CERN-KEK Cooperation

- Draft-081212b –

Research and Development of Advanced Superconducting Magnets for the LHC Upgrade - Interim Progress Report -

High Energy Accelerator Research Organization (KEK) and
National Institute of Material Science (NIMS)

in cooperation with
CERN, Fermilab, LBNL, (LARP), and CEA/Saclay

Dec. 12, 2008

Abstract:
A research and development program of "Advanced Superconducting Magnets for the LHC Luminosity Upgrade" has been carried out in the framework of the CERN-KEK cooperation program, since 2006. It aims to develop high field superconducting magnets using A15 superconductor. The first stage has ~~been~~ progressed in focusing to establish Nb3Al superconductor and cable technology to prepare for the high field magnet application expected in the LHC luminosity upgrade. This report describes the progress in the first stage being carried out in JFY2006-2008, and the proposal for the second stage to be carried out in JFY2009-2011.

1 Plan in the first stage

The first stage of the development was started with aiming ~~at~~ to:

1) establish fabrication process of Nb3Al conductor and cable,
2) improve effective current density of the conductor to be competitive current with that of the Nb3Sn conductor at 12-15T,
3) minimize magnetization effect in the conductor matrix
4) demonstrate cabling and coiling with simple "race-track coil" to evaluate the conductor paerformance,

2 Progress in the first stage

The development has ~~been~~ progressed in the first stage as follows:

1) FY2006
   - Three short (~100 m) strands with Nb-matrix, seeking to improve current density
   - One (~ 1km) strand with Nb-matrix to demonstrate stable fabrication
   - Electro-plating facility and trial,

2) FY2007

- One strand with Ta-matrix and Ta-skin, and with Cu-Plating
- One strand with Ta-matrix and Nb-skin, and with Ion-plating & Cu-plating,
- Basic study/training of bladder technology
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3) FY2008
- One strand with Ta-matrix and Ta-skin, and with Cu-Plating
- One strand with Ta-matrix and Nb-skin, and with Ion-plating & Cu-plating,
- Preparation for the race-track coil fabrication

As the above R&D results, we have learned:
- mechanical stability of Nb3Al and the advantage verified, specially at the stress level up to 200 MPa,
- Magnetization much reduced by using Ta-matrix, without much difficulty in fabrication, even at 2 K,
- the current density at Nb3Al conductor still limited to be < ~ 1000 A/mm2.

As the general status, we have realized
- strand with Ta-matrix, Nb-skin, Cu-ion plating and Cu-electroplating: 700 m
- strand with T-matrix, Ta-skin, Cu-eletroplating 200 m
- further strands are still in progress to be completed in early next year.

* Parallel R&D efforts with other resource:
A series of parallel R&D efforts has been carried out between NIMS and Fermilab, and two cables and race-track coils have been successfully fabricated and evaluated at Fermilab.

A model magnet technology using “sub-scale race-track coil”, bladder, and Al-shrinking technology developed at LBNL has been transferred to KEK.

3 R&D efforts combined with other resource:

1) A series of parallel R&D efforts has been carried out between NIMS and Fermilab, and two cables and race-track coils have been successfully fabricated and evaluated at Fermilab.

2) A model magnet technology using “sub-scale race-track coil”, bladder, and Al-shrinking technology developed at LBNL has been transferred to KEK.

3) Fundamental study of heat-transfer through electrical insulation in superfluid helium has been carried out in cooperation between KEK and CEA/Saclay in the frame work of Japan-France cooperation program (FJPPL).

4. Plan for the second stage

Based on the progress in the first stage, the following plan is proposed in the second stage to be carried out in JFY2009-2011.

1) Nb3Cable development
- develop two more, 1 km long strands, to be sufficient to develop the model magnet described below,

2) A race-track coils and a model magnet assembly
- develop a model magnet to realize > 13 T, with
- one Nb3Al casp-winding, double-pancake coil at center,
- two Nb3Sn race-track coil contributed by LBNL,
- two Nb3Al double-pancake coils
- with aiming at evaluation of the Nb3Al cable performance in the central coil,

3) Fundamental study of A15 conductor
- facilitate a conductor evaluation facility with a magnetic field of 15 T,
- mechanical stress/strain characteristics to be investigated by using "neutron beam" by using a unique facility at J-PARC intense neutron source,
- investigate radiation resistant insulation and resin,
- further advanced A15/Nb3Al conductor such as
- further sophisticated matrix structure, double stacking, Cu-tubing technologies,
- intending much longer strand with a level of 10 km (additional funding required),

4) Project Management

Internation Collaboration:

It is critically important to extend the collaboration between CERN and KEK in cooperation with NIMS, Fermilab, LBNL, and CES-Saclay for individual subjects. We expect the CERN-KEK committee to support this international collaboration to be further extended. Specially the US (Fermilab/LBNL)-Japan (KEK-NIMS) cooperation is still to be formally established.

Project Execution:

A revision of the organization is proposed with creating "Project/Program Manager" to assist leaders of this collaboration, with expecting to have leadership in execution of the program. This is to prepare for the further extended cooperation program between CERN and KEK, and in the field of the advanced superconducting magnet research and development.

Summary

The first stage R&D has progressed with the achievement of enabling the Nb3Al strand ~~enabled~~ to be cabled. The race-track model coil, however, has not been realized because of further necessary effort for conductor development and partly because of rack of FTE.

The second stage R&D is proposed with a more conservative and cautious plan ~~with~~ focusing on the fundamental study and technology, specially on the subjects to be carried our uniquely by KEK-NMS collaboration and in cooperation with CERN, Fermilab, LBNL, and CEA/Saclay

As a conclusion, we would like to propose to extend the R&D, and request the

aapproval of CERN-KEK cooperation committee.

Appendix:

1) Participants expected in the stage 2:
KEK: N. Kimura, T. Nakamoto, T. Ogitsu, K. Sasaki, A. Terashima, K. Tsuchiya, Q. Xu, and A. Yamamoto,
NIMS: N. Banno, A. Kikuchi, and T. Takeuchi,

In cooperation of:
CERN: L. Rossi et al., (to be filled)
Fermilab: M. Lamm et al., (to be filled)
LBNL: J. Sabbi et al., (to be filled)
(LARP/BNL*: P. Wanderer (to be discussed/accepted))
CEA/Saclay: B. Bourdy et al (to be filled)

2) Budget Profile (Progress and Plan
The budget has been planned with assumption of 90JYen = 1 CHF,
It has been consensus that the total amount of budget is to be 90,000 kJYen agreed for the first stage budget support, and the second stage is to be determined, base on the interium evaluation by the CERN-KEK committee.

JFY	2006	2007	2008	2009	2010	2011	Sum
1st. Plan	20,000	33,000	35,000	2,000			90,000
Progress	20,000	22,000	33,000	15,000			90,000
2nd Plan				39,000	30,000	21,000	90,000
Sum	20,000	27,000	33,000	54,000	30,000	21,000	180,000

* we would propose to discuss again further development possibility to prepare for the NB3Al conductor much longer (~ 10 km) to enable to provide it for further world-wide cooperation program. We intend to realize it in the last year of this program, if the above development plan proceeded, as expected.