IoP Optical Group & DMAC, ‘ Micro-optics and Metrology ’ meeting

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Light guide with internal mirror array for LCD backlight

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Requirements

- Wider viewing angle
- Higher contrast ratio
- Improved conversion efficiency of light generated by the backlight to light emitted from the front of the display towards the viewer
- Ideally no polarisers or colour filters which absorb a lot of light
- Lower electrical power consumption

Requirements

- Thin, flat, lightweight and small size light source, e.g. LED and backlight
- Good uniformity and high brightness
- Better colour gamut on CIE diagram by adopting three wavelength light sources
- Easy to fabricate

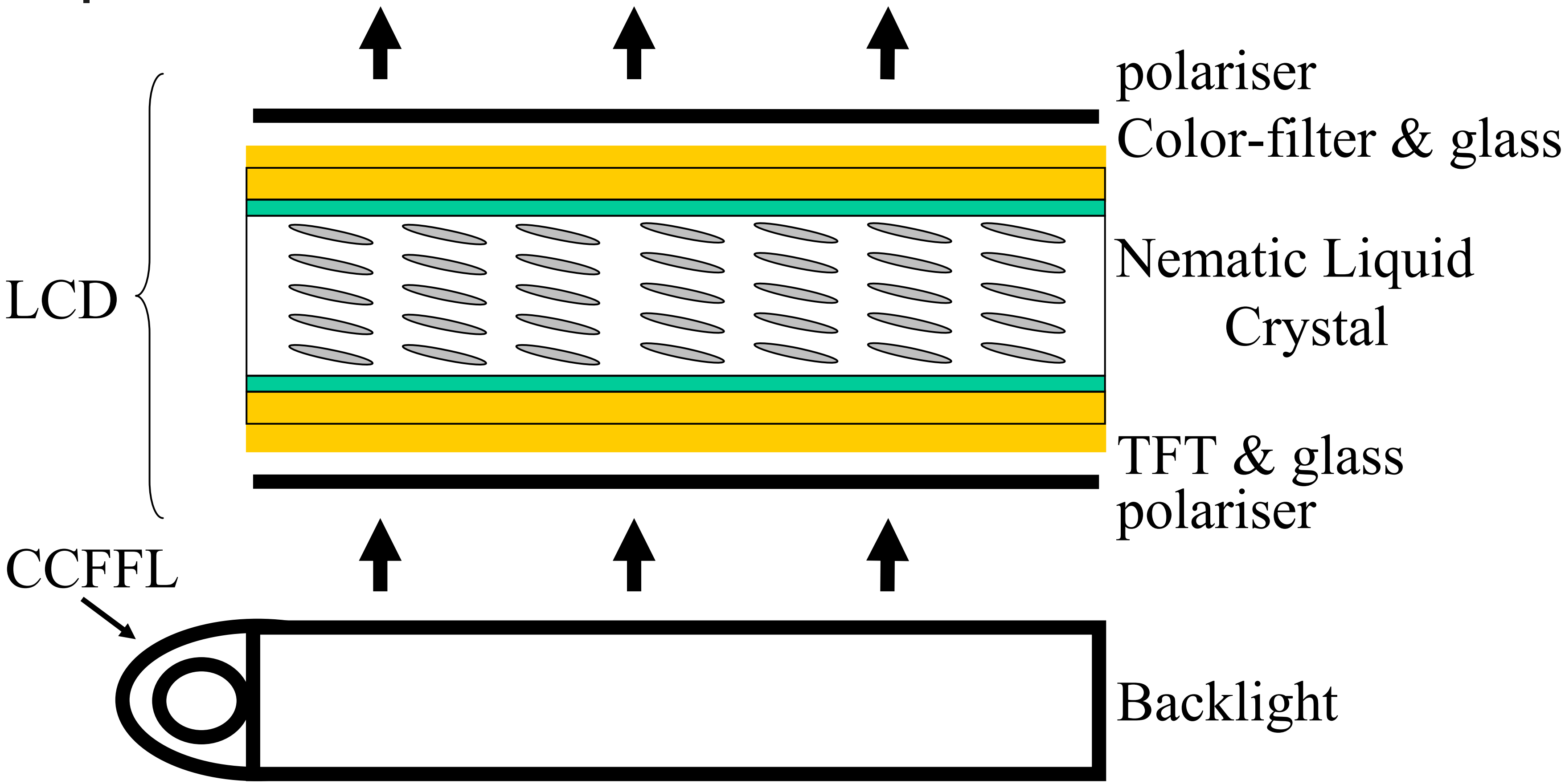
Introduction

- Research builds on earlier experimental work
- Foresight Challenge Displays Technology Alliance EPSRC/DTI LINK project: Novel Optics
- Participants included: EPIGEM, Philips, Hewlett Packard, CRL, Merck, British Aerospace, Screen Technology Ltd, Cambridge University, Heriot Watt University.
- UCL experimental work thanks to Tim York, Lawrence Commander, Veronika Tsatsourian.
- Polymer replication of components thanks to Tim Ryan, Tom Harvey of EPIGEM

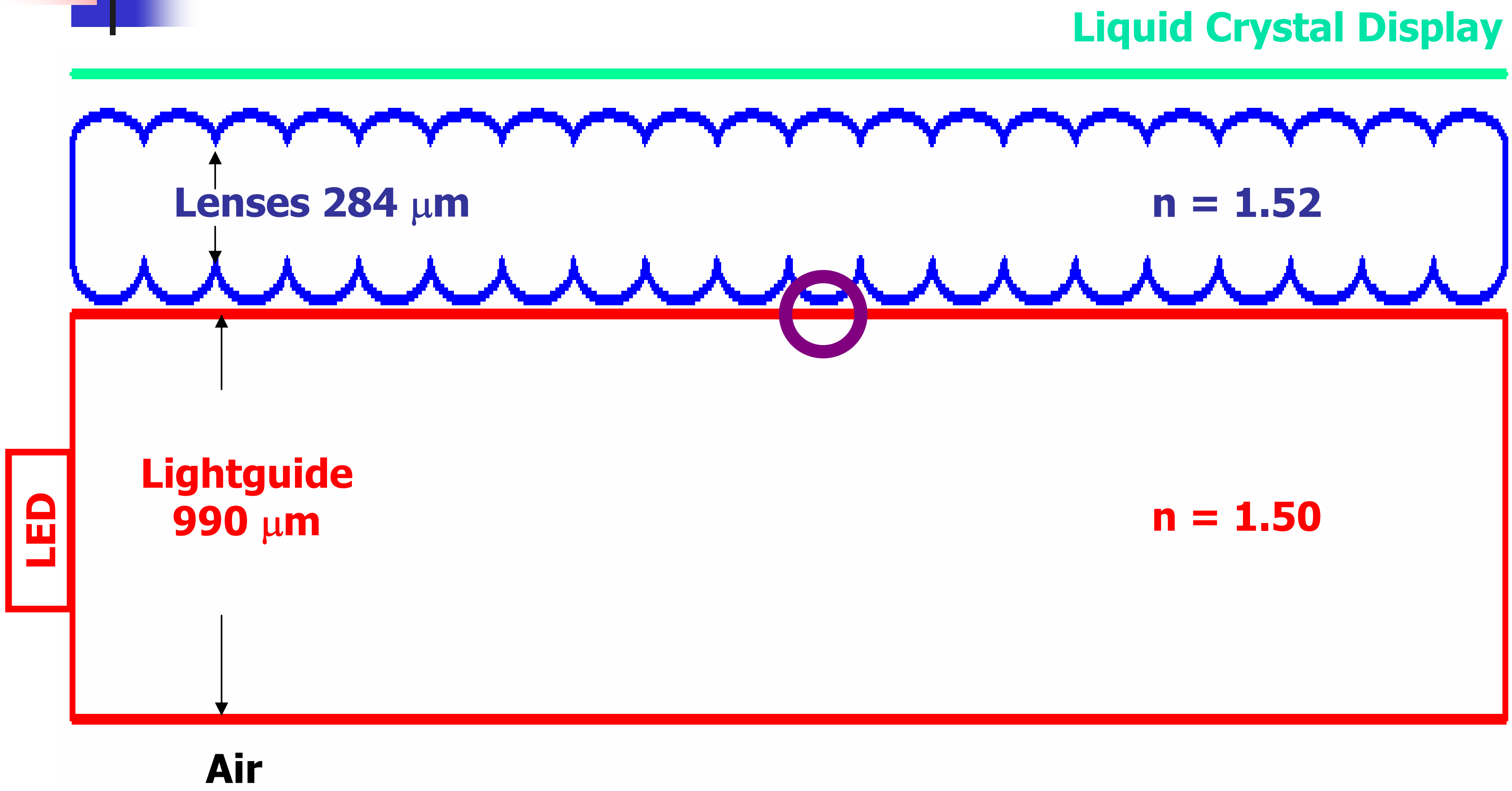
Overview

- Ray tracing models a total-internal-reflection (TIR) lightguide structure to optimise its performance.
- Light entering the multimode lightguide emerges at periodic "windows" but some is reflected out of the opposite side of the guide.
- An array of micro-mirrors set within the guide reflects these rays back out of the windows.
- Modelling measures the distance of the mirrors from the windows, the mirror size and guide dimensions to optimise the optical uniformity and efficiency.
- Other micro-optical polymer components are used to direct the light for optimum contrast

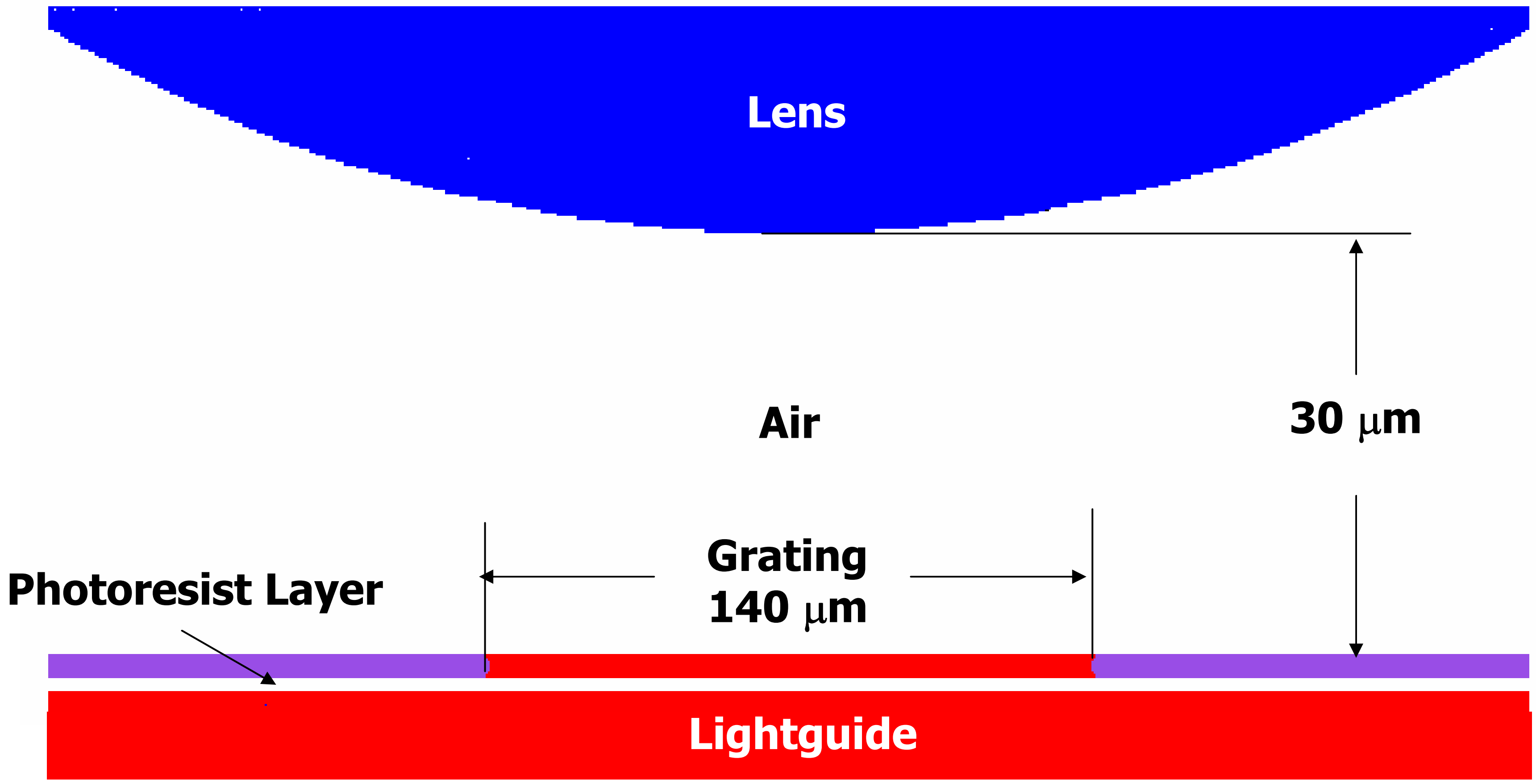
LCD Backlight Structure



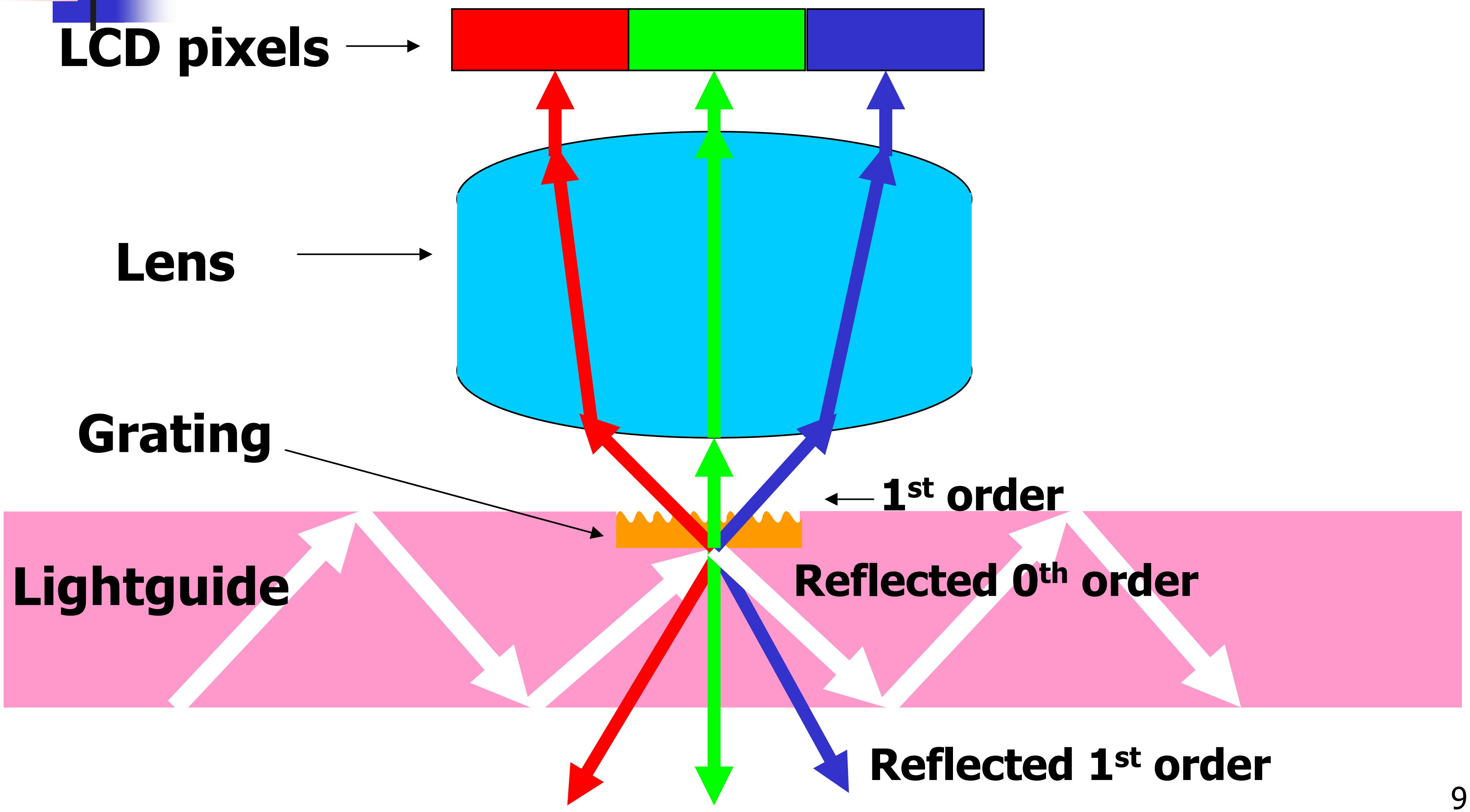
Light guide with cylindrical lens structure



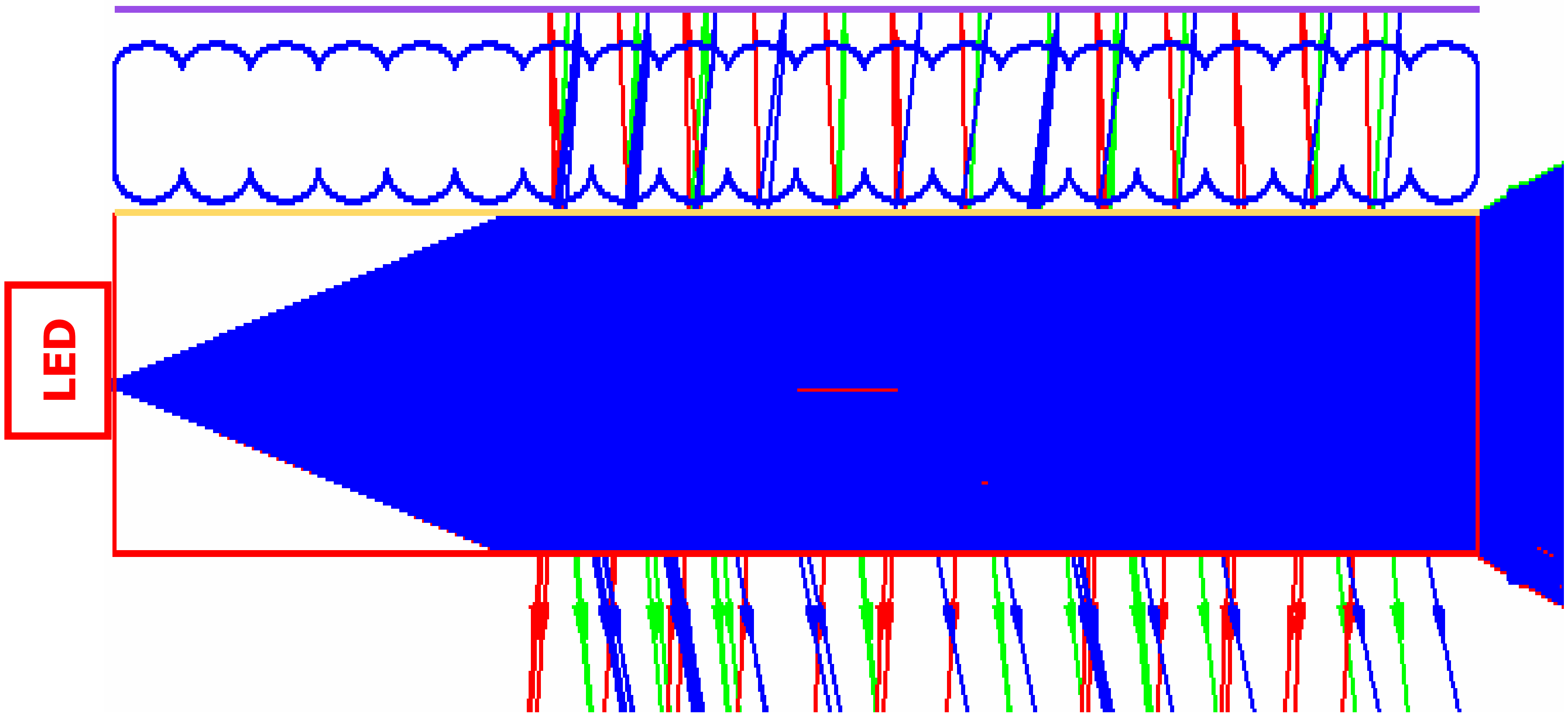
Lightguide with grating window



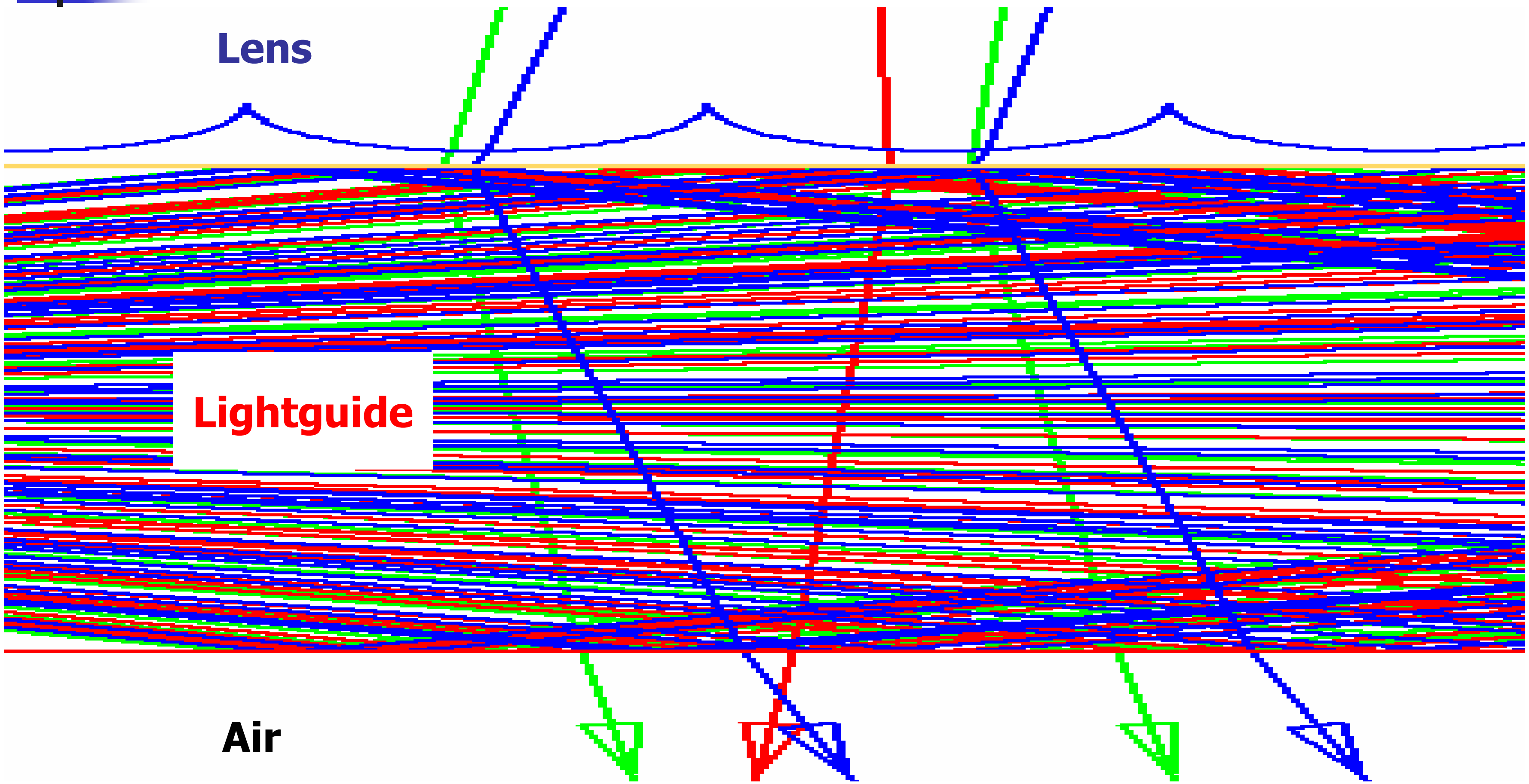
Backlight illumination system



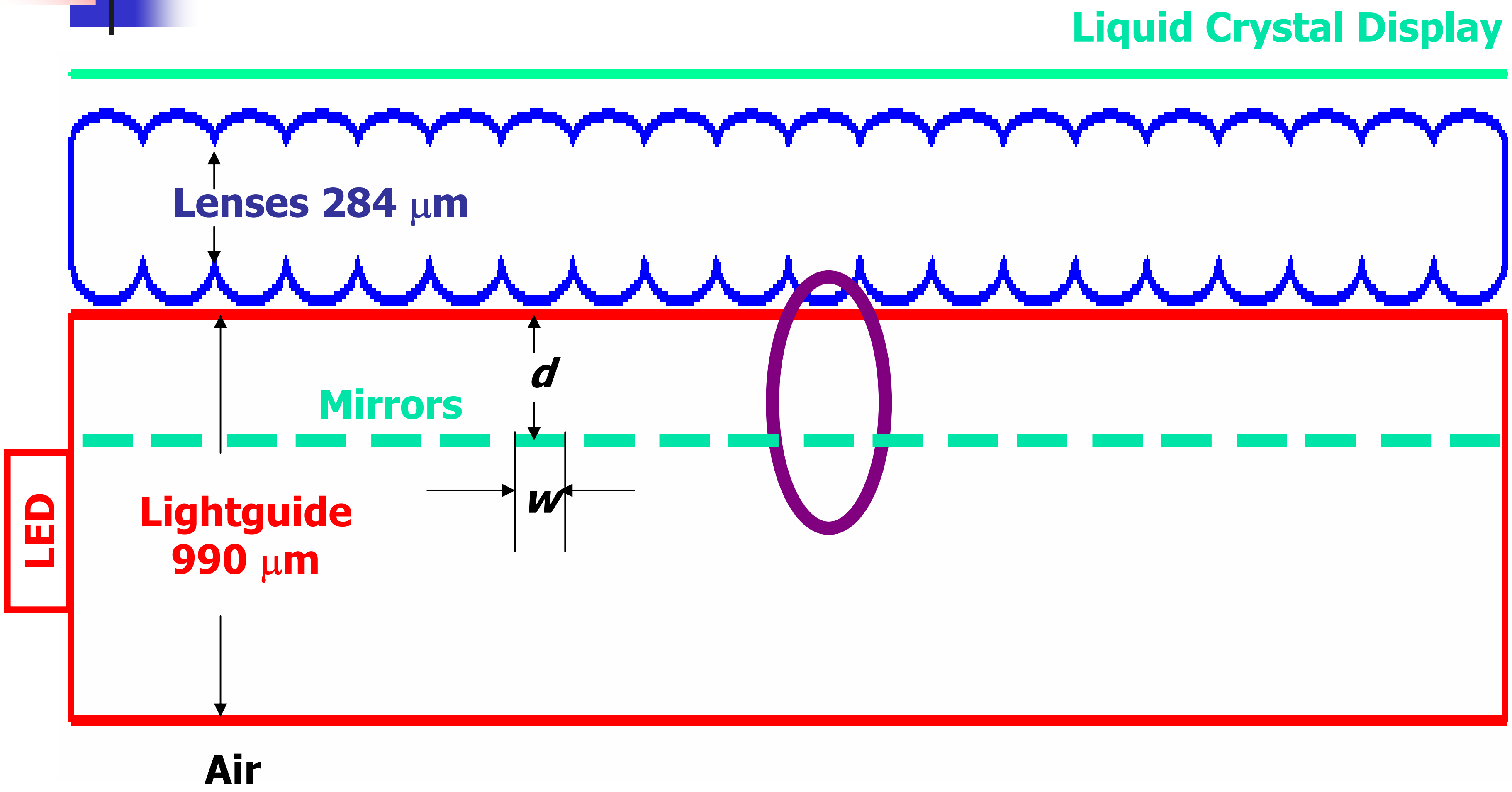
Illumination system without mirror (ASAP)



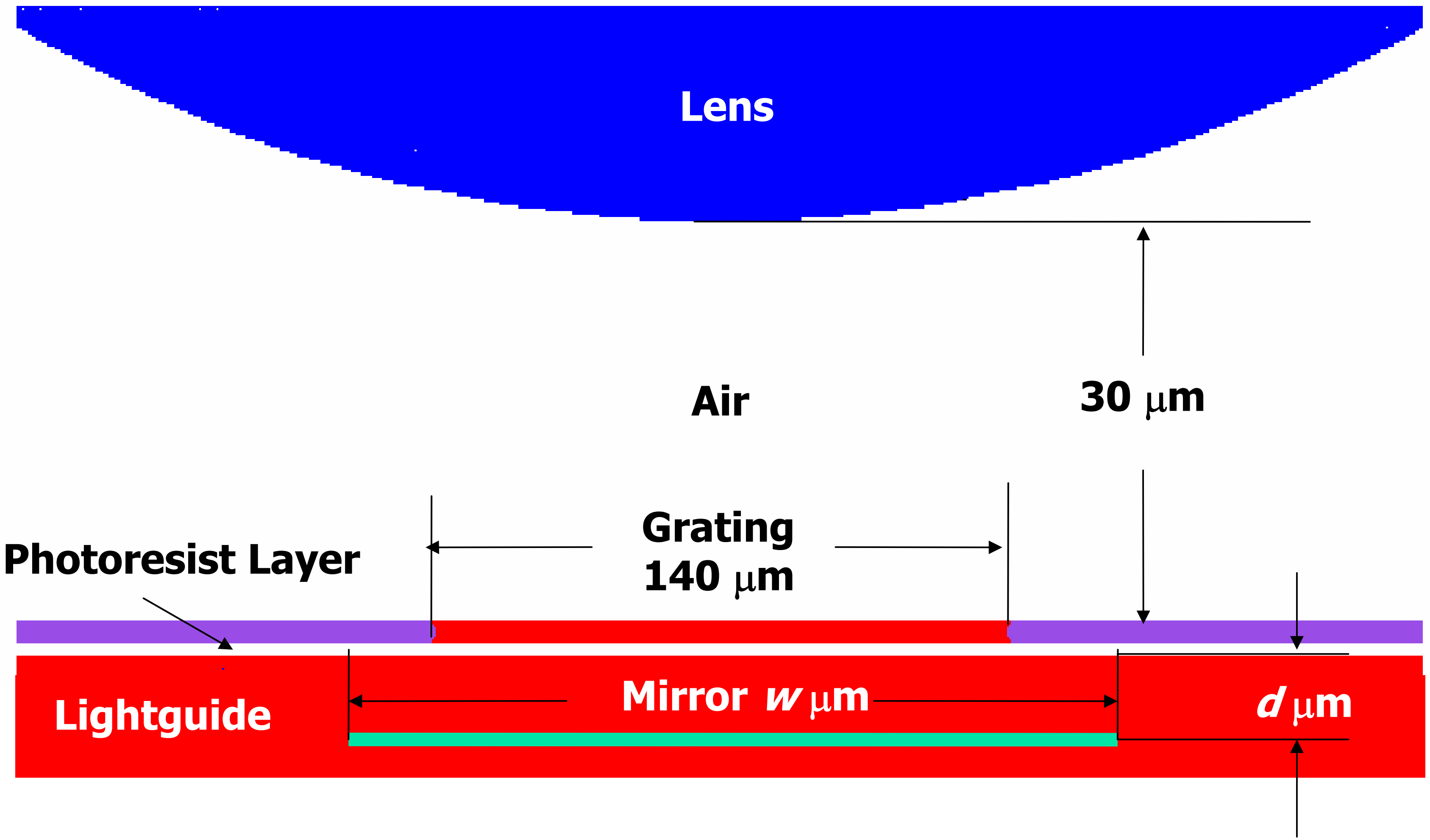
Light can leave from opposite side of light guide (ASAP)



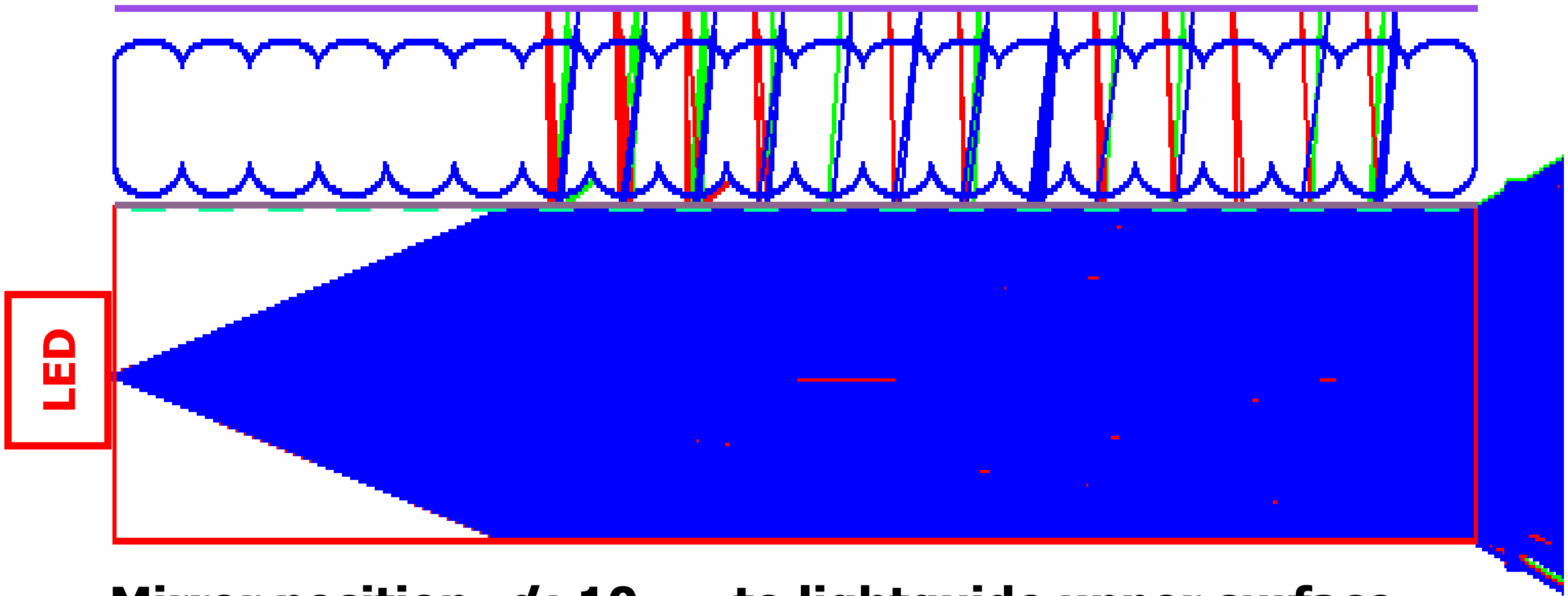
Light guide with embedded mirror structure



Lightguide with embedded mirrors

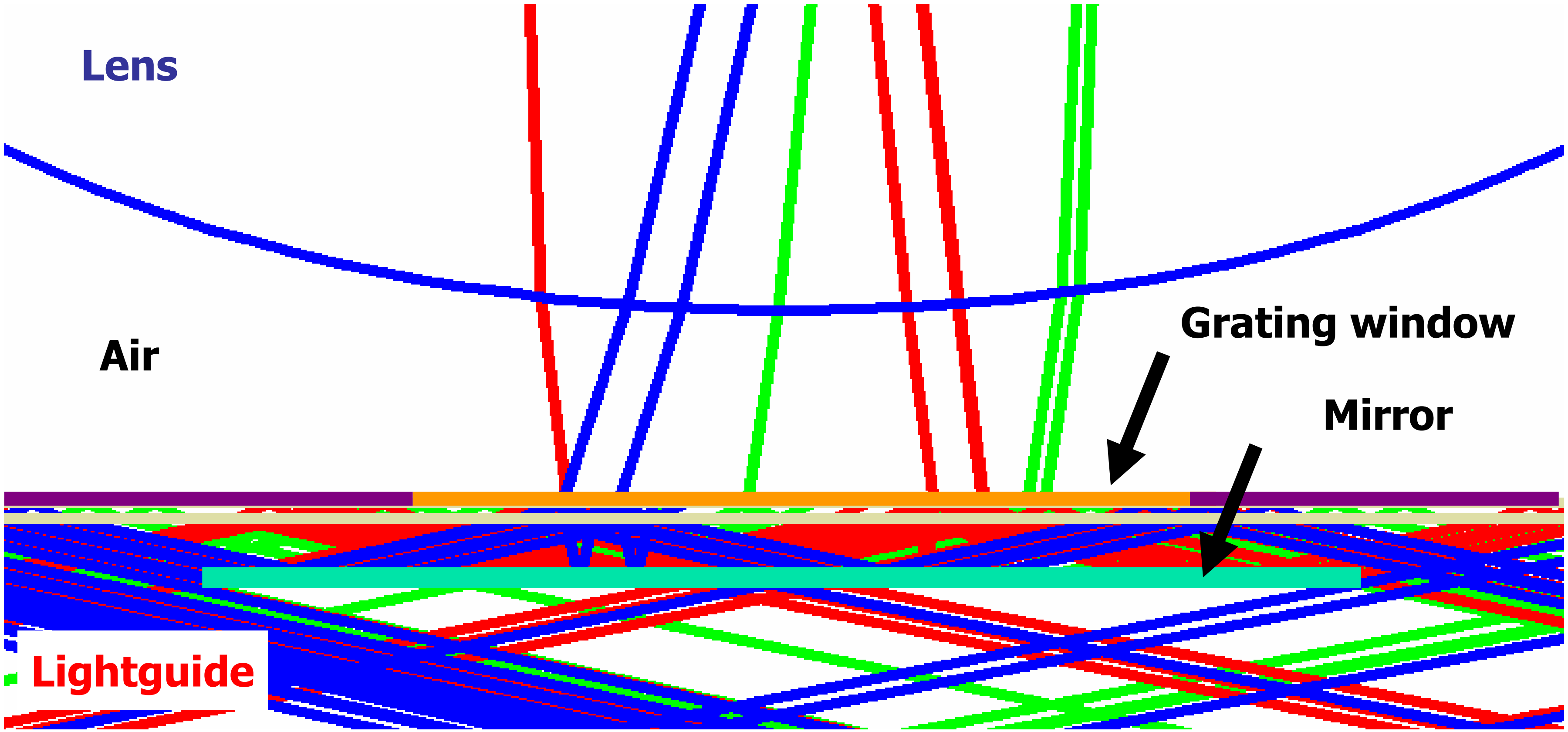


Illumination system with embedded mirrors (ASAP)

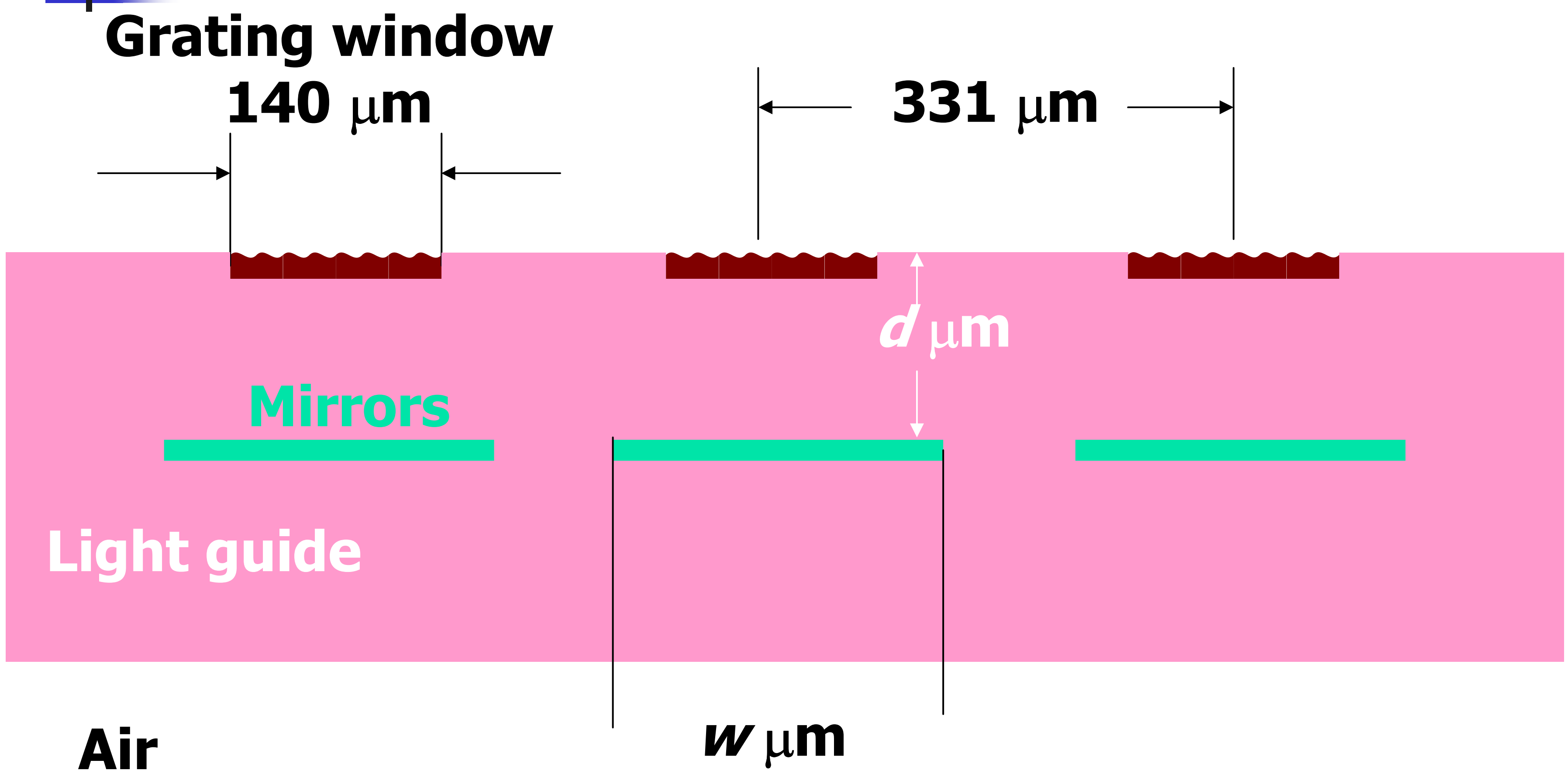


Mirror position, *d*: 10 μm to lightguide upper surface
Mirror Width, *w*: 160 μm

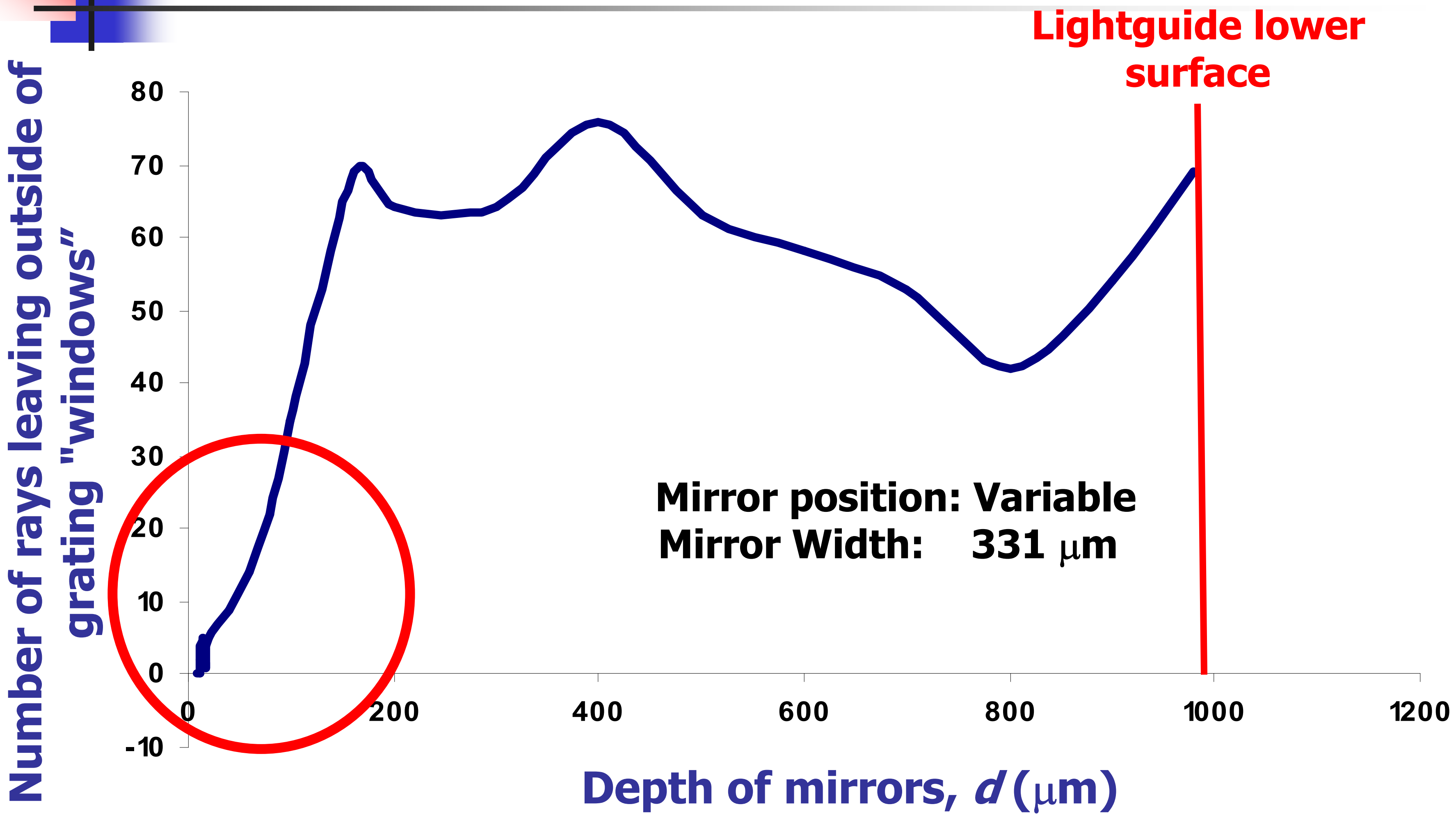
Light leaving from grating windows (ASAP)



Measurement of depth of mirror



Rays leaving outside of grating versus depth of mirrors



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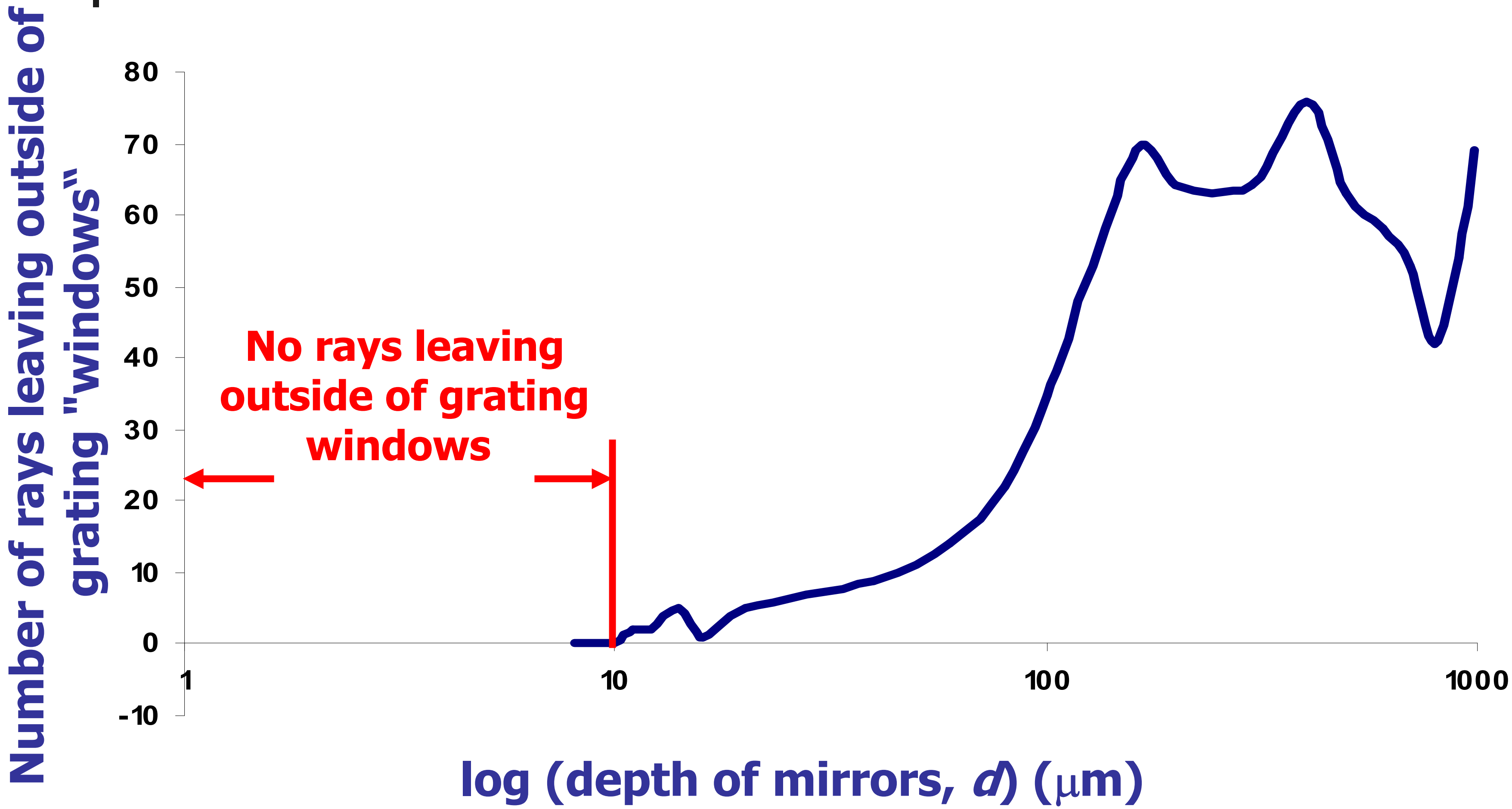
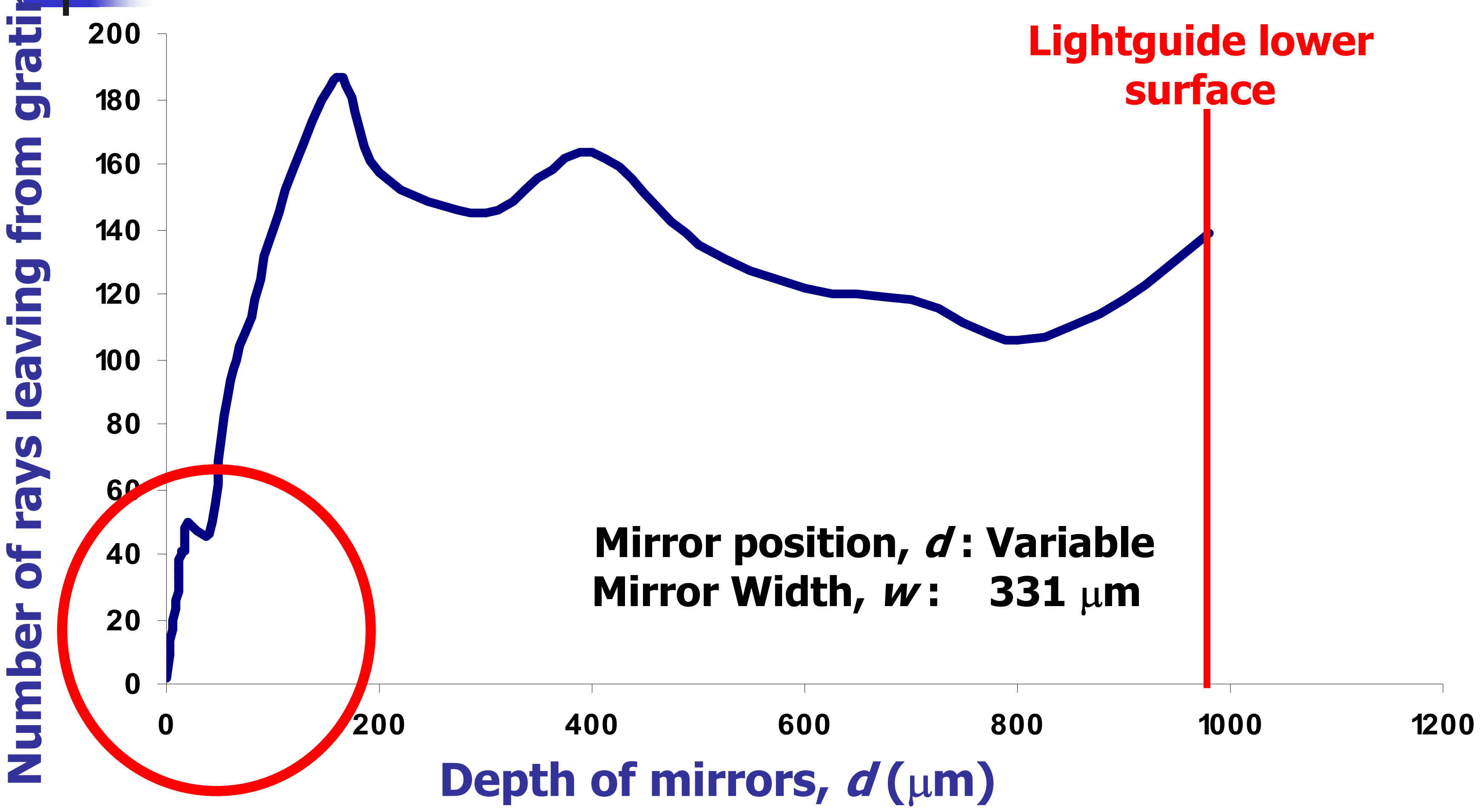
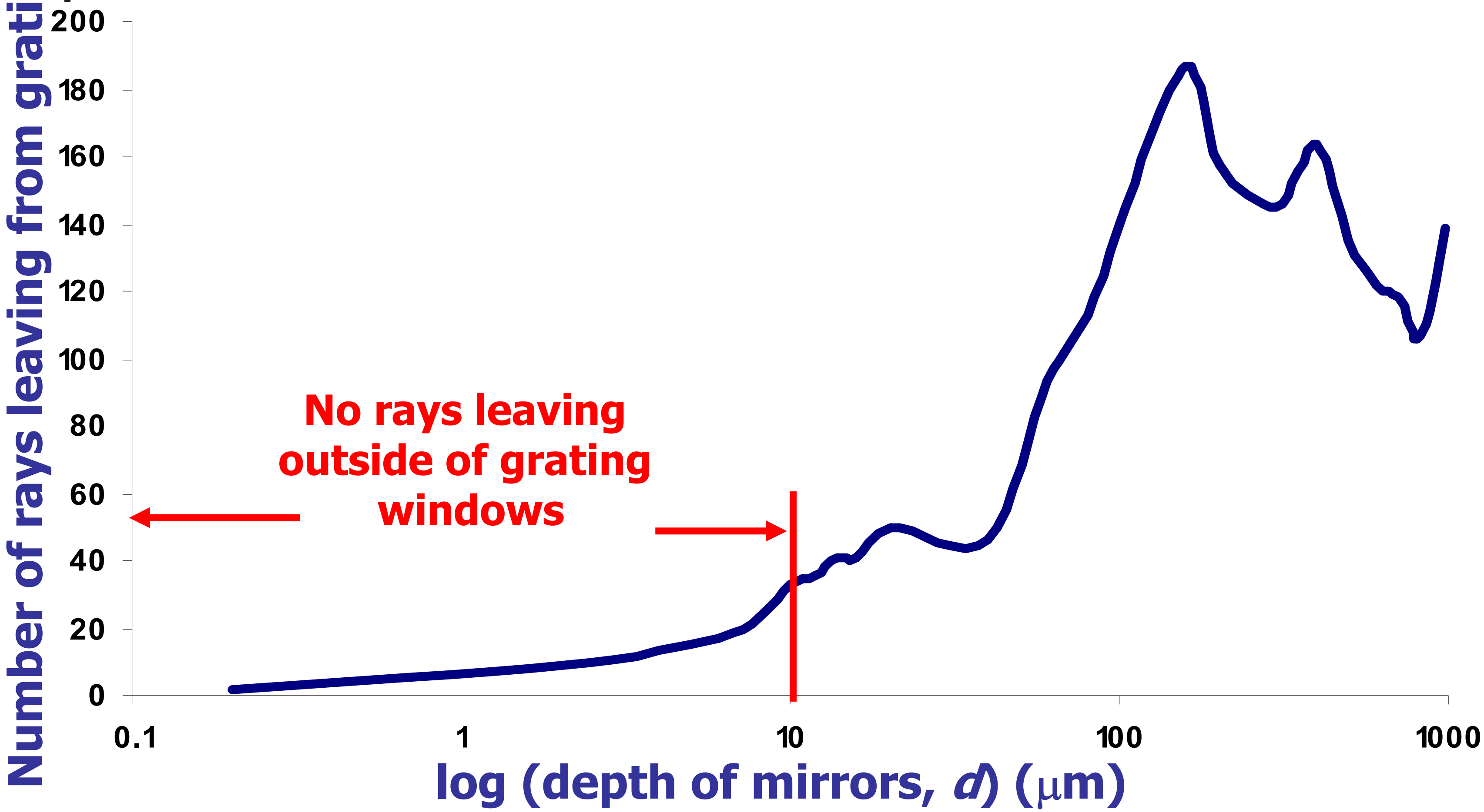


Rays leaving through grating versus depth of mirrors



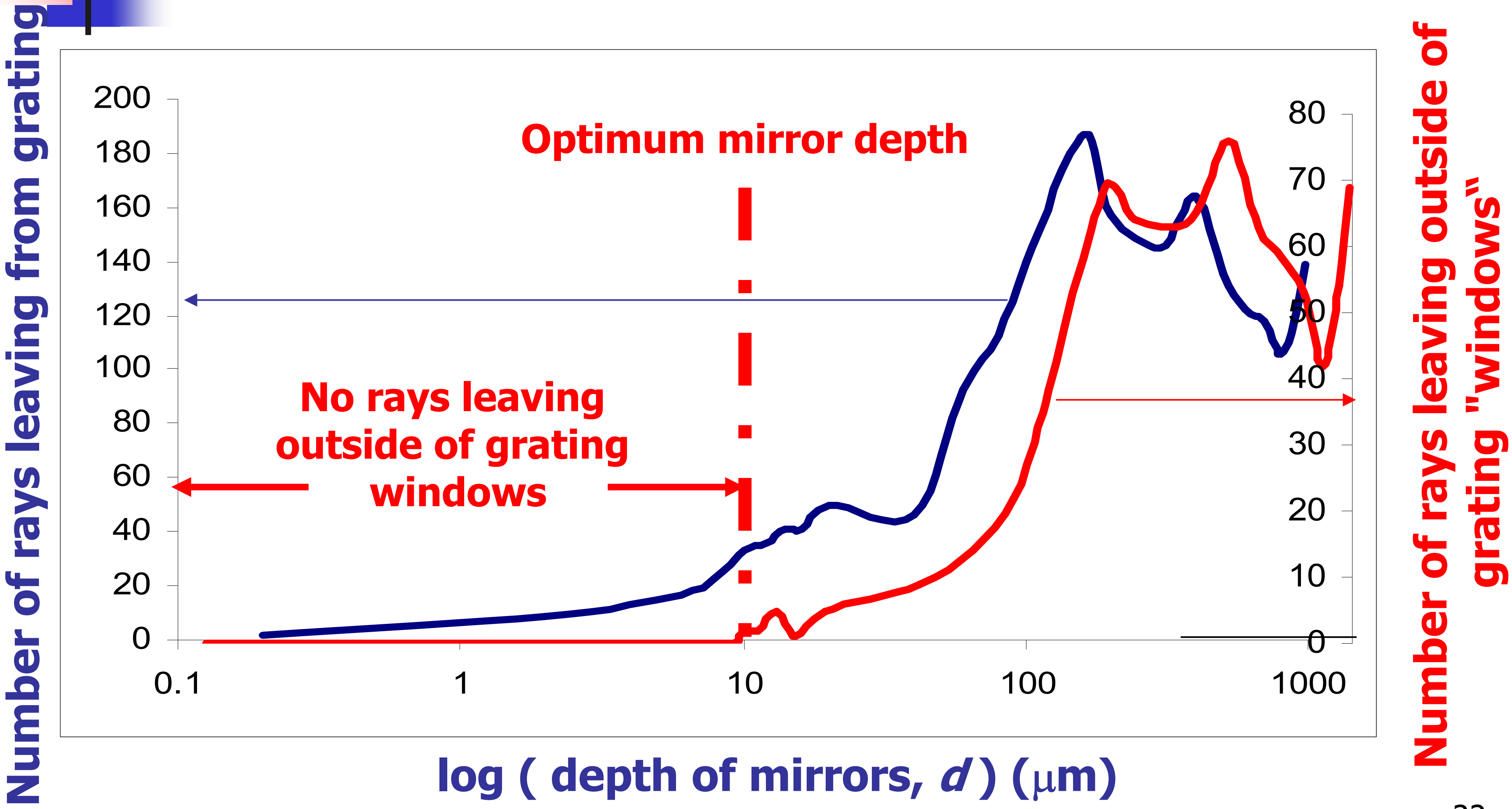
Rays leaving through grating versus depth of mirrors



How to establish optimum depth of mirror

- Mirrors must keep all reflected rays within the grating “windows”
- When mirror depth is shallower than 10 μm, there were no rays leaving from outside of the grating
- Mirrors too close to the upper lightguide surface can block the light from reaching the grating “windows” so the output is reduced.
- In the range of mirror depths, $d = 0$ to 10 μm, the maximum output occurs at 10 μm

Optimum depth of mirror



Conclusions

- A thin backlight illumination system was made without colour filters
- A mirror array layer inside the multimode lightguide can stop the light loss from the opposite side of lightguide and improve efficiency by up to 38.2%
- Replicated cylindrical micro-lens components are used to direct the light for optimum contrast and viewing angle

Future Plan

- Change position of light source, vary size of grating windows
- Use improved LED model.
- Improve design of micro-mirror within lightguide to obtain better uniformity
- Design new structure of lightguide to reduce the total light loss
- Experimentally investigate transmissive colour LCDs