Test of Aerogel Cherenkov counter for the J-PARC E36 experiment

Akihisa Toyoda[1A], Michael Hasinoff[B], Keito Horie[C], Youichi Igarashi[A], Jun Imazato[A], Hideyuki Kawai[D], Youhei Miyazaki[E], Jiro Murata[F], Reiya Narikawa[F], Suguru Shimizu[C], Makoto Tabata[G], and Hirohito Yamazaki[H] for the J-PARC E36 collaboration

KEK[A], UBC[B], Osaka University[C], Chiba University[D], Kyushu University[E], Rikkyo University[F], JAXA[G], Tohoku University[H]

Introduction

The J-PARC E36 experiment aims to measure the ratio of the decay rate Γ(Ke2) to Γ(Kμ2) with 0.25% accuracy. One of the most important issues of this experiment is the particle identification (PID) of the decay products, positrons and muons. We have prepared three kinds of PID detectors such as an Aerogel Cherenkov (AC) counter, a time of flight (TOF) counter, and a Pb-glass counter. The required performance for the AC counter is muon mis-ID as low as 1% and positron efficiency as high as 95%.

In this test experiment, we will measure the dependence of the positron efficiency and the muon mis-ID rate on the beam incident angle and position with three kinds of the Aerogel material and six types of the main mirrors to maximize the performance. We plan to do experiment at the K1.1BR beamline. We will use positrons and muons whose momentum is 250 MeV/c. We request 72 hours for the beamtime. We expect that our test experiment will be performed in December 2012.

AC counter

Figure 1 shows an AC counter schematically. The AC counter surrounding the target is divided into 12 sectors. This AC counter is a threshold type Aerogel counter. A kaon beam is injected into the target, and the decay products pass through the Aerogel counter. The Aerogel index is chosen so that only positrons emit Cherenkov light. The Cherenkov light is detected by two side photomultipliers (PMT) via a main mirror and the Winston cone. The Aerogel size, the counter size, the main mirror parameters, and the Winston cone parameters are optimized by simulation.

[1] Contact person, akihisa.toyoda@j-parc.jp

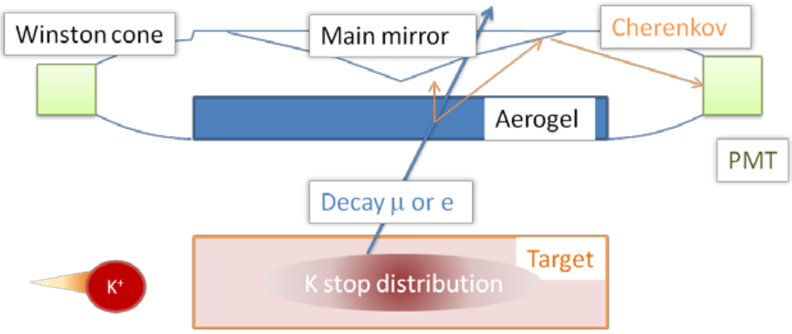

Figure 1: Schematic figure of the AC counter.

Figure 2 shows the second prototype AC counter. To measure the dependence of the efficiency and muon mis-ID rate on the incident angle and position, the AC counter is set up on a rotational stage and a linear stage. The tilt angle is changed by the exchange of a back adapter plate.

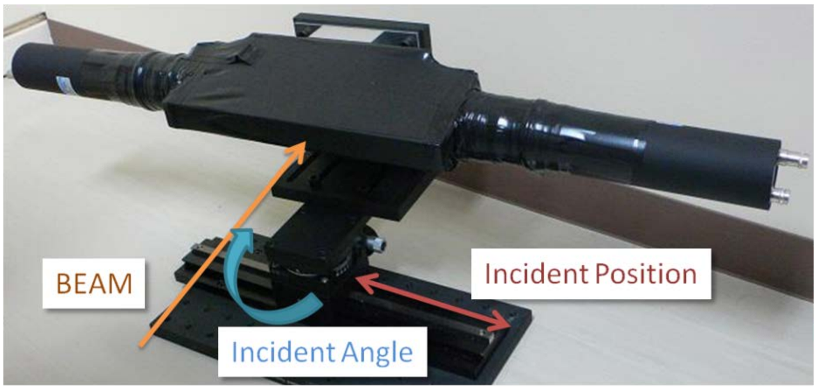

Figure 2: Second prototype AC counter

Experimental setup

Figure 3 shows the K1.1BR area setup for the AC counter test. We will prepare two gas Cherenkov counters and TOF counters with flight length of 5 m to define a muon beam with a purity greater than 99.9%. The beam is focused onto the beam defining counter (BDC). The finger counters (FCs) is placed in front of the AC counter limit the beam size to horizontally 10 mm x vertically 5 mm.

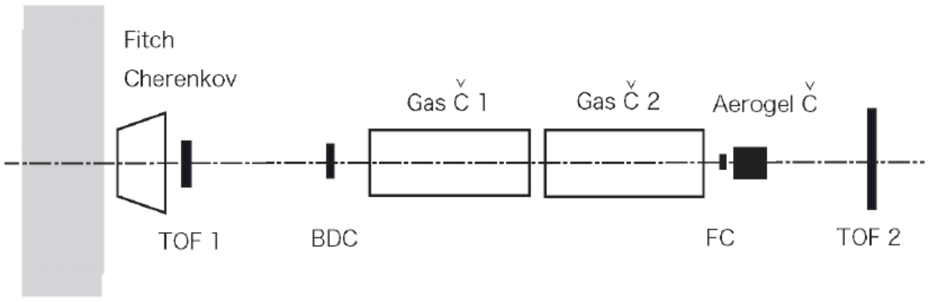

Figure 3: K1.1BR area setup for AC counter test.

AC counter test

We plan to measure the data set of 12 combinations of beam incident angle and position as shown in Figure 4.

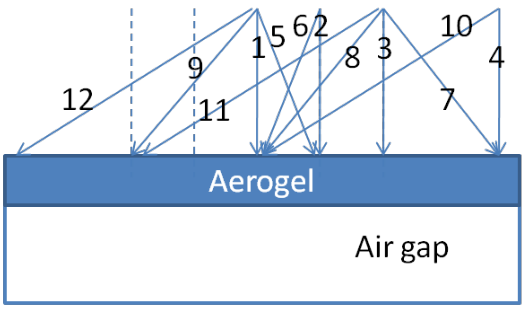

Figure 4: Data set of beam incident angle and position

We have prepared 6 types of the main mirror such as a polygonal flat mirror 1 (PF1), a polygonal flat mirror 2 (PF2), a polygonal diffused mirror 1 (PD1), a polygonal diffused mirror 2 (PD2), a diffused mirror, and a flat mirror. The flat mirror is prepared to calibrate the simulation. The other mirrors are optimized by the simulation.

We also have prepared 3 types of the Aerogel material such as the Aerogel with index n=1.05 and a transmission length TL=20 mm, the Aerogel with n=1.05 and TL=40 mm, and the Arogel with n=1.08 and TL=20 mm. The first one is used as a reference, the second one is measured for the TL dependence, and the last one is for the index dependence.

TRIUMF experimental result

At TRIUMF, we achieved muon mis-ID as small as 1-3 %, which is almost the same as the value expected by the muon mis-ID simulation including the delta-ray emission. We also achieved about 95% positron efficiency, but the error is as large as 5% due to the low positron beam intensity. Due to these small statistics, we cannot decide which mirror provides the best performance.

Beam time request

The positron efficiency is one of the most important points to decrease the muon mis-ID rate. Our main goal of this beam time is to measure the positron efficiency with an uncertainty as small as 1% by using the high intensity positron beam at the K1.1BR beamline. We will need 30 minutes beam time to achieve the 1% uncertainty according to the previous beam time measurement. This beam time also includes time to change the geometric condition. It is also important to measure the muon mis-ID simultaneously to check whether the Lucite Cherenkov light leakage is small enough. Thus we will first do beamline tuning for cloud muons. The beam momentum will be 250 MeV/c, which is near the Ke2 and Kμ2 decay momentum. We also plan to do delta-ray studies by changing the additional Lucite thickness which is placed in front of the AC counter.

- positron/ muon beam tuning @ 250 MeV/c (3 hours)
- n=1.05, TL=20 mm, PF1 mirror (6 hours)
- n=1.05,TL=40 mm, PF1 mirror (6 hours)
- n=1.08,TL=20 mm, PF1 mirror (6 hours)
- With best Aerogel material, PF1 mirror with tilt adapter (6 hours)
- With best Aerogel material, PF2 mirror (6 hours)
- With best Aerogel material, PD1 mirror (6 hours)
- With best Aerogel material, PD2 mirror (6 hours)
- With best Aerogel material, Diffused mirror (6 hours)
- With best Aerogel material, flat mirror (6 hours)
- With best Aerogel material and main mirror, delta-ray study (6 hours)
- Aerogel change time (2 hours x 3=6 hours)
- Mirror change time (0.5 hours x 6=3 hours)

We request 72 hours in total for the beam time.