Development of Threshold Type Fiber Cherenkov Counter

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Introduction:

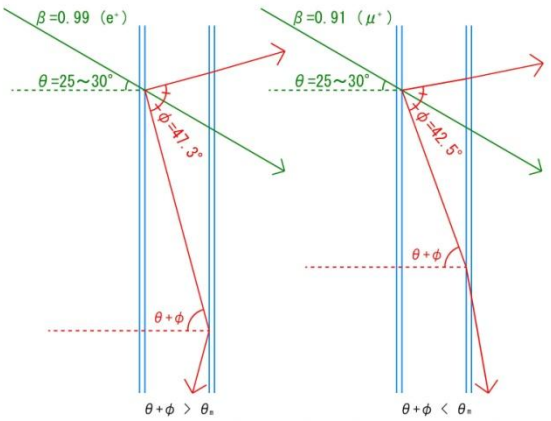
It is important to identify particles at the trigger stage for high intensity beam experiments. Although there exist several types of particle identification (PID) detectors, a threshold type Cherenkov counter is the only one that can identify particles at the trigger stage. We propose a new Cherenkov counter. The radiator is made of clear fiber. Total reflection occurs on a border between the core and cladding. Since the difference of reflective index between core and cladding is rather small, we distinguish two particles with same momentum by total reflection of Cherenkov light attend or not.

Clear Fiber Cherenkov Counter:

When a charged particle incident in a material, the Cerenkov radiation occurs when the speed of the charged particle is faster than speed of light in the material. The condition is particle velocity β (= v/c) >= 1/n. The radiation angle at that time is φ = arccos (1/nβ).

When light incident on the high refractive index to the low medium of the refractive index, the total reflection is the phenomenon that incident radiation reflects all back on a boundary surface. When the incidence angle is larger than the threshold angle, total reflection happens. The critical angle is $\theta_m = 72.3°$, because the cladding refractive index n_A is 1.42 and the core refractive index n_B is 1.49.

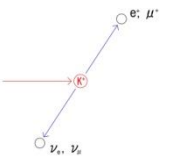
For example, a positron and a muon with 240 MeV over c through into clear fiber.



when θ+φ > θm, the total reflection happens. When θ+φ < θm, the total reflection doesn't happen. When fiber is connected to PMT, If total reflection happens, a signal from PMT arrives, and the signal from PMT does not arrive if total reflection does not happen. In this way, we perform particle identification.

J-PARC E-36 experiment:

E-36 experiment will be carried out in J-PARC (Ibaraki, Japan) 2014~2015. E36 is an experiment to the branching ratios of the kaon decay. The kaon with 800 MeV pass Degrader and stop in target scintillation fiber. The momentums of positron and muon which occur by the decay of the kaon which stood still are constants. We want to distinguish these two particles.

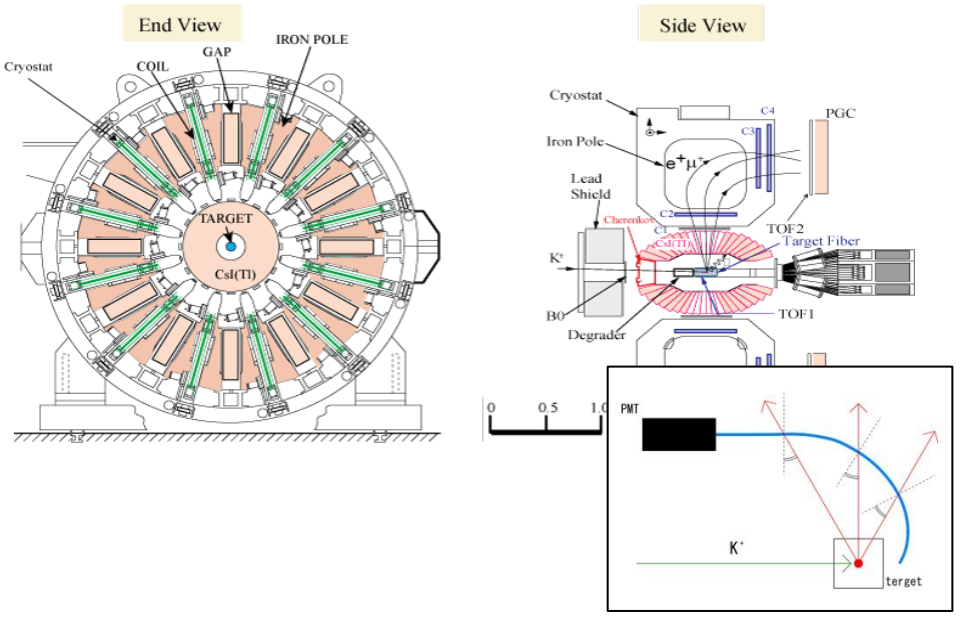


$K^+ \to e^+ \nu_e$ $(1.55 \pm 0.07) \times 10^{-5}\%$

$K^+ \to \mu^+ \nu_\mu$ $63.43 \pm 0.17\,\%$

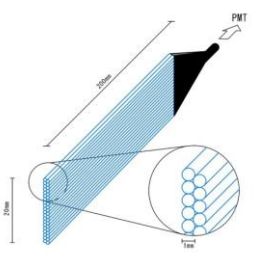
$K^+ \to \pi^0 e^+ \nu_e$ $4.87 \pm 0.06\%$

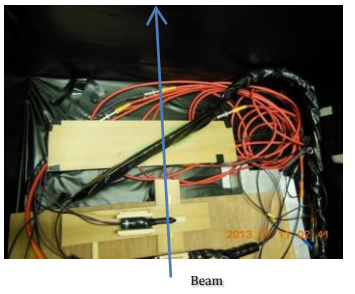
The outbreak probability of the positron is a one-100,000th or less of the muon. Trigger frequency becomes 100kHz without the identification. Silica Aerogel Cherenkov counter (SAC) can dicurrs trigger frequency to1kHz. If possibility, we want to install other threshold type Cherenkov counter. We are examining a plan to put the Clear Fiber Cherenkov counter in a detector of E36.



Experiment:

In July, In Spring-8 (Hyogo, Japan), we changed the incidence angle of the beam by changing the installation angle of the detector, and checked the relations of an incidence angle of the beam and the light requirement. We display fiber of 1mm in diameter by 20*2 2 layers structure, and let a beam of 0.7-1.0GeV be incident on it. We carried out the experiment the plural times, but didn't get effective data. Total reflection has happened at angles less than 30 degrees.





Consideration:

By this experiment, we didn't get effective data. Total reflection having happened on a border between the cladding of the fiber and the air is considered as the cause.

In future, after having painted the fiber surface black to prevent total reflection on a border between the cladding of the fiber and the air, we will perform an experiment to measure a light requirement by changing the incidence angle and the incident speed of the beam. We really develop an available detector in E36.

NO.	Incidence angle	The number of Event	Total date	Pedestal cut	Efficiency	Cut level	Remarks
52639	30		3944	797	20.2	85	
52641	35	4375	4016	850	21.1	87	PMT might fall down.
52644	35	3115	2859	421	14.7	87	
52647	40	2766	2507	35	1.39	89	Light does not arrive
52648	25	4377	4004	963	24.1	85	
52649	20	2789	2652	872	32.9	88	
52652	27.5	4735	4446	930	20.9	87	
52654	32.5	3172	2942	578	19.6	88	
52656	37.5	2333	2173	542	24.9	91	
52657	22.5	2306	2190	345	15.7	91	
52658	40	2217	2096	48	2.3	90	
52659	30	3537	3344	1845	55.2	87	PMT change
52660	30	2331	2229	1211	54.3	87	