

Measuring the Invisible: A Conversation with the President of the ICRU

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Radiation is invisible, yet it has profoundly shaped modern medicine, science and our understanding of the world. From the diagnosis of disease to cancer treatment, from nuclear medicine to radiation protection, our ability to measure and describe radiation accurately has been fundamental to using it safely and effectively. For more than a century, the International Commission on Radiation Units and Measurements (ICRU) has played a central role in developing the concepts, definitions and recommendations that underpin this field.

As ICRU celebrates its 101st Annual Meeting in Acibadem Maslak Hospital, Department of Radiation Oncology, Istanbul, we had the opportunity to ask our questions to Prof. Vincent Gregoire, to look beyond the technical definitions and numbers, and explore the broader meaning of radiation in modern life. We discussed how radiation science has evolved over the past century, how advances such as proton therapy, MRI-guided and adaptive radiotherapy, FLASH and artificial intelligence are challenging established concepts, and what the future may hold for radiation medicine and protection. In this conversation, we also reflect on how ICRU can continue to connect science, technology and clinical practice in the century ahead.

1. How would you explain ICRU's role and mission in a few words? Why does ICRU matter today?

The objective of ICRU is to develop and promulgate internationally accepted recommendations on radiation related quantities and units, terminology, measurement procedures, and reference data for the safe and efficient application of ionizing radiation to medical diagnosis and therapy, radiation science and technology, and radiation protection of individuals and populations.

2. ICRU has been contributing to the science of radiation measurement and its use in medicine and radiation protection for more than a century. What do you see as ICRU's most important contribution over this remarkable journey?

There are many possible answers depending on the area of ICRU activity. I would highlight three major contributions

- (1) First ICRU has played a fundamental role in defining quantities and units of radiation and radioactivity. The best example is the definition of the *absorbed dose* in gray, which is used daily in Oncology in general and in Radiation Oncology in particular to prescribe a radiotherapy treatment.
- (2) Second, ICRU has developed procedures suitable for the measurement and application of these quantities in diagnostic radiology, radiation therapy, radiation biology, nuclear medicine, radiation protection, and industrial and environmental activities. In Radiation Oncology, examples are the definition of the target volumes such as the Gross Tumor Volume (GTV), the Clinical Target Volume (CTV) and the Planning Target Volume (PTV), as well as the Organ at Risk (OAR), which are all used on a daily basis when prescribing, reporting and recording a treatment plan. In Medical Imaging, I would mention the assessment of image quality in chest radiography, mammography and in computed tomography, and the patient dosimetry. In Radiation Protection, our work covered the

measurement of both physical and biological dose in individuals, the environmental measurements of radioactive dose after a nuclear accident, and the dose estimate to aircraft crew members.

(3) ICRU provides and evaluates physical data needed in the application of these procedures, the use of which assures uniformity in reporting. Examples include stopping-power data for electrons and positrons (Report 37), protons and alpha particles (Report 49), and heavier ions (Report 73). Report 90 reassessed key fundamental data used in ionizing-radiation dosimetry, including mean excitation energies and stopping powers

3. Radiation oncology has changed dramatically—from conventional radiotherapy to IMRT, stereotactic treatments, proton therapy and now MRI-guided and adaptive radiotherapy. How has ICRU evolved alongside these technological changes?

The fundamental concepts of application of ionizing radiation in radiotherapy were outlined in ICRU reports 29, 50 and 62. As radiation therapy has evolved, ICRU has progressively extended these concepts to modern techniques such as IMRT/VMAT, stereotactic treatment, MRI-Linacs, proton-and heavy ions therapy have been comprehensively described in reports 78, 83, 91, 93 and 97. A new report 101 on protontherapy is due later this year 2026.

4. Today, we are entering an era of increasingly personalized and adaptive radiation therapy. What new challenges does this create for radiation measurement, dose reporting and treatment quality?

The role of ICRU in that evolution is to ensure that we still understand each other through the use of similar language and concept so that patient care is still delivered with the same quality and understandability than today.

5. Artificial intelligence is rapidly entering radiology, radiation oncology and radiation protection. Do you think AI will change the way we define, measure and communicate radiation dose?

AI is likely to have a major impact on how radiation-related information is generated, analysed and communicated, particularly in image analysis, segmentation, treatment planning and adaptive therapy. In fact, this is already happening today. We have to ensure that the quantities and terminology used by AI-based systems remain physically meaningful and scientifically well defined. This will be particularly important if AI systems begin to propose new quantities or concepts that have not previously been defined or standardized.

6. Proton therapy, FLASH radiotherapy and other emerging technologies are challenging some of the concepts that have guided radiation medicine for decades. How should organizations such as ICRU respond when technology moves faster than our existing definitions and standards?

These technologies do not necessarily challenge the fundamental concepts. They challenge rather their implementation, and the role of ICRU is to guide the users by implementing wise and comprehensive recommendations for a safe use of these emerging technologies.

7. ICRU brings together experts from radiation oncology, medical physics, radiology, nuclear medicine and radiation protection. How important is this multidisciplinary approach for the future of radiation science?

Due to its multidisciplinary nature in essence, ICRU has always been composed of experts from many fields of radiation science at large, with biologists, physicists, and physicians. In addition, when needed, the report committees include additional expertise such as in Artificial Intelligence, computer science, and psycho-social science. It allows the ICRU reports to tackle the various subjects from a wide angle and with complementary expertise.

8. Looking ahead to the next 10–20 years, what do you think will be the biggest scientific or technological challenge for ICRU? And what would you like ICRU to achieve during its next century?

The major challenge for ICRU will be to continue fulfilling its mission in an environment of increasingly rapid scientific and technological change. We must remain scientifically rigorous while becoming sufficiently responsive to emerging technologies and new applications of ionizing radiation. ICRU needs to pursue its missions by convincing users that common guidelines and recommendations are the best move ahead for a better and safe application of ionizing radiation in various disciplines of our societies be it medical diagnosis and therapy, radiation science and technology, and radiation protection.