Homogenization Without Scattering of Laser Illumination

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DYOPTYKA, Ireland.

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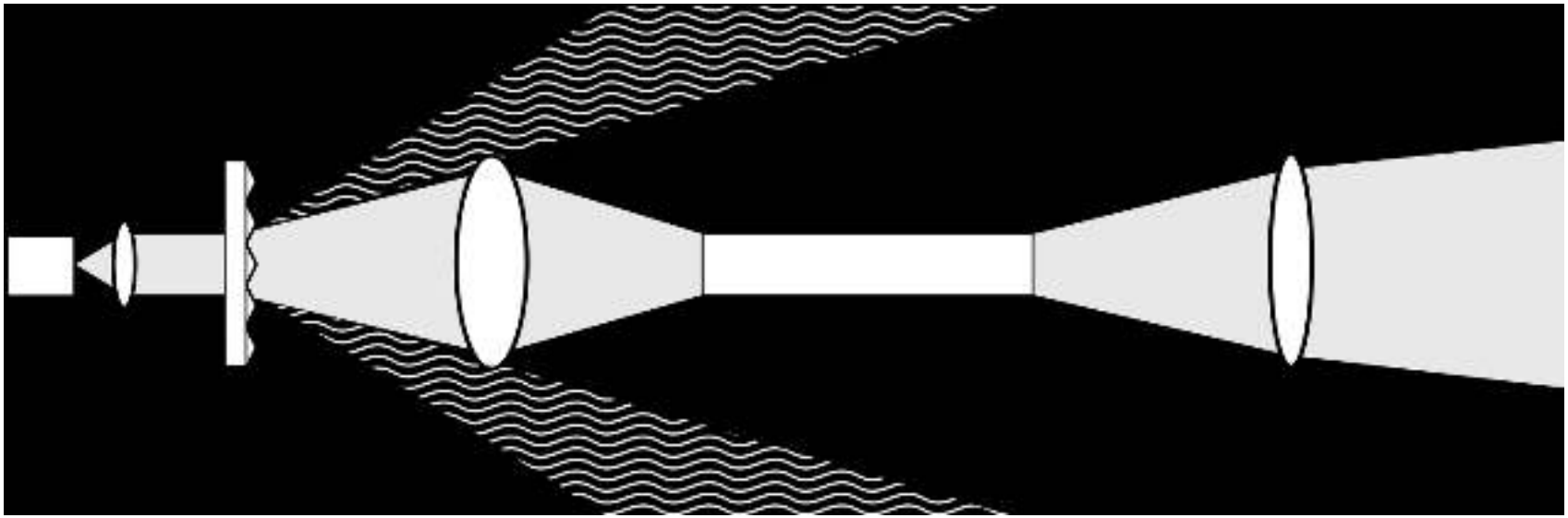
2019-04-24

Diffusers scatter outside apertures



Typical moving diffuser implementation to extend laser source size for intensity homogenization with light guide.

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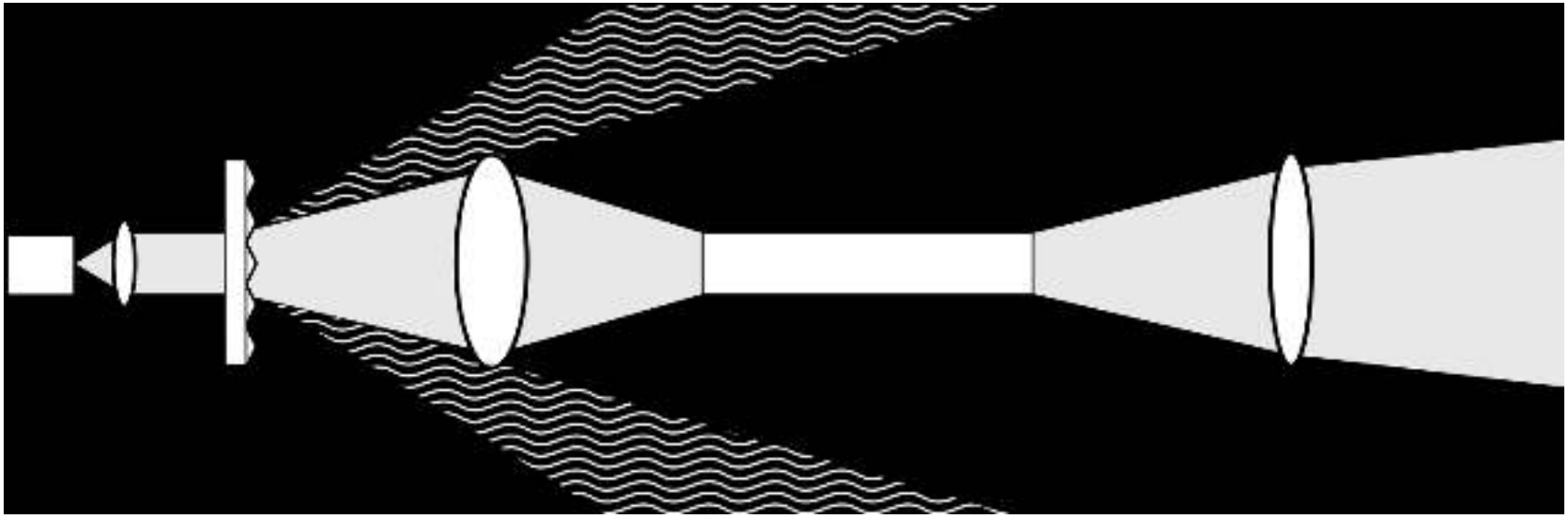

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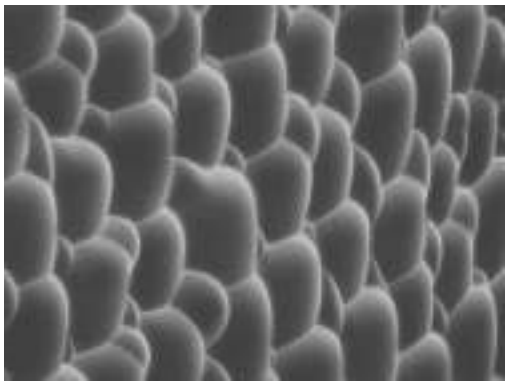

"Efficient" refractive diffusers diffract at microlens apertures.

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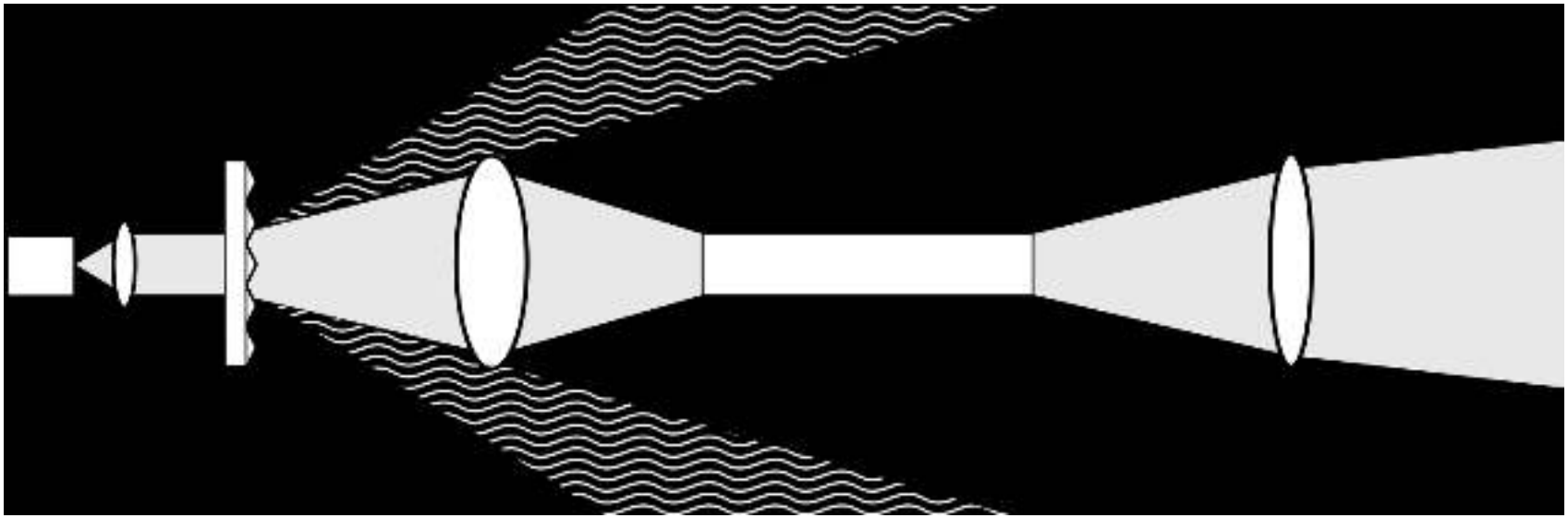

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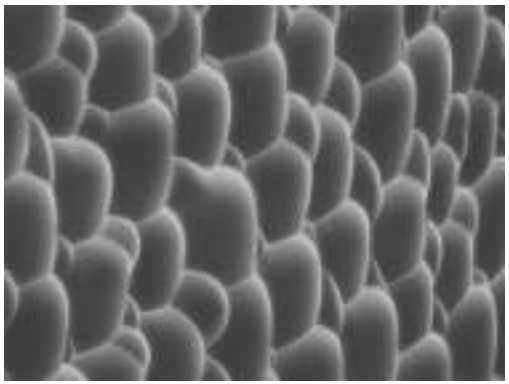

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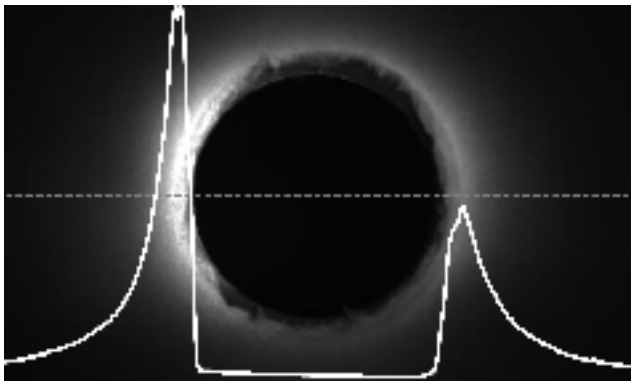
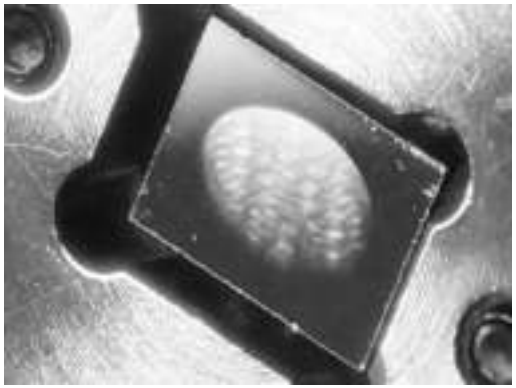


Intensity profile from $2 \times$"$2\,\mathrm{deg}$" *diffusers outside* $4\,\mathrm{deg}$ *aperture.*

Deformable Mirror does not scatter



DM active,
$\nu = 50\,\text{kHz}$—$1\,\text{MHz}$.

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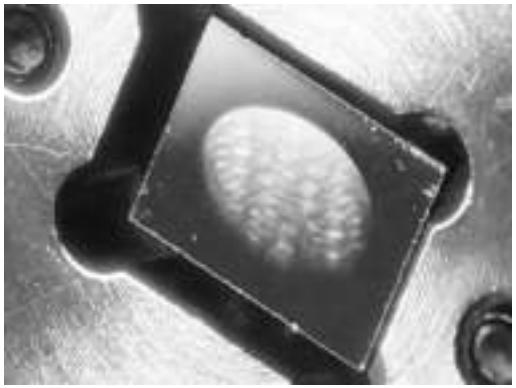

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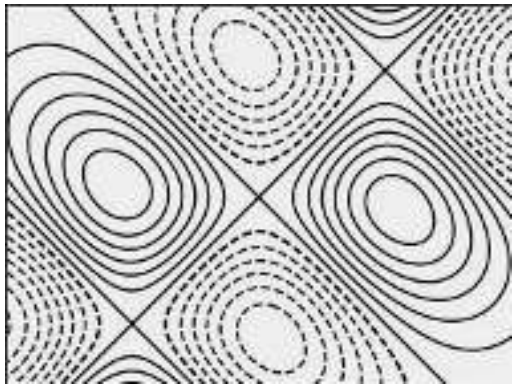

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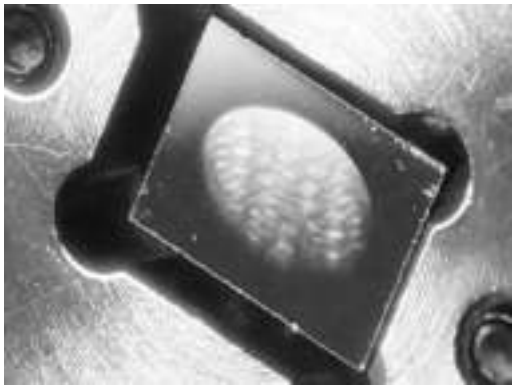

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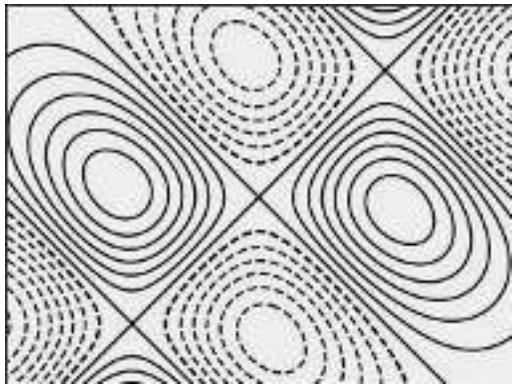

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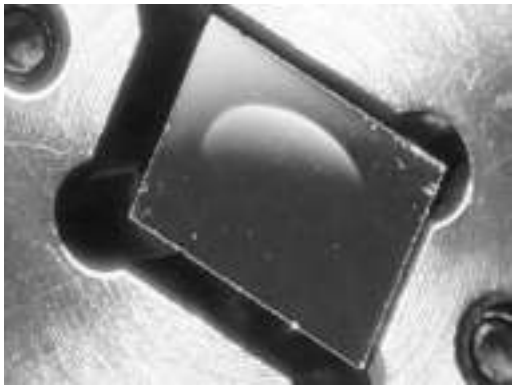

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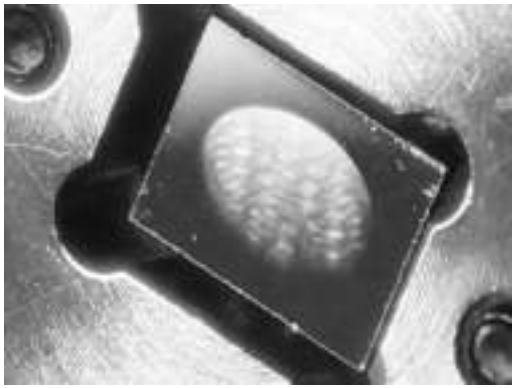

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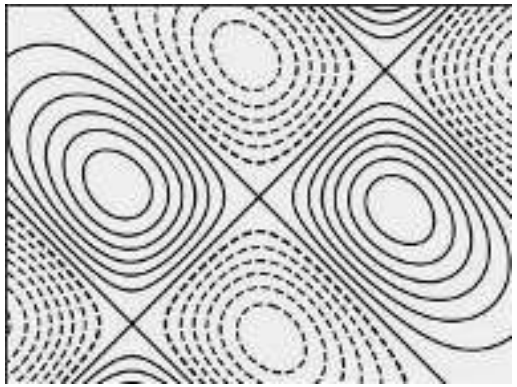

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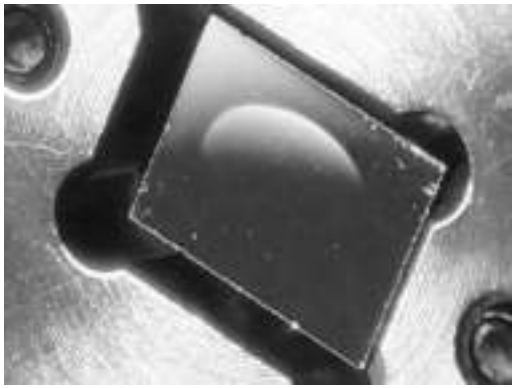

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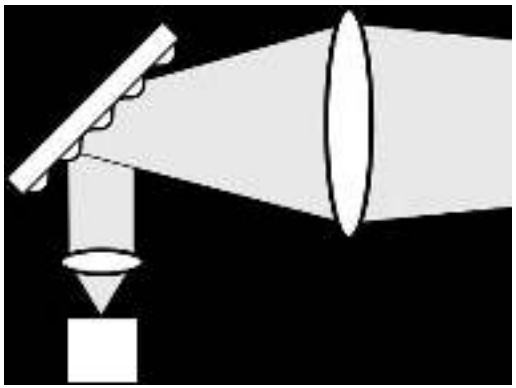

DM surface acts as an extended source.

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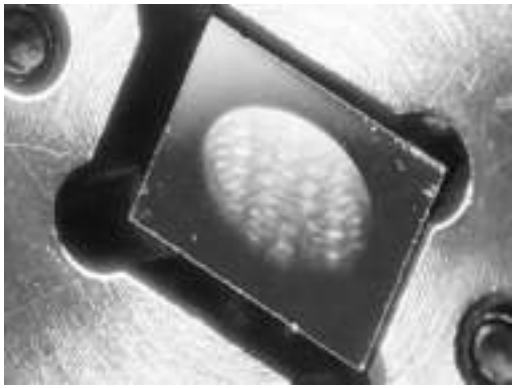

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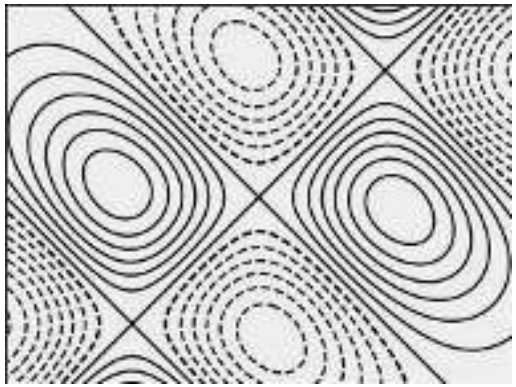

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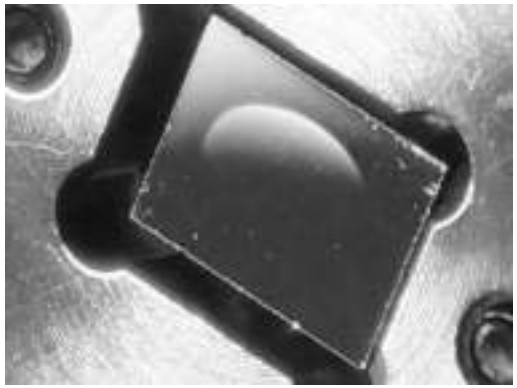

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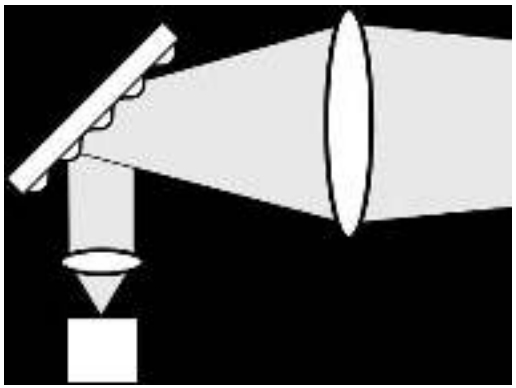

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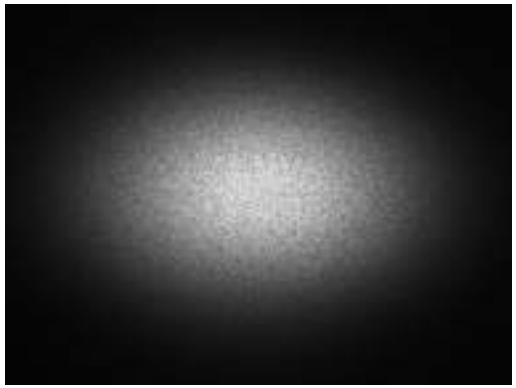

2—5 deg *"randomized divergence."*

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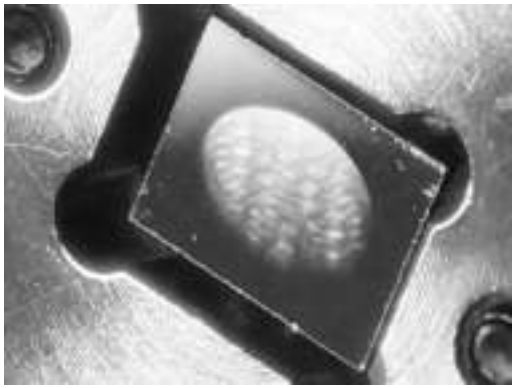

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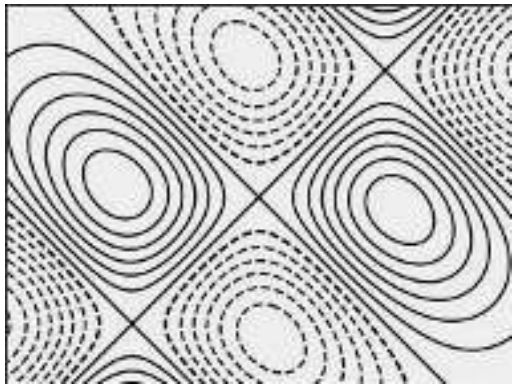

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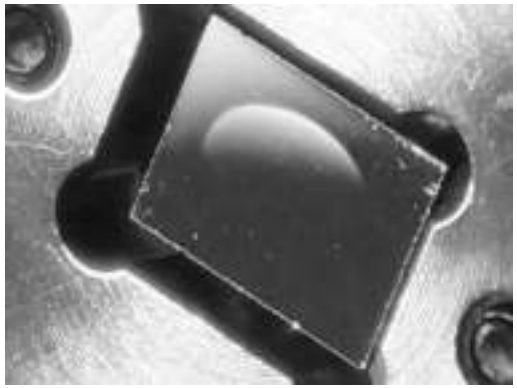

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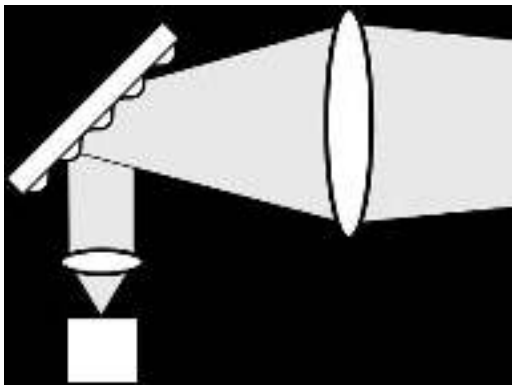

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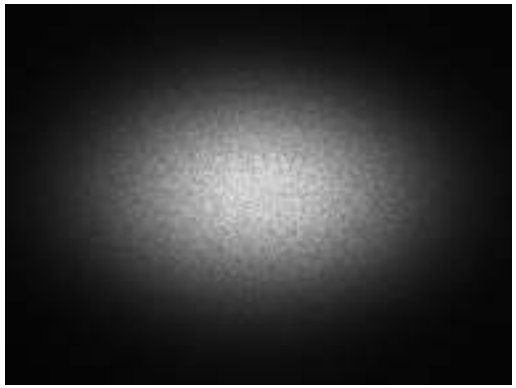

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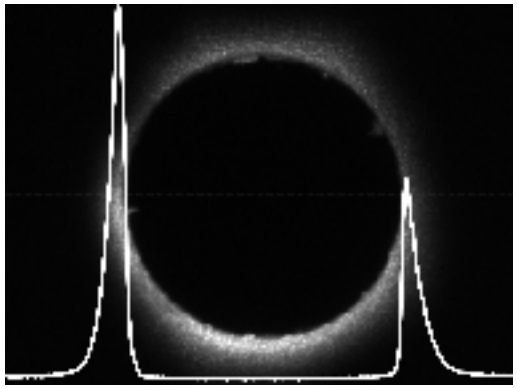
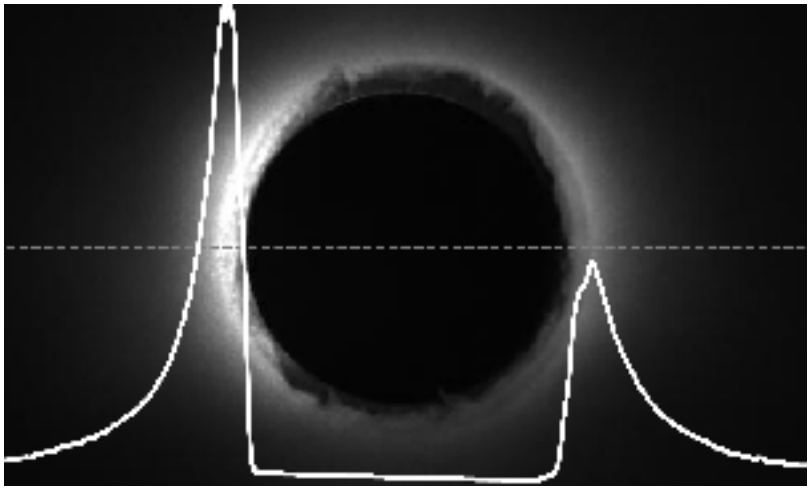
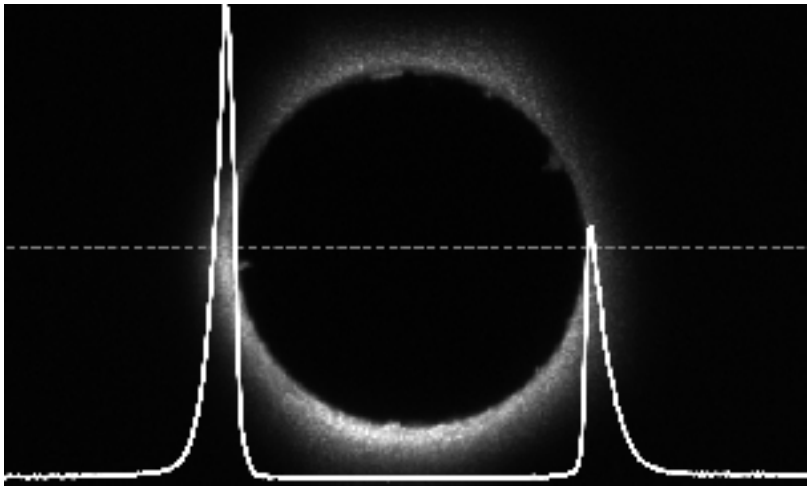


Intensity profile outside 4 deg *aperture.*

Diffuser scattering versus DM divergence

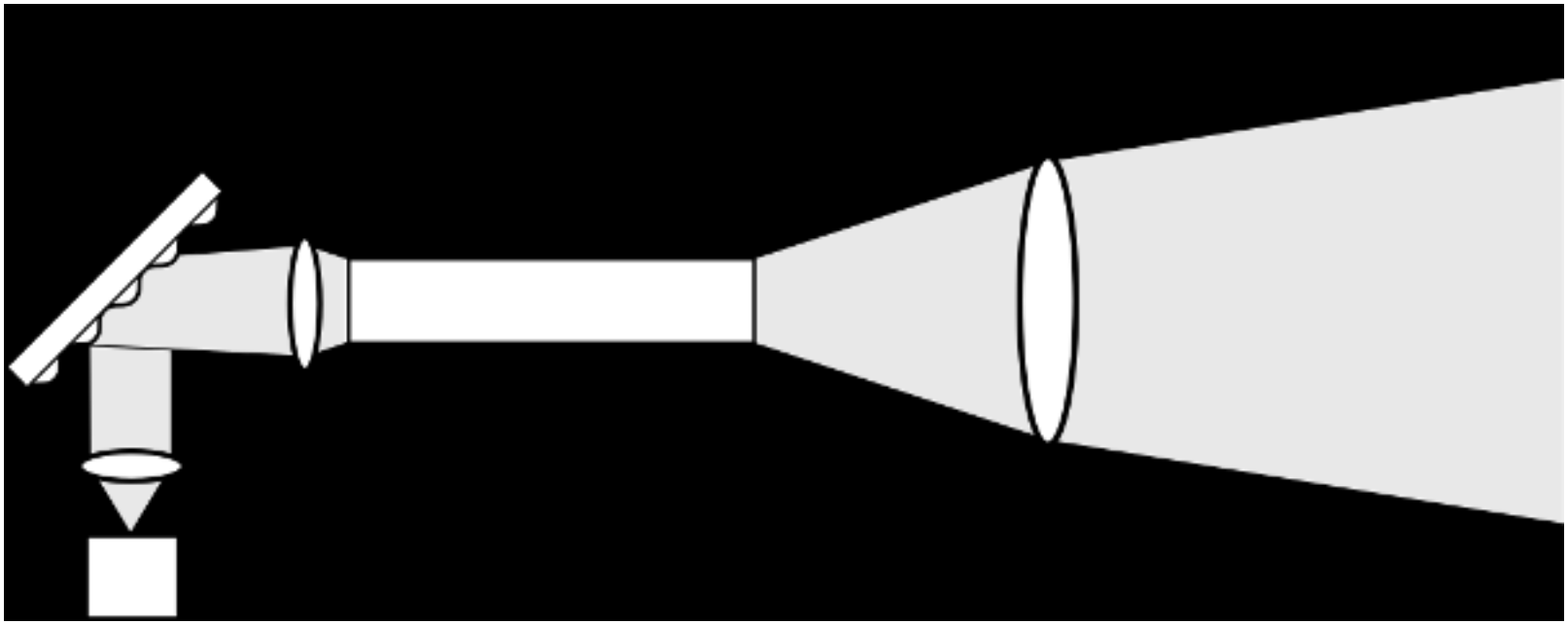


Thick *tails due to scattering from diffusers.*



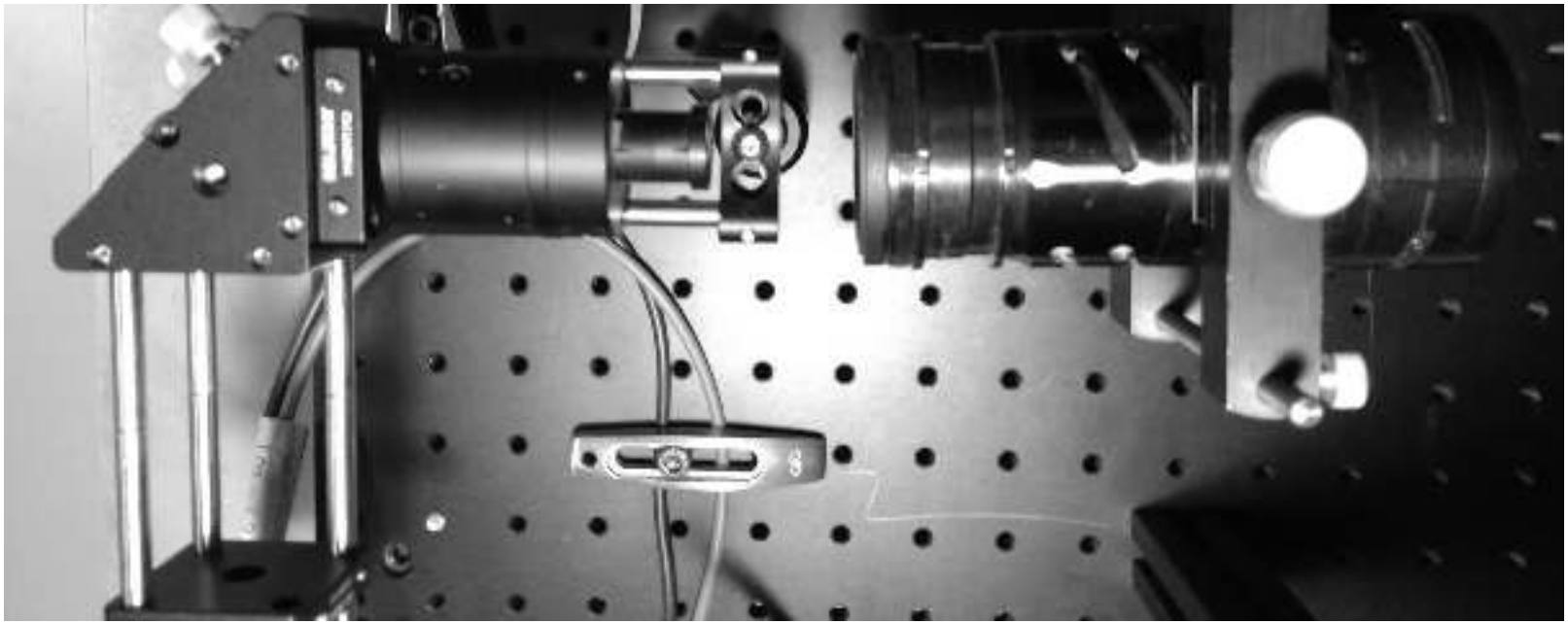
Thin *tails due to randomized divergence from DM.*

Small DM projection display apparatus



- Nichia LD, 520 nm, 1 W.
- f=4.51 mm collimating lens.
- Dyoptyka DM, $3 \times 4.5\,\mathrm{mm}^2$.
- f=4.51 mm focusing lens.
- BK7 lightguide.
- $f/2.4$ DLP projector lens.
- Screen at 5 m for 180$\times$ mag.
- Camera set-up to mimic eye.

Small DM projection display apparatus



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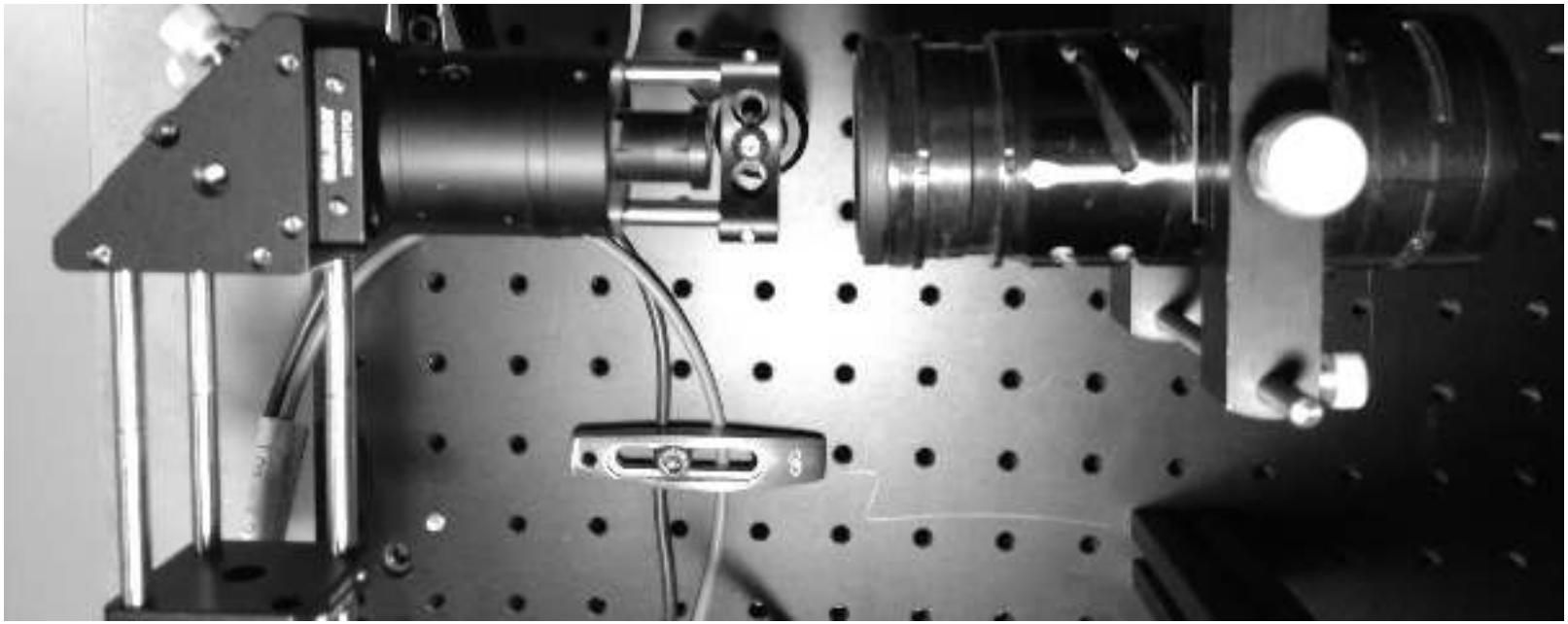

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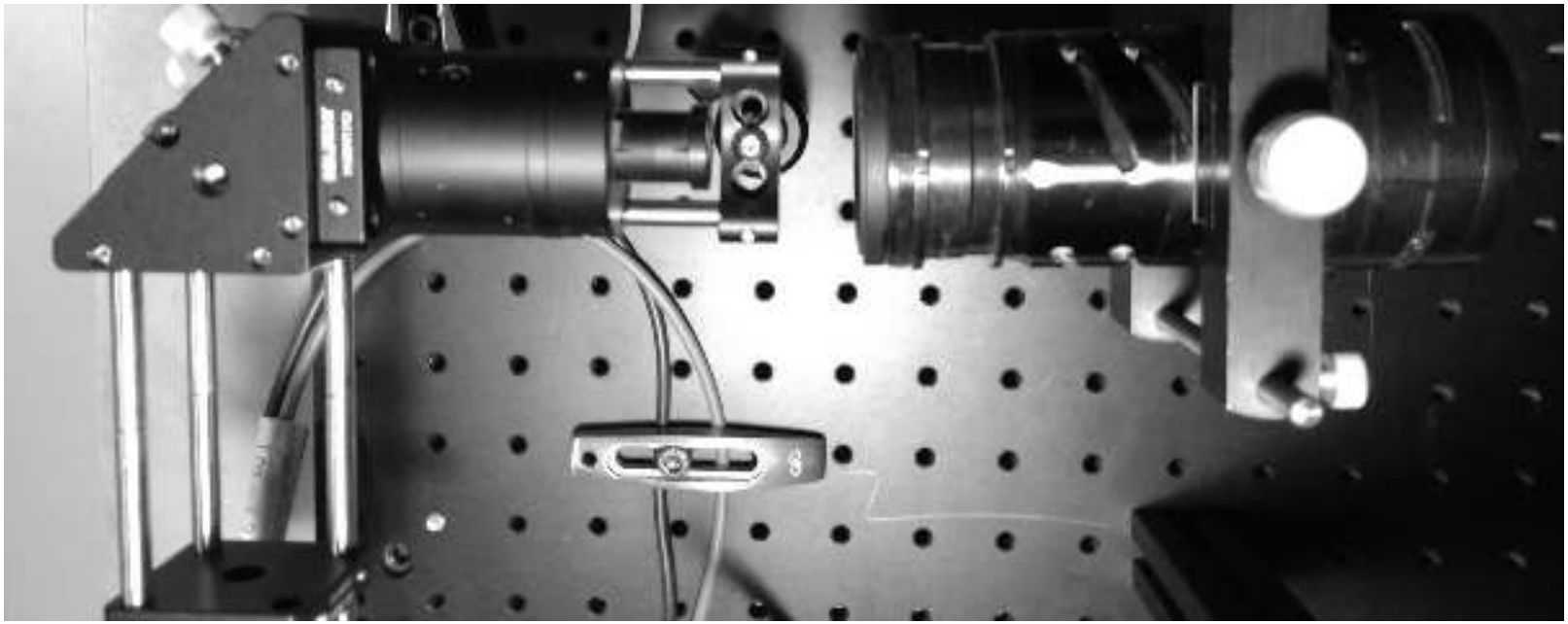

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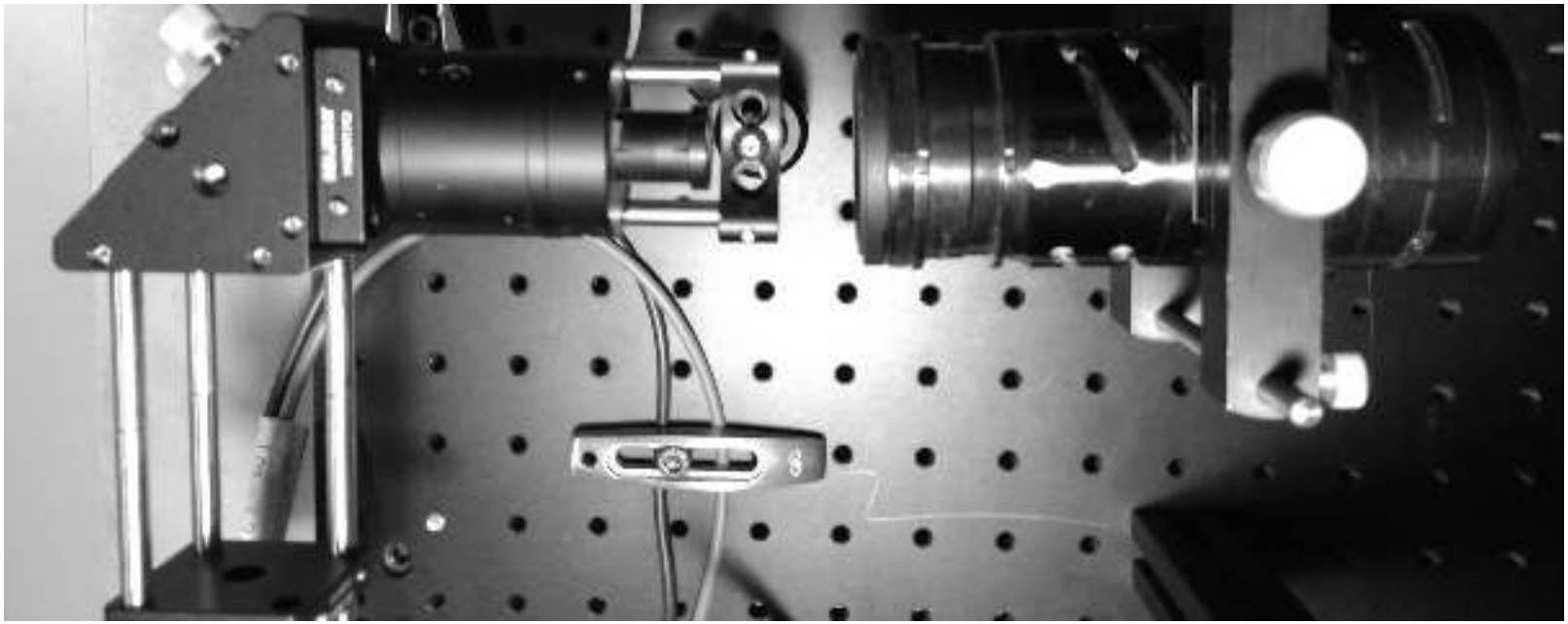

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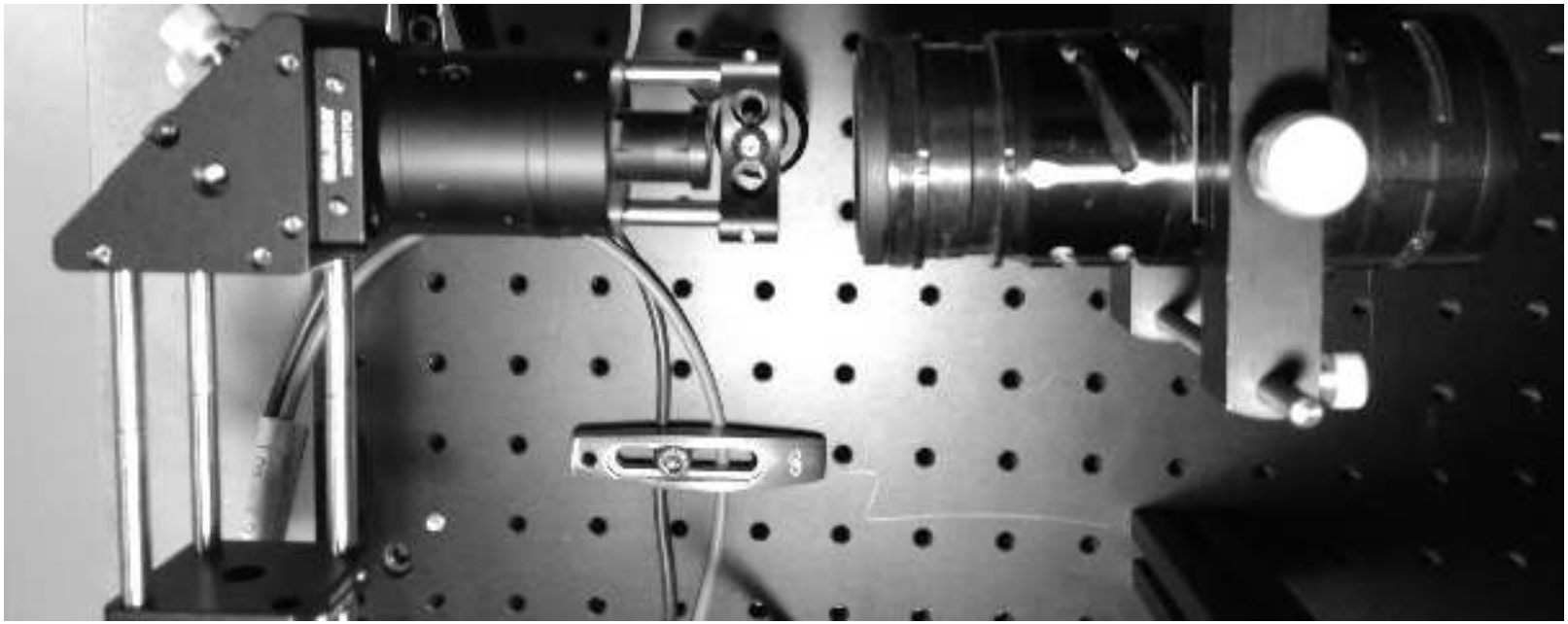

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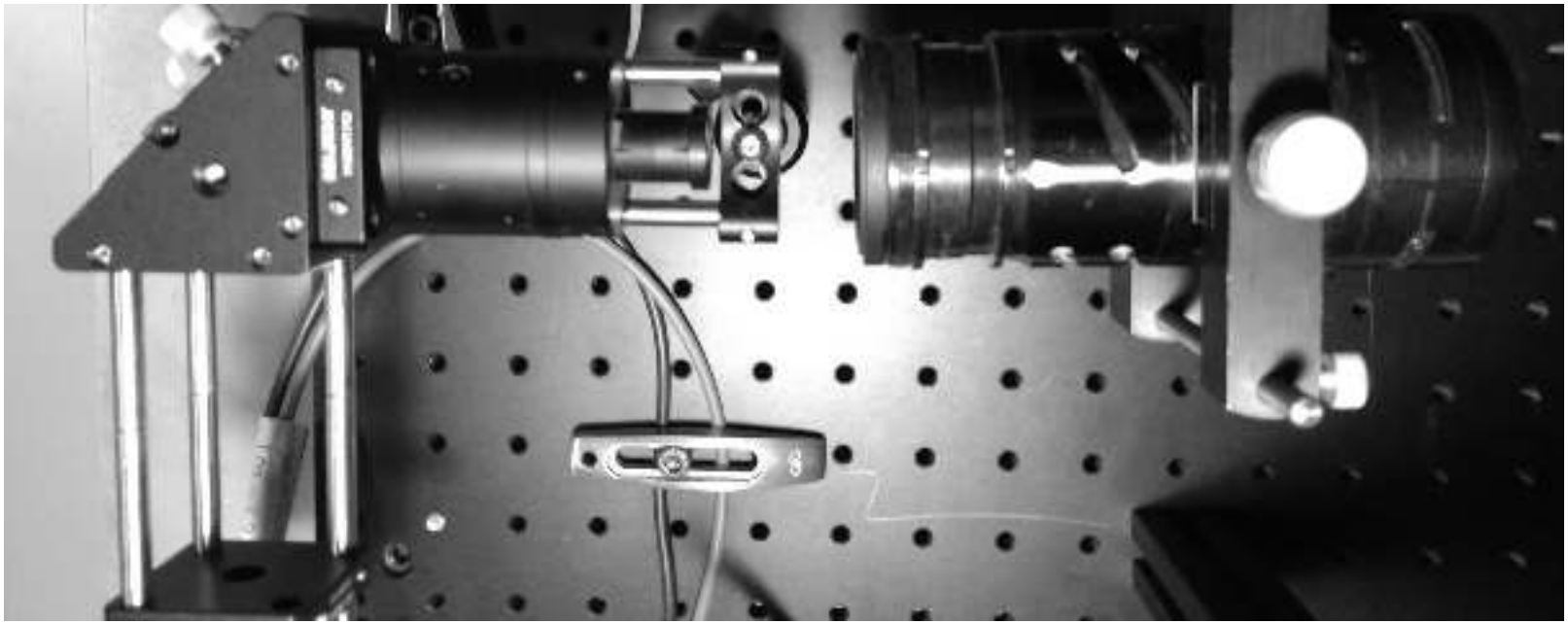

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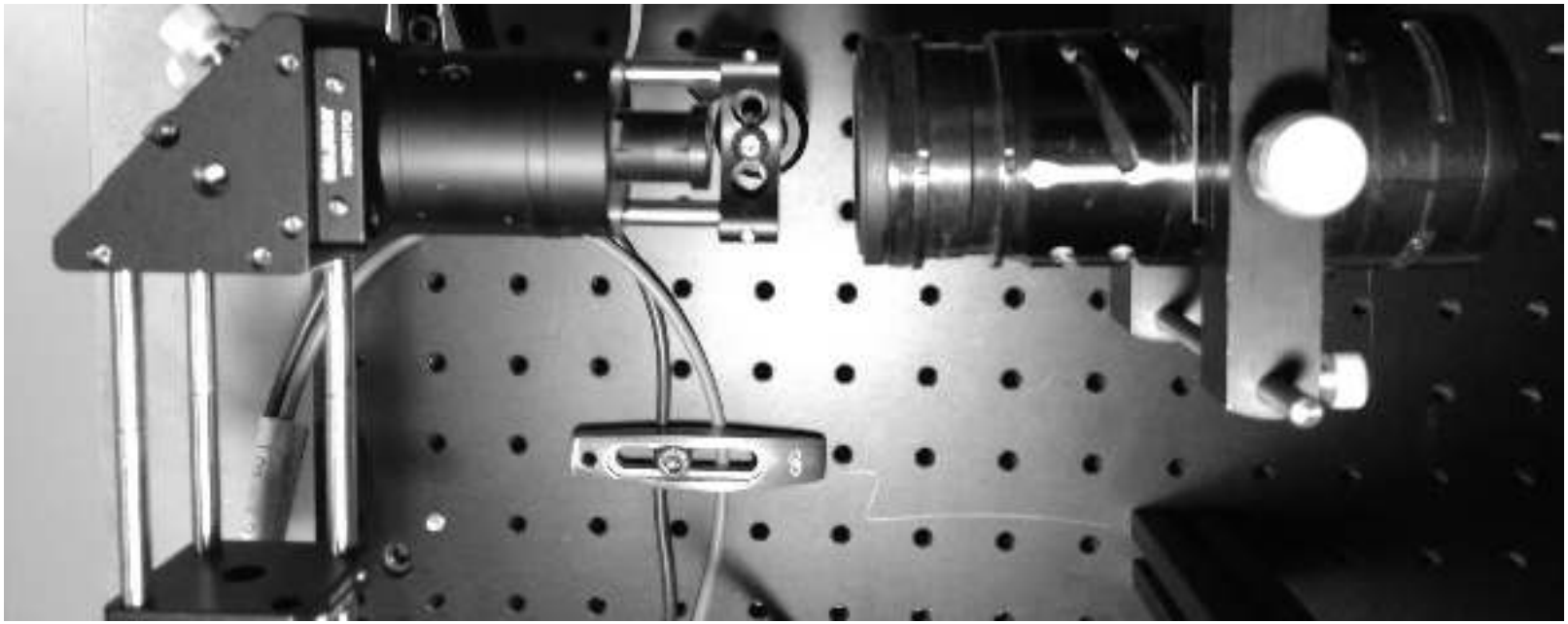

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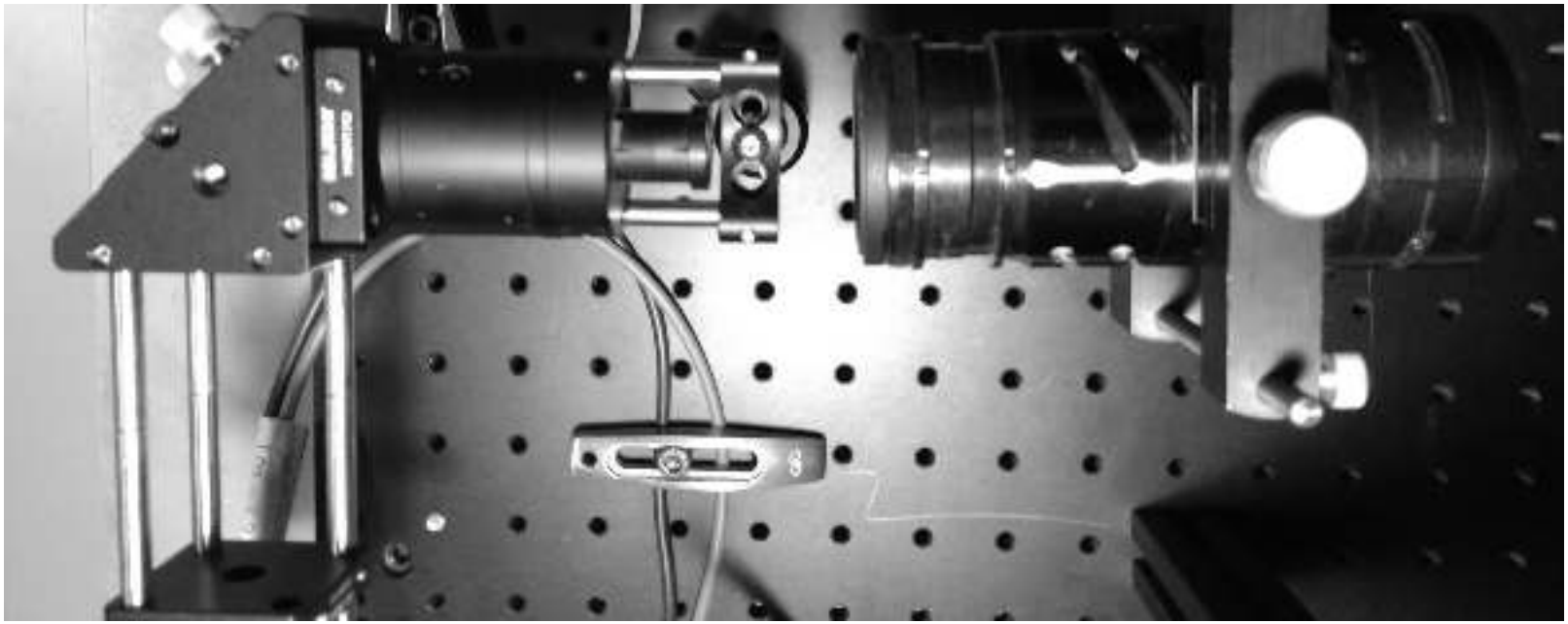

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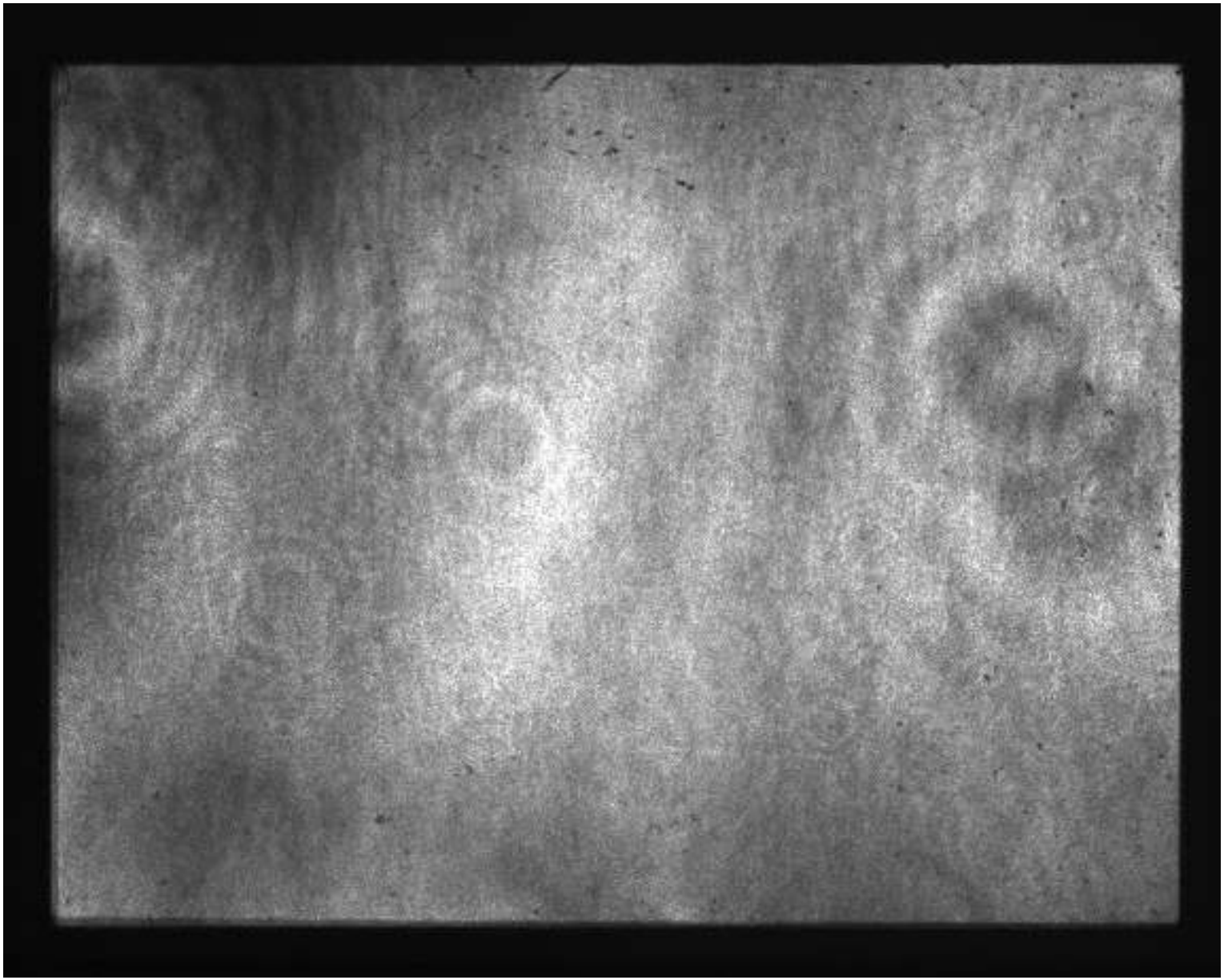
Projected image, 1.4 m diagonal, DM *inactive*
$6 \times 4.8 \times 60\,\mathrm{mm}^3$ LG



Projected image, 1.4 m diagonal, DM *active*
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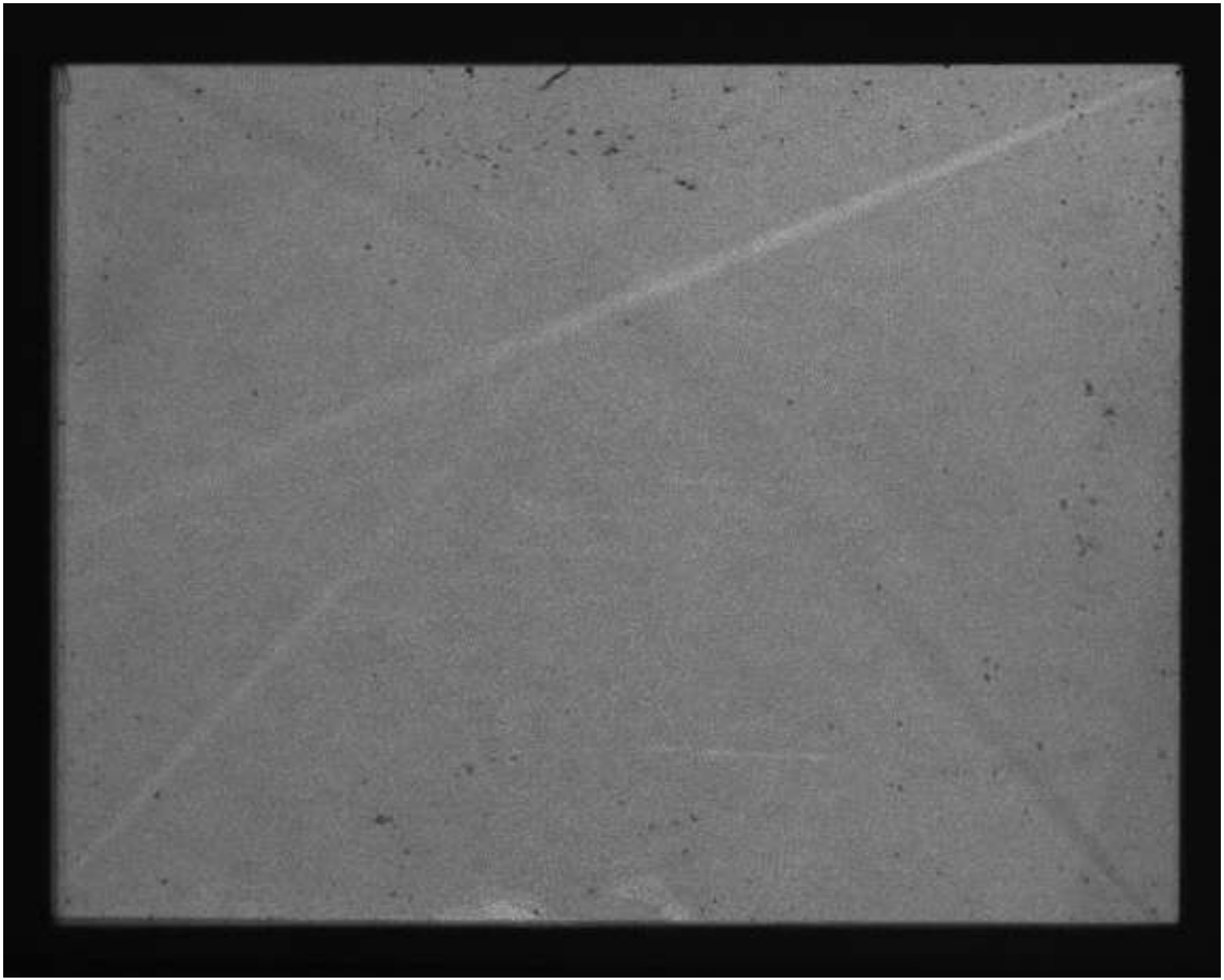
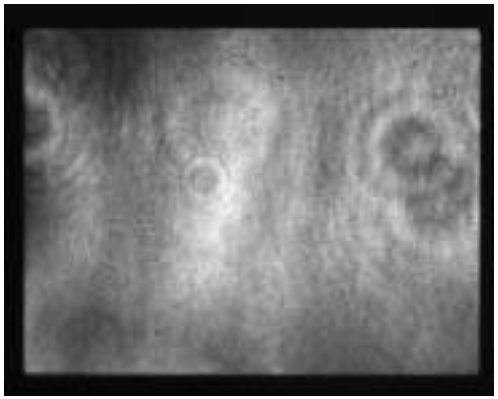
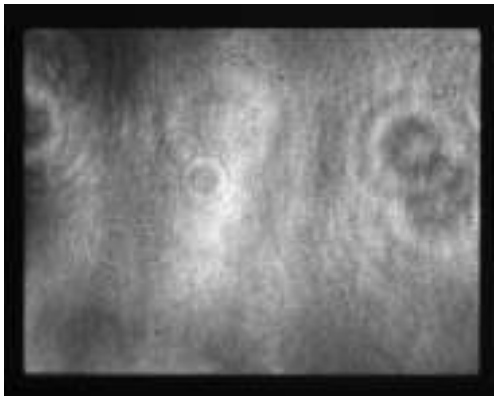


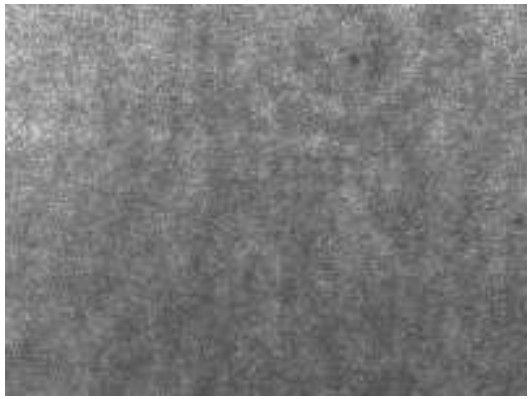
DM *inactive* versus *active*

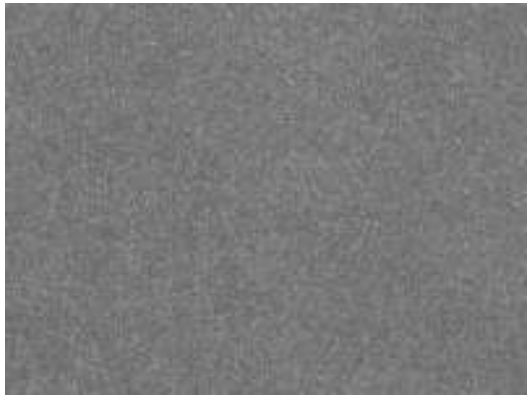


Mean intensities
52.4% vs. 46.8%.

DM *inactive* versus *active*



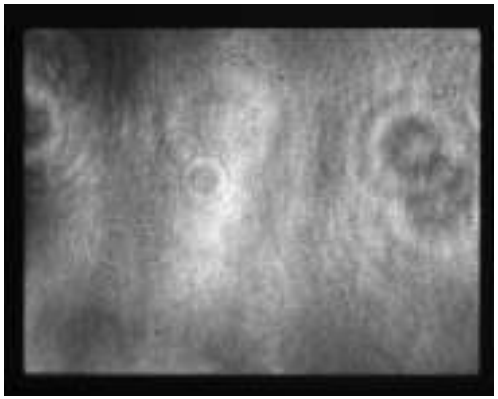


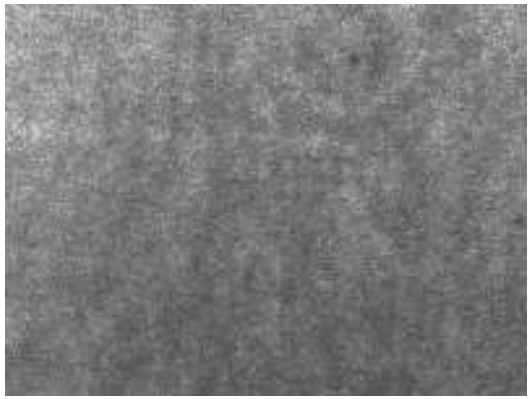


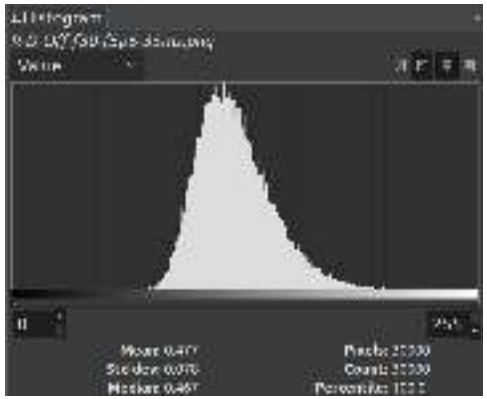
Mean intensities 52.4% vs. 46.8%.

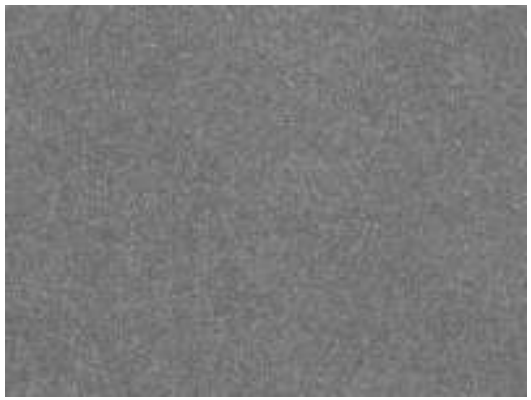
Regions of relatively homogeneous intensity.

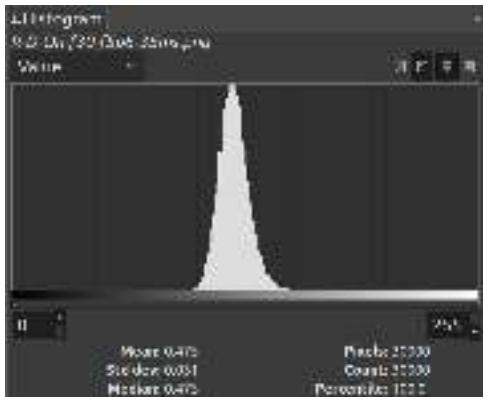
DM *inactive* versus *active*









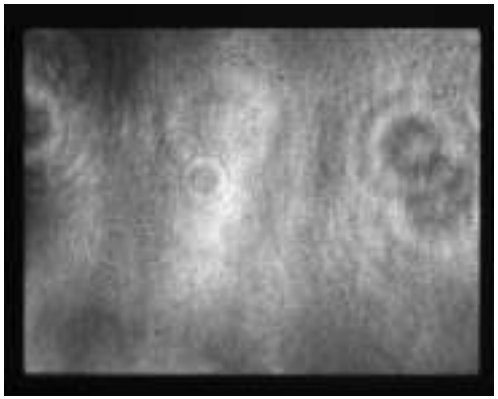
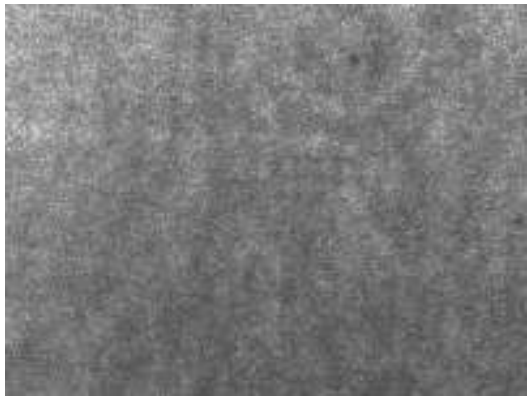
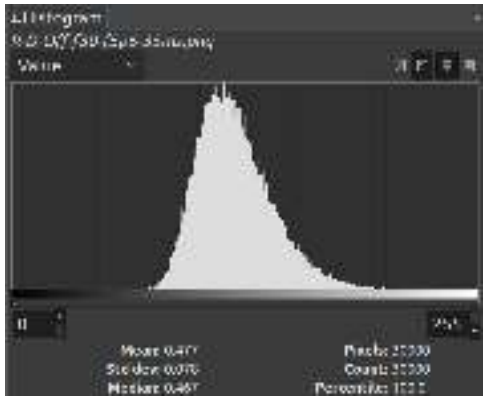


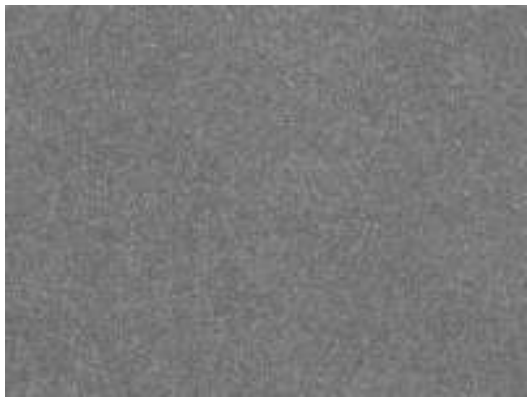
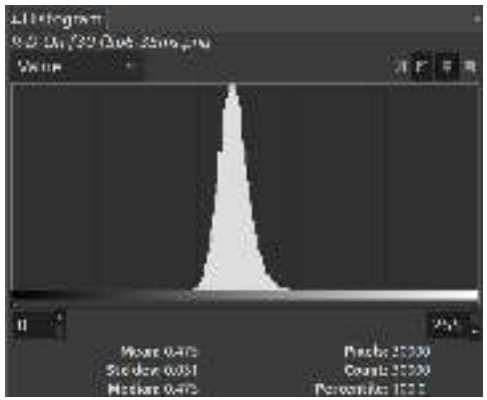
Mean intensities 52.4% vs. 46.8%.

Regions of relatively homogeneous intensity.

Speckle contrast ratios 16.3% vs. 6.5%.

DM *inactive* versus *active*

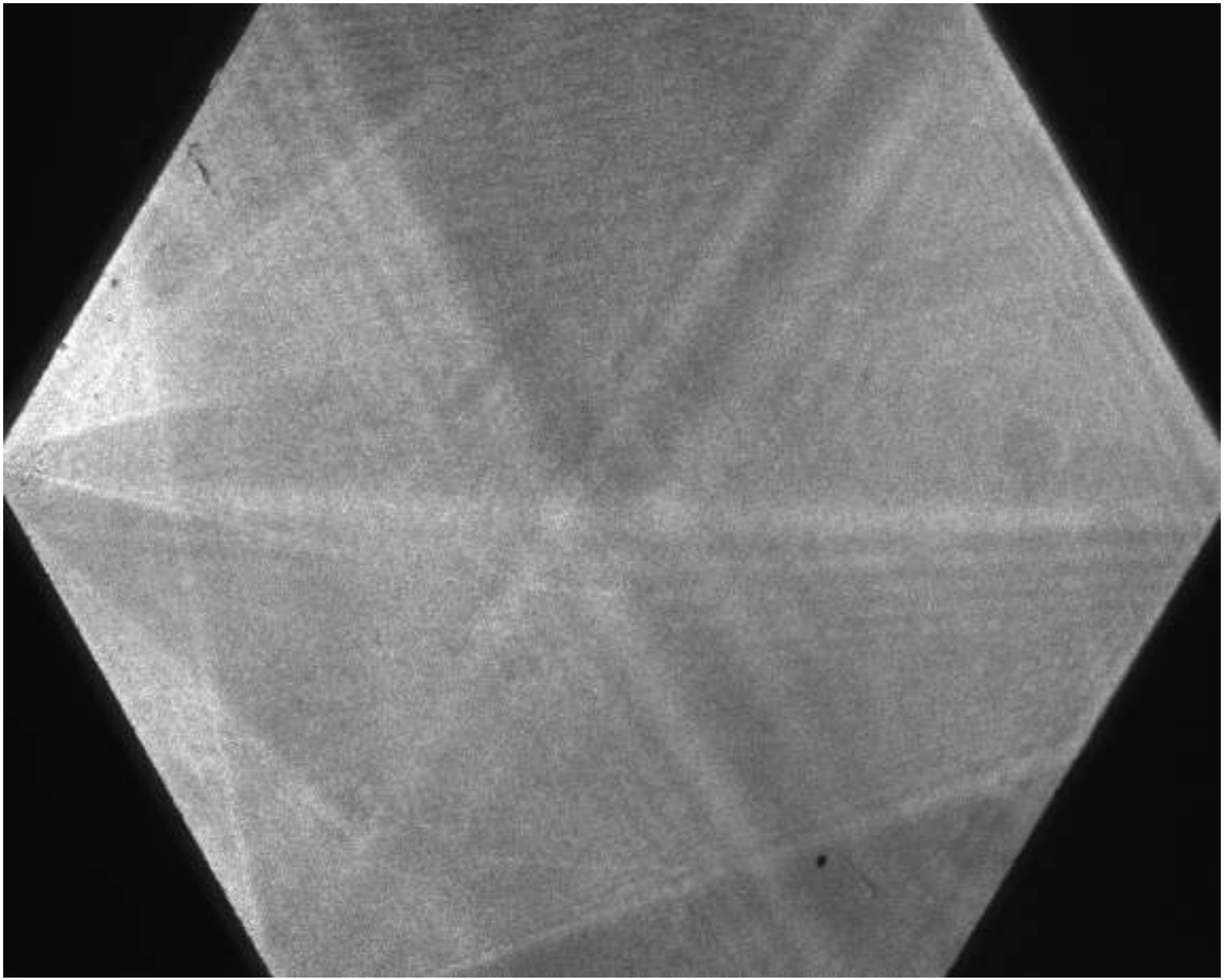
Mean intensities 52.4% vs. 46.8%.

Regions of relatively homogeneous intensity.

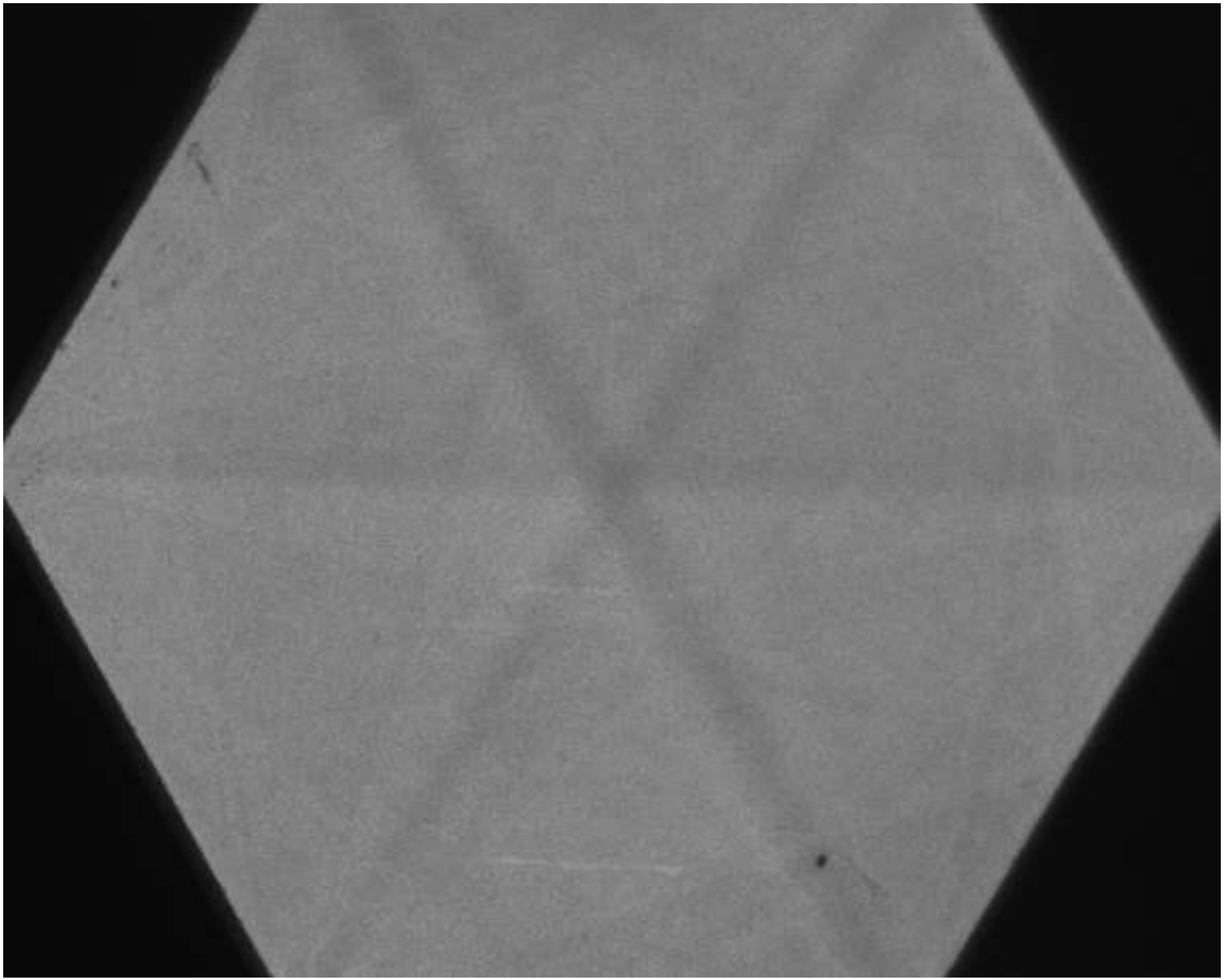
Speckle contrast ratios 16.3% vs. 6.5%.

- DM *active*: Intensity $\times 90\%$; SCR $\times 50\%$ (approximately.)

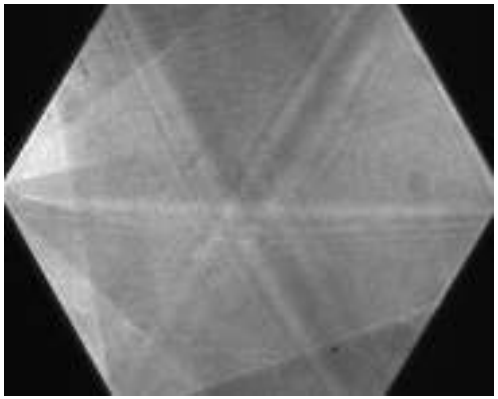
Projected image, 1.4 m diagonal, DM *inactive*
⌀6 mm × 150 mm LG

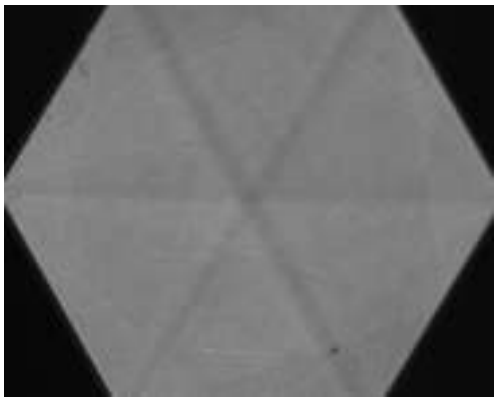


Projected image, 1.4 m diagonal, DM *active*
⌀6 mm × 150 mm LG



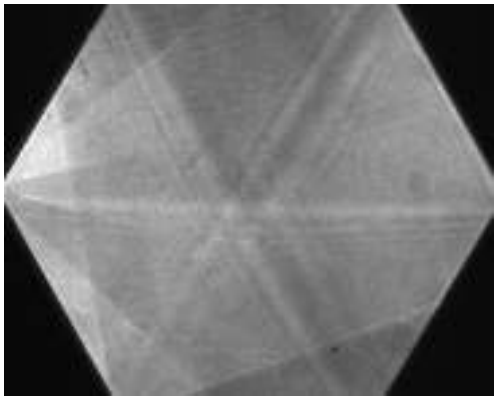
DM *inactive* versus *active*

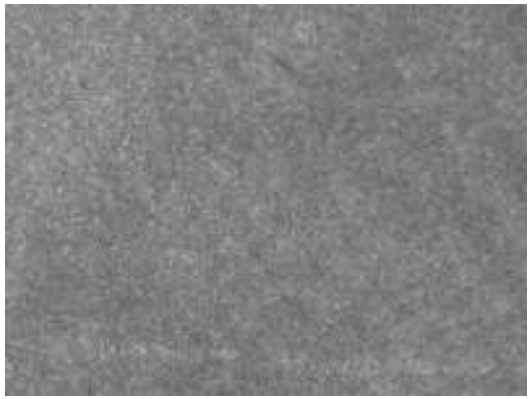


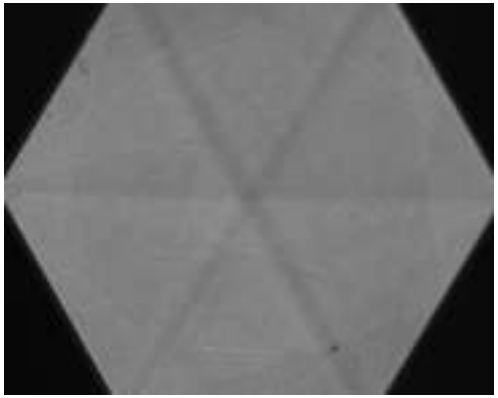


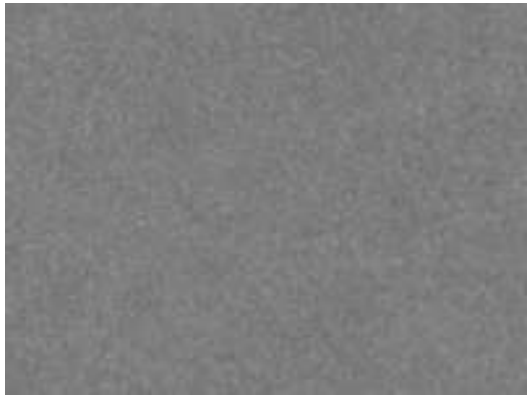
Mean intensities
44.4% vs. 40.8%.

DM *inactive* versus *active*





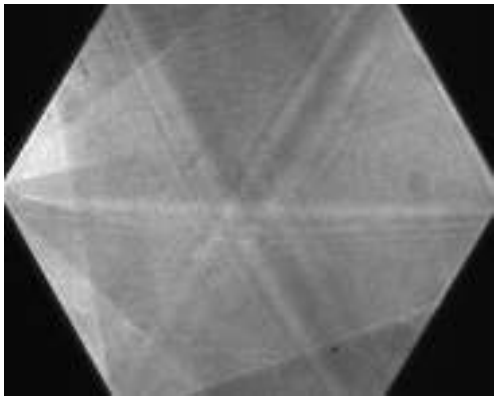


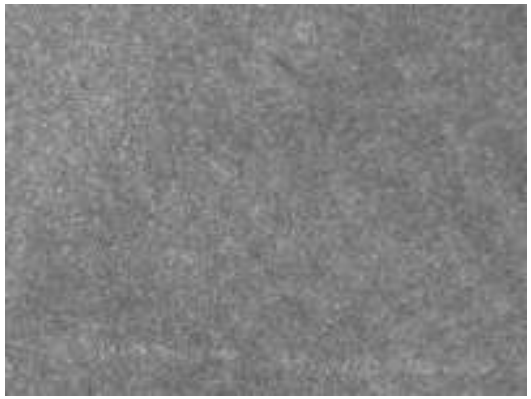


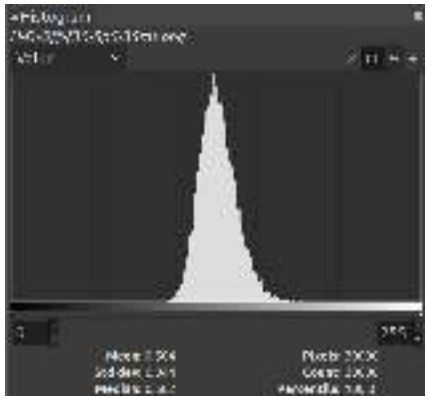
Mean intensities 44.4% vs. 40.8%.

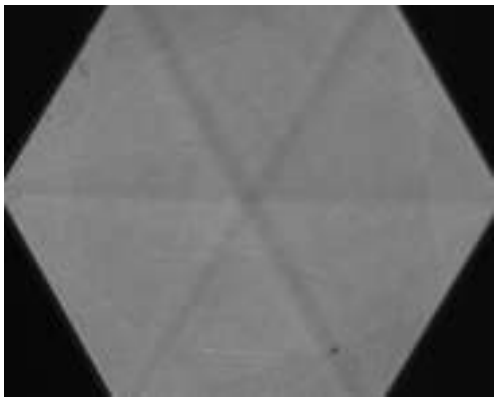
Regions of relatively homogeneous intensity.

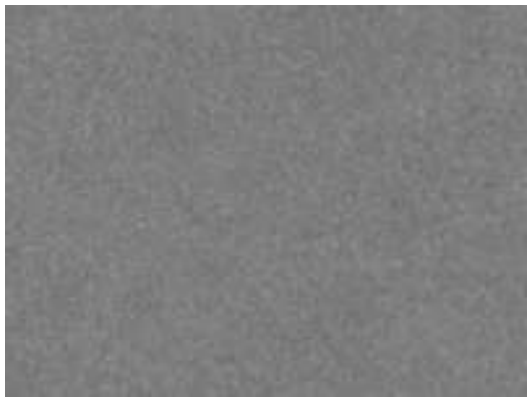
DM *inactive* versus *active*

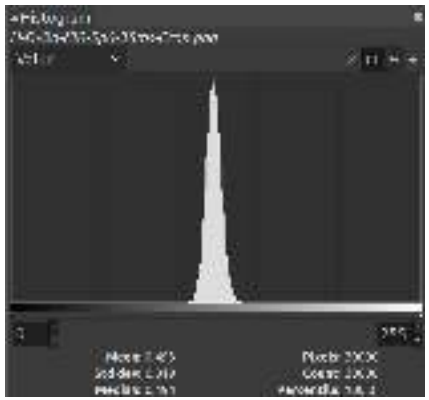










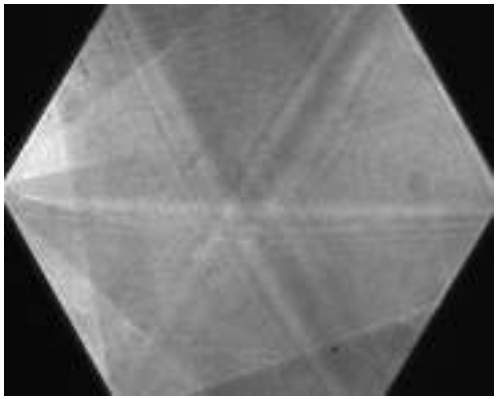
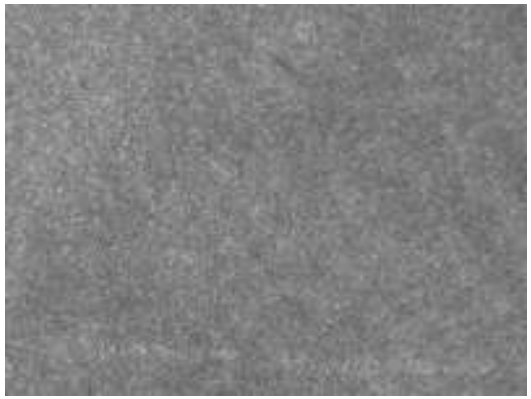
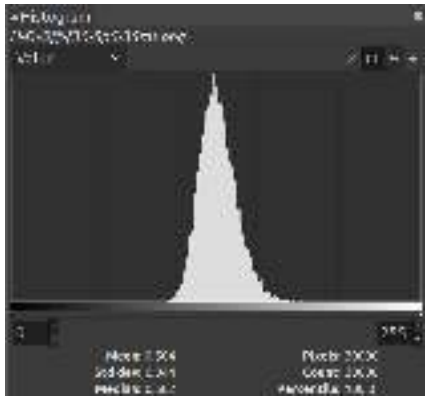
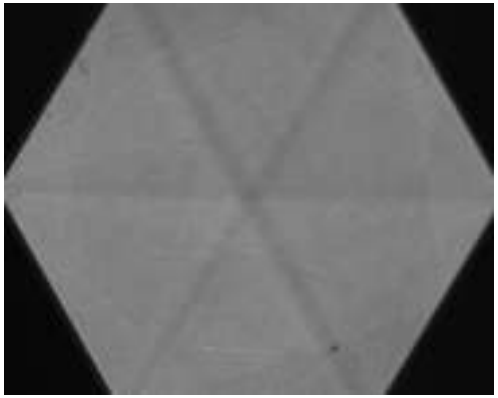
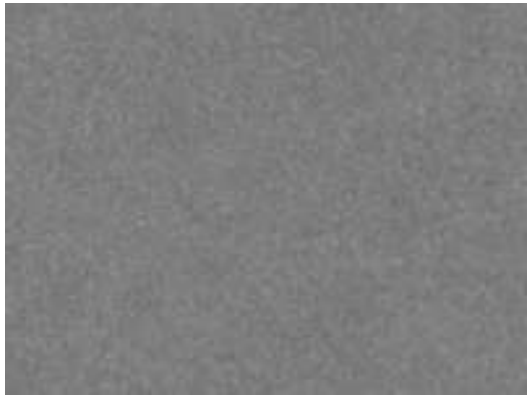
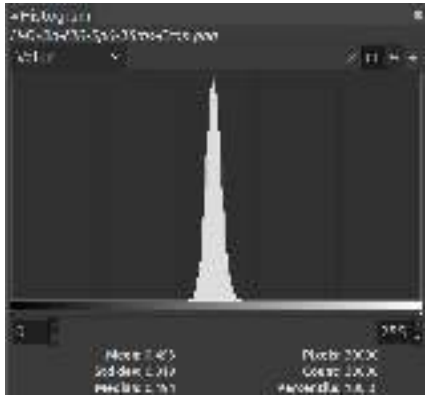


Mean intensities 44.4% vs. 40.8%.

Regions of relatively homogeneous intensity.

Speckle contrast ratios 8.7% vs. 3.8%.

DM *inactive* versus *active*

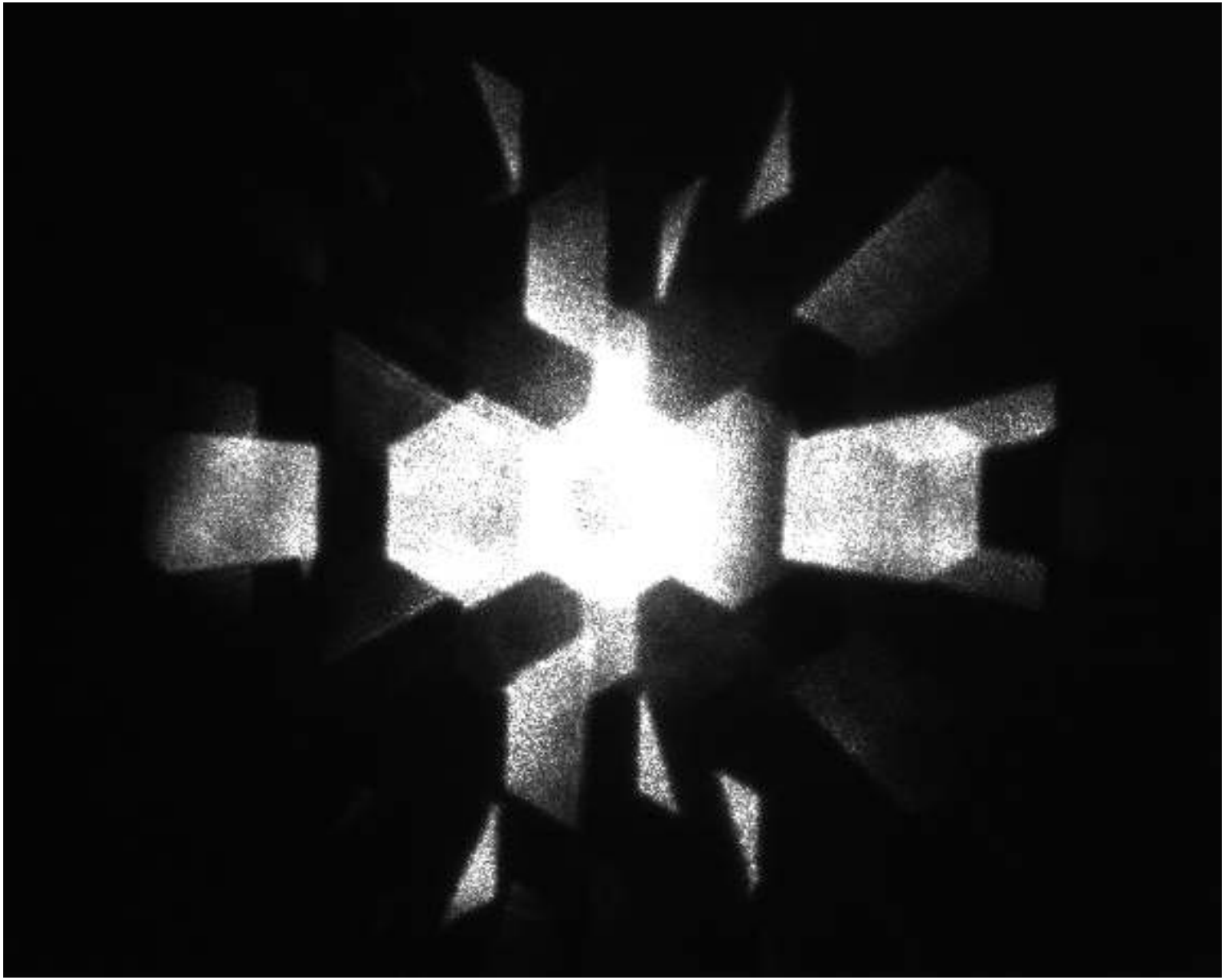
Mean intensities 44.4% vs. 40.8%.

Regions of relatively homogeneous intensity.

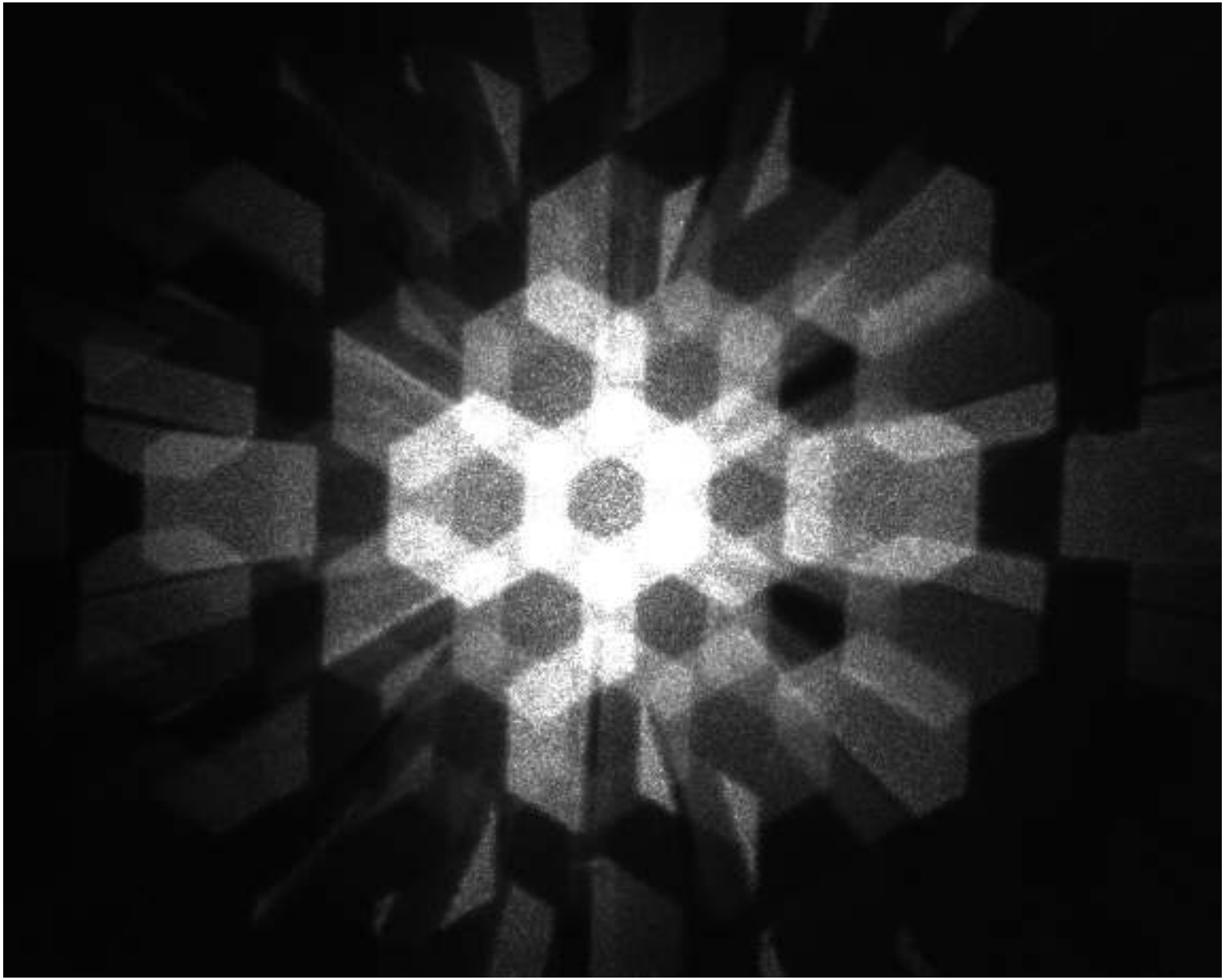
Speckle contrast ratios 8.7% vs. 3.8%.

- DM *active:* Intensity $\times 90\%$; SCR $\times 50\%$ (approximately.)

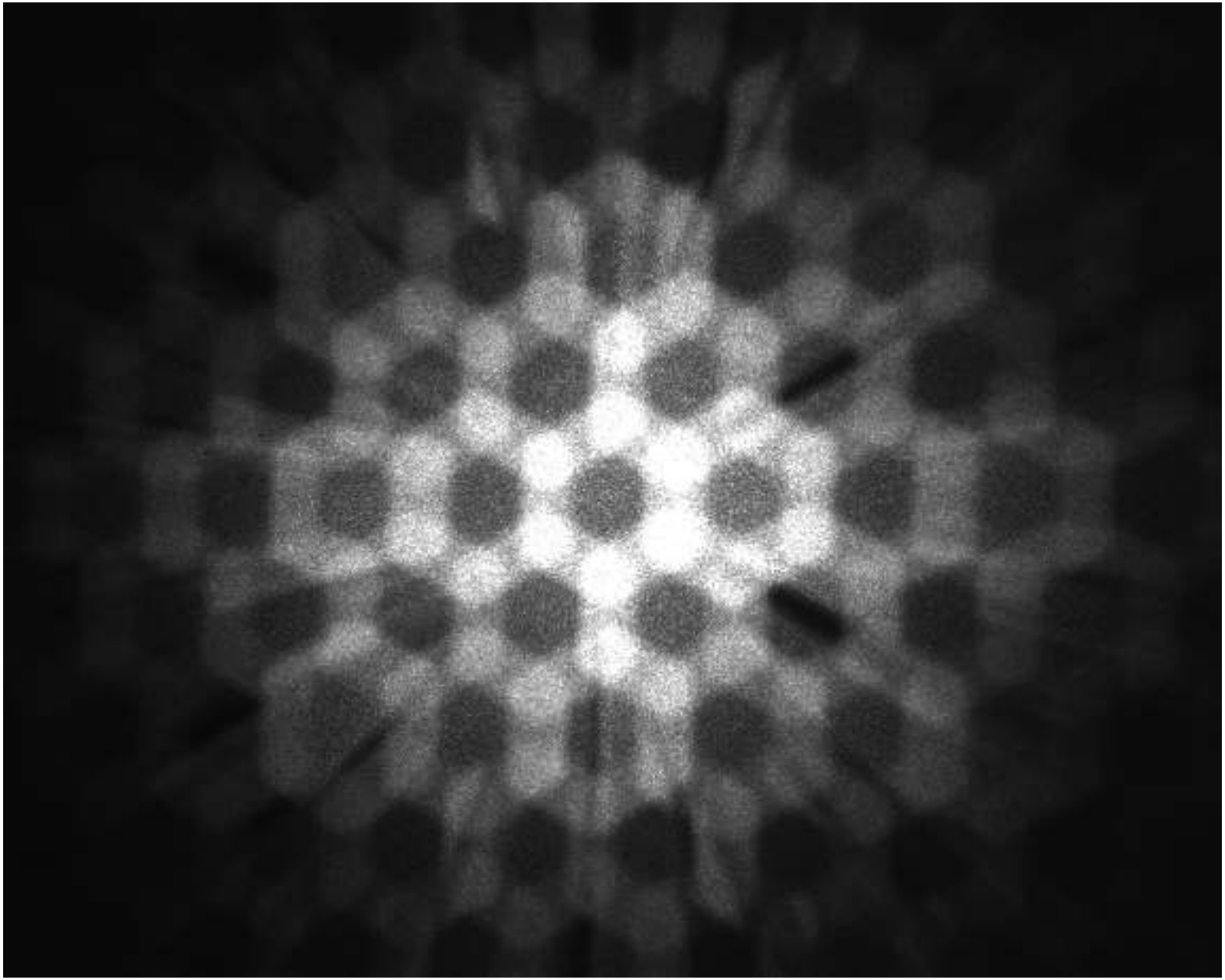
Lightguide exit face at 0.5 m, DM *inactive*



Lightguide exit face at 0.5 m, DM *active:* 3 deg



Lightguide exit face at 0.5 m, DM *active:* 5 deg

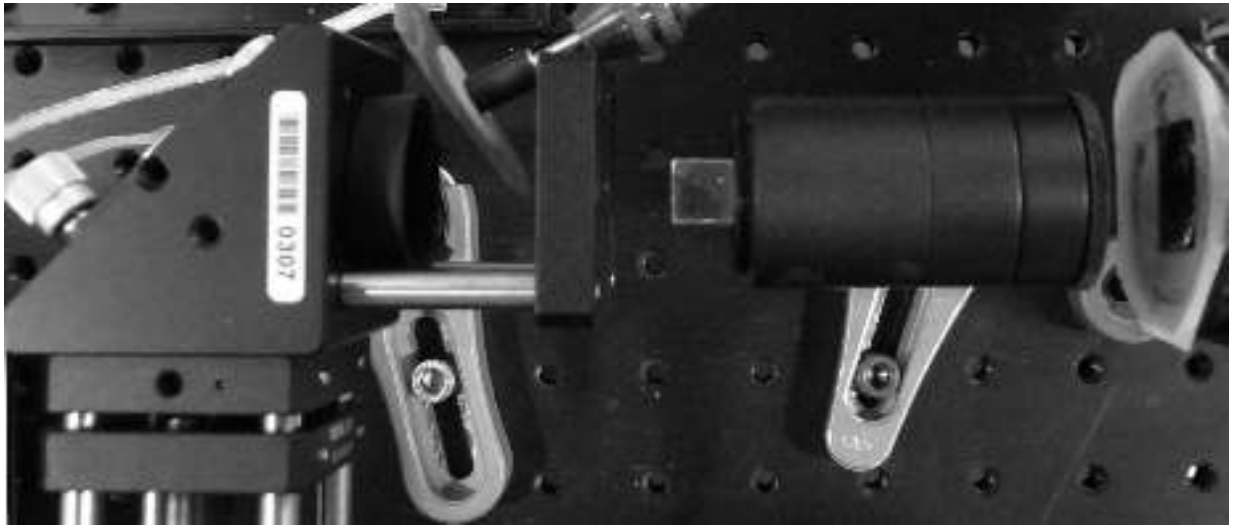


Moving diffuser implementation

"2 deg" *diffuser at 10,000 rev./min.*

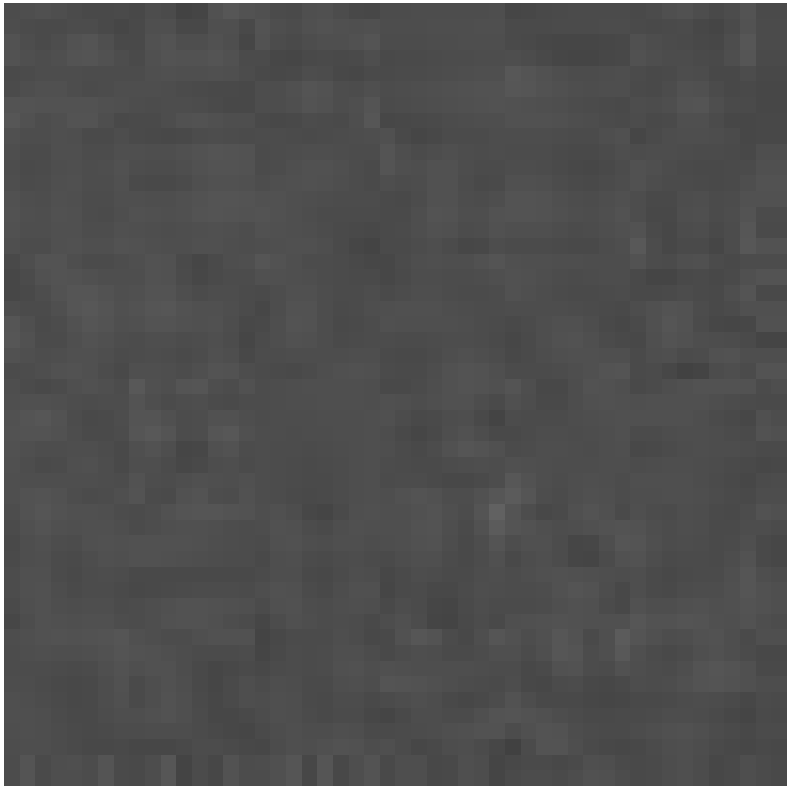
Moving diffuser implementation

"2 deg" diffuser at 10,000 rev./min.

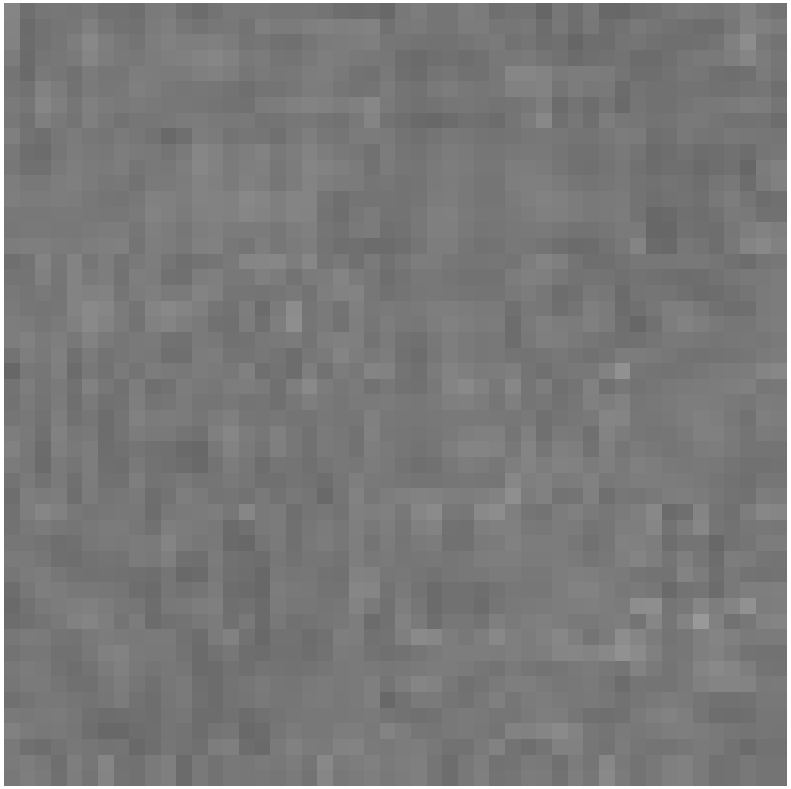


LD homogenization and projection apparatus with one stationary and one moving "2 deg" diffusers.

MD versus DM, low gain screen



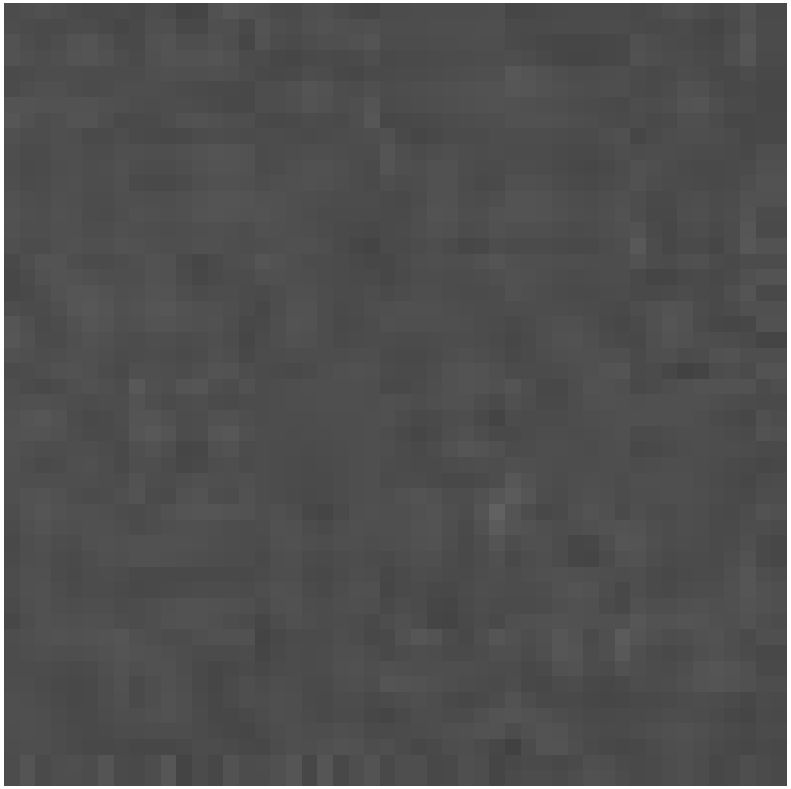
Mean intensities 30% vs. 47%.



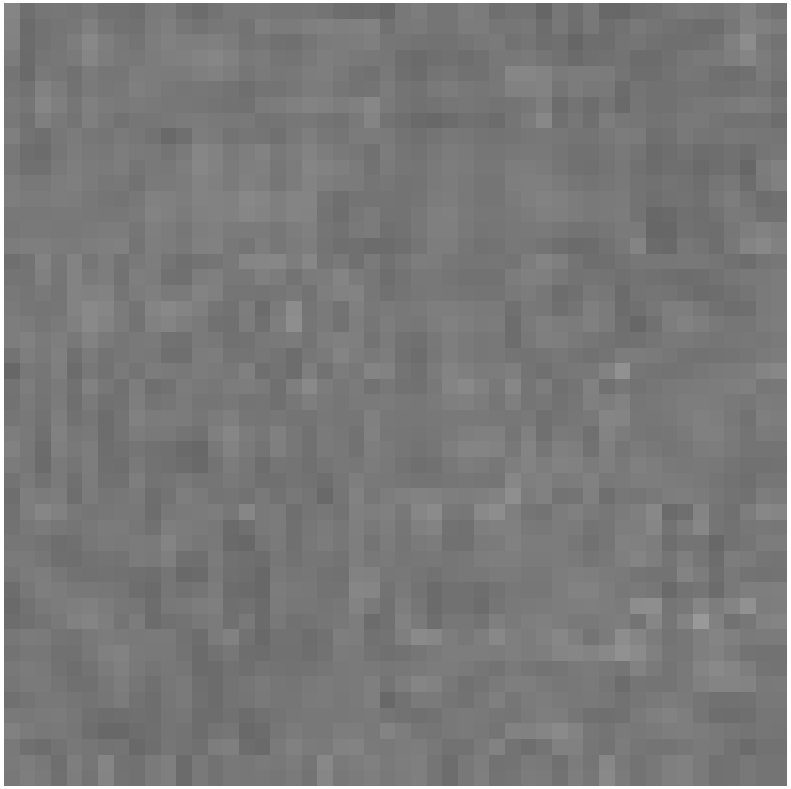
SCR 6% (LG length 50 mm*.)*

- DM *active*: Intensity ×150%; SCR *equal* (approximately.)

MD versus DM, low gain screen



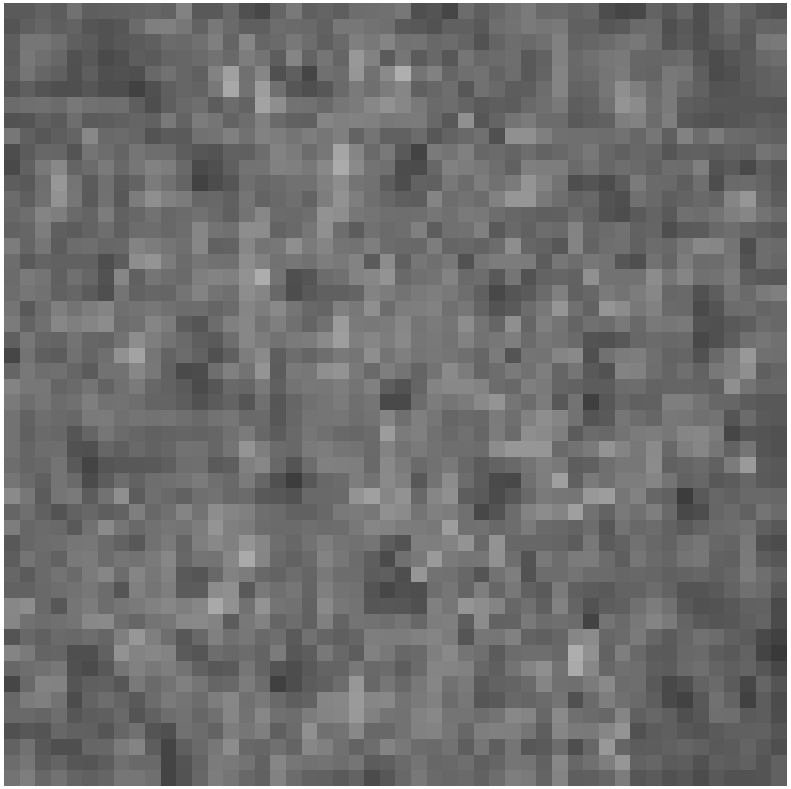
Mean intensities 30% vs. 47%.



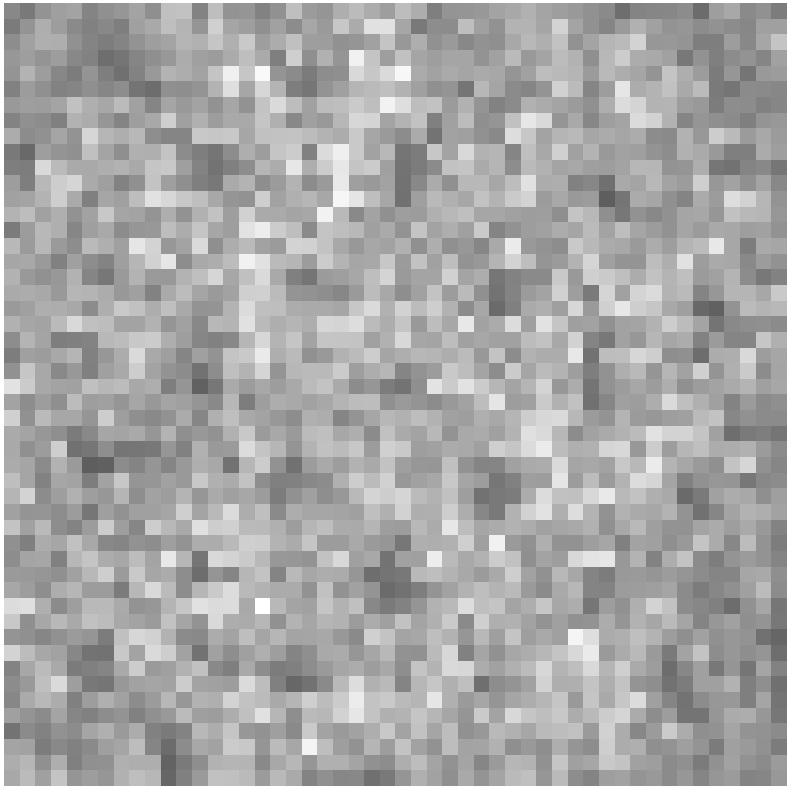
SCR 6% (LG length 50 mm*.)*

- DM *active*: Intensity $\times$150%; SCR *equal* (approximately.)

MD versus DM, high gain metallic 3-D cinema screen



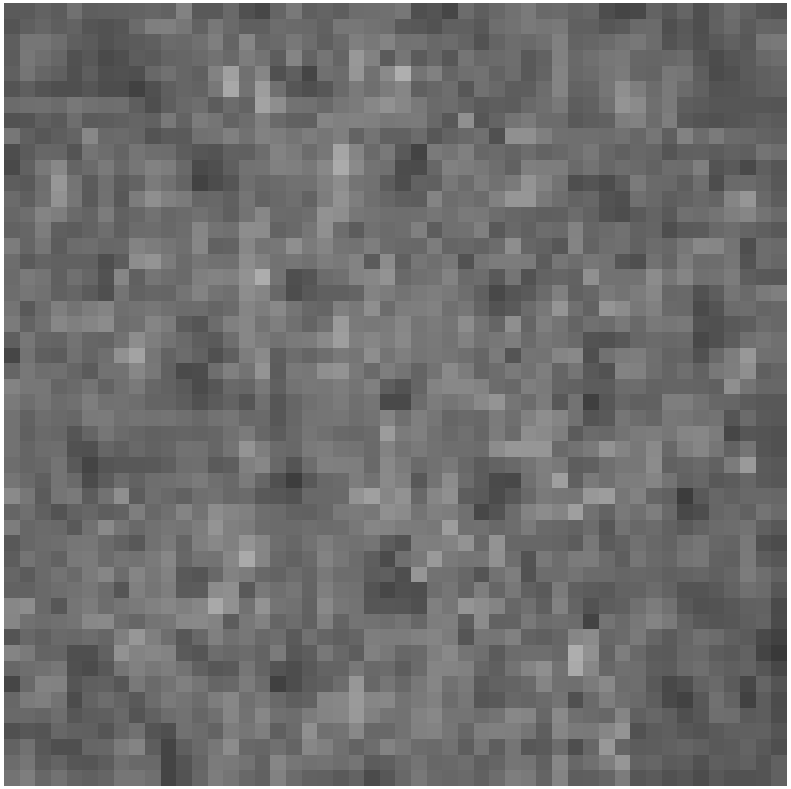
Mean intensities 43% vs. 65%.



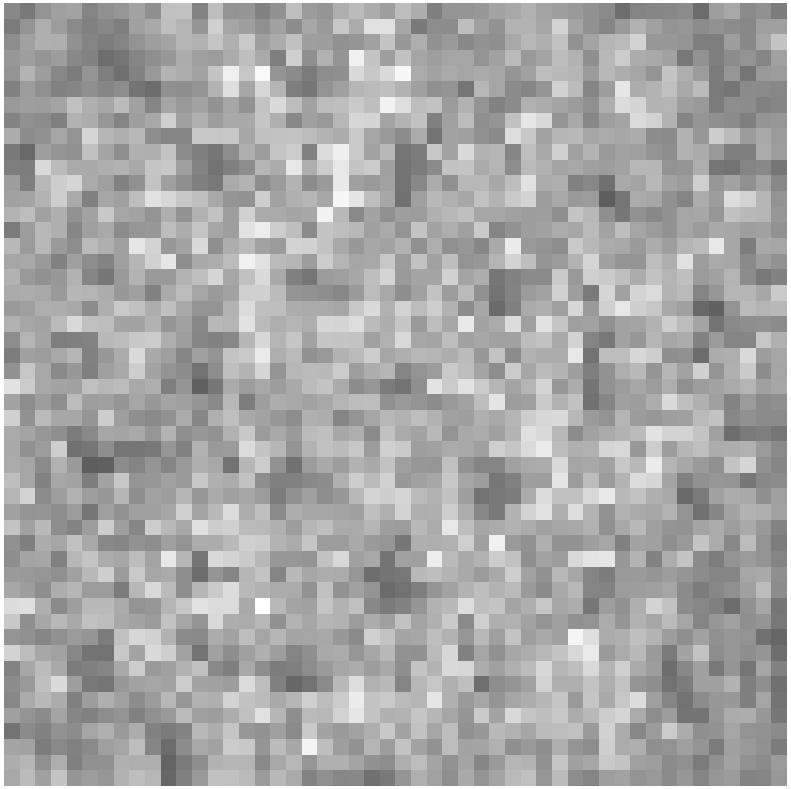
SCR 16% (LG length 50 mm*.)*

- DM *active*: Intensity ×150%; SCR *equal* (approximately.)

MD versus DM, high gain metallic 3-D cinema screen



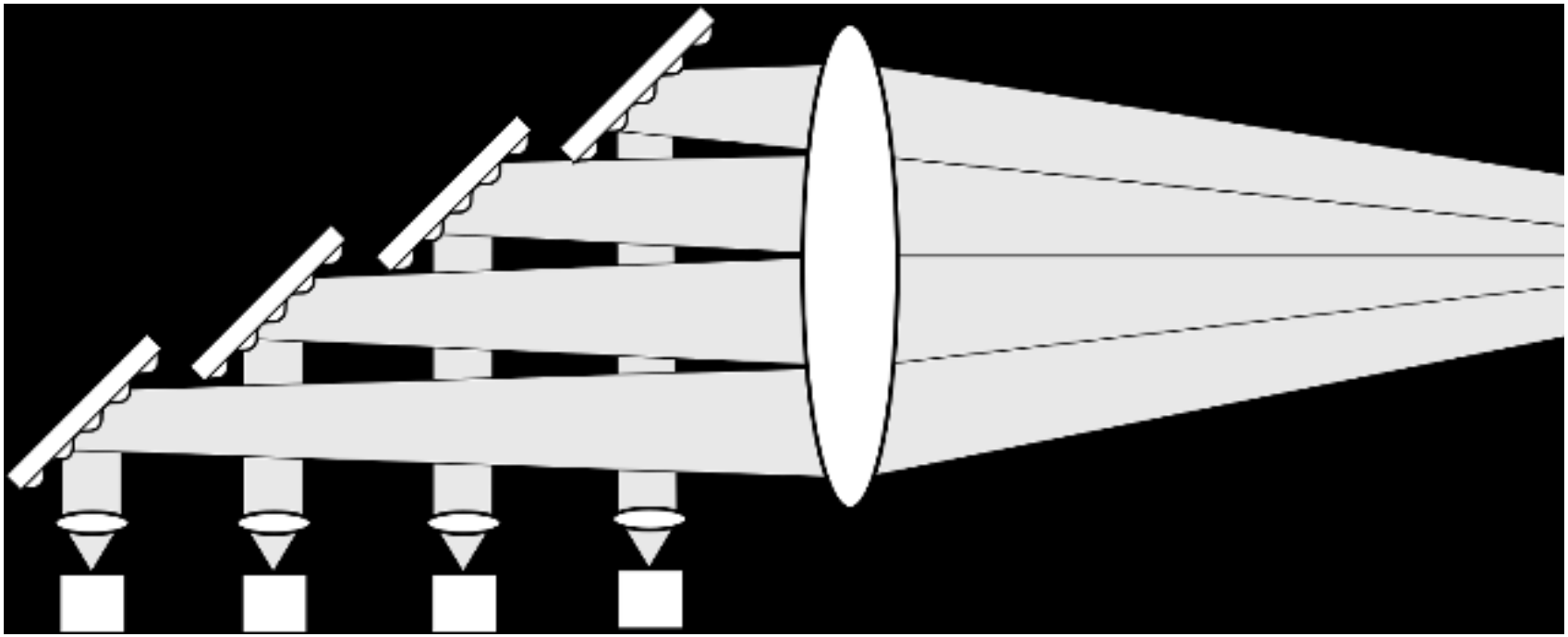
Mean intensities 43% vs. 65%.



SCR 16% (LG length 50 mm*.)*

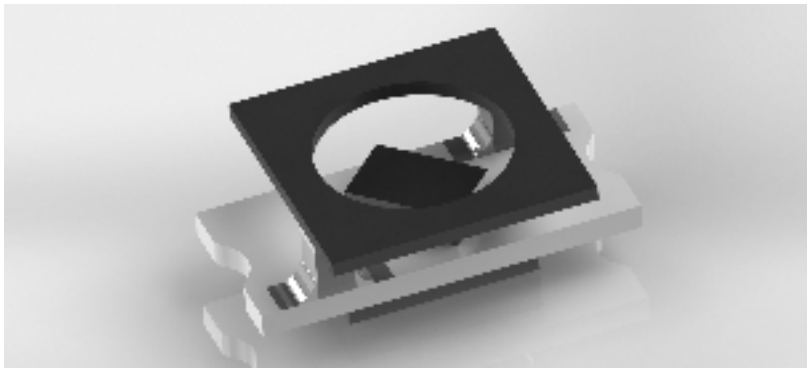
- DM *active*: Intensity $\times$150%; SCR *equal* (approximately.)

Multiple LDs, multiple small DMs

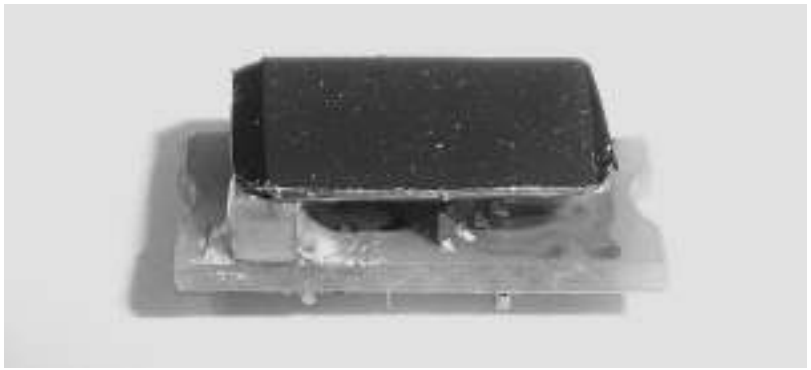


Each small DM can have coating optimized for LD wavelength.

Multiple LDs, multiple small DMs

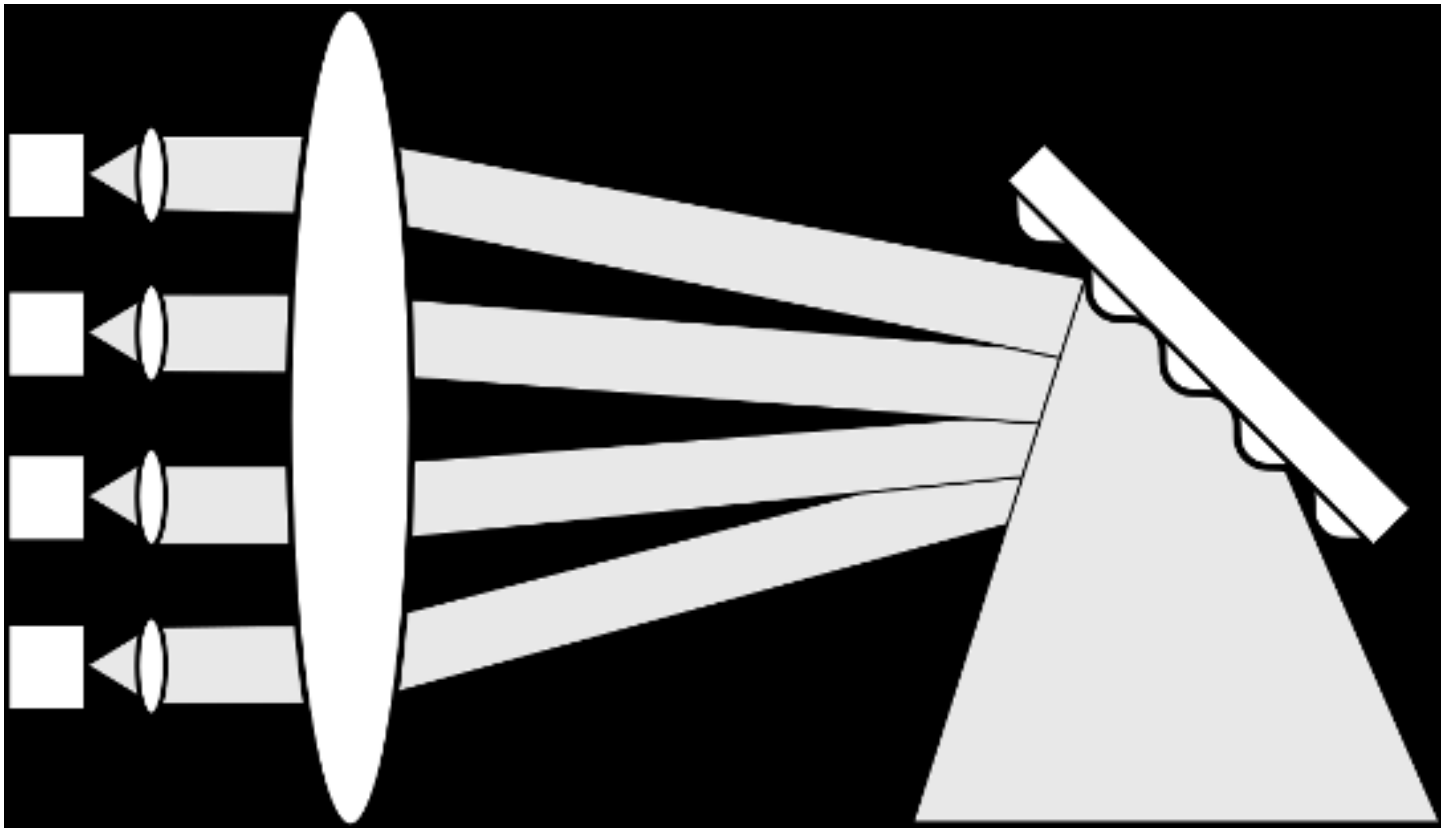


Design of $7 \times 4.5 \times 3\,\mathrm{mm}^3$ *module with fully integrated electronics.*



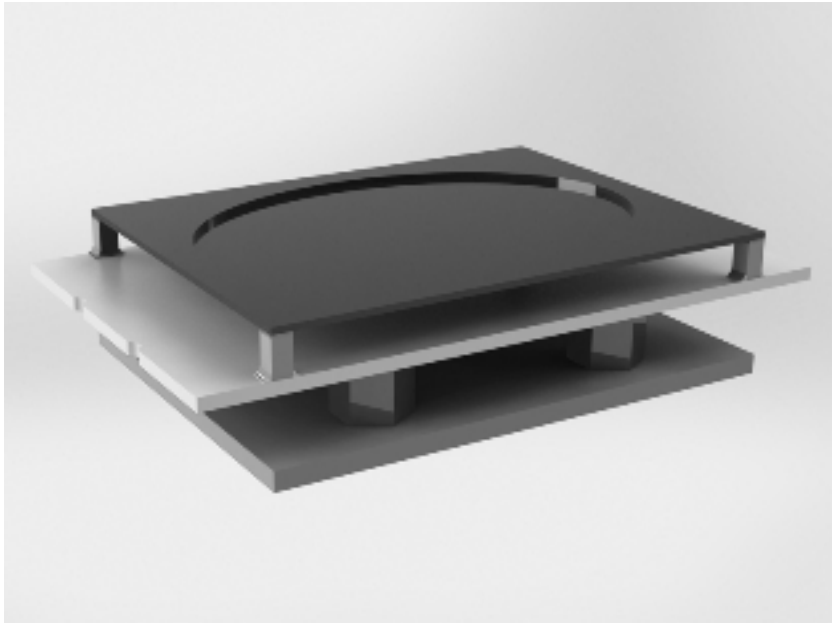
Functional prototype with approx. $6\,\mathrm{W}$ *damage threshold.*

Multiple LDs, single large DM

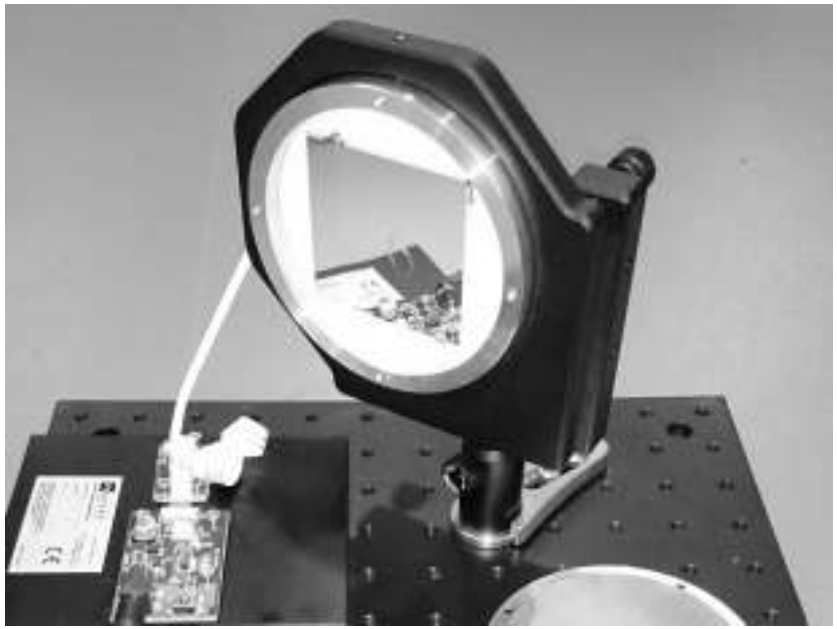


Large DM can have coating optimized for several wavelengths.

Multiple LDs, single large DM

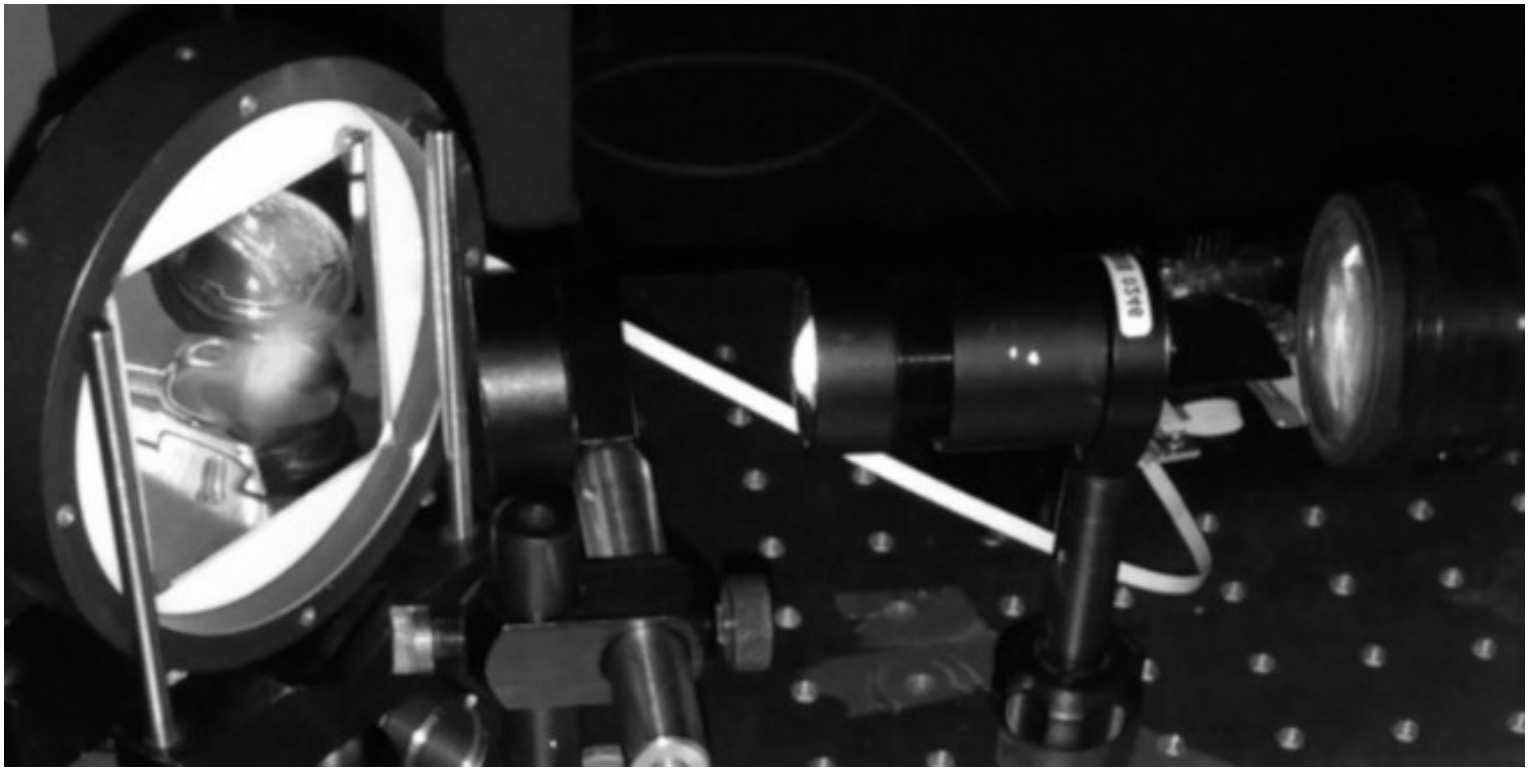


Design of $50 \times 40 \times 10\,\mathrm{mm}^3$ *module with fully integrated electronics.*



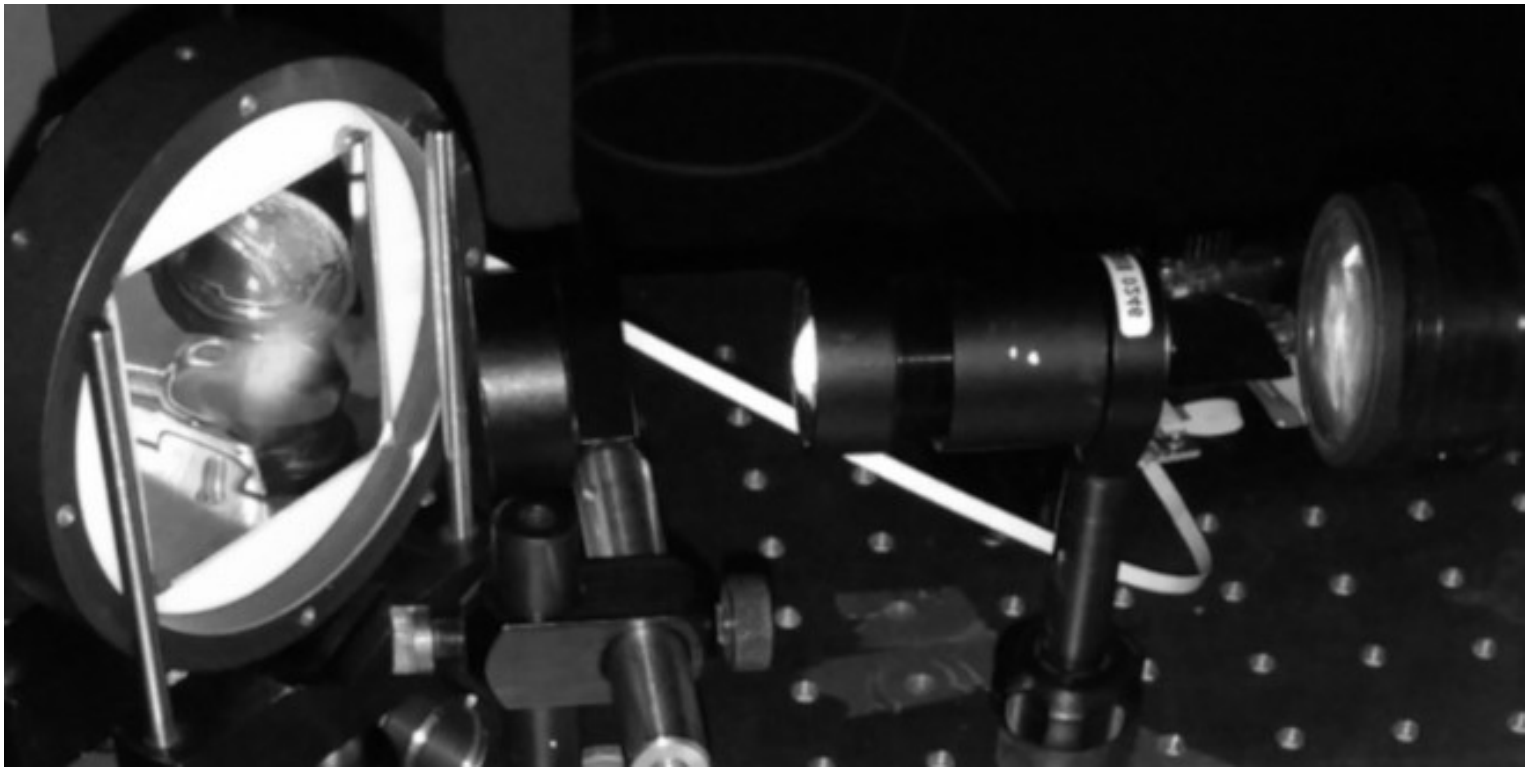
Functional R,G,B prototype with approx. 200 W *damage threshold.*

Large DM projection display apparatus.



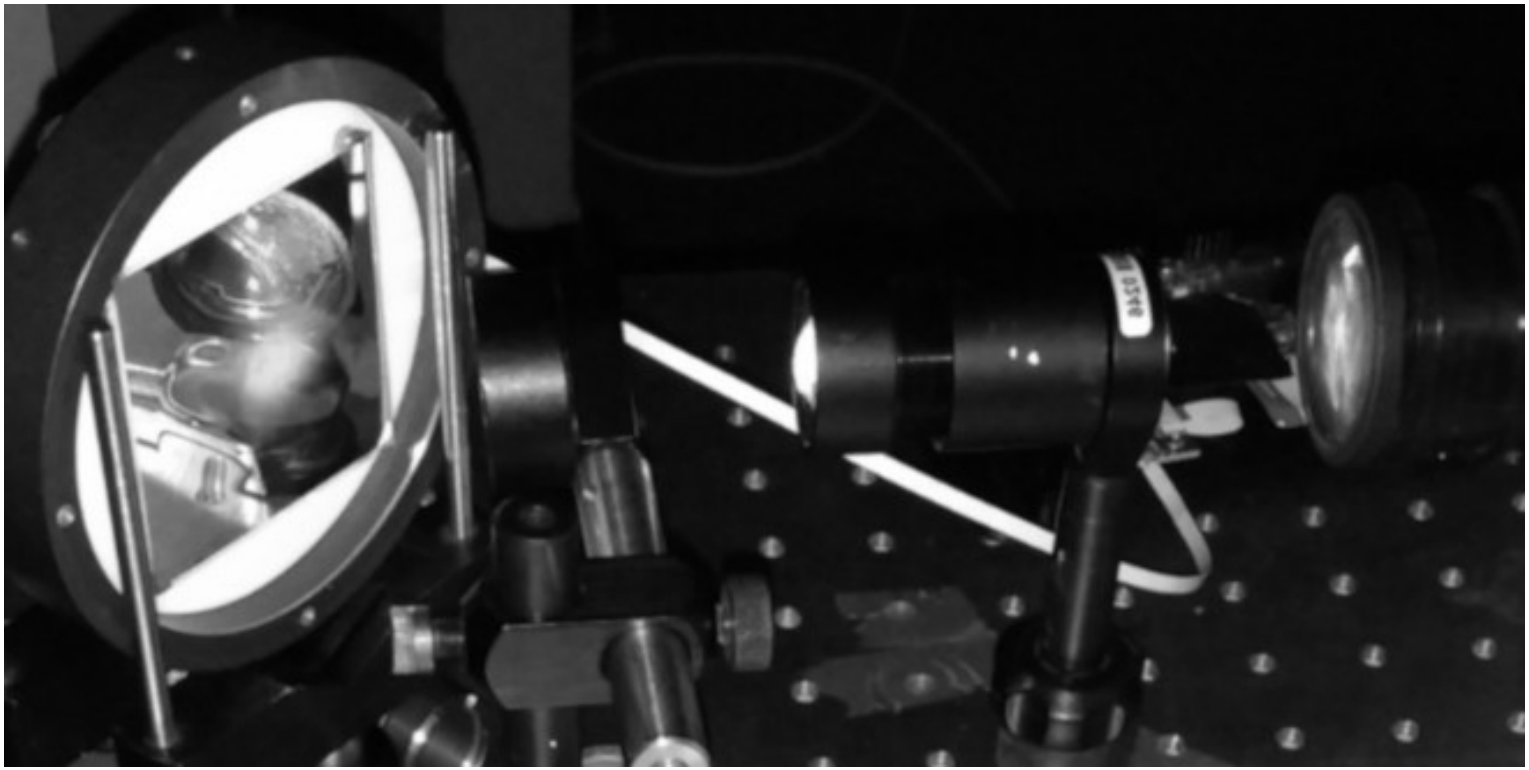
- Incident illumination ⌀25 mm on prototype large DM.
- Focusing lenses ⌀30 mm, effective $f \approx 30$ mm.
- Lightguides $6 \times 8 \times 50\,\mathrm{mm}^3$ and $6 \times 8 \times 150\,\mathrm{mm}^3$.

Large DM projection display apparatus.



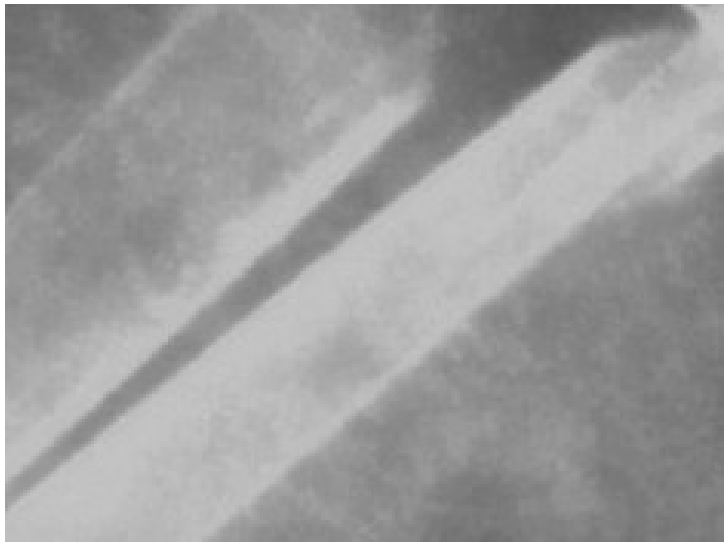
- Incident illumination $\varnothing 25\,\mathrm{mm}$ on prototype large DM.
- Focusing lenses $\varnothing 30\,\mathrm{mm}$, effective $f \approx 30\,\mathrm{mm}$.
- Lightguides $6 \times 8 \times 50\,\mathrm{mm}^3$ and $6 \times 8 \times 150\,\mathrm{mm}^3$.

Large DM projection display apparatus.



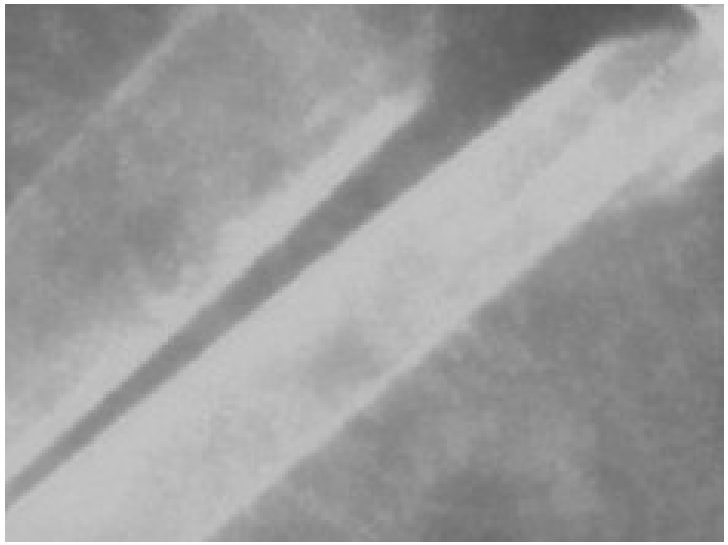
- Incident illumination $\varnothing 25\,\mathrm{mm}$ on prototype large DM.
- Focusing lenses $\varnothing 30\,\mathrm{mm}$, effective $f \approx 30\,\mathrm{mm}$.
- Lightguides $6 \times 8 \times 50\,\mathrm{mm}^3$ and $6 \times 8 \times 150\,\mathrm{mm}^3$.

Projected image, 1.4 m diagonal, large DM



DM inactive, LG length 50 mm.

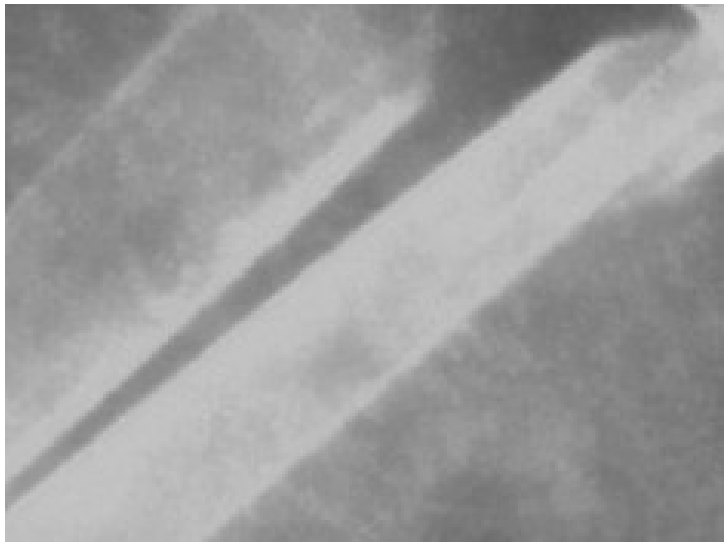
Projected image, 1.4 m diagonal, large DM



DM inactive, LG length 50 mm.

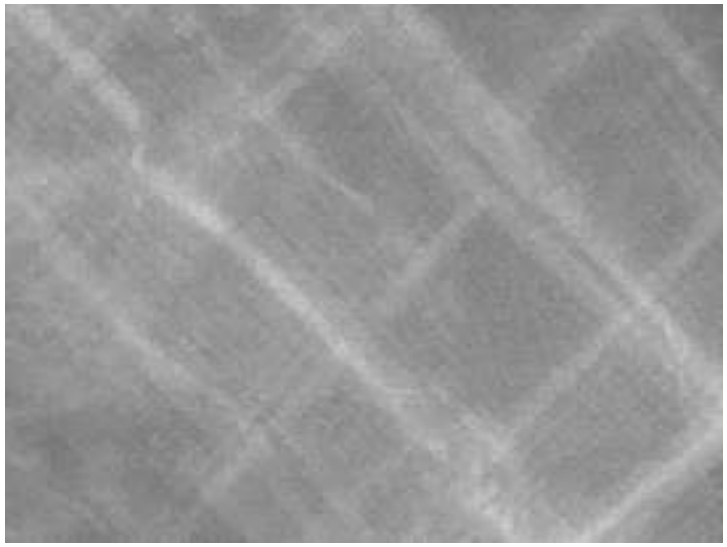
DM active, LG length 50 mm.

Projected image, 1.4 m diagonal, large DM



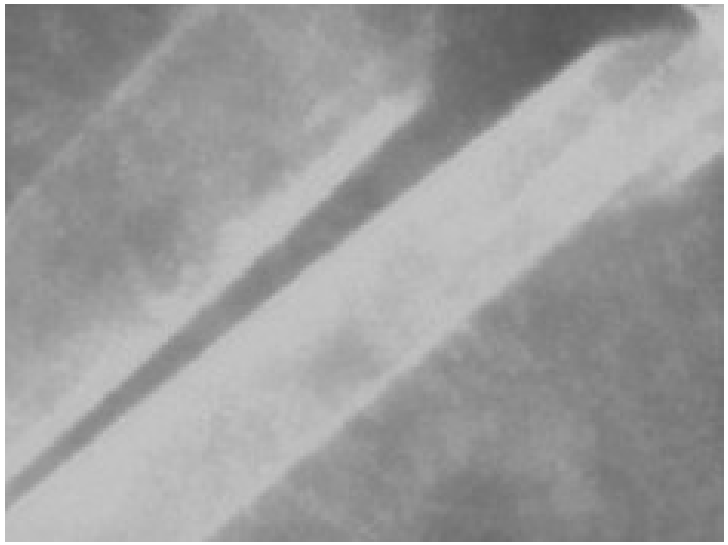
DM inactive, LG length 50 mm.

DM active, LG length 50 mm.



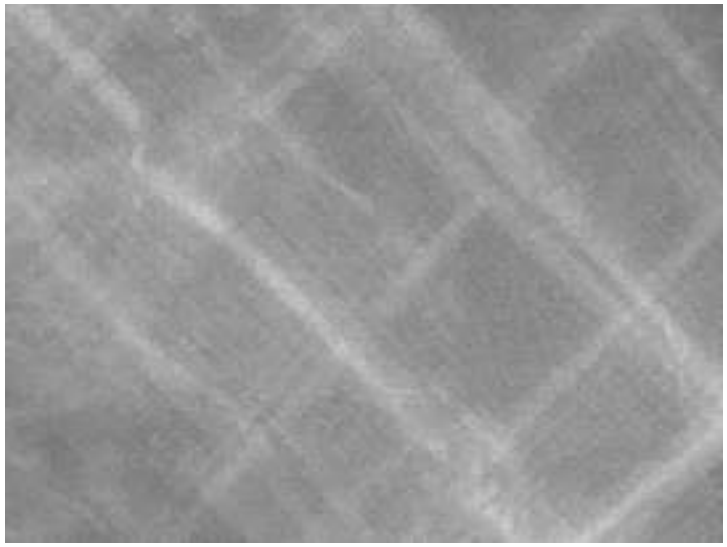
DM inactive, LG length 150 mm.

Projected image, 1.4 m diagonal, large DM



DM inactive, LG length 50 mm.

DM active, LG length 50 mm.



DM inactive, LG length 150 mm.

DM active, LG length 150 mm.

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Thank You!