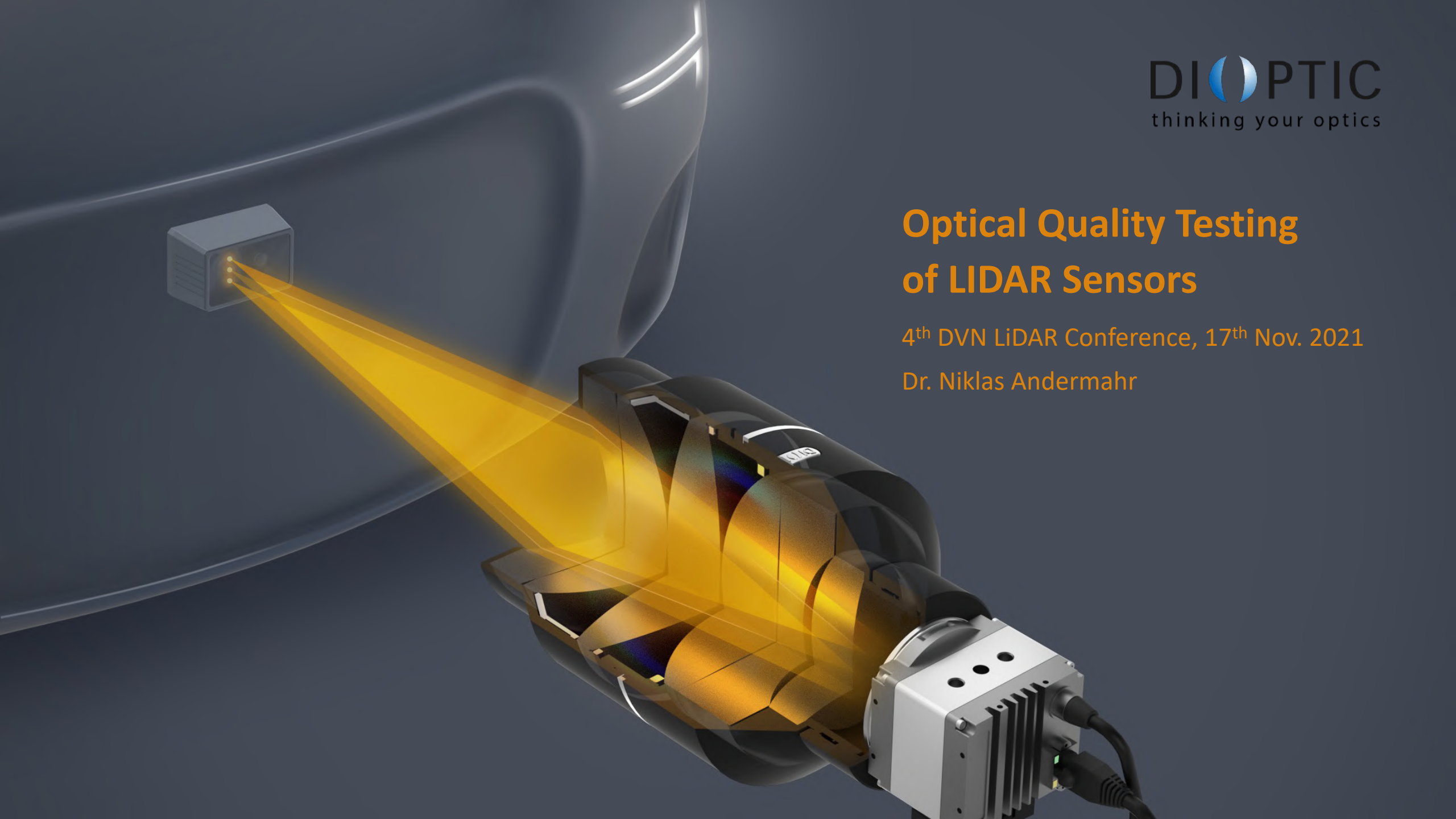
DIOPTIC
thinking your optics

Optical Quality Testing of LIDAR Sensors

4th DVN LiDAR Conference, 17th Nov. 2021

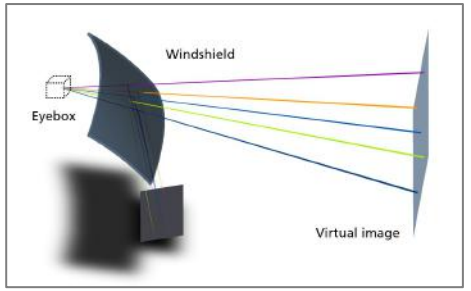
Dr. Niklas Andermahr



DIOPTIC – thinking your optics

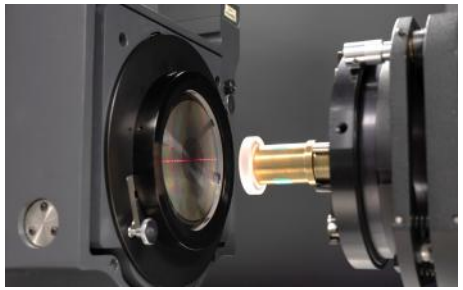
Lenses

- Optic design / lenses
- Interferometry
- Diffractive Optics



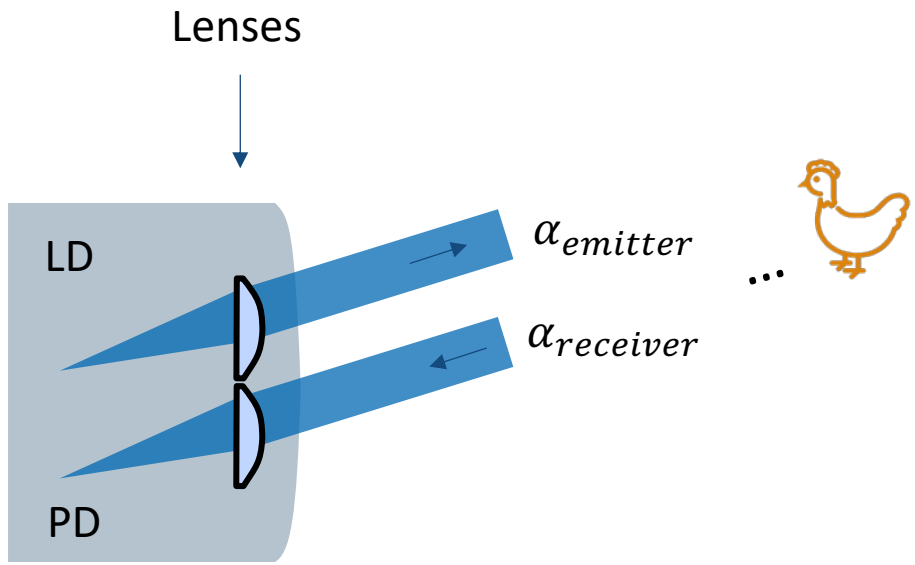
Quality Inspection

- Surface inspection
- Beam deflection measurement
- Custom inspection systems



LIDAR testing

The importance of angles

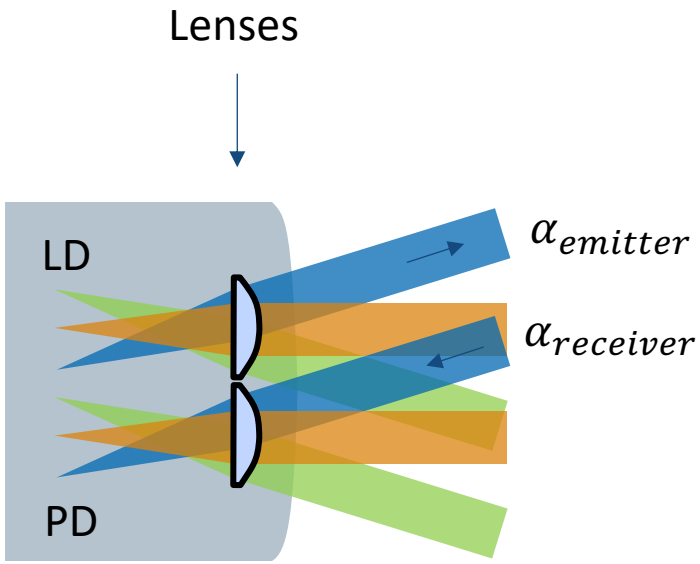


Quality Inspection

- Is light emitted to the correct angle?
- Does the receiver look at the correct angle?
- Is the alignment correct?
- Do I collect maximum number of photons?

LIDAR testing

The importance of angles



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- Does scanning / pixel switch work?

LIDAR testing

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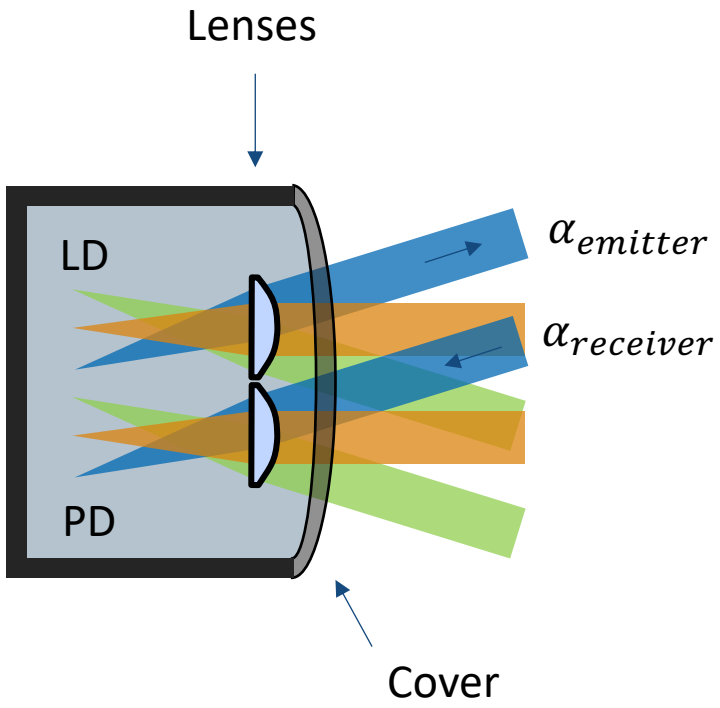

Quality Inspection

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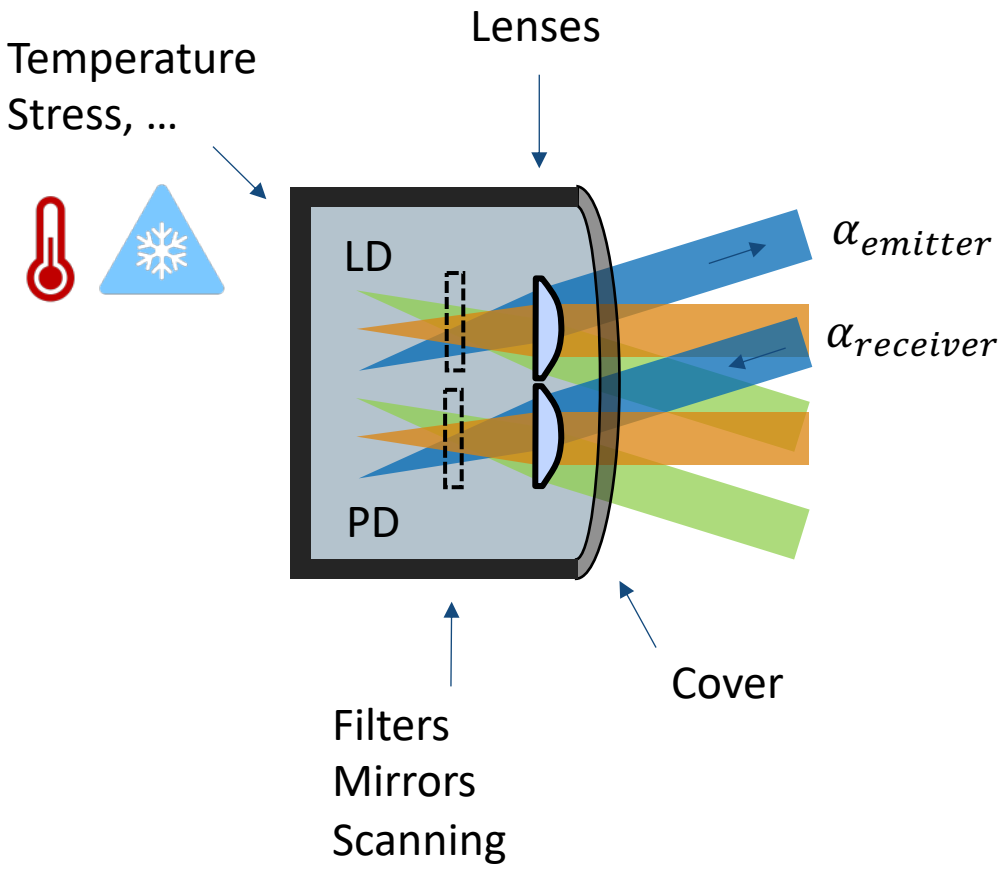
- Does the cover have an impact on the angles?

LIDAR testing

The importance of angles



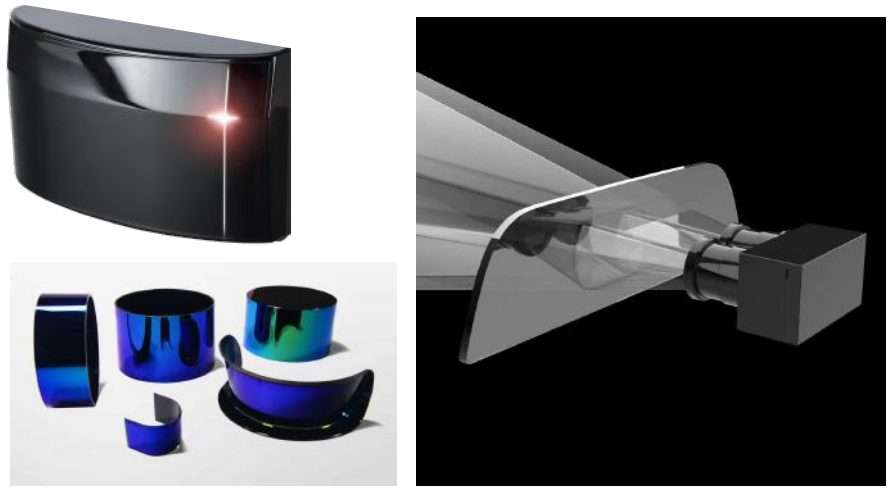
Quality Inspection

- Is light emitted to the correct angle?
- Does the receiver look at the correct angle?
- Is the alignment correct?
- Do I collect the maximum number of photons?
- Does scanning / pixel switch work?
- Does the cover have an impact on the angles?
- Does the LIDAR work?

Quality inspection of LIDAR covers

The cover influences the angle of LIDAR beam due to

- Form variation
- Thickness variation
- Temperature
- Mechanical stress

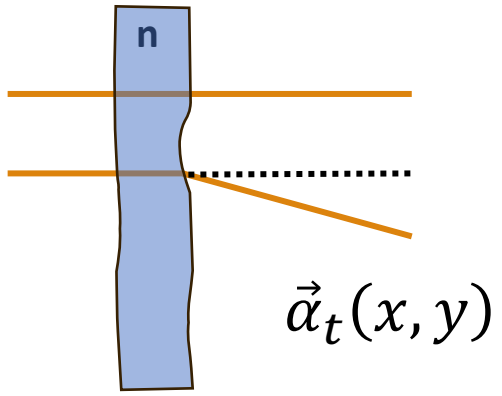


Sources: Websites: Valeo, Wideye, Alibaba

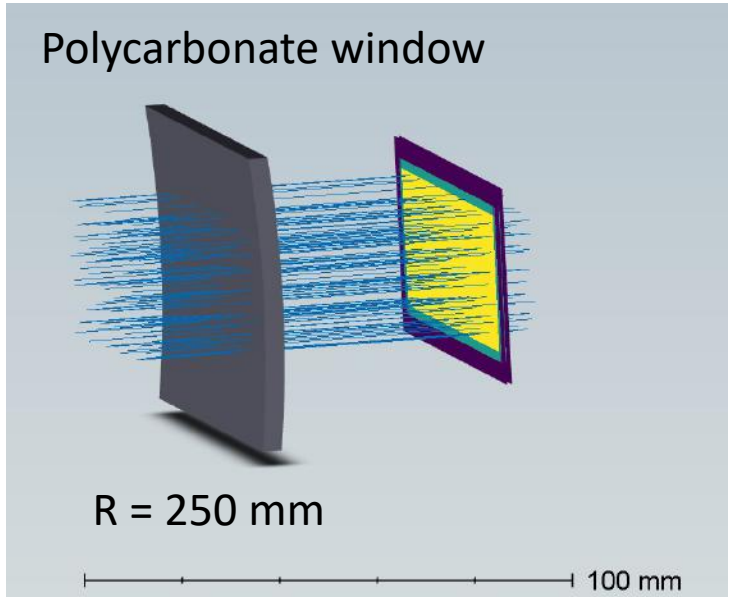
How is the quality characterized?

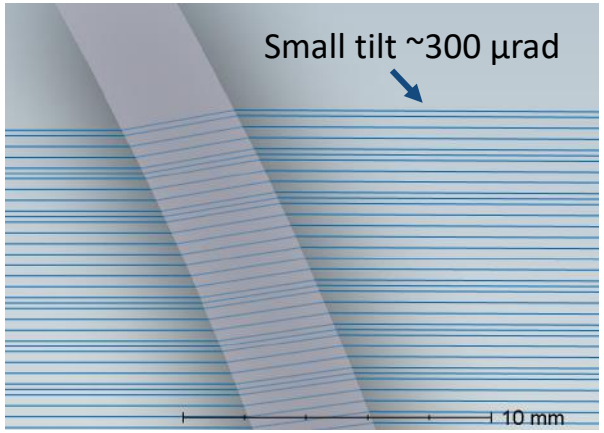
Beam Deflection Field

- Horizontal and vertical angle change after transmission through an optical component



Transmission through curved cover

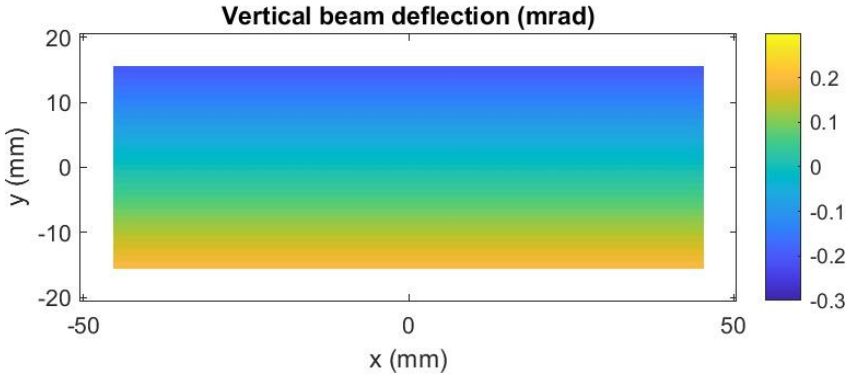


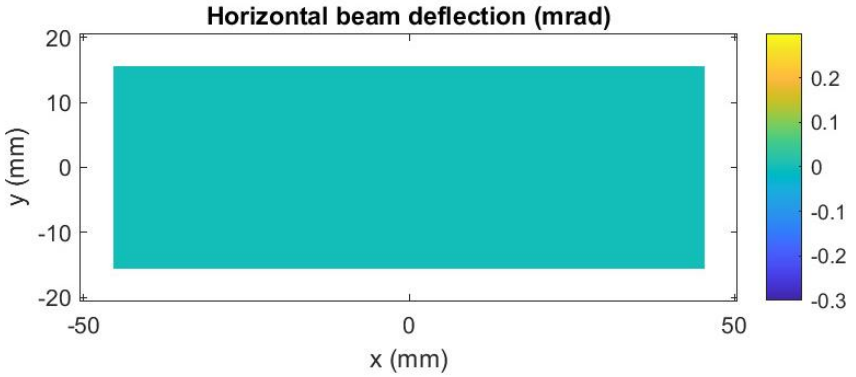


Impact of curved window

- Beam shift
- Small beam tilt (sub-mrad range)

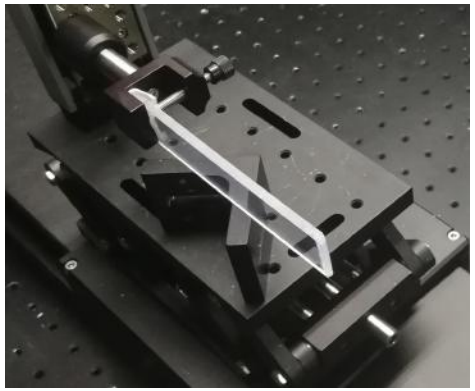
Vertical and horizontal beam deflection in dependence of position

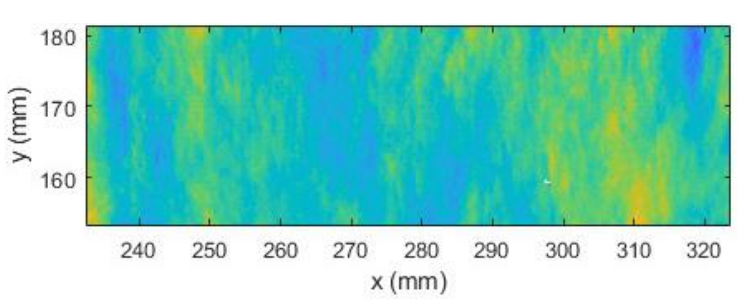


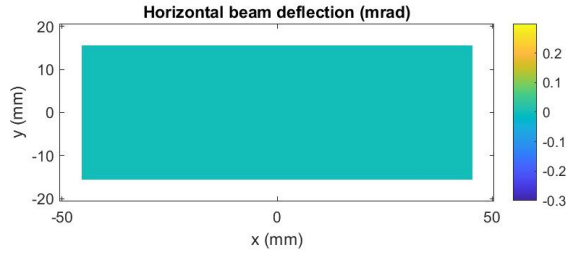


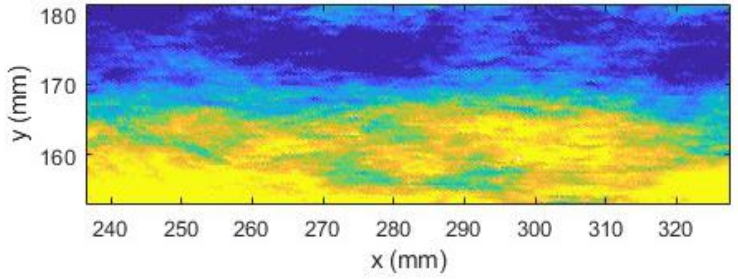
Measurement example of curved sample

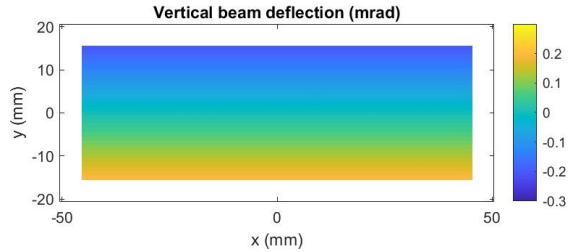
- Sample: Curved Window, R = 250 mm
- Material: Polycarbonate
- Test wavelength: 850 nm









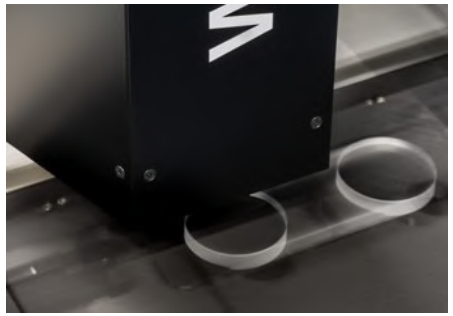


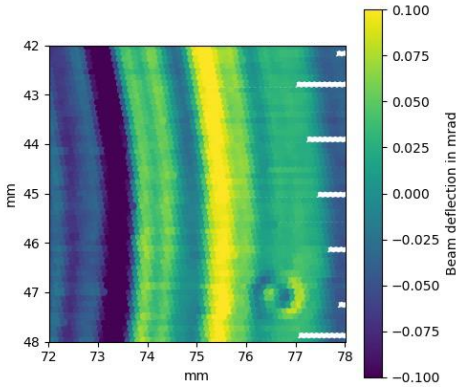
➔ Direct information on beam deflection of LIDAR beam

➔ Easy comparison to nominal beam deflection

WAVOS cover

Specifications



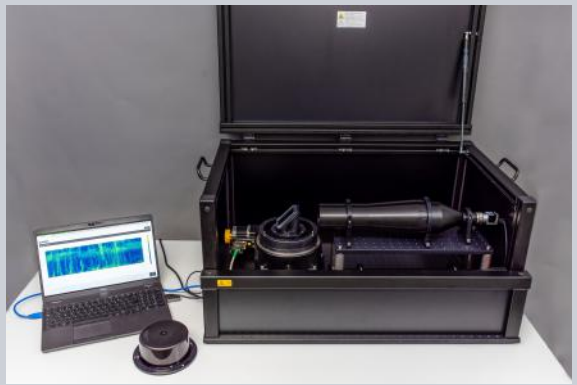
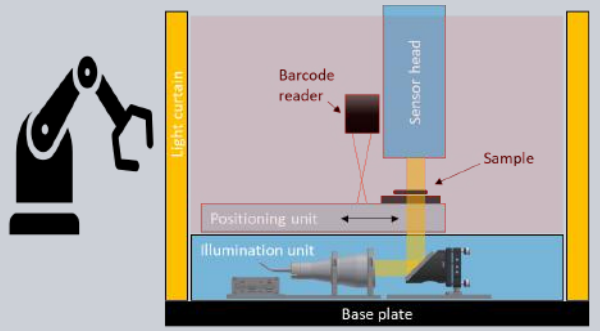


Parameter	WAVOS cover
Angular resolution	< 1/1000°
Dynamic range	±0.8°
Lateral resolution (single shot)	1 mm^2
Data points (single shot)	2000 px
Lateral resolution (pixel shift)	0.2 mm
Field of view (single shot)	Ø 40 mm
Field of view (stitching)	unlimited

Features

- Automated batch inspection
- Flexible illumination wavelength
- Precision and live mode
- Pdf-Report, Pass / Fail evaluation

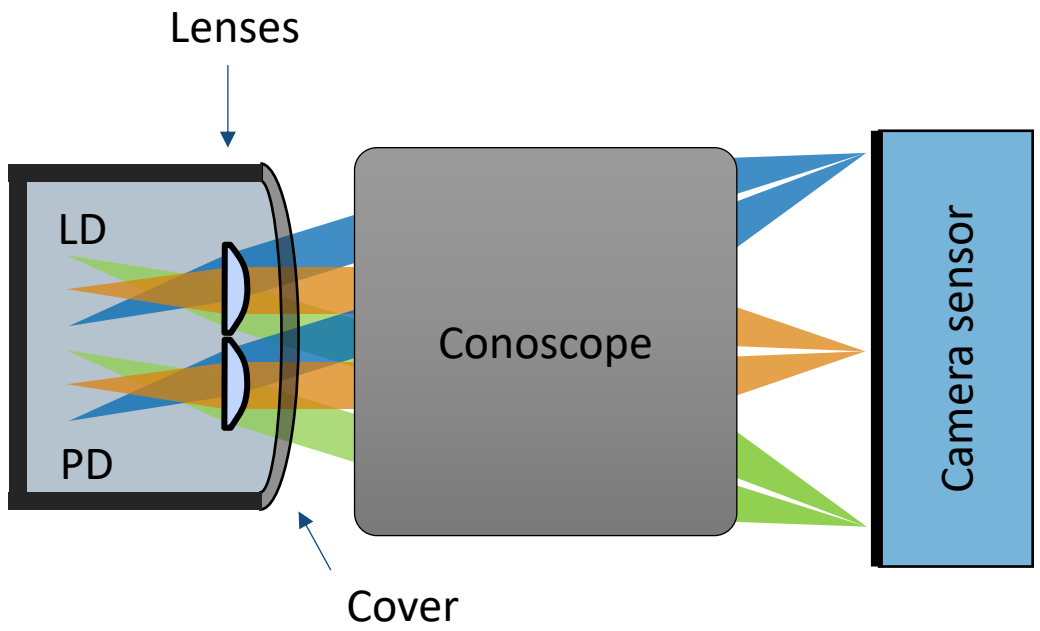
WAVOS cover systems

WAVOS cover 200	WAVOS cover 450	WAVOS cap	WAVOS production
			
▪ Design as table-top lab system ▪ Multi-part inspection as software option	▪ Larger scanning range ▪ Multi-part inspection as software option	▪ Beam deflection from protective domes ▪ 360° field of view ▪ Periscope for illumination from inside	▪ 24/7 operation ▪ Fast stages ▪ Adapted software and interfaces

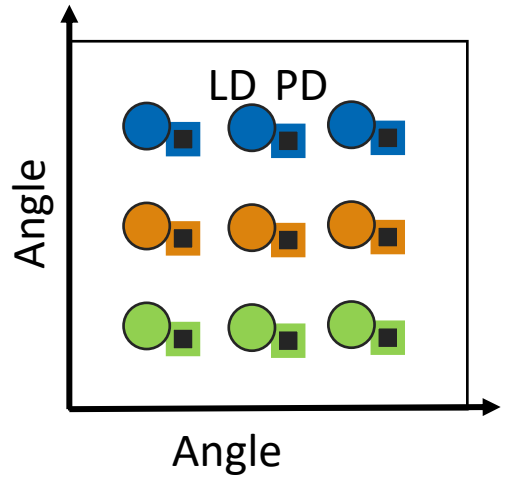
Conoscope

Emitter and receiver testing

Do emitter and receiver point to the same angles?



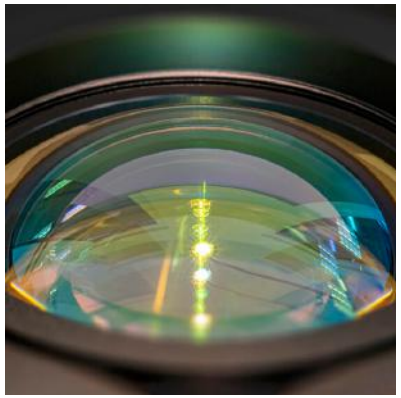
➔ Conoscope maps the angular field to camera sensor

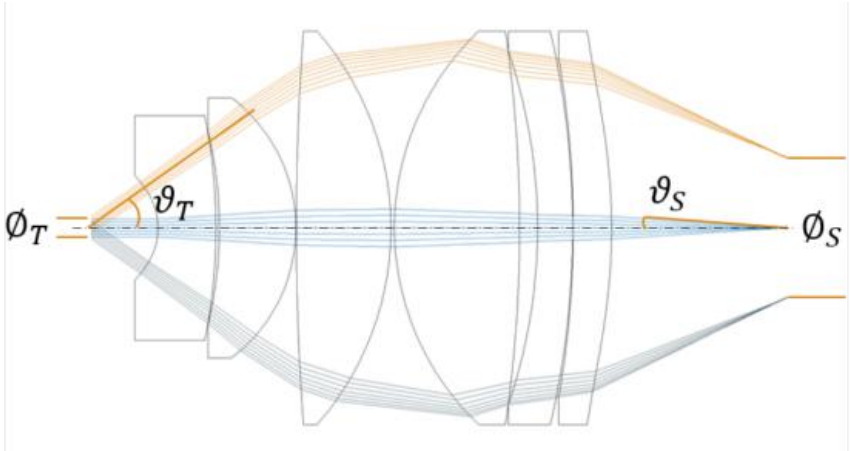


Conoscope

Emitter and receiver testing

- Conoscope lenses are used for quality inspection and end-of-line tests
- Lens design is adapted to specific LIDAR and test system requirements





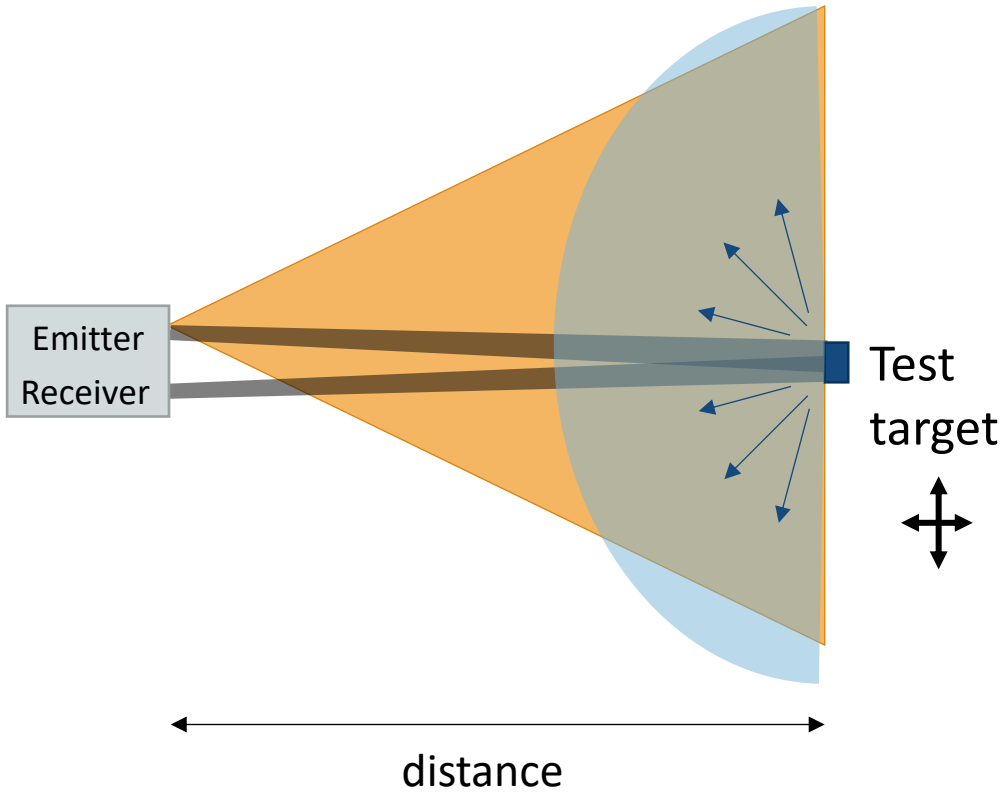
Parameter	Exemplary DIOPTIC conoscope
Angular resolution	0.04°
Field of view	+-20°
Aperture	Ø 40 mm
F-number	f/1.6
Sensor format	Medium Format
Wavelength	850-1550 nm

Conoscope

Range testing

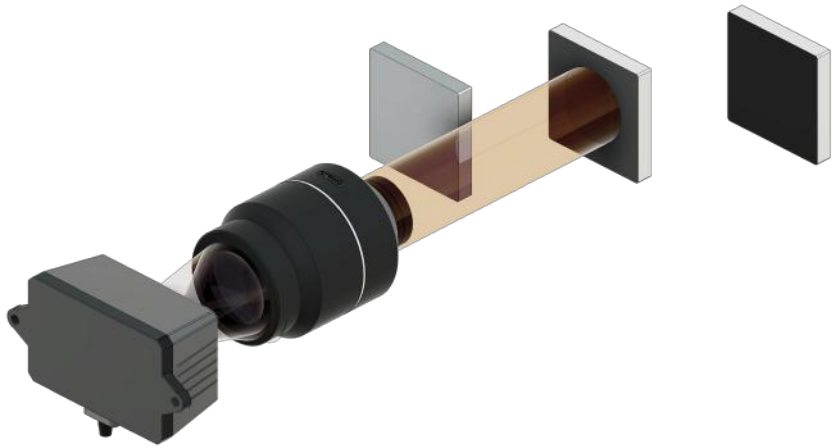
Real-world setup

- Issue: Very large setup



Conoscope setup

- Lab size setup
- Identical reflected rays are selected
- Time-of-flight is different, but SNR is used to derive LIDAR range



CONTACT LIDAR
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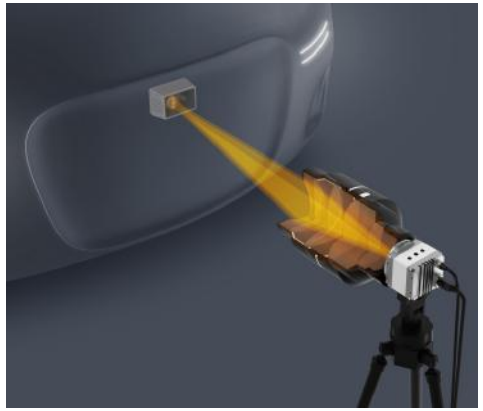

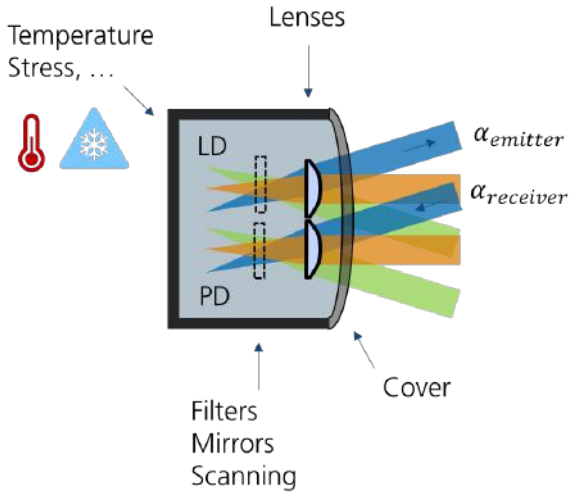

Notes