MOSAIC CCD array surface profile measurements

Version 0.6

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1 Introduction and background

The CFH MOSAIC array is being modified for the Palomar 48" Schmidt telescope. The array 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 shows the contour plots based on data obtained using Carnegie Observatories' confocal laser distance measuring device.

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. The CCD array was scanned at 2x2 mm spacing grid and a 1x1 mm spacing grid. To check the performance and repeatability of the scanning system, we first scanned the CCD window. The CD window is probably thin and is not particularly flat, so we repeated our measurements with a optical flat. A 6" diameter optical flat was obtained from LIGO for calibration the XY stage. The optical flat was scanned twice, once just by mounting it on the XY stage and later after rotating it 90 degrees to check the repeatability of the XY stage.

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 figures in the document. The profilometer's inablility to map the whole array is apparent in Figure 1. The gaps in the detectors and invisible areas were filled with a nominal threshold of 0.0 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 *good* 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.

3.1 2 mm data

Greg sent a second set of 2x2 mm *better* data points by providing extended settling time for the sensor. Even within this so-called *good* part there are oftentimes one or two bad pixels. So a 3x3 (for 2x2 mm plot) or a 5x5 filter (for 1x1 mm plots) was applied to smoothen the image.

3.1.1 sample plots

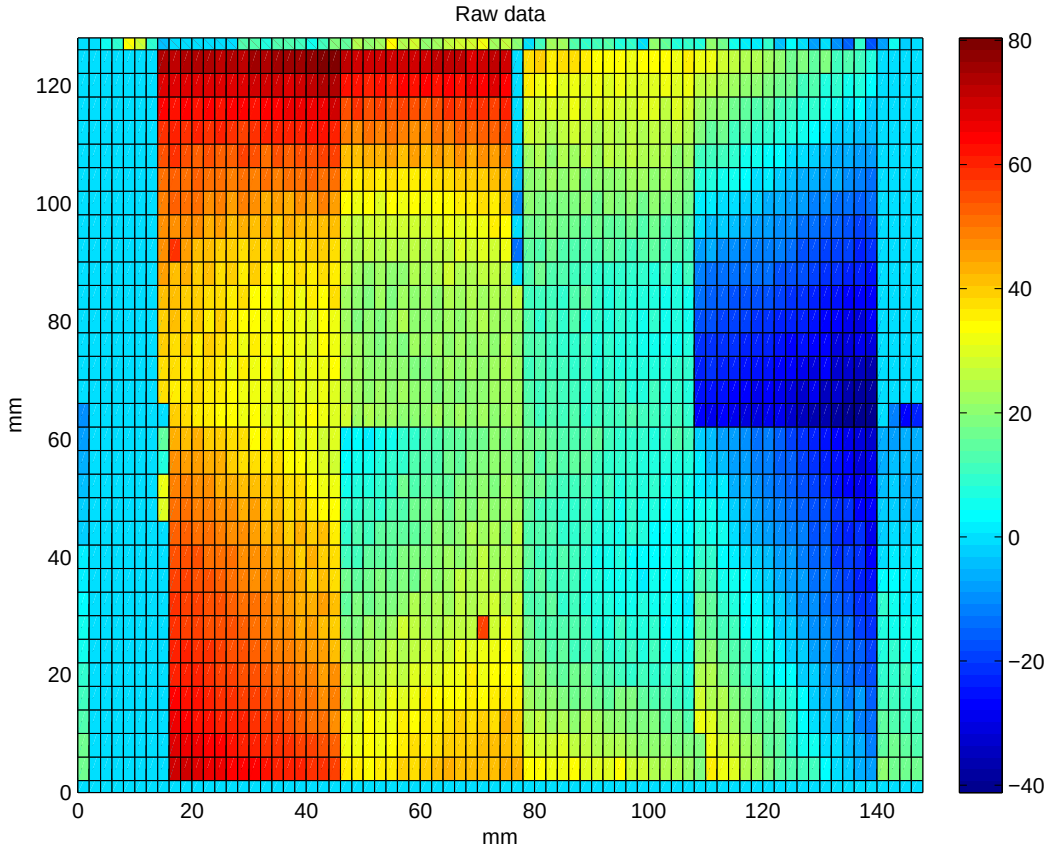

Figure 1: Contour plot of the MOSAIC array. The profilometer could not map the upper left, lower left and upper right parts of the array as the sensor didn't get enough signal. Scale is μm on Z axis

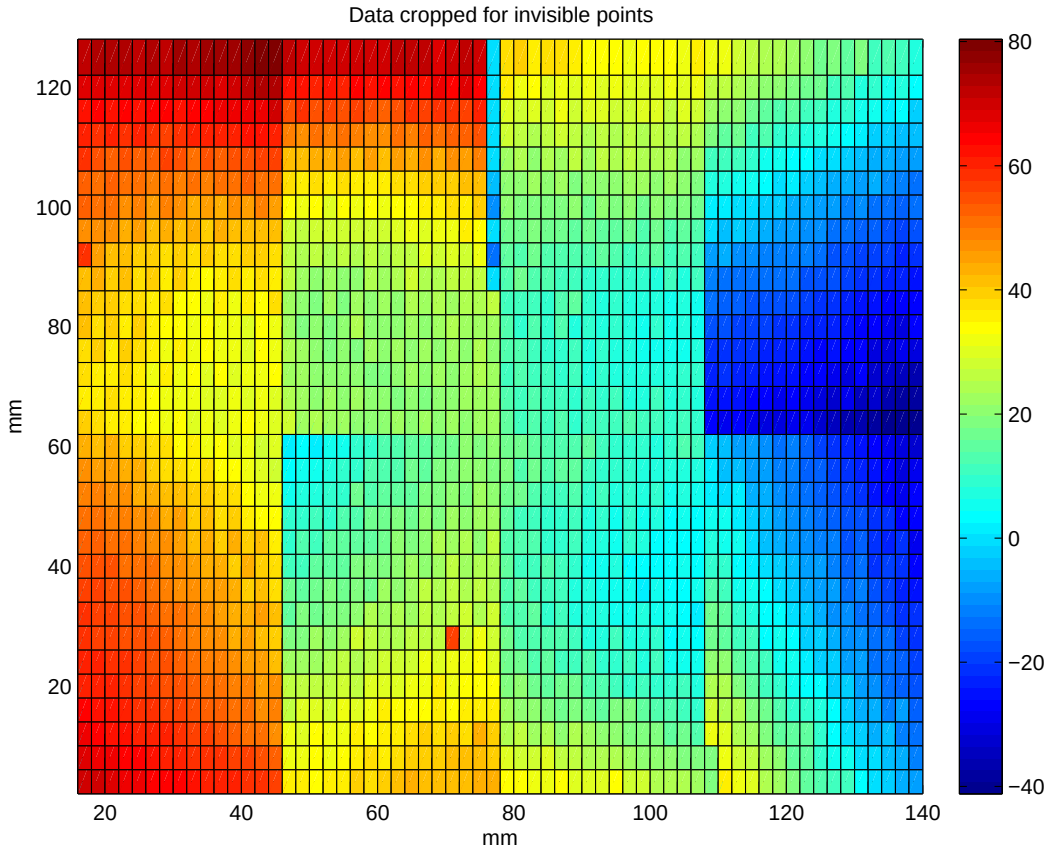

Figure 2: Contour plot of the MOSAIC array - cropped

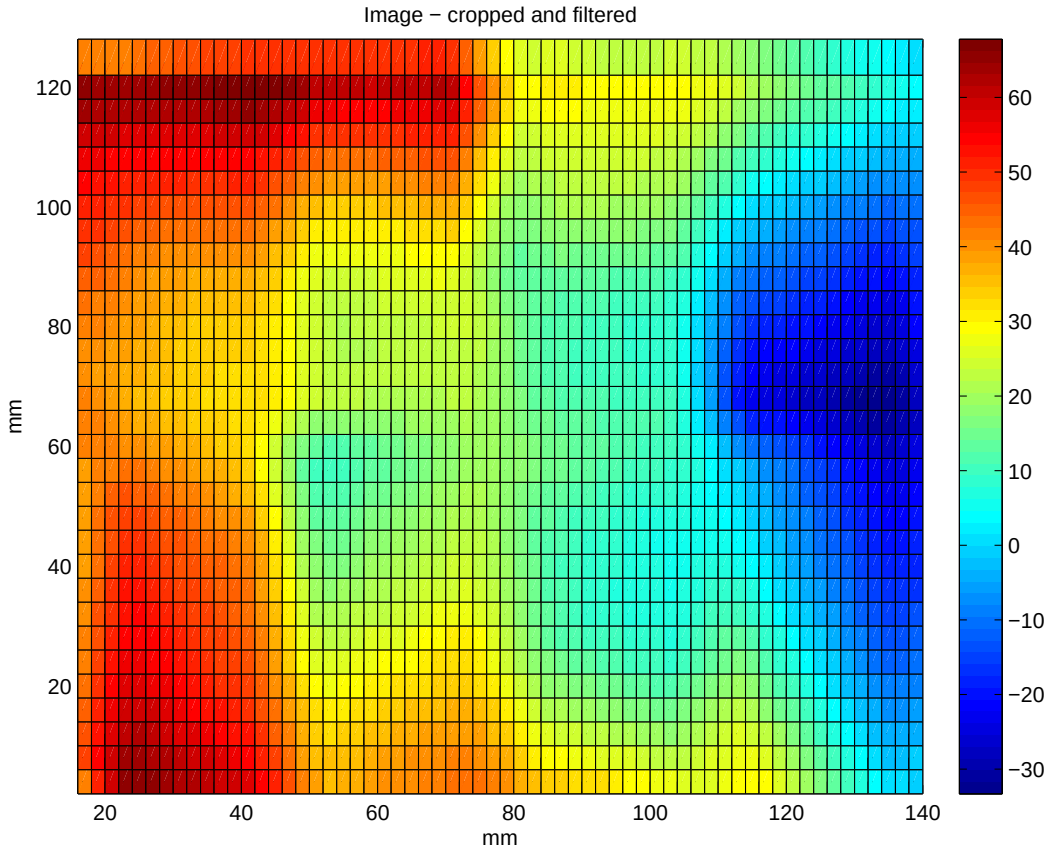

Figure 3: Contour plot of the MOSAIC array after applying 3x3 filter

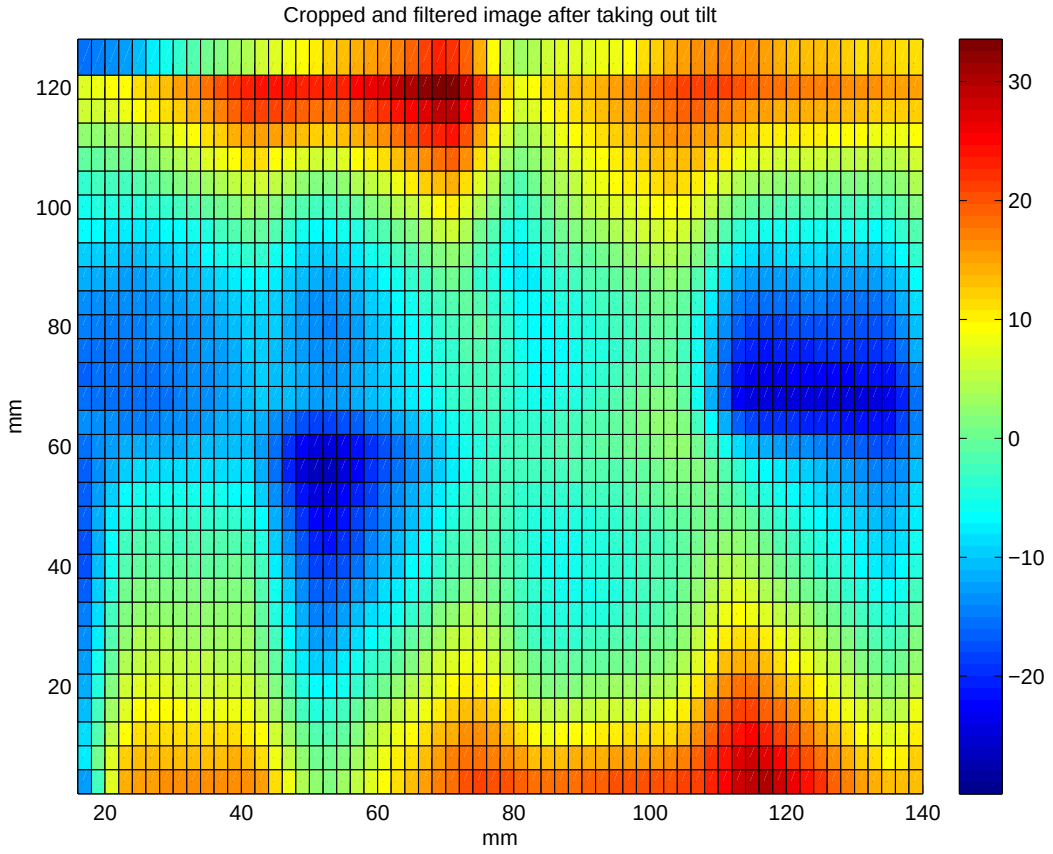

Figure 4: Contour plot of the MOSAIC array after applying 3x3 filter after taking out tilt

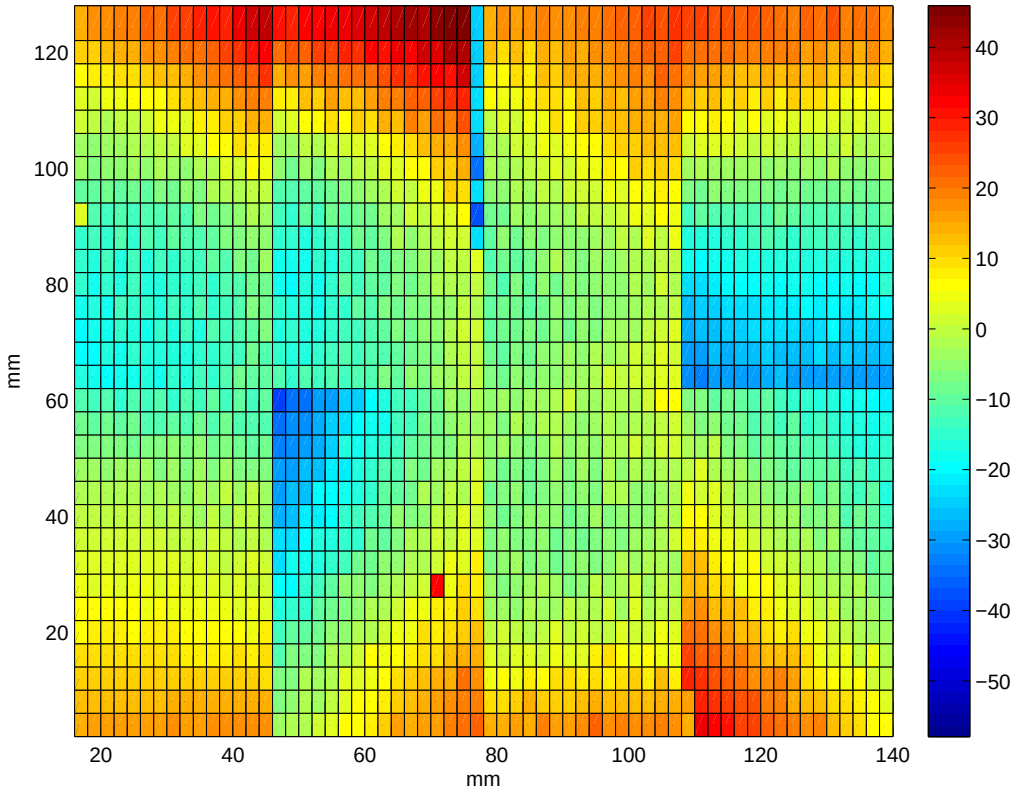

Figure 5: Contour plot of the MOSAIC array - cropped raw data sans tilt

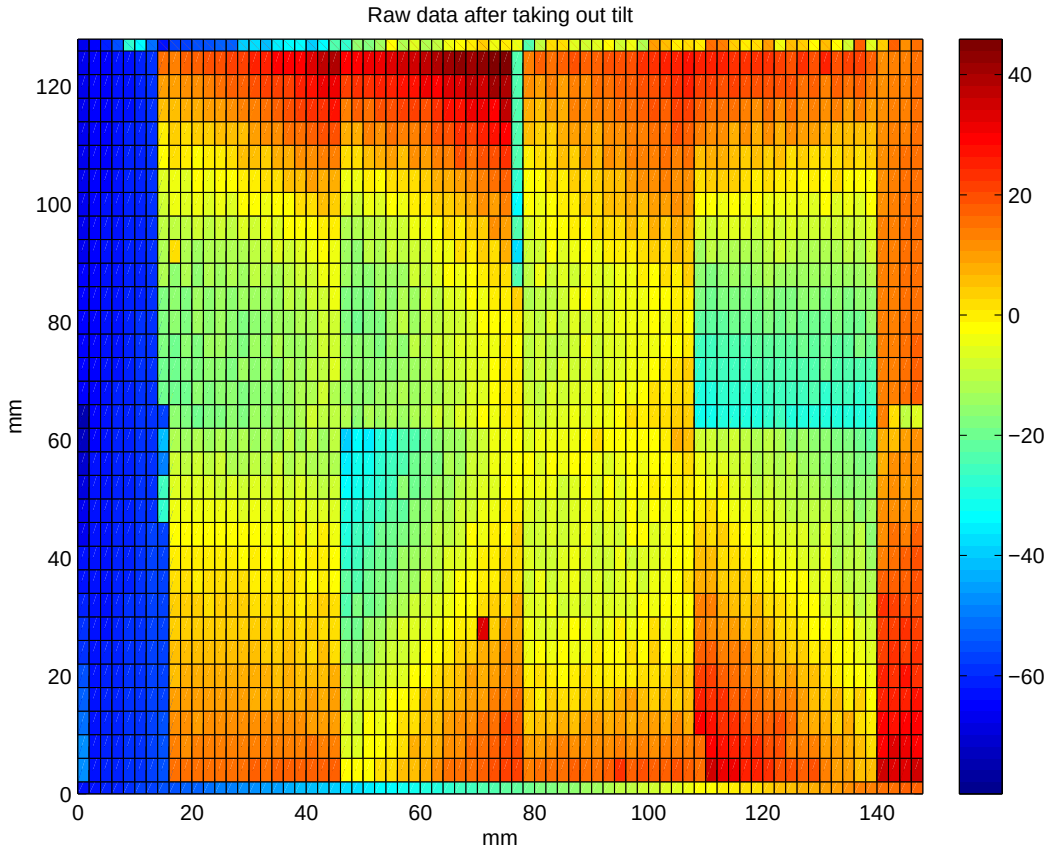

Figure 6: Contour plot of the MOSAIC array - raw original data sans tilt

3.2 1 mm data

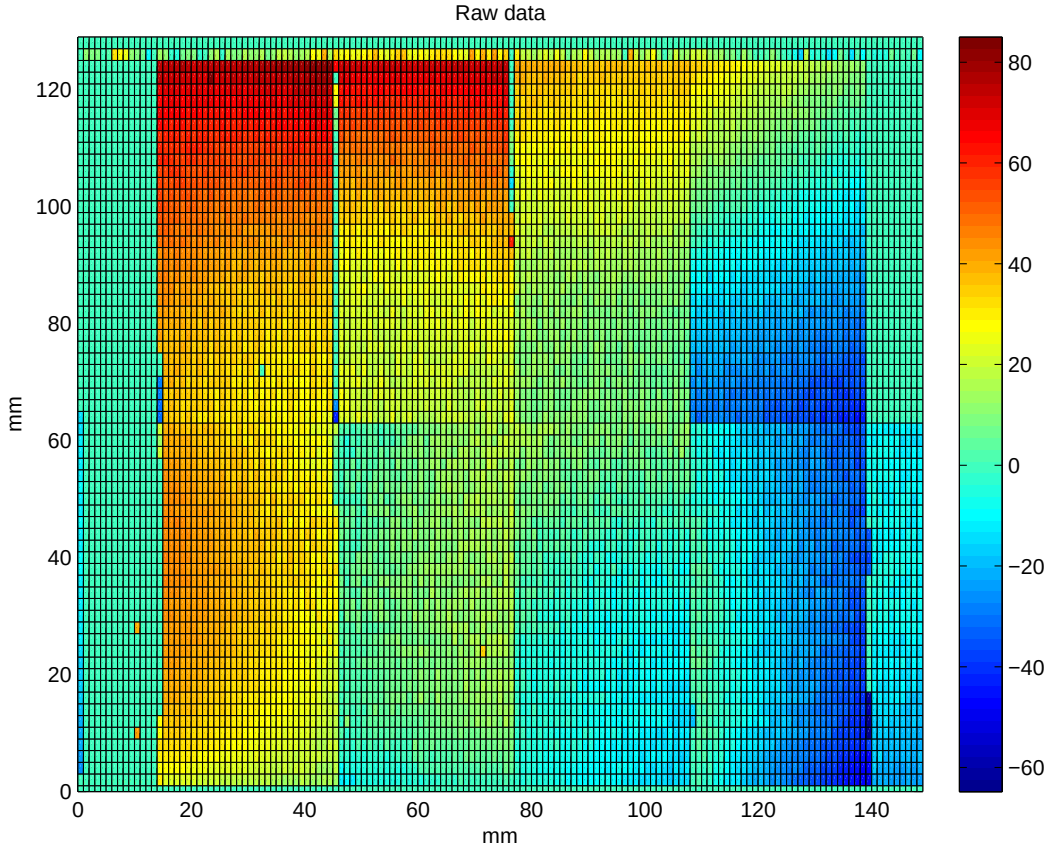

Figure 7: Contour plot of the MOSAIC array. The profilometer could not map the upper left, lower left and upper right parts of the array as the sensor didn't get enough signal. Scale is μm on Z axis

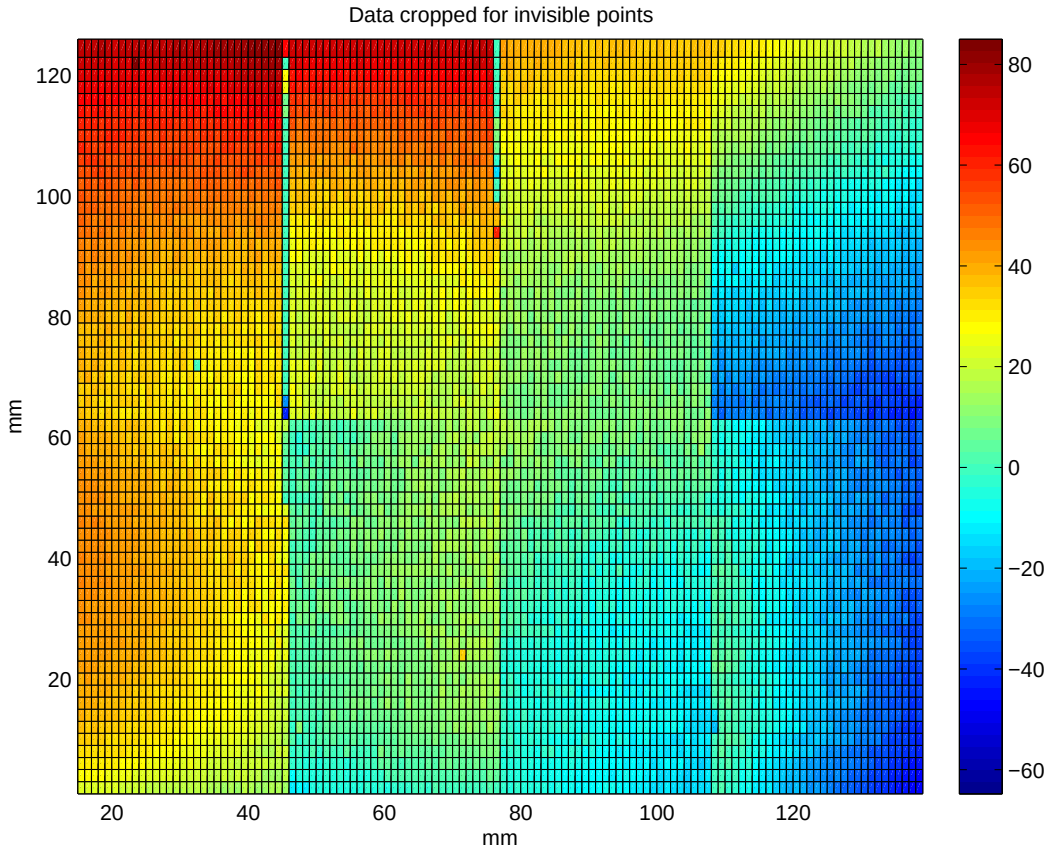

Figure 8: Contour plot of the MOSAIC array - cropped

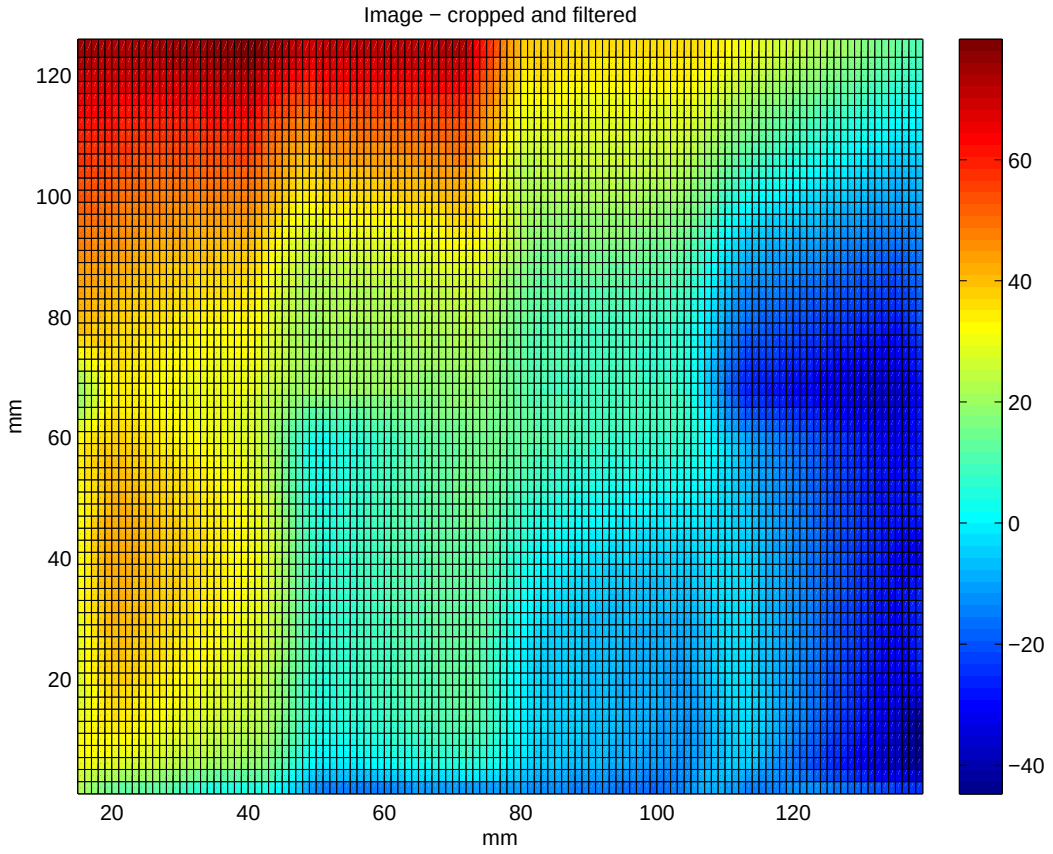

Figure 9: Contour plot of the MOSAIC array after applying 3x3 filter

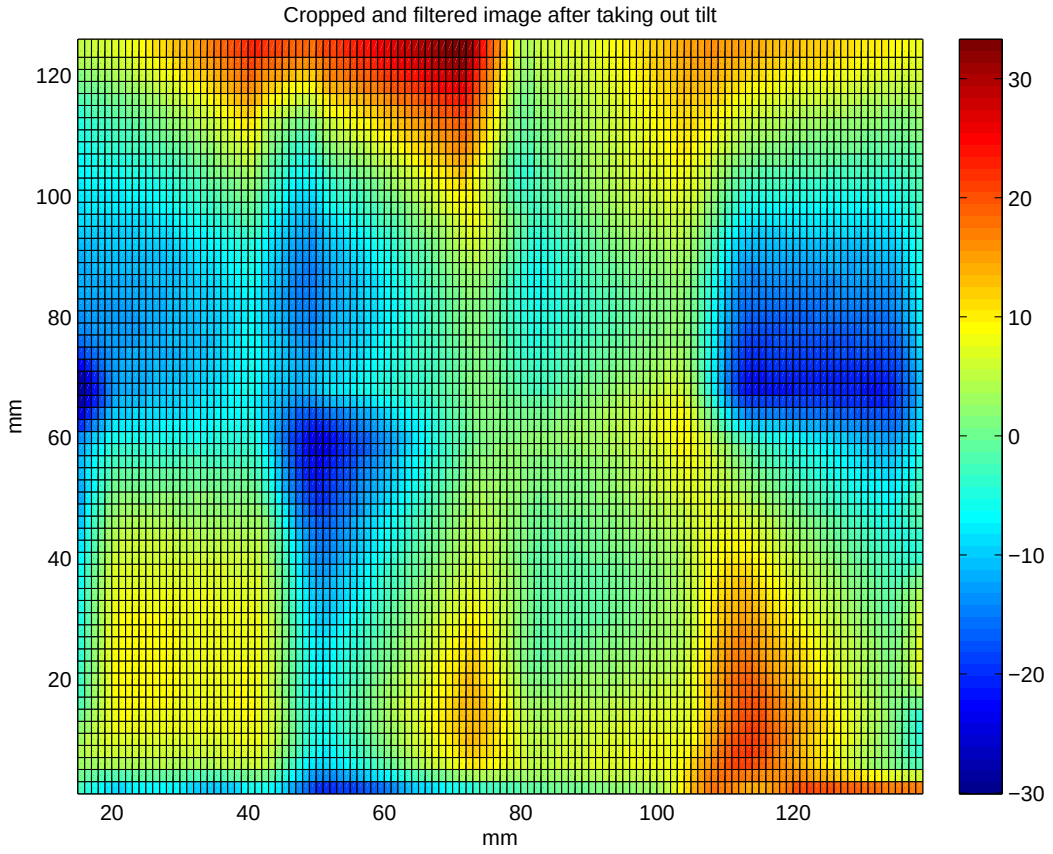

Figure 10: Contour plot of the MOSAIC array after applying 3x3 filter after taking out tilt

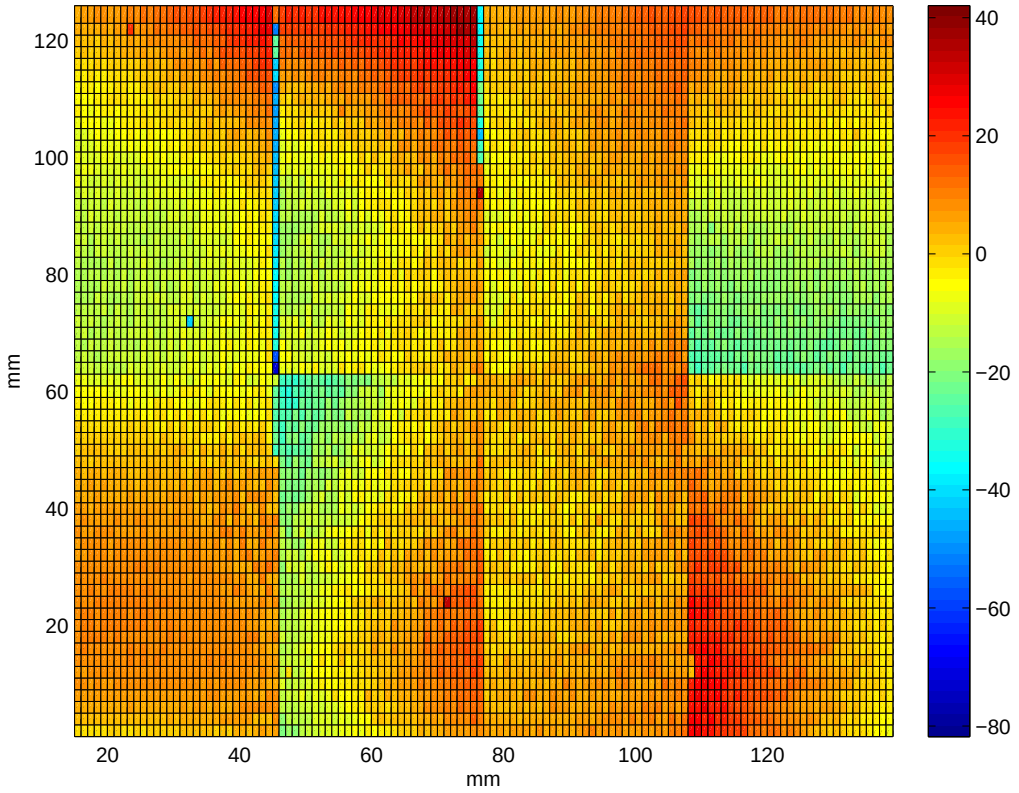

Figure 11: Contour plot of the MOSAIC array - cropped raw data sans tilt

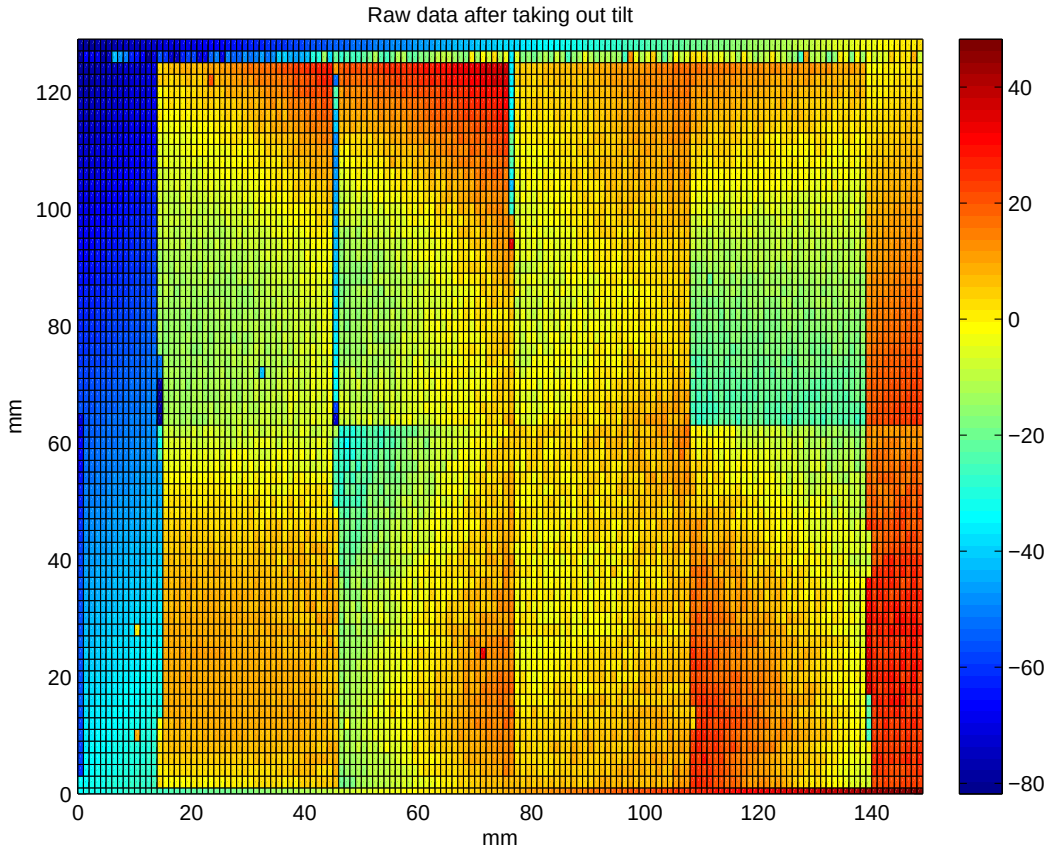

Figure 12: Contour plot of the MOSAIC array - raw original data sans tilt

3.3 CCD window

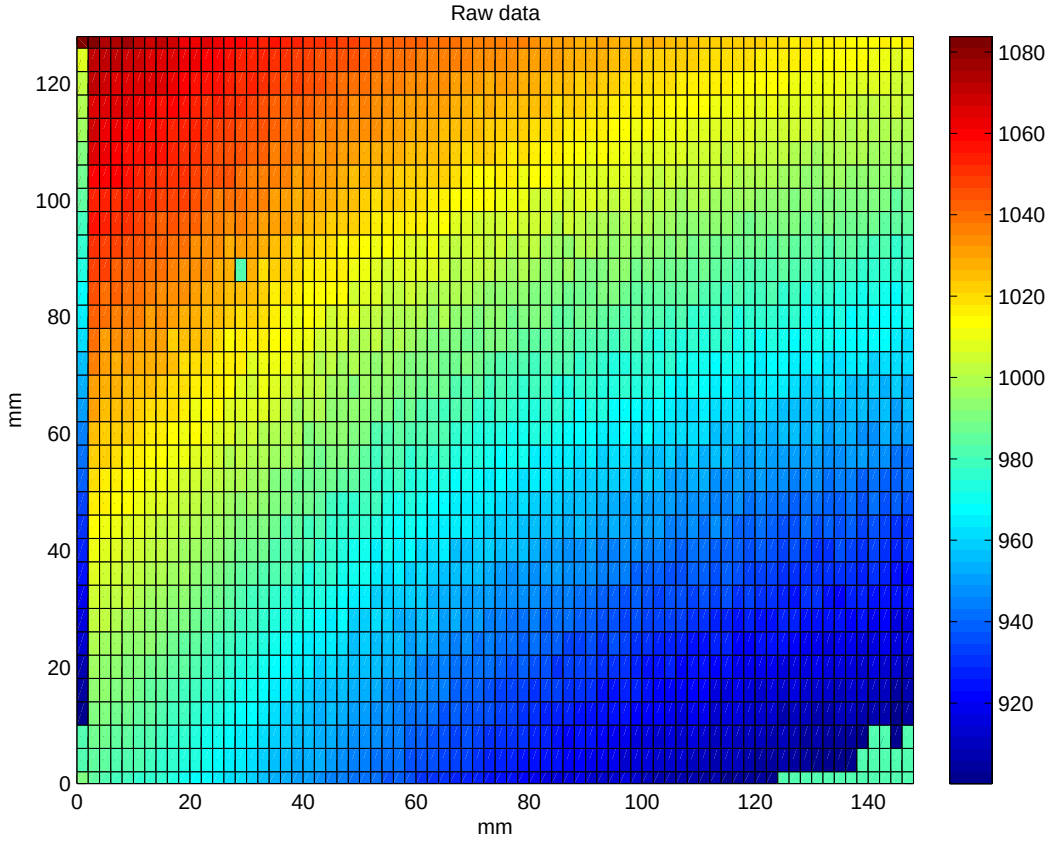

Figure 13: Contour plot of the CCD window

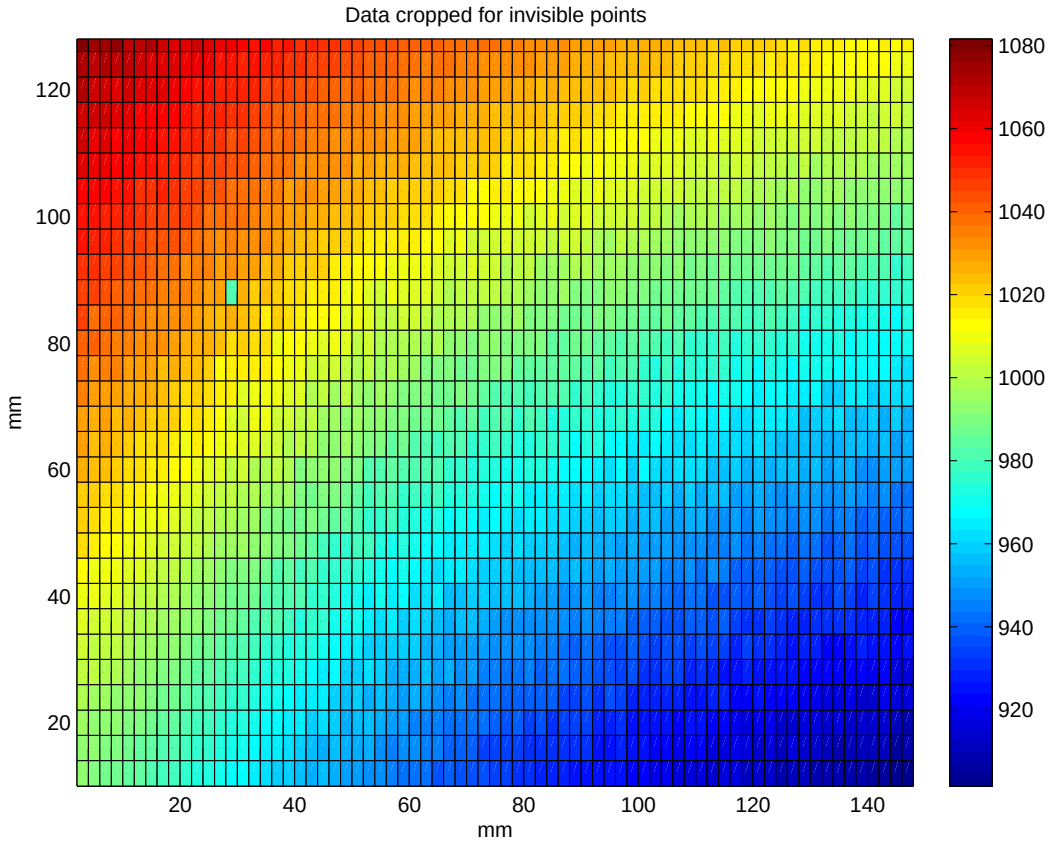

Figure 14: Contour plot of the CCD window - cropped

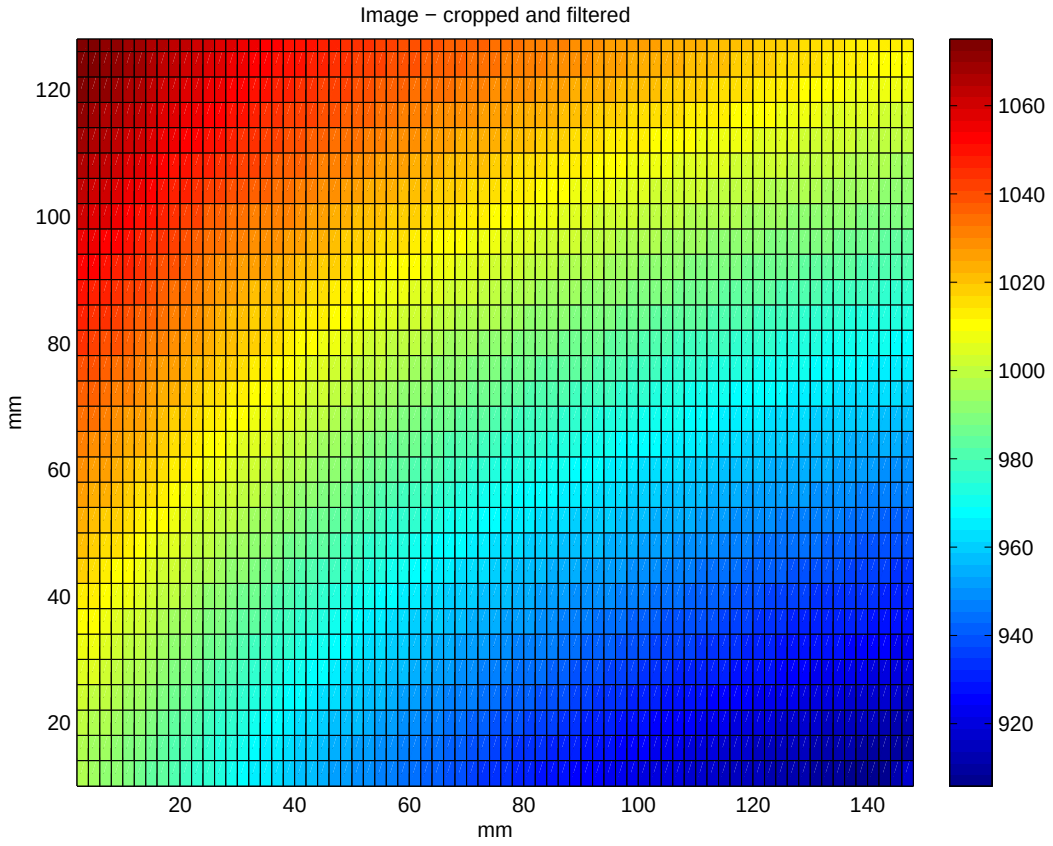

Figure 15: Contour plot of the CCD window after applying 3x3 filter

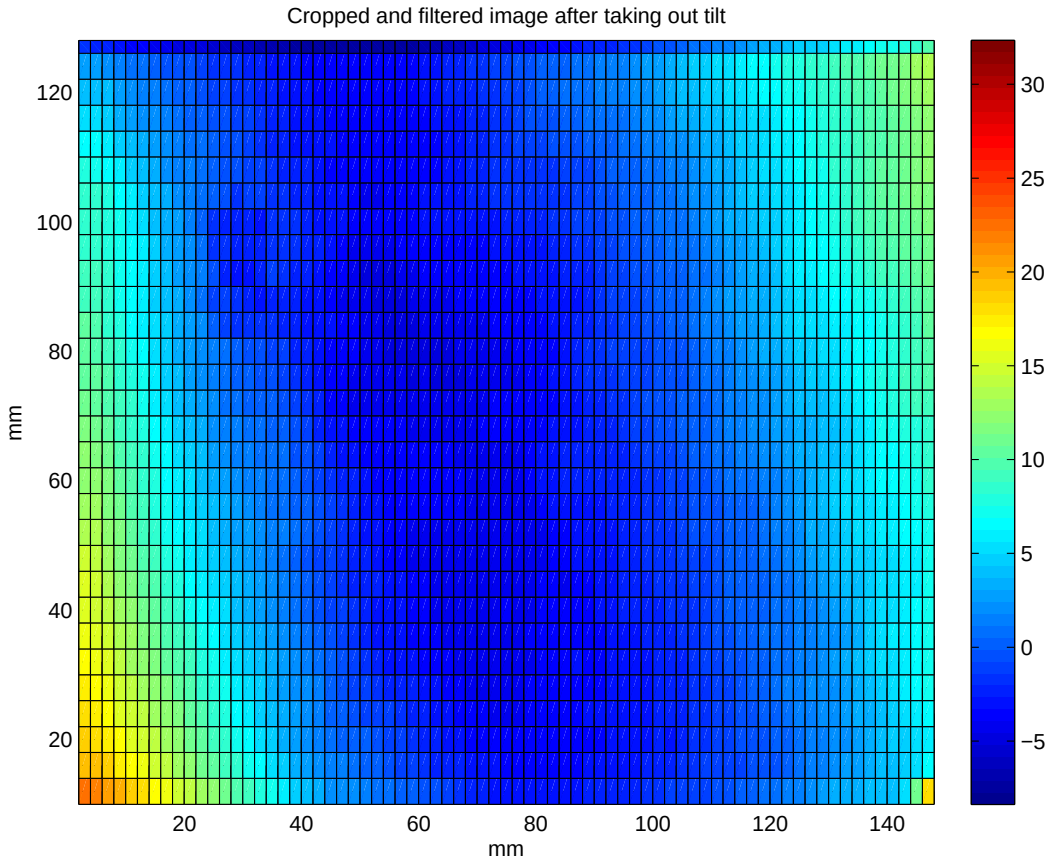

Figure 16: Contour plot of the CCD window after applying 3x3 filter after taking out tilt

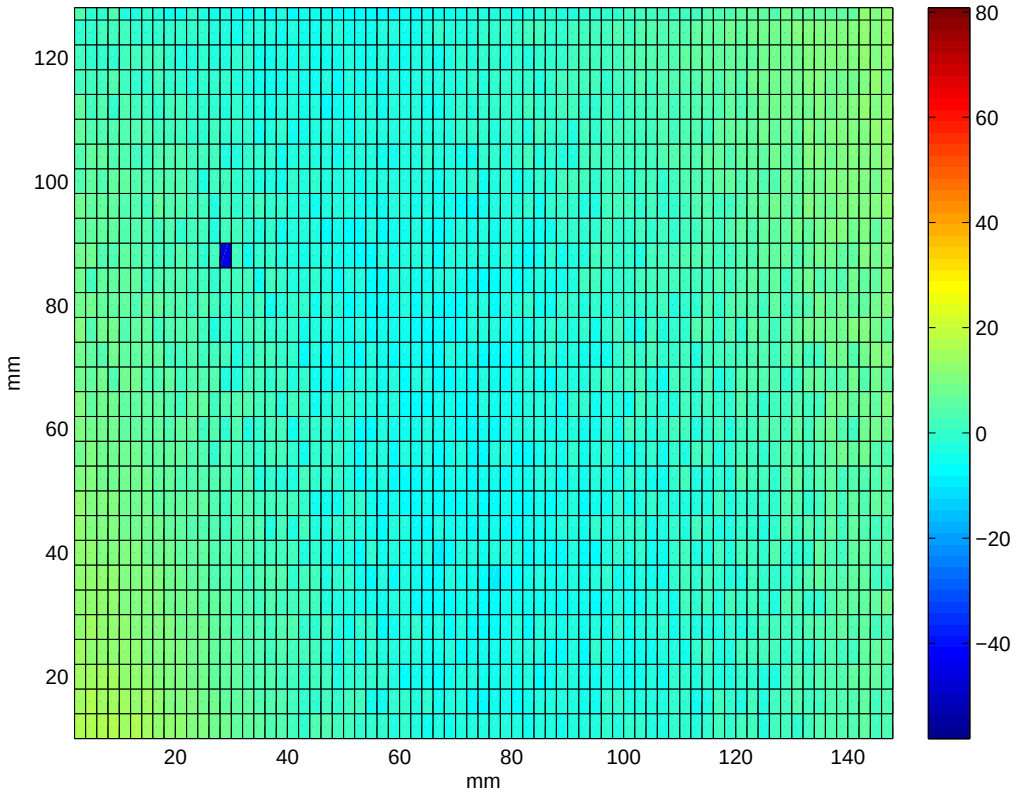

Figure 17: Contour plot of the CCD window - cropped raw data sans tilt

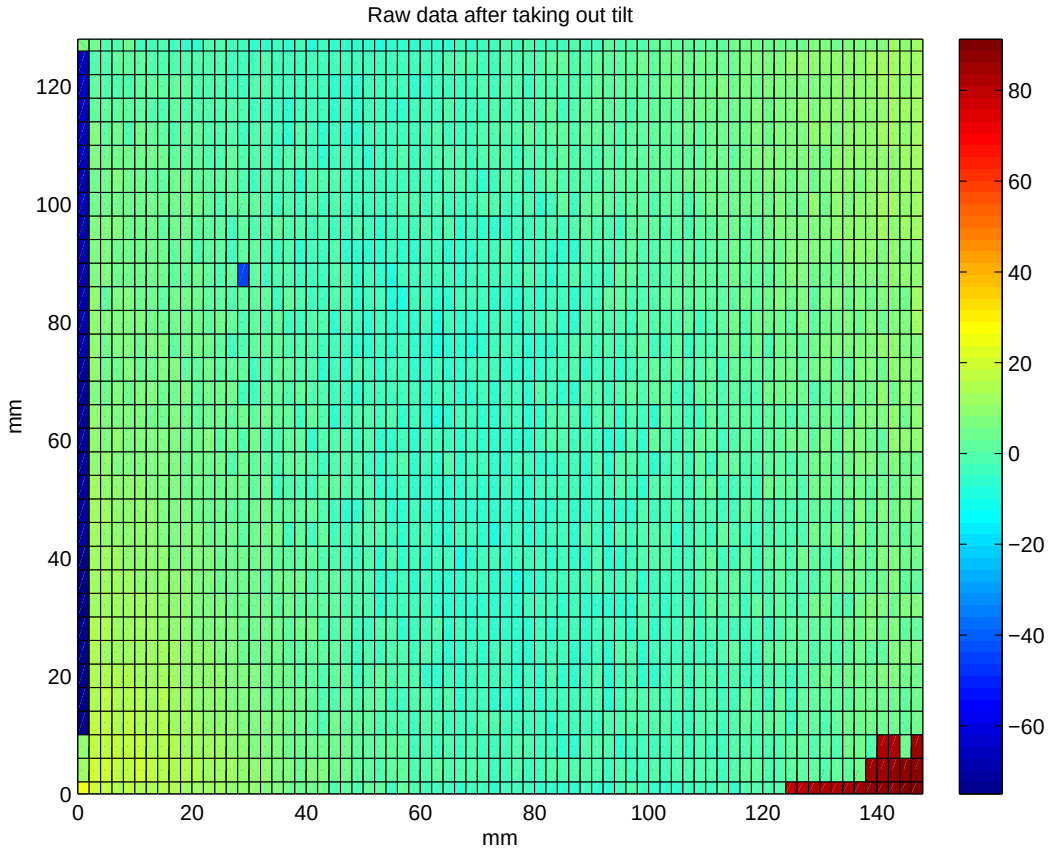

Figure 18: Contour plot of the CCD window - raw original data sans tilt

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).

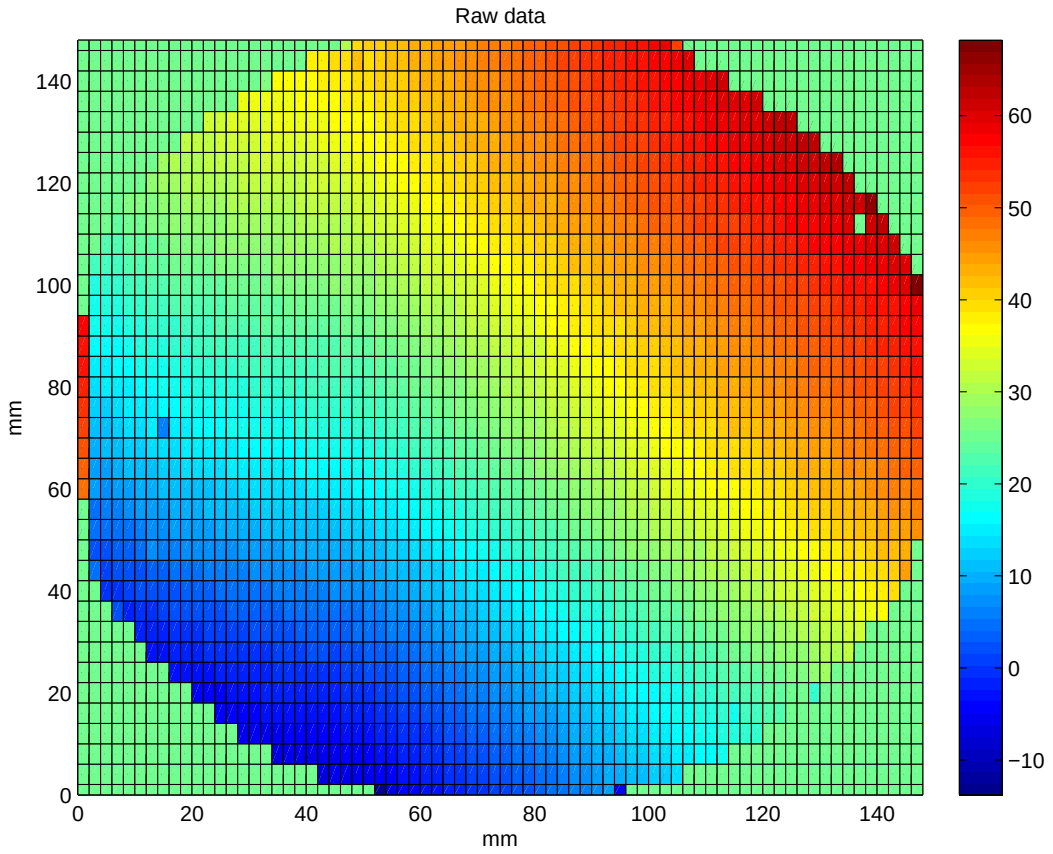

Figure 19: Contour plot of the LIGO optical flat

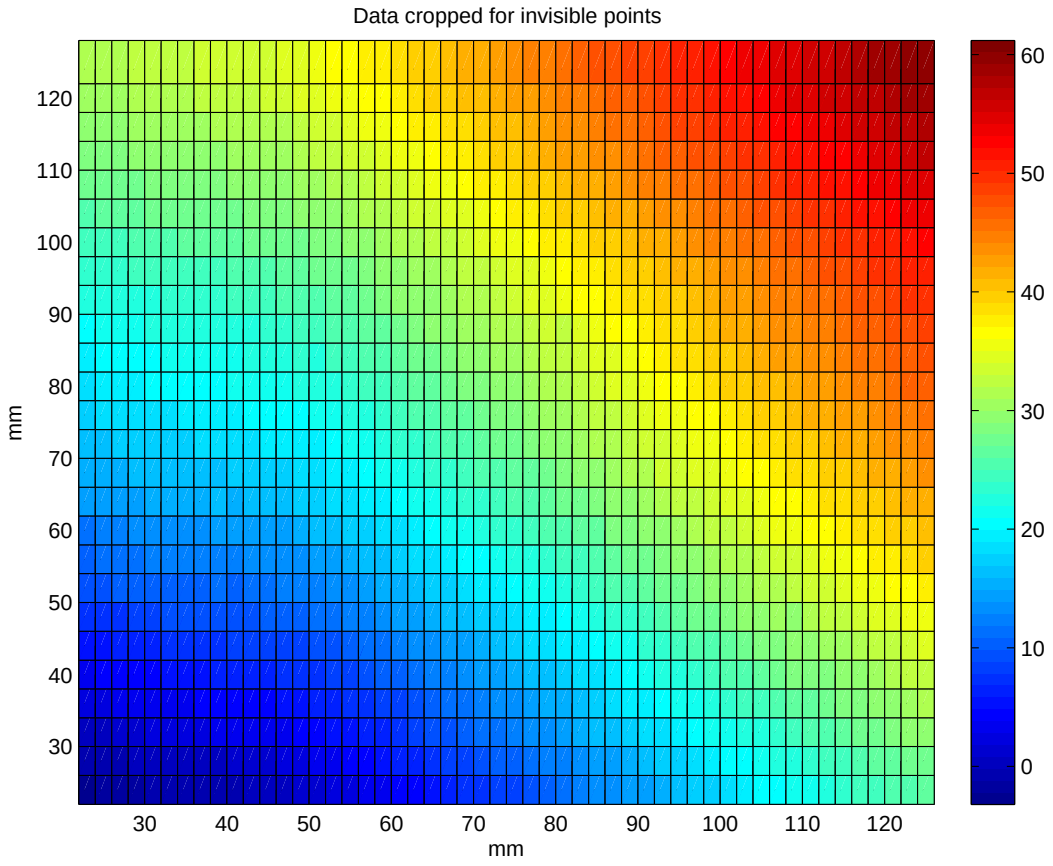

Figure 20: Contour plot of the LIGO optical flat - cropped

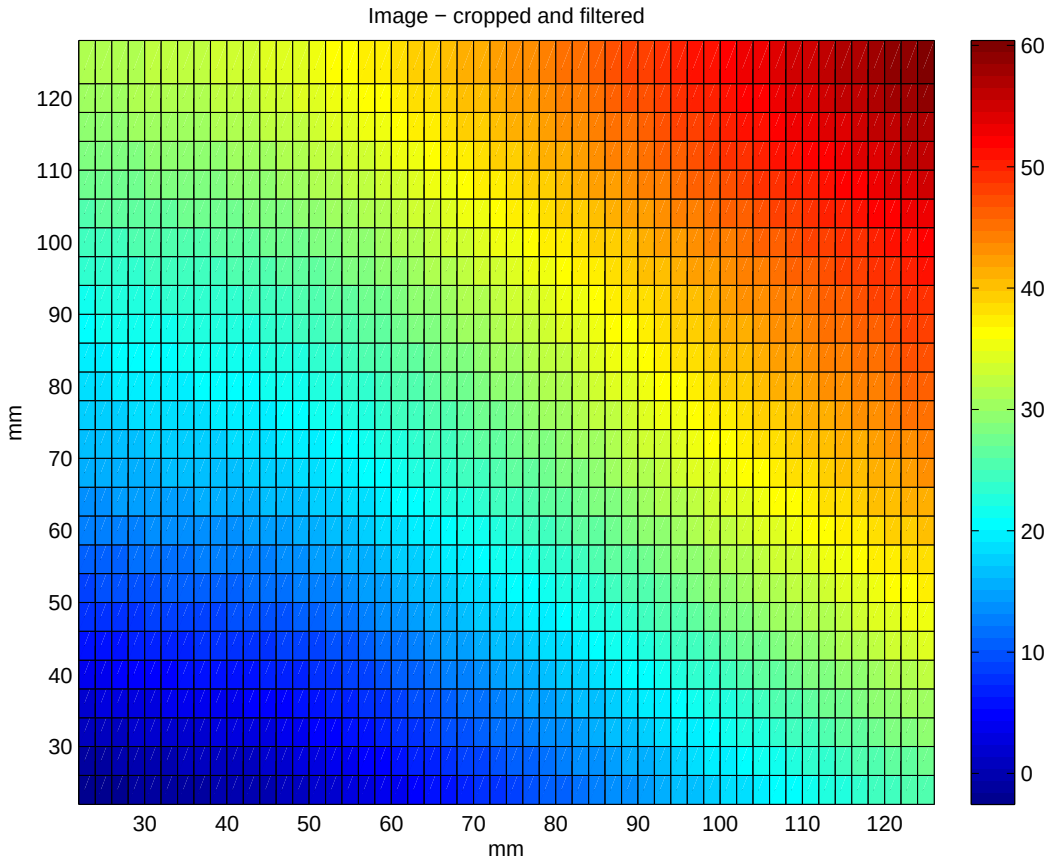

Figure 21: Contour plot of the LIGO optical flat after applying 3x3 filter

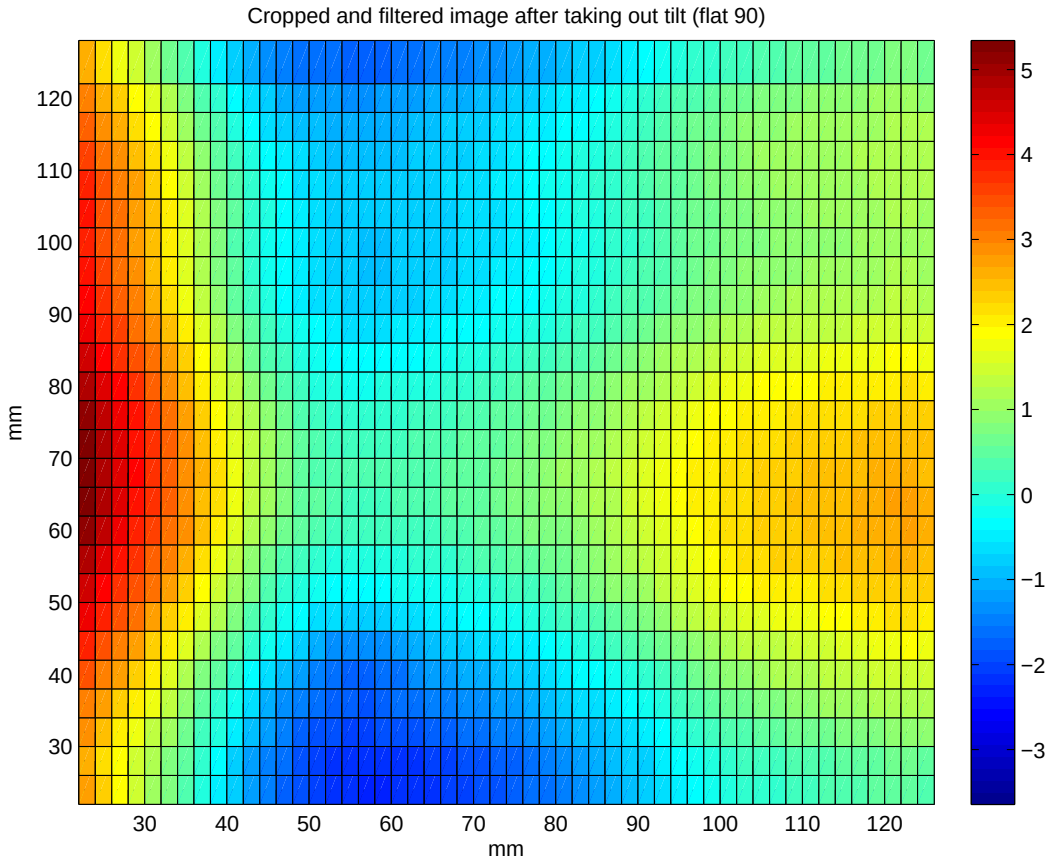

Figure 22: Contour plot of the LIGO optical flat after applying 3x3 filter after taking out tilt

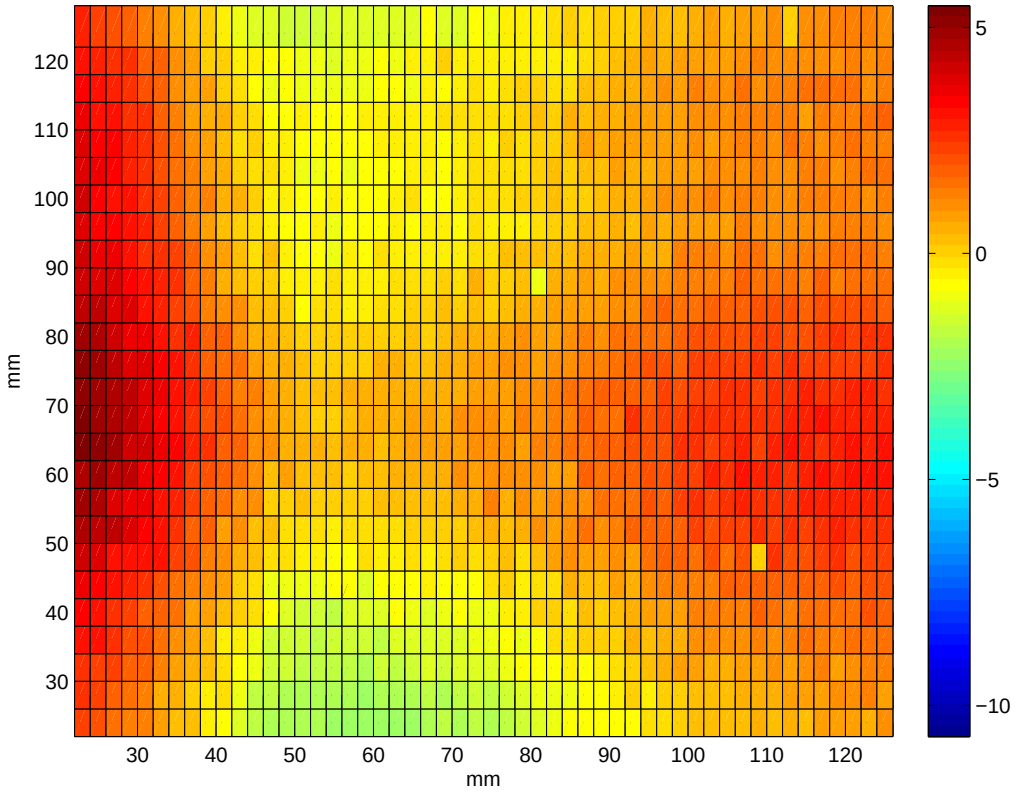

Figure 23: Contour plot of the LIGO optical flat - cropped raw data sans tilt

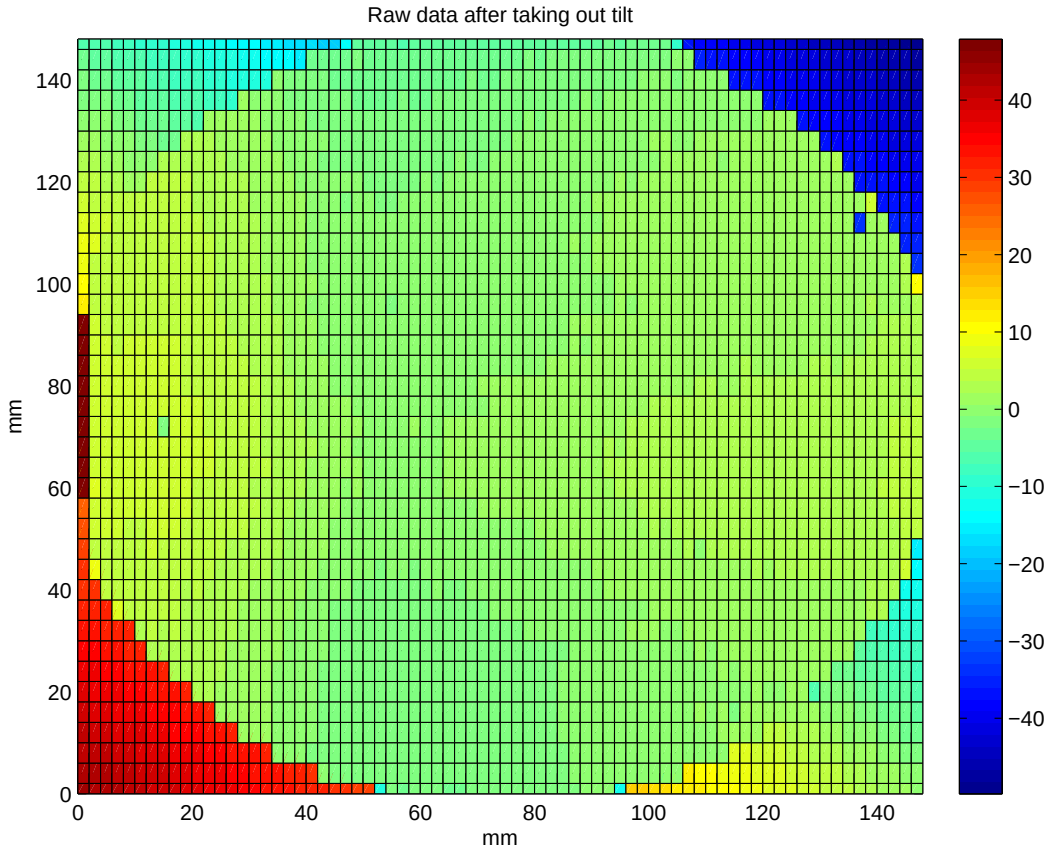

Figure 24: Contour plot of the LIGO optical flat - raw original data sans tilt

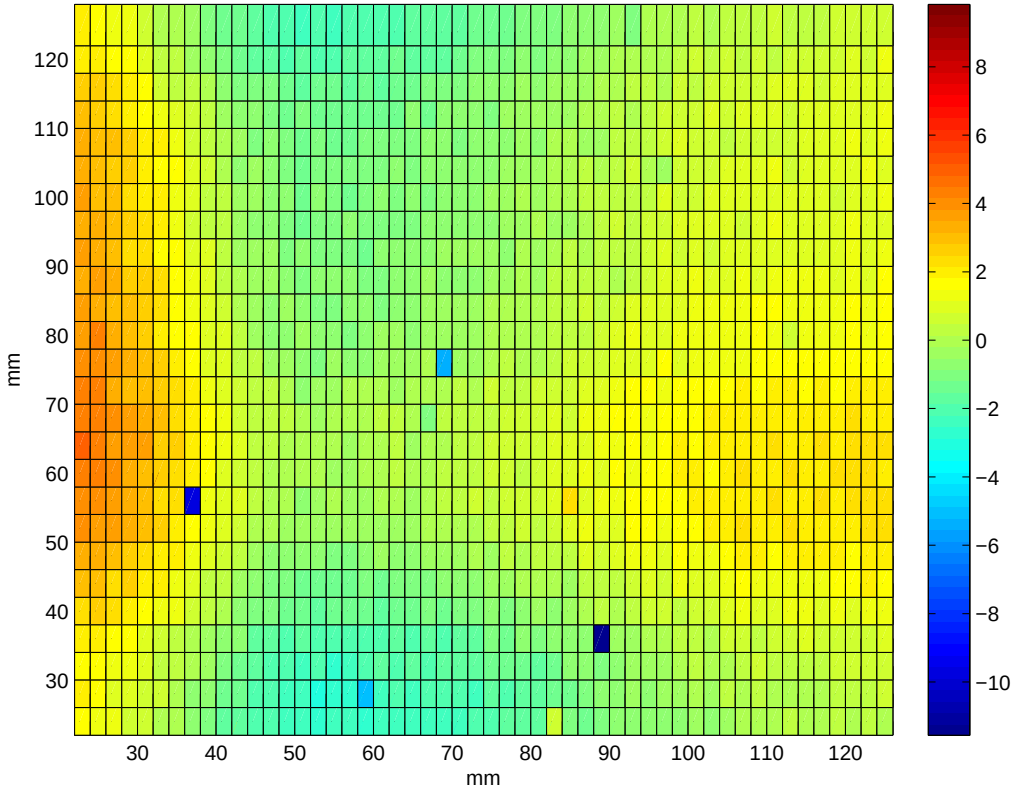

Figure 25: Contour plot of the LIGO optical flat rotated by 90-degrees - cropped raw data sans tilt

3.4.1 difference images

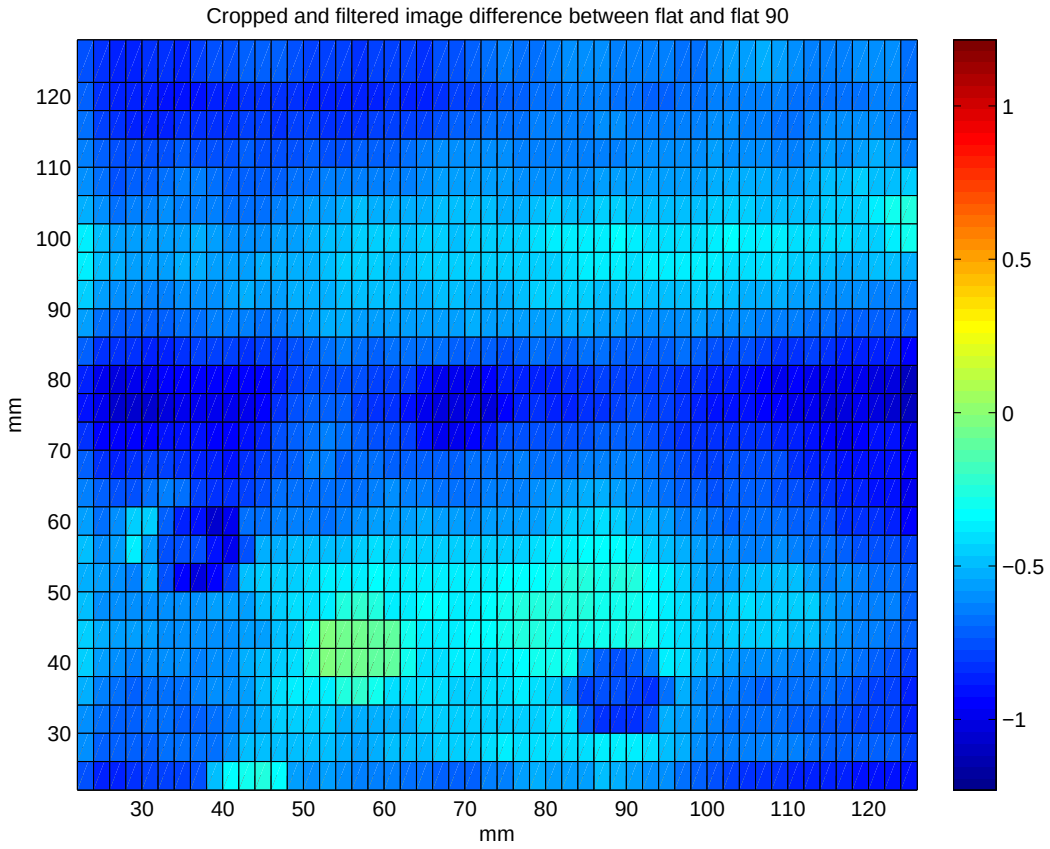

Figure 26: Contour plot of the difference between filtered and cropped images (sans tilt) of the optical flat when positioned at 0 degrees and 90 degrees.

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`

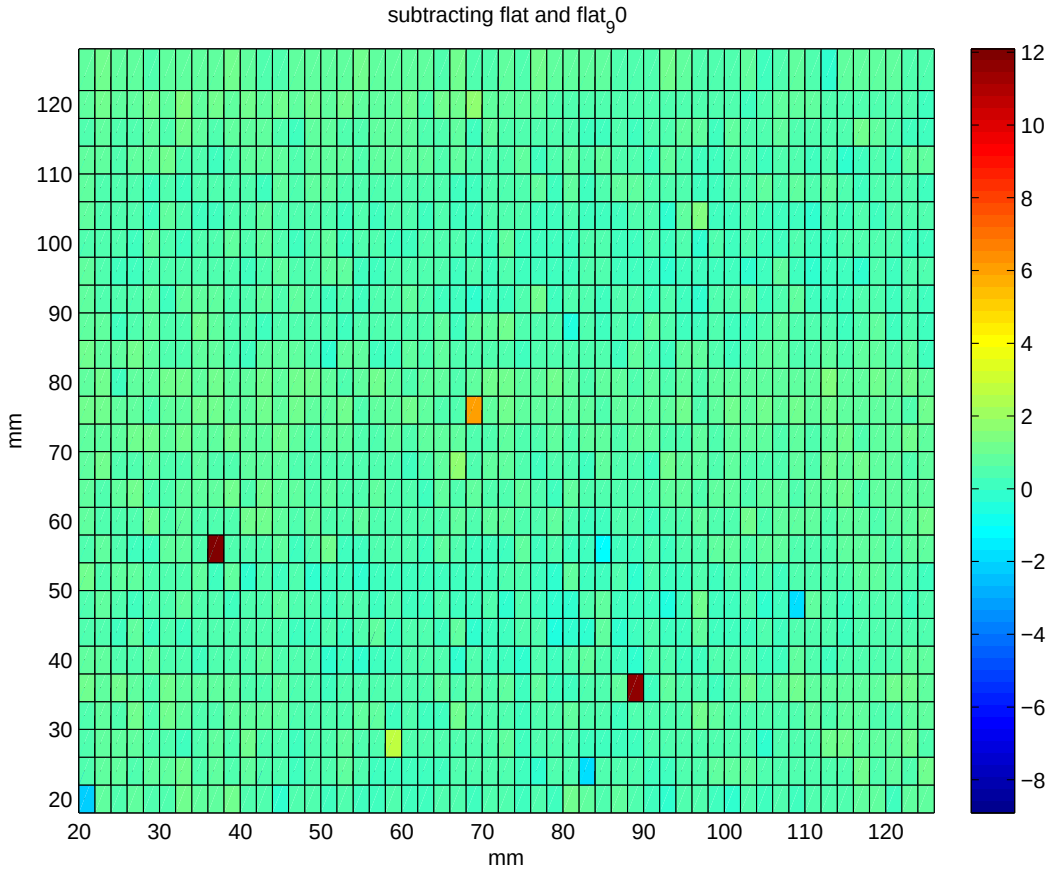

Figure 27: Contour plot of the difference between raw images (sans tilt) of the optical flat when positioned at 0 degrees and 90 degrees.