Aerogel Cherenkov Counter for the SND Detector

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The particle identification system for π/K separation in the momentum range from 300 to 870 MeV/c is being developed for SND detector at VEPP-2000 e^+e^- collider. The system consists of nine threshold Cherenkov counters with silica aerogel radiator with refraction index of 1.13. The aerogel of such high density was never used in experiments before. One counter of the system was constructed and tested with cosmic muons. The average number of photoelectrons obtained for muons with momentum above 1 GeV/c is about 10.

1. INTRODUCTION

The design and construction of the new particle identification system [1] based on threshold aerogel Cherenkov counter is a part of the SND detector upgrade [2] for experiments at new VEPP-2000 e^+e^- collider [3]. The system is intended for effective π/K-separation in the momentum range $300 \div 870$ MeV/c, where the upper limit of the range is the maximum K-meson momentum at highest e^+e^- collision energy at VEPP-2000. The lower momentum limit is determined by deterioration of the π/K separation due to decrease of π-meson Cherenkov signal. The particle identification in the momentum range below 300 MeV/c is based on the dE/dx measurement in the drift chamber. The optimum aerogel refraction index for this K-meson momentum range is 1.13. The aerogel counter design is similar to that developed for KEDR detector. It is based on the Aerogel, wavelength SHIfters and PHotomultiplier tubes (ASHIPH) [4–6].

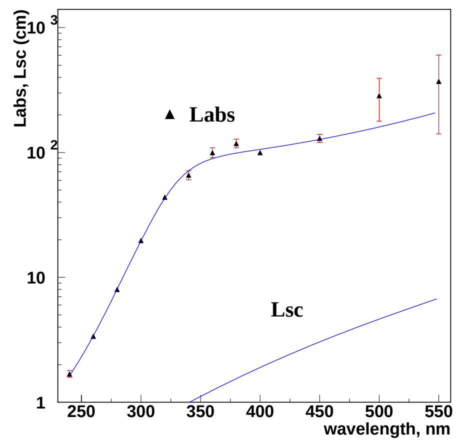

Figure 2: Aerogel light absorption length L_{abs} and scattering length L_{sc} as functions of wavelength.

2. COUNTER LAYOUT

2.1. General Layout

The aerogel counter system consists of three cylindrical segments surrounding the drift chamber. Each segment contains three separate counters in common frame. The general layout of the counter is shown in Fig. 1.

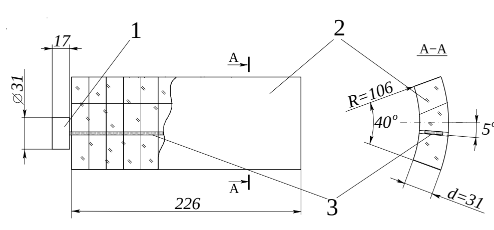

Figure 1: Layout of the SND ASHIPH counter: 1 — microchannel plate photomultiplier, 2 — aerogel radiator, and 3 — wavelength shifter bar

Cherenkov light emitted by the aerogel radiator is collected using fluorescence and total internal reflection in the PMMA wavelength shifter bar doped with BBQ. To maximize light collection efficiency the aerogel radiator with WLS bar are wrapped in the highly reflective PTFE (Teflon) film. As a photodetector a microchannel plate photomultiplier (MCP PMT) with multialkali photocathode was chosen. The MCP PMT has sufficiently small size and ability to work in the stray magnetic field of the VEPP-2000 13 T focusing solenoids. The multialcali photocathode has high quantum efficiency and spectral sensitivity well matched to the BBQ emission spectrum [4].

2.2. Aerogel

The production of aerogel with refraction index 1.13 is being developed at Boreskov Institute of Catalysis and Budker Institute of Nuclear Physics in Novosibirsk [7].

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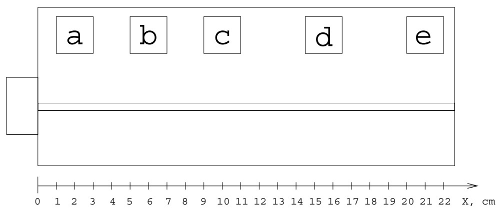

Figure 3: The map of the mean total signal charge measurements with cosmic muons. Boxes show the areas of the counter corresponding to signal values in Table 3.

Table I Average Cherenkov signal charge for cosmic muons in units of photoelectrons for different areas of the counter (Fig. 3). The errors are statistical.

	a	**b**	**c**	**d**	**e**
μ, *ph.e.*	8.2 ± 0.2	10.7 ± 0.2	10.4 ± 0.3	9.4 ± 0.2	8.9 ± 0.3
X, cm	2.0	6.0	10.0	15.5	21.0

Aerogel with such high refraction index cannot be synthesized directly. It is produced by sintering of the aerogel of lower refraction index. The aerogel absorption and scattering lengths as functions of wavelength are shown in Fig. 2. The scattering length dependence can be approximated as $L_{sc}(\lambda) = 19\text{mm} \cdot (\lambda[\text{nm}]/400)^4$.

3. TESTS WITH COSMIC MUONS

The tests were carried out with one full-size aerogel Cherenkov counter. Main goal of the tests was to measure μ — mean signal magnitude for relativistic charged particles which radiate Cherenkov light with an intensity close to maximum. For tests we used

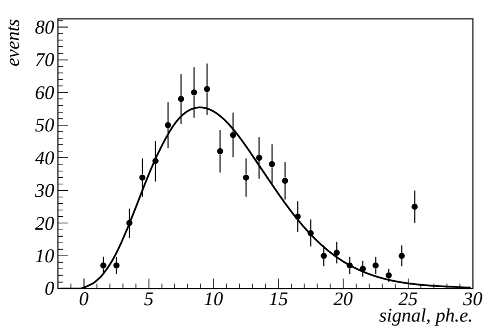

Figure 4: Charge spectrum for cosmic muons with $p \geq 1$ GeV/c in units of the mean single photoelectron pulse charge. Points with error bar are experimental data, the curve is the fit by convolution of the single-electron charge spectrum and Poisson distribution with a parameter μ uniformly distributed within some interval.

cosmic muons with the momenta $p \geq 1$ GeV/c, five times the Cherenkov threshold momentum for muons in $n = 1.13$ aerogel. The signal was measured at five points of the counter shown in Fig. 3. Boxes indicate the locations and dimensions of the trigger counter. All measurements were done for areas of the counter most distant from the WLS bar. The average amplitude for these points is close to 10 photoelectrons, which is enough for efficient π/K separation. Typical total signal charge spectrum for cosmic muons is shown in Fig. 4. The horizontal scale is in units of average single photoelectron pulse charge. The curve is a fit by the convolution of the single-electron charge spectrum and Poisson distribution with a parameter μ uniformly distributed within some interval. This additional spread allows for nonuniformity of the light output within tested area. The drop-out points at about 25 *ph.e.* are due to preamplifier saturation. The fit was conducted in the interval up to 20 *ph.e.*.

4. CONCLUSION

The ASHIPH counter system based on aerogel, WLS doped with BBQ dye, and MCP PMT is designed. With n= 1.13 aerogel this system provides π/K-separation for particle momenta in the range $300 \div 870$ MeV/c. The average signal of about 10 photoelectrons was obtained for cosmic muons with momentum $p \geq 1$ GeV/c.

Acknowledgments

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