

Requirements for dynamic levelling devices to prevent headlamp glare blinding oncoming road users



TECHNISCHE
UNIVERSITÄT
DARMSTADT



FACHGEBIET
LICHTTECHNIK

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

Submitted by Germany



Informal document GRE-83-03-Add.1
(83rd GRE, 19-23 October 2020,
agenda item 6 (b))

Introduction

Motivation

- **Goals for Development of new headlamps**

- Minimal glare
- Maximum viewing distance

→ Increasing safety for night time driving

- **Technical improvement**

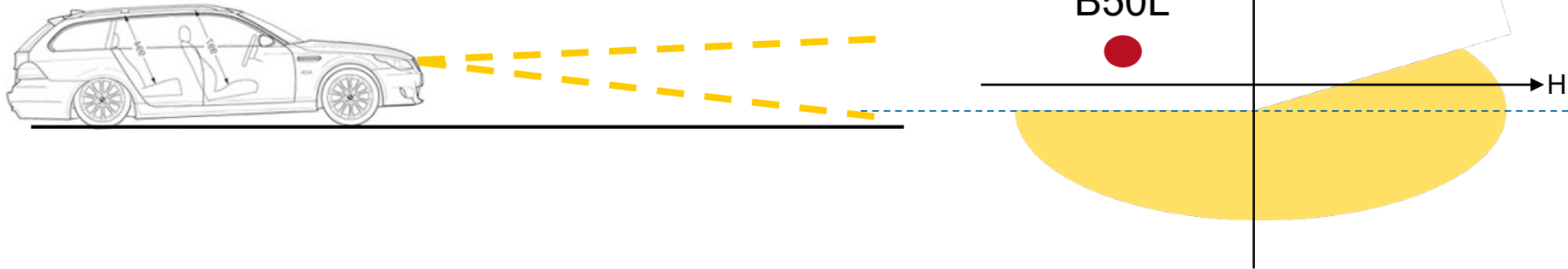
- Development/Introduction of new light sources (HID, LED, Laser)
- Development/Introduction of new functions/Technologies (ADB...)

- **BUT only with:**

- Correctly aimed Headlamps
- Including the vehicle pitch by levelling devices

Introduction

Goal and Use



■ Vehicle Pitchthrough:

- Load
- Suspension systems
- Driving Dynamics
- Road Geometry

■ Solution ECE-R48: Headlamp Levelling

- Static Requirements (Depending on Load only)
- No Requirements for dynamic Levelling

Current Requirements for Levelling (2016)

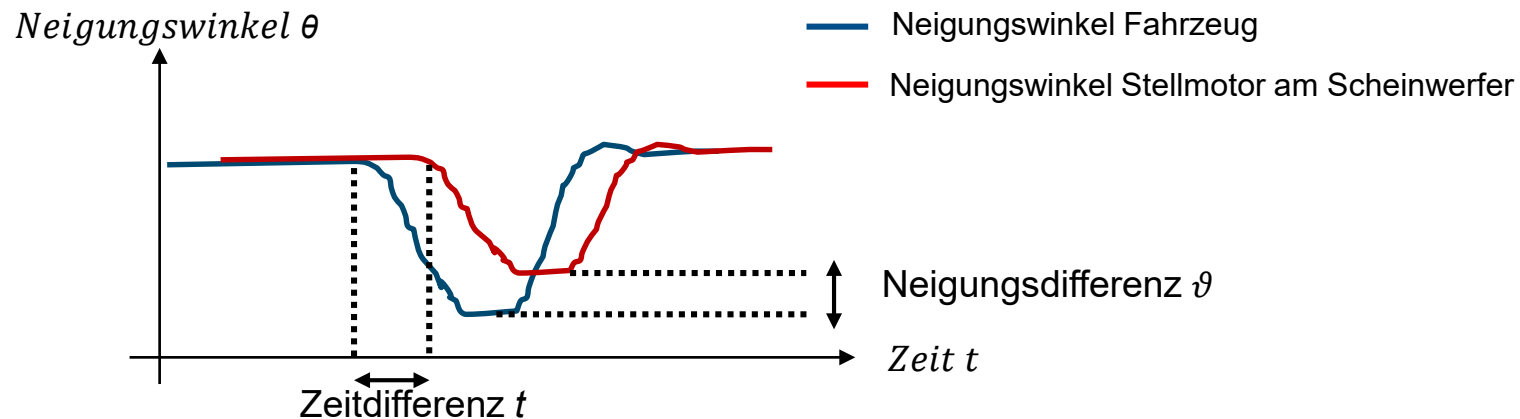
1. Load Dependant
2. Automatic Levelling:
 - Set to luminous flux (2000 Lumen)
 - Dynamic Levelling: No Requirements

Open Questions:

- Suspension vs Flux
- Controlling Speed for dynamic Levelling?

Dynamic Measurement of the Headlamp Orientation

- Using 2 Sensors for Pitch Measurement
 1. At the HID/LED Module
 2. At the Chassis
- Pitch Difference ϑ → Correction of the Motor
- Time Difference t → Reaction Time



Influence of driving dynamics:

- 2 Parameters:
 1. Suspension
 - soft | intermediate | hard
 - „empty“ | loaded
 2. Luminous Flux
 - Above 2000 lm | Below 2000 lm
 - Halogen | HID | LED
 - Levelling: active | deactive

2 Different Tests

1. Same suspension but different headlamps

→ All changes caused Headlamps

- Min. flux → Halogen
- Max. flux → HID > 2000 lm

→ **Opel Insignia with Halogen und HID headlamps**

2. Different suspension but same headlamps

→ All changes caused by suspension

- Soft and hard suspensions
- With and without load

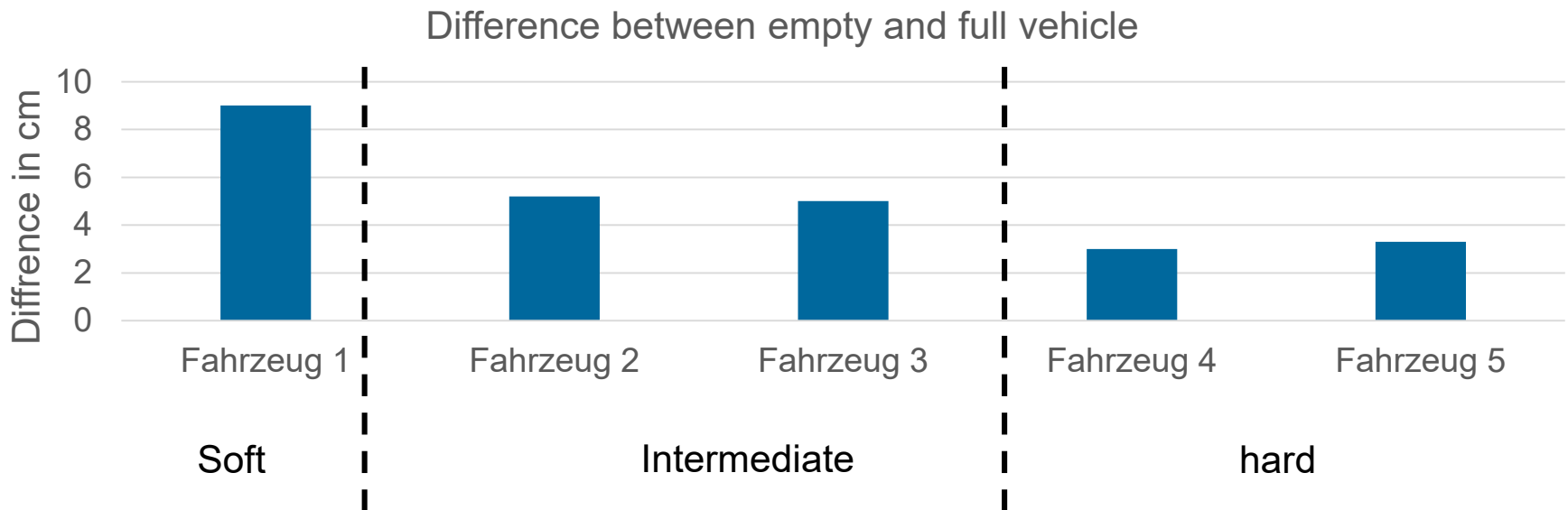
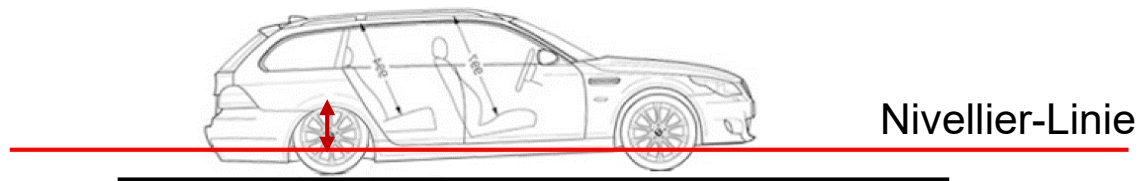
→ **Audi A3 with HID Headlamps**

→ **Audi S3 with HID Headlamps (Sportversion A3)**

Test Setup

Vehicle Classification

Suspension Classification



Test Setup

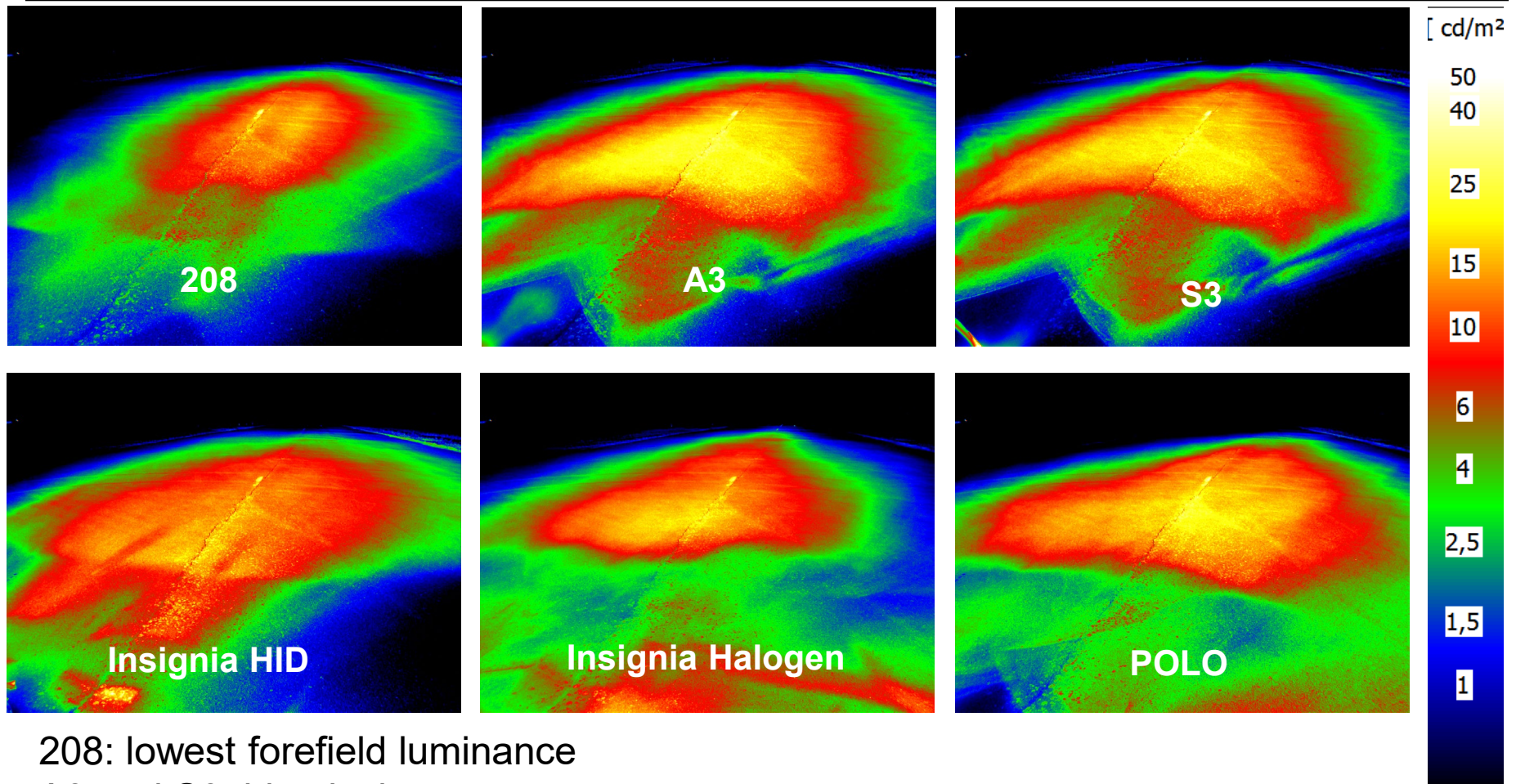
Test Vehicles



Abkürzung	Fahrzeug	Fahrwerk	Lichtquelle
Fzg. 1	Peugeot 208	Soft	Halogen
Fzg. 2	Opel Insignia	Intermediate	Halogen
Fzg. 2	Opel Insignia	Intermediate	HID
Fzg. 3	Audi A3	Intermediate	HID
Fzg. 4	Audi S3	Hard	HID
Fzg. 5	VW Polo	hard	LED

Test Setup

Light Distributions



208: lowest forefield luminance

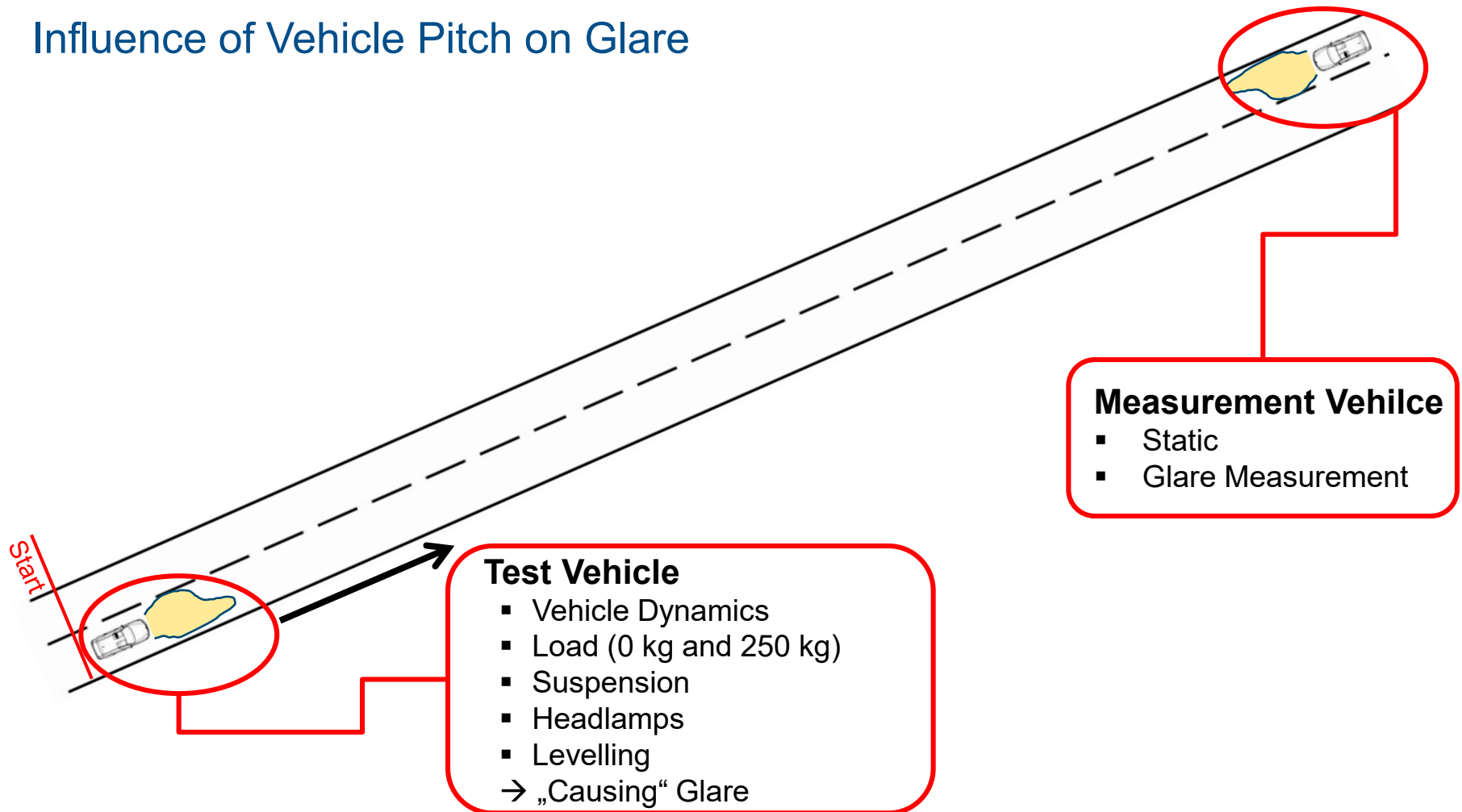
A3 and S3: identical

Insignia Halogen/HID: widest Distribution

AP2:

Versuchsaufbau: Grundlagen

Influence of Vehicle Pitch on Glare



Measurement Vehicle

- **Objective Measurement**
 - Illuminance E

- **Psychological and physiological Evaluation**
 - Test Subjects
 - DeBoer Bewertung → psychological glare
 - Kontrast Sensitivity → physiologische glare
 - *Glare button (new)*

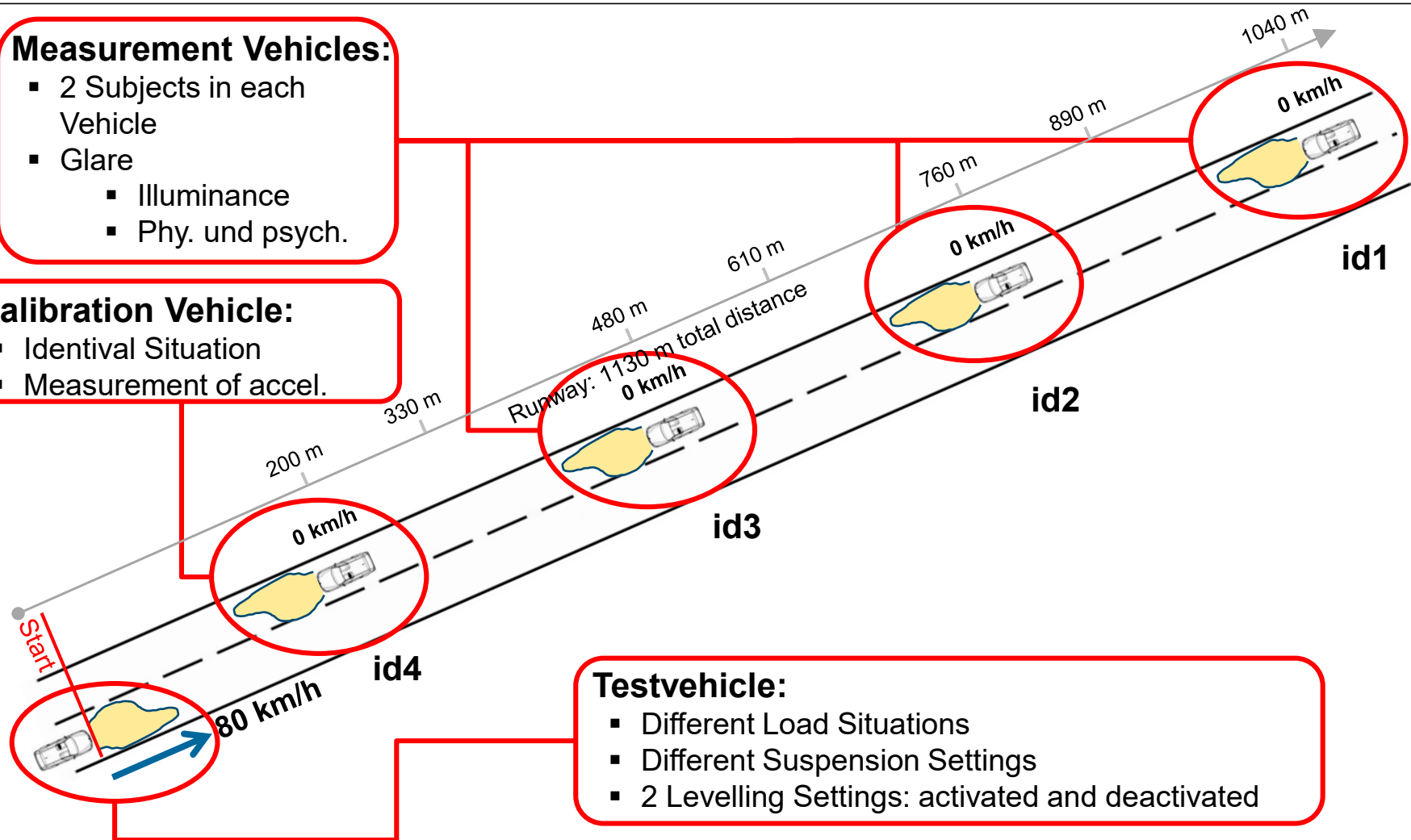
Test Setup

Measurement Vehicles:

- 2 Subjects in each Vehicle
- Glare
 - Illuminance
 - Phy. und psych.

Calibration Vehicle:

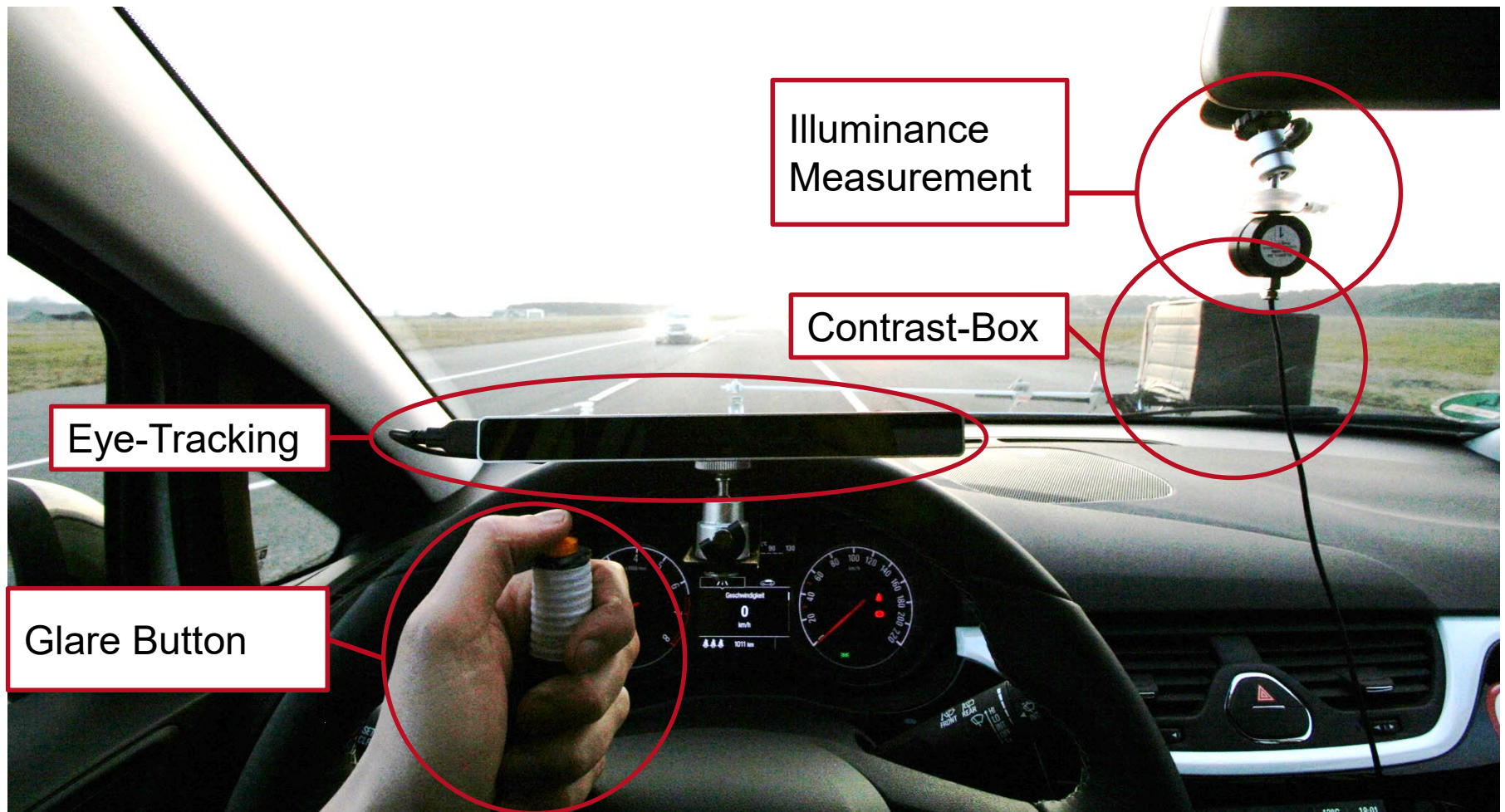
- Identical Situation
- Measurement of accel.



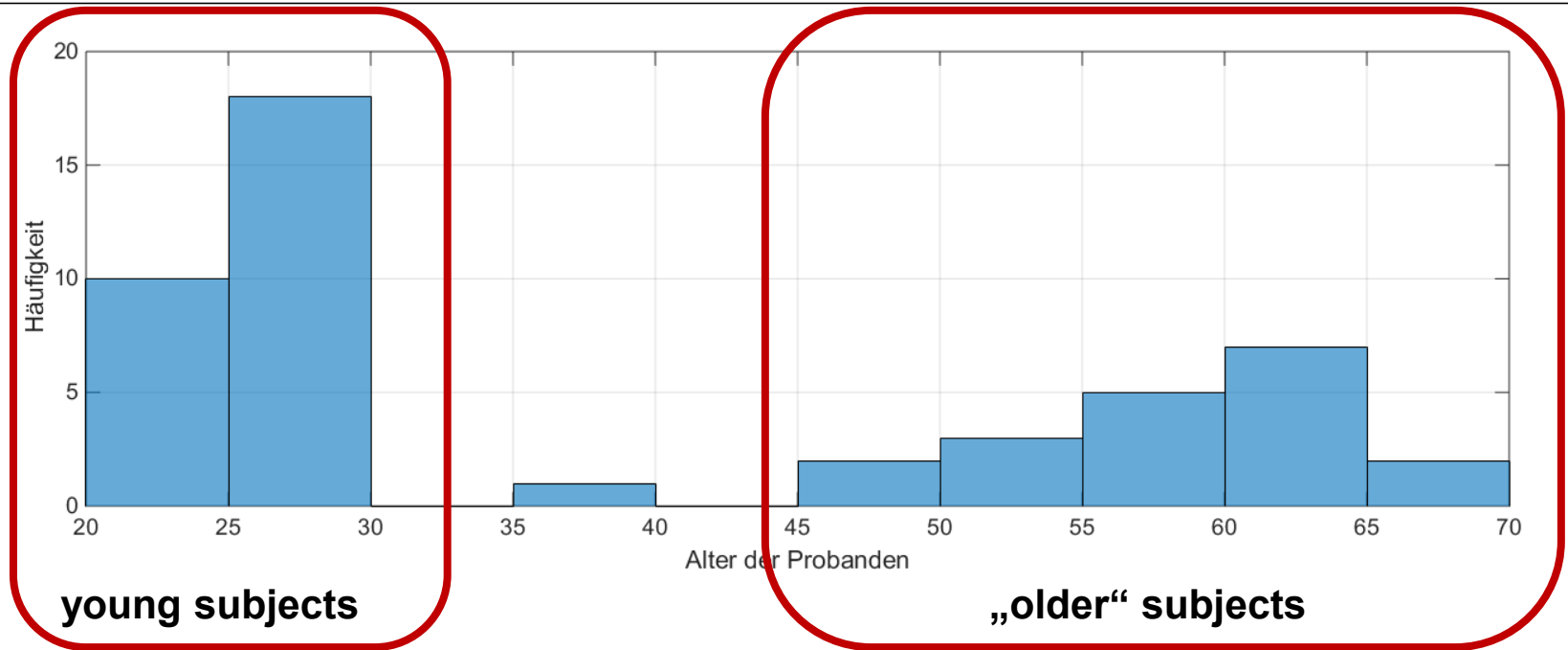
Testvehicle:

- Different Load Situations
- Different Suspension Settings
- 2 Levelling Settings: activated and deactivated

Test Setup

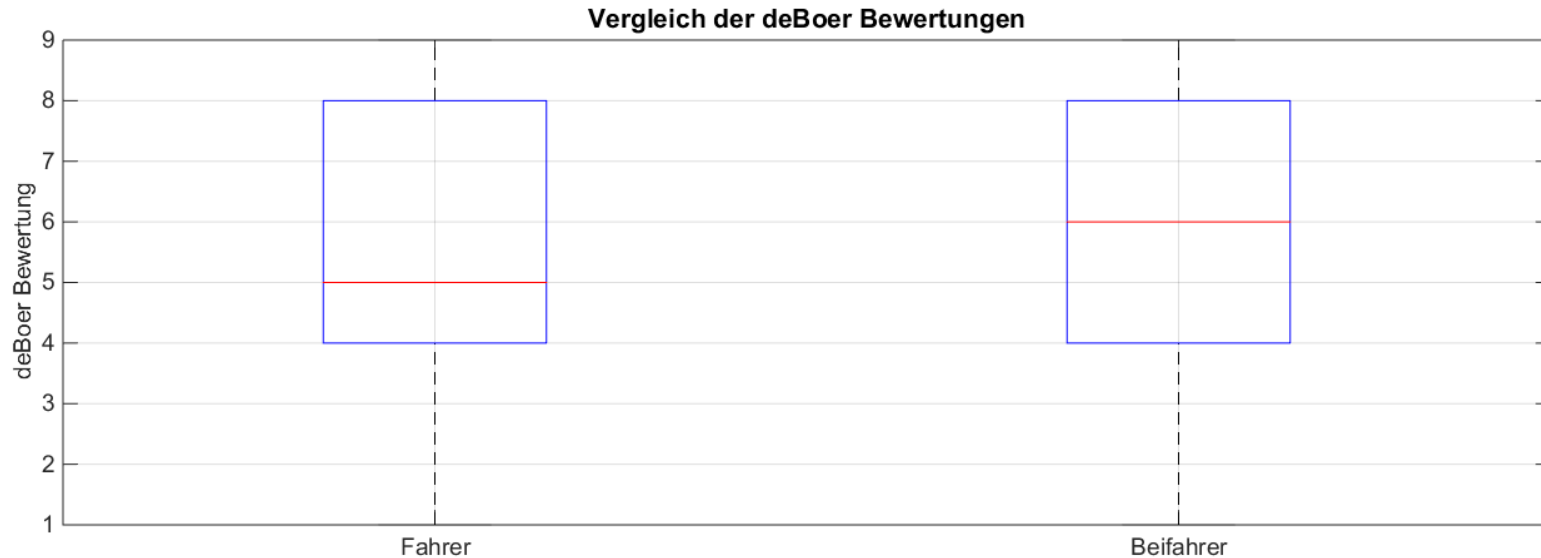


Test Subjects



- 48 Subjects
 - 28 under 35 years (\bar{x} 24,96)
 - 19 over 40 years (\bar{x} 54,4)

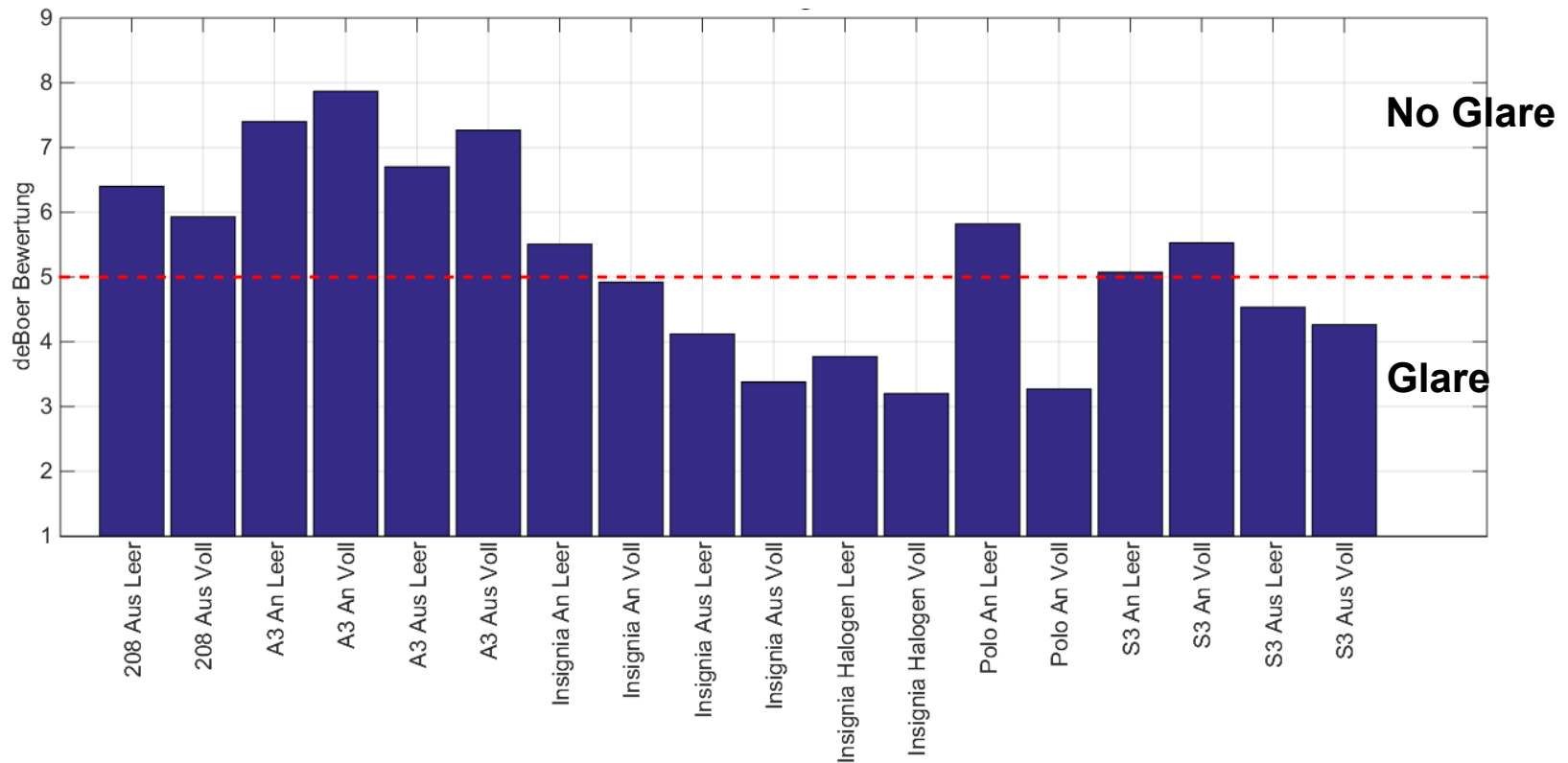
Psychological Glare



- No Difference between the age groups
- Subjects use the complete scale
- No significant difference between driver and codriver

→ No individual evaluation

Glare by Vehicle



Average over all Glare Ratings

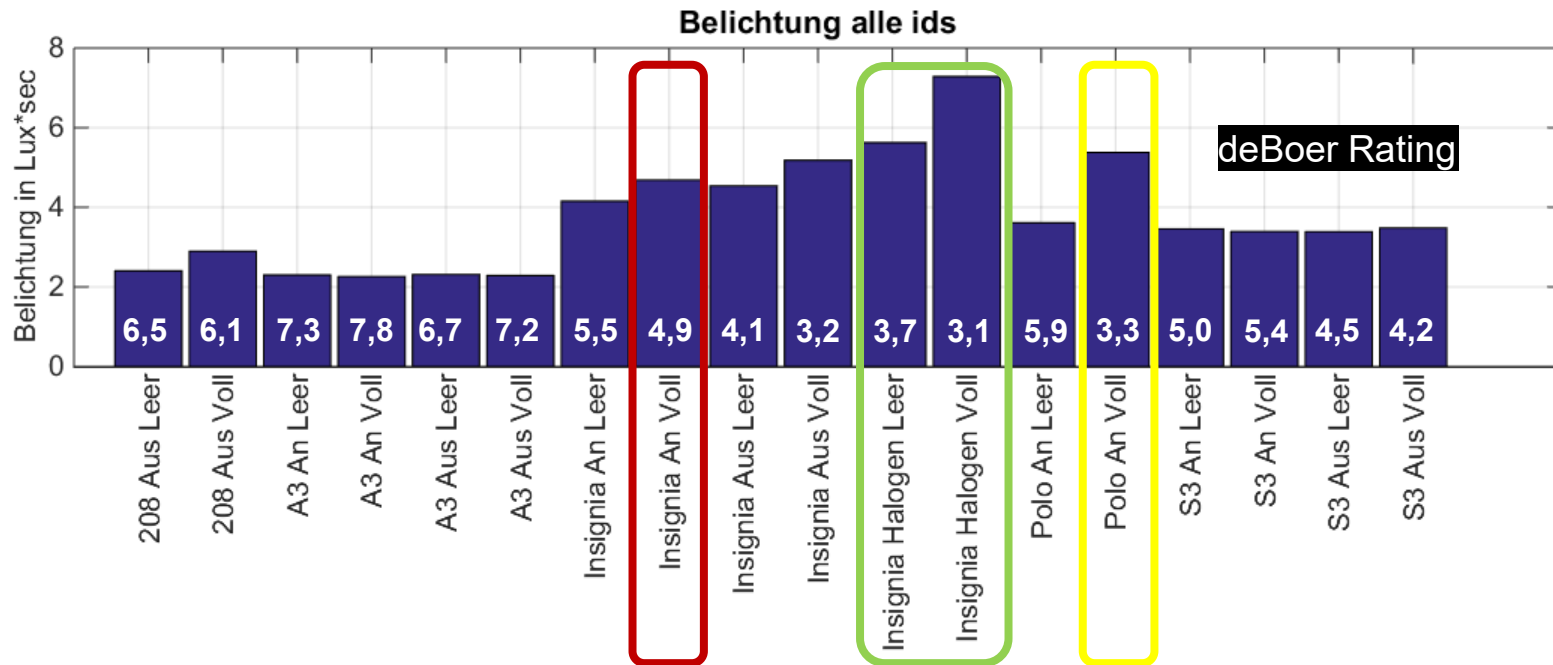
- 2 Groups
 - Vehicles that glare and that don't glare

Glare by Vehicle

No Glare	Glare
208, empty	Insignia Levelling off, empty
208, full	Insignia Levelling off, full
A3 Levelling on, empty	Insignia Levelling on, full
A3 Levelling on, full	Insignia Halogen empty
A3 Levelling off, empty	Insignia Halogen empty
A3 Levelling off, full	Polo Levelling on, full
Insignia, Levelling on, empty	S3 Levelling off, empty
Polo Levelling on, empty	S3 Levelling off, full
S3 Levelling on, empty	
S3 Levelling on, full	

- **usually no Glare with Levelling**
- **Usually Glare** without Levelling“
 - **BUT: Problem with 4 Vehicle combinations → Illuminance?**

Glare by Vehicle

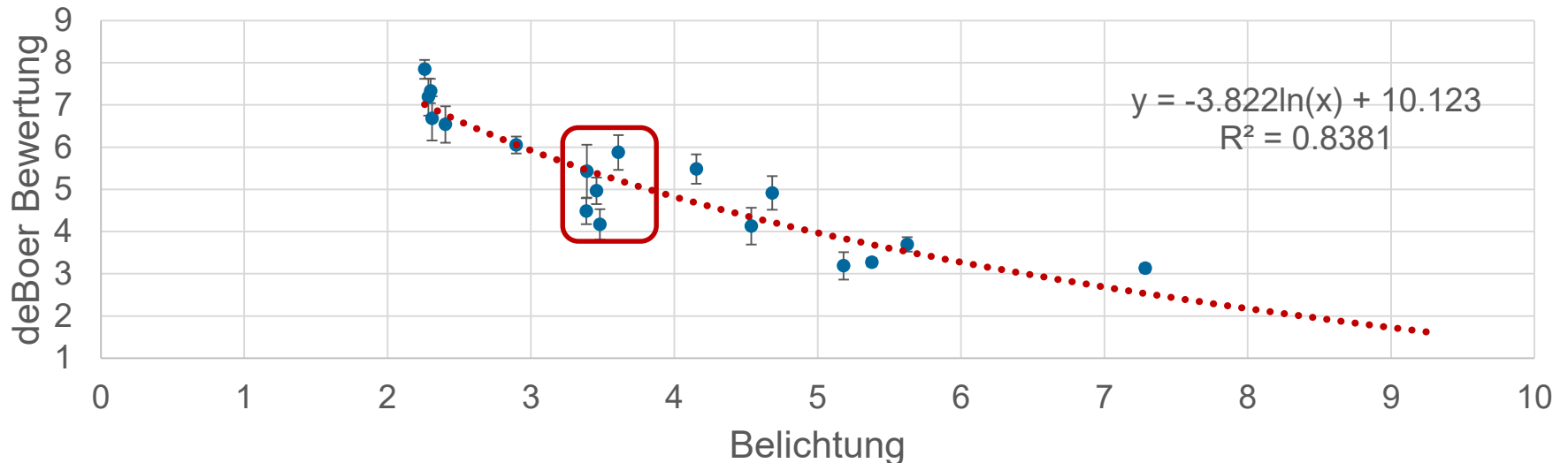


$$H_v = \int_{t_1}^{t_2} E_v(t) dt \rightarrow H_0 \text{ bis } 400 \text{ m} \left(80 \frac{\text{km}}{\text{h}} \right) = \int_0^{18 \text{ s}} E_v(t) dt$$

- High Exposure for the 4 Vehicles
- The higher the exposure – the higher the glare
→ Correlation between Exposure and Glare

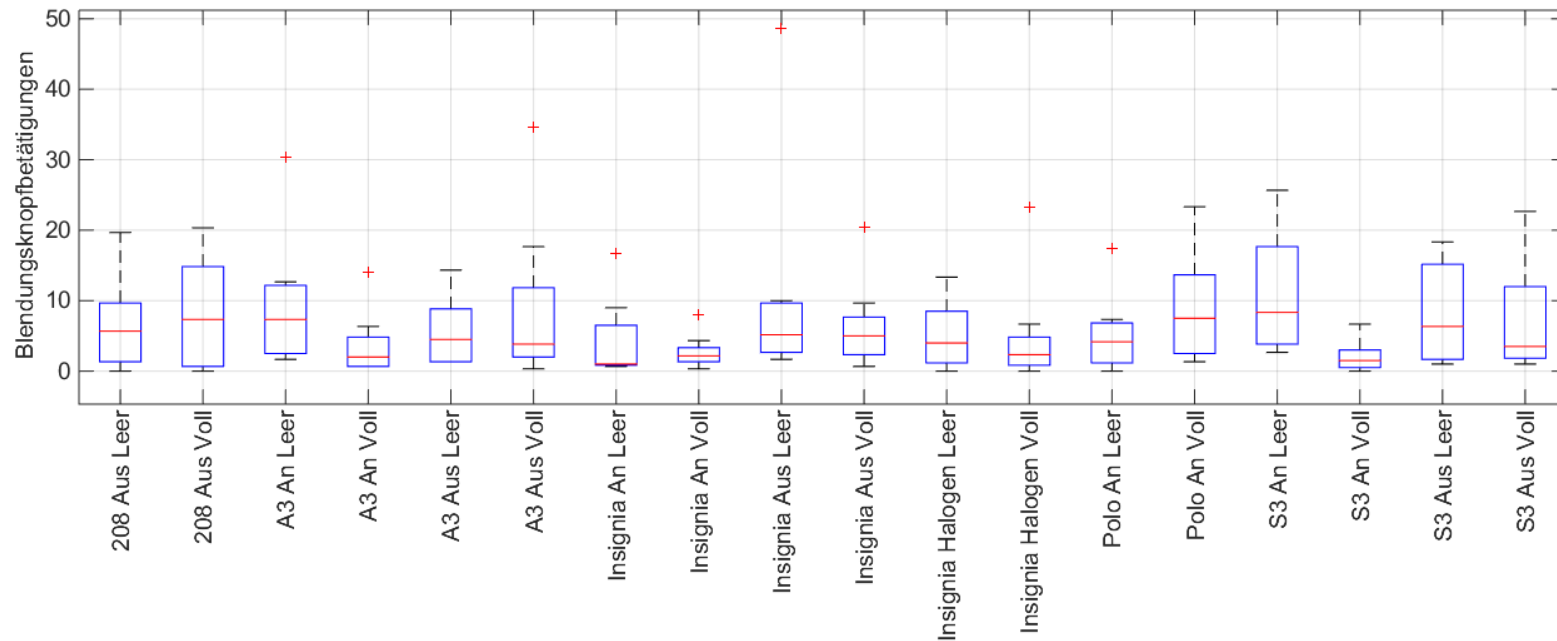
Glare by Vehicle

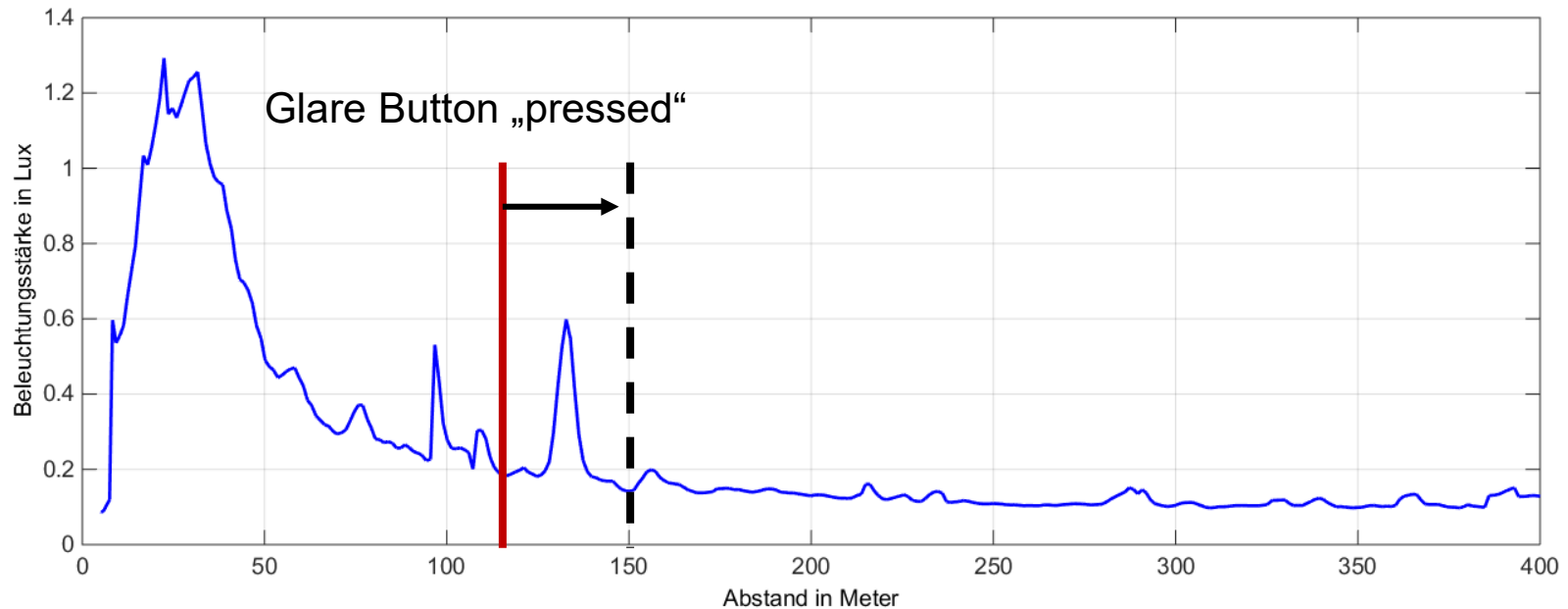
deBoer vs Belichtung



- Correlation between Glare and Exposure
 - But: Areas with similar exposure but different glare ratings
→ subjective rating
- Exposure and deBoer Rating can't represent dynamics
 - Integration over long stretch of road
→ **Glare Button**

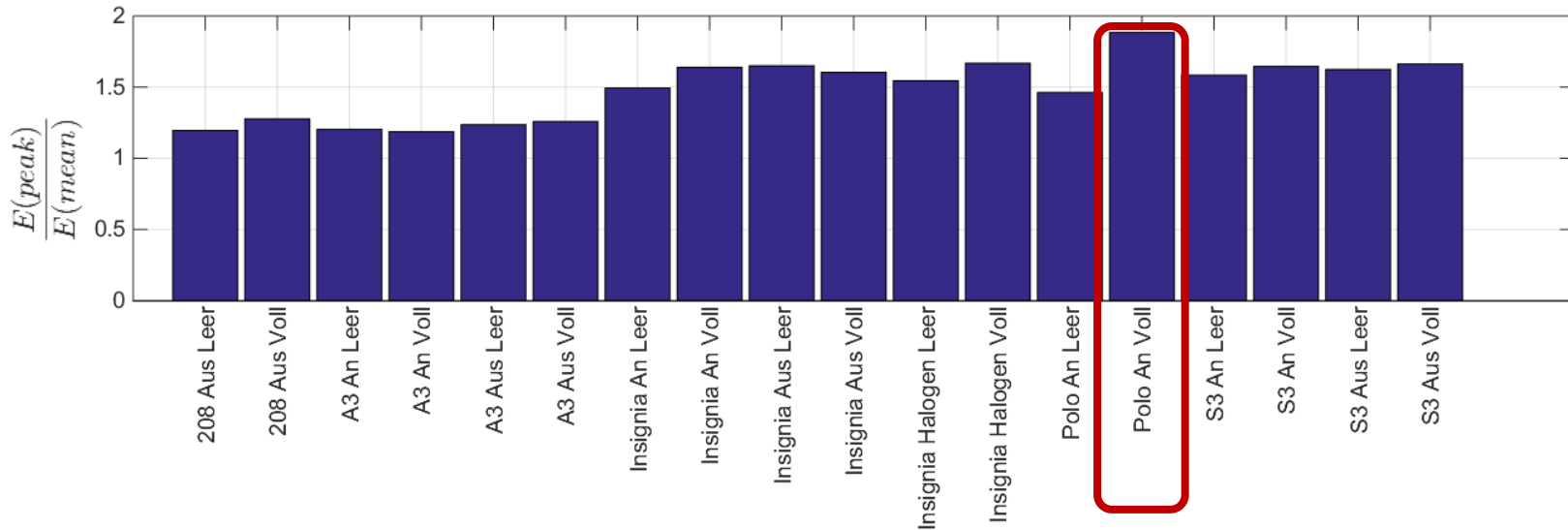
Glare Button





- Illuminance 1 sec prior to the glare button pressed
 - 1 sec. ~ 22 m @ 80 km/h
- Possible Parameters
 - Average, local and global Maxima, Number of Illuminance Peaks
 - Ratio $\eta = \frac{E(\text{peak})}{E(\text{mean})}$

Glare Button

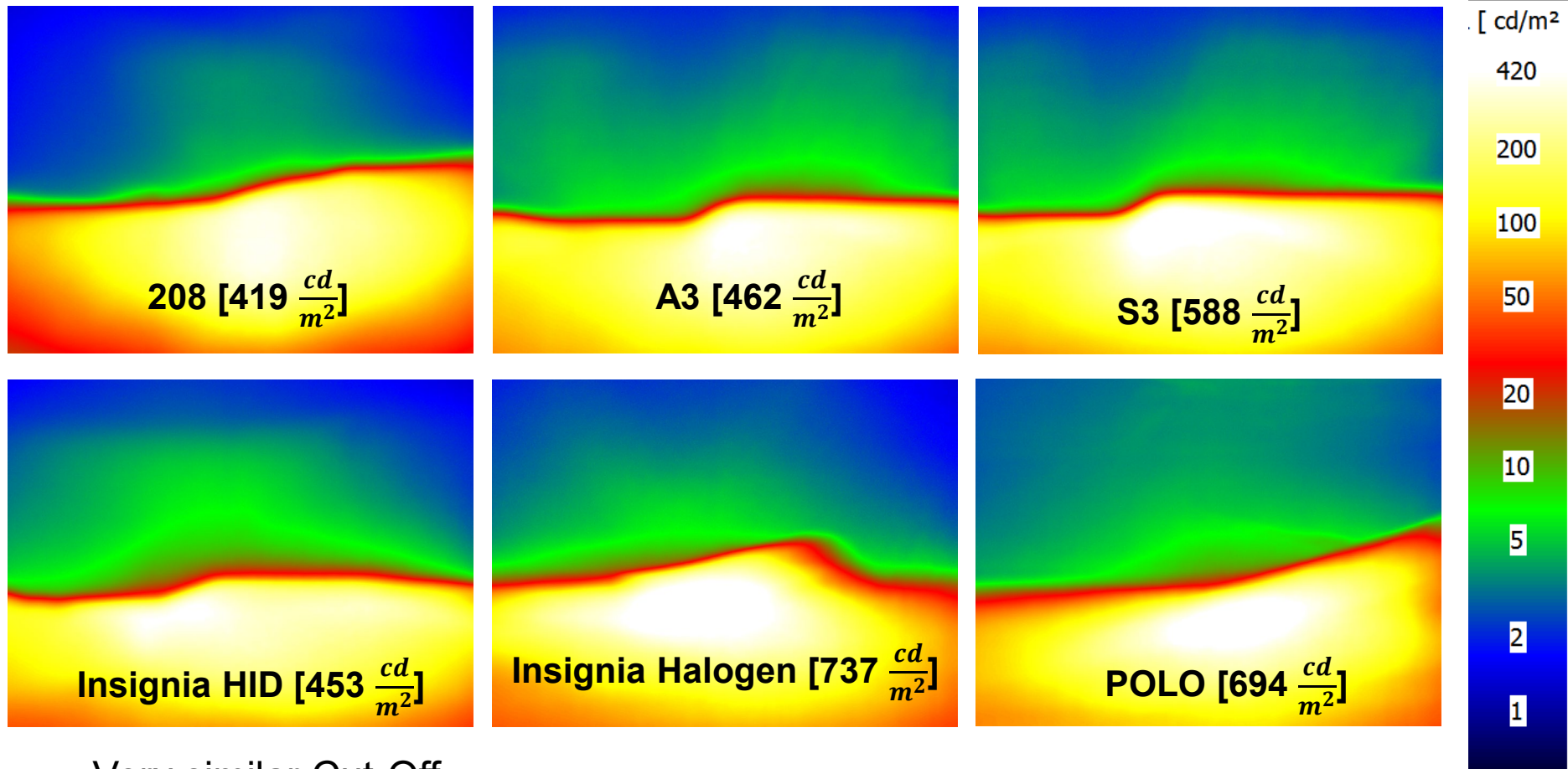


- No significant differences
 - Just: VW Polo, Levelling on, Full

→ Not the absolute illuminance but the ratio between „Glare Peaks“ and mean illuminance correlates to glare

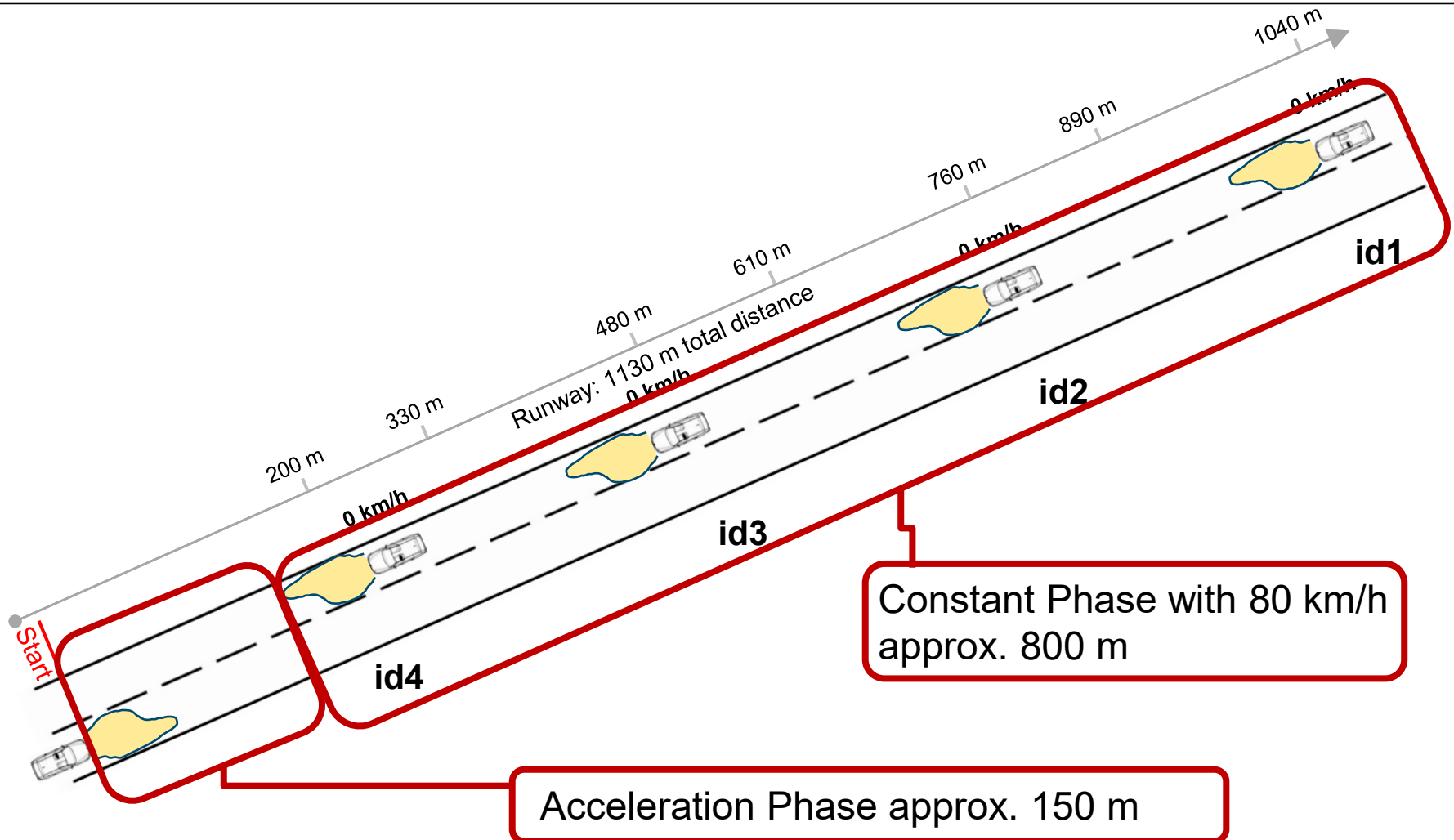
→ Suggestion: all Light Distributions are roughly similar

Light Distributions

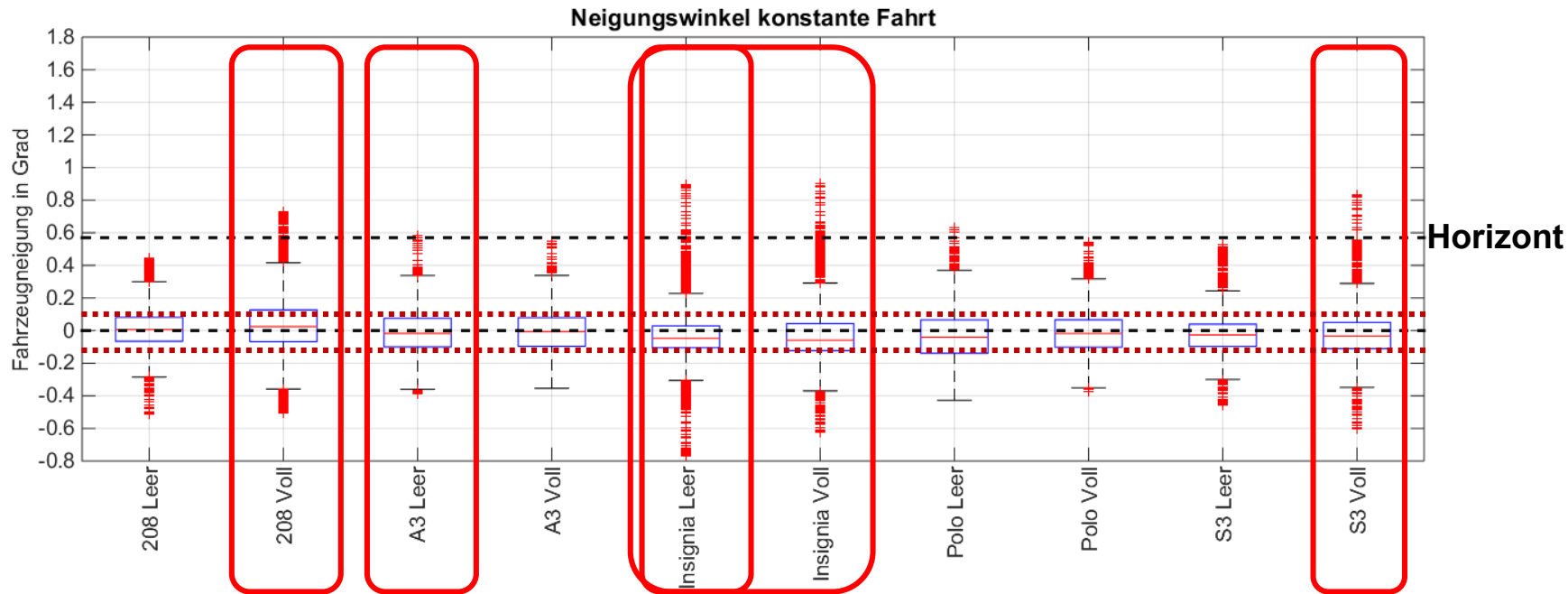


- Very similar Cut-Off
- Differences in Pitch Angles?

Test Setup

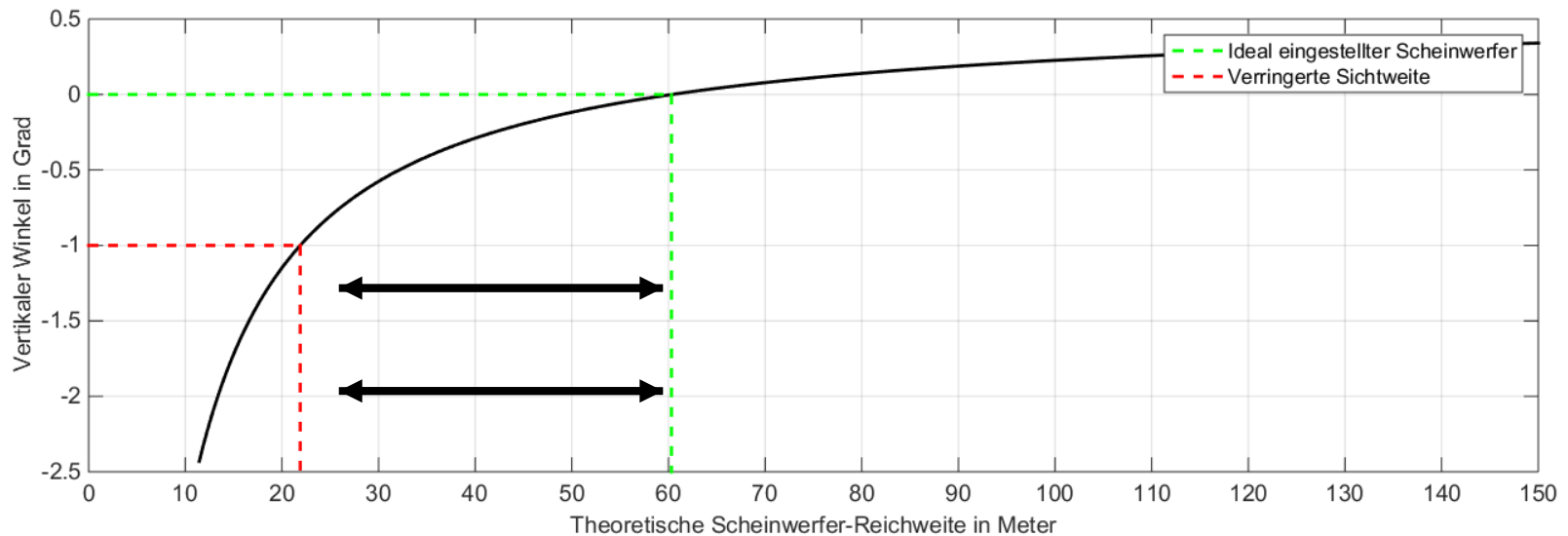


Pitch Angles – Constant driving (80km/h)



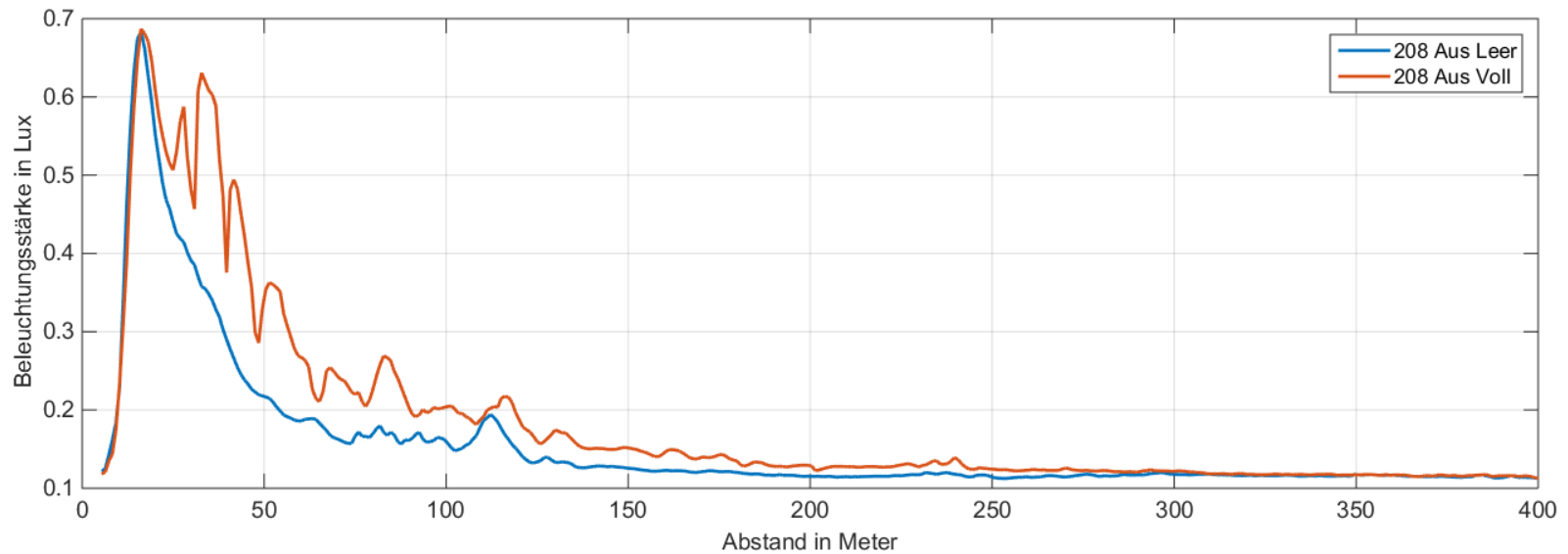
- 50 % of the data within $\pm 0,1^\circ$
 - Min. Pitch: $0,9^\circ$ (A3 empty)
 - Max. Pitch: $1,7^\circ$ (Insignia empty)
 - 4 vehicles over horizon
 - Max. Pitch downwards: -1°
- } „intermediate“ Suspension

Pitch Angles



- Pitch angles of up to -1° at constant speed:
 - Viewing Distance of only 20 m
 - Dynamic Levelling could compensate for that
- Closer Look at Glare:

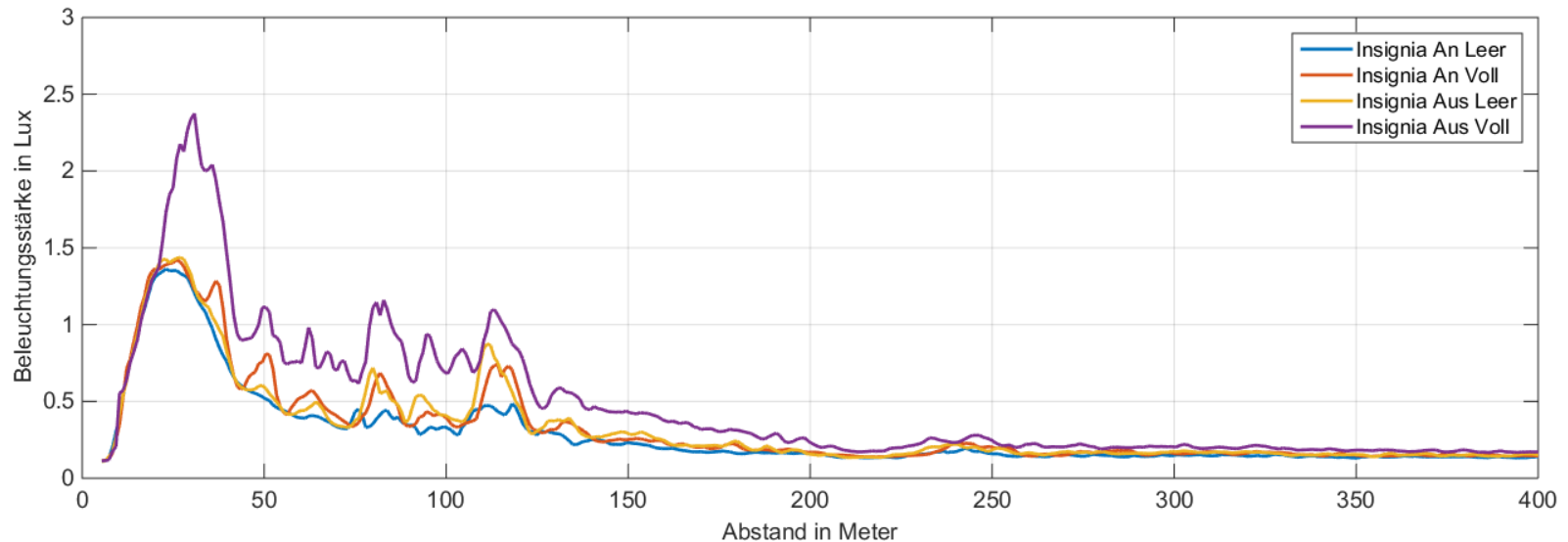
Illuminance at constant speed



	Max E	H	deBoer
208 empty	0,7	3,7	7,1
208 full	0,7	4,4	7,1

No Glare due to the low intensity

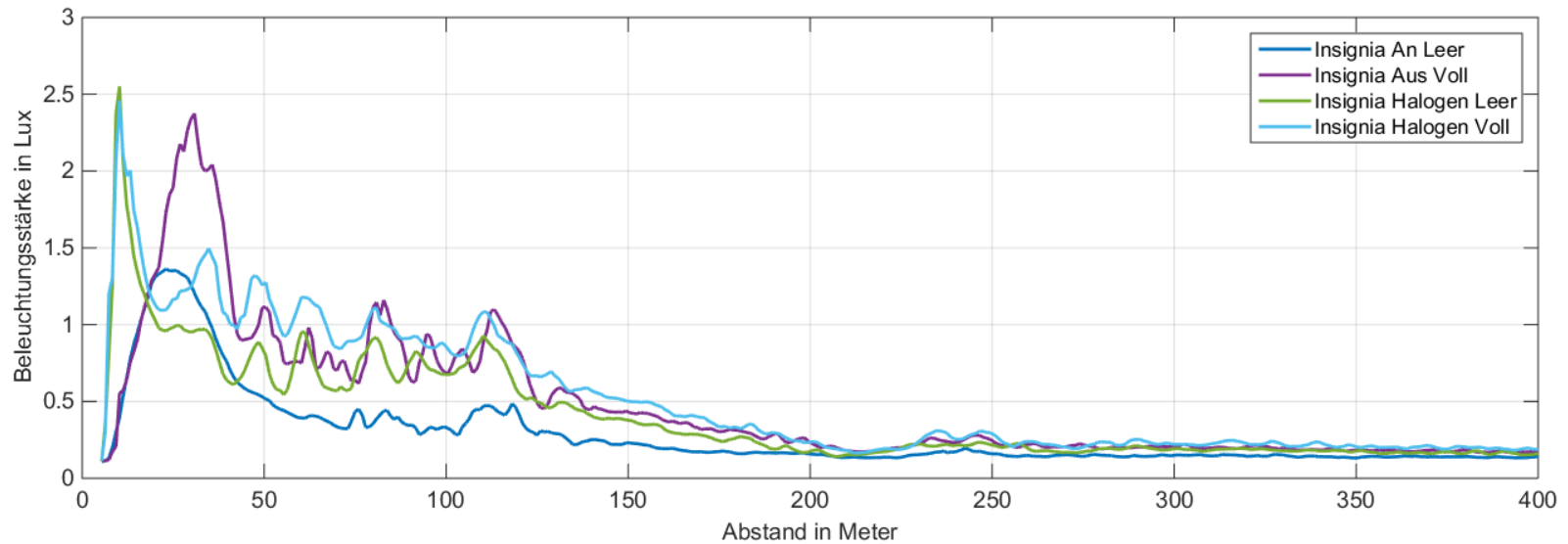
Illuminance at constant speed



	Max E	H	deBoer
Insignia Lev. on empty	1,4	6,8	5,5
Insignia Lev. On full	1,4	7,7	4,8
Insignia Lev. off empty	1,4	7,7	4,4
Insignia Lev. on full	2,4	10,0	3,5

1. Strong Pitch
2. Levelling too slow
3. High Illuminance HL
→ Glare

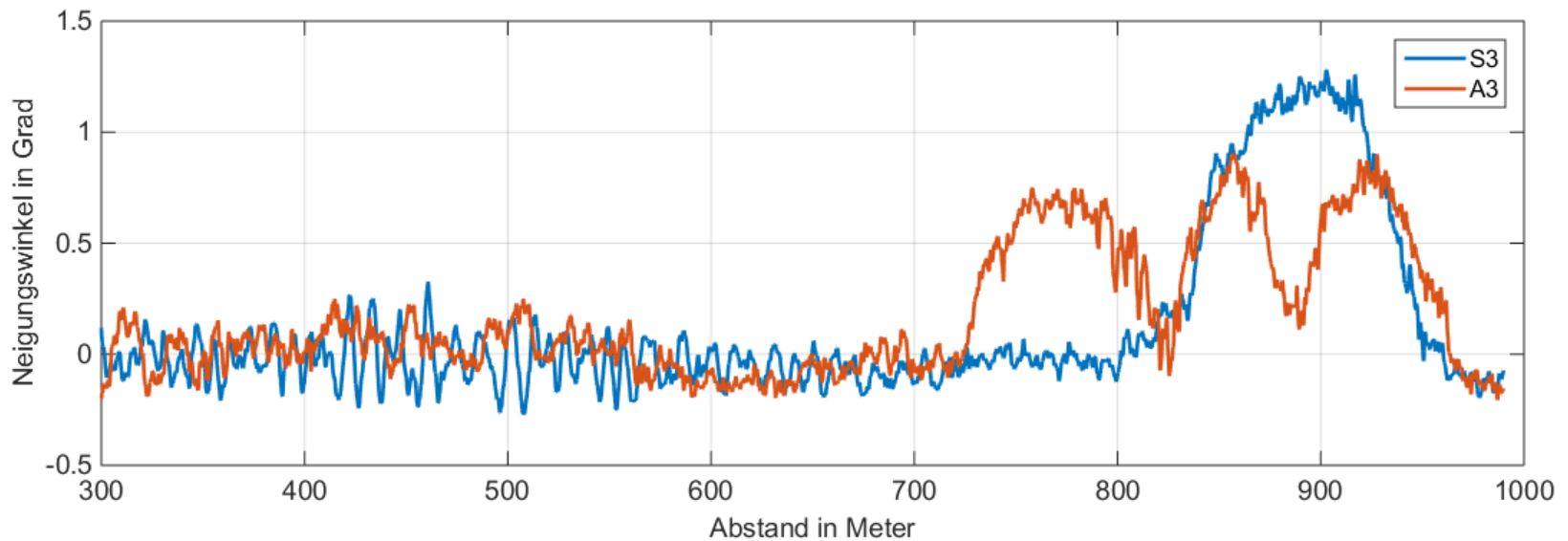
Illuminance at constant speed



	Max E	H	deBoer
Insignia Lev. on empty	1,4	6,8	5,5
Insignia Lev. off empty	2,4	10,0	3,5
Insignia Halogen empty	2,6	9,6	3,9
Insignia Halogen full	2,5	12,4	2,8

1. Strong Pitch
2. High Illuminance HL
→ Glare
3. Levelling for Halogen?

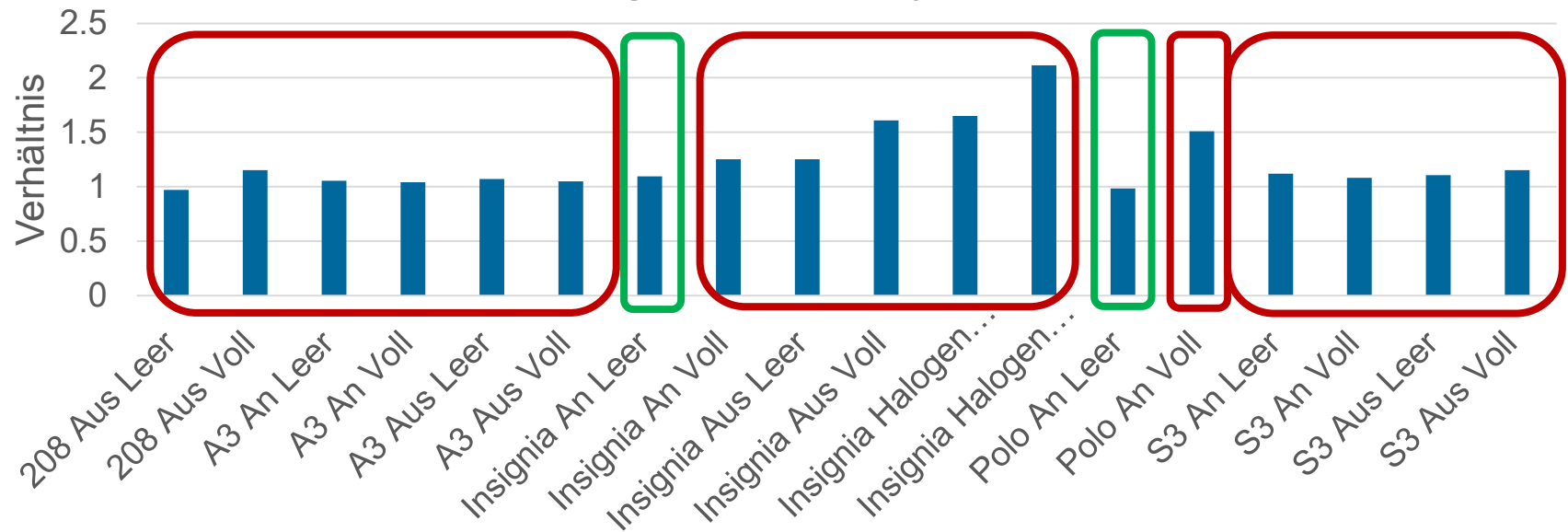
Illuminance at constant speed



	Max E	H	deBoer
S3 Level. on Empty	1,3	5,7	5,0
S3 Level. on Full	1,2	5,5	5,4
S3 Level. off Empty	1,2	5,6	4,6
S3 Level. off Full	1,3	5,8	4,6

Even with high pitch angles
no real measureable
differences in Illuminance
or Exposure

Belichtung statisch vs Dynamisch



- **static \approx dynamic**

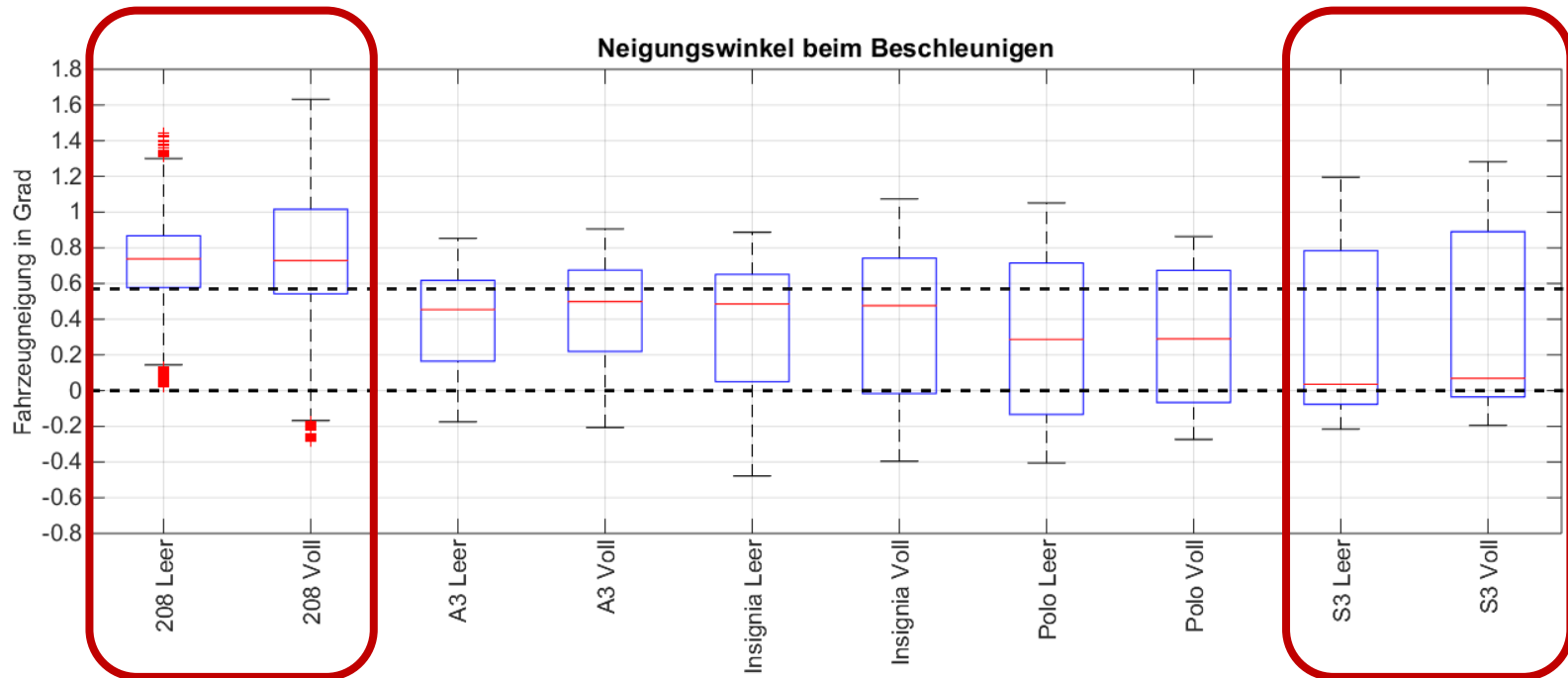
- suspension or **Levelling** flatten out „dynamic Vehicle Pitch“

- **static \neq Dynamisch**

- Suspension cannot compensate the movement

- Slow dynamic Levelling

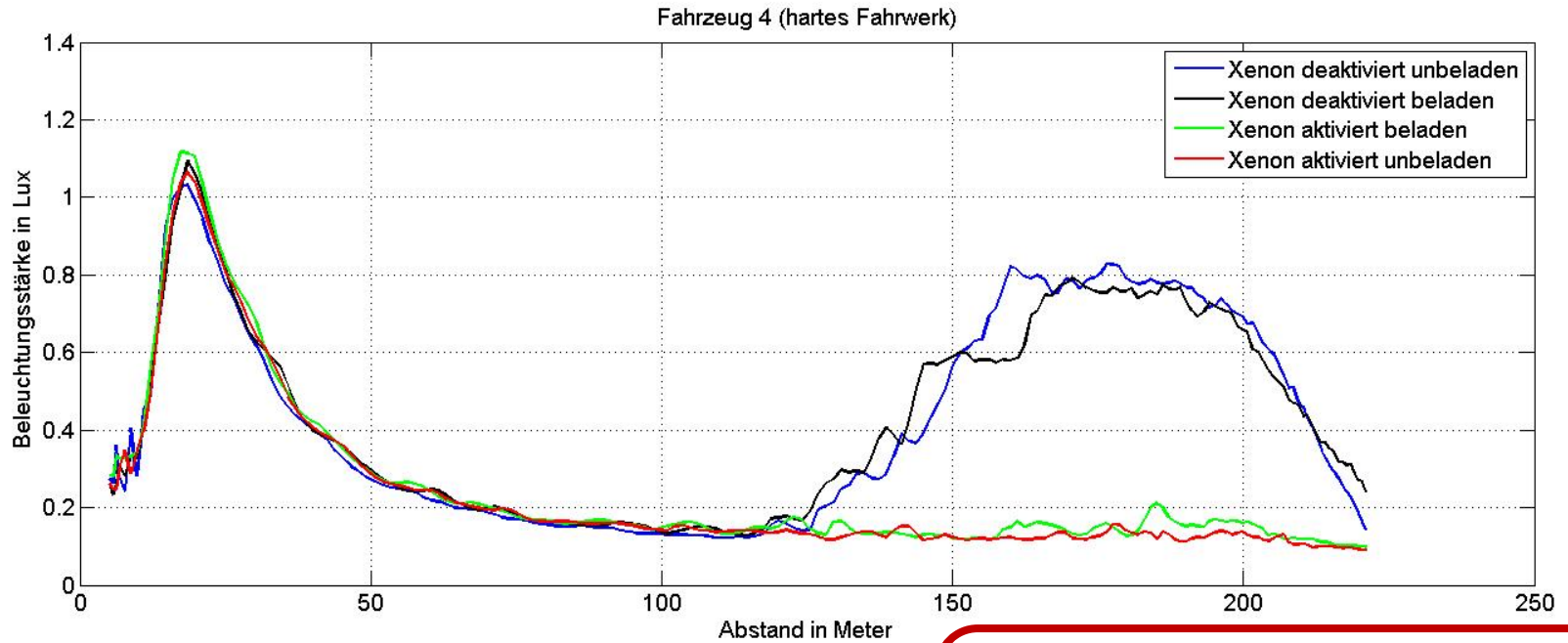
Pitch during Acceleration



- All Vehicles over Horizon
 - Highest Pitch for softest vehicle
 - Audi S3 even though the hardest suspension – highest power

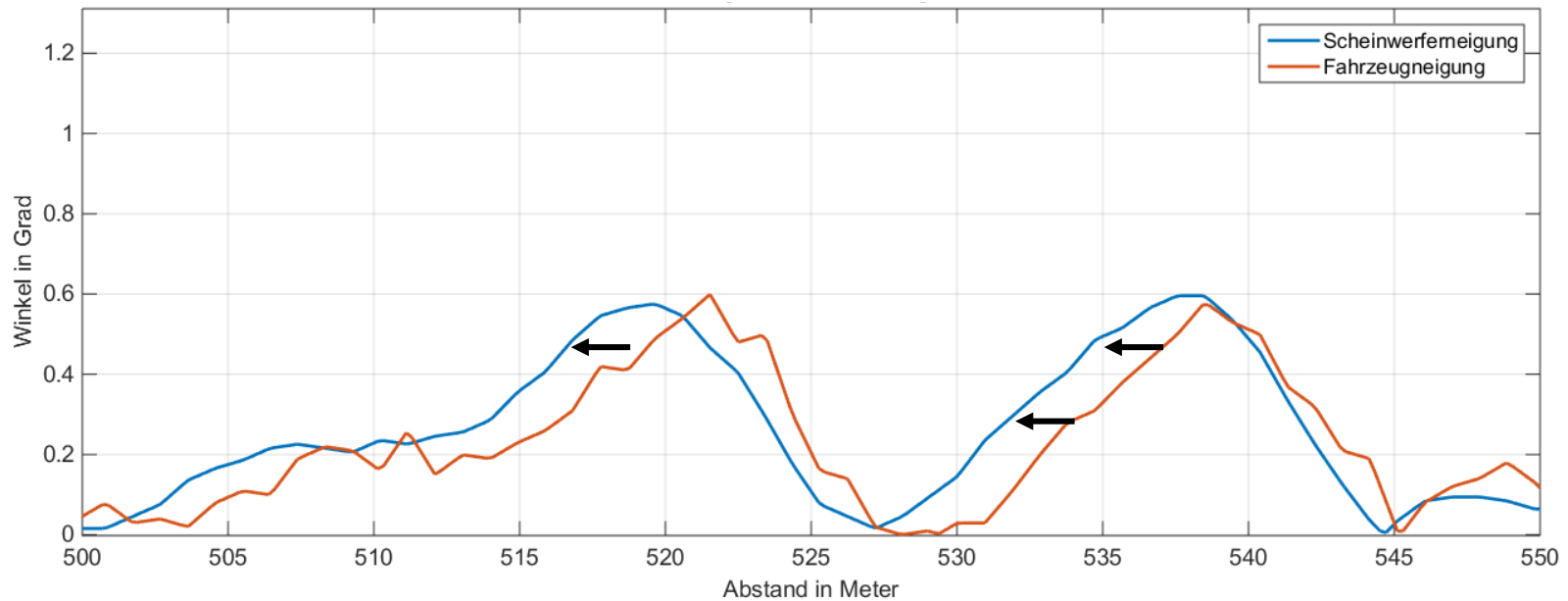
→ Fast dynamic Levelling to compensate

Illuminance Acceleration



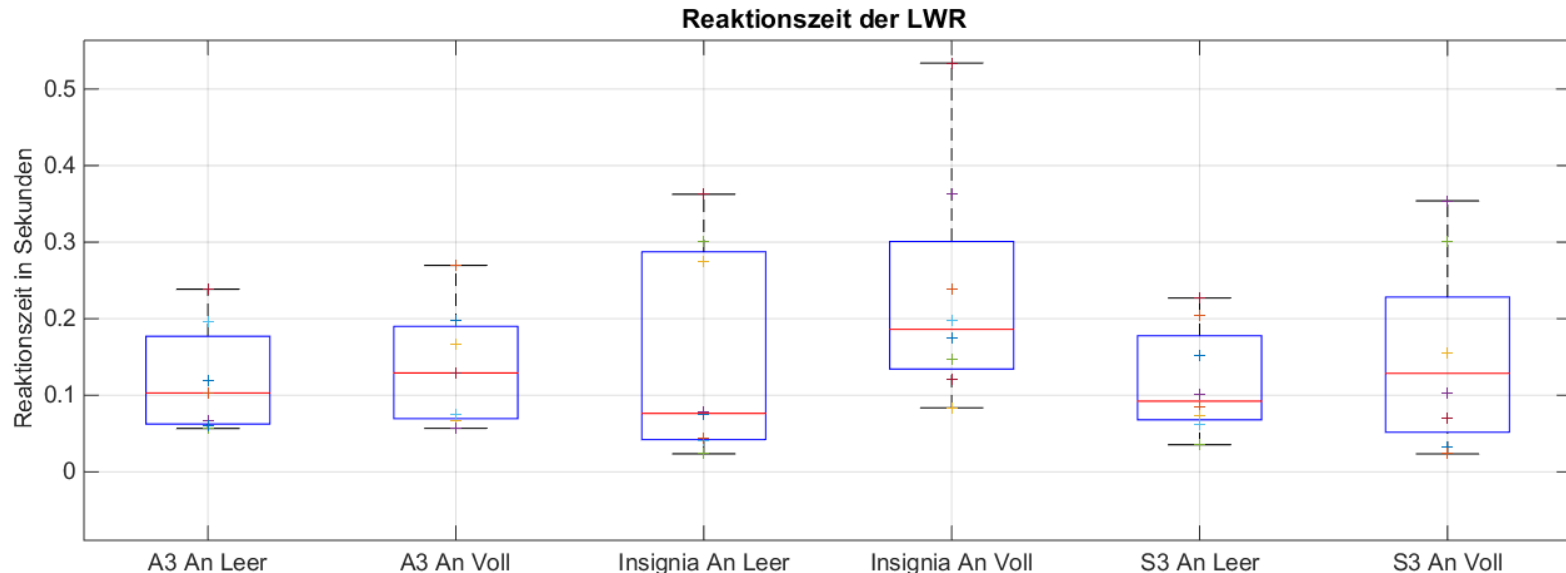
	On/Empty	On/Full	Off/Empty	Off/Full
H [lx · sec]	3,1	3,3	6,0	6,0

Reaction Time of Levelling Systems



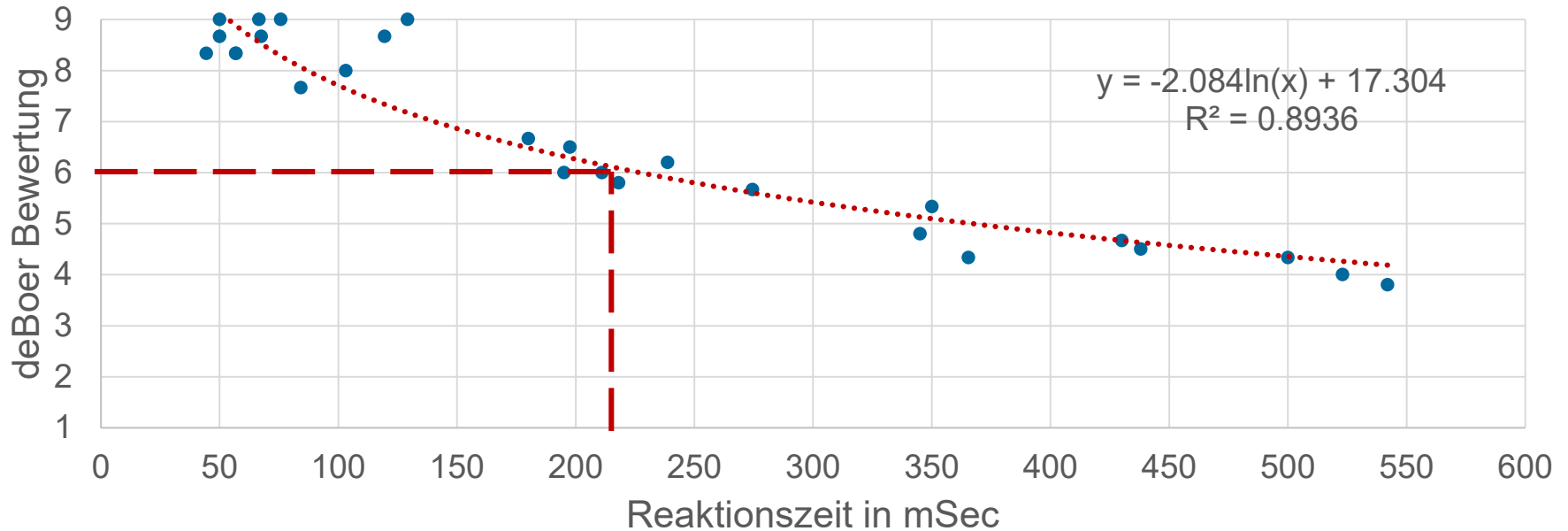
- Angle between Chassis and Headlamp
- Data is shown as positive only
- Constant offset

Reaction Time of Levelling Systems



	Median	25 % Quantil	75 % Quantil	Max.	deBoer
A3 Level. On empty	0,103	0,062	0,177	0,239	7,3
A3 Level. On full	0,129	0,070	0,190	0,270	7,8
Insignia Lev. On emp	0,076	0,042	0,287	0,363	5,5
Insignia Lev. On full	0,186	0,134	0,301	0,534	4,9
S3 Level. On empty	0,092	0,068	0,178	0,227	5,0
S3 Level. On full	0,129	0,052	0,228	0,354	5,4

Reaction Time of Levelling Systems



- Correlation between Reaction Time and Glare
- Faster Levelling → Less Glare
- No Glare for Levelling < 220ms

Summary

- Soft Suspension
 - High Pitch at Acceleration → Glare
 - High Pitch with Load
- Hard Suspension
 - Cant compensate for road unevenness
→ Peaks might lead to glare
- Intermediate Suspension
 - Mixed Results:
 - Audi A3: compensates pretty much everything
 - Opel Insignia: High Pitch and Glare
- Load influences Glare and Pitch drastically

Summary

- With active dynamic Levelling usually no Glare
- Not the absolute illuminance or Exposure correlates to glare
 - Sharp Cut-Off with vehicle pitch leads to higher glare
 - Even Halogen can lead to significant glare
- Subjects experience Glare at acceleration
 - Strongest Pitch Angles
- Fast dynamic Levelling compensates these changes

Thank you very much for your Attention