



Contents lists available at ScienceDirect

Physica Medica

journal homepage: <http://www.physicamedica.com>

Technical note

Use of IAEA's phase-space files for virtual source model implementation: Extension to large fields

Alexis Rucci^{a,*}, Claudia Carletti^a, Walter Cravero^a, Bojan Strbac^b

^a Instituto de Física del Sur (IFISUR, UNS-CONICET), Departamento de Física, Universidad Nacional del Sur, Av. Alem 1253, 8000 Bahía Blanca, Argentina

^b International Medical Centre, Centre for Radiotherapy, Dvanaest beba bb, 78000 Banja Luka, Bosnia and Herzegovina

ARTICLE INFO

Article history:

Received 1 December 2015

Received in Revised form 7 July 2016

Accepted 10 July 2016

Available online xxx

Keywords:

Radiotherapy

Monte Carlo

Phase-space

IAEA

Virtual source

Large fields

ABSTRACT

In a previous work, phase-space data files (phsp) provided by the International Atomic Energy Agency (IAEA) were used to develop a hybrid virtual source model (VSM) for clinical photon beams. Very good agreement with dosimetric measurements performed on linear accelerators was obtained for field sizes up to $15 \times 15 \text{ cm}^2$. In the present work we extend the VSM to larger field sizes, for which phsp are not available. We incorporate a virtual flattening filter to our model, which can be determined from dose measurements for larger fields. In this way a fully functional VSM can be built, from publicly available IAEA's phsp and standard dose measurements, for fields of any size and tailored to a particular linac.

© 2016 Associazione Italiana di Fisica Medica. Published by Elsevier Ltd. All rights reserved.

1. Introduction

General Monte Carlo (MC) methods have been used for a long time as a standard research tool for the simulation of ionizing radiation transport through material systems that exhibit complex geometry and/or composition. Such methods are well suited for dosimetry calculation in medical physics [1–3].

In a previous publication [4], we have shown how to build a VSM for linac simulation starting from phsp files provided by the IAEA, to which we refer the reader for a detailed description. Very good agreement was found with measured cross profiles and PDDs for field sizes up to $15 \times 15 \text{ cm}^2$.

When larger field sizes are considered, VSM performance worsens as decreasing spatial homogeneity in the corresponding phsp file is not taken properly into account in the VSM, which essentially uses the phsp spatially averaged energy distribution. Besides, IAEA's present database does not include phsp files for field sizes larger than $20 \times 20 \text{ cm}^2$ [5]. This is probably due to the fact that validation requirements for phsp files are, generally, more difficult to achieve for larger fields.

In this work we show how an extension of the VSM can be built, in order to include large field sizes, adding a virtual flattening filter (VFF), determined with the help of standard dose measurements.

2. Materials and methods

2.1. Experimental setup

The experimental results were obtained using the Varian Clinac iX accelerator from the International Medical Centre in Banja Luka, Bosnia and Herzegovina. PDDs were measured for open fields of different sizes. We used a remotely controlled water phantom MULTIDATA (Universal 3D water phantom 9850 $48 \times 48 \times 41.5 \text{ cm}^3$) and a small volume ionization chamber (All-purpose Multidata 9732-2 thimble ion chamber 0.125 cm^3) with holders included in the RTD water phantom systems [6]. Experimental data for $20 \times 20 \text{ cm}^2$, $30 \times 30 \text{ cm}^2$ and $40 \times 40 \text{ cm}^2$ fields are used in this work.

2.2. Virtual source from IAEA's phsp

All calculations were performed using the PENELOPE MC code [7]. We used a cut-off energy of $1 \times 10^5 \text{ eV}$ for electrons and $1 \times 10^4 \text{ eV}$ for photons. No variance reduction technique was used and scoring volume was 0.027 cm^3 . Number of histories was chosen so that MC statistical uncertainty was kept below 2%.

As in our previous model, a box shaped primary source with effective dimensions of $0.3 \times 0.3 \times 0.05 \text{ cm}^3$ was considered. Energy spectrum was defined as a superposition of three monoenergetic sources with energies of 1 MeV, 3 MeV and 5 MeV and

* Corresponding author.

E-mail address: alexisrucci@gmail.com (A. Rucci).

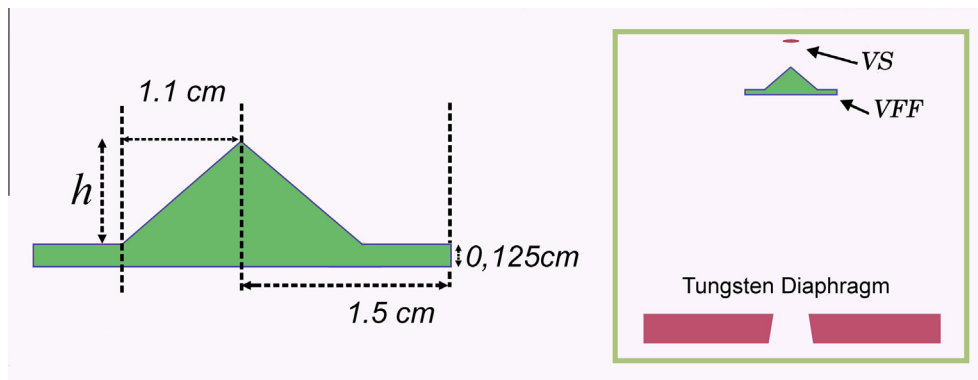


Fig. 1. Scheme of the flattening filter added to the virtual source model.

probabilities of 76.36%, 19.36% and 4.28%, respectively, obtained from a IAEA's phsp for a $20 \times 20 \text{ cm}^2$ field, which is the largest available for this accelerator model.

When field sizes larger than $20 \times 20 \text{ cm}^2$ are considered, photon spectral distribution changes as we move out of the beam axis towards the edges of the phase space scoring plane. In our case, photon mean energy extracted from the IAEA's phsp for the $20 \times 20 \text{ cm}^2$ field decreases 6% from field centre to corner, while energy variance decreases 2% and skewness decreases 10% [4]. This reflects the well-known fact that the accelerator flattening filter hardens as well as depletes the photon beam at the centre of the field. In order to maintain a good agreement as the field size increases, the effect of the flattening filter must be better taken into account in our model. However, the inclusion of a proper or "physical" flattening filter in the VSM would not be correct if we still want to base it on IAEA's phsps. These files contain particle distribution for beams that have already passed through the FF of the accelerator [8]. Should the accelerator FF material and geometry be known, its effects on the photon beam could in principle be discounted. Here we pursue a different (and simpler) approach instead. Photon fluence passing through the thinnest part of the FF is less affected. So, we propose to extract the photon energy distribution from the spatial periphery of the phsp corresponding to the largest available field, i.e., $20 \times 20 \text{ cm}^2$.

We used this energy distribution to build the primary virtual source. We then added a virtual flattening filter (VFF) to take again into account the full FF effect on the beam. This VFF has to be determined from simple dose measurements corresponding to the considered field size [9–12]. In our case we chose to use a simple copper-made VFF modelled with a circular cone of 1.1 cm radius and a variable height (which will be the fitting parameter), on top of a circular cylinder of 1.5 cm radius and 0.125 cm thickness (Fig. 1). The VFF base was placed at 12.5 cm from the primary virtual source [13].

To determine the cone height, we used the ratio between maximum dose (D_0) and central axis dose (D_i) calculated at maximum dose depth (in our case, 1.6 cm), as a function of the VFF height. We then used D_i/D_0 from measured cross profiles to determine the best VFF height.

Once we have redefined the VSM with the addition of the VFF, we performed simulations of $20 \times 20 \text{ cm}^2$, $30 \times 30 \text{ cm}^2$ and $40 \times 40 \text{ cm}^2$ photon fields, and compared them with dose measurements in photon fields of the same field size.

3. Results and discussion

Calculated ratio D_i/D_0 as a function of VFF height is shown in Fig. 2. For a VFF free field, maximum dose is at the central axis,

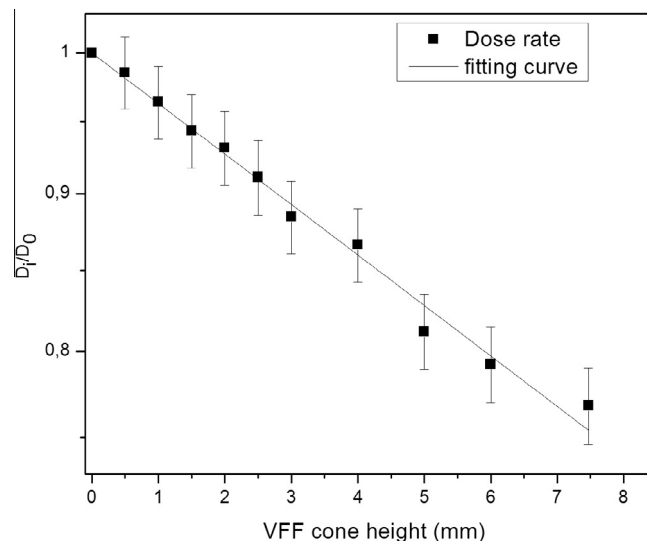


Fig. 2. D_i/D_0 in \log_{10} scale vs flattening filter height and fitting curve.

so $D_i/D_0 = 1$. D_i/D_0 was fitted with a simple exponential function $\frac{D_i}{D_0} = e^{-0.0378 \text{ mm}^{-1} h}$, with h expressed in millimetres.

In Fig. 3 we show the PDD for a $20 \times 20 \text{ cm}^2$ field and 6 MV corresponding to a Varian Clinac iX accelerator and the present VFF tailored to the same machine. The VFF cone height obtained from the curve in Fig. 2 and the measured D_i/D_0 is in this case 0.81 mm, with a difference of about 3% between the maximum and minimum dose value in the low gradient region for the measured cross profile. MC statistical uncertainty was in this case about 1.25%. We found that $\gamma_{3\%/3\text{mm}}$ for the entire range is less than 1.

In Fig. 4, normalized cross profiles for the same field, at 1.6 cm and 10 cm depth for experimental and VSM calculations are shown. Good agreement is found, with 95% of the points having a $\gamma_{3\%/3\text{mm}} < 1$ at 1.6 cm depth, while 100% have a $\gamma_{3\%/3\text{mm}} < 1$ at 10 cm depth [14,15].

Comparing the results of our VSM using VFF with that obtained in our previous publication (without VFF), we see that, in the high dose region, 100% of the points now verify the $\gamma_{3\%/3\text{mm}} < 1$ criterion, whereas in the previous model, 5% of the points did not complied with it [4].

Using the same photon spectrum obtained for the $20 \times 20 \text{ cm}^2$ field, we changed the aperture of the diaphragm in order to simulate a $30 \times 30 \text{ cm}^2$ and $40 \times 40 \text{ cm}^2$ fields.

For the $30 \times 30 \text{ cm}^2$ field size, the uncertainty reached in the simulation was approximately 1.2%. The VFF was the same as in

Download English Version:

<https://daneshyari.com/en/article/1886833>

Download Persian Version:

<https://daneshyari.com/article/1886833>

[Daneshyari.com](https://daneshyari.com)