PROBLEMS OF MAGNETIC SHIELDING FOR NEUTRINO BEAMS REQUIRING DETAILED STUDY

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ABSTRACT

Before the feasibility of magnetic shielding for a neutrino beam can be properly evaluated, certain engineering and physics questions require further study.

Exotic Processes

When considering the application of any magnetic shield to a neutrino beam, one must remember that the required reduction of muon flux is to a fraction of the order of 10^{-9} for bubble chambers, or in the range of 10^{-5} to 10^{-7} for spark chambers, assuming the magnetic shield itself ranges out muons below about 20 GeV. Thus exotic processes that throw muons into the detector must be considered in detail. These may include (among others):

1. Muons in the "halo" of the beam which escape magnetic deflection or are deflected toward the detector. Though presumably most of these muons are low in energy and thus range out, the high-energy tail must be considered carefully.

2. The tail of the ordinary multiple coulomb scattering distribution. Though magnetic deflection dominates coulomb scattering by at least an order of magnitude for the devices described in the accompaning reports, a few muons on the extreme tail may leak through.

3. Large-angle single scatterings of muons. Even taking into account solid-angle factors, processes that occur with a probability of 10^{-7} to 10^{-8} are sufficient to disturb a bubble chamber. Such processes involve a transverse momentum of at least 3 to 10 GeV (the lower limit depends on the particular design of the BC magnet), and thus a somewhat higher momentum transfer, and must nonetheless leave the muon with the bulk of its forward momentum. Thus the calculation is extremely dependent on theoretical models.

4. Processes initiated by the hadronic component of the beam halo.

Additional Shielding

Detailed consideration must also be given to the other shielding elements to be used with a magnetic shield. Questions of interest here include:

5. Is there any advantage either from the engineering or physics point of view to preceding the magnetized shield by a high-density or high-Z shield, possibly of uranium?

6. What should immediately follow the shield? Should it be open space, a short range shield to eliminate low-energy muons, or perhaps air magnets to provide additional sweeping power?

7. What is the best environment for the swept-out muons as they pass by the detector? Are they more or less likely to re-enter the detector if they are in earth than if they are in air?

Magnet Design

8. Finally, the optimum design of the magnet itself, in the two configurations proposed in the accompaning reports and in other configurations requires further study. Since the copper-to-iron ratio can be uniquely low in these magnets (there are essentially no air gaps), the possibility of using low-grade iron billets or even iron ore in a magnetic shield must also be considered.

Scheduling Problems

It seems likely that, even after detailed study, the performance of a shield which has substituted magnets and sweeping for even part of ranging out will be by no means certain at the level required for a bubble-chamber experiment. In this case it might be desirable to conduct a "survey" of such a shield immediately after beam turn-on. For example, a separate neutrino spark-chamber experimental area behind a partly magnetic shield could then be the front element of a longer bubble-chamber range shield, the study of which would be made in great part by the spark chambers. This poses the following scheduling and engineering problem:

9. Is it possible to delay the start of construction of a bubble-chamber building and/or part of its shield until after such a survey without seriously retarding the experimental program, and is the possible saving sufficient to justify the delay?