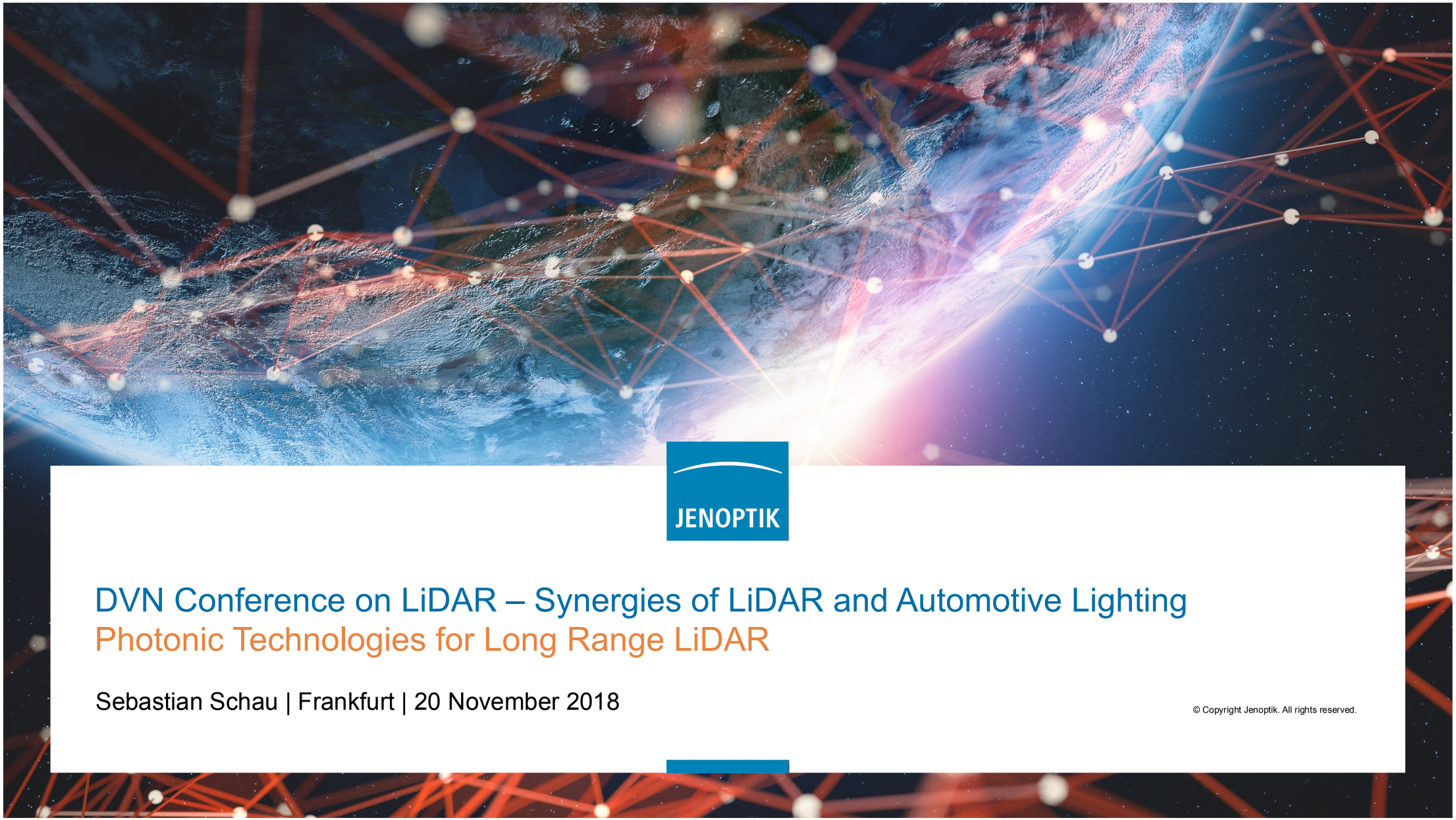


DVN Conference on LiDAR – Synergies of LiDAR and Automotive Lighting

Photonic Technologies for Long Range LiDAR

Sebastian Schau | Frankfurt | 20 November 2018

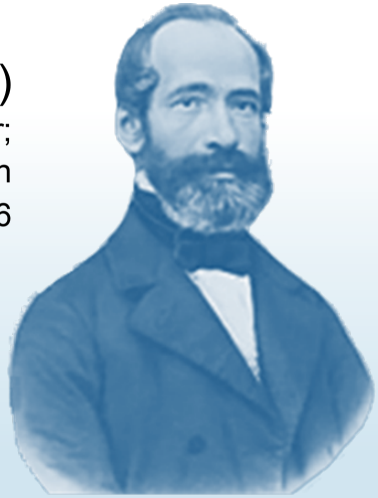
Jenoptik – Photonics for LiDAR-Technology

Our roots…

… go back to the German industrialization age more than 150 years ago.
Our tradition is based on the early German optical and precision industry.

Carl Zeiss (1816 – 1888)

mechanic and entrepreneur;
founded his first workshop for precision mechanics and optics in Jena in 1846

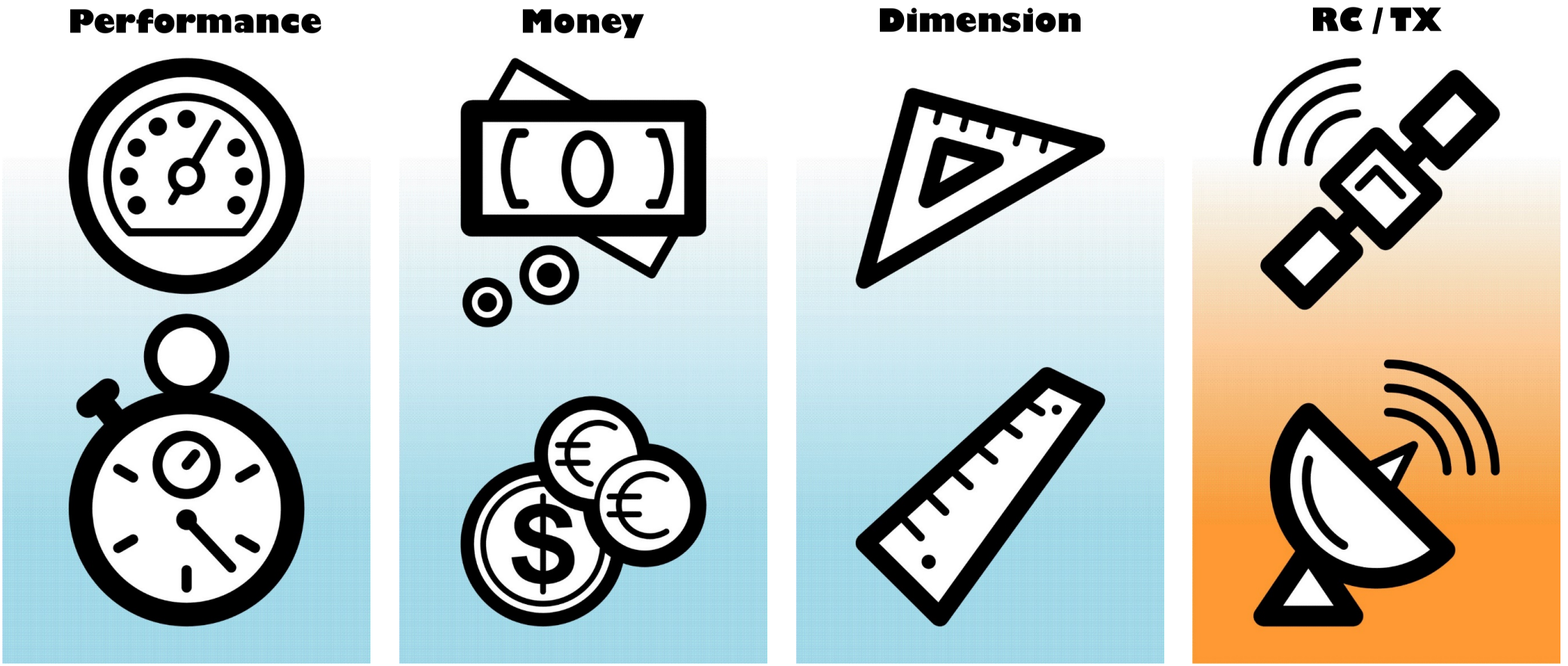


Ernst Abbe (1840 – 1905)

University physicist, Innovator and reformer;
in 1866 scientific director and
in 1875 partner in the Zeiss workshop

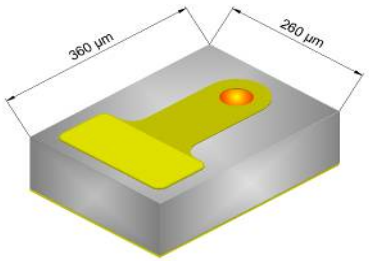
LiDAR for automotive

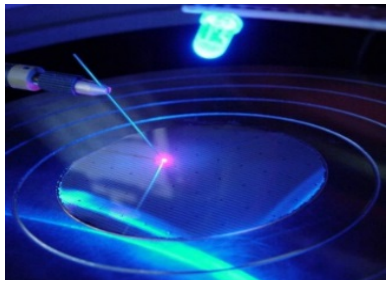
Challenges / main components

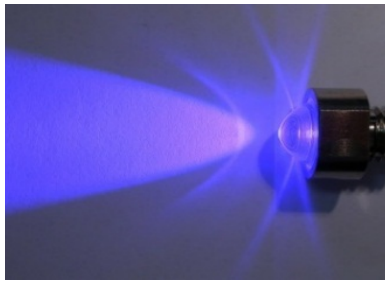


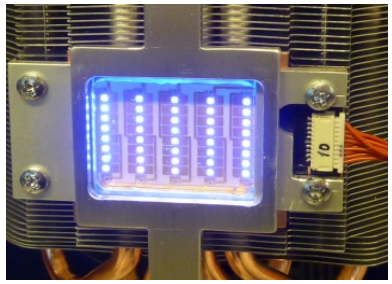
Performance Transmitter

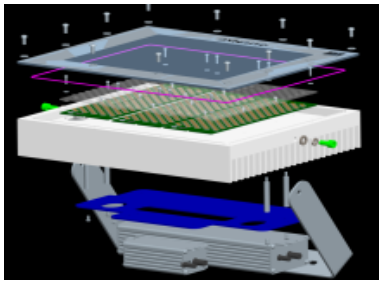
System design: from component to system









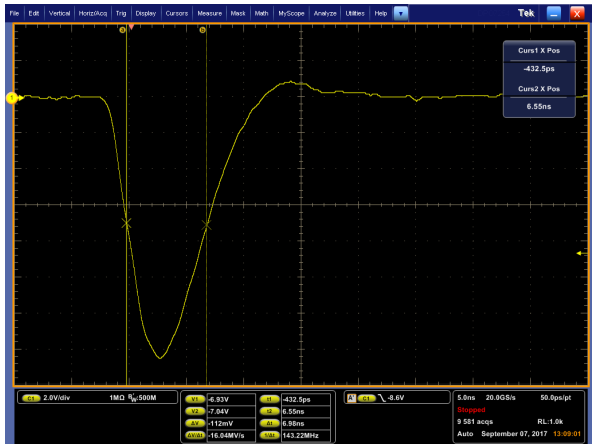


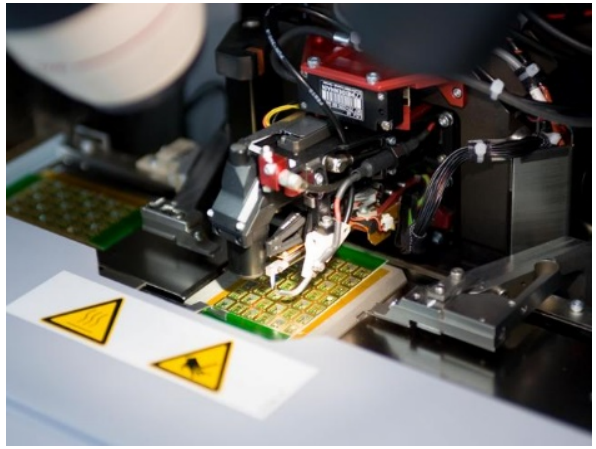
Specification & Development | Semiconductor manufacturing | Components | Sub-assemblies | System integration

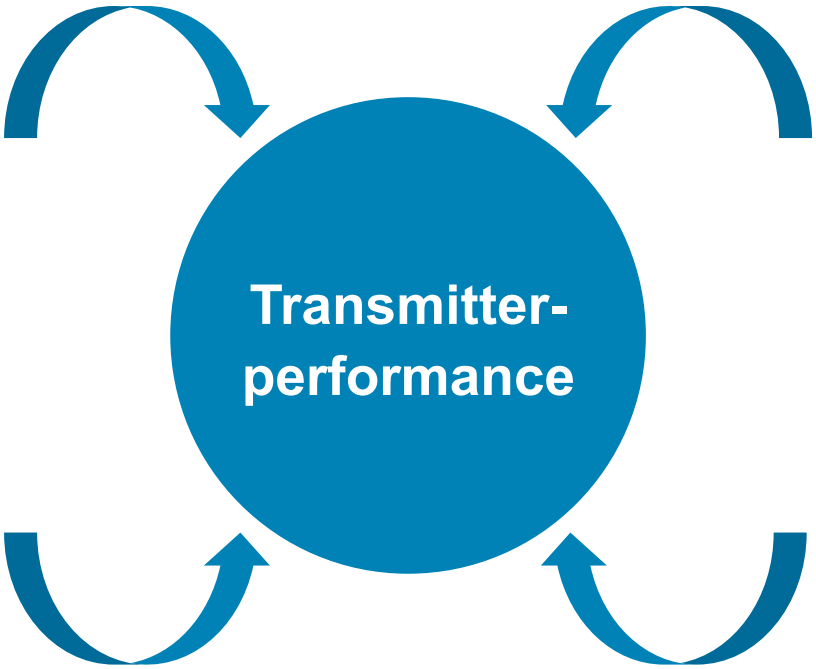
Epitaxy | Modules | Systems

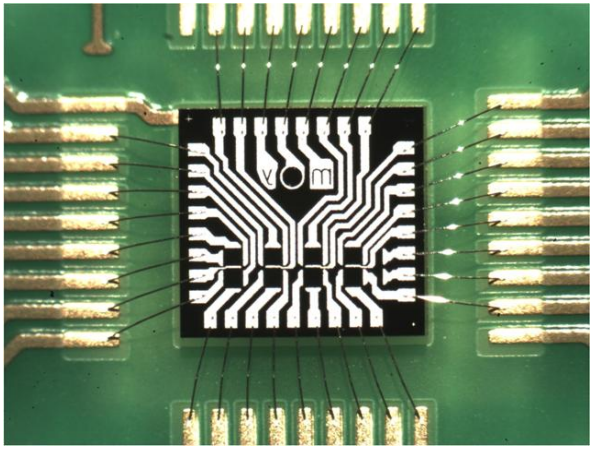
Performance Transmitter

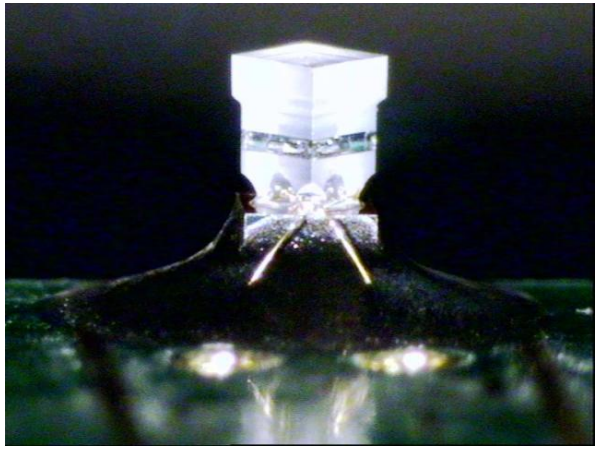
Short pulses & high power





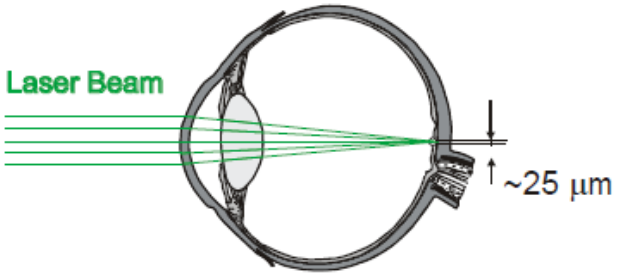






Performance Transmitter

Laser classification – the classic approach



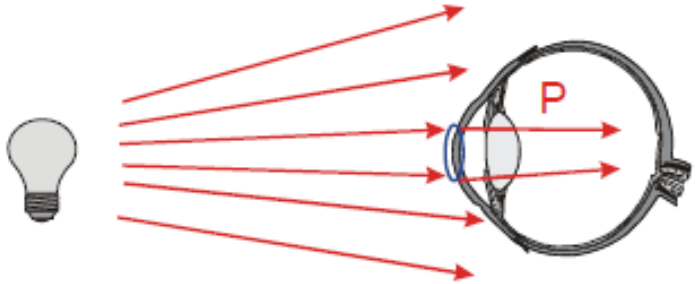
Source: 'The Apparent Source' – A Multiple Misnomer

Wavelength λ nm	Emission time t s										
	10^{-13} to 10^{-11}	10^{-11} to 10^{-9}	10^{-9} to 10^{-7}	10^{-7} to 5×10^{-6}	5×10^{-6} to $1{,}3 \times 10^{-5}$	$1{,}3 \times 10^{-5}$ to 1×10^{-3}	1×10^{-3} to 0,35	0,35 to 10	10 to 10^{2}	10^{2} to 10^{3}	10^{3} to 3×10^{4}
180 to 302,5	3×10^{10} W · m^{-2}		30 J · m^{-2}								
302,5 to 315	2, 4×10^{4} W		Thermal hazard ($t \le T_1$) $7{,}9 \times 10^{-7} C_1$ J					Photochemical hazard $7{,}9 \times 10^{-7} C_2$ J ($t > T_1$)	$7{,}9 \times 10^{-7} C_2$ J		
315 to 400			$7{,}9 \times 10^{-7} C_1$ J						$7{,}9 \times 10^{-3}$ J		$7{,}9 \times 10^{-6}$ W
400 to 450	$3{,}8 \times 10^{-8}$ J		$7{,}7 \times 10^{-8}$ J		$7 \times 10^{-4} t^{0,75}$ J				$3{,}9 \times 10^{-3}$ J		
450 to 500									$3{,}9 \times 10^{-3} C_3$ J and $3{,}9 \times 10^{-4}$ W		$3{,}9 \times 10^{-5} C_3$ W
500 to 700									$3{,}9 \times 10^{-4}$ W		
700 to 1 050	$3{,}8 \times 10^{-8}$ J		$7{,}7 \times 10^{-8} C_4$ J		$7 \times 10^{-4} t^{0,75} C_4$ J				$3{,}9 \times 10^{-4} C_4 C_7$ W		
1 050 to 1 400[d]	$3{,}8 \times 10^{-8} C_7$ J		$7{,}7 \times 10^{-7} C_7$ J			$3{,}5 \times 10^{-3} t^{0,75} C_7$ J					
1 400 to 1 500	8×10^{5} W		8×10^{-4} J			$4{,}4 \times 10^{-3} t^{0,25}$ J	$10^{-2} t$ J		$1{,}0 \times 10^{-2}$ W		
1 500 to 1 800	8×10^{6} W		8×10^{-3} J				$1{,}8 \times 10^{-2} t^{0,75}$ J				
1 800 to 2 600	8×10^{5} W		8×10^{-4} J			$4{,}4 \times 10^{-3} t^{0,25}$ J	$10^{-2} t$ J				
2 600 to 4 000	8×10^{4} W		8×10^{-5} J		$4{,}4 \times 10^{-3} t^{0,25}$ J						
4 000 to 10^{6}	10^{11} W · m^{-2}		100 J · m^{-2}		$5\,600\, t^{0,25}$ J · m^{-2}				1 000 W · m^{-2}		

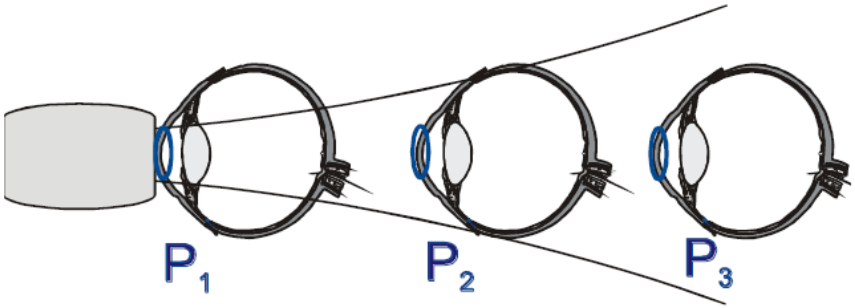
Safety of laser products: IEC 60825-1:2014

Performance Transmitter

Laser classification – extended source



Source: '*The Apparent Source' – A Multiple Misnomer*



Source: 'The Apparent Source' – A Multiple Misnomer

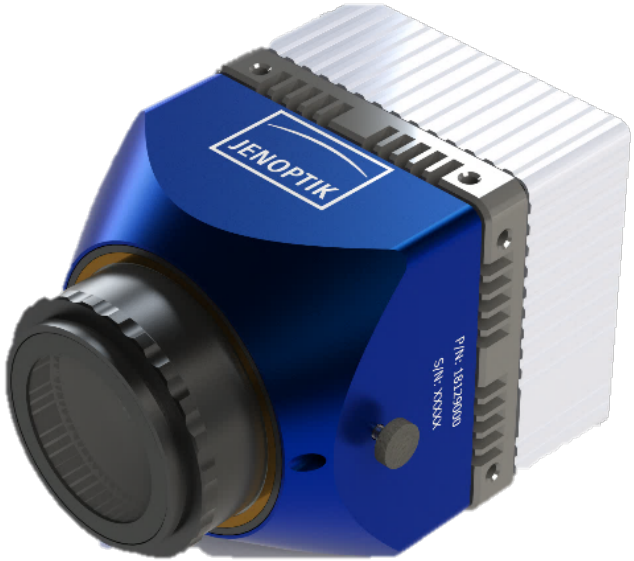
70 Nano Joule

290 Nano Joule

LiDAR Testing

From development to inline tests

LidarScope™



LiDAR Scope: Inline automated testing

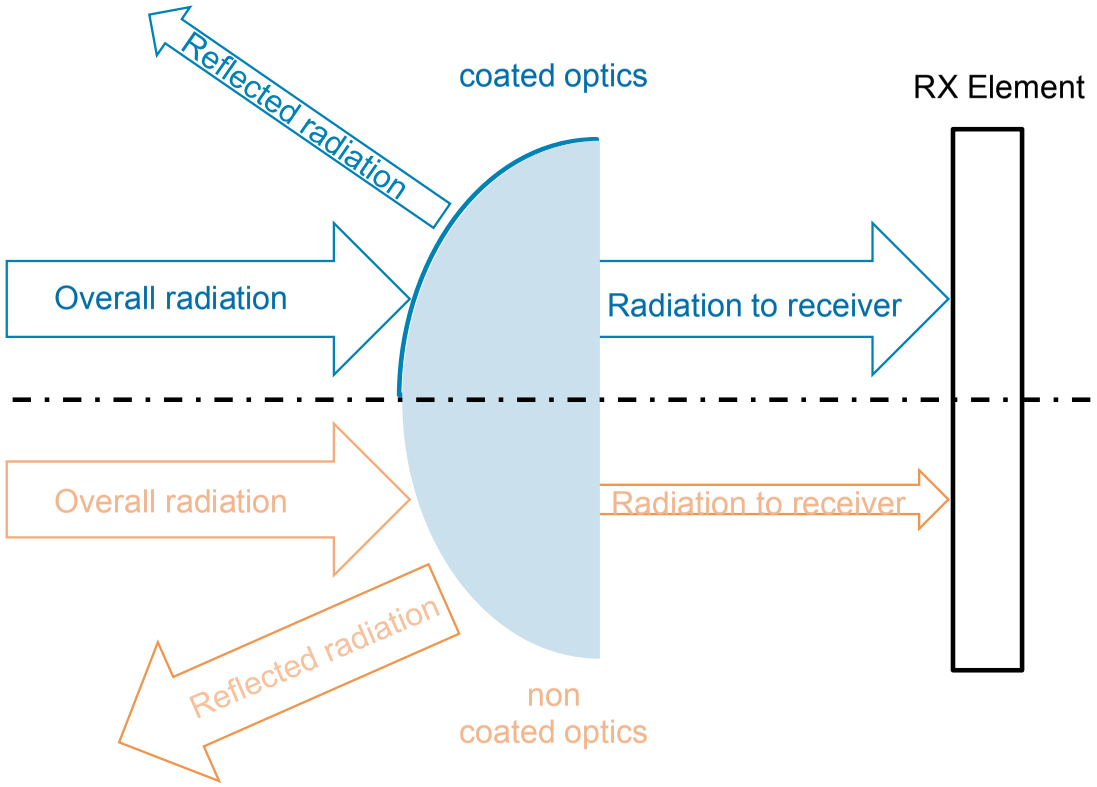
@ LiDAR manufacturers

@ technical inspection authorities (e.g. TÜV)

@ car workshops

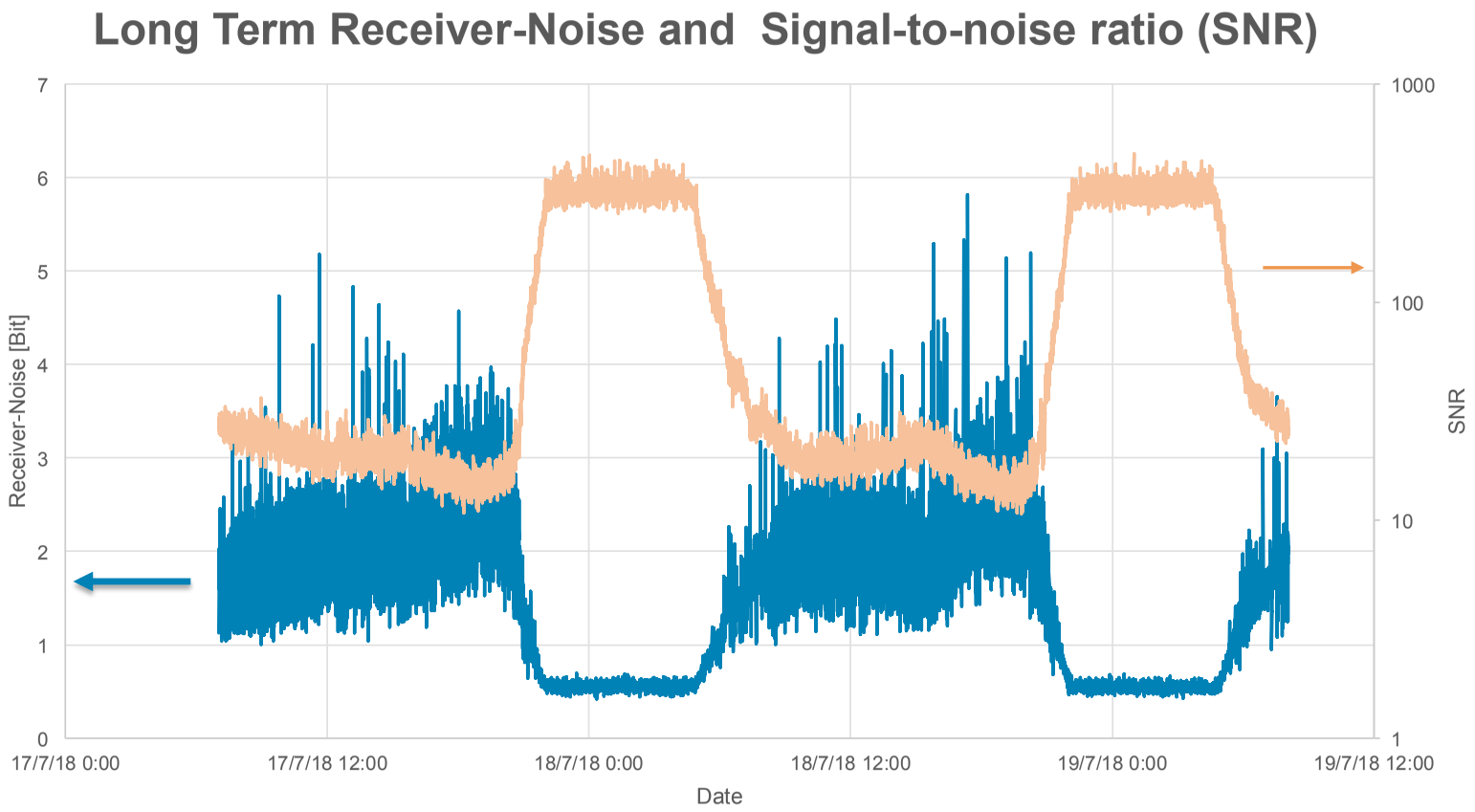
Performance Receiver

Coating



Performance Receiver

Optimizing the signal noise ratio

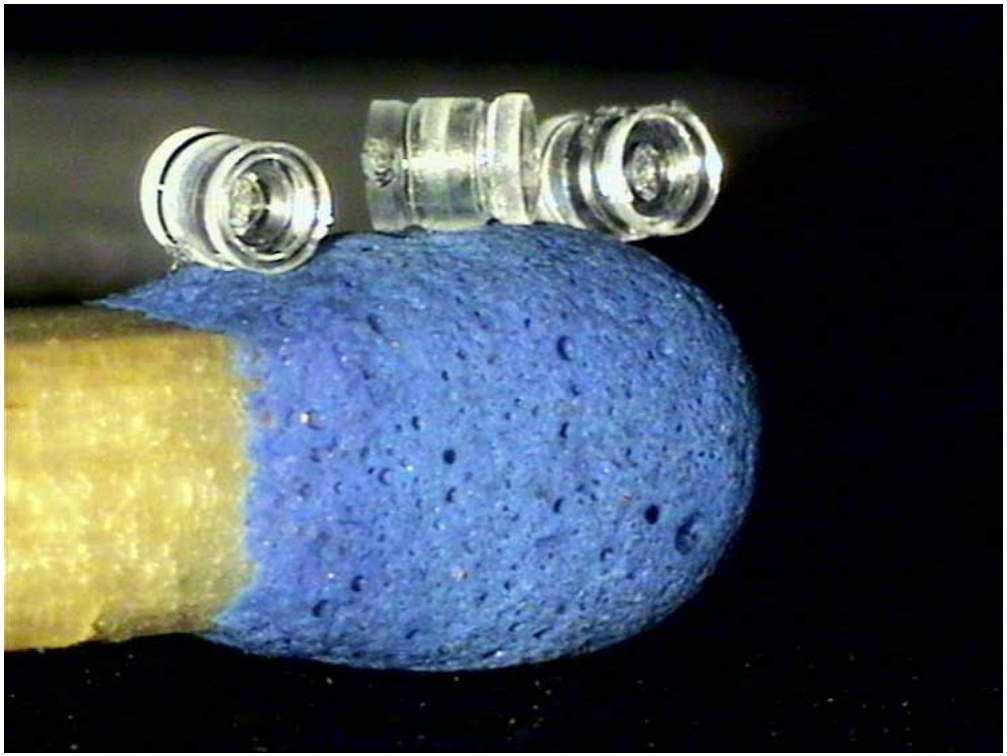


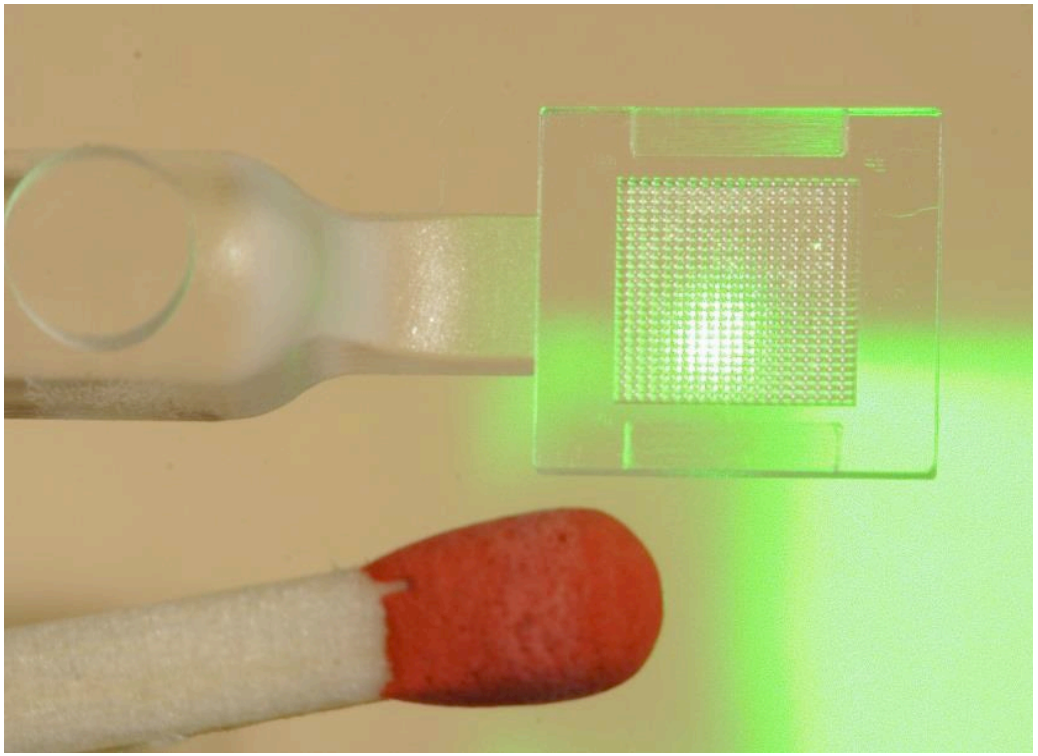
System Integration

Optic components to optimize size and cost

System Integration

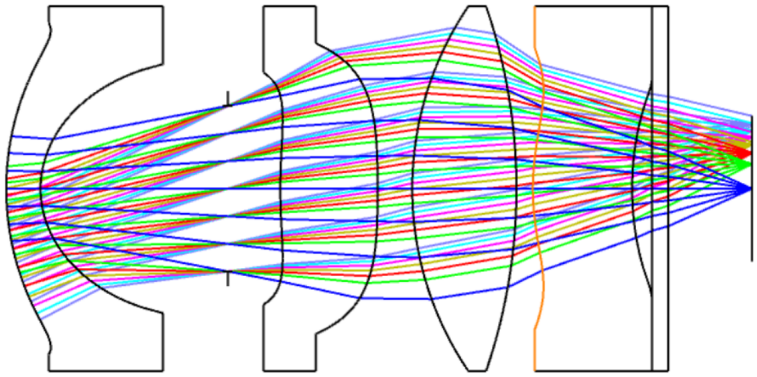
Micro optic components to optimize size and cost

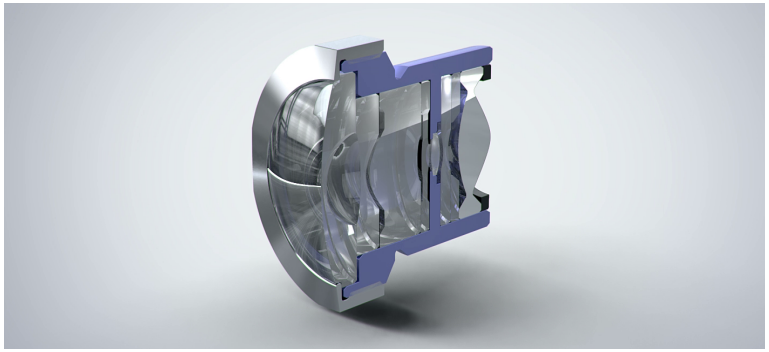


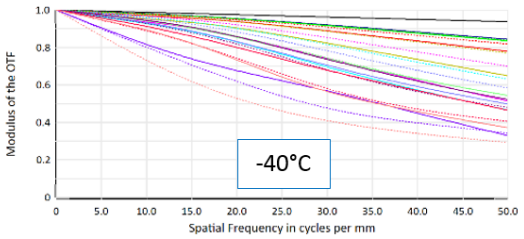


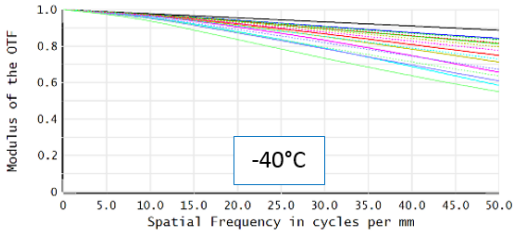
System Integration

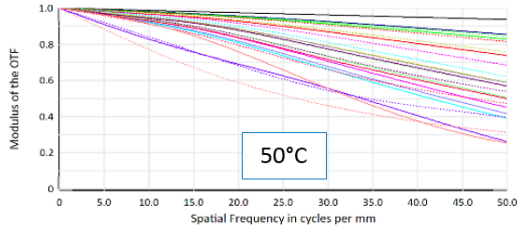
Optic components to optimize size and cost

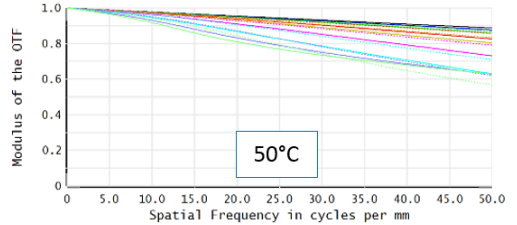


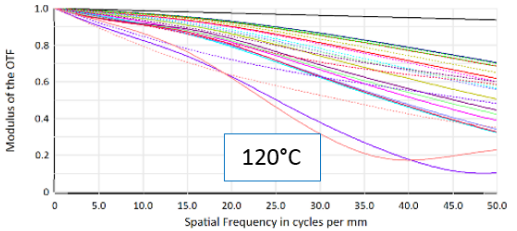


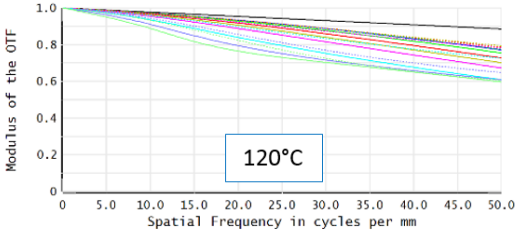






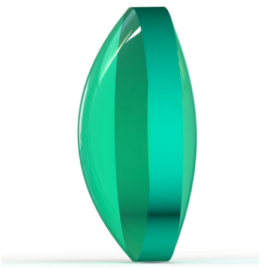




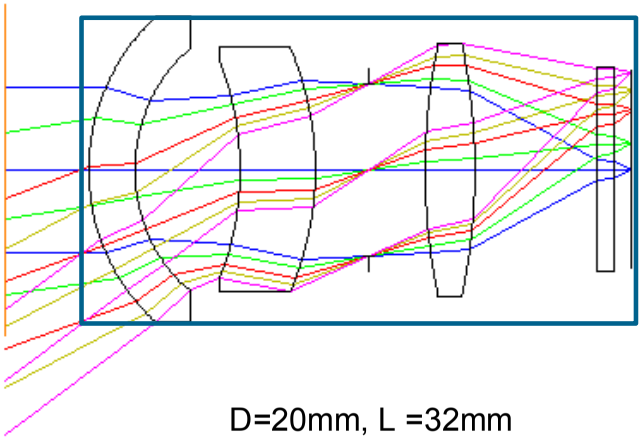


System Integration

Optic components to optimize size and cost



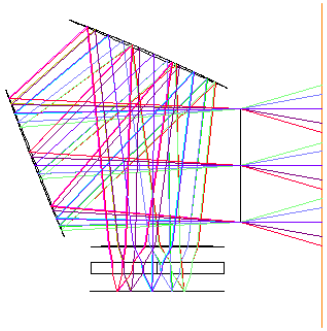
Conventional optic / 3 elements

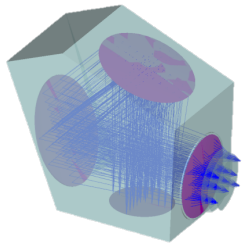


D=20mm, L =32mm

System ~10cm³

Freeform-Monolith / 1 element





12 x 15 x 14 mm³

System ~ 2.6cm³

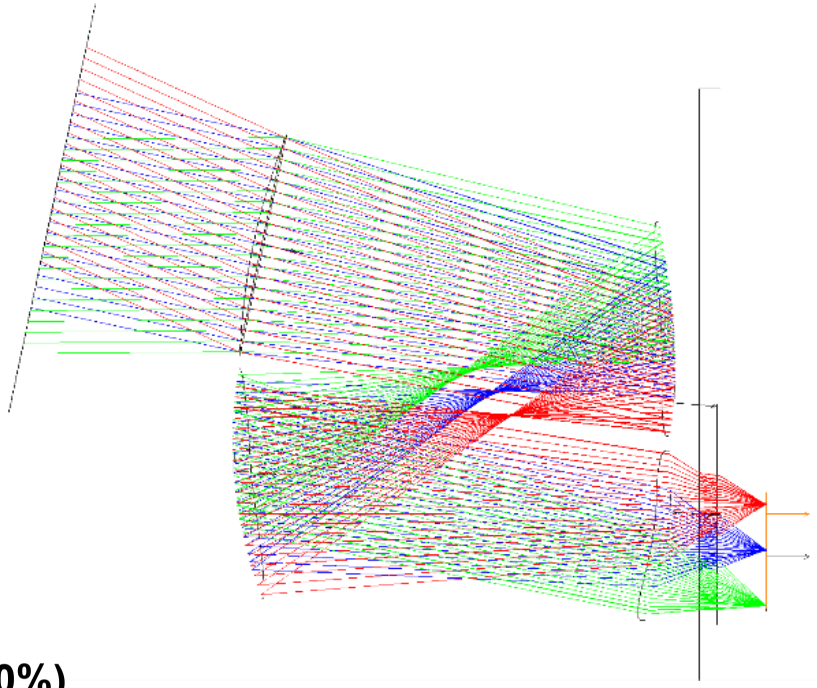
Monolith: 4x optical surfaces (1x freeform 3x Asphere and 2 of them are mirrors)

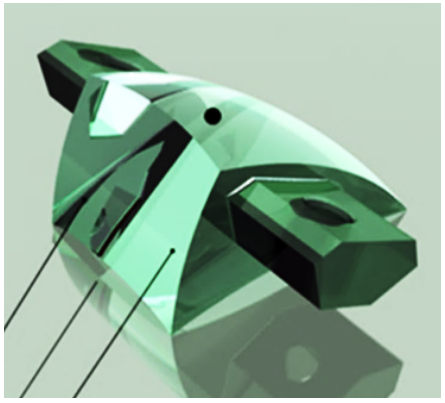
System Integration

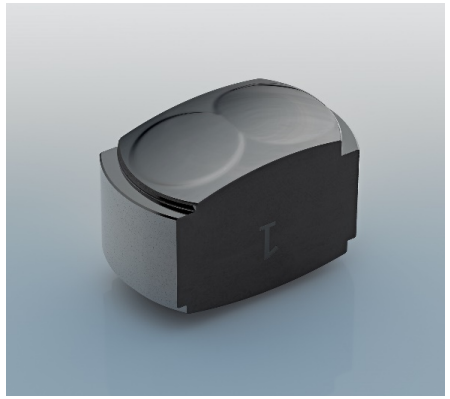
Optic components to optimize size and cost

Advantages & Conclusions

- **Simple thermal management**
  - Low thermal sensitivity
- **High mobility of user**
  - High robustness
- **Easy assembly needed**
  - Low assembling effort
  - Assembly simplified by reference discussions upfront
- **Reduce size and weight (goal: 30%)**
  - Smaller system volume
  - Less components

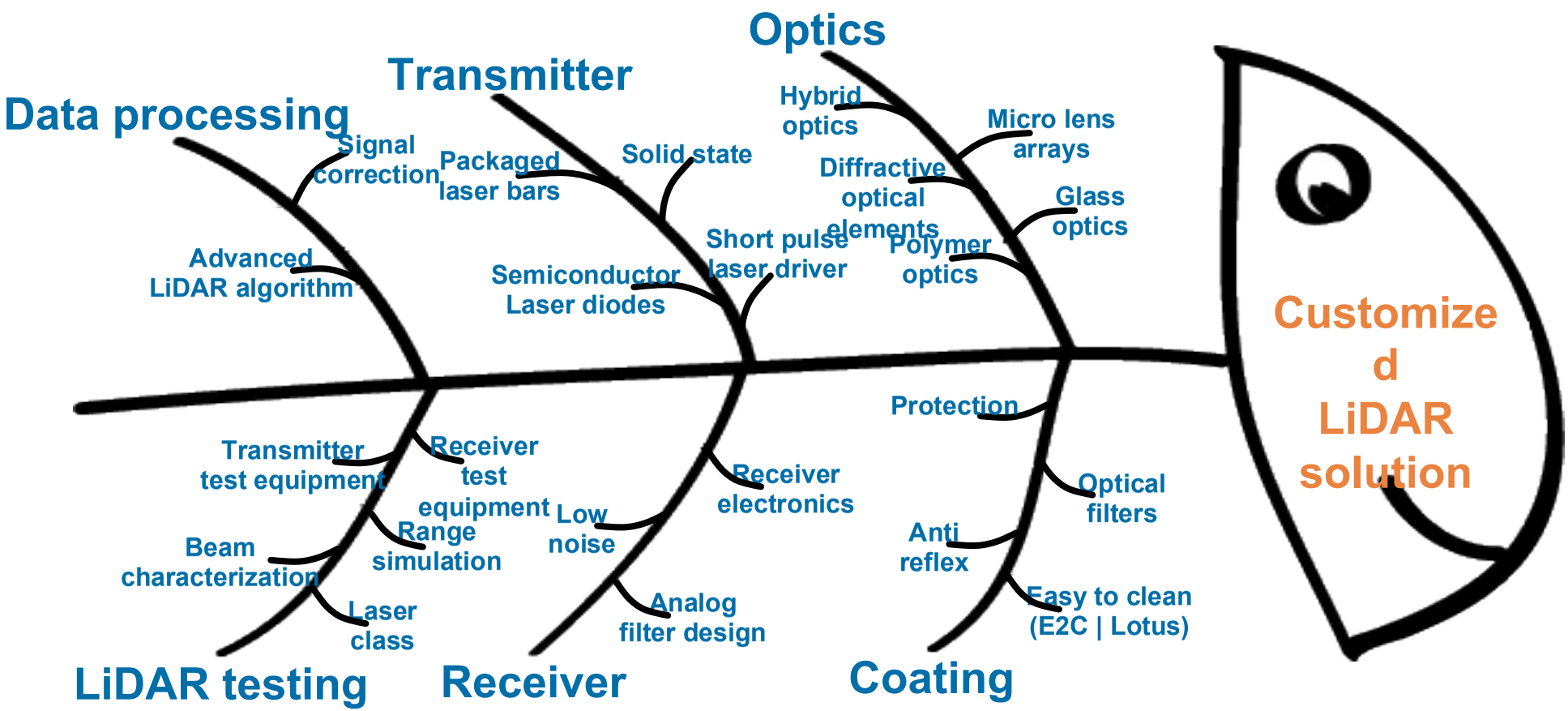






LiDAR technologies

Jenoptik LiDAR competencies



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Thank you for your attention!

Visit us at our Booth

Sebastian Schau | sebastian.schau@jenoptik.com | +49 3641 65-3347