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HIGH PRECISION STRAW TUBE CHAMBER WITH CATHODE READOUT

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1. INTRODUCTION

In last years the new modifications of gas coordinate detectors on the basis of straws have been simulated, constructed and investigated. These straw chambers possess the following properties:

- high coordinate capability and short-time memory;
- possibility of working with high pressure up to 3÷4 atm.;
- high precision determination of track coordinates measuring ionization drift time of the electrons (till 50 μm);
- industrial production of all detector elements, important to realize a large-scale detecting system.

The usage of such type of detectors as inner track systems has been proposed in the LHC and SSC systems [1]. The larger detector of the LHC, SSC systems is a muon detector which should give the high coordinate resolution and work at a low count rate. The drift chambers [2], drift metal tubes [3], honeycomb chambers with cathode readout [4] and so on, are considered as an example of the muon detector in LHC and SSC. In this article we try to show the possibility of constructing a muon detector on the basis of aluminized mylar straws with a window and cathode readout.

2. THE CHAMBER ACTION

The scheme of the chamber is shown in Fig.1. The chamber consists of a mylar straws set which is kept on the fiberglass basis. There are conductive strips with a step on the same basis. The straws are orthogonal to strips, the lengths are 0.5 and 1 m, correspondingly. The golden tungsten wires are kept with the requiring tension in the center of the straw. The wire diameters are 20 μm and 50 μm. The tube body tension is 100 gramm. The straws were made of the aluminized mylar strip via ultrasound welding and have the longitudinal seam. Constructing the straws we use the mylar strip with a small aluminiumless longitudinal window. Then we put the tubes on the basis of the chamber down by the aluminiumless windows. The angle window width equals 2ϕ.

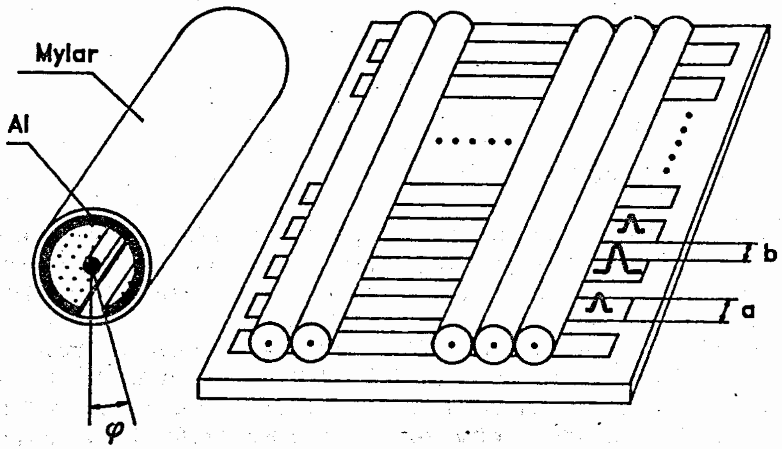

Fig.1. The scheme of the chamber (the right) and the straw (the left). Thickness of fiberglass plane is 2.5 mm. Thickness of cuprum strips is 50 μ m. Step of strips (a) is 3, 4, 5 mm. Interval value (b) is 0.5, 0.5, 1 mm correspondingly. Diameter of maylar straw is 10 mm. Thickness of aluminized maylar is 25 μ m.

One can determine the Y-coordinates of the charged particle tracks via drift time measurement registrating the signals from the anode wires. One can obtain the X-coordinate registrating the induced charges through the transparent window on the strips.

3. THE INDUCED SIGNALS VALUE

The best value of the detector spatial resolution is usually determined with signal/noise ratio when analogous methods are used. Due to this reason the amplitude characteristic for the straws with the cathode strip readout is especially interesting.

The minimization of accumulating effect with the positive ion charge on the window surface, stops us at selection of 36° window width because the positive ions can cause the modification of the signal amplitude. The count rate capability dependence on the angle window value is shown in Fig.2. The X-rays beam with 8 KeV energy and 1 mm diameter has crossed the tube between the anode wire and the window. Due to the window size increasing more than 36°, the charge accumulating effect has big influence for 10 mm diameter straws. The induced charge

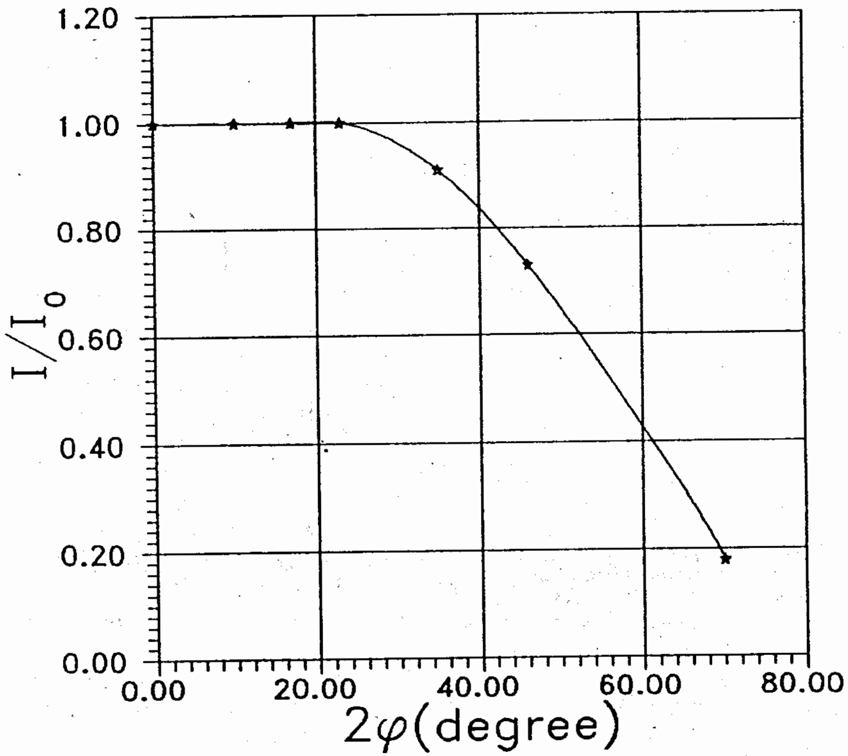

Fig.2. The straw count rate capability dependence on window angle width. The value Io for straws without window was $2\cdot10^4$ $1/(cm^2 sec)$, the diameter of X-rays beam was 1 mm. The gas gain was about $5\cdot10^5$, gas mixture was Ar/CH_4 (50/50).

distribution on the X and Y dimensions was shown in Figs.3 and 4, correspondingly. The full width of the distribution (FWHM) is about 3R in the first case, where R is the tube radius. Therefore, for the coordinate information readout the strips width should be about value R.

The distribution in the Fig.4 shows the decreasing of induced charge value with the shift from the window center to its boundaries. It means that the boundary field distortions took place in the tube. The measurements were made in the following way. Disposed between two grounded planes, the 0.2 mm diameter wire was placed on the window center outside the tube. One could turn the tube for the required angles. One can see

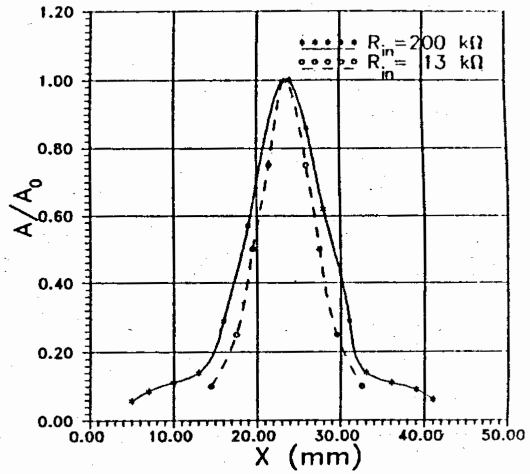

Fig.3. The spatial distribution of induced charge value on X-coordinate. The measurements were completed with charge-sensitive amplifires. Input resistivity was 13 and 200 k Ω.

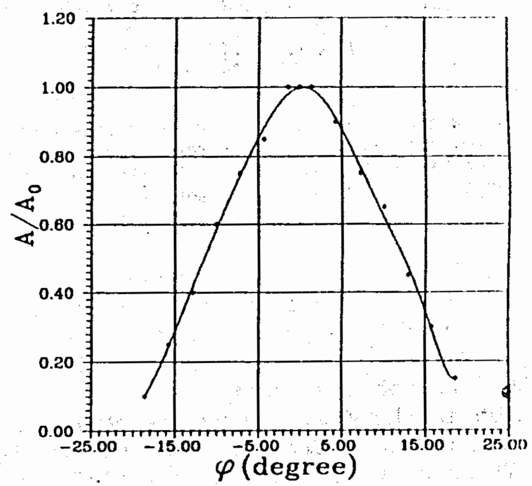

Fig.4. The induced charge spatial distribution in Y dimension orthogonal to longitudinal window. The angle window width is 2 ϕ = 36°.

the induced charge values on the strips were less by 1.6 times than it was expected, because the distribution has a trapezoidal character. It made the signal/noise ratio worse.

4. THE SPATIAL RESOLUTION

The chamber spatial resolution was investigated via X-rays of the collimated beam with the energy of 8 KeV, which can move with good accuracy in X and Y dimensions. The beam diameter was less than 100 μm (FWHM). The signals from the strips through the charge-sensitive amplifier were transported to the TDC and then go to PC. The anode signals gave the trigger of the system. The amplifier parameters are:

- input resistance has 13 kΩ;
- reforming coefficient is 6.7 V/pC;
- inner noise is $3\cdot10^{-3}$ pC (6σ);
- integrating time is 50 ÷ 60 ns.

The gas mixture Ar/CH_4 (50/50).

The spatial resolution is determined with charge readout from three neighbouring strips via centroid method. Also one can use the algorithms proposed in Endo [5] and G. van der Graaf [4]. We have used the spatial resolution determination algorithm described in article [5]. The resolution was determined for the strips with 3, 4 and 5mm width, correspondingly. The best value σ has been obtained for the 5 mm width strips (the 1 m length strip had capacity about 300 pF).

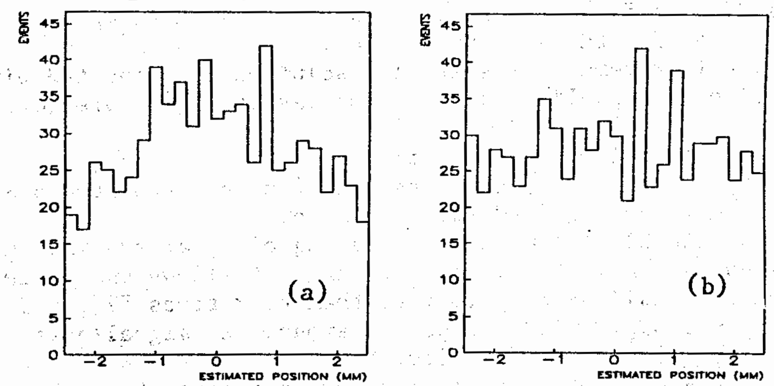

Fig.5. Events distribution on X-coordinate with X-rays proportional radiation of chamber, (a) - before, (b) - after data correction. Proposed in [6] method was used.

The avalanche coordinate determined with centroid method is given in the expression

$$X_g = \frac{(a + b)(\ln Q_L - \ln Q_R)}{2\,(\ln Q_L - 2\ln Q_M + \ln Q_R)},$$

where Q_M, Q_R, Q_L are induced charges read out from i, i+1, i-1 strips, respectively.

As was shown in [5], the avalanche position calculated with the centroid method, differs from its own real position. Figures 5 (a) and (b) show the event distribution in orthogonal to the strips dimension before and after correction. This correction is realized with the Chiba algorithm [6]. The spatial resolution dependence on avalanche position across the strips is shown in Fig.6. Figure 7 shows the σ dependence on signal/noise ratio (about the center of the strip). One can see that the signal/noise ratio should be about 100 for the security of the spatial resolution better than 100 μm. We have obtained the σ about 120 μm (Fig.8) with signal/noise ratio - 60 ÷ 65.

5. CONCLUSION

The mylar straw wire chamber with the window and cathode readout allows one to get the spatial resolution better than 120 μm when the signal/noise ratio is about 60.

This type of detector can be considered as an example of the muon detector for LHC and SSC systems.

Further improvement of spatial resolution is connected with the problem of signal/noise ratio increasing. There are several ways:

- using low-noise electronics;
- working with more higher gas gain (in the saturated proportional mode and limited streamer mode);
- using the aluminium-carbon covering of mylar straws, but the window has only the carbon covering. It allows one to increase the signal/noise ratio more than by 2 times [7], and probably, the angle window size. We expect the signal/noise ratio to be improved essentially.

The proposed chamber is similar to the honeycomb chambers [4], electronics is the same. There are no strict requirements for high stability of the gas mixture, pressure and temperature. In the case of a single broken wire, the full plane damage is excluded.

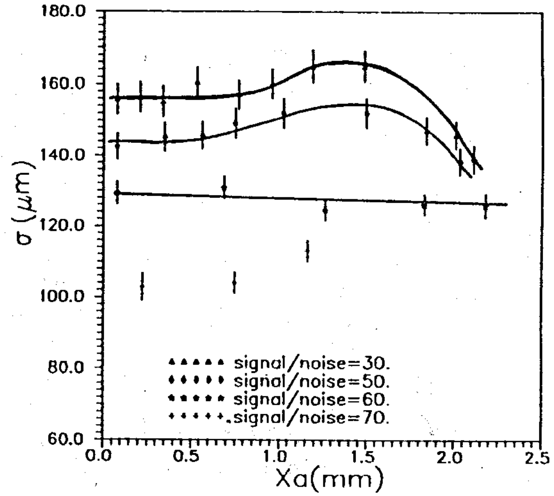

Fig.6. Spatial resolution dependence on X-rays collimated beam displacement orthogonal to strip. Measurements were produced for the different signal/noise ratios.

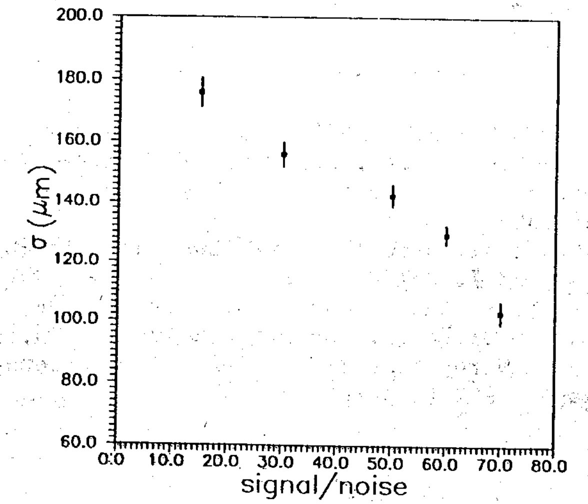

Fig.7. The detector spatial resolution dependence on signal/noise ratio.

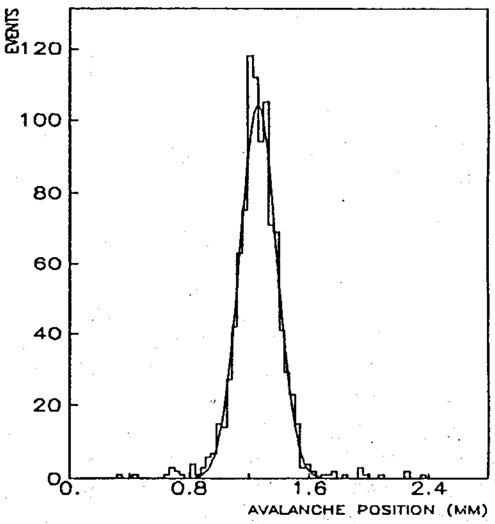

Fig.8. The detector spatial resolution for collimated X-rays beam (FWHM < 100 μm).

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REFERENCES

1. Walter H.Toki. - SLAC - PUB - 5232 (1990).
2. Adeva B. et al. - Nucl. Instr. and Meth. in Physics Research, 1990 , A289, p.35.
3. GEM. Letters of Intent.
4. H. van der Graaf et al. - Nucl. Instr. and Meth. in Physics Research, 1991 , A307, p.220.
5. Endo I. et al. - Nucl. Instr. and Meth., 1981 , 188, p.51.
6. Chiba J. et al. - Nucl.Instr. and Meth., 1983 , 206, p.451.
7. Peshekhonov V.D. - Wire Chamber Conference 1992, Vienna, Austria, February, 1992 (in proceeding).

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Бычков В.Н. и др. E1-92-199
Высокоточная проволочная камера
с катодным считыванием из пленочных трубок

Приведена конструкция и основные характеристики макета координатного детектора с катодным считыванием информации. Камера состоит из набора соломинок с продольным прозрачным окном, лежащих на электроде с перпендикулярно расположенными к окнам стрипами. Получено пространственное разрешение σ = 120 мкм при отношении сигнал/шум около 60. Описаны возможные пути улучшения отношения сигнал/шум.

Работа выполнена в Лаборатории сверхвысоких энергий ОИЯИ.

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High Precision Straw Tube Chamber
with Cathode Readout

The high precision straw chamber with cathode read-out was constructed and investigated. The 10 mm straws were made of aluminized mylar strip with transparent longitudinal window. The X coordinate information has been taken from the cathode strips as induced charges and investigated via centroid method. The spatial resolution σ = 120 μm has been obtained with signal/noise ratio about 60. The possible ways for improving the signal/noise ratio have been described.

The investigation has been performed at the Particle Physics Laboratory, JINR.

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