ibeo automotive

4D SOLID-STATE LIDAR

Next Generation Now

International SPAD workshop 2020 ISSW
8-10 June 2020
Ünsal Kabuk

Document class: Public

PUBLIC

LIDAR COMPETITOR LANDSCAPE

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BARAJA

blackmore

LUMINAR

Continental

BEAMAGINE

BOSCH

ASC

AEVA

LIVOX

Velodyne Lidar

LeddarTech

ON Semiconductor

sensL

CEPTON

AEYE

QUANERGY

WAYMO

oryx

OUSTER

robosense

HESAI

ARGO AI

INNOVIZ TECHNOLOGIES

Blickfeld

LiDAR / scan your world

Benewake

InnoVusion

DELTALiDAR

3D Haritalama Teknolojileri

TETRAVUE

SOLID STATE HD LIDAR

TRILUMINA

LUMOTIVE

镭神智能

LeiShen Intelligent System

STROBE

OURS

HYBRID LIDAR SYSTEMS AG

TOP 100 Top-Innovator 2019

AGENDA

- **About Ibeo**
- **Where we came from**
- **Where are we now**
- **Ibeo Research**
- **Key take aways**

ABOUT IBEO

Worldwide technology leader in the field of LiDAR sensors, associated products, and software tools.

- **Hamburg, Germany**
- **Eindhoven, Netherlands**
- **Detroit, USA**
- **Coming soon: China**

Sales increase:
342% from 2014 to 2018

400+ employees

A 20 YEARS SUCCESS STORY

Milestones

Sensor Products

1998 Founding year

2000 SICK AG Acquisition of 90% Ibeo stake

2005 ALASCA XT

2007 DARPA Urban Challenge

2007 ibeo LUX

2009 Foundation of Ibeo Automotive Systems GmbH

2010 Cooperation Agreement with Valeo Schalter und Sensoren GmbH

2013 Introduction of sub-brands ibeo.Reference and ibeo.HAD

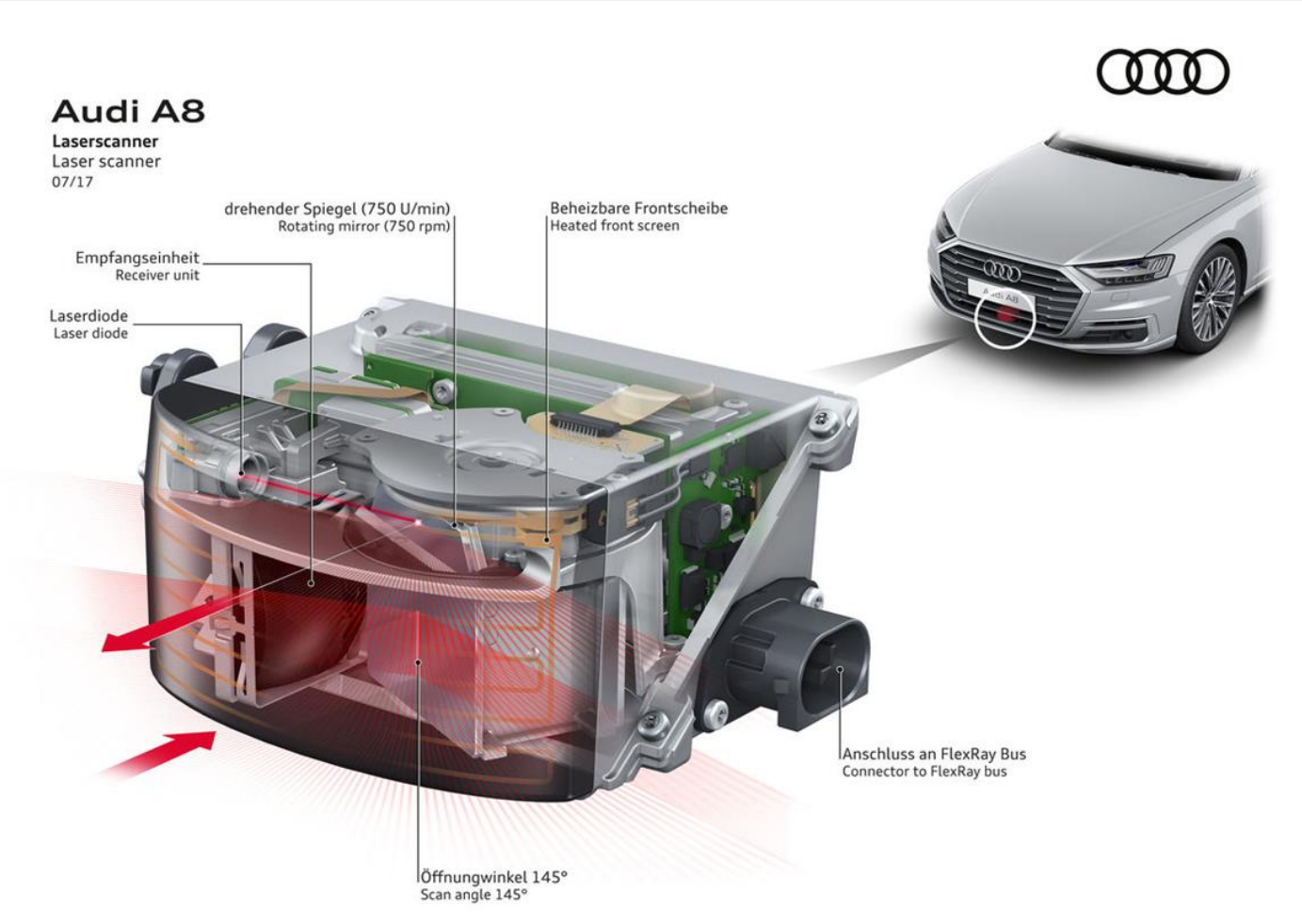
2016 ZF Friedrichshafen AG – Acquisition of 40% Ibeo stake

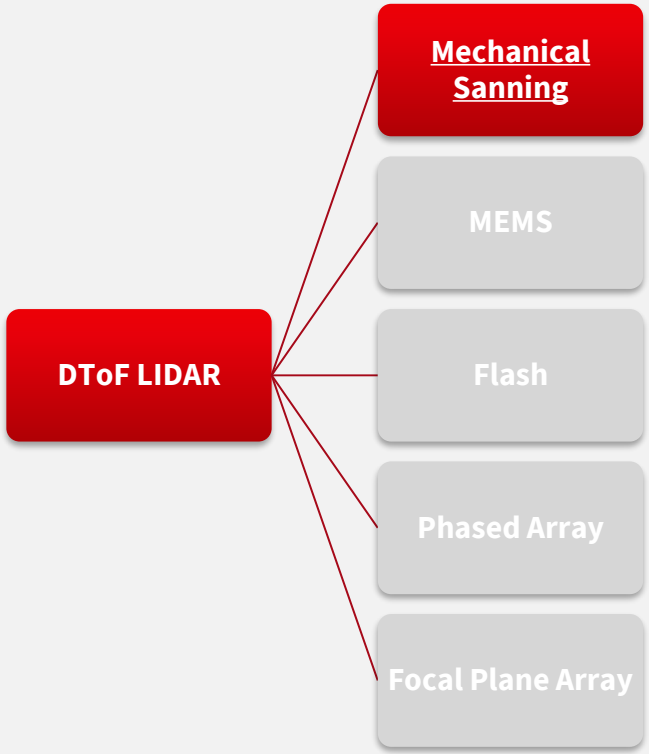
2017 Series production of ScaLa; the first LiDAR sensor going into serial production

2018 Valeo

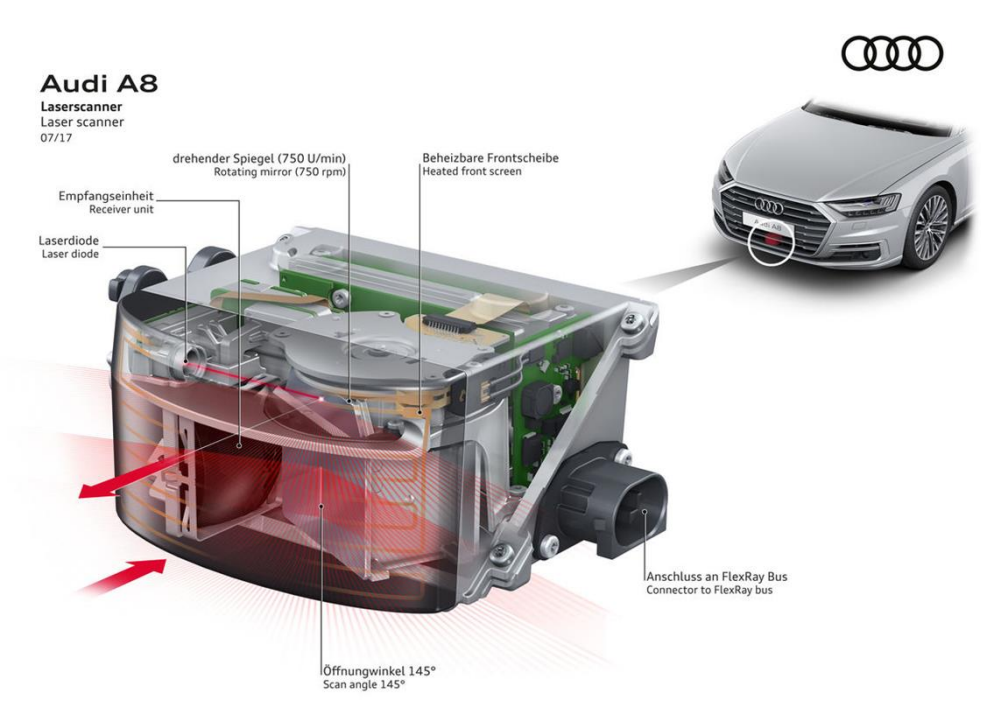
2019 ibeoNEXT

WHERE WE CAME FROM





WHY SOLID STATE(1 OF 2)



And with solid-state we mean SPAD technology

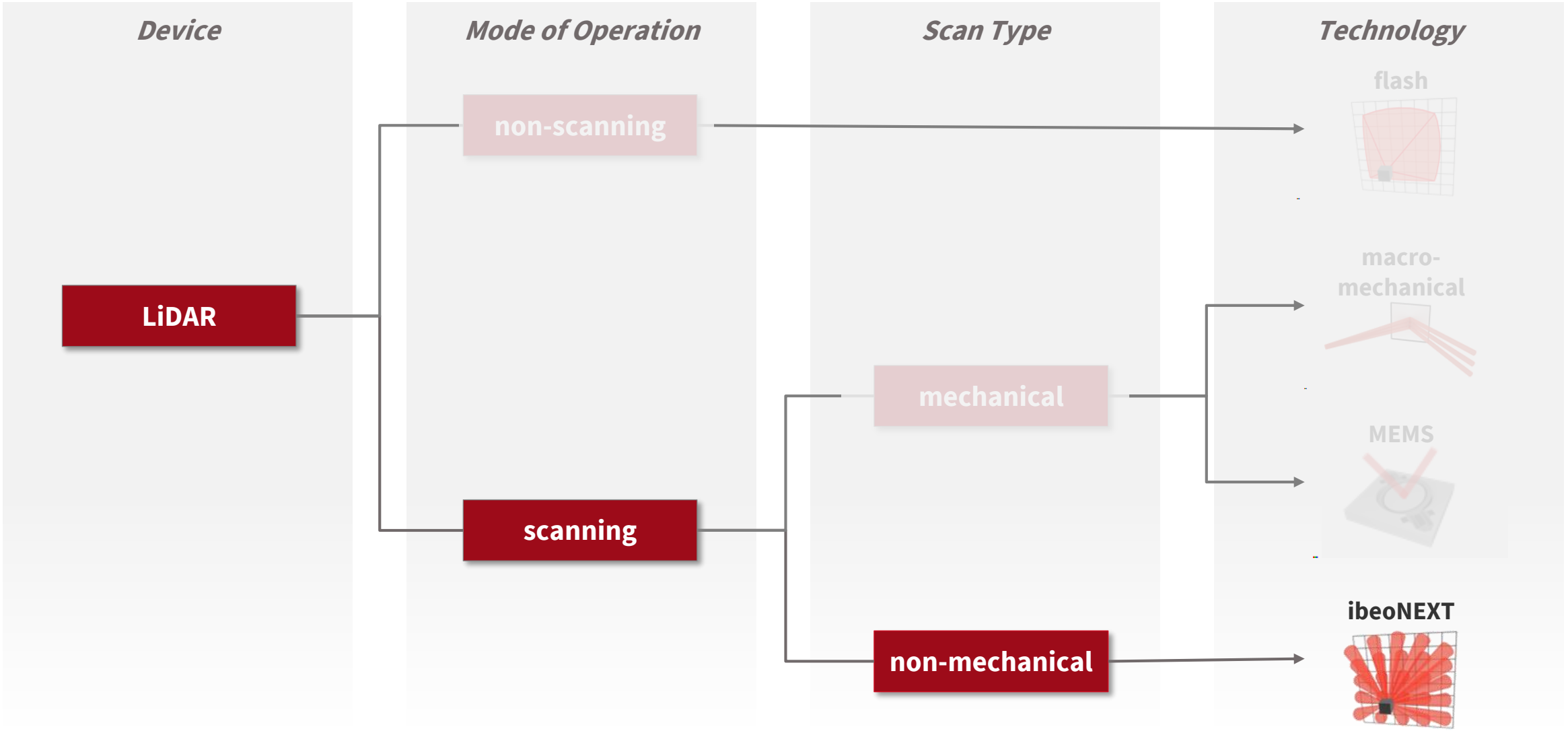
A real 3D environmental sensing solution

- **~30 % cost due to mechanical scanning**
- **~30 % Volume due to mechanical scanning**

- **~factor 1000 improved sensitivity in system, e.g nW - pW**
- **~factor 100 less power per detector**

Waveform information available → on-chip DSP per detector channel

THE IBEONEXT IS A 4D SOLID STATE, SEQUENTIAL FLASHING, NON-MECHANICAL LIDAR

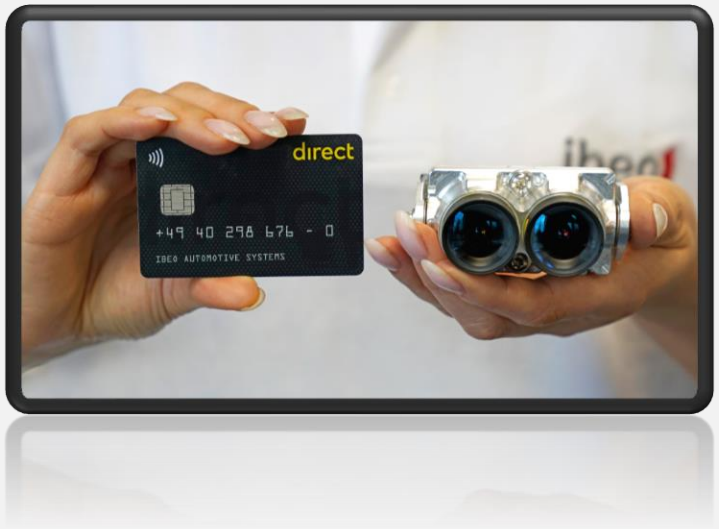


WHERE WE ARE NOW

ibeoNEXT

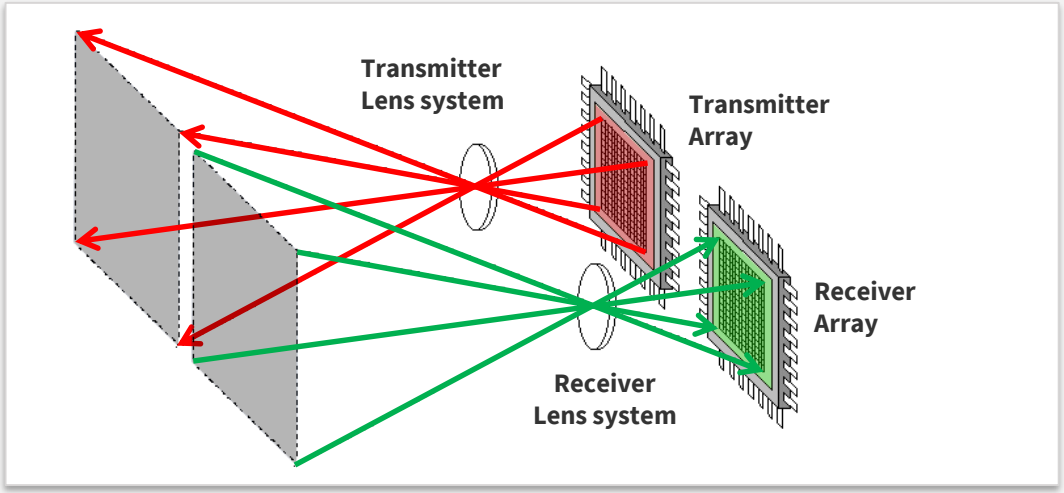
ibeoNEXT: 4D Solid State LiDAR

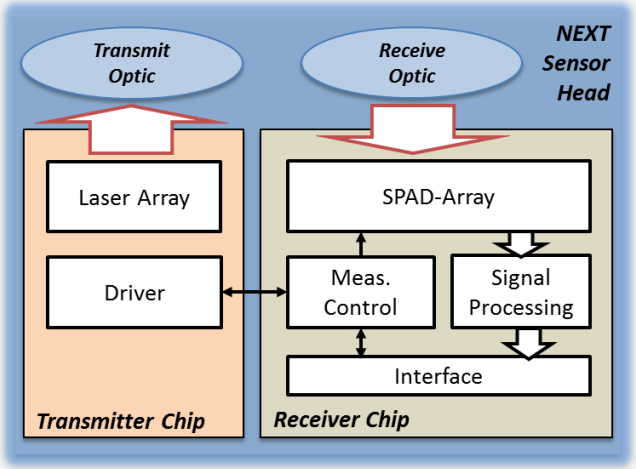
- **Very high resolution (e.g. 0.044 deg)**
- **Long range (e.g. 300 m)**
- **Large FOV (e.g. 120x60 deg)**
- **Eye-safe Laserclass 1**
- **Low energy consumption**
- **ADAS and AD (from L2+ to L5)**
- **Frame rate 25 Hz**
- **Modular concept**
- **Absolutely no moving parts**
- **Small size and small weight**
- **Output: 3D point cloud & intensity image**



The future in sensing for autonomous driving!

HOW IT WORKS - IBEO‘S FRONTEND DESIGN



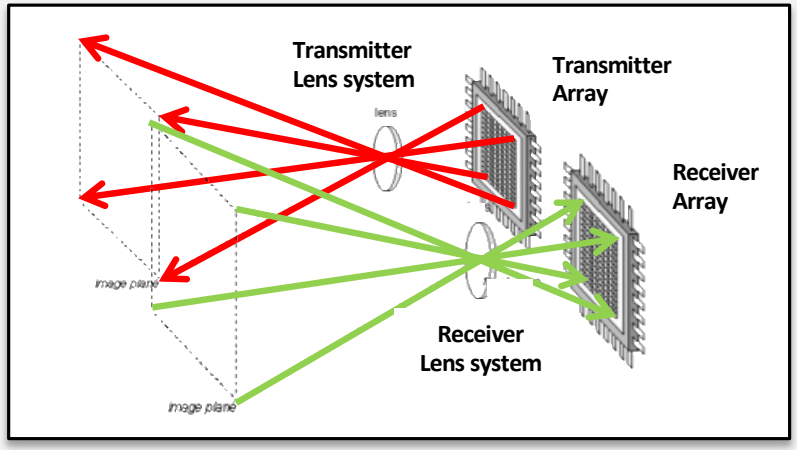


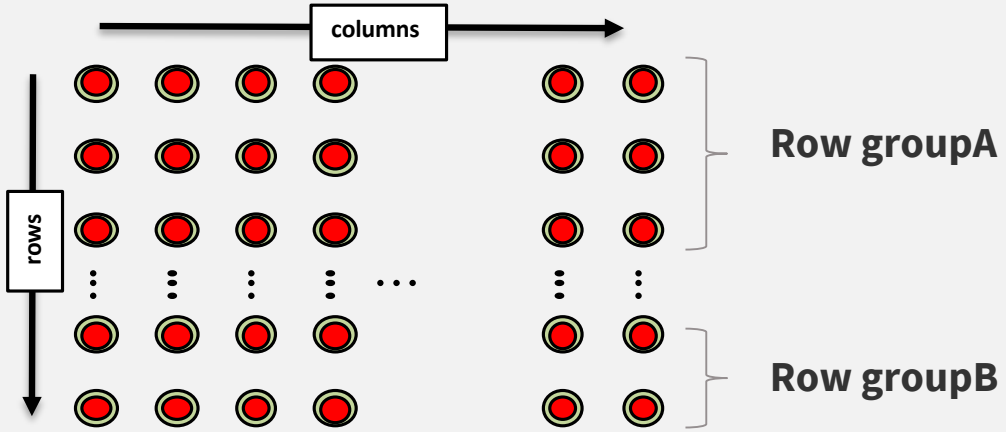
The Frontend consists of

- A transmitter array and a receiver array
- A transmitter lens system and a receiver lens system
- Digital receiver technology - SPAD based
- Digital processing unit to create point clouds (not visible in the picture)

- The Array consists of 100 rows and 128 columns
- 25Hz Frame time –> 40ms

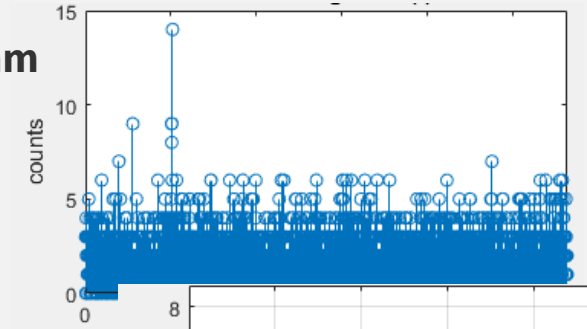
HOW IT WORKS – SEQUENTIAL FLASH SCANNING





HOW IT WORKS - IBEO‘S FULLY DIGITAL FRONTEND

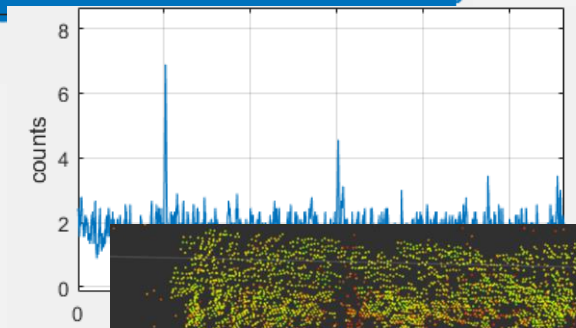
Raw histogram waveforms



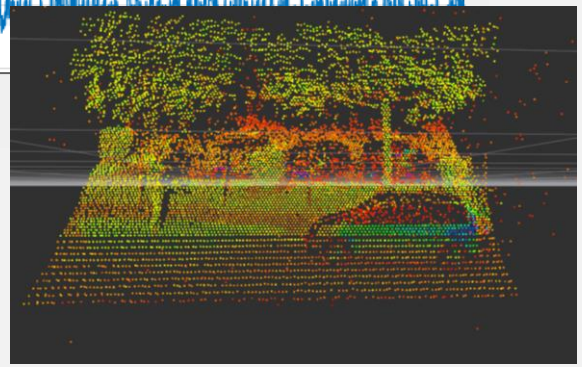
Histogram processing

Feature extraction

Detected events

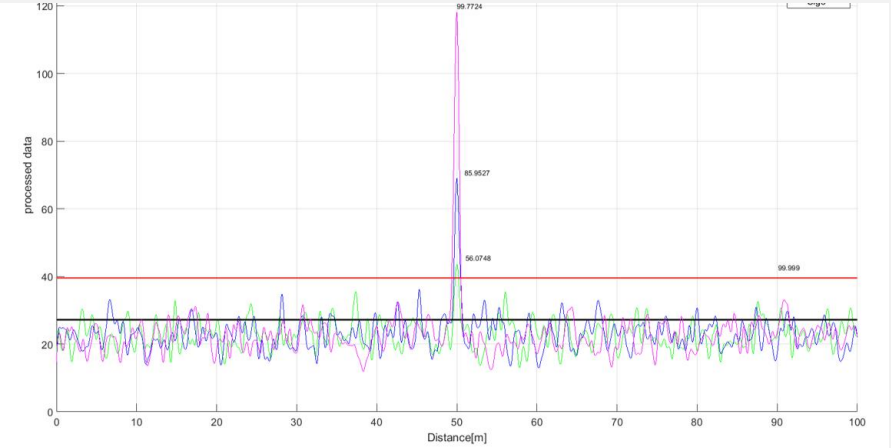


Point cloud



Point cloud generation

Quality measures



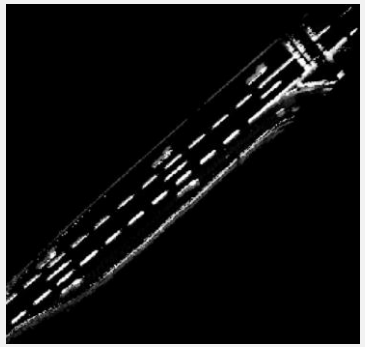
INTENSITY IMAGE USAGE FOR LANE DETECTION

Ground is an essential part of the Road model

Lanes are on the ground

Lanes are highly reflective

Hence: identify bright spots on the ground



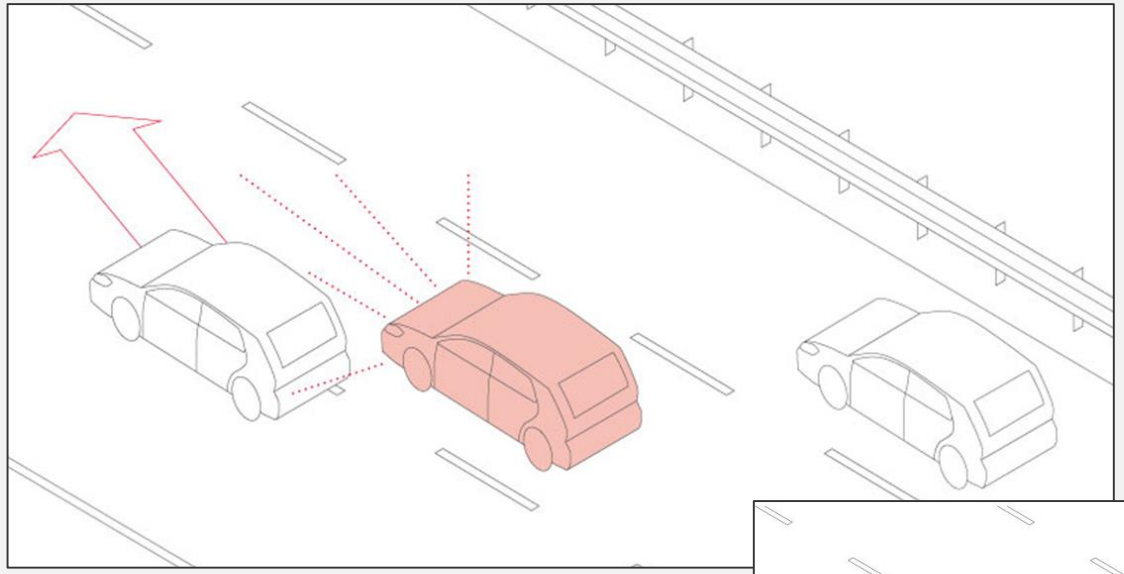
Lanes are always on the ground

Apply ground model, intensity range, and layer filtering

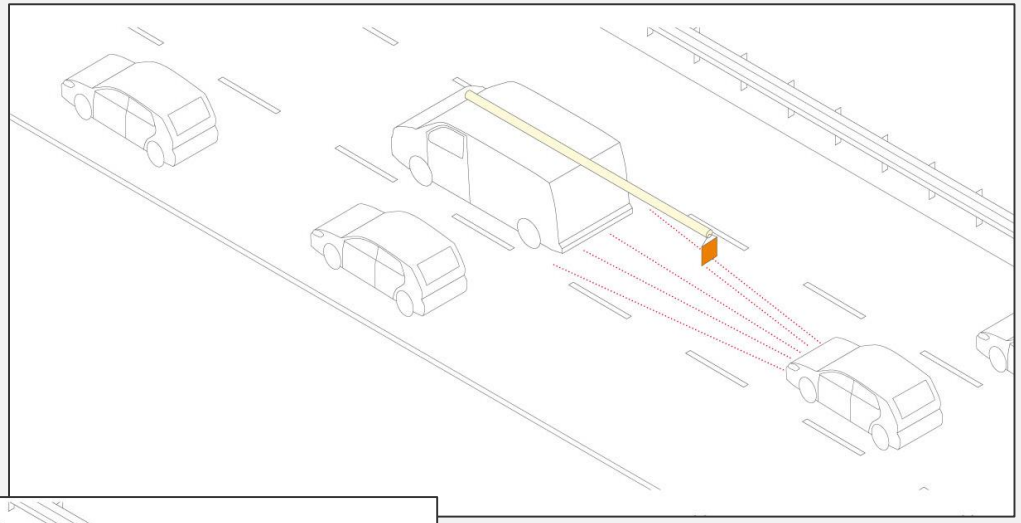
WHAT ARE THE IMPORTANT USE CASES

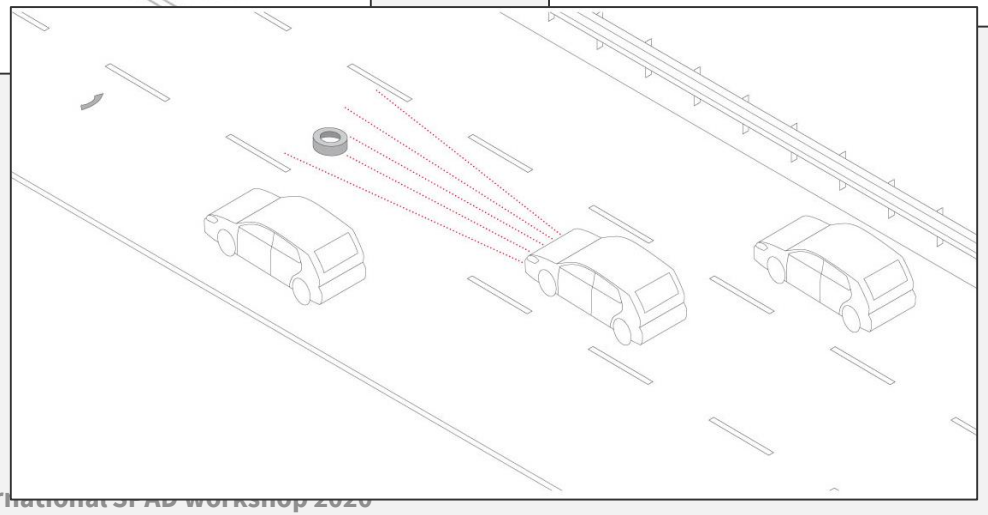
VEHICLE CUT-IN

Vehicle cut-in



Overhanging loads

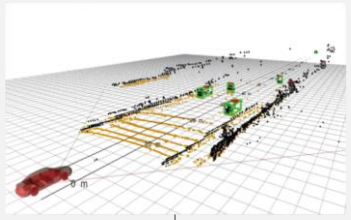




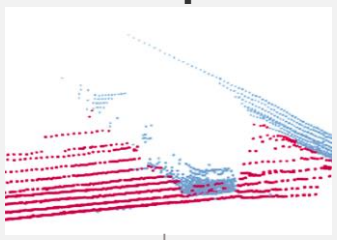
Small obstacles on the road

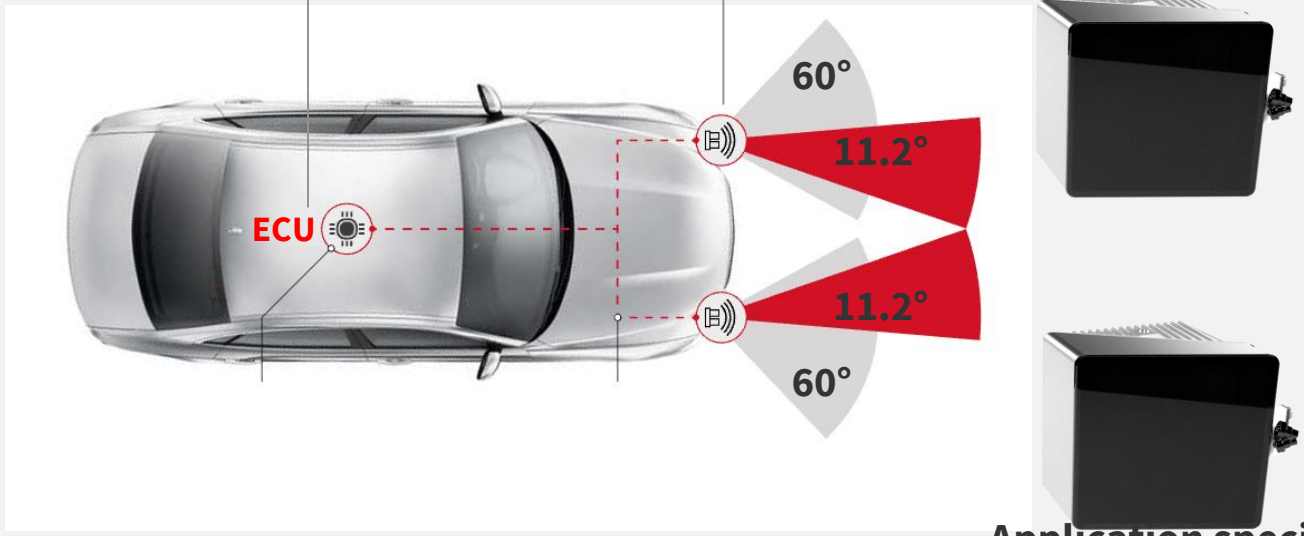
HOW WE SOLVED IT – FRONT LOOKING

Ibeo Enviroment representation



LiDAR point cloud





Application specific sensor heads

		Long-range sensor (11.2°)	Mid-range sensor (60°)
Columns	#	128	128
Rows	#	80 (+20)***	80 (+20)***
Pixel	#	10240	10240
Hor. FoV	°	11.2	60
Ver. FoV	°	5.6 (7)***	30 (37.5)***
Horizontal Angular Resolution (per row)	°	0.088	0.47
Horizontal Angular Resolution (interlaces)	°	0.044	0.23
Vertical Angular Resolution	°	0.07	0.38
Configured design range	m	260	80
Detection Range (10%)	M	150	60
Classification* of tire	m	85	15
Classification* of pedestrian	m	165	35
Classification* of car	m	250	60
First detection** of car	m	260	80

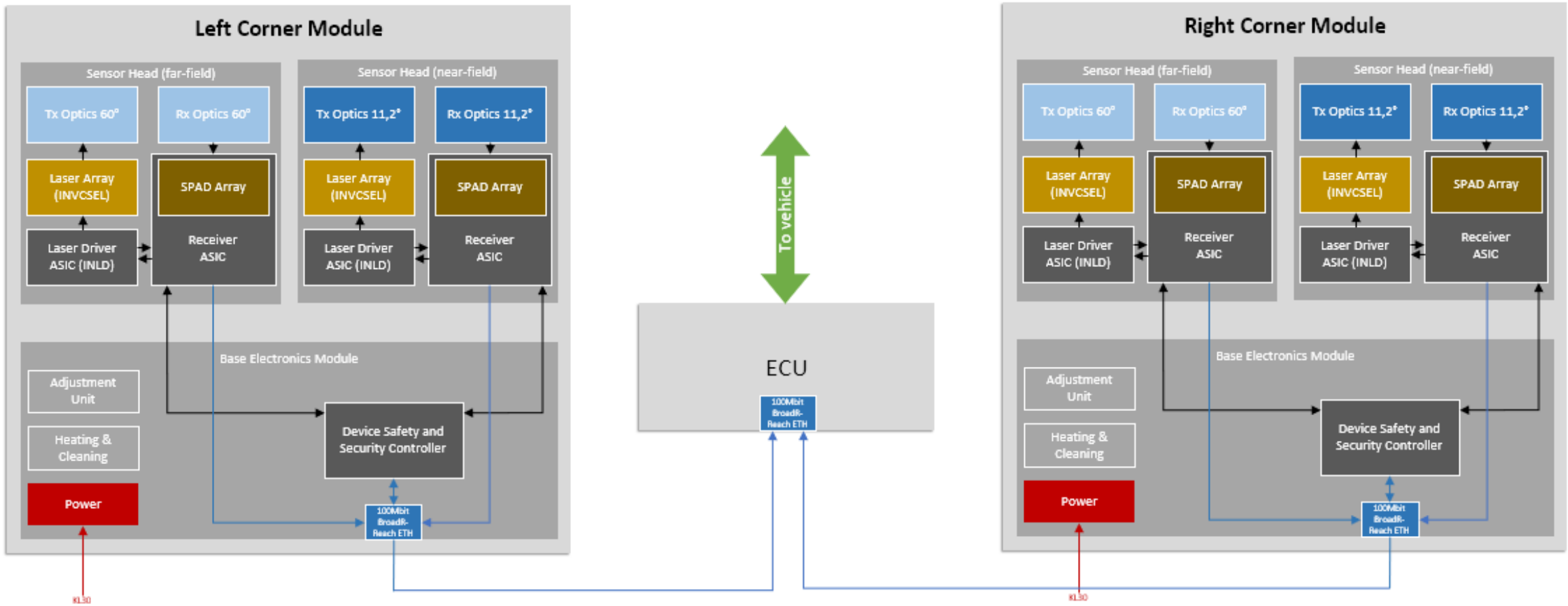
* Ranges for 40ms periodic scan (25Hz). Object is classified as an object on the interface with high confidence

** Ranges for 40ms periodic scan(25Hz) . Objects detected by pixel, i.e., an object is detected as a point in the point cloud

*** Sensor is reconfigurable at assembly-time to extend the vertical resolution and FoV depending on the use-cases

Author: Ünsal Kabuk/ Ibeo Automotive/ International SPAD workshop 2020

HW ARCHITECTURE OF FRONT LOOKING SYSTEM



SCALA VS IBEONEXT POINTCLOUD – WHY SOLID-STATE (2 OF 2)

LUX

IbeoNEXT in urban scenario

IBEONEXT 4D SOLID STATE LIDAR- ACC ON HIGHWAY

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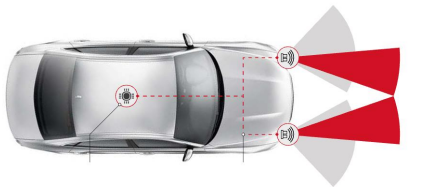
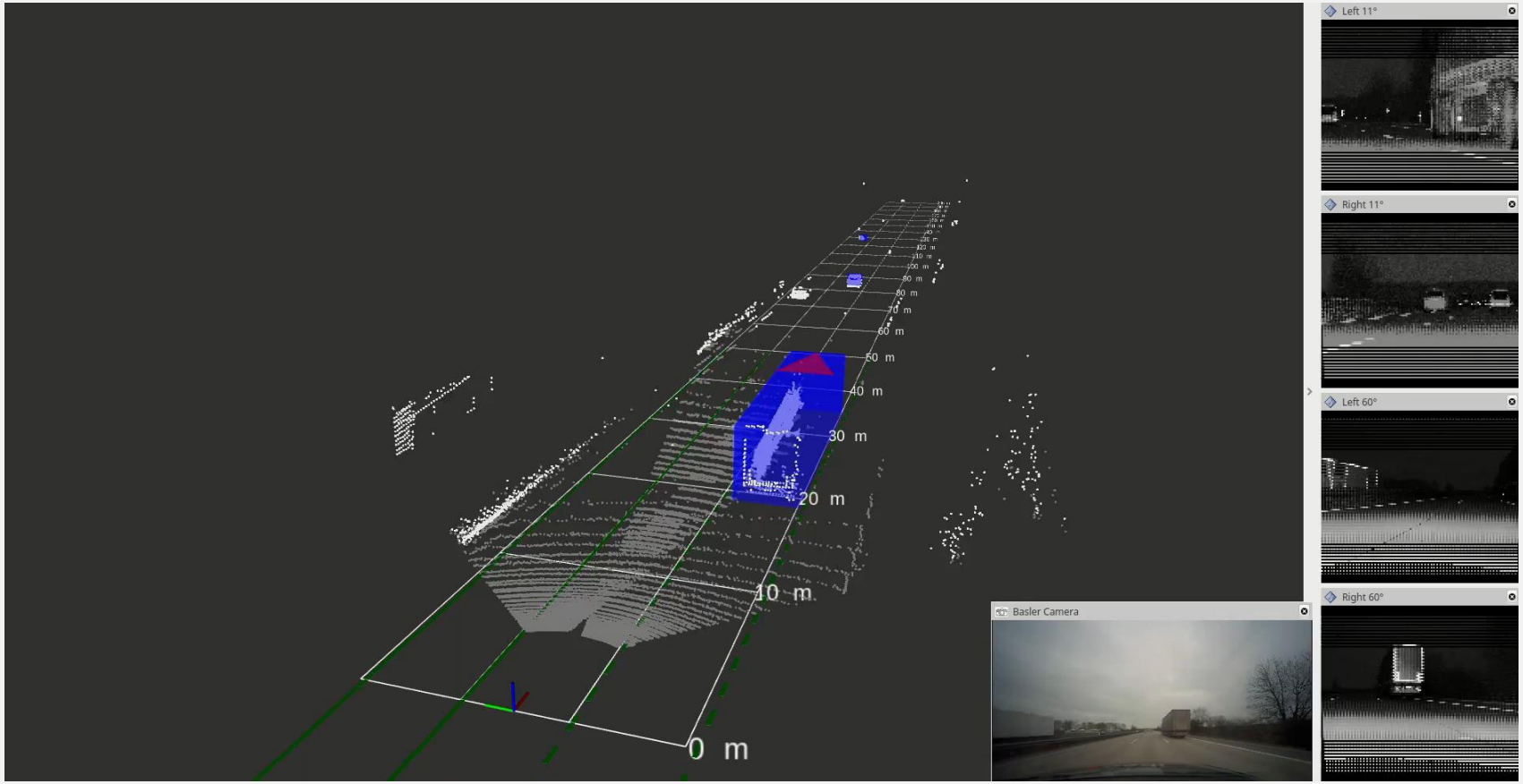




IBEO RESEARCH

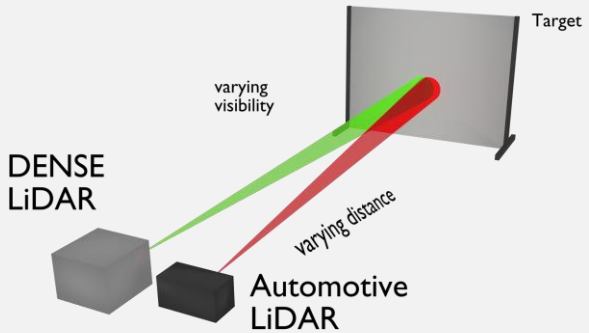
ADVERSE WEATHER

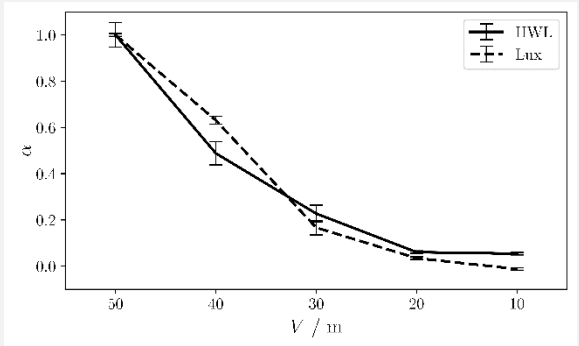
DENSE

Bundesministerium für Bildung und Forschung

ECSEL Joint Undertaking
Electronic Components and Systems for European Leadership

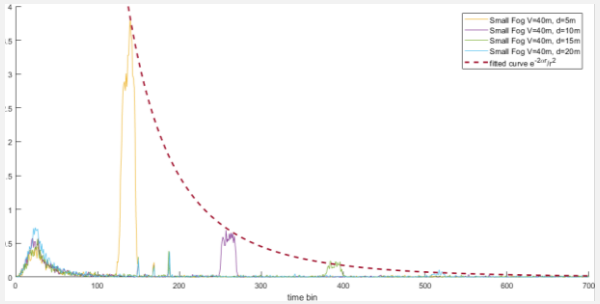
905 nm vs 1550 nm wavelength benchmark performance in Fog



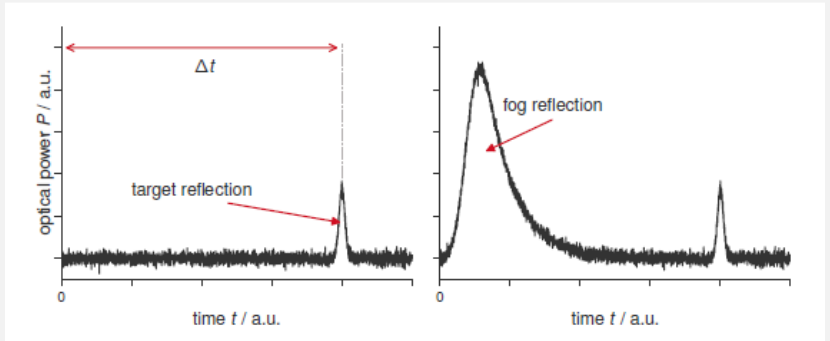


Automotive LiDAR performance verification in fog and rain, Kutila et al.

Performance prediction in Fog and Spray conditions



embedded Fog detection



VISION, IDENTIFICATION, WITH Z-SENSING TECHNOLOGIES AND KEY APPLICATIONS

VIZTA

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OBJECTIVE

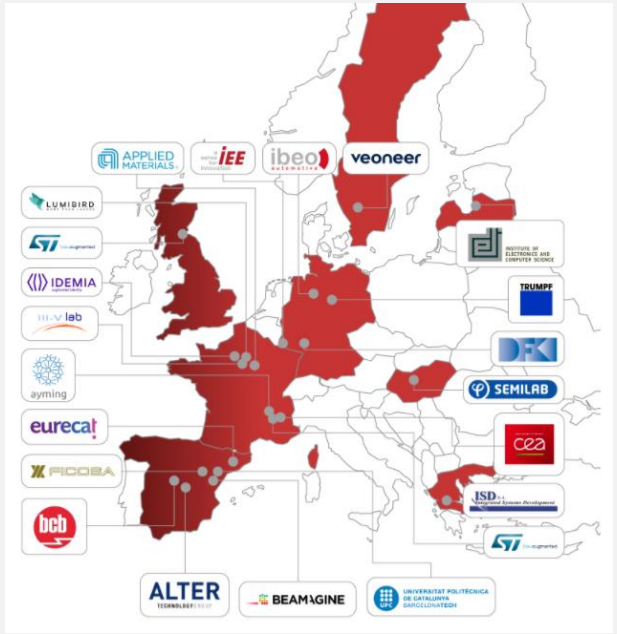
Develop innovative technologies for **optical sensors** and **laser sources,** for short to long-range **3D-imaging,** and **demonstrate their value** in several key applications

MAIN TARGETS

- **Develop innovative technologies** for 3D-imaging depth map high resolution sensors and associated IR light sources
- **Exercise new 3D sensors and light sources in key applications** with various ranges: Secured access, driver monitoring, object recognition, few cm to several meters, up to LiDARs systems with hundreds meters range
- **Build partnership ecosystems** foreseeing future competitive European products for Automotive, Security, Smart Cities and Industry4.0 and anticipate normative requirements

DURATION 3,5 years - May 2019 until Oct 2022 **FUNDING** **21 M€**

COORDINATION **STMicroelectronics Crolles (France)**



Bundesministerium für Bildung und Forschung

ECSEL Joint Undertaking
Electronic Components and Systems for European Leadership

See more at: **www.vizta-ecsel.eu/**

TAKE AWAYS

- SPAD's are the key enabling technology for solid-state based automotive LiDAR solutions
- VCSEL and SPAD fits very well together
- IbeoNEXT is smaller than a credit card (one sensor head output 4D point cloud), **smal package size**
- Detection range at a 10% target is **150 m** and angular resolution is **0.044° x 0.07°** for our front looking solution
- **Pedestrians** can be classified up to **165m**
- Use cases like **Vehicle Cut-In, Overhanging loads and small obstacles** are solved
- **on-chip digital signal processing per pixel**
- **Modular and flexible in adapting customer requirements**

- **First samples** available end of **June 2020**
- First in the market solid-state LiDAR **serial production in 2022**

- **We are first in lots of things and now with our next generation 4D solid-state LiDAR ibeoNEXT.**

THANK YOU FOR YOUR ATTENTION

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