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(JSC "NIIEFA")

Saint-Petersburg, Russia

PRODUCTION OF ACCELERATING EQUIPMENT FOR NUCLEAR MEDICINE IN NIIEFA. POTENTIALITIES AND PROSPECTS

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The D.V. Efremov Institute (NIIEFA) is the leader in Russia in designing and manufacturing of the accelerating equipment for medicine. About one hundred of linear accelerators for the beam therapy and more than forty cyclotrons for production of radiopharmaceuticals have been designed, manufactured and delivered to clinics of Russia and some foreign countries.

The equipment designed and manufactured in NIIEFA in its technical characteristics is on a par with foreign analogs and sufficiently cheaper in expenditures for personnel training, hardware and software compatibility, warranty and post-warranty service, delivery of spare parts and updating.

In accordance with Federal Targeted Programs on the development of medical and pharmaceutical industries up to 2020, the production facilities, material and technical resources have been prepared for the organization of serial production of cyclotrons and gamma tomographs.

Market of Medical Equipment Necessary for Radionuclide Treatment and Diagnostics. Current Status

Equipment \ Indices	Current Status	Equipment Wear and Tear, %	Demand
Gamma-tomographs	150	80	300
PET	7	28	95
Cyclotrons	7	28	95
Linear Accelerators	80	80	420

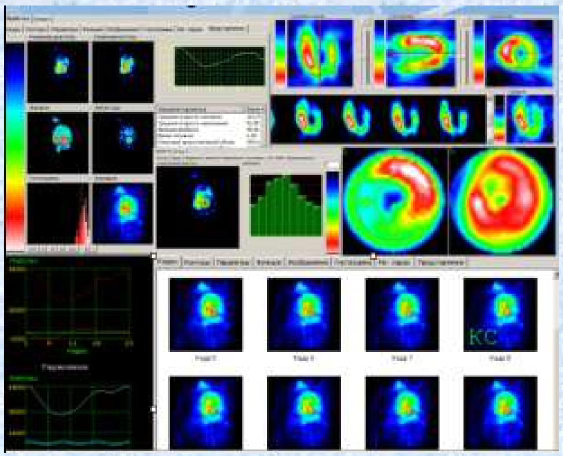
The “EFATOM” Gamma-Tomograph

A single-photon emission computer tomograph «EFATOM» has been designed in NIIEFA for radionuclide diagnostics. It is used to visualize images obtained by using special radiopharmaceuticals. This method allows the anatomy and functioning of various organs to be studied as well as, osteal pathologies to be diagnosed.

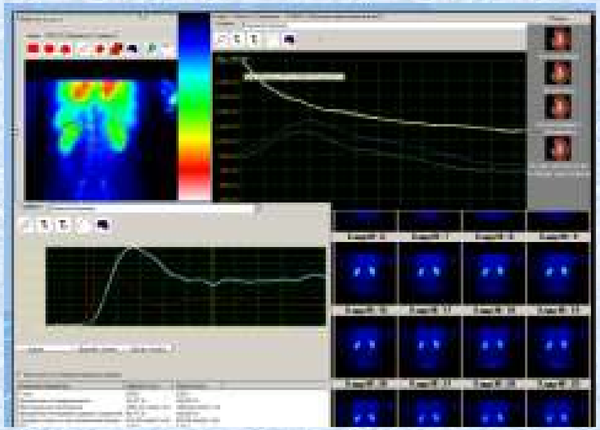
The “EFATOM” Gamma-Tomograph

Upon completing clinical tests, the «EFATOM» was included on the State Register of RF Medical Products, and in 2011 it was included on the List of products intended for serieal production. More than 15 thousand examinations have been performed with the «EFATOM» in clinical hospital № 83, Moscow.

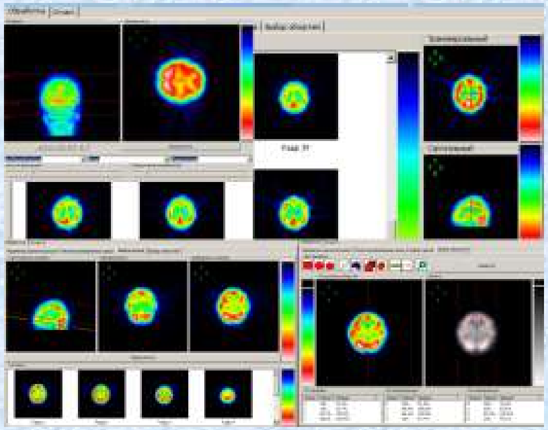
The package of clinical programs



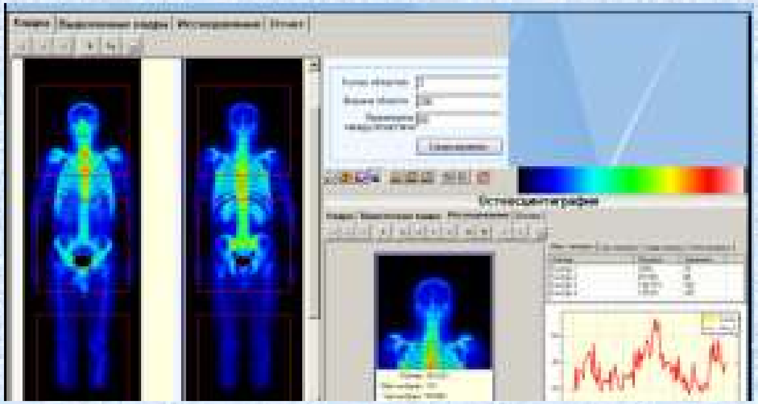
cardiology



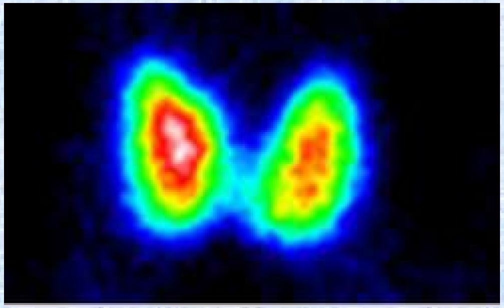
nephrology



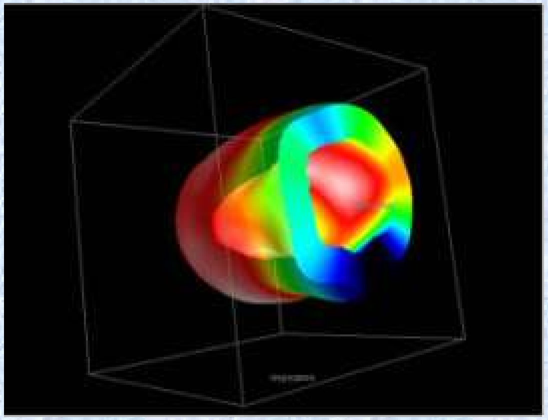
tomography of the brain



osteology

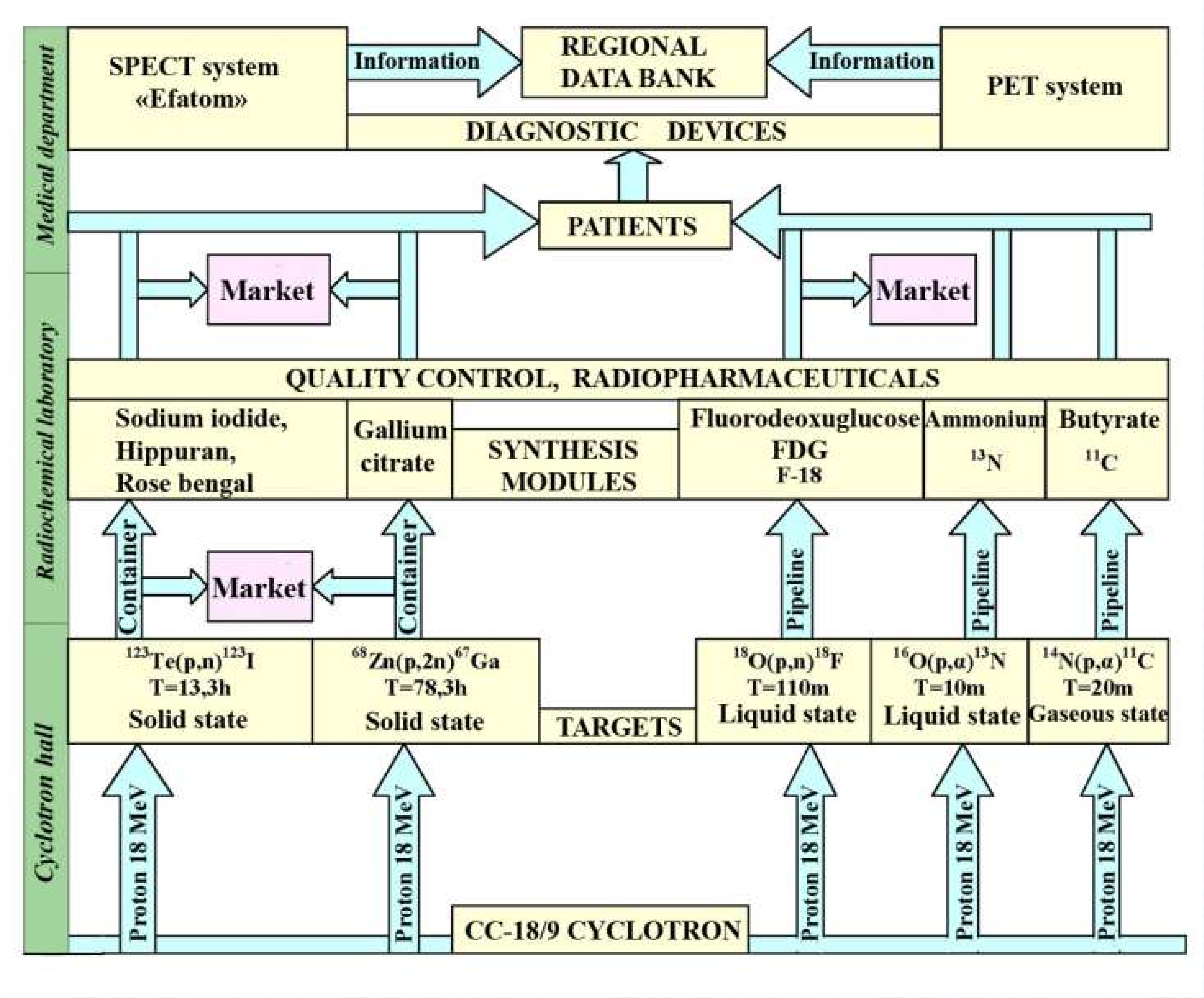


endocrinology



ventricle of heart

PET-center. Schematic Diagram



The Main Technical Characteristics of Compact Cyclotrons

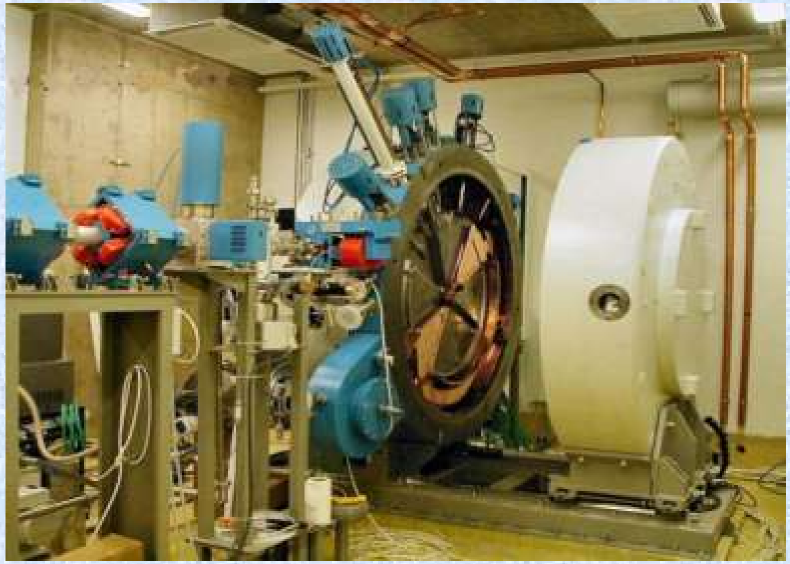
Technical Characteristics	Cyclotron model		
	CC-12	CC-18/9 M	MCC-30/15
Type of accelerated ions	H^-	H^-/D^-	H^-/D^-
Beam energy, MeV	12	12…18/6…9	18…30/9…15
Beam current, μA	50	150/70	200/100
Power consumption, kW	30	70	120
Shielding magnet weight, t	10	34	46
Output power of the RF power supply system, kW	15	25	25
Radionuclides produced	Ultra short-lived: C-11, N-13, F-18, 0-15	Ultra short-lived and short-lived: Rb-81,I-123, In-11, Tl-201, Ga-67, Y-87, etc.	Ultra short-lived, short-lived and long-lived: Na-22, Co-57, Cd-109, Ce-139, etc.

Distinctive Features of Compact Cyclotrons of the New Generation

- Shielding type magnet with the vertical median plane.
- Vacuum chamber of the cyclotron made as a part of the magnet.
- Resonance system completely located inside the vacuum chamber.
- Possibility to move apart the movable part of the magnet to a distance of up to 800 mm to give an easy access to the in-chamber devices.
- System for external injection of hydrogen and deuterium negative ions; acceleration of negative ions of hydrogen and deuterium at one frequency of the RF field (the 2nd and 4th harmonics, respectively).
- Extraction of beams of accelerated protons and deuterons by stripping negative ions on carbon foils practically with no loss of intensity.
- Completely automated control of all cyclotron systems from a computerized operator workstation.

The CC-series Cyclotrons

The CC-18/9 cyclotron installed and operated in the Russian Research Center for Radiology and Surgical Technologies, Pesochny, St.Petersburg. Delivered in 2006.



The CC-18/9 cyclotron delivered to the National Positron-Emission Center of Turku, Finland in 2005.

The CC-18/9 Cyclotron in the PET center, Chelyabinsk region, Russia. Delivered in 2010.

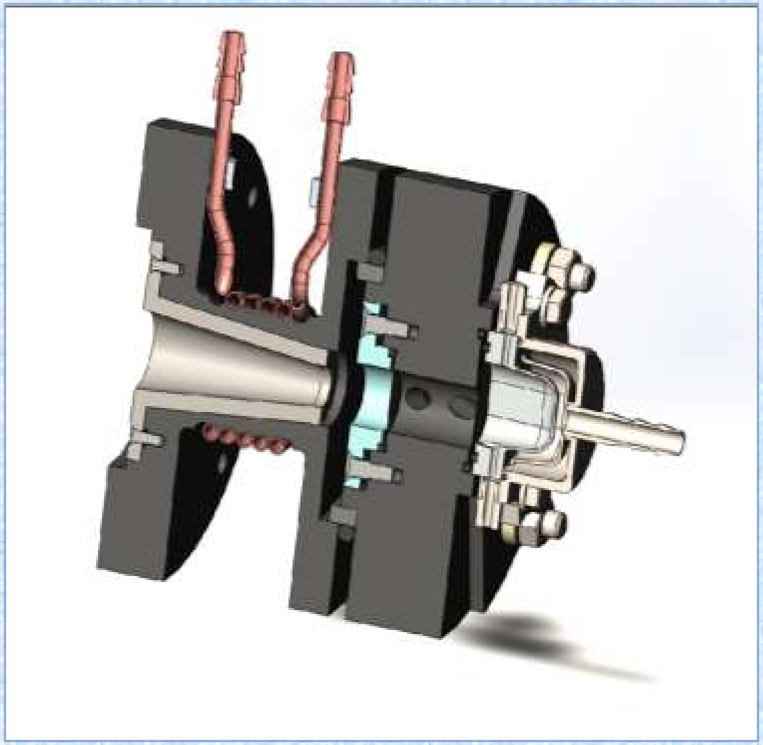
The MCC-30/15 cyclotron delivered to the University of Juvaskula, Finland in 2010.

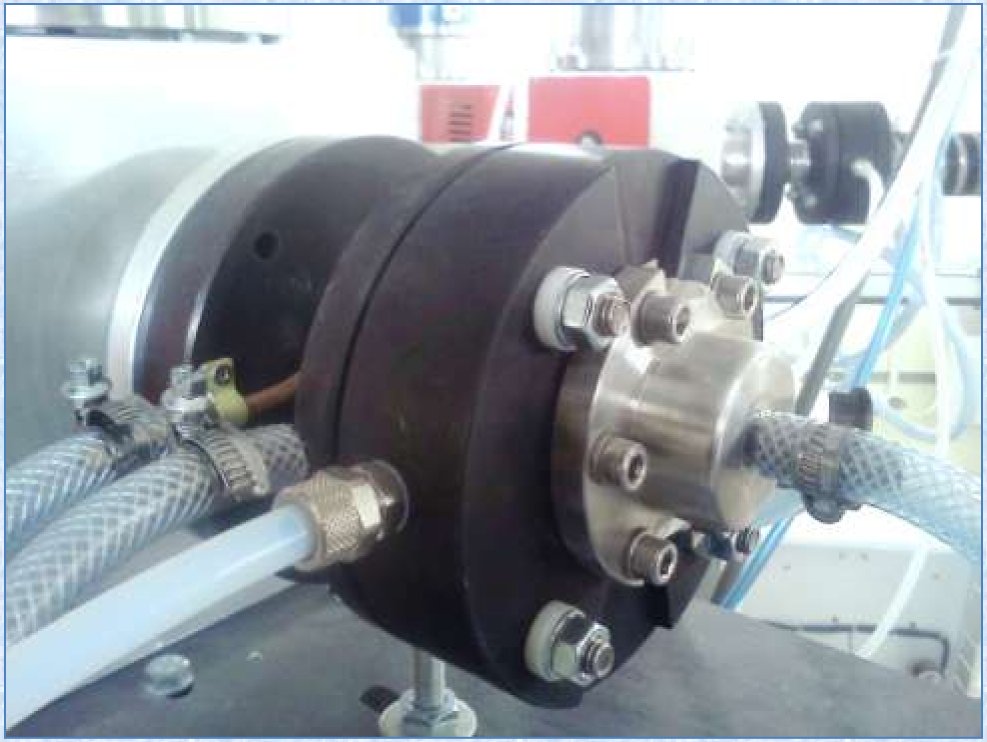
The CC-18/9M cyclotron installed and operated a PET center of Moscow Delivered in 2013.

The CC -12 cyclotron at a test facility in NIIEFA.

Target Device for Production of F-18 Radionuclide

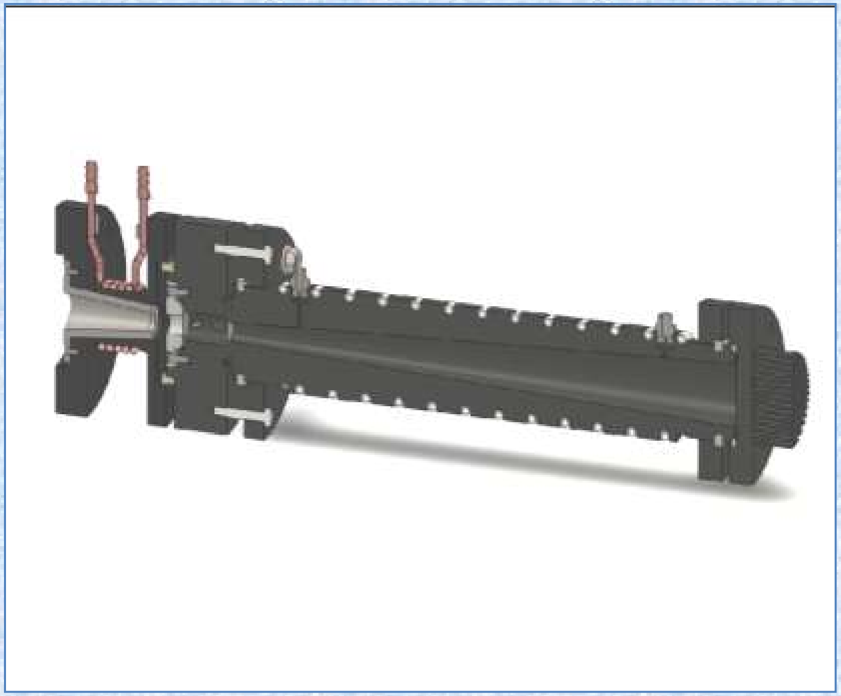
F-18 is produced by the $^{18}O(p,n)^{18}F$ nuclear reaction under irradiation of the water enriched with ^{18}O isotope (95%) with 12÷18 MeV protons.

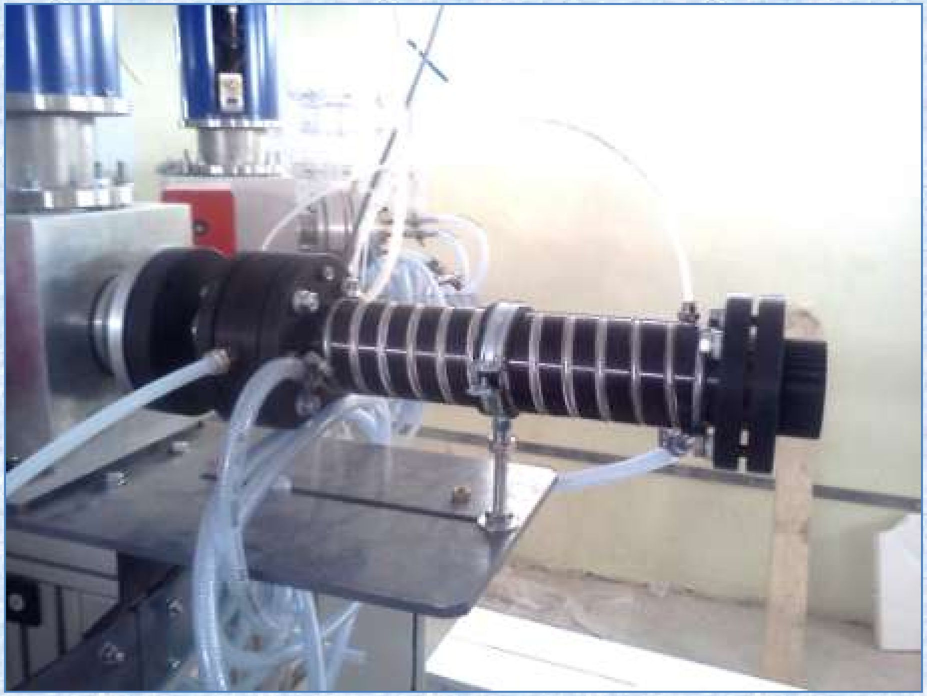




Target Device for Production of C-11 Radionuclide

C-11 radionuclide is produced by the $^{14}N(p,\alpha)^{11}C$ nuclear reaction under irradiation of gaseous nitrogen with protons.





The SL75-5MT Accelerator for Medicine

The SL-75-5MT accelerator is intended for X-ray radiation therapy with an energy of 6 MeV in the static and arc modes. About sixty machines have been manufactured and delivered to clinics of Russia.

Work center for assembly of SL-75MT irradiators

The SL-75MT accelerator. General View

Medical Accelerator ELLUS-6M

Technical Parameters	
Energy of accelerated electrons, MeV	6
Max absorbed bremsstrahlung dose rate, Gy/min	up to 5
Field size 1m from target, cm	from 2×2 up to 40×40
Parameters of the gantry rotation around horizontal axis passing through the isocenter: Irradiator rotation angle Rotation velocity, /min	 185 from 36 up 360
Radiation head rotation angle, degrees	180
Central beam deflection from the isocenter under irradiator rotation, mm, no more than	1

An accelerator of new generation «ELLUS-6M» with a set of additional medical equipment has been designed and manufactured in NIIEFA. This accelerator is an isocentric radiation facility intended for 3-D beam therapy with 6MeV X-rays in multi-static and arc modes. It is equipped with a multi-leaf collimator, portal vision system and patient-support system.

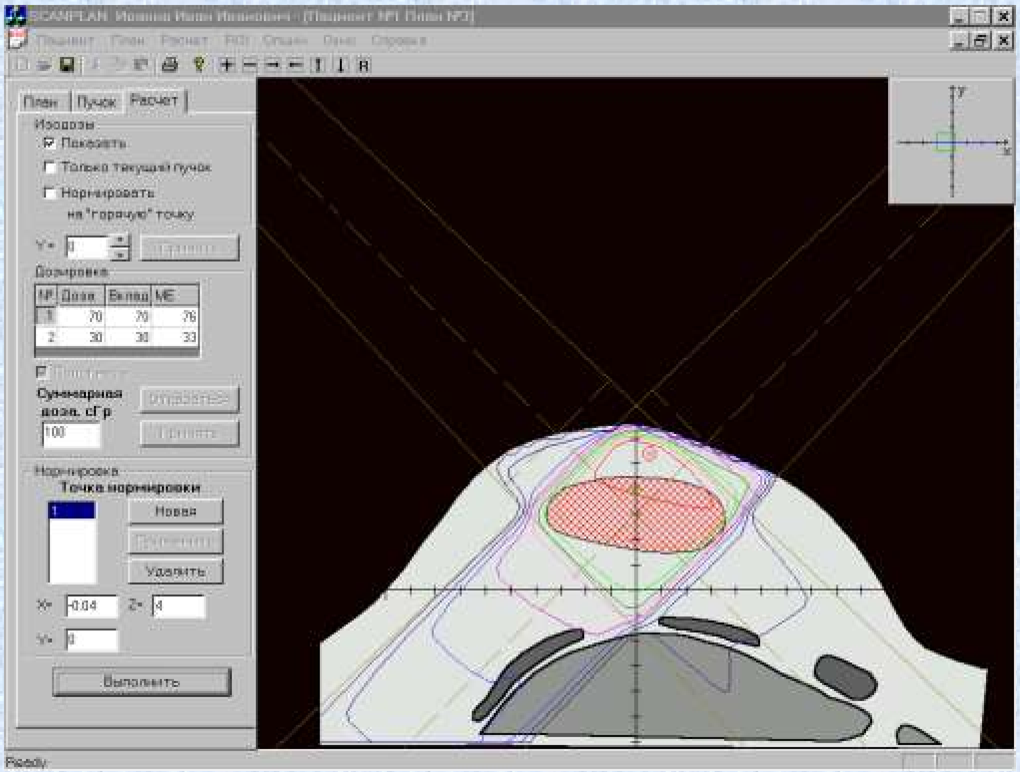
In 2012 in the N.I. Petrov Scientific Research Institute of Oncology of the RF Ministry of Health (St. Petersburg), clinical tests of «ELLUS-6M» were successfully completed. The accelerator was integrated into a radiotherapeutical system with a standard set of technological processes.

X-ray Topometric System TSP-100

Combines functions:

X-ray tomograph and medical simulator

Treatment Planning System «ScanPlan»



Modeling of configuration of radiation beams and calculations of parameters of dose fields generated by linear electron accelerators.

Planning of radiation treatment of oncology patients with photon beams of various energies.

Conclusion

NIIEFA has performed works on the reconstruction and technical re-equipment of production rooms. As a result, production facilities and processing equipment necessary for a planned annual production output of 10 CC cyclotrons with target devices and 20 «EFATOM» gamma-tomographs are provided.

However, until now the questions of procurement and introduction of domestic equipment for nuclear medicine, training of attending personnel, designing and construction of specialized areas to house radiation-dangerous equipment, its maintenance/repair and updating are still open.

These problems can be solved by working out an inter-ministerial Program of Nuclear Medicine Development, including all the stages of creation, introduction and operation of equipment.