GAMMA RAY SPECTRA FROM THE MARS OBSERVER GAMMA RAY SPECTROMETER: CRUISE DATA ANALYSIS

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This paper reports the preliminary analyses of special features of the gamma ray spectra acquired in the time period of Jan. 24, 1993 to July 30, 1993 by the Mars Observer Gamma Ray Spectrometer I (MOGRS1) in the flight of the spacecraft towards Mars. The purpose was to gather information on the electronic drift of the instrument, background photopeaks including the finger-printing of new ones and the evidence on the radiation damage of the detector. Attempts have also been made via comparison with terrestrial simulation experiments, to arrive at crude estimates of the overall proton dose on the detector and the neutron fluence incident on it in the space environment.

Spectrum analysis was performed by the gamma spectrum deconvolution program GANYMED [1] and standard graphics, spreadsheet and statistical analysis packages utilising a Sparc 10/41 Workstation and IBM PC 486. Optimisation of baseline fitting and peak shape parameters within GANYMED allowed a reasonably invariant standard for these spectra. The linear calibration coefficients, a_0 (intercept) and a_1 (slope), of the detector were obtained from the benchmark 198, 271, 984, 1117 and 1312 keV gamma rays whose full widths at half maximums (FWHMs) were investigated for information on the resolution of the detector. The possible effects of solar flares, spacecraft and detector manoeuvres on these variables were examined. It was found that there was no functional correlation between a_0 and a_1 and the time elapsed in the C6 to C10 flight paths which shows the absence of instrument electronic drift. There is however some evidence of a slow progressive change of the coefficients in the C12 flight path which was the path placemant of the spacecraft at the time of it's disappearance. No correlation of the calibration coefficients with detector temperature and high voltage (HV) at constant time were seen. For the detector resolution, the expected decrease with temperature and increase with HV at constant time were observed. To inspect the time variation of the FWHMs, the spectra were normalised to the HV setting of 2500V and spectra with temperature variation were not considered at all. Average FWHMs were obtained for each flight path and plotted with respect to the average (julian) day of each flight path. The points were regressivley fitted to the best polynomial. It was found that the detector resolution worsened with time which indicates progressive radiation damage, an idea of the rate of which was obtained from the coefficients of the polynomial fit.

For the purpose of determining overall spectral characteristics including unknown peak identification, the spectra in all the flight paths were summed up. It was possible to do so without special procedures because of the absence of instrument electronic drift. The FWHMs of all 42 peaks spanning 129-2222 keV in energy, were plotted as a function of gamma ray energy and the points fitted by polynomial regression. Figure 1 shows the plot in the 800-1500 keV region. Over this energy range the FWHM is found to increase almost linearly, if the small coefficients of the higher order terms are ignored. This conforms to the expected trend. However, implicit in this curve is the widening of the FWHMs due to the accumulated energetic particle dose. With the view to obtaining semi-quantitative information on the magnitude of this dose through the gamma spectrum alone, the controlled earth-bound experimental radiation-damage data of Bruckner et al

[2] were used. The FWHMs of the 1237 and 1312 keV peaks in the summed spectrum, chosen because of their proximity to the ^{60}Co peaks, were found to lie on or very close to one of the simulated radiation damage vs energy curves at a predetermined GeV proton dose. From this, a rough estimate of the accumulated Galactic Cosmic Ray dose on MOGRS1 can be obtained.

The summed spectrum was used to observe previously recorded background peaks and to identify new ones. The new activities were fingerprinted nuclide-wise on the basis of the most plausible nuclear reaction, the nuclide library NCC within the code GANYMED and other sources. This spectrum also showed the characteristic Ge(n,n'gamma)Ge saw-tooth peaks, whose FWHMs were recorded with a separate set of fitting parameters in the code GANYMED. Beck's [3] data on such peaks obtained by quasi-monoenergetic neutron bombardments on the Ge crystal in an HPGe detector, were taken as a rough control data set and were reanalysed and appropriately arranged. The flight data FWHMs as obtained from the summed spectrum were compared to the values obtained from the control data. Within the large constraints of the geometrical mismatch of Beck's detector and the one on MOGRS1 and the fact that space provides a continuum of neutron energies, crude estimates of the average neutron fluence and energy encountered by the MOGRS1 were attempted. The neutron fluence value of $\lesssim 10^5$ neutrons/cm^2 was found to correspond, to a degree, with a rough estimate obtained by inserting the counts of the 693 keV peak in the standard empirical formula [4]. It will be interesting to compare this value with the actual average neutron fluences obtained from the neutron spectrometers aboard the MOGRS1.

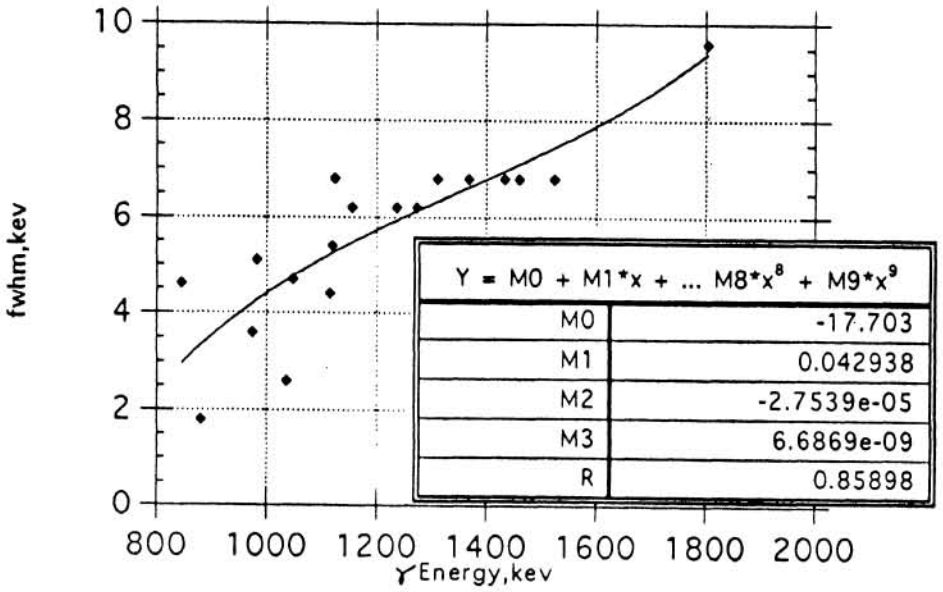

Figure 1.: FWHM of the gamma ray peaks versus gamma ray energy

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