

Laboratori Nazionali di Frascati

LNF-64/62 (1964)

C. Schaerf, R. Scrimaglio: HIGH RESOLUTION ENERGY LOSS MAGNETIC ANALYSER FOR SCATTERING EXPERIMENTS.

Estratto da: Nucl. Instr. and Meth. 30, 359 (1964).

64/62

HIGH RESOLUTION ENERGY LOSS MAGNETIC ANALYSER FOR SCATTERING EXPERIMENTS

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Received 5 August 1964

In this letter we propose a new magnetic analyser for scattering experiments. This particular spectrometer analyses directly and with high resolution the energy loss in the target. It requires a very poor resolution of the primary beam. It is an integrated analyser in the sense that integrates the functions of magnetic analysis of the particles before and after the scattering event. Basically the analyser consists of a magnetic system which is achromatic, symmetric and has an intermediate focus in the middle. The first half introduces dispersion in the beam and the second half focuses all the particles back in the same point irrespective of their energy. A very simple example of such a system is indicated in fig. 1. It consists of two 70° bending magnets with uniform field. The trajectories are represented in the median plane¹). Axis AA' is the projection of the plane of symmetry on the median plane. The particles emitted from S are first focused in D where they are dispersed according to their momentum and are focused again in I with zero dispersion.

If now we introduce a target along axis AA' the particles will focus again after the second magnet independently of their initial energy but they will be dispersed according to the energy lost in the target.

To measure the differential cross section at angles different from 0° we can rotate the second magnet around axis AA'. The dispersion being along axis AA' this rotation does not change the properties of the system. This particular analyser has no focusing in the transverse direction. However, the motion of the particles in this direction has no effect to first order. The ultimate resolution obtainable with a similar analyser depends on the optical properties of the two halves of the channel (dispersion, second order aberrations, etc.) and on the dimensions of the sources. It does not depend to first order on the energy spread of the primary beam²).

Such a device has been designed for electron-nucleus or pion-nucleus scattering³). The fractional line width of presently available electron linear ac-

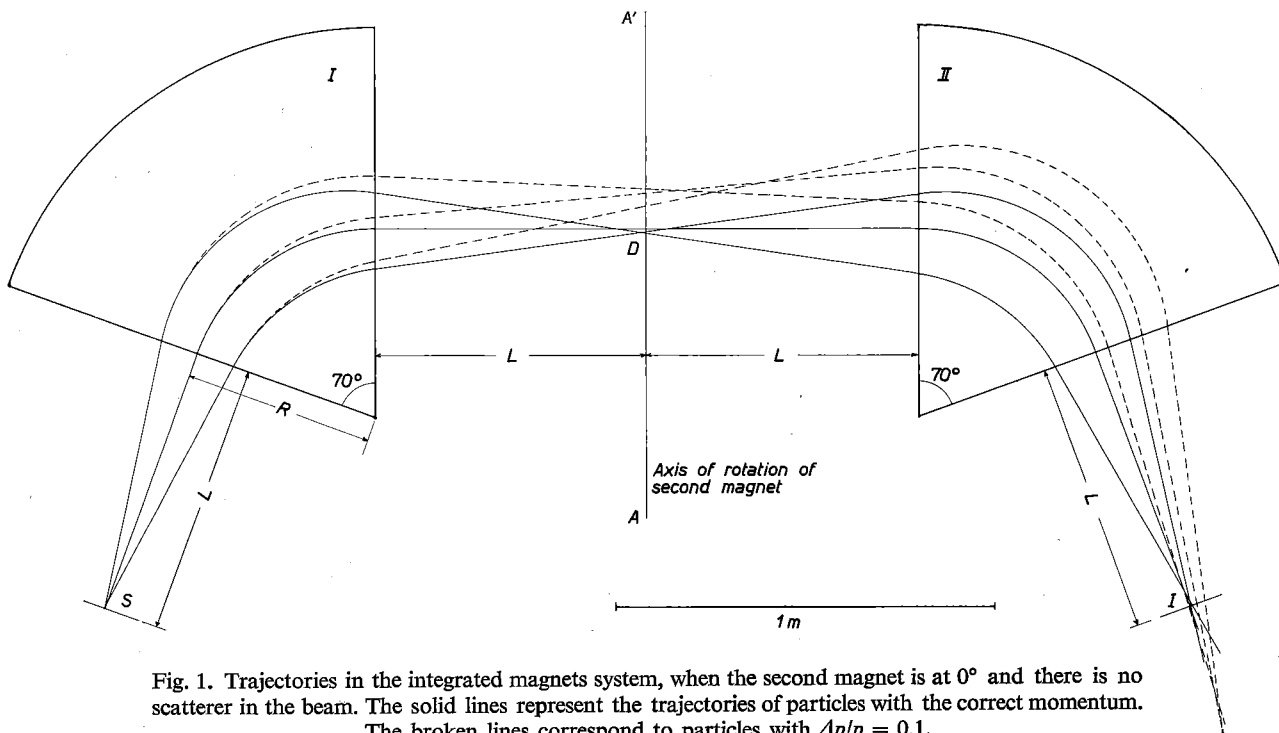


Fig. 1. Trajectories in the integrated magnets system, when the second magnet is at 0° and there is no scatterer in the beam. The solid lines represent the trajectories of particles with the correct momentum. The broken lines correspond to particles with $\Delta p/p = 0.1$.

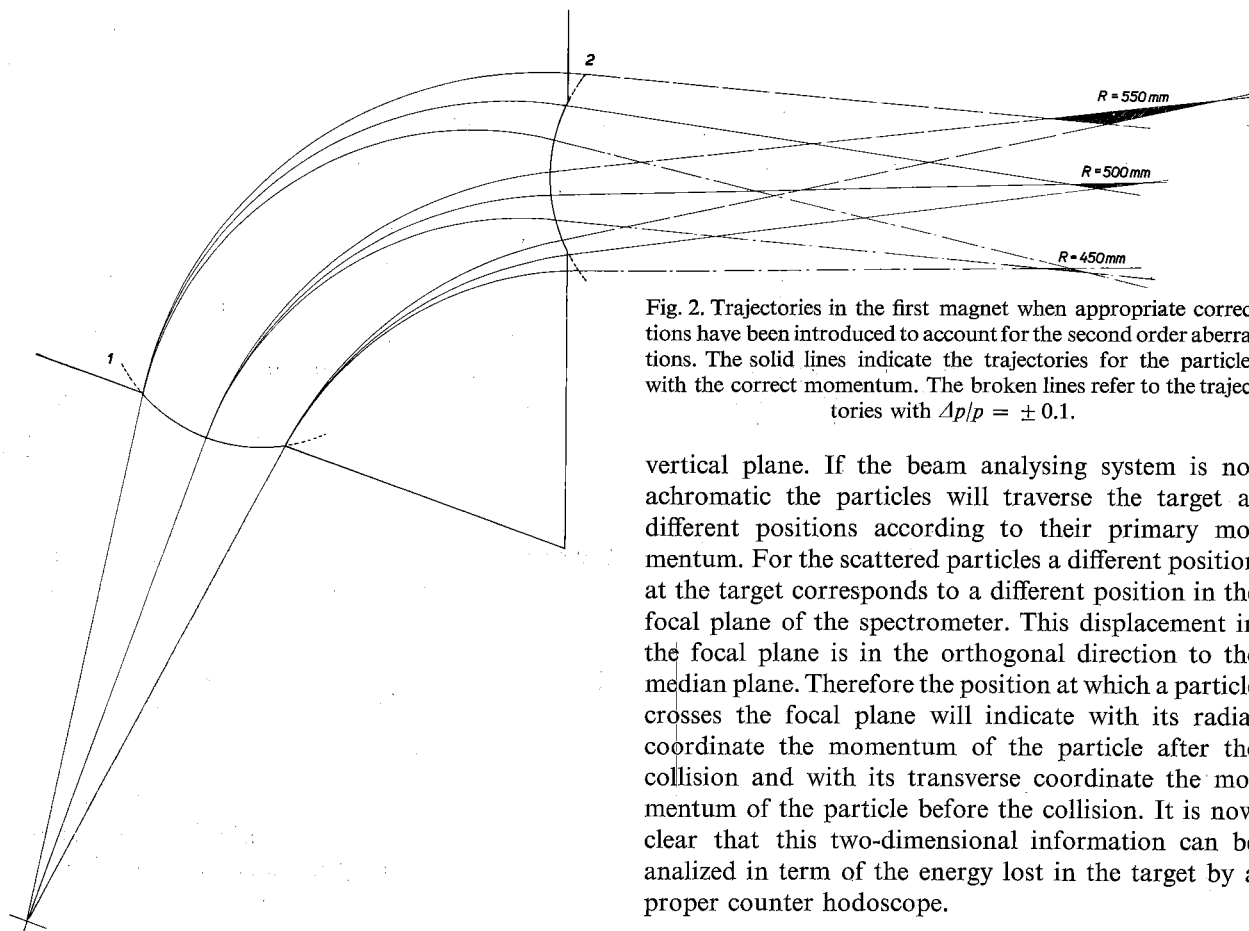


Fig. 2. Trajectories in the first magnet when appropriate corrections have been introduced to account for the second order aberrations. The solid lines indicate the trajectories for the particles with the correct momentum. The broken lines refer to the trajectories with $\Delta p/p = \pm 0.1$.

celerators is not better than 0.01. At an energy of 100 MeV this means a resolution of 1 MeV. Some experiments on electron-nucleus inelastic scattering require an energy resolution of 100 keV. This means that the useful current for such an experiment is one tenth of the total accelerated current. With the system proposed here we could use the total accelerated current and still hope for a resolution of 100 keV with respect to the energy lost in the target.

This technique might soon become attractive also for elementary particle physics. As the range of available energies increases the problem of separating elastic scattering from the case in which one or more pions are produced requires beams with high energy resolution. This limits the fraction of the total available current which can be used in a particular experiment.

We can also obtain very similar results with a conventional beam analysing system and double focusing spectrometer. For simplicity we consider the case in which the beam analyzing system bends the particles in the horizontal plane and the spectrometer in the

vertical plane. If the beam analysing system is not achromatic the particles will traverse the target at different positions according to their primary momentum. For the scattered particles a different position at the target corresponds to a different position in the focal plane of the spectrometer. This displacement in the focal plane is in the orthogonal direction to the median plane. Therefore the position at which a particle crosses the focal plane will indicate with its radial coordinate the momentum of the particle after the collision and with its transverse coordinate the momentum of the particle before the collision. It is now clear that this two-dimensional information can be analyzed in term of the energy lost in the target by a proper counter hodoscope.

It is a pleasure to thank C. Castagnoli and S. Penner for many enlightening discussions.

References and notes

- 1) The figure shows the second order aberration of the system to be very annoying. However we can reduce them to tolerable limits by proper shaping of the magnet edges as suggested by K. Brown⁴). In fig. 2 we have indicated the trajectories when the proper corrections have been introduced.
- 2) Some simple considerations indicate that the ultimate resolution as a function only of the momentum spread of the primary beam is approximately given by:

$$\frac{\Delta(P_1 - P_2)}{(P_1 - P_2)} = \frac{\Delta P_1}{P_1}$$

where: P_1 is the momentum of the particle before the scattering,
 P_2 is the momentum of the particle after the scattering,
 ΔP_1 is the momentum spread of the primary beam,
 $\Delta(P_1 - P_2)$ is the resolution of the measurement of the momentum lost in the target.

In a conventional magnetic system we have: $\Delta(P_1 - P_2) = \Delta P_1$.

- 3) C. Schaerf, Sulla utilizzazione del Linac per effettuare della sperimentazione con pioni, Laboratori Nazionali di Frascati, LNF-64/16.
- 4) K. L. Brown, First and second order aberrations coefficients of a wedge magnet, SLAC, TN-63-12.