BNL has been building racetrack coils and test magnets with Bi-2212 Rutherford cable for several years. During this period we have seen ongoing improvements in cable performance. We have made coils with these cables. Despite initial concerns, due to the brittle nature of these emerging conductors, we have been successful in making racetrack coils and achieved performance as expected. The latest coils carried significant current - over 4 kA at ~2 T.

Critical current as a function of applied field in the Rutherford cables tested at BNL (several years of on going progress may be noted):

We use “Rutherford cables” in “conductor friendly” accelerator magnet designs using “react-cool” and “React & Wind technology”.

### A Medium Field HTS Magnet Operating at ~30 K

This opens a possibility of a new class of superconducting accelerator magnet application with cry-coolers. It is useful when the field requirements can not be met by copper magnets and when there is no cryogenic facility available nearby.

### Design Issues for High Field Accelerator Magnets using HTS

- HTS materials are very brittle
- HTS materials are very expensive
- Large quantities are not available yet
- Unknown field quality issues

We are addressing that by measuring field harmonics in HTS magnets (also work on the magnet designs).

### HTS Coil for Accelerator Magnets

A 10-turn racetrack R&D coil recently built and tested at BNL.

- Minimum bend radius 70 mm
- Cable thickness 1.6 mm
- Blending strain 1.2% or 0.8% depending on whether the wires in the cable are stranded or not (they are stranded in the Rutherford cable)

Note the progress in the Engineering Current Density in HTS Cables.

### Progress in the Current Carrying Capacity of HTS Coils at Higher Fields

HTS coils can now be made with the cable carrying a respectable current at higher fields.

- Note that the current carrying capacity is somewhat limited beyond 5 T.

A continuous progress is noteworthy.

### Challenges with HTS

- HTS materials are very brittle
  - Work on magnet designs (“conductor friendly designs”)
  - Hope the concept comes down in future.
- HTS materials are very expensive
  - Also for some applications, the performance and not the material cost is determining factor.
- Large quantities are not available yet
  - Situation is improving. Even now we have enough to make test coils.
- Unknown field quality issues
  - We are addressing that by measuring field harmonics in HTS magnets (also work on the magnet designs).

### Modest field requirements of RIA can be met with the commercially available HTS tapes. The crucial issue is large radiation and heat deposition.

For more details visit: www.bnl.gov/magnets/Staff/Gupta/

### SUMMARY

- HTS has the potential to make a significant impact on future magnets for high performance accelerators as:
  - It can generate very high fields
  - It can work at higher temperatures and tolerate large heat loads
  - “Conductor friendly designs” allow HTS “React & Wind technology” to be incorporated in accelerator magnets
  - HTS has reached a level that allows one to do meaningful magnet R&D to address various technical issues
    - The recent test results from Brookhaven are encouraging
    - For select high field applications (example: LHC upgrade IR magnets), J₃ needs to increase by a factor of two
    - For large scale applications (example: energy upgrade of LHC), the conductor price needs to go down by a factor of ten
    - However, in some applications (either for very high fields or for medium fields), HTS as available today, can be used.

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