The first object is a 1/2-in.-diameter cylinder of PBX-9502, a mixture of an explosive (TATB) with a plastic Kel-F binder[8]. We calculated the optimal energy for the longest chord to be between 20 and 26 keV [9]. Using the chemical formula and the weight fractions, we find that the PBX-9502 pellet has a Z_{eff} of 7.6 [8]. A ^{109}Cd source was used to scan the pellet at 22 and 25 keV. The photon statistics obtained, the reconstruction parameters used, and the resultant statistical uncertainty in the data are reported elsewhere[8]. The Z_{eff}, TATB weight fraction, and density images are presented in Fig. 3, with associated grey scales for interpreting the values. The mean calculated Z is 7.8 ± 0.5, close to the expected value. The mean TATB weight fraction is 0.94 ± 0.03, within the target value of 0.95. The mean value of the density image, 1.9 ± 0.2 g/cm^3, matches the bulk wet/dry measured value of 1.904 g/cm^3 [8].

The second object is a lexan-aluminum phantom scanned with the same scanner and ^{109}Cd source. The phantom is a lexan cylinder, 30 mm in diameter, with three aluminum rods (10, 5, and 2 mm in diameter) inserted along the length of the cylinder. The optimal energy for the lexan alone is between 18 and 29 keV for the longest chord. However, for the chord with the 10-mm-diameter rod, the optimal energy is between 60 and 90 keV. Consequently, we performed the multiple-energy work using the results from the 25- and 88-keV reconstructed images. The 25-keV image has streaks as a result of the lack of transmission through the thickest rod, and this pattern will be written into the ratio data. This will be useful to determine how well multiple-energy techniques fare when a wide dynamic range is required and one of the energies is far from optimal.

Figure 4 presents the results, the Z_{eff} image, the histogram of the CT image, and the associated grey scales. The image is dominated by the streaking phenomena; this added variation is reflected in the noisy character of the histogram. In spite of these perturbations, the Zs for lexan (Z = 6) and aluminum (Z = 13) are clearly identified in the histogram. This suggests that, even over a wide dynamic range, multiple-energy techniques can identify the Zs of the components of a high-contrast object. We are investigating the possible applications of multiple-energy techniques using iterative reconstruction methods.

Machine Sources

To assess the viability of CT for examining soils that contain a variety of phases, we prepared a simulated soil sample consisting of oil, water, and air in a matrix of glass beads.* The beads were used to remove heterogeneous matrix uncertainties associated with real soil samples.

We used the VCAT/Photometrics scanner to perform the data acquisition [3]. Scans of the three-phase cylinder were acquired at two energies, 65 and 130 kVp. Figure 2 shows the two source spectra before and after the weighting function for our scintillator was applied. A beam-hardening correction was estimated [10] from the projection data of a cylinder of glass beads and air-scanned using the same data acquisition parameters as the three-phase sample. Separate beam-hardening corrections were estimated for the 65- and 130-kVp data.

* The chemical formulas and densities used in this study are iodododecane doped oil ($C_{20}H_{40}O_2$), 1.0 g/cm^3; H, O_2, and N_2, 0.00122 g/cm^3, for air; and SiO_2, 2.32 g/cm^3, for the glass beads.