From the first domestic betatron

to the largest synchrotron of the country

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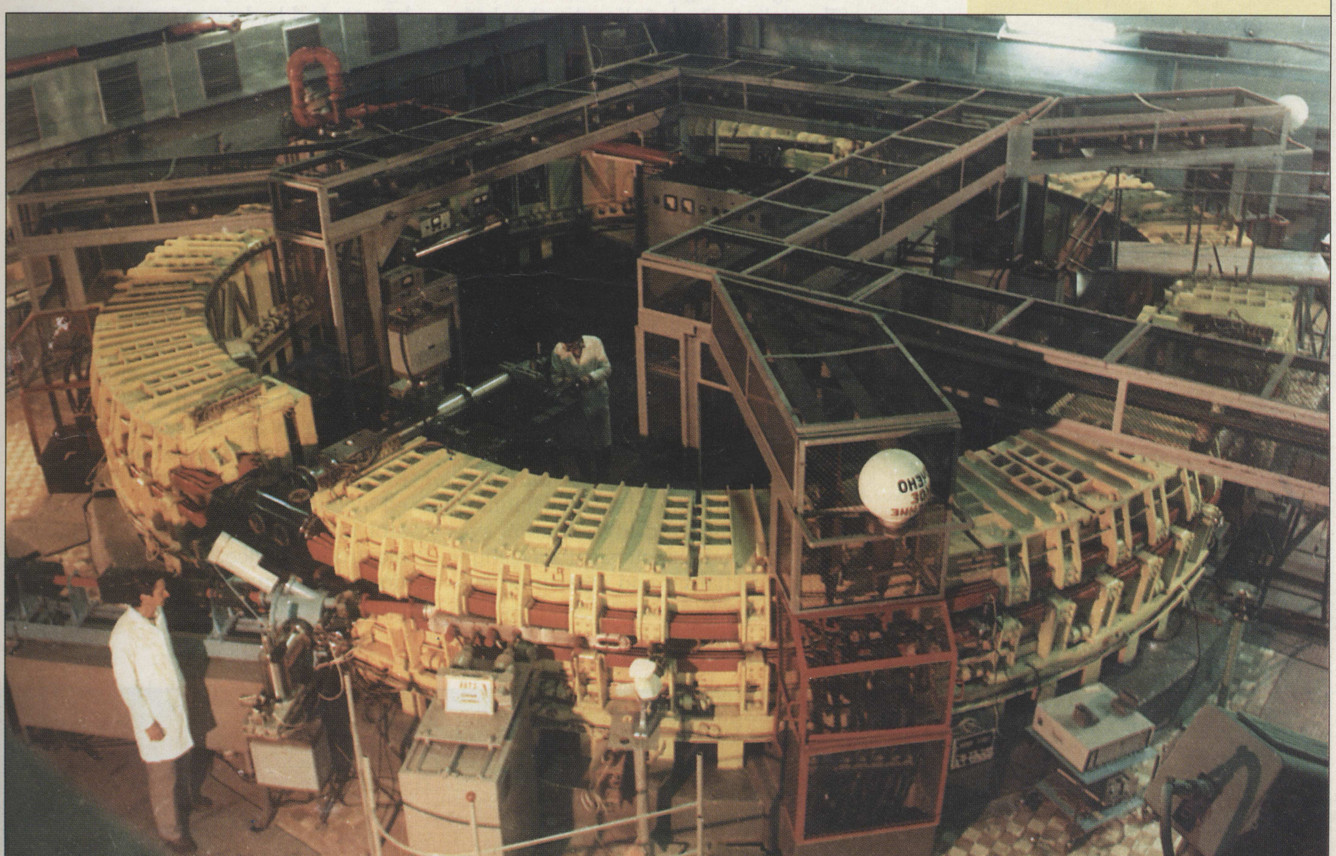
For the past two scores of years TPU has created such a set of charged-particle accelerators that no one educational institution has neither in Russia and abroad. The University presents production prototypes practically of all kinds of betatrons with the broad range of energies of accelerated particles. Among them high-current direct-acting accelerators with energy up to 1 million electron-volt (MeV), Van de Graaf's electrostatic generator of 2,5 MeV; linear accelerator of 5 MeV; a cyclotron with pole diameter of 1,2 m; a microtron ('electron cyclotron') with 5 MeV energy; an electron synchrotron ('Sirius' plant) with 1 500 MeV energy, and also a large family of induction electron accelerators (betatrons) with the energy range of 2 - 35 MeV and linear accelerators with electronic energy of ~ 0.4 MeV for a module.

In 1946 TPU started to develop theoretical and practical problems of acceleration of charged particles on the initiative of Professor A.A. Vorobiev. For many years all works related to accelerators both in the USSR and in other countries were restricted, and the possibility of mutual exchange of scientific information was practically ruled out. That is why the small scientific body created at TPU had to start the investigations from the very beginning. It studied theoretical basics of induction electron acceleration, developed some assemblies of an accelerator and the installation as a whole, developed production engineering, and then manufactured, assembled, adjusted, and implemented the finished accelerator.



Prof. Vorobiev suggested the induction electron accelerator — betatron — as the first accelerator to be devised in Tomsk Polytechnic Institute. The formulation of such problem was rather a bold step. In order to be solved, it required specialists competent in different fields of science and technology: in electromagnetic field theory, electrical engineering, high-current pulse technology, vacuum technology, radiation control, etc.

Subsequent events showed that the preferred scientific trend was the extremely fruitful, and the solution techniques accepted for scientific and practical problems have perfectly proved to be correct. Hundreds of our scientists, engineers and students were engaged later in betatron subjects. Many research laboratories and pilot productions were founded at TPU, specialist training was organized in a number of new disciplines, such as charged-particle accelerators, ionizing radiation control, non-destructive testing, etc. As a result hundreds of betatrons have been manufactured and delivered to customers. TPU betatrons operate all over the world: in China, India, England, France, Finland, Germany, Italy, Poland, Czech, and other countries.

The original constructions of betatrons are developed to investigate and provide engineering processes of material and article control, radioactive analysis and also to apply them in health care and biology areas. Lately such betatrons were used to conduct delicate experiments in the field of characteristic and transitional radiation occurred in interacting between electrons and the medium.

In the 1950's TPI set about constructing the largest accelerator in the country and one of the largest electron accelerators in the world — a synchrotron with energy of 1 500 MeV. Towards 1964 the construction has been completed, in January 1965 the synchrotron was introduced and in 1967 put into operation.

The synchrotron has two channels of bremsstrahlung and x-ray radiation, two synchrotron radiation channels, and the mechanized investigation system. To conduct physical investigations the radiating and measuring system was created on the basis of this synchrotron.

A resonator electron accelerator of the 'microtron' type with 5 MeV energy was developed simultaneously with the synchrotron. It is used as the source of electrons (injector) in synchrotron 'Sirius'.

While developing own accelerators TPI scientists mounted accelerators manufactured and delivered to the Institute from other research institutes of the USSR. For example, Leningrad Efremov Institute for Electrophysical Equipment delivered a cyclotron and the electrostatic generator ЭСГ-2,5. The cyclotron laboratory was founded at TPI in 1957. The cyclotron with the pole diameter of 120 cm allows accelerating protons up to 33 MeV. Later on it was modernized, which also allowed accelerating deuterons, helium nucleus, and heavy-gas ions — carbon, nitrogen, and oxygen. Along with physical investigations and obtaining of short-living radionuclides a medico-biological system for neutron therapy of malignant tumours has been developed on the basis of the cyclotron together with the Research Institute for Oncology.

Electrostatic generator of 2,5 MeV allows accelerating either electrons or protons and conducting research in radiation physics. This generator produces electron beams, helium ions' beams, and hydrogen ions' beams with energy of 2,3 MeV. On the basis of the electrostatic accelerator the 'ion microsound' was invented. The focus system produces a beam with the diameter of 10 mkm, which considerably enlarges its experimental potentials.

The linear electron accelerator 'Electronics' ЭЛУ-4 is intended for electron-beam treatment of electronic equipment products. This accelerator was developed in the Scientific Production Association 'Thorium' (Moscow) and in 1986 it was put into operation. The range of average energy control for accelerated electrons comes to 2,3-4,1 MeV. Maximal energy of accelerated electrons comes to 6 MeV. Maximal average current of accelerated electrons is 1000 mkA. The accelerator is supplied with a beam-scanning electronic device. It is used for radiation test of spacecraft airborne equipment, sterilizing of radiation resources and medical products, and also for working out radiation technologies.

On the basis of a set of accelerators consisting of the linear accelerator ЭЛУ-4, and МИБ`-6э and МИБ-10э betatrons the teaching and research laboratory 'Applied Physics' was organized to carry out researches by students of the Applied Physics & Engineering Faculty, Electrophysics & Electronic Equipment Faculty, and Electrical Engineering Faculty.

The 60's and 70's have seen remarkable advances in high-current electron and ion accelerator developments. For the short time period a series of accelerators with 1 MeV energy and beam power of 100 mVt has been invented. The high-current accelerator 'Tonus' is the first accelerator of this group. Soon afterwards such high-current accelerators as 'Tonus-2M' of microsecond duration with megajoule range stored energy; 'Vera', with intermediate capacity accumulation of energy, 'Lutch', a multipurpose accelerator; 'Double', and linear induction accelerators have been developed.

The research in transportation of high-current relativistic electron beams in gas and vacuum, their interaction with the interface of two media, different properties of materials, and generation of powerful SHF radiation was conducted by these accelerators.

The research in generation of high-current ion beams was started simultaneously with the research conducted into electron beams. New methods and systems for the effective formation of powerful ion beams with nanosecond and microsecond duration have been suggested and realized ('Temp', 'Vera', 'Muk'). High-current sources of accelerated ions and plasma have been invented, which operate in the mode of pulse-periodical extraction and acceleration of ions and in pulse-periodical or continued modes of forming plasma flows ('Raduga 1' – 'Raduga 5').

Ion beams are intensively used in research conducted into material surface modification and realization of highly concentrated implantation technology and plasma settling of coverings and dynamic modes of ion mixing.

Scientific teams contributed much to the accelerating subjects under the auspices of professors I.P. Chuchalin, A.N. Didenko, V.A. Moskalev, L.I. Ananiev, V.I. Gorbunov, Y.P. Usov, G.E. Ryemnev, A.I. Ryabchikov, V.A. Chakhlov, and others.

The students of Tomsk Polytechnic University have the unique opportunity of acquainting themselves with real accelerators of charged particles and the advanced electrophysical equipment with the help of which they can study profound natural laws, and the structure of matter. One can say with confidence that wherever our graduates leave, they will never have such a possibility to study accelerators as they have at TPU. During the last years physics teachers of TPU acquaint students of Faculties of Computer Science & Engineering and Electrical Power Engineering with boost installations of the Research Institute for Nuclear Physics and the Research Institute for Non-Destructive Testing. The University is able to organize such excursions for each student group of each Faculty regardless of the field the student is specialized in, so that all our students could get acquainted with laboratories of Research Institutes.