XMM-Newton CCF Release Note

XMM-CCF-REL-375

Astrometry: time variable boresight. 2020 update.

S. Rosen
P. Rodríguez

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1 CCF components

Name of CCF	VALDATE	List of Blocks changed	CAL VERSION	XSCS flag
XMM_BORESIGHT_0030	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 and XMM-CCF-REL-290.

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. Updates were made in 2014, 2015, 2017 and 2018, each update taking into account new data obtained after the previous one. They were implemented in XMM_BORESIGHT_00XX.CCF (XX=24-29), (see XMM-CCF-REL-315, XMM-CCF-REL-330, XMM-CCF-REL-332, XMM-CCF-REL-343, XMM-CCF-REL-351 and XMM-CCF-REL-361).

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, particularly for the EPIC instruments. Therefore it is necessary to produce a new update using the most recent data.

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}
EPIC/Y	$+0.64$	-0.50×10^{-3}	$+1.4 \times 10^{-7}$	-1.1×10^{-11}	$+0.18$	-6.86	362.6	-0.05	$+589.22$	2855.4
EPIC/Z	$+0.30$	-0.77×10^{-3}	$+1.3 \times 10^{-7}$	-4.8×10^{-12}	$+1.35$	-11.76	365.4	$+0.24$	-304.23	3782.1
OM/X	-1.60	$+1.04 \times 10^{-3}$	-1.02×10^{-7}		-1.06	-9.85	364.4			
OM/Y	-2.09	$+1.67 \times 10^{-3}$	-1.24×10^{-7}		$+0.80$	-11.74	364.1			

As previously, we have analyzed the astrometry offsets derived from the pipeline PPS source lists for the EPIC and OM instruments, adding to the previous data set the observations obtained until November 18, 2019 (Rev. 3652) for OM and to December 28, 2019 (Rev. 3672) 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 [1]). As before, for OM the long-term trend is characterised by a polynomial of second order. In this release, the long-term trend in the EPIC data is now represented by a third order polynomial plus a periodic variation with a timescale of order 10 years. The general functional form is

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

where Δ is the measured offset and T is the time in Julian days elapsed since January 1, 2000. The new best-fit parameters are given in Tab.1.

The long-term cyclic component in the EPIC data is of low amplitude (0.24 and 0.05 arcseconds in the Z and Y axes, respectively).

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 December 28, 2019, and P=840 and N=420.

As explained in XMM-CCF-REL-290, 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 and XMM-CCF-REL-290 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_0029.CCF and this new CCF can be seen there.

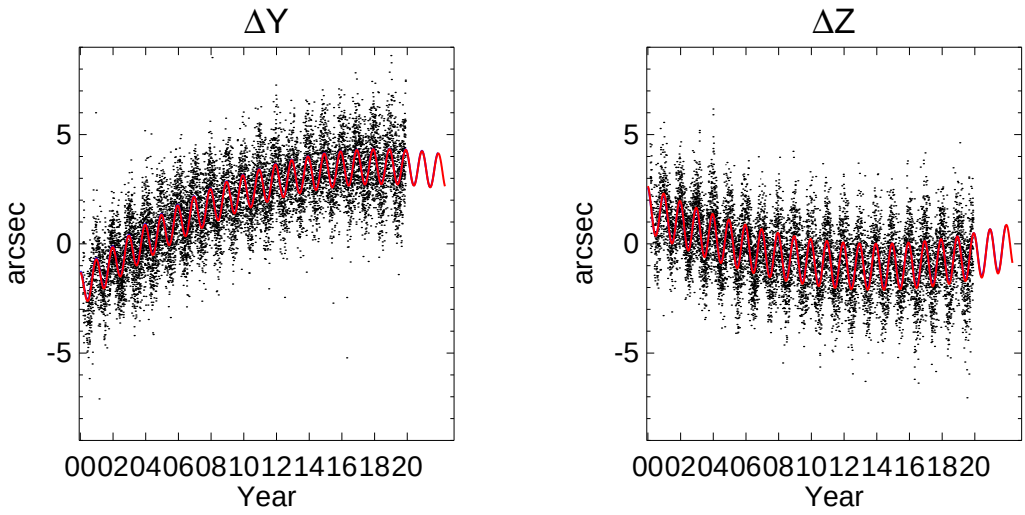

Figure 1: OM measured offsets and fit: in blue CCF_0029, in red CCF_0030

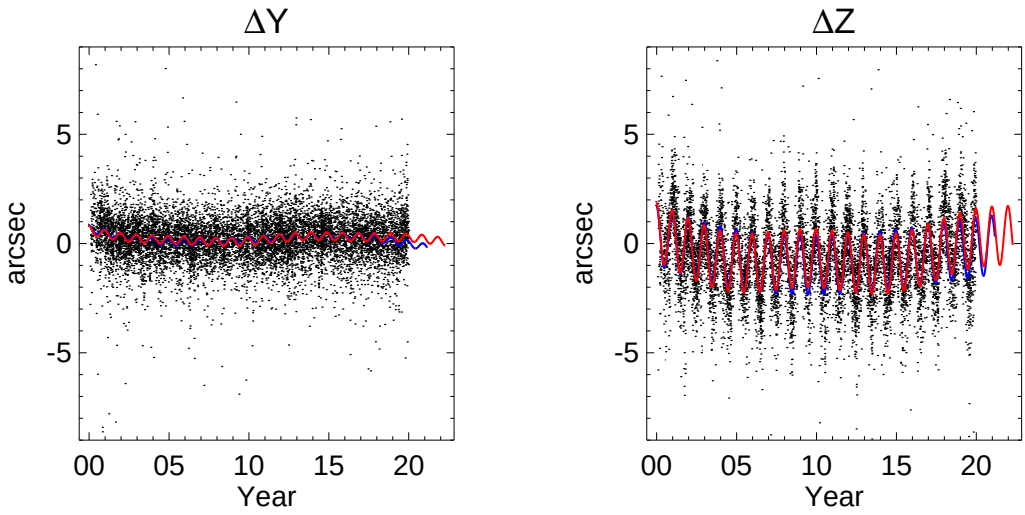

Figure 2: EPIC measured offsets and fit: in blue CCF_0029, in red CCF_0030

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 and XMM-CCF-REL-290.

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 only a couple of recent ODFs 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 and XMM-CCF-REL-290. For the latest update, the tests are limited to confirming that the new boresight is correctly implemented. For the OM, a comparison of the positions of OM sources detected in the same observation using the previous (0029) and new (0030) boresight CCFs, shows them to differ by (generally) less than 0.1 arcseconds, consistent with the small differences between the new and previous OM boresight CCF files. This was confirmed in observations from revolutions 533 and 3462. For EPIC, an observation from revolution 3501 was processed (an epoch where the new and previous boresights differ significantly, by $\sim$0.5 arcseconds) and we observe corresponding shifts in the coordinates of detected source, confirming the new boresight update performs as expected.

7 Expected updates

The fit to the long term trend observed in the measured offsets assumes an extrapolation beyond the available data. This update provides offsets until April 2022. However, following our experience these offsets will deviate from the correct trend in about one year. Therefore 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., 2011, XMM-SOC-TN-0041, available at:

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