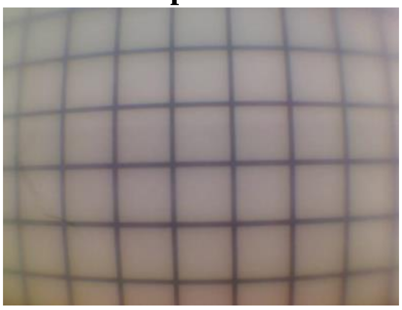
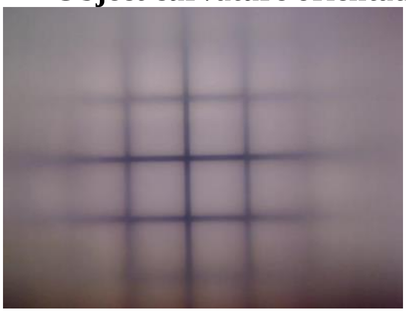
Aberrations

5. Summary of tasks of the experimental work

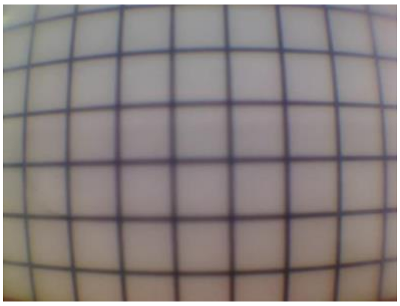
4.2. Imaging with a plan-convex lens for different orientations (30 min)

Make three images at different de-focalisation positions (-300, 0, 300 micron) for each orientation of the lens (object curvature - Landscape) and plot them in the report.

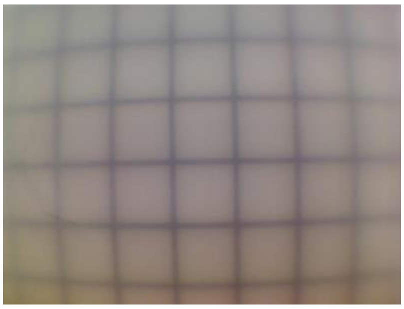
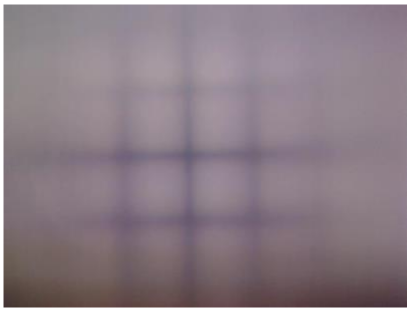
Landscape orientation **Object curvature orientation**

In focus




-300 micron – smaller distance lens detector

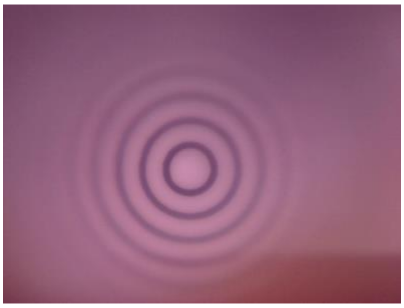
+300 micron – larger distance lens detector

Comment what you see (image quality, focalization over the field of view, aberrations...)

We see that in the landscape orientation mode the focalization is over all the field of view, there is barrel distortion and generally low contrast so that we see more that in the object curvature orientation which has a high contrast in the center so that we see only a small part of the image with a good focalization.

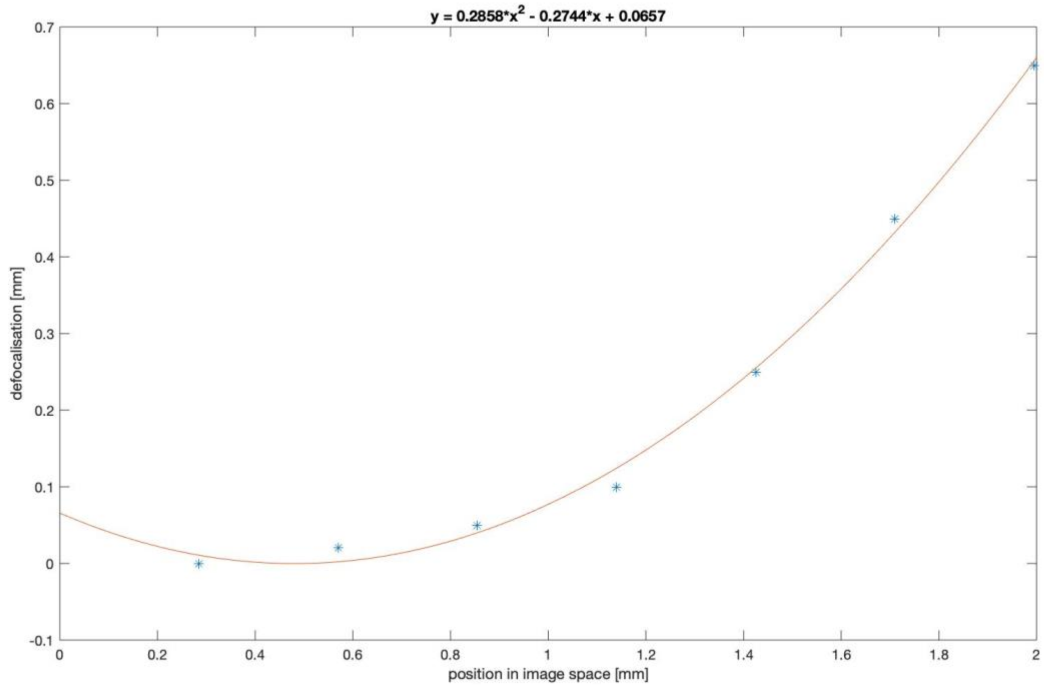
4.3 Direct measurement of the field curvature by defocusing of a test image (45 min)

Show three images (for instance focusing of ring 1,3,5). Measure the field curvature resulting in de-focalisation for a minimum of 7 rings. Plot the de-focalization distance (to be read at the linear stage) as a function of the position in the image (to be read in the image).



Measured diameter of first ring in image: d_0 = 0.57 mm

Ring No	Radius	Calculated theoretical Radius in image space (mm)	Absolute Focus position on linear stage (mm)	Relative distance in mm
1	$d_0/2$	0.285	7.35	0
2	$d_0/2+d_0/2$	0.57	7.32	0.02
3	$d_0/2+d_0$	0.855	7.30	0.05
4	$d_0/2+3d_0/2$	1.14	7.25	0.10
5	$d_0/2+2d_0$	1.425	7.10	0.25
6	$d_0/2+5d_0/2$	1.71	6.90	0.45
7	$d_0/2+3d_0$	1.995	6.70	0.65



NOTE: the plot for the report needs to be done in mm and not in normalized units!!

Calculate the radius of curvature at center position (0,0) for your data. This can be done be fitting a function $y=ax^2$ on the curve and calculate the Radius of curvature with the equation **R=1/(2a).**

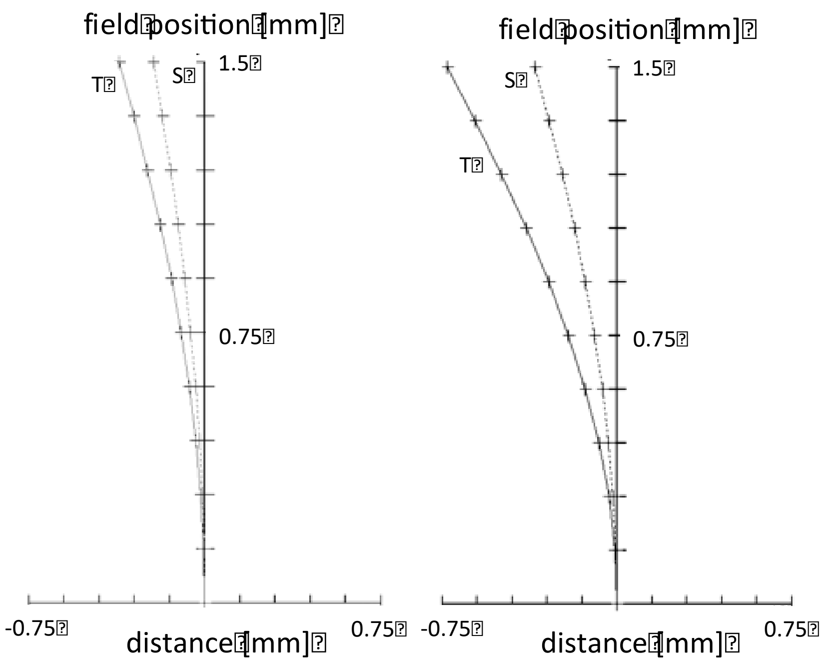
Radius of curvature **R = 1.75 mm**

Compare it with the Petzval curvature R_P= f n (f-focal lengths, n-refractive index of the lens) of the lens.

Petzval curvature **R_P= f n = 7.232 mm**

Comment on why the Petzval radius is so different from your measurement? Compare your result also with data given in.

The Radius of curvature is very similar to values in table.
The Petzeval radius is different from our measurement, we need a situation when astigmatism is corrected to fit correctly with the theory. In our case this hypotesis is maybe wrong.



Simulated field curvature for the planoconvex lens used in the experiments. On the left, in landscape orientation, the maximum field curvature is smaller than 0.5 mm and on the right values larger than 0.75 mm could be found. (T – tangential, S – sagittal)

Compare your result also with data given in the figure above!

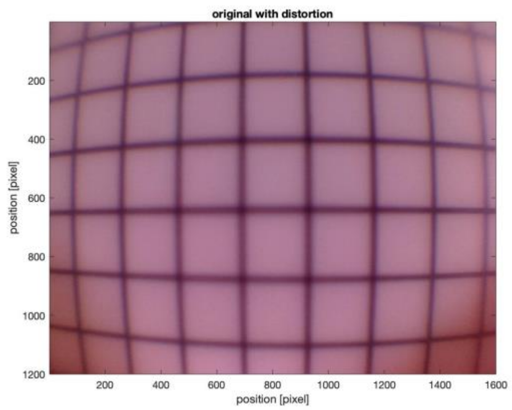
In our experiment, we use lens in object curvature orientation and looking at the figure above we determined that radius should be bigger than 0.75 mm. In our measurement, we found a radius of 1.75 mm which corresponds to explanations.

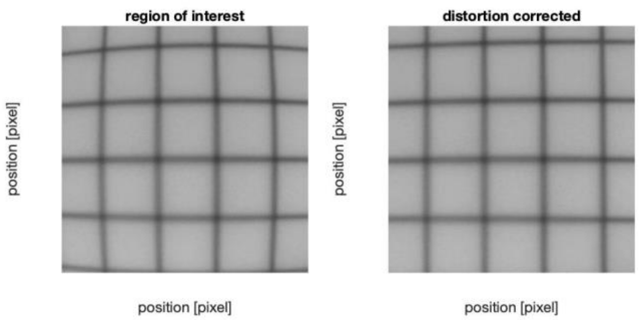
4.4 Distortion and its correction by coordinate transformation (20 min)

Show a series of images as given below. Try to find the best correction and give the following values:

Position of the center of the transformation (called center_point_x; center_point_y in the matlab script)

value of the correction (called “a” in the matlab script).



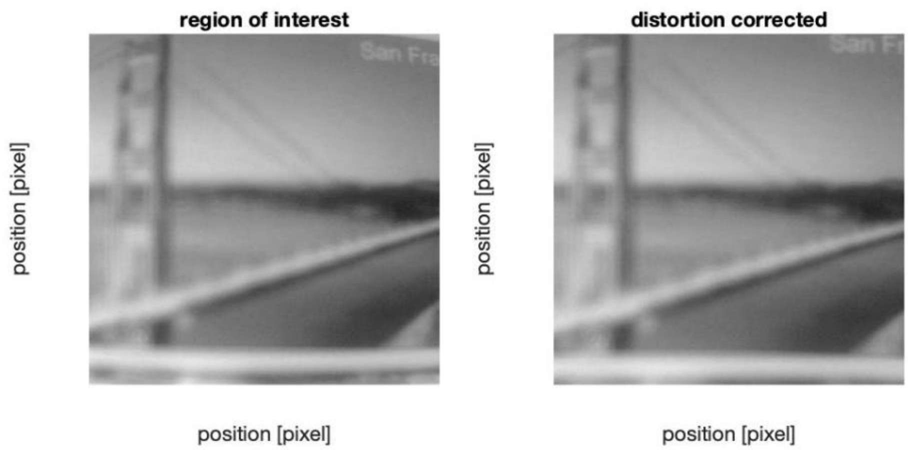


a = `-0.00000015, center_point_x = 600, center_point_y = 800`

Comment on the meaning of the sign of the correction value.

Positive value of a induces barrel distortion and negative value induces pincushion distortion. In our case the image already has barrel distorsion so that we want to correct it with pincushion distortion.

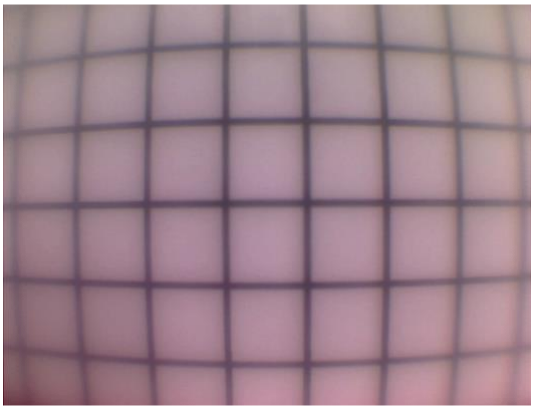
Give a real image example by taking an image of a scene and make the correction.

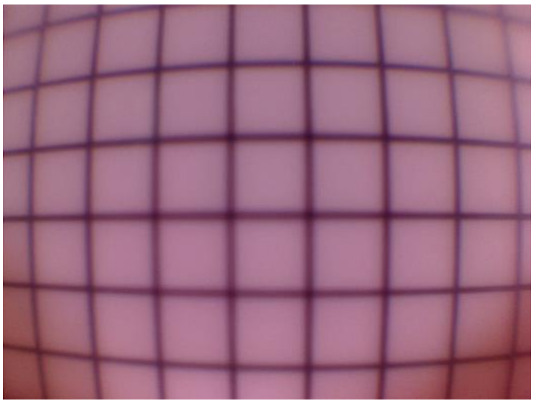


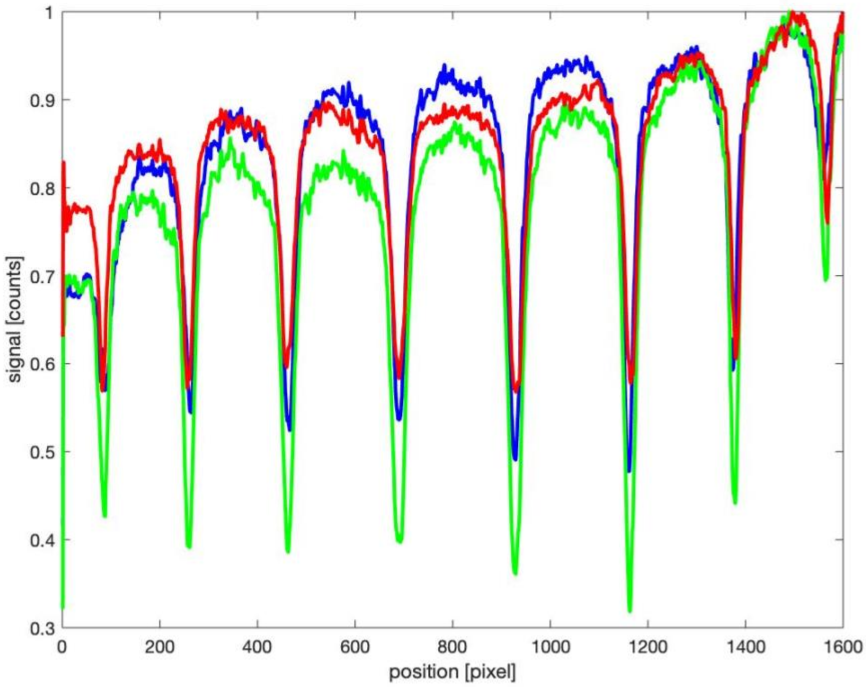
The correction is done with a = `-0.00000015` for the same reason explained before. We see that the beam at the bottom of the image is better corrected.

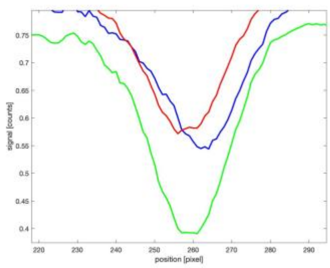
4.5 Observation of transversal chromatic aberrations for large field of views (25 min)

Present two images and show transversal aberrations like in Figure 26. Choose a convenient position in the image (middle) and plot the normalized line plot as given in Fig. 27. Use averaging to improve the quality of the measurement. Demonstrate the shift of the peaks for two positions (peaks) within the field of view by showing two graphs like in Fig 28 (Zoom plots of Fig. 27). Present a table that gives the peak positions for red green and blue as in the example above.

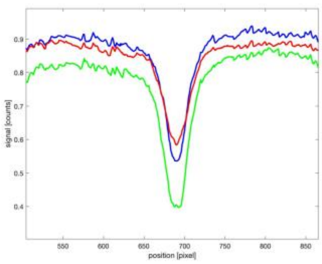




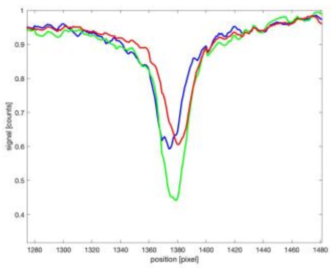




left



middle



right

NOTE: Your images might look different!!!

direction	Blue peak position	Green peak position	Red peak position	Blue peak relative to position of center peak (690)	Green peak relative to position of center peak (690)	Red peak relative to position of center peak (690)
left	264	260	255	-426	-430	-435
right	1375	1378	1380	685	688	690

Interpret your results!

By the analysis of the image with matlab we see the chromatic aberrations with shift between RGB peak position. It's also possible to see it by looking directly at the image, it's blurry. In general blue light is less shift than red light.

4.6 Example from the web

Find an image taken with a fisheye lens and print it into your report. Print also an image of the lens model as shown below so that one can read the parameters of the lens! Cite correctly!

Screenshot from :
https://www.youtube.com/watch?v=hROok7RwpxE
https://store.insta360.com/product/one (ultra wide fisheye lens, scroll at the end)

Personal feedback:

Was the amount of work adequate? Yes

What is difficult to understand? It was clear

What did you like about it? Impressed by the 200° of fish eye lens !

How can we do better? By doing real TP ☺ 8.1

Index of comments

8.1 Yeah, there was no other way given the current circumstances!