PROGRESS OF THE 1.7m SFC

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Summary

In this paper, the features of the 1.7m sector-focused cyclotron (1.7m SFC) including main parameters and some measured results are given, and the work on magnet, RF system and so on since 1984 are also presented.

Introduction

The 1.7m SFC is the injector of the HIRFL accelerator system and it can also operate separately to provide effective beam for nuclear physics experiments and isotope production. Figure 1 Shows the cross-sections of the cyclotron. Table 1 gives the anticipated beam data, while table 2 and table 3 indicate the main parameters for the magnet and RF system respectively. The extraction system consists of three segments of deflecting channel, one magnetic focusing channel and two pairs of steering magnets [1]. Table 4 gives the main parameters of the deflecting channel. Information about the cyclotron has been given in detail earlier[2]. So this paper mainly presents the work and progress for it in the last few years.

Table 1: Beam data of the 1.7m SFC

Particle type	C--Xe(used as injector) C--Ne(operating separately) d,α
Energy	6.85Mev/N(c)--0.47 Mev/N(X_e) 32 Mev (d) 64 Mev (α)
Maximum beam intensity (PPS)	10^{12}(Ne)- 10^{13}(c) 10^{11}(Xe) - 10^{12}(Ne) 10^{14} (d,α)
Beam phase width	$\pm$ 5°
Emittance	20 - 25mm mrad (radial) 20 - 25mm mrad (axial)

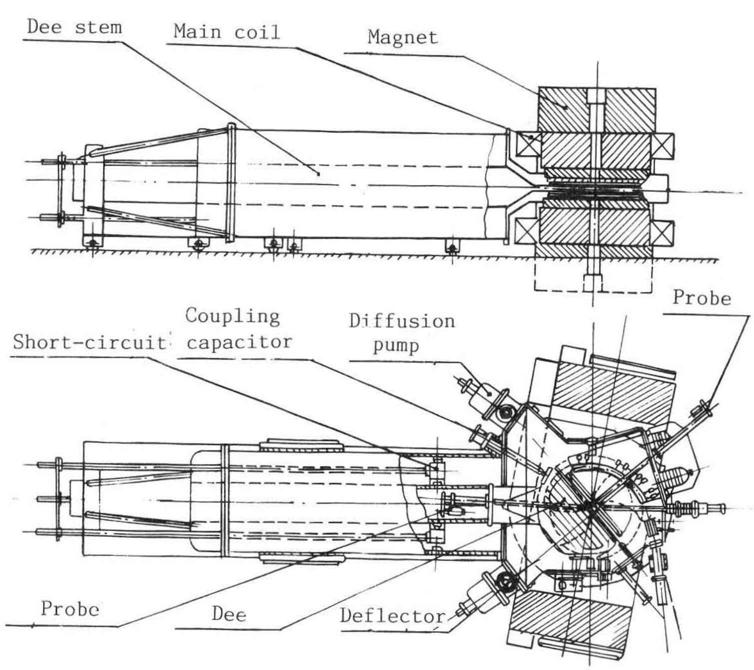


Figure 1: The cross-sections of the cyclotron

Table 2: Main parameters of the magnet

Energy constant K	69
Pole face diameter	170cm
Extraction radius	75cm
Average magnetic field	8KG-16KG
Number of sectors	3
Maximum sector spiral angle	33^{o}
Magnetic field flutter	20%
Number of trimming coils	12
Number of valley coils	4

Table 3:Main Parameters of the RF system

Accelerating electrode	180^{o} single dee
Effective aperture for beam	4cm
Frequency range	6MHZ-18MHZ
Maximum accelerating voltage	100Kv

Table 4: Main parameters of the deflecting channel

Ordinal number of segments	1	2	3
Cross-section	Plane	Hyperbola	Hyperbola
Azimuthal spread	35^{o}	37^{o}	32^{o}
Entrance angle (referring to co-axial resonator center line)	65^{o}	100^{o}	143^{o}
Maximum working voltage	100Kv	100Kv	120Kv

In February 1984, the main parts of the machine such as the pole tips, spiral sectors, trimming and valley coils, vacuum chamber and RF cavity had been or would have been manufactured according to schedule, so we stopped the 1.5m cyclotron's operation and began to set up the 1.7m SFC. The installation of the SFC has been finished and RF voltage has been applied on the RF cavity. We are trying to raise the amplitide of it. Beam adjustment will begin soon.

Magnet and magnetic field

The general shape of the SFC magnet is shown in Fig.2. In 1979, we had a chance to stop the 1.5m cyclotron's operation for several months[2], so that we carried out a basic magnetic field mapping of the SFC. According to the measured data and further analysis, two modifications of the magnet design were done:

(a) Twelve pairs of trimming coils are used instead of the original ten pairs.

(b) At the larger radii we added one extra set of valley coils for resonance extraction of light ions.

The trimming and valley coils, namely internal coils, are made of mineral insulating cable. Per 12 trimming coils are soldered in vacuum on a round copper base as a whole set mounted on the upper or lower pole face,while the valley coils are mounted on three valleys. The coils of these two kinds are shown in Fig.3. Considering that the center plugs, which will be mentioned below, might disturb the magnetic field symmetry, the currents of the trimming coils for the most inner pair are fed individually to correct the median plane of the magnetic field. In view of the corner effect, the maximum current of the two most outer pairs of trimming coils is designed as 1000 A, which is twice as large as that of the other coils. In order to minimize the first harmonic magnetic field component, the six spiral sectors, which had been made in 1978, were machined again more precisely.

The magnetic field measurement was finished in 1985.[3] In the measurement,

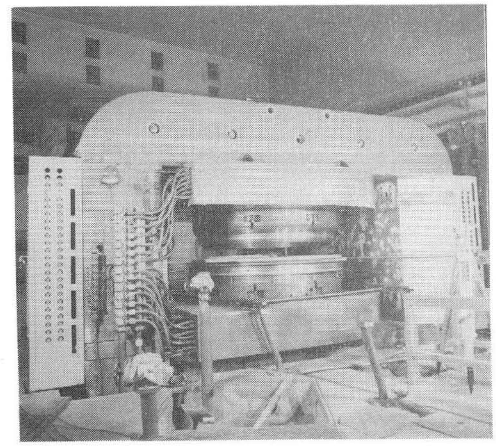
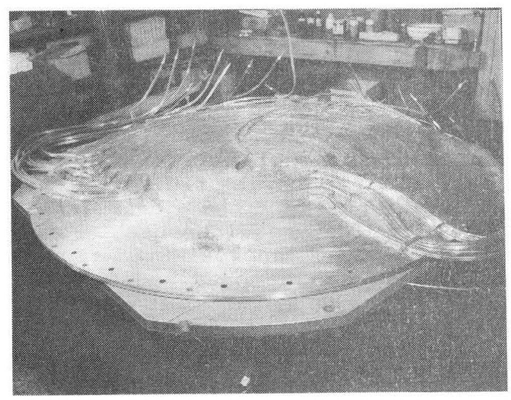
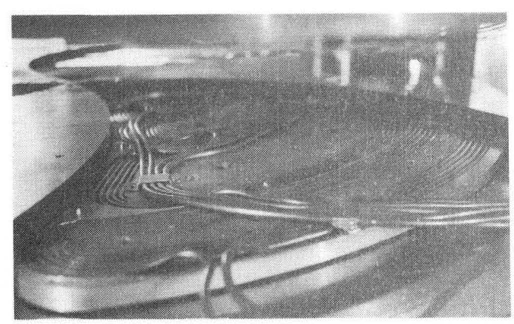


Figure 2: The Magnet



A



B

Figure 3: (A) Trimming coils
(B) Valley coils.

an automatic measuring system of multi-probes, which contained 48 pieces of Hall plates, was used. The Hall-plate positioning device with radial and azimuthal accuracies of respective 0.1mm and 10" is shown in Fig.4

Figure 4: Hall-plate positioning device

The Hall-plates are the model of SVB-579. The measured and calculated results indicate that the basic magnetic field profile and the contributions of the trimming coils satisfy the design requirements. For given energies and ions, approximate isochronous field within ±5G can be obtained by combining the currents of the main coils and trimming coils. Figure 5 shows the contributions of the trimming coils under the condition of about 14 KG basic field and the difference between the corrected field and isochronous field for C^{4+} of 5.9 Mev/N. Except that the light ions will undergo resonance extraction, important resonances, such as $\nu_z = 1/3$, $\nu_r=1$ and $\nu_r=2\nu_z$ will not be encountered from the acceleration region to the extraction radius. The amplitudes of the first harmonic component are smaller than 6G for all basic fields.

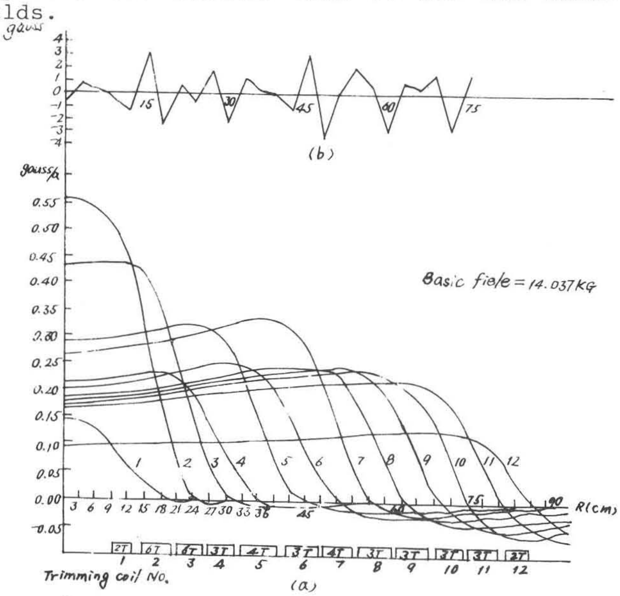


Figure 5:
(a) Contribution of the trimming coils
(b) Difference between the corrected and isochronous fields

RF system

In Fig.6, there is a photograph of the coaxial resonator with its single-dee.

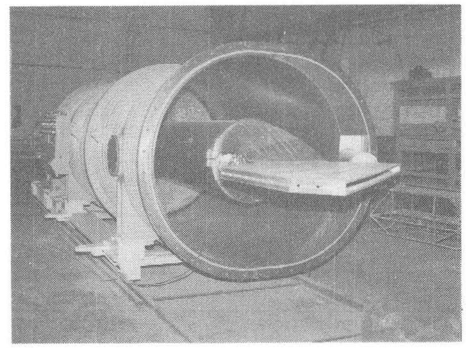


Figure 6: Coaxial resonator with its single-dee.

The measured resonant frequency range is from 5.5 to 18.3MHZ, which is a little wider than the designed value. The old RF transmitter will still be used for the SFC for a few years with two modifications.

(a) A push-pull to single-end convertor was inserted between the output of the transmitter and one of the feeders. Since 1983, it has operated successfully under O^{5+}, N^{5+} C^{4+} and α. The corresponding working frequency are 8.076MHZ, 9.2MHZ, 8.64MHZ and 12.9 MHZ respectively.

(b) The input circuit of the transmitter was modified to satisfy the requirements of an injector. In 1984 a new synthesizer, a 100 W wide-band amplifier and a new designed modulator were perfectly accomplished.

Although a lot of work has been done on the transmitter, it is difficult to raise the highest working frequency to more than 15 MHZ. In order to achieve the designed energy range for different ions, the highest frequency is asked to be 18MHZ, so that a new transmitter was ordered and will be delivered in April 1987. The specifications for the new machine are as follows:

Frequency range: 6MHZ to 18MHZ
Maximum RF power output: 200Kw
Output impedance: singe-end 50 ohm
Final tube: Thomson Th537 ceramic tetrode.

At the beginning, we intended to put the final stage close to the resonator. But at last we failed to do so, since the minimum length of the feeder is restricted by the existing compact site. Now the machine under constructing will still be installed in the original RF room.

Center rigion and ion source

The schematic drawing of the center rigion is shown in Fig.7 In addition, there is a pair of center plugs, as seen in Fig.8 for a center bump field[4]. In order to learn the relations betwwen the parameters of the center region and the beam behaviour and to define the varriable range for the parameters, theoretical analysis and orbit calculations for 12 given typical ions[5] were done. From this work, the following decisions are made:

(a) both the ion source and the puller should be moved in two directions along the horizontal plane, while the defining slits can only be moved radially.

The angle α_s between the accelerating-gap center line and the ion souce exit plane can not adjusted, but we can change the source head to obtain a required angle α_s, if needed.

(b) To simplify the adjustment on the center region during the cyclotron operation, we could adopt the constant orbit mode[6]

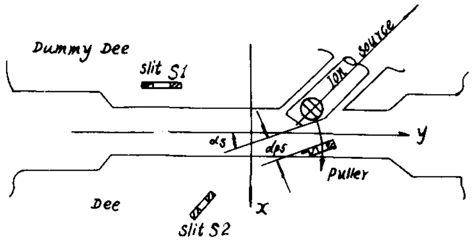


Figure 7: Center region

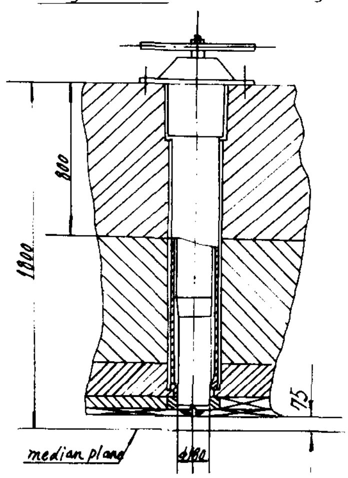


Figure 8: Center plug

The radially-inserted PIG ion source will still be used in the near future. In the HIRFL accelerator system, the main accelerator is a separated-sector cyclotron, namely SSC, whose energy constant K is 450. As well known, the PIG ion source can not produce heavier ions with highly charged state, and this is unfavourable for this system to reach high energies for heavier ions. For this reason, we intend to set up a ECR[7,8] source in HIRFL, and are drawing up the project for constructing it.

DC power supplies

There are three models of DC power supplies for main coils, trimming coils and valley coils respectively. The main coils supply is modified from the existing one, which is a moter-generator unit, by inserting transistor regulators into the DC output circuit and the excitation circuit. The block diagram is shown in Fig.9. The trimming coil supplies are regulated rectifier type, which were manufactured by Xian Rectifier Factory. The valley coils are fed by the so-called sinusoidal power supplies, so a first harmonic magnetic field can be obtained without changing the average field by adjusting their currents.

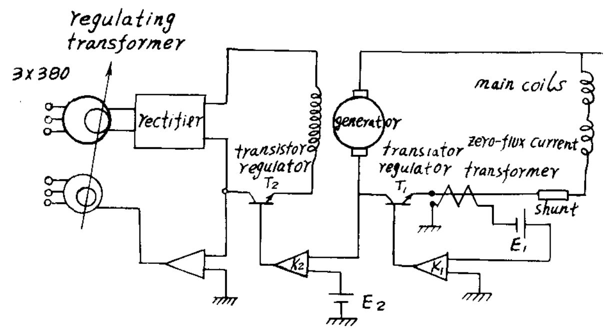


Figure 9: Main coil power sopply

The designed current stabilities of the main coils, trimming coils and valley coils are 5×10^{-5}, 1×10^{-4} and 1×10^{-3} respectively. All the supplies have operated for several months and the operation situation shows that they work reliably.

Acknowledgement

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