XMM-Newton CCF Release Note

XMM-CCF-REL-0399

EPIC Flare Vignetting Maps

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1 CCF components

Name of CCF	VALDATE	List of Blocks changed	Change in CAL HB
XMM_FLARE_0001.CCF	2000-01-01	INSTRUMENT, BAND, FILTER, ENERGY, FLAREMAP	NO
XMM_SPDETMAP_0001.CCF	2000-01-01	INSTRUMENT, SPDETMAP	NO

2 Initial Release

2.1 FLARE

The FLARE CCF provides a mapping of the vignetting function for the residual soft proton flare emission. This CCF was developed as part of the Extended Source Analysis Software (ESAS), whose functionality is now included within SAS itself. The purpose of the ESAS routines was to provide tools for determining the contribution of various non-cosmic backgrounds/foregrounds, and constructing images of those components so that they may be correctly subtracted from a raw image. This CCF allows the images of the residual soft proton flare emission to be constructed given a measure of the strength of the residual soft proton emission using the SAS routine `proton`.

This CCF contains a vignetting map for residual soft proton emission for each detector in six bands. Each vignetting map is in detector coordinates and was binned as the standard ESAS 780 by 780 pixel image[1]. The band definitions are shown in the table below.

[1] Given that ESAS is intended for faint diffuse emission, there is no need to allow overly small binning of the images. As a result, ESAS relies on all images to be produced either in detector coordinates with evselect parameters `imagedatatype='Int32' squarepixels=yes withxranges=yes withyranges=yes xcolumn='DETX' ximagesize=780 ximagemax=19500 ximagemin=-19499 ycolumn='DETY' yimagesize=780 yimagemax=19500 yimagemin=-19499` or in sky coordinates with evselect parameters `imagedatatype='Int32' squarepixels=yes ignorelegallimits=yes withxranges=yes withyranges=yes xcolumn='X' ximagesize=900 ximagemax=48400 ximagemin=3401 ycolumn='Y' yimagesize=900 yimagemax=48400 yimagemin=3401`.

Band	Energy
B1	0.30-0.75 keV
B2	0.75-1.25 keV
B3	1.25-2.00 keV
B4	2.00-4.00 keV
B5	4.00-8.00 keV
B6	8.00-12.0 keV

Each line in the FLARE CCF consists of the detector, the name of the band, the filter in which the data was accumulated, the energy of the band, and the 780 by 780 pixel flare vignetting map.

Entries with the band name "EX" are the exposure map for the data in a particular filter. While this is true for the MOS data, this is not true for the pn data, due to an error in the original calibration files; this is not currently an issue as the exposure map is never used and was included only for completeness.

The energies listed in the ENERGY column is currently in error; it too is never used and will be corrected in the next release.

The flare vignetting maps were created in 2007 for the MOS and in 2009-2010 for the pn, using the range of obsids used in Kuntz & Snowden 2008, every obsid public before 1 April 2006. Each obsid was processed with emchain (or epchain) and mos-filter (or pn-filter) to determine what part of the observation was unflared (having a rate within 3σ of the quiescent rate) and to form "unflared" images in each of six bands. GSFC in-house IDL code was then used to extract flared intervals having a count rate greater than 6σ of the quiescent rate and to form "flared" images in each of the six bands. The `cheese` routine was used to create a source mask. The contribution of a single obsid to the flare vignetting map would be the flared image from which is subtracted the unflared image scaled by the ratio of the flared exposure time to the unflared exposure time, all multiplied by the source mask. The aggregation of all of the useful obsids into flare vignetting maps was also done with GSFC IDL in-house code.

The amount of data used is shown in the following table:

Filter	MOS1 (ks)	MOS2 (ks)	pn (ks)
Thin	587	772	281
Medium	923	952	232
Thick	117	107	74

This process of constructing the flare vignetting maps was time consuming due to the need 1) ensure that the flare filtering was adequate and 2) ensure that there were no remaining bright sources (such as clusters or SNR) in the FOV. These steps were executed by hand/eye for each obsid.

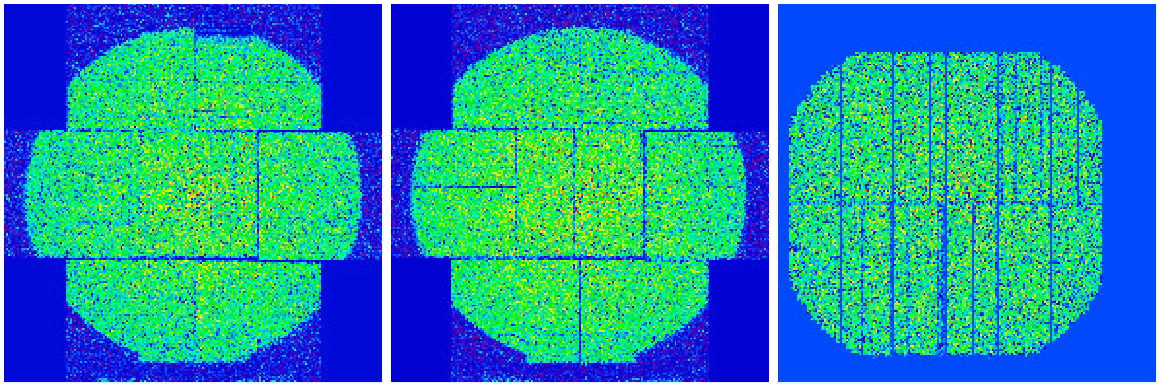

Figure 1: Example vignetting maps, that for the medium filter, and band B3, for MOS1, MOS2, and pn, left to right.

2.2 SPDETMAP

Each line in the SPDETMAP CCF contains a "mean" residual soft proton flare vignetting map for a given detector which can be used to scale a residual soft proton flare rate from one region of the detector to the residual soft proton flare rate from another region using the `protonscale` routine. Since the residual soft proton flare rate must be determined by spectral fitting, it is often determined from only a portion of the FOV; you would not want to determine the *residual* soft proton flare rate from the region including a bright cluster, for example. Thus, with `protonscale` one can use the fit results from an annulus at the edge of the FOV to determine what would have been determined for the full FOV.

The flare vignetting map contained in SPDETMAP for a single detector is the sum, for that detector, over all three filters and bands B1 through B5 (i.e., not including B6). This map is adequate for the scaling because, while the shape vignetting (for a given detector) varies with energy (see Kuntz & Snowden 2008), the overall shape does not depend (much) upon the filter, as one might expect. So, if one determines the normalization of the power law spectrum of the residual soft proton flare emission (necessarily over a wide range of energies), one would want to scale from one region to another using a broad energy band. We have excluded the B6 band (8.0-12.0 keV) as it does not contribute much to the spectral fit of the residual soft proton emission.

3 Scientific impact of this update

This CCF is the initial release for the inclusion of the `proton` and `protonscale` routines in SAS 21. The contents are identical to the mos1-flare.fits.gz, mos1-sp-tot.fits.gz, mos2-flare.fits.gz, mos2-sp-tot.fits.gz, pn-flare.fits.gz, and pn-sp-tot.fits.gz files that were used by the ESAS routines before those routines became part of SAS.

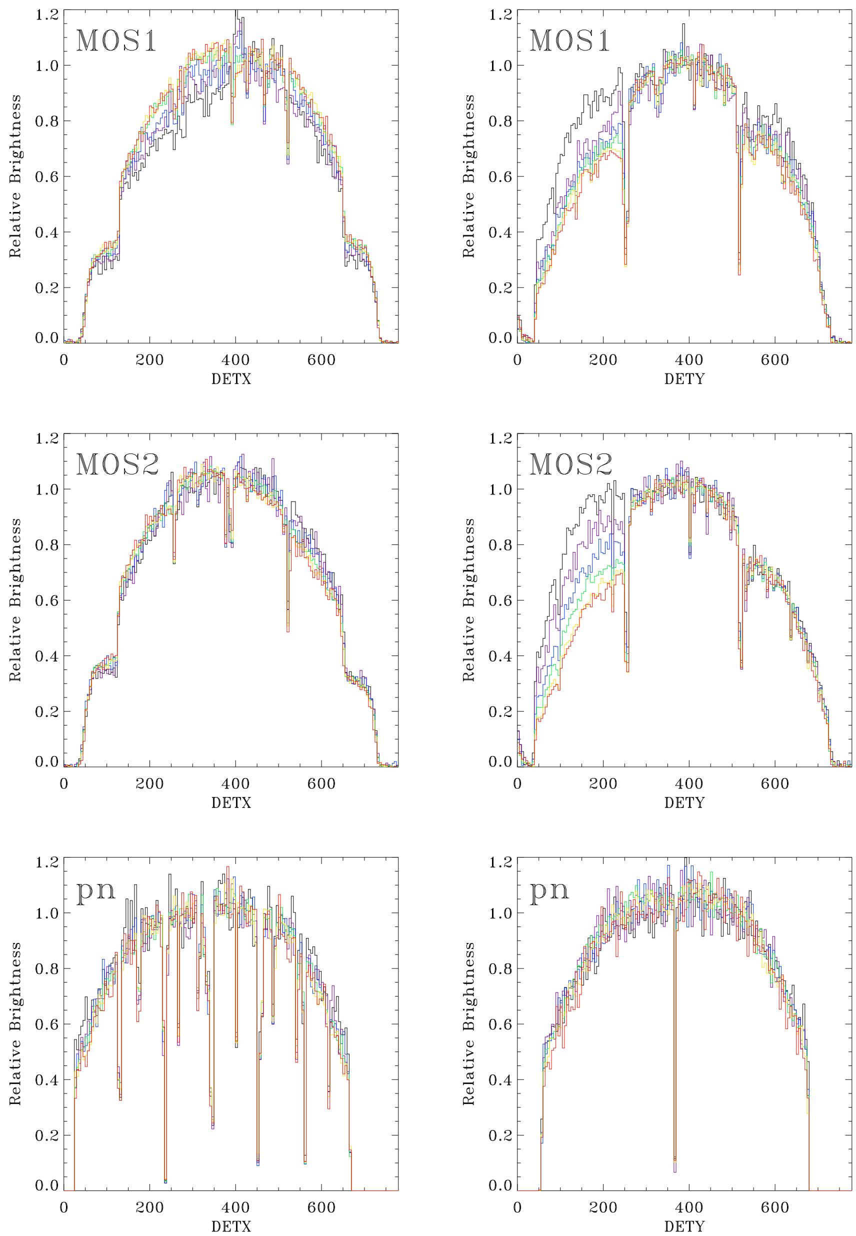

Figure 2: Projections of the vignetting maps in DETX and DETY directions. The bands B1 through B6 are shown in black, purple, blue, green, yellow, and red, successively.

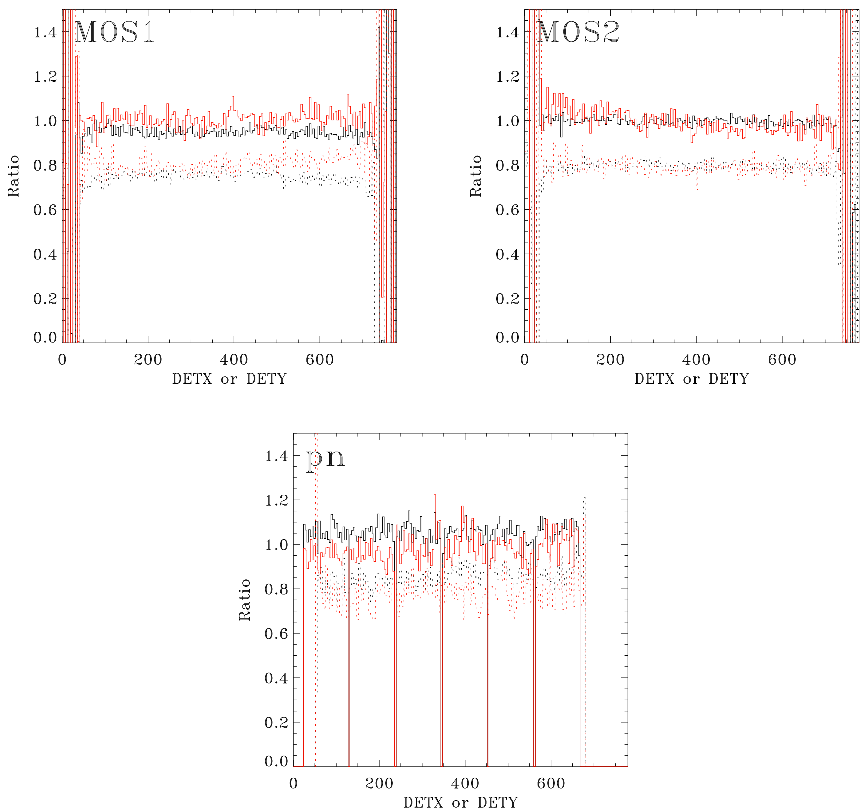

Figure 3: The ratio of the DETX and DETY profiles for Thin/Medium (black) and Thick/Medium (red). The DETX ratio is shown solid while the DETY ratio is shown dashed and lowered by 0.2. In each case we have summed over all bands before taking the ratio.

4 Estimated scientific quality

Not Applicable

5 Test procedure and results

The original vignetting maps were produced for the stand-alone ESAS software. The CCF was constructed from the original vignetting maps. Tests with the new `proton` routine in SAS using the CCF produced the same results as the old `proton` routine in ESAS using the original vignetting maps. The orientation of the maps was a particular problem that should be carefully scrutinized for future modifications.

6 Future changes

This CCF should be updated when the Quiescent Particle Background files are updated. The amount of data available has increased by a roughly a factor of six, which will allow a significant improvement in the vignetting maps. The new `espfilt` routine produces a number of diagnostics to identify obsids with inadequate soft proton filtering, which will allow a substantial reduction in the number of obsids which will require manual checking and removal. Further, if the soft proton filtering of the pn is good, the soft proton filtering of the MOS can be deemed to be good as well. While one can reduce the number of obsids to be processed by removing those containing clusters and large SNR, or made in timing modes, there is still significant manual labour required to screen the images to reduce those with significant remaining source contamination.

A reconstruction of the residual soft proton flare vignetting maps will also allow a revisit of both our understanding of the spectrum of the soft proton flare emission and our understanding of where and when soft proton emission occurs (see Kuntz & Snowden 2008 and Walsh et al 2014).

7 References

Kuntz, K. D. & Snowden, S. L. (2008) A&A 478, 575.
Kuntz, K. D. & Snowden, S. L. (2023) Cookbook for Analysis Procedures for *XMM-Newton* EPIC Observations of Extended Objects and the Diffuse Background.
Walsh, B. et al. (2014) Space Weather, 12, 387.