OGIP Calibration Note CAL/ROS/93-007

ROSAT PSPC: Informal Study Note

Stability of the PSPC Spectral Calibration

Calibration Observations of N132D

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Version: 1995 Feb 01

SUMMARY

The ROSAT PSPC data processing software SASS, gain corrects the pulse height analyser (PHA) spectral data to pulse invariant (PI) data. This study note tests the accuracy of those corrections by making a simple ratio comparison between spectra of a constant X-ray source, N132D taken at different epochs.

LOG OF SIGNIFICANT CHANGES

Release Date	Sections Changed	Brief Notes
1993 Jul 26		First public version
1995 Feb 01	All	Made compatible with `LaTeX2HTML` software

1 INTRODUCTION

The calibration corrections performed on PSPC events in the SASS processing are described in detail in "Calibration Corrections to individual PSPC events" by Hasinger and Snowden (1990). The correction from PHA to PI for the spectral data, essentially folds in calibrated gain variations. Quantities such as the detector gain (pulse height as a function of energy) change with time due to variations in the detector high voltage, temperature, gas pressure, density and composition (contaminants arise due to outgassing of the inner wall of the tank as the internal pressure drops). An additional variable will be the reduced gas flow rate during AO4. The temporal gain variations are currently parameterized by fitting Prescott functions to the Al Kα calibration data. Al Kα calibration observations before and after the target observation are linearly interpolated to estimate the appropriate temporal correction required. A spatial gain adjustment corrects for the variations due to the variable distance of the anode wires and event position relative to these (see Hasinger and Snowden 1990). The PSPC also shows some saturation of gain, which is a minor effect also corrected for in the SASS processing.

These corrections are performed in SASS and, if accurate, one should see no significant variations between spectra of a constant soft X-ray source extracted in a consistent manner. Some post-SASS corrections may need to be applied, ie a vignetting correction for off-axis data, and an exposure correction. This note examines the accuracy of the PHA to PI correction.

2 DATASETS USED

The constant X-ray calibration source, the supernova remnant N132D was used for this analysis. Only a limited number of the calibration and maintenance day data are currently available to the U.S. GOF.

2.1 PVC data

A large number of brief off-axis spectra were taken during the pre-survey calibration phase of June 1990, although no useful unfiltered on-axis data from N132D are available for the same epoch. Comparison between the $\sim$ 200 second off-axis spectra showed no significant variations between these, ie on a timescale of days (albeit at low signal to noise). Thus, we made a mean spectrum for the 40 arcminute offset spectra taken in June 1990, and applied a weighted vignetting correction to make it equivalent to an on-axis spectrum. Sequences used were: rp110063; rp110071; rp110076; rp110083; rp110088; rp110095 and rp110107.

Source spectra were extracted in a (conservative) 12 arcminute cell (the source is extended and 40 arcminutes off-axis) and were background subtracted. These were high gain state data, and taken with PSPCC.

2.2 Maintenance Day Data

All of the following observations were made with PSPCB. Four datasets are currently available:

Sequence	Date	Gain state
rp160084	May 1991	High
rp141800	Dec 1991	Low
rp500004	Apr 1992	Low
rp141937	Apr 1993	Low

RP500004 is available for calibration studies thanks to PI J. Hughes.

Spectra were extracted in a 5 arcminute cell centered on N132D, while a nearby source was excluded (at 4 arcminutes away, and with a count rate only 0.4% of N132D this nearby source is insignificant in this analysis).

The PSPC gain was lowered from 3060 volts to 3000 volts on October 14 1991, resulting in a gain drop of $\sim$ 30%. These data cover both gain states. Although the lower discriminator for valid events was raised from channel 9 to channel 11 (of 256) following this gain drop, thoughout this analysis we consistently used only channels 12-211 binned by a factor of 10.

3 RESULTS

Each spectrum in turn was compared to the most recent spectrum from rp141937, by making a simple ratio of pairs of spectra with the April 1993 spectrum as the denominator. Figures 1a, 1b, 1c, 1d show these ratios in chronological order with respect to the numerator. The early PVC spectrum is the numerator in Figure 1a, and more recent spectra appearing in subsequent panels. It can be seen that the further apart in time the spectra, the greater the discrepancy, although the most recent two (Figures 1c and 1d) agree acceptably well. Overall the data imply a time dependant gain variation has occured, which has not been taken into account in the gain correction procedure. The largest differences are between the high and low gain state spectra (Figures 1a and 1b), the SASS corrections, were they adequate, should make these spectra equivalent.

Inaccuracies in the vignetting correction function used may be partly responsible for the large discrepancy in Figure 1a, as may some (unknown) difference in the response of PSPCC and PSPCB. We cannot easily deconvolve the different contributions to the discrepancy in Figure 1a using these data.

Silvano Molendi has taken Steve Snowdens Exposure Maps, constructed from the survey data and (masking the ring and ribs) extracted counts in annuli out to the edge of the detector. The count rate ratios can then give the vignetting function. The survey data are of very high S/N, and show excellent agreement with the preflight vignetting function (ie double power law). Theres a small discrepancy above 40 arcmin, where they observe a dip in the survey data versus the model, this rises up again and goes above the model, crossing it at about 54 arcmin. The size of this discrepany and the radius where is starts seems to be a function of energy. The origin of this effect is not yet understood but the discrepancy between the preflight and in-flight vignetting functions seems to be less than 4%, hence this cannot be the predominant effect in Figure 1a.

4 WORK AT MPE: based on email correspondance of 1993 Jul 23 with GRH

Guenther Hasingers independant examination of N132D data yield the conclusion that there is some variation of gain, which is not currently corrected for in the conversion to PI data. GRH observes that the peak energy of the counts distribution in the N132D corrected data decreases monotonically as a function of time.

5 CONCLUSION

There appears to be a significant time dependance of the PSPC gain, which is not accounted for in the SASS correction from PHA to PI data. Although the data are temporally corrected using the position of the Al Kα calculated from a linear interpolation between calibration line observations either side of the target observation, this does not seem to provide an adequate correction across the PSPC bandpass. Work at MPE suggests that the peak channel for the N132D spectrum is decreasing monotonically with time even after the nominal corrections have been applied. A more sophisticated gain correction should be possible after examination of much more calibration data. This effect may explain some of the apparent anomalies noted in the PSPC spectral data.

Recent correspondance with MPE also suggests that a spectral recalibration is required to fold in a rate-gain correction to Mkn421 (estimated at 1-2%).

FIGURES

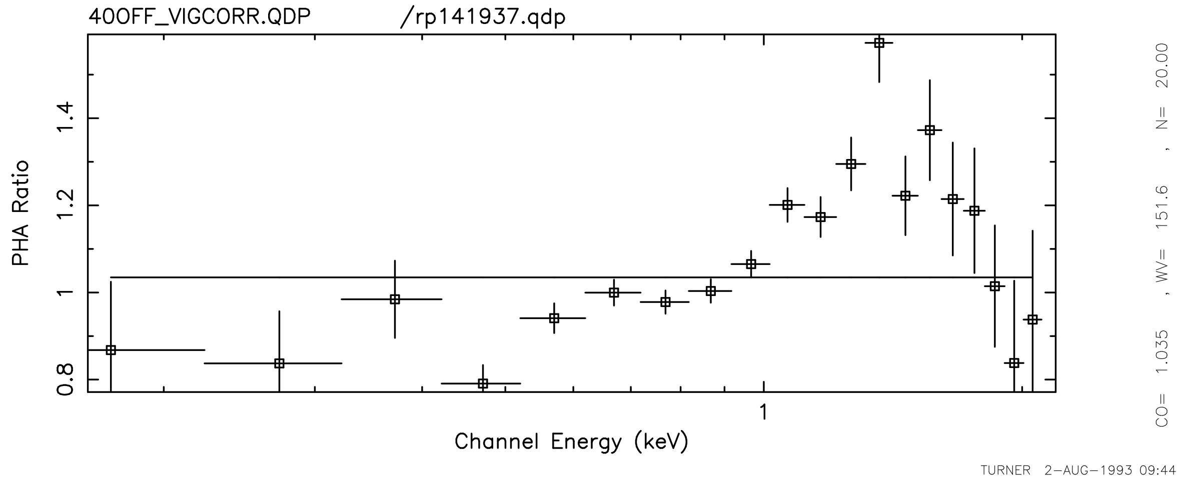

Figure 1: (a) Ratios of the PI spectra, the denominator is the 1993 April spectrum throughout. The right hand side of each panel shows the value of χ^2 obtained when the ratio data were fit with a constant model. The numerator is a mean spectrum of vignetting corrected data taken from 40 arcminutes off-axis. The data were taken with PSPCC at high gain state in the PVC phase (1990 June).

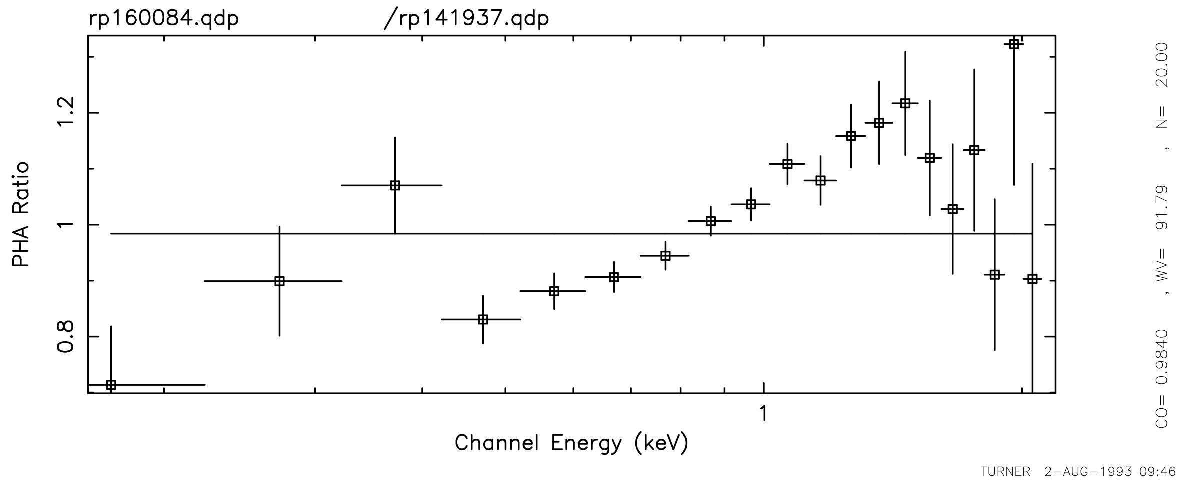

Figure 1: (b) Ratios of the PI spectra, the denominator is the 1993 April spectrum throughout. The right hand side of each panel shows the value of χ^2 obtained when the ratio data were fit with a constant model. The numerator is the high gain state 1991 May observation.

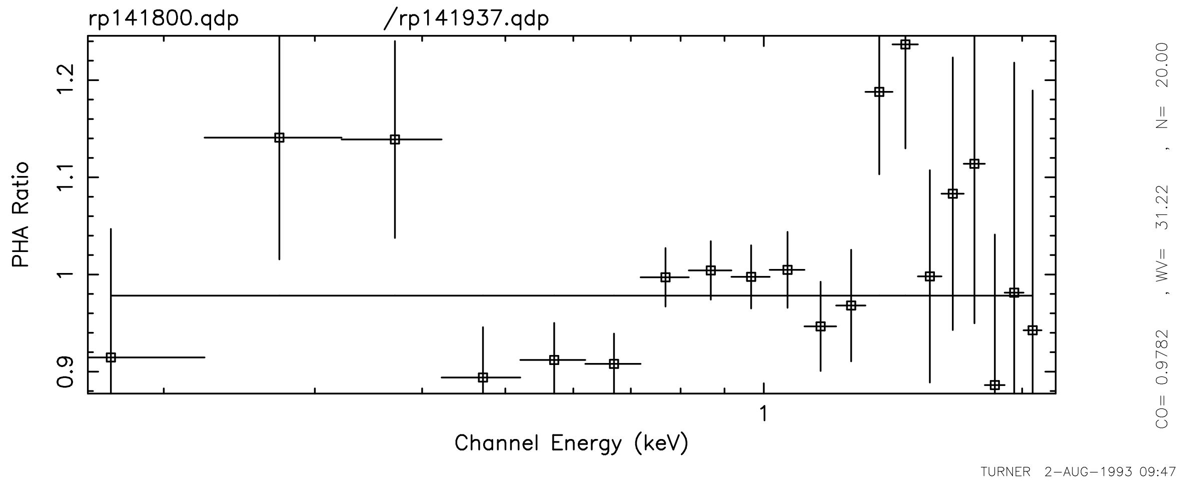

Figure 1: (c) Ratios of the PI spectra, the denominator is the 1993 April spectrum throughout. The right hand side of each panel shows the value of χ^2 obtained when the ratio data were fit with a constant model. The numerator is the low gain state Dec 1991 observation.

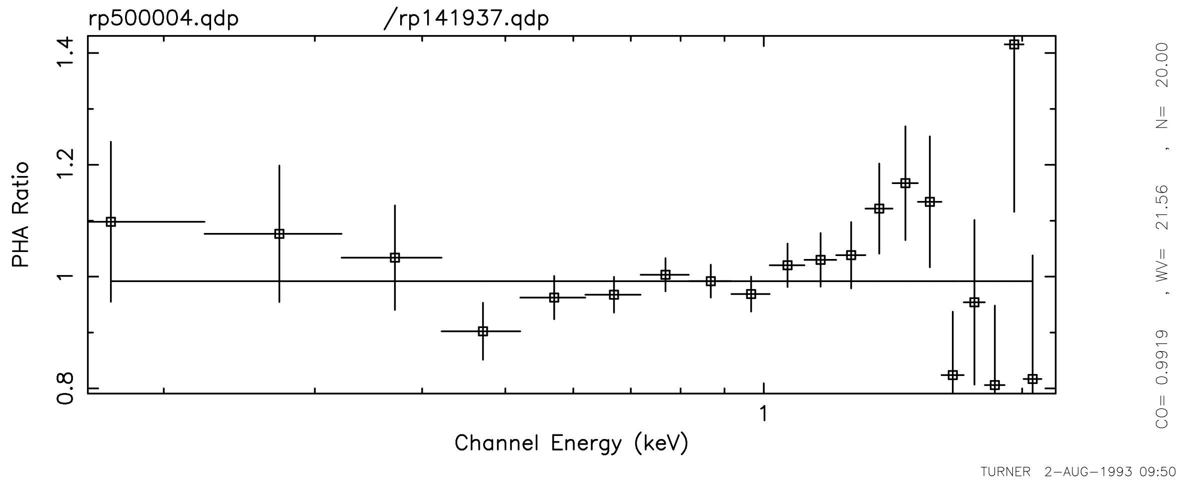

Figure 1: (d) Ratios of the PI spectra, the denominator is the 1993 April spectrum throughout. The right hand side of each panel shows the value of χ^2 obtained when the ratio data were fit with a constant model. The numerator is the low gain state Apr 1992 observation.