Fermilab Proposal No. 366

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STUDY OF HEAVY, NARROW MESONS USING A MASS-FOCUSING SPECTROMETER

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We propose to search for and study charged two-body decays of narrow massive neutral mesons produced near the forward direction in neutron-nucleon and neutron-nucleus collisions. The apparatus is a high-resolution, mass-focusing spectrometer capable of focusing masses up to 4.8 GeV/c^2 with resolution $\sim$15 MeV/c^2FWHM; it consists mainly of rearranged components of Experiment 12, now taking data in the M3 beam line. Range tagging of muons and Čerenkov identification of heavy hadrons allow us to form strong triggers for high-mass $\bar{\mu}\mu$, $\bar{p}p$ and (less strong) K^+K^- final states.

We emphasize that our apparatus is sensitive to peripherally or diffractively produced objects and is thus complementary to those that would search in the central region. (For a mass of 3 GeV/c^2, we cover a range of $0 \leq p_\perp \lesssim 0.8$ GeV/c, and of $0.4 \leq x \lesssim 1$.) The neutron beam has the advantages that 1) the heavy objects need not be restricted to quantum numbers accessible in e^+e^- collisions; 2) beam intensities an order of magnitude higher than those tolerable with charged beams may pass through the detectors. Targets of varying Z can be used to learn whether coherent production mechanisms are important.

A. APPARATUS

The spectrometer design is shown in Figure 1. It is based on the principle (familiar in neutral kaon physics) that the two charged particles from the decay of a neutral parent will emerge parallel from a dipole magnet of suitable strength, independent of the momentum of the parent and the point of origin, and nearly independent of the energy sharing. The virtues of such a scheme using our equipment are summarized below.

High analyzing power. The two BM109 magnets, run with 8" gaps and 3000 amp excitation, can achieve a total $\int B d\ell$ of over 80 kg-meters. This permits point-to-parallel focus of effective masses as large as 4.8 GeV/c^2. Very small effective masses are largely swept clear of the trigger hodoscopes.

Mass trigger. We can trigger on a selected mass bite by demanding that at least two particles emerge from the magnet nearly parallel to each other and to the beam. This is done by requiring pair-wise coincidences between elements of the H1 and H2 hodoscopes. The size of the mass bite is adjustable by rotating the elements of H2 to change their effective area. Since defining a very narrow mass bite in this manner restricts the accessible $p_\perp$ and decay asymmetry, we will position the counters to reject low effictive masses (below $\sim$2 GeV/c^2) where the cross-section is large but to accept the interesting high-mass region out to $\sim$4 GeV/c^2.

Mass resolution. We can achieve a mass resolution of $\delta M/M \simeq 0.5\%(p[\mathrm{GeV}/c]/100)$, where p is the lab momentum of the decaying object. This corresponds to $\delta M \simeq 15$ MeV/c^2 FWHM at M = 3 GeV/c^2 and p = 100 GeV/c.

Particle identification. Our apparatus includes a third coarse hodoscope behind a 10' iron wall for tagging muons emerging roughly parallel, and a large (existing) 45' gas threshold Čerenkov counter for identifying heavy hadrons. The $\bar{\mu}\mu$ signature should be worth at least a factor of 10^3 in background rejection. Because of the anticipated large spread in particle momenta behind the magnet, it is difficult to obtain large π/K rejection ratios using a single counter. It is certainly possible to pressurize the counter to obtain unambiguous identification of $\bar{p}p$ over the

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whole momentum range, with a pion rejection ratio of $\sim 10^3$. Depending on the severity of the background encountered, we may be able to run at sufficiently low pressure to provide in addition some K^+K^- identification for events of low momentum.

We are aware that the KK, and particularly πK, decay modes of narrow objects are extremely interesting and are studying improvements of the Čerenkov system to allow positive identification of these final states.

Overall trigger. Our very strong overall trigger then requires two charged particles with effective mass above ~ 2 GeV/c^2, and that the particles be either $\bar{\mu}\mu$ or $\bar{p}p$ (or possibly $\bar{K}K$ at low momentum). Any number of other particles may also be produced. (Further strengthening of the trigger could be achieved by demanding no other charged particles.) Other trigger possibilities such as a smaller mass bite but more kaon sensitivity are easy to implement.

Sensitivity. The magnet aperture and parallel-focus trigger restrict the useful rest frame decay angle to $\pm 20°$ ($\pm 45°$) at p = 100 (p = 200) GeV/c, and limit the accepted azimuthal angle about $\vec{p}$; the estimated average acceptance is .05. For a target (e.g. lead) of 0.1 interaction lengths and a cross-section for the detected decay modes of 10^{-33}cm^2, we expect about one event per day at 10^6 neutrons per pulse. It should be noted that multiwire proportional chambers are used exclusively on the upstream side of the magnet, and that these chambers are now operating routinely in the M3 beam at 5×10^6 neutrons per pulse with an effective target of .05 interaction lengths. Our spark chambers can easily run 30 triggers per pulse. In brief, we believe our trigger and chamber systems are strong enough to allow a beam approaching 5×10^6 neutrons/pulse, giving ~ 5 events per day at the 10^{-33}cm^2 level.

B. REQUIREMENTS AND STATE OF READINESS

With the exceptions noted below, all necessary items are on hand as components of Experiment 12 or as loans from other groups. We must of course retain those portions of Experiment 12 (fast logic, BISON PDP 11 computer system, magnets, etc.) which have been supplied by Fermilab.

Additional items needed from Fermilab.

1. Steel for muon filter, 6 existing pieces 2-1/2' × 1' × 10'.
2. One Transrex magnet power supply.
3. Miscellaneous fast logic.

To be constructed by experimenters.

1. 40 simple scintillation counters for hodoscopes.
2. Modification of Čerenkov counter optics and windows.

Proposed starting date. Most of the equipment is now in use in Experiment 12. We estimate that about two weeks of running beyond December 2 are needed to accomplish the goals of Experiment 12; conversion of the spectrometer may then begin. Construction of counter hodoscopes and modification of Čerenkov optics require one month. Given the scheduled shutdown periods, we estimate that we could usefully take beam by the middle of January 1975.

MASS-FOCUSING SPECTROMETER

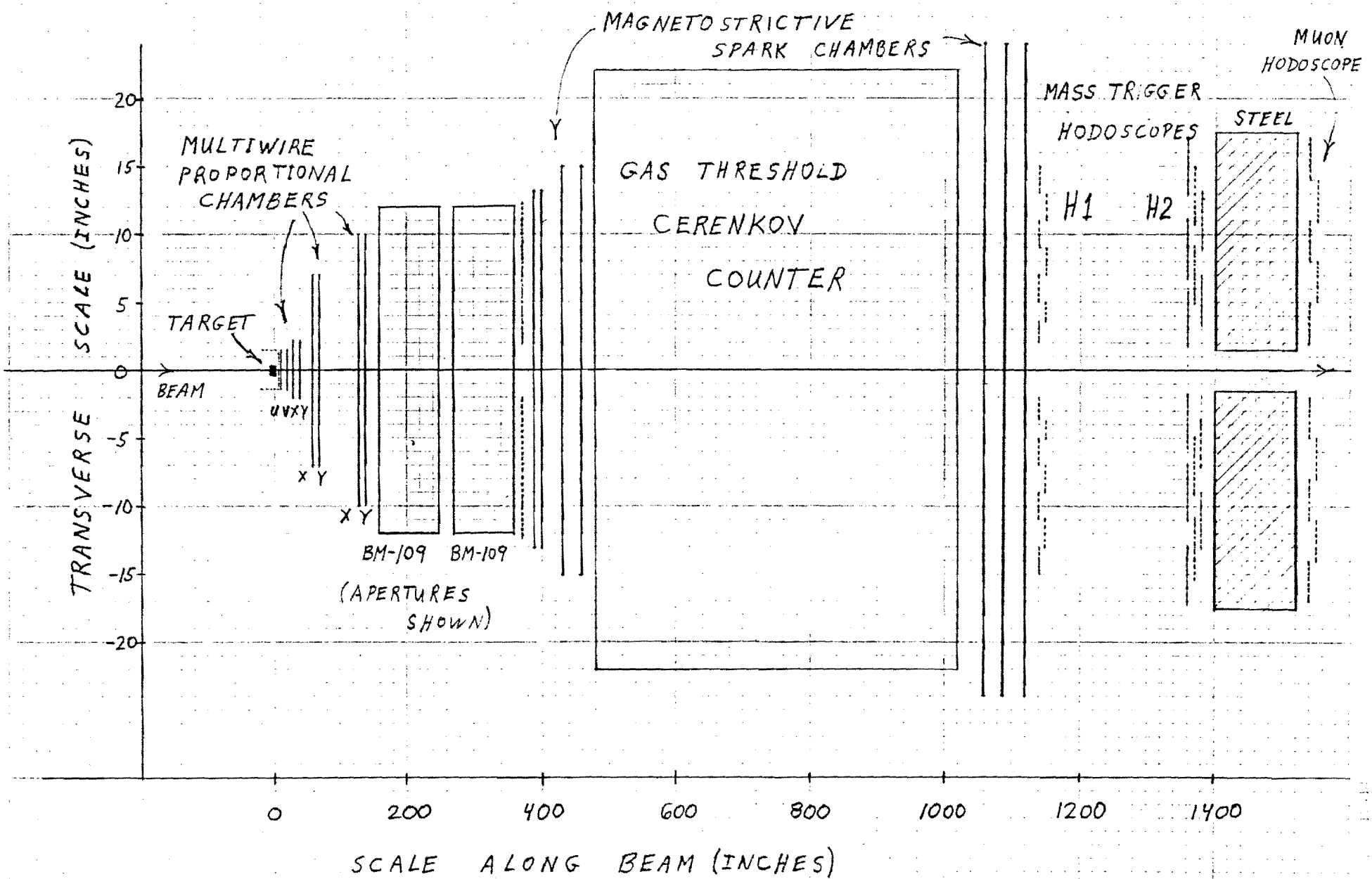

FIGURE 1