STUDIES OF THE INTERNAL AND EXTERNAL BEAM PROPERTIES OF THE INS SF CYCLOTRON

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1. Attempts to understand the beam properties have been continued since the first beam was obtained from the cyclotron. A few recent results of the study are given in this report just to show the present status of our understanding of the internal and external beam properties. The beam data shown in the fowllowing were taken under the conditions of operation for acceleration of 22.5-MeV protons in a "250-turn mode", which is usually adopted in this cyclotron in the cases of light ion acceleration.

2. It is known that a narrow exit slit of the ion source yields accelerated ions of better quality than a wide slit[1]. We applied this principle to the ion source of our cyclotron. The exit slit of the ion source which we normally use is a tantalum plate with a slit of 1 mm width and 10 mm height. Instead of this type of slit, we tried a narrow slit of 0.2 mm width with an opening angle of 60^{o}. As a result, the turn pattern of the beam observed with the differential beam probe became cleaner. This improvement enabled us to observe the whole acceleration process from the second turn to extraction.

An example of the beam data is shown in Fig. 1, where the observed radii of each turn, the difference of raddi between the successive turns and the frequency of the radial betatron oscillation are plotted as a function of number of revolution. From the period of oscillation we obtained the frequencies (shown as the open squares in the Fig.), which were found to be in good agreement with calculated one based upon the measured magnetic field data[2](shown with dots).

By adjusting the valley coil, we obtained another datum which showed a smaller amplitude of betatron oscillation. In Fig. 2 the differences x_K between the mean radii r_K observed and the radii r_{eK} of the equilibrium orbit are plotted as a function of number of revolution. The radii r_{eK} were assumed to be calculated from[3]

$$r_{eK}^2 = A(K+C) - BK^2$$

where the parameters A, B and C were obtained by fitting the observed r_K^2 with a quadrutic function of K in the middle turns where this formula was supposedly applicable. The large deviation from zero in the early turns and extraction region may be attributed to the phase slip. The parameters obtained from the fit were found to be consistent with those used for tuning. In particular the dee voltage calculated from the parameter A was found to be 42.6 kV while the setting was 44 kV. The number of revolution up to extraction was found to be

263, while the setting was intended to be 250.

3. A beam profile monitor has been installed just before the exit slit of the beam analyzing magnet in order to measure quickly the momentum distribution of the extracted beam. Our efforts have been directed mainly to understanding the relation between the properties of the internal beam and the energy spread of the extracted beam. While so far we have not succeeded in getting a clear solution of this problem, a good example is shown in Fig. 3. The momentum distributions were measured under the same conditions of tuning except that the usual exit slit of the ion source was used in the case of (a) while the narrow slit was used in the case of (b). The improvement in the energy resolution is evident.

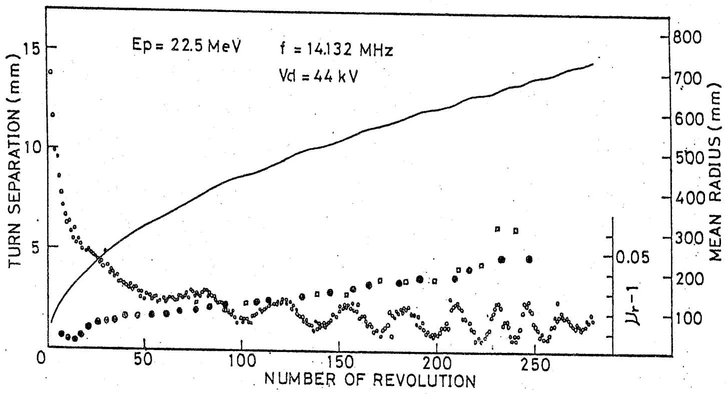

Fig. 1.

Mean radius, turn separation and frequency of the betatron oscillation

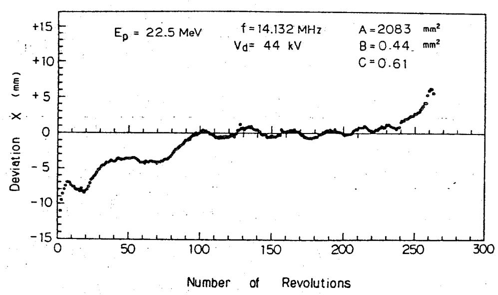

Fig. 2.

Deviation vs. number of revolution

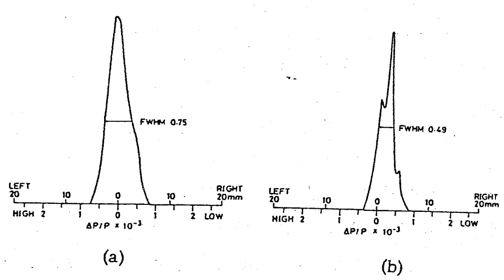

Fig. 3.

Momentum distribution

1. I Chavet and R. Bernas, Nucl. Instrum. & Methods 47(1967)77
2. T. Tanabe et al., INS-J 154(1975)
3. M. E. Losel et al., IEEE Trans. Nucl. Sci. NS-14(1979)1087