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Progress Report on PSI Subscale and Stress-Managed Asymmetric Common-Coils

HFM RD3 meeting, 2023

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Agenda

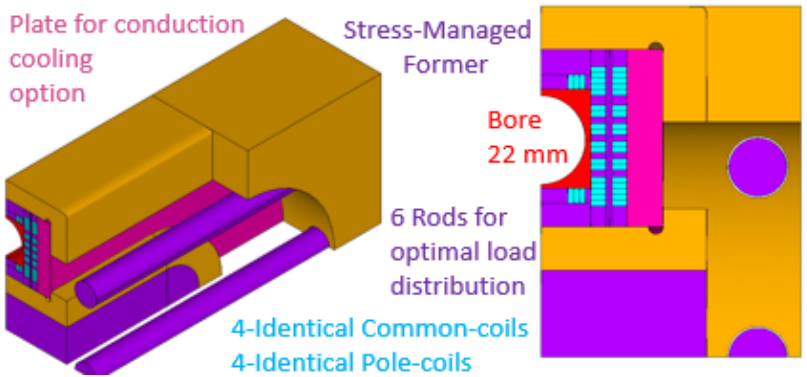
- Subscale Stress-Managed Common-Coils
  - The platform and parameters
  - Procurement and next steps
  - Instrumentation trials
  - Protection (CERN/MPE)

- Stress-Managed Asymmetric Common-Coils (SMAAC): 4 layers version

- Infrastructure: autoclave commissioning

Subscale Platform for LTS and Hybrid Coils

- Validating manufacturing process and introducing advanced concepts: coil pre-load free, at room temperature; stress-management structure and splicing on the low-field region.
- Fast turn-around platform for testing matrix systems; protection concepts and cooling options.
- Hybrid magnet with LTS Common-Coils and HTS racetracks
- LTS conductor manufactured by LBNL (cct subscale cable)

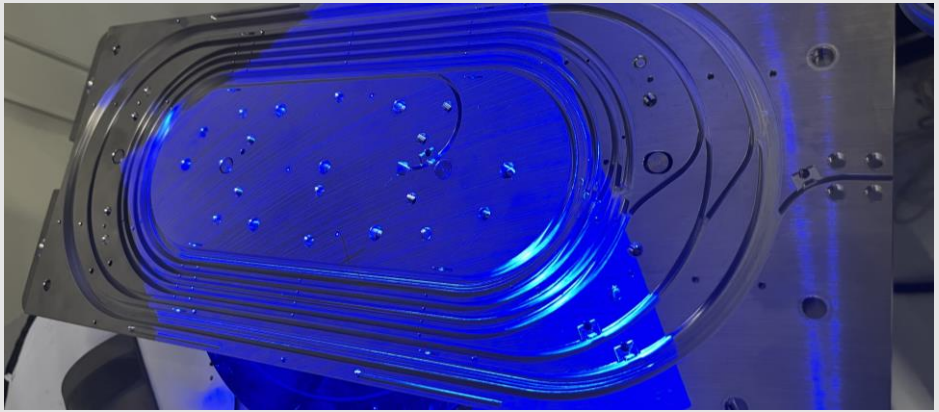


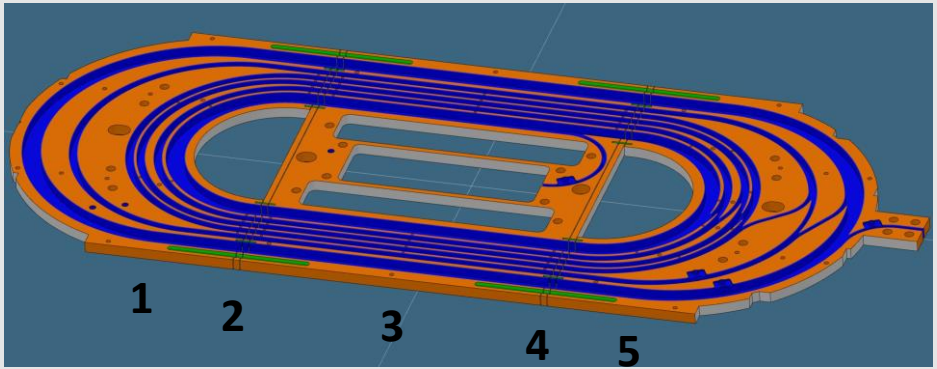
Magnet parameters for testing all coils or the common-coils. The coils straight section is 150 mm. The values refer to the fitted wire Ic curve at 4.5 K values.

Parameter	All coils	CCs
B_0 in T	5.15	5.1
B_{peak} in T	6.45	6.3
I_{op} in kA	8.25	9.2
E_{mag} in kJ	15.2	16.4

Subscale: procurement and next steps 1/2

- 5 formers premachined @ PSI
- 3D scans with GOM
- Segmentation into 5 pieces by wire-erosion; allows for shrinkage of cable during reaction
- Next step; glazing of channels with insulating layer

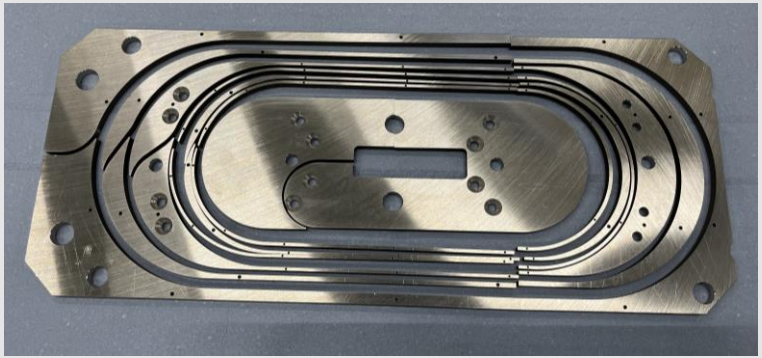


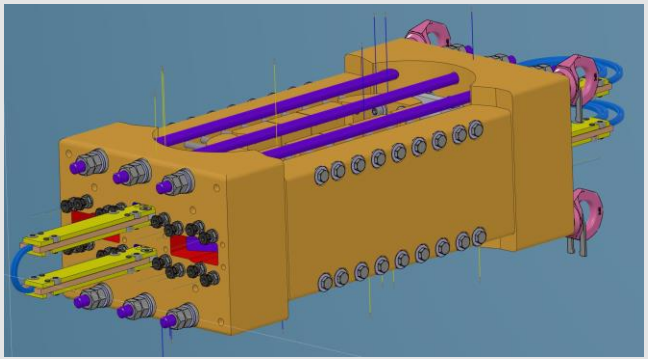


Subscale: procurement and next steps 2/2

- Winding tool: segmented into 3 parts per block
- Winding tool pinned to former
- Winding “above” former around tools
- Pusher plate to lower cable into former

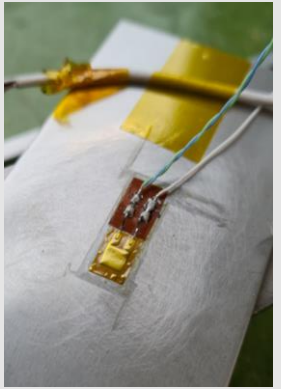
- Procurement of clamping parts
- Integration of rotating coil; design of mounting to end plates

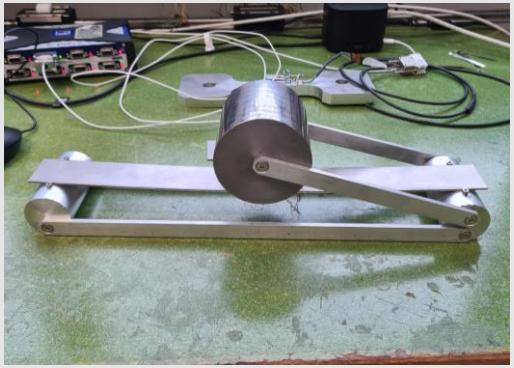




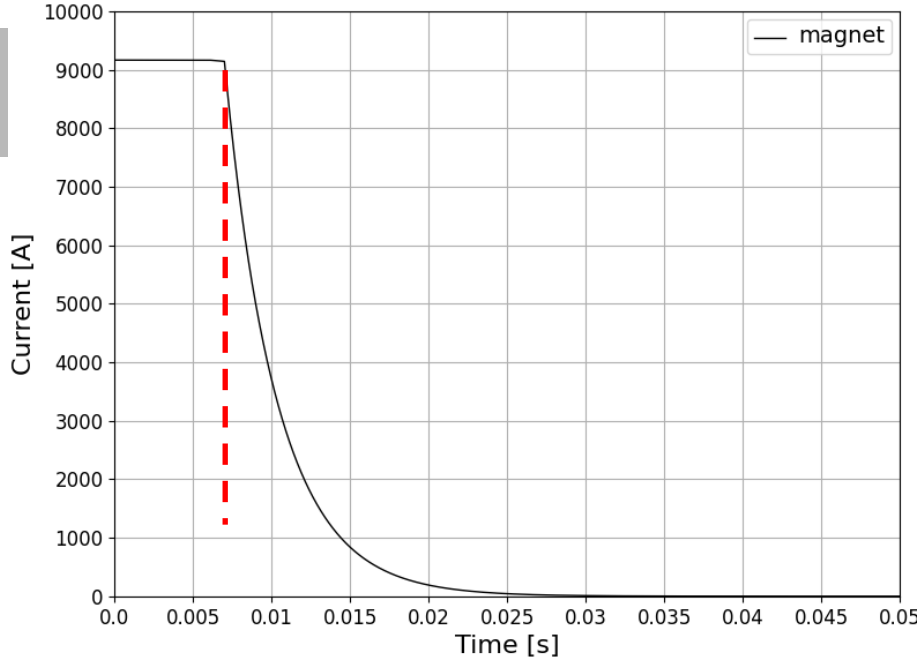
Subscale: instrumentation trials

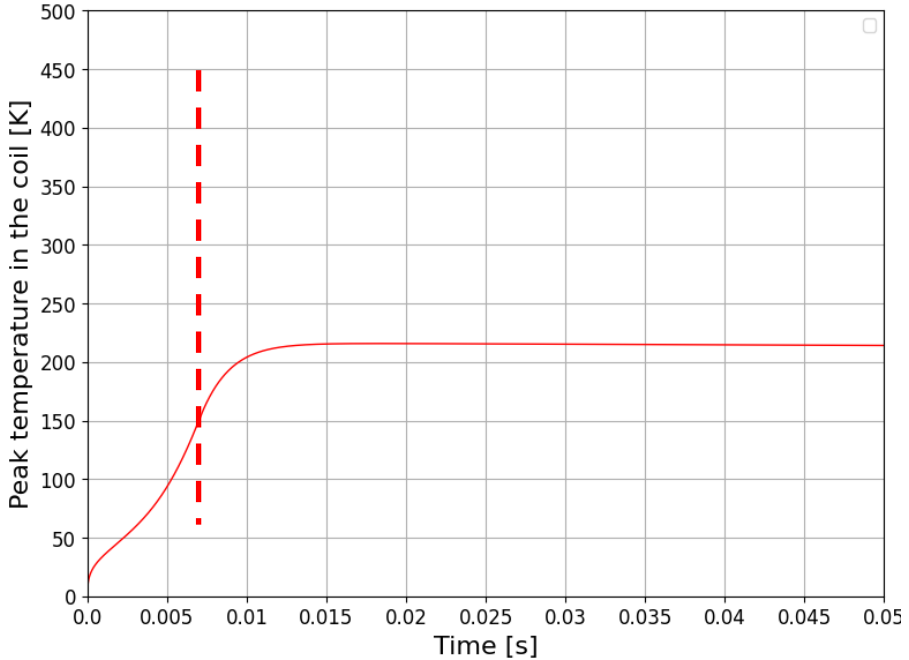
- Hot curing with two components epoxy resin
- Pressure and curing (120 C for 6h)
- Samples measurements with constant load
- Room temperature and LN2 to study the behaviour through thermal cycles





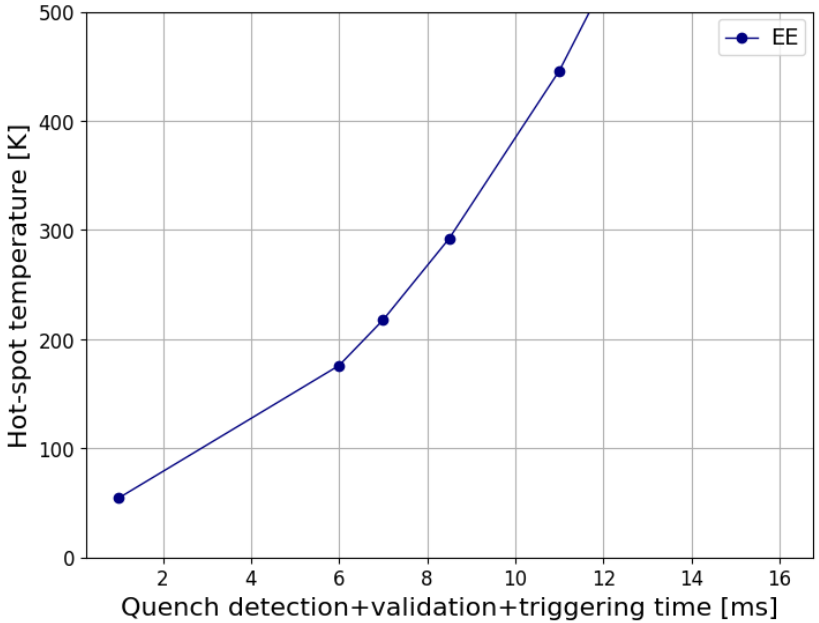
Quench protection based on energy extraction (EE)



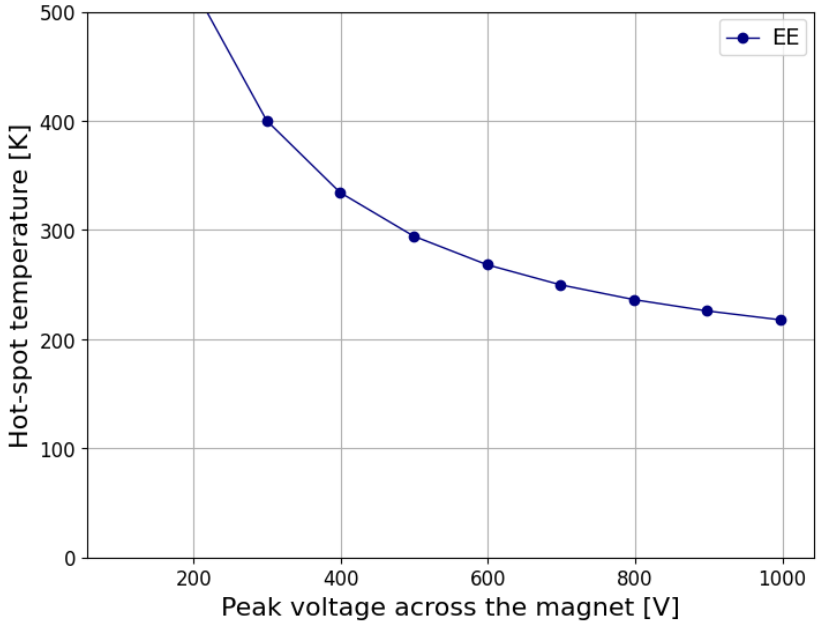


For R_EE=110 mΩ (i.e. peak voltage across the magnet of 1 kV) and quench detection+validation+trigger time of 7 ms

The challenge: Quench detection



For peak voltage across the magnet of 1 kV



For quench detection+validation+trigger time of 7 ms

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Subscale Platform: Planning

Task	November				December				January					February				March					April			
	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Engineering Design																										
Procurement of Coil Components																										
1st Coil Ceramic coating and winding																										
1st Coil HT																										
1st Coil Intrumentation																										
1st Coil Impregnation																										
2nd Coil Ceramic coating and winding																										
2nd Coil HT																										
2nd Coil Intrumentation																										
2nd Coil impregnation																										
1st and 2nd Coils splice																										
3rd Coil Ceramic coating and winding																										
3rd Coil HT																										
3rd Coil Intrumentation																										
3rd Coil Impregnation																										
4th Coil Ceramic coating and winding																										
4th Coil HT																										
4th Coil Intrumentation																										
4th Coil impregnation																										
3rd and 4th Coils splice																										
Coils Outer Splices																										
Magnet Structure: assembly with dummy Coils and instrumentation																										
Magnet Assembly and Final Checks																										
Shipment																										
Nov-23			CAS					Break																		

SMACC: Cross-Section

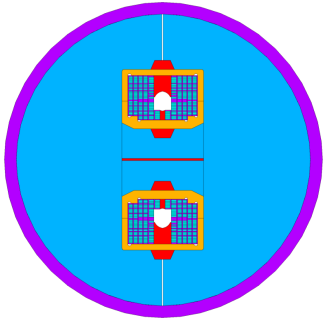
The asymmetric common-coils magnet was designed with an intra-beam distance of 250 mm, 50 mm **bore**, **yoke** diameter of 660 mm and 30 mm thick stainless-steel **shell.**

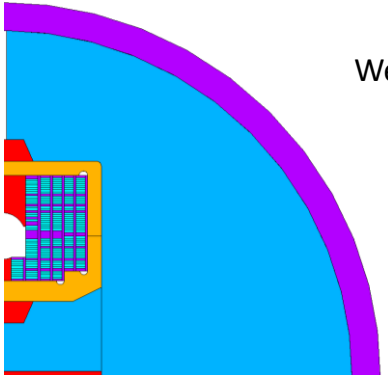
The massive **iron pole,** combined with the asymmetric concept, helps on the balance vertical force balance.

The load, due to Lorentz forces, is distributed between **pads** and **shell,** which limits the thickness of the **shell**.

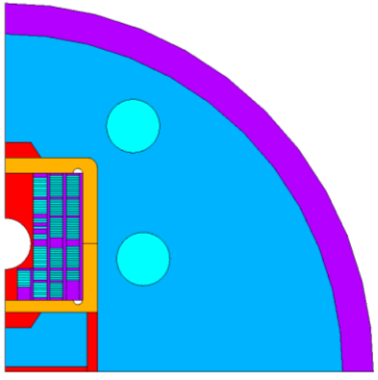
The magnet concept is based on bladder & keys technology for room temperature preload. The structure is loaded, but thanks to the stress-management formers, the coil stress after loading and after cooling is < 40 MPa.

The magnet has 4 different types of coils (layer 1, layer 2, layer 3,4 and layer 5,6) and 12 coils in total (for a double aperture magnet). The coils are placed in the stress-management **formers**. The preload is transferred towards the inner-most layers through the **ribs**.





We are now working on the 8 layers version



CHART/MagDev Laboratory Infrastructure

- New commissioned autoclave for R&D on impregnation systems
- Autoclave for 2-m-long coils, horizontal (or inclined) impregnation.
- Max temperature: 250 C
- Max pressure: 10 bar.
- Features:
  - direct heating
  - atmospheric heating
  - cooling water circuit
  - multiple vacuum circuits for pre-preg /vacuum bag impregnation
  - fully automated process