

AGN populations in a hard selected sample of the XMD5 survey

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and XMM-LSS, VVDS and SWIRE collaborations

The XMM Medium Deep Survey (XMDS)

- 2 deg² field covered by 19 XMM EPIC pointings with about 20 ksec exposure (deeper area within the XMM-LSS Survey region)
- Equatorial field (RA = 02h 26m dec = -4 deg)



easy access from ground based telescopes

- High galactic latitude \longrightarrow low N_H
- Absence of bright X-ray sources
- Multiwavelength coverage



Multiwavelength coverage

XMDS fields

Also covered by:

VVDS UBVRI(JK)

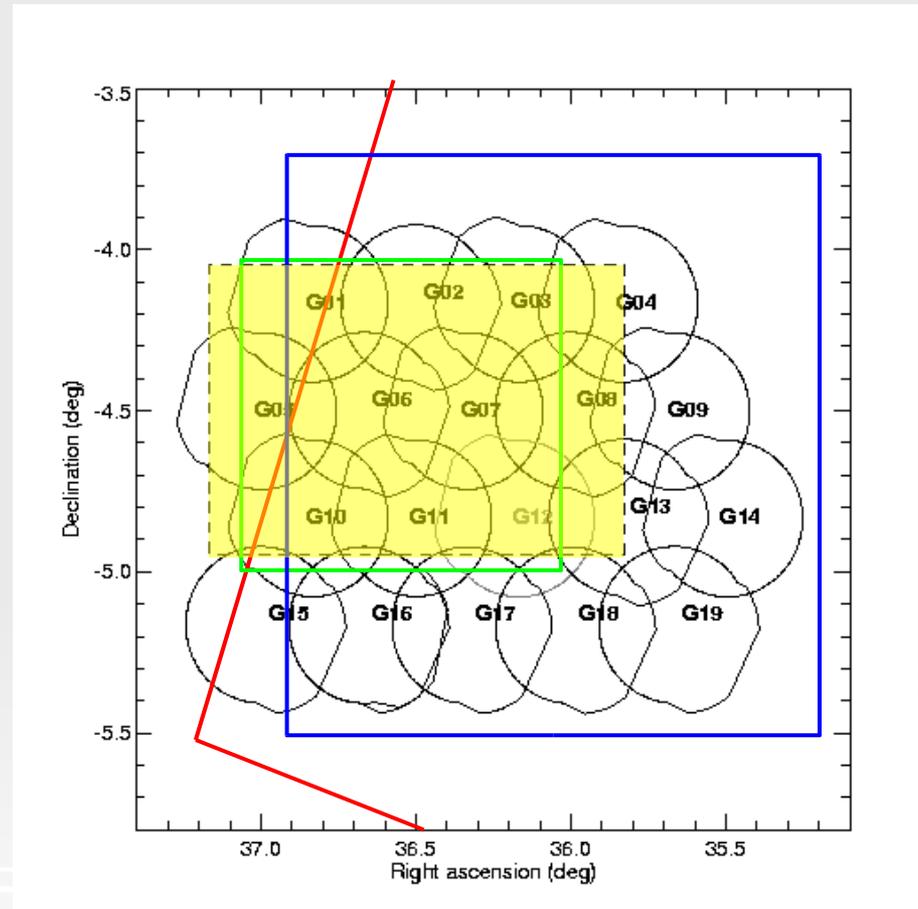
(optical spectroscopy)

CFHTLS D1 u*g'r'i'z'

CFHTLS W1

SWIRE 3.6, 4.5, 5.8,
8.0 and 24 μm

(VLA, GALEX,
UKIDSS)



Previous results

- X-ray detection and characterization: pipeline adapted from the HELLAS2XMM one (Baldi et al. 2002)
- LogN-logS of sources detected at $P < 2 \times 10^{-5}$ in the 0.5 - 2 and 2 - 10 keV bands consistent with those obtained by other X-ray surveys (HELLAS2XMM, CLASXS, SEXSI, see Chiappetti et al 2005, A&A 439, 413)
- Catalogue and optical identifications of X-ray sources detected at a significance $\geq 4 \sigma$ in **at least one** of the energy bands 0.3 - 0.5, 0.5 - 2, 2 - 4.5, 4.5 - 10 and 2 - 10 keV in the VVDS area (Chiappetti et al 2005)
- Catalogue and more information also available at <http://cosmos.mi.iasf.cnr.it/~lssadmin/Website/LSS>

The 3σ hard sample

Sources detected at $> 3\sigma$ in the hard (2 - 10 keV) band within the VVDS area (136 sources over about 1 deg^2 area).

Identifications:

122 X-ray/opt ids.

10 ambiguous

4 optically blank fields ($R > 25.3$), but detected in the IR

122 opt. id.

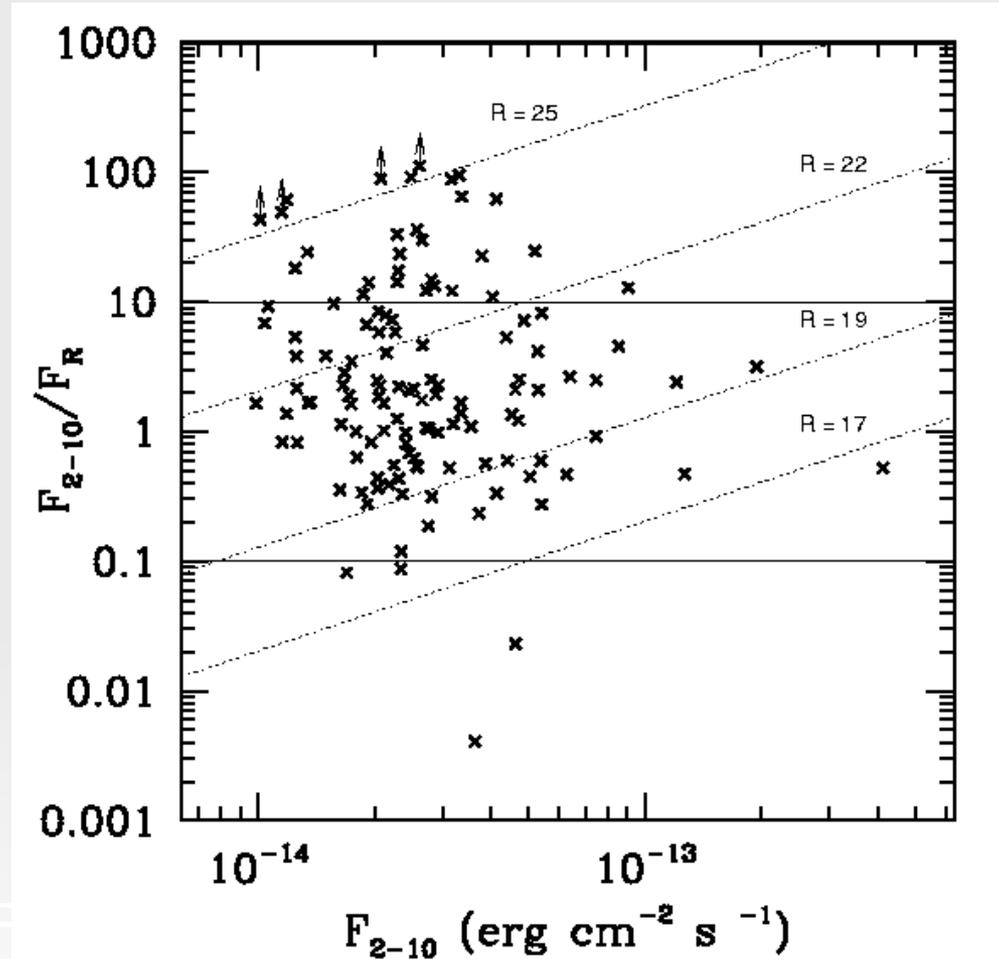
- 2 normal galaxies ($X/O < 0.1$, nearby galaxies)

- 2 clusters

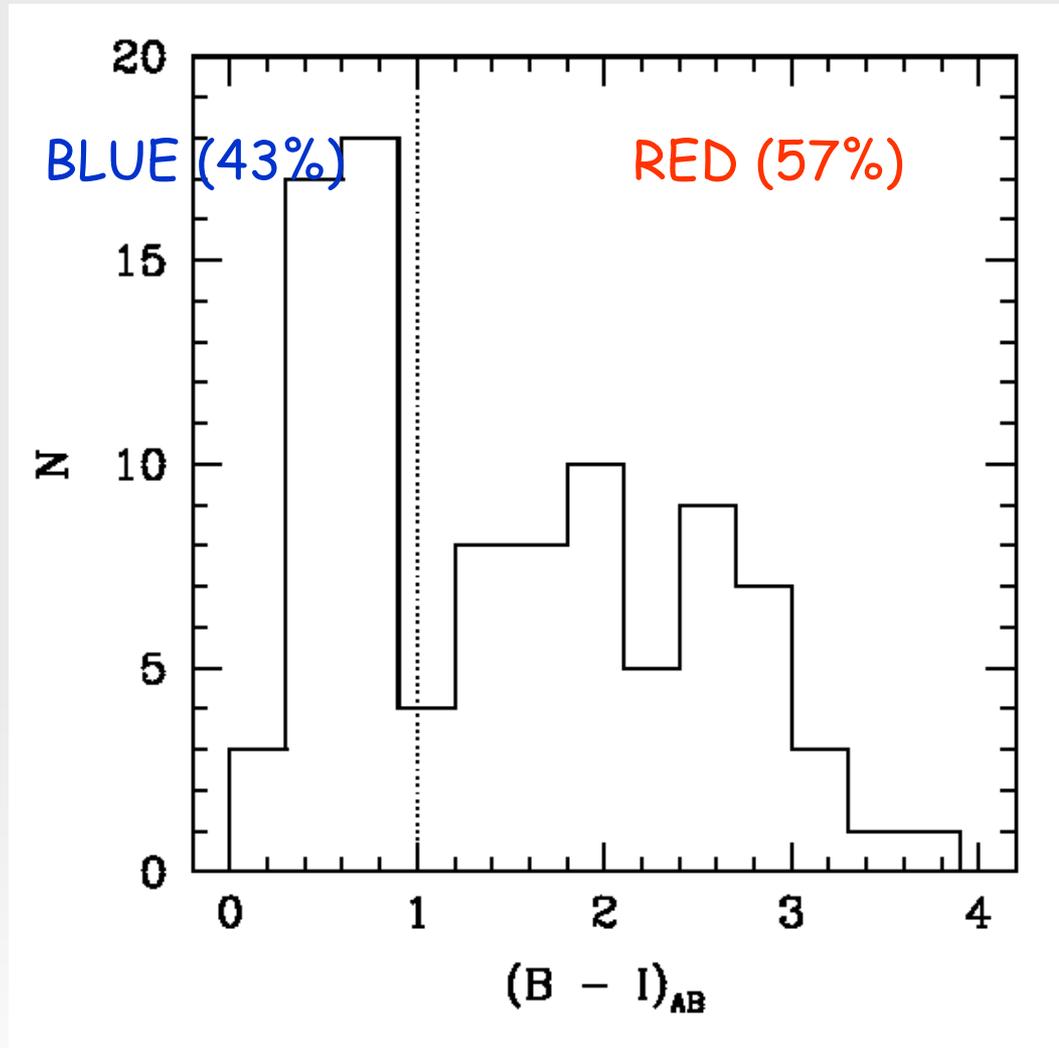
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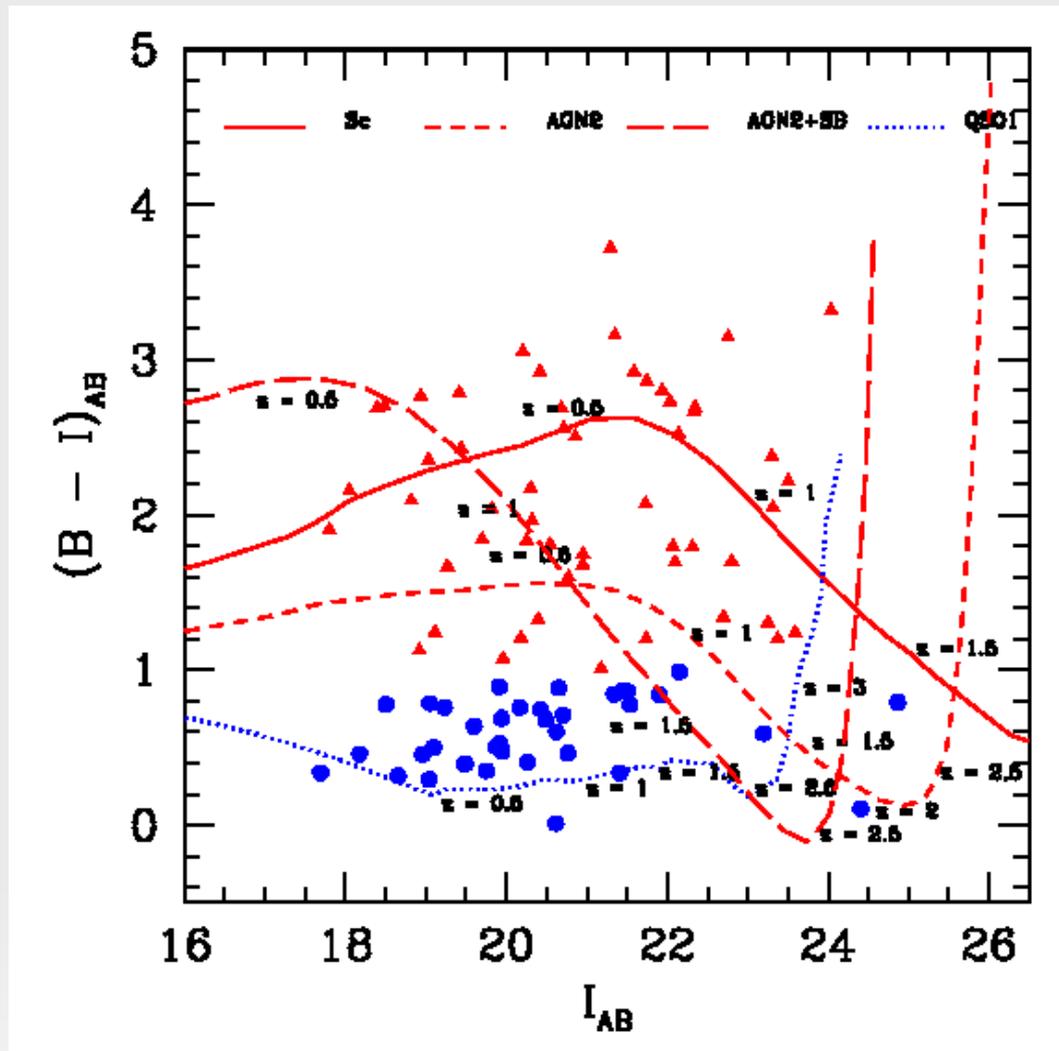
118 identified AGNs

+ 4 opt. blank fields ($X/O > 10$, potentially highly obscured)



Optical colors





Blue: Optical emission likely from the AGN

Red: Optical emission likely from the galaxy (but X/O typical of AGN)

SEDs and photometric redshifts

VVDS: UBVRI(JK)

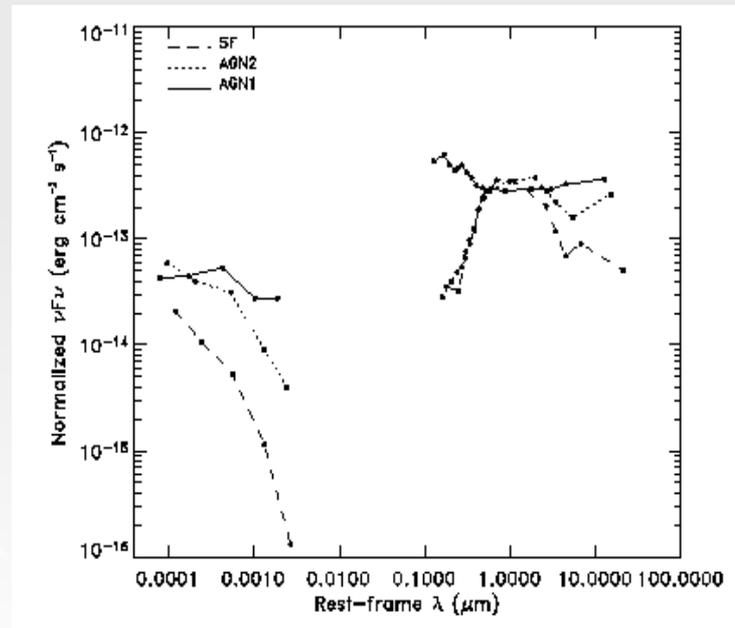
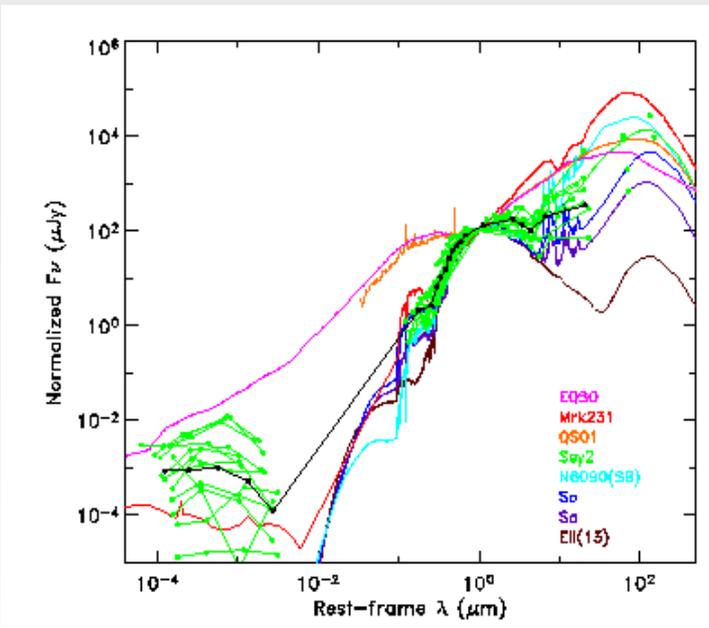
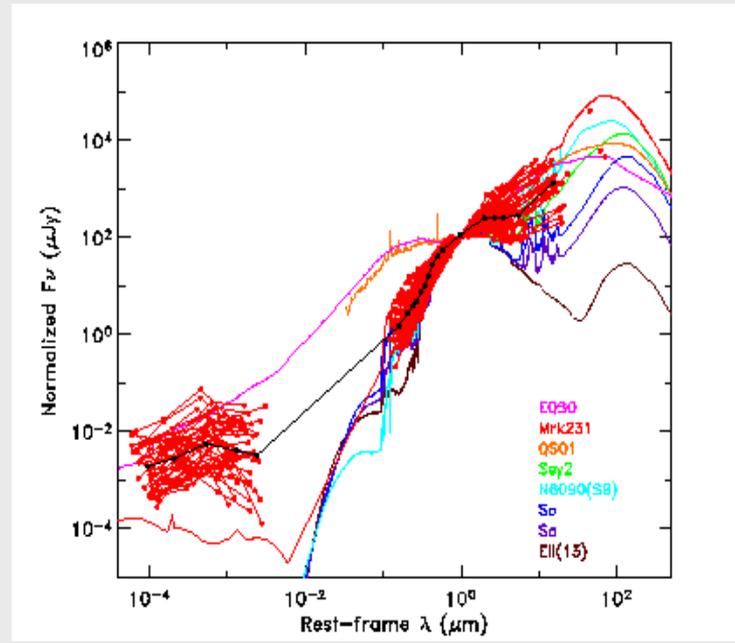
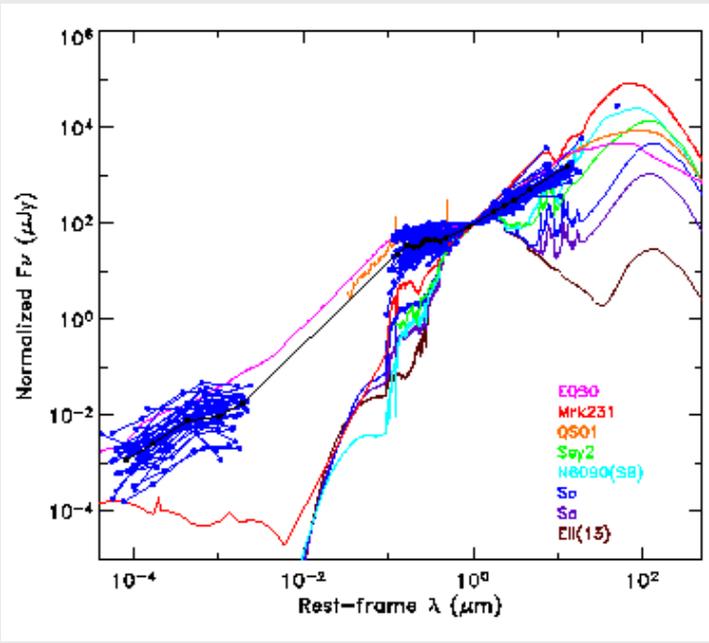
CFHLTS: u*g'r'i'z'

SWIRE: IRAC bands + MIPS 24 μm

HYPERZ code

SEDs fitted using 25 templates

(12 normal galaxies, 3 starbursts, 4 type 1 AGNs, 6 type 2 AGNs)



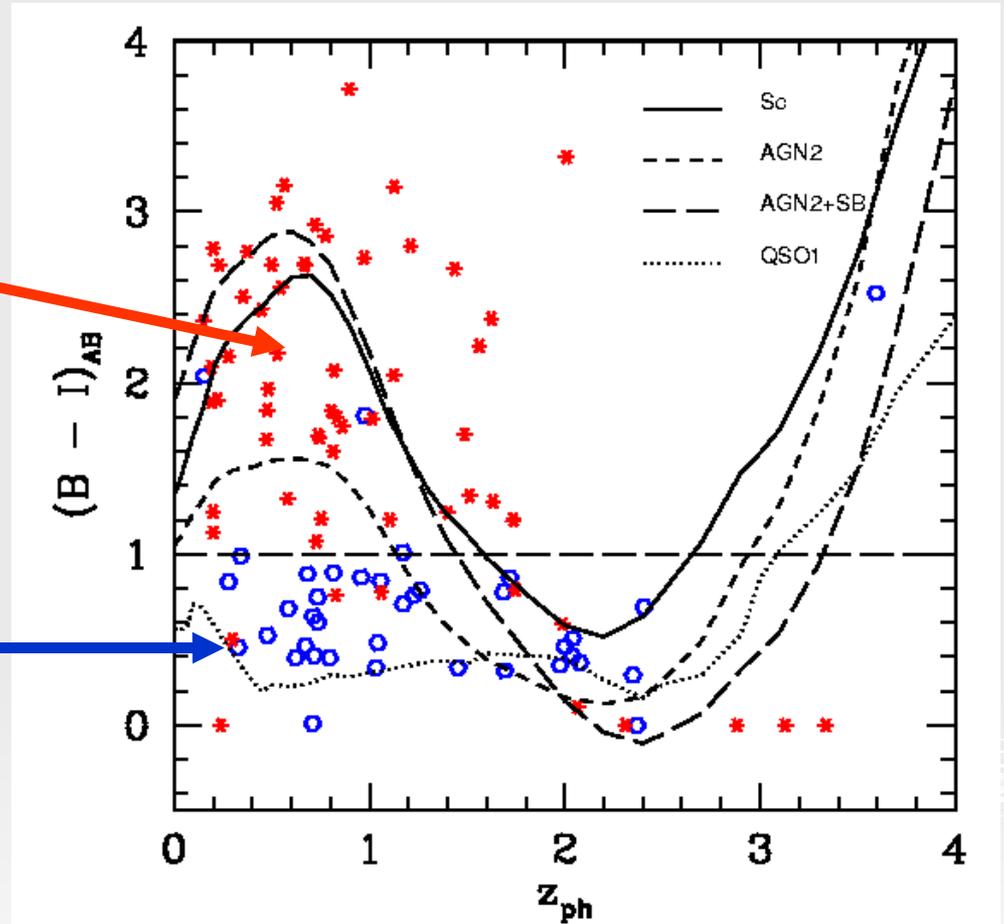
Polletta et al, in prep.

Photometric classification

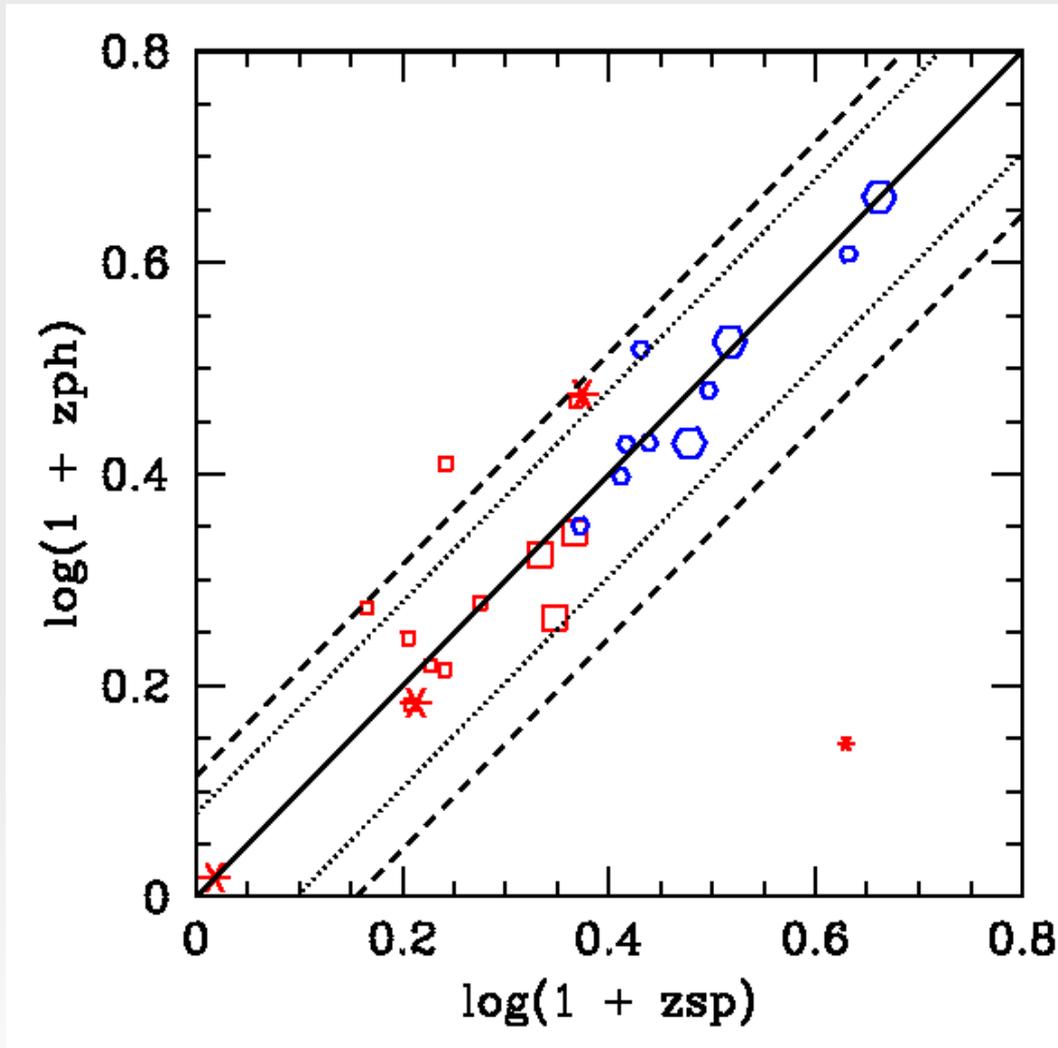
94 % of red objects are classified as "obscured AGNs"

76% of blue objects are classified as type 1 AGNs

Color criterion agrees with classification based on SEDs (at least for $z < 1$)



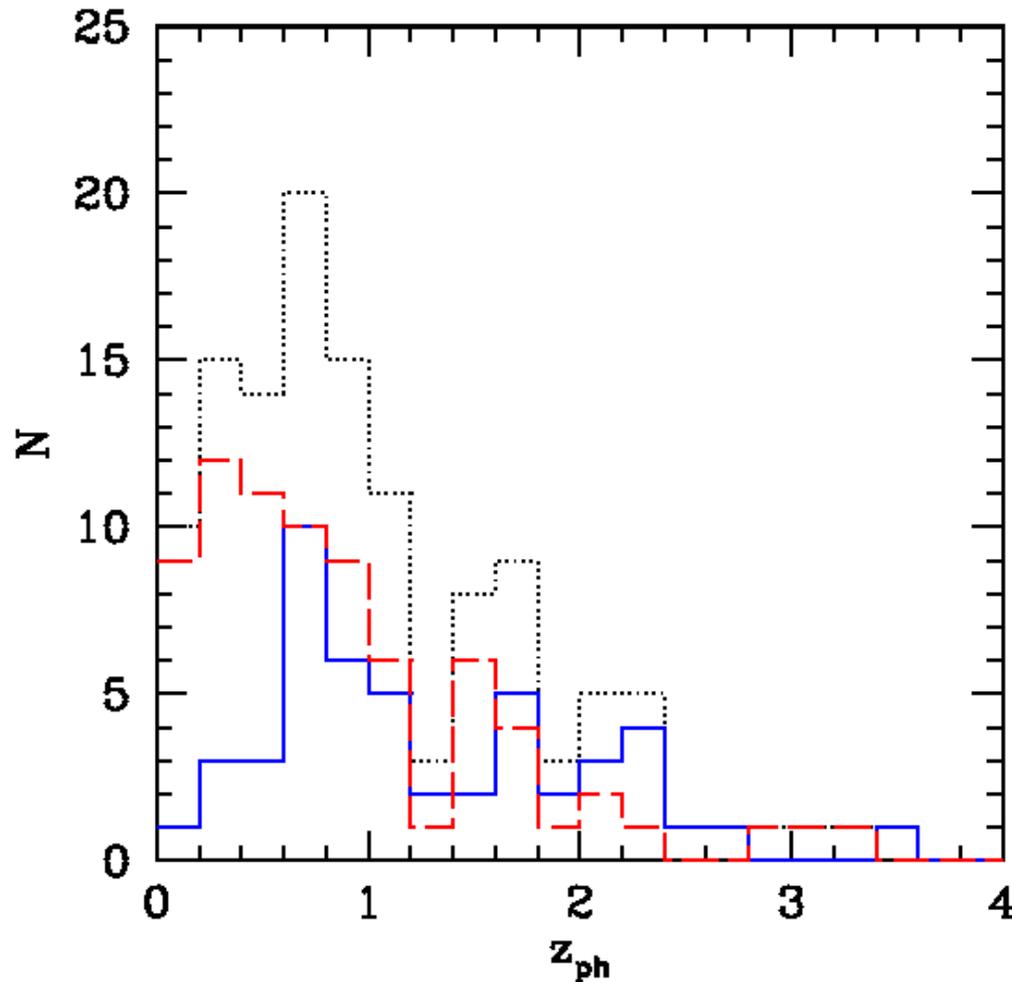
Photometric vs spectroscopic redshift



9 objects in the hard sample with spectroscopic z (large symbols)
+ 16 objects in the Chiappetti et al 2005 catalogue (small symbols)

19 of 25 with $\delta z < 0.2$
23 of 25 with $\delta z < 0.3$

Photometric redshifts: results



124 photo z

49 AGN1

46 AGN2

29 galaxies but X/O
typical of AGNs and
in all but 2 cases

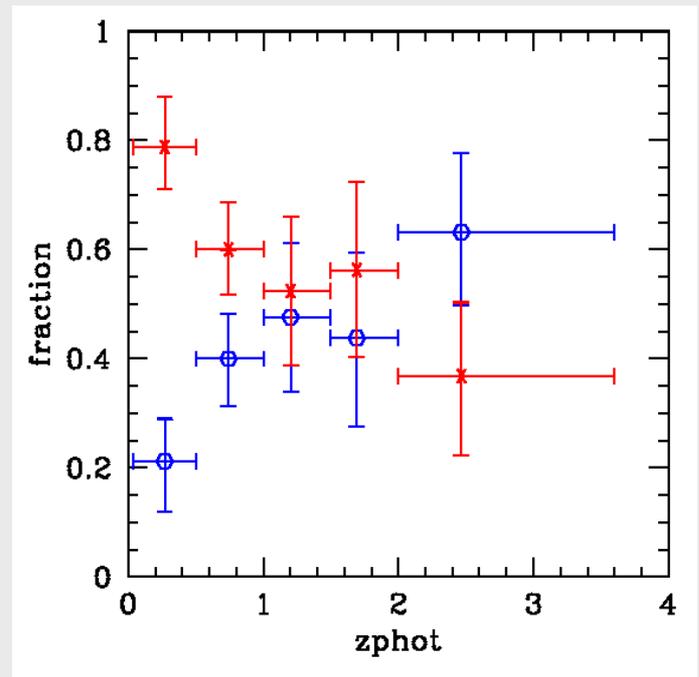
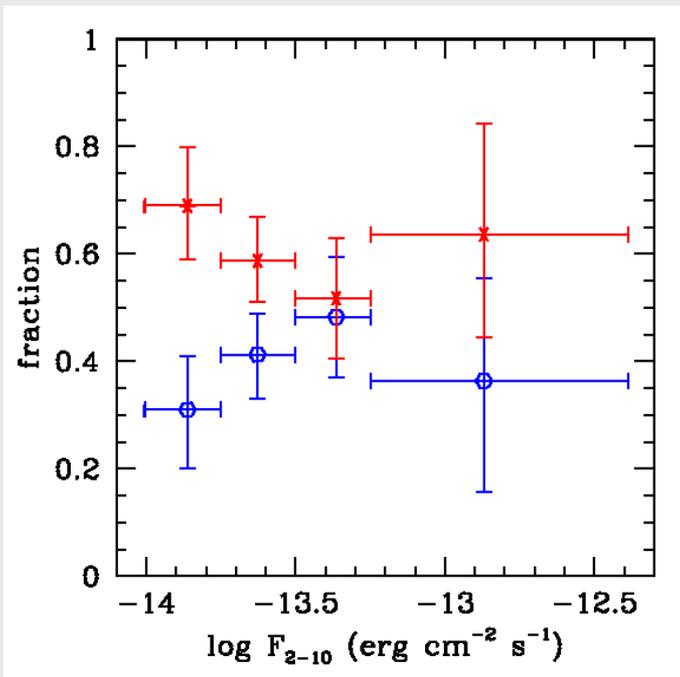
$L_x > 10^{42}$ erg/s



AGN2 + galaxies =
"obscured AGNs"

47% of AGN1 at $z < 1$

68% of "obscured
AGNs" at $z < 1$



“Obscured” AGNs:

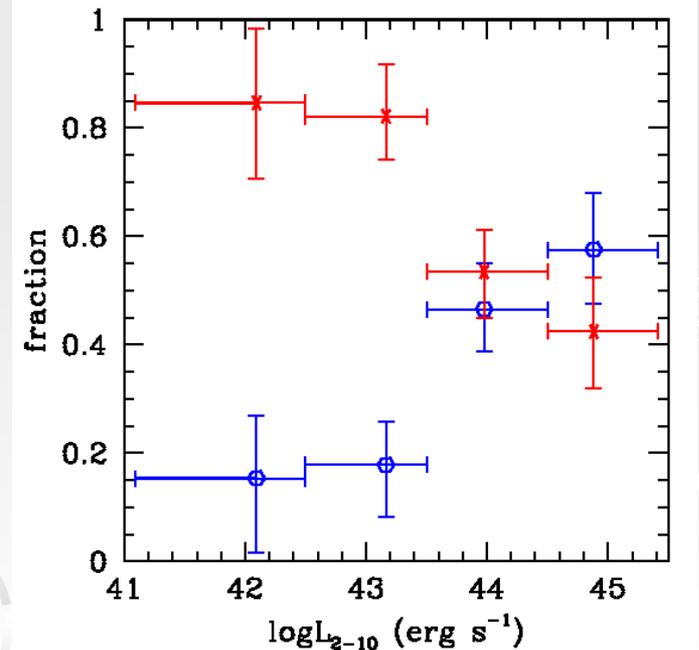
~ 80% at $z < 0.5$ \rightarrow ~ 40% at $z > 2$

Real or just a selection effect?

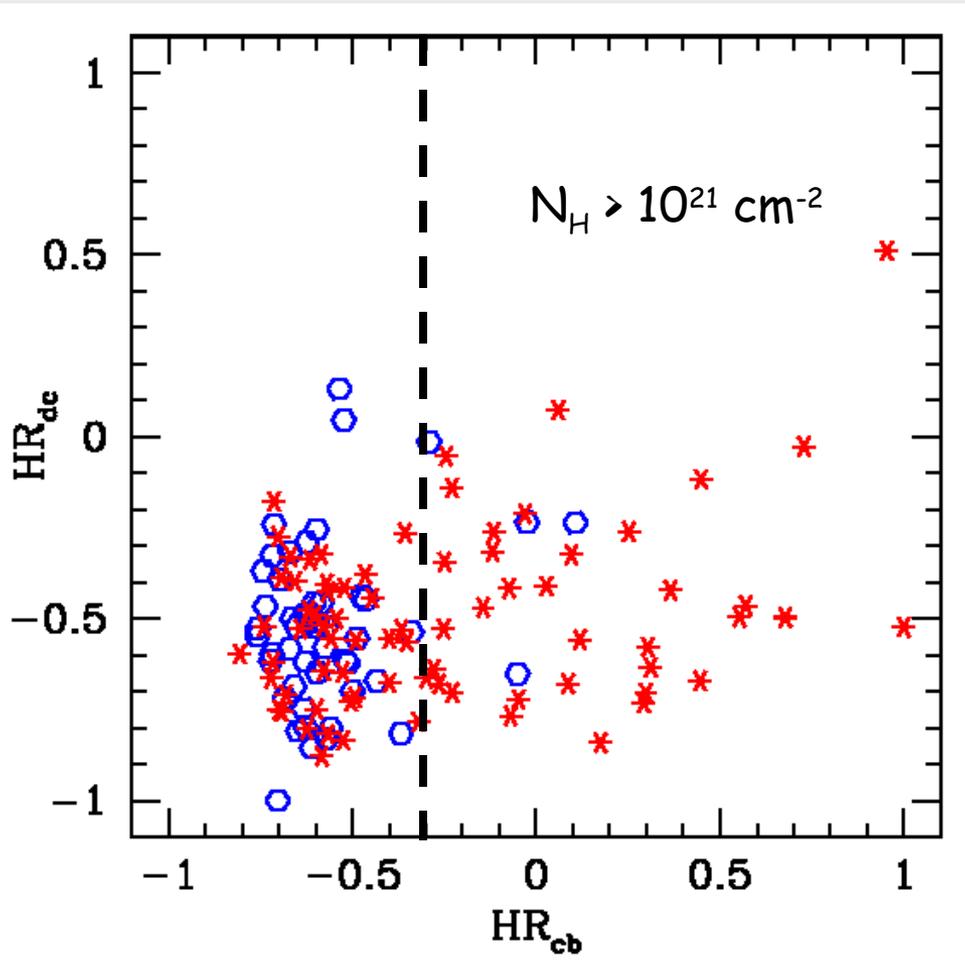
~ 80% at $\log L_x < 43.5$ \rightarrow ~ 40% at $\log L_x > 44.5$

Also trend with X-ray flux?

Tajer et al, in prep.



X-ray colors



Hardness ratios between
energy bands
B : 0.5 - 2 keV
C: 2 - 4.5 keV
D: 4.5 -10 keV

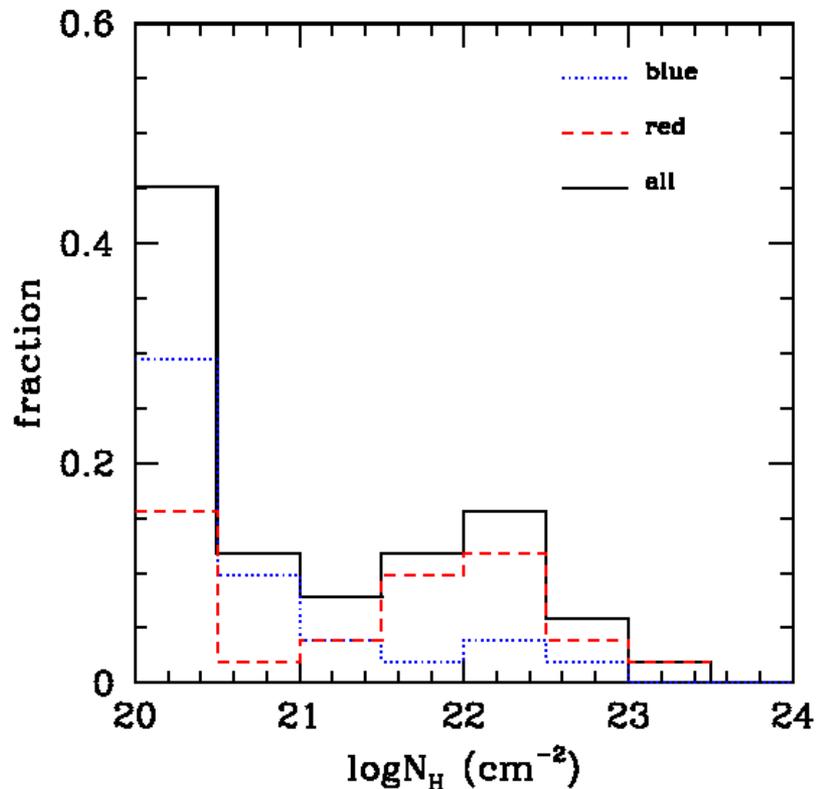
92% of type 1 AGNs have
 $HR_{cb} < -0.3$

46% of "obscured AGNs"
have $HR_{cb} > -0.3$ and 35/39
X-ray sources having
 $HR_{cb} > -0.3$ are "obscured
AGNs"

X-ray spectra

Simple absorbed power law model with galactic + intrinsic absorption and $\Gamma = 2.0$ (XSPEC model phabs*zphabs*pow)

51 X-ray sources with at least 50 net counts in the 2 - 10 keV band



26 blue sources

6 with $N_H > 10^{21} \text{ cm}^{-2}$

3 with $N_H > 10^{22} \text{ cm}^{-2}$

25 red sources

16 with $N_H > 10^{21} \text{ cm}^{-2}$

9 with $N_H > 10^{22} \text{ cm}^{-2}$

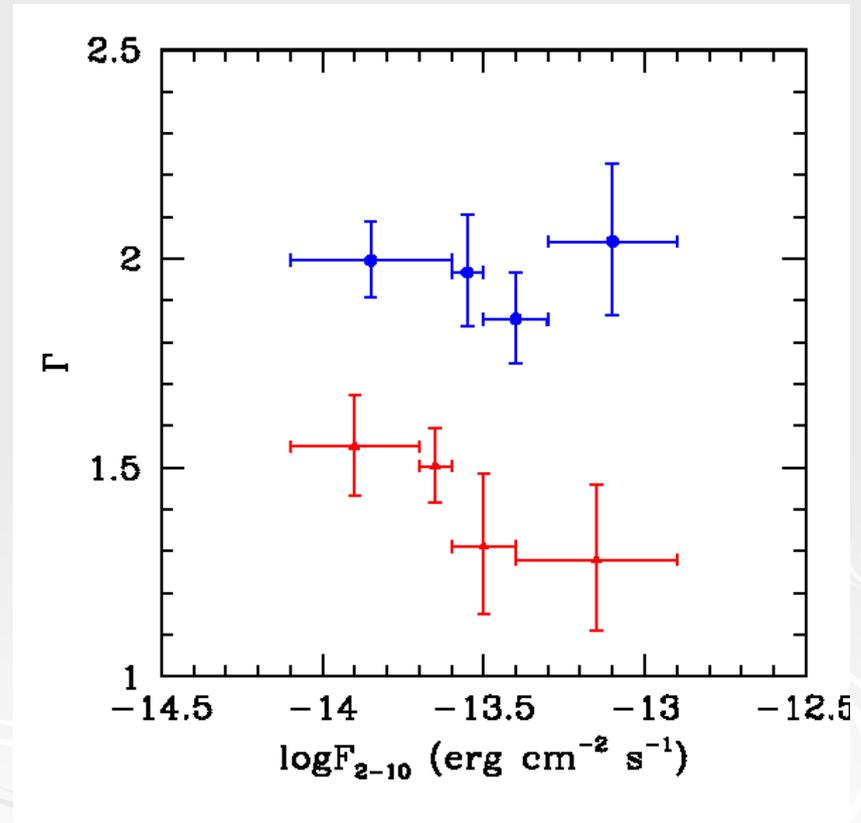
Stacking analysis

82 X-ray sources detected in pn at off-axis angle $< 11'$
Simple absorbed power law model with galactic column density

Blue sources consistent with typical spectra of unabsorbed AGNs ($\Gamma \sim 1.9 - 2.0$). No dependence with X-ray flux

Red sources consistent with the XRB spectrum ($\Gamma \sim 1.4$) (see also Georgakakis et al. 2006). Γ decreases with increasing X-ray flux?

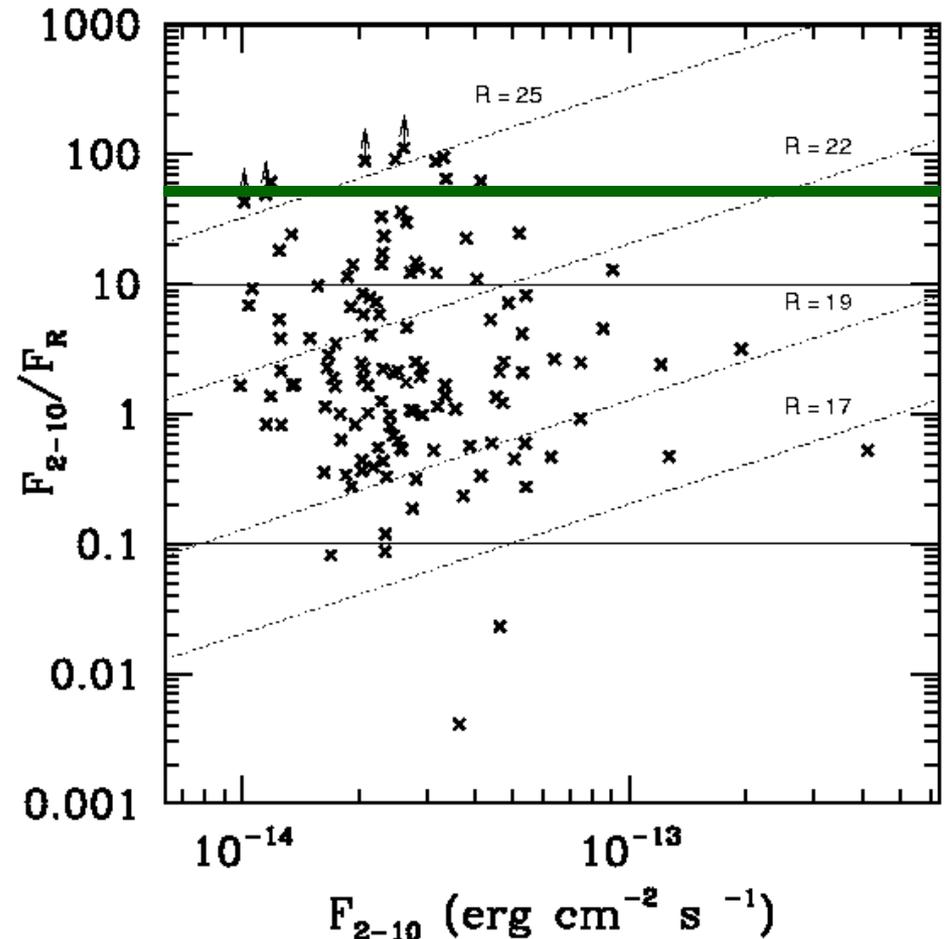
Tajer et al, in prep.

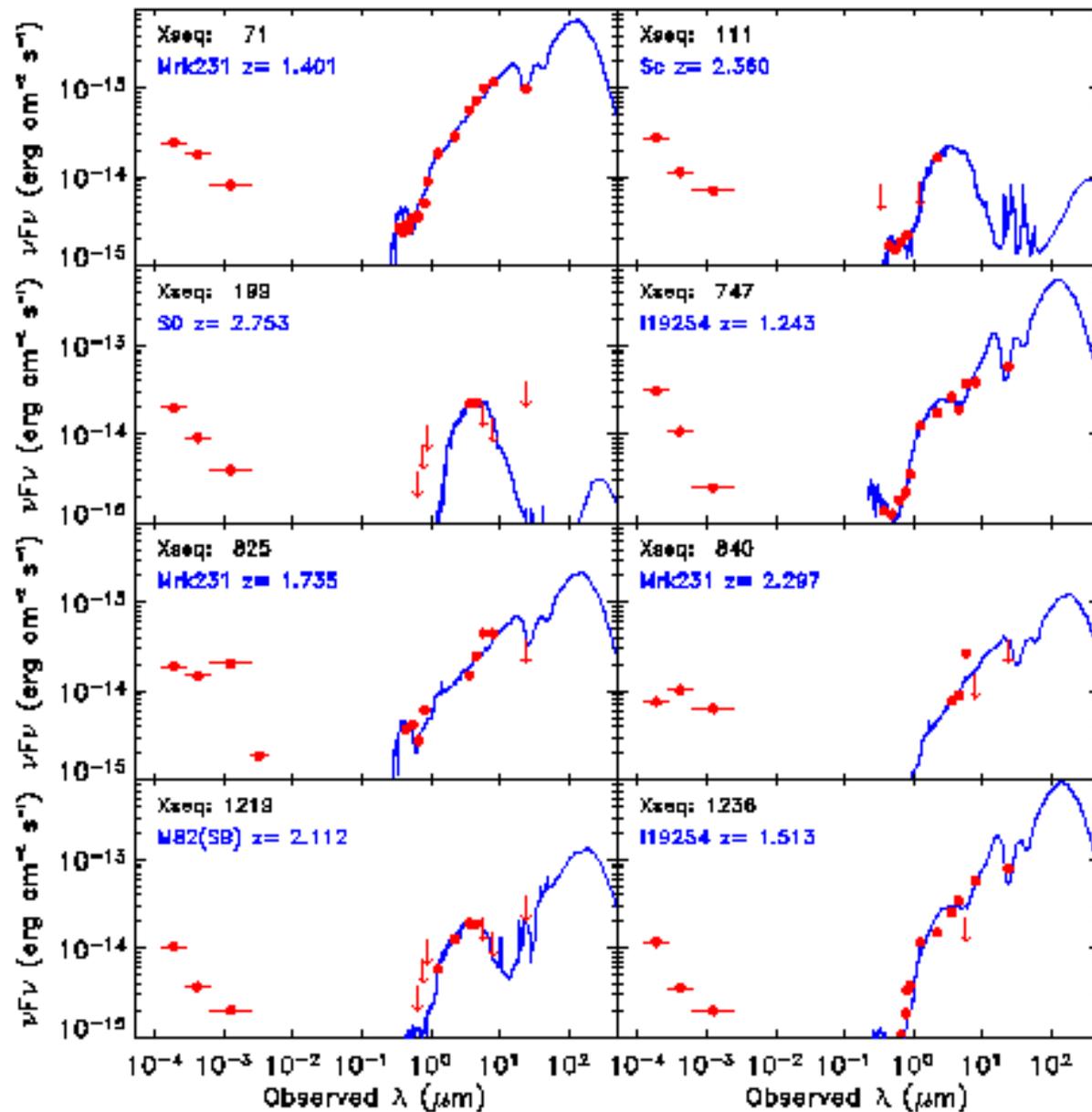


Type 2 QSO candidates

X/O selection: 8 objects with
 $X/O > 40$ (see Maiolino et al. 2006)

8 type 2 QSO candidates
 $F_x: 1 - 4 \times 10^{-14} \text{ erg cm}^{-2} \text{ s}^{-1}$
R: 24 - 26 (3 blank fields)
4 have K from the
UKIDSS: all are EROs (R -
K > 5)





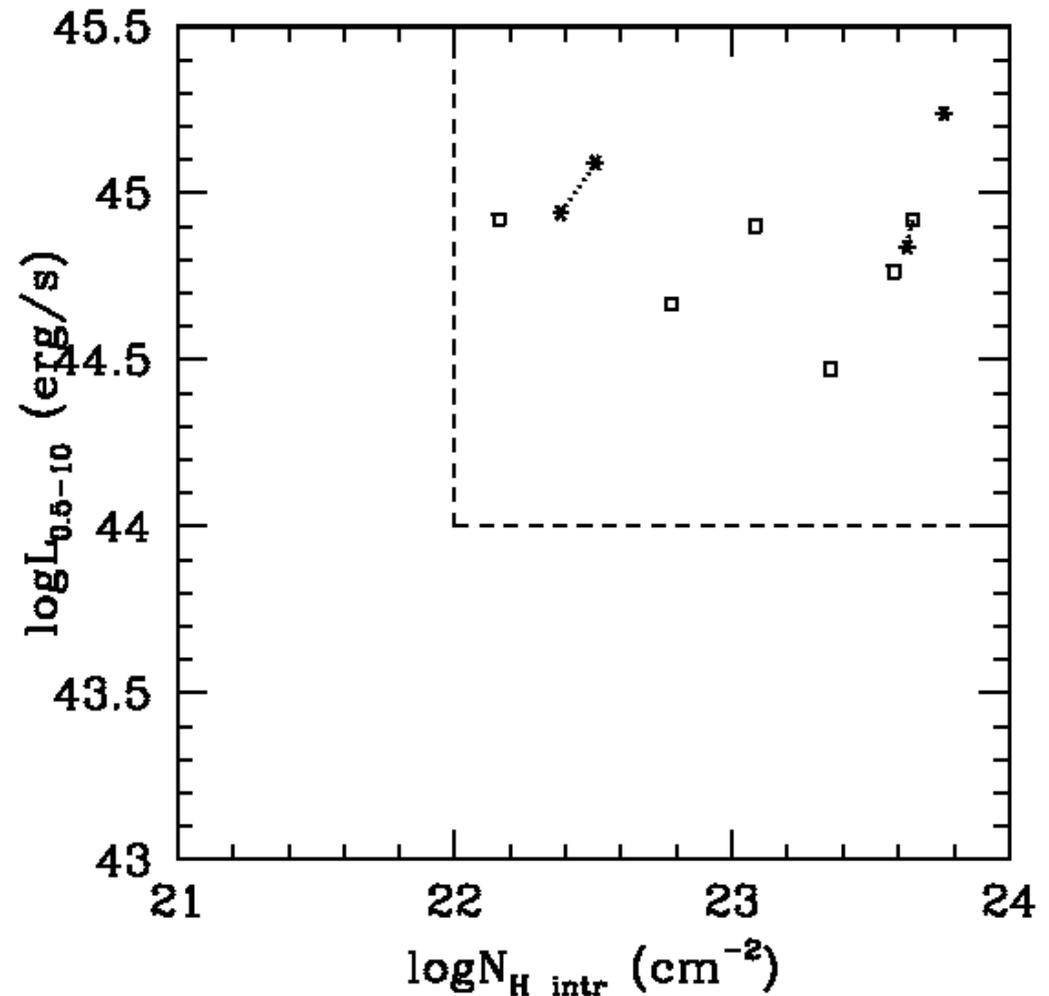
5 fitted by a type
 2 AGN template
 (ULIRG)
 3 fitted by a
 galaxy template
 Redshift range
 1.2 - 2.7

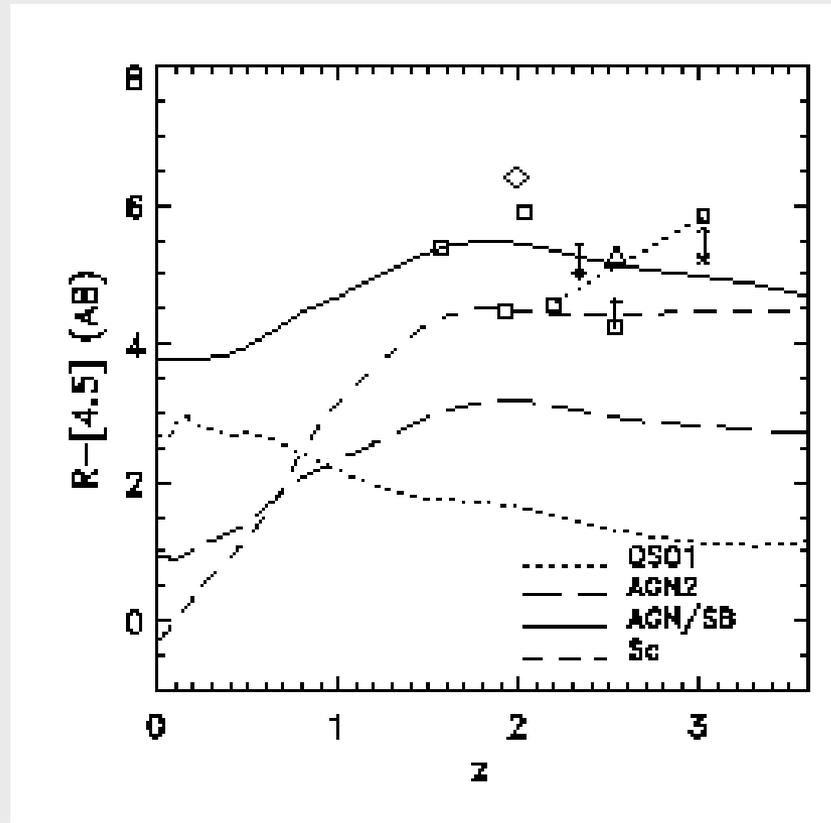
N_H measured for 3
objects, HR for the
others ->

$$N_H^{\text{intr}} > 10^{22} \text{ cm}^{-2}$$

$L_X > 10^{44} \text{ erg s}^{-1}$ for all
objects

All satisfy the X-ray
definition of type 2
QSOs





Infrared/optical colors consistent with highly obscured AGNs
 Also consistent with colors of spectroscopically confirmed type 2
 QSOs (Polletta et al 2006, Severgnini et al 2006)
 ESO FORS2/1 proposal for 5 candidates

Conclusions

136 X-ray sources detected at $> 3 \sigma$ in the 2 - 10 keV band
> 90% photometrically identified

Broad classification based on the B - I color

Blue objects:

- ❖ fitted by type 1 AGN templates
- ❖ no X-ray absorption
- ❖ $\Gamma \sim 2.0$



Unobscured AGNs

Red objects:

- ❖ fitted by galaxy/type 2 AGN templates
- ❖ in all but two cases X/O typical of AGNs and $L_x > 10^{42}$ erg/s
- ❖ about 50% moderately X-ray absorbed ($N_H > 10^{21}$ cm $^{-2}$)
- ❖ $\Gamma \sim 1.4$



Obscured AGNs

Conclusions II

- ❖ The fraction of obscured AGNs decreases with increasing redshift and X-ray luminosity
- ❖ The fraction of obscured AGNs possibly increases with decreasing X-ray flux
- ❖ 8 type 2 QSO candidates, 5 proposed for optical spectroscopy

