Evaluation of the DirectDensity Algorithm for Clinical Use

M Schwer, A Geiersbach, J Shah, G Grousset, E Klein, Rhode Island Hospital / Warren Alpert Medical School of Brown University, Providence, RI, Siemens Healthineers, Durham, NC

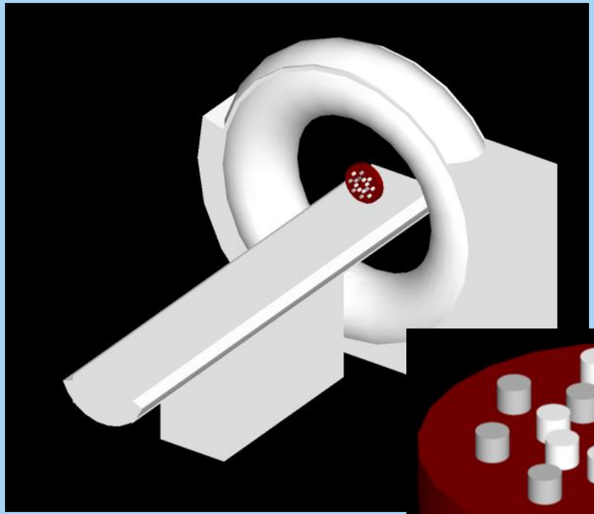
AAPM SPRING CLINICAL MEETING 2021

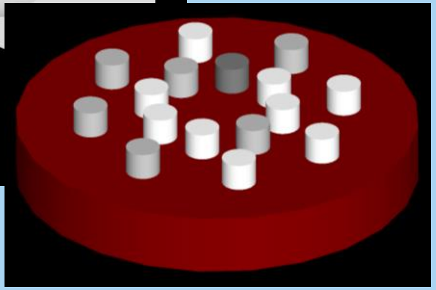
BROWN Alpert Medical School

Lifespan Cancer Institute
Rhode Island Hospital • The Miriam Hospital
Newport Hospital
Delivering health with care.

Purpose:

The Siemens DirectDensity (DD) algorithm is designed to allow for customization of scanning protocols. This algorithm is novel in that it will allow for scanning at energies between 70-140 kV with only one CT calibration curve in the treatment planning system instead of multiple curves or limiting scanning to 120 kV. DD has the potential to reduce dose to patients by customizing protocols to body habitus while also improving image contrast. A limitation of the algorithm is that calibration curve is truncated at 1.83 g/cm^3. While this includes most materials commonly encountered in RO, it leaves out high-Z materials that are often included in the scan range such as hip protheses, spinal stabilizations, etc. The aim of this project is to use a Monte Carlo simulation to extrapolate the calibration curve for high-Z materials. The results from the Monte Carlo simulation will then be used to quantify any the degree of dosimetric uncertainty in clinical treatment plans.



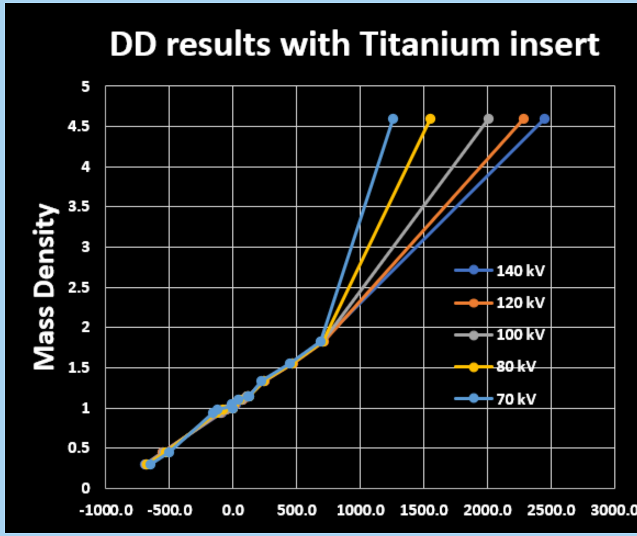


	Liquid Water	B-200 Bone	Solid Water	Inner Bone	CB2-50%	CB2-30%	Cortical Bone
140 kV	0.0	118.8	-3.2	111.5	461.8	248.5	700.8
120 kV	-1.1	120.0	-3.0	111.0	470.9	246.8	718.7
100 kV	-2.4	120.3	-6.0	115.0	463.3	239.0	707.4
80 kV	-2.4	125.2	-8.2	122.5	465.3	238.9	705.6
70 kV	1.2	127.1	-12.6	123.9	451.8	227.3	691.2
St. Dev.	1.6	3.6	4.0	6.1	7.0	8.4	10.0

	Brain	Liver	LN-300 Lung	LN-450 Lung	Breast	Adipose	Titanium
140 kV	22.8	76.1	-690.4	-551.6	-50.1	-85.6	2447.9
120 kV	17.9	73.6	-686.8	-552.5	-52.0	-94.3	2281.9
100 kV	10.7	71.8	-684.8	-545.5	-63.4	-103.6	2008.9
80 kV	5.1	49.9	-672.5	-531.5	-80.7	-128.6	1556.0
70 kV	-9.5	43.8	-648.9	-505.9	-121.0	-158.7	1263.1
St. Dev.	12.5	15.0	16.9	19.5	29.2	29.6	495.3

Methods and Results:

TOPAS version 3.6.1 MC was used to model a 64 slice Siemens Somatom Confidence and the Gammex 467 RMI tissue characterization phantom. Preliminary data has shown that multi slice projections can successfully be modeled. The data using the titanium insert is shown above. Inclusion of using filtered back projection and iterative reconstruction techniques will be modeled as well as materials commonly used in orthopedic prosthetics such as Ti, Ca, Cr, Al, and stainless steel.



Conclusions:

Many radiation oncology clinics scan only at 120 kV to reduce the potential for error in selecting the wrong calibration curve for a given scan, but with DirectDensity, many energies can be utilized with full confidence. Based on the preliminary data acquired with the MC simulation we anticipate the DD images to have a dosimetric uncertainty around 2% for high-Z materials, but further data acquisition is still required. If our hypothesis is correct, there will be no impediment to implementing the DD algorithm.