MAGNETIC MEASUREMENTS AT LNLS

W.A. Ortiz (*), F.W.B. Talarico and R.T. Neuenschwander

Laboratório Nacional de Luz Síncrotron

Cx. Postal 6192

13081 - Campinas, SP, Brazil

Abstract

A magnetic measurements facility has been set up for characterization and experimental development of the LNLS magnets. Measurements are computer controlled and include field mapping and harmonic analisys. In this paper we present the main characteristics of the measuring instruments developed at LNLS, as well as results obtained during test runs.

Introduction

In order to characterize the magnets of the LNLS machines and transfer lines, a magnetic measurements facility has been set up by the magnets group. The facility was designed to provide computer controlled mappings and harmonic analisys of the field generated by a given magnet. As in many other measurement facilities, field mappings are obtained through remote positioning of a Hall probe, and the multipole content of the field generated by a magnet is determined using the well-known rotating-coil technique.

Description of the Measuring Instruments

In the field-mapping instrument the Hall sensor is attached to a small plate (75X125 mm) supported at the corners by four linear bearings. These bearings can slide over two precision bars mounted on a second plate. This, in turn, is also sitting over four other linear bearings placed at its corners, and mounted on two other precision bars, perpendicular to the former ones. Each plate is remotely driven by step motors, one step corresponding to 0.2mm. The probe can be positioned within a rectangule of 200mm by 1000mm.

In the rotating-coil instrument a synchronous motor drives, through a pulley and a rubber ring, the spindle which supports a flywheel and the coil rod. A shaft encoder, driven by the spindle, triggers the voltage measurements. Strict mechanical tolerances, careful alignment and avoidance of vibrations are vital for the achievement of high accuracy measurements.

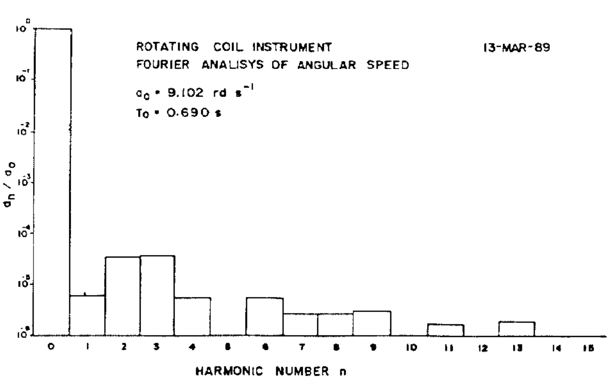

Fig.1: Harmonic analisys of the angular speed of a typical 8-turn run of the rotating-coil instrument.

Both instruments have been designed and built at LNLS, and recently brought into operation. During test runs, particular attention was devoted to the observation of accuracy levels and repeatability of results. Under routine operation the field-mapping instrument is supposed to provide measurement accuracy limited by probe linearity of about 0.1%, whereas the rotating-coil instrument is expected to operate around the 0.01% resolution level.

Data acquisition and storage are performed by PC-XT machines. The analog-to-digital converter (ADC) available so far, employed during the tests reported in this paper, is a 12-bit device. Hardware work is under way to have a 14-bit ADC installed in the near future, allowing for the desired resolution.

A great deal of work was devoted to ensure that the angular speed of the rotating system is a smooth and free-of-oscillations function of time. This is one of the most important features required from the apparatus. In practice the angular speed oscillates about its average value, and can be represented by a Fourier expansion in terms of the revolution frequency and its harmonics. When measuring a real magnet, each harmonic coefficient of the Fourier expansion for the angular speed may introduce 'false pole' contributions to the Fourier analisys of the field. The contribution of these 'false poles' must then be kept at negligible levels, what can be achieved by keeping the oscillation coefficients several orders of magnitude smaller than the zero-th harmonic, which represents the average speed. Figure 1 shows the harmonic content of the angular speed of the rotating-coil instrument during a typical 8-turn run. The constant coefficient is the average speed, and all other represent harmonic contributions at the revolution frequency and its multiples. It is seen that all harmonic coefficients are at least about four orders of magnitude below the constant term, ensuring that spurious terms in the field analisys will be negligible.

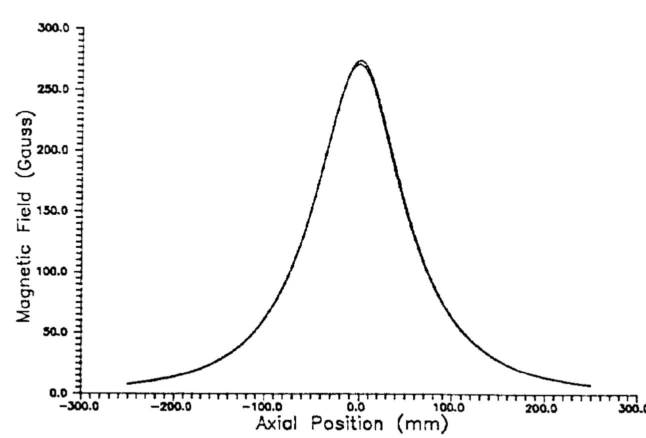

Fig.2: Calculated (upper curve) and measured profiles of the field generated by one of the LINAC lenses. The slight mismatching is due to a small misalignment between lens and instrument.

CH2669-0/89/0000-0378$01.00©1989 IEEE

Test measurements

While the measuring instruments were developed, three different types of devices became ready for magnetic characterization: the linac lenses, to be installed between the gun and the first accelerating structure; the elements of a long solenoid that will be set around the first three meters of accelerating sections; and a small quadrupole, serving as a prototype for the linac-to-booster transfer line focusing system, as well as a general-purpose test magnet.

Each linac lens is an air-core 277-turn winding of 30mm-wide, 0.25mm-thick copper ribbon, the insulation between layers being provided by 0.05mm-thick mylar tape. The lens is water-cooled at both sides. The clear diameter of the lens is 72mm. Figure 2 shows a comparison between calculated and measured field profiles along the axis of one of these lenses, at a current of 12A, which is about 70% of the maximum design value. A slight misalignment between the magnet support and the lens is responsible for the small unbalance of the experimental curve. We are presently working in a new support which will allow for better alignment procedures.

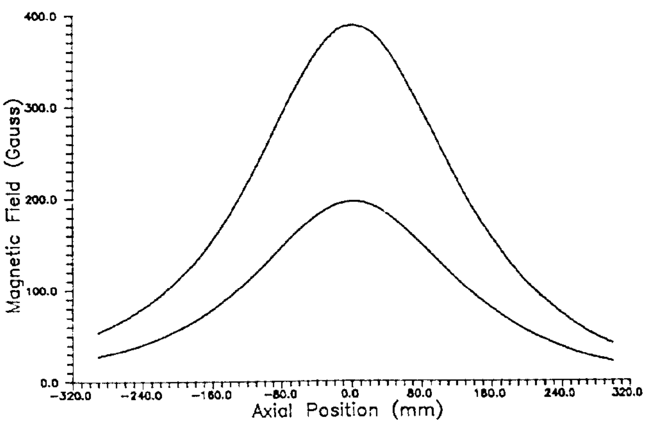

Fig.3: Measured profiles of the field generated by one element of the LINAC solenoid. Current was 40A for the upper curve and 20A for the lower.

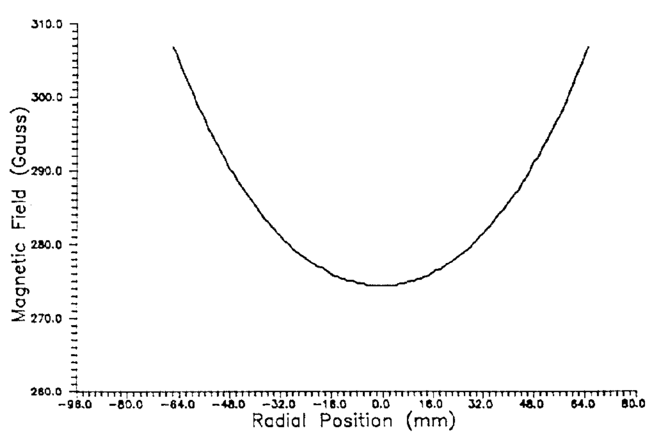

Fig.4: Radial dependence of the field generated by one element of the LINAC solenoid.

The elements of solenoid are constructed in the same fashion, with 70mm-wide copper ribbon of the same thickness as that employed for the lenses. The clear bore is 250mm. The axial field profile measured along the axis for two different values of the excitation current appear in Figure 3. All measured values are within 0.25% of the calculations. Figure 4 shows the expected strong dependence of the field with the radial distance to the center. This variation is owed to the short length of the elements, and will be significantly attenuated when they are set together to form a long solenoid.

The prototype quadrupole has a solid 1008-steel yoke with a clear bore diameter of 39.6mm and a length of 100mm. Each coil has 126 turns of AWG-10 wire. No provision for cooling was made for the particular set of coils presently installed. The excitation curve measured at 1cm from the center of the quadrupole is shown in Figure 5. According to the design, the maximum operating current is 2200 amp-turns, for which the magnet yoke is still well below saturation. Dependence of the field with the transverse horizontal distance from the center of the magnet is presented in Figure 6. The same dependence for the integrated field of the quadrupole is shown in Figure 7.

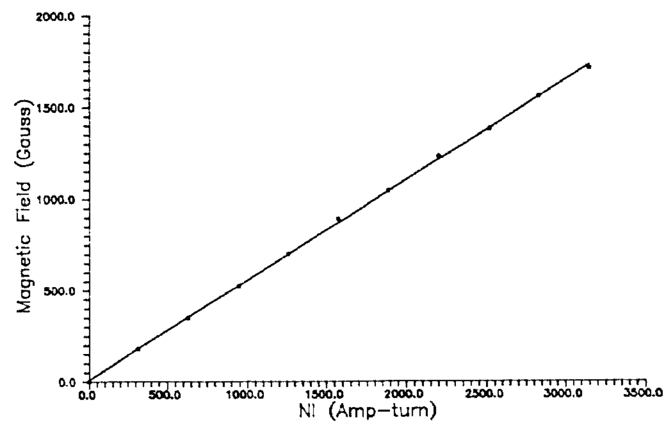

Fig.5: Excitation curve of the prototype quadrupole. The maximum design current is 2200 amp-turn, well below saturation.

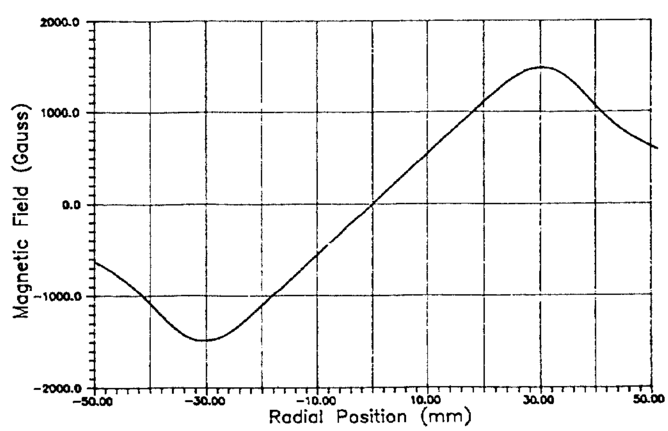

Fig.6: Field profile of the prototype quadrupole as a function of the transverse horizontal distance from the center of the magnet (corresponding to the radial direction of the electron beam).

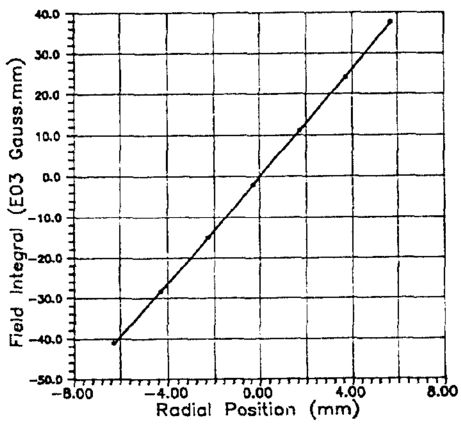

Fig.7: Dependence of the integrated field with the distance from the quadrupole center in the horizontal plane (radial direction).

Final Remarks

As reported, the magnetic measurements facility is not fully completed as yet. Some fine adjustments and minor developments are still needed, as far as soft and hardware are concerned. Nevertheless, the trial runs performed showed that both measuring instruments developed have adequate designs, and will be operating at their full capabilities in the near future. The same test runs were sufficient to have the air-core lenses and solenoid elements approved for installation. Furthermore, the tests performed with the quadrupole, although still not conclusive, revealed the potentialities of this first iron-core prototype developed and constructed at LNLS.

(*) on leave of absence from Universidade Federal de São Carlos.