U.S. MAGNET DEVELOPMENT PROGRAM

Nb_3Sn SMCT program overview and FY24 plan

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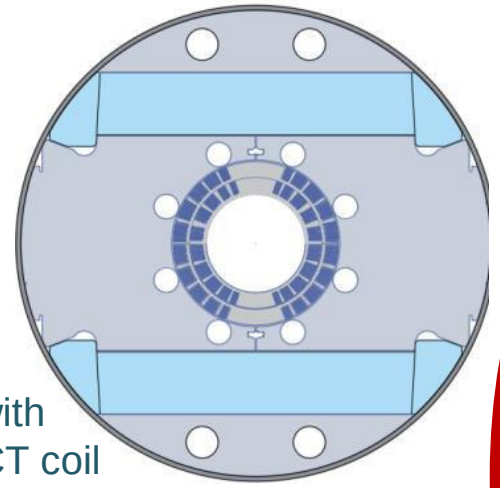
U.S. MDP General Meeting
10/11/2023

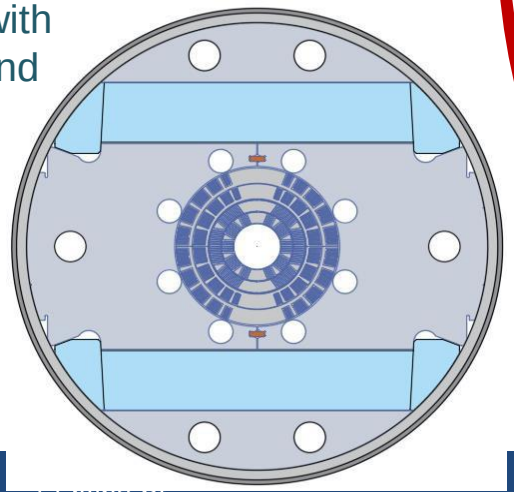
Nb_3Sn SMCT Dipole Program (US MDP-FNAL)

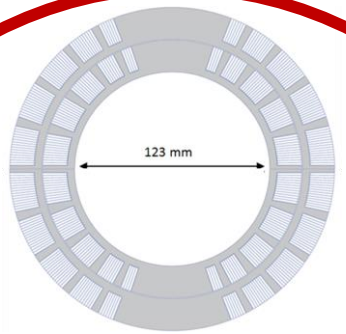
Nb_3Sn cos-theta dipole magnets with SMCT coils



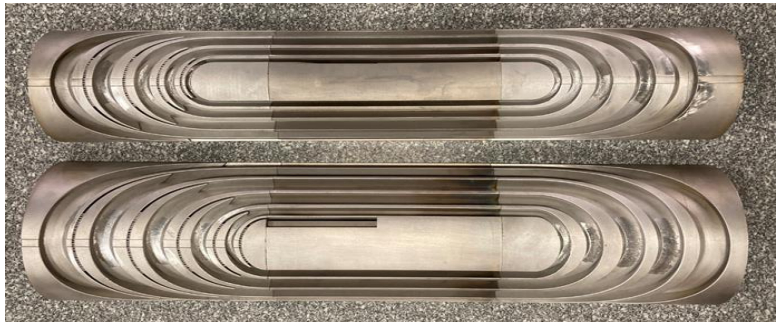
11 T 2L dipole with
123 mm ID SMCT coil

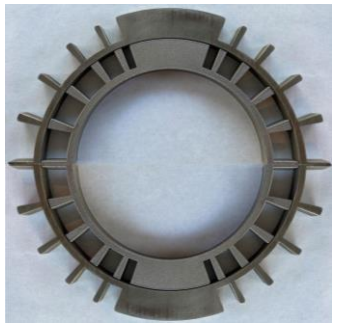
17 T 4L dipole with
60 mm ID coil and
SM in L3-L4



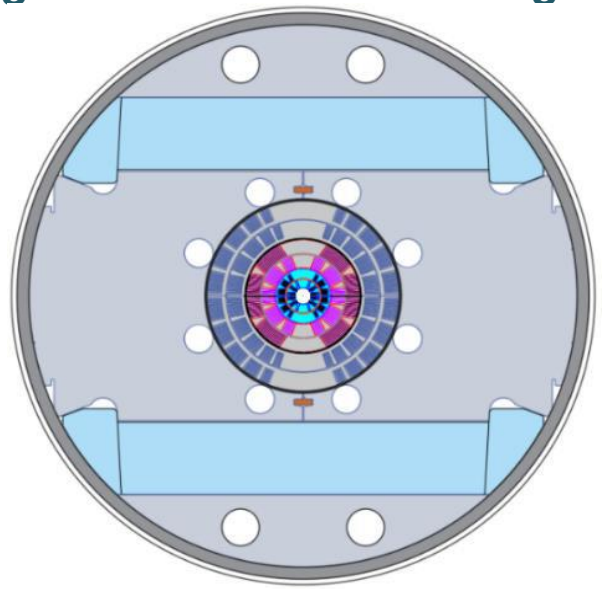


SMCT dipole coil structure



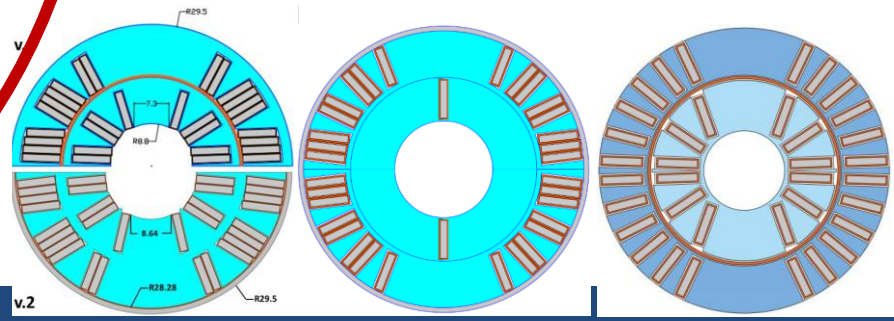


Multilayer HTS-LTS hybrid dipole magnets with stress management

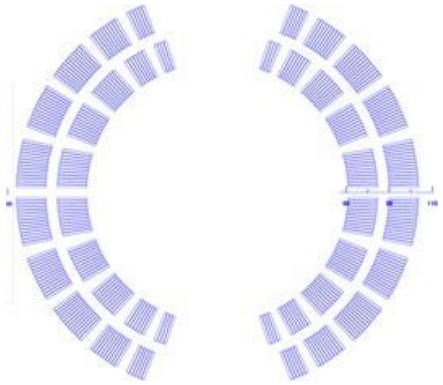


HTS insert in 60 mm ID 4L Nb_3Sn 4L coil

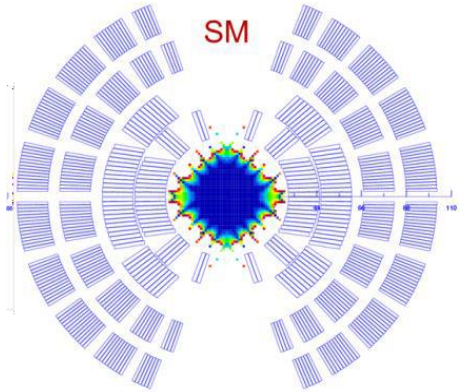
17-19 mm ID Bi2212 2L coil inserts with SM



US-MDP Task: Nb_3Sn SMCT R&D goals and milestones



ID=120 mm, B_{des}~11 T



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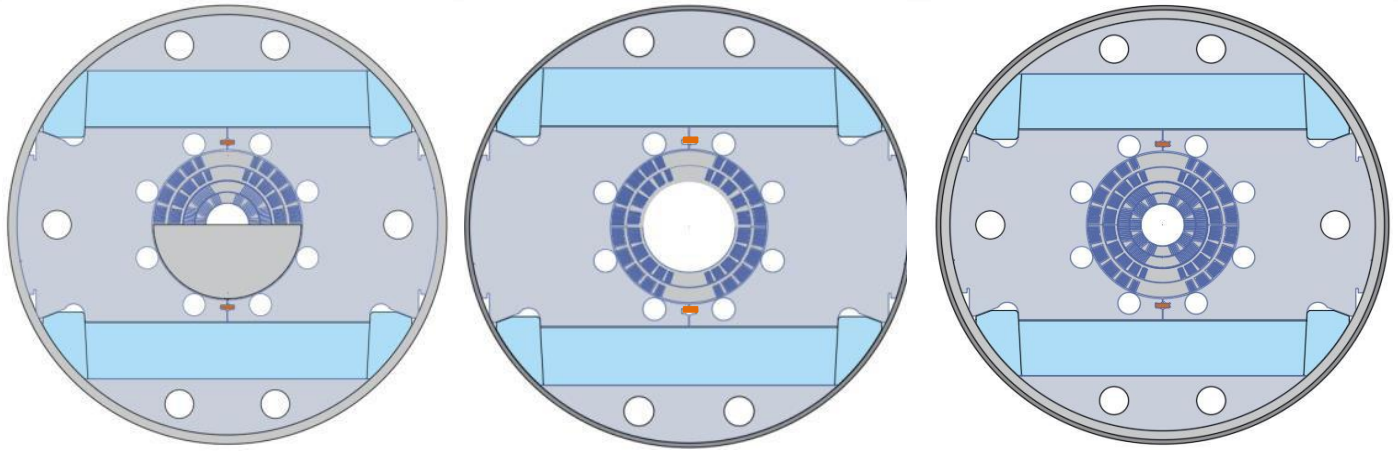
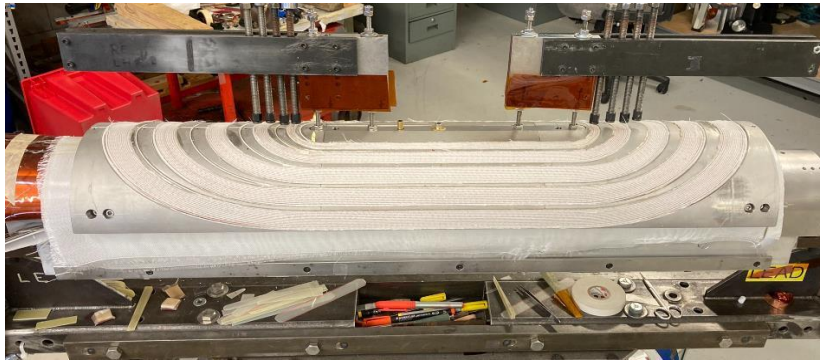


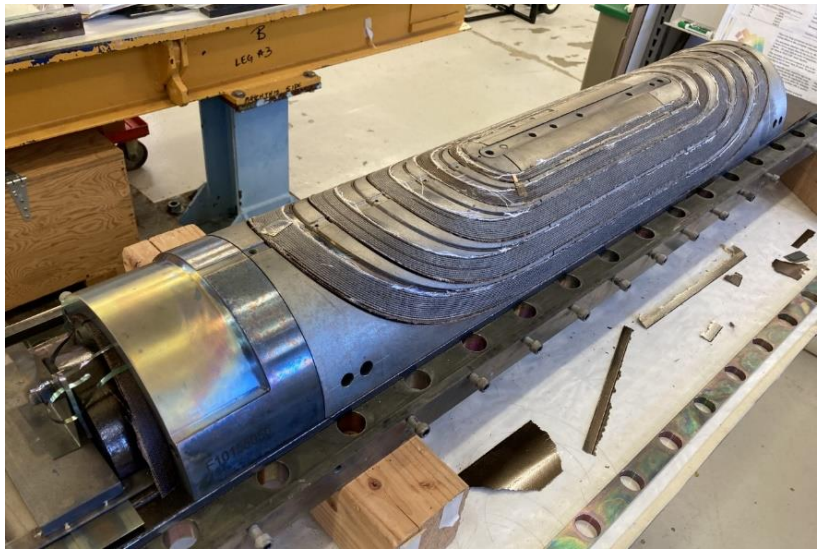
Cos-theta dipole coils with stress management

Milestone #	Description	Target
AI-M1a	Development and test of stress management concept using a 2-layer large-aperture and 4-layer small-aperture cos-theta coils and dipole mirror structure.	**Sept/Dec-23** ~~June-23~~
AI-M2a	Development, fabrication and test of stress management concept in a 2-layer 120-mm dipole with the field up to 11 T.	June-24
AI-M3a	Assembly and test of stress-management concept in a 4-layer 60-mm 17 T dipole with stress management.	Sept-24

FY22: SMCT1 coil fabrication and instrumentation

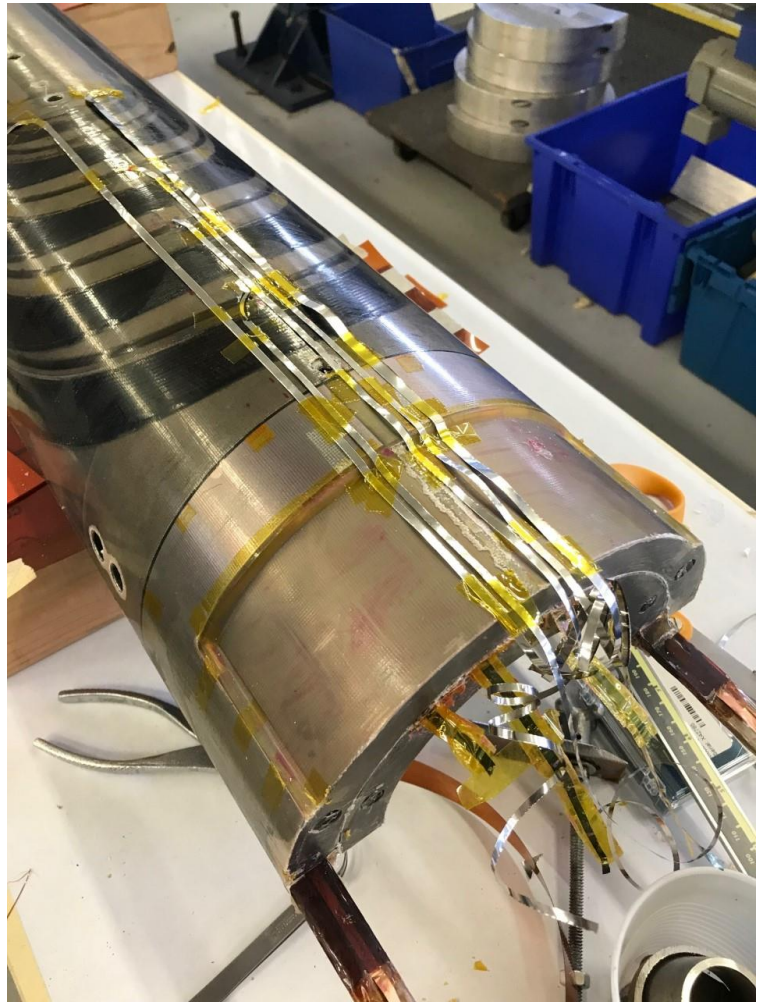


Coil winding



Coil reaction

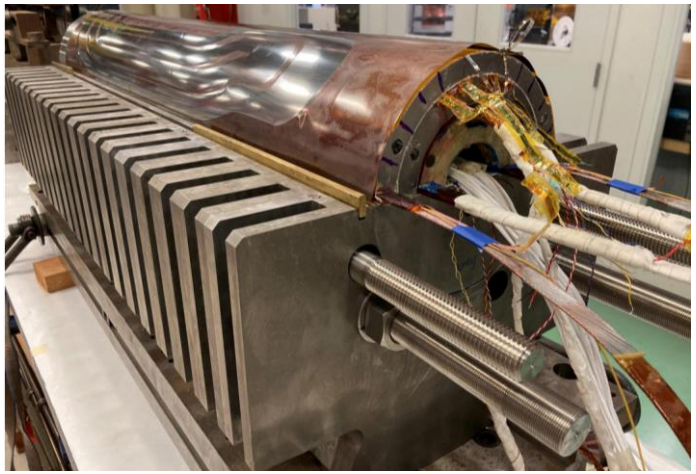
Coil impregnation with epoxy

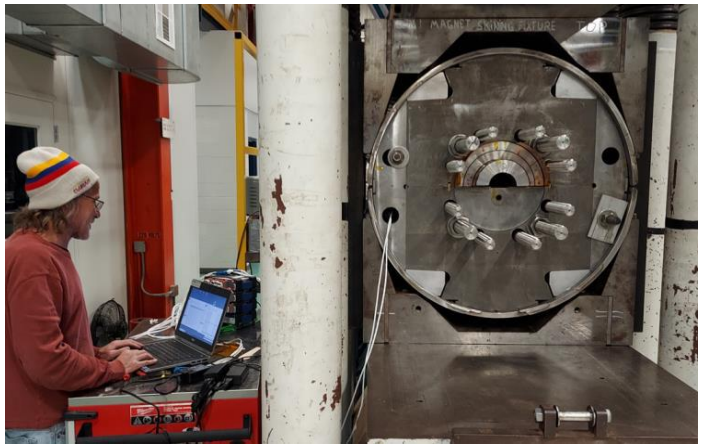


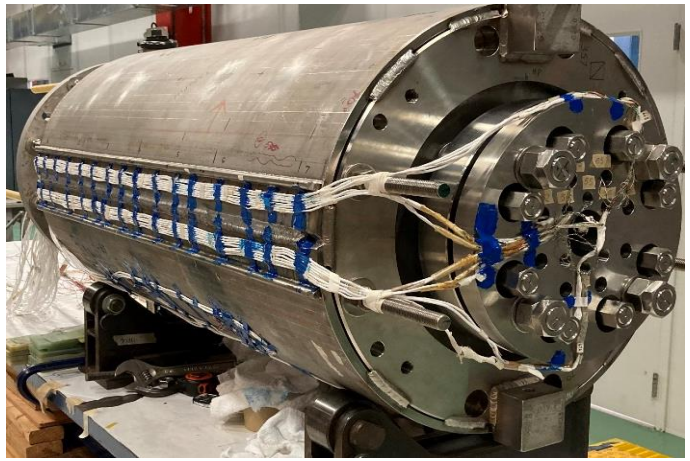
Coil instrumentation

FY23: SMCTM1 assembly

Dipole mirror configuration with horizontal yoke split

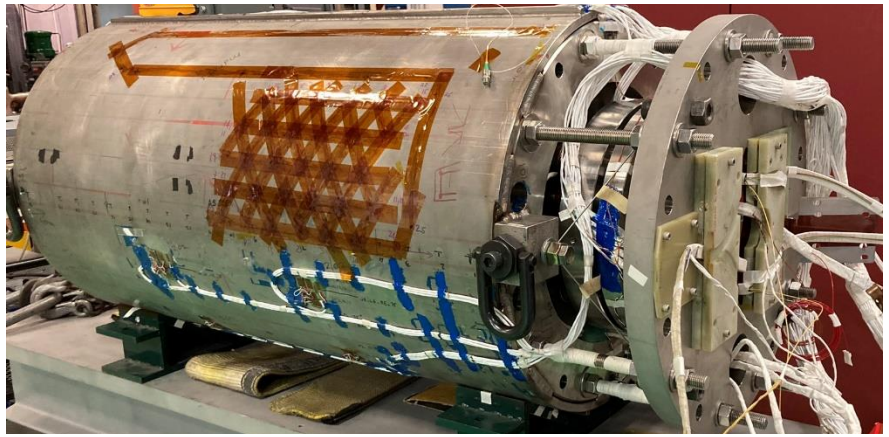




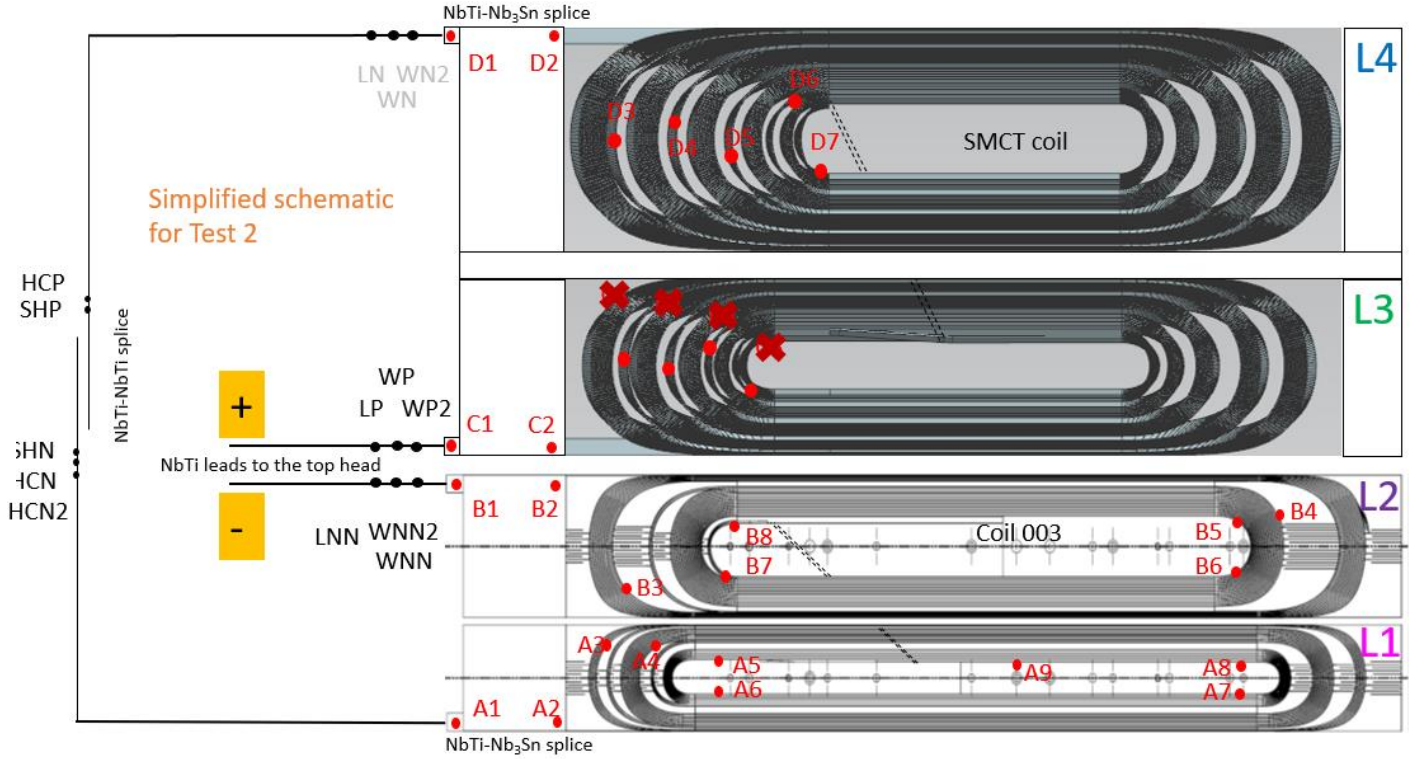


FY23: SMCTM1 Instrumentation

Acoustic sensors location on shell (1-4) and rods (5-8)



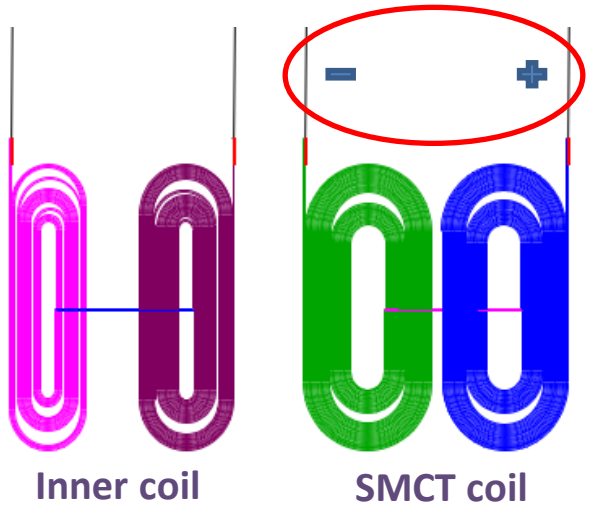
SGs and a fiber optics grid on the magnet shell

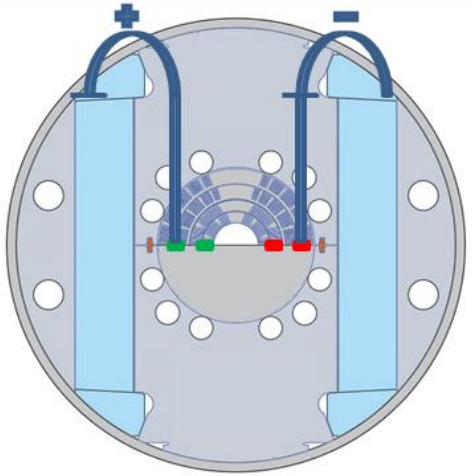


SMCT coil schematic for test #2 with VTs location

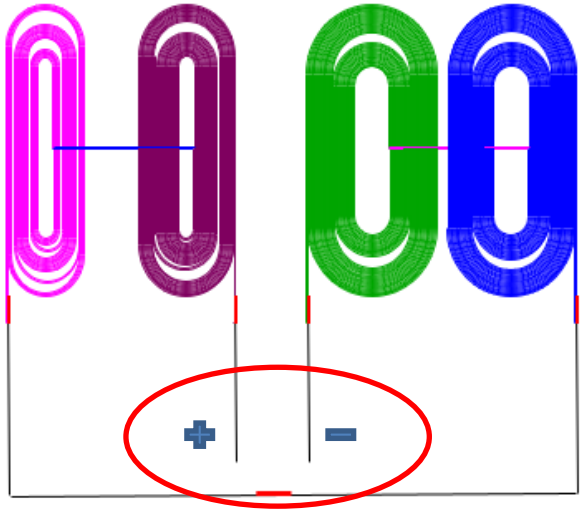
FY23: SMCTM1 test configurations

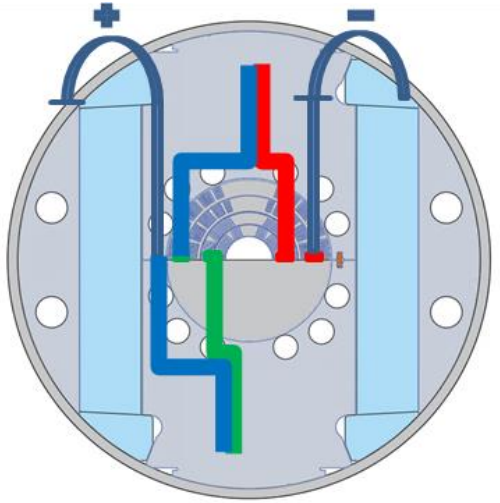
SMCTM1a Test 1:





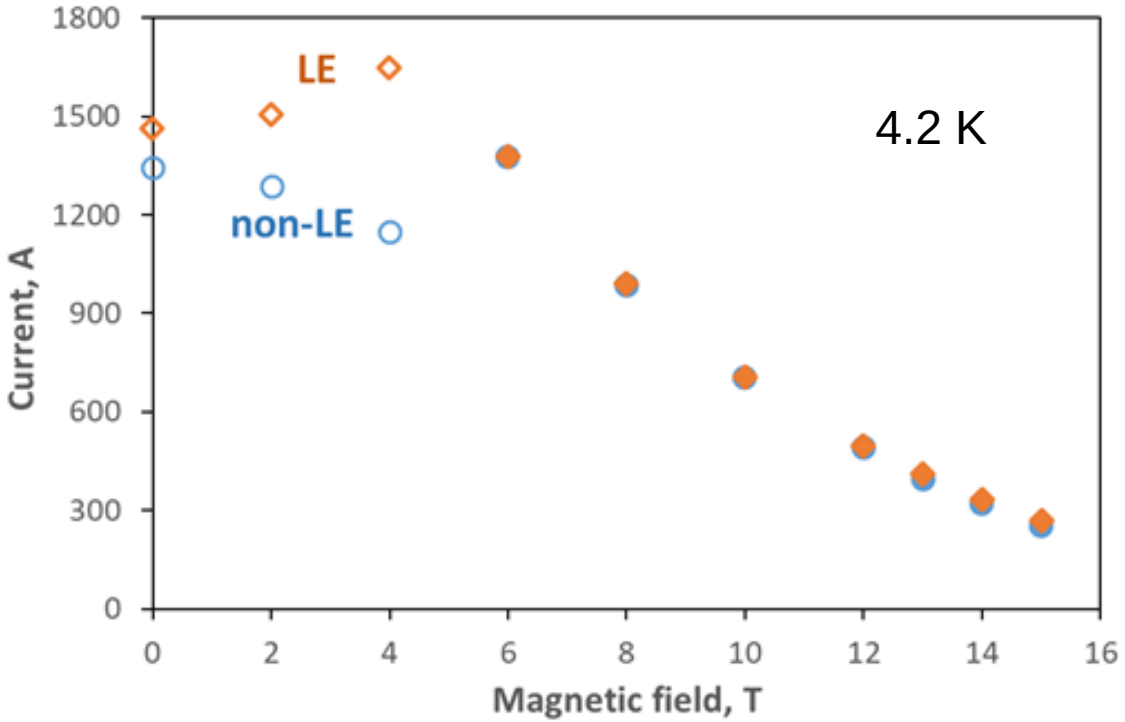
SMCTM1b Test 2:



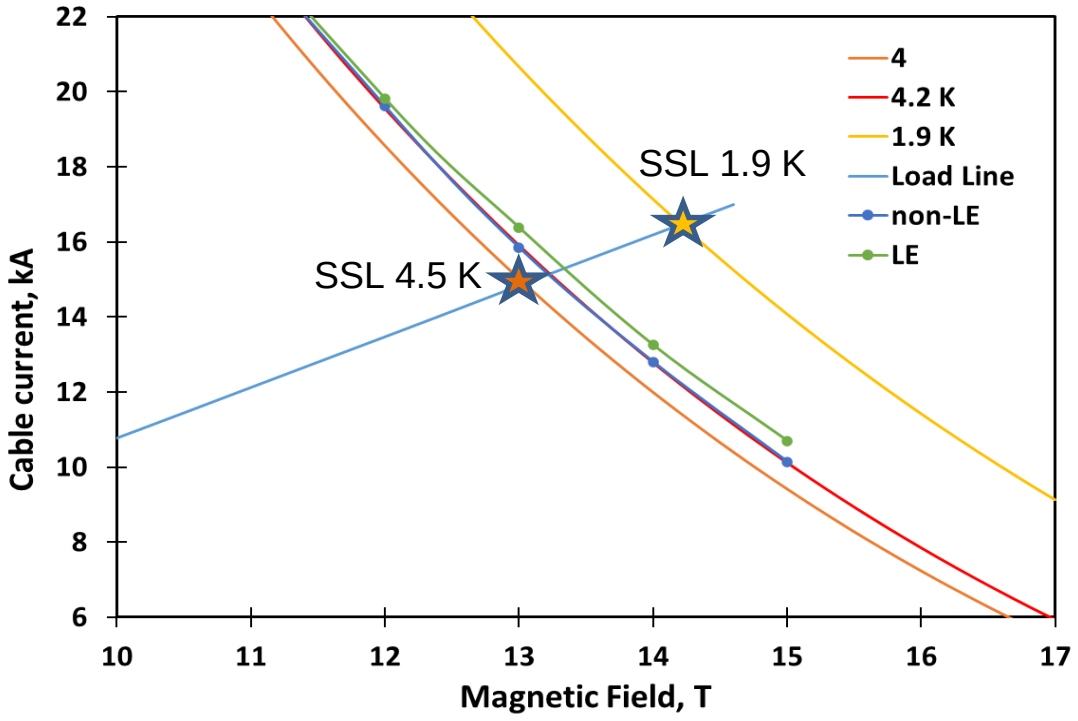


WS test and SMCTM1 conductor limits

FY22: WS test data



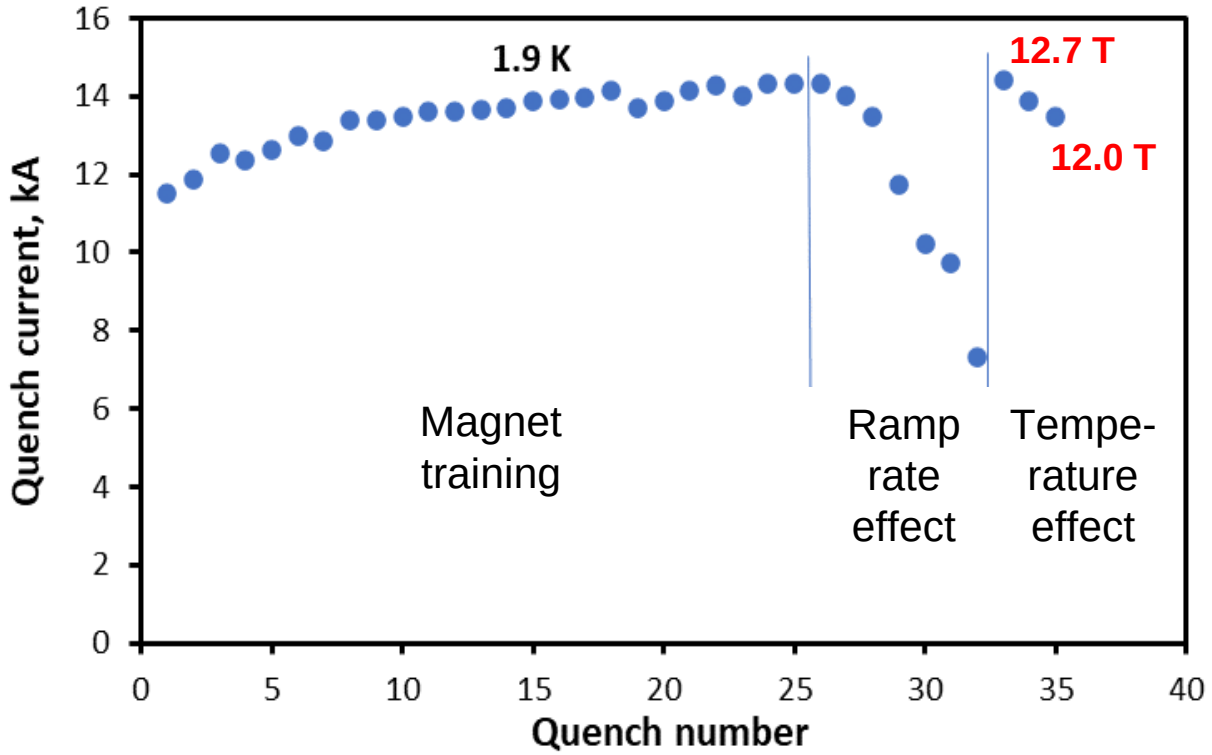
FY23: SSL calculation

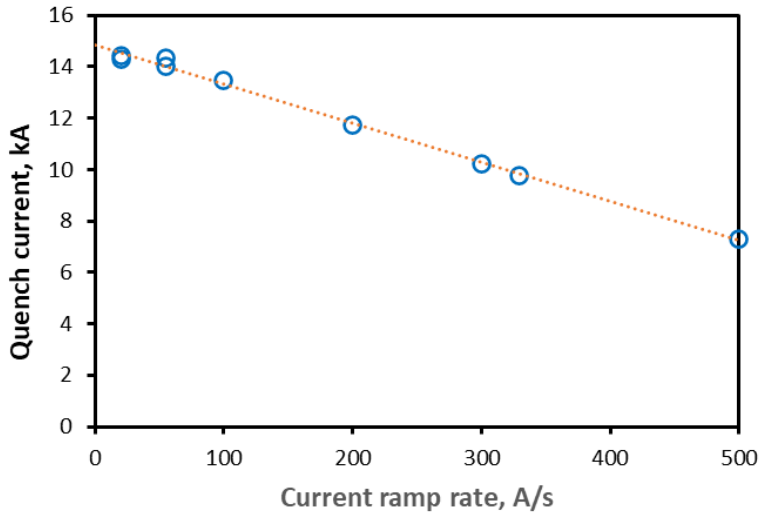


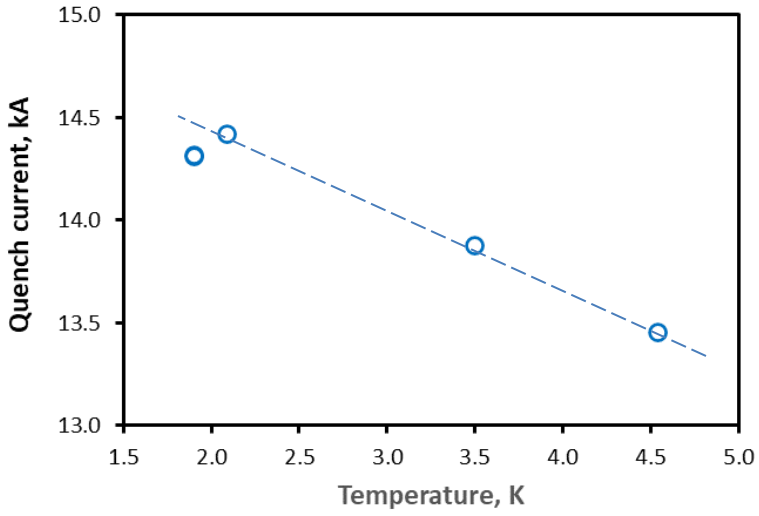
Short sample limits (2L mirror)

- B_{max}=14.2 T at 16.5 kA at 1.9 K
- B_{max}=13.04 T at 14.89 kA at 4.5 K

FY23: SMCTM1a test summary





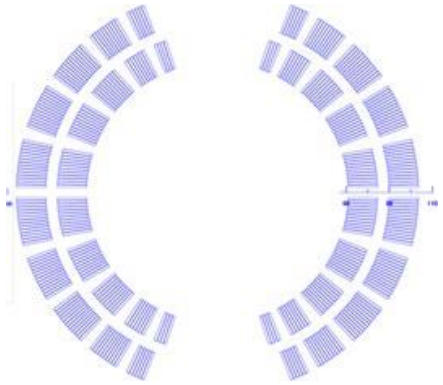


- SMCT1 coil reached conductor limit
  - B_{max}=12.7 T at ~2 K or 89% of SSL
  - B_{max}=12.0 T at 4.5 K (90% of SSL)
- SMCT1 coil test continues

FY24-25: SMCT R&D Plan and Schedule

Task	FY24 Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	FY25 Oct	Nov	Dec
SMCTM1b															
test	VMTF														
SMCTD1															
design															
procurement															
coil fabrication					M-PP	W	R	Pot-In							
magnet assembly									IB3						
test									WS			VMTF		VMTF	

US-MDP Task: Nb_3Sn SMCT R&D next steps



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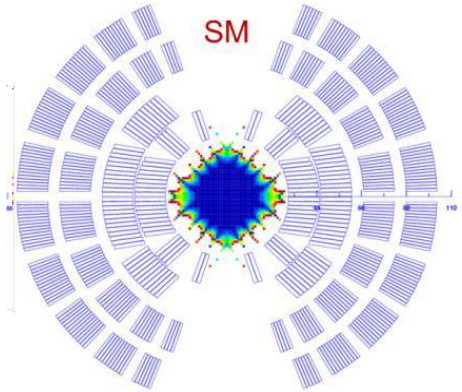

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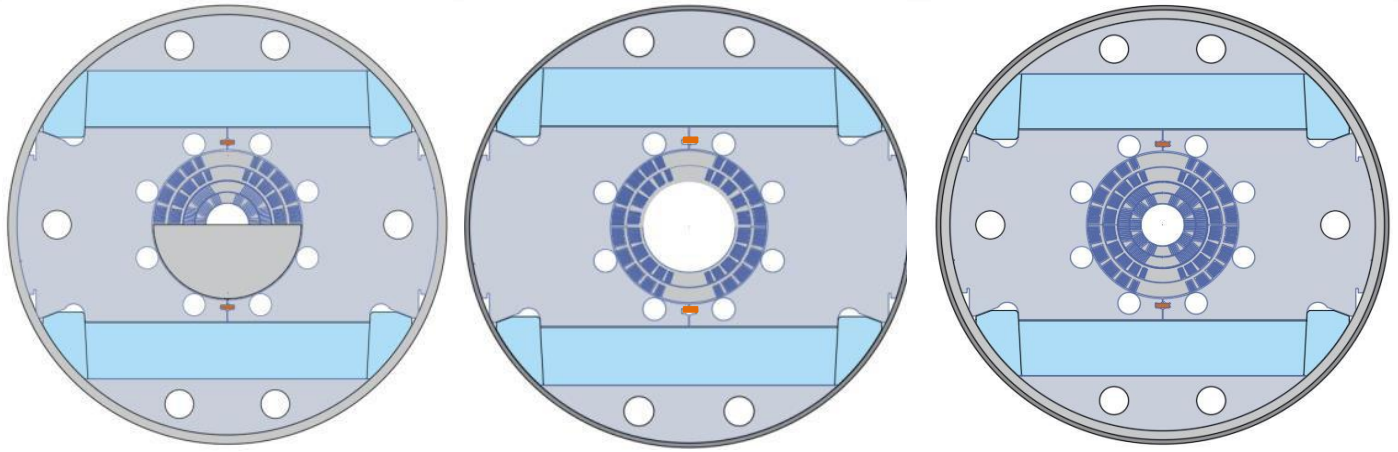

Cos-theta dipole coils with stress management

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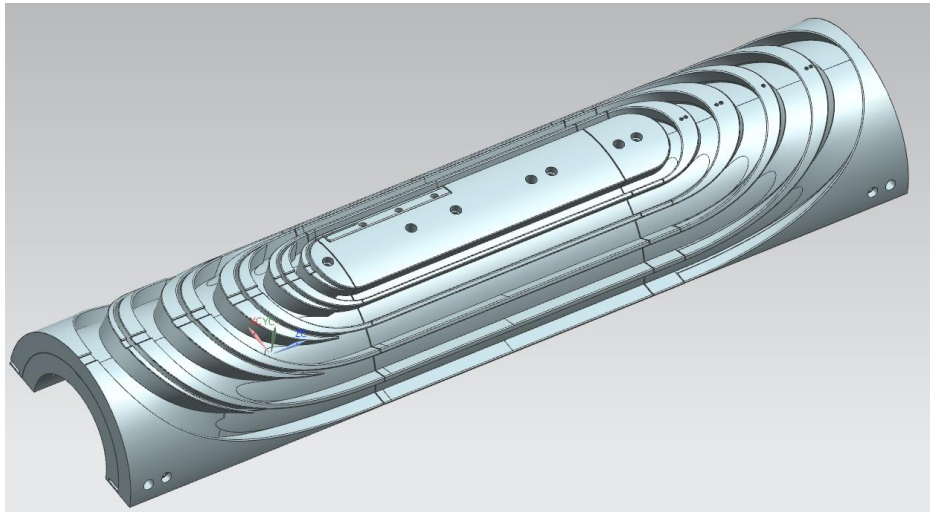
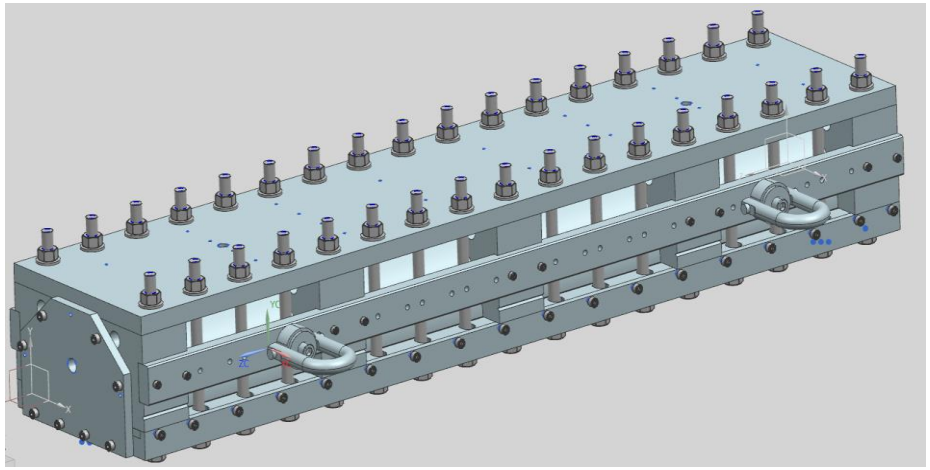
AI-M3a	Assembly and test of stress-management concept in a 4-layer 60-mm 17 T dipole with stress management.	**Dec-24** ~~Sept-24~~

Summary

- A 120 mm aperture Nb_3Sn dipole coil SMCT1 was designed and built at Fermilab to validate and study the coil SM concept
- The SMCT1 coil is being tested in dipole mirror configuration
  - In the first test, after a relatively short training, the SMCTM1a mirror magnet with the SMCT coil powered individually, has reached conductor limit with B_{max} in the coil of 12.7 T at 1.9 K and 12.0 T at 4.5 K which corresponds to ~90% of its SSL
  - SMCT1 coil test in 4-layer mirror configuration will follow
- FY24 plan, schedule and resources have been prepared and submitted
  - US-MDP milestone AI-M1a “Development and test of stress management concept using a 2-layer large-aperture and 4-layer small-aperture cos-theta coils and dipole mirror structure” will be achieved in Q1 FY24
  - MDP milestones AI-M2a and AI-M3a will be achieved in Q1 FY25

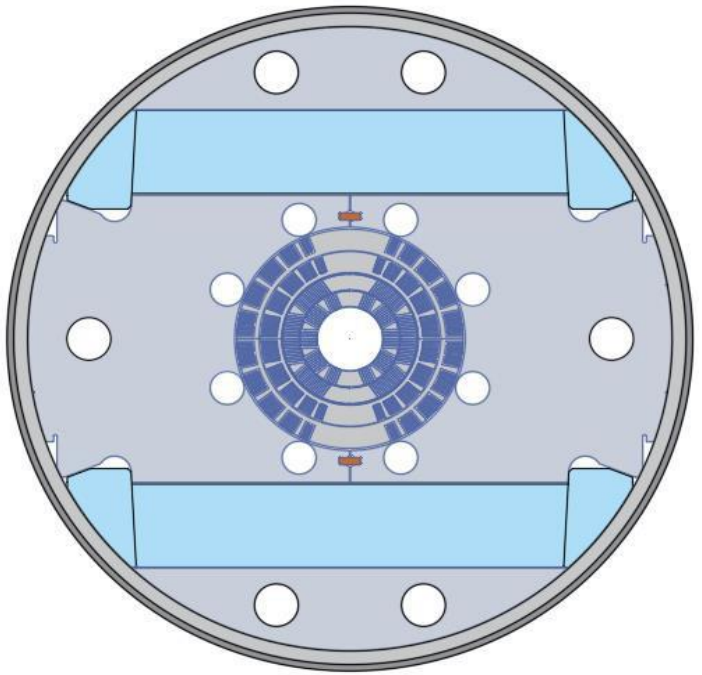
SMCT2 coil design, tooling and structure optimization





SMCT2 coil structure

- shorten inter-block transitions, optimize inter-block space and move interlayer transition to LE block to reduce coil end length and minimize SMCT2 structure post-processing
- *in progress*



Reaction-Impregnation tooling

- add blocks to improve coil size precision
- *in procurement*

Magnet structure

- Additional shell to reinforce structure radial strength
- *to be designed and procured*