PEAKS IN DAWN GAMMA-RAY SPECTRA AT AND NEAR VESTA. R. C. Reedy[1], T. H. Prettyman[1], and N. Yamashita[1], Planetary Science Institute, Northern Rio Grande Contingent, New Mexico, USA. <reedy@psi.edu>.

Summary: The peaks in gamma-ray spectra at various distances from Vesta are presented and summarized. Spectra from Vesta for low- and high-neutron leakage fluxes are also presented.

Introduction: The Gamma Ray and Neutron Detector (GRaND) instrument was on the Dawn spacecraft that orbited the asteroid 4 Vesta in 2011-2012 [1,2,3]. Some results from GRaND gamma-ray spectra have been reported [3,4].

The big advantage of gamma rays for planetary compositional studies is that it directly senses elements from the unique energies of the gamma rays. Planetary elemental mapping has previously been done for the Moon [5,6,7], Mars [8], Mercury [e.g., 9], and the asteroid Eros [10]. The observed gamma-ray spectra were studied after having determined the locations of the peaks in the observed gamma-ray spectra.

All planetary spectra (e.g., [5-10]) are calibrated using peaks measured during the mission, as laboratory calibrations are hard to apply to the very different conditions in space, especially the many effects of cosmic rays. The sources of the stronger gamma rays in planetary spectra were well known, including the major gamma rays from Fe, O, C, and Si. Often, gamma rays from material in or near the GRS produce strong peaks. For GRaND, those nearby elements include Al and, to a lesser degree, C and Si.

We present results for peak identifications using gamma-ray spectra measured by GRaND for 3 altitudes during the Vesta encounter. A spectrum during a solar-particle event during cruise to Vesta is included as it shows gamma rays from material within a few millimeters of space, the only parts of a spacecraft irradiated by the low-energy particles in solar-cosmic-ray events.

Spectra: The gamma rays from the surface of Vesta were split into those for regions with low and high densities of leakage neutrons (ND) and latitudes above 70N and below 70S. Spectra from the 3 main orbits about Vesta were included: survey (2750 km), high altitude mapping orbit (HAMO) at 680 km, and low altitude mapping orbit (LAMO) at 210 km. A spectrum during a solar cosmic ray (SCR) event during cruise was also used. These spectra are plotted in Fig. 1.

Fig. 2 shows the spectrum between 1000 and 3500 keV, the part of the spectrum with the most peaks. Fig. 3 shows the specrum for the higher enegies.

The decrease at the highest energies is a known effect of the electronics and how the data was processed.

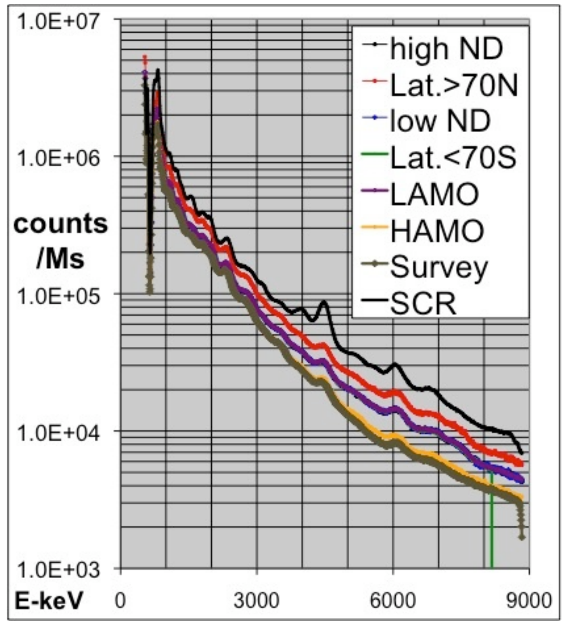

Fig. 1. The gamma-ray spectra from GRaND on the Dawn spacecraft near the asteroid Vesta for several compostional regions on Vesta and different altitude above Vesta, including one during a solar cosmic ray (SCR) event in cruise to Vesta. Some spectra plot under the LAMO spectrum (Ms is megaseconds, ND is neutron density.)

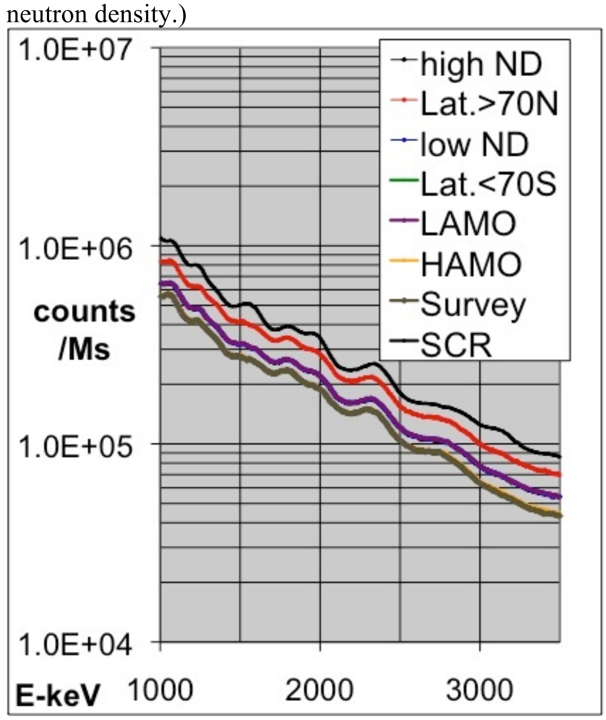

Fig. 2. The low-energy part of the GRaND gamma-ray spectra shown in Fig. 1.

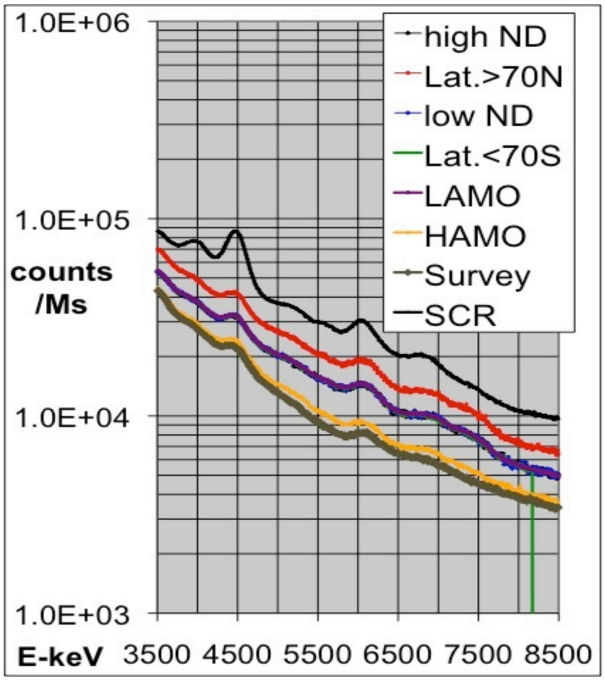

Fig. 3. The high-energy part of the GRaND gamma-ray spectra shown in Fig. 1.

Ch	E-cal	E-ref	ΔE	Source	Alt. source
87	1088	1014	-74	^{27}Al*	
124	1409	1369	-40	^{24}Mg*	^{24}Na
151	1643	1634	-9	^{20}Ne*	
175	1851	1809	-42	^{26}Mg*	^{28}Si*-1779
218	2223	2211	12	^{27}Al*	^{1}H(n,γ)-2111
269	2665	2685	20	^{208}Pb*	^{24}Mg*-2754
363	3479	3539	60	Si(n,γ)	
471	4414	4438	24	^{12}C*	^{16}O
563	5211	5240	29	^{15}O*	^{15}N*-5269
669	6129	6129	0	^{16}O*	
769	6995	7015	20	^{16}O*	
850	7696	7638	-58	Fe(n,γ)	

Table 1. The strong gamma-ray peaks in GRaND spectra. The calculated energy is that in the spectra. The reference energies are for the most like source or sources. Energies are in keV. A * indicates the gamma ray is from an excited level in that nucleus, which often can be made by several reactions.

All but the SCR spectra are similar in shape. Those for low and high neutron densities (ND) and Lat.<70S are very close and can't be distinguished in Figs. 1-3. The Lat.>70N region has spectra collected when Dawn was closer to the surface.

Peaks in GRaND Gamma-Ray Spectra: The most-likely and most-intense sources for the stronger peaks in the spectra in Fig. 1 have been identified and listed in Table 1. The gain (slope) and zero (offset) was calculated using the 2 strong gamma rays at 6129 and 2.21 MeV. The differences of the calculated and reference energies are plotted in Fig. 4. The trend is curved, a feature of many planetary gamma-ray spectra. The differences in energies are of the same magnitude as that from the laboratory calibration of GRaND [1] and probably reflect the uncertainties of peak positions for bismuth germanate (BGO) spectra.

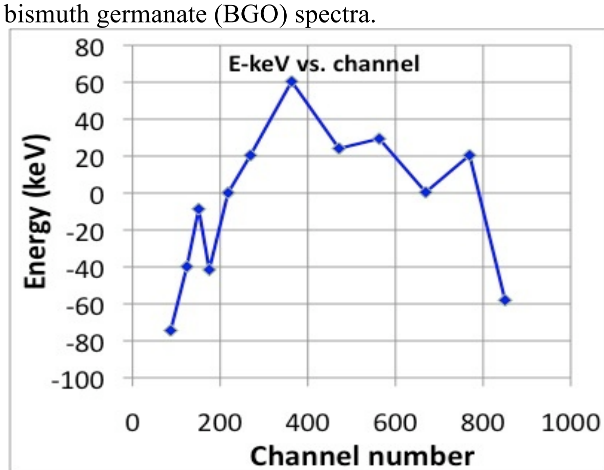

Fig. 4. Differences in calculated and expected energies versus spectral channel.

Many Al and C peaks appear in the spectrum during a solar-cosmic-ray (SCR) particle event, probably because those elements were near the very surfaces of GRaND or the spacecraft.

Summary: The major peaks in GRaND gamma-ray spectra have been identified. The trend for the differences of the actual and spectral energies is not linear but has a good systematic trend with delta energies similar to those in [1]. The energies of peaks in features are well known and provide confidence in locating peaks for other gamma rays of interest, such as from Si, Mg, and ^{40}K.

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