ADVANCED RADIOTHERAPY MODALITIES WITH HADRONS AND DEVELOPMENT OF ACCELERATOR TECHNOLOGY FOR MEDICAL APPLICATIONS

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In this talk we shall describe briefly the role of radiotherapy within the available treatment modalities for cancer. Subsequently we shall define the goal of radiotherapy and discuss how the advanced radiotherapy modalities using accelerated hadron beams compare to conventional photon radiotherapy stressing its important advantages. Hadrontherapy, as it is called, encompasses two variants. The first one is called Ion Beam Therapy and implies the direct use of highly collimated and focused charged particle beams to aim at geometrically well defined and confined tumors. The simplest form is Proton therapy, namely the use of highly energetic proton beams. For cases in which the tumor is particularly radio resistant the ion of choice is carbon. Its advantage has to do with the much higher energy deposition density along the track of the ion which implies an enhanced radiobiological effectiveness, a concept also to be briefly defined. Along the talk we shall describe the types of accelerators used for these cases. The second variant is much more sophisticated and concerns tumors which are diffuse and infiltrating so that there is no well defined target to aim at. This unique and "second generation" modality is denominated a binary treatment since it consists of two steps. First, the patient is given systemically an otherwise harmless drug which carries a neutron capture agent capable of selectively being uptaken by the tumor, this is 10B, and secondly the patient is irradiated with neutrons. This methodology is known as Boron Neutron Capture Therapy (BNCT). Traditionally the neutrons are produced in nuclear reactors, but this is not practical since a reactor cannot be installed into a hospital. We shall concentrate on accelerators as neutron production sources giving a brief introduction.

In recent years we have started a program to develop accelerator technology for different purposes but in particular for Accelerator-Based Boron Neutron Capture Therapy (A-B BNCT). The main piece of equipment is a low energy (1.5 MV) and high current (multi mAmps) accelerator for neutron production. The final goal is a complete facility for AB-BNCT. This ambitious goal encompasses a large number of different R&D areas, ranging from mechanical and electrical structures, ion sources, special acceleration and beam transport devices, high voltage generating supplies, high vacuum systems, high power neutron production targets and neutron beam shaping assemblies, to neutron transport simulations, patient treatment room design and treatment planning simulations. In particular, the neutron production targets have to dissipate many kW of beam power and withstand large radiation and hydrogen damage effects while preserving their integrity for the largest possible time span. This poses challenging problems from the materials science and technology sector.

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