PROGRESS REPORT ON THE DESIGN AND CONSTRUCTION OF ISOCHRONOUS CYCLOTRON AT GATCHINA

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Design and construction of isochronous 80 MeV H^--cyclotron is being in progress at PNPI. The cyclotron is intended both for extending the traditional for PNPI fundamental research and for production of high-quality radioisotopes for a medicine. The main parameters of a cyclotron are presented at the table 1 and have been described in more details at [1].

During 1994–1995 a design and an engineering of cyclotron components were being continued.

Table 1

Magnet:	
pole diameter	2.05 m
gaps:	
valley (max)	386 mm
hill (min)	146 mm
number of sectors	4
spirality	65°
flatter (max)	0.025
field in a centre	1.352 T
extraction radius	0.85-0.90 m
weight	250 t
RF-system frequency	41.2 MHz
voltage	60 kV
harmonic f_{rf}/f_{ion}	2
power	2 × 40 kW
Vacuum	10^{-7} Torr
Sources:	
internal	Eilers type
external	surface - plasma multicusp source
voltage	20 kV
Extraction:	
energy	40-80 MeV
method	Stripping

MAGNETIC SYSTEM. The computer calculations and measurements on models of magnetic system have been performed [2]. A specific feature of H^- cyclotron is an electrical dissociation of H^- ions during acceleration. Analysis of dissociation parameters and the calculation of the beam losses was performed [3]. As a result it was concluded that for H^- cyclotron it is reasonable to use a magnetic structure with a high spirality and a small value of flatter. Having provided a low beam losses due to H^- electrical dissociation those magnetic field structure ensures required Z-focusing at the expense of high spirality. However, it was shown small or zero spirality have to be used on a central region R<30 cm. Approximate method has been developed for a determination hill and valley gaps at a given average field, flatter and spirality. The calculation results have been verified experimentally on the 1:8 scale model.

The advanced approaches developed under design of Gatchina cyclotron have a more general significance and can be used for development of a new generation of H^--cyclotrons.

It was being continued a construction and manufacture of the magnetic system components also. The magnet has been installed at the shielded hall. At the final stage is manufacture of pole tips with sectors and shimms. The power supply and water cooling systems have been installed. The power supply for a small harmonic coils are under development.

The magnetic field mapping system is being under construction [4]. The field mapper consists of field measuring system on the base of the Hall probes, the scanning machine with computer control and date acquisition system. Due to a large body of measurement points it is made provision for high rate of measurements. The magnetometer consists of 20 Hall probes to increase the rate of measurements. The Hall probes are fed by two stabilised current sources. The Hall probes are calibrated by NMR and provides a measurement accuracy $\approx$1 Gs in the uniform field. The scanning movement is produced by electrical stepmotors, the coordinates are fixed by a encoders with accuracy $\pm$0.05 mm. All the system is being controlled by PC and time for the full map is equal 8 hours.

ACCELERATION SYSTEM (AS). The main design of AS and the drawings have been completed. Two manufacture technologies of AS have been examined. The first one is based on clod metal (copper and stainless steel) and second is traditional one to reduce expenditures. On the AS model it has been investigated accelerating voltage drop along the dee, effect of the frequency detuning due to termal deformation of the dee and also has been measured the frequency deviation produced by regulation elements [5,6].

ION SOURCES AND INJECTION. The test bench for the investigation and optimisation the internal H^--ion source have been put in operation [7]. The test bench for the external surface plasma ion source is under development. It is manufactured the source body and many power supply units are under test and tuning. The optic calculation of the beam line from H^--source up to central region of cyclotron has been carried out. The technical design of the beam transport line with the magnet optic elements, vacuum system with two turbomolecular pumps have been completed. As it is well known the central region of cyclotron to great extend determines the intensity and quality of the beam. The computer program for a design the central region of cyclotron has been developed [8]. The program provides calculation of isochronous magnetic field on central region, optimisation the relative position and shape of the accelerating electrodes for a good beam centering, a high energy gain and axial electrical focusing.

BEAM EXTRACTION. Program "ORBITA-1" has been developed for an investigation beam optic at the extraction. It was investigated as well stripping extraction as an extraction H^--ions by using electrostatic deflector. It was performed the calculation the beam property after stripping. It was carried out preliminary calculations of the magnetic channel optic and the selection of the field reduction and focusing gradients in the channel sections.

CONCLUSION. Coming from the presented data it may be concluded that for two last years a considerable advances have been made in the design and development of the cyclotron components. However the factory manufacture of the most expensive component such that a vacuum chamber, pumps, an acceleration system is frozen by deficiency financing. The next-future tasks are accomplishment the pole tips manufacture and start of the magnetic measurements.

During 1993-1995 the work was supported by Russian Fundation of Fundamental Researches 93-02-16718.

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DESIGN AND OPTIMIZATION THE MAGNET AND MAGNETIC STRUCTURE FOR THE 80 MeV H^- ISOHRONOUS CYCLOTRON

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Introduction. The design and construction of the 75 - 80 MeV H^- cyclotron is being in progress at PNPI [1]. To reduce the expenditure the cyclotron magnet has been designed to use the iron of the model magnet SP-72 of the operating 1 GeV synchrocyclotron.

Reguirements. The cyclotron magnetic field must meet some requirements. The magnetic rigidity on the final orbit must achieve Br = 13.2 kGs·m that corresponds to the 80 MeV energy. For isochronism it must be provided 8.5 % increasing of the azimuthally averaged magnetic field from center to final orbit. The azimuthal variation of the magnetic field must provide for z-focusing and permissible values of the horizontal ν_x as well as vertical ν_z oscillation frequencies. The value of the magnetic field in the hill must be as low as possible to confine the magnetic dissociation of the H^- ions in the limit of 5 %. To give the