Title: kQ factors in modern external beam radiotherapy applications to update IAEA TRS-398

Abstract

The TRS-398 of IAEA, which is the leading code of practice in Europe for absorbed dose determination in external beam radiotherapy, urgently needs updating to incorporate the latest developments in commercially available ionisation chambers and treatment modalities. To achieve this $k_{Q,Q0}$ factors traceable to absorbed dose to water primary standards need to be measured and calculated for a selection of ionising chambers. This needs to be done in a selection of beam modalities such as conventional (filtered) and flattening filter free (FFF) MV photons, medium energy x-rays and proton beams.

Keywords

Dosimetry, External beam radiotherapy, IAEA TRS 398, Absorbed dose to water, Photon beams, Hadron beams

Background to the Metrological Challenges

A key step in the radiotherapy process is the requirement for consistent reference dosimetry traceable to metrological primary standards. Dosimetry equipment, mostly ionisation chambers, are usually calibrated in terms of absorbed dose to water in primary or secondary standards dosimetry laboratories (PSDLs and SSDLs). Medical physicists use the so-called Codes of Practice (written standards) based on $k_{Q,Q0}$ factors to transfer the calibration coefficient to beam qualities and modalities other than the calibration beam quality. This $k_{Q,Q0}$ factor corrects for the difference between the responses of a detector in the calibration beam quality, often ^{60}Co, denoted Q_0, and the actual user beam quality, Q. Dosimetry codes of practice such as IAEA TRS-398 are essential in ensuring that each patient treated (regardless which treatment modality) gets the dose as intended for the treatment.

The leading code of practice in Europe and globally for absorbed dose determination in external beam radiotherapy is the IAEA TRS-398. However, the data in TRS-398, were prepared in the mid-1990s and deals with calculated $k_{Q,Q0}$ values for clinical radiotherapy beams over a limited range of beam modalities under standard reference conditions, that is: conventional (filtered) megavoltage photon beams, electron beams, low and medium energy kilovoltage beams, scanned and scattered proton beams and carbon ion beams.. Since then there have been a number of new developments, such as the development of primary standards for absorbed dose to water in a number of new beam modalities and advanced Monte Carlo codes for simulation of detector response which allows for more accurate determination of kQ data, together with the implementation of new treatment modalities such as flattening filter free (FFF) MV megavoltage photon beams, small field megavoltage photon beams, scanned protons beams and hadron beams;. As a consequence IAEA decided that TRS-398 needs updating to incorporate all these new developments to underpin the safe introduction of the new techniques and treatment modalities.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on metrology research and provide validated sets of k_Q factors for ionisation chambers necessary for the future update of IAEA TRS-398 to be used in modern radiotherapy facilities in the following beam modalities: conventional (filtered) megavoltage photon beams (4 MV to 18 MV), flattening filter free (FFF) MV photon beams (6 MV and 10 MV), medium energy x-ray beams (100 keV to 250 keV) and proton beams (230 MeV).

The specific objectives are

1. To measure $k_{Q,Q0}$ values, traceable to internationally accepted absorbed dose to water primary standards, for a selection of ionisation chambers and beam modalities required for the TRS-398 update.
2. To calculate $k_{Q,Q0}$ values, performed with validated Monte Carlo codes, for a selection of ionisation chambers and beam modalities required for the TRS-398 update.
3. To validate the measured and calculated $k_{Q,Q0}$ values of the selected ionisation chambers and beam modalities and their resulting uncertainties with a target value around 1.5 % for high energy X rays.
4. To facilitate the take up of methods, technology and measurement infrastructure developed in the project by IAEA and end-users e.g. manufacturers of ionisation chambers. In addition, to ensure that the outputs of the project are aligned with the needs of IAEA and in a form that can be incorporated into the updated version of IAEA TRS-398 at the earliest opportunity.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.6 M€, and has defined an upper limit of 0.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies, in particular the IAEA,
- Transfer knowledge to the primary or secondary standards dosimetry laboratories, radiotherapy medical treatment sector and manufacturers of ionisation chambers and radiotherapy equipment.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.