SWTEST

PROBE TODAY, FOR TOMORROW

Smart Cars –
Smart Probe Cards

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T.I.P.S. Messtechnik

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Overview

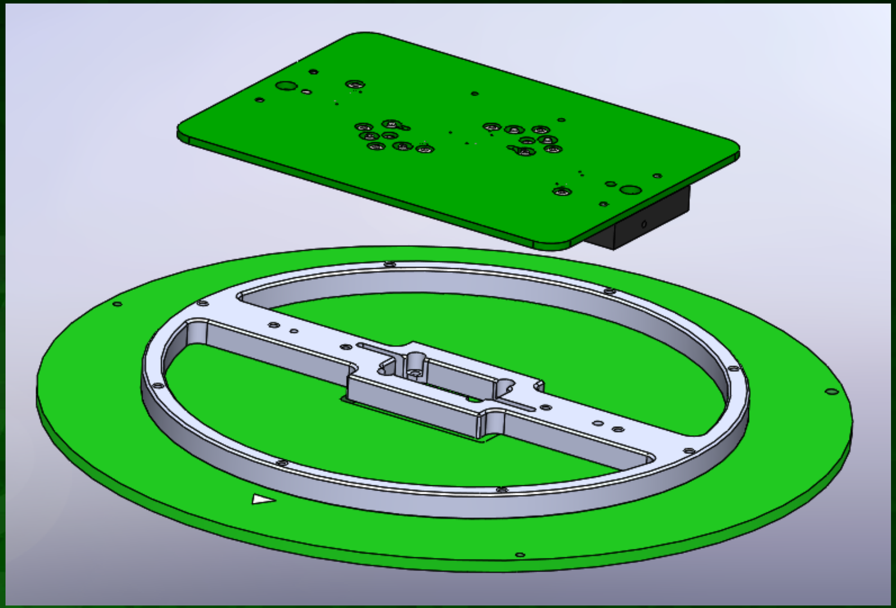
1. Introduction

Ongoing evolution within individual car traffic

- **Further improvement of Advanced Driver Assistance Systems**
  - Compensation/avoidance of human errors that lead to accidents
  - Driver becoming more and more to passengers of autonomous SMART CARS
- **Smart cars need multiple sensors to evaluate the status quo:**
  - Driving condition: Speed, acceleration, steering angle, wheel specific slip, etc.
  - Environment: Obstacles, distance to other cars, course of driving lane, etc.
- **Recent sensor types need additional functional testing, conducted by** SMART PROBE CARDS

2. Smart probe cards

What are the challenges?



- **Additional functional testing besides electrical tests**
  - Stimulation of chip-integrated sensors
  - Examination of micromechanical actuators and sensors
- **Enhancement of standard probe cards by add-on modules to provide this ability**
- **This presentation shows selected developments for the integration of add-on modules for *LiDAR* Systems**

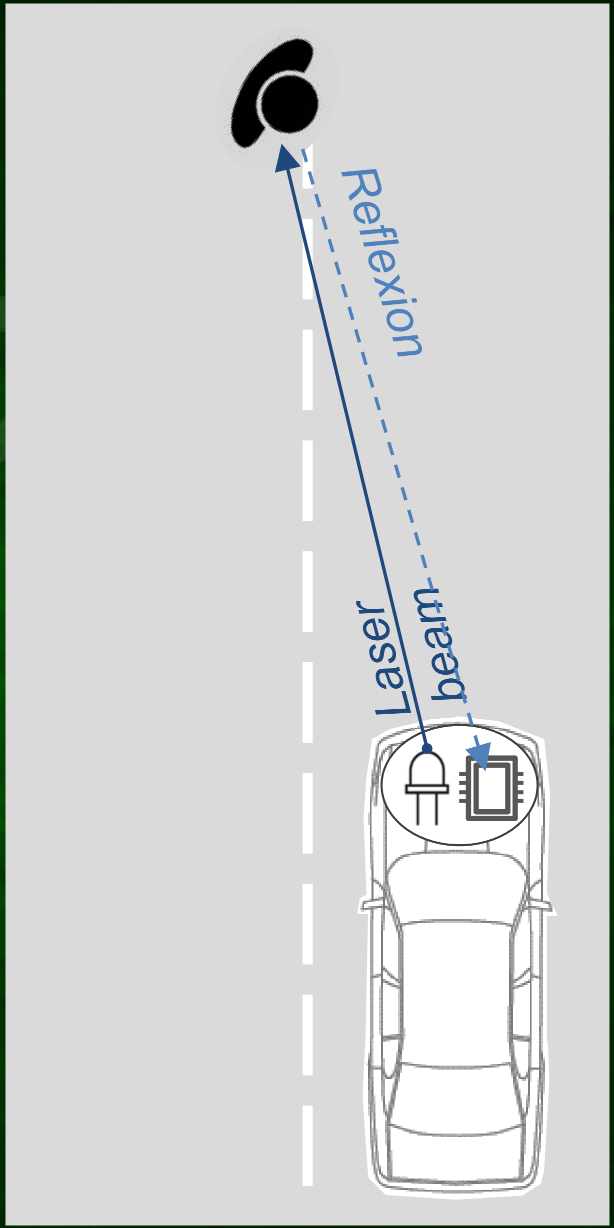
2. Smart Probe Cards

What is LiDAR?

- **Light Detection And Ranging - LiDAR**
  - System for optical distance measurement
  - First used in atmospheric research and meteorology
  - Key technology for autonomous driving

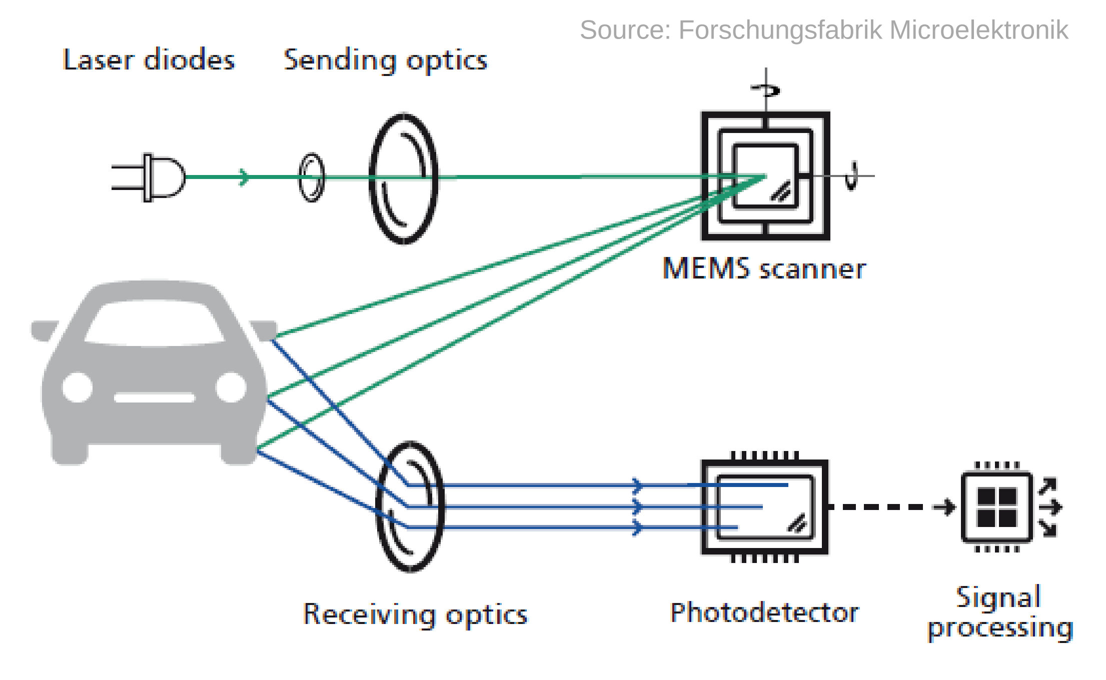
- **Determination of time-of-flight**
  - Light is emitted by the laser source in changing directions
  - This light is reflected by an object and then received by a detector
  - Time delay Δt between emission and receiving determines distance

$$Distance = Speed_{Light} \cdot \frac{\Delta t}{2}$$



2. Smart Probe Cards

Imaging with LiDAR



2. Smart Probe Cards

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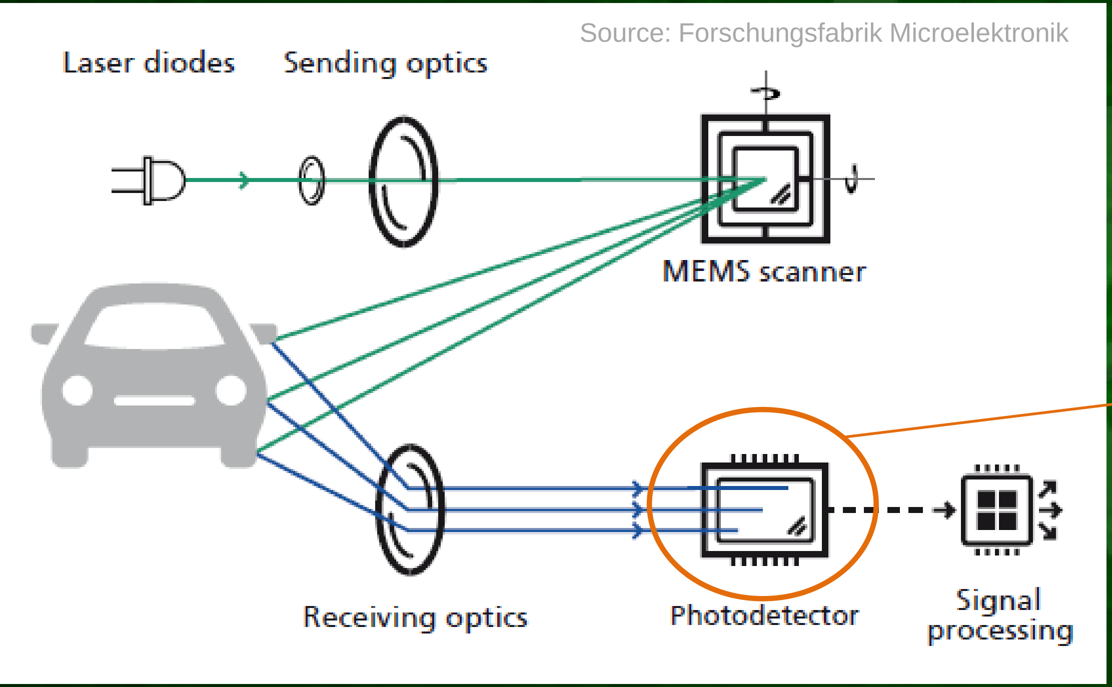


How to probe?

- **Photodetector with 1D/2D pixel array**
  - Stimulus of photodetector chip with ***Illumination field module***

2. Illumination field module

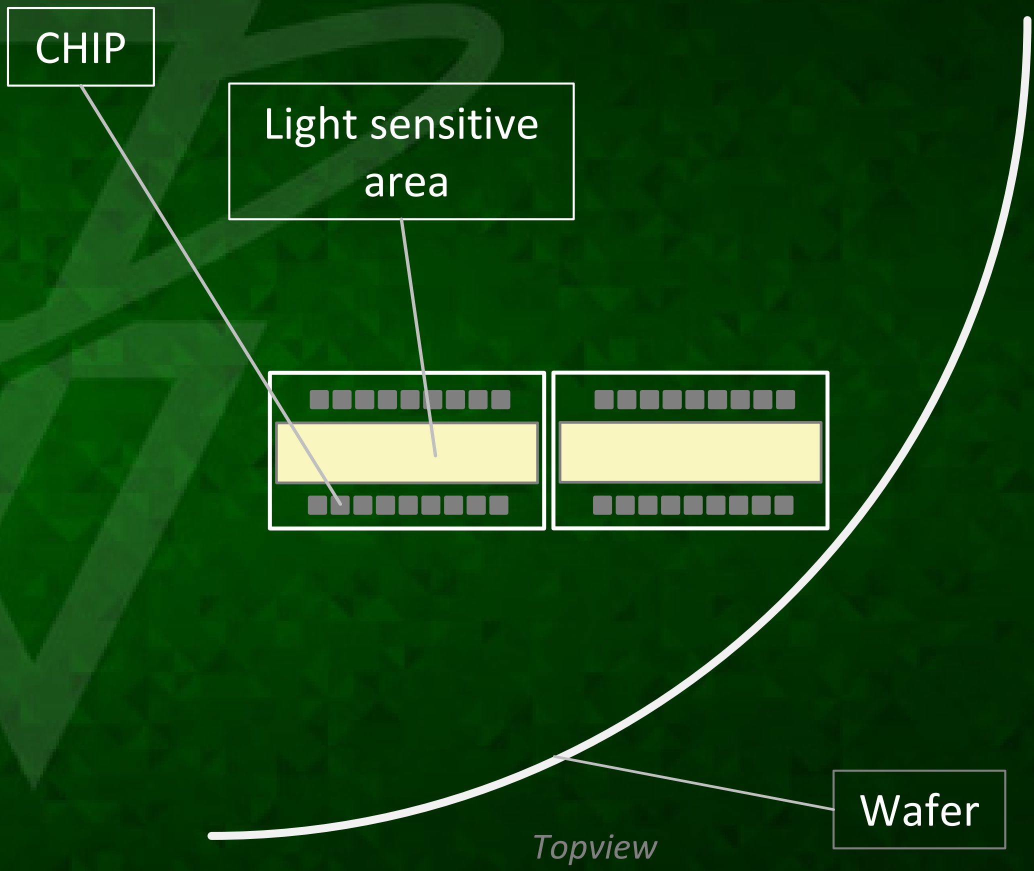
Requirements (from customer test development)

- Illuminated area in chip size scale
- High homogeneity of illuminated field: +/-2.5%
- Discrete intensity levels up to $10W/m^2$
- Narrow band illumination wave length
- Dual site measurement

2.1 Illumination field module

Design approach

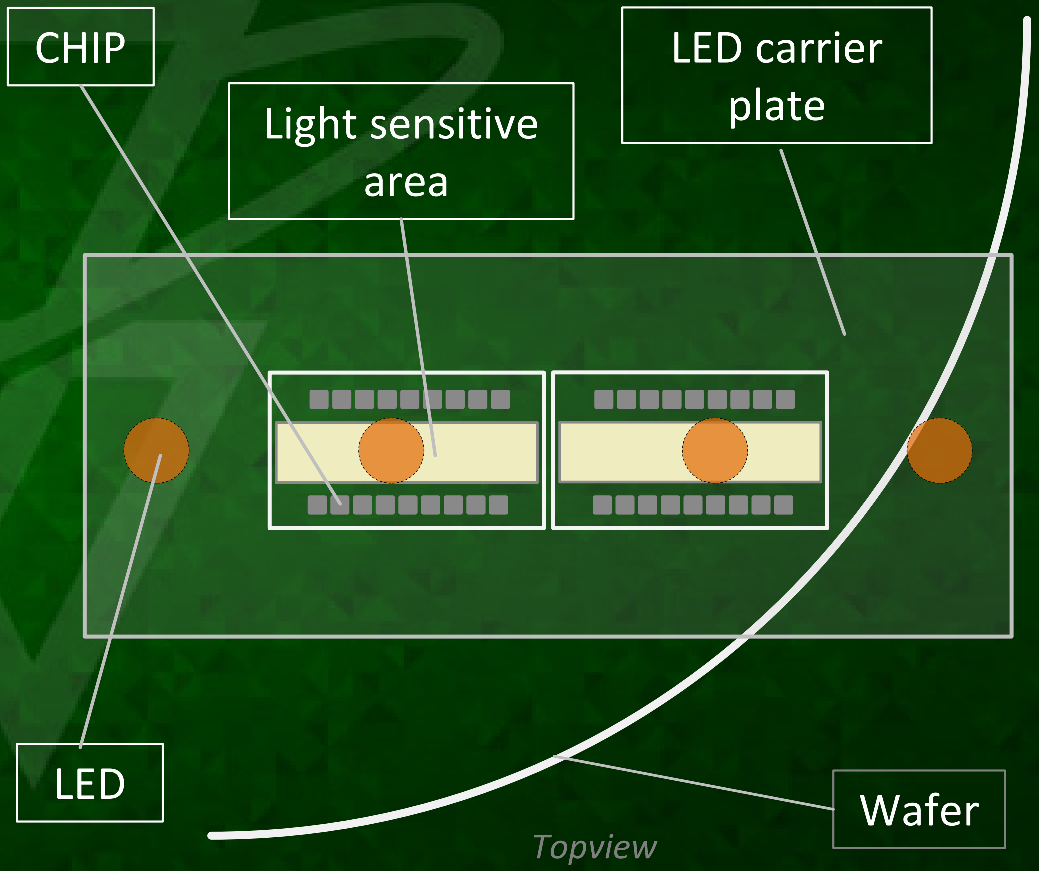
- **Situation on wafer**



2.1 Illumination field module

Design approach

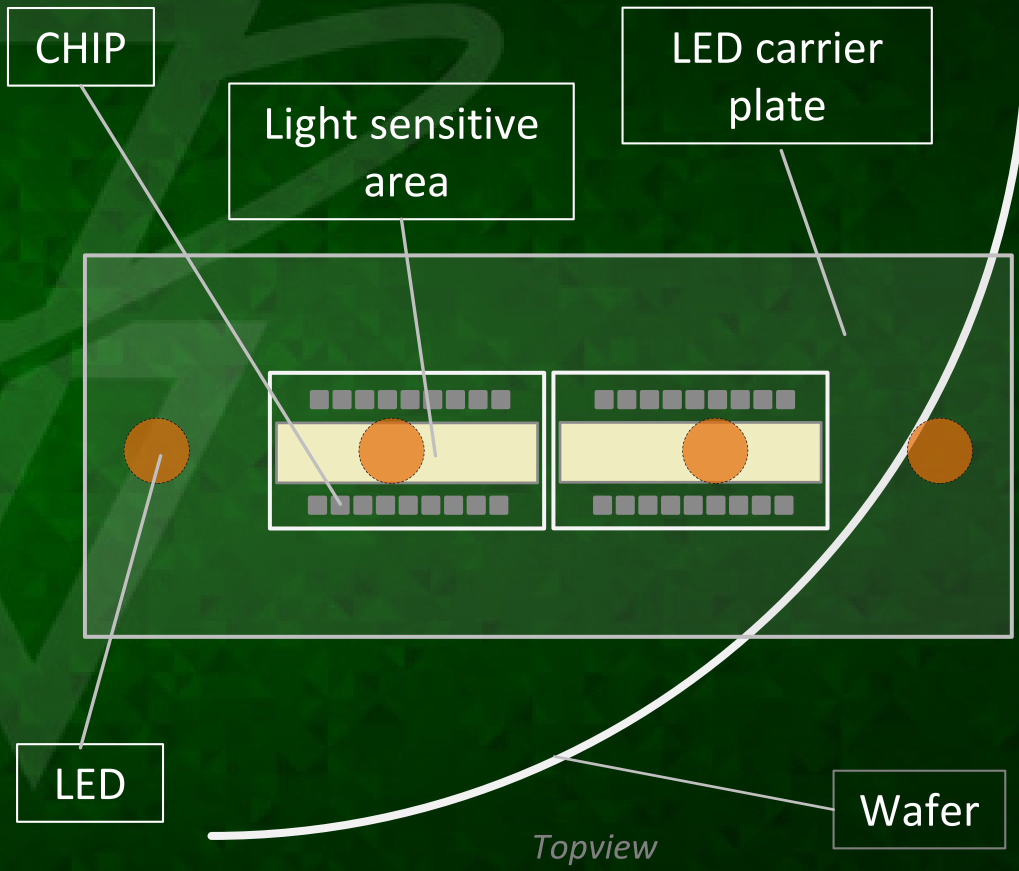
- **Situation on wafer**
- **1st Approach: 4 LEDs in line**



2.1 Illumination field module

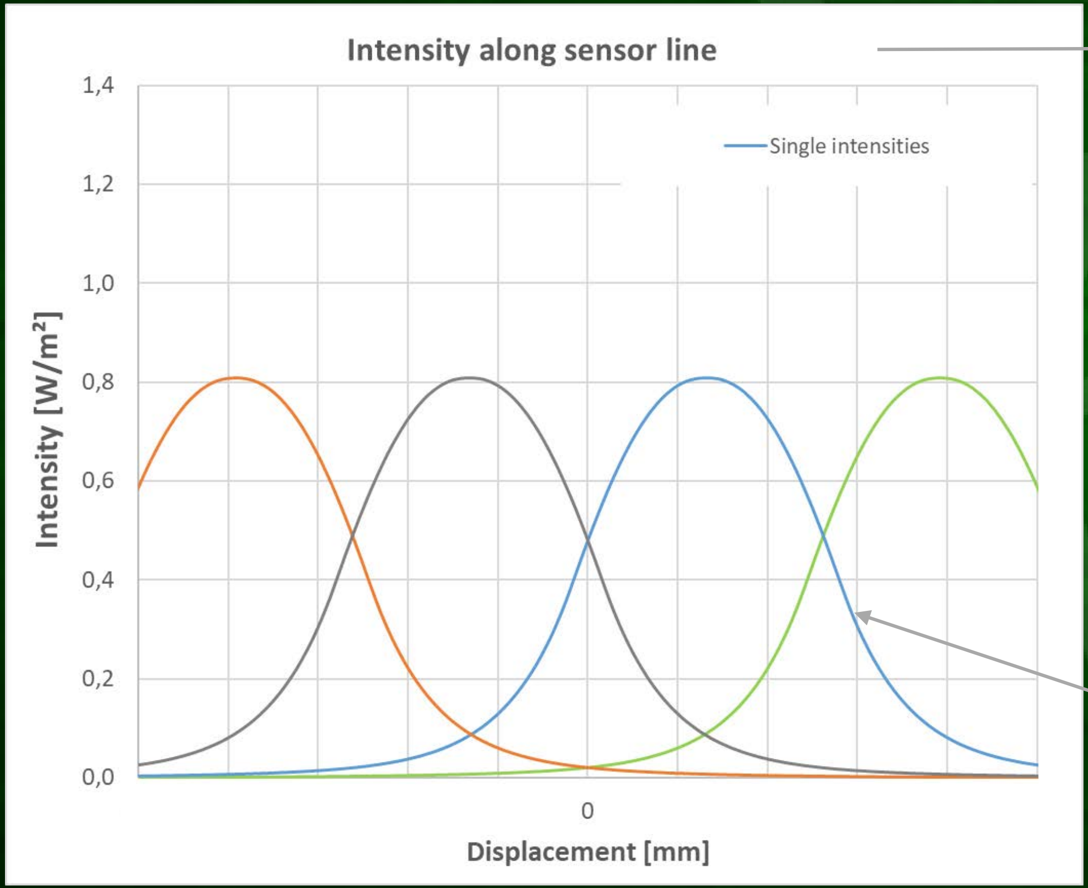
Design approach

- **Situation on wafer**
- **1st Approach: 4 LEDs in line**
- **Numerical simulation**
  - Light intensity along sensitive area on wafer
  - Intensity distribution of LED taken from datasheet
  - Iterative determination of ideal LED spacing

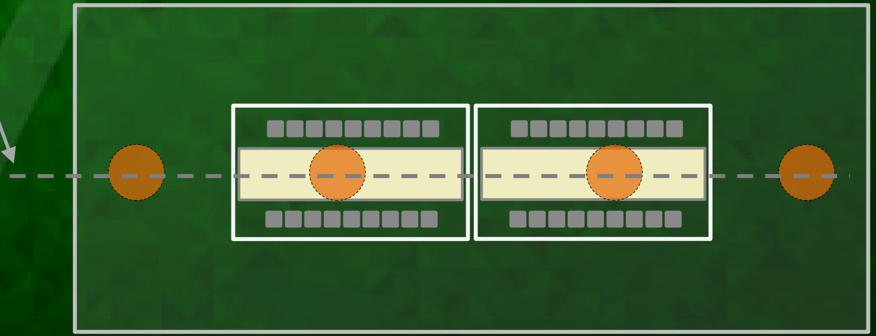


2.1 Illumination field module

Numerical simulation - Homogeneity



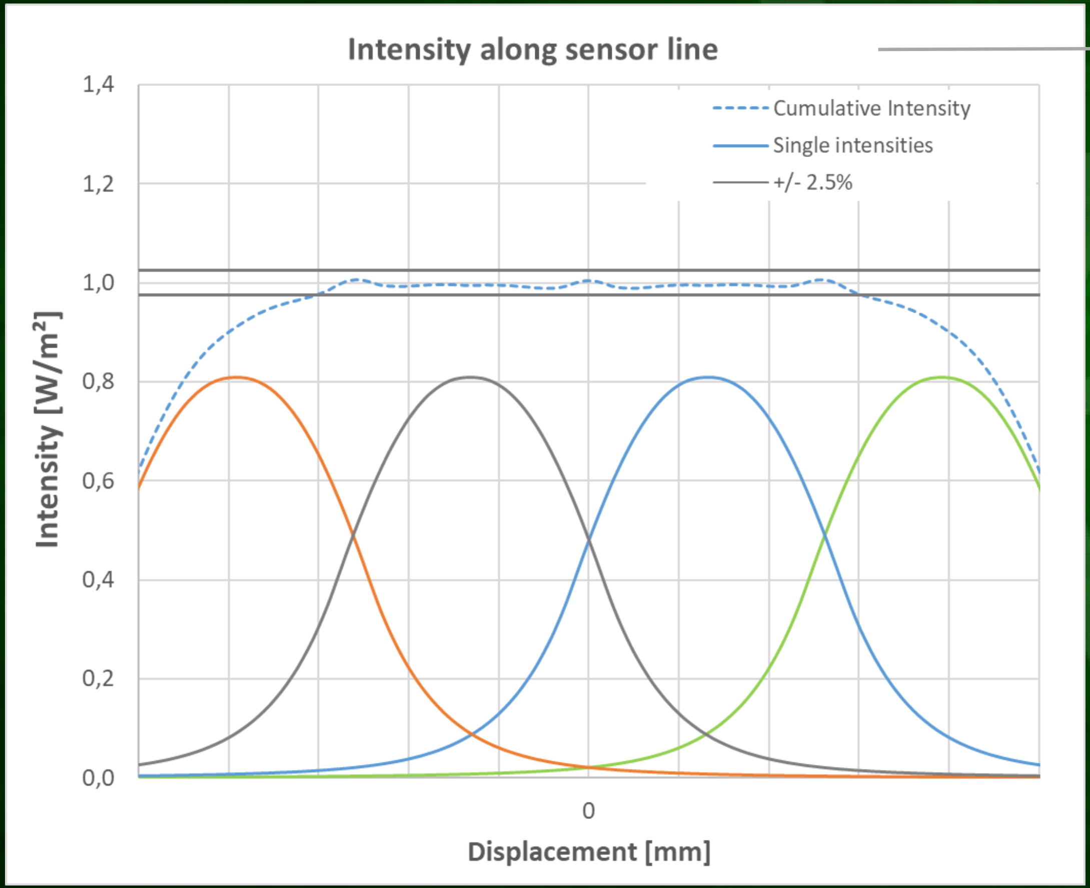
1st Approach: 4 LEDs in line



Intensity distribution from LED datasheet for specific distance

2.1 Illumination field module

Numerical simulation - Homogeneity



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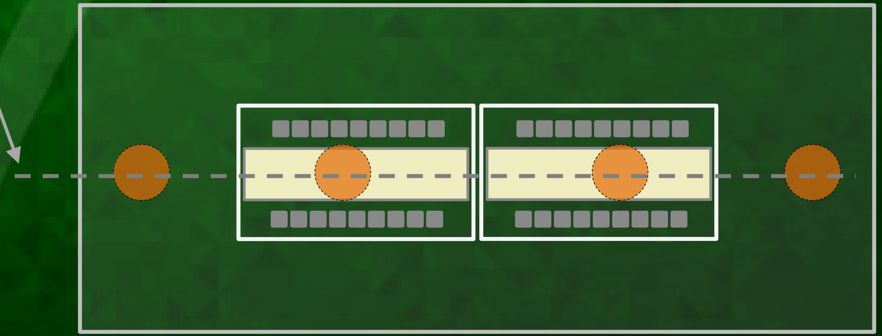
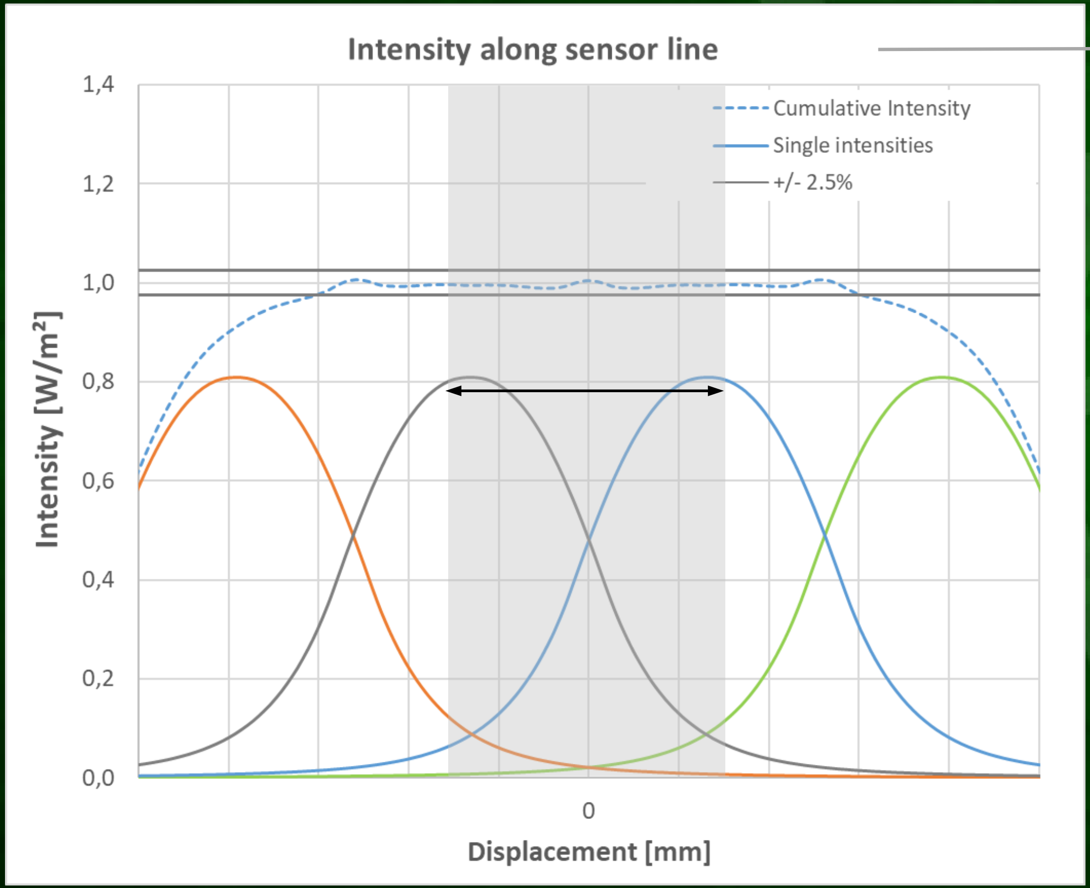
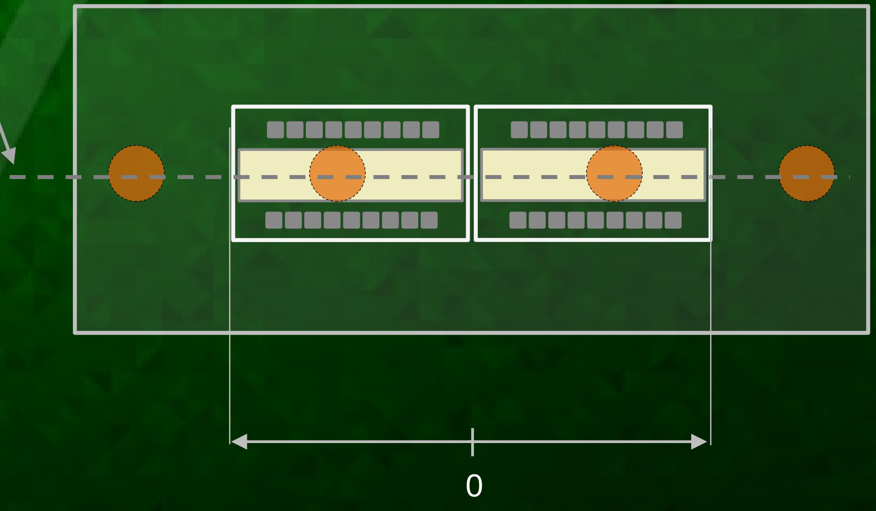


2.1 Illumination field module

Numerical simulation - Homogeneity

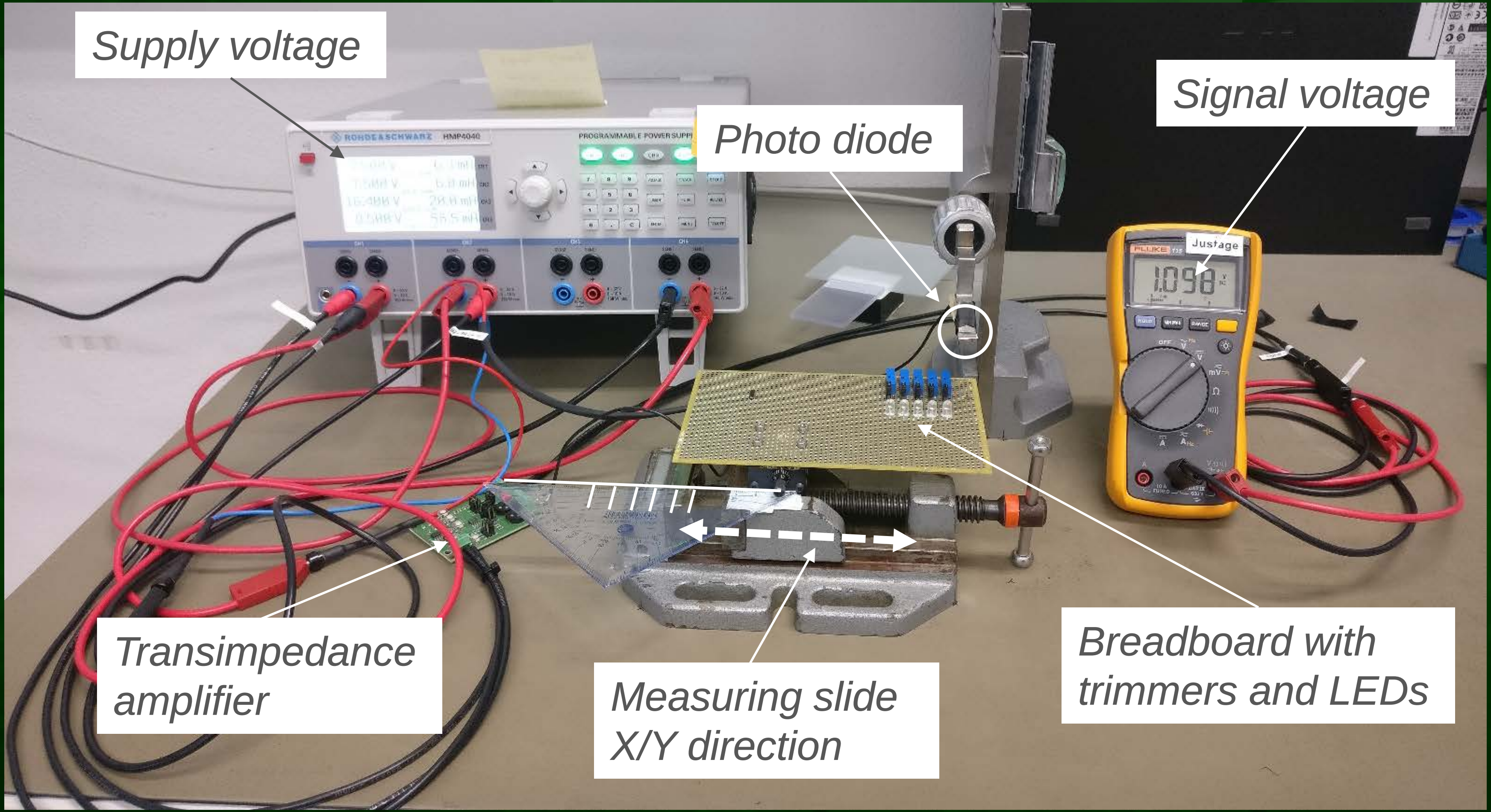


1st Approach: 4 LEDs in line



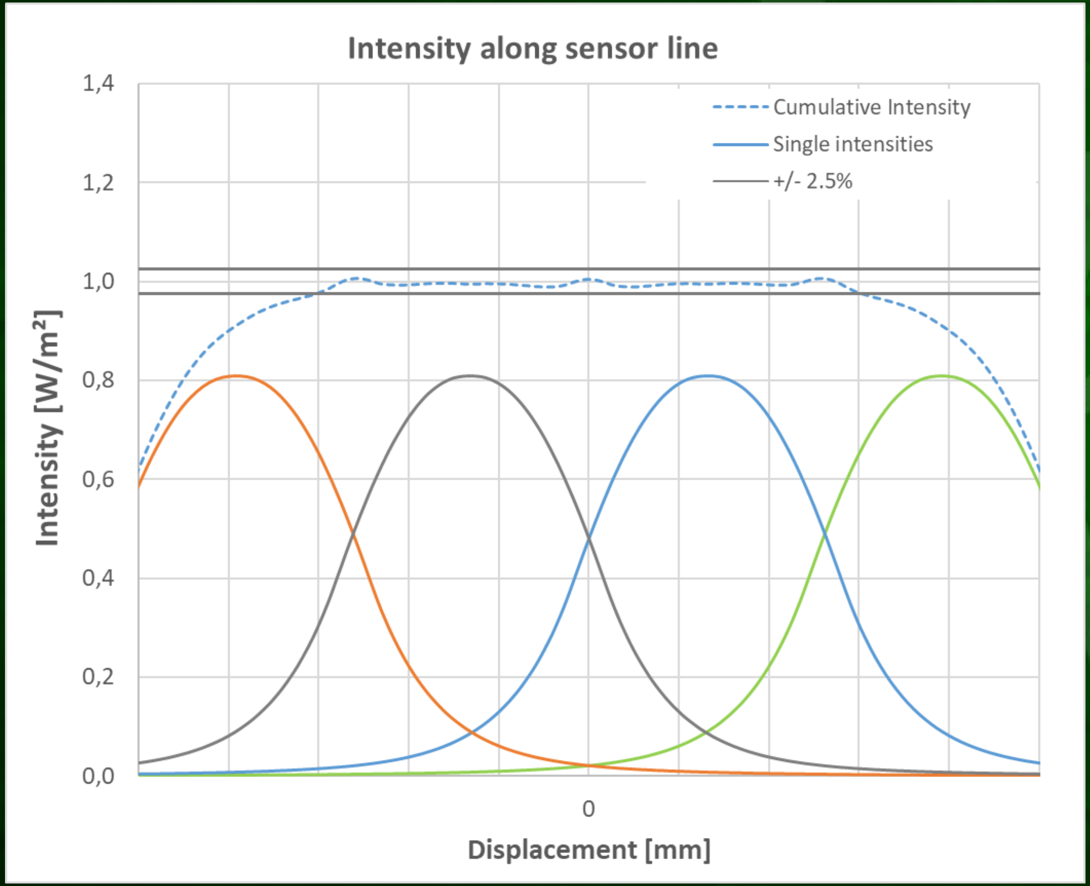
2.1 Illumination field module

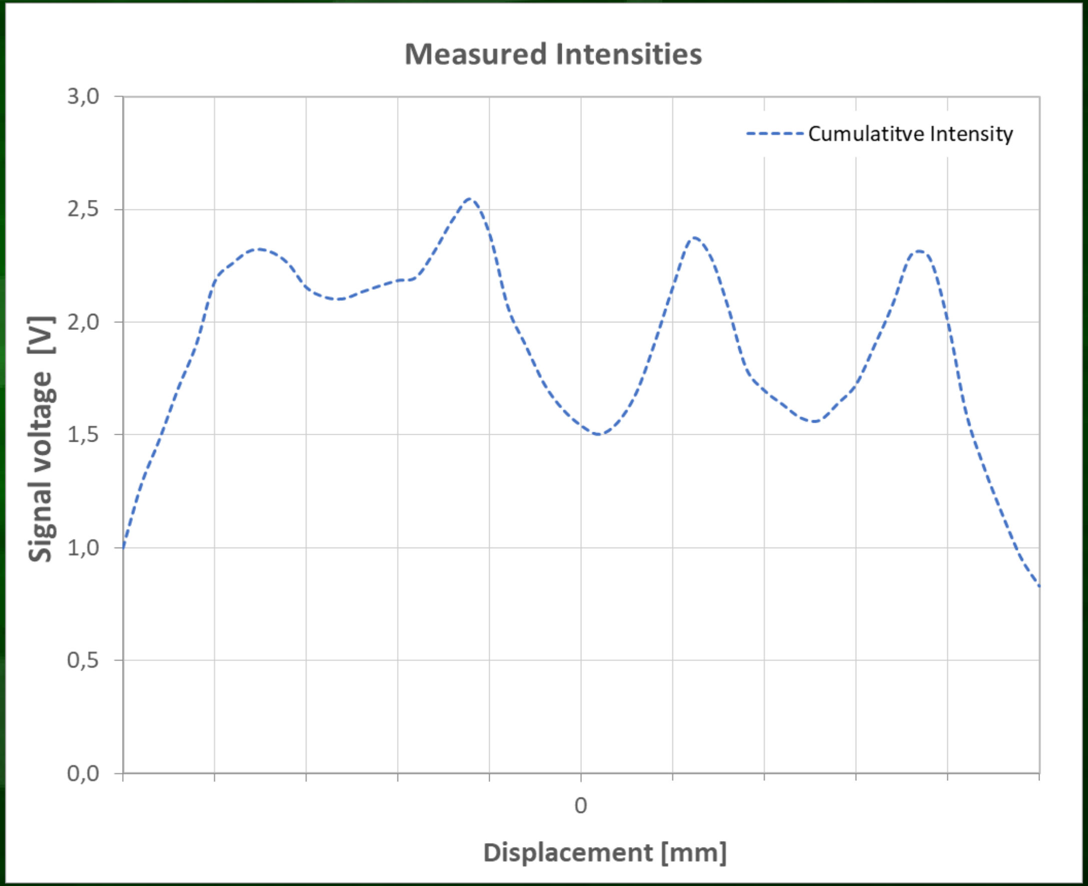
Verification – First measurement setup



2.1 Illumination field module

Verification homogeneity – Simulation vs. measurement





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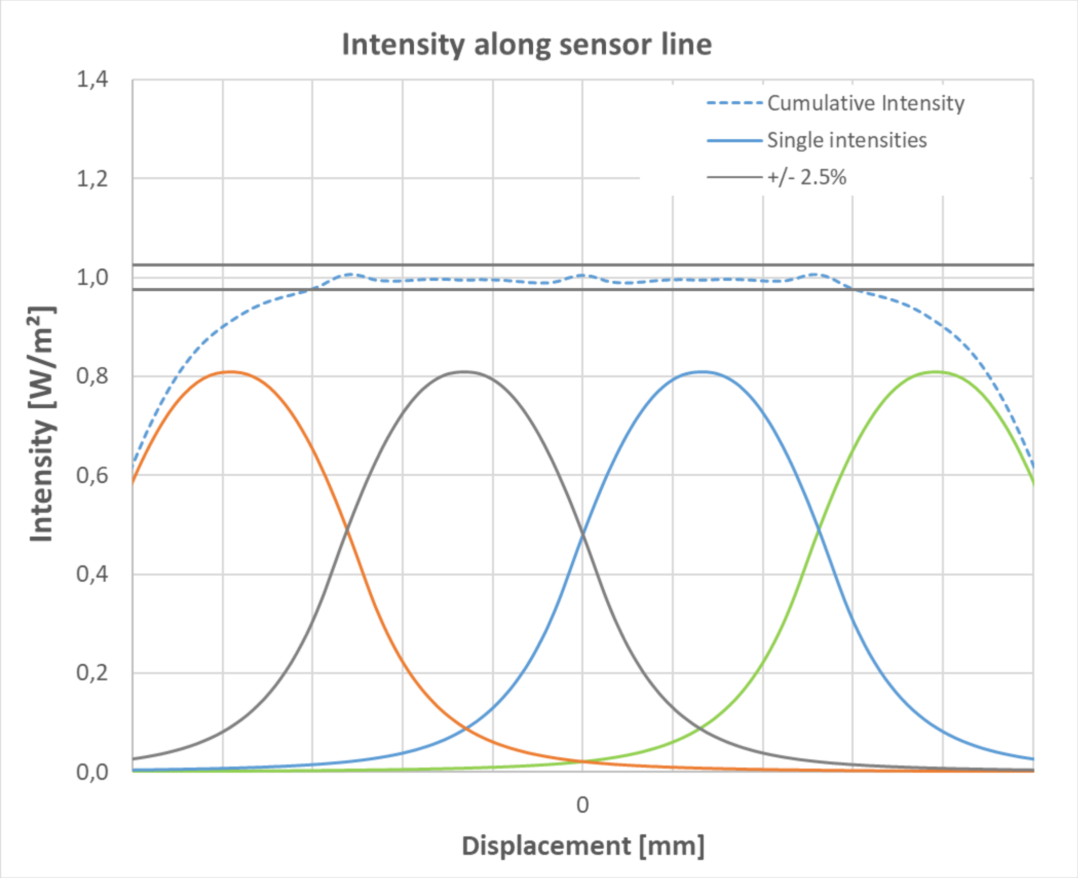

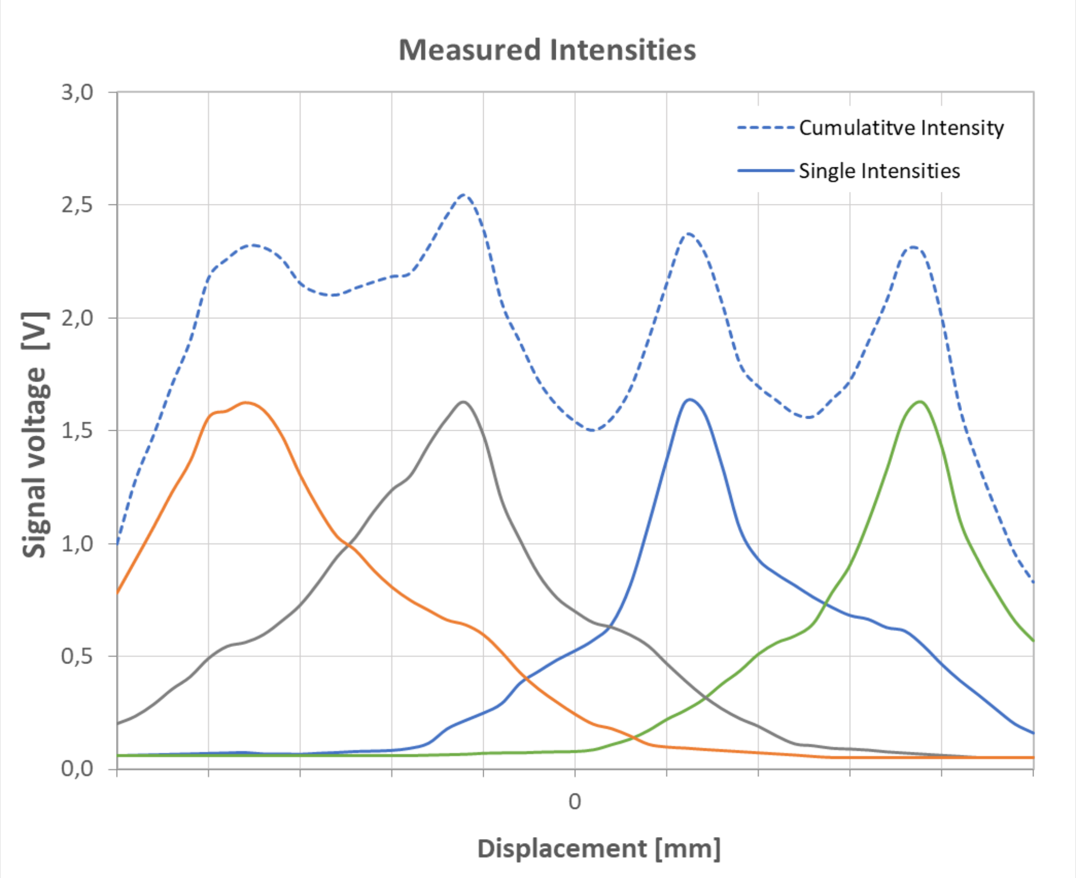

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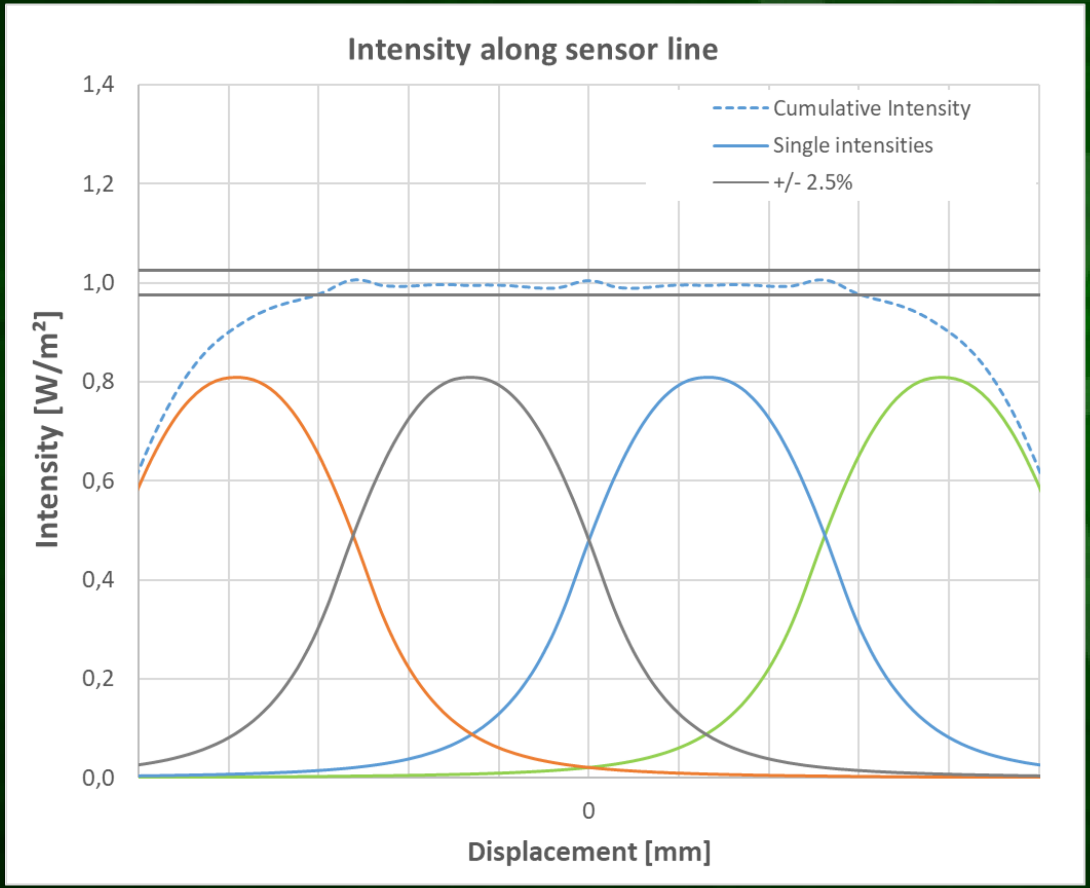

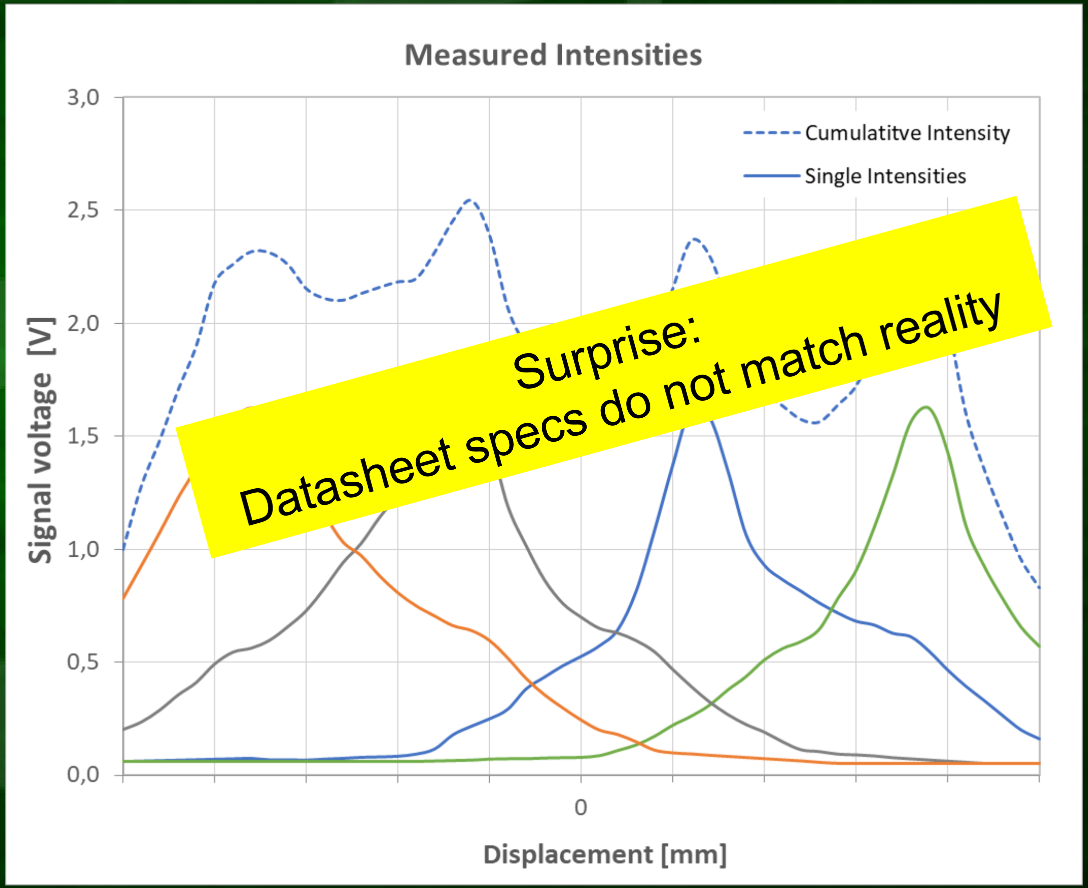

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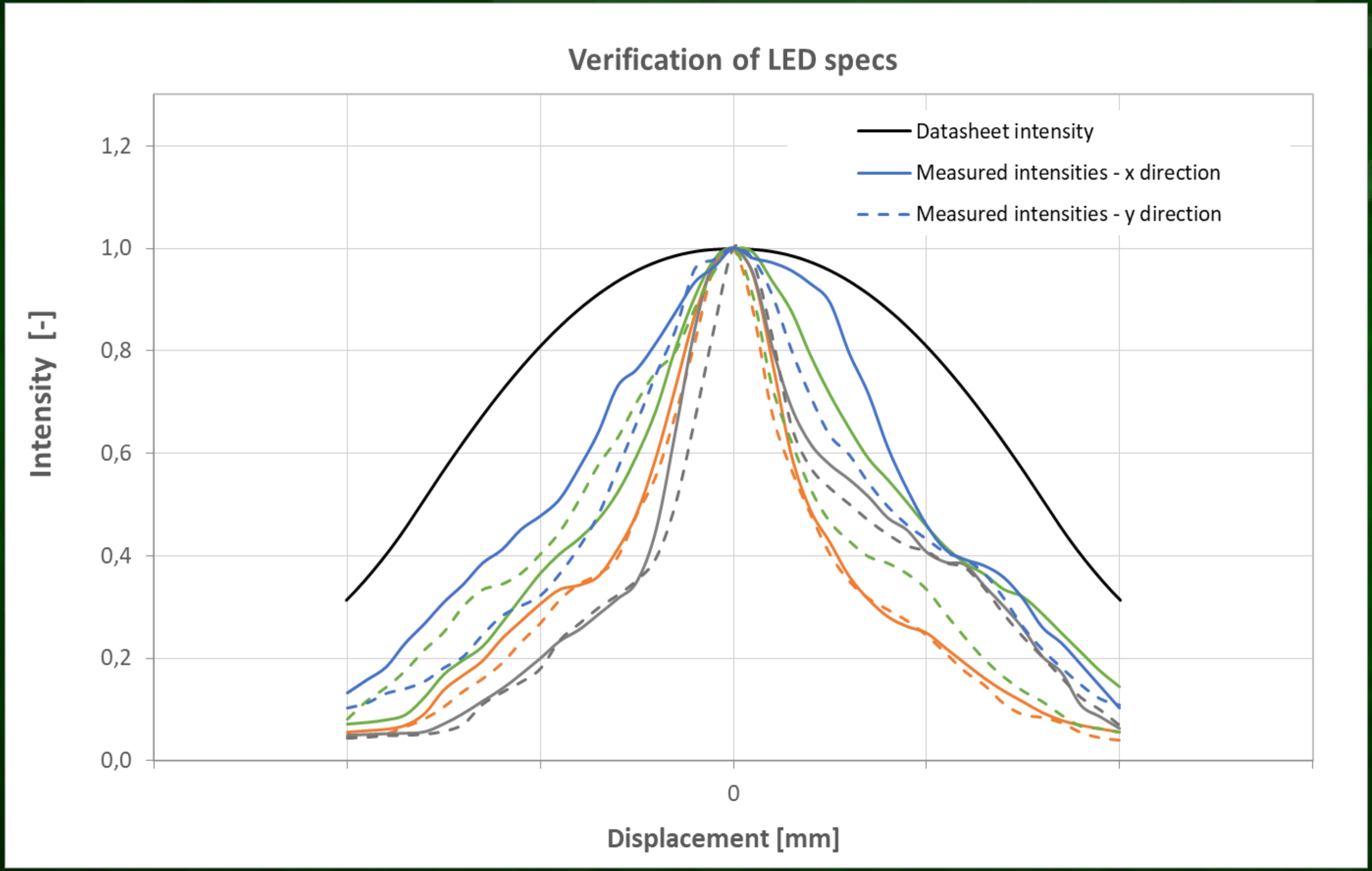
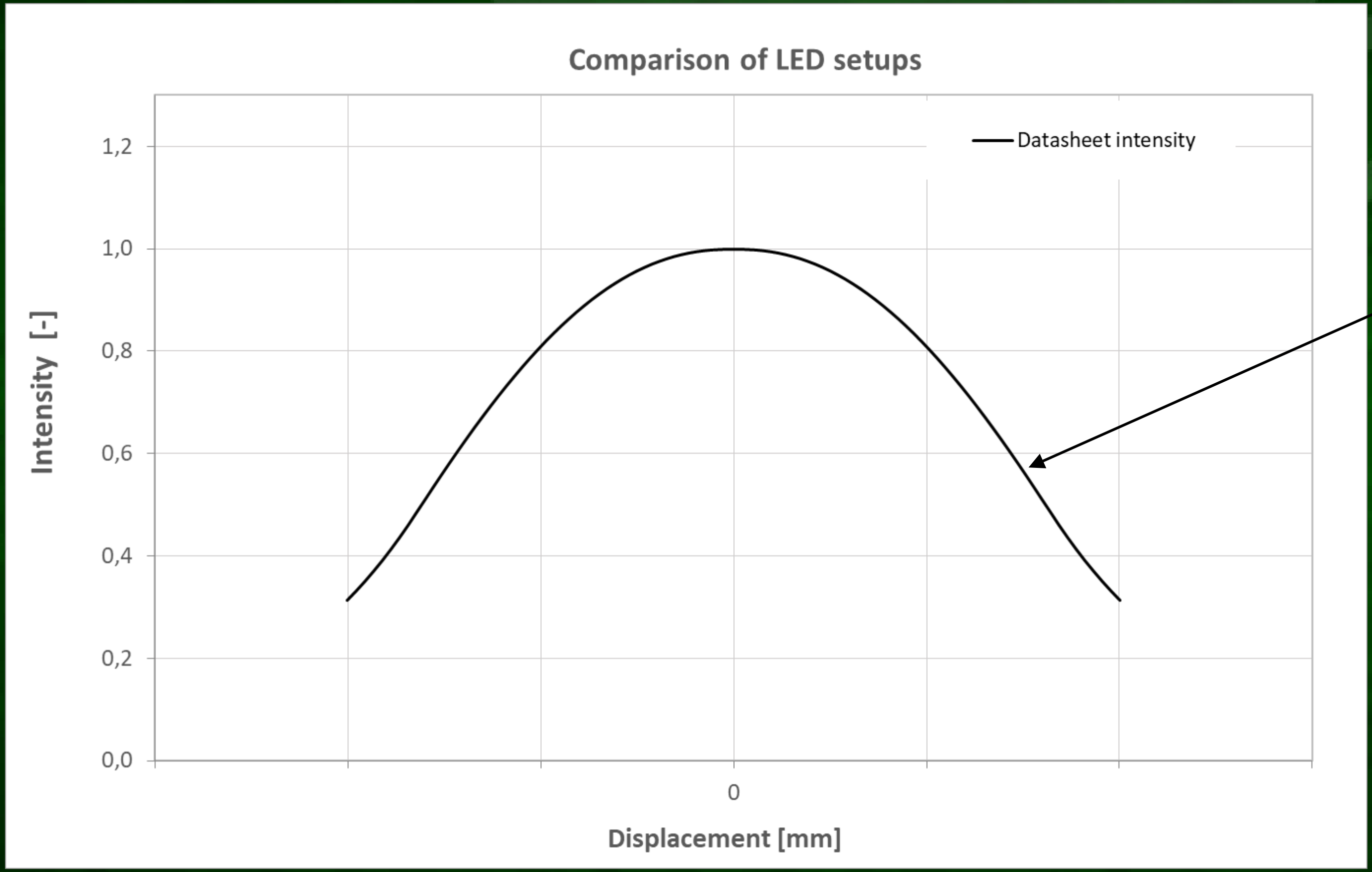
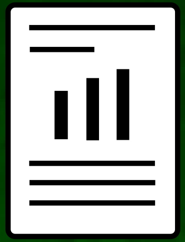


- **Measured intensity of LED much more focused around axis than specified**
- **Significant variance between single LEDs**

2.1 Illumination field module

Optimization of LED intensity distribution





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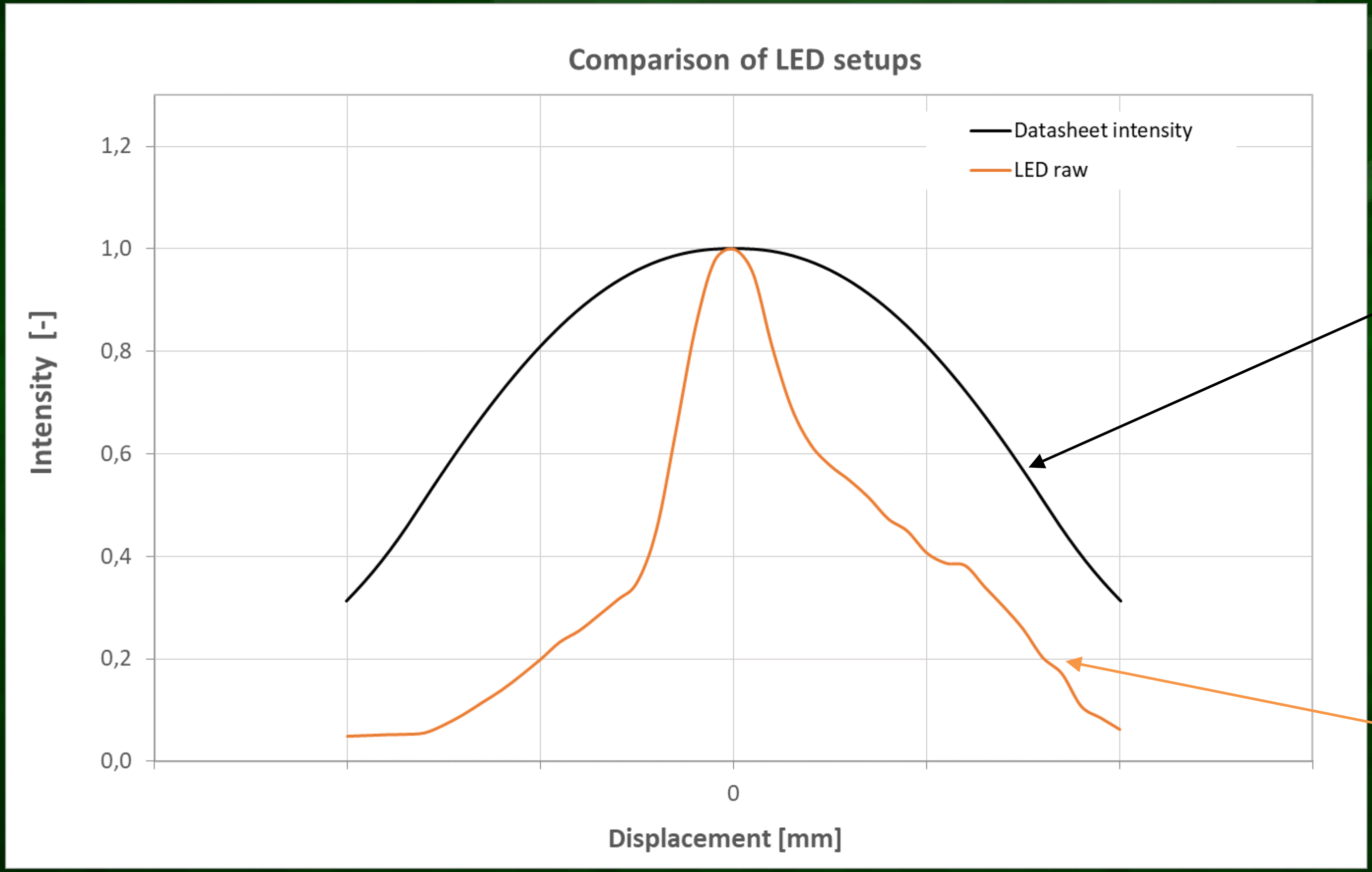

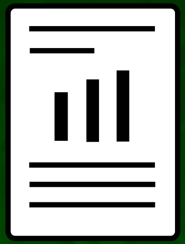

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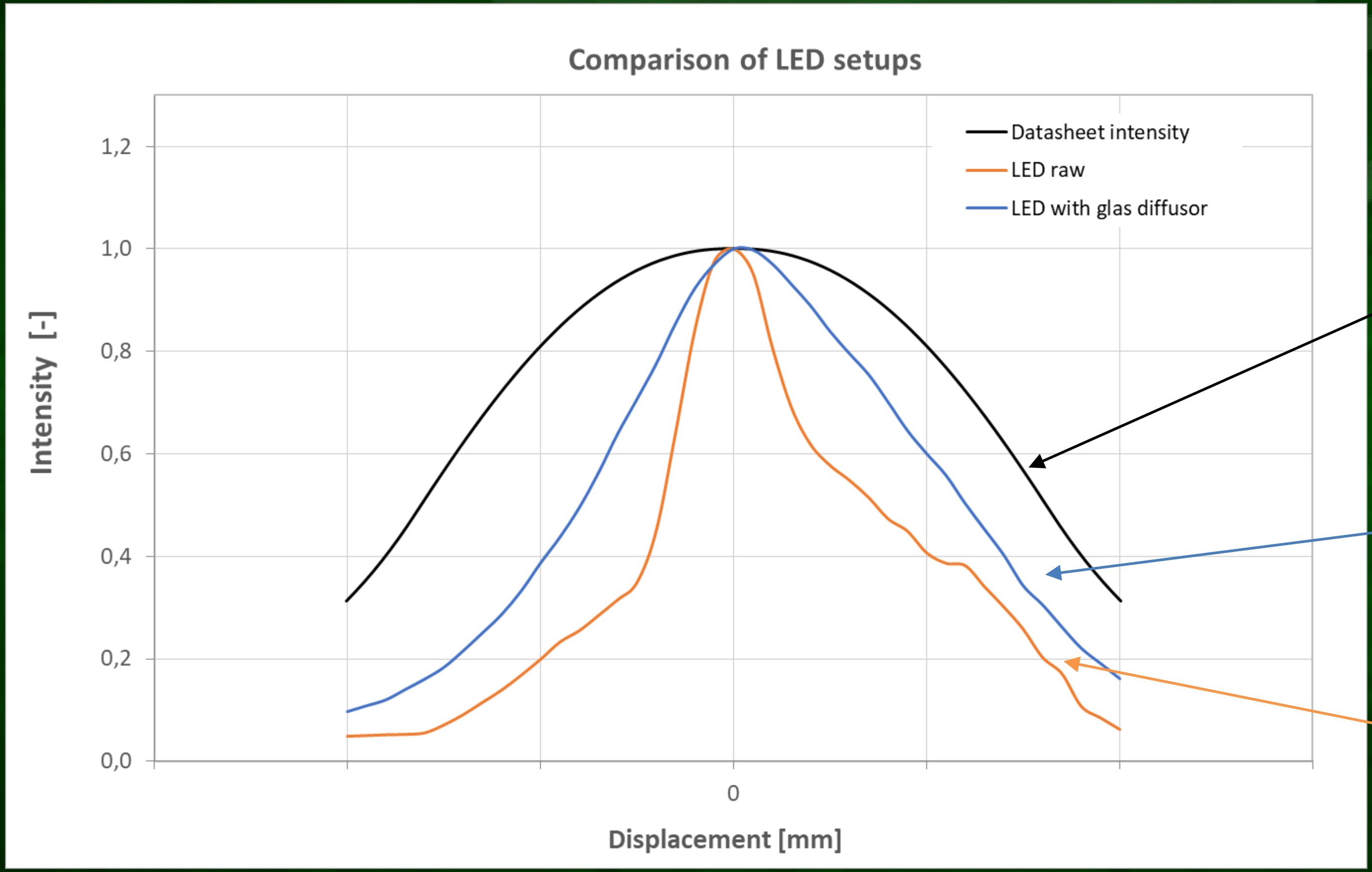
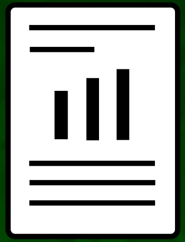
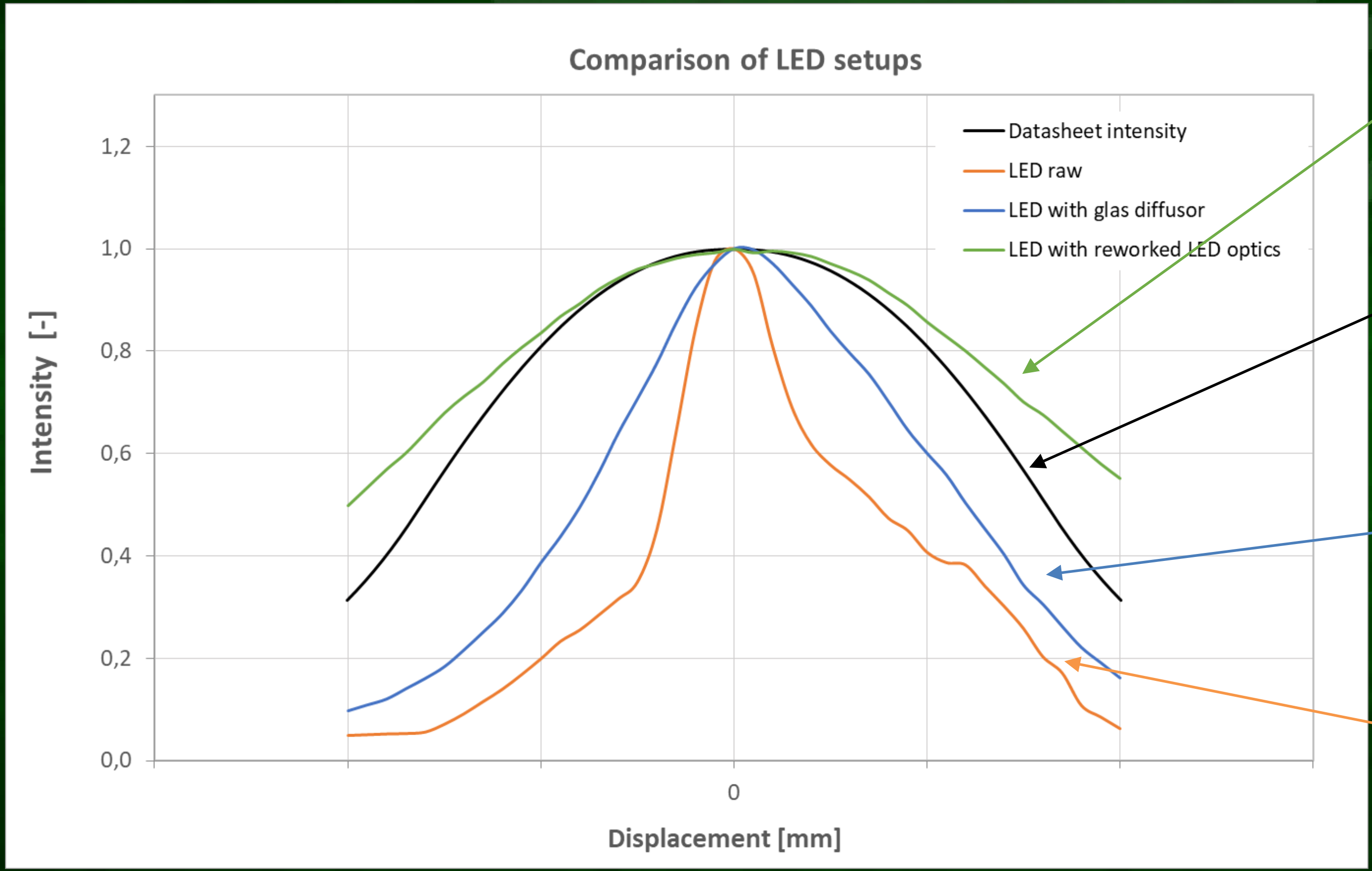


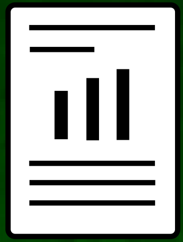


- Glass diffusor defocuses raw LED, but still asymmetric distribution

2.1 Illumination field module

Optimization of LED intensity distribution

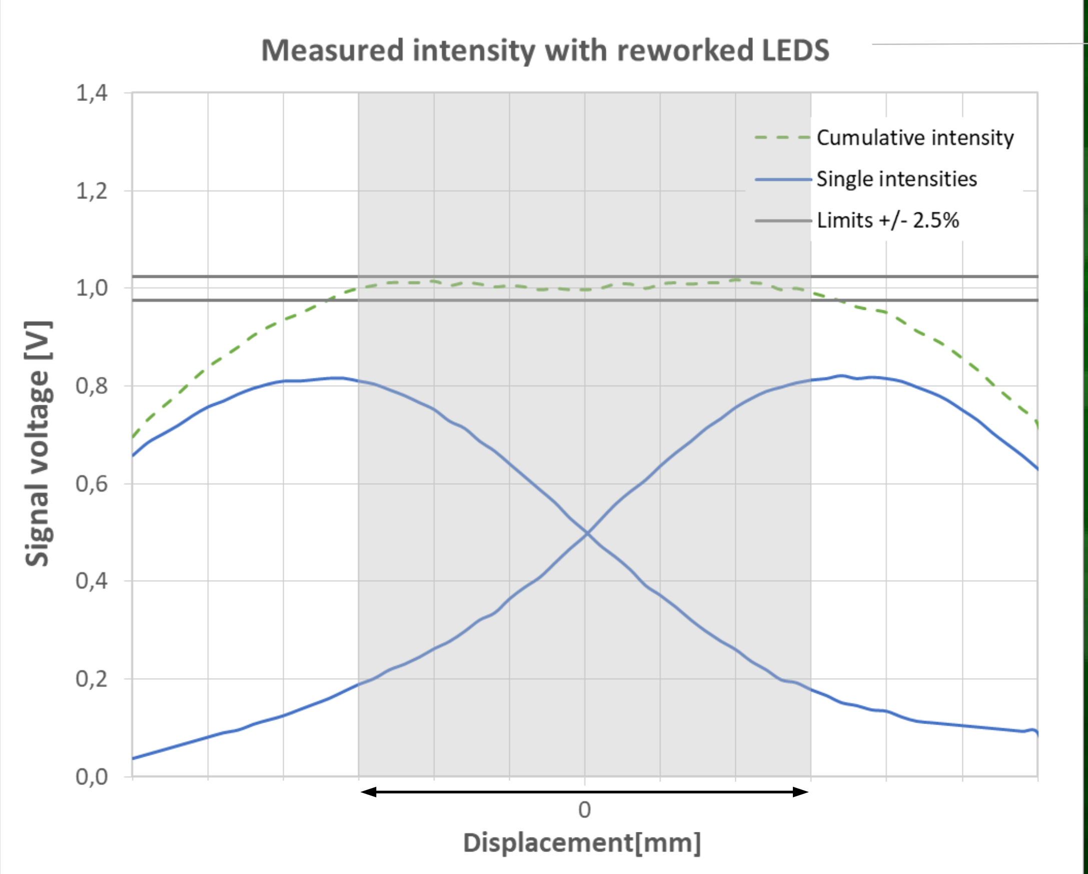




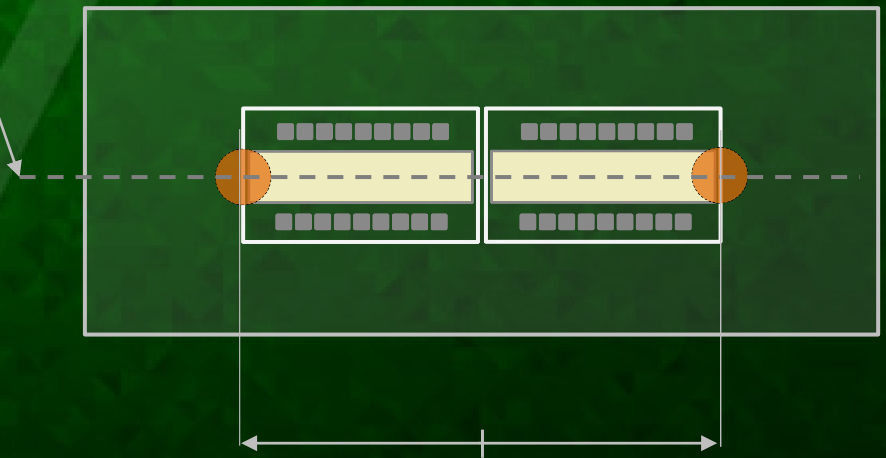
- Glass diffusor defocuses raw LED, but still asymmetric distribution
- Reworked LED optics leads to smoothed and symmetric distribution

2.1 Illumination field module

Optimization of LED intensity distribution



2nd Approach: 2 reworked LEDs in line

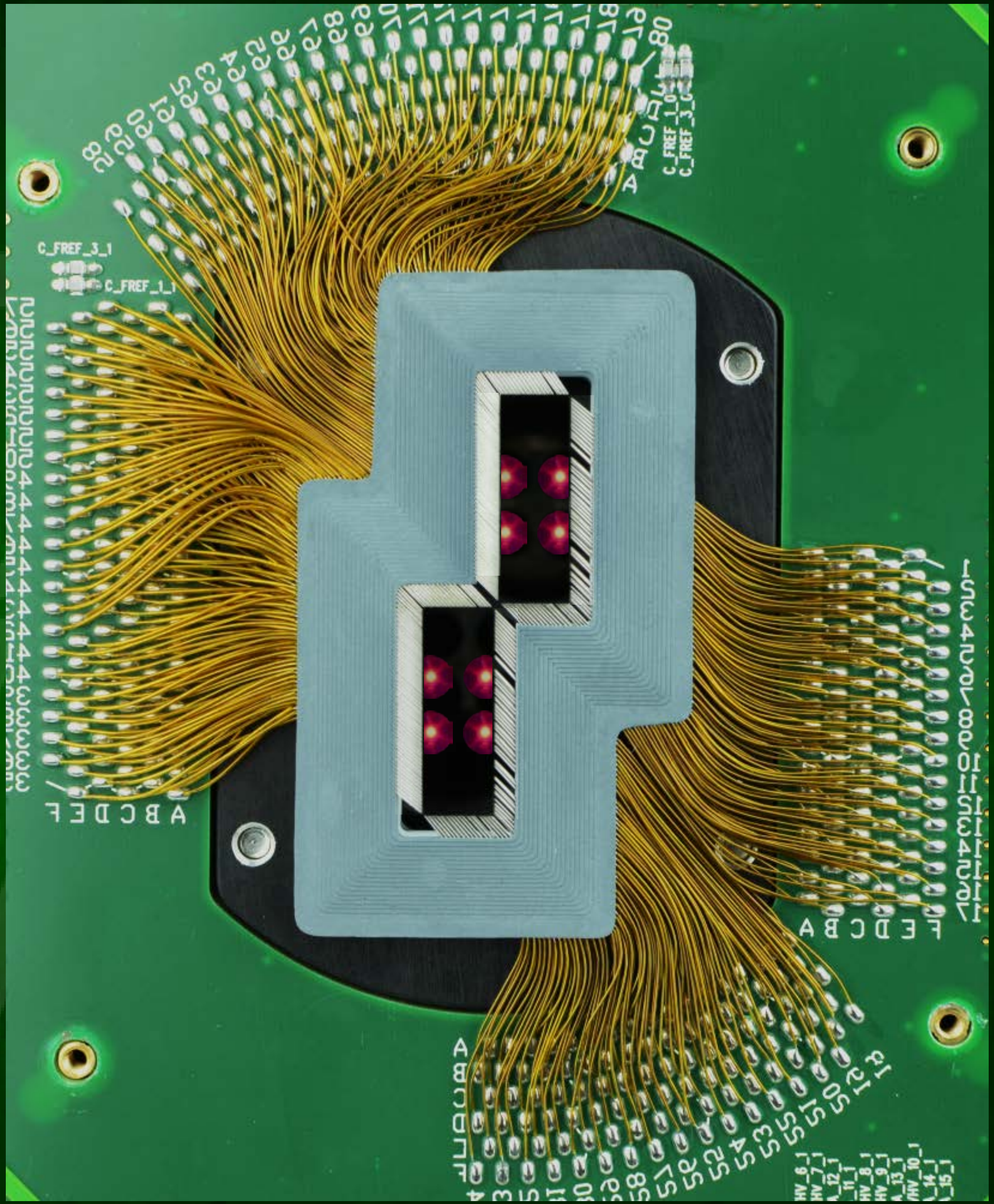


- Good results on the first try!

2.1 Illumination field module

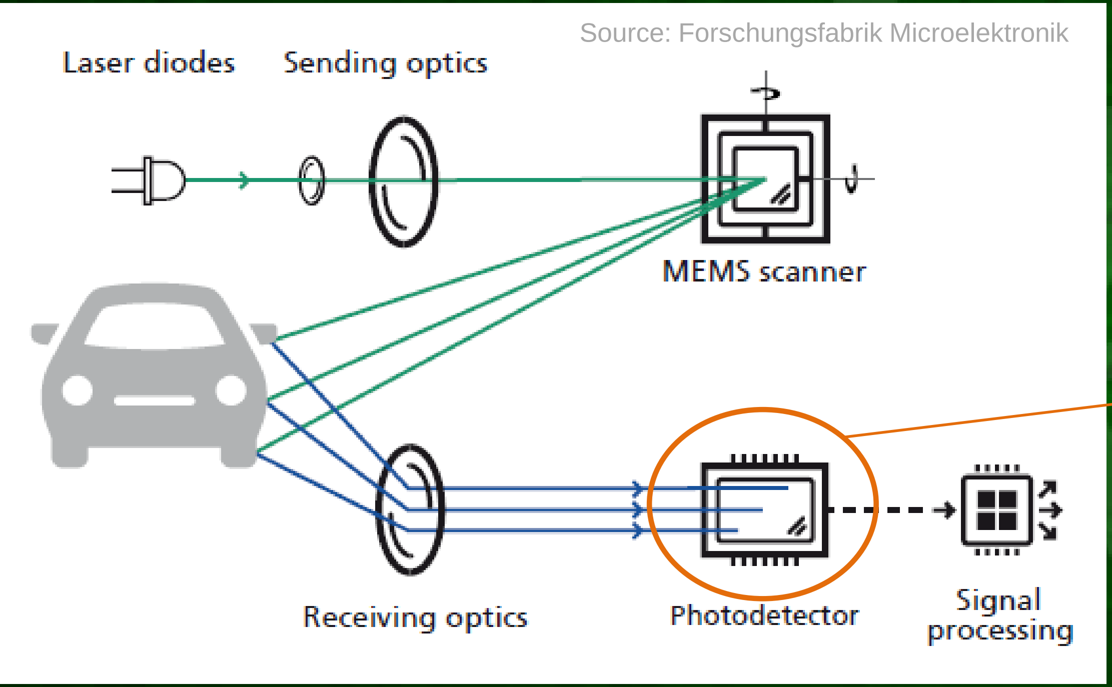
Final concept

- **Usage of LEDs with reworked optics**
  - learned from shown approaches
- **Final concept needed some more changes and evolution steps**
  - 2x2 LED arrangement per site
  - Staggered multisite probing due to needle spider configuration
- **Temperature control applied**
- **Evaluation of long term stability of LEDs**
  - Life time test conducted over month



2. Smart Probe Cards

Imaging with LiDAR



How to probe?

- **Photodetector with 1D/2D pixel array**
  - Stimulus of photodetector chip with ***Illumination field module***

2. Smart Probe Cards

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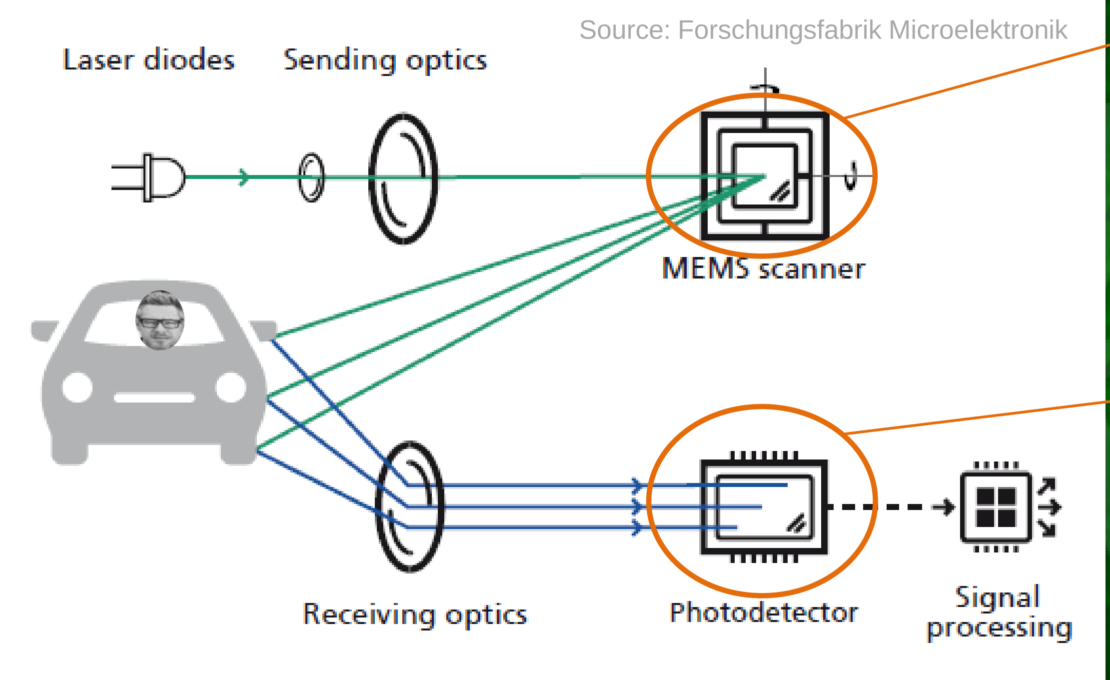


How to probe?

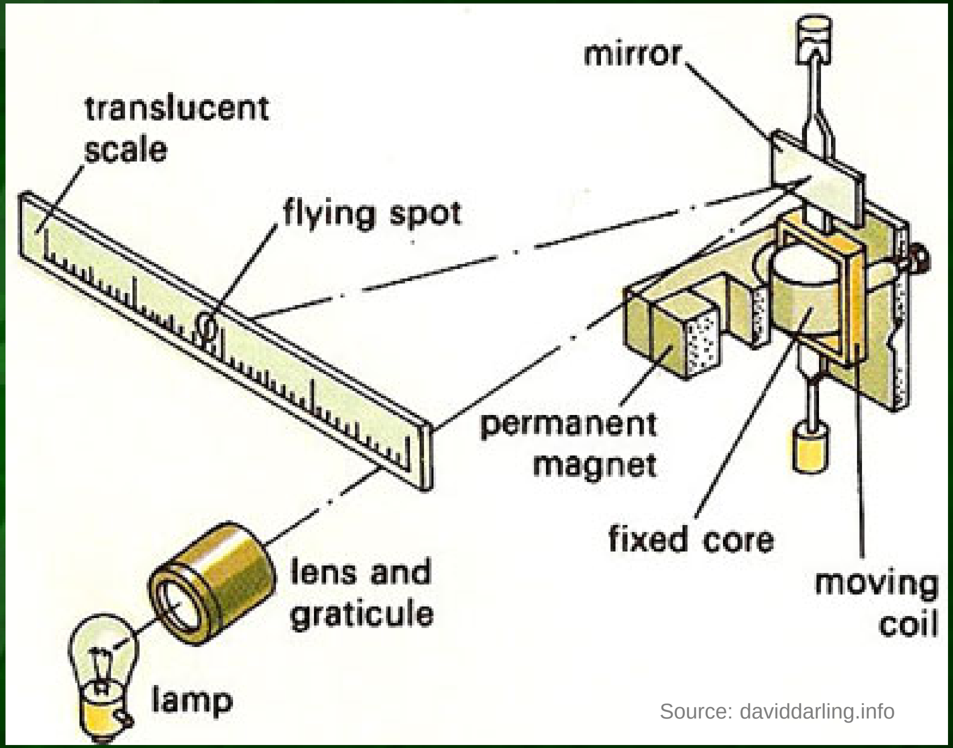
- **MEMS mirror**
  - Determination of tilt angle by use of a laser beam with ***MEMS mirror module***
- **Photodetector with 1D/2D pixel array**
  - Stimulus of photodetector chip with ***Illumination field module***

2.2 MEMS mirror module

Requirements

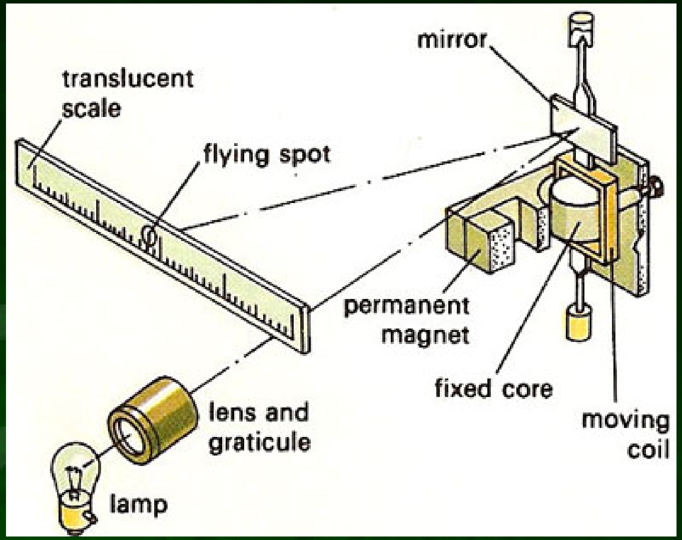
- **Detection of tilt angle of MEMS mirror**
- **High angular accuracy**
- **Integration in probe card with vertical needle technology**

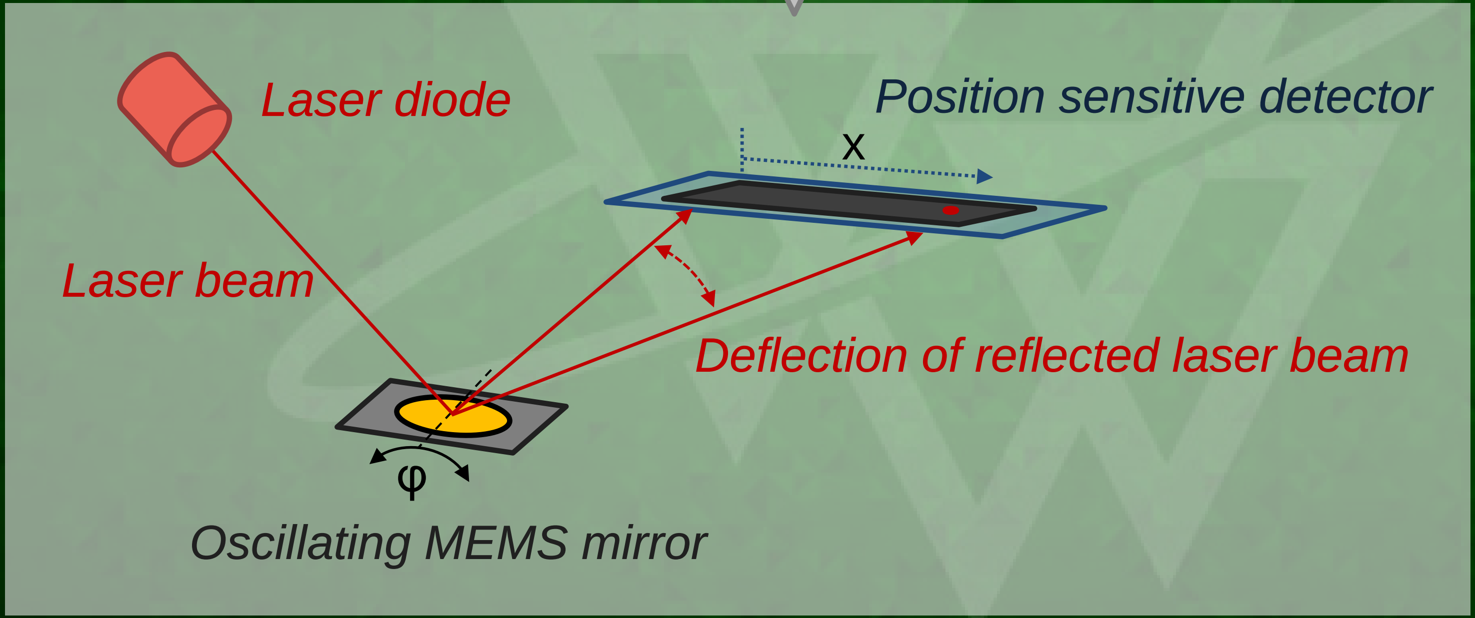
- **Measurement principle: Mirror galvanometer (1826)**
  - Usage of laser beam and Position Sensitive Detector



2.2 MEMS mirror module

Measurement principle



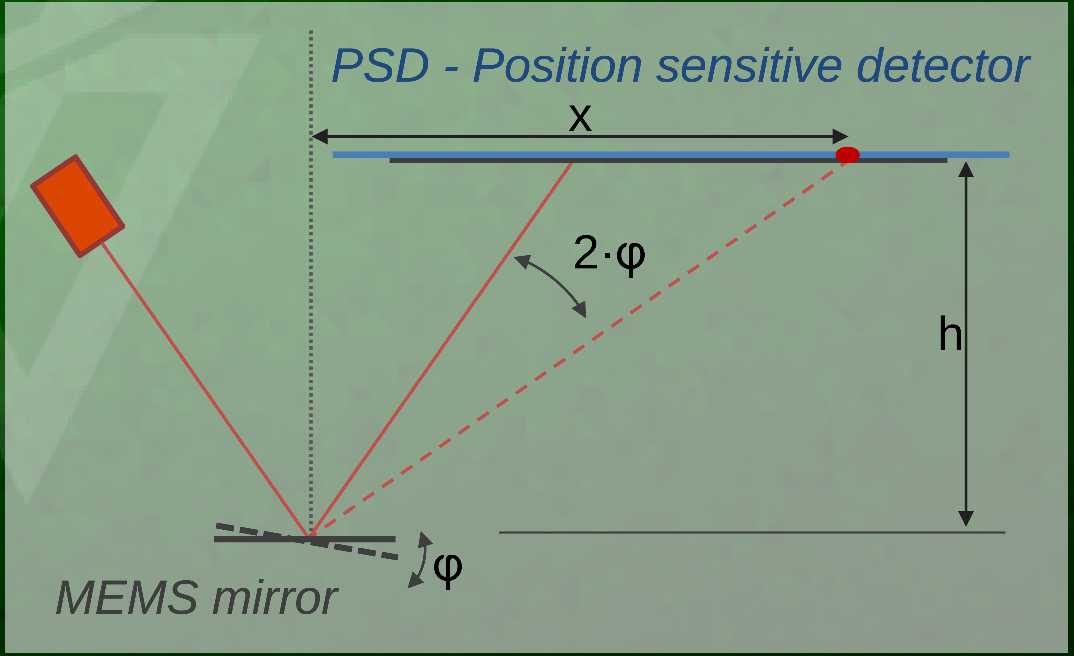


$\boxed{\varphi = f(x, \ldots)}$ ➡ Mathematic correlation and measurement error calculation needed

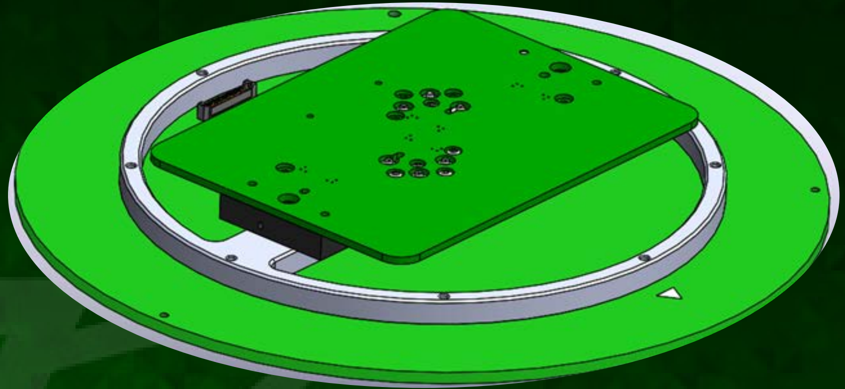
2.2 MEMS mirror module

Measurement principle

- **A change of the mirror angle leads to a double change of the reflected beam angle (law of reflection)**
  - Very sensitive measurement principle
- **Mirror angle is a function of laser spot position x and distance h between MEMS mirror and PSD**
- **Distance error Δh_{error} leads to measurement error $\Delta\varphi_{error}$**
- **Consideration of**
  - Needle wear
  - Prober stage accuracy
  - PSD accuracy

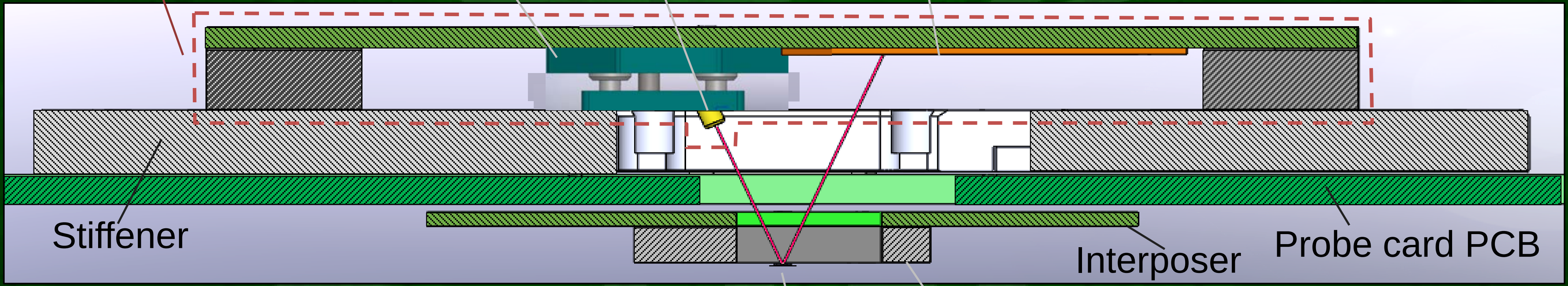


2.2 MEMS mirror module

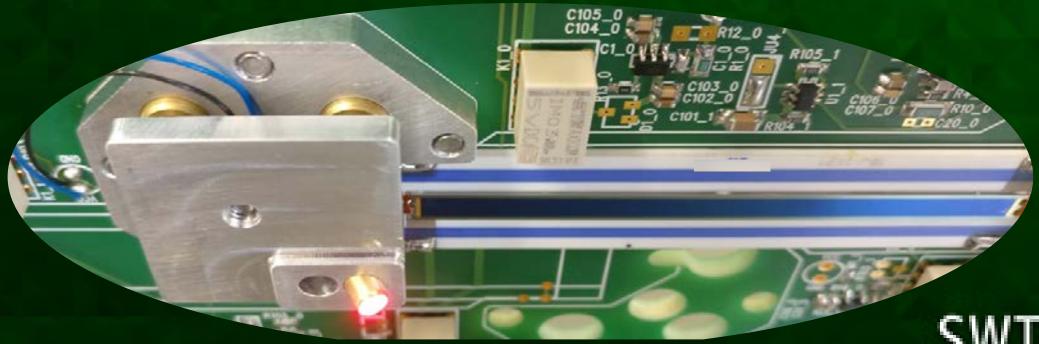


Design

MEMS mirror module:
Mounted on probe card

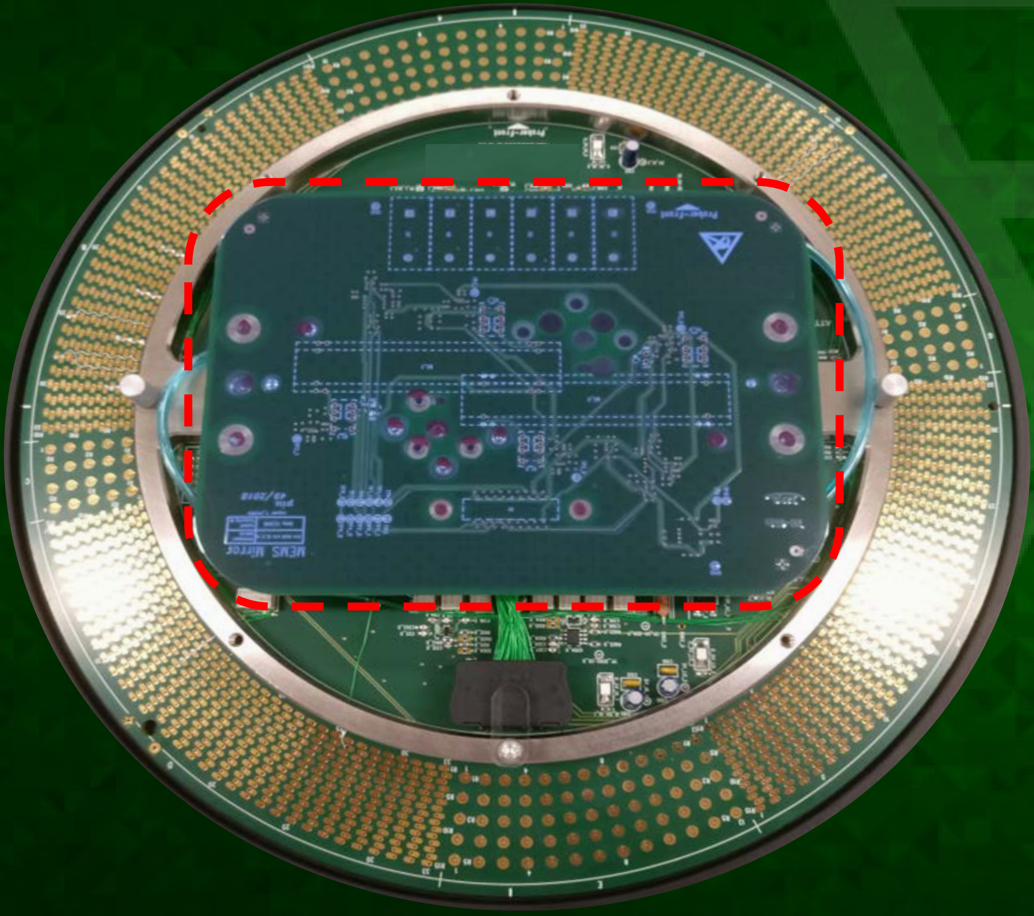


Cross section view

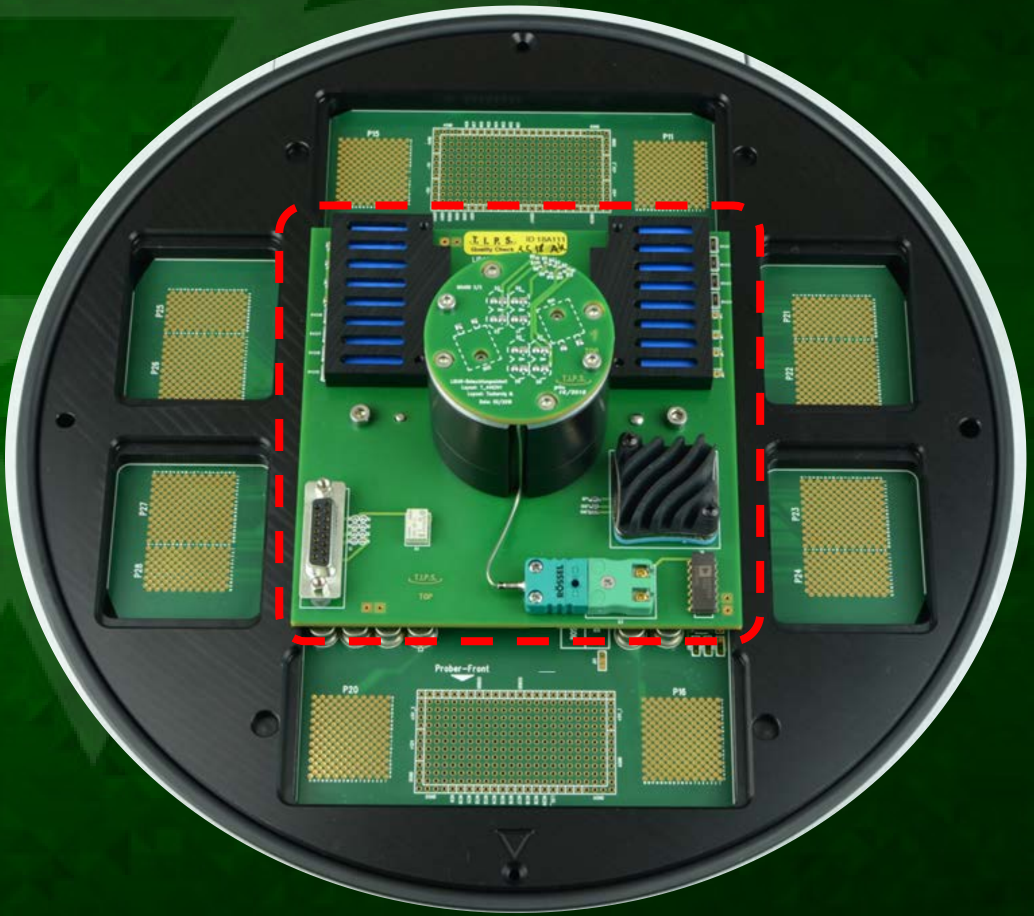


2. Smart Probe Cards

MEMS mirror module



Illumination field module



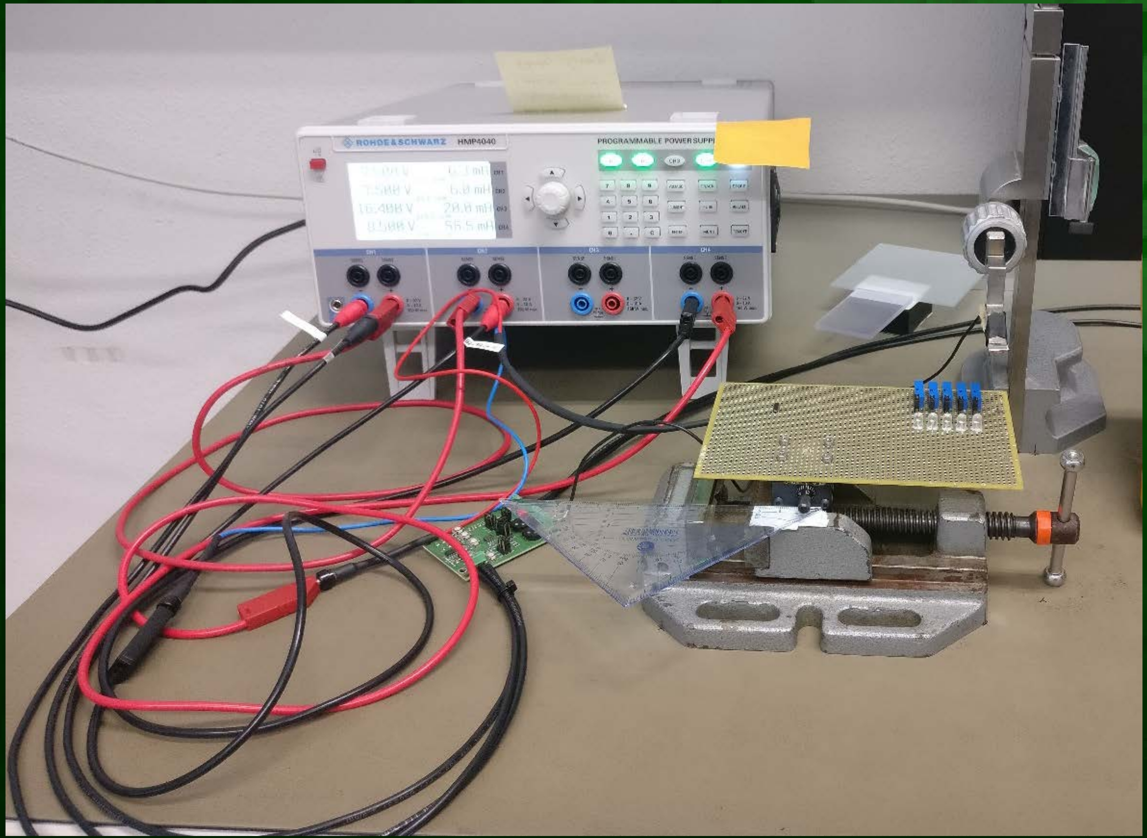
3. Conclusion

- **Development and integration of optical add-on modules for probe cards successful**
- **Added two more functional test technologies to our sensor test product portfolio**
  - Existing: Magnetic, pressure, gas atmospheres and light
  - New: Illumination field and MEMS mirror module
- **And….. never trust data sheets ☺**

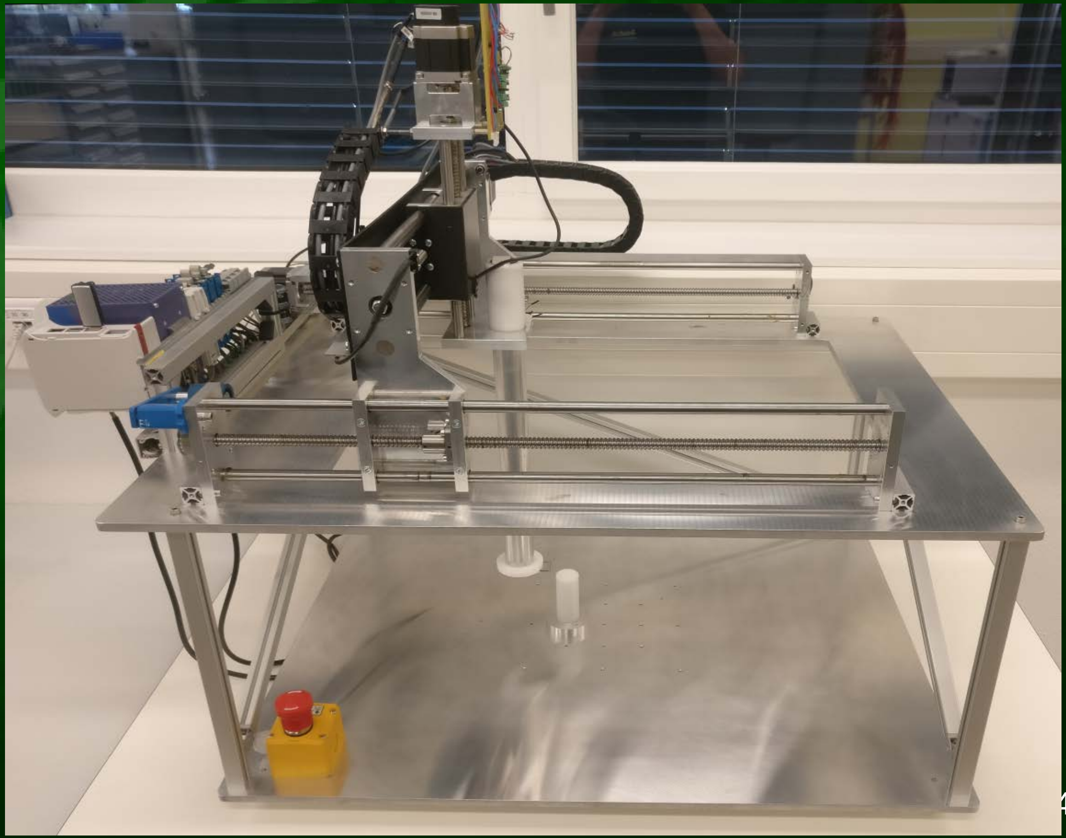
4. Acknowledgement

- **Unnamed customers willing to realize these interesting projects with us**
- **Our design and manufacturing team at T.I.P.S.**

First setup



3 axis scanning unit



Thank you for your attention!

Smart Cars –
Smart Probe Cards

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