The Use of Cerenkov Counters at MTEST

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1 Introduction

In order to trigger off of electrons in the beam, a particle ID detector is needed. The Cerenkov detectors at MTEST can be used as threshold counters for this purpose. One must understand the counters in order to use them.

2 Set-up

There is two Cerenkov counters at MTEST. The one upstream is 80' long (known as CC1) and the one downstream is 50' long (known as CC2). Both use nitrogen as the radiative medium.

In order to decrease the noise, we amplified their outputs and decreased the high voltage of the read out PMT. Also, a coincidence was made with the scintillators MT6SC1 and MT6SC3 for both CC1 and CC2. By doing the above, almost all the noise is eliminated. This is seen when no counts were observed outside the spill.

3 Theory

The Cerenkov angle for a charged particle with velocity βc in a medium with index of refraction n is

$$\theta_c = \arccos(1/n\beta) \tag{1}$$

and the number of photons produced obeys

$$N_\gamma \propto \sin^2(\theta_c). \tag{2}$$

Assuming isothermal and the simple spring model of electrons in a dielectric, we get the following relation for pressure and index of refraction

$$\frac{P_1}{P_2} = \frac{\rho_1}{\rho_2} = \frac{n_1-1}{n_2-1}. \tag{3}$$

Taking the index of refraction for nitrogen at $1atm$ as our reference, the various pressure thresholds for Cerenkov radiation can be solved as a function of beam energy and particle mass.

$$P_T = \frac{\frac{1}{\sqrt{1-\frac{m^2}{E^2}}}-1}{\delta} \tag{4}$$

where $\delta = n_{1atm} - 1 = 0.000297$ and P_T is in atm. Table 2.1 shows the pressure threshold values for the particles and energies of interest.

Pressure Threshold ($PSIA$)	$e \star 10^{-9}$	μ	π	p
$8GeV$	1000	4.34	7.47	343
$16.5GeV$	237	1.02	1.76	80.1
$33GeV$	59	0.26	0.44	20.0
$66GeV$	15	0.06	0.11	5.0
$120GeV$	4	0.02	0.03	1.51

Table 3.1 Pressure threshold for e, μ, π, p at various beam energies

4 Results

Taking pressure scans at 5 different beam energies, it can be observed that the Cerenkov counters worked as expected. Below are the scans for $120, 66, 33, 16.5$, and $8GeV$ where the fit function is defined as follows:

$$C = \frac{2A}{\sqrt{\pi}} \int_x^{\infty} e^{-(N_{th}-N_\gamma)^2/2N_\gamma} \tag{5}$$

where

$$N_\gamma = A_{conv.} \sin^2(\arccos(\frac{\delta P_{th}+1}{\delta x+1})) = A_{conv.}(1 - (\frac{\delta P_{th}+1}{\delta x+1})^2). \tag{6}$$

Where P_{th} is the pressure at threshold, N_{th} is the number of photons threshold, $A_{conv.}$ is the constant of proportionality for the number of photons produced and A is an overall normalization factor. N_{th} and $A_{conv.}$ should be independent of the beam energy or particle type and were determined by minimizing χ^2 for the pressure scan at $120GeV$ because it is assumed to contain only protons. Plots of the scans are below.[1]

[1] Plots were normalized to the total number of counts in coincidence with MT6SC1 and MT6SC3.

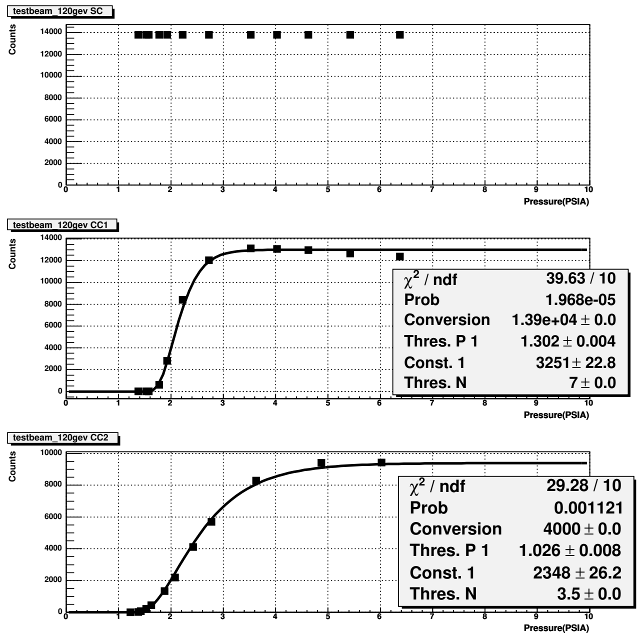

Figure 4.1 Pressure scan for a beam of $120GeV$ protons

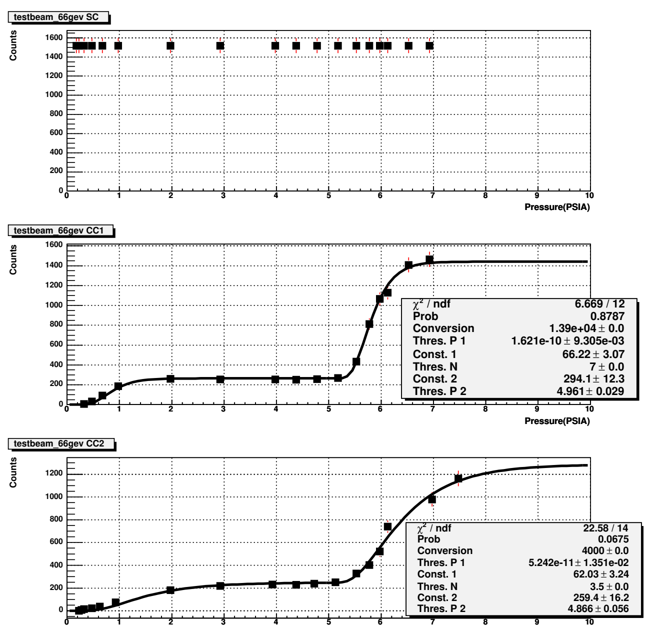

Figure 4.2 The so-called pion Beam (a mixture of pions and protons) at $66GeV$

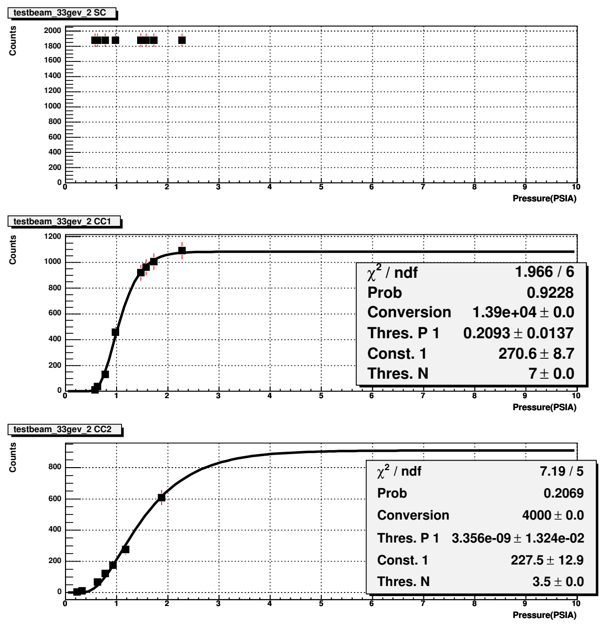

Figure 4.3 Beam energy of $33GeV$. We believe there are only pions and protons present in the beam. Note: Proton threshold greater then $20PSIA$.

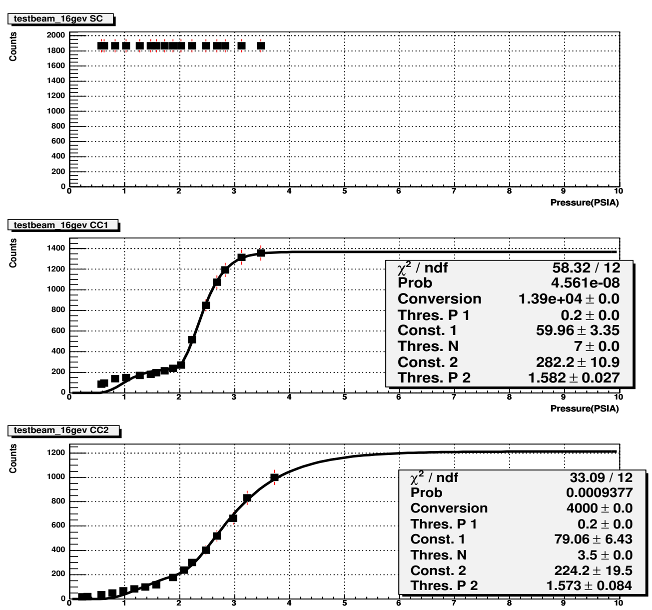

Figure 4.4 Beam energy $16.5GeV$. pions, muons, and electrons are present. The number of electrons present is small as can be seen by the low counts below the muon threshold.

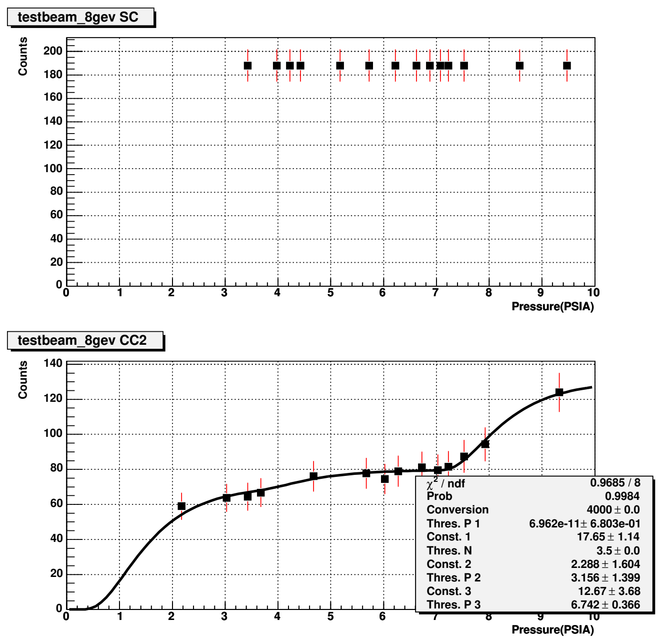

Figure 4.6 Beam energy $8GeV$. It is easily seen that pions, muons, and electrons are present.

Lastly, the pressure gauge used by ACNET (at least for CC2) is off by as much as $0.4PSIA$ at low pressures. This was determined by making controlled accesses to read out the analog meter located on CC2. This offset changes as the pressure in CC2 changes and could be the reason that some of the fit parameters do not agree with their calculated values.

5 Conclusion

Based on the results obtained, the Cerenkov Counters at MTEST worked sufficiently. The data agrees with what was expected. However, the offset needs to be investigated more in order to have confidence in using CC2 as a trigger in the beam test.