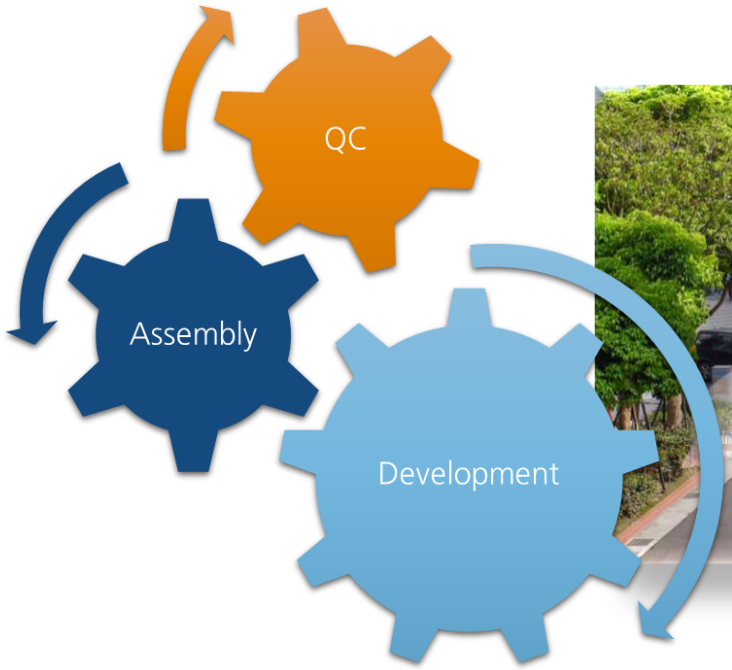
Challenges in development, assembly and testing of Lidar Sensors



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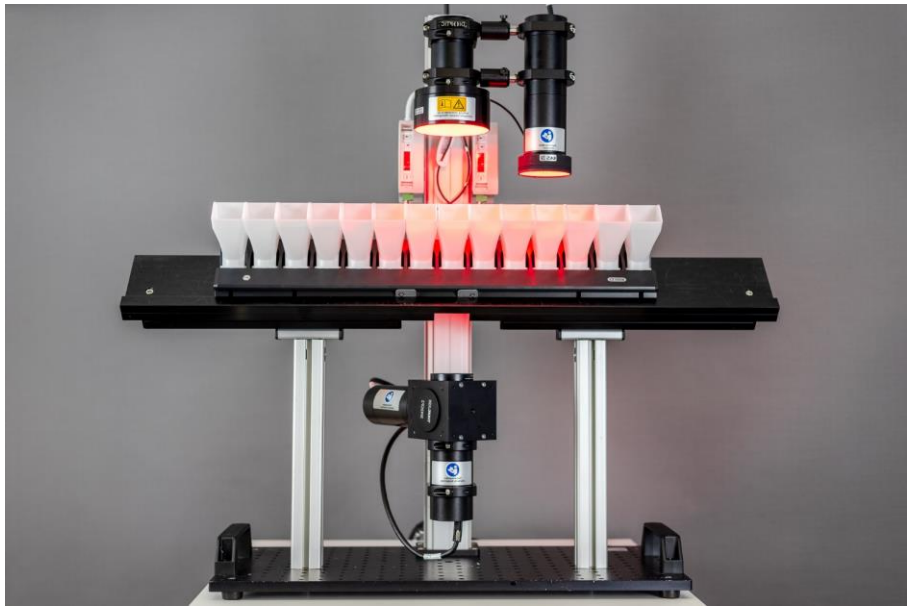
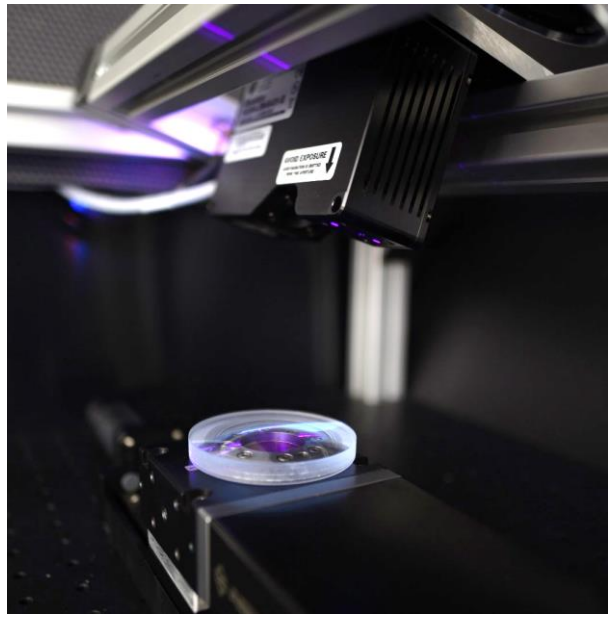
Dr. Roland Goschke
Weinheim 2019

Our Mission (1/3): *We develop and implement optical systems beyond the limits of standard solutions.*

- We combine camera, illumination and evaluation algorithm specific for your application
- We offer knowledge of a wide range of optical measurement technology



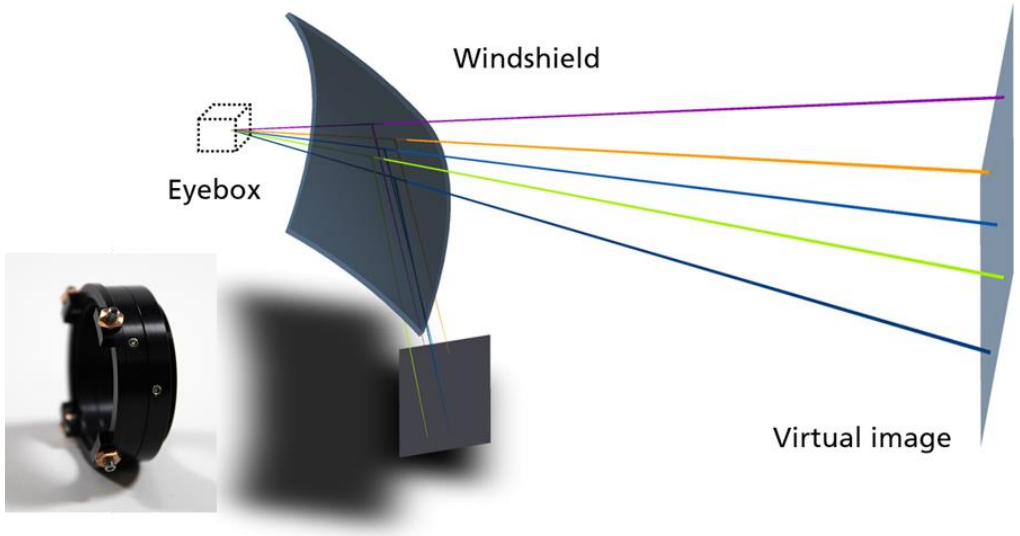
CIS – cuevette inspection system



3D geometry verification

Our Mission (2/3): *We offer a comprehensive system knowledge, short project launch times and a high degree of innovation.*

- Physical understanding and analysis of your application
- Creative solutions resulting from our interdisciplinary experience

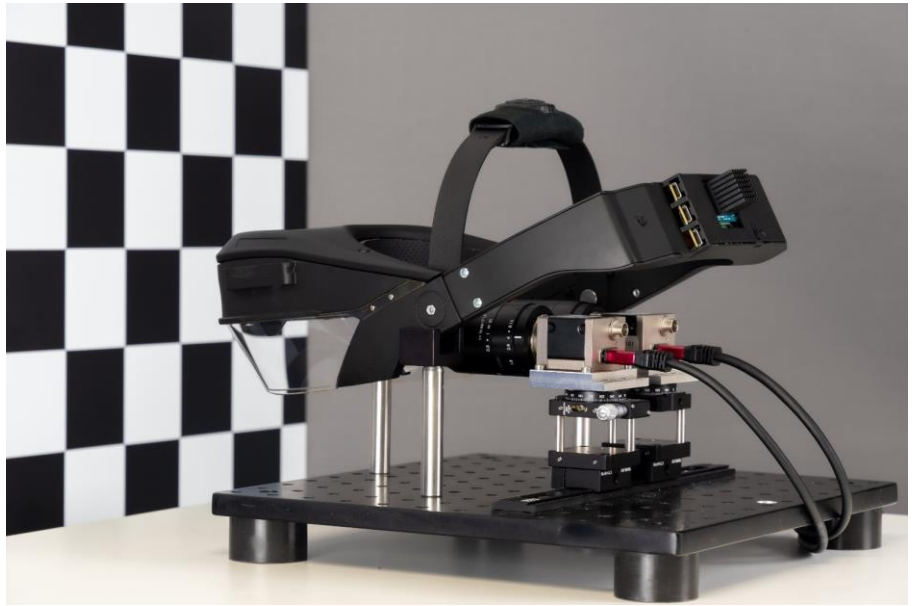


Improving windshield inspection with simple shaping optics

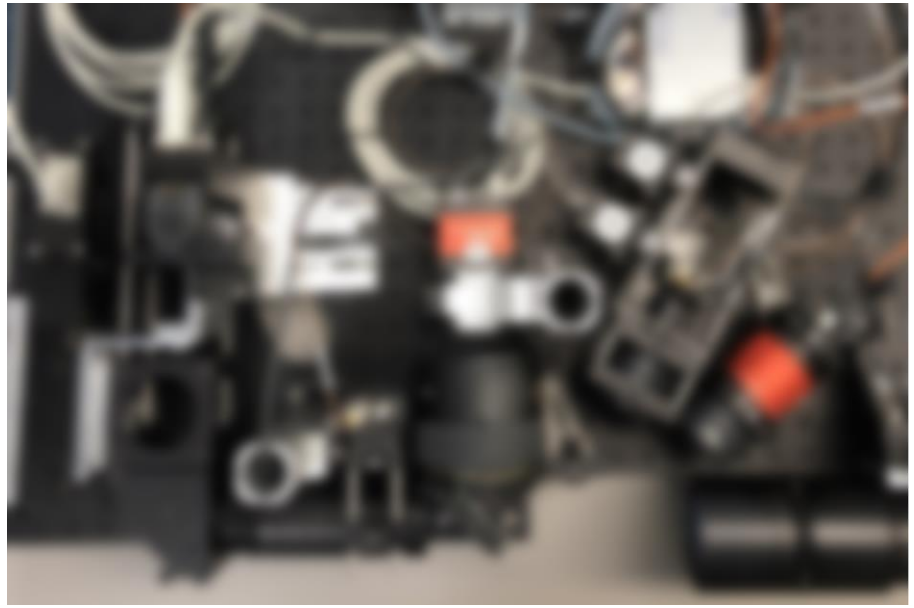
refence laser for LIDAR testing systems

Our Mission (3/3): *We offer complete solutions from a single source.*

- Design, development and prototyping of various optical systems
- Testing and characterisation based on ISO standards
- Turn-key systems with CE conformity
- Coordination and project management for complete system or inspection module

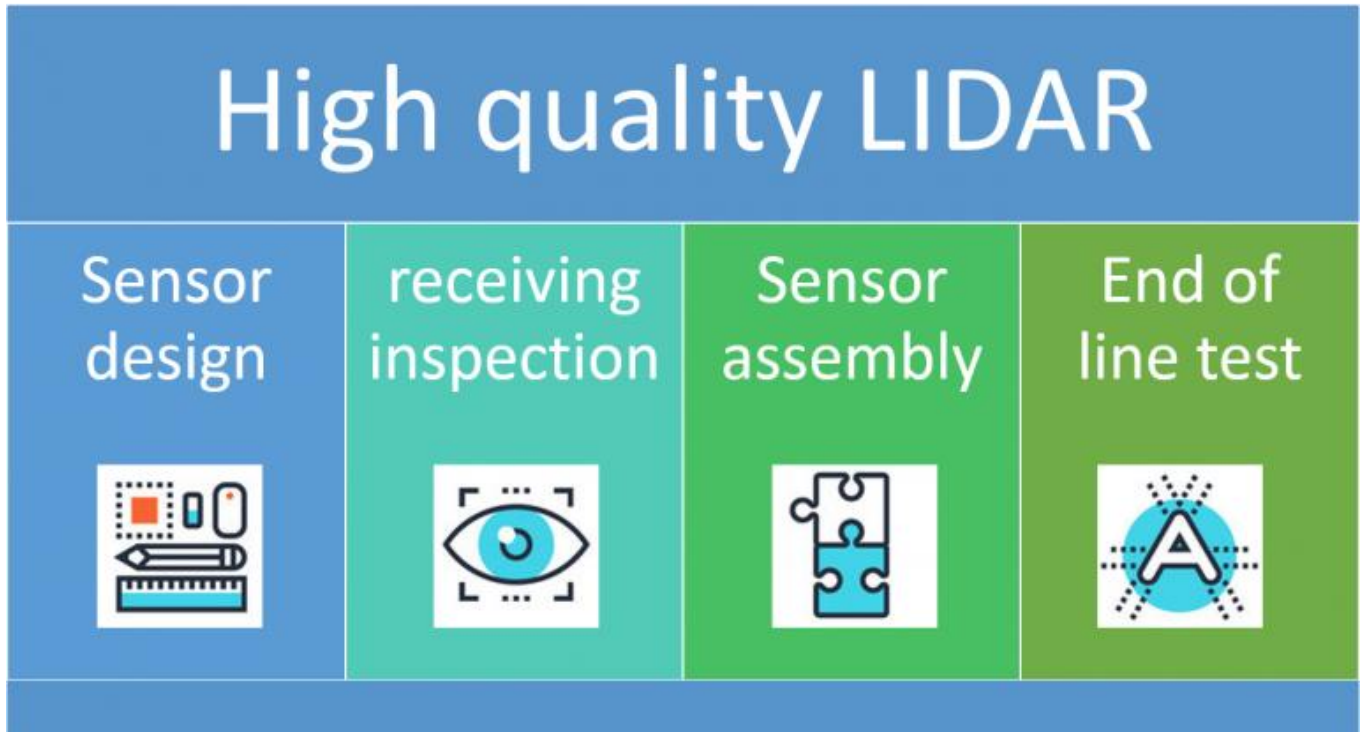


Distortion measurement for AR-glasses



Inspection optics for LIDAR sensors

Ensuring the *reliability* is challenging

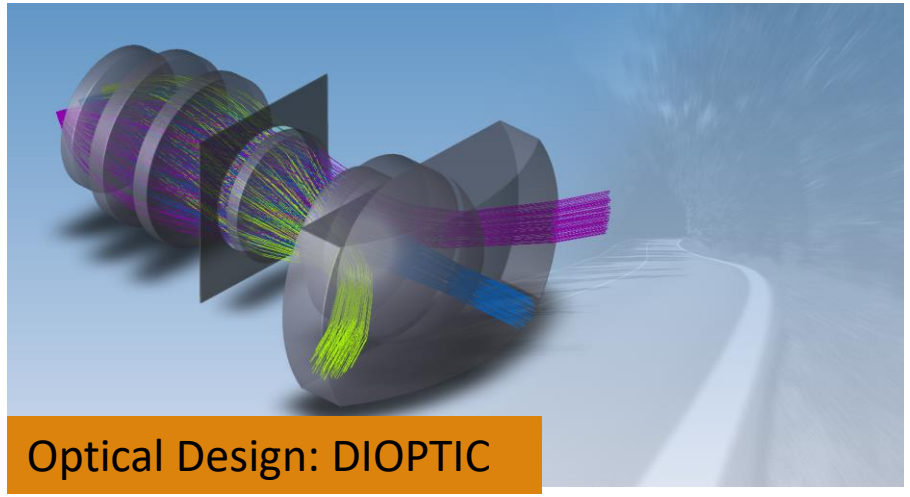


- **Sensor design:** susceptibility to manufacturing tolerances
- Quality of each **single component** counts
- Precise alignment required during **sensor assembly**
- **End of line test** critical to meet strict requirements

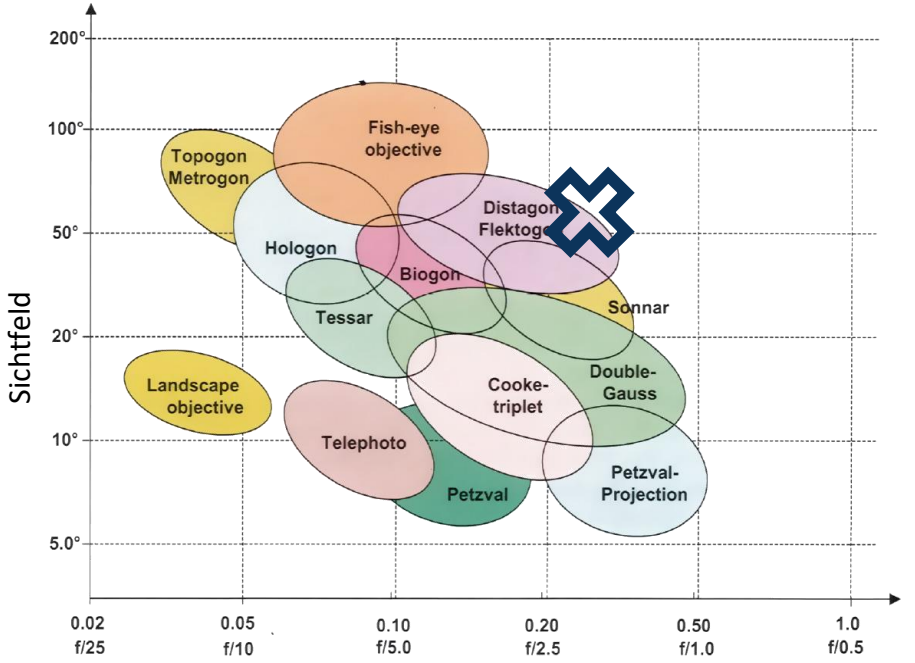
Optic design

Lidar Reciever

- Development and challenges depending on the concept (Flash vs. Scanning)
- Reciever
  - Horizontal field of view up to 150°
  - Cross-talk with light path of sender
  - Fast optical systems F/# < 1,0
- General challenges:
  - Costs of components
  - Limited space
  - Automotive temperature range -40°…+95°C
  - Lots of vibrations
  - Quality standards (→ Quality control)



Optical Design: DIOPTIC



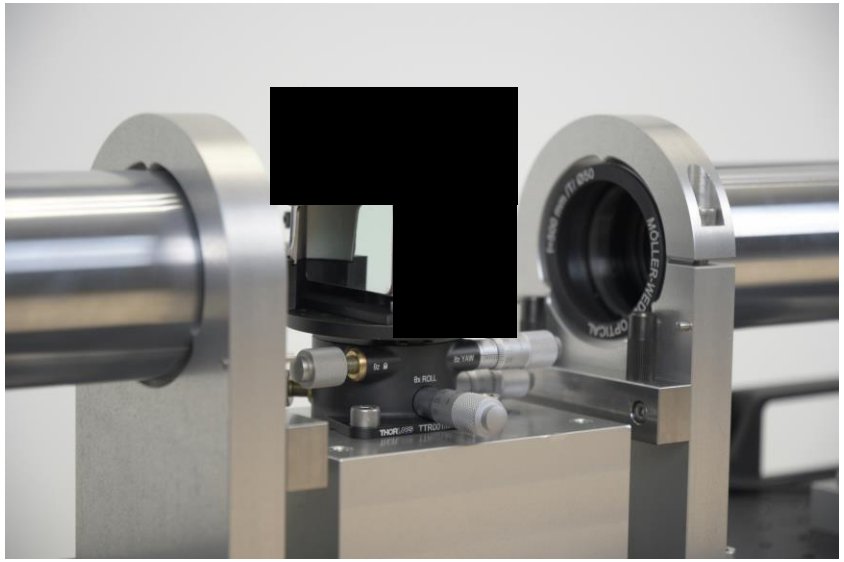
Source: H. Gross, Handbook of optical systems

Component inspection

Example: Rotating mirror

Part: Rotation mirror

- Critical specifications
  - Parallelism of the two mirrors
  - Angle of the mirrors to the reference surface
- Requirements for system
  - Angular measurement with accuracy < 0,001°



Mirror test system by DIOPTIC

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Component inspection

Example: Protection window

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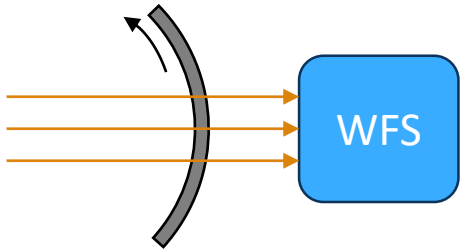
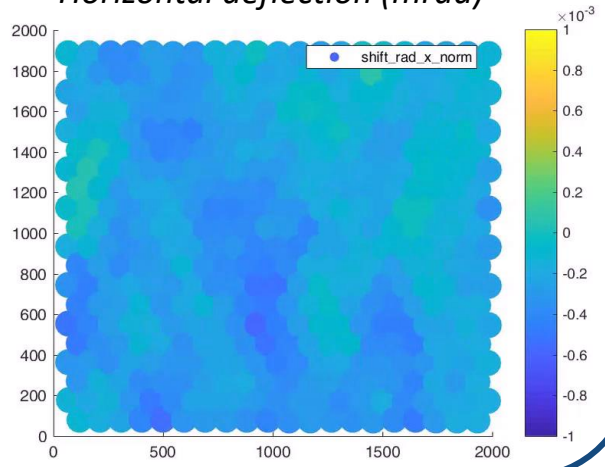
Component: Protection window

- Challenges
  - Form errors cause angular errors of the lidar
  - Testing to angular range of 360°
- Solutions
  - 3D-imaging (shape measurement)
  - Wavefront sensor

Setup measurement of angle deflection



Horizontal deflection (mrad)

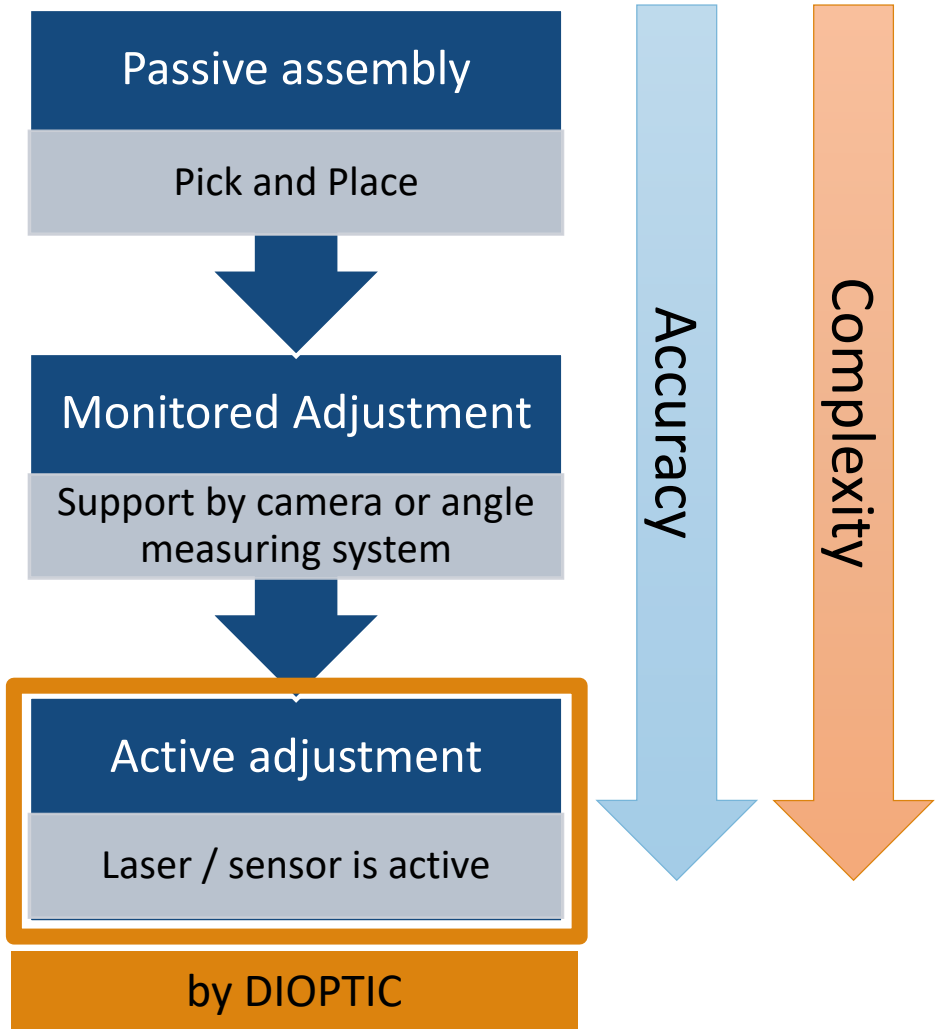


Angular distortion test system by DIOPTIC

Alignment and assembly

- Tight Tolerances: sender
  - Emission angle of the Lasers
  - Divergence of the laser
  - Decentralization, focal length of lenses
  - Angle and position tolerances
- Tight Tolerances: receiver
  - Aberrations
  - Location, angle of image sensor
  - Location APDs
  - Orientation rotation mirror

→ Concatenation of tolerances often requires monitored or active alignment



Alignment and assembly

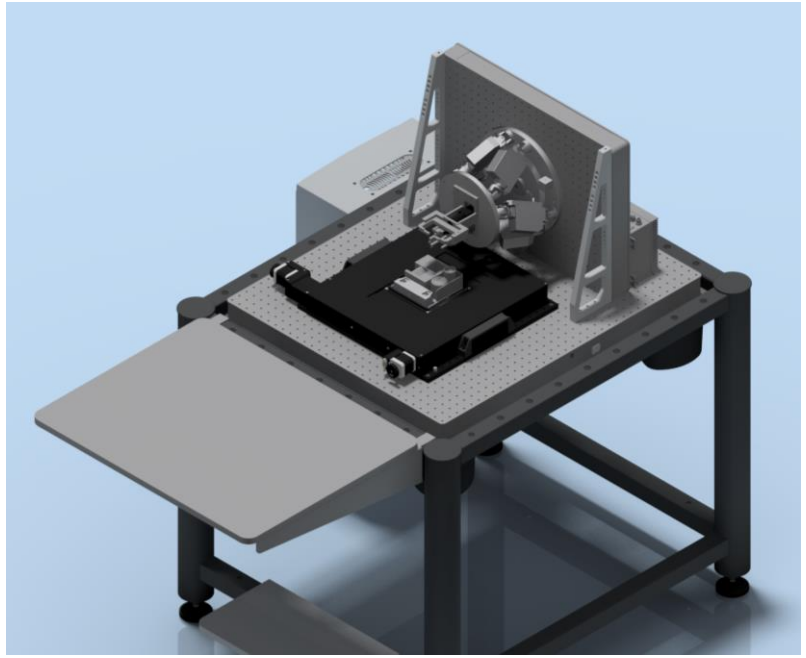
Emitter assembly

Challenges

- Multiple optical components must be aligned

Tasks

- Conception
- Measurement of
  - Position and angle of optical components
  - Emission angle of Laser
  - Focus position of Laser
  - Reference points
- Positioning and alignment
- Fixation by UV adhesive



Assembly tool by DIOPTIC

Alignment and assembly

Reciever assembly

Issue

- Cheap lenses typically have a tilted image plane due to tolerance
- 6 degrees of freedom

System

- Detection of reference markers for angular alignment
- Alignment of the sensor behind lens to correct tilting of the image plane

Benefit DIOPTIC

- Benefit from our knowledge in lens design and building high end inspection systems

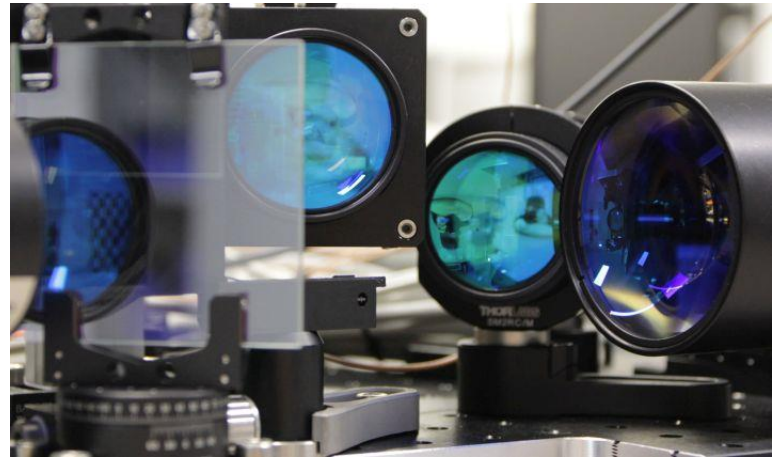
Alignment & Assembly by DIOPTIC

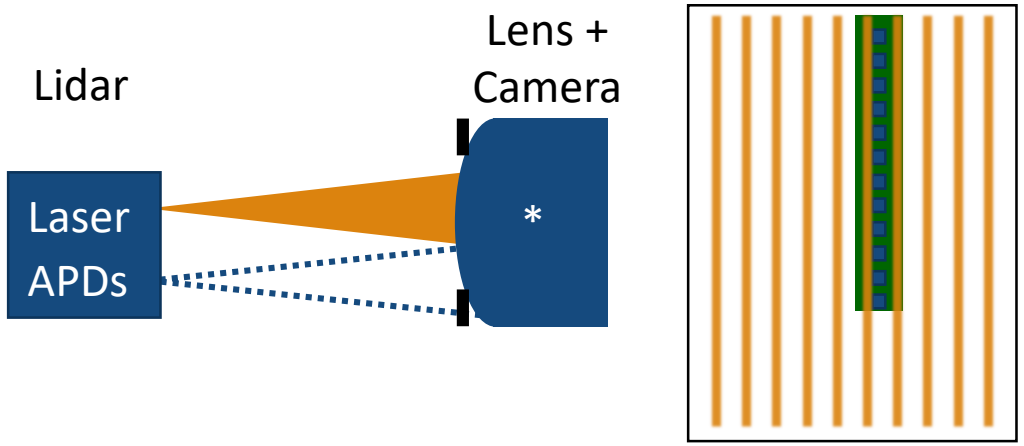
Inspection systems

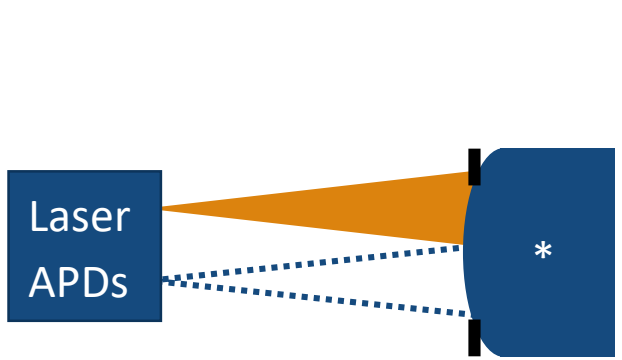
Alignment of send and receive path

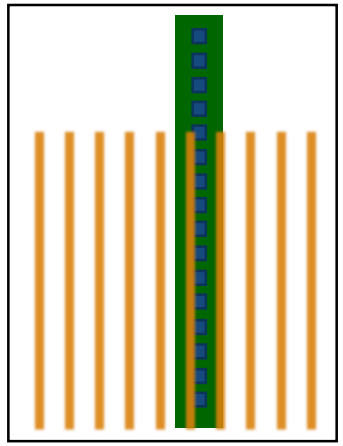
Challenges

- Synchronization
- Lighting of APDs
- Aperture of the lens must be very large









Huge aperture objective design by DIOPTIC

Inspection systems

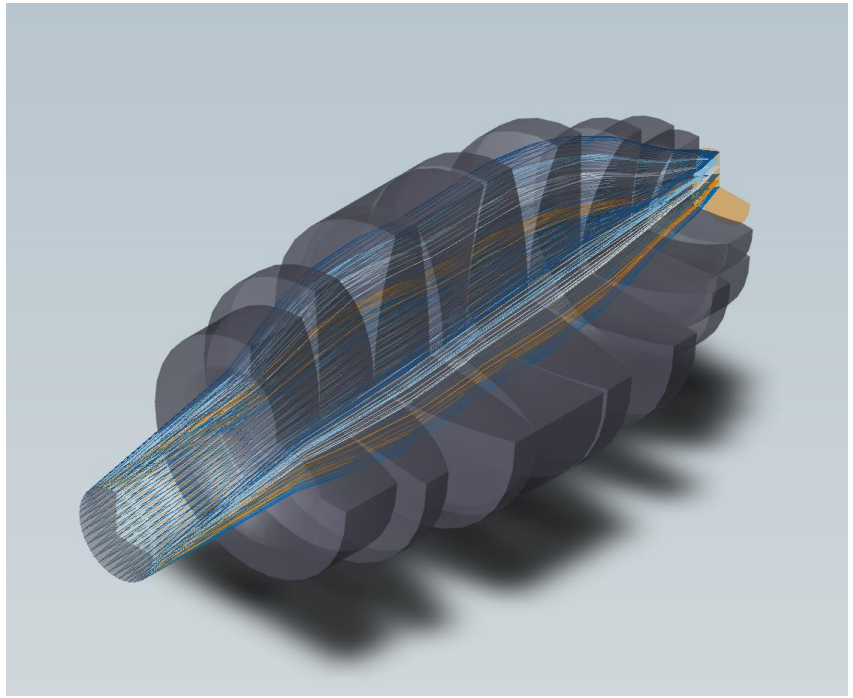
Conoscopy

Conoscopy

- *greek: konos = cone,*
  skopeo = to inspect
  → Inspection of angle fields

Challenges / Special features

- The entrance pupil is in front of the lens (all light emitted needs to be collected)
- Large aperture
- Calibration of distortion (“Object in infinity”
  → Use of DOEs)



Huge aperture objective design by DIOPTIC:
150 mm diameter
365 mm length
9 lenses

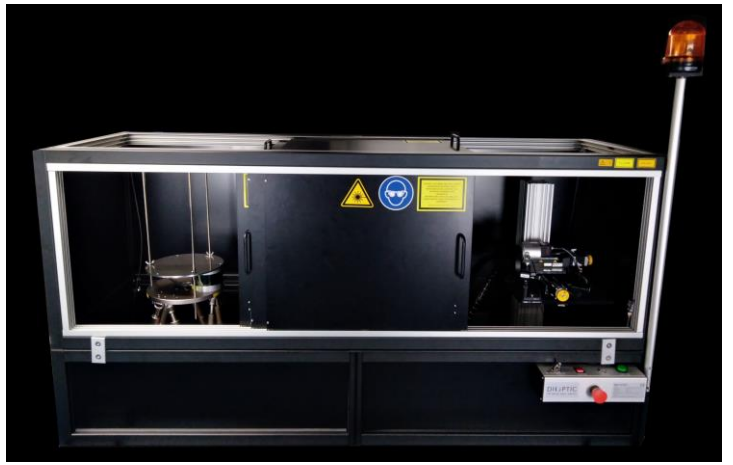
Inspection systems

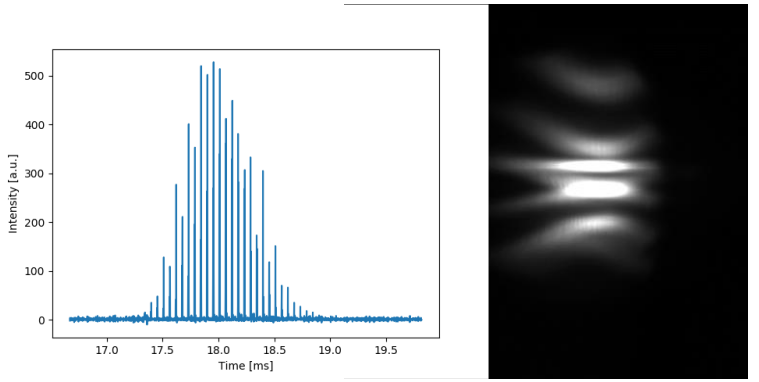
Eye safety

... more photons allow longer range of lidar

- According to DIN EN 60825-1, the permissible irradiance and duration on the retina is specified.
- Irradiance depends on:
  - Laser power
  - Pulse pattern
  - Beam parameters (divergence, diameter, focus position, beam quality)
  - Scanning speed
  - Accommodation of the eye
  - Pupil size (according to standard 7 mm)

➔ ***Inspection system must cover large number of configurations***





Eye Safety test stand by DIOPTIC

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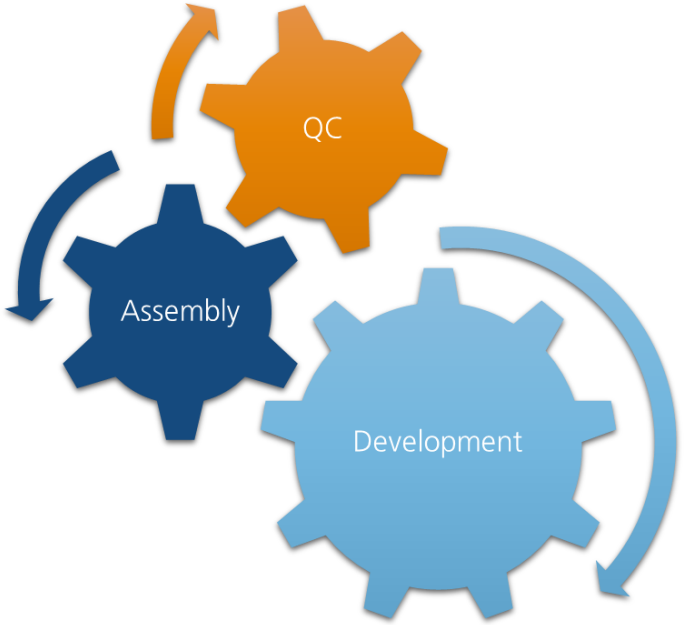
Our services for lidar systems

Development

- Consulting
- Optic design
- Prototyping



Assembly systems

- Conception
- Monitored alignment
- Active alignment

Inspection systems

- Component inspection
- End-of-line systems

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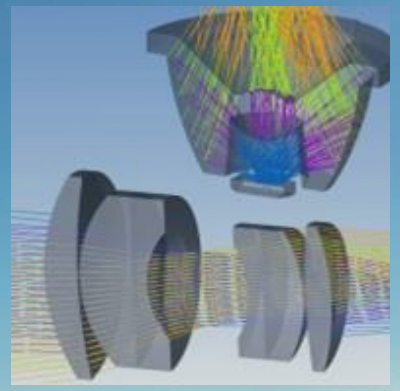
Weinheim 2019

DIOPTIC
thinking your optics



OPTIC DESIGN

CUSTOM INSPECTION SYSTEMS

DIFFRACTIVE OPTICS

IR-LENSES

ARGOS SURFACE INSPECTION

CONTACT
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