EUROPEAN SYNCHROTRON RADIATION FACILITY
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A Short Guide To The Alignment Of The ID10A Optics

C. Detlefs and A. Madsen

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1 Overview

This document is meant as a reminder for staff members. Interested users may however also have a look. Due to the nature of the Troïka I station ID10A, this guide is necessarily incomplete and out of date.

Except where noted, all optical elements are controlled from the beamline control SPEC application SIXC. This applications is normally running on the TROIKA04 X-terminal. If not, it can be started from the left mouse button menu.

When aligning the beamline, one has to bear in mind that some actions on the optical elements also influence the other Troïka branches. In particular, all movements of the undulators, front-end Be lenses, front end shutter, and the primary slits have to be coordinated with Troïka 2 (ID10B).

The Troïka 3 branch is more sensitive, since it "recycles" the Troïka 1 beam. Apart from the aforementioned elements, it is also sensitive to the secondary slits (`s0` and `s1`), the choice of monochromator crystal (especially. Si(111)), and the state of the photon shutter (!).

The steps of the alignment procedure are typically performed in the following order:

- Front-end graphite heat load filter (x, z).
- Primary slits (x, z, gaps).
- Secondary slits (x, z, gaps).
- Front-end Beryllium lenses (x, z).
- Monochromator (Energy, x, z, tilt).
- Undulators (gaps).
- Incident flight path (attenuators, mirror).
- Diffractometer (center of rotation, x, z).
- Radiation shielding at monochromator exit.
- Front slits/Pinhole (x, z, gaps).
- Diffractometer (straight beam direction).

The first steps, up to the secondary slit alignment are not repeated for each experiment. The complete alignment from the monochromator on downstream, however, is necessary whenever either the monochromator crystal or the photon energy is changed. This document describes the alignment of the machine elements (undulators, front-end) and the optics hutch components. The alignment of the monochromator and the diffractometer is described elsewhere.

2 Front-end graphite heat load filter

The graphite heat load filter installed in the front-end of ID10 does not need frequent realignment. Its position relative to the beam can only be determined if the beamline is at least partially aligned, so that the transmitted beam is detected in some kind of detector, e.g. the Troïka 1 monitor detector. Its position is controlled from a special GUI ("Fe filters") which can be started from the left mouse button menu

Currently, no spec application that would allow proper scanning of the front-end filters is available.

3 Primary slits

Similarly to the graphite heat load filter, the primary slits do not need frequent realignment. Again, their position relative to the beam can only be determined if the beamline is at least partially aligned, so that the transmitted beam is detected in some kind of detector, e.g. the Troïka 1 monitor detector.

Two alternative control applications are available: A graphical user interface, and a specialized SPEC application. Both can be started from the left mouse button menu on TROIKA04. As SPEC does not notice when the primary slits are moved from the GUI, it is advisable to read the updated motor positions from the hardware controllers before moving any motors from the SPEC application:

```
142.PSLITS> sync
```

On the hardware side, the slits are build from four blades which can be individually moved. On the software side, this is complemented by four "pseudo-motors" with move two blades in parallel (offset) or antiparallel (gap).

```
146.PSLITS> wpslit
Horizontal:  Offset(pvo)     Gap(pvg)    Blade(pu)    Blade(pd)
                 0.0000       0.5000       0.2500       0.2500    (User)

  Vertical:  Offset(pho)     Gap(phg)    Blade(pf)    Blade(pb)
                -0.0025       0.9850       0.4900       0.4950    (User)
```

4 Secondary slits (s0 and s1)

Two sets of secondary slits are available, the slit `s0`, located just downstream of the Troïka 2 monochromator, and the slit `s1` directly upstream of the Troïka 1 monochromator. Both slit sets are controlled from the standard beamline control

SPEC application SIXC. Again, each set of slits is composed of four individual blades, with pseudo-motors for gaps and offsets.

```
1303.SIXC> ws0
Horizontal: Offset(s0vo)    Gap(s0vg)   Blade(s0u)   Blade(s0d)
                  0.0000       6.0000       3.0000       3.0000   (User)

  Vertical: Offset(s0ho)    Gap(s0hg)   Blade(s0b)   Blade(s0f)
                  7.3475      20.6950      17.6950       3.0000   (User)


1304.SIXC> ws1
Horizontal: Offset(s1vo)    Gap(s1vg)   Blade(s1u)   Blade(s1d)
                  0.0000       0.1982       0.0991       0.0991   (User)

  Vertical: Offset(s1ho)    Gap(s1hg)   Blade(s1f)   Blade(s1b)
                  0.0000       0.1982       0.0991       0.0991   (User)
```

The first set of slits, `s0`, is new and is intended mostly to define a secondary source for coherent experiments. They can also be used to screen out unwanted parts of the white beam without increasing the background in the experimental hutch.

As long as the Troïka 3 branch (ID10C) is not affected, it is recommended to use the second set, `s1`, to define the beam size for the experiment. In this way, the unused radiation is stopped inside the shielded vacuum vessel (reduced background!), and the heat load on the monochromator is reduced (important for Si(111) used in coherent mode).

5 Front-end Be lenses

The Be lenses installed in the front end of ID10 are controlled from a separate SPEC application, BE_LENS, which can be started on TINA2 from the left mouse button menu.

Similar to the primary slits, the Be lenses can only be aligned if the beamline is prealigned and a detector signal is available. Typically, the alignment is done on a small aperture of the secondary slits, `s1`, or the front slits, `fx, fz, fgh, fgv`. The Troïka 1 monitor detector can be read out from BE_LENS.

All lenses are mounted together on a single carriage, as displayed in Fig. 1, and cannot be moved individually. The carriage therefore has to be positioned such that the right lens is centered in the beam. The horizontal and vertical positions can be aligned using the motors `reflx` and `reflz`, respectively.

Table 1: Some properties of the Be lenses installed in the front end of ID10 at E=8 keV

	Lens	f [m]	d'_s [μm]	R'_s [m]	ξ_T [μm]	Intensity
	no lens		930	46	3.8	1.00
			25	46	154	
A	1 $\times$1.2 (h)	56.5	1600	63.7	3.0	1.85
	2 $\times$1.0 (v)	23.6	1500	-1390	79	
B	3 $\times$1.2 (h)	18.8	3400	-64.8	1.5	3.40
	4 $\times$1.0 (v)	11.8	24	-1.2	3.9	
C			930	46	3.8	1.93
	3 $\times$1.0 (v)	15.7	47	-23.4	41	
C′			930	46	3.8	1.93
	6 $\times$1.0 (v)					
D	7 $\times$1.2 (h)	8.1	470	9.8	1.6	0.23
	10 $\times$1.0 (v)	5.9	8.1	14.2	146	

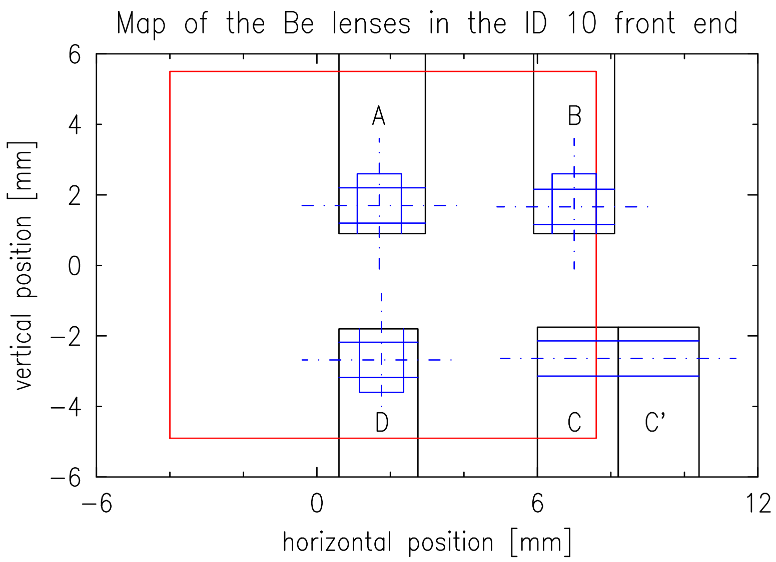
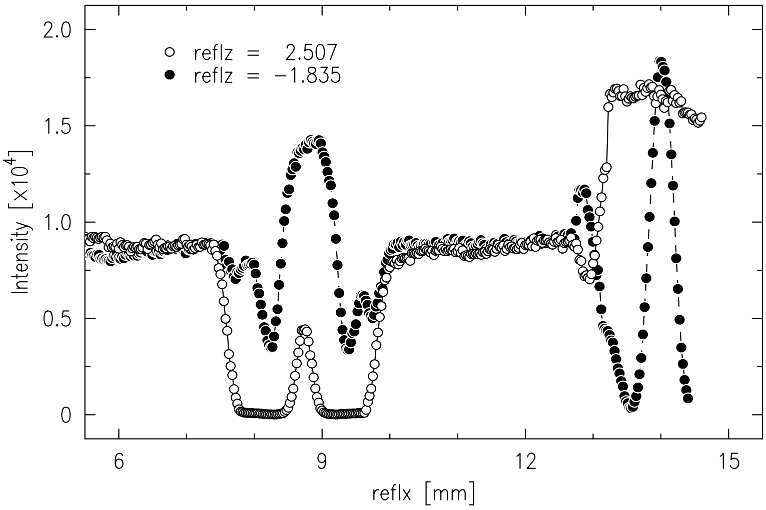


Figure 1: The geometry and relative position of the Be lenses installed in the front-end of ID10.



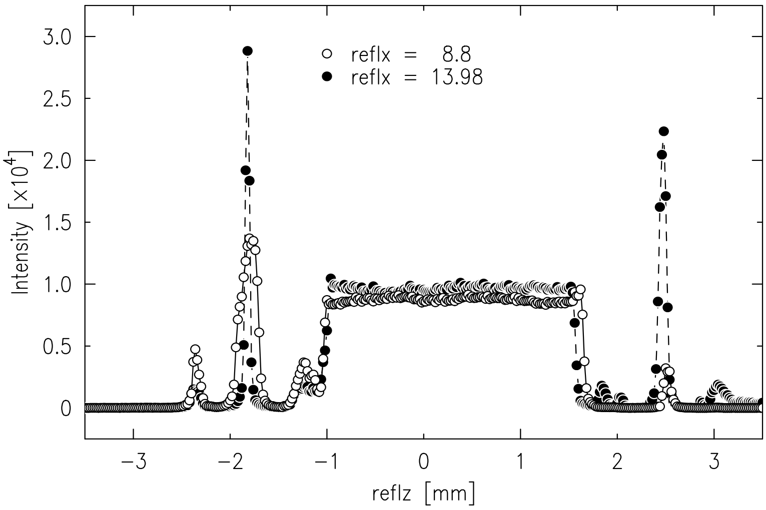


Figure 2: Scans of the Be lens carriage along the horizontal (`reflx`) and vertical (`reflz`) axes.

The current position of the carriage, and the nominal positions for the lenses that are installed on it can be displayed with the SPEC command `beinfo`:

```
935.BE_LENS> beinfo

         Beryllium lenses info:
---------------------------------------------------
                  reflx    reflz  Composition

       Current  11.0000   2.4910

       parking   9.0000   0.5000        empty
             A   5.6560  -1.7400        1h+2v
             B  10.9900  -1.7270        3h+4v
***          C  11.9050   2.5720           3v ***
            C'  11.9490   2.6700           6v
             D   5.6000   2.6000       7h+10v
---------------------------------------------------
     active lens is 'C' (3v).
---------------------------------------------------
```

The lenses are constructed from separate elements for horizontal and vertical focusing. *Currently the elements for horizontal focusing have been taken out due to a strong request from ID10B. Hence, the lenses are only focusing in the vertical direction!* The elements consist of a massive block of Be, into which cylindrical holes with diameters 1mm and 1.2mm for vertical and horizontal focusing, respectively, have been drilled. The space between two such holes is a good approximation to a concave lens which is a focusing lens in the X-ray regime. Details are given in Table 1.

Fig. 2 shows typical scans of the carriage position. The regions where the beam is not intercepted by any Be are clearly visible (`reflx` < 7.5, $10 <$ `reflx` < 12.5, and $-1 <$ `reflz` < 1.7). When a lens is in the beam, the image of the source lies on a direct line from the source through the center of the lens. By positioning the lens, this line has to guided through the center of the slit aperture. This produces the sharp peaks seen around `reflx` ≈ 8.8 and 14, and `reflz` $\approx$ -1.8 and 2.5. A particular case is lens C, which is focusing only in the vertical direction. Horizontal translations therefore do not move the image, as seen by the flat profile in Fig. 2 near $13.3 <$ `reflx` < 15 and `reflz` $= -1.835$.

For coherent experiments running at the ID10A line at 8 keV, the B lens is normally used. The alignment is done as follows: The lenses are moved out of the beam. An analyzing aperture, e.g. `s1`, is centered in the direct beam. The aperture is close to $\approx 100\ \mu$m. Then the selected lens is positioned in the beam, such that the flux through the aperture is maximized.

Note that the absolute values of `reflx` *and* `reflz` *might have changed (even though they shouldn't!). However, scans like the ones shown in Fig. 2 will quickly help to find the position of the desired lens*

In case no focusing through Be lenses is desired, the carriage has to positioned such that the beam is passing inbetween the lenses (`reflx`=8.30, `reflz`=0.00).

Remember that the focusing properties of the Be lenses depend of the X-ray energy!

6 Undulators

A set of macros is available to calculate the undulator gap for a given energy and harmonic, and vice versa.

```
241.SIXC> u42_harmonic 3

Using  3rd harmonic for undulatorcalculations.

242.SIXC> u42_energy 19.90
 3rd undulator harmonic at gap  19.90 is at
 lambda=  1.2402 Angstrom, E=  9.998 keV.

243.SIXC> u42_gap 8.979
 3rd undulator harmonic at gap  18.74 is at
 lambda=  1.3808 Angstrom, E=  8.979 keV.

244.SIXC> u42_harmonic 7

Using  7th harmonic for undulator calculations.

245.SIXC> u42_energy 19.90
 7nd undulator harmonic at gap  19.90 is at
 lambda=  0.5315 Angstrom, E= 23.328 keV.
```

The undulator gaps can then be set with the command “Set ID Values...” of the ID application (“idappli”), or from SIXC.

```
247.SIXC> wm u42u u42m

                U42U       U42M
                u42u       u42m
User
 High       300.0000   298.6950
 Current     19.9015    19.9000
 Low         16.0000     8.6950
Dial
 High       300.0000   298.6950
 Current     19.9015    19.9000
 Low         16.0000     8.6950
```

Since SIXC treats the undulator gaps as normal motors, the usual SPEC scans can be used to fine-tune the gap settings for a given beam energy.

Notice that the undulators are shared with the other Troïka branches, and that any changes should be coordinated!