X8a and U3c beamline monochromatic slits: Characterization (Vertical)

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Introduction and Motivation

The U3c and X8a beamlines each have a set of 4-jaw monochromatic UHV slits. The U3c set was installed before 2004 and the X8a set was installed in early 2007. These slits can in principle be used to modulate the beam size and/or flux in a systematic way, potentially useful for a number of different kinds of experiments or tests on optical devices. In particular, calibration of diamond photoconductive detectors depends critically on precise (10 um) control of beam extent at the sample plane. Since this extent is typically in the vertical direction, the present study is limited to vertical characterization of the monochromatic slits. The purpose of the present study is therefore to provide quantitative characterization of the vertical performance of both of these slits installations, for reference of experimenters which may find utility in them. Further, any observed deficiency is explained and mitigations are proposed.

Setup

On each beamline, the slits were closed from top and bottom to first confirm whether the beam position and flux was indeed adjustable, and to determine which parts of the beam at the slit plane correlate to which parts of the beam at the sample plane. The filter holder was scanned vertically using the beamline automation software, using the edge of an empty holder position effectively as a knife edge to profile the beam produced under various settings of the slits. The beam midpoint is used as a reference for subsequent scans with prescribed vertical slit openings: 25-3200 um, in steps of 2x. Where useful, additional slit opening sizes were also scanned. This provided beam size and uniformity data as presented below.

Beam current is cut in half from the fully open slit position using each of the upper and lower slits, one at a time. The position of this “half-cutting” is recorded and used to define starting points for incrementing the beam size. In all cases, the micrometers are adjusted towards the closed state last, with at least 1 mm backlash correction. On the U3c beamline, the lower slit micrometer is a bit loose and was found to vibrate open somewhat over several minutes, so tape is used to hold the micrometer in place once it is set.

The current versus position data is typically differentiated once with respect to position, in order to provide beam shape information. Units of the beam signal in this case are typically Amperes per inch. If the raw edge data is to be compared for different the slit size, the signal is scaled by the slit size, thus giving units of A/um.

Photos of the slit assembly at each beamline are provided below:

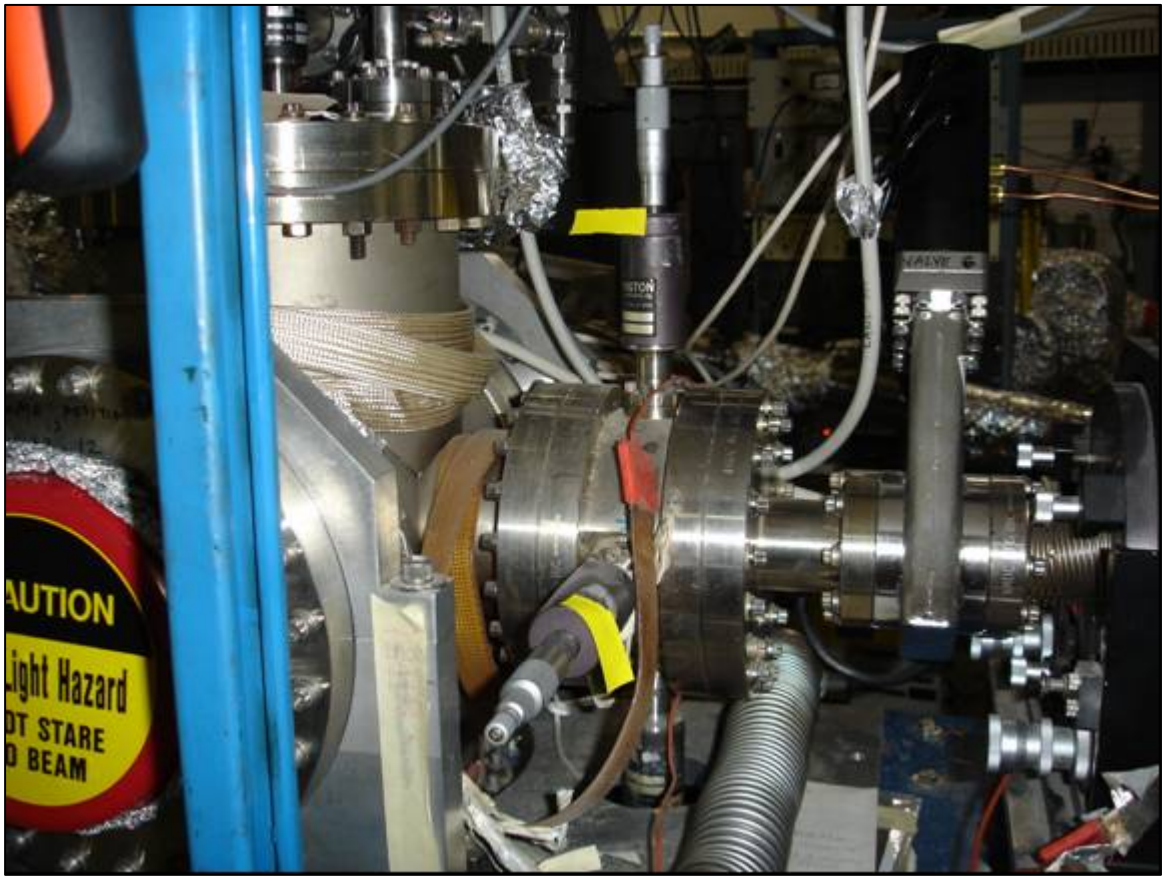

Figure 1. U3c monochromatic slits, located in the differential pumping station (DPS), just upstream of the downstream chamber (where the beamline filters are housed), roughly 55 inches upstream of the detector stalk.

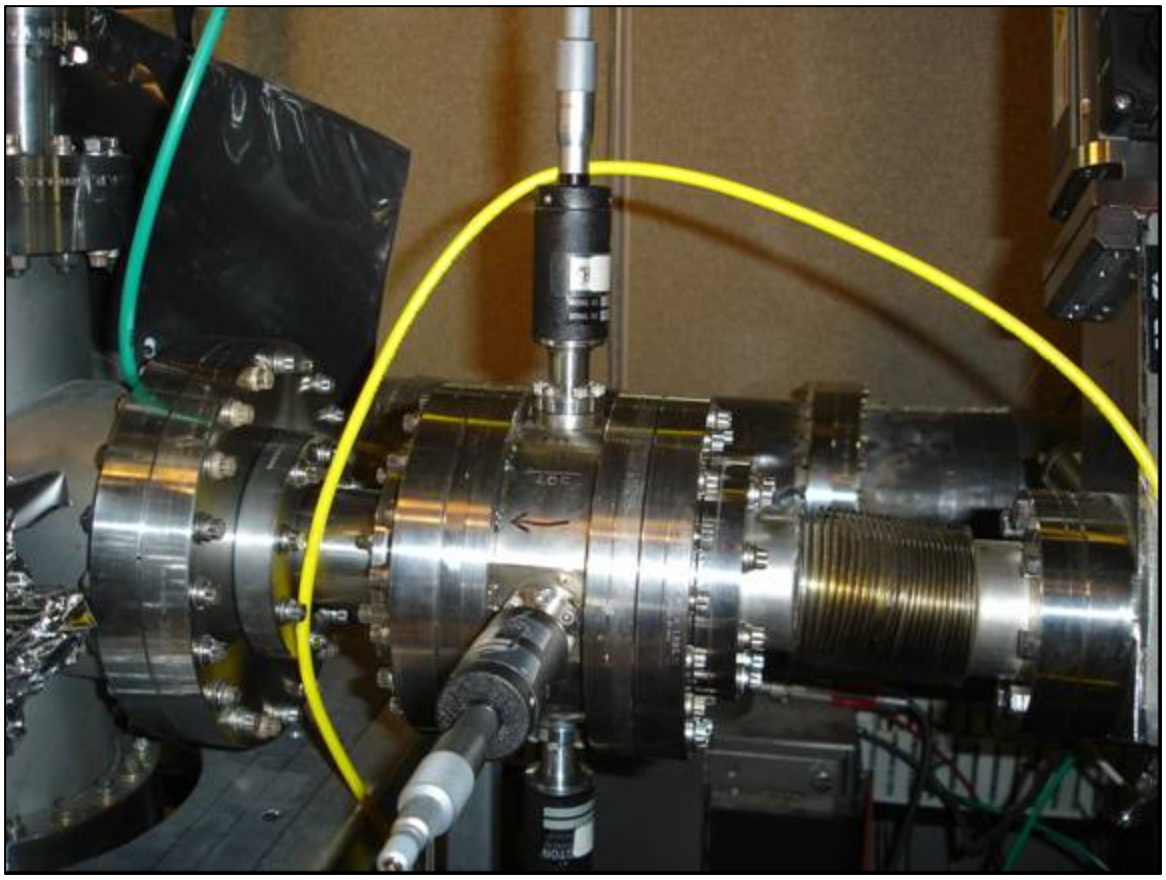

Figure 2. X8a monochromatic slits, recently installed just upstream of the downstream chamber (where the beamline filters are housed), roughly 18 inches upstream of the detector stalk.

Results

Similar data were collected for each beamline. Results are given for each independently.

U3c

600 eV beam is used. Half-cut scans from U3c are shown below. There is significant overlap of the "upper" and "lower" sections, indicating that the slits are probably not at a good location along the beamline for modulating beam size. Note that the detector stalk edge moves downward with increasing stalk position. Since the centroid of the "lower slit in" scan is at a higher stalk position (lower vertical position) than for the "upper slit in" we can conclude that in the "lower slit in" configuration, flux is preferentially being cut from the beam which normally strikes the upper part of the detector stalk. This means that the slits are upstream of the vertical focus, whereas the detector stalk is downstream of it. However, this effect is small. The fact that the two half-cut scans overlap considerably indicates that the slits are actually quite near the focus. This observation is in agreement with the recent vertical divergence investigation for

the U3c beamline. Extrapolating the diverging beam and size from the detector stalk gives an estimate for the focus position as being near the downstream edge of the downstream DPS chamber, roughly 42 inches upstream of the detector stalk. This estimate is accompanied by rather large (~8 inch) error due to the small divergence values measured (ranging from 0.5 to 1.2 mm/m, see that document for more detail). This focus is near the position of the beamline filters, and not far downstream from the position of the slits.

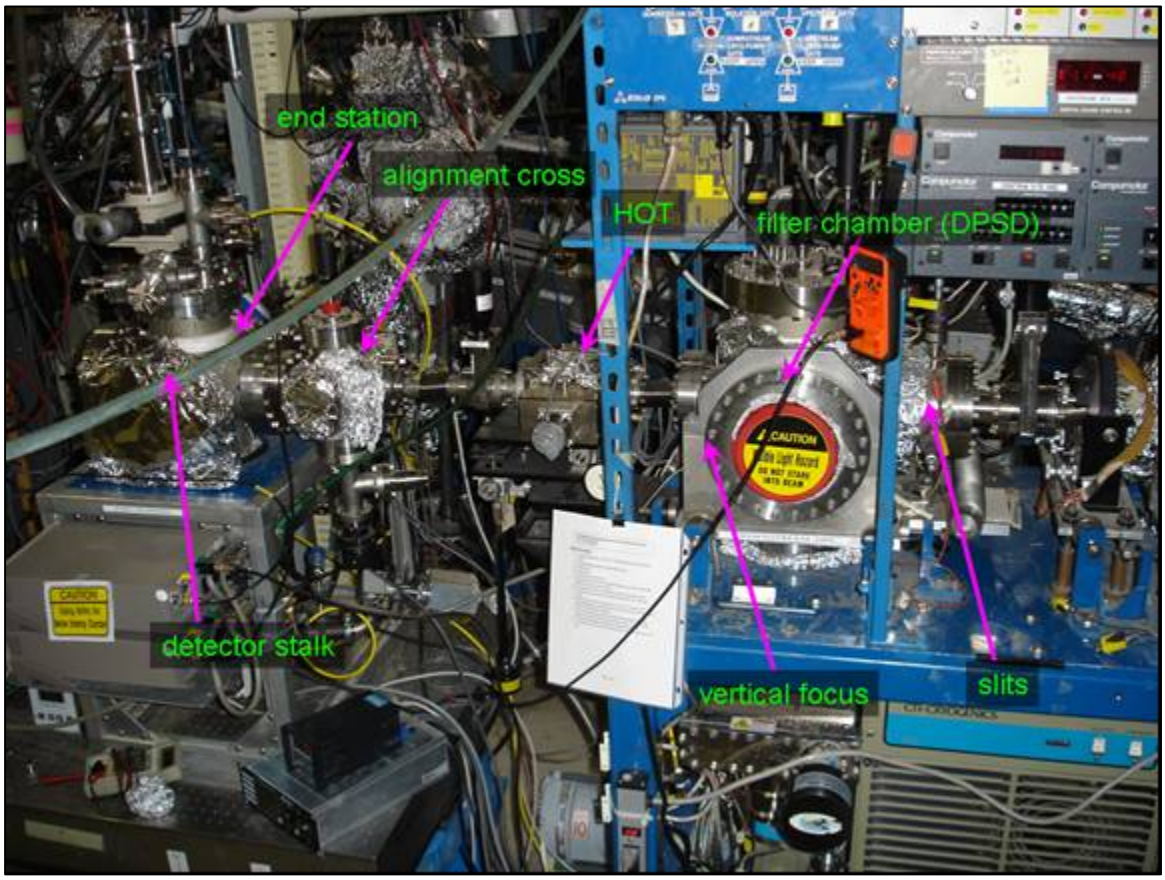

Figure 3. U3c beamline layout.

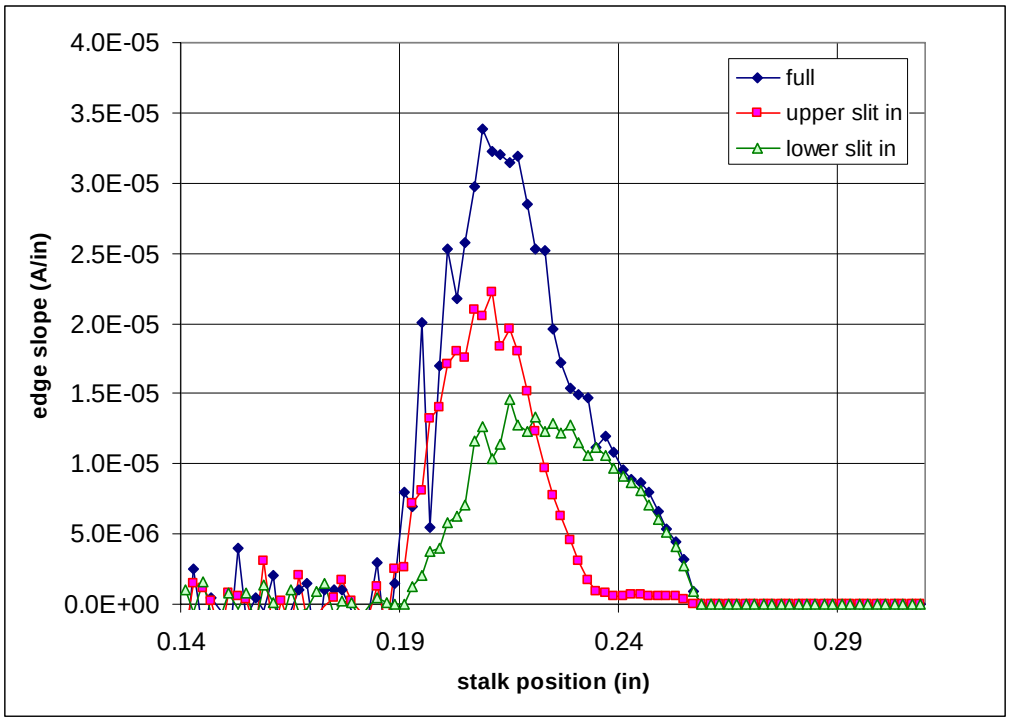

Figure 4. U3c “half-cut” scans.

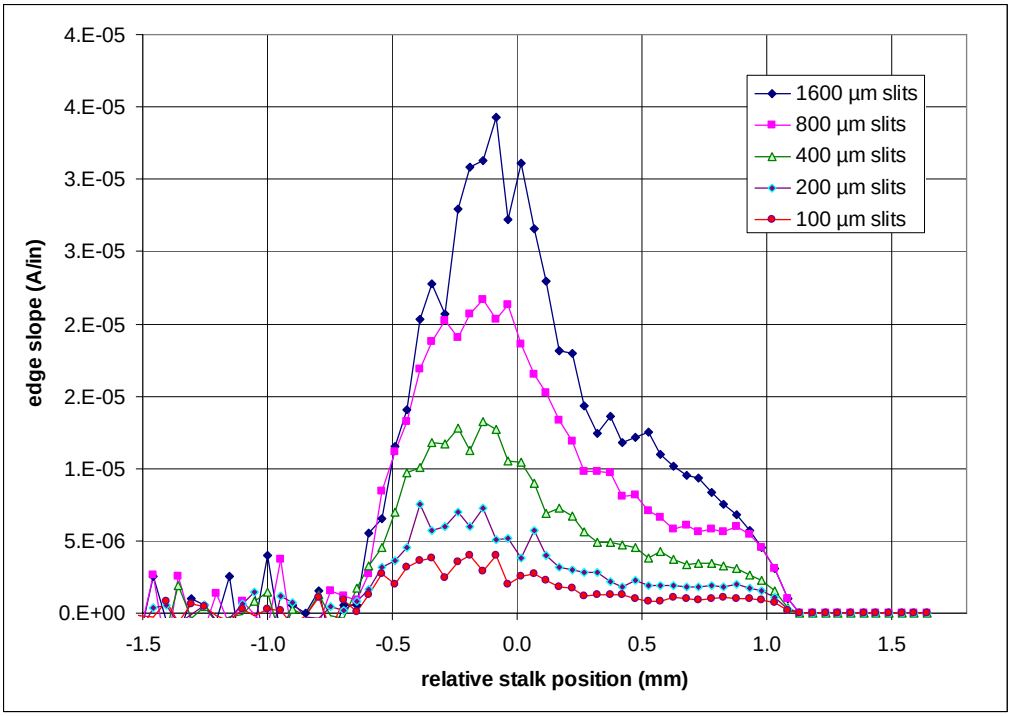

Figure 5. U3c profile scans for various vertical slit openings. Note the beam shape does not change, although the intensity does.

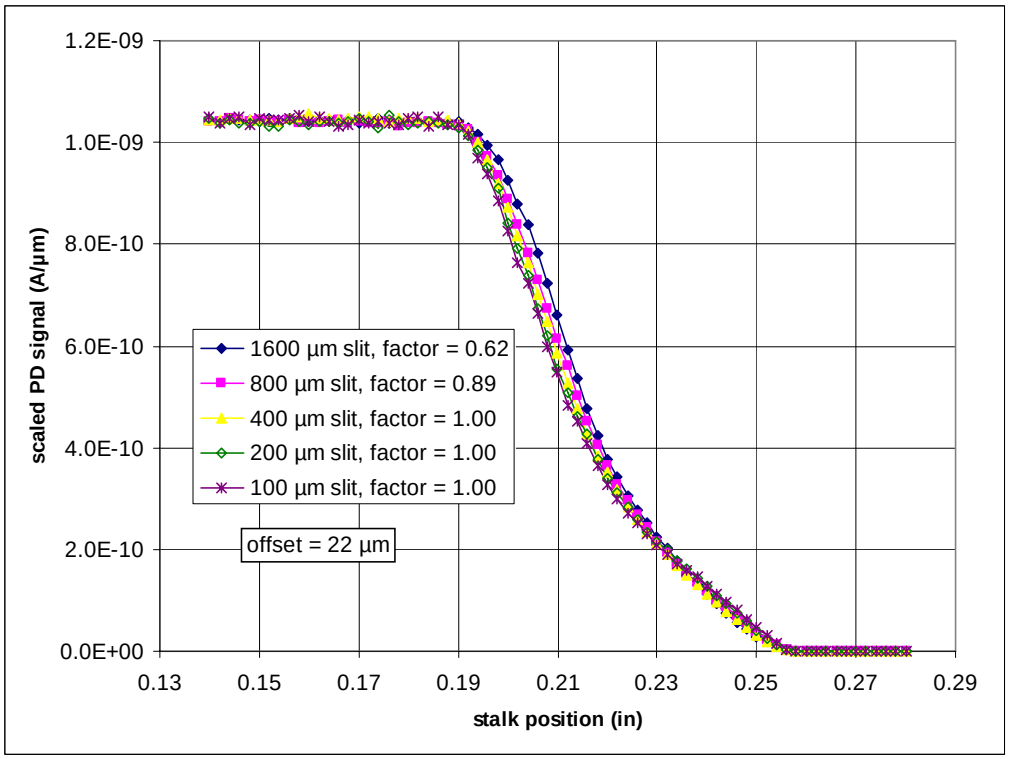

Figure 6. U3c raw scan data, scaled by slit size. The scans are normalized by the slit opening, as well as corrected for constant offset in the actual open size and any underfilling of the slits.

The non-unit scaling with slit size above 400 um suggests that the beam is between 400 and 800 um in size at the slit position (agreeing with the hypothesis that the slits are near the vertical beam focus).

Although the slits cannot be used to modulate the beam size, they can be used to modulate the flux, with minimal effect on the beam shape. This may be useful for a number of experiments.

Experiments were tried with the beamline filters and/or HOT in the beam and out of the beam and the behavior of the slits was found to not be affected by those things.

X8a

4000 eV beam is used. Half-cut scans from X8a are shown below. There significantly less overlap of the “upper” and “lower” sections, indicating that the slits are probably at a good location along the beamline for modulating beam size. Note that the detector stalk edge moves downward with increasing stalk position. Since the centroid of the “lower slit in” scan is at a lower stalk position (higher vertical position) than for the “upper slit in” we can conclude that in the “lower slit in” configuration, flux is being cut from the beam which normally strikes the lower part of the detector stalk. This means that the slits and endstation are both downstream of the vertical focus. The fact that the two half-cut scans do not significant overlap considerably indicates that the slits are far from the focus, and can probably be used to modulate beam size effectively.

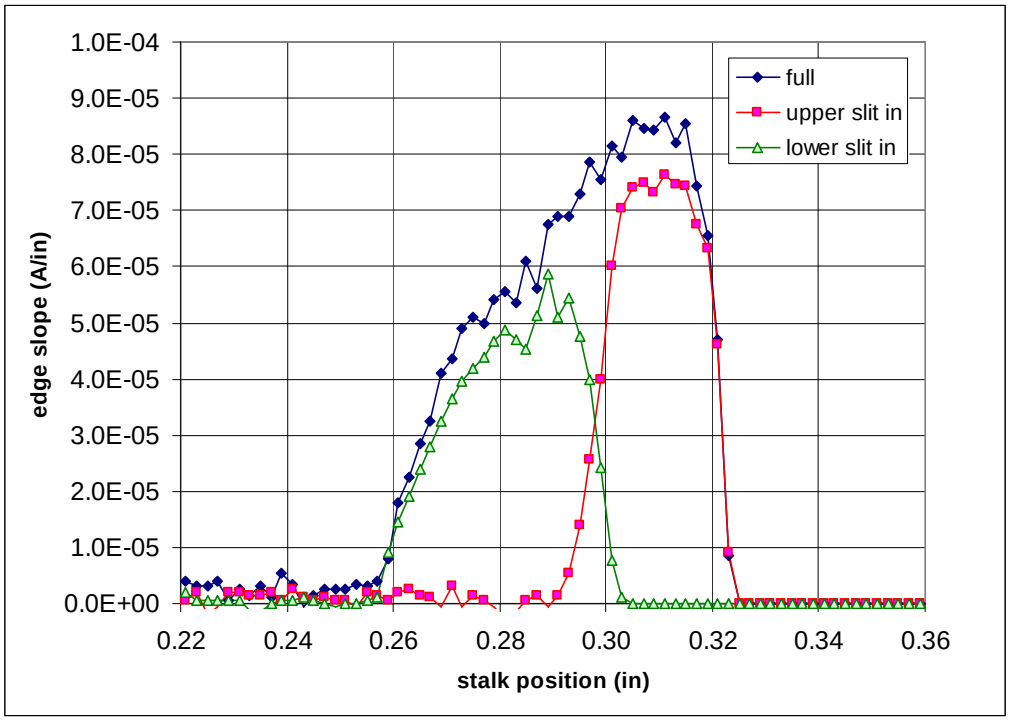

Figure 7. X8a “half-cut” scans.

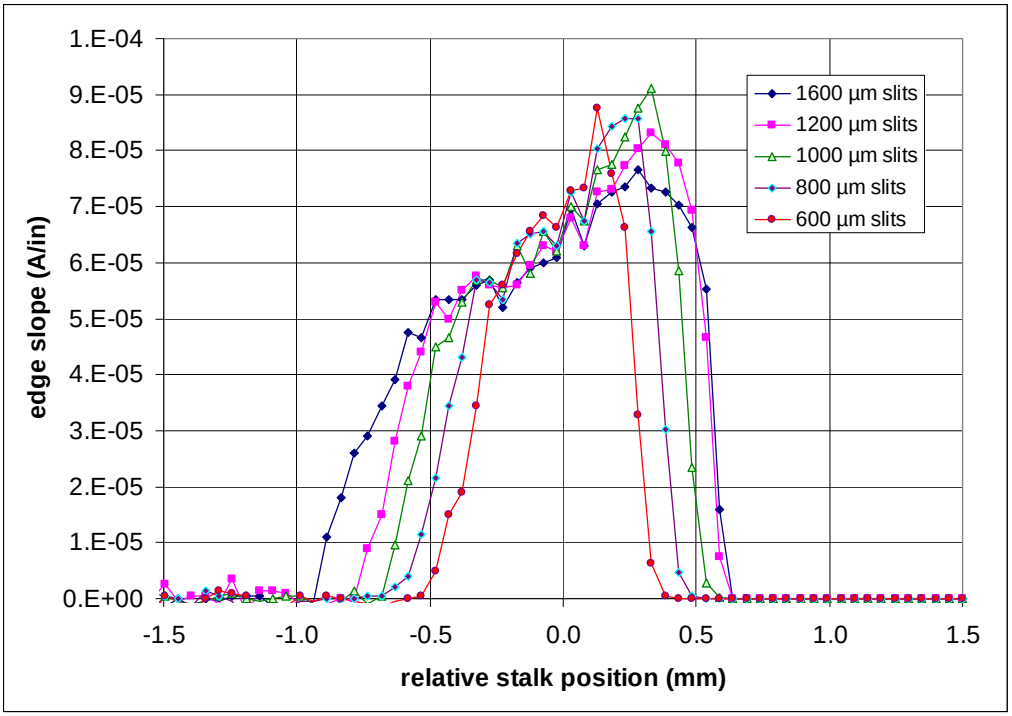

Figure 8. X8a profile scans for various vertical slit openings. Note the beam shape changes in a quite predictable way, in concert with total beam flux.

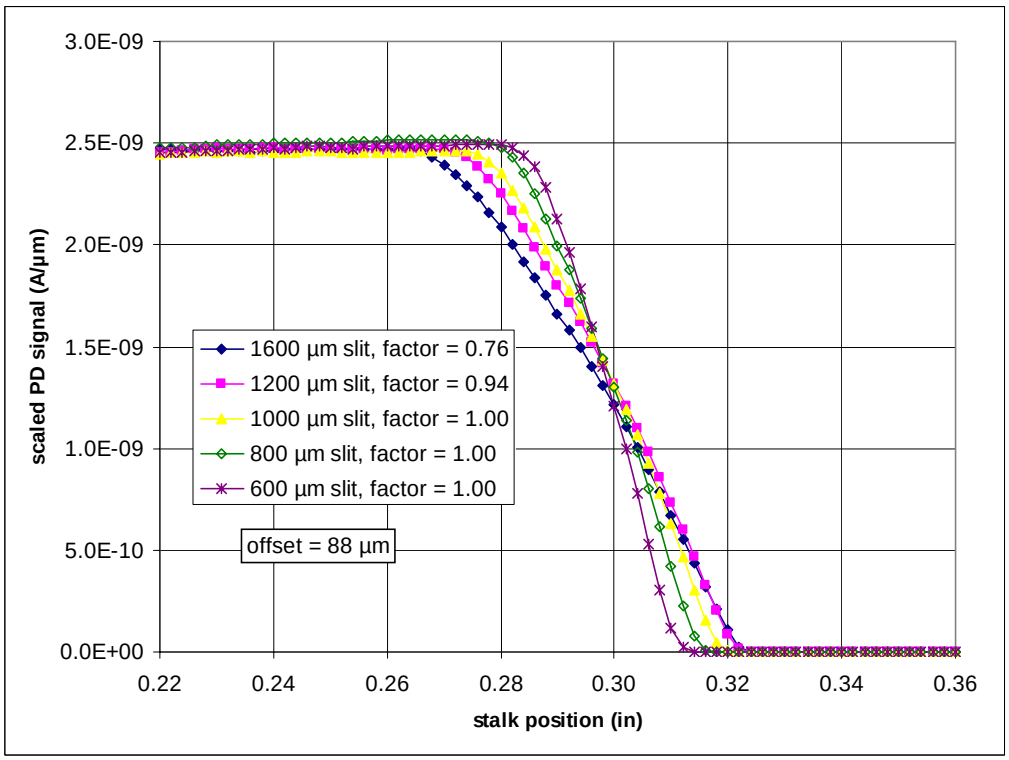

Figure 9. X8a raw scan data, scaled by slit size. The scans are normalized by the slit opening, as well as corrected for constant offset in the actual open size and any underfilling of the slits.

The non-unit scaling with slit size above 1200 um suggests that the beam is roughly 1200 um in size at the slit position.

The X8a monochromatic slits can be used to modulate the beam size, as well as the flux. This should be useful for a number of experiments, including diamond PCD calibrations.

Discussion

Both U3c and X8a monochromatic slits were tested for vertical beam flux and shape modulation capability. The experimental method found to be most effect in determining this is based primarily on scans at the endstation with the beam cut by 50% from above or below. This gives the imaging condition (position of the endstation / slits with respect to beam focus), and provides a starting point for modulating beam size. Subsequent scans with various beam sizes provided means for quantifying the beam shape and intensity as the slit opening is changed.

Conclusion

The X8a monochromatic slits can be used to modulate vertical beam size for endstation experiments effectively. The U3c slits can be used only to change the flux. This is because the U3c monochromatic slits are located near the vertical focus of the beam. For modulating the beam shape at U3c, slits should be installed closer to the detector stalk.

Future

The PRT may consider purchasing slits to go immediately upstream of the U3c endstation, in similar fashion to what is installed presently at X8a. The chamber presently located in this position can be replaced with a slit assembly (it functions only as alignment target presently, a function which the slits can also provide). This upgrade potentially can be coordinated with possible future upgrade of the beamline order sorter, which is adjacent on the beamline. See the photo in figure 10 below for an illustration.

Additional future possibilities include automation and horizontal characterization, as needs arise.

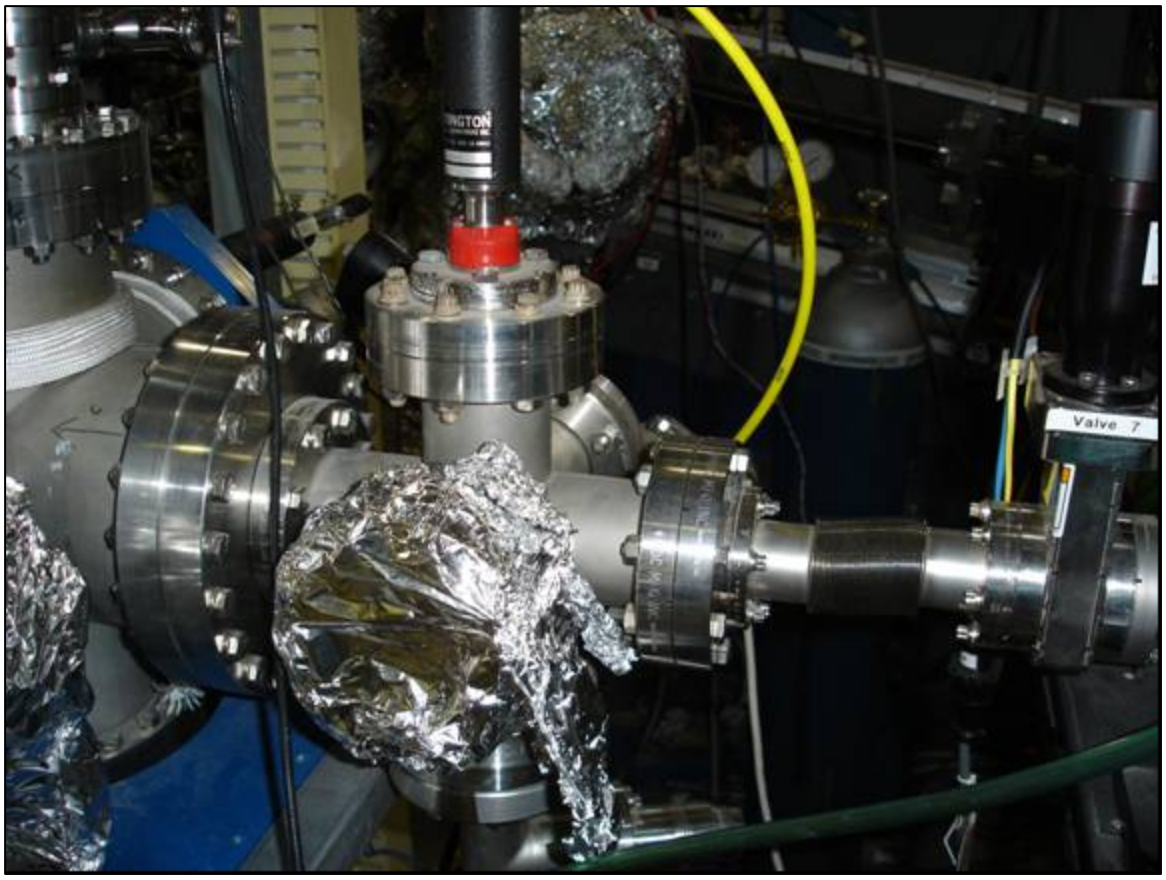

Figure 10. U3c “alignment cross” chamber. This might be a good place to install slits at U3c for modulating monochromatic beam size.