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Determination of the Effective SSD as the Function of Various Energy and Field Size for SIEMENS Digital Mevatron Linear Accelerator Model Type MXE 2 in HUSM

Dissertation submitted in partial fulfillment for the Degree of Bachelor of Health Science in Medical Radiation

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CERTIFICATE

This is to certify that the dissertation entititled

"Determination of Effective SSD as the Function of Various Energy and Field Size for SIEMENS Digital Mevatron Linear Accelerator Model Type MXE 2 in HUSM"

is the bonafide record of research work done by Mrs Noor Ainzza Binti Zakaria

during the period of October 2003 to April 2004 under my supervision.

Signature of Supervisor,

....

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First of all, a great thank to god for giving me a strength to finish up my research entitled as determination of effective SSD as the function of various energy and field size for DIGITAL MEVATRON linear accelerator model type MXE2 in HUSM. This work will not be completed without the involvement of a few individuals who were tried hard to help me to finish up this thesis.

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Finally I would like to give a great appreciation for my family, especially to my parents and my husband for understanding my career. Without your support,I could not finish this work successfully. Thank you very much.

CONTENTS

1. ABSTRACT

The purpose of this study is to determine the effective source to surface distance (SSD_{eff}) as the function of various energies and field sizes for the SIEMENS DIGITAL MEVATRON (model MXE 2) linear accelerator in HUSM. The experiment involved 3 electrons energies which deputized the lowest energy, the middle energy and the highest functional energy provided by this machine .The energies were 5 MeV, 7 MeV, and 9 MeV electron beams. The measurement for the energies level were done together with the application of the available applicators which carried the field size 5cm x 5cm, 10cm x 10cm, 15cm x 15cm, 20cm x 20cm ,and 25cmx25cm. Several materials and devices were used for the experiment which included the parallel plate chamber, solid water phantom and an electrometer. The method of measurement to determine the effective SSD was such that the parallel plate ionization chamber was located at the depth of dose maximum for the specific energies and fields sizes applied and after that a series of output measurements were made at that depth. The measurements started with zero air gap between an applicator surface and the phantom surface for a selected energy .Every single shoot, the gap between applicator surface and phantom surface was increased about 1cm until reach 15 cm. The same procedures were repeated for all defined energies and applicators. A few calculations involved in the process of determining effective SSD. For all of the energies used, the deviations of the measurement reading from the inverse square law estimation were found larger up to more than 50% for the smaller field size applied. An effective SSD, SSD_{eff} had been determined at d_{max} for each energy as a function of field size. For 5 MeV electron energy with 5x5 field size, 10 x10 field size,15x 15 field size,20 x 20 and 25 x 25, the values are 37.07 cm, 79.65 cm,95.15cm,100cm and 105.26.For 7 MeV energy with the same field size as mentioned above, the values are 46.47cm, 91.18cm, 96.83cm,

107.31cm, and 105.18cm.While for 9 MeV with all the field size as mentioned before, the values are 57.78cm,96.26cm,104.60cm,104.56cm and 104.77cm. The effective SSD values determined for the energies and fields sizes are fixed for a specific condition

2. INTRODUCTION

Treatment using electron beam began since 1947 after the successful extraction of the beam from betatron in that year (6). The most clinically useful energy for electron are in the range of 4 MeV to 15 MeV energy .These range of energies are very useful in threatening superficial tumors which define less than 5 cm depth under the skin. The beam is very useful to treat the skin and lip cancer, chest wall irradiation for breast cancer, administering boost dose to nodes, and threatening head and neck cancer. The distinct advantages rather than the superficial x-ray treatment and brachytherapy such that in term of dose uniformity in the target volume and in minimizing dose to deeper tissue. This is happen due to the sharp and rapid drop off in dose as electrons travel deeper inside the medium (9).

The modern linear accelerators nowadays produced electron beam by an electron gun. The electrons start from rest in the gun and gain enough energy to approach the velocity of light,c (2.998 x 10^8) after being accelerated by the microwave .The microwave slowed where the electron starts out and gains speed as the electron gains sufficient energy to approach the velocity of light,so that the two are synchronized, and continuous acceleration is possible in wave guide. The beam then exit the window of the accelerator tube in a narrow pencil beam of about 3mm diameter. In electron mode of linac operation ,instead of striking the target ,this beam is made to strike an electron scattering foil. Scattering foil is a material consists of a thin metallic foil usually lead which is used to spread the beam as well as get a uniform electron fluence across the treatment field.

Many treatment using the beam is done at standard source to surface distance (standard SSD). However, not all the treatment is done at the standard SSD. In certain condition, treatment using the beam at non-standard SSD is more preferable. Non-standard SSD treatment or extended SSD treatment mean that the treatment condition where the application of the source to surface distance is not at the standard value .The standard value refer to 100cm . Radiotherapy treatment utilized electron beam using non- standard source to skin distance (SSD) rather than standard SSD is important in the case where there is anatomical restriction or an irregular skin surface. In order to relate the standard SSD to non-standard SSD for the output correction purpose, it is important to find the real electron source to surface distance. One of the characteristics of the electron beam is that it will scatter along the way it passes through. The fraction of the scattered electron from the applicator wall and reaching the phantom has an influence on the percentage depth dose curve, field flatness, penumbra ,and relative output factor (5).These factors will change as the source to surface distance(SSD) changed.

Referring to the Siemens Digital Mevatron Linear Accelerator used for this study, once the high energy electrons had been produced in accelerator guide, they will pass through the accelerator end window, bending magnet, scattering foil, beam monitoring ionization chamber, intervening air and the other material before coming out from the applicator end surface .The electron will undergo multiple scattering and because of that the real location where electron originated is unknown .It seem like the electrons appear to come out from the virtual source.

If the nominal value of SSD is used, the corrections to dose rate at extended SSD does not follow the inverse square law (5).The reason why the correction to dose rate does not follow the inverse square law is that nominal SSD is often defined as the distance from the accelerator exit window to the phantom surface, but the apparent source is in the fact positioned not at the window but at various distances downstream from the window which depend on the amount of the scattering material that present in the beam (7).However, a position can be chosen to best fit measured data. This position is referred to the effective SSD(5). Effective SSD is defined as the distance from the location where electron is originated (virtual source point) to the face of standard electron applicator .It is depend on beam energy, type of collimator and field size (*5*).

The treatment using the electron beam at extended SSD need to be given a specific consideration because the output measurement didn't followed the inverse square law, so that the error is very large if no corrective measure have been taken. To prevent this effect, for every treatment at extended SSD using electron beam with application of a particular field size and energy, the effective SSD should be determine first so that the corrective measured could be taken as best as possible. By these, more accurate dose prescription to the patient might be performed.

3. REVIEW OF LITERATURE:

The characteristics of the clinical electron beam depend on the primary beam parameters as well as on the scattering materials present in the beam (2).The change of the output with SSD does not follow the inverse square law if extended SSD is used which the deviations are larger for the lower beam energies and smaller fields sizes (2).The PDD is modified over the entire range of the beam at extended SSD especially for the smaller field size. For given depth, penumbra increase with increase the treatment distance.

According to the previous study in 1978 by Khan et. al, a position can be chosen to best fit measured data in order to resolve the problem of the dose fall-off for extended treatment distance which does not follow an inverse square law(5).This position referred to as the effective source to surface distance (SSD_{eff})(5).With the effective SSD, the calculated outputs were found to agree with all the measured doses in all field sizes, all SSDs and all energies in the study(4).The output at extended SSD can be calculated accurately by applying the inverse square law with an effective SSD or using a measured gap factor(3).Although the effective SSD is obtained by making output measurement at the depth of measurement ,it value does not change significantly with the depth of measurement, thus the entire depth dose curve can be corrected by the same effective SSD(2).

The different linear accelerator over the entire states yields the different values of effective SSD (6).To date ,nobody have been yet measured the effective SSD for all the linear accelerators(linacs) available. One of the linacs is digital Mevatron model type MXE 2 in HUSM which located in Kubang Kerian ,Kelantan.Be aware of this, this study is carried out to determine the effective SSD for various energies and field size for this linac. In particular, attention have been focused on 5 MeV electron energy, 7 MeV electron energy and 9 MeV electron energy applied with the 5x 5 field size, 10 x 10 field size, 15 x 15 field size, 20 x 20 field size, and 25x 25 field size.

4.OBJECTIVES OF THE STUDY

There were 3 objectives of this study:-

1. To determine the effective source to surface distance (SSD_{eff}) values for 5MeV electron energy, 7 MeV electron energy and 9 MeV electron energy with all the available field sizes which are 5cm x5cm, 10cm x10cm, 15cm x 15cm, 20cm x 20cm and 25cm x25cm for SIEMENS DIGITAL MEVATRON machine model type MXE 2 in HUSM.
2. To summarize the deviation between the charges measured by the real experiment and from the inverse square law estimation.
3. To provide the basic informations for the non-standard SSD correction purpose for this SIEMENS DIGITAL MEVATRON linear accelerator.

5. MATERIALS AND METHODS

Linear accelerator (LINAC) unit that had been used for this research is a DIGITAL MEVATRON machine model type MXE 2 which supplied by SIEMENS Medical Laboratories Inc. This linear accelerator can produce electrons that have energies in the range of 5 MeV to 12MeV.The preferred energies that had been used for this research were 5MeV, 7MeV, and 9MeV.This LINAC was provided with 5 different types of applicators which carried the field size 5cm x 5cm, 10cmx10cm, 15cm x 15cm, 20cm x 20cm, and 25cm x 25cm. All of the available applicators was used in this study. This LINAC was invented such that the source to applicator end distance is 100cm. No air gap was introduced between the applicator end and nominal SSD plane. Nominal SSD refer to the SSD by the value of 100cm. At nominal SSD, the applicator end surface need to be put directly on the top of phantom surface.

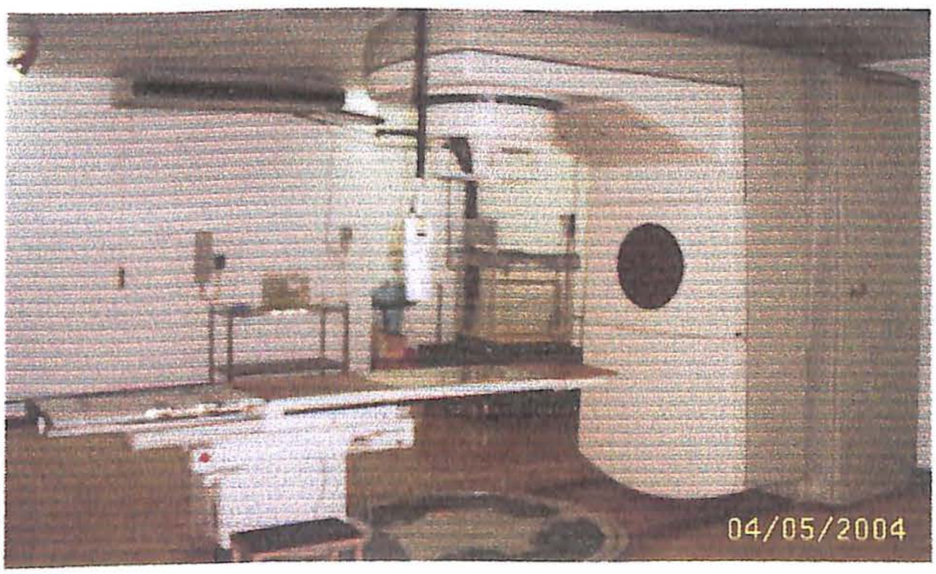

Figure 1. The picture showed the digital Mevatron Linear accelerator in radiotherapy department,HUSM.

Water phantom was recommended for beam dosimetry purpose. Because of the difficulty to put the applicator end surface on the water surface due to physical characteristic of the water (liquid state) and water surface tension effect, solid water equivalent phantoms were recommended (5).These water equivalent phantoms are made up of epoxy resin material which low in atomic number with effective atomic number closed to soft tissue. It was a strong material and inert. These solid water phantoms are conductive so that no charge storage effect with electron beam existed. These phantoms are available in various thicknesses. For this study, the thickness of the phantoms which had been used was in the range of 1 mm to 10mm.

For charge measurement purpose, PTW/MARKUS electron beam chamber model type 30-329 was used. This ionization chamber (IC) was supplied by VICTOREEN Inc. This parallel plate electron beam chamber was designed specifically for the dosimetry of electrons with energies above 100keV according to Bragg-Gray principle and suitable for measurements in either solid or water phantoms with equal accuracy in each. The chamber is flat and consisted of cylindrical plexiglass body whose measuring volume (5mm diameter x 2 mm high) was flushed to surface. The chamber window (polyethylene with a graphite layer: area density 2.3mg/cm$^{2)}$ was the polarizing electrode. The collector (Polystyrene with graphite layer: effective diameter = 4.6mm) was provided with a guard ring and rested at ground potential. The low collector volume minimizes polarity effect and electrostatic charge. It is useful in the dosimetry of electron beams where cylindrical chamber may produce significant perturbation in the electron field (7).The chamber is vented to the atmosphere and equilibrates through an aperture in the window ring. This chamber also provides both energy and directional independence with high measuring accuracy. The chamber is provided with a spacer for used in a solid water equivalent phantom.

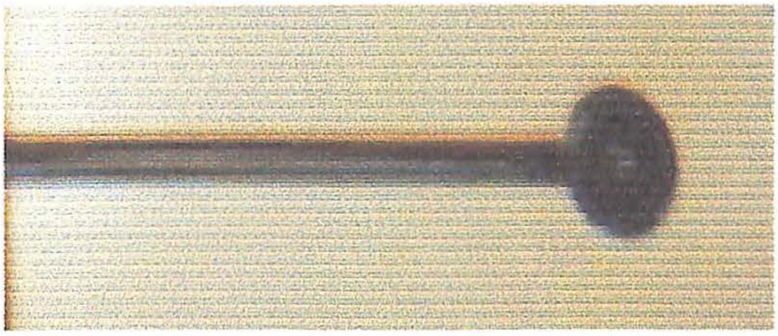

Figure 2. The PTW /MARKUS parallel plate chamber model type 30- 329 used in the experiment.

The other devices used for the charge measurement purpose is an electrometer model type Victoreen 525 supplied by Victoreen Inc.

5.1. OUTPUT MEASUREMENT

Before the measurement was done, firstly the machine had been warmed up for a few minutes. The calibration was done every time the machine was turned on to ensure the accuracy of the machine's operating system in order to deliver accurate dose prescription to the patient.

The first measurement was begun with 5 MeV energy with 5cm x 5cm applicators at nominal source to skin distance (nominal SSD = 100cm). The setup involved placing the ionization chamber inside the phantom at depth of dose maximum, d_{max} . The source to skin distance was adjusted to 100cm (nominal SSD) so that the applicator end surface touched the phantom surface (no air gap was introduced for this LINAC at nominal SSD). 200cGy was prescribed at that depth of dose maximum, d_{max}. Reading was taken twice to ensure the measurement accuracy. The same procedure was repeated for the same energy and field size with different air gap. The same procedure and measurement condition was repeated for all chosen.

In order to determine the effective SSD proposed by Khan et. al, a series of output measurement was made in phantom at depth of dose maximum (d_{max}), as the function of air gap between the applicator end surface and the phantom surface. If Qo is the ionization charge reading at d_{max} at the standard SSD without air gapand Q_g is the charge reading at d_{max} with air gap and assume the inverse square law works:-

$$Qo/Q_g = \frac{(SSD\ eff + d + g)^2}{(SSD\ eff + d)^2}$$

The symbol 'd' in the equation above referred to depth of measurement. Rewriting the equation:-

$$[Qo/Qg]^{1/2} = \frac{g}{SSD\ eff + d} + 1$$

By plotting $[Qo/Qg]^{1/2}$ as the function of air gap g, a linear graph is obtained which having slope $1/SSD_{eff} + 1$. The SSD_{eff} could then be determined from the slope which equal to:-

$$SSD_{eff} = \frac{1}{Slope} - d$$

5.2 .STATISTICAL ANALYSIS

In order to determine the values of the slopes (m) and the y-interception , one of the best methods was by looking for the best fitting line. The line is called regression line. The least-square formula was applied to estimate the data .To find the slope the equation was:-

$$m = \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

In this experiment, the symbol x refer to the values of the air gaps while the symbol y refer to the values of $[Qo/Qg\}^{1/2}$. Symbol n refer to the number of measurement done for the particular energies and field sizes at the defined air gaps. The summation of the individual values x and y characterized by the symbol Σ and the modification and manipulation of the x and y values yield the m value as needed. By manipulation and modification of the same symbols, the values of y-interceptions for individual measurement will be gotten which equal to:-

$$b = \frac{\Sigma x^2 \Sigma y - \Sigma x \Sigma xy}{n\Sigma x^2 - (\Sigma x)^2}$$

6. RESULTS

Table 1 : The result of measurement for 5 MeV electron with 5 x 5 field size is shown in the table below.

AIR GAP,g (cm)	READING 1 (nC)	READING 2 (nC)	MEAN OF READING (nC)	[Qo/Qg]1/2
0	2.340	2.342	2.341	1.000
1	2.283	2.276	2.279	1.014
2	2.198	2.197	2.1975	1.032
3	2.095	2.093	2.094	1.057
4	2.003	2.001	2.002	1.081
5	1.9179	1.9196	1.91875	1.105
6	1.8305	1.8308	1.83065	1.131
7	1.7552	1.7540	1.7551	1.155
8	1.6750	1.6755	1.67525	1.182
9	1.5887	1.5878	1.58825	1.214
10	1.5270	1.5261	1.52655	1.238
11	1.4604	1.4603	1.46035	1.267
12	1.3910	1.3910	1.3910	1.297
13	1.3282	1.3283	1.32825	1.328
14	1.2625	1.2618	1.26215	1.362
15	1.2161	1.2160	1.21605	1.3875

Table 2. The table showed the least square approximation of data for best fit line ,calculated to determine the slope and y interception for 5 MeV electron with 5 x 5 field size.

x	x^2	y	xy
0	0	1	0
1	1	1.0135	1.0135
2	4	1.0316	2.0632
3	9	1.0573	3.1719
4	16	1.0811	4.3244
5	25	1.1046	5.523
6	36	1.1308	6.7848
7	49	1.1549	8.0843
8	64	1.1821	9.4568
9	81	1.2141	10.9269
10	100	1.2384	12.384
11	121	1.2661	13.9271
12	144	1.2973	15.5676
13	169	1.3276	17.2588
14	196	1.3619	19.0666
15	225	1.3875	20.8125

$n = 16$ $\quad \Sigma x = 120$ $\quad \Sigma y = 18.8448$ $\quad \Sigma xy = 150.3654$ $\quad \Sigma x^2 = 1240$

$(\Sigma x)^2 = 14400$ $\quad n\Sigma xy = 2405.8464$ $\quad n\Sigma x^2 = 19840$

$$m = \frac{n\,\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

$$b = \frac{\Sigma x^2\, \Sigma y \; - \; \Sigma x\, \Sigma xy}{n\Sigma x^2 - (\Sigma x)^2}$$

$$m = \frac{2405.8464 - (120)(18.8448)}{19840 - 14400}$$

$$b = \frac{(1240)\,(18.8448) - (120)(150.3654)}{19840 - 14400}$$

$m = 0.\,0265$

$b = 0.9797$

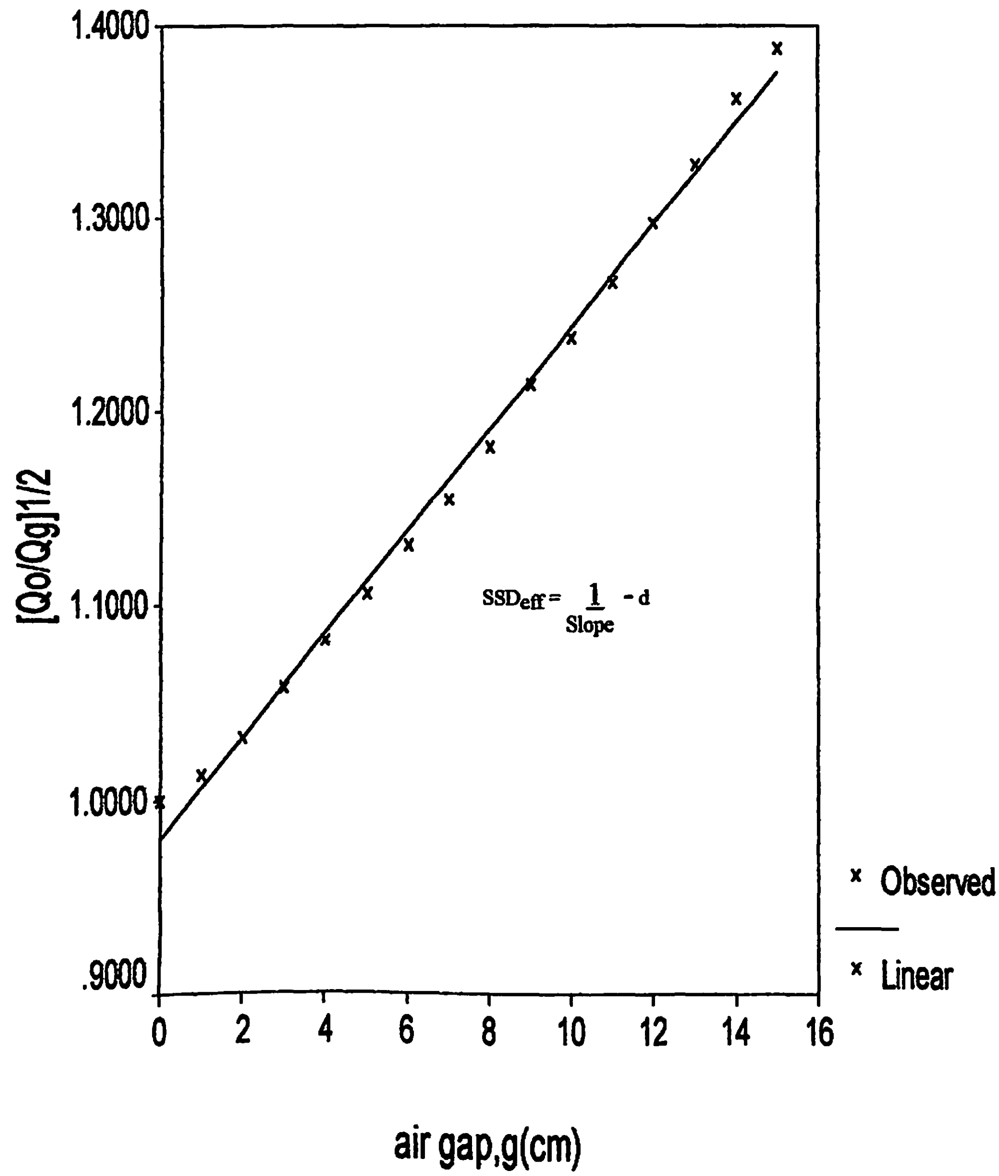

Figure 3.Graph $[Qo/Qg]^{1/2}$ versus air gap for 5 MeV energy ,5 x 5 field size

$$SSD_{eff} = \frac{1}{Slope(m)} - \text{depth of measurement(d)}$$

$$SSD_{eff} = \frac{1}{0.0265} - 0.81$$

SSD_{eff} = <u>36.93 cm</u>

Table 3 :The result of measurement for 5 MeV electron with 10 x 10 field size is shown in the table below.

AIR GAP,g (cm)	READING 1 (nC)	READING 2 (nC)	MEAN OF READING (nC)	[Qo/Qg]1/2
0	3.481	3.479	3.480	1.000
1	3.400	3.398	3.399	1.012
2	3.329	3.327	3.328	1.023
3	3.260	3.262	3.261	1.033
4	3.192	3.190	3.191	1.044
5	3.126	3.129	3.1275	1.055
6	3.066	3.062	3.064	1.066
7	2.991	2.989	2.99	1.079
8	2.911	2.909	2.91	1.094
9	2.838	2.835	2.8365	1.108
10	2.781	2.779	2.780	1.119
11	2.720	2.718	2.719	1.131
12	2.658	2.656	2.657	1.144
13	2.581	2.584	2.5825	1.160
14	2.527	2.531	2.529	1.173
15	2.482	2.478	2.480	1.185

Table 4. The table showed the least square approximation of data for best fit line ,calculated to determine the slope and y interception for 5 MeV electron with 10 x 10 field size.

x	x^2	y	xy
0	0	1	0
1	1	1.012	1.012
2	4	1.023	2.046
3	9	1.033	3.099
4	16	1.044	4.176
5	25	1.055	5.275
6	36	1.066	6.396
7	49	1.079	7.553
8	64	1.094	8.752
9	81	1.108	9.972
10	100	1.119	11.19
11	121	1.131	12.441
12	144	1.144	13.728
13	169	1.16	15.08
14	196	1.173	16.422
15	225	1.185	17.775

$n = 16$ $\Sigma x = 120$ $\Sigma y = 17.426$ $\Sigma xy = 134.917$ $\Sigma x^2 = 1240$

$(\Sigma x)^2 = 14400$ $n\Sigma xy = 2158.672$ $n\Sigma x^2 = 19840$

$$m = \frac{n\,\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

$$b = \frac{\Sigma x^2\, \Sigma y - \Sigma x\, \Sigma xy}{n\Sigma x^2 - (\Sigma x)^2}$$

$$m = \frac{2158.672-(120)(17.426)}{19840-14400}$$

$$b = \frac{(1240)(17.426)-(120)(134.917)}{19840-14400}$$

$m = 0.0124$

$b = 0.9960$

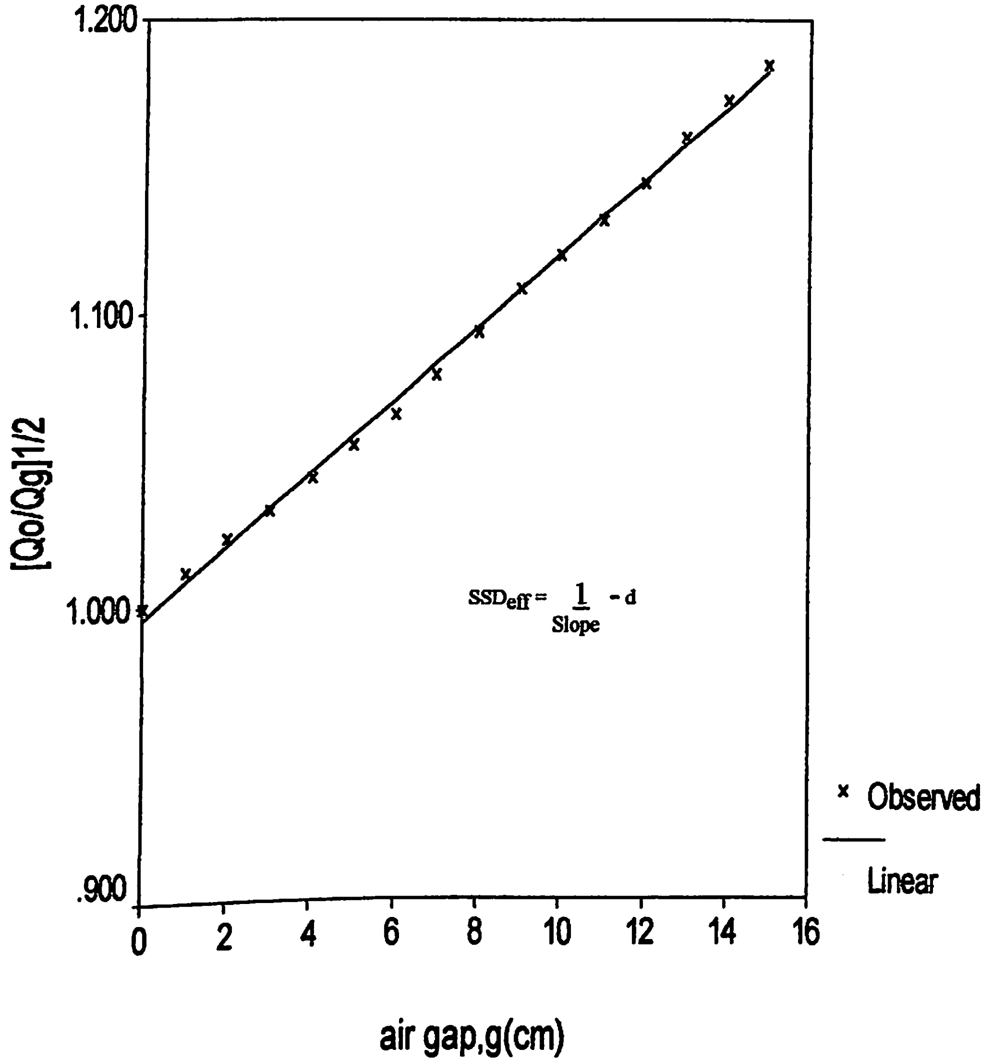

Figure 4. Graph $[Qo/Qg]^{1/2}$ versus air gap for 5 MeV energy ,10 x 10 field size

$$SSD_{eff} = \frac{1}{Slope(m)} - \text{depth of measurement(d)}$$

$$SSD_{eff} = \frac{1}{0.0124} - 1.0$$

$$SSD_{eff} = \underline{79.65cm}$$

Table 5 : The result of measurement for 5 MeV electron with 15 x 15 field size is shown in the table below.

AIR GAP,g (cm)	READING 1 (nC)	READING 2 (nC)	MEAN OF READING (nC)	[Qo/Qg]1/2
0	3.771	3.768	3.7695	1.000
1	3.695	3.692	3.6935	1.010
2	3.611	3.615	3.613	1.021
3	3.545	3.543	3.544	1.031
4	3.471	3.476	3.4735	1.042
5	3.412	3.412	3.412	1.051
6	3.350	3.348	3.349	1.061
7	3.284	3.280	3.282	1.072
8	3.224	3.220	3.222	1.082
9	3.158	3.153	3.1555	1.093
10	3.098	3.098	3.098	1.103
11	3.037	3.031	3.034	1.115
12	2.981	2.980	2.9805	1.125
13	2.927	2.924	2.9255	1.135
14	2.876	2.874	2.875	1.145
15	2.821	2.821	2.821	1.156

Table 6. The table showed the least square approximation of data for best fit line ,calculated to determine the slope and y interception for 5 MeV electron with 15 x 15 field size.

x	x^2	y	xy
0	0	1	0
1	1	1.01	1.01
2	4	1.021	2.042
3	9	1.031	3.093
4	16	1.042	4.168
5	25	1.051	5.255
6	36	1.061	6.366
7	49	1.072	7.504
8	64	1.082	8.656
9	81	1.093	9.837
10	100	1.103	11.03
11	121	1.115	12.265
12	144	1.125	13.5
13	169	1.135	14.755
14	196	1.145	16.03
15	225	1.156	17.34

$n = 16$ $\Sigma x = 120$ $\Sigma y = 17.242$ $\Sigma xy = 132.851$ $\Sigma x^2 = 1240$

$(\Sigma x)^2 = 14400$ $n\Sigma xy = 2125.616$ $n\Sigma x^2 = 19840$

$$m = \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

$$m = \frac{2125.616 - (120)(17.242)}{19840 - 14400}$$

$$m = 0.0104$$

$$b = \frac{\Sigma x^2 \Sigma y - \Sigma x \Sigma xy}{n\Sigma x^2 - (\Sigma x)^2}$$

$$b = \frac{(1240)(17.242) - (120)(132.851)}{19840 - 14400}$$

$$b = 0.9996$$

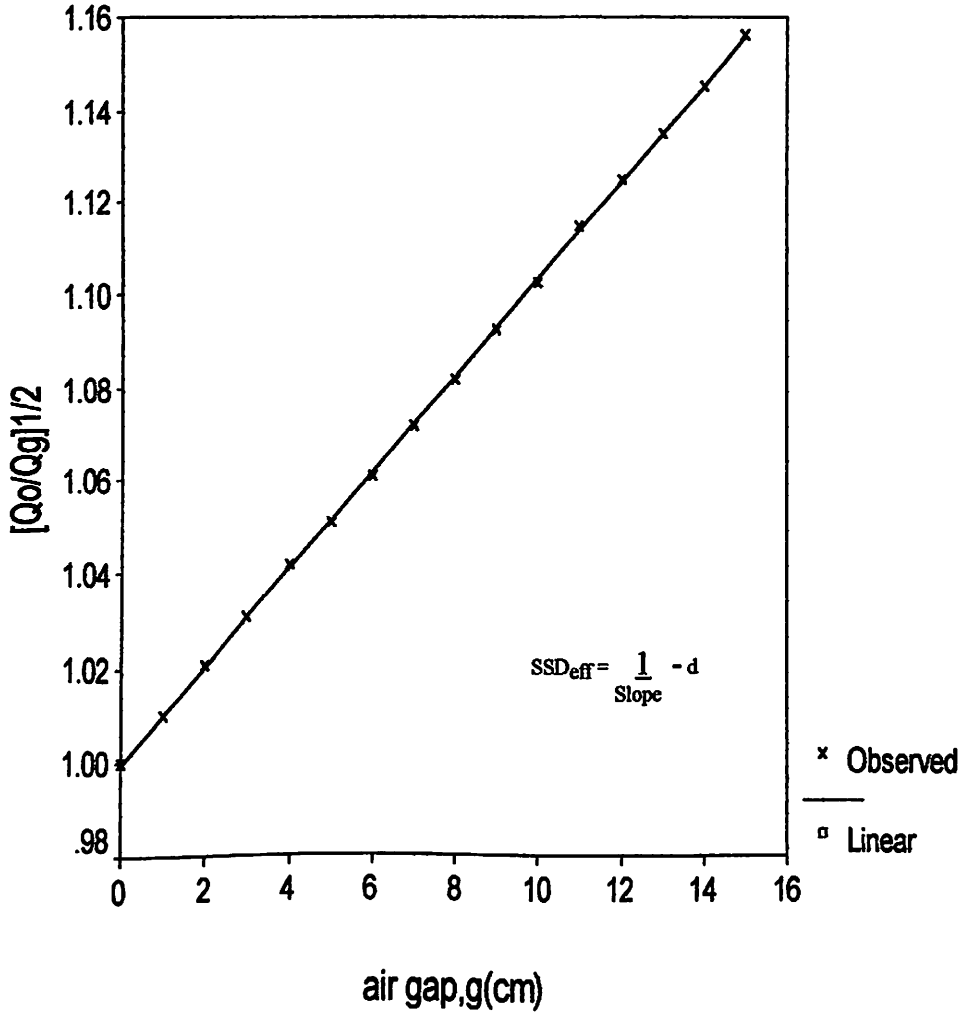

Figure 5.Graph $[Qo/Qg]^{1/2}$ versus air gap for 5 MeV energy ,15 x 15 field size

$$SSD_{eff} = \frac{1}{Slope(m)} - \text{depth of measurement(d)}$$

$$SSD_{eff} = \frac{1}{0.0104} - 1.01$$

$$SSD_{eff} = \underline{95.14cm}$$

Table 7 : The result of measurement for 5 MeV electron with 20 x 20 field size is shown in the table below.

AIR GAP,g (cm)	READING 1 (nC)	READING 2 (nC)	MEAN OF READING (nC)	[Qo/Qg]1/2
0	3.893	3.893	3.983	1.000
1	3.833	3.830	3.8315	1.008
2	3.749	3.760	3.755	1.018
3	3.683	3.682	2.6825	1.028
4	3.615	3.606	3.6105	1.038
5	3.532	3.534	3.533	1.050
6	3.481	3.481	3.481	1.058
7	3.417	3.412	3.4145	1.068
8	3.348	3.344	3.346	1.079
9	3.276	3.280	3.278	1.090
10	3.222	3.220	3.221	1.100
11	3.169	3.166	3.1675	1.109
12	3.111	3.110	3.1105	1.118
13	3.061	3.056	3.0585	1.128
14	2.997	2.996	2.9965	1.140
15	2.959	2.953	2.956	1.148

Table 8. The table showed the least square approximation of data for best fit line ,calculated to determine the slope and y interception for 5 MeV electron with 20 x 20 field size.

x	x^2	y	xy
0	0	1	0
1	1	1.008	1.008
2	4	1.0182	2.0364
3	9	1.0282	3.0846
4	16	1.038	4.152
5	25	1.0497	5.2485
6	36	1.0575	6.345
7	49	1.0677	7.4739
8	64	1.0786	8.6288
9	81	1.0879	9.7911
10	100	1.0938	10.938
11	121	1.1086	12.1946
12	144	1.1187	13.4244
13	169	1.1282	14.6666
14	196	1.1398	15.9572
15	225	1.1476	17.214

$n = 16$ $\Sigma x = 120$ $\Sigma y = 17.1705$ $\Sigma xy = 132.1631$ $\Sigma x^2 = 1240$

$(\Sigma x)^2 = 14400$ $n\Sigma xy = 2114.6096$ $n\Sigma x^2 = 19840$

$$m = \frac{n\,\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \qquad b = \frac{\Sigma x^2\, \Sigma y\ -\ \Sigma x\, \Sigma xy}{n\Sigma x^2 - (\Sigma x)^2}$$

$$m = \frac{2114.6096-(120)(17.1705)}{19840 - 14400} \qquad b = \frac{(1240)\,(17.1705) -(120)(132.1631)}{19840 - 14400}$$

$m = 0.0100$ $b = 0.9986$