MEG STATUS

Marco Panareo

MEG
Mu-E-Gamma Collaboration

Outlook

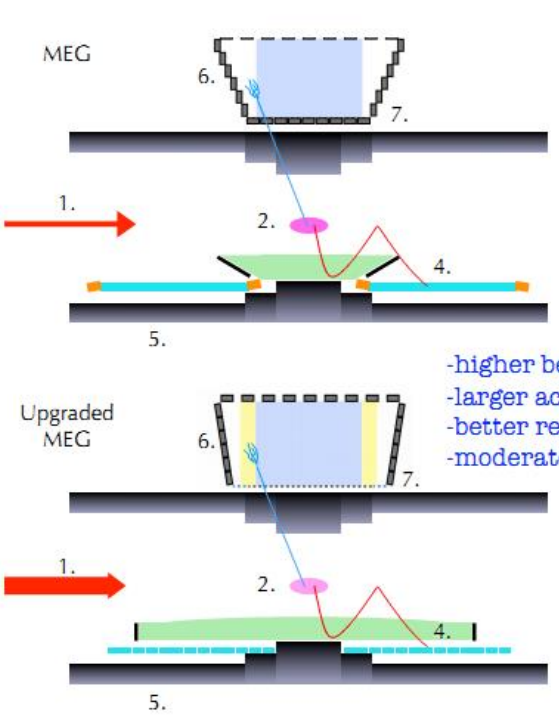
- MEG Experiment
- Upgrade – MEG II
- Lecce’s tasks
- Wiring machine
- Frontend development
- Peoples

MEG Experiment

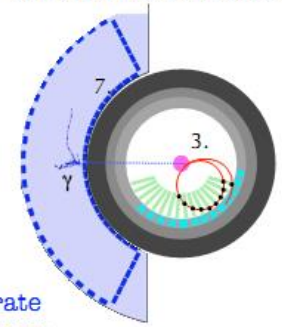
- MEG experiment at the Paul Scherrer Institute in Villigen (Switzerland) is studying the possible existence of the muon decay into an electron and a photon, trying to go to sensitivity to decay ratios of the order of 10^{-14} .
- Many theories, including those of Supersymmetric Grand Unification (SUSY-GUT), provide for the existence of the decay $\mu^+ \rightarrow e^+ + \gamma$ at a decay ratio of this magnitude.
- The experiment published in 2013 the best experimental limit (5.7×10^{-13}, 90% CL) on the existence of the decay and it has concluded the first phase of activity. From the analysis of the acquired data it is expected a sensitivity of the order of 4×10^{-13}.
- A second phase of the experiment (MEG II) will allow to achieve a sensitivity to the decay of about 5×10^{-14}, thanks to both the improvement and replacement of some detectors, including the drift chamber that is being assembled at laboratories of INFN Lecce / Pisa.

Upgrade – MEG II

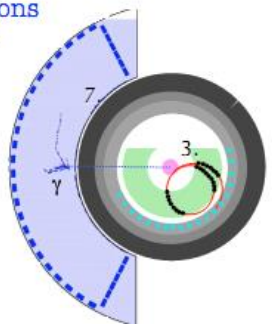
- The objective of the upgrade of the MEG spectrometer is to improve of a factor of 10 the overall sensitivity
-
- The upgrade plans to
  - Replace the tracking detector with a full coverage DC
  - Replacement of the PMTs of the inner face of the LXe calorimeter with SiPM (array of PMT 1" square), to improve the resolution of the γ impinging position
  - Increasing of spatial resolution of TC by replacing scintillator bars with tiles; use of SiPM for reading scintillators of TC (increases the time resolution, increases efficiency, reduces the pileup)
  - Use of an active target with scintillating fibers individually coupled to an array of SiPM, to improve resolution in the stop position / decay of μ



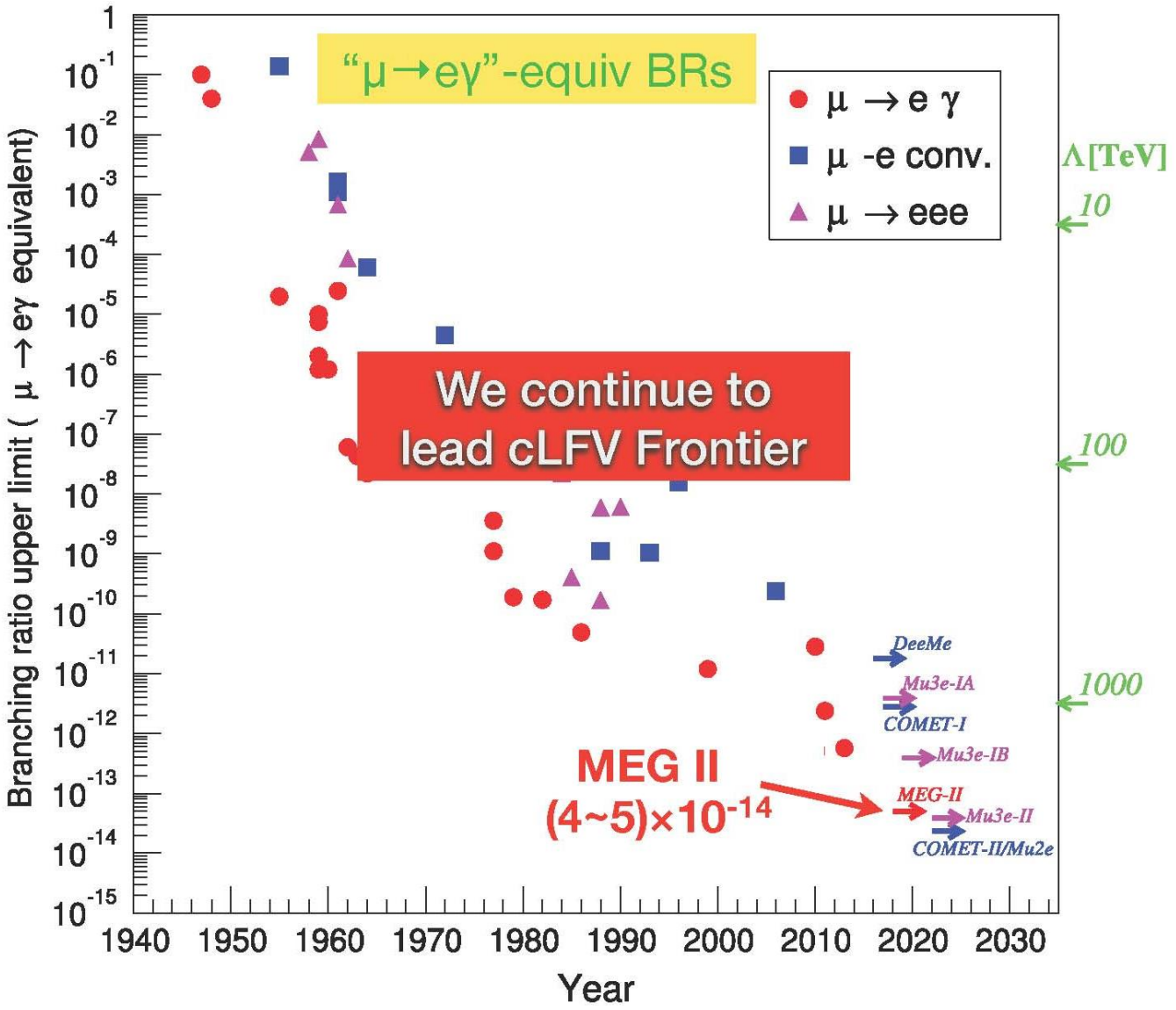
upgrade design based on our long time experience



-higher beam rate
-larger acceptance
-better resolutions
-moderate cost



cLFV upper limit vs. time



Pubblications

- J. Adam et al. (MEG collaboration), *A limit for the $\mu \rightarrow e\,\gamma$ from the MEG experiment*; Nucl. Phys. B834 (2010) 1;
- J. Adam et al. (MEG collaboration), *Calibration and monitoring of the MEG experiment by a proton beam from a Cockcroft-Walton accelerator*; Nucl. Instr. Meth. A641 (2011) 19.
- J. Adam et al. (MEG collaboration), *New Limit on the Lepton-Flavor-Violating Decay $\mu^+ \rightarrow e^+ \gamma$*; Phys. Rev. Lett. 107 (2011) 171801.
- A.M. Baldini et al. (MEG collaboration), *MEG Upgrade Proposal*; arXiv:1301.7225, arXiv:1301.7225v2.
- J. Adam et al. (MEG collaboration), *The MEG detector for $\mu^+ \rightarrow e^+ \gamma$ decay search*; Eur. Phys. J. C (2013) 73:2365
- J. Adam et al. (MEG collaboration), *New constraint on the existence of the $\mu^+ \rightarrow e^+ \gamma$ decay*; Phys. Rev. Lett. 110 (2013) 201801.
- J. Adam et al. (MEG collaboration), *Measurement of Inner Bremsstrahlung in Polarized Muon Decay with MEG*; Nucl. Phys. Proc. Suppl. 248-250 (2014) 108
- J. Adam et al. (MEG collaboratio), *Measurement of polarized muon radiative decay*; arXiv:1312.3217

Conferences

- 101° Congresso Nazionale della Società Italiana di Fisica, 2015
  - A. Corvaglia, G. Chiarello, C. Chiri, F. Grancagnolo, M. Panareo, A. Pepino, C. Pinto, G. F. Tassielli; *Sistema di misura della tensione meccanica dei fili metallici micrometrici della Camera a Deriva per l'upgrade dell'esperimento MEG*
  - A. Corvaglia, G. Chiarello, C. Chiri, F. Grancagnolo, M. Panareo, A. Pepino, C. Pinto, G. F. Tassielli; *Elettronica di Front End per la camera a deriva del nuovo tracciatore di MEG*

- 2015, FRONTIER DETECTORS FOR FRONTIER PHYSICS
  13th Pisa Meeting on Advanced Detectors
  - G. Chiarello, C. Chiri, A. Corvaglia, F. Grancagnolo, M. Panareo, A. Pepino, C. Pinto, G. F. Tassielli; *A high performance Front End Electronics for Drift Chamber readout in MEG experiment upgrade*
  - G. Chiarello, C. Chiri, A. Corvaglia, F. Grancagnolo, M. Panareo, A. Pepino, C. Pinto, P. Primiceri, M. Spedicato, G. F. Tassielli; G. Cavoto, L. Recchia, F. Renga, C. Voena; *A new construction technique of high granularity and high transparency Drift Chambers for modern High Energy Physics experiments*

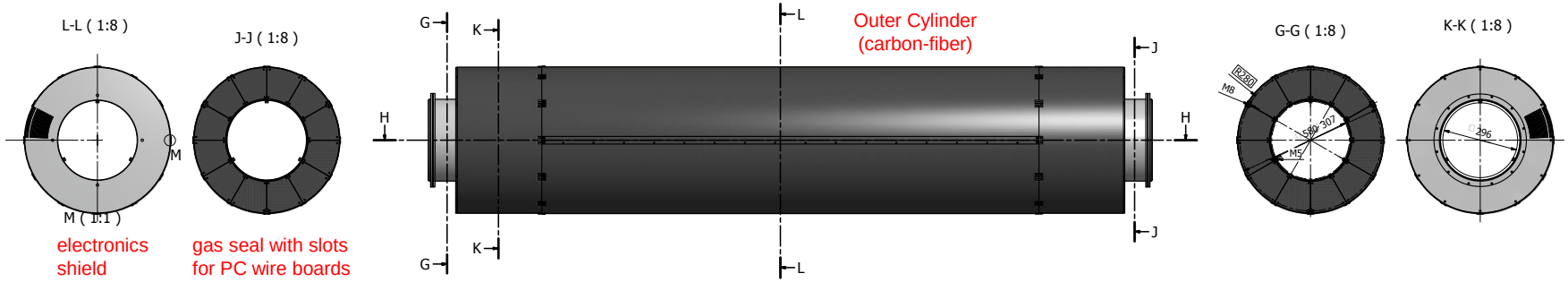
- 2015, 6th IEEE International Workshop on Advances in Sensors and Interfaces, IWASI
  - G. Chiarello, C. Chiri, A. Corvaglia, F. Grancagnolo, A. Miccoli, M. Panareo, A. Pepino, C .Pinto, P. Primiceri, M. Spedicato, G. F. Tassielli; *A new assembly technique of full stero Drift Chamber for High Energy Physics experiments*
  - G. Chiarello, C. Chiri, A. Corvaglia, F. Grancagnolo, M. Panareo, A. Pepino, C. Pinto, G. F. Tassielli; *A high performace Front End for MEG II tracker*

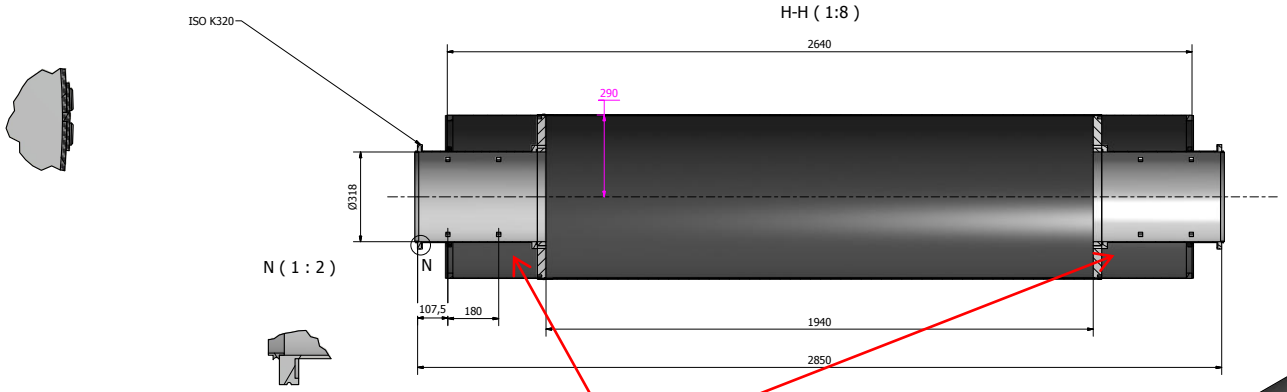
- 2014, 1st International Conference on Charged Lepton Flavor Violation (CLFV)
  - G. Chiarello, A. Corvaglia, F. Grancagnolo, M. Panareo, A. Pepino, P. Primiceri, G. F. Tassielli; *A Full Front End Chain for Drift Chambers*
  - M. Cascella, F. Grancagnolo, P. Mazzotta, A. Miccoli, M. Panareo, M. Spedicato, G. F. Tassielli; *Characterization of Gas Mixtures for Ultra-Light Drift Chambers*

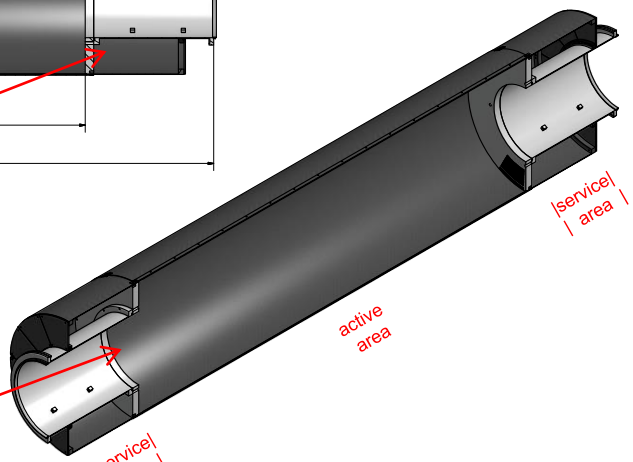
Lecce's tasks

- The Drift Chamber
- Wiring
  - Cleaning room refurbishing
  - PCB wiring/soldering
  - Mechanical tension measurement
- DC Front End
  - FE to WD connection cables
  - End Plates chillers system

The DC







front-end electronics cards

Inner Cylinder made of 20 μm Mylar tube containing the target

Progettato da raffaell	Controllato da	Approvato da	Data	Data 11/13/2013	
				camera_360	Edizione / Foglio 1 / 1

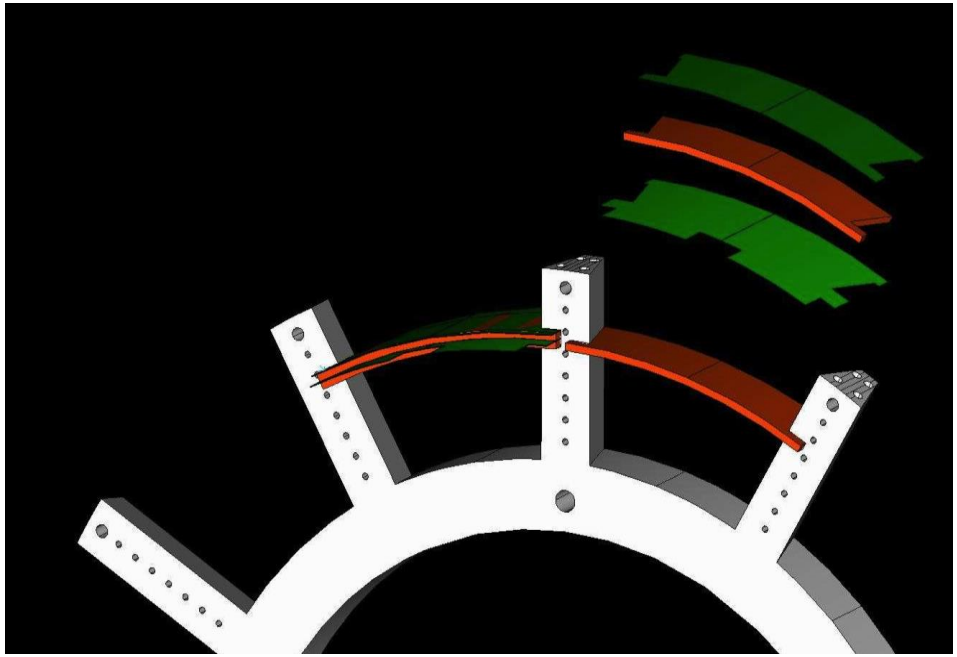
DC overview

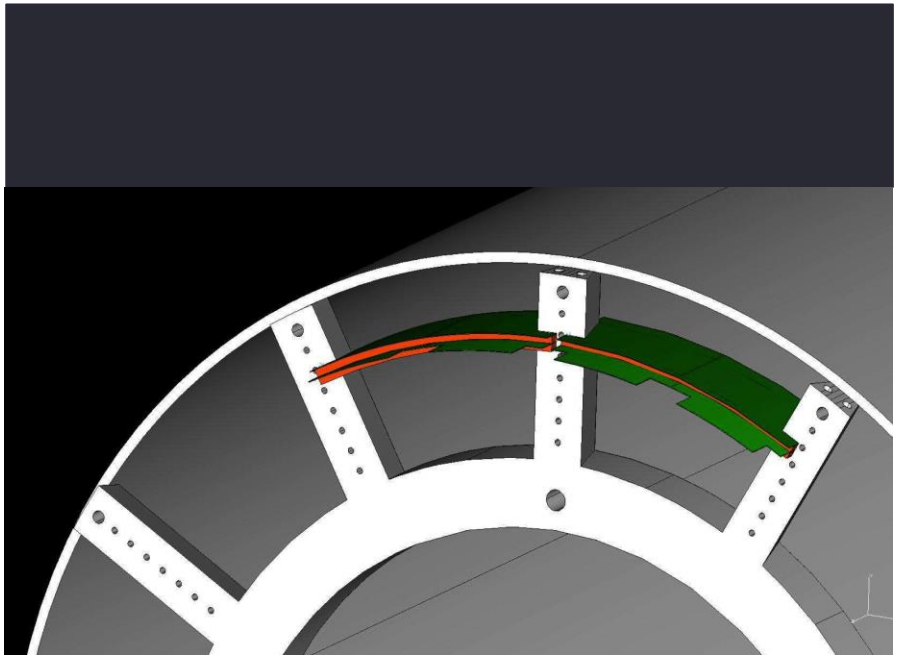
- Full stereo cylindrical DC with large stereo angles (102÷147 mrad)
- Redundant and background insensitive ($N_{hit} \approx 60$ on signal track)
- Small square cells (5.8÷7.8 mm @ z=0, 6.7÷9.0 @ z=±L/2)
- High ratio of field/sense (5 : 1) wires
- Light mechanical structure (Al/peek end-plates, C-fiber outer cylinder, Mylar inner cylinder)
- Innovative wiring solution (without wire feed-through)
- Light gas mixture (85% He − 15% iC_4H_{10})
- Cluster Timing readout capabilities (high bandwidth, high sampling rate)

Active length L	1960	mm
N. of layers	10	
N. of stereo sectors	12	
N. of cells per layer	192	
N. of cells per sector	16	
Cell size (at z=0)	5.8 ÷ 7.8	mm
Twist angle	±60°	
Stereo angle	102 ÷ 147	mrad
Stereo drop	35.7 ÷ 51.4	mm

Radii	z = 0	z = ±L/2	
Guard wires layer	170.7	197.1	mm
First active layer	174.5	201.5	mm
Last (10^{th}) active layer	242.0	279.5	mm
Guard wires layer	246.0	284.0	mm

Endplates

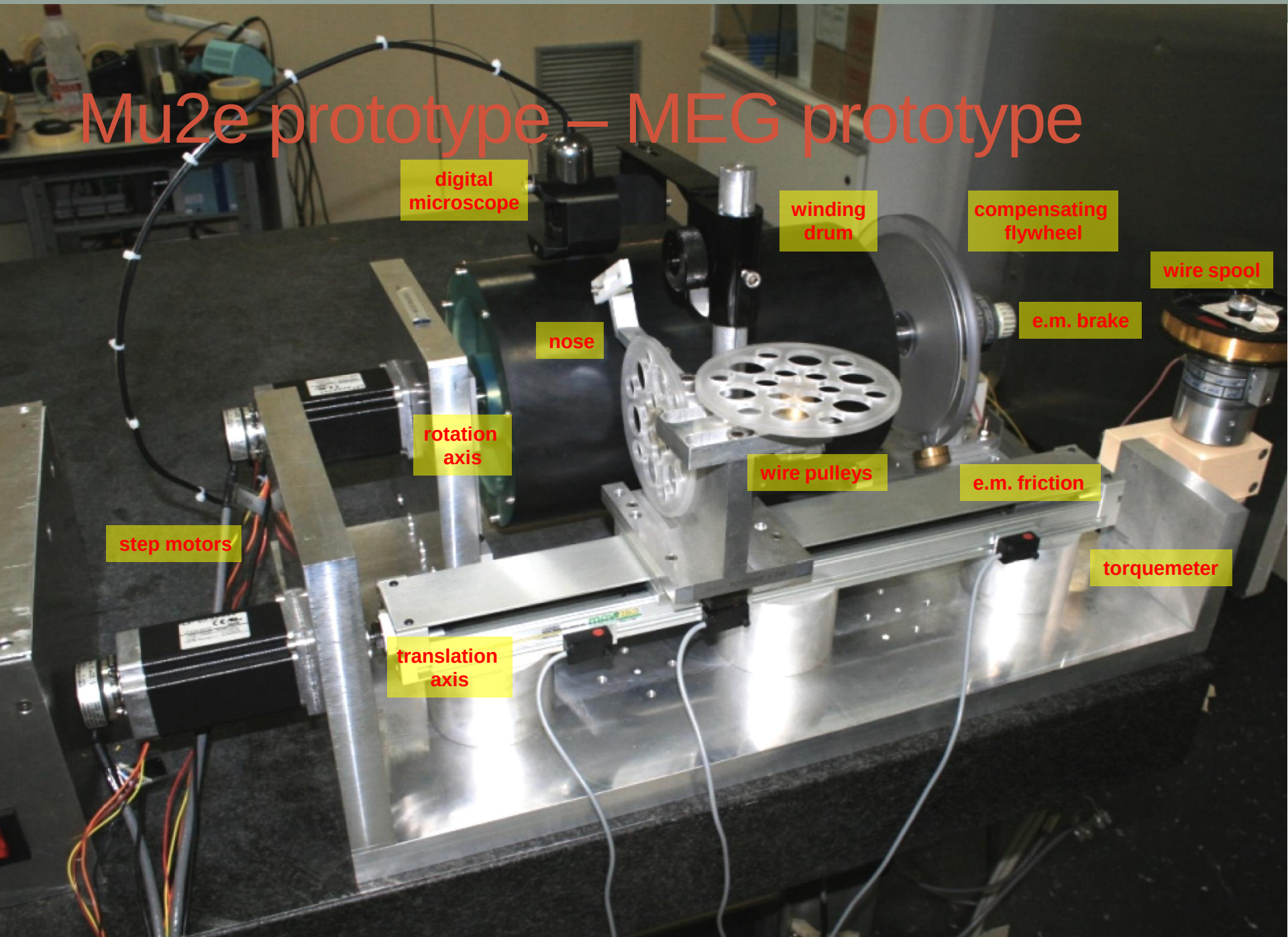




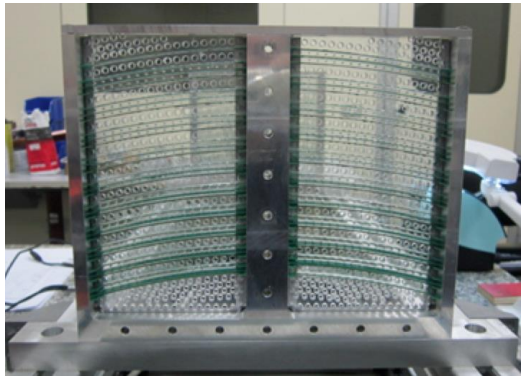
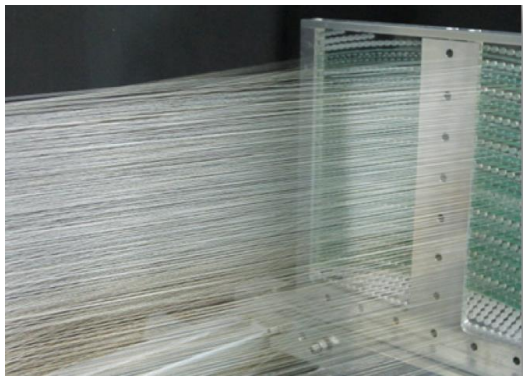
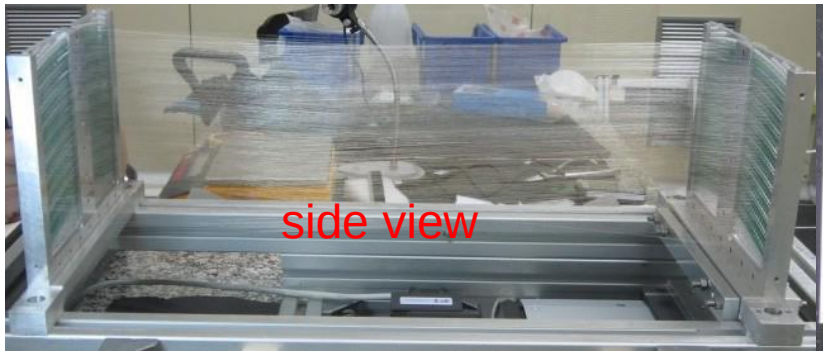
- End-plates numerically machined from solid Aluminum-Golden plated
- Field, Sense and Guard wires placed azimuthally by Wiring Robot with better than one wire diameter accuracy
- Wire PC board layers (green) radially spaced by numerically machined peek spacers (red) (accuracy < 20 μm)
- Wire tension defined by homogeneous winding and wire elongation (≈ 0.5 g)
- Drift Chamber assembly done on a 3D digital measuring table
- Build up of layers continuously checked and corrected during assembly

Cleaning room fully refurbished

Mu2e prototype – MEG prototype

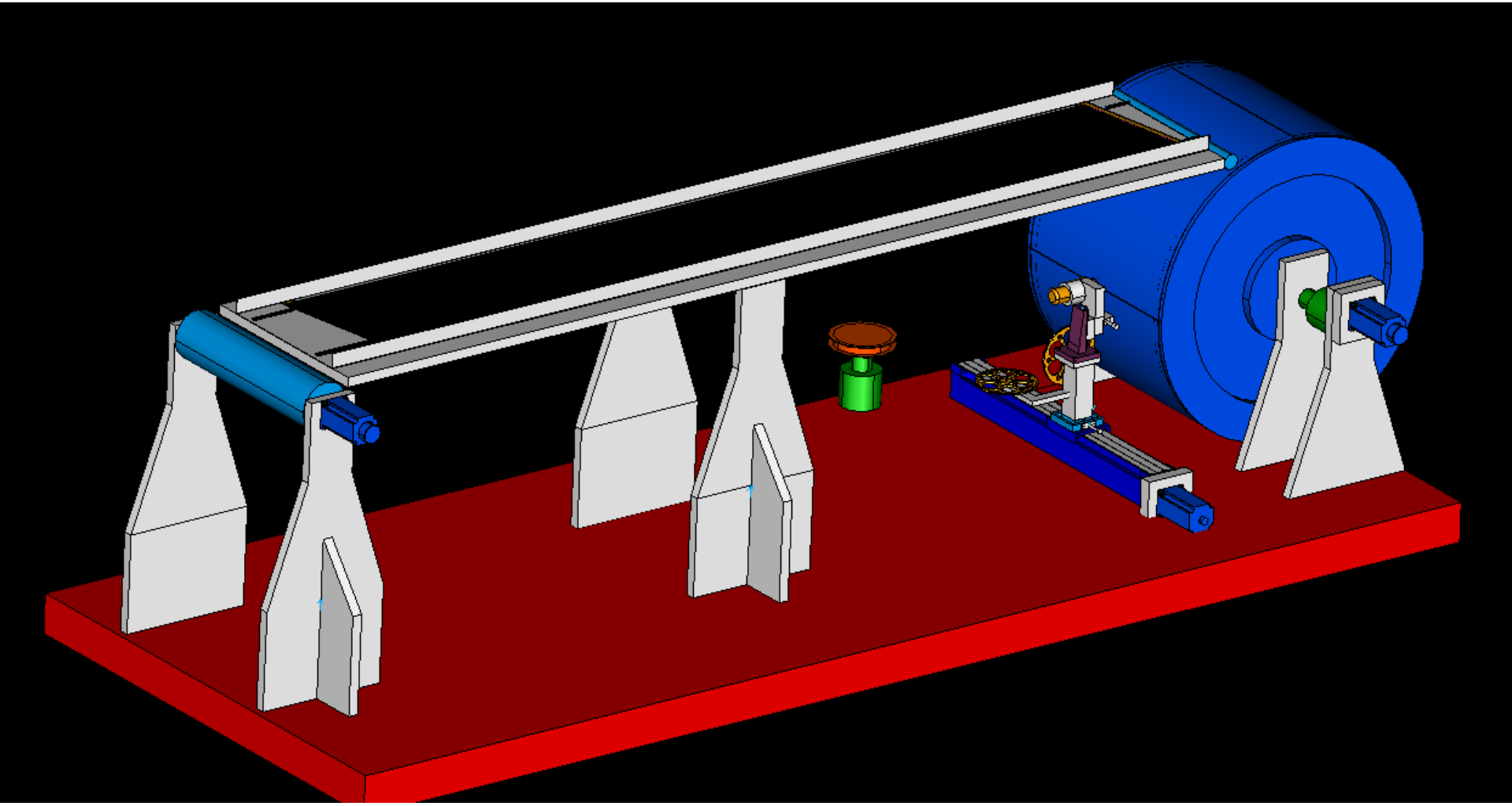


Mu2e prototype – MEG prototype

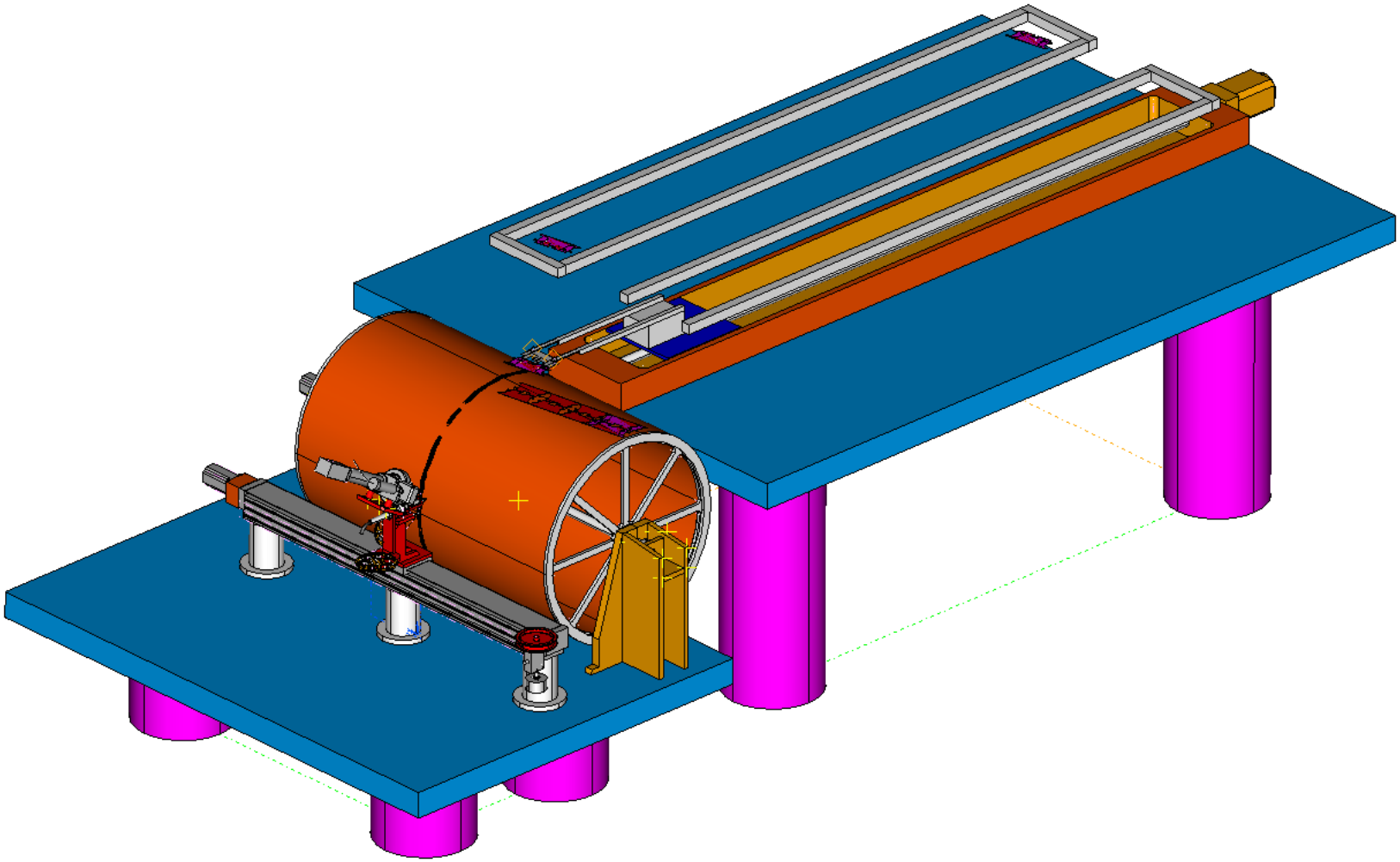





- 1302 wires
- 1102 field 40 μm Al(Ag)
- 200 sense 20 μm Mo(Ag) or W(Au)
- cell size 6 mm ÷ 8 mm
- stereo angle ± 200 mrad - length ≈ 60 cm
- Tested at BTF last year

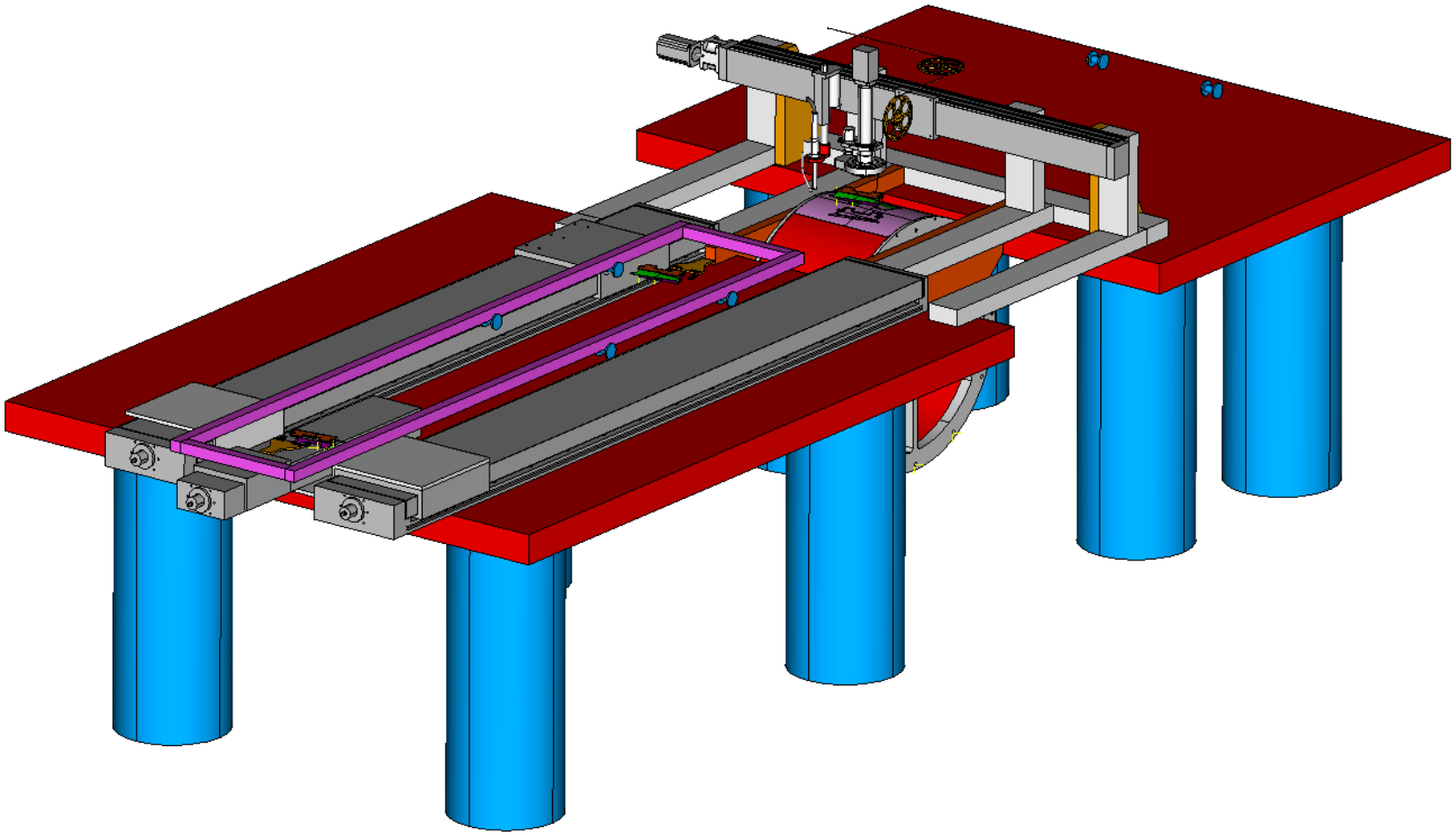
Wiring Machine - Evolution



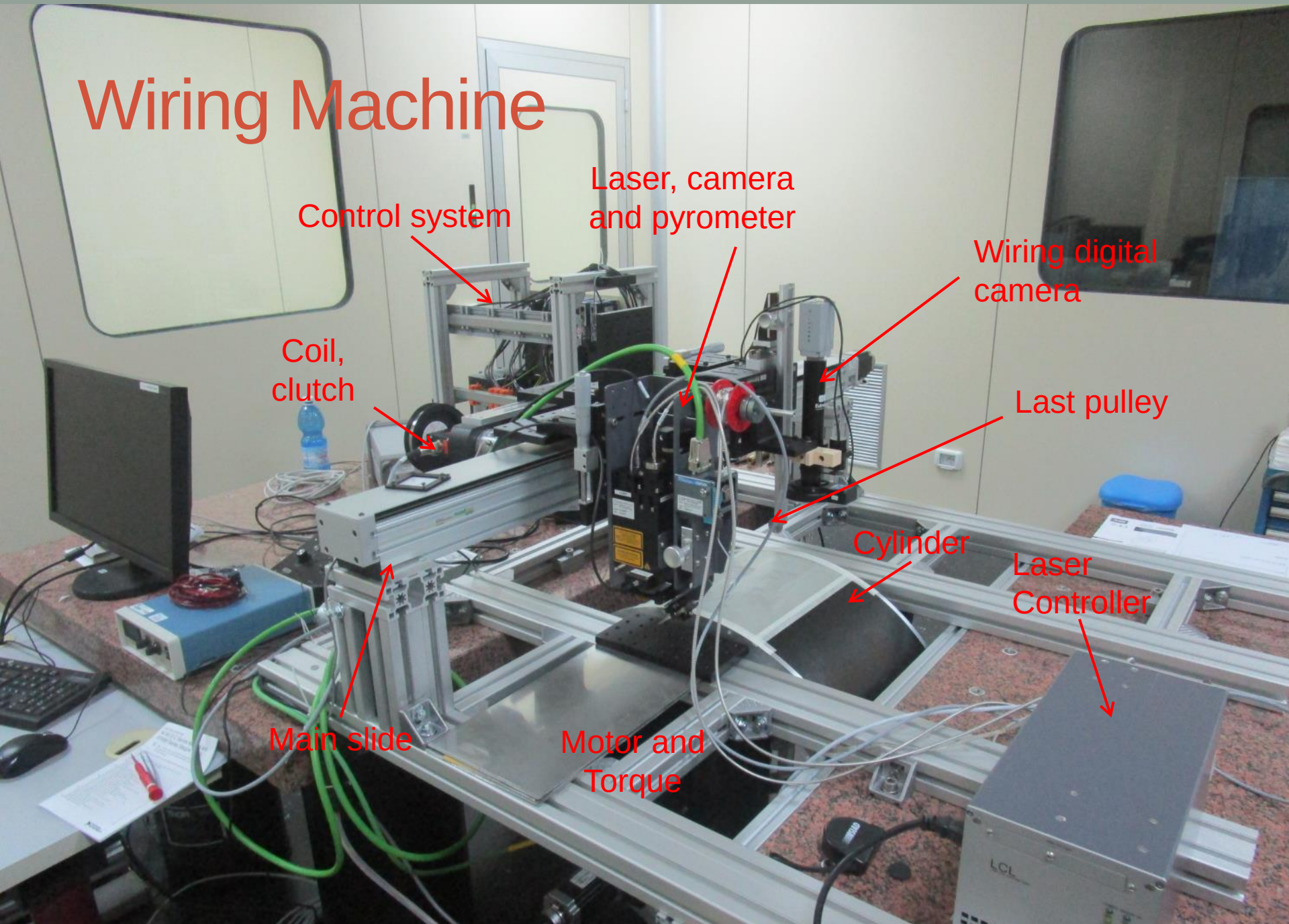
Wiring Machine - Evolution



Wiring Machine - Evolution



Wiring Machine

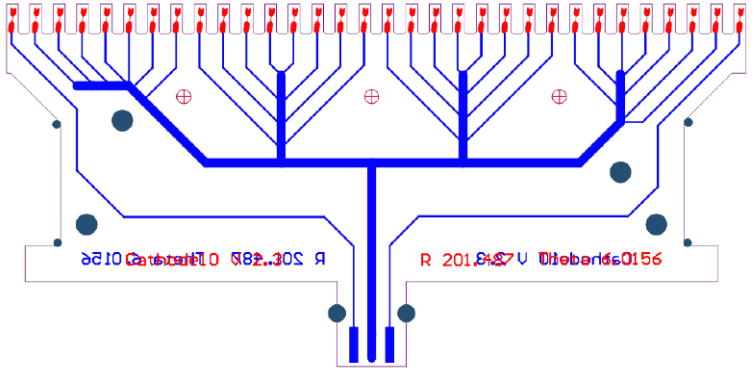


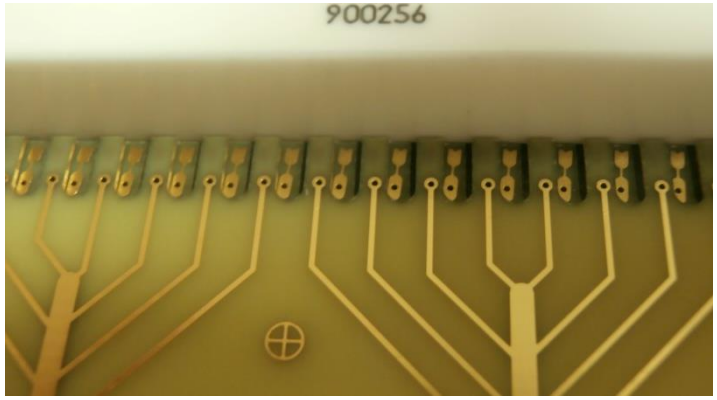
Wiring machine

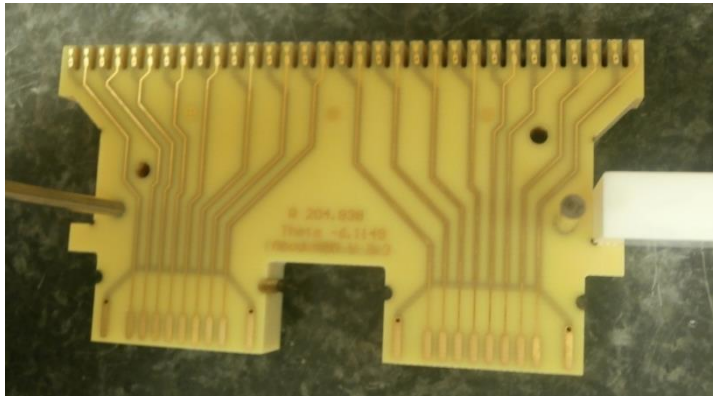
- Soldering system
  - Multiple approaches to welding tested (with preference for those contact-less)
    - (Hot tip)
    - Hot air
    - Infrared Laser
  - Laser soldering chosen (infrared: 900nm, 60W)
  - currently testing different solders
- Measurement of the mechanical tension during winding
  - a strain gauge integrated into the pulleys system
- Eccentricity of the wire coils
  - compensated with a feedback on the stepper motors
- Extractions System
  - A system of suction cups is connected to a manifold in order to create a vacuum ad release the wire-pcb
- Transport System
  - It is based on frames of standard profiles, the design is partially completed

Wiring status

- Wire PCB's
  - Delivered:
    - Guard/ Cathode/Anode
  - Problems:
    - Residual metallization on edges and holes due to problem in production sequence:
    - Partial superposition of PCB and pad:
    - Reference holes in wrong place
  - Mechanical precision:
    - Good reproducibility
    - Clean cuts
- New versions ready this week
  - PCB's for both the endplate enclosed in the same PCB to fix the relative position
- Next will be manufactured the templates that will host the wire PCBs on the cylinder

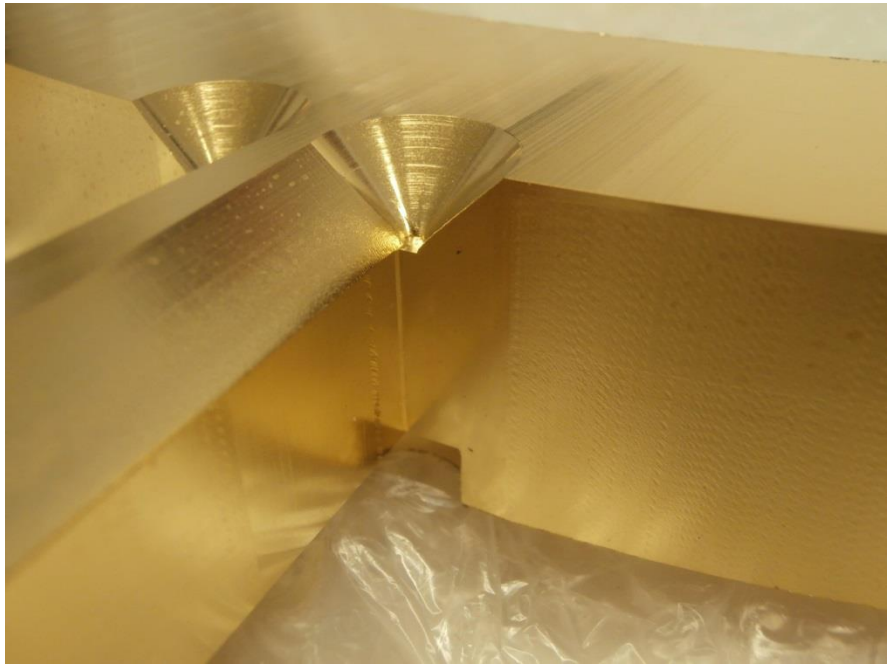




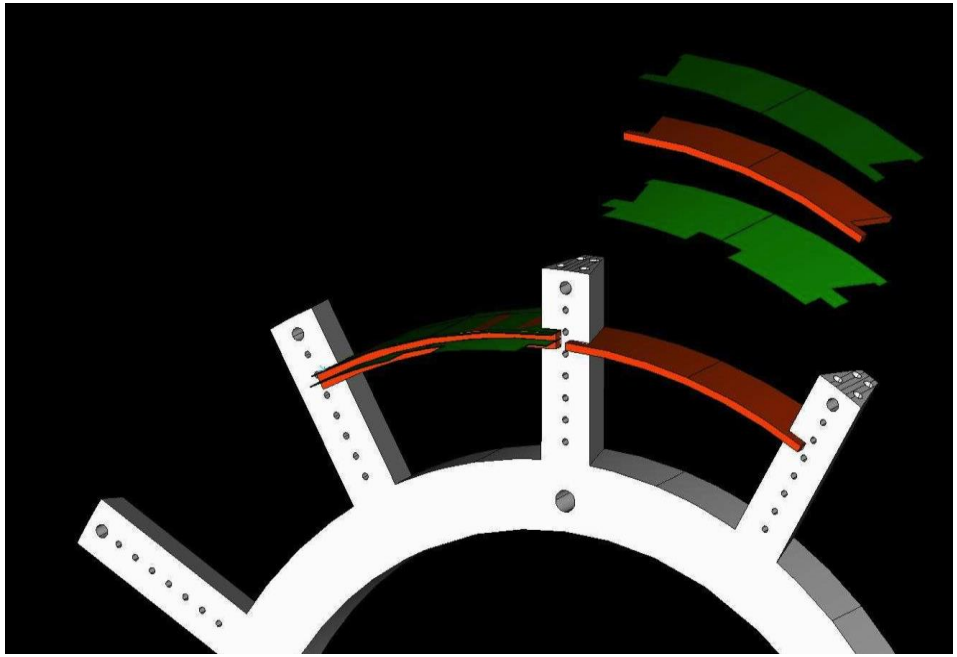


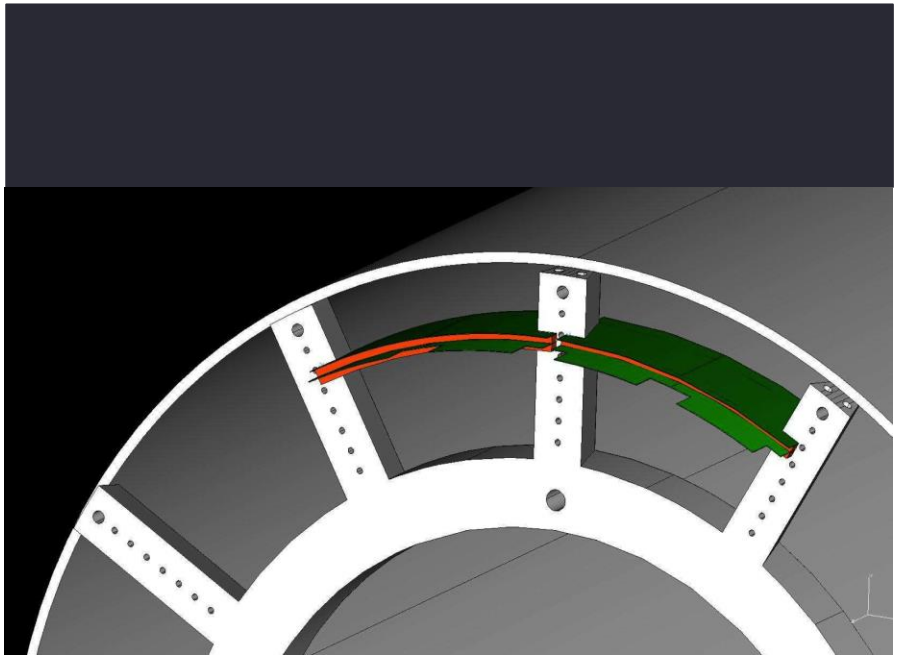
Final End Plates

- End-plates numerically machined from solid Aluminum
  - Golden plated
- Initial survey done:
  - Concentricity: better than 14µm
  - Roundness: max÷min ~ 40µm
  - Planarity: within 30µm



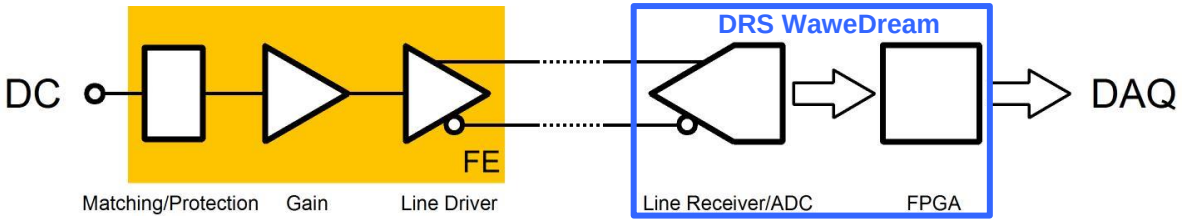
EndPlate stacking

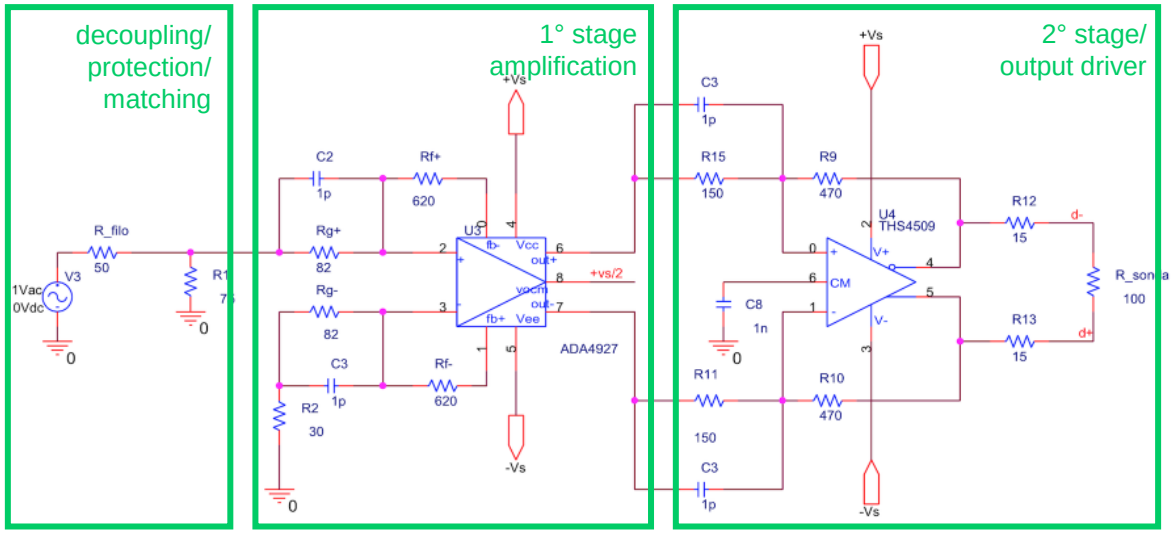




DC Front End

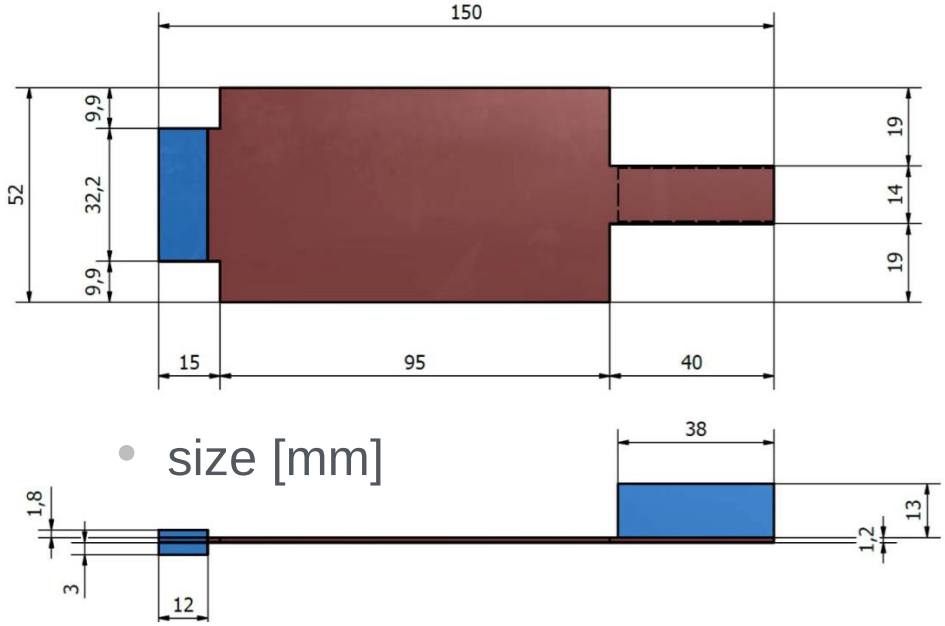
- 2 stage amplifier based on commercial devices:
  - ADA4927 (AD) Ultralow distortion current feedback differential ADC driver
  - THS4509 (TI) Wideband low noise fully differential amplifier
- Pre-emphasis implemented on both stages in order to balance the attenuation of output cable
- High overall bandwidth (FE input to DRS WD input): ~1GHz
- Low power: 50mW @ ±2V



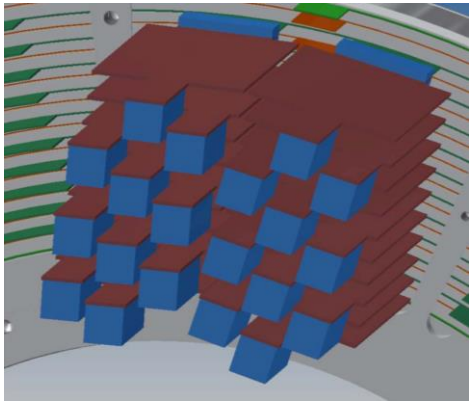


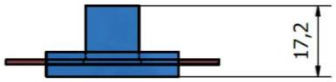
1920 channels (2/3) readout on both ends

DC Front End layout



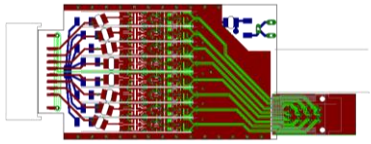
- size [mm]



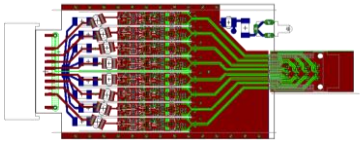


3 different card versions need for DC layers stacking

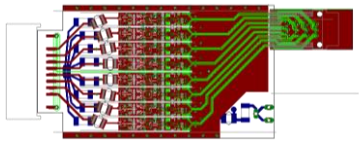
Right



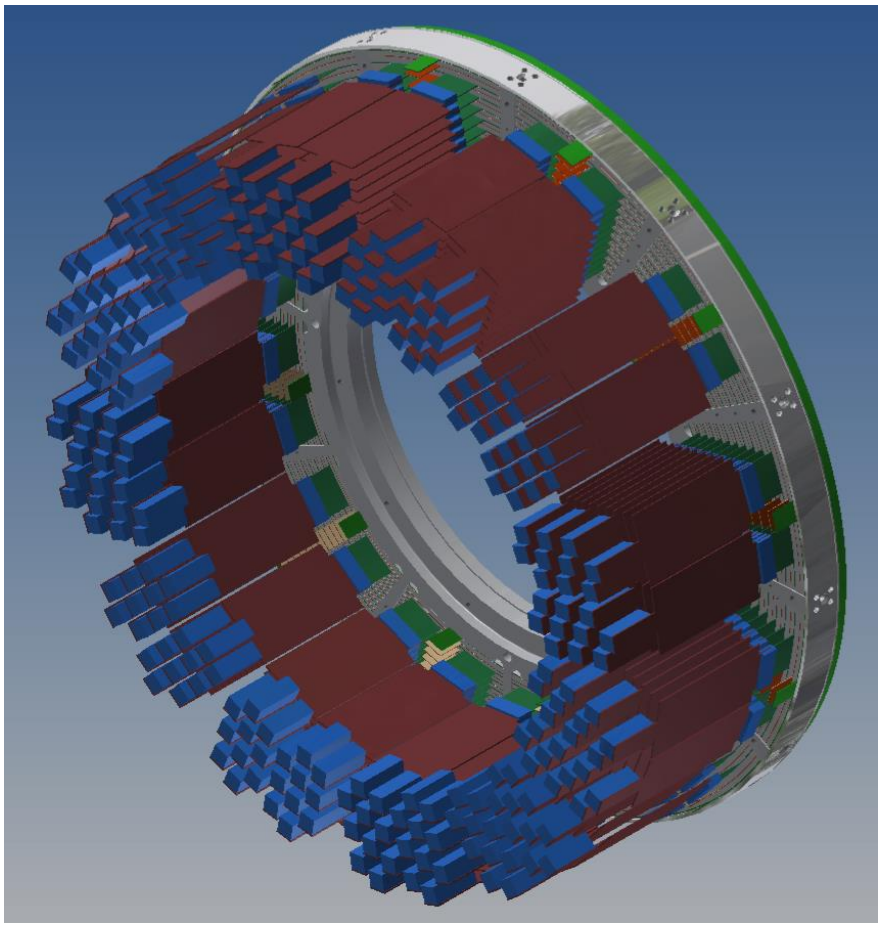
Central

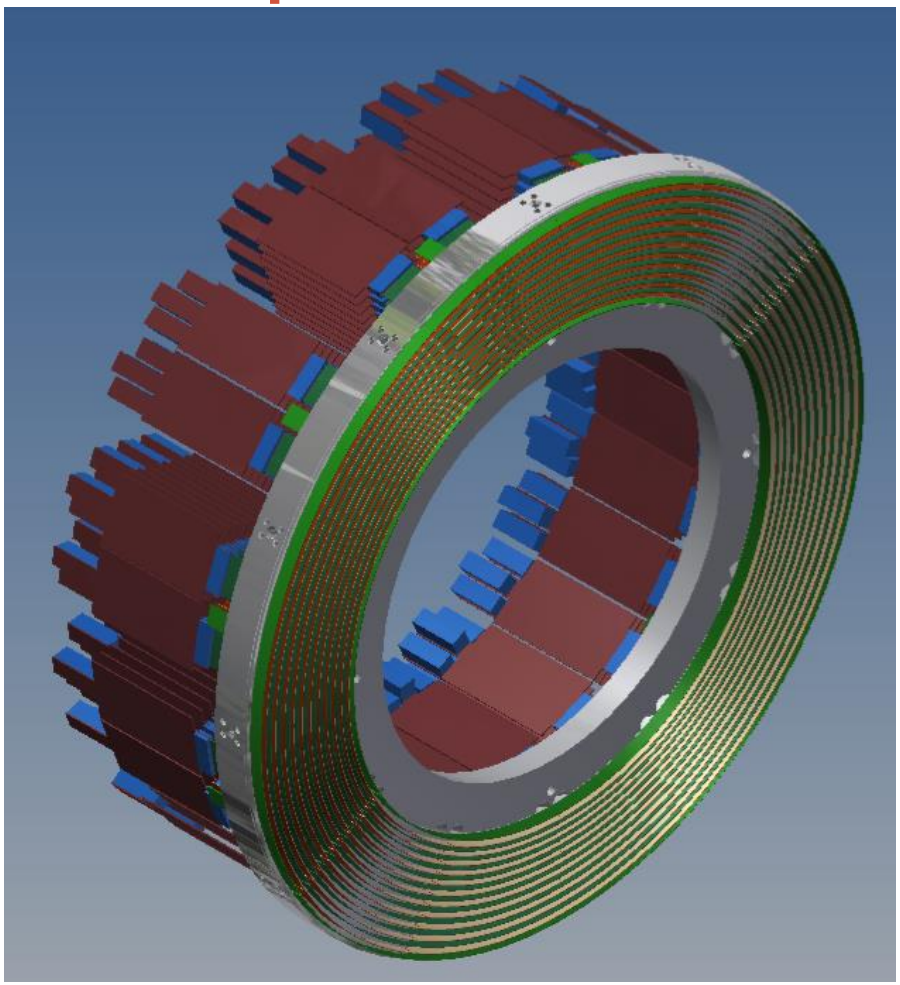


Left



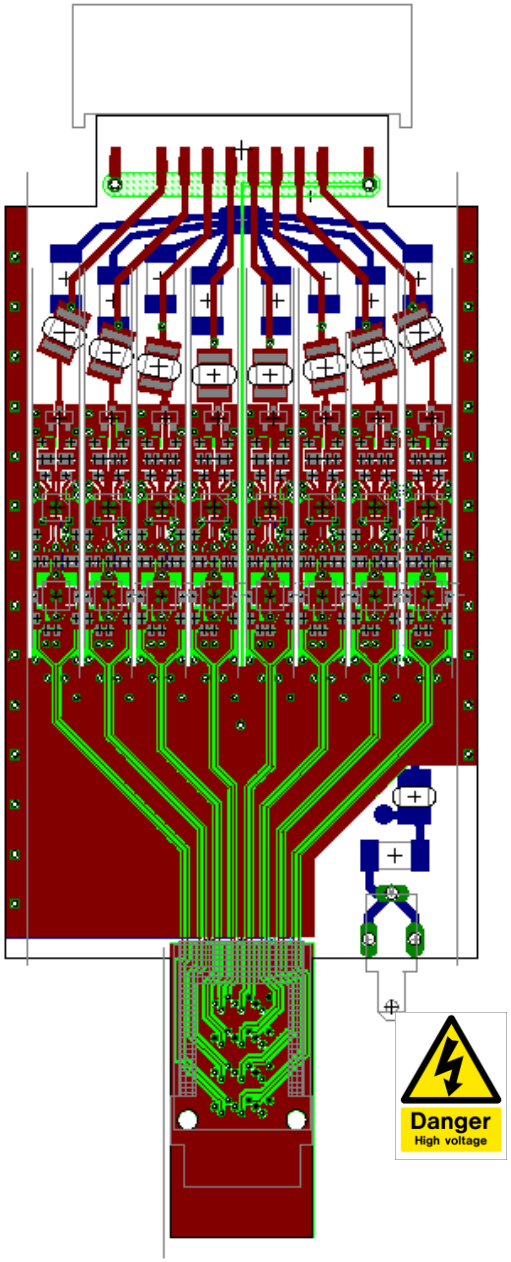
DC Front End on the End plates





Frond End PCB

- Input connector
  - Custom made by Sullins (edge card type)
- Output connector
  - miniSAS HD internal
- Ground:
  - Output connector ground and board ground separated in order to preserve ground loops
  - Possibility to connect the two grounds throughout 0 ohm resistors
- HV
  - Low cost, high reliability connector: Faston
  - HV supply will take place by means of an external wire soldered
- Layout
  - Channels distance to guarantee electrical insulation: 0,6 mm
  - Central channels distance: 1 mm
  - Power dissipation edge: 2,9 mm (2.3 mm reserved for mechanical rail - 0,6mm for electrical insulation)
  - HV decoupling capacitors arranged in order to make board more robust

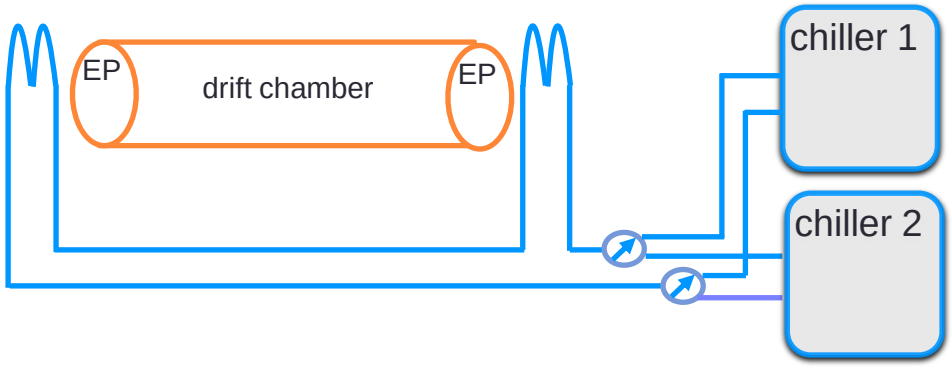


Orders status

- Output cables (*Amphenol Assembletech*):
  - Order placed Dec 12th, 2014
  - Delivered: Jun 20th, 2015
- Input connectors (*Sullins*):
  - Order placed Apr 5th, 2015 (need a wire pcb to test flexibility: *"… if possible, are you able to send Sullins a sample your .016" PCB so we are able to test flexibility..."*)
  - Production 2÷4 wks after approval of prototype
- PCB & assembly *(Aspek)*
  - Order for mass production placed Dec 17th, 2014
  - Order for 3 prototypes of each layout placed last week, need 20 days for production
  - Production 4÷5 wks after approval of prototype

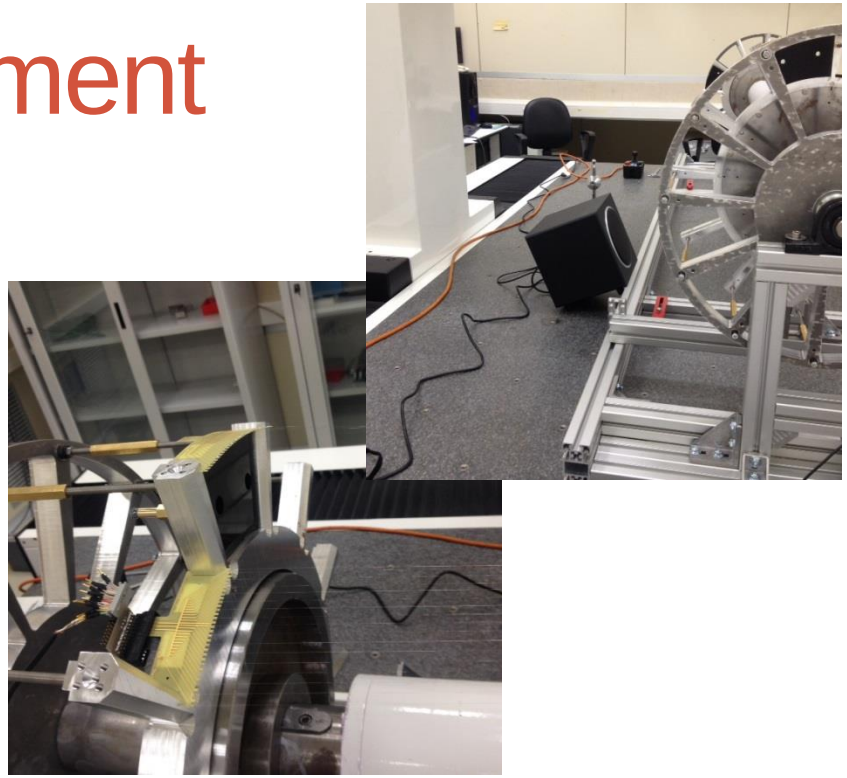
EndPlate chiller system

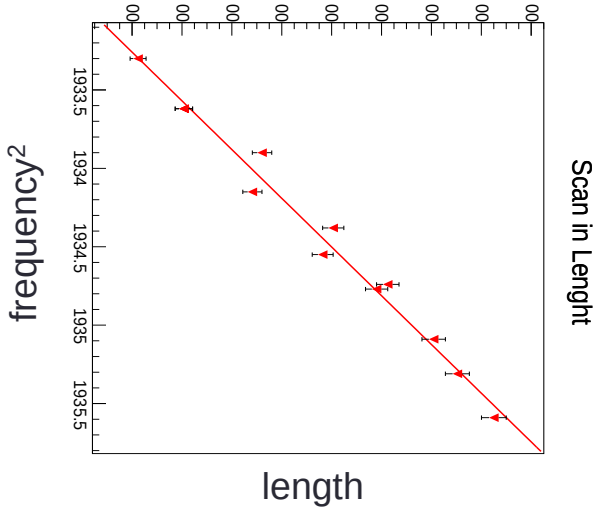
- Chiller cooling capacity up 1.2 kW
- Power on each end plate ~ 380 W
  - 1 chiller to cool all the DC
  - 1 chiller spare
- Each chiller is connected
  - if a chiller breaks down, the other becomes operational
- Delivered, tested in Lecce, sent to PSI



Wire strain measurement

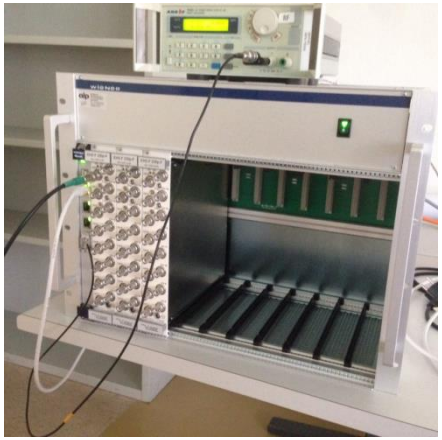
- Test with hand-soldered PCB done:
  - Good results achieved
  - Precision is adequate
- Items to improve
  - Better speaker (now available)
  - Hardware 50Hz noise suppression
  - Better grounding
- Measurement
  - Linear relation f^2 *vs.* wire length as expected at 1st order





HV distribution

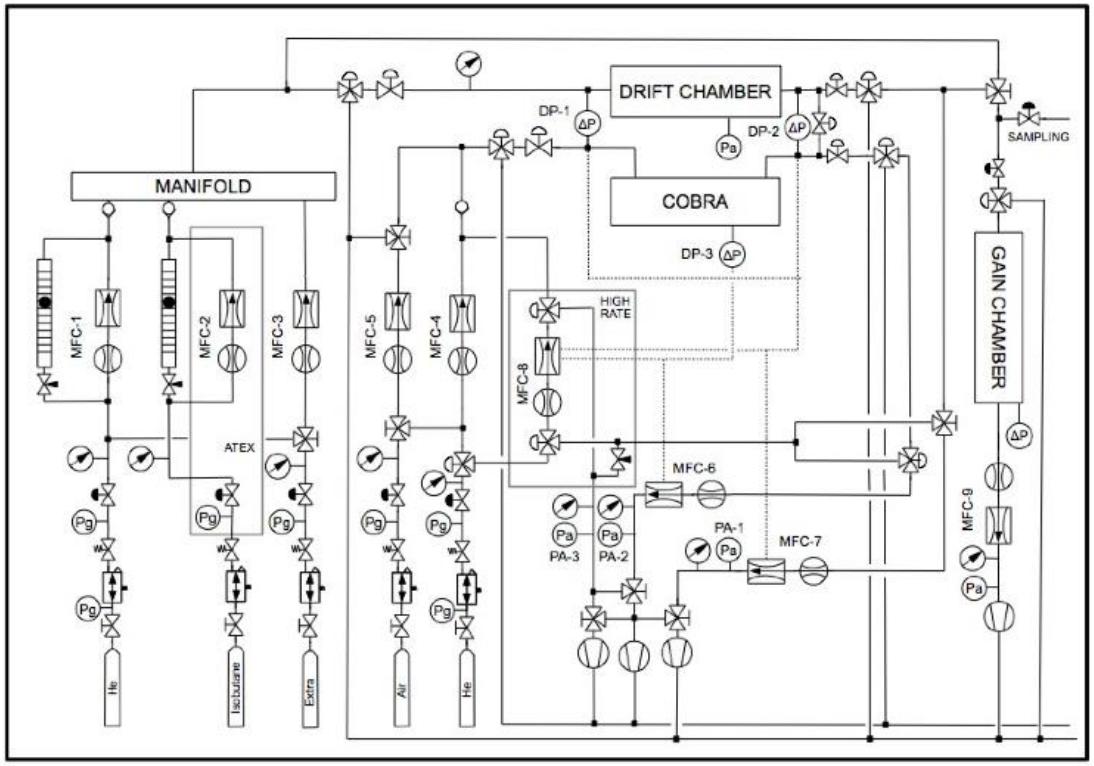
- Based on 6 ISEG boards 16 ch's each plus crate
  - Available
  - Tested



- Connections:
  - From ISEG to Radiall (691803004 type Multipin connector) SHV Adapter (foreseen by end of March):
    - HV-RG58 headed with SHV connectors (available)
  - From Radiall SHV Adapter to DC patch panel
    - Radial multiwire HV cable
  - From DC patch panel to Anode/Guard PCBs
    - Single wire fast-on headed

Gas system status

- All the components ordered, most of them received
- All the system will be arranged in a single rack



People

		MEG	FIRB
Chiarello Gianluigi	Dott.	100	
Chiri Claudio	AssRic	100	
Cocciolo Giuseppe	AssRic	100	
Grancagnolo Francesco	DirRic	40	30
Maffezzoli Alfonso	PO	20	
Panareo Marco	PA	70	30
Pepino Aurora	Dott.	100	
Tassielli Gianfranco	Ric		100
Zavarise Giorgio	PO	20	
TOT		550	