Investigations of nuclear reactions relevant in cancer therapy

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Goal of the proposed investigations is creation of the experimental database of cross sections for nuclear reactions in p+^{12}C, ^{14}N, ^{16}O and ^{12}C+^{12}C, ^{14}N, ^{16}O systems, in a broad energy range of 40-400 MeV/nucleon. The charged reaction products as well as neutrons and γ's will be measured. The data will be parametrized or general reaction models will be constructed. The results will be utilized in GEANT4 code, which will be adopted for precise calculations of the dose in hadron therapy. In parallel, studies on applications of the secondary reaction products to monitoring the deposited dose will be carried out.

One of the most important aspects in hadron therapy is a precise calculation of the dose during the therapy planning and real dose monitoring during irradiation itself. Both these aspects are of importance since small uncertainties caused by tissue in-homogeneity can result in a displacement of the Bragg peak into an adjacent organ and hence a corresponding undesirable irradiation of healthy tissue. These problems arise in the therapy with the proton beam as well as with the ^{12}C beam, however there are specific differences depending on the applied projectiles. The electromagnetic processes responsible for beam energy loss and the corresponding energy deposition in the tissue are well known. However, in order to achieve sufficient precision detailed knowledge of the nuclear reactions induced by beam in the tissue material is also required. For dose monitoring the secondary nuclear reaction products may be used. Presently, investigations are performed on the application of PET method utilizing reaction products with β^+ activity. Disadvantages of this method are a long time necessary for the measurement and displacement of the produced isotopes due to biological processes. These disadvantages may be eliminated when monitoring is based on neutrons or γ's, which emerge from the patient body without large distortions.

The best method for measuring the charge reaction products is the use of inverse kinematics. Therefore such measurements will be performed at GSI or Heidelberg, in collaboration with the group from RWTH Aachen University. At present a detection system for these measurements is constructed. At CCB measurements with the proton beam are proposed, with the detection of neutrons and γ's. The aim of these investigations is validation of the irradiation simulations and measurement of cross sections for neutron and γ emission. In these measurements a part of the presently being constructed system can be used. Test measurements of the detection systems constructed for the dose monitoring during irradiation are also planned.

There is a possibility to start measurements with the currently operating cyclotron at CCB. For that purpose a detection system for γ's with energy up to 20 MeV is necessary. Such measurements would deliver information about γ spectra and γ production cross sections close to the Bragg peak. Such experiments can be continued at FZ Juelich at higher beam energies. The results will form a very good basis for construction of a detection system for dose monitoring purposes.