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PHYSICS III COMMITTEE

LETTER OF INTENTION:

POLARIZATION MEASUREMENTS IN

π-NUCLEON SCATTERING WITH A POLARIZED PROTON-TARGET

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The aim of this letter is to inform the Physics III Committee of our intention to perform an experiment using a pion beam of the CERN Improved SC, in 1973. The proposed experiment takes place in an experimental program which will be later on continue at SIN.

As we are, at present time, designing a proton polarised target and a detection apparatus to determine the polarisation parameters in pion-nucleon scattering, we believe it is worth to achieve an experiment at the CERN-SC for testing this experimental set-up before the SIN machine starts.

In the following we just sketch the physical motivations for such experiments, outline the experimental technics we want to use and evaluate the running time.

At pion kinetic energy available now at CERN-SC and later at SIN, the I = 3/2, J = 3/2, p-wave phase shift dominates the pion-nucleon elastic scattering. Accurate mesurements of the polarisation parameters in both π^+p and π^-p elastic scattering and the charge exchange scattering, will be needed to determine precisely the s - p and possibly the d - wave phase shifts in importance at low energies. On the other hand the Cambridge-Rutherford group (Bugg et al.) has recently performed a precise measurement of the π^-p and π^+p differential cross section from 75 to 295 MeV; their final accuracy is typically $\pm$ 1 % or slightly better but the agreement with present phase shifts is only moderate; at some angles and energies, deviations of several standard deviation appears. So it will be very useful to check these amplitudes by accurate polarisation measurements.

An estimate of the accuracy needed for polarisation measurements has been made [1] using predictions for the scattering parameters at 98 and 200 MeV pion energies from energy dependant phase shift analysis by Roper and Wright [2]. It comes out that a measurement of the polarisation parameter for example with $\Delta p_0 = 0.05$, together with the 1 % accuracy differential cross section of Bugg et al. will permit a determination of the phase shifts to $\pm 0.5^o$, which will be a substantial progress over the present precision and will strongly improve the analysis "à la Hamilton".

Polarisation may be determined by measuring the asymmetry in a pion beam from a target containing polarised protons or by measuring the polarisation of the recoiling protons from an unpolarised target. The former method being preferable from experimental asymmetry point of view, the construction of such a target was decided at SIN. It will be a similar target to that developped at CERN, except it will make use of superconducting separated coils, which allow the protons to be polarised in the three directions to the scattering plane, transversed and longitudinal to the i.a. perpendicular incoming beam (useful for measurements of the Wolfenstein parameters).

Let us remark that today appreciable proton polarisation can be achieved only in a few substances, doped with paramagnetic centers, using dynamic polarisation methods. Such methods require the target sample to be maintained at temperature around 0.5^o K in a magnetic field of 25 kGauss and irradiated with a high intensity micro-wave field of 70 GHz. Under the above conditions one get approximately 70 % proton polarisation in butanol (C_4H_9OH) samples.

The experiment we considered to perform at the Improved SC is to measure the up-down asymmetry in scattering a pion beam of a butanol polarised proton target. A Berkeley Group [3] having already done such a measurement at 229 MeV in $\pi^- p$ elastic scattering, a first step of our proposed experiment will be to remake this measurement in order to have a good check of our set-up. The second stage of this experiment will extend this measurement at 100, 150 and 200 MeV for both $\pi^- p$ and $\pi^+ p$ elastic scattering. Both scattered pions and recoil protons shall be detected in coincidence to define the elastic scattering from the free protons in the target. On the pion-leg we will use scintillation-counters hodoscopes covering the scattering angle from 30^0 to 170^0; the energy of the recoiling protons will be determined by total absorbtion in a plastic scintallator. If the beam contamination is estimated too high, Cerenkov counters will be placed on the incoming beam line. For the data acquisition we want to use a PDP-11 on line computer.

The counting times have been evaluated to give a statistical accuracy of 1/10 of the spread in the polarisation predicted by the various phase shifts of Roper et al. previously mentioned. The conditions chosen are 1,7 gr/cm^2 of butanol and a beam intensity of 10^7 π^+/sec, using counter solid angle of 8 millisteradians ($\Delta\theta \approx 1.5^0$). At 80^0 scattering angle for 200 MeV the counting rate will be 7 events/sec with an asymmetry of 0.15. In order to achieve a statistical accuracy in polarisation of $\pm$ 0.01, counting time of 100 minutes are required. For $\pi^- p \rightarrow \pi^- p$, the count rate will be reduced by 100 from the $\pi^+ p$ experiment since both the beam intensity and the $\pi^- p$ scattering cross section are down by a factor of 10 each. A measurement at $\theta = 100^0$ lab. with a count rate of 3 events/min and an asymmetry of 0.12 will require 200 hours to measure the polarisation to $\pm$ 0.01. This counting rate could be increased by a factor 10 by increasing the thickness of the polarised target and the energy acceptance of the pion incoming beam. So a rough estimate of running time needed, will be approximately 120 shifts.

As a last point we have to mention that our beam requirements are more or less dependant of the pion-beams available after the SC Improvement program. Nevertheless, it seems clear that it must be a high flux pion-beam produced from an external target. Its optical caracteristics must fulfil the achromatism conditions with a resolution of about 1 % and momentum acceptance of 10 %.

References

1) W. Fischer, SIN Internal Report
2) L.D. Roper and R.M. Wright, Phys. Rev. 138 B, 921 (1965)
3) Arens et al., Phys. Rev. 167, 1261 (1968)