| ***Technology readiness questionnaire of HTS Conductors for the Muon Collider*** |
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| ***Charge: Are HTS conductors ready for the muon collider challenges yet?*** |
| ***Define: The next steps in the development program needed to get there*** |
| ***Discuss:******Address known limitations, weaknesses and outstanding issues w/re to the approach*** |
| ***Identify: critical path items and priorities*** |
| **Characteristic** | **YBCO** | ***Value Now*** | ***Goal Attained (est. date)*** | **Bi2212** | ***Value Now*** | ***Goal Attained (est. date)*** |
| **FundamentalProperties** | Temperature Range | 2-50 K, 4 K preferred  |  |  | 2-10 K, 4 K preferred  |  |  |
| Jc(B,T) | Highly anisotropic. C axis Jc limits magnet performance under most circumstances. JE at present can easily exceed 400 A/mm2 when field is applied parallel but such values also pose many quench concerns |  |  | Short sample Jc values are fully capable of Je ~ 600 A/mm2, but in long lengths are presently about half. Present R&D is strongly focused on understanding and removing this length limitation and is promising |  |  |
| Max Field | Bc2 >100T |  |  | Bc2 >100T  |  |  |
| **OperationalCharacteristics** | Field Uniformity | Good |  |  | Offers the best field uniformity since the conductor is round and isotropic.  Issues are rather similar to modern high Jc Nb3Sn conductors. |  |  |
| Field Stability | Probably OK but magnetization is a concern.  |  |  | Multifilamentary round wire  |  |  |
| Ramp Rate Sensitivity | Large hysteretic losses wherever there is significant perpendicular B.  |  |  | Expected to be less than REBCO, BUT filament coupling within bundles and demonstration that conductor can be twisted are needed.  |  |  |
| Quench Detection | Challenging. |  |  | Challenging. |  |  |
| Quench Protection | A big unknown – NHMFL 32T has quench heaters every 3 pancakes.  Present experience with small test coils is NOT proof for large magnets where fast detection and fast active quench spread will be needed. There is a basic lack of understanding of quench in large REBCO coils, the importance of conductor defects etc. Cables are almost certainly needed and not yet demonstrated |  |  | Perhaps manageable for 2212 because the superconductor is in direct contact with significant amounts of normal metal and the round wire form allows flexible cable design for multi-kilo amp conductors, but it is still a challenging issue |  |  |
| Inductance/Stored Energy | This is a BIG issue – NHMFL 32 T is a 10 MJ magnet.  It will be built from single 4 mm wide tape because this is the only available conductor form but it is not ideal. The external LTS coil will be powered separately from the internal REBCO coils and quench protection scheme is a.) fast detection, b.) firing of quench heaters for REBCO coils, c.) switch in external dump at about 100 msec, d.) hope it all works |  |  | Much easier to get to low inductance magnets with 2212 than with REBCO cables.   |  |  |
| Thermal Cycling |  |  |  |   |  |  |
| Radiation Hardness/Lifetime | Not very clear yet  |  |  | Ag can activate  |  |  |

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| **MechanicalConsiderations** | Splicing/joints | Typical piece lengths are fairly short so the number of splices required for a magnet remains a concern.  |  |  | Soldering to Ag is much easier  |  |  |
| Winding | Can be wound successfully, but conductor geometry presents limitations |  |  | No special difficulties – but the wire must be heat treated after winding which does pose issues.  |  |  |
| Cabling | "Roebel" is so far the preferred route but there are many concerns about the cost of the meander stamping required and mechanical stability of the cable. CORC is another concept (a barber pole that is transposed) but Je is only 25-35% of single strand due to its large core. |  |  | "Rutherford" – perfectly feasible for 2212 and good performance without cabling degradation was demonstrated in VHFSMC.6+1 or other cable geometry is feasible too. |  |  |
| Strain limits | Can operate to axial tensile strains of order 0.6% when Hastelloy substrate is used. Transverse strain limits are much lower due to delamination effects  |  |  | Reinforcement is needed. Introduction at cable stage is ideal  |  |  |
| Stability | Electromagnetic stability is high even for transverse fields.  |  |  | High.  |  |  |
| Uniformity | Much work needs to be done since production process can introduce many defects.  |  |  | As produced the wire seems to be quite uniform – but non-uniformities are introduced during heat treatment. We anticipate control of this problem in the near fiture.  |  |  |
| **Intrinsic Material/Processing Issues** | e.g., 'drop outs', piece length, Jc vs. (B ∕∕, B┴) |  |  | e.g., heat treatment, bubbles, leakage |  |  |
| **Industrial Supply** | Cost/unit length | $50-70 per 4 mm wide per meter  |  |  | Similar for round wire of about 1 mm diameter.  |  |  |
| Piece Length | 100-150 m at price premium, although made in km lengths already  |  |  | 200—300 meter today, can be scaled up without too much problem  |  |  |
| Vendor capability | SuperPower, AMSC |  |  | OST, Supercon  |  |  |
| Vendors/availability |   |  |  |   |  |  |
| ***"Other"*** | In the SC state as purchased and so easier to fabricate in test coils.  |  |  | Reaction requires pure O2 at 900C and only a few labs have this capability.  |  |  |
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