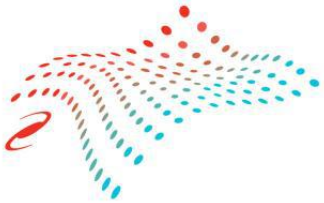

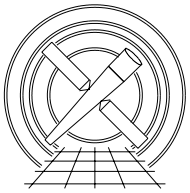

MIT Kavli Institute **Chandra X-Ray Center**

MEMORANDUM
August 11, 2015

To:	Jonathan McDowell, SDS Group Leader	(_____)
	Dale Graessle, DS Calibration Data Coordinator	(_____)
	Brad Wargelin, Calibration Scientist	(_____)
From:	David P. Huenemoerder, SDS	(initial / date)
Subject:	CALDB file test report: Updated HRC-S/QE, LETG/EEFRAC	
Revision:	1.0	
URL:	`http://space.mit.edu/cxc/docs/docs.html#letgslsf`	
File:	`~dph/CXC/Testing/lsfparm_custom/Doc/lsfparm_update-01.tex`	

1 Purpose for updates

The CXC Calibration Group has developed algorithms which can, in some circumstances, improve the signal-to-noise ratio of weak emission lines measured with LETG/HRC-S.[1]

These algorithms are performed by custom scripts and ancillary data which are not part of standard data processing nor part of standard CIAO analysis, but which are provided as "contributed" scripts and data, for use as deemed appropriate by the analyst.[2]

The proper implementation of the algorighms does, however, require some updated files which are part of the Calibration Database (`CALDB`) and which are used by CIAO response generation programs, `mkgrmf` and `mkgarf`. These are the "`lsfparm`" files, which encode the enclosed-energy-fraction (`EEFRAC`) of the effective area, dependent upon the spectral extraction region width, and the quantum efficiency (`QE`) files, which contain the mean `QE` vs. energy for the full aperture. The new files are designed to produce the same value for the effective area (the product of `EEFRAC` and `QE`) as in current processing which uses automatic `CALDB` lookup of the LETG/HRC-S "bow-tie" region (by `tgextract`) along with the `lsfparm` and `QE` file lookup by response tools.

[1] See details at `http://cxc.harvard.edu/cal/Letg/LetgHrcEEFRAC`

[2] See the entry TBD at `http://cxc.harvard.edu/ciao/download/scripts/contents.html#GratingAnalysis`.

Both the updated EEFRAC and the HRC-SQE are more accurate than the current CALDB values. Fluxes derived from HRC-S alone will be more accurate.

2 Files

The files provided by the Calibration Group are:

1. hrciD1999-07-22qeN0009.fits
2. hrcsD1999-07-22qeN0014.fits
3. hrcsD2012-03-29qeN0014.fits
4. hrcsleg-1D1999-07-22lsfparmN0004.fits
5. hrcsleg1D1999-07-22lsfparmN0004.fits

3 Tests

To test the files[3], I evaluated responses for LETG/HRC-S with both current and new files, for two epochs using CIAO 4.7 and CALDB 4.6.8.

Tests involved evaluation of the ratio of model counts over 8 orders (since HRC-S cannot resolve orders) for a flat model spectrum ($f(\lambda) = a_0\,[\,\mathrm{photons\,cm^{-2}\,s^{-1}\,\AA^{-1}}]$) and for an absorbed power-law model spectrum (a fit to a Mrk 421 spectrum[4]). I also evaluated the ratios of the effective areas (EEFRAC $\times$ QE) for individual orders between the two sets of CALDB files.

Specifically, I made responses for the following datasets:

OBS_ID	OBJECT	DATE-OBS
3722	LAMBDA AND	2002-07-23T23:52:00
16375	HZ43	2014-03-30T16:29:06
17391	MKN421	2015-07-02T02:47:26

Figure 1 shows the ratios of counts for new files to old for a flat model spectrum (top) and the ratio of effective areas (EEFRAC $\times$ QE) for each order (middle and bottom). The range for the 8-order summmed model counts ratio is about 1.5% with a systematic droop from short to long wavelengths, and for first order is below 1%. The bottom panel shows that the range increases with order.

Figure 2 is for a more realistic model spectrum, an absorbed power-law fit to Mrk 421, and shows the ratio of model counts for 8 orders (analogous to the top panel in Figure 1). Here the amplitude is a bit larger (3.5%) due to the increased relative importance of higher orders (strong high energy flux in high orders overlapping less flux in lower orders at lower energies).

[3] I did not do any tests of the HRC-I file, since this is not formally supported for users in conjunction with LETG.

[4] An ISIS model: fit_fun("Powerlaw(1)*phabs(1)"), norm $= 0.246$, alpha $= -2.31$, nH $= 0.02$

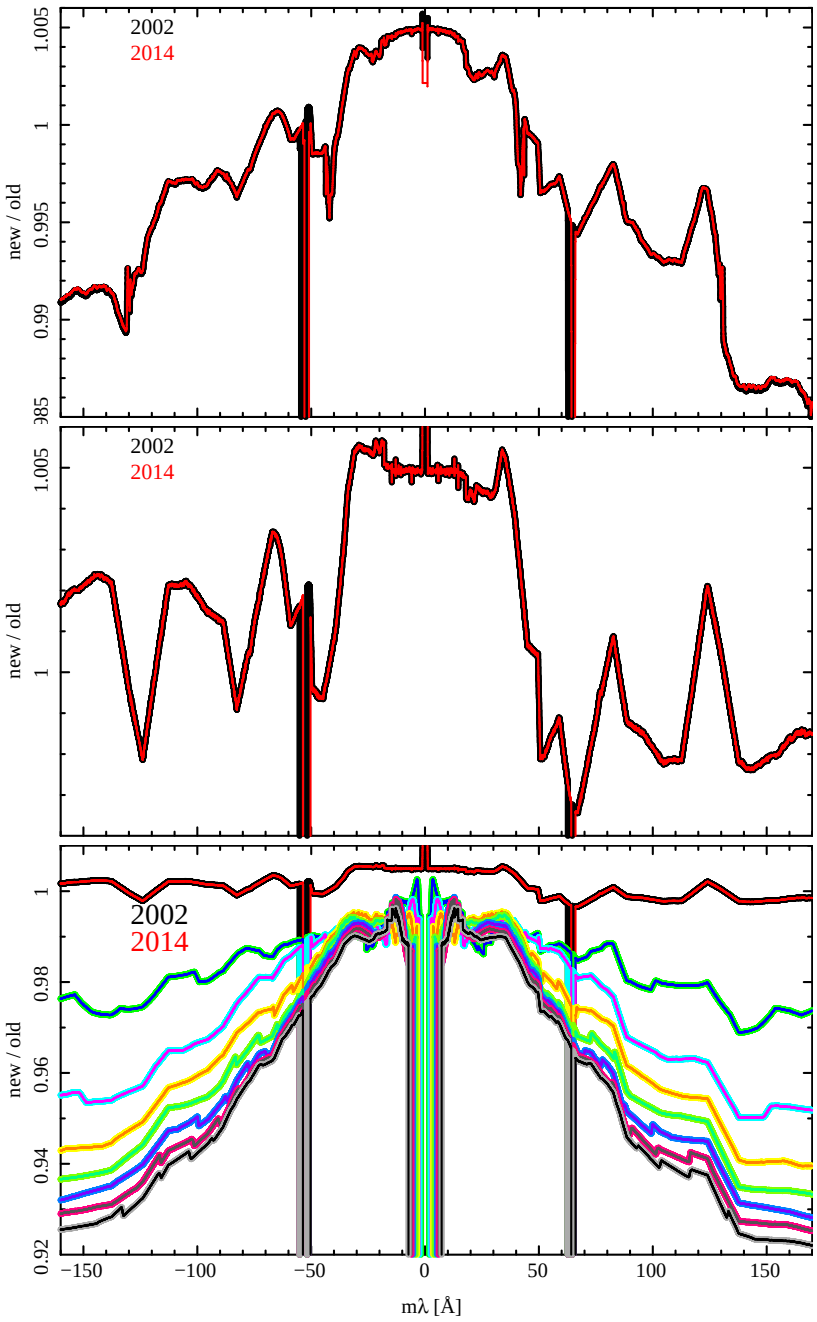

Figure 1: Top: ratio of model counts for the new files to old, for 8 orders (combined, as in a real observation) using a flat source model spectrum. Center: the ratio of effective areas (EEFRAC × QE) for first orders. Bottom: The ratio of effective areas (EEFRAC × QE) for orders 1–8 (top to bottom. In each panel, two epochs are overplotted and are identical.

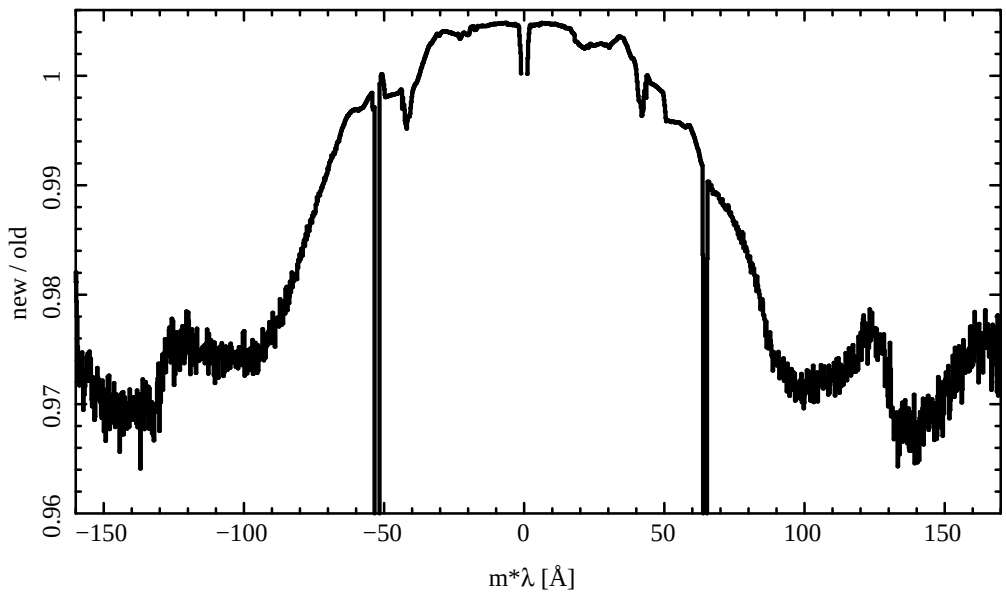

Figure 2: The model counts ratio (new/old calibration files) for a Mrk 421 model (absorbed power-law) spectrum. This has somewhat more range than the top panel of Figure 1 (3.5% vs 1.5%) because of the increased importance of higher orders from a steep spectrum.

4 Line Profile Check

The `lsfparm` files also contain the parameters for the line-shape. These have not been re-calibrated vs extraction width. Hence, line profiles should be exactly identical with the new and old files. I checked model profiles for a delta-function at $12\,\text{Å}$ for orders 1–8, which verified that the profiles have not changed.

5 Conclusions

There are two aims of these tests: to validate the file format as functional for use in `CALDB`, and to verify that the first order effective area has not changed under standard processing (extraction with the "bow-tie" region, and effective areas made from `CALDB` files and default parameters).

The files are valid (but require proper `CALDB` interface keywords).

The first-order effective area is essentially unchanged.

Higher order changes are as designed by Calibration.