**EPIC Calibration Meeting #24**
**Mallorca, 29-30 March 2011**

**Participants** (from the list distributed alongside the meeting agenda)**:** A.Tiengo (AT), S.Molendi (SM), N.La Palombara (NLP), N.Sartore (NS), S.Sembay (SS), A.Read (AR), J. Carter (JC), T. Abbey (TA), K.Byckling (KB), S. Rosen (SR), C.Tenzer (CT), E.Kendziorra (EK), B.Mück (BM), F.Haberl (FH), K.Dennerl (KD), R.Owen (RO), M.Guainazzi (MG), P.Calderon (PC), M.Santos-Lleo (MS-L), I.de la Calle (IC), M.Casale (MC), R.Saxton (RDS), M.Smith (MS), M.Stuhlinger (MSt), C.Gabriel (CG), J. Martin (JM), U.Weissmann (UW), H.Marshall (HM), P. Plucinsky (PP), K. Kuntz (KK)

**Actions from previous meetings**

The minutes of the previous meeting were not distributed before this meeting. A mechanism shall be put in place to avoid this from happening. In the meantime, the deadline of all open actions is automatically postponed to the next one.

**19.1** on **M.Freyberg**: Implement a warning for very bright sources with respect to non-perfect FIFO reset correction
*Status:* CLOSED – 3 SAS-SRC will be submitted following this e-mail from MF
this action is still relevant (I have to admit that I forgot about it) and should be kept open (well, should be closed very soon ;-)
When too many events (>512) are put into the FIFO then it is reset, and this causes a dead time (no new events are recorded). This reset time (mode-dependent) is in some calibration file. However, for very bright sources a FIFO reset may occur during the "recovery time" of a previous FIFO reset and this case cannot be recognized from PNAUX data (etc.) and thus the FIFO-reset related dead time may be under-estimated.
(1) Implementing a proper warning is the simplest solution.
(2) Applying an average "extra" correction value (mode-dependent) for the whole exposure in addition to a warning may be the next iteration.
(3) Finally, one could try to count all events (before any MIP rejection, i.e. only possible for 1-CCD-modes as in the 12-CCD-modes this is already done on board) and to compare with counter values (on 20 frames basis) to get some idea when such multiple FIFO resets could have occurred. I will do at least (1) for the task "epframes".

**20/4** on **M.Freyberg** and **E.Kendziorra**: provide comments to the draft document on the time jump and (MJF only) a specific section in the document under his responsibility. EK committed at the BOC-2010 to propose moving the most important parts of this document into the to-be-written Crab timing paper (lead author: A.Martin-Carrillo)
*Status:* CLOSED – the paper, including an Appendix on time jumps, has been submitted to A&A

**20/8** on **M.Stuhlinger**: Investigate the possible effect of BRAT table to he relative flux normalization between EPIC-MOS and EPIC-pn for MOS Timing Mode observation
*Status:* OPEN

**23/1** on **M.Guainazzi**: prepare skeleton of a Technical Note on the CAL-Thin/CAL-Medium NRCO
*Status:* OPEN

**23/2** on **M.Guainazzi**: change the mode of the CP Vela observation to CAL-Thin (pn), CAL-Medium (MOS)
*Status*: CLOSED – Routine Calibration Plan (RCP) v2.16 implements this change

**23/3** on **M.Guainazzi**: Ask the UG-2010 if an improvement in the accuracy of the energy reconstruction from 10 to 5 eV in EPIC-pn would be scientifically interesting
*Status:* SUPERSEDED – the correction will be implemented in SASv11.5 (see later)

**23/4** on **A.Read**: prepare a Technical Note on the analysis of the correlation between MOS noise

onset and other observables
*Status:* OPEN

**23/5** on **M.Guainazzi**: organize a cross-calibration workshop at ESAC in autumn 2010
*Status:* OPEN – the meeting will be tentatively held in autumn 2011

**23/6** on **F.Haberl/S.Sembay**: present a proposal on calibration papers number, topics and leadership (by UG-2010; drafts by BOC-2011)
*Status:* OPEN

**KD:** ***"Improving the spatial homogeneity of the energy scale in EPIC pn"***

KD has developed a new algorithm to correct spatial inhomogeneities in the EPIC-pn camera, using ground-calibration data as well as data of the RCP observation of the Vela Supernova Remnant. The new algorithm improves the accuracy of the energy reconstruction in imaging modes to about 5 eV (3 ). The algorithm is ready to delivery to the SAS Team. It will be implemented in SASv11.5 (expected to be released in autumn 2011).

**NS:** ***"Long term monitoring of RX J1856.5-3754"***

A systematic analysis of the EPIC-pn observation of RXJ1856.5-3754 has unveiled variations of its spectral parameters. However, current data do not allow discriminating between a dependency on either time or the source position in raw detector coordinates (or intrinsic source variability). In order to settle this issue, the next RCP observation will be performed at different RAWX positions ("raster experiment"). AT will estimate the minimum exposure time needed to achieve a measurement of the source spectral parameters sufficient for the calibration goal. If necessary, the RCP observation time will be extended at expenses of other RCP targets in the 2nd semester 2011 only.

**M.Guainazzi:** ***"Latest news on the EPIC-pn Timing Mode calibration"***

The Rate Dependent CTI (RDCTI) calibration has been refined by increasing the sample of EPIC-pn calibration exposures employed, as well as by using more stringent criteria to select them. The relevant CCF is ready to be released.

However, Sm has in parallel discovered that almost all exposures in EPIC-pn Timing Mode are affected by X-ray loading, even when the count rate is just a few tens counts per second, much lower than predicted. The origin of this problem is unknown. The X-ray loading depends intrinsically on the count rate, and could therefore naturally introduce a rate-dependent effect, that the RDCTI correction may have so far dealt with empirically (and incorrectly, as the energy-dependent of a CTI effect is different from a systematic energy offset due to loading).

Attempts to correct *a posteriori* for the energy scale shift theoretically introduced by X-ray loading failed, because the data do not request a correction as large as the measured X-ray loading would suggest.

It is agreed to ask the User's Group 2011 for an endorsement to undertake a systematic recalibration effort, including a proper correction of X-ray loading. The details of this plan will be discussed in a dedicated meeting between the EPIC-pn Instrument Team and MG, to be held in May.

**B.Mück: *"Blank field background templates for PN-Timing Mode observations"***

About 20 *bona fine* EPIC-pn Timing Mode blank fields have been identified through a systematic search through the XMM-Newton archive. These observations fulfil the following criteria: a) count profile in the RAWX direction consistent with a constant; b) lack of periodic and quasi-periodic variability. In some of these fields weak sources are still present in the simultaneous EPIC-MOS Imaging Mode exposures. The spectra of these sources will be integrated, and subtracted from the corresponding EPIC-pn "black field" spectrum.

After this step is completed, the resulting "blank field" spectra will be analysed to evaluate the possibility of distributing them as an alternative way to calculate the background spectra for highly obscured or steep sources.

**J.Carter: *"Fitting a comet spectrum with a charge exchange model"***

Comets are one of the sites in the solar system where Solar Wind Charge Exchange (SWCX) is likely to occur. Theoretical models of SWCX accurately predict the emission spectrum in terms of a combination of atomic transitions with negligible contribution of an underlying continuum. Hence, comets are potentially promising targets to be used for calibration of the energy redistribution at the lowest energies.

The application of this technique to the spectra of comets observed by the EPIC camera shows significant residuals below 300 eV. This piece of evidence, together with the significant discrepancy between the fluxes measured by the EPIC-MOS and the EPIC-pn camera below 300 eV after the most recent recalibration of the redistribution indicate that the calibration of the EPIC camera should currently be considered reliable only above such an energy threshold. The EPIC Calibration Status Document will be updated to reflect this recommendation.

**R.Owen, *"Study of the EPIC 2D-PSF using bright sources"***

A study of the EPIC PSF has been performed on a sample of bright sources (mainly X-ray binaries) observed by the EPIC cameras in imaging mode. After correction for pile-up, the stacked images were fitted with the 2-D PSF formula, and the best-fit parameters compared to the current (non default) 2-D PSF CCF. The comparison unveiled that corrections to the current model are required in two areas: a) the ratio between the spoke and inter-spoke intensity; b) the radial dependency of the spokes' intensity. They have been implemented.

**A.Read: *"The EPIC PSF"***

Astrometry tests of the 2-D PSF showed a systematic discrepancy between the XMM-Newton EPIC and the SDSS positions on a sample of quasars. The discrepancy exhibits a clear dependency with the azimuthally angle. It has been traced down to a energy- and off-axis dependent "littering" of the centroids of the MEDIUM CCF PSF by as much as ±1 arc second. The origin of this problem is unknown. As the subsequent calibration of the optical system has been based on this unstably centroided PSF, the usage of a properly centroided PSF introduces a systematic error in the position determination. In order to fix the problem, the matrix describing the misalignment between the optical axis of the star tracker and the instruments has to be recalibrated. Work is ongoing at the SOC (RDS) to achieve this goal.

Once the new misalignment matrix is tested and implemented, the 2-D PSF should be offered as a

default mode to SAS users, provided that an adequate level of testing of the encircled energy fraction correction as done by arfgen is performed.

**C.Gabriel, *"SAS and PPS status and future"***

The plan for the next SAS release is presented. The main EPIC-related innovations should be: a) 2-D PSF as default mode; b) pile-up correction library; c) EPIC-pn gain inhomogeneities correction algorithm.

Following the "managed withdrawal" of the U.K. contribution to the XMM-Newton project, the pipeline processing will be transferred to the SOC. It is expected that the transfer will be completed by the end of 2011, with the switch to a fully operational pipeline to be completed by the end of 2012.

**M.Stuhlinger: *"Status of XMM-Newton cross-calibration"***

The light curve of the flux ratios between the EPIC-pn and EPIC-MOS cameras exhibits behaviour consistent with being constant, save a step around the time when the MOS cameras were cooled. The overall calibration status with SASv11 shows a small improvement with respect to previous SAS versions (which did not include the latest refinement of the redistribution in both EPIC cameras). Below 0.85 keV the flux ratio distributions are consistent with 1. At higher energy, the MOS cameras yield fluxes systematically higher than the EPIC-pn by 5-9%. The distribution of the flux ratios in each energy band is ≈3-5%. MSt will check if this with is due to the statistical scatter of the individual measurements.

Spectra in the XCAL database are fit using the $\chi^2$ goodness-of-fit test, and standard XSPEC weighting. It is suggested to perform a test with the C-statistics, which may be more appropriate in the XMM-Newton context.

**S.Sembay: *"Time evolution of the EPIC XCAL"***

Two systematic studies have been recreantly performed at the LUX, which have a direct bearing on the cross-calibration among the EPIC cameras:

- the Mateos' at al (2009) study on the flux ratio has been extended by analysing sample of 2XMM sources selected by chip. While the cross-calibration status for sources sitting on the central MOS chip broadly agrees with the XCAL results, the discrepancy for sources sitting on external chips is ≥10%, and can be as high as 20% at some epochs and for some chips.

- the counts measured in a broad energy band from the calibration source have been measured as a function of time for all EPIC cameras, and their decay curve compared with the expected exponential decay. The agreement between data and prediction is excellent (within statistical uncertainties) for all cameras, suggesting that there is no time degradation of the Quantum Efficiency (QE) in any of the EPIC cameras. The results of this study will be added to the CSD.

**P.Plucinski: *"Recent Updates to the ACIS Calibration"***

The main calibration activities on the ACIS have focused on the implementation of a temperature-dependent CTI correction, and on the Continuous Clocking Mode (the equivalent of the Fast Modes

in EPIC). The thermal state of the spacecraft is continuously monitored, and constraints the *Chandra* visibility windows.

**H.Marshall:** ***"10 yr of Chandra/XMM-Newton Cross-calibration: Are we done yet?"***

Various projects in the framework of the IACHEC provide a rather consistent picture of the cross-calibration status among various missions. While this is reassuring (and useful for the users' community), there have been little improvements in understanding the origin of the remaining discrepancies, which are at the level of ≈15% in terms of hard X-ray measured flux between ACIS and EPIC-pn above 2 keV, and a differential 20% discrepancy in the same instrument between 0.5 and 2 keV. The agreement between the *Chandra* gratings and the EPIC cameras is ±10%

**S.Molendi:** ***"Clusters as calibration tools"***

A systematic study of the cross-calibration status among the EPIC cameras using 16 galaxy clusters suggests that the apparent discrepancy in cross-calibration at high-energy between EPIC-pn and EPIC-MOS could be actually due to a discrepancy at the peak of the effective area in both camera, which drives the fit. Tests will be performed on changing the effective areas around the instrumental edges to evaluate its bearing on the high-energy cross-calibration.

**Open discussion**

The following lines of action for the next year have been identified in different areas (in bracket the initials of the Team member/group primarily responsible for the task):

- EPIC-pn Timing Mode:
  - Recalibrate the mode after performing a proper correction of X-ray loading (MG)
  - Calculate the residual source contamination in blank fields to achieve a final *bona fide* set (BM)

- PSF:
  - Test the new misalignment matrix (SSC/SOC)
  - Test the encircled energy correction, and its impact on the cross-calibration in XCAL (SOC)
  - Code the new spoke intensity and radial dependence thereof in the SAS (RDS)

- EPIC-pn:
  - Implement KD's spatial inhomogeneity gain correction algorithm (SAS)
  - Analyse the 6keV resolution in imaging mode on astrophysical target (MSm)

- EPIC-MOS:
  - Refine the redistribution for MOS2 in the latest epoch (SS)

- Documentation
  - Publish study on pile-up in EPIC-pn Timing Mode in TN-0083 (MG)
  - Publish LUX's study on the QE stability in the CSD (MG)

- XCAL
  - Evaluate the effect of 2-D PSF on the cross-calibration among the EPIC cameras

(MSt)
    - Improve the XCAL spectral extraction algorithm by imposing the same radius for the extraction of spectral products in each source (MSt)
    - Play with the calibration of the edge depths in both EPIC-MOS and EPIC-pn to try and achieve a local improvement of the cross-calibration in the energy range around 1.5-2 keV (FH, SS), which may positively reverberate at higher energies

**New actions:**

- **24/1** on MG: distribute the EPIC-BOC minutes one month after the meetings
    - *Deadline:* 1 May 2011
- **24/2** on SS: make sure that the Action 24/1 happens
    - *Deadline:* 2 May 2011
- **24/3** on MG: write 3 SAS-SCR on M.Freyberg's FIFO correction for bright sources
    - *Deadline:* 31 August 2011
- **24/4** on MG: write SAS-SCR to implement KD's EPIC-pn spatial-dependent gain correction
    - *Deadline:* 31 August 2011
- **24/5** on AT: estimate the minimum RXJ1854 exposure time to get meaningful measurements of its spectral parameters
    - *Deadline:* 31 May 2011
- **24/6** on MG: propose an update of the Routine Calibration Plan to accommodate the raster observation on RXJ1856-3754 as well as a cycling filter observation on either RXJ1856-3754 or PKS2155-304
    - *Deadline*: 31 May 2011
- **24/7** on MG: propose an NRCO on offset map calculation in EPIC-pn Timing Mode
    - *Deadline:* 31 July 2011