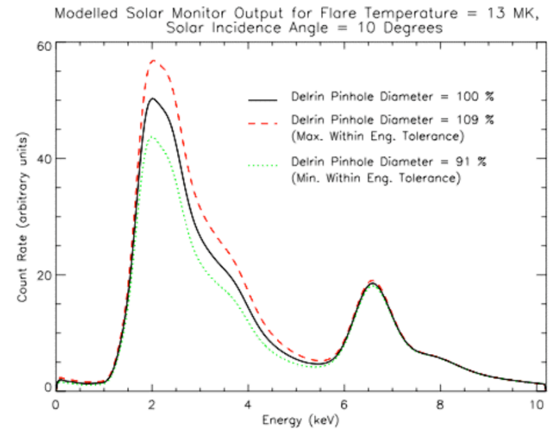
CALIBRATION OF THE NEAR XRS SOLAR MONITOR. L. F. Lim[1,2], L. R. Nittler[3], R. D. Starr[4], T. P. McClanahan[1]. [1]NASA Goddard Space Flight Center, Code 691, Greenbelt, MD 20771, [2]Cornell University, Ithaca NY 14853, [3]Carnegie Institution of Washington, Department of Terrestrial Magnetism, 5241 Broad Branch Rd NW, Washington DC 20015, [4]Department of Physics, The Catholic University of America, Washington DC 20064

Introduction: The NEAR-Shoemaker X-ray spectrometer measured elemental abundance ratios for six elements (Mg, Al, Si, S, Ca, Fe) on the surface of 433 Eros by remote-sensing x-ray fluorescence spectroscopy (1,2). The fluorescent x-rays are excited by x-rays from the solar corona. Therefore, accurate knowledge of the incident solar spectrum was critically important to interpreting the fluorescence spectra received by the NEAR detectors in terms of elemental ratios on the asteroid's surface. NEAR, therefore, carried two additional X-ray spectrometers dedicated to monitoring the solar spectrum between 1 and 10 keV. One of these, a Si PIN photodiode, failed prior to orbit insertion. The second consisted of a gas-filled proportional counter similar to the asteroid-pointing detectors, but covered by a graded filter (3) intended to attenuate the incoming solar flux and increase the dynamic range of the detector. Unfortunately, the response of this filter as a function of solar incidence angle was not adequately determined in the laboratory prior to launch. The response function had to be calculated from the assumed properties of the graded filter.

Design of the graded filter: The graded filter was constructed from thin layers of beryllium, aluminum, and the plastics Delrin and Kapton. The Delrin and beryllium layers were pierced by concentric pinholes intended to allow only a small fraction of the incident low-energy X-rays to reach the proportional counter underneath, while higher-energy X-rays would be relatively unimpeded by these materials. The dimensions of these pinholes, together with the thicknesses and X-ray attenuation coefficients of the Delrin and beryllium layers, are critical for determining the response of the gas solar monitor. Variations in these dimensions within the engineering tolerances of the filter can have substantial effects on the energy and angular response of the detector. For example, the engineering tolerances (4) for the pinhole diameters were ± 9-10%, which translates to ± ~20% uncertainty in the relative proportions of low-energy to high-energy solar flux admitted to the detector. (Figure 1)



Post-Launch Calibration: Post-launch calibration efforts, therefore, were directed at choosing the combination of pinhole sizes and layer thicknesses that would produce the best matches to the observed output of the gas solar monitor during the major solar flares observed by NEAR. Theoretical solar X-ray spectra from Mewe *et al*. (5) were multiplied by the attenuation expected from the model graded filter and convolved with the detector resolution to produce synthetic solar monitor spectra, which were then compared with observed spectra from the NEAR solar monitor. The model that provided the best match, in a least-squares sense, was used to interpret the XRS data.

This model, however, was based on the examination of a very limited number of spectra and, although it matched the solar monitor output very well at energies above 5 keV, it often performed relatively poorly at lower energies. For this reason, the systematic uncertainties in the resulting solar flare spectra dominate the error bars in the reported elemental ratios (1). Moreover, the model had never been useful for interpreting the thousands of XRS spectra taken during "quiet sun" (non-flaring) periods when the solar spectrum was limited to energies below 5 keV. A theoretical solar spectrum using an average plasma temperature of about 4 MK (based on broadband measurements from the geostationary operation environmental satellite 8 (GOES)) was applied to these data instead, but uncertainty in the GOES temperature calibration resulted in large uncertainties in the derived abundances.

Improvements to the Solar Monitor Calibration: An improved model of the gas solar monitor response as a function of energy and solar incidence angle, therefore, would substantially reduce the uncertainties in the elemental ratios derived from the NEAR XRS fluorescence data. Toward that end, we have begun a systematic search of the parameter space within the engineering tolerances of the graded filter. We test each model against actual gas solar monitor output at a wide range of incident angles and solar activity levels. For each NEAR spectrum, which represents a 50-second integration of the solar monitor, we generate a set of synthetic gas solar monitor spectra using the graded filter model to be tested and theoretical Mewe *et al*. models of solar output at thirty-nine different plasma temperatures between 2 and 40 MK. We then search for the best two-temperature fit (representing two separate volumes of plasma, such as a hot one in an active region and a cooler one for the remainder of the sun) to the observed data. The free parameters in the fitting process are the temperatures of the two single-temperature spectra to be combined, the relative proportions of the low- and high-temperature components, and the overall normalization, which is related to the emission measure of the spectrum. The two-temperature model that, when folded through the graded filter model and convolved with the gas counter's response function, produces the best chi-square match to the observed solar monitor spectrum is recorded. Over a large sample of incidence angles and solar spectra, the lowest average chi-square value should be produced by the graded filter model that best describes the flight hardware.

Comparison with GOES data. Each two-temperature best-fit spectrum is also tested against the data available from the two broadband GOES channels for the same 50-second period, corrected for the difference in light travel time between the sun and Earth vs. the sun and NEAR. The two-temperature synthetic solar spectrum is folded through the transfer function for each GOES channel (6) and the result is compared with the actual GOES output. Although GOES and NEAR did not always observe precisely the same hemisphere of the Sun, the asteroid-Sun-Earth angle remained below 30 degrees throughout June-August 2000. During this period most flares observed by NEAR were also observed by GOES. The correct graded filter model, therefore, should lead to a fairly accurate reproduction of GOES channel output over this time period as well.

New analyses of asteroid data from minor flares. In addition to improving the precision of the already published data from the major solar flares and "quiet sun" periods, the new graded filter model will enable the analysis of additional NEAR data taken during a number of smaller solar flares. The solar monitor data from these spectra could not be calibrated with the old method since the spectra had too few counts above 5 keV, but since the plasma temperatures had clearly been well above 4 MK they could not be included in the aggregate "quiet sun" analysis.

References: [1] Nittler L.R. *et al*. (2001) *Meteoritics & Planet. Sci*. **36**, 1673-1695. [2] Trombka J.I. *et al*. (2000) *Science* **289**, 2101-2104. [3] Clark P.E. *et al*. (1995) LPS XXVI, pp. 253-254. [4] Goldsten J. O., engineering drawings for the NEAR gas solar monitor. [5] Mewe *et al.* (1985) *Astron. Astrophys. Suppl.* **62**, 197-254. [6] Schwartz, R. (1998), NASA Solar Data Analysis Center.