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

A. M. Baldini[c], G. Cavoto[a,b], F. Cei[c,d], G. Chiarello[c], M. Chiappini[c], A. Corvaglia[e], M. Francesconi[c,d], L. Galli[c], F. Grancagnolo[e], M. Grassi[c], H. Benmansour [c,d], D. Nicolò[a,b], M. Panareo[e,f], A. Papa[c,d,g], F. Raffaelli[c], F. Renga[a,b], G. Signorelli[a], G. F. Tassielli[e,f], B.Vitali [a,b], C. Voena[a]

(a) INFN Sezione di Roma1, Italy; (b) Dipartimento di Fisica dell'Università "Sapienza", Roma, Ital;y (c) INFN Sezione di Pisa, Italy; (d) Dipartimento di Fisica dell'Università di Pisa, Italy; (e) INFN Sezione di Lecce, Italy; (f) Dipartimento di Matematica e Fisica dell'Università del Salento,, Lecce, Italy; (g) Paul Scherrer Institut (PSI), Villigen, Switzerland

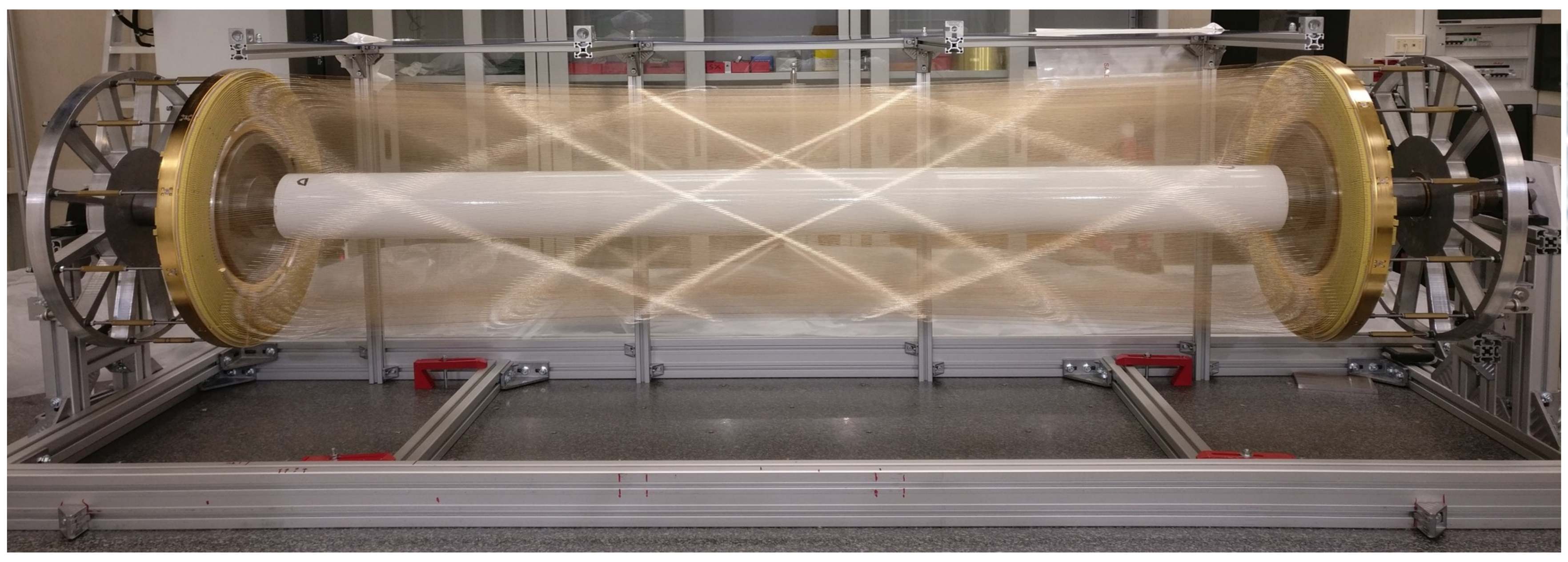
for information and details contact: gianluigi.chiarello@infn.it

Abstract

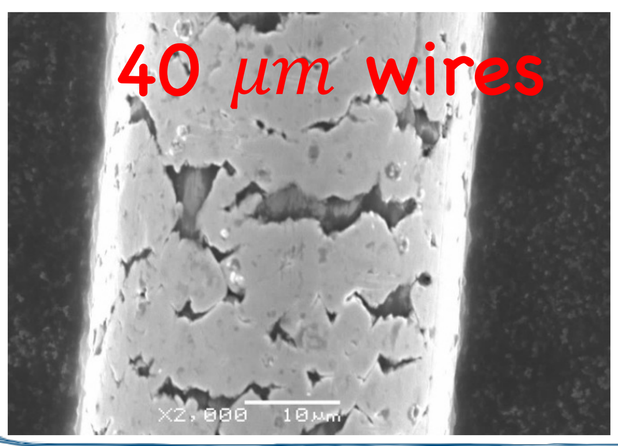
In the MEG II detector, the measurement of the momentum of the charged particle is performed by a high transparency single volume, full stereo cylindrical Drift Chamber (CDCH). It is composed of 9 concentric layers, each consisting of 192 drift cells. The single drift cell is approximately square, with a 20 μm gold plated W sense wire surrounded 40 μm/50 μm silver plated Al field wires in a ratio of 5:1. During the construction of the first CDCH, we had 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. We verified by means of simulations that the loss of one cathode does not change the cell electric field appreciably. We present the results of the analysis of the effects of mechanical stress and chemical corrosion observed on these broken wires and a simple empirical model that relates the number of broken wires to their exposure time to atmospheric relative humidity and their mechanical tension. Finally we will show the study 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 first, the wiring robot will be used by improving some weak points and using new wires with a diameter of 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 their used previously.

The cylindrical Drift Chamber (CDCH)

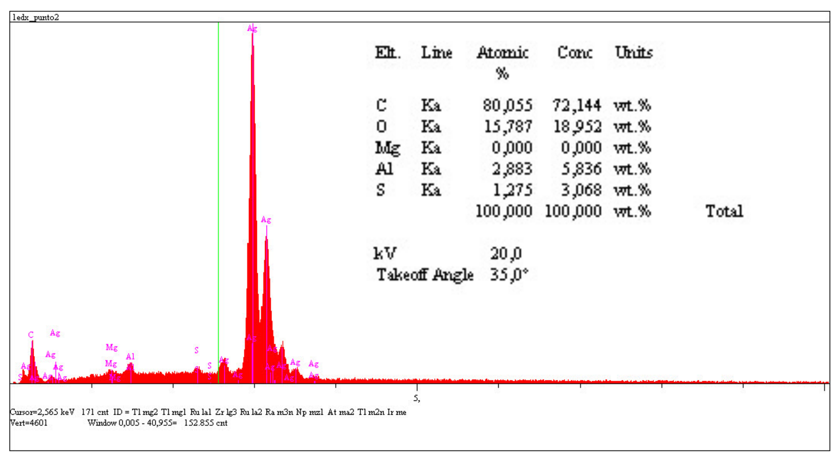
- Low-mass single volume detector with high granularity filled with $He:iC_4H_{10}$ 90:10 gas mixture + additives to improve the operational stability: 1.5% isopropyl alcohol + 0.5% Oxygen
  - 9 concentric layers of 192 drift cells defined by 11904 wires
  - Small cells few mm wide: occupancy of ≈1.5 MHz/cell (center)
- Total radiation length $1.5\times10^{-3}\,X_0$: less than $2\times10^{-3}\,X_0$ of MEG DCH or ≈150 μm of Silicon
  - MCS minimization and γ background reduction (bremsstrahlung and Annihilation-In-Flight r used previously.

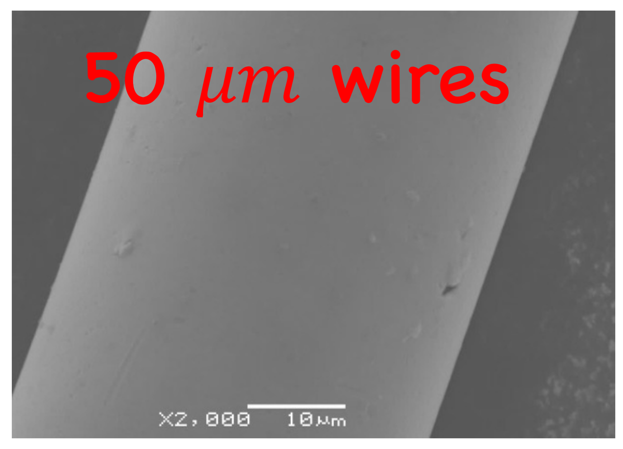


Wire used

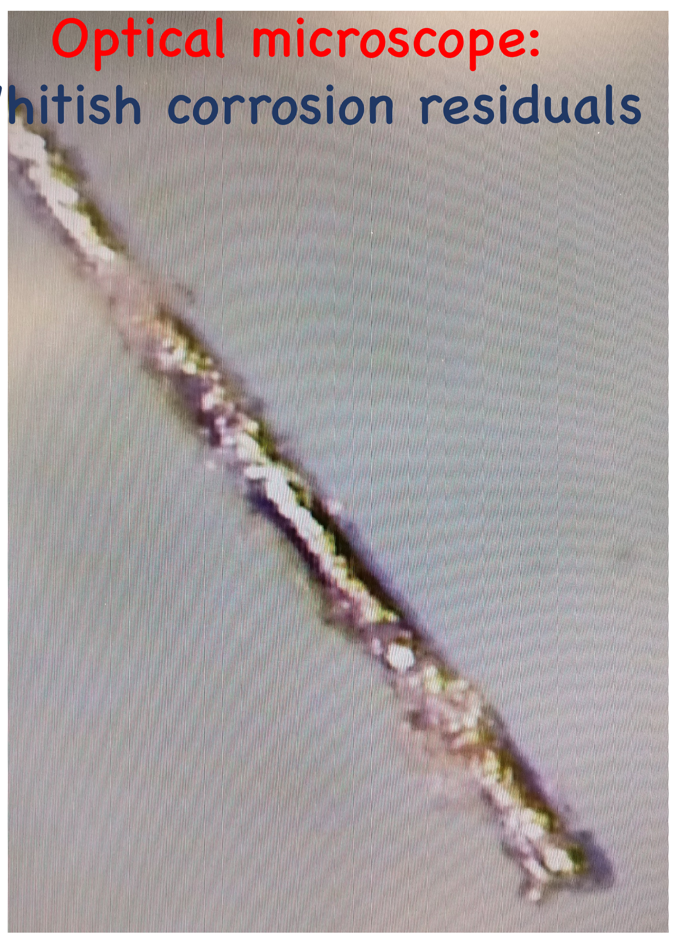


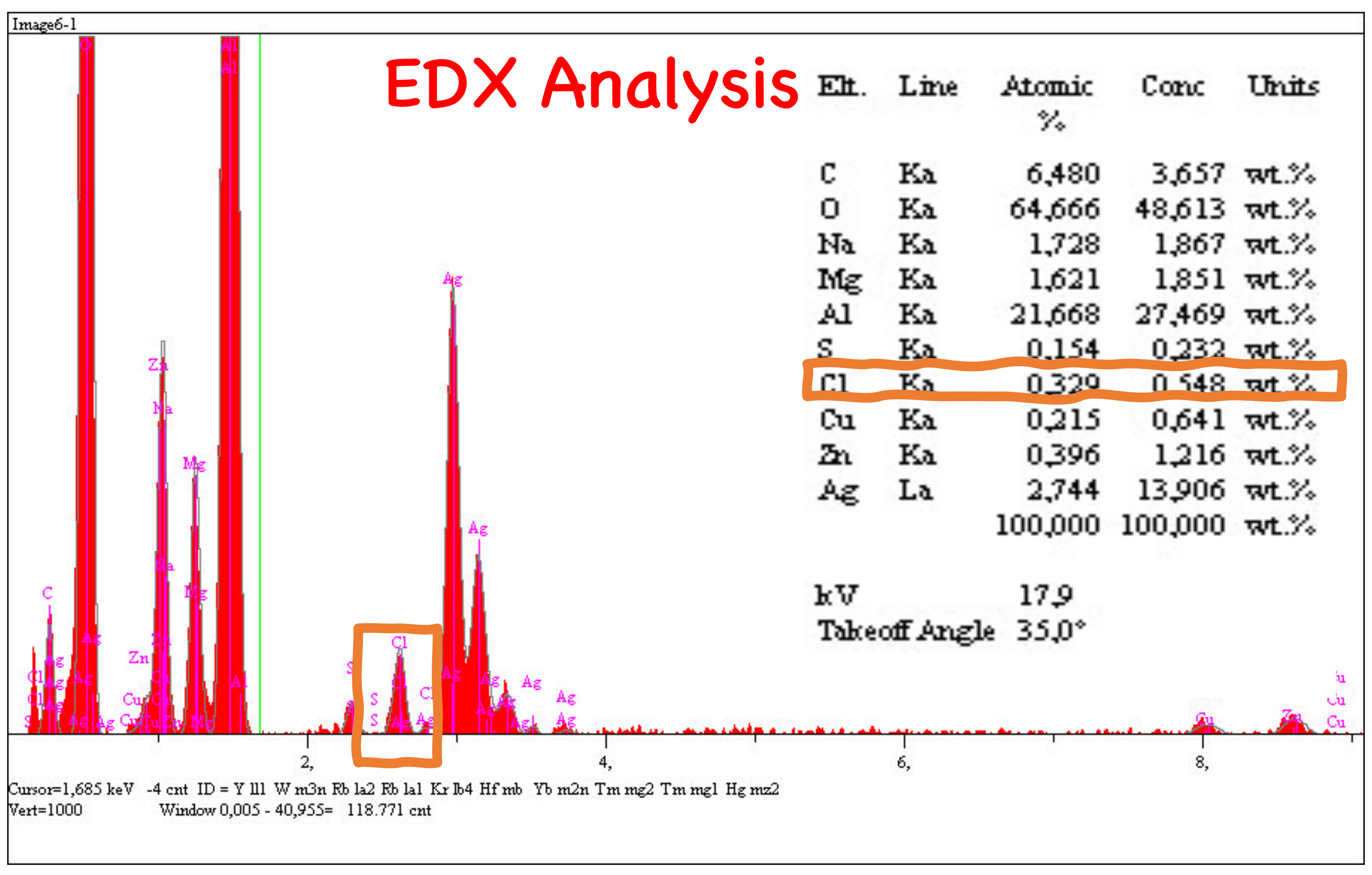
- The wires employed were produced in sets of several spools by the California Fine Wire
- The procedure consists of several stages which can be summarized:
  - First step : using an initial wire drawing procedure which decreases the wire diameter to 55 μm in several stages with plating.
  - Final step, called the ultra-finishing procedure, is used for reaching the design value of 40 μm or 50 μm.

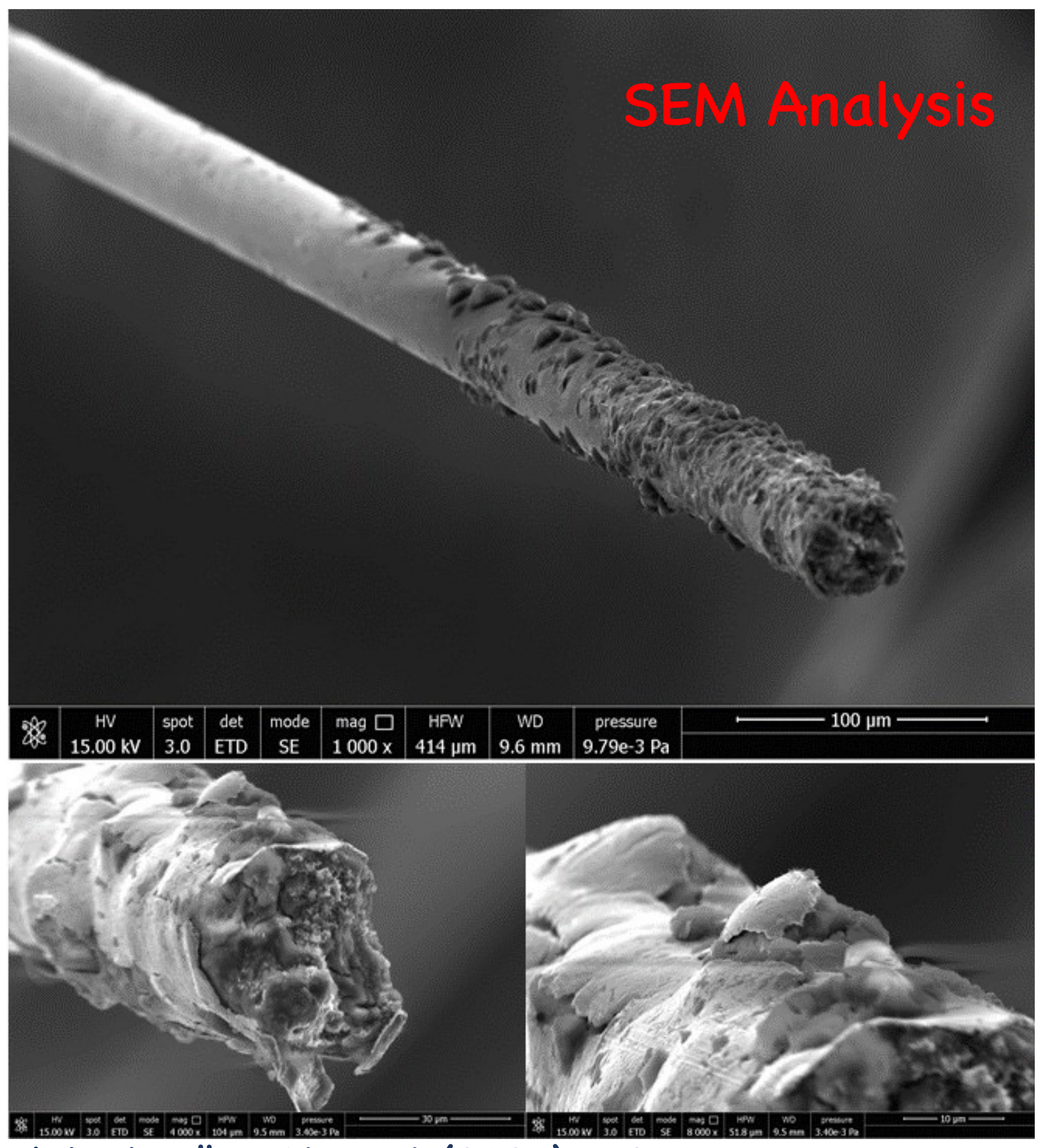




Investigations on wire breakages



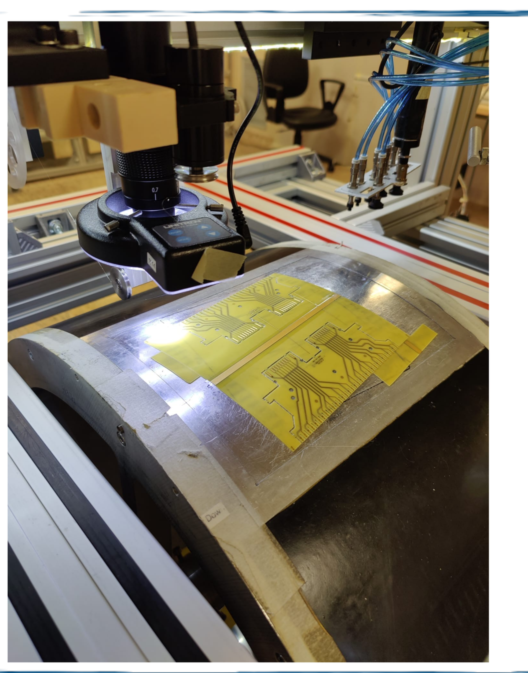




- Breakings due to corrosion of the aluminum wire core
  - Imply water as catalyst (Air moisture condensation inside cracks in the Ag coating)
- Found a good linear correlation between number of broken wires and exposure time to humidity
- The only way to stop the corrosion is to keep the wires in an inert atmosphere

For more information "Detailed analysis of chemical corrosion of ultra-thin wires used in drift chamber detectors", JINST 16 (2021) T12003.

Conclusion



- After several analyses carried out and considered different wires, we decided to use new wires with pros and cons for the CDCH2 (the choice is in progress):
  - 50 μm Ag-coated Al wires in which the ultra-finishing step is avoided
  - 50 μm pure Al wires (soldering plus glue)
- We are doing tests to understand the best wire to avoid problems
- The wiring robot has been transferred from Lecce to Pisa and is ready