Phase Randomization for Holographic AR Display

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DYOPTYKA, Ireland.

SID EuroDisplay 2026, Dublin.

2026-09-22

Holographic display ⇒ speckle



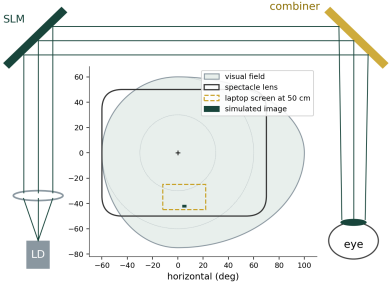
Fourier CGH; SLM image at pupil; combiner at glasses.

Binary phase-only CGH; full SLM aperture: $C_S = 76\%$.

And through a 3 mm pupil at eye: $C_S = 93\%$.

Complex SLM: flat phase ⇒ no speckle, no eyebox.

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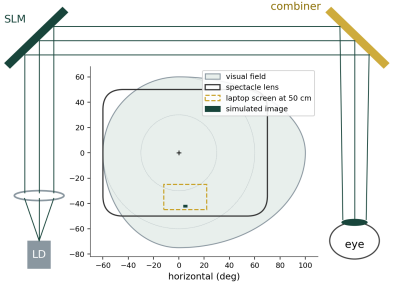
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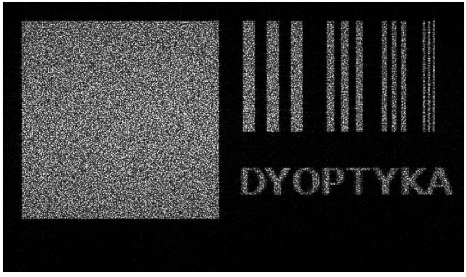
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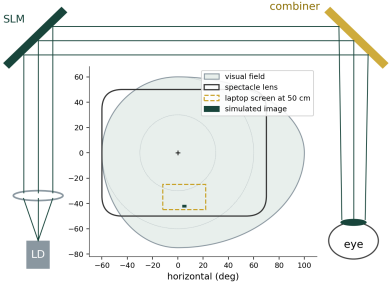


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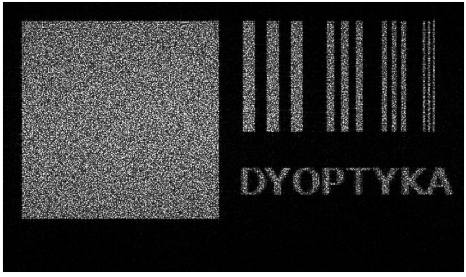
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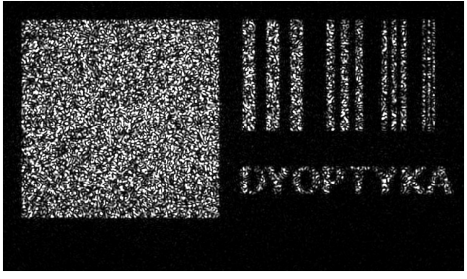
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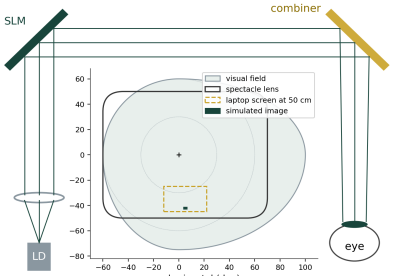
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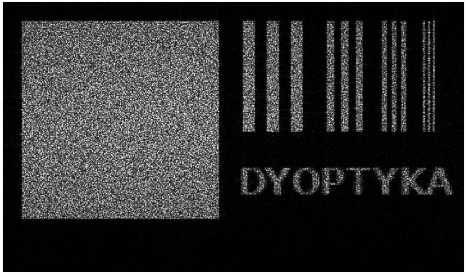
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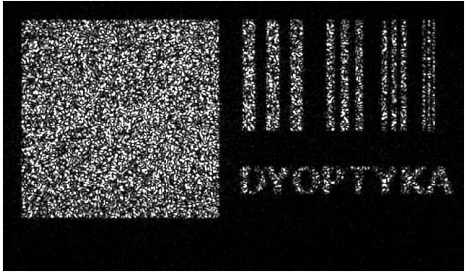
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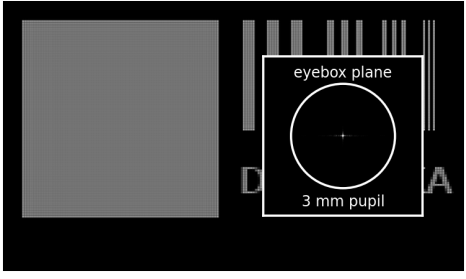
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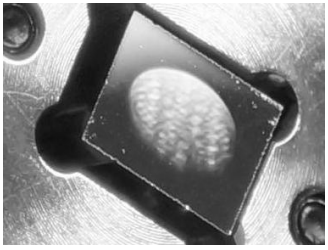


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Phase-randomizing deformable mirror



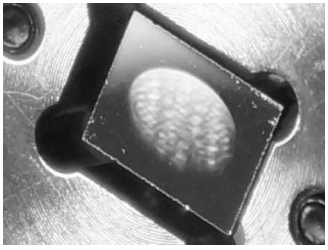
Standing and travelling waves up to 1.5 MHz, $\Lambda \gg \lambda$.

DM far field, 1 ms *exposure:* ±1.5° *on vs* ±0.17° *off.*

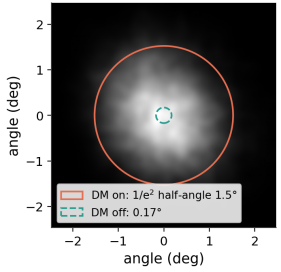
Coherence width 9 m *(van Cittert–Zernike.)*

DM ±1.5° *vs LED* ±90° *1400× less solid angle.*

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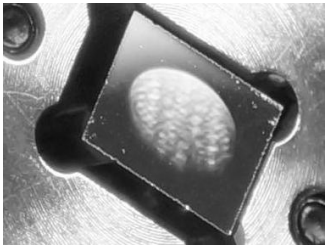


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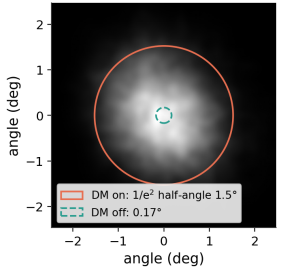
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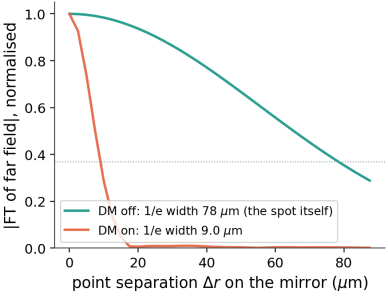
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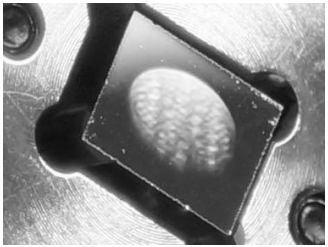
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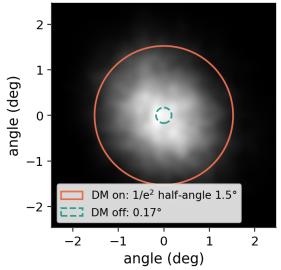
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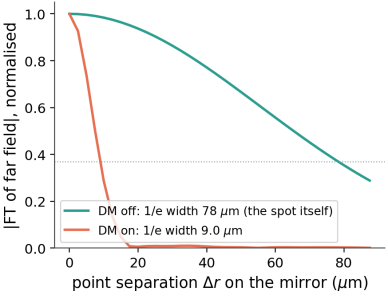
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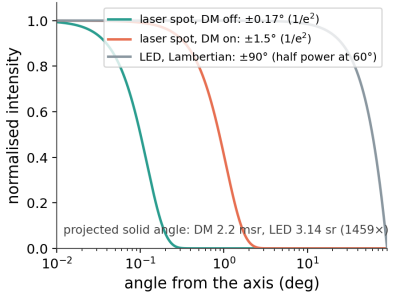
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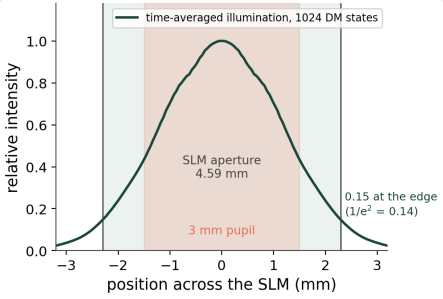


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DM effect: one convolution, any depth



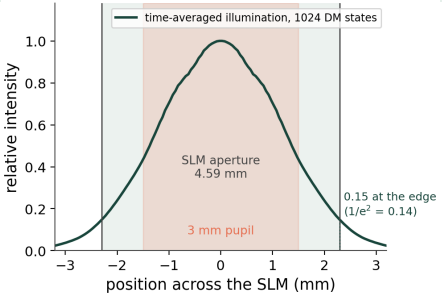
CGH encoder should know SLM illumination profile.

Time-domain model: $I_{coh} *$ DM spot profile.

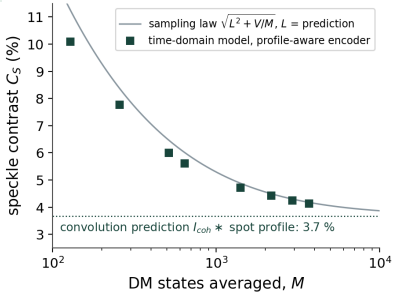
Content at ∞: edge 2.4′.

Content at 0.25 m: edge 2.5′.

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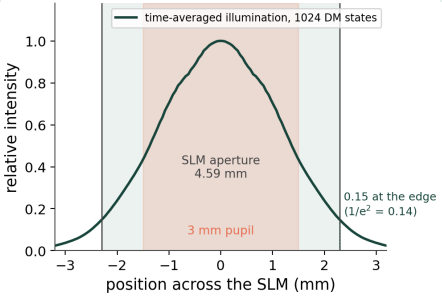
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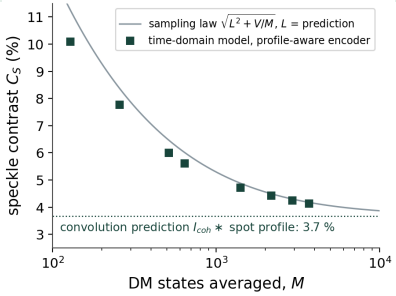
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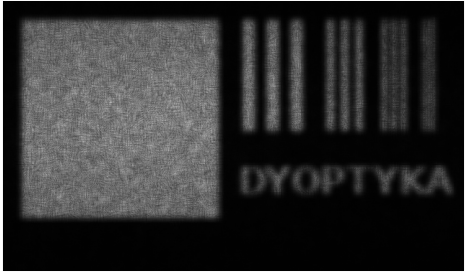
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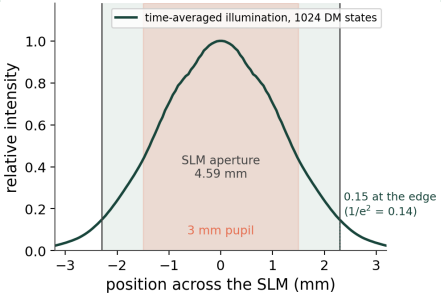
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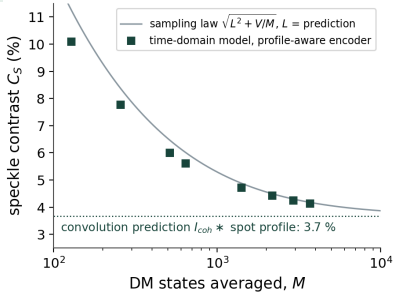
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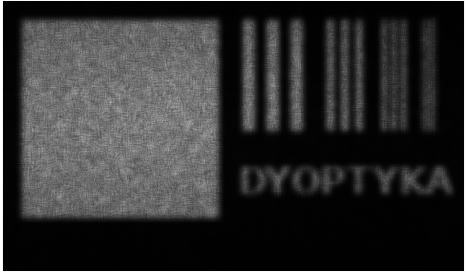
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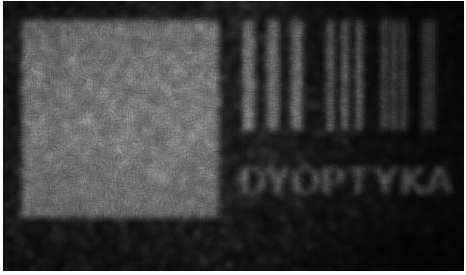
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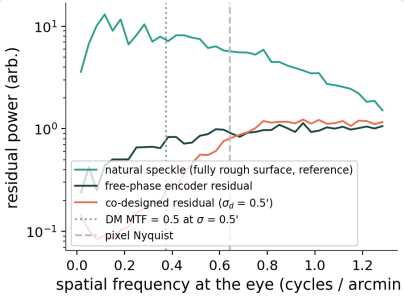


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Co-design: encoder residual above DM cut-off



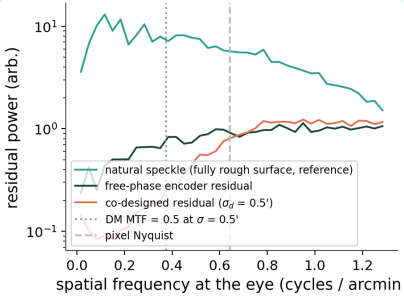
Residual error wrt DM cut-off.

SLM aperture: $C_S = 3\%$ at 0.68' blur.

Pupil aperture: $C_S = 3\%$ at 2.2' blur.

Eye pupil blur halved.

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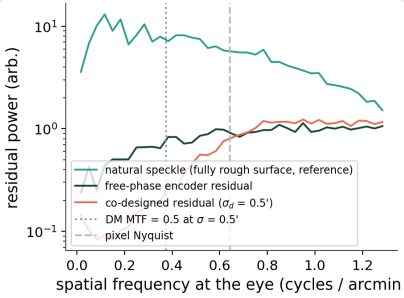


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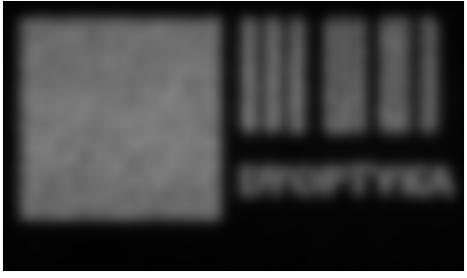
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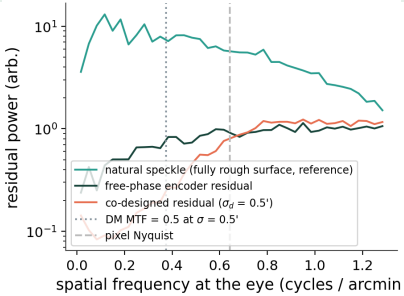
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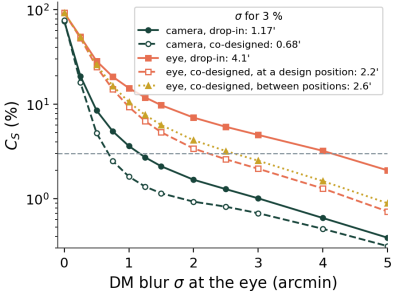
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$C_S = 3\%$: σ 2.2′.

$C_S = 4\%$: σ 1.8′.

$C_S = 5\%$: σ 1.5′.

$C_S = 6\%$: σ 1.3′.

Speckle–sharpness tradeoff



$C_S = 3\%$: σ 2.2′.



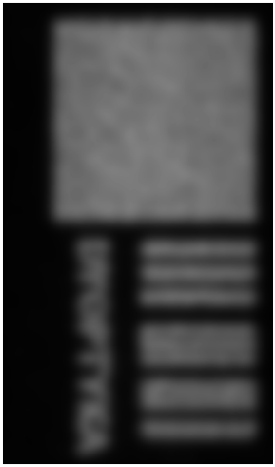
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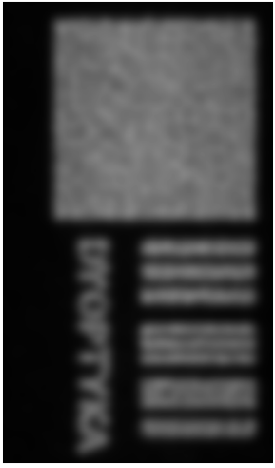


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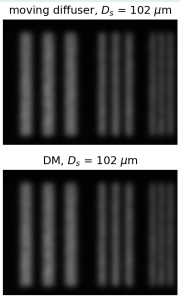


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Why DM, not diffuser, LED, or linewidth?



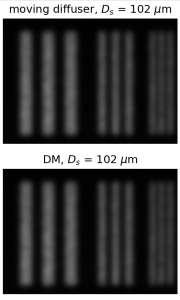
Same spot size, same image.

Divergence.

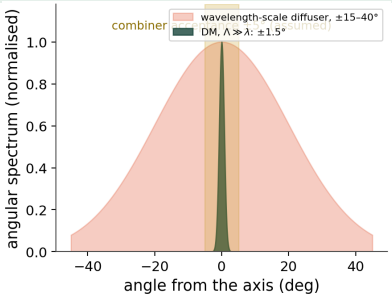
Coupling.

OPD ~1 m.

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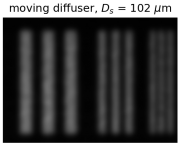


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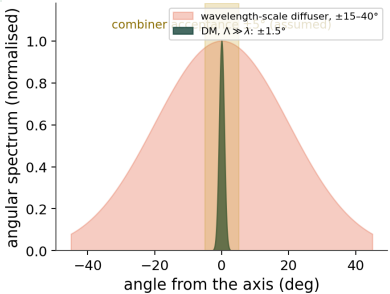
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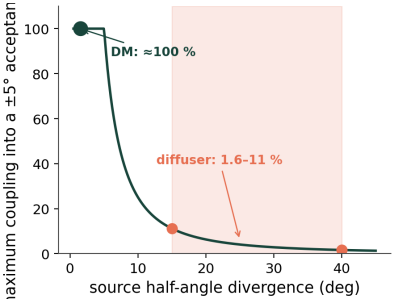
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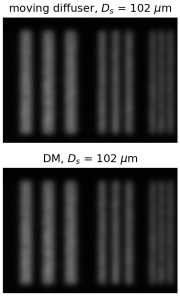
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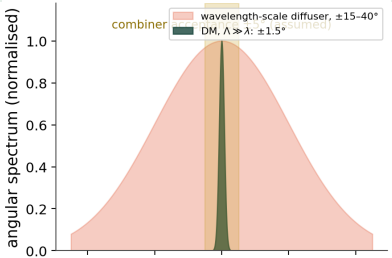
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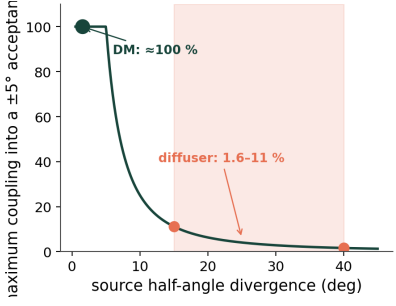
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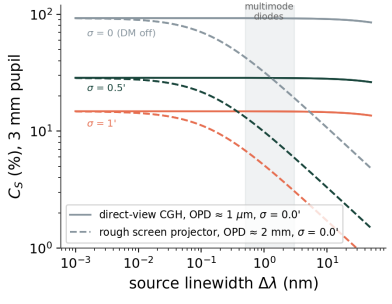
Same spot size, same image.



Divergence.

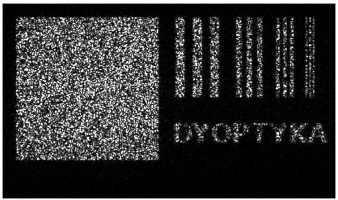


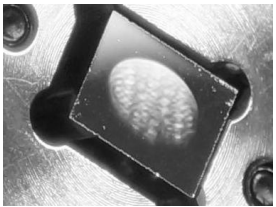
Coupling.



OPD ~1 μm.

Thank you!







Contact me at `fshevlin@dyoptyka.com` to discuss ...