Harnessing the XMM-Newton data with *XMM2ATHENA*: X-ray spectral modeling of 4XMM-DR11 detections

George Mountrichas

Instituto de Fisica de Cantabria

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The link among X-ray spectral properties, AGN structure and the host galaxy

G. Mountrichas, A. Viitanen, F. J. Carrera,
H. Stiele, A. Ruiz, I. Georgantopoulos, S. Mateos, A. Corral

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THE LINK AMONG X-RAY SPECTRAL PROPERTIES, AGN STRUCTURE AND THE HOST GALAXY

- Do X-ray obscured and unobscured AGN live in host galaxies with different properties (SFR, Mstar)?
- Is the accretion efficiency different in the two AGN populations?
- How do the M_{BH} of the two AGN populations compare?
- Is there a correlation between the photon index and n_{EDD}?

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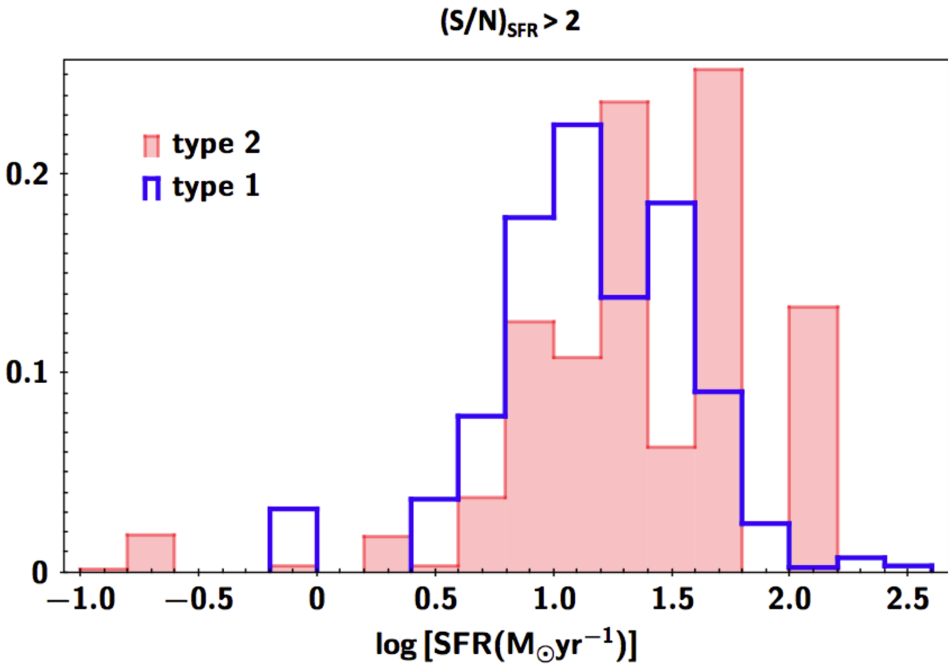
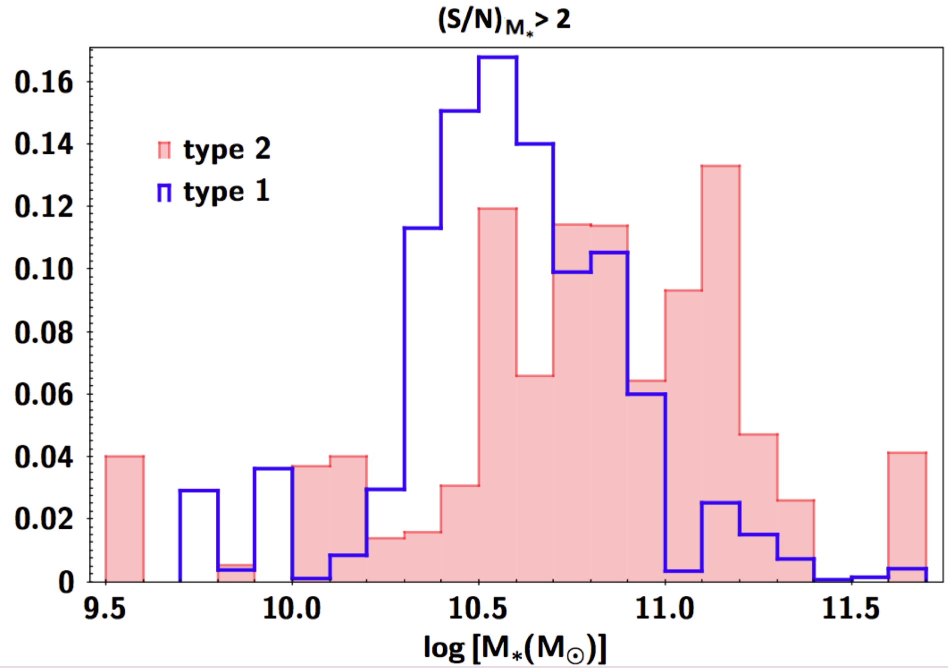
INTRODUCTION I – OBSCURATION AND HOST GALAXY PROPERTIES

Host galaxy properties based on ***optical criteria*** *(optical spectra)*





Mountrichas et al. 2021b (see also Zou et al. 2019)

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INTRODUCTION I – OBSCURATION AND HOST GALAXY PROPERTIES

Host galaxy properties based on *the **inclination angle*** *(SED fitting analysis)*

- Type 2 AGN tend to inhabit more massive galaxies compared to type 1.
- The comparison of the SFR between the two AGN populations depends on Lx and redshift: *Type 2 sources tend to have lower SFR compared to type 1 AGNs at z < 1. This picture reverses at z > 2 and log* L_X *> 44*

Mountrichas & Georgantopoulos 2024

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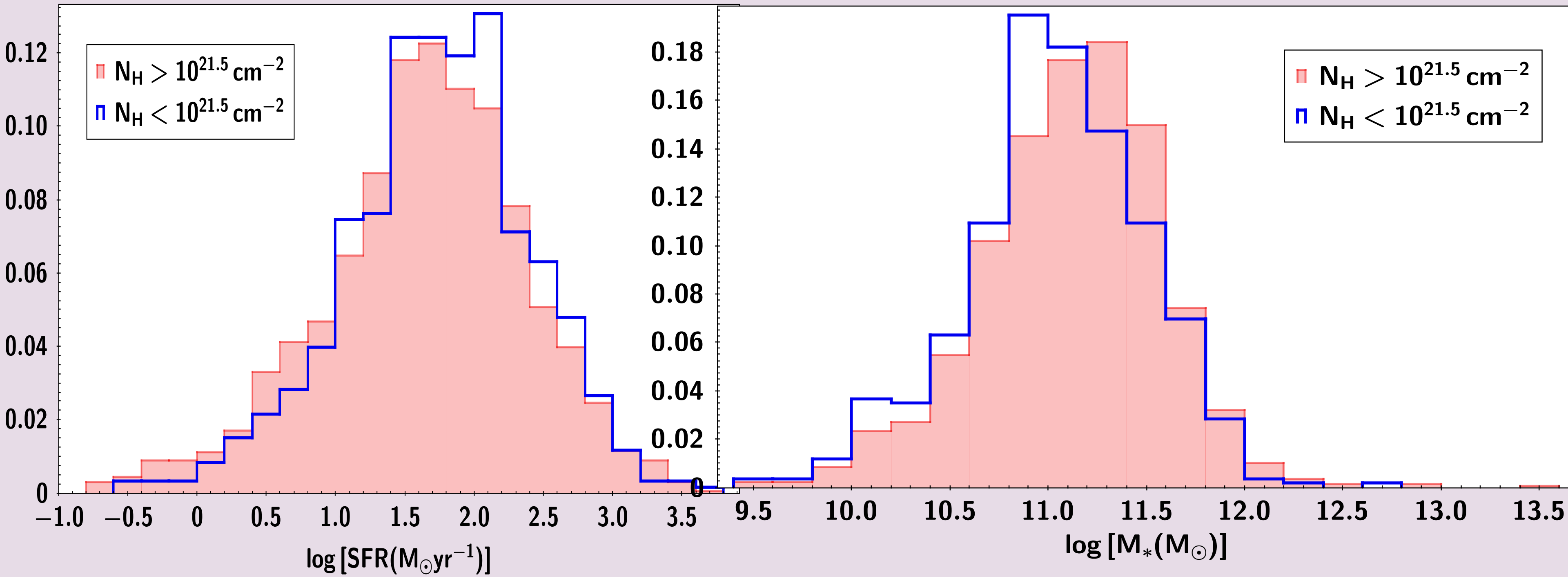
INTRODUCTION I – OBSCURATION AND HOST GALAXY PROPERTIES

Host galaxy properties based on ***X-ray criteria***



Mountrichas et al. 2021b
(see also Masoura, Mountrichas, Georgantopoulos et al. 2021)
BUT SEE
Lanzuisi et al. 2017 – increase of Mstar with N_H.

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INTRODUCTION I – OBSCURATION AND HOST GALAXY PROPERTIES

More recently, Georgantopoulos, Pouliasis, Mountrichas et al. 2023:

$N_H = 10^{23}\ cm^{-2}$

- Unobscured AGN tend to live in younger galaxies compared to obscured.
- Obscured AGN tend to live in systems with higher Mstar compared to unobscured.
- Obscured AGN have lower n_{EDD} compared to unobscured.

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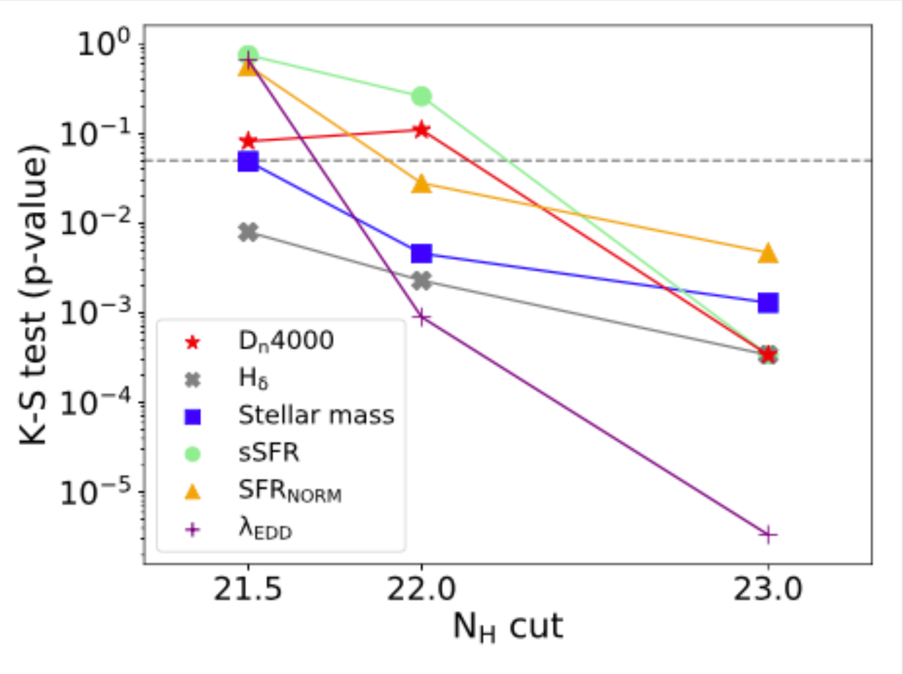
INTRODUCTION I – OBSCURATION AND HOST GALAXY PROPERTIES

Possible reasons for the discrepant results:

1 .Different N_H cut



2. Different L_X probed

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INTRODUCTION II – OBSCURATION AND SMBH PROPERTIES

- M_{BH} is strongly correlated with Mstar
(e.g., Jahnke et al. 2009, Merloni et al. 2010, Poitevineau et al. 2023, Mountrichas 2023)

- The M_{BH}/Mstar ratio does not evolve with redshift, at least up to redshift 2
(e.g., Mountrichas 2023, Setoguchi et al. 2021, 2023, Suh et al. 2020 , Sun et al. 2015, Jahnke et al. 2009)

Do these correlations hold for both AGN populations?

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INTRODUCTION III – OBSCURATION AND AGN STRUCTURE

X-ray spectral index is sensitive to the properties of the accretion disk (temperature, ionization state). X-ray emission is also associated with a hot, optically thin corona of electrons above the accretion disk. The properties of the corona (temperature, optical depth) can impact the X-ray spectral index.

The relation between Γ and n_{EDD} is interpreted as the link between the accretion efficiency in the accretion disk and the physical status of the corona (e.g., Vasudevan & Fabian 2007, Davis & Laor 2011).

or

A correlation between Γ and n_{EDD} could be explained by the significant dependence of the cut-off energy on the n_{EDD} (e.g., Ricci et al. 2018).

However:

It is not clear whether such a correlation between Γ and n_{EDD} is robust or universal!

(e.g., Shemmer et al. 2008, Risaliti et al. 2009, Sobolewska & Papadakis 2009, Brightman et al. 2013, Trakhtenbrot et al. 2017, Kamraj et al. 2007)

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THE LINK AMONG X-RAY SPECTRAL PROPERTIES, AGN STRUCTURE AND THE HOST GALAXY

DATA

Viitanen, Mountrichas, Carrera et al. (in prep.)

- 210, 444 sources with available spectrum in one or more detections, in 4XMM-DR11
- Cross-match it with the Tranin et al. 2022 sample of classified sources (AGN, stars, XRBs, CVs) → 76,610 AGN.
- We obtain photoz from Ruiz et al. (in prep.) →35,536 AGN (specz+photoz)
- Perform X-ray spectral analysis (powerlaw with two absorbing media: local Galactic absorption, in-situ absorption at the AGN redshift
- Construct the SEDs (SDSS/Pan-STARRS, 2MASS, WISE) →2,501 AGN
- Selection criteria → 1,443 AGN (1,231 at $z<0.7$ and 212 at $0.7<z<1.9$)

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THE LINK AMONG X-RAY SPECTRAL PROPERTIES, AGN STRUCTURE AND THE HOST GALAXY

Do X-ray obscured and non-obscured AGN live in host galaxies with different properties (SFR, Mtar)?

Is the accretion efficiency different in the two AGN populations?

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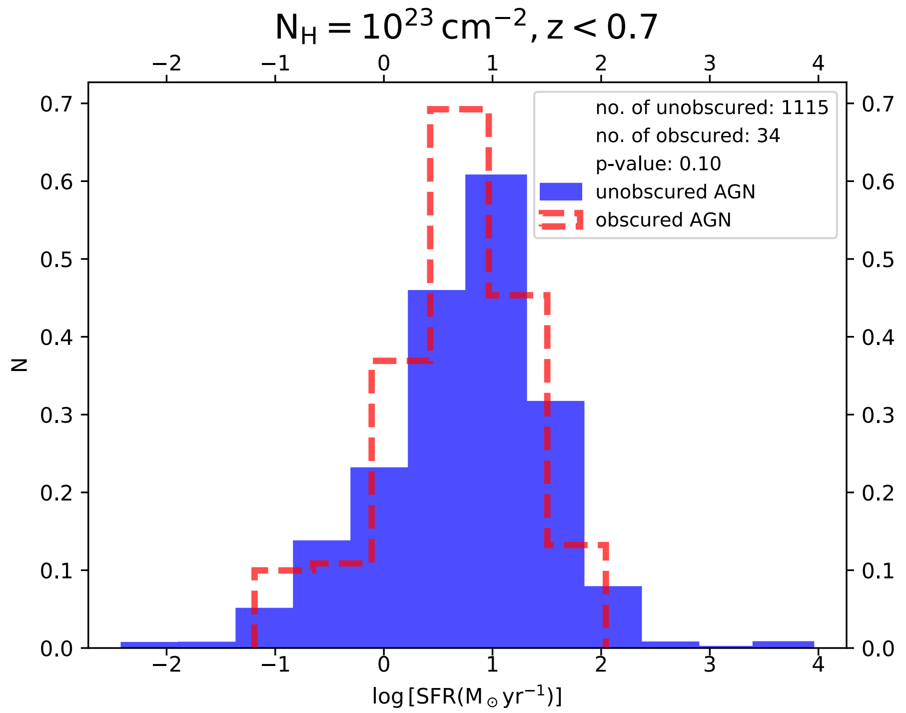
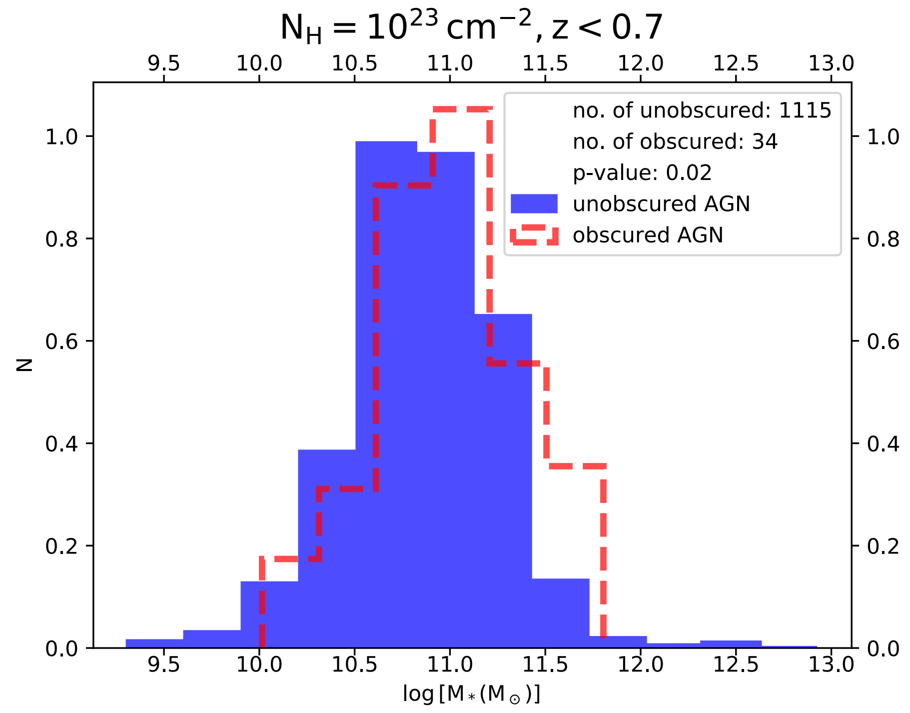
RESULTS I: OBSCURATION AND HOST GALAXY PROPERTIES





Obscured AGN tend to live in more massive systems and their hosts have lower SFR compared to their unobscured counterparts.

However, only the Mstar difference appears to be statistically significant!

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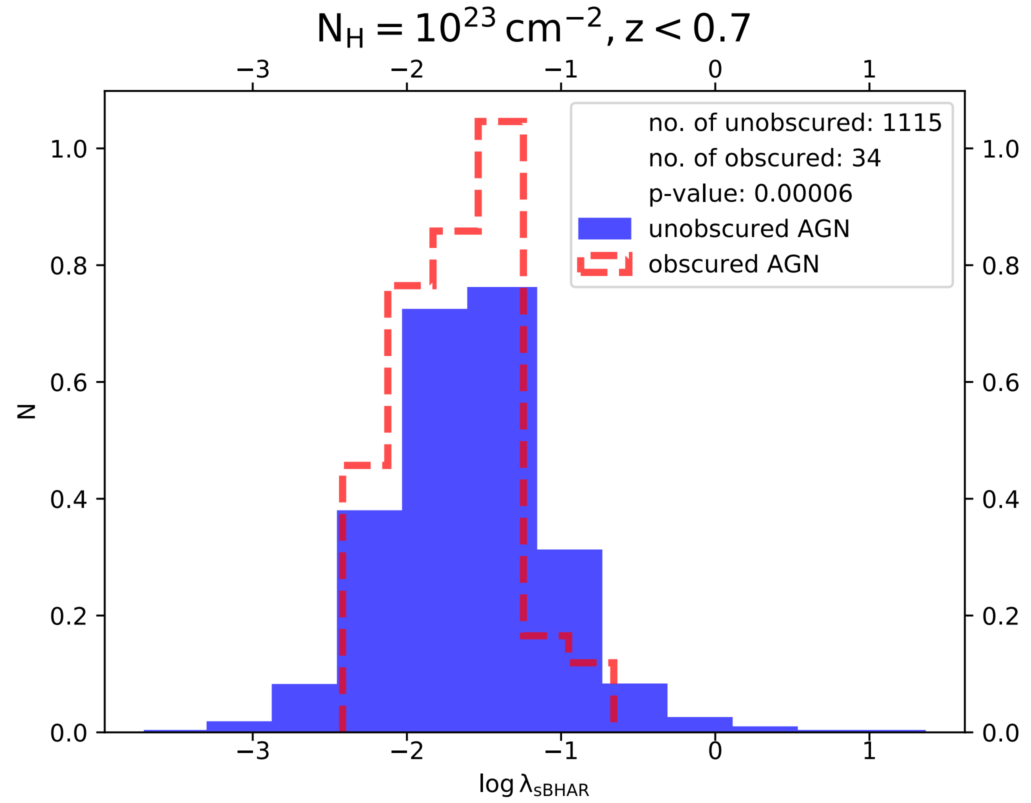
RESULTS I: OBSCURATION AND AGN ACCRETION EFFICIENCY



$$\lambda_{sBHAR} = \frac{k_{bol}\, L_{X,2-10\,keV}}{1.26 \times 10^{38}\ \mathrm{erg\ s^{-1}} \times 0.002 \frac{M_*}{M_\odot}}$$

Obscured sources tend to have lower λ_{sBHAR} compared to unobscured .

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THE LINK AMONG X-RAY SPECTRAL PROPERTIES, AGN STRUCTURE AND THE HOST GALAXY

How do the M_{BH} of the two AGN populations compare?

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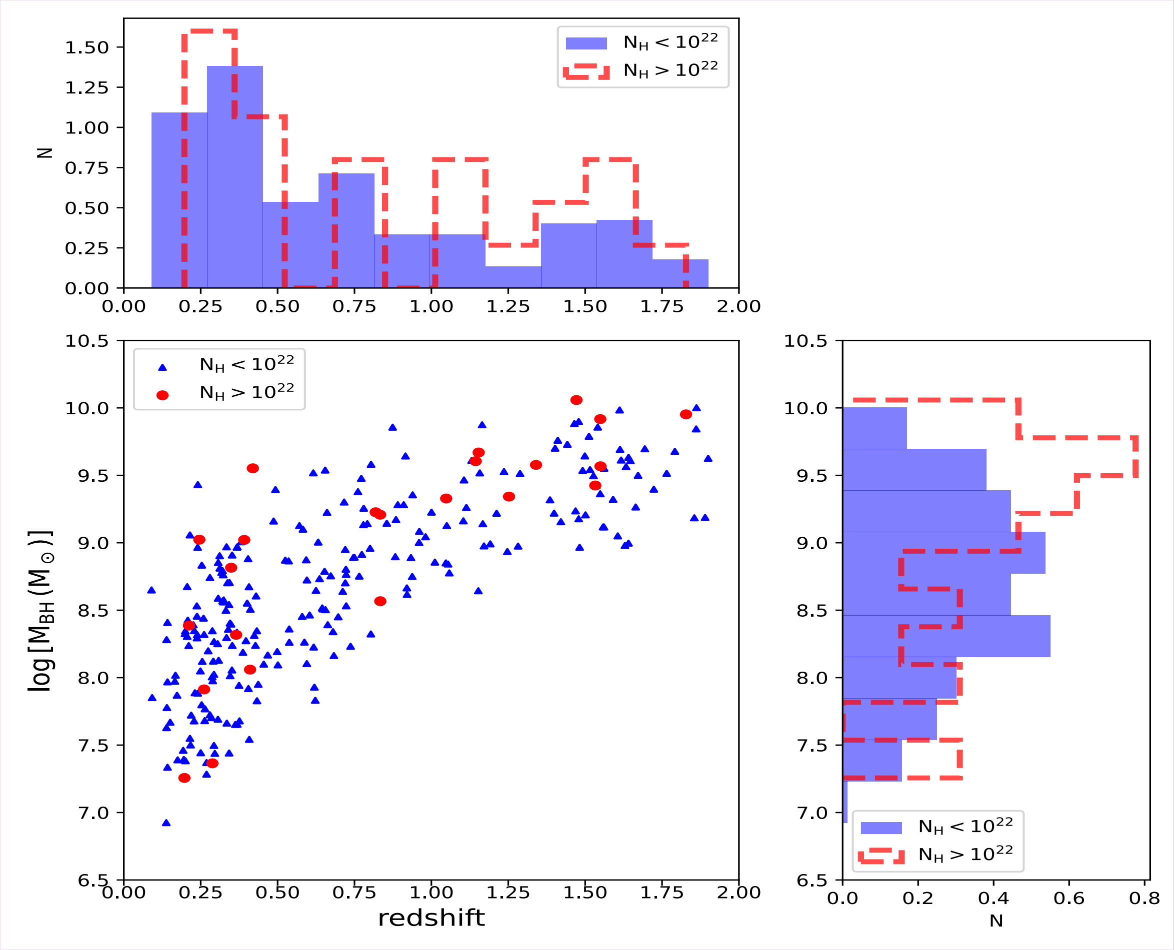
DATA

- From the 1,443 AGN, 344 are in the Wu & Shen 2022 catalogue.

271 are at z<1.9



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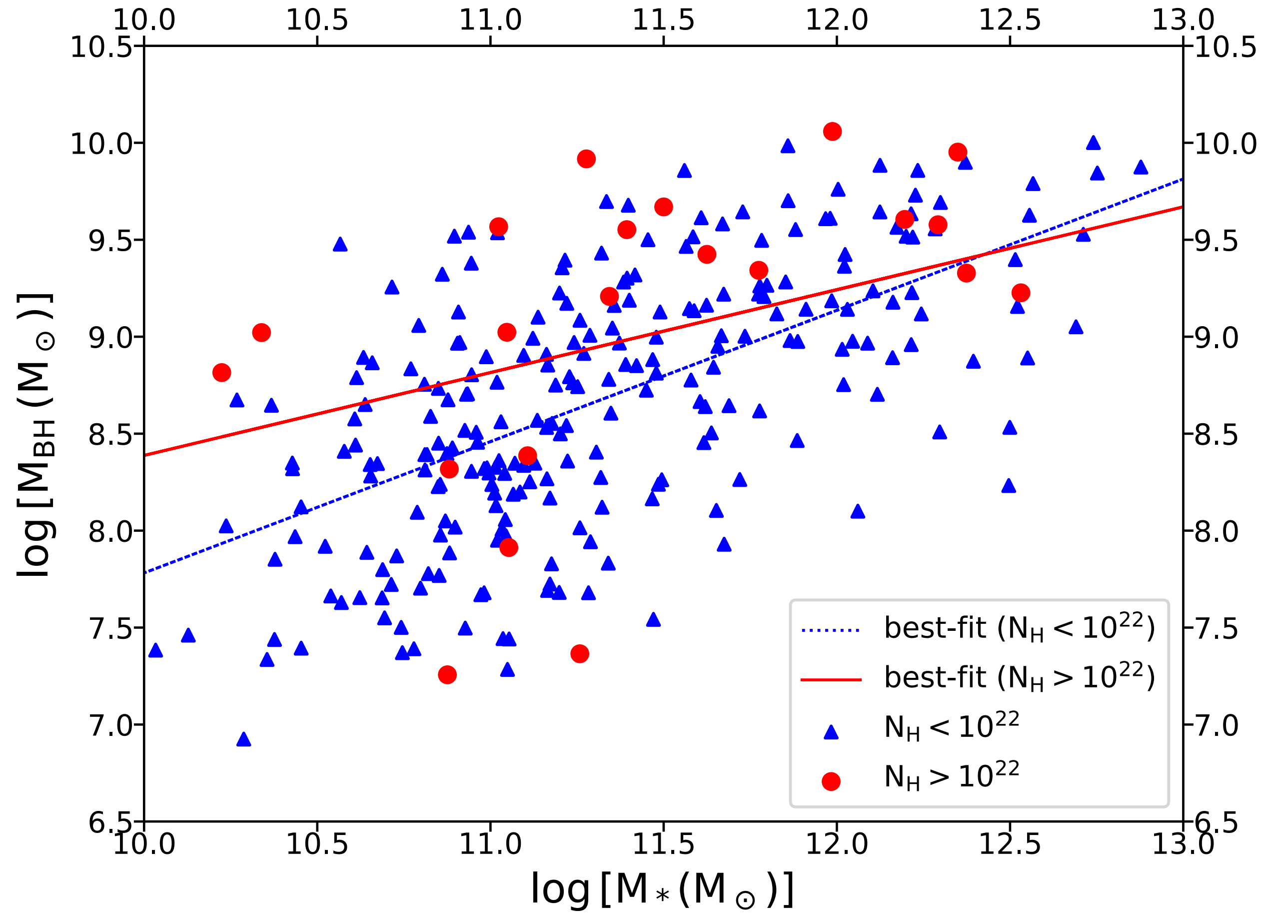
RESULTS II: OBSCURATION AND M_{BH}



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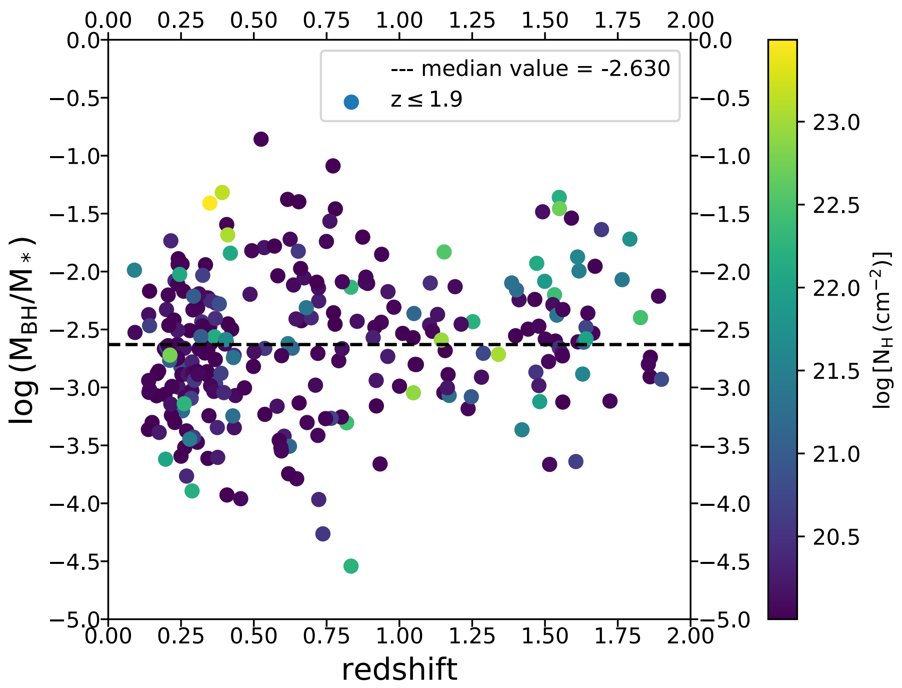
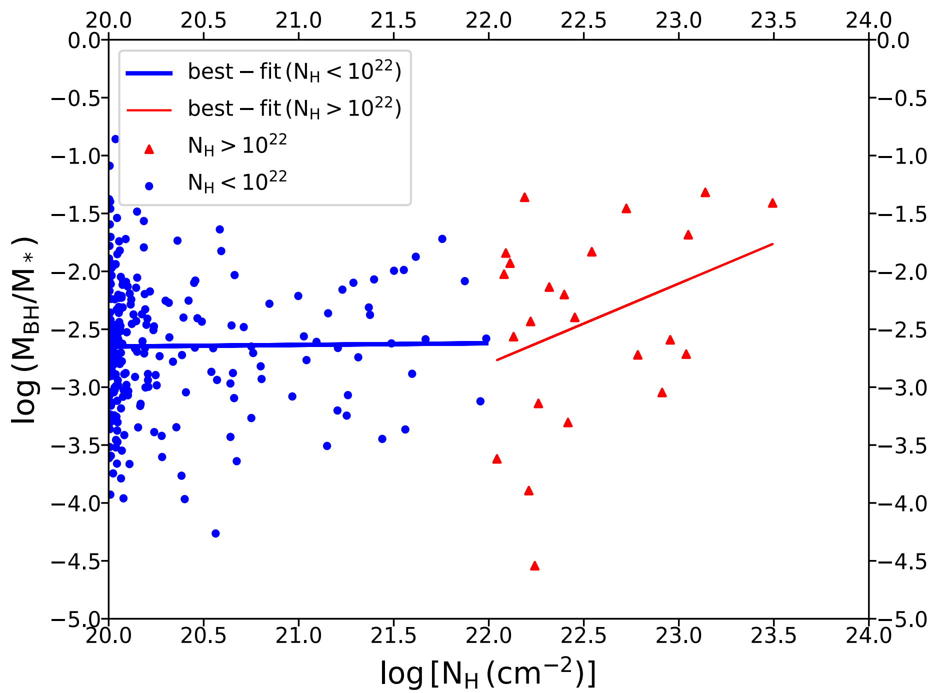
RESULTS II: OBSCURATION AND M_{BH}





SMBH growth in the obscured phase is higher than the galaxy growth?

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Is there a correlation between the photon index and n_{EDD}?

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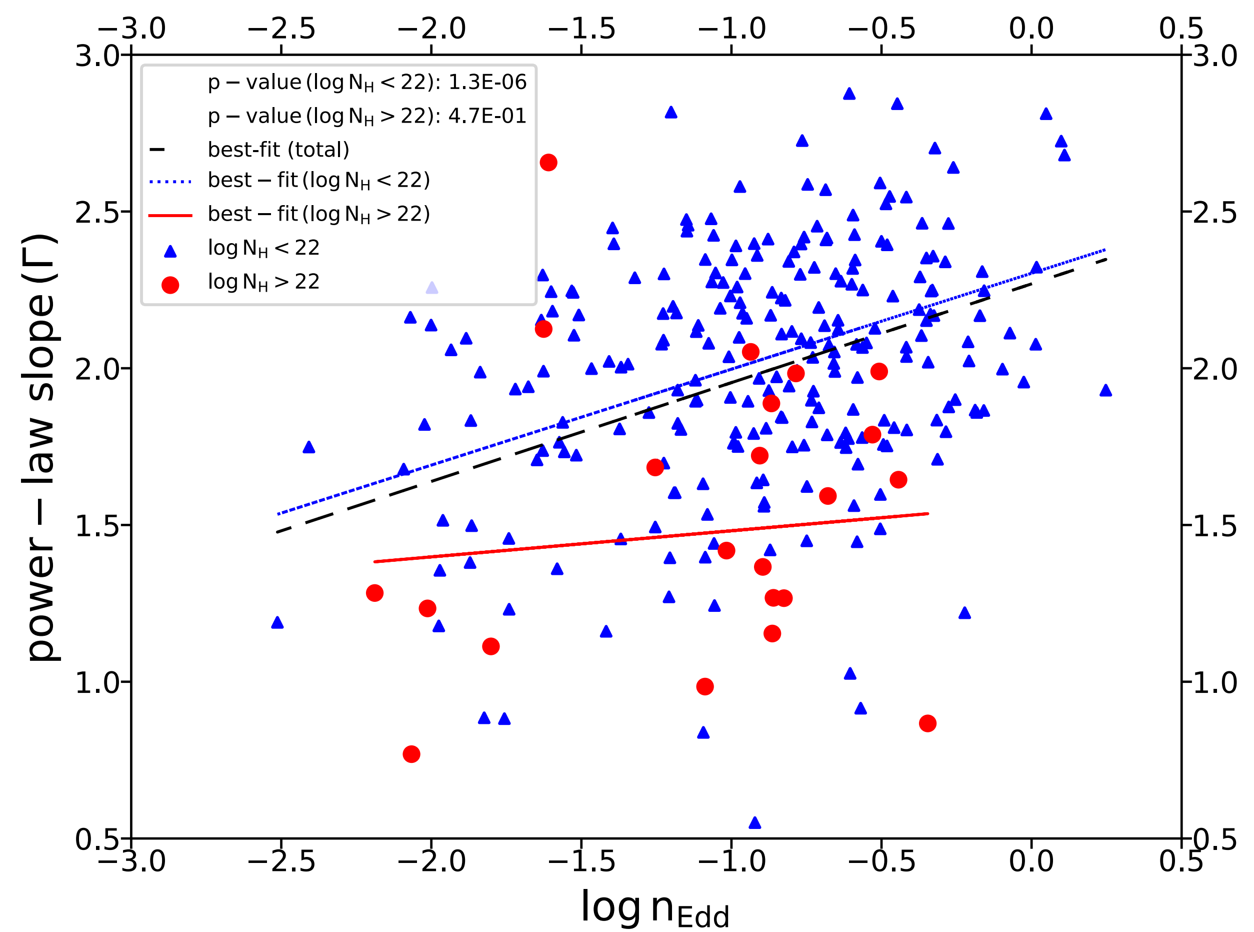
RESULTS III: OBSCURATION AND AGN STRUCTURE



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CONCLUSIONS I

- Obscured AGN tend to live in more massive systems (by ~ 0.1dex) compared to unobscured. The difference, although small, appears to be statistically significant.

- Obscured sources also tend to live in galaxies with lower SFR (by ~ 0.25 dex) compared to their unobscured counterparts, however, this different is not statistically significant.

- Unobscured AGN have, on average, higher specific black hole accretion rates (a proxy of the Eddington ratio) compared to unobscured sources. The difference is 0.1 − 0.2 dex and appears to have a high statistical significance.

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CONCLUSIONS II/III

- Type 1 AGN with NH > 10^{22} cm^{-2} tend to have higher M_{BH} compared to type 1 sources with lower N_H values, at similar Mstar.

- For type 1 AGN, the M_{BH}/M_{star} ratio is nearly constant with N_H up to N_H = 10^{22} cm^{-2}. However, our results suggest that the M_{BH} /Mstar ratio increases at higher N_H values

- A correlation is found between the spectral photon index, Γ, and the Eddington ratio, for type 1 AGN with $N_H < 10^{22}$ cm^{-2}

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