U.S. MAGNET DEVELOPMENT PROGRAM

CCT Progress Update

Diego Arbelaez, Lucas Brouwer, Shlomo Caspi, Dan Dietderich, Ray Hafalia, Scott Myers, Thomas Lipton, Maxim Marchevsky, Matt Reynolds, James Swanson, Marcos Turqueti, Xiaorong Wang, Soren Prestemon, Stephen Gourlay

07/12/2017

Outline

- Basic Parameters
- Fabrication
- Instrumentation
- Test Plan

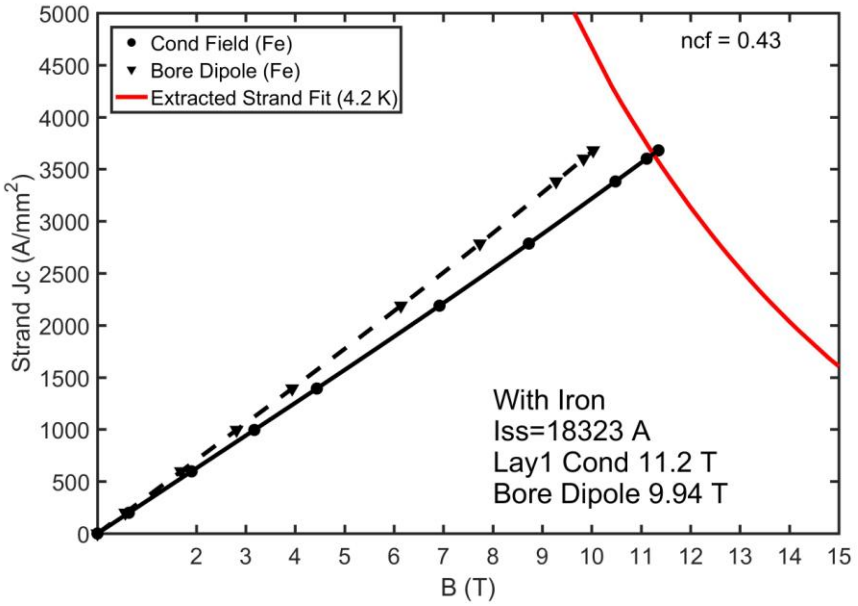
CCT 3/4 Parameters

- Tested and planned CCT 2-layer series has nearly identical geometry
  - 90 mm diameter inner bore
  - 1 m physical length
  - Mandrel grooves for ~10 mm wide and ~1.4 mm thick cable

Magnet Parameters

	CCT3/4
Conductor	Nb_3Sn RRP 54/61
Cu:SC ratio	0.85
Inner Bore Diameter [mm]	90
Cable Width [mm]	10.1
Cable Thickness [mm]	1.4
Number of Strands	23
Cable Insulation	S-glass Braid 0.2 mm thick
Iron Yoke	Yes
Impregnation Material	CTD-101K
Short Sample Current [kA]	18.3
Short Sample Bore Field [T]	9.9

Magnet Load Line for CCT4



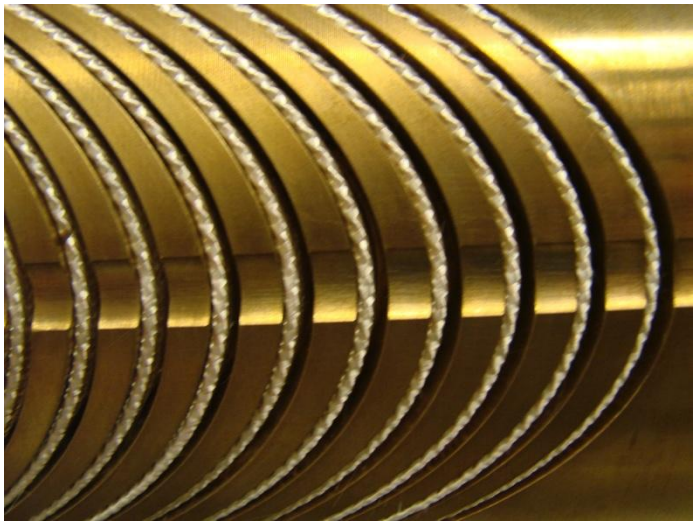
2-Layer CCT Nb_3Sn Plan (CCT Technology Development)

	CCT3	CCT4
Bore size [mm]	90	90
Groove design	constant width →	1.25 mm gap at pole
Conductor	RRP 54/61 Ta doped	RRP 54/61 Ta doped
HT Temp [C]	650 →	660
Potting configuration	full magnet	full magnet
Epoxy	CTD-101K	CTD-101K
Layer-to-layer interface	bonded →	mold released

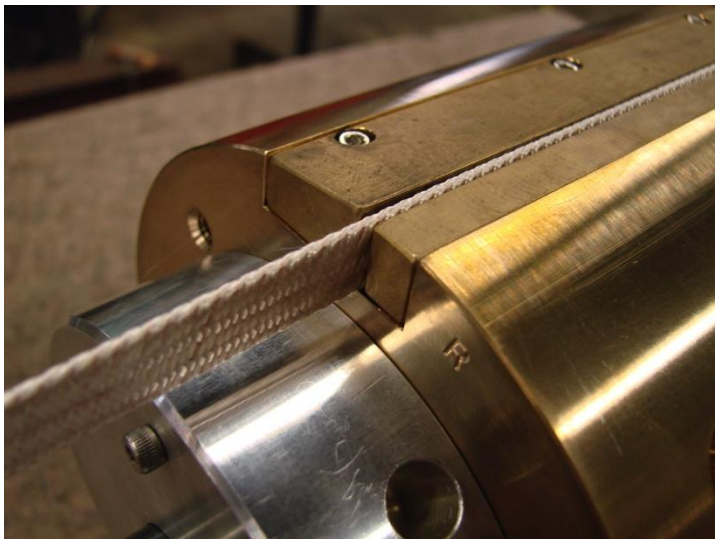
CCT4 Mandrels and Winding

- CCT 4 Mandrels have 1.25 mm gap at the pole for cable expansion
- Other features are the same as CCT3
- Cable is wound against the inner surface of the turn at the pole
- Resistance to mandrel > 5 kΩ
  - Wider groove by 0.1 mm
  - Extra space at the pole

Pole Gaps



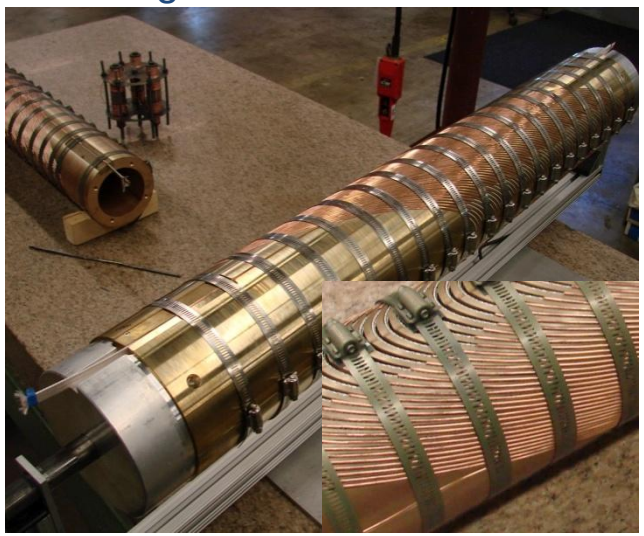
Lead End



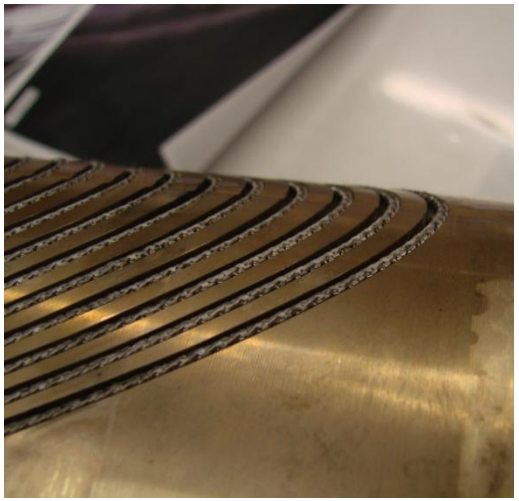
CCT4 – Heat Treatment

- Copper wire was inserted into groove to force the cable to the bottom of the channel (same as 10-turn tests)
- Mandrel is wrapped with hose clamps
- Cable stays in channel after heat treatment
- Mandrels distort 0.5 – 1 mm after heat treatment in the N/S orietation
  - Not yet clear how much influence cable has on distortion as opposed to machining stress
  - May require additional annealing step after grooves are machined to avoid distortions

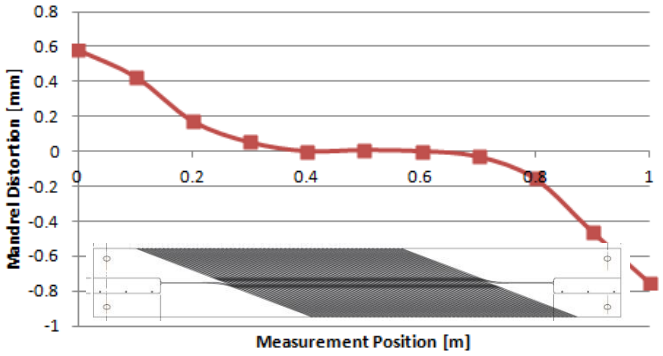
CCT4 Heat Treatment Configuration



Cable Position After Heat Treatment of CCT4



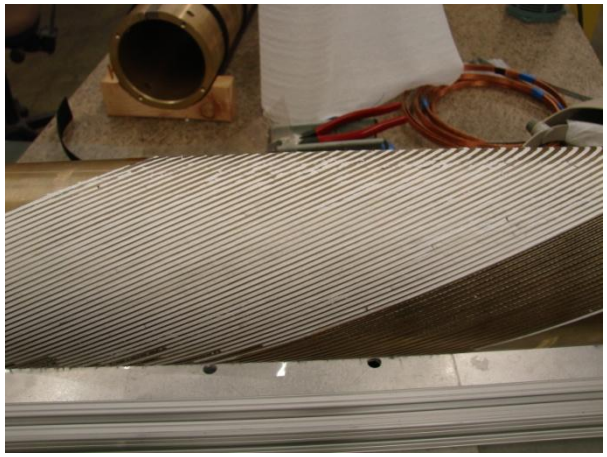
Mandrel Distortion After Heat Treatment



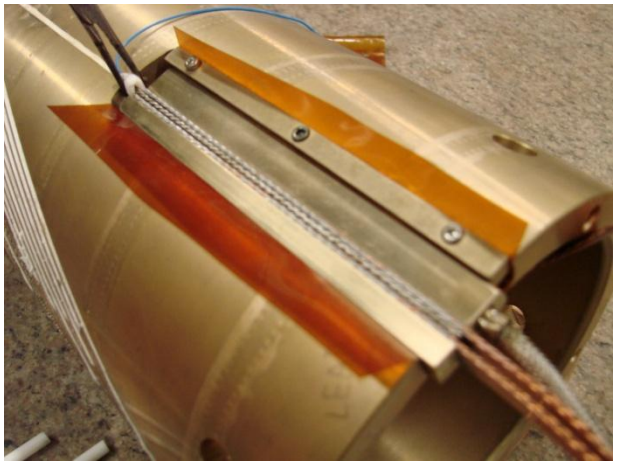
CCT4 – Coil Preparation

- Glass fiber mat used to fill remaining space in channels
- Nb_3Sn cable spliced with two NbTi lead cables in machined channel
- Voltage taps were soldered at the pole locations using flexible Kapton PCB

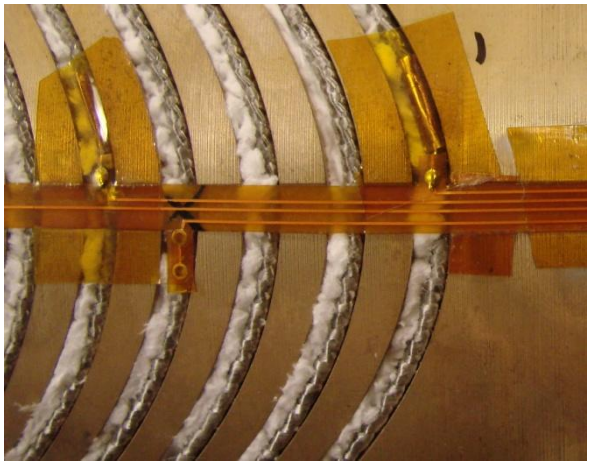
Glass Reinforcement



Lead Splice

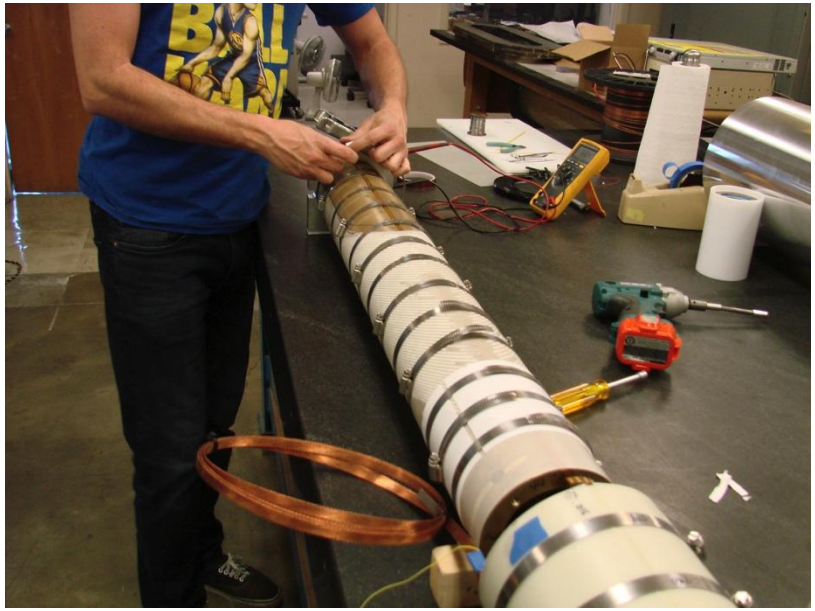


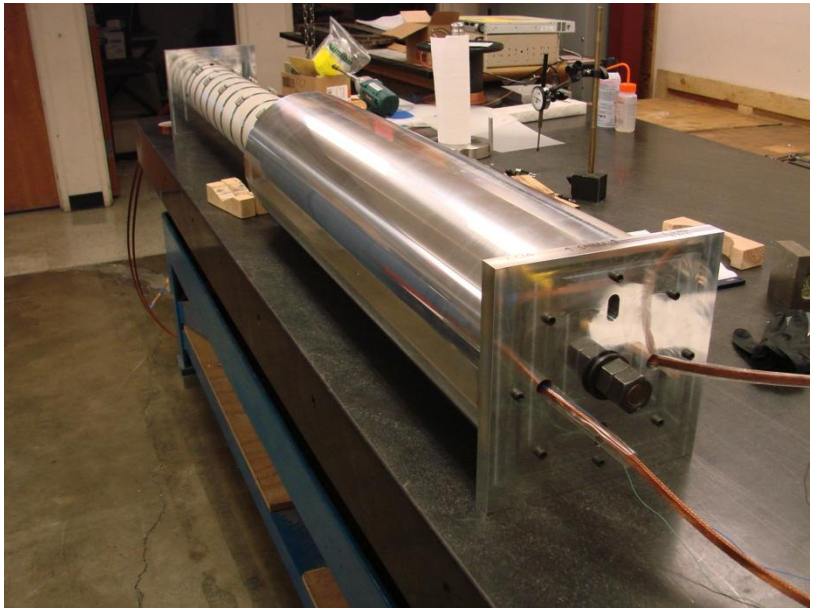
Voltage Tap Connections



CCT4 – Assembly

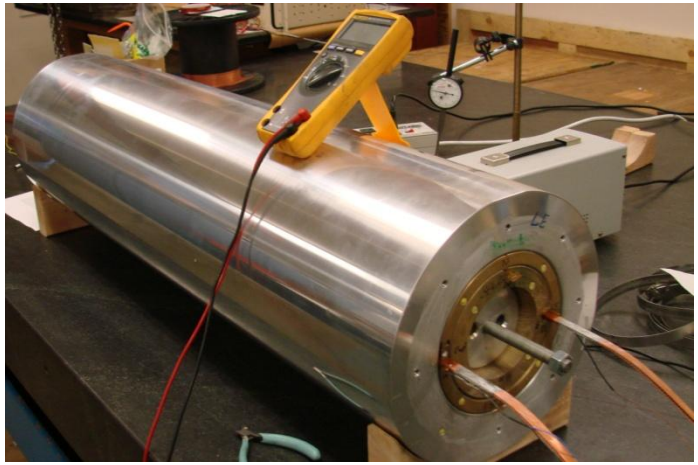
- Layers are wrapped with G10 sheet before assembly
- Assembly of layer 1 / layer 2 was difficult due to amount of mandrel distortion
- Cable is protected by mandrel since it is below the surface

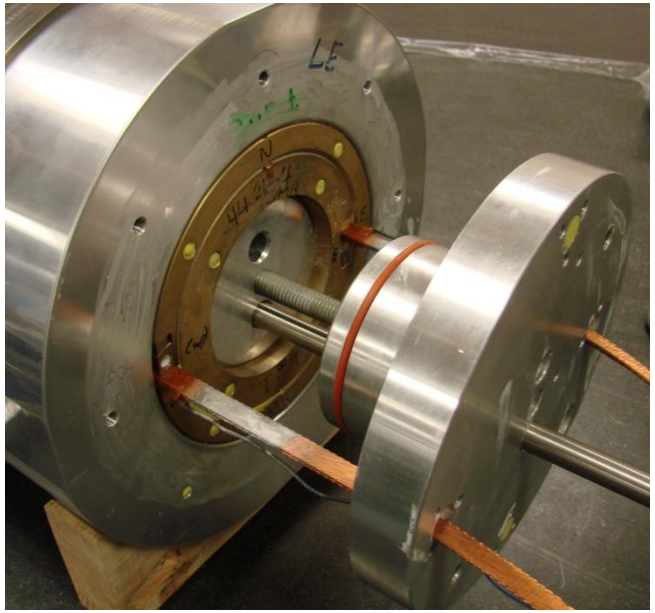


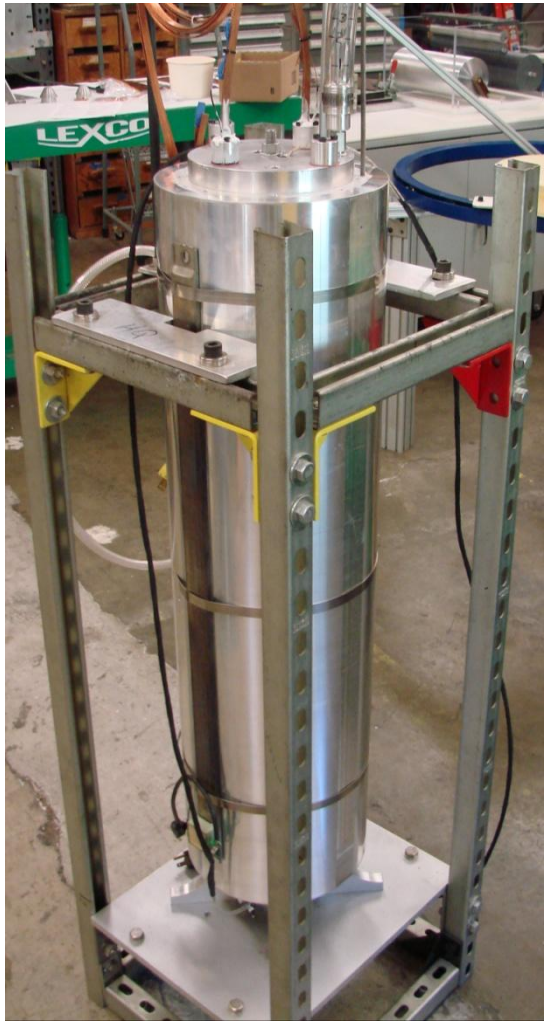


CCT4 – Epoxy Impregnation

- Mold release applied between layers
- Two layers and shell impregnated together
- Heaters placed inside the bore and on the shell surface

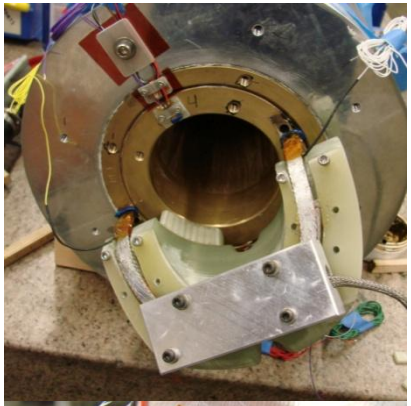






Test Preparation

- Layer-to-Layer splices were completed
- Voltage tap wires were added and secured
- Acoustic sensors were installed and tested
- Iron yoke was assembled

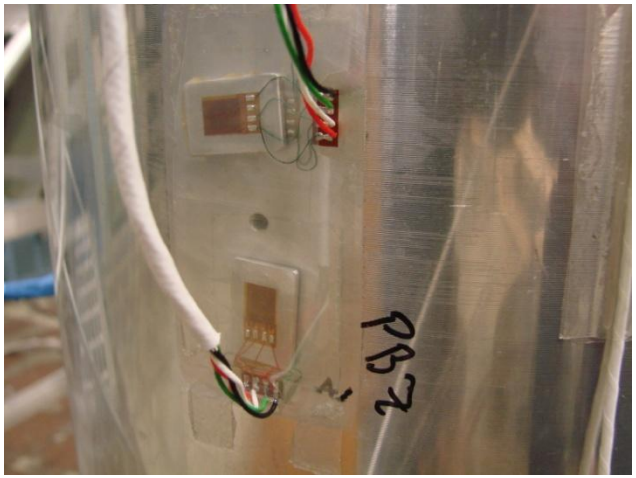


Instrumentation

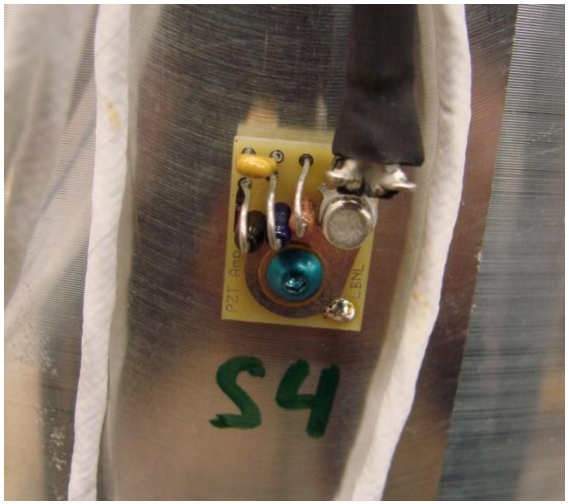
- Voltage taps
- Acoustic Sensors on Shell
- Strain gages on Shell (Pole and Midplane)
- Spot Heater and Thermometer in Groove

Spot Heater

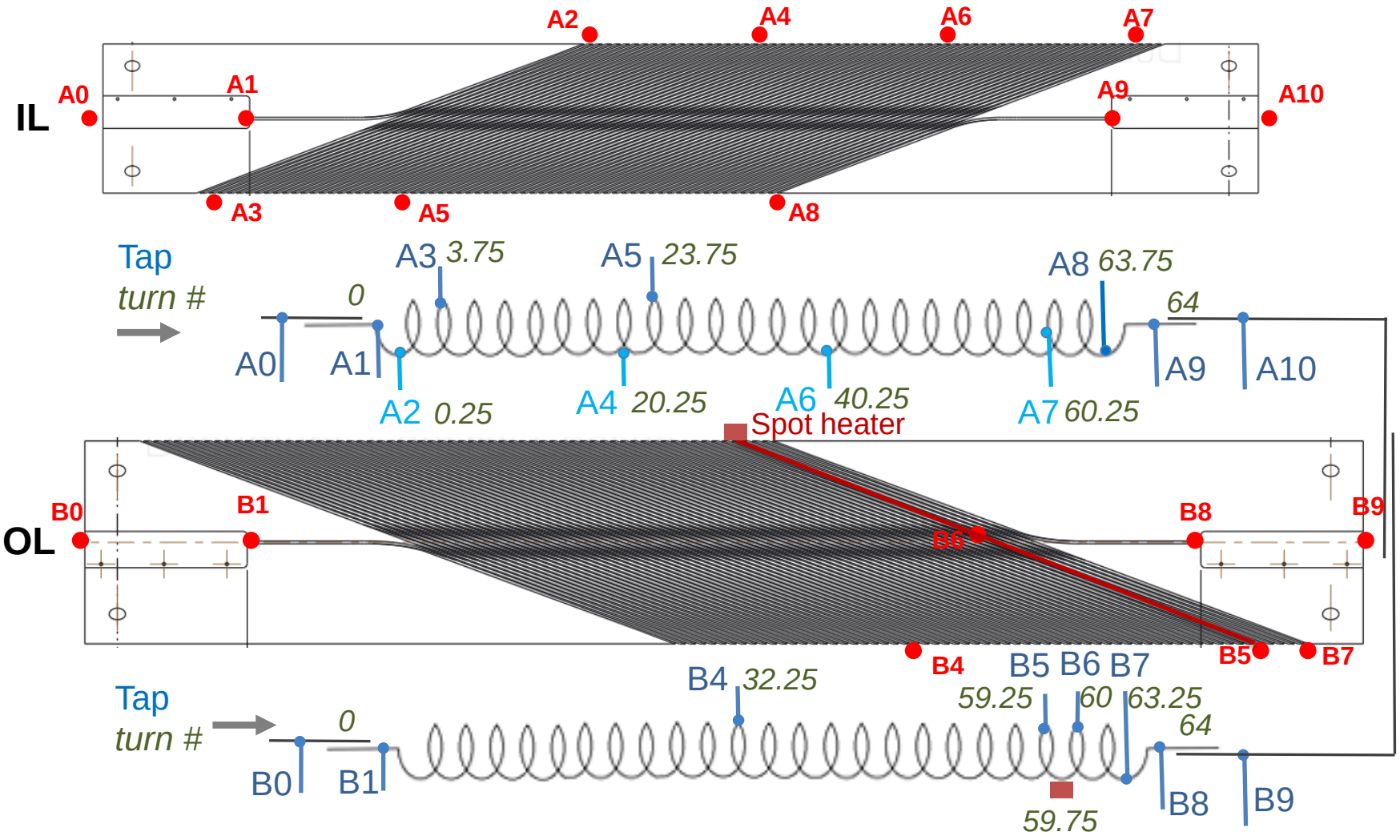
Strain Gages



Acoustic Sensors



Voltage Tap Layout



Test Plan

- Installation and electrical checks (5-7 days) (75 % complete)
- Cooldown and system checks (3-4 days – projected to start July 16)
- First magnet current cycle (1 day)
- Quench training (~3-4 days)
- Magnetic measurements (1-2 days)
- Magnetic measurements (1-2 days)