X-ray source populations from the XMM-Newton Medium Survey

Francisco J. Carrera, X. Barcons, M. Ceballos (IFCA, CSIC-UC, Spain)
J. Bussons (U. Murcia, Spain)
&
XMM-Newton Survey Science Centre
(J. Ebrero, A. Corral, S. Mateos, M. J. Page, M.G. Watson, J. Tedds, R. Della Ceca ...)

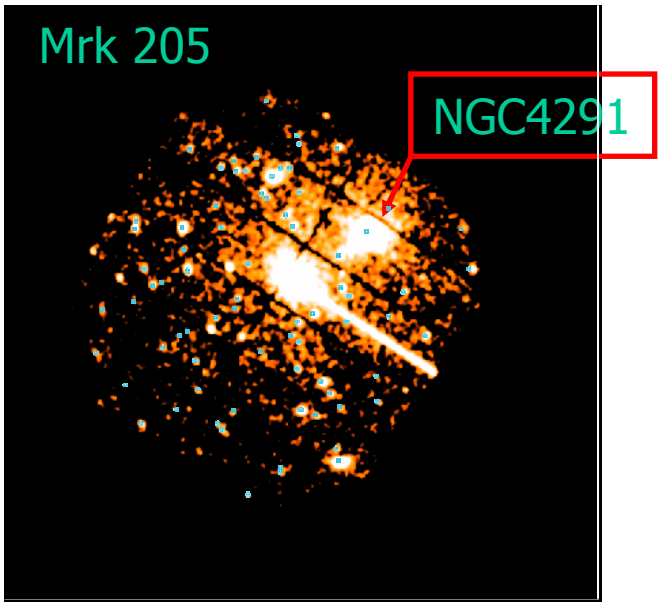
X-ray Universe, Granada, 28 May 2008

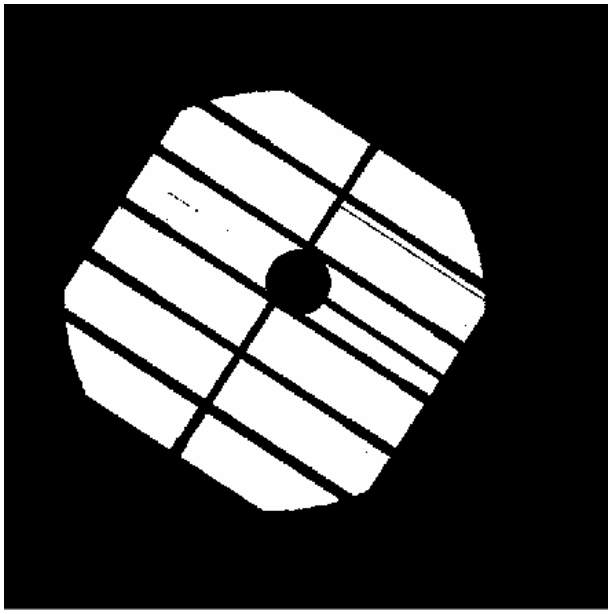
Why bother with Medium surveys?

- The maximum of the contribution of sources to the X-ray background happens at "medium" fluxes ($\sim 10^{-14}$cgs, Carrera+07)
- 2XMM (Watson+08) is a Medium Survey
  - Huge resource, barely tapped
  - Need pathfinder/reference
- Many (most?) XMM-Newton observations at $|b|>20^{o}$ would qualify
  - Periodical updates to 2XMM?
  - 100000s of sources end of XMM-Newton life (~2020?)

Definition of the surveys

- AXIS (Carrera+07):
  - 36 XMM-Newton target fields:
  - Galactic latitude |b|>20 deg
  - Good quality: source screening
  - Solid angle ~4.8 deg^2
  - Total of 1434 distinct X-ray sources with detection likelihood >15
- XMS: subset of AXIS (Barcons+07)
  - 25 fields chosen for follow-up: 3.3 deg^2
  - Flux limited in Soft, Hard and XID: total of 319 sourceS
  - Optical imaging: g,r,i (INT/WFC) to r~23-24
  - Reliable & unique candidate counterpart in r/i for virtually all sources (< 5" or < 5σ): only 8 "empties"
  - Optical spectroscopy
    - 5m and 8m-class longslit spectra





The XMS samples

Name	Band (keV)	Flux limit 10^{-14} cgs	# sources (unique)	# identified (fraction)
Soft XMS-S	0.5-2	1.5	211 (1)	202 (96%)
Hard XMS-H	2-10	3.3	160 (20)	134 (84%)
XID XMS-X	0.5-4.5	2.0	285 (56)	264 (93%)
Ultrahard XMS-U	4.5-7.5	-	71 (2)	61 (86%)

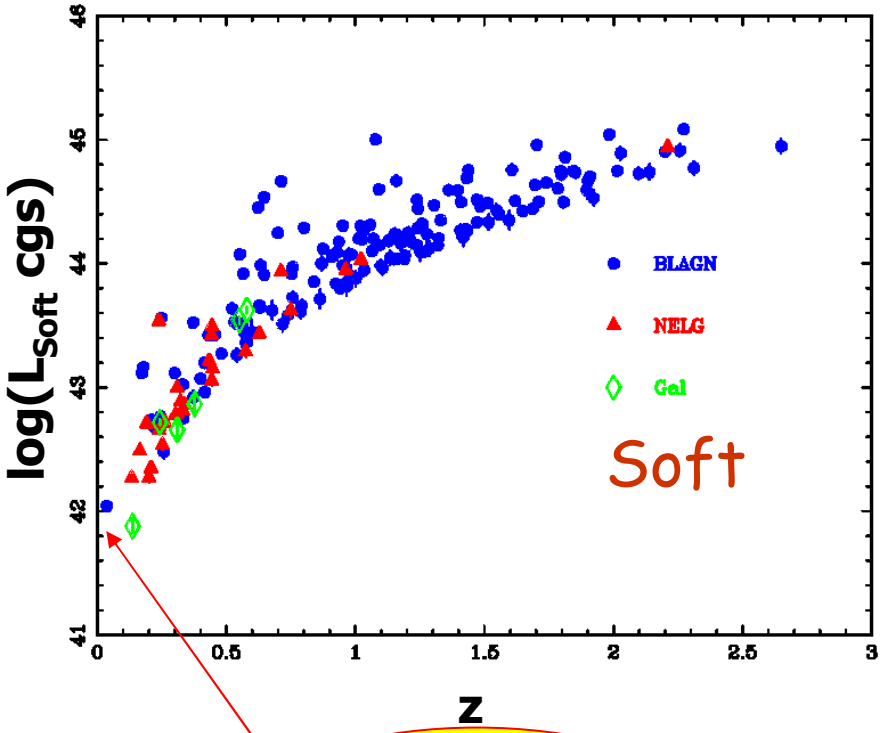
Breakdown of identified sources

+2 BL Lacs

	XMS-S **Soft**	XMS-H **Hard**	XMS-X XID	XMS-U Ultrahard
Broad-line AGN	**75%** (152/202)	**65%** (87/134)	74% (195/264)	69% (42/61)
Narrow-line galaxies (AGN)	**13%** (26/202)	**25%** (35/134)	14% (38/264)	25% (15/61)
Absorption line galaxies+clust	**3%** (7/202)	**6%** (8/134)	3% (9/264)	3% (3/61)
Stars	**7%** (15/202)	**2%** (3/134)	8% (20/264)	0% (0/61)

Clear differences between Soft/XID and Hard/Ultrahard –selected samples

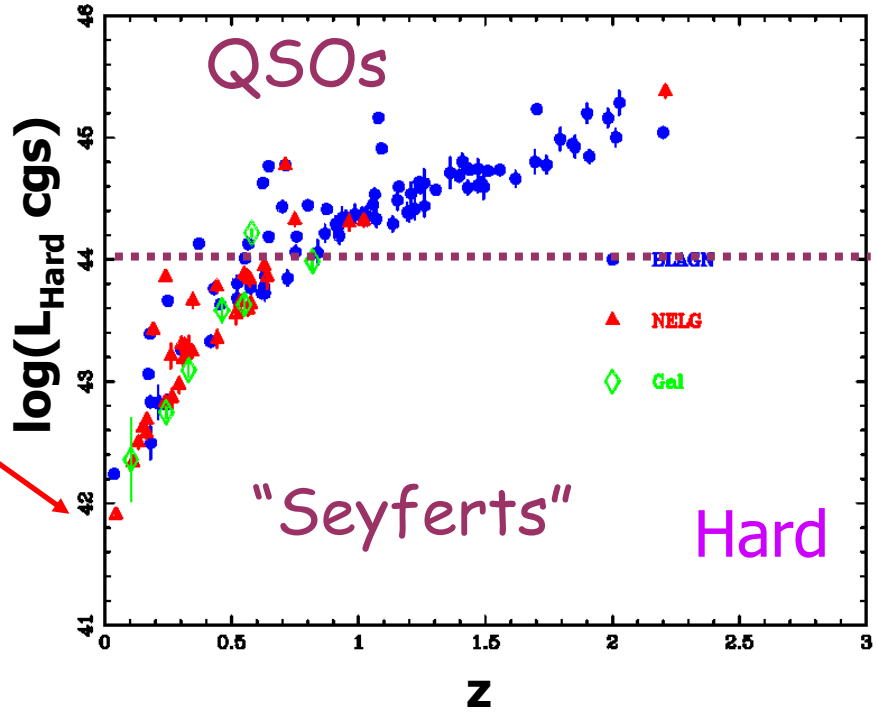
Luminosities and redshifts



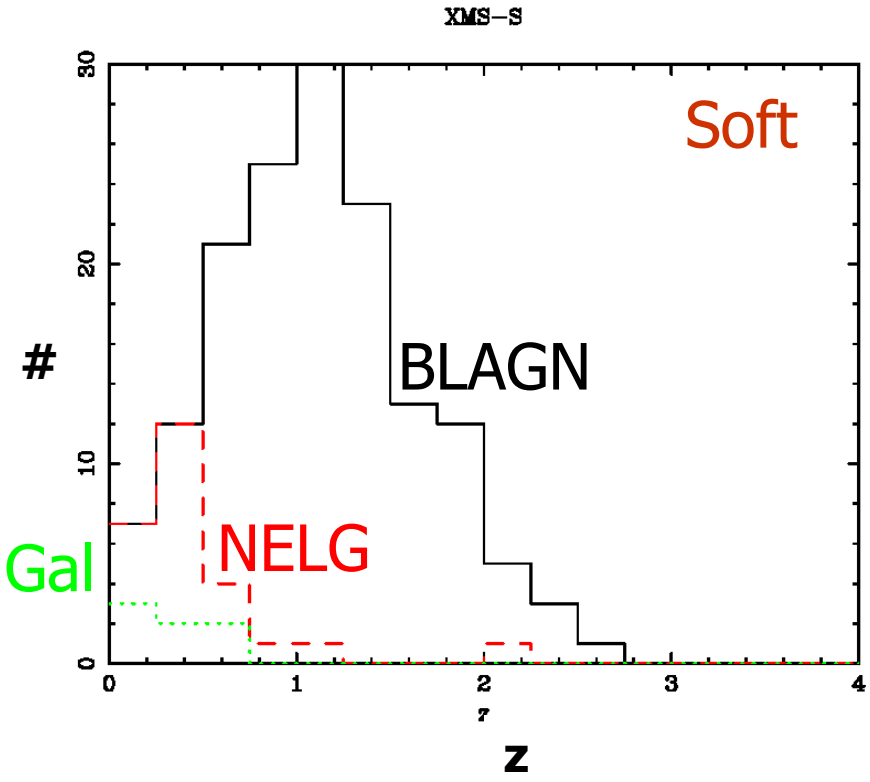
~1/3 NELGs have optical line ratios ~ STB (Barcons+)

All UnIDed Hard sources are optically extended: galaxies too

All galaxies consistent with hosting AGN $L_X>10^{42}$ erg/s: obscured AGN

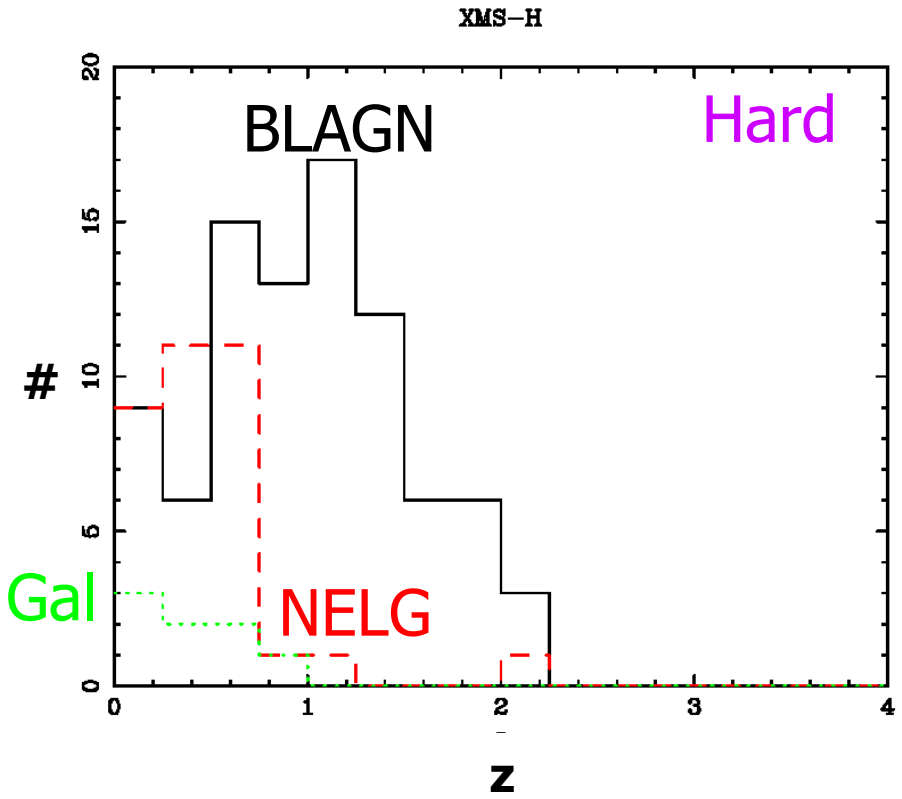


Redshift distribution



Peak of QSO distribution (z~1.5) well sampled.

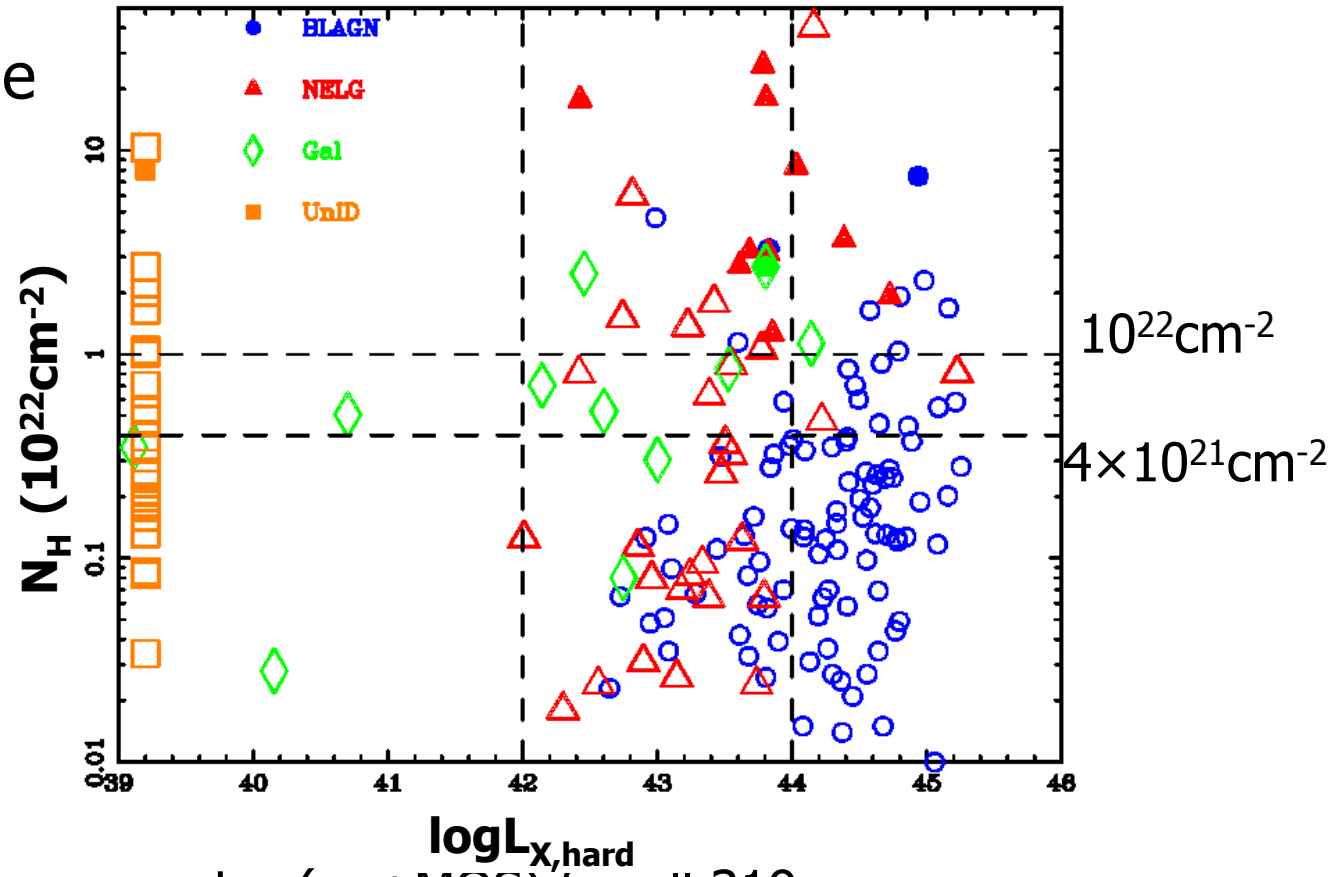
Obscured population out to z~1 in Hard sample



X-ray spectral analysis

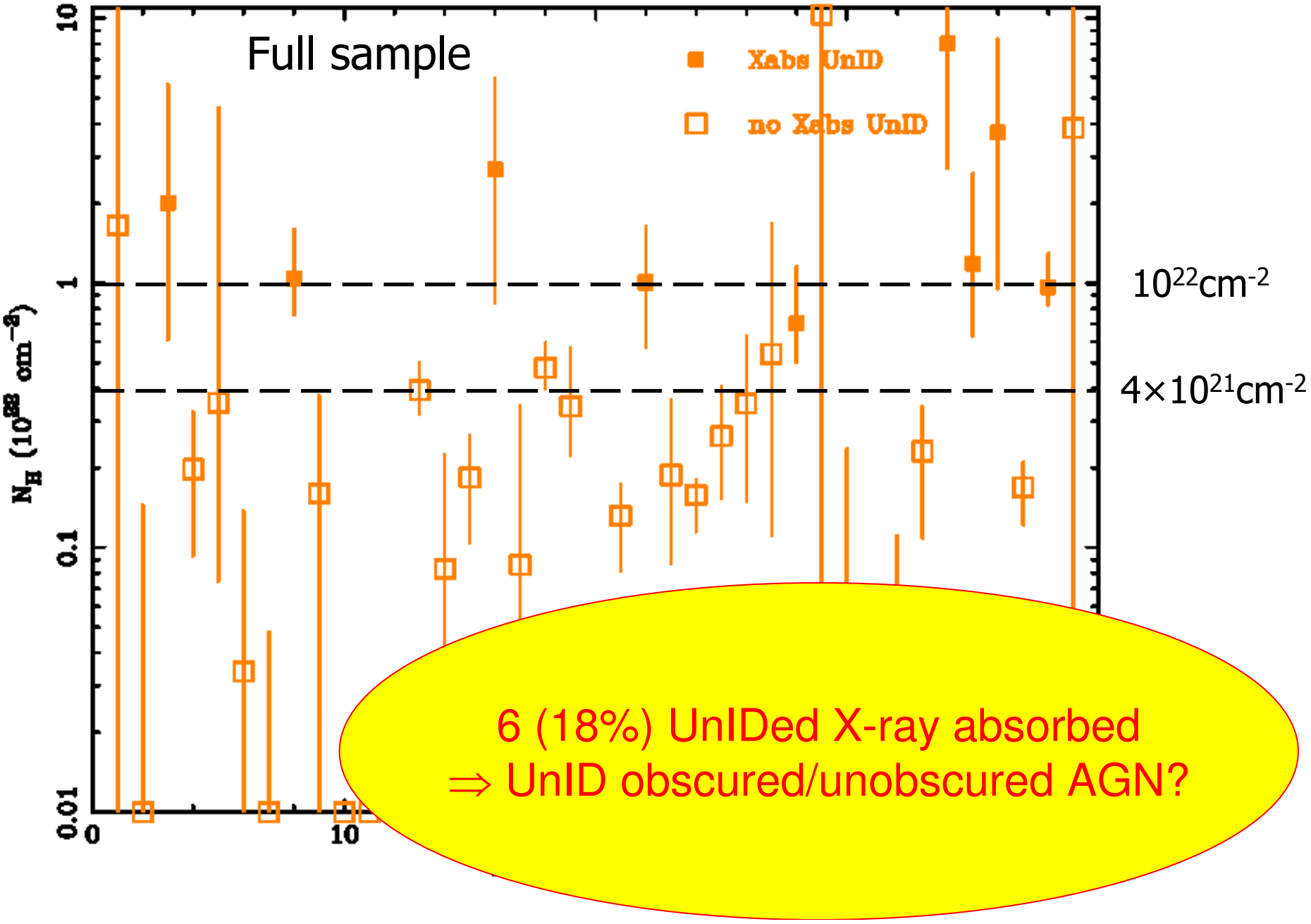
X-ray spectral analysis Corral+08,Bussons+08

Full sample



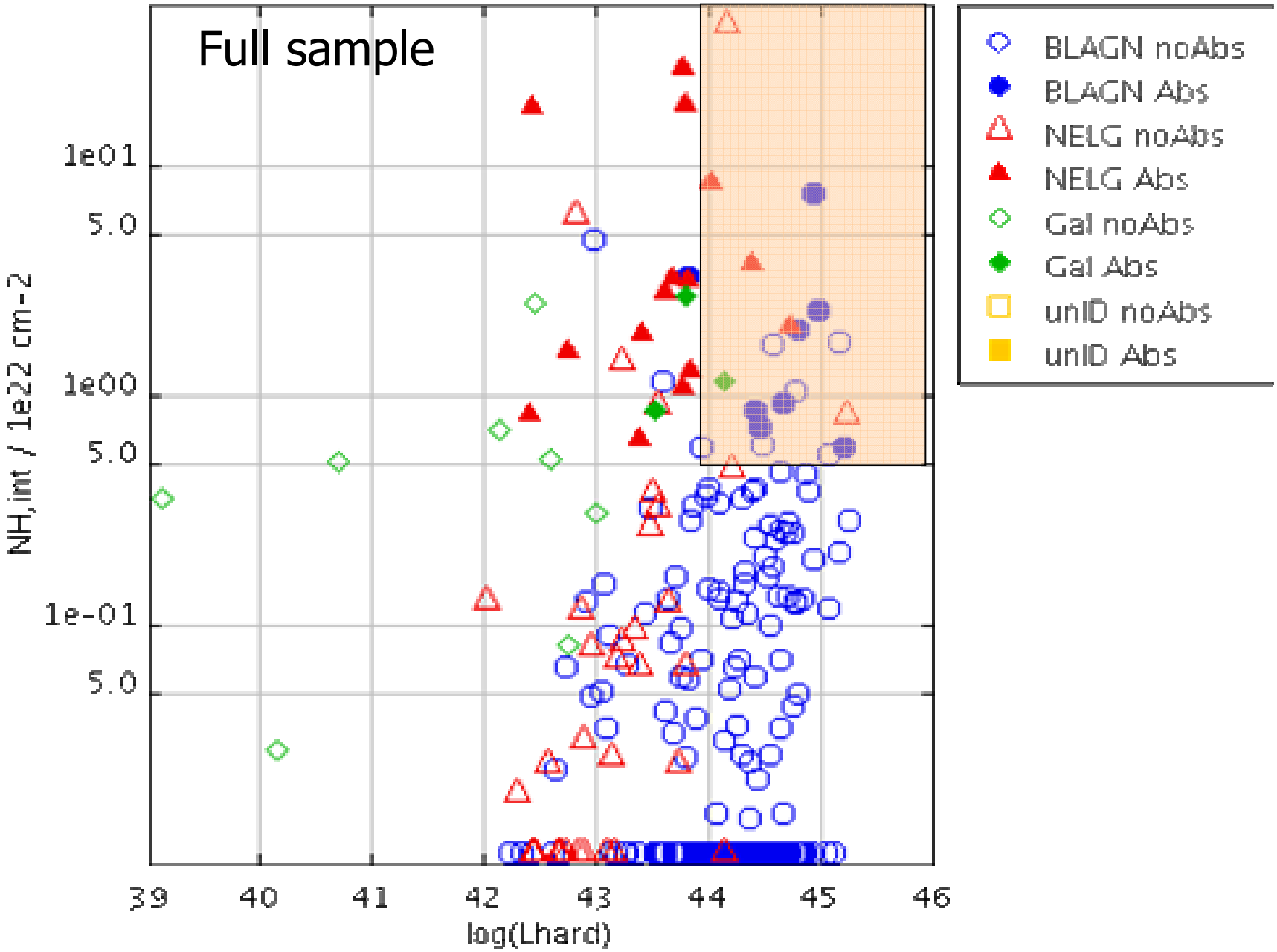
- Extracted X-ray spectra (pn+MOS) for all 319 sources
  - Fitted Gal. abs. * power law
  - Fitted Gal. abs. * Intrinsic abs. * power law
- N_H-ΔN_H(90%)>4×10^{21}cm^{-2}: X-ray absorbed 35 ⇒ Filled symbols
  - 8 BLAGN: 4% – 2 BLAGN: 1%
  - 15 NELG: 31% – 10 NELG: 11% N_H-ΔN_H(90%)>10^{22}cm^{-2}: 14
  - 3 Gal: 27% – 1 Gal: 9%

X-ray spectral analysis Corral+08,Bussons+08



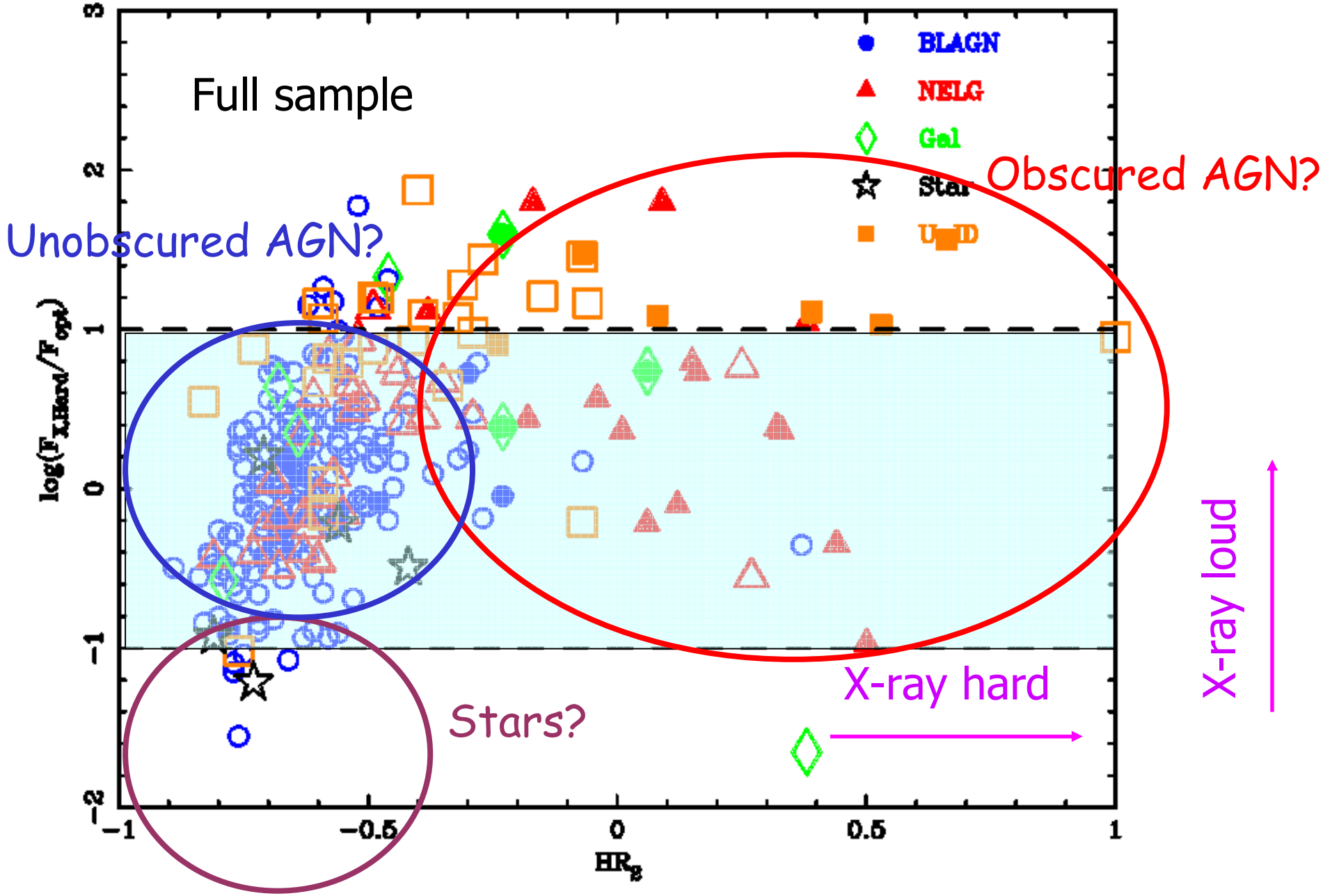
6 (18%) UnIDed X-ray absorbed
⇒ UnID obscured/unobscured AGN?

$L_{X,hard}$ vs. N_H: QSO2s

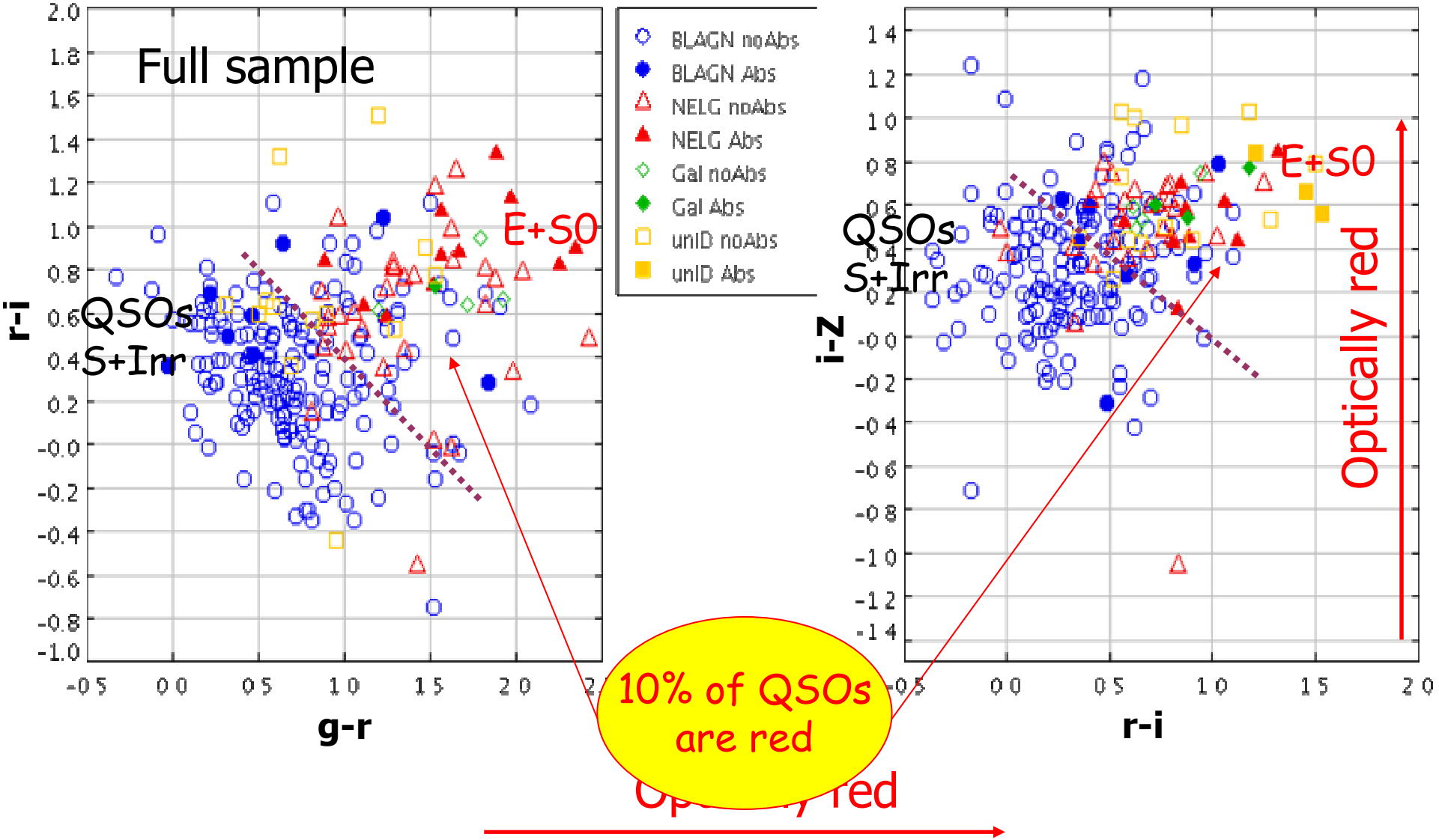


X-ray absorption and optical obscuration in AGN

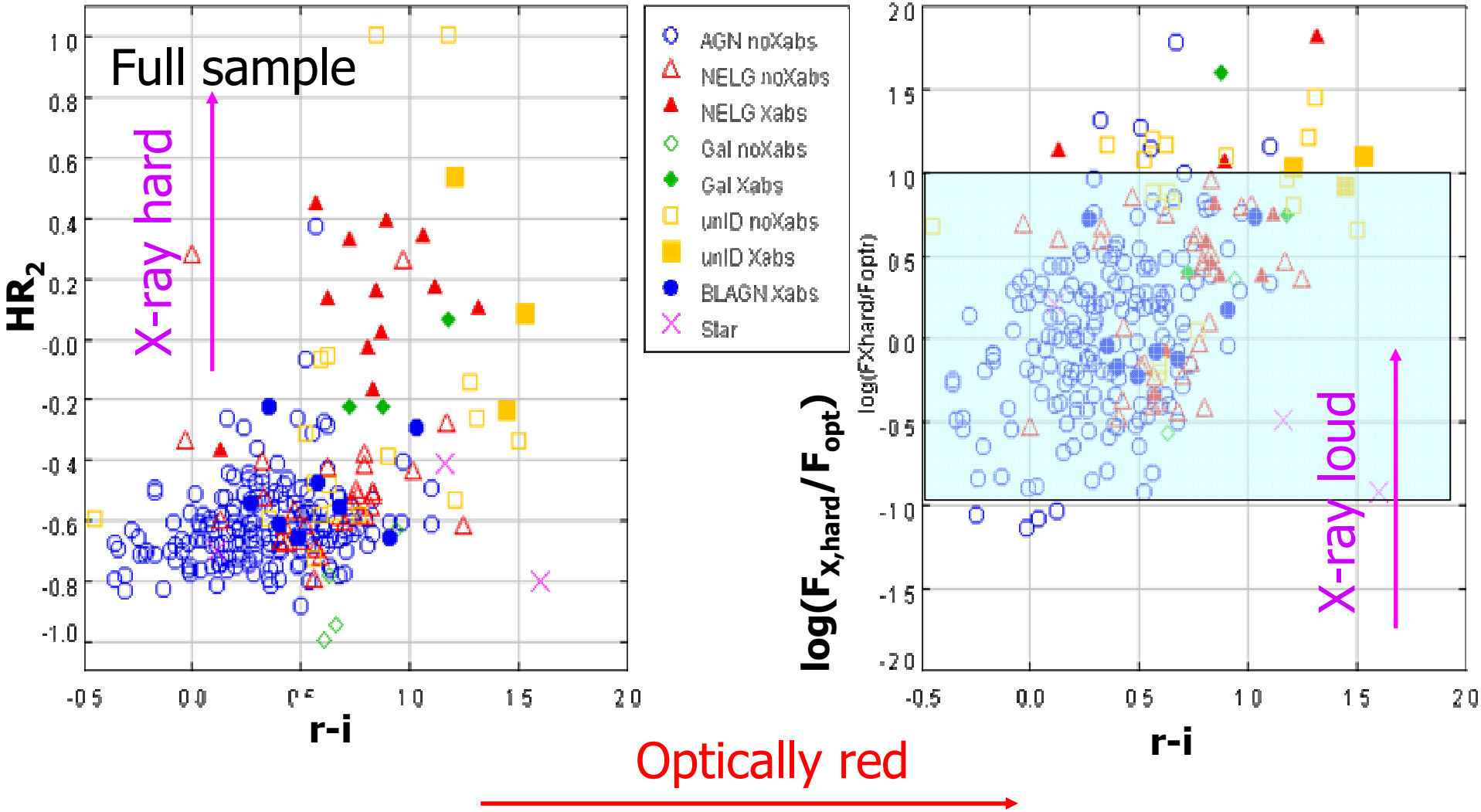
X-ray colours: $\log(F_{X,hard}/F_{opt})$ vs. HR_2



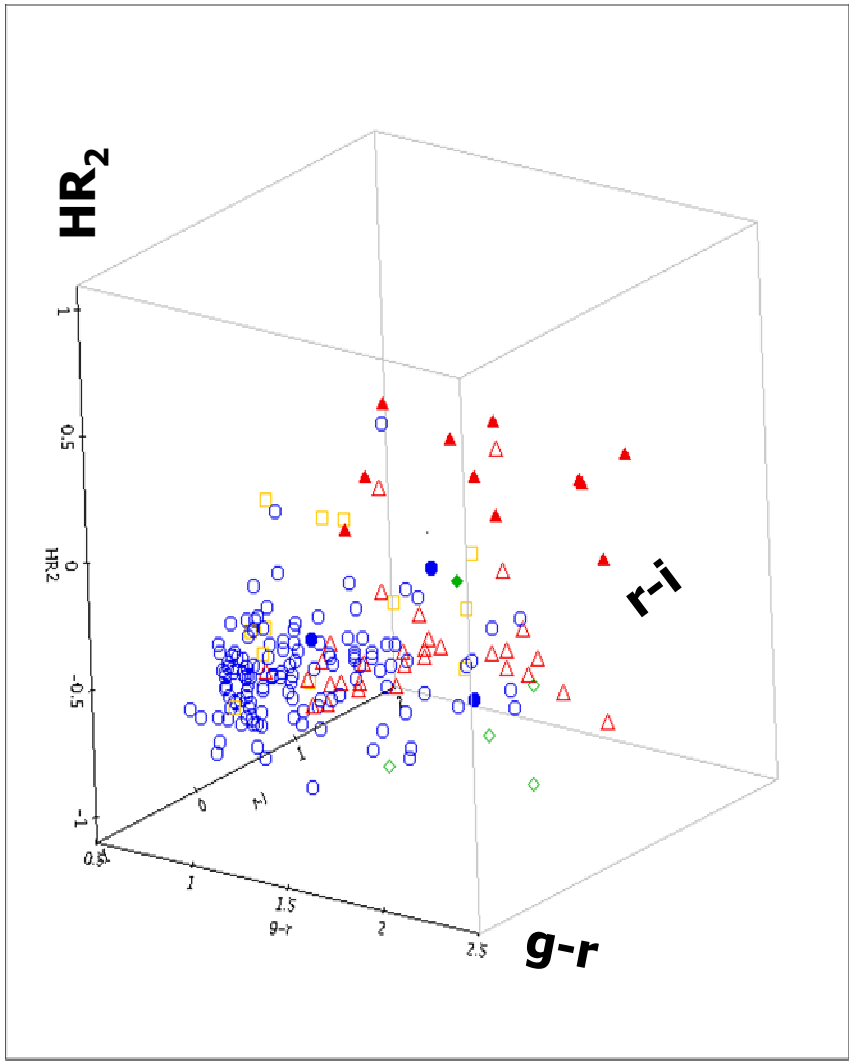
Optical colours



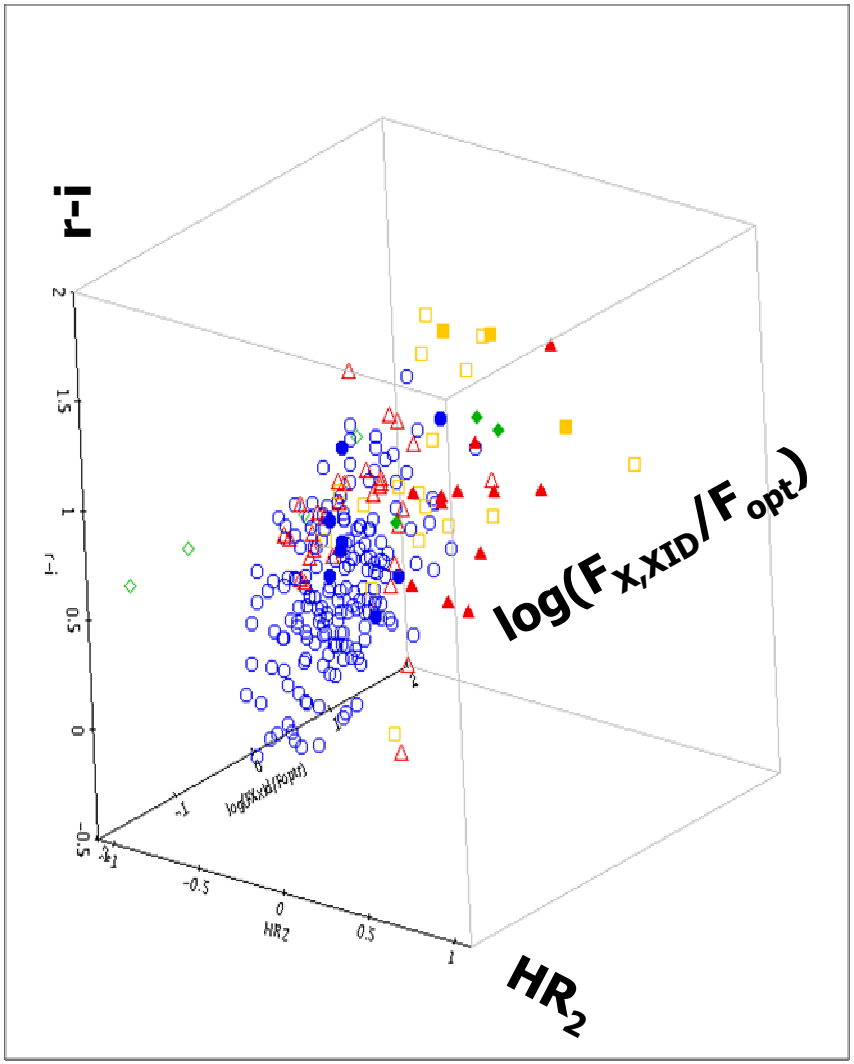
Now, let's mix them up



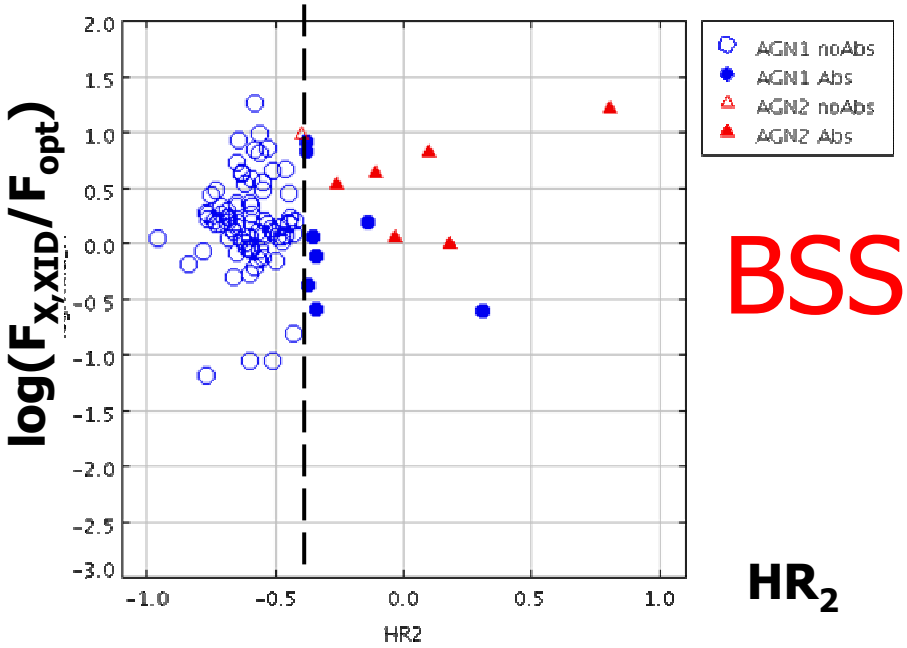
Now in 3D


HR2
r-i
g-r


BLAGN noAbs
BLAGN Abs
NELG noAbs
NELG Abs
Gal noAbs
Gal Abs
unID noAbs
unID Abs


r-i
log(FX,XID/Fopt)
HR2

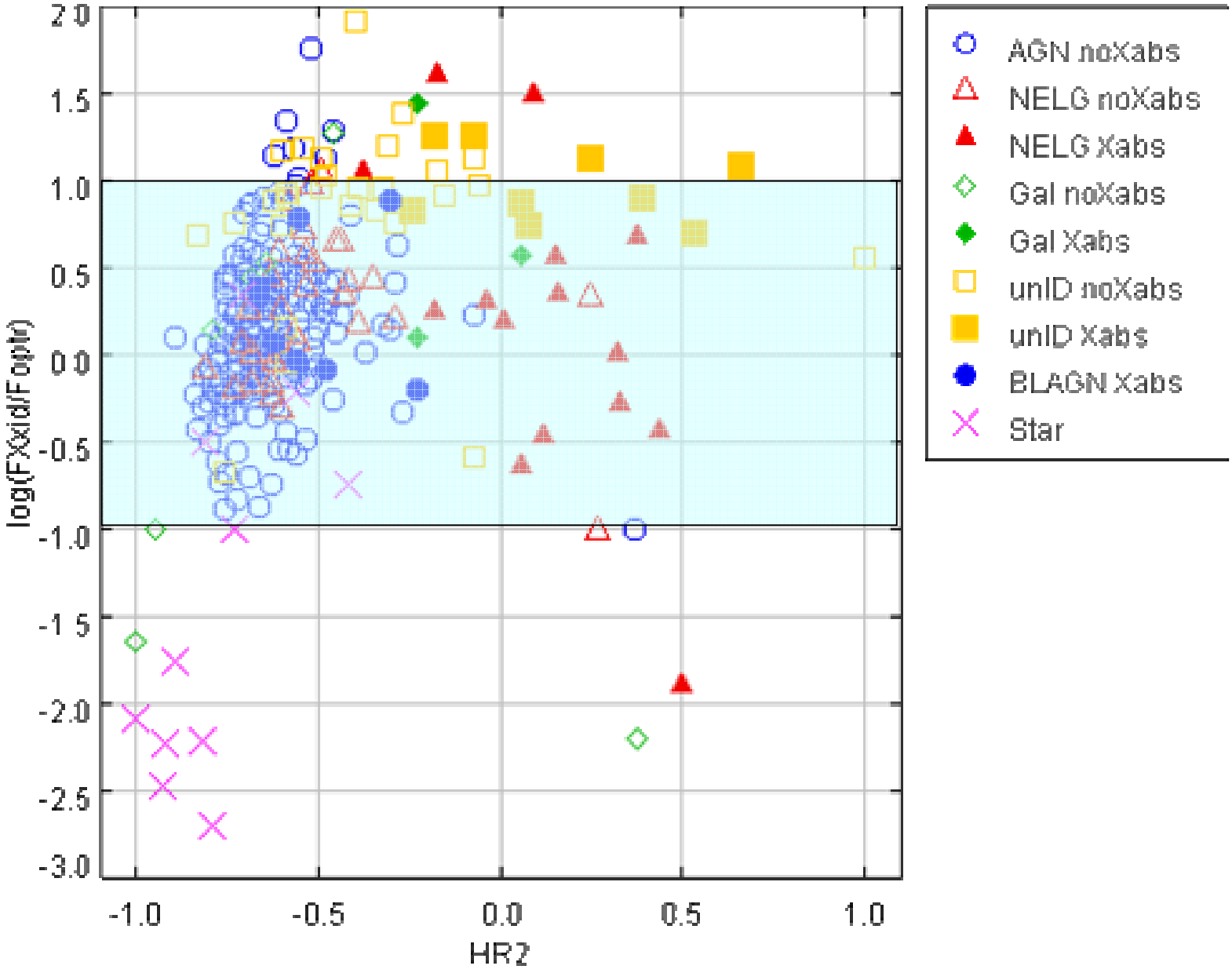
Increasing the sample: brighter sources



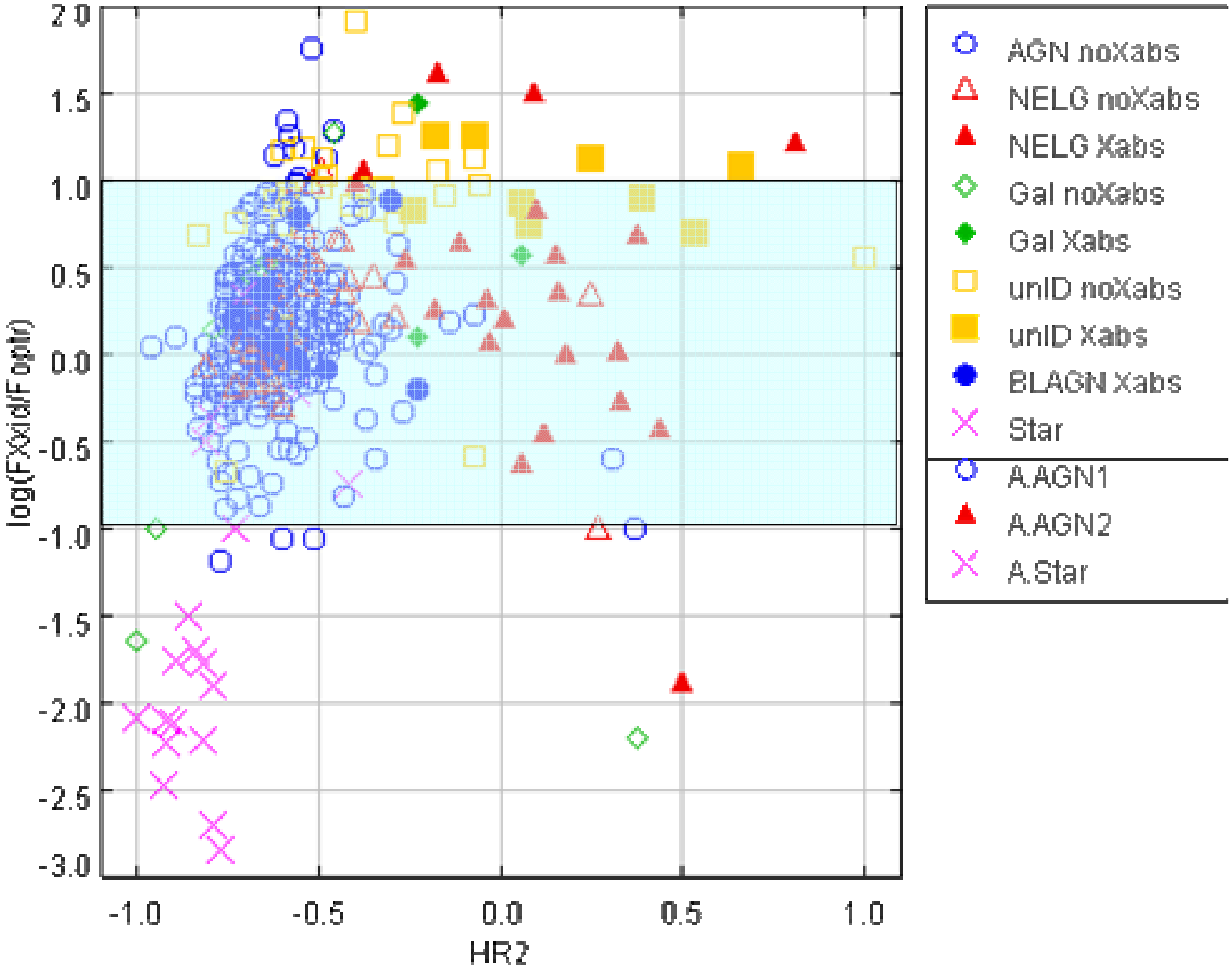
BSS: brighter cousins

- ~400 XMM-Newton/MOS2-selected objects down to 7×10^{-14}cgs in the XID band (DellaCeca+04)
- Subsample of 350 fully identified (Caccianiga+08):
  - More sophisticated classification scheme than XMS
  - In the end, ~AGN1/2 dividing line is ~HR_2(MOS2)=-0.4
    - "Our" Absorbed/unAbsorbed AGN classification
- X-correlated with SDSS DR6:
  - 112 sources with UgriZ magnitudes
  - Same average XID flux as parent sample
- Shallower in X-ray and optical than XMS:
  - Good for comparison/completeness?

X-ray colours: $\log(F_{X,XID}/F_{opt})$ vs. HR2



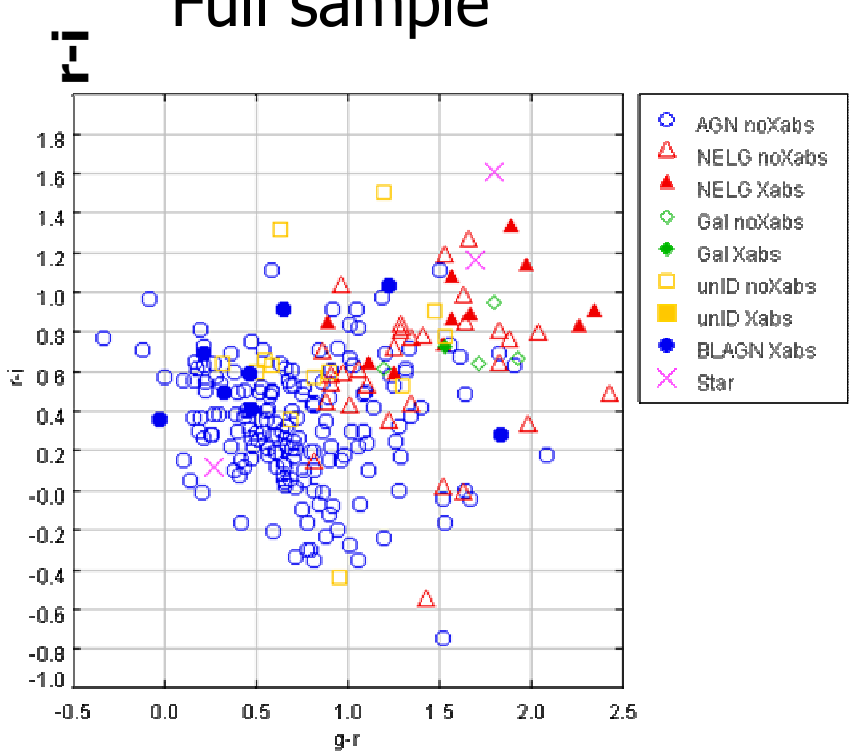
X-ray colours: $\log(F_{X,XID}/F_{opt})$ vs. HR2



Optical colours

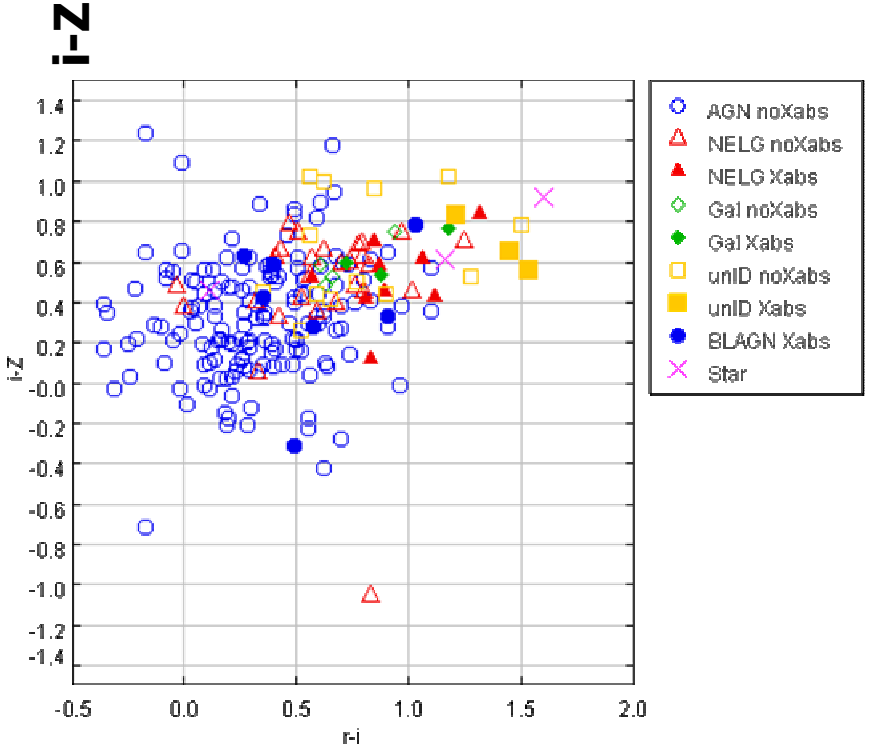
XBS bluer in g than XMS?

Full sample



g-r

Optically red



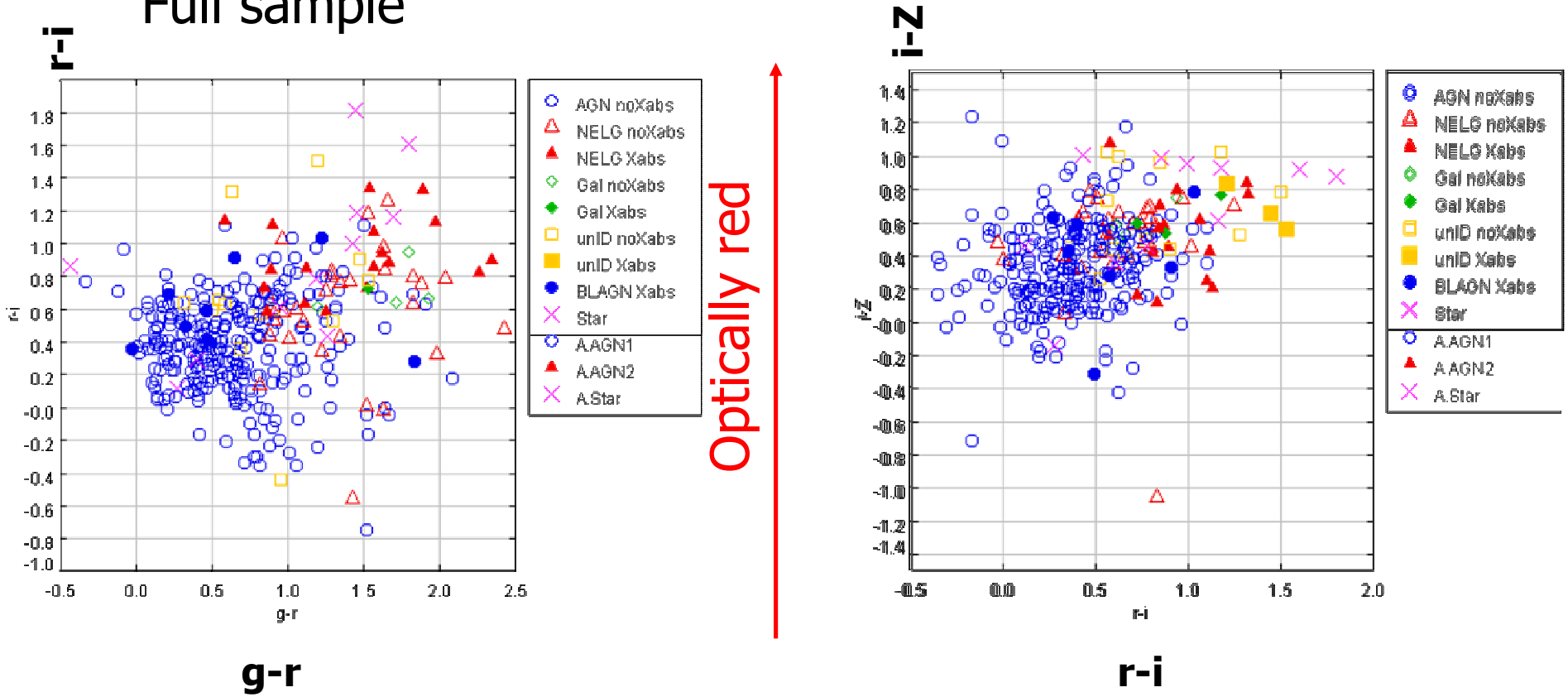
r-i

Optically red

Optical colours

XBS bluer in g than XMS?

Full sample



Conclusions

- Unobscured accretion dominates, but increasingly important contribution from obscured objects.
- X-ray absorption and optical obscuration not equivalent:
  - 4% of type 1 AGN are X-ray absorbed
  - 79% of type 2 AGN are not X-ray absorbed
  - 10% of X-ray selected type 1 AGN have red colours
- "Clustering" of AGN1/2 in X/opt col space
- Even at medium fluxes, an important fraction of the X-ray sources have optically faint and red optical counterparts:
  - Need 10m class observing time
- Most unIDed objects faint (r/i>21.5), ext. (and Xabs): NELGs?
- On-going work:
  - Comparing to XBS to increase sample/see difference from lower flux?