Prompt gamma imaging for online monitoring in proton therapy - the SiFi-CC project

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Over the last five years the number of proton therapy centres in the World has doubled. In Poland a new proton therapy facility Cyclotron Centre Bronowice (CCB) has been launched in Kraków in 2013. The accuracy of proton therapy could be improved if on-line monitoring of deposited dose became a standard in clinical practice. Different approaches for beam range verification (one-dimensional) or monitoring of deposited dose distribution (two- or three-dimensional) are being developed, exploiting different types of secondary radiation. One of them is prompt-gamma imaging, for which the detectors of the Compton-camera type featuring 3d reconstruction allow to obtain the richest information.

Physicists from the Jagiellonian University and the RWTH Aachen University have established a collaboration to develop a method for on-line monitoring of dose distribution deposited in proton therapy exploiting prompt-gamma radiation. In the first project called γCCB the relevant differential yields for gamma emission were measured at HIT Heidelberg and CCB Kraków. The new project focuses on development of a dedicated setup for prompt-gamma imaging, which will take advantage of the latest advances in scintillation detectors - fibres made from modern, heavy scintillators read out by SiPMs, hence the project name **SiFi-CC** (SiPMs and scintillating Fibre-based Compton Camera). The setup will have two modes of operation: as a Compton camera (CC), and as a coded-mask detector (CM). The CM system will consist of a multilayer array of scintillation fibres and a massive collimator with a specially designed pattern, and the CC system will be constructed of two arrays of fibres. The use of heavy scintillating fibres ensures high detection efficiency, excellent time resolution and good light output. The results of the initial simulations indicate that also the energetic and position resolutions are sufficient. The high degree of detector granulation and short duration of signals ensures high rate capability. Data from the detectors will be collected by a modern data acquisition system, based on the FPGA technology. This solution provides high throughput as well as the flexibility of the system needed to handle the two modes of operation.

The essential part of the detector development are tests in the close-to-clinical conditions. The experimental room available at the CCB would make a perfect environment for such tests, was it equipped with a laser guiding system and a beam nozzle of the same type as those used in therapy rooms. Installation of such a nozzle would allow to determine beam intensity and phase-space on the exit of the ion pipe. The first one is important for absolute normalization of experimental results, the second is crucial for simulations of expected detector response. This additional equipment would be beneficial not only for the presented project, but also for other physics experiments at the CCB.