CONSTRUCTION OF THE MAGNET SYSTEM FOR THE ATF2 BEAM LINE

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Abstract

New beam line, ATF2, has been constructed being connected to the ATF Ring at KEK. This beam line extracts 1.3 GeV electron beams from the ATF Ring in order to test the ILC final focusing beam optics. To construct this beam line, some number of magnets was newly fabricated and the rest were recycled from old KEK and SLAC beam lines.

Production, installation and alignment for these magnets are reported.

1. INTRODUCTION

The ATF (Accelerator Test Facility) Ring under beam operation at KEK is a test damping ring to achieve a very low emittance for ILC (International Linear Collider). It was proposed to extract these low emittance 1.3 GeV electron beams from the ATF ring to test the ILC final focusing beam optics aiming to achieve a vertical beam size as small as 37nm. They will also try to demonstrate a nano-meter level beam stability using numerous advanced beam diagnostics and feedback tools. This project is called ATF2 [1]. Figure 1 shows the layout for the ATF ring and the ATF2 beam line. The coordinate system used in this construction is shown in the figure by arrows. The origin is the center of the ATF ring. Middle part of the ATF2 beam line is parallel to the Y-axis.

The ATF2 beam line consists of 7 dipole, 3 septum, 43 quadrupole and 5 sextupole magnets and some number of correction magnets such as steering dipole magnets and skew quadrupole

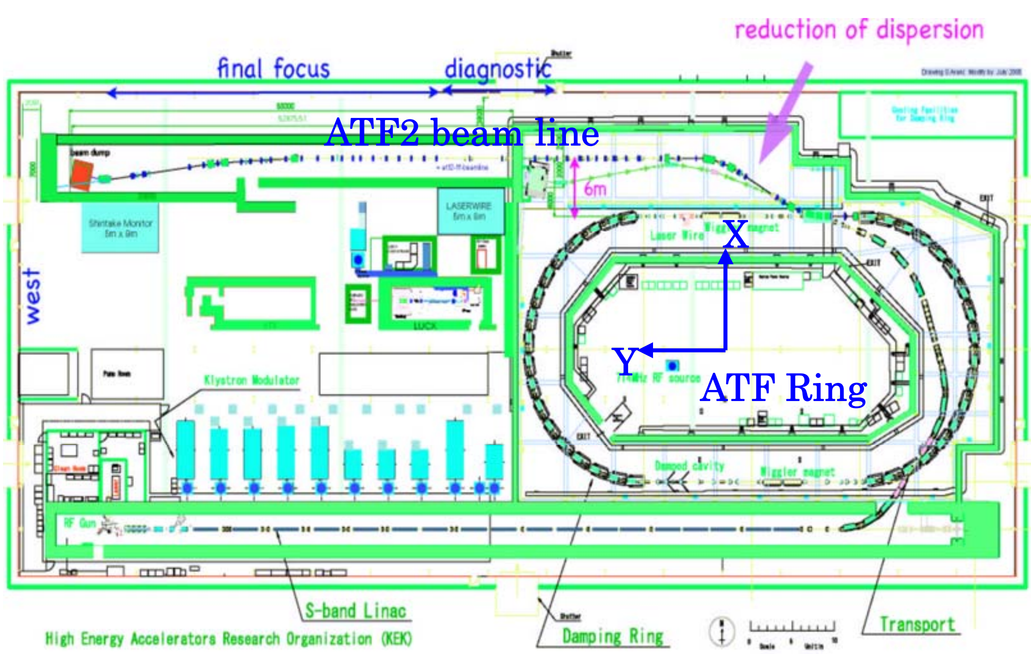


Figure 1: Layout for the ATF2 ring and the ATF2 beam line. Arrows show coordinate system.

magnets. Three dipole magnets and 27+1 (spare) quadrupole magnets were newly fabricated. Three sextupole magnets and the FD (Final Doublet) magnet system including two quadrupole magnets and two sextupole magnets were recycled from old SLAC beam lines. The rest were recycled from the old ATF beam extraction line.

Production and refurbishment of magnets were started in 2005, and installation and alignment of magnets were performed in 2008. The construction of ATF2 beam line was completed in the end of 2008, and the beam commissioning was started in December 2008.

Production, installation and alignment of magnets except for the FD system are reported. Installation and alignment of the FD system are reported elsewhere [2].

2. PRODUCTION OF MAGNETS

Three dipole magnets and 27+1 quadrupole magnets (one was a spare) were newly fabricated. The dipole magnets were designed at SLAC and qudrupole magnets were designed under the cooperation between SLAC and KEK [3]. The dipole magnets are called DEA-D38L575 (DEA for short), and the quadrupole magnets QEA-D32T180 (QEA for short). We asked IHEP at Beijing for their fabrication. Magnetic field measurement was also performed at IHEP. When the magnetic field was measured at KEK for the QEA magnets in the first batch, considerably large offset in the alignment references installed on the top of each magnet were found. Then KEK decided to measure the magnetic field for all QEA magnets and recorded offsets of alignment references [4]. Table 1 shows a part of the table for offset values, where dX is an offset in horizontal direction perpendicular to the beam axis and dY a vertical offset. Rotation is the roll angle of alignment reference plates around the beam axis with respect to the median plane of the magnetic field. These offsets were corrected in the alignment process for magnets.

Table 1. Sample of offset values for alignment references of QEA magnets.

Mag ID	QEA#	dX	dY	Rotatio
QM14x	01	0.36	0.07	-0.072
QM15x	02	-0.45	-0.18	-1.062
QD16X	03	-0.39	-0.09	-0.652
QM11x	04	0.07	0.17	0.364
QM13x	05	-0.05	-0.29	-0.092
QF17X	06	0.06	-0.32	0.028
Spare	07	0.01	-0.13	-0.052
QD18X	08	-0.41	0.00	0.068
QM16x	09	-0.02	-0.07	0.348
QF19X	10	0.02	-0.01	0.018
QF11X	11	0.03	-0.12	0.068
QD10X	12	0.03	-0.13	-1.122
Ring:QM12R1	13	-0.05	0.10	0.698
Ring:QM12R2	14	0.33	0.04	0.568
QM12x	15	0.10	0.12	-0.042

3. INSTALLATION OF MAGNETS

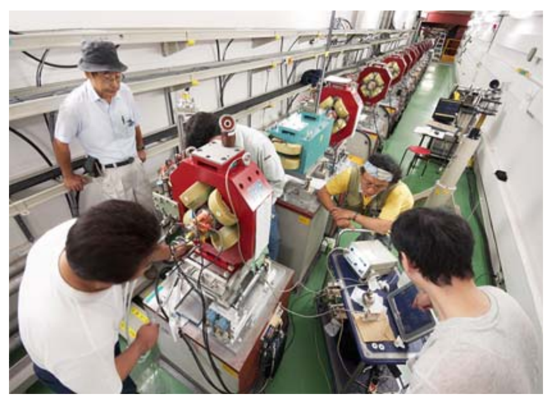
In March 2007, the beam line was drawn on the floor in the ATF ring building referring to the position of ATF ring magnets. Then, four QEA magnets were installed to check out the installation method in August. After finishing reconstruction of the floor in the ATF2 beam line area and piling up most of concrete shielding blocks for ATF2 tunnel structure outside of the ATF ring, pairs of alignment monuments, which are about 1.3m far each other in X direction were installed on the floor every about 10m along the beam line in October 2007. Their positions were surveyed and established. Two new beam level monuments were also installed outside of the ATF ring. These are addion to three beam level monuments inside the ring. The height of the center of an optical target, set on the beam level monuments or magnets, is 375mm high above the beam level.

Newly produced DEA and QEA magnets were installed in June 2008. The old magnets, recycled from the old ATF beam extraction line, were installed in August. The old magnets are fixed on iron or stainless-steel support tables and position adjusting mechanics. Supporting tables are bolted firmly to the floor. Position adjustment is performed by rotating adjusting screw bolts in X, Y and Z directions. The new magnets are fixed on concrete supporting blocks and position adjusting mechanics. Concrete supporting blocks are fixed to the floor with adhesive polymer concrete in order to avoid amplification of the floor vibration. Position adjustment is performed by rotating adjusting screw bolts in X, Y and Z directions. Remote controlled 3-axis cam movers are inserted between the concrete supporting blocks and the position adjusting mechanics for 20 QEA magnets and three sextupole magnets in the end part of ATF2. Two quadrupole magnets and two sextupole magnets in the FD system are also put on the same type of movers. These movers were recycled from the FFTB beam line at SLAC. The movers were adopted in order to adjust the magnet position remotely at the precision of a few micro-meters utilizing information from BPMs attached to the quadrupole magnets.

4. ALIGNMENT

The first alignment of magnets was started in August 2008. A laser tracker SMART310 of Leica with a mirror target was used to observe the horizontal position, a N3 leveling telescope of Leica with an optical target to observe the height and an electric level Talyvel-4 of Taylor-Hobson to observe the level. Figure 2 is a picture of the alignment work. The first alignment was performed by two groups, one for the old magnets and the other for the new magnets. As the first alignment was performed by two groups using different references each other, there was some discrepancy between their alignment results. Then second alignment was performed in the end of September 2009. This second alignment was a smoothing process. Data were fitted to the designed lattice coordinates and deviations of data from the lattice were calculated. These deviations were fitted to some smooth curves of second order of polynomials, and deviations of each magnet position were corrected if the deviations were larger than the tolerances: 0.1mm for X and Z directions, 0.2mm for Y direction, and 0.1mrad for roll and pitch angles.

Figure 2: A picture of alignment work



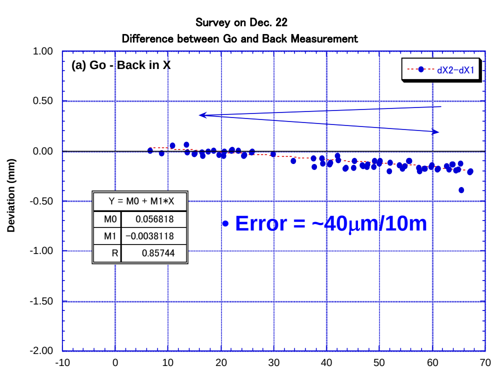


Figure 3: Difference of the second measurement from the first measurement in X direction in the

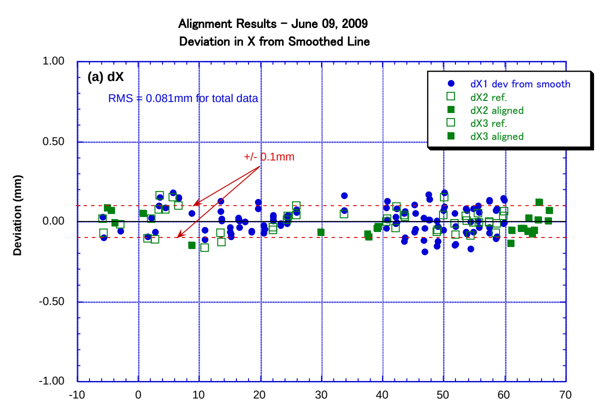


Figure 4 (a): Deviations in X direction of each magnet position from the smoothed curve. Total survey performed after the second alignment.

RMS is 0.081mm.

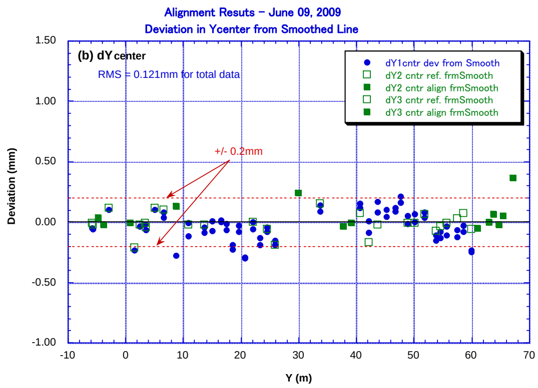


Figure 4 (b): Deviations in Y direction of each magnet position from the smoothed curve. Total RMS is 0.121mm.

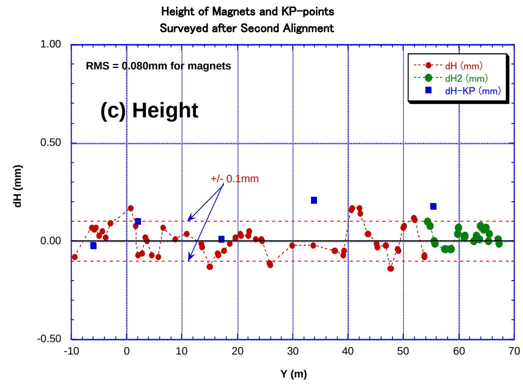


Figure 4 (c): Deviations in Z (vertical) direction. Total RMS is 0.080mm.

Figure 3 shows the results of survey after the second alignment. At this time, the survey was started from the end point of the beam line and went to the upstream, then return to the end point. That is, we measured the position of each magnet two times. This figure shows the difference of second measurement from the first one in X direction. This plot reveals that the measurement error is about 40μm/10m, which is almost comparable to the expected errors of the laser tracker measurement. Differences in Y direction were very small. After the correction of position for several magnets, we finally obtained the alignment results as shown in figure 4. The plots show deviations of each magnet position from smoothed curves fitted. Figure 4(a) shows the deviations in X direction, (b) in Y direction, and (c) in height. Total RMS values are 0.081mm, 0.121mm and 0.080mm in X, Y and Z (vertical) directions respectively. Those results are quite satisfactory comparing with the alignment tolerances.

SUMMARY

Production and refurbishment of magnets were started in 2005, and installation and alignment of magnets were performed in 2007 and 2008. It was finished in January 2009. Alignment errors are small enough comparing with the alignment tolerances. The survey all through the ATF2 beam line is planned in summer 2009 in order to observe the drift of magnet positions since January 2009.

REFERENCES

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[2] S. Araki et al., to be presented in this conference, 6th Annual Meeting of Particle Accelerator Society of Japan, August 5-7, 2009, Tokai, Ibaraki, Japan.

[3] Cherrill M. Spencer et al., to be presented on design and production of magnets at 21st International Conference on Magnet Technology, October 18-23, 2009, Hefei, China.

[4] Mika Masuzawa et al., to be presented on magnetic field measurement of QEA magnets at 21st International Conference on Magnet Technology, October 18-23, 2009, Hefei, China.