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Measurement of distribution of fast neutrons produced in ion beam therapy with the 3D sensitive voxel detector

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Ion beam therapy is a rapidly developing method for treatment of certain types of cancer. A main advantage of ions is that they deposit most of the energy at the end of their range according to the Bragg curve. Unfortunately, the ion beam often generates (by various mechanisms such as fragmentation) a substantial amount of secondary particles with longer range (protons and other light fragments, neutrons, gamma particles, X-rays and electrons). Thus, a certain fraction of dose is deposited by other than the primary ions outside of the planned volume. It is, therefore, very important to estimate and experimentally verify the distributions of these secondary particles.

It is particularly difficult to measure the distribution of fast neutrons generated by ions in tissue. Fast neutrons are usually detected via their interaction (scattering) with hydrogen nuclei (proton). The proton recoiled by neutron can be subsequently detected by various sensors. The problem is that certain fraction of secondary particles consists of protons as well. Therefore, it is necessary to distinguish protons recoiled by neutrons from protons naturally present in the sample.

In this work we present the experimental technique enabling the separation of fast neutrons from protons. The technique uses a 3D sensitive voxel detector composed of several layers of Timepix pixel detectors. These layers are interlaced with a hydrogen rich material (plastic) serving as a convertor of neutrons to recoiled protons. The device records the traces of all interacting radiation providing the timestamp and/or deposited energy for each single particle. A proton passing through the detector creates a trace in all layers, whereas a protons recoiled by neutron originates in the convertor inside of the structure creating a trace in the inner layers only. This way it is possible to distinguish the protons from neutrons with very high selectivity.

An initial experimental study to register the outcoming neutron radiation was performed at the Heidelberg Ion Beam Therapy Center (HIT) in Germany using medical proton and carbon ion beams. This work is carried out in frame of the Medipix Collaboration.

Primary author: Dr JAKUBEK, Jan (IEAP, CTU in Prague)

Co-authors: HARTMANN, Bernadette (German Cancer Research Center, Heidelberg, Germany); GRANJA, Carlos (IEAP, Czech Technical University in Prague, Czech Republic); OPALKA, Lukas (FBME, Czech Technical University in Prague, Kladno, Czech Republic); JAEKEL, Oliver (German Cancer Research Center, Heidelberg, Germany)

Presenter: Dr JAKUBEK, Jan (IEAP, CTU in Prague)

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