

DEVELOPMENT OF HIGH GRANULATED STRAW CHAMBERS OF LARGE SIZES

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We have developed the baseline design for the straw drift tube tracking detectors for high-rate environment application. The low-mass inner straw elements and the technology of the multianode straws assembly were devised and checked. The prototype chamber was constructed and studied. The granularity of similar chambers can be reduced to 1 cm².

Разработана конструкция трекового детектора на основе тонкостенных дрейфовых трубок (строу) для работы в условиях высоких нагрузок. Разработаны и исследованы внутренние элементы строу, обладающие малой массой. Также разработана технология сборки многоанодных строу. Создана и исследована прототипная строу-камера, показано, что гранулированность таких детекторов может быть уменьшена до 1 см².

PACS: 29.40.Gx

INTRODUCTION

Drift chambers on the basis of thin-walled drift tubes (straw) are widely used as track detectors especially in the high-rate environment [1–4]. The transition radiation tracker of the ATLAS Inner Detector [2] is a good example of the above applying the straw with the diameter of 4 mm and the length of ~ 40 and 150 cm for End-Cap and Barrel detectors, correspondingly. The tracker of the spectrometer COMPASS uses the straw with the diameter of ~ 9.6 mm for periphery of the chambers and 6 mm diameter for the central area, the sensitive length of the straw is to 325 cm. Granularity of the central area of the COMPASS chambers is equal to ~ 192 and ~ 76 cm² for the small part of the area near the beam hole in them. Each straw is read out from one end and the occupancy in each tube below 2% at maximum beam rates for the intensities about $2 \cdot 10^8$ muons and up to $4 \cdot 10^7$ hadrons per 5.1 s spill for muon and hadron beams, respectively. The expected rate for the Barrel TRT straws is about 17 MHz at the luminosity $L = 10^{34}$ cm⁻²·s⁻¹. To reduce the straw occupancy by 2 times, the Barrel straws consist of two electrically isolated anode parts [2, 5]. The read-out is performed independently of each part of the anode from two ends for each straw.

In the set-up CBM GSI under construction the expected rate is about 140 kHz/cm² for Au–Au collisions at 25A GeV with the reaction rate of 10 MHz [6]. To provide a small value of the occupancy for the track detectors of large area, their granularity should be several cm².

Using the straw chambers with the anode read-out will result in strong growing of this value in case of long straws. For the case when the detector is a set of small modules with the short straws there will be not only a low ratio of the sensitive area to the overall detector dimensions but also an increase of its average radiation thickness because of the external module frames.

A principle opportunity of constructing straw with three electrically isolated parts of its anode and read-out for the both straw ends from its end-plugs, and for the central anode segment — through the straw wall — has been earlier shown [5]. Construction of the big length straw with a multisegmented anode providing independent read-out from the electrically independent segments, allows one to obtain the necessary occupancy over all the area of the large-size detector by optimizing the segmented lengths.

The development of the low-mass read-out links for the inner anode segments, using new technologies, should result in preserving a minimal value of the straw detector radiation thickness in comparison with well-known coordinate detectors. Highly granulated coordinate straw detectors of large area having small radiation thickness and high radiation hardness, should be interesting for the CBM GSI, upgraded of the LHC detectors and construction of detectors for ILC.

Below there are some results of the first prototype made at JINR with multisegmented anodes for the straws 4 mm in diameter.

1. CONCEPT OF THE STRAW WITH A MULTISEGMENTED ANODE

To construct two segmented anodes, a stand has been developed at JINR as well as methods of their manufacturing [7]. Two anode wires separated from each other by an isolated gap, are fused into a glass capillary tube 6 or 7 mm length, 0.25 mm in outer diameter and 0.1 mm of inner diameter (Fig. 1). The mass of the boronsilicate capillary tube is 0.094 mg per 1 mm of its length.

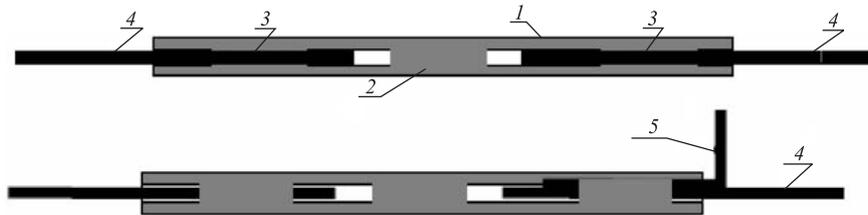


Fig. 1. Capillary tubes: capillary tube (1), isolation gap (2), molten location of wire (3). Anode wire (4) and additional contact wire (5) are the gilded tungsten wires in $30\ \mu\text{m}$ of diameter

The bottom part of figure shows an opportunity to fuse the additional wire and anode wire together in the capillary tube, for the galvanic contact to this segment for the read-out.

A concept of manufacturing straws having a segmented anode is demonstrated with an example of the straw with three anode segments (Fig. 2). A multisegmented anode assembled beforehand, is put into the straw and fixed at the ends. The read-out from the end anode segments is carried out from the straw end plugs. The information from the middle segment is read out over the contact wire going through the spacer supporting the capillary tube and

the hole in the straw wall. To compare the signals going through the straw wall and its end plugs, the right anode segment is equipped with two read-out outputs 3 and 4.

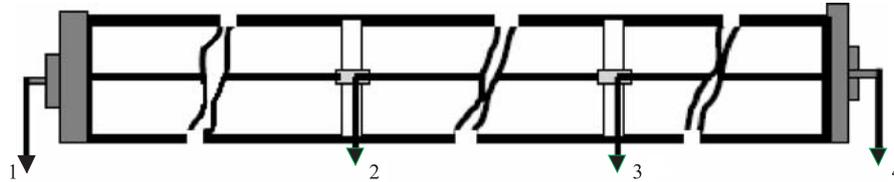


Fig. 2. Straw 4 mm in diameter contains three anode segments. From the left and middle segments the read-out is from the output 1 and 2, correspondingly. From the right segment the read-out can be performed either from the output 3 or 4

When assembling the segmented anodes some capillary tubes are combined with the specialized polycarbonate spacers, forming «assembly units» (Fig. 3), without preventing the passage of the gas mixture along the straw. The anodes are installed into the straws under tension of 70 g, the contact wires cross some holes in the spacers and are taken out through windows of the sizes $\sim 2 \times 2$ mm in the corresponding places of the straw walls. After testing over all read-out channels, each window of the straws is gas tightly closed. High voltage can be applied to the straw anodes as well as onto the cathodes in dependence on the read-out scheme from the straws.

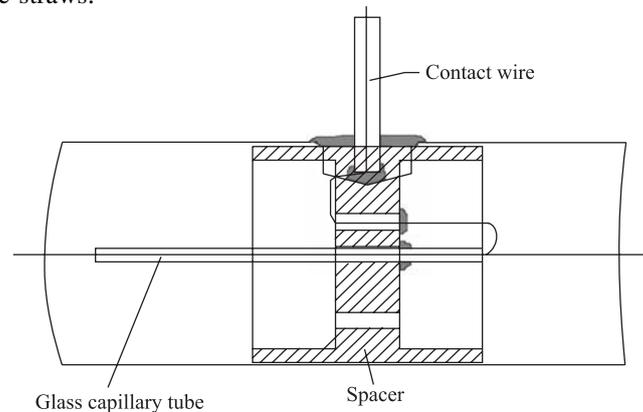


Fig. 3. Schematic of the spacer unit in the straw 4 mm in diameter

Several analogous straws shown in Fig. 2, have been assembled and tested. Three anode segments of these straws had a length of ~ 185 , 100 and 180 mm. The straw under testing was blown through with gas mixture ArCO_2 (70/30) and irradiated by the ^{55}Fe source through the slit collimator placed perpendicularly to the straw anode. The width of the gamma quiant beam in the median straw plane was ~ 1 mm. High voltage was given to the corresponding anode segment. The current amplifier with the input resistance of 300Ω and the sensitivity threshold of 750 eV was connected directly to the segment output through the capacitor of 200 pf. The test of straw durability to gas has shown the absence of gas leakages. Figure 4 demonstrates the general layout of straw.



Fig. 4. Straw 4 mm in diameter and about 465 mm long with three anode segments

Figure 5 shows values of the amplitudes being registered from the corresponding signal segments. The collimator was moved along the straw, for the right segment the signal amplitudes were measured in each position of the collimator from the 3 and 4 outputs by turns. The voltage precision on the anode was better than 1 V, the amplitude was measured with one and the same amplifier placed near the outputs 1, 2, 3 and 4 (Fig. 2).

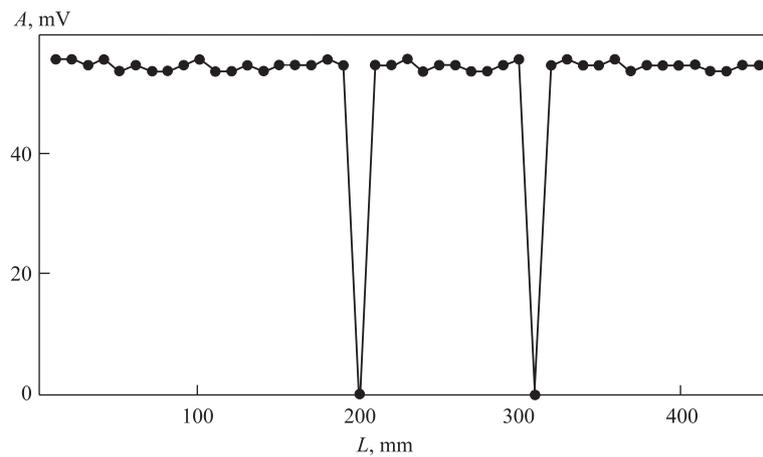


Fig. 5. Signal homogeneity along the straw at the fixed voltage and gas mixture

A small slope of the dependence can be explained by the direction of the gas mixture flow. An average deviation of the signal amplitudes D defined with the expression

$$D = 2(A_{\max} - A_{\min}) / (A_{\text{in}} + A_{\text{out}})$$

is not more than 3%. Values A_{\max} , A_{\min} — maximal and minimal signal amplitudes for the straw, and A_{in} and A_{out} are the signal amplitudes at the beginning and at the end of the straw along the direction of the gas mixture flow. Scanning of the spacer units length by using the collimated source, has shown that inefficient straw length is 7.2 mm when using a capillary tube 7 mm long, and a spacer 4.15 mm long and 3.95 mm in diameter. The radiation thickness of these straw lengths is not more than 0.4% X_0 for each. Figure 6 demonstrates inefficiency in the spacer unit area.

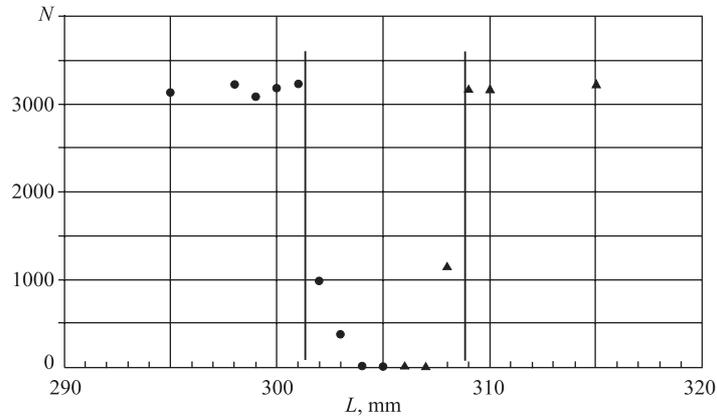


Fig. 6. Straw inefficiency on its length in the spacer unit length

Checking of the individual straws with 3 anode sectors has shown their good operation using the gas mixture of ArCO₂ in the range of the gas gain till 10⁵, and no discharges were observed between any elements placed under the anode-cathode potentials.

2. DETECTOR PROTOTYPE

To check a real opportunity of manufacturing the straw detectors with a big number of the anode segments, the prototype was made from 19 straws 50 cm long and 4 mm in diameter. The prototype consists of 2 straw layers and neighbouring straws of the layer were glued between themselves. Figure 7 shows the common view of the prototype.

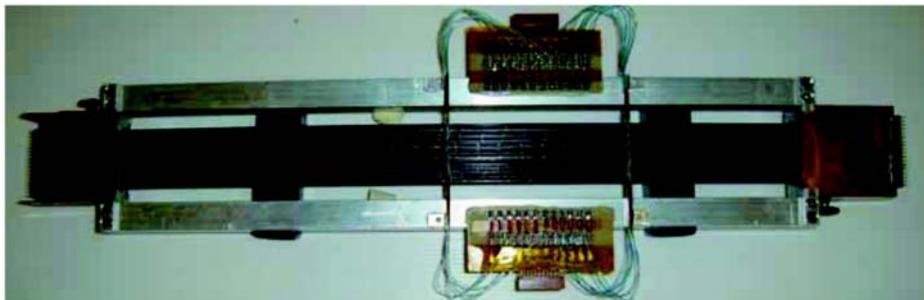


Fig. 7. The common view of the prototype with nineteen straws ~ 500 mm long and 4 mm in diameter

Four segmented anodes were installed into 10 straws of the top layer (Fig. 7), from nine straws of the second layer five straws had usual one-segmented anodes and four straws contained three-segmented anodes. The prototype with 19 straws had totally 57 read-out channels. Figure 8 shows the electrical scheme of the upper layer straws. The voltage onto the edge anode sectors of the both layers straws is given from the H/V bus via resistors 1 MΩ

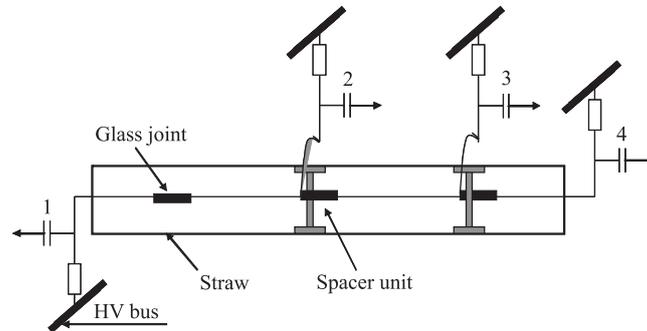


Fig. 8. The read-out scheme from the straw segments

to the crimping in the end-plugs anode wires, signals through the capacitors are transferred to the connectors 1 and 4 placed nearby. Signals from the middle segments are given to the connections 2 and 3 by using the contact wires of about 15 cm long. Resistance of the contact points between the anode and contact wires do not influence the registered signals due to their small values (Fig. 9).

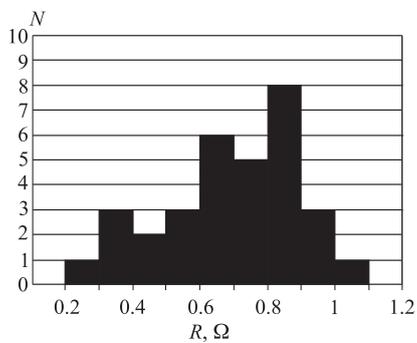


Fig. 9. Contact resistance in the capillary tube between the anode and contact wires

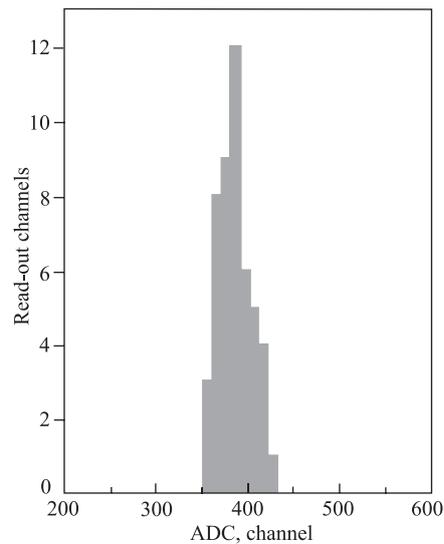


Fig. 10. Distribution of the registered signals for the prototype segments. The γ -source is ^{55}Fe . Gas gain — $2 \cdot 10^4$

Tests over the prototype over all registration channels have shown good signal identity at identical parameters of high voltage, environment temperature and partial pressure of the gas mixture (Fig. 10).

CONCLUSIONS

The fulfilled studies have shown an opportunity of assembling multisegmented anodes, their installation into the straw with the followed output of the contact wires through the

straw walls, the preliminary check of the read-out channels with the necessary changing of the wrong-working anodes and next gas tight closing the straws. The results are very promising and the study is needed to be continued.

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Received on November 14, 2006.