DEVELOPMENT OF THE COBRA MAGNET FOR THE MEG EXPERIMENT

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A superconducting solenoidal magnet was developed as part of the COBRA(COnstant Bending RAdius) positron spectrometer for the MEG experiment. The magnet is specially designed to form a gradient magnetic field in order to overcome some of the inevitable problems of a simple uniform solenoidal field. The gradient field is arranged so that the positrons from the target follow trajectories with a constant projected bending radius independent of the emission angle. It allows us to easily define the momentum window of the sought-after positrons. In the case of a simple uniform field, positrons emitted close to right angles with respect to the incoming muon, would make many turns and thus lead to an unstable operation of the drift chamber system. However, in a gradient field distribution, the positrons emitted close to right angles can be swept away much more rapidly. The central field is 1.27 T at $z = 0$ and slowly decreases as $|z|$ increases.

A cross section of the magnet is shown in Figure. 1. It consists of two main parts: the central set of superconducting coils and a pair of compensation coils to reduce the stray field around the photon detector which will be placed close to the main magnet. The superconducting magnet is cooled conductively from both ends by two mechanical refrigerators, without the use a cryogen such as liquid helium.

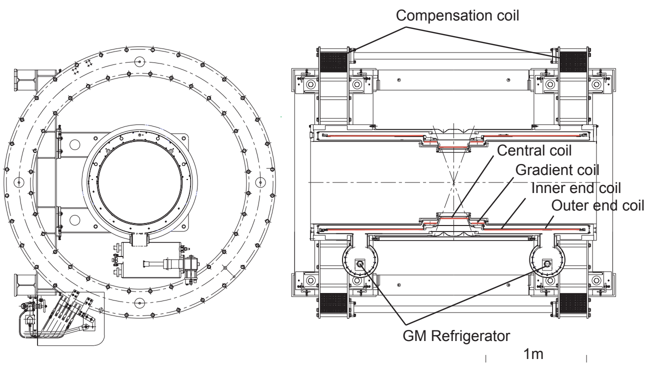

Figure 1: *A cross section of the COBRA magnet.*

Within the acceptance of the photon detector ($|\theta| \geq 70°$), the thickness of the magnet is reduced to $0.197X_0$ so that the photons from the target, placed at the centre of the magnet, can traverse. In order to achieve this thickness a high-strength aluminum-stabilized conductor was specially developed[1, 2]. The overall yield strength of the conductor is above 220 MPa at 4.2 K.

The stray field produced by the superconducting coils, has to be reduced to a level of 50 Gauss in the vicinity of the calorimeter. This is necessary since the photomultiplier tubes used in the photon calorimeter would suffer from gain variations as the applied magnetic field strength was changed. This would lead to a performance degradation of the calorimeter and will be avoided by the use of the compensation coils.

Excitation tests were carried out to measure the performance of the magnet. Quench propagation was measured by inducing a quench via several methods: by switching off the DC breaker of the power supply, by firing the heater or by switching off the refrigerator. We observed that the quench was propagated fast enough in the magnet to keep the temperature and voltage rise in the coils well below the acceptable level. Finally, the magnet was tested up to 380 A coil current, which is 5.6 % higher than the normal operating current, see Figure 2.

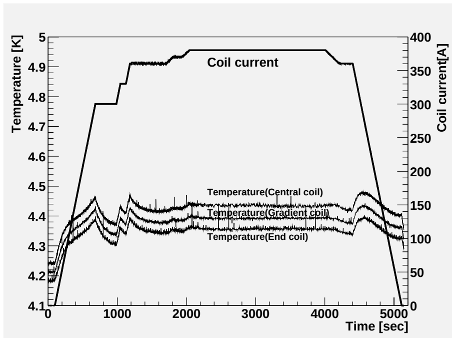

Figure 2: *Coil current and temperature change during the excitation. A current of 380 A was achieved.*

The magnetic field produced in the bore of the magnet was measured during the excitation test, Figure. 3 shows this field measured along the magnet axis at a coil current of 200 A. The gradient field property can clearly be seen in the figure, as well as good agreement with the calculation. The stray field measured during this excitation, was found to cancel to below 50 Gauss, over almost all the photon detector region.

The magnet was shipped from Japan to PSI at the end of the year and setup for testing in the SLS Hall.

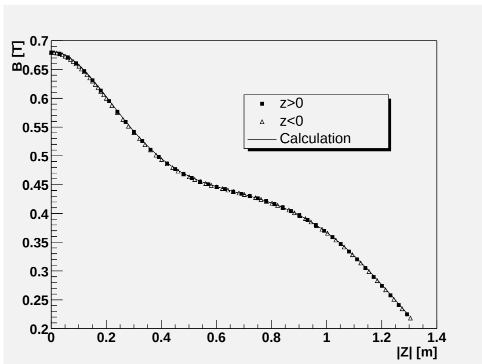

Figure 3: *Magnetic field along the magnet axis measured during the excitation test with a coil current of 200 A. The calculated magnetic field is also shown.*

REFERENCES

[1] A. Yamamoto *et al*., Nucl. Phys. **B78**,565 (1999).

[2] A. Yamamoto, Y. Makida *et al.*,
IEEE Trans. Applied Superconductivity **12**, 438 (2002).