

Minute of the VI Meeting GSI-INFN held at GSI on May 23rd 2007

This meeting was aimed to discuss the status of the R&D activities in view of the objectives of 2007:

- a) Conceptual Design
- b) Engineering Design (up to collared coil)
- c) Construction of the winding models

With the recently awarded contract to ASG Superconductors, the engineering and construction of the winding models started, in a way requiring a strong interaction between collaborating parts.

Participants:

GSI: E.Flock, J.Kaugerts, H. Leibrock, J.P. Meier, G.Moritz,
H.Mueller, P.Schnizer
GSI consultants: M. N.Wilson
IHEP: L.Tkachenko,....
INFN Genova: P.Fabbricatore and S.Farinon
INFN LNF: U.Gambardella
INFN Milano-LASA G.Bellomo, M.Sorbi and G.Volpini

AGENDA

- 1) Status of the R&D program
 - General Program updates (in view of the presentation at miniTAC)
 - Specific Program for 2007 updates (in view of the presentation at miniTAC)
 - Introduction to the technical points to be discussed
- 2) Status of the conductor R&D program
- 3) Paramagnetic effects in NbTi/ CuMn wires
- 4) Magnetic lay-out
- 5) Thermal steady state and transient analyses
- 6) Materials and lay-out for collars and steel lamination
- 7) Mechanical 2D analyses
- 8) Dimensions of insulation and mechanical properties.
- 9) Design integral harmonics. Harmonics measurements
- 10) Cryostat issues.
- 11) Activities at GSI (Ra measurement at BNL, 6T dipole model at IHEP, wire/cable measurements at UT, GSI001)
- 12) Material data base- status,....
- 13) Contribution INFN to the PAC invited talk : FAIR rapidly cycling magnets
- 11) Next meetings. Videoconferences.

P.Fabbricatore

G.Volpini

U.Gambardella

M.Sorbi

M.Sorbi

P.Fabbricatore

S.Farinon

S.Farinon

GSI

J. Kaugerts



SUMMARY OF MAIN POINTS

Plan and Schedule - INFN is working according a plan aimed to have two winding models (curved un-collared coils 3.8 m in length + ends,) constructed at ASG superconductors within February 2008, using a dummy cable provided by INFN. Conceptual design is going on with the aim to have the *reference lay-out* (2D) ready with June 30 and the *final lay-out* within the end of the year. Important activities just starting are the 3D studies, including the coil ends design, which actually are aimed to give indications to ASG Superconductors for constructing the winding models. Later on this year the end coil design will be refined and eventually finalised as the proper experience is gained from the winding model manufacture. On long terms, the construction of the prototype coils is planned for the period autumn 2008 to winter 2009. After the test of the cold mass at LASA, the coil (in its horizontal cryostat) will be provided to GSI at the end of 2009. [See presentation of P.Fabbricatore]

Conductor – The call for tenders was launched. Answers are expected by June 17 from some (or all) the five inquired companies: Alstom (France), EAS (Germany), Luvata Fornaci di Barga (Italy), Luvata Pori (Finland) and Luvata Waterbury (USA). The companies started to be involved in technical discussions. Some problems were analyzed and possible solutions discussed. Based on a not-very-high critical current density on finer filaments (2500 A/mm^2 expected @ 5T and 4.2K rather than the wished 2700 A/mm^2), INFN is considering design with lower matrix content. Presently it is not yet completely clear the impact of this choice on the wire stability. Issues related to coating/cabling not yet considered. [See presentation of G.Volpini]

Paramagnetism of Manganese – After magnetic measurements (employing VSM or SQUID systems) on several wires with CuMn matrix, it is clear that the Mn causes the appearance of a magnetic moment of paramagnetic nature. This is confirmed by investigation done by Juris Kaugerts on the magnetization measurements carried out at Twente. However from the magnetic analysis carried out by INFN it results that, since the paramagnetic magnetic moment has opposite sign with respect the magnetic moment due to persistent and coupling currents, we could have a benefit in reducing the total b_3 and b_5 variations due to all magnetic effects. [See presentations of U.Gambardella and M.Sorbi]



2D coil lay-out – The actual 5-blocks configuration with 100 mm inner diameter has a good field quality. The perturbation on the field quality due to magnetization of components (cable, collars and beam pipe) can be calculated with good accuracy (according to present models), and the several methods involved in the computation (some ones developed by INFN) converge to the same results. The analyses show a moderate harmonic perturbation during the ramp. The present lay-out has been discussed with CERN expert, who gave a good opinion, confirming the soundness of INFN choices. Before freezing the geometrical parameters for the so called reference design, INFN feels necessary to still work on the optimization of the collar thickness. In fact the actual value (30 mm) was chosen for limiting the coil deformation during energization to 50 μm . In fact the 30 mm thickness appears quite high when considering several other factors as: i) The peak stress on the collar (150 MPa according to 2D stress analysis, i.e. a negligible fraction (11%) of the yield stress of Nitronic 40, which is the most probable material for the collars), ii) The variation of b_3 during the energization (1.3 units, which could be reduced using a thinner collar), iii) The comparison with other self supported magnets (e.g. Tevatron or Hera) operating with larger deformations. From the several analyses carried out by INFN a thickness ranging around 25 mm seems more appropriate. *[See presentations of M.Sorbi, S.Farinon and P.Fabbricatore]*

Materials - Analyses based on a screening of the existing commercial components on the basis of the requirements of SIS300 dipoles in terms of field quality and ac losses gave some indications for the materials and shapes to be used in some components. Namely:

- 1) Electrical steel lamination M600-100A according to the standard EN10106. This component (sheath of 1 mm thickness) was produced some times ago by ThyssenKrupp. The actual market situation shall be checked.
- 2) Collars in austenitic steel Nitronic 40, composed of plates 2 mm in thickness. Juris Kaugerts will provide information about possible manufacturers

[See presentation of P.Fabbricatore]

Thermal analyses – The temperature margin when considering the peak field on the conductor (4.9 T) and the operating current (8924 A) is 0.99 K. This margin is reduced when adding the heat dissipation caused by ac losses. Steady state and transient FE analyses were carried out, under some simplified hypotheses but with a model including several details of the winding. The present results is that the temperature margin could be reduced to 0.81 K. There are factors which could worsen the margin (the thermal resistance between GHe and the insulation) or



improving the margin (the presence of GHe inside the winding). In future this analysis shall be improved by a still more detailed modelization and after a better knowledge of the thermal exchanges coefficients has been achieved : Presently this result gives a very important information for the next developments of the design. In the frame of this analysis, the beam pipe losses were calculated too, resulting in the not negligible value of 1 W/m, which, though not affecting, the cold mass temperature, should be consider when setting the coolant mass flow rate. *[See presentation of M.Sorbi]*

GSI activities – A lot of activities are going on for evaluating Ra:

- 1) Preparation of standard Ra measurement sample (rectangular cable stack) with Ra value to be used in IHEP 6 T straight model dipole magnet. GSI will consult with Arjan Werveij, regarding maximum Ra value to use, based on CERN Minimum Quench Energy (MQE) test results.
- 2) Preparation of standard Ra measurement sample to use for Twente AC loss sample
- 3) Preparation of Ra measurement samples for curved sample holder, to determine sample geometry and pressure effects on Ra. The azimuthal pressure on sample will be varied. An attempt will be done to also vary the radial pressure with shims
- 5) Use same (already measured at BNL) cable with EAS wire for all tests

GSI is putting effort for having the 6 T straight model under design and construction at IHEP within mid 2008. In fact this will be the second model (in 5 years) and important information is expected also in view of the development of INFN model.

[See presentation of J.Kaugerts]

Cryostat- It is not yet defined a lay-out of the cryostat. Some parameters of the lattice (now definitively FODO) may still change. As soon as a more steady condition of lattice design is gotten, GSI will perform some design activity for the cryostat. INFN is interested in having this information for designing the special cryostat (in fact it is a stand alone unit) for the DISCORAP magnet.

Magnetic Measurements- In the frame of the INFN activities no magnetic measurements are included. Nevertheless it would be very interesting to perform measurements of the field quality in two steps of the construction: 1) After the collaring, at room temperature, to check the level of attainable field quality ; 2) During tests at GSI in operating conditions. Since GSI is developing a mole for measurements on curved dipoles, INFN is asking the possibility to use



the GSI tool at ASG after the coil collaring. From preliminary discussions it seems that the GSI tool will be not available due to the large number of measurements to be done at GSI. At the same time it is also suggested to check the possibility to use the CERN tool presently at ASG. This point need to be better investigated.

Action Items:

- 1) J. Kaugerts will check the possibility to send more cored cable samples to INFN for mechanical stacking tests.
- 2) G. Moritz will check if the GSI has the B-H curve of the steel M600-100 A (or M250-50A)
- 3) GSI will provide to INFN information regarding the maximum yoke diameter compatible with cryostat

Next meeting – Next meeting will be held in Milano LASA in September at a data to be decided later on.

