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PROFILE DOSE AND PDD ANALYSIS IN SMALL PHOTON FIELD WITH PTW PINPOINT CHAMBER 0.015cc

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Abstract: Profile dose and PDD of a small field 6MV have been measured using a PTW PinPoint Chamber 0.015 cc detector. The aim of this study is to analyze the profile dose and PDD of small field using PTW PinPoint Chamber detector 0.015 cc. From the results of this study is expected optimal dose measurement accuracy can be achieved in clinical treatment. The analysis includes calculating the symmetry, penumbra value and PDD. Linear accelerator Electa Precise Treatment System™ and PTW PinPoint Chamber 0.015cc are the material used in this research. Profile Dose and PDD were measured with an SSD technique in 100 cm with a various of field sizes and depths. The results showed that the symmetry values for depth variations would decrease in ranges (0.55-6.27)% when the depth increase, and for field size variations will decrease in range (0.39-6.27)%. when the filed size increase. The result of the penumbra analysis shows that its value is more than 4 mm for all variations of depth and field size. PDD results showed that maximum dose for all fields size is achieved in maksimum depth (1.4 – 1.7) cm.
Keywords— Small Field; Ionization Chamber; Profile Dose; Radiotheraphy;

I. INTRODUCTION

There are modern radiation techniques such as 3D Conformal Radiation Therapy (3D CRT), Intensity Modulated Radiation Therapy (IMRT), and Volumetric Modulated Arc Therapy (VMAT). These techniques allow for a more optimal dose of radiation against the target tumor and low doses of healthy tissue.

One way for dose optimization can be done using a small field during treatment, often known as segmentation, as used in IMRT and VMAT techniques. The use of this small field will ensure the received radiation dose is more accurate and precision on the cancer target. In IMRT techniques the use of a small field for cancer therapy is 50% more than the total number of segments used. The small field is a field of size < 4×4 cm^2 [1-2].

External radiation safety verification may use results of commissioning test. External therapy commissioning test activities include dosimetry and geometry verification activities. Geometry verification activities are performed to ensure the correct position and form of a radiation field. While dosimetry verification includes measurement of the radiation beam of photons or electrons. The dosimetry of the photon profile dose in question includes the correction of the PDD, the output factor and the dose profile [3].

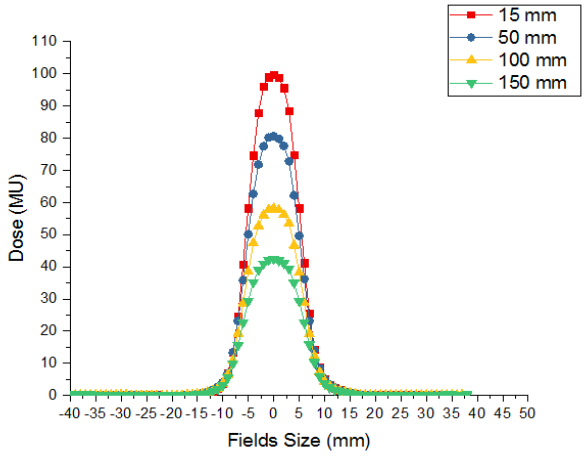
Small field dosimetry is one of the ways to know the performance of X-ray beams. The dosimetry in the small field itself has several problems, among others, disturbance of dose distribution because the detector dimensions are almost equal or too large with radiation sources [4], and reduced electronic equilibrium that may cause source occlusion [5]. So small dosimetry field results can be used as an evaluation of the function, equipment characteristics and dose calculations on radiotherapy. Some research on small field dosimetry continues to grow. Cheng et al (2007) have conducted a study of small field PDD determination with SFD detector, Exradin A-14 chamber ionization, and Farmer 0.6 cm^3[6]. The study obtained the measurement results of PDD with SFD detector having the best measurement result matching ± 1% [6]. Wulandari et al (2016) measured the output factor with ion chamber detector Exradin A11 plan-parallel and gafchromic film which resulted in a drastically decreased output factor of 0.1244 from 0.8724 when the radiation in (1×1) cm^2 [7]. Godson et al (2016) conducted a penumbral analysis with a chamber ionization RK cylinder detector, PFD and EFD. The results show that the RK cylinder detector produces the widest widening of the penumbra by 1,0 mm compared to other detectors such as PFD and EFD [8]. Fuadi et al (2015) show that gafchromic film detectors and farmer detectors are equally accurate when used to measure PDD and radiation beam profiles [9]. Problems in the small field disturb the of doses distribution of the photon beam on the target. In order to minimize the problem of dosimetry in the small field, the correct detector is needed. One of them by using a small volume sensitive detector to fit the radiation field. In this study we studied the characteristic distribution of doses of small field photon files with detectors that have small sensitive volumes. Therefore a PTW PinPoint Chamber detector is used 0.015 cc.

II. MATERIAL AND METHODE

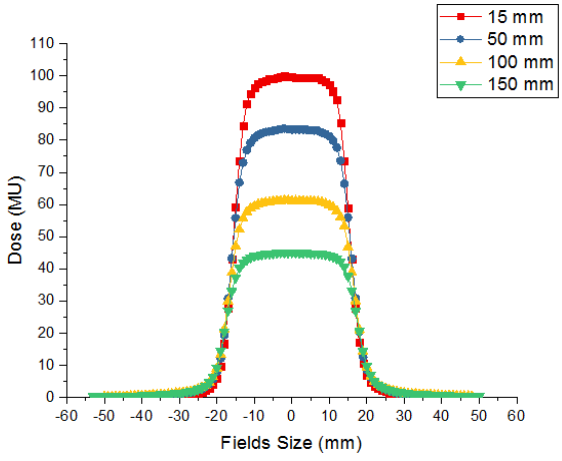
An Electa Precise Treatment System™ linear accelerator was used in this investigation. It is also used PTW PinPoint Chamber detector 0.015 cc TM31014 produced by PTW Freiburg [12]. The detector is coupled with PTW MP3 Water Phantom with PTW Tandem electrometer, PTW TBA Control Unit and Mephysto software. The percentage dose value at a certain depth compared to the dose at the maximum depth is called PDD (Percentage Depth Dose). The measurements of the PDD curve can be used to determine the specific dose. The PDD is influenced by energy, an area of the field, the source distance to the skin (Source Skin Distance, SSD) and the composition of the irradiated medium. While the radiation beams profile is a relative intensity in the perpendicular plane of the axis of the beam [10]. The calculated file profile parameters are beam symmetry and width penumbra. Measurements were performed with SSD 100 cm and used a step by step mode (1 mm) for x-ray 6 MV. The fields size that we used is (1×1) cm^2, (2×2) cm^2, (3×3) cm^2, (4×4) cm^2 and (5×5) cm^2. In addition, measurements were made for various depth variations (1.5 cm, 5 cm, 10 cm, and 15 cm). This measurement is done by directly detecting radiation beam of 500 MU using PTW PinPoint Chamber detector which is placed in the water phantom and driven by a controlled and controlled system in three dimensions. Excel and Origin software was used to extract and analyze data (beam symmetry, penumbra, and percent depth dose) measurement results.

III. RESULT AND DISCUSSION

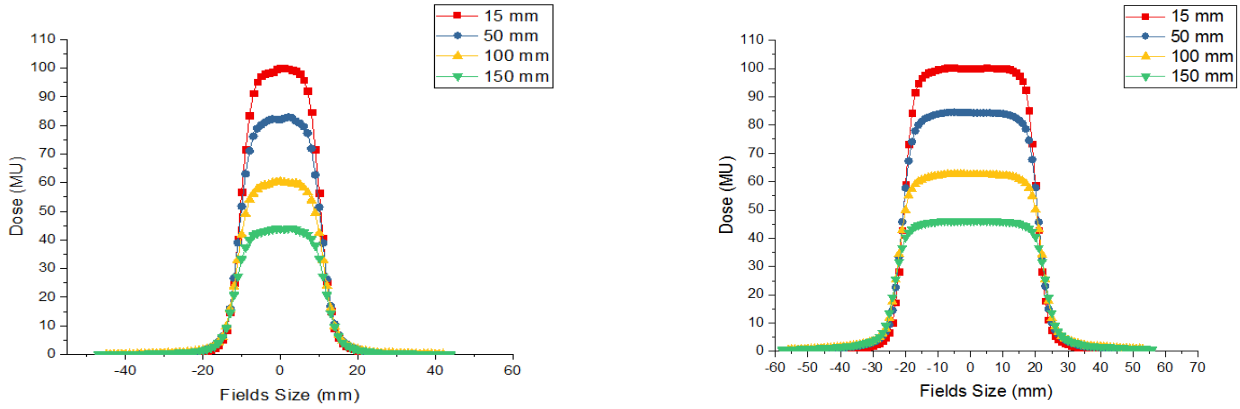
The results of measurement a 6MV photon profile dose were used to assess the dosee homogeneity by analyzing the quality of beam symetrys and penumbra. Profile dose measurements were performed on various fields size and various depth variations. The fields size is formed by MLC moving. All results of the measurements are displayed in the profile dose curves, can be seen in Fig. 1 and Fig. 2. The results for depth variation we can see in figure 1 and table 1.



Fields Size (1×1) cm^2



Fields Size (3×3) cm^2



Fields Size (2×2) cm² Fields Size (4×4) cm²

Figure 1. Profile doses curve of 6 MV photon with various depth

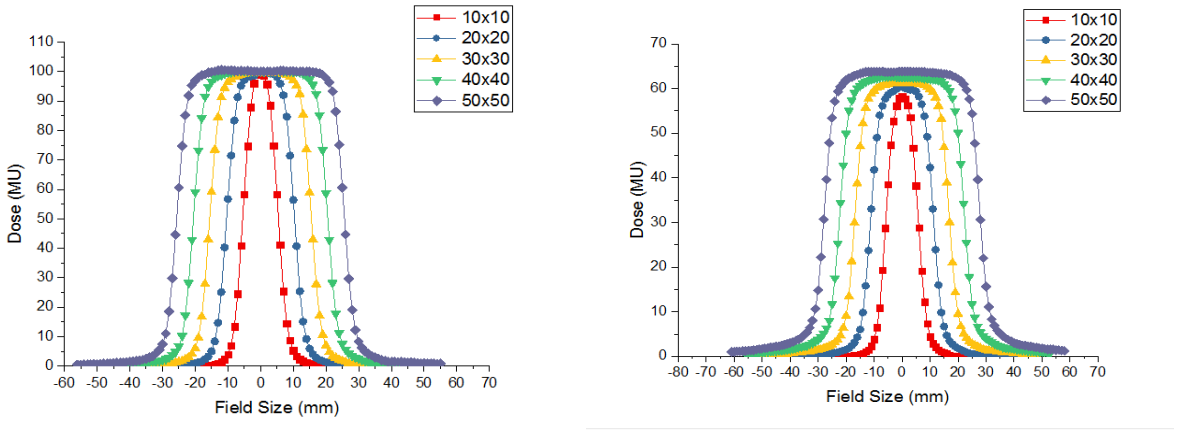
Table 1. Results of profile dose analyze in various depth

Fields Size (cm²)	Depth (mm)	Symetry (%)	Penumbra (mm)
1x1	15	6.27	4.00
	50	5.74	4.00
	100	4.92	4.10
	150	4.16	4.10
2x2	15	2.45	4.10
	50	2.46	4.40
	100	2.28	4.50
	150	2.08	4.80
3x3	15	1.21	4.10
	50	1.21	4.10
	100	0.90	4.90
	150	0.90	4.70
4x4	15	0.70	4.20
	50	0.77	4.40
	100	0.72	4.70
	150	0.55	4.80

Table 1 represents the data results for beam symetry and penumbra with various depth. For each depth variation we used fields size variation too. Beam symetry value at fields size (1×1) cm², (2×2) cm², (3×3) cm² and(4×4) cm² will decrease when the depth increase. Range value for beam symetry is (0.55-6.27)%. Previous reaserch had symetry value for standart field (10x10) was 3.20% [14]. In the reference region, the dose should not differ more than 2% at any pair of points situated symmetrically with respect to the central ray [15]. So, symmetricity value for fields size (1x1) cm² is more than 2% in all depth variation. Width penumbra value is an increase for all depth variation, at ranges value (4.00-4.90) mm. The detector volume averaging is cause the broadening penumbra.

The result for fields size variation, we can see at figure 2 and table 2.

The result of dose profile analysis with fields size variation shows that the value of symmetry will decrease when the filed size increase. Range value for beam symetry is (0.39-6.27)%. Penumbra value will increase when the filed size increase. Range value for penumbra is (4.00-5.00) mm. Penumbra values from the dose profile measurements with PTW PinPoint chamber detector have significant differences when compared to the penumbra on the small field when measured by the Farmer chamber detector. Zryan et al (2017) had the penumbra value that used Farmer chamber detector for field size (1x1), (2x2), and (3x3) at depth 100 mm are (5.6 mm, 5.6 mm and 6.3 mm) [11].PDD measurements were performed on various fields size using SSD 100 cm. Various radiation fields exposed with 500 MU. The results of the measurements are displayed in PDD curves, can be seen in figure 3.



Depth 15 mm Depth 100 mm

Figure 2. Profile doses curve of 6 MV photon with various fields size

Table 2. Results of profile dose analyze in various fields Size

Depth (mm)	Fields Size (cm²)	Symetry (%)	Penumbra (mm)
15	1x1	6.27	4.00
	2x2	2.45	4.10
	3x3	1.21	4.10
	4x4	0.70	4.20
	5x5	0.35	4.50
100	1x1	4.92	4.10
	2x2	2.28	4.50
	3x3	0.90	4.90
	4x4	0.72	4.70
	5x5	0.39	5.00

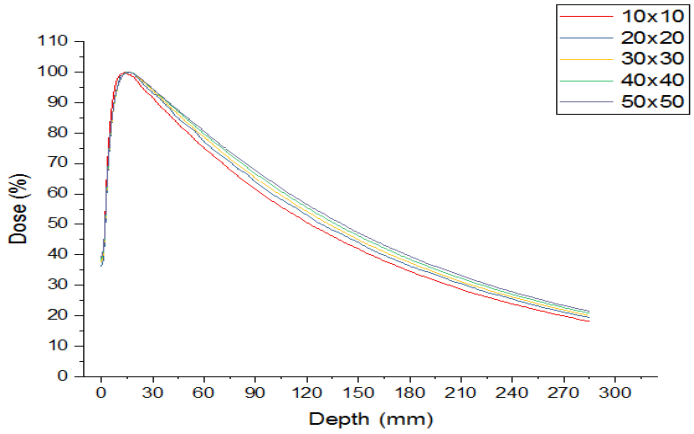


Figure 3. PDD curve of 6 MV photon with various fields size

Table 3. Results of PDD analyze in various fields Size

Field Size (mm)	Rmax (mm)
10x10	14.0
20x20	17.0
30x30	17.0
40x40	16.0
50x50	16.0

The maximum dose of the photon beam on the small field area achieved at maximum depth (Rmax). The percentage depth dose (beyond the depth of maximum dose) decrease with depth [15]. The results of PDD analysis of various field area showed that maximum dose was achieved at depth (14-17) mm (See Table.3). Previous research had results maximum depth for the standard field size (10x10) cm² was 14.8 mm [9,13]. So, in general maximum dose in a small field is achieve deeper than standard field.

IV. CONCLUSIONS

The results showed that detector PTW PinPoint Chamber 0.015 cc (TM31014) could be used for profile dose and PDD measurement in the small field. The symmetry values for depth variations will decrease in ranges (0.55-6.27)% when the depth increase, and for field size variations will decrease in range (0.39-6.27)%. When the filed size increase. The result of the penumbra analysis shows that its value is more than 4 mm for all variation of depth and field size. PDD results showed that maximum dose for all fields size is achieved in maximum depth (1.4 – 1.7) cm. Maximum dose in the small field is achieved deeper than standard field.

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