XMM-Newton

XMM-Newton Science Analysis System 14.0 scientific validation

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Revision history

Revision number	Date	Revision author	Comments
1.0	13 January 2015	C. Gabriel	first version

Contents

1 Introduction

1.1 Concept

Scientific Validation (SV) is required in order to ensure a constant high quality of the XMM-Newton Science Analysis System (SAS).
The main purpose of the SV is to provide the SAS community with a stable reliable software product, as well as to generate a list of caveats and known deficiencies. Together with these "functional" tests, the SV provides some information on the expected systematic uncertainties when basic data analysis products are generated through the current version of the SAS, using the best calibrations available at the moment SAS was released. It is important to stress that *this document does not supersede or substitute* the **instrument calibration status documents**, available from the XMM-Newton calibration portal. Instrument calibration is a continuous activity, whose results (update of calibration files) is intrinsically and necessarily decoupled from software releases. XMM-Newton users are recommended to consult periodically the URL: `http://xmm.esac.esa.int/external/xmm_sw_cal/calib`, which informs on the calibration status of the XMM-Newton instruments.
The SV is performed on a standard set of XMM-Newton observations, which cover all commissioned observational modes, and a number of observations, specially chosen for testing new / special aspects of the data reduction corresponding to the version to be validated. Tab. 1 lists all the datasets used for the validation of SAS version 14.0. Some of these observations are particularly suitable to test calibration-related items, as specified in the rightmost column of Tab. 1. These datasets are partly intended as a standard reference, which has been and will be used to verify the performances of all SAS versions. However, additional datasets may occasionally be used to test version-specific SAS items. Datasets discussed in a given report and not listed in Tab. 1 do not belong to the reference datasets, and are therefore not necessarily intended to be discussed in future SAS validation reports.

1.2 Methodology

The SV for SAS v14.0 consists of the following steps:

1. all the datasets listed in Tab. 1 are processed through the SAS 14.0 based testing Pipeline System (PPS) running at the SOC, and
2. the same datasets are also processed through the SAS reduction meta-tasks: `e[mp]proc`, `om[ifg]chain`, `rgsproc`
3. all the SAS threads are ran as documented, for checking the integrity of the software
4. products generated by the above steps are used as basis for the *interactive SV analysis*. Standard scientific products (images, light curves, spectra, source lists) are generated and analyzed. This allows to:
   - test the SAS interactive tasks.
   - verify the calibration accuracy obtained with SAS v14.0, and compare it with the expected accuracy on the basis of the calibration status at the time the SV is performed.

Table 1: SV datasets

Instrument	**Mode**	**Object**	**Revolution Obs. ID**	**ID**	**Calibration item**
EPIC MOS	Full Frame	Lockman Hole	544 0147511601	1	Astrometry + source detection
	"	G21.5.09	060 0122700101	2	Effective area
	Small Window (W2)	Mkn 421	165 0099280201	3	
	Large Window (W3)	PKS0558-504	153 0129360201	4	Effective area
	Timing Uncompressed	Her X-1	207 0134120101	5	Timing
EPIC-pn	Full Frame	Lockman Hole	544 0147511601	1	Astrometry
	Full Frame/Small Window	PKS0558-504	153 0129360201	4	Effective area
	Large Window	AB Dor	185 0133120201	6	
	Small Window	PKS0558-504	084 0125110101	7	Effective area
	Fast Timing	Her X-1	207 0134120101	5	Timing
		Crab	698 0160960201	8	
	Fast Burst	Crab	411 0153750301	9	Timing
		Crab	411 0153750501	10	Timing
	Extended Full Frame	G21.5-0.9	060 0122700101	2	Effective area
	Slew Data		1388 9138800002	18	Slew data processing
	Slew Data		1450 9145000003	19	Slew data processing
RGS	SPEC+Q	PKS0558-504	084 0125110101	7	
"		Mkn 421	165 0099280201	3	Effective area
	"	AB Dor	185 0133120201	6	Wavelength scale
	"	AB Dor	338 0134521301	11	Wavelength scale
	"	AB Dor	462 0134521601	12	Wavelength scale
	"	AB Dor	572 0134522201	13	Wavelength scale
OM	Image Mode	BPM 16274	261 0125320701	14	Photometry
	Fast Mode	X1822-371	228 0111230101	15	
	FF Low Resolution	BPM 16274	261 0125320701	14	Astrometry
	Optical grism	Hz2	503 0125910901	16	Wavelength scale & flux calibration
	UV Grism	HD13499 (offset)	657 0125911301	17	Wavelength scale & flux calibration

5. in addition the whole cross-calibration database is reduced by standard analysis scripts based on SAS but including also model fitting through Xspec.

In this report: best-fit parameter uncertainties are at the 90% confidence level for 1 interesting parameter ($\Delta\chi^2 = 2.71$); errors on positions or count rates are at the 1-σ level; energies are quoted in the observer's reference frame unless otherwise specified.

2 Validation

2.1 Upgraded platforms and compiler

A special circumstance of this release is that we have upgraded several SAS building machines which had somewhat older OS versions. We have upgraded on the Linux side, and both for 32bit as well as 64bit versions, Ubuntu V12.04 to V14.04, SuSE V11.2 to V13.1 and Fedora V17 to V20, keeping the stable version RHEL V5.8. On the MacOS side we have kept the V10.8.3 aka Mountain Lion and V10.9 aka Maverick and added V10.10 (Yosemite) as released binaries. In addition we have upgraded the gcc compiler (from V4.3.3 to V4.8.2) in all builders.

2.2 Parallel and iterating processes

The validation of SAS 14 was performed through parallel ways: after building the α version and producing the first binaries, all the standard sets have been processed up to the level of calibrated event lists in the case of the EPIC data, derived spectra and response matrices in the case of RGS and calibrated images and light curves in the case of OM data. Those products are used as starting point for interactive analysis. At the same time the whole cross-calibration database (around 100 observations) has been processed, including spectral extraction from the EPIC data and model fitting. Using the SAS 14 α version also a test pipeline has been built, used to process the same standard set to the final suite of products as delivered by the pipeline, including source detection and source products derivation.

Every one of these parallel paths has included some iterations, to eliminate errors, but also to cope with some advances and tweaks in the calibration, which this time, due to the complexity of the changes included, was not ready when this process started. The advantages of following the several different ways are obvious, and due to the very large parameter space of a complex software like SAS.

As a last final confirming step for the validity of the package, all the existing threads were ran, both for checking the software as for updating the threads where this should be done according to the new version.

3 Results

The final results of the standard data reduction (through `emproc`, `epproc` for the EPIC data, `rgsproc` for the RGS data and the chains `om[i][f][g]chain` for OM imaging, fast mode and grism data) have been used for detailed analysis. The most important ones are referred to here below.

3.1 EPIC standard analysis - G21.5-0.9

The non-thermal SNR G21.5-0.9 has been used as one of the standard targets for the validation of the EPIC effective area calibration. Additionally, this source has proven useful in multi-mission cross-calibration studies (Tsujimoto et al. 2011). Its spectrum can be well modelled by a simple power-law combined with a photoelectric absorption.
In observation 0122700101, G21.5-0.9 was observed with MOS in Full Frame mode and PN in Extended Full Frame Mode (all using Medium Filter) for 30 ks. MOS and PN source spectra were extracted from a circular region ($\sim$ 2.5 arcmin radius) around the SNR, and spatially filtered through their common exposure mask. MOS background spectra were obtained from annular regions around the source, whereas PN background was obtained from neighbouring source free regions. MOS data were reduced with SAS 14.0 and spectra were extracted with standard event pattern selection. PN data were reduced with SAS 13.5 and SAS 14.0 (with their most recent respective calibration files), and spectra were created using standard pattern, single-events only and double-events only. This allows comparison and validation of changes introduced by the PN-related calibration changes introduced in conjunction with SAS 14.
The results of the comparison of PN and MOS using SAS 14.0 are summarised in Fig. 1, and are essentially in agreement with the previous SAS science validation study. This is as expected, as the new PN energy scale calibration should not introduce significant changes in spectral shape of continuum dominated spectra.

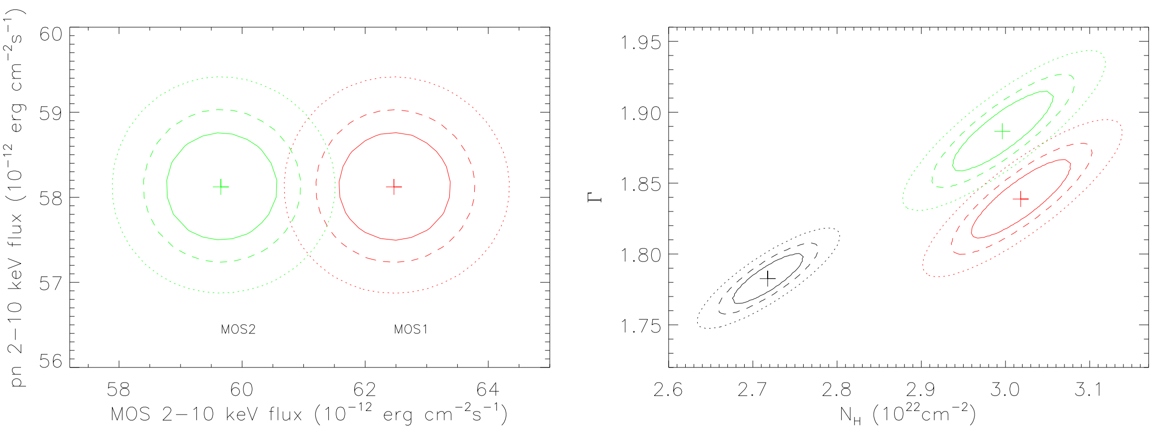

Figure 1: Comparison of PN versus MOS spectral fits of G21.5-0.9. Spectra based on data reduced with SAS 14.0, using standard pattern selection. *Left panel*: the 2-20 keV flux confidence contours for PN versus MOS1 (red) and MOS2 (green). *Right panel*: column density versus photon index confidence contours for PN (black), MOS1 (red), MOS2 (green). Levels shown are at 68%, 90% and 99% confidence.

A comparison of the spectral change introduced specifically by the new double-event calibration is shown in Fig. 2. As compared to the SAS 13.5 result, SAS 14.0 yields a minor improvement in the spectral parameter differences obtained with PN single-events with respect to double-events (PN single-event spectra show essentially identical results between SAS 13.5 and SAS 14.0.

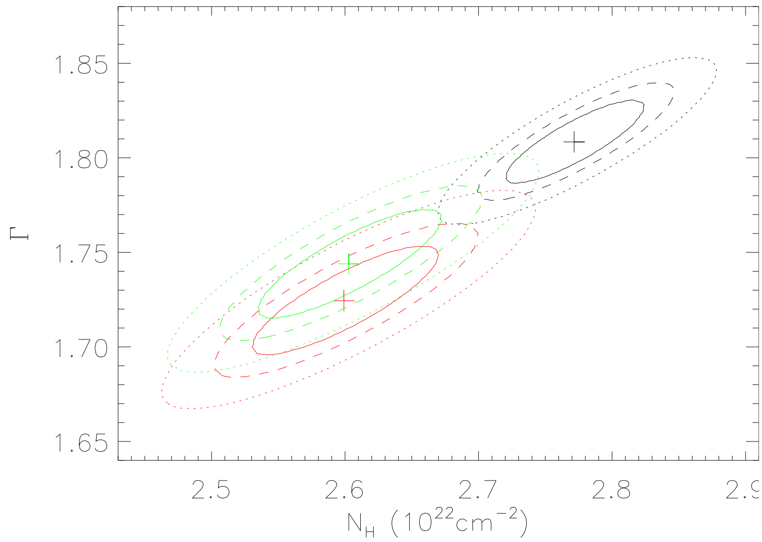

Figure 2: Comparison of PN spectral fits of G21.5-0.9 in terms of column density versus photon index confidence contours. Spectra obtained with different SAS versions and using different event patterns are indicated by the following colours: SAS 14.0 single-events (black), SAS 14.0 double events (green) and SAS 13.5 double events (red). The levels shown are at 68%, 90% and 99% confidence.

3.2 EPIC standard analysis - PKS 0558-504

PKS 0558-504 is a well studied radio loud Narrow Line Seyfert 1 galaxy (e.g. Siebert et al. 1999), and has been observed by *XMM-Newton* as calibration target. Its 2-10 keV spectrum is characterised by a spectral slope $\Gamma \sim 2.0$, and the 0.2-2 keV emission is dominated by a large and featureless soft excess.

As part of the SAS 14.0 science validation, PN and MOS spectra of ObsId 0125110101 are compared. PN was operated in Small Window Mode, and both MOS instruments in Large Window Mode. Data were reduced with SAS 13.5 and SAS 14.0 (using their respective latest calibration files), and resulting spectra were fit in the 0.3–10 keV band with a model consisting of a power-law plus a bremsstrahlung component (Papadakis et al. 2010). As the MOS data are subject to pile-up the spectra were extracted from annular regions.

As neither the PN nor MOS spectral fits changed significantly between SAS 13.5 and SAS 14.0, a comparison is made between spectra created with SAS 14.0 only. The results are summarised in Table 2. The main differences between instruments are due to the imperfect calibration at very low energies: the soft excess modelled by the bremsstrahlung component yields best-fit plasma temperatures which are formally not consistent across all three instruments.

Table 2: Comparison of MOS and PN spectral fits to PKS 0558-504 (ObsId 0125110101) with a power-law plus bremsstrahlung model.

Instrument	Γ	kT	Flux		χ^2/d.o.f.
		keV	10^{-11} erg cm^{-2} s^{-1}		
			(0.3–2.0 keV)	(2.0–10.0 keV)	
MOS1	$1.94^{+0.15}_{-0.16}$	$0.39^{+0.04}_{-0.04}$	$2.15^{+0.02}_{-0.02}$	$0.99^{+0.05}_{-0.06}$	272.4/273
MOS2	$2.07^{+0.14}_{-0.15}$	$0.34^{+0.04}_{-0.04}$	$2.25^{+0.02}_{-0.02}$	$0.92^{+0.05}_{-0.05}$	269.8/252
PN	$2.00^{+0.06}_{-0.06}$	$0.45^{+0.02}_{-0.02}$	$2.53^{+0.03}_{-0.03}$	$1.09^{+0.06}_{-0.05}$	626.2/528

3.3 Bug fixed in EPIC Fast Mode calculation

SASv14 fixes a numerical bug in `arfgen` when calculating the effective area in EPIC Fast Modes from a rectangular region in [`RAWX,RAWY`] after excising 7 columns (side) around the boresight. With SASv14 the effective area is accurately calculated for any number of excised columns around the boresight, as shown in Fig. 3.

3.4 Upgraded EPIC calibration in SAS 14

Several elements in the calibration of the EPIC instruments have been upgraded in the new SAS version. All the progress in the calibration have been tested and validated by the Instrument Dedicated Team coherently. They were:

- the so-called rate-dependent PHA correction (RDPHA), introduced in SAS 13 is now taken as the default for PN Timing mode, replacing the RDCTI correction. To avoid the difficulties posed by different corrections to be applied to different observation modes of EPIC-PN, a new parameter `withdefaultcal` has been added to the data reduction metatasks `epproc` and `epchain`. It serves the purpose of setting the default values for the specific modes of the data to be reduced,
- introduction of an energy dependency in the EPIC-pn long-term CTI correction. This addresses the increasing energy overcorrection in time of single events below 6 keV and of double events at all energies (see XMM-CCF-REL-323).
- EPIC-pn double-event energy correction. This modification is implemented as an empirically determined energy dependent offset which corrects the energy shift of double events with respect to single events (see XMM-CCF-REL-323).
- the introduction of correction factors for all three EPIC cameras in the telescope effective area calibration files should increase the flexibility for incorporating adjustments based on systematic studies, addressed in the calibration release note XMM-CCF-REL-0321.
- the EPIC pn long term CTI time dependency cannot be modeled anymore with 3rd order polynomials and therefore more flexibility for its evolution is implemented, in this case a 4th order polynomial has been introduced, (also addressed in the calibration release note XMM-CCF-REL-323),
- a time dependency in the pn spectral line widths is coped with, including the necessary differentiation between singles and doubles. This is addressed in the calibration release note CAL-SNR-0322.

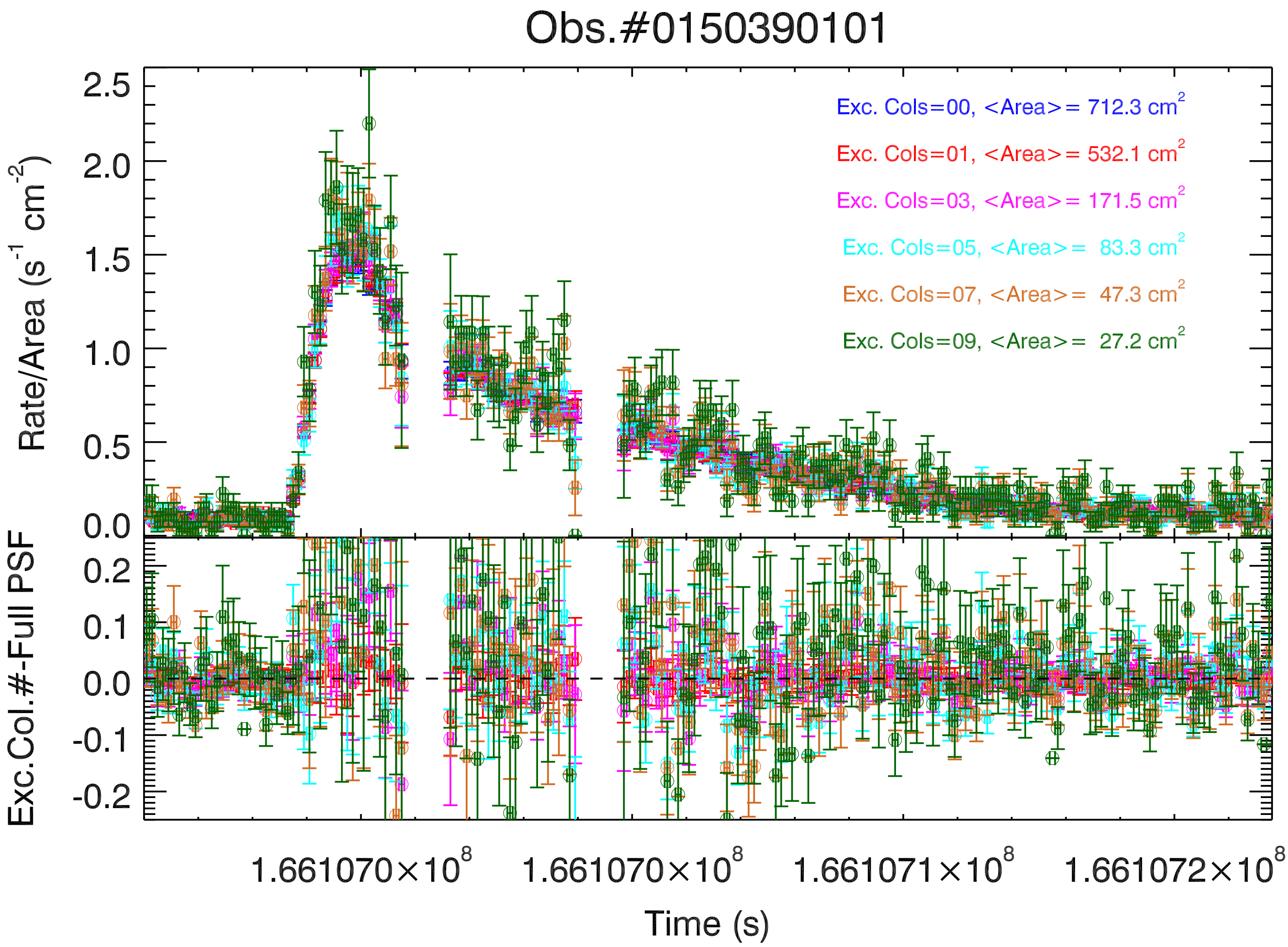

Figure 3: Count rates in the 2.5-10 keV energy range normalised by the effective area in the same energy range (*upper panel*), and residuals against the same quantity calculated over the whole PSF (*lower panel*) for a burst measured in an EPIC-pn Timing Mode observation of GS1826-24 (Guver et al., in preparation). The *colours* indicate different number of excised columns (side) around the boresight.

The release notes can be extracted from the CCF release notes page (http://xmm2.esac.esa.int/external/xmm_sw_cal/calib/rel_notes).

3.5 RGS standard analysis

This version of SAS does not include any important modification in the processing of RGS data. The only change is that, starting in this version, the default in `rgsangles`, and therefore also in `rgsproc`, is to include by default heliocentric and sun-angle corrections to the wavelength scale (through the parameters `withheliocentriccorr=yes` and `withsunanglecorrection=yes`, respectively).
The standard set of validation data processed with the SASv14 build of September 30 (`xmmsas_20140930_1703`) have been examined. Output products of rgsproc have been compared with the result of processing with SASv13.5. No significant differences have been found.

3.5.1 Specific points checked

Two points, related to SPRs that have been closed in this release, have been specifically checked:

- the use of the `rebin` parameter in `rgsspectrum`.
- the generation of combined model background with `rgscombine`.

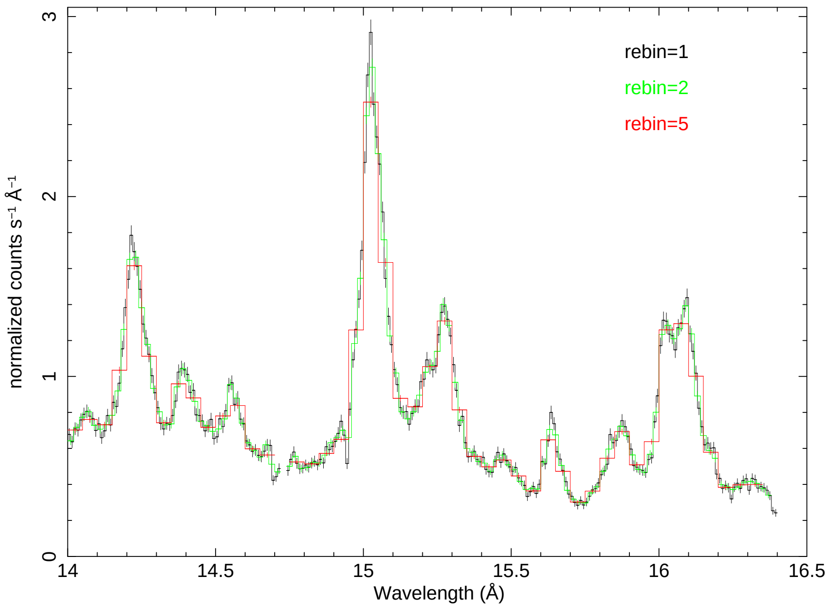

Figure 4: Comparison of spectra obtained using different values of the `rgspectrum` parameter `rebin`.

3.5.1.1 Test of `rgsspectrum` fix

The use of a value of the parameter `rebin` different from 1 was leading to a 'segmentation fault' when working in wavelength space (that is the current default).
This problem has now been fixed and has been tested processing one observation of Capella with values of the `rebin` parameter of 2 and 5. The task ends without error, and the result is satisfactory. The output spectra have been compared to the result of using the default value `rebin=1`, as shown in Fig. 4.

3.5.1.2 Test of `rgscombine` fix

It has been reported that in SASv13.5 the combined background resulting from running the task `rgscombine` using as input model background spectra computed with `rgsbkgmodel` was wrong. This problem was traced to an incorrect transformation of the individual model backgrounds from rate to counts (which is the output of `rgscombine`). This has been fixed in this version of SAS. Output combined background spectra have now correct values of `AREASCAL` and exposure time.

3.6 OM standard analysis

The computation of errors in OM image mode photometry has been changed in SAS 14. The new method was already included in the data processing for the new OM Catalogue.
In SAS 13 it was decided that the Fast Mode processing, driven by **omfchain** would have as default the measurement of the background in the image mode window that normally surrounds the fast mode one. However a late change in **omfchain** had as side effect that taking the background from the image was impossible and this went unnoticed in the validation of the system. This bug has been solved now.
Finally, the interactive tasks **omsource** and **omgsource** for which the graphic interface failed in 64 bits builds of SAS, have been amended.
In addition to checking the mentioned new implementations, as in previous deliveries, this Science validation has been devoted to check and confirm that the main functionalities already present in previous versions are maintained, in other words, we confirm the overall stability of the system. The reader is thus referred to previous Science Validation Reports for more detailed comments or descriptions.

3.6.1 New errors computation in SAS 14

The massive data reprocessing done for the compilation of the new OM Catalogue has allowed us to discover an inconsistency in the computation of errors in the measurement of the count rates of the detected sources. The characteristics of the OM detector make that the probability of photon detection does not follow a Poisson distribution, but a binomial distribution. This effect has been described by Kuin and Rosen (2008, MNRAS, 383, 383) and we have included it in the OM data processing with SAS 14, which is now aligned with the processing applied for the OM Catalogue.
In Fig. 5 we compare the new computed errors with the previously computed ones using SAS 13.5. It is clearly shown that the old errors were overestimated for low to mid count rate values, while they were wrong for high count rates.

3.6.2 OM Fast Mode processing

The measurement of the background in OM fast mode data is critical. For moderately bright sources and particularly in the UV, the size of the PSF exceeds the fast mode window (11 x 11 arcsec2). Since SAS 10.0 the **omfchain** offers the user the possibility of measuring the background in the image mode window that normally accompanies the fast mode data. This option has been made the default in SAS 14.
It should be noted that the odf must contain OM image data in a window that surrounds the fast mode window (this occurs in most cases).
Using the **omfchain** parameter *bkgfromimage=no* will in any case force the background to be obtained from the fast mode data, although this option is not recommended.
In case we want to compare the background obtained with the two methods, we should take into account that the BACKGROUND column in time series files (*TIMESR*) has different scaling depending on the type of measurement. If it is obtained from the fast mode data,the background is given for the extraction area, while if from image data it is scaled to a 12 pixels aperture radius. This difference can be seen in the plots produced by **omfchain** . Note that the background extraction area given in plot header is wrong when it is measured in the image data.

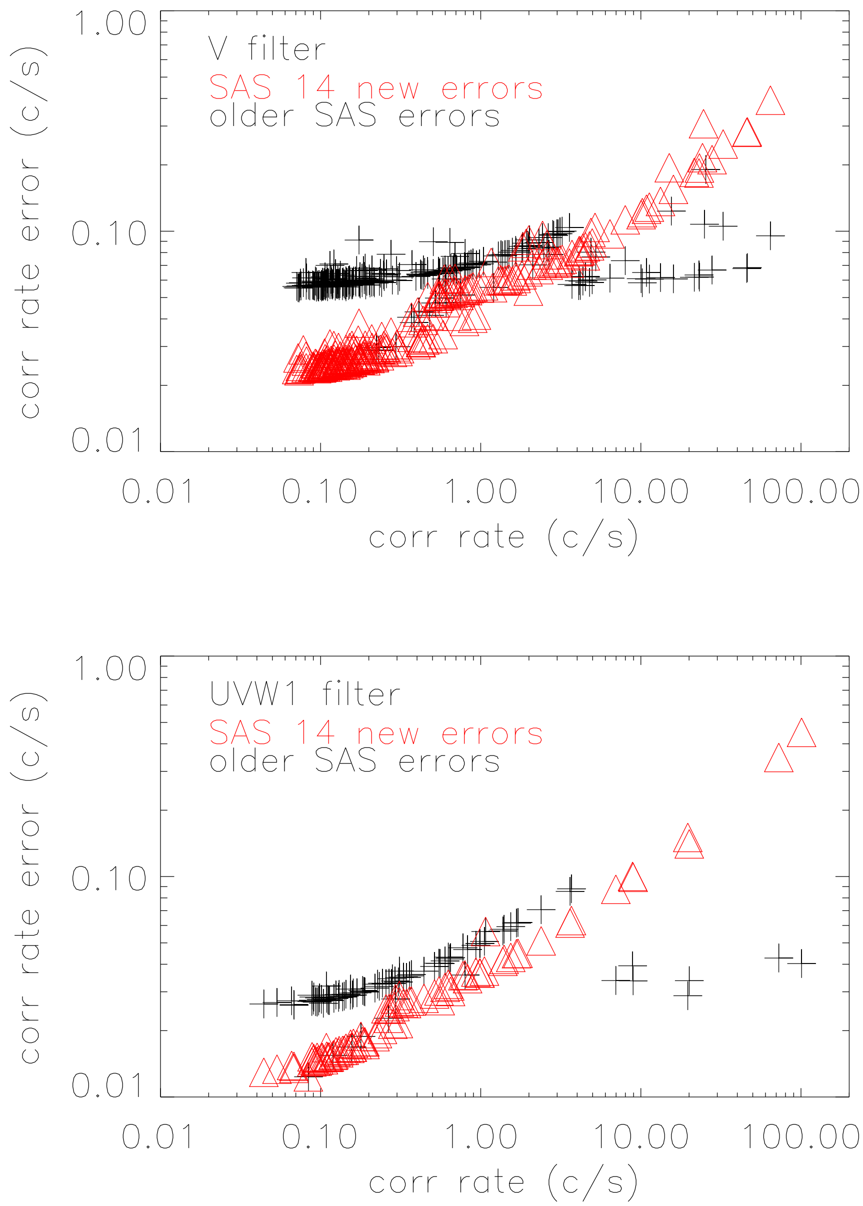

Figure 5: New errors computation in the photometry of sources in the field of BPM 16274 observed with OM in the V and UVW1 filters.

Additionally, a bug existing in the **omfchain** code has been corrected: the count rate of the last time bin was incorrectly calculated. This is now solved.

3.6.3 Interactive tasks:omsource and omgsource

When working with architectures of 64 bits, these tasks were failing because of errors in their graphics interface. This has been solved in SAS 14.
We should point out, however, some caveats:

- **omsource**

  After performing the interactive photometry of a given source, the results can be written to a fits file. The photometric values for the source (rate, magnitude, flux) are correct, while other file columns giving the applied corrections are wrong.

- **omgsource**

  During the interactive extraction of grism spectra (in 64 bits installations), a temporary plot is produced. This plot may be wrong. However, the final extracted spectra are correct.

3.6.4 Repeatability of OM filter photometry

Several spectrophotometric standard stars are observed repeatedly with OM in order to establish and monitor the photometric and flux calibrations. These are the white dwarfs GD 153, HZ 2 and BPM 16274.
As we have done in the past all existing data of these stars have been reprocessed using SAS 14. The results are presented in Tab. 3 and in Tab. 4.
The quoted errors are the standard deviation of the mean values given as percentage.
We see that after all corrections are applied, the count rates of these stars obtained from all observations taken during the life of OM do not vary within 3 %.

Table 3: Standard stars processed with SAS 10.0: average count rates of several observations

star	N_obs	UVW2	UVM2	UVW1	U	B	V
GD153	8	82.00	160.72	327.27	418.97	282.95	70.36
error (%)		1.1	1.1	0.8	1.8	1.2	1.5
HZ2	11	23.54	48.09	111.42	168.80	149.01	43.05
error (%)		2.7	3.0	1.9	0.9	1.2	1.2
BPM16274	18	14.60	30.28	72.78	112.85	107.87	32.57
error (%)		2.8	3.3	1.6	1.1	1.5	1.8

Table 4: Standard stars processed with SAS 14.0: average count rates of several observations

star	N_obs	UVW2	UVM2	UVW1	U	B	V
GD153	12	83.38	163.50	330.56	421.80	284.75	71.39
error (%)		1.5	1.7	0.9	1.5	1.0	2.5
HZ2	15	23.78	48.50	111.93	169.25	149.37	43.73
error (%)		1.9	1.7	1.3	0.9	0.9	3.0
BPM16274	27	14.74	30.55	73.15	113.06	108.08	32.92
error (%)		1.6	1.7	1.1	0.8	0.9	2.0

3.7 Standard validation of ESAS

ESAS, the Extended Sources Analysis System, was a package developed independently from the SAS years ago at the Goddard Space Flight Center (GSFC) by the XMM-Newton Guest Observer Facility (GOF). Later integrated into the SAS, their tasks are callable within it, but they preserve a number of peculiarities, e.g. their use of special calibration files which are not under the CCF suite, or the lack of the otherwise standard harness testing at the time of building the packages, etc. The GOF is working on adapting ESAS fully to SAS standards in a near future. In the meanwhile, we owe to pay special attention by every release.
This report includes the results of the analysis of the data set 0097820101 (Abel 1795 cluster). After running the standard tasks `epchain` both with and without switching the parameter `withoutoftime=true` and `emchain`, we started with one of the ESAS task: `pn-filter`, which failed to run in the internal call to `espfilt`, resulting in a segmentation fault. The problem has been SPR'ed and identified as solely happening in 32-bit versions.
Using a 64-bit version following tasks have been ran and log files checked for errors:

```
epchain >& epchain.log
epchain withoutoftime=true >& epchain_oot.log
emchain >& emchain.log
pn-filter >& pn-filter.log
mos-filter >& mos-filter.log
cheese (including pn and mos exposures)
  (cheese prefixm='1S003 2S004' prefixp=S005 verb=0 scale=0.5 rate=1.0 dist=40.0 clobber=1
  elow=300 high=10000 > & cheese.log)
pn-spectra
  (pn-spectra prefix=S005 caldb=/ccf/pub/extras/esas_caldb mask=1 elow=400 ehigh=2000
  quad1=1 quad2=1 quad3=1 quad4=1 > & pn-spectra.log)
mos-spectra (for mos1 and mos2)
  (mos-spectra prefix=1S003 caldb=/ccf/pub/extras/esas_caldb region=regm1.txt mask=1
  elow=400 ehigh=2000 ccd1=1 ccd2=1 ccd3=1 ccd4=1 ccd5=0 ccd6=1 ccd7=1
  > & mos1-spectra.log)
  (mos-spectra prefix=2S004 caldb=/ccf/pub/extras/esas_caldb region=regm2.txt mask=1
  elow=400 ehigh=2000 ccd1=1 ccd2=1 ccd3=1 ccd4=1 ccd5=0 ccd6=1 ccd7=1
  > & mos2-spectra.log)
pn_back
  (pn_back prefix=S005 caldb=/ccf/pub/extras/esas_caldb diag=0 elow=400 ehigh=2000 quad1=1
   quad2=1 quad3=1 quad4=1 >& pn_back.log)
mos_back (for mos1 and mos2)
  (mos_back prefix=1S003 caldb=/ccf/pub/extras/esas_caldb diag=0 elow=400 ehigh=2000
  ccd1=0 ccd2=1 ccd3=1 ccd4=1 ccd5=0 ccd6=1 ccd7=0 >& mos1_back.log)
  (mos_back prefix=2S004 caldb=/ccf/pub/extras/esas_caldb diag=0 elow=400 ehigh=2000
  ccd1=0 ccd2=1 ccd3=1 ccd4=1 ccd5=0 ccd6=1 ccd7=1 >& mos2_back.log)
proton (for pn, mos1 and mos2)
  (proton prefix=S005 caldb=/ccf/pub/extras/esas_caldb specname=pnS005-obj.pi ccd1=1 ccd2=1
   ccd3=1 ccd4=1 elow=400 ehigh=2000 spectrumcontrol=1 pindex=0.972080 pnorm=0.131099
   >& pn_proton.log)
  (proton prefix=1S003 caldb=/ccf/pub/extras/esas_caldb specname=mos1S003-obj.pi ccd1=0
  ccd2=1 ccd3=1 ccd4=1 ccd5=0 ccd6=0 ccd7=0 elow=400 ehigh=2000 spectrumcontrol=1
  pindex=0.972080mpnorm=0.131099 >& mos1_proton.log)
```

```
  (proton prefix=2S004 caldb=/ccf/pub/extras/esas_caldb specname=mos2S004-obj.pi ccd1=0
  ccd2=1 ccd3=1 ccd4=1 ccd5=0 ccd6=0 ccd7=1 elow=400 ehigh=2000 spectrumcontrol=1
  pindex=0.972080 pnorm=0.131099 >& mos2_proton.log)
rot-im-det-sky (for pn, mos1 and mos2 (mode=1 and mode=2), needed
                by the tasks comb and adapt_900 to produce images)
  (rot_det_sky mode=1 prefix=S005 elow=400 ehigh=2000 detx=-1079.810798 dety=1482.314823
  skyx=450.91 skyy=450.91 maskfile=1 clobber=1 >& rot-im-det-sky_pn_mode1.log)
  (rot_det_sky mode=2 prefix=S005 elow=400 ehigh=2000 detx=-1079.810798 dety=1482.314823
   skyx=450.91 skyy=450.91 maskfile=1 clobber=1 >& rot-im-det-sky_pn_mode2.log)
  (rot_det_sky mode=1 prefix=1S003 elow=400 ehigh=2000 detx=-1414.414144 dety=-1389.413894
   skyx=450.91 skyy=450.91 maskfile=1 clobber=1 >& rot-im-det-sky_mos1_mode1.log)
  (rot_det_sky mode=2 prefix=1S003 elow=400 ehigh=2000 detx=-1414.414144 dety=-1389.413894
   skyx=450.91 skyy=450.91 maskfile=1 clobber=1 >& rot-im-det-sky_mos1_mode2.log)
  (rot_det_sky mode=1 prefix=2S004 elow=400 ehigh=2000 detx=1211.812118 dety=-1637.716377
  skyx=450.91 skyy=450.91 maskfile=1 clobber=1 >& rot-im-det-sky_mos2_mode1.log)
  (rot_det_sky mode=2 prefix=2S004 elow=400 ehigh=2000 detx=1211.812118 dety=-1637.716377
   skyx=450.91 skyy=450.91 maskfile=1 clobber=1 >& rot-im-det-sky_mos2_mode2.log)
comb
  (comb caldb=/ccf/pub/extras/esas_caldb withpartcontrol=1 withsoftcontrol=1
  withswcxcontrol=0 elowlist=400 ehighlist=2000 mask=1 prefixlist="1S003 2S004 S005"
  > & comb_400-2000.log)
adapt
  (adapt smoothingcounts=50 detector=0 thresholdmasking=0.02 binning=2 elow=400 ehigh=2000
   withmaskcontrol=no withpartcontrol=yes withsoftcontrol=yes withswcxcontrol=no
   > & adapt.log)
```

as specified in the `ESAS` Thread.
The only problem found was that the task `proton` has a new mandatory parameter: `specname`. This is not reflected in the online documentation of the task. This parameter seems to be in `proton` since SAS13.0 (does not appear in SAS12.0). It is reflected correclty in the HTML online version of the ESAS cookbook.
In summary: the above list of tasks was run successfully in a 64 bit machine to produce a mosaic image of the three instruments with point sources removed (also smooth version of image produced). For simplicity, only the energy range `elow=400 ehigh=2000` was used.
All the expected files (final image, background, exposure, etc), as expected in the `ESAS` thread (http://xmm.esac.esa.int/sas/current/documentation/threads/esasimage_thread.shtml) have been correctly produced. The background subtracted exposure corrected image produce finally by `adapt` is shown in Fig. 6.

3.8 Tests of a new script for producing (combined) EPIC background subtracted, exposure corrected smoothed images

A new task is introduced with SAS 14, `eimageget`, for the creation of a set of images from one EPIC exposure, which make possible the derivation of combined background-subtracted exposure corrected images. `eimagecombine` is a perl script around that task for the combination of the images derived from one or several observations. For a given EPIC exposure and diverse spectral bands, `eimageget` creates images of the observation, scaled out-of-time (OOT) images (PN only), scaled filter-wheel-closed (FWC) images, vignetting corrected exposure maps and a mask.

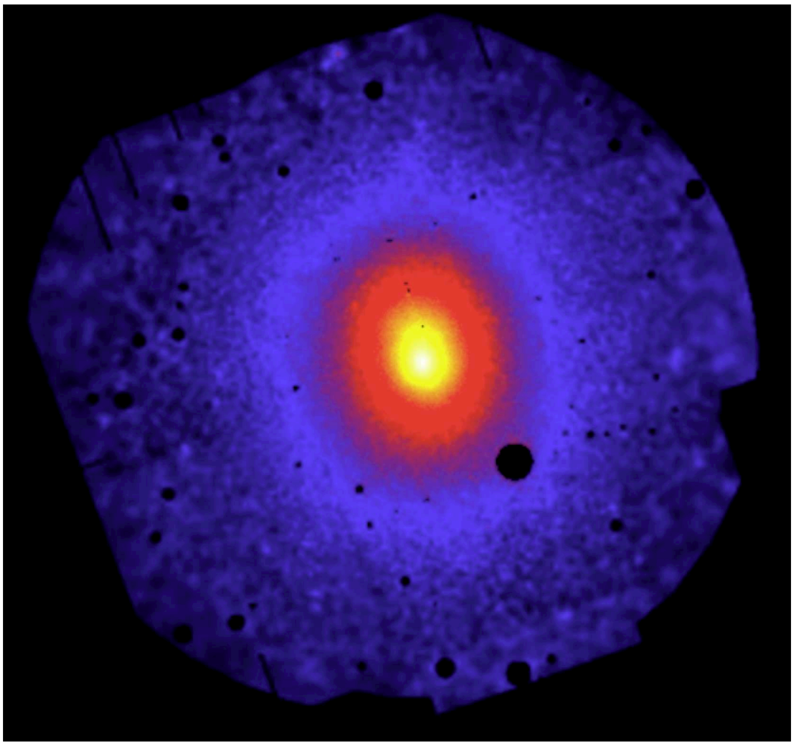

Figure 6: Background subtracted, exposure corrected adaptively smoothed image of the Abel 1795 cluster in the $E = [400 - 2000]eV$ band

.

Especially suited for the combination of different observations overlapping spatially, the task should provide a robust and useful approximation for the detector background, and allowing the user to create mosaic images through recalculation of image coordinates. `eimagecombine` makes possible the mosaic creation using the outputs of `eimageget`.
We have tested both new tasks using 12 observations of the Coma cluster region, repeatedly observed with partially large overlaps. All observations had been performed with all EPIC cameras in Full Frame mode. with a total of 36 exposures therefore. We have obtained the images in three spectral bands: $E = [0.4 - 1.0]keV, E = [1.0 - 2.0]keV$ and $E = [2.0 - 7.2]keV$, dealing at the end with 108 images. For all of them all the corresponding products from `eimageget` have

been obtained, 409 in total. `eimagecombine` running with default parameters finally combined all the products for obtaining the images exposed in Fig. 7.
These tasks have been therefore qualitatively tested. They run fast and efficiently. A more ambitious, quantitative testing of the products and the interactive possibilities (eg. using different adaptive smoothing techniques) against more sophisticated background determination (a la `ESAS`) is on-going.

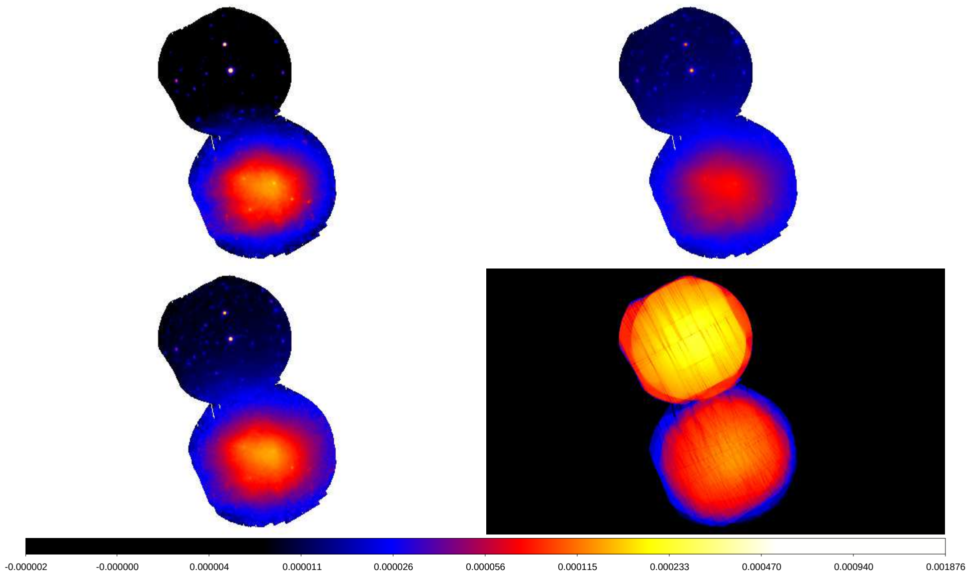

Figure 7: Combined observations of the Coma Cluster region: $E = [0.4 - 1.0]keV$ (upper left), $E = [1.0{-}2.0]keV$ (upper right), $E = [2.0{-}7.2]keV$ (lower left) background subtracted, exposure corrected adaptively smoothed images, as produced by `eimagecombine`, and the corresponding combined exposure map (lower right)

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References

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