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Nuclear Instruments and Methods in Physics Research A 553 (2005) 70–75
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

Focusing aerogel RICH (FARICH)☆

A.Yu. Barnyakov[a], M.Yu. Barnyakov[a], V.S. Bobrovnikov[a], A.R. Buzykaev[a], A.F. Danilyuk[b,*], V.L. Kirillov[b], S.A. Kononov[a], E.A. Kravchenko[a], A.P. Onuchin[a]

[a]*Budker Institute of Nuclear Physics, Novosibirsk, Russia*
[b]*Boreskov Institute of Catalysis, Novosibirsk, Russia*

Available online 9 September 2005

Abstract

In this work we investigate a Ring Imaging Cherenkov detector based on "focusing" aerogel (FARICH). In the proximity focusing RICH, one of the main factors determining precision of ring radius measurements is a finite thickness of a radiator. FARICH development aims at the reduction of this effect by means of using multilayer aerogel. Two options have been considered.

Single ring: refraction index and thickness of each layer are adjusted in such a way that Cherenkov rings from different layers are superimposed on each other.

Multi-ring: refraction index and thickness of each layer are adjusted so that ring images from different layers have different radii and are clearly separated from each other.

For the first time in the world we have developed a technique for production of multilayer aerogels (SAN-MULTI). A few samples consisting of four aerogel layers with indices from 1.022 to 1.030 have been produced.

A GEANT4 based simulation program has been developed. Velocity resolution was investigated for different momenta and particle incidence angles. It was shown that velocity resolution of 5×10^{-4} is achievable. This permits us to have π/K separation at the level of more than 3σ up to momentum 8.0 GeV/c, π/μ separation up to momentum 1.6 GeV/c.

PACS: 29.40.Ka

Keywords: Cherenkov counters; Aerogel; Identification

1. Introduction

One of the main factors determining precision of particle velocity measurement in RICH detectors is the finite thickness of a radiator. This problem is

☆Partially supported by Russian Foundation for Basic Research, Grants 02-02-16321, 02-02-17321 and INTAS-CERN 03-52-5579.
*Corresponding author. Tel.: +7 3833 397290; fax: +7 3833 308056.
E-mail address: danilyuk@catalysis.nsk.su (A.F. Danilyuk).

0168-9002/$ - see front matter
doi:10.1016/j.nima.2005.08.073

solved in RICH detectors by using focusing mirrors for Cherenkov light collection at PMTs [1,2]. In RICH detectors with proximity focusing this factor is one of the decisive, especially when the distance between radiator and photodetector plane is small, that is the case for colliding beam experiments.

Recently two groups started investigations of the possibility to use multi-layer aerogel for the improvement of particle velocity measurement. These groups from BELLE detector and from Novosibirsk are working on the development of aerogel RICH detectors for the super B-factories at KEK and SLAC.

In 2004 the BELLE group has suggested to use a stack of two aerogel tiles with different indices of refraction as a radiator. The idea is to reduce the width of ring (rings) of Cherenkov cone image on the plane of photon detector [3,4]. The test beam results with two layers of aerogel blocks were presented in the talk of Samo Korpar [5].

The Novosibirsk group started discussions of the possibility to use multi-layer aerogel in April 2003. The most important result was obtained in May 2004, when Alexander Danilyuk succeeded in producing 4-layered aerogel. It became obvious that the idea of Focusing aerogel RICH (FARICH) could be realized in the experiment and we have started Monte Carlo simulation.

Unfortunately, we have learned about publications of Belle group just before the Conference when our abstract had already been sent to the organizing committee. This was the reason that in our summary we have not referred to works of the BELLE group.

2. Focusing aerogel concept

The use of a stack of aerogel tiles as a Cherenkov radiator has some limitations:

- A thickness of a single tile cannot be significantly less than 10 mm because of mechanical properties of aerogel.
- Because of losses of light due to surface scattering (about 5–10% in one block) the number of blocks in a stack is limited.

If someone could produce a continuous aerogel with layers of different refraction index, this would help to avoid the above problems. In this case layers could be much smaller than 10 mm and their number is determined by the light scattering length and total thickness of aerogel tile.

Such aerogel was synthesized for the first time in the world by our group (Fig. 1). The thickness and index of refraction of each layer were calculated for the distance between aerogel and photodetector plane equal to 100 mm assuming that photons from $\beta = 1$ particles from each layer come exactly to the same ring. The calculated thickness of layers and their indices of refraction and measured ones are presented in Table 1. The light scattering length in this aerogel is high enough. It is equal to 44 mm at 400 nm.

3. Monte Carlo simulation

The GEANT4 based simulation program has been developed to describe a FARICH detector. The only process taken into account in simulation for charged particles was Cherenkov radiation, while for optical photons the processes of Fresnel refraction and reflection, Rayleigh scattering and bulk absorption were considered.

The model had further assumptions:

- A pixel size of the photodetector is smaller than the coordinate spread due to chromaticity and can be neglected.

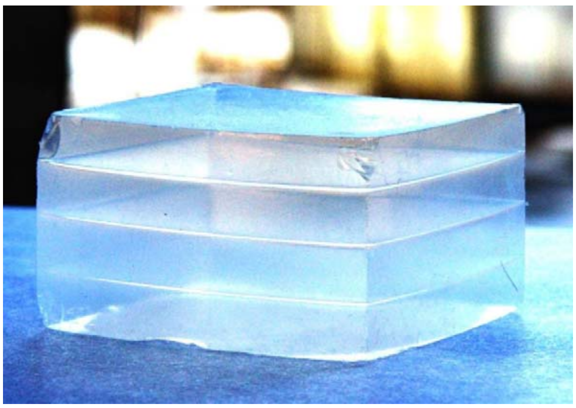

Fig. 1. The 4-layer aerogel block.