STATUS REPORT ON THE 680 MeV DUBNA SYNCHROCYCLOTRON RECONSTRUCTION

Yu. N. Denisov

Joint Institute for Nuclear Research, Dubna, U S S R

ABSTRACT

A review of the current state of modification of the operating 680 MeV JINR synchrocyclotron into the high intensity phasotron is presented.

INTRODUCTION

Similarly to other well-known projects of the increase of internal beam current in the synchrocyclotrons (CERN MPS, Columbia University, etc), the design of the 680 MeV JINR Laboratory of Nuclear Problems synchrocyclotron modification involves the increase of the dee voltage and replacing the operating open ion source by a hooded arc source with associated ion optics. The mean value of the synchrocyclotron magnetic field is increasing with radius. The focusing is provided by magnetic field with space variation. A new more efficient ejection equipment for accelerated protons and a system of large duty cycle for both external and internal beams using cee-electrode are under investigation. The beam current and the high efficiency of ejection system affects the reasonable use of the external beams system. In this connection, some modes of pion generation in both external and internal targets are provided. The main parameters of the modified synchrocyclotron are given in [1] .

PRESENT STATUS OF THE SYNCHROCYCLOTRON DEVELOPMENT

I. Magnetic field[3,4,5]

The modified cyclotron employs the magnetic field the mean value of which is increased with radius. The vertical beam focusing is done by the magnetic field space variation. The necessary topography of the magnetic field is set up by placing the ring and spiral ferromagnetic shim and four correcting coils as well, into the magnet gap of the accelerator.

The magnetic system was modelling to scale 1:5. The model testing is practically finished up to now, and the necessary configuration of spiral and concentric shims is selected. The relations of the mean field and variation values obtained on the model are shown in Fig.1. The new elements of the accelerator magnetic system will be performed in 1972-73. The main magnet coil of the accelerator is substituted simultaneously with the synchrocyclotrom modification. The operating magnet coil is made of cooper tire and air-cooled. A new coil fabricated from the 83×83 mm^2 aluminium tube will be water-cooled. All 14 sections of the new magnet coil will be executed by the end of 1972.

Fig. 2 shows the state of these works being carried out in one of the newly constructed Laboratory biulding.

2. Ion Source

Our modification project is aimed to the substitution of the operating open ion source with cold cathode by the hooded arc source. In the principle variant of this project performance it is expected that the ion source shaft will be introduced through the vertical hole drilled in the upper joke and pole of the accelerator magnet. The preparatory work to drill this gap (270 mm in diameter) in the under way. The certain difficulty is to conservate the the optimum conditions for particle extraction and passing the first turn under magnetic field reversal. The ion source design allows the appropriate ion optics to be adjusted by the special manipulating shafts introduced into the central part along the dee edge. The external source of polarized proton is also developed . The polarized proton injection into the central part of the accelerator will be performed through the vertical hole in the magnet joke. The model of this cyclotron central region is designed at present in the Laboratory for improvements to be made in the internal ion source and its optics, and in the polarized proton injection system as well.

3. RF System[2]

The use of the mean magnetic field increasing with radius allows one to narrow the frequency range from now operating 26-14.2 MHz to 18.2-14.4 MHz. This significantly alleviated the problem of producing the dee voltage with the amplitude up to 50 kV.

Fig. 3 shows the schematic drawing of the synchrocyclotron RF system as a rectangular, plane, half-wave, uniform line, 6m - in width, 7.3m - in length, and with the 78.5 mm constant gap. The tuning of the resonant system is done by two similar variators executed as condensors having the rotor, I m in diameter, with 10 blades. The shape of the rotor blades and stator plates allows one to get the operating cycle duration of the frequency variation up to 72%. The variator capacity changes from 1000 pF to 6000 pF, and the voltage between blades (with a gap not less than 4 mm) is not exceeding 48 kV. The design power consumed by the resonant system is 350 kw at dee voltage 50 kV. The high frequency generator is designed for 500 kw with provision for the anode modulation and manipulation of the voltage.

The frequency of the acceleration cycles at the maximum dee voltage is 500-600 Hz. The frequency properties of the RF resonant system have been tested on the full-scaled model (see Fig. 4).

4. Beam extraction

Three beam extraction systems are developed for the modified cyclotron. In the first and the second system the similar regeneration mode of beam radial gain per turn is used. The only difference is that the dumping of magnetic field in the first system is provided by the ferromagnetic elements only, while for the second one the combination of ferromagnetic and current elements is used.

In the ferromagnetic channel the transition area is 30 mm. The designed channel efficiency for the assumed amplitude range of the radial and vertical beam oscillations is 15%. In the magnetic channel with current septum the value of transition area is 4-6 mm, and the designed efficiency attains 50%.

However, the execution and operation of the septum with its high-current conductors (10 000 - 12 000 a) are considered more complicated in comparison with the ferromagnetic channel. At present the model testing of the second type magnetic channel is underway. The modelling of the ferromagnetic channel is finished. The configuration of selected magnetic elements and a shape of magnetic field in the transition area and inside the channel area at the initial part are shown in Fig. 5.

To obtain more high efficiency of the beam extraction system (up to 80-90%) we consider the preceding the magnetic channel by an electrostatic deflector. No model testing has been performed yet, and the calculations on the computer are being performed only.

5. External beams

Simultaneously with modification of the accelerator the works to enlarge the experimental halls and Data Processing Room are being carried out. Fig. 6 shows the new scheme of external beam systems for protons and secondary particles generated both in external and internal targets.

As is seen from this scheme, the possibility to perform simultaneously two experiments (for example, in π-meson neutron beam, etc.) is provided. The existemce of three separated experimental halls (instead of one available) will allow to increase considerably the efficiency of the accelerator use. At present the hall for π -meson experiments and a new building of Data Processing Room are under construction.

REFERENCES

1. A.A.Glazov et al. 700 MeV JINR high-intensity phasotron. Atomnaya Enegiya, vol.27, I (july 1969).
2. A.A.Glazov et al. RF system for high-intensity JINR phasotron. Second National Conference on Particle Accelerators. Moscow, 1970.
3. S.B.Vorozhtsov et al. Choice of parameters for the phasotron magnetic system. Preprint JINR 9-4617, 1969.
4. Yu.G.Alenitsky et al. Modelling of the phasotron magnetic system. Preprint JINR, P9-5246, 1970.
5. Yu.G.Alenitsky et al. Precise shimming on the model of the phasotron magnetic system. Preprint JINR, P9-5590, 1971.

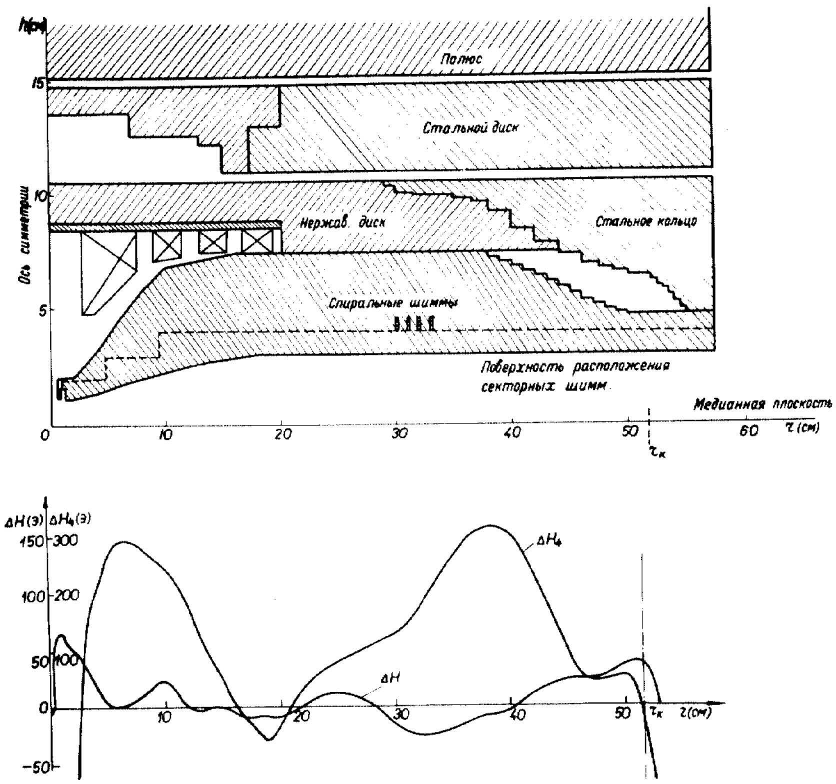

Полюс
Стальной диск
Ось симметрии
Нержав. диск
Стальное кольцо
Спиральные шиммы
Поверхность расположения
секторных шимм.
Медианная плоскость
τ (см)
$\tau_к$
ΔH(э)
ΔH_4(э)
ΔH_4
ΔH
z(см)

Fig. 1

Fig. 2

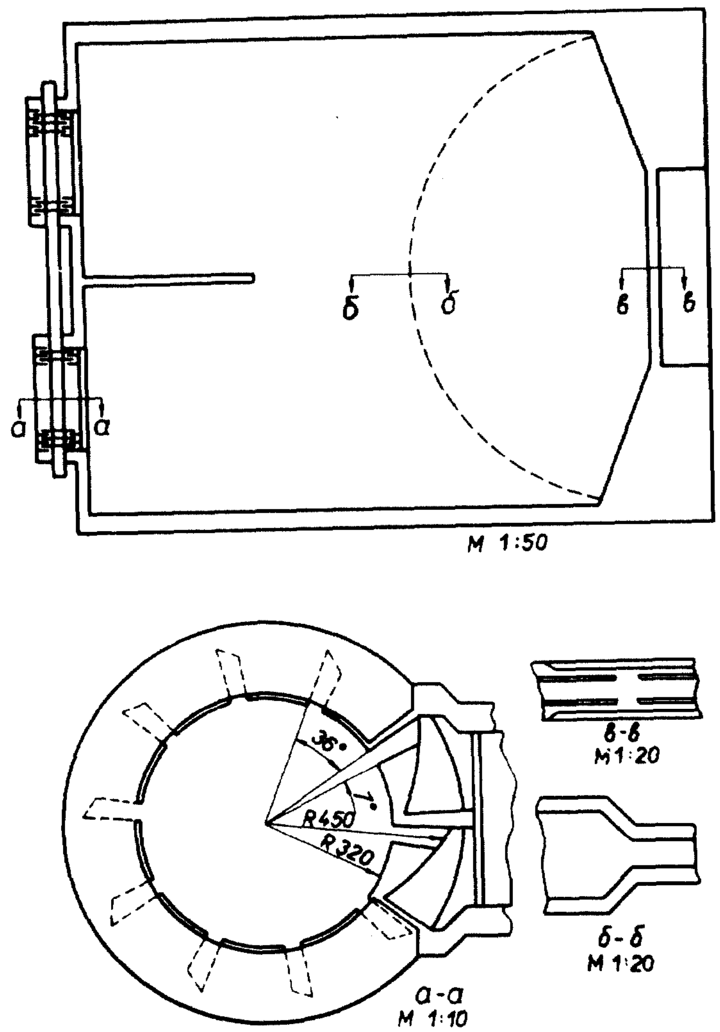


Fig. 3

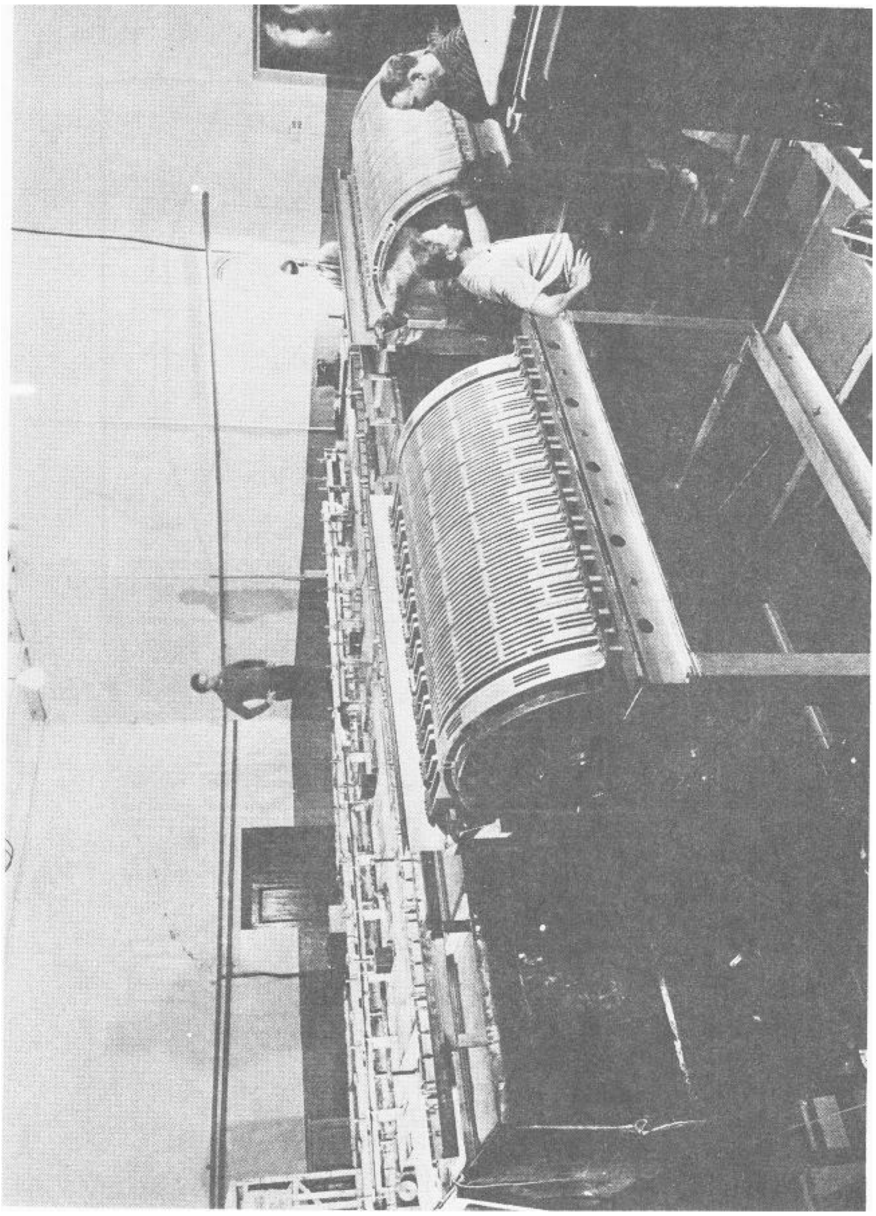
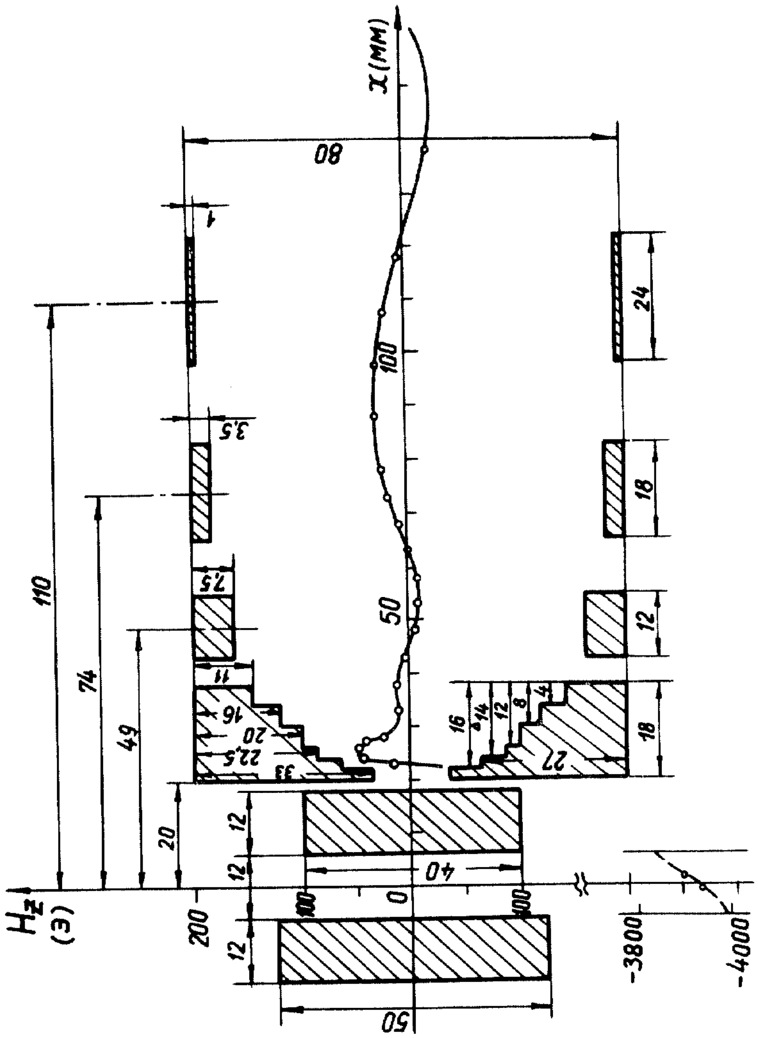
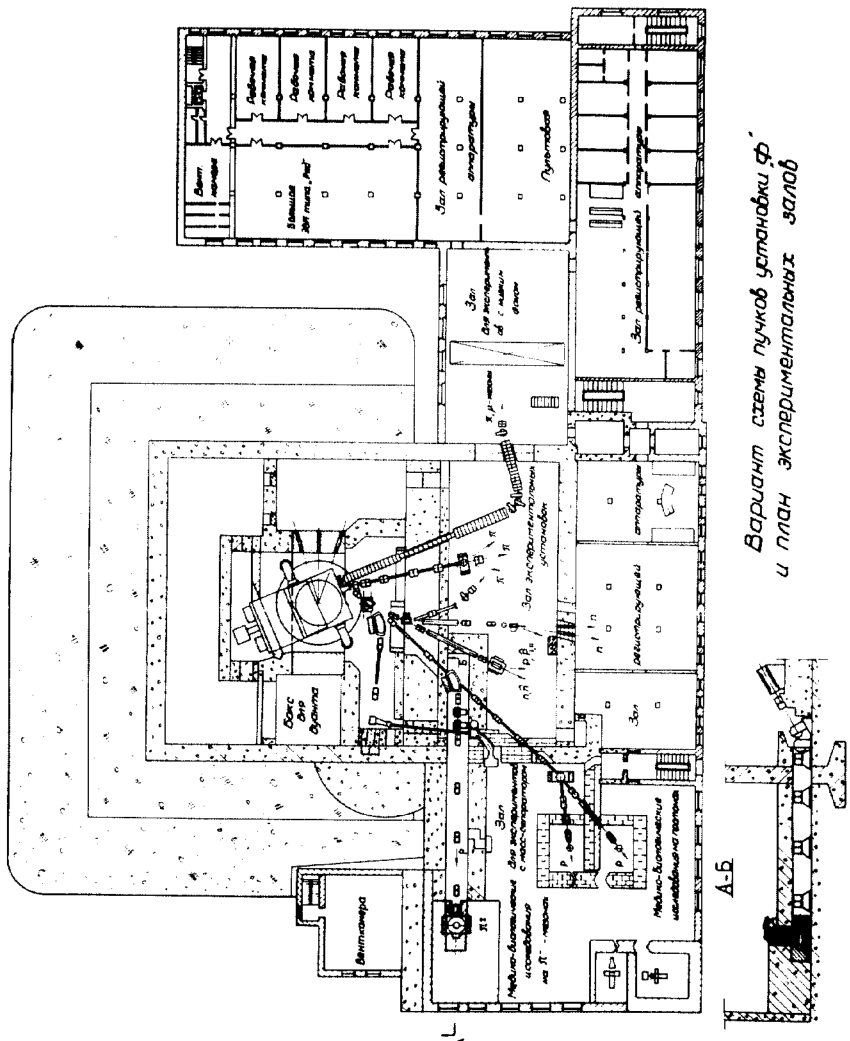


Fig. 4



Hz (Э)
X (MM)
80
110
74
49
20
50
40
200
100
0
-3800
-4000
24
18
12
16
14
8
4
27
33
22,5
11
7,5
3,5
1

Fig. 5



Вариант схемы пучков установки „Ф" и план экспериментальных залов

Fig. 6

DISCUSSION

RAINWATER: Is your machine presently running in its old mode, or have you shut down for the changeover?

DENISOV: Our machine is running, of course, and we hope that we will work to the middle of 1974 and only then do we plan to shut down to begin our work on this. We have a special building for the testing of the new system. This building, which you saw some minutes ago, was constructed especially for this work. When we have the new system, vacuum chamber and so on, preliminarily we will test this system in this building and pass it. Then we shut down and begin our work on that line.

MICHAELIS: Could I ask Dr. Denisov perhaps to explain a little bit more about the trim coils which I believe he is putting around the centre of the machine? How are they made, how much current do they take, are they water cooled?

DENISOV: We cannot achieve the desired low magnetic field in the central region using only ferromagnetic shims. We must hook up four coils in the central part of the magnetic field. These are water-cooled copper coils.

WILSON: I missed your statement of exactly what current you expect at the end of all these changes.

DENISOV: It is a very difficult question, of course, for us. We think in Dubna that we will have about 25 to 50 μA with 50 kV dee voltage.

BLOSSER: Could you tell me the separation between the iron at the centre?

DENISOV: The distance between shims in the central part is about 12 cm.

WARREN: It wasn't clear to me, did you mean 20 μA extracted beam from the machine? That was one point. Secondly, did I understand you correctly that you had four beam lines going to the medical area?

DENISOV: The first question about the extracting system: For such a large current, of course, we must have an extraction system with maximum efficiency because we cannot service this accelerator using only internal targets. The maximum beam current on this accelerator we can obtain with an extraction efficiency of 60-90%. If we use an electrostatic deflector and ferromagnetic channel without a current septum, we can have such an efficiency. The beam stop system is constructed in such a way that it will handle this current.

The second question about medical beams: Now about 10% of the full time for this synchrocyclotron is used for medical tests, especially for cancer therapy. We plan to have in addition--we have now one proton medical beam with energy about 150 MeV--one π-meson beam for cancer therapy. We plan to have a special place for the medical experiments, a special additional building.