Theses in Bragg Peak Online Monitoring

III. Physikalisches Institut B

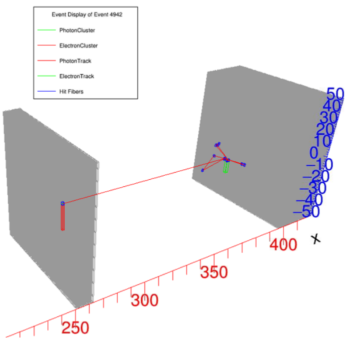
RWTH AACHEN UNIVERSITY

Ion therapy is a very precise tool in cancer treatment because of its characteristic longitudinal dose profile (Bragg peak). To optimize the precision of ion therapy, a real-time monitoring of the longitudinal Bragg peak position is needed. A promising approach towards online range verification in ion therapy is the analysis of prompt gamma radiation emitted by several nuclear processes. To detect these prompt gammas, we develop in a collaboration with the Jagellonian University in Krakow a **Si**PMs and scintillating **fi**ber-based **C**ompton **C**amera (SiFi-CC).

The SiFi-CC is built of heavy, scintillating crystals shaped into thin fibers and then glued together to two solid blocks. The blocks are the scatterer and the absorber plane of the Compton Camera. If the incoming photons interact first via Compton effect in the scatterer and then are absorbed in a second reaction in the absorber it is possible to confine the direction of the initial photon to a cone surface. By overlaying many of these cones we can reconstruct the distribution of the energy deposition.

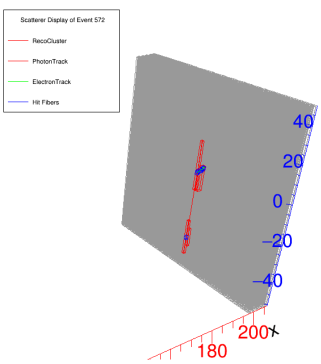
Master's Theses

Event identification for the SiFi-CC via machine learning



The ideal event to be reconstructed for a Compton camera is an event where the photon interacts via Compton effect in the scatterer and is afterwards absorbed in the absorber via photoelectric effect without any further interactions. In the ideal case both of these interactions happen in a well defined not wide spread area. But since the fraction of events that actually fulfil exactly these criteria is not high enough to reconstruct a Bragg Peak position events with a different signature needs to be used as well. To differentiate between different signatures of Compton events that can be used for the reconstruction and background events, a neuronal network can be used to sort the events in different event signatures. In this thesis it is your task to implement such a network and to optimize it for the simulated data of the SiFi-CC and to compare it to the existing event selection. For this thesis programming experience is advantageous.

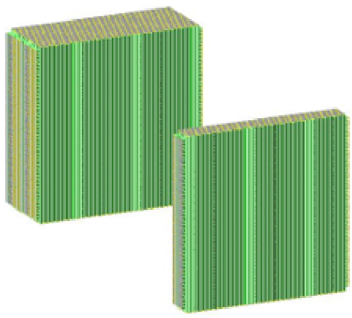
The SiFi-CC used as a Single Plane Compton Camera



A classical Compton Camera as the SiFi-CC depends on interaction of the photon in both, the scatterer and the absorber. All lot of events where the photon is actually scattered in one of the modules and interacts again in this module, but not in the other one, can not be used for the reconstruction of a Compton cone. The concept of a Single Plane camera is based on different energy depositions in two or more detectors that are placed in the same plane with respect to the source but next to each other. Based on this energy distribution, information about the original source place can be gained. Since the SiFi-CC modules are build in a very granular way, it is easy to subdivide a single module into sub-parts and so build the needed detectors for a Single Plane camera. In this thesis it is your task to use the data from the Geant4 simulation to test the capability of the SiFi-CC setup approach to function as a Single Plane camera and to determine the extra information that can be gained from this. As Geant4 and Root is run in C++, programming experience is advantageous.

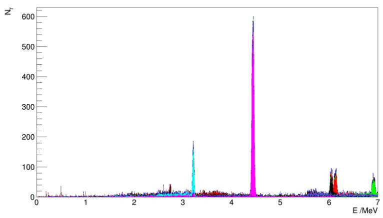
Bachelor's Theses

Simulation of a shielding for the SiFi-CC



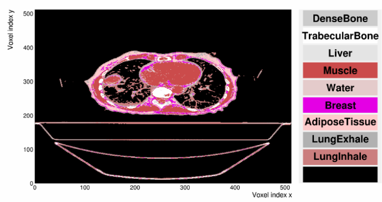
For reconstruction of the Compton cone, one needs the photon to interact in both the scatterer and the absorber. There are a lot of events where there is only an interaction in one of the modules or there are events with background interactions from additional particles. To identify particles leaving the camera without interaction an active shielding or veto detector could be build around the setup. To only stop particles from the outside, a passive shielding would be sufficient. In this thesis it is your task to implement a shielding in the Geant4 simulation of our Compton Camera and to evaluate its influence on the cleanliness of our event selection. As Geant4 is run in C++, programming experience is advantageous.

Evaluation of differences in gamma spectra from tumors



A Compton Camera evaluates the position of the proton beam inside the patient to monitor if this agrees with the position from the treatment planning. The even better approach would be to verify that the proton beam hits tumor tissue, but this requires differences in the gamma spectra depending on the origin of the gammas. These could be induced by naturally occurring differences in element concentration in tumors and healthy tissue or by tracers with prominent gamma lines which are accumulated in the tumor. In this thesis you will simulate gamma spectra in Geant4 which are produced by different target compositions and investigate if necessary concentrations for a notable change are feasible.

Simulation of the interaction of proton beam in a human body



The knowledge about the spectrum of the produced prompt gamma during the radiation therapy and the place where they are produced is crucial for the optimization process of a detector suited to detect this radiation. Since this cannot easily be measured during a actual treatment, a simulation of a treatment including the beam properties and a complex simulation of a human body can be used to determine the properties of the prompt gammas. Geant4 offers the possibility to load a dataset of a computed tomography scan and rebuild the corresponding geometry in Geant4. In this thesis it is your task to implement a human body based on a CT-scan in Geant4 and to compare the results with phantom measurements. The resulting phase space file can be used for the simulation of the SiFi-CC. As Geant4 is run in C++, programming experience is advantageous.

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