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The almost final XXL X-ray processing

Xamin 4.2 aka XaminF18

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Abstract. We present the 4.2 Xamin release, give basic information about the pipeline, the ingestion procedure in the Milan DB, the database tables and a comparison with the previous (3.3) release. The new release is essentially sound, with improvements in data statistics due to the better exploitation of overlapping exposures. It is however recommended to make a manual inspection of the few discrepancies (specially for extended sources).

Key words: XXL; database tables

1. Introduction

This document describes the actions done in the Milan DB for the ingestion (and subsequent actions) of the results of the final XXL pipeline (known as Xamin 4.2 or `XaminF18`).

An earlier draft of this document was issued with extremely limited circulation in late August 2018, regarding the attempted ingestion of Xamin 4.0 data, and is **completely superseded** by the present version.

For details on the inner working of the pipeline refer to Faccioli et al. 2018, hereafter Paper XXIV.

This report is arranged as follows: the next subsection of this introduction (1.1) gives an historical excursus; section 2 provides summary information about Xamin and the data used (in 3.3 and 4.2); section 3 describes the steps of the procedure; section 4 describes the 4.2 database tables; and section 5 provides a comparison between 3.3 and 4.2 results.

Note that *the PDF version of this report provides clickable links* to web pages like wiki pages and articles.

1.1. Historical excursus

I recall here the events between August 2018 and June 2019, with particular regard for what concerns database tables.

- The first dataset using the *original* `XaminF18` pipeline (Xamin 4.0) was received by Lorenzo Faccioli in Aug-Sep 2018 and included a full processing of all N and S tiles. It resulted in the ingestion of a `north40` set of tables, but the discovery of a *deficit of hard sources* instigated a revision of the pipeline, therefore any further ingestion of the S data as well as therelease to the Consortium *were suspended*. The original draft of this document (limited circulation) was related to it.
- A further *test* dataset was received by Christian Garrel (as all following versions) and processed in Jan-Feb 2019. This dataset included only 3 northern tiles, processed with an interim pipeline version (Xamin 4.1) and in the database is known as `north41` (*not intended for release*). The hard source deficit was cured, but background handling was still being investigated. A comparison report vs Xamin 3.3.2 was put on the wiki.
- A further dataset was received in May 2019 and included the processing *in the soft band only* of all N and S *pointings* with the final `XaminF18` pipeline. In the database it is known as `north42ptgb` and `south42ptgb`, which were *not intended for release*, and were used for the computation of astrometric corrections (see 3.4).
- A smaller dataset of 5 pointings and their combinations was produced at end May 2019 for verification of the astrometric correction (known as `north42specialb` and `south42specialb`, not for release).
- The full dataset of all N and S tiles processed with latest `XaminF18` was provided at end June 2019 in time for the Ovronnaz meeting (but for two N tiles supplied after the meeting) and has been ingested and released as `north42` and `south42` and *constitutes the main topic of the present report*.

2. Preliminary information

The *main* differences of the `XaminF18` w.r.t. the Xamin 3.3.2 used for the publication of the `3XLSS` catalogue (Chiappetti et al. 2018, hereafter Paper XXVII) are:

– *More pointings* (Brandt area, latest AOs, more archival data) were used as input to the tiles (see 2.1).
– X-ray observation data are *no longer* processed by individual *pointings* but by *1-square-degree tiles* (actually $68' \times 68'$ allowing some overlap at the edges).
– As a corollary the handling of the overlap is now different.
– As a further corollary there can be more than 999 per XAMIN FITS catalogue files (identifiers require four digits not three).
– In addition to the two standard "pointlike" and "extended" fits, two more fits are done for each detection, a "*double*" (DBL) fit considering two point sources, and an "*extended+pointlike*" (EPN or AC) fit considering an extended source with a central AGN.
– Also, while XAMIN 3.x worked inside 13′ in each pointing (which allowed to consider only the MOS+pn fits in ingestion), with 4.x is *now possible to have MOS-only or pn-only detections* (although few).
– Astrometric correction (see 3.4) is no longer a post-processing (Milan) task but is anticipated in the earlier stages of the pipeline (Saclay task).

2.1. Pointings and tiles

As said repeatedly in many places, in XAMIN 4.x XMM pointings are combined in 1-deg tiles (actually $68' \times 68'$). The layout of the 37 XXL-N and 31 XXL-S tiles is reported in the St Jacut presentation on the wiki. Here we summarize only the geometric arrangement for XXL-N:

	01	02	03	04	05			
06	07	08	09	10	11	12	13	14
15	16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31	32
						33	34	35
							36	37

And for XXL-S:

	01	02	03	04	05
06	07	08	09	10	11
12	13	14	15	16	17
18	19	20	21	22	23
24	25	26	27	28	29
30	31				

Information on the pointings as used up to DR2, whose list is published as Appendix B in Paper XXVII, were (and remain) available in the Milan DB in table `xxlpointings`.

The new list of pointings used as input to XAMIN 4.x are contained in the equivalent table `xxl4pointings`*, which will be released with the rest, and accessible also correlated with the merged X-ray tables.*

The new list contains 363 XXL-N and 272 XXL-S pointings. They cannot be immediately compared with those in the old list (294 and 328) because of the following reasons. Our own internal naming convention (the tables supply also the correspondence with ESA convention's obsId) uses names of the form XXL*xmmm*-*ppc* (e.g. XXLn000-01a) where: the single letter *x* is either "n" or "s" for XXL-N and XXL-S: the three-digit code *mmm* is the pseudo-mosaic identifiers, i.e. either is the same for all pointings using the newer mosaic-pointing mode (i.e. XXLn115-10b) or for all older pointings of a former program (like XXLn000-01a); the individual pointing identifier *pp* designates a specific pointing direction request within a given mosaic or program; the repeat code *c* indicates different observations of the same pointing direction, because the previous ones had an insufficient exposure for various reasons (this is a letter a,b,c,... in chronological order of the repeat). Note that on a first instance the convention was not used systematically in DR2: some "first repeats" and most "single repeats" (directions pointed only once) had a blank repeat code. *Now* all those cases have systematically a repeat code of "a" (so old XXLn001-01 is now XXLn001-01a, etc.) : the same pointing has a different name. On a second instance the old list included 81 pseudo-pointings with a repeat code of "z" (e.g. XXLs998-18z) which weren't actual pointings but the combination of 2 or more repeats which were very similar in pointing diretion and roll and could be combined in a way prototypal of the current tiling coaddition. These pseudo-pointings are obsoleted by the new tiling procedure and therefore do not exist any more. So the true number of DR2 *real* pointings was 278 XXL-N and 263 XXL-S.

These clearly shows that the new list contains a number of *newer pointings*. They can be due to newer observations of our own in AO13 after the DR2 observations; to newer archival (i.e. not our own) observations (like XXLn999-10a, 11a, and 12a: the code *mmm*=999 groups all archival observations); or to newer programs (the Brandt observations with codes *mmm*=995, 996 and 997). In addition few bad pointings might have been considered not eligible for the tiles and are now not listed. The quoted pointing tables contain the nominal pointing and roll coordinates (FITS columns suffixed `PNT`).

There is also a working table (not released) called `xxl4centres` *which contains the coordinates of the pointing centres from the FITS keywords* `RACEN` *and* `DECCEN`*. It was used during the ingestion of the XAMIN 4.2 individual pointing data to compute the off-axis angle (these data were used for the computation of the astrometric corrections).*

Moreover the *FITS pointing files* (new with XAMIN 4.2) are supplied *one per tile* and have several records for each *id* in the tile. Usually these go in groups of 5. Each group contains 5 "fits" (the PNT, EXT, EPN and DBL fit plus the background BCK), or exceptionally less. There is one group per camera combination (MOSPN, MOS, PN) so normally there will be 15 entries (unless some combination was not processed by XAMIN), and there is one such set of 15 or less for each pointing contributing to the tiles.

I have ingested those files in four *not released* tables, called `northb`*n*`pointings` and `southb`*n*`pointings`,where band n=2 or 3 for soft and hard bands. The tables contain the `id`, the camera combination and fit and the pointing *plus the tile number* (since otherwise the id won't be unique).

The tables are sort of bulky and complex to be used in conjunction with the X-ray data tables (one has to correlate on (tile,id) as well as on the same camera combination and preferred fit used by a given detection in its preferred classification). So I chose to do such operation on the fly myself and add to the X-ray merged tables `north42` and `south42` two columns called `nptgb` and `nptgcd` which contain the number of pointings used for the specific source in the soft and hard band.

Usually the two numbers are equal (unless one is zero because no detection occurred in one band). However there are a few cases (398 in XXL-N and 169 in XXL-S) in which the two bands used a different number of pointings (the difference is usually 1 or never more than 2 pointings). The impression is that it is physiological (for instance source 400907 used three repeats of the same pointing, XXLn000-13a/b/c, in the hard band while the soft one used only XXLn000-13c) and not a band merging artifact, as the inter-band distance `maxdist` is usually low. However 59 XXL-N and 24 XXL-S have `maxdist`$> 6''$, which could be suspect.

Currently the columns `nptgb` and `nptgcd` are not advertised in the menus, but their name can be inserted manually in the "advanced queries".

In addition the pointing files were used once to build a correlation table between `xxl4pointing` and the band-merged tables `north42` *or* `south42`*.*

If anybody feels to need to use detailed information on which specific pointings are used by which source, please contact me and we will arrange a way.

3. Processing steps

The input supplied by Saclay is, as before, in form of *FITS catalogues*, one per tile and per band (in addition there are additional *FITS pointing files* which contain the info, for each detection, of the pointings contributing to its position). Information about usage of pointing files in the database is provided in section 2.1.

The format of the catalogues is similar to the old XAMIN 3.3.2 with a substantially higher number of columns (112 instead of 87), since there are families of parameters for the DBL and EPN fit, mimicking the layout for PNT and EXT.

As before a number of columns is actually unused or uninteresting (this includes e.g. all the error columns which are undefined *and vestigial EPN_ML_EXT which I ingested but should be ignored*).

The columns concerning the off-axis angle are no longer present (since the concept of off-axis angle w.r.t. the pointing centre is not applicable to tiles).

3.1. Ingestion

The ingestion script `bandingest42.csh` has been mimicked on the earlier XAMIN 3.3.2 version.

It handles tile names instead of pointing names, it deals with the new columns as specified in section 4.1, and implements the new classification scheme, based on the following recipes (the C1, C2 and P1 recipes are unchanged w.r.t. XAMIN 3.3.2). *So far check that `detlik_ext` is not NaN is not implemented*.

- C1 recipe: `c1c2=1` where `corerad>5 and extlike>33 and detlik_ext>32`
- C2 recipe: `c1c2=2` where `corerad>5 and extlike between 15 and 33`
- P1 recipe: `p1=1` where `detlik_pnt>30 and (corerad<3 or extlike=0)`
- class `P` (pointlike) as default unless one of the following is set
- class `E` (extended) initially where C1 or C2
- class `A` (EPN aka AC) reset where `class='E' and epn_corerad >5 and ( (epnlike_ext>20 and epnlike_pnt>20) or epnlike_pnt>100)`
- class `D` (double) reset where `class='E' and dbllike>extlike`
- *this means class A and D are assigned only to sources previously classified as extended*
- non-spurious sources: `spurious=0` are by definition those classified E, A or D plus the P ones with `detlik_pnt>15`

The ingestion scripts now has provisions to handle *detections in single cameras*. This does not require any change to the SQL code, but acts on the temporary ASCII input file generated from the FITS XAMIN catalogue. While before such input file took only the MOS+pn entries, now it is the concatenation of MOS+pn entries for the cases where they do exist, plus MOS-only or pn-only ones where the MOS+pn one does not exist, handled by three separated awk scripts guided by a "preanalysed" detection list.

3.2. Band merging

The band merging script `bandmerge42.csh` has been mimicked on the earlier XAMIN 3.3.2 version.

Besides obvious changes because of table layout (see section 4.2), it generalizes the old logics to the new classification scheme.

The logics is that one merges a soft and a hard source where their *reference positions* are within $10''$. The reference position is the one corresponding to the classification *in the band*.

So if a source is classified `EP` the soft extended position is compared with the hard pointlike position, if it is classified `PA` the soft pointlike position is compared with the hard EPN position, if it is `PP` or `AA` positions from the same classification are used, etc.

Of course sources detected in a single band (`E-`,`-P` etc.) are also brought along.

Once a source is merged, it can be *reclassified*. This is tagged by flag `reclass`. A final value of `reclass=0` means the original classification is preserved, while `reclass=2` means the source was reclassified. Reclassification means that the classification in the soft band prevails.

Reclassification is rather *rare* (45 XXL-N and 34 XXL-S cases).

So a source classified `EP` will be considered as if it were `EE` (extended), one classified `PA` or `PD` as if it were `PP` (pointlike), an `AD`, `AE` or `AP` as if it were `AA` (EPN). This means the merged reference values (detection likelihood per band, coordinates, counts, rates[1]) are taken from each band based on the reclassification.

So for instance an `EP` was considered as such because the extended soft position was within 10″ from the pointlike hard position. But the positions stored in the band-merged tables will be both from the extended fit. So at the end the inter-band distance `maxdist` *might* exceed 10″. This is flagged by flag `suspect=1`.

This is actually very rare (16 cases in XXL-N and 13 in XXL-S).

Note that the extent parameter(s) `coreradb|cd` are taken from the EPN fit for class A, and from the EXT fit otherwise.

Note that the "ultimate" (now "intrinsically" astrometrically corrected) coordinates `ra,decl` are taken from the (reclassified) coordinates in the "best band" `bandid` (=2 or 3 for soft and hard respectively). This is the band with the best (highest) detection likelihood. A corollary of this is that if both soft and hard detection likelihoods are undefined, the source remains with `bandid=0` and has no coordinates assigned. *Note that even if the detection likelihood is undefined, a coordinate in the band (hidden columns `_rab,_decb` or `_racd,_deccd`) may have a value, but so far this is not copied into `ra,decl`.*

All the above is procedurally the same as for XAMIN 3.3.2. The number of `bandid=0` cases is 163 in XXL-N and 44 in XXL-S (slightly more than in 3.3).

The following auxiliary definitions may instead be different in the newer scripts.

[1] Note that summed counts and exposure-averaged rates present in the band-merged tables are historical *(and for this reason are no longer advertised)* and are not the ones used in the public catalogues which are *going to be* computed independently from individual band values

The `extended` flag is *now* set to 1 for sources (re)classified `E` or `A` or `D`.

The `spurious` flag is set to 0 (non-spurious) for cases flagged `extended=1` or for those having the (reclassified) detection likelihood above 15 in at least one band. The definition is identical to what used in previous scripts, but the results may not be what expected with the more complex classification.

The merged `c1c2` is similarly set to 2 or 1 if at least one of the bands is respectively C2 or C1 and the source has `extended=1`.

The *ambiguities in band merging* are dealt with in the same way as in the previous version of the scripts. If two soft sources match the same hard source, or two hard sources match the same soft source, they are initially flagged `suspect=2` (later the flag is transformed in a pointer to the associated source in the post-processing stage). *XXL-N gives 24 couples with a soft-to-same-hard or vv. ambiguity, and XXL-s 21 rather less than for* `north33` *or* `south33`.

3.3. *Post-processing*

Traditional post-processing did occur in this order for XAMIN 3.3:

- The "divorce and repoint partner" procedure for `suspect=2` merging ambiguities is now performed essentially as for 3.3.
- The computation of position errors based on a tabulation of rates and off-axis angle *Since this has not been verified by simulations and the off-axis is not defined for tiles, this step will **NOT** be performed*.
- the computation of fluxes from rates using "standard" CFs. is now performed essentially as for 3.3.
- The computation of errors on fluxes is now performed essentially as for 3.3. These standard tasks are briefly recalled below.
- The astrometric correction *is no longer a post-processing task as it is anticipated in the event file preparation, care of Saclay, before* XAMIN. Some elements are however given in 3.4.
- The tile overlap removal is discussed in 3.5
- A final step provides a pointer to the `3XLSS` sources (see 3.6).

3.3.1. Divorce-and-repoint

The small cases of band merging ambiguities is handled essentially as for 3.3 (the only difference is that now merged id's are now 8-digit strings).

The ambiguity occurs when two merged sources come from the same soft source (their id's will be `ssssaaaa` and `ssssbbbb`), or conversely from the same hard source (their id's will be `xxxxhhhh` and `yyyyhhhh`). In this case if one of the cases has an inter-band distance `maxdist` above 6″ and the other is below 6″, it is assumed that the largest distance case is an independent soft or hard source (and therefore it is *divorced*, it's id is reset to `0000bbbb` or `yyyy0000`, and the `suspect` flag is set to a negative value, the `seq` of the divorced partner changed of sign). If both inter-band distances are above or below 6″, the ambiguity is considered unresolved and the `suspect` flag is positive, the `seq` of the partner. The partner remains anyhow a two-band detection (de facto they are all `PP` pointlike).

In XXL-N of 24 cases (12 couples), 7 are the divorce of a soft source, 4 of a hard source, and one (sources 435155 and 435156, id's 04230376 and 04220376) remains unresolved.

In XXL-S of 21 cases, one has two unresolved couples (517027-28 and 523308-09), 4 hard divorces, and 4 soft divorces (one is a triplet, 523306 is a `PP`, and 523305 and 523307 are soft sources divorced from it).

3.3.2. Fluxes and errors

The flux computation script has been adapted from the previous flux and position error computation one, scrapping out the latter part.

It uses the same conversion factors used in Paper XXVII and earlier, computed *for a* $\Gamma = 1.7$ *powerlaw with* $N_H = 2.6 \times 10^{20} cm^{-2}$. As before, the flux is undefined for C1 sources, and is computed from *pointlike rates in all other cases* irrespective of classification !

The only difference is that for MOS-only or pn-only sources the flux is computed from single camera rates, while in the other case it is, as before, the mean of the MOS and pn fluxes.

The flux error computation script is also essentially the same used for Paper XXVII, propagating the errors on reconstructed number of gross counts, with adequate provisions for the cases of MOS-only or pn-only sources.

More details are documented in a note on the wiki.

3.4. Astrometric correction

The astrometric correction, in form of a per-pointing rigid shift, is now applied before Xamin when merging pointing event files into tile event files.

The astrometric offsets were computed beforehand for each pointing in a way *analogue* to what done in the past using the SAS task `eposcorr` (with no rotation), but with the following differences:

- Xamin catalogues produced using the 4.2 pipeline *on single pointings and in the soft band only* were used (database tables `north42ptgb` and `south42ptgb`).
- The reference X-ray list for each pointing consisted therefore of non-spurious pointlike *soft* sources (all, as baseline, and those with off-axis angle less than 10′ as auxiliary set).
- Since `eposcorr` requires an estimate of the X-ray position errors, they were computed using the offaxis-rate tabulation used in Paper XXVII and earlier.
- The reference optical list (unlike Paper XXVII, which had used the "official" CFHTLS or BCS photometry) uses the latest available photometry extraction by Sotiria Fotopoulou (2015, database tables `SFNcfht`, `SFSbcs` and `SFSdecam`, see Chiappetti 2016, hereafter Report XVIII), i.e. CFHT (including our own ABC fields) in XXL-N and BCS or DECam in XXL-S. For each X-ray source in case of multiple tentative counterparts it takes the one with the best chance probability computed using the density tabulations described in Report XVIII, taking sources brighter than magnitude 25 (bands y or i for CFHTLS, band g for ABC, band i for BCS and DECam).

The results of the computation of the astrometric coefficient has been supplied to Christian Garrel as ASCII files, and is also available for documentation as web pages for XXL-N (all data), XXL-N (10′ offaxis only), XXL-S (all data), XXL-S (10′ offaxis only).

Note that for some (poor) pointings `eposcorr` may not run at all if there are no X-ray sources meeting the criteria in the pointing or no optical reference objects are found (these are missing altogether from the web pages, "non-made"). Also the result of `eposcorr` might be less reliable in the case the number of X-ray sources (and therefore optical references) in the pointing is small, which usually results in computing offsets but not assigning an error to them ("zero-error").

My advice was (similarly to what done in the past) to do no correction at all for such pointings. Also restricting the X-ray reference lists below 10′ increases the number of such cases (from 8 zero-error and 6 non-made to 12 and 8 in XXL-N, from 9 zero-error to 14 zero-error and 1 non-made in XXL-S) therefore I advised to prefer those based on the "all source" reference list.

I have no idea whether some of those "very bad" pointings were to be excluded from the tiles already for other reasons, so I do not know which pointings were uncorrected or ignored.

For pointing XXLn999-01a (the Mira Ceti field where no CFHT observations were made) the astrometric offsets were computed using the USNO catalogue.

3.5. Overlap removal

In the past overlap removal was done on band-merged data after astrometric correction (and removed detection in multiple overlapping pointings), keeping with priority the detection from the "best field" (and, if two pointings were equally good - or equally bad, preferring the one with the smallest off-axis angle). The removal did not actually delete anything from the "physical tables" (like north33) but simply created *catalogue views* (like XXLN[2]) which made visible only the overlap-surviving sources. Contextually also all spurious detection were "removed" from the catalogue views.

Currently I have created no catalogue view yet. I am limiting the overlap removal to the provision of a flag for deletion to the detections which should be removed.

Therefore provisionally, in the merged tables north42 *and* south42 *only, one can limit to the overlap-surviving sources using the clause* *deleted=0*. The deleted flag assumes two other possible values (-1 for the spurious detections and 1 for the non-spurious redundant detections which should be removed).

I considered as potential overlaps the cases where two detections observed in different tiles (avoiding counting couples (a,b) and (b,a) twice) have their *reference* coordinate closer than 10″. Coordinates are natively astrometrically correct. Spurious detections and detections with bandid=0 (actually included within the spurious ones) are ignored from the very start.

Considering a criterion for overlap removal, I considered this. The overlap between two adjacent tiles is a strip, therefore one can expect that the detection in one tile could be close to the edge of the strip (and therefore be problematic), but the 10″-associated detection in the other tile would be towards the inside of the tile.

So I considered both the nominal distance to the tile centre, but also the individual RA and DEC offsets. If the offset in DEC is about 1 deg, and the offset in RA is small (tiles at same RA) one should prefer the source with smallest DEC offset. If the offset in RA is about 1 deg, and the offset in DEC is small (tiles at same DEC) one should prefer the source with smallest RA offset. Finally if the two tiles are not at same RA or same DEC, consider the distance to the tile centre and take the smallest (this caters for areas at the corner of tiles where a source may be detected 3 or 4 times).

Since rejection occurs in couples, one has to make sure that in each multiplet one and only one detection survives. Multiplets can be couples (a,b,0,0), triples (a,b,c,0) or quadruples (a,b,c,d). Of course one shall get rid of redundant multiplets (for instance if there is a quadruple (a,b,c,d) the couples (a,b,0,0), (b,c,0,0), (b,d,0,0) and (c,d,0,0), and the triples (a,b,c,0) and (b,c,d,0) shall be ignored). Then one applies the tile-centre distance criterion to each couple and builds a 4-char flag *xyzt* : each char in the flag is initialized to - (undeleted) or . (if the corresponding position is unused, i.e. last after a couple or triple), set to D when deleted and to x when a deletion is propagated. So a couple can be either -D.. or D-.. (first or second survives), a triple -DD., -Dx. etc. and the flag shall contain one and only one -: cases like -D-x or x--D or DD.. are anomalous.

[2] The Paper XXVII published catalogue 3XLSS is the *union* of the northern and southern portions XXLN and XXLS

Despite all criteria used I found no way to get an anomaly-free automatic solution, so I listed the cases with anomalous flags (2 in XXL-N and 31 in XXL-S) and manually checked and arbitrated them. Actually I had one "preparation script", one adhoc fixup script (incorporating the manual arbitration) and one "deletion flag application script", so the procedure at the end was still rather automatic.

In north42 the overlap-surviving detections are 15547, the to-be-deleted overlaps are 3917, and the spurious cases to be ignored 19195. In south42 the corresponding figures are 11116, 2707 and 14606.

3.6. Pointers to Xamin *3.3 sources*

It is rather important to keep track of the association of new 4.2 detections to previous 3.3 detections. To be *general enough* I am providing a "preferred association" in term of a column 3xlsspointer present in north42 and south42. When non-zero it contains the seq of the preferred source in north33 or south33.

This is not the *most general* solution, which may involve the use of *correlation tables* (see 4.4) and allow for multiple associations. Note that in fact there are issues like spurious detections, multiple detections in tile overlaps and multiple detections in overlapping pointings. Plus the fact north33 and south33 have raw and astrometrically corrected coordinates.

I started (for both XXL-N and XXL-S) from a couple of provisional correlation tables (i.e. the "corrected" one listing the associations with a distance below 10″ between north42 coordinates and north33 corrected coordinates, and the "uncorrected" one listing the associations between north42 coordinates and north33 raw coordinates). One can have cases like:

- no 3.3 counterpart either using corrected or uncorrected
- one 3.3 counterpart in one case and none in the other
- one 3.3 counterpart in both cases and it is the same, or it is different (this in practice does not occur)
- more than one 3.3 counterpart in one case and none in the other
- more than one in one case and one in the other (in practice always the same)
- more than one in both (equal or different)

The critical cases are those with more than one counterpart. In principle one should prefer "the closest" but …closest in corrected or uncorrected distance ? And also, what about if the closest was removed by the 3.3 overlap removal procedure ?

For each 4.2 source with more than one 3.3 counterpart, I flagged three conditions: (a) the couple is closest in corrected distance; (b) the couple is closest in uncorrected distance; (c) the 3.3 source is in the 3XLSS catalogue (i.e. non-spurious overlap-surviving). I then considered a priority: those with all three conditions set are preferred, then the 3XLSS closest-corrected, those closest-uncorrected, and those just in 3XLSS, then those not in 3XLSS with the two closest distance, and finally those with just the closest corrected distance: this way all 4.2 source have *at least one* preferred counterpart.

I said "*at least one*" because it is possible to have more than one with the same priority. In this case a tie-break is made, usually taking the couple with the smallest distance (when this is not possible because the distances are the same, because the two counterparts are "suspect ambiguous" and share the same distance, the tie-break just takes arbitrarily the one with the snallest seq).

In XXL-N, of 38659 sources, 19640 have no north33 counterpart (of these 15950 are spurious), and 19019 have a preferred counterpart (of these only 3245 are spurious): those where the counterpart is in 3XLSS are 14459 non-spurious and 1178 spurious.

In XXL-S, of 28429 sources, 12757 have no south33 counterpart (of these 11278 are spurious), and 15672 have a preferred counterpart (of these only 3328 are spurious): those where the counterpart is in 3XLSS are 11500 non-spurious and 1391 spurious.

A corollary of all above is that if you query a merged table for a given value of 3xlsspointer and you are returned more than one entry, one of them will have deleted=0 and the other will be flagged for deletion as they are due to tile overlap.

4. The updated database

The names and layout of the database tables for XaminF18 are similar to the ones for XAMIN 3.3.2, but for the *obvious addition and removal* of new or disappeared columns.

The old numeric field number has been discontinued (there is only a mnemonic FieldName in form XXL*x*Tile-*nn*, with *x*=n|s and *nn*=1-37 or 1-31 respectively), as well as the badfield flag. Also all astrometric-correction related columns have been discontinued since the coordinates are natively corrected.

The source sequence number seq *starts at 400000 for XXL-N and 500000 for XXL-S*, so that the two are natively distinct between them, and with respect to earlier pipeline version.

4.1. Individual band tables

Individual band tables (respectively soft and hard) are called north42b and north42cd for XXL-N and south42b and south42cd for XXL-S.

As customary they include all (MOS+PN) entries in the FITS catalogue, *plus now* the MOS-only or pn-only cases (they are rather few, 59+379 in north42b, 75+283 in north42cd, 24+316 in south42b and 21+336 in south42cd; they can be identified because the pn or MOS exposures are zero).

The mapping of database column names to the FITS column names (which in turn are not always the names in Paper XXIV) is sort-of hybrid. In most cases for historical reasons I maintained the names used for earlier versions of XAMIN, which used a suffix _ext or _pnt to which I now added _dbl and _epn, as specified in Table 1, but for altogether new columns I used straightly the FITS names (although in lower case).

The following column names are historical or mimicked on historical (the number between the database name and the FITS name is *nn* from the FITS TTYP*nn* keyword values).

- cutrad 37 PNT_CUTRAD[3]
- extlike 38 EXT_LIKE
- corerad 39 EXT
- dbblike 87 DBL_LIKE
- separation 88 DBL_SEP
- theta 92 DBL_THETA
- epn_corerad 63 EPN_EXT

epnlike_ext 61 EPN_LIKE_EXT and epnlike_pnt 62 EPN_LIKE_PNT are a hybrid case.

The following maintain the FITS name in lower case dbl_ratio 90, epn_ratio 65, and epn_ml_ext 17 *(vestigial)*.

As usual NaN values are replaced with -1.

4.2. Band merged tables

Band merged tables are called north42 and south42.

They include all detections in all tiles (i.e. also the multiple ones in the 8′ overlap strips between tiles), including spurious ones (i.e. any detection likelihood).

They have the same layout as north33 and south33, but for the removal of obvious columns and for the fact the merged id is now 8- instead of 6-character long (the id is the concatenation of soft and hard id. Since now each tile can have more than 999 detections, the individual id can occupy 4 digits, and since leading zeros are used, one has cases like 12350129 in tile XXLnTile-18 (for the merging of soft id 1235 with hard id 129) or 01060055 in tile XXLnTile-01 for soft id 106 merged with hard id 55.

The positions and fluxes in the merged table are those corresponding to the *new* classification of the source (i.e. E,P,A,D)

In addition north42 and south42 have two new columns, deleted (see 3.5) and 3xlsspointer (see 3.6).

As customary in the past, two clone tables north42dup and south42dup are provided in the case one wants to correlate one merged table with itself (e.g. to know how many sources exist in proximity of a given source). Since the current database interface does not allow to enter a table name twice in a query, this trick (e.g. correlate north42 with north42dup) using a "clone view" allows it.

[3] there are 4 values of cutrad for the 4 fits but they are all identical

Table 1. Mapping of database column table names to FITS column names for "suffixed" families. The number *nn* in front of FITS column names are the TTYP*nn* keyword values.

database name	*suf*=_pnt	*suf*=_ext	*suf*=_dbl	*suf*=_epn
detlik_*suf*	13 PNT_DET_ML	14 EXT_DET_ML	16 DBL_DET_ML	15 EPN_DET_ML
x_*suf*	18 PNT_X_IMA	41 EXT_X_IMA	93 DBL_X_IMA	67 EPN_X_IMA
y_*suf*	20 PNT_Y_IMA	43 EXT_Y_IMA	95 DBL_Y_IMA	69 EPN_Y_IMA
ra_*suf*	22 PNT_RA	45 EXT_RA	97 DBL_RA	71 EPN_RA
dec_*suf*	23 PNT_DEC	46 EXT_DEC	98 DBL_DEC	72 EPN_DEC
ratem_*suf*	25 PNT_RATE_MOS	48 EXT_RATE_MOS	100 DBL_RATE_MOS	74 EPN_RATE_MOS
ratep_*suf*	27 PNT_RATE_PN	50 EXT_RATE_PN	102 DBL_RATE_PN	76 EPN_RATE_PN
countm_*suf*	29 PNT_SCTS_MOS	52 EXT_SCTS_MOS	104 DBL_SCTS_MOS	78 EPN_SCTS_MOS
countp_*suf*	31 PNT_SCTS_PN	54 EXT_SCTS_PN	106 DBL_SCTS_PN	80 EPN_SCTS_PN
bkgm_*suf*	33 PNT_BG_MAP_MOS	56 EXT_BG_MAP_MOS	108 DBL_BG_MAP_MOS	82 EPN_BG_MAP_MOS
bkgp_*suf*	34 PNT_BG_MAP_PN	57 EXT_BG_MAP_PN	109 DBL_BG_MAP_PN	83 EPN_BG_MAP_PN
pixdev_*suf*	35 PNT_PIX_DEV	58 EXT_PIX_DEV	110 DBL_PIX_DEV	84 EPN_PIX_DEV

4.3. X-ray catalogues

Catalogues refer to source lists where spurious or multiple detections have been removed.

Currently they are not available, they are to be arranged in the future. In the meanwhile you can obtain a source sample comparable to the future catalogues, restricting queries to north42 *or* south42 *using the condition* deleted=0.

4.4. Correlation tables

4.4.1. Internal 4.2 correlations

Awaiting the generation of catalogues, the only way to get the complete per-band information of sources in the merged tables is to use the correlation table labelled "*on our own XAmin identifier*". This is offered when ticking a band merged table (e.g. north42) and *one* of its band tables (e.g. north42b). *Therefore this works one band at a time.*

A 30″ correlation table between a merged table and its clone (e.g. north42 and north42dup) allows to speed up queries for sources "in proximity" of another source.

Ad-hoc correlation tables exist between xxl4pointing and the band-merged tables north42 or south42, generated as described in 2.1, which can be used to query the pointings involved in a given detected source.

4.4.2. 4.2 to 3.3 correlations

Concerning the correlation between 4.2 (north42 or south42) and 3.3 (north33 and south33) I am providing two "merged" correlation tables for each N and S. One is labelled "*new-to-old 10 arcsec corr or uncorr coordinates*", and the other one is labelled "*old-to new (reverse) ...*". They are "merged" from the temporary ones used in 3.6 i.e. consider the cases where either the corrected or uncorrected distance is below 10″. The "direct" one has at least one entry for each 4.2 source, and may return a null 3.3 entry if no 3.3 counterpart exist, otherwise it will return *all potential* 3.3 counterparts (not just the ones preferred by 3xlsspointer). The "reverse" correlation table starts from the 3.3 side, hence it has an entry for each 3.3 source, which may have zero (null), one or more 4.2 counterparts. In either cases the objects in the "second" table without counterparts in the "first" are ignored (that's why one needs separate direct and reverse tables).

4.4.3. Correlations with other tables

Correlations of north42 *and* south42 *with the existing photometric and other tables will be arranged in the near future as the need for it arises in the preliminary work towards a multiwave catalogue.*

Correlation with the XXLDB cluster "clone" table lyon *within 30″ has been generated but will not be released until the correspondence between XXLDB and 4.2 data will be studied in detail. For the time being refer to the "Comparison" sections 5.2.1.*

4.5. Data products

4.5.1. Original catalogues

The access to the original FITS catalogues (per tile and per band) *is to be arranged in the future*

4.5.2. X-ray products

X-ray images, exposure maps etc. are currently not available and presumably will be arranged in the future

5. Comparison 4.2 vs 3.3

5.1. Basic statistics

I report below some basic statistics, usually in a three column-group format, where the first column report the item, the second group the 4.2 count, and the third group the 3.3 count. In the numeric column-groups, the first figure is for XXL-N, and the one in parenthesis for XXL-S.

First of all the total number of entries in the merged and individual band tables.

Total merged	38659	(28429)	26555	(27173)
Total soft	26524	(19691)	19352	(20067)
Total hard	20290	(14010)	13258	(12797)

Apparently 4.2 is deeper in XXL-N, but one has to check the number of *non-spurious* entries (as absolute value and percentage of total).

Non-spurious merged	19464	(13823)	17398	(18145)
Non-spurious soft	17286	(12325)	15245	(15749)
Non-spurious hard	8019	(5253)	6848	(6759)
Non-spurious merged	50%	(49%)	66%	(67%)
Non-spurious soft	65%	(63%)	79%	(78%)
Non-spurious hard	49%	(37%)	52%	(53%)

The *number of spurious detections is higher* for 4.2.

We consider now the various classifications first for the soft band (pnt means pointlike, ext means extended).

pnt spurious	9238	(7366)	4107	(4318)
pnt non-spurious	16916	(12081)	14873	(15306)
pnt P1	11335	(7585)	8775	(8562)
ext E	264	(185)	372	(443)
ext A (AC or EPN)	100	(55)	n/a	(n/a)
ext D (double)	6	(4)	n/a	(n/a)
ext C1	202	(128)	159	(172)
ext C2	168	(116)	213	(271)
Total ext	370	(244)	372	(443)

Then for the hard band.

pnt spurious	12271	(8757)	6410	(6038)
pnt non-spurious	7919	(5187)	6738	(6548)
pnt P1	4078	(2327)	2743	(2480)
ext E	86	(56)	110	(211)
ext A (AC or EPN)	9	(6)	n/a	(n/a)
ext D (double)	5	(4)	n/a	(n/a)
ext C1	26	(19)	29	(30)
ext C2	74	(47)	81	(181)
Total ext	100	(66)	110	(211)

And finally for the band merged case. I consider as A or D those which are such in at least one band.

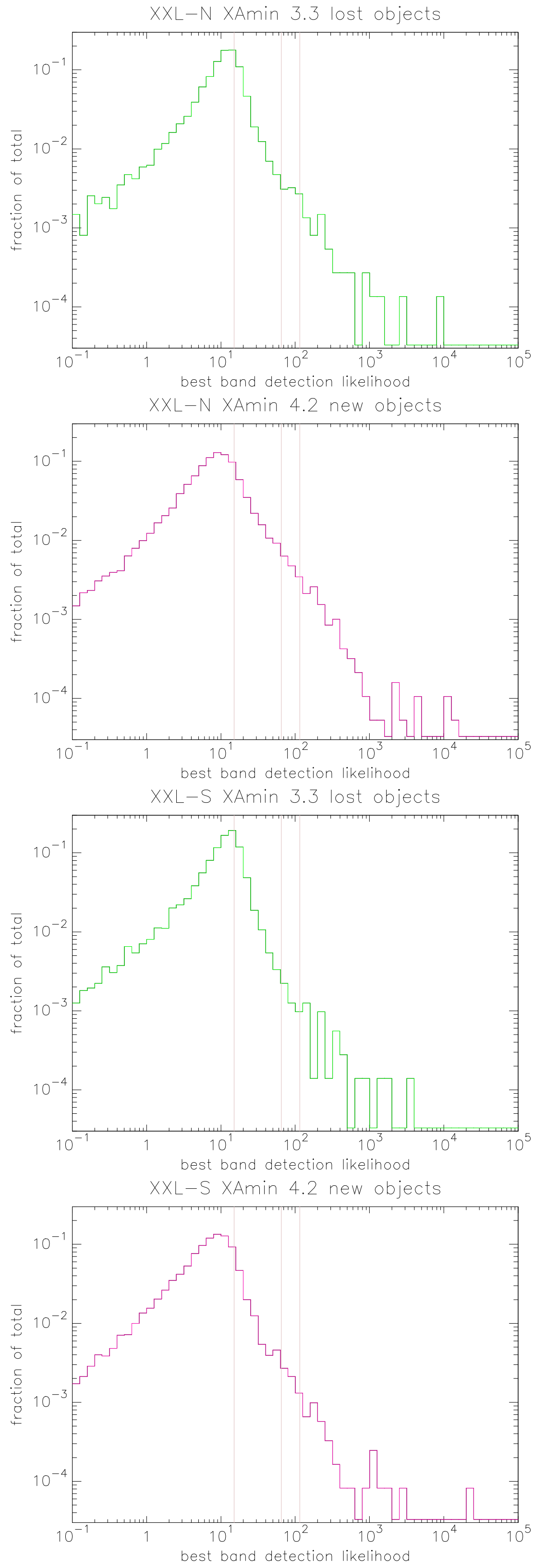

Fig. 1. Histogram of the best band detection likelihood for "lost" 3.3 detections (green histograms) or "new" 4.2 detections (red histograms), for XXL-N and XXL-S. See Fig. 4 for graphical conventions.

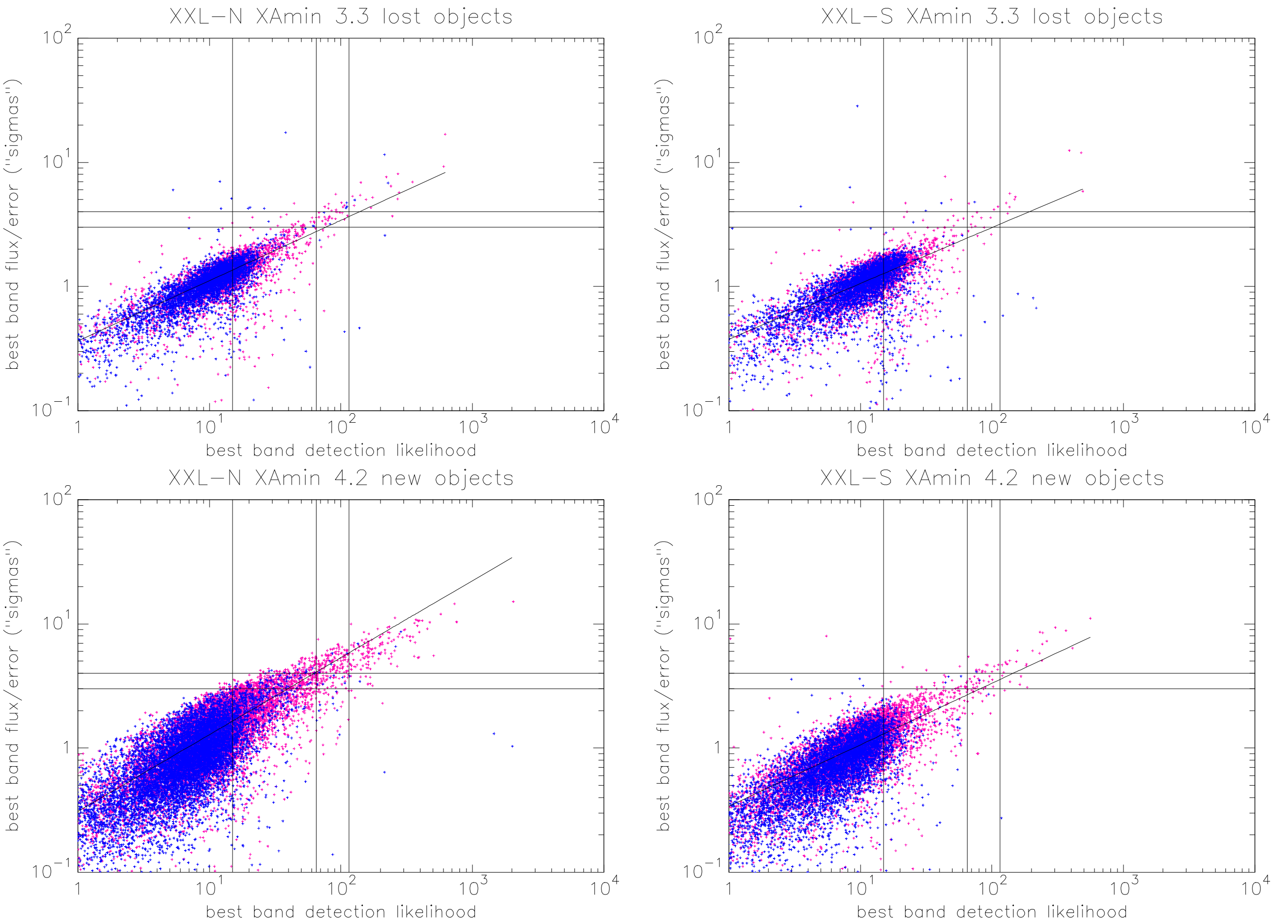

Fig. 2. Cross-calibration of the S/N vs detection likelihood (refer to caption of Fig. 5 for more details about colour coding and graphical conventions) for "lost" 3.3 detections (top row) or "new" 4.2 detections (bottom row). Left column: XXL-N; right column: XXL-S.

pnt spurious	19194	(14605)	9157	(9028)
pnt non-spurious	19024	(13534)	16950	(17541)
pnt P1	12034[a]	(7970)[b]	9307[c]	(9062)[d]
ext E	331	(223)	448	(604)
ext A (AC or EPN)	105	(58)	n/a	(n/a)
ext D (double)	11	(8)	n/a	(n/a)
ext C1	220	(140)	174	(188)
ext C2	227	(149)	275	(416)
Total ext	447	(289)	448	(604)
Best band soft	25399	(19025)	18694	(19429)
Best band hard	13097	(9360)	7835	(7711)

[a] 7 P1=-1 are nominally extended, 1 is spurious
[b] 1 P1=-1 nominally extended, 2 are spurious
[c] 12 P1=-1
[d] 13 P1=-1

The peculiar (seldom occurring) cases like reclessified sources, `maxdist` above 10″, `bandid=0` and merging ambiguities are counted above in sections 3.2 and 3.3.1.

5.2. Lost and Found

We can use the correlation tables described in 4.4.2 to tell how many 3.3 sources are "lost" and how many 4.2 sources are "new" without a 3.3 countepart. The `bandid=0` objects are excluded by construction.

The new 4.2 sources without 3.3 counterpart are 19475 in XXL-N and 12712 in XXL-S.

The lost 3.3 sources without 4.2 counterpart are 7585 in XXL-N and 7369 in XXL=S.

The common sources are 19021 (XXL-N) and 15672 (XXL-S): the figures refers to 4.2 sources with tile overlap (the number of 3.3 sources with pointing overlap is 18944 for XXL-N and 19771 for XXL-S). In the remainder we will consider the "preferred" couples associated via `3xlsspointer` (see 3.6), i.e. 19019 XXL-N and 15672 (XXL-S).

All values refer to the band-merged tables. No specific statistics will be supplied for individual-band tables. Whenever values like counts or rates from individual-band tables are quoted, they will be extracted using the correlation on tile and id within the tile with the merged `seq`.

It is apparent from Fig. 1 and Fig. 2 that, not surprisingly, both *the new and lost objects are concentrated among the spurious sources* and anyhow among those with relatively low detection likelihood. Note that all histograms in Fig. 1 and Fig. 4 are each normalized to the total number of elements under the curve.

It could be worth examining individually the brightest of the "lost" cases. There are 64 nominal C1 in the north (11 are hard-only though), and 61 C1 in the south (15 hard-only) which are lost from 3.3 to 4.2 (see next subsection for more considerations about missing extended sources).

Concerning pointlike sources, those above 4σ are 41 in XXL-N and 18 in XXL-S. Above 5σ they are 20 and 16, above 10σ 2 and 8. May be at least the latter (or their surrounding in the X-ray images) should be inspected manually. The two northern cases are 222660 (a `PP` in XXLn998-05a with a soft flux of 1.9×10^{-14} cgs, and 221183 (a hard-only in XXLn115-01 with a hard flux of 2.9×10^{-12} cgs). The southern ones are too many to give details here, but 310160, 319521 and 310046 (in order of increasing significance) are soft sources in the range $5 - 9 \times 10^{-14}$, while 310055, 326044, 312317, 312367, 310063 and 312369 are hard-only with fluxes usually in the range $2 - 7 \times 10^{-13}$.

5.2.1. Extended lost and new

Among the lost sources in the north there are 61 cases "nominally extended detected in the hard band only", 136 extended in the soft band, 2 extended in both bands and 6 `EP`. 101 are in XXLDB, 59 have an XLSSC number.

In the south the lost "hard nominally extended" are 130, the soft-only extended 144, the extended in both bands 2 and the `EP` 6. 108 in XXLDB of which 38 have an XLSSC number.

The number of new nominally extended sources in the north is 222. 50 are in the hard band only (of which 3 `-A` and 4 `-D`). In the soft band there are 117 `E-`, 47 `A-` and one `D-`, plus 5 `EP` and one each of `AE` and `AP`.

The equivalent number in the south is 125. 27 are hard-only (of which 4 `-D`). In the soft band one has 75 `E-`, 18 `A-`, 2 `D-` and one each of `EP` and `DP`.

The majority of pointlike new sources are detections in a single band (only 859 in XXL-N and 321 in XXL-S i.e. about 4 and 2%). Something similar can be said of the lost sources.

One can also do a different exercise for extended sources in the Lyon XXLDB. On one hand (using the clone table `lyon`) we know the 3.3 source natively associated to each tagged cluster candidate (`Xseq`), and, when different because of the pointing overlap removal procedure, the catalogued 3.3 source associated (`truXseq`), on another hand we could correlate `north42` or `south42` with `lyon` on a larger radius (30″), and check whether the 4.2 association matches the 3.3 one using the `3xlsspointer` (see 3.6).

25 northern and 22 southern XXLDB clusters have no 4.2 counterpart within 30″: of these 13 and 6 have an XLSSC number.

161 N clusters and 151 S clusters have one 4.2 counterpart but only 103 and 108 match the `3xlsspointer` (68 and 56 with XLSSC number). 2 northern objects previously not associated now have a 4.2 counterpart. In the other cases either there is no `3xlsspointer` or it does not match the association with XXLDB.

Of the 158 N clusters and 123 S clusters with more 4.2 counterparts within 30″, 111 and 88 have one matching the `3xlsspointer` and 3 northern objects previously not associated have a 4.2 counterpart.

5.3. *Common sources*

In the remainder we look only at the 19019 XXL-N (15672 XXL-S) common sources associated by `3xlsspointer`. The figure in parenthesis following one not in parenthesis is always for XXL-S.

Among those 4.2 sources having a 3.3 counterpart, the number of actually independent sources (`deleted=0`) is 12518 (9827)

Among the total, 14476 (11524) are confirmed non-spurious in both 4.2 and 3.3, 2053 (1927) are confirmed spurious, 1298 (820) are promoted non-spurious in 4.2 and 1192 (1401) are demoted.

Among the overlap-free (`deleted=0`) 11485 (9140) are confirmed non-spurious, and 1063 (687) are promoted (the 4.2 spurious are to be rejected ex officio from the catalogue, `deleted=-1`).

Concerning the *generic extended flag* (which for 4.2 groups also EPN and DBL), among the total one has 18660 (15381) pointlike and 128 (120) extended which confirm their status between 4.2 and 3.3. 134 (127) 3.3 extended are pointlike in 4.2, and viceversa 97 (44) pointlike become extended.

Among those non-spurious in 4.2, 15432 (12089) maintain their pointlike status and 117 (91) 3.3 extended become pointlike (the 4.2 extended are by definition non-spurious so the other figures are identical to the total case).

Among the overlap-free, 12243 (9612) pointlike and 105 (101) extended are confirmed, 79 (38) pointlike become extended and 91 (76) extended become pointlike.

Concerning the detailed (EPDA) classification, in the total one has, among the pointlike, the same classification (which in general means single- or double-band detection) for 7969 (7330) soft-only, 2441 (2299) hard-only and 5076 (3790) double-band (of which 1 (3) `PE`).

One has *compatible* classifications (e.g. `PE` vs `PP` or `P-` vs `PP` or vv.) for 2128 (1112) now detected in both bands, 611 (548) formerly detected in both bands and now soft-only, or 168 (137) now soft-only, while 267 (165) were formerly detected only in one band and now only in the other (i.e. *not compatible*).

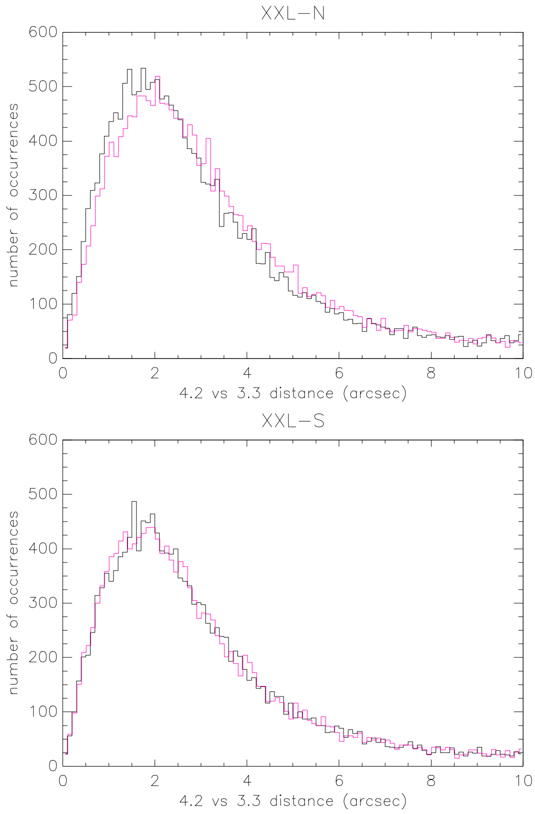

Fig. 3. Histogram of the distance between the 4.2 position and the 3.3 astrometrically corrected (black) or uncorrected (magenta) position.

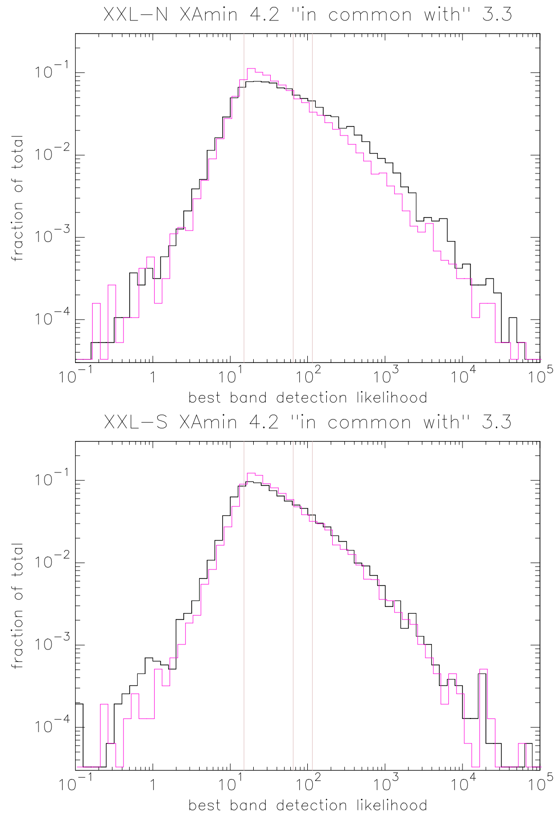

Fig. 4. Histogram of the best band detection likelihood for objects in common between XAMIN 4.2 and 3.3. The thick black curve refers to 4.2 likelihoods, the violet curve to 3.3 ones. The vertical fiducial lines are for likelihood 15, 65 and 115 (see caption of Fig. 5).

The above figures reduce to 1996 (1015), 577 (501), 112 (87) and 77 (52) if one limits to those non-spurious in 4.2.

For the confirmed extended, the same classification occurs just for 66 (71) cases, but this is coincidental mostly with the fact the new classification has new classes (A and D). The number of nominally compatible cases (like detection in one vs two bands) or nominally incompatible (detected as extended in single opposite band) is limited to two or one handful. The rest of the cases, 47 (35) is due to the new EPN (A) classification.

For the "new extended" a majority [57 (28)] are simply former soft pointlike now detected as soft extended, 6 (2) cases are now detected as A, 5 (1) cases as D, 12 (8) are miscellaneous cases now mostly detected in two bands and extended in soft, while 17 (5) are nominal extended hard sources.

For the "old extended now pointlike", 29 (20) were `EP` now `PP`, or 9 (7) `P-`, 14 (4) are former single-band detections now detected as `PP`, 58 (69) change from extended to pointlike in the soft band, 15 (–) are miscellaneous cases, and 23 (27) are now detected as pointlike in the hard band only.

Again I cannot but suggest manual inspection of the "changed extended" cases.

I report in Fig. 3 the histogram of the distance between the 4.2 position and the 3.3 position. Actually the latter exists in two incarnations (astrometrically corrected and uncorrected), while the 4.2 position, as explained above, should be natively correct. To play sure I computed both distances (which however are similar within 1″ in 75% of the cases, and differ by more than 2″ in less than 4%.

It is slightly surprising that there is no greater difference between corrected and uncorrected 3.3 positions (I'd expected the distance betweem 4.2 and 3.3 corrected to peak closer to zero).

Concerning the *detection likelihood*, taking the best (highest) one from the two bands, one can plot the histogram (Fig. 4) and the calibration with the flux SNR (Fig. 5), which can be compared immediately with the similar figures for "lost and new" sources (see 5.2).

One can clearly tell the difference between the "sound" common sources and the poorest lost and new sources, as well as note that the 3.3 and 4.2 behaviour is very similar (e.g. for the SNR calibration).

Fig. 6 compares the detection likelihood, in the best band used above, between 3.3 and 4.2. For simplicity the comparison is limited to sources considered pointlike in

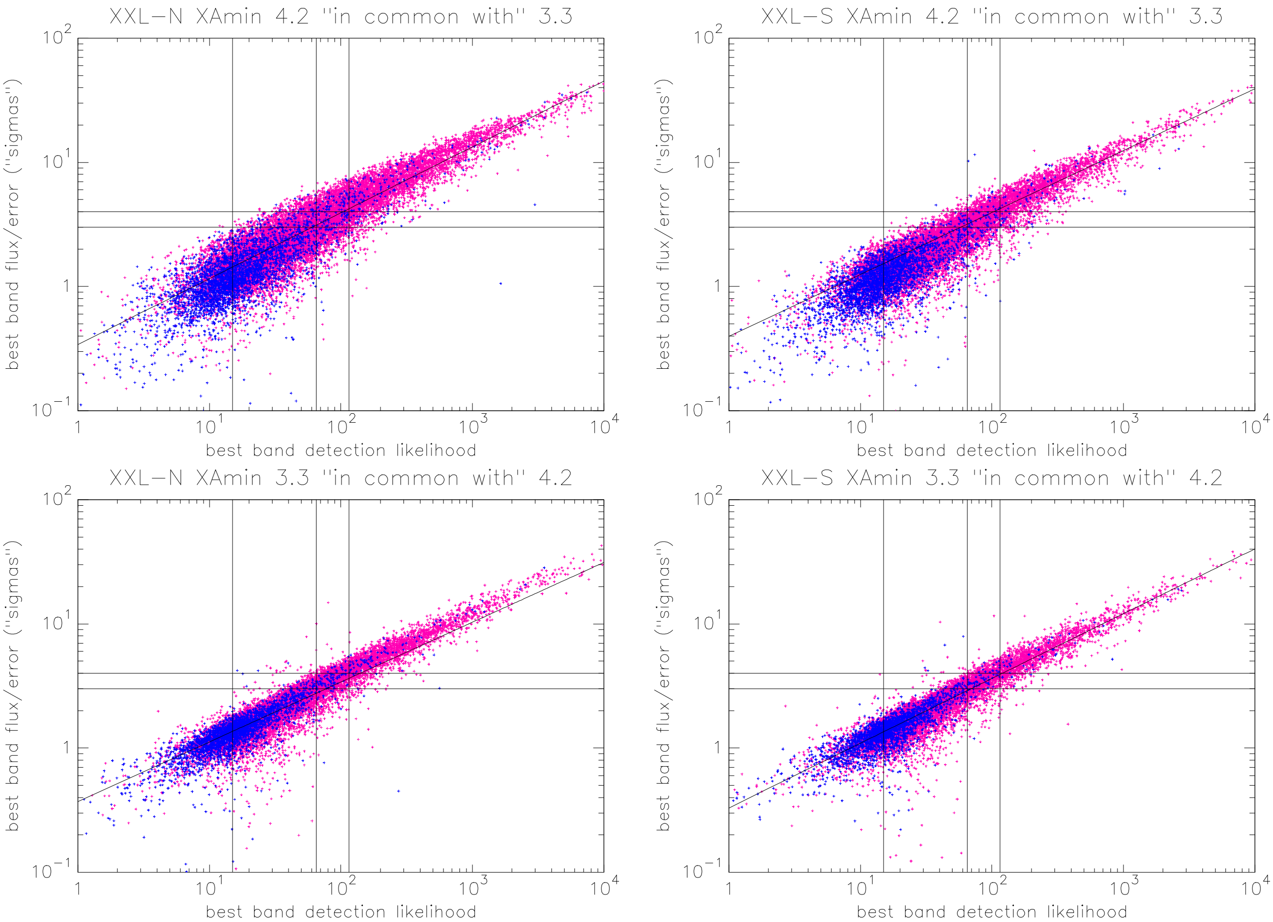

Fig. 5. Cross-calibration of the S/N (flux divided by computed flux error) vs detection likelihood in the best band for objects in common between XAMIN 4.2 and 3.3. Left column: XXL-N; right column: XXL-S. Top row: 4.2 data; bottom row: 3.3 data. In all plots red means best band is soft and blue best band is hard. The diagonal line is a linear fit in loglog space to the S/N averaged in pseudo-logarithmic bins ((the pseudo-logarithmic binning is a spacing of 1 in likelihood up to 100, then 5 up to 1000, 50 up to 10 000, and 500 above 10 000). The vertical fiducial lines are for likelihood of 15 (below which sources are considered spurious), 65 and 115, matching the levels of 3 and 4σ identified by the horizontal lines. The fit is done independently for each plot, while the fiducial lines are the same for all plots, and use the calibration established in Fig. 1 of Paper XXVII. The difference between the plots in Paper XXVII and those in the current report is that here we mix soft and hard data, and consider either one according to what is the best band for each source.

both releases. The figure uses different symbols for sources considered eligible for the catalogue because surviving the overlap removal procedure (see 3.5) and the other (spurious or not). There is a large scatter anyhow, with *indication of a trend by which sources resulting from the coaddition of several pointings in one tile have a better (larger) likelihood* in 4.2, while those located in a single pointing have comparable likelihoods in 3.3 and 4.2. Because of the large number of sources and of the large scatter, it might be better to look at the figure at a large magnification. But even in such case points plotted later (e.g. the black single pointing after the green double pointing, and so on) may hide a number of sources plotted previously.

Note that one has that single pointing sources are 43% (37%), double are 27% (46%), triple pointings 13% (12%) etc., considering all sources. Considering catalog candidates (`deleted=0`) the percentages become 36% (32%), 28% (51%), 14% (13%) etc. (the figures in parentheses refer to XXL-S).

The improvement is even more visible in Fig. 7 where one plots the flux/error ratio in the best band. Single pointing sources give similar SNR in 3.3 and 4.2, while *sources resulting from the tiling of more pointings have a better ratio*.

I generated plots (which are not reported here in toto and are available on request) similar to those in Fig. 5 but for all detections in individual (soft and hard) bands for both 3.3 and 4.2 data. They are rather similar to the "best band" plots (see a sample in Fig. 8), except for the fact the ML level corresponding to 3 and 4σ levels may vary

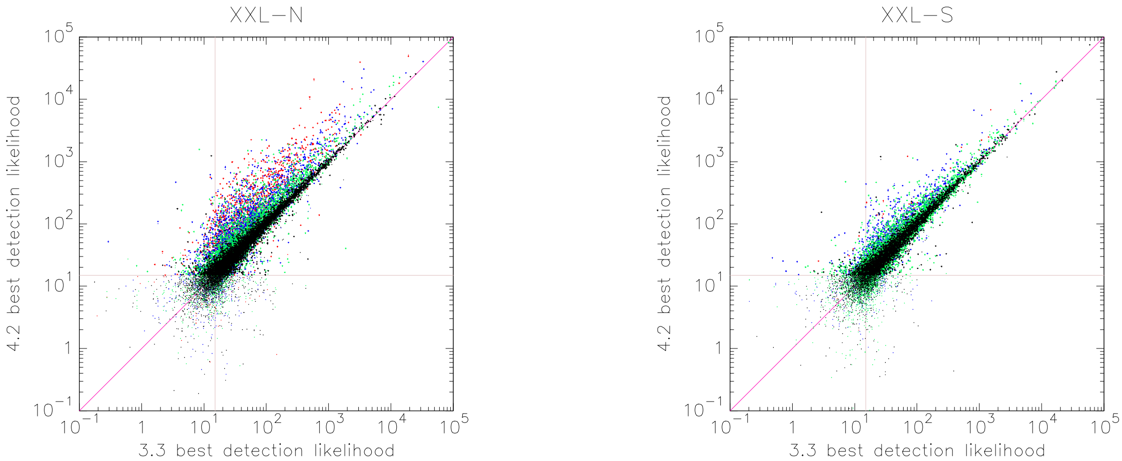

Fig. 6. Comparison of the detection likelihood in the best band for the 3.3-4.2 common pointlike sources (pointlike in both). Dots are sources not eligible for catalog (spurioous or overlap-removed), crosses are those eligible (`deleted=0`). Colour codes are: black, sources detected in a single pointing; green, detected in 2 pointings; blue, detected in 3-4 pointings; red, detected in more than 4 pointings. Fiducial lines are for ML=15 and for equal likelihood.

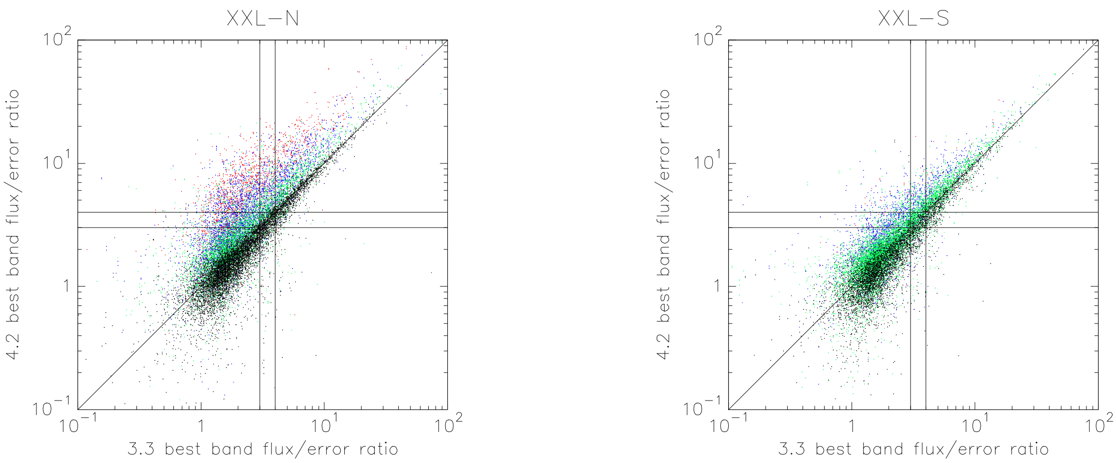

Fig. 7. Comparison of the flux/error ratio in the best band for the 3.3-4.2 common pointlike sources (pointlike in both). Colour codes as in Fig. 6. Fiducial lines are for 3 and 4σ and for equal ratio.

a bit according to case (e.g. 49 and 85 for XXL-N soft, or 80 and 135 for XXL-S hard), so, considered the scatter, I'll stick to the 3XLSS values of 65 and 115.

I generated also plots per band analogue to those in Figs 6 and 7 but I do not report them here (available on request) since they are extremely similar.

I have produced and inspected, but not saved except for the sample in Fig. 9, plots comparing the 4.2 and 3.3 fluxes in the bands. Fluxes look consistent, *almost irrespective* of the fact the 4.2 detection derives from a single pointing or from the tiling of more pointings (except perhaps for a large scatter).

Adding error bars on such plots would not help, it will just make the plot less legible. Comparing the flux error between 3.3 and 4.2 shows that the new error bars are usually (but not always) smaller, sometimes much smaller for bright sources.

It could be more useful to plot the flux error vs the flux. I have produced several plots of which I report here a sample (the other are available on request). I report in Fig. 10 one case comparing 3.3 and 4.2 fluxes and errors on the same frame, and in Fig. 11 all four cases plotting 4.2 fluxes and errors according to the number of pointings used for each "tiled" source. The 4.2 errors show a large scatter than 3.3 ones and are often smaller, specially for the sources resulting from the tiling of more pointings.

As I said, the 4.2 fluxes are usually compatible with the 3.3 ones. I have computed the 4.2 minus 3.3 flux difference (increase or decrease) and found an increase in 53-57% of the cases, and a decrease in 43-46%, and a variation (increase or decrease) in absolute value greater than 100% in 1% of the cases, greater than 50% in 7-10%, greater than 20% in 29-38%, and greater than 10% in 54-63%. The difference is usually *consistent with zero*. Fig. 12 is a sample

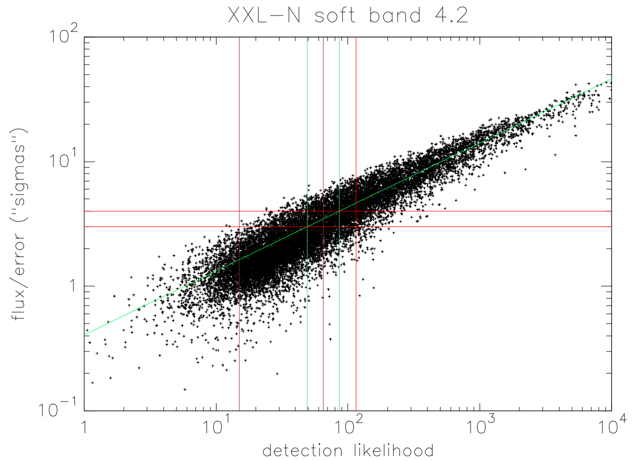

Fig. 8. Sample of cross-calibration of the S/N vs detection likelihood for a single band (soft) and dataset (4.2). Fiducial lines as in Fig. 5 except that: red lines are for the *standard* ML=65, ML=115 and 3 and 4σ levels; the green diagonal line is the fit from the *current* dataset made as in Fig. 5; the green vertical lines show the ML corresponding to 3 and 4σ based on such fit (intersection with the red horizontal lines).

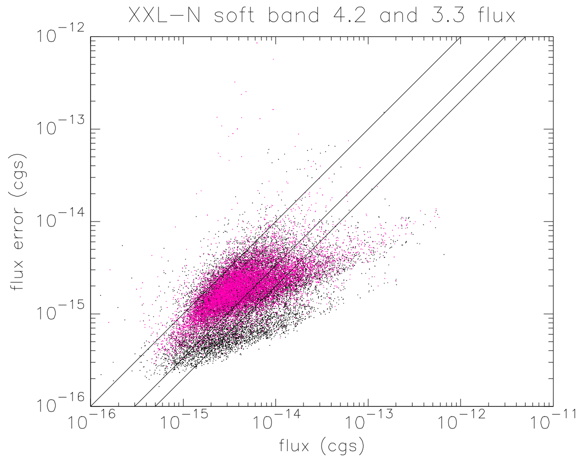

Fig. 10. Sample plot. The flux error is plotted vs the flux for the soft band for the 3.3-4.2 common XXL-N pointlike sources (pointlike in both). Black points are for 4.2 sources and magenta points for 3.3 ones. Fiducial diagonal lines are (from left to right) for significances of 1, 3 and 5σ.

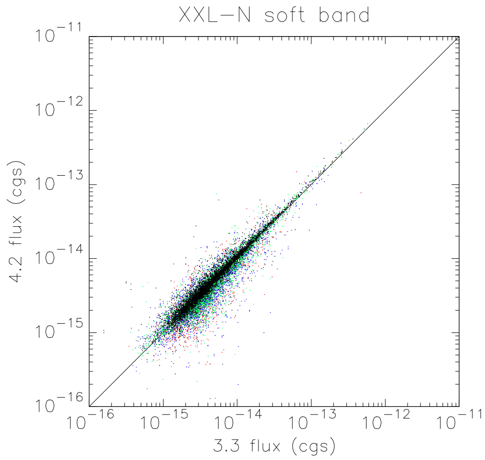

Fig. 9. Sample plot. Comparison of the flux in the soft band for the 3.3-4.2 common XXL-N pointlike sources (pointlike in both). Colour codes as in Fig. 6. Fiducial line for equal flux.

(other figures available on request) reporting the significance of the difference vs the error (quadratic combination of flux errors)

I have also examined some data in the individual band tables, like count rates and number of counts, which are available separately for MOS and pn cameras.

The count rates behave unconspicuosly and of course similarly to the flux (Fig. 9) which derives from them. Therefore I report in Fig. 13 only two sample plots (MOS and pn) for one case, which are immediately comparable with Fig. 9, i.e. rates, as fluxes, are *very similar* between 3.3. and 4.2.

I have also generated plots of the rate/error ratio, which are available on request and of which I report here just a sample in Fig. 14, which can be compared with the rather similar Fig. 7 (left panel). I remind that the flux errors are computed by the propagation of rate errors as described in 3.3.2 and wiki page cited therein. Fig. 14 is useful just to compare MOS and pn cameras before they are weighted and combined. Otherways it shows the *usual trend* that rate/error ratio is better for sources tiled from many pointings.

Finally I report some plots about the number of counts in individual bands. The counts are available separately for MOS and on cameras, however, unlike rates, they can be easily summed in a plain way. I report a sample of MOS and pn counts for one case in Fig. 15, and the full set of plots for summed counts in Fig. 16. In this case *the number of counts is also higher for sources tiled from many pointings*.

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References

Chiappetti, L., 2016, Further steps for identification of XXL X-ray sources using the 2015 homogenized photometry. XMM-LSS Internal Report N. 18-Mi (Report XVIII)

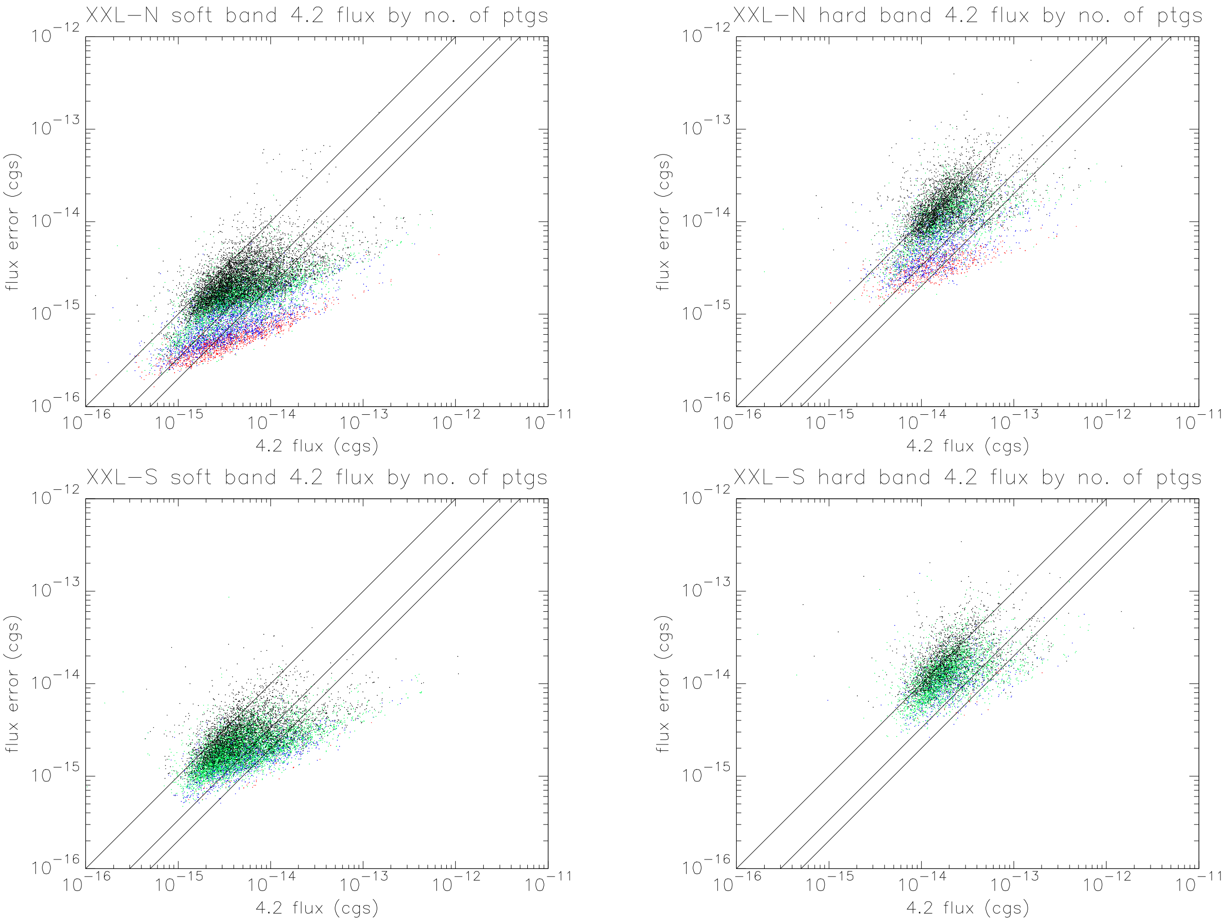

Fig. 11. The flux error is plotted vs the flux for all bands and areas, for 4.2 pointlike sources (pointlike in both 4.2 and 3.3). Colour codes as in Fig. 6 to tell the number of pointings used for each source. Fiducial diagonal lines are (from left to right) for significances of 1, 3 and 5σ.

Chiappetti, L., et al. 2018, The XXL Survey XXVII. The 3XLSS point source catalogue. A&A 620, A12

Faccioli, L., et al. 2018, The XXL Survey XXIV. The final detection pipeline. A&A 620, A9

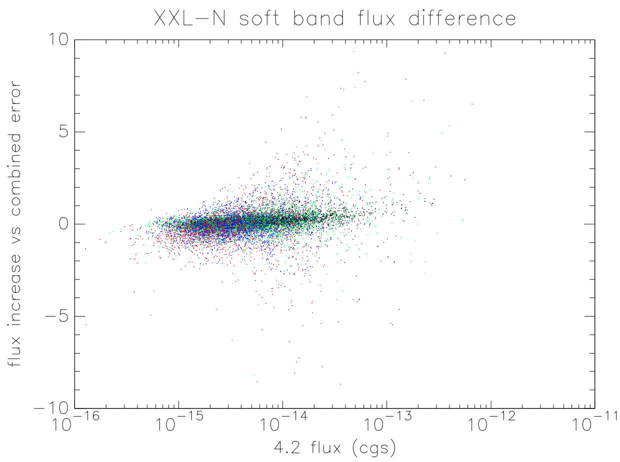

Fig. 12. Sample plot. The flux increase (or decrease, 4.2 - 3.3) divided by its error (quadratic combination of 4.2 and 3.3 flux errors) plotted vs the 4.2 flux in the soft band for XXL-N pointlike sources (pointlike in both 4.2 and 3.3). Colour codes as in Fig. 6 to tell the number of pointings used for each source.

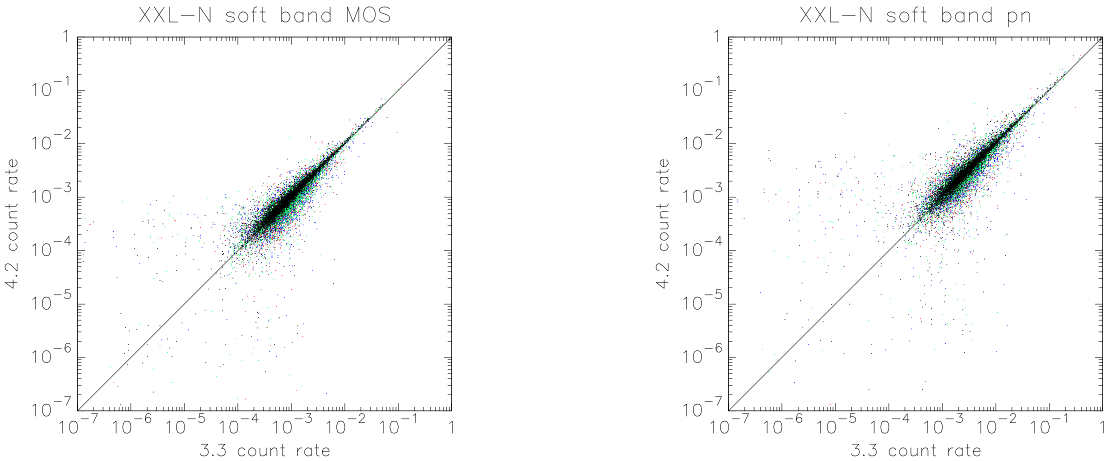

Fig. 13. Sample plot. Comparison of the count rate in the soft band for the 3.3-4.2 common XXL-N pointlike sources (pointlike in both). MOS camera on the left, pn camera on the right. Colour codes as in Fig. 6. Fiducial line for equal rate.

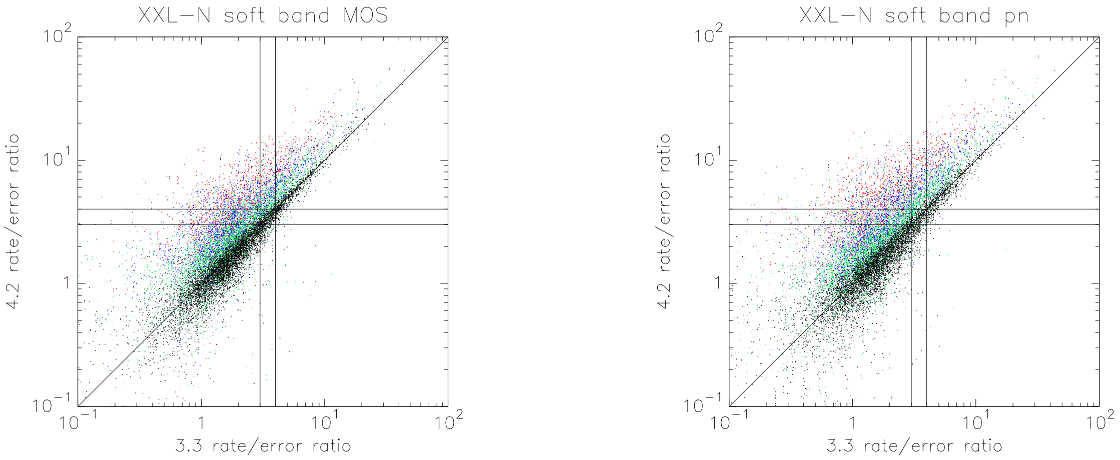

Fig. 14. Sample plot. Comparison of the rate/error ratio in the soft band for the 3.3-4.2 common pointlike sources (pointlike in both). MOS camera on the left, pn camera on the right. Colour codes as in Fig. 6. Fiducial lines are for 3 and 4σ and for equal ratio.

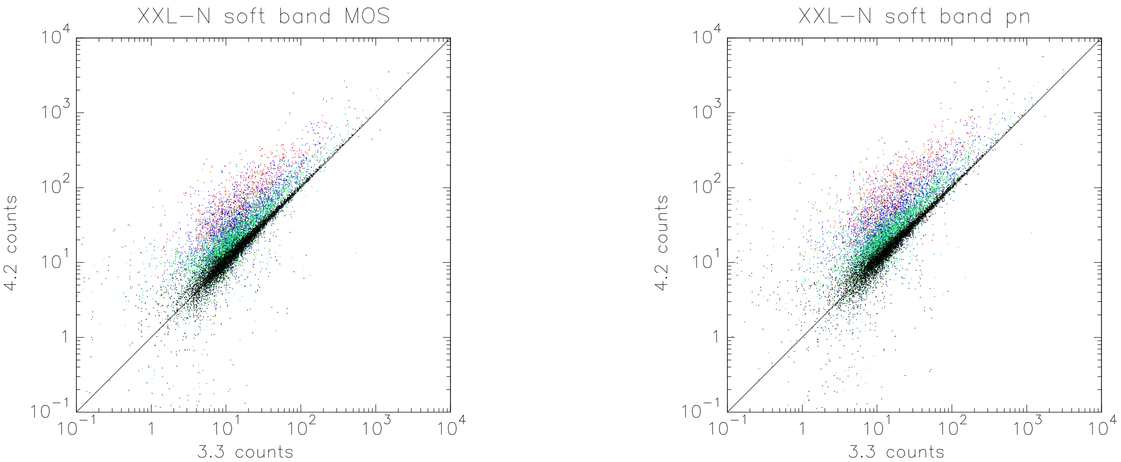

Fig. 15. Sample plot. Comparison of the number of counts in the soft band for the 3.3-4.2 common XXL-N pointlike sources (pointlike in both). MOS camera on the left, pn camera on the right. Colour codes as in Fig. 6. Fiducial line for equal counts.

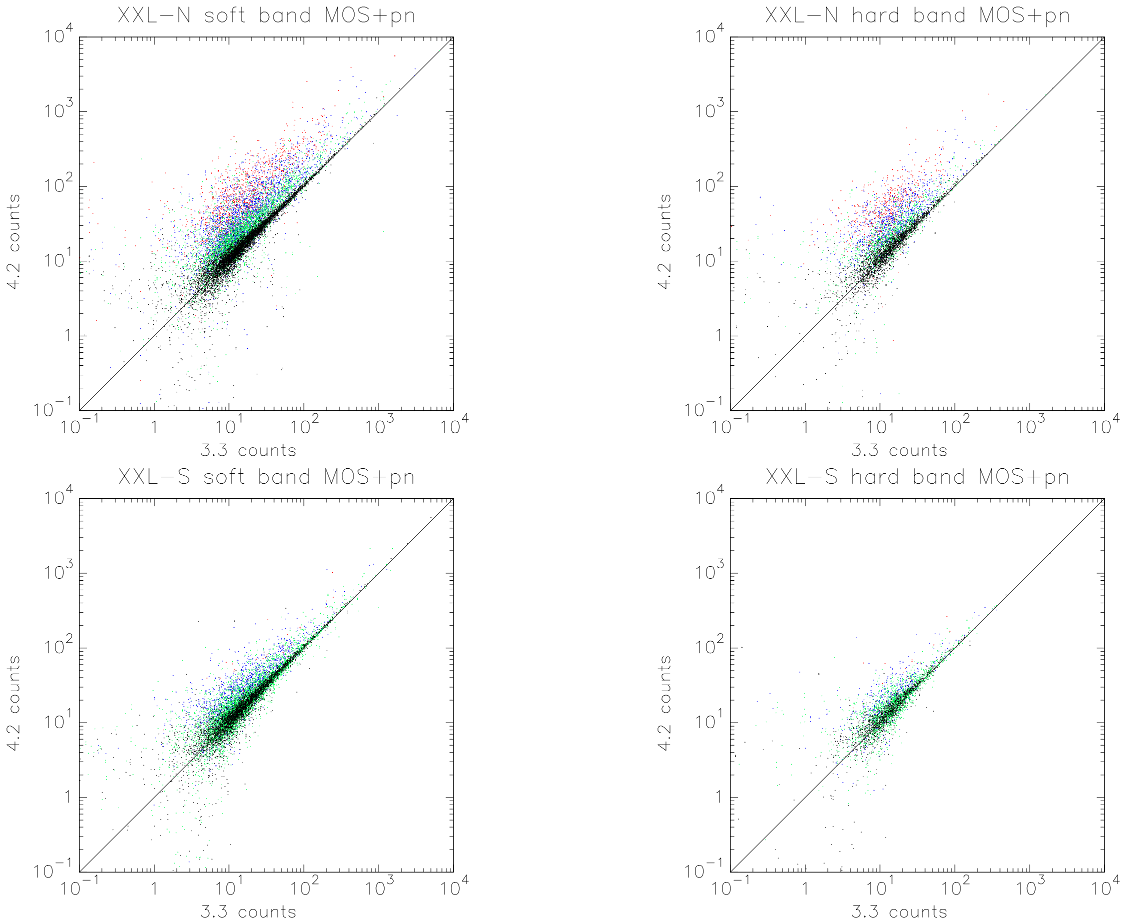

Fig. 16. Comparison of the MOS+pn summed number of counts in the soft band for the 3.3-4.2 common XXL-N pointlike sources (pointlike in both). Colour codes as in Fig. 6. Fiducial line for equal counts.