THE ASPECTS OF CYCLOTRON APPLICATION IN MEDICINE

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The basic aspects of cyclotron application in current nuclear medicine are presented in the report. It is shown, that the problem is rather acute. It is noted, that special cyclotron arrangements are needed to realize the programs of their medical application. Basic data on such an arrangement, constructed in the Central Scientific Research Roentgen Radiological Institute (Leningrad) are given.

Nowadays, there is a tendency for a wide cyclotron application in various fields of science and engineering, nuclear medicine being of special interest.

Short-lived (ShL) and ultra-short-lived (UShL) cyclotron - producted radionuclides have some advantages compared with reactor ones widely used in nuclear medicine:

- Short period of half-life (less than 24 hours and 1 hour for ShL and UShL radionuclides respectively) reduces greatly radiation loads on patients. For example, if the patient is investigated with radionuclide ^{123}I, the effective dose equivalent is 100 times lower, than with ^{131}I. This allows to apply higher doses with the aim to improve diagnostics information and to widen the contingent of patients, including even children.
- In most cases, cyclotron ShL and UShL radionuclides have better physical characteristics for spectrum and energy photon radiation or are positron radiators. In the latter case, the positron chamber may be used as a terminal instead of traditional gamma-radiation chambers.
- Application of ShL and UShL radionuclides in the best way solves the problem of environment protection.
- And last, the main advantage of such ShL and UShL radionuclides as ^{11}C, ^{13}N, ^{18}F, ^{77}Br is that; they widen much the variety of radiopharmaceutical preparations, giving the unique possibility for fundamental investigations and to study pharmokinetics of new pharmaceuticals.

To realize fully the program of medical ShL and UShL radionuclide application, special cyclotron arrangements are needed, including targets for radionuclide production, means to deliver them to consumers, complicated dosimetry apparatus and the automatic system on the current computer base.

The short period of half-life of ShL and UShL radionuclides imposes specific requirements on their application in the arrangement:

- radionuclide production should be close to the place of application;
- fusion duration should not exceed 2-3 periods of half-life;
- as initial activities of radionuclides are large (5.10^8÷6.10^{10}Bk) (0.1-2 Curie), then it is reasonable to make the whole production process automatic.

In addition to, some requirements are imposed on the cyclotron operation in clinics.

- the cyclotron operation control should be simple;
- cyclotron operation safety should be sufficiently large;
- the automized control of the whole complex operation is needed.

The cyclotron complex for wide application in medicine is being constructed in the Central Scientific Research Roentgen Radiological Institute in Leningrad.

The specific features of the complex are as follows:

1) wide scale of its application for medical purposes;
2) stage-by-stage putting into operation.

At the first stage, the compact isochronous cyclotron -20 has been installed. It is designed and fabricated by the D.V.Efremov Scientific Research Institute of Electrophysical Apparatus.

The physical start will be accomplished this year. Such parameters of the cyclotron as external target current up to 100 mkA and the energy of accelerated protons, deutons, helium - 3 and -particles being 20, 10, 24 and 24, respectively, provide its profitable application for radionuclide production, patient activization (in-vivo), neutron therapy and eye tumour treatment as well.

Radionuclide "on-line" production of simple chemical forms ($^{15}O_2$, $^{13}N_2$, ^{11}Co, $^{11}Co_2$, $C^{15}O$, $C^{15}O_2$) is supposed at the first stage.

Radioactive gases to study oxygen metabolism, to measure blood flow lung function and other purposes, will be transported directly to the procedure room with diagnostics apparatus or to the "hot chambers" in case, if ^{15}O, ^{11}C, $^{13}N_2$, ^{18}F are used as the base for production of more complex labelled compounds (^{11}C - aminoacids and ^{18}F - dioxiglucose etc).

The layout of the cyclotron complex is shown in Fig.1, 2, 3.

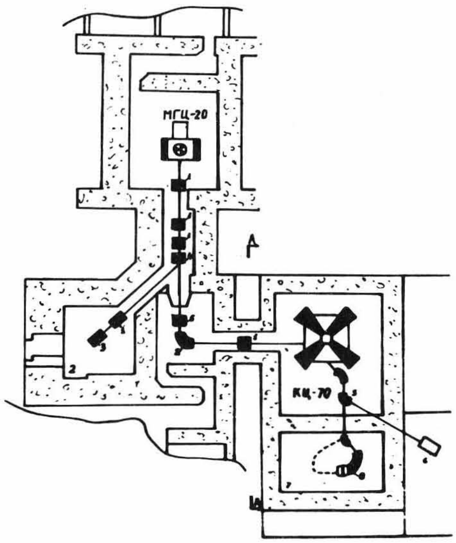

Fig.1. General view of the cyclotron complex

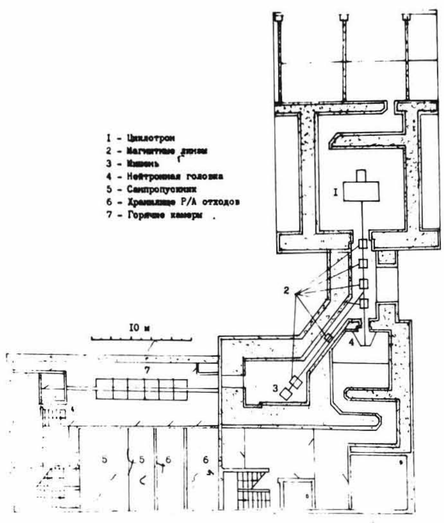

Fig.2. Layout of the cyclotron complex ground floor

The cyclotron itself will be assembled in the existing source building of the Institute. Then the beam is transported into the room over the ion tube by means of focusing lenses (1), using 45° rotatable magnet (4). If the latter is off, then the deutron beam is directed to the beryllium target, to the room for neutron therapy (5), where the neutron beam is formed.

The neutron theraply room is shown in Fig.2. Here the proton beam extraction is provided. The proton beam is supposed to be used for fluorescent analysis with proton excitation or for eye tumour treatment. In the eye tissue the 20 MeV proton path is 5 mm and therefore, the protons of such energy may be of certain interest for tumours of small thickness.

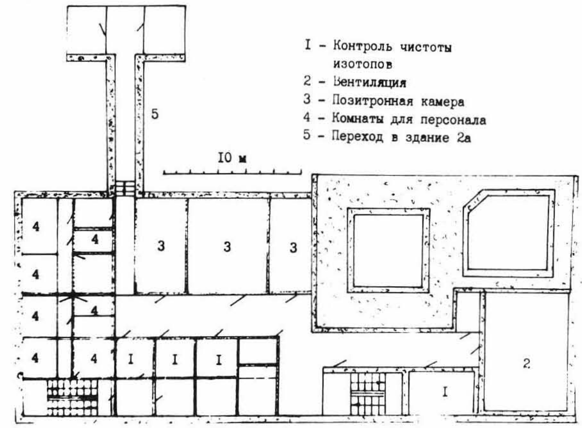

Fig.3. Layout of the cyclotron complex first floor

In future, at the second stage the cyclotron may be used as an injector for the ring cyclotron (RC) with the maximum energy up to 79 MeV. This part of the cyclotron complex (Fig.1) is shown right to the axis AA. The cyclotron complex with such energy is aimed for production of 123 201 and for neutron therapy of deeply located tumours as well (rooms 6 and 7, respectively). The dose rate of neutron radiation may be 1-1.5 Yr/min.

Application of the electrostatic splitting of the cyclotron-injector beam (instead of the rotatable magnet (4) with subsequent beam deflection by the rotatable magnet (8)) will allow both radionuclide production and neutron therapy with the isocentric head (9).

Thus, the cyclotron complex constructed will meet all current requirements needed for production of radionuclides with the aim of diagnostics, for neutron therapy and wide range of medical biological investigations.