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| meeting place *lieu de la réunion* | MPE, Garching | chairman *président* | M. Smith | | |
| minute's date *dates de minute* | 28/04/2017 | participants *participants* | J. Ballet, I. de la Calle, S. Carpano, K. Dennerl, J. Ebrero, T. Finn, M. Freyberg, C. Gabriel, F. Gastaldello, F. Haberl, C. Heinitz, A. Ibarra, M. Kirsch, H. Marshall, P. Plucinsky, P. Rodriguez, J. Sanders, M. Santos-Lleo, R. Saxton, N. Schartel, S. Sembey, M. Smith, S. Snowden, M. Stuhlinger, C. Tenzer, J. Truemper | | |
| *subject/objet* | **EPIC Operations Meeting #28** | copy/*copie* | P. Kretschmar, J.R. Muñoz | | |

**European Space Agency**
**Agence spatiale européenne**

*Villafranca Station*
P.O. Box 50727 - 28080 Madrid - Spain
Tel. (34) 91 813 1100 - Fax (34) 91813 1139

Description/description

**1. Review of open actions (M. Smith)**

**Action#27/1** on C. Gabriel and M. Freyberg:
Discuss how to move forward with SAS-SCR#7284 (EPIC-pn offset maps for slew data not (yet) accessible via OAL/SDF) in upcoming SAS-CCB.
**Closed** (in order to avoid duplication; this action already exists as an open SAS SCR).

**Action#27/2** on M. Smith:
Determine which additional HK parameters could be useful to propagate, and what time binning to use. Determine the mechanism within SAS to do so.
**Open** (propagation of discarded line data already discussed; however, any additional HK parameters still need to be defined).

**Action#27/3** on M. Smith:
Submit NRCOs for RXJ1856 and 1E0102 with cycling through filters thin, medium and thick.
**Closed**

**2. XMM S/C status with a special look to migration and fuel replenishment for the '20s (M. Kirsch)**

Spacecraft status:

Battery:
Status normal. Current margin 500W.

RF switch: on B switch, ~1450 switches down (qualified to 25000).

Fuel situation:
Remaining fuel 47 kg, yearly consumption: 2.7 kg. Several more years to go (2028), depending on amount of ESAMs (consumption ~500g).

Fuel taken from tank1, fuel will flow then from tanks 2-4 to tank 1. By design tank 1 empties first.
Current trick: cool tank 1 and heat tanks 2-4 will force fuel to move from warmer tanks to tank 1. Works up to rest of 30kg. Then second replenishment phase in about 2023.

Orbit evolution:
Lowest perigee ever: decreased to ~5200 km.

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ESAM#8:
16/03/2017 due to SEU on the reaction wheel drive electronics. Occurred once in 17 years (twice in 13 years for INTEGRAL). Recovered within 24 hours.

MOC system evolution:
Operating on SOL2 with SCOS2000.

Ground station:
Perth is off, using Kourou and Yatharagga. Back-up to Dangora. No ESA station, privatised and rented back.

SPACON merger:
Merge SPACONs from XMM/INTEGRAL with GAIA. One SPACON operate all three missions. Gaia in top priority, XMM second. If there is an issue with GAIA, spacon will not be available for XMM. Only safety is guaranteed, recoveries will take longer. Estimated reduction of science efficiency 5-8%.

Due to third satellite, spacons will not be trained any more on instruments. In case of events, instruments will stay in safe until special trained person will care for instrument recovery.

Identify critical events when spacon needs to “rescue” the instrument/mission. Only for these events spacon can leave GAIA passes and bring XMM to safe mode.

Question by M. Freyberg: How frequent are GAIA passes?
=> About 2 hours every 24 hours. But spacon are not allowed any more to recover XMM instruments.

**3. Status of instrument operations (M. Smith for P. Calderon)**

Routine maintenance:
ODB update to version 6.29 9. Mostly pn bad pixel table v5): Rev. 3061 (25.08.2016) for CCD11 column 64.

Eclipses:
No changes in operations, largely automated by MOC now.
19/04/2016: manual switch-on of both MOS chains A+B.
PN configuration twice interrupted due to ground station problems. PN powered OFF/ON again.

General events:
- False current limiter activation NCR#133 21/05/2016

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- PN crash 9/06/2016 in NCR#138 style

SEU:
- PN quadrant failure
- possible micro-meteorite impact into MOS2 24/03/2017

Change in operations:
MOC merge with GAIA.

**4. EPIC-MOS monitoring (M. Stuhlinger)**

Flash monitoring:
New flash detected on 24/3/2016 (Rev 3166, Obs 0780690201, MOS2). Comparison of the exposure before and after event shows no significant damage. However, one single new hot pixel does appear to be related to event (MOS2 CCD4 RAWX/Y = 135,360). In particular, comparison of FF exposure before and after impact shows no damage to CCD1.

Telemetry monitoring:
MOS1 telemetry reflects mainly activity of the "meteorite column". There is also evidence of the counts resulting from the blooming column in CCD2.
Latest PN BPT successfully reduces FF mode count rates.

Evolution of the meteorite column shows erratic column offset, making it impossible to correct through a change in the on-board offset table.

Energy scale monitoring:
The reconstructed energies at Al and Mn are close to nominal for the central CCDs. However, some peripheral CCDs show larger deviations in recent revolutions requiring CTI/gain updates.

New CTI epochs for updates are mostly defined, triggered mainly by trap offset changes. Some trap offsets show significant variability in depth. First 12 epochs (revs.<1074) identical, with new CTI epochs differing between MOS1 and MOS2 (currently 12+11 vs. 12+15). CTI/gain results for few peripheral CCDs not yet entirely satisfying due to negative measured CTI trends for the most recent epoch.

**5. EPIC-MOS focal plane temperature excursions (M. Stuhlinger)**

Systematic MOS focal plane temperature excursions at the start of science observations became an issue

Description/description

during the Autumn 2014 eclipse season. However, the origin of the problem is both eclipse, and non-eclipse dependent:

Eclipse independent: change of perigee in May 2013, which although saving fuel lead to the radiators pointing to earth albedo for ~ 2 hrs around perigee. This makes the radiators less efficient, and requires the MOS CCDs ~ 3 hrs to reach nominal temperature. This cooling time exceeds the perigee break period.

Eclipse dependent: Kourou discontinued around perigee and eclipses. Covering this gap with other stations requires hand-overs introducing additional instrument operation constraints. Instruments remain in eclipse configuration for longer: in power-OFF, no CCD thermal control, MOS CCDs heated by substitution heaters.

As result, MOS starts first exposures with CCDs still not at nominal temperature. A corrective action was introduced for the 2015 eclipses (pre-cooling the MOS FP to -130° C), which alleviated the problem, however only for the eclipse periods.

Since 2014, a substantial number of exposures were found which started before focal plane reached nominal operation temperature:
- Individual exposures are effected by up to about 5 ks.
- Both eclipse and non-eclipse seasons are effected.
- Amount of effected exposure time within autumn eclipse seasons is decreasing (due to the corrective scheme with pre-cooling)
- Amount of effected exposure time in non-eclipse summer seasons is increasing.

**6. EPIC-pn monitoring (M. Smith)**

CTI: Steady smooth increase, modelled with polynomial.

Long-term CTI correction: uses table model instead of polynomial, better constraint on extrapolation.

Question: F. Haberl: Why worse results for very early epochs at Al?
=> Long-term CTI correction is null by definition at start of the mission. The deviation from the nominal energy at launch could point to inaccuracy of the CTI model or the gain (which was determined by the data obtained at Mn).

Line energy resolution: slow steady decreasing trend, in SAS corrected for by the time dependent RMF.

Description/description

**7. Monitoring of Epic-pn timing (J. Ebrero)**

Routine calibration observation of the Crab twice per year (spring, autumn) for timing monitoring in both TI and BU modes.

Scheduled at different orbit phase to calibrate orbital time delays.

Relative timing:
Relative deviation to Jodrell Bank radio data: ~$3x10^{-8}$s. Stable over mission.
deltaP/P: stable, except one outlier.
Question: M. Kirsch: Due to new ground station? => probably not, as such long exposures are not done any more in recent epochs. Guess exposure is from early mission.

Absolute timing: -346+/-10 microseconds. No trend over mission

Pulse profile anomaly in TI mode observations:

The Crab pulse profile show systematic differences between spring and autumn TI mode exposures (BU mode is unaffected): the inter-pulse valleys have different levels in spring/autumn season.

Check of HK parameters indicate the cause is the number of FIFO overflows:
Number of FIFO overflows is much higher in TI than in BU mode. FIFO overflow rate shows seasonal difference for TI mode. The FIFO overflows are not corrected, and the resulting dead time causes a loss of counts at different phases of the Crab pulse profile. The seasonal dependence is due to the slightly different coverage of the nebula due to the 180 degree change in PA between spring and autumn.

**8. EPIC-MOS stability measurements using SNR 1E0102 (S. Sembay)**

MOS contamination monitor source is SNR 1E0102.2-7219, and cross-checked with RXJ1856.
Method is to look for changes in low-energy (O-lines) versus high-energy (Ne-lines) count rate ratios.
Ratio trend (in terms of O-lines count rate drop over mission) seen for MOS2 but not for MOS1.

Essential constant rate of increase of contaminant for MOS2, although different to RGS trend (which is slowing down), no such trend seen for MOS1.

RXJ1856: 0.25-1.0 keV band: pile-up < 1%, estimated background < 1%.

MOS1 flux over orbit: no clear trend. Flux over count rate show clear trend. MOS2 similar.

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Complication seen in images of rev. 0878: some bright columns running through MOS2 PSF resulting in soft artefacts not removed by standard SAS flagging. Similar in images are seen in other revolutions.

Nevertheless, RXJ1856 probably yields consistent results with 1E0102 for contamination modelling.

Comment: J. Ballet: SAS badpix finder task probably not intelligent enough to identify this type of artefact on top of bright sources; parameters may need to be tweaked in these cases.

**9. Calibrating the EPIC-pn energy scale with the Cu fluorescent line (J. Sanders)**

Use Cu line as reference for astrophysics using galaxy clusters Virgo and Centaurus:
correlation found of Cu and Fe energy shifts.

Cu emission model is multicomponent Lorentzian fit for K alpha+beta (Hoelzer 1979).

dE/E maps show column to column variations with higher values in the inner CCD areas for EFF, more centred in FF mode.

Time evolution seen in dE/E offset maps for FF and EFF in 500 revolution bins. Offsets are seen from observation to observation. Caveats:
- correct rmf/arf to be used?
- should PATTERN==0 be used?
- perhaps improved screening for flares / optical sources required.

Could be useful for calibration, although more investigation required. Note that central region is excluded. Also, RAWX dependence may have to be fitted.

**10. Thoughts about randomisation (K. Dennerl):**

Fits to RX J1856: repeated SAS processing 100 times give slightly different results; differences caused by randomisation within PHA channels. Pairwise comparison show significant differences between best/worst pairs in term of fit statistic.

Taking the average of 100 SAS processings give improved spectral quality.

General problem is how to rebin already binned data. Rebinning already binned data using the bin centre leads to beating. Better is to create randomised data based on information in the original binned data, and rebin. Reduced jitter when multiplying randomised data by a large factor (e.g. 100), rebin, and then divide by the factor. However, this approach is not practical.

Investigate replacing randomisation with propagation of probability distributions; different distributions for each valid pattern type. Additional floating point columns would be required, however, OGIP format supports floating point numbers, so no file format issues would arise.

Comments:
J. Ballet: One could propagating the modelling on unbinned raw data (thus avoiding the need for randomisation) but this is complicated to realise.
N. Schartel: In the case of 100 randomised runs, it would be interesting to see the distribution of chi2 values.

**11. Improving the EPIC-pn RMF (K. Dennerl):**

Comparing 1E0102 residuals for different detectors (as done within IACHEC framework) reveal that there is need for improvement for the EPIC-pn RMF.

The RMF is modelled using a limited set of energy dependent parameters. Given a spectral model the parameters are modified in order to minimise data to model residuals. This method depends on reliable reference models for astronomical targets.

By observing the same source with multiple filters (under similar conditions, close in time) one can “modify” the incident spectrum. This was done for RX J1856 and 1E 0102. Simultaneous fitting in three filters resulted in significant improvement in RMF modelling.

An apparent low energy deficit is likely caused by a threshold induced sensitivity drop: event in pixel with total measured charge below threshold will not be registered. In the case of multi-pixel events this drop may extend to 4 * 19 = 76 ADU. This is not accounted for in current calibration.

Questions:
S. Sembay: You use LETG model for RXJ1856. Have you taken the new RMF and checked the line normalisations in 1E0102 fits? => Yes, they are within the confidence range of IACHEC results.

R. Saxton: When you measured QE on ground were the threshold effects are not calibrated? => Threshold effects were assumed to be compensated by RMF.

Description/description

R. Saxton: Are the improvements expected to work on other sources? => No, as the optimisation is based on these two targets. It would be surprising if it would work, as the correction modelling needs to include more spectrally different targets, in particular with emission above the escape peak.

H. Marshal: Does the method improve the often required gain shifts? => No, as these are assumed to be due to the particle background.

**12. XRT PSF investigations (M. Smith)**

Issue with spectra extracted from annular extraction regions (e.g. when excising piled-up core).
EPIC-pn-to-MOS residuals at high energies are larger in case of pile-up compared to non-pile-up samples.
Systematics in the current PSF modelling for all 3 XRTs.

Current ELLBETA PSF: 240 parameters per XRT.
Limit the problem to 14 parameters per XRT: 2 PSF model parameters r0, alpha, 7 energies, 1 off-axis angle (no changes beyond 3' from optical axis).

Iterative scheme for empirical correction of XRT XPSF parameters: extract spectra of circular and nested annular regions. Compare spectral fits of annular region extractions with the encompassing circular extraction and minimise residuals by modifying the ELLBETA parameters.

Source sample used consists of 11 observations of bright non-piled-up point sources. Mainly FF mode, two SW mode observations.

Result show mainly improvements for pn, for MOS in general on smaller scales, too, although also some annuli show slight worsening.

PN shows improvement in correcting the deficit at high energies for large annuli. Less obvious for MOS.

Comments:
J. Ballet: Radial profiles and images should be investigated; not sufficient to just look at spectral fits.

N. Schartel: Main objective of the mission is to get good spectra. If required go back to the old PSF model. JB: Disagree, the spoke modelling is essential for finding sources.

J. Ballet: Can rerun the analysis based on images using the new parameter CCFs.

Description/description

Action: 28/1 on M. Smith: include radial profile comparisons in XRT XPSF analysis.

**13. Cross-calibrating effective areas for a default empirical correction (C. Heinitz)**

Based on CORRAREA extension in XAREAEF-CCFs.

Starting point: source selection, screening and stacking according to Read et al 2014.

46 sources with 1,700 Ms good time interval exposure time.

Stacked residual method, using EPIC-pn as reference.
The reference PN model is convolved with instrument responses of MOS1 and MOS2.
Fit resulting residual ratios to define parameters in CORRAREA extension.

For re-calibration: change background regions: avoid annuli due to inhomogeneous Cu emission in pn. For MOS, obtain background from CCD1 but allow a circular region in the corners of the CCD1.

Do a more strict pile-up check using the MOS diagonal pattern fraction; exclude target if fraction in PSF centre exceeds 1.5%. However, this reduced the sample size to quite a low number of acceptable observations. A solution is to include windowed mode data. Up to 252 possible additional sources for the sample which still need careful screening.

**14. ESAS and the quiescent particle background calibration (S. Snowden)**

Build database of corner data from all observations. Characterise shape of each spectrum, hardness ratios sufficient.

Background spectra composed of lines and continuum features.

Corner data show long term variations due to solar cycle. And temporal variations in hardness ratios.
Anomalous states in chips MOS1-4, MOS1-5, MOS2-2 and MOS2-5.

Compared to 2008 work, current analysis contains 6 times more data, can include pn now, too.

Comments:
J. Ballet: Were OOT events removed? => Yes, although there still seem to be some issues with this.

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M. Freyberg: Unlike the MOS, pn does not have a proton mask, but a cone, so the corners are not as protected for pn as for MOS. Also the differences such as the decrease from thin to thick filters point to soft proton contribution.

**15. XMM-Newton background studies (F. Gastaldello, remote presentation)**

Motivation: for galaxy clusters, spatial background characterisation is crucial for SB radial profiles.
If no soft proton treatment is done, XMM and ROSAT profiles will diverge at very high radii. With correct treatment, the profiles agree nicely.

MOS corner data are good representation of background by high energy (E>100 MeV) particles, mainly cosmic rays protons. And low energy ions (E<100 keV) in flaring periods.

40% of data dominated by flaring.

Soft proton count rates show dependence on filter: consistent with absorption in thicker material layer.

Quiescent and flaring components have very different spectral shapes.

No strong dependence on magnetosphere environment.

Quiescent component stable. Flaring component intensity anti-correlated with distance to Earth.

Comparison of XMM data with environmental estimates of soft proton (ACE LEMS data 50-100keV @ L1) show loose correlation which is insufficient to calibrate soft proton effective area.

Correlation of out-of-FOV data with Standard Radiation Environment Model (SREM). Strongly supports hypothesis of high energy cosmic ray protons as ultimate source of this background component.

Comparison between MOS versus pn: MOS has out-of-FOV (sharp drop of counts), but EPIC-pn does not (steady decrease following the in-FOV slope). Confirmation from analysis of ~500 blank fields.

Comments:
J. Ballet: did you look into spatial distribution of soft proton component? => We are just starting this. There is enough data. We clearly see some trends. Some vignetting and a clear radial trend with higher level in the centre. Working hypothesis is Compton introduced background.

S. Sembay: Any idea what the quiescent component is? => As said, Compton by high energy X-ray. We

Description/description

know it must be there to a certain level, need to prove that is it really there. In pn this component should be higher than in MOS. First we have to get rid of the soft proton component before we can see whether it is there.

**16. Fitting the pn and MOS data with the IACHEC model for N132D (P. Plucinsky)**

IACHEC model on 1E0102: paper is published, please use it with reference "1E0102 IACHEC model"

Normalisation differences for the 4 line complexes between MOS and pn are higher (15-20%) than for continuum sources (5-7%).

Question: H. Marshall: With K. Dennerl's correction presented yesterday, would the pn line fluxes go up? => Only lowest energies would be affected, not predictable what exactly would happen at 0.5 keV (O-line), one would have to test on the data.

Count rates of lines prove that pn is the most stable instrument, stable within a few percent over mission.

PN requires a gain fit for all observations.

Next project is N132D:
Model is in development: currently more than 120 gaussian lines plus continuums and absorptions; use APEC "no-line" model for continuum.

Make sure the complete remnant is extracted as N132D has spatial spectral variations. For EPIC: check for pile-up in various instruments. Avoid MOS patch.

Again, pn requires gain fit, small slope, mostly offset. Different if restricted to either low energies (O-Ne) or higher energies (Si-FeK). Background becomes dominant around 7 keV.

Experiments for MOS extraction: as extended and as point source.
S. Sembay: encircled energy correction is problematic, extended extraction use detector map, no EE correction at all. Treating data as point source would result in bad pixel/columns possibly being overcorrected. Best would be to allow the SAS to use a Chandra image as detector map.

**17. Chandra/ACIS contamination (H. Marshall)**

Timeline:

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2000: C-K edge found with LETG/ACIS
2001: cluster data showed time dependency, gratings indicating composition of C-K, O-K, F-K
2003: ECS (cal source) shows more absorption at edge, tau from grating lower than ECS, contamination is time and spatially dependent.
2016: carbon absorption with physical model now.

LETG/ACIS for O-edge and F-edge time variability using blazar spectra; definitely no nitrogen (no edge in grating data).

Dither observations to cover spatial distribution: move spectrum over the detector about 20 times within 60 ksec. Covers half to ¾ of the surface.

Time evolution of contaminant: fast rise up to 2001, nearly constant (low rise) up to 2010, fast increase since 2010 up to now. Composition since 2010 is chemically different (aromatic) than 1999-2001 composition (non-aromatic).

**18. The cross-calibration concordance project (H. Marshall)**

Use formal statistical method to evaluate the required effective area corrections to the individual instruments to get all instruments fluxes to optimal agreement => “concordance”.

Shrinkage method as presented by Meng (IACHEC 2015), proof of concept done with help of MIT/Harvard (Meng) students and data from Chandra and XMM-Newton.

Question:
F. Haberl: Are uncertainties of redistribution matrices taken into account? This would be important at low energies for CCD detectors. => No, this kind of additional complication is as yet not taken into account.

First results:
O/Ne-lines of 1E0102: changes of few percent suggested for all missions.

2XMM: no changes suggested: low flux targets, data not powerful enough overrule prior uncertainties.

Blazars: more conclusive results as data has higher statisticl value. Complications due to pile-up, and clipped PSFs. Outliers in XMM blazar set. EXO 0748-676: MOS2 too high, H2356-309 and 3C111: MOS1 too low.

Still to be done: trials on cluster data.

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Question:
M. Freyberg: how to avoid applying a suggested correction to the wrong component? => Much care is needed to identify the corresponding components that need to be changed.

Comment:
S. Sembay: e.g. use source where you get all photons to avoid applying encircled energy corrections, that would allow to address general effective area changes.

**19. EPIC cross-calibration: status and developments (M. Stuhlinger)**

With regards to cross-calibration, no substantial changes in SAS or calibration since last meeting's presentation.

The XMM-Newton cross-calibration archive (XARV) is a s/w package used in data reduction, fitting and presenting the cross-calibration results.

Contains ~300 observations of over 50 different targets. Spectral products are extracted from ODF level, models are fit and narrow band fluxes are derived. Largely automated, running on computer grid. Enables fast turn-over for testing of new calibration products.

Current XARV package hard to maintain do to incremental evolution. Aim is to redesign the package with the experience gained through its use. This gives an opportunity to add / change requirements.

**20. Summary of EPIC calibration issues (M. Smith)**

Epic Aeff:
7-10% MOS—pn residuals above 2 keV, pn slope steeper than MOS
Empirical correction with CORRAREA could fix it; could (partially) be justified by error budget in mirror effective area.

EPIC PSF:
Core to wing spectral differences above ~ 5 keV.

PN fast mode energy scale:
Comparison of PN TI mode with Chandra gratings show larger than expected disagreement at ~ 6keV. Also residual features at instrumental edges.

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Cross-calibration:
NuSTAR crab: pn show ~12% flux deficits.
Clusters: pn shows lower temperatures than ACIS.

Other:
Optical axis: some indication the current definition may be off.
Quiescent background gain correction – aim is to be implemented in SAS 17.
PN to MOS line versus continuum flux difference – new PN RMF may address this issue.