Chapter 10
The History of Cherenkov Detectors

ABSTRACT

As early as 1937 Pavel Alexejevitj Cherenkov wrote in one of his papers (Cherenkov, 1937), “...it is possible to pose the problem: for a given electron velocity find a liquid with such a refractive index, that the effect begins to show up. After some additional work this variant of experiments can be used for determination of electron velocities.” Since then many different types of Cherenkov detectors have been successfully developed and used, without which particle physics would probably not have come as far as it has today.

1. CHERENKOV DETECTORS

All Cherenkov detectors consist of a radiator and some photosensitive device to detect the faint light. In the early experiments performed by Cherenkov the radiator was water, or some other liquid, and the photosensitive device either his eyes or a photographic emulsion.

The development of the photomultiplier tubes in the 1940’s revolutionized the concept of particle physics, and made it possible to detect small light pulses electronically with much higher efficiency and in shorter times. It became possible to detect the Cherenkov light from a single particle.

Cherenkov detectors are normally designed to benefit from one or several of the following relations:

1. No light is emitted when the velocity $\beta < 1/n$.
2. Light is only emitted when the velocity $\beta > 1/n$.
3. Light is emitted in the forward direction.
4. $\cos \Theta_c = 1/\beta n$.
5. The number of emitted photons per meter radiator in the wavelength interval $(\lambda_{\text{min}}, \lambda_{\text{max}})$:

$$N \approx 2\pi\alpha Z^2 \left(1 - \frac{1}{\beta^2 n^2}\right) \left(\frac{1}{\lambda_{\text{min}}} - \frac{1}{\lambda_{\text{max}}}ight)$$

(1)

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Normally Cherenkov counters are designed for some of these relations depending on the purpose of the detector. Threshold Cherenkov counters use a radiator with a refractive index chosen in such a way that one type of particle produce Cherenkov light while another does not. In this way they can be separated. Direction sensitive detectors use the property that light is emitted in the forward direction. Other detectors use the Cherenkov relation \( \cos \Theta_c = 1/\beta n \) to detect light only in a specific angular interval. Finally, Ring Imaging Cherenkov (RICH) counters also use the Cherenkov relation to calculate the velocity of the particle from the Cherenkov angle \( \Theta_c \).

2. THE PIONEERS

The first really useful Cherenkov counter was developed and constructed by Jelley in 1951 (Jelley, 1951). It was direction sensitive and used the directional property of Cherenkov light. The construction is shown in Figure 1.

*Figure 1. Jelley’s direction sensitive Cherenkov detector from 1951; the aim of the detector was primarily to detect cosmic rays with a velocity high enough to produce Cherenkov light in water. It was also used to reject particles moving upwards instead of downwards. Only the light from particles traveling downwards will reach the PM tube as Cherenkov light is only emitted in the forward direction. From Ekspong, 1958.*

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