MOSAIC CCD array surface profile measurements
Version 0.6

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1   Introduction and background

The new MOSAIC array for the Palomar 48" Schmidt telescope is composed of twelve CCDs. Since the optical system is fast ($f/2.5$) it is important to understand the surface profile of the detector array, both when warm and cold. This document maps the profile to contour and surface plots based on data obtained using Carnegie Observatories' confocal laser distance measuring device with 2 μm resolution. The optically polished CCD window is to be scanned later for checking the performance of the X and Y stages.

2   Depth of focus for the array

According to [1], the seeing limited depth of focus is given by: DoF $= \pm$ 0.2 F pixelsize $= \pm$ 0.2 *(2.5) * 15 $= \pm$ 7.5 μm (based on [2]).

3   Data and Results

The CCD array was scanned using a Keyence 8110 confocal displacement meter.

Scan spec.	RMS (μm)	P-V (μm)	Comments
2x2 mm flat	11	63.40	data from slower scan
1x1 mm flat	8.92	63.3914	resembles 2x2 mm scan
CCD window	5.52	40.72	bowed
Optical flat	1.57	8.9	
Optical flat rotated 90 deg.	1.35	7.66	close resemblance to 0 degrees
Optical flat difference between 0 and 90-deg. data	0.647	2.44	

Table 1: PV and RMS in μm for the profilometry measurements for the different scans using the filtered image. The Keyence sensor resolution is 0.2 or 0.4 μm (depending on scan mode) [3]

The data from the profilometer is shown in Figure 27. The profilometer's inablility to map the whole array is apparent in this Figure. The gaps in the detectors and invisible areas were filled with a nominal threshold of -150 μm for this plot.

Only 8 CCDs were fully scanned by the profilometer, the rest mostly gave spurious data. So I cropped the image to just use the useful part of the surface profile. Even within the 8 CCDs, the scanner either saw a small invisible area or picked up a detector edge, this can be seen clearly in 2.

It is clear from both Figures 1 and 2 that there is a general tilt on the detector. So, I fitted a plane to the data and subtracted the plane out of the data. To make an effective plane, I filtered the image get rid of sharp edges. I have also plotted the raw data with the tilt taken out for most of the scans.

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3.1 2 mm data

I reformatted the data to look like the previous one. I used a 0 μm threshold instead of a -150 μm threshold this time. The tilt of the plane was almost left-to right this time, the original data had it go somewhat diagonal from the bottom-right to the top left. The quality of second set with extended settling time sure seems better than the first one. Figure ?? shows the 8 CCDs clearly having slightly different orientations with respect to each other.
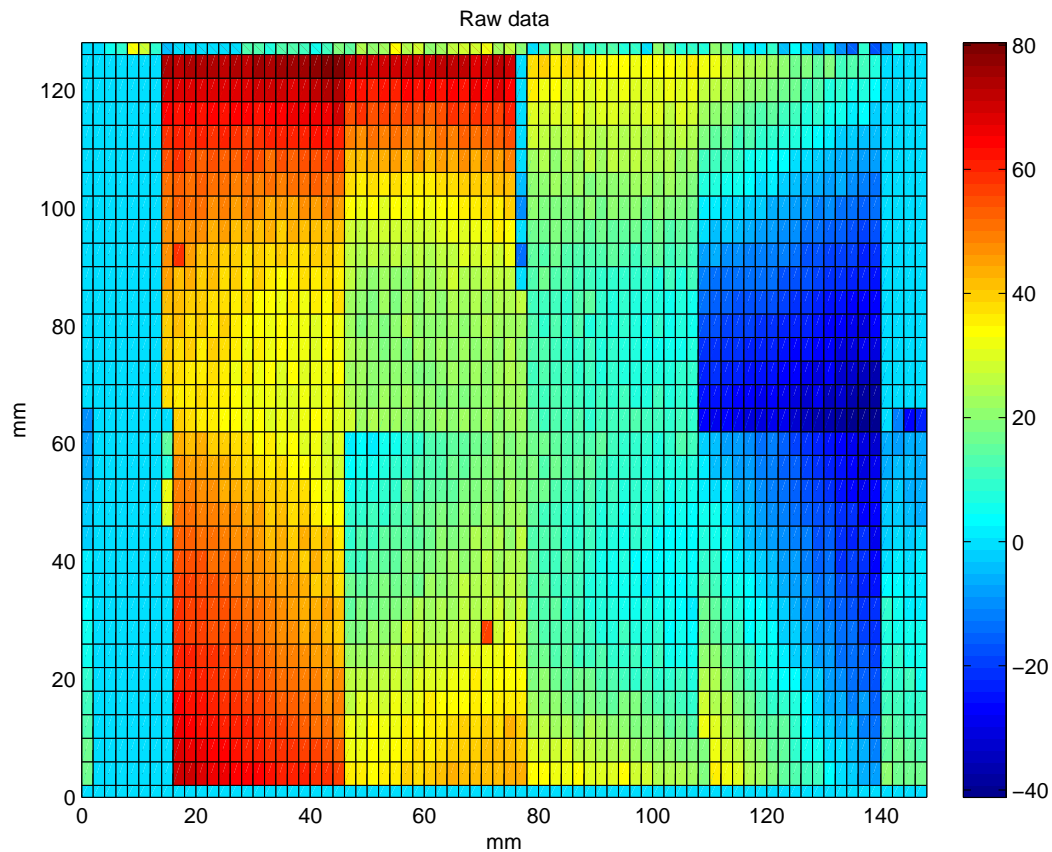
3.1.1 sample plots

Figure 1: Contour plot of the MOSAIC array. The profilometer could not map the upper left, lower left and upper right parts of the array as the sensor didn't get enough signal. Scale is μm on Z axis
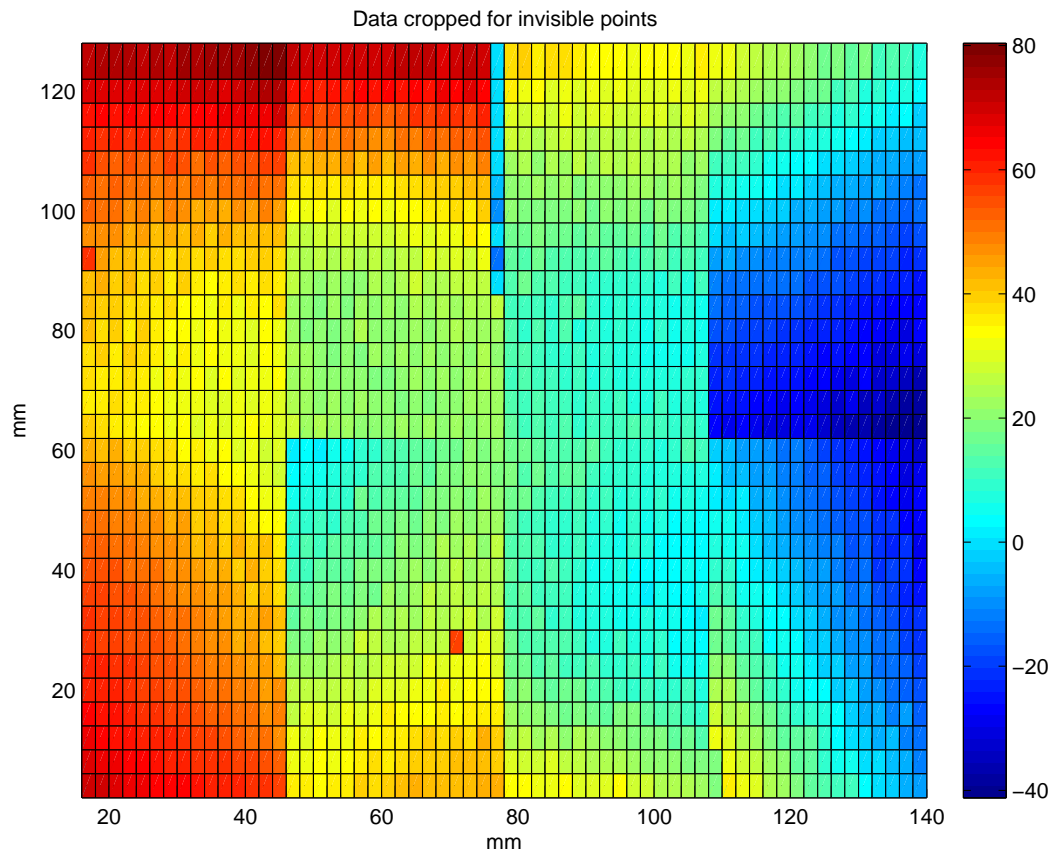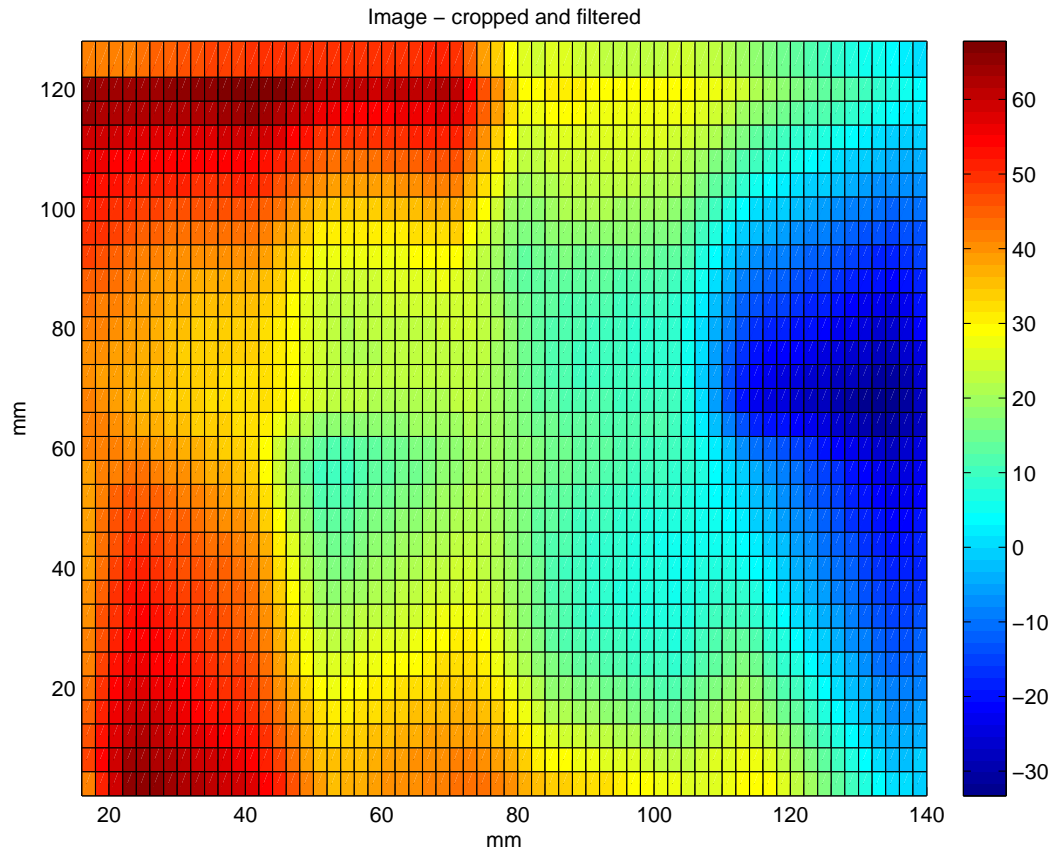
Figure 2: Contour plot of the MOSAIC array - cropped

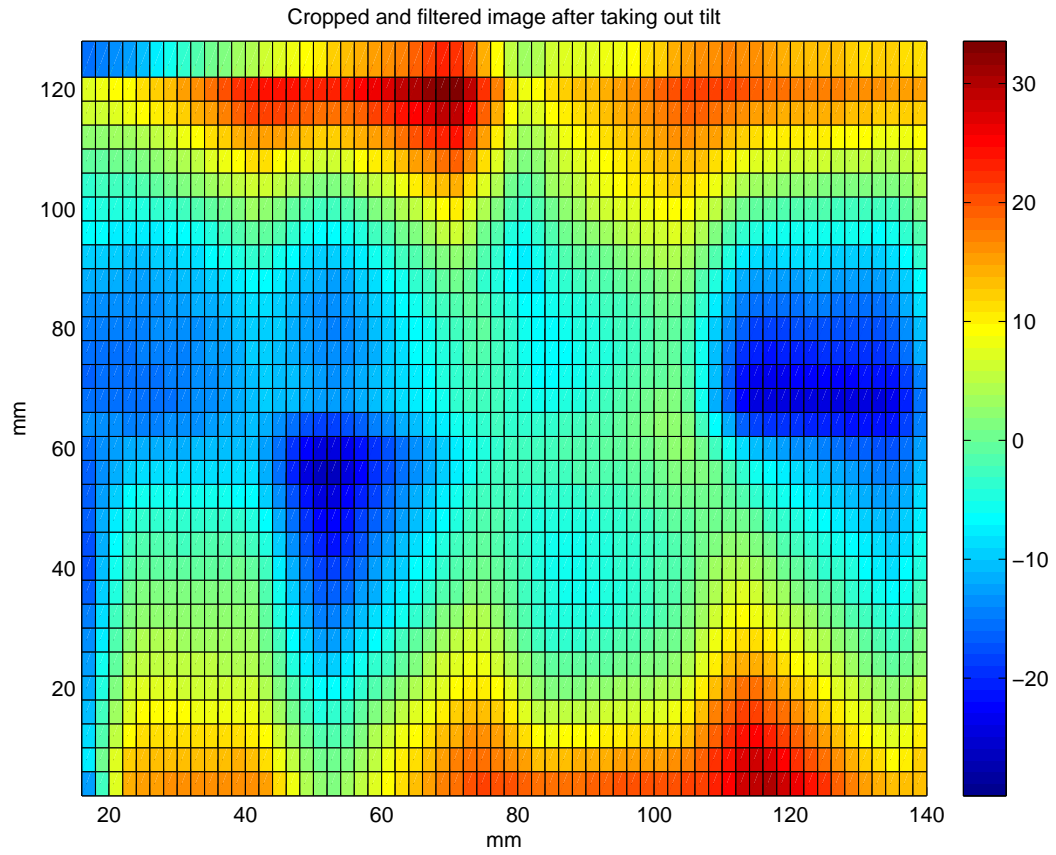Figure 3: Contour plot of the MOSAIC array after applying 3x3 filter

Figure 4: Contour plot of the MOSAIC array after applying 3x3 filter after taking out tilt
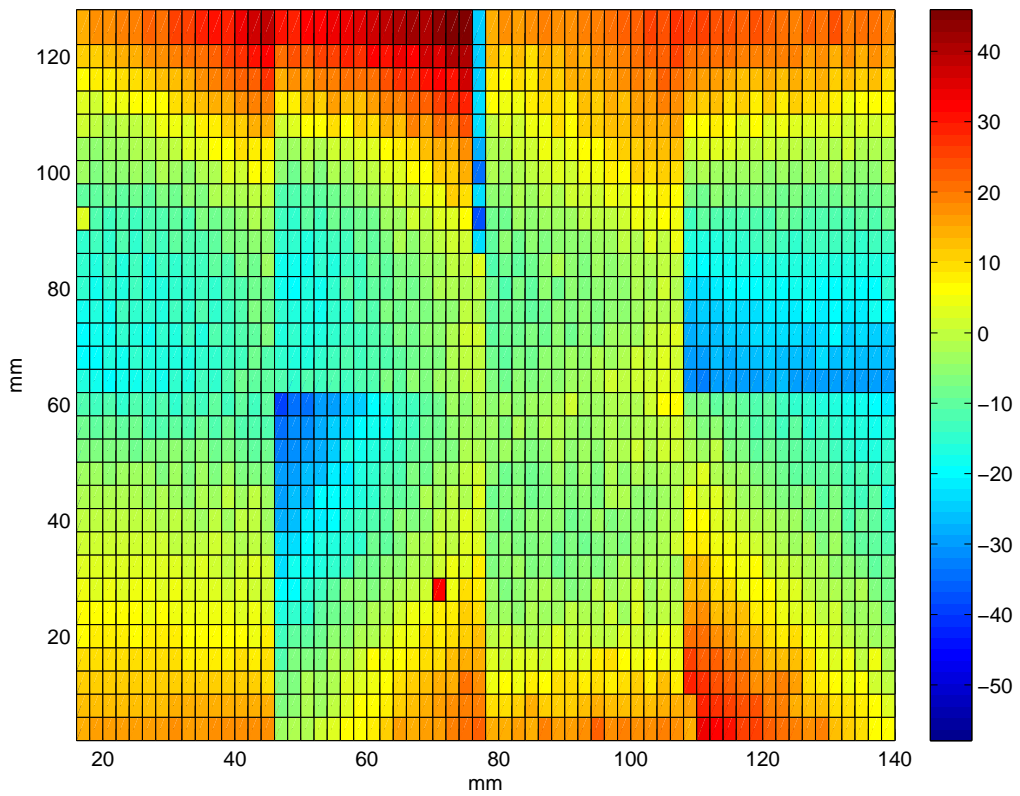
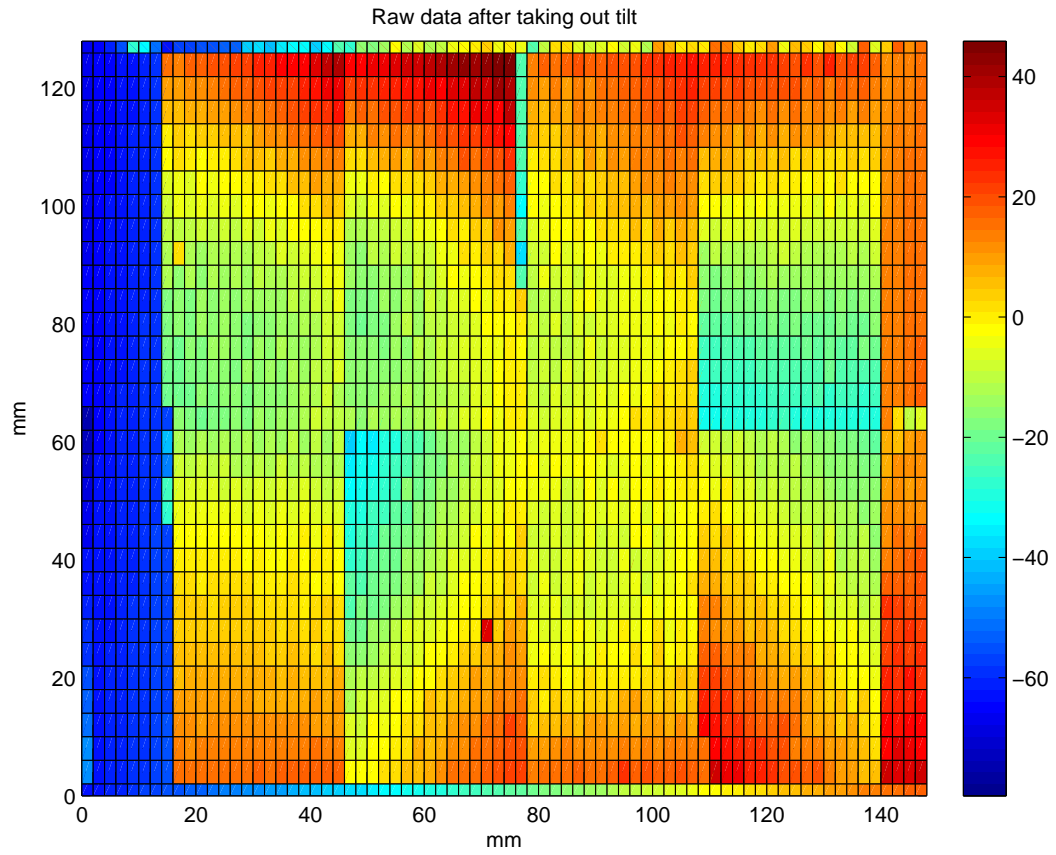Figure 5: Contour plot of the MOSAIC array - cropped raw data sans tilt

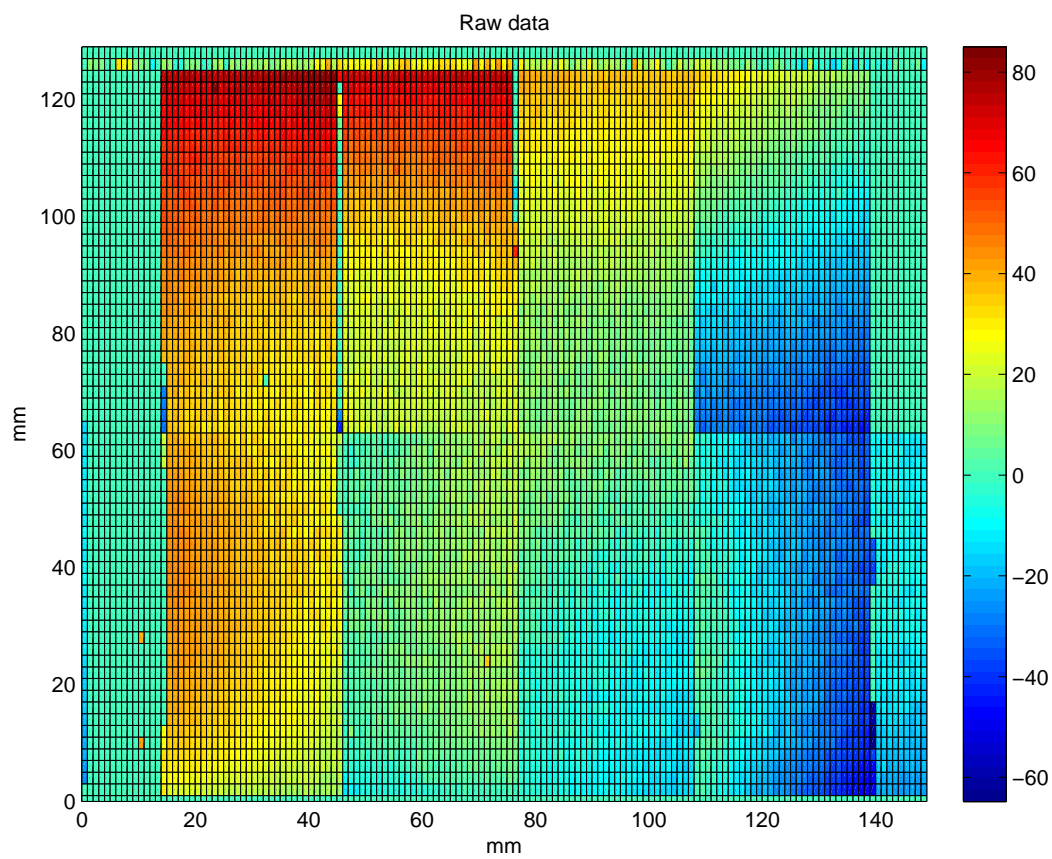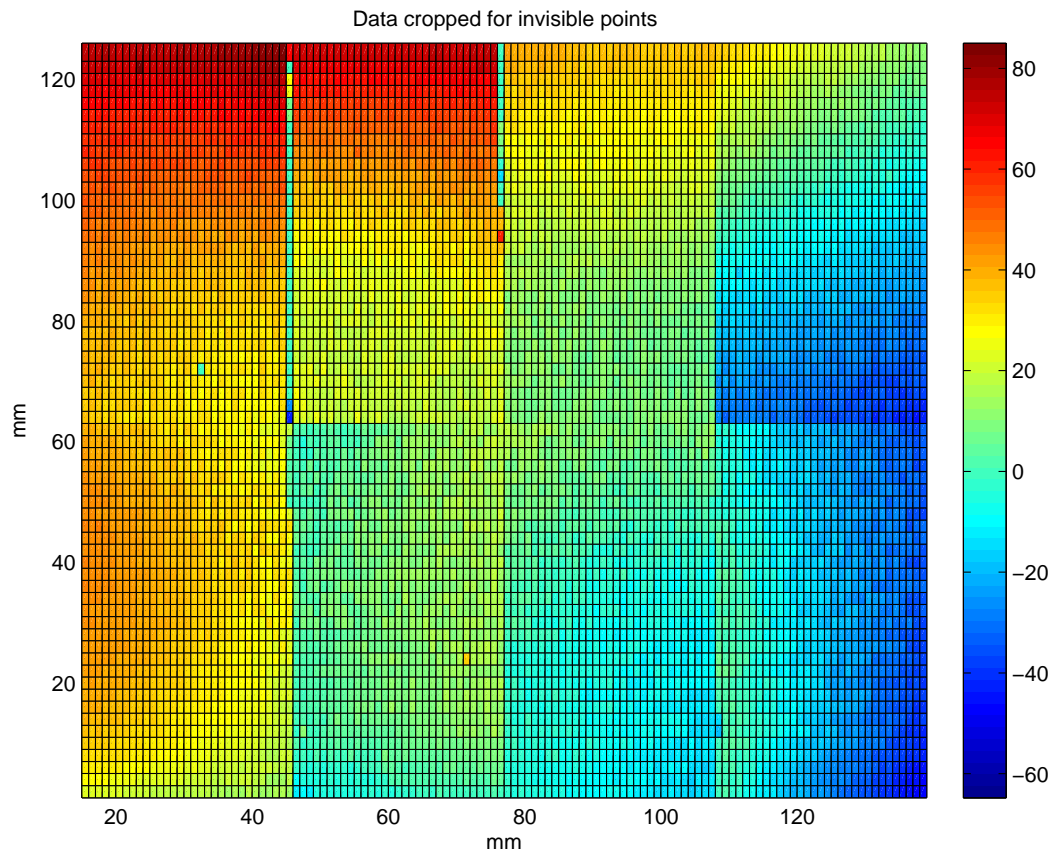Figure 6: Contour plot of the MOSAIC array - raw original data sans tilt

Figure 7: Contour plot of the MOSAIC array. The profilometer could not map the upper left, lower left and upper right parts of the array as the sensor didn't get enough signal. Scale is μm on Z axis

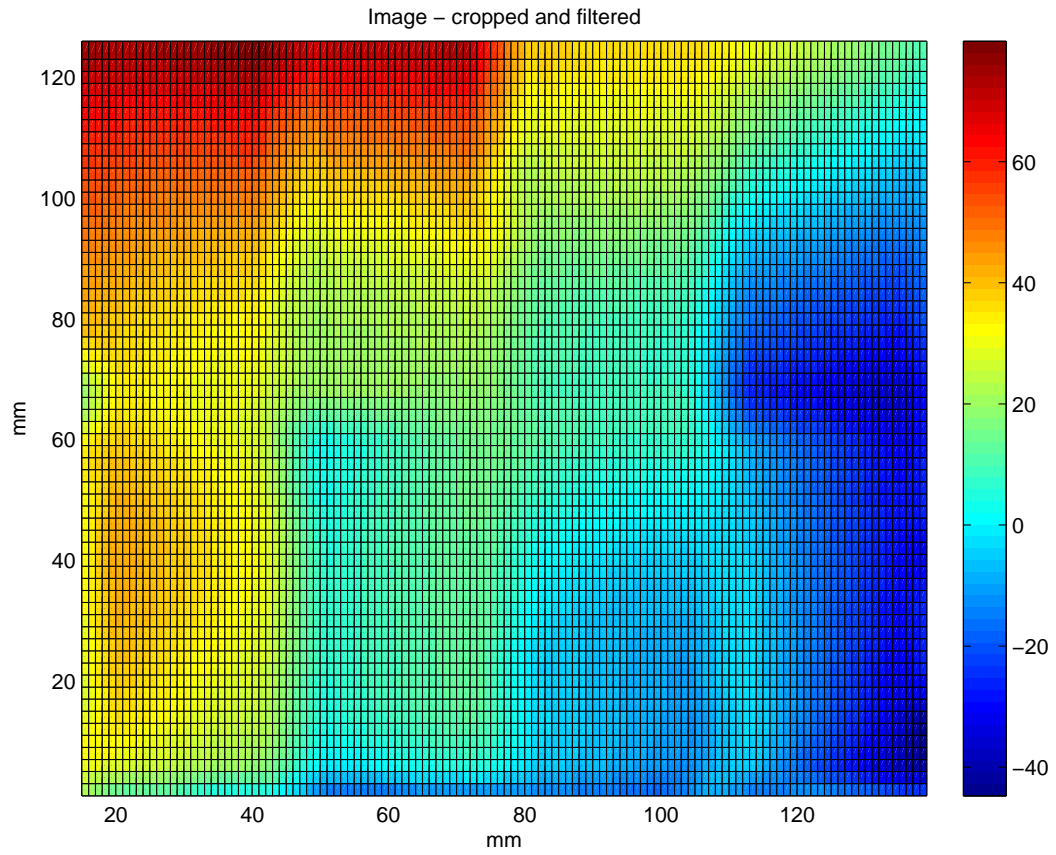Figure 8: Contour plot of the MOSAIC array - cropped

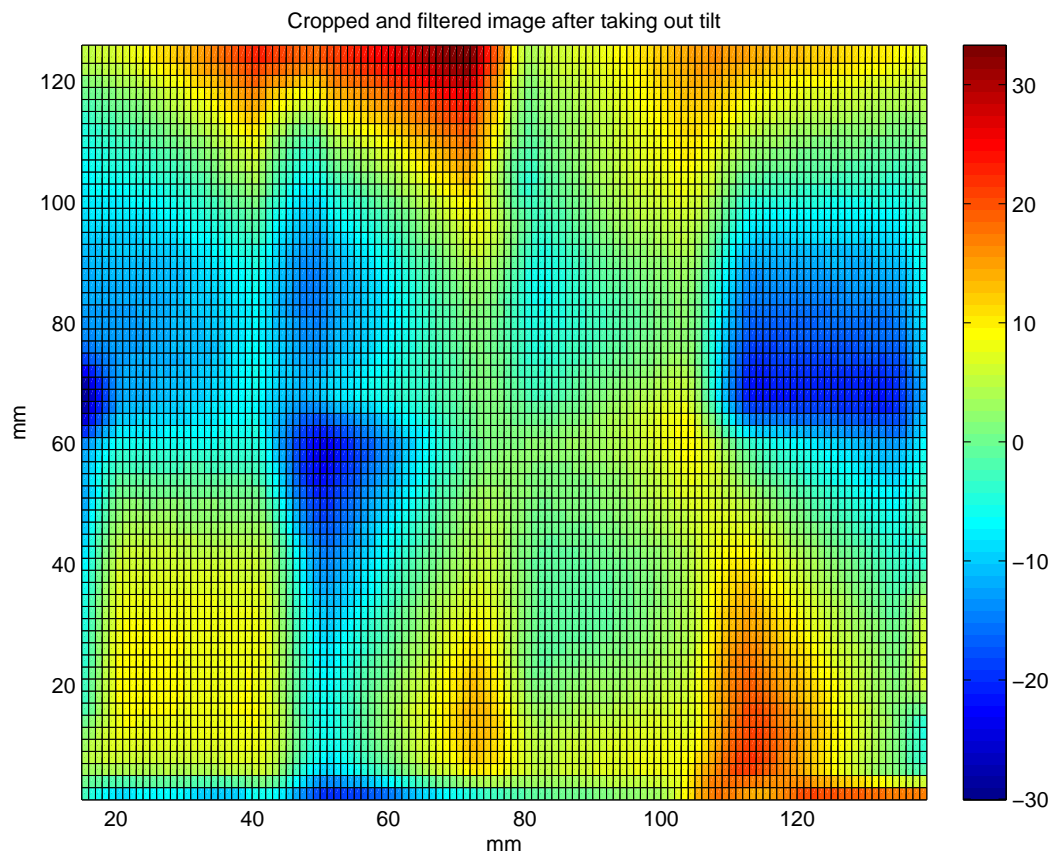Figure 9: Contour plot of the MOSAIC array after applying 3x3 filter

Figure 10: Contour plot of the MOSAIC array after applying 3x3 filter after taking out tilt
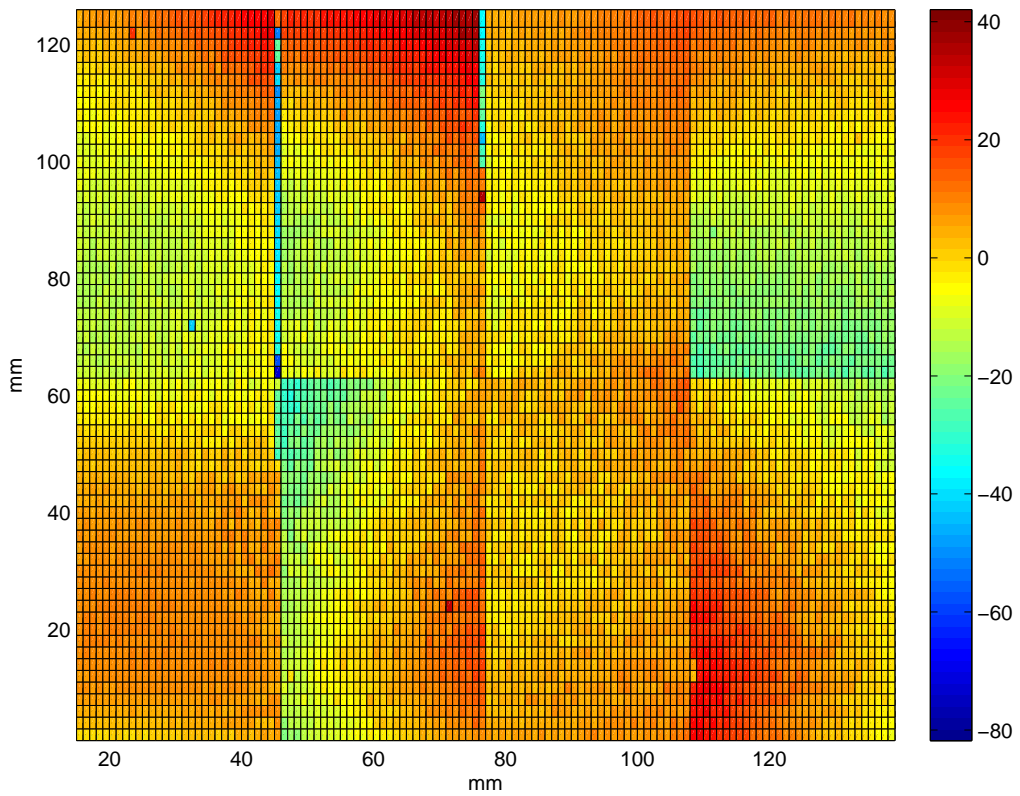
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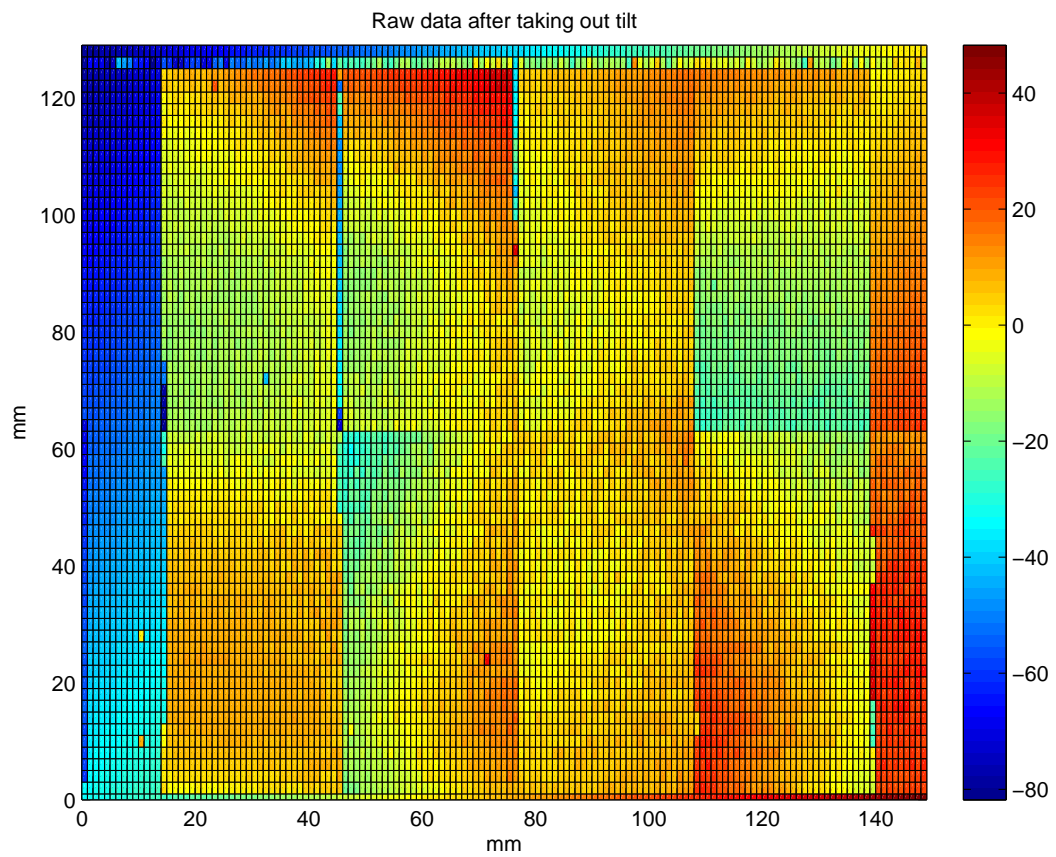Figure 11: Contour plot of the MOSAIC array - cropped raw data sans tilt

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Figure 12: Contour plot of the MOSAIC array - raw original data sans tilt

3.2 1 mm data

3.3 CCD window

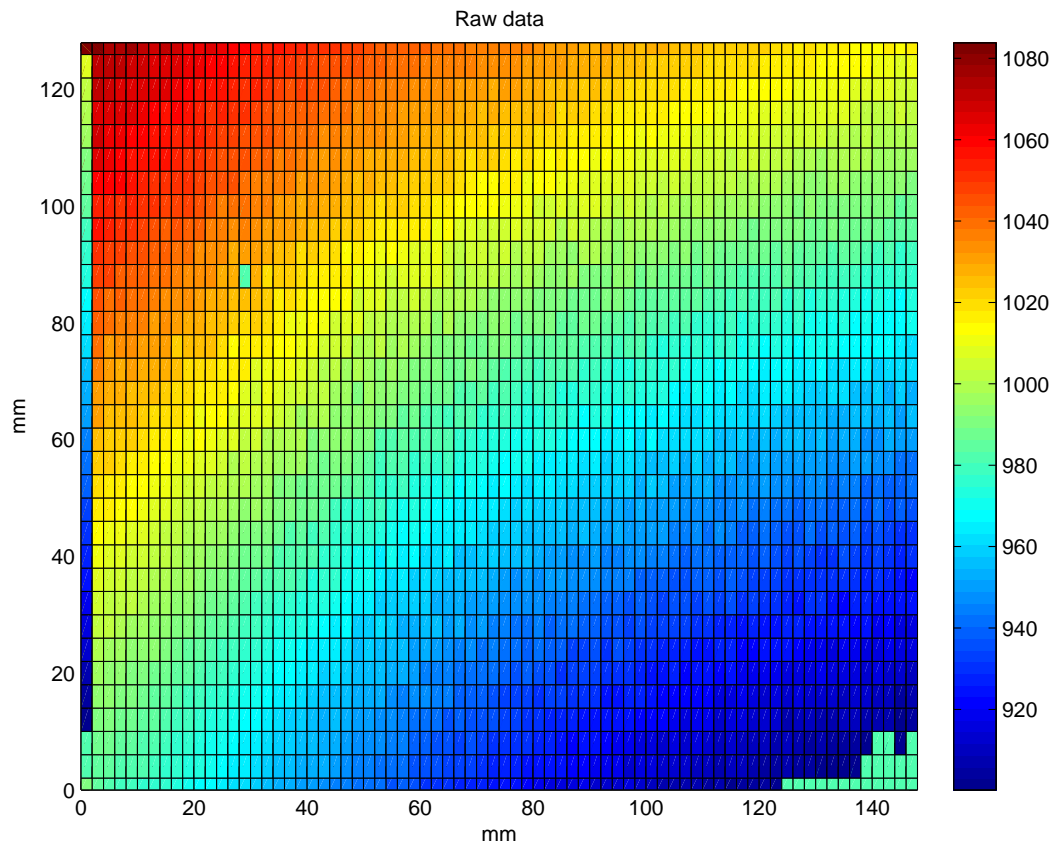Figure 13: Contour plot of the CCD window

3.4 optical flat

The optical flat was scanned twice, the second scan was performed after rotating the optical flat 90-degrees. The optical flat is a WYKO interferometric flat that is known have a ¿40nm of focus (and flat to that point).
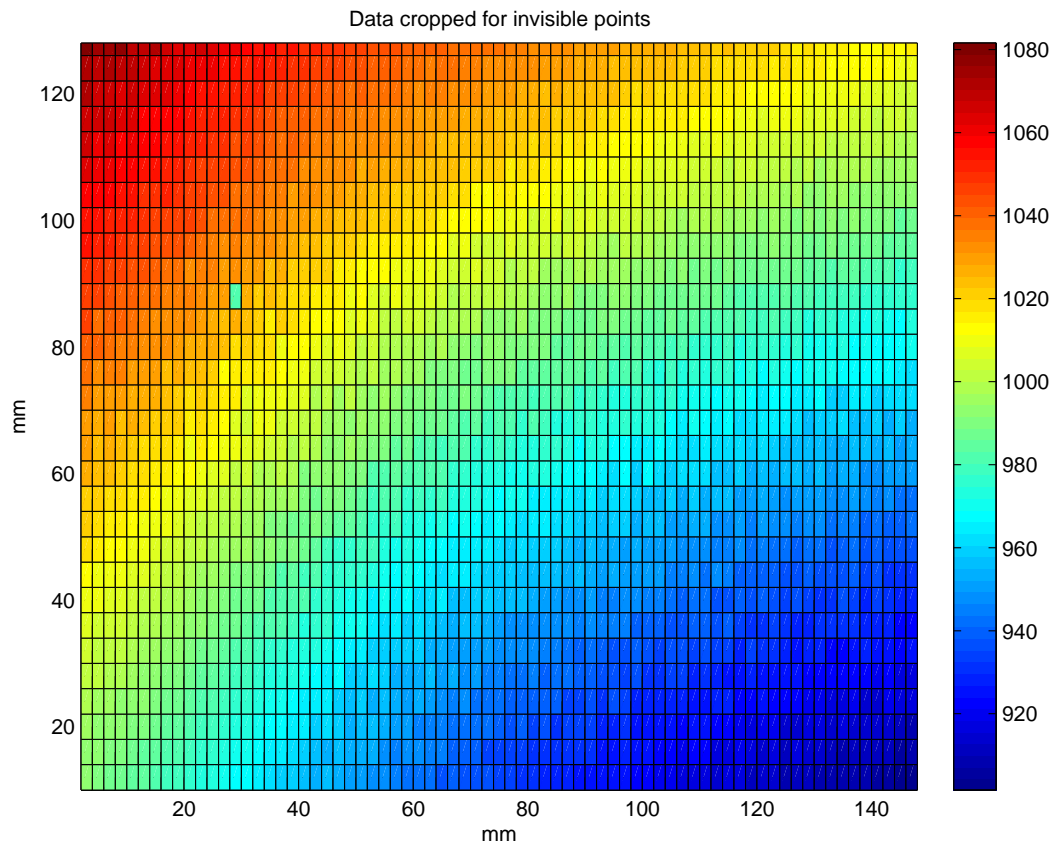
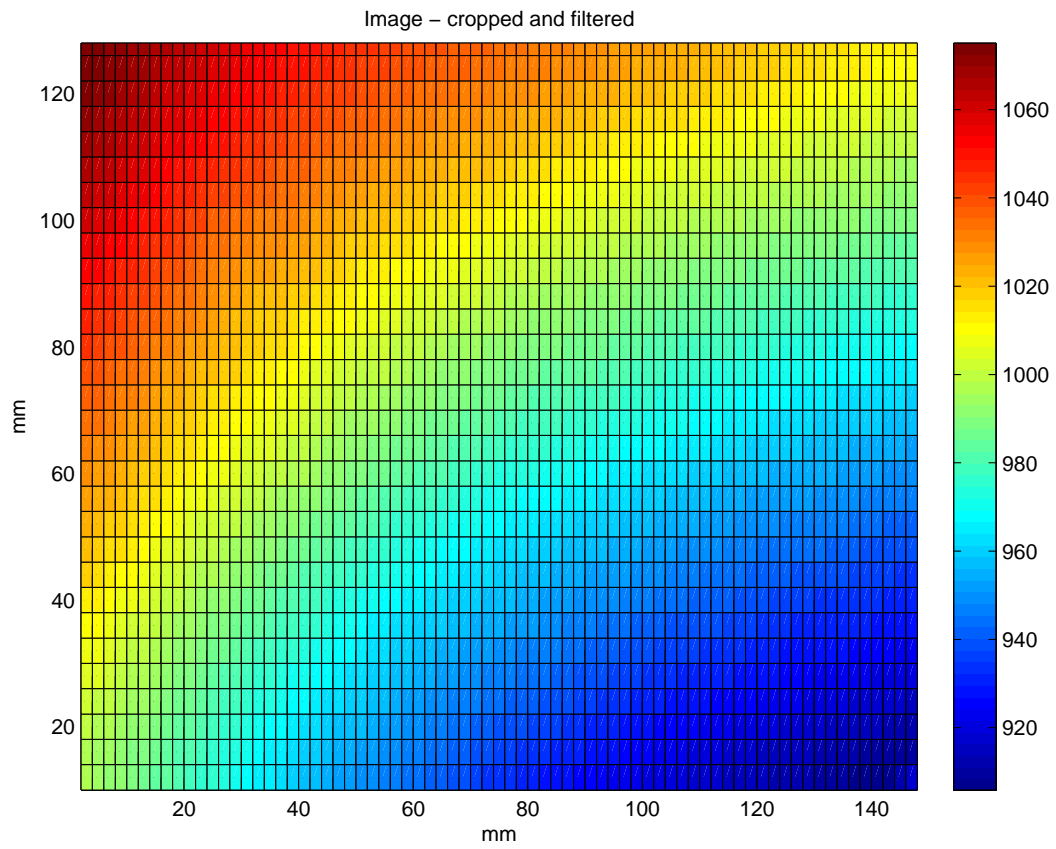Figure 14: Contour plot of the CCD window - cropped

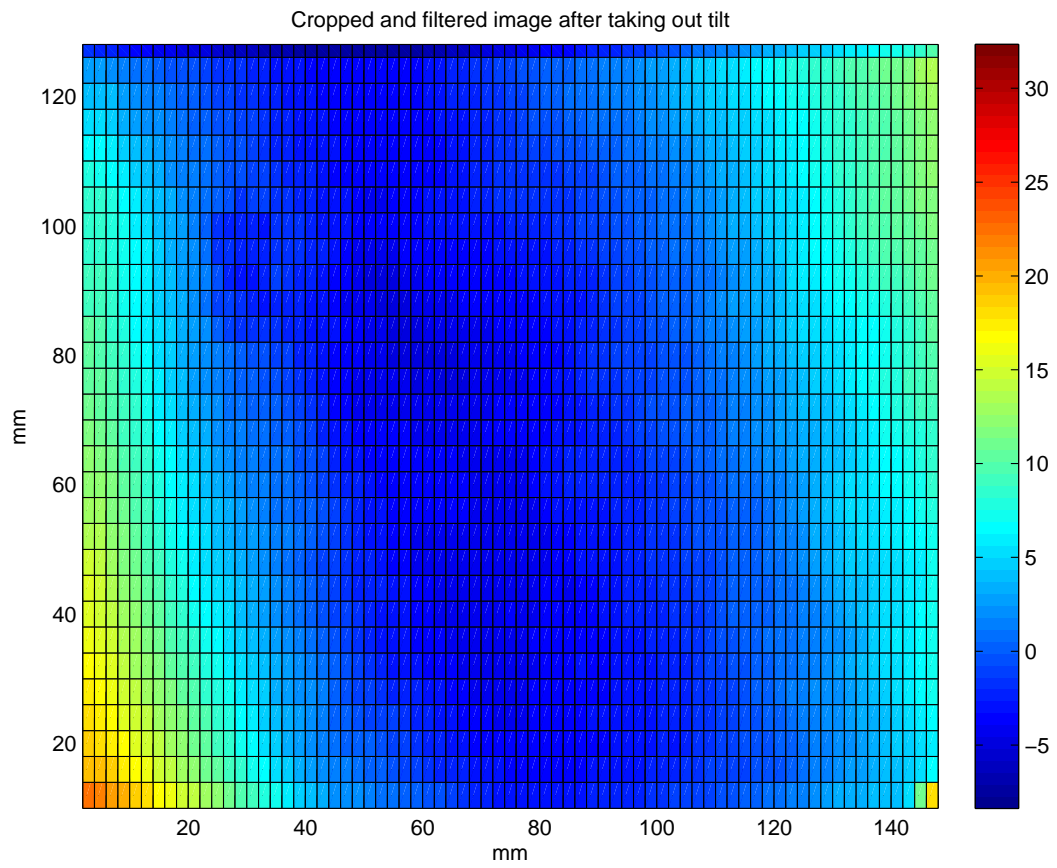Figure 15: Contour plot of the CCD window after applying 3x3 filter

Figure 16: Contour plot of the CCD window after applying 3x3 filter after taking out tilt
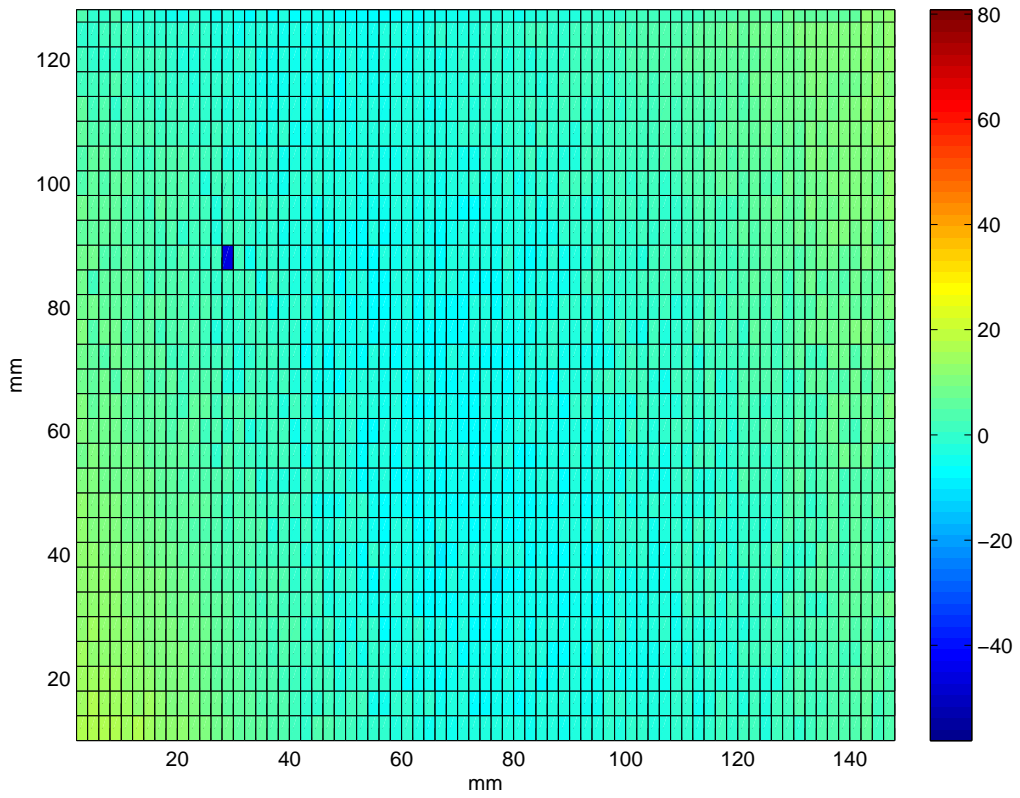
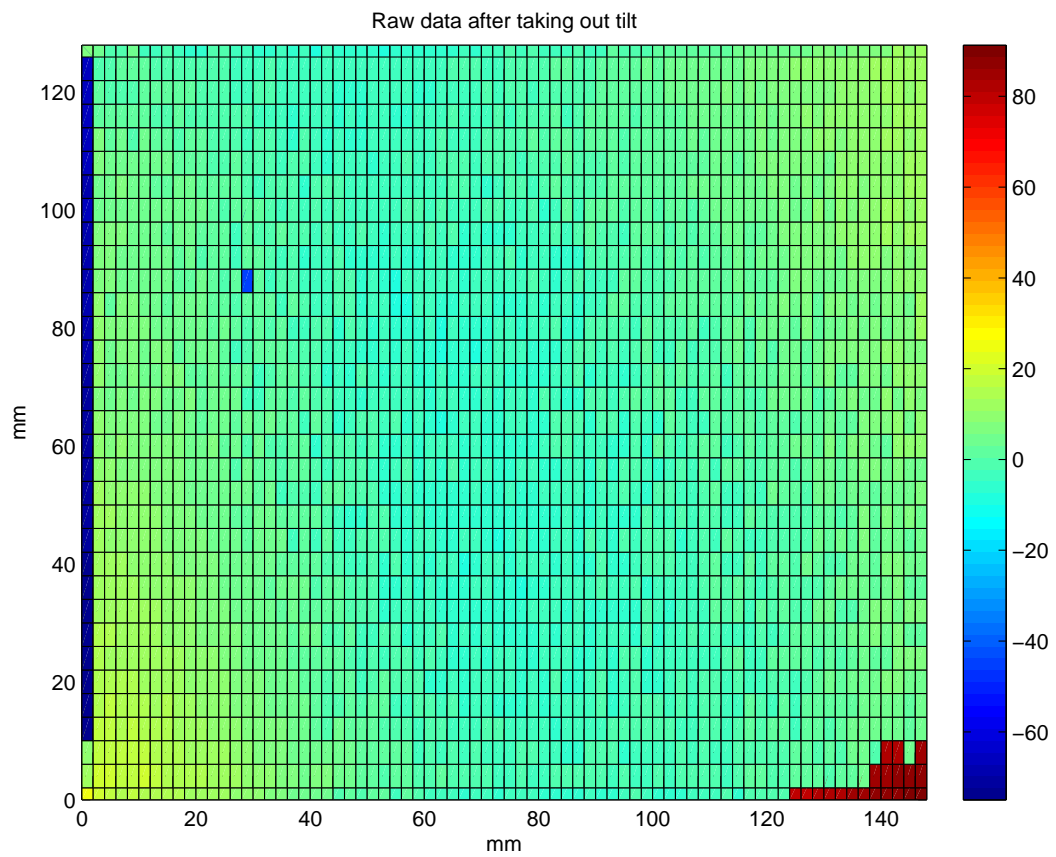Figure 17: Contour plot of the CCD window - cropped raw data sans tilt

Figure 18: Contour plot of the CCD window - raw original data sans tilt
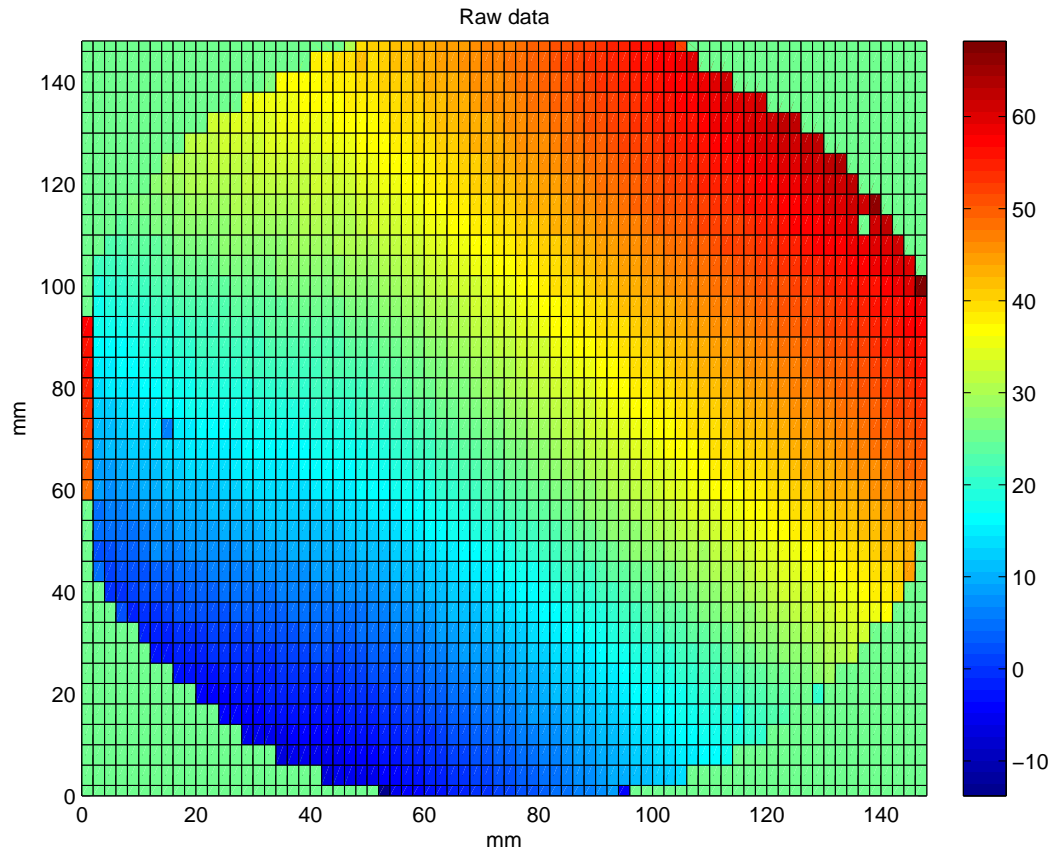
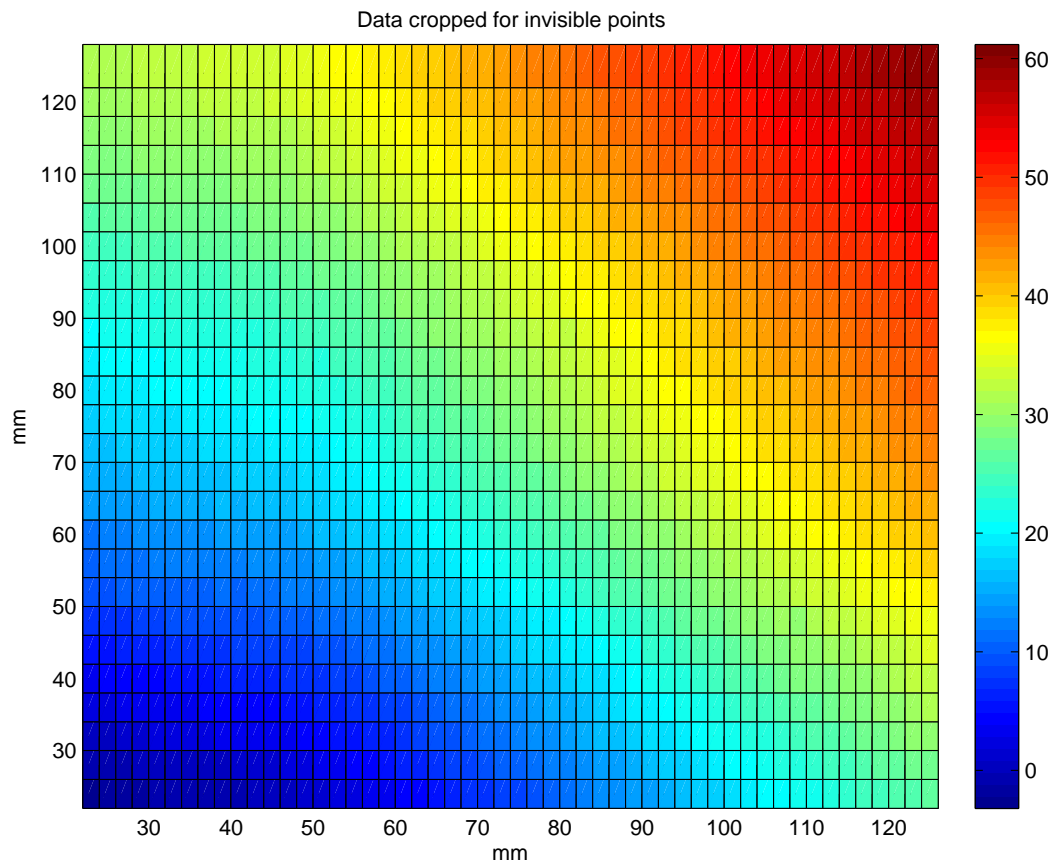Figure 19: Contour plot of the LIGO optical flat

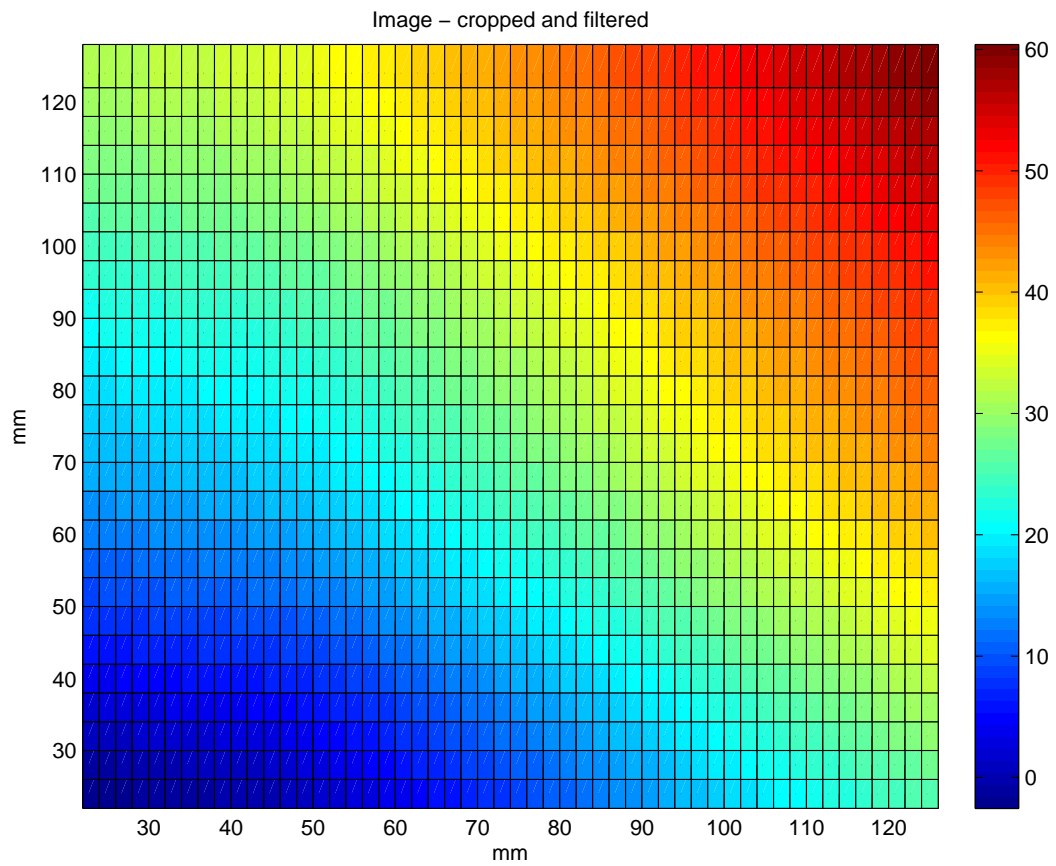Figure 20: Contour plot of the LIGO optical flat - cropped

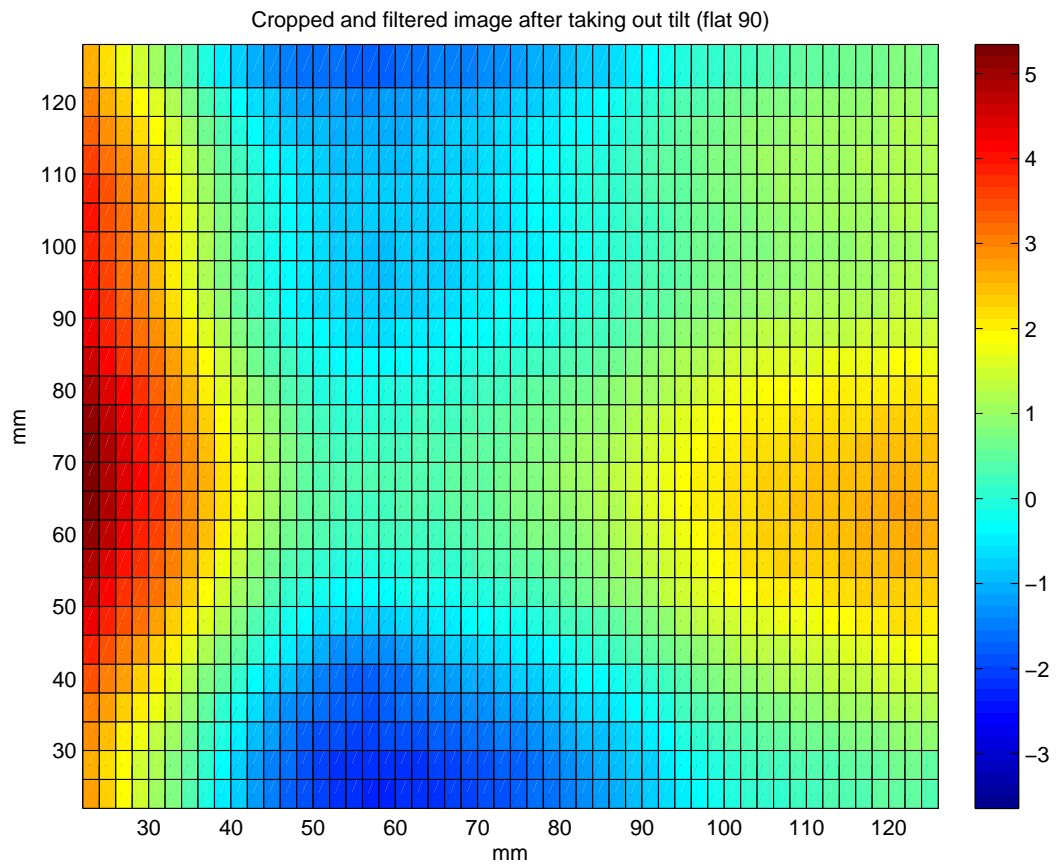Figure 21: Contour plot of the LIGO optical flat after applying 3x3 filter

Figure 22: Contour plot of the LIGO optical flat after applying 3x3 filter after taking out tilt
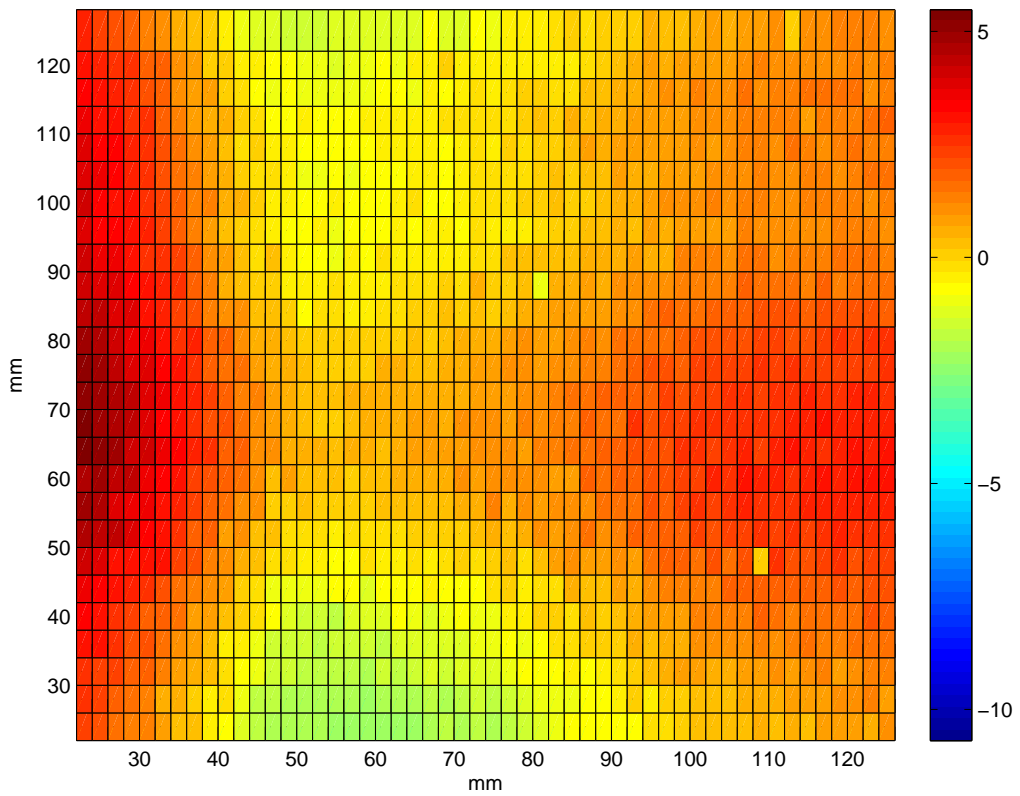
Figure 23: Contour plot of the LIGO optical flat - cropped raw data sans tilt
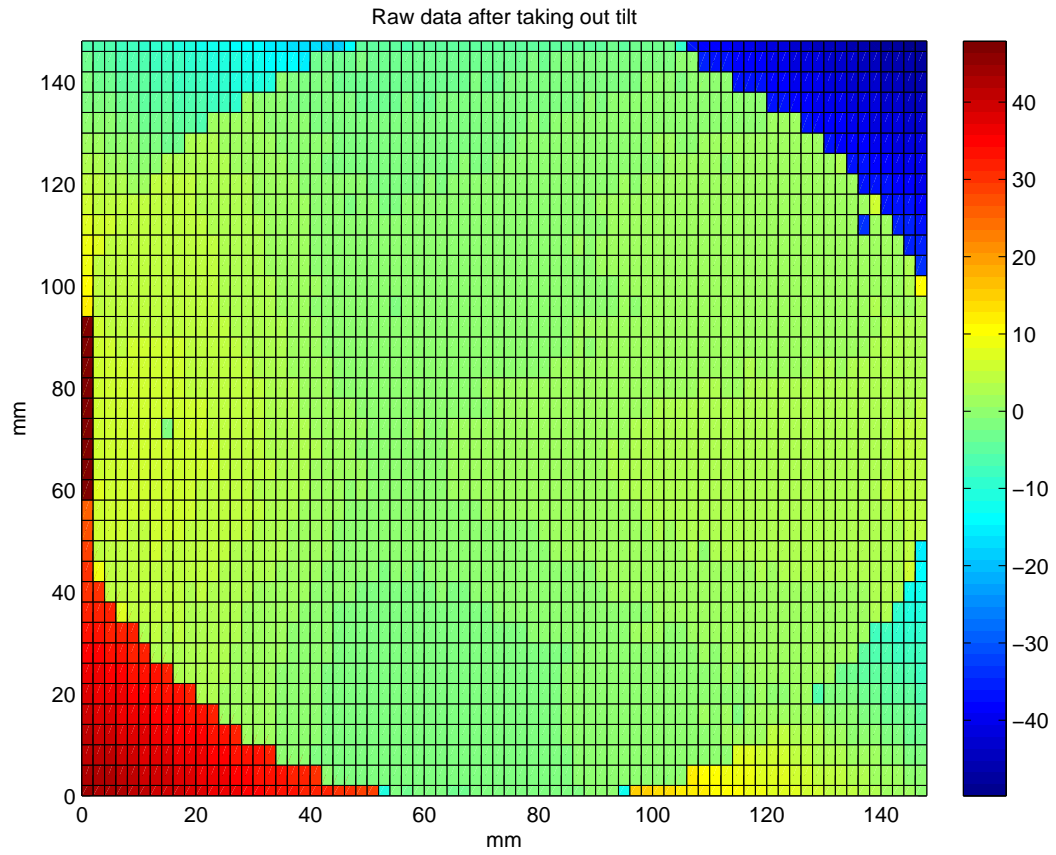
Figure 24: Contour plot of the LIGO optical flat - raw original data sans tilt
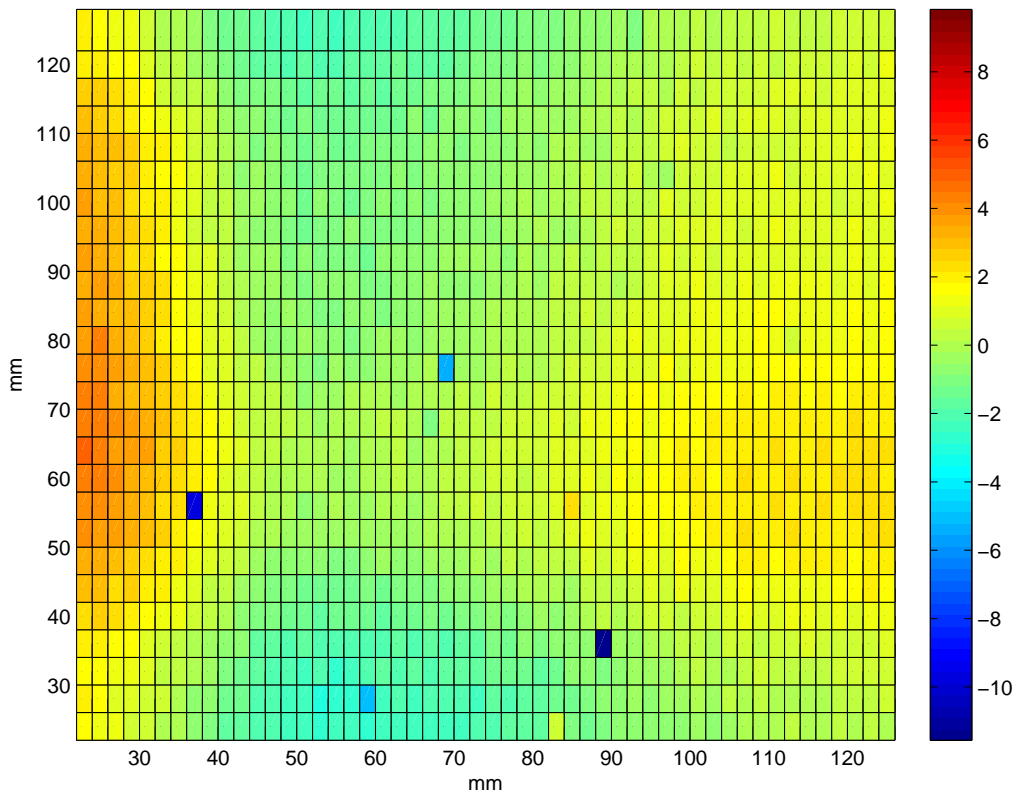
Figure 25: Contour plot of the LIGO optical flat rotated by 90-degrees - cropped raw data sans tilt
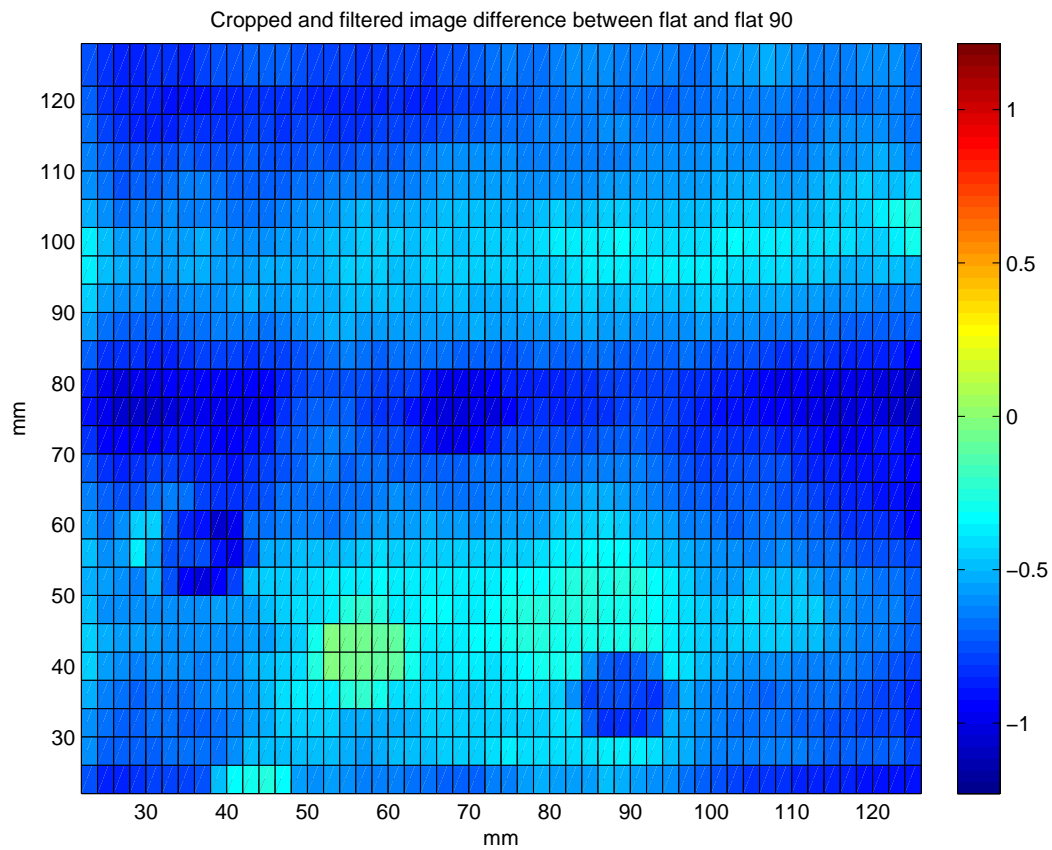
Figure 26: Contour plot of the difference between filtered and cropped images (sans tilt) of the optical flat when positioned at 0 degrees and 90 degrees.
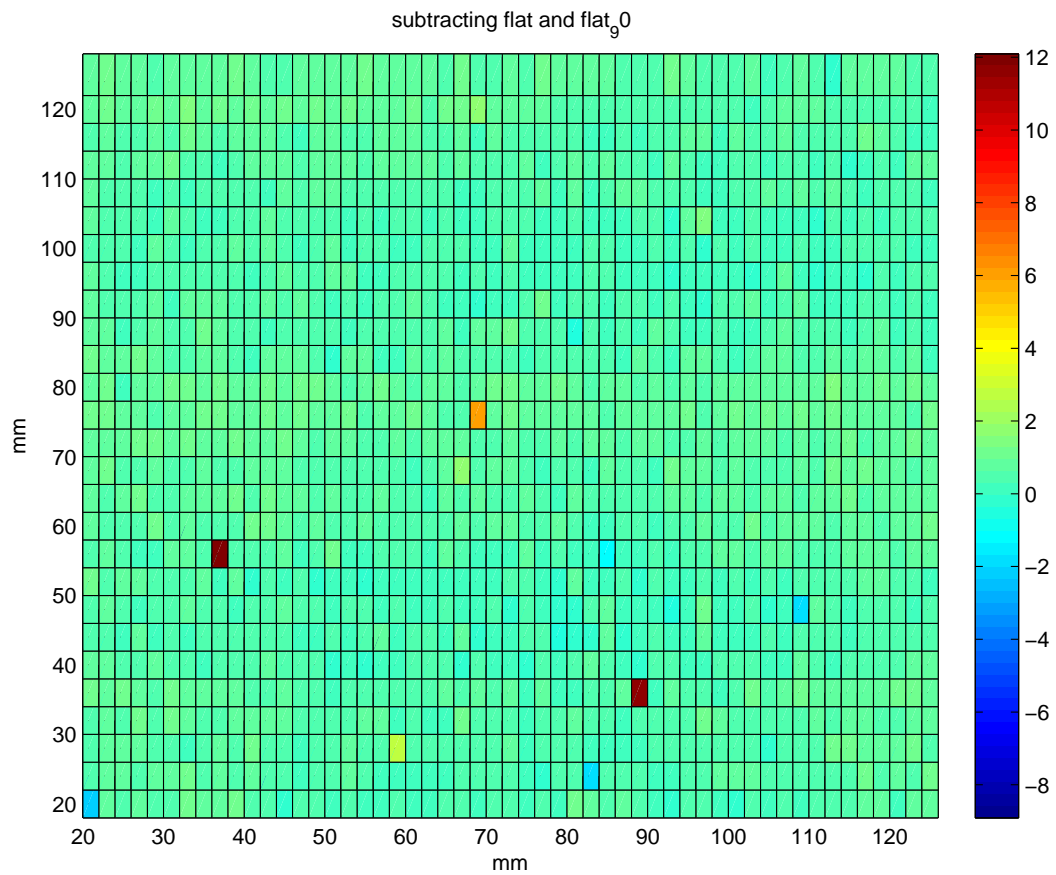
Figure 27: Contour plot of the difference between raw images (sans tilt) of the optical flat when positioned at 0 degrees and 90 degrees.

3.4.1 difference images

References

[1] J.M. Hill, `http://medusa.as.arizona.edu/lbto/tech/ua9302.htm`

[2] `http://hepwww.physics.yale.edu/quest/oshin.html`

[3] `http://www.keyence.com/dwn/downloadlt_ka.pdf`