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CONSTRUCTION AND TEST OF A PROTOTYPE OF A SEGMENTED STRAW TUBE

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Abstract

We have realized a prototype of a segmented straw tube with the intention to use it with straight straws in order to reconstruct particle trajectories in three dimensions.
The basic idea is that of using the information of the "curved" straws, to allow the determination of the space coordinate along the wires of the straight tubes. To realize this project we started with the construction of a single-tube prototype made of linear segments of straw inscribed in a circle.
We report here the details of the construction of the prototype, together with some preliminary tests.

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1 – INTRODUCTION

In high-energy physics experiments, straw tubes are widely used as tracking detectors. Basically, they are single channel drift chambers that allow good spatial resolution in two dimensions. In order to reduce single tube inefficiencies and to resolve left-right ambiguity, they are normally arranged in staggered double layers (see Fig. 1).

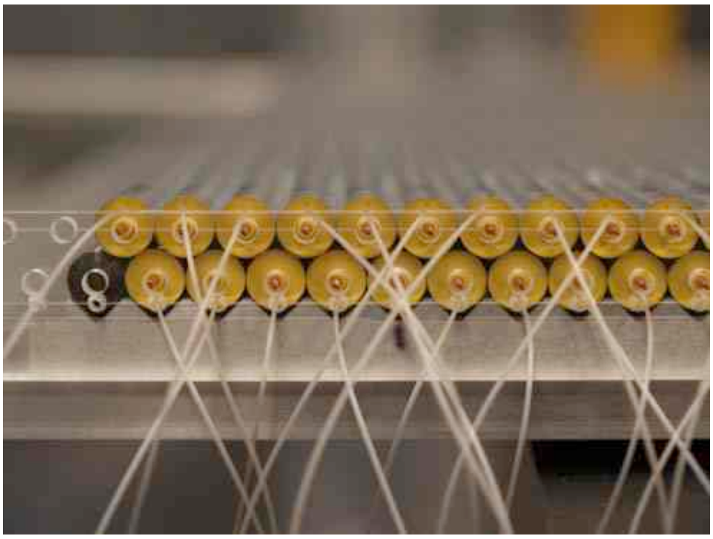

Fig. 1. Straw tubes arranged in a double-layer.

To have a full stereo picture of the events, one has also to measure the third coordinate, i.e. the distance of the track along the anode wire. One solution adopted to solve this problem is that of mounting some layers of straws with a skew angle with respect to the detector axis. A typical example of such an arrangement is the FINUDA straw tube tracker [1]. Here an axial double-layer of straw tubes is followed by two stereo double-layers inclined, with respect to the z-axis, of ± 13^{O}.

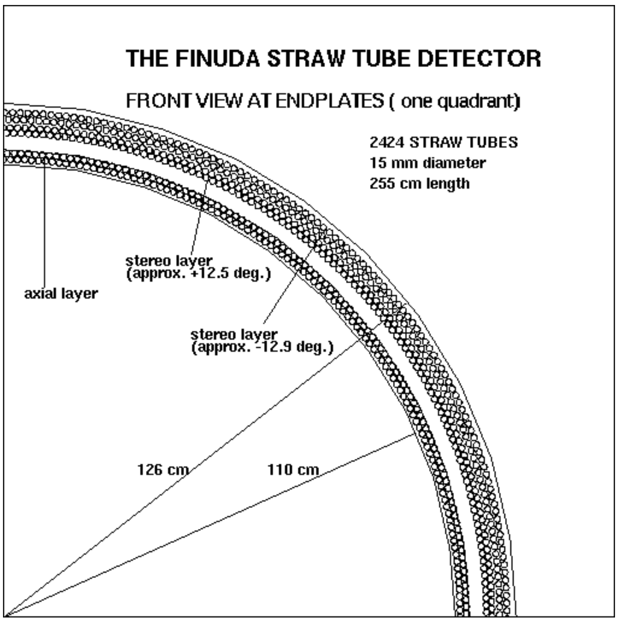

Fig. 2. Layout of the FINUDA straw tube tracker.

Stereo layers impose some complications to the mechanics of the detector; therefore, we decided to test an alternative solution based on segmented modules.

Our idea is that of covering the circular surface of an axial straw tube detector, with an array of segmented straws (see Fig. 3).

In the following sections we report the details of the construction, and of the starting operation, of the first segmented straw tube.

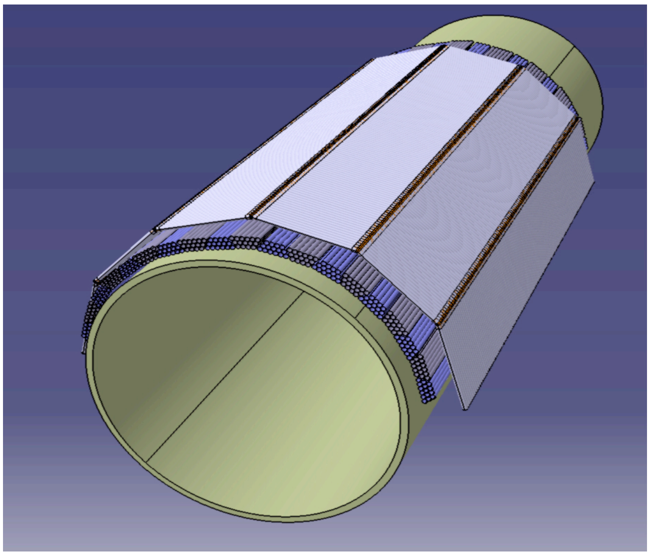

Fig. 3. A possible detector layout with axial straw modules and segmented straw modules.

2 – PROTOTYPE CONSTRUCTION

Our first goal was that of demonstrating that a curved straw tube can be constructed and operated. We chose to use straw tubes with a diameter of 6 mm made of two layers: the external one was aluminized Mylar and the internal one was Kapton carbon loaded [2]. The anode used was a gold-plated 6%, tungsten wire with 3% rhenium and a diameter of 25µm [3].

To sustain the "curved" straw tube we used a mechanical semi-circular frame realized by the LNF mechanical workshop (see Fig. 4). We used also plastic end-plugs and angular joints, realized with the stereo-litography prototyping technique by an external company [4]. The end-plugs closed the tubes at both ends and housed Cu gold-plated pins. The pins are needed to fix the anode wire and to allow the electronics connection. Furthermore, through the end-plugs, we realized gas in-let and out-let. The gas mixture chosen for the tests was Ar-CO_2 (80-20).

Fig. 4. First prototype of a segmented straw tube. The straw tube is mounted on a mechanical frame to allow a safe handling.

To build the prototype we cut 6 pieces, 20 mm long, of straws. Then we glued the plastic angular joints to the mechanical structure with a cyanoacrylate based fast-acting adhesives. After cyanoacrylate hardening the joints were painted with a conducting glue and the straw pieces were fixed on them. The use of the conductive glue is necessary to assure conductivity to the whole cathode and to have the same grounding in the whole tube. At the two ends of the curved straw we put end-plugs to fix it to the frame and also to keep the anode wire at the tube center.

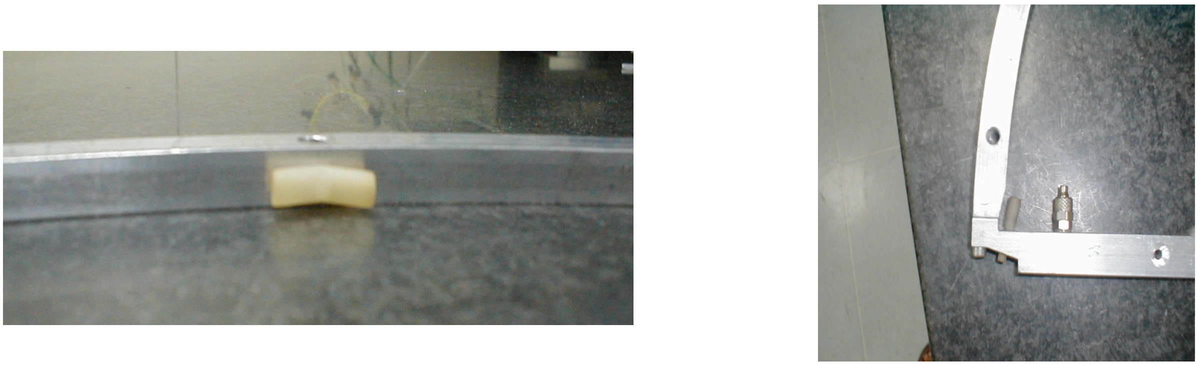

Fig. 5. The plastic joint (left) used to connect straw pieces, and the end-plug fixed to the mechanical frame (right).

A small hole (diameter 0.5 mm) has been realized in the end-plugs to allow gas flowing inside the tube. Fig. 5 shows pictures of a plastic joint (right) and of an end-plug (left).

To insert the anode wire, we fixed it to a pilot steel wire of 100 μm diameter and we shut it inside the curved straw using a compressed-air pistol. The plastic joint has been realized in such a way that the wire is centered inside the tube by means of a v-shaped support (see Fig. 6) located in the middle of it.

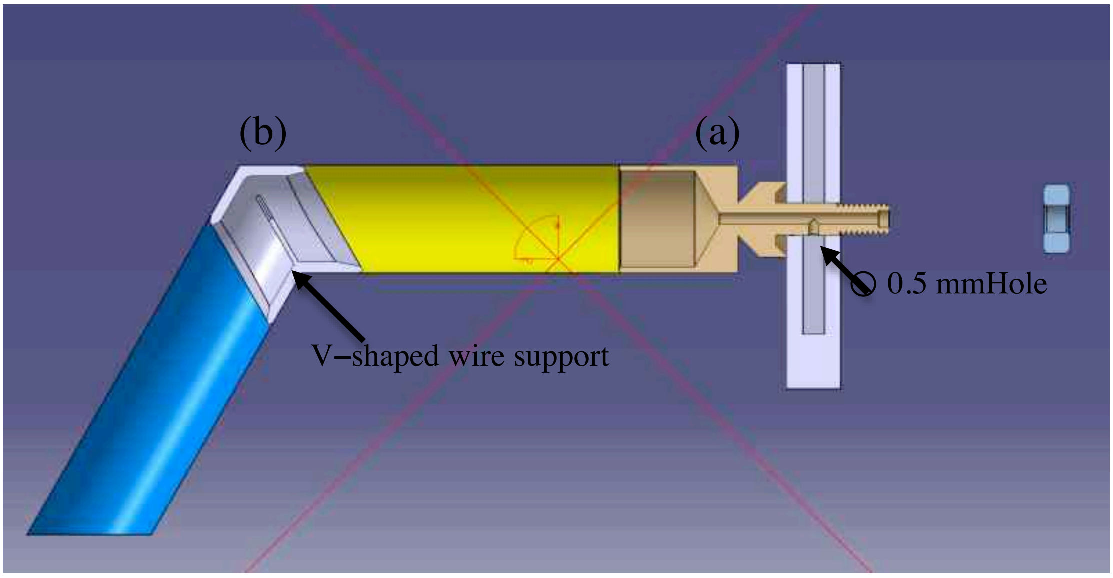

Fig. 6. Sections of the straw end-plug (a) and of the plastic joint (b).

At the two ends of the wire we crimped copper gold-plated pins. The wire is tensioned with 50g.

After the wire fixation, the gas mixture was fluxed inside, and the straw tube was then tested for possible gas leaks.

After the leakage test we connected the segmented straw to a trans-impedance preamplifier, realized by LNF electronics service for the FINUDA straw tube detector [4], whose characteristics are reported in Table 1.

TABLE – 1 Main characteristics of the trans-impedance preamplifier

Input impedance	300 Ω
Gain	2mV/μA
Charge gain	20-60
Dynamic range	2V
Rise time	2 ns
Needed voltages	± 6V
Power consumption	50 mW

This allowed also to set the anode wire to a proper positive high voltage value. In fact, the pre-amp PCB also houses a high voltage feeding system.

We then prepared a cosmic ray test bench made of two plastic scintillator detectors placed above and below the curved straw tube, respectively.

The coincidence of the two scintillators was used to trigger on cosmic rays traversing the straw. Fig. 7 shows the counting rate of the tube as a function of the high voltage applied to the anode wire. After a first rising of the counting rate, a plateau region is reached. The working point of the straw tube has been fixed within the plateau region to 1600 V.

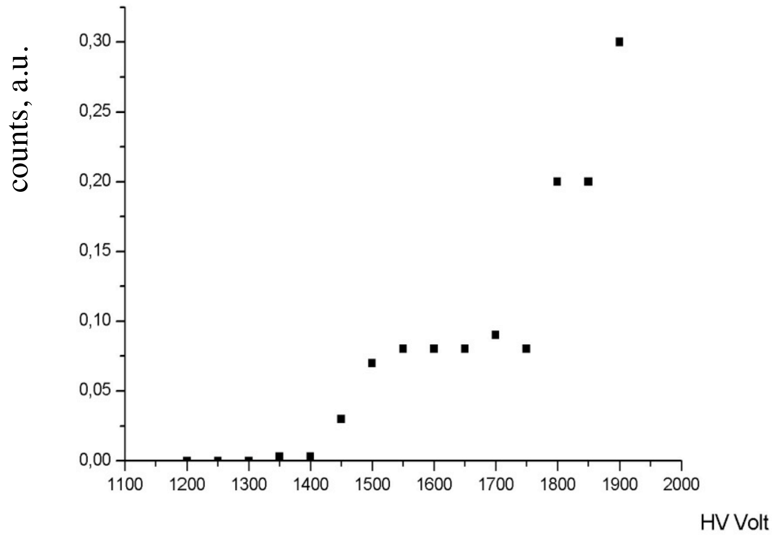

Figure 7. Straw tube counting rate (arbitrary units) as a function of the high voltage (see text for more details).

The electronics chain connected to the straw tube is illustrated in Fig.8.

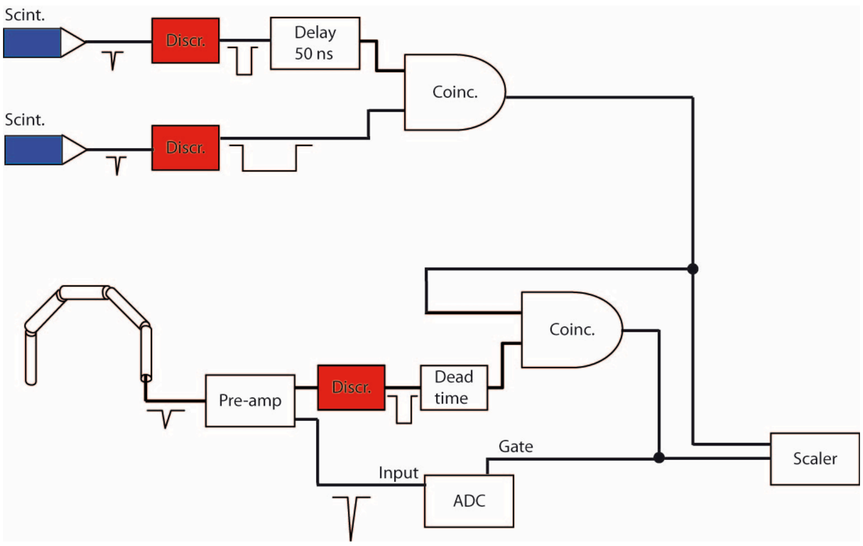

Fig. 8 Electronics chain for the tests on the “curved” straw tube.

With this electronics layout we were also able to integrate the charge collected by the straw tube when a cosmic ray crossed it.

We performed two sets of measurements:

1. the scintillator detectors are placed on the straw segment close to the preamplifier (near-end);
2. the scintillator detectors are placed on the straw segment far from the preamplifier (far-end).

The ADC spectra collected for the near-end and the far-end are shown in Figure 9 and 10.

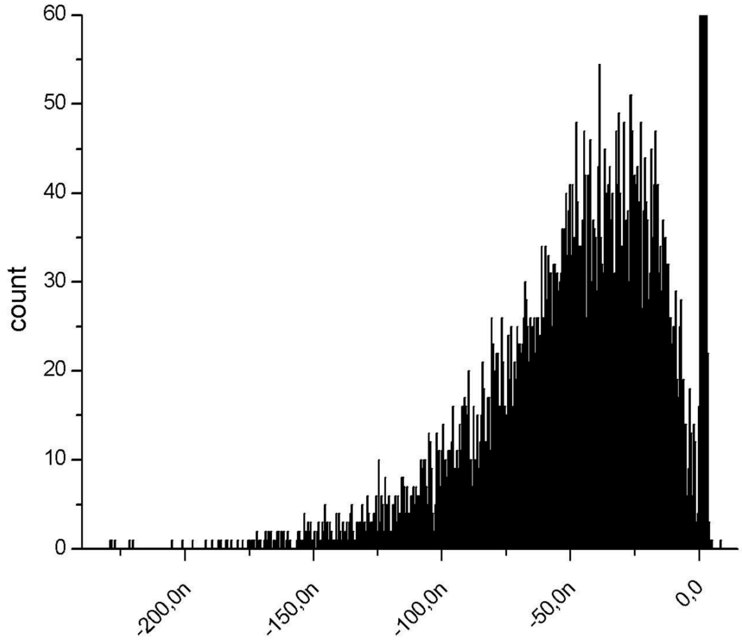

Fig. 9. ADC spectrum of cosmic rays crossing the straw segment close to the amplifier (near-end).

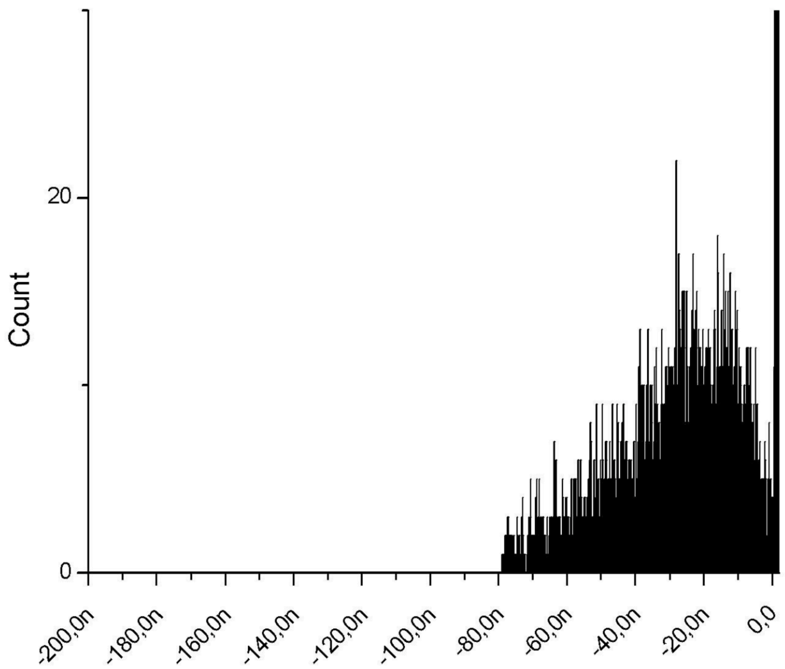

Fig. 10. ADC spectrum of cosmic rays crossing the straw segment far from the amplifier (far-end).

The plots show that the collected charge at both ends is similar. There is just an attenuation due to the transmission line as observed in straight straw tubes.

3 – CONCLUSIONS

We setup a technique to assemble for the first time a segmented straw tube. The preliminary tests performed with cosmic rays on the “curved” tube shows promising results.

Next steps will be the construction of a module of curved tubes made of 10 elements glued together. In this way we could avoid the external mechanical frame.

4 – ACKNOWLEDGEMENTS

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