Latest Progress of the Development of an In-Vacuum Minipole Undulator

Toshiya TANABE 1), Takashi TANAKA 1), Hideo KITAMURA 1) and Peter STEFAN 2)

1) JAERI-RIKEN SPring-8 Project Team, Kamigori, Ako-gun, Kyogo 678-12, JAPAN
2) National Synchrotron Light Source, Brookhaven National Laboratory, Upton, NY 11973

1. Introduction

Development of an in-vacuum minipole undulator (NSLS-IVUN) which will be installed in the X-ray ring (E = 2.584 GeV) at National Synchrotron Light Source (NSLS) in Brookhaven National Laboratory (BNL) is approaching to the final stage [1]. In this paper the latest progress of the development is described.

2. Magnetic Field Measurement

A picture of our magnetic field measurement facilities are shown in Fig. 1. There are two types of systems; a Hall probe field mapping system which includes a moving stage on a granite bench, holders for magnet arrays and a base plate, and a rotating coil field integral measurement system which is seen at the upper right corner in the picture.

Fig 1. Hall probe field mapping system and rotating coil system.

As for the Hall probe, we use AREPOC HHP-MP which has an active area of 100mm × 100mm, and the thickness of enclosure is 1mm. It is placed in 1.5mm thick copper plate and sandwiched by Kapton tapes. Even though there is no temperature controlling device in the enclosure of the probe, sufficiently low (3.0 × 10 s up7(-4)/ K) temperature coefficient of the probe with software compensation and reasonable ambient temperature control ensure the accuracy of the measurement. Extra attention was paid to the straightness and flatness of travel. The center of the probe has been found to stay on axis within a range of ± 1 mm vertically, and ± 7 mm horizontally.

The rotating coil device is the same one as is used for SPring-8 IDs [2] except for narrower coil width (1.5mm) and shorter length (1.6m.) Magnetic field correction was made by first using simulated annealing [3] for coarse correction, then inserting magnet chips on the back of magnets for fine adjustment. A stainless chip is always inserted between a main magnet and chip magnets to warrant removability, in case it becomes necessary. The multipole components are measured within a range of x = ±4mm. They are derived from polynomial fitting of the first integral distribution along horizontal axis using the following formula.

$$\int_{-\infty}^{\infty}(By + iBx)\,dz = \sum_{n=0}^{\infty}(b_n + ia_n)(x + iy)^n \qquad (1)$$

where bn are normal components and an are skew ones. Integrated multipole requirements for NSLS X-ray ring and our measurement results are presented in Table 1.

Table1. Integrated multipole requirements for NSLS X-ray ring versus the results of magnetic field measurement of IVUN arrays at 3.0mm gap

(n)	Goal	Measurement
Normal/Skew (0) Dipole	100 G*cm	77 / -70 G*cm
Normal/Skew (1) Quadrupole	10 G / 100G	25 G / -192 G
Normal/Skew (2) Sextupole	50 G/cm	161 / 41 G/cm
Normal 2nd Integral	8 G*m^2	0.031 G* m^2
Skew 2nd Integral	8 G*m^2	N.A.
RMS Phase Shake	2 degrees	1.45degrees

Figure 2-(a), (b), (c) show gap dependence of integrated dipole, quadrupole, sextupole component, respectively. It appears that determining the sextupole components is susceptible to curve fitting errors

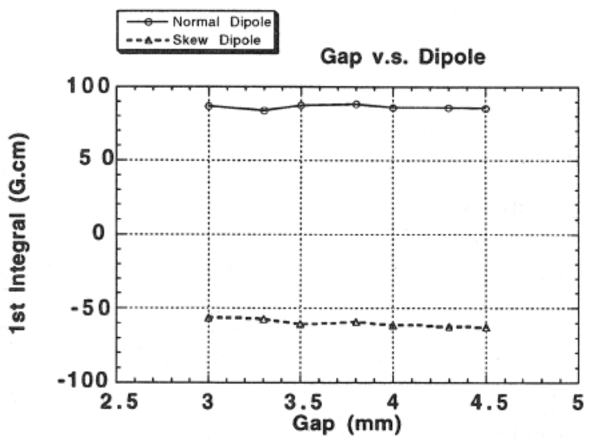

Fig. 2-(a) Gap versus dipole components of the field

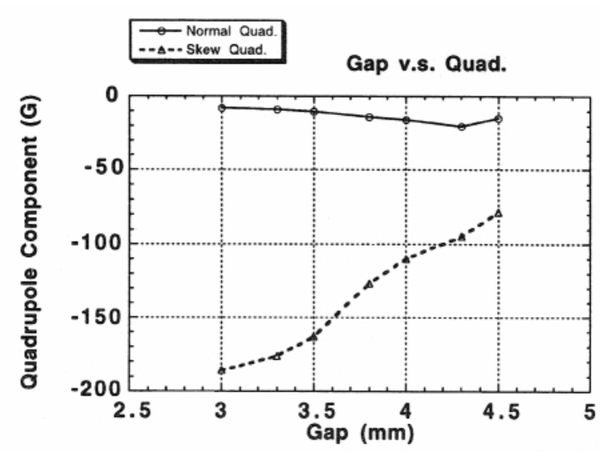

Fig. 2-(b) Gap versus quadrupole components of the field.

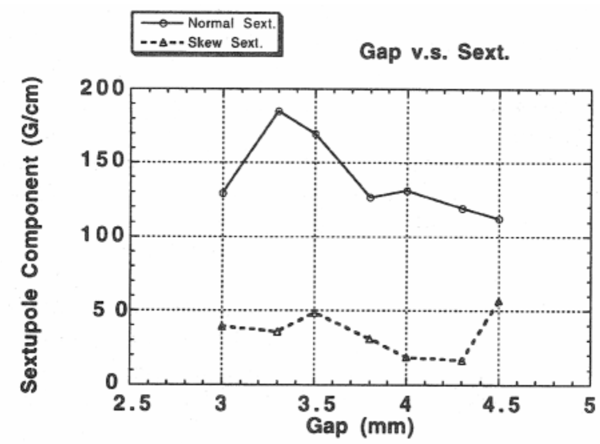

Fig. 2-(c) Gap versus sextupole components of the field.

5. UHV Test

After magnetic field correction was finished, a vacuum test in UHV minichamber was conducted to make sure of no degassing elements in the magnet-arrays before installation. Figure 3 shows schematic of the vacuum testing facility. The final value of vacuum reading by an extractor gauge (Palzers TPG251) reached 2 × 10 s up7(-9) Pa, which indicates sufficient ultra-high-vacuum (UHV) compatibility of the arrays.

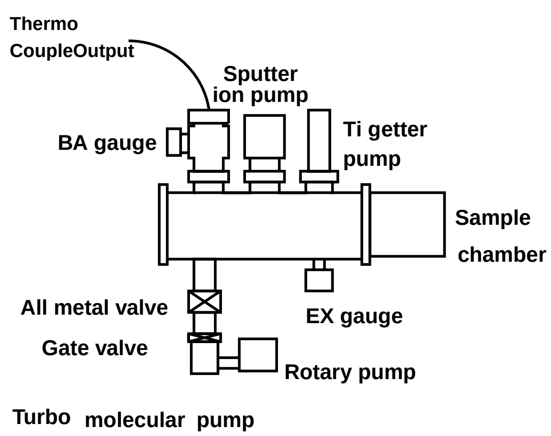

Fig. 3. Schematic illustration of the vacuum testing facility

6. Mechanical Support and Vacuum System (BNL)

IVUN is comprised of three major components: a rectangular vacuum chamber with bellows feedthroughs, magnet array units with drive system, and an elevator base stage, upon which all of the above components are supported.

Transition systems upstream and downstream of the magnetic array holders provide a controlled taper and electrical continuity for conduction of electron beam image currents. The chamber is also equipped with three forms of pumping, a 300 l/s ion pump, a titanium sublimator, and a non-evaporable getter. Provisions for in-situ glow discharge cleaning have also been made, with a movable electrode which will concentrate the discharge in the regions immediately surrounding the electron beam.

The rectangular form of the vacuum chamber permits a minimum cantilever in the magnet drive design, to provide a rigid drive system. Precise alignment of the magnet arrays is facilitated by removable top and bottom rectangular flanges on the chamber: With the central section of the vacuum chamber removed, the magnet arrays are precisely aligned, with full access to the arrays. Then, using auxiliary pneumatic cylinders on the magnet drive, the magnet gap is opened to nearly 300 mm, and the central section of the vacuum chamber is replaced, without disturbing any of the adjustments.

The undulator magnet arrays are mounted on the water-cooled beams of the drive system, directly in the accelerator ultra-high vacuum. The drive system enables magnet gaps between 1 mm and 10 mm. The design operational magnet gap is 3.3 mm. The elevator base stage provides mounting fixtures for the IVUN vacuum chamber and the undulator magnet drive. In addition, it provides a 3 mm vertical translation of the combined chamber/magnet assembly about the nominal beam height.

7. Conclusion

With in-vacuum structure, a minipole undulator having modest tunability and harmonics has been constructed. The magnetic field quality is found be satisfactory after spectral and mutipole correction, and the magnet arrays show excellent UHV compatibility. A clever design of vacuum chamber greatly improves accessibility of magnet arrays. A complete device is expected to be installed in the X13 R&D straight section of the NSLS X-ray Ring in May 1997.

References

[1] T. Tanabe et al, SPring-8 Annual Report 1995, 173
[2] Insertion Device Handbook '96, (SPring-8 OPSRR 1996-0003)
[3] A. Cox and B. Youngman, Proc. SPIE 582, 91 (1986)