Minutes of the EPIC Calibration Meeting
Madrid, 23-24 March 2010

Review of actions from previous meetings:

19/1 on **M.Freyberg**: Implement a warning for very bright sources with respect to non perfect FIFO reset correction

STATUS: OPEN

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.

STATUS: OPEN. It is agreed that EK will propose moving the most important parts of this document into the to-be-written Crab timing paper (lead author: A.Martin-Carrillo)

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

STATUS: OPEN

F.Haberl, "EPIC-pn redistribution matrix: an update"

Two main changes are being implemented in the EPIC-pn redistribution

- The overall resolution is being increased to bring the measured width of the calibration lines at the beginning of the mission to 0
- The low-energy redistribution is being recalibrated based on RGS models of line-rich sources (1E0102-72, Zeta Puppis, and the comet C/2000 WM1)

These results are included in a new version of the redistribution calibration file to be distributed soon.

Remaining items to be investigated during the next year:

- Time-dependency of the resolution: while a clear trend in the measured width of the calibration line is measured, this trend is not confirmed when repeated observations of astrophysical sources across the mission are analysed. If eventually confirmed, this recalibration would require a change of the CCF as well as a change in the SAS

- Possible differences in the redistribution between single and double pixel events: this would also require a SAS change

M.Guainazzi, "Status of EPIC-pn Timing Mode calibration"

The main news in 2009 were: a) the implementation of the rate-dependent CTI correction, and b) the correction of a bug in the encircled energy fraction calculation by `arfgen`.

More recently, the pattern fraction has been recalibrated as a function of the location of the source in `RAWY` coordinates, which allows a much more accurate determination of whether a source is affected by pile-up via `epatplot`. The calibration is very good for `RAWY`≤`189`, less so at higher `RAWY`. The reason is a so far unknown energy-dependent count-rate dependency of the pattern fraction, with single events being comparatively less numerous at high count rates. Despite of this discovery, it is still recommended to release the new CCF, as well as to submit the SAS SCR required for `arfgen` and `rmfgen` to be able to use it (this is less critical, as the change in the combined fraction of single and double events with `RAWY` is tiny).

K.Dennerl: "Experience with the combined Fe^{55}/Vela SNR calibration – EPIC-pn"

In NRCO-81 the Vela SNR has been observed together with the calibration source (`CAL-Thin` filter). The observation followed the filter sequence: `CAL_CLOSED`, `Thin`, `CAL-Thin`. The results can be summarized as follows:

- The measured energy of the OVII line during the `CAL-Thin` exposure is statistically indistinguishable from that measured during the `Thin` exposure
- The energy of the calibration lines is significantly higher in `CAL-Thin` than observed during the `CAL-CLOSED` exposure: the energy difference is 4.5±0.8 eV for Al-K, 5.0±0.7 eV for Mn-K

The energy shift occurs between the `CAL-CLOSED` and the `CAL-Thin` exposure. It is *not* due to first singles.

A possible interpretation of these results is the impact of photons/particles penetrating the `Thin` filter. They may release additional charge in the CCDs that is below the low energy threshold and thus not transmitted, but still capable of reducing the charge transfer losses by trap saturation.

Notwithstanding the ultimate cause of these results, the illumination pattern during the `CAL-Thin` observations is likely to be closer to that occurring during standard science exposures.

In conclusion, the Vela SNR is perfectly suitable for the simultaneous measurements of the SNR together with the calibration source spectrum.

A.Tiengo, ""Experience with the combined Fe^{55}/Vela SNR calibration – EPIC-MOS"

The MOS results are similar to those presented by K.Dennerl for the EPIC-pn. The shift in the calibration line energy is not due to optical loading, it is rather a true CTI effect as the CTI analysis of the NRCO data clearly indicates. Trap saturation under the higher illumination condition of the `CAL-Thin` exposure is the most likely mechanism. A preliminary reanalysis of the data of the similar NRCO performed on N132D indicates that the energy shift is correlated with the count rate *below* (and not *in*) the extraction region, consistently with such an explanation.

Following the results presented in the last two talks, it is agreed that from now onwards the Vela SNR observation in the Routine Calibration Plan (RCP) will be performed in this mode.

Action 23/1 on **M.Guainazzi**: prepare the skeleton of a Technical Note describing the results of NRCO-81

Action 23/2 on **M.Guainazzi**: change the mode of the RCP Vela observation to `CAL-Thin` (EPIC-pn), `CAL-Medium` (EPIC-MOS)

K.Dennerl, "Correcting spatial inhomogeneities of the absolute energy scale"

A spatially dependent comparison between the measured and the nominal laboratory energy of the OVII line in the RCP observations of the Vela SNR shows a ring-like pattern around the centre of the EPIC-pn CCDs. The size of the effect is ±10 eV. The ring-like structure coincides with the ventilation hole at the centre of the electronic board. Combining the flight with the available ground calibration data it could be possible to improve the energy reconstruction accuracy to ±5 eV.

Action 23/3 on **M.Guainazzi**: ask the User's Group 2010 if an improvement in the energy reconstruction from 10 to 5 eV in EPIC-pn would be scientifically interesting

A.Read, “MOS noise”

Previous analysis of the MOS “noisy CCDs” (primarily MOS1-CCD4 and MOS2-CCD5) showed that the noise is correlated with PATTERN=2 (P2) and P4 events in the Energy1-Energy2 (E1-E2) plane. This suggests a problem with the readout amplified rather than with the CCD. However, a specific engineering observation designed to test whether repeatedly switching on and off the cameras affected the presence or onset of the noisy CCDs didn’t yield a positive result.

A systematic analysis of the parameter *fP2S1* (the fraction of P2 events in a certain “stripe” of the E1-E2 plane) across the mission is presented. The ultimate goal is to find possible correlations, which may explain the origin of the noise as well as suggesting an operational strategy to mitigate its effects. This analysis suggests that the “noisy CCD” switch between “clean” and “noisy” states with a rather irregular pattern. This switch occurs between exposures (and not during an exposure). Exposures when the switch occurs are often in `CAL_CLOSED`. This suggests a possible correlation between “switch-points” and the radiation level.

While these results still need to be verified and consolidated, they may suggest at face value a possible operational strategy to mitigate the impact of noisy CCDs, based on dynamical radiation-based observational windows at the beginning and at the end of each revolution. The principle behind this strategy would be to allow “noisy” CCDs to be subject to an increased radiation level to favour them switching back to a “clean” state again, whereas “clean” cameras should be more protected against radiation to prevent them from switching to a noisy state.

Action 23/4 on **A.Read**: prepare a Technical Note on the correlation between MOS noise onset and other observables

M.Guainazzi, “Investigation of the RGA obscuration”

An investigation has been carried out to interpret the “Mateos’ effect” (the azimuthal angle dependency of the MOS to pn flux ratio) as due to a mis-calibration of the RGS obscuration. Even an extreme (and physically implausible) change of the RGA α_0 parameter to 1.9° would be unable to cure the problem. It is possible to “smooth” the pn to MOS flux ratio by introducing a 10% fudge to the vignetting function in the 4.5-12 keV energy band only. Before implementing this empirical solution, it is advised to complete an analysis of the possible changes in the sieve buffer geometry obscuration currently under study by Dave Lumb, which may provide a physical explanation for this effect.

A.Pollock, “RGS calibration status”

Three main items are being currently investigated:

- a new and shallower temporal dependency of the contamination
- a mechanism to “rectify” the RGS to EPIC-pn residuals
- the new Small Window mode for bright sources

P.Plucinsky, “Status of ACIS calibration”

There have been two main improvements in the ACIS calibration during the last year:

- A new contamination model is being implemented. Measurements suggest a significant deviation from the time evolution of the contaminant optical depth in the current calibration as of 2005. It implies a change of the effective area by about 20% (5%) at 0.4 (1.25) keV
- A temperature-dependent CTI correction is being introduced. It yields an improvement of up to 50 eV (20 eV) for I3 (S3)

M.Stuhlinger: “Cross-calibration status with SASv10.0”

The cross-calibration (XCAL) analysis has been aligned to SASv10.0. Its results are now compared with a sample of spectra extracted from on-axis 2XMM sources. The results can be summarized as follows:

- Statistical analyses of XCAL archive (dominated by piled-up SW observations) and 2XMM sample (285 pile-up free FF observations) are consistent.

- Significant spread between single observations in nearly all energy bands, both for fluxes and slopes.

- The EPIC cameras flux ratios show only weak flux time evolution for higher energies (≥0.85 keV), some evolution is seen at lower energies (<0.85 keV).

- RGS and EPIC fluxes diverge with time at low energies.

- Nearly no time evolution of either EPIC or RGS slopes in any of the energy bands.

S.Sembay: "Using standard candles to calibrate the strongly variable MOS response"

A new empirical algorithm to calculate the MOS redistribution is presented. The method is based on the simultaneous fit of astrophysical models and of an empirical parametrization of the MOS redistribution ground-based calibration with a combination of a Gaussian and of a Voigt function. Four "standard candles" have been used for the calibration: Zeta Puppis, Cal83, 1E0102-72, and RXJ1856-354. The method takes into account the spatial dependency of the MOS redistribution close to the boresight position ("patch") as well as its time-dependency. The new algorithm significantly improves the quality of the MOS spectral fits as well as the agreement with the simultaneous pn spectra. It will be implemented in the next SAS version.

S.Molendi, "Clusters as calibration tools"

A systematic comparison of 16 galaxy clusters spectra observed by EPIC shows:

- An agreement within 3% in the 0.7-3.5 keV band
- Larger deviations at higher energy

Action 23/5 on **M.Guainazzi**: organise a cross-calibration Workshop at ESAC in autumn 2010

R.Saxton: "Recent changes in EPIC-related SAS tasks"

There are three main SAS-related changes in SASv10.0.

- `specgroup`: a new task to rebin XMM-Newton spectra according to wide range of criteria
- `arfgen` support to the 2-D PSF, including the calculation of the optimal (in terms of signal-to-noise ratio) elliptical spectral extraction region
- `epfluxer`: a new task to calculate fluxed EPIC spectra

T.Song, "`psfgen`, a new SAS task"

A new SAS task (`psfgen`) is available to generate a PSF 2-D profile as a function of various input parameters.

A.Read: “2-D PSF: into the SAS”

The 2-D PSF parametrization is now an extension (ELLBETA) of the PSF CCF. This parametrisation includes the parameter re-evaluation following a new CIAO/Sherpa release, which significantly changed (!) the fit results.

During the past year the 2-D PSF has undergone a wide range of tests, which unveiled strengths of the new approach as well as some remaining limitations associated with its current implementation:

- Tiny changes in parameter values of the fiducial calibration points can result in very large changes of the interpolated values. The dot-to-dot “linear interpolation” seems to be the most robust solution and is currently implemented for PSF interpolation
- Boundary problems with the current (MEDIUM) PSF are mitigated by ELLBETA
- Fewer number of spurious sources are detected around bright sources
- The 2-D PSF is an overall great improvement in the description of the source observed profile
- However, no significant improvement of the detection likelihood for weak (close to detection limit) sources is seen with the 2-D PSF
- The intensity of the spokes is probably too large
- The 2-D PSF yields a 2% difference in the measured flux (this may contribute to alleviate the cross-calibration discrepancy between EPIC-MOS and EPIC-pn)

There is still a long list of items which need to be revised before the 2-D PSF can be offered as default mode in the SAS: intensity of the spokes, proper handling of the Sagittal-Meridional effect, MOS spread of events along the RGS dispersion axis, out-of-time events, φ dependency, dark lanes due to the detector deflector, pn pentagon envelope parametrisation, and lots, lots, lots of testing of the PSF parameters and its implementation in the SAS source detection software

A.Garcia, “Spectral effects of PSF core excising”

A systematic analysis of the XCAL blazars, many of whose EPIC exposures are affected by pile-up at various degrees, shows an unexpected dependency of the spectral parameters with the radius of the excised core even for radius beyond which pile-up is no longer expected to be an issue. Spectra become typically harder for larger excised radii.

Action 23/6 on **F.Haberl/S.Sembay**: prepare a proposal on calibration paper topics, numbers and leadership by the UG-2010