External Beam Cancer Therapy

EURAMET
European Association of National Metrology Institutes

The need for the project

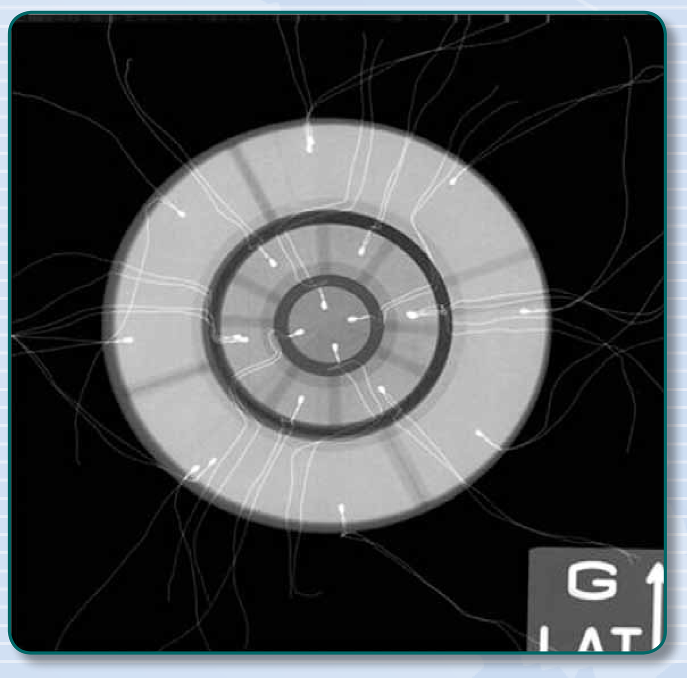
Approximately 1.3 million people will die due to cancer, in Europe, in 2011. Therefore, a way to improve patient treatment and increase survival is urgently needed.

This project aimed to improve dosimetry for high-intensity therapeutic ultrasound (HITU) and modern ionising beam radiotherapies. Therapies such as Intensity Modulated Radiation Therapy (IMRT) can be used to provide a more conformal dose distribution than conventional radiotherapy, thereby increasing the dose of radiotherapy to tumours, while sparing healthy tissue. However, to support the use of HITU further knowledge on the temperature of the 'dose' and its distribution during administration is required.

In addition, both HITU and IMRT techniques pose a challenge for dosimetry, due to the small size of the radiation field. The International Commission on Radiation Units states that the applied dose should have an uncertainty of less than 2.5%, but to achieve this, both the radiation and field size need to be precisely quantified.

Technical achievements

Dosimetry in small fields:
The measurand absorbed dose to water, (D_w) was measured using a graphite calorimeter and a water calorimeter with beam qualities 6, 10 and 12 MVX with field sizes of 10 cm x 10 cm down to 3 cm x 3 cm. The obtained uncertainties were as low as 0.3%.



Radiography of the core of the graphite calorimeter (LNHB) for the realisation of D_w in photon fields with a size down to 2 cm x 2 cm.

The calibration coefficients of ion chambers and the responses of alanine dosimeters determined in these fields showed no dependence on the field size within the limits of uncertainty. By Monte-Carlo simulations, the response of alanine was extrapolated for smaller fields (1 cm x 1 cm). No significant size dependence was found within the uncertainties. A diamond detector, developed in co-operation with the Roma Tre University, Italy, was used for measurements in the fields 1 cm x 1 cm, 6 and 10 MVX in comparison with alanine, and demonstrated limits of uncertainty of less than 1%.

Dosimetry for hadron therapy:
Measurements to demonstrate D_w in a 12C-beam with 280 MeV/u at GSI: The Centre for Heavy Ion Research in Darmstadt were performed successfully. The calibration coefficients of ion chambers were determined and were in agreement with the uncertainties given in the International Atomic Energy Agency (IAEA) report TRS 398.

HITU:
Better sensors for measuring spatial pressure distributions and total acoustic output power of HITU transducers were developed with the aim of determining the temperature applied with a higher accuracy. The first inter-laboratory comparison of HITU power measurement methods was successfully carried out.

Transportable water calorimeter (PTB) at the 12C beam line at GSI in Darmstadt, Germany.

Input to dosimetry standards

The project's beam quality correction factors (kQ factors) are being incorporated into an update of the German standard DIN 6800-2 *'Procedures of dosimetry with probe type detectors for photon and electron radiation - Part 2'*. The kQ factors will also be incorporated in a future version of the IAEA report TRS 398 *'Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry based on Standards of Absorbed Dose to Water.'*

Verifying dose delivery

The results of the project have supported two national dose verification studies for IMRT. In Belgium the quality assurance study BELdART will involve virtually all Belgian therapy centres. Whilst in the UK, a national audit was performed by the National Health Service and NPL, the UK's National Metrology Institute, between June 2009 and March 2010. The aim of both studies was to provide an independent check of IMRT delivery.

Validating the use of alternative detectors

Validated the use of alternative detectors, such as alanine and diamond detectors, as standards for IMRT. This offers new possibilities for calibration in situations where ion chambers cannot be used.

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