STUDIES ON BEAM TUNING PARAMETERS OF KOLKATA SUPERCONDUCTING CYCLOTRON

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Abstract

All the major components of the of the Kolkata superconducting cyclotron are installed and functional. First acceleration of beam has now been achieved in the superconducting cyclotron. This success has confirmed that fundamentally the complex magnetic field and electric field required for acceleration has been achieved in the cyclotron. Rigorous beam dynamical calculations have been carried out to find out operational parameters to accelerate the beam in the cyclotron using the measured magnetic field. We will present here the studies on the different parameters related to beam tuning

INTRODUCTION

The Kolkata Superconducting Cyclotron at VECC Kolkata has accelerated Neon beam up to the extraction radius in 2009. Very soon it will deliver a large variety of ion beams over a wide range of energies (up to ~ 10-80 MeV/nucleon medium heavy ions with mass A<60 and ~5-20 MeV/nucleon for heaviest ions). The operating diagram has been shown in figure1. The minimum and maximum field limits are 30 & 50kG, the maximum Q/A is 0.5. The optimised isochronous magnetic filed is produced by the combined contribution of the two main coils, the iron core and from the 14 nos. of trim coils. The present study of the beam dynamics has been carried out using the magnetic field maps [1] obtained from the measured data.

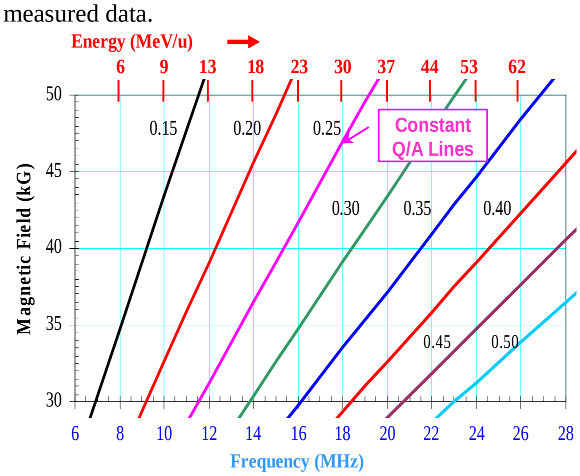

Figure 1: Operating diagram in the (ν_o ~Bo) plane

The Dee voltage and inflector voltage are decided by the central region characteristics of the cyclotron. For this machine it has been designed to work in fixed orbit mode. In a fixed-orbit geometry mode of cyclotron operation the magnetic field B, the Dee voltage (V_{Dee}), particle frequency ν_0 must be changed in such a way that V_{dee} /(B 2π ν_0) remains constant This is the well known Reiser parameter [2]. The scaling of Dee voltage, Magnetic field and Energy for different RF Frequencies has been shown in figure 2 for Q/A = 0.25 and 0.35.

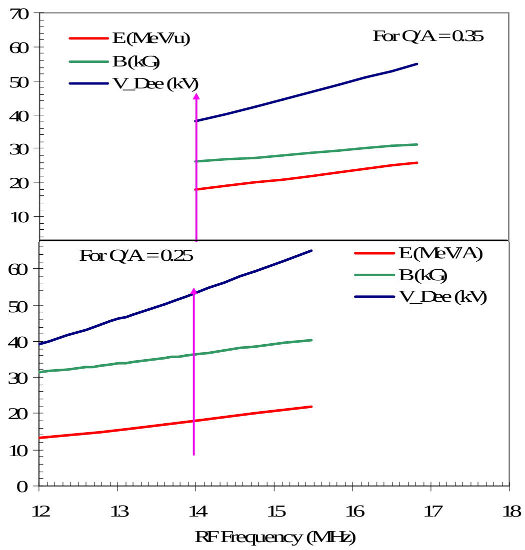

Figure 2: Plot of RF Frequency ~ E/A, B_o & V_{Dee}

ORBIT PROPERTIES STUDY

The test beam Ne^{3+} , which has been accelerated up to the extraction radius, was studied using The code *'TrimCoilFit'* with the following parameters: Ion: Ne^{3+}, Q/A = 0.15, E=4.454 MeV/nucleon, RF harmonic mode h=2, ν_{RF} =14.0 MHz, B_0=30.599 kG, V_{Dee}=35 kV, R_{Def} =26.49 inches, V_{ECR}=4.4 kV. For a given particle (say $^{20}Ne^{3+}$), final energy E (MeV/u), the Energy~phase relation [3] and the Dee voltage (V_{dee}), *'TrimCoilFit'* determines a set of optimised currents that will produce an appropriate field in which the particle phase history will match the given phase history. We have studied the above said beam taking into account different "Energy vs. phase" curves. In figure3 two such cases have been shown. The resultant frequency error (Ω(E)) plots have been shown in figure4. The frequency error curves also show that Ω(E) is nearly equal to zero from 6 to 24 inch radiuss suggesting good degree of isochronism.

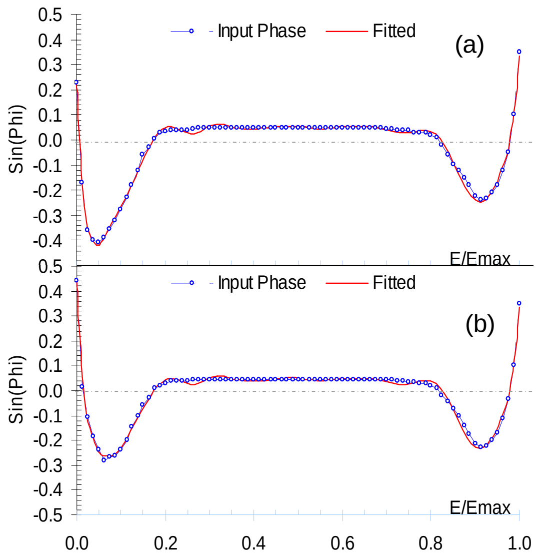

Figure 3: Energy ~ Sin(phi) curves. Energy is normalised by E_{max}

Table1 shows the current settings obtained from 'TrimCoilFit' by fitting 'Energy ~ Phase' curve for two cases (a) and (b). Comparison between the calculated and actual current settings (two main coils and 14 trim coils) for the test beam $Ne3^{+}$ has been shown in figure5.

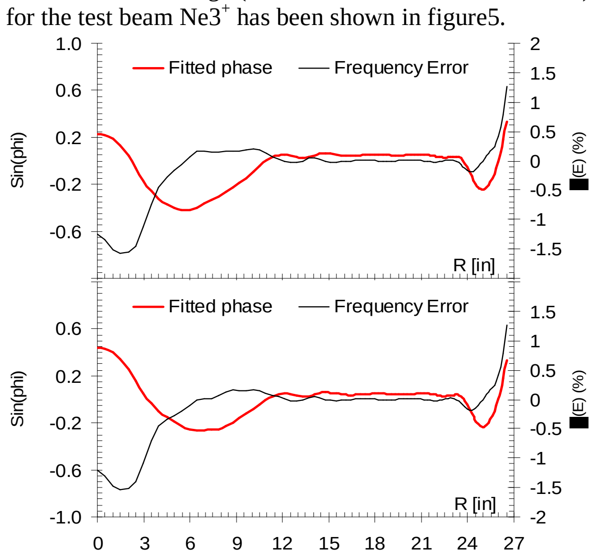

Figure 4: Plot of Ω(E) and Sin(phi) vs. radius

REMARKS

The beam dynamical computations [4] using the measured magnetic fields provided a very good and "close to the actual" parameter settings as can be readily seen from the graph. The deviation of some trim coil settings are partly due to first harmonic present in the field and partly due to the improper 'energy phase' history. So we are still studying for a improved 'Energy ~ phase' history so that we can predict the tuning parameters more accurately.

(a)		(b)	
Alpha	446	Alpha	447
Beta	264	Beta	265
TC# 0	0	TC# 0	0
TC# 1	135	TC# 1	91
TC# 2	202	TC# 2	203
TC# 3	80	TC# 3	150
TC# 4	-27	TC# 4	-36
TC# 5	-158	TC# 5	-123
TC# 6	-169	TC# 6	-169
TC# 7	-113	TC# 7	-99
TC# 8	-5	TC# 8	0
TC# 9	0	TC# 9	8
TC# 10	55	TC# 10	61
TC# 11	40	TC# 11	45
TC# 12	73	TC# 12	80
TC# 13	-263	TC# 13	-264

Table1. Main coil and Trim coil current settings for two different phase curves.

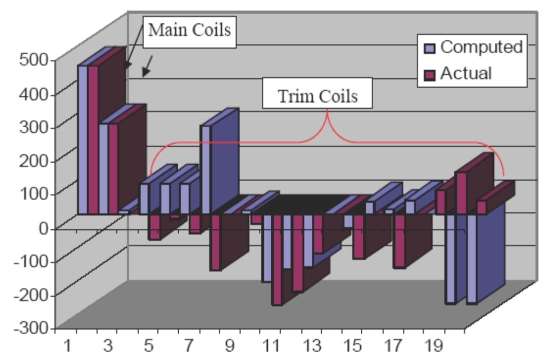

Figure 5: Comparison of the Main coil & trim coil current (in Amp) settings for the test Beam Ne3+.

REFERENCES

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