Minutes of the EPIC Calibration Meeting
Majorca, March 30-April 1, 2009
Participant list: Anthony Abbey (AA), Ulrich Briel (UB), Jenny Carter (JC), Hubert Chen (HC), Konrad Dennerl (KD), Carlos Gabriel (CG), Matteo Guainazzi (MG), Frank Haberl (FH), Eckart Kendziorra (EK), Marcus Kirsch (MK), Kip Kuntz (KK), Herman Marshall (HM), Jim Martin (JM), Paul Plucinsky (PP), Andy Read (AMR), Pedro Calderón Riano (PCR), Maria Santos-LLeo (MSL), Richard Saxton (RS), Steve Sembay (SS), Michael Smith (MS), Tao Song (TS), Andrea Tiengo (AT)

List of Actions:

14/1 on RD, MK, MJD: Additional time column with other 0 point for OHL
STATUS: CLOSED
CLOSURE NOTE: Implemented in the SAS

17/8 on SS: Calibrate Pattern 0 for 3x3 mode
STATUS: CLOSED
CLOSURE NOTE: Once the slew mode is not going to be implemented, the main motivation behind this mode has faded away. Effort to calibrate it is no longer deemed worth.

19/1 on MJF: implement warning for very bright sources with respect to non perfect FIFO reset correction
STATUS: OPEN [MG will contact MJF for clarifications]
CLOSURE NOTE:

20/1 on MG: prepare a update of the pn CTI CCF with a new extension for the parameters of the special FF gain correction
STATUS: CLOSED
CLOSURE NOTE: Submitted to the SAS-CCB on March 11; final approval pending minor comments by M.Santos-LLeo

20/2 on MG: write a SAS SCR describing MK software to identify time jumps not detected by the SAS, with the ultimate goal to correct for all of them
STATUS: CLOSED
CLOSURE NOTE: Approved by SAS-CCB on January 15, 2009

The algorithm discussed by Kirsch et al. (2009, XMM-SOC-CAL-TN-0071) to identify uncorrected time jumps should be implemented in the SAS. A warning should be issued whenever a time jump is encountered. In a nutshell, the algorithm can be summarized as follows:

1. calculate for each event the difference between its the arrival time and the arrival time of the previous one (DISTANCE)
2. calculate for each event the modulo between DISTANCE and the frame time (DELTA)
3. correct DELTA for the effect of oscillator temperature drift. The correction term is calculated through a linear fit of the DISTANCE versus DELTA data points in a given exposure
4. whenever DELTA>TOL a time jump warning is issued, where TOL=22/48828.125/FT (calculation to be performed in double precision), and FT is the (mode-dependent) Frame Time

Ideally, SAS should be able to correct for these remaining time jumps. However, for the time being, their origin is generally unknown, and therefore no further correction can be applied.

20/3 on CG: contact MJF to clarify whether any strong reasons exists, vetoing the extension of time randomization in SAS to the pn
STATUS: CLOSED
CLOSURE NOTE: Time randomization implemented in SASv8.0

20/4 on MJF and E.Kendizorra: to provide comments to the draft document on the time jumps, and (MJF only) a specific section of the document under his responsibility
STATUS: OPEN [MG to send a reminder to MJF and EK]

20/5 on MG: modify the NRCO procedure to include the notification to the Instrument Team by the Calibration Scientist of the scheduling of an NRCO observation
STATUS: DONE
CLOSURE NOTE: New step added to the procedure as of March 28, 2009. A PDF file with the instrumental configuration will be sent to the Calibration Scientists and the Instrument Team after submission (and before scheduling!)

20/6 on UB: review the pn configuration of the Tycho observations in the routine calibration plan
STATUS: CLOSED
CLOSURE NOTE: A change of the pn mode to LW has been implemented in the plan, and will be operation as of the second semester of 2009.

20/7 on SS and UB: review the sources in the routine calibration plan to see whether for any of them observations in source+calibration source mode would be advisable
STATUS: CLOSED
CLOSURE NOTE: No change needed

20/8 on MSt: investigate on the possible effect of the change of BRAT table to the relative flux normalization between MOS and pn for MOS Timing Mode observations
STATUS: OPEN
CLOSURE NOTE:

20/9 on MG: change the MOS cameras instrumental mode of the Crab routine calibration plan to Timing mode
STATUS: CLOSED
CLOSURE NOTE: effective as of the 2nd semester 2008

20/10 on MG: contact MJF on Calibration Objective 5 (“Spatial exposure correction for pn”
STATUS: CLOSED
CLOSURE NOTE: E-mail from MJF

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the task "epframes" computes for each quadrant separately the time-
resolved exposure (column FRACEXP in the EXPOSURE extensions), and
this includes dead-times due to MIP rejection and FIFO overflows.
Spatial exposure correction is currently only on quadrant level
e.g. if a quadrant is in counting mode (handled via GTI).

The basic assumption is, that exposure losses are spatially homogeneous
over one quadrant (as quadrants are quasi-independent detector units).
This is not fully true. Columns rejected in the MIP suppression scheme
(on-board) do show some spatial variations, mainly for 3 reasons:

- the MIP rejection scheme itself has CCD boundary effects
- some noisy or bright pixels may emit charge above the MIP trigger
  threshold of 3000 ADU (~15 keV)
- extremely bright (and hard) sources may due to pile-up accumulate
  charge in a pixel (core of PSF) above the MIP trigger threshold
  ("pseudo-MIPs", Elisa Costantini had also worked on this, and the
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  PN masked mode has also been introduced for this reason).

When a charge above 3000 ADU is recorded in a pixel in a readout frame
then the CCD column of this pixel and 1 (or 2 in the beginning of the
mission) columns to either side in this CCD are rejected onboard, and
the occurrence of these rejections is accumulated in the DLI files
over the whole exposure (no temporal information, only the total
number in 20 frames in the PNAUX2 extension via NDSCLIN counters).

The idea is to use/analyse the DLI files in the task "epexposure"
and propagate the relevant information to the tasks "eexpmap" and
"arfgen", for spatially correct maps or effective areas.

The interface from "epexposure" is ready, I am working on the interior.
I do not know whether "eexpmap" and "arfgen" are already able to read
this information (relative exposure of a column in a quadrant) in the
event file extensions (DLIMAP DLIEXPCO).

[...]

I plan to have this fully ready by the end of the year ("arfgen" and
"eexpmap" are independent of this progress, as the current information
in the DLIMAP DLIEXPCO data keeps the "old" behaviour for backward
compatibility).
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Guainazzi: Post rate-dependant CTI EPIC fast mode calibration status

In December 2008 the pn rate-dependent CTI CCF was delivered. Following a recommendation by the XMM-Newton Users' Group, a systematic assessment of the spectral quality in pn fast modes has been performed, using the whole ensemble of observations available in the XSA as of March 2007 (sample still defined by M.Kirsch). The scope of the study is to compare the centroid energies of emission and absorption lines observed in astrophysical sources (corrected for intrinsic kinematic shifts whenever this measurement is independently available) with laboratory energies. The results of this comparison can be summarized as follows:

- in Timing Mode below ≈2 keV, the difference is ≤20 eV. Most of the measurement in this energy range are based on observation of the SNR CasA and N132D, which are slightly extended. This may yield to a not perfect CTI correction. The aforementioned bound is therefore to be considered as an upper limit. Work is ongoing to extend the sample to a couple of active stars observed early in the mission
- in Timing Mode around 6 keV regime the scatter is significantly larger (±50 eV, and occasionally larger)
- in Burst Mode, measurements of the FeXXV resonant absorption line in GROJ1655-40 suggest a good agreement with the astrophysical expectations

Although it is unrealistic to aim at a spectral accuracy comparable to that achieved for imaging mode (±10 eV), it is worth to pursue the goal of improving the quality of the energy reconstruction, especially in the 6 keV band in Timing Mode where important astrophysical lines are present. The strategy which will be developed in the next months to achieve this goal will be based on the following points:

- Re-calibration of the rate-dependent CTI correction with SASv9.0, where a bug in the calculation of the PSF encircled energy fraction in `arfgen` (see R.Saxton's talk) is expected to be fixed
- Expansion of the sample used for the calibration of the rate-dependent CTI, which may also allow to unveil possible time-dependent effects
- Recalibration of the Timing Mode pattern fraction

- Inclusion of an energy-dependent term in the rate-dependent CTI correction
- Study of a possible observation-based rate-dependent CTI correction

An assessment of the spectral quality has been also performed (following another independent recommendation of the Users' Group) for observations where the MOS camera is used in Timing Mode. The results of this assessment, based on the comparison of emission line centroid energies measured in CasA and N132D against the same measurements obtained in simultaneous pn or MOS exposures in imaging modes suggest an accuracy better than 20 eV.

Two documents summarizing the results of this analysis have been publicly available as of April 2009.

Dennerl: Update of EPIC-pn long-term monitoring

The loss of contact with the spacecraft did not yield any effect on the CTI.

The evolution of the CTI with time continues along the extrapolation of the parabolic function measured so far, although the latest measurements suggest that a combination of two linear trends fits more appropriately the data. Similar conclusions apply to the evolution of the energy resolution,

The dimming of the calibration source is the main limitation is the accuracy of the measurements. 30 ks at the beginning of the mission yielded a number of counts comparable to 300 ks now. That's the main driver behind the attempt to find an alternative source of CTI/resolution measurements.

Dennerl: Low energy calibration with the Vela SNR

12 long Full Frame observation of the Vela SNR have been performed between 2001 and 2007. The source illuminates the whole detector in a fairly homogeneous way. Its spectra exhibits a strong OVII line (triplet).

Thanks to the excellent statistical quality of the data, the whole EPIC-pn field of view could be divided in 422 fields, having each approximately the same counts. Fitting the spectra in the 0.43-0.74 keV with a combination of a phenomenological continuum and a combination of Gaussian lines to account for the OVII He-α triplet and the Ly-α OVIII lines yield a rather homogeneous energy scale (±10 eV). However, a ring-like pattern in the energy scale pseudo-image is also visible, most likely associated with the ventilation hole in the circuit board.

These results are a part of a three-step recipe to correcting spatial inhomogeneities in the energy scale:

correct errors in the energy scale due to errors in the offset maps (done now via the SAS task `epreject`)
correct column gain variations (implemented)
correct CTI changes due to residual light through the ventilation hole

Dennerl: Update on pn noise suppression

The method currently implemented for the suppression of pn low energy noise (`epreject`) is based on the spatial and spectral characteristics of these events. However, these properties are time-dependent. It is rather complex to include explicitly this time-dependency in the currently existing SAS task.

An alternative approach is being studied: entirely removing “noisy” frames, whose counts exceed a threshold determined on the basis of the Poissonian noise distribution. First tests are promising.

A prototype code implementing this correction has been developed, and is currently under testing both at MPE and at the SOC. The suggested implementation consists in applying a noisy frame filtering step on the final calibrated event lists. This would only require maintaining the `rawevent*.dat` uncalibrated event lists produced after the `badpix` stage up to the end of the pn processing pipeline. The calibrated event list would be filtered with a GTI determined by the new task `(“epnoise”)` on the basis of the uncalibrated event list.

Haberl: Using RGS line-rich spectra to calibrate the spectral re-distribution of epic-pn

The redistribution parameter are being refined, using RGS-based models of deep observations of line rich sources: a) 1E0102.2-7219 (especially strong and well separated O and Ne emission lines); b) Zeta Puppis (strong N lines); c) Comet C/2000 WM1 (strong N and C lines). The recalculation of the redistribution matrices yield significant improvements in the spectral fit quality at low energies in the above sources, as well as in a certain number of other continuum spectra sources such as MS1229.2+6430 and H1426+428. On the other hand the fit on RXJ1856.5-3754 worsens. This is not entirely surprising, because the spectrum of this very soft source was used to calibrate the current public matrix.

Carter: PLOTOBS - A visualisation tool for monitoring instrument health

A new tool is being developed at LUX to visualize the effects of different screening criteria on various scientific products (images, spectra, light curves, E4 maps, and the corresponding histograms).

Chen: Low energy noise on the MOS CCDs

MOS2/CCD5 shows an increase frequency of high-noise intervals. A similar phenomenology is being observed – at a lower frequency – in other MOS CCDs. The only solution so far (implemented as of SASv9.0) is to remove the noisy events (mostly concentrated below 1 keV), which unfortunately yields a significant loss of exposure time for sources lying on the affected CCDs.

The cause of this noise is currently still unknown. A series of correlations between E_i energies were presented, which, however, do not provide the ultimate clue on the origin of the problem. The problem seems to be related to the read-out amplifier circuit. The onset of this noise could be therefore related to the readout sequence. An experiment will be performed to restart the sequence in the middle of an observation, to see whether this leads to the disappearance of the noise.

Sembay: A phenomenological approach to the MOS detector response

A new descriptive model of the MOS redistribution is being developed. The main aim of this model is to be computationally quick enough to allow a good sampling of the parameters space potentially affecting the spatial and temporal variation of the MOS redistribution.

The model has been devised after a re-analysis of the ground calibration campaigns data. Assuming the standard deconvolution of the redistribution into a “main” and a “loss” peak, the following empirical relations have been discovered:

- The position of the loss peak relative to the main peak (hereafter E_{peak} parameter) is constant with energy (at least above ~300 eV)
- The strength of loss peak follows a simple exponential relation with energy.
- The normalisation of this relation is correlated with E_{peak}

In this simple descriptive model, a single parameter, $E_{peak,}$ defines the position and strength of the loss peak as a function of energy.

On the basis of the above pieces of evidence, a phenomenological description of the redistribution shape as a function of energy has been developed, which required only four free parameters: E_{peak}, the width of the main peak (with its usual dependence on the squared root of the energy), and an overall normalization factor. First results of the application of this new approach to three spectra of 1E0102.2-7219 taken at difference positions with respect to the "redistribution patch" are very promising, both in terms of the overall fit quality and of better residuals red-wards the Oxygen lines complex (more in A.Tiengo's talk later).

The usage of cometary spectra to nail down the redistribution at energies lower than 300 eV is also under investigation.

Tiengo: Monitoring the MOS redistribution using the SNR 1ES0102.72

The new phenomenological model of the MOS redistribution matrix presented by Sembay has been applied to all the observations of 1ES0102.2-7219 performed so far by XMM-Newton. Again, the IACHEC model has been applied, allowing only the normalization of the four brightest lines in the SNR spectrum (OVII, OVIII, NeIX, NeIX), an overall normalization factor, and a linear gain shift (`gain fit` command in XSPEC) to vary as free parameters in the fit. The results are very promising. The main improvements can be summarized as follows:

- overall residuals against the best-fit model in the 0.2-0.5 keV band are strongly reduced
- the value of E_{peak} discriminates well early (pre-cooling), on-patch, and off-patch observations
- the best-fit normalization of the O and Neon emission lines agree significantly better between the MOS1 and the MOS2 with the new matrix
- the best-fit width of the Oxygen lines decreases significantly with the new matrix (the same effect is visible for the Ne lines, however at a lower level). The resolution is stable with time
- the parameters of the gain shift applied to the RGS-based model are closer to nominal "no shift" values (the new redistribution matrix seems to correct the gain as well)

Read: Update of the XMM-Newton EPIC PSF

The development of the new 2-D PSF is at a rather advanced stage, based on the ingredients already presented in previous meetings. The status can be summarized as follows:

- the parametrization of the elliptical envelope in `arfgen` has been included in SASv8.0 (non-default mode), and tested on a sample of the 24 brightest off-axis (5' to 12') 2XMM sources. The results of this test are inconclusive due to the small dimension of the sample; however, they seem to suggest a decrease in the discrepancy in the highest energy band (>4.5 keV) with respect to the results published by Mateos et al. (2009)
- the full 2-D PSF parametrization will supported by the CAL in SASv9.0
- testing will be performed both at the SOC (elliptical envelope on the same sample as above and on bright on-axis blazars in the cross-calibration database) and by SSC (source detection)

Saxton: Timing Mode PSF

A bug has been discovered in the `arfgen` algorithm for the calculation of the encircled energy fraction with the PSF in Timing Mode. This bug may produce estimates of the flux when the central column around the boresight are excised as large as 50% (for a total number of excised columns of 9).

A new algorithm has been developed, and will be integrated in SASv9.0. First results show that ±10% energy-dependent effect (in terms of flux discrepancy against the determination of the flux from the whole PSF) may still be present. This may have a not negligible impact on the determination of iron line emission line centroid energies (≈100 eV) when a large number of columns are excised. First tests on various observations of Mkn421 in Timing Mode indicate that within 3 excised columns the flux variations are limited to 15% without a measurable effect on the spectral shape.

Song: Update of image deconvolution software

A SAS task (`psfgen`) is currently available to retrieve the PSF at a given position on the detector or from an image generated via `evselect` or `xmmselect`. This task is complementary to `calview`, because it allows a number of features not included in the existing SAS calibration viewer, such as: a) arbitrary PSF size; b) multiple energy PSF and energy weighting; c) self-centring; d) command-line input parameter specification.

An improvement of the image deconvolution software is being developed, based on `psfgen`.

Plucinsky: Recent Updates to ACIS operations and calibration

Operation-wise, the main news is a significant decrease of the focal plane temperature due to the DH heater switch off. The number of post-switch off observations, whose temperature is above the FI limit is only 2%.

With respect to calibration, the main activities are in the following fields:

1. Calibration of less-frequently used ACIS modes
2. Temperature-dependent CTI correction for FI and BI CCDs
3. 1E0102 fits with new HRMA effective area and proposed revision to the ACIS contamination model (see Marshall's presentation)

Marshall: Chandra HRMA effective area update and the implications for cross-calibration

A new model for the HRMA overlay has been released in October 2008, primarily motivated by measurements in the grating XRCF data and by the difference in the cluster temperatures between ACIS and EPIC. The new model yields a flux ratio between MOS and ACIS ±10%, and a significant decrease of the discrepancy in the cluster temperatures measured by ACIS and EPIC.

Work on a new contamination model is still ongoing. A two component model (elemental plus "ad hoc") has been worked out. Further complications come from chip- and spatial-dependent time evolutions.

Once a preliminary version of this model are applied, energy-dependent flux differences between

LETG/ACIS and EPIC of ±15% are still present.

Tiengo: EPIC/Chandra cross-calibration with the Perseus Cluster

The effect of the release of the new Chandra HRMA effective area on the ACIS versus EPIC cross-calibration has been evaluated on the spectra of the Perseus Cluster. Spectra extracted in annuli at radii from the core between 1' and 2' contain about 3 million photons – a rather good baseline for cross-calibration! Multi-temperature physical models need to be used to properly fit the spectra. The results can be summarized as follows:

- the spectral shapes above 1 keV are now in much better agreement. The data/model ratio against a common model is now ±5% and energy-independent
- the overall flux agreement has worsened: in the same energy range the flux ratio difference is about 15%, against an average (energy-dependent) 5% with the previous calibration

Guainazzi: Scientific monitoring of a Routine Calibration Plan source: the case of RXJ1856.6-3754

Following an objective defined at the previous calibration meeting, a automatic software infrastructure has been implemented for the reduction and analysis of the data of the Routine Calibration Plan source RXJ1856.6-3754. This project has been mainly carried out by Nathan Dickinson, a student of the University of Leicester visiting ESAC for 6 months. This software produces automatically a web page, where all the fit and cross-calibration results can be consulted. It is planned that this web page will be made public, once the improvements in the redistribution matrices of pn (see Haberl's talk) and MOS (see Sembay's talk) are publicly available.

Saxton: Cross-calibration between MOS and pn using the 2XMM catalogue

The main results of the Mateos et al. (2009) paper on the cross-calibration between MOS and pn in the 2XMM catalogue can be summarized as follows:

- Excellent agreement of the two MOS cameras (<4%) at all energies
- MOS cameras register
  - 7-9% higher flux than pn below 4.5 keV
  - 10-13% flux excess at the highest energies
- No evolution of flux ratios with time except in the 0.2-0.5 keV band
  - Gradual degrading of the MOS redistribution function
- MOS to pn excess increases with off axis: ARF effect
- Strong dependency of MOS to pn excess 4.5-12 keV flux on azimuthal-angle

New actions from this meeting:

21/01 on PC: send the history of the MOS Timing Mode configuration in the operational database to TA

21/02 on MG: formalize in an operational procedure the yearly attempt to resurrect MOS1-CCD6.

21/03 on MG: contact KD on the pn "double anomalous behaviour" to evaluate the priority of this

item

Future calibration plans - discussion:

Objective 1: pn CTI (MG)

The pn rate-dependent CTI for Timing Mode shall be improved, with the primary goal to improve the accuracy of the energy reconstruction around 6 keV. The following paths will be explored:

1. Re-calibration of the rate-dependent CTI correction with SASv9.0, where a bug in the calculation of the PSF encircled energy fraction in `arfgen` is expected to be fixed
2. Expansion of the sample used for the calibration of the rate-dependent CTI, which may also allow to unveil possible time-dependent effects
3. Recalibration of the Timing Mode pattern fraction
4. Inclusion of an energy-dependent term in the rate-dependent CTI correction
5. Study of a possible observation-based rate-dependent CTI correction

The goal is to complete at least the activities 1. to 4. **by the next BOC**

Objective 2: OFF axis calibration

a) 2-D parametrization of the PSF (AR): the new CCF shall be released to the public after successful completion of the test on the elliptical envelope (SOC) and the source detection efficiency SSC **by the next BOC**

b) a plan to check the calibration of the RGS obscuration refinement shall be defined **after the release of SASv9.0**

Objective 3: MOS patch (SS)

The new phenomenological model of the MOS redistribution shall be release for implementation in **SASv10.0.**

Objective 4: Low energy noise reduction (KD)

The algorithm to remove noisy pn frames shall be released for implementation in **SASv10.0.**

Objective 5: CTI/contamination monitoring (ESAC)

Monitoring software shall be operational by **summer 2009**. Routine generation of CCF shall be operational **by the next BOC**

Objective 6: refinement pn redistribution (FH)

An improved CCF shall be release to the public **by the next BOC.**

Objective 7: documenting the cross-calibration database

The data reduction and analysis procedure employed in the cross-calibration database shall be fully documented **by the next BOC**.