Beam profile characteristic points designation for off-axis, wedged and FFF beams

Jacek Wendykier[1], Aleksandra Grządziel[1,2], Barbara Bekman[1], Marcin Bieniasiewicz[2], Adam Bekman[3], Piotr Wendykier[4], Bożena Woźniak[3], Marta Reudelsdorf[5], Krzysztof Ślosarek[1]

[1]***Radiotherapy Planning Department, Maria Sklodowska-Curie Institute – Oncology Center*** *Gliwice Branch, 15 Wybrzeże Armii Krajowej Street, 44-101 Gliwice, Poland;*
[2]*Radiology Therapeutic Center Poland, Amethyst Radiotherapy Centre, Medical Physics Department, 11-12 Lubanska Street, 59-900 Zgorzelec, Poland;*
[3]*Medical Physics Department, Maria Sklodowska-Curie Institute – Oncology Center Gliwice Branch, 15 Wybrzeże Armii Krajowej Street, 44-101 Gliwice, Poland;*
[4]*Interdisciplinary Centre for Mathematical and Computational Modelling, University of Warsaw, 15/17 Tyniecka Street, 02-630 Warsaw, Poland;*
[5]*Instytute of Physics, University of Opole, 48 Oleska Street, 45-052 Opole, Poland.*

Background

Commissioning and validation of a treatment planning system (TPS) is very important process [1]. One of the tasks in this process is a comparison between measured and calculated beam profiles. For open symmetric fields without any beam modifications the problem is minor, but some necessary steps should be performed. In our previous work [2] the following steps were implemented: determination of measured field size (defined as distance between 50% intensity of the normalized to 100% in axis beam profile), symmetrisation and renormalization to nominal size. All the above steps should lead to the minimization of uncertainty in the modelling of the linac's jaws and MLC. However, these steps are not applicable to other kind of beams: wedged, unfiltered or off-axis ones.

Aim

The aim of this work is to extend our method to the modified, unfiltered (Fig. 1.) or off-axis beams. The main problem is in finding the characteristic points of profile instead of points designating nominal field size. The proposed characteristic points are the base of symmetrisation and renormalization processes.

Materials and methods

The study was carried out for two linacs: Elekta Synergy with 40-pair MLC (Elekta Instruments AB, Stockholm, Sweden) and Varian TrueBeam (Varian Medical Systems, Palo Alto, CA, USA) equipped with HD120 MLC. All the profile measurements were performed with full-scattering phantoms and 0.125 ccm air chambers. For Elekta profiles the continuous mode of measurement was used. Varian profiles were measured using step-by-step technique with different step size depended on dose gradient.

Necessary calculations of dose distribution were made in the Oncentra External Beam v. 4.3 with resolution of 2.0 mm and with the Eclipse v. 13.6 using resolution of 2.5 mm for Elekta and Varian data respectively.

The desired point was determined as the peak of dose profile derivative, in other words: the point of original profile curve inflection.

The measured and calculated profiles were examined in the software package developed by T. Jedynak (alfard.5v.pl) to determine if the inflection points are useful for automated comparison purposes. To find more precisely the abscissas of the inflection points, the Gaussian fitting of the first derivative was applied. The usefulness of inflection points for open symmetric field was checked and compared to points describing the nominal field size. Finally, the wedged, unfiltered and off-axis beams were examined.

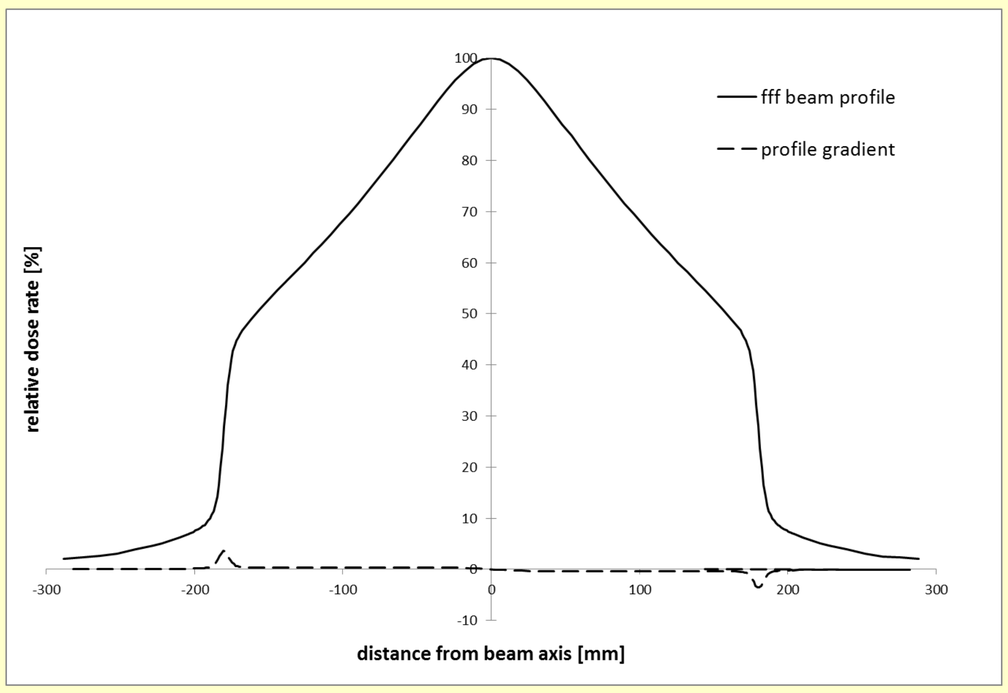

Fig. 1. Varian TrueBeam® measured profiles of beam without a flattening filter (solid line) and its gradient (dotted line). Field size 30x30 cm, depth = 20 cm for 10 MV photons SSD = 100 cm.

Results

For open symmetric fields the differences between derived values of inflection points abscissa and field size were less than 1.0 mm. For wedged, unfiltered and off-axis beams the difference for distance between the inflection points and simply calculated nominal field size was determined. For off-axis fields the differences were not bigger than 1.0 mm. For wedged beams all the results were smaller than 0.5 mm.

Conclusions

Points of the curve inflection are independent of a way of normalization and can be used for comparison of off-axis, wedged and FFF profiles.

Acknowledgements

To Tadeusz Jedynak for sharing his software (alfard.5v.pl).

[1] Commissioning and Quality Assurance of Computerized Planning Systems for Radiation Treatment of Cancer. Vienna. 2004 (Technical Reports Series no 430, IAEA)
[2] Wendykier J, Bieniasiewicz M, Grządziel A, Jedynak T et al., Determination of bounds between ranges of high and low gradient of beam profile, Reports of Practical Oncology and Radiotherapy, 2016; 21 (3), 168-173

Any questions? Call me: +48 608 195 522
If I understand, I will answer with pleasure ☺