CUMIN - TIM

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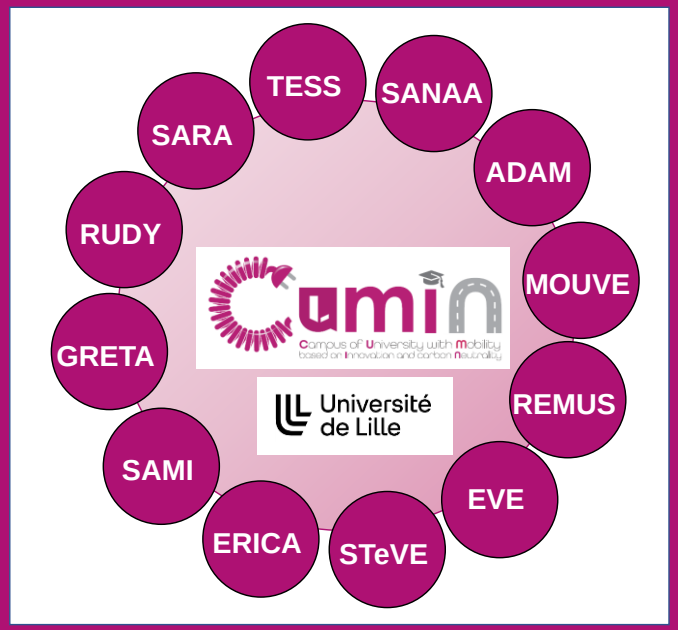

Optimal Combination of Regenerative and Mechanical Braking for Electric Vehicles

Jean-François Brunel, LaMcube

Walter Lhomme, L2EP

CPER RITMEA

Outline

1. Context

2. Work approach

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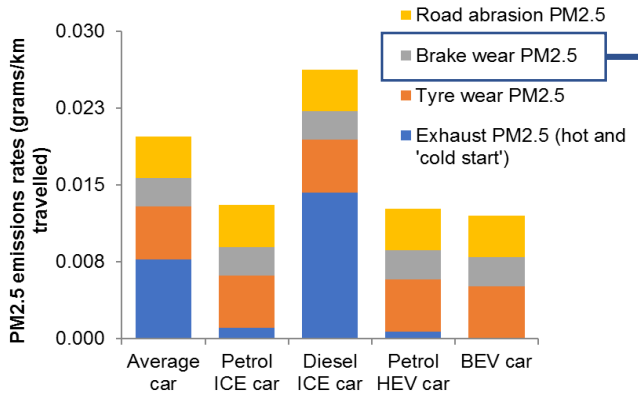
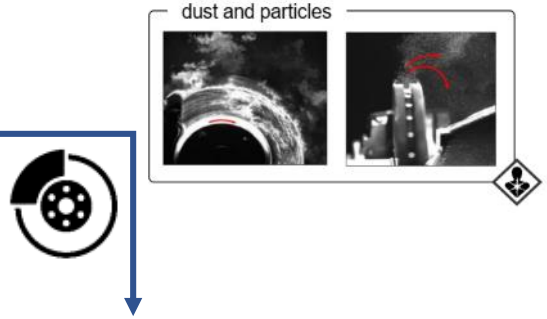
1. Context

Scientific Context

- Air Quality : Major concern in urban/suburban areas

PM2.5 emissions rates by car fuel types (UK 2015)
(Fine particles with a diameter of 2.5 µm or less)





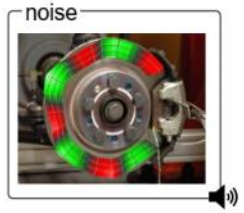
Exceeding of the regulatory AQ thresholds in the EU in 2020

[developpement-durable.gouv.fr]

→ ***Automotive braking*** *: Limitation of particle emission from Euro7 Norm (European Commission) :*

7 mg/km until 2035 , 3 mg/km after 2035.

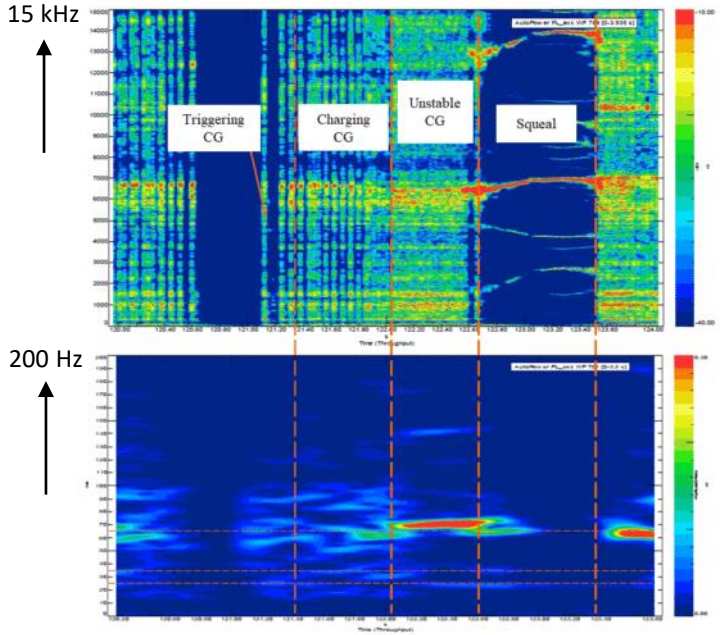
- Noise emissions : Request for quieter systems



→ ***Automotive braking*** *:*

Squeal noise : High-frequency

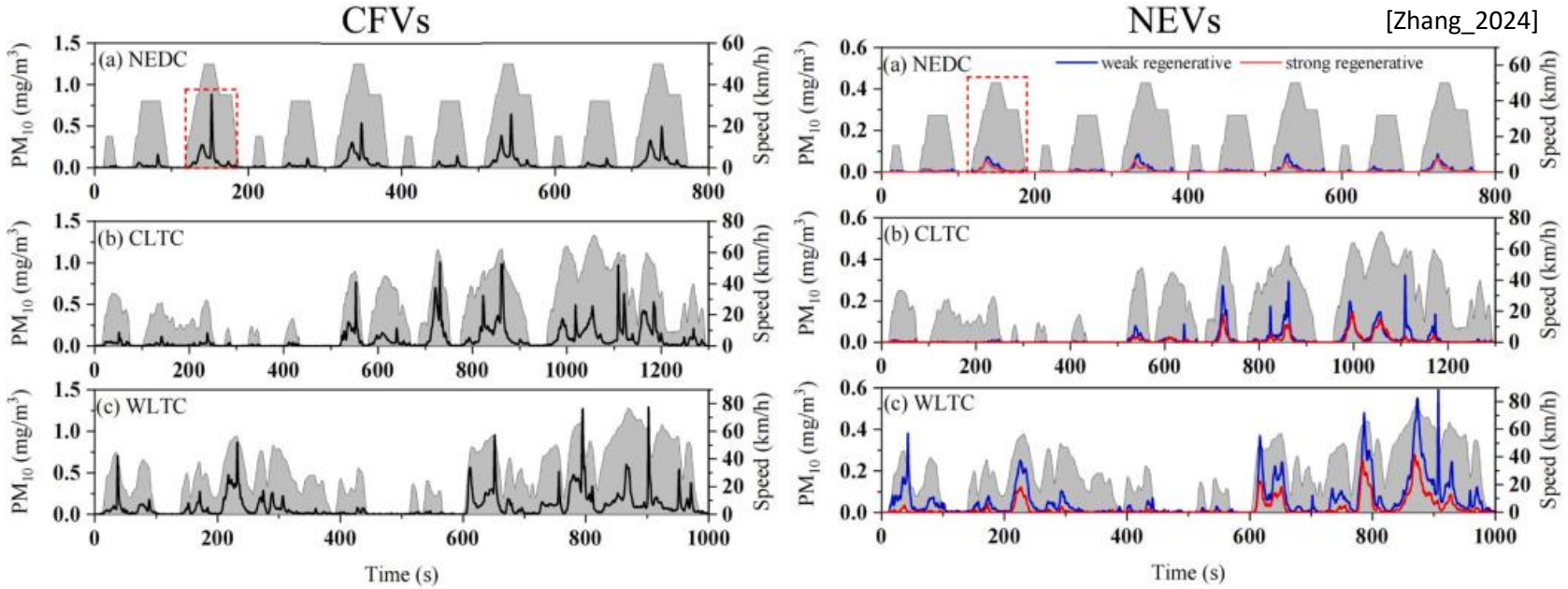
Creep groan noise : Low frequency at low speed



Scientific Context

How to limit brake emisions (noise and particle)

→ Use of the regenerative braking



[Zhang_2024]

How to optimize the combination of the Mechanical Brake and the Regenerative Braking to limit emissions (particles & noise)?

→ **Project TIM**

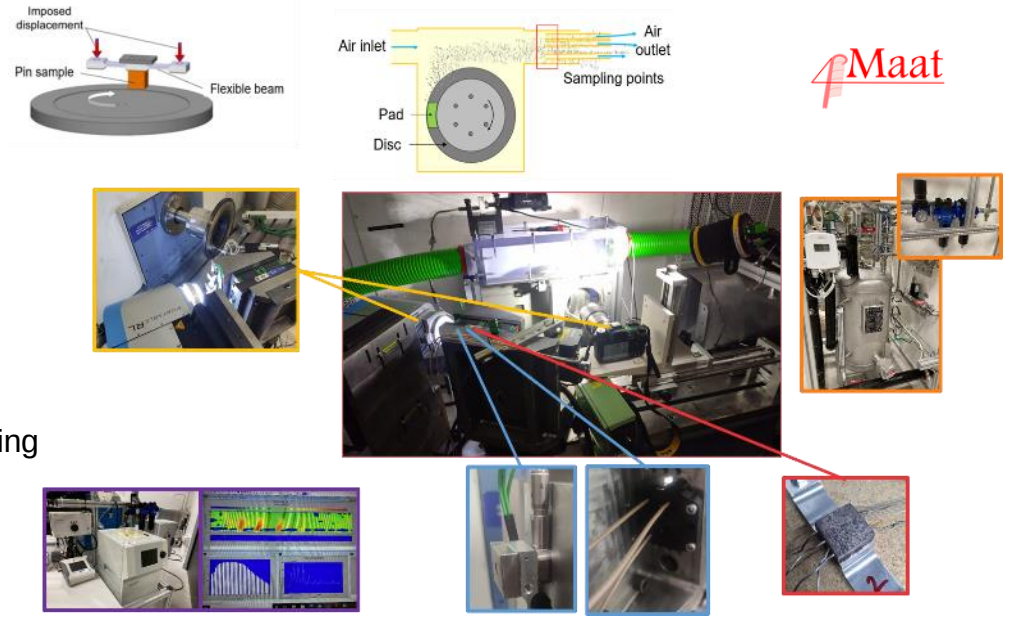
Complementary of the labs

LaM CU3E
Laboratoire de mécanique, multiphysique, multiéchelle

Better understanding of **multiphysic** and **multiscale aspects** of mechanical brake systems

Highly instrumentalized tests for particle and noise emissions

- Acoustic
- Particles + VOC
- Discrete surface tracking
- Atmosphere
- Mechanical
- Thermal

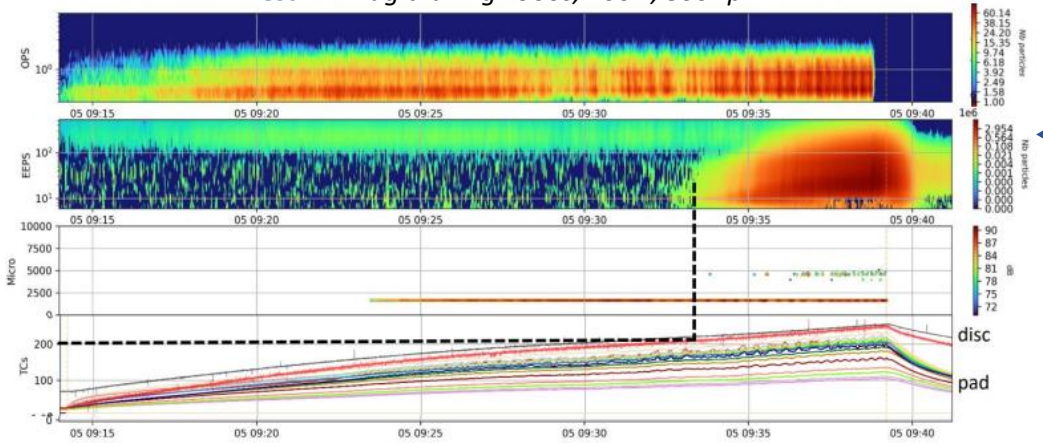


Example of results

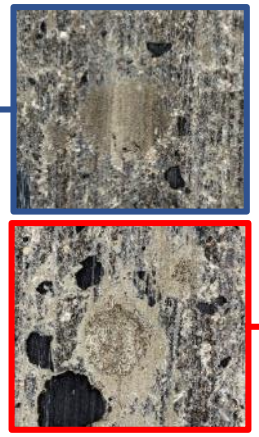
Ultrafine particle emission
→ correlated with temperature threshold (friction material degradation)

Fine, coarse particle emission
→ Influence of the initial surface state

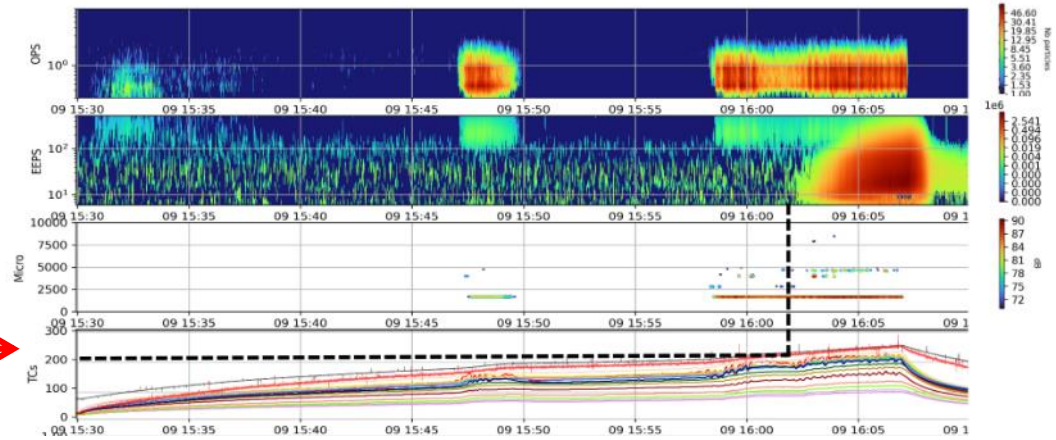
Test 1 : Drag braking 1500s, 200N, 800 rpm



Optical observations at before the tests



Test 2 : Drag braking 1500s, 200N, 800 rpm



Complementary of the labs

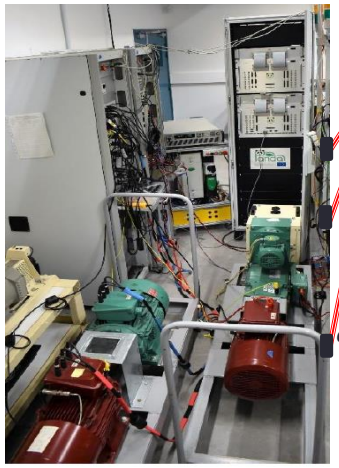
L2EP Laboratoire d'électrotechnique et d'électronique de puissance de Lille

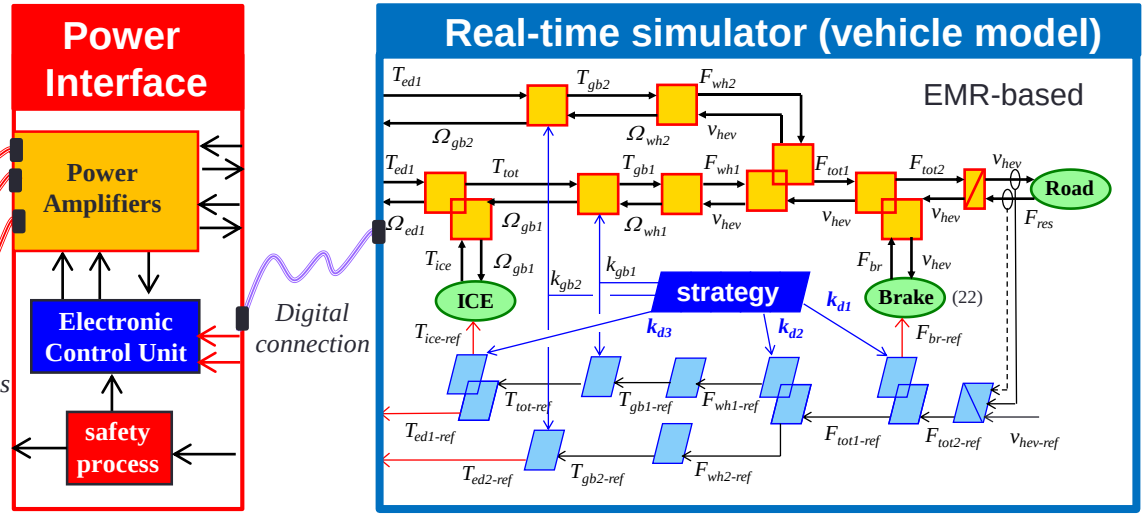
Validation of new concepts of electrified vehicles for more sustainable transport

Originalities:

- from real components to **real vehicles**
- **graphical formalism (EMR)** for model and control organisation
- **Hardware-In-the-Loop testing** (coupling hardware & software)

real e-motors under test





Hardware **Software**

Example from H2020 PANDA

Université de Lille Valeo

Plug-in Hybrid demo car

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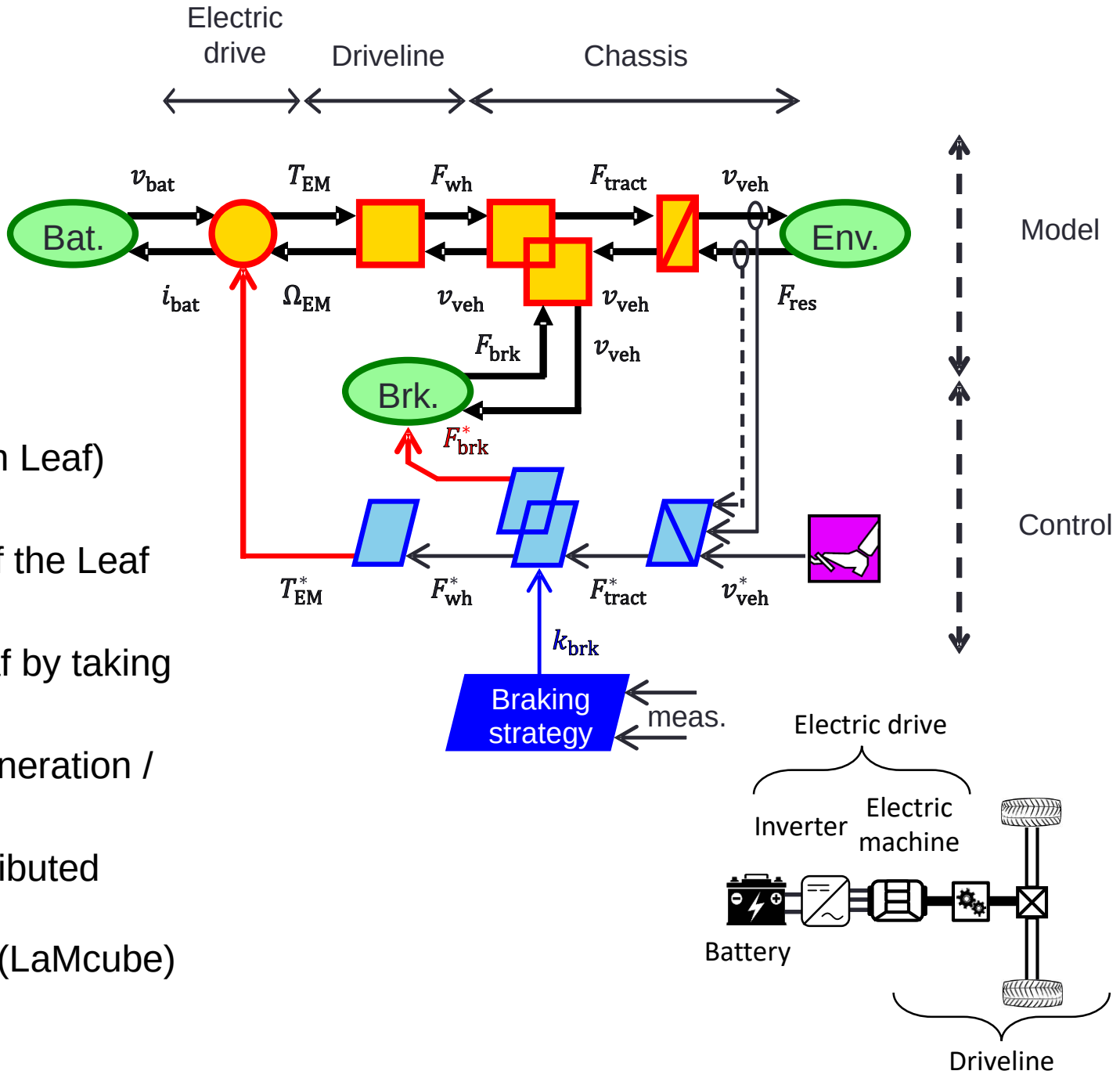
2. Work approach

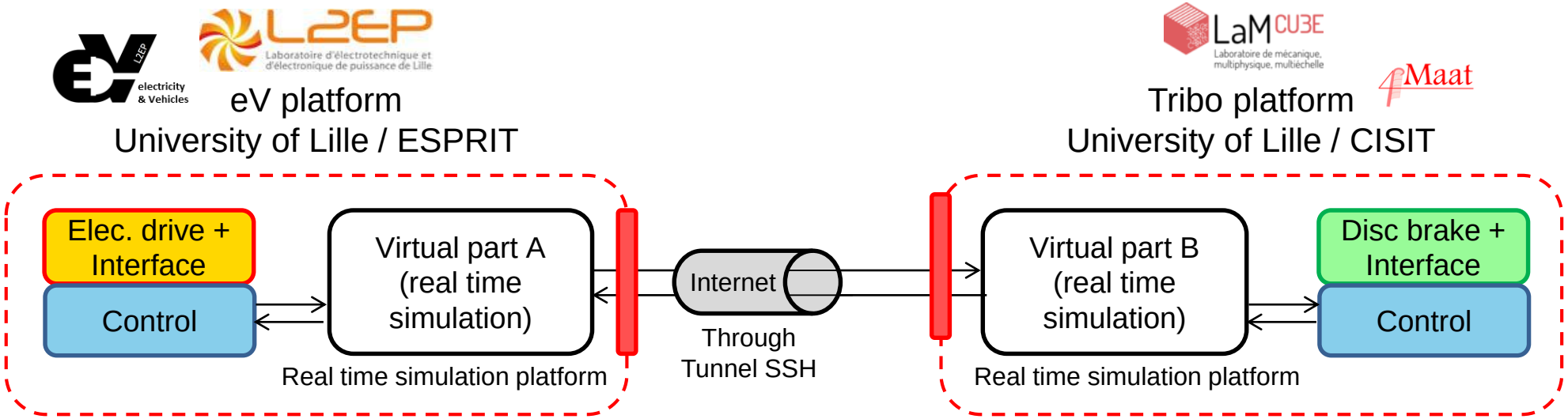
Work approach

1. Energetic model on a real battery EV (Nissan Leaf)
   eV platform / L2EP
2. Tribological characterization on the brakes of the Leaf
   4MAAT-Tribo platform / LaMcube
3. Multi-physical modelling and EMR of the Leaf by taking into account both models
4. Multi-objective braking strategy: battery regeneration / particle emissions
5. Validation of the strategy using multisite distributed Hardware-in-the-Loop (HiL) testing
   eV platform (L2EP) & 4MAAT-Tribo platform (LaMcube)



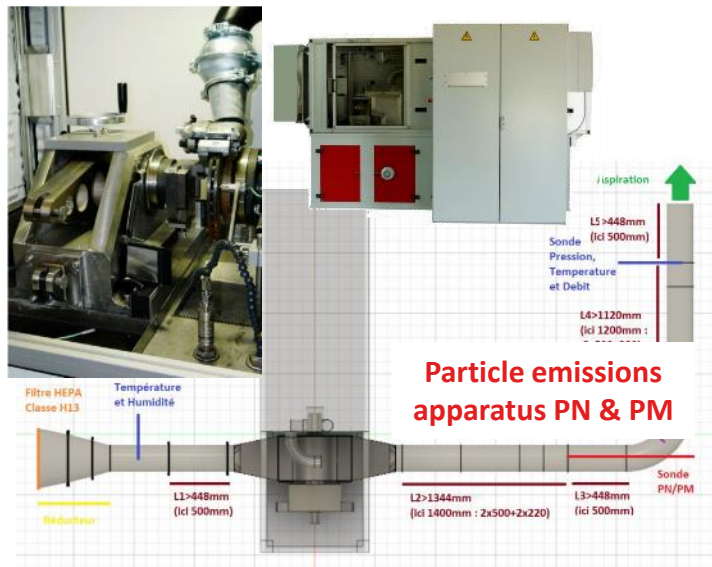
Method from [Tournez 23]

Multisite distributed HiL testing



1:1 disc brake test bench

1:1 electrical drive test bench

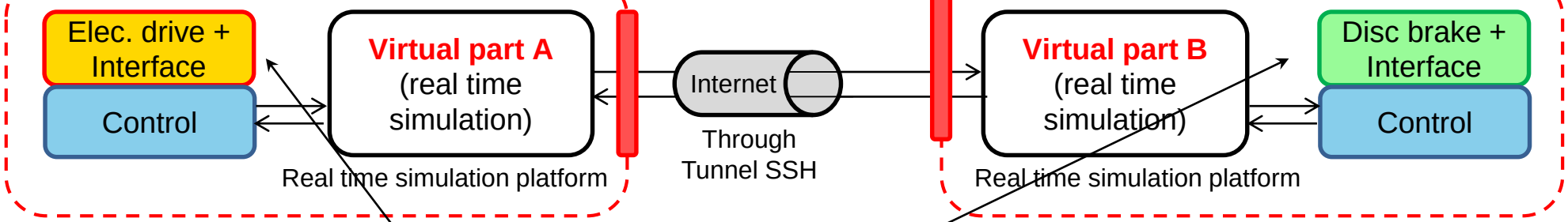


Multisite distributed HiL testing

How to split the virtual parts A & B?

eV platform
University of Lille / ESPRIT

Tribo platform
University of Lille / CISIT



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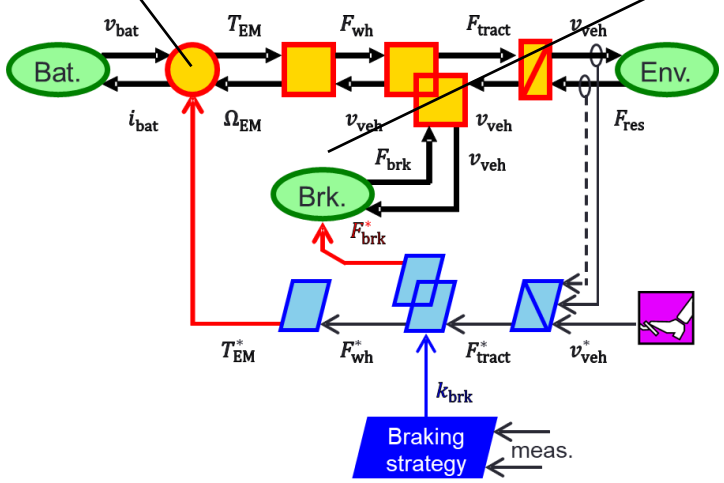

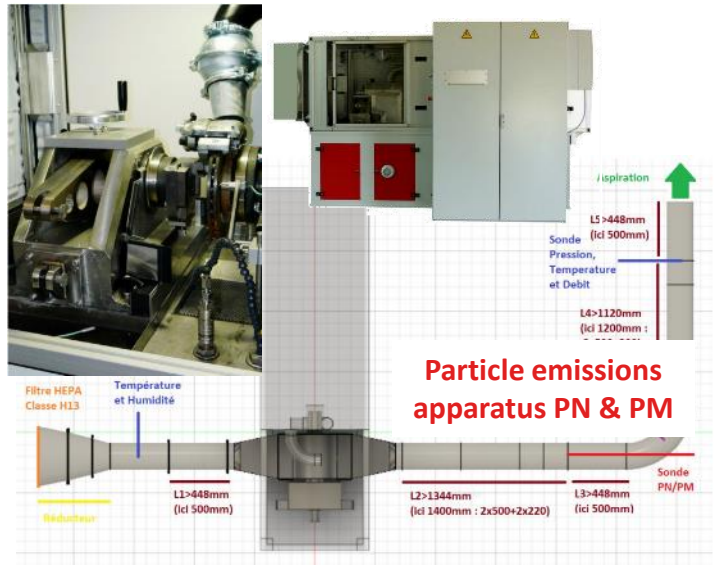

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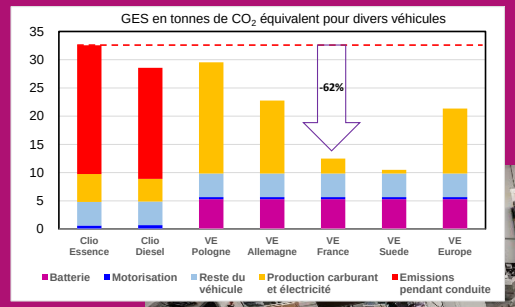
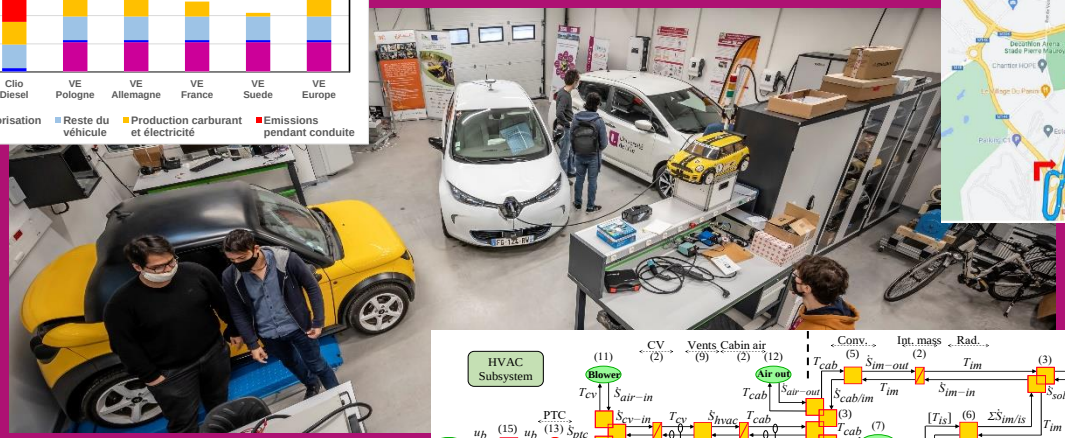
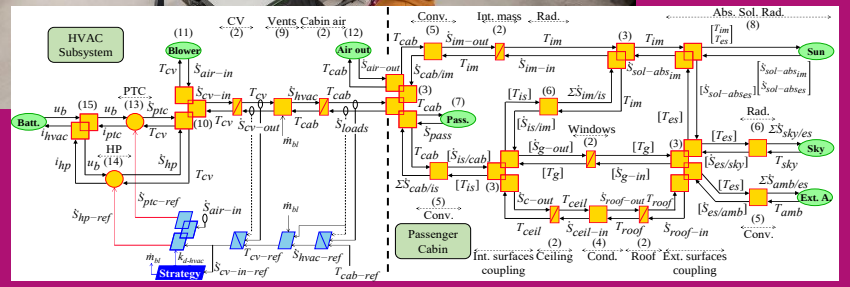
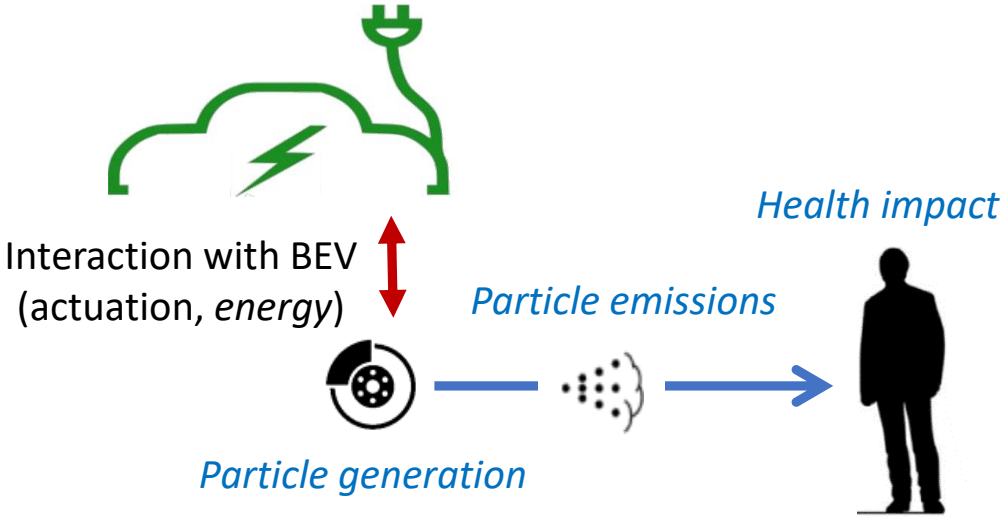






Our university as an exciting living lab towards eco-cities through an innovative transdisciplinary framework !

Objective of the project



- **How to reduce the brake emissions?**

➢ Materials / Component design / Actuation

➢ Battery EV: optimize the use of the brake distribution considering the energy flows (Project TIM CPER RITMEA)