XMM-Newton CCF Release Note

XMM-CCF-REL-420

Astrometry: time variable boresight - 2026 update

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1 CCF components

Name of CCF	VALDATE	List of Blocks changed	CAL VERSION	XSCS flag
XMM_BORESIGHT_0036	2000-01-01T00:00:00	OM_ANGVAR EMOS1_ANGVAR EMOS2_ANGVAR EPN_ANGVAR RGS1_ANGVAR RGS2_ANGVAR		No

2 Changes

The XMM-Newton Time Variable Boresight was implemented in 2012. It is described in the release notes XMM-CCF-REL-286 ([1])and XMM-CCF-REL-290 ([2]).

The extrapolations made to derive corrections to the Euler angles based on past data imply that new updates of these corrections may be necessary from time to time. Several updates have been made since 2014, the latest being in early 2025, each update taking into account new data obtained after the previous one. They were implemented in XMM_BORESIGHT_00XX.CCF (XX=24-35), the latest being described in XMM-CCF-REL-414 ([3]).

The existing CCF elements allow an extrapolation of the offset trend to be made but as new observations arrive, after some time we witness systematic deviations from the predicted offsets. Therefore it is necessary to produce a new update using the most recent data.

As previously, we have analyzed the astrometry offsets derived from the pipeline PPS source

Table 1: Best-fit parameters implemented in this CCF.

Instrument/ coordinate	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}
EPIC/Y	+0.52	−0.00024	$+4.61 \times 10^{-08}$	-1.78×10^{-12}		+0.15	−5.91	361.8	−0.09	−2681.26	4660.7
EPIC/Z	+0.26	−0.00093	$+1.95 \times 10^{-07}$	-1.11×10^{-11}		+1.41	−8.71	365.2	+0.25	−308.46	3398.1
OM/Z	−1.58	+0.000996	-5.25×10^{-8}	-1.49×10^{-11}	$+1.26 \times 10^{-15}$	−1.02	−21.60	366.0			
OM/Y	−3.13	+0.00351	-9.13×10^{-7}	$+1.18 \times 10^{-10}$	-5.47×10^{-15}	+0.75	−18.10	365.0			

lists for the EPIC and OM instruments, adding to the previous data set the observations obtained up to 2025 Nov 23 (Rev. 4754) for OM and to 2025 Sep 21 (Rev. 4722) for EPIC. We have modeled the offset variations with time by means of long term variations plus a periodic (nearly one year) oscillation (Talavera & Rodríguez-Pascual [4]). As in XMM-CCF-REL-414 ([3]), for OM the long-term trend is characterised by a 4th order polynomial. The long-term trend in the EPIC data is, as for the last release, represented by a third order polynomial plus a periodic variation with a timescale of order 10 years. The general functional form is

$$\Delta = (P_1 + P_2 \times T + P_3 \times T^2 + P_4 T^3 + P_5 T^4) + P_6 \times \cos[2\pi \times (T - P_7)/P_8)] + P_9 \times \cos[2\pi \times (T - P_{10})/P_{11})]$$

where Δ is the measured offset and T is the time in days elapsed since January 1, 2000 (MJD 51544.0). The new best-fit parameters are given in Table 1.

To avoid large deviations in the extrapolation, for EPIC we have used the IDL function TS_FCAST(X,P,N), where X are the fitted values up to 2025 Sep 21 (rev 4722), and **P=954 and N=477**.

As explained in XMM-CCF-REL-290 ([2]), the same offsets obtained for EPIC can be used to process RGS data.

3 Scientific Impact of this Update

The release notes XMM-CCF-REL-286 ([1])and XMM-CCF-REL-290 ([2]) explain, in detail, the improvements in the astrometry achieved with the Time Variable Boresight.

Although the corrections derived are very small, we annually update the model parameters to minimise the growth of significant deviations in the near ($\sim$ 1 year) future.

We show in Figures 1 and 2 the offsets and the fitted corrections. The differences between XMM_BORESIGHT_0035.CCF and this new CCF can be seen there.

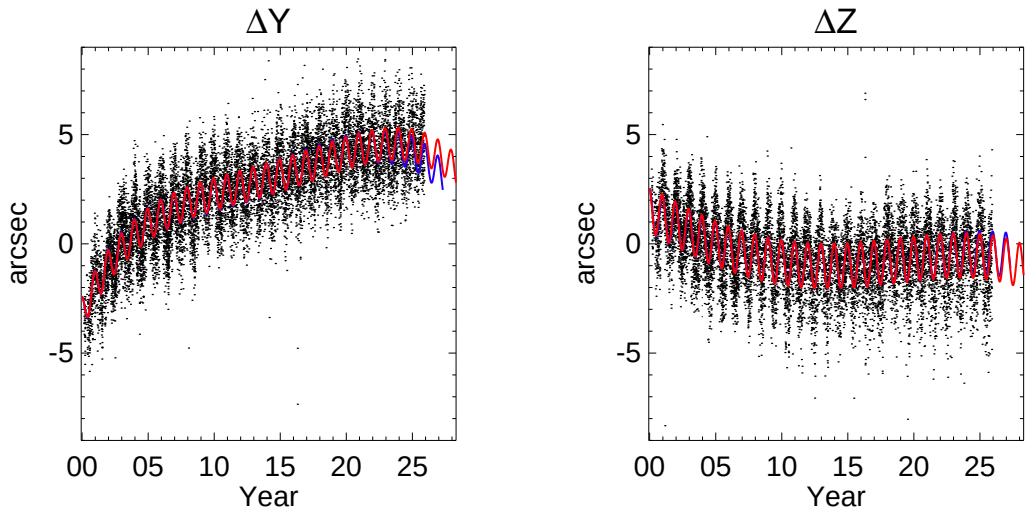

Figure 1: OM measured offsets and fit: in blue CCF_0035, in red CCF_0036.

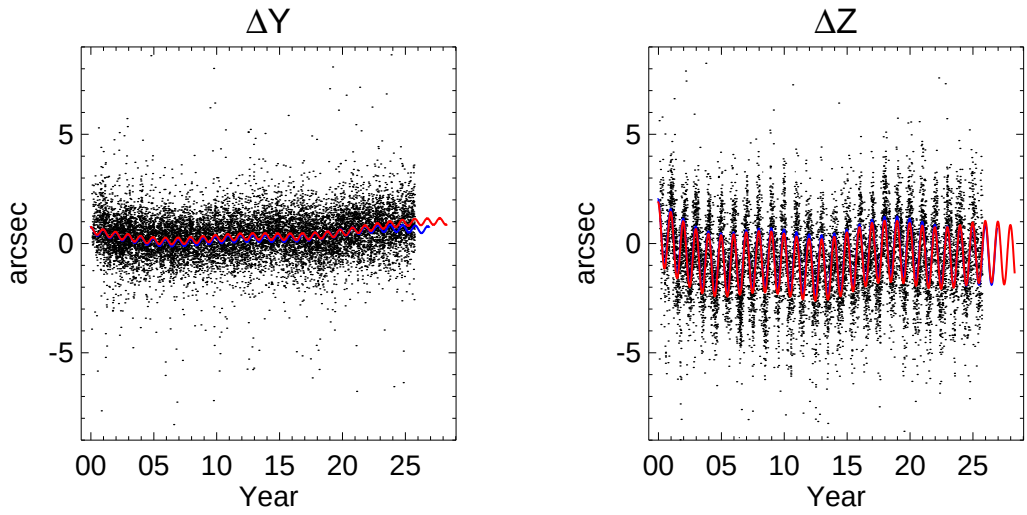

Figure 2: EPIC measured offsets and fit: in blue CCF_0035, in red CCF_0036

4 Estimated Scientific Quality

The quality of the corrections can be assessed by comparing the catalogue offsets obtained with the constant and the new variable boresight. This comparison was presented in the previous release notes, XMM-CCF-REL-286 ([1]) and XMM-CCF-REL-290 ([2]).

5 Test procedures

The concept of time variable boresight and its implementation were intensively tested in their first issue. At that time more than 4000 observations obtained since the beginning of the XMM-Newton operational life were processed with SAS using the new concept CCF.

Since this new release implements just a small increment in the variation of the Euler angles offsets, we have processed a recent ODF to confirm the normal functioning of the related SAS tasks.

6 Summary of the test results

As noted before, the results of extensive tests on the time-variable boresight approach can be seen in XMM-CCF-REL-286 ([1])and XMM-CCF-REL-290 ([2]). For the latest update, the tests are mainly limited to confirming that the new boresight is correctly implemented. We confirm, however, that for the OM, tests with an observation from revolution 3462 yield a difference of < 0.1 arcsecs between the positions of the ensemble of commonly detected sources in the V band image, when using the new (0036) and previous (0035) CCFs. For EPIC, a data set processed from revolution 3600 with the new and old CCFs yields a mean difference of 0.7 arcsecs

7 Expected updates

The fit to the long term trend observed in the measured offsets permits an extrapolation beyond the available data. This update provides offsets until April 2028. However, following our experience these offsets may deviate from the true trend on a timsecale of about a year - we shall continue monitoring the offsets in the future to confirm the predicted trend or to modify the fit as we have been doing with the last updates.

References

[1] Talavera, A., Rodríguez-Pascual, P., & Guainazzi, M., 2012, XMM-CCF-REL-286,

`https://xmmweb.esac.esa.int/docs/documents/CAL-SRN-0286-1-1.pdf`

[2] Gonz ález-Riestra, R., XMM-CCF-REL-290,

https://xmmweb.esac.esa.int/docs/documents/CAL-SRN-0290-1-1.pdf

[3] Rosen, S. & Rodríguez-Pascual, P., 2025, XMM-CCF-REL-414

https://xmmweb.esac.esa.int/docs/documents/CAL-SRN-0414-1-1.pdf

[4] Talavera A., Rodríguez-Pascual P., 2011, XMM-SOC-TN-0041

http://xmm2.esac.esa.int/~xmmdoc/CoCo/CCB/DOC/Attachments/INST-TN-0041-1-0.pdf.