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Characterization of a new transmission detector for patient individualized online plan verification and its influence on 6MV X-ray beam characteristics

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Abstract

Purpose
Online verification and 3D dose reconstruction on daily patient anatomy have the potential to improve treatment delivery, accuracy and safety. One possible implementation is to recalculate dose based on online fluence measurements with a transmission detector (TD) attached to the linac. This study provides a detailed analysis of the influence of a new TD on treatment beam characteristics.

Methods
The influence of the new TD on surface dose was evaluated by measurements with an Advanced Markus Chamber (Adv-MC) in the build-up region. Based on Monte Carlo simulations, correction factors were determined to scale down the over-response of the Adv-MC close to the surface. To analyze the effects beyond d_{max} percentage depth dose (PDD), lateral profiles and transmission measurements were performed. All measurements were carried out for various field sizes and different SSDs. Additionally, 5 IMRT-plans (head & neck, prostate, thorax) and 2 manually created test cases (3 × 3 cm^2 fields with different dose levels, sweeping gap) were measured to investigate the influence of the TD on clinical treatment plans. To investigate the performance of the TD, dose linearity as well as dose rate dependency measurements were performed.

Results
With the TD inside the beam an increase in surface dose was observed depending on SSD and field size (maximum of +11%, SSD = 80 cm, field size = 30 × 30 cm^2). Beyond d_{max} the influence of the TD on PDDs was below 1%. The measurements showed that the transmission factor depends slightly on the field size (0.893-0.921 for 5 × 5 cm^2 to 30 × 30 cm^2). However, the evaluation of clinical IMRT-plans measured with and without the TD showed good agreement after using a single transmission factor ($\gamma_{(2\%/2mm)}$ > 97%, $\delta_{\pm 3\%}$ >95%). Furthermore, the response of TD was found to be linear and dose rate independent (maximum difference <0.5% compared to reference measurements).

Conclusions
When placed in the path of the beam, the TD introduced a slight, clinically acceptable increase of the skin dose even for larger field sizes and smaller SSDs and the influence of the detector on the dose beyond d_{max} as well as on clinical IMRT-plans was negligible. Since there was no dose rate dependency and the response was linear, the device is therefore suitable for clinical use. Only its absorption has to be compensated during treatment planning, either by the use of a single transmission factor or by including the TD in the incident beam model.