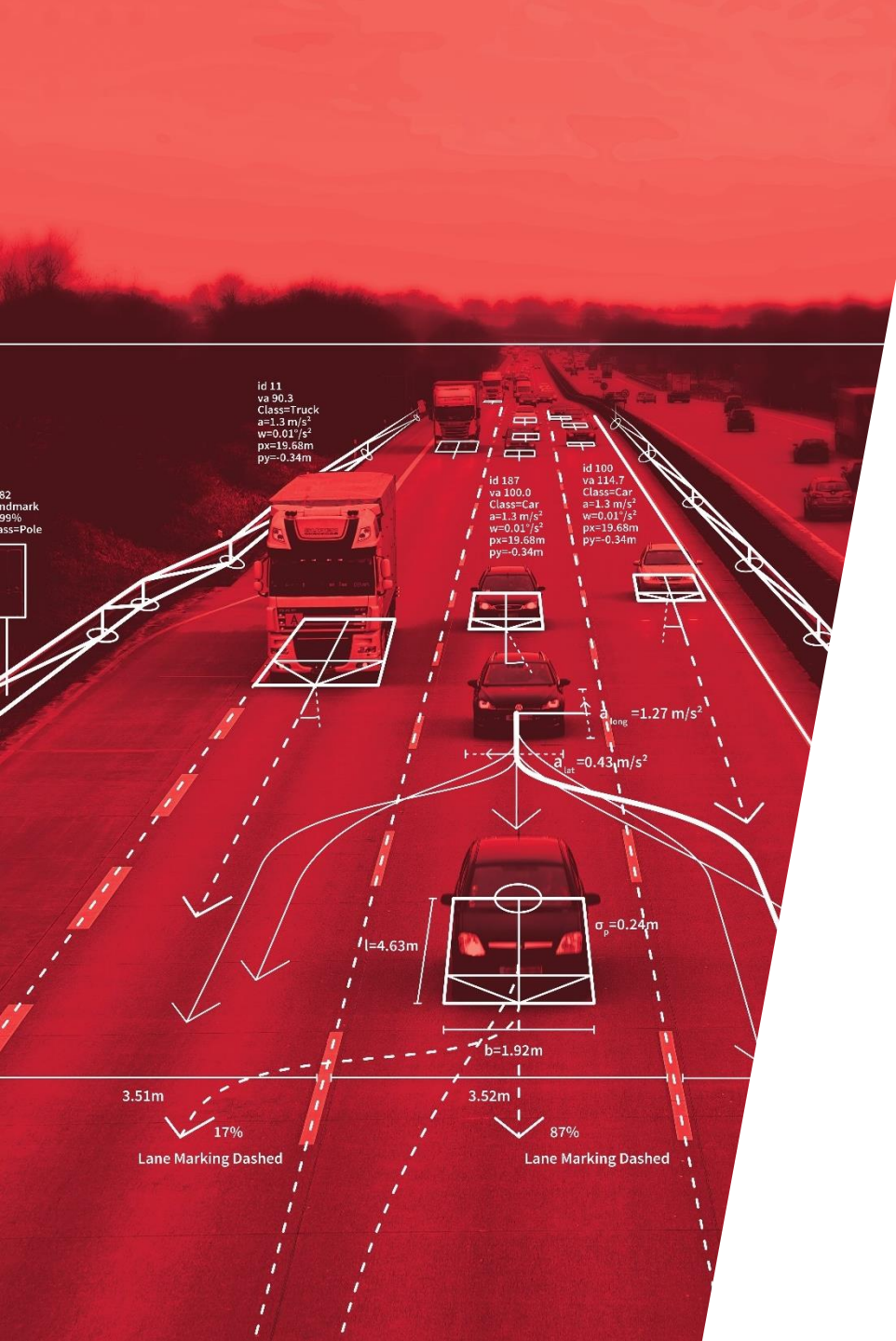


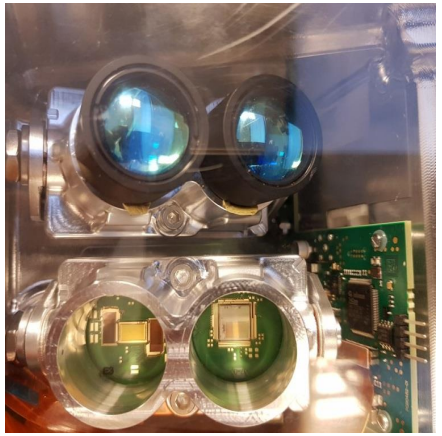
4D SOLID-STATE LIDAR UTILIZING VCSEL AND SPAD ARRAYS

EPIC Meeting on LIDAR Technologies for Automotive
Anteryon | Eindhoven | 2019-10-31

Hanno Holzhüter

Why it's hard to build a solid-state LiDAR

One way to do it



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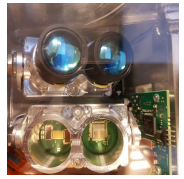
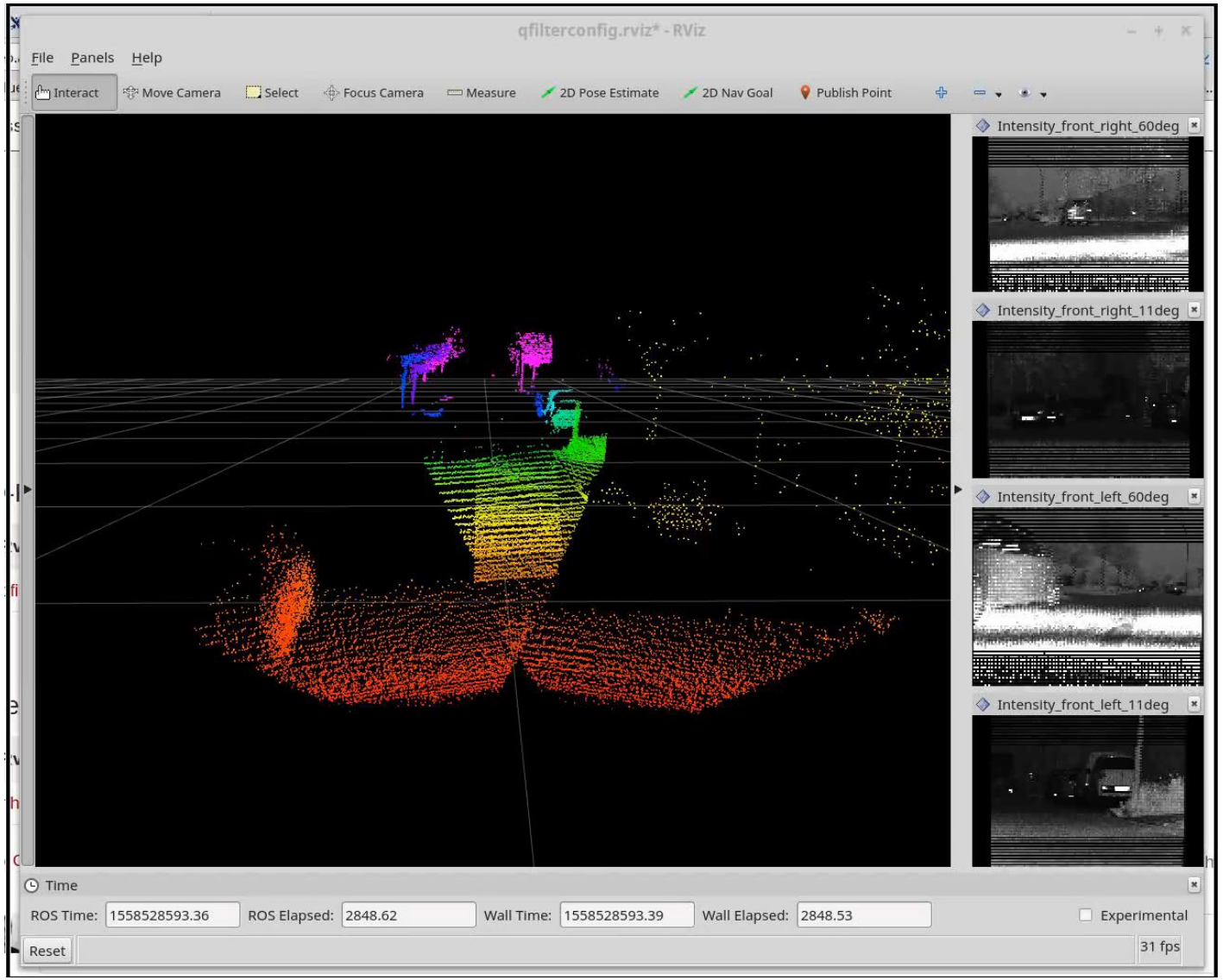


ibeo automotive



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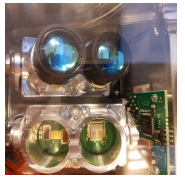
PUBLIC

IBEO HISTORY



ibeo automotive

ibeo automotive

20 YEARS | PIONEERING THE FUTURE OF MOBILITY

Specialized in the field of automotive LiDAR Sensors

Employees

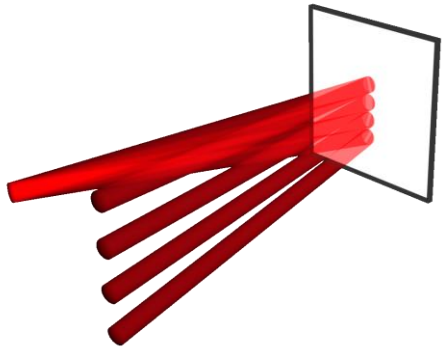
- 380+ (2019)

Offices

- Hamburg, Germany (Headquarters)
- Eindhoven NL, Detroit USA, China (coming soon)

Partnership with ZF

Together with Valeo in automotive serial production



“too bulky”

“too expensive”

“limited vertical FOV”

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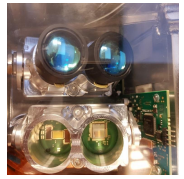
NEXT GENERATION LIDAR REQUIREMENTS



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“too bulky”

“too expensive”

“limited vertical FOV”

solid-state

high resolution	**0.1° x 0.1° (H x V)**
wide FOV	**120° x 20° (H x V)**
long range	**300m (80m 10%)**
frame rate	**25 Hz**

fast **in 2020 (2022)**

cost efficienct and automotive qualified

$$d = \frac{c\Delta t}{2} \qquad \Delta t_{300\,\mathrm{m}} = \frac{2 \cdot 300\,\mathrm{m}}{3 \times 10^{8}\,\mathrm{m\,s^{-1}}} = 2\,\mu\mathrm{s} \qquad \frac{40\,\mathrm{ms}}{2\,\mu\mathrm{s}} = 20\,000$$

e.g. 500 x 40 Points

➔ scanning FOV point-wise is not feasible

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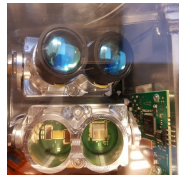
SOLID-STATE SCANNING



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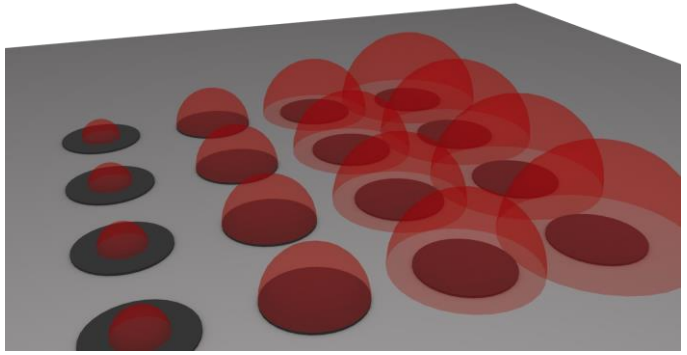
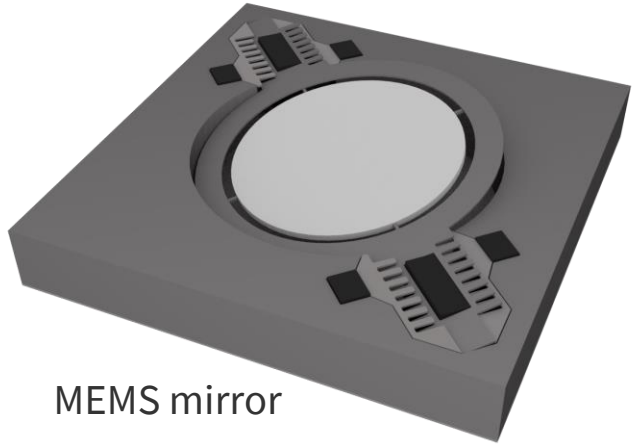
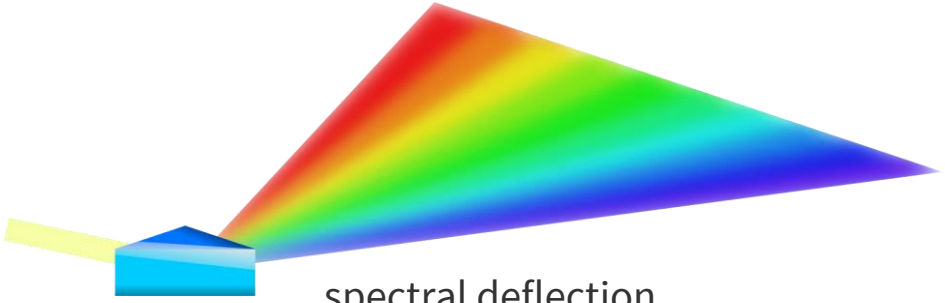
How to **solid-state** but
wide FOV and **high resolution**?



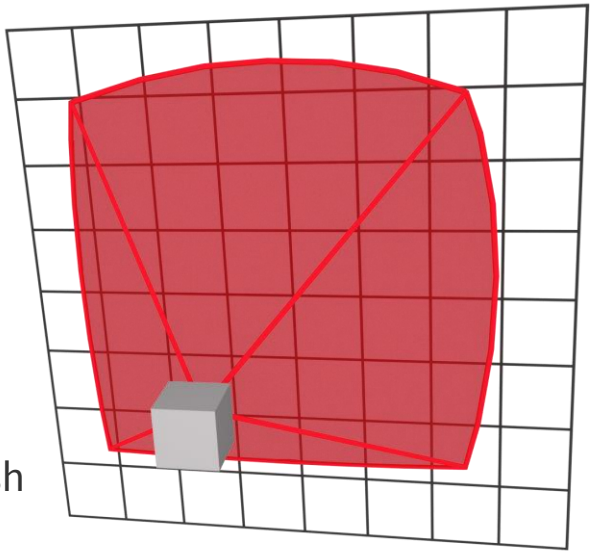
OPA



MEMS mirror



spectral deflection



flash

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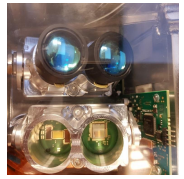
FOCAL PLANE ARRAY



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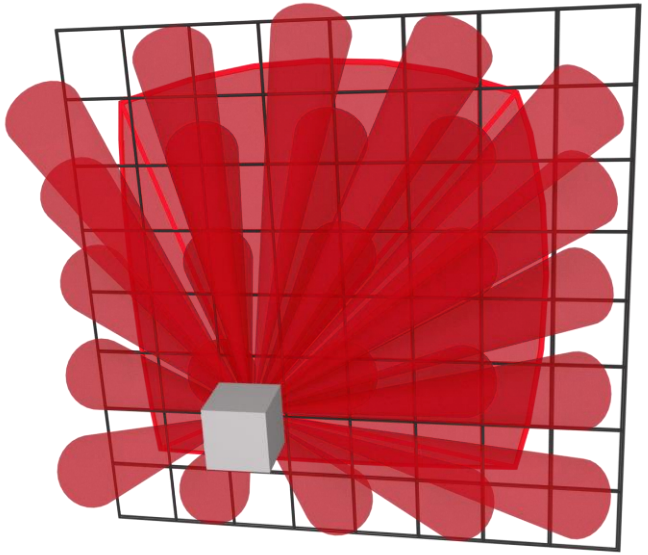
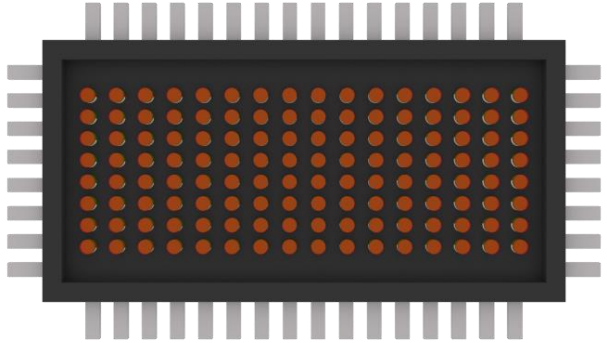




Power hungry (optical) with

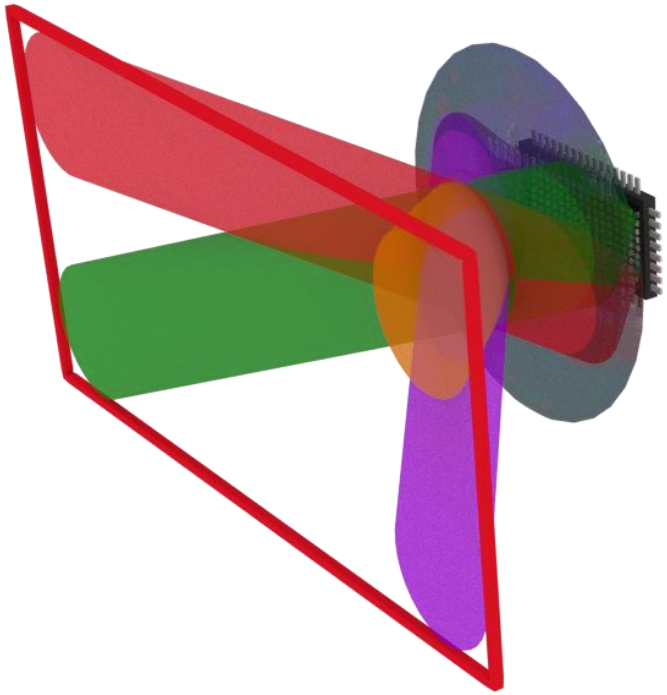
- technical and
- eye-safety limitations

$E_{\mathrm{Pulse,905\,nm}} \approx 100\,\mathrm{nJ}$
(DIN EN 60825)

Array of emitter
→ no edge emitter but VCSELs

Focal Plane Array (FPA)

Map receiver to emitter
→ enhanced optical power budget



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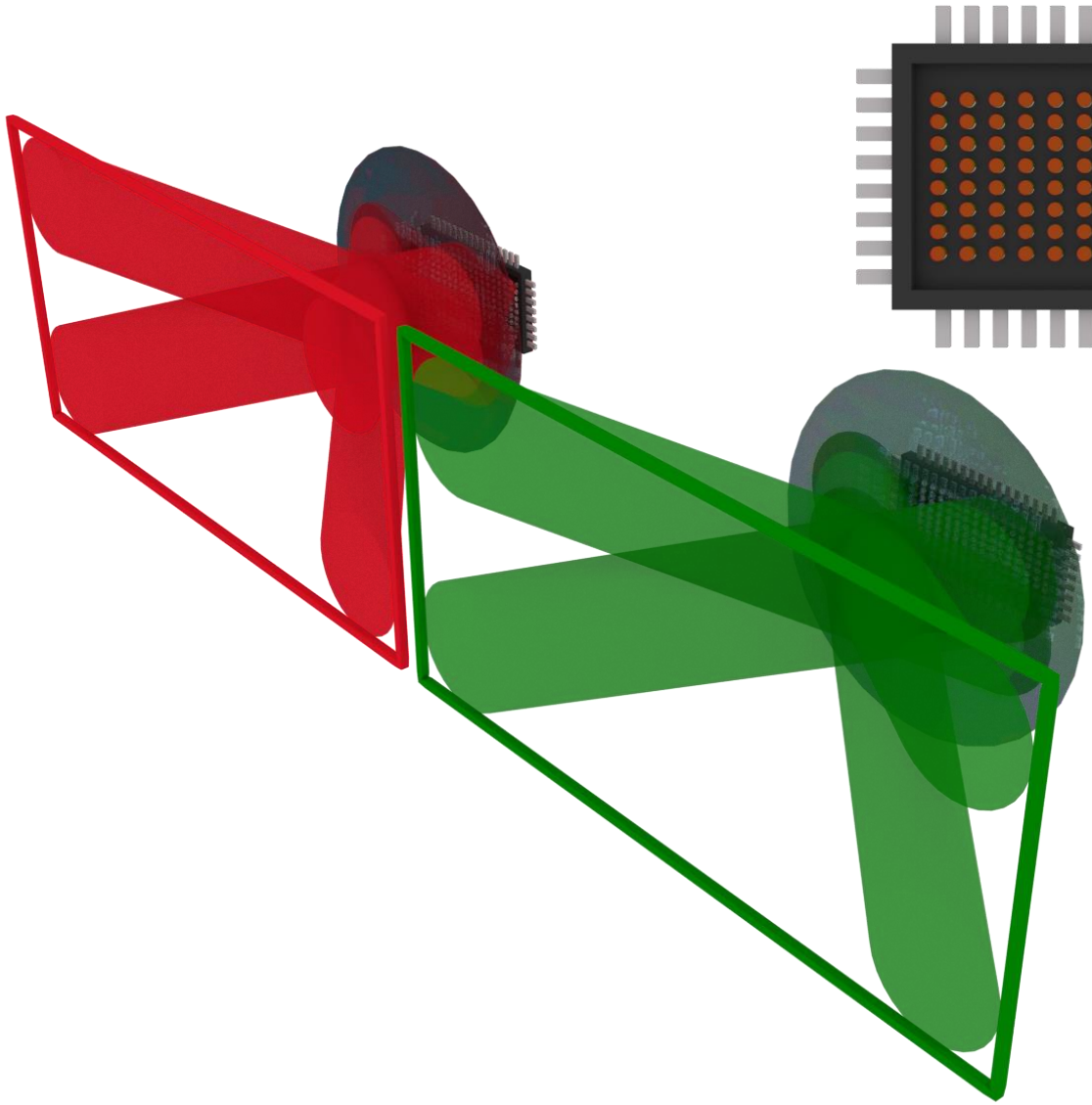
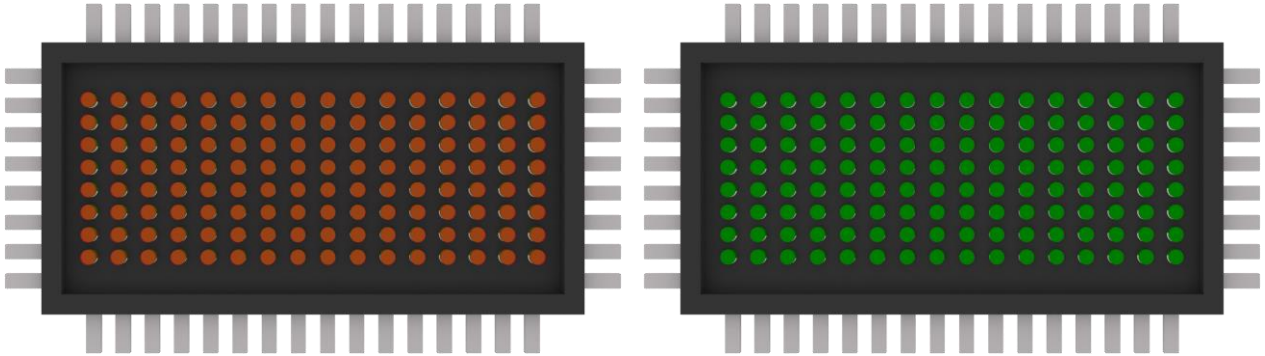
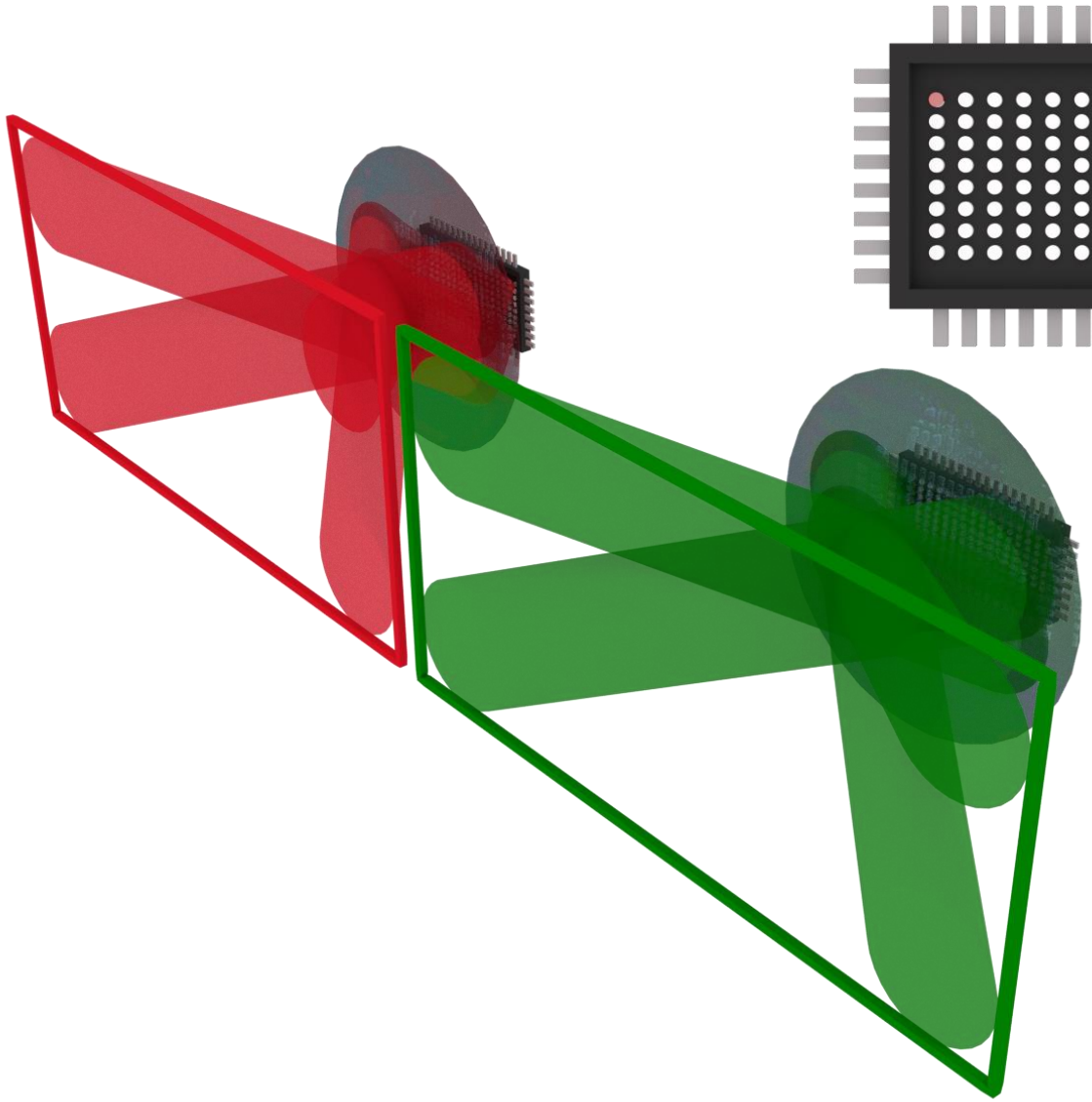
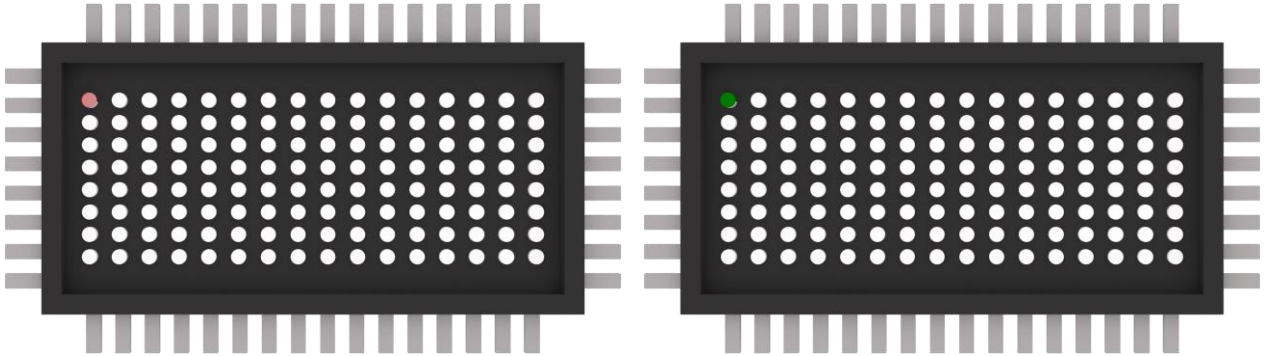
FOCAL PLANE ARRAY





SOLID-STATE SCANNING





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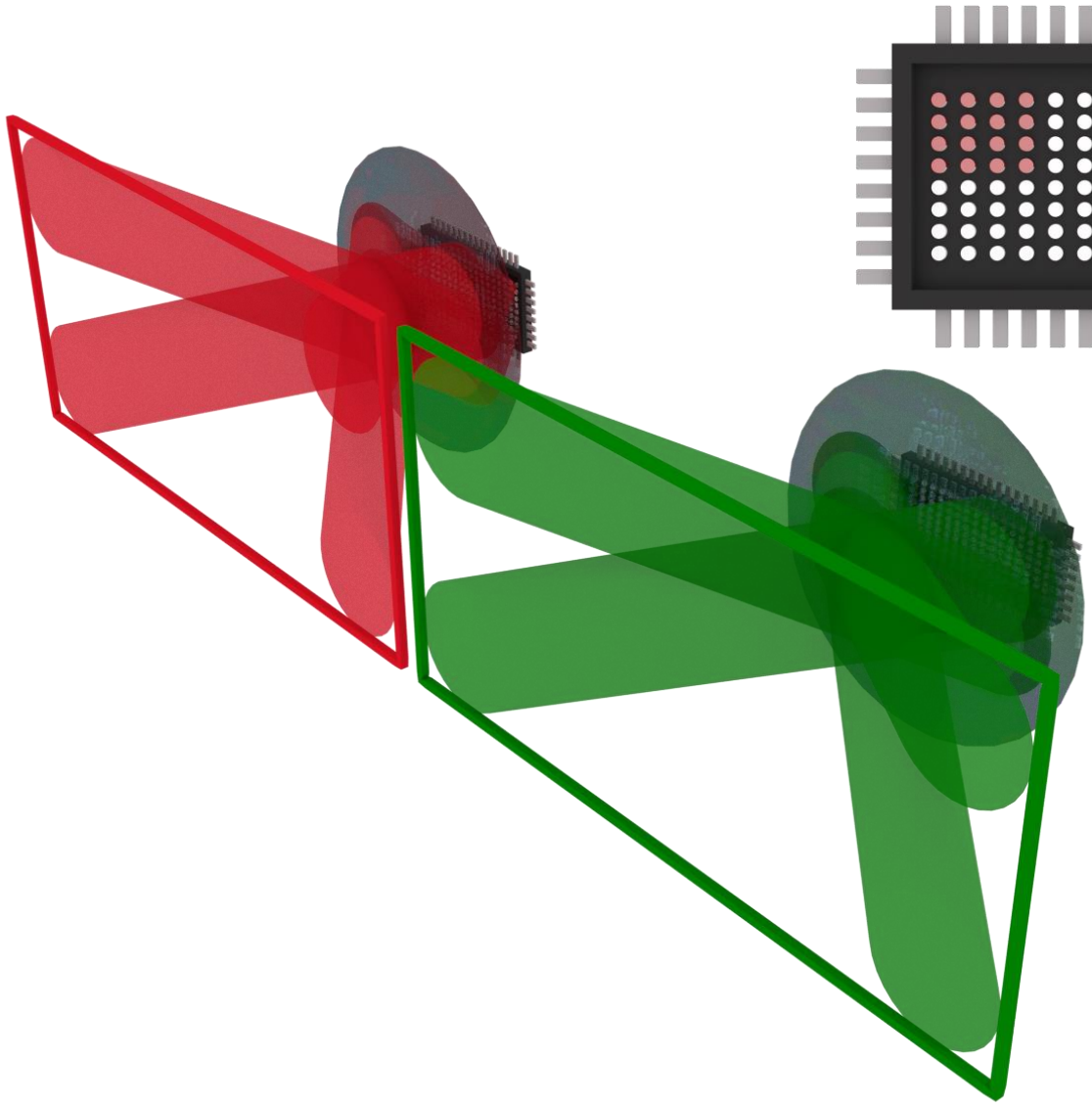

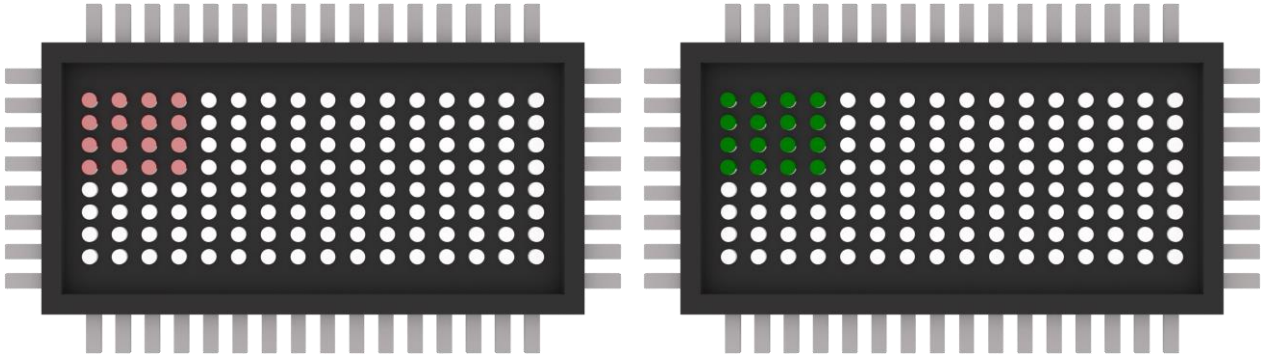

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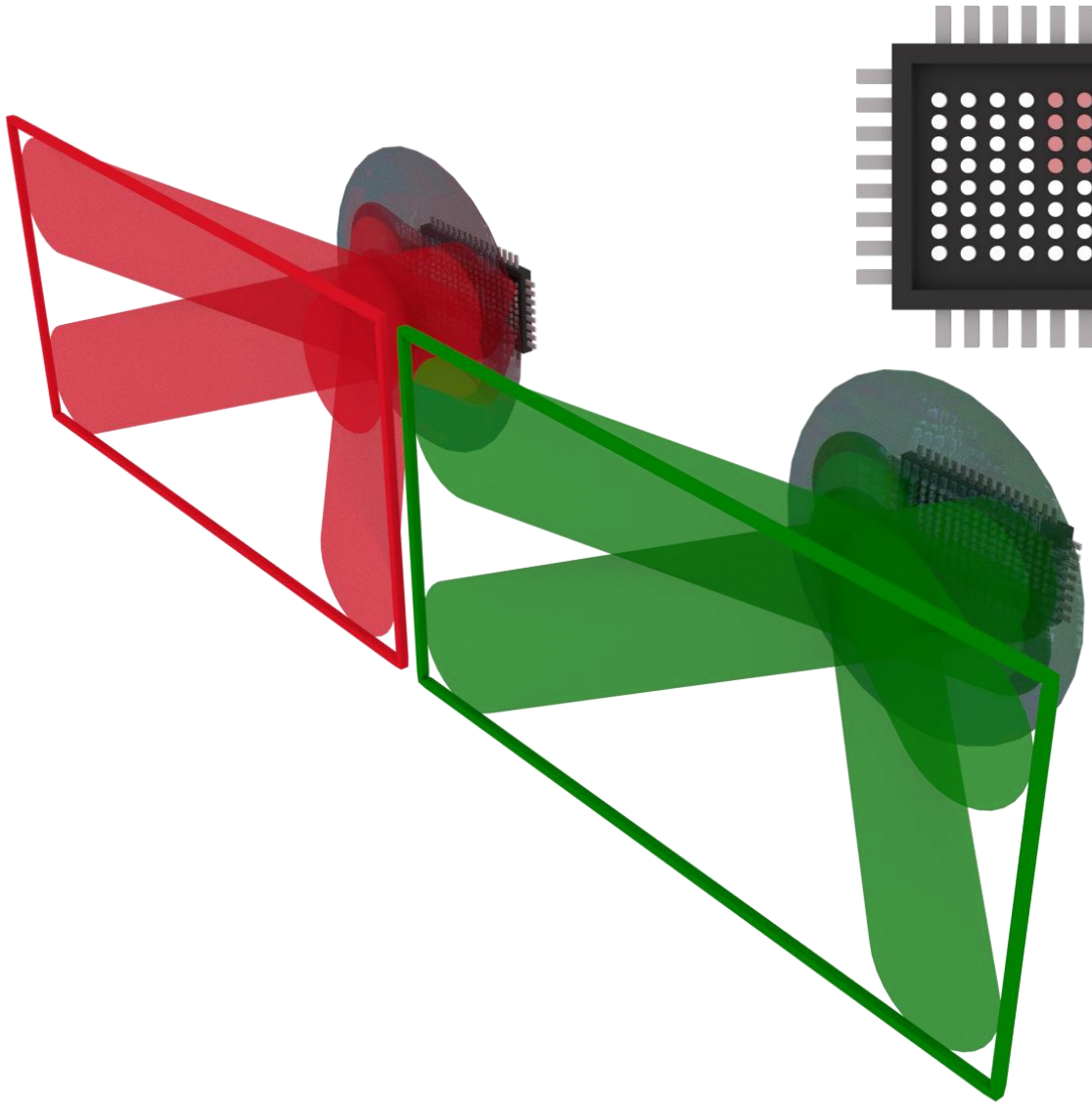

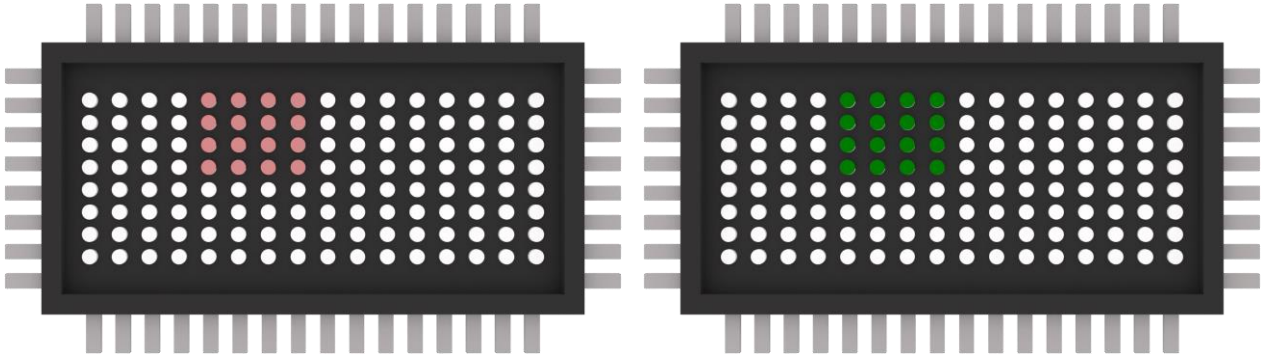

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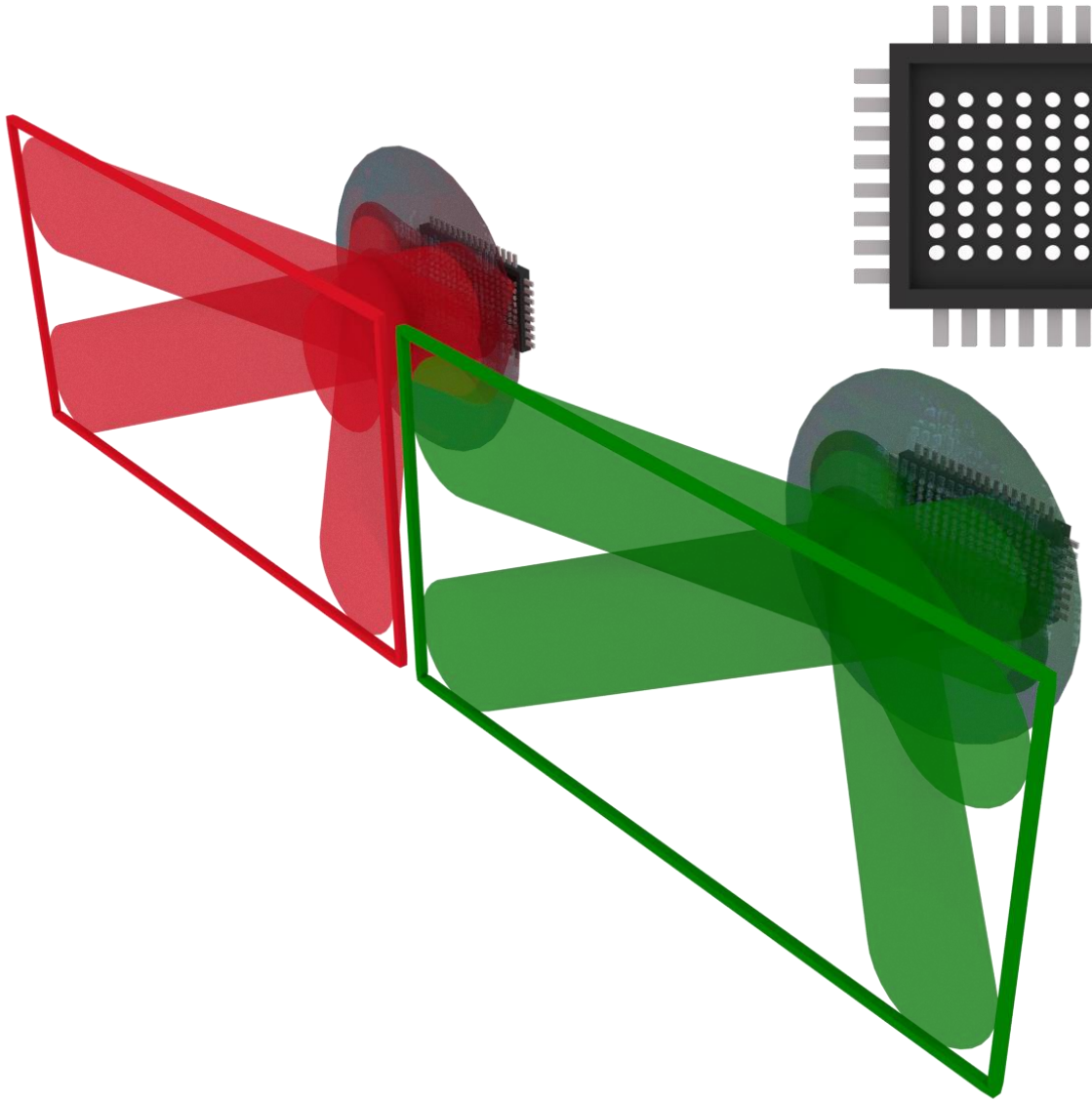

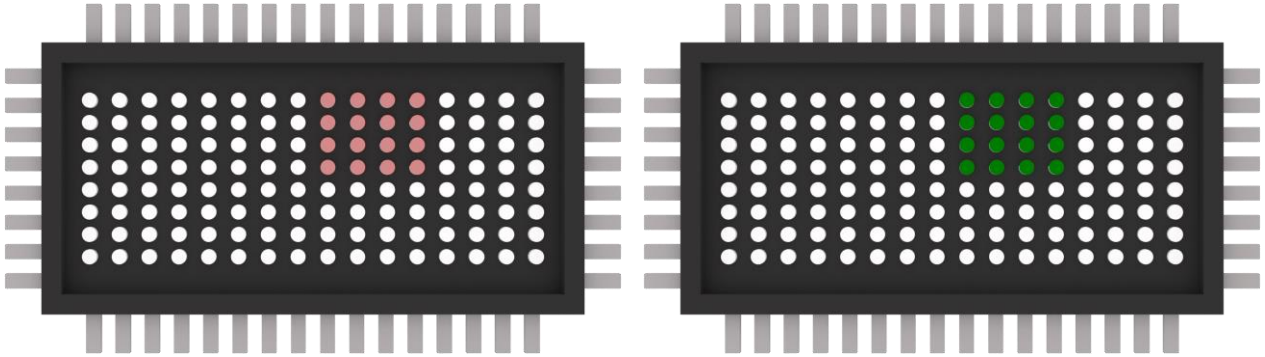

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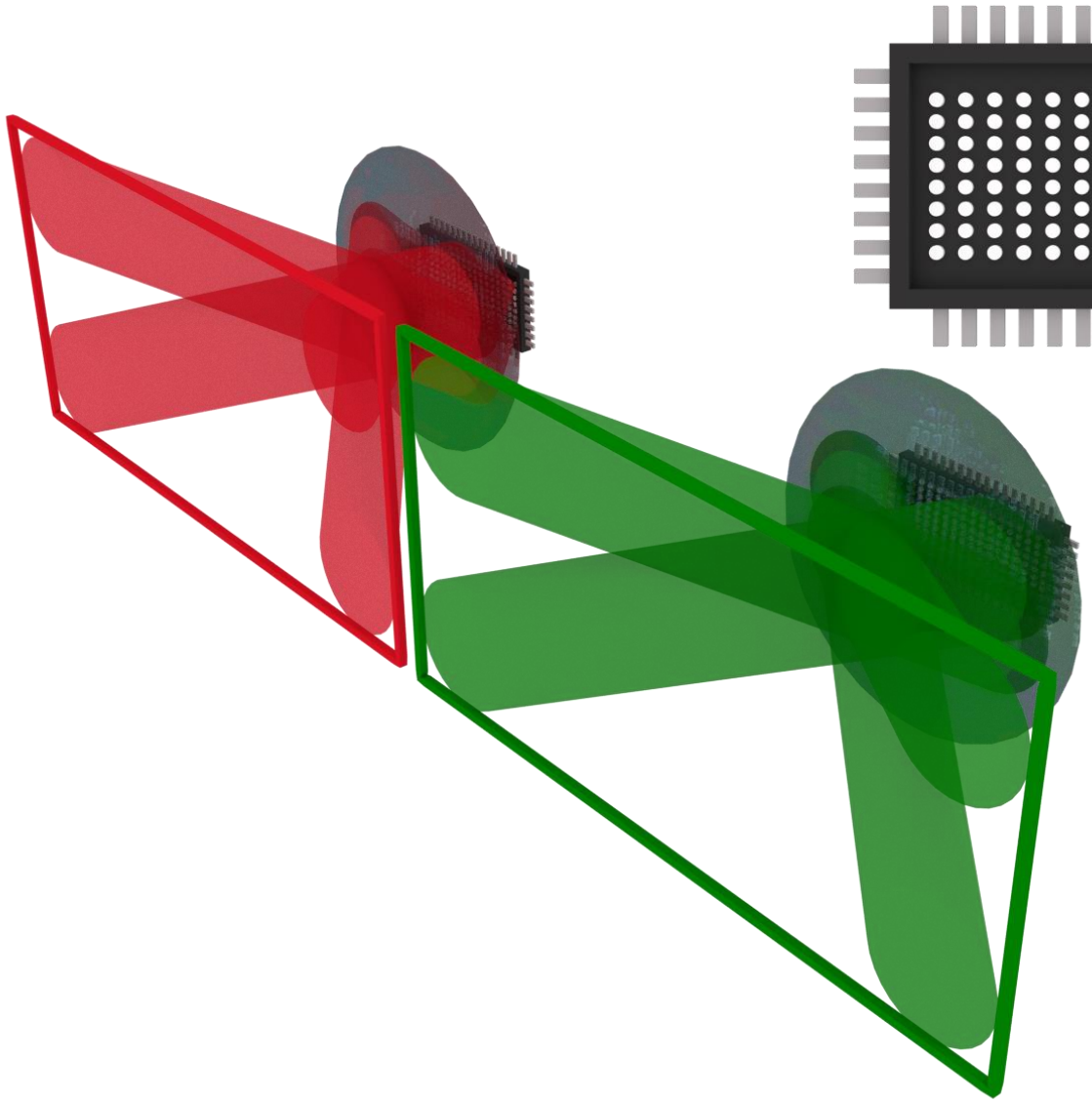

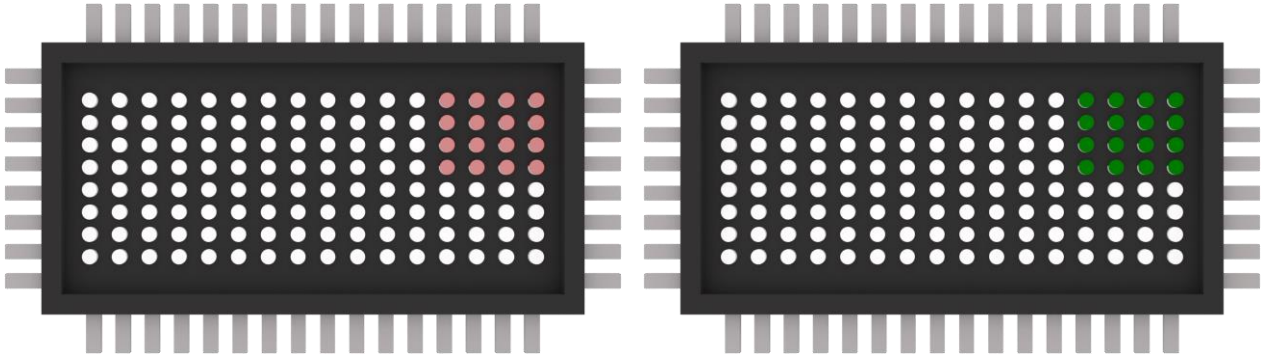

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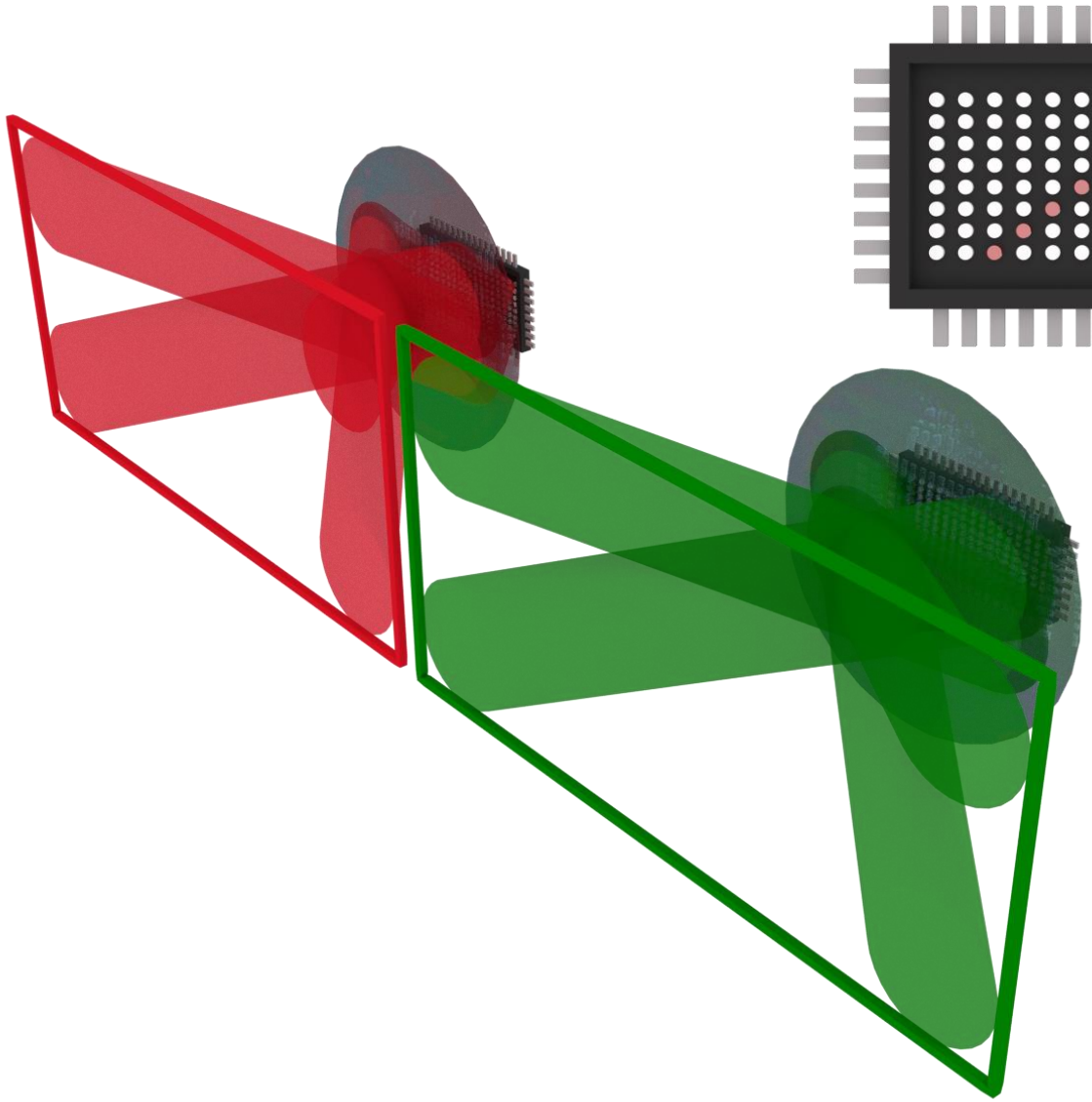

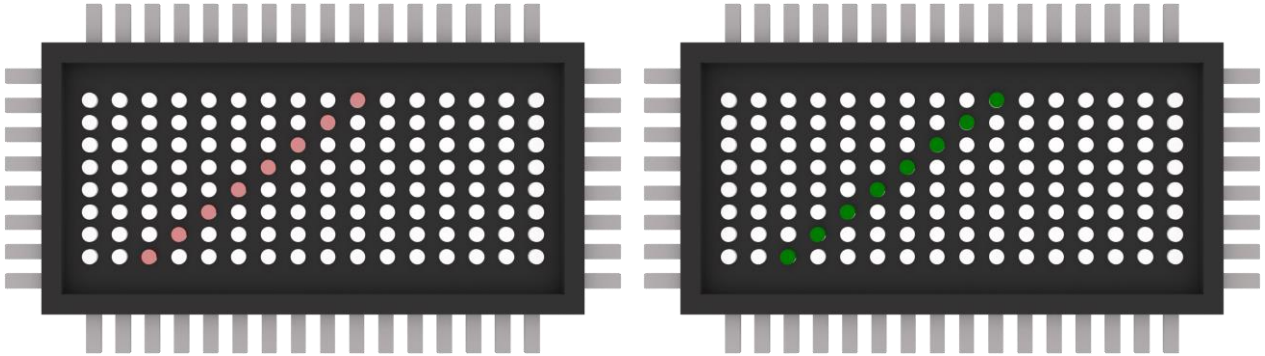

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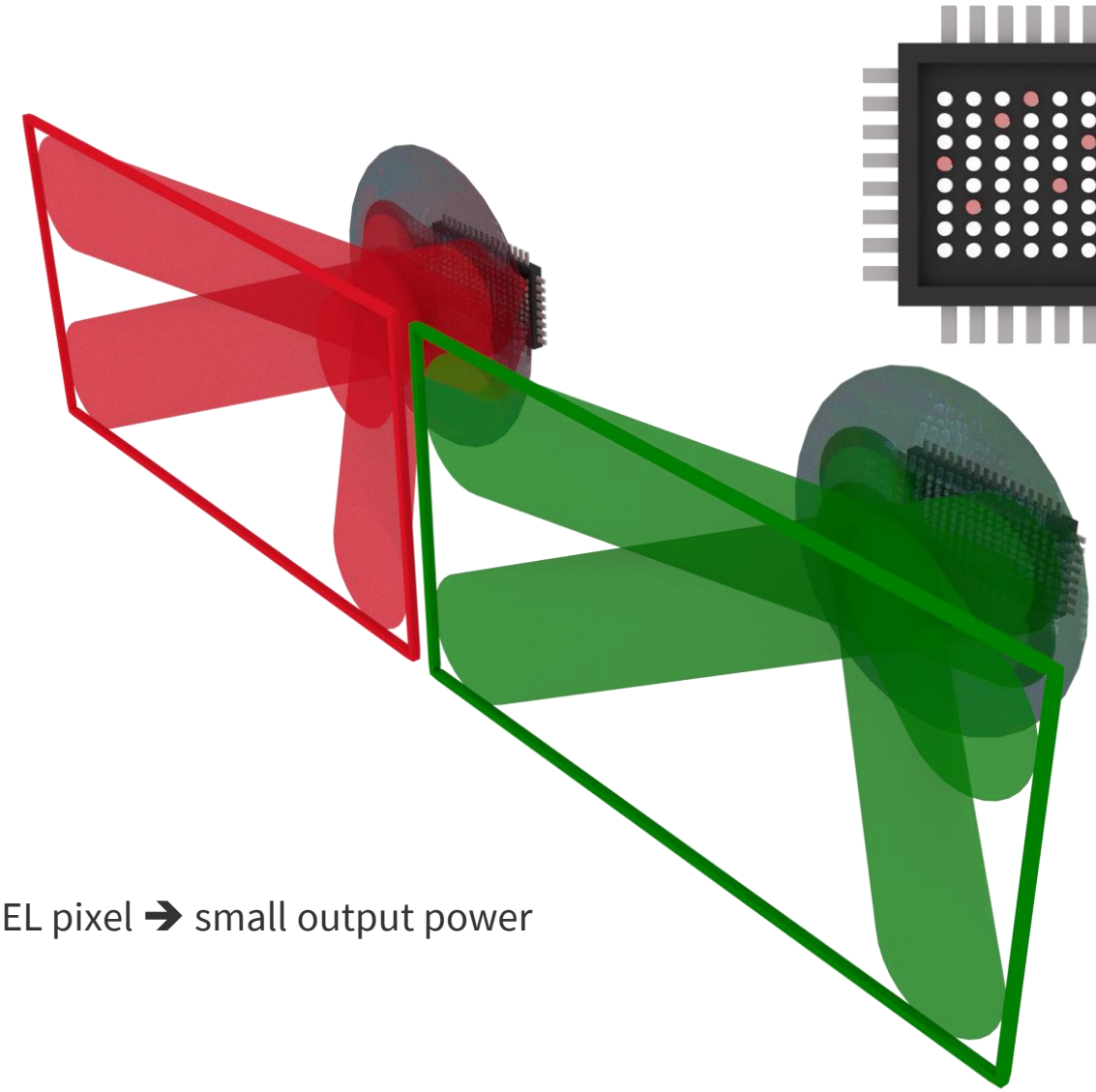
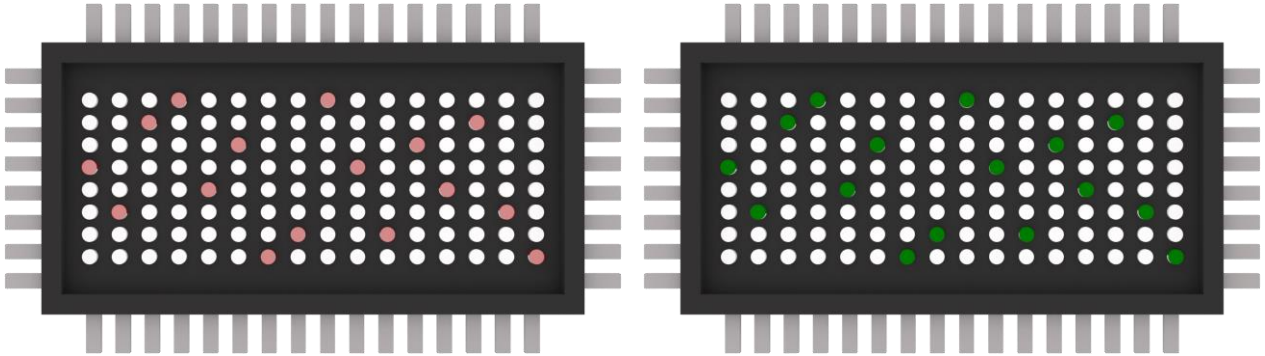




small VCSEL pixel ➔ small output power

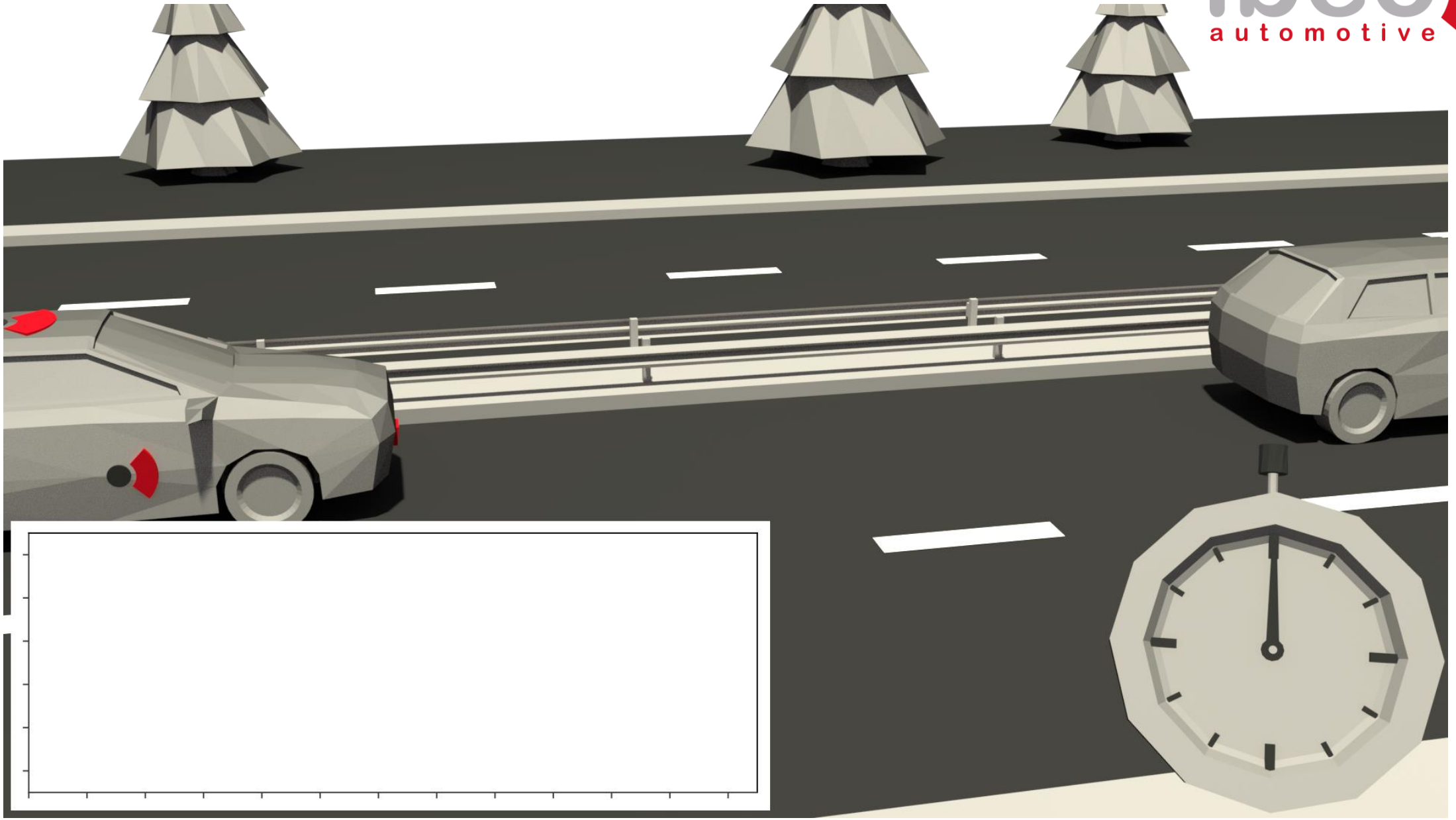
SINGLE PHOTON AVALANCHE DIODE (SPAD)

small VCSEL pixel ➔ small output power

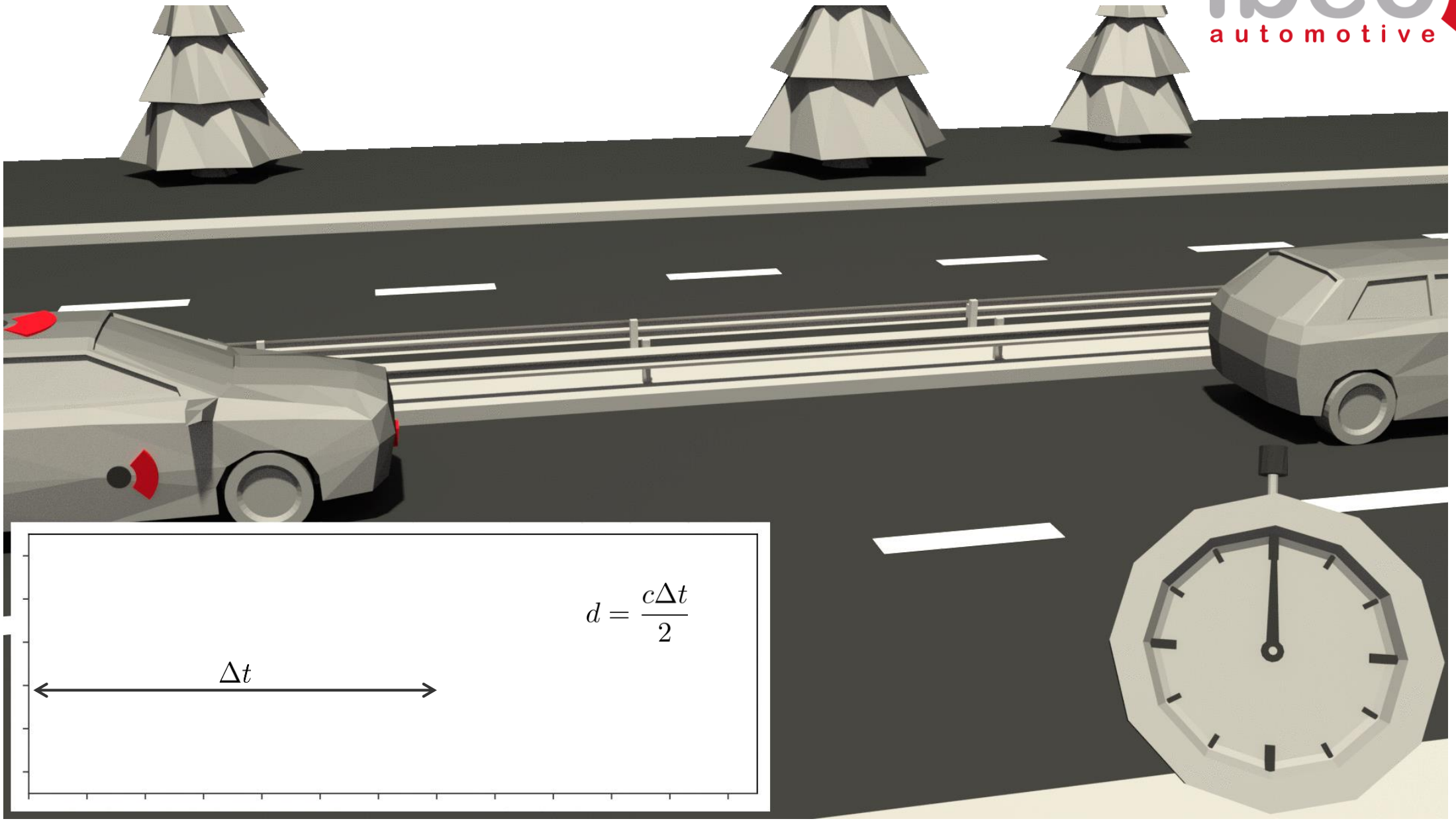
→ utilize SPADs instead of linear photodetectors

→ classical time-of-flight not possible

CLASSICAL TIME-OF-FLIGHT



CLASSICAL TIME-OF-FLIGHT



SPADS

small VCSEL pixel ➔ small output power

→ utilize SPADs instead of linear photodetectors

→ classical time-of-flight not possible

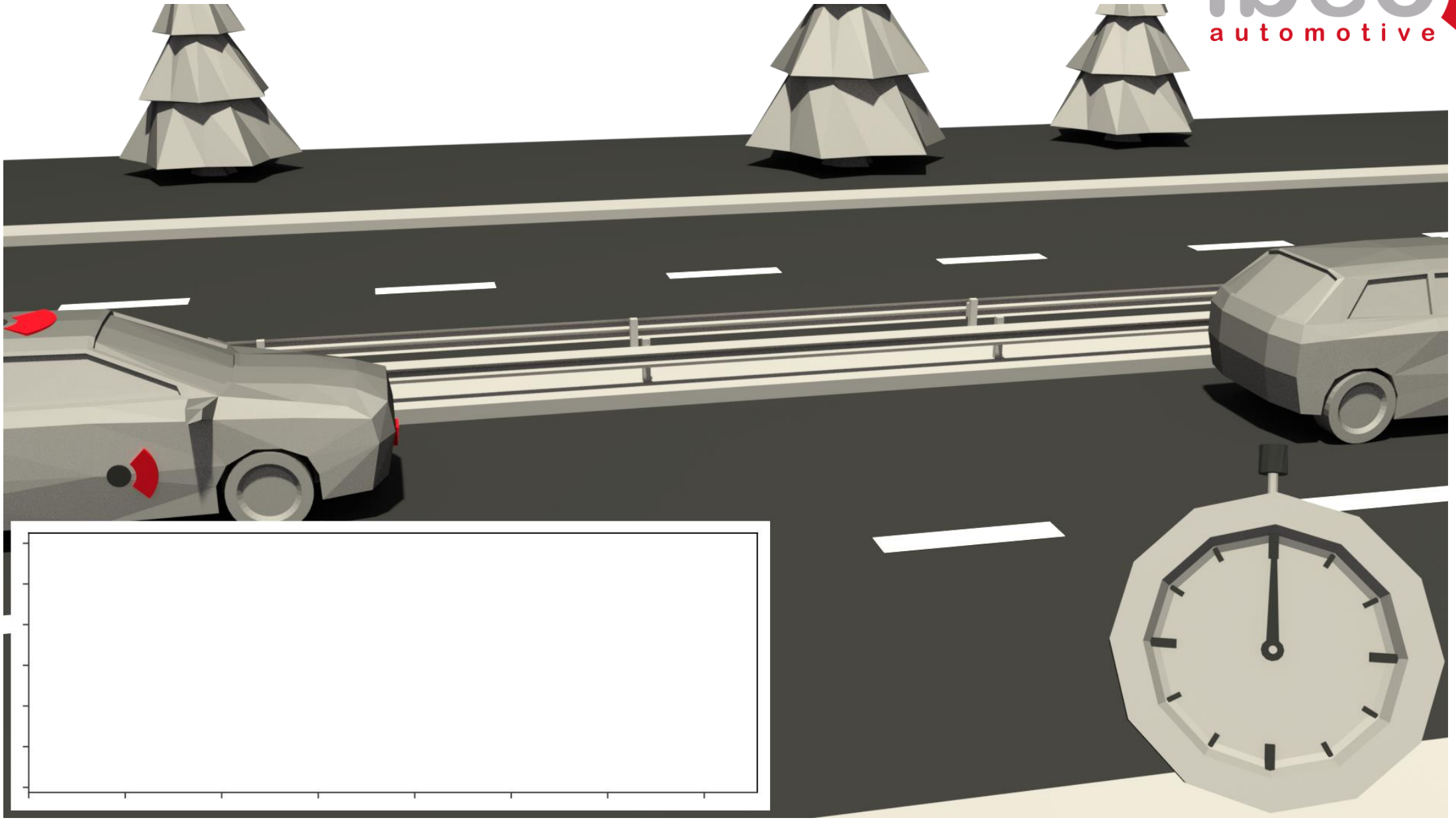
single-photon avalanche diodes (SPADs)

→ binary detection, i.e. trigger devices
(what is signal/noise?)

→ repeat measurements (build histograms)

➔ time-correlated single-photon counting (TCSPC)
with new DSP possibilities in the automotive market

TCSPC



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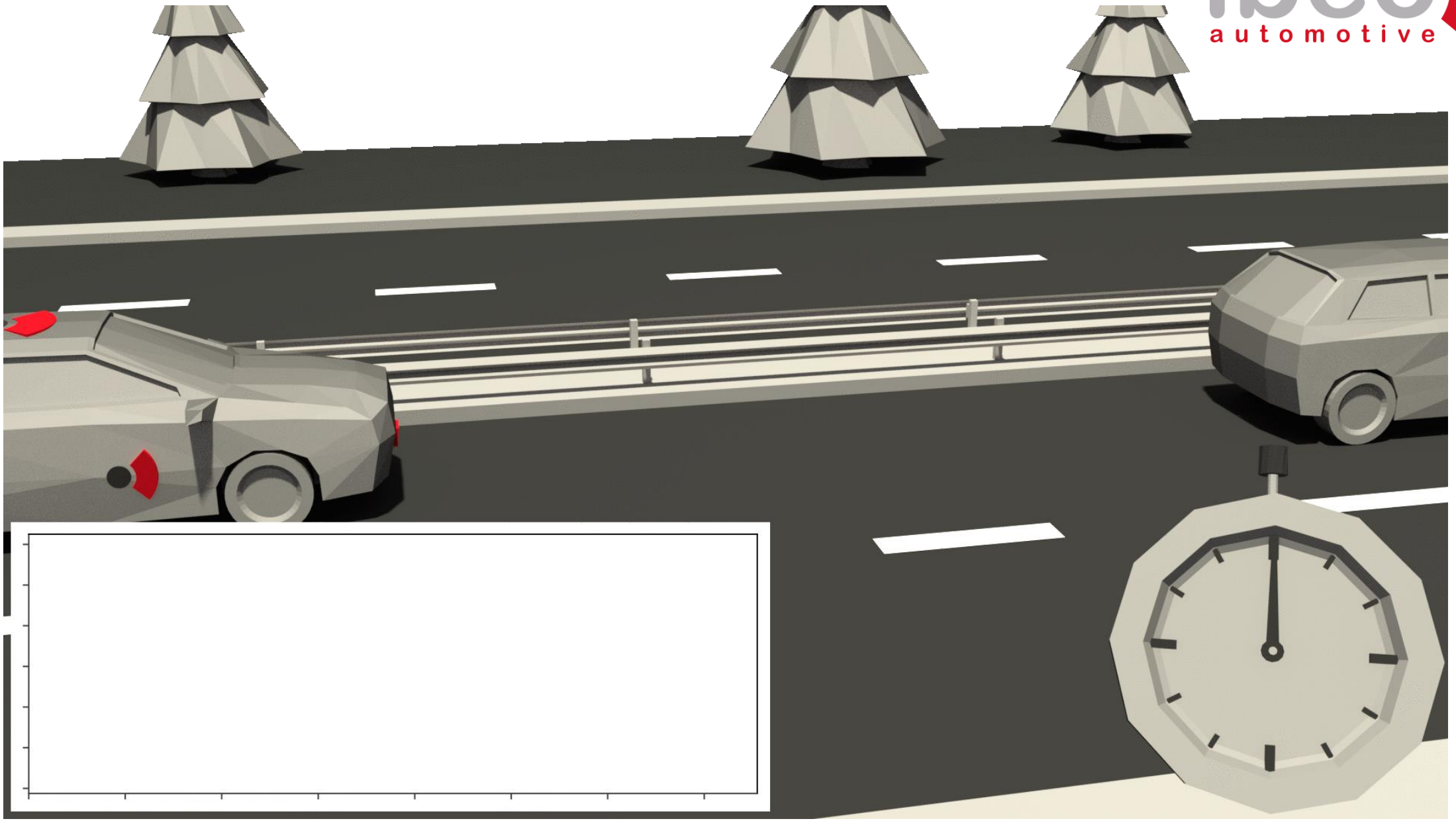

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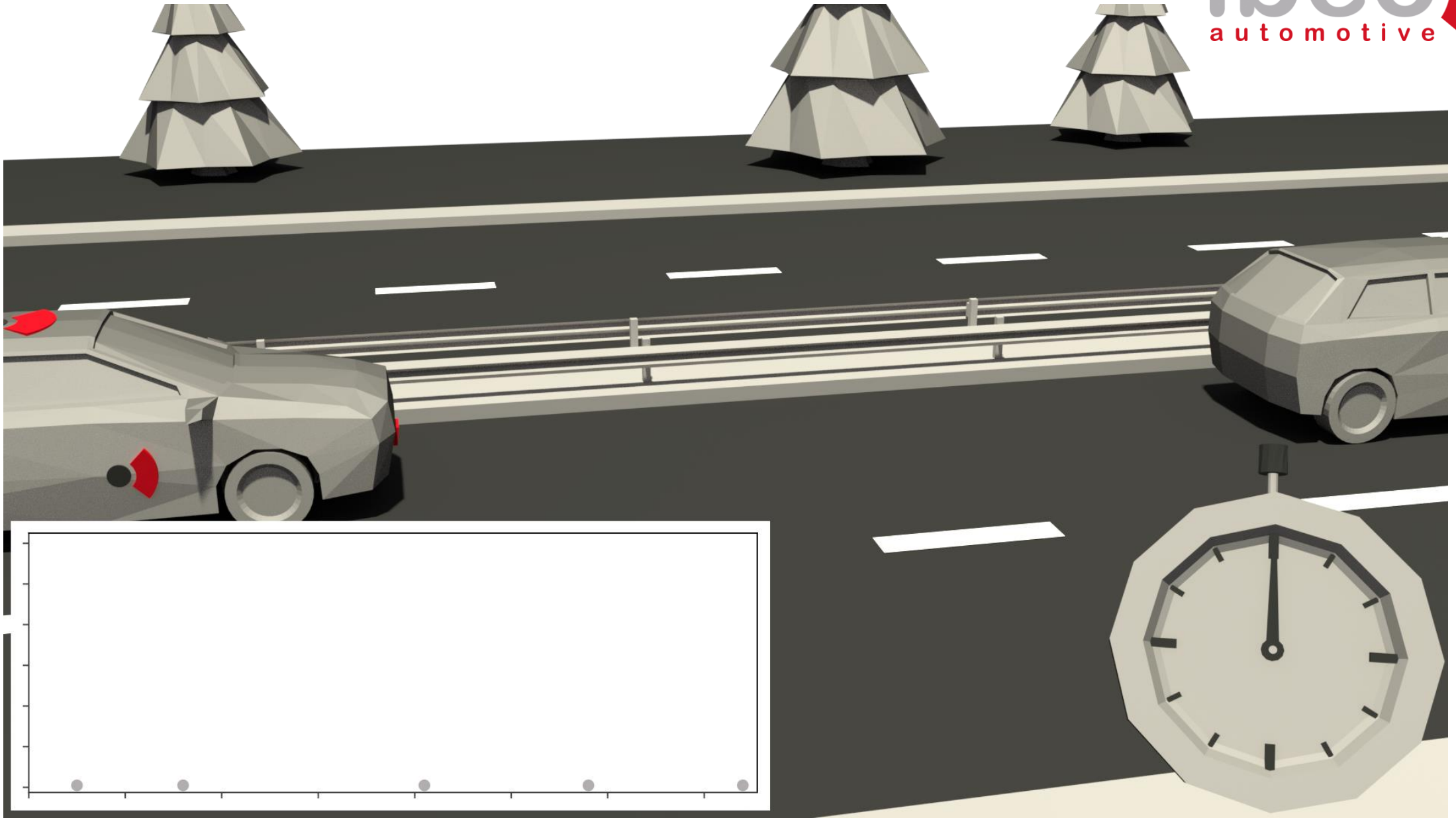

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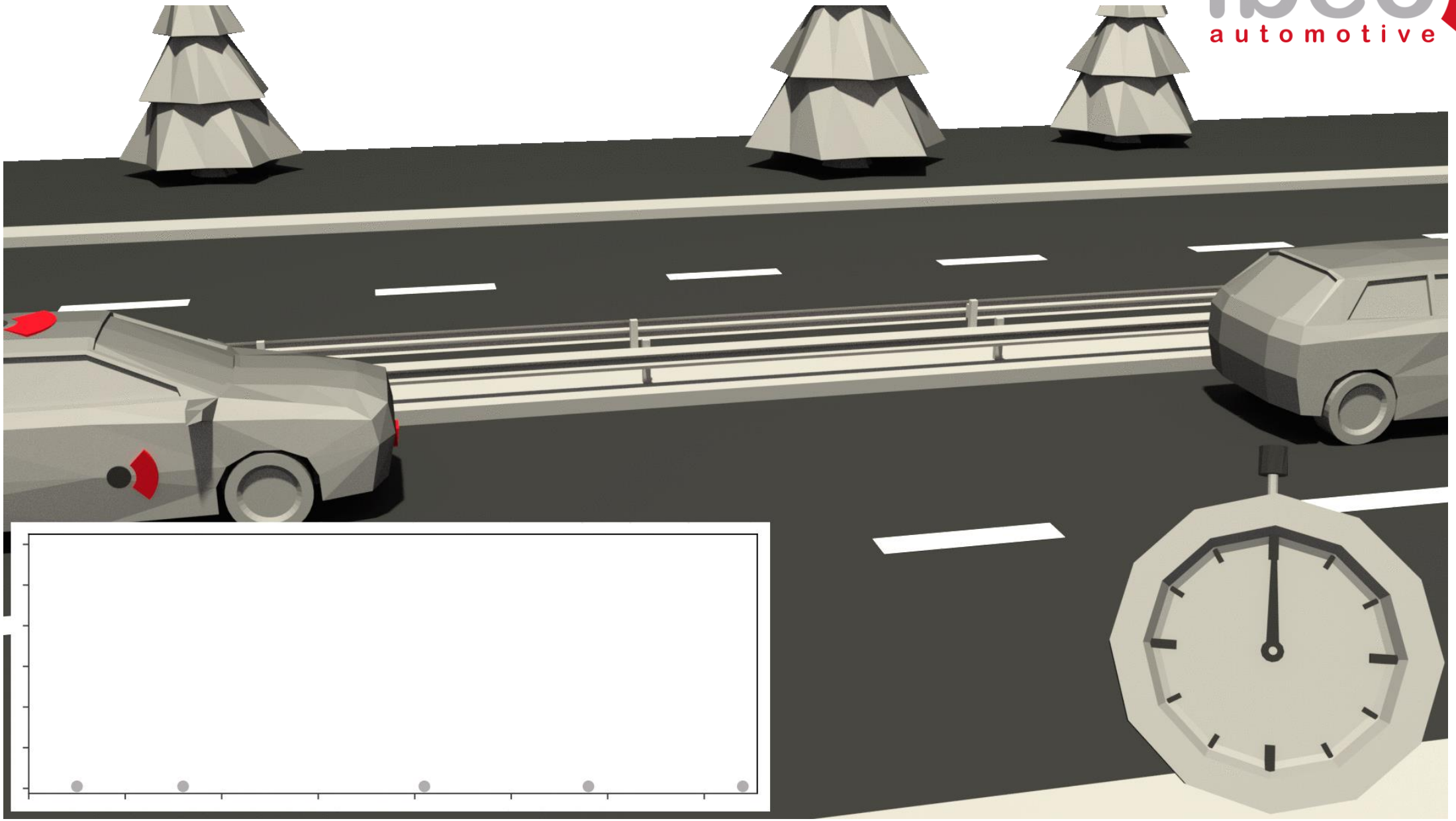

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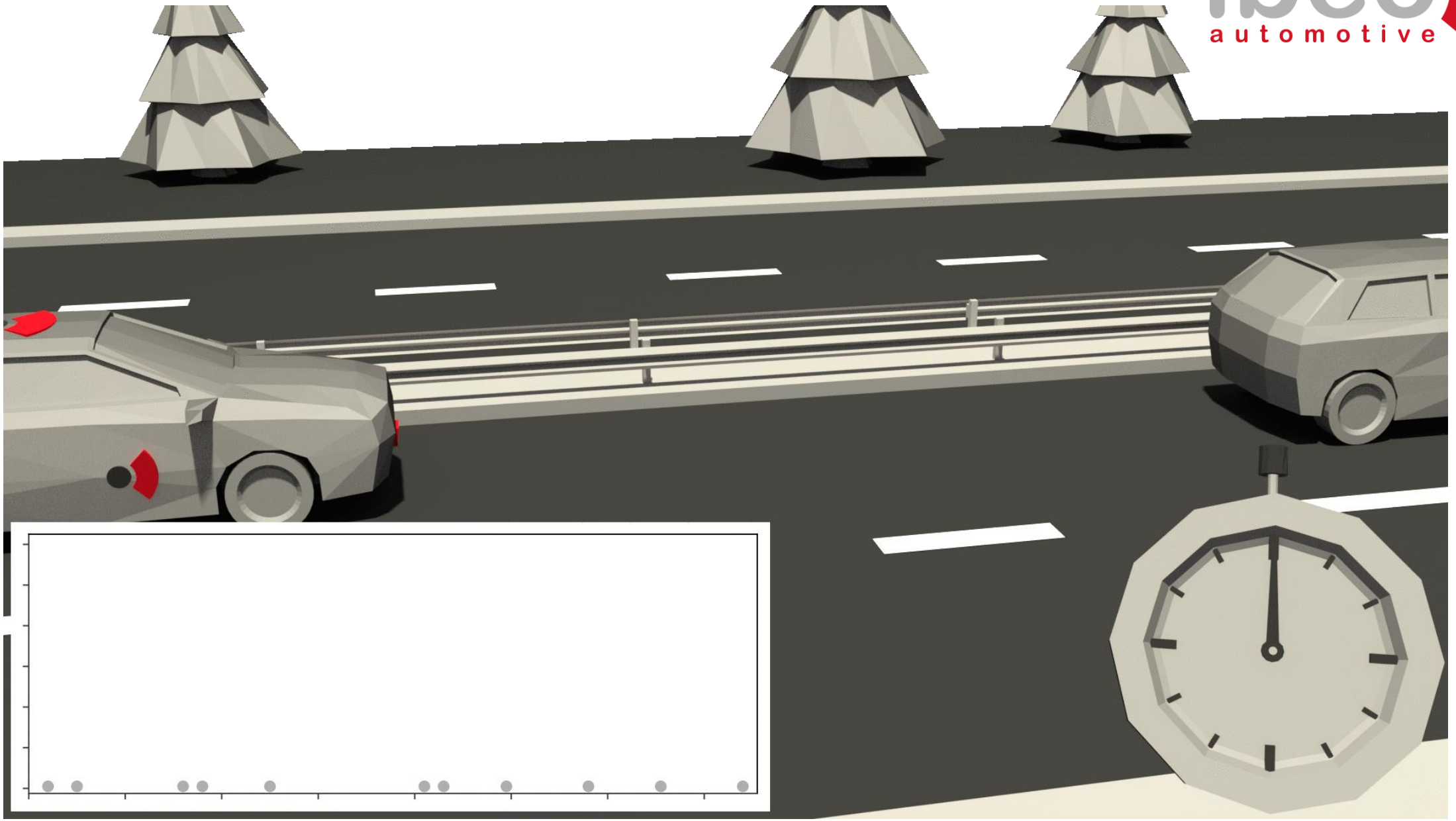

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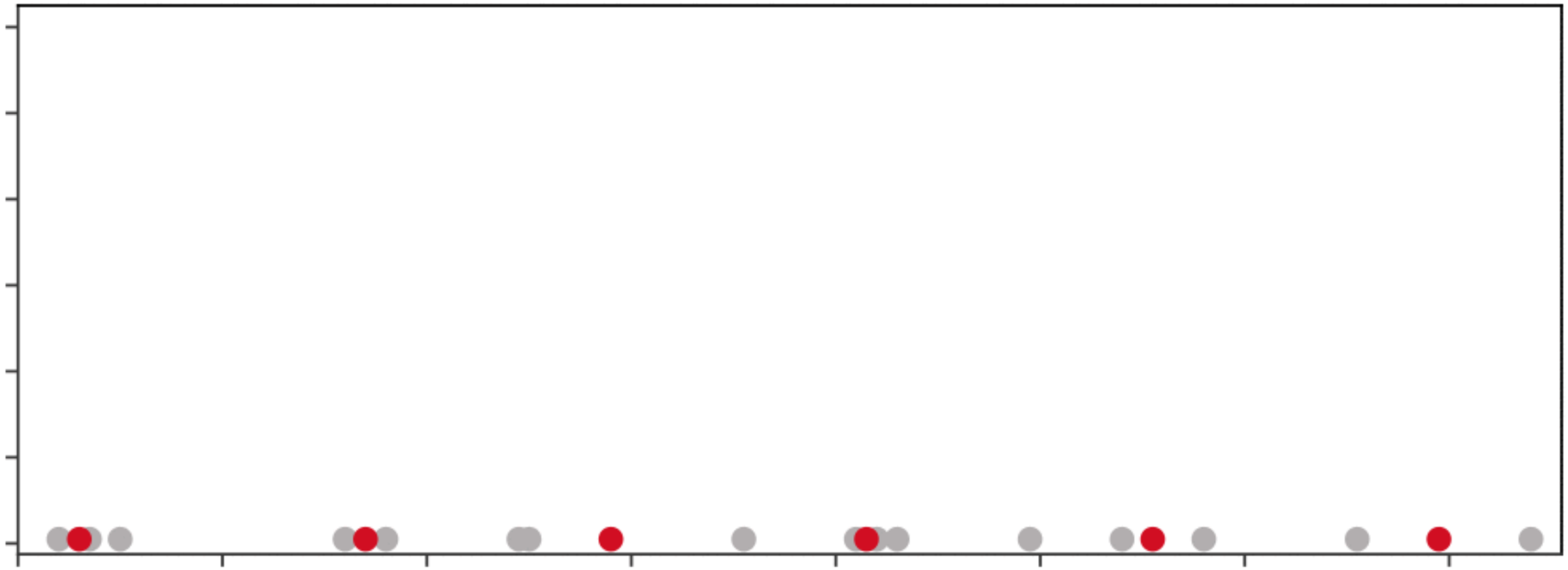
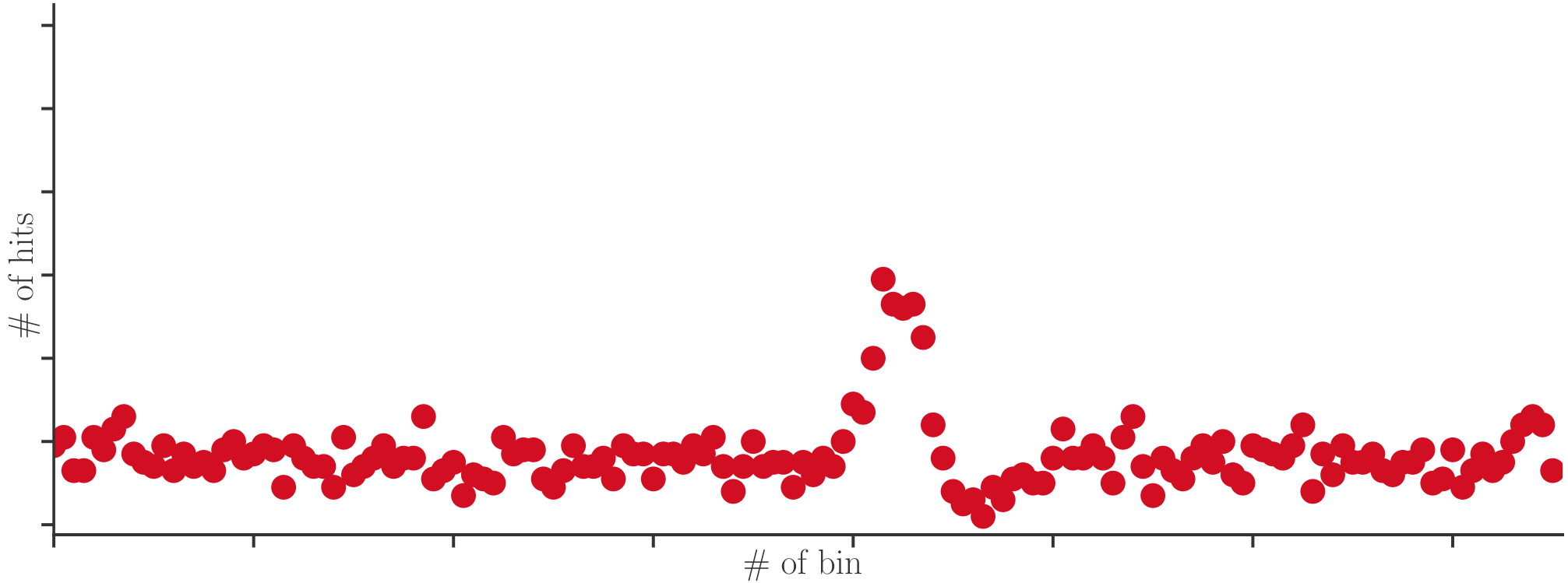
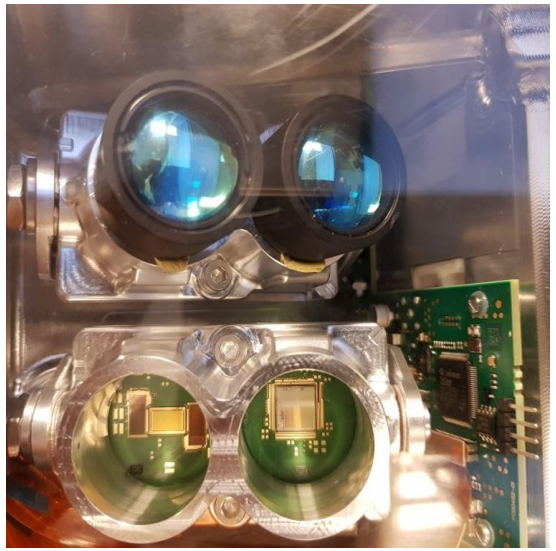
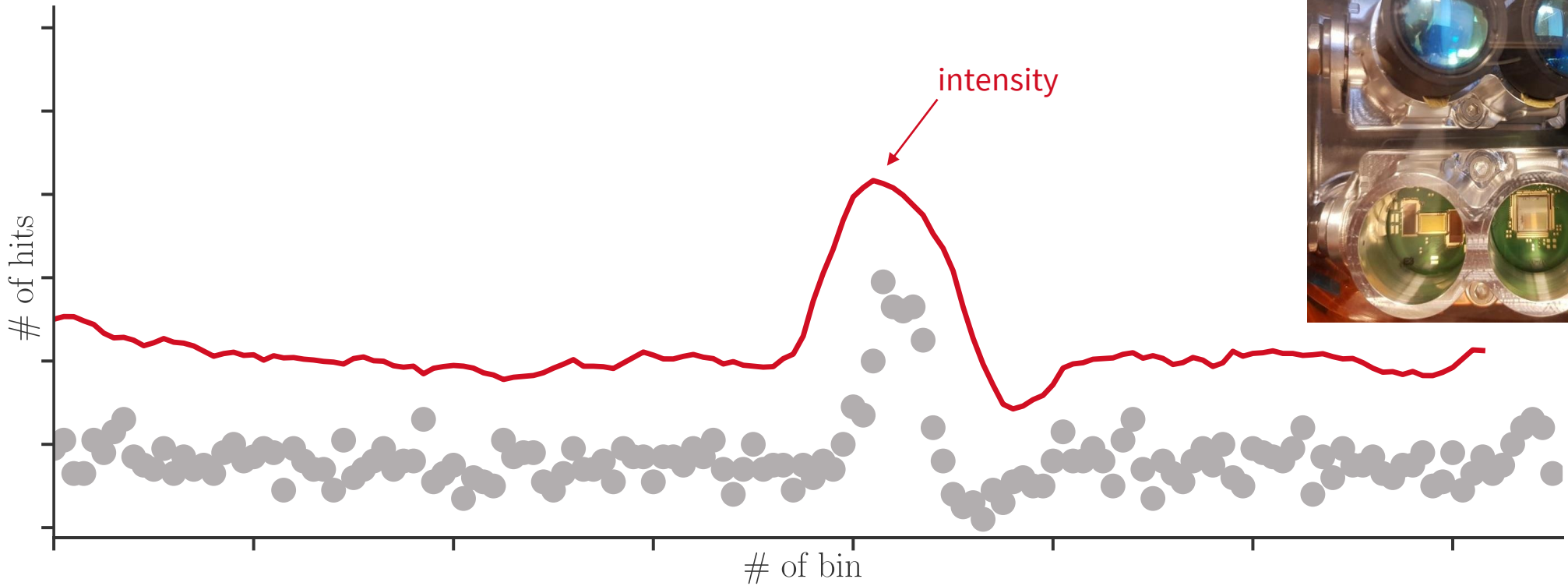


TCSPC



TCSPC - DSP





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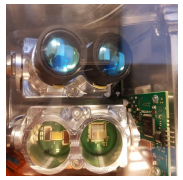

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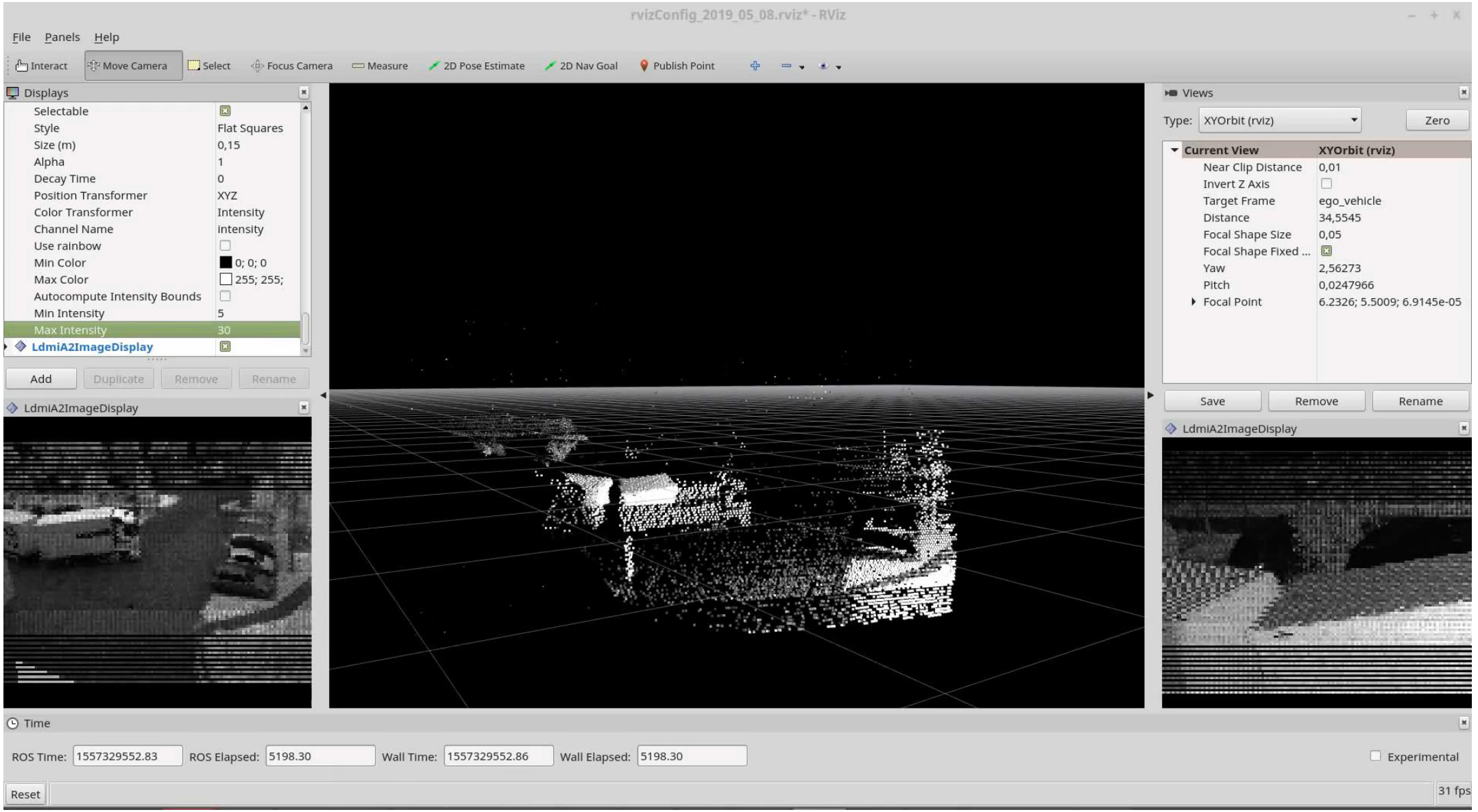

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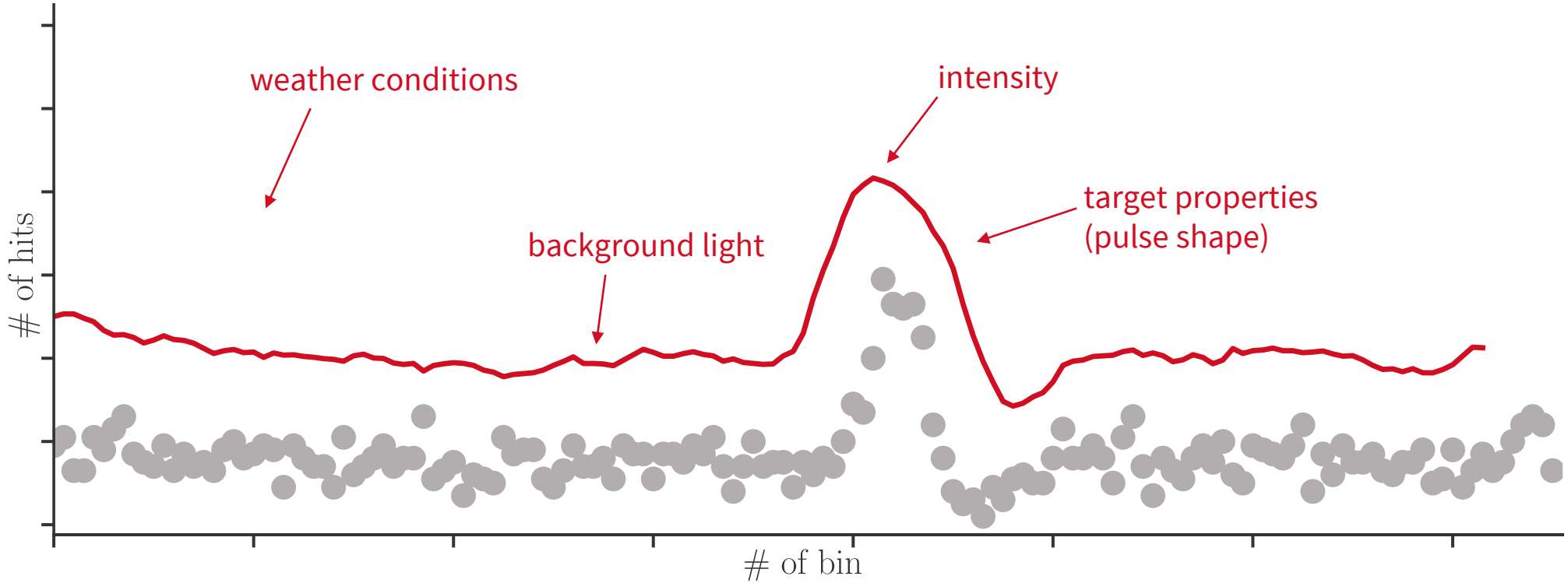
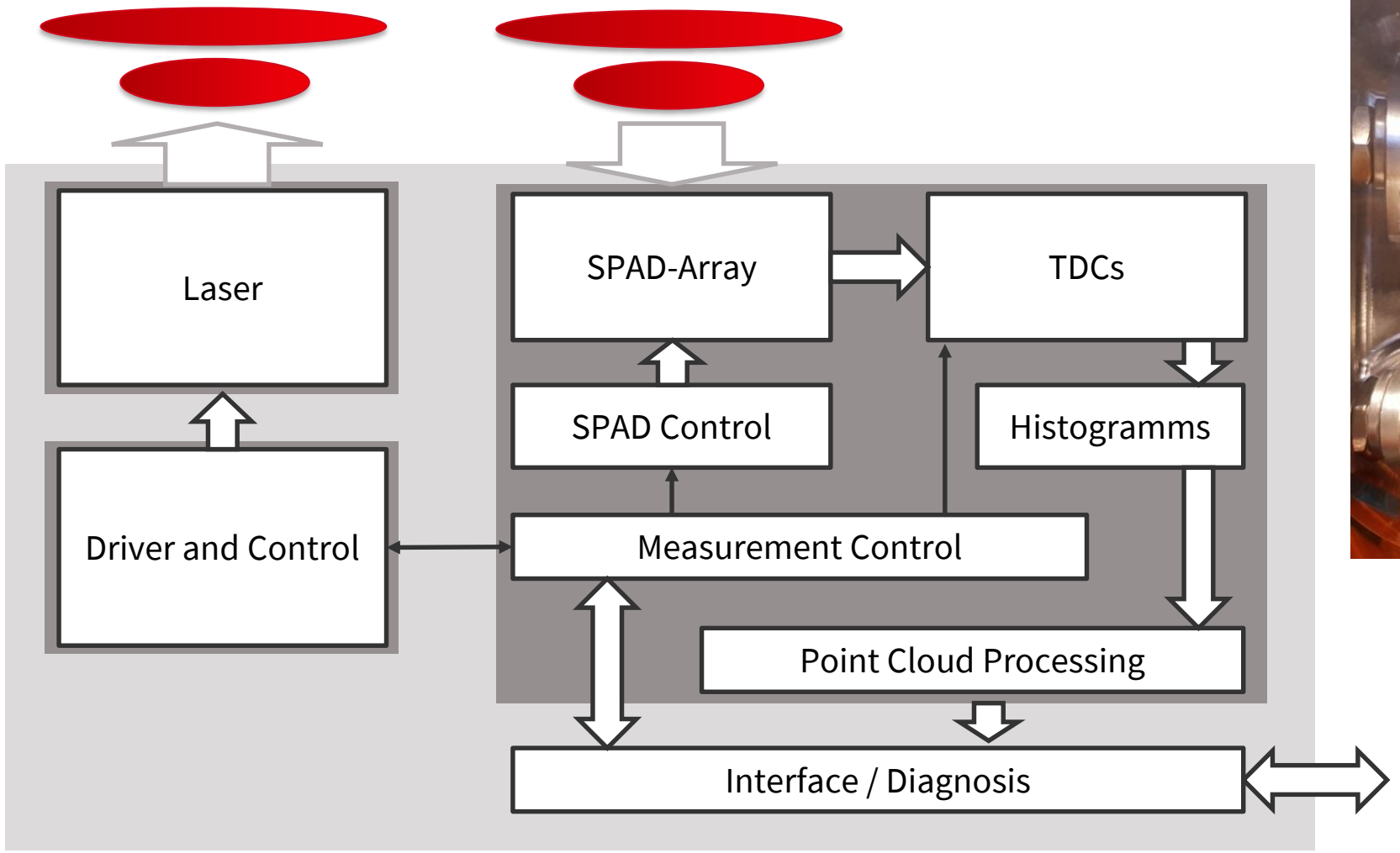
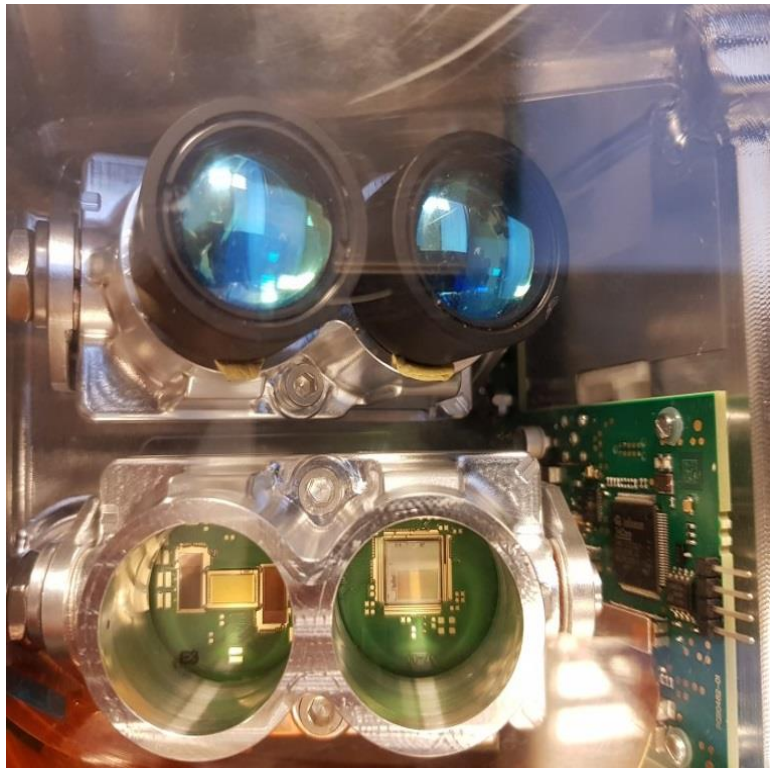
TCSPC - DSP



SUMMARY





SUMMARY

Why it’s hard to build a solid-state LiDAR

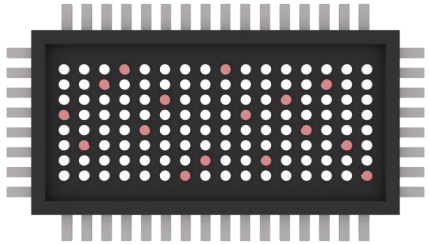
Requirements are tough

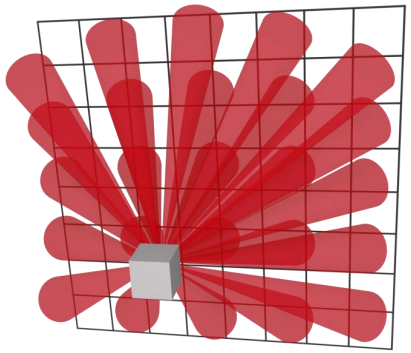
solid-state **wide FOV** **frame rate** **cost efficienct and automotive qualified**

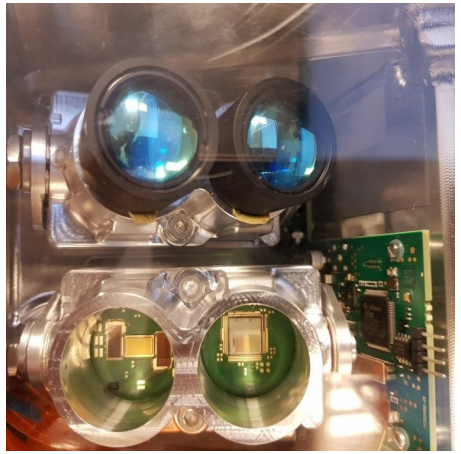
high resolution **long range** **fast**

One way to do it

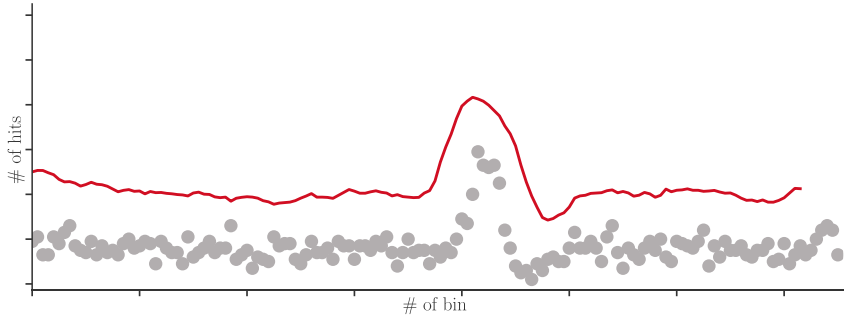
Truly solid-state LiDAR







Allows for advanced signal processing



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Web: www.ibeo-as.com

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