A LABORATORY DEMONSTRATION OF STRONG PARTICLE FOCUSING

Strong focusing is crucial to modern high energy accelerators like the superconducting super collider.

A beam of charged particles being guided along in the +x direction may deviate from its path (in the transverse y or z directions). Restoring forces due to radially varying transverse magnetic fields ($B_y$ and $B_z$) can reduce such y or z wanderings. Strong focusing results from a sequence of magnetic lenses with successive reversals in the magnetic field gradients, say, $-dBy$ and $+dBz$ followed by $+dBy$ and $-dBz$. $\frac{dz}{dy}$ $\frac{dy}{dz}$ $\frac{dy}{dz}$ $\frac{dy}{dz}$

A detailed discussion of this highly technical subject is available in Livingstone and Blewett’s book and will not be attempted here.

We demonstrate this important principle to students in our advanced laboratory course using a student grade oscilloscope and four small permanent magnets. The electron beam is set to maximum intensity and defocused. The case is removed from the oscilloscope and the magnets are positioned on either side of the cathode ray tube using ring stands and clamps (figure 1). The positioning of the magnets is fairly critical and we usually begin our demonstration by displaying a magnetically focused beam. In our present setup, the beam spot diameter is then about 1.0 mm. After making this measurement we then proceed to remove each of the four magnets and reveal an "unfocused" beam of about 3.0 mm diameter.

The polarity and orientation of the magnets is, of course, important and we demonstrate that 2 axis focusing (y and z direction) is not possible without the alternating pole geometry. Typically, we remove the magnet pair nearest the CRT screen first leaving a single axis line focus.
REFERENCES

1The students are referred, for instance, to *Particle Accelerators*, M.S. Livingstone and J.P. Blewett, McGraw Hill, New York, 1962, Ch. 15.

2We use an old Heathkit Model 10-18 student laboratory oscilloscope.

3We use ceramic magnets, type N40, 818 available from Edmund Scientific Co., 101 E. Gloucester Pike, Barrington, NJ, 08007-1380.

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