TRANSPORTATION OF THE PROTON BEAM AT THE EXPERIMENTAL COMPLEX OF LINEAR ACCELERATOR INR OF THE RAS

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Abstract

Experimental Complex of Linear Accelerator INR of the RAS, work of channels, the equipment, parameters of the proton beams and facilities.

The Experimental Complex of Linear Accelerator INR of the RAS (ECLA), based on the heavy current linear accelerator [1], was developed by Institute of Nuclear Research of Russian Academy of Science together with the D.V. Efremov Scientific Research Institute of Electrophysical Apparatus (NIIEFA), the Dollezhal Research and Design Institute for Power Engineering (NIIKIET). It was designed by GSPI and built in 1997. It consists of a single building complex, which includes: the tunnel, which connects linear accelerator with the experimental hall; experimental hall with the sizes of 60x130 m^2; additional building, which accommodates experimental physicists with the registering apparatus, technological systems and personnel, which ensures appropriate level of working capacity of the entire equipment and experimental installations in the hall.

A unique system of separation and transportation of the heavy current proton beams [2] was proposed for ECLA. It makes it possible to ensure the simultaneous work of several installations and the transformation of the time structure of beam.

Today we have five channels of the transportation of the proton beam, including of medical application, and majorities of the installations of neutron complex completely installed. The overall length of proton circuit - 304,3 m. Fig. 1 shows the latest version of the situation plan of the ECLA.

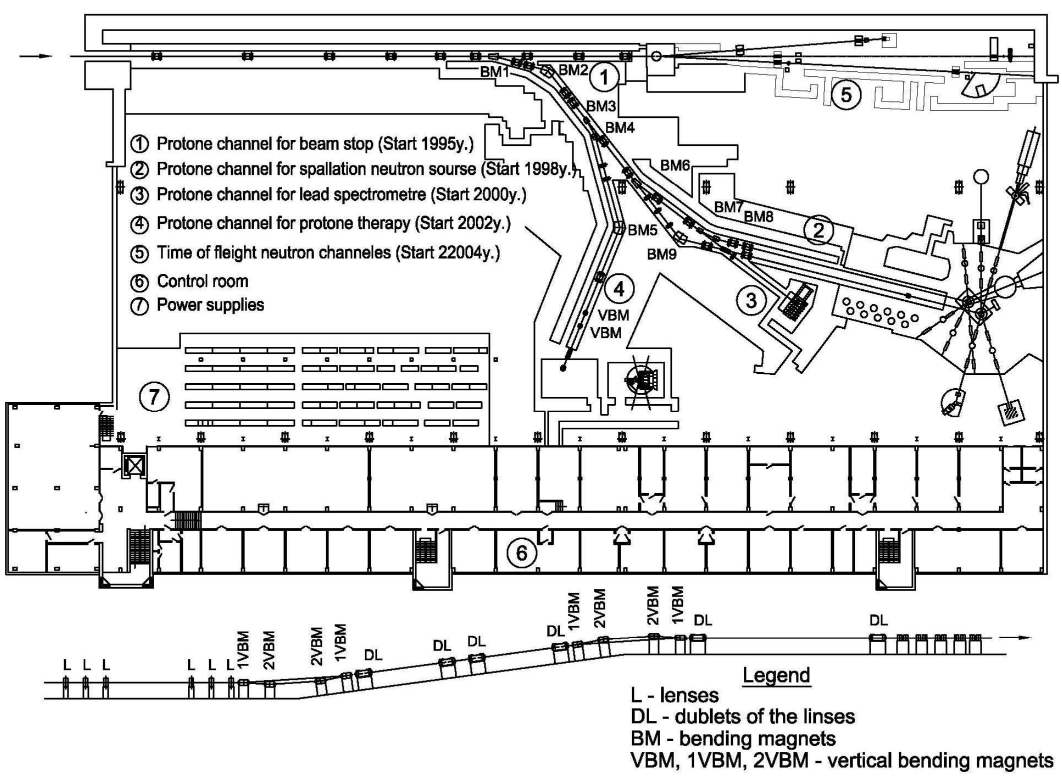

Figure 1: Beam layout at the experimental complex on 2008.

The unique radiation-resistant equipment for the work with high currents of beam was developed in NIIEFA (Fig.2).

Figure 2: Radiation resistant electromagnets.

Following systems were created for control and monitoring of the transportation of proton beam: control system for the elements of channel; measuring system for the parameters of beam and losses of protons.

On the proton channels there are six current-sensing devices for the beam, twenty-nine 32-channels profilometers with a step of the measurement of 2 mm and 4 mm for the inspection of profile and position of proton beam and 64 ionisation chambers for measuring the losses of protons during their transportation and channel tuning.

Measuring section is shown at Fig.3.

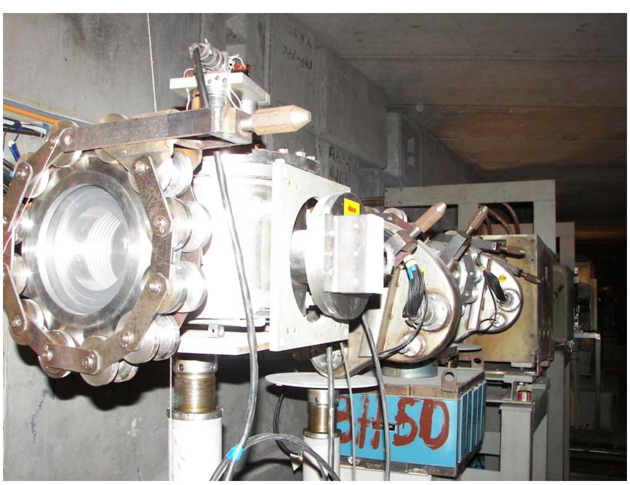

Figure 3: Beam measurement part of the channel. .

An example of the measured time structure of the beam is shown at Fig.4.

At the moment we are in the process of completing the development of the first stage of ACS ECLA - automated control system for the channels.

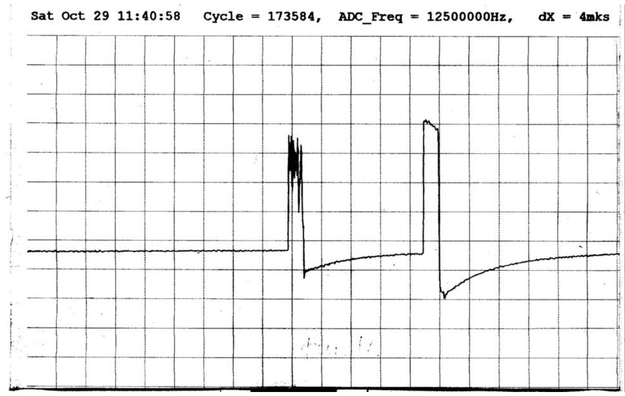

Figure 4: Pulse of a beam current with high time resolution at the end of a channel .

Following installations for the neutron research [4] are set up at ECLA: the pulse neutron source SNS, equipment for science of radiation materials RADEX, time-of-flight channels, the superluminous lead slowing-down neutron spectrometer.

The complex of the proton therapy is being built [5].

Introduction of channels and installations into operation is done step by step. The first channel for the transportation of the proton beam to the trap of protons (entering the neutron complex) was initiated in 1995. The geometric parameters of beam, measured during the transportation of the beam to the trap, were in accordance with the calculated parameters. The analysis of the losses of protons along the channel exposed the need to change the apertures of vacuum chambers of the first bending magnets of 1VBM (Fig.1).

In 1998 it was put into operation the channel for the beam transportation at the main pulse neutron source IN-06. The purpose was to demonstrate the efficiency of the entire system of ECLA as a whole.

In the process of experimental transportation of the proton beam the energy-saving system of power supply for the equipment components of ECLA was tested thoroughly. That achievement made it possible to transport the proton beam with the energy up to 600 MeV to all installations of ELAC with only two affiliate transformers (instead of 8).

In 2000 a channel of 150 meters in length was put into operation to the new 100-ton superluminous lead slowing-down neutron spectrometer. As a result experimental physicists now have a present-day experimental device with the world standard parameters. Fig. 5 shows the profile of the beam before the spectrometer.

In addition to original plans a unique neutron installation with three time-of-flight neutron channels was created based on RADEX spectrometer. In 2002 a requirements specification was prepared. In 2002-2003 equipment was developed, manufactured and installed.

The big scopes of construction-assembly works were carried out as well.

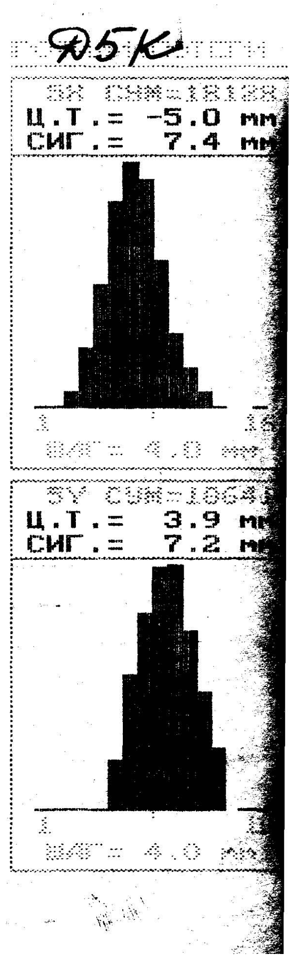

Figure 5: Profile of proton beam on an input of the lead spectrometer.

Following basic components of the neutron time-of-flight spectrometer were developed and created: tungsten target, three vacuum time-of-flight channels, and biological shield. The target was optimised for absorbing the proton beam with the energy of up to 300 MeV and the average current of up to 150 A. Finally the neutron time-of-flight spectrometer was put into operation in 2004. At the moment this spectrometer works in the normal mode. Fig.6 demonstrates the time schedule of work with proton beam on the channel with the maximum intensity of the accelerator.

At the same time in 2001 it was proposed to place an irradiating facility of the first stage of the complex of proton therapy on the base of ECLA (building #25). The layout of the channel and irradiating facility was developed. The project of the first stage of the complex of proton therapy is prepared together with GSPI. The electromagnetic equipment of channel, vacuum system, and systems of diagnostics and control of the beam were prepared and installed at the same time. In 2002 the channel of proton therapy was put into operation.

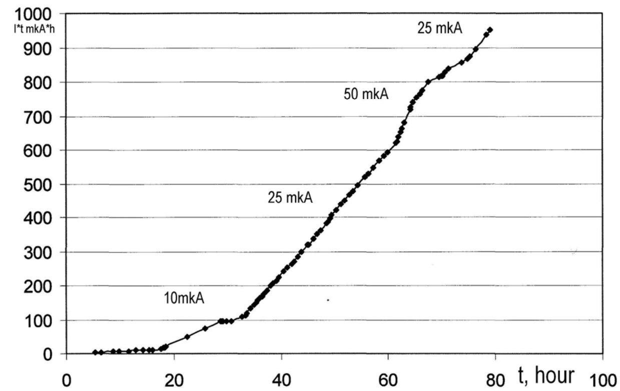

Figure 6: The time schedule of work with proton beam on the channel with the maximum intensity of the accelerator.

In order to improve the quality of beam the system of preliminary beam formation in the channel with control of energy and density of the beam independent of the regime of accelerator was proposed, developed and installed.

RESUME

The ECLA channels with the beam current of up to 100 mkA operate at present. The first stage of the complex of proton therapy was completed. The pulse neutron source SNS was been preparing to operation with 150 mkA proton beam. The experiments on the superluminous lead slowing-down neutron spectrometer and time-of-flight neutron channels continue.

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