a high quality detalization. The developed program allowed to display the coordinates of the beam, its dimensions and the total current. The use of a modernized scanner made it possible to detect the effect of space charge and the effect of spherical aberration of focusing magnetic lenses on a beam of negative hydrogen ions.

Conclusion

The OWS-30 wire scanner was upgraded to suppress secondary electron emission. For the first time, a new method for measuring the phase portrait of an ion beam was proposed and implemented. A diaphragm was introduced into the beam in front of the wire scanner and the profile of the passed beam was measured. Methods for calculating the position, dimensions of the beam and calculating the total current, are proposed and developed. Software for displaying beam parameters has been developed. The use of the modernized scanner made it possible to optimize the injection of a beam of negative hydrogen ions into the accelerator, which led to an increasing in the proton current and an improvement of the accelerator stability. The modernized scanner with an additional program for processing the results data and visualization has become a reliable device for beam diagnosing and for controlling its entry into the accelerator.

Keyword: vacuum-insulated tandem accelerator, BNCT, profilometer

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Visualization of a negative hydrogen ions beam in a vacuum insulation tandem accelerator

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Introduction

A source of epithermal neutrons based on vacuum-insulated tandem accelerator and a lithium target was proposed and developed for the technique of boron neutron capture therapy. A stationary proton beam of 2 MeV with a current of up to 6 mA was obtained in the accelerator. High acceleration rate (up to 25 kV/cm) and a strong input electrostatic lens that determines the trajectory of the ion beam and the heating of the accelerator elements characterize the accelerator. It was necessary to develop a diagnosis of the position

of the beam and its size in the accelerator for optimal beam injection into the accelerating channels.

Materials and Methods

The work was carried out on an accelerating neutron source created at the Budker Institute of Nuclear Physics. It is proposed to detect the optical radiation produced by the interaction of ions with the residual and stripping gas. To convert negative hydrogen ions into protons a stripping target with argon gas is used. Registration of optical radiation is carried out by two network cameras DS-2CD4025FWD-A of Hikvision, aimed from above and from the side to the diaphragm of the first intermediate electrode providing a potential of 160 kV. A software was developed that connects to cameras, calculates position and beam dimensions and stores these parameters in a local database. The program was developed using the Qt 5.8 framework in C++.

Results

On the video image from the cameras, the luminescence due to the interaction of the accelerated ions with the residual and stripping gas was clearly recorded. Software was developed that processes frames from both cameras and displays information about the position and size of the glowing area in real time. The use of the developed diagnostics made it possible to control the ion beam along the axis of the accelerator with the use of correctors installed in transportation path. The use of the developed diagnostics made it possible to explore the effect of a magnetic focusing lens installed in the transportation path of negative hydrogen ions beam and the effect of the potential of the first accelerating electrode on the beam size. Optimization of ion beam injection into the accelerator allowed increasing the proton beam current up to 6.7 mA and increasing the stability of the accelerator.

Conclusion

Optical diagnostics has been developed and introduced, which makes it possible to monitor the position and size of the ion beam accelerated in a vacuum-insulated tandem accelerator. The use of diagnostics made it possible to optimize the injection of a negative hydrogen ions beam into the accelerator, improve the stability of the accelerator and increase the proton current.

Keyword: vacuum-insulated tandem accelerator, BNCT