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DESIRABLE BEAM CHARACTERISTICS OF HIGH INTENSITY ACCELERATORS

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ABSTRACT

A discussion of the beam characteristics which are desirable from a high intensity accelerator in order to optimize its experimental utility.

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It is recognized that the importance of internal target facilities depends upon the qualities of the external beam which can be achieved. Properties required of internal target arrangements are essential only inasmuch as such properties or combinations of properties cannot be achieved by the external beams. The converse is also true.

It is desirable that internal targets can be positioned so that particles of both signs, produced at small angles to the beam direction, can be extracted. It is also particularly advantageous if these particles can be extracted through a field free region, as in such a situation a single experimental assembly can easily examine phenomena as a function of energy.

It is possible to estimate the smallest angle which can be of any importance. This is set by the uncertainty principle and the Fermi momentum in the target. For a 15 Bev machine this angle will be about $2\text{-}1/2^{\circ}$. For most work 5° may be reasonable; at angles much larger than 5° the intensity of the beams of high energy particles will probably be severely restricted.

In considering targets which might be used internal to the machine, size is an important criteria. A high luminosity target has a great advantage since in subsequent lens systems a large solid angle acceptance with small image size can be attained. Any machine should be capable of using a target less than 1 cm. x 1 cm. in cross section which accepts the whole beam and it would be very desirable to use targets 2 x 2 mm. Probably a target size smaller than this does not gain you much.

Since intense secondary beams can be attained using thin targets and multiple traversals, this is a very desirable feature which should be incorporated into the machine design. Such a possibility also conveniently admits splitting the beam between several experiments.

The luminosity of thin targets multiply traversed will be exceedingly high. The energy lost in targets, particularly thin targets, may pose some problems. A 10 μ amp beam will lose about 2 K. W. energy in traversing a mean free path. A thin target of refractory material should be able to dissipate this, but perhaps not much more.

Radiation demage to coil insulation must also be considered if very high currents are incident upon internal targets.

It would be useful to have the possibility of putting hydrogen targets in the machine. This is possibly of less importance than some other criteria if external beams of high quality are available which can be used when hydrogen targets are needed.

For counter experiments and luminescent chambers there is a considerable advantage in having a steady beam of particles. Both the R. F. structure in the beam and in the case of a pulsed machine, the time between pulses can be serious and may markedly reduce the useable beam intensity and increase the complexity of experimental equipment.

For bubble chamber experiments it is desirable to be able to store the beam over a certain length of time, then deliver the beam to the target in one short burst. The time between such bursts should be variable from a fraction of a second to very long times. These comments on duty cycle apply equally to internal and external beams.

It is advantageous to have the accelerator designed so that the beam may be split among several experiments. For example, part of the beam may be spilled out suddenly on some target for a bubble chamber, then the rest dribbled out slowly on another target for counter experiments, or ejected for external beam experiments.

The more versatile the machine can be made in this regard, the more possibilities will exist for running several experiments simultaneously with a minimum of interference.

An external proton beam has many general advantages over an internal beam, and is almost essential for certain experiments. The accessibility of the beam will allow experiments to be set up without concern about interference with the accelerator or its shielding. New secondary beams may be set up without shutting the machine down to rearrange the shielding. Larger solid angles can be obtained from the target since focusing devices may be placed closer to the point of interaction. Since the whole angular range is available, it becomes possible to use reaction kinematics to help in particle separation. Many experiments using fairly thin targets may be strung out along the beam. In addition, many R. F. Bunching schemes become simpler in an external beam. At present 86% of the Cosmotron running time is spent using the external beam.

The study of short lived particles ($T = 10^{-10}$ sec) becomes feasible with the close approach to the target allowed by an external beam. Absolute cross sections, excitation functions, and the primary proton-proton interaction can be measured reliably.

It should be noted, however, that very long straight sections in the machine (5-10 meters) can be used to do some of the things for which an internal beam would otherwise be necessary.

Characteristics of an external proton beam which appear to be desirable at this time include the following:

<u>(1) Variable Energy.</u> For the purpose of studying the excitation of the production of π's, K's, $\overline{P}$'s, etc., and the differential proton-nucleon scattering

cross sections, it is desirable that the external beam be variable in energy without sacrifice of beam quality, i.e., from 50% E_{max} to 100%.

(2) Good Beam Quality. In order to take advantage of the good geometry experiments possible in the external beam, the spot size at the target should probably be no more than one centimeter in diameter with an angular divergence of 1 milliradian. (The Cosmotron external beam is of the order of 2 cm. x 2 cm. in size, with an angular divergence of about 10 milliradians). A one centimeter spot size is also suggested by the desirability of being able to place a target for the production of secondaries in the beam and focusing the secondary beam on some beam separator. For most applications a few percent momentum spread in the beam will be sufficient; however, it would be advantageous if the spread can be reduced.

(3) Geometric Stability. The advantage of good beam quality will be lost if the pulse-to-pulse geometric instability of the beam is not considerably less than the 1 centimeter spot size or the few percent allowable momentum spread. In addition, the geometric stability of the beam as a function of energy of the external beam has the same requirements for experiments pre-aligned at one energy.