ITracker Poster for XII Pisa Meeting 2012 (practice talk support slides)

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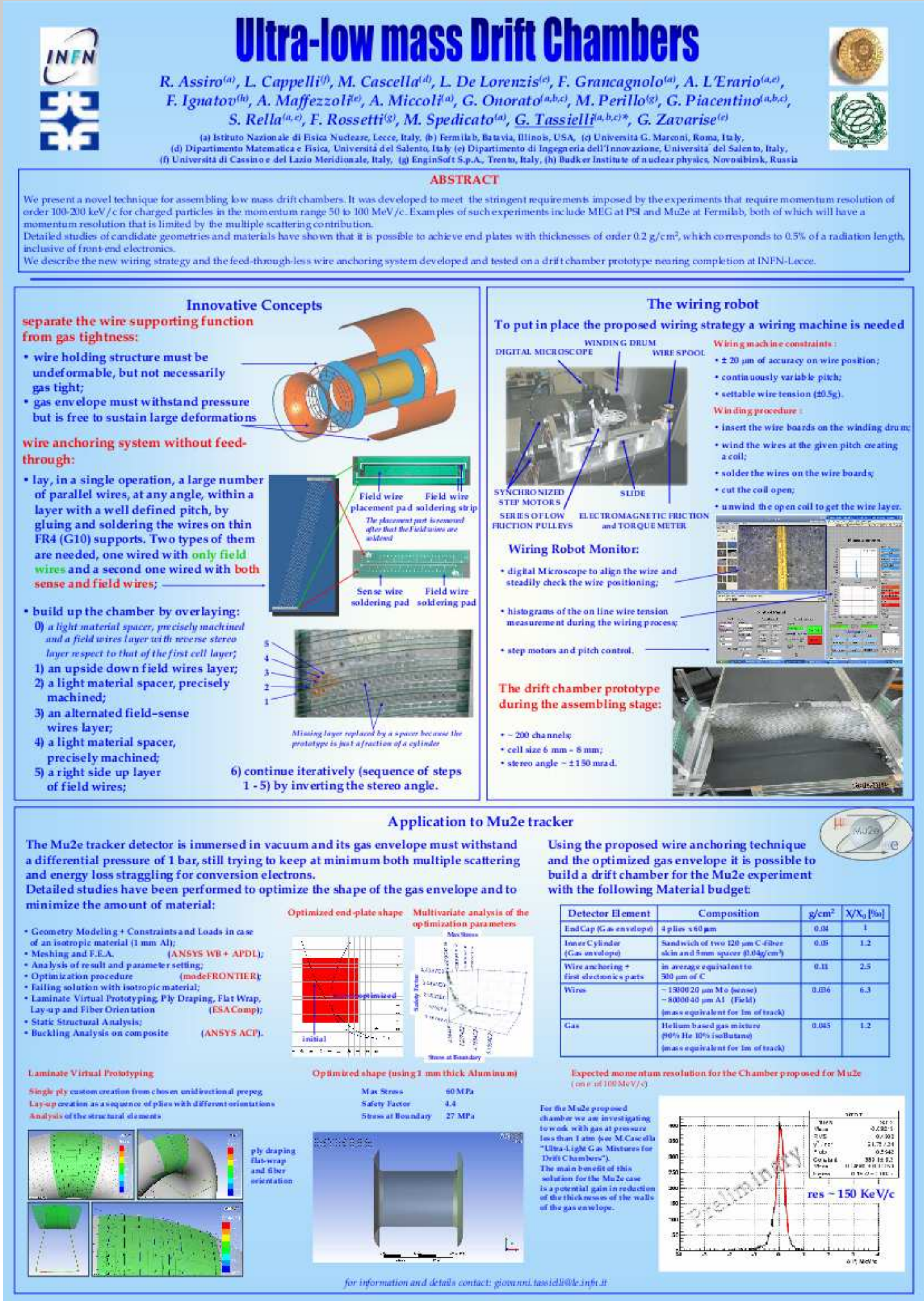
Layout

1. Title;
2. Abstract;
3. R&D: new way of building a Drift Chamber;
4. R&D: the building of a prototype;
5. proposal for the Mu2e tracker;



Ultra-low mass Drift Chambers

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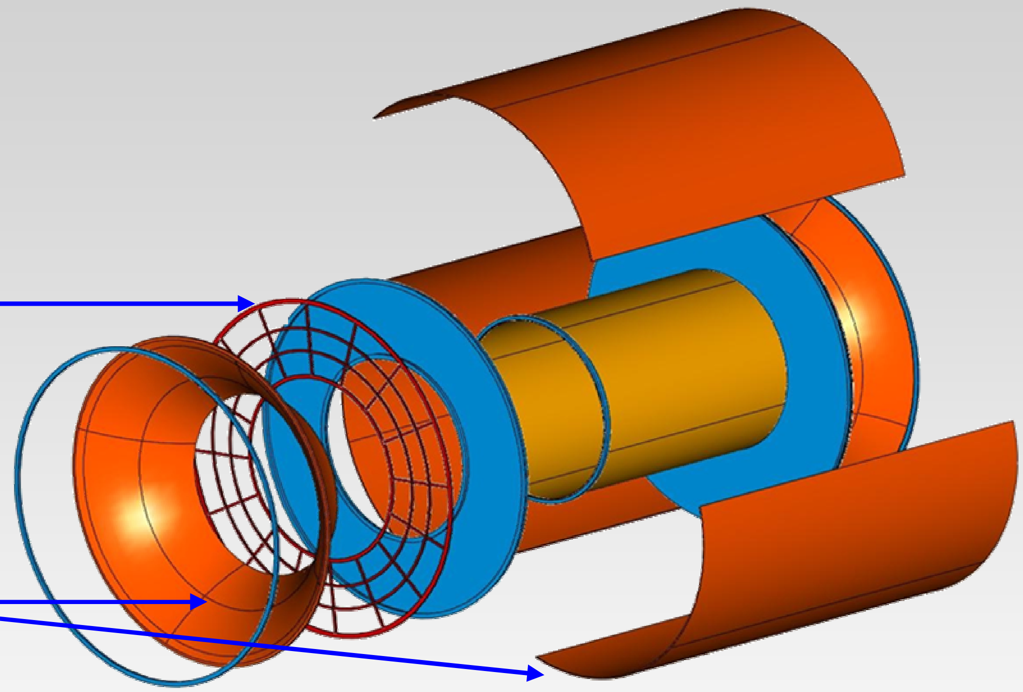
Abstract

We present a novel technique for assembling low mass drift chambers. It was developed to meet the stringent requirements imposed by the experiments that require momentum resolution of order 100-200 keV/c for charged particles in the momentum range 50 to 100 MeV/c. Examples of such experiments include MEG at PSI and Mu2e at Fermilab, both of which will have a momentum resolution that is limited by the multiple scattering contribution.
Detailed studies of candidate geometries and materials have shown that it is possible to achieve end plates with thicknesses of order 0.2 g/cm^2, which corresponds to 0.5% of a radiation length, inclusive of front-end electronics.
We describe the new wiring strategy and the feed-through-less wire anchoring system developed and tested on a drift chamber prototype nearing completion at INFN-Lecce.

Innovative Concepts

separate the wire supporting function from gas tightness:

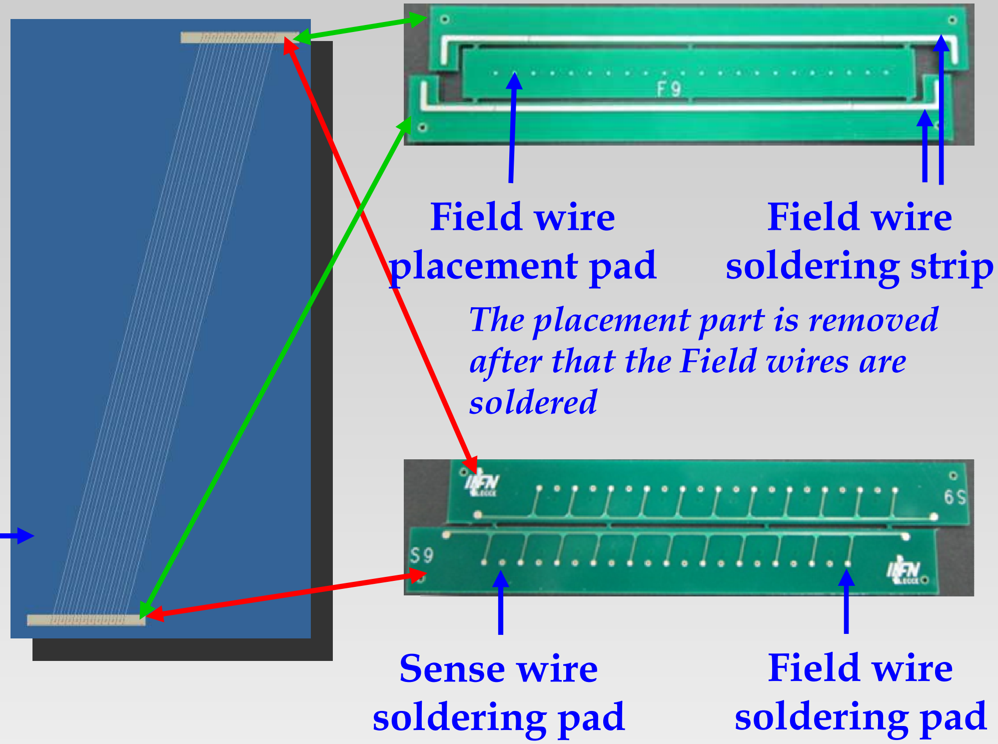
- **wire holding structure must be undeformable, but not necessarily gas tight;**
- **gas envelope must withstand pressure but is free to sustain large deformations**



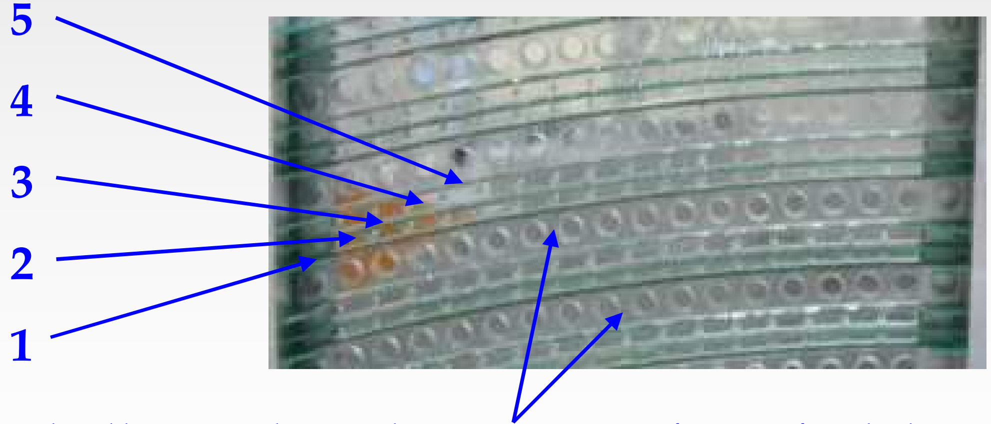
Innovative Concepts

wire anchoring system without feed-through:

- lay, in a single operation, a large number of parallel wires, at any angle, within a layer with a well defined pitch, by gluing and soldering the wires on thin FR4 (G10) supports. Two types of them are needed, one wired with only field wires and a second one wired with both sense and field wires;



- build up the chamber by overlaying:
  0) *a light material spacer, precisely machined and a field wires layer with reverse stereo layer respect to that of the first cell layer;*
  1) an upside down field wires layer;
  2) a light material spacer, precisely machined;
  3) an alternated field–sense wires layer;
  4) a light material spacer, precisely machined;
  5) a right side up layer of field wires;



Missing layer replaced by a spacer because the prototype is just a fraction of a cylinder

6) continue iteratively (sequence of steps 1 - 5) by inverting the stereo angle.

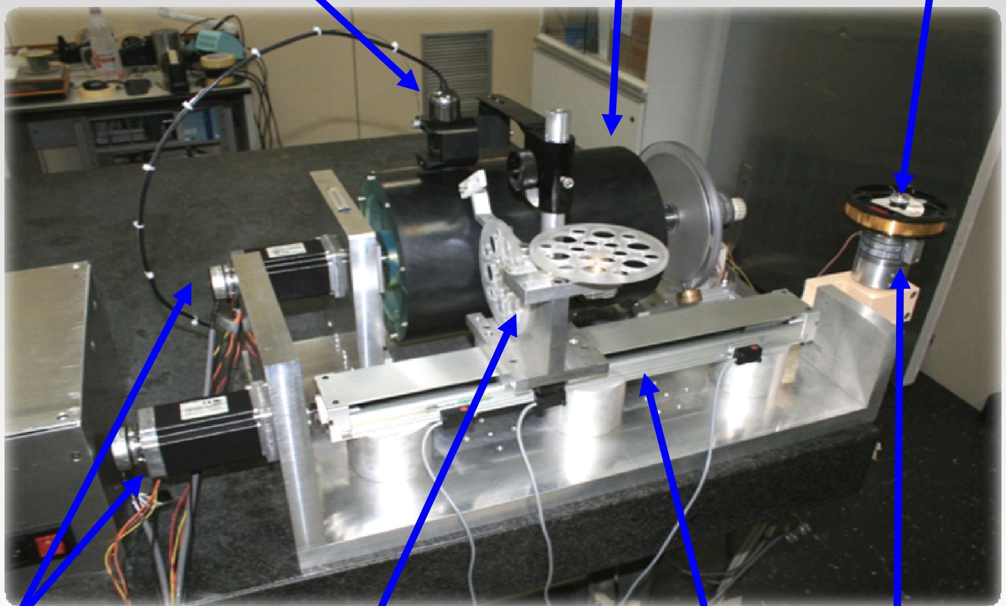
The wiring robot

To put in place the proposed wiring strategy a wiring machine is needed

WINDING DRUM

DIGITAL MICROSCOPE

WIRE SPOOL



SYNCHRONIZED STEP MOTORS

SLIDE

SERIES OF LOW FRICTION PULLEYS

ELECTROMAGNETIC FRICTION and TORQUE METER

Wiring machine constraints :

- ± 20 μm of accuracy on wire position;
- continuously variable pitch;
- settable wire tension (±0.5g).

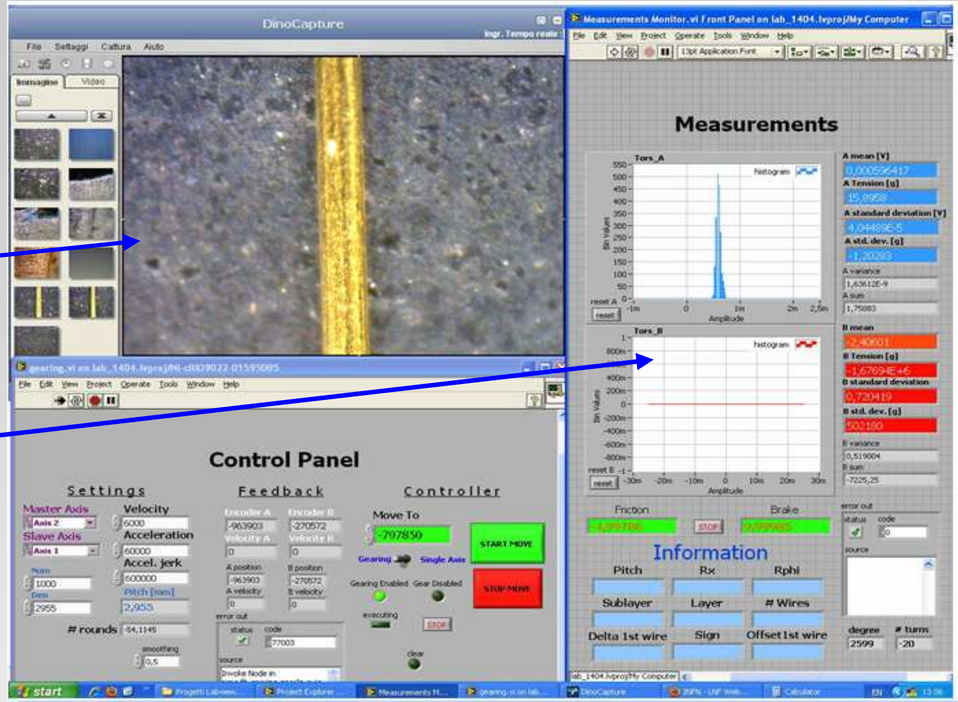
Winding procedure :

- insert the wire boards on the winding drum;
- wind the wires at the given pitch creating a coil;
- solder the wires on the wire boards;
- cut the coil open;
- unwind the open coil to get the wire layer.

The wiring robot

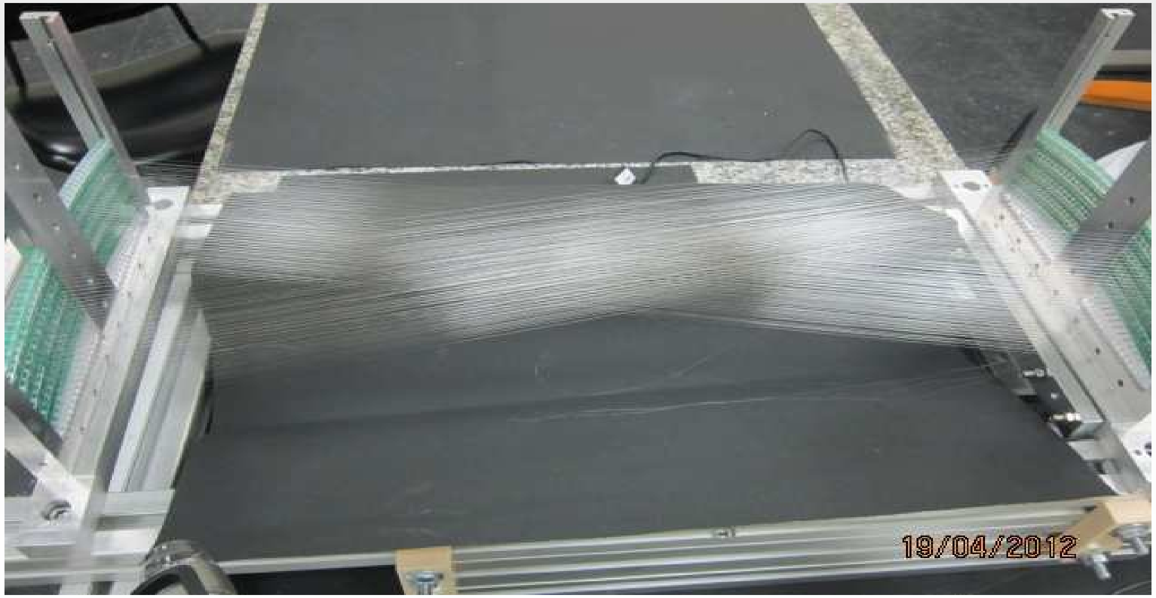
Wiring Robot Monitor:

- digital Microscope to align the wire and steadily check the wire positioning;
- histograms of the on line wire tension measurement during the wiring process;
- step motors and pitch control.



The drift chamber prototype during the assembling stage:

- ~ 200 channels;
- cell size 6 mm – 8 mm;
- stereo angle ~ ± 150 mrad.

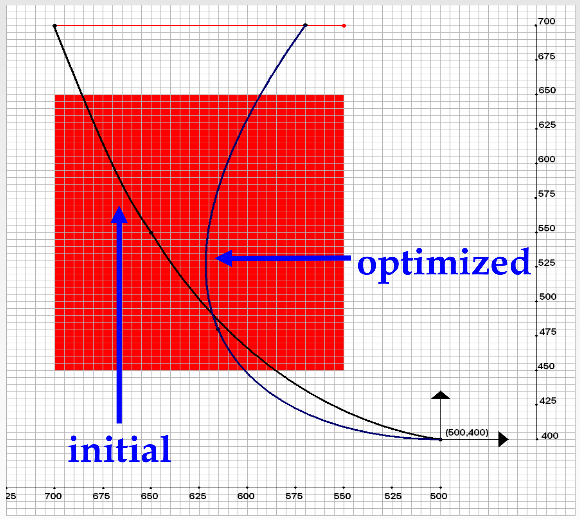


Application to Mu2e tracker

The Mu2e tracker detector is immersed in vacuum and its gas envelope must withstand a differential pressure of 1 bar, still trying to keep at minimum both multiple scattering and energy loss straggling for conversion electrons.
Detailed studies have been performed to optimize the shape of the gas envelope and to minimize the amount of material:

- Geometry Modeling + Constraints and Loads in case of an isotropic material (1 mm Al);
- Meshing and F.E.A. (ANSYS WB + APDL);
- Analysis of result and parameter setting;
- Optimization procedure (modeFRONTIER);
- Failing solution with isotropic material;
- Laminate Virtual Prototyping, Ply Draping, Flat Wrap, Lay-up and Fiber Orientation (ESAComp);
- Static Structural Analysis;
- Buckling Analysis on composite (ANSYS ACP).

Optimized end-plate shape



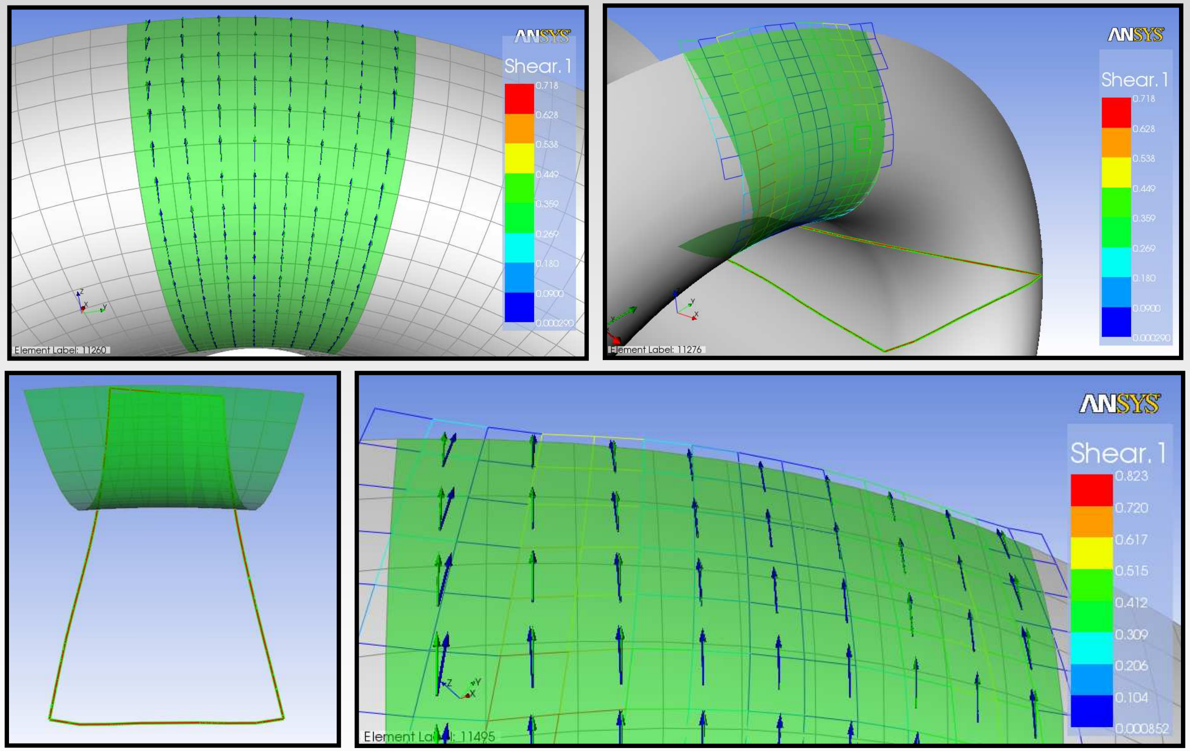
Application to Mu2e tracker

Laminate Virtual Prototyping

Single ply custom creation from chosen unidirectional prepeg

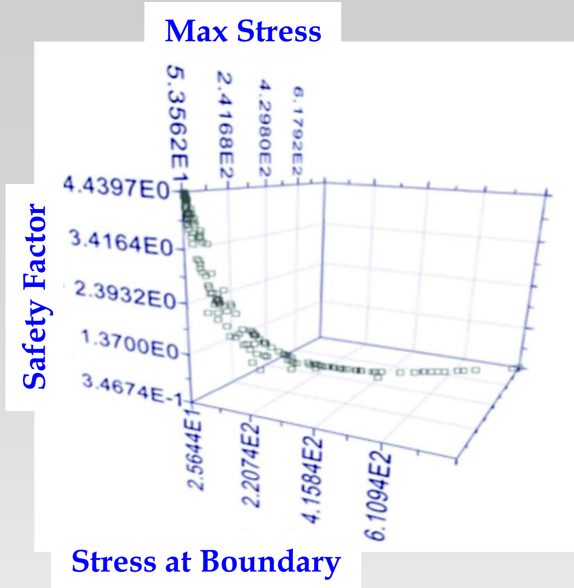
Lay-up creation as a sequence of plies with different orientations

Analysis of the structural elements



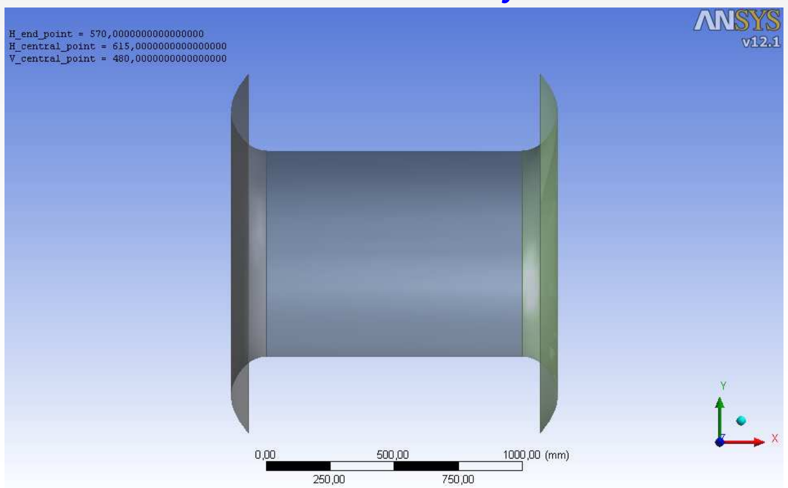
ply draping
flat-wrap
and fiber
orientation

Multivariate analysis of the optimization parameters



Optimized shape (using 1 mm thick Aluminum)

Max Stress	60 MPa
Safety Factor	4.4
Stress at Boundary	27 MPa



Application to Mu2e tracker

Using the proposed wire anchoring technique and the optimized gas envelope it is possible to build a drift chamber for the Mu2e experiment with the following Material budget:

Detector Element	Composition	g/cm²	X/X_0 [‰]
EndCap (Gas envelope)	4 plies x 60 µm	0.04	1
Inner Cylinder (Gas envelope)	Sandwich of two 120 µm C-fiber skin and 5mm spacer (0.04g/cm³)	0.05	1.2
Wire anchoring + first electronics parts	in average equivalent to 500 µm of C	0.11	2.5
Wires	~ 15000 20 µm Mo (sense) ~ 80000 40 µm Al (Field) (mass equivalent for 1m of track)	0.036	6.3
Gas	Helium based gas mixture (90% He 10% isoButane) (mass equivalent for 1m of track)	0.045	1.2

Expected momentum resolution for the Chamber proposed for Mu2e (on e^- of 100 MeV/c)

For the Mu2e proposed chamber we are investigating to work with gas at pressure less than 1 atm(see M.Cascella "Ultra-Light Gas Mixtures for Drift Chambers"). The main benefit of this solution for the Mu2e case is a potential gain in reduction of the thicknesses of the walls of the gas envelope.