Purpose: To demonstrate the potential for fast 3D dose profile imaging of a LINAC beam using images of the induced Cherenkov radiation in a water tank. A specialized time-gated imaging system was developed as a prototype to quantify and compare with Monte Carlo, to illustrate the concept.

Methods: Images were acquired from a water tank during irradiation from a 6 MV Varian-2100C linear accelerator beam using a time-gated CCD-based imaging system. The camera was placed normal to the tank wall to minimize parallax reflections, and resultant images were produced by evaluating the median of each pixel in a stack of 2000 images taken at a rate of 60 Hz with an exposure time of 10 ms. Experimental data was compared to images obtained from GEANT4 simulations of the optical setup.

Results: Examination of the scored quantities for dose and generated Cherenkov photons indicates that there is a strong similarity, which can be explained by considering the electron energy losses per unit path length. However, due to the complex convolution of the Cherenkov emission directionality and camera lens angular field of view, this relationship is distorted. These errors can be calibrated using the GEANT4 simulations to more accurately reflect the intrinsic dose in the water volume.

Conclusions: This work demonstrates dose profiling using the induced Cherenkov radiation signal for the first time. These preliminary results serve as a proof of concept of imaging at one azimuthal angle. Analogous to SPECT, the technique could easily be translated to multiple angles yielding full dose reconstructions following filtered back projection. Further refinement of this technology could be the first step in a paradigm shift towards an alternative method for fast radiation field analysis. Advantages would include increased speed, as well as the ability to profile dynamic beam shapes within transparent solid anthropomorphic phantoms.

Funding Support, Disclosures, and Conflict of Interest:

This work has been financially supported by NIH grant R01CA109558.