USE OF A DIFFRACTED PROTON BEAM TO PRODUCE TERTIARY BEAMS

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ABSTRACT

The use of tertiary beams produced from a diffracted proton beam is discussed. It is concluded that in many cases such beams have several advantages--particularly, though not exclusively, for lower momenta. The flexibility inherent in a diffracted proton beam station makes it especially useful in the early days of the accelerator.

I. INTRODUCTION

A number of reports[1-3] have suggested the use of a diffracted proton beam (of intensity ~ 10^{10} protons/pulse) to produce tertiary beams which for various reasons can sometimes be produced better in this way than with the external proton beam (EPB). We wish to extend this, and suggest that in the early days of running it may be advantageous to have a number of beams for counter/spark-chamber experiments, particularly those of lower momentum, originate from a target in a diffracted proton beam (DPB).

II. COMPARISON OF EPB AND DPB TARGET AREAS

We first make the following observations about beams produced directly from the EPB. The shielding around the ensemble of beams coming from an EPB target is considerable; thus a change in beam layout once the accelerator is in use will be no small task, with the result that any set of beams will tend to be "frozen" for an appreciable length of time. Since we would hope to have a number of beams in the target station ready for turn-on, decisions about the beams must be made perhaps as much as 2 years before then in order to fabricate, test, and position all components. (One of the reasons for a summer study, after all, is to aid in such a decision.)

This is in contrast to the practice at existing accelerators; for instance in the early years of the AGS, most experimenters designed their own beams, until after a few years as the needs of experimenters became clearer, a set of beams evolved that covered most needs, and these have remained relatively stable since then. The initial period was invaluable for producing a useful set of beams, particularly since the type of physics that would be popular could not be predicted with great certainty at accelerator turn-on. (For instance K^o beams have only been in high demand since 1964.)

A DPB target station will look somewhat similar in terms of shielding to the AGS G10 area, since comparable radioactivity will be present. Shielding can be stackable concrete blocks, making changes in beam layout possible in short shutdowns; also it will be possible for instance, to go into the target area when required and adjust a collimator. It is this ability to make changes in beams in a short time that is the principal reason for advocating a DPB station for the early days of the accelerator when demands for types of beams may change frequently. Also, of course, this can lead to much greater flexibility in scheduling experiments.

In spite of all the above, it is obvious that the "best" beams, in terms of highest momentum and intensity, must originate from the EPB. Nevertheless, there will be some beams, particularly of lower momentum or of short-lived particles, that can be produced from the DPB station more advantageously, and so the two are complementary. In particular, any beam at the EPB station, no matter how simple, is expensive due to its needs for heavy shielding, special collimators, etc., and so "simple" beams, such as low momentum or test beams may be produced more cheaply at a DPB station. In case this type of beam is dismissed as unimportant, it is worth noting that probably half of all AGS experiments so far have used beams of under 1/4 of the accelerator momentum, and the problems caused by experiments with untested pieces of equipment are well known, even at accelerators where the scheduling pressure is lower than that at NAL will be.

III. FLUXES OF PARTICLES FROM A DPB TARGET

The DPB has intensity $\sim 10^{10}$/pulse compared with $\sim 10^{13}$ of the EPB, which leads us to expect low tertiary beam intensities. However, it is possible in principle to use larger solid angles in tertiary beams. The necessity for large proton and muon stoppers at EPB stations causes the first quadrupole of a secondary beam to be a considerable distance from the target; in contrast, the shielding around a DPB target is much less, and thus it is possible for quadrupoles to be placed closer to the target (this can also lead to shorter beam lengths which is an advantage for beams of unstable particles).

In any detailed layout of beams from a DPB target, we run into the same problems as at the EPB target, namely the physical size of a quadrupole when placed close to the target to achieve a large solid angle forces other beams to be at larger production angles. However, since we believe that a DPB area is especially useful for lower momentum beams, the larger production angles of some of the beams are not so detrimental.

In Fig. 1, we show a possible 3-beam layout just in order to estimate beam intensities, and do not suggest that this is in any way a particularly desirable layout; quadrupoles used are 10 feet long, 2 inches i.d. and 3 inches o.d.[4] Beams 1, 2 and 3 have production angles and solid angles ≈ 2.5 mrad, 20μsr; 6 mrad, 10μsr; and 11 mrad, 10μsr respectively. The approximate π^- intensity available in beam 1, with ± 1.5% Δp/p is[5]

Momentum (GeV/c)	25	50	75	100	125	150
Intensity/pulse	3×10^6	4×10^6	3×10^6	2×10^6	0.6×10^6	0.1×10^6

These figures are only indicative of magnitude of fluxes: for instance if beam 1 were at 0° or had a quadrupole placed closer to the target, more flux could be obtained at the expense of larger production angles for the other beams. Nevertheless, the above intensities are adequate for many experiments up to ~ 125 GeV/c; similarly beam 2 can be used up to ~ 50 GeV/c, and beam 3 up to ~ 25 GeV/c.

We may note that the target magnet system of Frauenfelder and Wenzel[6] could be used to obtain a larger solid angle for more beams, particularly of lower momentum where larger quadrupoles may profitably be used. Also, two proposals for the use of a DPB, namely to produce neutral[1] and charged[2] hyperon beams, require a target magnet; they could thus be made compatible with the beams advocated here if the Frauenfelder-Wenzel scheme is used. White et al.[7] point out that there are some accompanying disadvantages with this scheme, and so more study is needed on this point.

IV. ALTERNATIVE TO THE USE OF THE DPB TO PRODUCE TERTIARY BEAMS

A. Maschke[8] has suggested that it may be possible to make a hole in the EPB beam stop which would let through ~10^{-3} of the protons; this involves some severe technical problems since the EPB spot is only ~ 1 mm. However, if it can be done then much of the beam transport for the DPB can be eliminated, giving a considerable cost saving. The philosophy of using a 10^{10} proton beam to produce "tertiary" beams is still applicable.

V. CONCLUSIONS

As a result of all the above discussions, we believe that there is a strong case for the use of tertiary beams in many applications, particularly, though not exclusively, for lower momenta. The flexibility inherent in a DPB station may be particularly desirable in the early days of the accelerator.

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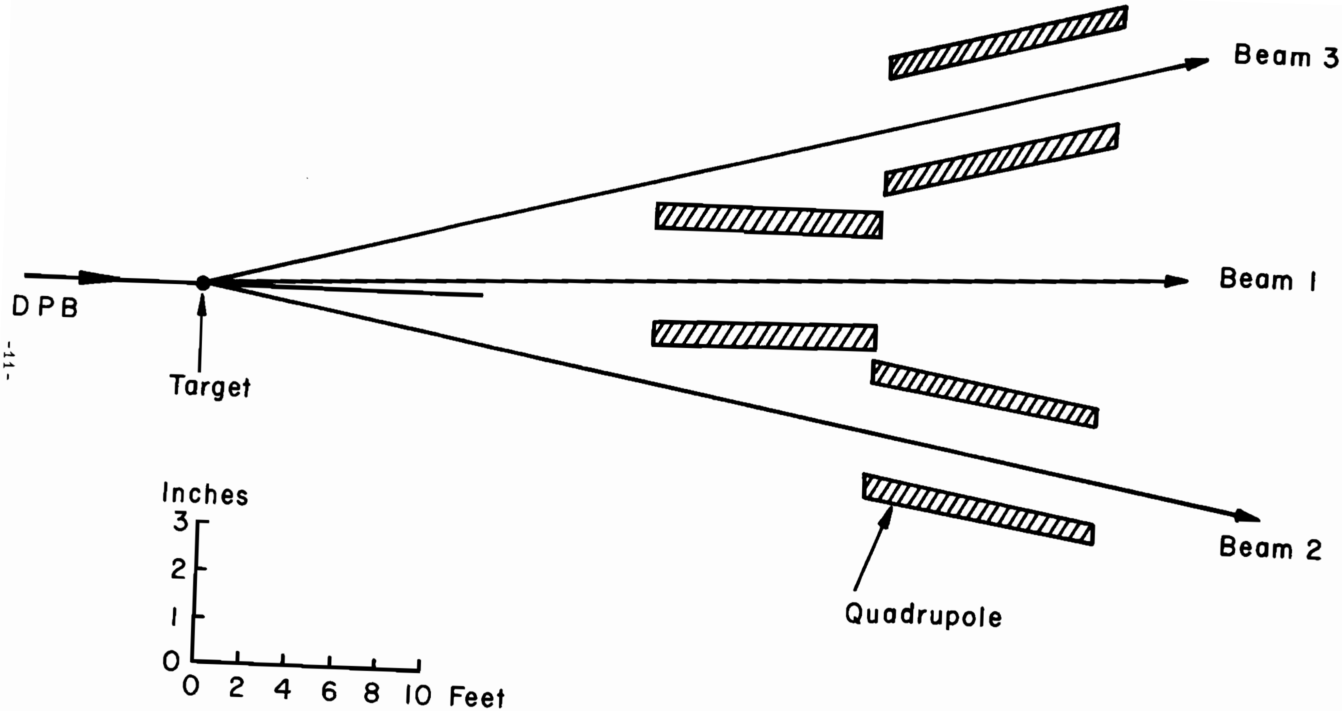

Fig. 1. Beam layout.