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CYCLOTRON SYSTEM FOR THAILAND INSTITUTE OF NUCLEAR TECHNOLOGY

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Abstract

In 2020, the CC-30/15 cyclotron complex is planned to be commissioned at the Institute for Nuclear Technologyes of the Kingdom of Thailand. The main task of the project is the development of nuclear medicine in Thailand.

The complex is created on the basis of the cyclotron of negative hydrogen and deuterium ions with finite energy in the ranges 15-30/9-15 MeV and the current of the extracted beam of 200/50 μA, respectively. A beam transport system ensures the formation and delivery of beams to five ports. Two of them are target devices designed for large-scale production of radionuclides of zirconium-89, copper-64, thallium-201 and gallium-67. A pneumatic system for the installation, discharge and delivery of targets to radiochemical laboratories is provided. The remaining ports will be used in the program of scientific research in the field of neutron physics and radiation technologies.

The main equipment of the complex was developed; production and factory testing should be completed in the third quarter of 2019.

In September 2017, a project was launched to create a modern nuclear physical center at the Institute of Nuclear Technology of the Kingdom of Thailand (TINT). The center is intended for large-scale production of radionuclides and the implementation of a program of scientific research in the field of neutron physics and radiation technologies. The Center is based on the cyclotron system CC-30/15 of JSC "NIIEFA". The system includes the CC-30/15 cyclotron, the branched beam transport system, the target complex, the system for transporting irradiated targets to protective boxes of radiochemical laboratories, the sample irradiation system and support systems. The main parameters and characteristics of the cyclotron system are presented in Table 1.

Table 1: The Main Parameters and Characteristics of the Cyclotron System

Parameter name, characteristics	Parameter value
Type of ions:	
• accelerated	H- / D-
• issued	H+ / D+
Accelerated ion energy, MeV	
• protons	15...30
• deuterons	9…15
Energy regulation in steps of not more than 1 MeV	
Number of beam output devices for simultaneous operation	2
Total current of the output beam, μA	
• protons	200
• deuterons	50
Current control from 0 to maximum value	
The stability of the current is not worse than ± 5% when operating in continuous mode at the maximum energy for 12 hours	
Power consumption, no more, kW	
• in standby mode	30
• in the operating mode	200
Number of beam lines	3
Number of ports for setting targets or other end devices, not less than	5
Target complex with solid targets	availability
Automated system for transporting irradiated targets to protective boxes	availability
Sample irradiation system	availability

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The cyclotron CC-30/15 is a modernized version of the MCC-30/15 cyclotron, developed, manufactured by the NIIEFA and put into operation in 2010 [1-5]. In the new version, the range of energy tuning is extended and the current of the released proton beam is increased, cardinal changes are made to the design of a number of units and systems in order to improve reliability and ease of operation. The list of main changes is given below.

Electromagnet of cyclotron:

- The armored version with the vertical arrangement of the median plane and the use of the reverse magnetic circuit as the body of the vacuum chamber is retained.
- For the release of proton beams with energy in the range 15-30 MeV, the magnetic structure is rotated by~8.5°clockwise (view from the side of the external injection system), this allowed to leave the altitude of the axes of the ion-conductors of the transportation system unchanged.
- The design of the vacuum chamber body is processed in connection with the change in the position of probes, stripping devices, nozzles for the release of accelerated ions and the installation of cryogenic pumps, as well as the new design of the resonance system and the AFM trimmer.
- The new design of the shims allowed to get rid of the stationary patches in the valleys, intended for placement of the resonance system.

Resonance system:

- Developed anew to improve its thermodynamic characteristics while maintaining the basic dimensions.
- Dees and stems are made of thick-walled plates (oxygen-free copper), machined on the machine, the stem cages missing.
- The number of contact connections is minimized.
- Newly developed automatic frequency trimmer; the dependence of its influence on the frequency of the resonant system, close to linear, is provided.

High Frequency Power Supply System:

- For the first time for cyclotrons of the CC series, the high-frequency generator was fully developed by NIIEFA.
- The pre-final and final cascades of the high-frequency generator are built on the basis of the 3CX3000 and 3CW30000 generator triodes, respectively.
- Blocks providing measurement and stabilization of the parameters of the high-frequency generator and resonance system, as well as controlling the characteristics of the operating mode, are developed taking into account the experience gained in the creation of the generator of the CC1-3 cyclotron.
- The power supply and control units of the buncher are newly developed.

External injection system:

- The nodes of the multiple source of ions and the vacuum chamber have been modernized.

The system for transporting accelerated beams is built on the basis of standard electromagnets, quadrupole lenses and diagnostic devices developed by NIIEFA. The system consists of three beam lines that ensure the delivery of beams to three target halls (see Fig. 1). The cyclotron model with the initial sections of the transportation system is shown in Fig. 2

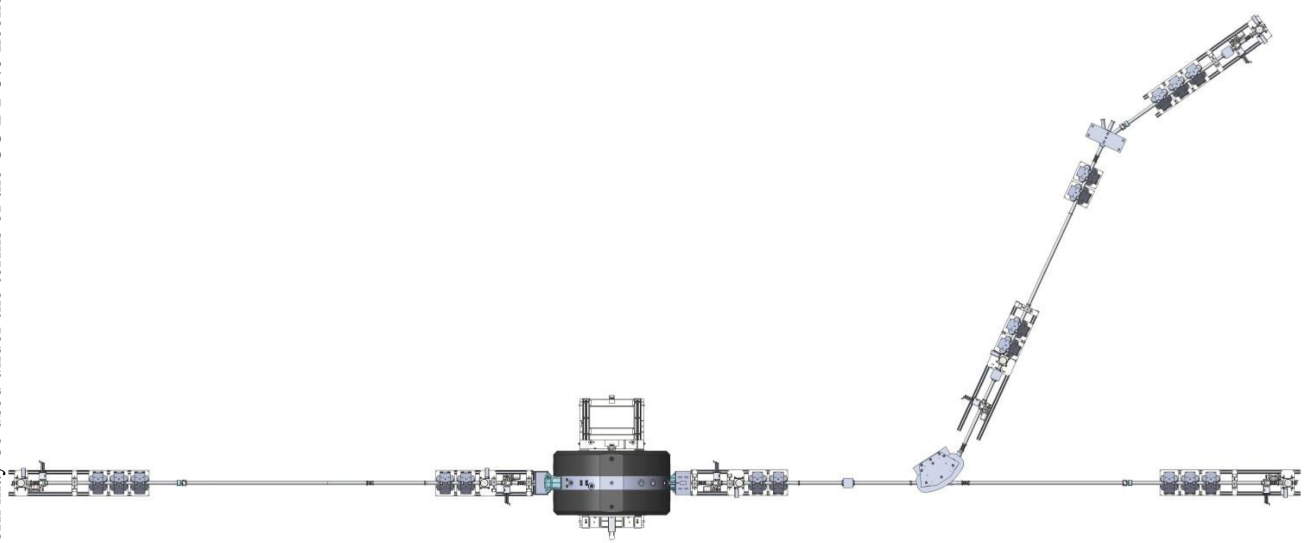

Figure 1: Scheme of equipment placement for transportation routes.

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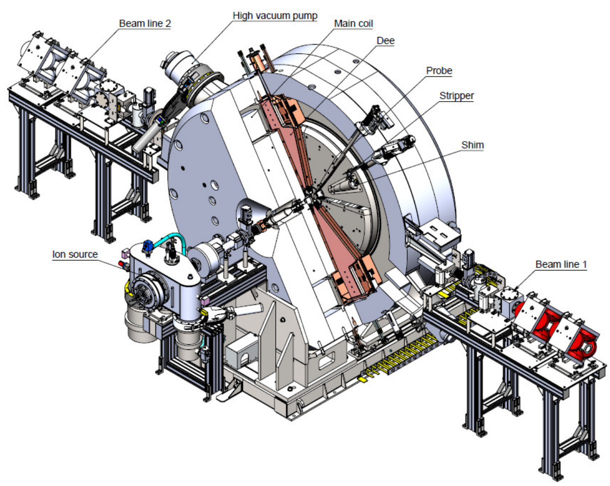

Figure 2: The cyclotron model.

In the straight directions, identical target devices are installed for the production of radionuclide's in the solid phase (Tl-201 and Ga-67 on the left, Cu-64 and Zr-89 on the right). Projected operating time: 1 Cu (thallium and gallium) and 0.2 Cu (copper and zirconium) per irradiation cycle 12 hours. Transportation of irradiated targets to protective boxes of radiochemical laboratories and targets prepared for irradiation to target devices is carried out by pneumatic pipelines. The pneumatic system is equipped with routers and braking devices, providing a change in the direction of transportation of targets and fixing their position and discharge into receiving devices. The process of charging target devices, target irradiation and activity transfer is fully automated and is operated by the operator remotely.

The third beam line is intended for the research program and should provide the possibility of forming a beam with an energy resolution of 50 keV and a cross-sectional area in the range from 1 to 100 mm^2. These requirements are realized by including in the right path an analyzer consisting of a bending electromagnet, two collimators and a diaphragm. The first direction of research use of this line is irradiation of samples with the release of a beam into the atmosphere. The main unit of the irradiation system is a device that ensures the movement of irradiated samples along three axes of coordinates with an error of not more than 0.1 mm and their rotation about the vertical axis within ± 90° with an error of not more than 1°. The device provides simultaneous scanning of the irradiated sample on four axes, both in automatic and manual mode. A laser guidance system is provided for sample positioning, a surveillance camera and a non-contact thermometer. The control of this equipment can be done from a computer located in a remote physical laboratory. The switching electromagnet allows further transport of the beam to several final research ports.

This line is equipped with a switching electromagnet, which creates the prospect of expanding the program of scientific research.

The automated control system monitors, diagnoses and controls the operation of the cyclotron complex and associated systems, including systems for pneumatic transport of targets, as well as communication between systems. If the normal operating conditions are violated, equipment is fixed where an abnormal situation occurs, the operation mode with the beam is disconnected or the cyclotron is shut down without damage to the equipment. There is a system of users administration, according to which the list of persons having access to the control system is determined and adjusted, users are identified and full information about all accesses with the indication of the user, the action he produced, the date and time is saved. For officially authorized TINT employees, remote access to the control system with guaranteed identity of information displayed on the monitors of the operator's workplace and in the room indicated by the TINT management is organized.

CONCLUSION

The main equipment of the complex is developed; production and factory testing should be completed in the third quarter of 2019.

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