MAGNETIC SPECTROMETER SYSTEMS USING DIGITIZED DISCHARGE PLANES

G.B. COLLINS, J. FISCHER and W.A. HIGINBOTHAM
Brookhaven National Laboratory, Upton L.I., N.Y.

(presented by G.B. Collins)

Digitized Discharge Planes are being developed at Brookhaven, together with fast electronic systems to read out the planes and transfer to computers the information they contain on particle coordinates. The first version of these discharge planes has been tested and the results reported by Fischer, Collins and Higinbotham[1]. These tests showed efficiencies over 99%, spatial resolution of ± 0.5 mm, and that the performance of the planes was quite reliable. The planes also contain very little material in the area traversed by particles so that multiple scattering is small ($\Delta\ \Theta = 1$ mr at $p = 1$ GeV/c). Multiple as well as single particles can be recorded as shown by Fig. 1. The energy per discharge in these planes is quite small, and we believe counting rates as high as 1000 per 0.2 sec are feasible. In fact, earlier experiments by Fischer[2] indicate that in small planes recovery can be accomplished in a few hundred µsec or less. The combination of high spatial resolution, high speed and large physical dimensions possessed by these planes, makes possible magnetic spectrometers with the following characteristics:

1. Angular resolution $\Delta\ \Theta \sim 0.3$ mr
2. Momentum resolution $\frac{\Delta p}{p} \sim 0.5\%$
3. Solid angle of acceptance $\sim 10^{-2}$ ster (limited by aperature of magnets)
4. Momentum acceptance of several GeV/c
5. Counting rates ~ 1000 per pulse
6. Resolving times ~ 300 nsec.

These are a representative set of characteristics which can be varied to meet particular needs.

We have planned a series of experiments with magnetic spectrometers which use discharge planes. Two out of the series of experiments now being planned using these spectrometers are:

1. Very small angle elastic P-P scattering*

   Two discharge planes separated by 10 metres are located in front of a hydrogen target and a magnetic spectrometer with corresponding dimensions is located behind the hydrogen target (Fig. 2). An incident beam of 1000 protons per pulse traverses this array and the coordinates of every proton before and behind the target are recorded. Thus, very small scattering angles (limited by multiple scattering in the target) can be measured without bias. The magnetic spectrometer separates the elastically scattered protons from the inelastic ones.

2. Inelastic processes at large momentum transfers

   Two magnetic spectrometers are used in this experiment. A high momentum spectrometer (5 to 20 GeV/c) and a low momentum spectrometer (0.8 to 8 GeV/c) will determine the angles of emission and momenta of pairs of protons resulting from the process

$$P + P \rightarrow P + P + X$$

   The missing mass M_X will be computed on-line and displayed for different ranges of momentum transfer. The high resolution of the spectrometers should make it possible to identify missing masses as small as a single π^0 up to 30 BeV incident energy. The large solid angles should make it possible to explore this reaction to high momentum transfers where the cross-section is small. We are prepared to carry out fast event recognition, i.e. accept or reject events on the basis of the missing mass (or other kinematic quantity) calculated on-line either during the 200 μsec between events, or during the 2 seconds between pulses. Final analysis will be made on selected events from data recorded on magnetic tape.

These are experiments which involve one particle per plane per event. If the discharge planes are used in sets of three, events with two or more particles per plane can be analysed.

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*) This experiment was suggested by J. Menes.

<u>References</u>

1. J. Fischer, G.B. Collins, W. Higinbotham, "International symposium on nuclear electronics", November 25, 1963.

2. To be published.

Figure captions

Fig. 1 Particle tracks obtained in three digitized discharge planes

Fig. 2 Schematic experimental layout for small-angle p - p elastic scattering using digitized discharge planes

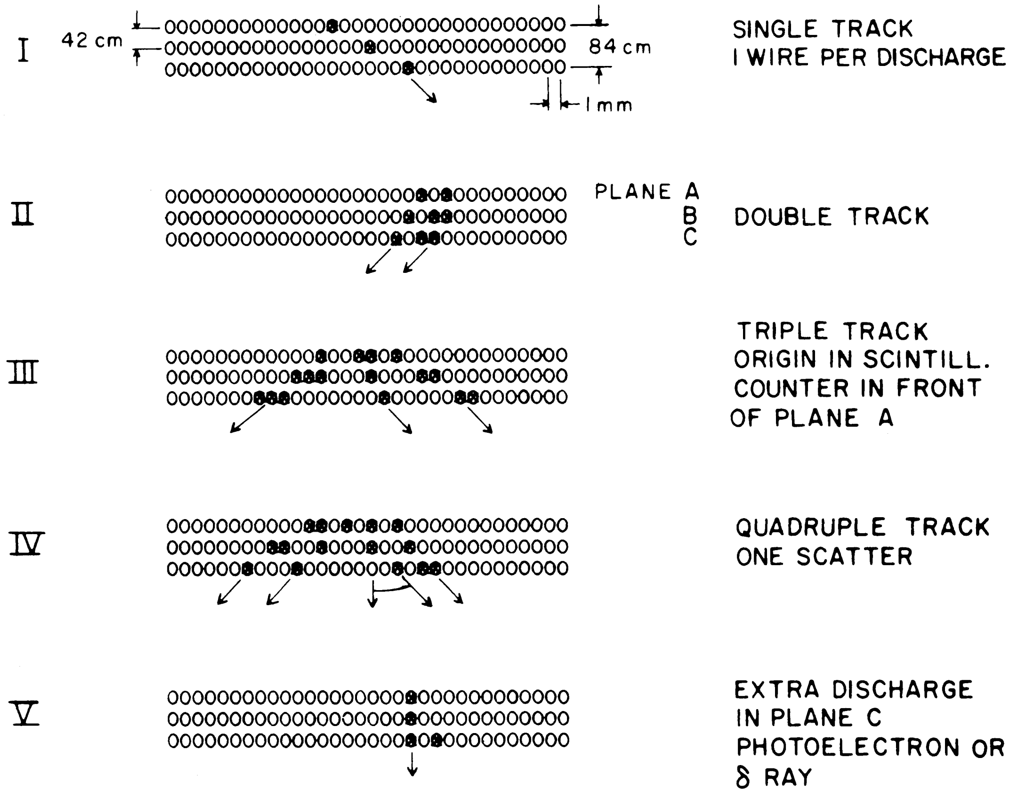
I
42 cm
84 cm
1 mm
SINGLE TRACK
1 WIRE PER DISCHARGE
II
PLANE A
B
C
DOUBLE TRACK
III
TRIPLE TRACK
ORIGIN IN SCINTILL.
COUNTER IN FRONT
OF PLANE A
IV
QUADRUPLE TRACK
ONE SCATTER
V
EXTRA DISCHARGE
IN PLANE C
PHOTOELECTRON OR
δ RAY

Fig. 1

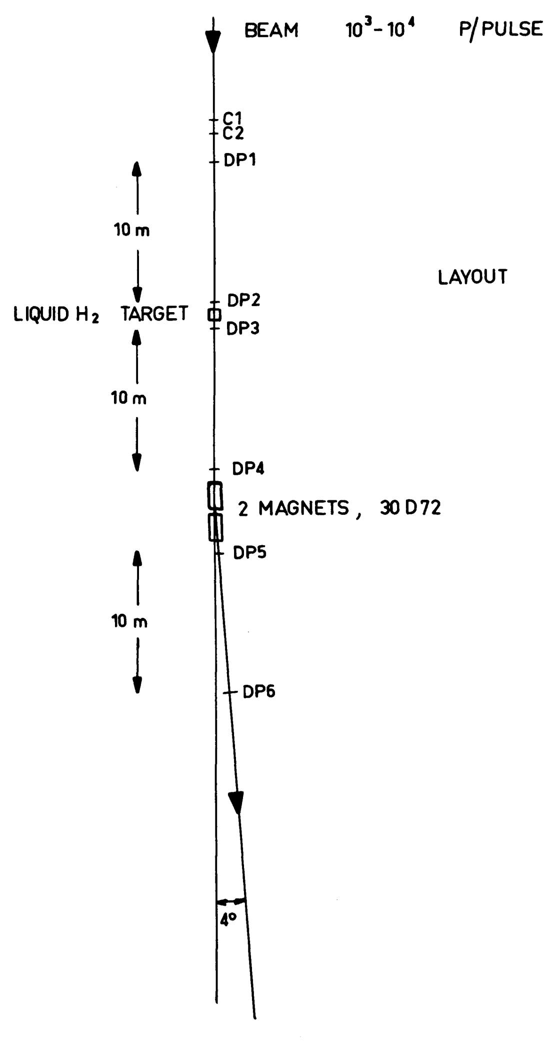
BEAM
10^3-10^4
P/PULSE
C1
C2
DP1
10 m
LAYOUT
LIQUID H_2
TARGET
DP2
DP3
10 m
DP4
2 MAGNETS, 30 D72
DP5
10 m
DP6
4°

Fig. 2

DISCUSSION

MAGLIC: How would you handle an experiment where 4 sparks per gap are required ?

COLLINS: Let me suggest that if I take cross planes and then put a third plane at right angles to this, I can cope with almost an unlimited number of particles. The reason being that 3 coordinates of a particle over-determine it. For example, if I have a Y coordinate, an X coordinate and an R coordinate you simply ask the computer to make these agree and if the accuracy is high I can, without any uncertainty, identify as many particles as you wish.

GORENSTEIN: You showed us instances of adjacent wires discharging under the influence of a single ionizing particle. This could add complications to an encoding system. I wonder if this has been observed in other wire chambers.

COLLINS: These observations repeat our observations almost identically.

SALVINI: When the spark chamber is working in a heavy background, for instance, in the electron synchrotron, we found it quite important to be careful with the clearing field. Do you need the clearing field in your chamber, and how much did you try ?

COLLINS: The clearing field is connected with the resolving time. In general we have a small clearing field, about 10 volts.

SALVINI: Speaking of the resolving time, how would you define it ? If two particles arrive with a distance in time of 100 msec the spark chamber could confuse the two. Is this your definition ?

COLLINS: Yes, it is the time during which a particle will be recorded by a discharge. A particle comes through and then there is an interval I must wait before I apply the voltage to this discharge plane. It is the maximum time which I can delay the application of this voltage and still record the passage of this particle.

FESSEL: You have these discharge planes scattered all round the experimental area. Have you thought about the problem of the sending read and sense lines over long distances ?

COLLINS: These problems we simply have not faced. Having never set-up this system I am sure there are troubles of which we know nothing, and this may be one. We have tried running wires around through the laboratory and I have put many cores in series with them and made an attempt to see whether there are any obstacles to this way of doing things. None have shown up as yet but we have not done this on the floor of an accelerator.

STARK: What kind of display are you using and what amount of computer capacity are you using for your experiment ?

COLLINS: We don't have the computer, we have asked for one and it has not as yet been approved. We would like to get a very fast computer without a particularly large memory. We do have a 4K memory with 48 bits per word.

ROBERTS: Has sufficient attention been paid to the problem of accurately locating the wires in space, to take advantage of the high accuracy of which the system is capable ? In addition the wires may vibrate.

COLLINS: These chambers have very substantial frames, and they have been constructed so that there are fiducial marks on the edge of these frames which are set to a precision of less than 10 mils. We have gone to a lot of trouble to see that we know exactly where these wires are, and I think one will survey these in to an accuracy which is certainly less than 0.5 mm.

ROBERTS: I suppose ultimately you will end up by running an elastically scattered proton beam through it and check it this way ?

COLLINS: I admit there is a problem and we have not solved it, but I have a feeling that it can be done.

ROBERTS: I agree that you can get the frames in the right place but do the wires vibrate ?

COLLINS: They are tight, they stand still there is no question.