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THE MAGNETIC MEASUREMENT FOR LOW MAGNETIC FIELD STABILITY OF DIPOLE MAGNET FOR CEPC*

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Abstract

The CEPC (Circular Electron Positron Collider) project is in the pre-research stage. When the beam energy of booster is 120GeV, the magnetic field of deflection magnet is 640 G. In order to save funds for scientific research, we are ready to select the injection energy for 6 GeV, this corresponds to a magnetic field about 32 Gs. In such a low magnetic field, the effects of earth's magnetic field and ambient temperature variations cannot be ignored. In this paper, first written the collection procedures for magnetic field value and ambient temperature values by Labview software, then used a one-dimensional probe to measure the background magnetic field for three directions (Bx, By, Bz) and the value of the ambient temperature values, the time of data collection for each direction are more than 24 hours (every minute collecting a set of values). Finally, plus the different currents (3A, 6A.. 15A) to the dipole magnet, the time of measured and the data collected by over 24 hours. Based on the results of the analysis of large amounts of data, summarized and analyzed the effect of Earth's magnetic field and ambient temperature for dipole magnet in a low magnetic field.

INTRODUCTION

The Circular Electron Positron Collider (CEPC) is a long-term collider project, which will be divided into two phases. The first phase will construct a circular electron-positron collider in a tunnel with a circumference of 50 – 70 km, and detectors installed at two interaction points. The machine is expected to collide electron and positron beams at the center-of-mass energy of 240 – 250 GeV, with an instantaneous luminosity of 2×1034 $cm^{-2} s^{-1}$. The baseline design considers a single ring in a 50/70 km tunnel and electron/positron beams following a pretzelled orbit in the ring[1]. The accelerator parameters have been calculated and shown in Table 1.

Table 1: The Accelerator Parameters

Accelerator Parameters			
Beam energy[E](Gev)	120	**Lorentz factor[γ]**	234834.66
Circum Ference [C](km)	53.6	**Revolution period[T0](s)**	1.79×10^{-4}
SR power/ beam[P](MW)	50	**Magnetic rigidity[Bp](T*m)**	400.27
Bending radius[ρ](m)	6094	**Momrntum compaction factor[αp]**	4.15×10^{-5}

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When the beam energy of booster is 120GeV, the magnetic field of deflection magnet is 640 G. In order to save funds for scientific research, we are ready to select the injection energy for 6 GeV, this corresponds to a magnetic field about 32 Gs. In such a low magnetic field, the effects of earth's magnetic field and ambient temperature variations cannot be ignored.

According to the physical requirements of this experiment, first, a new program of measurement has been written by Labview software.Second, the preparation for hardware, the device of measurement and collimation. The device about measurement includes the Hall-probe measurement facility, the power supply and the dipole magnet; the device of collimation includes theodolite, level and collimation target.

THE DESCRIPTION OF PROGRAM

The Tesla meter is via RS-232 serial port to communicate with the computer. The main program consists of several parts, the serial port is defined, write, read, close, data acquisition (temperature and magnetic field values).The main structure of the program is the while loop and conditional structures.The the front panel of the program is shown in Fig. 1.

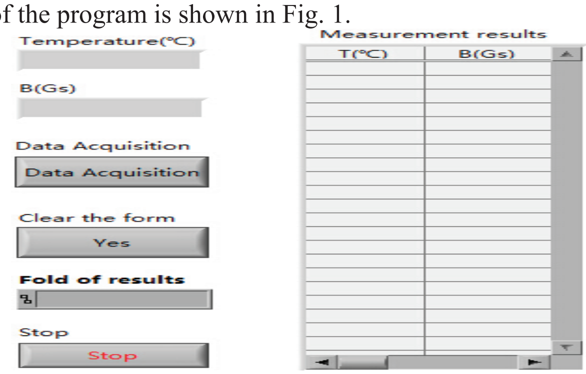

Figure 1: The front panel of the program.

THE DESCRIPTION OF HALL-PROBE MEASUREMENT FACILITY

The Hall-Probe measurement facility is a 3-axises mot ion bench. The movement of 3-axises(x, y and z) can be o perated by computer. The positioning accuracy of x, y and z axis is ±0.001mm and the positioning repeatability accu racy is ±0.01mm. In addition, this machine can be also us ed to adjust the rotation and pitch adjustment probe ensur e that the probe can measure the magnetic field perpendic ular to enter the area of the magnet, so that the total is a fi ve-dimentional adjustment system. The Teslameter and H all probe are produced by Group3 Led. The sensitive of th e MPT-141 Hall Probe is 1×0.5(mm).

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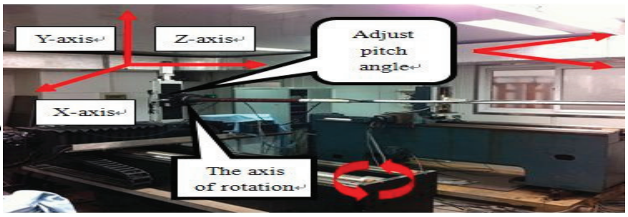


Figure 2: Hall-Probe Measurement Facility.

The DTM-151 Digital Teslameters offer accurate, high resolution measurement of magnetic flux densities, with direct readout in tesla or gauss, and serial communications by fiber optics or RS-232C for system applications.The instruments are light and compact, and the probes are easy to use. The DTM-151 has been engineered to withstand the severe electrical interference produced by high voltage discharge[2].

Group3 Hall probes are built to be as robust as possible for a small,precision device.However,it is most importtant that certain precautions be taken when handling and installing probes so that they are not damaged or destroyed[3].

Table 2: The Performance Overview of DTM-151 and MPT-141

Hall Probe	MPT-141	**The measurement of maximum magnetic field**	3T
Sensitive area(mm)	1×0.5	**Zero drift(μT/ºC)**	±1
Accuracy/ 25 ºC	±0.01％	**Temperature coefficient**	10ppm/ºC overall achieved using temperature sensor in probe
Basic accuracy	0.01% of reading + 0.006% of full scale	**Time stability**	±0.1% max. over 1 year

THE PROCESS OF MEASUREMENT

The Content of Measurement

(1) Using one-dimentional Hall probe with three directions [Bx(The probe is parallel to the north-south direction), By(the probe is perpendicular to the north-south direction), Bz(the probe is perpendicular to the east-west direction)] to the earth's magnetic field measurement of 24 hours(A set of magnetic field and temperature values has been collected by every minute.The magnet current is 0, the directions of probe is in the air gap of the magnet and outside the magnet).

(2)The probe is located in the position of By (y, z) = (0,0) , the magnet current has been from 0A, 3A…15A and then to 3A. A set of magnetic field and temperature values has been collected by every minute.

Some pictures for the device of measurement are shown in Fig. 3.


Figure 3: The device of measurement.

The Process of Collimation

The collimation of magnet is by Theodolite and Level. These devices are shown in Fig. 4.

(1) The theodolite has been levelled, and then the probe has been moved back and forth along the Z axis for align ment of the theodolite.

(2) Adjusted the level of the magnet by the Level and the engraved lines of the magnet.

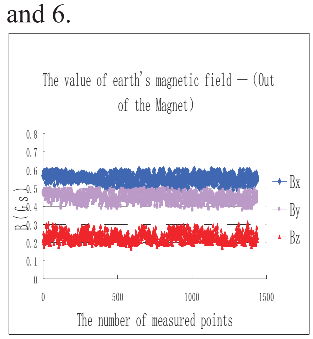
(3) Adjusted the rotation of the magnet by the theodolite and the engraved lines of the magnet.

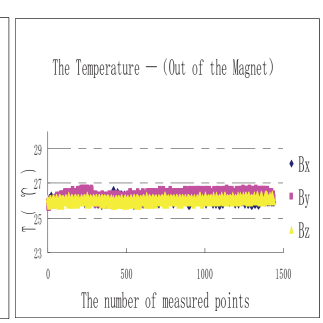
The collimation of the magnet has been completed by t he above steps.


Figure 4: The Theodolite and Level.

THE RESULTS OF MEASUREMENT

The measurement result is shown in the following Fig. 5 and 6.





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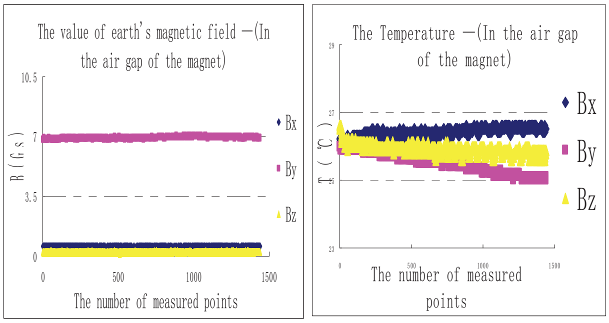

Figure 5: The measurement of earth'magnetic field and T ºC.

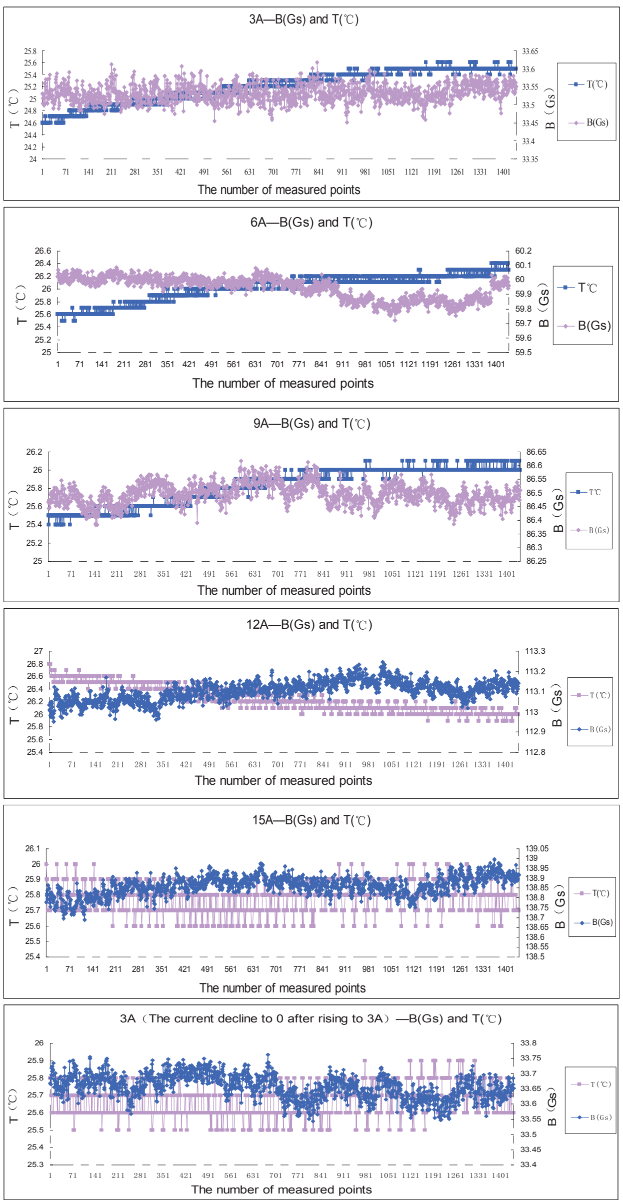

Figure 6: The magnetic field and temperature values under different current.

The analyzed of data is shown in Table 2. The value of ΔB is each magnetic field data of the difference between maximum and minimum for every group; the value of B0 is the average of magnetic data in every group.

Table 2: The Analyzed of Data (RSD-Relative Standard Deviation)

Current(A)	△T（℃）	△B/B0
0(Bx Outside the magnet)	0.9	28.3%
0(By Outside the magnet)	1.1	26.4%
0(BzOutside the magnet)	0.7	60.2%
0(Bx in the air gap of the magnet)	0.6	66.3%
0(Bz in the air gap of the magnet)	1	54.3%
0(By in the air gap of the magnet）	1	4.1%
3	0.6	0.49%
6	0.9	0.61%
9	0.7	0.27%
12	0.9	0.26%
15	0.4	0.22%
The current decline to 0 after rising to 3A	0.4	0.65%

Current(A)	**B(Gs) (RSD）**	**T(ºC) (RSD）**
0(Bx Outside the magnet)	4.77%	0.66%
0(By Outside the magnet)	6.05%	0.82%
0(Bz Outside the magnet)	12.19%	0.48%
0(Bx in the air gap of the magnet)	10.94%	0.49%
0(Bz in the air gap of the magnet)	11.10%	0.51%
0(By in the air gap of the magnet）	0.76%	1.16%
3	0.07%	1.07%
6	0.13%	0.82%
9	0.04%	0.77%
12	0.18%	0.77%
15	0.04%	0.37%
The current decline to 0 after rising to 3A	0.12%	0.35%

CONCLUSION

According to the measurement results, the value of Bx is 0.3Gs and 0.5Gs in the magnet inside and outside. It's proves that the magnet does have influence on the earth's magnetic field.

The changes of the environmental temperature within ±0.55 ºC.

According to the measurement results of the current rising, when the environmental temperature is rised slightly, the magnetic field is decreased slightly; when the environmental temperature is unchanged, the magnetic field value is steady.

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