Comparison of different methods for measuring CT dose profiles with a new dosimetry phantom

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1 INTRODUCTION

Computed tomography (CT) has become one of the largest contributors to medical radiation dose in radiology. Therefore, attention should be paid to optimize patient dose estimation. The most common dose quantity in computed tomography is the computed tomography dose index 100 (CTDI100) which is measured with an ionization pencil chamber in a standardized acrylic phantom. However, for large beam collimations of multi slice CT scanners the CTDI100 value underestimates the equilibrium dose. Therefore, the precise measurement of the (single axial slice) dose profile or dose profile integral (DPI) using different measurement techniques becomes more important in CT dosimetry.

The aim of this work was to evaluate different ionization chambers (semiflexible thimble ionization chambers, PTW Freiburg) and Gafchromic XR-QA2 radiochromic film for the determination of relative and absolute dose profiles and integrals from a modern multi slice computed tomography scanner. For this purpose a new PMMA phantom for multi-detector use [1] was developed and the ionization chambers were cross-calibrated with a diode for kV-dosimetry.

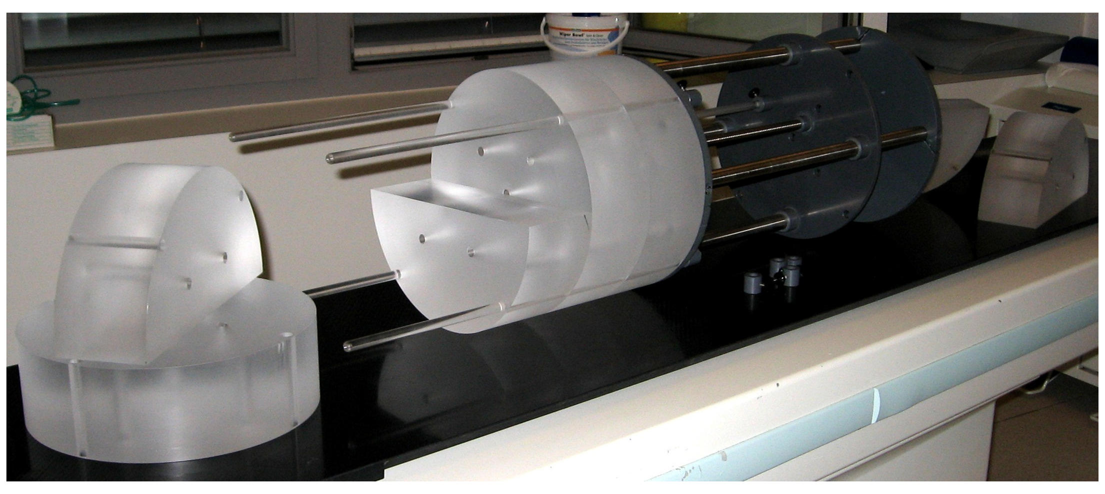

Fig. 1: *Partly disassembled phantom with stepper motor mounting, consisting of 4 half-slabs and 3 full-slabs*

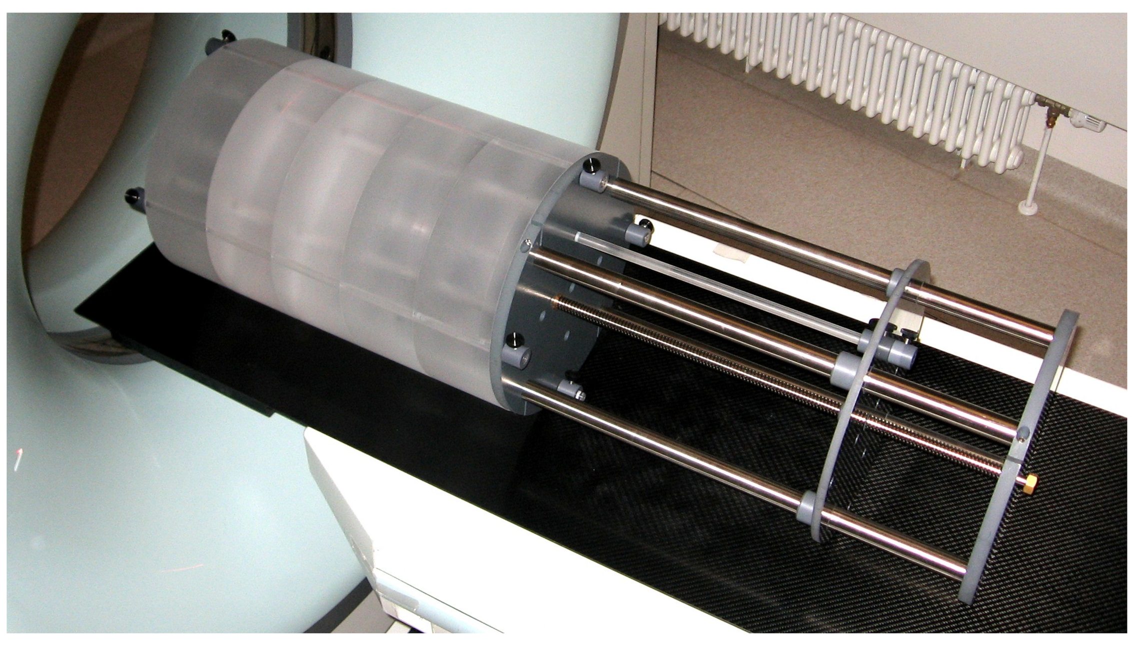

Fig. 2: *Assembled Phantom with rod-system for detector movement*

2 MATERIAL & METHODS

The new developed phantom is 32 cm in diameter and up to 50 cm long which allows a more appropriate consideration of radiation scattering than the rather short standard CTDI phantom, especially for large beam collimations. The design of the phantom enables measurements with different ionization chambers, thermoluminescence detectors or radiographic films. Using the detectors listed in table 1, dose profiles for different beam collimations in certain depths were determined for a Siemens SOMATOM Sensation 64 scanner and compared to a film measurement with Gafchromic XR-QA2.

Tab. 1: Compared ionization chambers

chamber type	sensitive volume / cm³	sens. volume length / mm
PTW 31006	0.015	5.0
PTW 31010	0.125	6.5
PTW 31013	0.3	16.25

3 RESULTS & DISCUSSION

An overview of the influence of scattering inside the phantom and the according broadening of the incident beam is given in figure 3.

Figure 4 shows the obtained profiles for the smallest possible collimation (5 mm) available at the Siemens CT scanner. The influence of the volume effect of the ionization chambers on the dose distribution is shown in figure 4 and 5. With increasing length of the sensitive volume the FWHM grows (figure 4), while the diameter of the sensitive volume has only minimal influence in a homogenous phantom. For larger collimations the volume effect is also notable, but for larger depths scattering flattens the dose gradient in the penumbra region (figure 5). The sensitive volume diameter only averages the measurement in terms of actual depth.

In conclusion it is shown that the PTW 31010 ionization chamber with 6.5 mm sensitive volume length is sufficient for beam profile measurements but for studies near the phantom surface the volume effect has to be taken into consideration.

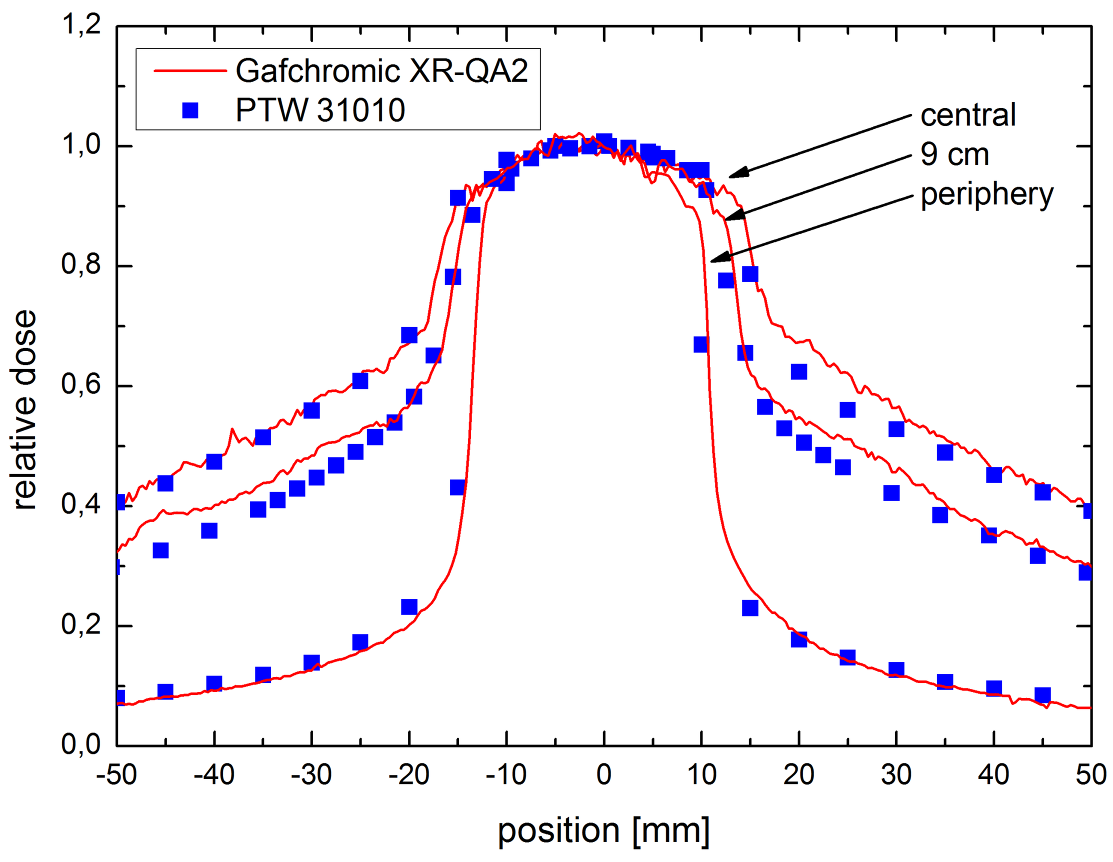

Fig. 3: *Siemens Sensation 64 relative dose profiles at z-axis, 120 kVp, 28.8 mm collimation*

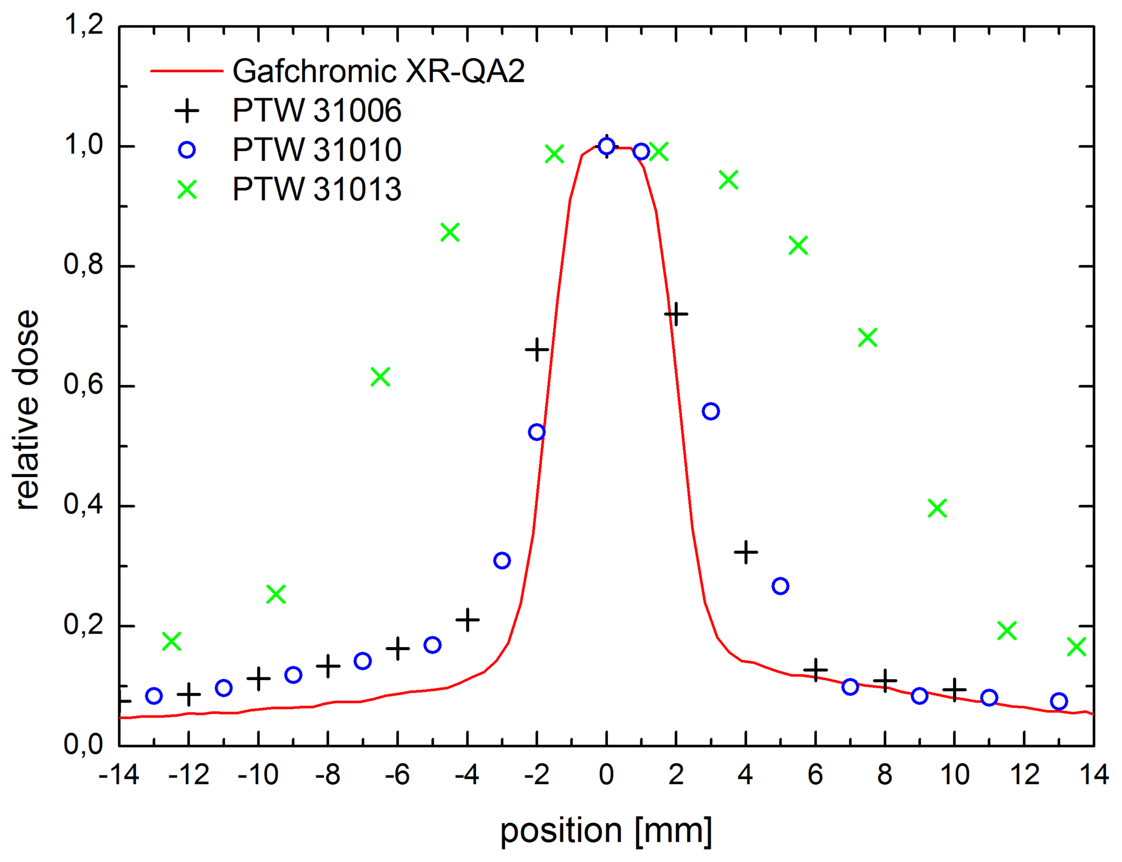

Fig. 4: *Siemens Sensation 64 relative dose profile at z-axis, 120 kVp, 5 mm collimation, peripheral CTDI position*

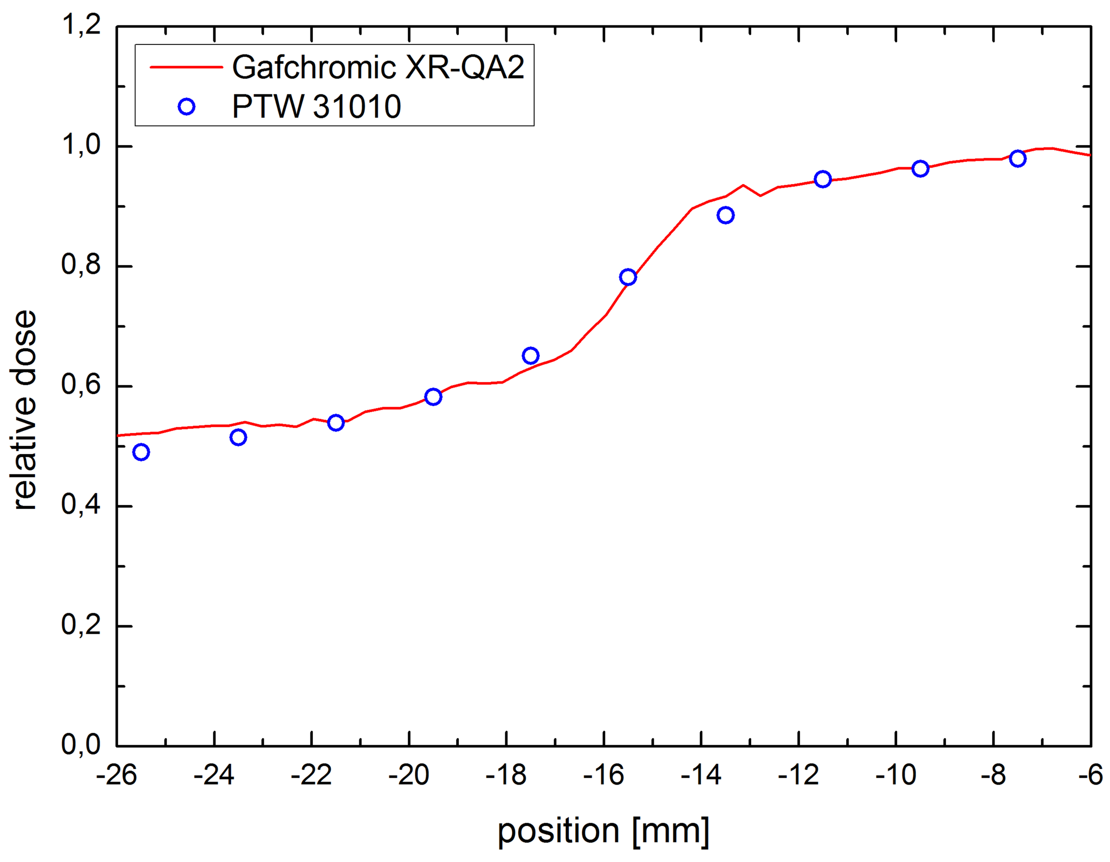

Fig. 5: *Siemens Sensation 64 relative dose profile at z-axis, 120 kVp, 28.8 mm collimation, 9 cm phantom depth*

References

[1] M. Liebmann, T. Lüllau, C.H. Uhlig, M. Feltes, R. Kareem, B. Poppe, H. von Boetticher: Development of a Multi-Purpose Phantom for CT Dosimetry. Drei Länder Tagung Medizinische Physik, ÖGMP-DGMP-SGSMP, Wien; 2011

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