To: Steve Gourlay
From: Shlomo Caspi s_caspi@lbl.gov
Snowmass 2020 June 25, 2020

Dear Steve,

I am writing this letter to express my view on the needed direction in future R&D of superconducting accelerator magnets. The cost and risk of future SC magnets, e.g. 16 T, are directly related to the increase in the length of accelerators, e.g. 100 Km. Some important questions on the performance of SC magnet still remain partially unsolved and will require a different and a more daring approach if progress is to be made. One such critical question is what to do in order to reduce magnet training. Presently many SC accelerator magnets require 20, 30 or even 50 training quenches to reach their short-sample limit, a risk that can put an entire accelerator machine in jeopardy or at best may require reducing the machine energy target. Over the past half century, it has been understood that "training" is associated with conductor events that are under stress, motion, epoxy cracking etc, all mechanical mechanisms that generate an energy release and required preventive measures during assembly in the form of applied pre-stress. With fields approaching 16 T the internal stress on the coils has reached unacceptable limits and required a new approach.

With the development of the Canted-Cosine-Theta magnet (CCT) the inclusion of structure into coils behaved as a stress intercept preventing stress accumulation and left turns solely under their own Lorentz force. However, reducing conductor stress and by simplifying the design substantially, magnet performance did not improve. The training performance was still unsatisfactory pointing out towards a more intrinsic mechanism surrounding individual turns. The reduction of stress in a CCT magnet removed an important R&D variable but had little impact on training. It provided however an opportunity to focus on other sources of training.

It brought with it some new and "out of the box" ideas, concepts that are specifically suitable for Nb3Sn and HTS conductors. The "Wind-React-Wind" (WRW) method allows removing reacted CCT winding from a reacted mandrel and placing them into an entirely new mandrel of the same size. The act of moving a reacted brittle conductor from one mandrel to another is based on the fact that the newly annealed conductor not only maintains its elliptical formed shape but also contains a certain degree of elasticity. Those two mechanical properties in combination with small stranded cable assures that even brittle conductor can be undamaged during the removal process (with some analogy to flexible glass fibers). Moreover, the new mandrel not undergoing a high temperature reaction, maintains tolerances and can be made of any material. In addition, by coating the new mandrel with an insulator (e.g. anodizing), there will be no need for placing insulation around the conductor, an important safety feature.

The impact of removing the conductor from the reaction mandrel will greatly help in the study of training. From the release of local sintering taking place during reaction to all together removal of epoxy impregnation and replacing it with liquid helium new ways will be provided to do R&D that was never done before.

I would like to encourage the SC magnet community to step outside, explore new ways and dare to try.