European Partnership on Metrology
Call 2025 – Health, Integrated European Metrology, Regulation and Research Potential

Selected Research Topic number: **SRT-h12**
Version: 1.0

Title: Metrology for diagnostic imaging using spectral computed tomography

Abstract

Spectral computed tomography (sCT) opens new diagnostic possibilities by providing quantitative data, but current approaches lack harmonisation of data acquisition and measurement systems which are required to characterise sCT radiation fields and patient safety. This requires traceable radiation dose measurements, and tested methods for personalised radiation dosimetry. Therefore, a metrology infrastructure needs to be developed to improve extraction of quantitative sCT data and to establish traceability for sCT dose measurements for emerging patient-specific dose estimation methods.

Keywords

Spectral computed tomography (sCT), X-ray computed tomography (CT), artificial intelligence, multi-energy CT, dual energy CT, photon counting CT, imaging biomarkers, dosimetry, personalised medicine, x-ray spectrometry

Background to the Metrological Challenges

Computed tomography (CT) is one of the most widely used imaging modalities in clinical medicine (more than 60 million examinations per year in Europe) and plays a key role in many different clinical applications, including cancer, cardiovascular disease, trauma and stroke. Today, Spectral computed tomography (sCT) with energy-resolved CT images opens a new horizon of improved tissue characterisation with the creation of virtual monoenergetic images, iodine maps, virtual non-contrast images, virtual non-calcium images and electron density maps. Quantitative imaging data are highly likely to be used for predicting the course of disease, patient risk assessments and timepoints for meaningful therapy adjustments based on changes in an individual patient. Robust quantification of disease processes with sCT will allow a targeted approach for treatment and monitoring (precision/personalised medicine).

In this case, the sCT images consist of spectrally resolved Hounsfield Units (HU) maps. Therefore, reliable extraction of quantitative data from these images requires traceable measurements of the physical quantity linear attenuation coefficient at specific x-ray photon energies based on well-characterised physical and virtual anthropomorphic reference phantoms. Various commercial phantoms exist for comprehensive testing, but independent verification of the phantom material properties is generally not performed.

Reliable quantitative data is a prerequisite for the extraction of imaging biomarkers but harmonised procedures within and across CT scanners linking quantitative imaging features with biological processes is lacking. Variability in sCT data acquisition, image reconstruction and analysis/post-processing, leads to unwanted variability in measurements and subsequent uncertainty in clinical decision making. Therefore, it is essential to ensure that all sCT-derived biomarkers are well characterised as measurands from a metrology perspective to enable reliable and reproducible clinical decisions based on those biomarkers. Complicating factors for sCT are the different approaches in acquiring energy resolved data including repeated imaging of body parts under different radiation conditions, (rapidly) switching x-ray tube voltages, use of two x-ray tubes operating at different voltages, use of layered energy-integrating detectors, or photon-counting detectors. There is a clear need for harmonisation of image acquisition, reconstruction, image analysis and post-processing and guidelines for quality assurance procedures and potential calibration should be developed.

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In addition, detailed simulations of the imaging detectors used are currently hampered by spectrometric methods that have not yet been adapted to clinical CT x-ray tubes. An International standard (IEC 61267) defines reference radiation conditions for use in the determination of characteristics of diagnostic dosemeters. Traceable calibrations for these reference radiation conditions are generally available. On the other hand, the standardised reference radiation conditions have not been adapted to new developments in CT and sCT, where new filters (e.g., made of silver, gold and tin) are used. To clarify some of these issues, the IEC (TC 62/SC 62B) is currently preparing a new IEC standard for sCT (IEC 63483).

Well-developed spectrometric measurement systems are also essential for the application of modern approaches for personalised dosimetry but as explained above, sCT technology still lacks a consistent metrological structure. With the development of new diagnostic possibilities in CT, the number of examinations is also increasing. This leads to an increased radiation dose to the population and thus to an increased excess risk of cancer. Overall, metrology for sCT dosimetry is not well developed to support the justification of the new and promising diagnostic approaches.

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 proposal shall focus on the traceable measurement and characterisation of diagnostic imaging using spectral CT to improve personalised diagnosis by CT applications.

The specific objectives are

1. To develop anthropomorphic reference standard phantoms (physical and virtual). This should include i) use of characterised materials and quality assured manufacturing methods for traceable measurements of the physical quantity linear attenuation coefficient at specific x-ray photon energies with Spectral computed tomography (sCT), and ii) a sensitivity analysis using these phantoms for the determination of material and electron densities as well as stopping power ratios.
2. To assess the variability of the physical quantities between multiple sCT scanners in a multicentre and vendor study using the anthropomorphic phantoms from objective 1. This should include the determination of a data set of parameters for harmonised imaging protocols to derive physical quantities and the development of guidelines for harmonised imaging protocols in patient studies to facilitate the exploitation of imaging biomarkers in sCT.
3. To develop metrological equipment and procedures for the spectral characterisation of sCT radiation fields. This should include i) development of approaches for the improvement of sCT imaging and personalised radiation dosimetry (e.g., measurement setups for spectrometry at clinical CTs) and ii) the application of the developed procedures on a representative set of sCT scanners for measurement of sCT spectra.
4. To develop a harmonised and validated procedure to facilitate personalised risk assessment in sCT and CT in clinical practice. This should include developing i) algorithms for AI-assisted data-driven personalised dose assessment, ii) algorithms for AI-based organ segmentation and matching methods, iii) calculations of organ-dose volume histograms based on real patient anatomies, and iv) testing the applicability of the procedure in a multi-centre study.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations (IEC TC 62/SC 62B), other stakeholders (European Society of Radiology - ESR, Radiological Society of North America – RSNA, European Imaging Biomarkers Alliance - EIBALL, Quantitative Imaging Biomarkers Alliance - QIBA, European Trade Association representing the medical imaging - COCIR, American Association of Physicists in Medicine - AAPM, European Federation of Organisations for Medical Physics – EFOMP, European Radiation Dosimetry Group - EURADOS, International Atomic Energy Agency – IAEA, International Commission on Radiological Protection - ICRP) and end users (e.g. clinical stakeholders, manufacturers of medical and healthcare products).

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, the involvement of the appropriate user community such as medical practitioners, medical (academic) hospitals and industry is strongly recommended, both prior to and during methodology development. Where relevant, proposals are encouraged to build on, or seek collaboration with,

existing projects and develop synergies with other relevant European, national or regional initiatives and funding programmes. In particular, links are encouraged with (i) the projects funded under earlier relevant topics of the Horizon Europe programme; or (ii) other relevant European Partnerships.

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

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.1 M€ and has defined an upper limit of 2.6 M€ for this proposal.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated 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 proposal's 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,
- Facilitate improved industrial capability, or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the healthcare, diagnostics and therapeutics sector.

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 the Metrology Partnership 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.

Timescale

The project should be of up to 3 years duration.

Additional information

The links provided in this section are only correct at the time of publication up until the end of the Call year.

These references have been provided by EURAMET.

[1]. EMN for Mathematics and Statistics (Mathmet) Strategic Research Agenda
https://www.euramet.org/european-metrology-networks/mathmet/strategy/strategic-research-agenda

[2]. EMN for Advanced Manufacturing Orientation paper 2025 Call
https://www.metpart.eu/component/edocman/call-2025-orientation-emn-advanced-manu-health/download.html?Itemid=0

[3]. EURAMET TC IR WG1 Orientation Page 2025 IEM and Health
https://www.metpart.eu/component/edocman/call-2025-orientation-tc-ir-wg1-iem-health/download.html?Itemid=0

[4]. EMN for Traceability in Laboratory Medicine (TraceLabMed) Orientation paper 2025 Call https://www.metpart.eu/component/edocman/call-2025-orientation-emn-tlm-health/download.html?Itemid=0

[5]. EMN for Radiation Protection Orientation paper 2025 Call https://metpart.eu/component/edocman/call-2025-orientation-tc-ir-wg1-iem-health/download.html?Itemid=0

[6]. EURAMET TC IR WG2 Orientation Page 2025 All calls https://www.metpart.eu/component/edocman/call-2025-orientation-tc-ir-wg2-all/download.html?Itemid=0