Measurements of Full Width at Half Maximum with point detectors in Computed Tomography: A comparative study

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Background

The Full Width at Half Maximum (FWHM) of a longitudinal dose profile is an important metric in CT. It can be used to evaluate, e.g., the dose efficiency of a CT scanner. In this study, we have measured longitudinal dose profiles using two methods (both methods with detectors that have small sensitive volumes) and compared the resulting FWHM.

Methods and materials

Step and shoot. A liquid ionization chamber (LIC) with a small detector volume, see table 1 for a full description of this method, was stepped through the x-ray beam using a custom built high precision linear actuator, see figure 1 (Umeå University, Sweden). Air Kerma was measured at different longitudinal positions. At each position a 360-degree (full) exposure was made.

This method is considered to be a reference method for measuring air Kerma profiles due to its high reproducibility, accuracy and dosimetric calibration traceability to the Swedish National Metrology Laboratory. However, this method is time consuming and it can take up to 30 minutes to measure a single air Kerma profile.

Sweep. Air Kerma profiles were measured by continuously translating (sweeping) a real-time solid-state detector, the CTDP (RTI Group AB, Sweden), along the z-axis of the exposure using a LoniMover v3 (LoniTech AB, Sweden), see figure 1. The CTDP has a sensitive volume comparable to the LIC (see table 1 for a full description of this method). Air Kerma as a function of longitudinal position were exported from the Ocean 2014 (RTI Group AB, Sweden) software.

Table	1.	System	specifications
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	Step and shoot	Sweep
Detector	microLion	CT Dose Profiler
	(PTW GmbH,	(RTI Group AB,
	Germany)	Sweden)
Detector	0.35 mm along the	0.25 mm along the
volume	longitudinal axis	longitudinal axis
Electrometer	Unidos Universal	Black Piranha
	Dosemeter (PTW	(RTI Group AB,
	GmbH, Germany)	Sweden)
Linear	Custom built system	The LoniMover v3
actuator	(Umeå University,	(LoniTech AB,
	Sweden)	Śweden)
Accuracy	0.02 mm position	Better than 1 %
-	accuracy	speed accuracy



Figure 1. Linear actuator systems used. The LoniMover at the bottom.

Results

Air Kerma profiles and FWHM of 40 mm and 160 mm nominal total collimation widths, using the two methods, is presented in figure 2 and table 2. Take note, since this study focuses primarily on the FWHM all data is normalized to the max air Kerma of the LIC measurements (this study's reference).



Figure 2. Air kerma distribution profiles, 40 mm and 160 mm nominal collimation (GE Revolution CT). Sweep vs. step and shoot

Table 2. FWHM results

Nom. collimation	Step and shoot	Sweep
40 mm	45.1 mm	45.1 mm
160 mm	165.6 mm	165.7 mm

Conclusion

In comparison, the sweep method is significantly faster (takes seconds compared to half an hour) and provides equivalent results to the step and shoot method (this study's reference).

Appendix



Nom. collimation	Step and shoot	Sweep	
40 mm	45.1 mm	45.1 mm	
160 mm	165.6 mm	165.7 mm	