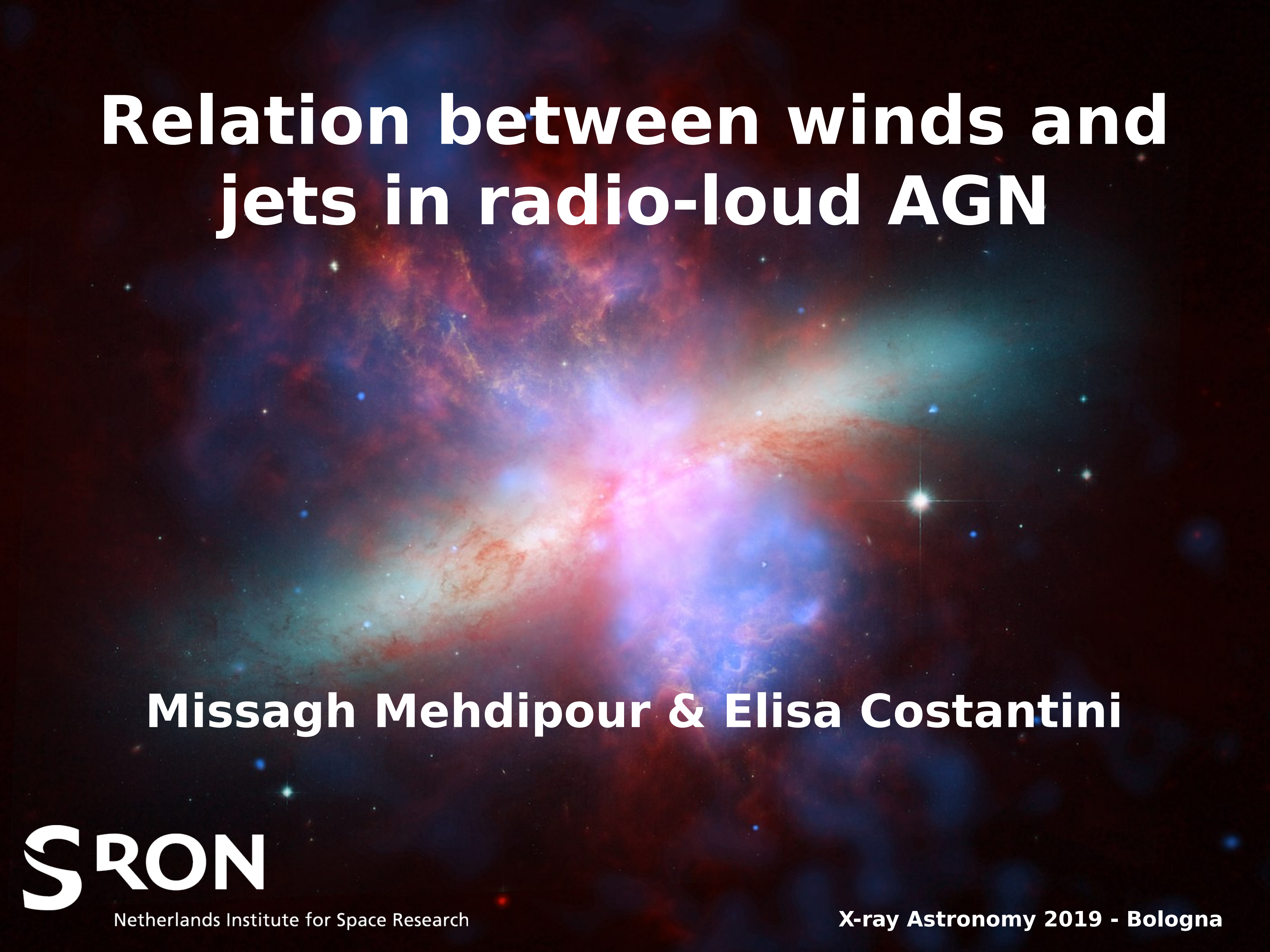
Relation between winds and jets in radio-loud AGN



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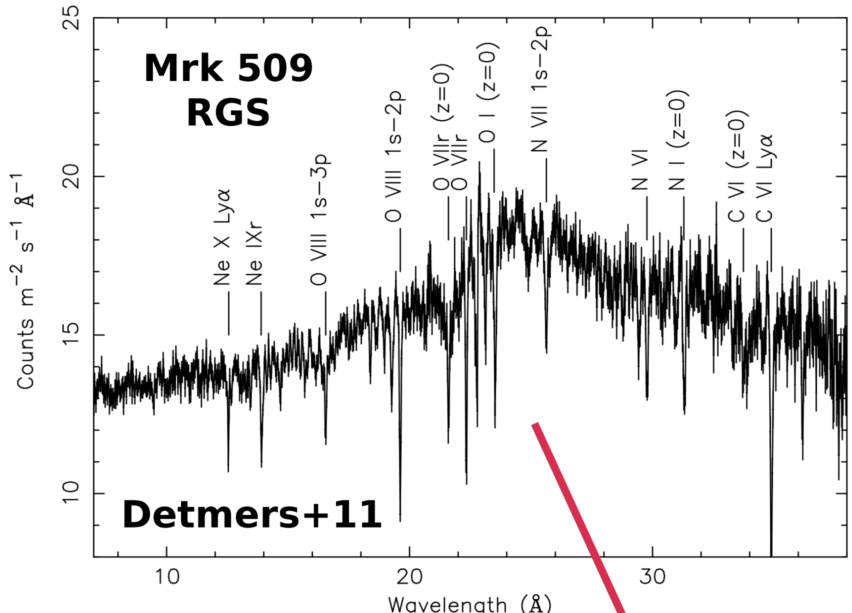
Ionised winds in AGN



Warm-absorber winds

Outflows of photoionised gas from the nucleus

Multiple ionisation and velocity components

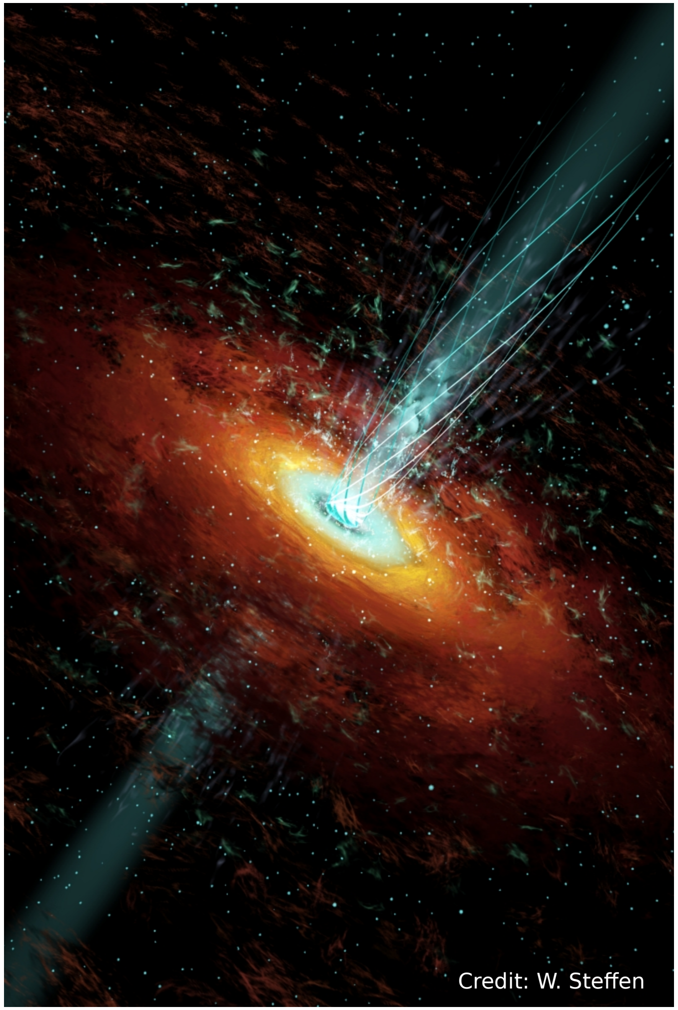
Ionised winds in AGN

Ionised winds mostly studied in radio-quiet AGN

- Large campaigns on Seyferts
- Sample studies

How about ionised winds in radio-loud AGN?

- Ballantyne+05
- Reeves+09
- Torresi+12
- Tombesi+14
- Di Gesu & Costantini 16

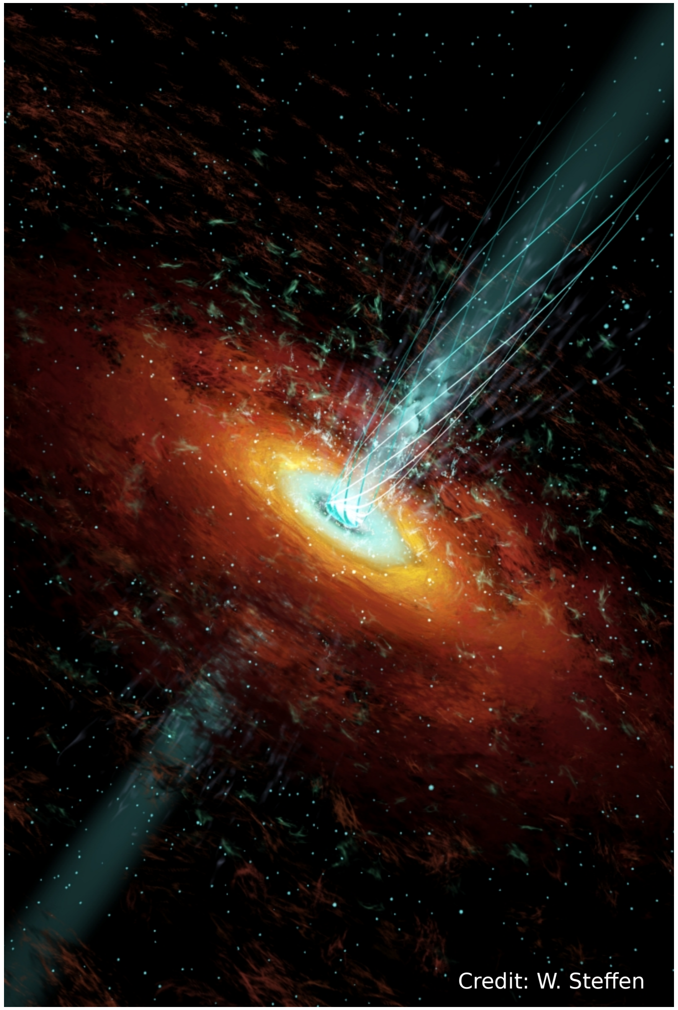


Link between winds and jets?

Questions:

- Differences between ionised winds in RL and RQ AGN?
- Are wind and jet parameters related?
- Common or different origin and driving mechanism?

➡ **We carried out an XMM-Newton spectroscopic study of Type-1 RL AGN**



Sample selection

- Started with Quasars and Active Galactic Nuclei Catalogue (Véron-Cetty & Véron 2010)

- Selected radio-loud Type-1 AGN

  Radio-loudness parameter: $R = F_{6\,\mathrm{cm}}/F_{\mathrm{opt}}$

  Radio-loud AGN: $R > 10$

- Selected those with XMM-Newton observations

- Selected those with RGS S/N > 3 per resolution element for high-resolution X-ray spectroscopy

→ **16 radio-loud Seyfert-1 AGN**

Modelling of the X-ray spectra

X-ray continuum:

- Power-law (primary X-ray continuum)
- Modified black body (soft X-ray excess)
- Reflection component

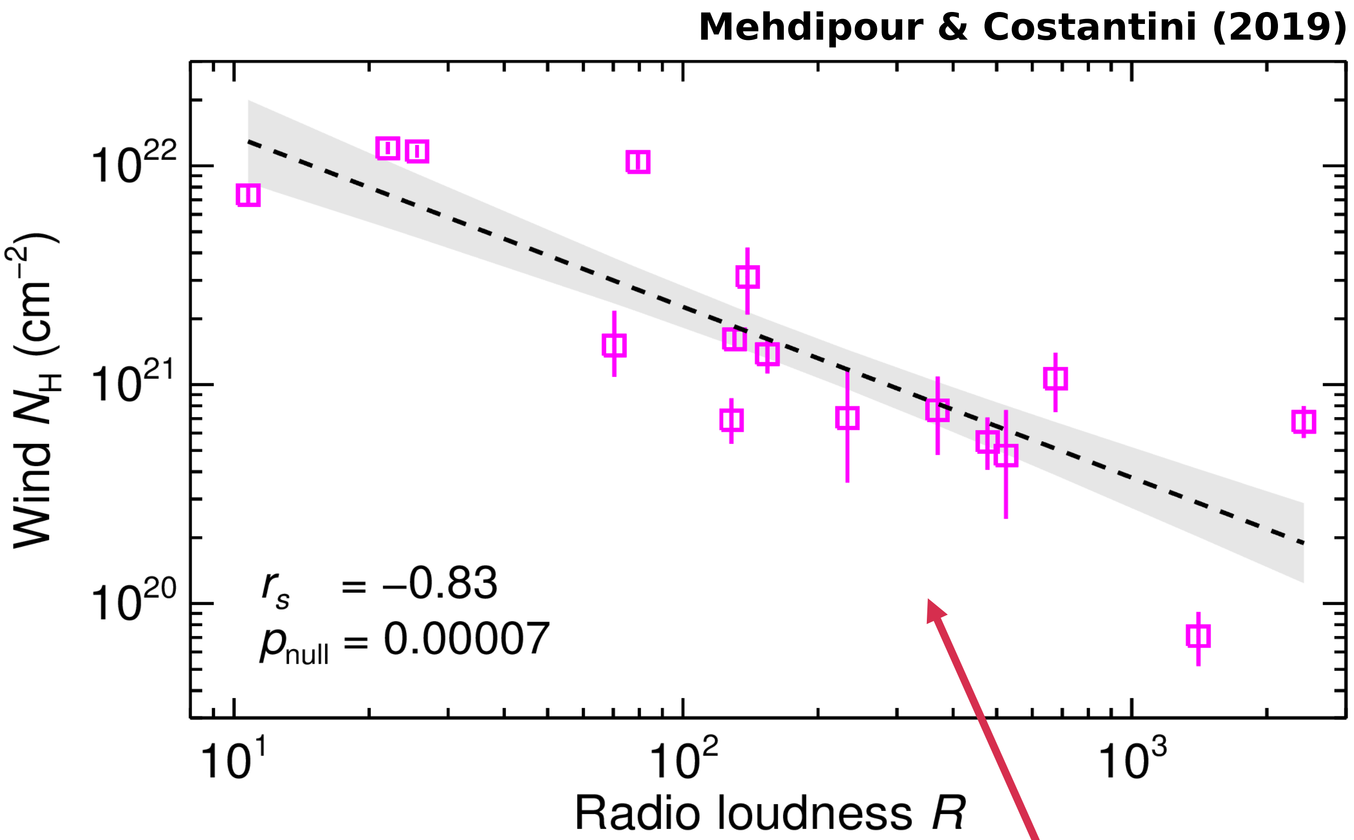
X-ray absorption:

- Milky Way neutral ISM absorption
- Host galaxy neutral ISM absorption
- Photoionised absorption by the wind

→ column density
ionisation parameter
outflow velocity

Modelled with SPEX (Kaastra et al.)

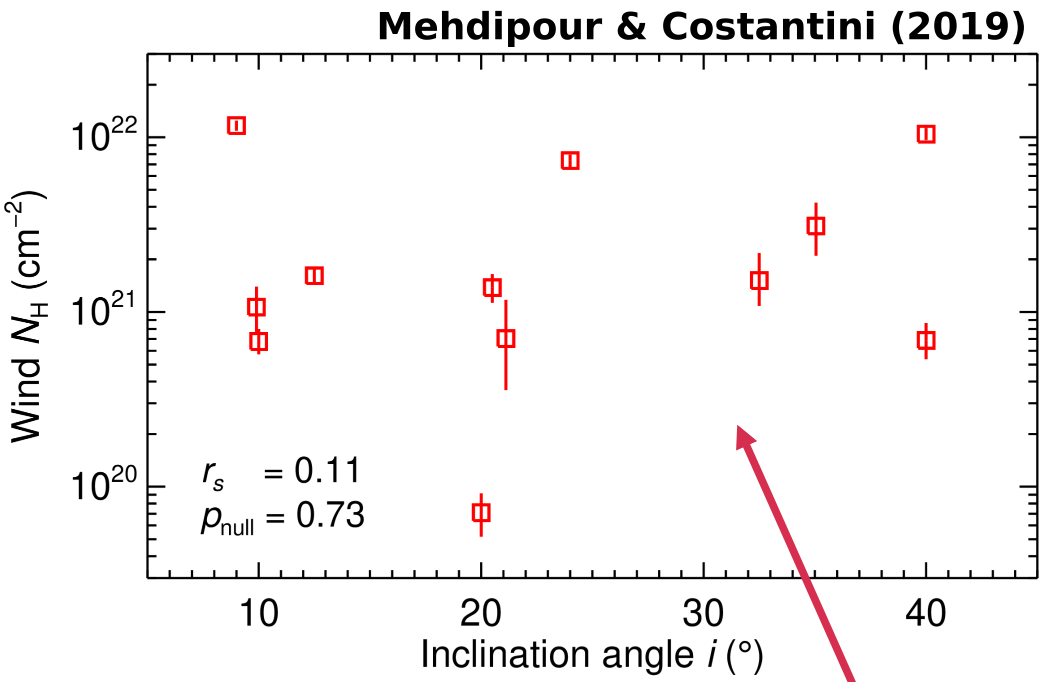
Wind-jet relation in RL AGN



Significant inverse correlation between NH and R

As the radio jet becomes stronger the wind becomes weaker

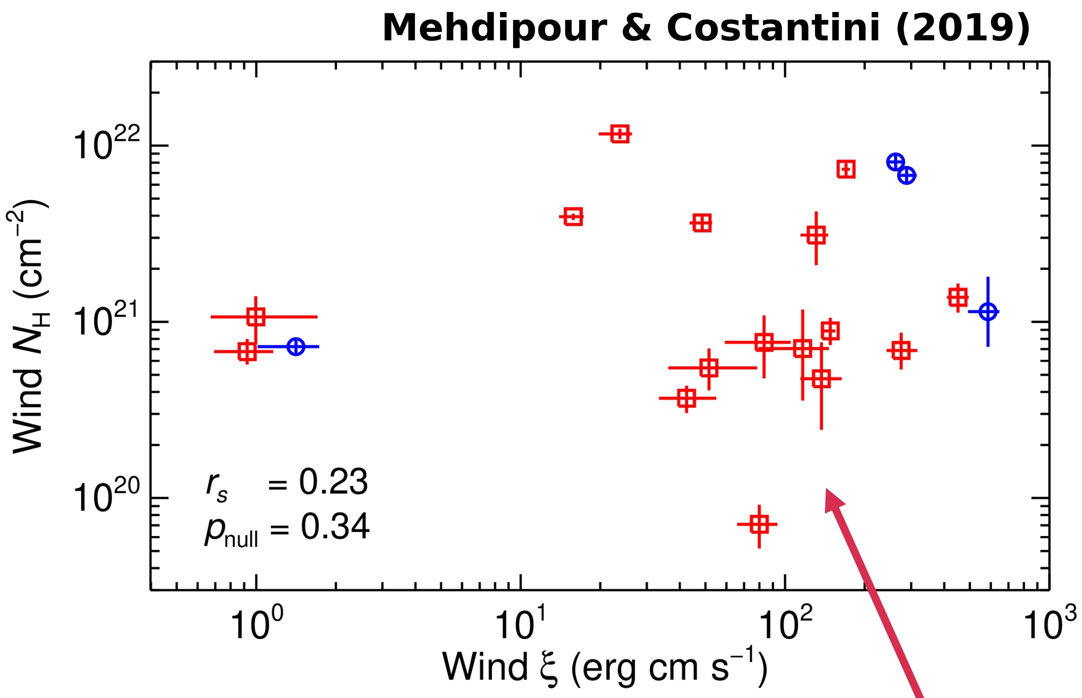
Origin of the NH-R relation?



No dependence on the inclination angle

- **Not preferentially equatorial winds**
- **Similar to UFOs in RL AGN (Tombesi+14)**

Origin of the NH-R relation?

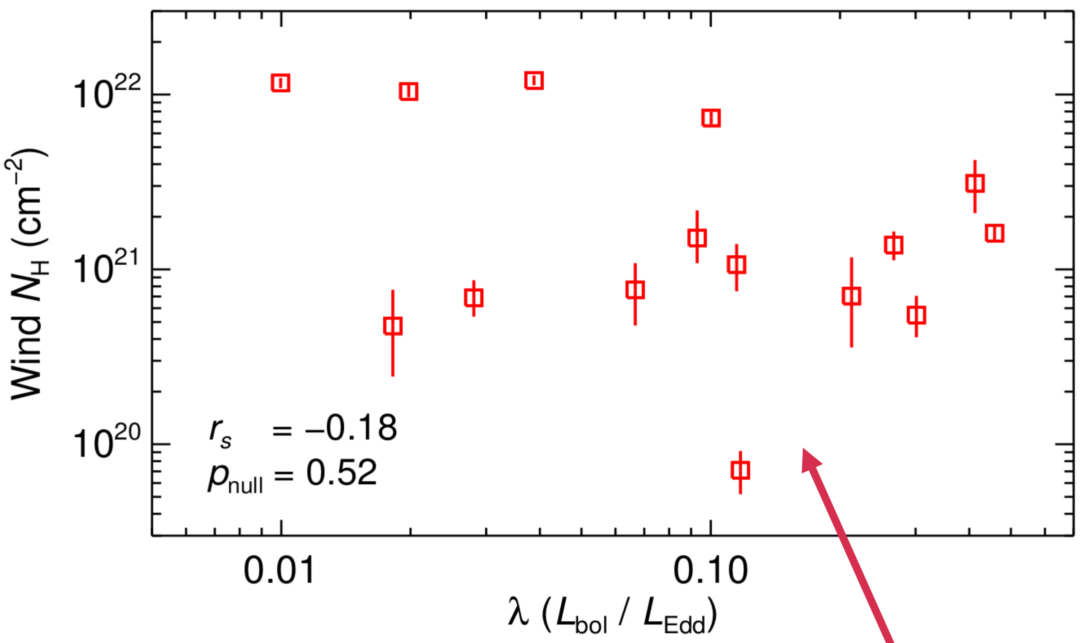


Not an ionisation effect

NH of the warm absorber does not decrease with the ionisation parameter

Origin of the NH-R relation?

Mehdipour & Costantini (2019)

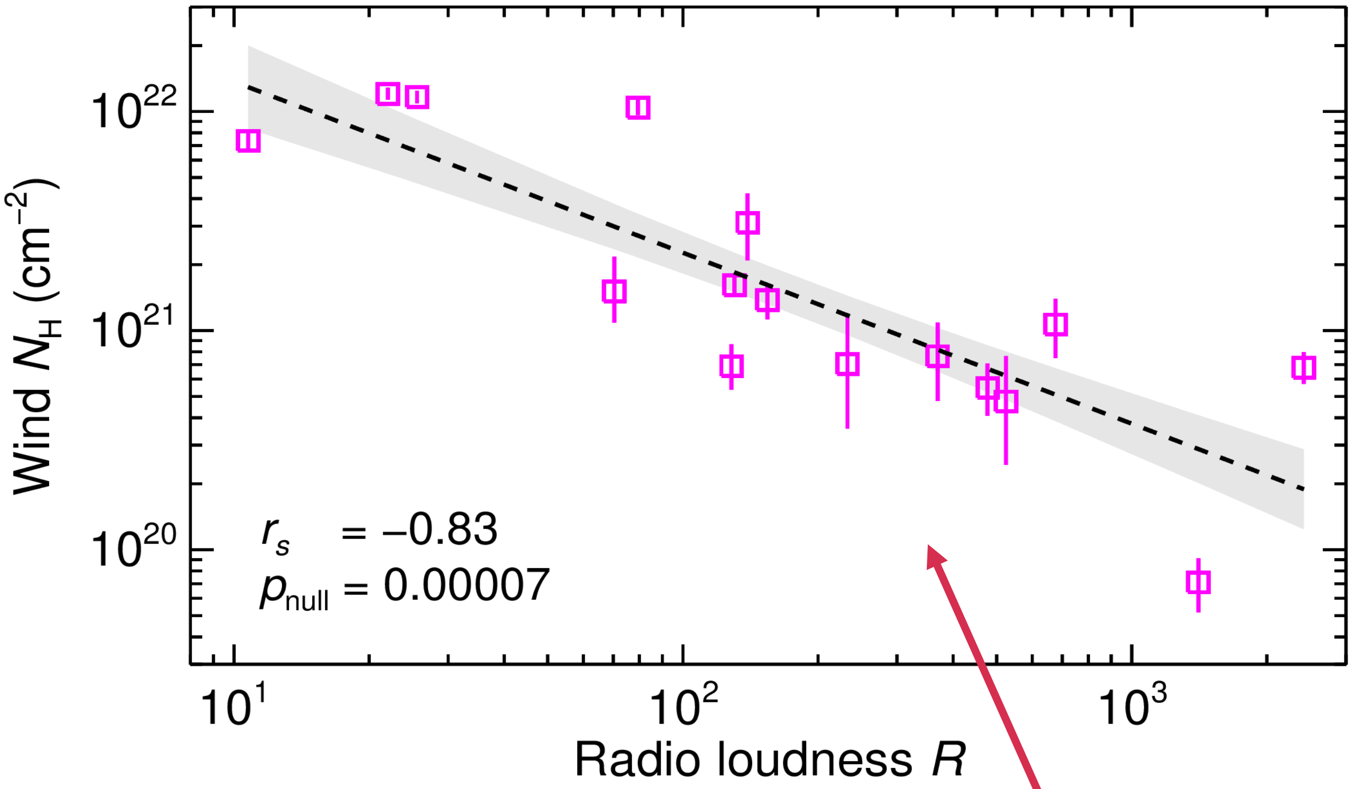


No dependence on the Eddington luminosity ratio

- **Sub-Eddington AGN**
- **Not caused by widely different accretion rates**

Wind-jet relation in RL AGN

Mehdipour & Costantini (2019)



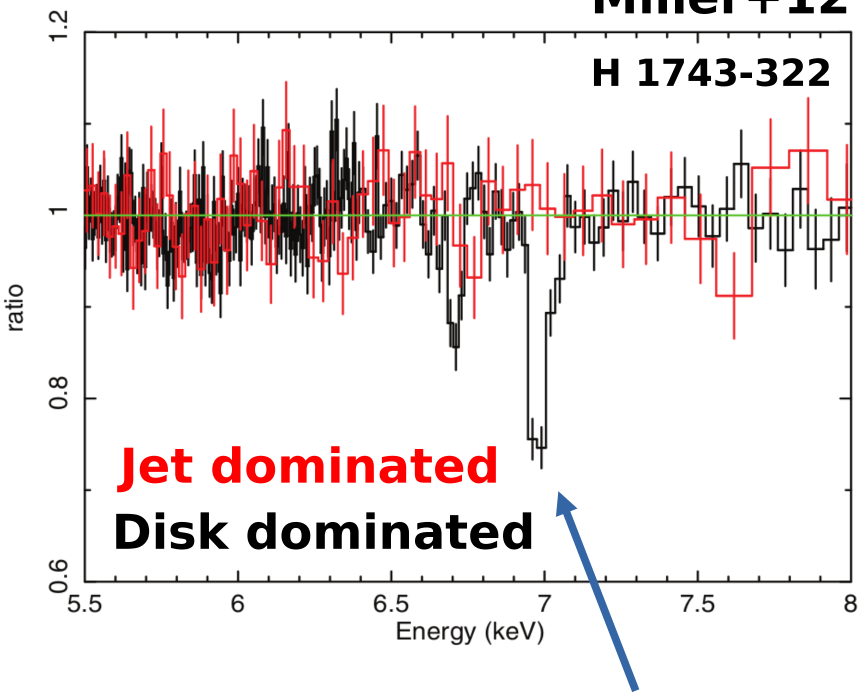
Significant inverse correlation between NH and R

Suggests common mechanism behind both winds and jets: magnetic driving

Anti-correlation between winds and jets in BHBs

- Wind-jet bimodality seen in BHBs
- Wind transition across states suggested to be a magnetic wind
- Different magnetic field configurations drive winds and jets
- Similar wind-jet behaviour in BHBs and RL AGN

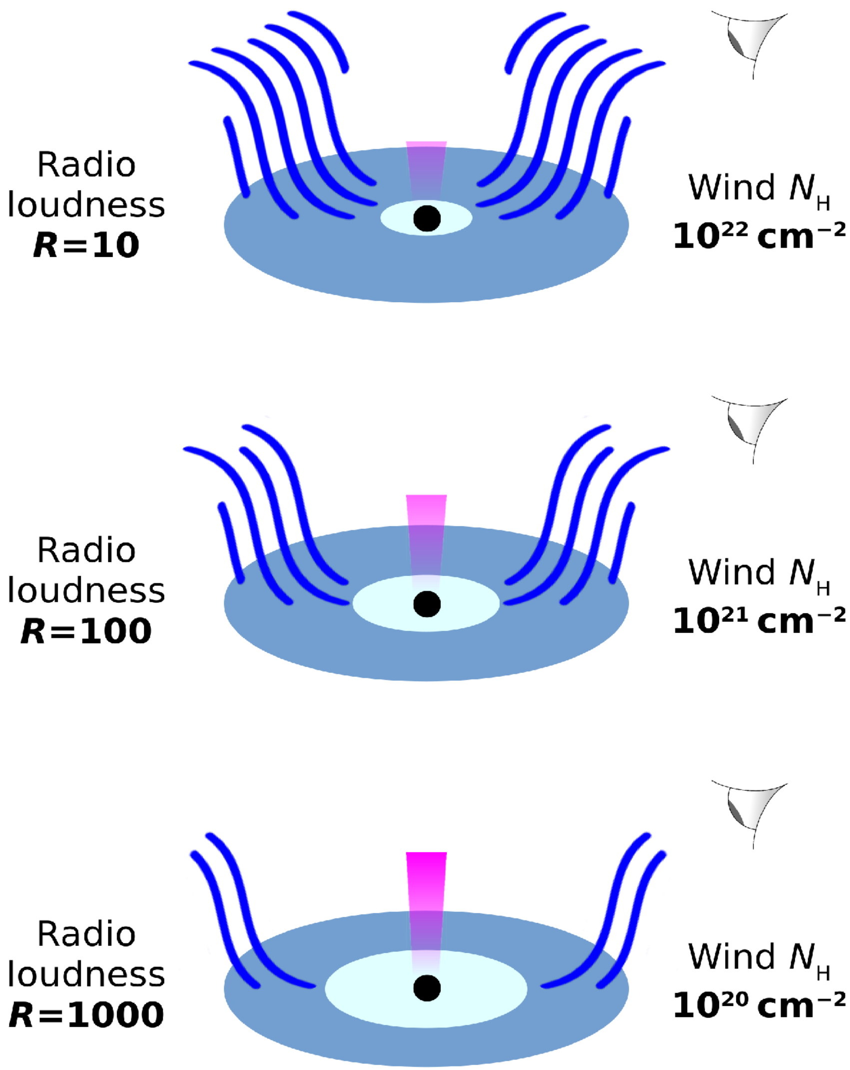
Miller+12



Wind absorption seen when jet is weak

- Neilsen & Lee 09
- Ponti+12
- Miller+12

As the jet becomes stronger the wind becomes weaker in RL AGN



Mehdipour & Costantini (2019)

Conclusions

- Inverse relation between radio loudness of the jet and column density of the ionised wind
- Inclination, ionisation, or luminosity effects are not responsible for the relation
- It is linked to the magnetic driving mechanism of both winds and jets in RL AGN
- Analogous to the wind-jet bimodality seen in stellar mass black holes
- Larger sample size needed for a more general characterisation (deeper XMM, XRISM, ATHENA)

Supplementary slides

Radio-loud AGN sample

Table 1. Properties of the 16 radio-loud AGN in our sample.

Mehdipour & Costantini (2019)

Object (1)	Class (2) [a]	z (3) [a]	B (4) [a]	$F_{\rm mid-IR}$ (5)	$F_{\rm 6\,cm}$ (6)	R (7) [k]	i (8)	$M_{\rm BH}$ (9)	Gal $N_{\rm H}$ (10) [ah]	$F_{\rm soft}$ (11) [k]	$F_{\rm hard}$ (12) [k]	$L_{\rm X}$ (13) [k]	$L_{\rm bol}$ (14) [k]	λ (15) [k]
1H 0323+342	S1n	0.063	15.72	n/a	0.30 [d]	130	13 [l]	0.36 [v]	21.7	0.53	0.81	0.278	2.08	0.46
3C 59	S1.8	0.111	16.80	n/a	0.02 [d]	22	n/a	7.94 [w]	6.59	0.36	0.86	0.538	3.88	0.04
3C 120	S1.5	0.033	15.72	0.54 [b]	0.36 [e]	154	21 [m]	0.69 [x]	19.4	3.03	5.27	0.309	2.33	0.27
3C 273	S1.0	0.158	13.05	0.60 [b]	38.4 [f]	1407	20 [n]	65.9 [y]	1.77	5.34	7.93	9.16	97.4	0.12
3C 382	S1.0	0.058	16.50	0.09 [b]	0.15 [d]	128	40 [o]	11.5 [z]	8.96	2.03	3.44	0.544	4.07	0.03
3C 390.3	S1.5	0.056	16.06	0.22 [b]	0.12 [e]	70	33 [o]	2.87 [aa]	4.41	2.10	3.48	0.459	3.36	0.09
4C +31.63	S1.0	0.298	15.85	0.07 [b]	1.40 [d]	676	10 [p]	20.0 [ab]	12.0	0.28	0.45	3.28	29.0	0.11
4C +34.47	S1.0	0.206	15.58	0.05 [b]	0.37 [d]	139	35 [q]	3.16 [ac]	3.36	0.70	0.86	2.19	16.4	0.41
4C +74.26	S1.0	0.104	15.13	0.14 [b]	0.32 [g]	79	40 [r]	41.7 [ad]	23.1	0.85	2.46	1.41	10.4	0.02
ESO 075-G041	S1	0.028	14.78	0.12 [c]	13.4 [h]	2416	10 [s]	n/a	2.90	0.49	0.67	0.023	0.31	n/a
III Zw 2	S1.2	0.089	15.96	0.13 [b]	0.43 [d]	233	21 [q]	0.72 [x]	7.13	0.39	0.72	0.251	1.94	0.21
Mrk 6	S1.5	0.019	15.16	0.55 [b]	0.10 [d]	26	9 [t]	1.80 [ae]	9.80	0.17	1.51	0.026	0.23	0.01
Mrk 896	S1n	0.027	15.27	0.13 [c]	0.04 [i]	11	24 [u]	0.12 [af]	4.03	0.54	0.37	0.021	0.15	0.10
PKS 0405–12	S1.2	0.574	15.09	0.09 [b]	1.99 [j]	477	n/a	29.5 [ad]	4.16	0.39	0.43	13.4	112	0.30
PKS 0921–213	S1	0.053	16.50	n/a	0.42 [h]	369	n/a	0.79 [w]	5.75	0.41	0.68	0.083	0.67	0.07
PKS 2135–14	S1.5	0.200	15.63	0.11 [b]	1.33 [h]	525	n/a	44.7 [ag]	5.22	0.36	0.60	1.21	10.2	0.02

Radio jet information taken from the literature

X-ray modelling of the wind done by us using the SPEX code (Kaastra et al.)

Ionised wind parameters

Table 3. Best-fit parameters of the ionised AGN wind and the neutral ISM gas in the host galaxy of the radio-loud AGN in our sample, derived from our modelling of the *XMM-Newton* observations.

Object (1)	Wind N_H (2)	Wind log ξ (3)	Wind v_{out} (4)	Neutral N_H (5)	C-stat/d.o.f. (6)
1H 0323+342	9 ± 2, 7.2 ± 0.7	2.17 ± 0.02, 0.15 ± 0.12	−830 ± 170, −880 ± 120	<0.01	2296/1488
3C 59	40 ± 2, 81 ± 8	1.20 ± 0.05, 2.42 ± 0.03	−3530 ± 130, −1000 ± 120	<2	2036/1477
3C 120	14 ± 3	2.65 ± 0.04	−2160 ± 360	<0.02	1949/1496
3C 273	0.7 ± 0.2	1.90 ± 0.08	−3670 ± 170	<0.01	2588/1532
3C 382	7 ± 2	2.44 ± 0.06	−1350 ± 370	<0.02	1805/1467
3C 390.3	3.7 ± 0.6, 11 ± 5	1.63 ± 0.11, 2.77 ± 0.06	−1550 ± 160, +50 ± 100	<0.2	1847/1481
4C +31.63	11 ± 3	−0.00 ± 0.20	−960 ± 200	<0.3	1783/1423
4C +34.47	31 ± 11	2.12 ± 0.05	−1500 ± 210	<0.3	1546/1398
4C +74.26	36 ± 3, 68 ± 8	1.69 ± 0.04, 2.46 ± 0.04	−1490 ± 90, −3000 ± 500	<0.09	1986/1511
ESO 075−G041	7 ± 1	−0.03 ± 0.11	−210 ± 180	<0.05	1832/1415
III Zw 2	7 ± 4	2.07 ± 0.13	−1780 ± 670	<0.2	1763/1468
Mrk 6	116 ± 8	1.38 ± 0.06	−4000 ± 500	27 ± 4	2287/1449
Mrk 896	73 ± 6	2.23 ± 0.02	−130 ± 150	<0.2	1679/1429
PKS 0405−12	6 ± 2	1.71 ± 0.17	−130 ± 200	<0.05	1715/1465
PKS 0921−213	8 ± 3	1.92 ± 0.12	−3540 ± 360	<0.2	1700/1458
PKS 2135−14	5 ± 3	2.14 ± 0.08	−1240 ± 530	<0.1	1831/1414

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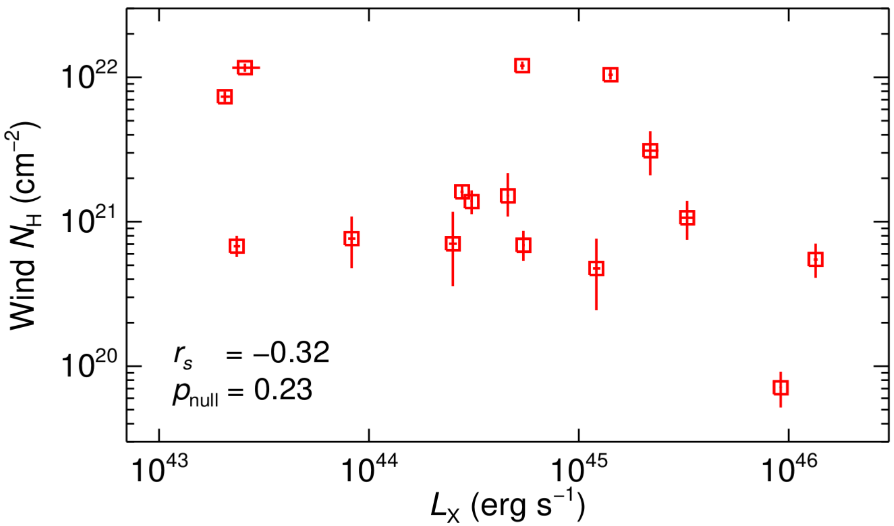
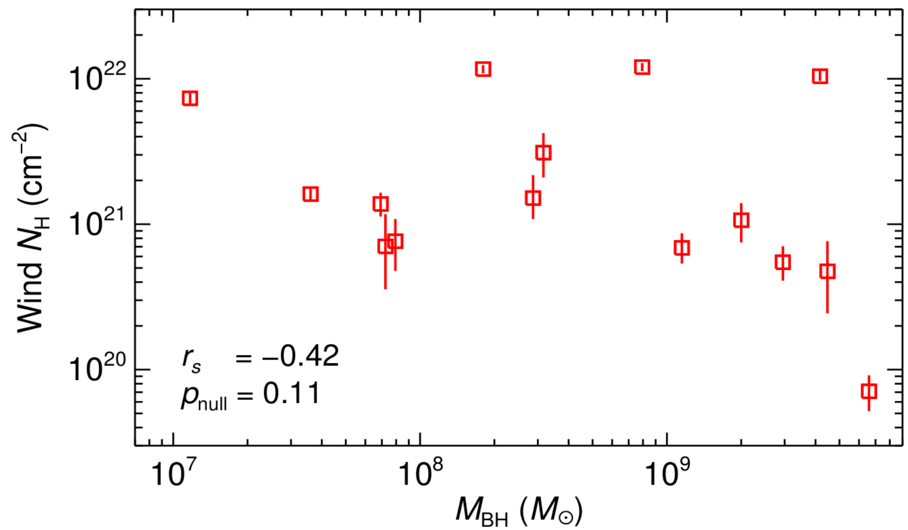
Relation between parameters





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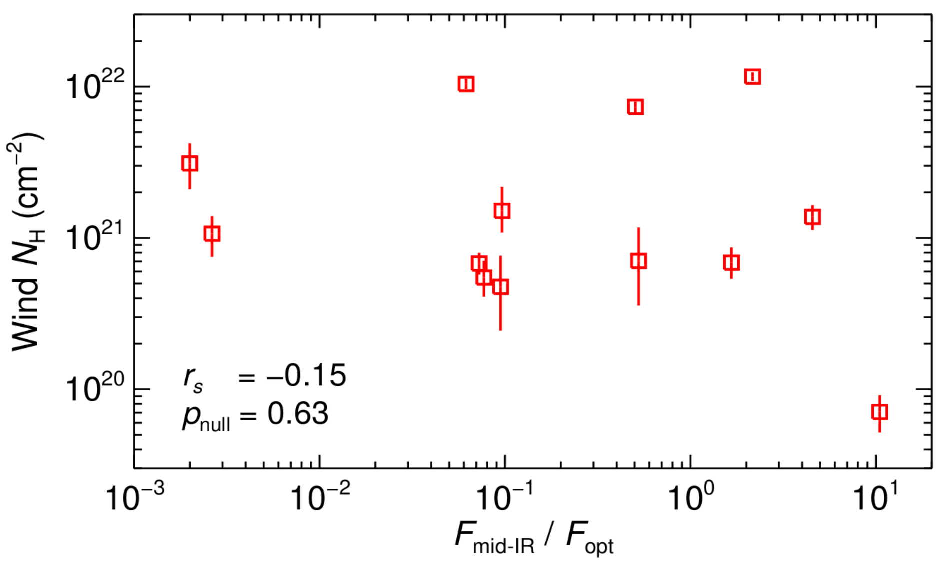
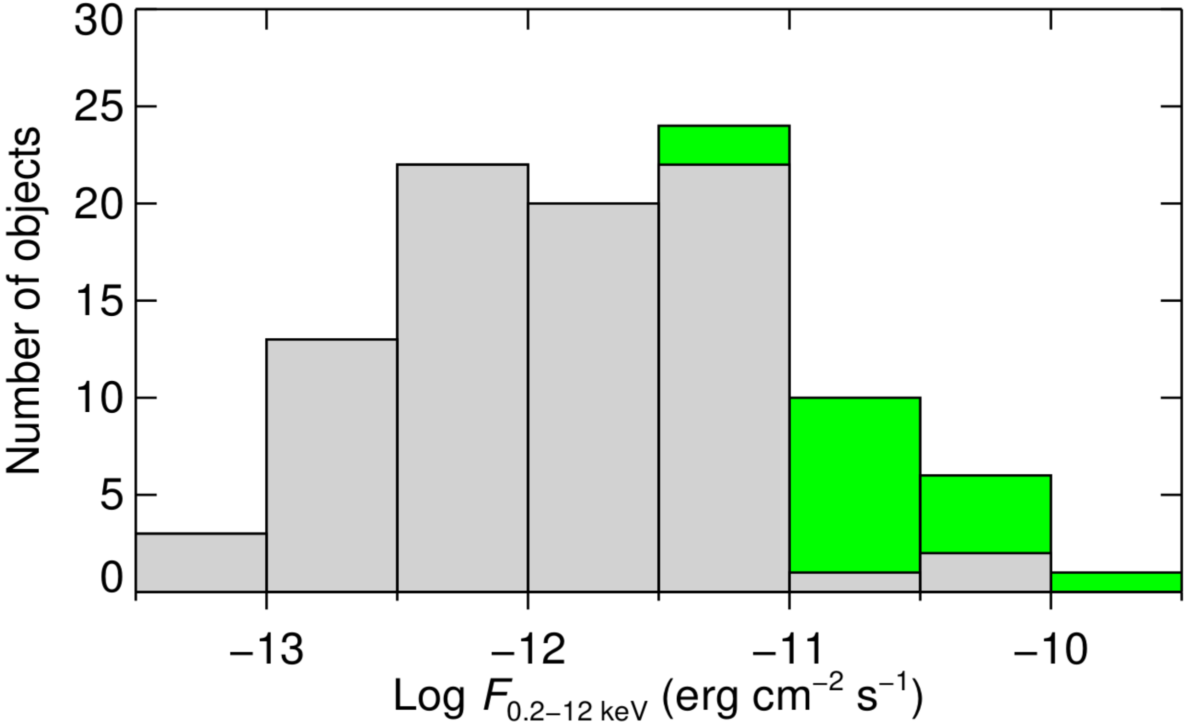


AGN sample



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SED model of NGC 5548

Mehdipour+15a