# the Growing Impact of Proton Accelerators in Cancer Care

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Among the various applications of accelerators contributing to sustainable development goals, the evolutionary contributions of proton accelerators for cancer care are a major highlight. Proton accelerators of low to medium energy (Ep 10-30 MeV) are widely used for production of several radionuclides (RN) required for cancer imaging, mostly by positron emission tomography (PET) and hybrid PET/CT system in nuclear medicine (NM), as standard-of-care procedure for many cancers. Very high energy proton accelerator systems (e.g. Ep 230 MeV) are invaluable for high-end radiation therapy of cancer patients.

The cyclic accelerator, cyclotron and its compact version, medical cyclotron (MC, 10-20 MeV proton machines), have emerged as the mainstay for production of important radionuclides like 18F (110min), 68Ga (68min) for PET imaging of tumour metastases. Over 1200 MC are in operation globally (over 200 MC in Europe); tens of TBq of RN, mostly 18F, being produced daily. In recent years, daily production of 68Ga using enriched 68Zn target (by 68Zn(p,n) 68Ga reaction) has gained momentum. Development and adoption of appropriate technologies by the industry in rendering simplicity and ruggedness of the high-intensity proton cyclotron and associated targetry systems, have led to a paradigm shift in the production and distribution of these short-lived RNs.

Cyclotrons delivering 25 to 70 MeV protons are also of interest for (p,2n) and other (p,xn) reaction-based production of RNs like 67Cu, 47Sc, 68Ge, required for medical research as well as clinical use, e.g. 70 MeV cyclotron facility Arronax in France. The need for diversifying production options to secure the availability of 99mTc in large demand for NM imaging has led stakeholders (e.g. in Canada) to evince greater interest in proton accelerators for (p,2n) reaction on highly enriched 100Mo target.

Thanks to the emerging interest in 225Ac (10d), for targeted alpha therapy of tumours (e.g. prostate cancer), and which is producible through spallation reaction on thorium target, interest in using the limited number of high-energy proton Linacs (few hundreds of MeV) operating as multi-purpose R&D facilities (e.g. in USA, Canada) has been high. New high-budget projects are also underway. Another option is to use medium energy proton cyclotrons to produce 225Ac by 226Ra(p,2n) reaction, if successful technology development of encapsulated targetry system for the radioactive target 226Ra can be achieved soon.

Well over 50% of all cancer patients require radiation treatment at some stage of their management, with about 8 million cases being treated per annum. Electron Linacs continue to remain the mainstay for the external beam radiotherapy of cancer patients. There are additional superior features in the use of the high-LET energetic protons (>200 MeV), which is an option (hadron-therapy), for very precise and efficacious delivery of radiation to patients. This is especially invaluable in children and young women affected by cancer. The noteworthy technology extension from the 30 MeV cyclotron to the 230 MeV (proton) cyclotron for use in cancer therapy was first promoted by IBA company in Belgium. Such systems are likely to remain restricted in numbers and at a very few locations - for example, there are only three facilities in India (cf. over 400 electron Linacs) - the scope for their wider deployment can be envisaged in the future.

The impressive growth and sustained impact of the application of proton accelerators in cancer care, immensely contribute to the UN-SDG 3, ‘Good Health and Well-Being’. The IAEA support to its Member States, in terms of overall capacity-building and facilitation to technology adoption, guidance on quality assurance, safety, security and HRD, as well as by making available numerous relevant documents, has been very important.