Data analysis of images and movies taken on June 18, 2006

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Abstract. On June 18, 2006, I imaged the new monochromatic beam produced by the new 7ID-A Kohzu HLD-4 diamond monochromator in 7ID-C. This report describes my findings.

Keywords: Beam stability, beam profile.
PACS: APS Sector 7 Report 7ID-2006-1, v1.1, last edited September 1, 2006

On June 18, 2006, I set up our high-spatial resolution CoolSNAP CF set up at the front of the 7ID-C hutch[1]. I used a Thick YAG:Ce crystal (0.5mm), and a X5 Mitutoyo objective with its X1 tube lens to image the visible fluorescence from hard x-rays onto the CoolSNAP CF camera. The pixel size is 4.65 μm, thus the effective pixel size is slightly under one micron. The imaging device was about 51.5 m from the source, and 21.5 m from the monochromator. The double diamond (111) Kohzu monochromator was set to diffract 10 keV x-rays. Our white beam slit were set to 0.5 mm x 0.5 mm. There was no vertical beam position feedback.

Fig. 1 shows the output of a simple centroid calculation of the images, after subtraction of a dark field, and selection of a tight region of interest around the peak. The stability is good, but about a factor 3 worse than measured with the old Si (111) mono with vertical feedback on [2]. Vertical feedback wasn't available at the time of the test. We expect that these measurements are an overestimate of the beam motion.

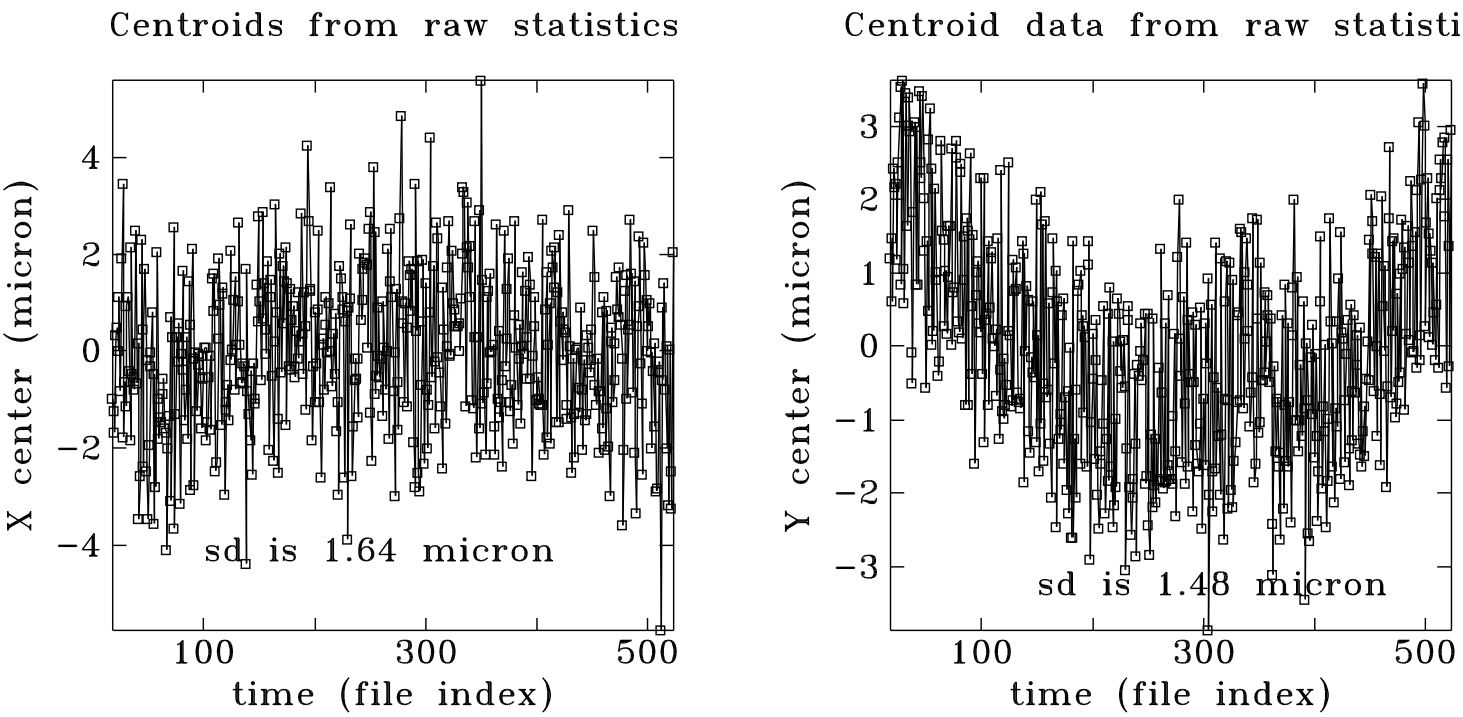

FIGURE 1. The centroid positions Xcenter and Ycenter as a function of file index. The average time per exposure is 0.51 s/file.

Fig. 2 shows an image of the CCD as well as a tilted Gaussian fit of the whole data set. The Gaussian non-linear least-square fit of the data uses a tilt angle[3]. The data is fit to

$$I(x,y) = I_0 \exp[0.5((x-x_c)/\sigma_x)^2] \exp[0.5((y-y_c)/\sigma_y)^2], \quad (1)$$

where (x_c, y_c) is the centroid position on the image, and σ_x, σ_y its RMS standard deviations. I found the fit χ^2 improves by a factor 2 when the function is allowed to have a non-zero tilt angle. The fit routine tilts the image, and fits a two dimensional Gaussian in the rotated frame of reference. Six parameters are allowed to vary, the peak intensity, the center (x_c, y_c), widths (σ_x, σ_y), and tilt angle.

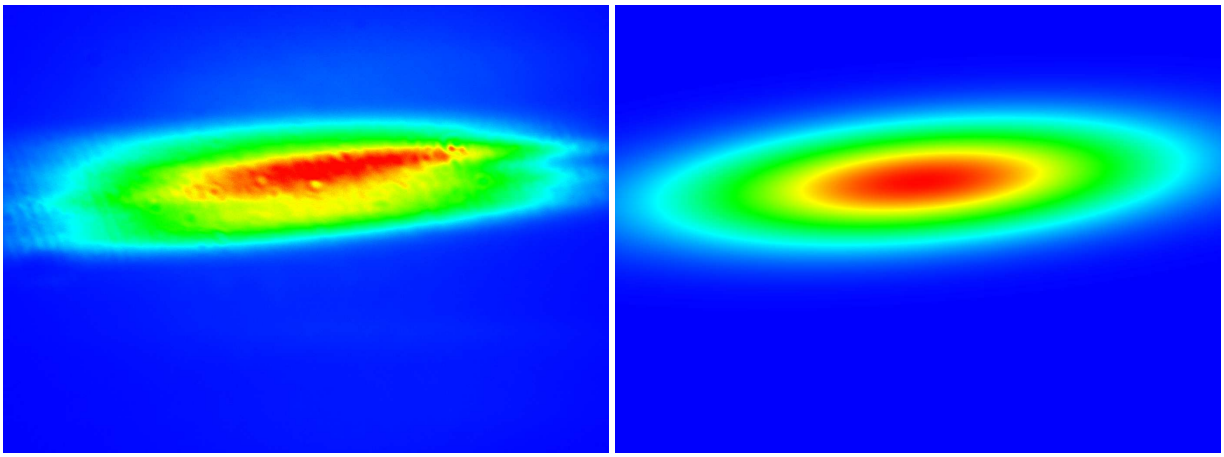

FIGURE 2. One frame of the CCD, file 19 (left) and its Gaussian fit (right).

Fig. 3 shows the fit peak intensity and angle versus time in a 250s long movie. The peak intensity is stable to $16.1/2416 = 0.67\%$ rms, and the average tilt angle is 4.55 degrees.

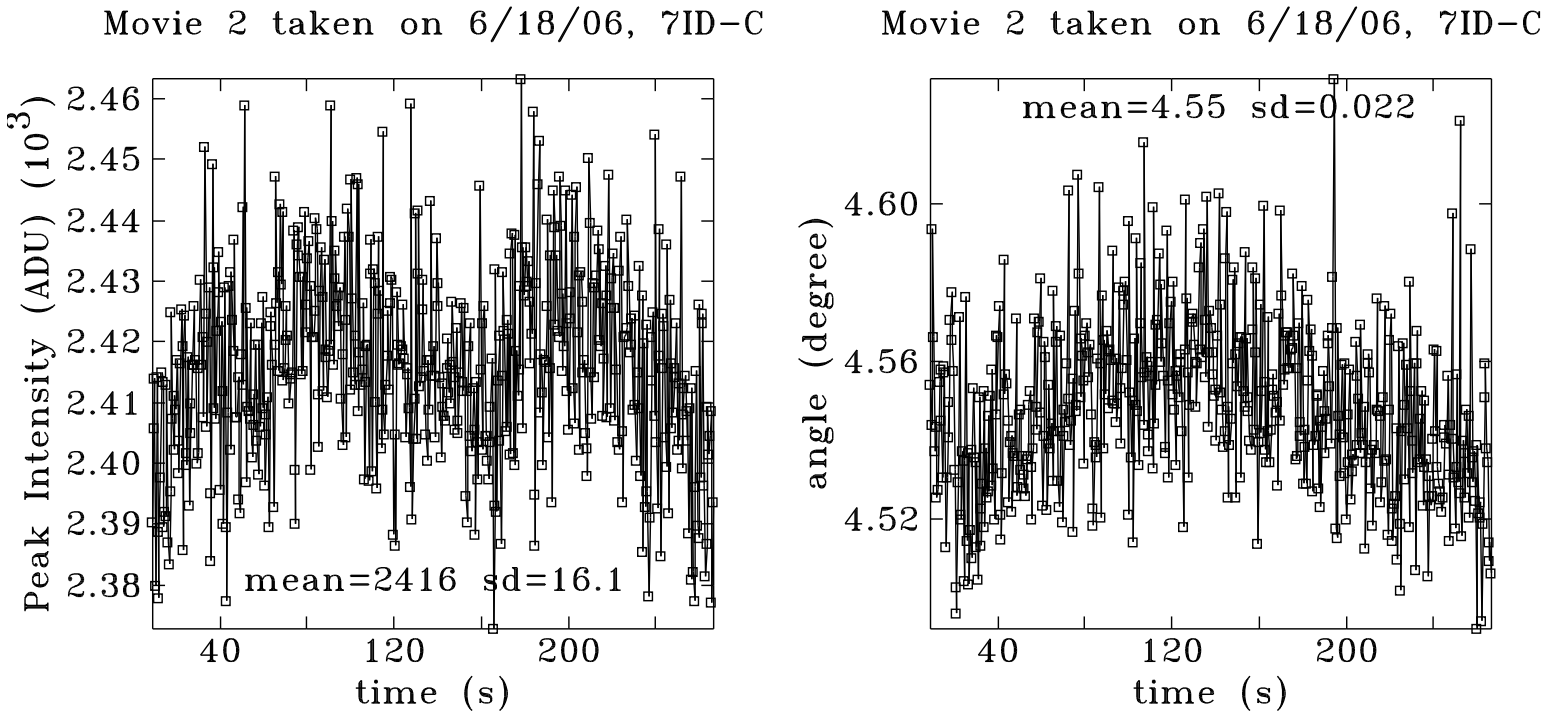

FIGURE 3. Fitted parameters of a tilted Gaussian. (Left) Peak intensity, (Right) tilt angle versus time.

The centroid position is shown in Fig. 4. The data compares well with Fig. 1, although the fit centroid motion has a larger standard deviation that the centroid derived from statistics (e.g. 2.3 versus 1.64 for X motion). I would suspect the fit is more sensitive to beam motion than the statistics.

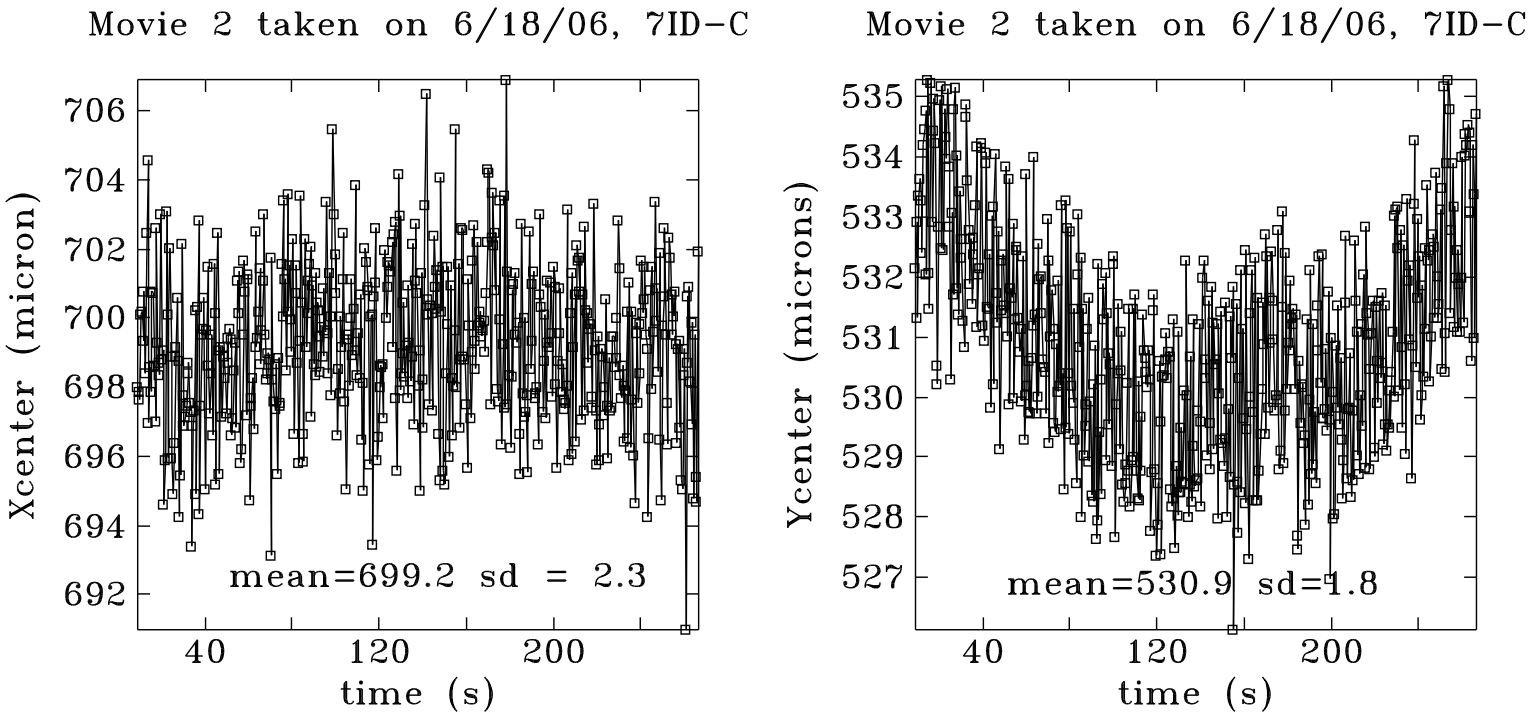

FIGURE 4. (Left) Gaussian fit X center versus time. (Right) Gaussian fit X center.

The fit Gaussian standard deviations are shown in Fig. 5. The widths do not change significantly over time (0.1 and 0.4% for σ_x and σ_y respectively.) The vertical beam size is much too narrow when compared to previous experiments (factor 3.5 times).

In December 2005[3], with white beam slits wide open, we measured a vertical $\sigma_y = 277$ μm. In the vertical direction, the white beam slit opening of 0.5 mm in the June 06 experiment does not affect the beam size measured in 7ID-C. The beam is much smaller than expected but the flux is comparable to the flux delivered by our old Si (111) monochromator.

In an experiment performed later on on June 23, 2006, we also measured the vertical beam profile in 7ID-D. The measurement was done by scanning a 5 μm diameter pinhole in the beam and recording the transmission in an ion chamber. A Huber slit set to 0.7 mm by 0.7 mm was placed between the pinhole and the ion chamber but did not affect the vertical beam profile. The monochromator was set to the Kr edge around 14.3 keV.

Fig. 6 shows the vertical beam profile. The vertical beam full width at half maximum (FWHM) is 92 μm. The FWHM measured in 7ID-C is $2.35\sigma_y = 184.5\mu$m. In the first version of this document, I speculated that the beam was focused in the vertical by the monochromator, explaining the shrinking of the beam as it propagates. Following a realignment of the monochromator in July 2006, we found the FWHM of the x-ray beam in 7ID-D much larger than 92 μm, so it appears that the small beam size first measured was an alignment issue. Also, once the vertical feedback was implemented, the beam stability improved significantly (not shown). This was done well after these measurements.

REFERENCES

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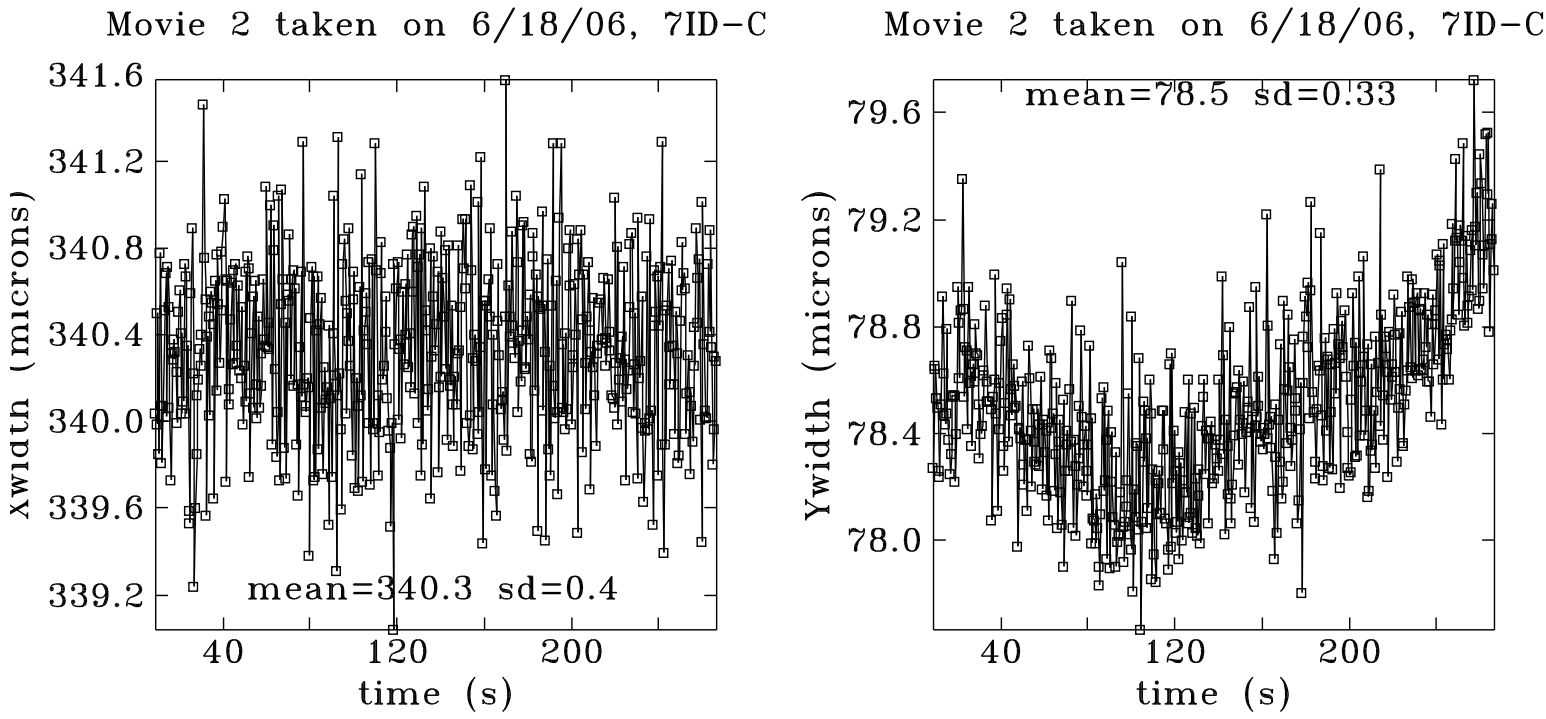

FIGURE 5. (Left) Gaussian fit width σ_x versus time. (Right) Gaussian fit width σ_x versus time.

2. Eric M. Dufresne, Dohn A. Arms, E. C. Landahl, D.A. Walko, Presented at the SRI2006 conference, May 28, 2006, to appear in the Proceedings of the conference.
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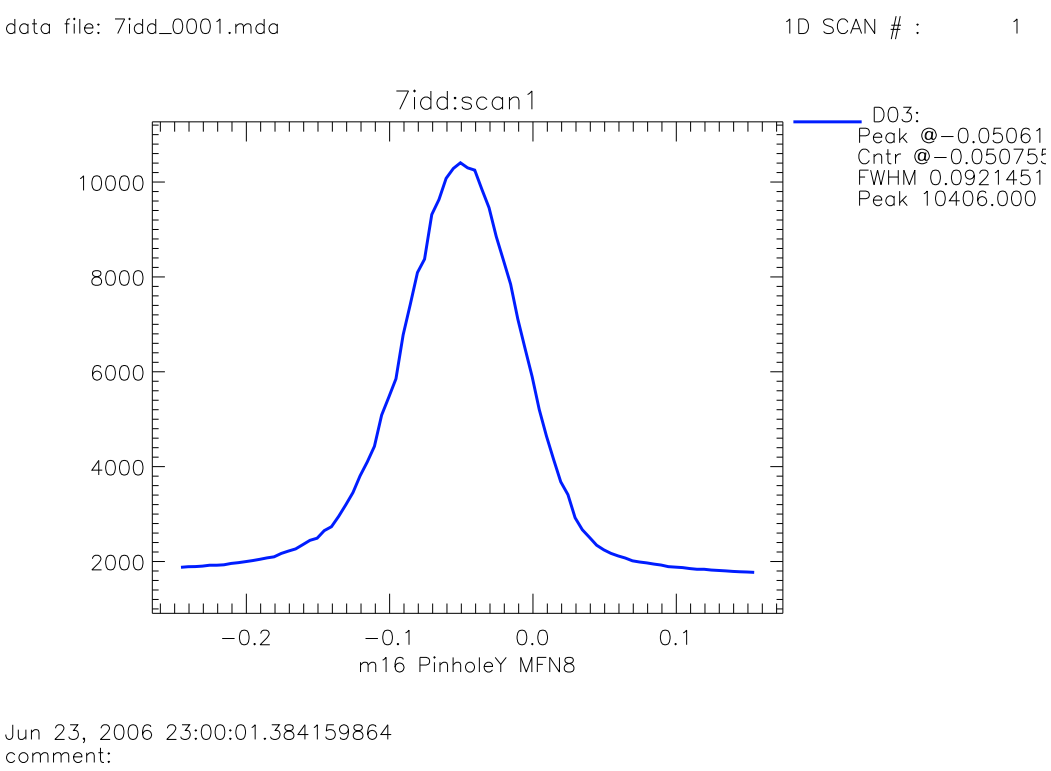

FIGURE 6. (Left) Beam profile in 7ID-D, 59 m from the source.