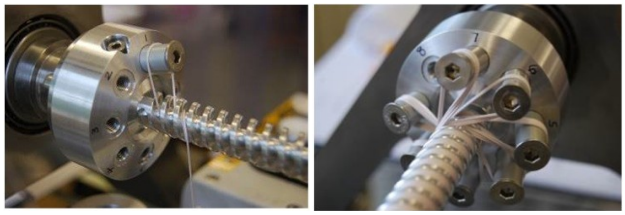

Figure 13: Winding trails for the helical undulator

SUPPORT STUDIES

The aim of the support studies is to study radiation effects on and thermal behaviour of Nb3Sn magnets to prepare for accelerator application of these magnets. For the EuCARD-Fresca2 magnet of task2 solutions for the insulation and the thermal design are to be proposed possibly compatible with accelerator applications.

Magnets in accelerators like the upgraded LHC and are subjected to very high radiation doses. In the low beta insertion quadrupole the integrated peak dose on the coil can attain 50 MGy over the lifetime of the HL-LHC. The electrical insulation employed on the coils need to be resistant to this radiation. A certification program for the radiation resistance is needed in parallel to the modelling efforts for such magnets. The same radiation is also depositing heat in the coils. The heat removal from the coils needs to be modelled. These models have to be supported with measurements. A thermal design of the dipole model coil can then be made.

Four potential impregnation materials will be tested (RAL mix 71, Epoxy TGPAP-DDS(2002), LARP CTD101K with filler ceramic and 3 Cyanite Ester mixes) to assess their suitability for high radiation environments. For this mechanical, electrical and thermal conductivity measurements will be done on samples irradiated with and electron beam up to 50 MGy. The irradiation will be done at IJP Swierk (Po) in 2011.

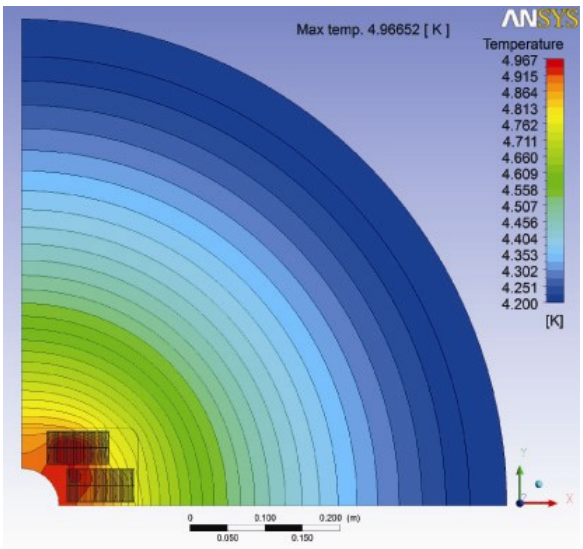

Figure 14: Calculated temperature distribution in the magnet at a total heat load of 0.167 W/m during ramping (start temperature 4.2 K)

Thermal models of Nb_3Sn magnets are being used to study cool-down scenarios and steady state heat load (at 4.2 K and 1.9 K) on the coils. In Fig 14 a thermal map from a preliminary steady state heat load study can be found.

FUTURE R&D

At present ESGARD has launched preparations for a successor project for EuCARD (EuCARD2), which is to start by the beginning of 2012. Four institutes (CERN, CEA, LBNL and KEK) envisage taking the lead in starting a larger collaboration to develop high field magnets for HE-LHC. Following the development of the 13 T wide aperture magnet in EuCARD and the HTS insert and under the condition that these developments are successful, the logical successor project is to prepare for a high field magnet for a HE-LHC type collider application.

The project could consist of the following R&D items:

1) Make a design study for a 20 T magnet for HE-LHC.

2) Construct a technology demonstrator model dipole magnet in the 15 T - 18 T range.

3) Conductor development for the 20 T field range.

For the LHC it took 22 years from the start of the magnet development to the switch-on of the machine. One has to start now with the development of 20 T magnets in order to be ready for HE-LHC in the 20+ year time scale. Experience from the LHC and presently from LARP, with the development of the low beta insertion quadrupoles for HL-LHC, indicates that this has to be done in a large international collaboration.

ACKNOWLEDGMENT

I would like to thank the colleagues of the FP7-EuCARD-HFM collaboration for their contributions to this paper.

REFERENCES

[1] T. Boutboul, L. Oberli, A. den Ouden, D. Pedrini, B. Seeber, G. Volpini, “Heat Treatment Optimization Studies on PIT Nb3Sn Strand for the NED Project”, IEEE Trans. Appl. Supercond. 19 (2009) 2564-2567.

[2] T. Boutboul, A. Devred, P. Fabbricatore, M. Greco, D. Leroy, L. Oberli, A. den Ouden, D. Pedrini, G. Volpini, “Nb3Sn conductor development and characterization for NED”, J. Phys.: Conf. Ser. 97 (2008).

[3] http://www.uslarp.org/

[4] P. Ferracin, B. Bingham, S. Caspi, D.W. Cheng, D.R. Dietderich, H. Felice, A.R. Hafalia, C.R. Hannaford, J. Joseph, A.F. Lietzke, J. Lizarazo, G. Sabbi, and X. Wang, “Recent test results of the high field Nb3Sn dipole magnet HD2”, IEEE Trans. Appl. Supercond. 20 (2010) 292.