Purpose: Stereotactic body radiation therapy (SBRT) of lung uses sub-centimeter MV x-ray fields. Under these conditions, lateral electron disequilibrium (LED) can occur in lung tissue, which causes perturbations of the dose distribution near the tumor. This purpose of this work is to characterize the LED effect in lung for clinically relevant ranges of beam energies, field sizes, and lung densities.

Methods: The MC code DOSXYZnrc (National Research Council of Canada, Ottawa, ON) was employed to simulate two 20x20x25cm3 water-lung-water slab phantoms. The two phantoms were identical in composition except that the second phantom also included a 3x3x3cm3 centrally located water cube to mimic a small lung tumor. To characterize LED, dose calculations were performed using combinations of beam energy (Co-60 up to 18MV), field sizes (1x1cm2 up to 15x15cm2), and lung densities (0.001g/cm3 up to 1g/cm3) for both phantoms.

Results: MC lung slab phantom simulations revealed that for each combination of beam energy and field size, a critical lung density (CLD) could be defined to establish LED. For example, a 6MV 5x5cm2 photon field was subject to LED for lung densities of 0.2g/cm3 or lower. On the contrary, employing an 18MV 5x5cm2 photon field increased the CLD to 0.5g/cm3. With regard to the second lung tumor phantom, the LED effect caused major reductions in the calculated dose near to the tumor. For instance, dose reductions of 24% and 16% were found within the distal and proximal tumor surfaces, respectively.

Conclusion: We have fully characterized the LED effect and shown that it causes dose reductions in both lung and tumor tissues. To avoid these dose perturbations, SBRT of lung cancer patients should be optimized to select radiation therapy parameters carefully in accordance with patient lung density.

Funding Support, Disclosures, and Conflict of Interest:

Financial support from the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Canadian Institutes of Health Research (CIHR) are gratefully acknowledged.