

XMM-Newton User Calibration Release Note

XMM-SOC-CAL-REL-423 Issue 1.0

OM Photometry. Update of the Time Dependent Sensitivity Degradation.

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Revision history

Revision number	Date	Revision author	Comments
0	Jul 21, 2026	S. Rosen	2026 update
1	Jul 24, 2026	S. Rosen	Added missing component table



1 CCF Components

Name of CCF	VALIDATE	List of Blocks changed	CAL VERSION	XSCS flag
OM_PHOTTONAT_0010.CCF	2000-01-01T00:00:00	EXPDEGRAD		No
OM_PHOTTONAT_0010.CCF	2000-01-01T00:00:00	BORECORRFACORS		No

2 Introduction

With this release of the OM_PHOTTONAT (version 0010) Current Calibration File (CCF), we provide updates for both the general time-dependent degradation of the XMM-OM instrument, and for the extra degradation that affects (mainly) targets observed at the pn boresight position in the OM detector. This new format was introduced for the first time in version 0009 (see XMM-CCF-REL-409 (Rosen, 2024)).

Here, as in version 0009, for each filter, we represent the general degradation trend as an exponential function, which provides a good description of the decline profile.

A further, apparently linear, decline due to additional degradation at the pn boresight, is also measured. The additional correction required, applied specifically to sources at the pn boresight, is derived from the ratio of the exponential general decline to the linear boresight decline, the resulting correction curve in the CCF being characterised by a slowly curving quadratic.

A more detailed description of the analysis for both components of the degradation is given in XMM-CCF-REL-409 (Rosen, 2024).

This new version makes use of measurements of the standard stars up to revolution 4794 and the boresight correction curves are extrapolated to MJD 62451 (11 Nov 2029 or XMM revolution 5468).

3 Results

3.1 General degradation

In table 1, we present the parameters of the simultaneous exponential fits to the measured data of the 3 standard stars, for each filter. Following the fuller description in XMM-CCF-REL-409, the count rate, $R_s(t)$, of star, s , at time, t (MJD), is $R_s(t) = R_s(t_0)[f.e^{-(t-t_0)/t_d} + (1 - f)]$, where $R_s(t_0)$ is its rate at t_0 (the start of the mission, taken as MJD 51544.0), t_d is the decay constant of the exponential (in days) and f is the fraction of the initial count rate that is subject



to decline; $(1 - f)$ is the asymptotic (residual) constant level.

Table 1: Parameters (f, t_d) of the new exponential sensitivity degradation model, for each OM filter, together with R_J (the initial residual fraction of the throughput immediately after rev 3224 cf that immediately before), and the slope (α) parameters of the linear profile that defines the extra degradation at the pn boresight after rev 3224. At time, t (in MJD), $R_J + \alpha(t - t_J)$ gives the residual throughput at the pn boresight, as a fraction of the exponential model at $t_J = \text{MJD } 57951$ (rev 3224).

filter	f	t_d (days)	R_J	α (d ⁻¹)
V	0.1388	1781	0.933	-3.312x10 ⁻⁵
B	0.1195	4974	0.937	-2.562x10 ⁻⁵
U	0.1195	4837	0.950	-2.206x10 ⁻⁵
UVW1	0.1457	3270	0.952	-1.804x10 ⁻⁵
UVM2	0.2414	2765	0.991	-2.313x10 ⁻⁵
UVW2	0.2285	2599	0.964	-2.605x10 ⁻⁵

In figure 1 we show the measured data, in each filter, from the 3 standard stars (normalised by their respective scaling factors, i.e., $R_s(t_0)$) - the data from GD153 were not used for the B, U, UVW1 filters because it suffers substantial coincidence losses ($>$ a factor 2 loss of photons) and although corrections are applied for this coincidence-loss, we have been conservative and excluded those data. The fitted exponential function (dashed black curves) and the previous exponential function (solid orange curves) are overlaid, for each filter. The impacts are discussed later.

It should be noted that all detections in an OM exposure are corrected automatically for the general degradation. The CCF file also contains another extension, DEGRADATION, which simply contains a copy of the quadratic correction coefficients that were used in OM_PHOTONAT_0008. This is included solely to provide backward compatibility for the case where a user employs the new calibration file with SAS 21 or earlier SAS versions (the normal use of the ALGOID keyword in this case, to distinguish between CCF versions or application methods, is insufficient) - it must be emphasized that use of the polynomial functions in version 0008, well beyond the last data points used in their determination (MJD ~ 58000), is strongly deprecated.

3.2 pn boresight degradation

Since the pn boresight, where most targets are placed during observations, lies within the wings of the Jupiter patch (see Sullivan et al., 2024 and also Rosen, 2023), the reduced sensitivity of

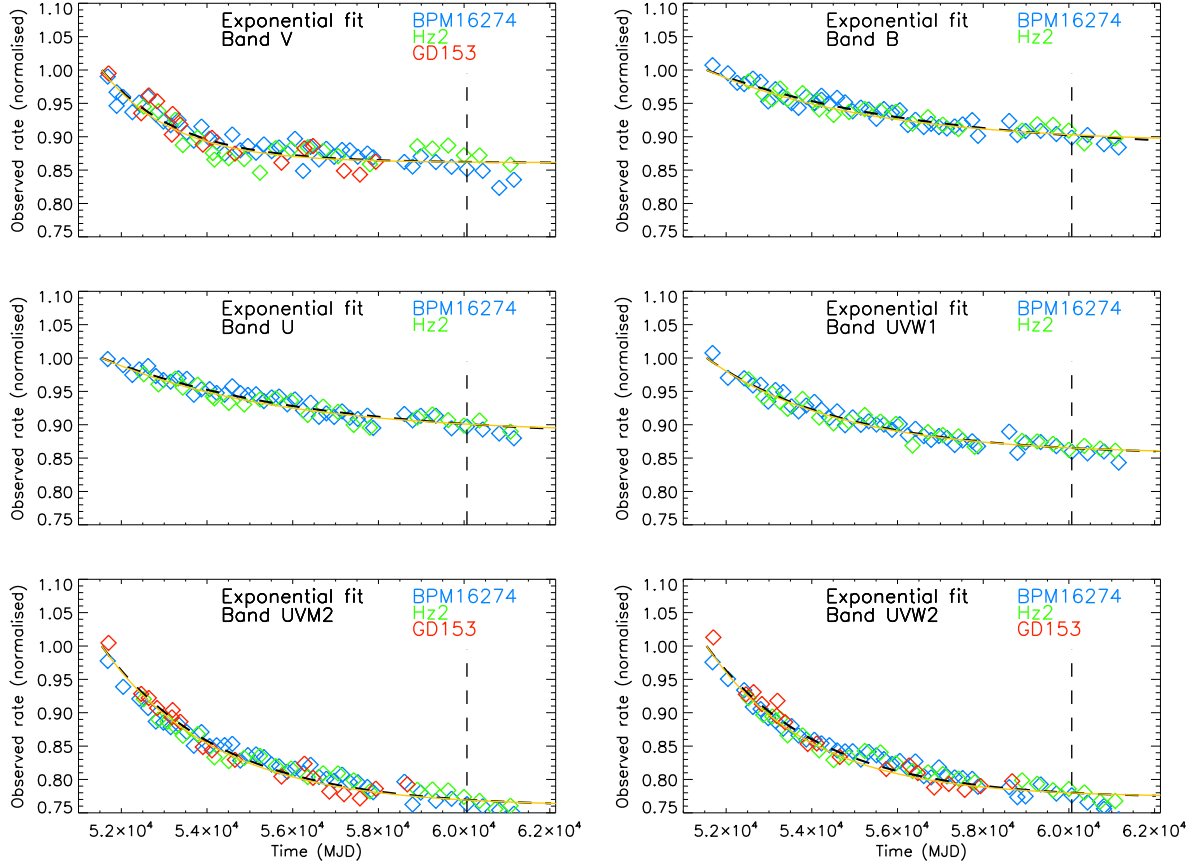


Figure 1: OM time dependent sensitivity degradation of the calibration standard stars in each OM filter (the filter is indicated in the panel). In each panel, the observed data is shown as blue (BPM16274), green (Hz2) and red (GD153) markers. For B, U and UVW1 filters, the data from GD153 are not used in the fitting process because the star suffers from substantial levels of coincidence losses. The black dashed curve shows the exponential model fitted simultaneously to the available data in the filter. The previous exponential functions from OM_PHOTTONAT_0009, are shown as orange curves. Data points to the right of the black, vertical dashed lines are the new points added to the analysis.



the patch reduces further the throughput at the pn boresight. However, the linear decline of the standards when measured at the pn boresight after rev 3224 (the revolution in which an observation of Jupiter damaged the detector), while other measurements of them at other locations in the patch show little decline, suggests there is specific degradation at the pn boresight, probably due to cumulative light damage, as is expected.

For the boresight degradation analysis, we use only the light curve of BPM16274 as it has been observed more regularly than the other two standards. The parameters of the linear function are included in table 1. In figure 2 the uncorrected light curves of each filter from BPM16274 are shown.

It must be emphasized that the additional boresight correction is only applied to detections within 7.5 arcsecs of the pn boresight position. The correction is applied automatically in SAS from SAS22 onwards. Other detections within the Jupiter patch are only corrected for the general instrument decline¹.

4 Scientific Impact of this Update

Since this update yields minor changes in the correction functions of version 0009, we comment only on the scale of those changes - the impact of applying the corrections to the uncorrected data was presented in CAL-SRN-0409 (Rosen, 2024).

4.1 General degradation

A comparison of the new and previous exponential curves shows that they differ by $< 0.7\%$ in all filters, with the largest difference generally near MJD=54000. The small differences between the black (new) and orange (previous) curves in figure 1 demonstrates this graphically. In all cases, the new function is slightly shallower for epochs between about MJD=52000 (revolution 240) and 58000 (revolution 3250). When extrapolated to 2030, the new and previous curves differ by less than 0.004 (0.4%) in normalised rate, for all filters.

4.2 pn boresight degradation

The ongoing decline at the pn boresight continues to show a very linear trend, as seen in figure 2. In most filters the linear decline trends at the pn boresight are very similar to those presented in version 0009, the most deviant being the UVM2 filter where the new fit, at MJD=61162, yields a 2.2% lower rate than the previous linear function. For other filters, the difference amounts to

¹It is expected that a position-dependent correction for the whole Jupiter patch will be available soon

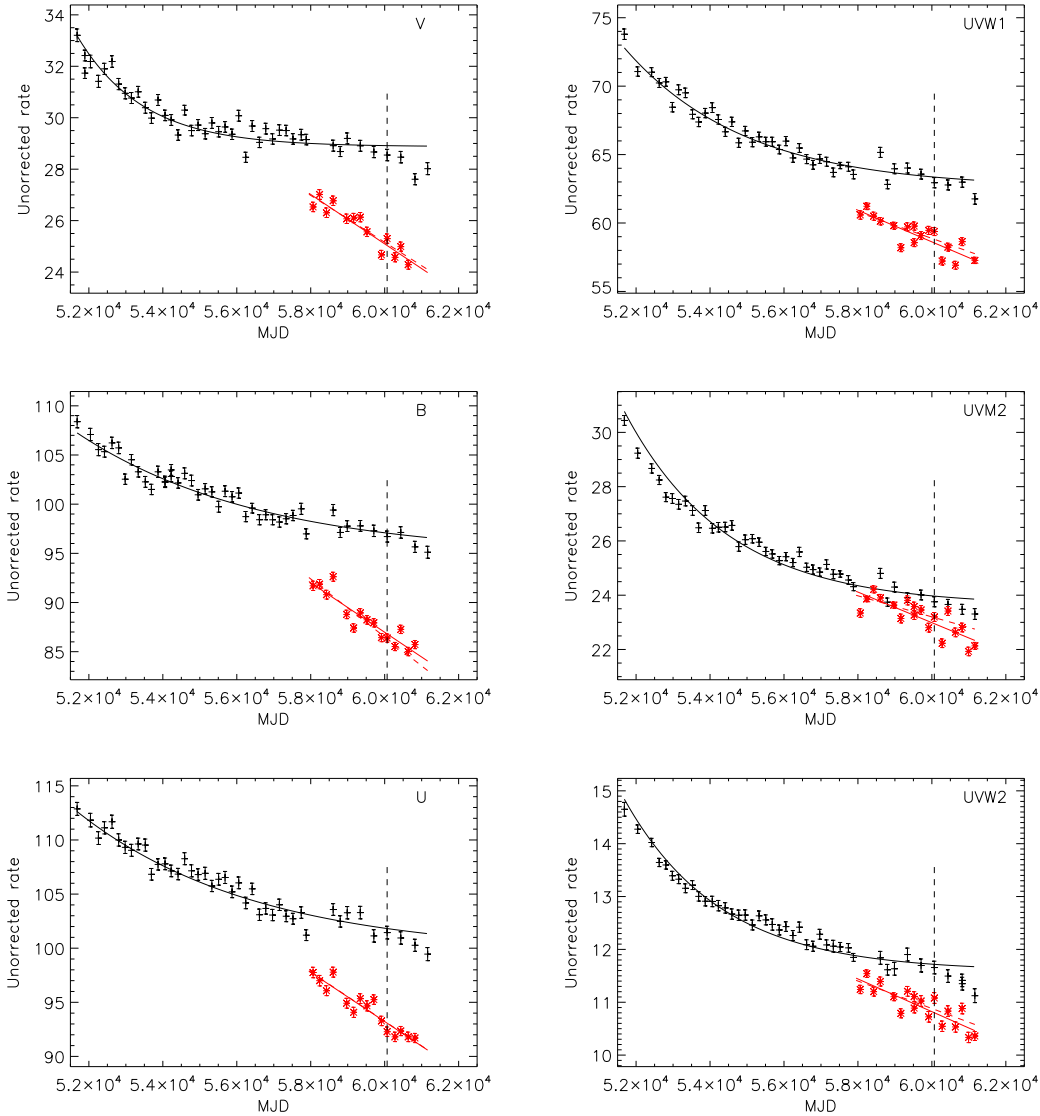


Figure 2: Time-dependent degradation for the various OM filters measured from observations of BPM16274 at the (mainly) OM boresight (before revolution 3224 (MJD 57950)) and offset locations (after revolution 3224) (black points). The black curve is the general exponential decay, scaled by $R_s(t_0)$ for BPM16274. It should be noted that although BPM16274 was generally observed at the OM boresight prior to revolution 3224, available measurements of Hz2 and GD153 observed at the pn boresight are consistent with the trend within 2%. In red we show the count rates measured at the pn boresight after revolution 3224, together with the best-fitting linear function (solid red line); the dashed red lines in each case show the linear fit from the previous 0009 CCF release, for comparison. Data points to the right of the black, vertical dashed lines are the new points added to the analysis.



$\sim 1\%$ or less.

5 Expected Updates

As the general instrument degradation trend changes in the future, a further update of the exponential correction coefficients may become necessary. We note, however, that in all filters, the rate of change in general throughput is now very slow and not expected to change by more than about 2% in any filter up to 2030.

In terms of the pn boresight, we will continue to monitor the decline. Any significant changes in the decline profile will trigger an update of this component of the CCF. As noted in section 3.2, a near-term goal is to produce flat-fields, for each filter, which will enable photometry of all sources in the Jupiter patch, where sensitivity degradation is greatest, to be corrected.



References

- Sullivan, S. et al. 2023, RAS Techniques and Instruments, Vol 2, Issue 1, 673-685: available at:
<https://doi.org/10.1093/rasti/rzad048>
- Rosen, S., 2023, XMM-SOC-CAL-TN-0019, <https://xmmweb.esac.esa.int/docs/documents/CAL-TN-0019.pdf>
- Rosen, S., 2024, CAL-SRN-0409, <https://xmmweb.esac.esa.int/docs/documents/CAL-SRN-0409-1-2.pdf>