Aerogel Cherenkov counters for the KEDR detector ⋆

M.Yu.Barnyakov [a], V.S.Bobrovnikov [a], A.R.Buzykaev [a], A.F.Danilyuk [b], S.F.Ganzhur [a], I.I.Goldberg [c], G.M.Kolachev [a], S.A.Kononov [a], E.A.Kravchenko [a], G.D.Minakov [a], A.P.Onuchin [a,1], G.A.Savinov [a], V.A.Tayursky [a]

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

[b] *Boreskov Institute of Catalysis, Novosibirsk, Russia*

[c] *AOOT "Katod", Novosibirsk, Russia*

Abstract

The project of Cherenkov counters based on Aerogel, wavelength SHIfter, and PHotomultiplier (ASHIPH) for the KEDR detector is described. The Monte Carlo simulation of number of photoelectrons was carried out. The first counters have been produced. Measurements with cosmic particles were performed. As compared with the direct light collection on PMT, the ASHIPH method allows to diminish the number of PMTs essentially. The optical properties of aerogels produced at KEK and at Novosibirsk are presented.

Key words: Particle identification, aerogel, Monte Carlo, wavelength shifters
PACS: 29.40.Ka
1991 MSC: 65C05

1 Introduction

This work is devoted to the development of the aerogel Cherenkov counters for the KEDR detector which will run on e^+e^- collider VEPP-4M. The counters

⋆ Partially supported by Russian Foundation for Basic Research, grant 97-02-18516, 99-02-16712.

[1] Corresponding author, address: Budker INP, Novosibirsk, 630090 Russia, tel: +7(3832)-394731, fax: +7(3832)-342163, E-mail: onuchin@inp.nsk.su.

must work in the magnetic field up to 1.8T and separate π- and K-mesons in the momentum range of 0.6-1.5 GeV/c. Refractive index of the aerogel is 1.05.

The first project of aerogel counters for the KEDR detector was based on the direct light collection on 2-inch fine mesh photomultipliers (FM PMT) from Hamamatsu. A prototype testing showed that this system needs about 400 such PMTs [1,2]. The analogous system of aerogel counters has been built for the Belle detector (KEK) [3]. It contains 1800 PMTs. The large number of PMTs is the basic disadvantage of this method.

To decrease the number of PMTs we have started the development of ASHIPH counters [2]. For the light collection in this method a light guide with the wave length shifter (WLS) is used. A prototype of the ASHIPH counter with FM PMT and "blue" WLS was tested on beam at CERN [4]. After that we developed the ASHIPH counter on the base of microchannel plate (MCP) PMT with multialkali photocathode [5,6].

In this article we present for the first time the test results for the ASHIPH counters on the base of "green" WLS with BBQ and MCP PMT.

2 ASHIPH project for KEDR

The ASHIPH system for the KEDR detector [6] is shown in Figs. 1,2. The system contains of 160 counters: 80 barrel and 80 endcap counters.

An important feature of the project is a two-layer design. The counters are arranged in such a way that a particle from the interaction point with a momentum above 0.6 GeV/c does not cross the shifters of both layers. It is possible to use the information from both layers for the essential part of the particles.

3 Aerogel

We use the high optical properties aerogel SAN-96 [7–9] produced at Novosibirsk in collaboration of Boreskov Institute of Catalysis and Budker Institute of Nuclear Physics. The data for the light absorption (Labs) and scattering (Lsc) lengths in the SAN-96 aerogel are presented in Fig. 3. The data for aerogel samples with n=1.03 produced at KEK(Japan) [10] are presented also. The KEK samples were kindly delivered by prof. T.Sumioshi. Measurements were carried out by us.

Note that the aerogel from KEK is hydrofobic [10] while the Novosibirsk aerogel is hydrofillic.

4 BBQ wavelength shifter

The absorption and emission spectra of BBQ were presented in [6]. The production of plexiglass plates doped with BBQ was mastered in Institute of Polymers at Dzerzhinsk. The cutting, polishing and twisting were organized in Budker Institute of Nuclear Physics.

The results of the photon to photoelectron conversion probability measurement $W(\gamma \to pe)$ as a function of distance from conversion point to PMT photocathode are presented in Fig. 4. A light with $\lambda = 380nm$ from monochromator was used [6].

5 MCP PMT

The data for our MCP PMTs were presented in [6]. We carried out measurements of the relative coefficient of photoelectron collection G as a function of voltage between photocathode and MCP (Fig. 5). Two types of PMTs were tested: with film and without film between photocathode and MCP (Fig. 5). The purpose of the film is to prevent the ion feedback and thus to increase the life time of the device. In the working conditions of the KEDR detector the load of counters from particles is rather small. The output current of the PMT is defined by the dark currents. We have done tests on the stability for 4 PMTs without film. We didn't see the change in the photocathode quantum efficiency within the accuracy of measurements (5%) after 1400 hours under dark currents at nominal multiplication coefficient (10^6). We are continuing these tests now. We decided to use PMT without film. The measurement of the absolute value of G is in our plans.

6 MC and test results

To calculate the number of photoelectrons we use a special Monte Carlo code which takes into account all basic processes of the light collection [1,2,11]. The MC results are presented in Table 1. Relativistic particles coming from the interaction point cross the endcap counter in the points 1-6 (Fig. 6,2). In the Table 1: LC_{WLS} is the light collection coefficient on WLS for the wavelength region of 250-450nm, A_{aer}/A_{wall} is the ratio of the aerogel to wall absorption, N_{pe} is the number of photoelectrons (assuming that photoelectron collection coefficient $G = 1$). "Whole area" is an average over the whole area of the counter. In the "Trigger" line it is shown the MC results for the conditions in which the number of photoelectrons from cosmic particles was measured. A special "telescope" was used to separate particles crossing the hatched area (Fig. 6).

The amplitude spectra for cosmic particles and for one photoelectron calibration are shown in Fig. 7. The average value is $N_{pe}(exp) = 7.8 \pm 0.2$. One can see that MC and experiment are in agreement.

At present the first 20 endcap counters (one layer of one endcap) have been produced. 15 counters were tested with cosmic particles.

7 Conclusion

The success of the ASHIPH method on the real counters for the KEDR detector was shown. The first estimations for this method were published by authors in 1992 [2]. Project of the system for the KEDR detector contains 160 PMT with photocathode diameter of 18mm. The project of system with the direct light collection contained about 400 PMTs with diameter of 36mm. So, the ASHIPH method allows to decrease total photocathode area about ten times.

The direct comparison of the optical properties of aerogels produced at KEK and at Novosibirsk was presented in this article.

References

[1] A.P.Onuchin et al., 5th Int. Conf. Instr. for Colliding Beams Physics, Novosibirsk, 1990 (World Scientific,1990) p.208.

[2] A.Onuchin et al., Nucl. Instr. and Meth. A315(1992)517

[3] T.Iijima "Aerogel Cherenkov counters for the Belle detector", Talk at the INSTR99.

[4] A.R.Buzykaev et al., Nucl. Instr. and Meth. A379(1996)453

[5] A.R.Buzykaev et al., Journal of Non-Crystalline Solids 225(1998)381

[6] M.Yu.Barnykov et al., Nucl. Instr. and Meth. A419(1998)584

[7] A.R.Buzykaev et al., Nucl. Instr. and Meth. A433(1999)396

[8] A.R.Buzykaev et al., Nucl. Instr. and Meth. A379(1996)465

[9] A.F.Danilyuk et al., Nucl. Instr. and Meth. A433(1999)406

[10] I.Adachi et al., Nucl. Instr. and Meth. A355(1995)390

[11] A.G.Shamov and A.R.Buzykaev, Proc. of 'Computing in High Energy Physics 97', http://www.ifh.de/CHEP97/paper/212.ps

List of Figures

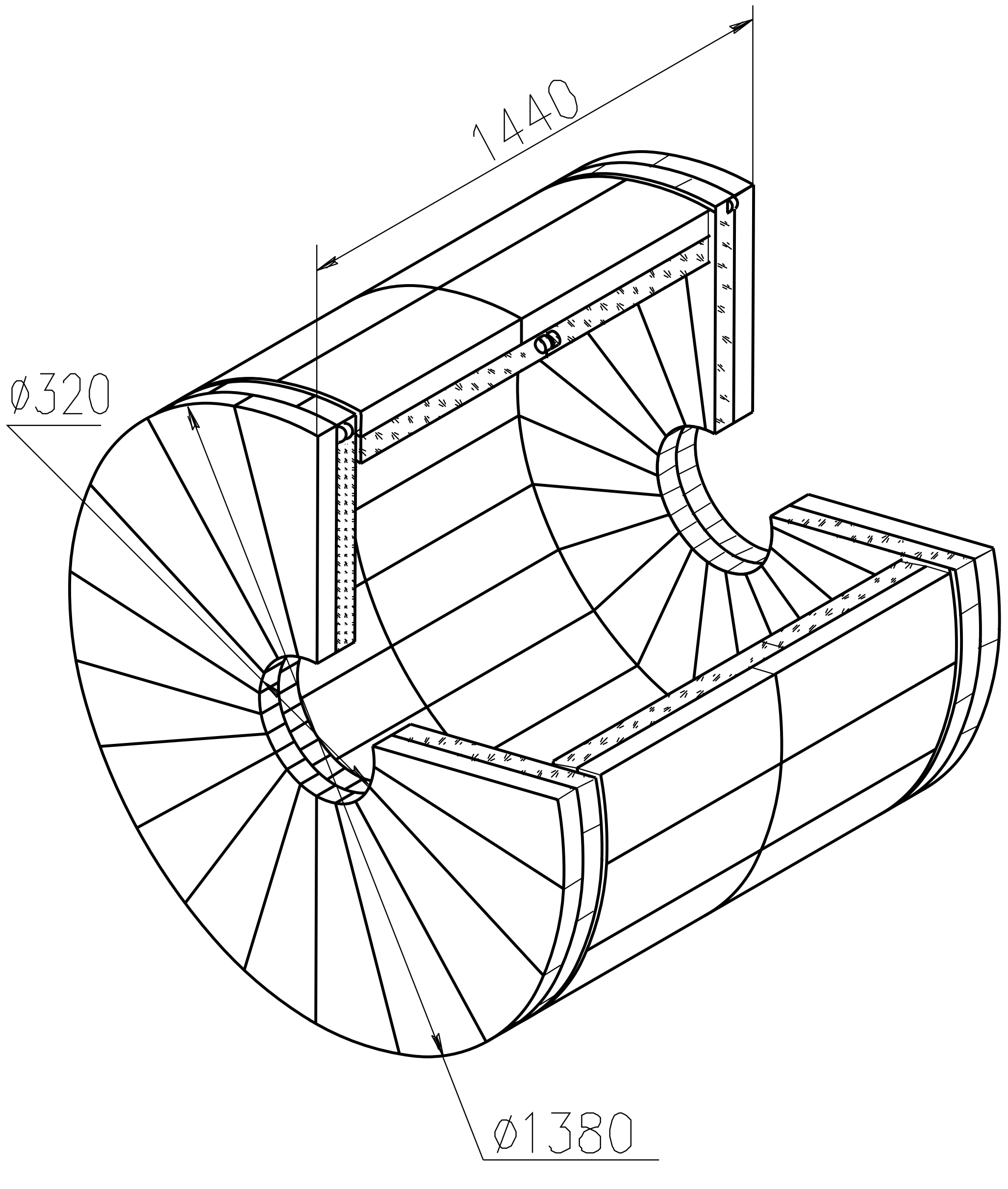

Fig. 1. The KEDR ASHIPH system.

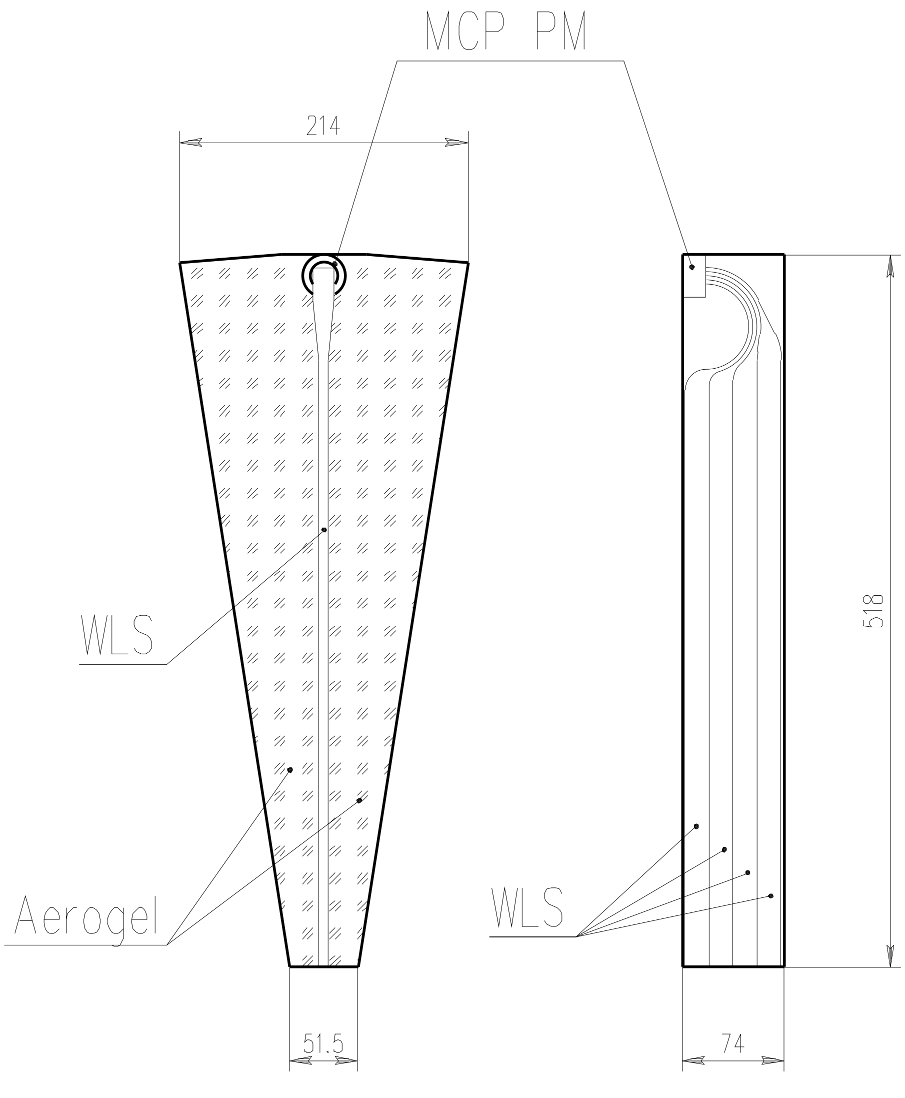

Fig. 2. The endcap counter. Photocathode diameter of PMT is 18mm.

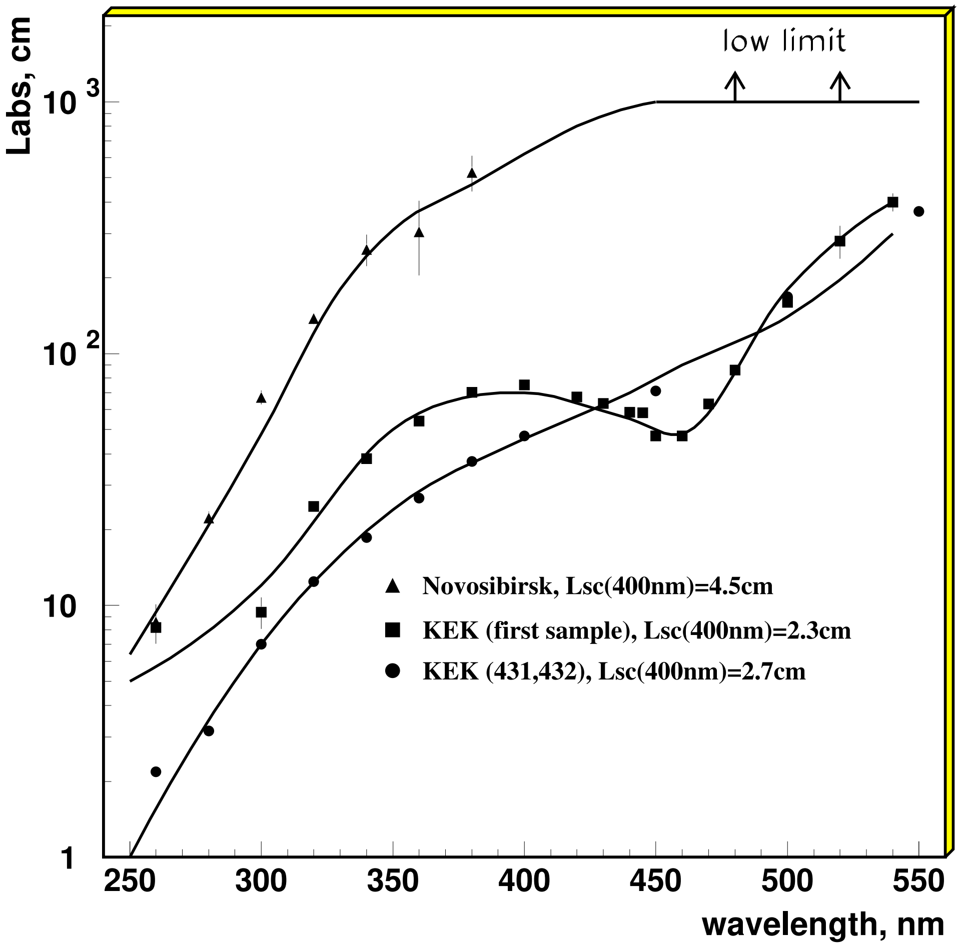

Fig. 3. Labs and Lsc (in comments) for Novosibirsk and KEK aerogels.

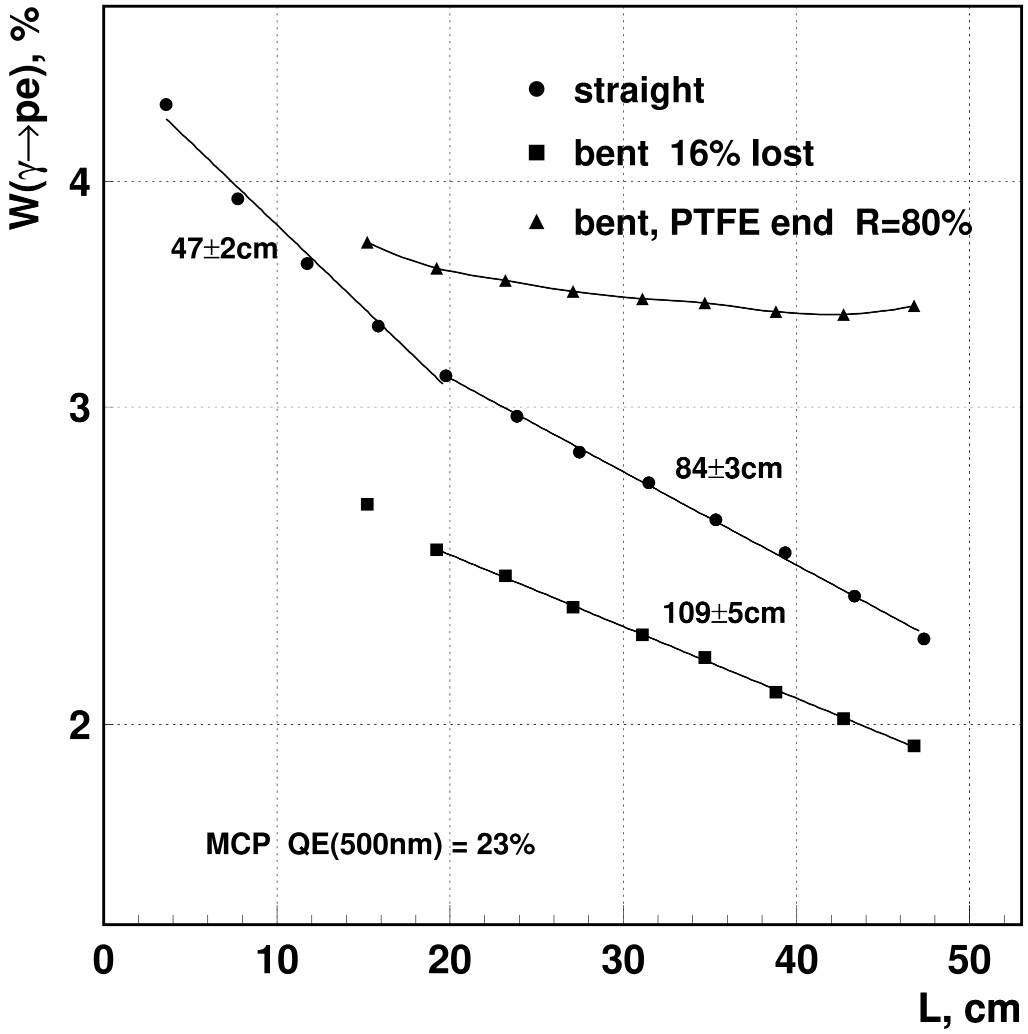

Fig. 4. Photon to photoelectron probability for some stages of WLS preparation.

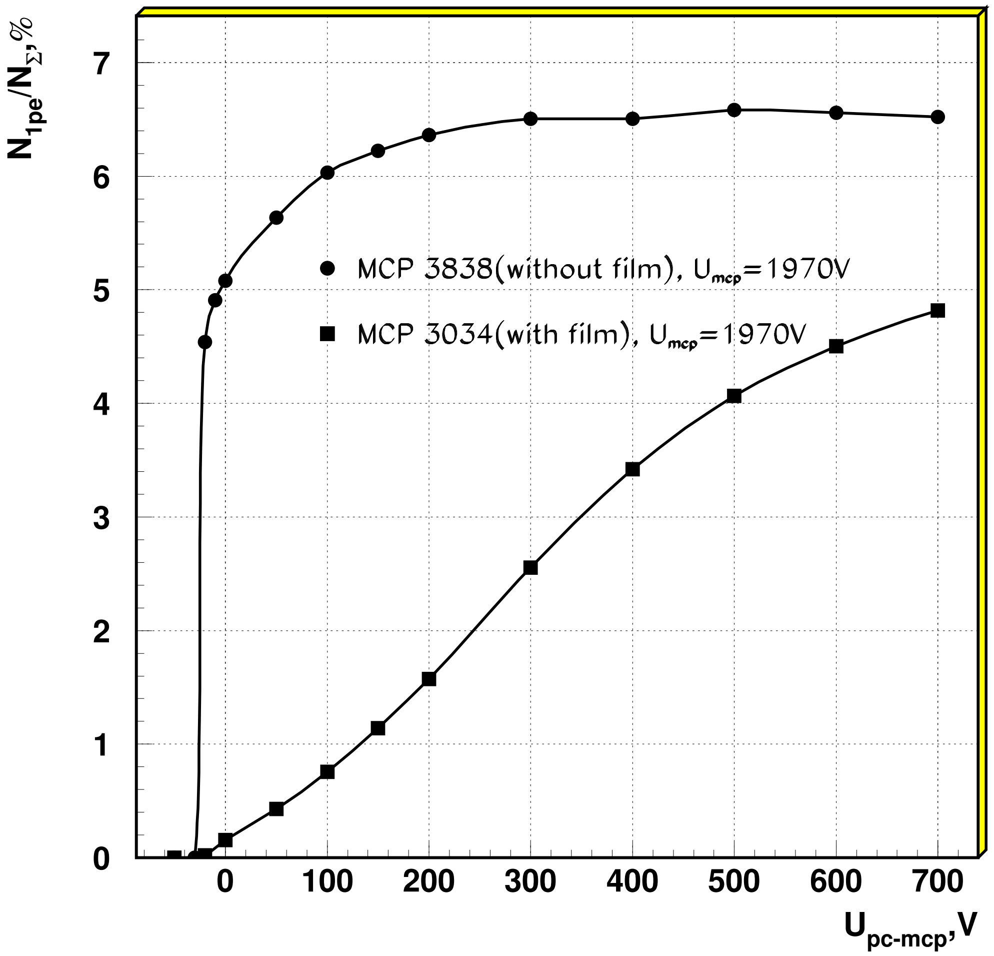

Fig. 5. Relative photoelectron collection coefficient for MCP PMT with and without film.

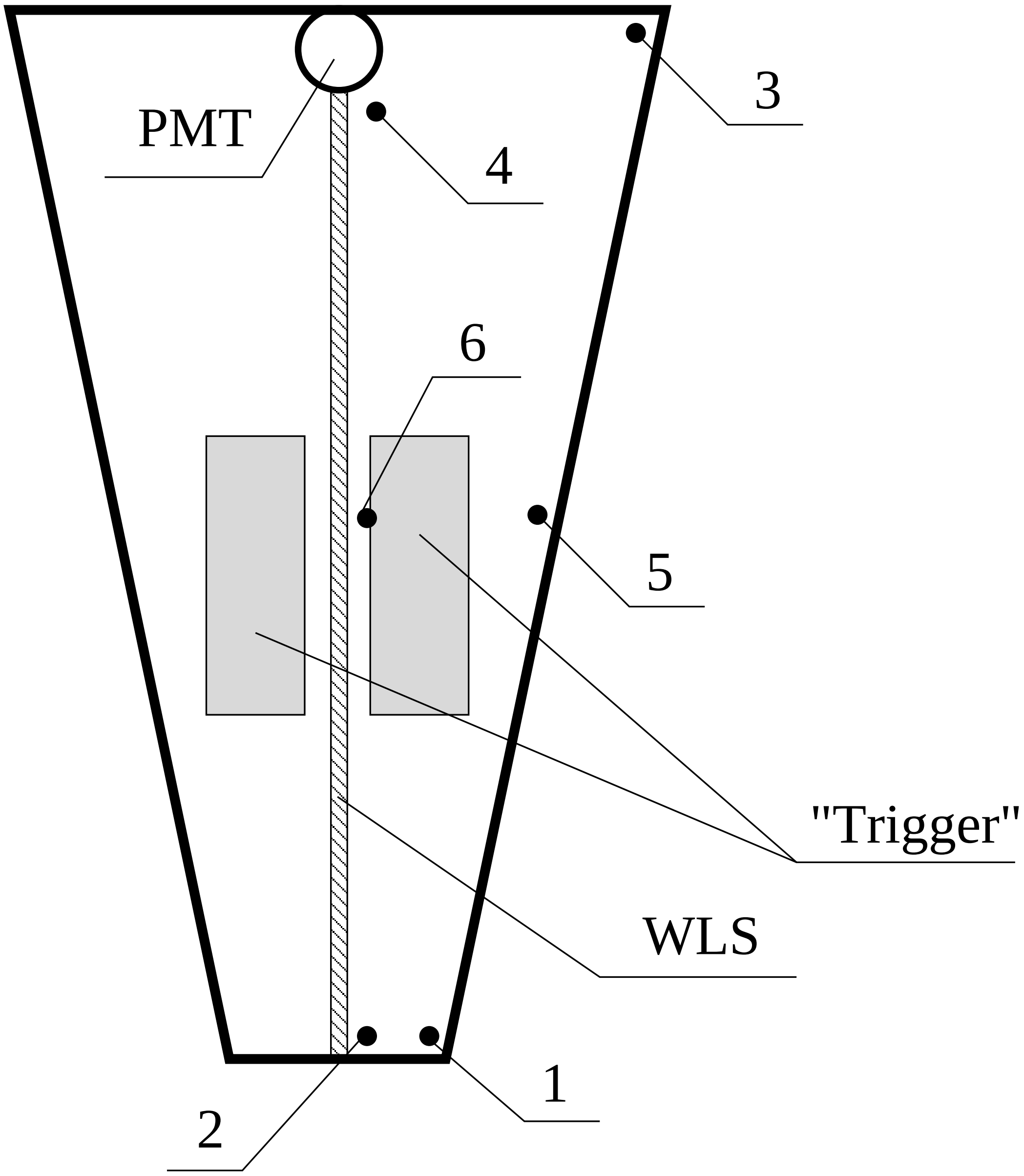

Fig. 6. Geometry for MC simulation.

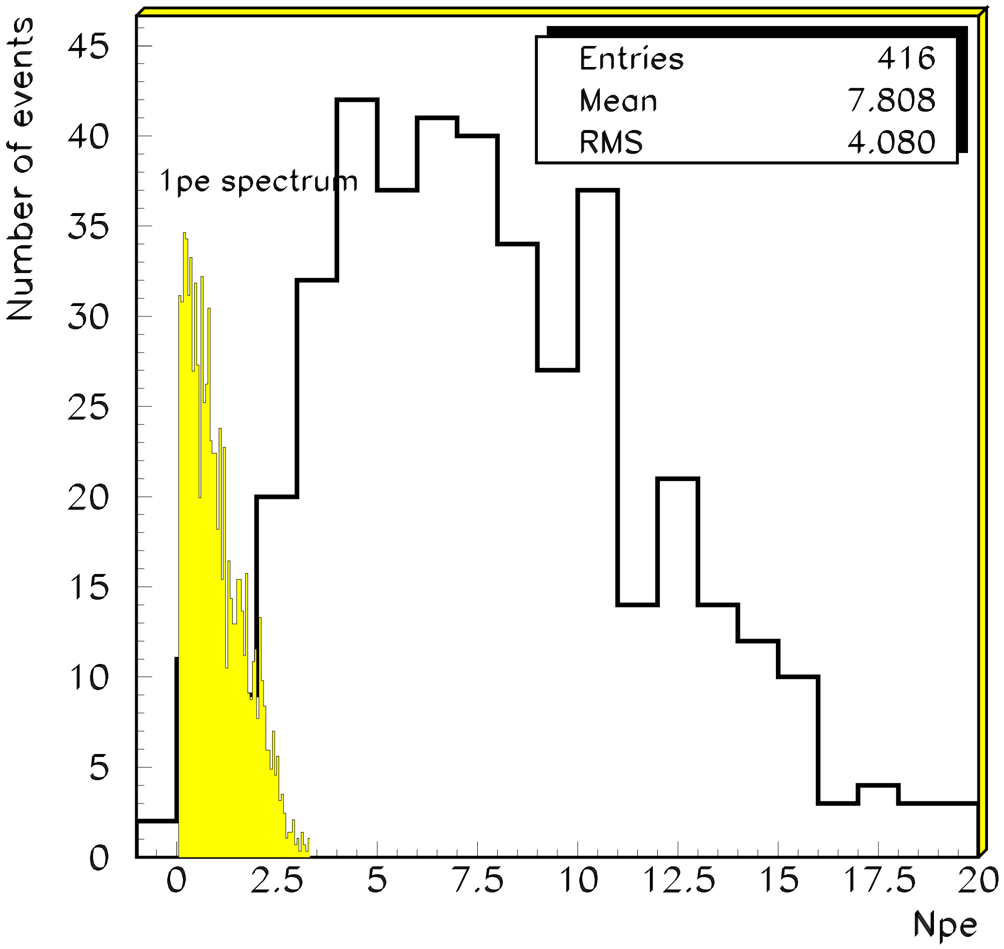

Fig. 7. Cosmic muons and one photoelectron spectrum.

Table 1
MC data for the counter #6.

Point	LC_{WLS},%	A_{aer}/A_{wall}	N_{pe}
1	66 ± 1	2.6	8.2 ± 0.8
2	83 ± 1	2.6	9.2 ± 0.8
3	26 ± 5	2.0	6.2 ± 1.5
4	62 ± 5	4.1	13.1 ± 2.3
5	50 ± 1	3.8	8.5 ± 0.8
6	83 ± 1	5.0	13.4 ± 0.9
Whole area	52 ± 1	3.9	8.8 ± 0.9
”Trigger”	60 ± 1	4.8	8.2 ± 0.8