COMMENTS ON AREAS FOR EXPERIMENTS WITH THE PRIMARY EXTRACTED PROTON BEAM

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ABSTRACT

This report emphasizes the necessity of having a target area where experiments can be done directly with the full-intensity extracted proton beam and the necessity that an area be available for simple production experiments at machine turn-on. Comments and recommendations are made on some of the possible types of areas for these purposes.

PRIMARY PROTON EXPERIMENT AREA

Proton intensities which will be available for experiments in a small angle (2.5 mrad) secondary beam range from $(10^7 - 10^8)/10^{13}$ interacting protons for inelastic proton production to $(10^9 - 10^{10})/10^{13}$ for quasi-diffracted protons at full machine energy. So, for equivalent targets, there is at least a factor of 10^3 higher reaction rate possible for p-p experiments done in the primary proton beam than in the secondary beam. Since there is certain to be great interest in carrying p-p scattering to as high a momentum transfer as possible, an area utilizing the primary proton beam for experiments must surely be made available. It does not appear crucial that such an area be the first at the accelerator; good p-p experiments over a sizeable momentum transfer range, possibly to $t = 6\ (\mathrm{GeV}/c)^2$, can be done with the diffracted beam. But a primary proton area, in which studies can extend the t range to perhaps 16 $(\mathrm{GeV}/c)^2$, should be constructed within a year or so.

There are other factors which have relevance to experimental areas of this type and the timing of their construction. One of these is the requirement that at machine turn-on, regardless of technical or financial restrictions limiting construction, there be at least one place available for doing simple production experiments, total cross sections of secondary particles, etc. Another is that one type of area suggested for p-p experiments (the thin target stations) has the possibility of serving also as the source of moderately low intensity secondary beams, suitable for a number of good experiments as well as equipment testing.

POSSIBLE AREAS FOR PRIMARY BEAM p-p EXPERIMENTS

Some sample layouts for specific large momentum transfer p-p experiments have been worked out. Krisch[1] proposes a two-arm spectrometer for elastic scattering and a one-arm spectrometer for inelastic production; Terwilliger[2] suggests a high-precision one-arm spectrometer for both elastic scattering and N^* production. These layouts require detector equipment at least 120 meters downstream from the hydrogen target, extending laterally 8 to 20 meters for the high-momentum arms, and 50 meters for the low-momentum arm of the two-arm p-p elastic setup.

Here are some possible areas for these types of experiments:

1. An end station devoted to primary beam p-p studies and other special setups like hyperon beam production.

2. Thin target areas using about 1% of the proton beam, the rest of the beam supplying an end station farther downstream. Simultaneous running is sometimes feasible. The thin target areas may be constructed with movable concrete block shielding[3] or with more inflexible earth shielding.[4]

3. A standard multibeam end station can be temporarily modified to run a p-p experiment with the full extracted beam.

4. A double target box[5]: two close end stations using many common facilities, one for multiple beams, the other for special purpose experiments, possibly p-p scattering.

5. The proton beam tunnel, perhaps with an expanded section, can be used as an experimental area for early experiments.[6]

COMMENTS

Fairly strong judgments can be made on some of these possibilities. One is that the double target-box system would preclude double-arm p-p experiments, in addition to cutting out some of the secondary beams from the multibeam box. There seems to be little reason for not moving the boxes apart, considering them as separate end stations, as in #1. Another judgment is that there will be great pressure against #3 since a double-arm p-p setup would take out all the secondary beams; the user demand will almost certainly exclude this. Even if a single-arm p-p experiment were run, the 1% interaction rate in a thin hydrogen target would prevent the other secondary beams from being used simultaneously for most experiments. Although method #3 is possible, it is probably a last resort.

Method #1, an end station specifically designed for flexibility and rapid rearrangement of setups, could handle the p-p experiments as well as others requiring the full proton intensity. Such experiments would be done sequentially, not in parallel as at a multibeam station. An end station of this kind is quite reasonable as long as a fairly large set of standard secondary beams is available in other areas. This station would have a strong advantage over an in-line thin target type of area since there would be no interference with any downstream end station. However, it would cost more than a thin-target area, probably as much as the multibeam station, the main costs for muon shielding, buildings, paving, etc. being comparable. The initial equipment costs would be considerably less, there being just one setup rather than many beams. However, subsequent operating costs might be considerably more because of the rerigging required for each experiment.

The thin target area, #2, with a small fraction of the beam interacting, the rest available for a following multibeam end station, also is a reasonable approach. In addition to p-p experiments, its use as a source of low-intensity secondary beams, running in parallel with the following end station, is a strong attraction. Part of the setup work on an experiment would of course interfere with running the downstream station. Excitation-function p-p experiments, using a front porch, would require a pulsed transport system for the lower energy protons which would normally not be used by the end station. Also, further work remains to be done for this type of station, on the effect of internal deflecting magnets on the required muon shielding.

The most flexible thin-target station arrangement of this type is that of Baker[3] with movable shielding and a 50-foot wide building along 200 feet of beam line, followed by earth shielding and some outside paving up to the end station. An extra 500 feet of beam-transport equipment would be required. Six feet of heavy concrete under the target area would be necessary for ground shielding. The estimated construction cost is $2.2 million including contingency; equipment would be in addition. The 200-foot length would be a minimum; a one-arm spectrometer beam with 130 milliradians of bend gets 8 meters away from the beam line only after 120 meters.[2] For that layout the earth berm would have to start there, requiring for the thin-target area about twice the building, shielding, and cost of the Baker proposal. The experiment could be done with a shorter movable shielding section, using an even larger bending angle, but 120 meters would seem a better match to a standard experiment. The cost of the 120-meter layout would be about half of an end station.

Another thin-target station approach is that of Krisch[4] who advocates earth shielding pierced with fixed secondary beam holes. Scattered particles could be directed through the holes with steering magnets. The system is not nearly as flexible as the movable shielding setup. It does, however, have a considerably lower cost; Krisch estimates well under $1 million. This type of area, ahead of a standard end station, would provide a moderately inexpensive way of guaranteeing a place for early production experiments and must be seriously considered.

A variant of the above which also solves the early experiment problem has been suggested by D. H. White.[7] He suggests that particle holes in the vertical plane be provided in the overhead earth shielding of underground proton beam line #1. The holes could be plugged if production experiments were easily done in an end station. This would be an inexpensive and simple solution but not as convenient or permanent a station as the horizontal plane layout of Krisch.

Production experiments could be done in the proton beam tunnel itself (#5) with the machine running at low intensity as suggested by Wilson.[6] The 10-foot width is rather restrictive; if it were doubled, the previously mentioned one-arm spectrometer could almost fit in. The area would be too hot to do experiments requiring high intensity. A variant of this idea would be to leave the target chamber of experimental area #1 open, without neutrino and secondary beam equipment. This would have some advantage over the tunnel since experimental equipment could be more readily serviced. However, the Krisch approach, i.e. ports in the earth shielding, giving more lateral spread, seems preferable to the above enclosed-area schemes.

RECOMMENDATIONS

For a high intensity p-p interaction station, which we consider essential, we would choose first a thin-target station (#2) of the movable shielding type, or, second, an end station (#1), probably not to be built the first round but later. First priority should go to getting multibeam areas going.

We also believe it necessary that there be an area ready for early experiments at machine turn on. An excellent insurance policy against possible trouble with the complex end station would be to provide horizontal particle ports on the earth shielding, plus a paved area in the beam line, ahead of end station #2 (or vertical ports in line 1, the minimum version of #2). Use of the tunnel (#5) should be kept in mind as a last resort.

REFERENCES

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[5] R. Carrigan, E. J. Bleser, F. A. Nezrick, and A. L. Read, Research Facilities Design Concepts-Summer 1969, National Accelerator Laboratory Internal Report TM-181, May-June, 1969.

[6] R. R. Wilson, private communication.

[7] D. H. White, private communication.