91-390

объединенный
институт
ядерных
исследований
дубна

E1-91-390

V.N.Bychkov, I.A.Golutvin, L.G.Ignatova,
A.V.Makhankov, S.A.Movchan, V.D.Peshekhonov,
T.Preda, S.V.Sergeyev

SOME CHARACTERISTICS OF THE MICROSTRIP GAS CHAMBER

Submitted to "ПТЭ"

1991

1. Introduction

The Microstrip Gas Position-Sensitive Chamber (MISGAC) has been developed in 1986-1988 /1/ and investigated by some groups /2, 3,4/. The main detector element is microstrip electrode, which is made on an isolating plate. A high precision micro electronic technology was used for this purpose. This industrial method allows one to use this kind of detector in the large detection systems for the next generation of high-luminosity colliders (SSC, LHC, UNK). Their characteristics and further improvements in the near future would permit their use as vertex detectors and as elements of the muon mosaic-type detector. The useful investigation of the their foil microstrip chambers /5,6/ pointed out that they are interesting as X-ray detectors for example for transition and synchrotron radiation. We give some characteristics of the microstrip chamber which were investigated in order to find requirements that meet electrodes technology.

2. The detector structure

The detection process takes place in the gas volume bounded by the front cathode and the microstrip electrode. The electrode consists of a set of cathode and anode strips, which are alternating fixed on an isolating plate. The cross-section of the microstrip chamber is given in fig. 1. The electrode 50*50 mm in size, was made by electron-beam lithography. The strips were made of chromium, anode and cathode strips width is 5 mkm,30 mkm respectively. The resulting electrode was used as the mask to make elect-

rodes with 1 mkm aluminum strips thickness, by photolitography method.

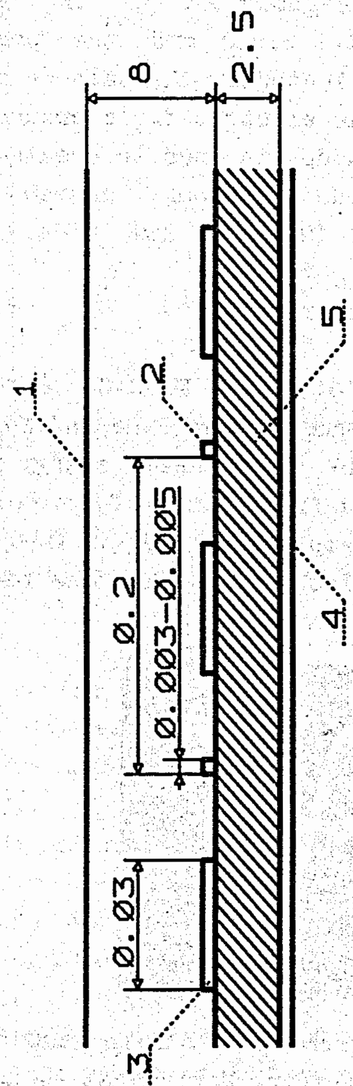

Fig. 1. The schematic cross section view of the microstrip detector.
1 - the aluminized mylar front cathode,
2 and 3 - anode and cathode strips,
4 - back cathode,
5 - glass plate.

Primary electrons, produced in the drift region when an ionizing particle passes through the gas, drift towards anode strips. In the neighborhood of the anode strips, the avalanche process takes place and the positive ions created are quickly collected by the cathode strips. The cathode strips magnify the electric field around the anode and the back side cathode is used to create an electric field, of the form needed. In our search we used an argon-methane gas mixture (80 % Ar, 20% CH4).

3. The detector characteristics

The characteristics of the MISGAC detector were studied by means of a gamma-source 55Fe and X-ray tube with cooper anode of 5.9 KeV and 8 KeV energy respectively. The signal was collected from groups of seven anode strips by a low noise current amplifier. Figure 2 shows the shape of the output pulse witch has a rise time of about 20 ns.

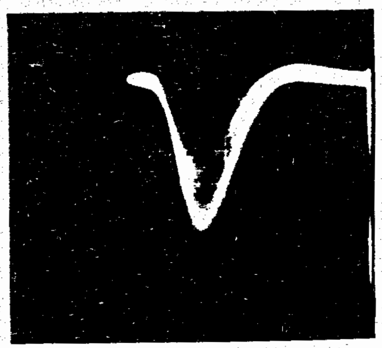

Fig. 2. The signal from anode strips read by a small-noise amplifier. Horizontal 20 ns/cm, Vertical 200 mV/cm. E_gamma=8 KeV, Um=2.5 KV, Ub=5 KV, Ust=580 V.

The counter characteristics as a function of the anode-cathode voltage for given potentials on the front and back - side cathodes are given in fig. 3.

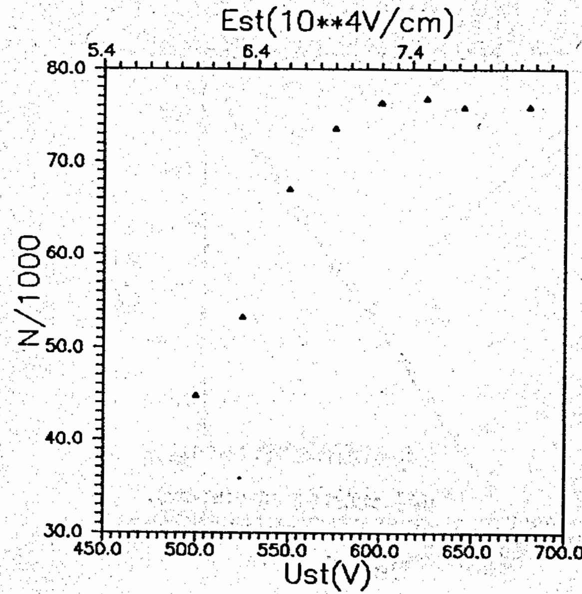

Fig. 3. Count from 8 KeV X-ray versus the anode-cathode strip voltage.

In the picture one can see that the plateau width is about 100 V. The noise level in the center of the plateau is less than 100 Hz/strip.

The gas gain as a function of the anode-cathode voltage is shown in fig. 4. The maximum gain reached in our case was $6*10^4$. The signal-noise ratio near the plateau end was more then 80.

Figs.5 and 6 show the influence of the voltage on the front (Um) and back (Ub) cathodes on gas gain (on the ordinate axis is given the centroid of the amplitude spectrum of the anode signals). The curves in Fig. 4,5 and 6 show that the 1% change of the rate is caused by the voltage change Um (Em), Ub (Eb) or Ust (Est) of about 380 V (480 V/cm), 130 V (530 V/cm) and 0.65 V (80 V/cm) respectively.

It is possible to read-out the signals from the front or the back cathode as is shown in figs 7 and 8. These

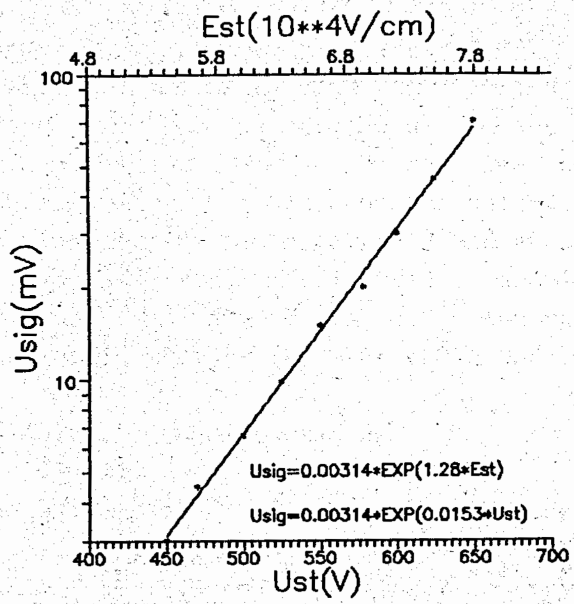

Fig. 4. The signal amplitude versus anode-cathode strip potential difference. Ub=4.75 KV, Um=3.5 KV, E_gamma=5.9 KeV. The maximum gas gain value - $6*10^4$.

were registered using the 8-KeV X-ray.The ratio of the signal volumes corresponds to that of the distances from the cathodes to microstrip electrodes.

The back cathode signal is quite enough for the registration and the ratio of the signal/noise is easily obtained over 15-20. These signals can be properly used to obtain the second coordinate with the submillimeter accuracy, for example using the delay line.

The pulse spectrum measured on anode for 8 KeV X-ray is shown in Fig. 9. The energy resolution was 23%.

The rate capability of the detector was checked via the 8 KeV X-ray 0.6 mm diameter beam. The results are presented in Fig.10 where A0 is the signal amplitude at low intensity and A is the corresponding signal amplitude at a given intensity. For comparison in the same picture is shown the

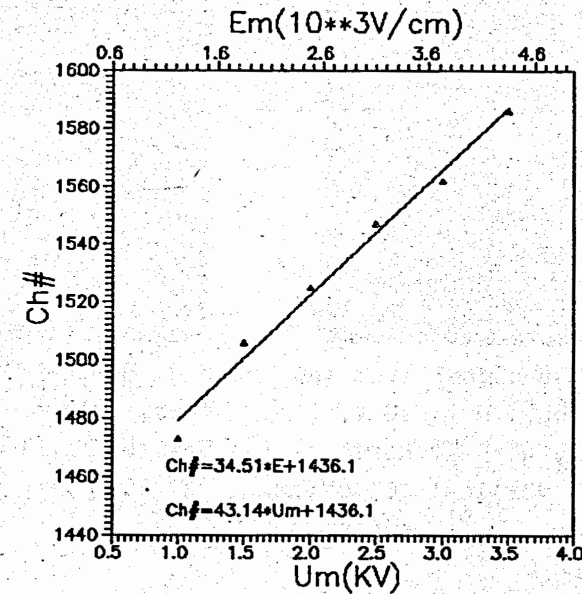

Fig. 5. The anode signal amplitude versus the front cathode potential. Ub=5 KV, Ust=500 V.

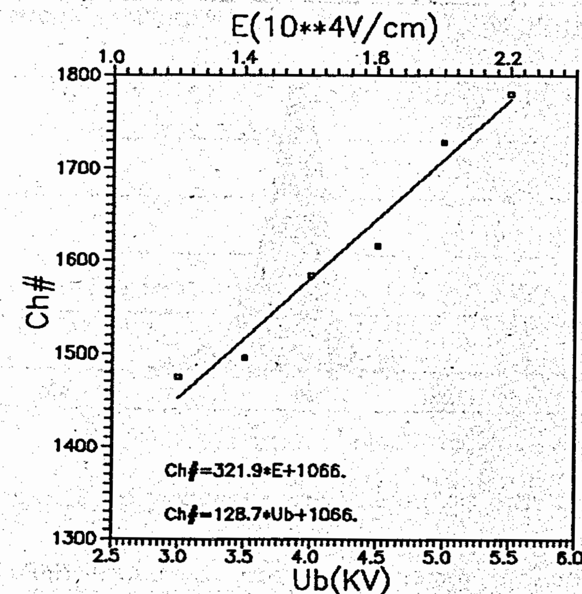

Fig. 6. The anode signal amplitude versus the back cathode potential. Ub=3.5 KV, Ust=525 V.

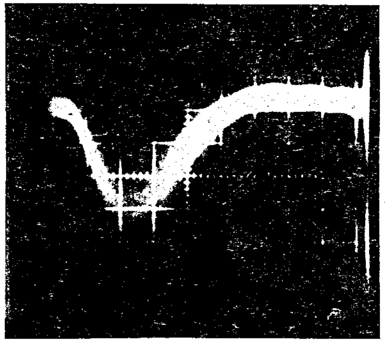

Fig. 7. The signal from the back cathode. Ust=630 V, Um=2.5 KV, Ub=5 KV.Horizontal 20 ns/cm, vertical 100 mV/cm.

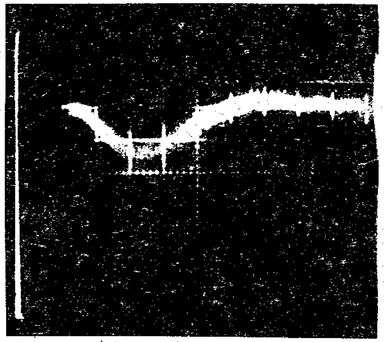

Fig. 8. The signal from the front cathode. Ust=630 V, Um=2.5 KV, Ub=5 KV.Horizontal 20 ns/cm, vertical 50 mV/cm.

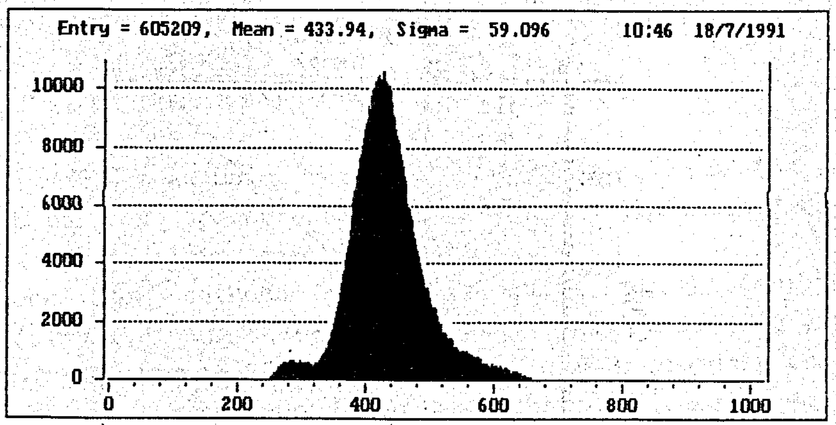

Fig. 9. The pulse height spectrum of 55-Fe source.

corresponding dependence for a usual MWPC with 2 mm gap between the signal wires; taken from /7/. In our case for the microstrip detector we have obtained the 20% decreasing

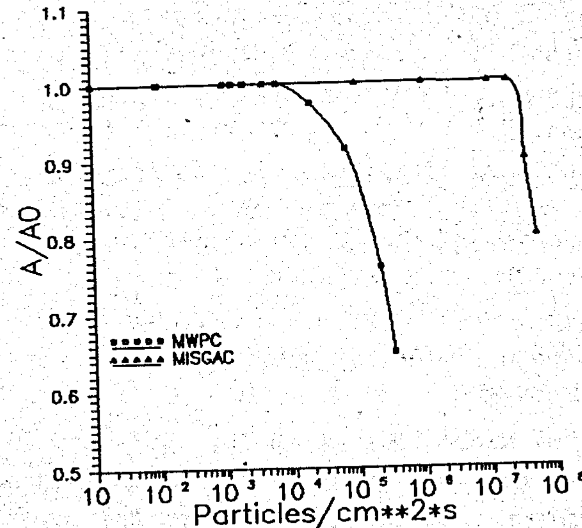

Fig. 10. The relative signal amplitude versus the incoming flux for a standard MWPC and microstrip detector. For the microstrip detector was used 8 KeV X-rays.

of the signal amplitude for the flux of $5*10^7$ particle/(s*cm^2) of 8 KeV X-ray.

Conclusions

The microstrip detectors seem to become very useful in the near future by the following reasons:

a) good time response;

b) high rate capability;

c) the precision of industrial detector production allows as it seem to us to construct quite simple elements at high accuracy in big detecting systems;

d) the ability to get, in a simple way, information about the second coordinate of the tracks, but with the relatively low precision.

We note that the photolitography method does not provide a good quality of microstrip electrode. The electrode defects can lead to burning up of the strips. Thus it is necessary to make microstrip electrodes via a high quality technology method.

Comparing the sensibility of microstrip and silicon detectors shows that the first may be better. The ratio of the registered charges Qst and Qsi is given by the expression:

$$Qst/Qsi = Nst * Hst * G / (Nsi * Hsi),$$

where G is the microstrip gas gain, Hst and Hsi are the thicknesses of the gas gap in mm and the sensitive silicon layer in mkm respectively, Nst and Nsi are the mean numbers of primary electron-ion pairs in 1 mm of gas and electron-hole pairs in 1 mkm of silicon for minimum ionizing particles respectively. For $G=2*10^4$, Hsi=200 mkm, Nsi=103 and Nst=8 for Argon or Nst=30 for Xenon we have Qst = 8*Hst*Qsi or Qst=30*Hst*Qsi respectively.

The authors wish to thank Dr.N.I.Zamiatin and Dr. A.B.Ivanov for their help during our work.

References

1. A.Oed, Nucl. Instr. and Meth., A263 (1988) 351.
2. F.Angelini et al., Nucl. Instr. and Meth., A283 (1989) 755.
3. F.Udo, Proseedings of the Large Hadron Collider Workshop, Aahen (1990), CERN 90-10, v. III, p. 219.
4. F.Angelini et al.,Proseedings of the Large Hadron Collider Workshop, Aahen (1990), CERN 90-10, v. III, p. 222.
5. F.Sauli, Proseedings of the Large Hadron Collider Workshop, Aahen (1990), CERN 90-10, v. III, p. 485.
6. H.Stahl et al.,Nucl.Instr.and Meth., A297 (1990) 95.
7. F.Angelini et al, Particle World, vol.1, No 3, 1990, p. 85.

Received by Publishing Department
on August 22, 1991.

Бычков В.Н. и др. E1-91-390
Некоторые характеристики микростриповой газовой камеры

Разработана и исследована микростриповая газовая позиционно-чувствительная камера. Рассмотрена конструкция и приведены основные характеристики детектора. Газовое усиление детектора достигает $6\cdot10^4$, энергетическое разрешение-около 20% для гамма-квантов с энергией 6 КэВ.

Работа выполнена в Лаборатории сверхвысоких энергий ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1991

Bychkov V.N. et al. E1-91-390
Some Characteristics of the Microstrip Gas Chamber

The microstrip position-sensitive gas chamber was constructed and investigated. The construction was considered and main characteristics of the detector were given in this article. The gas gain of this detector is $6\cdot10^4$, the energy resolution is over 20% for the 6 KeV X-ray.

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

Preprint of the Joint Institute for Nuclear Research. Dubna 1991