Operation of Cerenkov Detectors at the PS East Hall

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1 Technical Aspects

Beam Cerenkov Counters (BCCs) are provided as an optional device for the PS East Hall facility [1]. Its operational usage is mainly left to the user provided that the general CERN SAFETY RULES are followed.

Each BCC consists of a 1m long aluminium tube with a diameter of 20 cm. It is possible to connect a number of these devices in series. The overall desired length should be chosen in accordance with the light efficiency and allowable multiple scattering. Both open ends of the BCC are terminated with 0.6 mm thick Mylar foils. When filling or emtying the BCC, a bang may be heard due to the turn down of the foil. Cerenkov gases can be selected by the user, but must not be flammable. The maximum pressure in the BCC ought to be kept below 3 atmospheres relative to STP.

Gas racks and control panels in the East Hall are provided by the PS, and will be located near the test beam areas. The requested position of the BCC along the beamline should be given to the PS Coordinator well in advance. The panel on the rack front is self-explanatory; however, before switching on the vacuum pump the BCC must be depleted (use the FUITE regulator). In case of first usage or gas change, pumping for at least 1 hour is recommended to empty the BCC properly.

The filling requires careful adjustment of the regulators. Before opening a valve completely, check the pressure by slightly turning it and watch the manometer on top of the rack. Open the gas bottle only if all valves are closed. Never exceed an overpressure of more than 3 atmospheres (relative) even while filling. If filling is completed, close the bottle and all regulators to prevent leakage in both directions. Proceed with the same care and patience when depleting BCC from high pressure.

The BCC are equipped with UV sensitive photomultipliers of type: XP2020Q, C3100M, 9813KB or similar. There exist different PM bases; however all should be powered at 1800 to 1900V, and should draw a current of roughly 1.1 mA. The HV and signal cables must be provided by the user. Due to the small signal of the PM, a 10-fold amplification could be useful to explore the dynamic range of any ADC.

2 Experimental Aspects

Following the common definition of the Cerenkov angle $cos\theta_c = \frac{1}{\beta\ n}$ with β being the velocity of the particle and n the refractive index of the gas penetrated, the number of photons produced in a particle's transition through the BCC is equal to

$$N_\gamma = N \cdot L_{BCC} \cdot sin^2\theta_c \quad .$$

The normalisation factor N depends mainly on the spectral sensitivity of the PM (see [2]) and has been estimated to be N=490. L_{BCC} is the length of the passage (i.e. BCC tube), which will be typically 1 to 4m (depending on the space in the experimental zone and the user).

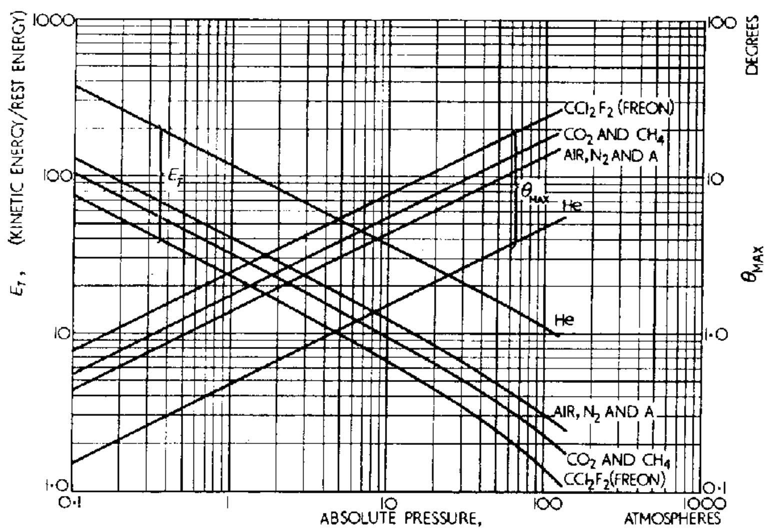


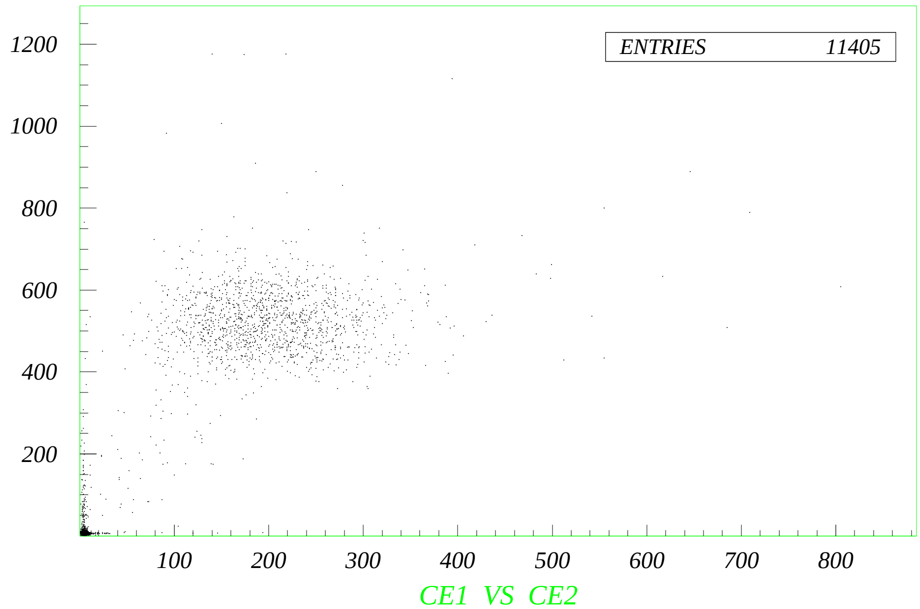
Figure 1: Empirical dependence of the Lorentz Factor γ and Cerenkov angle θ_c on the gas pressure [3]. Note that the pressure is given in absolute units.

Fig.1 shows the relation between the absolute pressure P and the Lorentz Factor γ (left side) or Cerenkov angle (right). The curve for the commonly used Cerenkov gas CO_2 has been parameterized as follows:

$$\gamma(P) = 10^{-0.525 \cdot log(P) + 1.503}$$

with a $\chi^2 = 0.2 \cdot 10^{-4}$. Pressures should be set below a sufficient safety margin from the calculated thresholds.

For a provisional efficiency evaluation, two BCCs have been mutually tested in a 1GeV pion beam, using a CnS screen as proton target. Both detectors are put at maximum pressure (3 atm



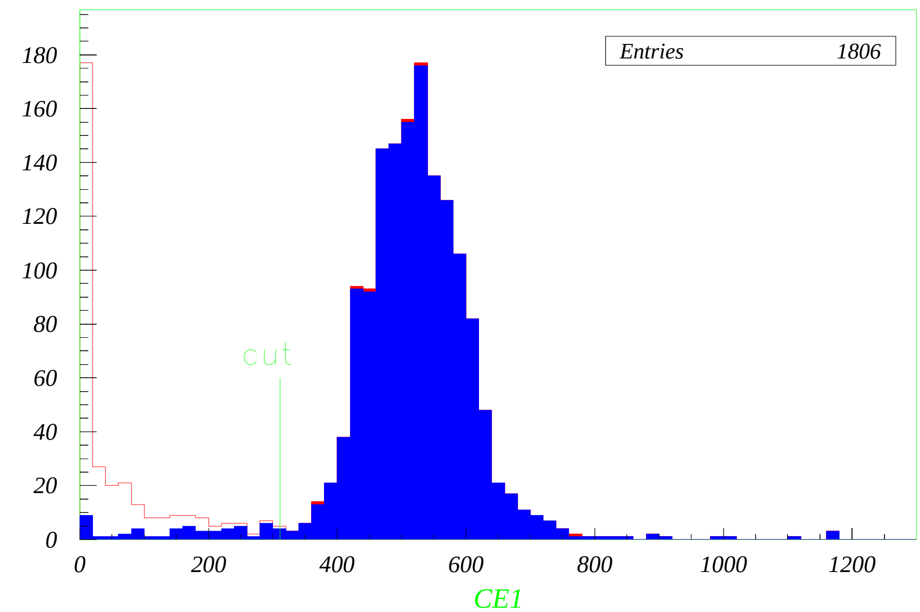


Figure 2: Results of two consecutively placed BCC in a 1GeV pion beam. The upper plot shows the electron contamination as populated spot above the noise (pion and muon tracks), well separated in both detectors. The lower graph overlays the pulseheight histogram of CE1 two times. In red the original distribution is shown, whereas the blue superposition keeps only entries in which CE2 would have its corresponding pulseheight within 3 σ of the electron distribution of CE2. The 'cut' represents the 3 σ deviation of the CE1 electron distribution (Gaussian fit).

CO_2), still well below the μ threshold (10 atm). About 2000 photons will be produced by each parasitic electron crossing the BCC. The result is graphically shown in Fig.2, where CE1 corresponds to a 4m and CE2 to a 2m long BCC. The ADC pulseheights are given in arbitrary units.

The average electron detection efficiency was found to be $97\% \pm 1\%$.

3 Bibliography

[1] http://www.cern.ch/CERN/Divisions/PS/Reports/PA9321/Welcome.html

[2] PDG 1998, p.156

[3] 'Cerenkov Radiation', J.V. Jelley, Pergamon Press 1958