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Medical applications with heavy/radioactive ion beams

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Particle accelerator institutes have extensively contributed to biomedical research programs worldwide, which are of particular importance for their societal benefit and impact on human health. Ionizing radiation possesses the ability to directly damage the DNA structure of cells, causing DNA breaks, which can ultimately result in cell death.
This property has been used since many years for cancer treatment and sparked the interest of the nuclear physics research community to develop charged particle therapy at the end of last century. The technique exploits the Bragg peak of charged particles in order to reduce toxicity and improve local control compared to conventional X-ray based radiotherapy for cancer treatment. Cyclotrons and synchrotrons for charged-particle therapy are blooming worldwide and nowadays, the field is characterized by a fast succession of technological advances in additional to intense preclinical research programs on topics such as FLASH and spatially fractionated mini-beams with both protons and heavy ions. While the underlying radiobiological mechanisms of these new techniques are still a topic of active debate, several studies have already illustrated that these novel beam delivery methods largely reduce normal tissue toxicity in animal models.
In parallel, several imaging techniques are making use of radiation properties to improve the diagnosis and the efficiency of cancer treatments. This brings us to another, main medical application of accelerator produced beams, which is the production of radioisotopes for imaging, therapy, or both under the theranostics umbrella. Major advances in theranostics are expected by the introduction of α-particle and Auger electron emitting isotopes, due to their higher cytotoxic effectiveness to kill radioresistant tumour cells compared to more conventionally used β-emitters. Improvements in radiation dosimetry and genomic assessment of radiosensitivity will guide precision theranostics to avoid both undertreatment and off-target toxicity.
Research in space radiation protection also needs accelerators to simulate the cosmic radiation that astronauts encounter in the space environment and particularly beyond lower earth orbit. In fact, most of our knowledge on radiation risk in space comes from experiments at ground-based particle accelerators.
We are currently facing an era in which several new accelerator centers are under construction and existing facilities are upgraded. Those facilities will soon deliver their first beams of higher intensity and energy than we could ever produce before and all these institutes have ambitious biomedical research programs that are innovative and potentially can lead to breakthrough discoveries. High energy is obviously important for to mimic high energy cosmic rays for space radiation research, but can also be useful for particle radiography in order to reduce range uncertainty in particle therapy. The higher intensity can also be a potential major breakthrough in particle therapy, where ultrafast treatments are convenient for clinical workflow and the mitigation of the problem of moving targets. Finally, radioactive ion beams (RIB), one of the main nuclear physics topics that justify the construction of new nuclear physics facilities, are potentially an extraordinary tool for cancer therapy as they allow the online visualization of beams during irradiation and for the production of novel radioisotopes.

Attendance Type

In-person

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