CURRENT STATUS AND FUTURE PROJECT OF CYCLOTRON LABORATORY IN ALMA-ATA

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ABSTRACT

The present paper describes the results of improvements performed at the cyclotron facility in Alma-Ata during last years. Among them are increasing the efficiency of beam extraction system and opportunity of increasing time range between two successive beam pulses by RF-beam pulser. Future plans on the K=600 heavy ions separated sector cyclotron are also presented.

1. INTRODUCTION

The main trend of the Cyclotron laboratory in the INP in Alma-Ata is the improvement of the accelerated particles beam parameters and isochronous cyclotron systems to meet the increasing demands of nuclear physics experiments and commercial applications of the cyclotron[1]. Since commissioning the isochronous cyclotron in 1972[2] the beam transport system, ion source, vacuum system were modernized and RF voltage was stabilized. The present paper describes further modernization of the beam extraction system including remote controllable electrostatic deflector located inside the dee. The installation of an additional external deflector for ion bunches selection is also considered.

Another trend of the Cyclotron laboratory research was development of the project of accelerator installation the main part of which is the separated sector cyclotron with K=600. Some results of the model magnet magnetic field measurements are presented.

2. ADJUSTABLE DEFLECTOR

The main feature of the Alma-Ata cyclotron is the accelerating system, consisting of two 180° dees. This system affords the large energy gain per turn thus decreasing influence of magnetic field disturbances and enlarging the turn separation at extraction radius. At the same time the necessity of placing the deflector inside the dee complicates substantially it's design.

The high effective and reliable extraction system must meet the needs of necessary deflection and focusing of the beam and to be reliable under large heat load. At changing magnetic field in the wide range it is necessary also to take into account the changing of the shape of the orbit at extraction radius. For this reason a new electrostatic deflector with nonuniform electric field and with precise replacing of it's parts without switching off high voltage potential was designed. This deflector located inside the dee is shown schematically in Fig. 1, the angular coordinates (15°, 55°, 125°) of three movable parts of the deflector are depicted.

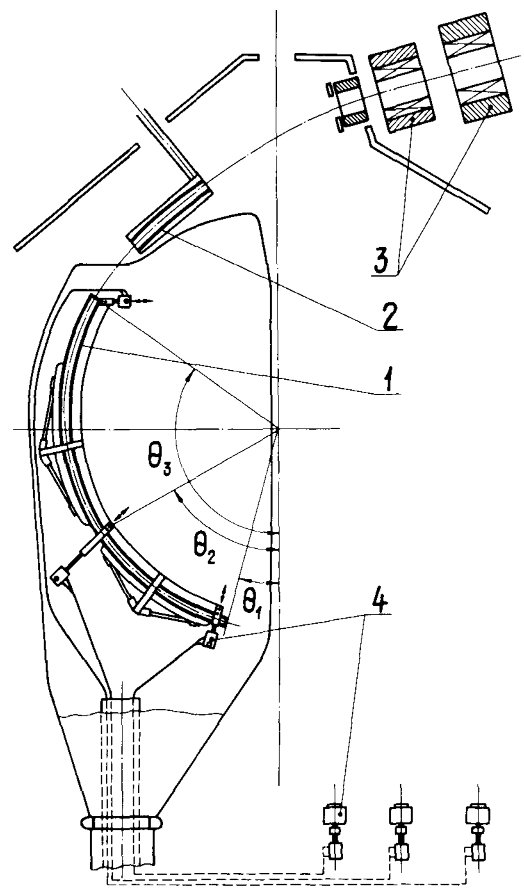

Fig. 1. The beam extraction system: 1-adjustable deflector, 2-additional deflector, 3-steering magnets, 4-hydraulic cylinders.

The fine displacement of these parts of the deflector may be made in the range of ± 7 mm with accuracy of 0,1 mm and be produced remotely from the main control panel with three pairs of hydraulic cylinders. General view of the deflector is shown in Fig. 2. This device is very effective in adjusting the acceptance of the deflector to the emittance of the internal beam.

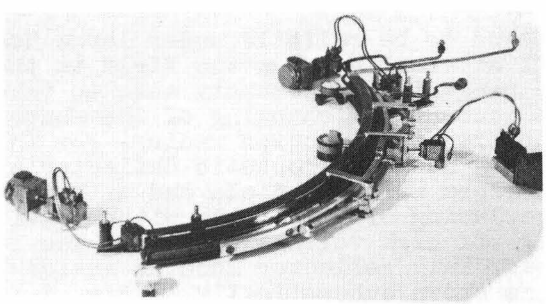

Fig. 2. General view of the adjustable deflector.

3. THE SYSTEM FOR REDUCTION OF PARTICLE BUNCHES REPETITION RATES

This system is designed for increasing the resolution of a neutron spectrometer based on time-of-flight measurements by reducing the beam repetition rate. Using a selection slit, three successive accelerated particles bunches of every four ones are stopped at a collimator after sweeping off by high-voltage RF deflector. Only the bunches which see a zero resulting electric field between the electrodes of the deflector are able to pass the selection slit. Usually as a bunch selector a deflector with flat electrodes and sinusoidally varying potential difference between them is used[3,4].

An effective sweeping off system assumes absence of beam losses, minimum deflecting voltage, reliable design, simple tuning and easy running. To meet these needs a deflection system was developed which is located in the fringing magnetic field of the cyclotron immediately after the main deflector. Such a system gives substantial reduction of deflection potential in comparison with ordinary one located in nonuniform magnetic field free space. The deflection system is shown in Fig. 1. An additional deflector (pulser) is located inside the accelerator chamber and outside the dee (θ=142°–162°), where the beam size is sufficiently small yet.

The deflector is composed of a pair of plates 30 cm long and separated by 3 cm, in cross section they have hyperbolic profile for increasing radial focusing of the beam. The results of the numerical calculations of the beam envelopes in the horizontal plane for different potentials at the deflector are shown in Fig. 3. The experimentally measured beam emittance and ion transit time in the deflector have been taken into account. The minimum potential for 30 MeV protons burst separation is 15 kV.

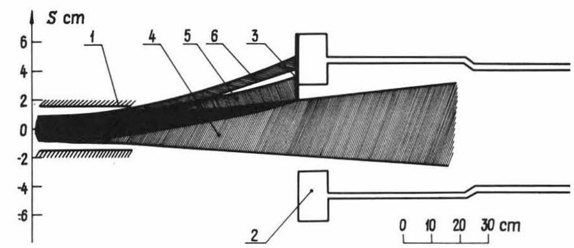

Fig. 3. Particles bursts sweeping off system and beam envelopes: 1-RF selector, 2-beamline, 3-collimator, 4,5,6-beams at potential difference of 0, 15 kV and 30 kV.

The power-supply electrical circuit is analogous to those of [3,4] and is shown in Fig. 4.

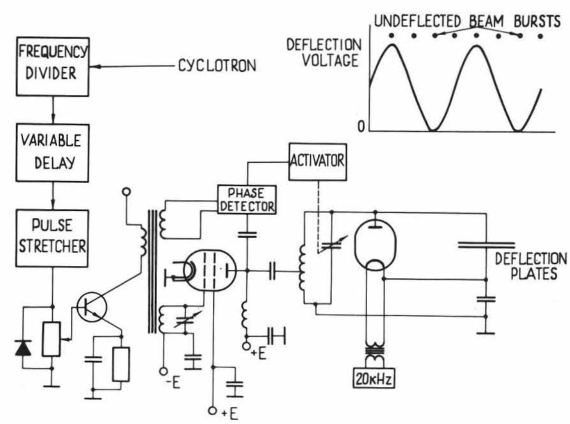

Fig. 4. Simplified scheme of particles bursts selection system.

The final section is a resonant LC circuit in which the selector is a capacitive element. In this circuit a sinusoidal voltage is excited. The frequency varies from 2-4,5 MHz. The final amplifier stage consists of a power tetrode run in class AB with a total power of 0,8-1,0 kW. The resulting potential difference generated between the electrodes of the selector varies sinusoidally from zero to the peak value. This signal is phased with the particles bunches, so that the interesting bunch passes through the deflector when the potential across the electrodes V is zero and dV/dt is zero also.

4. CYCLOTRON PROJECT WITH K=600

In order to develop accelerator-assisted scientific research in the Republic of Kazakhstan after 20 years of intensive use of 150-cm isochronous cyclotron in Alma-Ata it was decided to carry out preliminary accelerator science research on new K=600 cyclotron facility, for these research necessary financies were allowed. The facility consists of a separated sector cyclotron and injector cyclotron with K=100. The ion species and energy range are considered to be from 200 MeV protons to very heavy ions with A 200 and energy as high as possible. Up to this time magnetic field mapping on the model magnet were carried out and orbit characteristics were investigated numerically and analitically. The schematic plan of the four sector cyclotron is shown in Fig. 5. The 1/20 scale model of the sector magnet is shown in Fig. 6.

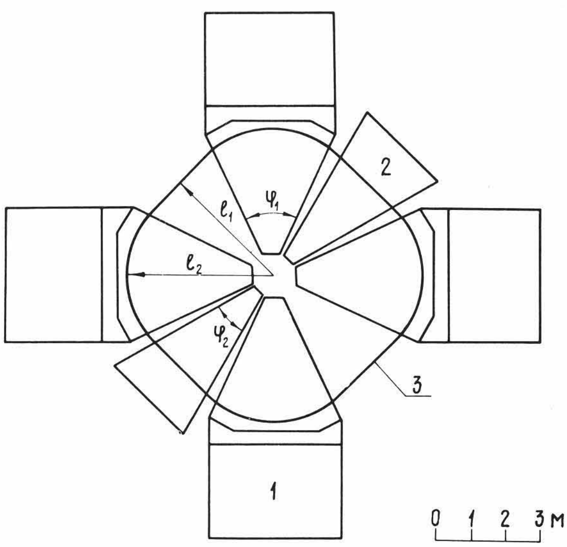

Fig. 5. Simplified scheme of separated sector cyclotron: 1-sector, φ_1=50°, 2-dee, φ_2=30°, 3-equilibrium orbit.

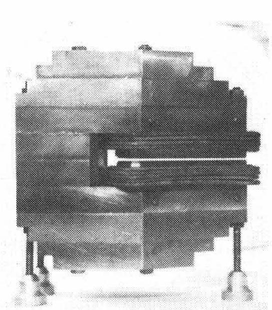

Fig. 6. Model magnet.

Magnetic field mapping was carried out at the full range of radii and angles for different levels of magnetic field density. Tipical azimuthal distribution of magnetic field is shown in Fig. 7.

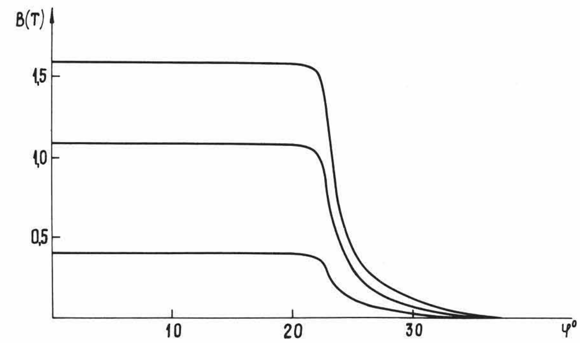

Fig. 7. Azimuthal distribution of magnetic field in the median plane.

The choice of general scheme of the main cyclotron, determination of injection and extraction radii at this stage were carried out at the simplifying assumption of sharp end fringing field. Accurate calculations of equilibrium orbits, betatron frequences and isochronous magnetic fields were performed using different computer programes. The frequency band of the RF system is from 6 to 29 MHz, the orbital frequency band is from 2 to 7,3 MHz. Detailed design of different elements of the facility is now in progress but the future development of the project is not yet approved by the Kazakhstan government.

5. REFERENCES

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