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Proton Beam for Radiation Therapy –Requirements, Dosimetry and Quality Control

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In the last decade significant technological progress lead to the real boom in the proton therapy The major progress was observed in introduction of the active Pencil Beam Scanning (PBS) and construction of dedicated medical proton accelerators. The PBS technique allows to irradiate target volume spot-by-spot, without any mechanical collimation, leads to further reduction of the entrance doses and the unwanted scattered neutron component. Intensive research and development is oriented for decreasing the price of proton therapy by constructing the smaller, cheaper and energy efficient accelerators with integrated gantries, which can be installed also in the existing clinics. First prototypes of single-room superconducting synchrocyclotrons have been installed last year and applied for patient treatment (MEVION S250 and Proteus-One from IBA).
However, the PBS technique is very demanding both for accelerator and medical physicists. The beam parameters, such as energy, current, spot symmetry must be well controlled and stable in time. Energy distribution in monoenergetic beam should be minimized in order to obtain a sharp distal fall-off of the dose distribution in the irradiated tissue. The decrease the lowest clinical proton energy from accelerator to about 20-30 MeV would eliminate the application of mechanical range shifters for irradiation of shallowly sitting tumors. Stability of proton energy available at the treatment unit must be controlled for reduction of range uncertainties. The scanning time should be minimized in order to allow for sequential irradiation of this same volume (repainting) to avoid cold and hot spots in moving targets. Since the local dose rate in the cyclotron PBS is about 3 orders of magnitude higher than in proton scattering techniques thus dosimetry must take it into account possible recombination effects in ionization chambers and saturation of response in solid state detectors. All beam parameters are submitted to regular, time consuming Quality Control using specialized equipment for 2-D dosimetry, range verification, spot position, symmetry etc. The future solutions must require more automated solutions to reduce the workload and to increase the patient throughput.
All new technological solutions in delivery of proton therapy beams for clinical applications have to compete with the presently available systems.

Primary author: Prof. OLKO, Pawel (Institute of Nuclear Physics PAN)

Co-authors: STOLARCZYK, Liliana (Bronowice Cyclotron Centre, Institute of Nuclear Physics PAN, Kraków, Poland); KAJDROWICZ, Tomasz (Bronowice Cyclotron Centre, Institute of Nuclear Physics PAN, Kraków, Poland)

Presenter: Prof. OLKO, Pawel (Institute of Nuclear Physics PAN)

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