CONSIDERATION OF AN INTERNAL TARGET FACILITY

A. W. Maschke
National Accelerator Laboratory

A. Wattenberg
University of Illinois

and

D. H. White
Cornell University

July 12, 1968

At the present time the plans for the 200-BeV machine do not include an operating internal target or an internal target experimental area. Some of the reasons for this decision are covered in the accompanying report by A. W. Maschke, who along with other NAL staff members has spent considerable effort developing the arguments in support of this decision.

A second report by A. Wattenberg lists a number of experiments which under detailed study might argue for an internal target facility. With the possible exception of an experiment to search for magnetic monopoles, the need for an internal target is not proven in our opinion. We feel that a detailed study is necessary for each experiment in order to establish the need, and until such a need is clearly demonstrated, there is no physics reason to challenge the present plans.

OBITUARY FOR THE INTERNAL TARGET AREA

A. W. Maschke
National Accelerator Laboratory

ABSTRACT

Some factors motivating the decision to make the internal target area a proton beam target station are discussed.

During the course of design of the 200-GeV accelerator many technical decisions were made which bear very strongly on the experimental utilization of the machine. The design problem as posed in June, 1967, consisted of building the best possible high-energy physics facility of 1.5×10^{13} protons/sec at 200 GeV, with an option for higher energy (400 GeV, say), and for a cost of 240 million dollars. In addition, there was the desire to make the machine operate as reliably as possible, and with as small a maintenance and operation staff as possible, thereby leaving the major portion of the operating budget for the execution of the research program. Some of the immediate consequences of the line of reasoning are as follows:

1. The machine will be built underground. The advantage is reduced cost for foundation, yardwork and earth moving and landscape maintenance, as well as assuring greater stability without the use of piles or caissons. This represents savings on the order of 15 million

dollars. However, it does represent substantial increases in the cost of utilizing an internal target area.

2. The machine is designed for nearly continuous operation with very brief maintenance periods. The speed of maintenance and/or component replacement is enhanced by maintaining low radiation levels in the main-ring enclosure. It also facilitates the implementation of future modification. Here again, this puts the internal target area at a disadvantage. For one thing, it would contribute to machine activation out of all proportion to the amount spilled on target, compared with an external target. Furthermore, setup changes and repairs could only be done at the expense of stopping all other experimental programs.

3. The machine has only six special long straight sections. One is used for beam transfer, and another for the rf system. A storage ring bypass combination may use three of these. This tends to argue against blocking future options by designing in at the outset an internal target facility.

Past comparisons of internal versus external targets have come to the general conclusion that the internal target has an advantage only with respect to multiple traversal targets, single traversal targets being much better exploited in a proton beam target station. Therefore, the "physics" reasons given for an internal target area really speak for the desirability of a multiple traversal target area. Operationally, the appropriate way to implement the multiple traversal target area is via a proton beam bypass. A bypass system avoids all the objections previously ascribed to an internal target area, and at the same time provides a means to do clashing-beam studies.

The problem then gets down to the question of building a bypass as part of the initial construction package. There are two reasons for rejecting this proposal. One is that the design of such a facility is quite uncertain at present, especially with regards to possible superconducting bending magnets. The other factor is that it is doubtful that the physics output of the multiple traversal facility alone would justify the cost of the bypass at the expense of several proton beam target stations.

THE SEARCH FOR QUEER AND ODD BUT NOT STRANGE PARTICLES OR EXPERIMENTS THAT MIGHT REQUIRE AN INTERNAL TARGET OR VERY THIN TARGETS

A. Wattenberg
University of Illinois

ABSTRACT

Rather superficial consideration was given to processes that might require an internal target facility. It appears as if they would be rare production processes or production of "Queer" particles. Particles which were considered include magnetic monopoles, heavy leptons, quarks, and intermediate bosons (weak). Only the magnetic monopoles search would benefit by about a factor of 10 by the internal multiple traverse target. However, this is based on the assumption that there will be a versatile thin target facility off the external beam.

We have tried to think of the characteristics of experiments that would require an internal target. They are

1. A low cross section so that one needs multiple traversal of a very thin target combined with

2. A low probability of escape

   a) as for example a short decay time (in the range of 10^{-10} to 10^{-13} sec) or

b) a very high energy loss or

c) a very high cross section for interaction

In regard to the last alternative, 2c, it is very difficult to imagine an interaction of a single elementary particle that would not lead to a cross section commensurate with nuclear size. One would need a very long range strong interaction.

In regard to consideration of the other alternatives, one can think of specific examples of conjectured but so far unobserved particles and evaluate whether they have the requisite characteristics.

a) Magnetic Monopoles -- They probably satisfy 1 in that they would be massive and produced in pairs, and they partially satisfy 2b in that it is estimated to lose about 8 $GeV/gm/cm^2$ in passing through matter. Therefore, if one planned on scanning a target of the order of 1 gm/cm^2, we are dealing with the order of 1% of an interaction length. If one could use 10% of the circulating beam with multiple traversals, one would gain a factor of 10 in their production. If one ran for one month, the radiation damage (and radioactivity after one year) would be comparable with that from a 99% efficient extraction system.

b) Heavy Leptons --If they have the same weak interaction constants as muons, depending on their lepton quantum number scheme, they will have decays of the form

$$L \rightarrow \mu^+ + \nu_\mu + \nu_L,$$

$$L^{+(o)} \rightarrow \pi^{o(-)} + \mu^{+}.$$

One could then hope to search for them by observing a particle which gave off energetic muons and had a lifetime in the range 10^{-10} to 10^{-13} sec. (Time dilation will convert these to cm or mm decay lengths depending on the mass of the particle.) One therefore looks for evidence of an experimental decay distribution in the space immediately downstream from the target. These satisfy condition 2a; the question is do they satisfy condition 1?

The production cross section will depend on the masses. One can set limits on their masses from requiring that their decay rates be observable and that they haven't been seen in searches below the mass of the K meson. (See Thesis, E. Buess, University of Illinois, 1967; M. Perl et al.; and L. Okun.) Liberally 2 BeV < M_L < 470 MeV. One can visualize production processes (from discussions with Francis Low) for particles of such masses which lead to cross sections as large as 10^{-34}cm^2 (my guesstimate--not Low's). Therefore, in terms of a target 3 mm thick (1 gm of aluminum), one would be better off by a factor of 10 with an internal target. However, one would be able to get closer to an external target at large angles and to obtain the requisite spatial resolution needed for the experiments. Maschke has pointed out that in this case one could probably separate in space a series of thin targets to make the equivalent of the internal target facility.

Therefore, if there is a capability of looking at thin targets in the external beam, one does not need an internal target facility.

We have not considered strange heavy leptons or heavy leptons that couple only to baryons.

c) Quarks--They do not satisfy condition 2; namely, they are expected to have cross sections of a nuclear size or less. Therefore, one can use an external target facility.

d) I.V.B. of Weak Interaction--In almost all models the lifetimes are too short and the cross sections too small to satisfy condition 2. However, if one wishes to try to search for them due to the emission of high-energy muons at large angles, one wants a thin target to avoid secondary reactions. One can use a thin external target facility, if it exists.

e) Rare Production Processes--There have been searches for rare production processes as for example antideuteron production (or antinucleus production). These satisfy 2c to a first approximation in that the cross sections are appreciably above nuclear size. These are curiosities at the present time. If there were very serious interest in them in the future, one would need to carefully analyze the need for an internal target facility.