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RADIAL AND VERTICAL BETATRON OSCILLATION FREQUENCIES OBSERVED BY A SCINTILLATION PLATE AND A THREE WIRE TOMOGRAPHY MONITOR

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Abstract

We report here diagnostic measurements of accelerated protons of 400MeV in RCNP Ring Cyclotron.

1.Introduction

To clear the problems on the extracted beam qualities concerned with accelerated beam dynamics in RCNP Ring Cyclotron[1] , we developed a beam viewing system with TV camera and a phosphor covered scintillation plate. It enable us to take a continuous picture of beam position and size in full radius of acceleration. The scintillation plate is mounted in front of the copper beam stopper of the main probe head. From these measurements, we can deduce the vertical and radial oscillation frequencies in each radial positions.

2. T.V. camera and scintillation plate

The phosphor plate which has scintillating surface obtained by spraying Zns on an aluminum plate(1mm thickness) is mounted in front of the copper beam stopper(on the main probe head for an integral current monitor). The viewing ports for this is set at the valley region beyond the one sector magnet from the main probe location. The T.V. monitor camera outside the vacuum chamber views the inside mirror inclined 45-degree to the median plane of the accelerator. In order to look over the whole view for the radial range of the main probe, the setting of the mirror and T.V. camera should be changed several times. One measurement for that radial range is about 600mm. The scintillation plate on the main probe moves at the speed of 20mm/sec by taking a picture for the monitor TV with POLAROID camera at B-mode. The observed vertical oscillation is shown in Fig. 1.

3. Main probe

A main probe measures the current and the transverse shape of the beam in the Ring Cyclotron. It consists of a tomography head of three thin platinum wires and an indirectly cooled beam stop. The probe can be adjusted for the probe head to face the tangential direction of the beam orbit at any radius. The driving speeds can be chosen between 20mm/sec and 200mm/sec. At the beam tuning, the current measured with this probe is about 10nA. Thus the efforts to get good signal to noise ratio for weak beam current down to 1nA are being made. A 30 Hz 5th order(30dB/Oct.) low pass filter is used. Moreover, the attenuation of 30dB for 60Hz was

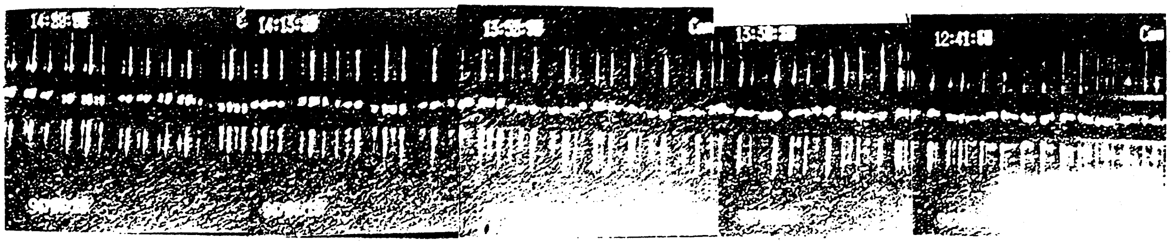

Fig.1. Observed vertical oscillation

achieved by using an integrated circuit of switched capacitor filter LTC1062.

4.Results and discussion

(1) Both from the observed pattern for the vertical beam oscillation and from the recorded turn numbers obtained with the three wire tomography monitor, we can deduce the turn numbers in each oscillation cycle. Thus, there are two results when the cycle is estimated from the successive top peak positions or from the bottom peak positions in the observed figures. Specified radial length in Fig.2. shows this oscillation intervals and specified ones are described at the middle of the cycle in the radial axis. The betatron oscillation frequency can be estimated from the reciprocal number of turns in this cycle plus one. Less than about 1500mm in radial, the pattern of tomography monitor can be distinguished in turn by turn, although some of them are a little overlapped each other which introduced more errors.

With these procedures, we can obtain vertical betatron oscillation frequency at each radial intervals as shown in Fig.2.

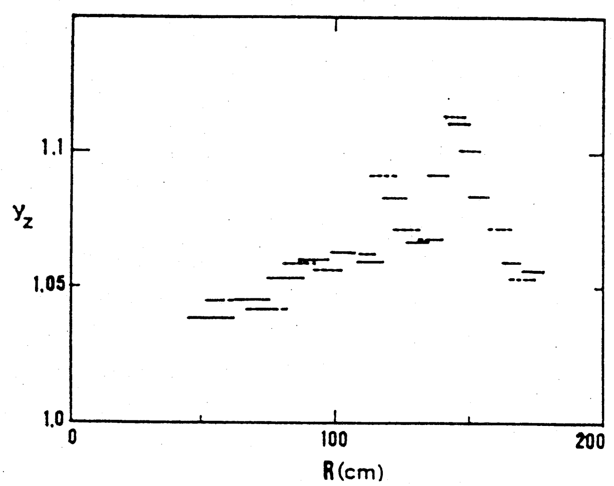

Fig. 2. Deduced vertical oscillation frequency

(2) We assume that the betatron oscillation of the beam is enhanced with miss matching in the injection to the Ring Cyclotron and purely introduces the unequal separation in successive turns. Thus, we measured dr separation in each turn of the radial spectra observed with vertical wire of the tomography monitor from injection to the distinguished turn about 1600mm where we can put the turn number 260-revolutions. Thus, we plotted dr separation to this revolution numbers. It shows oscillatory pattern with a increase of the radial position as shown in Fig. 3.

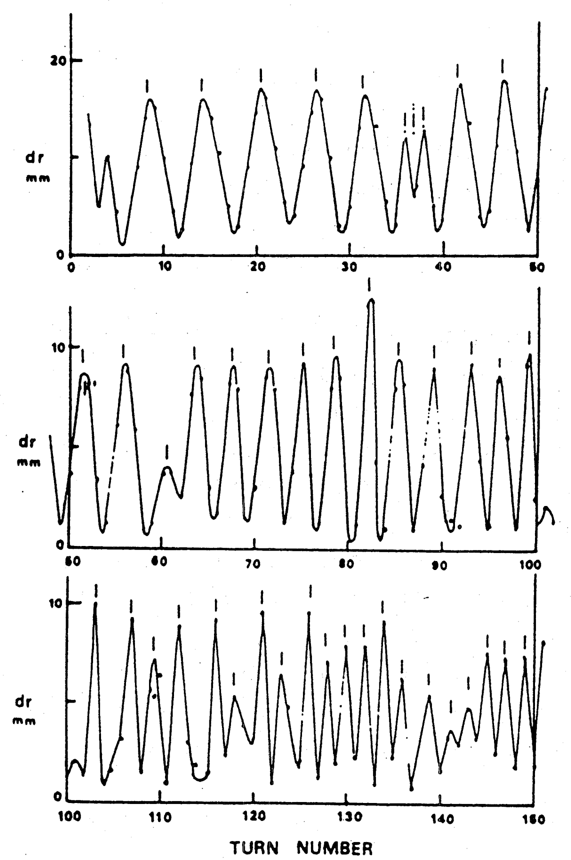

Fig.3. Measured dr separation in each acceleration turn

Between the successive dr maxima or dr minima in this figure we can measure the turn numbers in the one cycle from which we estimated radial betatron frequencies. Over the 1000mm in radius the figure shows an irregular pattern mixed with two or three cycles of oscillation intervals. Even taking into account the regular increase of the radial betatron oscillation frequency, the observed structure was somewhat disturbed with several processes such as unequal acceleration process in beam phase, imperfect isochronous field and considerable amount of beam dispersion in energy.

As a result, we can deduce radial betatron frequencies from injection to almost full acceleration radius as shown in Fig.4.

Compared with the betatron frequencies calculated from the data of magnetic sector field, these observed values are roughly consistent with their radial response for both betatron oscillation frequencies[1]. However, vertical oscillation frequency rapidly increases at around 1500mm over ν_r=1.0 which may suggest the unstable behavior of accelerated beam induced from magnetic field structure and trim coil parameter optimization.

This phenomena is coincided with the measurement of induced radio activities remained in acceleration gaps of three cavities. Although this oscillation have not brought about a fatal situation for obtaining the full transmission from the injection to the extraction, it needs precise tuning the isochronous field shape and the beam injection phase.

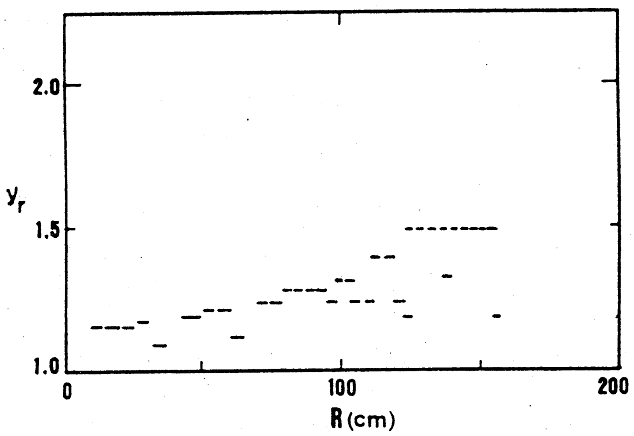

Fig.4. Observed radial betatron frequency

Acknowledgments

The authors wish to express their thanks to RCNP cyclotron operation crews for the various tuning of machine for the accelerator development.

References

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