CLEAR study paves the way for novel electron-based cancer therapy

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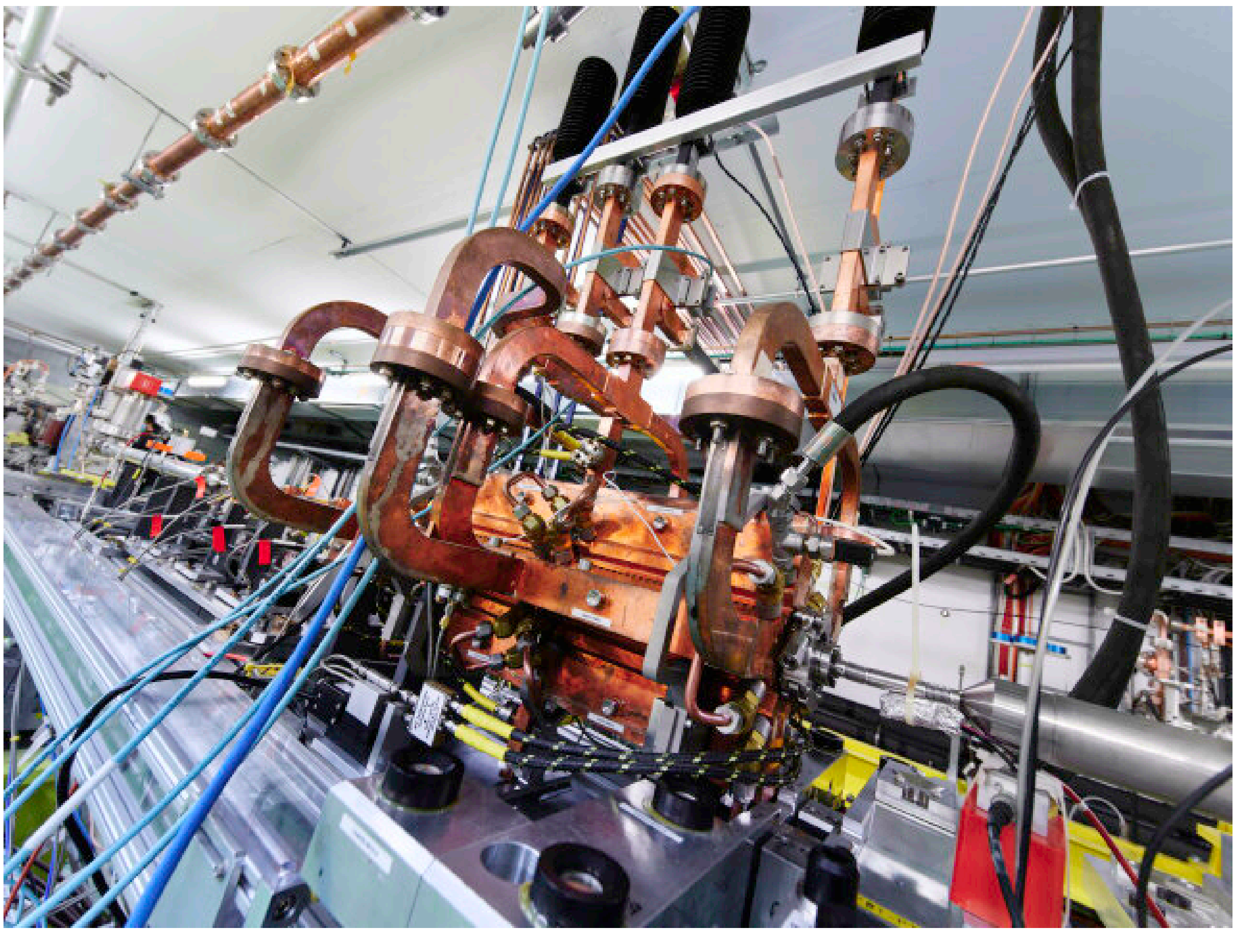

CERN's CLEAR facility, where tests on very high-energy electron beams were carried out. Credit: CERN

There are some cancer tumors that not even surgery, chemotherapy or traditional radiation therapy can cure. These resistant tumors contribute to making the disease one of the main causes of mortality worldwide, but the scientific community is teeming with ideas to make cancer fatalities a thing of the past. Among the latest medical and technological innovations, progress in particle therapy—the process of irradiating tumors using highly energetic particle beams generated by a particle accelerator—allows the treatment of tumors that would otherwise have been fatal.

More than 10,000 small electron linear accelerators (linacs) are currently used for cancer treatment worldwide. Most of these machines rely on photon beams generated by electrons to irradiate their target. Some, however, use the electron beam itself for direct low-energy electron irradiation, although this can only reach superficial tumors. These methods differ from hadron therapy, a technique based on irradiation with protons or heavy ion beams.

A possible complement to hadron and low-energy electron therapy is the use of high-energy electron beams, which can penetrate much deeper into tissues. However, this technique is rarely used due to the higher cost and larger size of the accelerator needed to produce them compared to photon facilities. In addition, their depth profile is less well defined than that achieved with hadron beams. Recent developments in high-gradient acceleration for compact linear accelerators, mainly driven by the CLIC study at CERN, have started to change the story.

A recent finding might constitute a further step towards the use of high-energy electron beams. Two studies involving the universities of Strathclyde and Manchester were carried out at CERN's linear electron accelerator for research (CLEAR), a test facility that serves research and development efforts on accelerator technology. Researchers tested a new irradiation technique involving very high-energy electron (VHEE) beams focused on a small, dense spot. By focusing a VHEE beam with a large aperture electromagnetic lens, they established that the particles could travel several centimeters deep into a water phantom (a large bucket of water used for studies on radiation) without significant scattering—that is, while remaining focused on a well-defined, targeted volume. Such a beam could thus theoretically be used to treat deep-seated cancerous cells with limited harm to the surrounding tissues.

This is promising news for the medical technology community for a variety of reasons: VHEE beams produced by compact linacs in clinical settings would not only offer a more cost-effective alternative to other particle beam therapies but would also provide doctors with a highly reliable medium, as their scattering in inhomogeneous tissue is limited. These factors could drastically expand the pool of patients eligible for electron therapy. Additionally, VHEE beams would be compatible with FLASH radiotherapy, a technique for delivering highly energetic particles to tissues almost instantaneously (in less than a second). CERN and the Lausanne University Hospital (CHUV) recently joined forces with the aim of building a high-energy clinical facility for FLASH therapy, with preliminary tests to be conducted at the CLEAR facility.

The ultra-focused VHEE beam is the direct fruit of advances in linear acceleration technology achieved by the CLIC study at CERN. It attests to the relevance of this field of research not only for particle physics but for society as a whole. Although VHEE beams require more research before practical applications in a clinical setting are found, the CLEAR results contribute to widening the field of possibilities for cancer treatment.

Provided by CERN

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