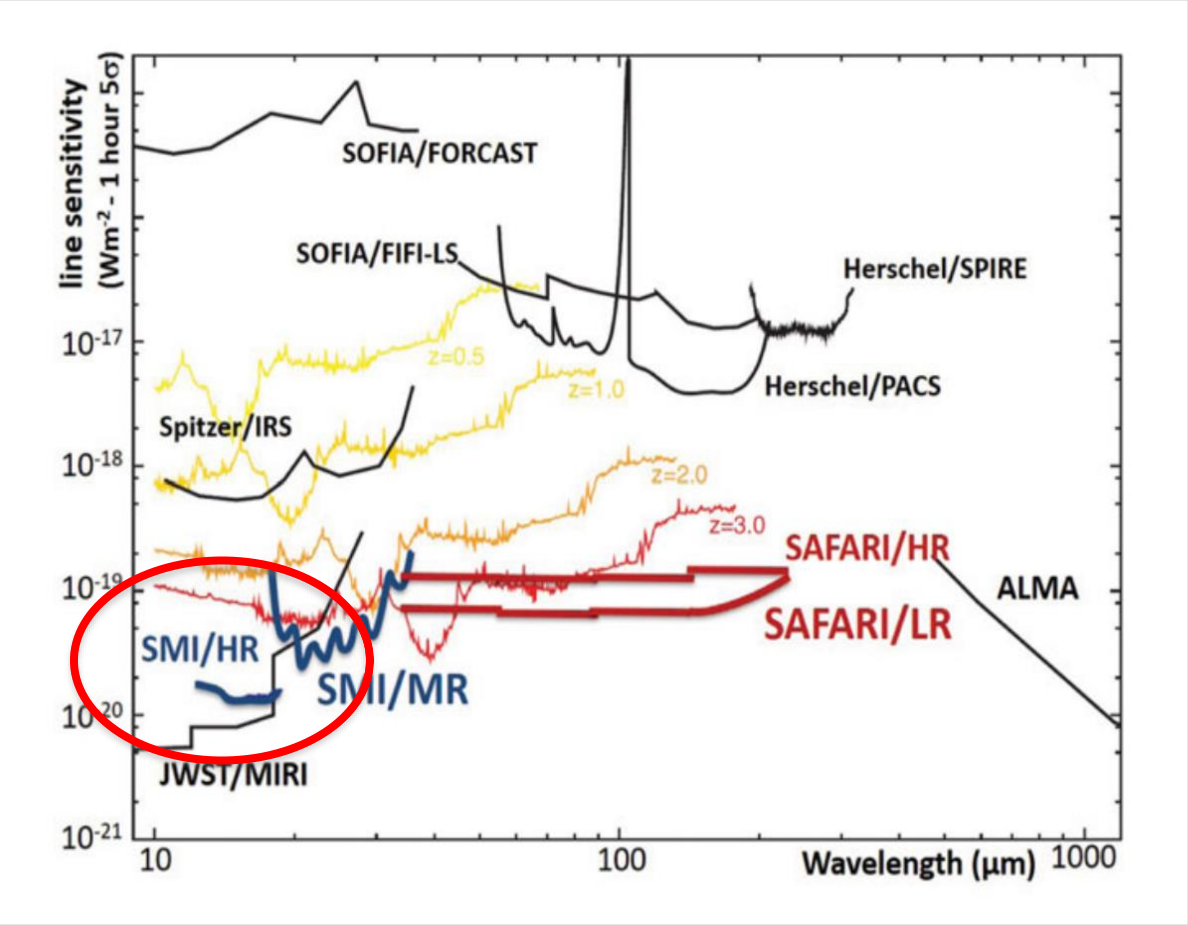
È stato svolto uno studio sulla possibilità di usare gli spettrografi nel NIR-MIR della missione SPICA (proposta ASI-ESA-JAXA) per misurare le BLR degli AGN oscurati

WP3160: The Black Hole accretion rate history of the early universe

Federica Ricci (PUC - Chile), Fabio La Franca (Università Roma Tre)
Federica Duras (Marseille Univ.)

Measuring the BH mass of early AGN

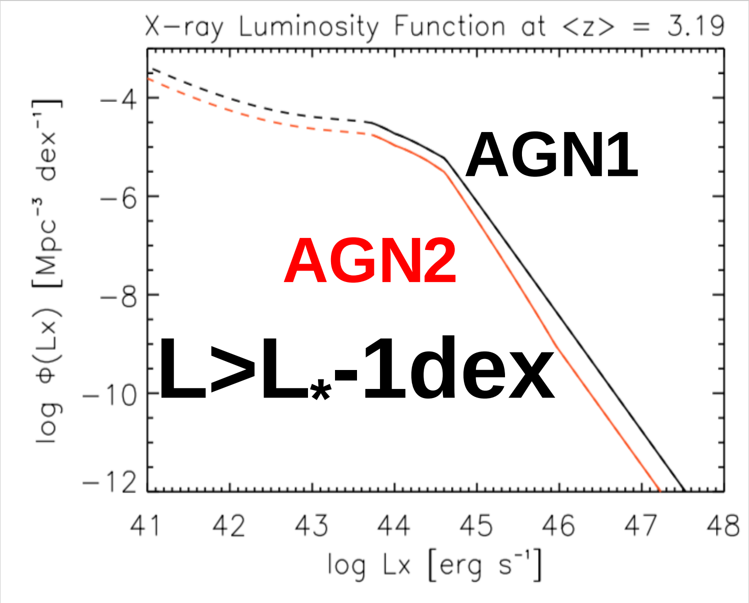
- **SMI HR spectroscopic observations at 12-18** μm open the possibility to measure the BH masses of obscured Galaxies at redshift 2<z<3.5 by measuring the width of the **Bracket Alpha** line (4.05 μm).

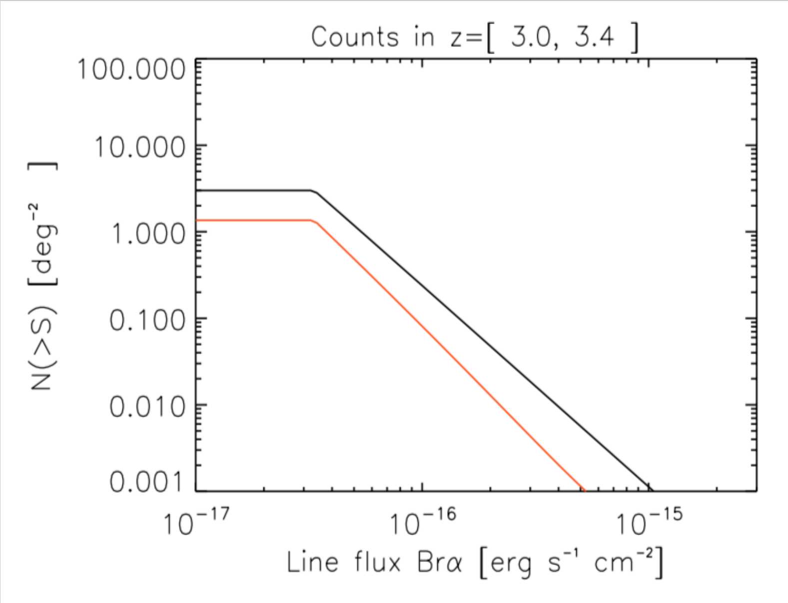


Federica Ricci et al.

Sarà possibile evidenziare la presenza della BLR a z~3.2 in AGN2 con luminosità di 1dex inferiori alla L*

SMI - SN (Brα) = 50 σ / 1 h





Z=3.2

Federica Ricci et al.