XMM-Newton CCF Release Note

XMM-CCF-REL-333

EPIC-pn SLEW-specific PSF parameterisation

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1 CCF components

Name of CCF	VALDATE	List of Blocks changed	Change in CAL HB
XRT3_XPSF_0017.CCF	2000-01-01	SLEWPSF_PARAMS	YES

2 Change

The elliptical beta, 2-D model (ELLBETA; Read et al. 2011) is used to model the point spread function (PSF) of a source in pointed observations. The PSF varies with the off-axis angle (the distance from the optical-axis) and photon energy. When the satellite is slewing, the cameras pass over a source, spreading the received photons with a continuously varying PSF as the off-axis angle changes. This release introduces a PSF for slew sources detected in the EPIC-pn camera, calculated by averaging PSFs from different off-axis angles. With this description of the spreading of photons over the detector, source detection in EPIC-pn slews should be more effecient and accurate.

In principle, the track which a source takes may pass through the centre of the detector or just through the edge, giving rise to a potentially infinite number of average PSFs which would be difficult to tabulate or expensive to compute on-the-fly. Tests show that a single slew PSF, based on an average track through the detector is sufficient to characterise the majority of the sources well and improve over the static PSF. It was also found that a single PSF for all the slew observation modes was sufficient.

A slew-averaged PSF, for a set of energies, was calculated from the vignetting-corrected fraction of time that slew sources spend at different off-axis angles. While this varies in detail from source to source, mean fractions have been calculated from an ensemble of slew sources. These fractions are presented in Table 1 in the six off-axis angle ranges and eight energies which are used to define the ELLBETA PSF in the CCF. A slew PSF, at each energy, was then computed by adding the ELLBETA PSF parameters (from XRT3_XPSF_0016.CCF), at each off-axis angle, weighted by these fractions.

Table 1: The average fraction of photons, from a source slewing through the field of view, which fall in a certain off-axis range

Energy	Off-axis angle range					
(keV)	0-3'	3-6'	6-9'	9-12'	12-15'	15+'
0.1	0.0623	0.1623	0.2153	0.2304	0.2223	0.1071
1.5	0.0626	0.1630	0.2158	0.2302	0.2214	0.1067
2.75	0.0641	0.1659	0.2176	0.2292	0.2178	0.1050
4.25	0.0645	0.1668	0.2182	0.2291	0.2167	0.1043
6.0	0.0704	0.1786	0.2249	0.2238	0.2011	0.1009
8.0	0.0849	0.2009	0.2294	0.2089	0.1822	0.0934
10.25	0.1042	0.2203	0.2216	0.1935	0.1721	0.0880
15.0	0.0993	0.2095	0.2235	0.2011	0.1763	0.0900

3 Scientific impact of this update

The new PSF is used in source detection within EPIC-pn slew data. It leads to a more sensitive detection, resulting in different, generally higher, source significances being returned compared with the use of the pointed mode PSF. The encircled energy fraction is also changed slightly and hence the returned count rates and fluxes may be different.

In Fig. 1 we show the detection likelihood and count rate of sources found in slews used in the XMM-Newton slew catalogue (Saxton et al. 2008), using the pointed and slew PSFs. Fitting with a linear function we find that the measured counts are actually nearly identical (slope=0.998) with the two PSFs. However, the maximum likelihood value of the detection is slightly higher with the new PSF. The new detection likelihoods may be approximated by:

$DET\_ML_{new} = 1.5 + DET\_ML_{old} * 1.02$

The difference is especially noticeable for likelihoods below $DET\_ML \sim 20$.

4 Estimated scientific quality

With this release, sources detected within EPIC-pn slews should have their count rates corrected by an encircled energy function accurate to $\sim 2 - 3\%$.

5 Test procedure and results

The new CCF has been used to produce a full catalogue of detections from 2000 slews. For sources which have been detected in the new processing at exactly the same position as a source in the current, XMMSL1, catalogue (produced using the ELLBETA PSF) we

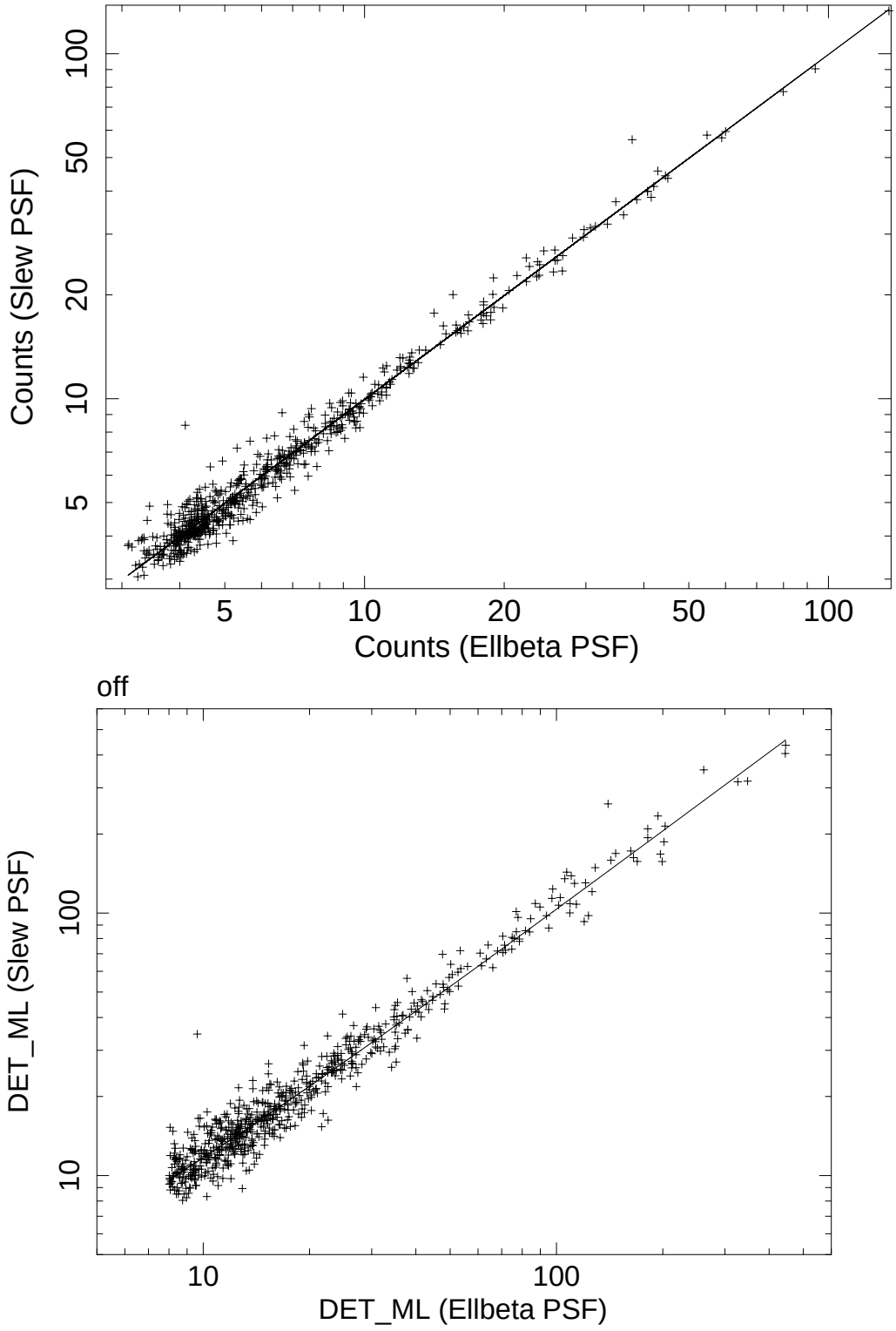

Figure 1: A comparison of the properties of 660 sources detected in EPIC-pn slew data using the previous, ELLBETA, PSF and the new, SLEW, PSF. The upper panel shows the registered counts, after background subtraction and correction for the encircled energy, while the lower panel displays the maximum likelihood of the detection. The solid line represents the best linear fit to the data in each case.

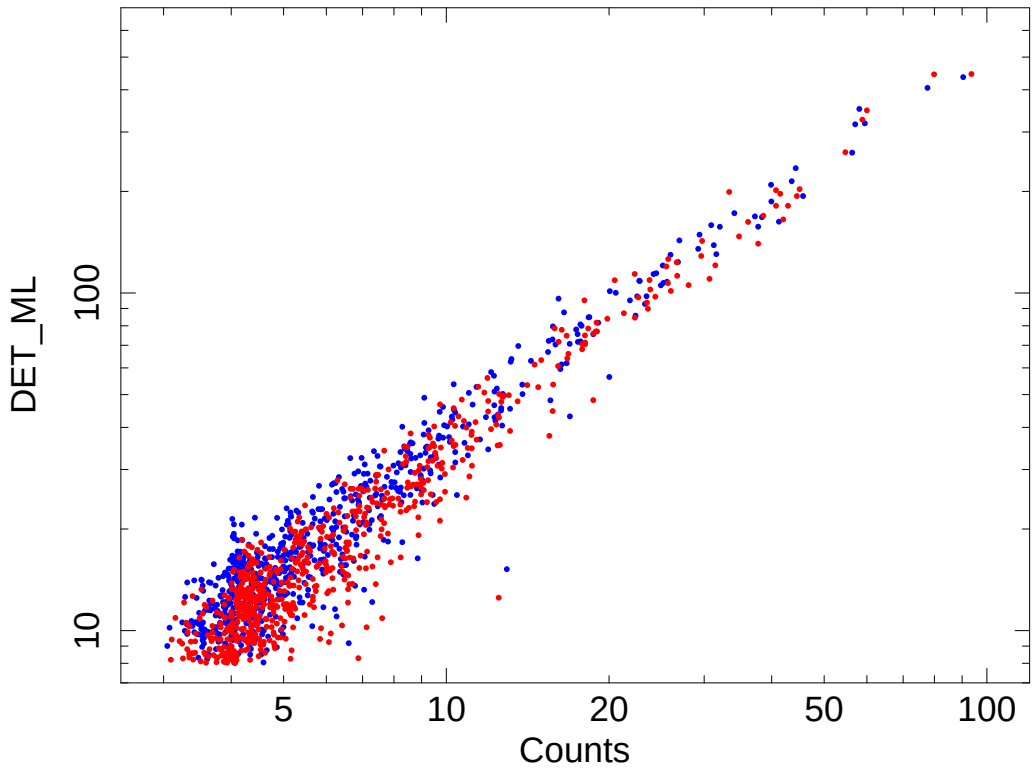

Figure 2: Detection likelihood against counts for sources in the current XMMSL1 slew survey catalogue, parameterised with the ELLBETA PSF (red) and the SLEW PSF (blue).

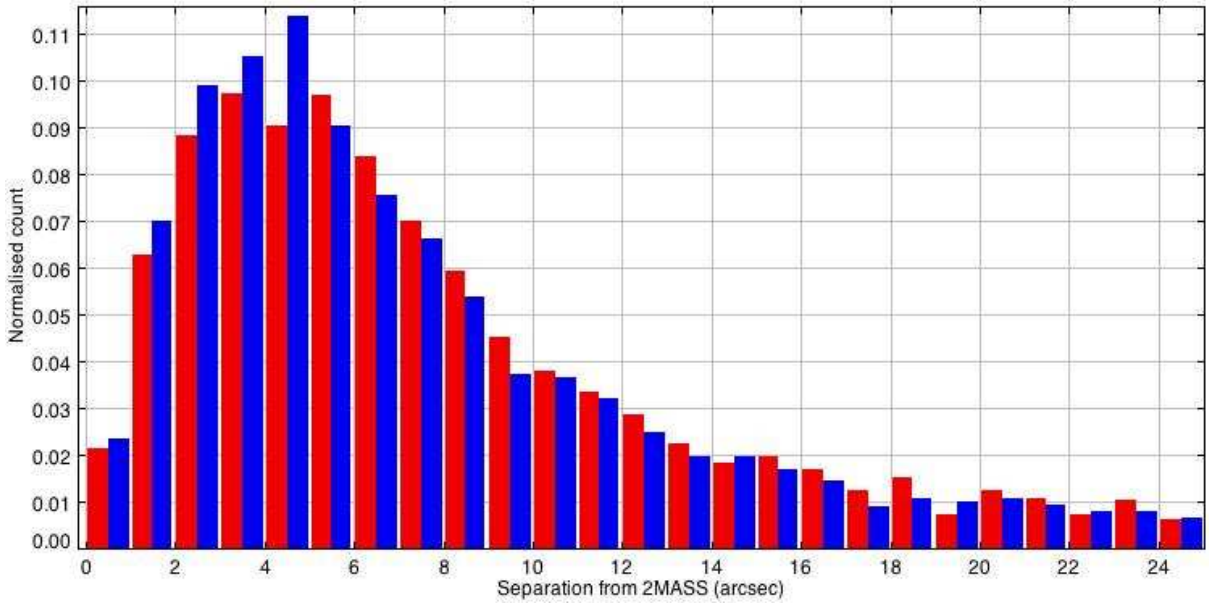

Figure 3: A histogram of the offset of slew sources from 2MASS counterparts. Values from sources in the current XMMSL1 slew survey catalogue, parameterised with the ELLBETA PSF, are shown in red, while source positions from the new catalogue, which is being constructed with the SLEW PSF are shown in blue.

have compared the counts and detection likelihood. Results are shown in Fig. 2; generally higher detection likelihoods are found, indicating a better fit to the real source profile.

To test the fidelity of the source positions returned with the new slew PSF, we have compared the positions with the 2MASS catalogue. A histogram of the offsets from the current *XMMSL1* slew catalogue, which has been generated using the ELLBETA PSF, and a new catalogue generated with the slew PSF is shown in Fig. 3. The median offset with the new processing is 6.0 arcseconds and with the old, 6.5 arcseconds. This improvement cannot be completely attributed to the new PSF and part of it is likely due to changes in the software. It does show, however, that positional accuracy with the new PSF parameterisation is as good as, if not better, than with the previous PSF.

6 Future changes

7 References

[1] Read, A., Rosen, S., Saxton, R. & Ramirez, J. 2011, A&A 534, 34
[2] Saxton, R., Read, A., Esquej, P., Freyberg, M., Altieri, B. & Bermejo, D. 2008, A&A 480, 611