Title :	**Monitoring RGS contamination**
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1 Introduction

Since the CCD detectors on the RGS have very low temperatures, the possibility exists that all sorts of compounds may be deposited on the detecors, leading to loss of sensitivity. Major suspects are outgassing products from the satellite like water vapor and hydrocarbons (from the carbon fiber telescope tube). Each of these compounds has a very specific absorption profile in X-rays. This report looks at the possibility of deposited contaminants on the detectors by monitoring possible changes in effective area, keeping the absorption characteristics of likely contaminants in mind.

2 Calibration sources

The calibration sources in RGS offer the possibility to check on the likelyhood of increasing deposition of contaminants. The calibration sources generate two distinct X-ray lines at energies of 1.4867 (Al) and 0.6768 (F) keV. In the likely contaminants ice (H_2O) and hydrocarbons (C_nH_m) mainly the elements of oxygen and carbon respectively are expected to give considerably more absorption at 0.6768 keV than at 1.4867. Hence the change in ratio between the intensity of the 0.6768 keV and 1.4867 keV line may be an indication of possible comtaminants. However, other factors, which influence the RGS effective area may also contribute.

Fig 1 and 2 show the count rates of the individual calibration sources for RGS1 and RGS2 separately. The bottom plots show the change in ratio over the course of the mission.

Initially the count rates drop, about linearly with time. However after the cool-down of the RGS's around rev. 530-540 the count rates suddenly increase, after which the slow decrease continues. This is interpreted that the loss of good pixels due to radiation damage leads to a direct loss of effective area which in turn leads to decreasing count rates. Cooling the CCD's did decrease the effects of radiation damage and hence did increase the effective area. This explains the sudden increase in count rates around rev. 530-540.

Another effect which decreases count rates is the decay of the radio-active compound in the calibration sources (mainly Cm^{243}) which has a half life of 29.1 years. This leads to a drop in count rate of about 3.5 %/year.

Still, this means that the sources have an additional decrease in count rates of 3.2 %/year at 0.6768 keV and 0.4 %/year at 1.4867 keV.

This can also be seen in the change in the ratio. However, looking at the ratio plot there is indication that the ratio decreases only up till approximately revolution 350 and that the ratio is stable after that time.

When taking the measured decays at 0.6768 keV and predict the expected decays at other energies for the expected compound (ice and hydrocarbons) we get the results listed in table 1.

As can be seen, both contaminants satisfy the observed ratio changes of the calibration sources. However, around the oxygen edge, strong differences are expected and considerable loss of effective area should be expected at the RGS lowest energy. About 60% loss !!! over the mission lifetime of about three years.

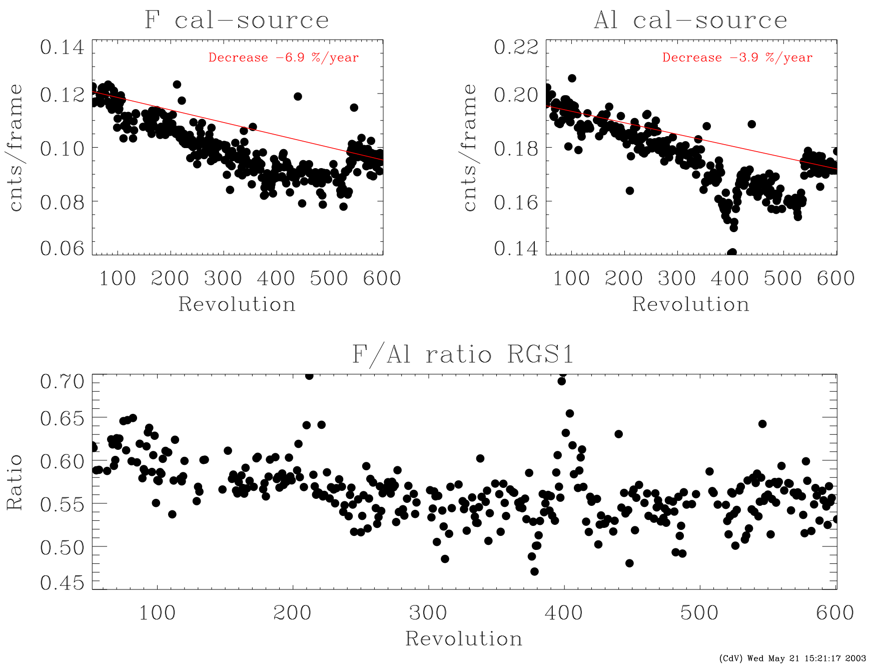

Figure 1: RGS1 calsource rate trends. Top plots show the count rates for the individual sources, while the bottom plot shows the change in ratio.

Table 1: Modelled QE losses per year for given compounds

	Energy (keV)	Wavelength (Å)	QE loss (%) for compound ice (H_2O) (0.033 μm)	hydrocarbons (C_nH_m) (0.060 μm)
RGS lowest energy	0.33	37.57	-1.1	-19.6
Carbon line	0.37	33.51	-0.9	-15.5
Below Oxygen edge	0.53	22.96	-0.3	-6.7
Above Oxygen edge	0.55	22.50	-5.9	-6.1
Fluor line	0.68	18.23	-3.5	-3.5
Aluminium line	1.49	8.32	-0.5	-0.4

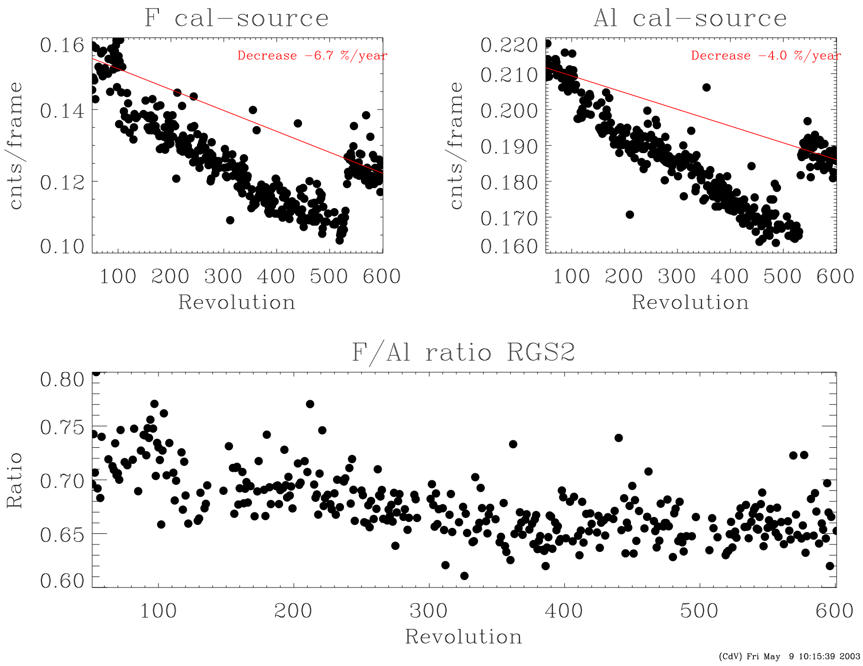

Figure 2: RGS2 calsource rate trends. Top plots show the count rates for the individual sources, while the bottom plot shows the change in ratio.

3 Monitoring the oxygen edge

The behaviour of the instrumental Oxygen edge was monitored by looking at the changes in the spectra of the calibration source Mkn421 which is observed at regular time intervals during the mission. Mkn421 has a smooth power-law spectrum, is quite a strong source and has very little interstellar absorption. A comparison of spectra around the oxygen edge at start of mission (rev. 0084) and after about 2.5 years of mission (rev. 0546) is shown in fig. 3.

A can be seen, there is no obvious change in the depth of the oxygen edge. The change is estimated at less then 5%. Therefore it is conluded that there is no significant buildup of ice on the detectors.

4 Monitoring the effective area at longest wavelengths

A suitable astronomical calibration source for monitoring the effective area at longest wavelengths is RX J0720.4-3125. This is an isolated neutron star with a very soft spectrum and very little interstellar exctinction. The spectrum can be assumed to be reasonably constant over long periods of time. Fig 4 compares the spectra of this source at mission start (rev. 0078) and after about 2.5 years mission time (rev. 0534).

As can be seen there is no large change in the spectra and no systematic trend of significant lower

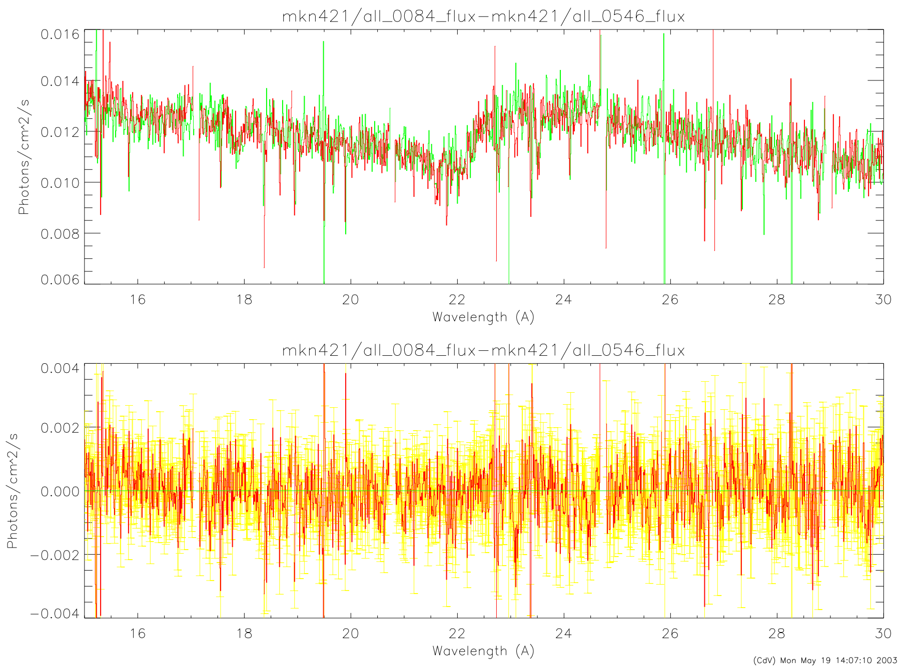

Figure 3: Comparison of the Oxygen edge in the Mkn421 spectra (top plot) at start of mission (rev. 0084, red line) and after about 2.5 years of mission life time (rev. 0546, green line). Bottom plot shows the difference (error bars in yellow)

effective area towards longer wavelengths. Maximum decrease of effective area at lowest wavelength is about 20%. However, it should be noted that other factors. like e.g. changes in thresholds and system peaks, can also introduce a loss of effective area towards long wavelengths.

5 Discussion and conclusions

Clearly the results of the calibraton sources and the monitoring of the astronomical sources seem to contradict. Although there is room for some contamination by water(ice) and hydrocarbons leading to a maximum loss of effective area of 2% per year at the Oxygen edge and 8% per year at the longest RGS wavelength, this does not explain the total change in ratio between the Al and F cal source rates. Clearly, other factors must play a role, changing the cal-source ratios.

At this moment there is no unambiguous indication that one should worry about contamination on the RGS CCD detectors.

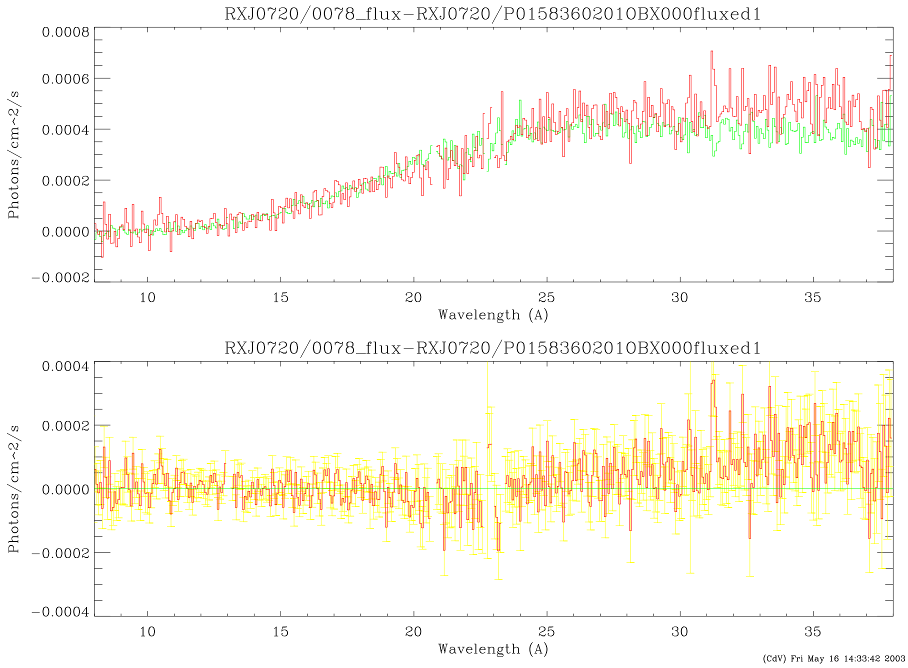

Figure 4: Comparison of the low energy response in the RXJ0720 spectra (top plot) at start of mission (rev. 0078, red line) and after about 2.5 years of mission life time (rev. 0534, green line). Bottom plot shows the difference (error bars in yellow)