Compensator for advanced radiation field homogeneity

K.-J. Dörner

Abteilung für Strahlentherapie, ALLGEMEINES KRANKENHAUS CELLE, Celle, Germany

Abstract— **To produce a homogenous dose distribution in a phantom depth just behind the depth of the dose maximum a compensator is drilled. The compensator is inserted into the block tray holder of the linear accelerator. With this easy to use solution irradiations of detectors and probes are possible with a new quality of dose homogeneity.**

Keywords— **Radiotherapy, Dosimetry**

I. INTRODUCTION

The flattening filters of commercial available treatment machines are optimized to give a homogeneous as possible beam flattening at a specified water depth. The basic idea of this paper is to realize a uniform beam intensity at a different phantom depth by inserting an additional flattening filter in the pathway of the beam. The motivation to produce a homogeneous dose distribution in an appropriate phantom arises for example from calibration and test measurements: Thinkable tasks are cross-calibration of ionisation chambers or calibration and sensitivity test of detector arrays (like PTW-seven29) or to expose special probes to well defined doses: For MR-gel-dosimetry a reference probe with the dimensions of e.g. 2 cm x 2 cm x 5 cm has to be exposed to a uniform dose distribution in a handsome procedure.

II. MATERIAL AND METHODS

A. Eequipment

The radiotherapy department in Celle is equipped with a linear accelerator PRIMUS (Siemens), a Somatom Emotion Computer Tomograph (Siemens), a treatment planning system Oncentra Masterplan (Nucletron / Theranostic), an afterloading microSelectron (Nucletron / Theranostic) with the corrsponding brachytherapy planning system Plato (Nucletron / Theranostic), an Oncologist Workspace (Siemens) for virtual simulation and the verify and record system LANTIS (Siemens). The images generated from these entities and the portal images generated by the BeamView (Siemens) are handled by a DICOM archive and viewing device called MagicView (Siemens). Additionally patient set up documentation photos and treatment plans are stored in this archive. With a MP3-water phantom controlled via Mephisto mc² software dose distributions are measured. A solid RW3 phantom with a farmer type ionisation chamber (Type 30001 PTW) is used for daily checks. Absolute dosimetry could be carried out in a small water phantom. UNIDOS (PTW), MULTIDOS (PTW) and tandem electrometer (PTW) are the calibrated dosemeters. Additional dose measurement devices are a linear array LA48 (PTW) and a two dimensional array *seven29* (PTW).

B. Theorie

In radiation therapy the gross tumour volume has to be hit by a sufficient dose to achieve a proper tumour control. Therefore the accelerated electron beam has to strike a target to produce high energy photons. The result in a pencil beam (2-3 mm diameter) that has to be opened to produce a field size in the patient plane of 40 cm x 40 cm: A flattening filter is inserted to make the beam intensity uniform across the field. Due to absorption and scatter the field homogeneity could not be achieved for all phantom depth. The incoming photon spectrum will change depending on depth in the irradiate matter and in regions with small distances to the field boundary. Close to the boundary radiation is scattered outwards of the field what causes a drop of the dose. Compared to the photons with higher energies in the spectrum those with lower energies will be stopped in a larger portion with growing depth. This has a direct influence on the cross beam profiles. As the flattening filter is optimized by the vendor of the linear accelerator to equalize a cross beam in a specified depth profiles upstream and downstream are altered depending on the spectral energy fluence. Close to the central beam axis the spectrum is hardened because the part of the photons with the lower energies is more scattered and absorbed than the higher energies. With growing distance to the central axis the portion of the out scattered photons with the lower energies raises and the spectrum becomes weaker.

C. Measurements

In a water phantom a dose matrix is measured with a spatial resolution of 5 mm. The collimator of the accelerator is set to an isocentric field size of 40 cm x 40 cm. The matrix is taken with a scan limit of 300 mm x 300 mm in a water depth of 20 mm. The nominal energy of the photon radiation is 06 MV.

III. RESULTS

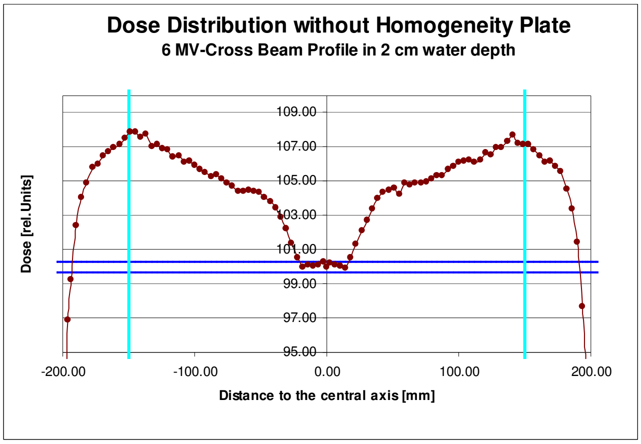

Fig. 1: Cross-Beam-Profile of the open beam

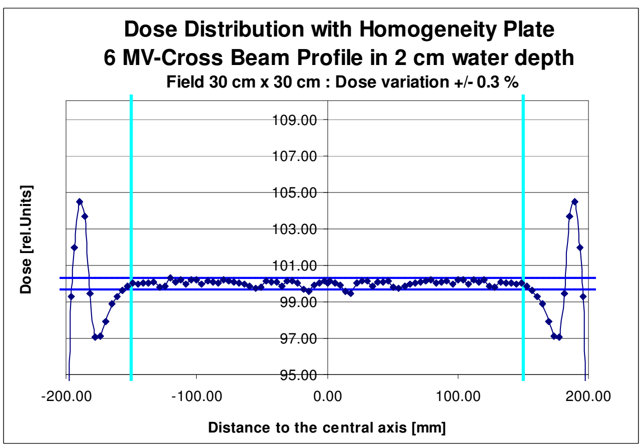

Fig. 2: Cross-Beam-Profile with compensator

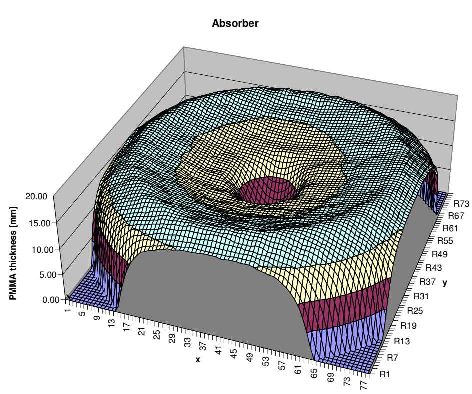

Fig. 3: Shape of the PMMA-Absorber

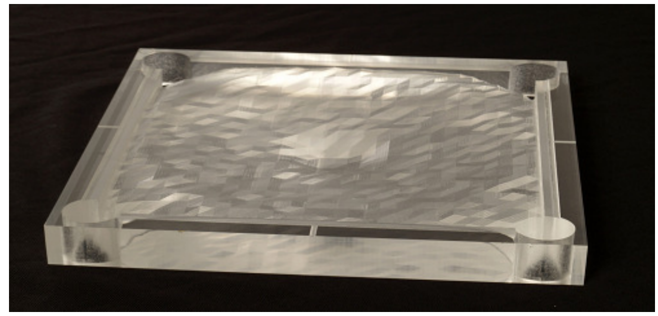

Fig. 4: Photo of the PMMA-Absorber

Similar to the manufacturing of a missing tissue compensator the shape of a PMMA-absorber is calculated from the measured dose distribution.. This absorber modifies the dose distribution as shown in figure 2.

IV. CONCLUSIONS

A very homogenous dose distribution is produced with the very easy to use solution: The insert of an additional low Z compensator into the block tray holder of the linear accelerator. The variation of the dose in the measuring plane is reduced from 8 % to +/- 0.3 %.

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positronic beam service GmbH
Industriestraße 10E
25462 Rellingen
www.beamservice.de

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Author: Dr. Karl-Joachim Dörner
Institute: Abteilung. Strahlentherapie
ALLGEMEINES KRANKENHAUS CELLE
Street: Siemensplatz 4
City: D-29227 Celle
Country: Germany
Email: kajo.doerner@AKH-Celle