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heynen

Implementation of light into product designs - The benefits and how to get there

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Topics

- The opportunities and benefits of implementing light designs
  - What kind of effects can be achieved and what is the impact on the user?
- How to implement the light design
  - Set-Up of light module
  - Definition of light requirements
  - Prediction of required luminance intensity
  - Rough estimation of the efficiency of the Set-Up
  - Light guide designs and application examples

Light in the product ...

... allows orientation

... creates atmosphere

... creates moods

... gives security

... offers comfort

... sets accents

... makes the invisible visible

... creates individuality

... provides information

... promotes interaction

... enables communication

... shapes identity

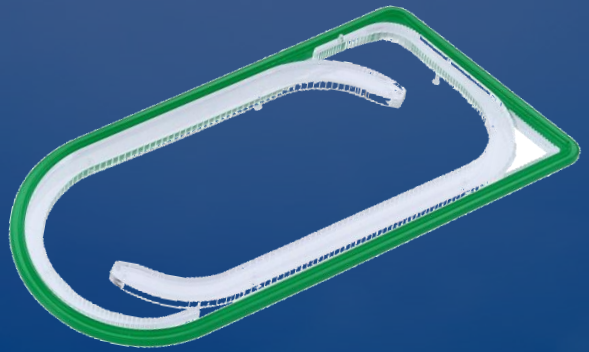
... generates emotions

...

Light creates orientation

Light module gives orientation only at night. A brightness and proximity sensor provides the cleverness to the module.

Light provides information



Cook-Key Module connects via WiFi with the Vorwerk Cloud and downloads recipes.
Status of WiFi Connection is indicated by a green light flashing.

Light enables interactions

Light provides information about the status of the Module.
Via touch on one of the two surfaces, the module controls a water treatment system.

Blue light idicates cooled water

Green light indicates sparkling water

Light creates individuality

By selecting a color, the preference of the customer can be adjusted individually.

Additionally, moods can be created by choosing a Color.
e.g. Green for calming down after a stressful day in the office.

Light supports corporate identity

How to implement light designs?

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One Possible Set-Up

Diffusing Component
light smoothing

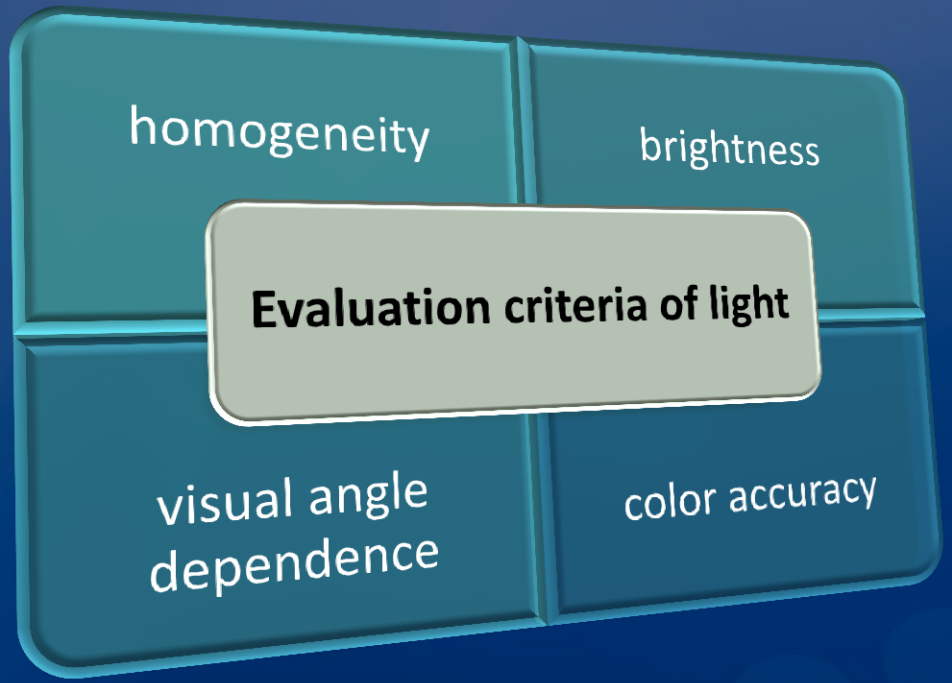
Housing
Mounting all components to each other

Lightguide
transparent plastic which transports the light to intended surface

Reflective Component
increasing efficiency of the module

Light Source
e.g. RGB-LED

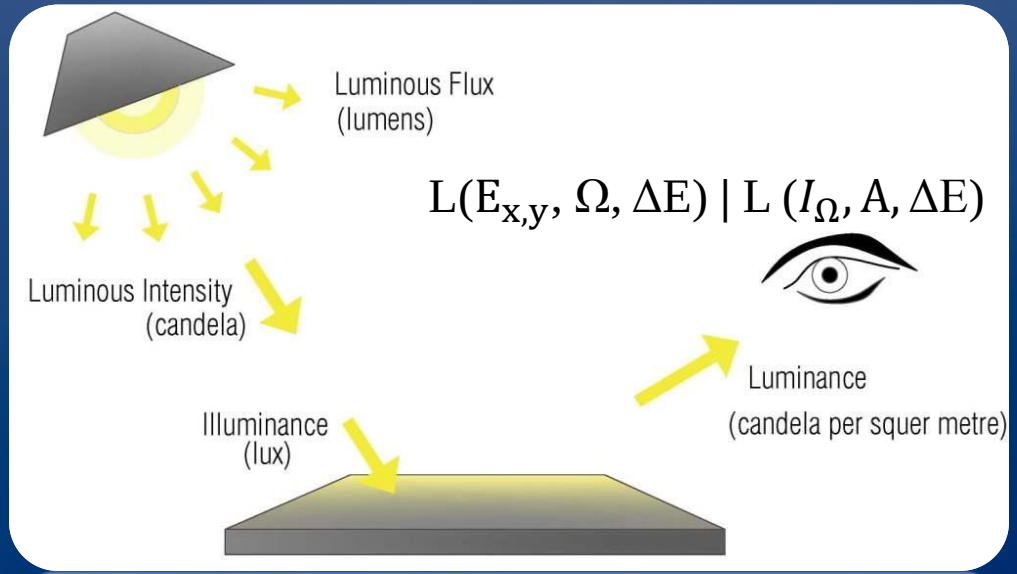
How does one evaluate light?



The Human Eye perceives the Luminance L. The luminance represents a illuminance E which is emitted into a certain viewing angle Ω. Alternative it can be described by the luminous intensity I which is emitted from a certain surface A

The Luminance can be separated in contrast to the position on the light emitting surface $\mathrm{x,y}$ and the color accuracy $\Delta\mathrm{E} \rightarrow \mathrm{L}(E_{x,y}, \Omega, \Delta\mathrm{E}) = \mathrm{L}\,(I_{\Omega}, \mathrm{A}, \Delta\mathrm{E})$

How does one evaluate light?



Defining the desired luminance requires to know the illuminance on the surface, the color coordinate and the viewing angle.

If the luminace shall be equal for all viewing angles, one might estimate the required luminous intensity for the light source by the following equation:

$$\boxed{I = L \cdot A}$$

Example for calculating the required luminance intensity

Size of a surface which shall be illuminated homgenously:

A = 5mm x 100mm

Required luminance (for an office light application):

L_{Target} = 300cd/m²

Result for applying the equation $I_{Target} = L_{Target} \bullet A$

I_{Target} = 150mcd

Typical luminance intensity for a RGB-LED

ASMB-MTB0-0A3A2

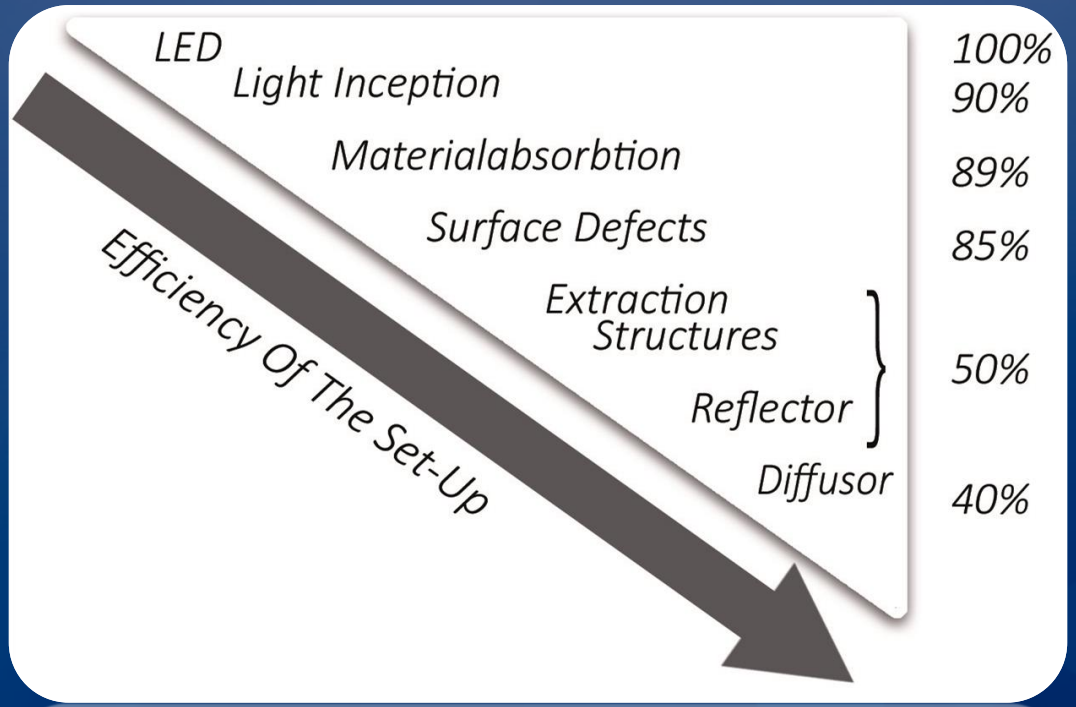
PLCC-4 Tricolor Black Surface LED

AVAGO TECHNOLOGIES

Color	Luminous Intensity, I_V (mcd) @ I_F = 20 mA [1] Min.	Typ.	Max.
Red	450	540	900
Green	1125	1600	2240
Blue	285	350	560

Typical LEDs will suffice if the Set-Up works well!

Estimation of the efficiency of the Set-Up



Conclusion: η ≈ 40%

$$I_{LED} = \frac{I_{Target}}{\eta}$$

Luminous Intensity I_{LED} ≈ 375mcd

Lightguide Design

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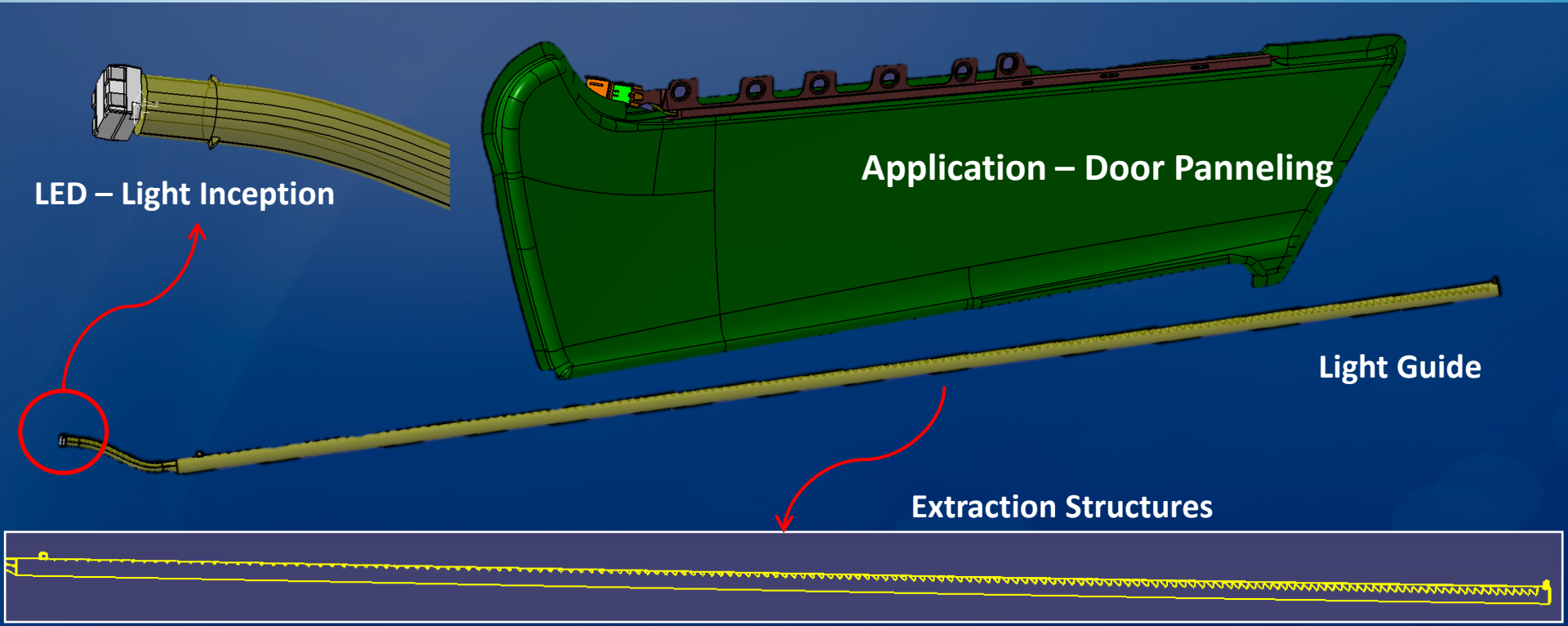
Input Parameters for Optical Design Algorithm

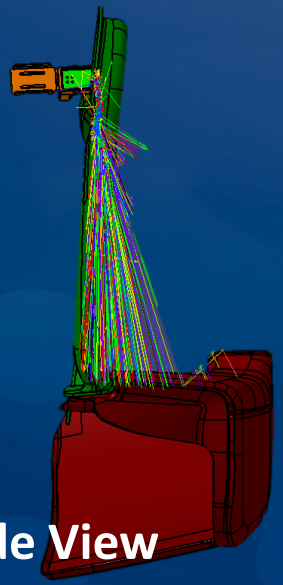
- Ray-File of the LED → Flux, Color, Intensity, etc.
- Material → transparency / absorption / reflection, surfaces, etc.
- Light extraction geometries → geometrical shape, surfaces, distribution, etc.
- Illuminance target value → target area, contrast, brightness, color, etc.
- Validation of optimization → defining luminance camera, viewing angle, etc.

Lightguide Design – Example – Door Pannel

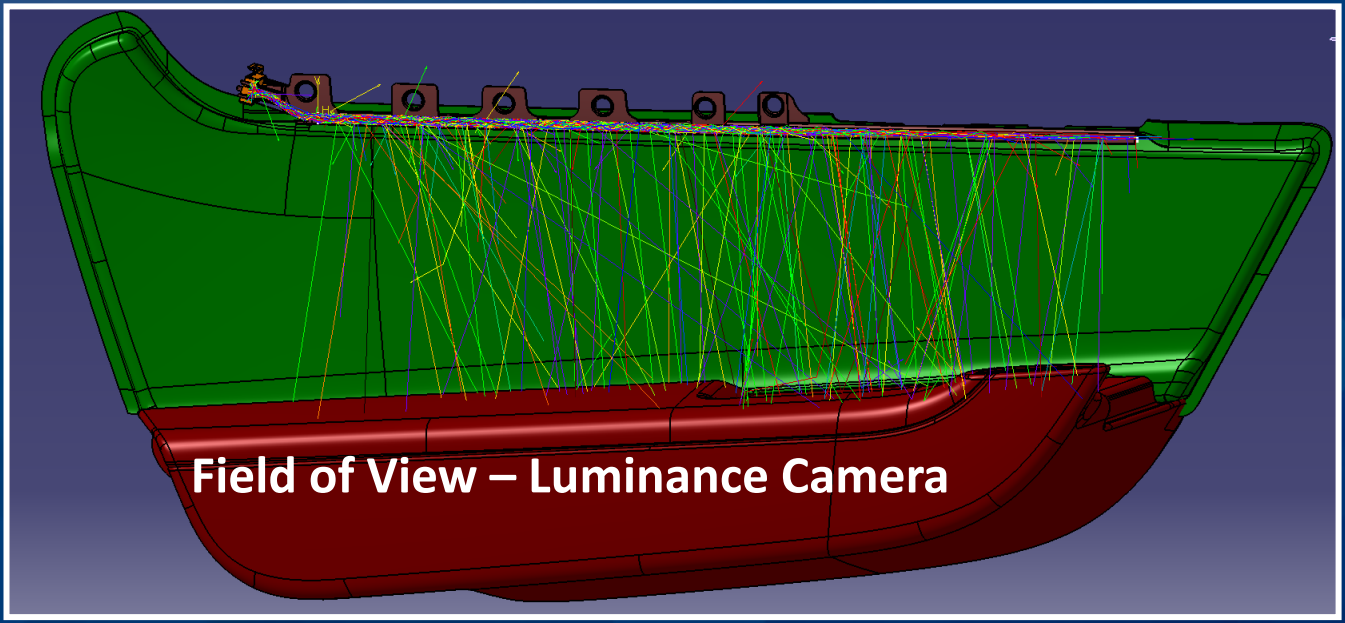


Lightguide Design – Simulation

Light Simulations – Showing Ray-Tracing

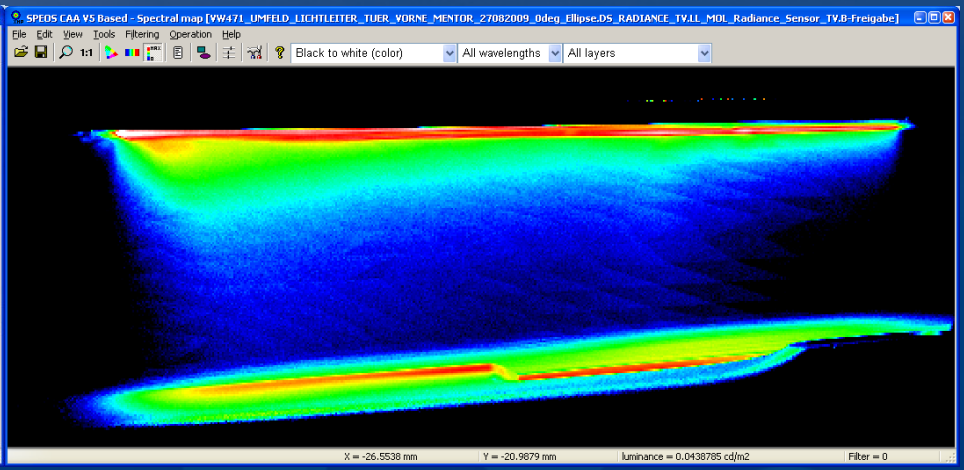


Side View

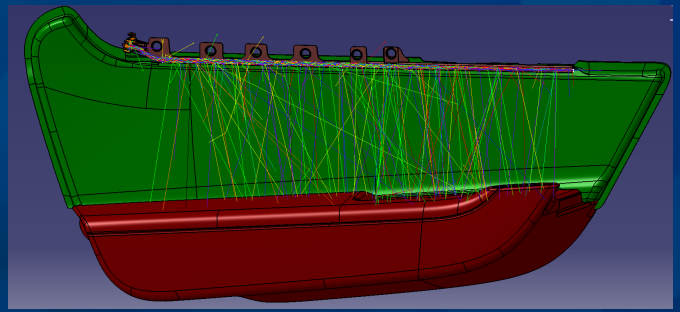


Field of View – Luminance Camera

Light Guide Design - Simulation - Results



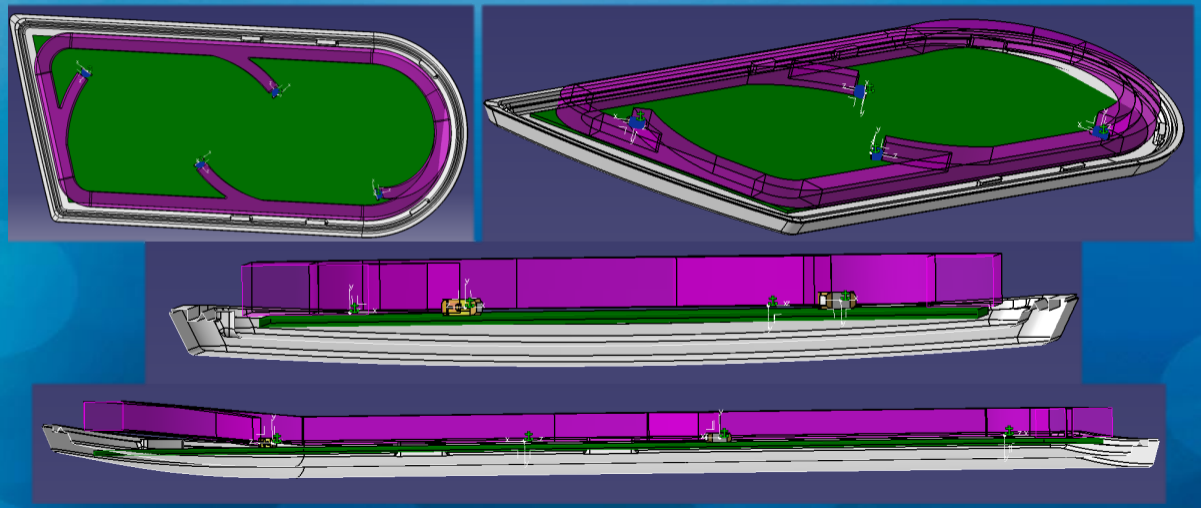
Real Color Presentation



False Color Presentation

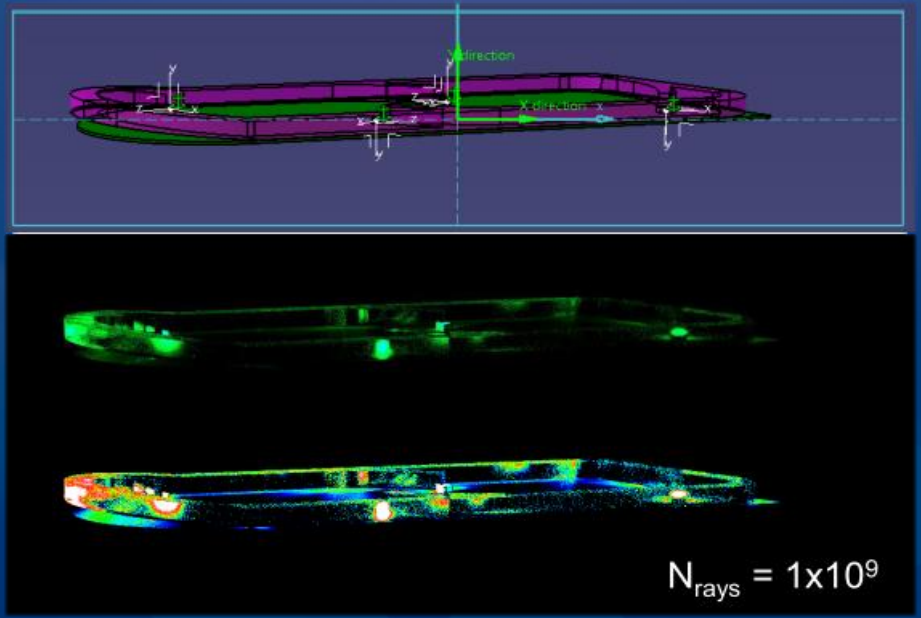
Light Guide Design – Example - Cook-Key

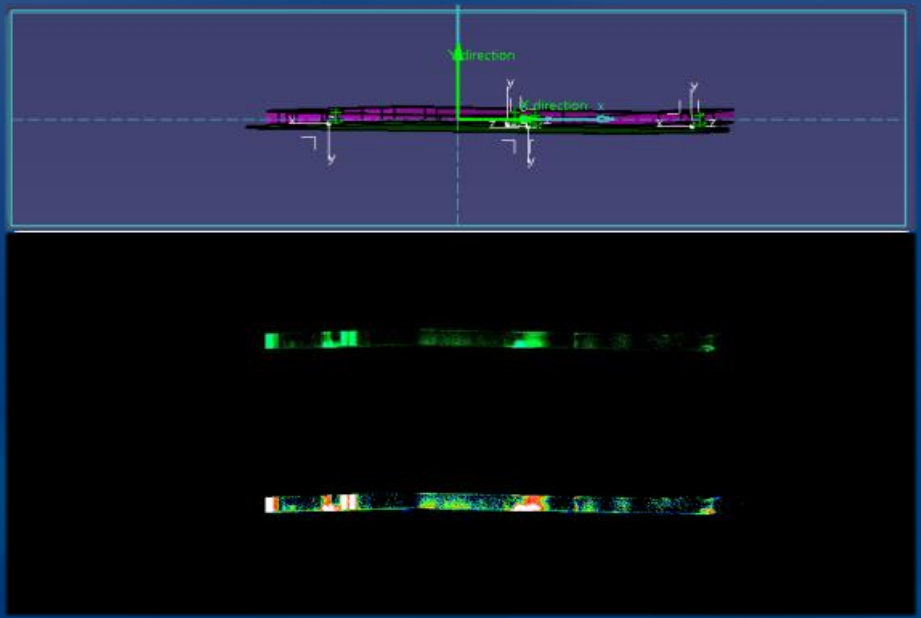
First Set-Up with 4 LEDs and one continous light guide



Light Guide Design – Example Cook Key

Luminance Simulationen of first Set-Up – 4 LEDs



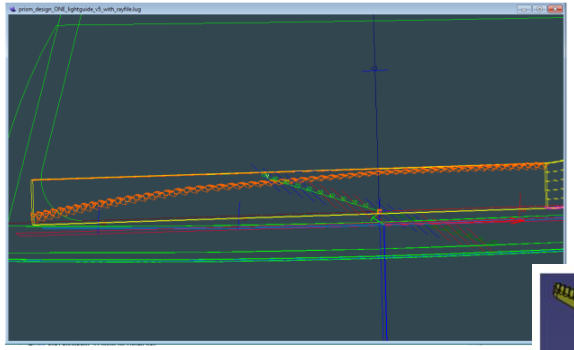


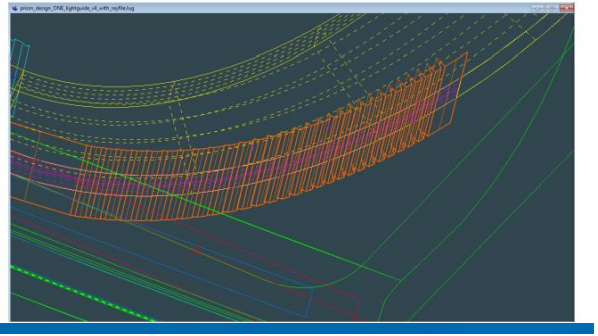
Realisation: 4 LEDs don‘t suffice regarding the contrast

Conclusion: 2 LEDs with more complex light guides

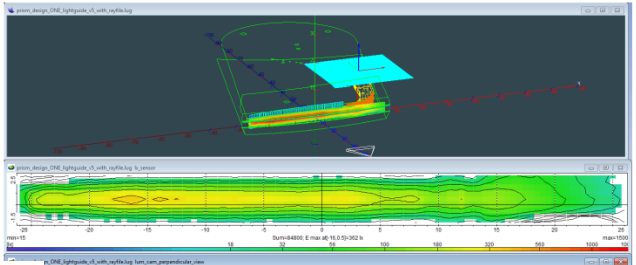
Light Guide Design - Cook-Key

Definition Mikroprisms

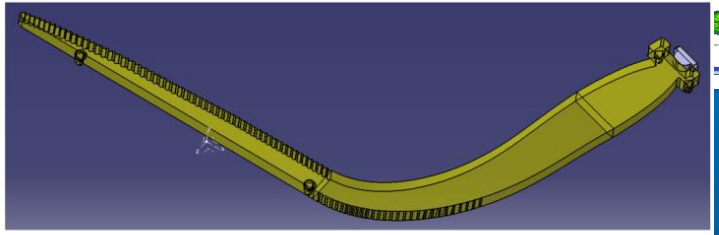


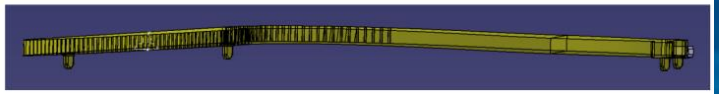


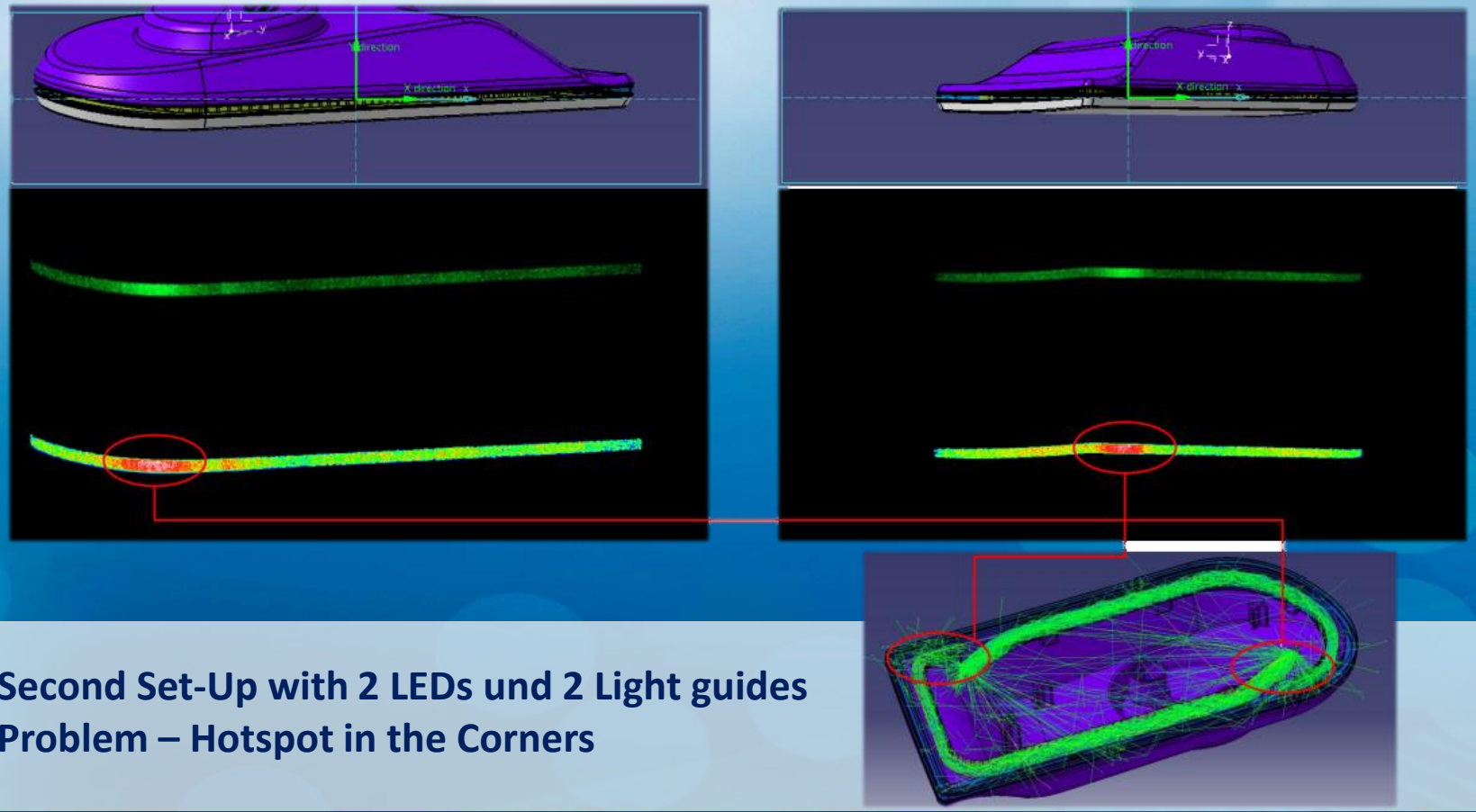
Definition Sensor



Geometry of the Light guide



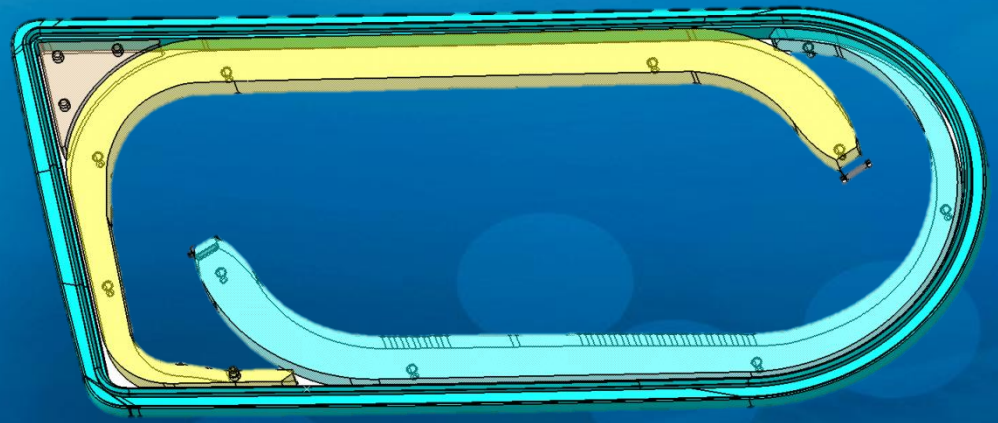




Second Set-Up with 2 LEDs und 2 Light guides
Problem – Hotspot in the Corners

Final Geometry after the Design

Third Light implemented for decreasing the Hot Spot



Thanks for your attention

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