PARTICLE IDENTIFICATION IN AREA 2 BEAMS

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ABSTRACT

Cerenkov counter needs of Area 2 are discussed, and a combination of DISC and threshold Cerenkov counters is recommended.

For most experiments simultaneous identification of pions, kaons, and protons (or antiprotons) is sufficient and desirable. Although there are several promising new techniques for particle identification, at the present time it appears that the detection of Cerenkov radiation is still the most reliable. The highest resolution Cerenkov detectors are the chromatically corrected differential counters or DISC's.[1] These, however, are somewhat more expensive and difficult to build than threshold Cerenkov counters. A reasonable solution to the particle identification problem (which also has the advantage of allowing a comparison between these two techniques) would be to identify kaons with a DISC counter in each beam and to identify pions and protons with threshold counters.

Three DISC designs should cover the range of particle momenta expected at NAL. These are:

1. A 2-meter long counter using a Cerenkov angle of 45 milliradians with a $\delta\theta \sim 0.08$ milliradian. This counter will give good identification of kaons up to about 120 GeV/c and will give reasonable efficiency down to $\gamma = 12$. For good efficiency it requires the beam divergence to be $\leq \pm 0.04$ milliradian $\times$ $(P_{max}/p)^2$. (That is, at lower beam momenta the diaphram may be opened somewhat since $\Delta\beta_{\pi K}$ increases. This allows acceptance of greater divergence.)

2. A 5-meter long counter using a Cerenkov angle of 25 milliradians with a $\delta\theta \sim 0.036$ milliradian. This counter should identify kaons up to above 200 GeV/c and

will give reasonable efficiency down to $\gamma = 25$. For good efficiency it requires the beam divergence to be $\lesssim \pm 0.018$ milliradian $\times (P_{max}/p)^2$.

3. An 8-meter long counter using a Cerenkov angle of 20 milliradians with a $\delta\theta \sim 0.02$ milliradian. This counter will identify kaons up to the full energy of the machine, 500 GeV/c. It will have good efficiency providing the beam divergence is less than ± 0.01 milliradian $\times (P_{max}/p)^2$. (These counters and DISC design in general are more fully described in SS-170.)

One of the advantages of the DISC-type counter is that the outputs from the several phototubes may be combined in different fashions in parallel logic chains. If, for example, the DISC has eight phototubes, very high resolution is achieved by requiring a signal from at least seven out of the eight. This configuration may have only moderate efficiency. That is, if the counter identifies a particle as a kaon, there is a probability of less than 0.01% that the particle is not a kaon, but the counter may identify only 94% of kaons in the beam as being kaons. A second logic chain (perhaps requiring signals from four or more of the eight tubes), running in parallel with the first, could give a signal with a nonkaon contamination of 5% but with a kaon inefficiency of < 0.1%. If one now has a threshold Cerenkov counter set to detect both kaons and pions but not protons, then the second logic signal could be put in veto with the threshold signal to produce a pion signal. (This is useful since a pion threshold counter that is allowed to count some kaons but no protons need only be 26% as long as one which should count no kaons.)

It is very desirable to separate different Cerenkov counters by magnetic elements so that off-momenta particles with the wrong mass, perhaps produced in the entrance window of a Cerenkov counter, are not misidentified. This could be done by having a threshold Cerenkov counter followed by quadrupoles producing a parallel section in the beam containing one or more DISC counters followed by quadrupoles focusing the beam onto the target with another threshold counter between the quadrupoles and the target.

The best solution would be one in which the parallel section is long enough for three DISC counters and the threshold counters can be made as much as 40 meters long. In this case, if the DISC counters cannot be completed by the time NAL turns on, then the parallel section could be filled with a threshold counter containing both pions and kaons while the other two threshold counters count pions but not kaons. This configuration would give good separation of pions, kaons, and protons up to ~170 GeV/c. On the other hand, when the DISC's are complete and well understood, they could be used alone to pick out the rarer particles in the highest intensity beams (e.g., 10^6 K^- and 10^5 $\bar{p}$ in a 10^8 π^- beam). (This assumes that the beam halo is sufficiently suppressed that the singles rate in the DISC phototubes is not too high.)

Note also that the self-collimating feature of a DISC can be of great help in tuning the beams (e.g., making the $\Delta p/p$ acceptance function as near a square wave as possible) as was done at Serpukhov.

REFERENCE

[1] P. Duteil, L. Gilly, R. Meunier, J. P. Stroot, and M. Spighel, High Resolution Gas Cerenkov Counter--DISC, Rev. Sci. Instr. 35, [11], 1523 (1964).