



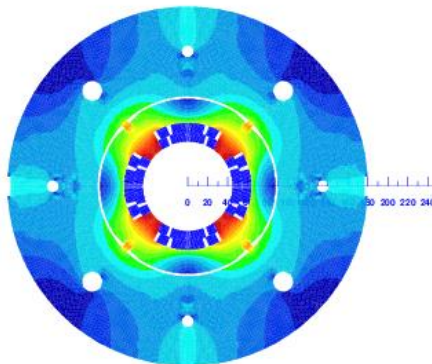
Status report on MQYY

06/07/2017

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

MQYYM: MQYY short model



- Physical L = 1350 mm endshoe to endshoe
- Magnetic Length = 1204 mm at 1,9 K
- Outer diameter = 360 mm

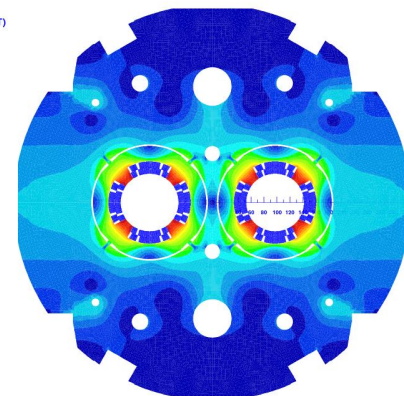
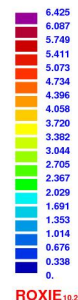
OUTLINE:

- Overview of the magnetic design
- Overview of the mechanical design
- Status on engineering design
- Status on magnetic measurement preparation
- Status on preparation
- Next steps

MQYY prototypes within QUACO

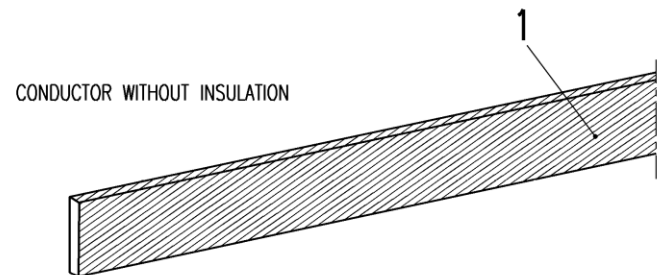
Based on a design study carried out at CEA (M. Segreti)

|B| flux density (T)

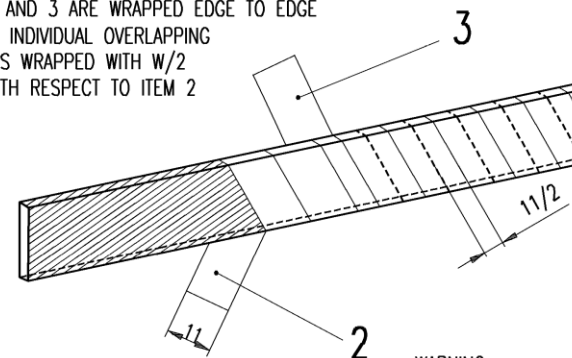


- **Selection of 4 companies** to design and manufacture MQYY quadrupole (competitive process 4/3/2 in conceptual/engineering/manufacturing phase)
- **Starting point: CEA magnetic design**
Mechanical design is **NOT** provided
- Phase 2: Offers have been evaluated by technical committee and validated by QUACO Steering committee.
- Beginning of phase 2: July 4th and 5th 2017
- Phase 2 duration: 13 months

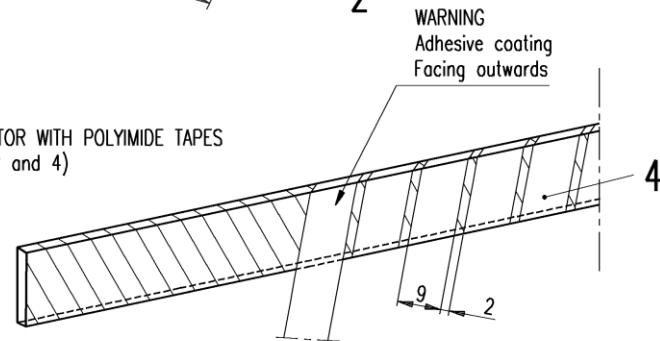
- **Bare dimensions:** 8,8 mm x (0,77/0,91)mm
- **Insulation:**
 - Polyimide wrap 2x 0,025 mm
 - Polymide wrap 0,055 mm with adhesive on the outside
 - 0,105 mm => 0,080 mm at nominal
- **Insulated dimensions:** 8,96 mm x (0,93/1,07)mm

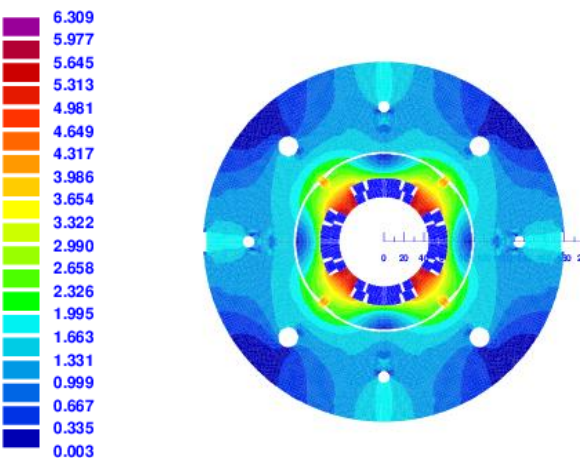


CONDUCTOR WITH FIRST TWO INSULATION POLYIMIDE TAPES
ITEMS 2 AND 3 ARE WRAPPED EDGE TO EDGE
WITH 0% INDIVIDUAL OVERLAPPING
ITEM 3 IS WRAPPED WITH W/2
SHIFT WITH RESPECT TO ITEM 2



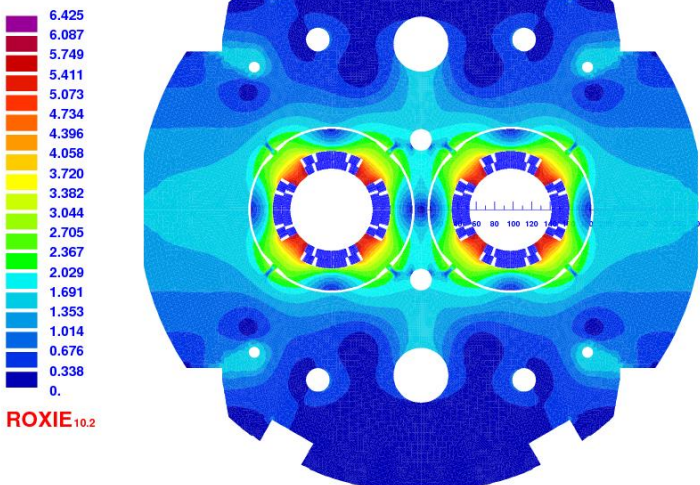
CONDUCTOR WITH POLYIMIDE TAPES
(Items 2 and 4)





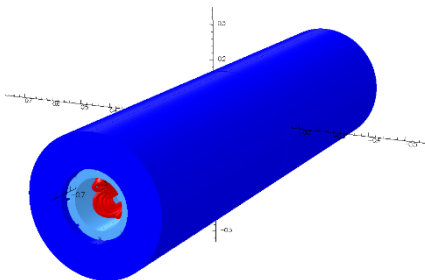
ROXIE 10.2

|B| flux density (T)



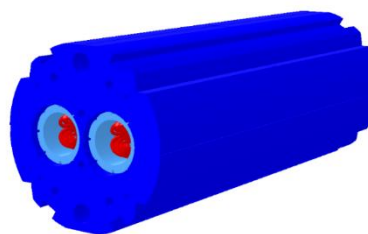
ROXIE 10.2

MQYYM: MQYY short model

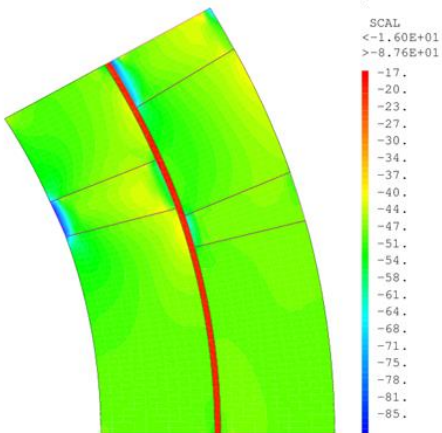
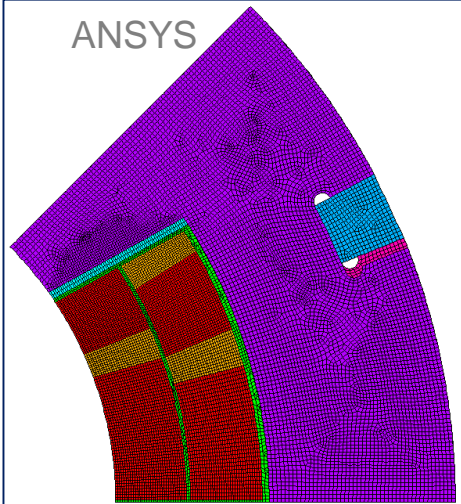
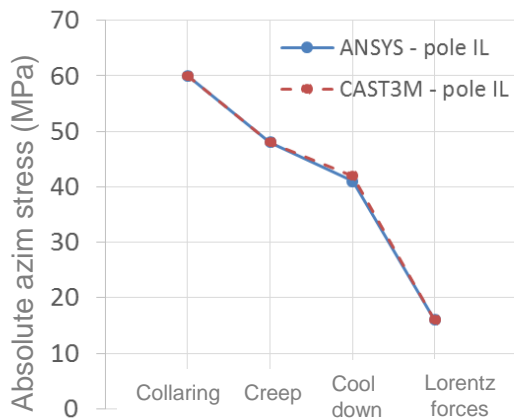
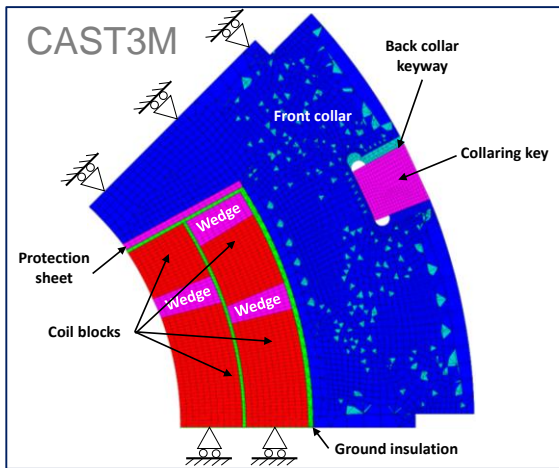


Operating Gradient	120 T/m
Operating current	4550 A
Bpeak at operation	6,42 T
Short sample current	5980 A

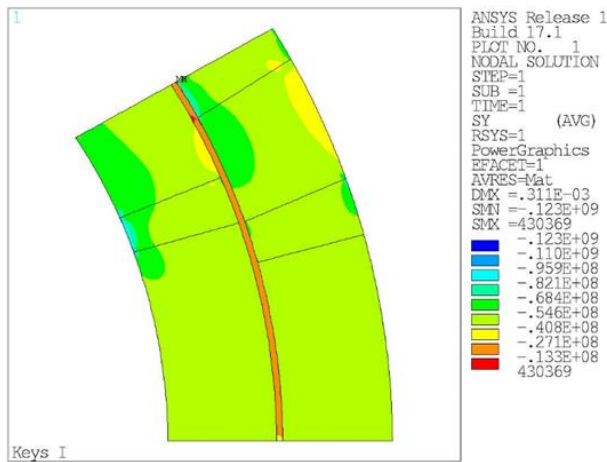
MQYY: prototype design (CEA)



Operating Gradient	120 T/m
Operating current	4590 A
Bpeak at operation	6,44 T
Short sample current	5997 A

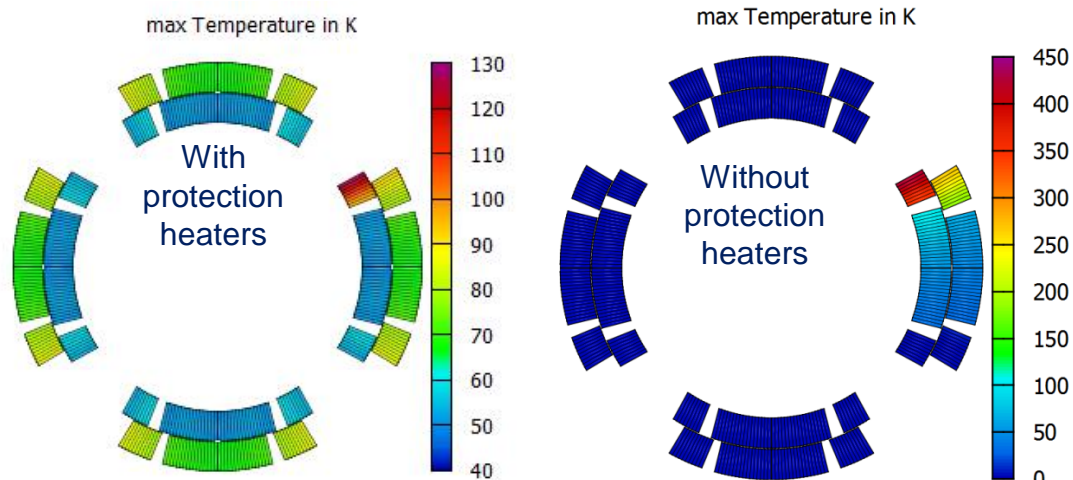


- Self standing collar structure
- Required stress during assembly: 60 MPa
- Very good agreement between CAST3M and ANSYS



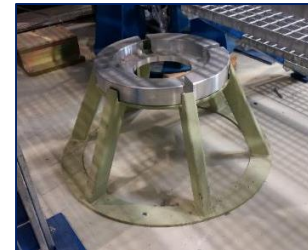
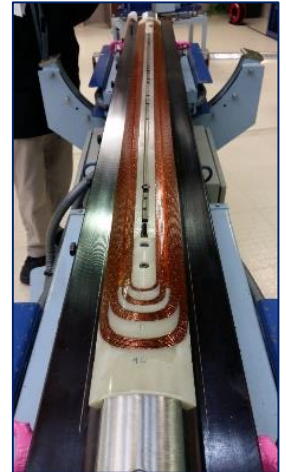
ROXIE RESULTS

Without protection heaters	
Hot Spot	≈440K
Voltage to ground	≈700V
Without the half of the protection heaters	
Hot Spot	≈160K
Voltage to ground	≈145V
With protection heaters	
Hot Spot	≈130K
Voltage to ground	≈135V



- Simulation with Qtransit and ROXIE. Ongoing work on benchmarking and fine tuning the models

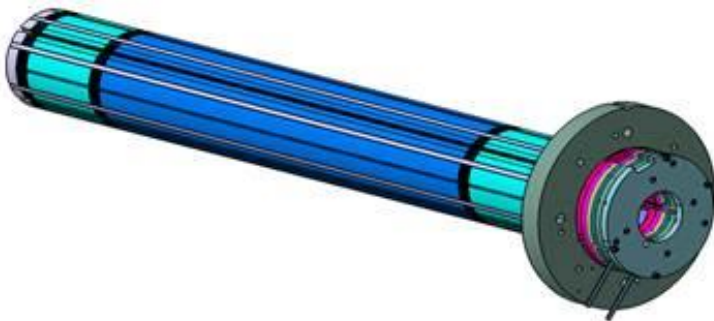
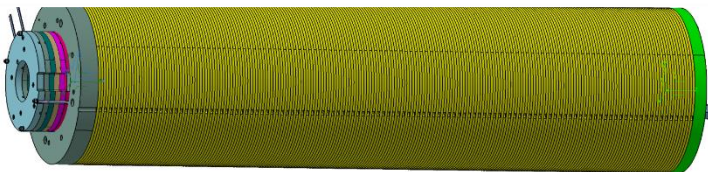
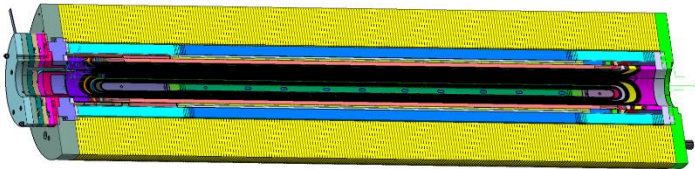
- **Conductor from CERN**
 - Insulated conductors for 10 coils at CEA
- **Coils fabricated at CEA/Saclay**
 - Winding and polymerization
 - Coil instrumentation
- **Assembly will be performed at CERN (927) by CEA team supported by 927 team**
 - Collaring using 927 collaring press
 - Yoking
- **All components 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 existing tooling)
 - Coil measuring tooling (based on CERN existing 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 / H el ene Felice (CEA)



Most of the orders

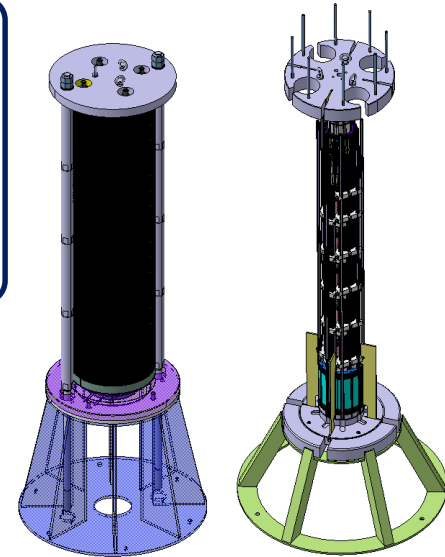
• Magnet

- CAD model completed
- Drawings under finalization
- Spec ready



• Assembly tooling

- 2D and 3D CAD model completed
- Specification is ready
- Call for Tender expected next week

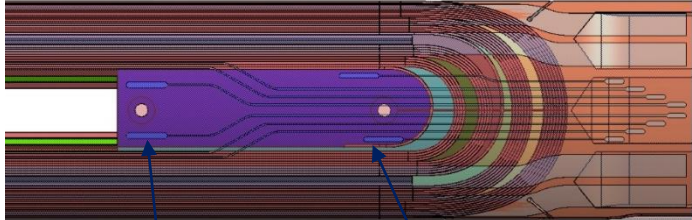


• March 1st 2017: assembly tooling review with Nicolas Bourcey and Juan Carlos Perez

- Review of the tooling
- General review of the magnet design
 - Some corrective actions were decided:
 - ⇒ Protection heater/instrumentation will be on a trace
 - ⇒ End shoes modification accordingly
 - ⇒ Review of the ground insulation
 - ⇒ Review of the connection box
 - ⇒ Review of the assembly process

Minutes: <https://indico.cern.ch/event/652038/>

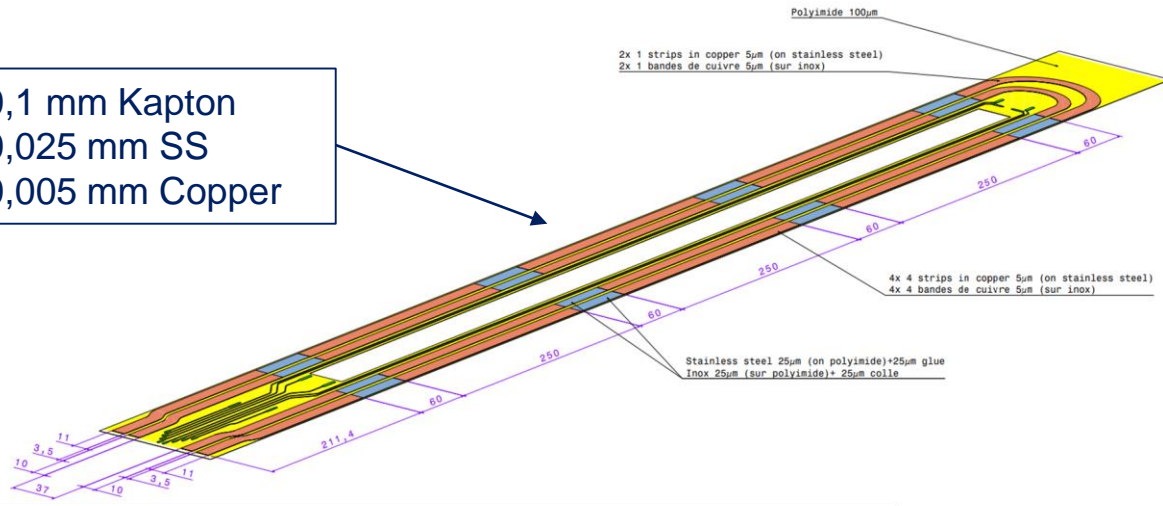
- Similar technology as in Nb₃Sn magnet : trace
- Decision on vtaps : Scheme flags on OD and wires on ID (4 per layer)
- Protection Heaters: a prototype heater is being fabricated at CERN (J. C. Perez)



ID vtaps: wires routed through holes to the trace soldering pad

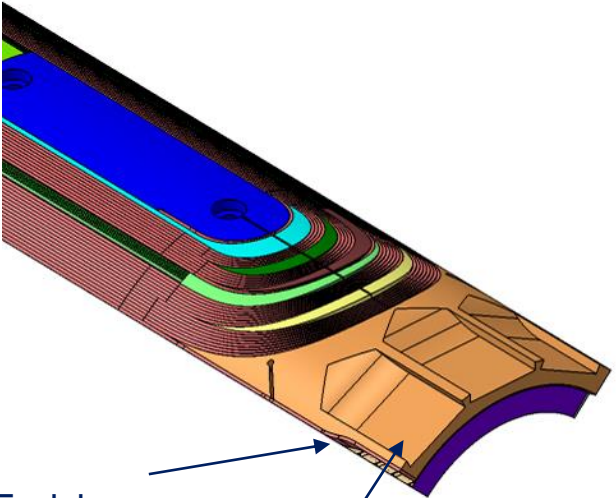
OD vtaps: flags connected to traces

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



Ground plane insulation assembled on top of the PH

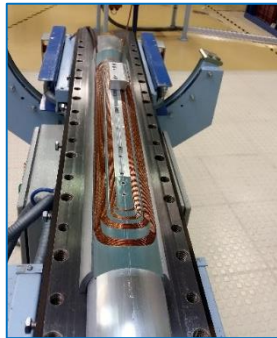
- L shape of 0,125 mm
- 4 layers of 0,125 mm



Endshoe modification from initial design

Coil Mock-ups:

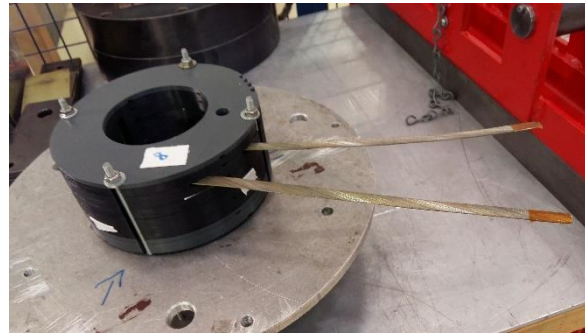
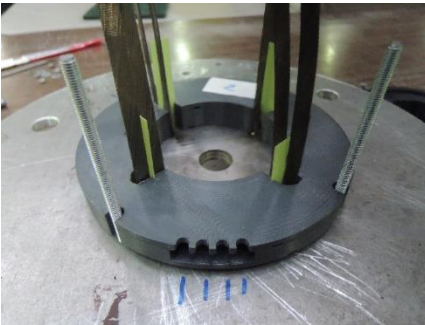
- ABSPlus : Inner layer Winding only
 - Blue-stone epoxy : Winding and curing
- ⇒ Layer jump chosen with $R_{\text{bend}} = 300$ mm
- ⇒ Successful curing



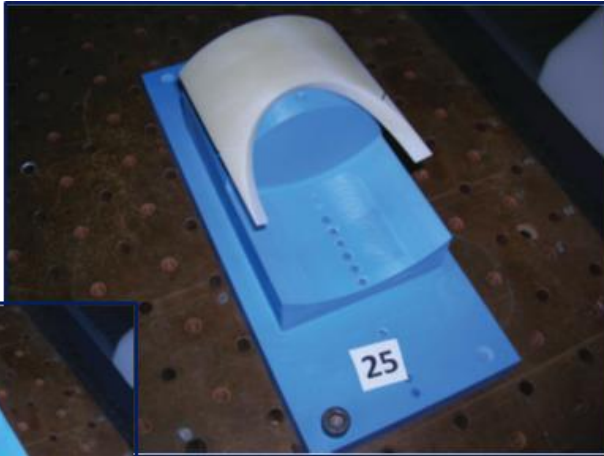
Validation of the end spacer geometry

Validation of the polymerization procedure

Connexion box mock-up



Iteration on the bending radius in the connection box



MQYYM components

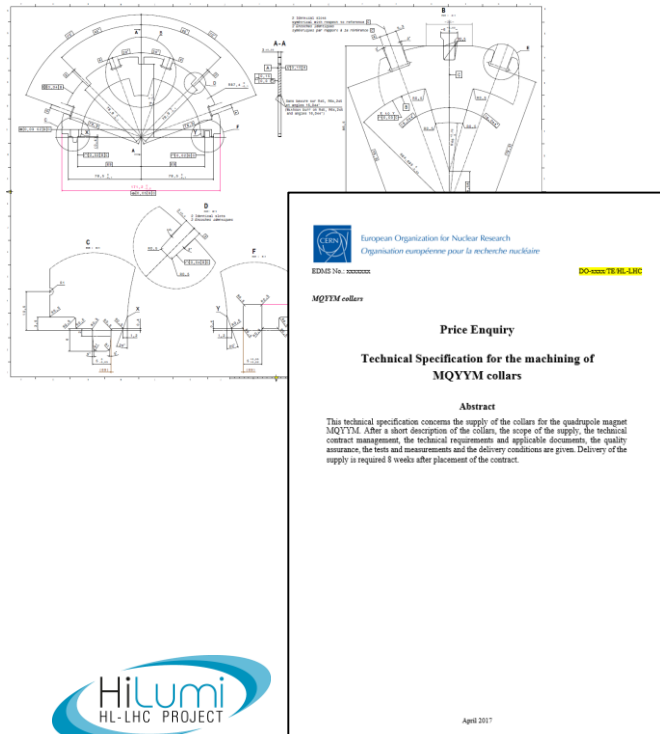
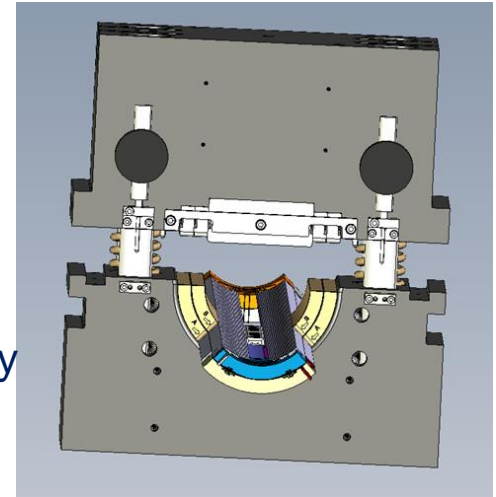
- End spacers:
 - 2 sets (delivered without grooves)
 - 6 sets on order via a direct order.
Expected delivery on July 17th 2017
- Insulated Angular wedges at CEA since 03/2017
- Interlayer insulation for 10 coils at CEA

Orders and call for tenders

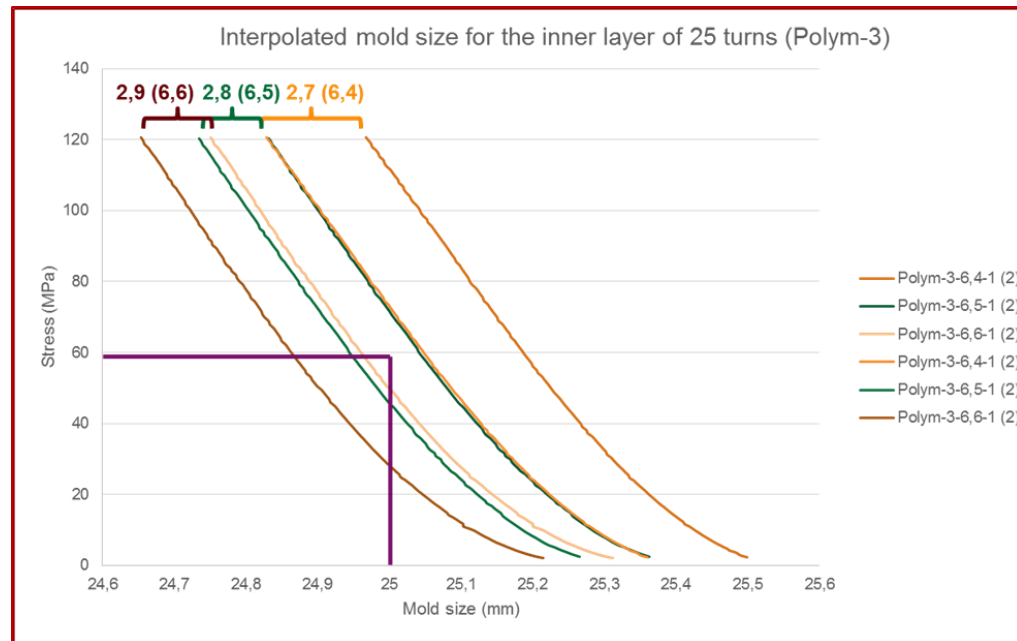
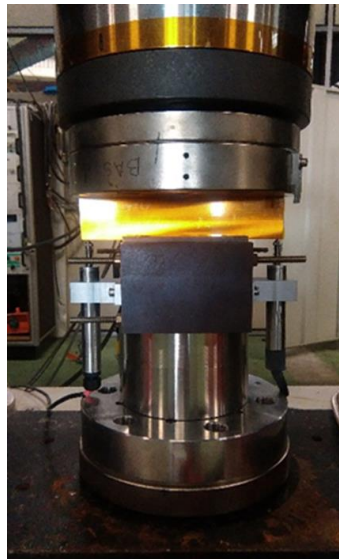
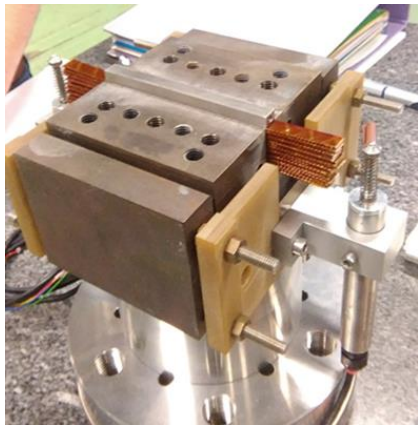
- **Collars:** order placed, manufactured by HV wooding => Delivery expected end of 08/2017
- **Yoke laminations and alignment keys / end flanges:** specification ready, CFT expected this month
- **Connection box + G11 components:** specification in preparation, drawings ready

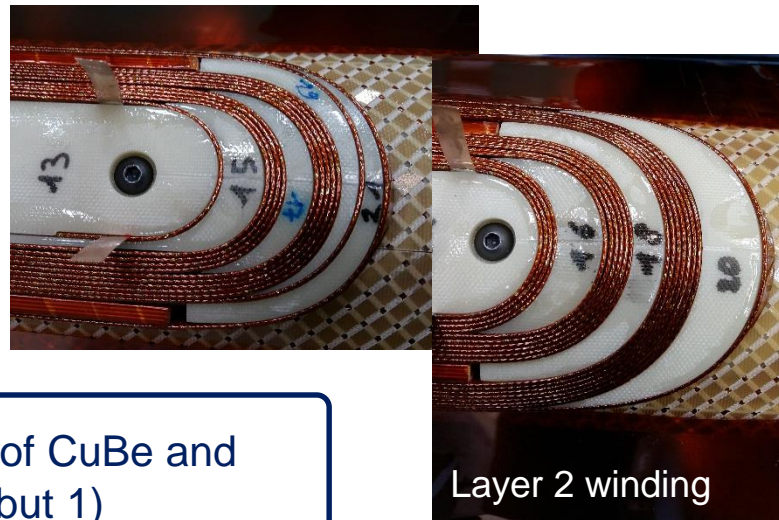
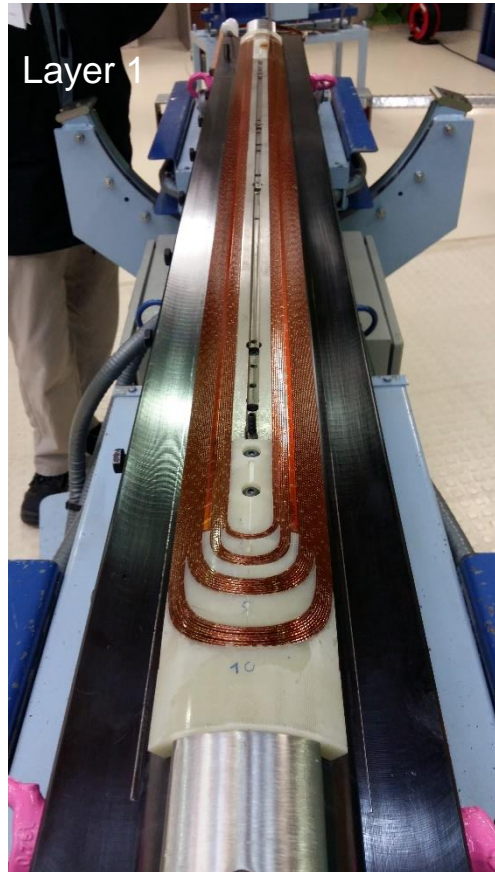
CAD

- **GPI forming tooling:** being designed by CEA
 - Adaptation of the **mechanical measurements tooling** ongoing
- ⇒ Completion expected end of July
- ⇒ Design developed in discussion with N. Bourcey and J.C. Perez



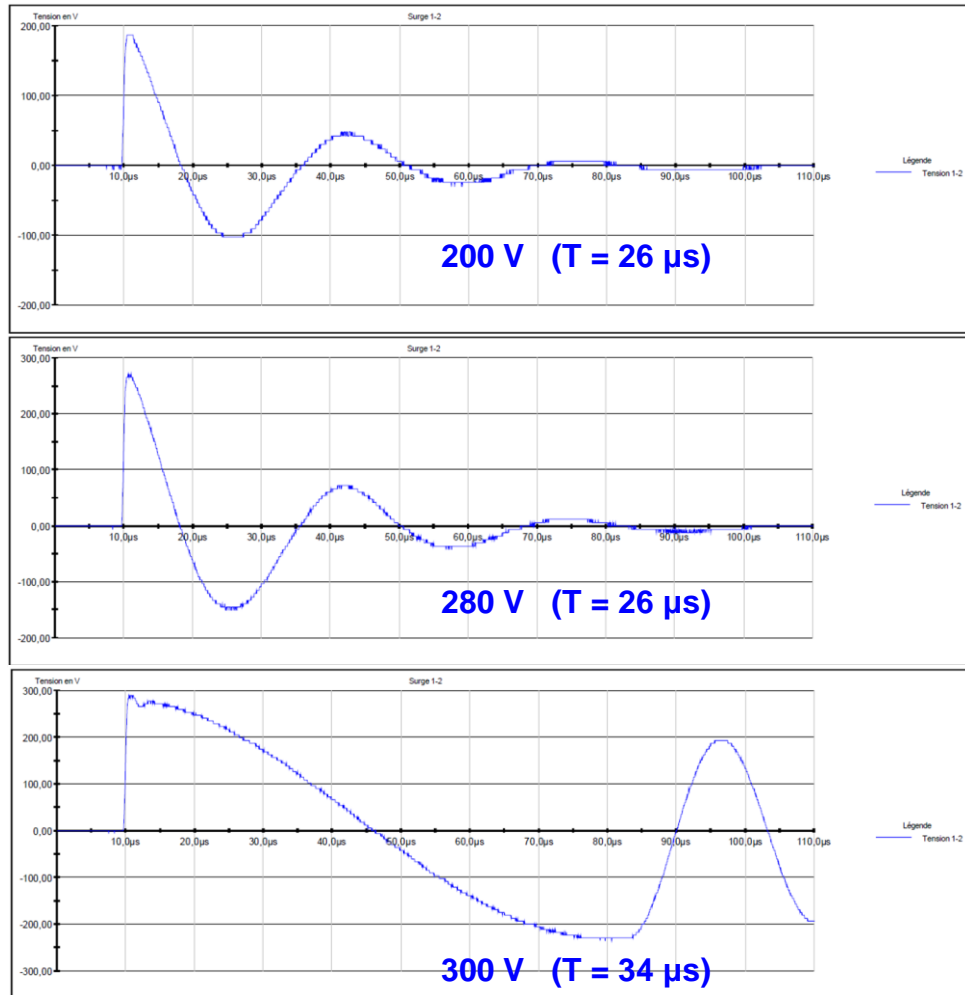
- 2 goals for the ten stack measurements :
 - Young's Modulus of a cured stack of MQM cables => **mechanical analysis**
 - Shim thickness for the coil polymerization
 - => size of the coil to obtain target azimuthal preload (60 Mpa) when the collar cavity is closed: **Shims of 2,8 mm were chosen**



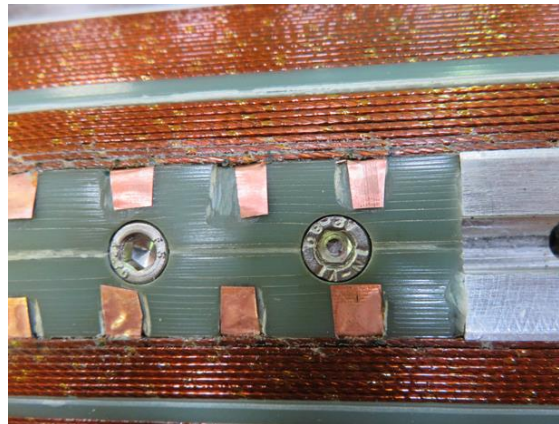
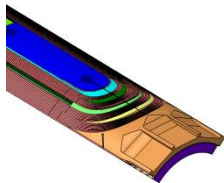


Vtaps Flags made out of CuBe and soldered to the cable (but 1)

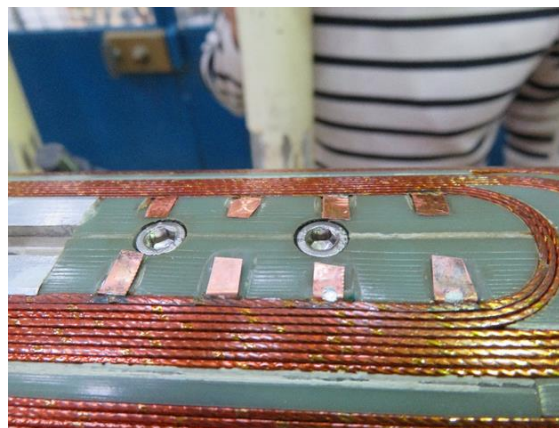
- Good matching of the coil parts with the winding
- Broken flags after polymerization
=> Need to smooth the sharp edges to avoid damaging the flags
- Impulse test showing increase of frequency at 280 V
=> Turn to turn weakness?
=> likely due to the weld of the vtaps using Tin Indium solder (fusion T < polymerization T!)
=> Under investigation



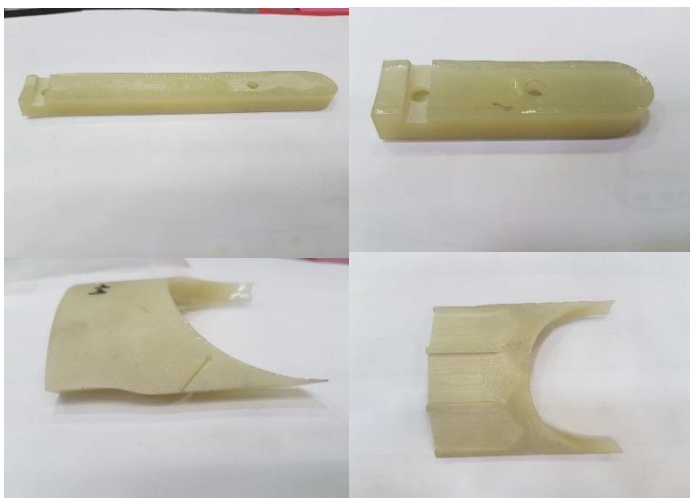
- 2 Mock ups made to validate the Vtaps welding method
 - Iteration with JCP and NB on flux, welding iron
- Coil end parts remachined to include the notches for instrumentation and protection heaters.



Mock-ups Vtaps 1



Mock-ups Vtaps 2



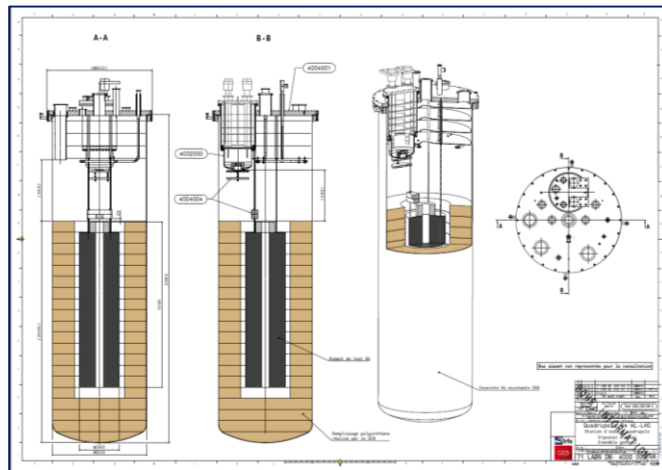
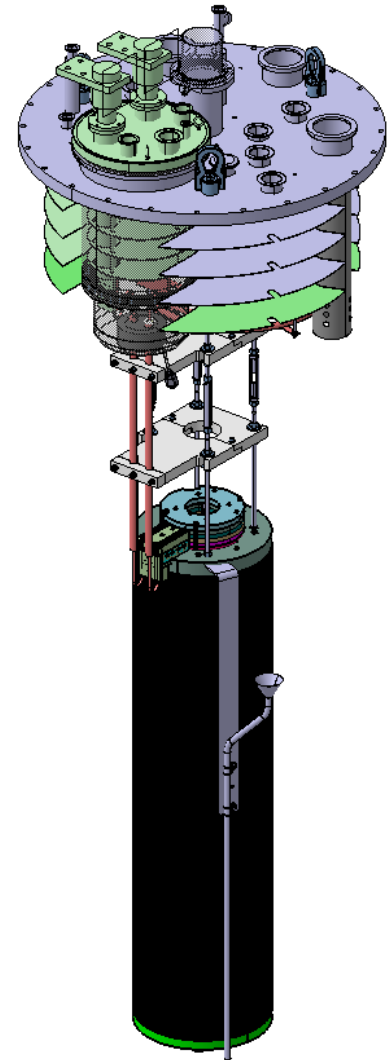
Cryogenic facility

- 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

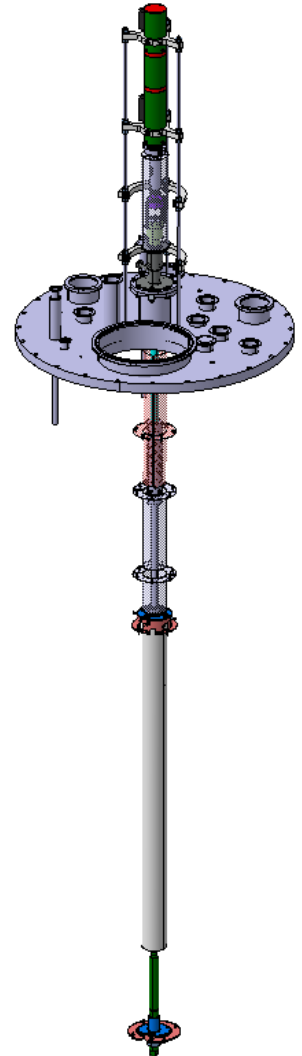
Top plate and related equipment: modified/procured and ready at CEA

Data acquisition and magnet protection

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



- Meeting at CERN on 27/07/2016 with L. Fiscarelli, O. Dunkel and S. Russenschuck
 - Cold Probe, rotating unit and measuring system will be provided by CERN
 - Agreement on a probe: 47 mm in diameter, 5 modules of 222 mm in length
 - Main difference identified between CERN and CEA facilities:
 - CERN: **pressurized** bath
 - CEA: **saturated** bath (23 mbar)
 => Need to design a sealed system using the cold probe provided by CERN
 - Agreement on the fact that the operation of the system will be done by CEA (supported/trained by CERN)
- Design work at CEA for the adaptation of the cold probe to CEA cryogenic facility
- **Magnetic measurement technical review at CEA on June 14th 2017** with L. Fiscarelli, O. Dunkel and A Foussat from CERN
 - To validate the design and agree on a tentative schedule
<https://indico.cern.ch/event/647406/>
- Slight modification to be made after the review and call for tender in the coming weeks
- Training of Damien Simon planned in Fall 2017 on magnetic measurement acquisition system



	2017						2018						
	July	August	Sept	October	Nov	Dec	Jan	Feb	March	April	May	June	July
Fabrication of 4 coils for MQYYM	█	█	█	█									
All components and tooling at CERN					x								
coil mechanical measurements						█	█						
Collaring and connection								█					
Warm magnetic measurements									█				
Yoking										█			
Magnet at CEA										x			
Magnetic Measurement Acquisition System at CEA										x			
Cold test preparation											█	█	
Cold test and cold magnetic measurements													█

QUACO will provide 2 prototypes of MQYY to be tested at CEA ~mid 2020

Cryogenic facility at CEA

- Effort carried out by Hervé Allain
- CEA 8 m vertical cryostat
 - Lambda plate or other system?
 - Compatibility with anti-cryostat
 - Joint interest of CERN and CEA to develop a vertical anticryostat
 - Discussion started with MM section at CERN

HL-LHC effort

- Importance to join effort with MQ testing (C. Lorin) at CEA
 - Handling, tilting tooling => minimize tooling and optimize process
 - Meeting at CEA on July 5th 2017 with A. Foussat

SUMMARY

- **MQYYM Magnet design completed**
- **Progress made on the fabrication**
- **Delays in tooling and components procurement**
 - **Delays at companies**
- **Coil 0**
 - **satisfying in term of end spacer fitting and overall fabrication process**
 - **Concern about the electrical integrity of the coil**
 - **Under investigation**
 - **Explainable by the mistake on solder used**
- **Assembly prep and test prep on track**

NEXT STEPS

- **Complete the procurement of the tooling and coil components**
- **Finalize some tooling design (GPI, coil measurement)**
- **Proceed with MQYYM fabrication...**
- **Preparation of the short model and prototype tests ongoing**