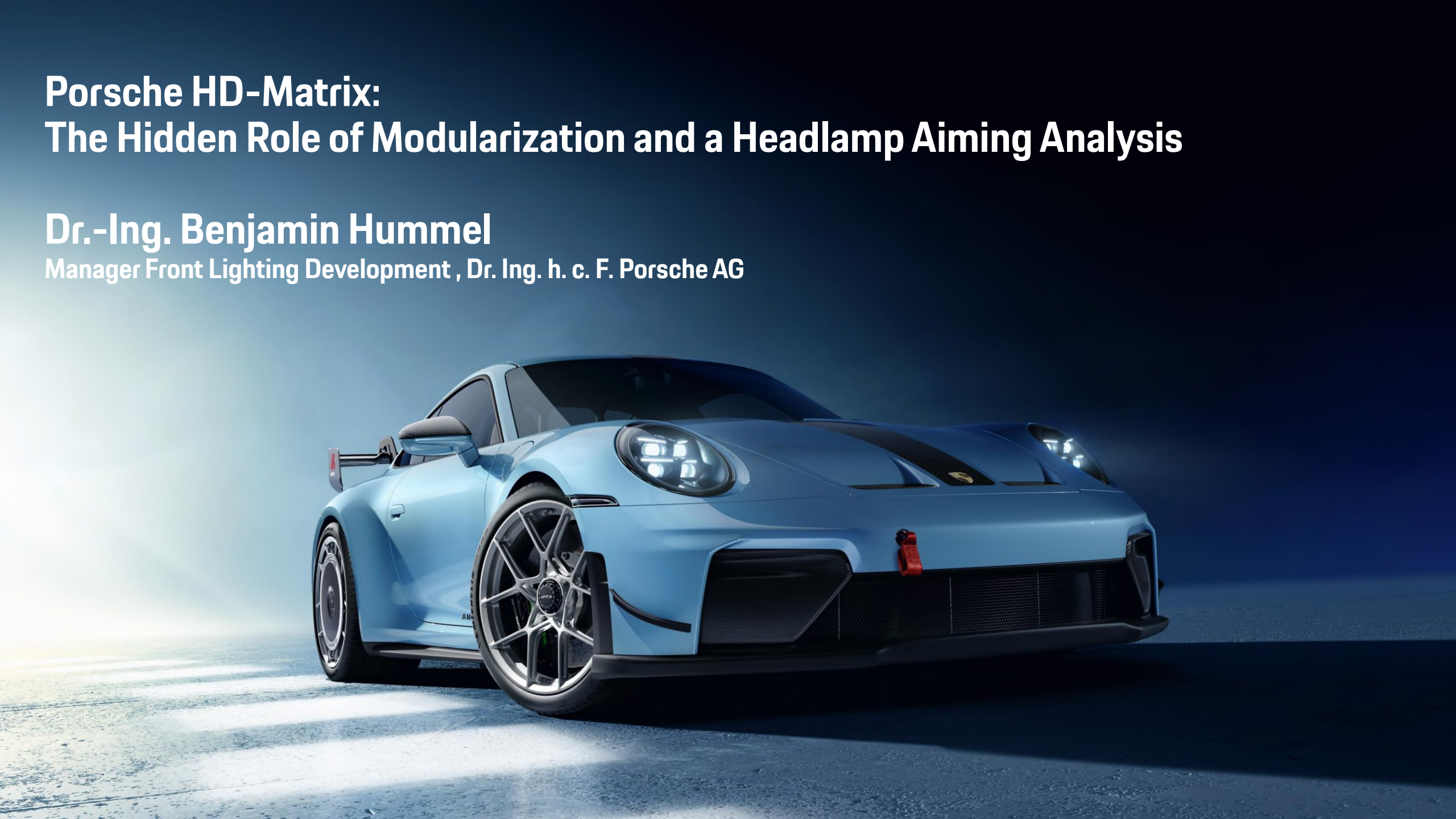
PORSCHE

Porsche HD-Matrix:
The Hidden Role of Modularization and a Headlamp Aiming Analysis

Dr.-Ing. Benjamin Hummel
Manager Front Lighting Development , Dr. Ing. h. c. F. Porsche AG



The Porsche HD-Matrix-Concept

The double HD-System – presented at DVN 2023

total illumination

above 2500 lm and 300 lx

Bi-Function modules:
Additional high-beam

Bi-Function modules:
Ground illumination

HD-module
Illumination

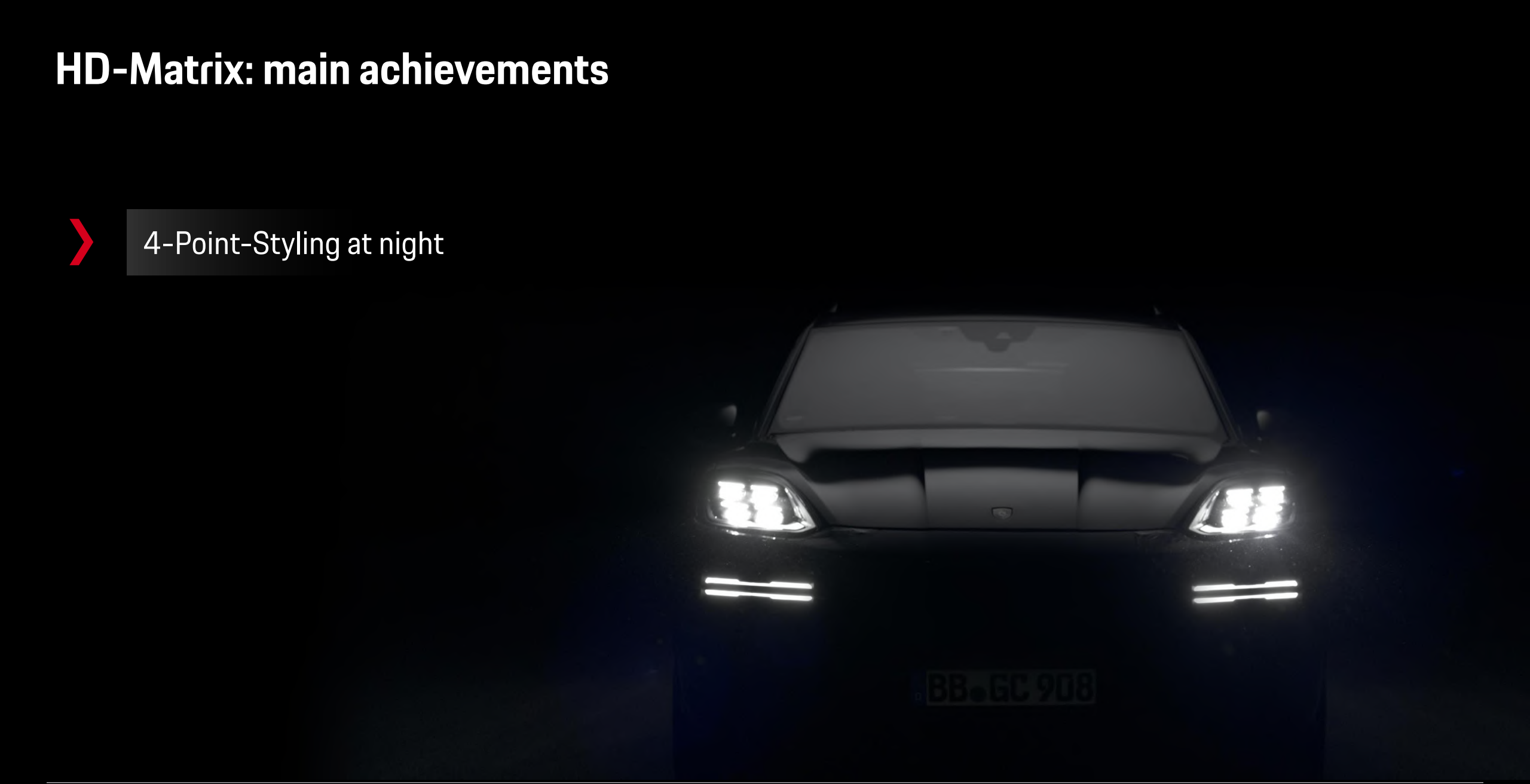
HD-module
Performance

Introduction HD-Matrix

- Cayenne – First to Market
- Panamera
- 911
- Taycan
- Cayenne Electric

HD-Matrix: main achievements

- 4-Point-Styling at night



HD-Matrix: main achievements

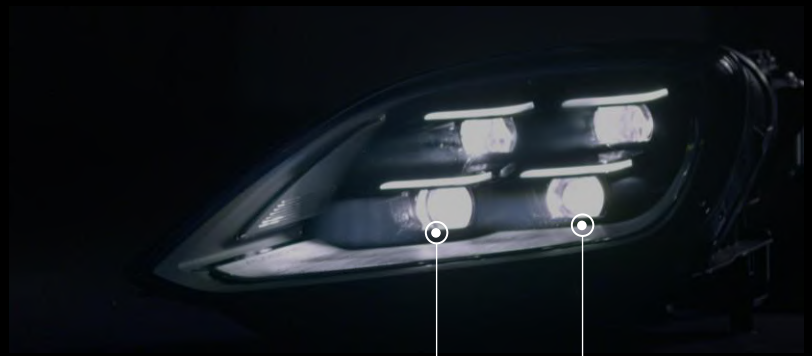
- 4-Point-Styling at night

BRAND IDENTITY
"It is a Porsche"

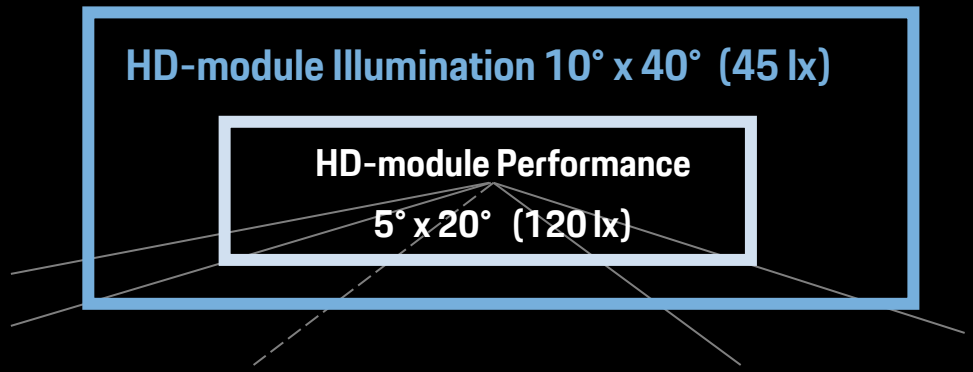
PRODUCT IDENTITY
"It is a 911"

HD-Matrix: main achievements

- 4-Point-Styling at night
- Micro LED Innovation



LED Aspect Ratio = 1:4 = double HD concept

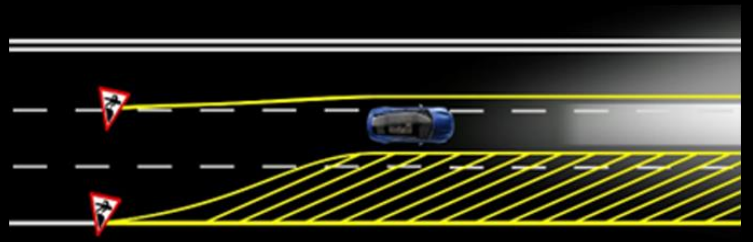


HD-Matrix: main achievements

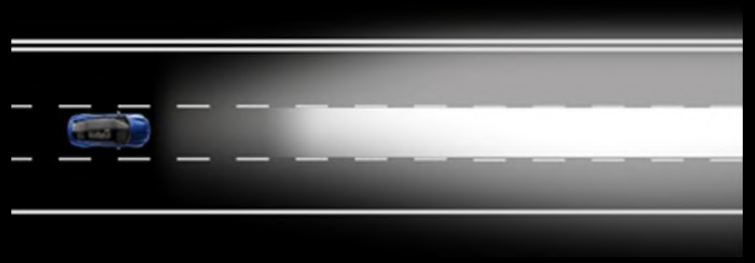
- 4-Point-Styling at night
- Micro LED Innovation
- Functionality

Driver information

lane light



construction zone light

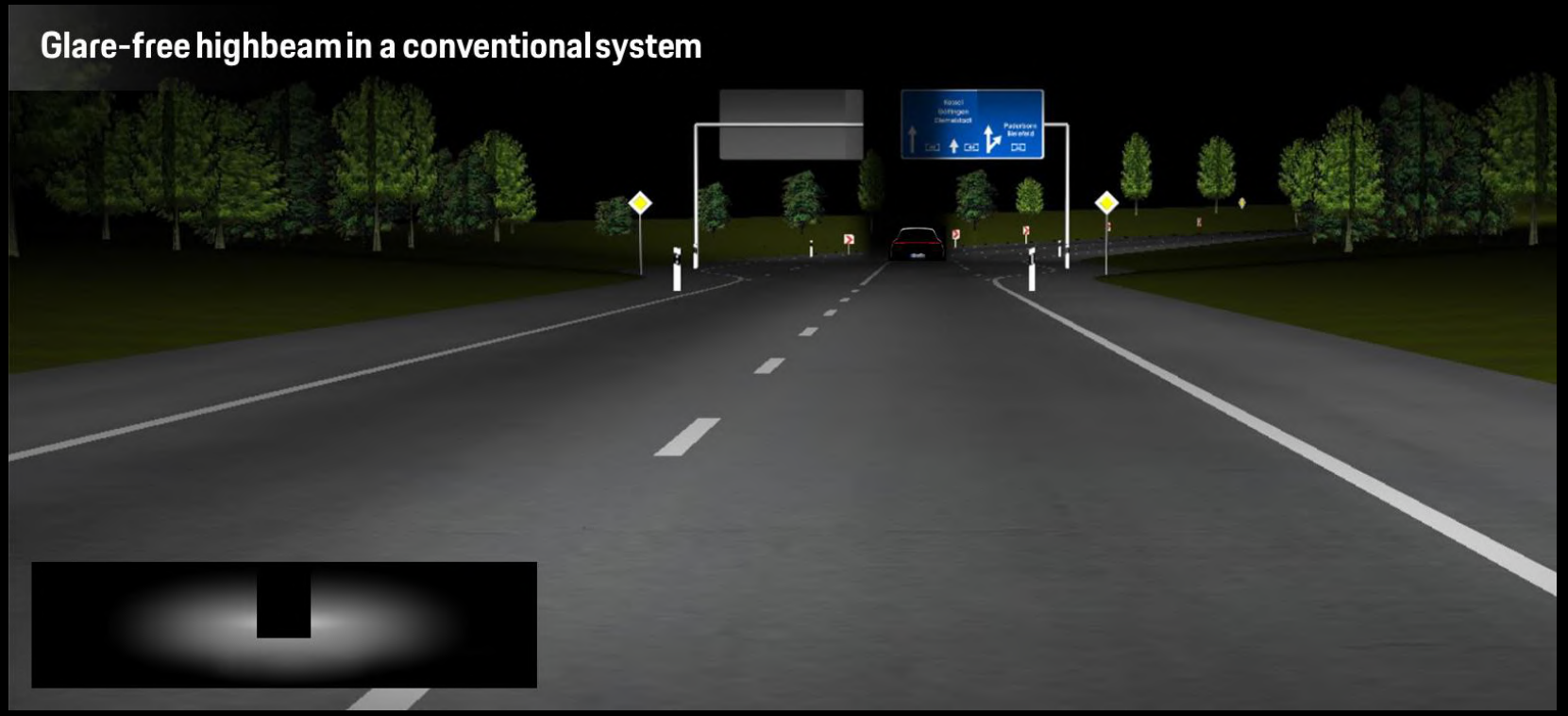


Animations

coming- / leaving Home
welcome and goodbye animation

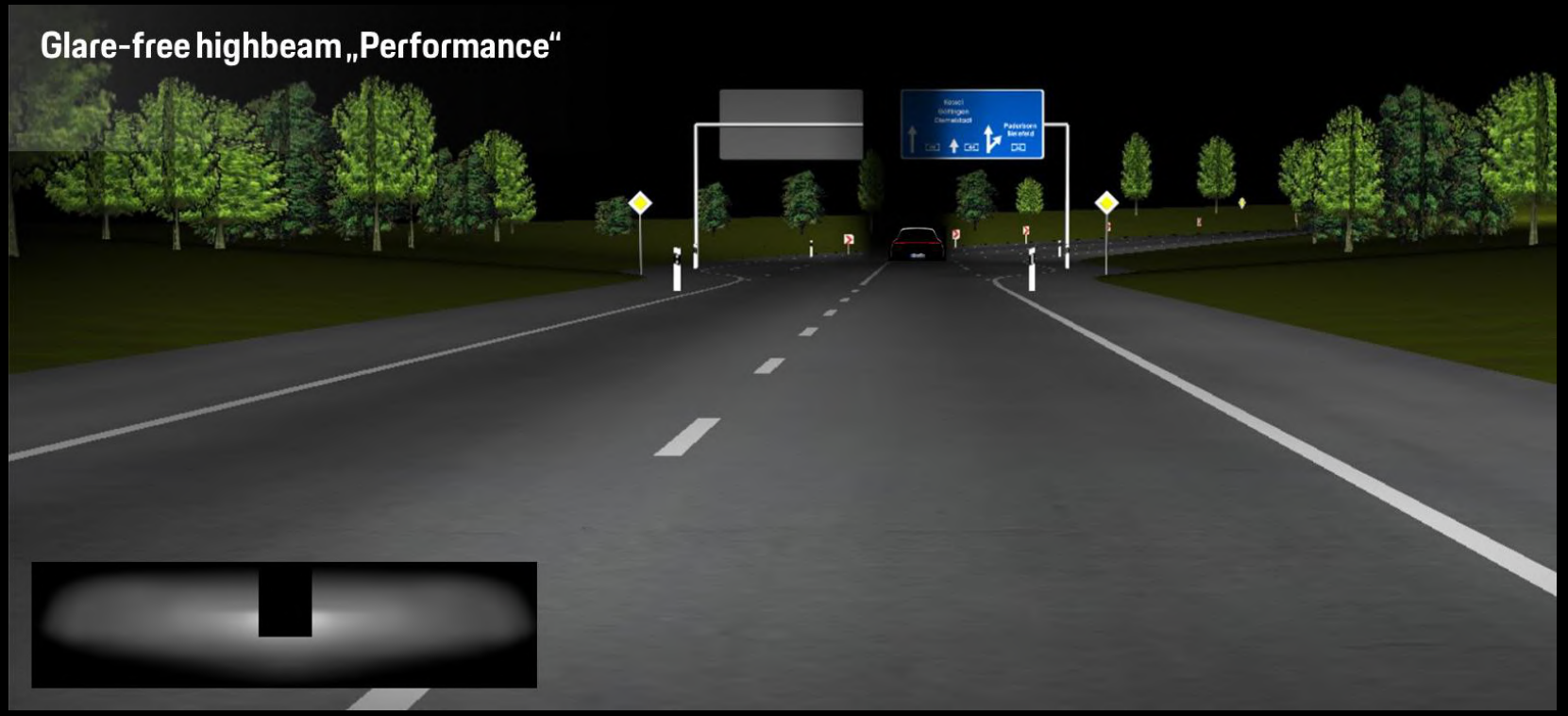
HD-Matrix: main achievements

- 4-Point-Styling at night
- Micro LED Innovation
- Functionality
- Performance



HD-Matrix: main achievements

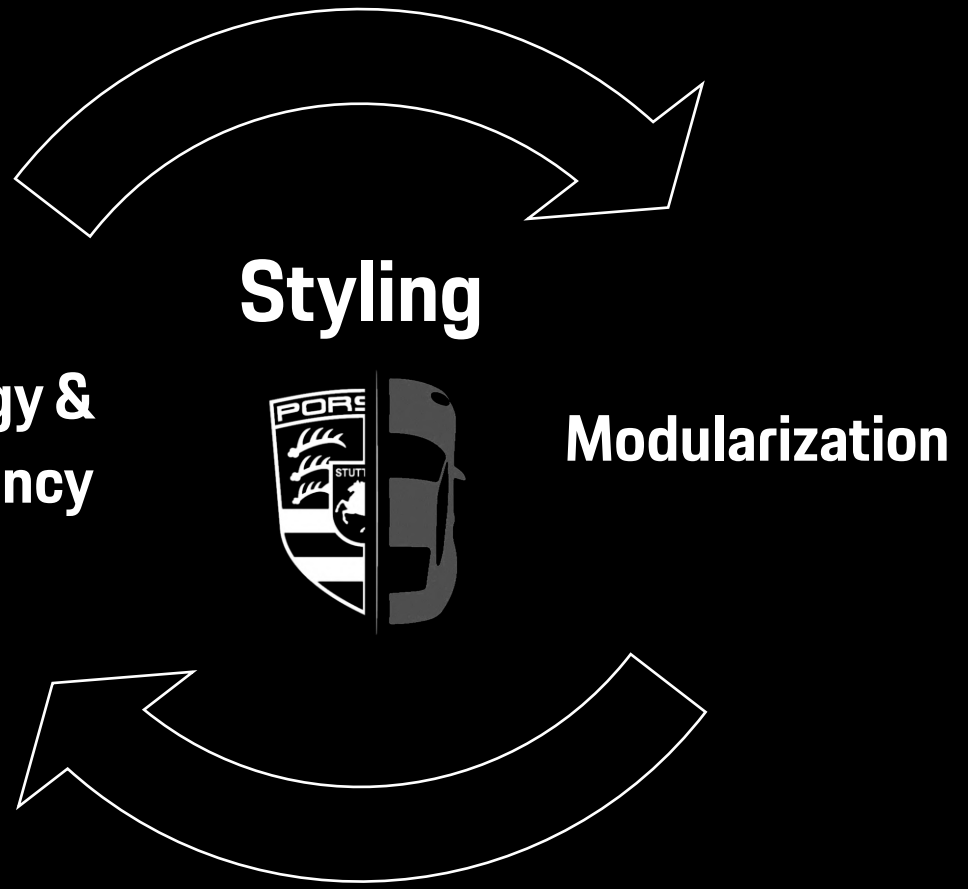
- 4-Point-Styling at night
- Micro LED Innovation
- Functionality
- Performance



Doubling luminous flux for Matrix function in highbeam area

The hidden Enabler: Synergy due Modularization

- Styling: the initital and overall driving force
- Strategy: strong commitment to modularization
- Positive effect across all project aspects



The hidden Enabler: Synergy due Modularization

Not just shared modules: Identical modules (COP A) across all 5 projects

Panamera

Cayenne Electric

Cayenne

911

Taycan

pictures modified by AI

Headlamp Aiming Analysis

- Headlamp aiming: the hidden foundation for lighting performance & customer facing functions
- Test study: visual aiming accuracy with different light distributions

- 13 subjects
- Headlamp Cayenne HD-Matrix
- Headlamp tester: (analog) Maha MLT 1000 on rail system
- Measurement:
  test pattern at wall & luminance camera & Matlab code
- Task: 3 x aiming (with Maha 1000) of each light distribution

Picture generated with AI

Headlamp Aiming Analysis

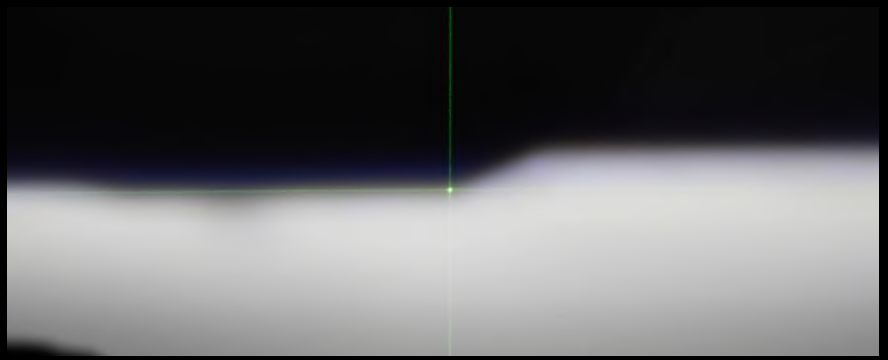
- Headlamp aiming: the hidden foundation for lighting performance & customer facing functions
- Test study: visual aiming accuracy with different light distributions

- 13 subjects
- Headlamp Cayenne HD-Matrix
- Headlamp tester: (analog) Maha MLT 1000 on rail system
- Measurement:
  test pattern at wall & luminance camera & Matlab code
- Task: 3 x aiming (with Maha 1000) of each light distribution

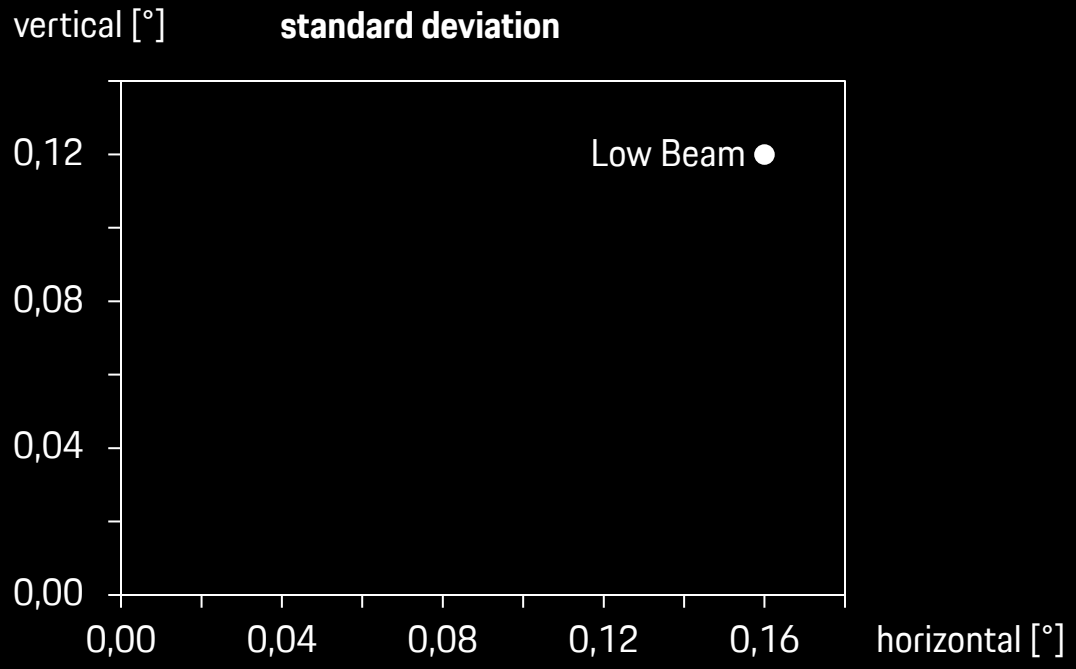
Picture generated with AI

Headlamp Aiming Analysis

- 90° shape improves horizontal accuracy
- Overall improvement due sharper cutoff line: 0,32 -> 0,58
- Best accuracy with Aiming Cross



Lowbeam: digitally softened cutoff



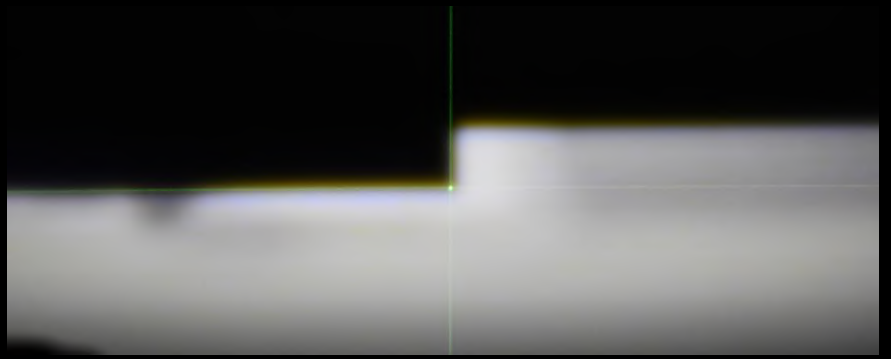
Aiming Distribution	vertical [°]*	horizontal [°]*	gradient (G)**	view into headlamp tester
Low Beam	0,12	0,16	0,32	

*standard deviation

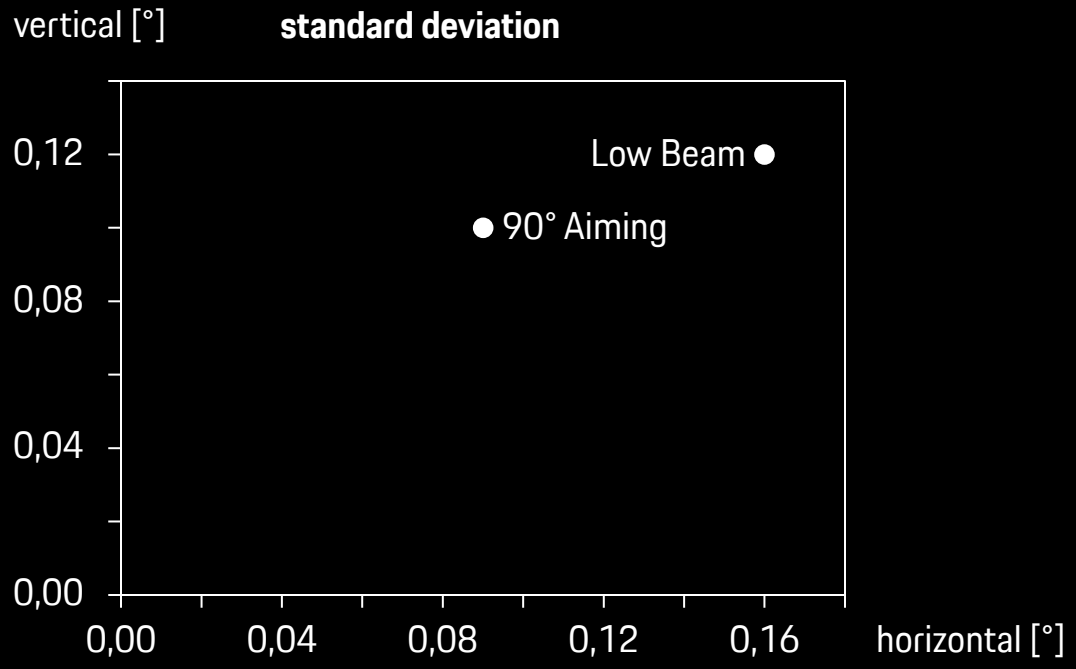
** ECE R149.01 G= $\log E(\beta) - \log E(\beta + 0{,}1°)$

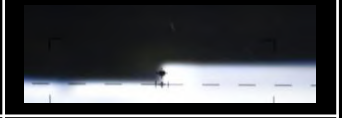
Headlamp Aiming Analysis

- 90° shape improves horizontal accuracy
- Overall improvement due sharper cutoff line: 0,32 -> 0,58
- Best accuracy with Aiming Cross



90° Shape: shape known from 84 Pixel-systems & max. digital sharpness



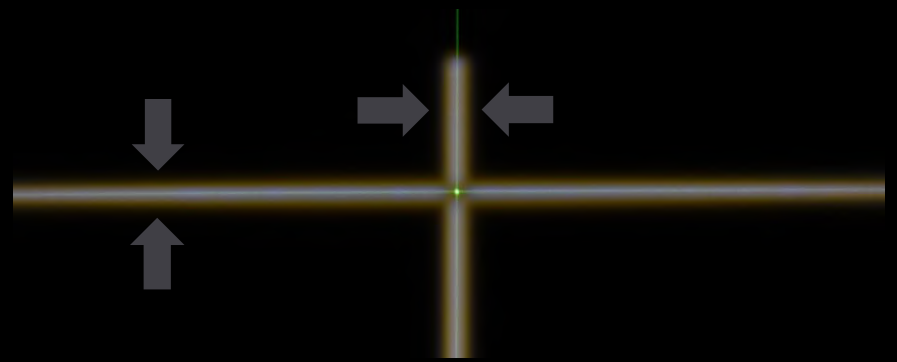
Aiming Distribution	vertical [°]*	horizontal [°]*	gradient (G)**	view into headlamp tester
Low Beam	0,12	0,16	0,32	
90° Shape	0,1	0,09	0,58	

*standard deviation

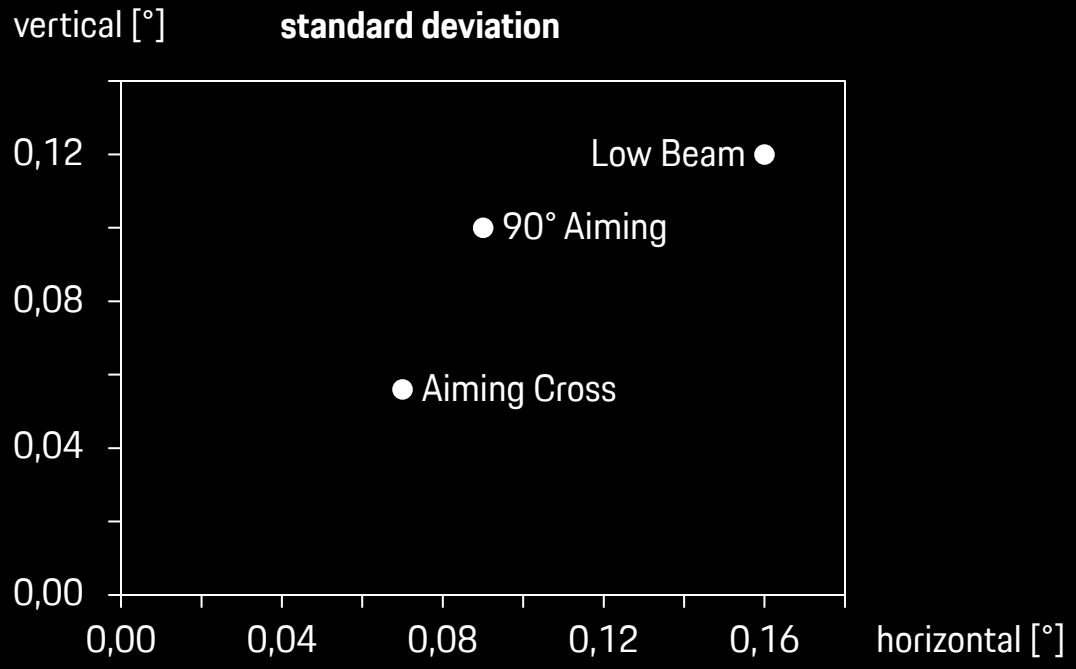
** ECE R149.01 G= $\log E(\beta) - \log E(\beta + 0{,}1°)$

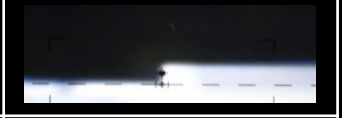
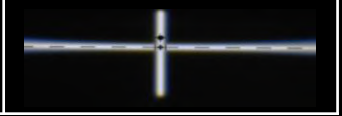
Headlamp Aiming Analysis

- 90° shape improves horizontal accuracy
- Overall improvement due sharper cutoff line: 0,32 -> 0,58
- Best accuracy with Aiming Cross



Aiming cross – orientation between the two cutoff-lines



Aiming Distribution	vertical [°]*	horizontal [°]*	gradient (G)**	view into headlamp tester
Low Beam	0,12	0,16	0,32	
90° Shape	0,1	0,09	0,58	
Aiming Cross	0,056	0,07	0,56	

* ECE R149.01 G= $\log E(\beta) - \log E(\beta + 0{,}1°)$


PORSCHE
Thank you very much for your attention!

Literatur

- **Hähle, R.; Hummel, B.** (2023): *Porsche HD-Matrix Headlight*. Driving Vision News Workshop, Paris, 2023. [Conference presentation]
- **Redlich, H.** (2022): *Presseveranstaltung Vorabkommunikation HD-Matrix-Technologie: 4-Point Styling*, Porsche AG, Weissach.
- **United Nations Economic Commission for Europe (UNECE)** (2025):
  UN Regulation No. 149.01 — Road Illumination Devices. Geneva.
- **Hummel, B.; Walter, D.** (2024): *Verfahren zum Einstellen eines Scheinwerfers mittels einer Einstelllichtverteilung.*
  Deutsches Patent DE102024121324B3, Dr. Ing. h. c. F. Porsche AG.
- **Hummel, B.; Walter, D.** (2024): *Verfahren zur Einstellung eines hochauflösenden Scheinwerfers eines Kraftfahrzeugs.*
  Deutsches Patent DE102024107185B4, Dr. Ing. h. c. F. Porsche AG.
- **Bauer, A.; Sander, H.; Söhner, S.; Hummel, B.; Brinkmann, D.** (2015):
  Deutsches Patent *DE102014105818A1 – Scheinwerferanordnung eines Kraftfahrzeuges in LED-Matrix-Ausführung sowie ein Verfahren zur Einstellung einer derartigen Scheinwerferanordnung.*
- **Uber, C.** (2024): *Abschlussbericht Werkstudenten.*
  Interner Bericht, Dr. Ing. h. c. F. Porsche AG, Stuttgart.
- **Porsche AG** (2026): *Press database.*
  Origin of all Porsche pictures in the document from the official press database, available under: https://press.porsche.com, January 2026.