Microdosimetry of Charged Particle Beams Using MiniTEPC and MiniPIX Detectors

Leaders: Dr. Gennady Valentinovich Mytsin (JINR) and Dr. Marie Davídková (Nuclear Physics Institute ASCR, Řež, Czech Republic)

In the field of medical procedures, proton therapy, or proton radiotherapy, is a type of particle therapy that uses a beam of protons to irradiate diseased tissue, most often in the treatment of cancer.

Many features make proton beam therapy suitable to treat tumours, which are low-LET radiation resistant. The radiation-field biological action varies with the spatial coordinates inside the treated volume. As far as the RBE can be assessed from the radiation field quality, it should be known with high spatial resolution in order to optimise the therapeutic plan and its success. That is of specific utility when complex radiation fields, namely radiation fields with several radiation quality components, are used (IMPT for instance). The only available technique for such an aim is the experimental microdosimetry.

The TEPC is the master detector in microdosimetry. It measures pulse height spectra due to charged particles that ionize the filling gas. Charge particles can come from high-energy ion beams or fields, like in ion therapy and in space, or can be set in motion in the detector tissue-equivalent wall by uncharged particles, like photons and neutrons. Generally, large detectors are used in low intensity radiation fields, while very small detectors are required in very intense radiation fields, like those of ion therapy, to prevent pile-up distortions. For application in radiotherapy, mini TEPCs have been constructed. MiniTEPCs are cylindrical gas proportional counters of 1 mm or less of sensitive volume diameter.

The MINIPIX is miniaturized and low power radiation detector with particle tracking and imaging detector Timepix3 (256 x 256 square pixels with pitch of 55 µm). The MINIPIX chip is equipped with semiconductor sensor (standardly 300 µm thick silicon). The Timepix3 detector is position, energy and time sensitive: For each ionizing particle (e.g. X-ray photon) it digitally registers its position, energy, time of arrival and track shape - basically all information you can want. The other measures can be often calculated from the track shape (particle type, direction of flight, LET, charge).

The aim of this research - to test the ability of mini-TEPC and miniPIX detectors to properly measure microdosimetric spectra of different hadron beams. For this study, the JINR proton and carbon ion beams and Czech Proton Therapy Center scanning therapeutic proton beam will be used.