EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

EXPERIMENTAL PROPOSAL FOR E.E.C.

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TO SEARCH FOR BACKWARD PRODUCTION OF ρ MESONS

D. Meyer, B.D.Hyams, W. Koch, E. Lorenz, G. Lütjens,
D. Pellett, D. Potter, U. Stierlin, P. Weilhammer

In the last year several experiments have yielded evidence that a peak exists in elastic scattering of π mesons on protons in the backward direction. By using the triangle inequalities it is also clear that there must be a peak in the charge exchange scattering. This backward peaking first appears clearly at about 4 GeV/c and seems to be a general feature of the scattering above this energy[1]. It is generally suspected of being the result of nucleon or N^* exchange.

The purpose of this experiment would be to see if a similar backward peaking exists in the production of meson resonances by π's and therefore whether it is possibly a general feature of all strong interactions at high energies. In deciding the best method of conducting the search, it looks most promising to pick a resonance with $I = 1$ or greater since in this case the final nucleon on which the identification of the resonance depends can be a proton and therefore accurate momentum measurements are possible. The most logical candidate is the ρ meson although the higher $I = 1$ resonances such as the A_1 can also be observed in the proposed experiment.

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1) Meyer et al., P.R.L. 15, 838 (1965) and Oxford Conference.
Orear et al., P.R.L. 15, 313 (1965.
Baker et al., Oxford Conference.

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In choosing the energy one must go high enough so that N and N* exchange would be expected to be important. While it is not clear at what energy this will be the case, we can guess from the experimental data on elastic scattering taking into consideration that the ρ mass is greater than the π. As the energy is increased, two difficulties arise. The proton momentum from ρ production and from elastic scattering become hard to resolve for 180° scattering. In addition, indications from elastic scattering are that the backward peak becomes smaller and narrower with increase in energy and therefore becomes more difficult to detect. Based on these arguments we would plan on running at between 8 and 10 GeV/c.

The experimental detection is greatly facilitated by the ability to separate the proton from the incoming beam. Therefore it should be easier to study the reaction

$$\pi^- + p \rightarrow \rho^- + p$$

than the similar reaction with π^+ and ρ^+ despite the fact that from the backward elastic scattering one might guess that the reaction using π^+ meson might have a considerably larger cross section.

The experimental apparatus of the CERN - Munich group now set up on the experimental floor is ideal for conducting this search with only minor modification. Since the backward elastic scattering peak has a width in $\cos\Theta$ which is roughly comparable to the forward diffraction peak, it is hoped that this may also hold for the backward peak in ρ production. If so by taking a solid angle in the forward direction of $\pm 2^\circ$ in the laboratory system, it should be possible not only to establish the existence of the peak but also to measure its width.

The signature for an event (see figure) is $1\,2\,\bar{3}\,\bar{4}\,\bar{C}\,5$. The Čerenkov counter will be set to eliminate π mesons. Since in this type of counter the efficiency is never 100% we have taken advantage of the bending of the magnet which, together with the slit defined by $\bar{3}$, allows us to eliminate from counter 5 all π^- mesons, both those in the beam and those produced by interactions, and all π^+ mesons with momentum less than 6 GeV/c.

Background due to neutrals is greatly reduced by the fact that $\bar{\bar{3}}$ is between counter 5 and the target and therefore a lead converter in front of 3 will convert most of the gamma rays which could otherwise trigger the system by producing pairs in counter 5 or in the material in the back of the Čerenkov counter. While $\bar{\bar{\check{C}}}$ will not detect K^+ mesons, production within the 2° angular region and momentum < 6 GeV/c should be small enough so that they will not constitute any serious triggering problem. In general those sources of background which do trigger the system will be easily eliminated by measuring the spark chamber pictures. Since the proton from ρ production has a momentum greater than the incident π momentum, there is little ambiguity in identification.

Assuming that the integrated cross section of the backward peak is 1 μb which seems reasonable from the elastic scattering data, we estimate the background for triggering the system to be about a factor of 30 greater than this.

Since the identification depends entirely on the recoil proton momentum, this resolution must be very good. We believe that the apparatus will give a momentum resolution of $^1/_2$%. The protons from ρ production and elastic scattering at 180° are separated by 3% in momentum. The elastic scattering will provide a convenient check on the calibration for the height and position of the ρ.

It might be expected that the backward production by the process $\pi + N \to \pi + N^*$ would be comparable in size and shape to the elastic scattering and ρ production distributions in the backward direction. On decay, the proton from this N^* would overlap that from the ρ production only in a very small portion of its decay solid angle. It should therefore create no problem. The same statement is true for the higher N resonances.

Using 1 μb as an integrated production cross section, there should be 1 ρ produced backward per 3×10^5 incoming π's. If the background is 30 times this great, then a beam intensity of 1 or 2×10^4 π's per machine pulse would allow us to take one picture per pulse and obtain approximately 1000 ρ's/day. The beam as presently constituted yields 5×10^5 π's/pulse so that less than 5% of the PS intensity is required. Since the width of the backward ρ peak (if it exists) is an unknown, it seems sensible to take a second point centred at 3° in the lab. to ensure some measure of the shape if the peak is broad.

Since the spark chamber system will have been running for some time, it should require little testing. The electronic logic is simple.

The experiment should take 5 days for testing and running with less than 5% of the proton beam.

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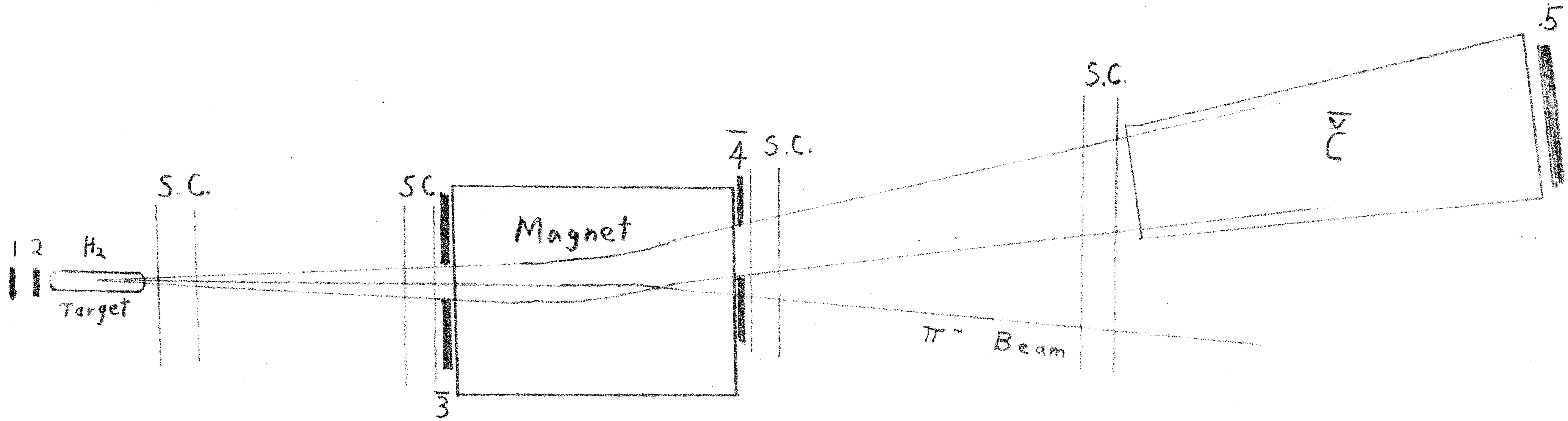

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