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DETERMINATION OF THE ANODE WIRE POSITION IN A NEW TIPE OF STRAW USING VISIBLE LIGHT

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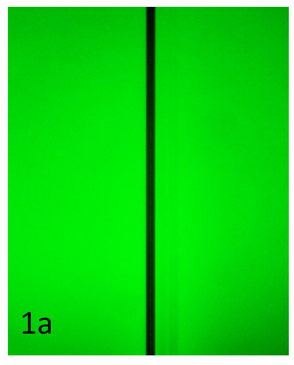
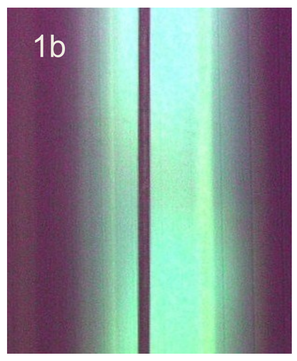
Introduction

Spatial resolution of charged particle tracks in drift chamber experiments depends on several factors and among them, accuracy of anode wire positioning and spacing in the tubes is one of the significant. Therefore, it is important to measure the real position of anode wires in a chamber. When the anode wire cannot be seen, a radioactive or an X-ray source is used [1-3]. Devices based on these methods are rather complicated.

We propose a simpler way to control the coordinates of the anode wires in a new type of the drift tubes used in the drift chambers operating in vacuum for the NA62 experiment (A total of 8000 tubes [4,5].). These are made from the 36-mm Mylar film ultrasonic weld along the generatrix with 9.80 mm in diameter and covered with 0.05 μm of copper and 0.02 μm of gold from inside. The anode was a 30-μm wire of gilded tungsten.





The walls of these tubes turned out to be semitransparent. Under visible light illumination anode wires are well seen through a microscope and thus their positions can be measured while moving the chamber or the microscope. This fact allowed us to develop a relatively simple method for measuring coordinates of anode wires in drift chambers with these tubes. Positions of wires in tubes and consequently anode spacing can be directly measured under the microscope with an accuracy of 10 μm. Wires are observed under transmitted or reflected light. Figures at right shows an image of the Ø30 μm anode wire inside a drift tube obtained under transmitted light (1a) and reflected light (1b).

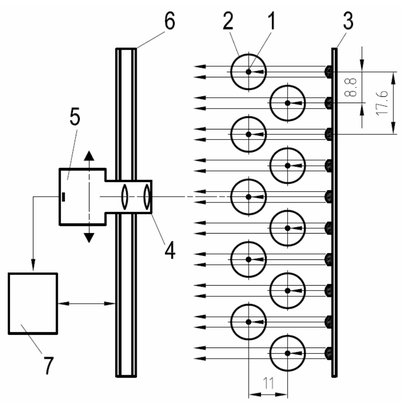
The method and results of measurements

Fig. 2a and 2b show the schemes of setups we used for determining the position of the wires in the tubes **under transmitted and reflected light**. It consists of a microscope and a chamber mockup with tubes mounted on a common support. The two-row arrangement of the tubes and their spacing were exactly the same as in the drift chamber for the NA62 experiment.

An extended light source like a LED matrix placed behind the row of tubes was used for transmitted light (Fig. 1a). Each LED illuminates its own wire through the tube wall. This permits to move only the microscope and simplifies the setup.

Microscope should have a magnifying power of 40-70^{x}, working length of ~30-70 мм, and maximum possible depth of focus. The microscope moves along a row of tubes perpendicular to them in one plane with the LED matrix in the direction shown by the arrows in the figure. The operator reads the wire image coordinates either directly or with the aid of the electronic ocular. It is desirable to read coordinates of both wire image edges to increase the measurement accuracy. This will allow calibration against the known wire diameter to be performed and the accuracy of the determination of the wire center coordinate to be increased.

We performed two independent series of measurements using the **UIM-23** and the **MBS-10** microscope. UIM-23 microscope allows moving and measuring an object with an accuracy of 1 μm, but the actual measurement accuracy depends on how the operator brings the microscope cross hair into coincidence with the wire image edges.



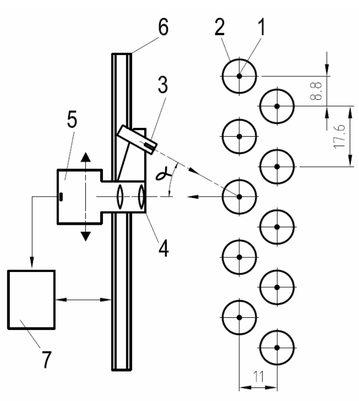
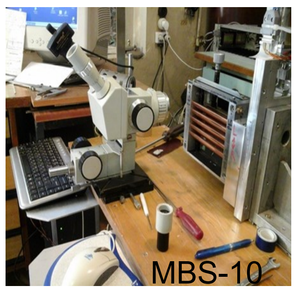
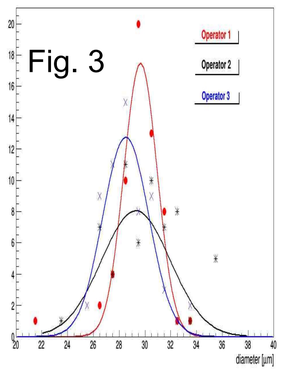


Fig. 2. Setup for measuring the wire position under transmitted (a) reflected light (b). (1) Anode wire, (2) drift tube, (3) extended LED light source, (4) microscope, (5) electronic ocular, (6) optical bench, (7) control PC.

To minimize systematic errors, three operators performed measurements for both ends of the wire. In each measurement the microscope cross hair was successively brought into coincidence with the two wire image edges and both coordinates were read. Their difference gave the calibration value of the known wire diameter 30 μm, distributions see in Fig. 3. Their average gave a more accurate coordinate of the wire center. The results of those measurements yielded the diameter value **29.2±2.0 μm**, which we think to be quite acceptable.





Measurements should be performed in at least two separate planes to determine directions of particular wires. We performed measurements in three planes along the tubes. The measurements in the middle of the wires can be considered control ones. The thus obtained coordinates allow determining both linearity of the wires and the distance between them. At each travel step of 17.6 mm we measured the deviation of the anode wire from the cross hair. The final results of measuring the anode spacing are summarized in Table 1 and 2. The accuracy of our wire position measurements is about ±5 to ±10 μm, which is quite sufficient in many practical cases. A comparison of the data in the tables shows good agreement of two independent measurements within the error, which proves applicability of the method.

Table 1

One row anode wires inter distance

Top			Bottom		
Average	Sigma (σ)	МБС-10	Average	Sigma (σ)	МБС-10
UIM-23			UIM-1		
17.648	0.003	17.650	17.574	0.023	17.575
17.654	0.002	17.675	17.627	0.003	17.631
17.598	0.002	17.606	17.612	0.004	17.625
17.601	0.001	17.613	17.621	0.002	17.628
17.710	0.006	17.712	17.578	0.004	17.576
17.572	0.004	17.588	17.603	0.003	17.618
17.594	0.004	17.594	17.622	0.005	17.632
17.580	0.014	17.94	17.556	0.005	17.575

Table 2

Two rows anode wires Inter dIstance

Top		Bottom	
Average	Sigma (σ)	Average	Sigma (σ)
UIM-23		UIM-23	
8.903	0.013	8.890	0.016
8.745	0.011	8.683	0.018
8.966	0.013	8.894	0.018
8.689	0.014	8.732	0.017
8.884	0.012	8.879	0.021
8.715	0.013	8.741	0.018
8.879	0.014	8.881	0.014
8.722	0.014	8.740	0.012
8.859	0.014	8.816	0.016
8.818	**0.003**	**8.806**	**0.016**

Results obtained under reflected light

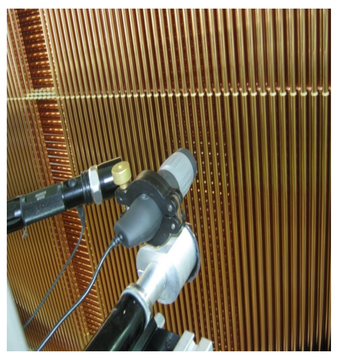
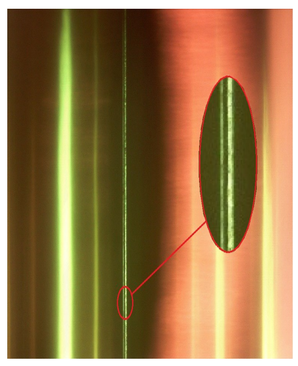


Fig. 2b shows the scheme of setup we used for determining the position of the wires in the tubes under reflected light. The microscope and the light source are on the same side of the tube plane. These measurements were performed directly at a module of the chamber for the NA62 experiment. But only wires in the tubes of the first row were measured. The results of the measurements are presented in plotted in Fig. 4. Difference between actual and nominal wire position for 97 straws is shown in Fig.4a. Deviation of anode wire distribution with σ= 48 μm are presented in Fig. 4b. Main part of wire deviation is inside ±100 μm corridor that satisfies requirements of NA62 Experiment.



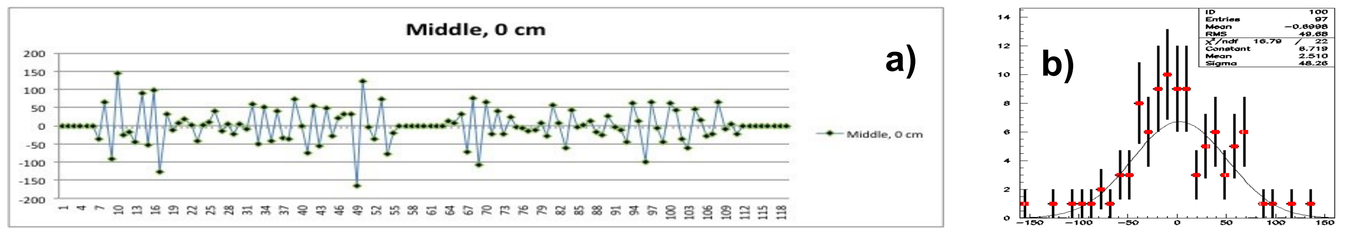


Fig.4. Deviation anode wire from it nominal position (a) and distribution (b).

Conclusion

It is shown that in the thin-wall tubes of the new type, which turned out to be semitransparent for visible light, the positions of the anode wires in the chamber can be measured under transmitted or reflected light with an accuracy of ±5 to ±10 μm using an optical microscope. It should be stressed that reflected-light measurements are performed with the microscope and the light source located on the same side of the tube plane, which is especially helpful when the tubes cannot be illuminated from the opposite side.

This method is applicable in other cases as well, e.g., for determining the shift of the wire under the effect of the electric field when high voltage is supplied to the tube or, when tubes are arranged in one row, for simultaneously measuring the wire position in general and relative to the ends of the tube. In this case, a wide light source should be used which is capable of illuminating the tube over its entire width.

An electronic ocular and an image recognition program can allow the coordinates of the wire ends to be automatically read when the wire passes through the microscope cross hair. Almost the entire process can be automated except the referencing of the coordinates to the chamber body and the aiming of the microscope at the wire. This will help improve the measurement accuracy and eliminate systematic errors as the operator brings the microscope cross hair into coincidence with the wire image edges.

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