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Towards a European roadmap for using physics tools in the development of diagnostics techniques and new cancer therapies

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PHYSICS *for* HEALTH *in* EUROPE

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Accelerator based epithermal neutron source for boron neutron capture therapy

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Presently, boron neutron capture therapy is considered to be a promising method for selective treatment of malignant tumors. The results of clinical tests with nuclear reactors showed the possibility of treating brain glioblastoma and metastasizing melanoma not subject to treatment by other methods. The broad implementation of the BNCT in clinics requires compact inexpensive sources of epithermal neutrons. A low-energy accelerator has the potential for meeting the requirements. It is world-recognized that the best reaction is the 7Li(p,n)7Be reaction. This report describes the "best" epithermal neutron source created.

The novel tandem-accelerator with vacuum insulation is used to produce a 2 MeV proton beam with the current up to 10 mA. While the 7Li(p,n) reaction is excellent from the neutronics point of view, the mechanical, chemical, and thermal properties of lithium metal prevented it from being a candidate for a target. By now all problems of a lithium target have been solved, namely i) the effective cooling was implemented to keep lithium layer solid in order to preclude the propagation of Be radioactive isotope, ii) the controlled evaporation of a thin lithium layer was used to reduce the accompanying gamma radiation, iii) substrate materials as resistant to blistering as possible were found.

Thus, a pilot accelerator-based source of epithermal neutrons, which is specially designed for a wide use in oncology clinics for BNCT, has begun to operate successfully in the neutron generation mode. The facility is ready to measure neutron spectra and can be used for in vitro and in vivo investigations. We believe there is no technical reason that a machine capable of generating the current needed to deliver therapy in reasonable times could not be built.

Antiproton Cancer Therapy - Current Status and Future Plans

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The ultimate goal of radiotherapy is to maximize the dose to the tumor while minimizing the effect on surrounding healthy tissue. Heavy charged particle show a clear physical advantage over x-rays due to the inverse depth dose profile where the maximum of energy is deposited at the Bragg peak. Additional therapeutic advantages are expected compared to protons when using heavier particles through enhancements of the relative biological efficiency (RBE) of densely ionizing particles.

In 1985 it was proposed by Kalogeropoulos et al. to use antiprotons. Due to the annihilation at the end of range the physical dose deposited in the Bragg peak is enhanced by a factor of two. Additionally it is expected that the RBE is enhanced as part of the additional energy deposited locally comes from ion recoils and nuclear fragments.

Since 2003 the AD-4 collaboration at CERN has been studying the biological effect of antiprotons on V-79 Chinese Hamster cells. We have collected clonogenic survival data and initial analyses show enhanced biological effects tightly confined to the Bragg peak area. Based on these results we have performed comparative dose planning studies between protons, carbon ions, and antiprotons. Dose volume histograms can be used to analyze different scenarios. Additional activities of the collaboration include studies on real time imaging of the dose distribution and R&D on liquid ionization chambers and there use as LET measuring device.

In this talk we will present an overview of the experiment, the current status of the measurements, and describe plans for future studies.