The purpose of this study was to implement the Monte Carlo method in a radiotherapy treatment planning system for routine dose calculations. We used the EGS4/BEAM code to obtain the accurate phase-space data for 6-20 MeV electron beams and 4, 6, 15 MV photon beams for Varian Clinac 1800, 2100C and 2300C/D accelerators. A multiple-subsource model was further developed to reconstruct the phase-space data for both electron and photon beams, which retained the accuracy of the Monte Carlo data but reduced the data storage requirement by a factor of 1000 and the accelerator simulation time by a factor of 10 or more. Good agreement (within 2%) was achieved between the Monte Carlo calculations and measurements of the dose distributions in homogeneous and heterogeneous phantoms for various field sizes, SSDs and beam modulations. For example, the Monte Carlo calculated electron output factors were within 2% of the measured ones for fields 2 x 2 cm^2 – 20 x 20 cm^2 while the photon heterogeneity correction factors for lung and bone were within 1%. The Monte Carlo calculations were used to verify the "optimized" dose distributions given by a commercial treatment planning optimization system prior to an IMRT treatment. Significant differences (> 5% in dose and > 5 mm shift in isodose lines) were found between the Monte Carlo and the analytical calculations as implemented in the commercial systems especially in the head and neck, lung and breast cases.

This investigation was supported in part by grant CA43840 from the NCI.