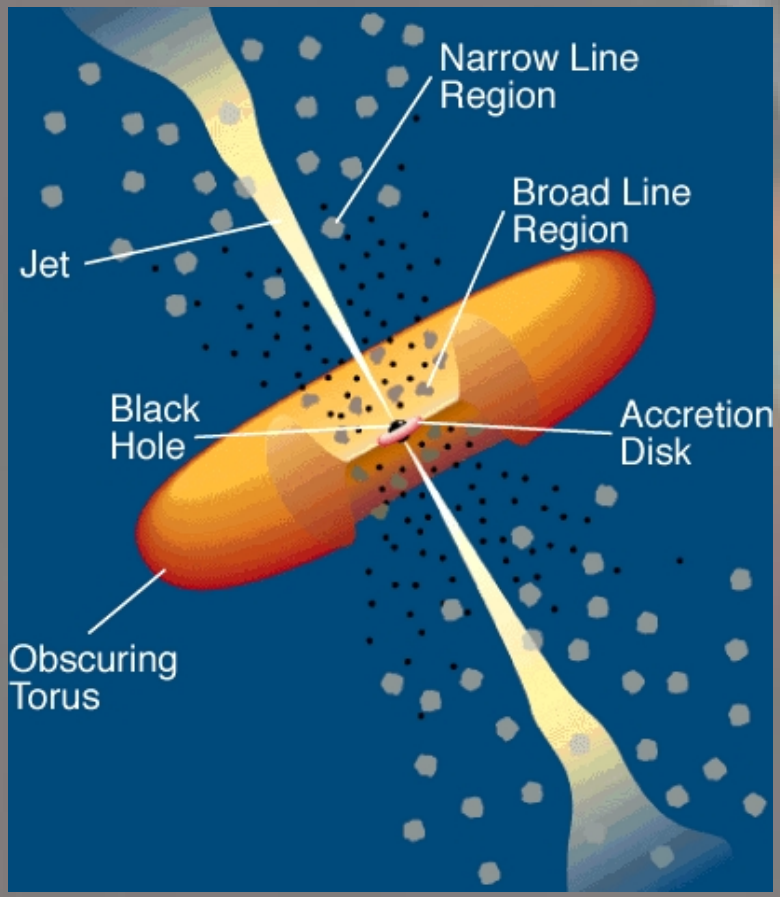
Probing the nature of X-ray weak QSOs: the XMM-*Newton* contribution

Lucia BALLO

ESA Research Fellow - ESAC

AGN overview



(Adapted from Urry & Padovani 1995)

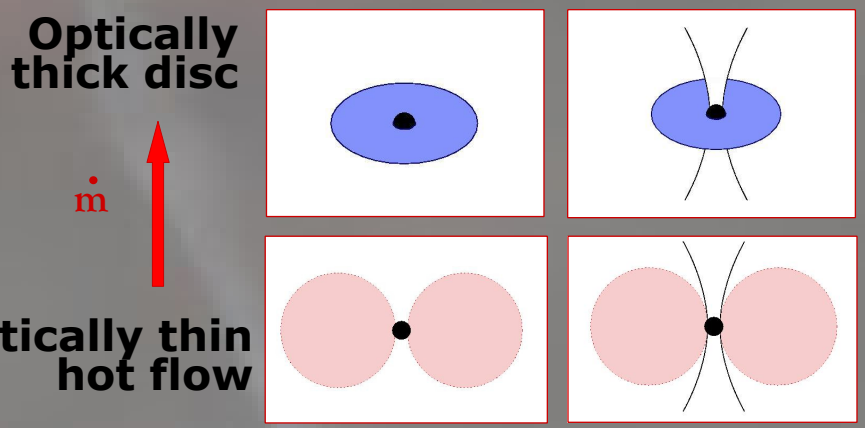
Extreme luminosities
(L_{bol} between 10^{42} erg s^{-1} and 10^{47} erg s^{-1})
emitted from *compact regions*

Broad-band continuum emission
(radio to TeV)

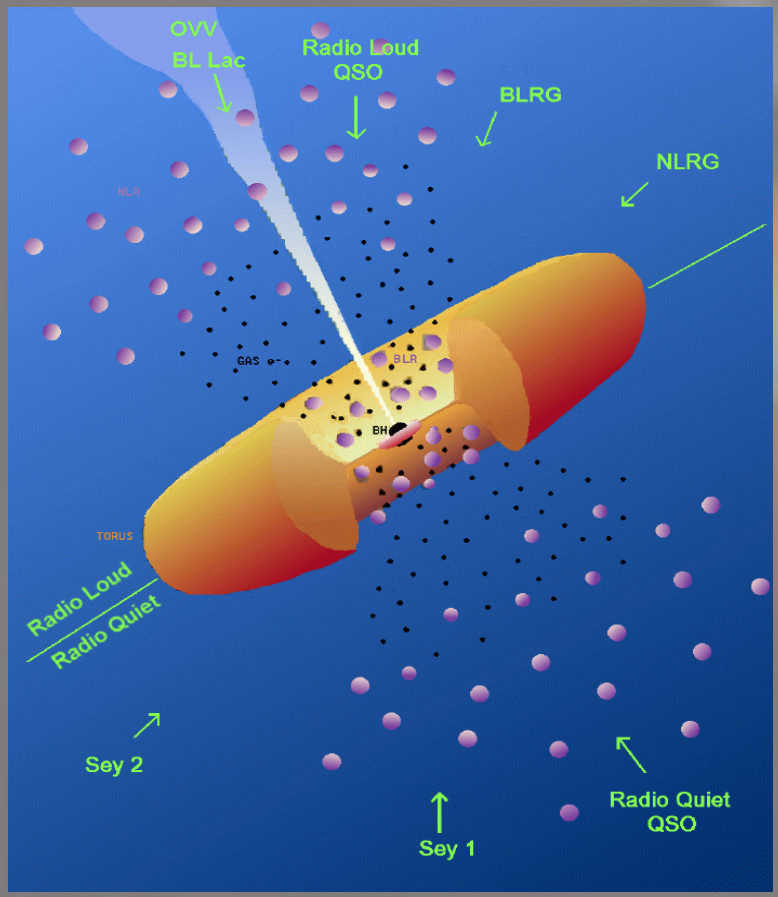
➡ *Non-stellar origin*

AGN = SMBH + $\dot{m}$

Weak or no jet — **j** → **Powerful jet**



AGN overview



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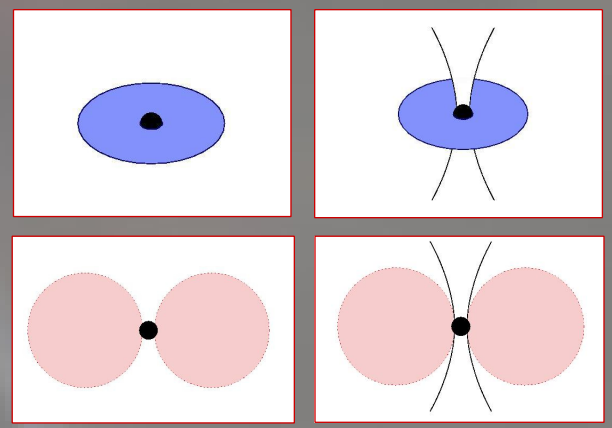
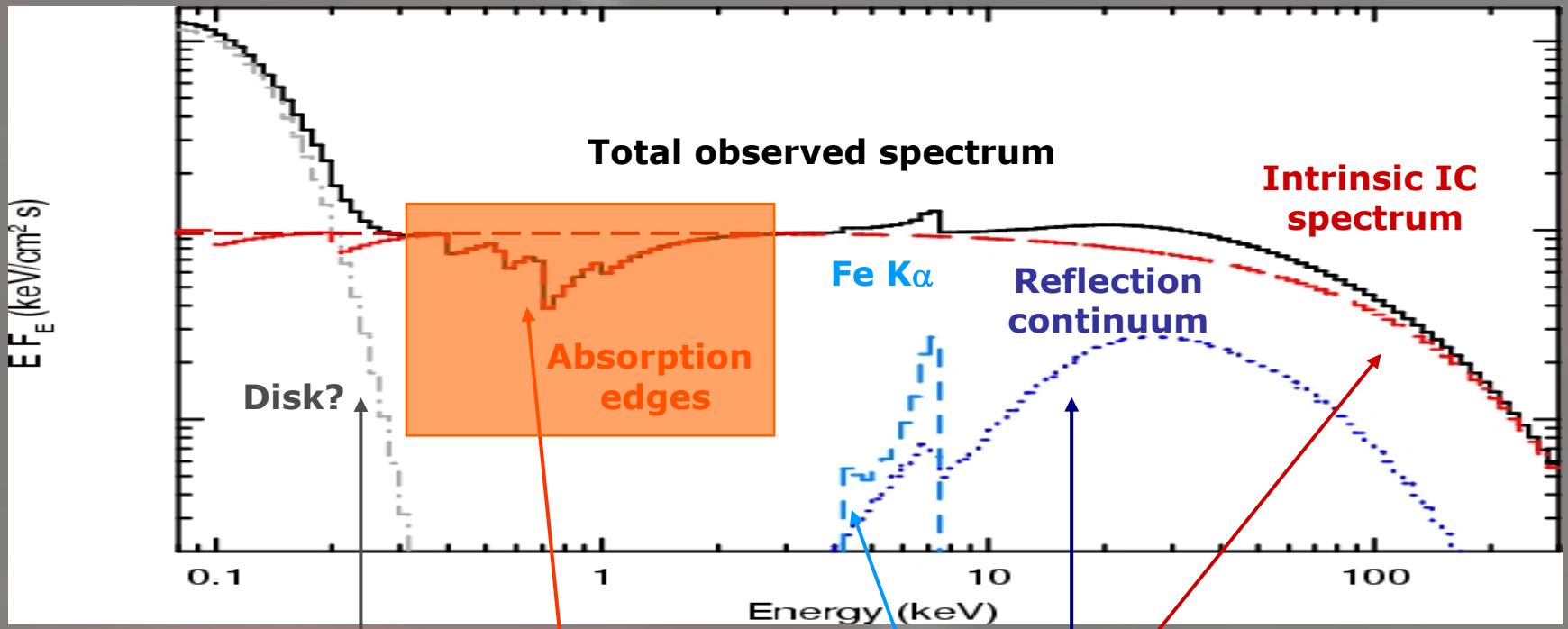
Optically thick disc

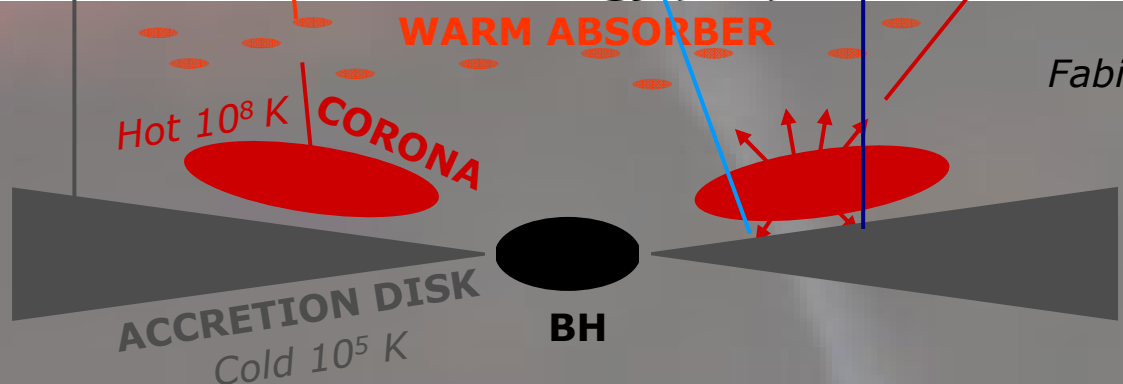
$\dot{m}$

Optically thin hot flow



AGN X-ray spectrum





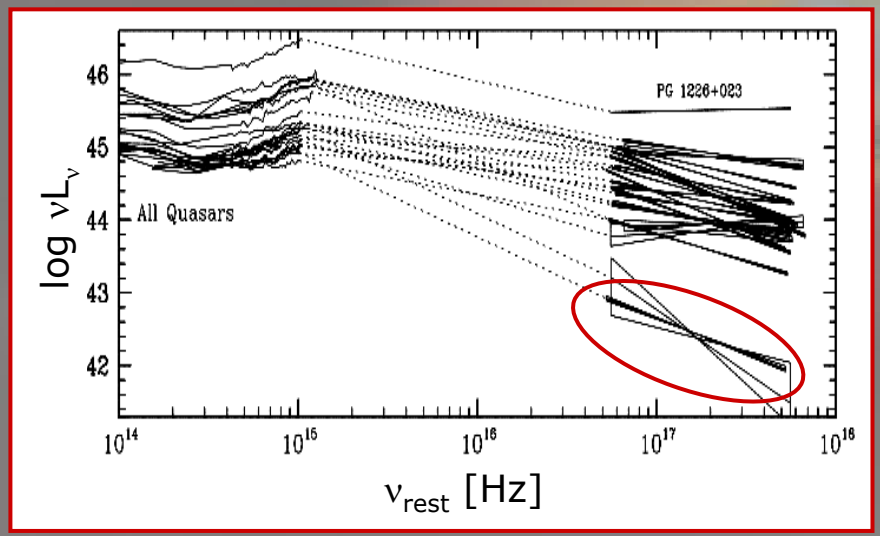
(Adapted from Fabian et al. 1997)

(Haardt, Maraschi & Ghisellini 1994)

Soft X-ray Weak AGN

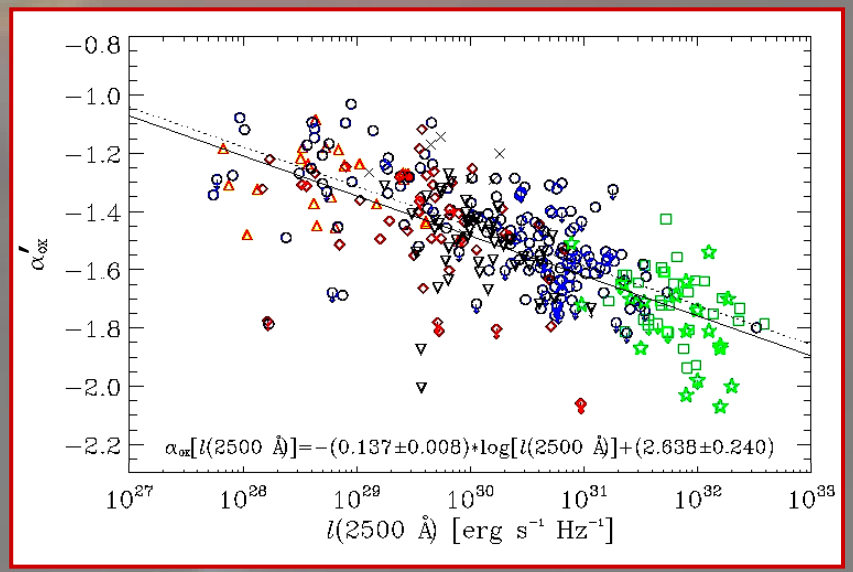
AGN notably faint in soft X-rays wrt their optical fluxes

$\alpha_{OX} = \log (F_{2keV}/F_{3000Å})/\log (\nu_{2keV}/\nu_{3000Å}) < -2$



(Laor et al. 1997)

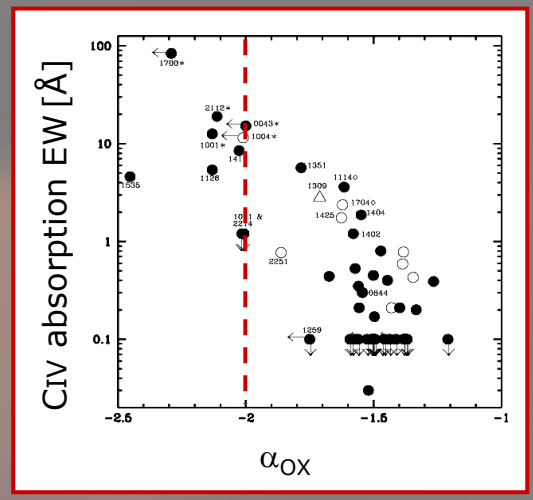
(Steffen et al. 2006)



X-ray weakness origin

1) X-ray absorption

   - important targets to study WA ionization structure & geometry



(Brandt et al. 2000)

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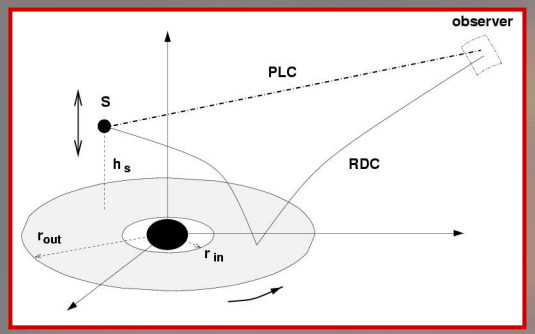
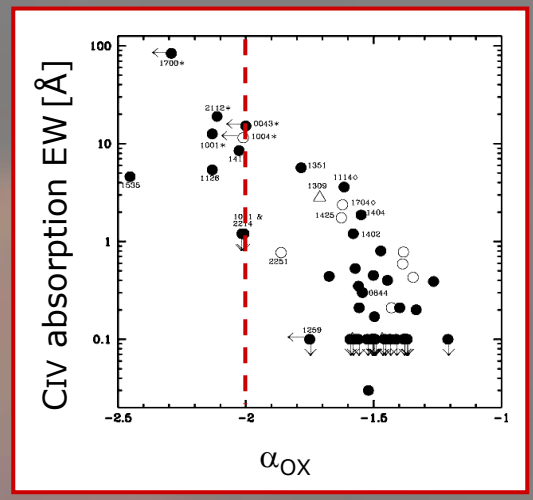


(Miniutti et al 2003; Miniutti & Fabian 2004)

2) Strong variability

- cf light bending



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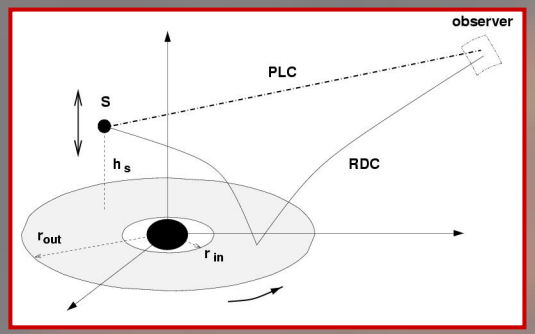

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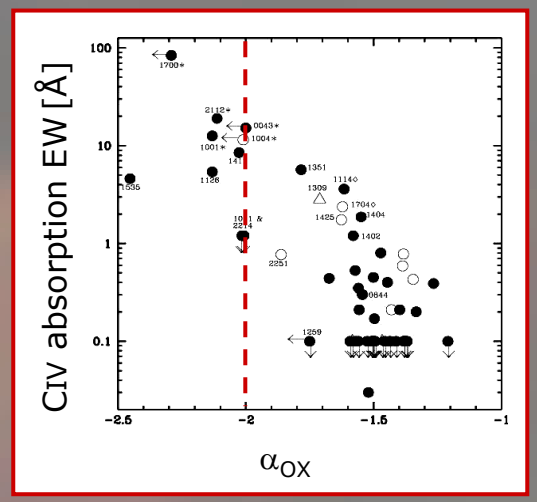
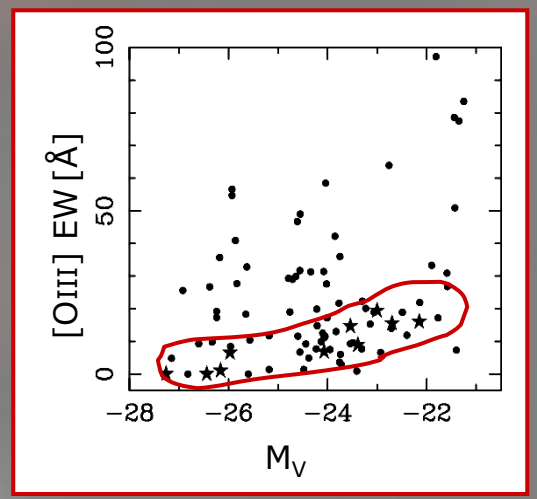


(Brandt et al. 2000)

3) Intrinsic property

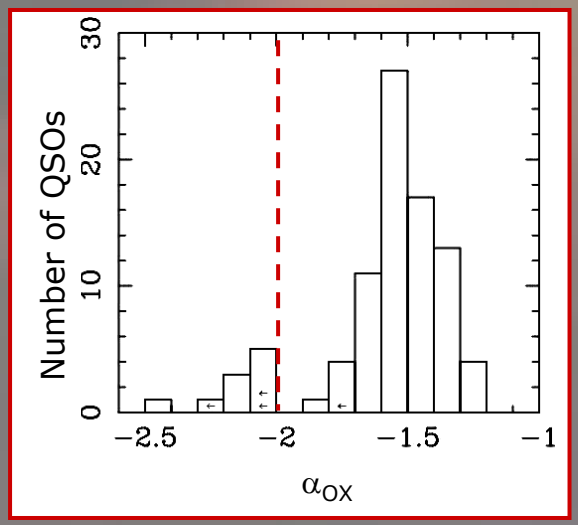
- high accretion rate: photon trapping, inefficient corona, etc



1) U-B - selected SXW AGN

- AGN in the PG catalog
- z < 0.5
- ROSAT observations

10/87 soft X-ray weak AGN

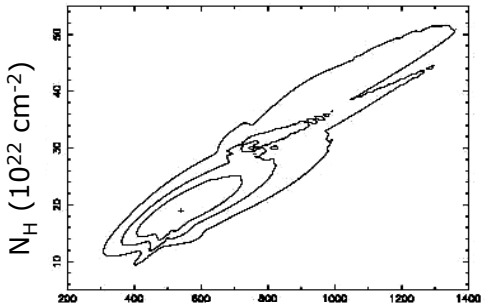


(Brandt et al. 2000)

PG Name	α_{ox}/ C IV EW (Å)	PG Name	α_{ox}/ C IV EW (Å)	PG Name	α_{ox}/ C IV EW (Å)
0003+158	−1.38/0.8	1115+407	−1.45/0.4	1425+267	−1.63/1.8
0003+199	−1.50/0	1116+215	−1.57/0.1	1426+015	−1.46/0
0007+106	−1.43/···[a]	1119+120	−1.58/···	1427+480	−1.52/0.03
0026+129	−1.50/0	1121+422	−1.59/0	1435−067	−1.63/···
0043+039	< −2.00/15.2[b]	1126−041	−2.13/5.4	1440+356	−1.38/0
0049+171	−1.27/···	1149−110	−1.42/···	1444+407	−1.57/···[a]
0050+124	−1.56/0.4	1151+117	−1.46/···	1448+273	−1.59/···
0052+251	−1.37/0	1202+281	−1.27/0.4	1501+106	−1.64/···
0157+001	−1.60/···	1211+143	−1.57/0.5	1512+370	−1.43/0.2
0804+761	−1.52/···	1216+069	−1.44/0	1519+226	−1.51/···
0838+770	−1.54/···	1226+023	−1.47/0	1534+580	−1.38/···
0844+349	−1.54/0.3	1229+204	−1.49/0	1535+547	−2.45/4.6
0921+525	−1.41/···	1244+026	−1.60/···	1543+489	−1.67/0.4
0923+129	−1.41/···	1259+593	< −1.75/0	1545+210	−1.38/0
0923+201	−1.57/···[a]	1302−102	−1.58/0	1552+085	−1.77/···
0934+013	−1.39/···	1307+085	−1.52/0	1612+261	−1.41/0
0947+396	−1.33/0.20	1309+355	−1.71/2.8	1613+658	−1.21/0
0953+414	−1.50/0.17	1310−108	−1.52/···	1617+175	−1.64/···
1001+054	−2.13/12.6	1322+659	−1.40/0.2	1626+554	−1.37/0
1004+130	< −2.01/11.5	1341+258	−1.53/···	1700+518	< −2.29/84
1011−040	−2.01/< 1.2	1351+236	−1.52/···	1704+608	−1.62/2.4
1012+008	−1.66/···	1351+640	−1.78/5.7	2112+059	−2.11/19
1022+519	−1.34/···	1352+183	−1.50/0.5	2130+099	−1.47/0.8
1048+342	−1.52/···	1354+213	−1.39/···	2209+184	−1.49/···
1048−090	−1.41/···	1402+261	−1.58/1.2	2214+139	−2.02/< 1.2
1049−006	−1.56/0.2	1404+226	−1.55/1.9	2233+134	−1.66/···
1100+772	−1.39/0.6	1411+442	−2.03/8.5	2251+113	−1.86/0.8
1103−006	−1.51/0	1415+451	−1.51/0	2304+042	−1.29/···
1114+445	−1.62/3.6	1416−129	−1.56/0	2308+098	−1.35/0.4

The Brandt et al. SXW AGN sample

NL QSO PG 1001+054



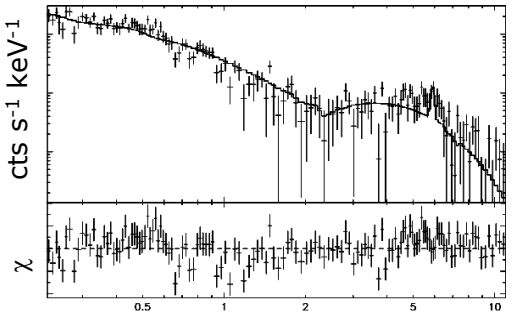
PL modified by a WA

(Piconcelli et al. 2005, Schartel et al. 2005)

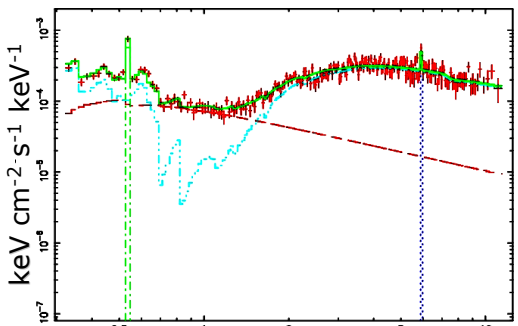
Heavy absorption (WA?)
+ soft excess
+ Fe line

(Piconcelli et al. 2005, Brinkmann et al. 2004)

BAL QSO PG 1411+442



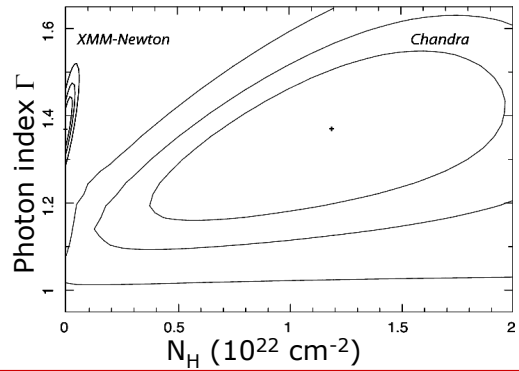
Sy PG 2214+139



Two-zone WA
+ soft excess
+ lines from torus or WA

(Piconcelli et al. 2004, Brinkmann et al. 2004)

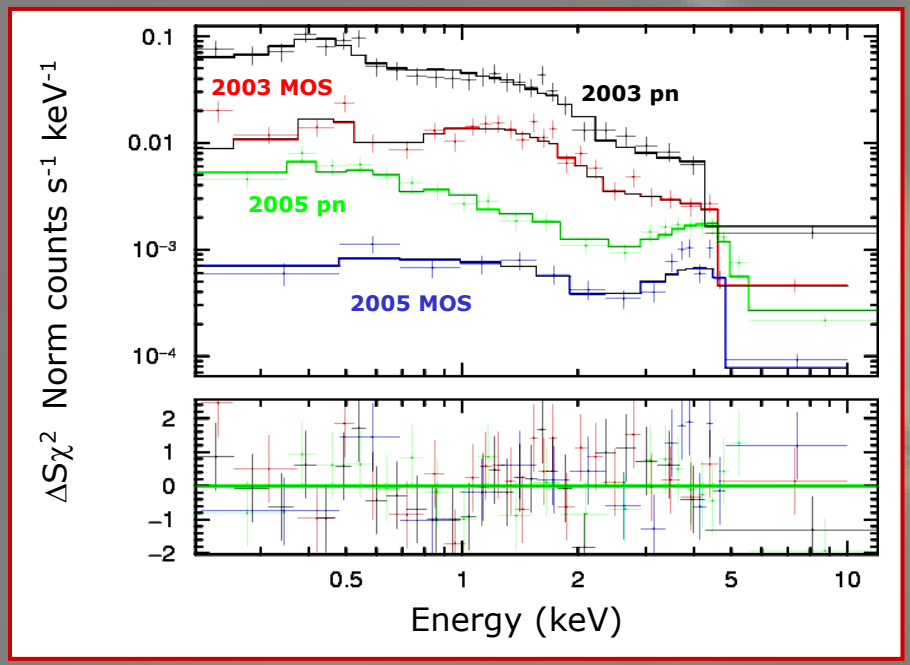
RL BAL QSO PG 1004+130

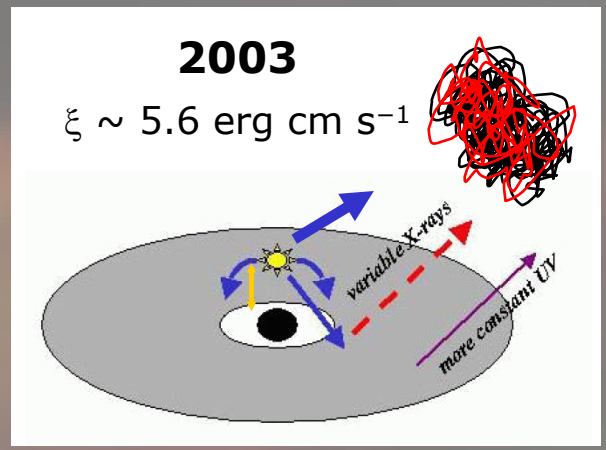


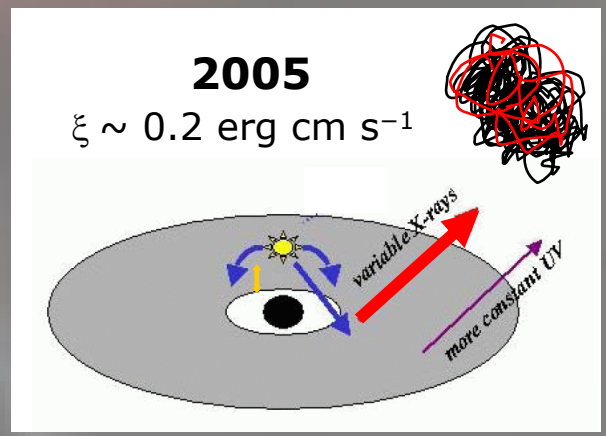
Variable complex absorber
Still X-ray weak

(Miller et al. 2006)

BAL QSO PG 2112+059



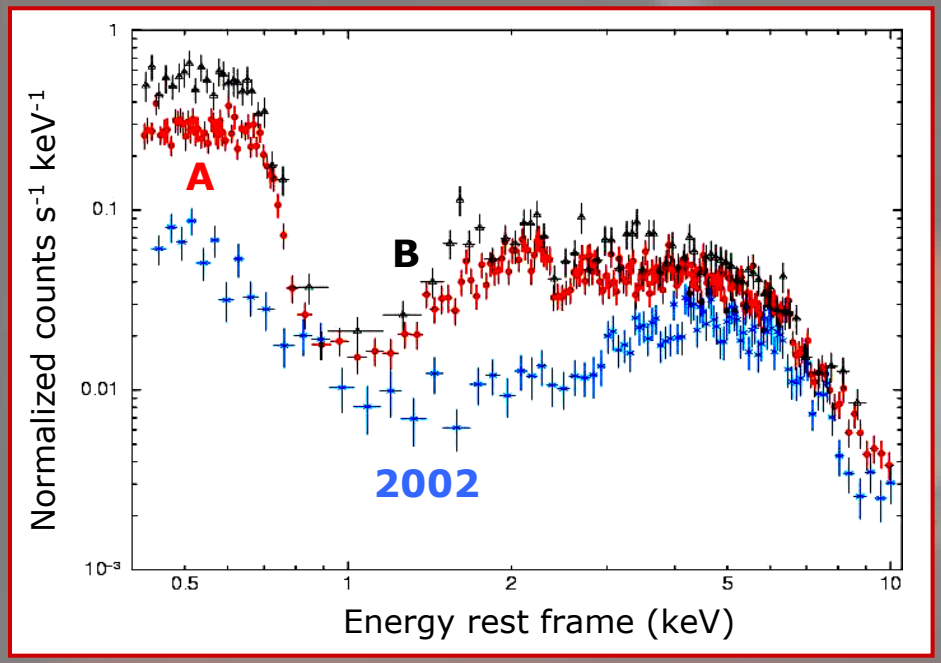


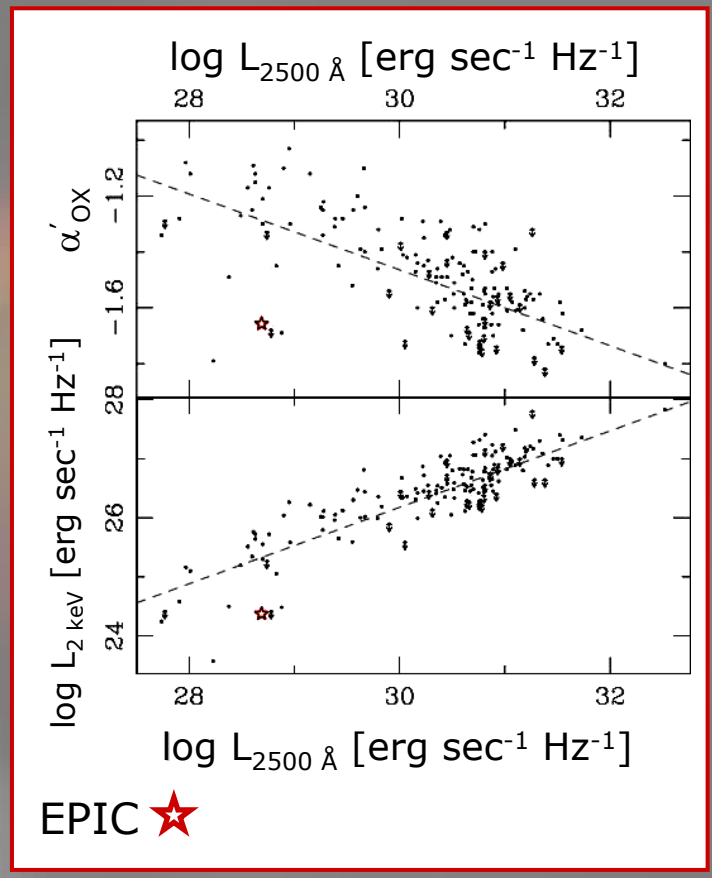


- Deep minimum states:
  WA+reflection from ionized disk
- Variability: light bending

(Schartel et al. 2005, 2007)

miniBAL NLSy1 PG 1535+547



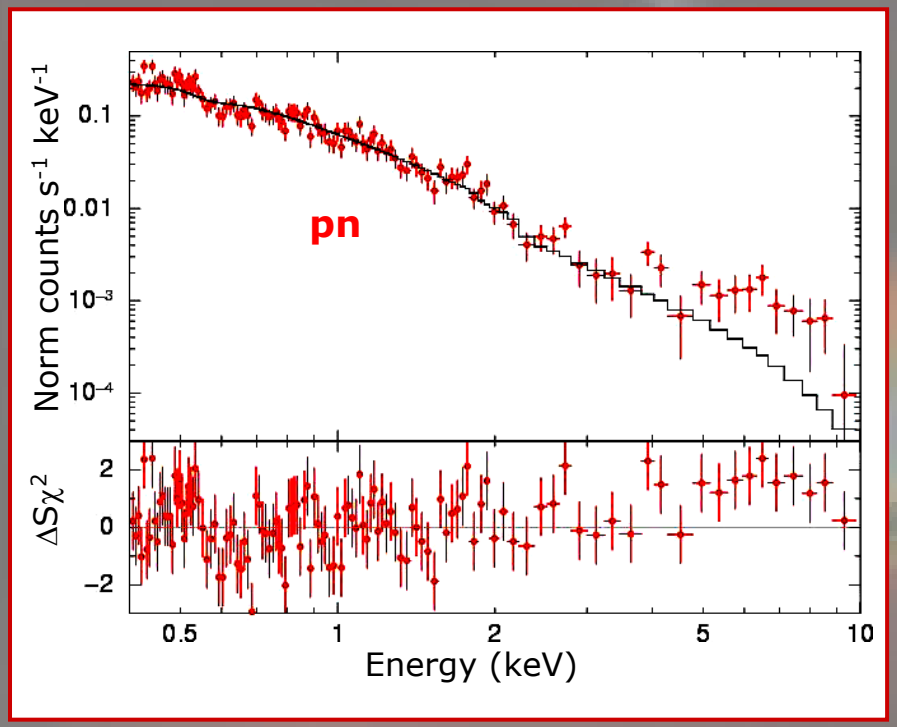


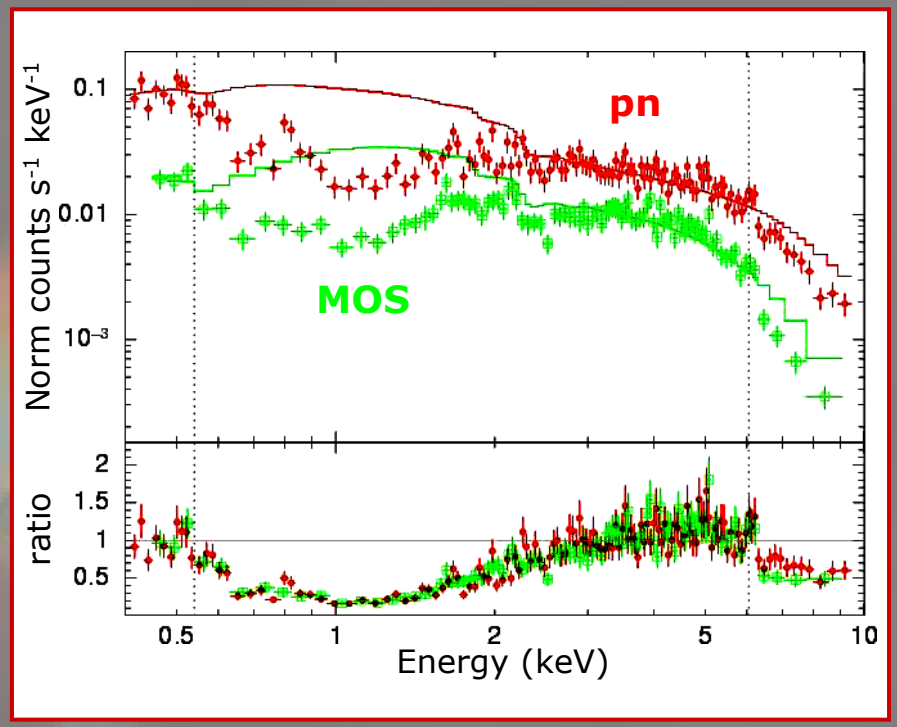
- Disk reflection-based or absorption-based model
- Variable WA
- No more SXW → α_{OX} is definitely a variable parameter

(Ballo et al. 2008)

PG 1535+547 vs. optically selected QSO → underluminous in X-ray

PG 1011-040 & PG 1126-041



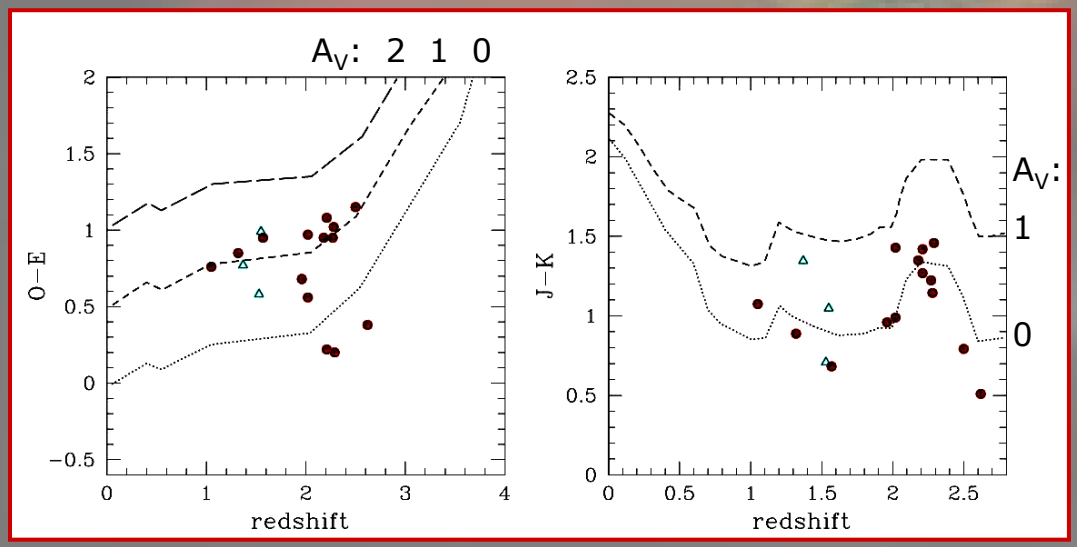


- Excess @ E > 5 keV described adding an absorbed PL - $N_H \sim 9 \cdot 10^{23}$ cm^{-2}
- Very steep PL ($\Gamma \sim 2.8$), also for a NLSy galaxy
- Still features in the residuals
- Evident strong absorption (cf EPIC spectra of PG 1535+547)
- Emission features @ ~ 0.57 keV (OVII) and ~ 6.4 keV (Fe Kα)

2) Spectroscopically-selected SXW AGN

- HQS sources in the WGACAT:
  ~40/85 SXW candidates (ROSAT u.l.)
- Randomly selected undetected sources for *Chandra* & XMM-*Newton* observations:
  14/54 SXW candidates
  3/54 normal AGN candidates

HS Name	redshift	*Chandra* if weak	XMM-*Newton* if observed
0017 + 2116	2.02	✓	–
0830 + 1833	2.27	✓	–
0848 + 1119	2.62	✓	✓
0854 + 0915	1.05	✓	✓
1036 + 4008	1.96	✓	✓
1111 + 4033	2.18	✓	✓
1202 + 3538	2.28	✓	✓
1251 + 2636	2.02	✓	✓
1415 + 2701	2.50	✓	–
1417 + 4722	2.21	✓	–
1422 + 4224	2.21	✓	✓
2135 + 1326	2.29	✓	–
2146 + 0428	1.32	✓	–
2251 + 2941	1.57	✓	–
△ 1229 + 4807	1.37	–	–
△ 1230 + 4741	1.53	–	✓
△ 1237 + 4756	1.55	–	✓



- Higher *z* than PG QSOs

(Risaliti et al. 2001, 2003)

SXW candidates: *Chandra* results

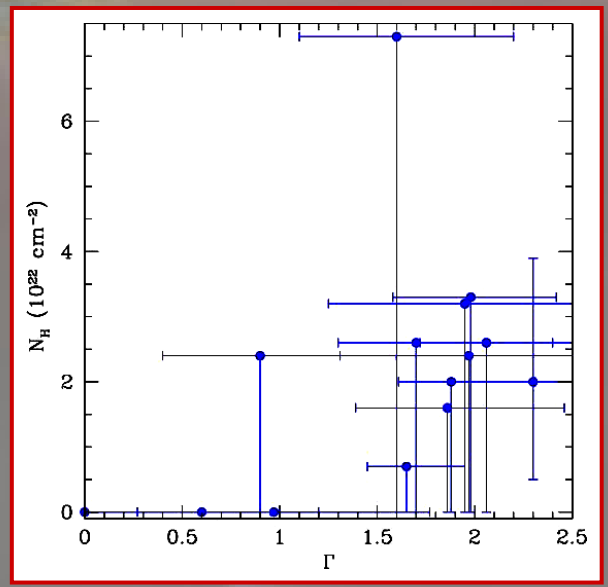
- 14 + 3 observations (T<10 ksec) ➡ all sources but one detected
- Adopted model: absorbed PL

  11/14 observed properties different from standard QSO

  9/14 incompatible with intrinsic normal SED + absorption

Large errors and strong degeneracy between Γ & N_H (statistic not good enough)

(Memola, Ballo et al. in prep.)



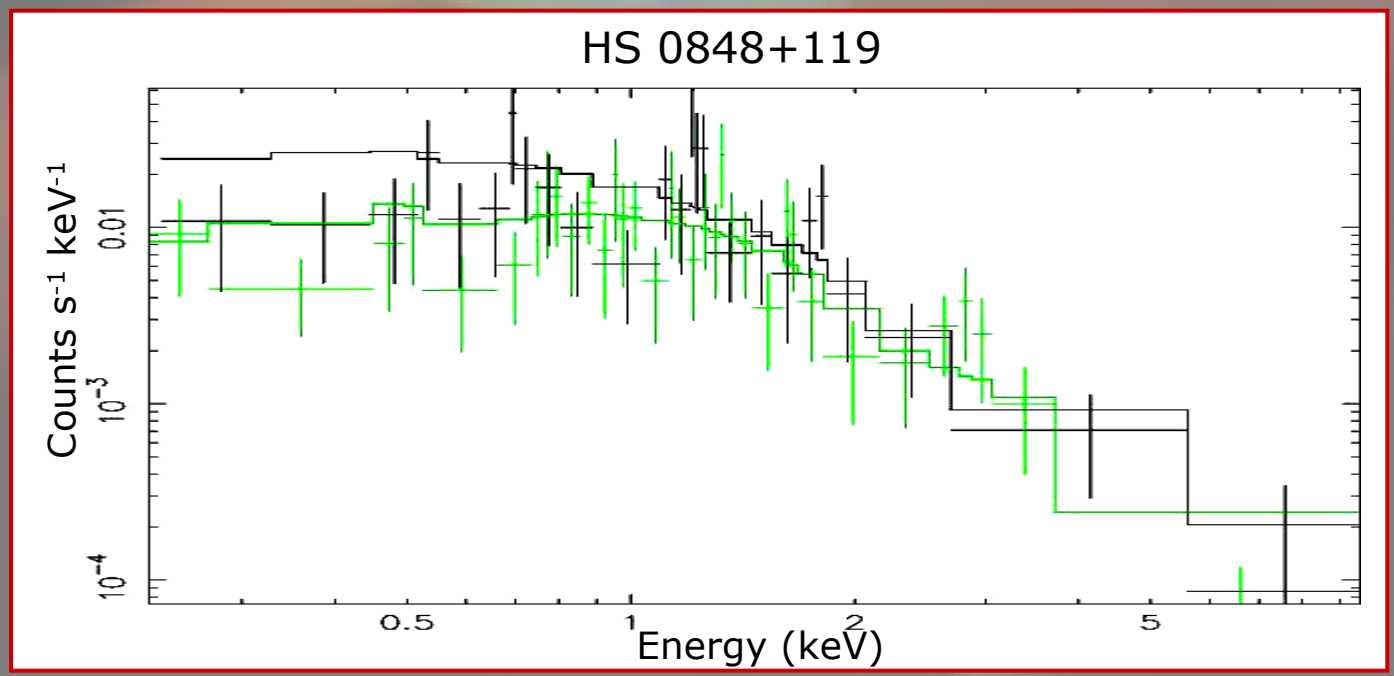
The XMM-*Newton* data (I)

7/14 observed ➡ statistic good enough to disentangle the parameters

- 1/7 $N_H > 10^{22}$ cm^{-2} required

  Γ typical

  compatible with intrinsic standard QSO SED – blue QSO

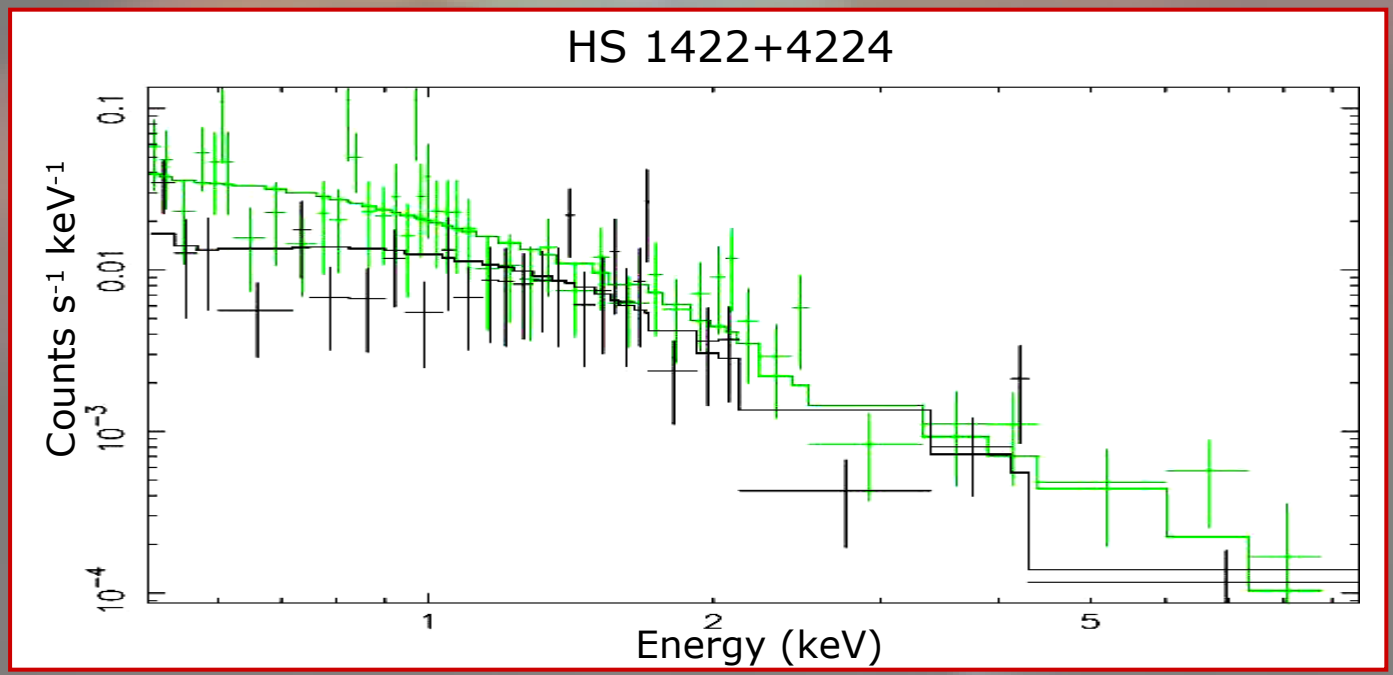


The XMM-*Newton* data (II)

7/14 observed ➡ statistic good enough to disentangle the parameters

- 1/7 Γ typical, no absorption required

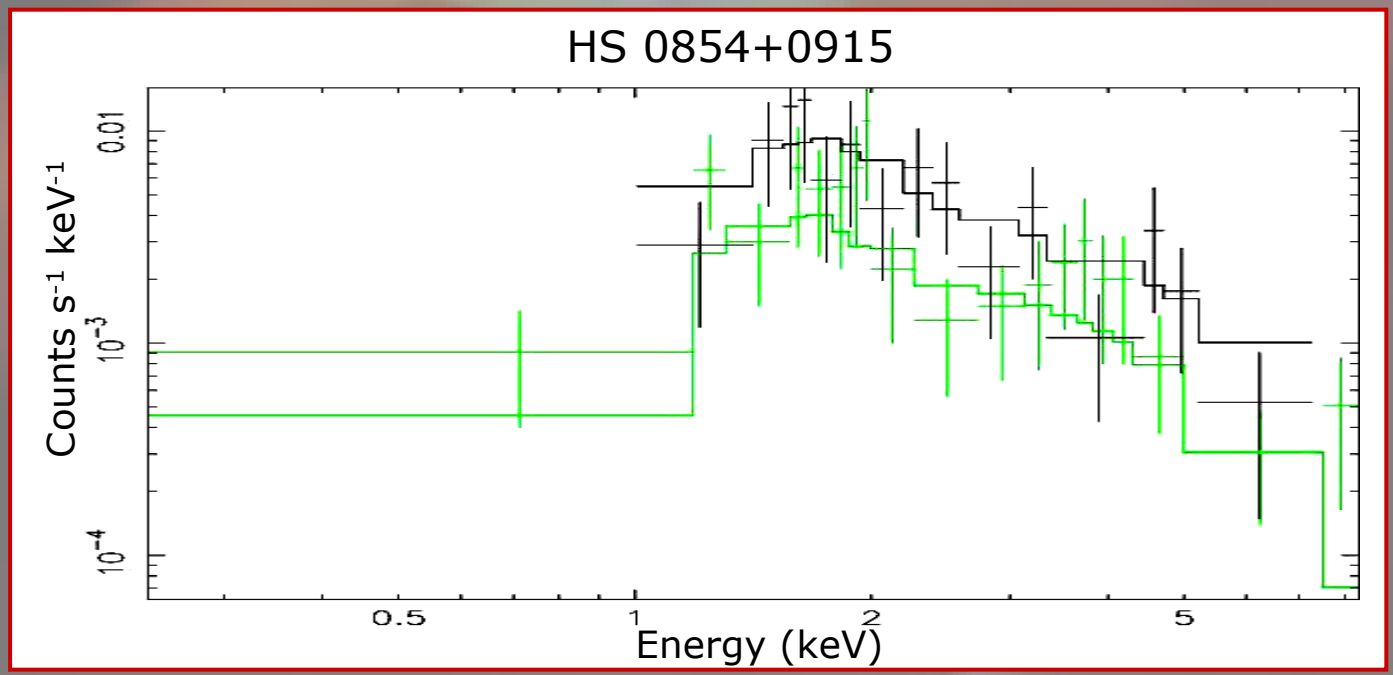
  compatible with intrinsic standard QSO SED – blue QSO



The XMM-*Newton* data (III)

7/14 observed ➡ statistic good enough to disentangle the parameters

- 1/7 $N_H > 10^{22}$ cm^{-2} required
  flatter than mean QSO
  absorption *not* enough to obtain the expected α_{OX}

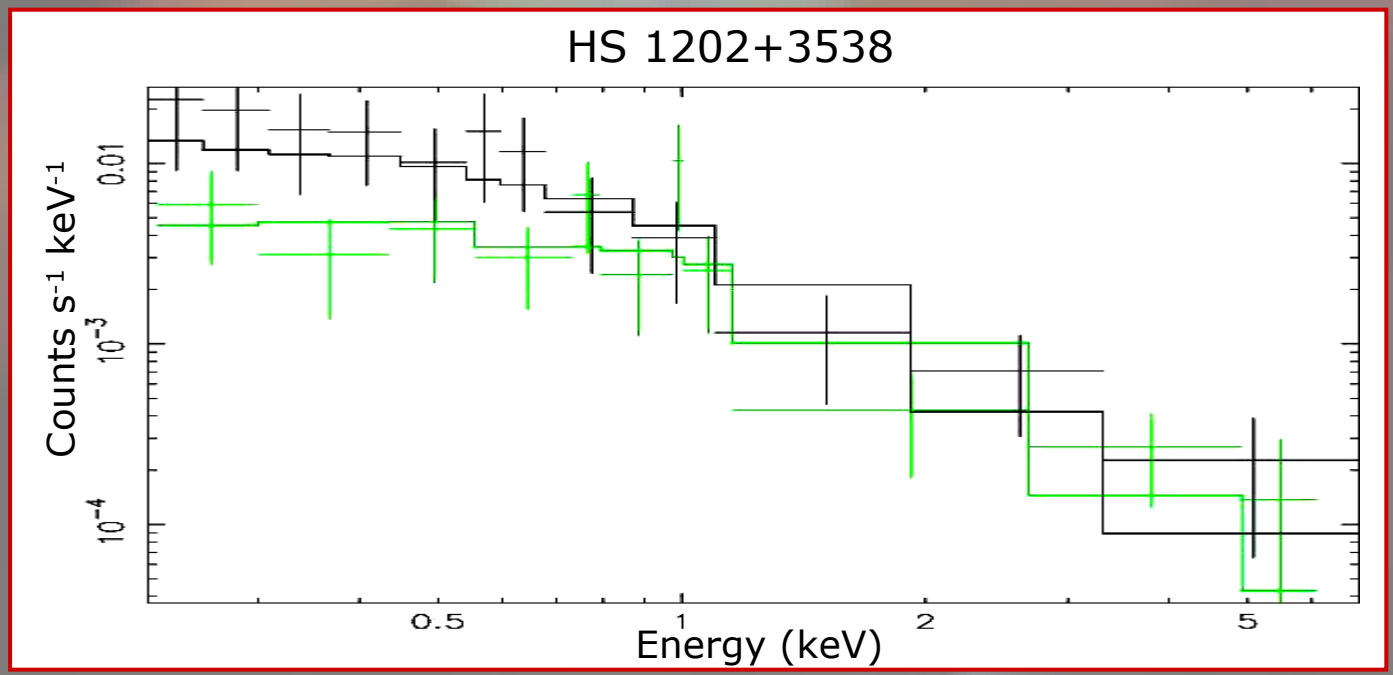


The XMM-*Newton* data (IV)

7/14 observed → statistic good enough to disentangle the parameters

- 4/7 Γ typical, no absorption required

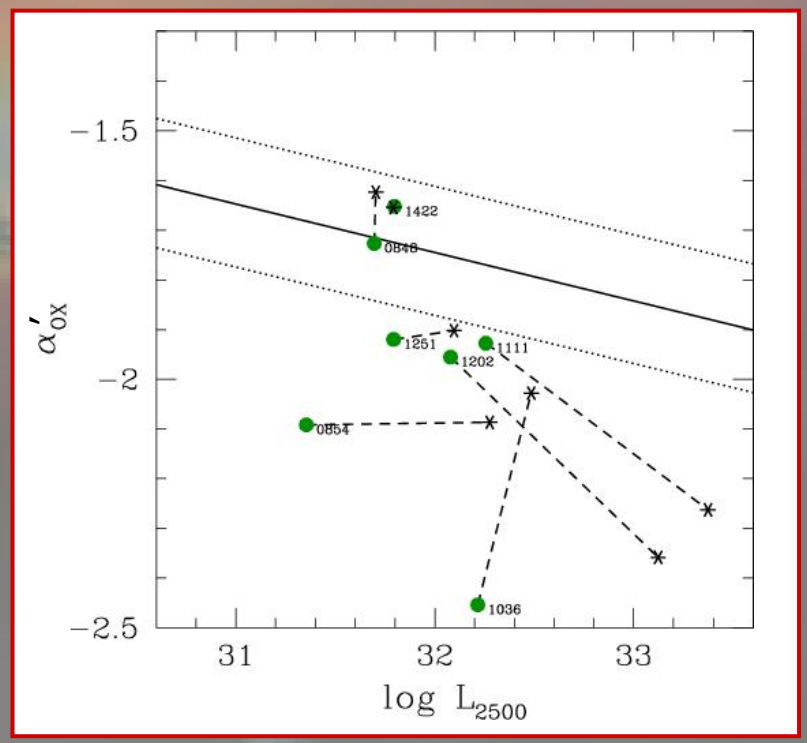
  not compatible with intrinsic standard QSO SED



XMM-*Newton* results

7/14 observed → statistic good enough to disentangle the parameters

5/7 (all red QSO) *not* compatible with intrinsic normal broad band QSO SED



● observed

✳ intrinsic

(Memola, Ballo et al. in prep.)

CONCLUSIONS:

- SXW selected between standard blue QSOs:

  X-ray weakness mainly due to absorption phenomena

  (see also Gibson et al. 2008)

- Spectroscopically selected SXW AGN:

  mainly instrinsically X-ray weak AGN in red QSO

- Link between red optical colour and weak X-ray emission?