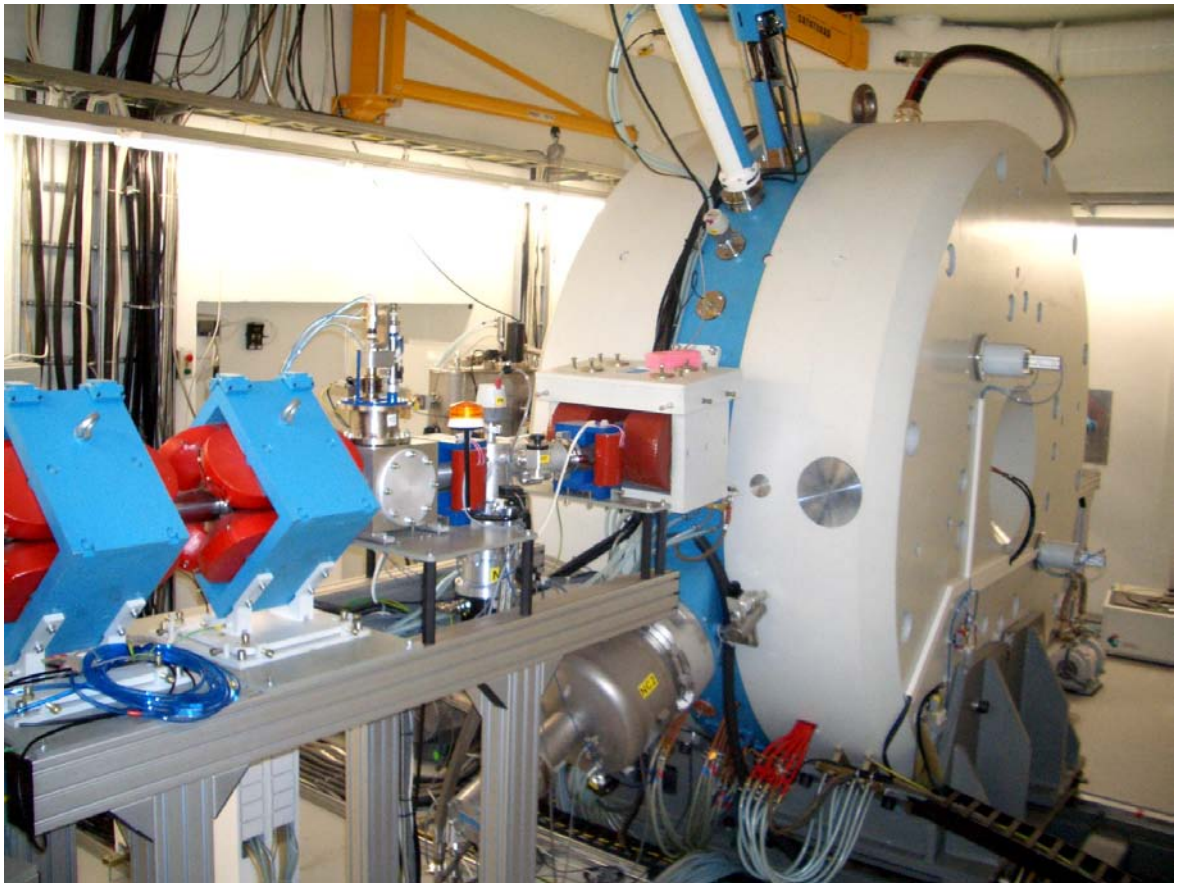
D.V. Efremov Scientific Research Institute of Electrophysical Apparatus

Scientific and Production Complex of Linear Accelerators and Cyclotrons

NPK "LUTS" NIIEFA

MCC-30/15
MEDICAL COMPACT CYCLOTRON

MCC-30/15 is a compact isochronous cyclotron of novel design for accelerating negative ions of hydrogen and deuterium up to energy of 30 MeV and 15 MeV consequently, with 100% efficiency of extraction by stripping to positive ions. 40% variation of beam energy on target is provided. The beam extraction is realized by negative ion stripping. Thin carbon foils are used for stripping. The extracted beam current equals to 100 μA for protons and 50 μA for deuterons.



MCC-30/15 cyclotron is used mainly for the production of short-lived (ultra short-lived) and long-lived radioactive isotopes.

The maximum proton energy of 30 MeV and the deuteron energy of 15 MeV with an energy variation from 0.6 up to a maximum provides the high potentialities of the accelerator for an isotope production. First, the assortment of single-photon short-lived radio nuclides (Rb-81, I-123, In-111, Ta-201, Ga-67, Y-87 and others) is wide and the yield is high. Second, some long-lived radio nuclides (Na-22, Co-57, Cd-109, and Ce-139) can be produced and the investigations can be carried out aimed at production of new radiopharmaceuticals, which allow the range of radionuclide diagnostics to be widened. Third, isotopes for radiotherapy of malignant tumours are produced. In addition, when equipped with a special target, the cyclotron can be used for neutron therapy of oncological patients.

Also large regional hospitals equipped with MCC-30/15 cyclotron ensures clinical diagnostics, production of isotopes for radiotherapy (Pd-103), beam therapy and allows serious fundamental investigations in the field of medicine and biology to be carried out. MCC-30/15 cyclotron and beam transport system are installed in buildings with the biological protection

CYCLOTRON COMPRISES

- Main electromagnet with power supply,
- High-frequency accelerating system,
- Ion beam injection system with power supplies ,
- Beam extraction stripping devices,
- Beam transport system with power supplies and diagnostics,
- Vacuum system,
- Cyclotron beam diagnostics,
- Water cooling system,
- Control system.

SPECIFICATIONS

Beam	
type of ions	
-accelerated	H^-/D^-
-extracted	H^+/D^+
energy(adjustable), MeV	18…30/9…15
energy spread, % (FWHM)	1.0/2.0
current, μA	100/50
Exit ports	2
Magnetic structure	
pole diameter, cm	140
power consumption, kW	12
magnet weight, t	46
Radio-frequency system	
number of dees	2
harmonic mode	2/4
frequency, MHz	40,68
dee voltage, kV	35…40
RF-generator	
output power, kW	25
Ion source	
type of source	CUSP
location	external
Mains	415/230V, 50Hz
Power consumption	
stand-by condition, kW	15
beam on the target, kW	120

ELECTROMAGNET

A shielding-type magnet with the diameter of poles of 1400 mm is a 4-sector structure with a sector angle radial varying from 42° to 45°. Average induction amounts to 1.2-1.24 T. Air gaps in “hills” and “valleys” are 30 and 150 mm, respectively. In the center of the poles, axial holes are made. The hole in the lower pole and bar is used for beam transport from an external source; an inflector is installed in the upper hole. Power supply of the electromagnet is 12 kW.
Electromagnet mass is 46 t.

VACUUM CHAMBER

The vacuum chamber consists of a casing and two covers. The casing of the chamber is a hollow thick-wall cylinder made of carbon steel; it is simultaneously a part of the iron core. The pole shoes of the magnet with the stainless steel flanges welded to them serve as the covers for the vacuum chamber, which ensures the necessary reliability of the vacuum chamber and forms a certain collector to facilitate its pumping.

RF-SYSTEM

The RF-system is located completely inside the vacuum chamber and fixed to the side surface of its body. RF-system consists of two quarter-wave cavities excited in-phase. The dees are located in opposite valleys and conductively coupled in the vicinity to the electromagnet axis. The hydrogen and deuterium ions are accelerated at the 2^{nd} and 4^{th} harmonic accordingly. In this connection, the cavities are excited at operating frequency of 40.68 MHz. Aperture of the dees is 20 mm. The system also comprises RF-power input unit, trimmer of the frequency auto tuning system and RF measurement probe.

RF-GENERATOR

RF-generator ensures an output power of 25 kW at 40,68 MHz frequency in the band of about 0.5 MHz. The generator frequency stability amounts to 10^{-8}, amplitude stability is not lower than 10^{-3}. The RF generator is located outside the cyclotron hall; RF-power to the accelerating system is supplied through a feeder**.**

EXTERNAL SOURCE

External source of negative ions of CUSP type shall ensure the current of hydrogen and deuterium ions of 1…1.5/ 0.5…0.75 mA accordingly.

VACUUM SYSTEM

Operating vacuum in the chamber of cyclotron shall be about $5*10^{-7}$ Torr. Two cryogenic pumps with a pumping capacity of 3200 l/s (for air) are used for high-vacuum pumping. Two turbo pumps are used for pumping beam transport from the external source.

CONTROL SYSTEM

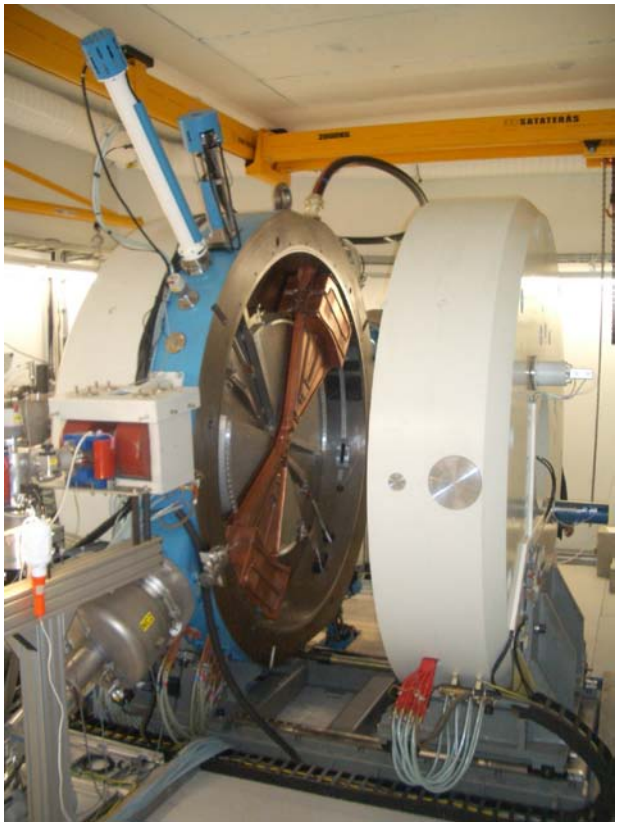
Control system provides automated control based on Mitsubishi PLC and consists of two rack with controllers and an operator workstation with a PC. The control system also realizes acquisition and processing of data on the current status of units and systems of the cyclotron; automatic tuning of the cyclotron to the standard modes of external targets’ irradiation; radiation safety monitoring and switching off of the machine in non-standard situations, etc.

OPTION. BEAM TRANSPORT LINE

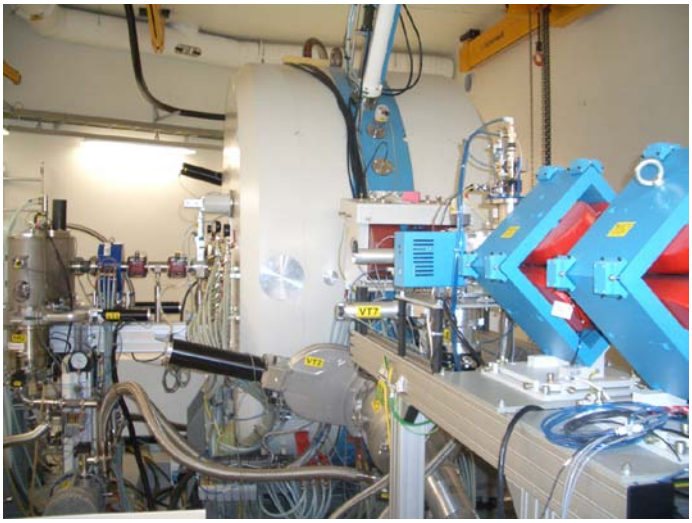
Beam transport line is designed for concrete Buyer.
There are two stripping devices for beam extraction at two exit ports. Beam transport line shall be equipped with doublets of quadruple lenses, correcting, switching and bending electromagnets, Faraday cups, beam profile probes and vacuum equipment.
The MCC-30/15 cyclotron allows extracting two beams simultaneously.

QUALITY

The quality of the cyclotron (in accordance with the ISO 9001 Quality Assurance) shall be in full conformity with the technical requirements for the accelerator and will be confirmed by the Quality Certificate issued by the manufacturing plant.



The cyclotron installment on installation site of Jyvaskyla University, Finland



The MCC-30/15 cyclotron with beam transport line and external injection system

The supply and control systems

The water cooling and ion-exchange purification systems of the MCC-30/15 cyclotron

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