EMRP Call 2011 - Health, SI Broader Scope & New Technologies

Selected Research Topic number: **SRT-h14**
Version: 1.0

Title: Metrology for radiotherapy using complex radiation fields

Abstract

The treatment success of cancer patients depends considerably on the accuracy of the applied dose and knowledge of the radiation field. In modern radiotherapy, localisation of the dose distribution to the target volume is more and more improved involving locally strongly varying dose distributions. This is the case for all treatment beam types (high-energy photon, electron and hadron beams) and for all treatment modalities like e.g. IMRT, brachytherapy. The extension to small and composite fields of established reference dosimetry, which is based solely on measurements of dose at a point and on central axis depth dose data, introduces unacceptable measurement uncertainty. In addition, the dosimetry of these beams has not reached the same level of accuracy as that of conventional high-energy x-ray beams. The aim is to develop traceable measurement systems for the verification of dose and dose distributions and establish “dose area” primary standards for IMRT, rotational and stereotactic modalities (high energy) and introducing absorbed dose to water for medium energies in such complex fields. This will enable the clinical physicists to verify the dose calculated by treatment planning systems with a higher accuracy.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Health, New Technologies & Fundamental Metrology on pages 10, 21 and 22.

Keywords

cancer therapy, dosimetry for teletherapy (photon, electron and hadron radiation), dosimetry for brachytherapy, treatment planning, multidimensional dose distribution, dose verification

Background to the Metrological Challenges

Radiotherapy contributes to some 40 % of cancer cures while consuming a relatively small proportion of the estimated total cost of oncology. Thus radiotherapy is relatively inexpensive while being highly cost-effective as a treatment for cancer. The goal of radiotherapy is to kill the tumour cells and simultaneously to achieve a high survival rate of the surrounding healthy tissue. In the range with the highest dose effect to tumour cells the highest accuracy of the applied dose is required.

At present, the most critical regions for dosimetry are areas where an organ at risk is located in the vicinity of the tumour. In modern radiotherapy new methods with the capability to localise the dose to the target volume, i.e. volumes smaller than 0.1 cm^3, are more and more employed in clinics. Radiation fields with steep dose gradients are used. A variation of the dose of 80 % to 90 % in a range of a few mm is common. Up to now the dose measurement in such very small or composite fields is not standardised. For high energies, the treatment field sizes are today so small that current primary standards are not adapted, even with those established during the EMRP IMERA-Plus project “External Beam Cancer Therapy”. For medium energy, dose to the tumour calculations are still based on air kerma instead of absorbed dose to water (D_w). Thus, the traceability of the dose to the tumour to primary standards in terms of D_w is not fulfilled. This means, that there is no Code of Practice for dosimetry for so-called non-reference conditions, i.e. very small fields (smaller than 1 cm^2) or in regions with very strong dose gradients (up to 90 % in a range of few mm), as it is available for clinical reference dosimetry in large fields (10 cm x 10 cm fields).

In complex treatments, it is the large uncertainty associated with point dose measurements in the presence of steep dose gradients that presents the problem. The high-resolution information provided by two-dimensional and three-dimensional dose maps enables a more robust basis for the verification of complex dose distributions. For in-vivo dosimetry, such dose distributions must be measured non-invasively.

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Intensity Modulated Radiotherapy is a relatively new modality and a number of clinical trials designed to test IMRT are currently in progress or in development. Stereotactic radiotherapy, SRT, involves the use of a large number of very small beams precisely directed at the target volume from many independent directions. This makes possible, for example, the non-invasive treatment of tumours in surgically inaccessible regions of the brain.

The gap between established reference radiation fields, for which traceable dosimetry with acceptably small uncertainty is possible, and fields which are representative of much advanced radiotherapy, may be bridged by the development of protocols for reference class dosimetry in non-reference fields.

Scientific and Technological 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 JRP-Protocol.

The JRP shall focus on developing novel metrological tools, methods and reference standards for dosimetry in radiotherapy. This comprises traceable measurements of delivered dose and dose distributions for a variety of high-energy photon, electron, hadron, and carbon ion beams.

The specific objectives are:

1. Develop and compare new references in term of absorbed dose to water for medium X-ray energies;
2. Study new integral quantities for the characterisation of high energy X-rays for SRS and SRT (Stereotactic RadioSurgery and RadioTherapy) and IMRT (Imaging Modulated RadioTherapy) including new quality index, new calibration and transfer methods in static and dynamic modes related to treatment conditions and option for TPS beam model parameter;
3. Improve the consistency and traceability of proton and carbon ion beams, in particular novel types like scanned particle beams;
4. Develop traceable measurement system for the verification of dose and distribution in complex radiation field with strong variation of dose and small fields, and which are useable for the variation of treatment planning systems (TPS).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes, and it is expected that multidisciplinary teams will be required. To enhance the impact of the research this JRP will require a close cooperation with experts from the relevant medical area.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond the EURAMET funded Joint Research Project “T2.J07: EBCT / External Beam Cancer Therapy”.

The total eligible cost of any proposal received for this SRT is expected to be significantly above the 2.7 M€ guideline for proposals in this call.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (eg letters of support) is encouraged.

You should detail other impacts of your proposed JRP as detailed in the document “Guide 4: Writing a Joint Research Project”

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to the Medical sector.

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology. 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.