SUMMARY OF AN INFORMAL MEETING ON BEAM TRANSPORT EQUIPMENT - APRIL 8-10, 1968

A. Roberts

April 12, 1968

PRESENT: NAL: T. Collins, A. Maschke, A. L. Read, A. Roberts, L. C. Teng
Visitors: G. Danby, M. L. Good, T. Yamanouchi

The purpose of the meeting was to try to arrive at decisions that would make possible the drawing up of a tentative schedule of beam transport equipment, to be used as a point of departure by participants in the summer study program who are concerned with beam design. The principal topics of concern were therefore the apertures and lengths of dipoles and quadrupoles for general use. It was agreed at the outset that in the target area, within the hadron and muon shield, special transport equipment would most likely be required in addition. Other topics discussed included the possible use of superconducting and cryogenic magnets, allowable magnet aberrations, and possible accurate momentum definition within the momentum passband transmitted by a given beam.

Considerable time was spent trying to find specific criteria on which to base the choice of aperture for magnets - i.e., the scale factor. The lower end is determined by the increasing difficulty of making small quadrupoles with reasonable aberrations and reasonable ratio of aperture to total width; the upper end is limited by the fact that high energy secondary beams occupy small phase-space areas and large magnets have to be set very far apart.

It was pointed out early by Maschke that dipole apertures in the vertical plane should be considerably smaller than quadrupole apertures, otherwise the design is wasteful. No serious design limitation is imposed by this restriction.

There was considerable discussion on dipole design. Opinion tended to favor the window-frame rather than the H-style of construction, with additional pole pieces being added as needed to reduce the magnet gap. The same magnet may then be useful for both transport and for spectrometry. Since the lateral width is a minor factor in magnet cost, opinion favored making the width of dipoles larger than the minimum required in order to allow flexibility and in order to make it possible to use only the central portion of the field to decrease aberrations. However, making the gaps less than 2" tends to increase the difficulties, because of the close machining tolerances smaller openings require. A typical design might be a dipole with a 2" vertical gap, (produced by shimming a window-frame with a 4-inch gap), 8- to 10-inch lateral width, and about 10 feet long, with a field somewhere around 15 to 20 kgauss. Coil cross-sections of 3" x 5" and current densities of 3000 amps/in^2 lead to total power consumptions of about 150 kw., a reasonable value.

Settling on a 2" dipole aperture then leads, by partly mystical steps, to a choice of 4" for the quadrupole apertures.

Mention was made of the desirability of individual cooling units and power supplies for magnets (or magnet pairs) scattered about the cold prairie. Ethylene glycol or alcohol-cooling (with airtight cooling systems) and automobile-type heat exchangers operating at high pressure were thought reasonable.

Danby discussed briefly superconducting and cryogenic magnets. It was agreed that for general purpose transport superconducting magnets seem at present to offer no great advantages. Cryogenic magnets, using very pure aluminum at temperatures about 30^{o}K., cooled by liquid neon (which has a very high heat capacity) may, on the other hand, be advantageous. The power consumption of cryogenic magnets in this temperature range is a factor of 300 to 1000 lower than at room temperature for the same current density, leading to typical power consumptions well under one kw. They can be pulsed, thus materially decreasing the total refrigeration load. The estimated power consumed by the refrigerator is then about 1/10 that taken by corresponding room-temperature water-cooled magnets. In addition, higher current-density designs are possible that may lead to important qualitative design improvements. This subject requires considerably more study.

Aberrations and Momentum Analysis. The extremely small emittance of the primary beam, and the small target, make possible the design of secondary beams with small emittance and good momentum dispersion, so that the energy of the incident particle on a secondary target can be obtained with high accuracy merely by dispersing the beam. Good reported a calculation for very high momentum secondaries (300 Gev/c) for which he found that a magnet of strength sufficient to bend the secondary beam 14 mrad allows momentum resolution sufficient to determine whether a single neutral pion is missing. This is less bending than would be desirable in any case for beam isolation.

The high beam quality also indicates the need for careful control over magnet aberrations to avoid losing beam quality in the transport system. No quantitative data exist at present on aberrations at the required level.