VERY LOW ENERGY PARTIALLY SEPARATED K BEAMS

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ABSTRACT

Methods for producing very low energy K beams are discussed.

In the 1968 Summer Study, two papers pointed out the possibility of a demand for very low energy beams from the NAL accelerator. Stiening[1] designed a stopping K beam (~ 500 MeV/c) using the booster synchrotron feeding into a storage ring for improving the duty cycle. This would involve the construction of both the storage ring and a new experimental area, and consequently would be a somewhat expensive proposition, and current plans do not include the use of the booster for high-energy physics. Cline[2] made a case for $K^{\pm}$ (and $\bar{p}$) beams in the 5-20 GeV/c range. Both papers mention experiments to be done with these beams, many of which involve precision studies of decay modes of charged K's (and also for the production of K^{o} by charge exchange, for similar studies).

Although Stiening discussed stopping K beams, it is becoming more common now to study many K decay modes in flight. Experiments at various laboratories that are being carried out now or in the near future in this way include $K^{\pm} \rightarrow \pi^{\pm} \pi^{o} \gamma$ (2-5 GeV/c), K_{e4} (2 GeV/c), $\tau^{\pm}$ decay (3 GeV/c), and study of K^{o} decays produced by 3 GeV/c K^{-}. At the AGS, most counter/spark-chamber experiments of this type are done in Beam #5; this beam uses dc separators, covers the momenta 1-3 GeV/c, and with a K/π ratio of $\approx 1/2$ is considered partially separated. This ratio is quite satisfactory since a differential Cerenkov counter can reduce the π contamination to a negligible level.

Judging from the number of experimental proposals for this beam, interest in the type of physics available using it appears to be increasing, and it seems reasonable that there will continue to be useful physics in this momentum region (see discussion in Refs. 1 and 2). We have therefore studied partially separated beams in the range 2-5 GeV/c at NAL and show that reasonable beams can be obtained. We do not discuss the detailed layout of the beams but use the design of the AGS Beam #5 for 2 GeV/c, with total length of 125 feet. For 5 GeV/c, we assume that a similar beam can be built, using more dc separators, and very pessimistically take a total length of 250 ft.

The most obvious way to produce a low-energy K beam is from the EPB target in area T_2, but this involves a number of problems. Because of the heavy shielding and muon stopper in the vicinity of such a hot target, and the presence of other beams from the same target of higher priority, it appears from current drawings of the target station that the first quadrupole of such a beam would have to be at least ~60 feet from the target. From Walker[3] we see that production angles can be as large as 40 mrad, and we take the first element of the beam to be a 4-in. diameter quadrupole 60 feet from the target. Beam lengths are as discussed above for calculating K decays, and we take 3×10^{12} protons interacting in the target, use Awschalom and White[4] curves for particle production, and take the beam-momentum bite as ±1%. We obtain K^- intensities/pulse of 1.4×10^4 at 2 GeV/c and 2.0×10^5 at 5 GeV/c. Comparing with the 4×10^4 2 GeV/c particles per pulse at AGS Beam #5, we see that this is only really useful above about 3 GeV/c.

We now show that it is possible to produce comparable intensities in another way. Barish[5] and Reeder[6] have designed secondary beams produced at 3.5 mrad and 2.5 mrad from a target in the EPB which should have intensities of 200 GeV/c protons above 10^{10} per pulse. A target placed at the final focus of one of these beams can be used for our partially separated K beam. There are a number of advantages to this method. The proton beam is much less intense than the EPB, and consequently less shielding will be required in the vicinity of its target, presumably approximately the same as around the G10 area at the AGS. Because of this, the first quadrupole of the beam can be placed much closer to the target, and we take the first element as an 8-in. diameter quadrupole 10 feet from the target. As in the previous discussion, the production angle is not definite. From Walker[3] it can certainly be 40 mrad and probably larger, though the upper limit is not defined from available curves. Even at 40 mrad, the proton beam will strike the first quadrupole, and a bending magnet before the quadrupole may be desirable. Discussion of this and questions regarding placement of shielding around the target await knowledge of what other beams will originate from this target, since it appears[5] that there may be considerable demand for tertiary beams produced in this way.

Assuming 10^{10} interacting protons in the target, and beam lengths as given earlier, we obtain K^- intensities/pulse of 1.6×10^4 at 2 GeV/c and 10^5 at 5 GeV/c. At 2 GeV/c, the K^- flux is lower than desired, but at 3 GeV/c and above partially separated beams of the intensities obtained here are quite desirable. Corresponding fluxes for K^+ are about 2 times those of K^- and for antiprotons are about 2/3 K^-.

We conclude that worthwhile partially separated K and $\bar{p}$ fluxes can be obtained in the form of tertiary beams, and the discussions in Refs. 1 and 2, together with the observation that more and more K decays are being studied in flight, suggest that the demand for such a beam would justify its construction. We may also note that if the problems of dc separation at higher momentum can be solved, this tertiary beam method can be used to produce very useful partially separated beams up to several tens of GeV/c.

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REFERENCES

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