XMM-LSS
INTERNAL
REPORT n°11-Mi

March 26, 2013

Comparing XXL and 2XLSSd catalogues

A preliminary report

L.Chiappetti[1]

INAF, IASF Milano, via Bassini 15, I-20133 Milano, Italy

Abstract. I report very quickly on a preliminary comparison between the published 2XLSSd catalogue (Chiappetti et al., 2013) and the XAMIN 3.3 reprocessing of the XMM-LSS fields included in the recent bulk release of the XXL database (northern area).

Key words: LSS; XXL

1. Introduction

I have recently (20 Mar 2013) released in the XXL ("pink") database a bulky, substantial, set of X-ray pointings, which include the reprocessing with XAMIN 3.3 of the XMM-LSS fields (and the SXDS fields), which were recently published as the 2XLSSd catalogue (Chiappetti et al., 2013), using the earlier XAMIN 3.2.

In order to allow people of the XXL collaboration to exploit both dataset, I prepared this report. Its *preliminary* nature will be clearer if you read on. I am also soliciting from interested people ideas about what they want to do with the data, so that I can set up adequate provisions within the XXL database.

Since there is not yet a standard LaTeX template for XXL, and this report concerns (also) XMM-LSS data, I am writing this as a formal XMM-LSS report. However I intend to make it public not only in the XMM-LSS Milan report repository, but also on the XXL wiki.

I will first of all provide some quick background information mainly for the benefit of XXL members which are not familiar with XMM-LSS "historical" features.

1.1. Preliminary information

I will recall here some basic terminology, and some general background information.

- 2XLSSd is what I term a *catalogue* i.e. it is technically an SQL VIEW which provides access to a selected subset of columns (or functions thereof) for a selected subset of X-ray sources (the main points are that duplicate sources in overlapping adjacent fields *have been removed*, and that sources which are *spurious*, i.e. have detection likelihood $ML < 15$ in both energy bands, have also been removed).
- A VIEW relies on an underlying *physical table* which contains all the X-ray detections, spurious and not spurious, before overlap removal. The physical table underlying 2XLSSd is called jan11.
- The overlap removal procedure relies on the knowledge of which fields are flagged bad (see Table 1 of Chiappetti et al. 2013). In each pair of duplicated sources, if one is flagged good and the other one is flagged bad, the one flagged good is unconditionally preferred. If they are flagged equally, the one with the smallest off-axis angle is preferred.
- XXL table north33, which contains all X-ray sources processed with XAMIN 3.3 (from all fields, be they XXL proper or older XMM-LSS ones or whatever), is a *physical table*.
- The flagging of *bad fields* for XXL **is not yet complete**, therefore *overlap removal* **can not yet be performed**. Note also that it might give different results than before (for 2XLSSd) for various reasons, including that there are now XXL fields overlapping with XMM-LSS ones mainly on the E and W of the latter (see Fig.1).
- Therefore we have not yet a "catalogue" for XXL, but just a physical table.
- 2XLSSd (jan11) and XXL have been processed starting from the same X-ray data (full exposures, unlike 2XLSS 10 ks), but using different versions (resp. 3.2 and 3.3) of the XAMIN pipeline. This may result in *different source detections* and, even for the "same" source in *different positions* and different parameters.
- Additionally the astrometric corrections are generally different, although usually consistent (2XLSSd uses CFHTLS T004, XXL uses CFHTLS T007), which may result in *further differences of the corrected positions*.
- Although the X-ray fields are the same, they are *named differently*, which is described in the next section.

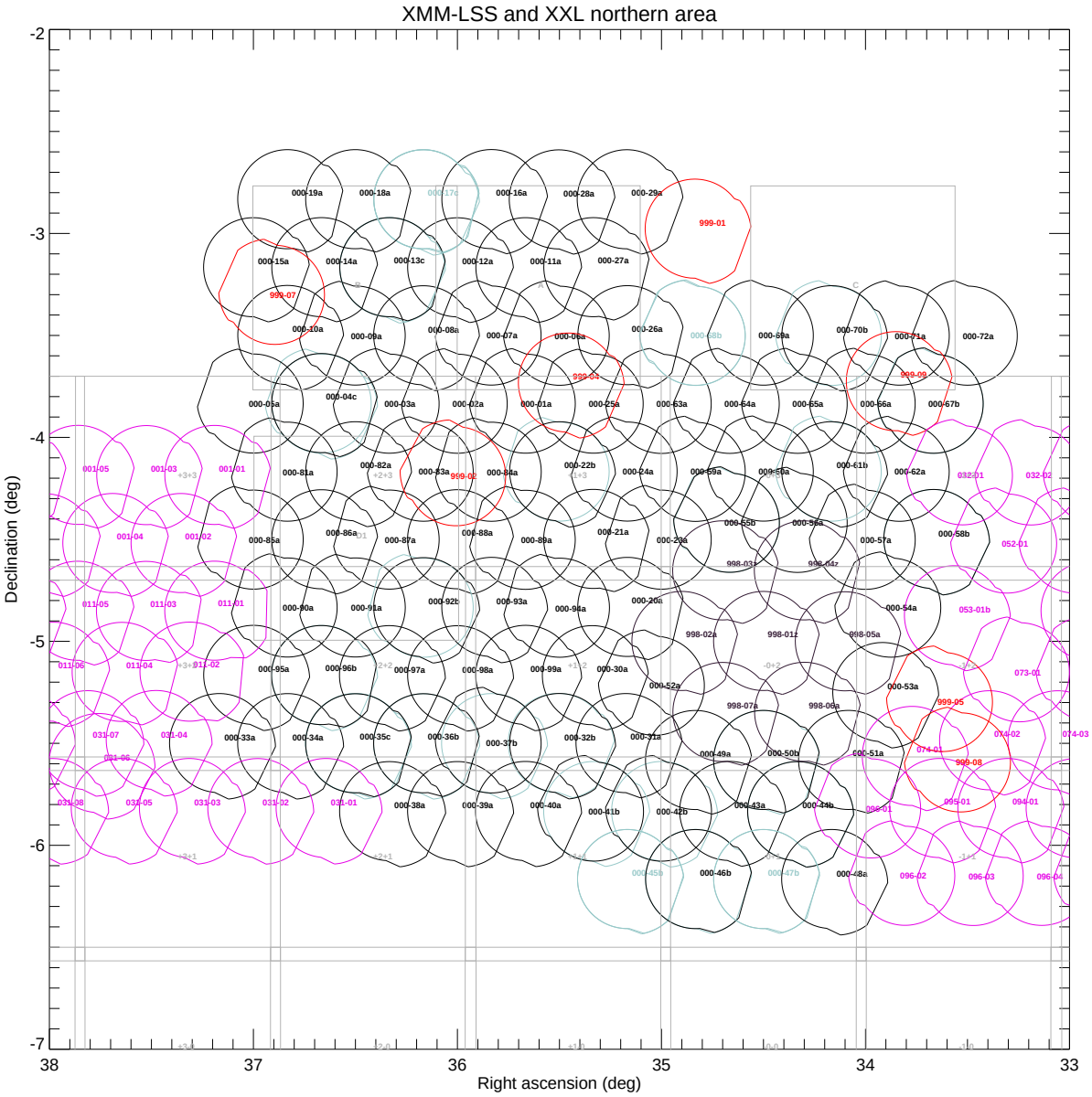

Fig. 1. XMM-LSS pointings labelled with their new names are shown in black when good or in blue-gray when bad (unlabelled unless they are the last repeat), SXDS pointings are in pink-gray. XXL proper fields (in magenta) and archival fields (in red) will impact on future overlap removal procedure. Light gray rectangle indicate the CFHTLS and ABC optical fields. This figure can be directly compared with Fig. 1 of Chiappetti et al. (2013).

1.2. Field position and naming

The XMM-LSS X-ray pointings (fields) can be logically grouped in three families, with their short 2XLSSd name: (a) the Guaranteed Time Observation G fields, G01 to G19; (b) the Guest Observer fields, or B fields, B01 to B72; (c) the SXDS "Subaru" fields, S01 to S07. Some of the fields were observed more than once, and are identified by an additional letter code (e.g. B04a, B04b and B04c). Usually the last pointing of a repeat series is good, while all the other are invariably flagged bad. The fields, with the names used in 2XLSSd, are reported *in chronological order* in Table 1 of Chiappetti et al. (2013), and here in Table 1 *with the new XXL names*.

Table 1. The list of XMM-LSS and SXDS pointings in name order (for chronological order refer to Table 1 in Chiappetti et al. 2013). Field XXLn000-35b was not used in 2XLSSd. Field S01_40 was preferred to S01 in 2XLSSd. Column (1) in each group is the new XXL field name; column (2) is the internal database field number; columns (3) and (4) are the older field name and number used in the 2XLSSd database tables; column (5) flags the bad fields.

(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
XXLn000-01a	1100001	B01	1		XXLn000-35a	1100035	B35a	35	bad	XXLn000-63a	1100063	B63	63	
XXLn000-02a	1100002	B02	2		XXLn000-35b	1200035	–	–	–	XXLn000-64a	1100064	B64	64	
XXLn000-03a	1100003	B03	3		XXLn000-35c	1300035	B35b	735		XXLn000-65a	1100065	B65	65	
XXLn000-04a	1100004	B04a	4	bad	XXLn000-36a	1100036	B36a	36	bad	XXLn000-66a	1100066	B66	66	
XXLn000-04b	1200004	B04b	504	bad	XXLn000-36b	1200036	B36b	736		XXLn000-67a	1100067	B67a	67	bad
XXLn000-04c	1300004	B04c	704		XXLn000-37a	1100037	B37a	37	bad	XXLn000-67b	1200067	B67b	767	
XXLn000-05a	1100005	B05	5		XXLn000-37b	1200037	B37b	737		XXLn000-68a	1100068	B68a	68	bad
XXLn000-06a	1100006	B06	6		XXLn000-38a	1100038	B38	38		XXLn000-68b	1200068	B68b	768	bad
XXLn000-07a	1100007	B07	7		XXLn000-39a	1100039	B39	39		XXLn000-69a	1100069	B69	69	
XXLn000-08a	1100008	B08	8		XXLn000-40a	1100040	B40	40		XXLn000-70a	1100070	B70a	70	bad
XXLn000-09a	1100009	B09	9		XXLn000-41a	1100041	B41a	41	bad	XXLn000-70b	1200070	B70b	770	
XXLn000-10a	1100010	B10	10		XXLn000-41b	1200041	B41b	741		XXLn000-71a	1100071	B71	71	
XXLn000-11a	1100011	B11	11		XXLn000-42a	1100042	B42a	42	bad	XXLn000-72a	1100072	B72	72	
XXLn000-12a	1100012	B12	12		XXLn000-42b	1200042	B42b	742		XXLn000-81a	1100081	G01	1001	
XXLn000-13a	1100013	B13a	13	bad	XXLn000-43a	1100043	B43	43		XXLn000-82a	1100082	G02	1002	
XXLn000-13b	1200013	B13b	513	bad	XXLn000-44a	1100044	B44a	44	bad	XXLn000-83a	1100083	G03	1003	
XXLn000-13c	1300013	B13c	713		XXLn000-44b	1200044	B44b	744		XXLn000-84a	1100084	G04	1004	
XXLn000-14a	1100014	B14	14		XXLn000-45a	1100045	B45a	45	bad	XXLn000-85a	1100085	G05	1005	
XXLn000-15a	1100015	B15	15		XXLn000-45b	1200045	B45b	745	bad	XXLn000-86a	1100086	G06	1006	
XXLn000-16a	1100016	B16	16		XXLn000-46a	1100046	B46a	46	bad	XXLn000-87a	1100087	G07	1007	
XXLn000-17a	1100017	B17a	17	bad	XXLn000-46b	1200046	B46b	746		XXLn000-88a	1100088	G08	1008	
XXLn000-17b	1200017	B17b	517	bad	XXLn000-47a	1100047	B47a	47	bad	XXLn000-89a	1100089	G09	1009	
XXLn000-17c	1300017	B17c	717	bad	XXLn000-47b	1200047	B47b	747	bad	XXLn000-90a	1100090	G10	1010	
XXLn000-18a	1100018	B18	18		XXLn000-48a	1100048	B48	48		XXLn000-91a	1100091	G11	1011	
XXLn000-19a	1100019	B19	19		XXLn000-49a	1100049	B49	49		XXLn000-92a	1100092	G12a	1012	bad
XXLn000-20a	1100020	B20	20		XXLn000-50a	1100050	B50a	50	bad	XXLn000-92b	1200092	G12b	1112	
XXLn000-21a	1100021	B21	21		XXLn000-50b	1200050	B50b	750		XXLn000-93a	1100093	G13	1013	
XXLn000-22a	1100022	B22a	22	bad	XXLn000-51a	1100051	B51	51		XXLn000-94a	1100094	G14	1014	
XXLn000-22b	1200022	B22b	522		XXLn000-52a	1100052	B52	52		XXLn000-95a	1100095	G15	1015	
XXLn000-23a	1100023	B23	23		XXLn000-53a	1100053	B53	53		XXLn000-96a	1100096	G16a	1116	bad
XXLn000-24a	1100024	B24	24		XXLn000-54a	1100054	B54	54		XXLn000-96b	1200096	G16b	1216	
XXLn000-25a	1100025	B25	25		XXLn000-55a	1100055	B55a	55	bad	XXLn000-97a	1100097	G17	1017	
XXLn000-26a	1100026	B26	26		XXLn000-55b	1200055	B55b	755		XXLn000-98a	1100098	G18	1018	
XXLn000-27a	1100027	B27	27		XXLn000-56a	1100056	B56	56		XXLn000-99a	1100099	G19	1019	
XXLn000-28a	1100028	B28	28		XXLn000-57a	1100057	B57	57		XXLn998-01z	1099801	S01	2001	†
XXLn000-29a	1100029	B29	29		XXLn000-58a	1100058	B58a	58	bad	–	–	S01_40	2901	–
XXLn000-30a	1100030	B30	30		XXLn000-58b	1200058	B58b	758		XXLn998-02a	1199802	S02	2002	
XXLn000-31a	1100031	B31	31		XXLn000-59a	1100059	B59	59		XXLn998-03z	1099803	S03	2003	
XXLn000-32a	1100032	B32a	32	bad	XXLn000-60a	1100060	B60	60		XXLn998-04z	1099804	S04	2004	
XXLn000-32b	1200032	B32b	532		XXLn000-61a	1100061	B61a	61	bad	XXLn998-05a	1199805	S05	2005	
XXLn000-33a	1100033	B33	33		XXLn000-61b	1200061	B61b	761		XXLn998-06a	1199806	S06	2006	
XXLn000-34a	1100034	B34	34		XXLn000-62a	1100062	B62	62		XXLn998-07a	1199807	S07	2007	

XXL proper uses in fact a different naming, which in the north is XXLn*mmm-ppc*, where *mmm* is the mosaic identified, *pp* is the pointing number inside the mosaic, and *c* is the optional repeat code. XMM-LSS and SXDS fields are grouped in two *pseudo-mosaics*. Pseudo-mosaic 000 groups the B and G fields, pseudo-mosaic 998 contains the SXDS fields. Therefore the B fields are XXLn000-01 to XXLn000-72, the G fields are XXLn000-81 (G01) to XXLn000-99 (G19). the Subaru fields are XXLn998-01 to XXLn998-07.

Repeat codes are the same, with two kinds of exception explained below. Moreover the "a" repeat code is used systematically even for non-repeated pointings.

One concerns the special code "z" which is used only for XXLn998-01z, XXLn998-03z and XXLn998-04z. It indicates that the observation was split in two pointings, which have been combined during the analysis in a single, longer exposure. This is exactly the same which was done (silently with no special code) for 2XLSSd. So those three fields are *the same* as S01, S03 and S04. However note that S01 (the 80 ks full exposure) was artificially flagged bad in 2XLSSd, so that the truncated 40ks version (S01_40 or 2901) was preferred to it.

The other exception concerns field B35. This has been observed *three* times (XXLn000-35a, XXLn000-35b and XXLn000-35c), but the middle pointing (35b) was not used in 2XLSSd! Therefore 2XLSSd B35b corresponds to XXLn000-35c.

Fields S01_40 and XXLn000-35b are *not used* in the present comparison.

Besides the field names (column FieldName), the database contains also a field number (column field). Its use is discouraged, however a mapping between old and new field numbers has been implemented and is reported in Table 1 here. We do not provide however any documentation in the present report, although it is available on the XXL wiki.

The position of the fields on the sky is reported in Fig. 1. It does not cover the entire XXL northern sky area (for which a figure is available on the XXL wiki), but

only the immediate surrounding of the XMM-LSS area. It marks in different colours the XXL-proper and archival (pseudo-mosaic 999) fields, which will *impact on the overlap removal procedure*, but however are ignored for what concerns the present report.

2. Comparison

The comparison presented in this report is mainly between the *physical tables* north33 and jan11, and limited to detections *in the same field*, where "same" means according to the mapping in the above Table 1, and excluding both the old 201_40 and the new 35b fields.

At a first glance the number of detections per field is usually grossly comparable, but it seems that XAMIN 3.3 (XXL) usually (but not always) finds *less* sources in *bad* fields than version 3.2 (2XLSSd). The reason for this is not clear to me although I suspect different proton flare or background handling.

If we limit to the common fields, jan11 has a total of 14000 detections, and north33 in such area has 12605. The common sources, associated *either* with a distance in astrometrically corrected coordinates *or* in raw uncorrected coordinates below $6''$, are 9777. They correspond to 9762 distinct jan11 entries, or 9765 distinct XXL entries. Of the 9777, 9690 cases have both the corrected and uncorrected distances below $6''$.

There are 4454 jan11 sources with no XXL counterpart, and 2840 XXL sources with no jan11 counterpart.

5904 entries (corresponding to 5897 distinct jan11 sources) are present in the 2XLSSd catalogue (i.e. survive its overlap removal procedure), out of a total of 6721. Remember that 2XLSSd contains 216 sources in field S01_40 which are not considered here (while we compare S01 sources which are mostly not in 2XLSSd).

Of the 694 (10% of 2XLSSd objects) unconfirmed in XXL, most of them are single-band detections (only 53 are detected in both bands). 430 of them are very poor (the best $ML < 20$!), 633 are below 3σ ($ML < 40$) and 663 are below 4σ ($ML < 75$).

We can now first considered among the possible classifications (for all the sources in jan11 and north33, ignoring whether they are in 2XLSSdor not) the *spuriosity* (i.e. the fact $ML < 15$). We have that

- 73.8% of the jan11 with XXL counterpart are non-spurious
- only 22.3% of the jan11 *without* XXL counterpart are non-spurious, namely
- 13.5% are very poor, $ML < 20$
- 19.7% are below 3σ, $ML < 40$
- 21.3% are below 4σ, $ML < 75$

Conversely

- 78.1% of the XXL with jan11 counterpart are non-spurious
- only 26.6% of the XXL textitwithout jan11 counterpart are non-spurious, namely
- 15.6% are very poor, $ML < 20$
- 23.9% are below 3σ, $ML < 40$
- 25.1% are below 4σ, $ML < 75$

In both cases more than 80% of the non-spurious without counterpart are single-band (soft or hard) pointlike detections, while the equivalent percentage for the non-spurious with counterpart is around or less 60%.

Considering the common objects, 9699 have the same *extended/ non-extended flagging*. The remaining 87 (less than 1% of the total) divide in equal proportion as jan11 extended becoming pointlike, or pointlike becoming extended.

If we go to the *detailed "PE" classification*, we see that 9040 have the same identical classification (i.e. pointlike, extended or undetected in both energy bands). 659 have the same overall extended/ non-extended flag but nominally different classifications. Most of them are however compatible (same in one band and different or undetected in the other, the most diffuse case being 206 soft P- becoming PP and 300 PP becoming P-). Only 7 cases are extended and all compatible. Only 24 cases are incompatible (10 -P become P-, 13 P- become -P and one PE becomes -P).

From the figures above, one might have noticed some possible *association ambiguities*. There are 15 cases of jan11 sources with two possible XXL counterparts and 12 XXL with two jan11. They are independent of each other and looks real ambiguities with rather close ifnot identical distances. Anyhow note that the number of ambiguities is really limited (less than 0.2% of the total !).

2.1. Positions

The histogram of the distances between XXL and jan11 positions is reported in Fig. 2. Curiously enough the distance between uncorrected coordinates (i.e. the pure result of the different XAMIN version) peaks at 0.25; not at zero (compare panel c of Fig. 5 of Chiappetti et al. (2013), which reports the difference betweem 2XLSSd and 2XLSS, i.e. the analysis of full and 10 ks exposure of the same data with XAMIN 3.2).

The distance in corrected coordinates peaks a bit outwards, which probably adds to the above effect the possible differences in the astrometric correction coefficients in some fields.

2.2. Likelihood and flux

In the final figures we compare two key parameters like the *detection likelihood* (Fig. 3-4) and the *flux* (Fig. 5-6) in the two energy bands.

The figures are rather complex. In each band we consider the common sources which are detected in the band

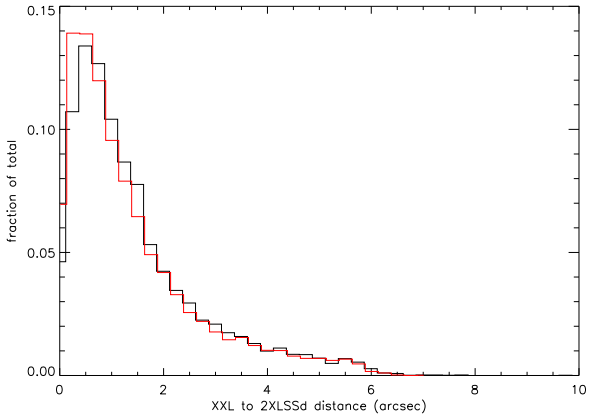

Fig. 2. Histogram (as a fraction of the total number of objects) of the distance between XXL and 2XLSSd positions in astrometrically corrected coordinates (black) or in raw coordinates (red).

in both catalogues (XXL and jan11), the common sources which are not detected in the band in one of the two catalogues (to which the blue histogram refers), the common sources not detected in the band in both catalogues (just counted and annotated on the top as "undef"), and the sources present in only one of the two catalogues (shown along both axes as histograms).

I.e. for common sources detected in the band we plot the parameter (likelihood or flux) in one catalogue vs the other, while when only one value is available we report an histogram along the corresponding axis.

From the first two figures (Fig. 3-4) we can see that the majority of the sources present in one catalogue only (specially the gray histograms for pointlike sources) are either with rather poor likelihood, or even spurious, so it is not surprising they are missed by the other catalogue.

For the rest the likelihood of the best sources (the black ones, i.e. pointlike, detected in both catalogues as such, belonging to good fields, and included in the 2XLSSd published catalogue) has values matching within a very reasonable scatter. The scatter is larger for the gray cases, which are like the black but not part of 2XLSSd. Sources detected in bad fields are more scattered but not excessively. The largest deviations occur for the few sources which have changed classification from extended to pointlike or viceversa.

Coming to the fluxes (Fig. 5-6) the majority of the sources present in one catalogue only (gray histogram) have a flux distribution not unlike those detected in both, but nevertheless are mainly spurious in the band (the cyan histogram covers most of the gray one, and the totality at lower fluxes).

For sources detected in both catalogues fluxes match within a reasonable scatter.

3. Conclusion

There is a reasonable agreement between the XAMIN 3.2 (jan11 and 2XLSSd) and 3.3 (XXL) results in the XMM-LSS area. However it is not yet the time to provide final correlation tables associating XXL sources with the previously published catalogue (although provisional ones could be produced on request), because of the inhomogeneous nature (2XLSSd is a spurious-free, overlap-free catalogue, while handling of adjacent fields has not yet been performed for XXL, and might give results different from 2XLSSd specially at the edges of the XMM-LSS area).

Acknowledgements. I acknowledge the work done by F.Pacaud who processed all XXL data with XAMIN 3.3 and supplied the input data for the XXL database

References

Chiappetti, L., Clerc, N., Pacaud, F., et al. 2013, MNRAS, 429, 1652

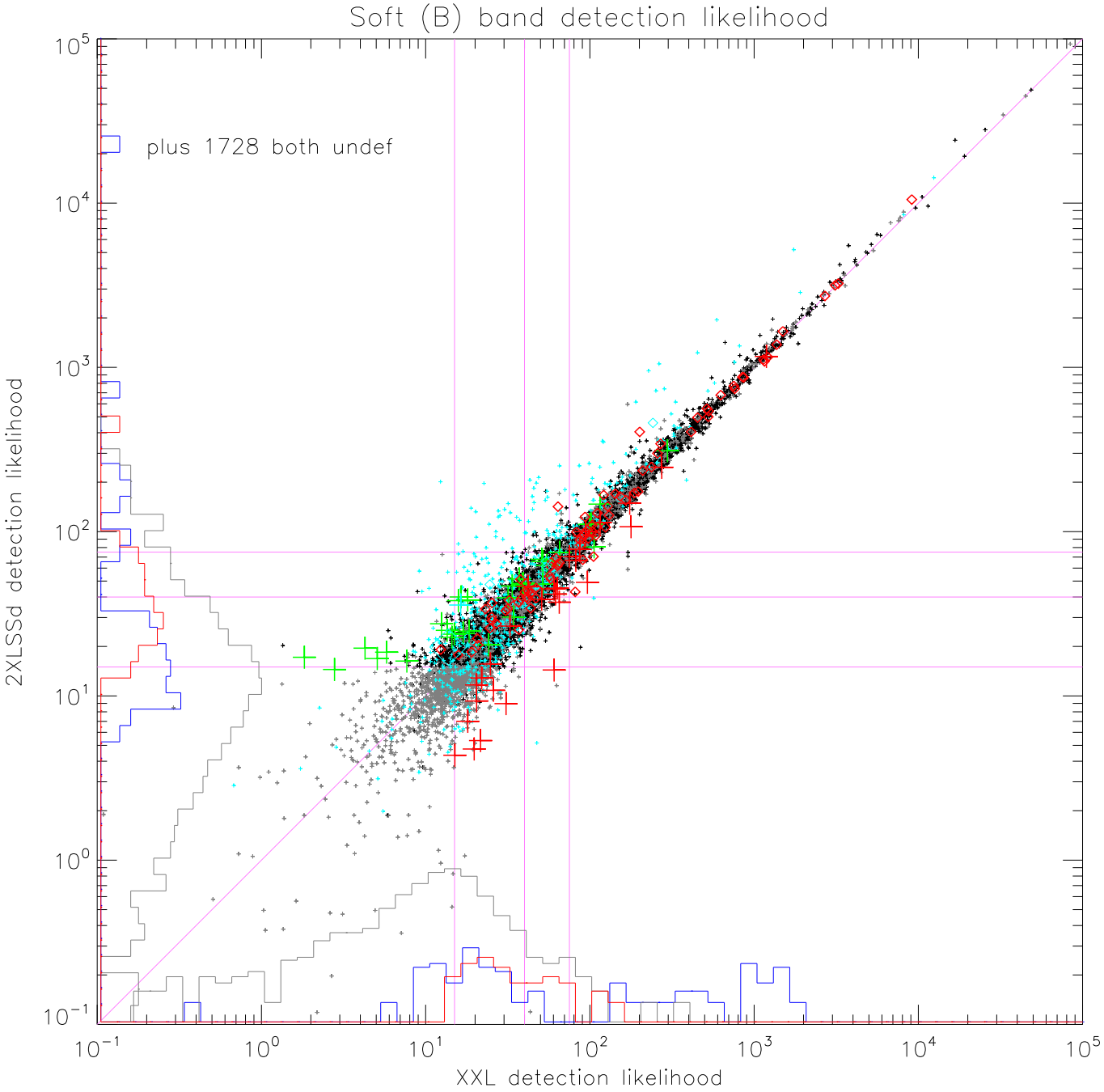

Fig. 3. Comparison of the *detection likelihood in the soft band* between the XXL and 2XLSSd data. The pink fiducial lines mark the likelihood levels of 15 (below which a source is classified *spurious*, 40 and 75 (corresponding to 3σ and 4σ according to Appendix C of Chiappetti et al. (2013) and (diagonal line) the locus of equal likelihood. Symbol and colour coding is explained in the caption of Fig.4.

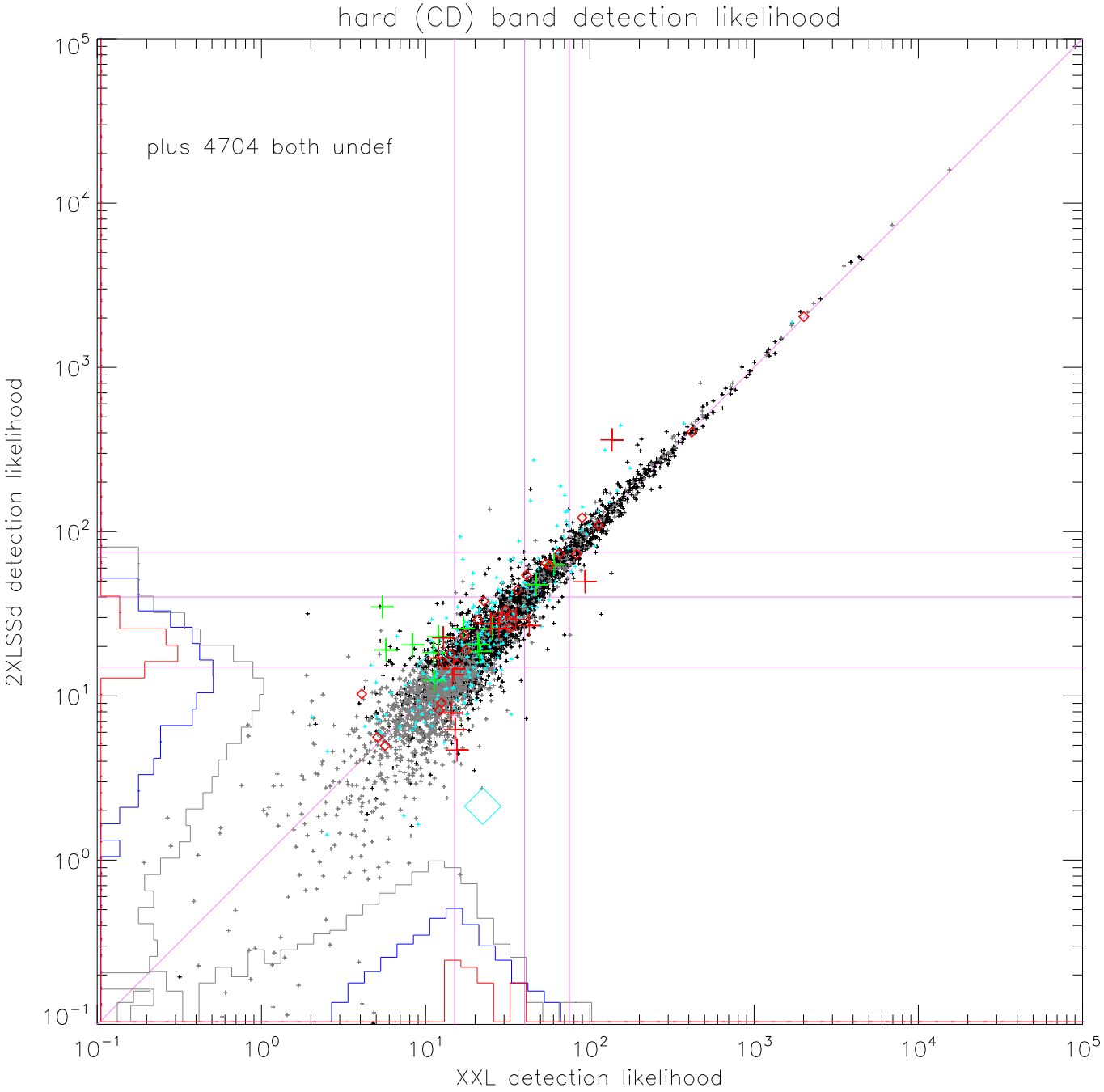

Fig. 4. Comparison of the *detection likelihood in the hard band* between the XXL and 2XLSSd data. Fiducial marks as in Fig.3. Symbol and colour coding is as follows: black crosses are sources classified pointlike both in jan11 and XXL, detected in good fields, and included in 2XLSSd; gray crosses are the same, but *not included* in 2XLSSd; little cyan crosses are the same, but detected in bad fields (no distinction between 2XLSSd or not); big thick green crosses are objects extended in jan11 and pointlike in XXL, detected in good fields; big thick cyan crosses are the same but in bad fields; red diamonds are sources classified extended both in jan11 and XXL, detected in good fields; little cyan diamonds are the same but detected in bad fields; big thick red crosses are objects pointlike in jan and extended in XXLdetected in good fields; big cyan diamonds are the same but in bad fields. The histograms (arbitrary y log axis in number of occurrences) indicate: blue, sources present in both jan11 and XXL but having undefined likelihood in the soft band in one catalogue; gray, pointlike sources detected only in one catalogue; red, extended sources detected only in one catalogue.

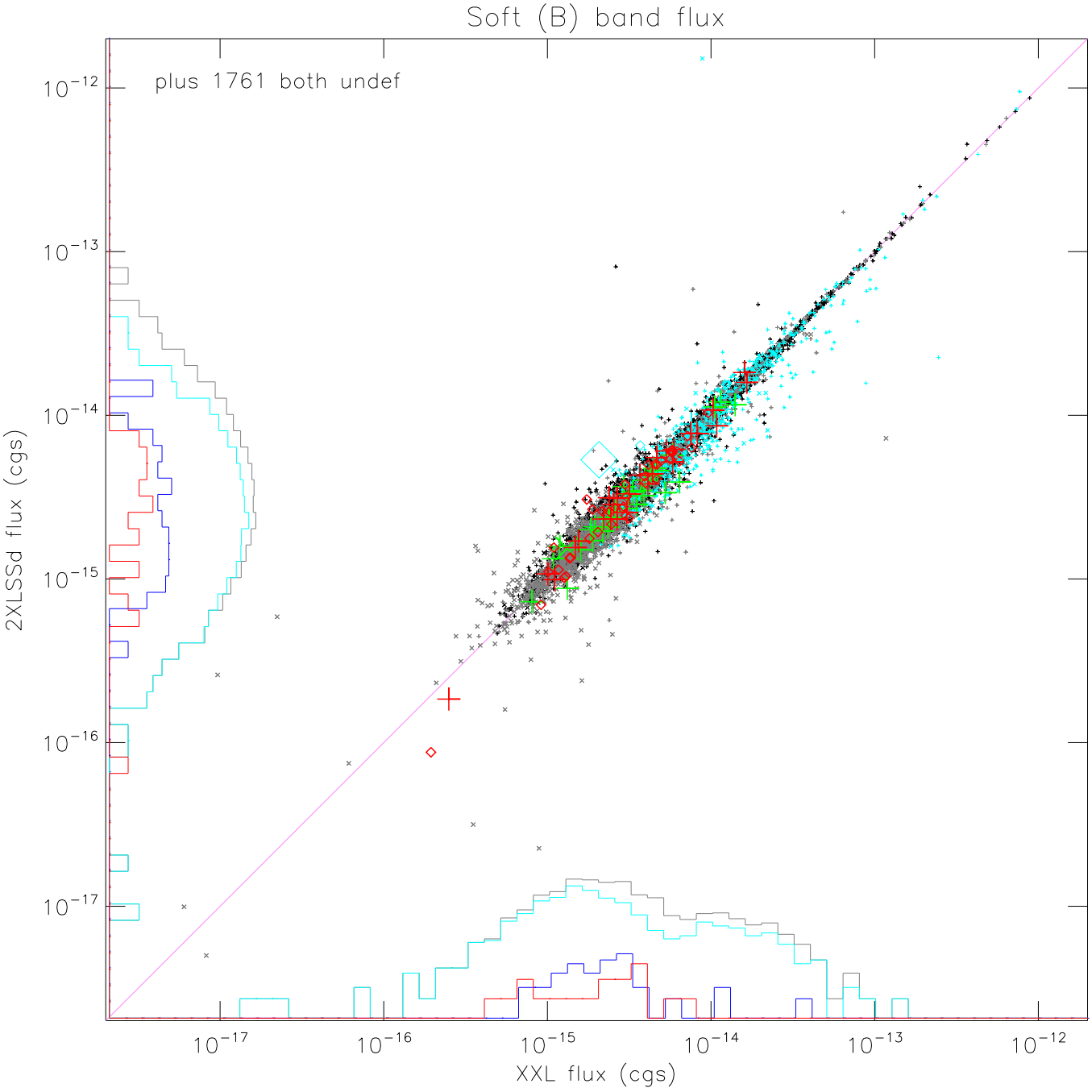

Fig. 5. Comparison of the *fluxes in the soft band* between the XXL and 2XLSSd data. The pink fiducial diagonal line is the locus of equal fluxes. Symbol and colour coding is similar to the one of Fig.3 and 4, with the following additions: gray, black, cyan and green crosses correspond to common pointlike (or *now* pointlike) which are non-spurious in the band in one of jan11 and XXL; they are replaced by gray, black, cyan or green X's when they source is spurious in both catalogues. In the histograms a cyan histogram indicates the subset of the pointlike sources (gray histogram) which are spurious in the band.

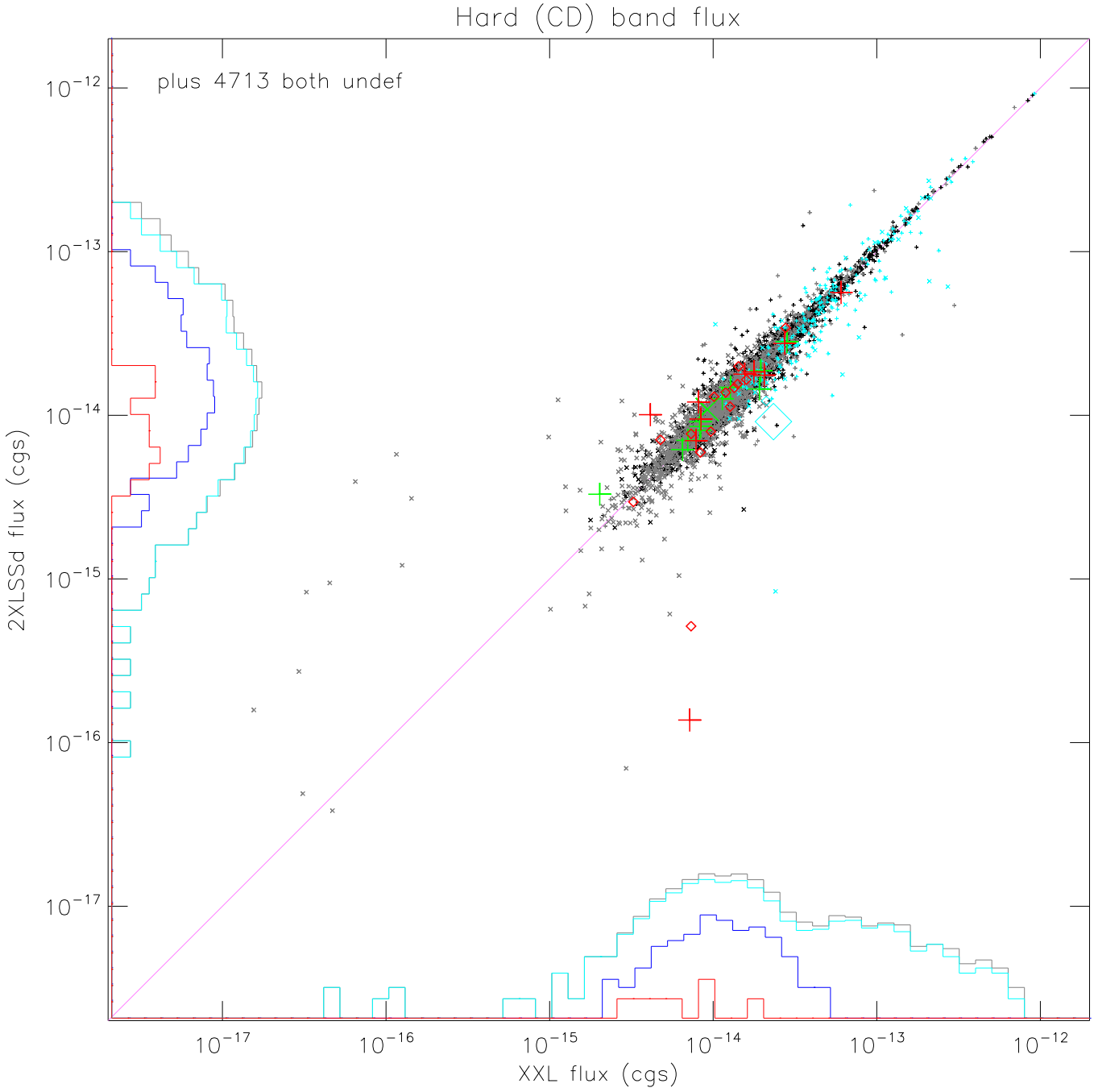

Fig. 6. Comparison of the *fluxes in the hard band* between the XXL and 2XLSSd data. Fiducial marks, symbol and colour coding identical to Fig. 5.