MEASUREMENT OF THE ION BEAM PROFILE WITH THE D-PACE WIRE SCANNER*

E.O. Sokolova#, D.A. Kasatov, A.M. Koshkarev, A.N. Makarov, I.N. Sorokin, I.M. Shchudlo, S.Yu. Taskaev, BINP SB RAS, Novosibirsk, Novosibirsk State University, Russia
A.A. Gmyrya, Ya.A. Kolesnikov, A.S. Kuznetsov, BINP SB RAS, Novosibirsk, Russia

Abstract

In The Budker Institute of Nuclear Physics the accelerator-based source of epithermal neutrons was invented and now operates to be used in the Boron Neutron Capture Therapy (BNCT) [1]. For several reasons the real beam flow in the facility differs from the calculated one. To take into account this distinction it is necessary to provide continuous monitoring of the beam parameters. This paper describes the method of diagnostics of the ion beam with the D-pace wire scanner and the results, which were obtained, using this method.

INTRODUCTION

The principle of operation of the facility is as follows. The negatively charged ion beam is generated on the ion source, then it is injected in the tandem accelerator with vacuum insulation. After a recharge of negatively charged ions of hydrogen into positively charged protons in the gas stripper a proton beam is formed, which is accelerated to the doubled potential of the high voltage electrode. On the lithium target, as a result of a threshold reaction $^{7}Li(p,n)^{7}Be$, the neutron flux is generated [2].

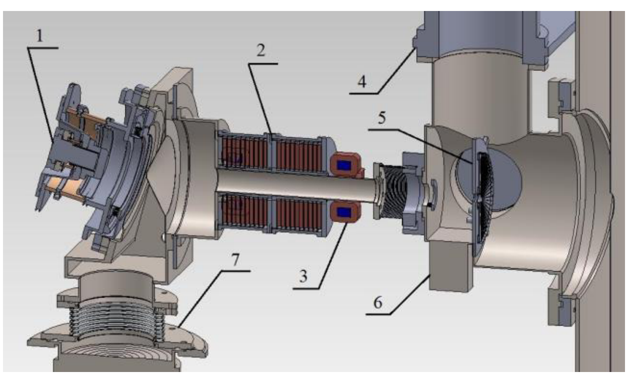

Figure 1: Low-energy part of accelerator. 1 – H^- ion source, 2 – magnetic lenses, 3 – corrector, 4 – cryosorption pump, 5 – cooled diaphragm, 6 – D-Pace wire scanner, 7 – differential pumping system.

Figure 1 shows the view of low-energy part of the facility, where the measurement of the beam profile was carried out. Between the diaphragm and the first electrode the beam is accelerated by the electromagnetic field. In the area of the diaphragm the powerful electrostatic lens is formed, also the accelerating field falls into the collimator of the diaphragm, as it could be seen in the figure 2. This phenomenon could lead up to the refocusing of the beam, in this way it could become strongly divergent and the emittance could increase significantly. Moreover, a huge part of the beam could be lost, as it wouldn't fall into the gap of electrodes, setting on their surface, which could lead up to redistribution of voltage and to electrical breakdown as a result [3].

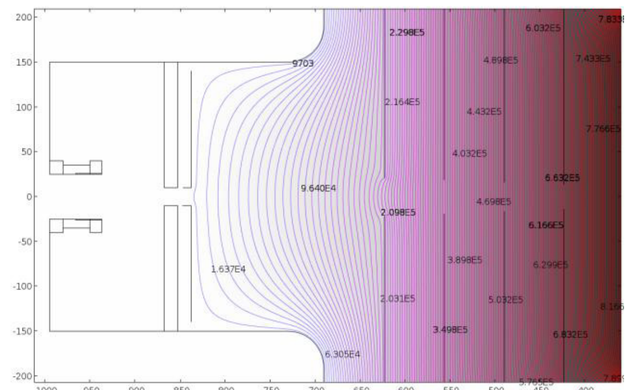

Figure 2: Calculated field distribution inside the vacuum chamber at the entrance to the accelerator.

In order to take into account the described phenomena it is necessary to monitor the beam thoroughly, since the beam should be led with minimal losses. In this way, it was proposed to install The D-Pace OWS-30 Oscillating Wire Scanner Probe (TRIUMF-Licenced) inside the vacuum chamber before the diaphragm. For this purpose the necessary changes of the design of the vacuum chamber were implemented, which allow to set the device with the possibility of adjustment of its position.

RESULTS OF EXPERIMENTS

The experiments were carried out under different conditions of focusing and current of the ion beam. In the standard mode the current is supplied to the lenses is 54 A, to the corrector 2.4 A.

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#e-mail: buiya@bk.ru

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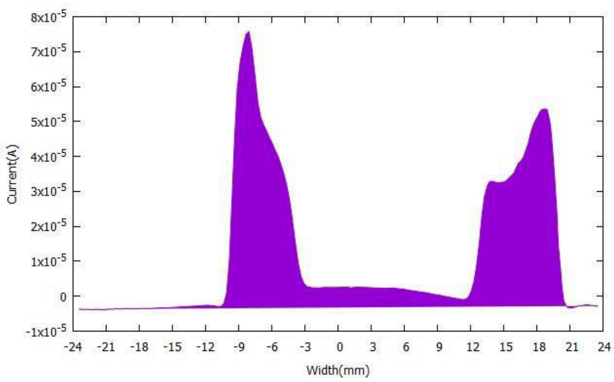

Figure 3: Readings of the wire scanner in the standard mode.

In the figure 3 there are two distinct peaks, each of which is a result of scanning by a single wire. One peak is the X-beam profile, measured by one wire, and the other is the Y-profile, which is obtained by the second wire. The center of the distance between the peaks characterizes the position of the beam relatively to the horizontal axis of the installation. Under constant conditions of the focusing relative distance between the peaks will characterize the displacement of the beam along the vertical axis.

The current density in the ion beam of 5 mA with the cross-section of 3 cm^2 ~ 1.5 mA/cm^2. Thus, the current on the wire with a cross section of 0.5 mm, is equal to 0.45 mA. The estimation of the maximum temperature of tungsten wires with a current of 5 mA was obtained by the condition of the thermodynamic equilibrium of the wire radiation. The estimation gives a value of about 1000 K.

Using the experimental data and the assumption of the Gaussian form of the beam shape, an approximate profile was restored as it is shown in the figure 4. The point [0;0] in the figure corresponds to the central position of the scanning wires.

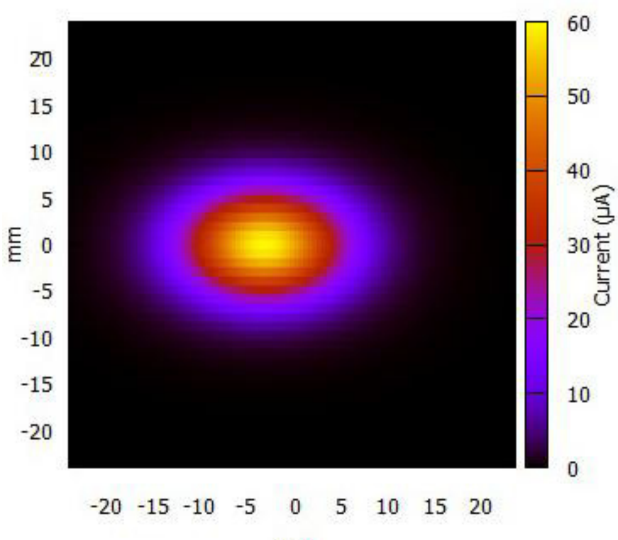

Figure 4: Profile of the ion beam.

During the experiments it was found that in the low energy part the beam is elliptical with the lengths of the major and minor axes 15 and 10 mm, respectively. The relative displacement of the device axis was 3 mm.

IMPROVEMENTS

In an effort to supress a secondary emission from the wires of the scanner it was proposed to install a ring with the cut-off potential inside the vacuum chamber. Volt-ampere characteristics of the wire scanner is shown in the figure 5. It reveals the maximum signal, registered by the wire scanner, plotted against the voltage, which is set on the ring.

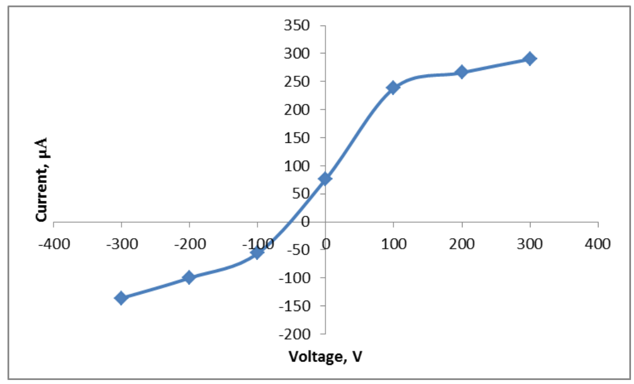

Figure 5: Volt-ampere characteristics of the wire scanner.

In this way, applying a cut-off potential to the ring, secondary electrons would not leave wires of the scanner, and the device would register only the readings of the ion beam, as it is shown in the figure 6. An integrated current, falling on the wires, which is actually a full current of the ion beam, thus is equal to 5.54 mA.

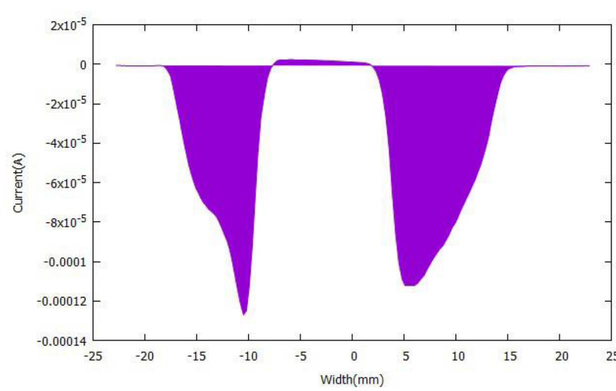

Figure 6: Readings of the wire scanner with suppressed secondary emission.

CONCLUSION

In The Budker Institute of Nuclear Physics the research to obtain a high-current proton beam is pursued in the tandem accelerator with vacuum insulation. For the diagnostics of the ion beam in the low energy part The D-Pace OWS-30 Oscillating Wire Scanner Probe (TRIUMF-Licenced) was installed.

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The experiments were carried out under different conditions of focusing and current. In this way, the possibility to control the focusing and the position of the beam, using the magnetic correcting elements was clearly demonstrated. For the first time the elliptical shape of the beam was realized. Using the experimental data, the profile was restored, also its sizes and position were determined. Moreover, the secondary emission from wire scanner was suppressed, that allows to measure the full current of the ion beam.

The application of the wire scanner allows to operatively monitor and correct the beam injection into the accelerator.

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