**Purpose**: To develop a compact and powerful FPGA-based dose calculation system to meet the performance requirement of emerging radiation therapy technologies.

**Method and Materials:** One challenge for advanced radiation therapy technologies such as intensity-modulated arc therapy (IMAT) is the speed of dose calculation since a large number of beams are used to approximate continuous rotational delivery, resulting in significantly increased dose calculation workload. To accelerate this process, we built a multi-FPGA (field-programmable gate array) accelerator with 8 independent computing channels, which can be plug into a PCI slot of any computer to serve as a coprocessor to the CPU and turn it into a powerful dose calculation workstation. The algorithm we implemented is the popular collapsed-cone convolution/superposition (CCCS) algorithm. After receiving the total energy released per unit mass (TERMA), density and necessary geometrical information from the PCI bus, the accelerator will work on its own to do transport-line generation, raytracing, kernel tilting, and dose deposition.

**Results:** With the support of memory-rich multi-FPGA platform, our floating-point-based design working at 90Mhz provides a speedup of 20X over the commercial multi-threaded software on a state-of-the-art quad-core system. The FPGA architecture was optimized in design to achieve the best performance specifically for the CCCS algorithm with the minimum resources as compared with a general purpose FPGA board. Our modular approach can also be easily expanded to achieve even greater speedup for cases where the computation time is still an issue by inserting additional such FPGA boards into the computer.

**Conclusion:** We developed a complete dose calculation system powered by a multi-FPGA plug-in board, which is capable of delivering very fast dose calculation based on the collapsed-cone convolution/superposition algorithm. Experimental studies demonstrated the potentials of our new approach to dynamic radiation delivery technologies such as IMAT that demand tremendous computation power for dose calculation.