A1900 QUADRUPOLE TRIPLETS CONSTRUCTION PROGRESS

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Significant progress has been made on the A1900 quadrupole triplet assemblies. The description and configuration of the A1900 are described elsewhere[1-3]. A total of 9 triplets are to be built, 8 for the A1900 beamline and 1 spare, the triplet immediately following the target station which will be subjected to high radiation levels.

Mechanical design was completed on the T4 and T5 triplets on either side of the intermediate image, and is 50% complete for the remaining triplet cryostats. A heavier winding table was built to handle the heavier coils and wire spools. Coil winding production is underway with all coils being wound for the T4 and T5 triplets. Quadrupole coil winding is 15% complete and multipole coil winding is 15% complete. Machining of all quadrupole steel assemblies is complete. Both of the large D size magnets for the T4 and T5 triplets have been assembled and successfully tested. Both the B and E size quads for T5 were assembled and tested and the assembly of the 3 magnets with their rigid spacers into a triplet is in progress. Final machining of the rigid spacers needed for the remaining magnets are in progress. Magnet assembly and testing of the last 2 magnets for the T4 triplet are in progress. All parts needed for the LHe containers are in house with welding and machining of the container shells in progress. The multipole assembly on the T5 LHe bore tube is complete with the one for T4 in progress. Support link prototypes have been fabricated and tested. Fabrication of the cold mass support links is 50% complete with orders placed for all support link parts for all magnets with outside vendors. All bore tubes, 30 in all, have been received. Fabrication of the LN_2 tanks are complete for T4 and T5 and they have been vacuum furnace brazed to their copper shield sections. All LN_2 shield end bells are in-house. The remaining LN_2 shield parts for T4 and T5 are presently being fabricated. The cryostat shells for T4 and T5 are in house with bids on machining in the hands of outside vendors. Current leads are complete for T4 and T5 are complete and are 75% complete for the remaining triplets. Cryostat assembly tooling has been designed and is being fabricated.

Significant equipment purchases such as a 5-ton gantry crane, Meta-lax stress relieving equipment, and a new welding machine help to upgrade the lab's present and future fabrication abilities. A large surface plate already in the lab was resurfaced for assembly alignment of the triplets

Magnet Assembly and Testing

The D size coils were wound first as they were very similar to the coils in the Q2 quadrupole of the S800 spectrograph[4], only they are 3 inches longer. Their maximum operating current is 380 A giving a gradient 11 T/m with a warm bore of 17 cm. (cold bore is 21 cm.). The coils are shimmed against each other and against shims between the coils and inner diameter of the yoke. Retainer bars are installed against the circumferential shims and welded to the ends of the yoke to restrain the wedges from coming apart. The original shims which spaced the coils circumferentially against each other were made as a 2 piece, 316 s.st. wedge set which ran the entire length of the steel assembly. Thin G-10 makeup shims were used to fine tune the wedge engagement and provide for ground plane insulation. The shims spacing the coils radially were 1 piece, 316 s.st. bars which adapted the yoke radius to the flat coil surface. A thin G-10 makeup shim was used here also between the coil and s.st bar to fine tune coil fit and provide ground plane insulation. Both D size quadrupoles were first assembled in this fashion and tested with both giving similar results. The magnets trained to a current of about 300 A, significantly below their maximum operating current. The quench current was somewhat erratic with large differences in the quench current from one to the next. Because of the erratic quench behavior it was thought that the training was limited by frictional heating at the boundary surfaces of the coils. These magnets were shimmed similar to previous superconducting quadrupoles at the NSCL except that segmented shims had been used previously. Peak fields in the coils were similar to our previous designs around 2.5 T. The resultant coil forces are higher but the coil stresses are not much greater, as the coil has a larger cross section. The surfaces for boundary friction on these coils are larger, and with shims running the length of the iron, little LHe is present around them to remove heat at the boundary before it can propagate into the conductor. Larger relative movements also can occur between the coils and shims as the forces increase. The shims cannot separate lengthwise, and they stretch very little as the coil moves in the axial direction (the axial shim stiffness is much larger then the axial coil stiffness). These magnets are also longer than other NSCL quads. The shimming surfaces of the potted coils are also not perfectly smooth and flat. Comparison against the Q2 quadrupole of the S800 spectrograph could not be readily done as its required operating gradient was lower than that needed for these quads, about the same as what these magnets trained to (a peak pole tip field of 1.8 T). The Q2 quad was never pushed beyond this point. The two D-size quads were disassembled and reshimmed, segmenting the shims axially into 4 sets that occupy about 40% of the existing volume. It is also important that the coils are radially tight against the yoke and not bearing against the ground plane insulation shims between the coil and poletip surfaces. The remaining volume was left mostly open with thinner pieces being placed between the segments to restrain them from axial motion. A final shim pack arrangement is shown in fig. 1. Some preloading of the coil in the direction opposite to the coil forces is done circumferentially by wedging the center of the coil a little further apart than the ends that are restrained by the coil ends. This bends the straight section of the coil in a direction opposite to that of the coil forces and reduces the stress at full field. Both magnets then readily trained to the necessary operating current in a more reasonable manner. The quench history of both D size magnets is shown in fig. 2. This shimming design has been applied to all the magnets and resulted in successful initial tests of the first E and B size quads.

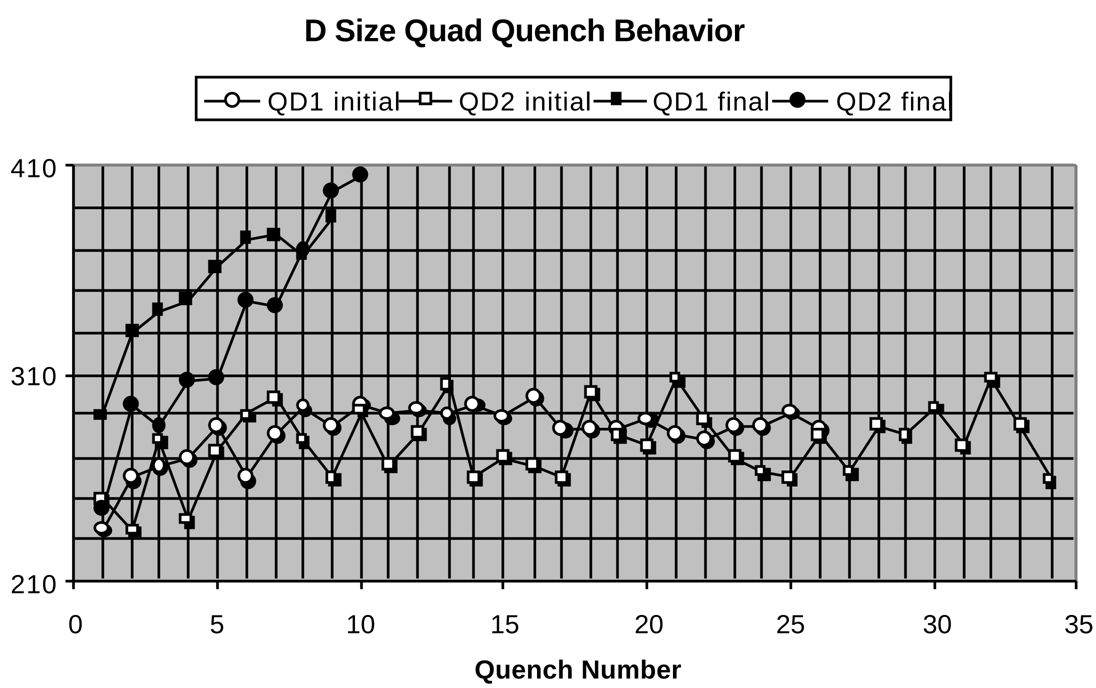

Fig. 1: Quench number vs. current for the D size quads as initially shimmed with wedges and shims running the entire length of the steel assembly, and with final shimming using axially segmented wedges and shims occupying about 40% of the existing volume.

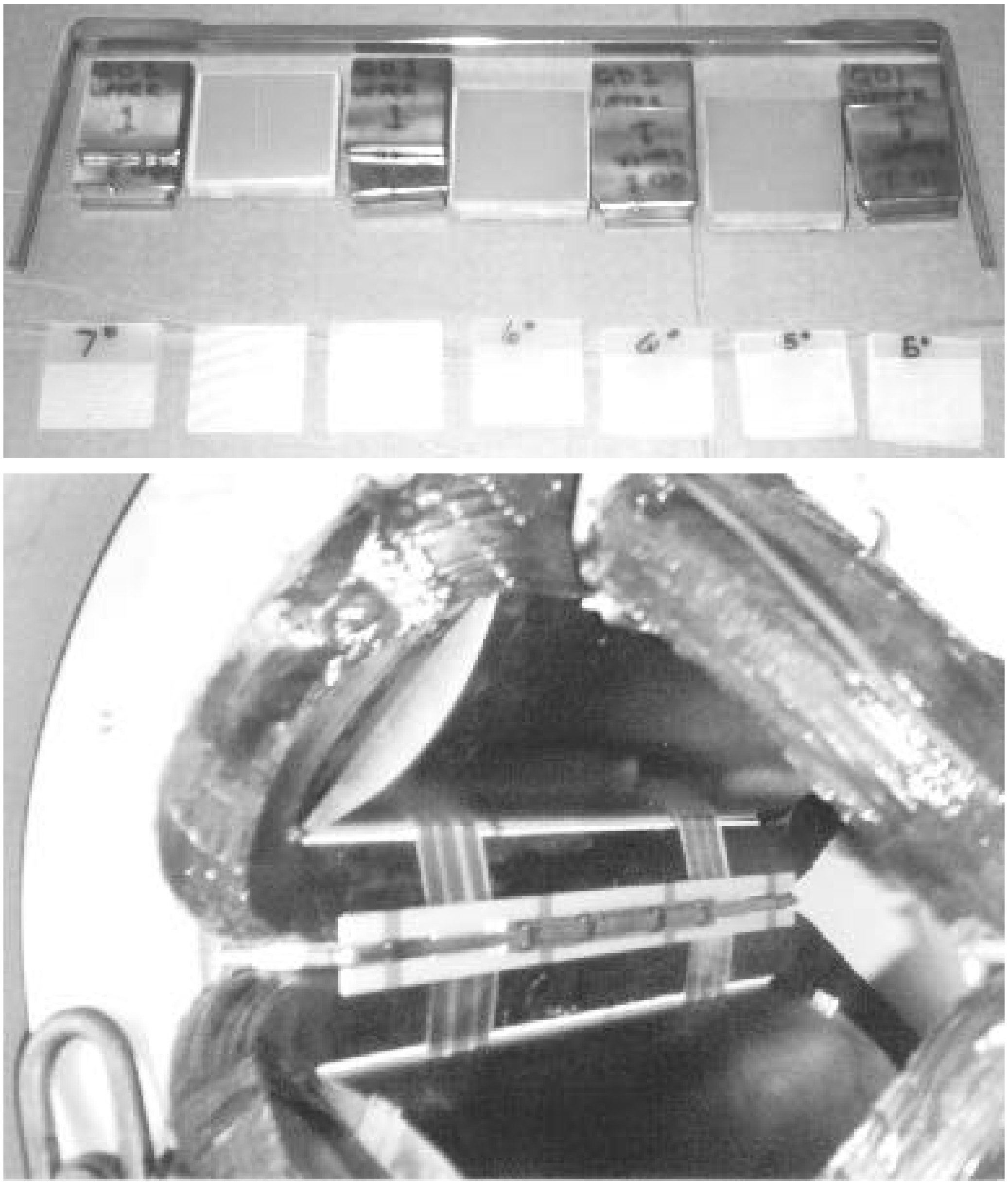

Fig. 2: At the top is a view of the circumferential wedge-shim packs used between the coil surfaces. At the bottom is a view of the inside of the quad. The hyperbolic shapes of the poletips lie in the middle of the coils. The wedge retainer bars are seen and are radially inside of the wedge-shim packs, being bent to provide some spring force against the 2 center wedge-shim packs. The bars are welded to the ends of the yoke at a radially outward location so that thermal contraction will apply more pressure against wedges as the magnet cools down to LHe temperatures.

References

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