ANALYTICAL FORMULISM FOR THE OUTPUT FACTOR CALCULATION OF SMALL RADIATION BEAMS

SAED J. Al ATAWNEH[1], LINA M. ABU-ARIDA[2], and K. TŐKÉSI[1]

[1]Institute for Nuclear Research, ATOMKI, Debrecen, Hungary, EU

[2]*Al-Balqa Applied University, Faculty of Science, AL SALT, Jordan*

The motivation

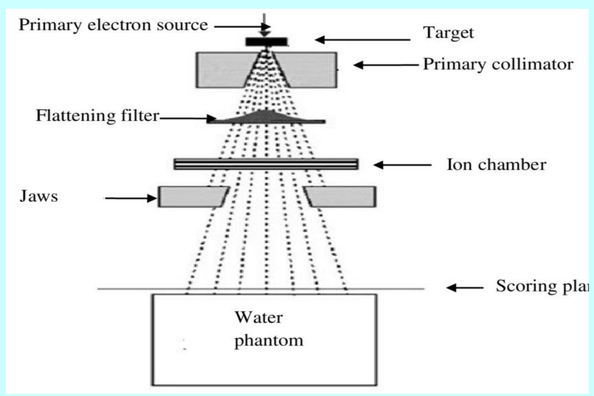
Determination of the corrected Output Factor (OF) for the multileaf collimator (MLC) and regular Jaw-shaped radiation beams.

The Output Factor (OF) has been extensively studied in recent decades. In most cases, MLC-Collimator was used. For corrected OF results, the Analytical Formula was figured out for different MLC-collimators starting from large filed size down to zero filed size, OF is a very important factor for mounter unit (MU) calculation, machine output, that used in Radiation therapy.

The Experiment Setup

In the experiment, the Water phantom was placed in such way that the surface to source distance (SSD) was 100 cm from the radiation source (medical linear accelerator). The ion chamber is set up within the phantom such that its axis should always be parallel to the beam central axis (CAX), and the center of the ionization chamber assumed to be located at the depth of 10 cm (d=10 cm). This depth was kept constant while changing the field size of the photon beam for each measurement. Readings for the OF were taken for field sizes 10x10 cm^2 down to 1x1 cm^2 for both collimators shapes, the MLC-shaped fields with constant jaw-opening of 10x10 cm^2 and Jaw-shaped fields only. Readings were normalized to the reference field size of 10x10 cm^2.

The relative position of the medical linear accelerator (Linac) to water phantom



Analytical Formula

$$OF|_E = \overline{a_0}|_E + \overline{a_1}|_E * Field\ size$$

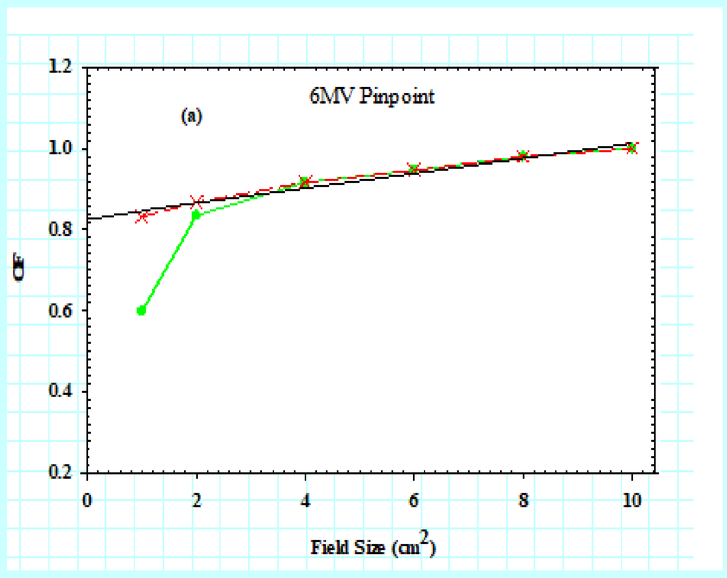
Standard Deviation

$$SD_{a_0} = \frac{\sum(a_i - \overline{a_0})^2}{N-1}$$

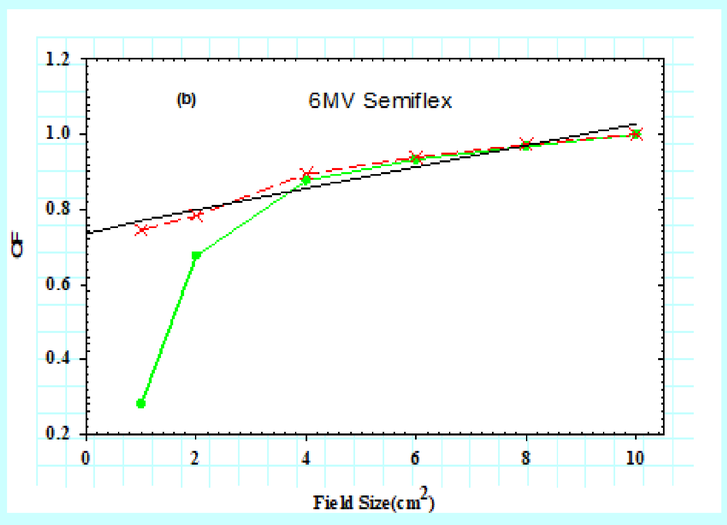
$\overline{a_0}|_E, \overline{a_1}|_E$. are the average value of fitting parameters over different ion chambers and *SD is a standard deviation*

The Output Factor measurements at 6MeV Photon beam

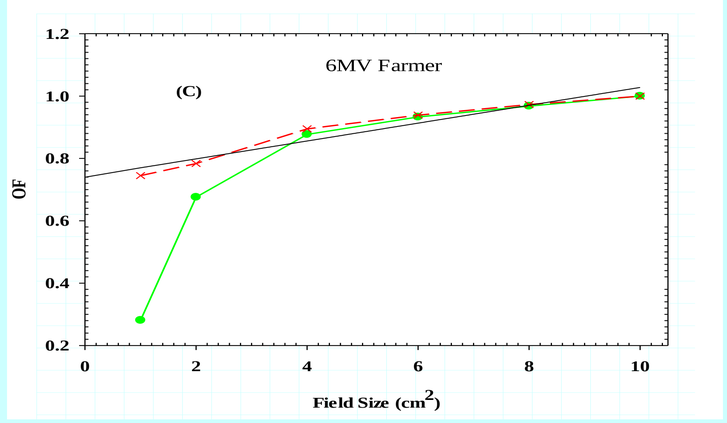
Pinpoint Ion chamber



Semiflex Ion chamber



Farmer Ion chamber



Experiment Validation

The Analytical formula for output factor was verified and compared with measured data for both of MLC and Jaw-shaped beams**.**

Experiment Validation for Pinpoint Ion chamber

Pinpoint					
Field size (cm^2)	Measured OF MLC	Measured OF Jaws	Analytical	diff (MLC)	diff (Jaws)
10	1	1	1	0	0
8	0.98	0.98	0.98	0	0
6	0.947	0.947	0.947	0	0
4	0.917	0.917	0.917	0	0
2	0.868	0.835	0.891	0.023	0.056
1	0.832	0.599	0.862	0.03	0.263

Experiment Validation for Semiflex Ion chamber

Semiflex					
Field size (cm^2)	Measured OF MLC	Measured OF Jaws	Analytical	diff (MLC)	diff (Jaws)
10	1	1	1	0	0
8	0.972	0.971	0.972	0	0.001
6	0.938	0.932	0.938	0	0.006
4	0.899	0.885	0.899	0	0.014
2	0.843	0.803	0.868	0.025	0.065
1	0.801	0.609	0.834	0.033	0.225

Experiment Validation for Farmer Ion chamber

Farmer					
Field size (cm^2)	Measured OF MLC	Measured OF Jaws	Analytical	diff (MLC)	diff (Jaws)
10	1	1	1	0	0
8	0.973	0.968	0.973	0	0.005
6	0.939	0.933	0.939	0	0.006
4	0.895	0.877	0.895	0	0.018
2	0.784	0.676	0.865	0.081	0.189
1	0.745	0.281	0.83	0.085	0.549

CONCLUSION

In conclusion, we found that the Analytical Formula could be utilized to calculate the output factor for the linear accelerator, Elekta (Synergy Platform model number (151150)), that undergoes VMAT and IMRT treatment techniques precisely, and also its strongly recommended to use for the commission data in case the small detectors such as pinpoint, micro-diamond, or even diode detectors do not achievable to use.

Acknowledgements

The work was support by the National Research, Development and Innovation Office (NKFIH) Grant KH126886.

Email: saed.al-atawneh@atomki.mta,hu

References

Das, I. J., G. X. Ding and A. Ahnesjo (2008). *Med Phys 35(1): 206-215*.
Hrbacek, J., S. Lang and S. Klock (2011). *Int J Radiat Oncol Biol Phys 80(4): 1228-1237*.
Huq, M. S., M.-S. Hwang, T. P. Teo, S. Y. Jang, D. E. Heron and R. J. Lalonde (2018). *Medical Physics 45(9): 4257-4273.*
Laub, W. U. and T. Wong (2003). *Med Phys 30(3): 341-347.*
Palmans, H., P. Andreo, M. S. Huq, J. Seuntjens, K. E. Christaki and A. Meghzifene (2018). *Medical Physics 45(11): e1123-e1145.*
Zhu, T. C., A. Ahnesjö, K. L. Lam, X. A. Li, C.-M. C. Ma, J. R. Palta, M. B. Sharpe, B. Thomadsen and R. C. Tailor (2009). *Medical Physics 36(11): 5261-5291.*