

A DISC counter specially designed to identify charged hyperons. The optics are housed in the cylindrical sections. The photomultipliers with their magnetic shielding are shaded black.

Alongside is a diagram of the same instrument.

to do but also in revealing some very unexpected features of nuclear structure.

DISC counters

When a fast-moving charged particle passes through a transparent medium such as air, water or glass, it can emit light by the Cherenkov effect. The mechanism of this effect is often compared to that of an aeroplane travelling through air. When the plane travels through the air faster than the speed of sound, a supersonic bang is produced; when a particle travels through a transparent medium at a speed faster than that of light in the medium, Cherenkov light is produced. The light wave is conical, like the shock wave of a supersonic plane, and the angle of the cone depends on the relationship between the speed of the particle and that of

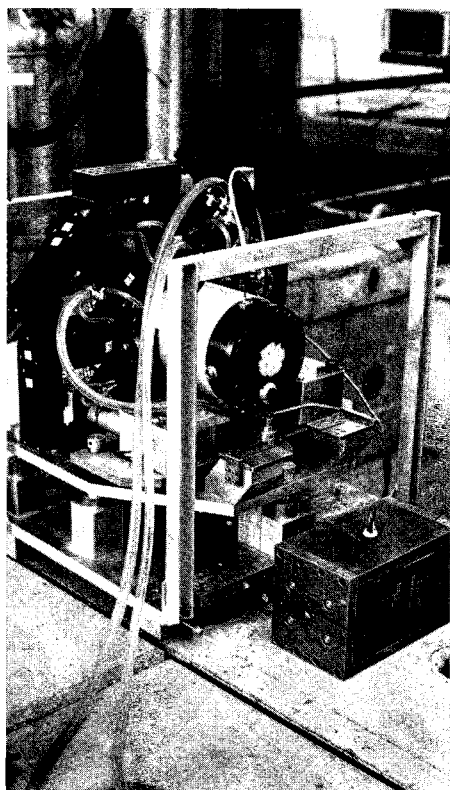
light in the medium — this is the basis for the measurement of the speed of charged particles in Cherenkov counters.

A special optical system picks up the light produced and focuses it into a ring. The speed of the particle is determined from the diameter of the ring of light. If particles of different mass such as pions, kaons and anti-protons are sorted magnetically in a beam-line so that they all have the same momentum, their velocity will depend on their mass (the heaviest being the slowest). A Cherenkov counter will record for each type of particle a ring of different diameter which can be distinguished by means of a combination of screens and photomultipliers. The measurement of the particle velocities can then be calculated knowing the refractive index of the medium

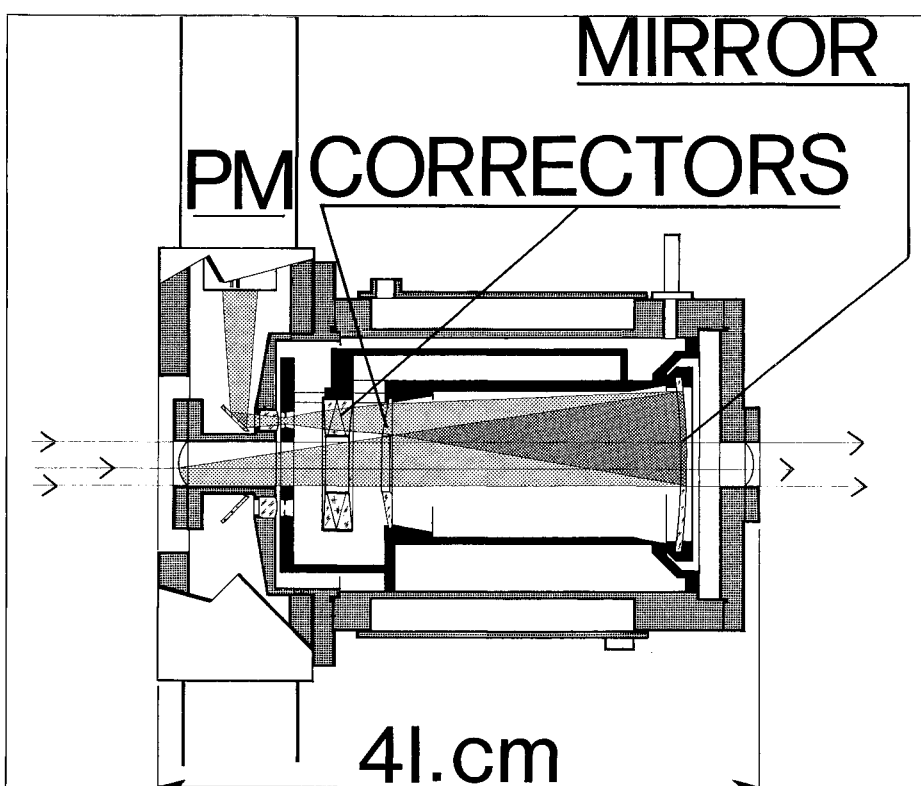
$$\frac{v}{c} = \frac{1}{n \cos \theta}$$

The first counters of this type were in use long before physicists had access to accelerators of even 1 GeV. Their performance was limited by the quality of the photomultipliers then available and by their relatively simple optics. From 1959 studies were undertaken at CERN to perfect an optical system. The main difficulty in the optics is that there is a chromatic dispersion of the Cherenkov light which limits the ultimate velocity resolution of the instrument. A counter was finally developed in which chromaticism was corrected, using a doublet of axicons. The resolution was greatly improved.

The first models of this type of counter, known as Differential Isochronous Self Collimating (DISC) counters, which were liquid-filled, were used on the 600 MeV synchrocyclotron for a variety of experiments with pions and were then tested without modification on the 28 GeV

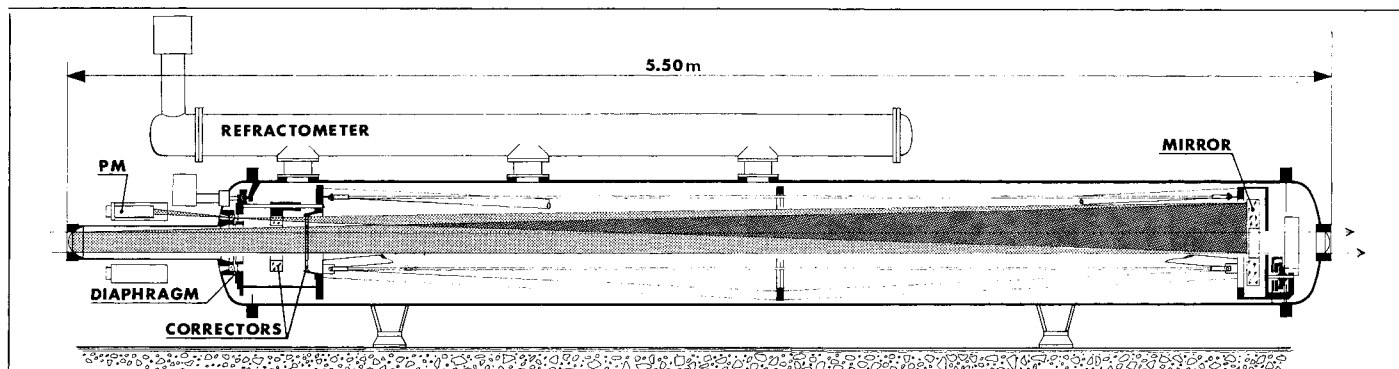
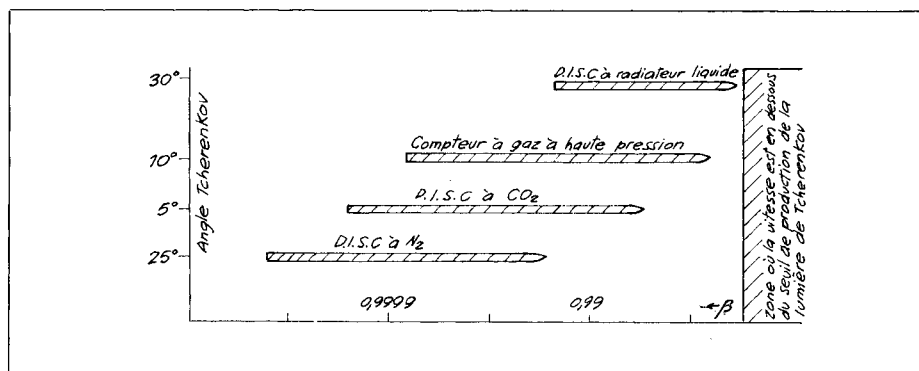


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The velocity ranges (the x-axis gives the velocity of the particle compared with the velocity of light) over which different types of DISC counters can be used. This particular graph refers to the identification of a kaon.

Diagram of the DISC counter built at CERN by a CERN-NAL collaboration, to be used in an experiment at Batavia.



proton synchrotron when it came into service in 1960.

Their adaptability and development potential were clear: the ability to identify π^+ , π^- , K^+ , K^- , p , $\bar{p}$, d , He^3 and He^4 with the same instrument provided the impetus to continue this line of development systematically and to extend the range of application of the early models from energies of a few GeV to cover the entire energy spectrum available from the PS. To this end the liquid was replaced by a gas and the old optics, consisting of lens and aspherical mirrors made out of a plastic material, were replaced by a new unit of fused silica and sodium chloride.

In this way the counters were transformed into high resolution DISC counters. With these counters the accuracy of the measurement of the velocity of the particle depends upon the accuracy with which the speed of light in the gaseous medium can be determined for a given wave-length and Cherenkov angle characteristic of the counter. The latest method consists of employing long wave-length digital interferometers, specially produced at CERN for this purpose, which, coupled with the use of a gas laser, make it possible to achieve absolute accuracy of the order of 3×10^{-8} .

The liquid counters built around 1963 are still used in CERN and various other laboratories. The high

resolution counter built in 1964 has not exhausted its full possibilities. After it had been used in many different experiments, including the first tests of the slow ejected beam at the PS, it was realized that the counter's capabilities exceeded what was necessary at the PS and that it could even be used at the maximum energy of the Serpukhov 76 GeV accelerator. Hence it was used in the first experiment of the CERN-Serpukhov collaboration where, in conjunction with a similar counter built at Serpukhov, it was used with beams of pions, kaons, antiprotons and antideuteron.

Thinking about the future use of these instruments in high energy physics has underlined their great flexibility particularly for very high energy work where, in various forms, they are still a basic method for distinguishing particles at energies beyond the reach of almost all other techniques. Over the years a better understanding of the ways in which they may be used has made it possible to optimize their construction. New optical units have been perfected which are both more efficient and easier to make.

A new use is in the first beam-line for Σ^- and for Ξ^- hyperons, which came into operation at the PS at the beginning of 1971 (see vol. 11, page 191). Two miniature DISC counters are incorporated in this beam-line.

There is no lack of future plans.

Investigations are being carried out as to what kind of DISC will be needed for the SPS. In the meanwhile, efforts are concentrating on the Batavia 200/500 GeV machine where a group from CERN will take part in an experiment using DISC counters built specially at CERN to deal with this new energy range. The cost will be shared by the two Laboratories.

There is no reason to believe that the limits of application for detectors using the Cherenkov effect have been reached. Developments in optical techniques used in astronomy in association with the remarkable properties of Cherenkov light are being brought into the study of new types of detectors capable of measuring the particles produced in interactions at several hundred GeV.

Sodium jet beam detector

The range of beam detectors at the ISR has just been increased by the installation of a novel type of instrument — a beam profile detector which observes the ionization caused in a sodium curtain through which the beam passes.

This detector is a distant relative of the familiar luminous screen placed in the beam which lights up in the path of the beam. The high intensity of the beam in the ISR, and the cata-