Small fields and non-equilibrium condition for 6 and 18 MV photon beam dosimetry

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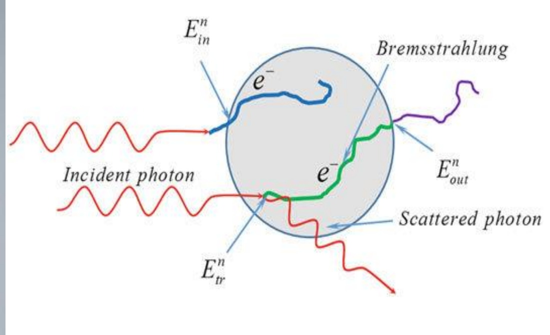
INTRODUCTION

- A number of detectors used in clinical dosimetry measure not the **absorbed dose**, but **Collision Kerma**.
- The presence of a constant ratio between the absorbed dose (*D*) and the collision kerma (*Kcol*) allows you to correctly calculate the absorbed dose.
- However, the picture is very significantly changed when moving to small fields, where quasi-CPE disappears. Such beams are used in modern IMRT, SRS, SBRT irradiation techniques.
- **Objective: studying the relationships between the spatial distributions of basic dosimetric quantities in water: absorbed dose, kerma and collision kerma, in the electronic non-equilibrium area for small circular fields of 6 and 18 MeV photon beams.**



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STANDARD CONDITION

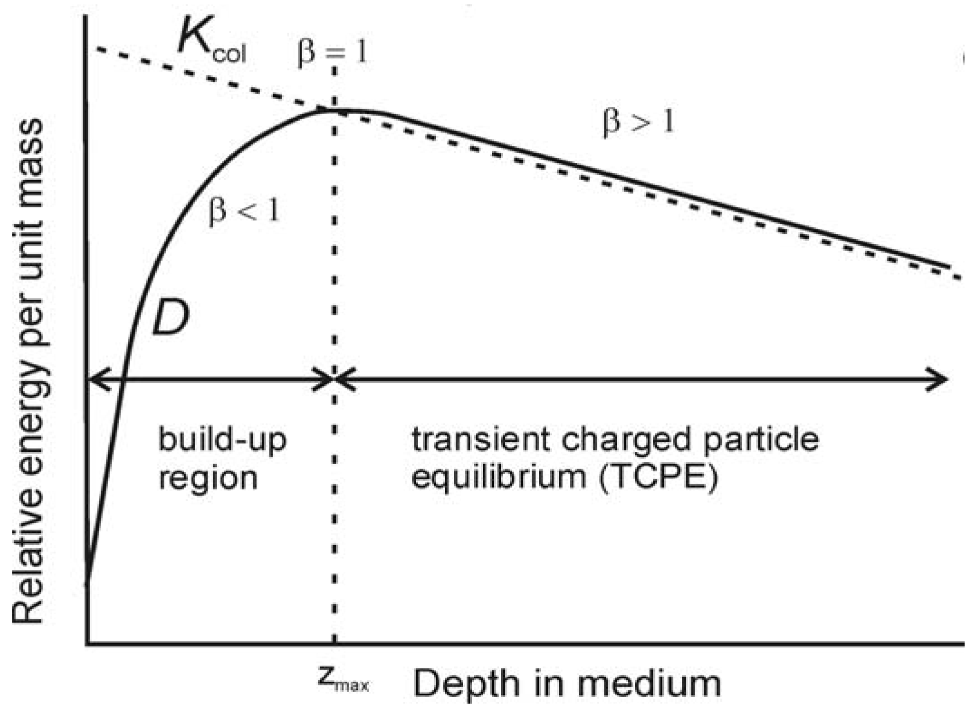

FIG.1. Collision kerma and absorbed dose as a function of depth in a medium, irradiated by a high-energy photon beam.

β=D/K$_{col}$ parameter for recalculating collision kerma into absorbed dose. Due to photon attenuation and scattering in the medium, a region of TCPE occurs (Fig. 1) where there exists an essentially constant relation between collision kerma and absorbed dose. This relation is practically constant since, in high energy photon beams, the average energy of the generated electrons and hence their range does not change appreciably with depth in the medium. [Attix F. H., 1986]

Problem of small field dosimetry (IMRT, RapidArc SRS, SBRT)

- The use of small fields in modern radiotherapy techniques leads to growing uncertainty in carrying out clinical dosimetry for which standard protocols are not suitable [TRS 398, TG-51].
- The first data on the issues of static small field dosimetry were collected in [Alfonso, 2008], and then IPEM Report103 highlighted practical aspects of non-standard beams dosimetry.
- In 2017, the IAEA TRS №483 was published dedicated to small field dosimetry for photons with the energy up to 10 MV. **Yet, far fewer papers have addressed the problems of small field dosimetry over 10 MV.**

What are small fields?

The radiation field is considered small if at least one of the conditions is performed [TRS 483] for external photon beam:

a) There is a loss of lateral charged particle equilibrium (LCPE) on the beam axis;

b) There is partial occlusion of the primary photon source by the collimating devices on the beam axis;

c) The size of the detector is similar or large compared to the beam dimensions.

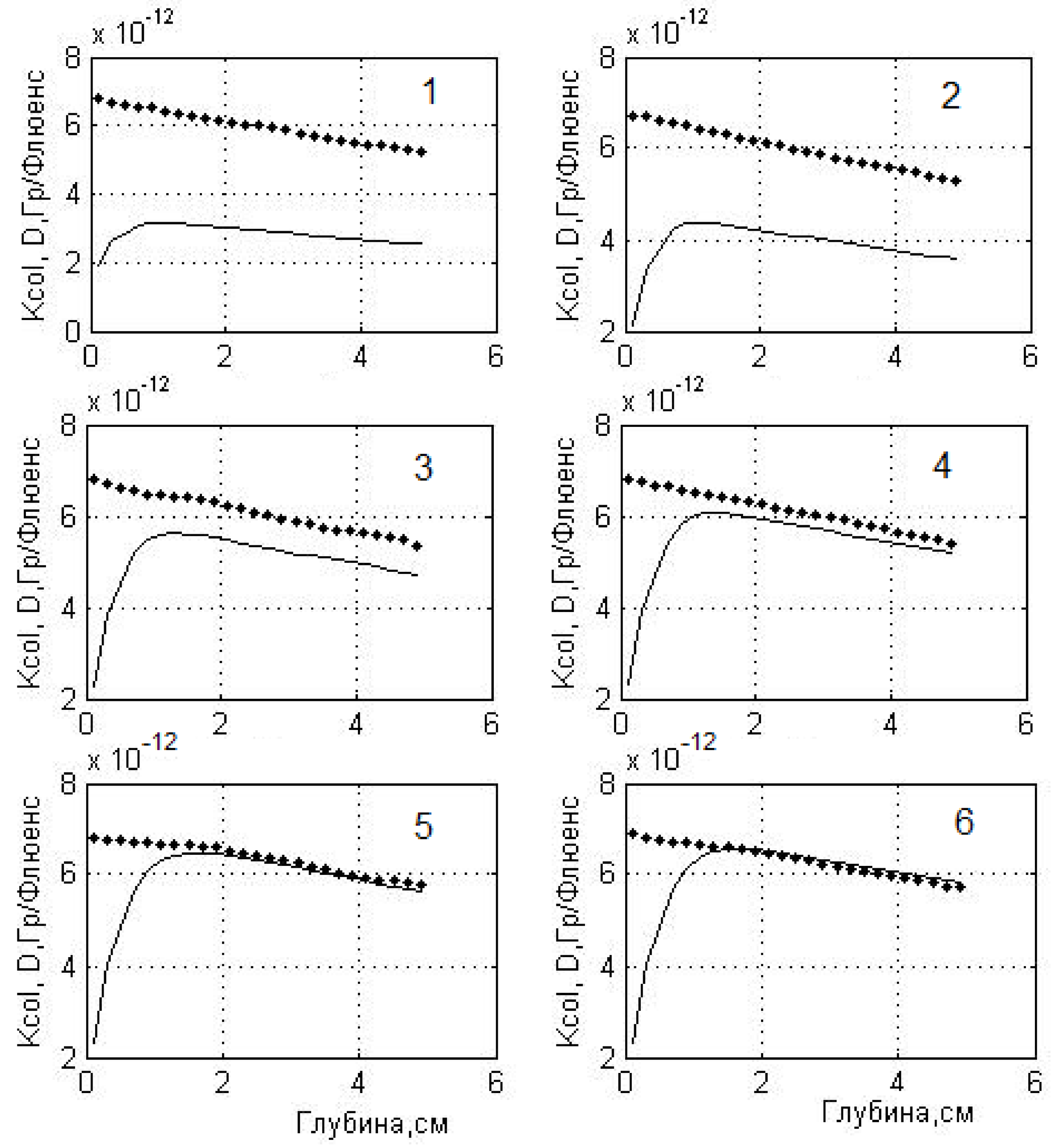

Fig. 2. Depth dose distributions (- -) and collision kerma (-) created in water by cone divergent 6 MV circular beams, with a distance from point source to phantom surface of 100 cm for different values of the section's radius on the phantom surface. Legend: 1 – 0.1 см; 2 – 0.2 см; 3 – 0.4 см; 4 – 0.6 см; 5 – 1.25 см; 6 – 2.0 см.

Materials and Methods

Spatial distributions of absorbed dose, kerma and collision kerma were calculated in a water phantom for photon beams with radius on the phantom surface from 0.1 to 3.0 cm and for depths from 0.1 up to 40 cm using the Monte Carlo method of codes EGSnrc and MCNP4C2. The build-up region has been studied in detail for both 6 and 18 MeV photon beams spectra.

Results and Conclusions

Results: The calculation results show that the ratio of collision kerma to kerma for both beams at depths up to 40 cm is almost constant and is equal to:

$$K_{col}/K = 0.993 \pm 0.0005 \ \ for\ 6\,MV\ beam;$$
$$K_{col}/K = 0.975 \pm 0.001 \ \ for\ 18\,MV\ beam;$$

D/Kcol ratio < 1 at radius of 1.5 cm for 6 MV and 2.5 cm for 18 MV at all considered depths in a water phantom in contrast to conventional square fields. The state of "dynamic" equilibrium between collision kerma and absorbed dose also occurs for small fields, but field size depend on the point of interest depth.

Conclusion: The data obtained indicate that the relations between the absorbed dose, kerma and collision kerma for photon fields created by photon beams of small cross sections differ greatly from those for traditional beams. This fact should be taken into account during of small fields dosimetry.

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