A.9: Beam energy spread measurement of new 20 MeV microtron in Indus

A new 20 MeV microtron has been installed and commissioned in Indus Accelerator Complex (Fig. A.9.1). It is important to know the beam energy spread for calculating the beam size blow-up due to dispersion in the line, so that the beam transport line can be optimized/tuned such that minimum loss of particles takes place. Beam energy spread also plays an important role during the beam injection in the booster synchrotron. Electrons having energy deviation larger than the energy acceptance of the booster are lost during injection process and causing excessive radiation in the booster hall.

Fig. A.9.1: New 20 MeV microtron

This 20 MeV microtron is being used as a pre-injector for the booster synchrotron where energy of electron beam is raised from 20 MeV to 450 MeV for injection into Indus-1 and 550 MeV to Indus-2 storage ring. A beam transport line-1 (TL-1) is used to transport the electron beam from the 20 MeV microtron to the booster synchrotron. In order to carry out diagnostics of the beam, a branch line is separated downstream to first quadrupole doublet of TL-1 using a 45° bending magnet (Fig. A.9.2). Switching on the power supply driving this magnet with appropriate current, bends the beam and sends it in branch line for diagnostics. Energy spread of the microtron beam is also measured in this branch line. Dispersion is generated in the beam by the 45° bending magnet.

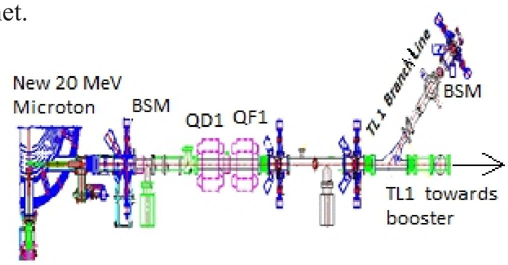

Fig. A.9.2: Layout of initial part of TL-1 with the TL-1 branch line

Total beam size in a line at a certain location is defined as

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

Where β and η are amplitude and dispersion functions, respectively, ε is the beam emittance and ΔP/P is momentum spread in the beam. For the relativistic particles, beam energy spread and momentum spread are equal to each other i.e. ΔP/P = ΔE/E. For energy spread measurement of the microtron beam, initially emittance and twiss parameters of the new microtron were measured in TL-1 using the quadrupole scan method. Measured horizontal beam emittance (ε_x) was 1.545 mm-mrad. Based on the measured parameters, beam optics was optimized using both the quadrupoles of the first doublet (QD1 and QF1) such that the ratio of dispersive contribution to the betatron contribution in the beam size is maximum and at the same time keeping the vertical beam size within the acceptable limit. In the branch line and at the location of Beam Slit Monitor (BSM), horizontal betatron function (β_x) and dispersion function (η) were 2.0 m and 2.31 m, respectively.

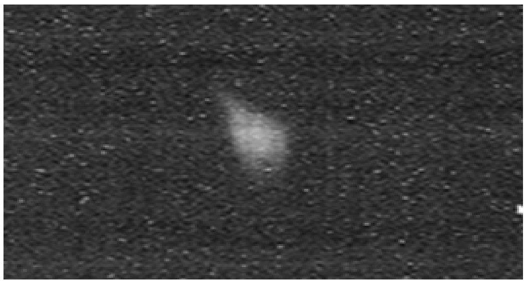

Fig. A.9.3: Beam profile on BSM in TL-1 branch line

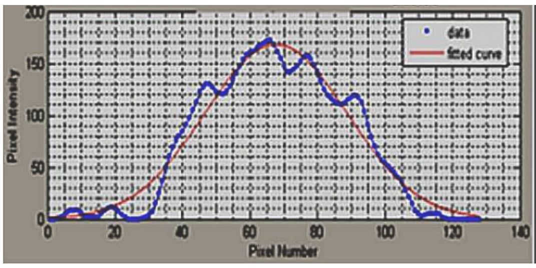

Fig. A.9.4: Gaussian fitting of beam intensity in horizontal plane

Measured horizontal beam sizes (σ) on the BSM of TL-1 branch line was 4.81 mm (captured image of beam in Fig. A.9.3 and obtained profile in Fig. A.9.4). According to above mentioned equation, the calculated beam energy spread $(\Delta E/E)_{rms}$ of the microtron beam was found to be equal to ~ 0.194 % . This energy spread is within the acceptance of the booster synchrotron.

Reported by:
R. S. Saini (rssaini@rrcat.gov.in) and Y. Tyagi