Instrumentation for the 15 T dipole

(summary for 11/4/2016)

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We discussed the following key instrumentation items:

Voltage tap and heater traces

We agree that this is our first-priority item. The plan of actions is as follows:

- FNAL will provide coil drawings to LBNL
- LBL will propose trace and heater design based on the finalized Vtap schematic by FNAL, and protection-driven requirements for the heaters
- CAD work will be done at LBNL or FNAL, depending on the engineering load and schedule constrains at both labs
- Trace fabrication can be done either at LBNL shop (typical turnaround time 2-3 weeks) or by the commercial partner (endorsed by FNAL), to be decided.

Quench antennas

We agreed that having quench antennas is essential for analyzing magnet behavior, especially given the minimal amount of Vtaps in the magnet and its four-layered structure. Three options are on the table:

1. FNAL expressed interest in adapting / re-designing the QXF-style warm bore quench antenna earlier developed by LBNL to fit the 40-mm bore of the 15 T dipole. Its modular design suits best the diagnostic needs. LBNL will work full time on this new antenna, coming up with a more compact and flexible version of the modular design.
2. FNAL will be using a PCB-based antenna that is already built into the warm bore of their test facility cryostat. This are a useful addition, although the elements of this antenna are sparse, and its spatial resolution will be limited compared to the QXF-style antenna.
3. We discussed plans on incorporating a quench antenna in the trace of Coil 3 (or having it fabricated on a separate trace, directly on top of the Vtap trace of Coil 3. Without such antenna it will be quite difficult to localize quenches in the outer layers, should such quenches occur. Two potential issues are:
    - Schedule timing (traces for Coil 3 need to be fabricated in Dec 2016 / Jan 2017)
    - Lack of prior test experience for an inductive antenna placed in-between the coil layers. Should we build such an antenna, an adequate mean of testing it should be realized, possibly by incorporating spot heaters in the Coil 3 trace together with the antenna

    A potential compromise could be fabricating a short antenna with a spot heater on the initial Coil 3 trace, testing it with the magnet, and then extending it for the full trace length in future generations of coils – to be further discussed. The trace antenna will be designed jointly by FNAL and LBNL (MM and Joe DiMarco).

For all quench antenna options a multi-channel data acquisition will be required that is beyond the currently available one at the FNAL test facility. We agreed that such data acquisition system can be set up either based either on one of the existing setups at LBNL, or some newly acquired hardware. Interfacing with the test facility DAQ will be done by a synchronizing acquisition of the quench trigger signal.

Acoustic emission diagnostics

FNAL expressed interest in installing the acoustic diagnostic system previously developed at LBNL. A request was made by FNAL to reduce a footprint and dimensions of the acoustic emission sensors, in order to safely fit the limited space (~ 3 cm) between the magnet shell and the cryostat wall, and also to enable installation of the sensors in magnet bore. This is in line with LBNL's plans on building new generation of acoustic sensors, and LBNL will work on this.

The locations of acoustic localization sensors are tentatively at the coil ends (8 sensors in total), coil shell and coil inner island (locations and amount to be decided). In combination with the quench antenna, these sensors should give us an accurate information on quench locations, as well as provide monitoring of magnet structural "health" through the test cycle. An active transducer can be later installed on a magnet to allow for a detection of heat and structural changes during magnet training.

Strain gauges

We did not discuss strain gauges in detail yet. A possibility is to use same kind of gauges and installation procedures that were used in the past LARP magnets. Wiring those gauges using Vtap traces was discussed, and should be examined at the trace design stage. As potentially many gauges (up to 64) will be installed, it may be attractive to use the cryogenic strain gauge interface that is currently being developed by LBNL (and presently tested with the MQXF-S magnet). This option may drastically reduce number of instrumentation wires and simplify strain data acquisition.