MEASUREMENT OF THE SPATIAL DISTRIBUTION OF GAMMA RADIATION AT TANDEM ACCELERATOR WITH VACUUM INSULATION *

I. Schudlo#, D. Kasatov, A. Makarov, S. Taskaev
Budker Institute of Nuclear Physics SB RAS, Novosibirsk, Russia

Abstract

The experiments on generating 2 MeV proton beam with the current of 1.6 mA were carried out at BINP. During the experiments the spatial distribution of the bremsstrahlung dose rate was studied. According to the experimental results the suggestion of the reasons for the radiation appearance and ways to reduce it were made.

INTRODUCTION

At the BINP, the source of epithermal neutrons for boron neutron capture therapy of malignant tumors based on the tandem accelerator with vacuum insulation and a lithium target is created and put in operation [1]. The circuit source is shown at Fig. 1. The proton beam energy of 2 MeV and a current of 1.6 mA is obtained at the accelerator-tandem with vacuum insulation, marked by rapid acceleration - 25 kV/cm. Generation of neutrons occurs as a result of the threshold reaction $^7Li(p,n)^7Be$ while dumping the proton beam onto the thin lithium target with intense cooling.

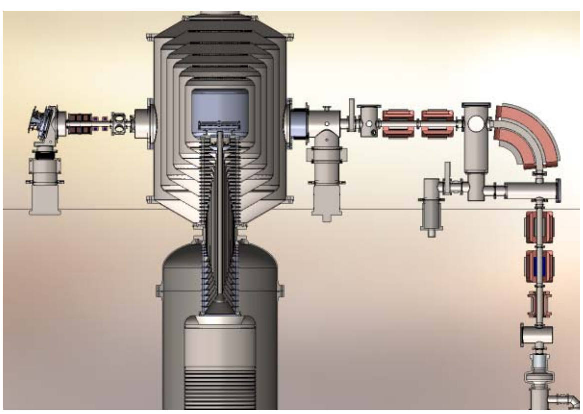

Figure 1: High-current vacuum insulation tandem accelerator.

To conduct BNCT it is required to increase the proton beam current at least up to 3 mA. But the increase in the injected current accelerator leads to unstable operation of the accelerator and requires research to ascertain the causes of the current limit. It was assumed that one of the beam current limitations is presence of accompanying electrons in the accelerator channel. The electrons are produced by the interaction of low energy beam of H^- ions with the residual gas in the input node of the accelerator. The electrons are accelerated to the full energy according the accelerator voltage and absorbed in the construction materials of the accelerator generating intense bremsstrahlung radiation. To investigate the electron current the experiment was conducted on measurement of the angular distribution of the accelerator gamma radiation.

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# Cshudlo.i.m@gmail.com

EXPERIMENTAL LAYOUT

During the experiment, the beam of accelerated protons with a current of 0.5 mA is measured by the Faraday cup, located at the accelerator output. Measurements of gamma dose are carried out using two dosimetry detectors Berthold LB-112. One detector is placed at a distance of three meters from the center of the accelerator at a 90 degree angle to the beam axis, the measurements with the second detector were carried out at different angles to the beam axis at the same distance to the accelerator. The detectors are located at the horizontal plane with the acceleration tract.

EXPERIMENTAL RESULTS

The measured gamma dose distributions are presented at Fig. 2 and 3.

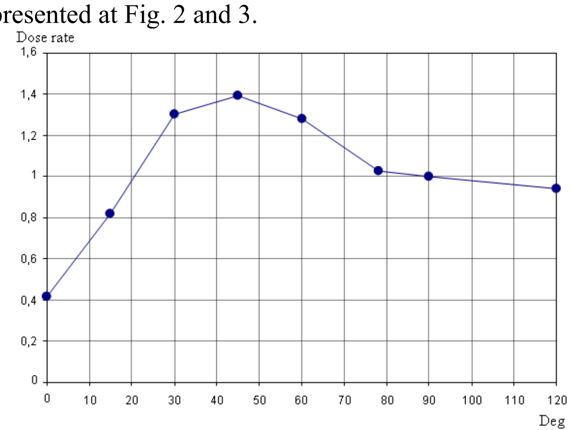

Figure 2: A gamma dose rate in dependence on the radiation emission angle. The value is normalized to the reading of the detector mounted at an angle of 90° to the beam axis.

The dose rate lowering at the angles 0°-30° is the result of gamma attenuation by the construction elements: the stripping tube and output pumping volume are located between the detector and the gamma source area. Actual trend should have higher values according to Fig. 3. Such a dose distribution having the preferred direction coinciding with the accelerated beam could be explained if the bremsstrahlung radiation is caused by the relativistic electrons.

Forward direction of radiation can be attributed to the direction of flow of electrons incident on the materials of the facility construction. The most probable process is the following: negative hydrogen ions injected into the accelerator ionize the residual and stripping gas at the entrance of the accelerator with high efficiency because the velocity of the injected particles is small. Arising in the area with the accelerator electric field, electrons are accelerated to the full energy by 1 MV voltage and thereof the appreciable part of electrons reaches the end of the stripping tube installed inside the high voltage electrode. Such a directed high-energy electrons flow causes the directed flow of the bremsstrahlung while absorbing in the construction metals.

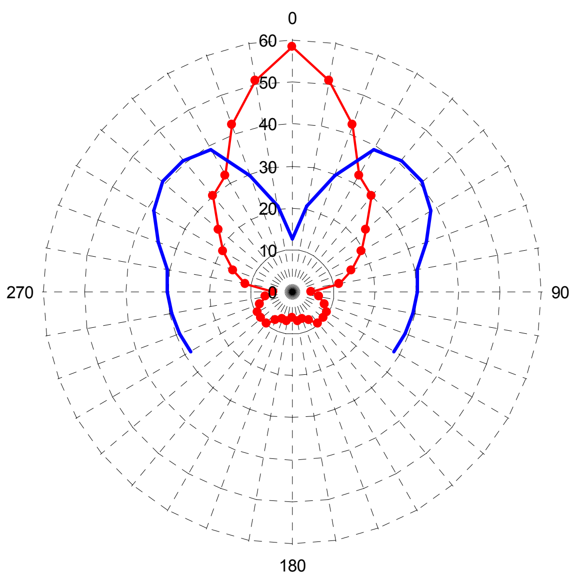

Figure 3: Angle distribution of gamma radiation. Blue line – experimental results, red line – theoretical dependence for the case of 1 MeV electrons dumped onto an iron [2].

SUMMARY

The measurements of the spatial distribution of the X and gamma radiation dose rate were carried out at the tandem accelerator with vacuum insulation. Directional effect of bremsstrahlung is discovered, which is described as radiation of 1 MeV electrons. This result confirms the assumption that a significant current in the accelerating gap is a result of the interaction of the injected and accelerated beam of charged particles with a residual and the stripping gas. The understanding of the processes allows one to propose suggestions for the modernization of the accelerator in order to obtain 3 mA proton beam.

REFERENCES

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