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Researchers report method to determine the absolute dose for new radiotherapy cancer treatment technique

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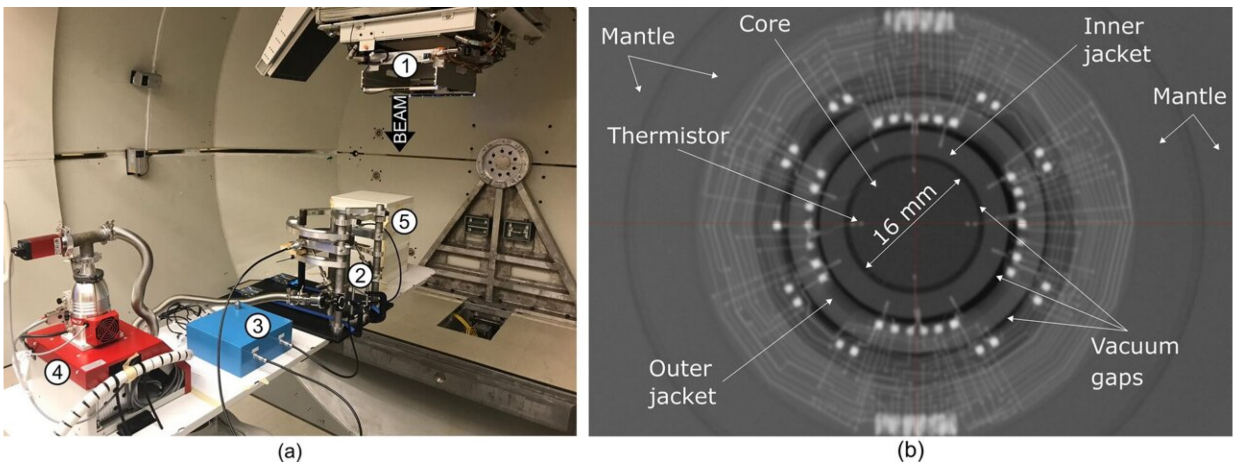

Experimental setup mounted on the patient couch and radiograph of the NPL PSPC. (a) (1) Gantry, (2) NPL PSPC, (3) measurement instrumentation for the NPL PSPC, (4) vacuum pump, (5) ionization chamber setup. (b) Radiograph of the front view of the NPL PSPC. Credit: *Scientific Reports* (2023). DOI: 10.1038/s41598-023-28192-0

Scientists at the National Physical Laboratory (NPL) have achieved an important breakthrough in the development of a new and highly accurate radiotherapy treatment for cancer called FLASH RT. The new treatment is as effective as current techniques but could also prevent unnecessary damage to healthy tissue and considerably shorten the time that patients spend in the hospital.

Using their pioneering measurement technology, NPL scientists measured and standardized the absorbed dose for a potentially revolutionary form of proton beam radiotherapy known as FLASH. The breakthrough led to the first in-human clinical trial of FLASH radiotherapy (RT) in 2020, which involved 10 patients at Cincinnati Children's Hospital's Proton Therapy Center in Ohio, U.S. The findings of the NPL team's research were published in the journal *Scientific Reports* in February, titled "Absolute dosimetry for FLASH proton pencil beam scanning radiotherapy."

The FLASH RT technique uses short pulses of ultra-high dose rate (UHDR) radiation to treat cancer. Currently, any form of radiotherapy results in some undesirable and unavoidable deposition of radiation to healthy tissues around the targeted tumor. Studies have suggested that treatment using UHDR radiation exposures could significantly spare healthy tissue while being at least as effective as treatments at conventional dose rates in controlling the tumor. This has been named "the FLASH effect."

Using an NPL designed and built device called a proton calorimeter, the NPL team conducted research to calibrate the UHDR radiation dose needed for treatments at a much reduced uncertainty of +/- 0.9%. The calorimeter quantified the amount of energy absorbed from the radiotherapy by first measuring the temperature rise caused by a typical patient treatment: and then converting it into "Grays" (Gy), the unit of measurement for ionizing radiation used in cancer treatment. For a typical patient fraction of 2 Gy, this would equate to a temperature rise of less than 0.003o C.

Radiotherapy is used around the world as a treatment in up to 50% of all cancer cases. It is by far the most cost-effective method of cancer treatment when compared to surgery and chemotherapy. Accurate dosimetry is essential to avoid errors which might cause incorrect quantification of dose delivered to the patient and flawed interpretation of the clinical outcomes related to the FLASH effect. It could also reduce considerably the amount of time that cancer patients spend in hospital, freeing hospital staff and equipment to treat more patients and reducing both post-treatment complications and costs.

NPL has been applying its metrology expertise to support collaborative research and development within U.K. health care for more than 100 years. In the past few years, NPL's Medical Radiation Science team has been actively involved in the pre-clinical and early clinical implementation of innovative new radiotherapy treatments such as FLASH RT by providing accurate and traceable dose measurements.

Ana Lourenço, Senior Research Scientist at NPL's Medical Radiation Science group, said, "This work has increased our understanding of the characteristics of this type of beams and will be invaluable in the development of future protocols to enable safe and accurate implementation in the clinic of this significant treatment technique. The work done during this trial has provided the hospital with the confidence to commence clinical implementation of this important new technology."

Russell Thomas, Science Area Leader of Medical Radiation Science at NPL, said, "In 2003, an exploratory project collaborating with Dr. Andrzej Kacperek, and his team at The National Center for Eye Proton Therapy [The Clatterbridge Cancer Center :: Eye Proton Therapy (clatterbridgecc.nhs.uk)], examined how NPL might support improvements in dosimetry for Proton Radiotherapy. That initial discussion grew into a 20-year long collaboration that has resulted in us developing not only a world-leading portable primary standard calorimeter for proton therapy but a device that we can use, directly in the clinic, to help standardize dose measurements from promising treatment techniques like FLASH and other ion therapies such as Carbon and Helium beams as they become more widely adopted by the clinical community."

"In support of the world's first in-human clinical trial (FAST-01) for proton ultra-high dose rate (UHDR) FLASH radiotherapy (FRT), the collaboration between Cincinnati Children's Hospital and the National Physical Laboratory was instrumental in validating the absolute dose methodology, using an advanced, NPL-designed calorimeter well suited for true absolute dose measurements, particularly in a high dose rate environment. The work from this collaboration is truly first-of-its-kind and of highly scientific and clinical value, as evidenced by multiple publications, presentations and invited talks at national and international conferences. We, in Cincinnati, regard the scientists from the NPL as part of our large, extended team that helped successfully launch FAST-01," said Anthony Mascia, Ph.D., Director of Medical Physics, Cincinnati Children's Hospital, Proton Therapy Center, University of Cincinnati, Department of Radiation Oncology.

More information: Ana Lourenço et al, Absolute dosimetry for FLASH proton pencil beam scanning radiotherapy, *Scientific Reports* (2023). DOI: 10.1038/s41598-023-28192-0

Provided by National Physical Laboratory