A new construction technique of high granularity and high transparency Drift Chambers for modern High Energy Physics experiments

G. Chiarello[a,b], C. Chiri [a] , A. Corvaglia[a], F. Grancagnolo[a], A. Miccoli[a], M. Panareo[a,b], A. Pepino[a,b], C. Pinto[a,b], P. Primiceri[b], M. Spedicato[b], G.F. Tassielli[a,b]

(a) Istituto Nazionale di Fisica Nucleare, sez. Lecce, LECCE (Italy)
(b) Dipartimento Matematica e Fisica "Ennio De Giorgi", Università del Salento, Via Arnesano 73100 LECCE (Italy)

G. Cavoto[c], L. Recchia[c], F. Renga[c], C. Voena[c]

(c) Istituto Nazionale di Fisica Nucleare, sez. Roma-1, ROMA (Italy)

ABSTRACT

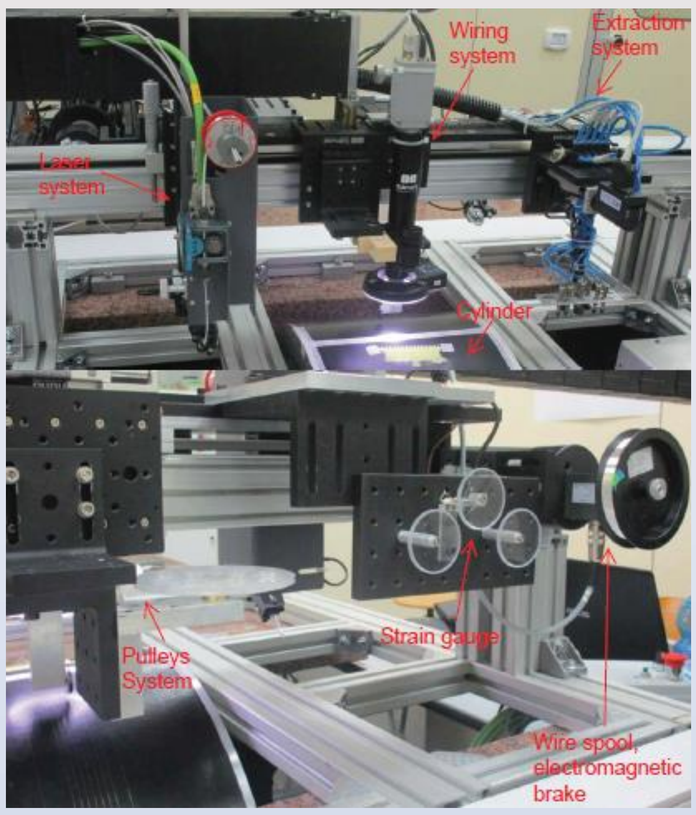
Modern experiments for the search of extremely rare processes require high resolutions (order of 50-200 keV/c) tracking systems for particle momenta in the range of 50-300 MeV/c, dominated by multiple scattering contributions. We present a newly developed construction technique for ultra-low mass Drift Chambers fulfilling this goal. It consists of:

- a semiautomatic wiring machine with a high degree of control over wire mechanical tensioning (better than 0.2g) and over wire positioning (of the order of 20μm) for simultaneous wiring of multi-wire layers;
- a contact-less IR laser soldering tool designed for a feed-through-less wire anchoring system;
- an automatic handling system for storing and transporting the multi-wire layers to be placed over the drift chamber end-plates.

These techniques have been successfully implemented at INFN-Lecce and University of Salento and are currently being used for the construction of Drift Chamber of the MEG (μ→e+γ) upgrade experiment.

The MEG upgrade Drift Chamber is a challenging apparatus made of 1920 20μm Au plated W sense wires, 2304 50μm and 7680 40μm Ag plated Al guard and field wires respectively, with a transvers wire density of about 8 wires/cm^2. Electrostatic stability considerations and the total length of the chamber, ~2m, require that all the different wires be stretched at mechanical tensions between 20-30g, controlled at a level of about 0.2g during all the different assembling stages. To fulfill this goal, we have developed two different and complementary measuring systems both designed to determine the wires first harmonic resonant frequency.

THE WIRING ROBOT



Wiring robot features:

- ~20 μm of accuracy on wire position;
- ability to wind continuously variable pitch and stereo angle configurations;
- settable wire tension (±0.2g);
- controlled soldering procedure to avoid the modification of mechanical property of the wire;
- all parts must work precisely and synchronized, the use of the real-time system is needed.

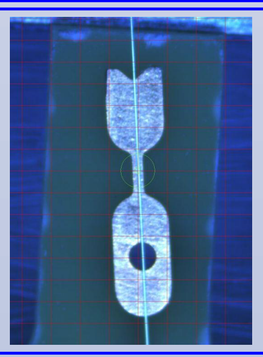
Wiring robot consists:

- a semiautomatic wiring machine to simultaneously wire the multi-wire layers with a high degree of control on the wire mechanical tension;
- an Infra Red (IR) laser soldering tool designed for contact-less welding;
- an automatic handling system to extract the multi-wire layers from the wiring system and to move them on support frames.

Winding procedure :

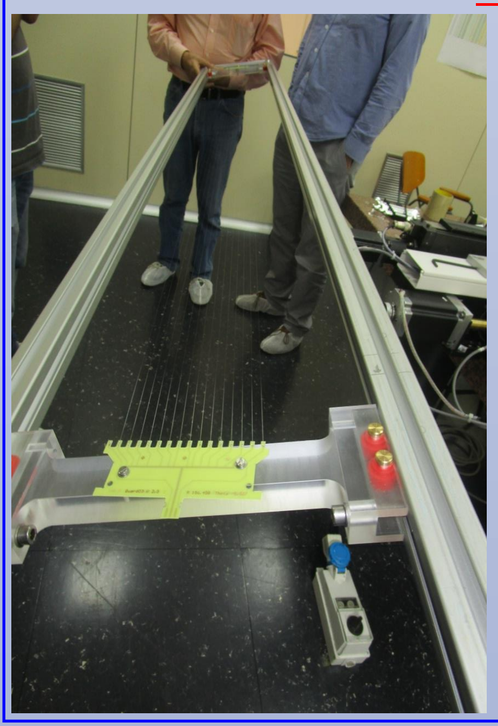
- insert the wire PCBs on the template of the cylinder;
- align the wire with the first pad and start the winding;
- start solder the wires on the wire pads;
- extract the multi-wire layer.

WIRE POSITIONING



The wires are placed on the PCB pads with a precision of about 20μm.
The 40μm Al wire is cantered on the 125μm pads connection strip.
During the whole winding process all the wires are well contained inside the central strip.

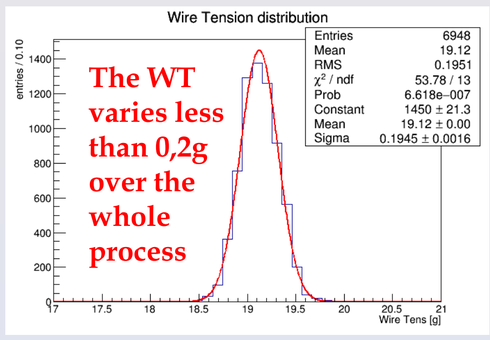
CONCLUSION

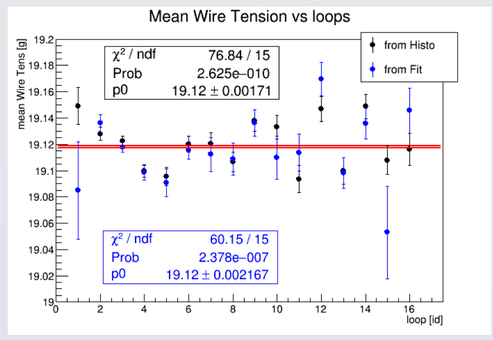


We have described a novel technique for wiring high granularity and high transparency drift chambers by using ultra-thin wires anchored with a feed-through-less strategy. It makes use of an automatic system for a precise positioning and for a well controlled and uniform mechanical tension of the wires. Moreover a contact-less IR laser soldering system is used to solder the wires without mechanical and overheating stresses. Two orthogonal systems to measure the 12000 wires resonant frequency have been developed.
These techniques are currently used for the construction of the Drift Chambers of the MEG upgrade experiment at PSI.

THE WIRE TENSION SYSTEM

The mechanical Wire Tension (WT) is set by an electromagnetic brake with an online feedback related to the strain gauge value.



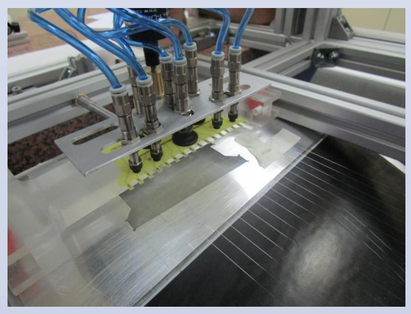


The mean WT per loop is stable better than 0.05g

CONTACT-LESS IR LASER SOLDERING

The soldering phase is accomplished by an IR laser soldering system (LASCON Hybrid) and a pattern matching software to find and place automatically the soldering system over a pad.

AUTOMATIC HANDLING SYSTEM



The wire PCB is lifted from the cylinder surface with a linear actuator connected to a vacuum system to operate suction and positioning.

WT CHECKING SYSTEM BY RESONANT FREQUENCY MEASUREMENT

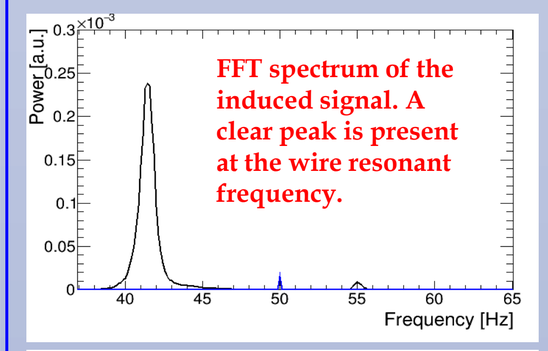
To monitor the WT of all the 12000 wires during the different assembling stages two independent systems were developed to measure the first harmonic resonant frequency of the wires:

An acoustic based system developed by INFN Roma-1 "Sapienza"

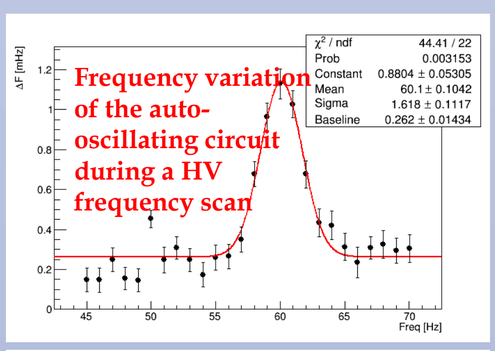
A periodic signal at a frequency related to the wire resonance is measured in the readout circuit by applying a HV difference between two adjacent wires and by using an acoustic source to excite the wires oscillation. This system has the ability of measuring simultaneously up to 16 wires.

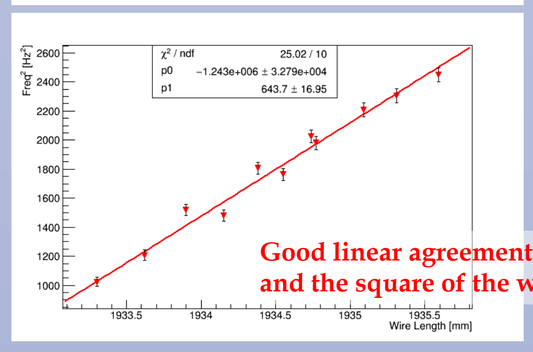
A sinusoidal HV based system developed by INFN Lecce

The wire oscillation is forced by applying a known frequency HV signal. The mutual capacitance variation between two adjacent wires is then measured during a HV frequency scan on an external auto oscillating circuit connected to the wires.

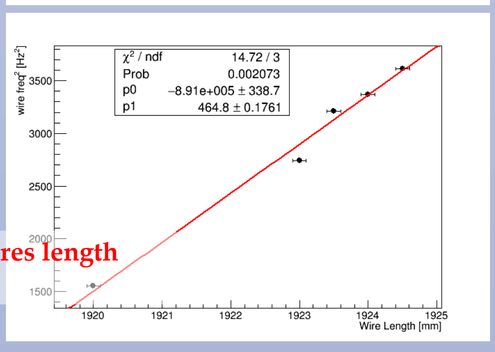


Examples of the resonant frequency measured for different wire tensions.





Measured frequency of different set of wires as function of the wires length.



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