Observations of beam-tilt on the 7ID monochromatic beam.

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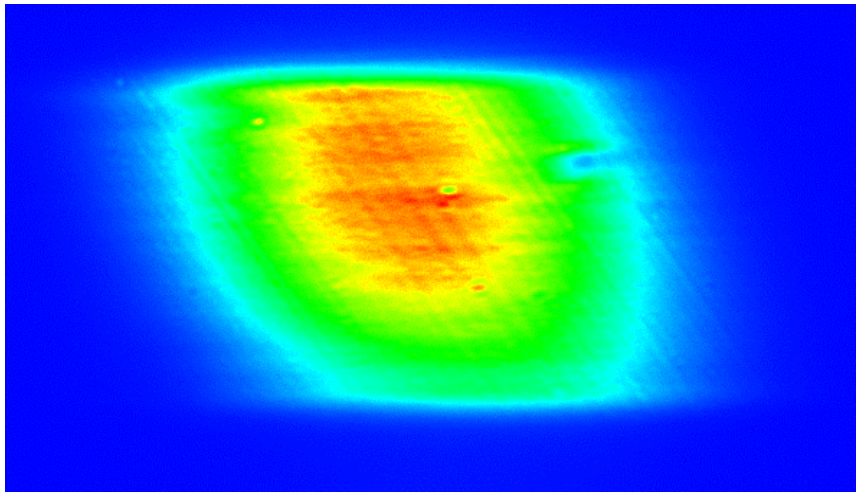
Outline

- Motivation.
- Experimental set up.
- Pinhole camera measurements.
- Beam profile 51.5 m from source.
- Gap energy dependence of beam profile at 51.5 m.

Motivation

- In preparation for testing new CXRL made of Li, we needed to characterize the beam profile before the lens.
- Also we wanted to try to see the effect on the focal spot of cutting the horizontal source size with our 7ID-A WB slits.



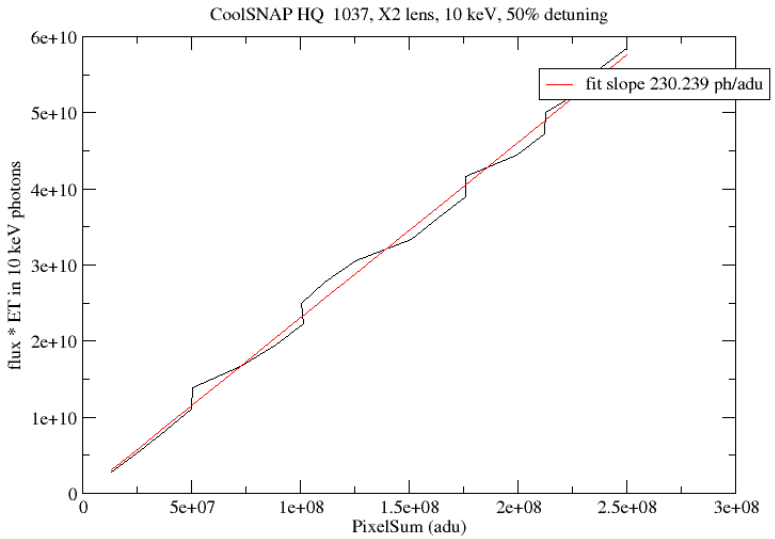
WB slit set to 500μm x 500 μm

N.B. poor hor. edge contrast and strange tilt

Experimental set up on 7ID

- Front end mask limits the white beam to 3mm (H) x 2 mm (V). 7ID gap optimized for 10 keV monochromatic beam.
- L5-20 white beam slit can reduce the beam size on the monochromator. (Location 26.5m.)
- Double crystal Monochromator Si (111) 30m from the source set to 10.000 +/- 0.001 keV.
- Imaging system: YAG:Ce imaged with a CoolSNAP HP, using a X2 Mitutoyo objective.
- FOV 4.5mm (H) x 3.4 mm (V), resolution 0.003 mm.
- Full monochromatic flux ~2.0x 10^{13} ph/s

Experimental set up (cont.)



Calibration from ADU to 10 keV photons

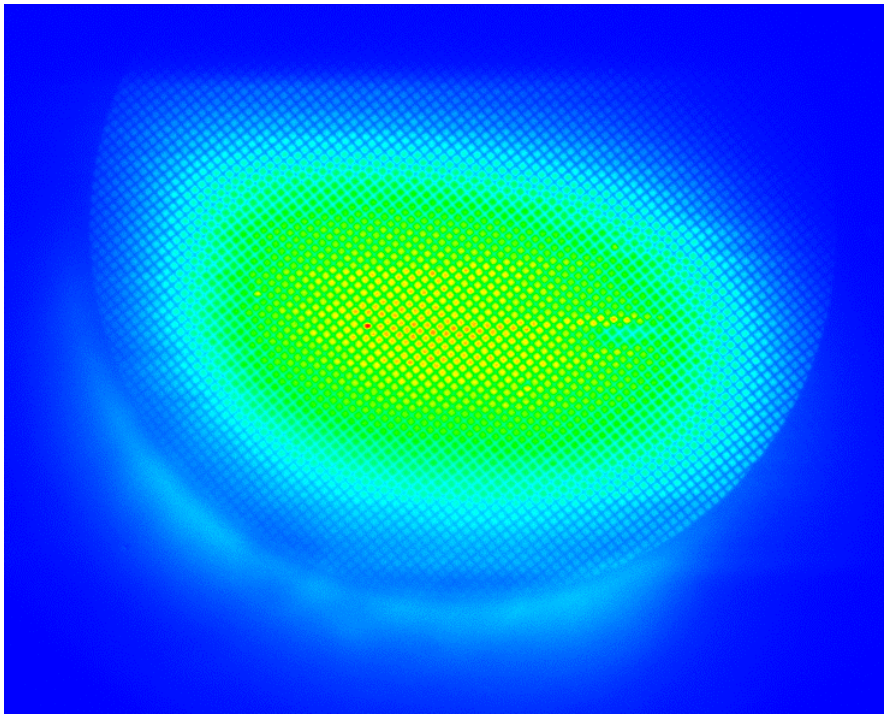
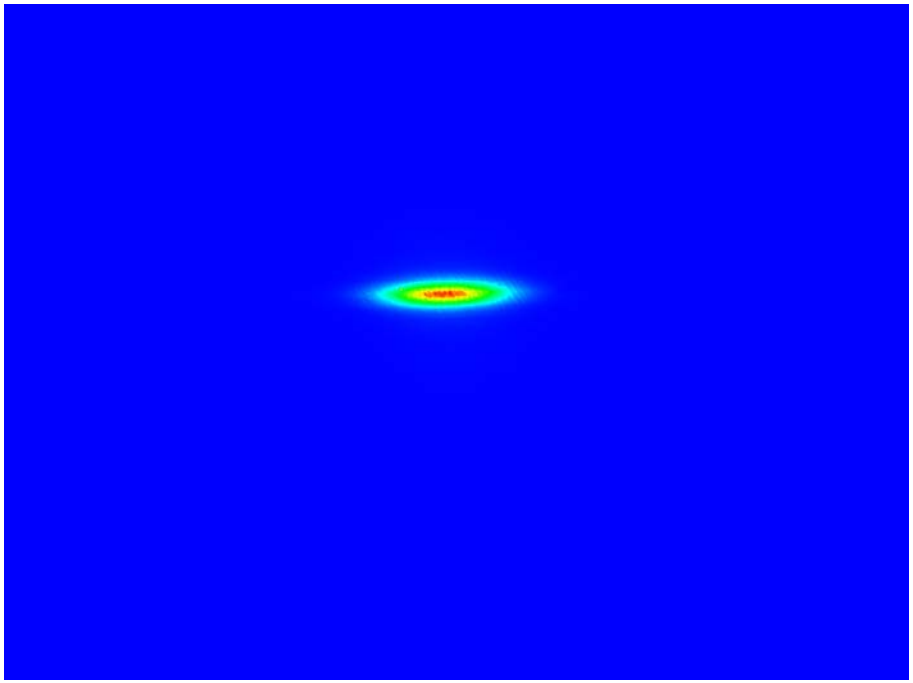


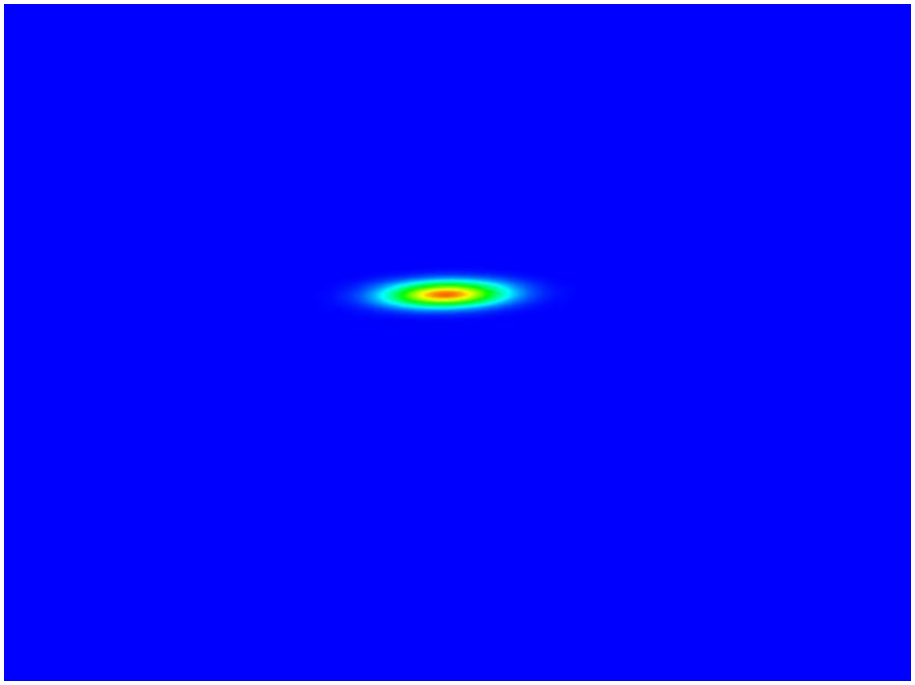
Image of a 25 μm pitch Au grid

Data and fit for pinhole camera

Set L5-20 WB to ~ 0.1 mm x 0.1 mm opening (calibration may be off).
L5-20 should be smaller since slit Fraunhofer diffraction pattern ~ 0.031mm wide.



Data



Fit to a tilted Gaussian

Pinhole camera (cont)

- Effective pixel resolution 3.225 microns.
- First if one fixes the tilt angle to ZERO, and performs a non-linear LSQ fit to a 2D Gaussian, then the following fit parameters are found: Xisq = 149.711, PEAK_INTENSITY = 2958.7 +/- 0.3, Xcenter = 678.060 +/- 0.007 pixel, Ycenter = 594.820 +/- 0.002 pixel, Xwidth = 60.909 +/- 0.007 pixel, Ywidth = 13.057 +/- 0.002 pixel, **tilt angle= 0 degree**
- If one includes a tilt angle to the 2D Gaussian fit, then Xisq = 119.6 (reduced), PEAK_INTENSITY = 2963.2 +/- 0.3, Xcenter= 689.90 +/- 0.02 pixels, Ycenter= 581.09 +/- 0.02 pixels, Xwidth= 61.014 +/- 0.006 pixels, Ywidth = 13.022 +/- 0.001 pixels, **tilt angle= 1.150 +/- 0.002 degrees**. This is a better fit.
- The fitted hor. source size σ_X= 61 pixels x 3.2 μm/pixel = 196.8 μm RMS. σ_y= 13 pixels x 3.2 μm/pixel = 42.0 μm RMS.
- From the APS parameters provided by the OAG, one expects σ_X= 280 μm (observed 197).
- In the vertical the camera cannot resolve the source size σ_y= 8.6 μm. The RMS vertical divergence is $\sigma_{y'}$= 5.9 μrad, thus 26.5 m away, the beam vertical FWHM is 367 μm. The slit limits the FWHM to about 200 μm in the plane of the CCD camera and we observe ~ 100 μm FWHM.
- The slit opening wasn't carefully calibrated, so it may have been smaller than 100 μm x 100 μm.

Analysis of tilted beam from divergent beam in 7ID-C

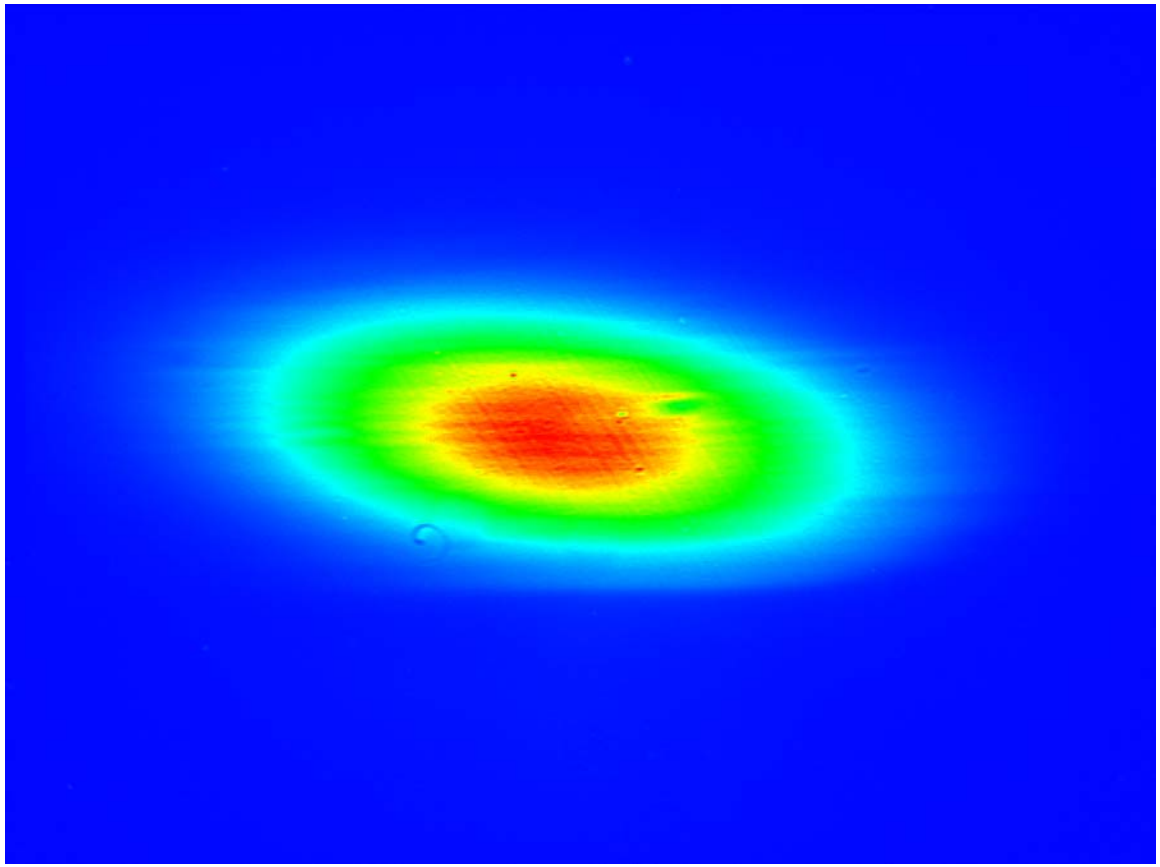
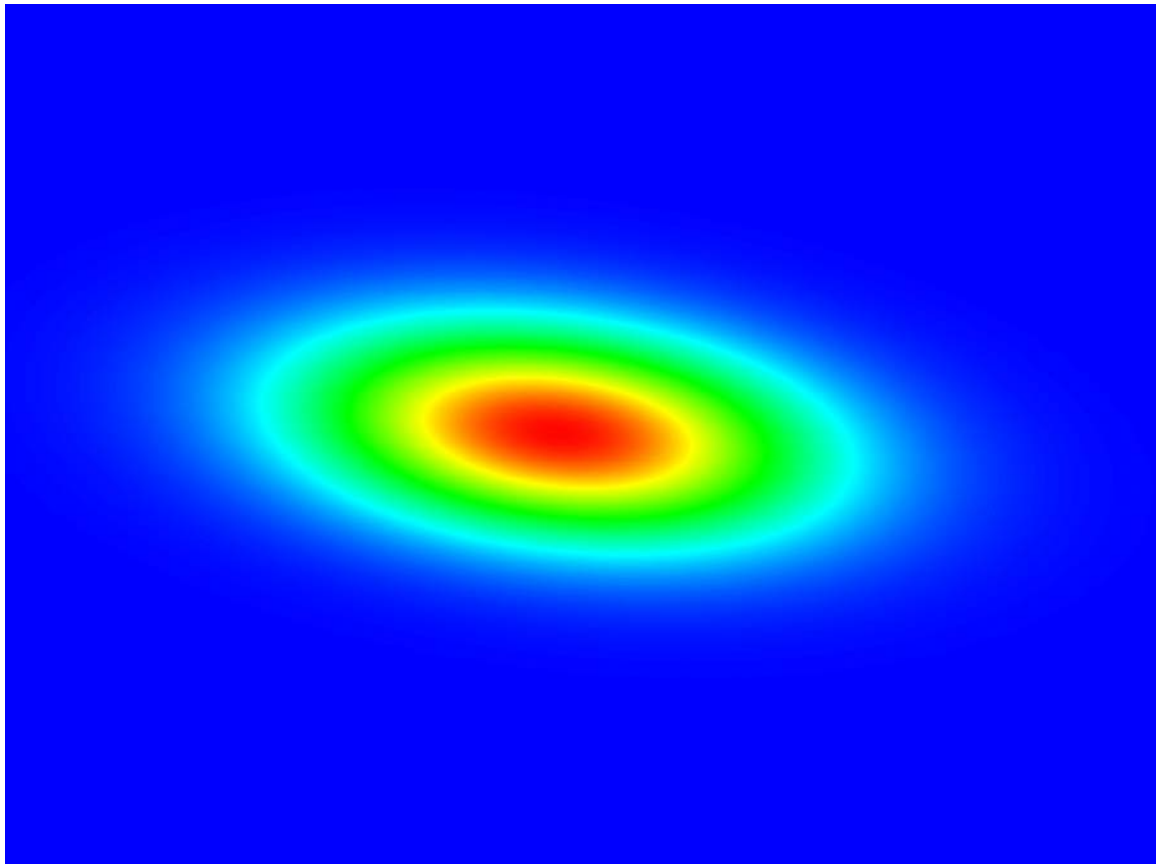


Fig. 1: Data taken
In 7ID-C. WB slit
Set to 3mm (H)
x 2mm (V)
Mono 10 keV
ID gap 10.055 keV
Exp. time 15ms

7ID-C divergent beam (cont.)



Tilted Gaussian fit
Same color map as
Data from previous page
Tilt –6.66 deg.

Fit details

Xisq = 1667.14

PEAK_INTENSITY = 2973.9 +/- 0.2 ADU

Xcenter = 603.71 +/- 0.04 pixel

Ycenter = 596.36 +/- 0.03 pixel

Xwidth = 217.44 +/- 0.02 pixel **(Σ_x = 701 μm, one expects 738 μm) (RMS)**

Ywidth = 85.975 +/- 0.007 pixel **(Σ_y = 277 μm, one expects 296 μm) (RMS)**

tilt angle = -6.656 +/- 0.003 degrees

Very good agreement between theory and experiment for Σ_X and Σ_y

If one does not use a tilted coordinate system, the fits are worse than above with a higher chi^2.

Xisq = 6831.96 (factor 4 worse)

PEAK_INTENSITY = 2946.2 +/- 0.5 ADU

Xcenter = 669.08 +/- 0.03 pixel

Ycenter = 522.37 +/- 0.01 pixel

Xwidth = 213.62 +/- 0.03 pixel

Ywidth = 87.89 +/- 0.01 pixel

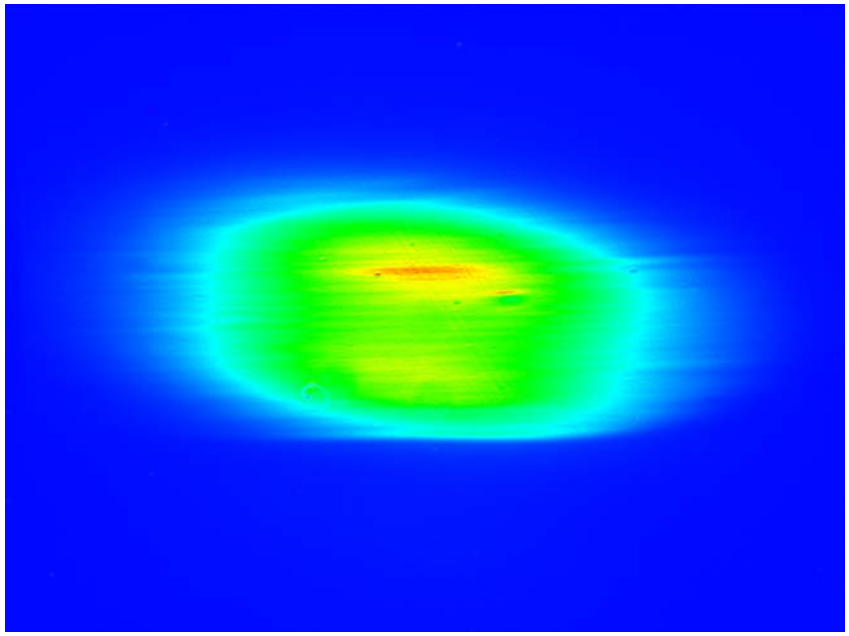
tilt angle = 0 degree (fixed)

Tilted beam discussion

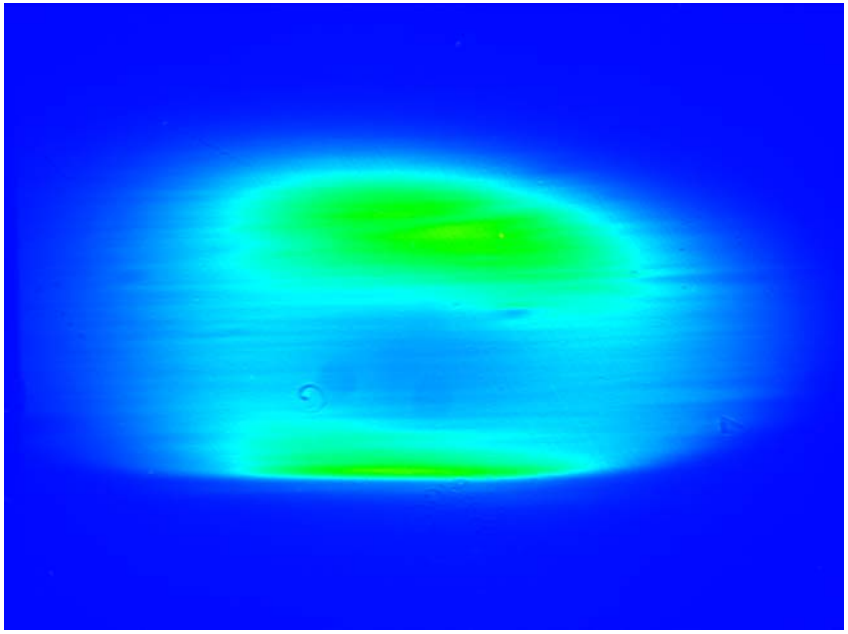
- After discussion with Louis Emery, he explained that the tilt on the pinhole camera image at sector 35 is real, and that it is larger than last run for unknown reasons. To get better lifetime they had to apply current to the skew quadrupole magnets to increase the vertical beam size. The by-product is some beam tilt everywhere.
- Louis also expects that the tilt far away from the source is a factor $\beta x/\beta y$ larger than in the source plane. Since, $\beta x/\beta y = 20/2.9 \sim 7$, the measured 6.7 degree is consistent with his estimate.

ID Alignment 101

When the gap energy is set above the monochromator energy, a valley in the beam profile develops on-axis. This is a useful trick to find the ID axis location. Below the mono is set to 10.000 keV.



Gap energy = 10.155 keV
(100 eV above optimal)



Gap energy = 10.555 keV
(500 eV above optimal)
Same color map.