From Physics to Cancer Treatment: Current Status and Advances in Radiation Therapy

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The challenging demand for particle physics has pushed the detector performance to very high limits both in terms of spatial and time resolution and the cross-fertilization between particle physics detectors and imaging tools is bringing real benefits to the medical field especially in diagnosis and treatment of disease. Accelerators are routinely used in hospitals for conventional cancer radiotherapy with X-rays as well as for the production of radioisotopes, which are used for diagnosis and treatment of cancer.

The main aim of radiation therapy is to deliver a maximally effective dose of radiation to a designated tumour site, while sparing the surrounding healthy tissues as much as possible. Conventional X-ray radiation therapy is characterised by almost exponential attenuation and absorption, and consequently delivers the maximum energy near the beam entrance, but continues to deposit significant energy at distances beyond the cancer target.

Hadron therapy or Particle therapy (protons and other light ions) can overcome the limitations of X-rays since hadrons/particles deposit most of their energy at the end of their range and these beams can be shaped with great precision. Hadrons allow for a more a conformal treatment of the tumour while reducing damage to surrounding healthy tissue. The use of protons and carbon has grown over the last 20 years; however, carbon ions are still in the research and development stage and for both protons and carbon more clinical studies are needed. In spite of concerted efforts made on the compactness and cost reduction the equipment is still relatively large and expensive, making such facilities economically challenging for most hospitals.

Rapid advances in development of compact high-gradient (~100 MV/m) linear accelerators in the last few decades are making Very High Energy Electron (VHEE) an interesting possibility to achieve more cost-efficient facilities and thereby give improved access to patients. However, much research is needed for delivering effective RT to a greater number of patients more economically and effectively.