SCHEME FOR BEAM ENERGY SPREAD MEASUREMENT OF 20 MEV MICROTRON

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Abstract

The 20 MeV microtron beam is the first part of injector network for both the storage ring Indus-1 and Indus-2 and is being used for the injection into the booster synchrotron. The beam is mainly characterized by its emittance and the energy spread. In this paper a scheme is proposed for measurement of the beam energy spread. The beam transport line-1 (TL-1) consists of three quadrupole doublets. A branch line just after the 45 degree bending magnet of TL-1 will be used for this measurement. In this paper we describe the optimization of the first quadrupole doublet to achieve the desired condition of lowering the betatron contribution as compared to the dispersive term.

INTRODUCTION

A 20 MeV microtron is being used as an injector for the booster synchrotron. It is important to know the energy spread for calculating the beam size below up due to dispersion in the line, so that the transport line can be optimise/tuned such that the minimum loss of particles takes place. Beam energy spread also plays an important role during the beam injection in the booster ring. Electron with energy deviation higher than energy acceptance of the booster are not acceptable in it. The total electron beam size is given by contribution from betatron part and the dispersive part. For measurement of the energy spread, the betatron contribution to the beam size is minimized where as the contribution due to dispersion is maximised. Beam transfer line-1 transports the electron beam from the 20 MeV microtron to the booster synchrotron which consists of one bending magnet and three quadrupole doublets. There is a 45° bending magnet, ~ 1.8m downward from the first quadrupole doublet of TL-1, which is switched off during beam injection into the booster ring. A branch line just after the 45° bending magnet will be used for the energy spread measurements. Length of the branch line will be ~ 3.2 m. Dispersion will be generated in the beam by the 45° bending magnet. Both the quadrupoles of the first doublet were optimised such that the ratio of dispersive contribution to the betatron contribution in the beam size is maximum and keeping the vertical beam size within the acceptable limit. Optimal condition was obtained at 3 m from the 45° bending magnet. A beam profile monitor will be installed at that location.

SCHEME FOR THE MEASUREMENT

To calculate the beam energy spread, parameters shown in the table1 were considered.

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Table1: Beam parameters

S.N	Beam parameters	At Microtron exit point
1	Emittance ε_x	0.8 mm mrad
2	Emittance ε_y	3.0 mm mrad
3	β_x	1.9 m
4	β_y	1.8 m
5	α_x	0.44
6	α_y	-0.77
7	Energy spread (ΔE/E)	± 0.1 %

Total beam size at a profile monitor is the contribution of two terms, contribution due to betatron part and due to dispersion part.

$$\sigma = \sqrt{(\beta_x \times \varepsilon_x) + \left(\eta \frac{\Delta p}{p}\right)^2}$$

Where η is the dispersion function and ΔP/P is momentum spread in the beam. By using the above parameters, first quadrupole doublet was optimised to get minimum betatron contribution after the 45° bending magnet and beam sizes are shown in the table2.

Table2: Beam size after the 45° bending magnet

Distance after the 45° BM (m)	Betatron contribution in H-Plane (mm)	Dispersive contribution in the H-plane (mm)	Total Beam size in the H-plane (mm)	Beam size in the V-plane (mm)
1	3.3596	1.713	3.77	13.93
2	2.4153	3.127	3.951	19.21
3	2.189	4.54	5.041	24.51
4	2.8582	5.955	6.606	29.82
5	3.995	7.369	8.382	35.13

From table2 it is clear that, the ratio of dispersive contribution to the betatron contribution is maximum at 3 m after the 45° bending magnet, so a beam profile monitor will be installed at that location to measure the beam energy spread. Optimised quadrupole strength values for the quadrupole are as:

Defocusing Quadrupole (QD1) = - 6.73/m^2
Focusing Quadrupole (QF1) = 8.26/m^2

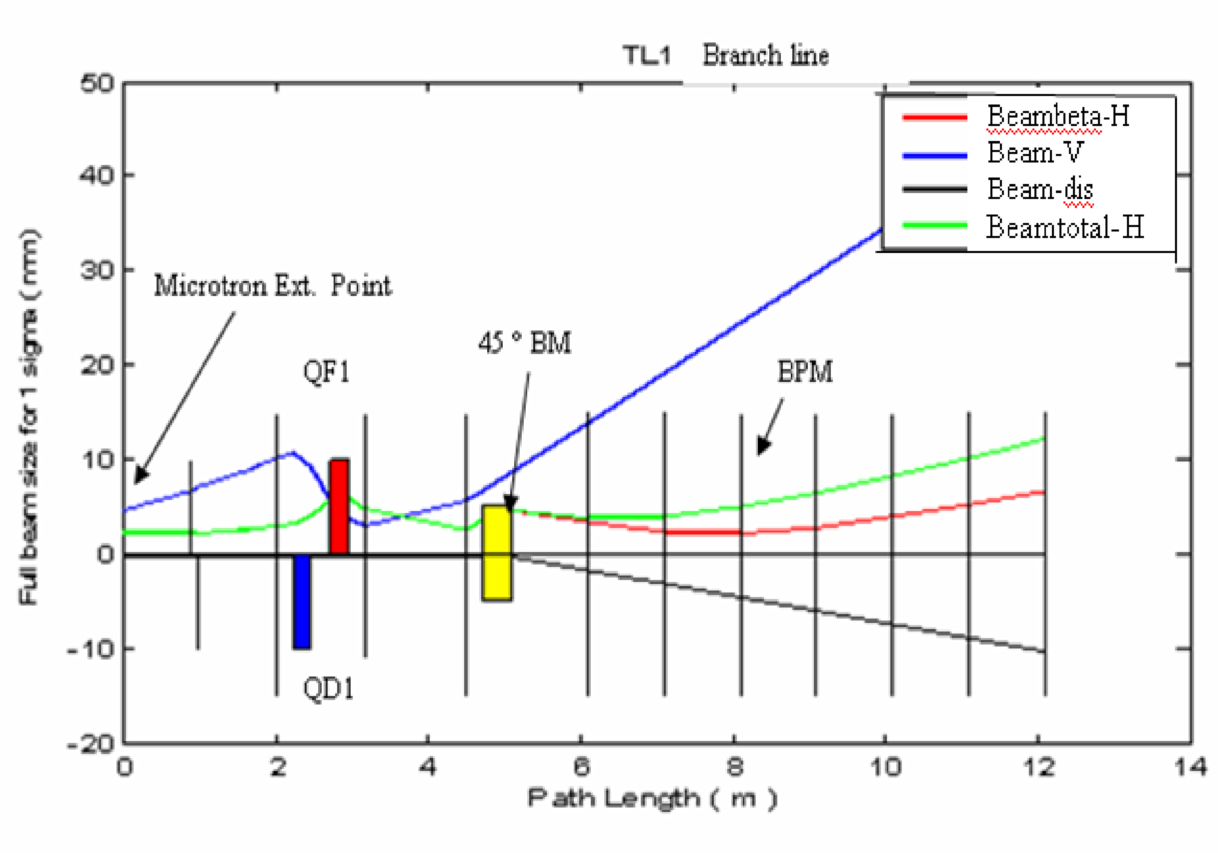

Figure 1: Lattice of TL1 with branch line

In the figure1 beam sizes in the horizontal as well as in the vertical plane are shown. Dispersive and betatron contribution to the horizontal beam size are also shown. With the vertical beam size within acceptable limit, dispersive to betatron contribution is maximum at 3 m from the 45° bending magnet.

CONCLUSION

The first quadrupole doublet of TL1 was optimised to achieve the desired condition of lowering the betatron contribution as compared to the dispersive term in the branch line. For this scheme of energy spread measurement, it is important to know the beam emittance and the twiss parameters at the extraction point of the microtron in advance.

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