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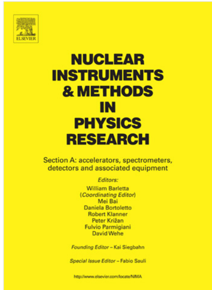

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Analysis and study of the problems on the wires used in the MEG CDCH and the construction of the new drift chamber

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Abstract

In the MEG II detector, the measurement of the momentum of the charged particle is performed by a high transparency single volume, full stereo cylindrical Drift Chamber (CDCH). It is composed by 9 concentric layers, each consisting of 192 drift cells. The single drift cell is approximately squared, with a 20 μm gold plate tungsten sense wire surrounded by 40 μm/50 μm silver plated aluminum field wires in a ratio of 5:1. During the construction of the first CDCH, we observed the breaking of about hundred cathode wires: 97 of these were 40 μm aluminum wires, while 10 were 50 μm wires. Since the number of broken cathodes is less than 1% of the total, one can expect the influence on the track reconstruction efficiency to be not so dramatic. We verified by means of simulations that the loss of one cathode does not change the cell electric field appreciably. Here we present the results of the analysis of the effects of mechanical stress and chemical corrosion observed on these broken wires. Finally, we show the studies carried out on new wires to overcome the weaknesses found and the process that will be used for the construction of the new drift chamber (CDCH2). It will be built with the same modular technique, as for the previous one, the use of the wiring robot will be optimised to improve some weaker step in the procedure, new wires will be adopted with a 25% thicker diameter, which has very little effects on the resolution and efficiency of the detector. Furthermore these wires are made with a manufacturing process different from that used previously.

Keywords: gas detector
2010 MSC: 00-01, 99-00

1. The cylindrical Drift Chamber (CDCH)

The Cylindrical Drift CHamber of the MEG II experiment (CDCH) [1, 2] is unique volume low-mass full stereo drift chamber . The inner radius is 17 cm to sweep low energy e^+ out of the sensitive volume and the outer radius is 29 cm to fully cover 52.8 MeV/c signal e^+.
The CDCH (Figure 1) is composed by 9 concentric layers, divided in 12 identical sectors, each covering 30° and 16 drift cells wide. Each layer consists of two criss-crossing field wire planes enclosing a sense wire plane at alternating sign stereo angles with respect to contiguous layers for a precise reconstruction of the longitudinal coordinate. The single drift cell is approximately squared, with a linear size between 6 mm to 8 mm wide, a 20 μm Au-plated W sense wire surrounded by 40/50 μm Ag-plated Al field wires in a 5:1 ratio. For equalizing the gain of the innermost and outermost layers, two layers of 50 μm Ag-plated Al guard wires have been added at proper radii and HV. The total number of wires amounts to 11904 for an equivalent radiation length per e$^+$ track turn of $\approx 1.5 \times 10^{-3}$ X$_0$ when the chamber is filled with 90:10 He/i-C_4H_{10} gas mixture + additives to improve the operational stability: 1.5% isopropyl alcohol + 0.5% Oxygen.[3].

2. Wires used

The wires used in the CDCH were produced in several 4-inch spools by the California Fine Wire (CFW) company [4]. Starting from wires with a diameter higher than hundreds of microns, they carry out various drawing stages which reduce the diameter of the wire to 55 μm. A final step, called the ultra-finishing procedure, is used for reaching the wire correct dimensions.

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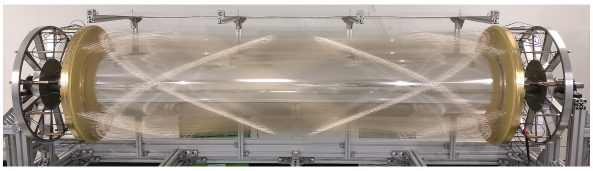

Figure 1: The MEG II drift chamber. The drift chamber is still mounted on the assembly structure in the clean room, the two carbon fiber support half-shells are not yet mounted

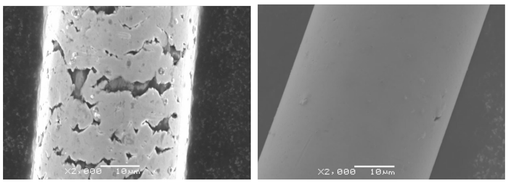

Figure 2: SEM image showing the difference in the Ag coating of silver plated aluminum wires. Several cracks on a 40 μm wire are visible on the left, while a normal 50 μm wire is shown on the right.

The initial drawing procedure is only effective for wire diameters larger than 50 μm therefore ultra-finishing is unavoidable for 40 μm wires but not for 50 μm wires. Ag coating (needed for our method of fixing the wires) is performed by electrochemical deposition before the ultra finishing stage, therefore this coating is exposed to a mechanical stress which can produce localized cracks (Figure 2 for a 40 μm wire on the left and for 50 μm wire on the right). The fabrication procedure of the MEG II wires was chosen so that their plastic region was as small as possible to avoid the plastic deformation of the wires (due to a possible extra elongation) which could lead to possible electrical short circuits when the chamber is powered. In Figure 3 we show an Energy Dispersive X-ray Analysis (EDX) analysis on a 50 μm wire, one can see the main component is the silver coating with small traces of aluminum because the EDX beam analyzes under the external surface.

3. Investigations on wire breakages

During the construction of the first CDCH, we observed the breaking of a hundred cathode wires: of these, 97 are 40 μm aluminum wires while 10 are 50 μm wires. Since the number of broken cathodes is less than 1% of the total, one can expect the influence on the track reconstruction efficiency to be not so dramatic. However, these wires must be removed to avoid areas of the CDCH which must be turned off due to short circuits.

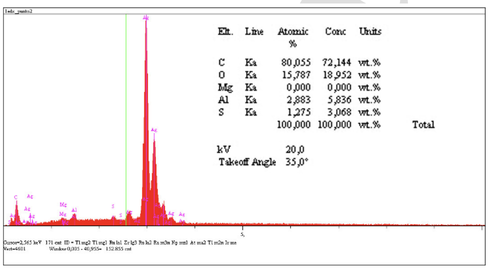

Figure 3: EDX analysis (Energy Dispersive X-ray Analysis) on a 50 μ wire

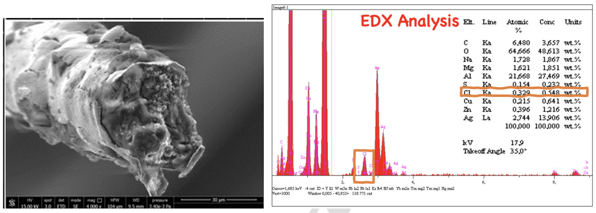

Figure 4: SEM image showing the corrosion point of a 40 μm wire on the left and EDX analisys on right.

From the Scanning Electron Microscope (SEM) images (Figure 2) one can see cracks and discontinuities on the silver coating, making the aluminum core of the wire clearly visible. An analysis of the chemical composition sometimes shows the presence of elements not strictly related to the aluminum or silver alloys used for wire fabrication; traces of chlorine and other halogen elements are measured in some cases. These observations favour wire breakages induced by the development of corrosion processes in the aluminum alloy (Figure 4) , under the silver coating [5]. At room temperature, the onset of corrosion processes requires the presence of water or water vapour condensed on the aluminum surface. A humid environment is then the natural scenario in which the corrosion can start and proceed. Nevertheless, the water vapour is by itself sufficient to produce corrosion processes on aluminum alloys, since hydrogen ions are easily liberated by water dissociation and formation of aluminum oxide. The cracks in the silver coating are particularly dangerous, since they expose the aluminum alloy to the environmental relative humidity. The galvanic coupling between silver and aluminum and the presence of a large percentage of magnesium in the aluminum alloy 5056 used for wire fabrication make possible a rapid and severe corrosion attack in localized regions close to the cracks.

4. Conclusion

After several analyses carried out and considering different wires, we decided to use new wires, evaluating the pros and cons for the costruction of the new CDCH. The final decision about the wire characteristics is still in progress, the possible choices are 50 μm Ag-coated Al wires in which the ultra-finishing step is avoided and 50 μm pure Al wires (soldering plus glue). We are doing tests to understand the best solution to avoid problems. The wiring robot [6] has been transferred from Lecce to Pisa and is ready to be operated.

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Highlights

The highlights for our paper ""NIMA_PROCEEDINGS−D−22−00278 -Analysis and study of the problems on the wires used in the MEG CDCH and the construction of the new drift chamber." can be:

- Brief description of the MEG CDCH;
- Analysis and study of the problems on the wires used in the MEG CDCH;
- Analysis and study of the problems on the wires used in the MEG CDCH;
- The construction of the new MEG CDCH;
- Behavior of the wires used in the CDCH in the presence of humidity;
- Chemical and SEM analysis of the wires used in the CDCH;