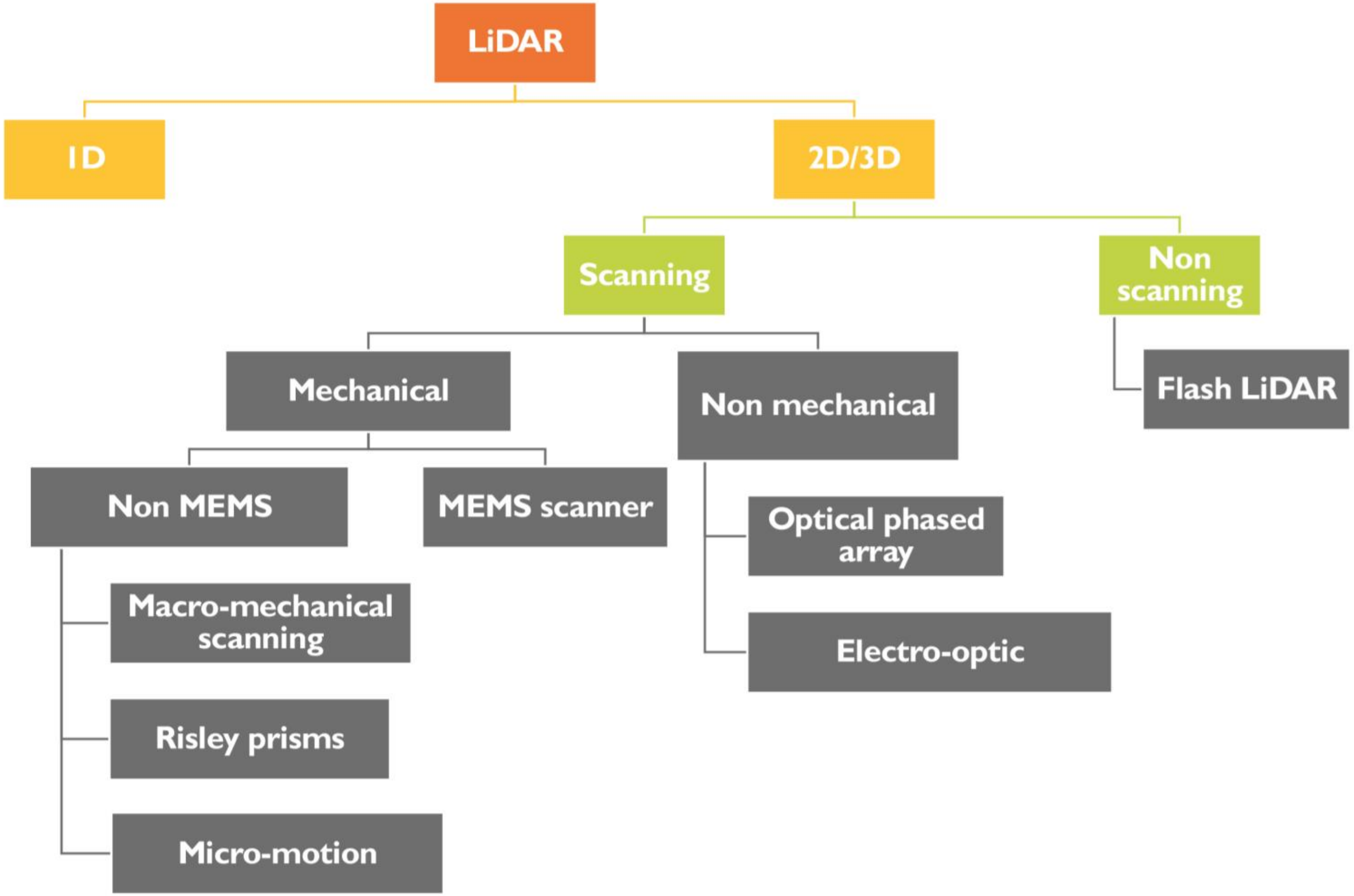
Anteryon

Hybrid lenses for Lidar

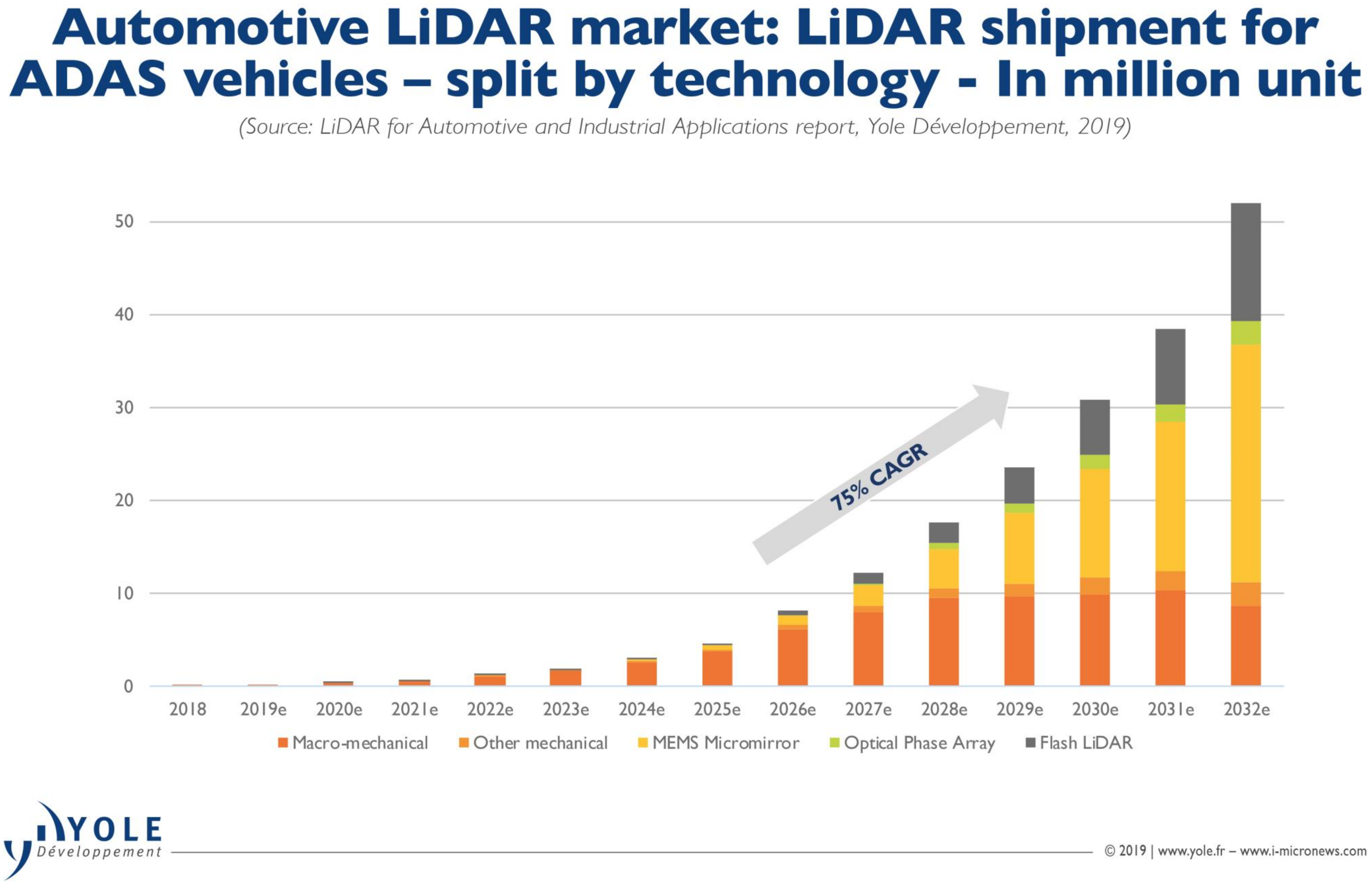
LiDAR technologies overview

(Source: LiDAR for Automotive and Industrial Applications report, Yole Développement, 2019)



Courtesy Yole

Room for more than one solution

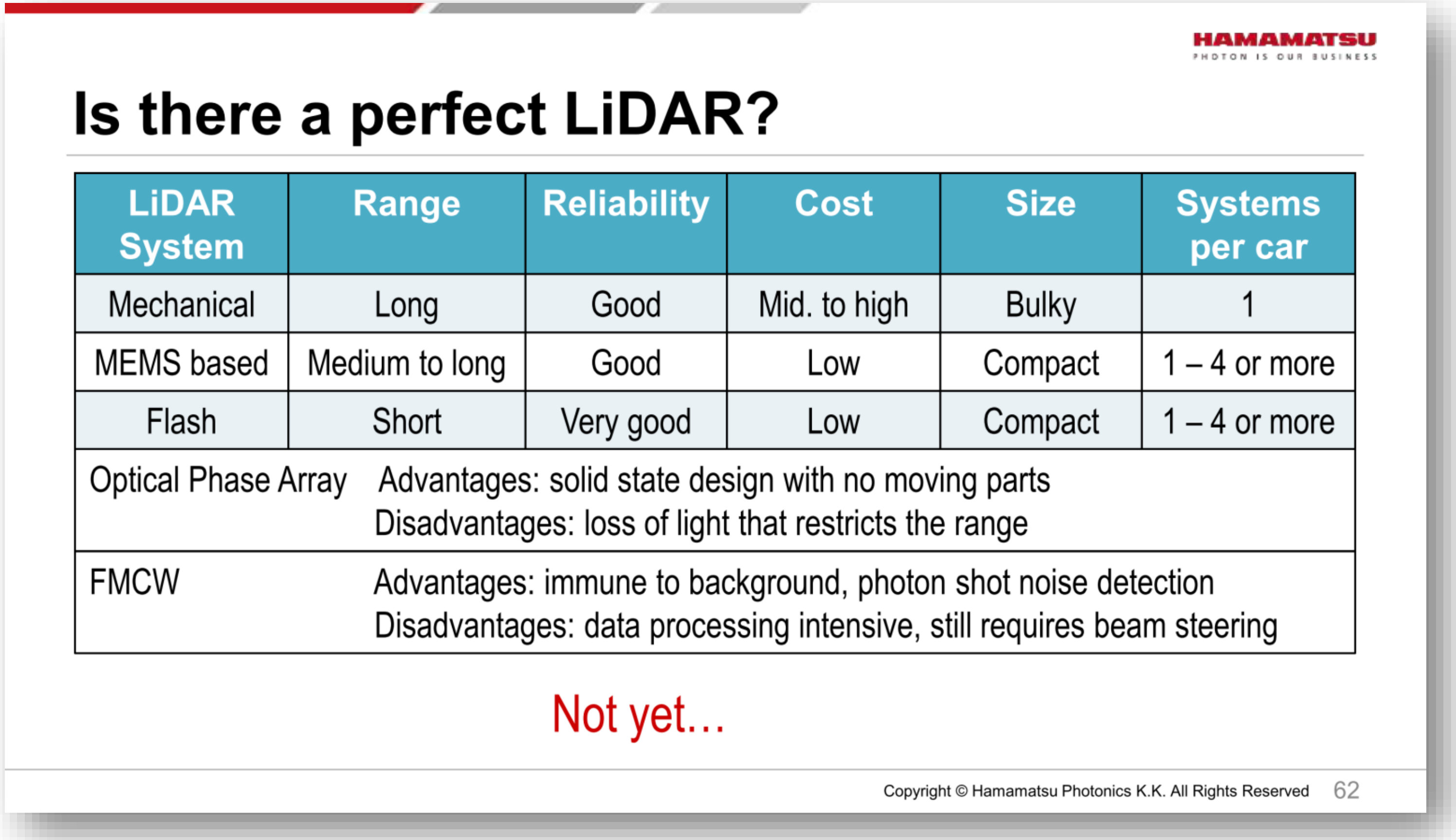


Automotive LiDAR market: LiDAR shipment for ADAS vehicles – split by technology - In million unit

(Source: LiDAR for Automotive and Industrial Applications report, Yole Développement, 2019)

Courtesy Yole

Is there a perfect LiDAR?

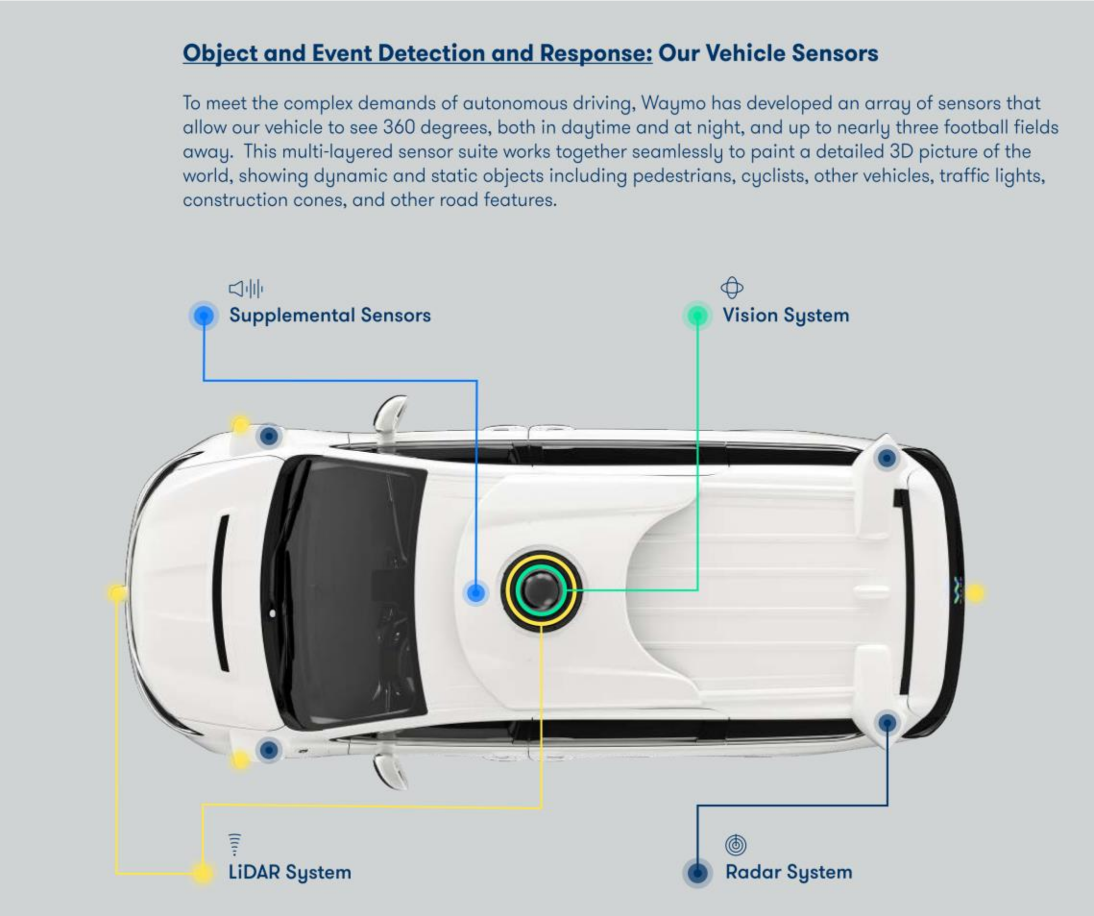


Is there a perfect LiDAR?

LiDAR System	Range	Reliability	Cost	Size	Systems per car
Mechanical	Long	Good	Mid. to high	Bulky	1
MEMS based	Medium to long	Good	Low	Compact	1 – 4 or more
Flash	Short	Very good	Low	Compact	1 – 4 or more
Optical Phase Array	Advantages: solid state design with no moving parts Disadvantages: loss of light that restricts the range				
FMCW	Advantages: immune to background, photon shot noise detection Disadvantages: data processing intensive, still requires beam steering				

Not yet…

Multiple LiDARs in current pilots



Object and Event Detection and Response: Our Vehicle Sensors

To meet the complex demands of autonomous driving, Waymo has developed an array of sensors that allow our vehicle to see 360 degrees, both in daytime and at night, and up to nearly three football fields away. This multi-layered sensor suite works together seamlessly to paint a detailed 3D picture of the world, showing dynamic and static objects including pedestrians, cyclists, other vehicles, traffic lights, construction cones, and other road features.

Source: Waymo safety report 2018

LiDAR (Laser) System

LiDAR (Light Detection and Ranging) works day and night by beaming out millions of laser pulses per second—in 360 degrees—and measuring how long it takes to reflect off a surface and return to the vehicle. Waymo's system includes three types of LiDAR developed in-house: a short-range LiDAR that gives our vehicle an uninterrupted view directly around it, a high-resolution mid-range LiDAR, and a powerful new generation long-range LiDAR.

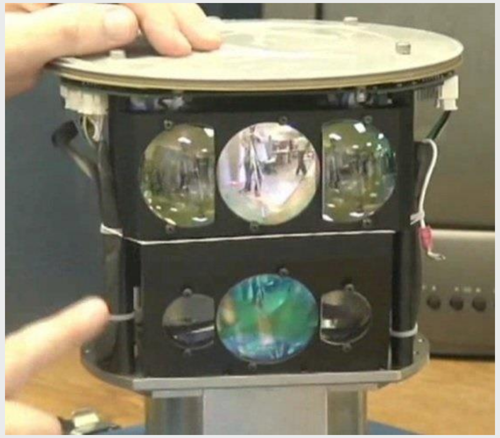
Besides Vision Systems and Radar Systems, multiple LiDAR systems are used to deal with wide distance range.

Mechanical scanning vs Solid state

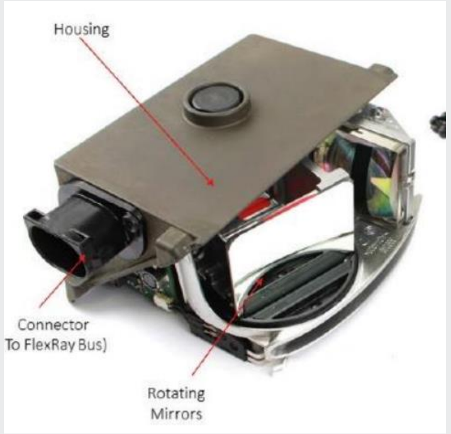
Scanning

Non Scanning

Mechanical LiDaR



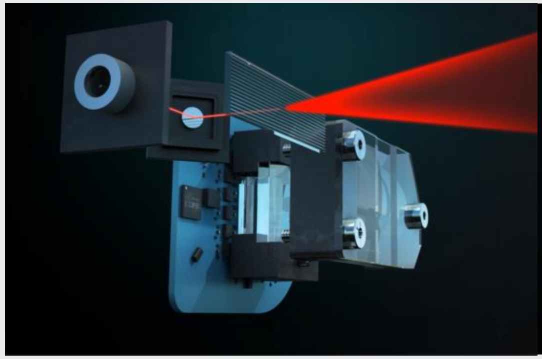
Velodyne HDL-64E Laser Rangefinder



Valeo Scala

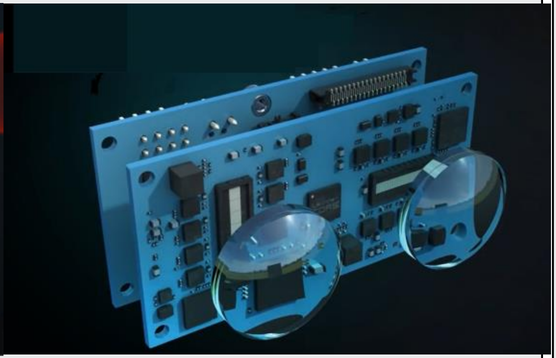
Solid state LiDaR

MEMS based



Courtesy LeddarTech

OPA based



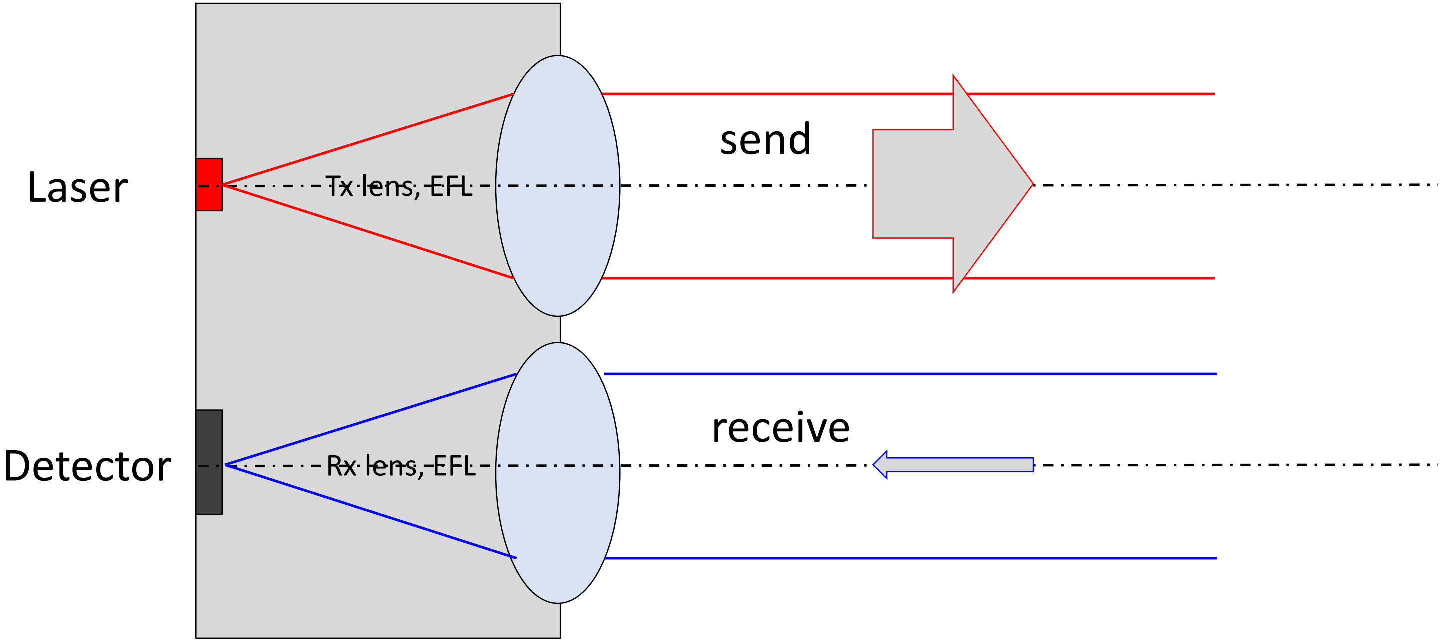
Courtesy LeddarTech

Flash based

Continental

→ what kind of optics is required?

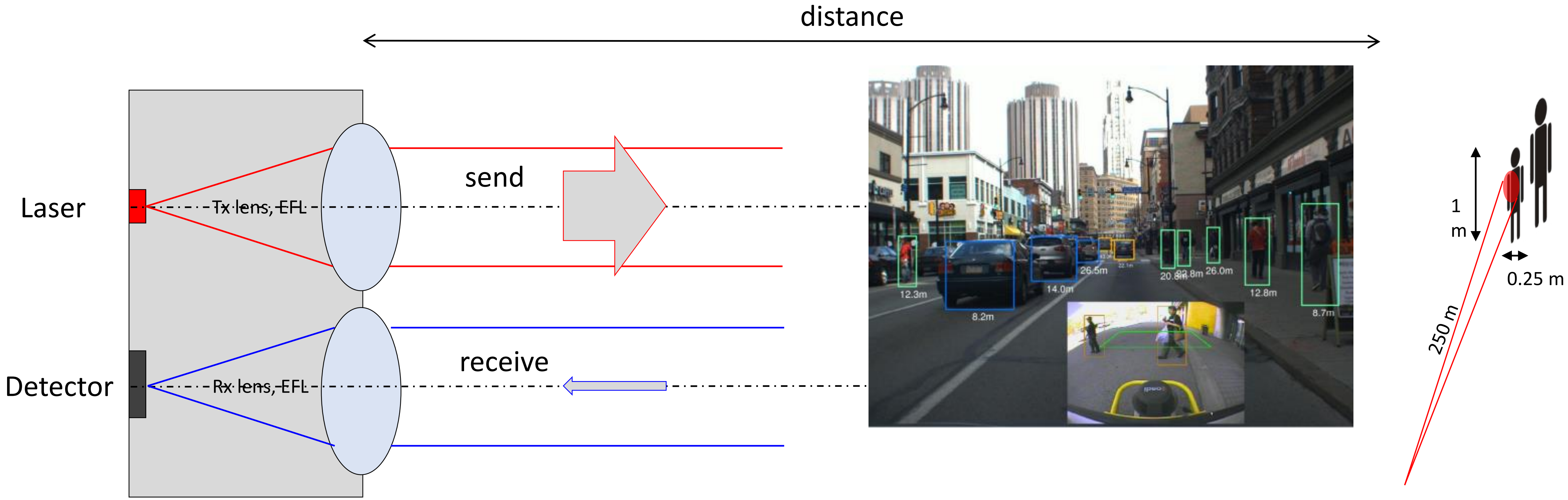
Scanning spot systems - considerations

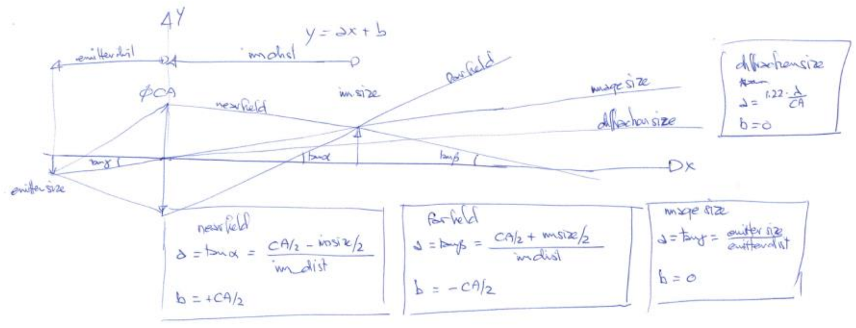


Let’s consider beam size →

Sending lenses determine the spot quality, related to the laser source.
Receiving lenses usualy are less critical to spot size since detector sizes are usualy bigger than emitters.
However – receiving lenses should be BIG to collect as much light as possible.

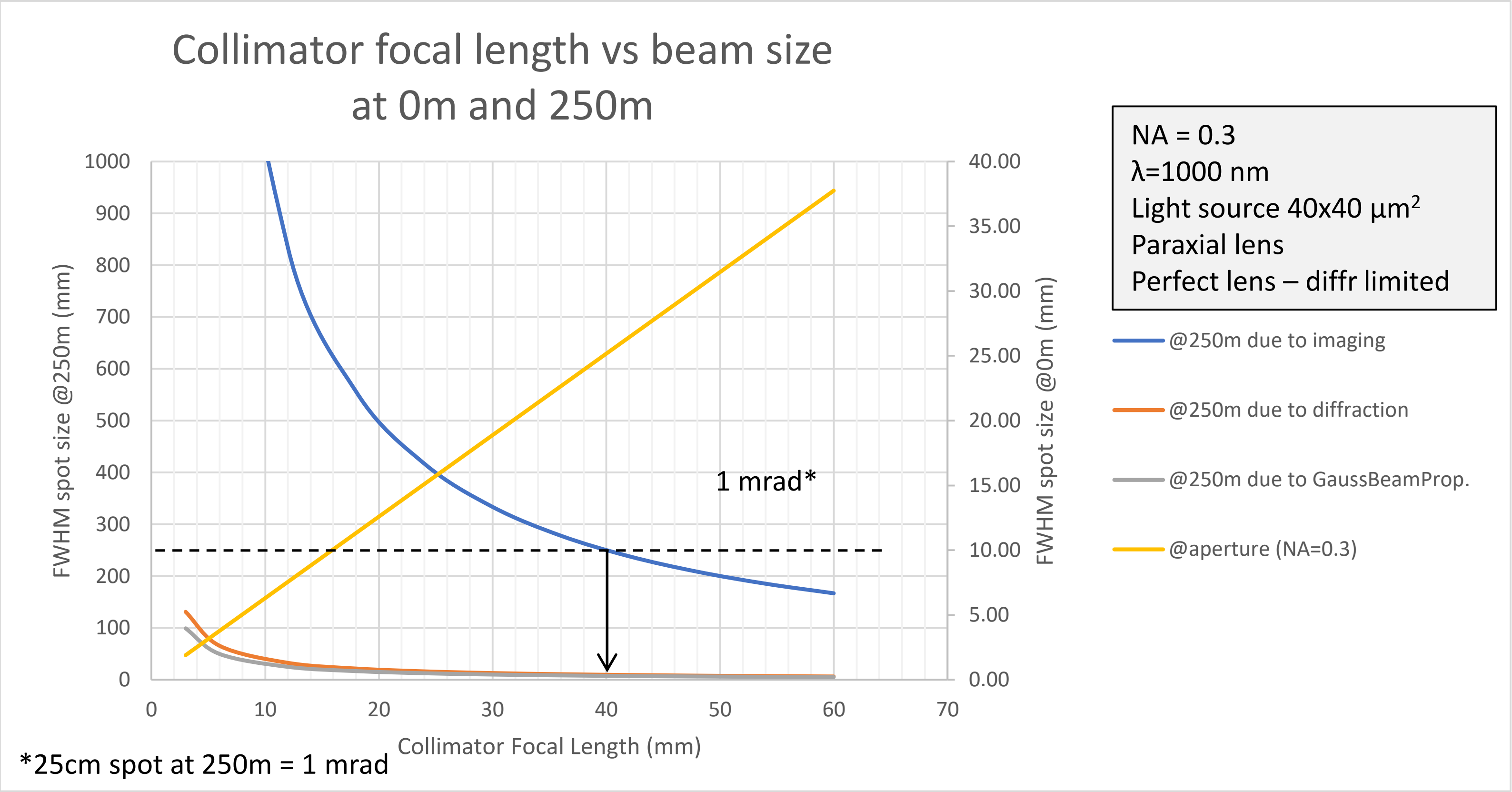
Detection of persons at ‘high speed break’ distance





A small laser spot is required to distinguish objects at large distance.
Let’s assume a human should be detected by a few ‘pixels’.
→ What optics is needed to create a 25 cm spot at 250 m?

Case study - projected spot size at 250 m

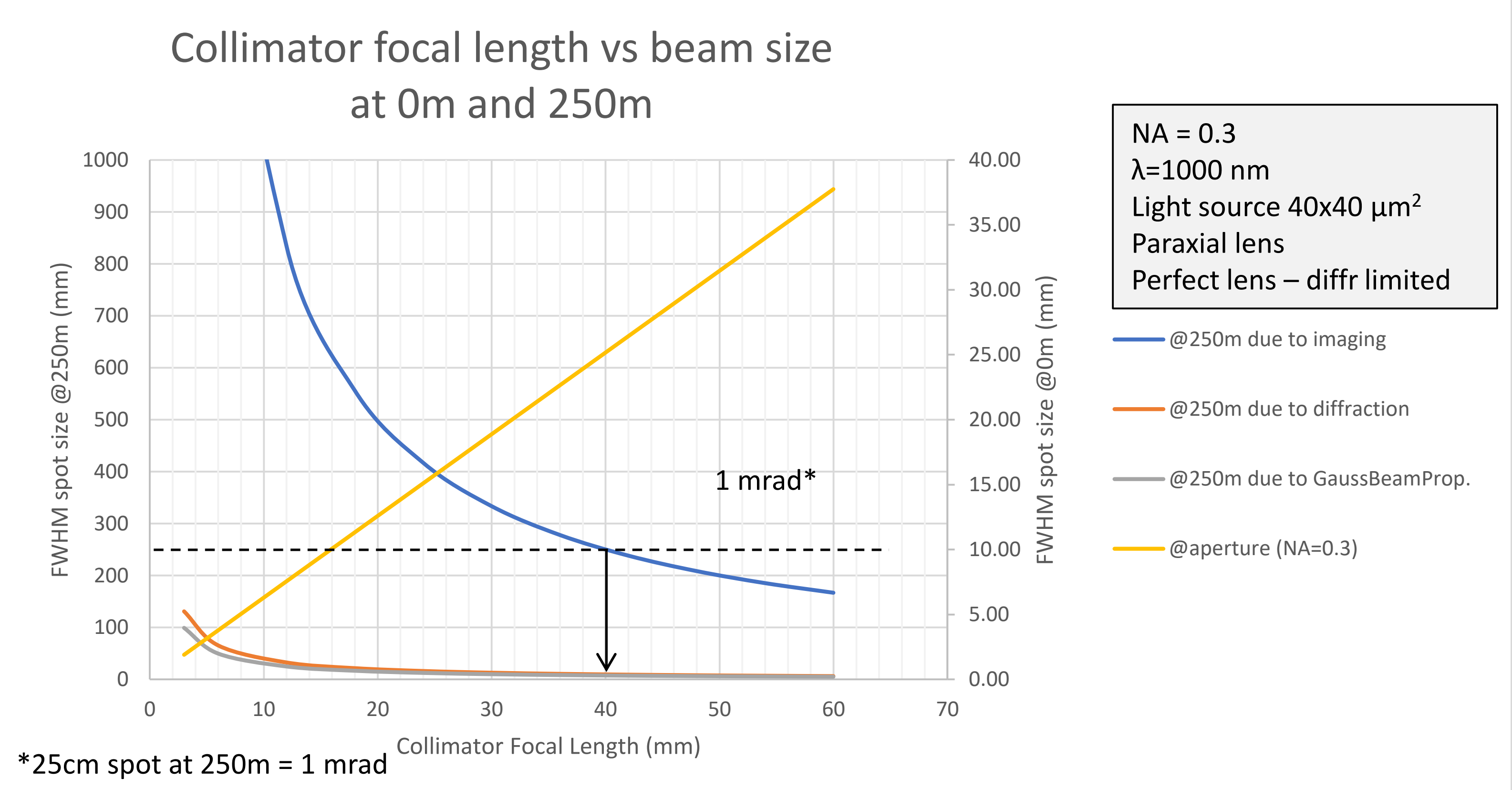


*25cm spot at 250m = 1 mrad

In order to create a spot of 250x250 mm @ 250 m, the collimator has to have a Focal length of at least 40 mm.

The spot size is mainly determined by imaging (due to relative big light source). Contributions of diffraction and Gaussian beam propagation are small.

Case study - projected spot size at 250 m



Collimator focal length vs beam size at 0m and 250m

NA = 0.3
λ=1000 nm
Light source 40x40 µm^2
Paraxial lens
Perfect lens – diffr limited

*25cm spot at 250m = 1 mrad

Brand	Emitter size range (um)
Excelitas	75 x 1 um 400 x 340
Osram	220 x 10
Hamamatsu	230 x 1 360 x 10

Hamamatsu - L11854-307-05_-55

Osram - SPL DS90A_3

In order to create a spot of 250x250 mm @ 250 m, the collimator has to have a Focal length of at least 40 mm.

The spot size is mainly determined by imaging (due to relative big light source). Contributions of diffraction and Gaussian beam propagation are small.

Actual laser sources are even bigger, and asymmetric.

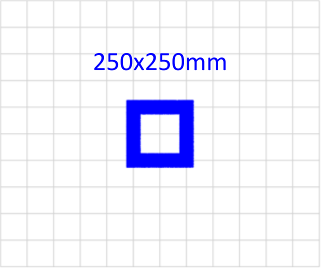
→ Beam shaping required

→ Difference in Hor-Ver resolution

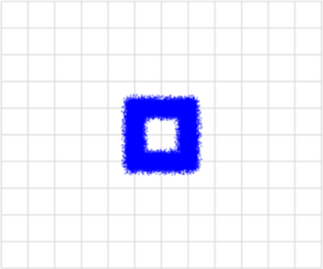
Lens aberration causes spot degradation

Lens shape error

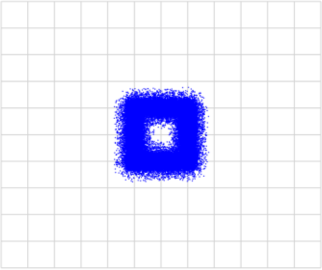
Wave Front error



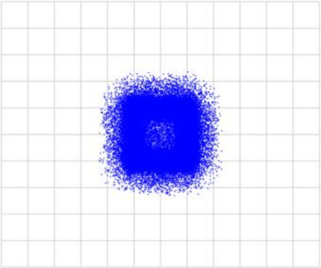
0nm
0λ rms



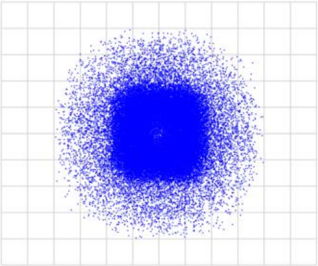
250nm
0.05λ rms



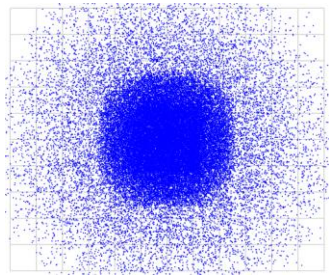
500nm
0.09λ rms



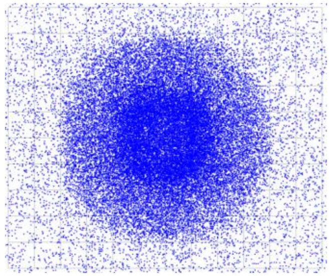
1000nm
0.19λ rms



2500nm
0.47λ rms



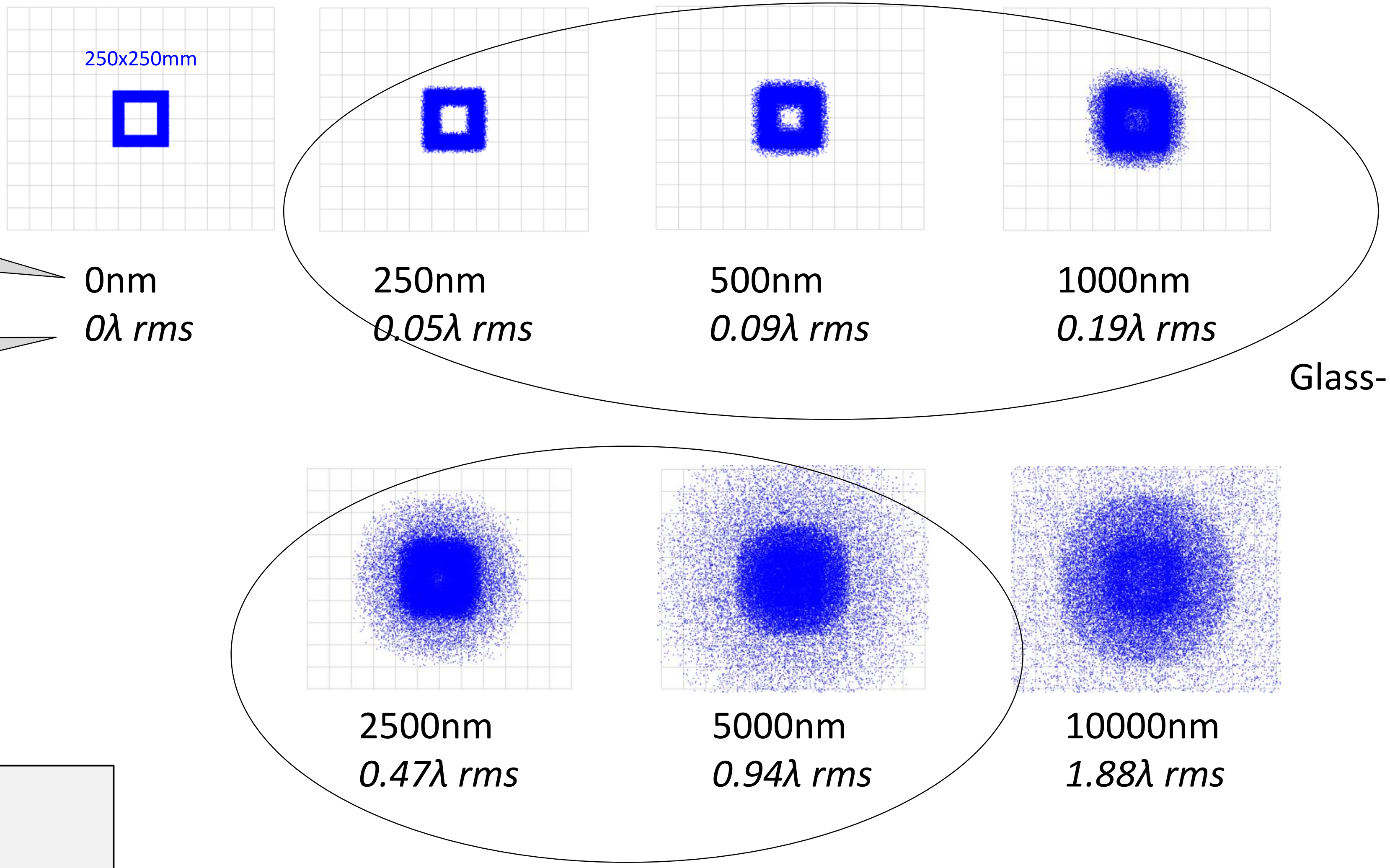
5000nm
0.94λ rms



10000nm
1.88λ rms

Efl 40 mm, paraxial lens
NA 0.3, CA=24 mm
λ=1000 nm
Light source 40x40 µm^2
Image of projected light source @250 m
Lens deviation: spherical aberration (A40)

Lens aberration causes spot degradation



Lens shape error

Wave Front error

0nm
0λ rms

250nm
0.05λ rms

500nm
0.09λ rms

1000nm
0.19λ rms

Glass-replicated lenses

2500nm
0.47λ rms

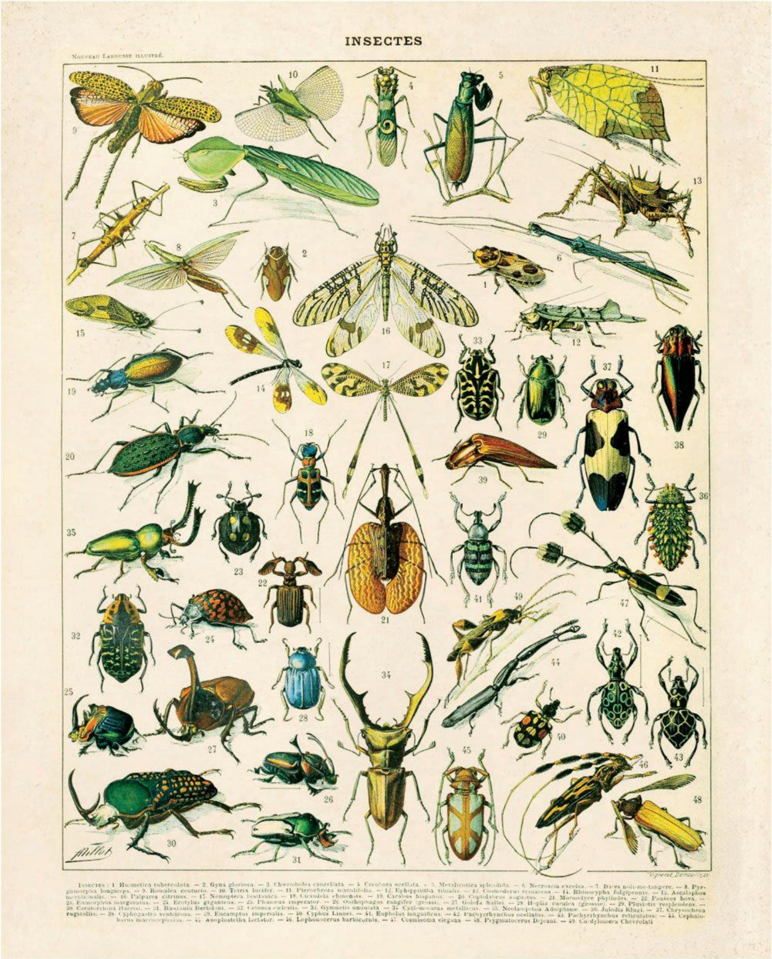
5000nm
0.94λ rms

10000nm
1.88λ rms

Glass-molded lenses

Efl 40 mm, paraxial lens
NA 0.3, CA=24 mm
λ=1000 nm
Light source 40x40 μm^2
Image of projected light source @250 m
Lens deviation: spherical aberration (A40)

Flying ‘objects’

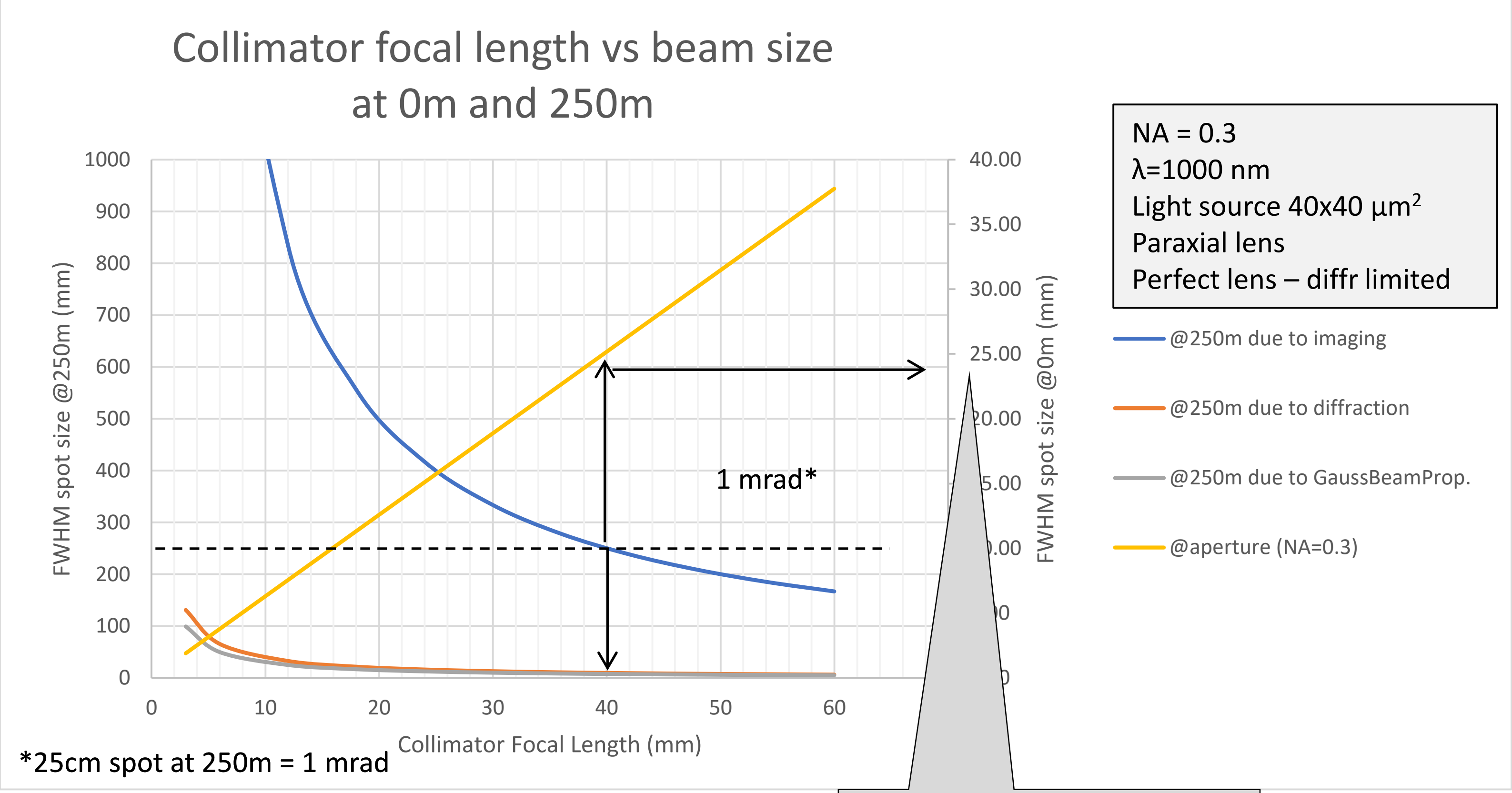


Insects & dirt within the lightpath form an obstruction, reducing the power or destroying the function.

→ Cleaning
→ Redundancy
and
→ Big optics

How Big? →

Dirt sensitivity



*25cm spot at 250m = 1 mrad

For NA 0.3 and Efl 40 mm, lens CA should be 25 mm

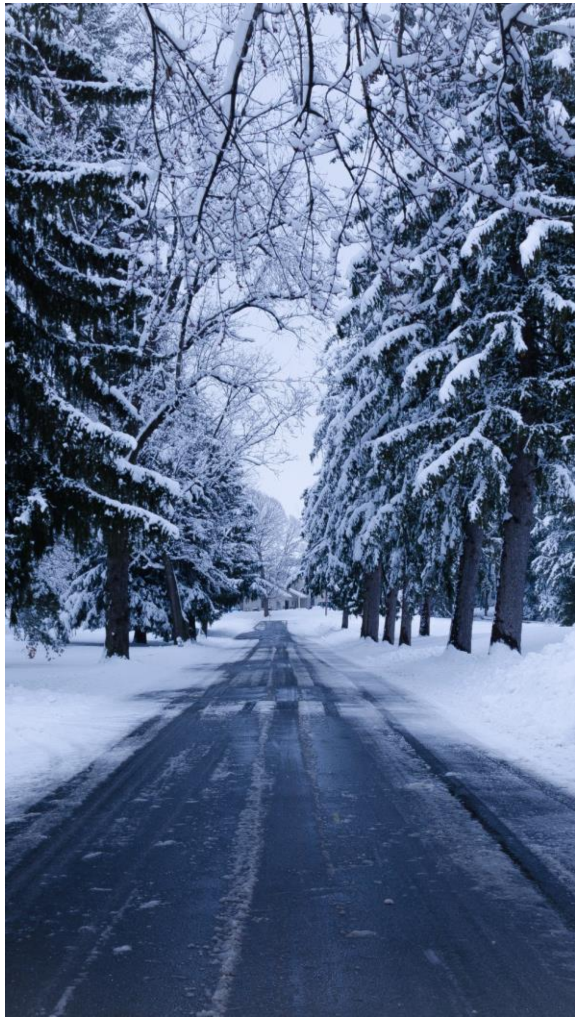
Insects / dirt may not obstruct the beams

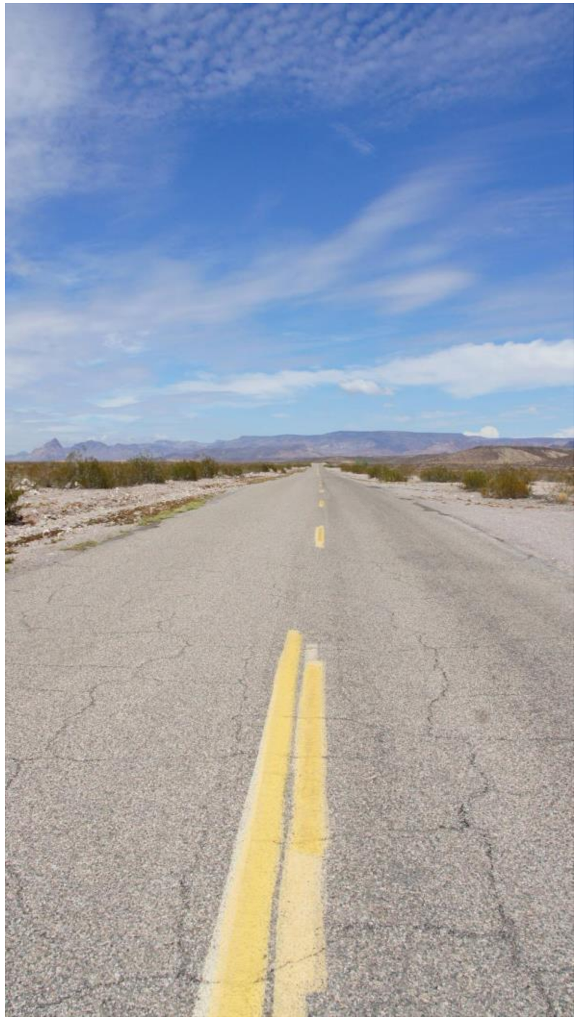
From optics point of view, CA> 25 mm needed

Bigger is better – less sensitivity to insects

…and cleaning !

Thermal stability





LiDAR should work
under every condition

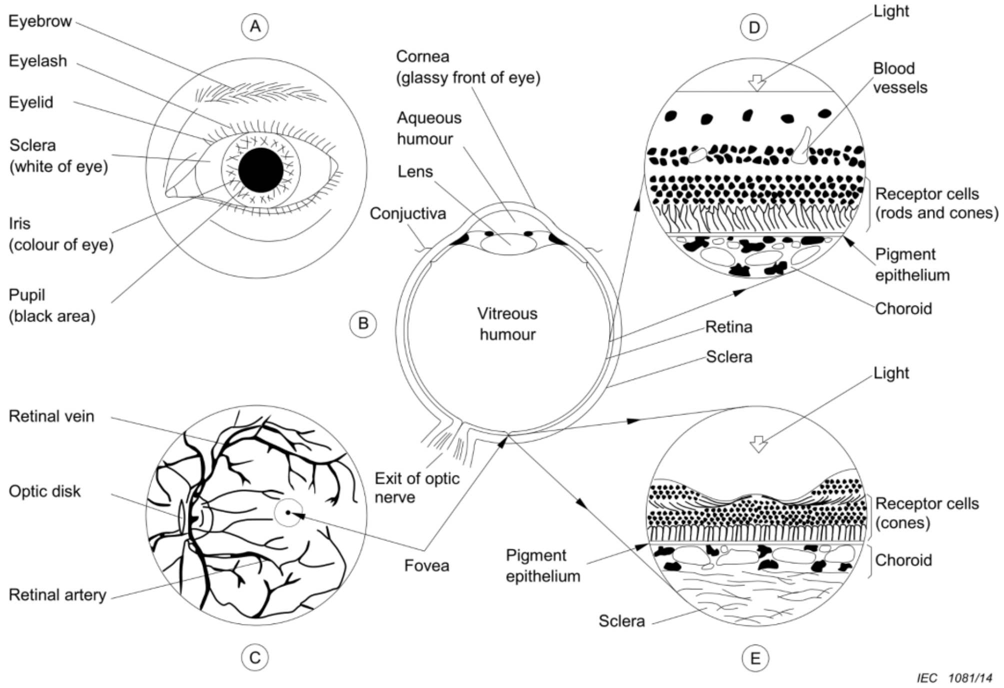
→ Stable optics

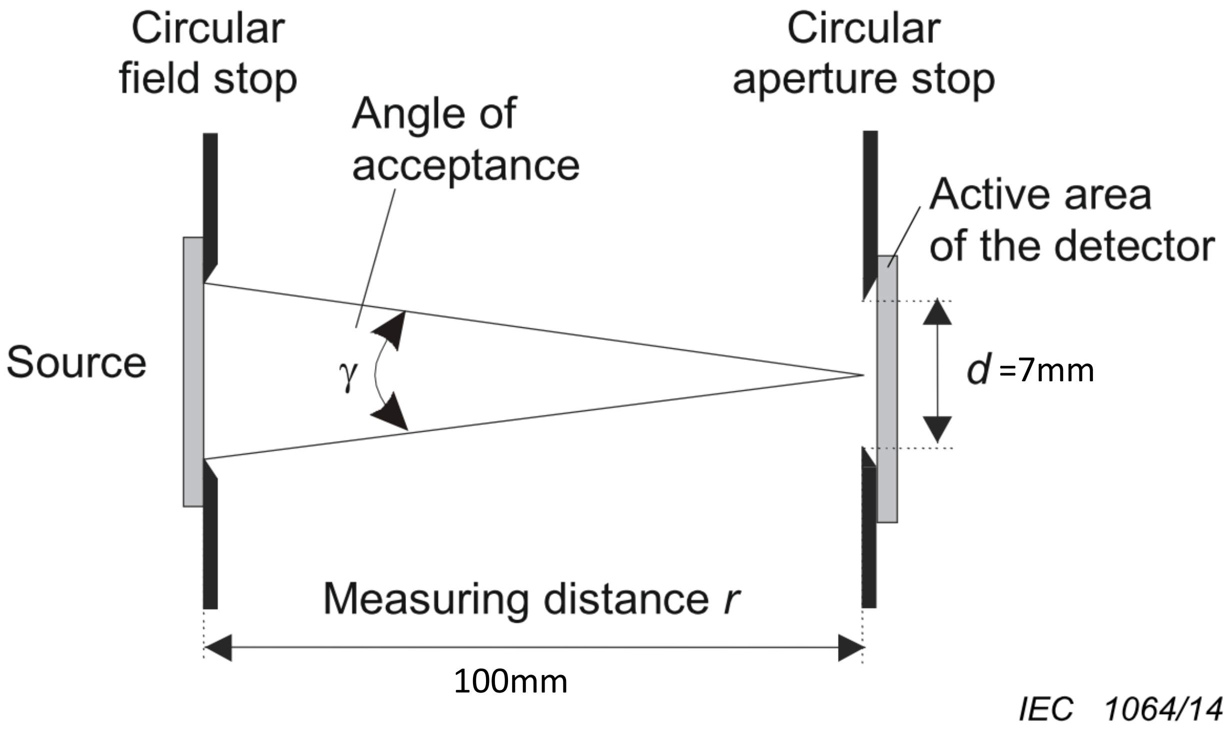
→ Glass

Eye safety

D.1 Anatomy of the eye

Figure D.1 provides anatomical details of the human eye.





Eye safe: IEC 60825-1 class 1 → big beams are safer

Lens Requirements summary

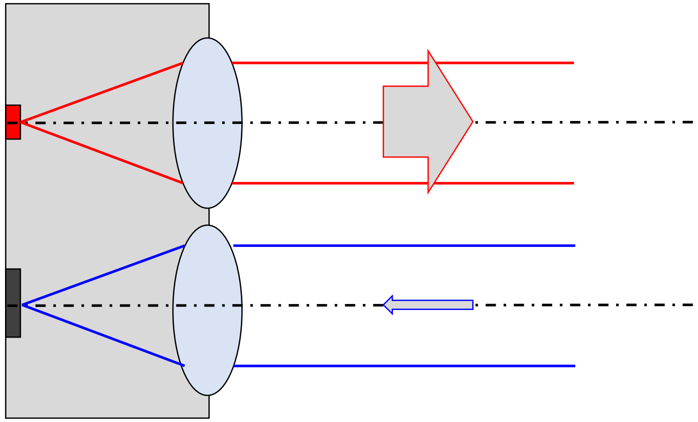
Lenses should be:

Big → 30..50 mm
Accurate → diffr. limited quality
Stable → Glass based

However,

LiDAR modules should be as small as possible for cosmetic reasons

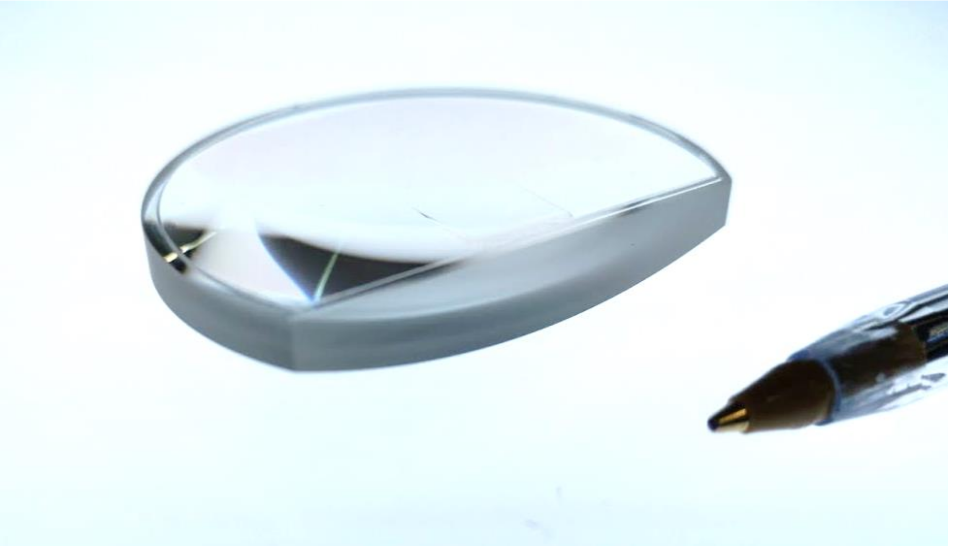
→ Hybrid lenses



Hybrid lenses are made of glass and polymer, offering the stability of glass
and the
freedom of shape of polymer
→ new design options!

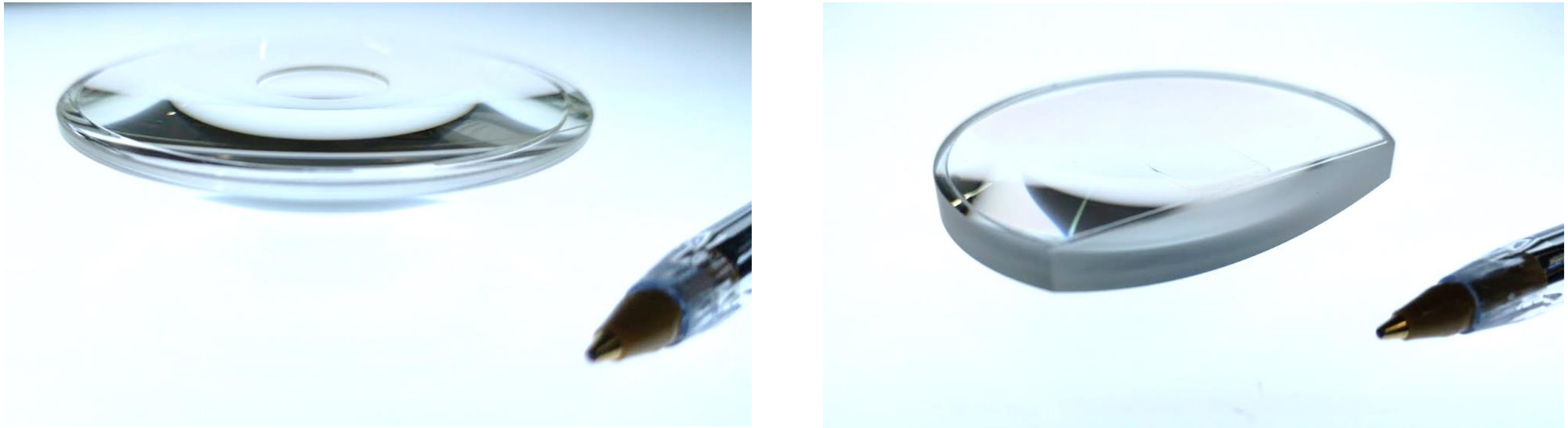
Anteryon offers hybrid lenses

Big, accurate and stable lenses – glass based hybrid lenses



Anteryon offers hybrid lenses

Big, accurate and stable lenses – glass based hybrid lenses

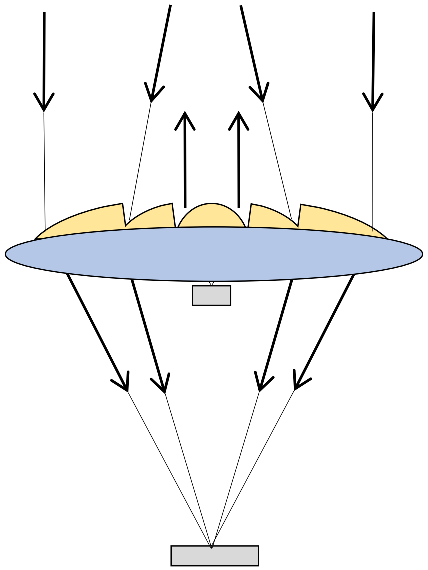


With cool features allowing best performance

Combined send/receive lens
→ Big lens - compact modules

Multi-focus & cut-off lens
→ Best performance over entire working range
→ Big lens – compact module

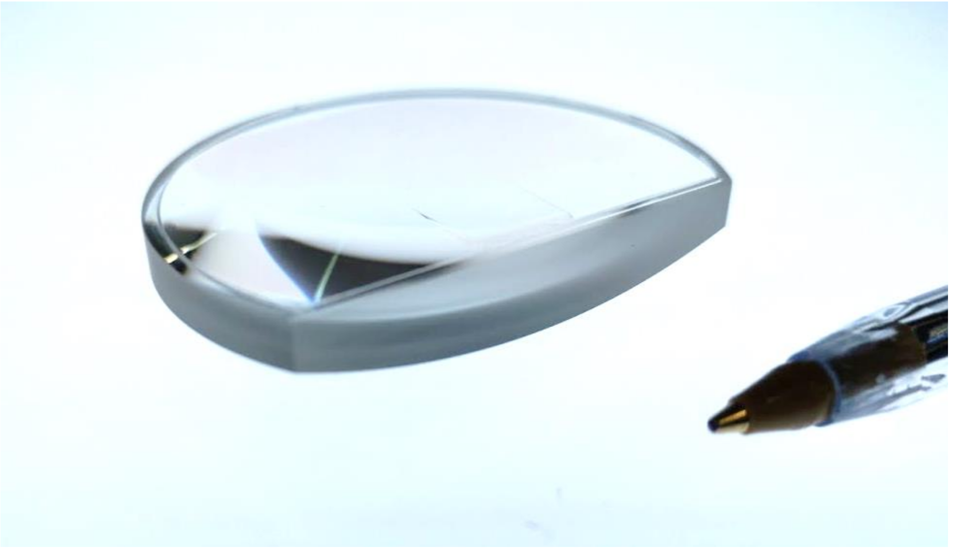
Concentric send/receive lens

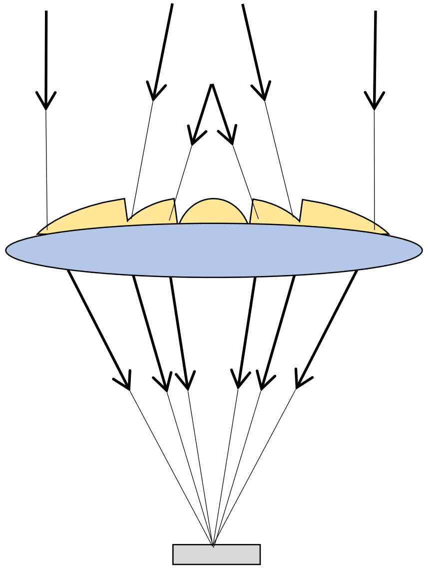


Integrated concentric send/receive
→ Big lens, yet compact module

Multi Focus function

(Cut-Off) multi focus lenses

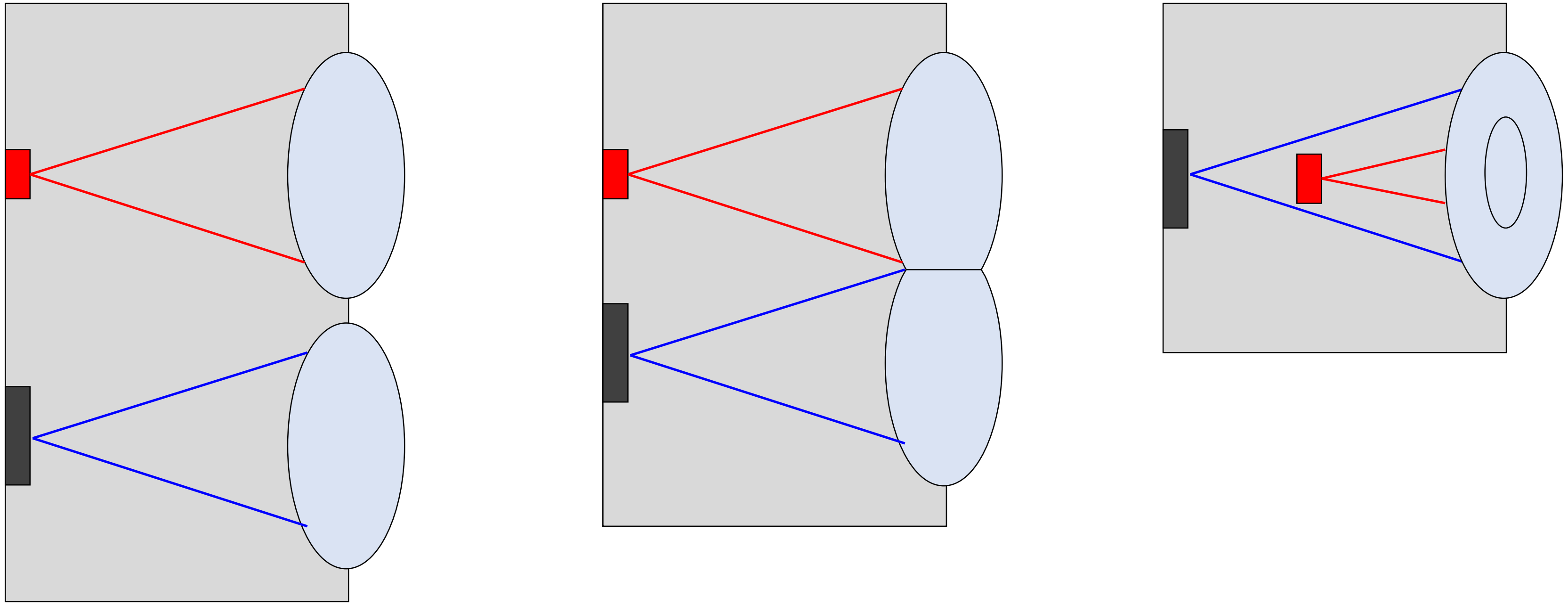


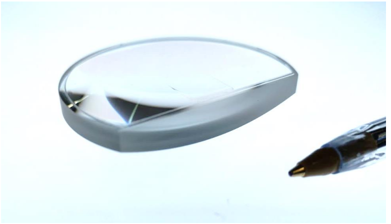


Multi-focal lenses

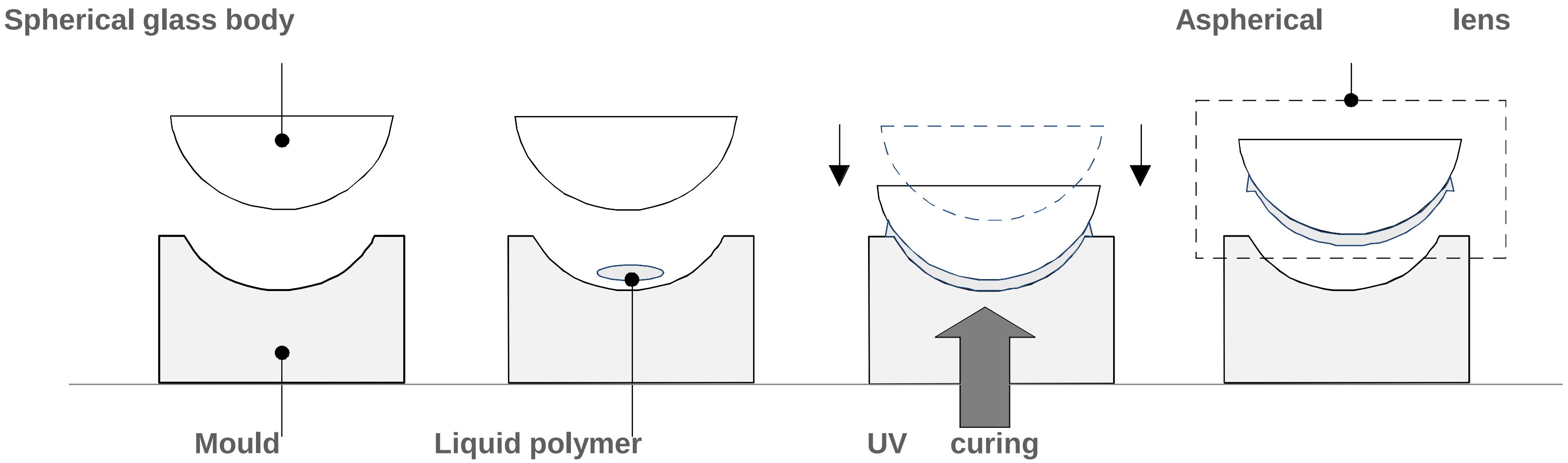
Cover widest range

Big lenses – Compact modules

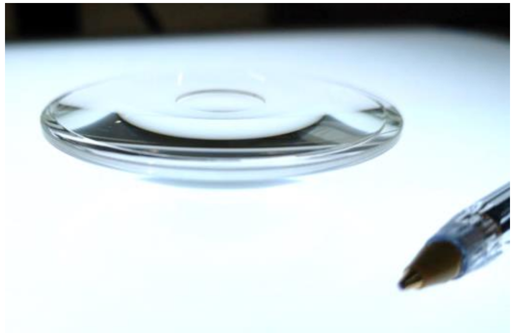




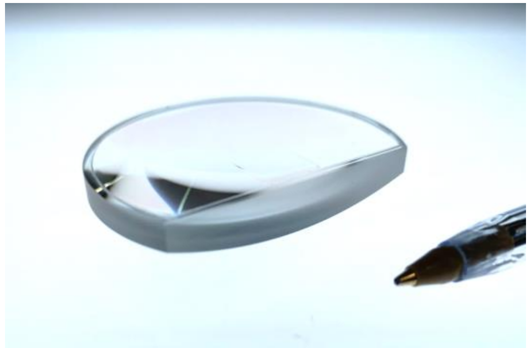
How it’s done - replication



Replication process (schematic figures) for aspherical glass-polymer lens

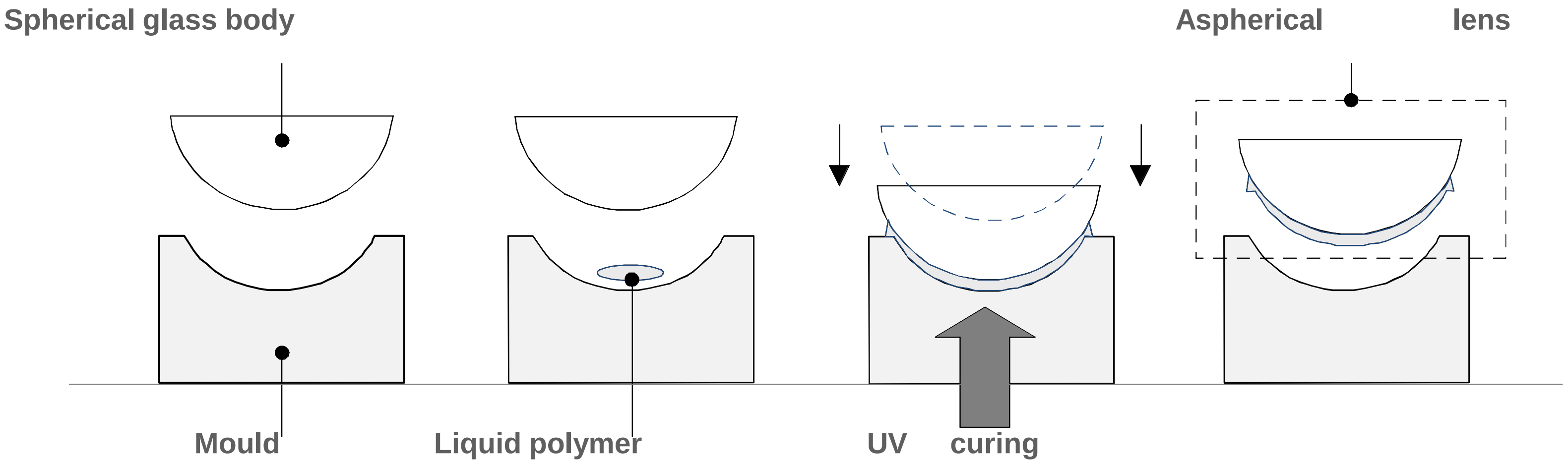


Combined send/receive lens



Multifocus lens

How it's done - replication



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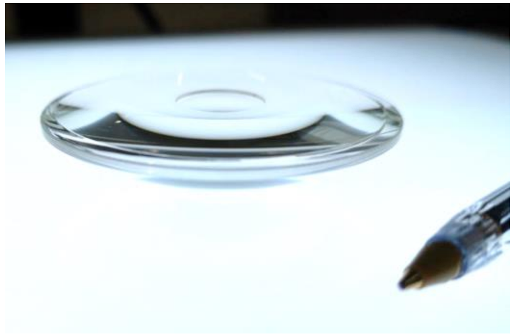
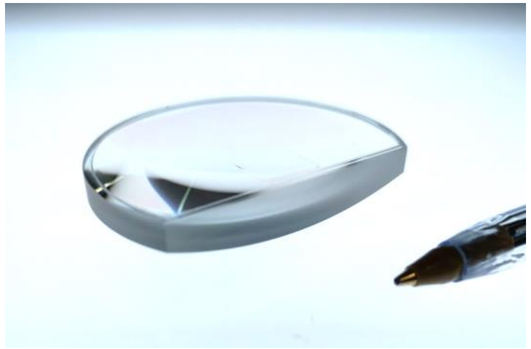
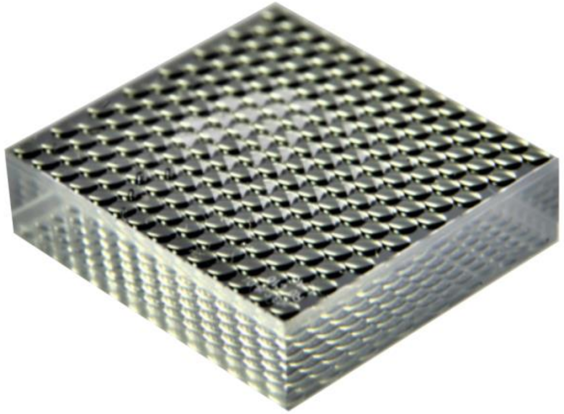


Combined send/receive lens



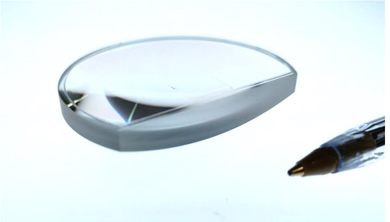
Multifocus lens



MLA

Anteryon LiDAR solutions

Hybrid optics inside

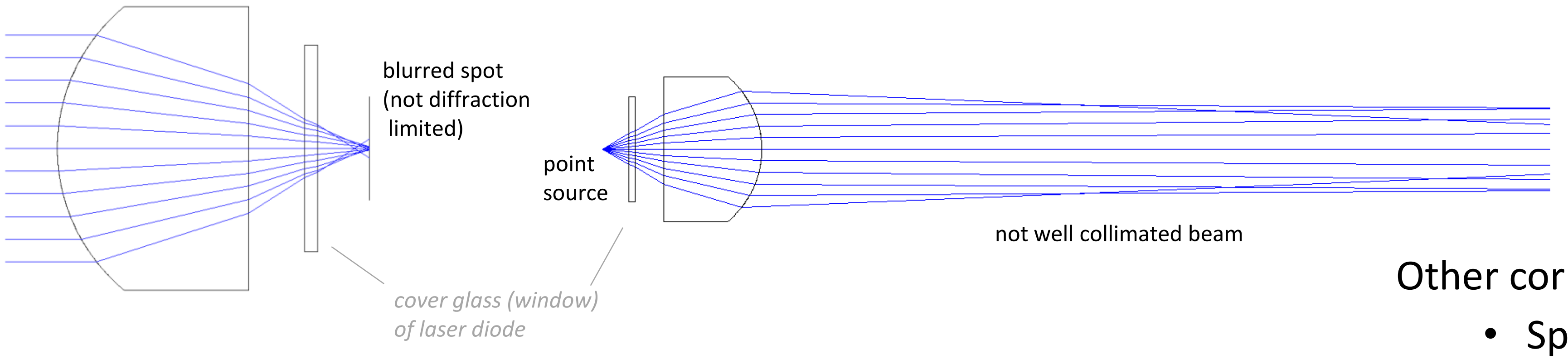


Questions

www.Anteryon.com

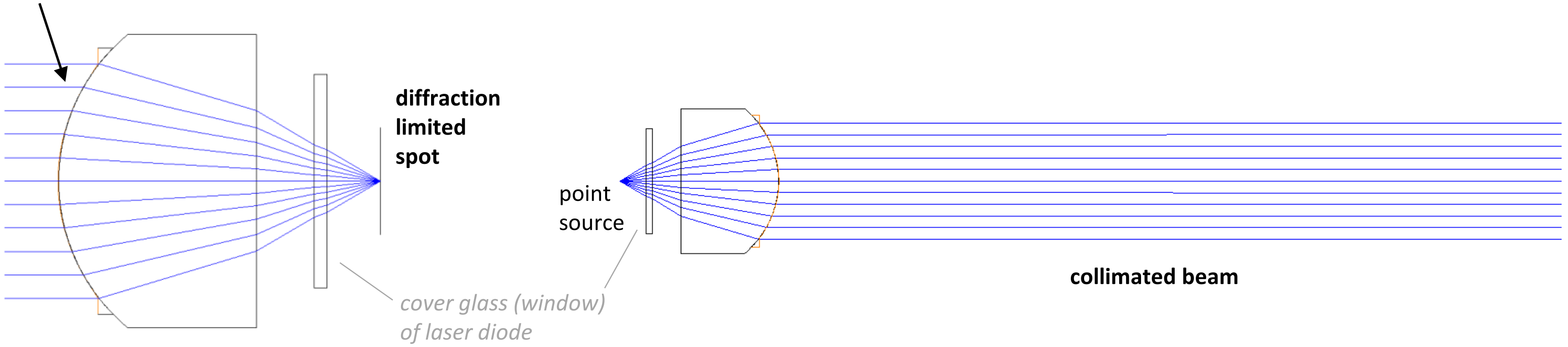
Basic function of polymer layer: aberration correction

Spherical lens shows Spherical Aberration



Aspherical Collimator lens optimised for Spherical Aberration → 0

Spherical **glass lens body** with replicated
Aspherical polymer layer



Other corrections

- Spherical aberration correction
- Astigmatism correction
- Coma correction
- Chromatic aberration correction

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