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M e m o r a n d u m

To : The EEC and Members of the Directorate

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J.C. Olivier and M. Poulet<sup>\*\*\*)</sup>.

Subject : EXPERIMENTAL PROGRAMME TO STUDY SPIN EFFECTS IN HIGH  
ENERGY ELASTIC SCATTERING REACTIONS;

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The need of extensive experimental investigations of spin effects in high energy scattering reactions is becoming clearer and clearer. The presence of such effects in the  $\pi^-p$  scattering on polarized protons in the multi-GeV energy region and at small momentum transfers was recently established by this group<sup>1)</sup>. Relevant effects are also being found by another group in the  $\pi^-p$  charge exchange reaction at 6 GeV/c<sup>2</sup>). On the other hand, definite predictions on the polarization parameters in hadron-proton scatterings are given by the dynamical models for high energy scattering being proposed today, in particular by the Regge pole models<sup>3)</sup>. In several cases polarization measurements appear to be critical tests of such models.

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Therefore, we would like to start as soon as possible on a high-energy, high-intensity secondary beam from the slow ejected  $e_3$  beam; the following experimental programme:

- a) Measurements of the polarization parameters  $P_0$  in p-p,  $\pi$ -p, and K-p scattering, at high energy and small momentum transfers, using the existing CERN polarized proton target and a detector system similar to that described in<sup>1)</sup>. A sketch of the experimental set-up is shown below in Fig. 1.

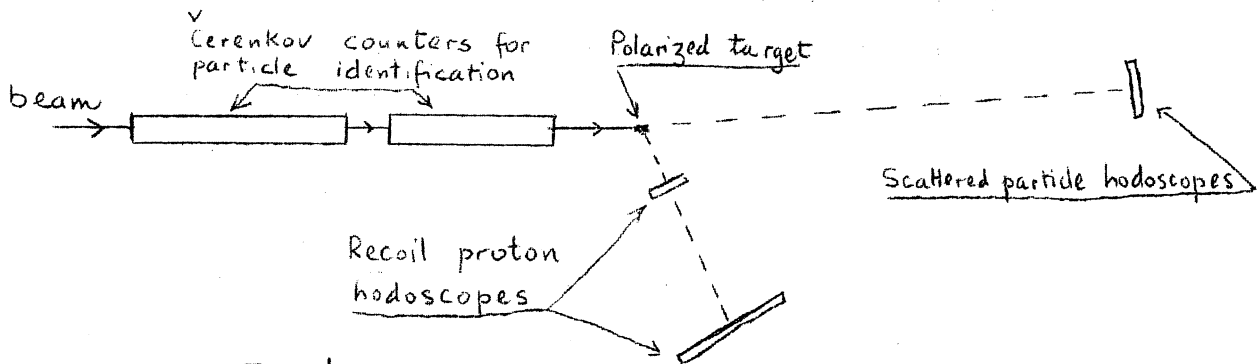


Fig. 1

To face the severe background and rate problems present on the new beam, all detectors will be highly space-and-time resolving scintillation counter hodoscopes, and a magnetic core buffer will be used to allow acquisition of up to 100 events per accelerator burst.

In Fig. 2 the regions of four momentum transfer  $t$  over which polarization measurements can be performed, are shown for the different particles as functions of the momentum. It was assumed that the measurements could not be extended at higher momentum transfer when the reaction rate became smaller than 100 events per day, in an interval  $\Delta t = 0.05 \text{ (GeV/c)}^2$ . Such a practical limit is derived from previous experience.

Four weeks of effective running time with about  $2 \cdot 10^{11}$  protons incident on the source target are estimated to be needed to obtain definite statistical evidence for a possible polarization  $\geq 10\%$  all over the momentum transfer regions illustrated in Fig. 2.

- b) Measurements of the recoil proton polarization,  $P_f$ , in p-p collisions on polarized protons, at high energy and small momentum transfers. In this way, the Wolfenstein D parameter is measured, defined as

$$P_f = \frac{P_o + DP_t}{1 + P_o P_t}$$

$P_t$  being the known target polarization. The importance of measuring the D parameter, in connection with a Regge pole model, is discussed by Leader and Slansky<sup>3)</sup>.

The proton polarimeter needed in this experiment will basically consist of a carbon scatterer, counter hodoscopes to define the incoming and outgoing proton trajectory, and a magnet to analyse the outgoing proton momenta. Using a 1 cm thick carbon plate, about 4% of the recoil protons undergo a second elastic scattering in the useful angular region. This would produce about seven double scattering events/burst at 10 GeV/c, for  $t$  values from  $-0.2$  to  $-0.8$  (GeV/c)<sup>2</sup>, and about 30 events at 15 GeV/c. A measurement of D at a given beam momentum would therefore be obtainable in about half a week of machine time.

Together with the measurements of  $P_f$  in p-p scattering, a simultaneous measurement of the same parameter in  $\pi$ -p scattering will also be made, in order to calibrate the recoil proton polarimeter. In this case, in fact,  $D = 1$  by general principles, and therefore the value of  $P_f$  can be predicted by the knowledge of  $P_o$  and  $P_t$ .

c) We wish to study the  $\pi$ -p scattering reaction on polarized protons in the backward region, from about  $170^\circ$  to about  $180^\circ$  C.M. angles, and momenta of the order of 4 - 8 GeV/c. In this region of angles and energies it was recently found that the differential cross-section peaks backwards<sup>4)</sup>, and that it shows considerable structure as a function of the energy<sup>5)</sup>. Polarization measurements have been suggested as being essential for throwing light into the nature of the process<sup>6)</sup>.

The experimental arrangement is sketched in Fig. 3.

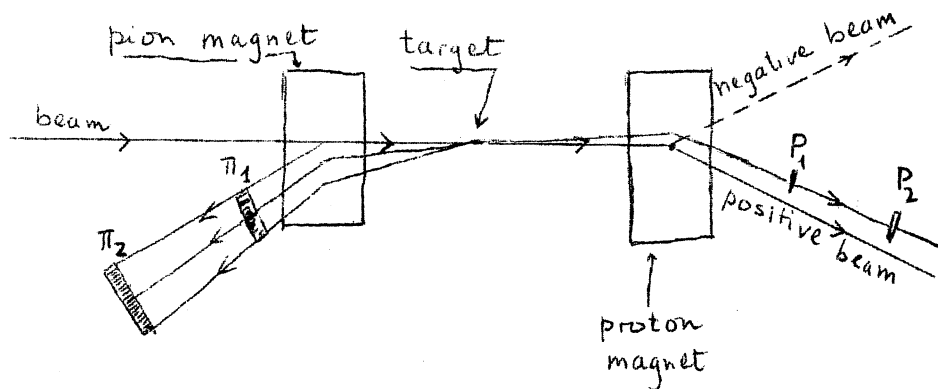


Fig. 3

It will consist of two large acceptance magnetic spectrometers for the forward recoil proton and for the backward scattered pion, and counter hodoscopes for particle identification. The counting rate is calculated to be of the order of 50 events per hour for the whole angular region mentioned above, which will imply a considerable amount of running time. However, it appears that it is possible to run this experiment in parallel to the small angle scattering experiments described in a) and b).

- d) As a natural extension of the described research programme with the existing transverse polarized target, we are considering doing similar experiments as in a) and b) using a target polarized in the scattering plane and the same detector system. Under these conditions other Wolfenstein parameters as A and R would be measurable, the knowledge of which would be of similar theoretical interest as the knowledge of  $P_0$  and  $P_f$ .

The new polarized target needed for such experiments would have to be such as to leave free way out both to the forward scattered particle and to the recoil proton. We envisage that a possible simple solution to this problem can be found by making use of a special magnet already existing in our laboratory. (Such a magnet has practically no fringing field around the useful region, which would considerably reduce spurious spin rotation of the recoil proton). Minor modifications are at the moment being made on this magnet, and the magnetic field is being studied, to check whether the high homogeneity needed for the polarized target can be achieved. If the answer to this question will turn out to be positive, a longitudinal polarized target employing this magnet will be built by making use of our standard cryostat.

The field and the geometrical requirements for a longitudinally polarized target can also be met by making use of superconducting coils, which would allow reaching sensibly higher magnetic fields ( $\approx 25$  kgauss). M. Morpurgo together with some of us is looking into the technological problems of a target based on this method.

- e) An extremely attractive extension of the above programme would be to study the spin-spin interaction effects at high energies in the scattering of polarized protons on polarized protons, which would be possible if a polarized high energy proton beam

is available. It is conceivable that high energy polarized protons could be produced in the coherent scattering on nuclei, which was recently investigated by a CERN group<sup>7)</sup>. If this is actually the case, a polarized proton beam could be obtained from the source target provided particular values for the production angles were chosen (of the order of one degree). To leave open the possibility of making such a beam, we propose that in the source target region the optics of one of the high energy secondary beams from the  $e_3$  beam be studied in such a way as to allow changing the beam production angle of a small amount around the forward direction. G. Petrucci is studying the possible practical solutions to this problem.

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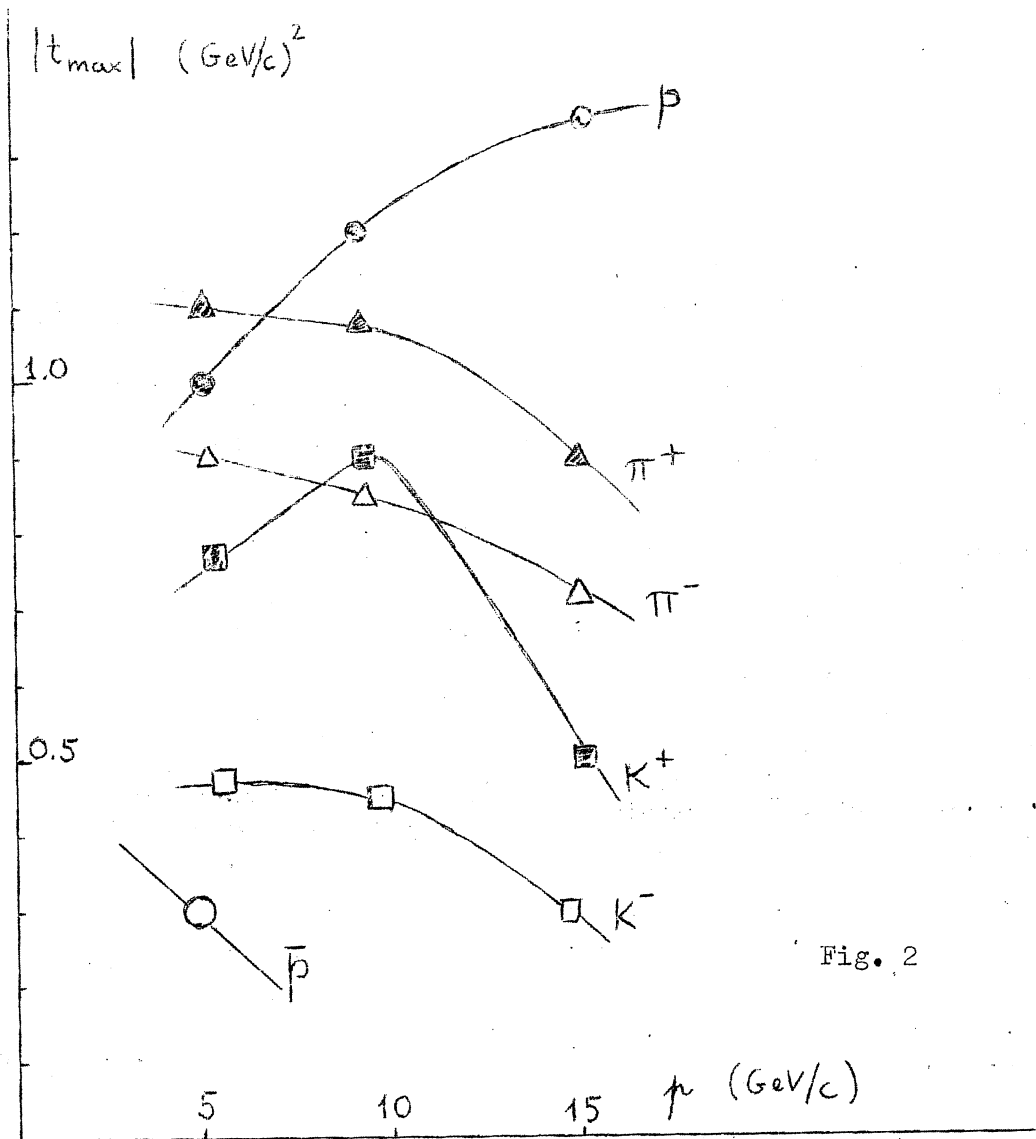


Fig. 2

CAPTION

Maximum  $|t|$  values up to which measurements of the polarization parameter  $P_0$  in the forward scattering can be extended, as functions of the momentum and for the various particles. Particle fluxes in the beam were evaluated under the following conditions:  $2 \cdot 10^{11}$  protons incident on the source target per 2.3 seconds; a source target one interaction length thick; a solid angle of  $10^{-4}$  sr at the forward direction; a momentum resolution of  $\pm 1\%$ ; a beam length of 60 metres.