

Glare and Visibility in Automotive Lighting

Lighting Forum Geneva - Glare and Visibility

J. Kobbert, K. Kosmas, Prof. T. Q. Khanh



TECHNISCHE
UNIVERSITÄT
DARMSTADT



FACHGEBIET
LICHTTECHNIK



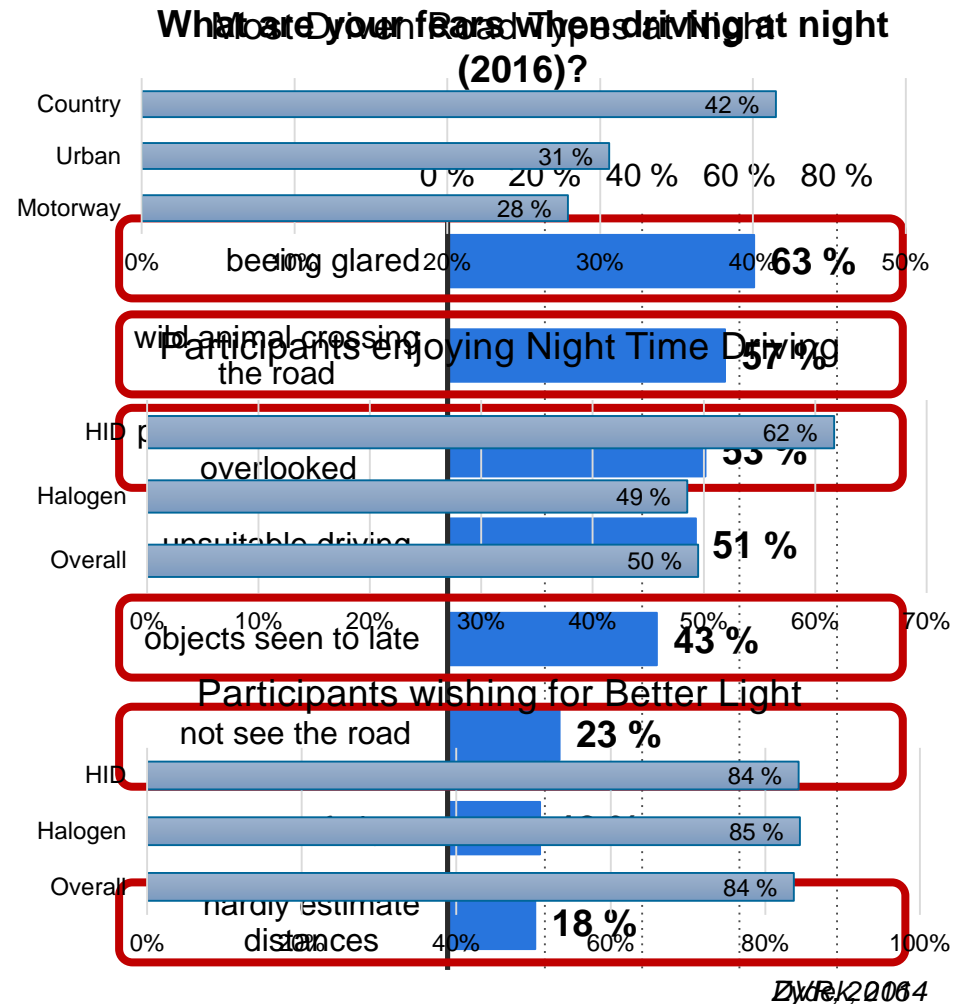
Motivation

Questionnaire (567 Participants)

- Most relevant: country roads
- Second: Urban Roads

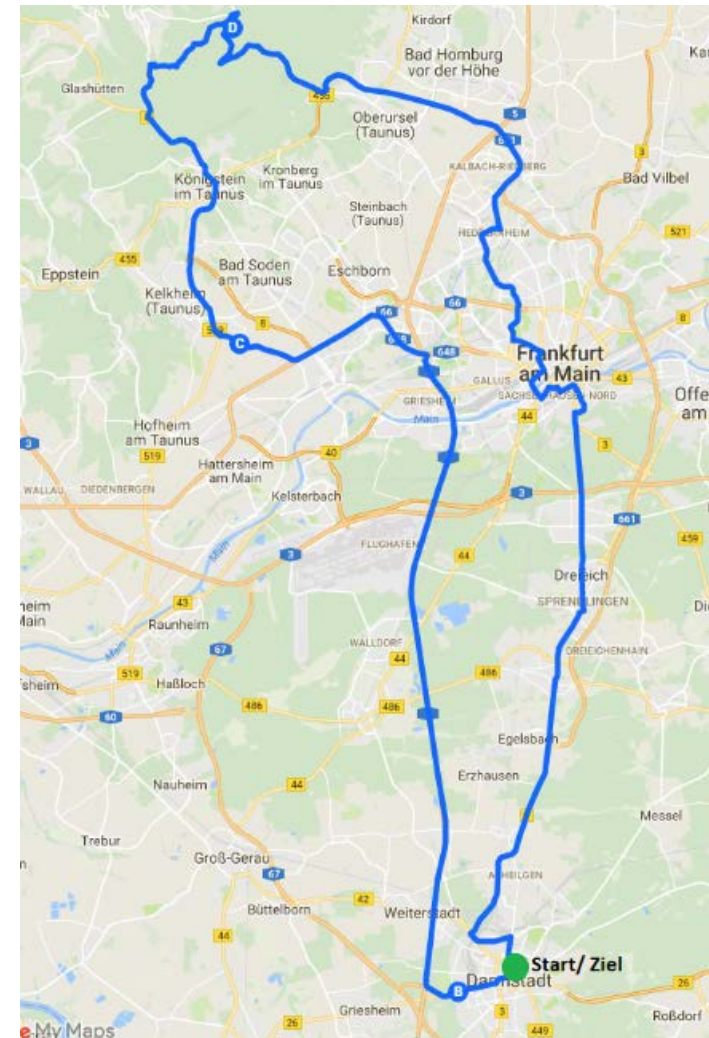
Newer systems lead to more acceptance

- Nearly everyone wishes
for more Light and better
viewing Distance



Investigating the Real Life Lighting Situation

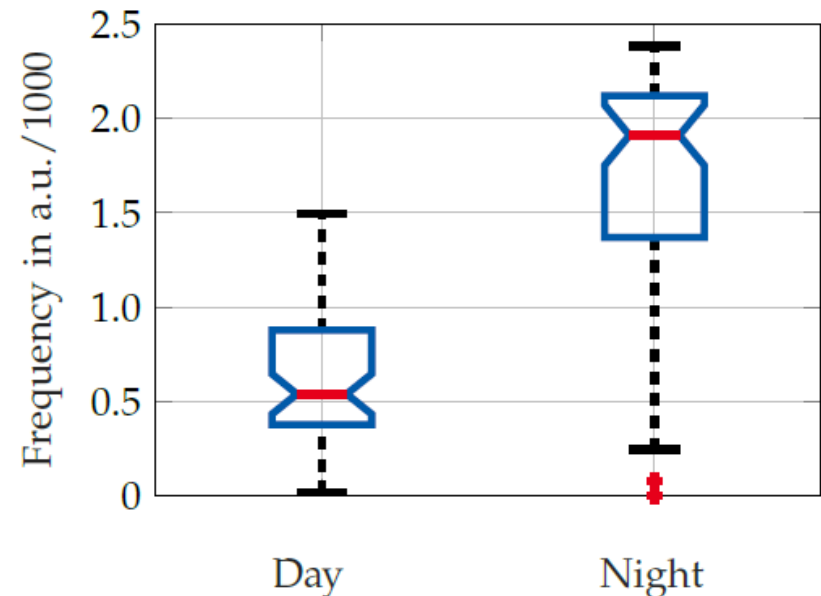
	Distance	Time
Urban Roads	20 %	38 %
Country Roads	42 %	36 %
Motorways	38 %	26 %
Total	128 km	2h 35 min



Glare Load Comparison

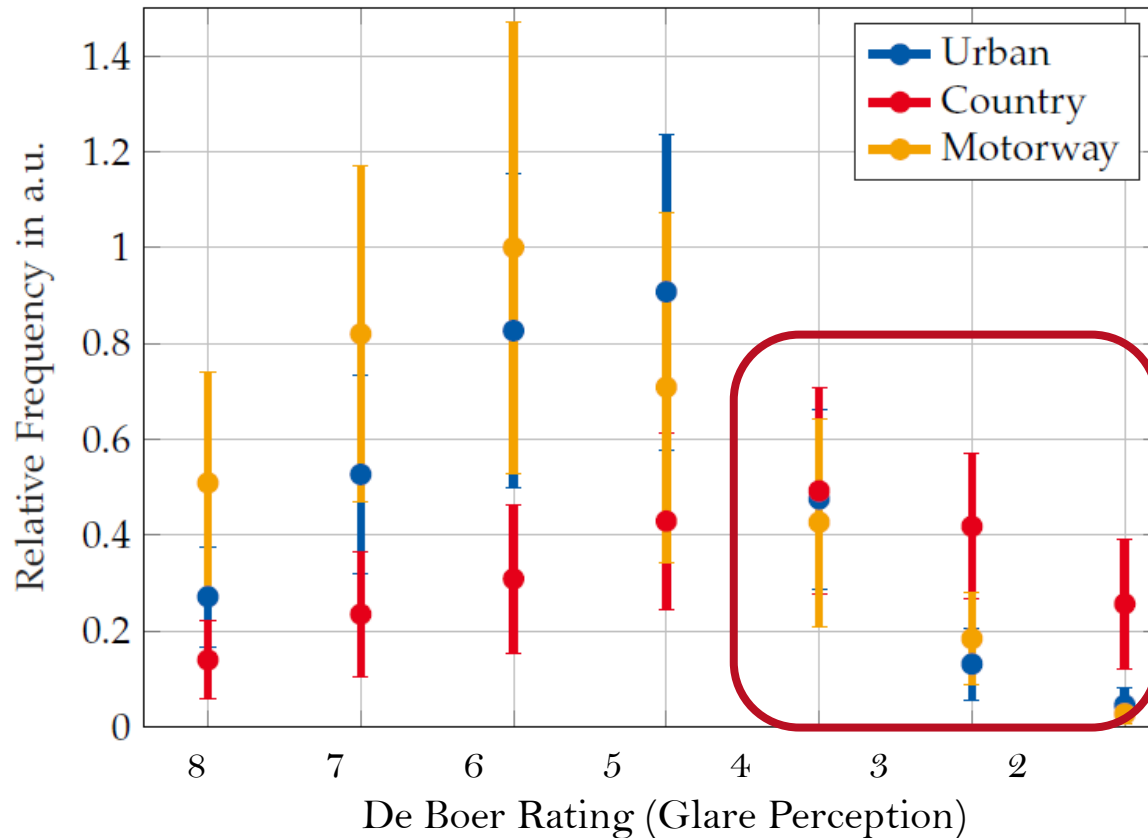
Day vs Night

- Significantly more Glare occurrences during the Night
 - 1800 Peaks during night
 - 510 Peaks during day
- Different Adaptation Level
 - 2 lx Night
 - $2 \cdot 10^3$ lx Day
- Different Light Sources
 - Headlamps vs „Natural Light“



Glare Load Comparison at Night

Different Road Types



- Low Intensity (No Glare) in Cities and Motorways
 - High Adaptation in Urban Areas
 - Low Peaks on Motorways
- Strong Peaks, High Glare on Country Roads
 - Oncoming Traffic

Reasons for High Glare Load

Insufficient headlamp aiming

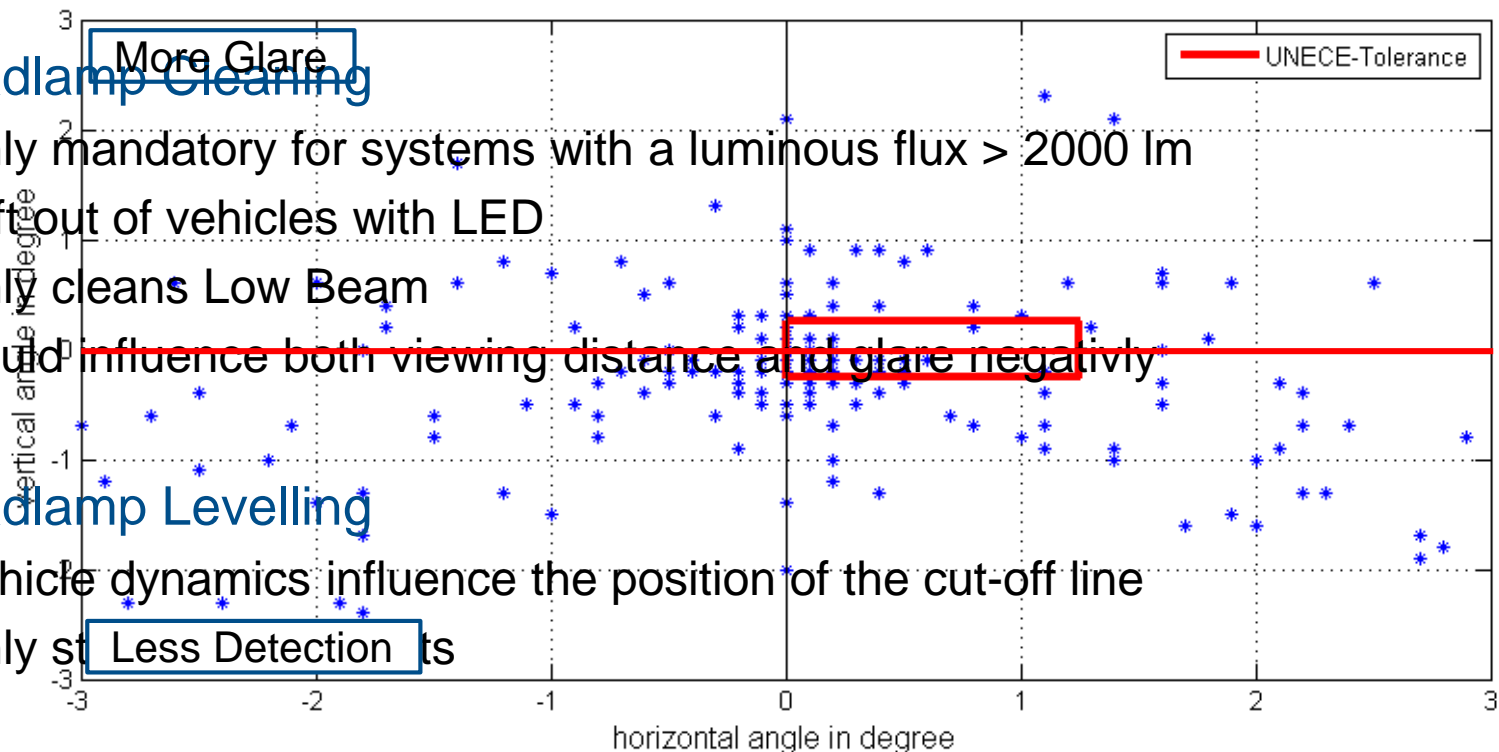
- Only about 20% of all vehicles are properly aimed
- Kosmas: TU Darmstadt 2013 & IFAL 2015 & Internal Documents 2018

Headlamp Cleaning

- Only mandatory for systems with a luminous flux $> 2000 \text{ lm}$
- Left out of vehicles with LED
- Only cleans Low Beam
- Could influence both viewing distance and glare negatively

Headlamp Levelling

- Vehicle dynamics influence the position of the cut-off line
- Only still **Less Detection** its



Field-Test

Influence of dirt on the headlamp light distribution

Measurements under real traffic conditions

- Alps or towards Norway with uncertain weather / road conditions
 - Low reproducibility
 - Measurements in public road traffic

Measurements on a testing area under semi realistic conditions

- Setup of the measurement in a fixed location
 - Same testing conditions for each day
 - Controlled environment
 - High frequency of measurements possible

→ The testing area's advantages outweigh

Testing circuit

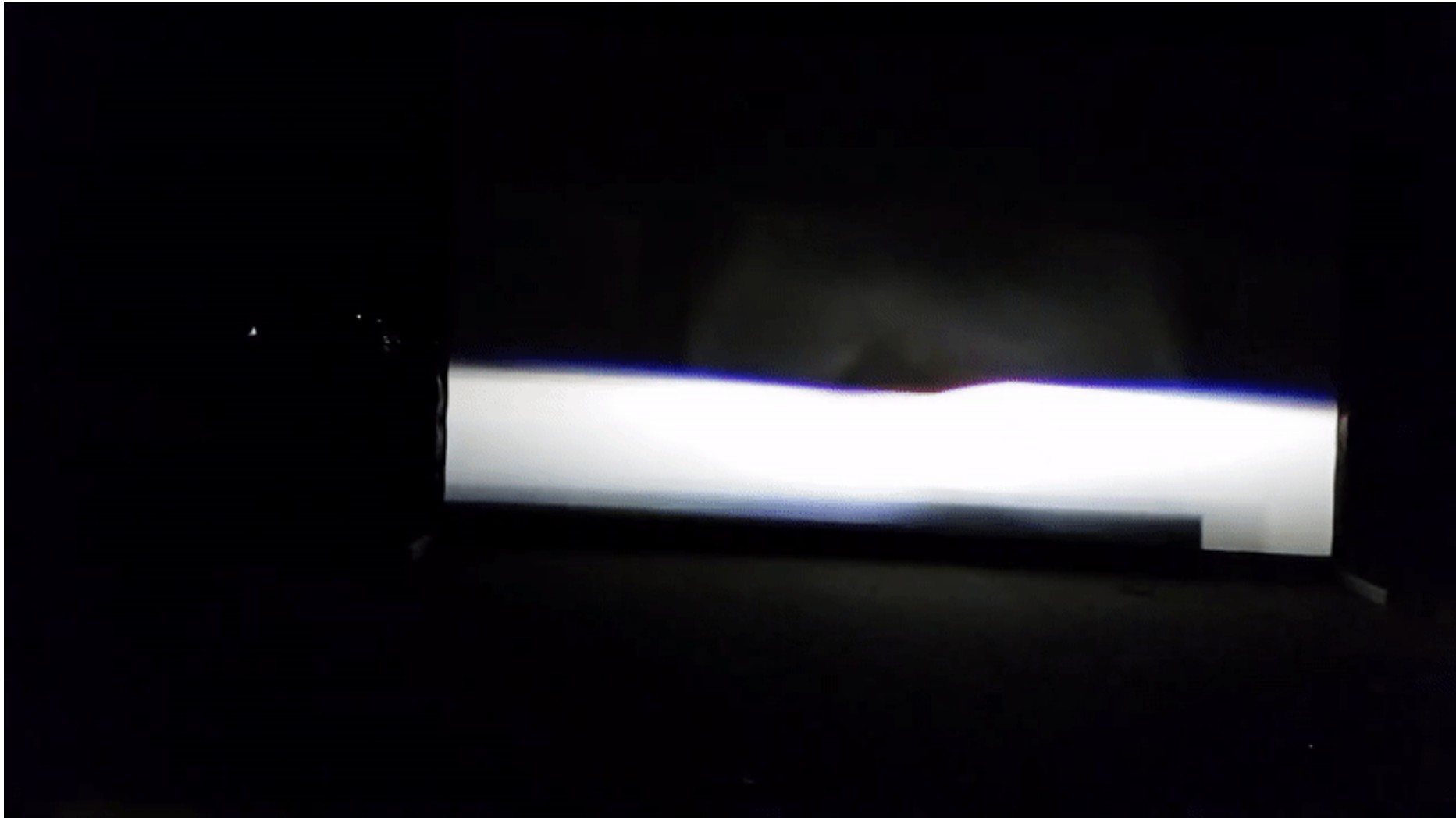
Test Circuit
length: approx. 410 m
width: approx. 3,5 m

Measurement
place direct at the
test circuit



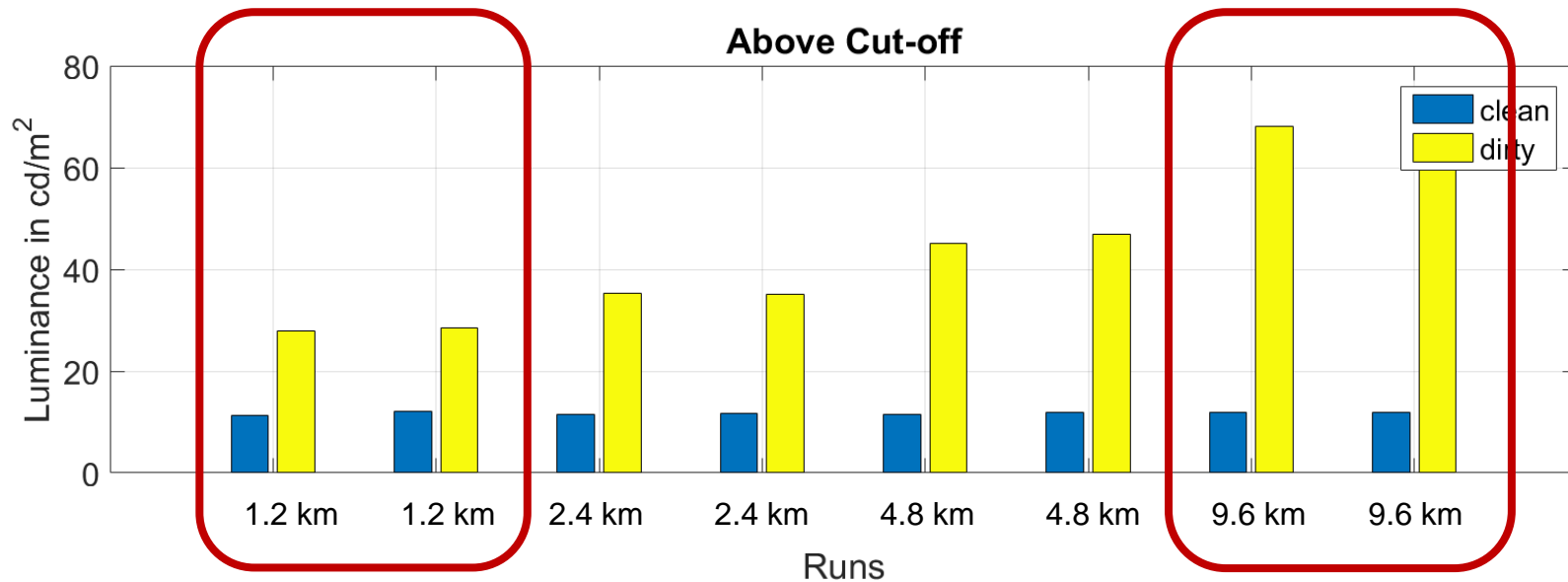
Data Visualization

Clean Headlamp vs. Dirty Headlamp



Results

Light Distribution: influence of dirt



Average Luminance above the Cut-Off (Glare)

- clean: $12 \text{ cd}/\text{m}^2$ (2.27 lx at 25 m)
- dirty:
 - 1.2 km: $30 \text{ cd}/\text{m}^2$ (5.69 lx at 25 m)
 - 9.6 km: $70 \text{ cd}/\text{m}^2$ (13.29 lx at 25 m)

→ Higher Glare with dirty Headlamps

Results

Light Distribution: influence of dirt



Average Luminance below the Cut-Off (Detection)

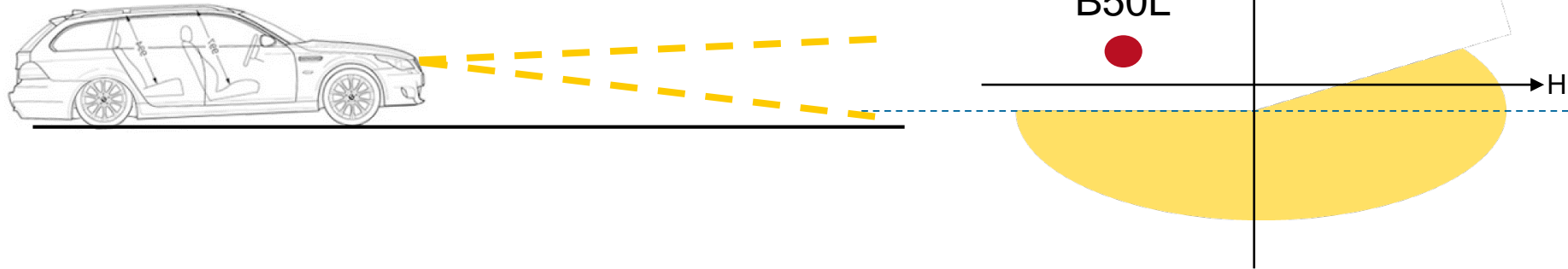
- clean: $155 \text{ cd}/\text{m}^2$ (29.4 lx at 25 m)
- dirty:
 - 9.6 km: $80 \text{ cd}/\text{m}^2$ (15.2 lx at 25 m)

→ Lower Detection Distances with dirty Headlamps

Reasons for High Glare Load

- **Insufficient headlamp aiming**
 - Only about 20% of all vehicles are properly aimed
 - Kosmas TU Darmstadt 2013 & IFAL 2015 & Internal Documents 2018
- **Headlamp Cleaning**
 - Only mandatory for systems with a luminous flux > 2000 lm
 - Left out of vehicles with LED
 - Only cleans Low Beam
 - Does influence both viewing distance and glare negatively
- **Headlamp Levelling**
 - Vehicle dynamics influence the position of the cut-off line
 - Only static requirements

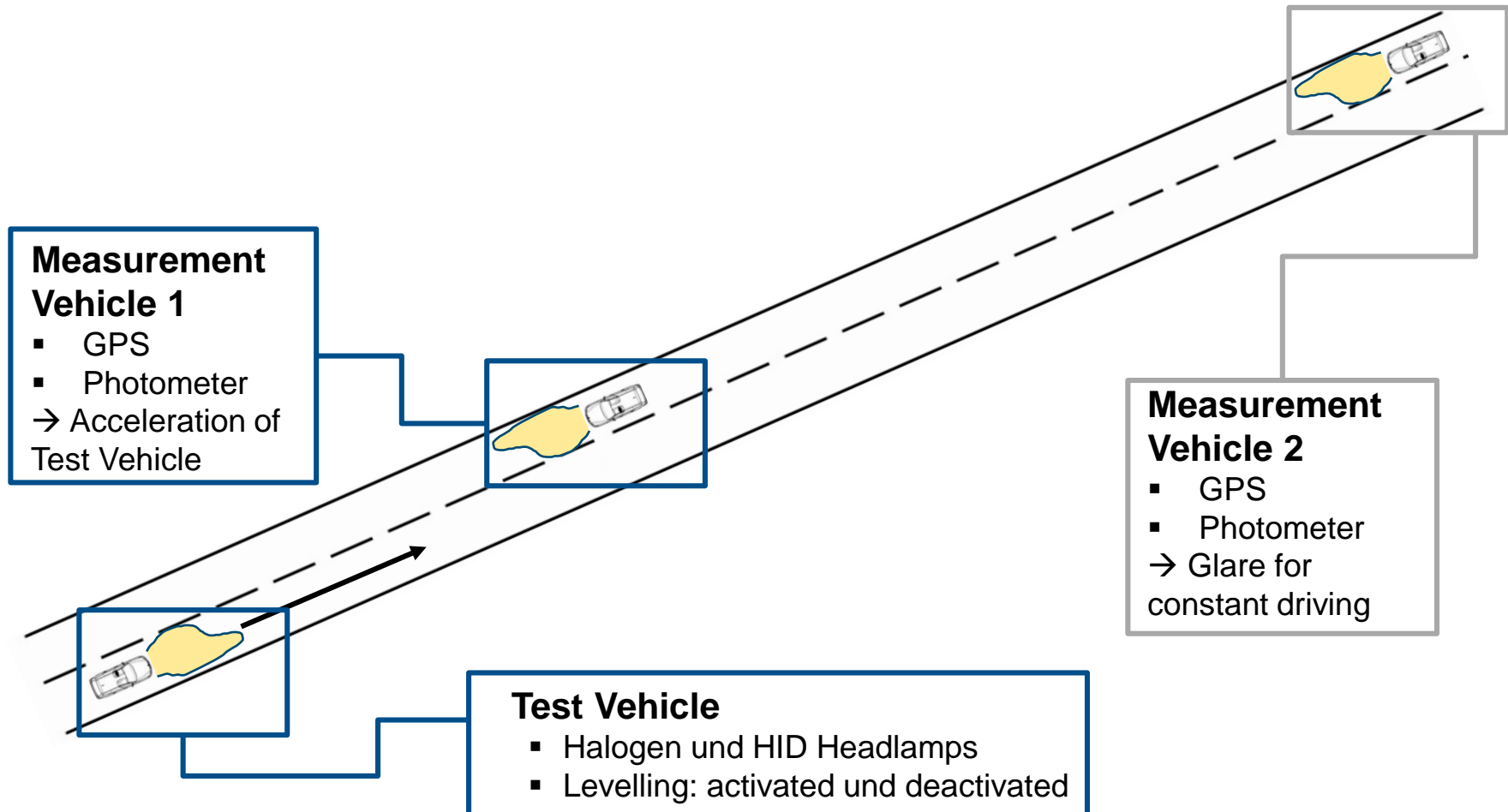
Headlamp Levelling



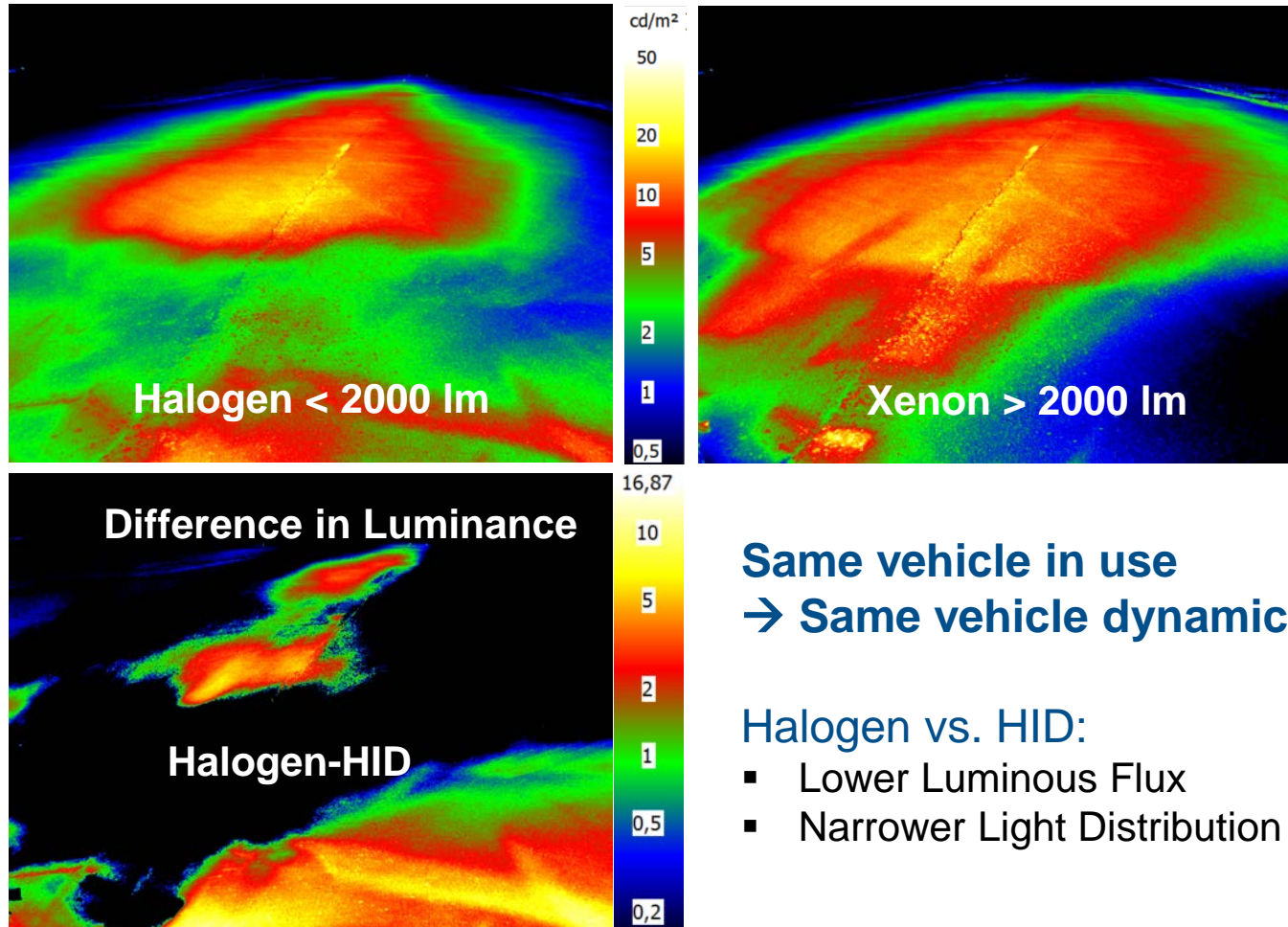
- Vehicle Pitch → Change the absolute position of the Cut-Off Line
 - Load
 - Chassis
 - Driving Dynamics
 - Roadgeometry and -surface
- Comparison of
 - HID Headlamps with dynamic Levelling
 - Halogen System without Levelling

Test Setup

Headlamp Levelling



Comparison of the Light Distributions Halogen vs. HID

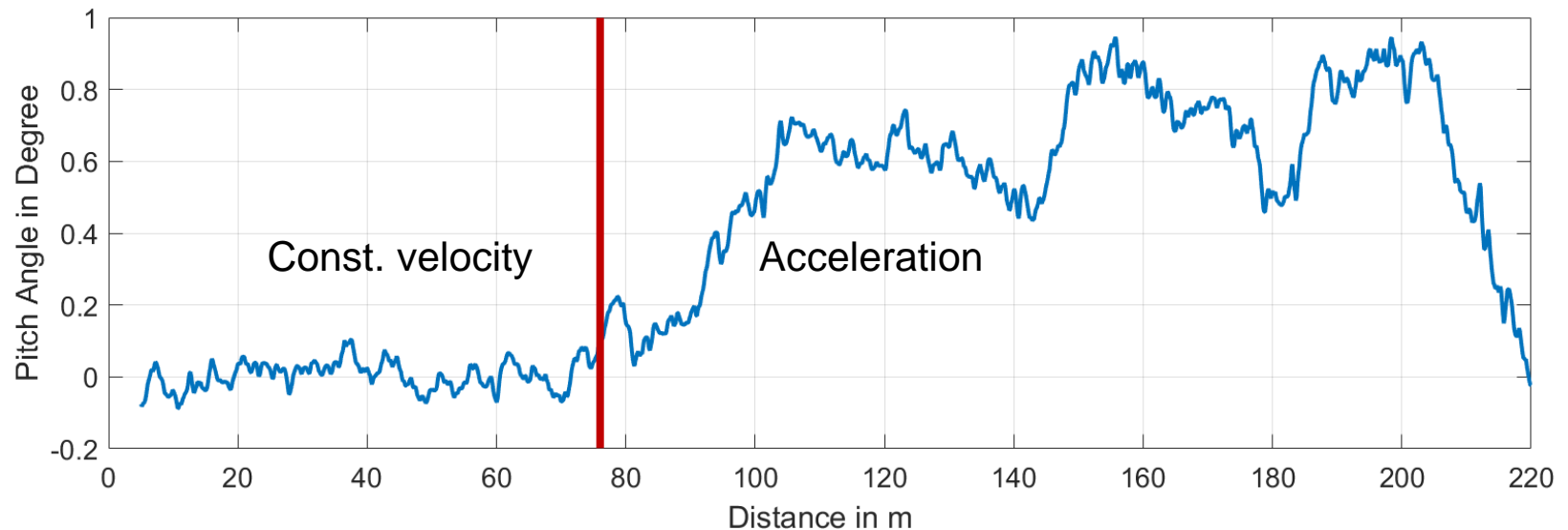


Same vehicle in use
→ Same vehicle dynamics

Halogen vs. HID:

- Lower Luminous Flux
- Narrower Light Distribution

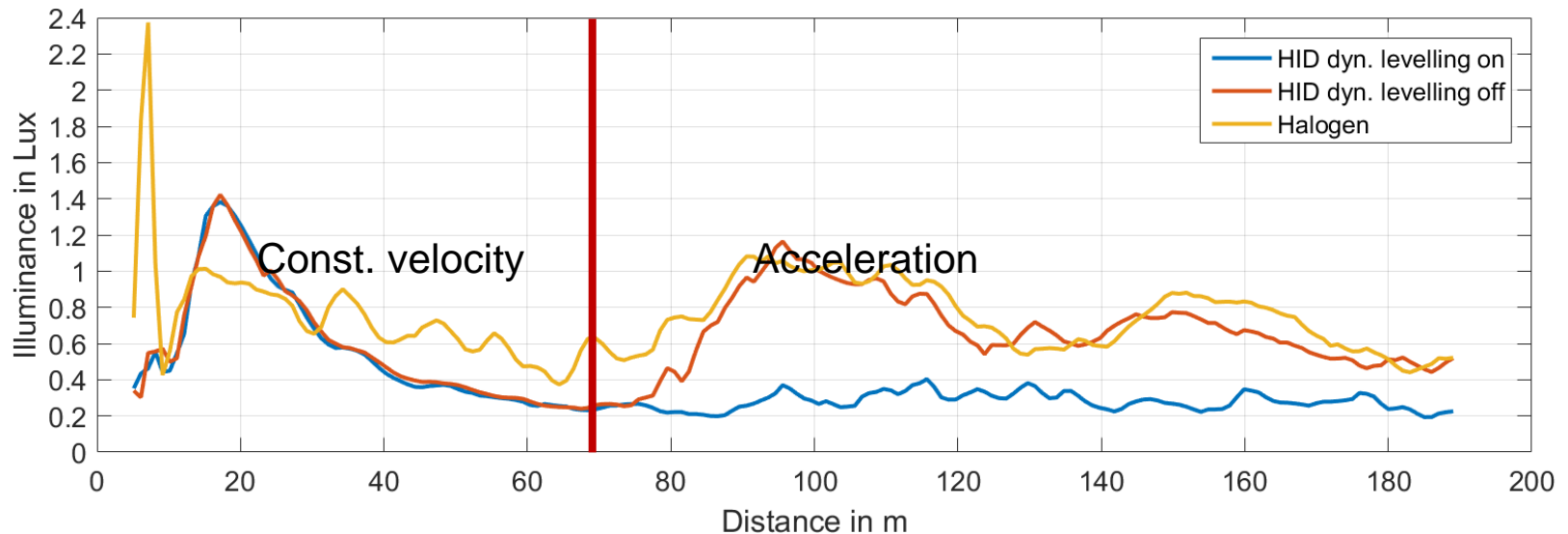
Pitch Angles during Acceleration



- When accelerating pitch angles of up to 1°
 - Potentially high illuminance values for oncoming traffic

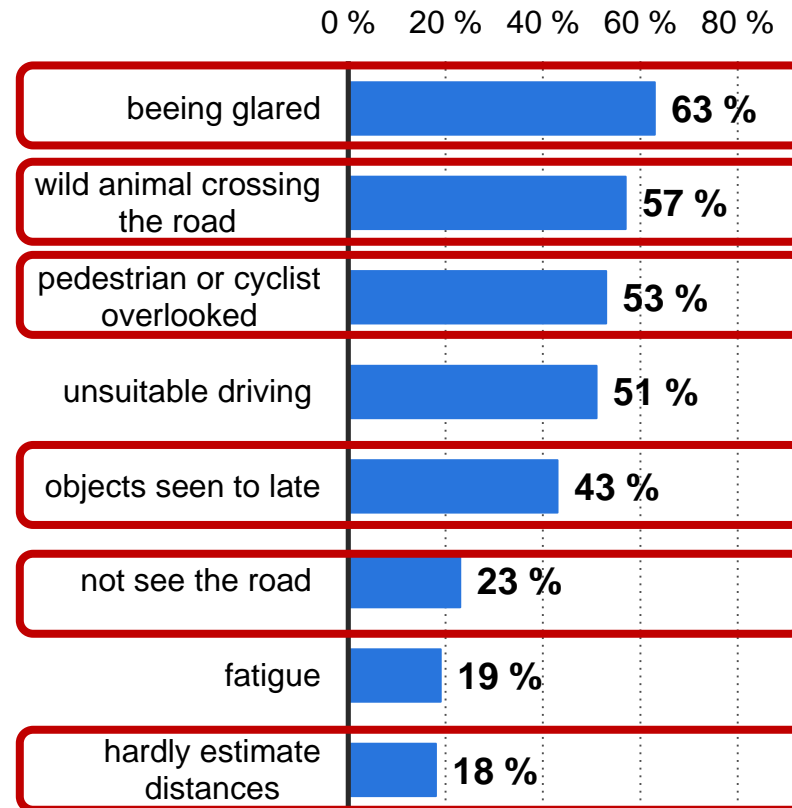
How does the levelling system influence the illuminance for oncoming traffic?

Comparison of Illuminance HID vs. Halogen



- Dynamic levelling compensates the pitch angles for acceleration
- Without dynamic levelling high illuminance values are recorded during acceleration
- For constant velocity identical values
- Halogen headlamps have identical values as HID for acceleration
 - **Reminder: Same Vehicle – different Headlamp**
 - **Luminous flux not a suitable factor for levelling**

What are your fears when driving at night (2016)?



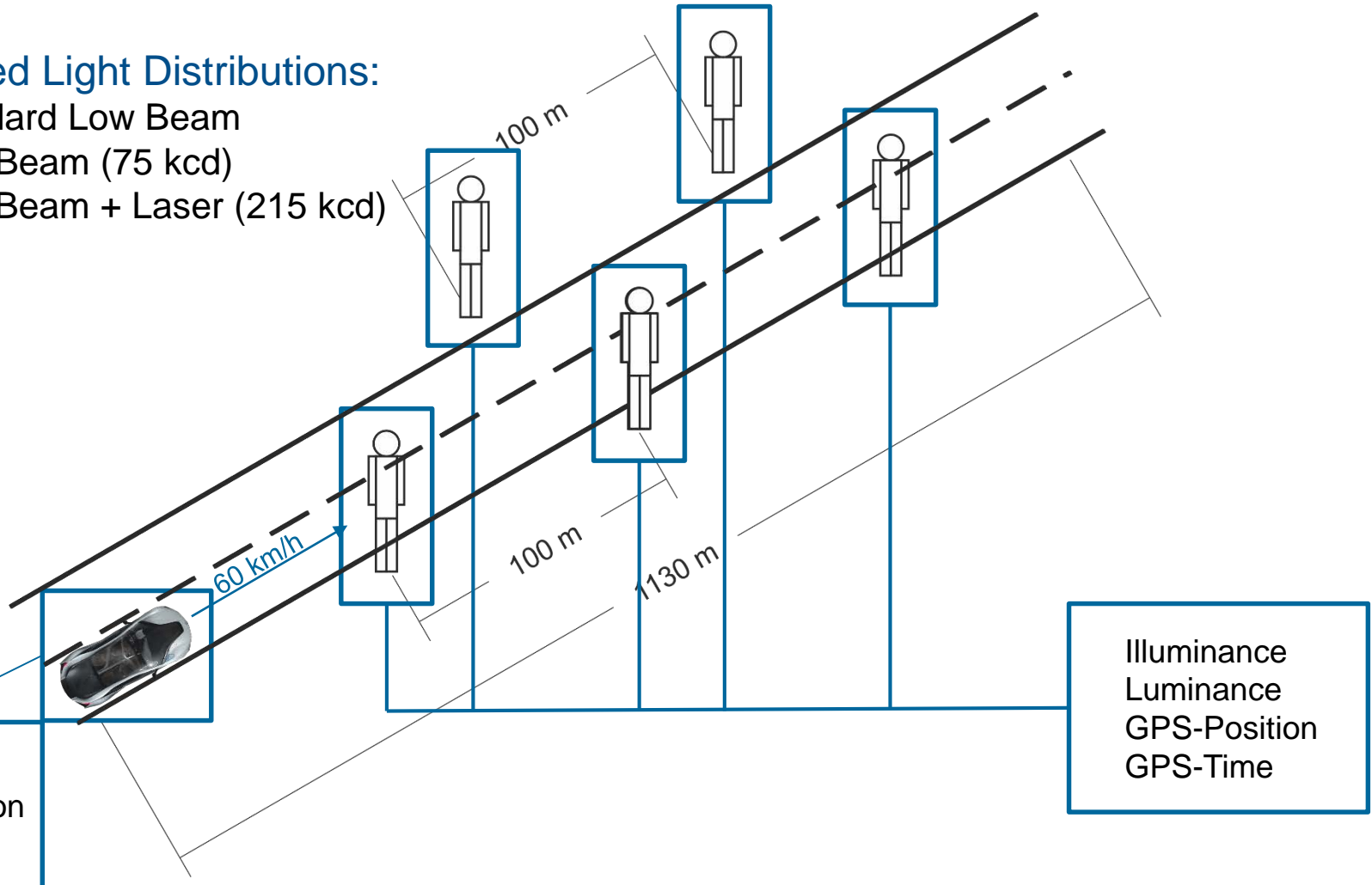
Detection Test

Viewing Distances with different Headlamp Intensities



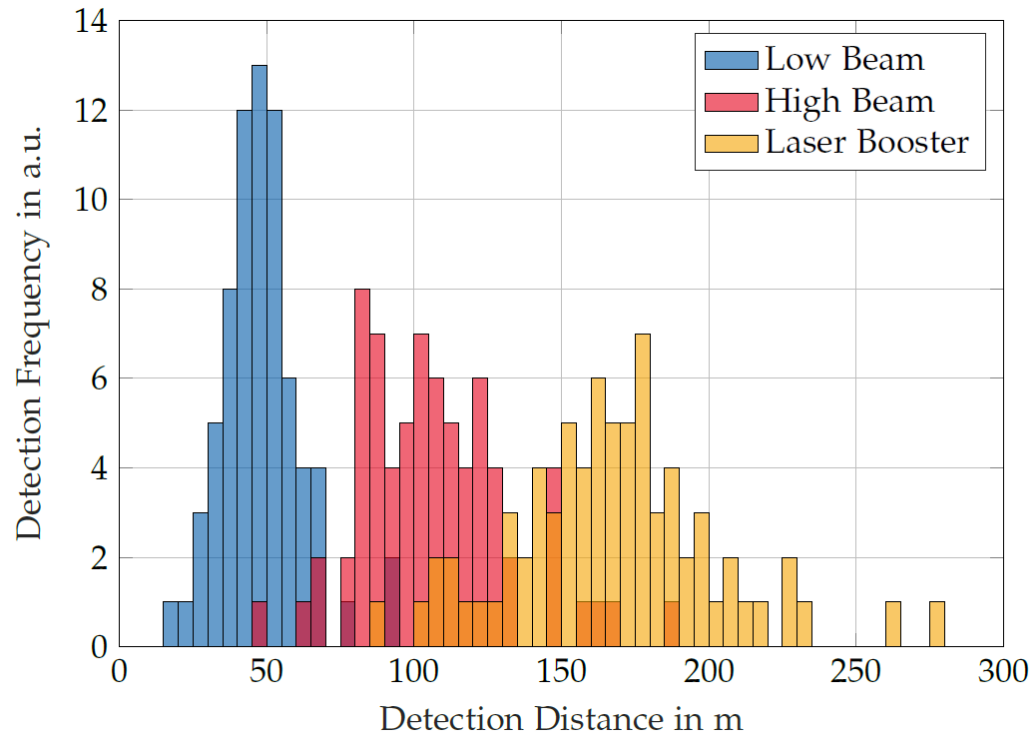
Measured Light Distributions:

- Standard Low Beam
- High Beam (75 kcd)
- High Beam + Laser (215 kcd)



Detection Test

Viewing Distances with different Headlamp Intensities



- Significant differences between Intensities
- Mean Detection Distances:
 - 48.0 m Low Beam, 103.2 m High Beam, 167.4 m High Beam + Laser Modul
- Elderly drivers – 15% lower detection distances

Results

Detection probability at various stopping distances

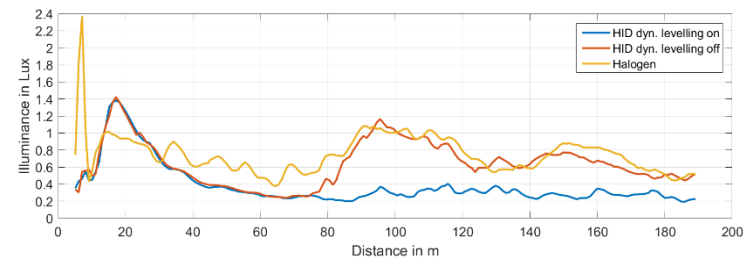
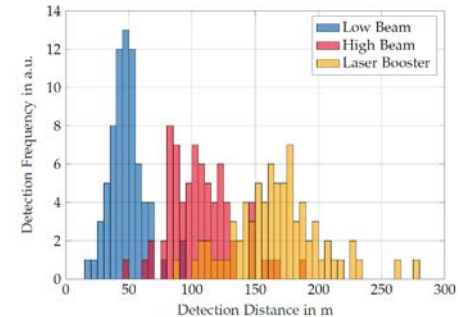
Distance in m	Passing Beam	Driving Beam	Laser Booster
55	27,72 %	97,05 %	99,91 %
80	1,18 %	85,92 %	99,60 %
110	0,00 %	44,64 %	97,57 %
160	0,00 %	2,69 %	65,93 %

150 km/h average speed in Germany
160 km/h average speed in the USA
180 km/h average speed in China

→ **Low Beam is not suitable!**

Summary

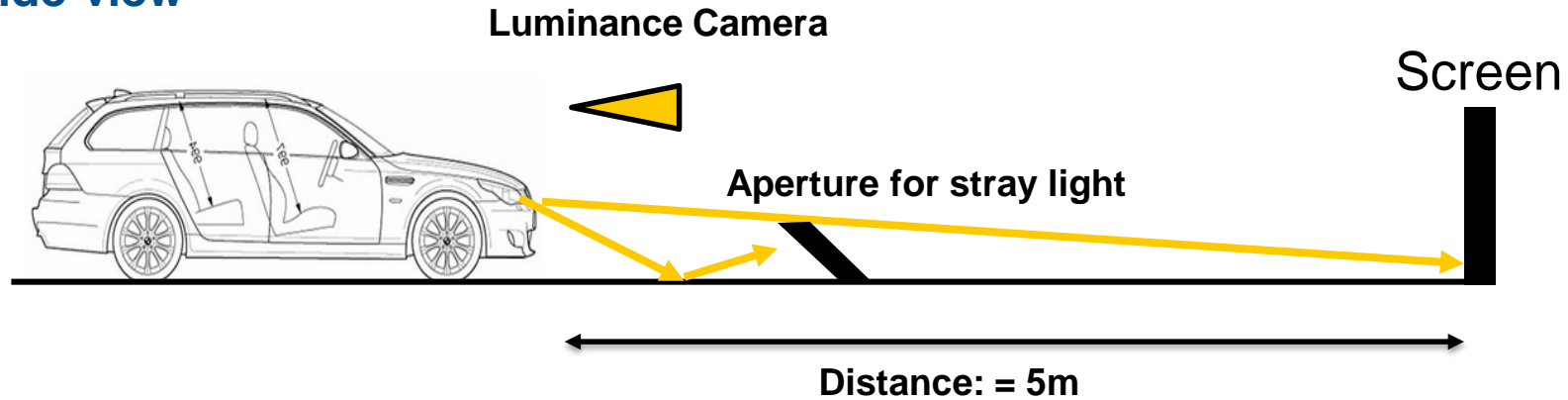
- **Detection dependant on luminous Intensity**
 - Low Beam should only be used if necessary
 - High beam needs to deliver a certain amount
 - Assistent systems should be used widely
- **Dirt influences the light distribution**
 - More glare (up to 5x higher illuminance)
 - Less detection (0.5x lower illuminance)
 - Decreases the already critical distances
- **Levelling can help prevent more glare**
 - Vehicle dynamics influence potential glare
 - Headlamp types are not the crucial factor



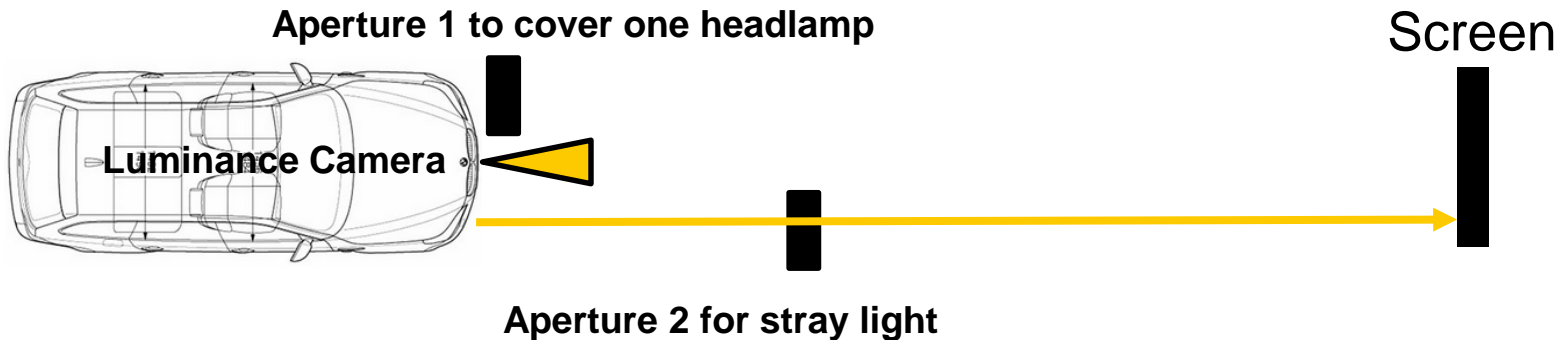
Thank you for your attention

Measurement Setup

Side-view



Top view

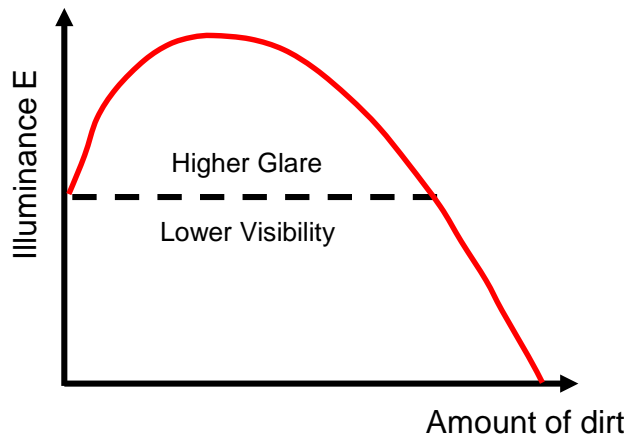


Research so far

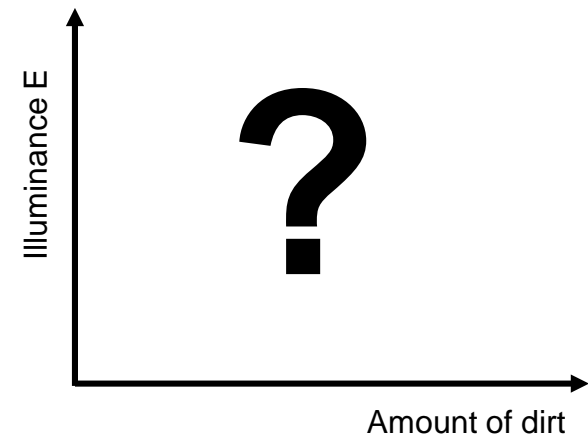
Schmidt-Clausen (1978) & von Laarhoven (1994)

- Glare-Illuminance:
at first it increases with amount of dirt on the HL (scattered Light) and decreases then

Above cut-off line



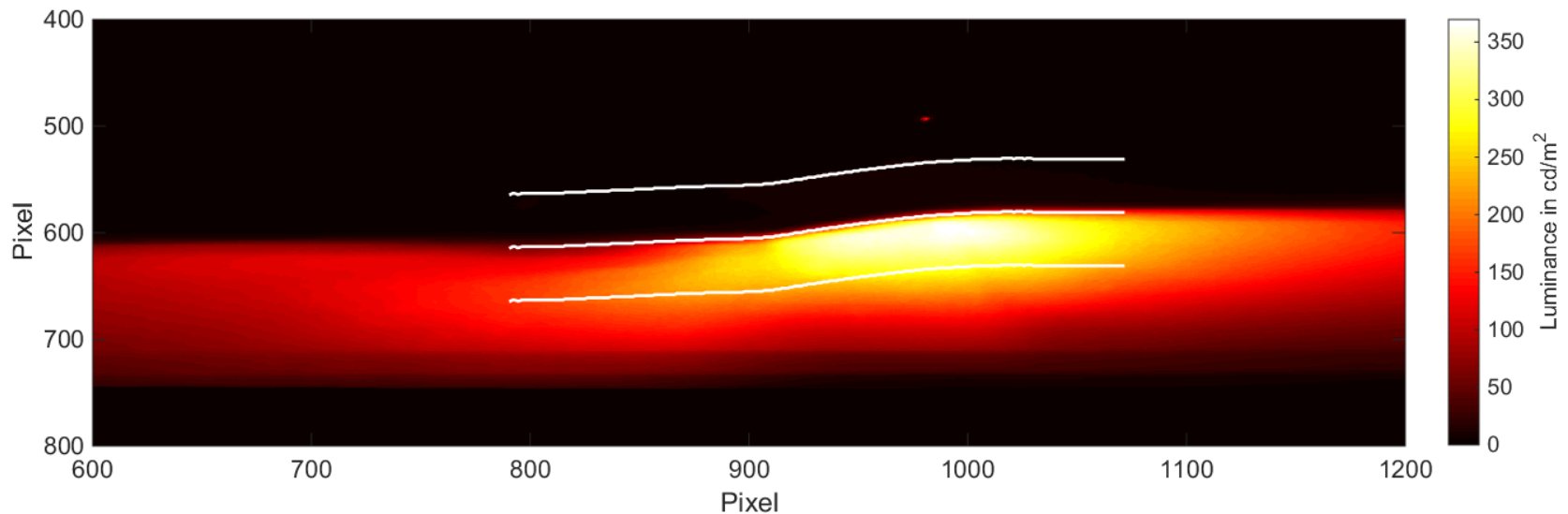
Below cut-off line



→ Frequent measurements in dependency of distance or time

Data Analysis

finding the Cut-off



- Luminous picture of clean headlamp
- Finding the cut-off line through image processing
- Region of Interest:
 - Horizontal: $\pm 4^\circ$
 - Vertical: $\pm 1^\circ$

Region **Above** Cut-off → Glare-Region
Region **Below** Cut-off → Visibility-Region