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

(Nota interna: n. 256)

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C. Schaerf and R. Scrimaglio: HIGH RESOLUTION ENERGY LOSS MAGNETIC ANALYSER FOR SCATTERING EXPERIMENTS.
(Submitted for publication to Nuclear Instruments and Methods)

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^{o} bending magnets with uniform field. The traiectories are represented in the median plane[1]. Axis AA' is the projection of the plane of simmetry 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 indipendentely 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^{o} 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 beam(2).

Such a device has been designed for electron-nucleaus or pion--nucleus scattering(3). The fractional line width of presently available electron linear accelerators is not better then 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 actractive also for elementary particles 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 analising system and double focusing spectrometer. For semplicity we consider the case in which the beam analizing 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 analized 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 tollerable limits by proper shaping of the magnet edges as suggested by K. Brown[4]. In figure 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.

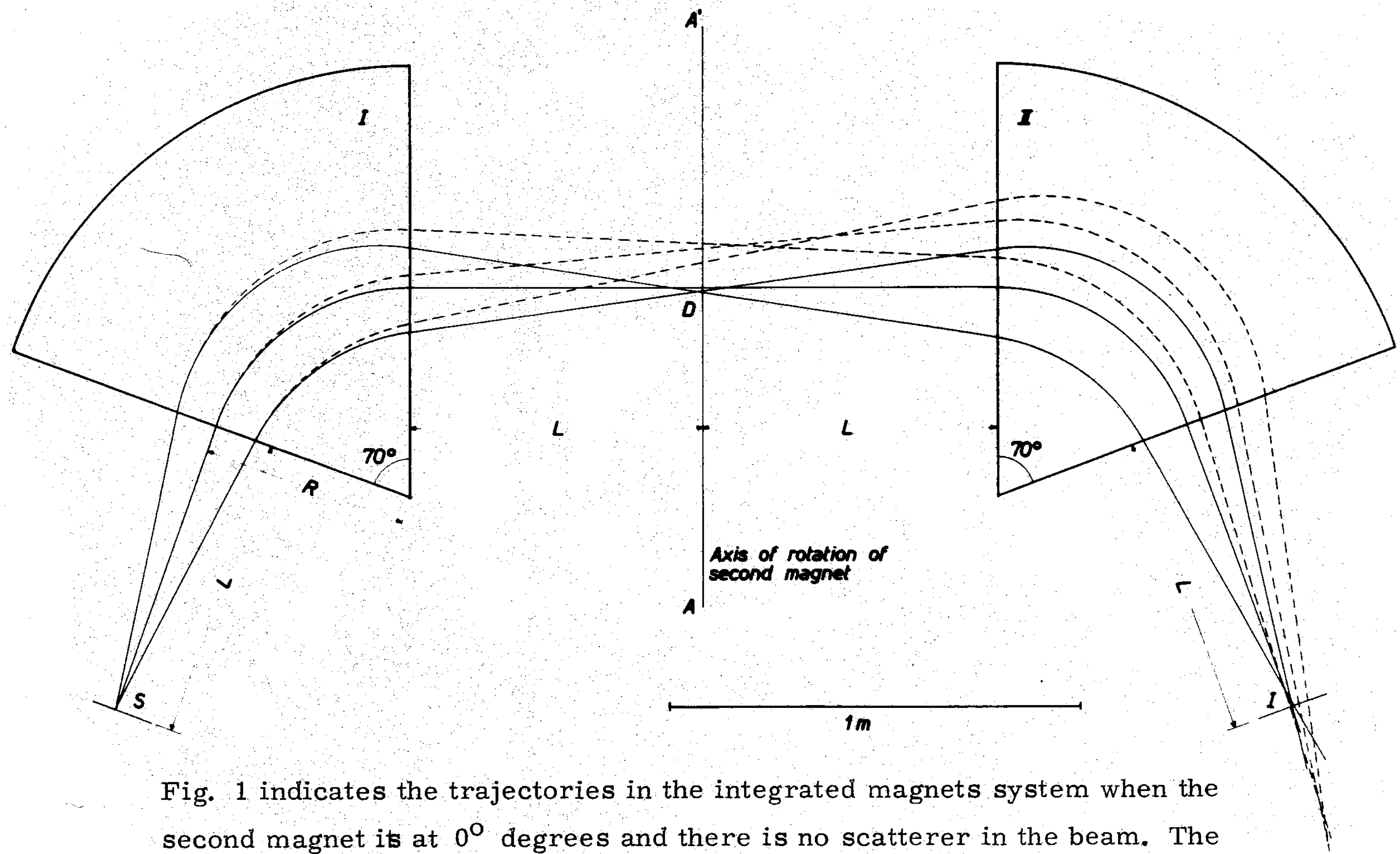

Fig. 1 indicates the trajectories in the integrated magnets system when the second magnet is at 0^{o} degrees and there is no scatterer in the beam. The solid lines represents the trajectories of particles with the correct momentum. The broken lines correspond to particles with $\Delta p/p = 0.1$.

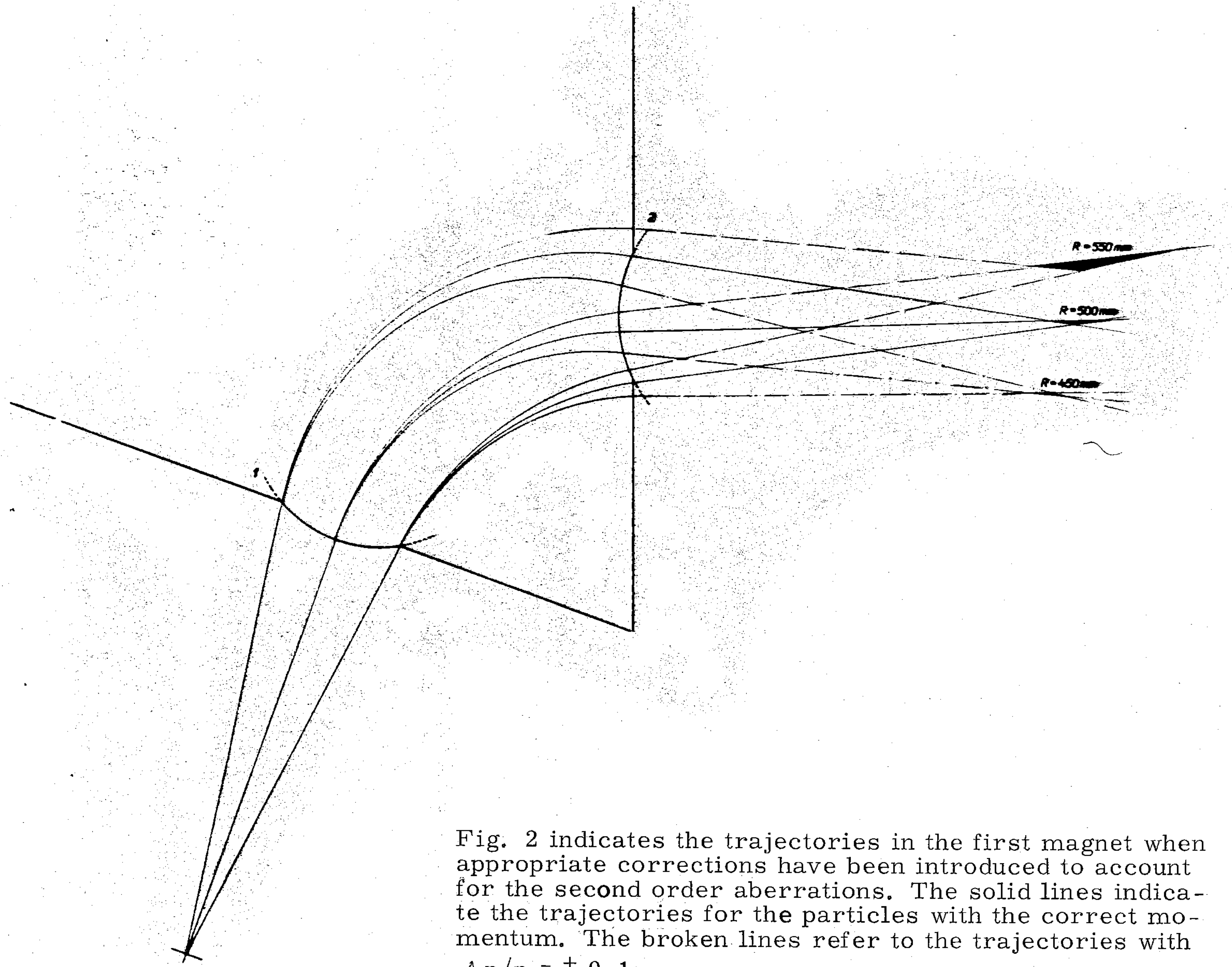

Fig. 2 indicates the trajectories in the first magnet when appropriate corrections have been introduced to account for the second order aberrations. The solid lines indicate the trajectories for the particles with the correct momentum. The broken lines refer to the trajectories with $\Delta p/p = \pm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