Homogeneity tests using a Microlens array 10 x 10 mm and the tuneable laser NT242 ATLAS and a HeNe laser

Julian Gröbner 23 January 2017

The measurements were performed in the Optic lab 2 of PMOD/WRC using the tuneable laser NT242 ATLAS, a Microlens array 10x10 mm and the DaraRay WebCam with 2048 x 2048 pixel (5.5 µm), representing an area of 11.3x11.3 mm. The aim was to test the homogeneity achieved at the nominal working distance of 115 mm behind the MLA.

The pure laser beam

The beam profile of the tuneable Laser is shown in Figure 1 for several wavelengths.

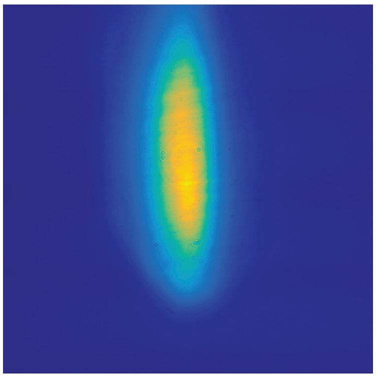
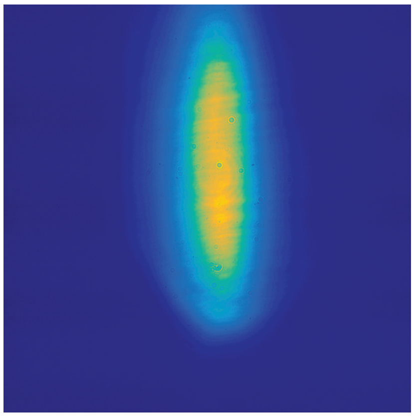
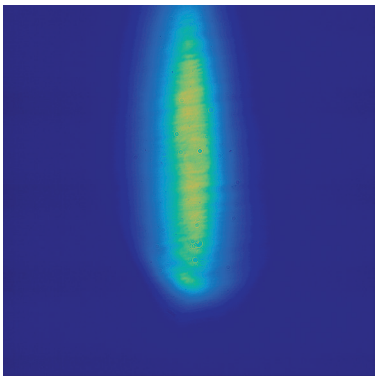
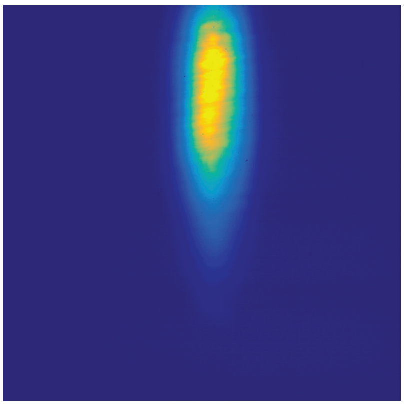
632 nm	532 nm
	
432 nm	352 nm
	

Figure 1 Beam profile of the tuneable laser NT242 ATLAS Laser.

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The Homogeneity of the MLA was measured at the nominal distance of 115 mm behind the MLA array where the detectors are usually mounted.

ATLAS & MLA

The homogeneity was measured at a laser wavelength of 630 nm behind the MLA. Figure 2 shows the radiation field 11.3 x 11.3 mm at 115 mm behind the MLA.

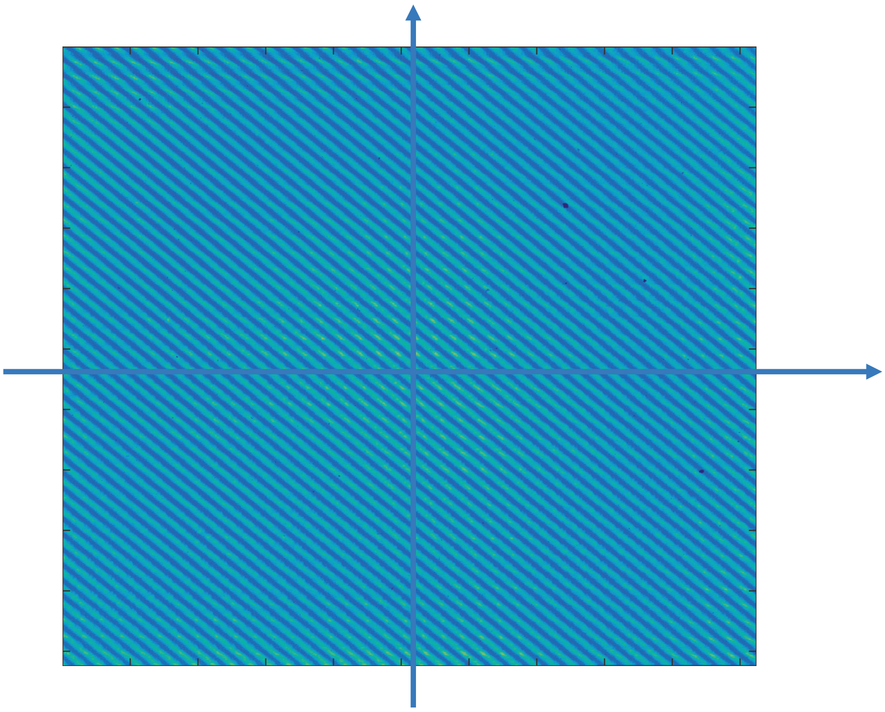
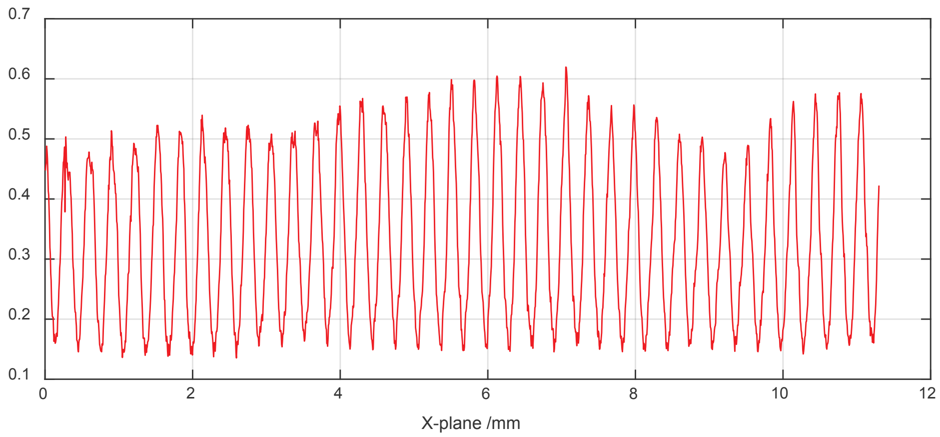


Figure 2 Radiation field at 630 nm behind the MLA.

The high spatial inhomogeneity can be better seen when a cut is made through the X and Y plane:

X-Plane



Y-plane

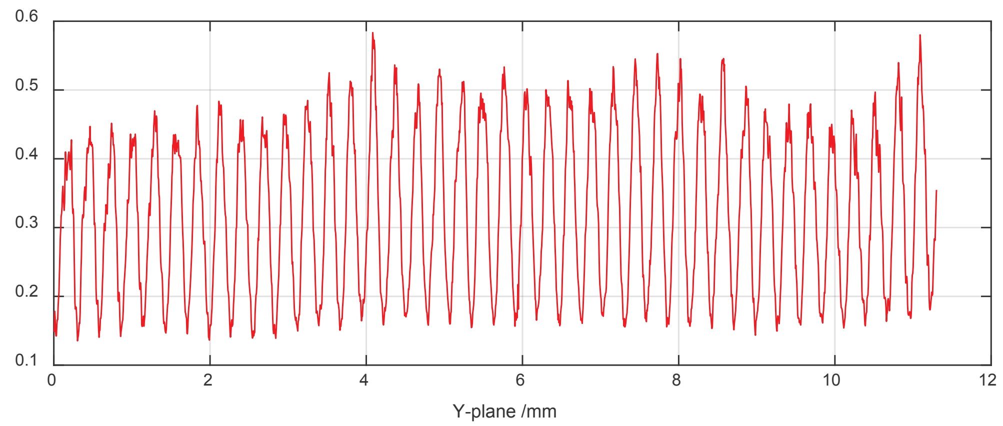


Figure 3 Cut through the X and Y plane.

The high spatial inhomogeneity observed in these images has a periodicity of 250 µm, which is the same as the pitch of the MLA.

The same measurement at 430 nm shows a significantly different pattern, with a much higher homogeneity:

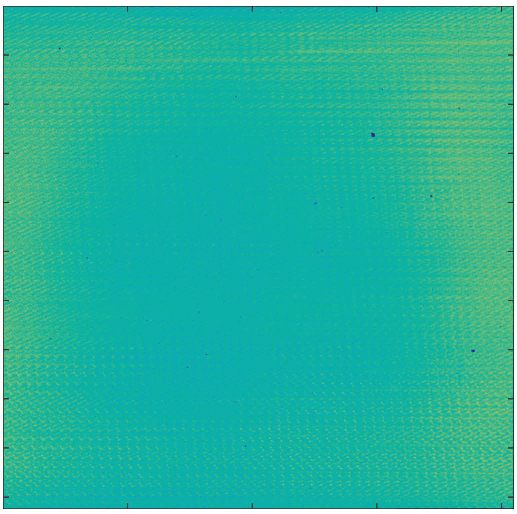
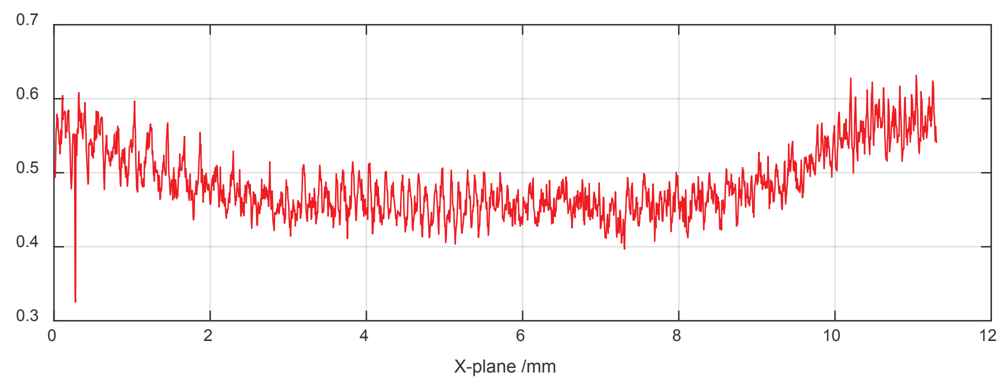


Figure 4radiation field behind the MLA at 430 nm

X-Plane



Y-Plane

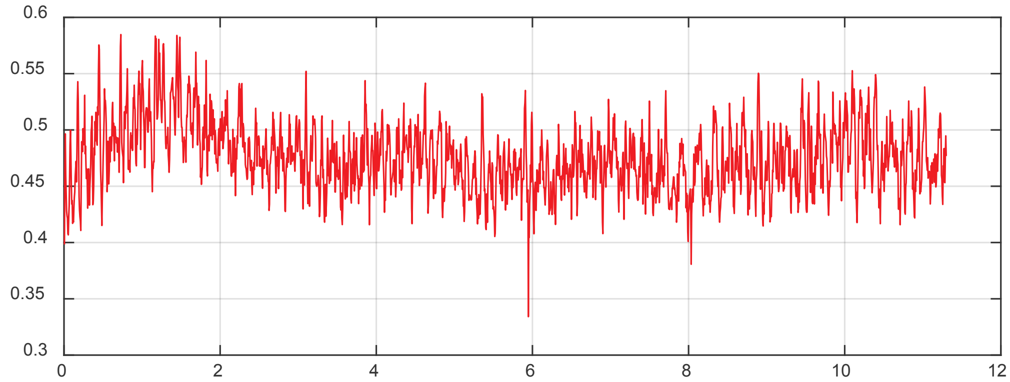


Figure 5 Cut through the X and Y plane at 430 nm.

At 830 nm the radiation field is the following:

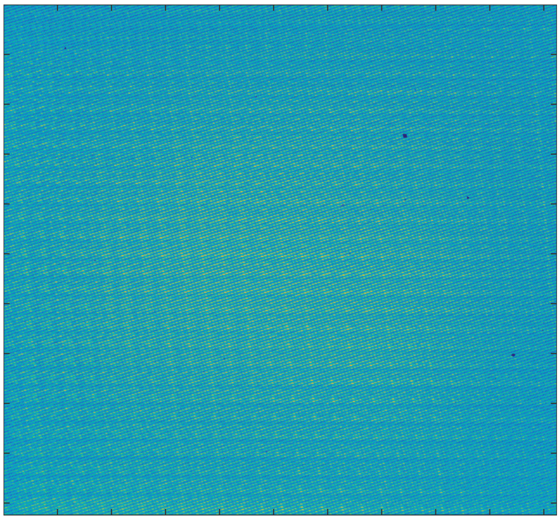
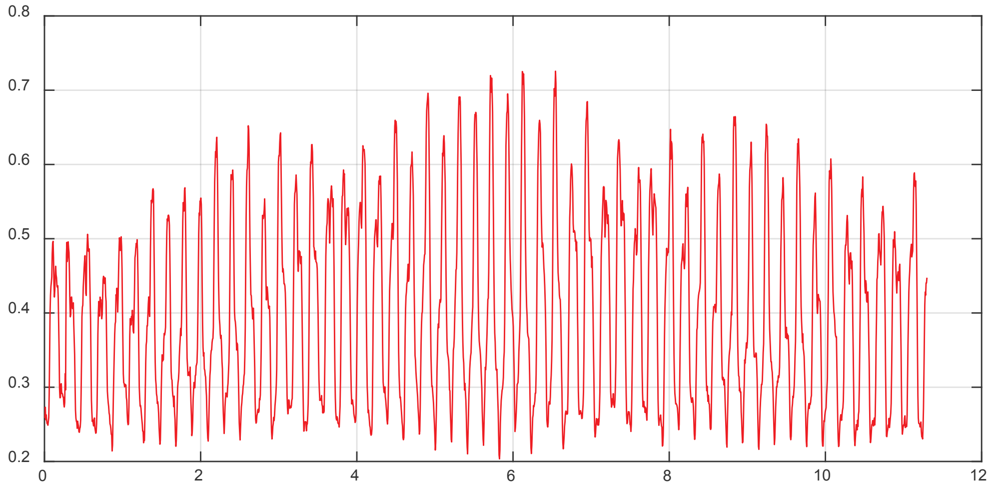


Figure 6 Radiation field at 830 nm behind the MLA

X-plane



Y-plane

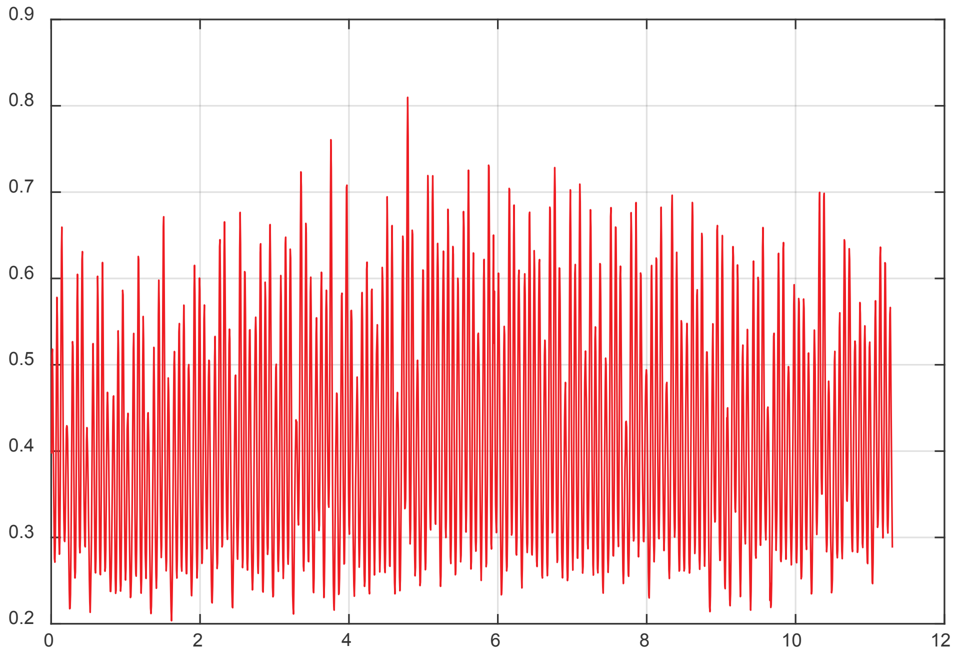
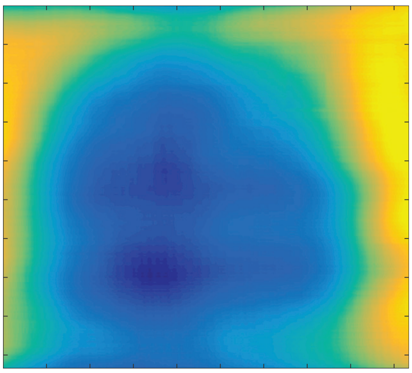


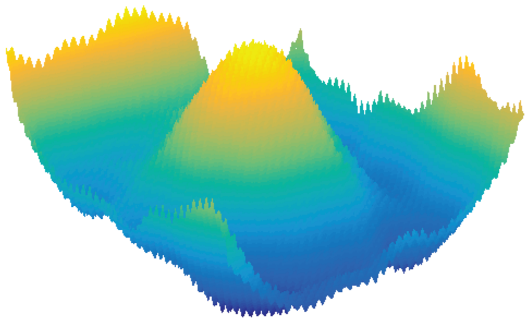
Figure 7 X and Y plane cut through the radaition field at 830 nm.

It is clear that at a spatial resolution of around 200 µm, the radiation field behind the MLA is highly inhomogeneous. However typical detectors have a much larger active area of at least 1 mm. The measurements were therefore smoothed with different detector areas to simulate the signal seen by such detectors:

The following figures show the radiation field at 430, 630 and 830 nm smoothed with a 1mm^2 filter.

430 nm std=4.4%





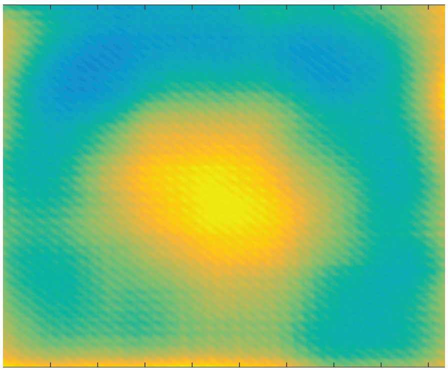
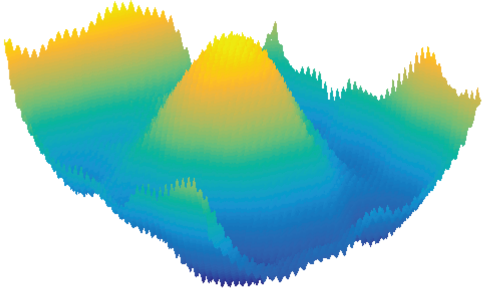
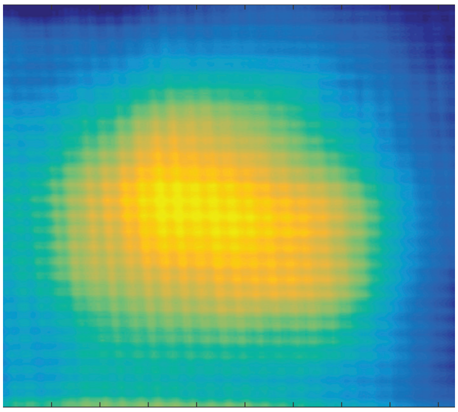
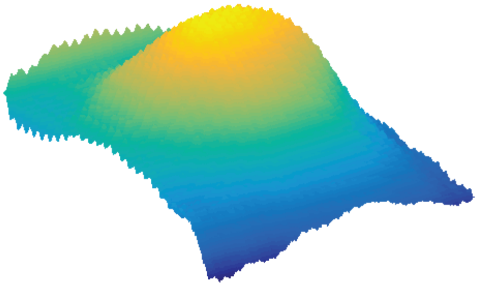
630 nm, std=3.1% 	
830 nm std=4.8% 	

Figure 8 Radiation fields behind the MLA at 430, 630 and 830 nm, smoothed to simulate the size of a $1mm^2$ diameter square detector.

While the overall variability is less than 5%, the minimum to maximum signal range extends over 20%.

The highest homogeneity is obtained at the output of an integrating sphere, as shown in Figure 9 below:

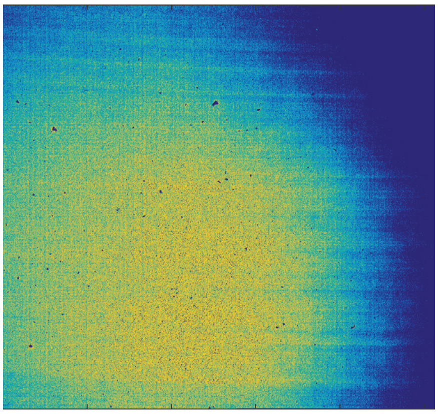


Figure 9 Radiation field at the output of an integrating sphere. The homogeneity is better than 2% directly at the output of the sphere (yellow region).

Conclusion

The radiation field behind the microlens-array shows a spatial pattern strongly correlated to the size of the micro-lenses in the MLA. The size of the observed inhomogeneities are of the order of 200 µm. Assuming detector receiver areas of the order of $1mm^2$ or larger, these inhomogeneities are smoothed out and become negligible. Nevertheless, care must be taken when using bare multi-core optical fibers with diameters of the size of 100 µm to 200 µm as they might be affected by the sptatial inhomogeneities. In this case, it is suggested to use the output of an integrating sphere which produces a very homogeneous radiation field.

The files can be found at: \\ad.pmodwrc.ch\Institute\Labs\OpticsLab2\NT242\homogeneity_tests

Matlab code:

```
f=imread('HeNe_MLA3.tiff');f=double(f);
q=filter2(ones(183),f,'valid');
figure;mesh(q/max(q(:)));colorbar;axis off
figure;imagesc(q/max(q(:)));axis equal;colorbar;axis off
```

Homogeneity tests using a Microlens array 10 x 10 mm and a HeNe Laser

The measurements were performed in the Optic lab 2 using a HeNe Laser, a Microlens array 10x10 mm and the DaraRay WebCam with 2048 x 2048 pixel (5.5 µm), representing an area of 11.3x11.3 mm. The aim was to test the homogeneity achieved at various distances behind the microlens array.

The pure laser beam

The beam profile of the HeNe Laser is shown in Figure 1.

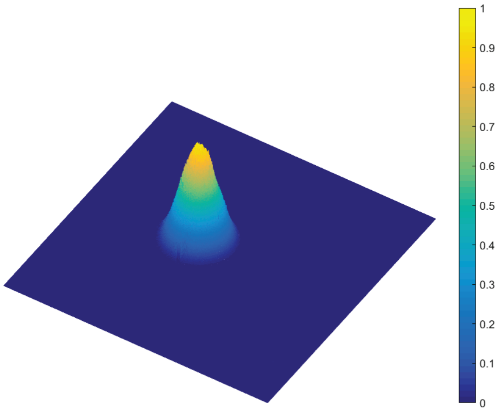


Figure 10 Beam profile of HeNe Laser. The size of the image is downsampled to 1024 x 1024 pixels.

The Homogeneity of the MLA was measured using different configurations. The initial configuration is with only the MLA in the beampath and the camera at various distances. As can be seen in Figure 1, the MLA produces a square top image with a distinct maximum at every micro-lens location (pitch of MLA is 250 µm).

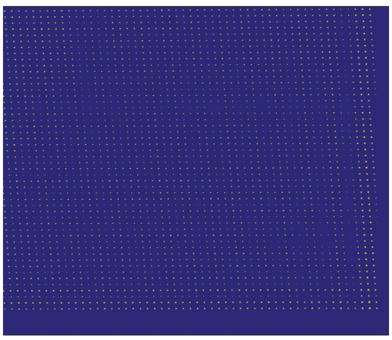
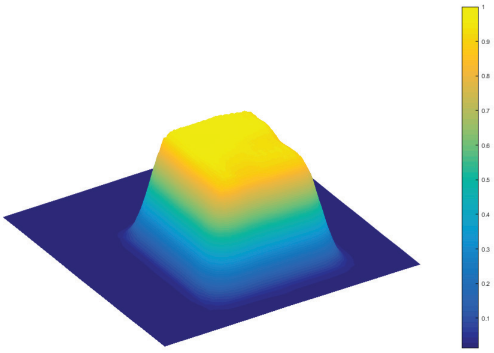
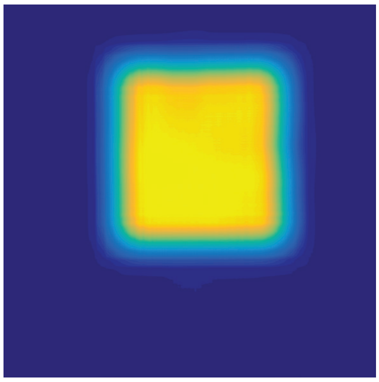
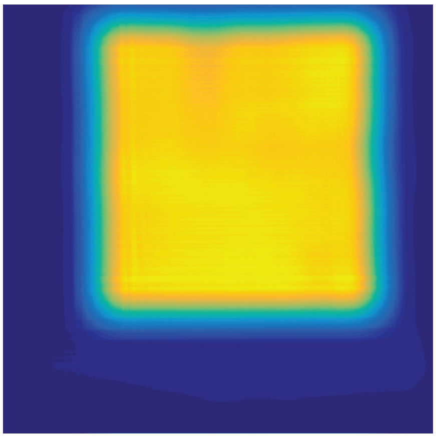
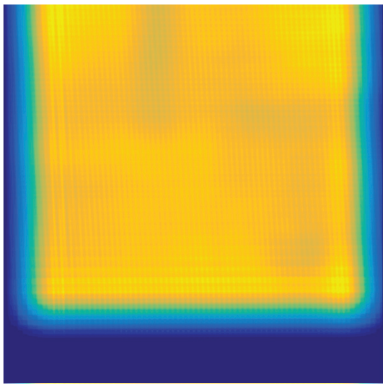


Figure 11 Image of the Radiation field 80 mm behind MLA. The locations of the micro-lenses are clearly seen and produce a strongly anisotropic radiation field at this high spatial resolution.

In order to simulate the field seen by detectors with a larger diameter active area, all subsequent measurements will be averaged with a 1 mm square area filter. This simulates the homogeneity seen by a detector with a 1 mm area.

HeNe & MLA

The following measurements are done at various distances behind the MLA.

 fn='HeNe_20mm.tiff' **D= 20 mm std = 2.1%**	
 fn='HeNe_35mm.tiff';**D=35 mm, std=2.5%**	 fn='HeNe_50mm.tiff';**D=50 mm, std=3.0%**

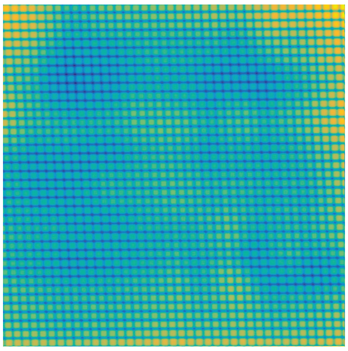
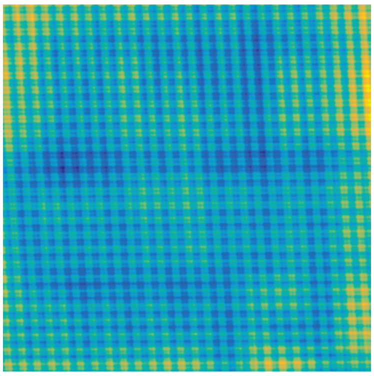
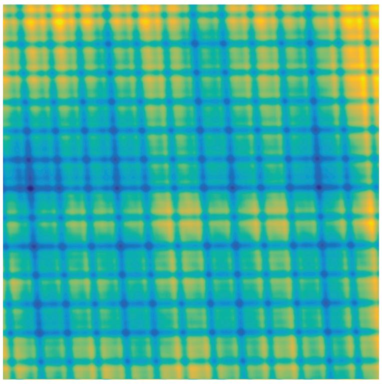
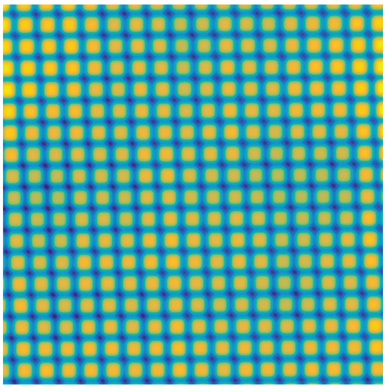
 fn='HeNe_80mm_nobaseline.tiff'; **D=80 mm, std=5.1%**	 fn='HeNe_150mm_nobaseline.tiff'; **D=150 mm, std=4.2%**
 fn='HeNe_300mm_nobaseline.tiff'; **D=300 mm, std=6.4%**	 When the same measurement is performed with a lens behind the MLA, the inhomogeneity is increased, fn='HeNe_lens_300mm_nobaseline.tiff'; **D=300 mm, std=14.4%.**

Figure 12 Radiation field averaged over 1 mm^2 area at different distances behind the MLS.

The same measurements were performed using a defocus lens in front of the MLA to expand the laser beam to cover the whole MLA.

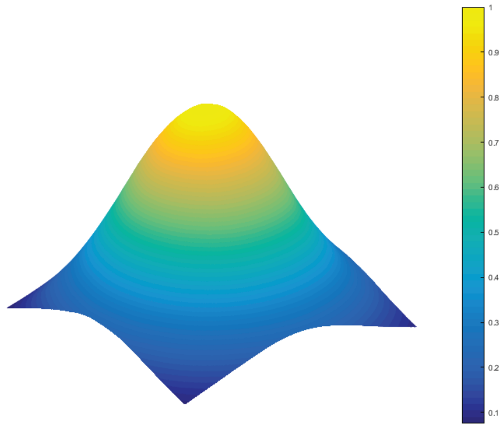
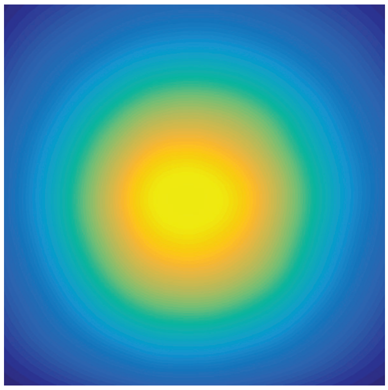
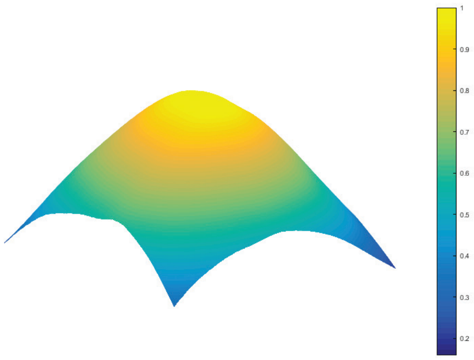
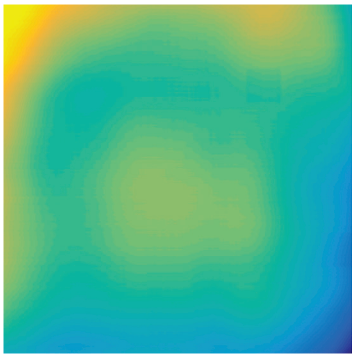
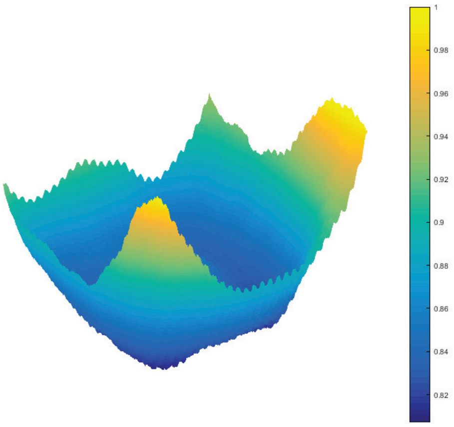
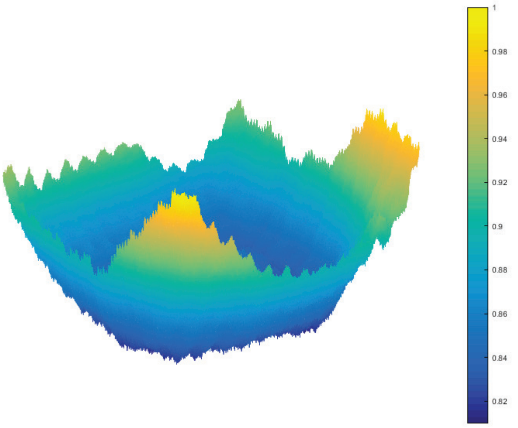
 fn='HeNe_30mm_nobaseline_defocuslens.tiff'; **D=30 mm, std=22%**	 Same as left figure
 fn='HeNe_50mm_nobaseline_defocuslens.tiff'; **D=50 mm, std=12%**	 fn='HeNe_80mm_nobaseline_defocuslens.tiff'; **D=80 mm, std=1.9%**
 fn='HeNe_150mm_nobaseline_defocuslens.tiff'; **D=150 mm, std=1.9%**	 fn='HeNe_300mm_nobaseline_defocuslens.tiff'; **D=300 mm, std=1.8%**

Figure 13 Radiation field averaged over 1 mm^2 with a defocussing lens before the MLA.

When using a distance of 80 mm behind the MLA, the homogeneity of the field is determined for different detector sizes:

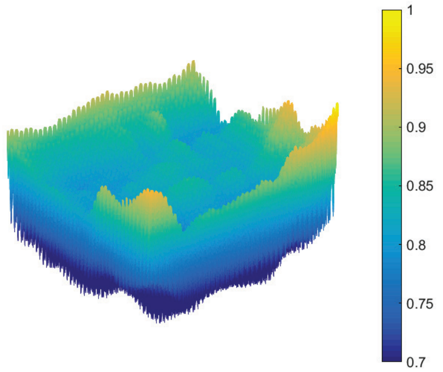
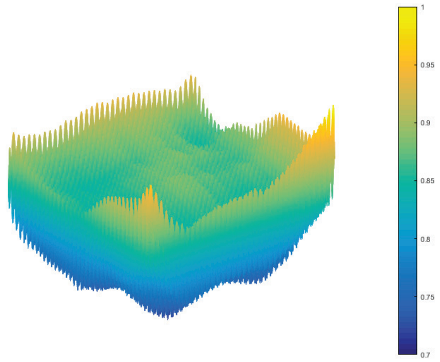
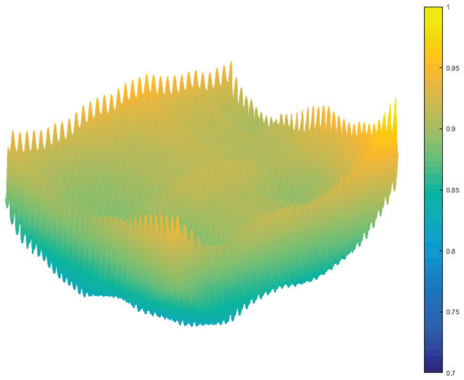
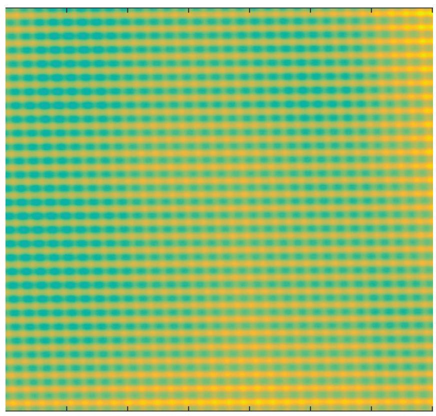
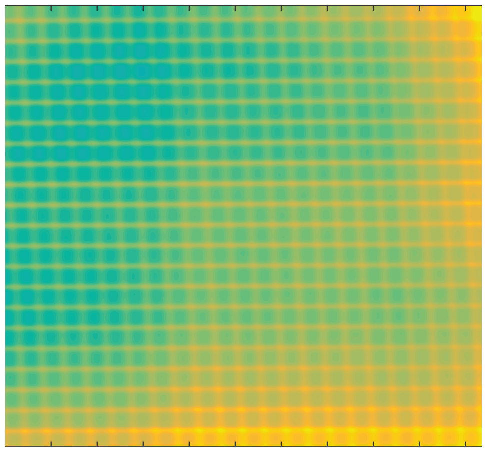
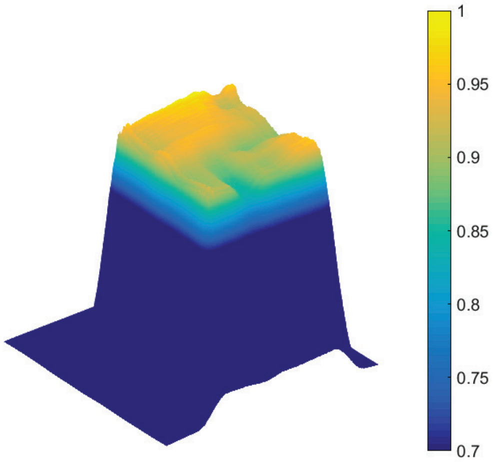
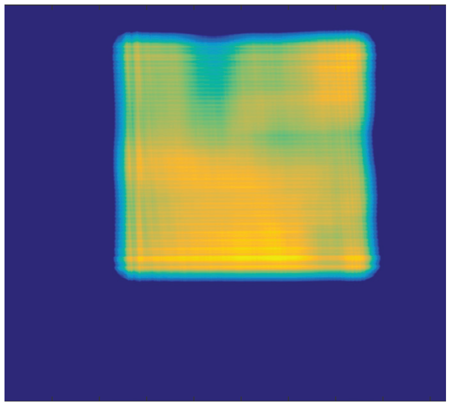
1 mm^2 detector, std=4.9% 	2 mm^2 detector, std=3.6% 
3 mm^2 detector, std=2.6% 	Idem to left figure 
5 mm^2 detector, std=0.9% 	

Figure 14 Field homogeneity 80 mm behind the MLA for different detector sizes.

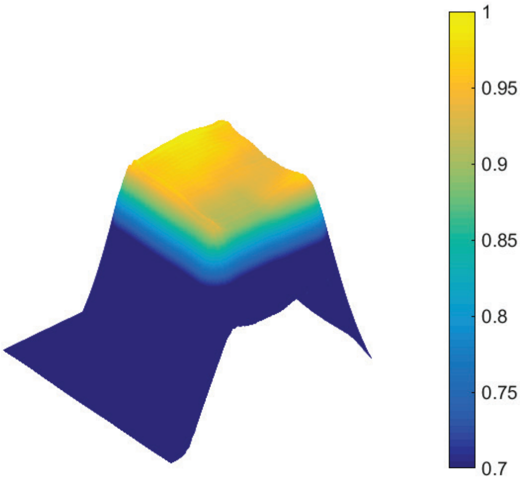
The homogeneity 50 mm behind the MLA is even better:

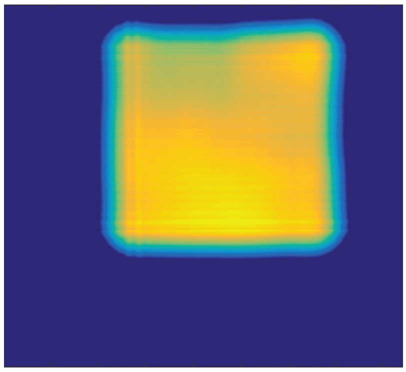
1 mm2 detector std=2.5%



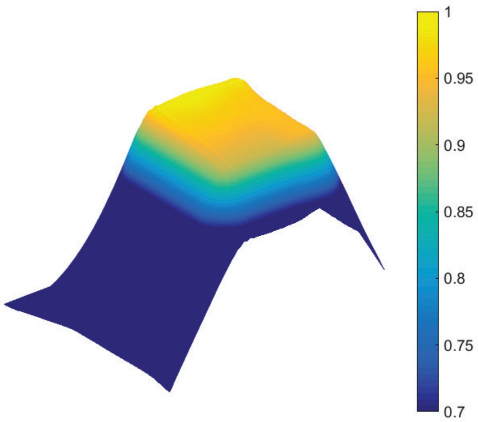


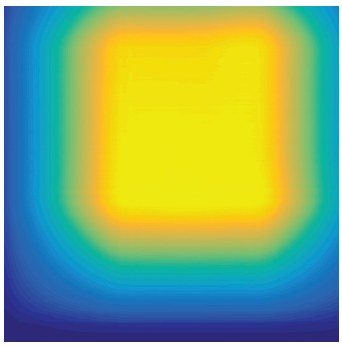
2 mm2 detector std=1.8%





3mm2 detector, std=1.1%





Conclusion

The objective of reaching a field homogeneity of 1% can be achieved by placing a detector closer than 80 mm behind the MLA. The homogeneity seen by the detector will depend on its active detector area.

Matlab code:

```
f=imread('HeNe_MLA3.tiff');f=double(f);
q=filter2(ones(183),f,'valid');
figure;mesh(q/max(q(:)));colorbar;axis off
figure;imagesc(q/max(q(:)));axis equal;colorbar;axis off
```