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Invited article

The INFN Experience in the Hadron Therapy Field

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Abstract

At Laboratori Nazionali del Sud of the Istituto Nazionale di Fisia Nucleare (LNS-INFN) in Catania the first Italian proton therapy center, named CATANA (Centro di AdroTerapia ed Applicazioni Nucleari Avanzate), has been realized.

CATANA was born from the collaboration between the LNS-INFN and the Catania University (Physics and Astronomy department, Ophthalmologic and Radiology Institute) and was realized to treat patients affected by ocular tumours (like choroidal and iris melanomas) using 62 MeV proton beams. Since February 2002, 110 patients have been treated coming from all Italian regions. In this work the actual status of the facility will be presented together with the idea of a new cycloron dedicated to the acceleration of light ions for hadron therapy.

Keywords: proton therapy, hadron therapy, cyclotron, ocular melanoma

Introduction

High energy protons represent a very promising alternative in the tumor irradiation, as respect the photon and electron beams. Proton beams, in fact, offer the advantage to improve tumor control, especially for the treatment of small tumors, where it is necessary to obtain a localized dose distribution while sparing the surrounding normal tissues [1, 2].

In Italy, the first and actually unique protontherapy facility, named CATANA (Centro di AdroTerapia e Applicazioni Nucleari Avanzate) was built in Catania, at the Istituto Nazionale di Fisica Nucleare-Laboratori Nazionali del Sud (INFN-LNS). Here a 62 MeV proton beam, produced by a Superconducting Cyclotron (SC), is used for the treatment of shallow tumors like those of the ocular region. The CATANA project was developed to treat ocular pathologies like uveal melanoma or choroidal haemangioma, conjunctiva melanoma, eyelid tumors and embryonal sarcoma.

The proton beam line

The CATANA proton beam line has been entirely built at INFN-LNS and its global view is shown in Figure 1. The proton beam exits in air through 50 μm Kapton window placed at about 3 meters from isocenter. Just before the exit window, under vacuum, is placed the first scattering foil made from 15 μm tantalum. The first element of the beam in air is a second tantalum foil 25 μm thick provided with a central brass stopper of 4 mm in diameter. The double foils scattering system is optimised to obtain a good homogeneity in terms of lateral off-axis dose distribution, minimizing the energy loss. Beam data are acquired with a silicon diode in a water phantom, at the treatment depth of 12 mm, corresponding to the middle of the Spread Out Bragg Peak (SOBP). Range shifter and range modulator are placed inside a box, downstream of the scattering system. Two diode lasers, located orthogonally and coaxially to beam line, provide a system for the isocenter identification and for patient centering. A key element of the treatment line is represented by two transmission monitor ionization chambers. The aim of the chambers is, respectively, to provide the on-line control of the dose delivered to the patient and of the beam symmetry. The last element before isocenter is the patient collimator located at 8.3 cm upstream of the isocenter. Finally, two Philips x-Ray tubes, with axes defined by crosshairs, are placed perpendicular and coaxial to beam line, to provide lateral and axial view of the tumor, during simulation of treatment [3].

Clinical results

Since March 2002, 110 patients with different ocular tumors have been treated at the CATANA facility. Most of them suffered from uveal melanoma (92%), that is the most common tumor of the ocular region in the adult. We have also treated other pathologies with proton beams, like conjunctival melanoma (4%), conjunctival rhadbomyosarcoma (1%), eyelid carcinoma (2%) and conjuntival Mucosa-Associated Lymphoid Tissue-Non Hodgkin Lymphoma (MALT-NHL) (1%). Among the 92 patients, THE 51% were women and the 49% men. Patient age ranged from 14-81 years (mean 55.6).

During the follow-up, the first data regarding local tumor control are available only after 6-8 months from the end of the treatment. Actually, we have the preliminary results of the follow-up for 56 patients at 6-8 months, and for 36 patients at 1 year. The local control is defined as a tumor shrinkage or cessation of growth at B-Mode ultrasonography, or as an increase of ultrasound reflectivity at A-Mode ultrasonography (a surrogate for tumor control). A size reduction, especially regarding the thickness of the tumor, was seen in the 75% of the patients, while the 25% maintain a stable dimensional lesion. An increased A-Mode

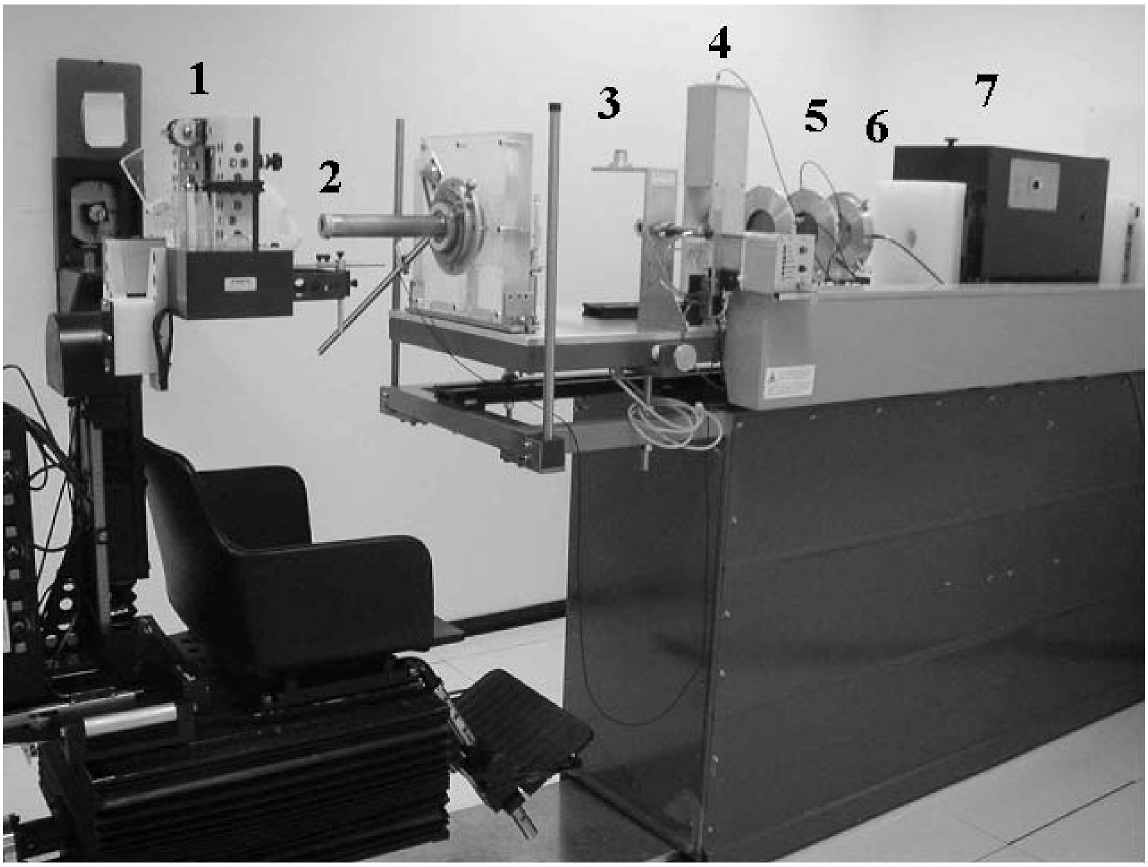

Fig. 1. View of the CATANA beam line: 1. Treatment chair for patient immobilization; 2. Final collimator; 3. Positioning laser; 4. Light field simulator; 5. Monitor chambers; 6. Intermediate collimator; 7. Box for the location of modulator wheel and range shifter

ultrasound reflectivity was detected in almost all patients. These data clearly show a tumor control, particularly for those patients with 1 year follow-up. No major side effects requiring eye enucleation have been detected and about 40% of the patients still maintain a useful visual acuity.

Perspectives and further initiatives

The radiation oncologist community is more and more interested in using light ions for tumor treatments. Usually the maximum energy of ions like carbon to treat the deepest tumors is 400 AMeV, up to now reachable with large synchrotron accelerator. But according to the distribution of the number of patients vs target depth treated world wide, it is possible to act with regard to 50-70% of cases using lower beam energy. In the case of treatment with the carbon ion, an energy of 300 AMeV is required to affect the most of tumors. These lower energies are achievable at cyclotron accelerators which are smaller and cheaper than a synchrotron. Moreover, its continuous beam and better current control are two crucial features allowing delivering the right dose on the target. To combine the advantages of a superconducting cyclotron with the goal of accelerating different species of ions in addition to protons, the accelerator R&D group of LNS has developed a concept for a multiparticle-therapy cyclotron, able to deliver carbon ions up to 300 AMeV and high intensity beam for radioisotopes production [6]. This is based on LNS Catania's extensive experience both with cyclotron technology and operation, and with its successful proton-therapy programme previously indicated. Finally, on the basis of existing experience and desired future perspectives about the hadrontherapy, we think that a medium-size facility for medical applications, based on the cyclotron machine, represents a good compromise between commercial costs keeping and benefit-effectiveness of use of this kind of therapy.

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