CT Number Accuracy Along the Z-Axis of a Wide-Beam 320-Detector Dual Energy CT scanner

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INTRODUCTION

- Dual energy CT (DECT) uses two X-ray spectras to generate material- specific images created as a function of atomic number (Z) and mass attenuation coefficient (μ/ρ) [1]
- By using a wide detector, both spectras can be acquired in less than 2 seconds, allowing for dynamic imaging of entire organs, like the heart or brain, with material differentiation of DECT[1]
- However, wide beams introduce geometric mismatch (Fig. 1), increased scatter, increased noise, and cone beam artifacts [2]

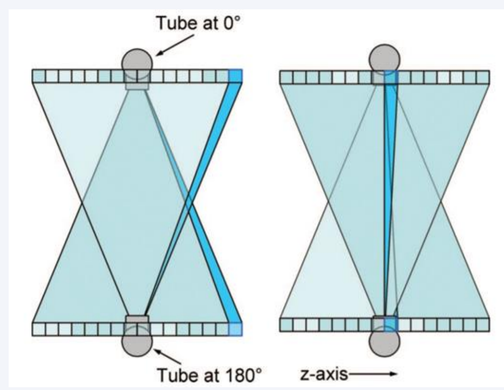

Fig 1. Geometric mismatch at the periphery of the scan range in wide-area CT detectors [3].

PURPOSE

The accuracy of DECT reconstructions using a wide must be quantified to determine whether diagnostic accuracy and clinical utility of DECT is affected at the periphery of the scan range

MATERIALS AND METHODS

1. A DECT phantom was centered in the 16-cm wide volumetric beam (Fig. 2) and scanned with 2 consecutive rotations of 135 kVp and 80 kVp
2. Material-equivalent rods were inserted in the "head" portion of the phantom (Fig. 3): adipose, brain white matter, gray matter, chronic blood, acute blood, and 5 concentrations of iodine (0.2-5.0 mg/mL)
3. DECT images were reconstructed at the workstation : 120 kV Equivalent (kVe), 66 keV Virtual Monoenergetic (VM), Iodine Map (IM), and Virtual Non-Contrast (VNC)
4. CT number (HU) and noise (SD) were measured automatically in Regions of Interest (ROI) using Matlab for each material and image along the scan range
5. A tolerable scan range was defined for each material and image to include CT numbers within ±5% or ±5 HU of the central CT number (z=80 mm), whichever was greatest

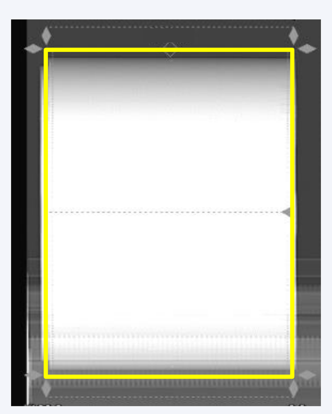

Fig 2. Scanogram of the phantom included in the 16-cm scan range and field of view (yellow lines)

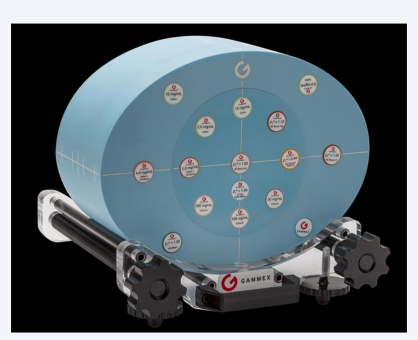

Fig 3. Picture of the DECT phantom with inserted rods. The "head" portion is within the outer "body" portion [4].

RESULTS

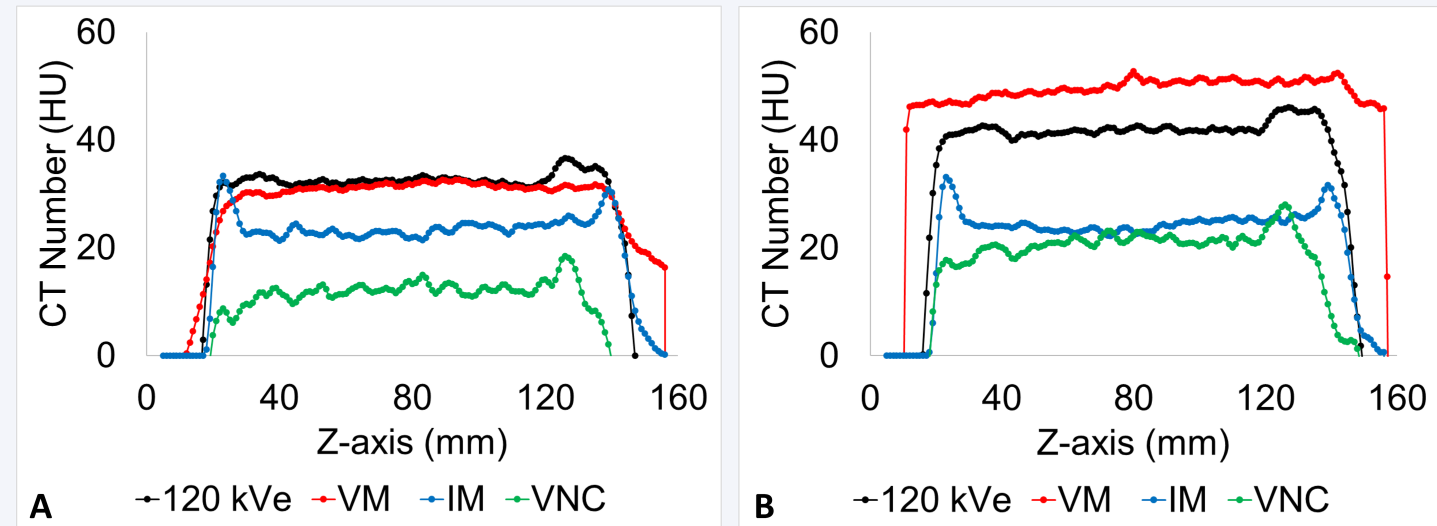

Fig 4. CT numbers along the z-axis for all images for **A**) Gray and **B**) White brain matter

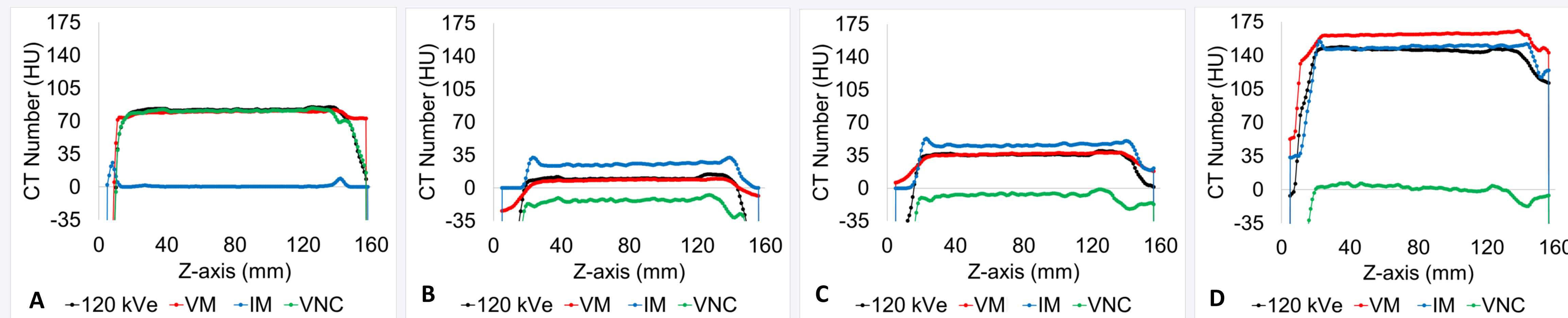

Fig 5. CT numbers along the z-axis or all images for **A**) Acute Blood and **B**) 0.2 mg/mL, **C**) 1.0 mg/mL and **D**) 2.0 mg/mL Iodine

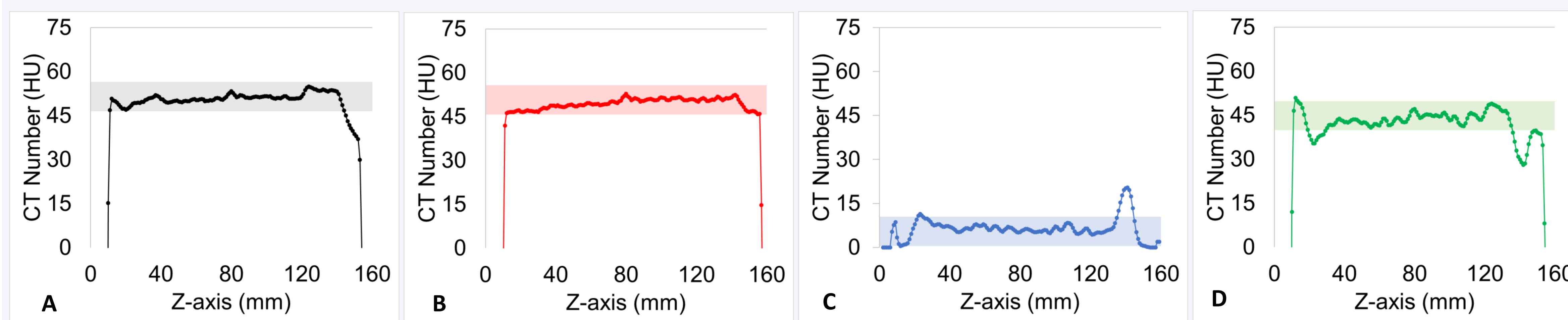

Fig 6. CT numbers for Chronic blood along the z-axis with tolerable ranges overlaid for **A**) 120 kVe , **B**) VM, **C**) IM, and **D**) VNC images

Table 1. Tolerable range (mm) for all materials and images series

Average range represents average of all materials for each image series. Average shift represents the shift along the z-axis from center (with + towards anode and - towards cathode).

Material	kVe	VM	IM	VNC
Adipose	104.0	120.0	113.0	107.0
White Matter	122.0	121.0	111.0	103.0
Gray Matter	122.0	120.0	111.0	99.0
Chronic Blood	135.0	146.0	127.0	107.0
Acute Blood	127.0	128.0	134.0	123.0
Iodine 0.2 mg/mL	124.0	121.0	111.0	110.0
Iodine 0.5 mg/mL	124.0	122.0	117.0	106.0
Iodine 1.0 mg/mL	124.0	123.0	116.0	108.0
Iodine 2.0 mg/mL	123.0	124.0	129.0	116.0
Iodine 5.0 mg/mL	125.0	125.0)	126.0	116.0
Average Range	**123.0**	**125.0**	**119.5**	**109.5**
Average Shift	**-0.30**	**+2.80**	**+0.15**	**-2.35**

CONCLUSIONS

- For all images, none of the materials maintained accurate CT numbers beyond 146.0 mm, and some were only accurate within 99.0 mm
- Averaging the tolerable range for all materials, the 120 kVe and VM images had the largest tolerable ranges (123 and 125 mm, respectively) and the VNC image had the smallest tolerable range (109 mm)
- Radiologists may prioritize accuracy of certain materials (i.e., iodine and blood is more important than white matter, for example), in which case it may be more advantageous to look at material specific ranges rather than averaging them per image series
- Diagnostic accuracy and material characterization may be affected in the peripheral images located at the beginning and end of the scan range in volumetric DECT images
- These preliminary findings may translate clinically to suggest reduced quantitative accuracy and diagnostic confidence at the top of the skull region in a brain DECT exam, for example

FUTURE WORK

- This work will be extended to assess accuracy of differentiating similar materials using DECT images with volumetric acquisitions
- New tolerable ranges may also be defined based on the ability to differentiate materials in the images

REFERENCES

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