| ESRF | **Experiment title:** Kirkpatrick-Baez optics for a microbeam experiment | **Experiment number**: MI 564 |
|---|---|---|
| **Beamline**: BM5 | **Date of experiment**: from: 26 June 2002 to: 29 June / 2 Aug 2002 | **Date of report**: 16 Feb. 2003 |
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## Report:

The aim of this experiment was to test a Kirkpatrick-Baez (KB) optics, namely its stability in time: position and intensity of the focused X-ray spot. Although very small (micron or even sub-micron) spots are routinely obtained at the ESRF with KB devices (O.Hignette *et al.*, Proc. SPIE Conf. San Diego, 29 July 2001, paper #4499-19), it was not the only requirement for our experiment (proposal **HS-1776**). It is mandatory to ensure a good stability of the focused beam at the sample position, as well as inducing the lowest possible fluctuations in the focused beam intensity, in order to separate critical fluctuations in the sample from noise (experimental report **HS-1483**).

The KB device was extensively tested on beamline BM5, most of the time being dedicated to long-term stability tests. Additional stability tests on ID22 were mandatory. In the following the results of the tests at both beamlines are shown.

a) The measured efficiency of the system was 40% (specifiaction: 50%). This yields a gain of a factor of 20 in the focused beam with respect to the previously used Al CRL (exp.report **HS-1483**).
b) **Figure 1** shows the variation in size of the focused spot *vs.* secondary slit gap (horizontal) proving its imaging (demagnification) by the KB device.
c) The smallest measured beam size (FWHM, vertical × horizontal) was 1.7 × 2.6 and 1.3 × 1.4 $\mu m^2$ on BM5 and ID22, respectively, with a secondary source size of 30 × 60 $\mu m^2$ situated 17 m upstream the KB. The size was measured by performing knife-edge scans, without any deconvolution.
d) Monitoring the high frequency vibrations (~ 10 Hz) of the whole device shows the presence of vibrations with an amplitude of ±0.6 μm, both in vertical and horizontal direction at the focal spot. They artificially increase the (apparent) spot size of the focused beam.
e) On both beamlines (BM5 and ID22) a long term (thermal) drift in the spot position (but not in the intensity) was detected: the whole system relaxes on a time scale of several hours before reaching a stable configuration in which the position of the spot is defined within the high frequency oscillations (**Figure 2**): the spot is moving sidely by at most 1 to 1.5 μm. Please note the general stability of the system even during a refill. Significant instabilities are created by user interventions in the Experimental Hutch by introducing temperature fluctuations and gradients on the KB device.

All these results are grouped together in the following table. The reported values for the spot size are the measured ones, without deconvoluting the vibration contributions.

| Values | Focal length (mm) (**Figure 3**) | | Spot size (μm) | | Stability (μm, %) | | | Efficency (%) |
|---|---|---|---|---|---|---|---|---|
| | vertical | horizontal | vertical | horizontal | vertical | horizontal | Intensity | |
| Predicted | 580 | 300 | 0.86 | 1.32 | 1.1 | 2.2 | - | 50 % |
| BM5 | 579 ± 2 | 299 ± 2 | 1.7 | 2.6 | 2 to 6 | 2 to 6 | ± 8 % | 38 % |
| ID22 | 581 ± 2 | 301 ± 2 | 1.3 | 1.4 | 1 | 1.6 | ± 3 % | 40 % |

In conclusion, the KB device is well suited for the investigation of critical fluctuations in $Fe_3Al$ with a lower limit in the spot size of $1.3 \times 1.4\ \mu m^2$ and a good stability. The reported results comprise the first long-term stability test of these devices. They are crucial for our subsequent measurements and prove the applicability of KB devices in extended experimental campaigns. The less usual long focal length (300 mm) allows for the use of bulky sample environment (UHV, cryostat) in a general microbeam experiment.

We would like to thank all the people and different teams from ESRF (Optics Group, Machine Shop, Design Department, etc.) which were involved in the project. The gain with respect to the last CRL experiment (**HS-1483**) is a factor of 20 in the absolute intensity and a reduction of a factor of 1.5 in the illuminated sample area*.

* We believe that an important part of the measured spot size was coming from the vibrations of the whole device. Although for this experiment sub-micron beam size is not crucial we believe that smaller spot-sizes can be achieved.

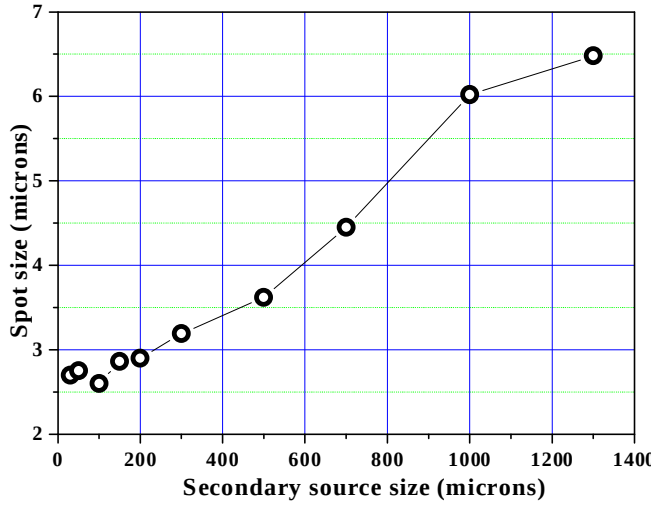


**Figure 1**: Horizontal spot size on BM5 beamline, function of the secondary source size, located at 17 meters upstream the KB.

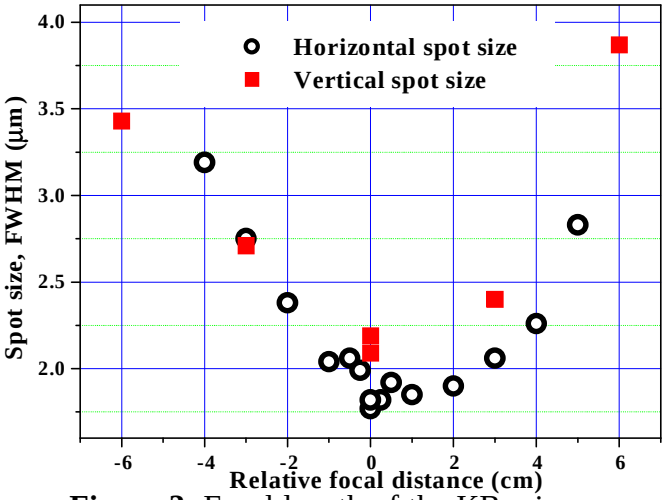


**Figure 3**: Focal length of the KB mirrors on the ID22 beamline.

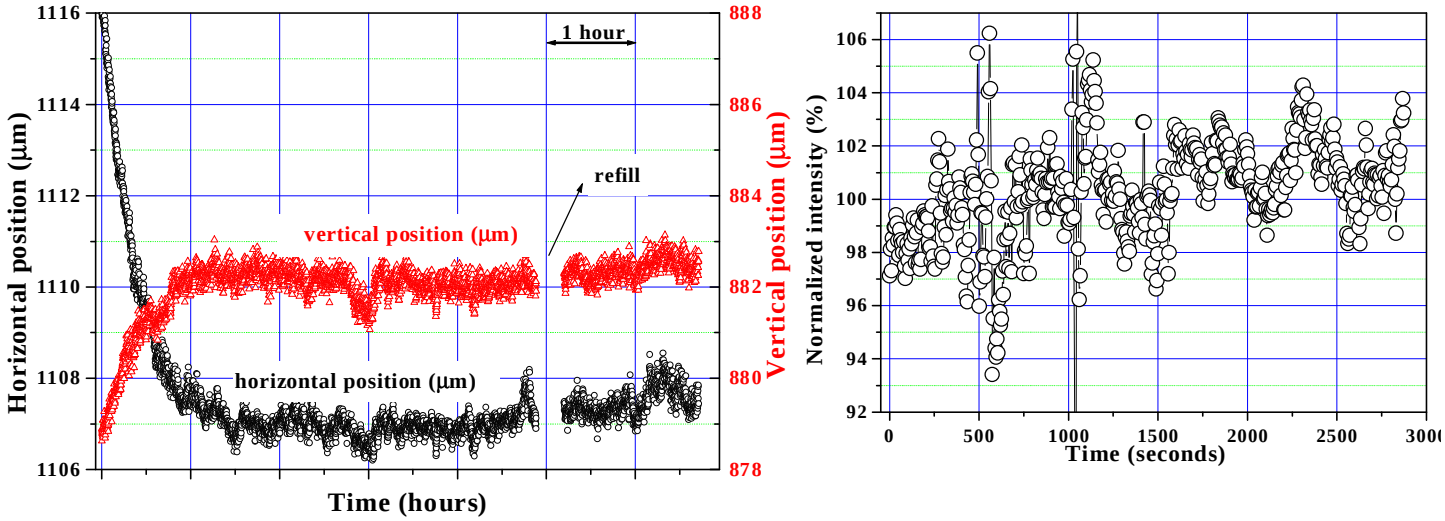


**Figure 2**: Beam stability (position – left and absolute intensity - right).

***Ref:*** C.Mocuta, H.Reichert, I.Ramsteiner, H.Dosch, A.Freund, O.Hignette, M.Drakopoulos, E.Chinchio, E.Ziegler, *A Kirckpatrik-Baez focusing optics for a microdiffraction experiment* (*in prep*aration)