Letter of Interest, submitted August 31, 2020

Hyper Tech Research Inc. 539 Industrial Mile Rd. Columbus, OH 43228

Michael Tomsic, President, PH 614-481-8050 Ext. 2432, email: mtomsic@hypertechresearch.com

Developments needed to lower the cost of future high field accelerators, accelerators need to be more affordable to build. The major cost items are superconductor wire, cables and magnets.

Need Hybrid Magnets using all three types of superconductors. NbTi, Nb3Sn, and ReBCO to effectively lower the cost of accelerators. No organization can afford to build high field accelerator magnets just using ReBCO tapes. So we need improvements for all three superconducting wire types. The lowest cost wire is NbTi, next is the cost of Nb3Sn wire, followed by ReBCO superconductor tapes. We need to maximize the use of the lower cost superconductors, to minimize the use of the expensive ReBCO superconductors.

Here is a list of needs, there are potential technologies, that could be funded and pursued to match up with the desired needs listed below. Methods to fulfil the needs, are not discussed due to being proprietary information.

Magnets

1. Need Hybrid Magnets using NbTi, Nb3Sn, and ReBCO to lower cost of accelerators. So we need improvement for all three wire types
2. Need magnet designs that can provide high coil current density and packing factor but also provides localized stress control at 16-20 T.

ReBCO

1. Need is for lower cost of ReBCO tape- how can this be obtained.
   A. Good performance tape needs to be made with low cost sol-gel processing equipment. Current vapor deposition equipment is too expensive. For the cost of vapor deposition equipment, life of the equipment, it gives a base line cost of around $10/meter for a 4 mm wide tape, before you consider manufacturing costs (materials, processing cost, overheads, and profits).
   B. The thickness of ReBCO layer needs to be increased without sacrificing processing speed, this will increase the price/performance of ReBCO.
   C. Need better defect detection and QC tools to help identify and prevent drop outs.
2. Need is for better quench detection, this will only be accomplished, economically, and practically, when a tailored Tc superconductor (to match the application temperature, 1.8-7 K) that has faster normal zone superconductor, that is imbedded in the ReBCO tape. This is difficult to do, because the tailored superconductor needs to be superconducting in the 16-25T range. Only other options are fiber optics and acoustic emission but both have their difficulties.

3. Need development of improved ReBCO cables with higher engineering current density with built in cooling. Coil designs are needed that do not rely on heat going thru epoxy and insulation for cooling of coil hot spots.

Nb3Sn

1. Need new ways to refine Nb from the oxide to obtain pure Nb metal (lower the cost Nb per kg)
2. Need new ways to reduce the cost of making Nb alloy billets (Nb-Ta-Zr-Hf)
3. Need new ways to reduce fabrication cost of making Nb alloy rods, sheet, and tubing to be used in Nb3Sn wires.
4. Need new ways to reduce the fabrication cost of the wires (improve drawing speeds, increase bonding between filaments and subelements)
5. Need better quality control tools during manufacturing to prevent defects and minimize wire breaks
6. Need to continue to dramatically increase the in-field performance of Nb3Sn wires in the 16-20T range using artificial pinning and grain refinement (APC route)
7. Need to continue to increase the stability and specific heat of the wires to decrease training quenches
8. Need to reduce the price differential between NbTi and Nb3Sn (NbTi wire basically sells in volume around $200/kg. Nb3Sn wire basically sells for $600/kg in volume. Nb3Sn wire, just based on the material cost the price in volume should be around $300/kg (more Nb is used in Nb3Sn wire, than in NbTi wire). Need to lower the differential between the selling price of NbTi and Nb3Sn superconductors. The objective should be to lower the cost of Nb3Sn wire from $600 per kg to closer to $300 per kg.

NbTi

1. Need new ways to refine Nb from the oxide to pure metal (thus lower the cost of Nb per kg)
2. Need more stable NbTi superconductors, need to build in more high specific heat material, to minimize the number of training quenches.