EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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MEMORANDUM

To : Members of the EEC

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Subject : Intentions for experiments using the polarised target in the CERN-ETH magnet.

In the current experiment (S102) on $K^- p\uparrow$ charge exchange the 15 cm polarised target has been successfully operated in the modified CERN-ETH magnet with an average polarisation of more than 60%. We are now considering other experiments with polarised targets in this magnet and three, namely

(i) $\pi^- p\uparrow \to \Lambda K^0$ (backward peak)

(ii) $\pi^- p\uparrow \to \rho^0 n, \omega n$

(iii) $\pi^- p\uparrow \to K^0 \Lambda$ (with a frozen spin target)

are discussed below:

The first of these would require only minor additions to the existing apparatus and could therefore be done in 1972 in the p7 beam collaborating with the group which is at present conducting experiment S102. Substantial modifications would be required for the other two experiments; they could be done in a high energy unseparated beam some time after June 1973.

Measurement of helicity amplitudes in $\pi^- p \to \Lambda K$

Introduction:

Differential cross section and polarisation of Λ's produced forward in the reaction $\pi^- + p \to \Lambda + K^0$ (1) have been measured in the CERN-ETH-IC magnet spark chamber. Incident pion momenta ranged from 4 GeV/c to 12 GeV/c. In this experiment a hydrogen target was used and the polarisation was measured from the asymmetry in the $p\pi^-$ decay of the Λ.

We intend to perform a similar experiment using the polarised target. This will allow a measurement of the spin parameters P, A and R; alternatively a complete measurement of the helicity amplitudes up to an arbitrary phase. Such a measurement has previously been made at high energies only for πp elastic scattering (2). Many of the difficult experimental techniques which were necessary in this πp experiment are not needed in a study of the associated production reaction for the following reasons:

(a) Λ-decay acts as a polarisation analyser, so a double scattering experiment is not necessary,

(b) the target proton does not have to be polarised along the beam direction (this is necessary if a carbon analyser is used),

(c) since we will select Λ's produced in the forward direction $(0 < |u| < 1 (\mathrm{GeV}/c)^2)$ the iron pole pieces of the polarising magnet do not restrict the angular acceptance. In particular, the acceptance is high when the scattering plane is parallel to the polarisation direction - this angular region is the most sensitive for a measurement of R.

Trigger system:

The trigger system will be an extension to that used at present in the $\bar{K}p\uparrow \to \bar{K}^0 n$ experiment (PH I/COM-69/59-S102). The tungsten-scintillator sandwich anticoincidence completely surrounding the polarised target will demand a neutral final state (and no π^0's). A large counter in coincidence downstream of the magnet spark chambers demands a charged decay of the neutral strange particles produced. With such a trigger the ratio

$$\frac{\text{forward } \Lambda\text{'s}}{\text{All } V^0\text{'s produced}} \sim 4\% \text{ at } 5 \text{ GeV}/c$$

was found in the earlier experiment (1). A study of the background (mainly forward K^0's from the process $\pi^- p \to K^0 Y^0$: Y^0 is a slow Λ or $Y^* \to nK_L^0$) has shown that 70% of this can be eliminated by adding very simple (two planes of three counters each) scintillator hodoscopes downstream. This effectively selects the high energy protons from the Λ decay rejecting the more symmetric $K_S^0 \to \pi^+\pi^-$ decays. The Λ

acceptance in this system is higher than 90% so the polarisation measurements are relatively unbiased.

Estimate of rates for a measurement at 5 GeV/c:

The following figures are based on results obtained from the previous experiment and the present performance of the polarised target.

Cross section $\pi^- p \rightarrow \Lambda K^o$ $(0 < |u| < 1\ GeV^2) \sim 1\mu b$
A beam intensity of 300.000 π^-/burst will yield:
Number of fast Λ's from free protons $\sim$ .03/burst
Number of K^o's from free protons $\sim$ 0.2/burst
Number of V^o triggers from Carbon nuclei $\sim$ 0.35/burst

With these figures $\sim$ 15.000 backward peak events on polarised protons can be obtained in 20 days of PS beam time. This should be sufficient to provide significant measurements of P, A and R as a function of 'u' in the range $0 < |u| < 1(GeV/c)^2$.

In order to extract these data 250.000 V^o's will have to be measured on HPD. The 'background' triggers are very interesting however. They are mainly from the reactions

$$\pi^- + p \rightarrow K^o + \Lambda \quad (K^o \text{ forward})$$

$$\pi^- + p \rightarrow K^o + Y^*(1520) \quad (K^o \text{ forward})$$
$$\searrow n + K^o_L$$

Although both reactions suffer form the biased angular acceptance of the anticoincidence this will not affect a measurement of the polarisation which is determined from the spin up-spin down asymmetry at a given value of 't'.

About 15.000 events on free polarised protons would be obtained for each reaction.

Measurement of polarisation and density matrix in $\pi^- p\uparrow \rightarrow \rho^o n$ and $\pi^- p\uparrow \rightarrow \omega n$

Introduction:

The production of vector and tensor mesons on a polarised target is another field where it is possible to obtain more detailed information on helicity amplitudes than has been achieved so far. In particular we intend to study the reaction $\pi^- p \rightarrow \rho^0 n$ and $\pi^- p \rightarrow \omega n$ on polarised protons. The decay angular distribution of the ρ and ω together with the correlation with target polarisation enables a total of ten density matrix elements to be measured (cf. four elements with an unpolarised target). The results of such a measurement could clarify the role of meson trajectories and cuts in the production process. For example a polarisation measurement will give information on pole-cut interference terms.

Trigger system:

The trigger requirements for this reaction will be that two and only two charged particles be detected in each of two multi-wire proportional chambers downstream of the polarised target. The trigger will further be restricted by charged and gamma anticoincidence counters surrounding the target, leaving only a limited forward cone of acceptance. Such a trigger will be comparatively free of bias for ρ production at 8 GeV/c and will also have a good efficiency for f^0 production.

Heavy plate γ-detecting spark chambers downstream of the magnet will enable ω production in the reaction $\pi^- p \rightarrow \pi^+ \pi^- \pi^0 n$ to be studied using the same trigger.

Possibilities with a frozen spin target

Should a frozen spin target be available, many interesting experiments become feasible. In particular we should like to study the forward peak (backward Λ's) of the reaction $\pi^- p \rightarrow K\Lambda$. It is not possible to measure the spin rotation parameters in this reaction using the existing conventional target since the magnet pole pieces restrict the angular acceptance, excluding an analysis of the slow Λ decay. However, a frozen spin target, where the supplementary pole pieces are unnecessary, will not suffer from this drawback.

References

(1) W. Beusch et al., Nuclear Physics B19 (1970) 546.

(2) B. Amblard et al., Mesure du paramètre de rotation de spin R en $\pi^- p$ à 16 GeV/c. Conference sur la physique des Hautes Energies, Aix-en-Provence, Sept. 1970.