US Belle II Summer School 2022

Particle Identification: Solutions

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Problem 1

We use the following formulae: $\beta = p/\sqrt{p^2 + M^2}$, $\theta_c = \cos^{-1}(1/n\beta)$, $R \approx d \tan\theta_c$, and N_γ per cm $\approx 390 \sin^2\theta_c$. With these formulae and the constants $n = 1.050$, $M(\pi^+) = 0.139570$ GeV/c^2, $M(K^+) = 0.493677$ GeV/c^2, and taking $d = 22.0$ cm, we construct the following table:

Particle	$\boldsymbol{p}$ **(GeV/c)**	$\boldsymbol{\beta}$	$\boldsymbol{\theta_c}$ **(°)**	$\boldsymbol{R}$ **(cm)**	$\boldsymbol{N_\gamma}$
π^+	3.0	0.998920	17.558	6.9611	142
K^+	3.0	0.986729	15.162	5.9616	107
Difference			2.40	1.00	35
π^+	4.0	0.999392	17.644	6.9972	143
K^+	4.0	0.992470	16.3404	6.4501	123
Difference			1.30	0.547	20

Note that the radius of the Čerenkov ring depends on the position at which Čerenkov photons are radiated. In this problem, photons are radiated uniformly along the path length inside the aerogel. As the aerogel has a thickness of 4.0 cm, for this calculation we use the average position inside the aerogel, i.e., the middle of the aerogel, which is 22.0 cm from the photon detector array.

Problem 2

The total amount of material the μ^- must traverse is:

$$(2.0 \text{ cm}) \cdot (2.201 \text{ g/cm}^2) \ + \ (30 \text{ cm}) \cdot (4.51 \text{ g/cm}^2) \ + \\ (10 \text{ cm}) \cdot (2.710 \text{ g/cm}^2) \ + \ (4.7 \text{ cm}) \cdot (7.874 \text{ g/cm}^2) \ = \ 203.8 \text{ g/cm}^2 \, .$$

If the μ^- loses 2.0 MeV of energy for every g/cm^2 of material it passes through, it will lose 407.6 MeV of energy traversing all these layers. Thus, the minimum energy required for a μ^- to make it to the KLM is 408 MeV.