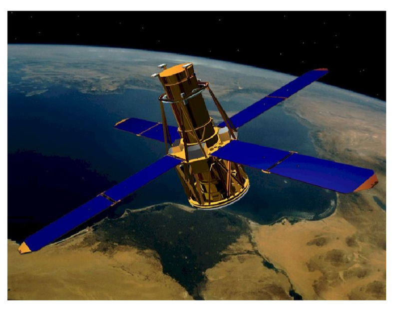
The Effect of the Annealing Procedure on the Gamma-Ray Burst Measurements by RHESSI



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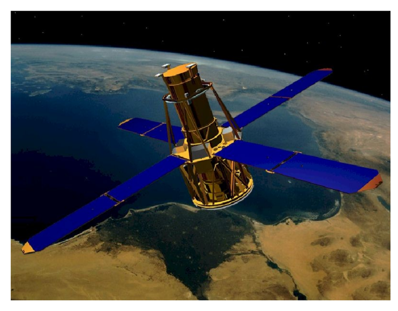


Abstract

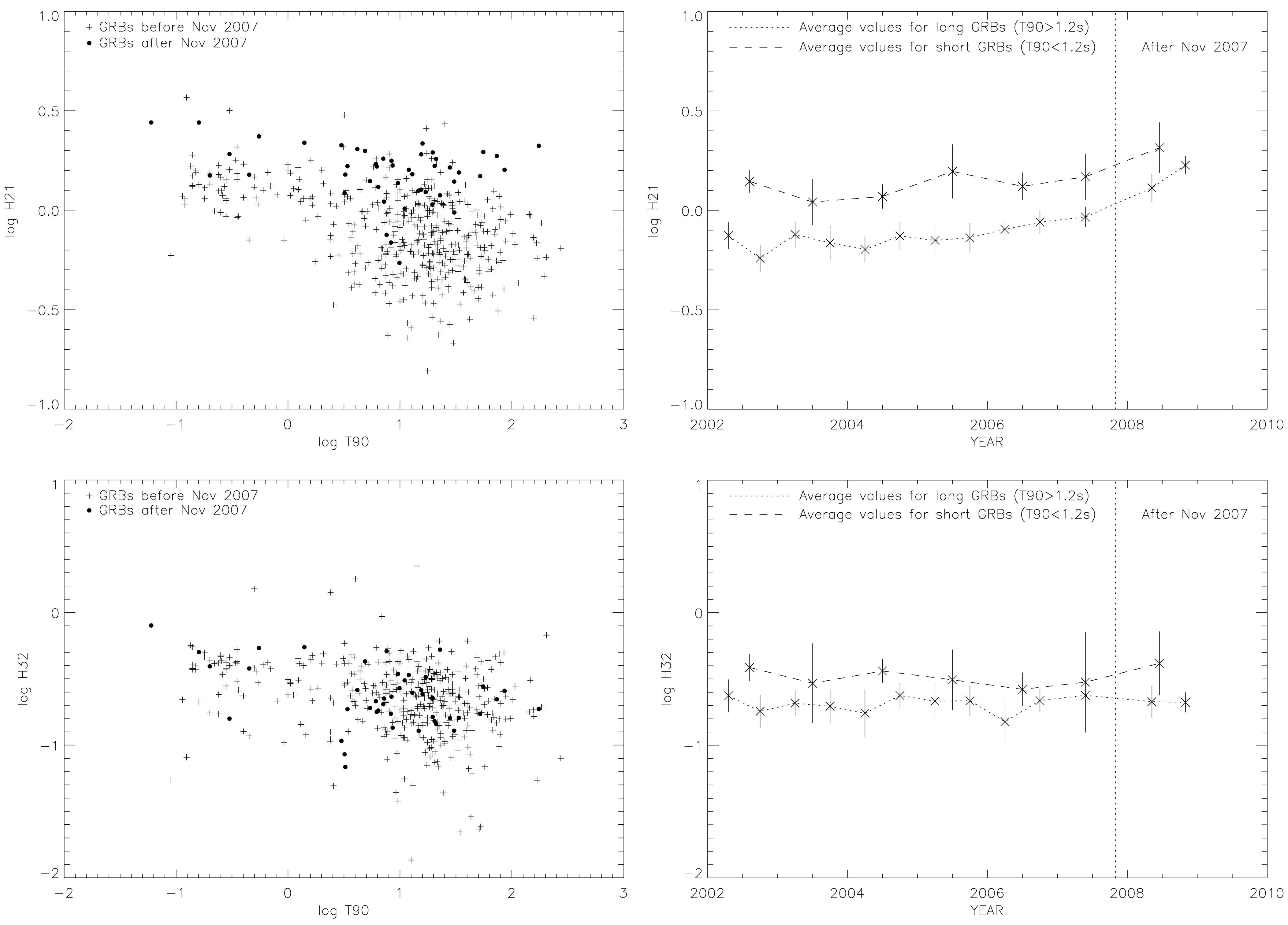
The performance of the nine RHESSI germanium detectors has been gradually degrading since launch in 2002 because of radiation damage caused by the charged particles of the Earth's radiation belts. To correct this problem, the detectors underwent the procedure called 'annealing' in November 2007. It led to the change in the RHESSI response. We present how this affected Gamma-ray burst measurements, e.g., detected bursts' hardness ratios. We also compare the RHESSI spectral fits with that of gained from other instruments.

The RHESSI Satellite

The Ramaty High Energy Solar Spectroscopic Imager (RHESSI) [1] (http://hesperia.gsfc.nasa.gov/hessi) is primarily dedicated for studying solar physics in X-ray and gamma ray region. It's spectrometer [2] consists of nine germanium detectors, which are, however, only lightly shielded and thus also allow omnidirectional gamma-ray burst (GRB) detection (http://grb.web.psi.ch) [3,4]. The energy range extends from ~ 50 keV up to 17 MeV. The effective area reaches up to 200 cm². With a field of view of about half of the sky, RHESSI observes about 70 GRBs per year.

The RHESSI Annealing

In November 2007 the spectrometer underwent a procedure called annealing which was hoped to restore its sensitivity that had been gradually deteriorating because of radiation damage [5]. It consisted in heating up the germanium detectors to over 90 °C for one week (operating temperature is about 90 K) [6,7]. This procedure was only partly successful, because the low-energy response did not improved as much as the high-energy one. We have found that GRBs observed after the annealing have hardness ratio measurements systematically shifted to higher values that those observed before.



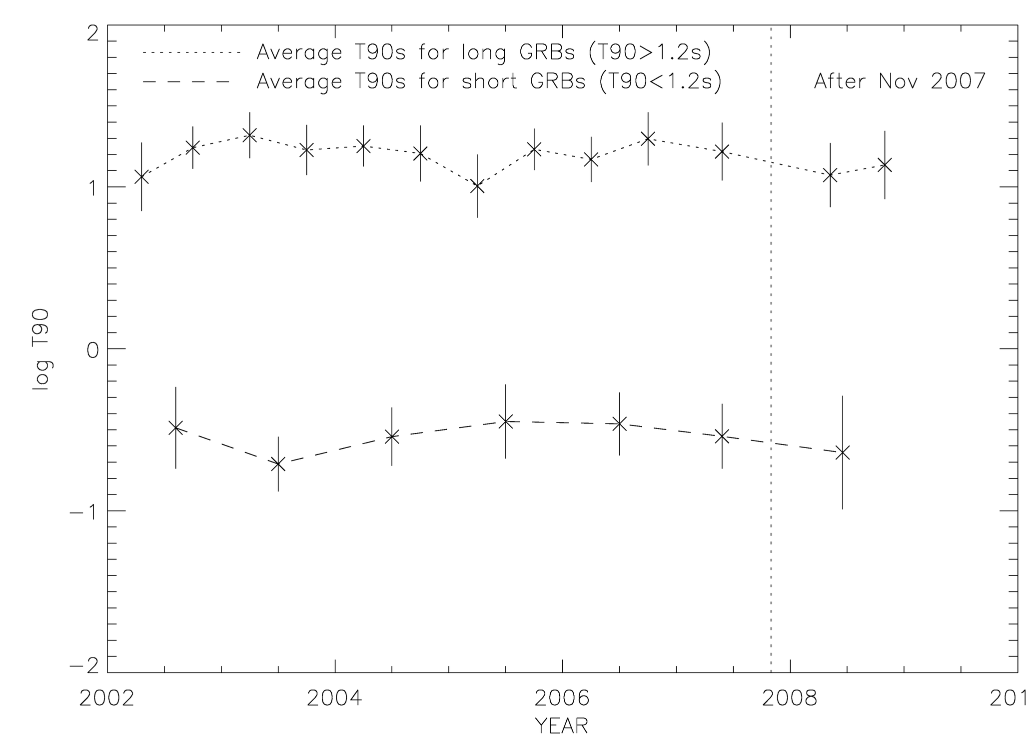


Fig. 1. Development of the average GRB RHESSI hardness ratio H21 and H32 over the years. H21 is a low energy ratio. It is the ratio of the GRB counts in the energy ranges (120 - 400)keV / (25 - 120) keV. H32 is a high energy ratio. It is the ratio of the counts in the ranges (400 - 1500) keV / (120 - 400) keV. Also the development of the average GRB T90 durations is shown (the plotted errors are 2 sigma). Emphasised are the data after the annealing realised in Nov 2007.

			α	β	E_p (keV)	χ^2_r
GRB 061121	cutoff power law	Swift	0.63±0.02			
		Konus*	0.68±0.05		606±80	1.27
		RHESSI	0.63±0.10		532±57	1.01
GRB 080607	cutoff power law	Swift	0.85±0.03			0.70
		RHESSI	**-0.33±0.18**		434±19	1.39
GRB 080825	Band function	Fermi	0.54±0.21	2.29±0.35	180±23	1.23
		RHESSI	**-3.36±0.86**	2.92±0.57	256±25	0.80

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cutoff power law:

$$\frac{dN}{dE} \sim \left(\frac{1}{E}\right)^{\alpha} \exp\left(-\frac{E}{E_0}\right)$$

Band function:

$$\frac{dN}{dE} \sim \begin{cases} \left(\frac{1}{E}\right)^{\alpha} \exp\left(-\frac{E}{E_0}\right) & \text{if } E < E_{\text{break}} \\ \left(\frac{1}{E}\right)^{\beta} & \text{if } E > E_{\text{break}} \end{cases}$$

where $E_p = E_0 (2 - \alpha)$

Results and Conclusion

From the figures it is seen that the low energy hardness ratios H21 were systematically shifted to higher values after the RHESSI annealing in Nov 2007. Contrary to this the high energy hardness ratio H32 remained on average the same. The T90 durations had not been affected.

We have also compared the spectral parameters of 3 GRBs. Whereas the low-energy photon index for the pre-annealing burst 061121, detected by Swift, Konus, and RHESSI, was found to be approximately still the same, for the after-annealing bursts the situation is different. The RHESSI low-energy index for bursts 080607 and 080825 markedly differ from those obtained by the Swift or Fermi satellites.

This finding and the H21 systematic shift point to the fact that the RHESSI low energy sensitivity was not recovered well by the annealing procedure and using the RHESSI data for a future GRB spectral analysis, employing current response matrix, might be problematic.

References

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