Measurements of turn pattern influenced by deviation of the magnetic field of the RCNP AVF cyclotron

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It has been already reported that beam quality have strongly correlated to a magnetic field of the injector AVF cyclotron in the RCNP[1]. In our measurements, the magnetic field should be kept the level within $\pm$ 2.5x10^{-6} for ultra-precise beam ($\Delta E/E \approx 2$ x10^{-4}). However, a quantitative correlation between the magnetic field and the beam quality was still unknown. On the first step to obtain such relationship, turn pattern in the AVF cyclotron was measured nearby an extraction region as a function of deviation of the magnetic field.

The deviation of the magnetic field, ΔB, influences the total turn number N via an energy gain per one turn. Assuming a perfect isochronous condition and an Rf-top acceleration, a variation in turn number, Δn, is represented as

$$\Delta n = \frac{2\pi^2 h^2 N^3 \left(\Delta B / B\right)^2}{3} \qquad (1)$$

where h is harmonic number. A similar formulation has been already reported by W. Braeutigam *et al*[2]. However, the degrees of ($\Delta B/B$) term was 1 and their numerical prediction was inconsistent with their equation in their paper.

For the RCNP AVF cyclotron, $N \approx 500$. Thus, $\Delta B/B$ must be controlled by 10^{-5}. Careful temperature control of the iron core and a special one-turn coil makes us possible to satisfy this critical condition.

Figure 1 shows observed Δn for the last five turns near extraction. From these results, Δn=1at $\Delta B/B$=4x10^{-5}. Calculated values of Δn from eq.(1) are also shown in fig.1 with three different N values. It should be noted that the isochronous condition can not be perfectly satisfied in an AVF cyclotron. Nevertheless, Quantitative agreement was well.

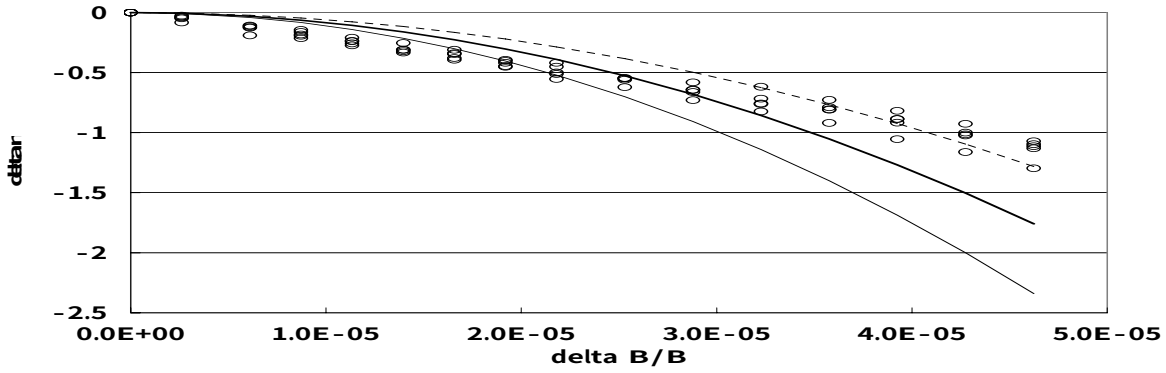

Figure 1 Observed Δn as a function of deviation of the magnetic field. Calculations for N=450(dotted), 500(thick) and 550(thin) are also shown.

The deviation of a beam energy equals to $\Delta n/N$. Thus, in order to keep the beam energy within 1x10^{-4}, the $\Delta B/B$ should be kept in the level of 10^{-5}. It is noted that the influence of $\Delta B/B$ to the energy deviation can reduce both by using higher Rf field(i.e., smaller N in eq.(1)) and by using flat-topping system to the AVF cyclotron.

References

[1] S. Ninomiya *et. al.*, RCNP Annual Report 2001 p.148.

[2] W. Braeutigam and R. Bring, Proc. of the 14th Conf. on Cycl. and their App., Cape Town, South Africa, p.280, 1995.