Beam based alignment in a compact THz-FEL facility

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Abstract:
In this paper, we presented the beam based alignment results in a compact THz-FEL facility. The alignment was divided into two sections, the transport line and the optical line. In the transport line, all the five quadrupoles upstream of the undulator were adjusted one by one to fit the electron beam downstream of the traveling wave linac. In the optical line, a set of auxiliary coils were winded on the yokes of the quadrupole downstream of the double bend achromat (DBA) to produce a vertical steering force. Another X-Y combined type steering magnet, together with the auxiliary coils, corrected the beam orbit in the optical line. Dispersion free test demonstrated that after correction the displacement between the magnetic centers of the quads and the beam orbit was less than 0.3mm.

Method:
The lattice of the THz-FEL prototype mainly consists of a triplet (Q1+Q2+Q3) and a double bend achromat (DBA, B1+Q4+B2). The alignment was divided into three steps: (1) alignment of Q1, Q2 and Q3; (2) alignment of the beam line and the optical line; (3) alignment of Q4 and Q5. The displacement of the quads can be calculated as

$$\delta = \frac{p}{e \cdot D \cdot L \cdot k} A$$

where e is charge of an electron; p is the longitudinal momentum of the beam; D is the drift space between the quadrupole and the screen; L is the effective length of the quadrupole; k is the linear coefficient between the gradient and the current of a quadrupole; A is the linear coefficient after fitting the beam spot variation and the current.
Correction of the optical line: (1) using S2 to adjust the orbit to pass the center of S3; (2) using S3 to adjust the orbit to be coaxial with the optical axis.

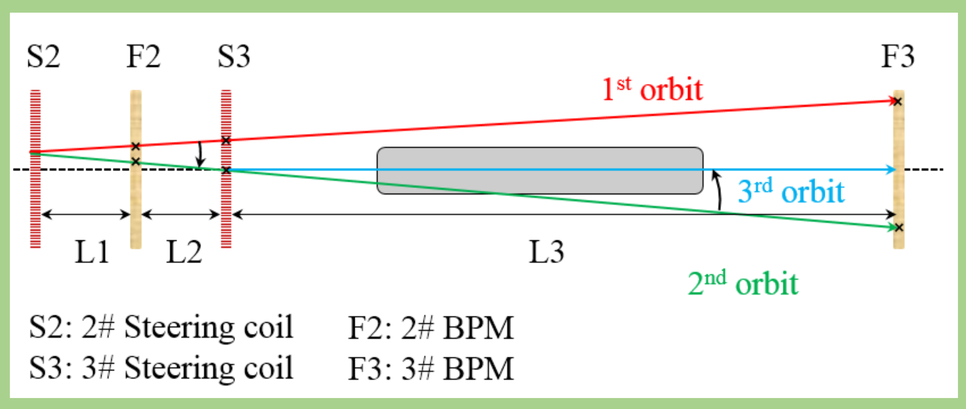

Fig. 1 Illustration of the correction of the optical line.

Fig. 2 Vertical steering coil S3 winded on Q5.

Results:

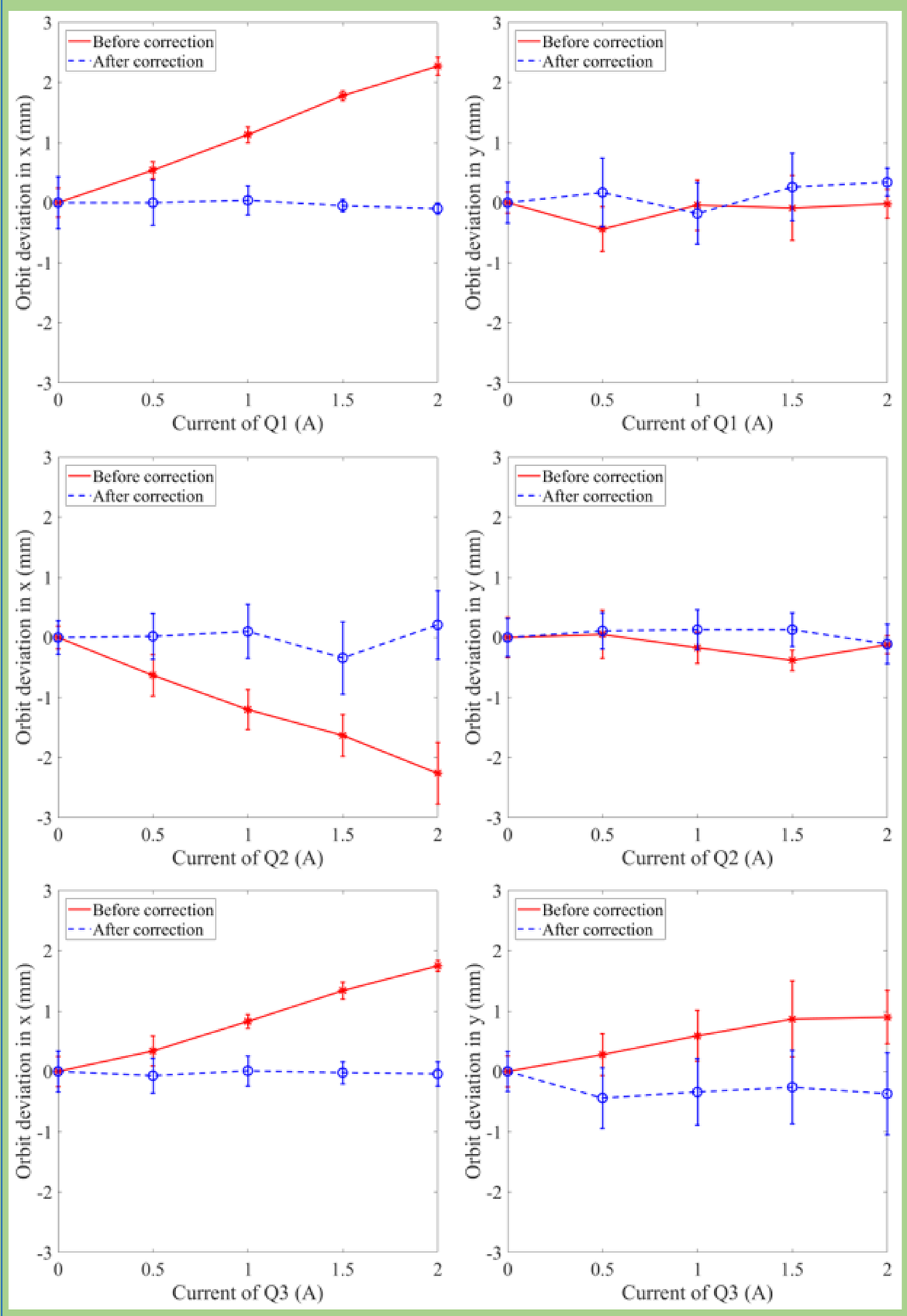

Fig.3 Beam drift when scanning the Q's current.

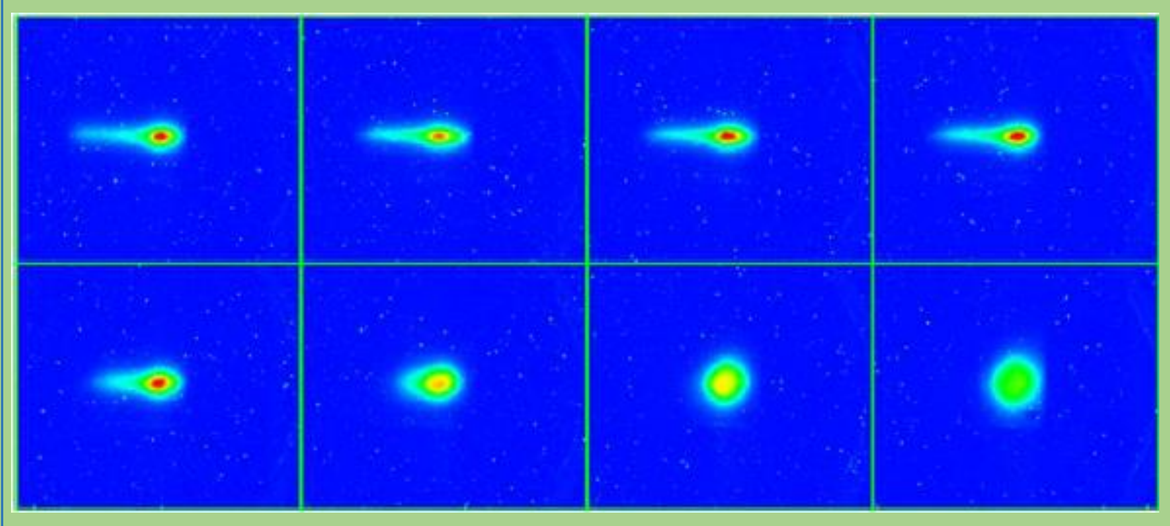

Fig. 4 Beam profile on F2 when the current of Q4 varies: 0, 1A, 1.5A, 2A, 4A, 6A, 8A,10A.

Quad	Deviation in x (mm)	Deviation in (mm)
Q1	-0.06(-0.10,-0.04)	0.14(0.05,0.22)
Q2	0.02(-0.18,0.21)	-0.03(-0.15,0.08)
Q3	-0.01(-0.10,0.08)	-0.21(-0.48,0.06)
Q4	No data	-0.01(-0.07,0.03)
Q5	No data	0.27(0.23,0.30)

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