Status report on MQYYM

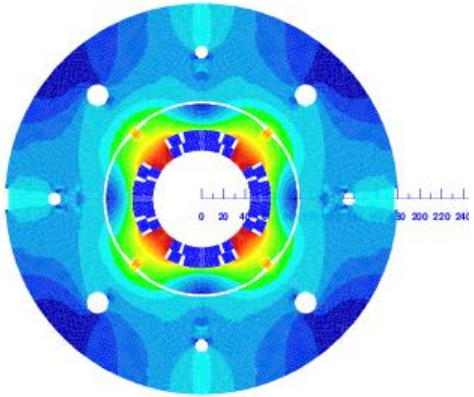
04/10/2017

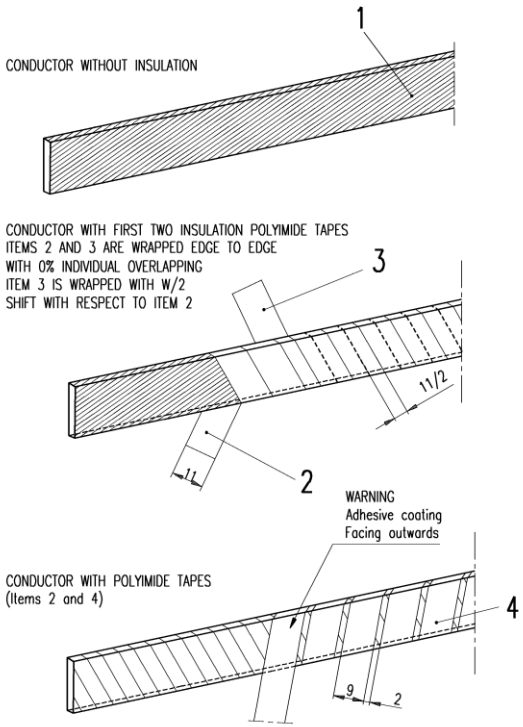
CEA: H. Felice, D. Simon, M. Segreti, J. M. Rifflet, R. Correia-Machado, S. Somson, D. Bouziat, J. M. Gheller, H. Allain, P. Graffin, H. Savador, A. Acker, A. Madur

CERN: A. Foussat, J. C. Perez, N. Bourcey, L. Fiscarelli, O. Dunkel, G. Kirby, J. Fleiter, E. Todesco, M. Guinchard, P. Gros-Claude

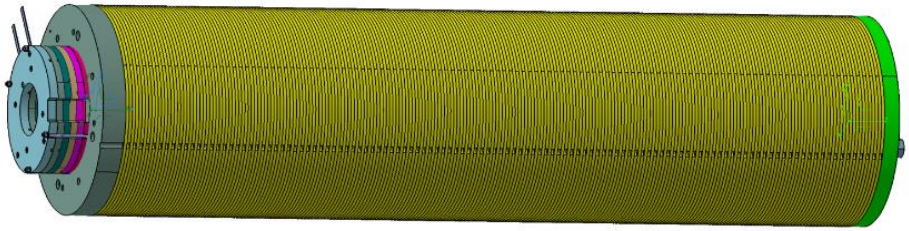
Thank you to Fernando Toral for fruitful discussions

OVERVIEW OF MQYYM



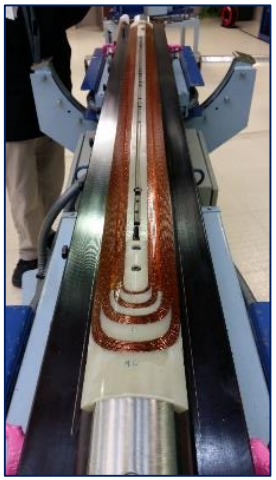


Physical length	1350 mm
Magnetic length at 1,9 K	1204 mm
Outer diameter	360 mm
Bare cable width	8,8 mm
Bare cable thickness	0,77/0,91 mm
Insulation thickness at nominal	0,080 mm
Short sample current	5980 A
Operating Gradient	120 T/m
Operating current	4550 A
Bpeak at operation	6,42 T



MQYYM MANUFACTURING PLAN

- **Conductor from CERN**
  - Insulated conductors for 10 coils at CEA

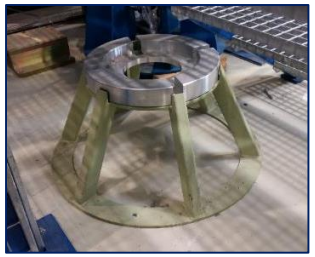


- **Coils fabricated at CEA/Saclay**
  - Winding and polymerization
  - Coil instrumentation

- **Assembly will be performed at CERN (927) by CEA team supported by 927 team**
  - Collaring using 927 collaring press
  - Yoking

- **All components designed by CEA**

- **All interface tooling or specific tooling designed by CEA**. Design is supported/reviewed by N.Bourcey and J.C. Perez
  - Winding tooling
  - Assembly tooling (based on CERN exisiting tooling)
  - Coil measuring tooling (based on CERN exisiting tooling)
  - GPI forming tooling
  - …



- **Procurement**
  - < 5 kCHF: order placed directly by CEA
  - > 5 kCHF: procurement through CERN but followed by CEA
    - Writing of a CERN spec by CEA team
    - Nordine Azizi / Arnaud Foussat (CERN)
    - Hubert Neyrial / Hélène Felice (CEA)

Most of the orders

MQYYM MANUFACTURING PLAN

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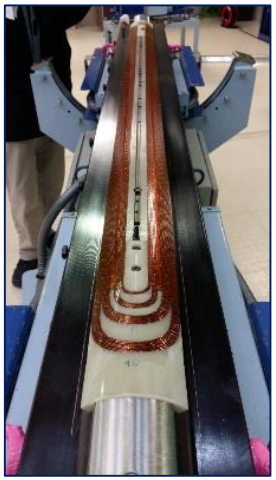


New HL-LHC QA rules request double stamping of drawings for CFT and fabrication.

⇒ More time to launch the CFT

⇒ More room for mistakes

Particulary critical for critical path items

⇒ **Exemption asked by CEA to I. Bejar Alonso.**

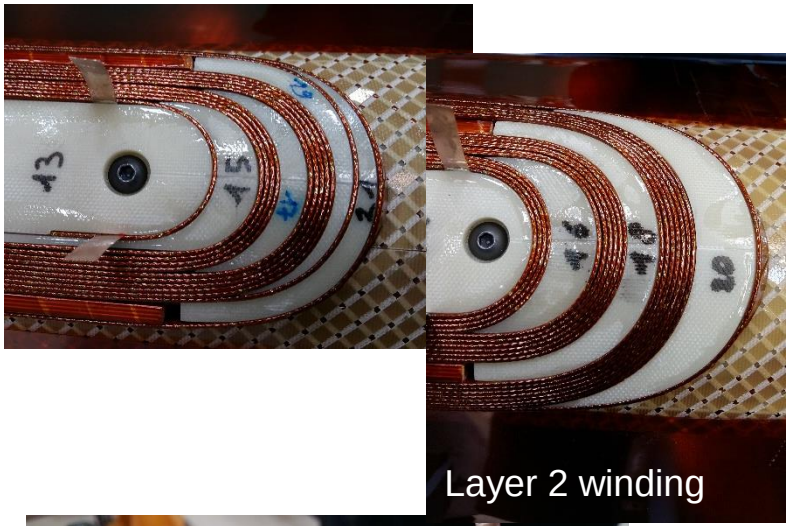
⇒ Accepted by Isabel this morning

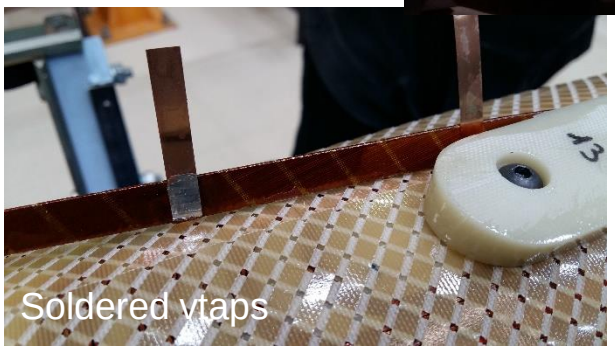
COIL FABRICATION STATUS

	Fabrication dates
Coil 0	22/03-27/04/2017
Coil 1	17-31/07/2017
Coil 2	4-14/09/2017
Coil 3	15-29/09/2017
Coil 4	16-28/10/2017
Coil 5	27/11-9/12/2017
Coil 6	8-19/01/2018
Coil 7	5-16/02/2018

- Technical crew shared with Eucard2 project

FABRICATION: COIL 0





- Good matching of the coil parts with the winding

- CuBe Broken flags after polymerization

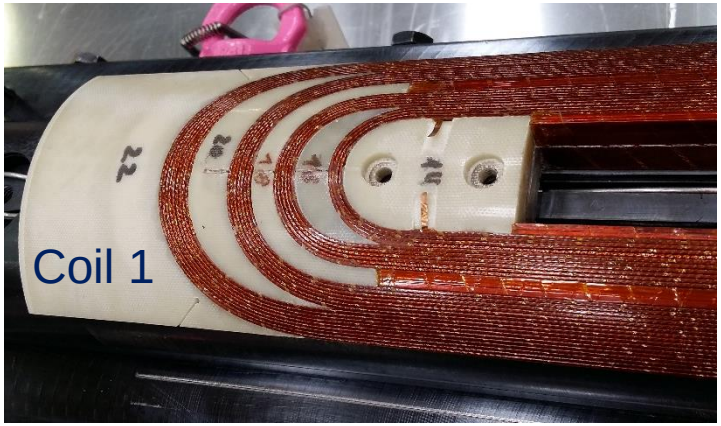
=> Need to smooth the sharp edges to avoid damaging the flags

- Impulse test showing change of frequency at 280 V and above

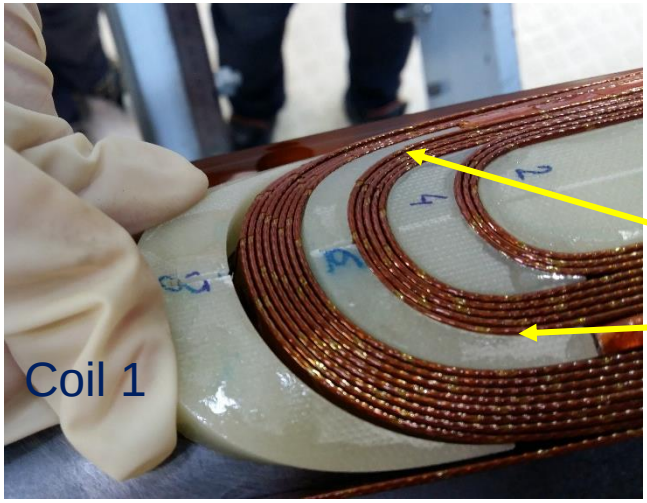
=> Turn to turn weakness?

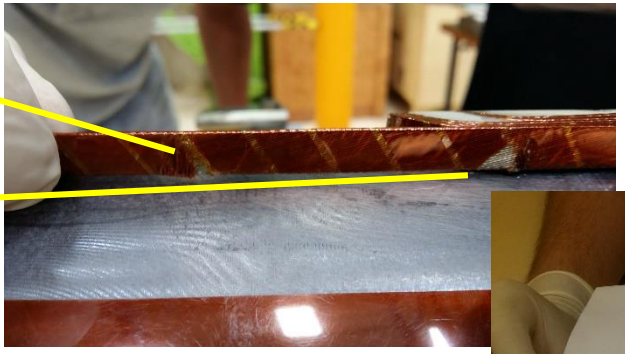
⇒ likely due to the weld of the vtaps using Tin Indium solder (fusion T < polymerization T!)

COIL 1



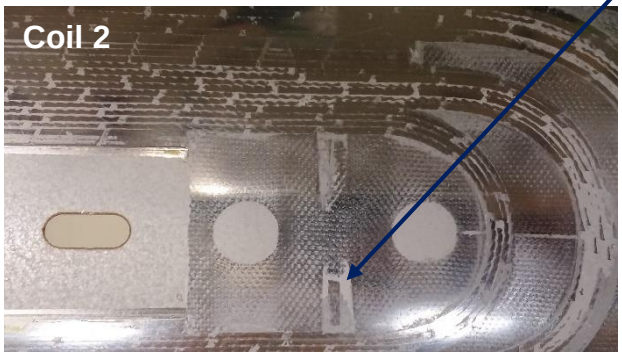
- Vtaps:
  - narrower $CuSn_6$ flags and SnAg solder
  - Grooves added in the end part
- **Slit** in some of the spacers, filled with G10 pieces before polymerization
- Development of procedures for insulation of angular wedges

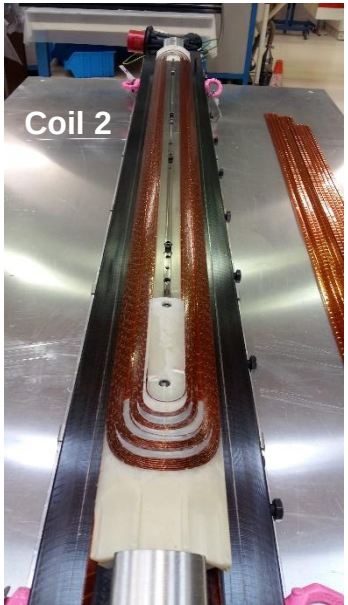


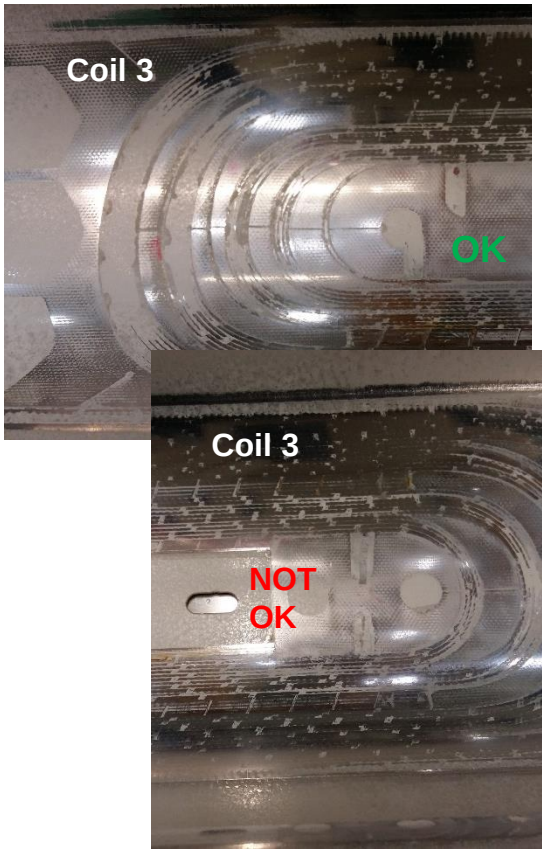


COIL 2 TO 3

- No major issue during coil fabrication of coil 2 and 3
- Concern on vtap flags: grooves are not deep enough => some compression of the taps

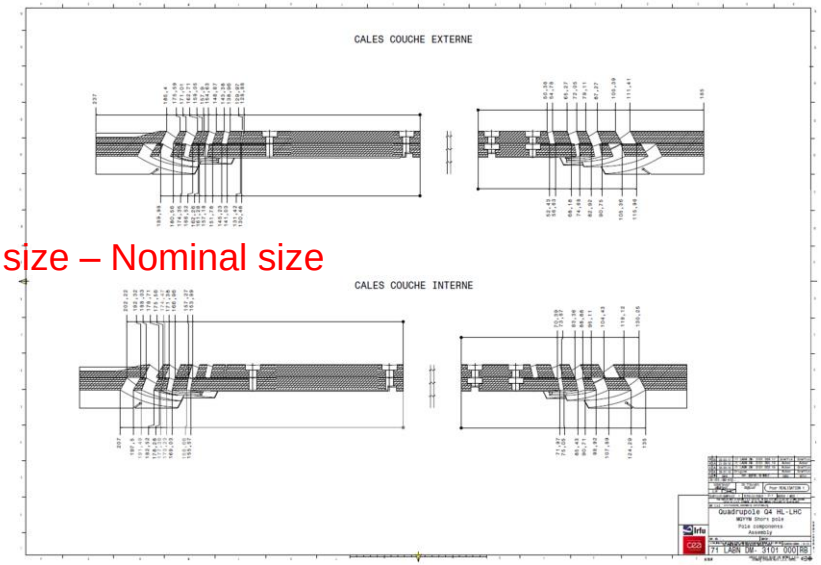




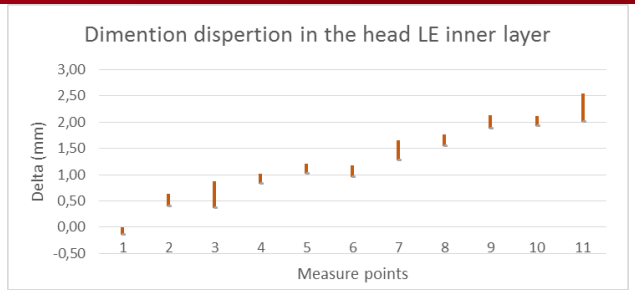


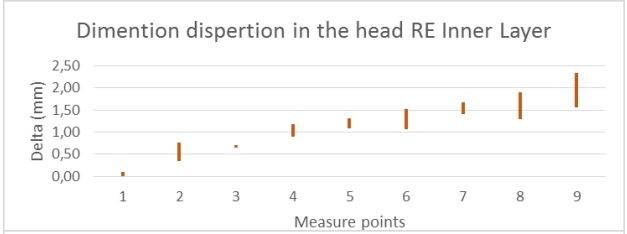
COMPARISON OF COIL DIMENSIONS

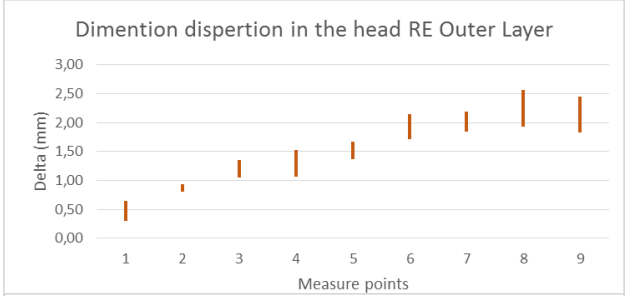
- Coils are 5 mm longer in average than nominal:
  - Coil 0: 4,9 mm longer
  - Coil 1: 4,2 mm longer
  - Coil 2: 5,3 mm longer
  - Coil 3: 5,4 mm longer
- Length build-up in end regions
- Measurement dispersion (avg btw outer an inner layer):
  - ~ 2,5 mm on the lead end side
  - ~ 2 mm on the return end side
- Measurements taken with a large caliper. Uncertainty of about 0,5 mm

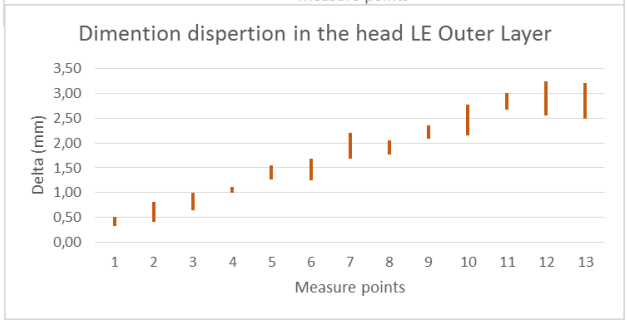


Delta = Actual size – Nominal size



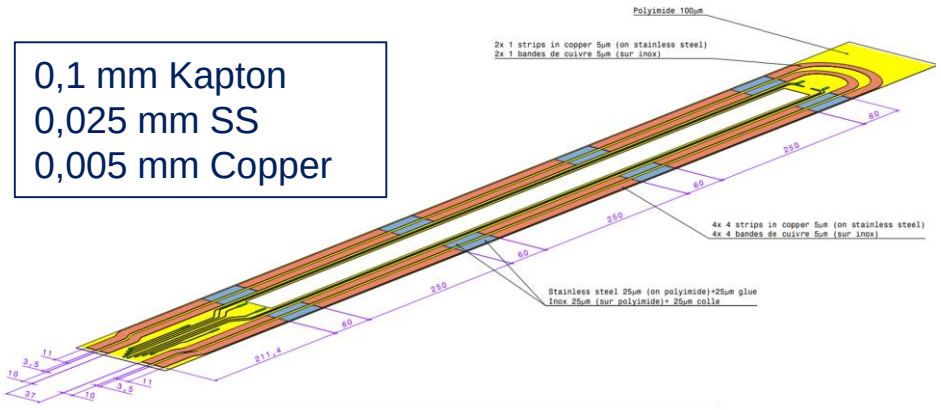






TRACES

0,1 mm Kapton
0,025 mm SS
0,005 mm Copper



- Agreement to order 1 prototype trace to CERN
- Decision to produce 5 traces at CERN for efficiency reason
- Delivery of traces at CEA on 06/09/2017

- Measurements of the trace thickness at CEA: 145 µm of Kapton (instead of 100)
  - Impact of hot spot temperature
  - Impact on magnet build-up

- Matching of vtaps pad and flags ok on coil 1
- Matching test of vtaps planned next week on coil 2 and 3

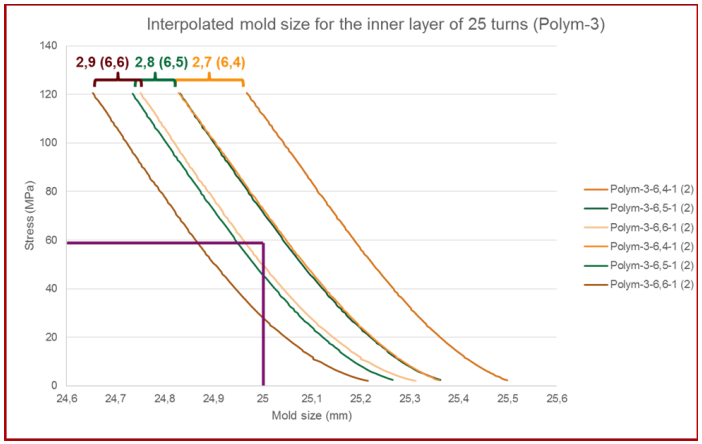
=> fabrication of new traces under discussion

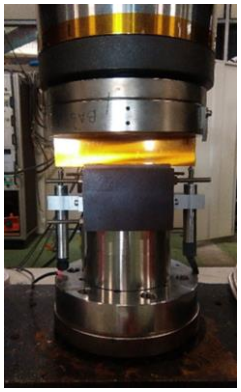
TEN STACK MEASUREMENT

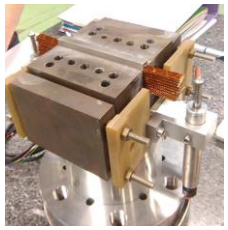
STACKS MEASUREMENTS AT CEA

Presented on 06/07/2017

- Young's Modulus of a cured stack of MQM cables => mechanical analysis
- Shim thickness for the coil polymerization
  Shims of 2,8 mm were chosen

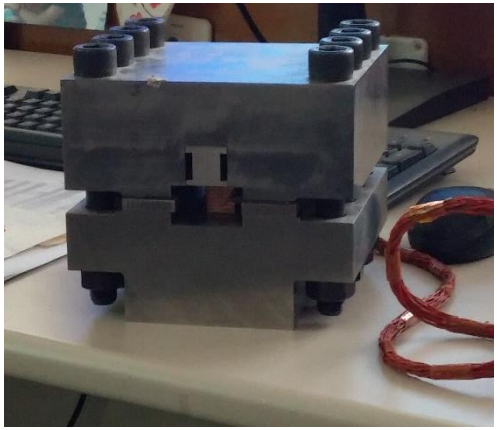






STACKS MEASUREMENTS AT CERN

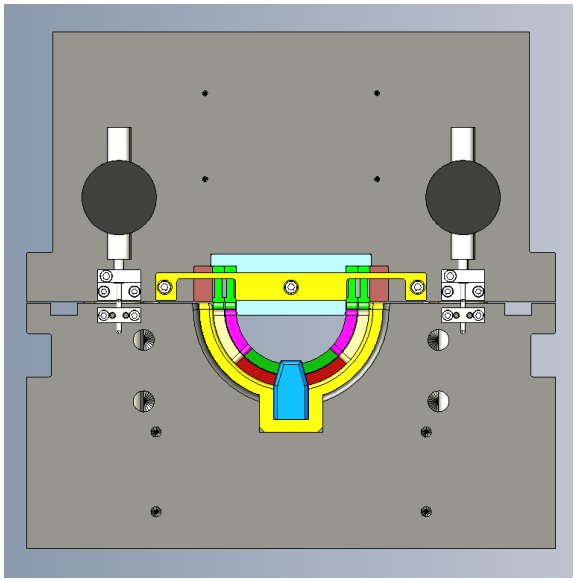
- Crosscheck by M. Guinchard's team
  - Conductor stacks sent to CERN
  - system used for the 11T and MQXF
  - 77K measurements pending set-up availability
- Investigation of Creep and stress relaxation (pending agreement with P. Fessia)

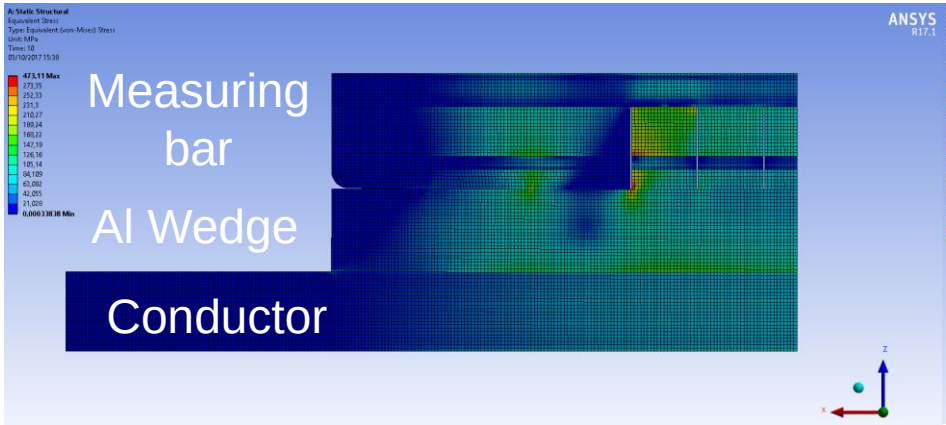


MECHANICAL MEASUREMENTS OF THE COILS

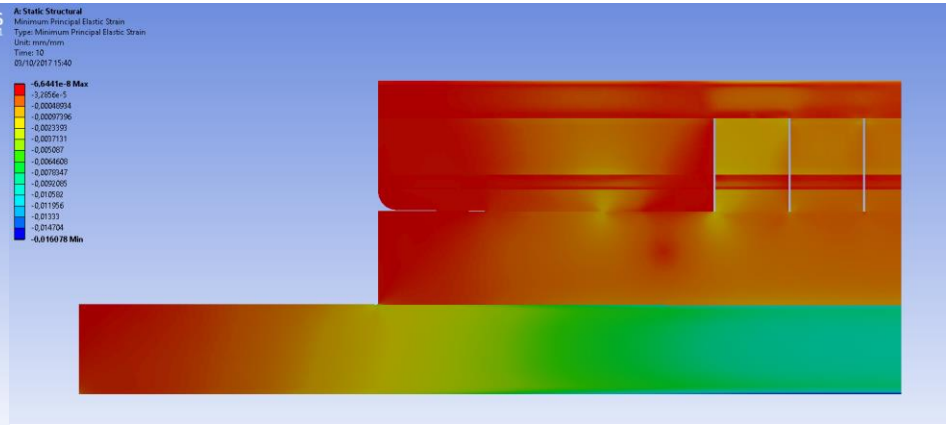
- CAD Adaptation of the mechanical measurements tooling ready
- FEA analyses done to dimension the measuring bar
- CFT should be launched by the end of the week
- **Item procurement on the critical path**

⇒ Design developed in discussion with N. Bourcey and J.C. Perez





Von Mises Stress (65 MPa on the conductor)



Strain (ε_{zz}) (~520 με average on the measuring finger)

MECHANICAL INSTRUMENTATION

TOOLING FOR MECHANICAL COIL MEASUREMENTS

- 40 biaxial Gauges on the measuring bar

- **Proposal:**
  - Instrumentation, software and calibration of the bars by M. Guinchard's team
  - Estimated budget proposal: 15 kCHF
  - Calibration on the press:
    - Request to WP11 for the help of Jose Luis Rudeiros
    - Help from CEA technicien (Antoine Bonelli) approved at CEA

MAGNET INSTRUMENTATION

- **Proposal**
  - Instrumentation of 4 collars (top/bottom/left/right noses) at 3 given longitudinal positions (close to LE, at the center and close to RE)
- 2 biaxial gauges per face on one azimuthal side of the collar (4 gauges/collars)
- Instrumentation of collar flanges
- Instrumentation by M. Guinchard's team
- Estimated budget proposal: 17 kCHF

STATUS ON COMPONENTS AND TOOLING

Orders and call for tenders

- Collars: manufactured by HV wooding => delivered on 18/09/207 at CERN.

Inspection is ongoing

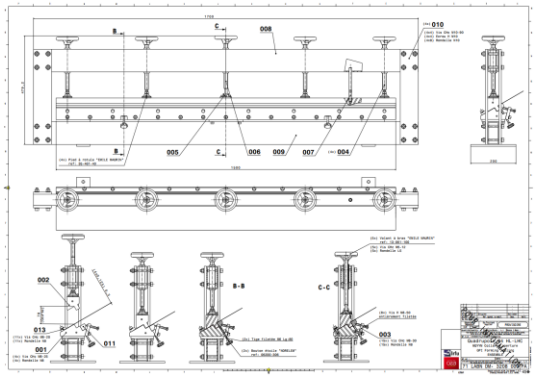
- Yoke laminations : Agreement with N. Azizi to place a **direct order**. Written justification provided by CEA. Now in fabrication at HV wooding. Delivery expected in October 2017
- Connection box + G11 components: specification in preparation, drawings ready, cross-checks with instrumentation
- Flange and mechanical parts: specification in preparation, drawings ready (to be adjust for the routing of the instrumentation)
- Protection shoe and radial protection: Order to be placed
- Assembly tooling: order placed on 26/09/2017

CAD

- GPI forming tooling: designed by CEA. Drawings in preparation

⇒ Design developed in discussion with N. Bourcey and J.C. Perez

- Transportation tooling and splicing tooling: ongoing design



MQYYM: PREPARATION OF THE TEST FACILITY

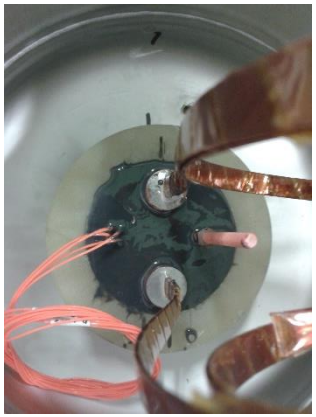
Cryogenic facility

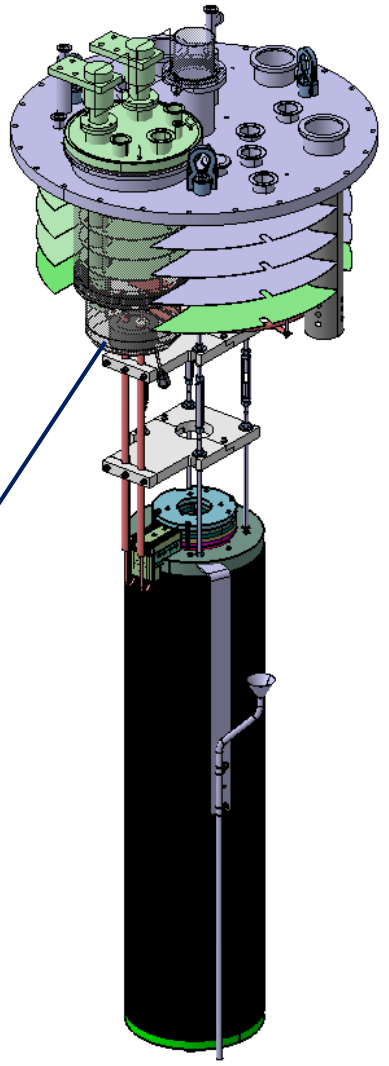
- Effort carried out by J.M Gheller
- CEA 8 m vertical cryostat equipped with a 3 m long « sock » (tank)
- Adaptation of an existing top plate
- Saturated LHe bath at 1,9 K 23 mbar

the top plate and 4,2 K lead assembly ongoing

Data acquisition and magnet protection

- Effort carried out by Denis Bouziat
- Support from another group at CEA (DIS)
- Agreement made on work sequence and resources to be ready for the test





MQYYM SCHEDULE

Nom de la tâche	Durée	Début	Fin	Prédécesse
Coil fabrication	**70 jours?**	**Lun 04/09/17**	**Ven 08/12/17**	
Connection box assembly training	1 sm	Mar 13/02/18	Lun 19/02/18	59;85
Tooling and components procurement	**225 jours?**	**Mer 10/05/17**	**Mer 04/04/18**	
Assembly tooling	**119 jours**	**Mer 12/07/17**	**Mar 09/01/18**	
Collars	**114 jours?**	**Mer 10/05/17**	**Lun 16/10/17**	
Yokes	**61 jours?**	**Lun 07/08/17**	**Mar 31/10/17**	
connexion box (2)	**80 jours**	**Lun 09/10/17**	**Lun 12/02/18**	
Design finalization	5 jours	Lun 09/10/17	Ven 13/10/17	
CFT	2 sm	Lun 16/10/17	Ven 27/10/17	82
Order + fab	3 mois	Lun 30/10/17	Lun 05/02/18	83
Delievery at CEA	1 sm	Mar 06/02/18	Lun 12/02/18	84
Coil parts (6 sets)	**1 jour**	**Mer 26/07/17**	**Mer 26/07/17**	
other components	**80 jours**	**Lun 16/10/17**	**Lun 19/02/18**	
V supports for magnetic measurements	80 jours	Mer 01/11/17	Mer 07/03/18	
V supports for magnet tilting	80 jours	Mer 01/11/17	Mer 07/03/18	
GPI tooling	**90 jours**	**Mer 15/11/17**	**Mer 04/04/18**	
Coil shipping tooling	**62 jours**	**Lun 06/11/17**	**Mer 14/02/18**	
Magnet shipping tooling/crate				
measuring coil tooling	**196 jours**	**Ven 09/06/17**	**Lun 26/03/18**	
Trace fabrication	**118 jours**	**Mer 26/07/17**	**Lun 22/01/18**	
Assembly preparation and assembly	**171 jours?**	**Lun 06/11/17**	**Mer 18/07/18**	
Assembly of the assembly tooling (at CE	1 jour?	Mer 21/03/18	Jeu 22/03/18	113DF-3 jour
Coil measurements + set up	2,5 mois	Mar 27/03/18	Lun 04/06/18	101
soldering/wiring of the trace	3 jours	Mar 05/06/18	Jeu 07/06/18	113
GPI preparation	3 jours	Mer 17/01/18	Ven 19/01/18	101
Collaring	**156 jours**	**Lun 06/11/17**	**Mar 26/06/18**	**69;115;114**
electrical integrity tests	1 jour	Mer 27/06/18	Mer 27/06/18	116
Connection box assembly	5 jours	Mer 27/06/18	Mar 03/07/18	116
Magnetic measurements	5 jours	Mer 04/07/18	Mar 10/07/18	121
Yoking	1 sm	Mer 11/07/18	Mer 18/07/18	122
Warm magnetic measurement with yoke	2 sm	Jeu 19/07/18	Mer 01/08/18	123

Critical path

	Fabrication dates
Coil 0	22/03-27/04/2017
Coil 1	17-31/07/2017
Coil 2	4-14/09/2017
Coil 3	15-29/09/2017
Coil 4	16-28/10/2017
Coil 5	27/11-9/12/2017
Coil 6	8-19/01/2018
Coil 7	5-16/02/2018

other components	**80 jours**	**Lun 16/10/17**	**Lun 19/02/18**
keys	80 jours	Lun 16/10/17	Lun 19/02/18
flanges	80 jours	Lun 16/10/17	Lun 19/02/18
protection shims	80 jours	Lun 16/10/17	Lun 19/02/18
collaring shoe	80 jours	Lun 16/10/17	Lun 19/02/18

measuring coil tooling	**196 jours**	**Ven 09/06/17**	**Lun 26/03/18**
Design (CFT + design work)	90 jours	Ven 09/06/17	Jeu 12/10/17
CFT	5 sm	Ven 13/10/17	Jeu 16/11/17
Fabrication	3 mois	Ven 17/11/17	Ven 23/02/18
Delivery at CERN	1 jour	Lun 26/02/18	Lun 26/02/18
part validation/instrumentation	1 mois	Mar 27/02/18	Lun 26/03/18

Collaring	**156 jours**	**Lun 06/11/17**	**Mar 26/06/18**
collars instrumentation	3 sm	Lun 06/11/17	Ven 24/11/17
assembly on vertical stand	8 jours	Ven 08/06/18	Mar 19/06/18
Collaring on press	5 jours	Mer 20/06/18	Mar 26/06/18

MQYYM : SUMMARY AND NEXT STEPS

SUMMARY

- **MQYYM Magnet design completed**
- **Coil 1 to 3 completed**
- **The best is done to keep a reasonnable schedule:**
  - **Direct order when relevant and possible**
  - **Exemption on QA process to speed up procurement of items on the critical path**
  - **Tight connection between CERN crew and CEA team**
- **Assembly prep and test prep on track**
- **Mechanical instrumentation defined**
- **Cross-check on rigidity measurements ongoing**

NEXT STEPS

- **Complete the procurement of the tooling and coil components**
- **Finalize some tooling design (transport, splicing…)**
- **Proceed with MQYYM fabrication**
- **Test remains forseen in Fall 2018**