XMM-Newton

XMM-Newton Science Analysis System 12.0 scientific validation

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Revision history

Revision number	Date	Revision author	Comments
0.9	14 April 2012	C. Gabriel	Plan including schedule
1.0	5 December 2012	C. Gabriel	Full report
1.1	10 December 2012	C. Gabriel	Full report

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 document you are reading (*SAS Science Validation Report*) contains information about:

- which instrumental modes are fully supported by SAS,
- which scientific products SAS can produce,
- the level of accuracy associated with those products,
- a list of caveats and problems.

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 12.0. 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. This is the case, for instance, for the datasets discussed in Sect. 2 of this report. Datasets discussed in a given report and not listed in Tab. 1 do not belong to the reference datasets, and are therefore not intended to be discussed in later SAS versions validation reports.

1.2 Methodology

The SV for SAS v12.0 consists of the following steps:

1. all the datasets listed in Tab. 1 are processed through the SAS 12 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. 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:

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

- test the SAS interactive tasks.
- verify the calibration accuracy obtained with SAS v12.0, and compare it with the expected accuracy on the basis of the calibration status at the time the SV is performed.

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

The conclusions of the SV are to be summarized in Sect. 5. A list of instrument modes supported by SAS v12.0 shall be reported in Appendix A. A summary of SAS v12.0 capabilities detailed in Appendix B.
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 New in SAS 12

There are several new elements as well as fundamental upgrades in SAS v12.0 with respect to former versions. They can consist of new tasks, or new analysis methods within already existing tasks. All of them have to be scientifically validated, in addition to their standard integration tests. Under the MacOS builds there are also for the first time native 64-bits, for which we want to provide a SAS version (Darwin 10.6.5 aka Snow Leopard and Darwin 10.7 aka Lion).

2.1 New in SAS12: New MacOSX running native 64-bit

All the data listed in Tab. 1 will be processed using SAS v12.0 also on the new platforms running native 64-bit OS version: Darwin 10.6.8 (Snow Leopard) and Darwin 10.7.3 (Lion). The products will be checked and partially used for interactive analysis. In addition full comparison of following products (at least one of each sort) from a 32bit and a 64bit run will be done:

- event files from MOS, PN and RGS - comparing number of events before and after cleaning selection
- spatial images from MOS, PN, OM and RGS
- spectra from EPIC and RGS
- source detection - comparing number of sources found

2.2 New in SAS12: time dependent boresight correction

Introduction of a time dependent boresight correction should help to reduce the systematic error in the source coordinates determination of EPIC sources and in the RGS wavelength scale . Proper testing requires the data reduction of a considerable fraction of all XMM-Newton observations, comparing the results of the corrections applied by the task `eposcorr` or `catcorr` when correlating the source coordinates found with astronomical catalogues. This is as such outside the scope of this Validation. Such level of testing is though conducted by the XMM-Newton Calibration Team for validation of the corresponding CCFs. This document should point to the technical note describing those tests and the subsequent tests with RGS data referred to the wavelength scale. In addition, a single ODF test should be performed comparing the source coordinates found with and without the time dependent boresight correction: the Lockman Hole observation 0147511601 in revolution 544 offers best conditions with a large number of sources and a large correction. All 4 AB Dor observations in the standard testing data set, should be reduced with and without the time dependent boresight correction and the single wavelengths dispersion compared.

2.3 Upgraded and default in SAS12: 2D PSF

There have been several upgrades in the 2D PSF approach, and the results of intensive testing carried out by the 2D PSF Working Group are considered satisfactory, as to decide to switch it in as the default PSF approach to be used in SAS and PPS. A validation report on its own is merited here. As in the former point this document should point to the technical note describing performed tests and results as well as to the corresponding CCF release notes. The same EPIC data used for 2.2 (Lockman Hole observation 0147511601 in revolution 544) should be analysed in terms of sources found using both the "2D PSF" and the "medium PSF".

2.4 New in SAS12: X-Ray Loading correction for EPIC-pn Fast Modes

As of SAS 12, `epreject` supports the correction for X-ray Loading (XRL) in EPIC-pn Fast Modes (see Guainazzi at al. 2012a for a description of this effect, and of its impact on the energy scale). The correction should be tested using an exposure with a high count rate, eg. one of the Crab Nebula observations.

2.5 Upgraded in SAS12: Encircled Energy Fraction for EPIC-pn Fast Modes

EPIC-pn Fast Modes are treated in SAS 12 as a special case within `arfgen`. For the EPIC-pn camera, regardless of the spatial region used to extract the spectra the source is assumed to be located at a DETY position calculated from the SRCPOS keyword in the spectrum header (or RAWY=190 if this keyword isn't present). The vignetting and encircled energy corrections are applied assuming a point source at this position. Bad pixels, columns and chip gaps are corrected for in the same way as for imaging mode observations.
A sample of X-ray binaries should be studied for investigating the stability of the flux reconstruction.

2.6 New in SAS12: `epspatialcti`, a new task for correcting EPIC PN CTI spatial variations

Measurements of the spectra of bright extended sources have shown that there is a pixel-to-pixel variation in the energy scale which is mainly caused by CTI changes due to partial trap saturation. These can be represented, and corrected for, by a spatial CTI correction.
It is currently recommended to apply this correction for observations taken in FullFrame and ExtendedFullFrame modes. There is some evidence that it may also produce an improvement in LargeWindow and SmallWindow modes, however, it should not be applied for Timing mode or Burst mode observations.
To avoid the corrections being applied twice, a keyword SPATCTIC is set in the header of the EVENTS extension when the task terminates successfully.
The correction should be validated through the analysis of several observations of extended bright sources.

2.7 New in SAS12: `catcorr`, a new package used for cross correlation with catalogues

tt catcorr extends the capability of `eposcorr`, making also possible cross correlation with the 2MASS and sdss catalogues in addition to the USNO-B, increasing the number of XMM-Newton observations able to be cross-correlated from 40% to 85%. An observation with a large number of detectable sources, able of being corrected by both packages is ideal for testing the results, eg. the Lockman Hole observation 0147511601 in revolution 544. Comparisons between the results shall be made.

2.8 Upgraded in SAS12: source detection with slew data

`eboxdetect` has been upgraded to make possible a better source detection with slew data. The version of this task from SAS 7 on has produced a large number of spurious sources when applied to slew data.

2.9 New in SAS12: RGS heliocentric correction

`heliocentriccorr` is a new task for the calculation of the heliocentric correction. It writes the correction to be taken into account as a keyword, which can be used in conjunction with a model at the time of fitting a high resolution spectrum. Wavelength shifts of up to 3 mAngstrom can result out of the correction. All the 4 different AB Dor observations contained in the standard data set should be used for calculation of the corresponding correction, performing this tests in conjunction with the ones for section 2.2.

2.10 Upgraded in SAS 12: ESAS

The package ESAS, included in SAS for analysis of extended sources, has been upgraded. Many of the calibration files corresponding to this package have been updated (ESAS calibration DB is still outside the normal CCF mechanism). The whole ESAS data reduction (as specified in the "ESAS threads") shall be exercised and results compared to the ones achieved in the SAS 11 validation.

3 Validation plan

3.1 Validation schedule

The schedule for the validation foresees a period of $\tilde{7}$ weeks for performing the different tasks. This is the projected schedule with the different milestones:

- SAS into release track mode - 30 March 2012
- SAS builds on different platforms - 10 April - [EO]
- SAS 12 binaries (at least 1 platform) - 12 April - [EO]
- Processing of all the standard datasets (32 bit + 64 bit subsets - finished - 15 April - [AI]
- Communication to validators about success and data location - 15 April - [CG]
- Preparation of a SAS 12 based PPS test version - 17 April - [EO]
- Installation of SAS 12 binary in XCal grid - 25 April - [EO]
- Processing of standard datasets by testing pipeline - 30 April - [CG]
- Processing of XCal archive - 4 May - [MSt]
- First evaluation of XCal - to be ready by 11 May - [MSt]
- first I/A analysis of standard data - to be ready by 11 May - [MG, AP, AT]
- Dedicated analysis - to be ready by 11 May:
  1. MacOSX 64-bit vs 32-bit data products comparison - [CG]
  2. time dependent boresight correction - [RDS, AP]
  3. EPIC 2D-PSF handling - [RDS]
  4. `catcorr` tests - [CG]
  5. source detection with slew data - [RDS]
  6. RGS heliocentric correction determination - [AP]
  7. Upgraded ESAS - [IdC]
- Summary reports due on 15 May - [All]
- Release notes + SAS 12 web pages contents ready - 18 May - [CG]
- SAS 12 distribution tarfiles ready - 18 May - [EO]
- SAS 12 release - 21 May
- Final SV individual reports - 1 June [All]
- Final SV Report compilation - 22 June [CG]

4 Validation results

SAS 12 has been successfully validated and finally released with a delay of only 9 days with respect to the planned schedule, on 30 May. Four weeks later a patch, SAS 12.0.1. had to be released for fixing a bug in the response matrix generation (`arfgen`) for PN burst mode data. Also an initialization of variables in the `epatplot` task has been included, which if not done led to crashes by some of the binaries distributed.
The problems leading to the necessity of a patch release were not detected during the validation due to their interactive nature. In the first case, due to the fact that no specific check of response generation for PN burst mode data was included in the validation procedure (and the procedures got correspondingly updated for next exercises). The case of `epatplot`, where a lack of variables initialisation produced crashes by some SAS binary distributions, is clearly exposing limitations of validation testing which will remain. We do not have the necessary manpower to cope with I/A testing of ALL the different binaries distributed (and we recall that the total number of different binaries in SAS 12 are 15!). These type of problems should pop-up at the level of single task harness testing (harness testing of `epatplot` has been correspondingly extended).

4.1 General processing

The standard data set (see Table 1) has been fully processed as expected, both in the 32-bit and 64-bit chains, without any problems. Processing is performed using dedicated scripts. Same (randomly selected) products from the two different chains have been compared and been found fully compatible (very minor differences can always be found due to the randomisation applied in the data processing).
The same standard data set has been processed by a testing (SAS 12 based) PPS version with the same excellent results.
Furthermore, the whole X-Cal DB has been processed without problems for determination of the cross-calibration levels between the XMM-Newton instruments. No problems have been found by the automatic full data reduction. Paraphrasing the X-Cal chapter within the Calibration Technical Note addressing the status of EPIC calibration (XMM-SOC-CAL-TN-0018):

- At energies $\leq 0.54keV$ (fluorescent photo-absorption edge of neutral Oxygen) RGS yields typically fluxes 7% larger then EPIC-pn
- At energies $\geq 0.54keV$ RGS yields typically 2% higher fluxes then pn
- At energies $\leq 0.85keV$ MOS and pn yield consistent fluxes
- At energies $\geq 0.85keV$ MOS yields typically 7% higher fluxes then pn
- The MOS cameras yield typically mutually consistent fluxes over their whole energy bandpass.

The full results of the X-Cal exercise can be seen using the "Calibration Review Tool" as offered in the calibration area of the XMM-Newton web pages (http://xmm2.esac.esa.int/cgi-bin/ept/preview.pl). Using these data, it can be appreciated how the different improvements in processing and calibration have contributed to a better agreement by all different source types between the X-ray cameras on board XMM-Newton.
With respect to the OM data there were no problems found in the general validation. Several standard stars were processed. Count rates measured agree well with those of previous SAS versions. This was expected, since there have been no modifications in the main core of the OM processing, except some adjustments in performance and correction of bugs.

Table 2: Detection statistics for MEDIUM and ELLBETA PSF

Band	ELLBETA		MEDIUM	
	Mean_SCTS	Mean_DETML	Mean_SCTS	Mean_DETML
0	1004	364.7	982	367.8
1	517	193	505	197
2	296	159	284	159
3	77.5	12.9	78.1	12.9
4	39.7	2.94	39.8	2.91
5	73.9	1.63	74.9	1.63

4.2 New elements in SAS 12

4.2.1 New in SAS12: New MacOSX running native 64-bit

The validation standard datasets have been reduced using the standard validation scripts, both with MacOSX Snow Leopard in 32 and 64 bits. Same random seeds have been used for same data as to allow us a comparison file by file. The results from both versions are fully identical, therefore the native 64-bit binaries have been declared as validated.

4.2.2 New in SAS12: time dependent boresight correction

Validation of the time dependent boresight correction has been performed for OM and EPIC and reported with the release notes of the associated calibration file "XMM_BORESIGHT_0022.CCF" (http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0286-1-1.pdf) at basically the same time SAS 12 was released. A further release of the same CCF, extended this time to the RGS instruments, followed two months later (http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0290-1-0.pdf).

4.2.3 Upgraded and default in SAS12: 2D PSF

While a thorough analysis of the improvements for source detection are going to be published with the next XMM-Newton X-ray sources catalogue (3XMM), a fast validation has been performed using the "2D PSF" with one observation.
The Lockman hole observation 0147511601, from revolution 544, was analysed to compare the effects on source detection of changing from the MEDIUM mode point spread function (PSF) used in SAS v11 to the new ELLBETA mode PSF, which is the default in SAS v12. The data were processed with `odfingest` and `epproc` and images created from the EPIC-pn camera in the 0.2-0.5, 0.5-2.0, 2.0-4.5, 4.5-7 and 7-12 keV energy bands. A calibration index file was created using the XRT3_XPSF_0014.CCF and XMM_BORESIGHT_0022.CCF file to represent the most recent PSF (see CAL-SRN-0280) and time-variable boresight calibrations (CAL-SRN-0286).
The images were source searched using `edetect_chain`; initially using the MEDIUM mode PSF and then with the ELLBETA PSF. The detection statistics for the two PSFs are given in table 2 for each energy band.
In total there were 139 sources detected with the ELLBETA PSF and 146 with the MEDIUM PSF. A median offset of 0.7 arcseconds was seen between the returned positions of the sources with the two PSF models.

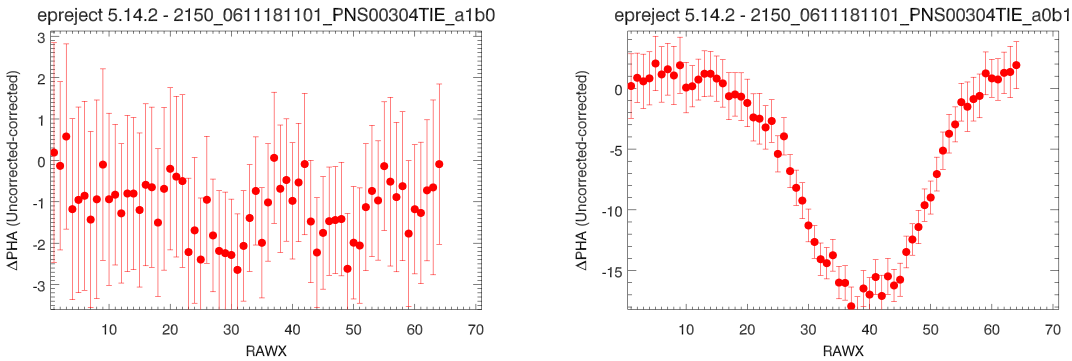

Figure 1: Shift in PHA space ΔPHA required to re-align spectra with and without the XRL correction by *epreject* on a Crab Nebula observation in EPIC-pn Timing Mode (Obs.#0611181101). *Left Panel*: a =1; b = 0. *Right panel*: a =0; b = 1.

4.2.4 X-Ray Loading correction for EPIC-pn Fast Modes

`epreject` supports from this version the correction for X-ray Loading (XRL) in EPIC-pn Fast Modes. This correction applies a linear adjustment to the PHA values, according to the formula:

$$\Delta PHA = a = b \times L$$

where L is the XRL in ADU units (1 ADU = 5 eV in EPIC-pn).
This correction is currently being calibrated. The a and b coefficient in the `XRL2PHA` extension of the public version of the `EPN_REJECT` CCF (`0006`) are therefore both equal to 0 (*i.e.*, no correction is currently applied). During the SASv12 scientific validation, the correction was tested on a Crab Nebula observation performed in September 2011 (Obs.#0611181101). Due to its high count rate, the Crab Nebula yields a strong XRL, with a profile closely following the spatial profile of the nebula X-ray emission, and a peak XRL value of L_{peak} = 18 ADU at `RAWX` = 38. In Fig. 4.4.1, we show the shift in PHA space required to realign the spectra with to that without XRL correction in two cases: a = 0, b = 1; a = 1, b = 0. The scattering around the expected value of -1 in the latter case (as well a small part of the data scattering in the former) is due to a further correction for ionizing particles hitting the offset maps, as described in the SAS on-line help of the `epreject` task.

4.2.5 Encircled Energy Fraction for EPIC-pn Fast Modes

With SAS 12.0 a novel algorithm was introduced in `arfgen` to calculate the Encircled Energy Fraction (EEF) of EPIC-pn Fast Modes. A bug in the implementation of this algorithm for EPIC-pn Burst Mode led to the SAS 12.0.1 patch. This is explained in the SAS watchout pages. The stability of the flux reconstruction with the new algorithm was tested on a sample of X-ray binaries, by measuring their flux as a function of the number of excised columns around the boresight ones (the standard technique to mitigate pile-up). A perfect EEF calculation should lead to strictly constant flux measurements, notwithstanding the number of excised columns. The stability of the *flux* reconstruction in the 3–10 keV band is constrained within ±4%, while the stability of the *spectral* reconstruction (measured through the hardness ratio between the 5–10 and the 3–10 keV energy ranges) is stable within ±2%. Readers are referred to Guainazzi et al. 2012b (Versions 1.6 and later) for further details.

The performances of the same algorithm in EPIC-pn Burst Mode was tested through a systematic comparison of the spectral shapes measured on a sample of X-ray binaries by strictly simultaneous spectra obtained with the RXTE/PCA. Systematic differences are found. They are described in Guainazzi et al. (2012b). It is impossible to disentangle software from mere cross-calibration issues. The overall consistency among the results obtained with different sources covering a wide range of spectral properties is interpreted as an indirect indication of the stability of the EEF algorithm.

4.2.6 New in SAS12: `epspatialcti`, a new task correcting EPIC PN event lists for CTI spatial variations

The correction has been verified through the analysis of 9 observations of the Vela SNR (extended, bright) and it can be shown that epspatialcti makes some improvement both in the line width, and the central energy of the Oxygen vii triplet, integrating events across a large portion of the detector.

4.2.7 New in SAS12: `catcorr`, a new package used for cross correlation with catalogues

The new task `catcorr`, which is going to be used in the next version of the XMM-Newton pipeline for cross correlating source positions found in an observation with diverse catalogues (USNO-B, 2MASS and SDSS), in order to get an improved astrometry through position rectification (small frame shifts and / or rotation of the whole field), has been successfully tested functionally. The results for the Lockman Hole observation 0147511601, were compatible with the results obtained using `eposcorr`, the SAS task used so far in PPS for the correction, which is solely based in the use of the USNO-B catalogue. A full validation should be performed together with the derivation of the 3XMM and it is expected that until then the task, actually still under development, get optimized.

4.3 Upgraded in SAS12: source detection with slew data

`eboxdetect` has been upgraded to make possible a better source detection with slew data. The version of this task from SAS 7 on has produced a large number of spurious sources when applied to slew data, therefore for the slew catalogue production an old version of `eboxdetect` (corresponding to SAS V6.5) is still used.
The source search mini-pipeline that we have built for the slew produces slightly less sources with version 4.23 of eboxdetect than with the previous version. However, taking into account following results, using slew 9189300004:
Current (SAS 6.5) = 21 sources,
SAS 12 with eboxdetect 4.22 = 33 sources,
SAS 12 with eboxdetect 4.23 = 31 sources,

the upgraded version still produces an excess of low count but relatively high significance sources which are found false by optical inspection. Therefore, for source detection with slew data we still recommend the use of `eboxdetect V4.19`.

4.4 New in SAS12: RGS heliocentric correction

`heliocentriccorr` has been used for a thorough analysis on the accuracy of the RGS wavelength scale (http://xmm2.esac.esa.int/docs/documents/CAL-TN-0098-1-1.pdf). The analysis goes far beyond the scope of the SAS validation (but including it), basing the results on 119 exposures. The task can be considered fully validated in this sense.

4.4.1 Upgraded in SAS 12: ESAS

The sub-package ESAS has been tested through the analysis of odf 0097820101 (Abel 1795 cluster) with the same sequence used for testing the tasks under SAS v11.0
Following processing validation procedure has been followed:
`epchain`
`epchain withoutoftime=true`
`emchain`
`pn-filter`
`mos-filter`
`cheese` (including pn and mos exposures)
`pn-spectra`
`mos-spectra` (for mos1 and mos2)
`pn_back`
`mos_back`
`proton` (for pn, mos1 and mos2)
`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)
comb
adapt_900

No problems found. The above list of tasks was run successfully 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. The results are fully compatible with the example in the ESAS documentation.
Fig. 4.4.1 shows the EPIC combined soft proton contamination map produced by `proton`, as well as the rotated and smoothed image of Abell 1795 as produced by `adapt_900`.

5 Conclusions

The main conclusions of the SAS 12 scientific validation exercise can be summarized as follows:

- SAS 12 can reduce data taken with all the EPIC, RGS and OM scientific observation modes,
- SAS 12 is distributed in all supported platforms both for 32 and 64 bit versions, which are fully validated,
- it takes into account and correct for a time dependency of the boresight position,
- it uses the 2D PSF as the default EPIC point spread function, both for optimizing the source search as for obtaining the encircled energy values,
- for EPIC-pn Fast Modes a correction for X-ray Loading is included, a fundamental improvement for high calibration accuracy,
- heliocentric corrections are calculated for the high resolution RGS spectra.

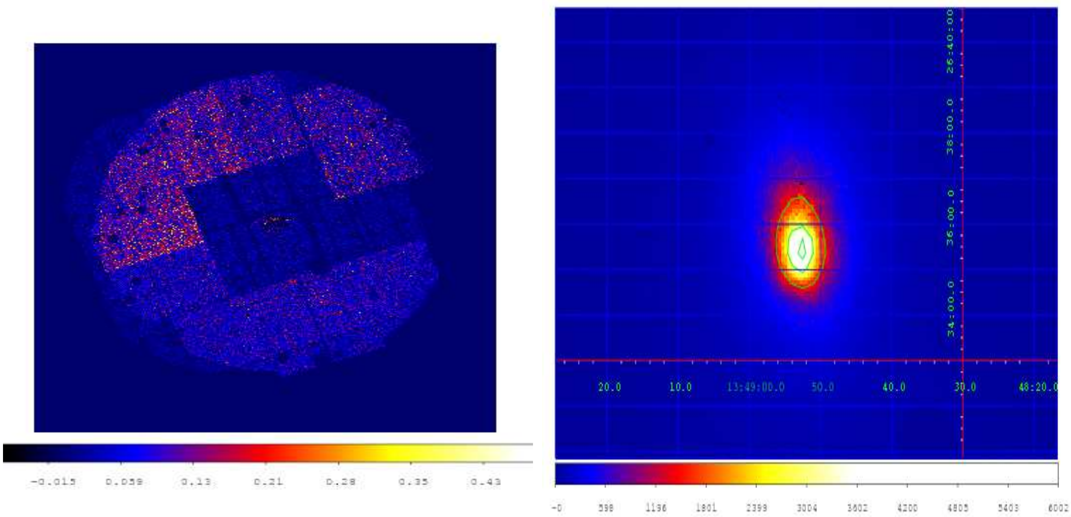

Figure 2: EPIC combined proton contamination map of observation 0097820101 and final source clean image of the cluster Abell 1795.