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INTERNAL BEAM MEASUREMENTS OF INELASTIC PROTON SCATTERING

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INTRODUCTION

This note outlines an extension of measurements on inelastic p-p scattering begun in 1961 [Cocconi, Diddens, Lillethun, Manning, Taylor, Walker, Wetherell, Phys.Rev.Letters 7, 450 (1961) and Diddens et al. Proc. Int. High-Energy Conf. 1962, p. 576].

The experiment is to measure, with good momentum resolution (~ ⅓%), the momentum spectra of protons scattered at a fixed angle and various incident energies from CH_2 and C targets in the internal beam of the synchrotron. The measurements would be done using straight section 61 and counting equipment on the east side of the East Hall.

THE NUCLEON RESONANCES

The experiment proposed is to study the excitation of the nucleon isobars, the spectrum of which has recently been enriched by the discovery of a T = ½ and a T = 3/2 state at masses 2.19 and 2.36 GeV, respectively [Diddens, Jenkins, Kycia, Riley -- private communication, Jan. 1963]. These states were found as bumps in the $\pi^{\pm}p$ total cross-sections between 2 and 2.5 GeV pion kinetic energy.

The previous CERN experiments on p-p inelastic scattering showed bumps corresponding to strong excitation of the T = ½ states of mass 1.52 and 1.69 GeV for a range of energies between 9 and 26 GeV

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and momentum transfers of about 0.30 to 1.4 GeV/c (scattering angles 20, $\approx$ 60 and 110 mrad have been used). The results were consistent with observation of the process

$$p + p \underset{\Delta T=0}{\rightarrow} p + p^* . \qquad (1)$$

No significant trace of the ($^3\!/_2$,$^3\!/_2$) state has so far been found at these high energies and rather high momentum transfers. The measurements were performed, however, with a momentum resolution large enough for a weak ($^3\!/_2$,$^3\!/_2$) bump to be lost in the tail of the strong elastic scattering peak. The aim of the present proposal is to increase the resolving power and to reduce momentum-dependent backgrounds in the experiment with the aim of searching for excitation of the ($^3\!/_2$,$^3\!/_2$) state and also to look for evidence of production of the new higher mass states. The data from this experiment would contribute information on the rate of change of the ($^3\!/_2$,$^3\!/_2$) state ($\Delta T = 1$) in the energy momentum transfer plane to compare with that available for the $T = ^1\!/_2$ states ($\Delta T = 0$). If observed, the new resonances, being $T = ^1\!/_2$ and $^3\!/_2$, give another possibility in this direction.

APPARATUS

The magnetic spectrometer consists of 4×2 m magnets, giving twice the dispersion available in the previous work, and 5 - 10 scintillation counter telescopes covering a momentum interval of about 1%. The magnet current supply will have to be stable to $\sim ^1\!/_{1000}$ and the machine energy must also be stable to this order. Both of these requirements have already been achieved. An attempt to reduce background effects will be made by defining the particles entering the spectrometer magnet with a pair of counters rather than a slit. This appeared to be effective in the most recent runs using the internal beam. Targets of CH_2 and C of about 1 gm cm^{-2} must be used in the machine.

THE EXPERIMENT

a) $(\frac{3}{2},\frac{3}{2})$ state

Excitation of the $(\frac{3}{2},\frac{3}{2})$ state has been observed in the p-p experiments of Chadwick et al. [Phys.Rev. 128, 1823 (1962)] at about 3.7 GeV/c incident momentum, and at momentum transfers (q) of 0.19, 0.29, 0.53, 0.73 and 1.01 GeV/c. The intensity of the state was very strong up to q = 0.73 GeV/c.

Selecting a scattering angle of about 60 mrad for the present experiment gives a range of momentum transfers for a two-body process such as (1) of about 0.18 - 1.62 GeV/c for energies between 3 and 27 GeV. The relatively large angle is chosen so as to avoid fringing field effects and to allow the particles to emerge through a window. The search for the $(\frac{3}{2},\frac{3}{2})$ excitation would begin at about 5 GeV/c incident momentum, i.e. at $q \approx 0.3$ GeV/c and at an energy not too far above a region where the excitation has been observed. Having observed the state at this low energy, its excitation as a function of increasing energy could be studied. It would be reasonable to programme the energies to give momentum transfers equal to those of the Brookhaven work; this would mean incident momenta of 4.9, 8.8, 12.5 GeV/c. The estimated time to do the momentum spectra at three energies is six shifts. It is doubtful whether any other group would be interested in using these low energies with non-standard targets, and one must therefore request six special shifts for this part of the experiment. These would come most conveniently after the equipment has been set up parasitically on the N5 experiment.

b) The new $T = \frac{1}{2},\frac{3}{2}$ states

A search for bumps in the scattered proton momentum spectrum corresponding to these states would go on parasitically with the N5 experiment. The latter is expected to be run at 19, 24 and 26 GeV/c and two shifts of $CH_2 - C$; operation at each of these energies would enable good scans over the appropriate regions of the spectra to be made.

TOTAL TIME NEEDED

~ 4 shifts parasitic on N5, standard operation for setting up.

6 shifts CH_2 - C energy stable operation at 4.9, 8.8 and 12.5 GeV/c.

6 shifts CH_2 - C stable energy operation during N5 experiment.

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