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Radiotherapy Wedge Filter AAA Model 3D Simulations for 18 Mev 5cm-Depth Dose with Medical Physics Applications

Francisco Casesnoves

PhD Engineering, MSc Physics-Mathematics, Physician. Independent Research Scientist. International Association of Advanced Materials, Sweden. Uniscience Global Scientific Member, WYOMING, USA. Harjumaa, Estonia

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ABSTRACT

In a previous study based on series of contributions for Anisotropic Analytic Model (AAA) improvements, several exact/approximated formulations/corrections for wedge filters (WF) photon-dose delivery were presented. Namely, dose delivery correction Omega Factor for 15° WF, Photon Beam Intensity I(z), and Photon Fluence magnitude for 18 Mev for z=15 cm depth-dose. Based on all these algorithms/software, 3D comparative-simulations results with Matlab are developed for AAA model 18 Mev photon-beam, but at superficial depth-dose z=5 cm. The 15° WF corrected AAA photon Beam Intensity I(z) magnitude modification, Standard 18 Mev Fluence and geometrical Omega Factor are implemented. Scatter radiation, tissue inhomogeneities, and contaminating electrons correction are not applied. The calculations with AAA model formulas for these parameters are developed/improved. Findings comprise a number of 3D graphics with 3D Graphical Optimization, and a series of numerical data for AAA WF photon-dose delivery at depth-dose z= 5. Results for 4D Interior Optimization imaging-development-approximations are presented in 3D charts, and compared to 3D Graphical optimization photon-dose at z=15 cm depth. Radiotherapy Medical Physics applications for WF usage photon-dose calculations at superficial depth z=5 cm emerge from all the numerical and graphical outcomes. Clinical radiotherapy applications are obtained from 3D graphical simulation series. Radiation Therapy uses for breast cancer at depth-dose z=5 cm are explained and presented.

Keywords : Software Engineering Methods, Radiation Photon-Dose, Attenuation Exponential Factor (AEF), Simulations, Nonlinear Optimization, Matrix Algebra, Spherical-Spatial Analytical Geometry, Series Approximations, Multi-Leaf Collimator (MLC), Wedge Filter (WF), Conformal Wedge Filter, Anisotropic Analytic Model AAA, Intensity Modulated Radiotherapy (IMRT), Intensity Modulated Protontherapy (IMPT), Fluence Factor (FF), Treatment Planning Optimization (TPO).

I. INTRODUCTION

In a previous study, a 3D computational-simulations comparison among several software systems for 18 Mev depth-dose at z= 15 cm was presented. The selected model was the AAA one for photon-dose delivery in water. This article, instead, is focused on 3D/4D Graphical and Interior Optimization of AAA 18 Mev model for superficial depth-dose at z= 5 cm. Evolution of AAA model and its modifications were explained/commented in [1].

Several ideas about recent advances in cancer research, from [1], comprise pre-hypotheses about future radiation oncology. Namely, [Casesnoves, 2007], Radiation Therapy will remain/continue in clinical oncology future for the primary attack to eliminate the tumor volume, and set/open the field for subsequent Chemo-Inmuno Therapy, or Nano-Inmunotherapy stages. Preventive Medicine in early stage diagnosis and prevention (for example, elimination of smoking, alkohol abuse, etc), has proven be useful/significant for cancer incidence reduction.

An important difference between depth-dose tumor and superficial dose tumor TPO is that at nearly skin-dose, the photon spectrum energy magnitude is usually very high. This implies that the TPO accuracy is a must, since the organs at risk could be seriously damaged [1-7, 16-23].

Radiation therapy has reached excellent innovations for oncological treatments. Among them, IMRT, IMPT, Carbon-Ion Therapy with their variants, new dose-delivery models (for instance, biological models) have got significant improvements/advances for tumor growth-control/cure, terminal patients, methastasis treatment, and side-effects reduction [1-7,15, 16-23].

Grosso modo, the advances and future-applications in cancer therapy can be classified into several groups—which act all together, are synergic, complementary and interactive each other. First one is the science-strictly radiation physics, chemistry, bio/molecular-chemistry, pharmacology, and biology group. Second is the computational-software, imaging, and software framework, which is integrated in oncology optimization, speed up and get all the efficacious advances of the first one—for instance, the Artificial Intelligence for radiotherapy treatment planning optimization/selection, TPO. Other important strand is the mechanical-electronics new manufacturing designs/improvements, for example, modern LINACs, Proton Therapy instalations, and Radioprotection structures at radiation oncology services. All these up-to-date advances are reduced for the rising difficulty to control the growing incidence/prevalence of almost all tumor types. There are multiple factors for this incidence/prevalence population-rate grow of cancer apart from lifetime elongation [1-7, 16-23].

In summary, this study reports a software programming series of methods to get primary radiotherapy numerical and 3D imaging simulations for dose delivery with AAA model and 16 Mev photon spectrum at superficial depth-dose of z= 5 cm . A number of modifications/approximations were applied to prove the utility of 3D superficial dose modelling numerical and 3D graphical simulation. Selected computational system in this study is Matlab. Medical Physics use-applications both for clinical radiotherapy TPO and radiotherapy physics modelling research emerge from all the article results.

II. MATHEMATICAL AND COMPUTATIONAL METHODS METHODS/DATA

Based on [1-7], the section is divided into two sub-sections. Firstly the principal AAA model mathematical formulation is presented. Secondly, for superficial depth-dose at z= 5 cm, the algorithms, computational software and program implementation are explained.

Mathematical and algorithmic development

A brief reminder of principal formulas from previous contributions [1-7, 53-57] is included into this section. Principal equations are 1-3, whose parameters are explained all together. Eq. 1 is the dose delivery with Omega factor modification. Eq. 2 is the Omega Factor formula. Eq. 3 is the final dose formulation for WF with the model. Calculations both analytical and geometrical are laborious and explained in [1-7, 53-57]. The principal WF dose delivery algorithms and integral equations of first kind in water without tissue-attenuation corrections are,

$$D(x,y,z)=\frac{I(z)\,A}{4(1+z/F)^2}\,x\ldots$$
$$\ldots x\int_{-a'}^{a'}\int_{-b'}^{b'}\Phi_{\Omega}\;x\ldots$$
$$\ldots x\sum_{K=1}^{K=3}\frac{C_K}{\pi\,\sigma_K^2}\,x\,e^{[-[(x-u)^2+(y-v)^2/\sigma_K^2(z)]]}\,du\,dv\,;$$
$$\text{with modified fluence in } [\Omega]_F\,,$$
$$\Phi_W(u,v,z)=\Phi_0(u,v,z)\,x\ldots$$
$$\ldots x\,e^{\left[-\mu_w x\left[L\pm\frac{Cu}{F+z}x\left(\frac{\sin\alpha}{\cos(\alpha+\phi)}\right)\right]\right]x[[\Omega]_F]}\;;$$

Equation 1

$$[\Omega]_F=\left[1+\frac{\tan^2\phi_2}{1+\tan^2\phi_1}\right]^{\frac{1}{2}};$$

Equation 2

$$D(x,y,z)=\frac{I(z)\,A}{4(1+z/F)^2}\,x\sum_{K=1}^{K=3}e^{[\sigma_K^2(z)S^2-2Sx]}\ldots x$$
$$\ldots x\left[\left[\mathrm{Erf}\left(\frac{y+b'}{\sigma_K(z)}\right)\right]-\left[\mathrm{Erf}\left(\frac{y-b'}{\sigma_K(z)}\right)\right]\right]\ldots x$$
$$\ldots x\left[\left[\mathrm{Erf}\left(\frac{x+a'+\sigma_K^2(z)S^2}{\sigma_K(z)}\right)\right]-\left[\mathrm{Erf}\left(\frac{x-a'-\sigma_K^2(z)S^2}{\sigma_K(z)}\right)\right]\right];$$
$$\text{where } S=S([\Omega]_F),\text{ and } A=A([\Omega]_F);$$

Equation 3

where I(z) is the area integral of the dose over a plane perpendicular to the z-axis at depth z, normalized to one incident electron, σ (z) (tabulated) is the depth-dependent mean square radial displacement, x, y, z are the coordinates of the dose-delivery point at beam-output coordinates system, and u, v, z, are the coordinates of photon-fluence at depth z. Then a, b, are the field-size magnitudes. F as the source-surface distance (SSD). C_K (tabulated) are optimization parameters resulting for a triple Gaussian function setting. Φ_W is the photon fluence modified for WF. Parameters a and b correspond to field-size. Then at depth z, the field size rectangle varies such as: a'(z) =a(1 + z/F), b'(z) =b(1 + z/F) which are the halfside lengths projected into depth z, with F as the source-surface distance (SSD). C is the distance in z-coordinate from source to WF surface, L is half-length of WF for y coordinate. Fluence at depth u is modified: $\Phi_U = \Phi_0 / (1 + z/F)^2$ according to [30,31,55,57]. For WW, there is a second correction for Fluence Φ_W as Eq. 1. That is, he source fluence is modified primarily for the dose-delivery depth z, Φ_U and secondly by the WF parameters [1-7, 16-23, 30,31]. That is, WF modifies the photon-beam energy spectrum. A = exp [$-\mu_W$ L x (sinα/ (cos (α + φ)))] [55,57]. Parameters μ_w (WF material parameter) , α (WF angle) and φ (photon-beam divergence angle) are defined at [1-7, 16-23, 30,31, 53-57]. Φ_1 and Φ_2 at Eq. 2 are the geometrical angles for Omega Factor [Ω_F] computation defined in Figure 1 at [1] and various Figures at [1-7]. Analytical geometry calculations and programming of these angle ranges is complicated [1-7]. S([Ω_F]) and A([Ω_F]) are defined in [1-7]. Development of Equations 1-3 are extensively presented in [1-7]. All these parameters are defined in [1-7, 30,31, 53-57].

This model of WF was proven be not totally exact [1-7], because the exact path through WF was calculated approximately [1-7]. Therefore, in [1-7, 30,31], the proofs of the approximate path and exact path was developed.

Software-programming method

The computational method is based on previous software works [1-8,16-23]. This first kind Fredholm integral equation complete analytical solution, Eq. 3 will be correctly simulated in dosimetry-matrices from 100 x 100 dimensions to 1000 x 1000 dimensions in the following sections, and compared with simulations of equations [1-7, 16-23, 55, 57] of classical AEF [1-7] in AAA model foundations. Further development of Equations 1-3 are extensively presented in [1-7, 16-23]. Table 1 shows numerical values implemented for algorithms programming. Table 2 shows the main numerical data for the 3D simulation graphics program at z = 5 cm. The magnitude of Omega factor is about 1.12, for a WF of 15 degrees, and increases with the WF angle till 45° [1-7, 16-23]. Note that this apparently small value of Omega Factor becomes propagated by multiplication to other constants in formulation, Table 2, and the result is a change of 3D dose delivery magnitude as shown in imaging simulations. The structure of the program comprises the summatory of every part of Eq. 3. Firstly, these parts of Erf functions are set independently one by one for z= 5 cm. Secondly all of them are summed. Finally, the resulting numerical values are set in the imaging subroutine, and visualized in 4D as shown in Fig. 4. These individual Erf parts are proven numerically in Table 2. In this study, they are implemented in Matlab. But in [1], for z= 15 cm depth-dose, Eq. 3 was developed in imaging processing also for GNU-Octave and Freemat. Every of these programming system requires an specific modification of the main program to obtain correct simulations. Imaging processing tools and subroutines/options vary in every system, Matlab, GNU-Octave and Freemat [1] . Table 1 shows all the subroutine(s) implementation data with corrections from [1-7]. Table 2 shows the Eq. 3 model functions [based in Erf function parts for WF] adjusted/improved for setting z= 5 cm depth-dose at the new functional software, Figs 1-7.

Data from AAA algorithm foundation in water, [9,54,55,57], whose numerical computational software used for constants and parameters optimization was Monte Carlo Code EGS-4 and curve fitting MAAFS from CERN (European Union Center for Nuclear Research).

COMPUTATIONAL RADIOTHERAPY DATA [For Eq. 14 [ref 57] F= 100 cm, c=30 cm]	
Photon-beam WF dimensions [cm] and angle Divergence angles,	**Sigma constants [adimensional] for Model Gaussians at Siemens LINAC Mevatron KD2, output 18 MeV**
WF Angle=15° 12 x 12 [cm]	σ_1=0.124795
φ_1=30°	σ_2=3.083817
φ_2=30° [approximately]	σ_3=0.630286
Data from AAA algorithm foundation in water, [9,54,55], whose numerical computational software used for constants and parameters optimization was Monte Carlo Code EGS-4 and curve fitting MAAFS from CERN (European Union Center for Nuclear Research).	
Photon Beam Intensity [Gy cm²] and Fluence [Number photons/cm²/Gy]	**Depth z=5 cm with summatory Model constants [adimensional]**
I(z)=20.9505 x 10^{-12} [corrected [9]]	C_1=0.566
$\Phi_0 \in$ [4.16 x 10^9,2.82 x 10^{10}] [corrected [10,11]]	C_2=0.254
	C_3=0.189
WF correction Omega Factor $[\Omega]_F$ [adimensional]	
Example, For z=5 cm and C_1 part $[\Omega]_F$=1.1181	

Table 1.-AAA model main parameters for 3D Graphical simulations at z= 5 cm [1-7, 9,10,11, 54, 55,57].

NUMERICAL METHOD FOR COMPUTATIONAL PROGRAMMING IMPLEMENTATION (18 Mev, z= 5 cm) with $[\Omega]_F$
Dose summatory element 3D (Omega Factor) D_Ω [i=1,..,3] (x,y,z)
D_Ω [i=1] (x,y,z) = 1.1 · 10^{-2} · · exp (2.3809e-05 - 0.0782 · x) · · [Erf [(x+12.5994)/0.124795] - Erf [(x-12.6066)/0.124795]] · · [Erf [(y+12.6)/0.124795] - Erf [(y-12.6)/ 0.124795]]
D_Ω [i=2] (x,y,z) = 0.4847 · 10^{-2} · · exp (0.0145- 0.0782 x) · · [Erf [(x+12.2282)/3.083817] - Erf [(x-12.9718)/ 3.083817]] · · [Erf [(y+12.6)/ 3.083817] - Erf [(y-12.6)/3.083817]]
D_Ω [i=3] (x,y,z) = 0.3739 · 10^{-2} · exp (6.0734e-04 - 0.0782 x) · · [Erf [(x+12.5845)/0.630286] - Erf [(x-12.6155)/0.630286]] · · [Erf [(y+12.6)/0.630286] - Erf [(y-12.6)/0.630286]

Table 2.-Program software parts, z= 5 cm, numerically calculated for Eqs. 1-5 with [1] corrections and [1-7, 9, 10, 11, 16-23, 54, 55-57] modifications. The data from Tables 1-3, was implemented. Depth doses numerical equations comparison between z= 15 cm in [1] and z= 5 cm in Table 2 shows significant differences.

III. GEOMETRICAL AND NUMERICAL IMPROVEMENTS FOR AAA MODEL

Following the 1995 and 1996 AAA model foundation, several I(z) important corrections were developed by Ulmer and Harder [9]. Along 2008-15, an significant number of geometrical analytic improvements for WF were developed/published [Casesnoves, 1-7,16-23]. These are Omega Factor, Eqs. 1-3, exact path length determination through WF and WF limit angle for photon-beam through WF [1-7, 16-23, 55, 57]. Omega Factor extent calculations and analytical geometry are shown in geometrical Figures [1-7]. The I(z) corrections at [1,9] were numerically important as I(z) magnitude varied in one magnitude order less. Namely, from 10-11 till 10-12 . The corrections were mathematically done, [1,9], by an exponential-fit in the function I(z) as follows in Table 3.

I(z) MODIFICATIONS [9]	
DEPTH	I(z)
Z= 5 cm	20.9505 x 10^{-12}
Z= 15 cm	17.6951 x 10^{-12}
I(z) ALGORITHM [9]	
$I(z) = Ae^{-az} - Be^{-bz}$;	
TOTAL DELIVERY DOSE EQUATION (TDD)	
TDD = [primary photons] DOSE + [extra-focal photons] DOSE + [contaminating electrons] DOSE	

Table 3.-Program I(z) software depth magnitude parts, for z= 5 cm, compared to z=15 cm from [1]. I (z) corrections [1997, 9] and formula related to [54,55, 1995-6] Standard Equation for TDD [1-7, 16-23, 54, 55-57].

In Table 3, parameters A, B, a, b, are graphically shown in [9] related to depth-parameter z. As a result in [9], from this numerical fit, it was determined that l(z) changes by up to 0.7 % in the I(z) maximum and up to 5 % at large depth. Tables 1-3 show these corrections implementation for the 3D simulations study here, with magnitude difference order implemented as in [1]. In these paper simulations, the standard Fluence [10,11] is set as (particles number/cm2 /Gy). Consequently, the numerical modification for Fluence Factor (FF) magnitude, according to Eqs. 1-3, Tables 1-3, is significant [10,11]. That is, FF ϵ [4.16 x 10^9 , 2.82 x 10^{10}], and it is taken the average for programming. The objective of the study is to demonstrate primarily/approximately the utility/efficacy for clinical/research in 3D/4D Graphical Optimization AAA WF dose-delivery at z= 5 cm, and compare to previous research at z= 15 cm in [1]. However, acceptable primary numerical dose delivery data is got, Table 4, Figs. 1-7.

Just remark that the implemented model in these simulations is the original AAA one with Omega Factor [Casesnoves, 2015, 1-7, 16-23] WF geometrical correction for water. This model was the base for further developments after foundations [9, 54, 55,57]. Among them, tissue inhomogeneities, scatter radiation, or contaminating electrons [53-57] for photon-ose AAA model were found. That is, primary photons and extra-focal photons, scattered in the flattening filter or the beam collimator, flattering filters, jaws, blocks, multi-leaf collimator, and the group of direct dose delivery beam modificators, such as WF, satellite filters, shielding blocks, rectangular satellite filters, etc [14, 53-57]. Later on, and in following studies/developments, superposition-convolution analytical models for proton therapy emerged from this AAA mathematical method [12], although for proton therapy equations resulted different and in some cases simpler. According to all these physical evolutions and developments/constraints, in practical clinical medical physics treatment planning implementation dose is calculated better at present.

IV. RESULTS

The numerical results and differences between z= 5 cm depth-dose and z= 15 cm one are shown in Table.. . Matlab software results for 3D Treatment Planning Optimization images and numerical data, are presented in Figs, 1-7 with two imaging processing methods [1-7, 16-23, 54, 55,57]. The fourth dimension of photon dose is explained in Fig. 4.

COMPARATIVE 3D GRAPHICAL OPTIMIZATION DOSE [Gy]			
DEPTH	MIN	MAX	DIFF
Z = 5 cm	0.0257	0.1756	25.33 %
Z = 15 cm	0.0167	0.1309	36.74 %

Table 4.-Comparative dose magnitude for 3D/4D Graphical optimization between z= 5 cm and z= 15 cm depth doses. The minimum corresponds to thinner part of WF and the maximum to broad part of WF [1-7, 16-23, 54, 55,57].

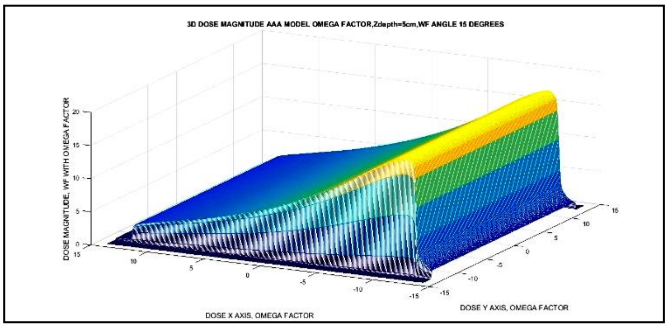

Figure 1.- Matlab simulation 3D image for 18 Mev photon-beam at 5 cm depth-dose with Omega Factor scaled to 10^2. Matrices for Image Processing have about 10^3 elements. Imaging Processing Method 1.

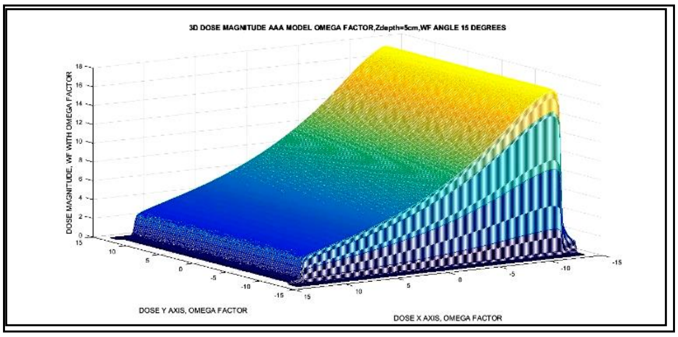

Figure 2.- Matlab simulation 3D image for 18 Mev photon-beam at 5 cm depth-dose with Omega Factor scaled to 10^2. Matrices for Image Processing have about 10^3 elements. Imaging Processing Method 1.

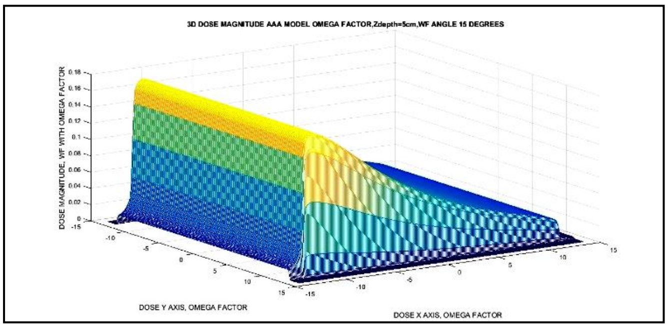

Figure 3.- Matlab simulation 3D image for 18 Mev photon-beam at 5 cm depth-dose with Omega Factor. Matrices for Image Processing have about 10^3 elements. Imaging Processing Method 1.

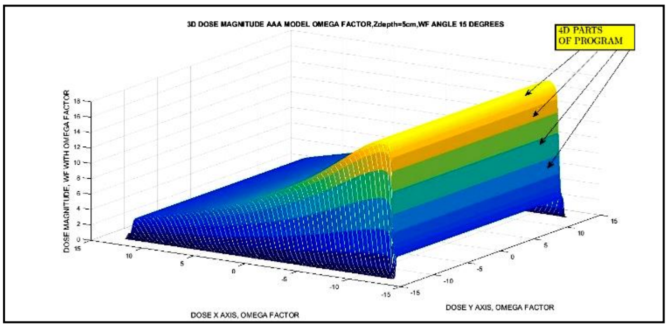

Figure 4.- 4D inset details for Matlab simulation 3D image for 18 Mev photon-beam at 5 cm depth-dose with Omega Factor scaled to 10^2 . Matrices for Image Processing have about 10^3 elements. Imaging Processing Method 1. Enhanced at Appendix.

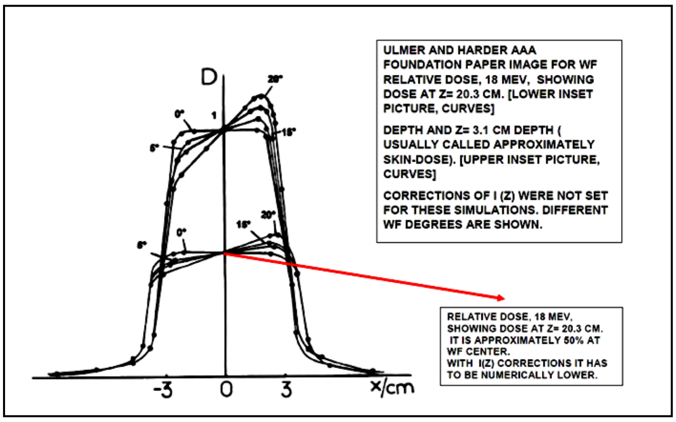

Figure 5.-From [1, 54,57], it is sketched a graphical composition from its Figure 5 [Ulmer and Harder 1996]. In this 2D simulation, with non-corrected I (z) function, the dose for WF,18 Mev, at z= 20.3 cm (deeper than 15 cm) is around 50% of maximum dose.

Numerical 3D Graphical simulations for this study show a dose of about 20% related to maximum dose with I(z) adjustments. In addition, when field size increases, as it is here [12 x 12 cm], compared to [-3 , 3], the relative dose generally decreases. Therefore, it is straightforward to guess that approximations of the numerical and imaging software/model are acceptable. Important remark: the very good image/simulation from Ulmer and Harder [54] has a numerical inconsistency at coordinate x=0. That is, the dose at center through WF of different angles cannot be exactly equal. The probable reason is that in the graphical sketch the points at around (-3) and (+3) were matched with curves. That caused quality of dose for different angle WF at x=0 and along D axis.

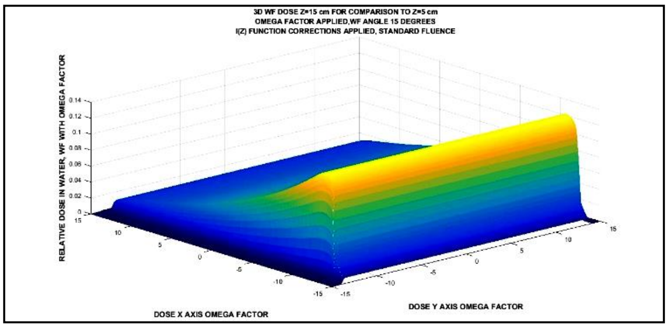

Figure 6.-Comparative dose Matlab simulation 3D image for 18 Mev photon-beam at 15 cm depth-dose with Omega Factor. Matrices for Image Processing have about 10^3 elements. Imaging Processing Method 1. Enhanced in Appendix

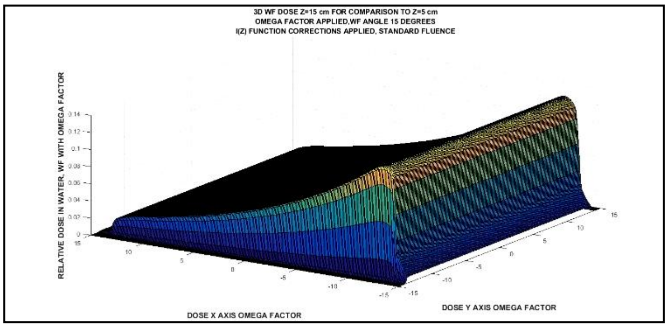

Figure 7.-Comparative dose Matlab simulation 3D image for 18 Mev photon-beam at 15 cm depth-dose with Omega Factor. Matrices for Image Processing have about 10^3 elements. Imaging Processing Method 2.

V. CLINICAL MEDICAL PHYSICS SUPERFICIAL DOSE APPLICATIONS

CLINICAL MEDICAL PHYSICS APPLICATIONS		
TYPE	**CLINICAL**	**RESEARCH**
Treatment planning optimization	Post-dose verification. Pre-dose delivery plan	Modelling improvements. New models applications, for example biological models
LINAC improvements optimization	Accuracy of photon-dose	LINACs Parameter optimization Extrapolation to IMRT, IMPT
Theoretical new models	When new models are proven better, the better dose accuracy	Theoretical Radiotherapy Physics model investigation, extrapolation to IMRT, IMPT
TYPE	**MIXED**	**SUPERFICIAL TUMOR**
Treatment planning optimization	Clinical modifications after research	In the past, planning system was in 2D, accurate 3D for breast,lung, neck tumors, etc
LINAC functional optimization	Clinical and laboratory trials for new LINACs	Rather difficult to set with extreme precision new modifications for superficial tumors saving organs at risk, e. g. , brain tumors for new LINACs manufacturing design
Theoretical/ validation of new models	Approximations for superposition/ convolution models. Clinical trials for new models. Biological models applications	Radiotherapy improved/specific models for breast, lung, etc tumors significantly

Table 5. Radiotherapy Medical Physics study applications, with details for superficial tumors applications [57].

In Table 5, improved from [1], shows a resume of principal applications of the numerical/imaging results and software programming. Further applications, e. g. IMRT or IMPT, can also be extrapolated for clinical/research radiotherapy developments.

VI. DISCUSSION AND CONCLUSIONS

The study has got primary results from previous improvements/modifications of AAA model WF from [1] at superficial z = 5 cm depth-dose. The previous contribution [1] showed advantages/inconvenients for 3D computational simulations of WF dose delivery with a 18 Mev photon beam at 15 cm depth-dose with three computational software-systems. These modifications/approximations were related to I(z), standard 18 Mev Fluence and Omega Factor analytic geometry algorithms [1-7, 9].

The difference with the previous research [1], is this study objective to approximate dose magnitude for superficial tumors. For example, lung, breast, neck, brain, and skin ones. Results 3D/4D Graphical Optimization with developed software and algorithms are acceptable. Applications on TPO constitute also a number of practical findings. At z= 5 cm, the doses are about 30 % higher both for thin and broad part of WK, subject to implemented AAA parameters of WF dimension and angle, focus-surface distance, and others.

For practical visualization, Matlab provides fast images with data adquisition facilities. Tissue inhomogeneities, scatter radiation, or contaminating electrons modifications for 3D/4D graphics have not been applied.

Medical Physics applications are theoretical and clinical-TPO oncological-practical. Theoretical ones involve research in TPO, 3D/2D simulations, implementation in software planning systems, LINAC calibration improvements, photon-dose theoretical-experimental model fitting, specific tumor optimization, anatomical delivery optimization, or development/comparison of new optimization methods. Clinical-practical applications comprise TPO improvements, medical physics oncology functionality, high-precision/efficacious superficial dose to minimize radiation on organs at risk, training in delivery simulations, etc.

In summary, this WF numerical and 3D/4D graphical determinations show algorithms, software, and useful graphics for 3D AAA photon-dose simulation at z= 5 cm or closely delivery depths. 3D/4D Imaging processing and computer vision methods are also demonstrated. Multiple applications in Clinical and theoretical Medical Physics and Bioengineering emerge from the results.

VII. SCIENTIFIC ETHICS STANDARDS

This contribution is based on Graphical Visualization and Software Optimization methods for radiotherapy modelling improved from previous articles [1-7, 16-23]. All Radiation Therapy algorithms and developments [1-7, 16-23] correspond to MSc thesis development of Dr Casesnoves from 1999-present. Graphical-Optimization Methods were created by Dr Casesnoves on December 2016. The image processing and computer vision tools programs and special software to obtain new dosimetry images positioning, panoramic vision, enhancement of selected WF dose-deposition parts, or imaging tiles optimization was originally developed by author in Matlab. The sections II and III with parameter and formulas descriptions contain necessary explanatory text from [1]. This advanced article has a few previous paper Tables for z= 5 cm depth-dose formulation information, [1-7, 16-23], whose inclusion is essential to make the contribution understandable. Figure 5 was taken for essential understanding from [1]. Table 5 is improved from [1]. This study was carried out, and their contents are done according to the European Union Technology and Science Ethics. Reference, 'European Textbook on Ethics in Research'. European Commission, Directorate-General for Research. Unit L3. Governance and Ethics. European Research Area. Science and Society. EUR 24452 EN. Also based on The European Code of Conduct for Research Integrity. Revised Edition. ALLEA. 2017. Revised Edition. ALLEA [59,60]. The applications section has some mandatory words from previous contributions. This research was completely done by the author, the software, calculations, images, mathematical propositions and statements, reference citations, and text is original for the author. When a mathematical statement, proposition or theorem is presented, demonstration is always included. The Omega Factor demonstration is not included as it is rather large and can be found at [1-7]. The primary Omega Factor calculations were obtained during MSc Thesis in 1999. The article is exclusively scientific, without any commercial, institutional, academic, political, religious, religious-similar, non-scientific-ideology, or economic influence. When anything is taken from a source or previous contribution, it is adequately recognized [59,60].

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IX. AUTHOR'S BIOGRAPHY

Dr Francisco Casesnoves earned the Engineering and Natural Sciences PhD by Talllinn University of Technology (started thesis in 2016, thesis defence/PhD earned in December 2018, official graduate Diploma 2019). He works as independent research scientist in computational-engineering/physics. Dr Casesnoves earned MSc-BSc, Phys-ics/Applied-Mathematics (Public Eastern-Finland-University, MSc Thesis in Radiotherapy Treatment Planning Optimization, which was developed after graduation in a series of Radiation Therapy Optimization-Modelling publications [2007-present]), Graduate-with-MPhil, in Medicine and Surgery (Public Madrid University Medicine School, MPhil in Radioprotection Low Energies Dosimetry). Casesnoves studied always in public educational institutions. Casesnoves resigned definitely to his original nationality in 2020 for ideological reasons, democratic-republican ideology, and ethical-professional reasons, and does not belong to Spain Kingdom anymore. His constant service to International Scientific Community and Estonian technological progress (2016-present) commenced in 1985 with publications in Medical Physics, with further specialization in optimization methods in 1997 at Finland—at the moment approximately 100 recognized publications with approximately 62 DOI papers. His main branch is Computational-mathematical Nonlinear/Inverse Methods Optimization. Casesnoves best achievements are the Numerical Reuleaux Method in dynamics and nonlinear-optimization [books 2019-2020], the Graphical and Interior Optimization Methods [2016-8], the new Computational Dissection-Anatomical Method, [2020] and invention of Forensic Robotics [2020-2021]. Dr Casesnoves scientific service since 2016 to the Free and Independent Republic of Estonia for technological development (and also at Riga technical University, Power Electrical and Electronics Department) is about 35 physics-engineering articles, two books series, and 1 industrial radiotherapy project associated to Europe Union EIT Health Program (Tartu University, 2017).

X. APENDIX

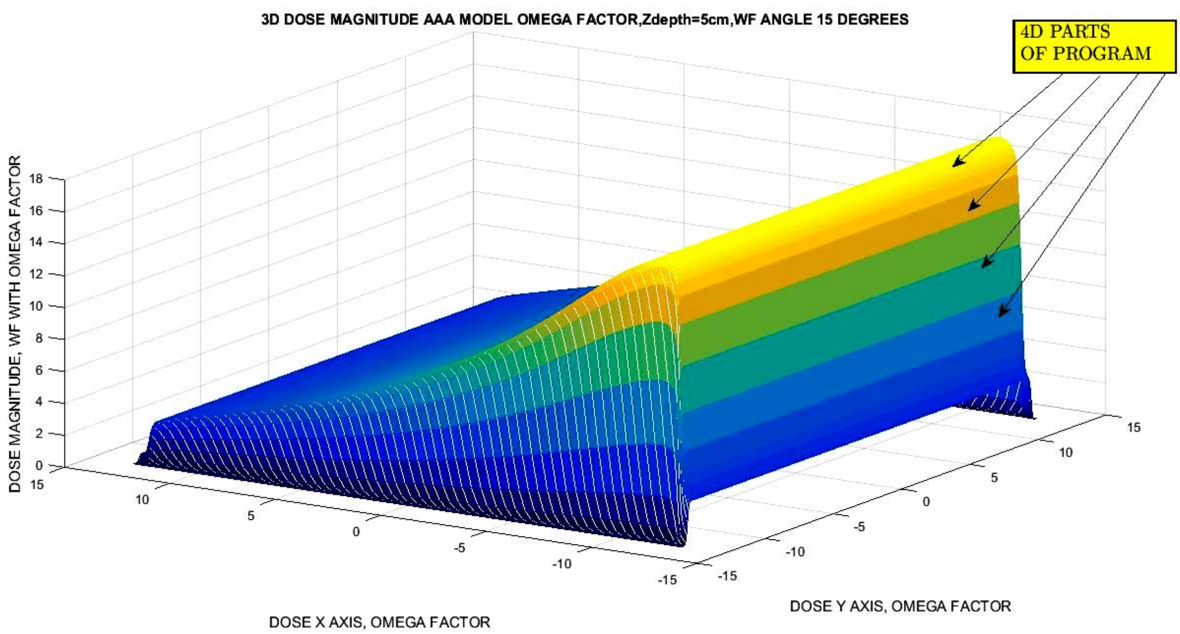

Figure 4 enhanced .- 4D inset details for Matlab simulation 3D image for 18 Mev photon-beam at 5 cm depth-dose with Omega Factor scaled to 102 . Matrices for Image Processing have about 103 elements. Imaging Processing Method 1.

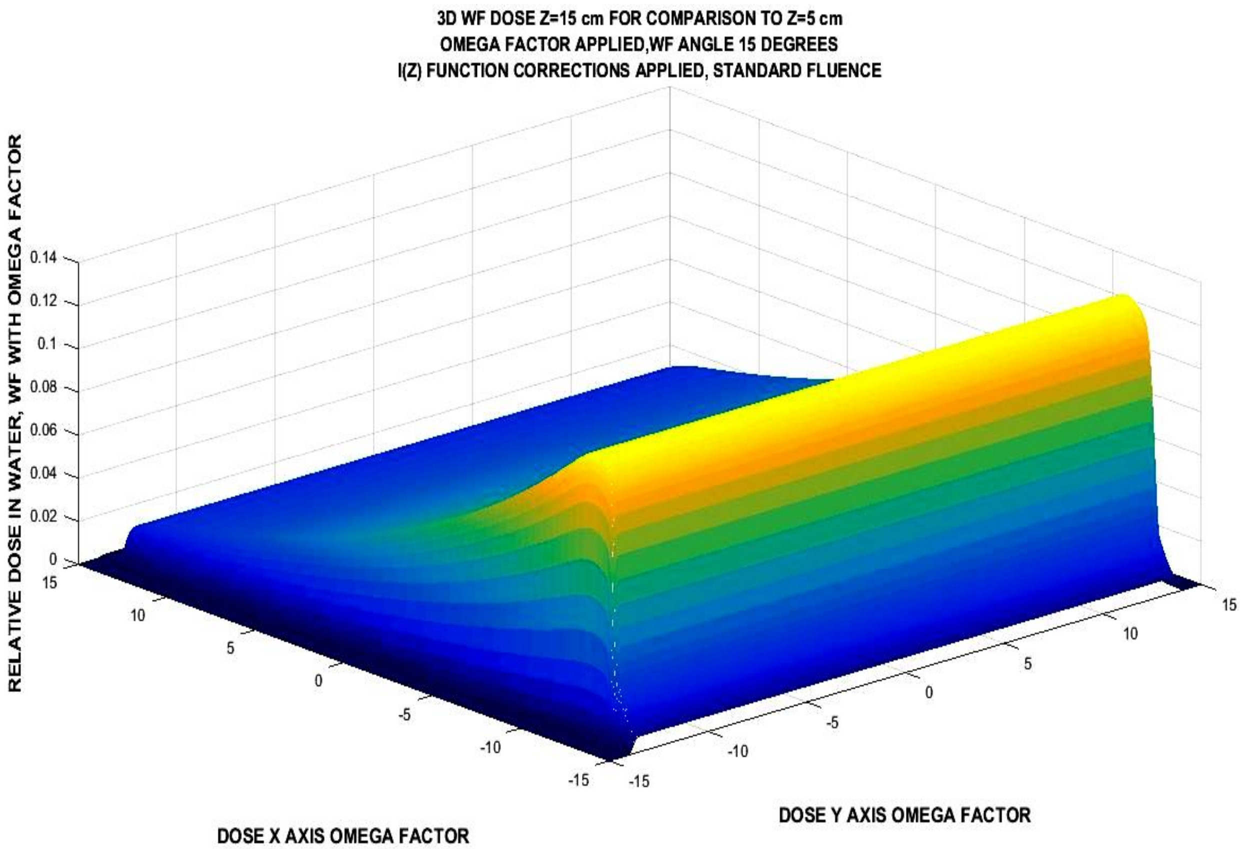

Figure 6 enhanced.-Comparative dose Matlab simulation 3D image for 18 Mev photon-beam at 15 cm depth-dose with Omega Factor. Matrices for Image Processing have about 103 elements. Imaging Processing Method 1.

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