XMM-Newton CCF Release Note

XMM-CCF-REL-108

Correcting RGS Quantum Efficiency calibration defects

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1 CCF components

Name of CCF	VALDATE	EVALDATE	List of Blocks changed	XSCS flag
RGS1_EXAFS_0001	1999-01-01T00:00:00	–	H2O-P-CCD# (#=1-9)	NO
RGS2_EXAFS_0001	1999-01-01T00:00:00	–	H2O-P-CCD# (#=1-9)	NO
RGS1_QUANTUMEF_0007	1998-01-01T00:00:00	–	CCD_DESC, RGA_EFFCORR, RGA_SELFVIGNCORR, RGA_EFFAREACORR	NO
RGS2_QUANTUMEF_0008	1998-01-01T00:00:00	–	CCD_DESC, RGA_EFFCORR, RGA_SELFVIGNCORR, RGA_EFFAREACORR	NO

2 Changes

To cope with several defects observed in the RGS calibration a new calibration file RGS#_EXAFS has been defined for each RGS instrument, containing the mean absorption probability used for establishment of the CCD Quantum Efficiency. The mean absorption probability is tabulated as a function of energy. There is one table per element and per CCD, if changes to the Henke tables have to be replaced. In this version a table for the element H2O has been instroduced, used for modeling the absorption around the O-edge, as if it would be caused by a certain amount of water on the CCDs.

The corresponding H2O thickness (84.2 nm) for each CCD has been added to the CCD_DESC binary extension of the CCF constituents RGS#_QUANTUMEFF. In addition several new correction tables to RGS#_QUANTUMEFF have been defined:

- A systematic difference between RGS1 and RGS2 with RGS1 being 20% less efficient at larger β (outgoing angle from the grating) than RGS2 could be explained by additional blocking of the beam halfway between the gratings and the detectors, therefore it can be treated as additional vignetting. A β dependant correction is defined for each RGS, to be multiplied with the already existing vignetting factor. For RGS1 it ranges from $f = 1.0$ at $\beta = 0.038$ rad (6.5Åat first order) to $f = 0.8$ at $\beta = 0.075$ rad (37.7Å) and is linear interpolated in between. It is set to unity for RGS2.

- Systematic wavelength dependant discrepancies in efficiency have been observed between first and second order. A tabulated wavelength dependant correction of the reflection efficiency has been introduced as RGA_EFFCORR per order (1st to 5th order).

- After all corrections are applied still some differences do exist between observed data and power model for PKS2155. These differences seem to be constant over time and similar to the ones observed with other sources. Provision for an energy dependant correction factor to the effective area is done via the table RGA_EFFAREACORR. Waiting for accurate numbers from the calibration they have all been set to unity in this version.

All these calibration improvements are discussed in [1].

3 Scientific Impact of this Update

The effective areas should be affected by the changes introduced in the computed quantum efficiency. The discrepancies between RGS1 and RGS2 and between 1st, 2nd and 3rd orders should decrease considerably. The effective area around the O-edge, including the detailed structure, will be corrected for the instrumental absorption.

4 Estimated Scientific Quality

The accuracy of the effective area after applying the corrections is estimated to be better than 10% overall.

5 Test procedures

5.1 RGS#_EXAFS

General checks:

- use FV (or another fits viewer) for file inspection. It should contain binary extensions of the defined layers for all 9 CCDs (so far only for H2O and same for all CCDs),

- use the SAS task CALVIEW to see if the CAL digests and uses the new files. Perform comparisons between the Quantum Efficiencies (Intrinsic QE Pattern 0) obtained with old and new calibration data.

Check improvements:

In order to see how the changes are expressed in terms of effective area around the O-edge, data from bright sources with featureless spectra (Mkn421 or PKS2155 or 3C273) should be processed using the new EXAFS files and compared to the same data processed either with previous EXAFS files or without them at all (eg. not applying any correction). For this the SAS task RGSRMFGEN should be run twice for the first order and the output effective areas compared. As final check the differences between the results from fitting a power-law function to the obtained spectrum using the one and the other response file should be computed, in order to quantify the calibration improvements, specially in the O-edge region.

5.2 RGS#_QUANTUMEF

General checks:

- use FV (or another fits viewer) for file inspection. It should contain 16 binary extensions (as defined in the CalHB). Check the contents of the changed extensions.
- use the SAS task CALVIEW to see if the CAL digests the files. Perform comparisons between RGS1 and RGS2 calibration viewables (eg. Grating Properties Self-Vignetting: RGS1 and RGS2 should show a 20% difference at larger β). Compare the effective areas vs E for the different orders using the new CCFs and the former ones.

Check improvements:

In order to see how the changes are expressed in terms of effective areas and how large systematic differences between the two RGSs and between spectra from different reflection orders, data from bright sources with featureless spectra (Mkn421 or PKS2155 or 3C273) should be processed using the new QUANTUMEF files and compared to the same data processed with previous QUANTUMEF files. For this the SAS task RGSRMFGEN should be run for $m = -1$ and $m = -2$ orders on both RGS1 and RGS2 and the output effective areas compared.

As final check the differences between the results from fitting a power-law function to the obtained spectra using the different response files should be computed, in order to quantify the calibration improvements with respect to RGS1 / RGS2 and $m = -1$ / $m = -2$ differences.

6 Test results

6.1 RGS#_EXAFS

FV inspection of the file done. All expected binary extensions present.Values OK.

Checking with CALVIEW the quantum efficiencies obtained when using the H2O absorption expressed in RGS1_EXAFS show the expected improvements (Fig. 1). Similar results yields the use of RGS2 CCF files.

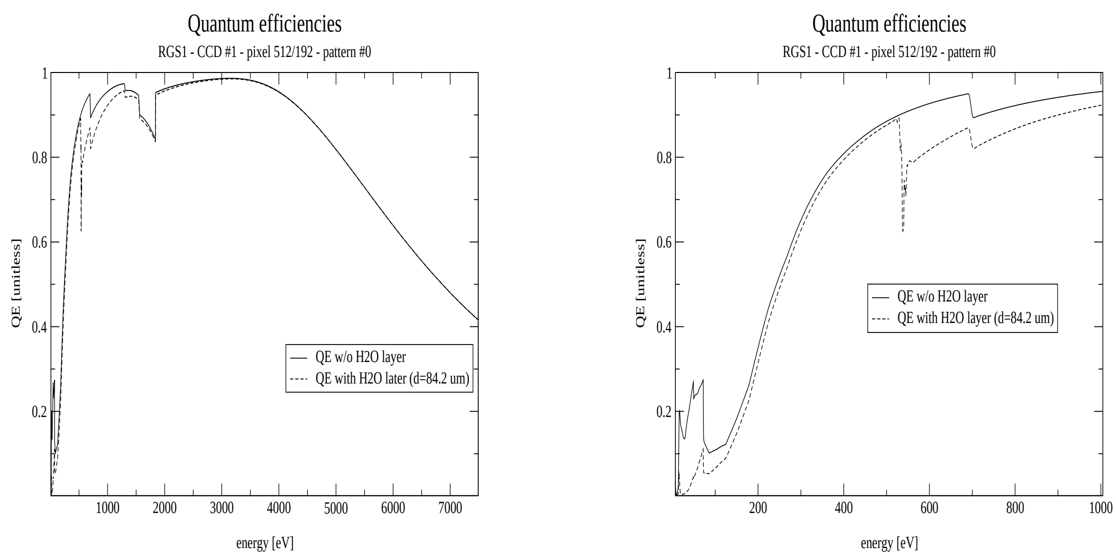

Figure 1: Quantum efficiency distribution comparison with and without H2O absorption, as defined in RGS1_EXAFS. The right figure shows the O-edge region blowed up

Data from an observation of PKS2155-304, pre-processed with the pipeline V5.2, was taken for deriving effective areas. We use RGSRMFGEN 0.50.1 (SAS V5.3_alpha version) and see a large improvement in the O-edge region when comparing the results obtained fitting a simple power law using the old and the new RGS1_EXAFS and RGS1_QUANTUMEF calibration files (Fig. 2).

6.2 RGS#_QUANTUMEF

FV inspection of the file done. All expected binary extensions present. At the moment the final correction (RGA_EFFAREACORR) is waiting for more definitive numbers and filled just with all correction numbers set to unity.

CALVIEW ingestion performs OK. Several tests show:

- new CCF files can be read with older SAS (CAL) versions,

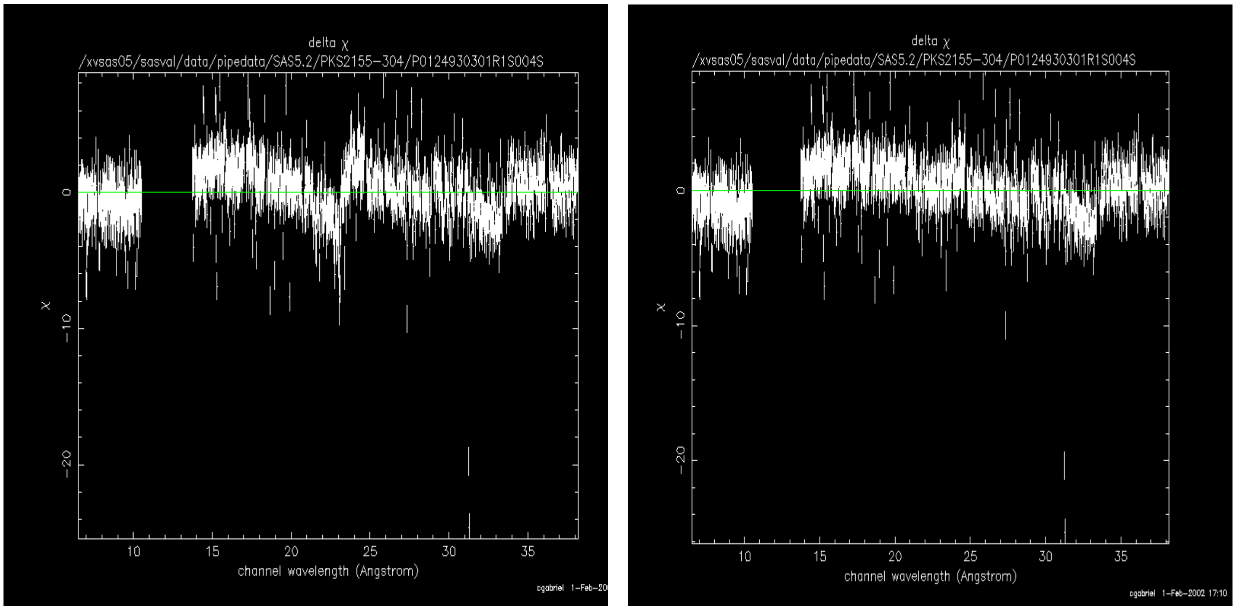

Figure 2: Results of fitting a simple power law model to PKS2155-304 without (left) and with (right) the absorption defined in RGS#_EXAFS

- the correction to self-vignetting leading to a 20% smaller efficiency at larger β by RGS1 is shown in Fig. 3.
- the changes in the effective areas can be seen in the comparison of the $m = -1$ order RGS1 and RGS2 effective areas as derived with the old CCFs to the ones found using the new CCFs (Fig. 4),
- the comparison of "old" vs "new" second order effective areas for RGS1 and RGS2 (Fig. 5) show the expected features, a general change in shape caused by RGA_EFFCORR and in addition a general reduction by the RGS1 effective area caused by RGA_SELFVIGNCORR.

In addition effective areas were derived using SAS V5.3 alpha for both RGSs, first and second order. Fig. 6 shows the first order effective areas of RGS1 and RGS2 as obtained with the new calibration.

Simultaneous fitting of RGS1 and RGS2 PKS2155-304 data with a simple power law model (without normalization), as already described above shows that the discrepancies observed in the past between RGS1 and RGS2 have now almost completely disappeared (Fig. 7). Similar good results are obtained fitting simultaneously in the same way first and second order RGS1 or RGS2 spectra (Fig. 8).

7 Expected Updates

The introduction of a fudge correction factor to the effective area is planned in the next future to correct for differences still observed by several sources to the expected straight power law model (see [1]).

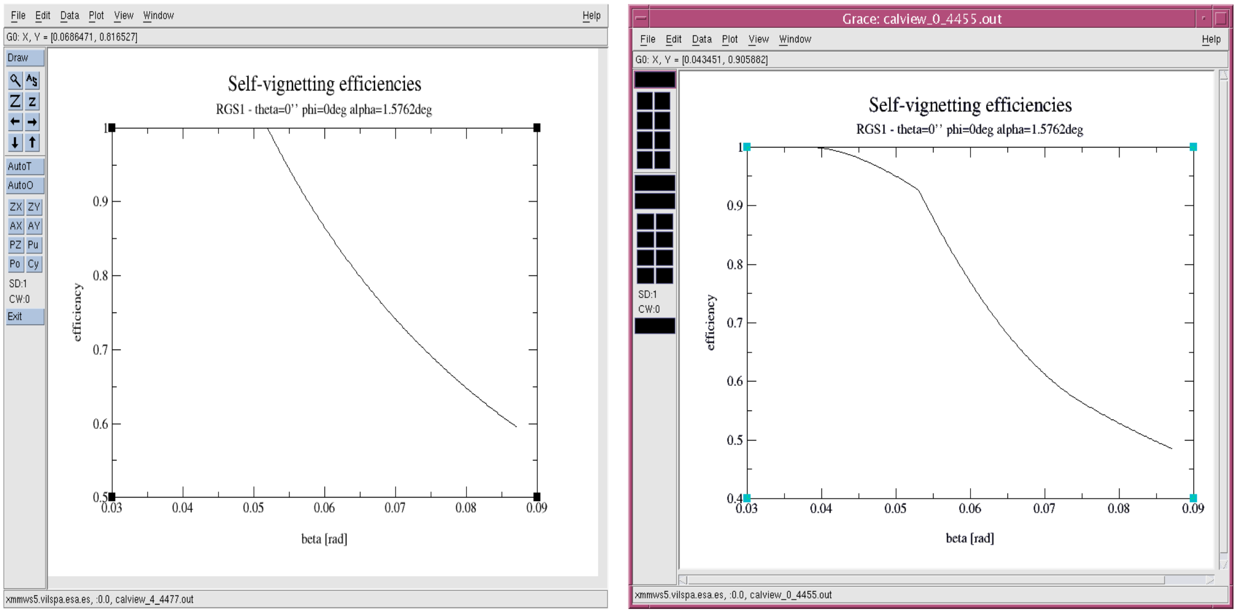

Figure 3: CALVIEW: RGS1 self-vignetting before (left) and after (right) the correction

References

[1] "RGS status of calibration and data analysis", J.W.den Herder on behalf of the RGS consortium, SRON, RGS-SRON-RP-CAL-01/006, December 2001

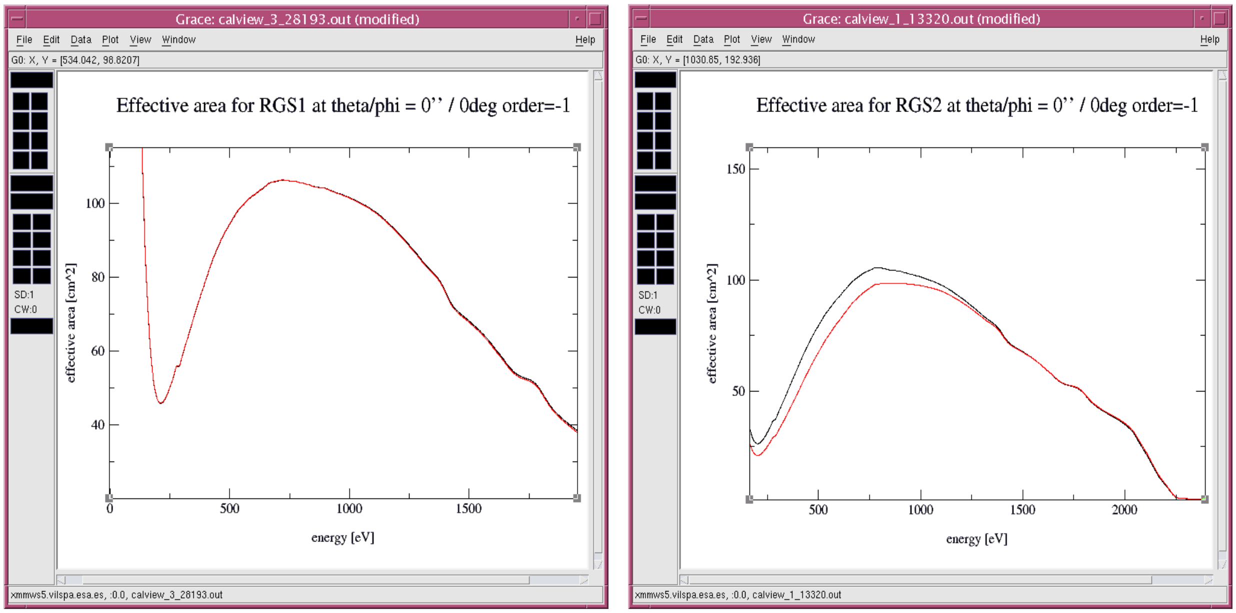

Figure 4: CALVIEW effective areas RGS1 (red) vs RGS2 (black) using the previous (left) and the new QUANTUMEF CCF constituents

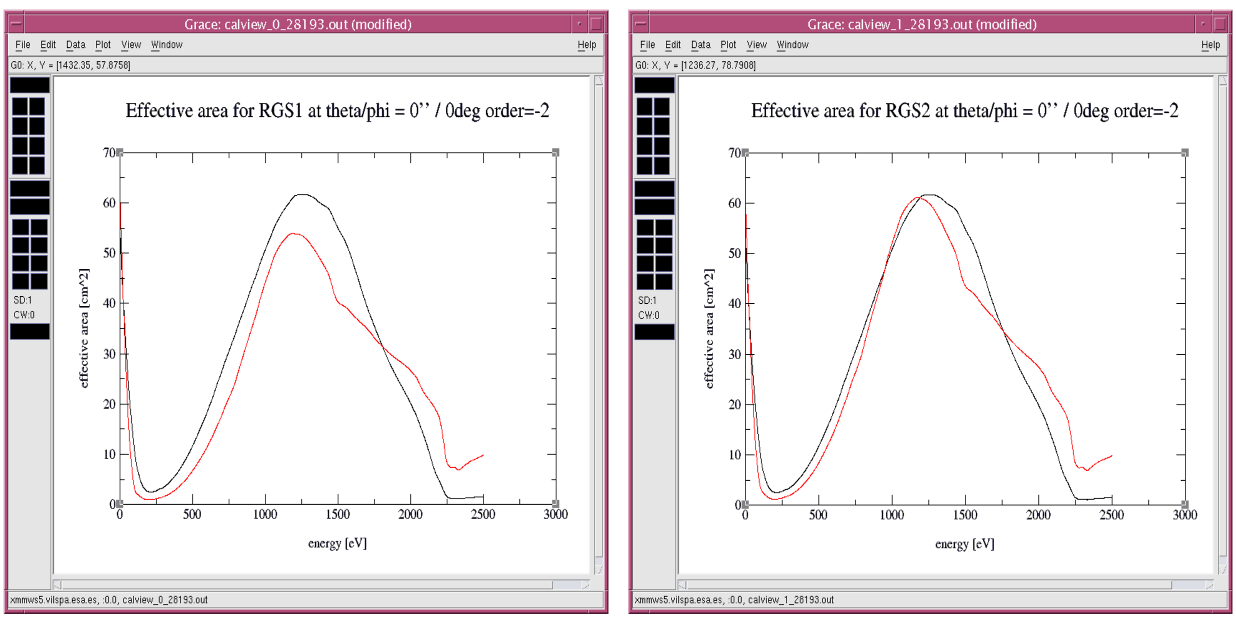

Figure 5: CALVIEW new (red) vs old (black) 2nd order effective areas for RGS1 (left) and RGS2 (right)

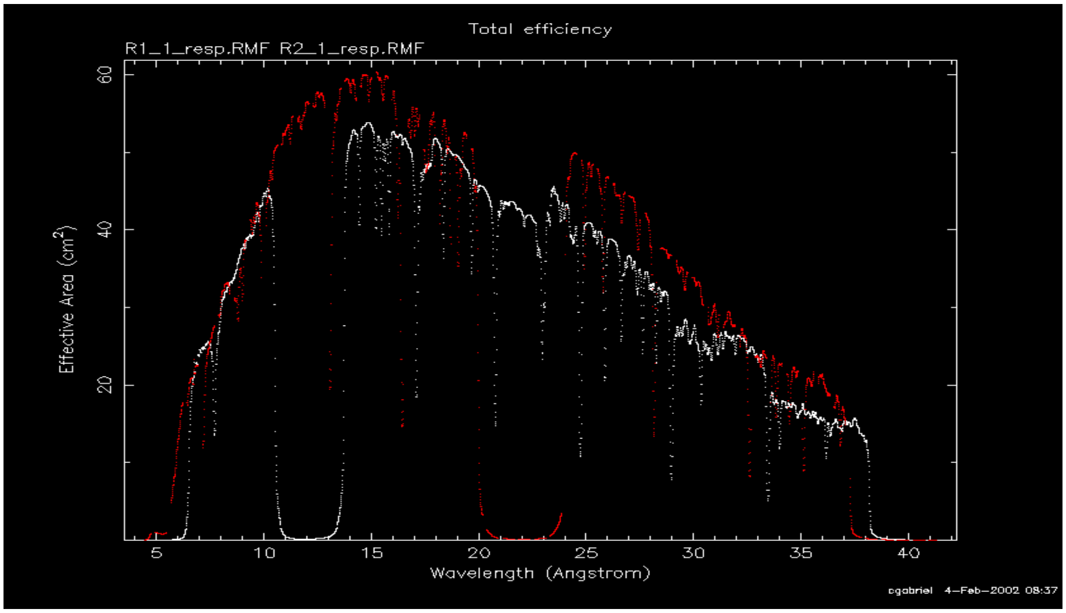

Figure 6: First order RGS1 (in white) and RGS2 (in red) total effective areas as derived by RGSRMFGEN

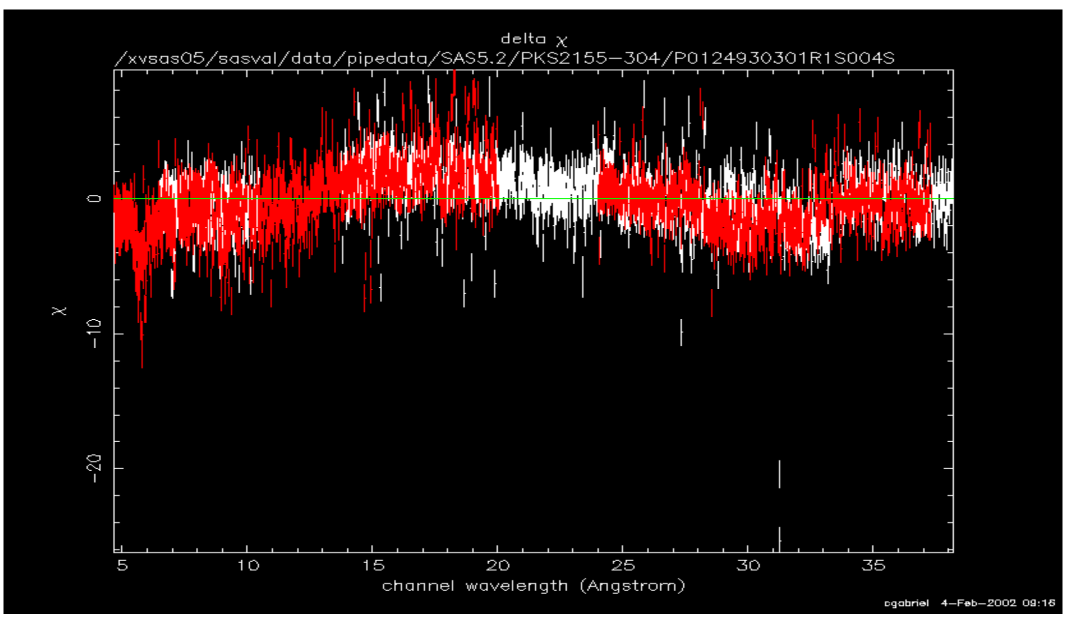

Figure 7: Simultaneous fitting of RGS1 (white) / RGS2 (red) PKS2155-304 data

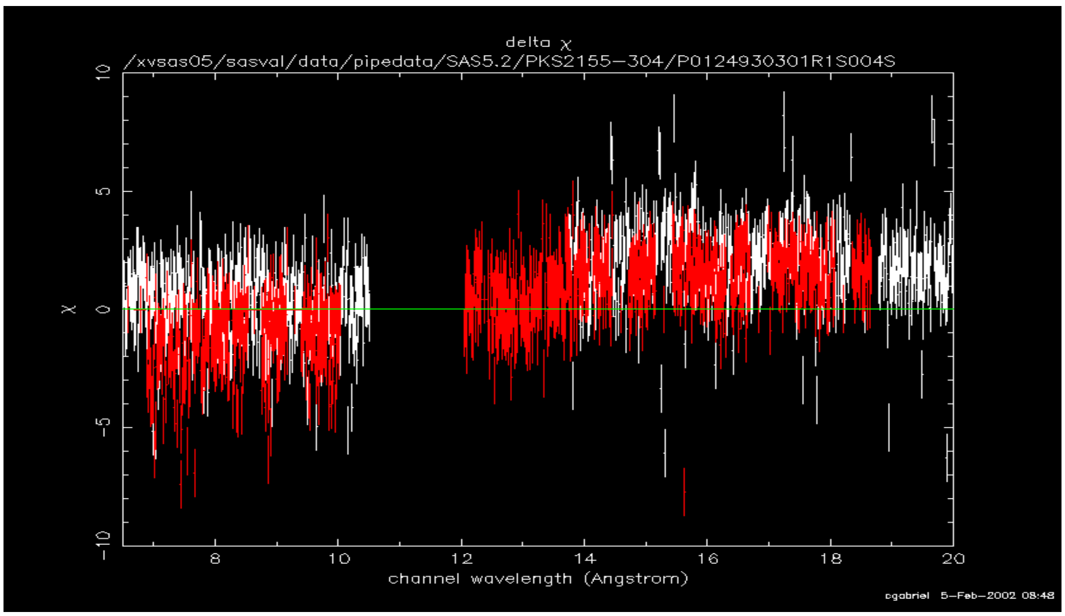

Figure 8: Simultaneous fitting of RGS1 first (white) and second (red) order PKS2155-304 spectra