NUCLEAR PHYSICS FOR MEDICINE - HADRON THERAPY

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The basic factor which determines the success of radiotherapy is delivering the highest possible dose of ionizing radiation to the tumor volume while sparing the neighboring critical organs and healthy tissues. Protons with energies from about 60 MeV to 250 MeV are useful for cancer treatment because of the phenomenon of the Bragg peak i.e. increasing of energy deposition the at the end of protons path in tissue and the well-defined range. Therefore, the unwanted doses to healthy organs, particularly the entrance dose, are minimal as compared to MV X-rays used in conventional radiotherapy. This is of particular importance to pediatric patients in whom the probability of later radiation-induced cancer should be minimized. Protons were first tested as a cancer therapy for humans at Berkeley Lab beginning in 1954, using 730 MeV cyclotron as the source of the proton beams. Now, more than 50 particle therapy centers, mostly clinically dedicated, are operational around the world and treated up to now almost 150,000 patients. In Europe between 2012 -2016 eight new modern proton therapy centers will be put in operation. In Poland, Kraków, the Bronowice Cyclotron Centre with two rotating scanning gantries, eye treatment room and the experimental hall will be fully operational in September 2015.

This boom in proton therapy started in the last decade, with introducing of the new techniques and technologies, frequently a spin-off from nuclear physics research. The new superconducting synchrocyclotrons allowed to minimize size and energy consumption of the dedicated medical accelerators. Active Pencil Beam Scanning eliminated application of mechanical collimators and compensators, which were expensive and produced unnecessary secondary neutrons. New detector developments, based on the position sensitive detectors, were applied for two-dimensional dosimetry and Quality Assurance of the proton beam. Since the uncertainty in beam range in patient remains one of the biggest problem of proton therapy, significant research concentrated on the development of methods for the range verification. Here, Positon Emission Tomography is applied for determination of activity of □+ isotopes induced by proton beam. Prompt gamma radiation and secondary particles induced in the patient body during the treatment are investigated for on-line determination the beam range. The research and development in nuclear physics will significantly contribute in the next years for the improvements of proton therapy and the outcome of the patient treatment.