



EGVI
European Green
Vehicles Initiative



▶▶ PaREGEEn

Particle Reduced, Efficient Gasoline Engines


Simon Edwards, Ricardo
5th December, 2018



This project has received funding from
the European Union's Horizon 2020
research and innovation programme
under Grant Agreement No. 723954

Administrative Information

Partner Number	Partner Name	Partner Code	Partner Country	Organisation Type
1	Ricardo UK Ltd	RIC	UK	IND-SUPP
2	Daimler AG	DAI	DE	IND-OEM
3	Jaguar Land Rover Ltd	JLR	UK	IND-OEM
4	Robert Bosch GmbH	BOSCH	DE	IND-SUPP
5	FEV GmbH	FEV	DE	IND-SUPP
6	Johnson Matthey plc	JM	UK	IND-SUPP
7	Honeywell, Spoll. S.R.O. / Garrett Motion Czech Republic s.r.o.	HON / GAR	CZ	IND-SUPP
8	JRC - Joint Research Centre	JRC	IT	RESEARCH
9	Uniresearch BV	UNR	NL	IND-SME
10	IDIADA Automotive Technology SA	IDIADA	ES	IND-SUPP
11	Siemens Industry Software SAS	SIEMENS	FR	IND-SUPP
12	Lund Combustion Engineering LOGE AB	LOGE	SE	IND-SUPP
13	Eidgenoessische Technische Hochschule Zuerich	ETH	CH	HE
14	Universitaet Duisburg - Essen	UDE	DE	HE
15	Rheinisch-Westfaelische Technische Hochschule Aachen	RWTH	DE	HE
16	UFI Filters	UFI	IT	IND-SUPP
17	University of Brighton	UOB	UK	HE


BUDGET: €12.1 million
FUNDING: €9.95 million
START: October 2016
DURATION: ~ 39 months
Call: H2020-GV-02-2016-INEA
CONTRACT NUMBER: 723954
COORDINATOR: Simon Edwards, Ricardo
CONTACT: secretary@uniresearch.com
WEBSITE: www.paregen.eu



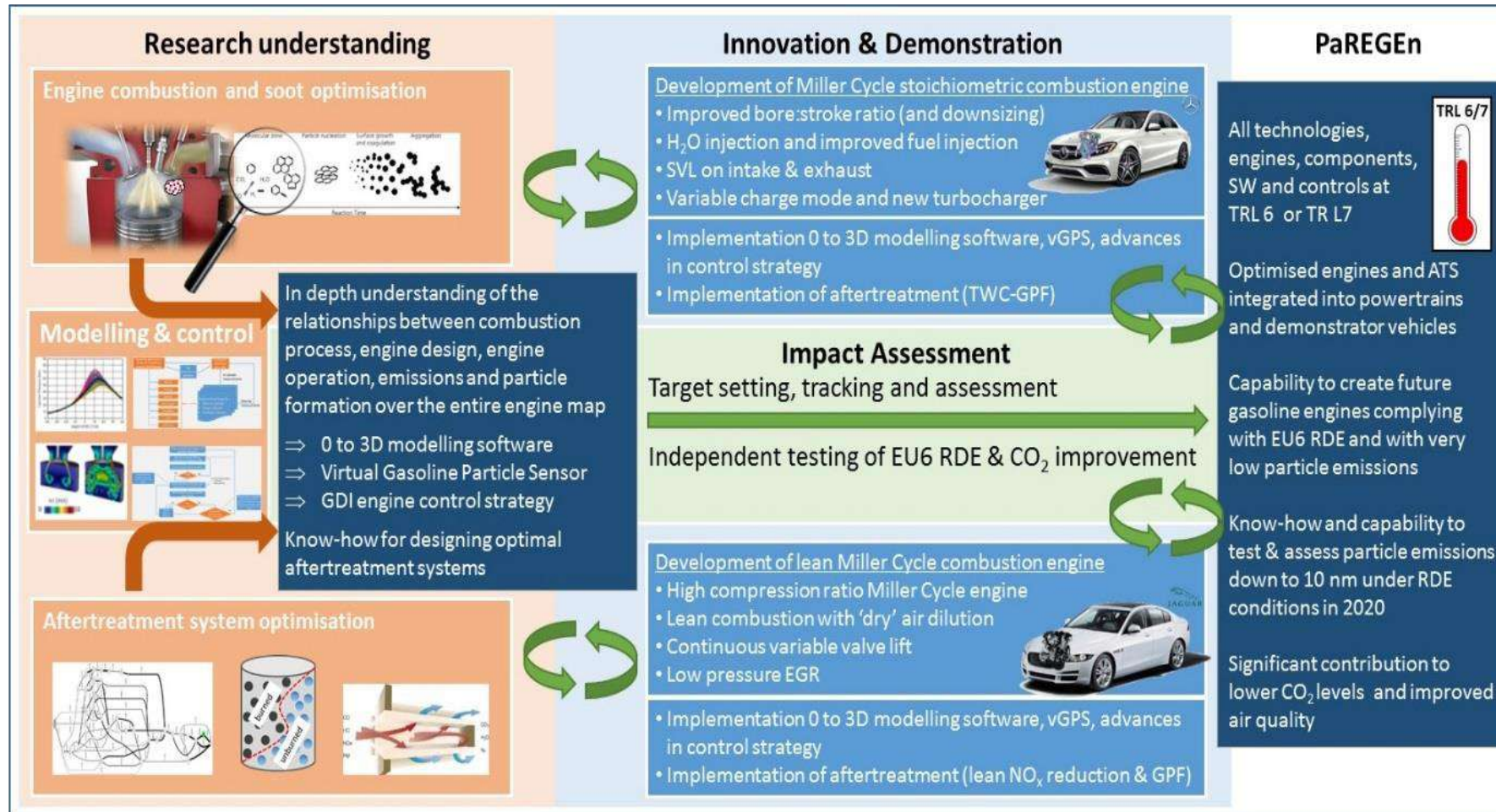
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Objectives

- Demonstrate a new generation of gasoline direct injection engines achieving a $\geq 15\%$ reduction in CO₂ emissions through the optimal combination of advanced engine and robust aftertreatment technologies
- These vehicles will comply with upcoming Euro 6 RDE limits with particle number emissions measured to a 10nm size threshold
- Modelling and simulation software will be verified that can improve the design and the control capability of subsequent vehicles



Project Approach



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Project Results

JOINT FINAL EVENT 128 PaREGEEn



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Project Results



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PaREGEEn + PEMs 4Nano

Optical investigations in a single cylinder engine

Investigations in an optical engine

UT for fuel film quantification

Infrared Absorption to visualize water

Endoscopic investigations in a thermodynamic engine

Optical investigations in a single cylinder engine

JOINT FINAL EVENT
PaREGEEn + PEMs 4Nano

LES 3D CRFD – Development and Knowledge Transfer

Constant Volume Vessel

Flow channel

Context & objectives

Methodology

Optical and thermodynamic engine

LES 3D CRFD Development and Knowledge Transfer

JOINT FINAL EVENT
PaREGEEn + PEMs 4Nano

Surrogate Composition, Mechanism Development and Reduction

Gasoline Surrogate Model Development

Ethanol Toluene Reference Fuel formulation

Mechanism reduction

Conclusion

Surrogate Composition, Mechanism Development and Reduction

JOINT FINAL EVENT
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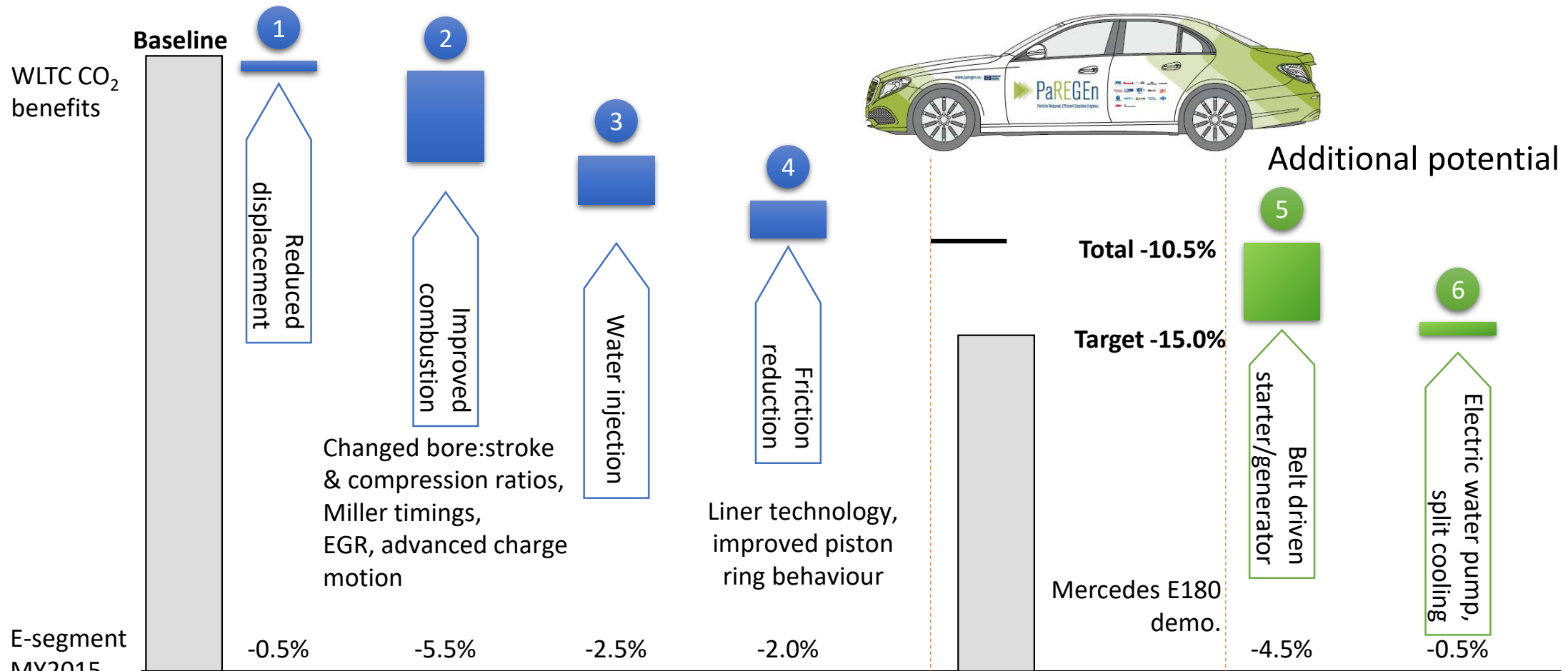
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Project Results



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Demonstrate a new generation of gasoline DI engines achieving a $\geq 15\%$ reduction in CO₂ ... Stoichiometric small TC-VVA-DI water injection engine (WP3)



E-segment MY2015



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Demonstrate a new generation of gasoline DI engines achieving a $\geq 15\%$ reduction in CO₂ ... Stoichiometric small TC-VVA-DI water injection engine (WP3)



WLTC CO₂ benefits

Baseline

CO ₂		Standard emissions			PN	
* Reduction of 15% based on the WLTC results of the baseline vehicle * Additionally: reduction of 15% based on the 2015 BIC (* New Reg 1.48 (2020))		Compliance with Euro 6 (d) limits			Reduction of sub-23 nm to at least 10 nm	
RDE Final Conformity Factor of 1.5 in case of NOx (*)		RDE Final Conformity Factor of 1.5 in case of NOx (*)			RDE Final Conformity Factor of 1.5 in case of PN	
Vehicle-test	THC (mg/km)	NOx (mg/km)	CO (mg/km)	CO ₂ (g/km)	PM (mg/km)	PN ≥ 10 nm (pk/km)
Mercedes Demonstrator WLTC Low	100	60	1000	Base Vehicle $\rightarrow -15\%$	4.5	6.0E+11
Mercedes Demonstrator WLTC High	100	60	1000	Base Vehicle $\rightarrow -15\%$	4.5	6.0E+11
Mercedes Demonstrator RDE	---	90	---	---	---	9.0E+11

Targets on vehicle dyno and test bench fulfilled



Results from independent testing of demonstrator vehicle (emissions compliant)

Mercedes E180 demonstrator with 11.7:1 CR, PWI

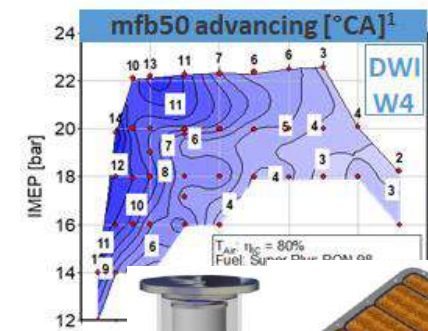
Total -11.5%

Additional potential Including improved shift strategy

Target -15.0%

With CR 13.5:1 & DWI

With CR 14.5:1



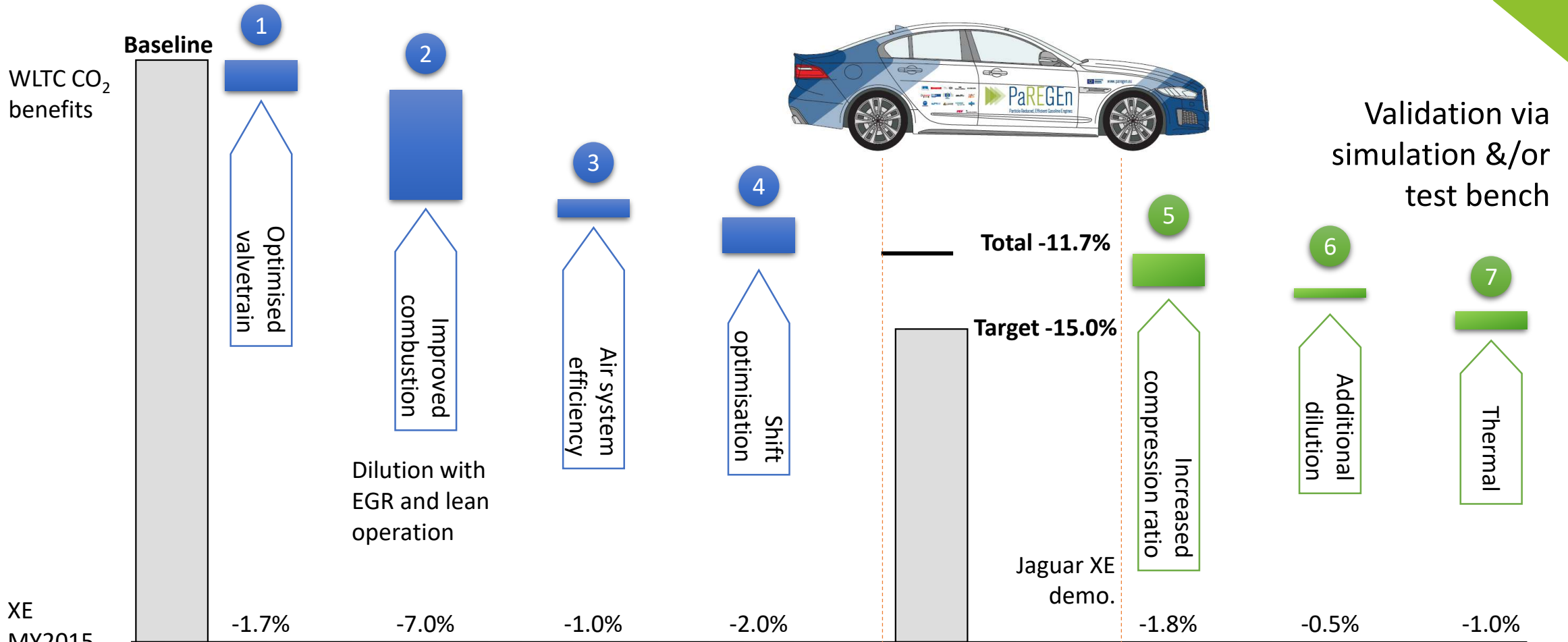
E-segment MY2015



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Demonstrate a new generation of gasoline DI engines achieving a $\geq 15\%$ reduction in CO₂ ...

Dry Dilute Combustion Demonstrator (WP4)



XE MY2015

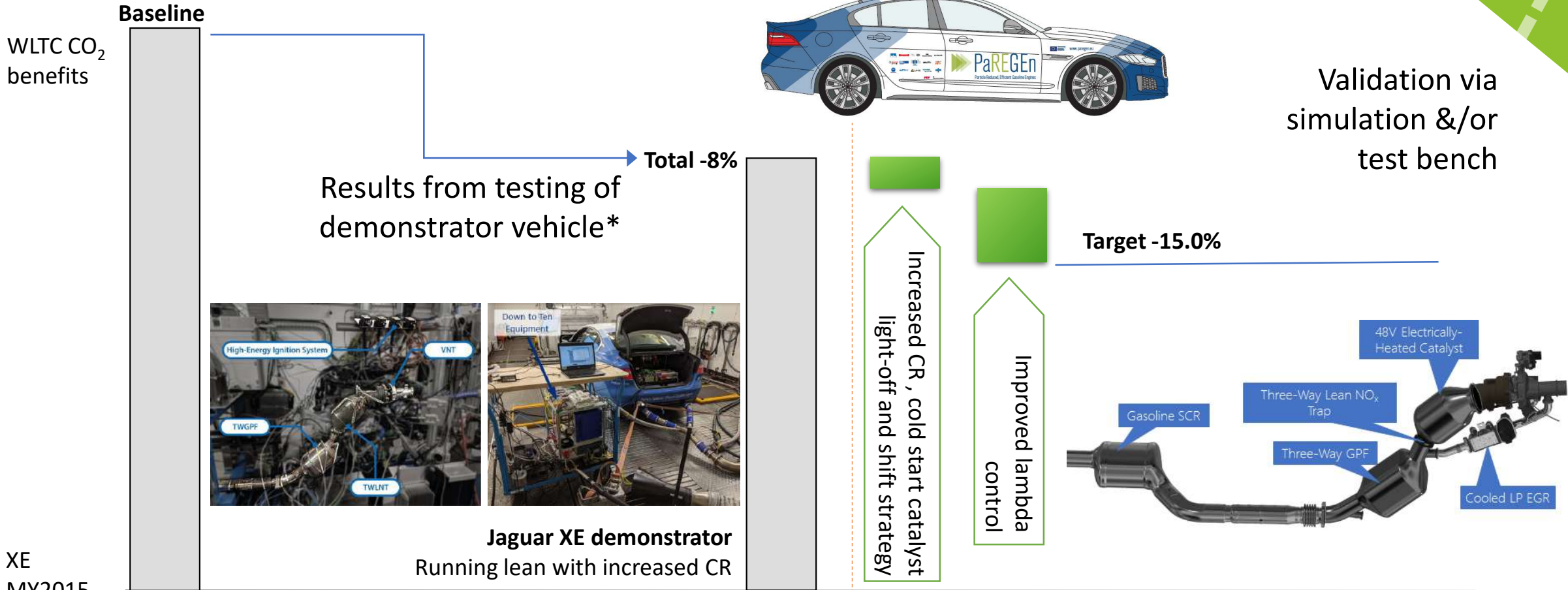


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Validation on the vehicle

Demonstrate a new generation of gasoline DI engines achieving a $\geq 15\%$ reduction in CO₂ ...

Dry Dilute Combustion Demonstrator (WP4)



XE
MY2015

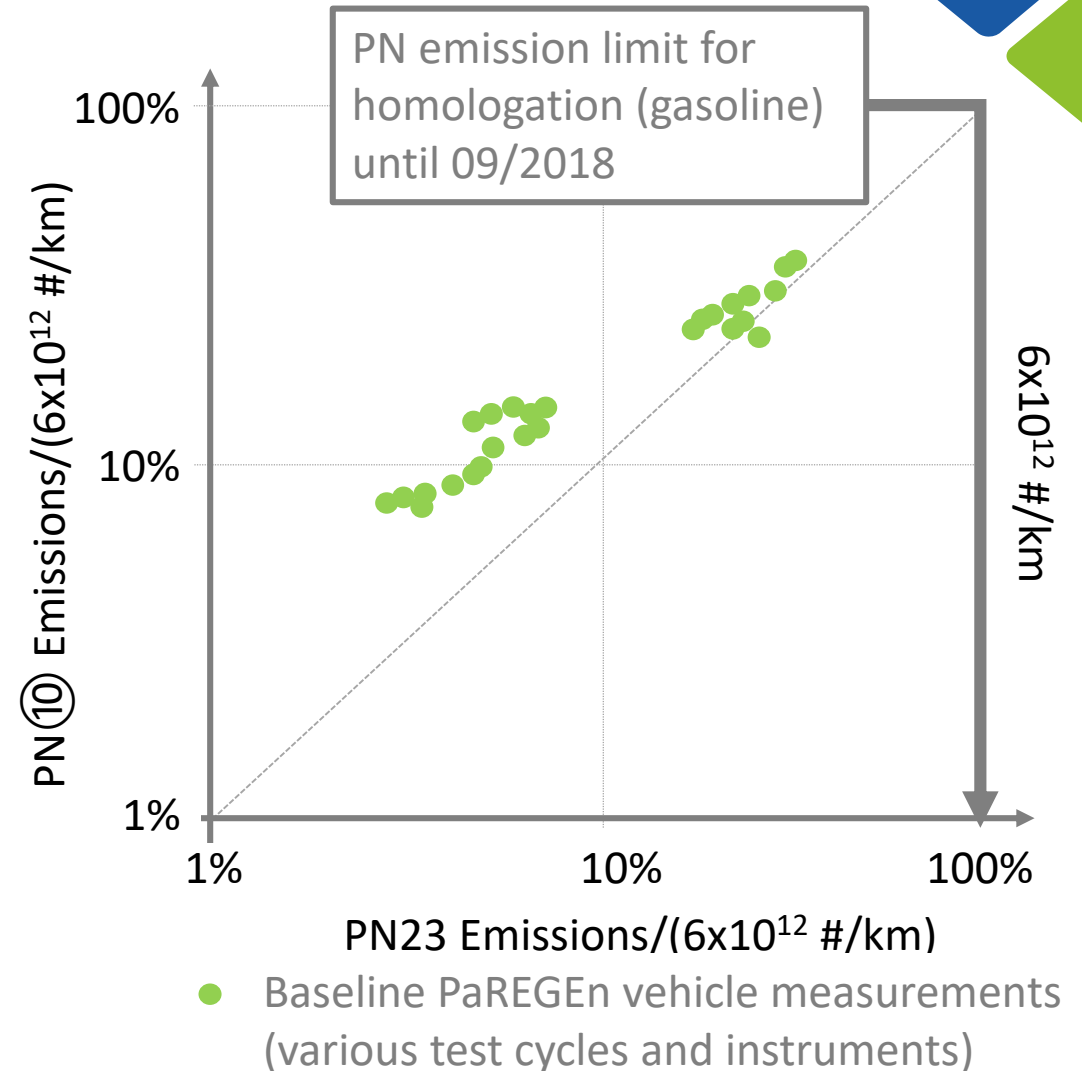


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*when running with the same start-stop feature as the baseline
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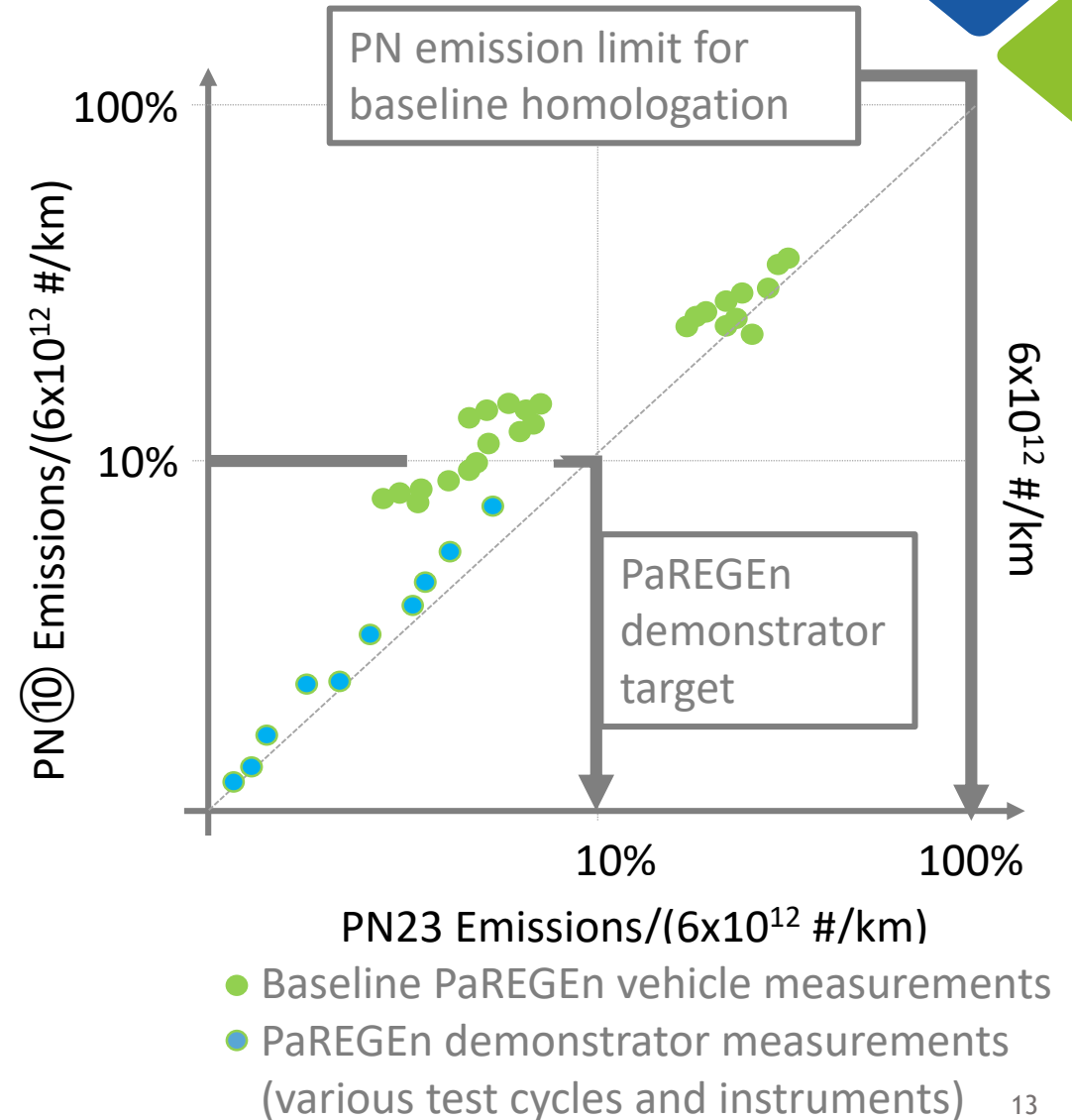
... Vehicles will comply with upcoming Euro 6 RDE limits with particle number emissions measured to a 10nm size threshold

- PaREGEn baseline vehicle measurements made over the NEDC, WLTP (high and low), and RDE (on-road and on-dyno) with AIRMODUS and EEPS instruments
- Over the wide range of tests the **baseline vehicles** were well below the relevant legislative PN levels
- The relationship between the PN23 and PN⁽¹⁰⁾ measurements is consistent with the other measurements made within the DownToTen project

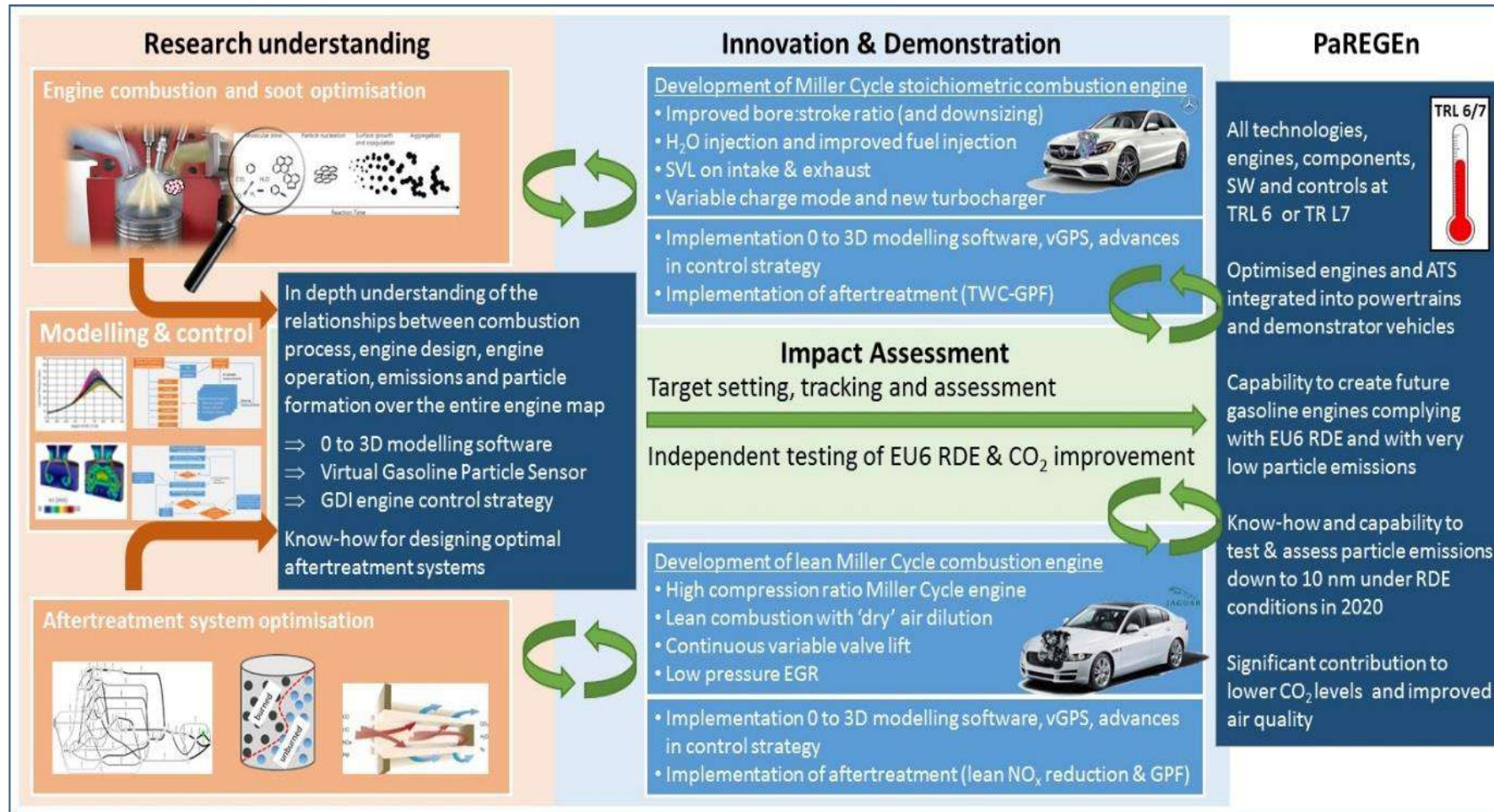


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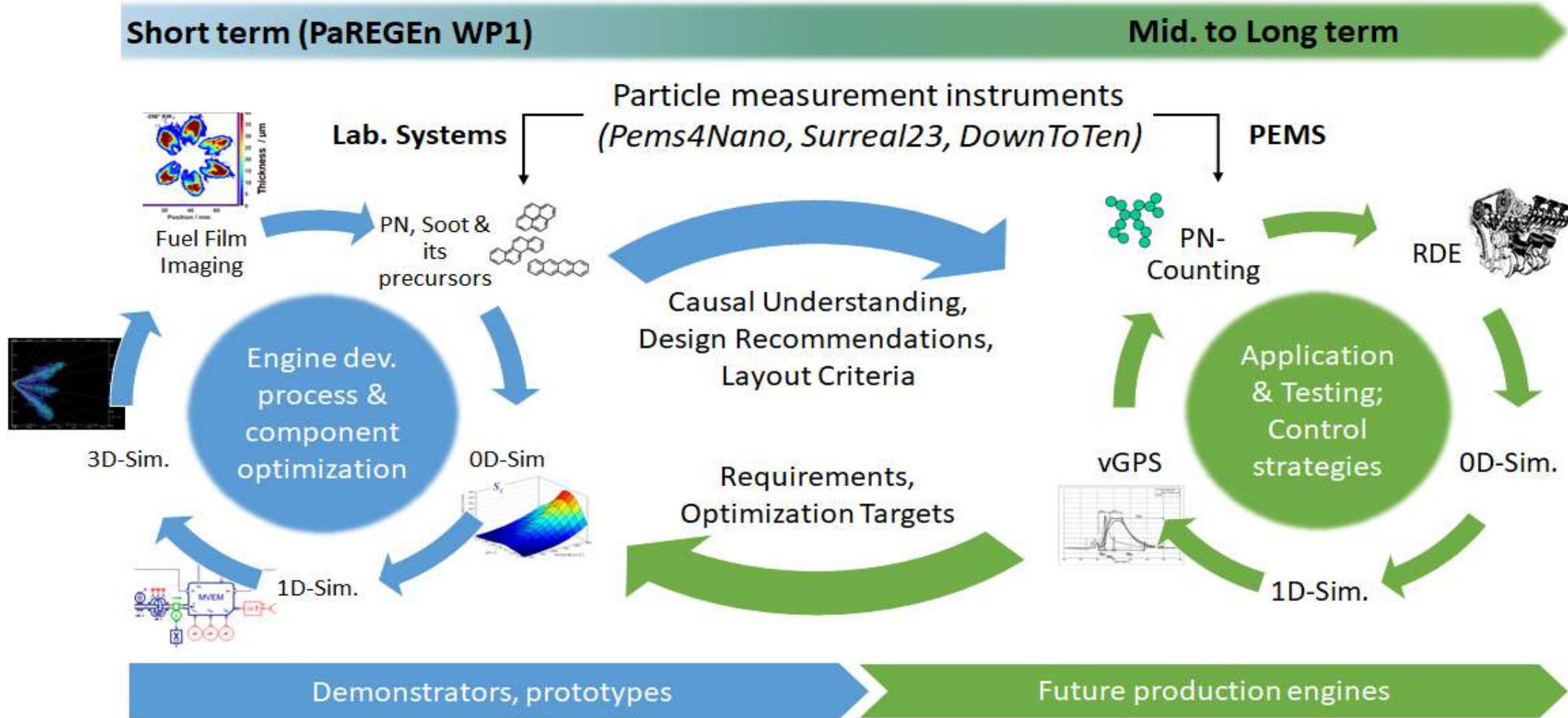


Project Approach



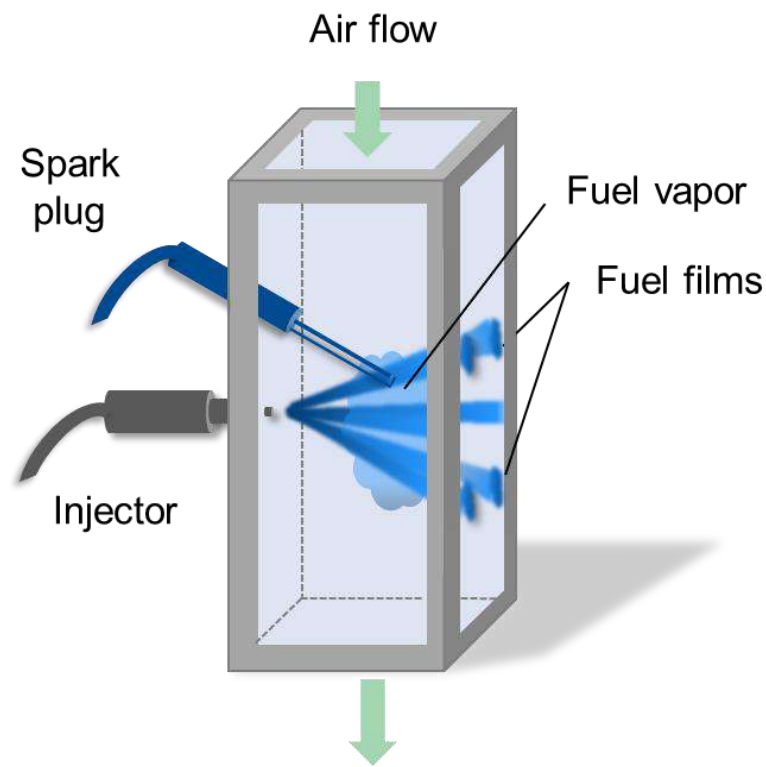
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Modelling & simulation software that can improve the design & the control capability of subsequent vehicles

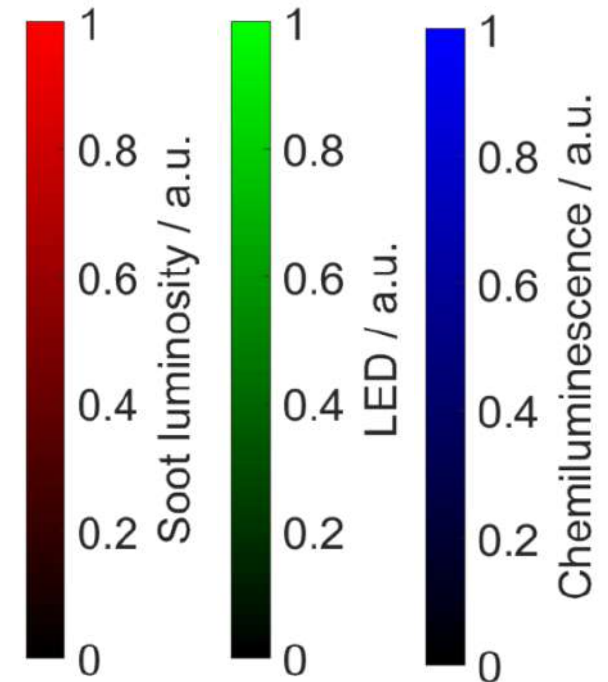


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Modelling and simulation software, that can improve the design and the control capability of subsequent vehicles, will be verified



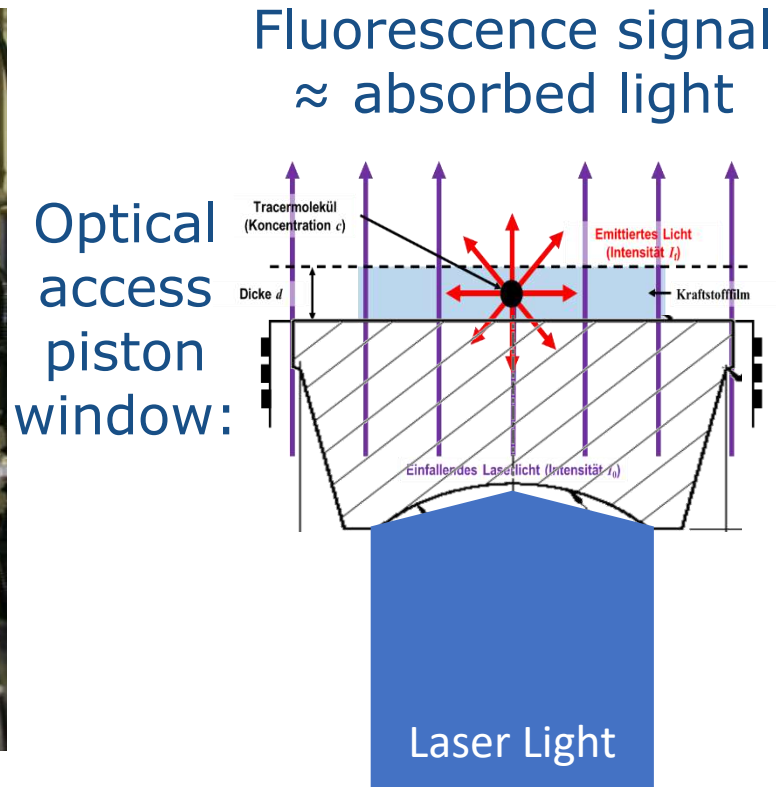
Fuel-film positions



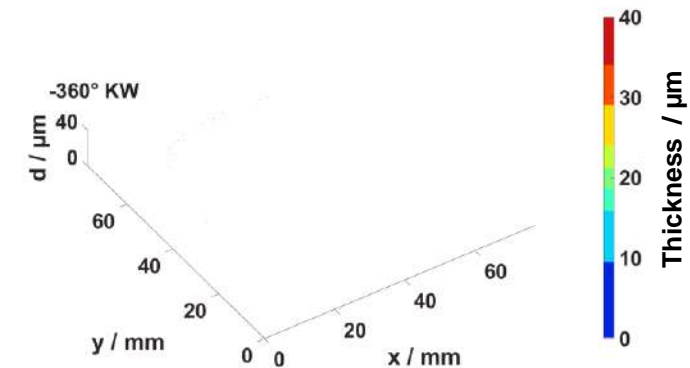
Modelling and simulation software, that can improve the design and the control capability of subsequent vehicles, will be verified



Viewed from below



$p_{\text{rail}}=200 \text{ bar}$, $t_i=2079 \mu\text{s}$

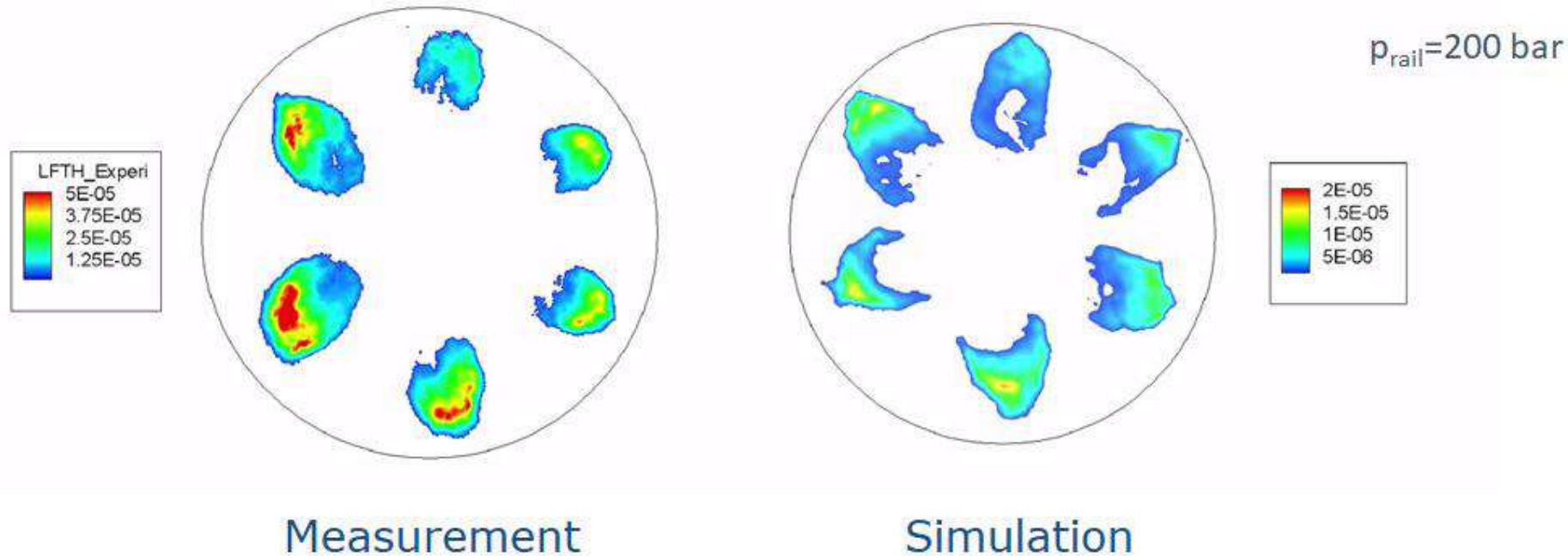


PhD Thesis: J.N. Geiler, Bosch



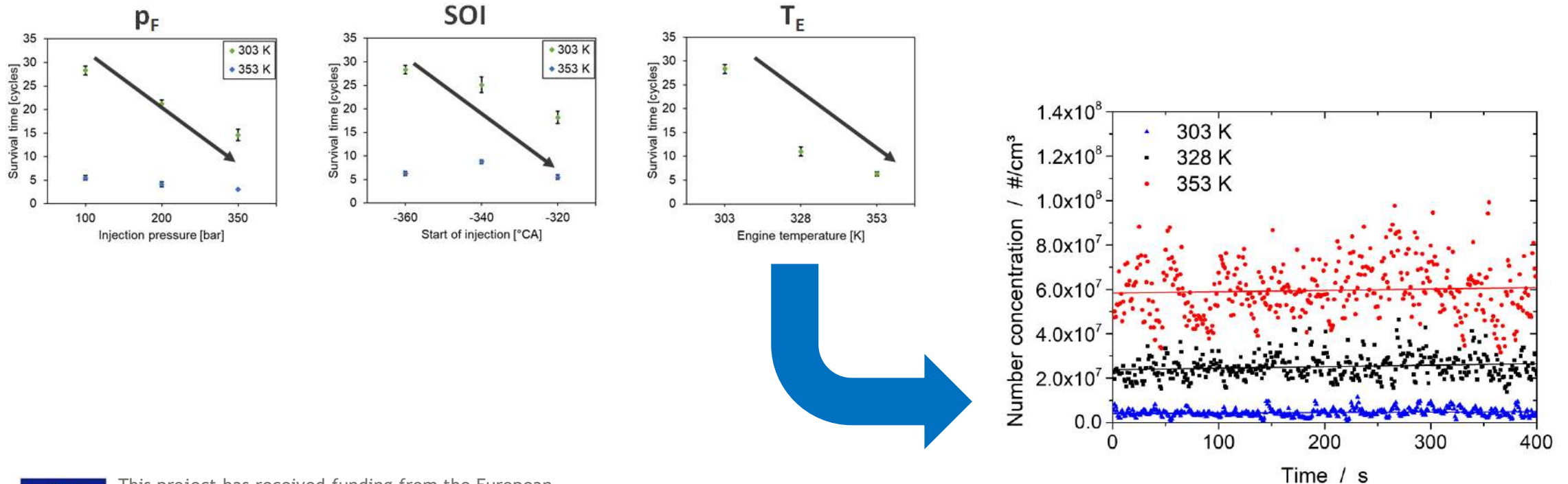
Modelling and simulation software, that can improve the design and the control capability of subsequent vehicles, will be verified

- Evolution of liquid film distribution in motored conditions



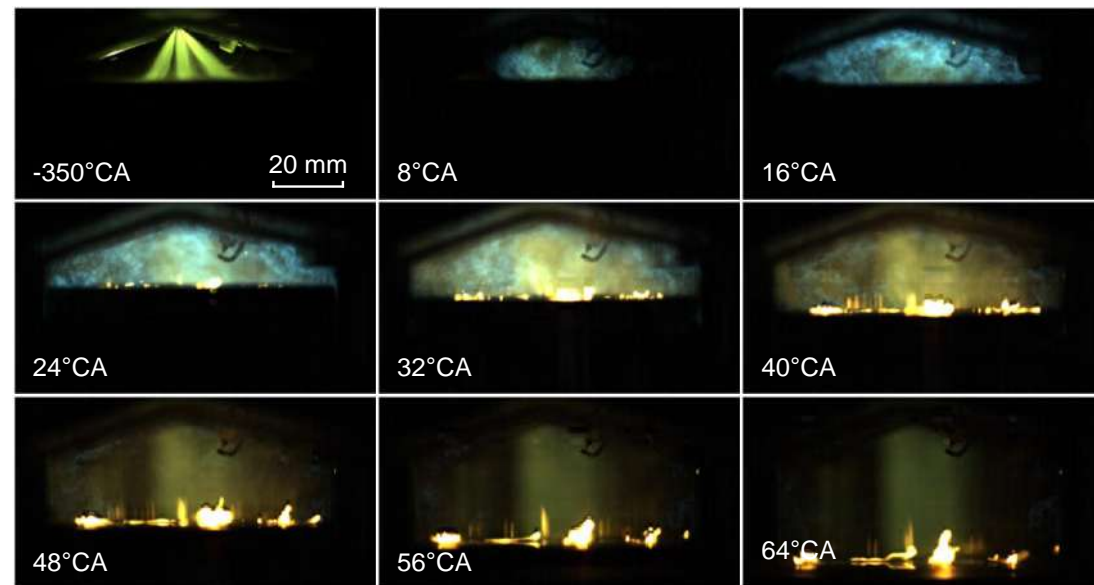
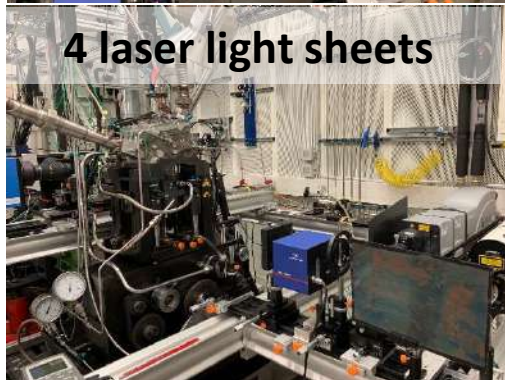
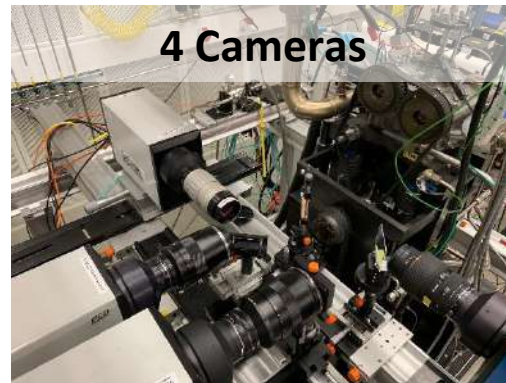
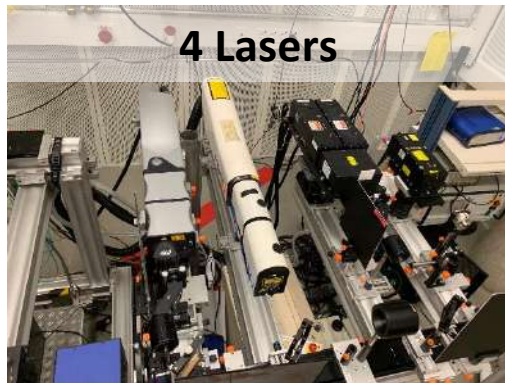
Modelling and simulation software, that can improve the design and the control capability of subsequent vehicles, will be verified

- Understanding of the effects of calibration parameters on fuel films and PN emissions (EEPS measurements)



Soot Precursor LIF and LII in an optical engine

- High-speed imaging: techniques and results



$N=1200$ rpm; $p_{mi}=4$ bar; skip-fired operation, $R/W=20:1$;
 $SOI=360^\circ$ BTDC; $p_F=100$ bar; $t_i=1050$ μ s



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