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EFFECT OF SUPERMAGNETS ON EXPERIMENTAL AREA LAYOUT

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ABSTRACT

The effect of the availability of high-field supermagnets on the layout of 200-BeV experimental areas is considered. If it is possible to develop 60 kG bending magnets, the length of some secondary beams may be reduced by a factor of two. It appears that it is more important to develop high-field bending magnets than high-field quadrupoles.

A recent study[1] of the cost and feasibility of using supermagnetic beam-transport elements at the proposed 200-BeV accelerator has shown that they may, over a long period of operation, be more economical than conventional copper-iron magnets. There is, however, presently not enough practical experience with the fabrication and use of supermagnets to justify a decision to field a target station with supermagnets rather than with conventional utilities. It is expected, however, that within the next year or so much more practical experience will be accumulated.

Presently the most frequently discussed advantage of a supermagnet beam-transport system is the greatly reduced electric power consumption. There may be, however, an even more compelling reason why supermagnets should be adopted. The maximum magnetic field available in reasonable iron-copper magnets is 20 kG. It appears that supermagnet elements may operate at much higher fields. Such magnets will considerably alter the layout of beam-transport areas and in some cases, there may be a considerable saving in beam-transport floor space. I shall discuss below the manner in which various types of beams that have been proposed for the 200-BeV accelerator might be altered to take advantage of high-field magnets.

Unseparated Beams

A typical copper iron magnet unseparated beam system with an intermediate focus at 100 BeV/c would be 700 feet long and would provide a transverse displacement of 75 feet from the initial beam line at the final focus. In such a beam there might be 160 feet of bending magnets that operate at 15 kG and 56 feet of quadrupole sections operating at 5 kG/in. The 75-foot displacement of the beam line is needed in order to separate experiments adequately. If 2× stronger bending magnets are available, the beam can be made shorter by a factor of 2, preserving the 75-foot separation. The quadrupoles would have to be 2× stronger also, but the fields needed are within the range of conventional magnets. The quadrupole and bending magnet apertures could be 2× smaller for the same beam intensity, except for a field lens which would have the same aperture. A typical list of magnets for a 100 BeV/c, two-stage intermediate focus beam, 350 ft long, providing 75 ft separation between experiments would be

2 bending magnets 60 kG × 180 in. long
gap 1 in. high × 1-1/2 in. wide

2 quadrupole triplets 20,000 g/in. × 168 in. long
1 in. diameter effective bore

1 quadrupole singlet (field lens)
10,000 g/in. × 34 in. long
2 in. diameter effective bore

A bending angle error $\delta\theta/\theta$ in the quadrupoles of ±10% would still permit a momentum resolution of ±0.1% if a narrow slit or set of counters were placed at the intermediate focus.

<u>RF Separated Beams</u>

RF separated beams have been described by Lach.[2] It does not appear that these beams can be shortened more than 25% if superconducting magnets are used because the main contribution to the length of these beams is the drift space between the deflectors. The length of the drift space depends on the velocities of the particles being separated and on the frequency of the deflectors. Lach concluded that the maximum practical frequency is 10^{10} cps. The deflector separation in a 100 BeV/c K beam is 2260 feet at this frequency. In this beam the length of the beam transport, other than drift spaces, is about 2000 ft. Supermagnet elements might reduce this to 1000 ft. As this beam requires beam-transport elements of very high quality, and as the savings in length is only 25%, I do not think that it is reasonable to consider making it with first-round supermagnets. If it appears, however, that the neutrino beam is shorter than the separated beam--and both must run into the bubble chamber; the length reduction may be very valuable.

Neutrino Beams--Muon Beams

In a neutrino beam, as described by Keefe,[3] the length of the pion decay channel (1 km) is much longer than the remainder of the beam-transport system. It does not appear that supermagnets will significantly alter the design of such beams.

Charged Hyperon Beams

Supermagnets with high fields will make possible experiments with hyperons that would not be feasible with conventional magnets. Supermagnets can be used either to momentum analyze hyperons from reactions (with spark chambers), or in conventional but very short length secondary beams of hyperons.

When one does spark chamber-magnet spectrometer experiments with hyperons, the length of the spectrometer probably can not be greater than a decay length. At 100 BeV/c, this length for Σ^- is 4 meters. If the resolution of a typical spark chamber is $\delta x = \pm 0.1$ cm, the $\delta p/p$ of the system, with the magnet operating at 100 kG would be ± 0.03. This resolution may be adequate for many experiments.

The surprising result of the secondary particle flux prediction of

Hagedorn and Ranft that the Σ^-/π^- production cross-section ratio (200 BeV/c protons, 130 BeV/c secondary momentum) is 15/1 makes it reasonable to consider conventional--but very short length--Σ^- beams. If 1/100 is a practical lower limit on the Σ^-/π^- ratio at the final focus of the beam, the upper limit on the beam length is 30 meters. It may be possible to construct such a beam with magnets of the type discussed in the section on unseparated beams.

REFERENCES

[1] M. Green, G. Coombs, and J. Perry, Refrigeration for Superconducting Magnets in the 200-BeV Accelerator, Weston, Illinois, Report of "500" Inc., 1968.

[2] J. Lach, Lawrence Radiation Laboratory UCRL-16830, 1966, p. 190.

[3] Lawrence Radiation Laboratory UCRL-16830, Vol. I, 1964, p. 311.