Irfu

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Nb_3Sn development at CEA/Saclay

J.M. Rifflet

On behalf of:
Maria Durante, Michel Segreti, Alain Przybylski and all other people who have participated to this project

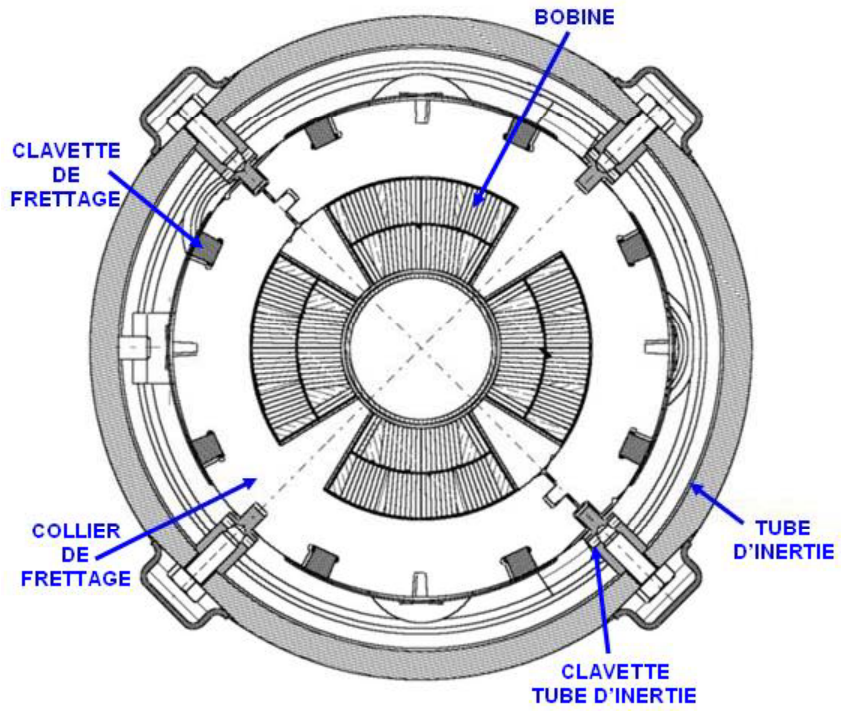
Outline

- Objectives of the Nb_3Sn Quadrupole project
- Components and fabrication process
- Coils Fabrication
- Coil assembly and collaring
- Warm magnetic measurement of collared coils
- Current and future activities
- Conclusions and perspectives

Objectives

- Learn Nb_3Sn technology, using process that can be transferred to industry.
- Build a quadrupole magnet based on NbTi arc quadrupoles design in order to reuse, when possible, existing components or tooling

Gradient	211 T/m
Nominal currenty	11870 A
B_{max}	8.3 T
Straight part length	1 m



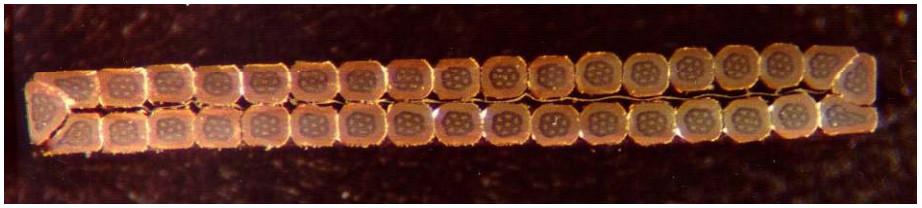
Section of the cold mass

Wind, React and Impregnate

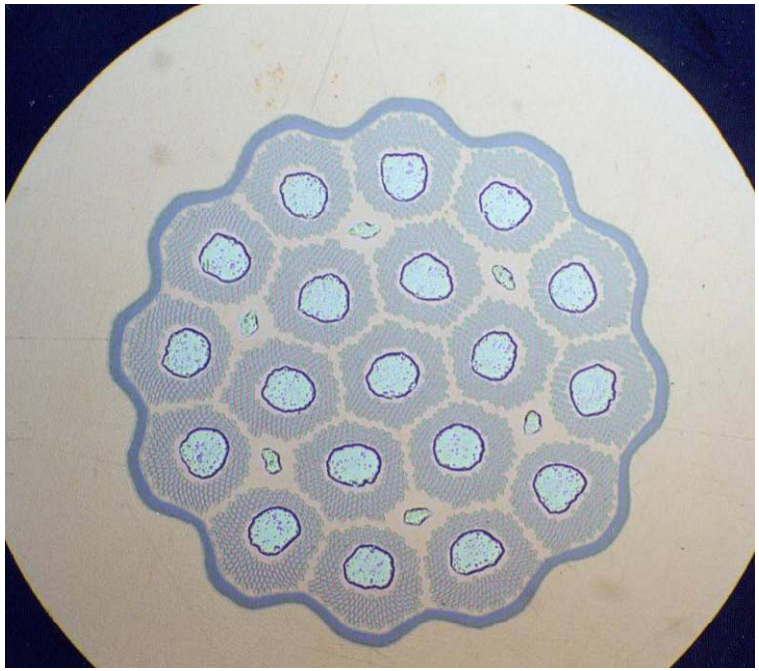
Coil components 1/2

- The conductor was developed in the framework of a collaboration with ALSTOM/MSA.

36 strands cable, with a 125 µm thick stainless steel strip



Cable width: 15.1 mm
Mean thickness: 1.48 mm
Keystone angle : 0.9°



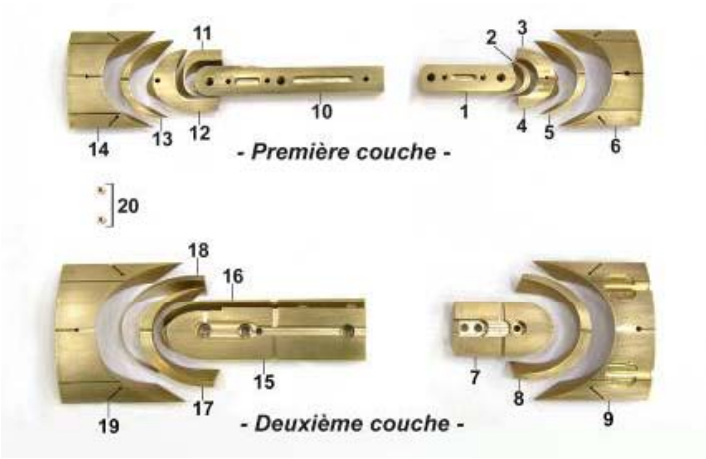
Ø strand : 0.825 mm

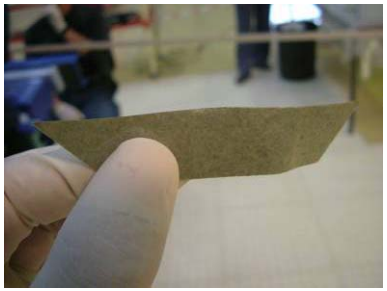
19 sub elements
3762 filaments
anti diffusion barrier in NbTa

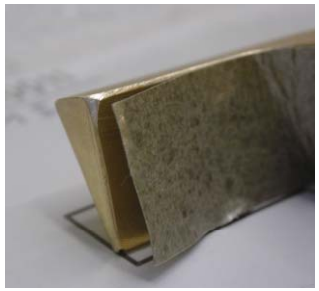
Jc (4.2K, 7T) : 1850 A/mm2
Ø filaments : 19 µm (effective)

Coil components 2/2

- Coil components must resist to heat treatment







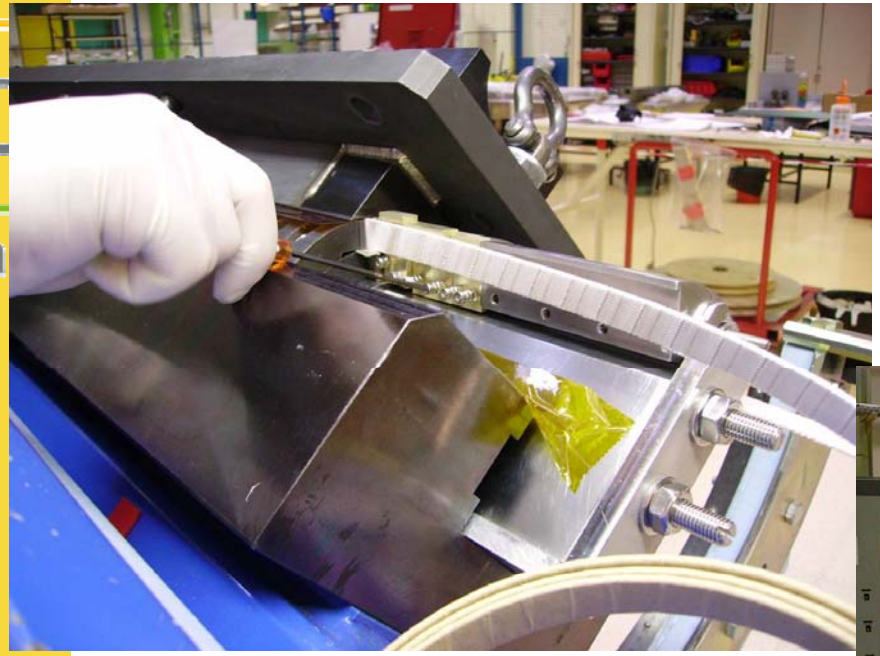
Conductor insulation : S2 glass cloth (+ vacuum epoxy resin impregnation after heat treatment

End spacers : and angular wedges : CuAl9

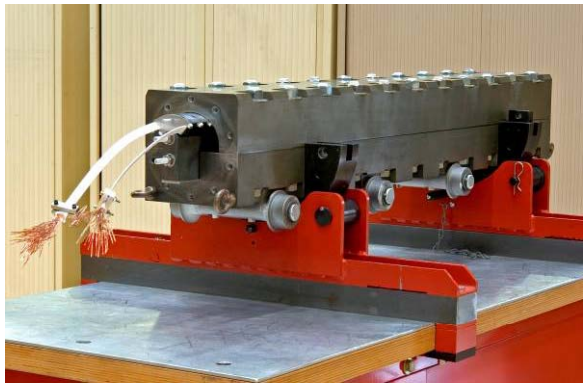
End spacers insulation ; inter turn insulation in ends and inter layer insulation : mica foils; 0.1 mm thick

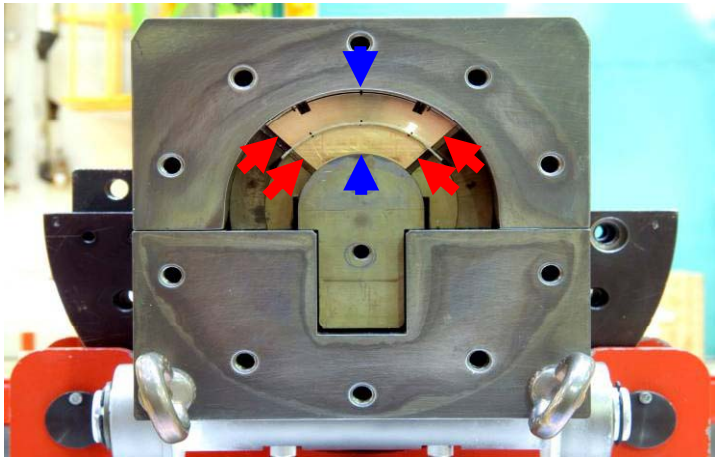
Winding

- Both layers are wound on top of each other, without junction



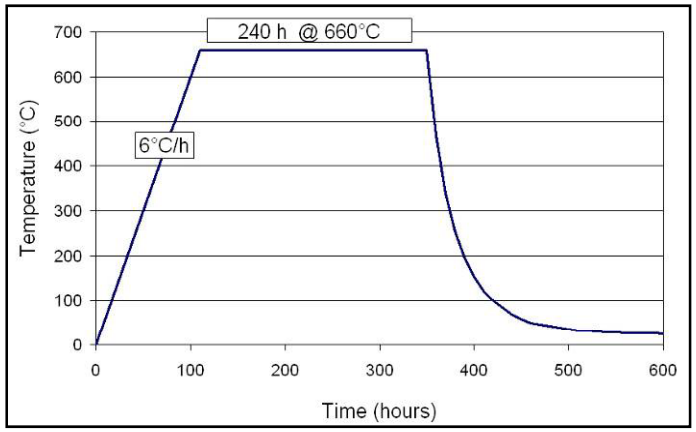
Heat treatment





radially and azimuthally blocked.

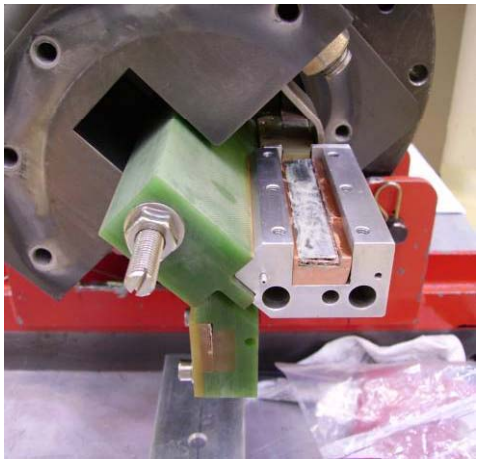
Axially free

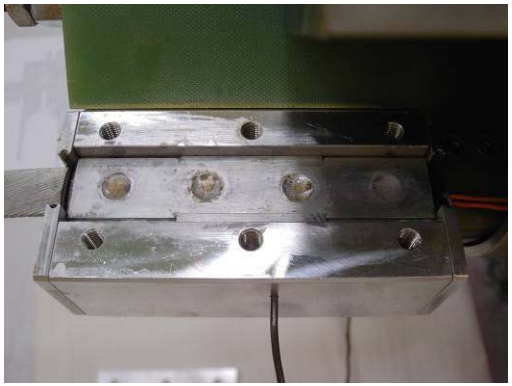
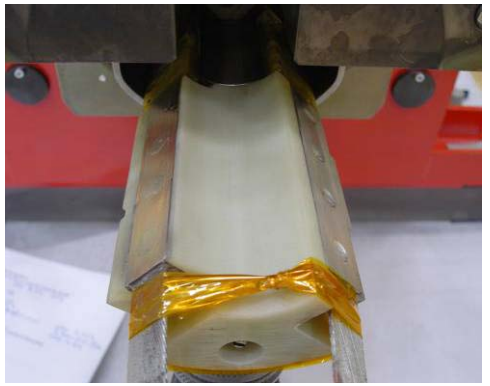


660°C plateau - 10 days
Heat treatment = 20 days
operation : 4 weeks

Nb3Sn/NbTi junctions

- Each Nb3Sn end is soldered to NbTi . Inter coil connexions are standard NbTi connexions

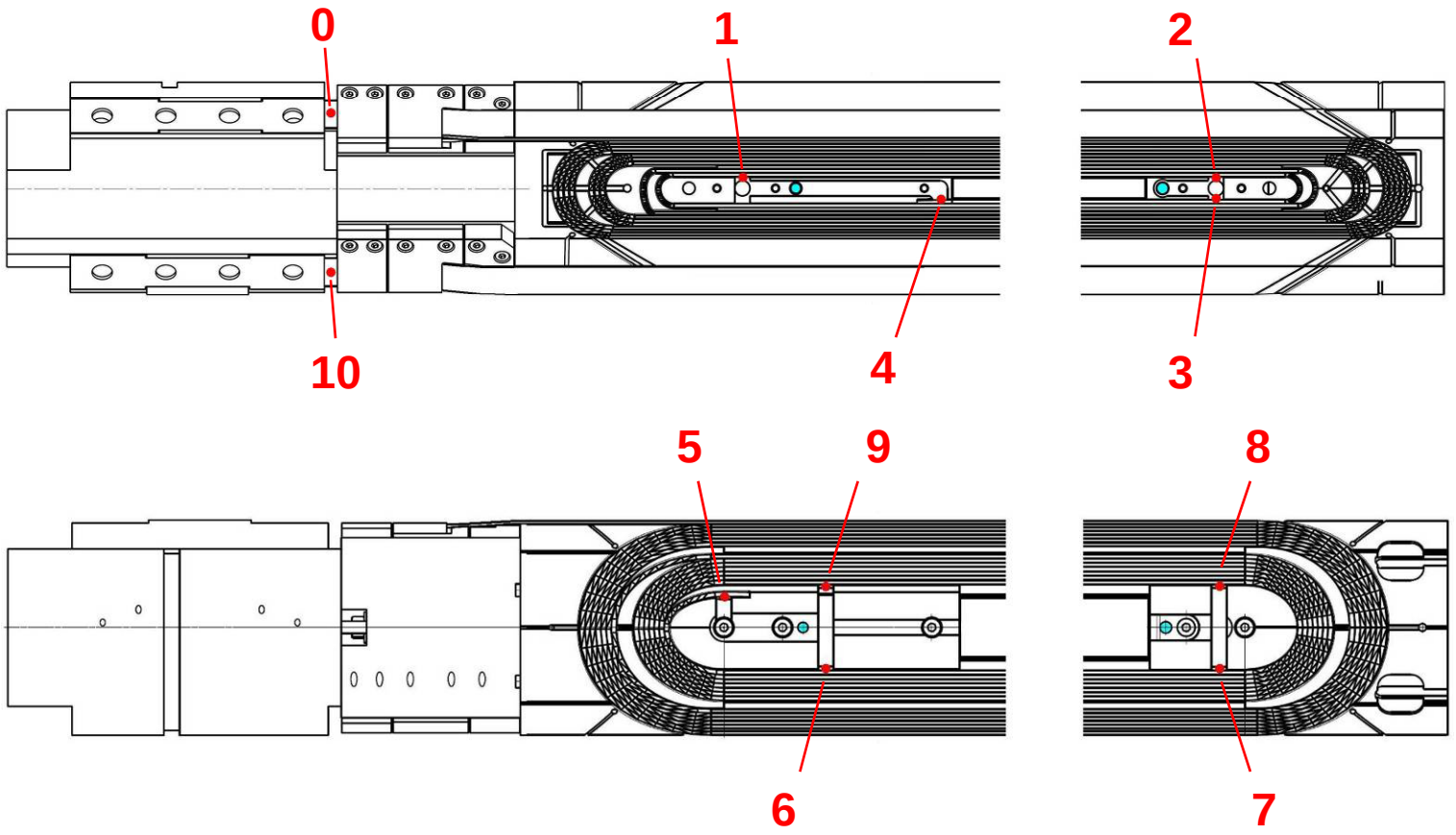



1.5 week

Instrumentation

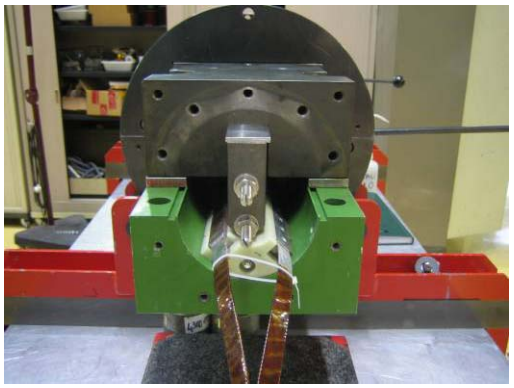
- Each coil is equipped with 13 potential wires



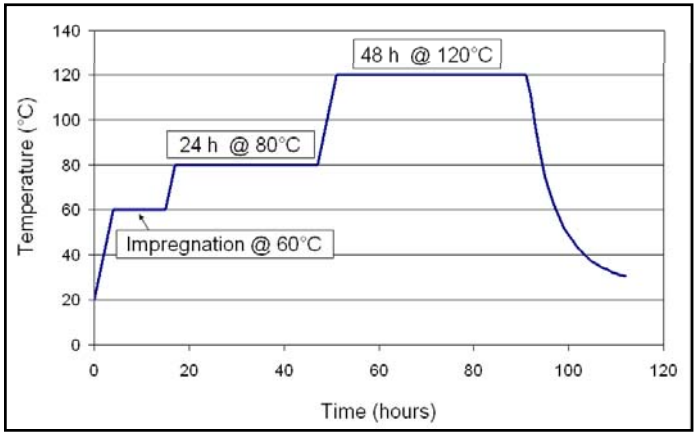
0.5 week

Vacuum Impregnation

- Epoxy resin : Araldite CY192-1 + HY918

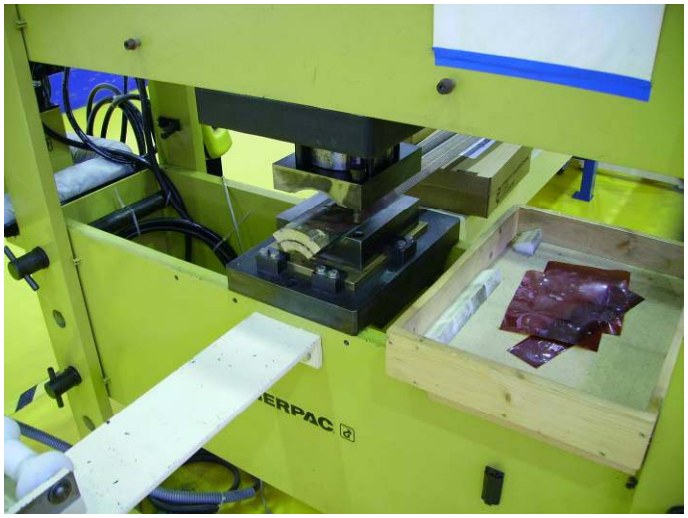




2 weeks, including coil cleaning

Coil Tests

- Electrical and mechanical tests by ACCEL, Germany



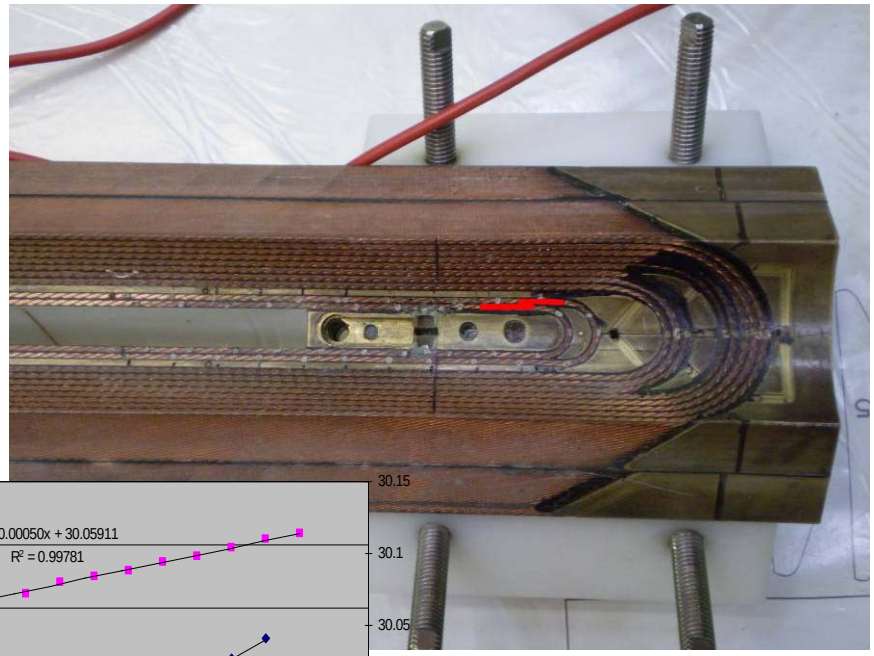
Coils fabrication

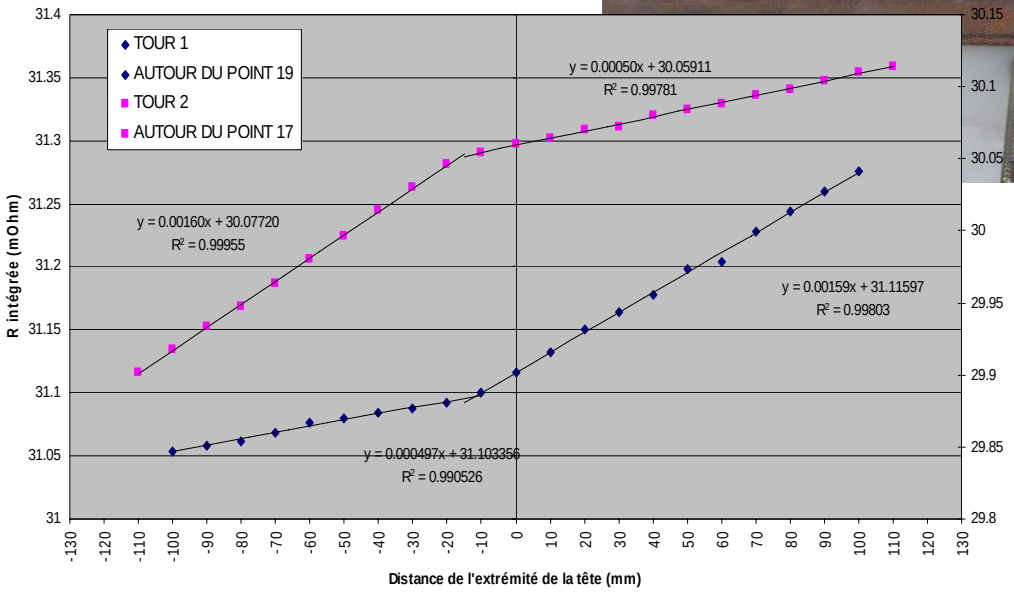
- 2 coils have been wound to check tooling and process
- The 2 coils have been used for 3 collaring tests (with capacitive sensors and strain gauges
- 6 real coils (with checked conductor) have finally been wound

- **Critical points** :
  - Metallic end spacers
  - winding : 2 coils with shorts
  - Heat treatment : how to control the mould closing; twist of the coils after unmolding , coil elongation (2 to 4 mm)
  - junctions : reduce space; brittle conductors
  - Impregnation : leaks; control of resin curing

Coils with short between turns

2 Coils shows short between turn (jump from first to 2nd layer)

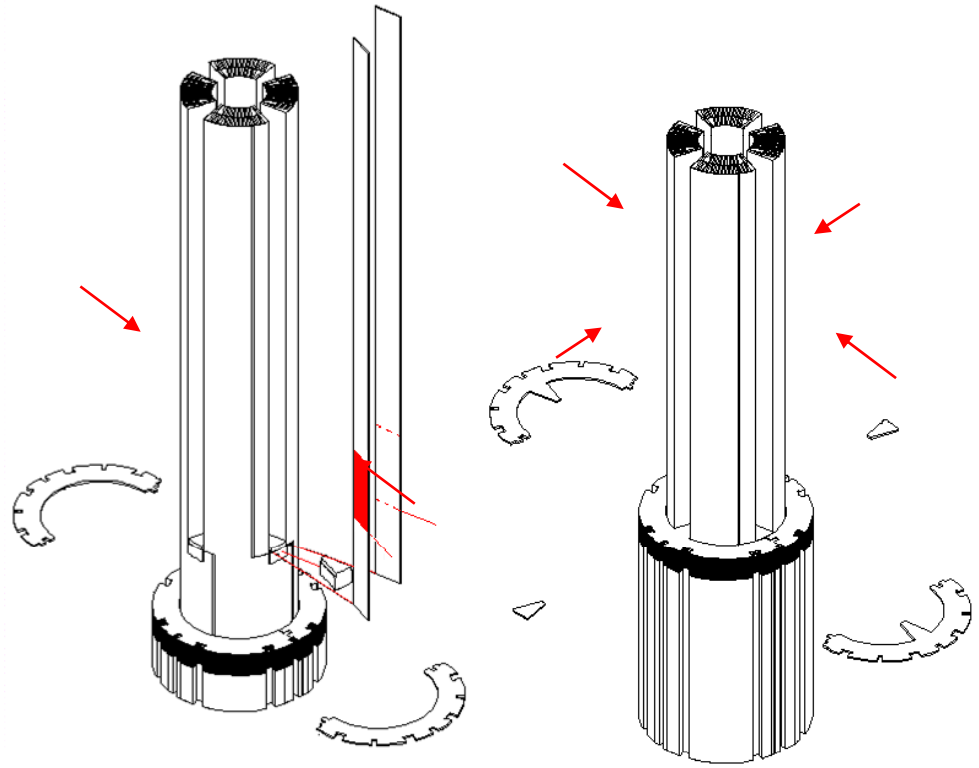


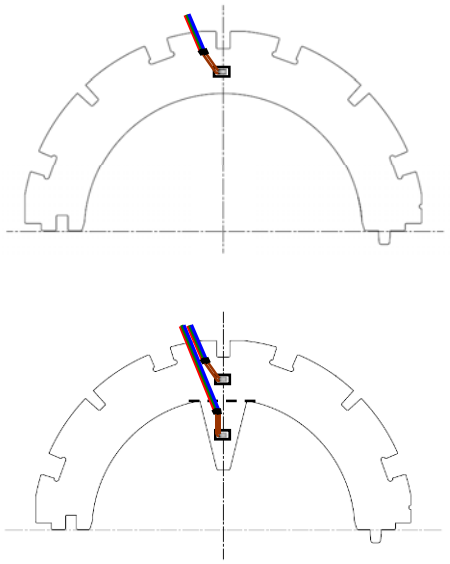


Coils with short between turns

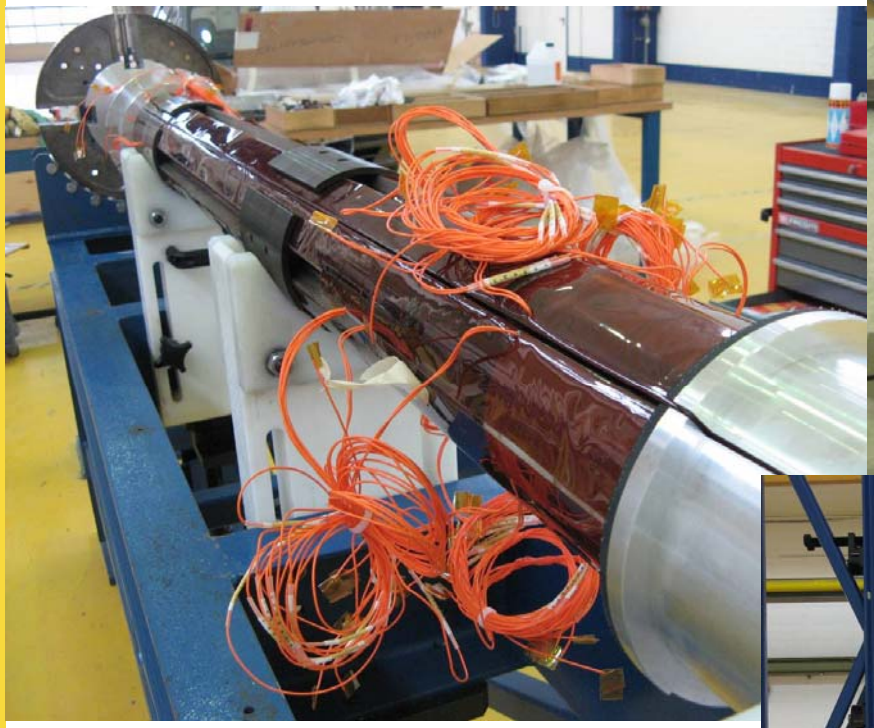
Coil assembly

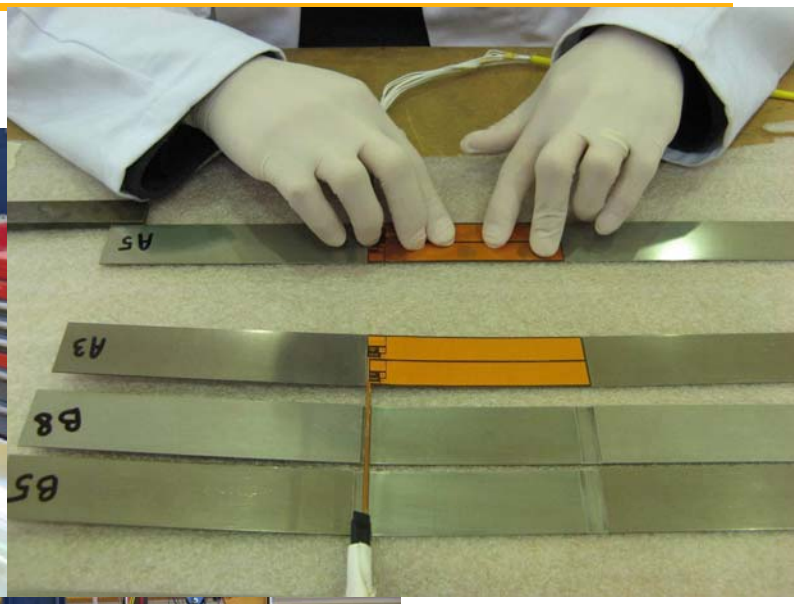
- Same principle as for LHC main quadrupoles
- The magnet is equipped with 8 double capacitive sensors and 12 strain gauges



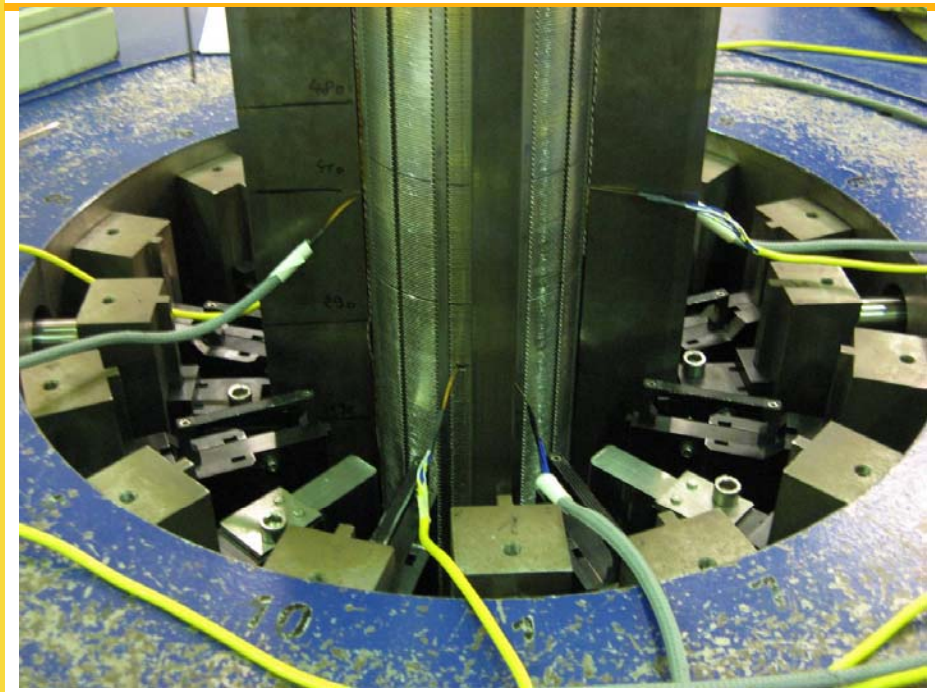


Coil assembly

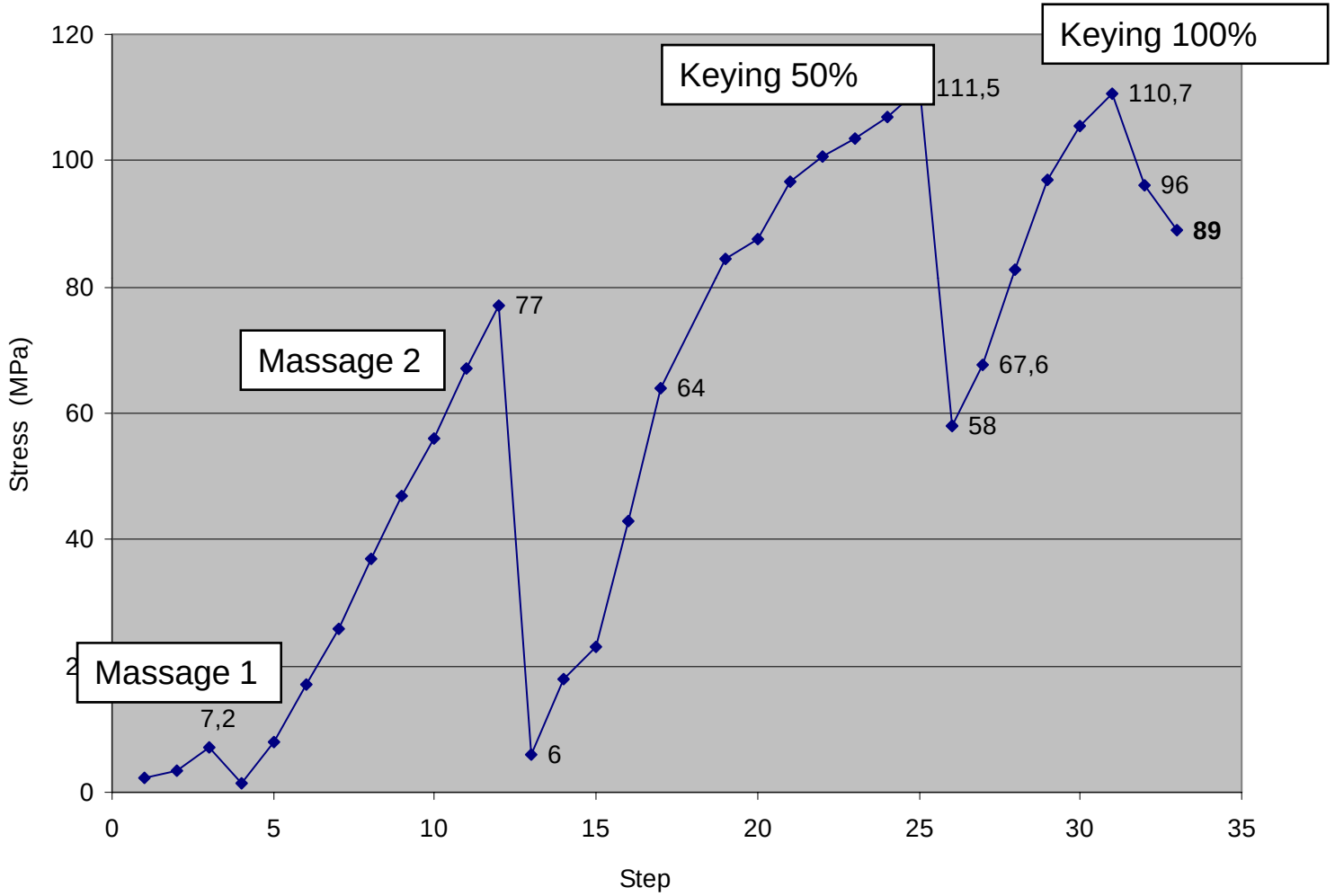




Coil assembly

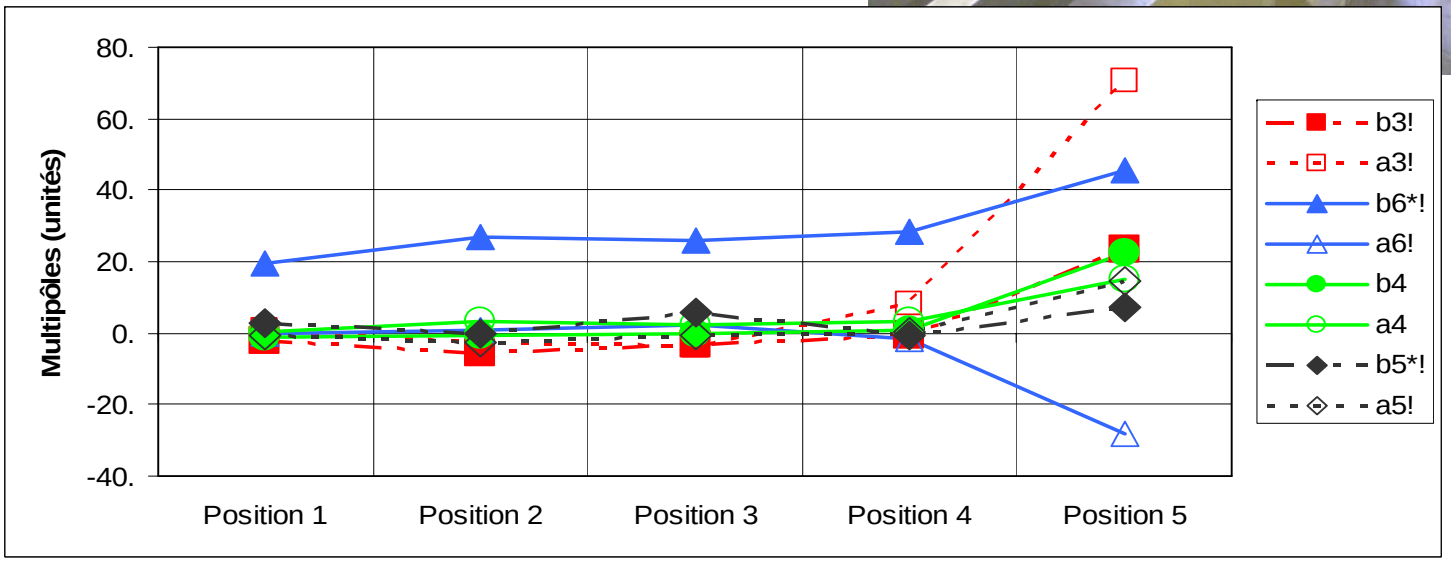


Stress during collaring



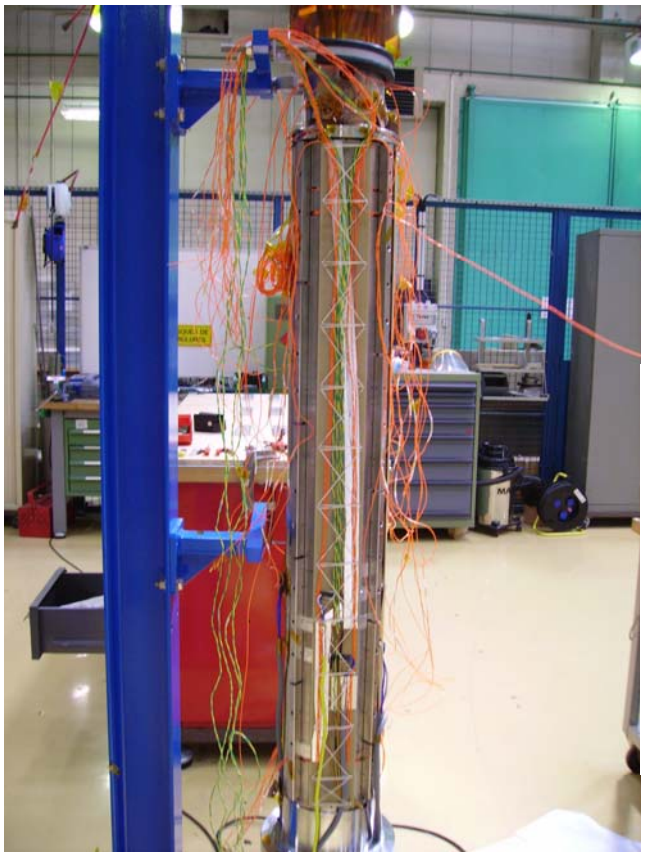
Warm magnetic measurement

- Before inter coils connexions



Magnet essembly

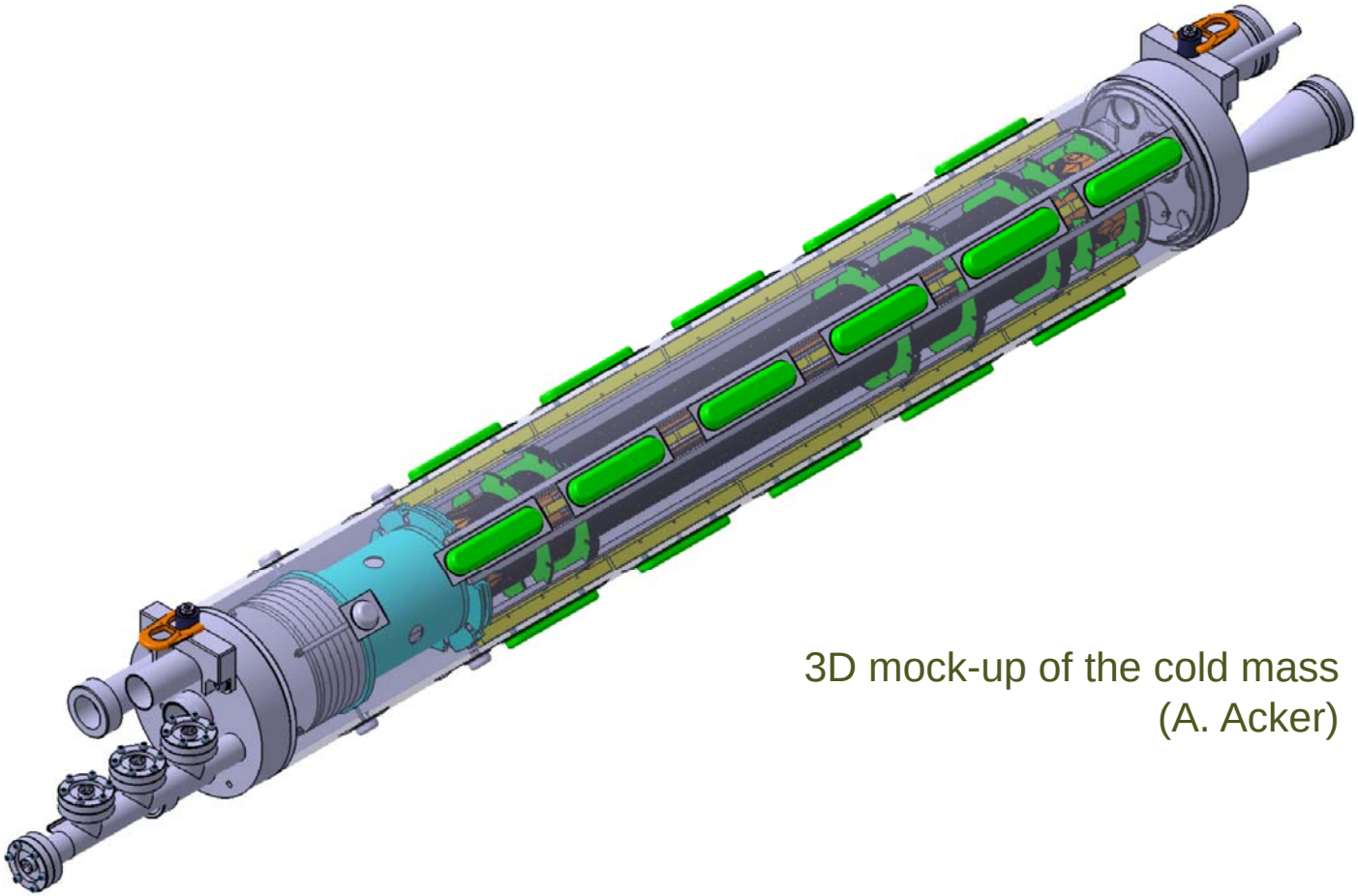
- Inter coils connexions



- Instrumentation wires routing

Cold mass assembly

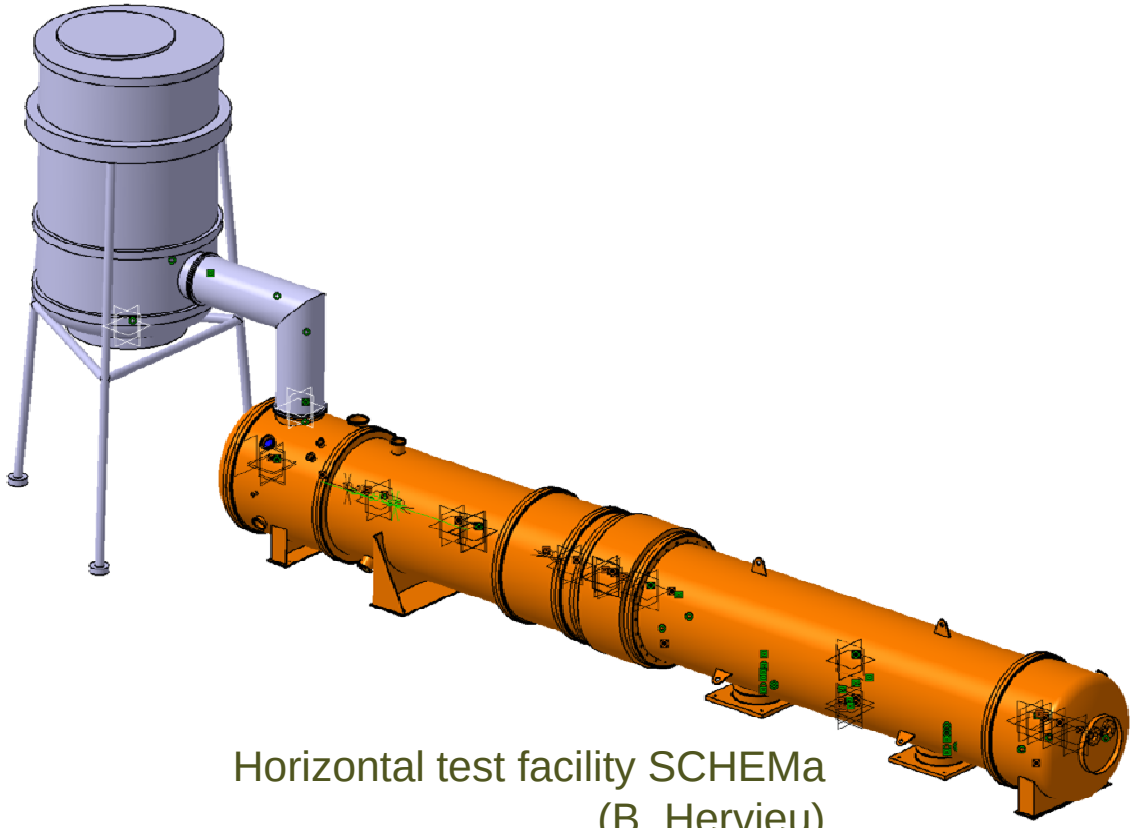
- The cold mass assembly will take place in june 2008



3D mock-up of the cold mass
(A. Acker)

Cold tests

- Cold tests will occur in SCHEMa test facility at Saclay, starting in summer 2008



Horizontal test facility SCHEMa
(B. Hervieu)

Conclusions

- The Saclay's Nb3Sn quadrupole magnet fabrication will be finished within a few weeks.
- A lot of Nb3Sn specificities have been encountered.
- In particular, we have learned how to repair such coils

- But :
  - **The validity of the repair and of all the fabrication process will be proven only during cold tests (summer 2008)**
  - **There is still work to perform in order to achieve the objective of "industrial process"**
  - **Further development will take place (see High field magnet program in Europe – Gijs de Rijk)**