THE 40 MeV MEDICAL BETATRON. EXPERIENCE VERSUS PREDICTIONS

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Abstract

Since the radiation beam parameter values given by the international documents are prediction and the obtained experimental values with the 40 MeV medical betatron are experiences, this paper presents a comparison between the measured values and the predicted ones. The results of the comparison are within normal limits.

1. INTRODUCTION

The 40 MeV medical betatron was built in the Institute of Atomic Physics, and was set up at the Fundeni Clinical Hospital in Bucharest. It supplies four electron beams with mean energies of 10, 15, 20 and 25 MeV and a 35 MeV X-Ray.

The 40 MeV medical betatron is a cyclic electron accelerator. Electrons emitted by a Kerst type 60 KeV energy injector are guided to move on a 50 cm diameter circular orbit. The orbit is crossed by a magnetic field, variable in time, with the maximum value of 5.4 kG. The electron gain energy from the electric field induced according to Faraday's law. When the electrons reached one of the above mentioned energy values, from the fixed control panel which is interconditioned with a mobile control panel located in to the treatement room, by means of a helipot, one may control the radiation beam extraction. The electron target made of platinum is 3 mm diameter.

The homogeneity of the electron beams is provided by a foils system consisting of two aluminium made dispersions foils and one filter for homogenezing the absorbed dose up to 20 x 20 cm^2 irradiation fields.

Each energy and field is employing a typical combination of foils and filters for homogenezing. The X-Ray beam homogenezing is performed by means of some lead-made homogenezing filters.

The 40 MeV medical betatron is also equipped with a laser for some combined radiotherapy and hyperthermic tretements.

Some electron and photon beam data from a prototipe 40 MeV medical betatron in Romania have been published [1-3].

In this paper we present all results of the absorbed dose calculations and measurements as well as their comparision with those recommended by the international standards [4-16].

2. APARATUS AND MATERIALS

In the electron beam operation mode of the 40 MeV medical betatron, the following measuring instruments were used for collecting the data: 1) an automatic therados system with related phantom, 2) a PTW FREIBURG dosimenter DL4/DI4 type no. 775 equipped with a M 23343 - type Markus ionization chamber and a M 23332 ionization chamber, 3) a Hewlett - Packard X, Y marker, 4) a plexiglas phantom and 5) Kodak XV film irradiated in a plexiglas phantom analysed with 6) Machbet isodensitometer.

In the photon beam operation mode, we used: 1) the same therados system with the related phantom and 2) the same X, Y marker of Hewlett-Packard type, 3) the PTW FREIBURG DL4/DI4 type no. 775 dosimenter equipped with the ionizing chambers of E 233641 - 290 and M 233641 - 291 type, 4) the tertriary standard dosimeter of FARMER type 25002/3 equipped with a ionization chamber 2505/3 and 5) the secondary standard equipped with the ND-1006/8113 type ionization chamber obtained upon the technical assistance programme ROM - 1/007 from IAEA - Vienna.

3. MEASURING CONDITIONS

The dosimetric measurements were performed from electrons with the 10,15, 20 and 25 MeV average energy at the entrance field as well as photons with 35 MeV peak energy.

The water phantom was placed as the source skin distance: SSD = 1000 mm and SSD = 1085 mm. The irradiation fields were the standard ones namely 10 x 10 cm^2 and 20 x 20 cm^2.

All the calculations methods for the absorbed dose were based on Bragg - Gray relations described in references [1 - 13].

4. RESULTS AND COMPARISIONS

The quality of the radiation beam employed in radiotherapy is determined by the following considerations: homogeneity, penumbra, symetry, the dose at the entrance field and the absorbed dose gradient.

The main results obtained by the measurements and calculationd made for the five beams genetated by the 40 MeV betatron (Fig. 1) are specified in Table 1.

Table 1 includes 5 columns out of which the first 4 columns represent the measured and calculated data and the 5th column represents the recommended values as per some international documentations on the radiation beam qualityes for radiotherapy or the reference literature containing the measuring method and/or the employed calculation method.

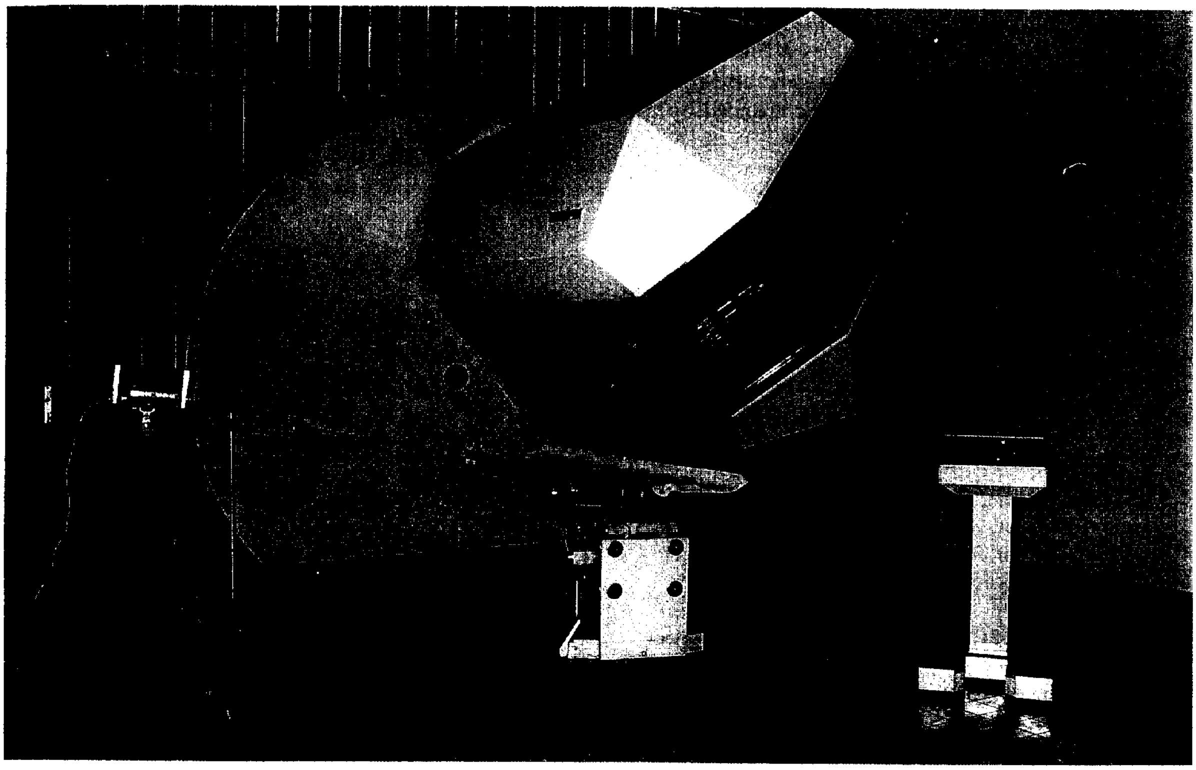

Fig. 1 The tretement room of the 40 MeV medical betatron

Table 1. Radiation parameters of the 40 MeV medical betatron.

Electron beam mode:					
Nominal energy E_n (MeV)	10.95	16.60	21.76	28.84	[4-7]
Probable energy E_p (MeV)	10.36	15.72	20.47	26.58	[4-7]
Mean energy E_0 (MeV)	10	15	20	25	[4-7]
Depth of dose maximum Z_M (mm)	26	38	30	30	[4-7]
Surface dose D_x/D_M (%)	80	90	92	94	[7-8]
Depth of reference plane Z_R (mm)	20	20	30	30	[4-5]
Bremssstrahlung contamination (%)	2	2	3	4	[8-9]
Therapeutical range R_{85} (mm)	36	53	65	70	[4-7]
Half value depth R_{50} (mm)	43	63	84	104	[4-5]
Practical range R_p (mm)	53	78	101	131	[4-7]
Depth R_q (mm)	35	59	65	73	[4-7]
Dose gradient (-)	2.7	2.9	2.95	2.34	2,5 [4]
Physical penumbra at Z_M (mm)	<--	11	- 12	-->	12 [5]
Homogeneity index (%)	<--	3	- 5 %	-->	5% [10]
Dose rate min (cGy/min)	150	200	180	250	[4-13]
Absorbed dose variation in the target volume [a] (%)	<--	±3	%	-->	± 5 % [7]
Ratio J_1/J_2 [b] (%)	<--	± 0.5	%	-->	± 1 % [4]
Absorbed dose mesurements on patients [c] (%)	<--	± 3	%	-->	± 5 % [5]
Ratio between the monitor reading and the determined absorbed dose value [d] (%)	<--	± 1	%	-->	± 2 % [5]
X-Ray mode:					
Energy ($h\nu$) (MeV)				35	[5,14]
Depth of dose max. Z_M (mm)				50	[4-7]
Surface dose (%)				38	[4-9]
Physical penumbra (mm)				9-10	[5,9]
Homogeneity index (%)				± 3 %	[15]
Dose rate min. (cGy/min.)				50	[4,15]
a, b, c, d, col5/col6	(± 3%; ± 3%; ± 2%; ± 1%) / (± 5%; ± 4%; ± 5%; ± 5%)				[4,5]

By comparing the data in the first 4 columns with the data in column 5, it results that the values obtained for the quality parameters of the radiation beams generated by a 40 MeV betatron correspond to the values recomanded by the international standards.

5. CONCLUSIONS

The conclusions results from the analysis of Table 1. The characteristics provided by the 40 MeV betatron meet ICRU and NACP previsions.

6. REFERENCES

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