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SPARK-CHAMBER EXPERIMENT ON $\pi^- + p \rightarrow N^* + \rho^o$

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Consider the reaction $\pi^- + p$ at 100 GeV/c in which a nucleon or N^* is produced and recoils at a large angle and some neutral resonance is produced forward which decays into two charged particles. A number of such reactions should be of interest to study. To be specific suppose the products of the reactions are n and ρ^o. The details of the kinematics will be different for other reactions and slightly different triggering schemes will be needed but the approximate characteristics of the apparatus will be valid.

We could in principle measure the recoil mass by knowledge of its decay products and this will indeed provide knowledge when no missing π^o are present. However, to properly constrain the reaction we must measure the mass, momentum and angle of the forward ρ^o. To separate the 1238 from the nucleon (which puts the most stringent requirement on momentum measurement of the ρ^o) we need $\Delta p = M_{n^*}^2 - M_n^2/2M_n = 0.37$ GeV. Thus a $\Delta p/p$ of 0.1% at 100 GeV is needed for momentum accuracy of the ρ^o. If we depend entirely on the ρ^o for identification we could still wrongly identify the event type if an extra π^o were produced. The most straightforward procedure to handle such processes is to blanket the forward direction with anticounters which detect γ rays. The assumption is made that the π^o's at large angles, if such exist, can be associated with the recoil. By eliminating the forward π^o events a clean sample of events of the desired type is obtained. The sideways π^o's contribute to the recoil mass and hence their presence is reflected in the ρ^o momentum.

Angular Measurements

The minimum ρ^o decay opening angle at 100 GeV is 0.014 rad. Thus, an angular accuracy of 0.001 rad is needed to adequately determine the mass. Since we want the ρ^o production angular distribution we must also check to be sure our accuracy is great enough for this measurement. A reasonable value for the accuracy of each track seems to be 0.0005 rad. This matches the multiple scattering in a 1-foot H_2 target of 5 GeV π's. Only a small fration of the ρ^o-decay π's are below this value of momentum.

Trigger Requirements

Assuming a cross section for production of 10 μb, a 30 cm H_2 target and 10^5 π/pulse in a 0.1% momentum bite we would get approximately 1 event per beam pulse. A reasonable rate for a wire-chamber computer system is 10 per pulse. Thus, the trigger must have a rejection to about 100 μb per pulse to make full use of the beam of 10^5. This is about 1/200 of the particles which interact in the H_2 target. One of the difficulties at these high energies is that it is not possible to use a single beam anti after the H_2 target because many of the interesting products of the reaction will be very close to or in the beam. There are two rejection mechanisms we can use. These are, first, two anticounters which subtend 45° with a hole for the ρ^{o} decay products; second, a hodoscope of counters in the path of the ρ^{o} decay products in which we insist on at least two but not more than two particles. Approximately 10 counters in each direction should be adequate.

<u>Beam</u>

The π beam of 10^5 per pulse should have an angular divergence of < 0.3 mrad and a diameter < 2 mm with a momentum resolution of ± 0.1%.

<u>Magnets</u>

The overall spectrometer arrangement is shown in Fig. 1. The spectrometer is designed in two sections. The first section measures particles from 5 to 30 GeV, the second from 30 to 100. To minimize solid angle in the second spectrometer the fields in the two magnets are in opposite directions. The gap sizes can be easily calculated from the geometry by considering the bending of the particles in the field and the production and decay kinematics. They are as follows:

Mag	Field	L	W	H
1	40 kG	2 m	1.40 m	0.30 m
2	40 kG	6 m	1.40 m	0.75 m

These are adequate to pick up all ρ^{o} decay products above 5 GeV when the ρ^{o} is produced at $-t < 1.0\ (\mathrm{GeV}/c)^2$ at between 25 and 100 GeV/c incoming π momentum. Somewhat larger magnets might be desired for compatability with other experiments. Momentum measurements will be accurate to $\Delta p = 0.1$ GeV/c at the highest momentum in each spectrometer and proportionately better at other momenta.

One might ask whether smaller gap magnets can be used by reducing solid angle without introducing bias. For example we might allow the ρ^o to be produced in any direction but decay within $\pm 30°$ of the horizontal and with the large angle low momentum track always in the $+x$ direction. This reduces solid angle by a factor of 6. The magnets can then be reduced to the following sizes:

Mag	L	W	H
1	2 m	0.85 m	0.20 m
2	6 m	0.85 m	0.40 m

This is a reduction in field volume to 40% of the original. Whether it is desirable to make such a reuuction depends on the cost of the magnets which constitute the major nonaccelerator costs for the experiment.

Estimating the cost of a superconducting magnet at this time seems like extremely hazardous game. Scaled from the 12-ft Argonne bubble-chamber magnet we get:

	Full Scale	Reduced Size
Mag 1	$\$0.6 \times 10^6$	$\$0.3 \times 10^6$
Mag 2	3.0×10^6	1.2×10^6

It should be noted, however, that if we scale these from the BNL 25 foot bubble-chamber magnet or the 10 m streamer chamber proposals and in addition include money for iron return paths we get numbers approximately half those given above. It is probable that by the time these magnets are constructed it will be possible to realize this factor of 2 in cost.

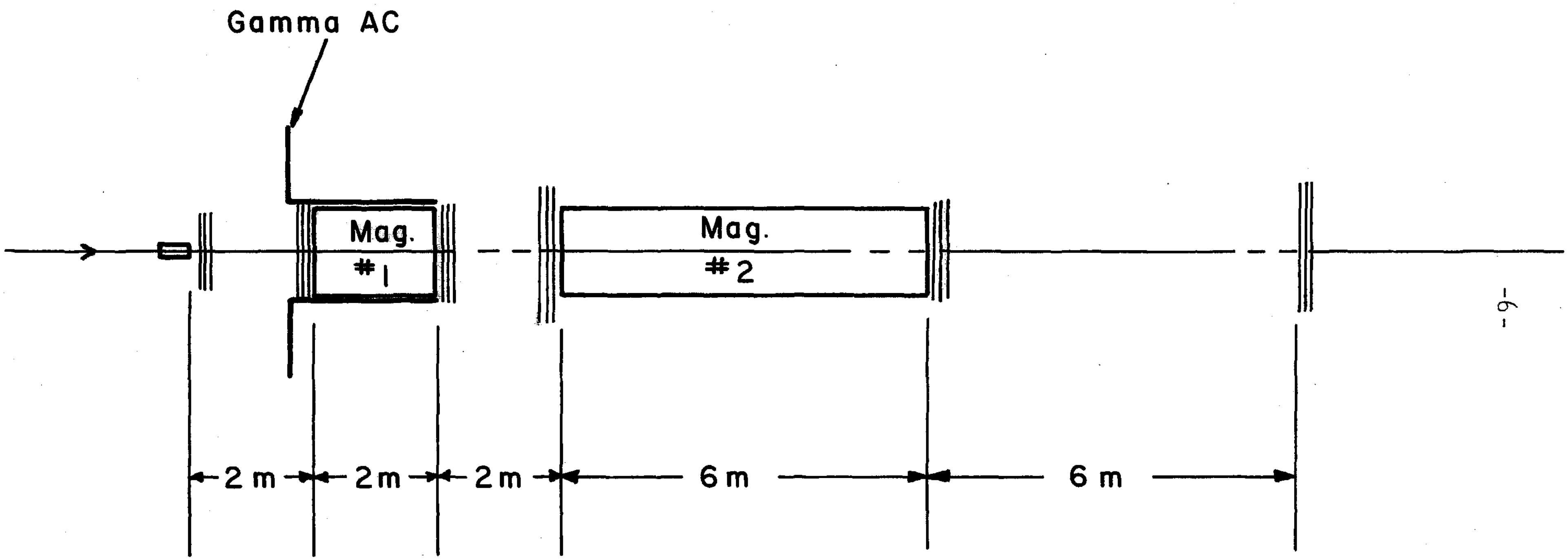

Fig. 1. Experimental arrangement showing magnets, wire planes, and ac gamma detector.

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