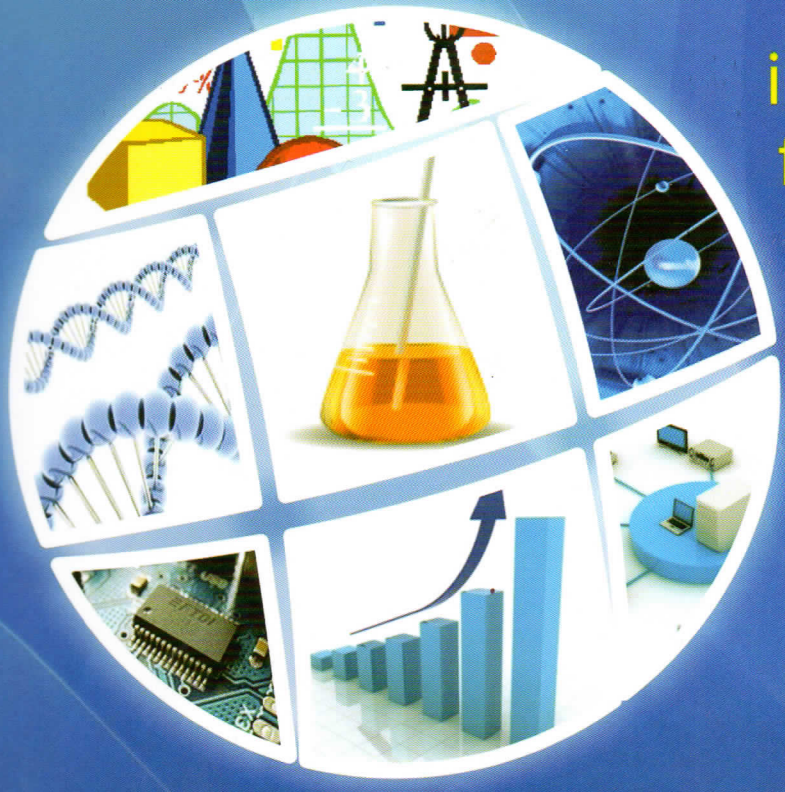
4th iSNPiNSA

International Seminar on New Paradigm and Innovation on Natural Sciences and its Application



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PROCEEDINGS

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CONTRIBUTED PAPERS 2 : NANOSCIENCE, NANOTECHNOLOGY, NANOTOXICOLOGY AND APPLIED PHYSICS

CONTRIBUTED PAPERS 3 : APPLIED INFORMATICS AND TECHNOLOGY, MATHEMATICAL MODELS

Profile Dose Analysis of Half Blocked Technique on Linear Accelerator (LINAC)

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ABSTRACT

Linear Accelerator (LINAC) is done radiotherapy planning before radiation to provide the correct evaluation dose. Half blocked technique is a technique which is using two asymmetry fields with one isocentre. This technique is mostly used because it can produce precision dose distribution. Remember that almost all of cancercous is irregular, so it needs precision field limitation in efficient time. To see the obtained dose distribution so profile analysis is needed to conduct.
Measurement is conducted to relative dose on profile dose by using photon energy of 6 MV in maximum depth that is 1.5 cm in water phantom with 100 cm SSD, by giving the various field spaces (10 x 10 cm^2, 15 x 15 cm^2 and 20 x 20 cm^2). The treatment against the detector is towards crossline and inline.The measurement result is obtained the flatness, symmetry, and penumbra value less than 2%, the overlapp dose value is 102,88% to 105,23%, and the highest value in differences is 5,12% for all of the various fields and detector treatment either towards crossline or inline. This obtained value is still in tolerance limit according to ICRU Report 50, 1993 that is optimal between 95% and 107%.

Keywords: *Linear Accelerator (LINAC), photon beam, half blocked technique, profile dose, flatness, symmetry, penumbra*

1. INTRODUCTION

LINAC (Linear Accelerator) is a device which can produce high energy of ionizing radiation in Megavolt order. This device can produce electron beam or photon beam [1].

Ionizing radiation can damage tissue because it can interact with cell or tissue in human body which causes the changing structure of normal cells. So the given radiation dose against the tumor cell has to be distributed fairly and make sure that the dose which drop out of radiation field is small [2]. The optimum dose distribution will determine the success and radiation efficiency. Radiation dose is said as optimum if there is homogeneity dose in radiation field, uniformity of distributed photon energy in radiation field, radiation dose out of radiation field, is all devised as minimum as possible.

Half blocked technique is a technique which is using two asymmetry fields, by controlling jaw to divide each beam to be half a part. This asymmetry technique is often used because it can produce dose distribution more precisely. The use of this technique is also because of all of the cancer form is irregular, the radiation of risk organ around the cancer needs asymmetry field forms, moreover the using one isocentre so this half blocked technique is mostly used. To see the obtained dose distribution, profile dose analysis when using half blocked technique on LINAC is needed to conduct.

This research means to analyze the result of profile dose and to get doe distribution of the use of half blocked technique on Linear Accelerator (LINAC) references to constant of International Commision on Radiation Units (ICRU) Report 50, 1993 [4].

2. REVIEW OF LITERATURE

2.1. Radiation Beam Profile

Radiation beam profile is relative intensity on perpendicular plane of axis beam. Radiation beam profile describes relative measuremen, or relative dose. It is usually measured by doing scanning as long as crossplane and inplane. One of parameters which show uniformity of beam on radiation beam profile is flatness, symmetry and penumbra.

Flatness, symmetry and penumbra on radiation beam profile are determined in area 80% from FWHM (Full Width half Maximum). FWHM is profile width in 50% dose.

Secondary collimator is used to make radiation field. This collomator is made of lead-pig which is used to control radiation out of the expected radiation field. This secondary collimator consists of two pairs of collimator sides where one of them is under the other pair. Symmetric field is usually stated as (X1, X2, Y1, Y2), which shows that each X collimator side is controlled by opening in distance X/2 from the main axis beam, thus the same opening for Y collimator. The making of asymmetric and symmetric field uses four movements from each collimator side. The beam of profile dose is showed in Figure 1.

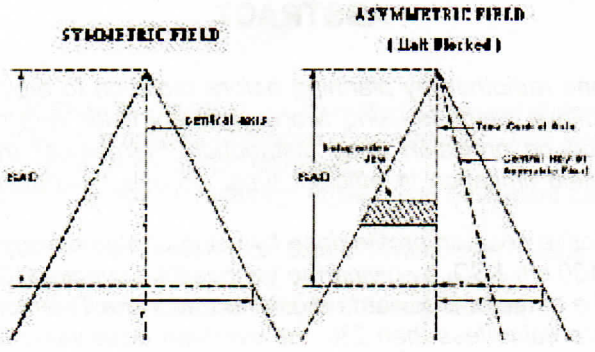

Figure 1: Diagram shwos symmetric and asymmetric beam

Half blocked asymmetric field is made when one of collimator side is not opened. This is used for such as to make uniform junction between two fields. Figure 1 above shows the opening collimator for symmetric and half blocked asymmetric fields.

From X-ray profile beam which obtained from measurement that some uniformity beam parameters on X-ray profile beam will be evaluated that is flatness, symmetry and penumbra. Flatness, symmetry and penumbra are parameters that determine the quality of X-ray profile beam. Flatness value is determined by the highest and the lowest relative dose on X-ray profile beam. This Figure 2 below is the example of profile dose.

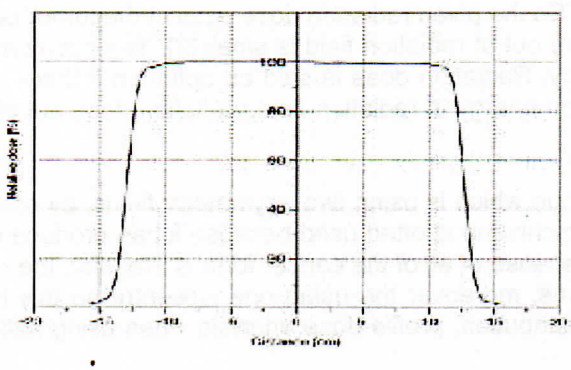

Figure 2: Profile Dose in Zmax maximum depth on energy of 12 MeV in 25 x 25 cm^2 field [5].

The parameter of profile dose as follows:

a. Flatness

According to American Association of Physicists in Medicine (AAPM) No. 47, 1994, Flatness value is determined by the highest and the lowest relative dose on X-ray profile beam. Flatness of profile dose radiation is determined in area 80% from FWHM (Full Width half Maximum). By using this equation:

$$F = \frac{M-m}{M+m} x\ 100\ \% \quad (1)$$

Where, M and m is maximum dose and minimum dose value in area 80% from profile.

Generally, standard spesification on LINAC is F value less than 3%, measured in water phantom in 10 cm depth and 100 cm SSD (source skin distance) and for the biggest available field will be 40 x 40 cm^2 [5].

b. Symmetry

Symmetry is usually defined as the permitted percentage maximum deviation from either left side dose or right side dose profile, it is mostly at 80% from FWHM FWHM (Full Width half Maximum) point.
The symmetry beam usually determined in z_{max}, which is the most sensitive depth to value this uniformity of beam parameters. A symmetric beam with special spesification is there are two dose points on profile bar, they have same distance from the centre axis, in 2% from one another. Alternatively, the area under z_{max} on profile beam in every side from the centre axis expands to specified 50% dose level (normalyzed to 100% of centre point). Then the symmetry is calculated on this equation 2:

$$S = 100\ x\ \frac{Area\ left - Area\ right}{Area\ left + Area\ right} \qquad (2)$$

c. Penumbra

Penumbra is parameter of radiation beam profile uniformity defined as profile area which receive dose between 80% and 20% from main axis [6].
The amount of penumbra which is more than the axis on profile will produce hotspot and coldspot on the target volume. Cold spot is an area where the dose on target volume is less that 95% from specified target dose. Hot spot is an area out of the target which receive higher dose from the specified dose. On maximal target dose, hot spot is reputed clinically meaning is just when it covers minimally 2 cm^2 [7].

3. RESEARCH METHOD

A. Devices and Materials

This research is conducted by using Linear Accelerator (Linac) and the merk is Siemens, type Primus M Class 5633, with the output photon energy 6 MV and electron energy 5, 7, 8, 10, 12, 14 MeV. Then, compact camber detector ionizing, water phantom, computer control unit and computer equipment.

B. Research Procedure

Prepare the water phantom and ionizing detector, then the setting of gantry on LINAC with 0o angle, so the central ray source is upright to central point in water phantom. SSD is set 100 cm. Then the first detector (field detector) is entered in water phantom in maximum depth (1,5 cm) and the second detector is connected to the CCU (computer control unit). The setting of devices and materials of this research is showed at this scheme:

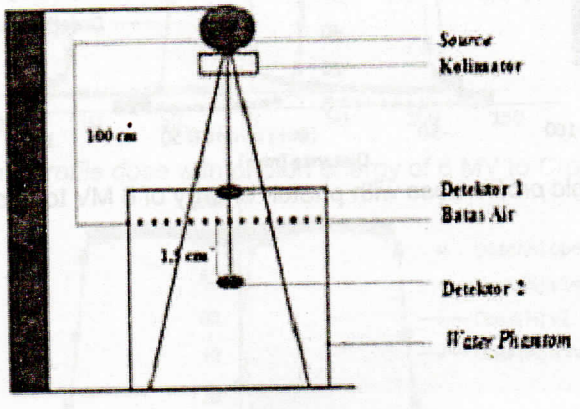

Figure 3: Research Scheme

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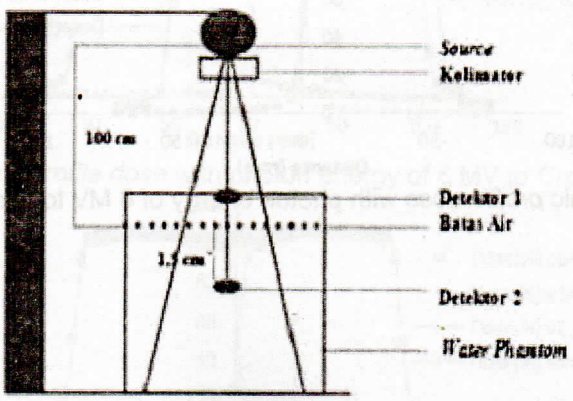

Figure 3: Research Scheme

After that, set the mode or energy selection that is photon with MU=150-400cGy (as the standard). Continued by doing treatment by setting radiation field using half blocked technique as follows:

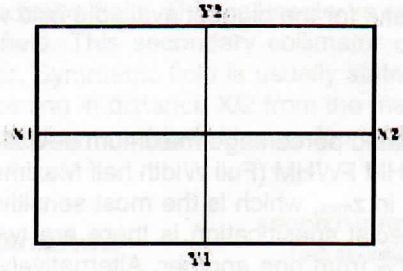

Figure 4: Radiation Field

Lapangan $10x10cm^2$	Lapangan $15x15cm^2$	Lapangan $20x20cm^2$
Crossline	Crossline	Crossline
- x1,x2,y1,y2=5 - x1=0 - x2=0	- x1,x2,y1,y2=7,5 - x1=0 - x2=0	- x1,x2,y1,y2=10 - x1=0 - x2=0
Inline	Inline	Inline
- x1,x2,y1,y2=5 - y1=0 - y2=0	- x1,x2,y1,y2=7,5 - y1=0 - y2=0	- x1,x2,y1,y2=10 - y1=0 - y2=0

4. RESEARCH FINDINGS AND DISCUSSIONS

Profile dose analysis of half blocked technique on LINAC using photon energy of 6 MV in maximum depth (1,5 cm) in water phantom with SSD 100 cm by using various field space (10 x 10 cm2, 15 x 15 cm2 and 20 x 20 cm2), tha various collimator opening (jaws) and treatment against the detector to the crossline and inline get the result as follows:

$10x10cm^2$ field

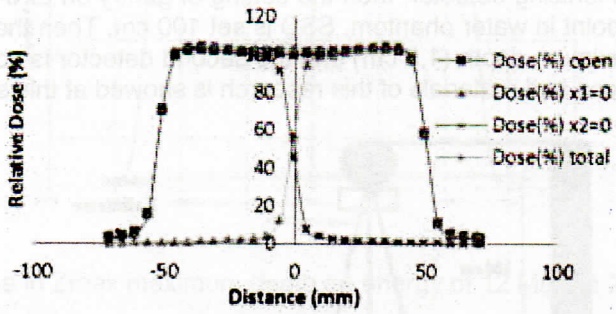

Figure 5: Graphic *profile dose* with photon energy of 6 MV to *Crossline detector*

After that, set the mode or energy selection that is photon with MU=150-400cGy (as the standard). Continued by doing treatment by setting radiation field using half blocked technique as follows:

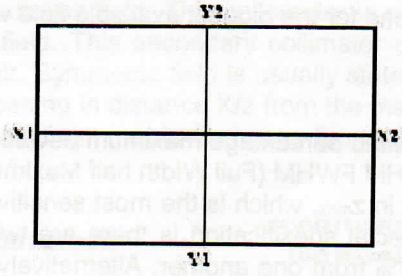

Figure 4: Radiation Field

Lapangan 10x10cm²	Lapangan 15x15cm²	Lapangan 20x20cm²
Crossline	Crossline	Crossline
- x1,x2,y1,y2=5 - x1=0 - x2=0	- x1,x2,y1,y2=7,5 - x1=0 - x2=0	- x1,x2,y1,y2=10 - x1=0 - x2=0
Inline	Inline	Inline
- x1,x2,y1,y2=5 - y1=0 - y2=0	- x1,x2,y1,y2=7,5 - y1=0 - y2=0	- x1,x2,y1,y2=10 - y1=0 - y2=0

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Profile dose analysis of half blocked technique on LINAC using photon energy of 6 MV in maximum depth (1,5 cm) in water phantom with SSD 100 cm by using various field space (10 x 10 cm2, 15 x 15 cm2 and 20 x 20 cm2), tha various collimator opening (jaws) and treatment against the detector to the crossline and inline get the result as follows:

10x10cm² field

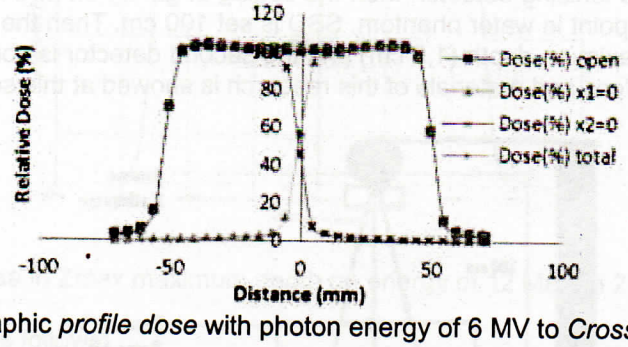

Figure 5: Graphic *profile dose* with photon energy of 6 MV to *Crossline detector*

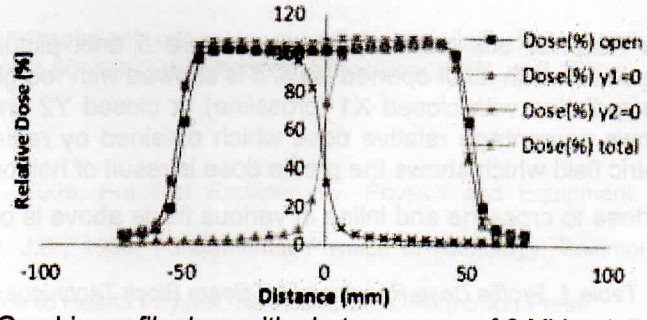

Figure 6: Graphic *profile dose* with photon energy of 6 MV to *Inline detector*

15x15cm² field

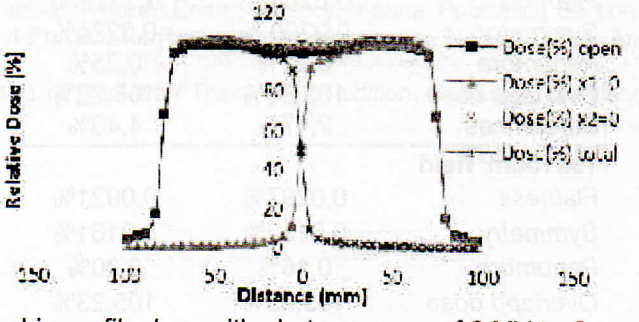

Figure 7: Graphic *profile dose* with photon energy of 6 MV to *Crossline detector*

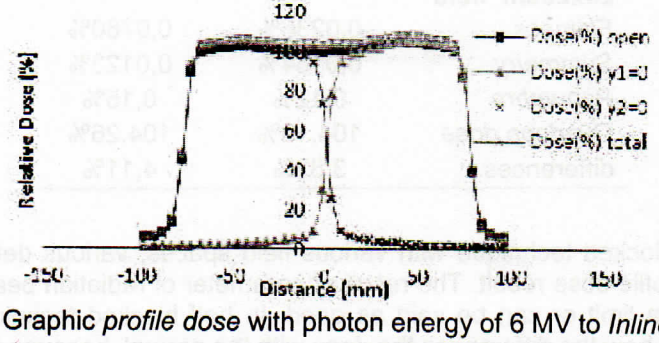

Figure 8: Graphic *profile dose* with photon energy of 6 MV to *Inline detector*

20x20cm² Field

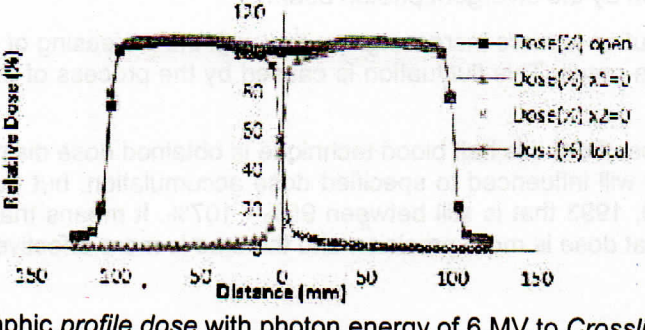

Figure 9: Graphic *profile dose* with photon energy of 6 MV to *Crossline detector*

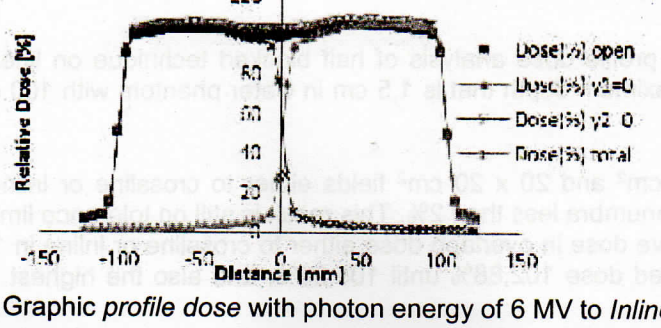

Figure 10: Graphic *profile dose* with photon energy of 6 MV to *Inline detector*

On those six graphics of the result of this research above, picture 5 until picture 10, radiation I have made symmetric field which shows radiation with all of opened jaws, it is showed with red graphic. Radiation II have made asymmetric field which shows radiation with closed X1 (crossline) or closed Y2 (inline), it is showed with purple graphic. The blue graphic shows percentage relative dose which obtained by radiation II and III (symmetry and asymmetry), made the symmetric field which shows the profile dose is result of half beam block technique.

From measurement of profile dose to crossline and inline in various fields above is obtained result as relative dose like in this Table 1:

Table 1. Profile Dose Result on Half Beam Block Technique

Parameter	Crossline	Inline
10x10cm² field		
Flatness	0,0264 %	0,1219 %
Symmetry	0,0290 %	0,0234%
Penumbra	0,21%	0,25%
Overlapp dose	102,88%	105,22%
Differences	2,47%	4,46%
15x15cm² field		
Flatness	0,0297%	0,0921%
Symmetry	0,0152%	0,0161%
Penumbra	0,16%	0,20%
Overlapp dose	103,29%	105,23%
Differences	3,01%	5,12%
20x20cm² field		
Flatness	0,0236%	0,0760%
Symmetry	0,0154%	0,0123%
Penumbra	0,12%	0,15%
Overlapp dose	104,19%	104,26%
differences	3,82%	4,11%

From measurement of half blocked technique with various field spaces, various detector placement and various jaws, obtained differences profile dose result. The result of parameter of radiation beam in flatness, symmetry, and penumbra is still on tolerance limit or can be said as good. In half blocked technique, the emphasized thing is overlapp dose parameter and how the differences the dose with the normal, because this technique obtains hotspot area because of twice radiation by the divergent photon beam.

For crossline, the dose distribution is more increasing in a row with the increasing of radiation field, different with for inline which obtains fluctuative result. This fluctuation is caused by the process of exit photon on LINAC in parallel with inline.

Measurement to the profile dose from this half blood technique is obtained dose distribution in higher overlapp dose area than the normal dose, it will influenced to specified dose accumulation, but the increasing dose value is still permirred by ICRU Report 50, 1993 that is still between 95% - 107%. It means that half blocked technique is still permitted in considering so that dose is more precision and the time is more effective caused the object of radiation is irregular.

5. CONCLUSION

According to research about profile dose analysis of half blocked technique on linear accelerator (LINAC) using photon energy of 6 MV, in maximum depth that is 1,5 cm in water phantom with 100 cm SSD, so it is obtained the conclusion:

a. In 10 x 10 cm², 15 x 15 cm² and 20 x 20 cm² fields either to crossline or inline, obtained dose profile with flatness, symmetry, and penumbra less than 2%. This result is still on tolerance limit by AAPM No. 47, 1994.
b. The result of highest relative dose in overlapp dose either to crossline or inline in 10 x 10 cm², 15 x 15 cm² and 20 x 20 cm² fields, obtained dose 102,88% until 105,23%, and also the highest difference value 5,12% to a

various fields and detector treatment either to crossline or inline. The result of this dose value is still on tolerance limit by ICRU Report 50, 1993 that is optimal between 95% and 107%.

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