# ESPROS Photonics Corporation

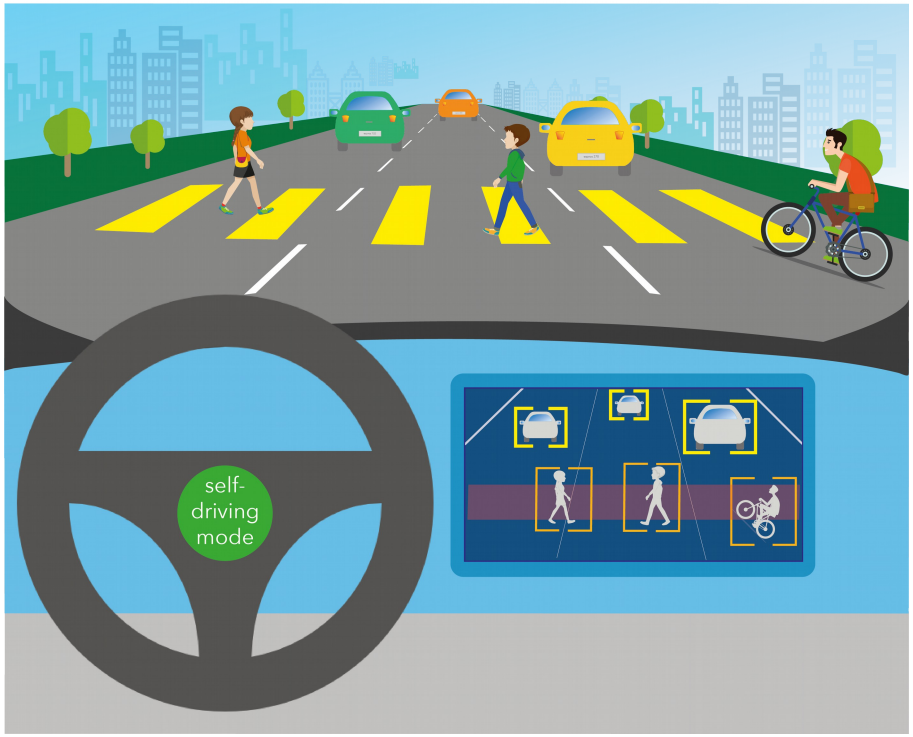

## Next generation pulsed time-of-flight sensors for autonomous driving

Beat De Coi

# Topics

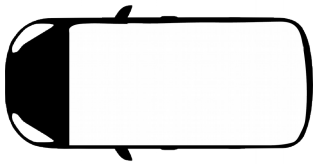
- ADAS requirements
- Sensor technology overview
- ESPROS CCD/CMOS technology OHC15L™
- Technology comparison of receiver elements
- Performance data of EPSORS OHC15L™ Imaging LiDAR
- A few words about the company

# Our driving future: The aim of ESPROS




«Siri, drive me home, please!»

# Requirements and solutions today



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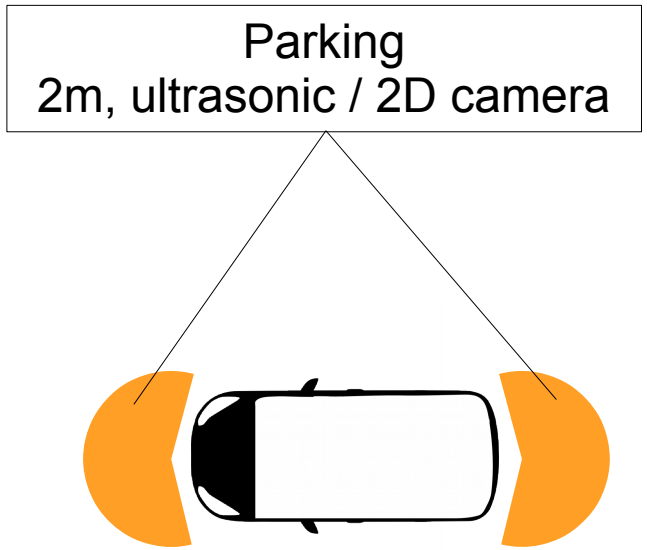

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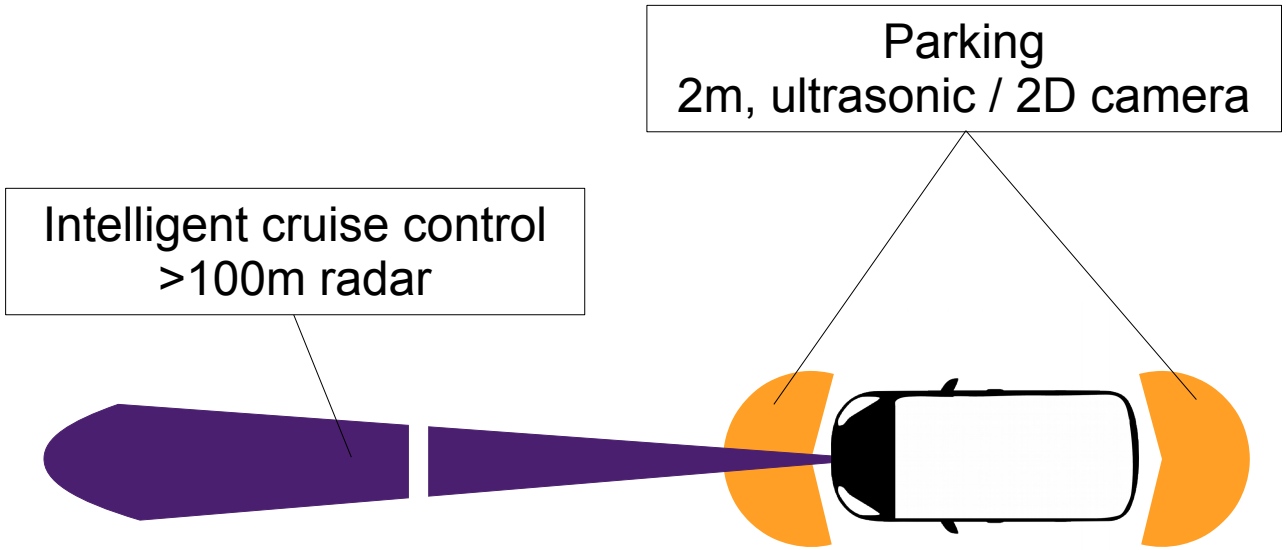

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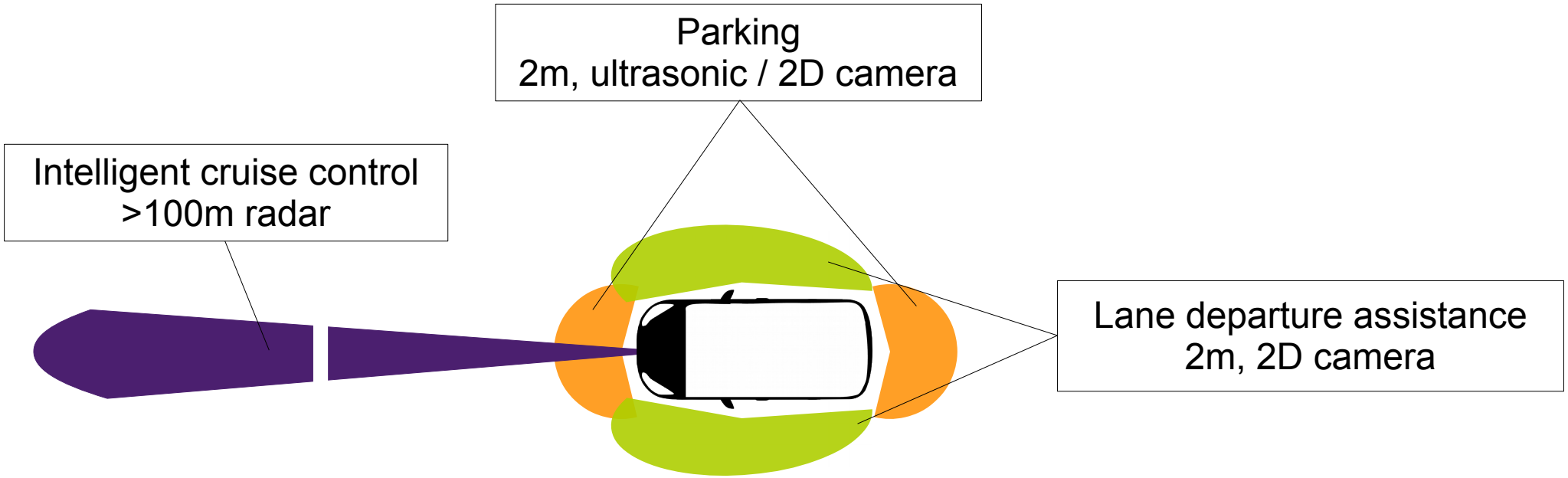

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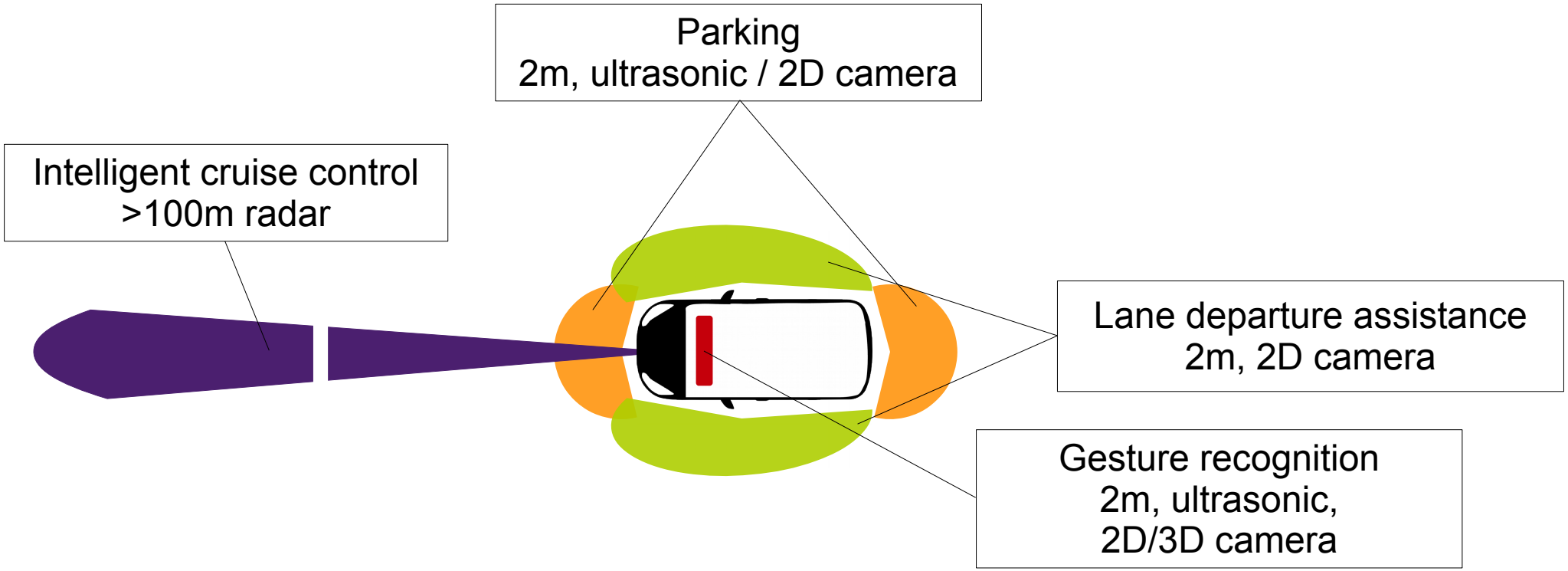

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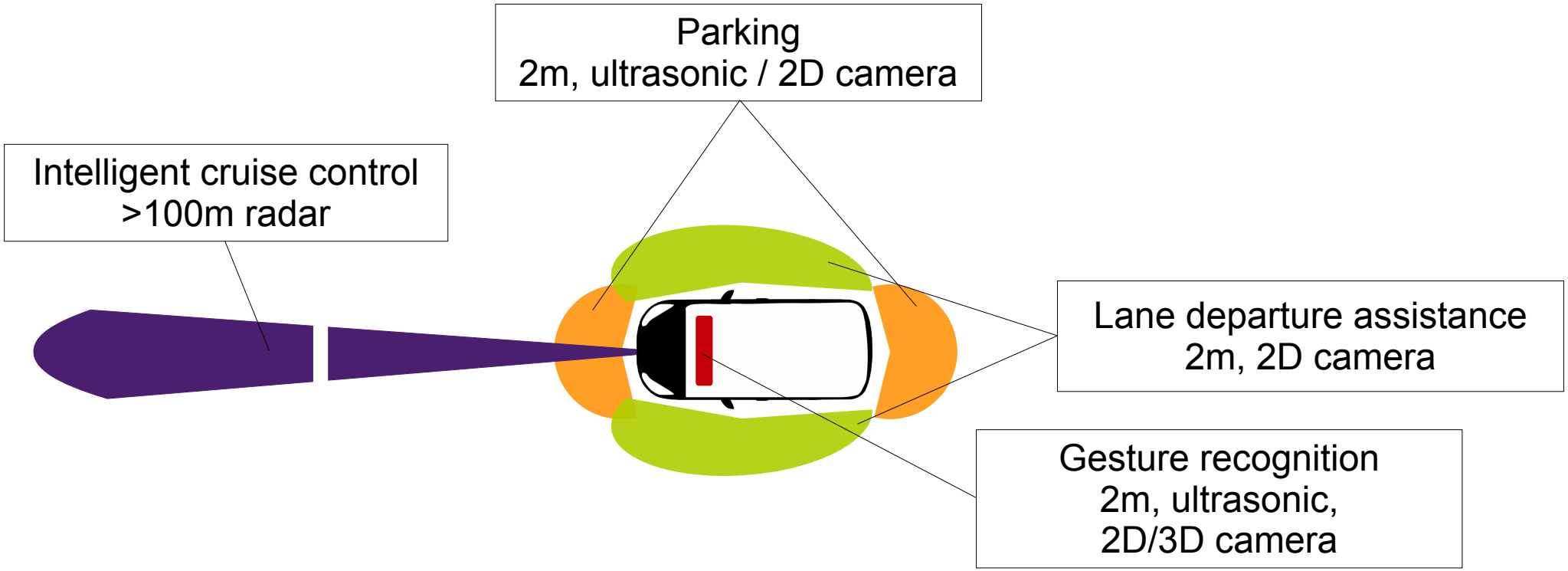
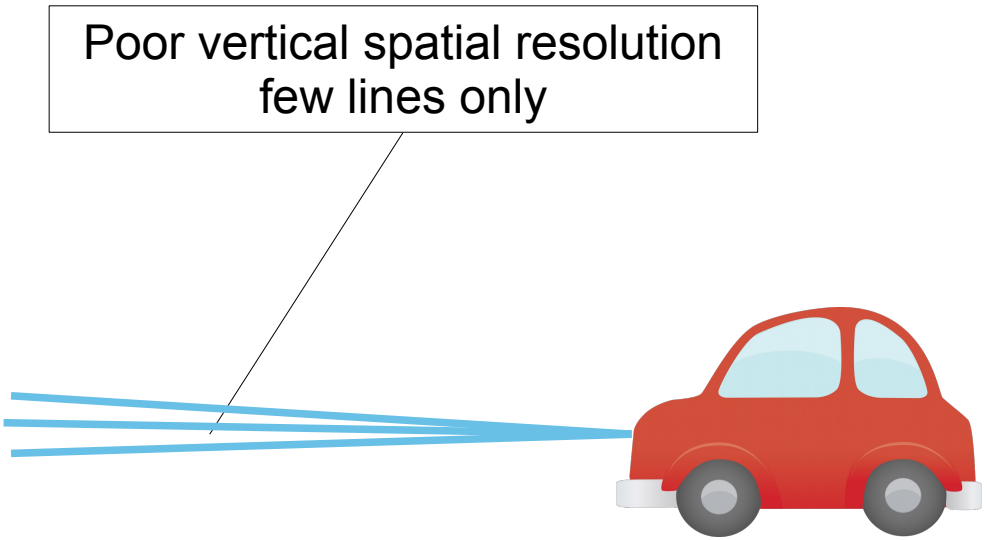
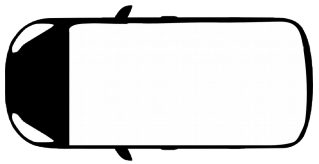



- Quite good sensors and technologies available
- Already well deployed and mature

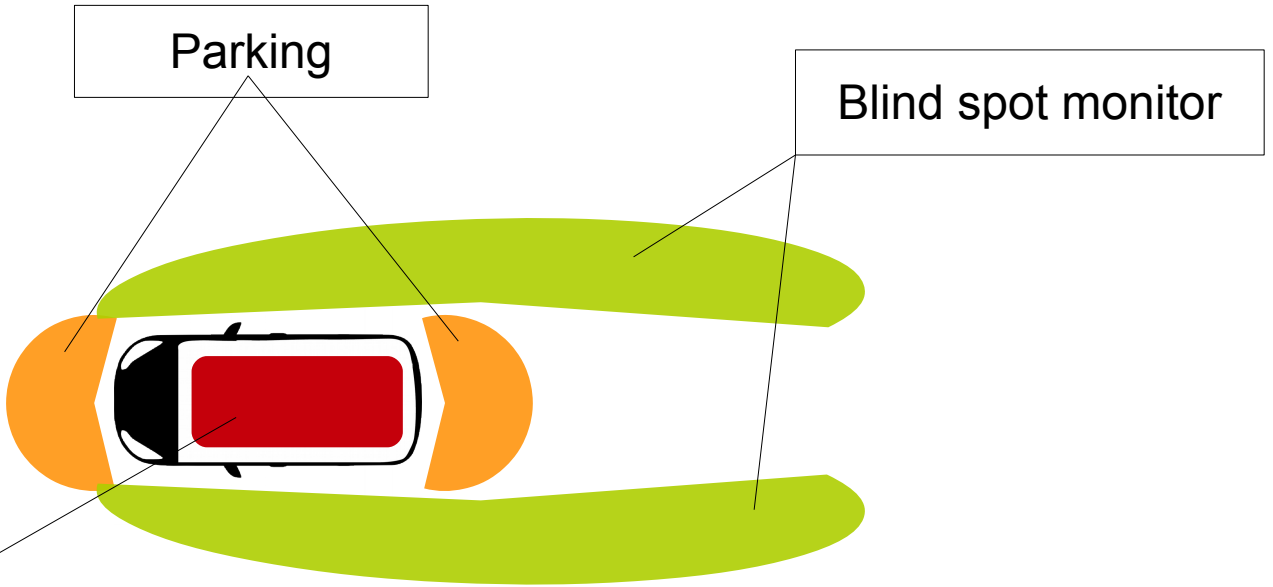
# Current LiDAR solutions



# Future requirements:

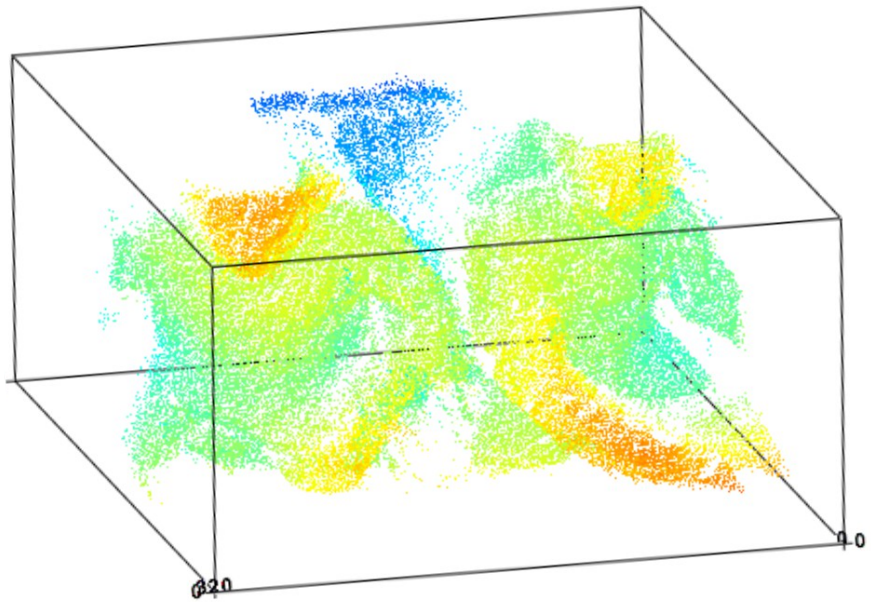


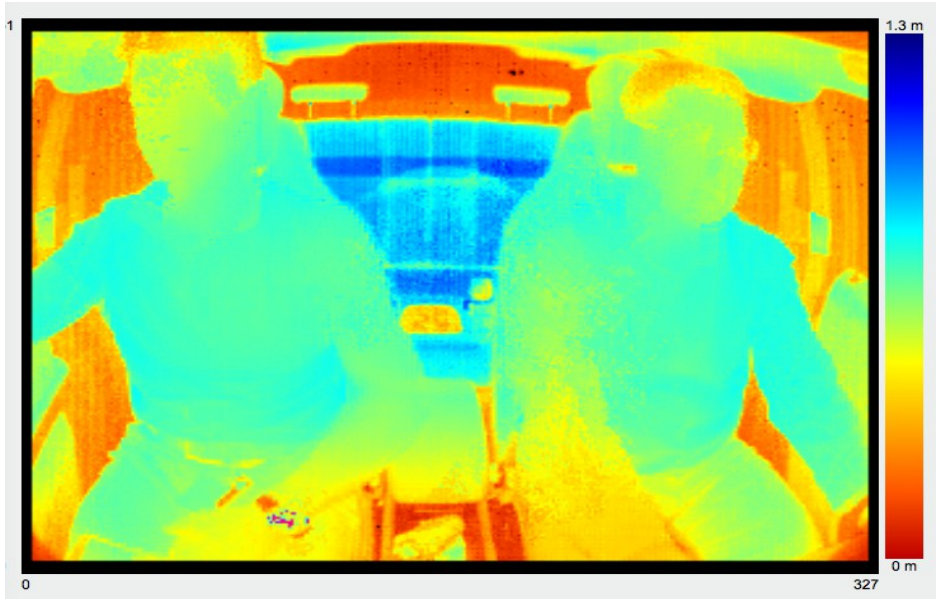
# Future requirements: close range with cwTOF




- Gesture recognition
- seat position
- Driver awareness
- left behind objects

# Already existing imaging cwTOF OHC15L™






- Lens F# 1.4
- hFOV 94°
- vFOV 70°
- LED power 1W (cw)

- Frame rate 50fps
- Wavelength 850nm
- Range 6m
- Sunlight >100kLux

# Future requirements: long range

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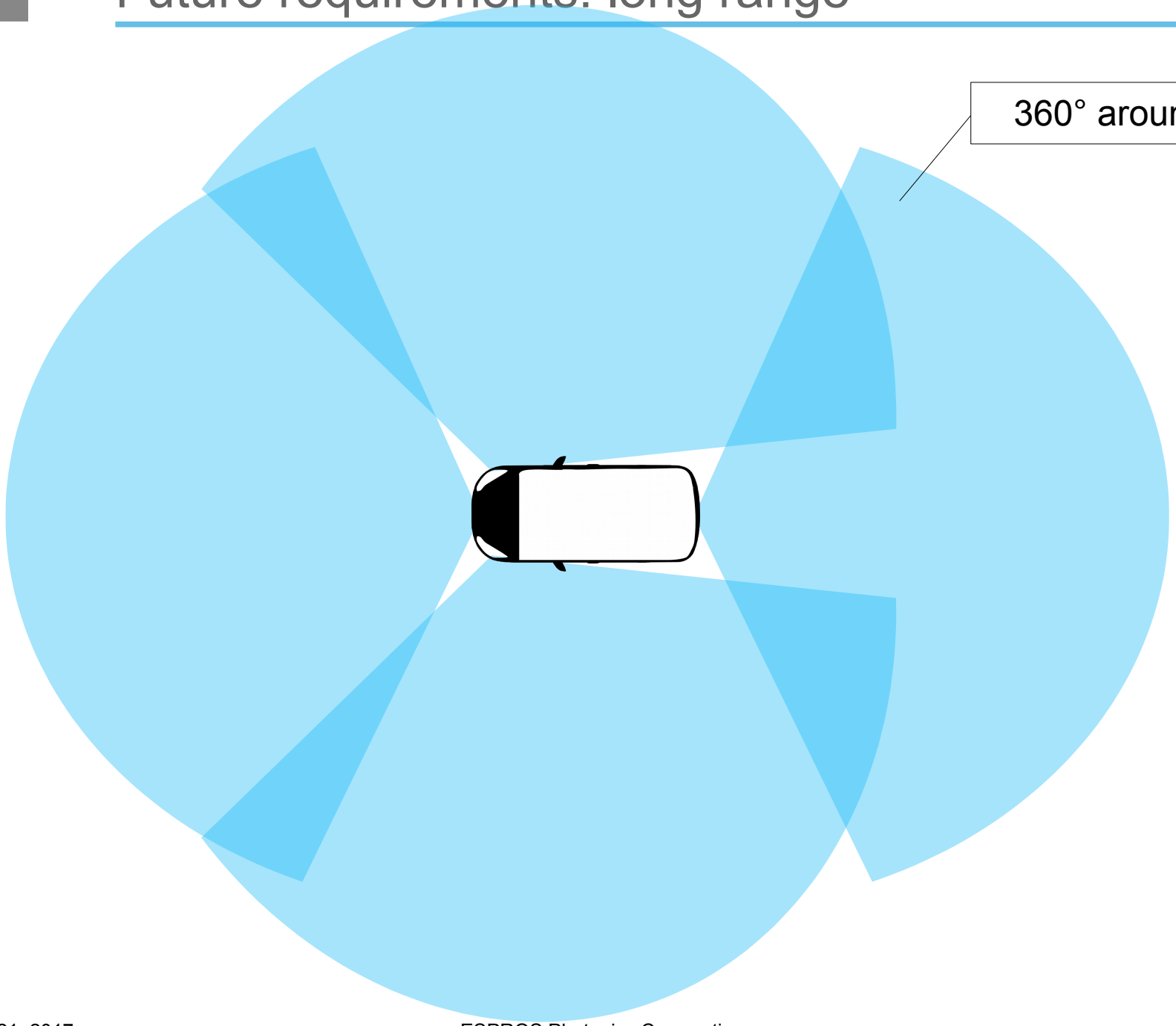

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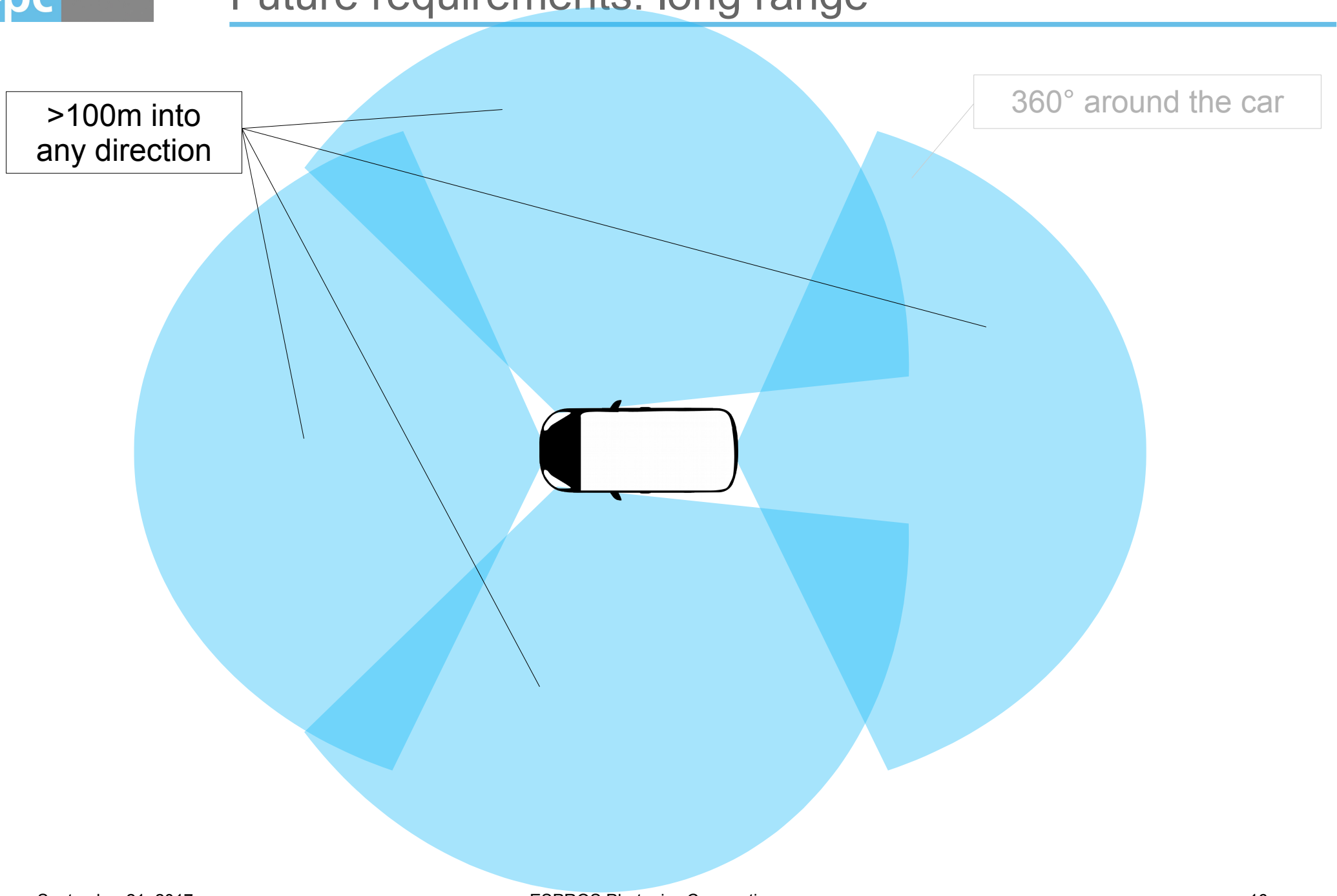

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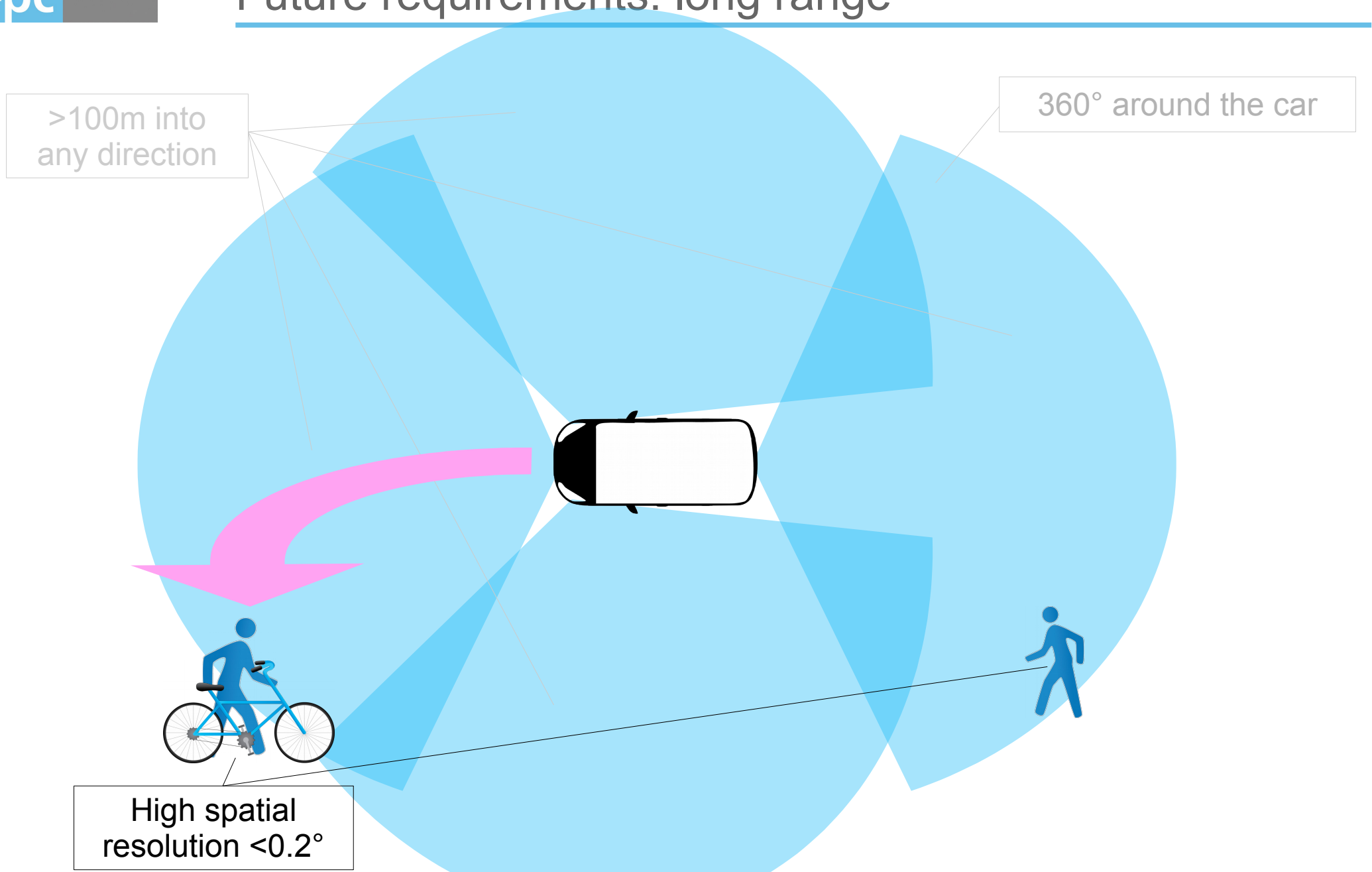
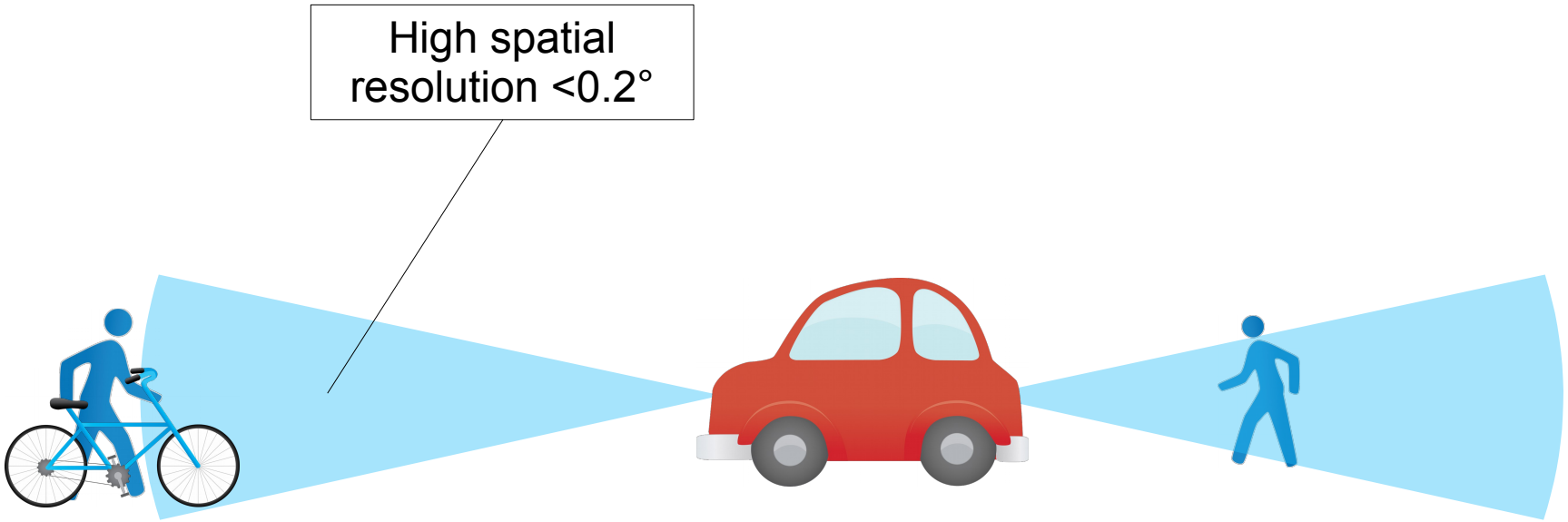


# Future requirements: Large vertical FOV, high spatial resolution



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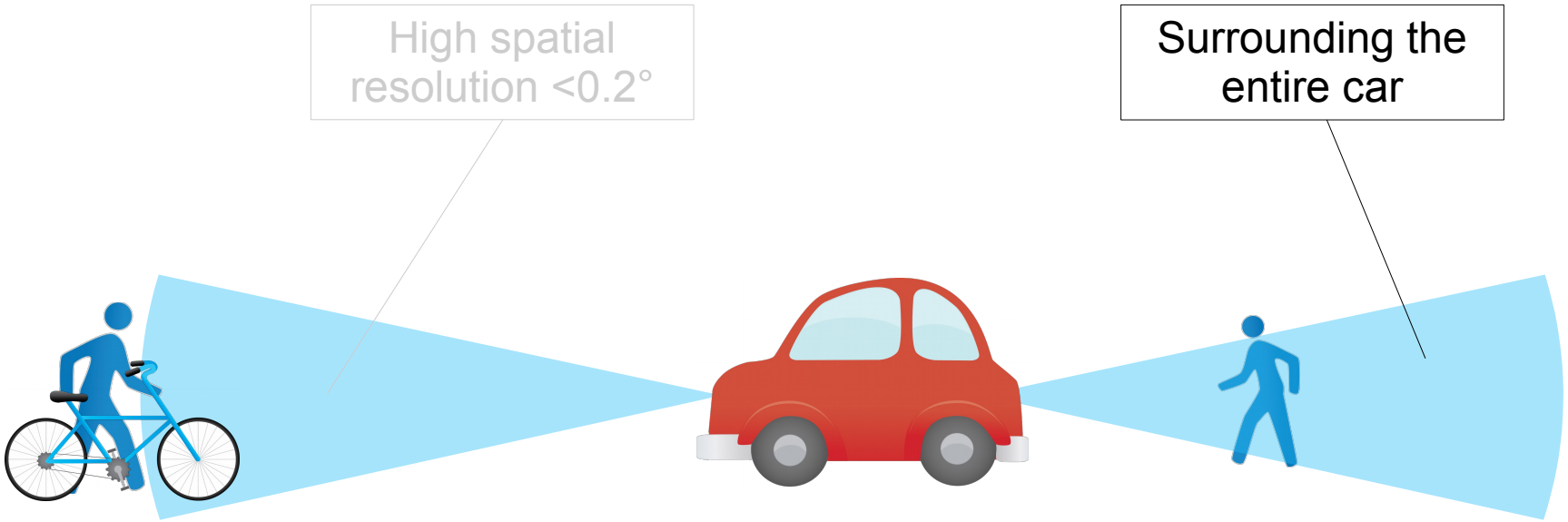


# Sensor requirements summary

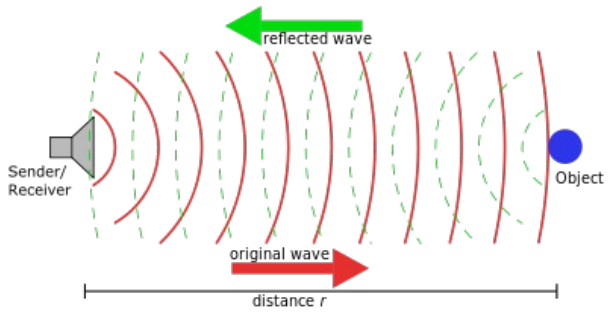
| | |
|---|---|
| Long range | >100m |
| Range resolution | <10cm |
| High spatial resolution | <0.2° |
| FOV horizontal | 360° |
| FOV vertical | >25° |
| Weather condition | all weather |
| Daytime | day & night |
| Frame rate | >25 fps |
| Safety | eye safe, ASIL |
| Multiple sensors | no interference |
| Cost | low |

# Sensor technology overview

- Radar

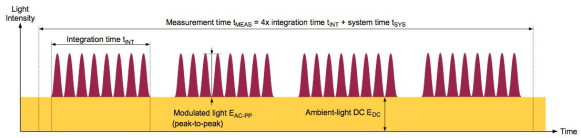
Source: Kaspersky Lab

- Ultrasonic



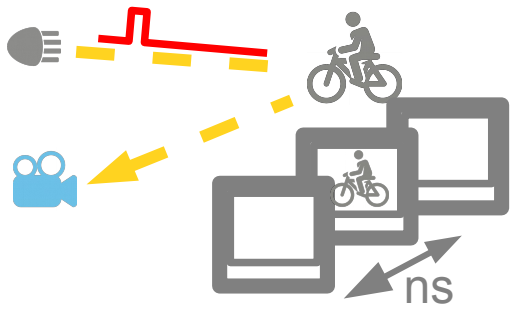

Source: Wikipedia

- cwTOF




Source: ESPROS

- LiDAR

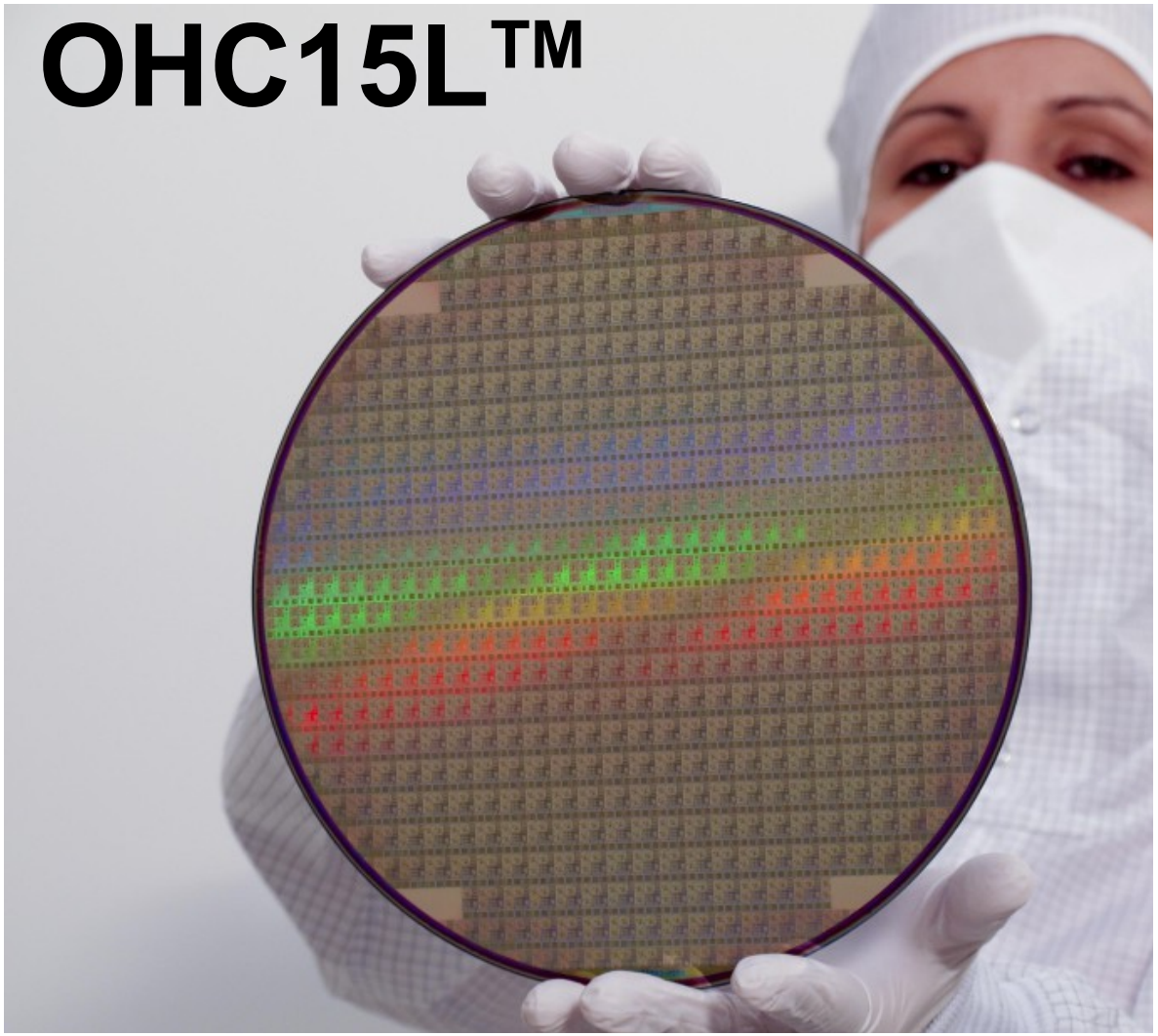



Source: ESPROS

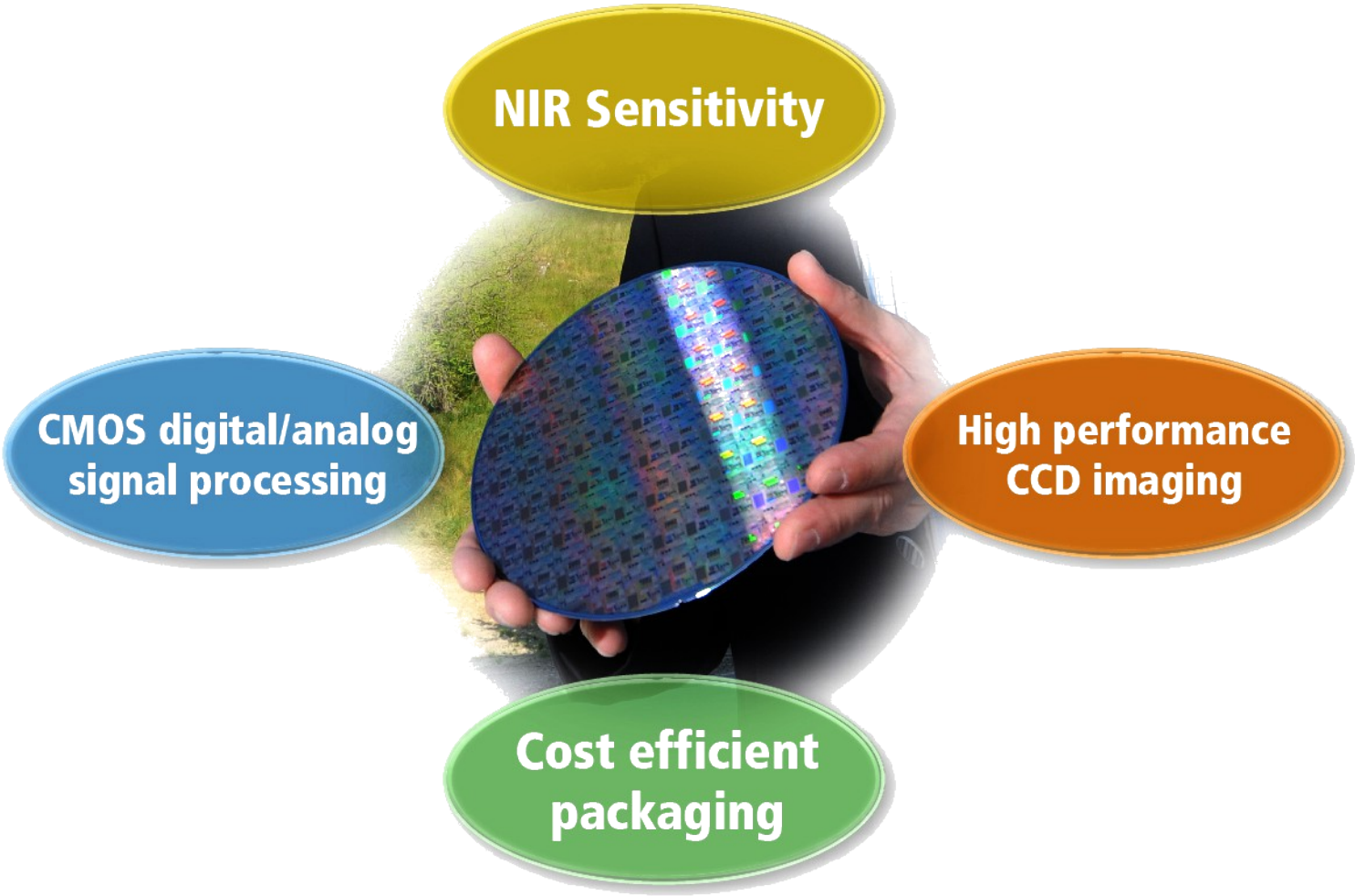
# Technology comparison

| Parameter | Requirement | Radar | Ultrasonic | cwTOF | pTOF (Imaging LiDAR) |
|---|---|---|---|---|---|
| Long range | ≥100m | | | | |
| Short range | 0 .. 2m | | | | |
| Spatial resolution | ≥0.2° | | | | |
| FOV horizontal | 360° | | | | |
| FOV vertical | ≥25° | | | | |
| Distance resolution | cm | | | | |
| Weather condition | all weather | | | | |
| Daytime | day & night | | | | |
| Response time | >25 fps | | | | |
| Safety | eye safe, ASIL | | | | |
| Multiple sensors | no interference | | | | |
| Cost | low | | | | |

# ESPROS imaging LiDAR technology



# Key ingredients needed for a good LiDAR imager



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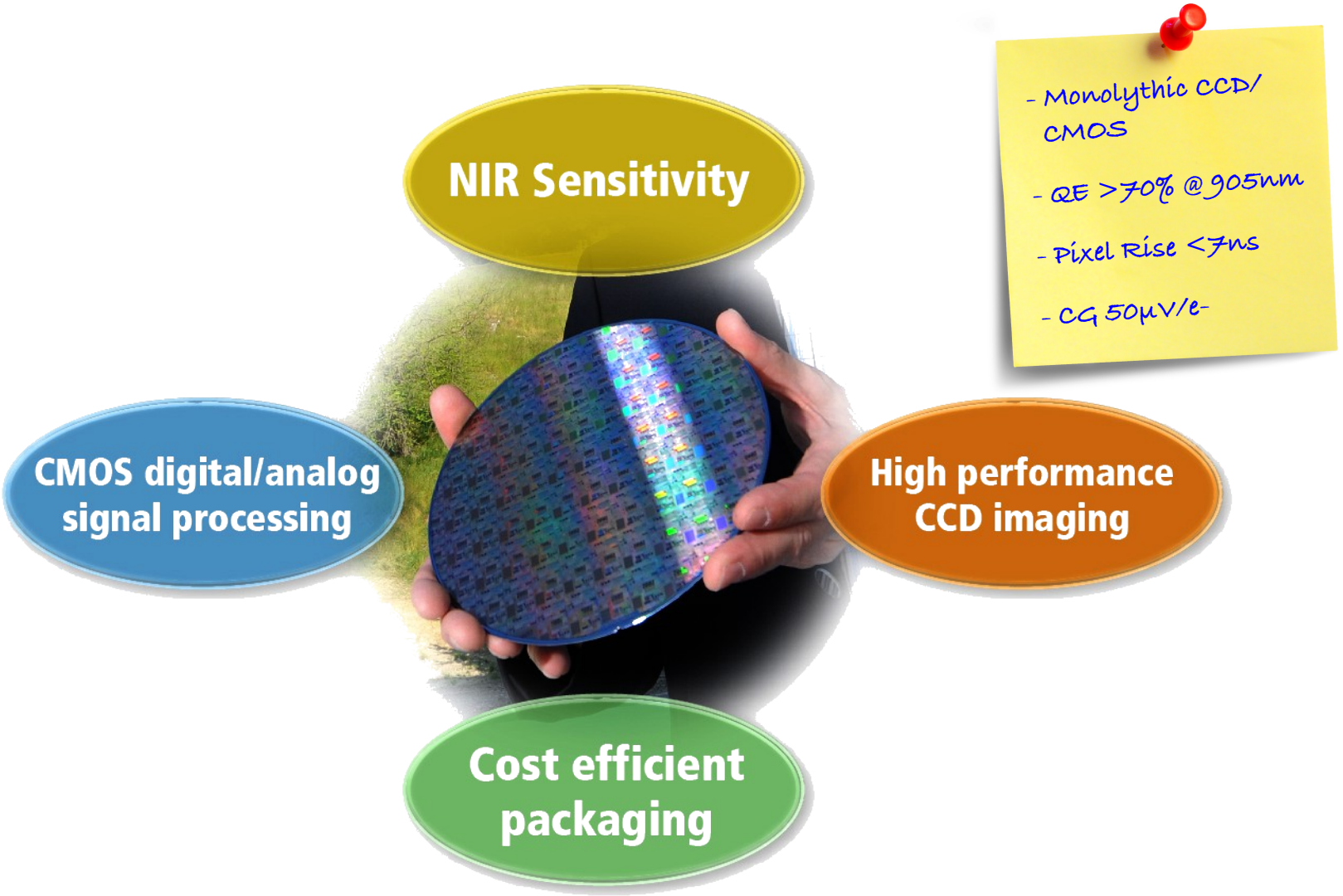
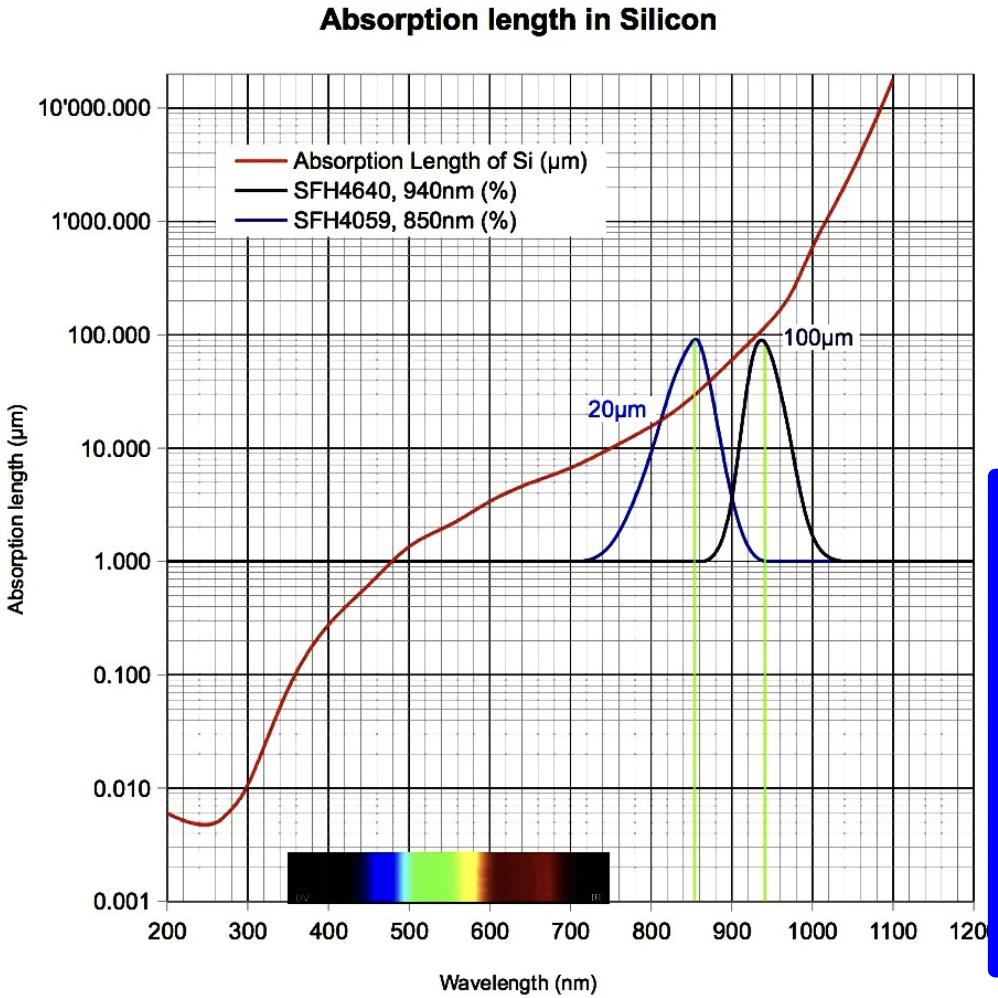


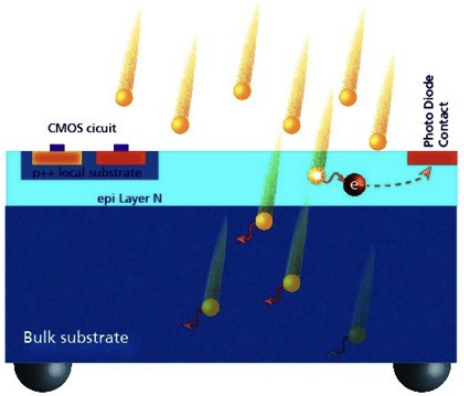
# ESPROS OHC15L™ technical concept




**CONVENTIONAL CMOS**

a) thin active layer

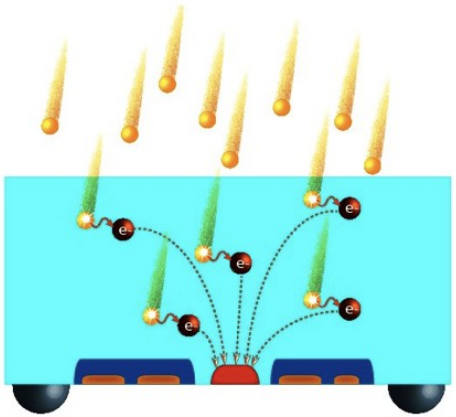
b) 20% fill factor only



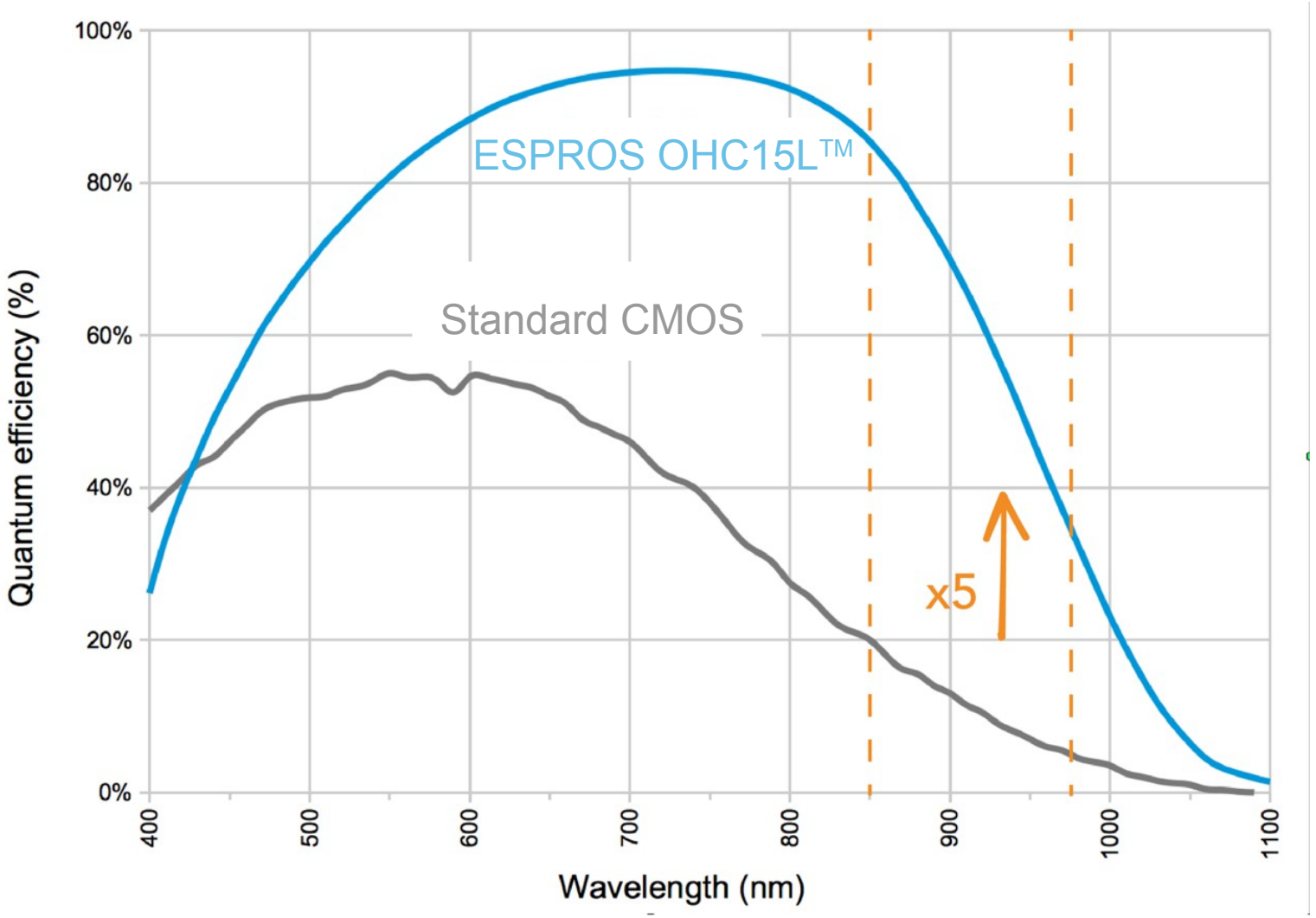

**ESPROS OHC15L™**

a) 50 micron absorber

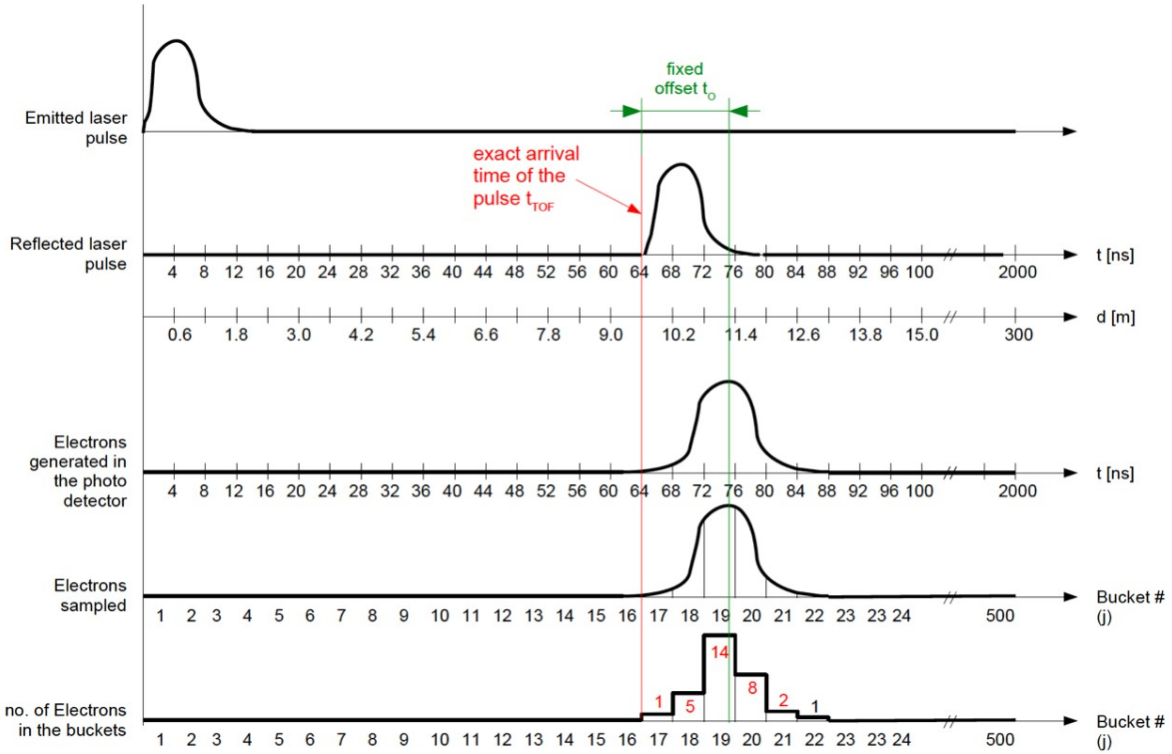
b) 100% fill factor



# Quantum efficiency improvement



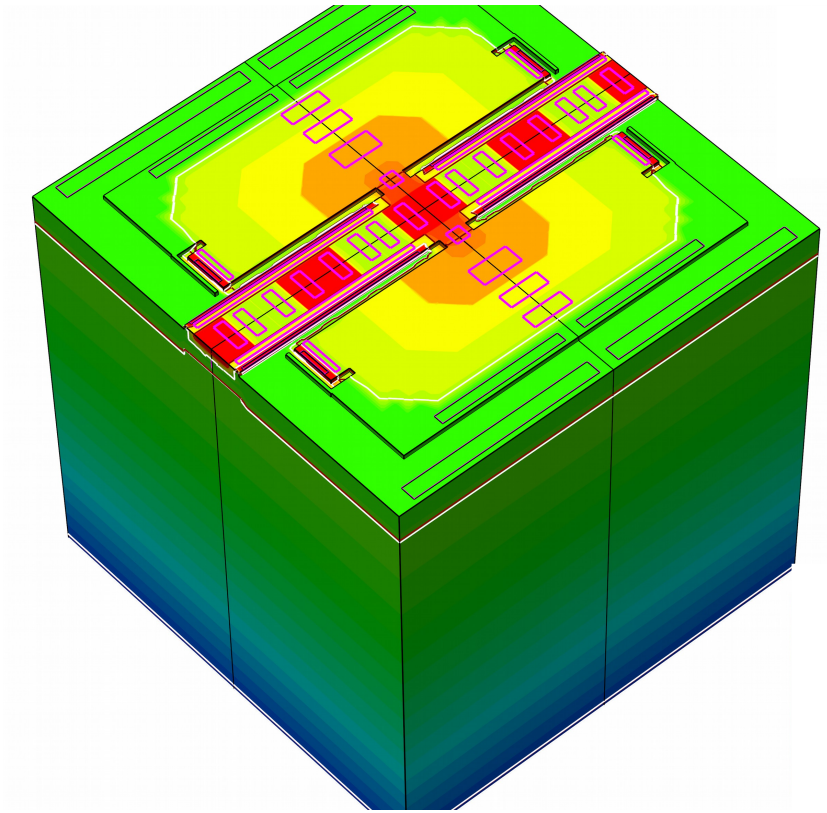
# ESPROS pTOF Principle: Gated imaging with CCD




## Working principle:

- Sampling of arriving light pulses into fast CCD
- A/D conversion of the sampled signal
- Calculation of the exact pulse arrival time point
- Multiple echoes from one laser pulse are detectable

# ESPROS pTOF pixel (example)



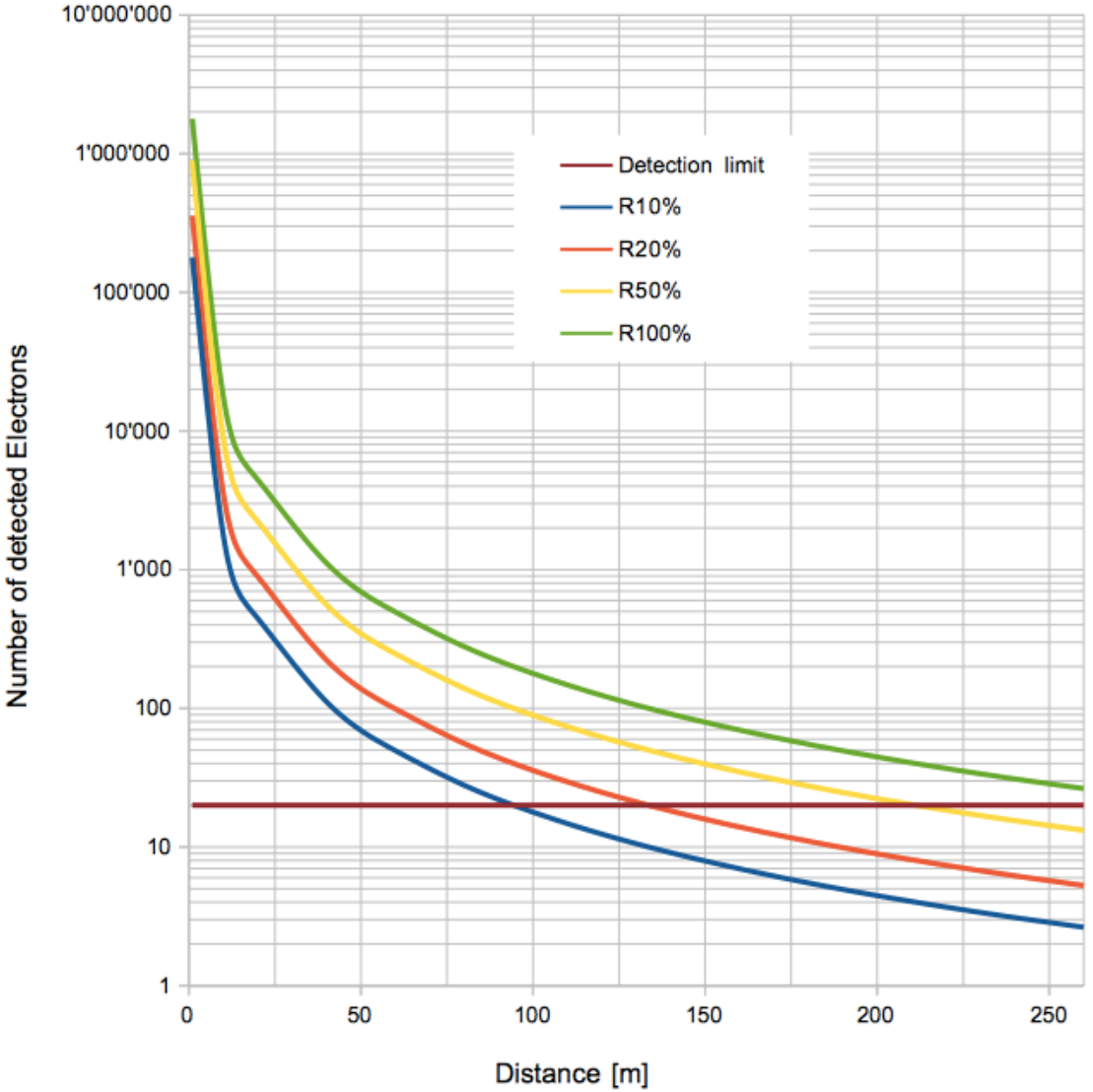
**Pixel & imager parameters:**

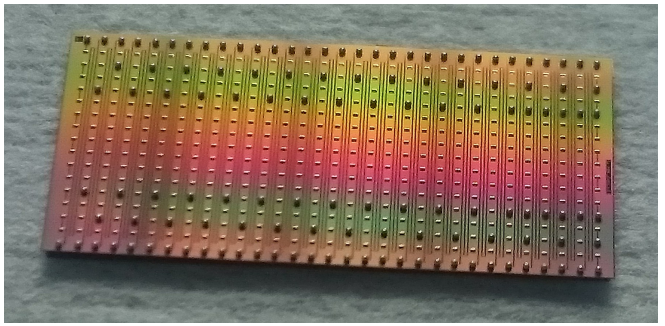
- QE >70% @ 905nm
- Speed 6.5ns (FWHM)
- Sensitivity 20e-
- CCD sampling 250MHz
- CCD 450 stages (270m)
- Pixel pitch 45µm
- Field 262 x 150 pixel
- No. of pixels 38,864
- Frame rate >100fps (full 3D TOF)

# Comparison of receiver device technology

| Parameter | APD | SPAD | ESPROS OHC15L™ |
|---|---|---|---|
| Rise time | 2ns | 300ps | 6ns |
| Bias voltage | 200V | 30V | 10V |
| Max. no. of electrons | unlimited | up to 100 | $10^6$ |
| Photo detection efficiency | 80% | 8% | 70% |
| Min cell distance (pixel pitch) | 30μm | 25μm | 7.5μm |
| Sensitivity (practical) | 15 photons | 6 photons | 20 photons |
| Night vision | impossible | poor | good |
| Typ. Resolution | 16 (64) | 1,000 | 40,000 |
| Cost per channel | very high | medium | very low |

# ESPROS pTOF operating range performance



LiDAR Imager

**System parameters:**

- Lens F# 0.8
- hFOV 50°
- vFOV 25°
- Laser power 3W peak
- Laser pulse 5ns
- Laser Energy 15nJ
- Wavelength 905nm

# At the end: A few words to ESPROS

# At the end: A few words about ESPROS


## Key data

- Established in 2006
- Privately held corporation
- 70 million CHF initial investment
- Photonics chip design and manufacturing
- 60'000m² space built into solid rock for further expansion
- Technology protected with 15 patents or patent applications

## Locations

- HQ Sargans, Switzerland
- Regional offices: USA and China
- 600m² class 1-10 cleanroom for backside processing
- 360m² class 1000 cleanroom for testing, backend and assembly

## Supply Chain

- Frontside processing of OHC15L™ by TSMC
- Established 2nd sources
- Product qualification according JEDEC and AEC-Q100 standards

## Products

- 1, 8x8, 160x60, 320x240 pixel cwTOF image
- Customer specific gated imagers
- Customer specific pTOF imagers

# Thank you!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