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Modelling of a Colour Separating Backlight for Liquid Crystal Displays

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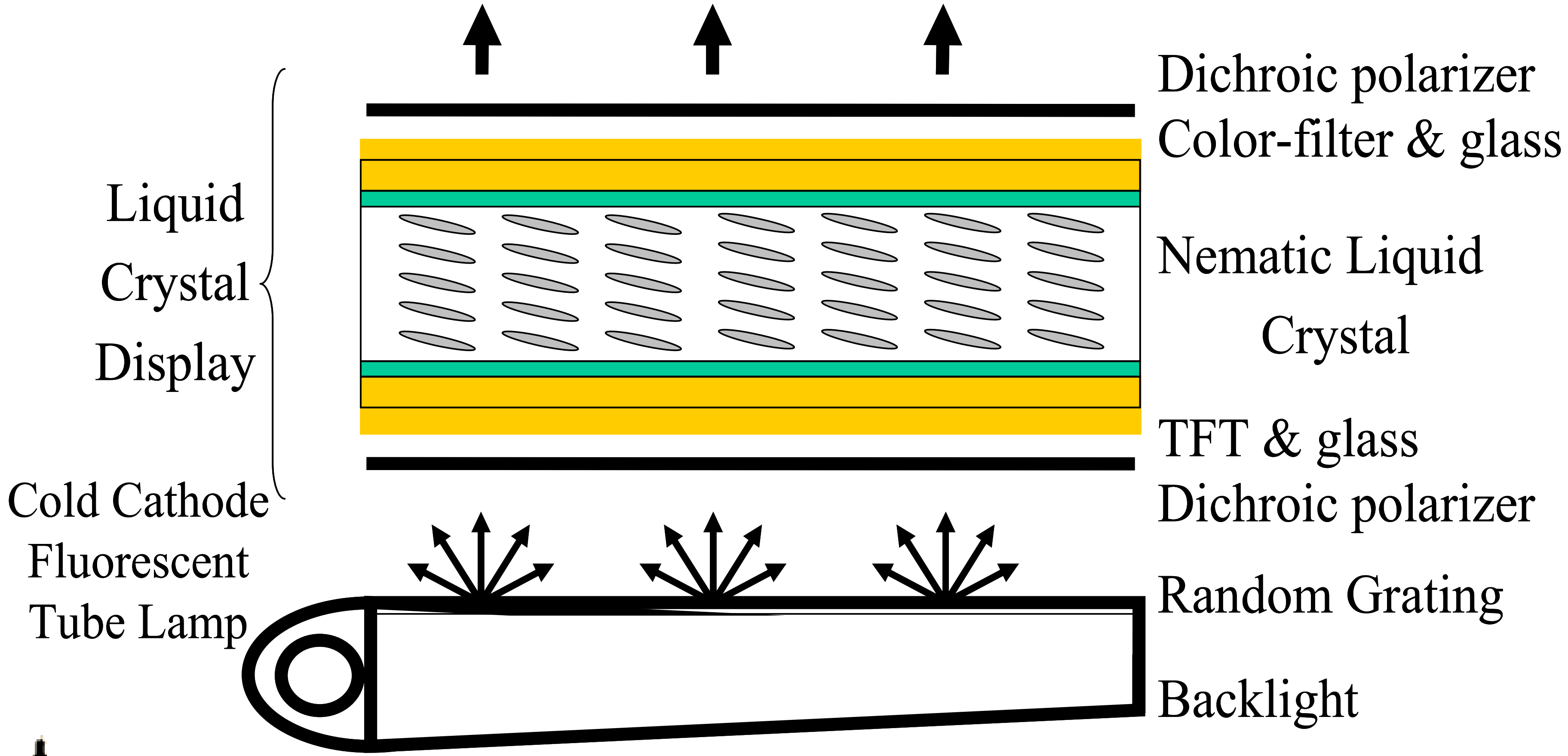
Outline

1. Standard backlight design for LCDs
2. Backlight requirements
3. LCD backlighting with LEDs
4. Work at UCL
5. Ray tracing modelling of the colour separating backlight
6. Conclusion

1. Standard backlight design for LCDs

Conventional LCD backlight structure



2. Backlight requirements

- Wider LCD viewing angle or narrow viewing angle
- Higher LCD contrast ratio
- Improved conversion efficiency of light generated to light emitted from the front of the display towards the viewer
- Ideally no polarizers or colour filters which absorb a lot of light
- Lower electrical power consumption
- Thin, flat, lightweight and small size light source, e.g. LED with backlight
- Good uniformity and high brightness
- Better colour gamut on CIE diagram by adopting three wavelength light sources
- Easy to fabricate

3. LCD backlighting with LEDs

LCD backlighting with LEDs

- **Advantages of LEDs for backlighting:**
- long life time
- no mercury
- low operation voltage

Edge--lit backlighting

–**Luxeon LEDstrip (1W)**	**3300 lm/m^2**
–**CCFL**	**750 lm/m^2**

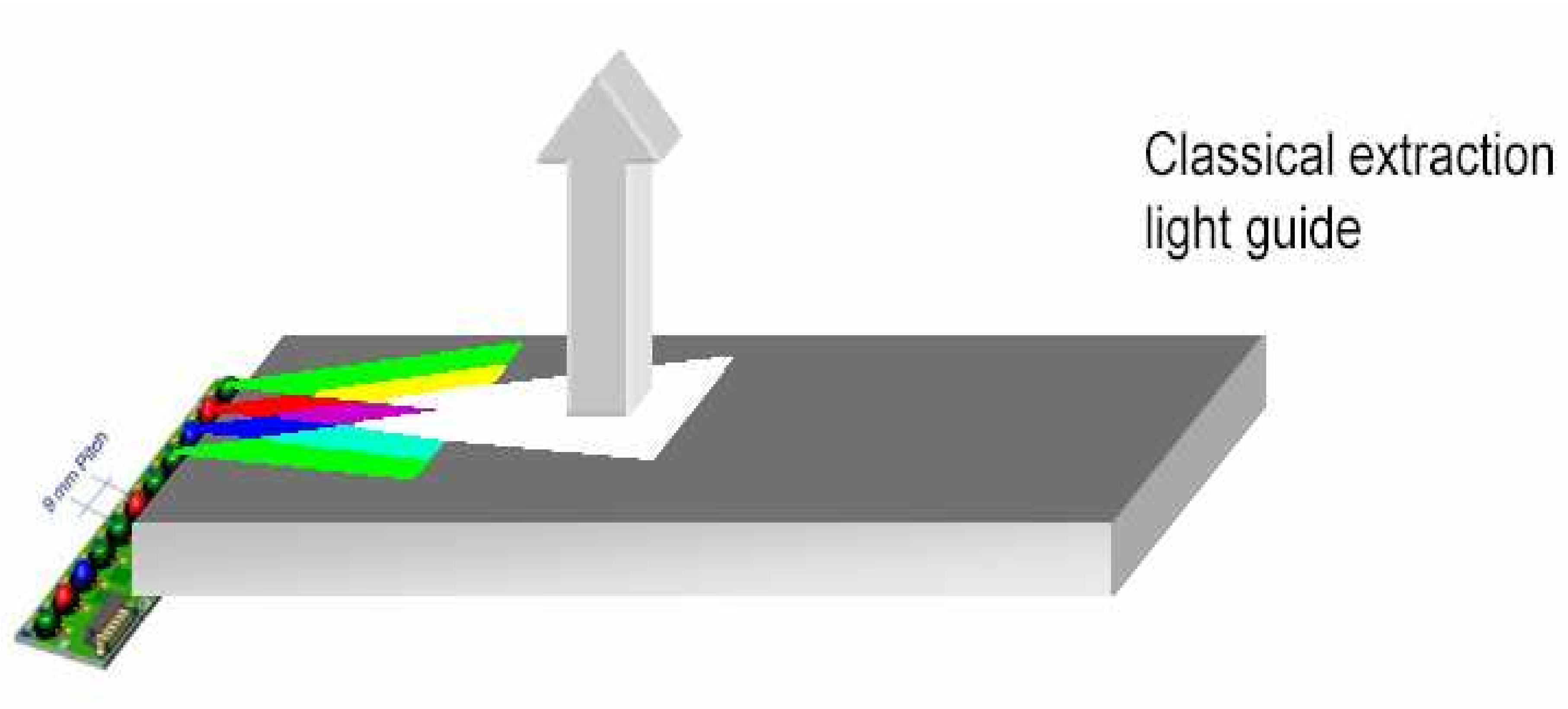
***Note: data from Lumileds: High--efficiency slim LED backlight system with mixing light guide**

White LED backlights

- LCD Module with Light Guide and White LEDs
- OEM for light guide panel
- For small-size LCD panels such as PDAs, cell phones, MP3 players

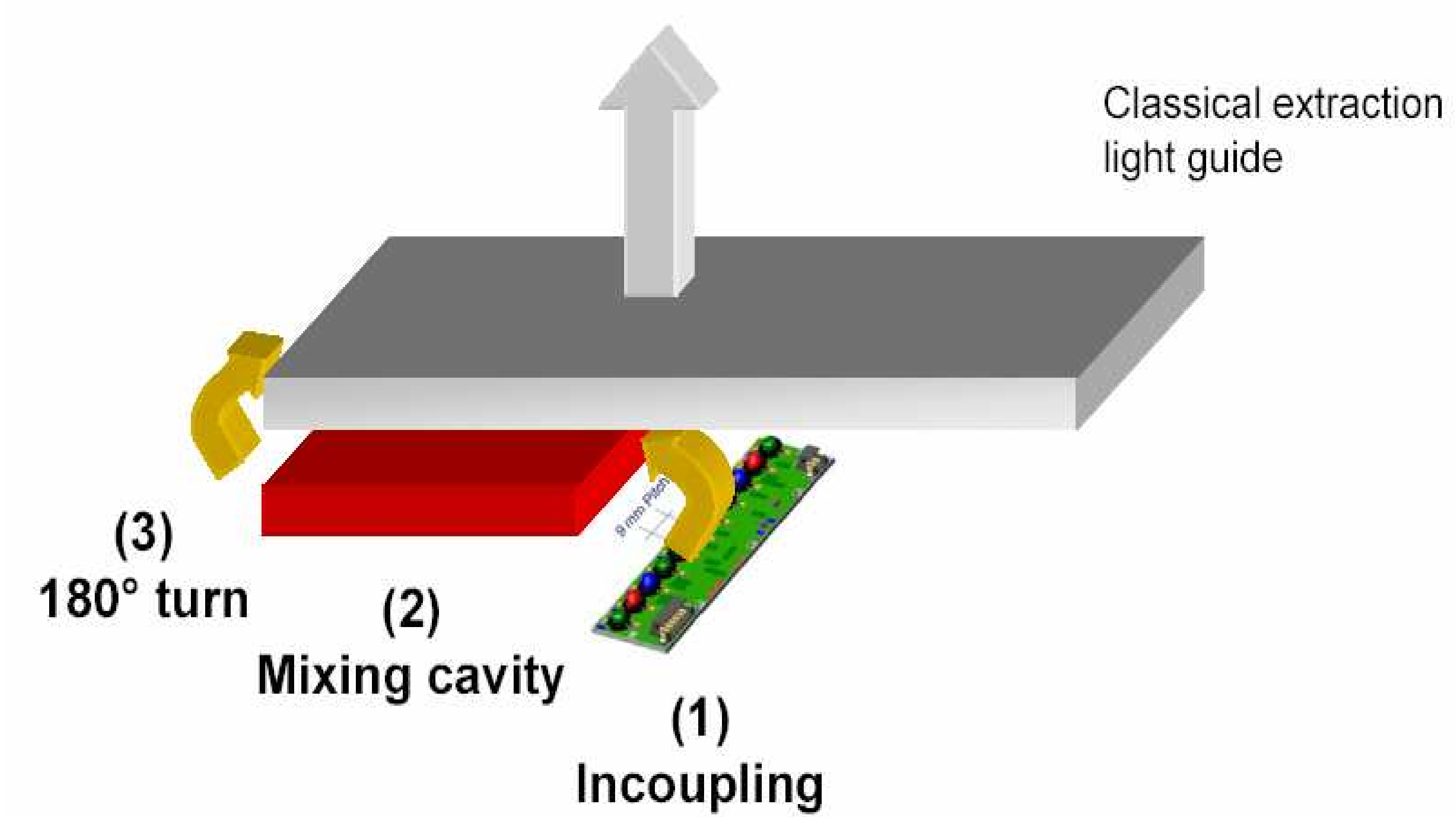
provide courtesy of
Taiwan Oasis Technology Co Ltd ,
Taiwan

Backlight configuration



provide courtesy of Lumileds

Backlight configuration: Mixing panel + 180° turn



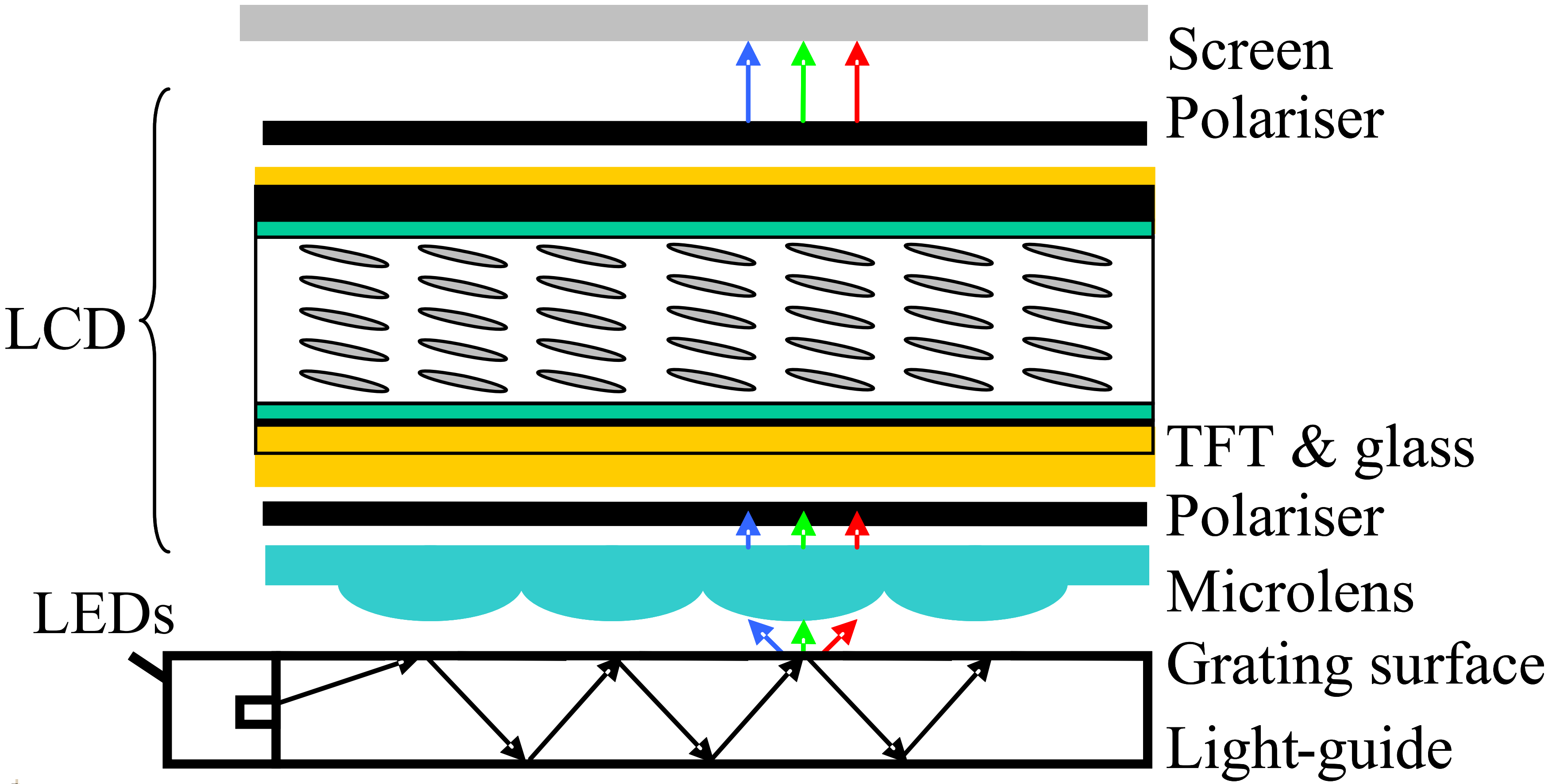
provide courtesy of Lumileds

4. Work at UCL

Work at UCL

- Liquid Crystal Displays (LCDs) require an advanced illumination system to give high contrast and power efficiency.
- The objective is to design a power efficient backlight which collimates light rays normal to the display.
- Using the novel backlight design, LCDs avoid the high cost and loss of colour filters.
- Non-sequential ray trace modelling is a potential tool for the design of the total internal reflection (TIR) backlight.

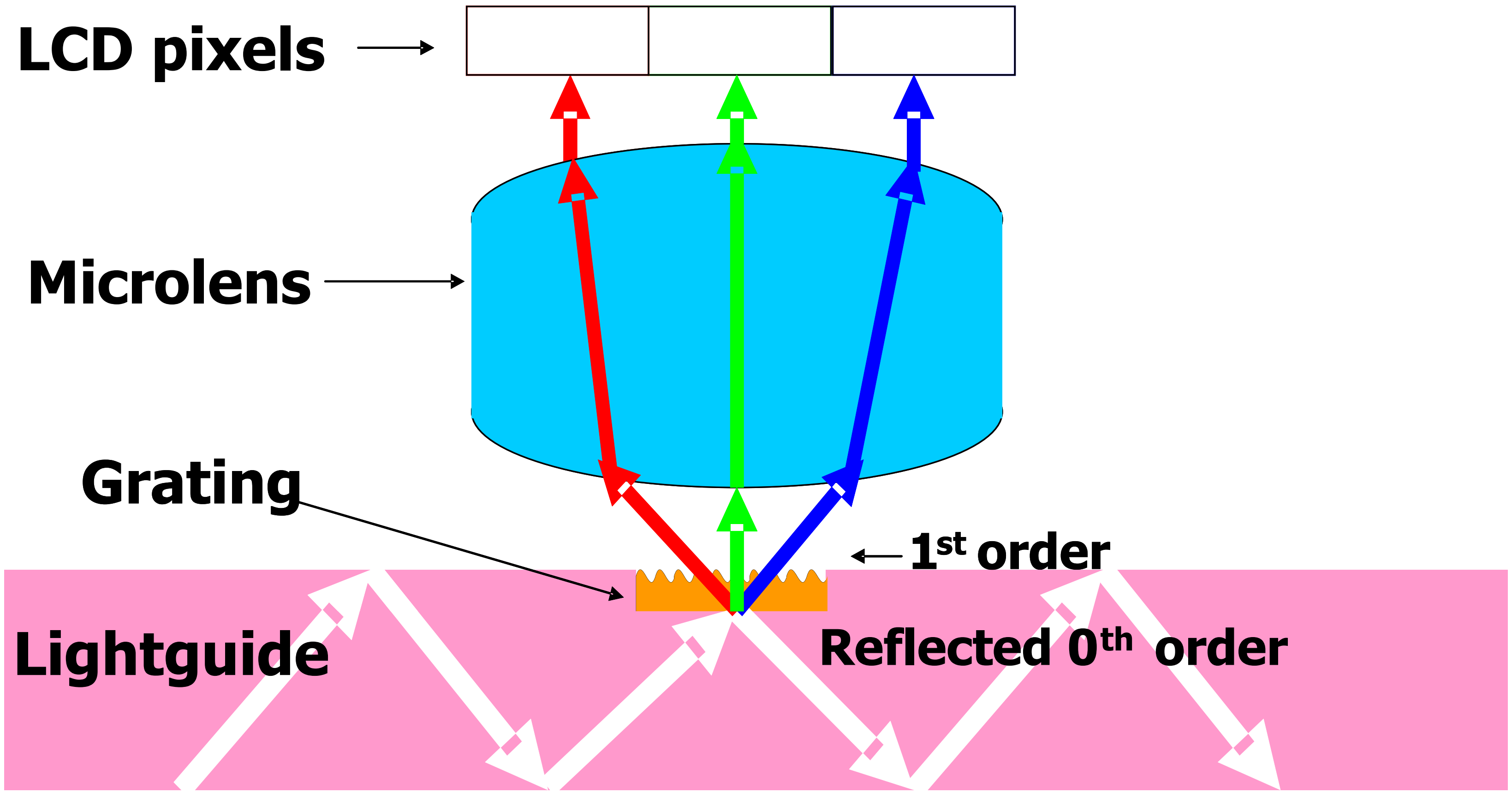
Work at UCL (cont.)



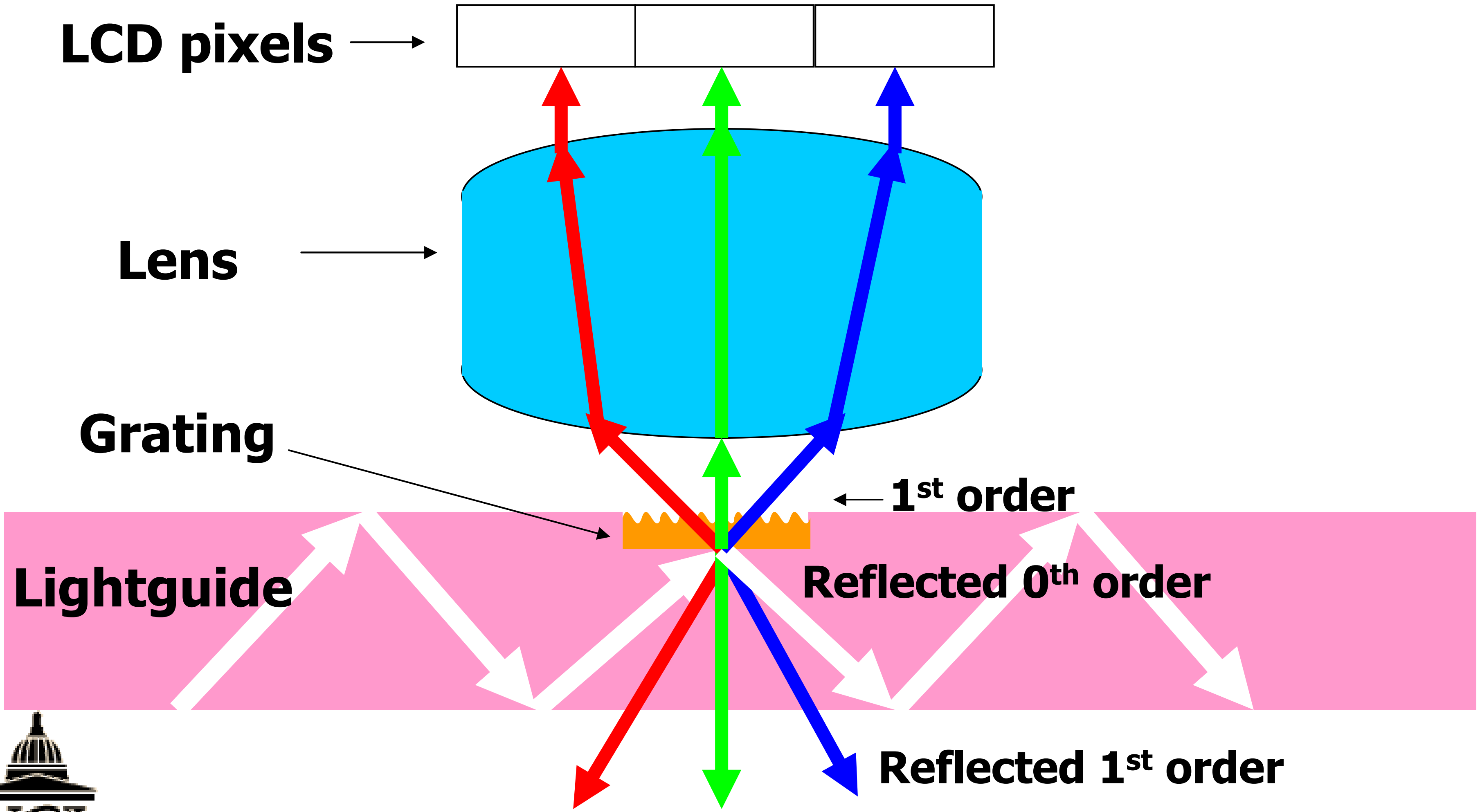
Introduction

- 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
- The authors thank Adrian Geisow from HP for helpful theoretical discussions on Holographic grating and Niall Gallen from Screen Technology for discussions on Ray Tracing modelling.

Advanced ideal backlight illumination system

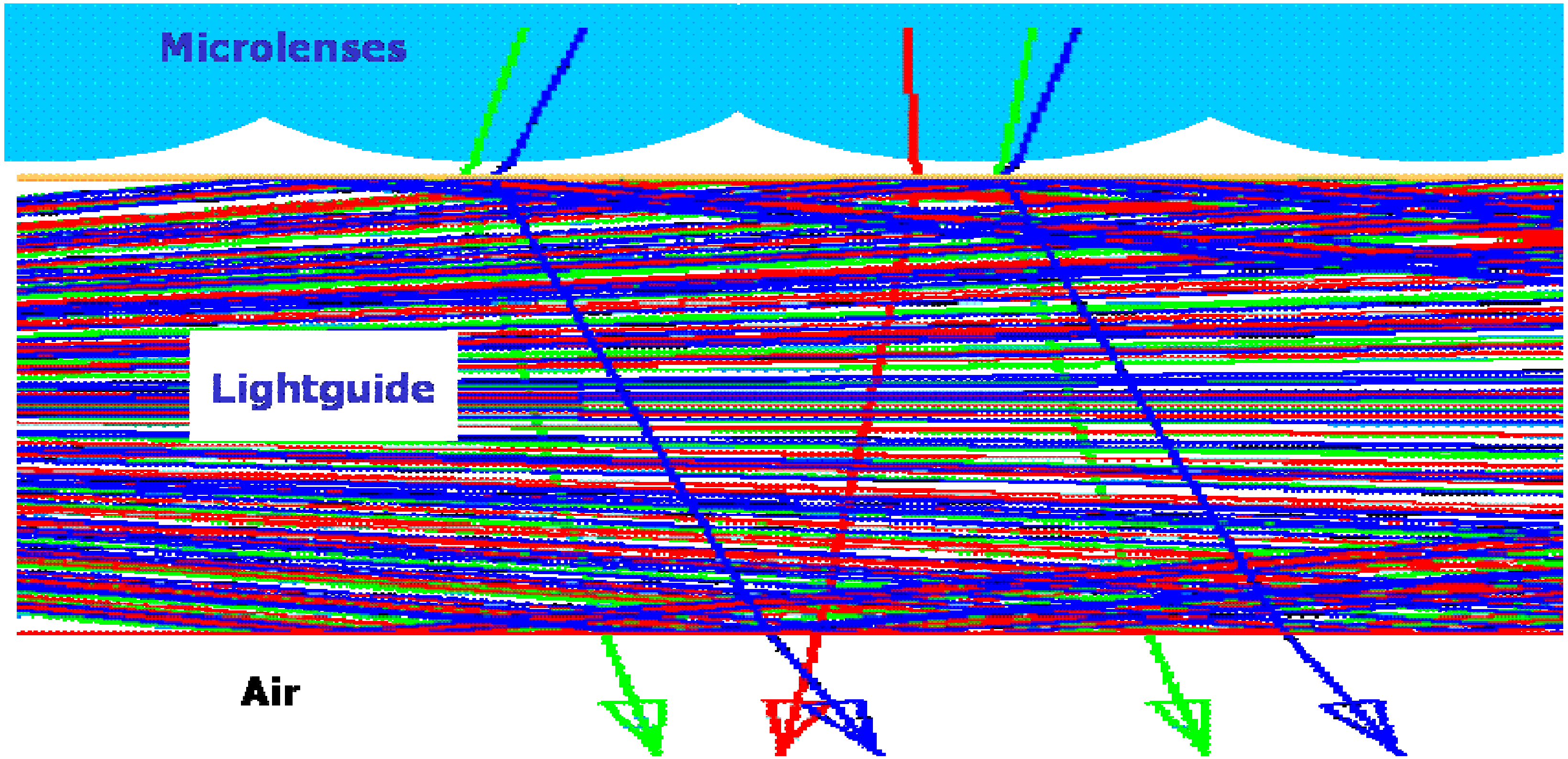


Backlight illumination system with reflected diffraction orders

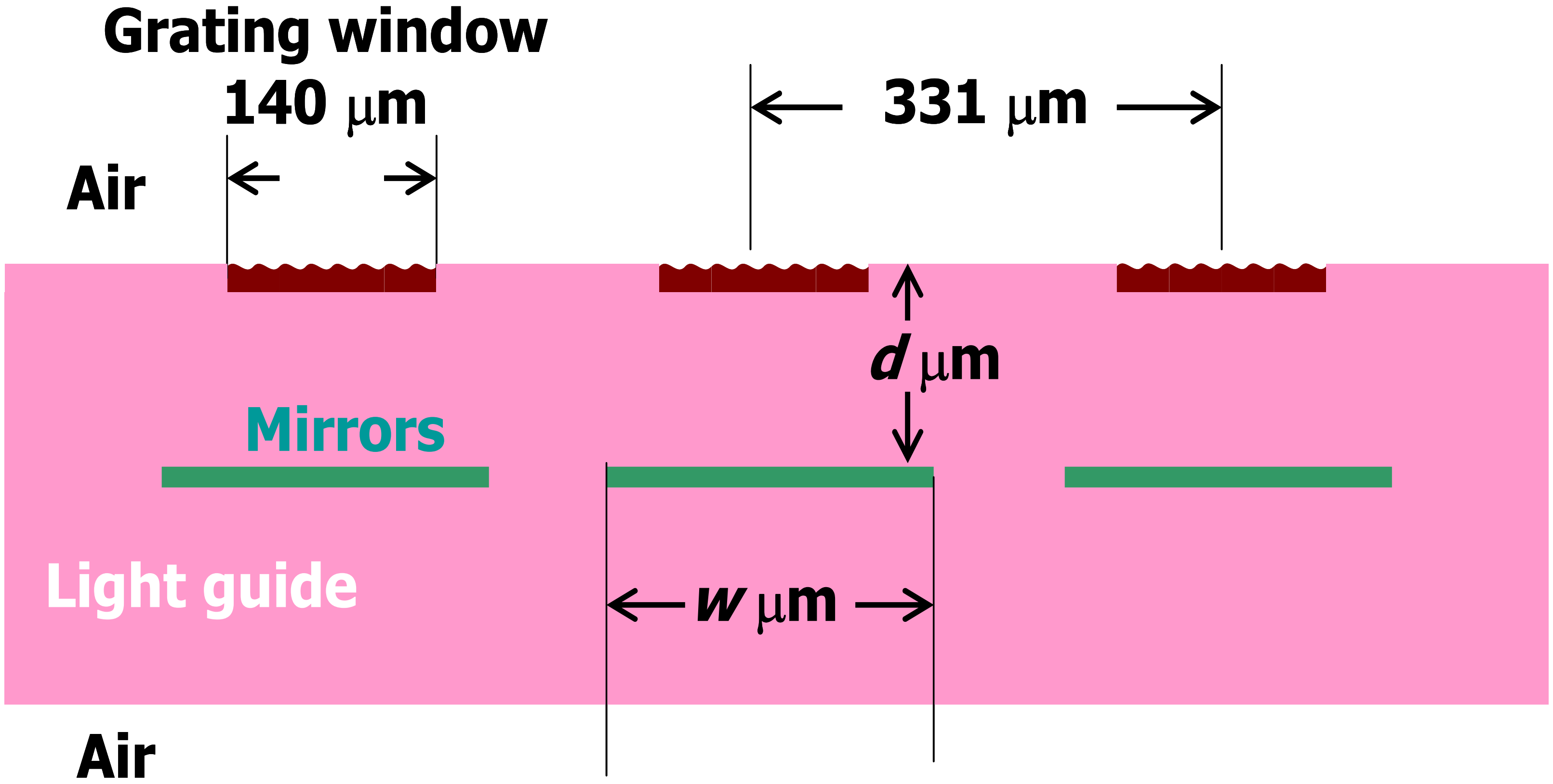


5. Ray tracing modelling of the colour separating backlight

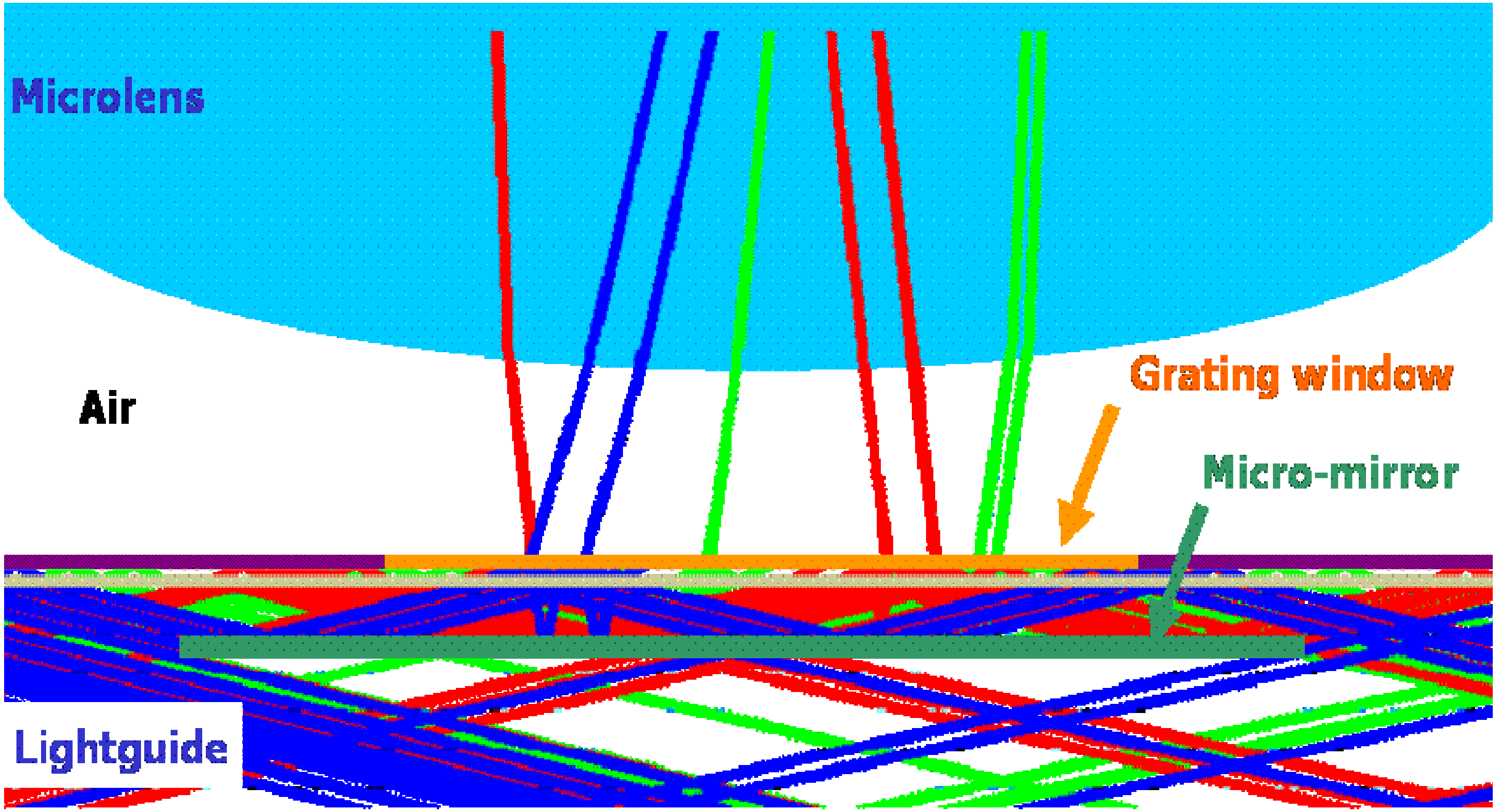
Multimode lightguide with diffraction gratings



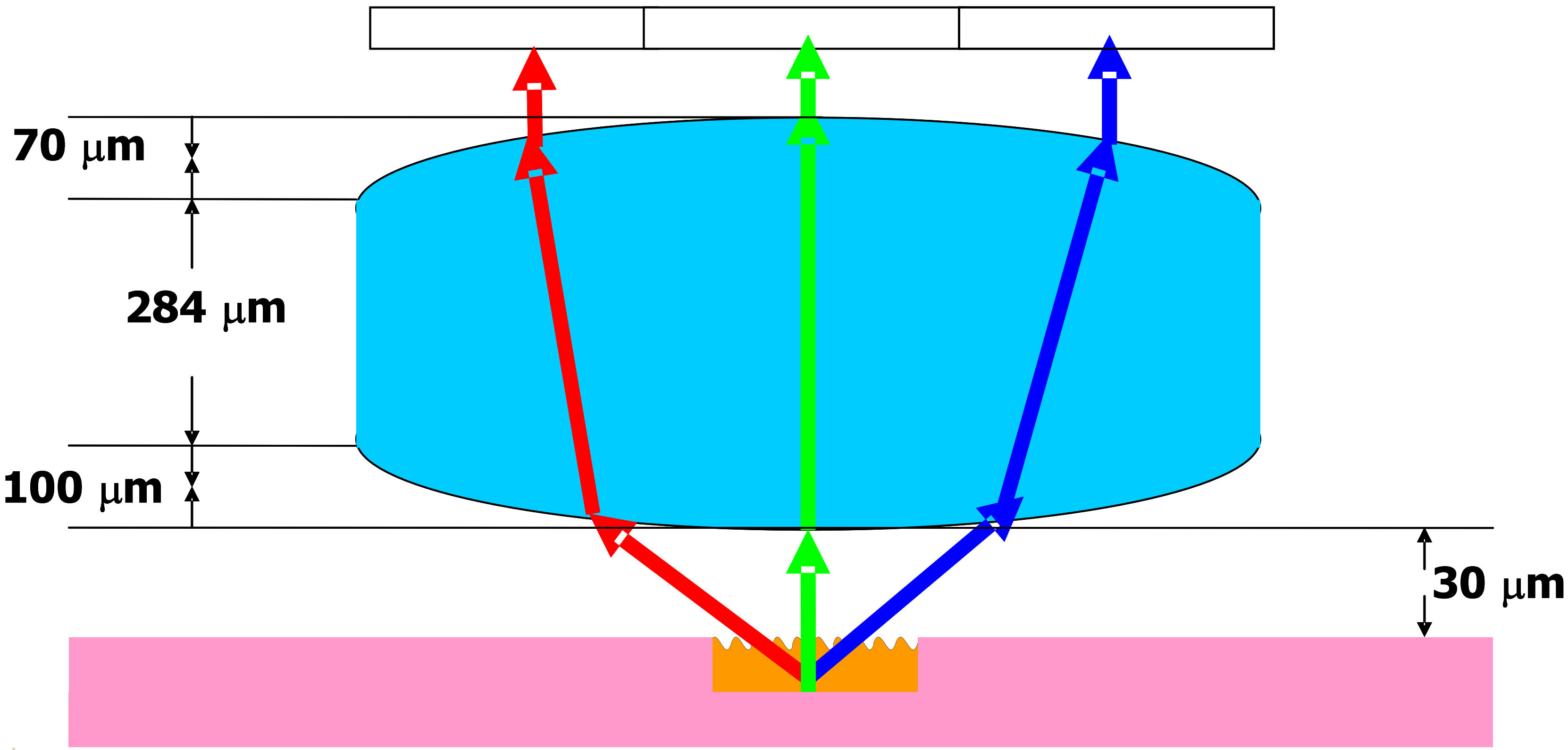
Position and width of micro-mirror array



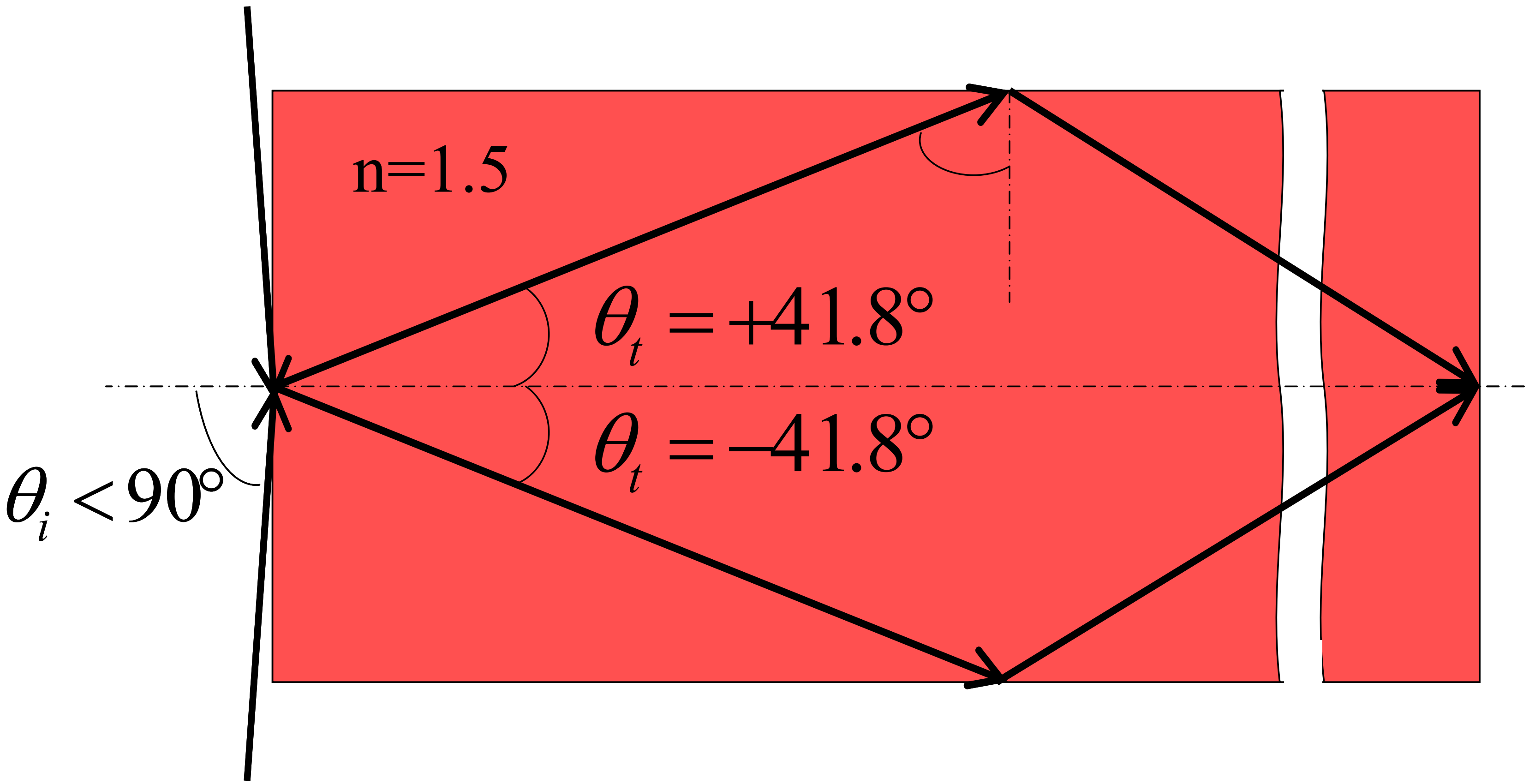
Lightguide structure with internal mirror



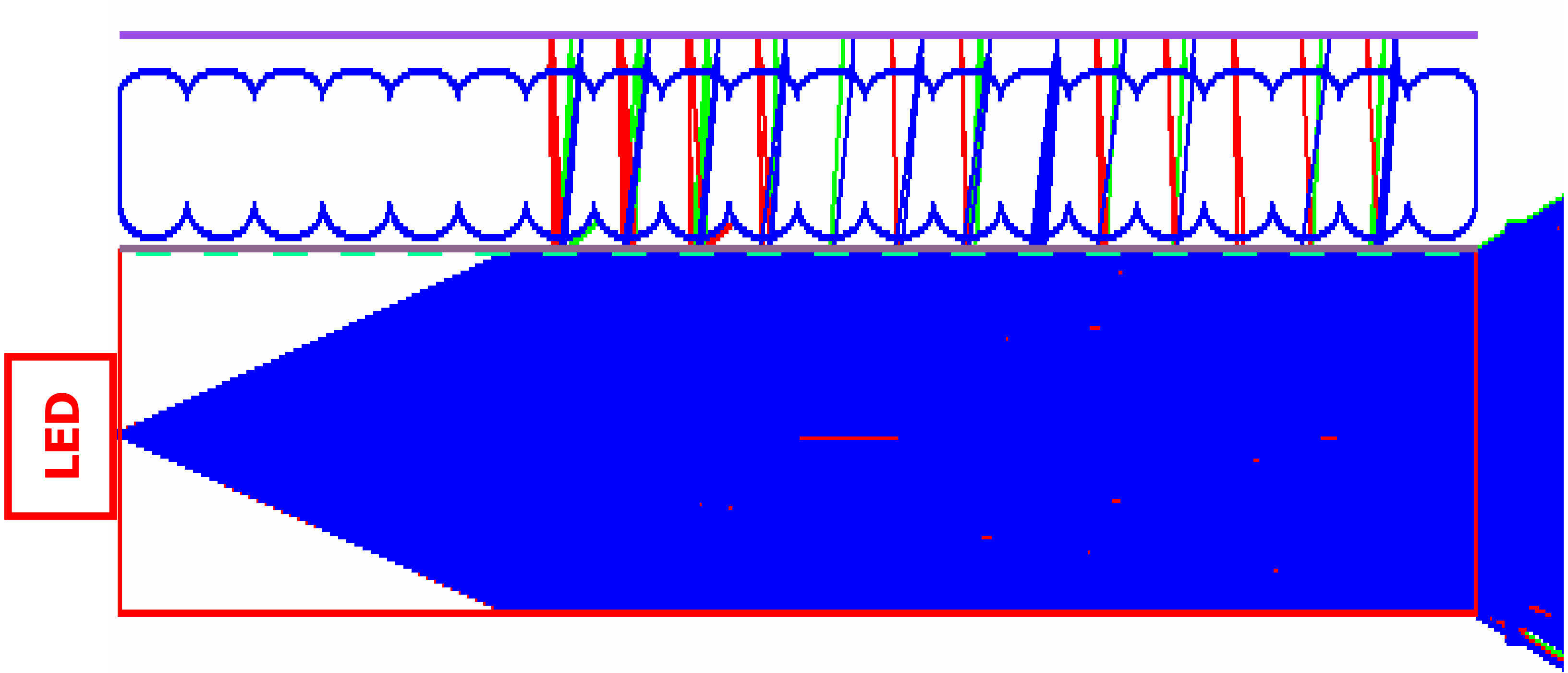
Cylindrical microlens



Total Internal Reflection (TIR) Lightguide

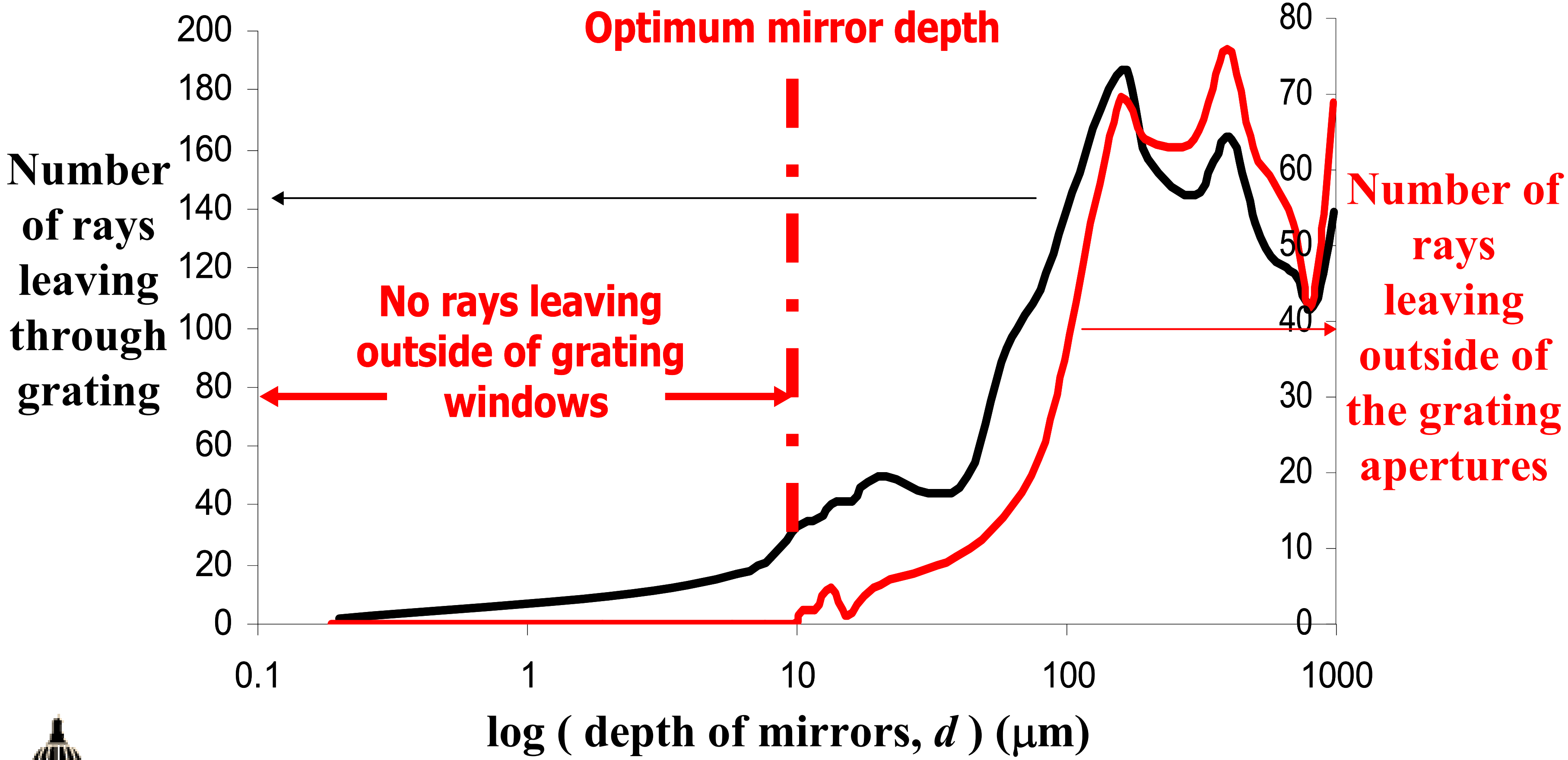


Illumination system with embedded mirrors

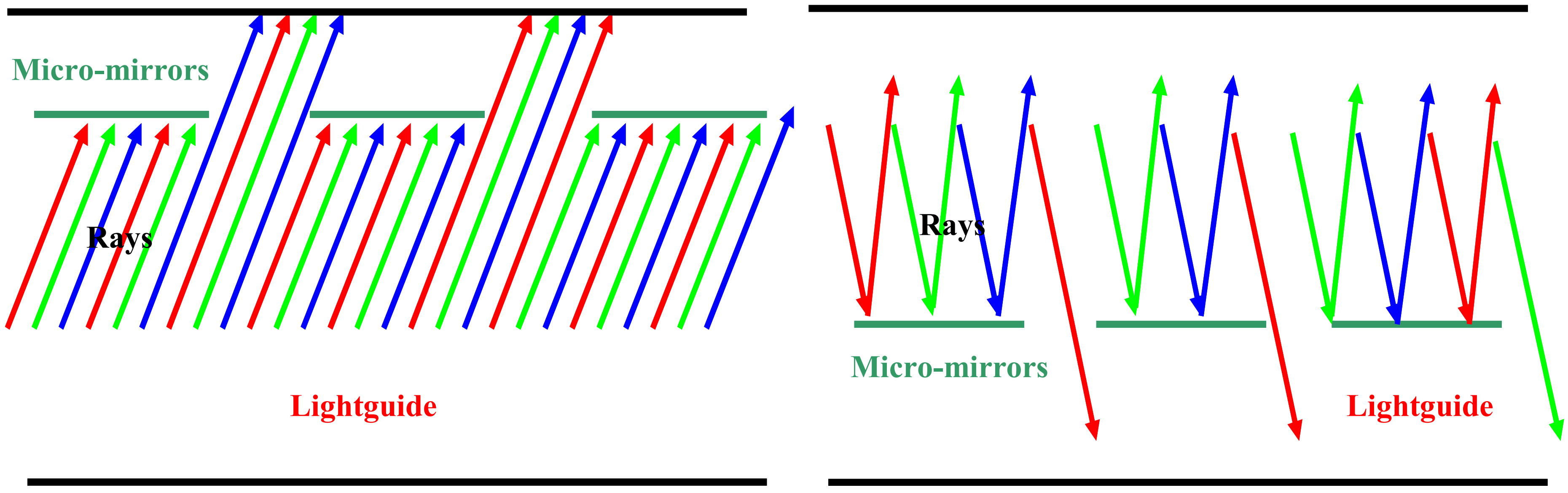


Mirror position, *d* : 10 μm to lightguide upper surface
Mirror Width, *w* : 160 μm

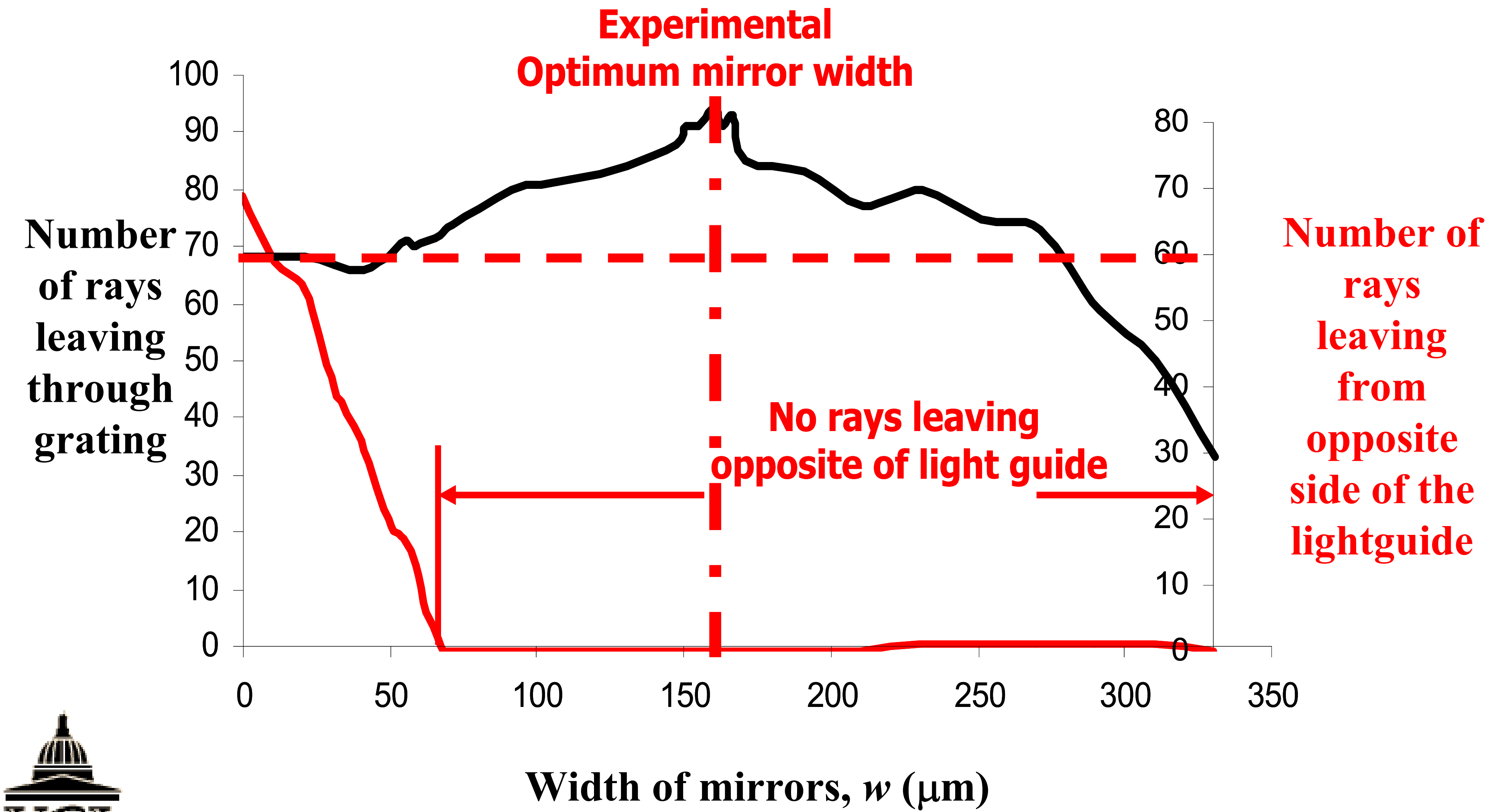
To establish the optimum depth of the micro-mirror array



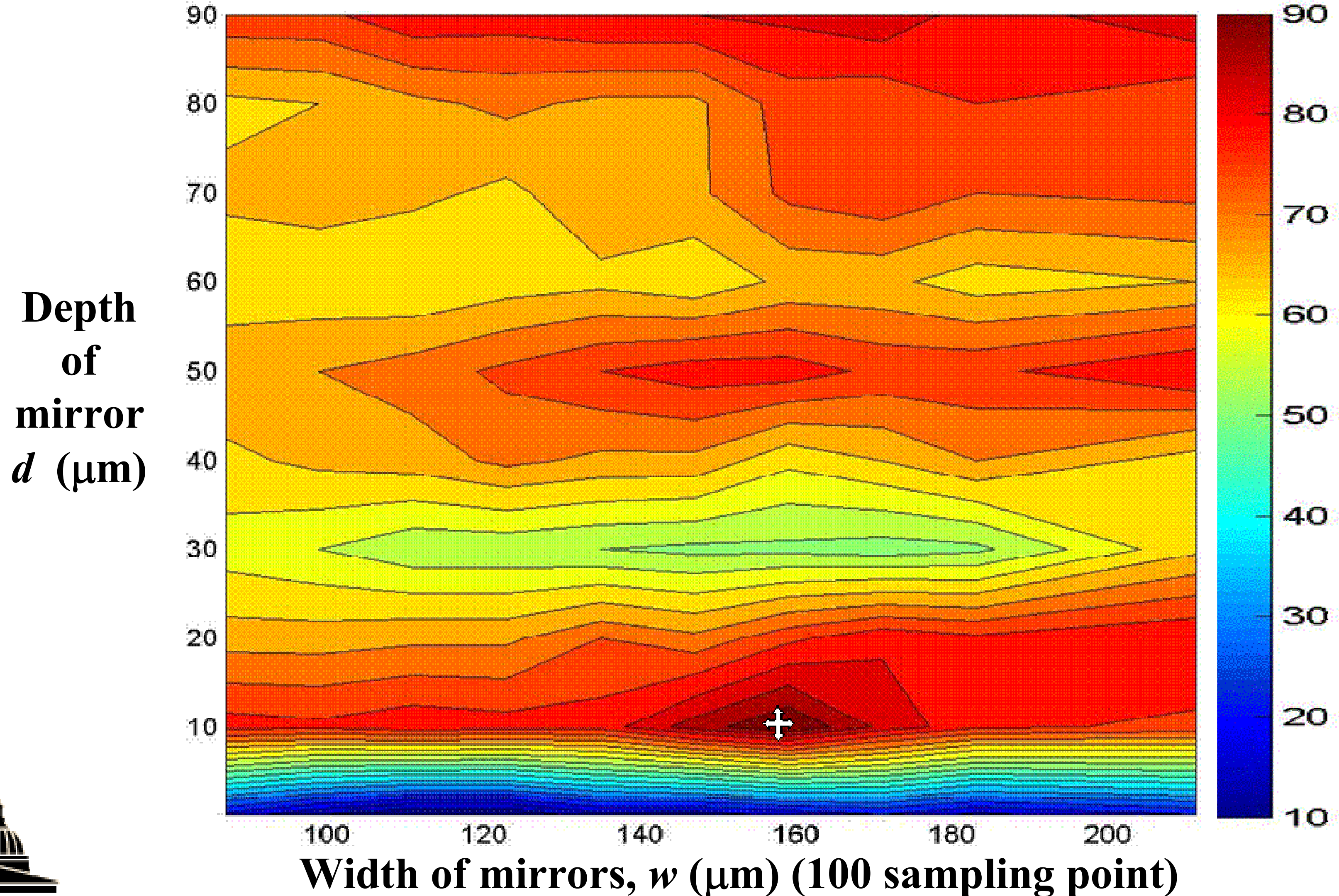
To establish the optimum width of the micro-mirror array



To establish the optimum width of the micro-mirror array (cont.)



Micro-mirror depth/width coupling



Conclusions

- A thin, efficient backlight illumination system was modelled and designed which did not require the usual power absorbing colour filters.
- A micro-mirror array layer inside the multimode lightguide reduces the light lost from the opposite side of lightguide improving light intensity by 38.2%
- A microlens system was designed to collimate and to direct the light normal to the display for optimum contrast.
- Periodic, limited length, discrete gratings are used instead of a continuous grating surface. It also allows us to control the strength of each grating window individually to obtain better uniformity.