

MAGNET FIDUCIALIZATION METHOD BASED ON SINGLE STRETCHED WIRE AND PRECISION SURFACE PLATE

Baohou Liu, Chao Zhang, Xiaoye He

University of Science and Technology of China, Hefei, China

Please Contact: lbh0116@mail.ustc.edu.cn

ABSTRACT

A high-precision magnet fiducialization method based on a single stretched wire system is proposed. This system accurately measures the relative coordinates between the magnetic center and magnet fiducials. The fiducialization accuracy is better than 10 μm , satisfying the stringent alignment requirements for accelerator magnets of the Hefei Advanced Light Facility (HALF).

1. System Layout

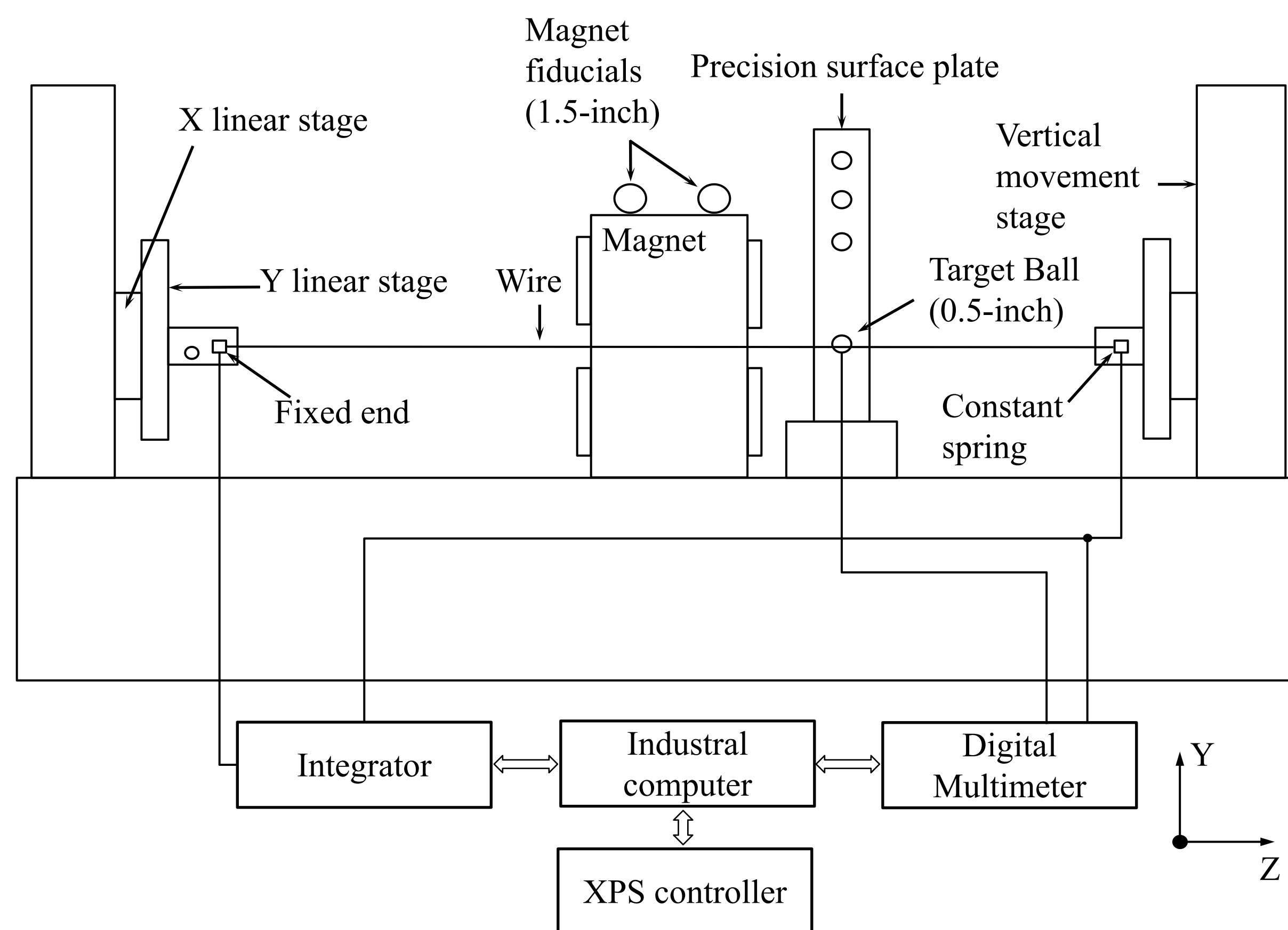


Figure 1: Layout of the measurement bench for the magnet fiducialization of the HALF.

Instrument	Linear stage	XPS controller	Digital integrator	Digital Multimeter	Wire	Vertical movement stage
Model	Newport ILS100CC	Newport XPS-D6	FDI-2056	Tektronix DAQ6510	Goodfellow Ti90Al6V4	Yaskawa SGMJV-08ADE6E THK BIF2505VS-1000C3(D)

2. Magnetic center Measurement

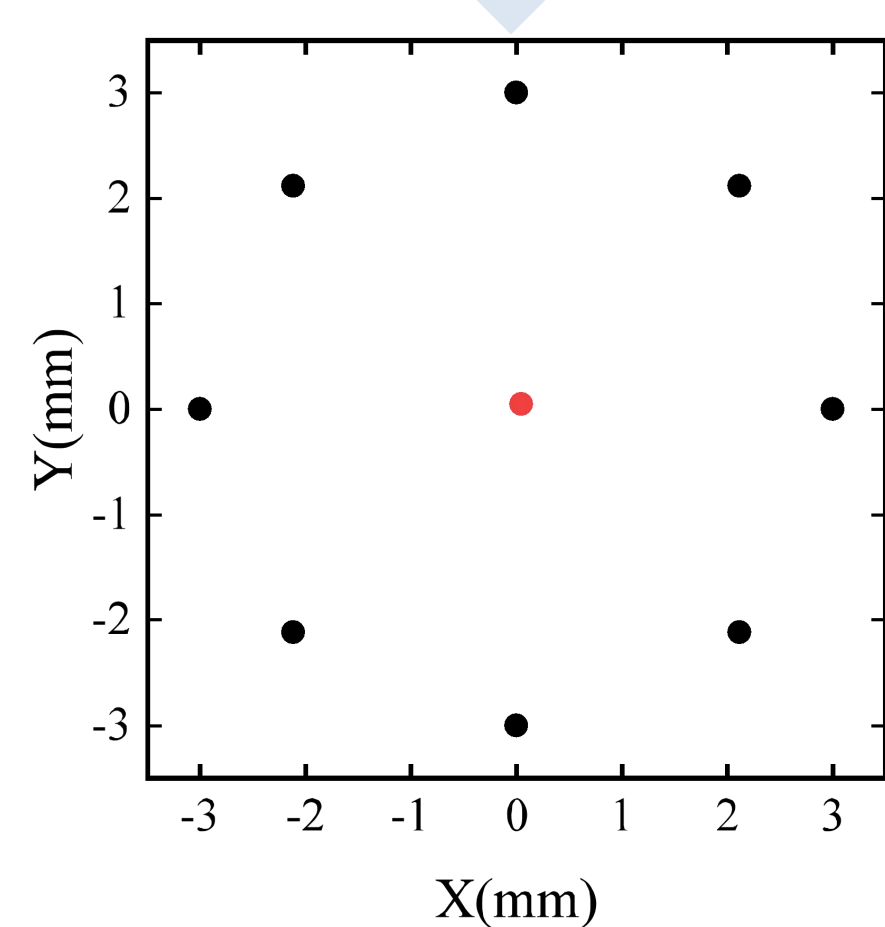
For a quadrupole magnet, the integral field along the X - and Y -directions can be expressed as:

$$I_y = Gl(x - x_0)$$

$$I_x = Gl(y - y_0)$$

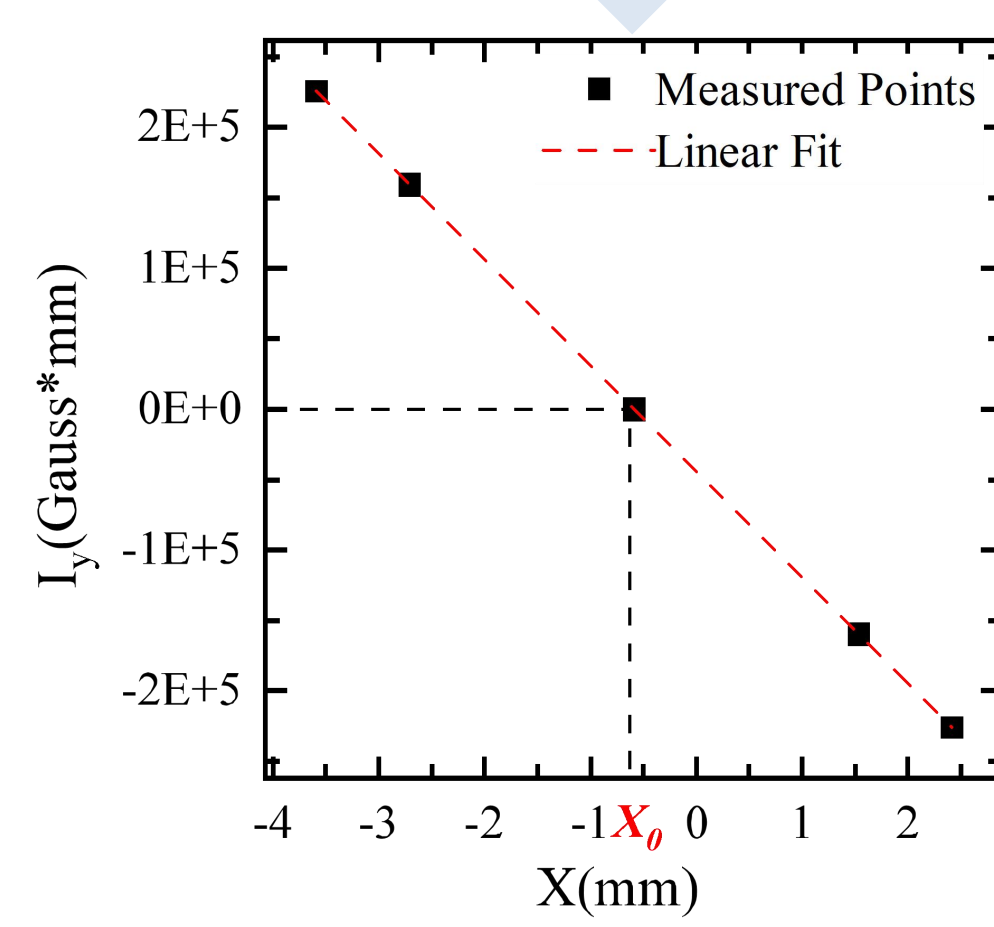
where x_0 and y_0 are magnetic center coordinates, x , y are the transverse coordinates in the X - and Y -directions, respectively, G is the quadrupole field gradient, and l is the effective magnetic length.

Measurement Sequence



a) Magnetic center measurement sequence. Black dots represent the measured points, and red dot indicates the magnetic center.

Fitting Method



(b) Magnetic center fitting method.

Figure 2: Magnetic center measurement method.

3. Fiducialization

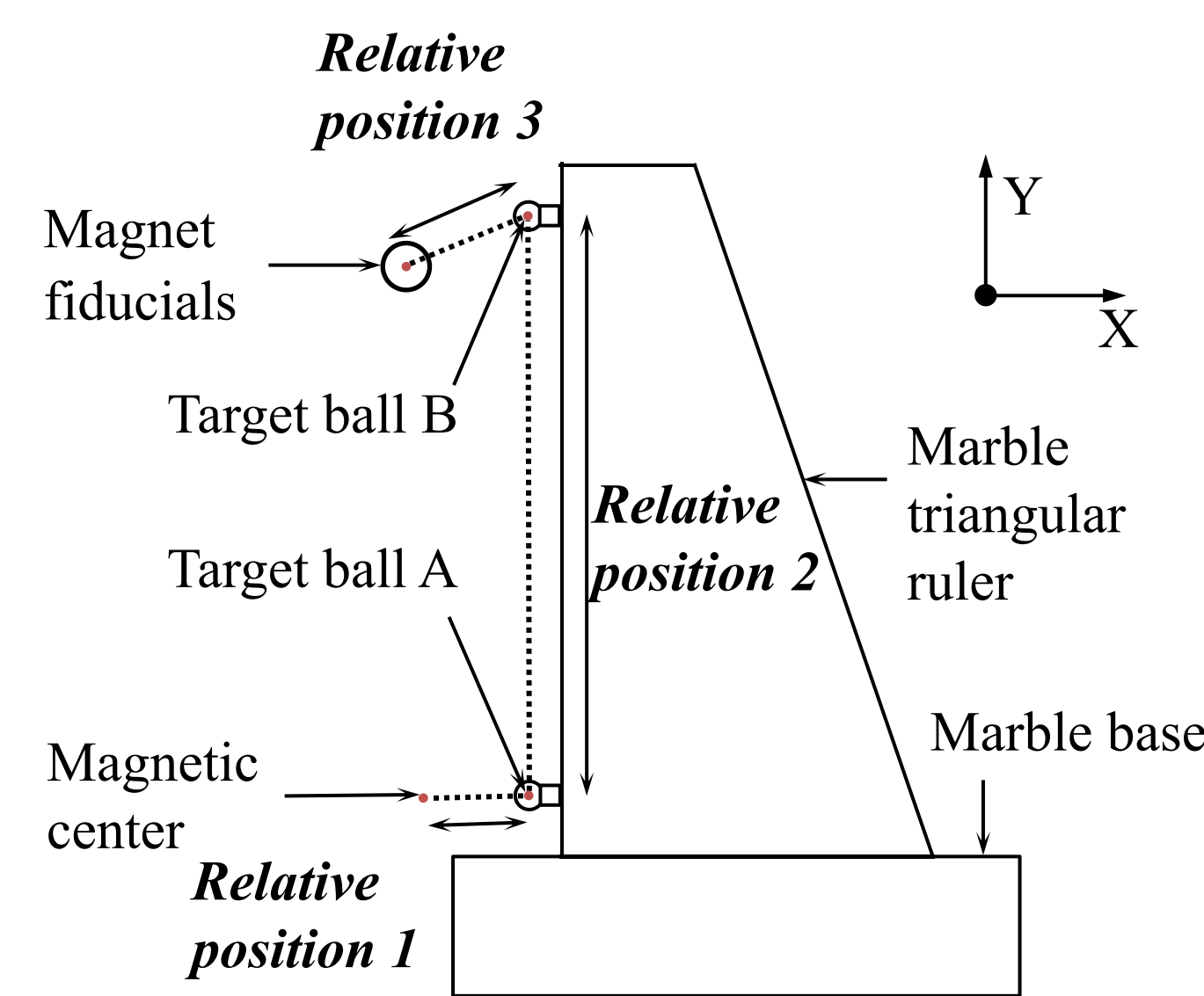


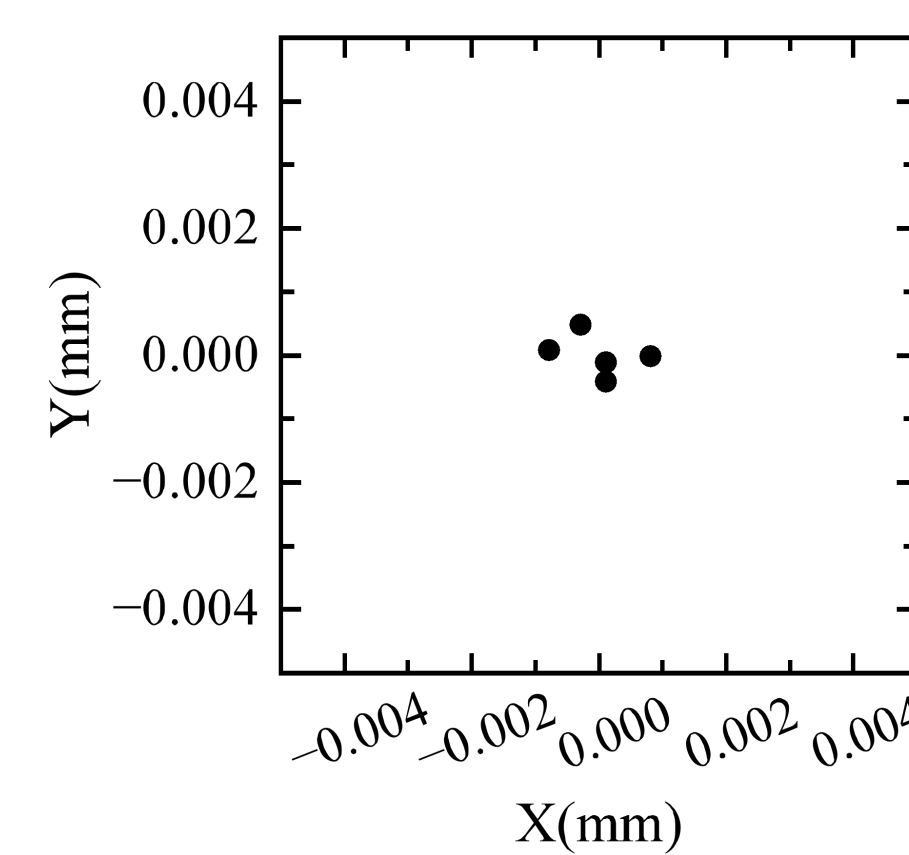
Figure 3: Cross-section of the precision surface plate viewed along the axis of the wire. The position of fiducial relative to the magnetic center of the magnet was determined through three measurements: Relative position 1, Relative position 2, and Relative position 3.

Relative Position Measurement of Target Ball A with Respect to the Magnetic Center

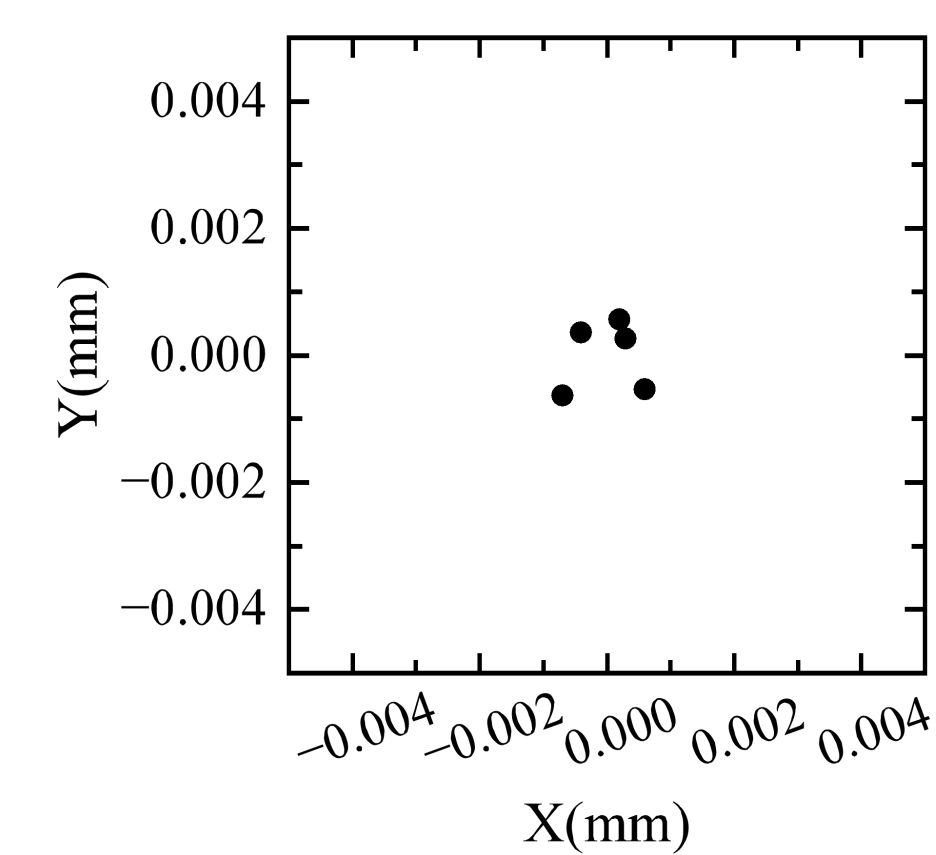
Relative Position Measurement of Target Ball B Relative to Target Ball A — Pre-calibrated by CMM, No Remeasurement Needed

Relative Position Measurement of Magnetic Fiducials(C/D) with Respect to Target Ball B

4. Results



(a) Five measurements of 0.5-inch target ball center.



(b) Five measurements of 1.5-inch target ball center.

Figure 4: Measurement results of 0.5/1.5-inch target balls.

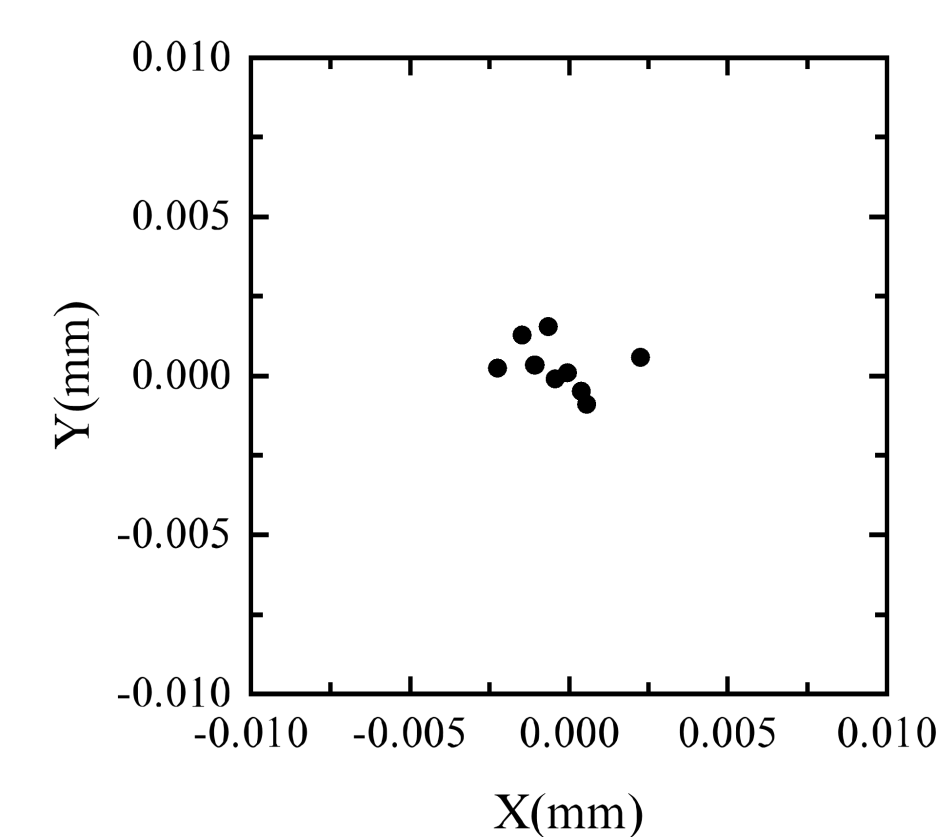


Figure 5: Measurement results of the magnetic center.

Table 2: Results of three consecutive fiducialization measurements

N	X(mm)	Y(mm)
1	-0.0007	-0.0198
2	0.0035	-0.0182
3	-0.0006	-0.0174

Table 3: Results of two independent measurements with realignment

N	X(mm)	Y(mm)
1	0.0011	-0.0146
2	0.0081	-0.0120

The relative coordinates between the magnetic center and the magnet fiducials during practical measurement.

CONCLUSION

- A high-precision magnet fiducialization method based on SSW and a precision surface plate is proposed for HALF.
- The magnetic center and magnet fiducials are measured with reference to target balls.
- The total measurement uncertainty is within 10 μm .
- This method is feasible for HALF and can be widely applied to various accelerator magnets.

REFERENCE

- G. Le Bec, J. Chavanne, and Ch. Penel, "Stretched wire measurement of multipole accelerator magnets", Phys. Rev. Spec.Top. Accel. Beams., vol. 15, no. 2, pp. 022401, 2012.
- B. H. Liu et al, Z. L Ren, and T. H. Sun, "Measuring the magnetic center and multipole coefficients of sextupole magnets using the single stretched wire", Nucl. Instrum. Methods Phys. Res. A, vol. 1092, pp. 171893, 2026.
- B. H. Liu, C. Zhang, and Y. T. Huang, "Magnetic center measurement and fiducialization with single stretched wire and precision surface plate", Nucl. Instrum. Methods Phys. Res. A, vol. 1082, no. p2, pp. 171051, 2026.