Approach for Measuring Volatile Tyre Particle Emissions

Tsakonas, G., Kontses, D., Dimaratos, A., Ouzounis, R., Ntziachristos, L, and Samaras, Z.

LABORATORY
OF APPLIED
THERMODYNAMICS

Research Objectives

Tyre emissions are a critical source of airborne particulate matter, contributing to urban air pollution and posing potential risks.

The **scope** of this work is to improve the understanding and quantification of **tyre particle emissions**, specifically by:

- Identifying the **temperature conditions** under which volatile particles are released
- Developing a methodology for **volatile particle removal**
- Validating the **methodology**
- Observe the differences between **solid** and **volatile** particles

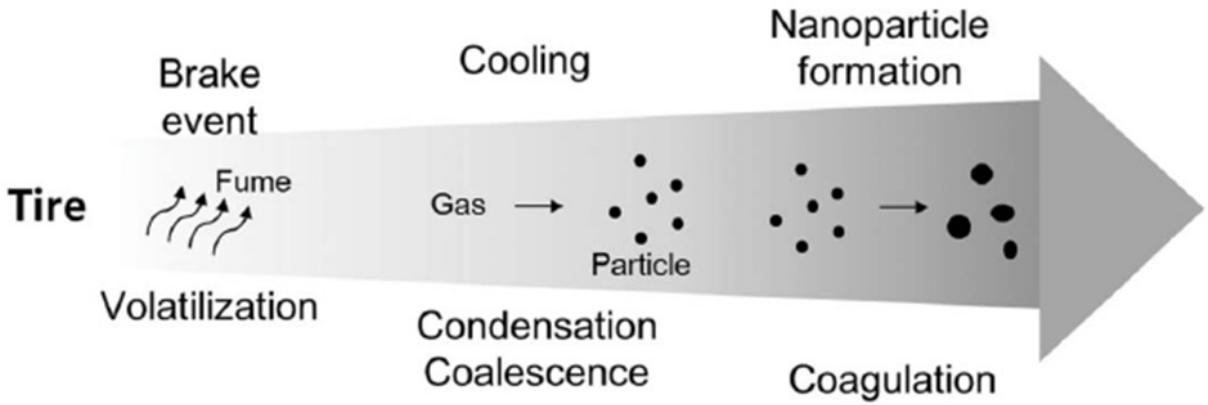
Temperatures Leading to Volatile Particle Emissions from Tyres

Volatilization mechanism generates nanoscale particles, especially at elevated temperatures

These particles are **small in mass but highly toxic** *(Barouch Giechaskiel, 2024)*

Volatile particle generation has been observed at **two temperatures**: *(Michał Gągol, 2015)*

- **160 °C** → Highest concentration of VOCs
- **200 °C (Extrusion)** → Thermal degradation creates new compounds, affecting VOC levels



A schematic of the formation procedure of nanoparticles from tyre. (Inyong Park, 2016)

Building a strategy

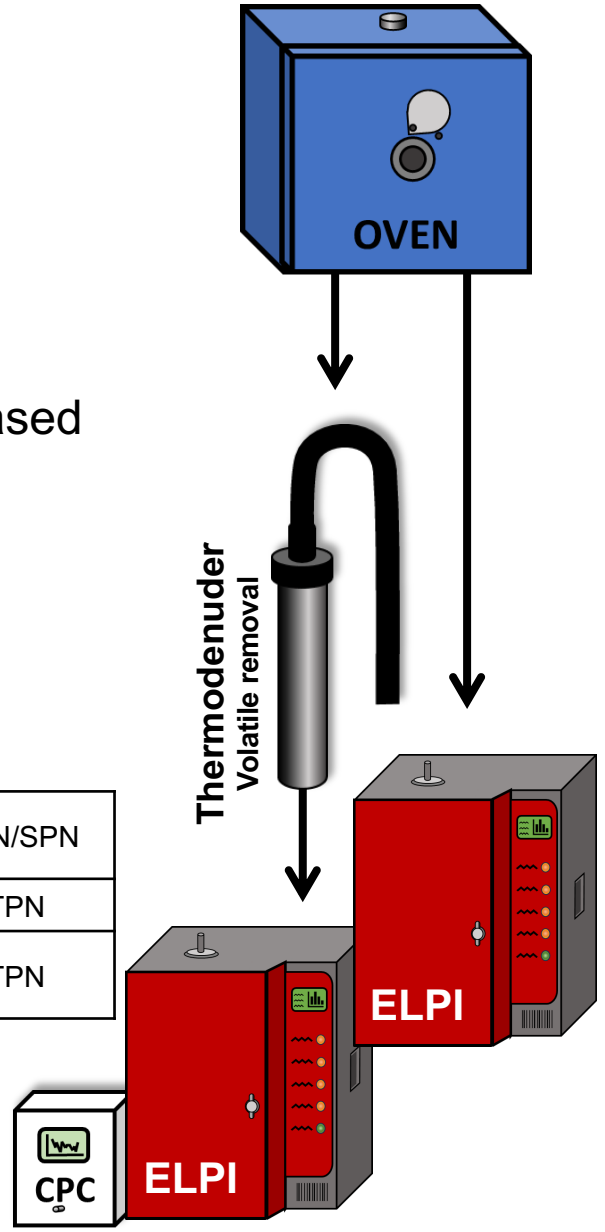
→ Design the measuring set-up

→ Gradually heat a piece of tyre tread and monitor emissions

→ Identify the temperature ranges where volatile particles are released

→ Verify if the thermodenuder effectively removes volatile particles

→ Apply and expand this method under real driving conditions

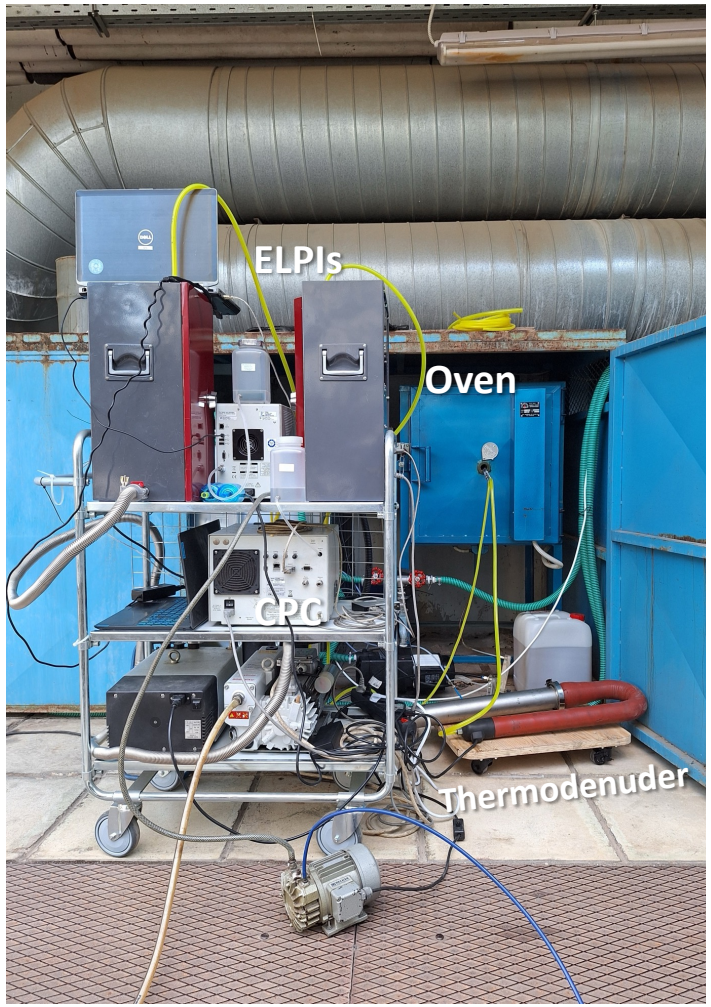


Measurement device	PSR	**PSD**	PNC	**PM 2.5 – PM10**	**Sampling frequency**	TPN/SPN
CPC 3750	10 nm	-	0-10^5	No	1 Hz	TPN
ELPI	7nm- 10µm	12 classes	100-3x10^7	PM2.5, PM10	1 Hz	TPN

Testing

Measuring set-up

Pieces of tyre tread

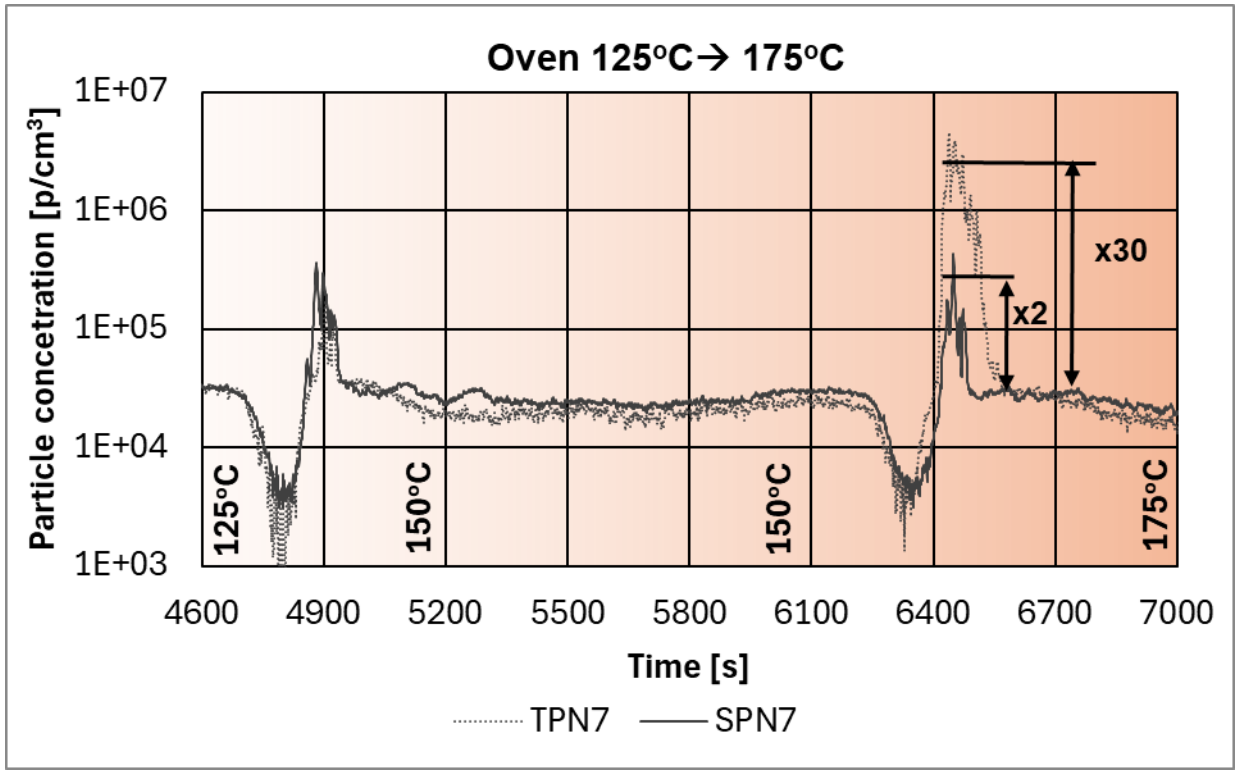


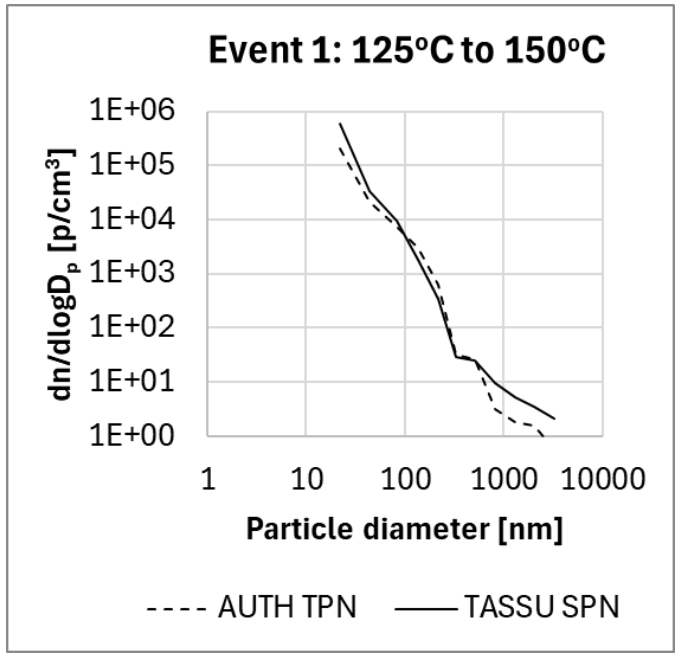
The experiment

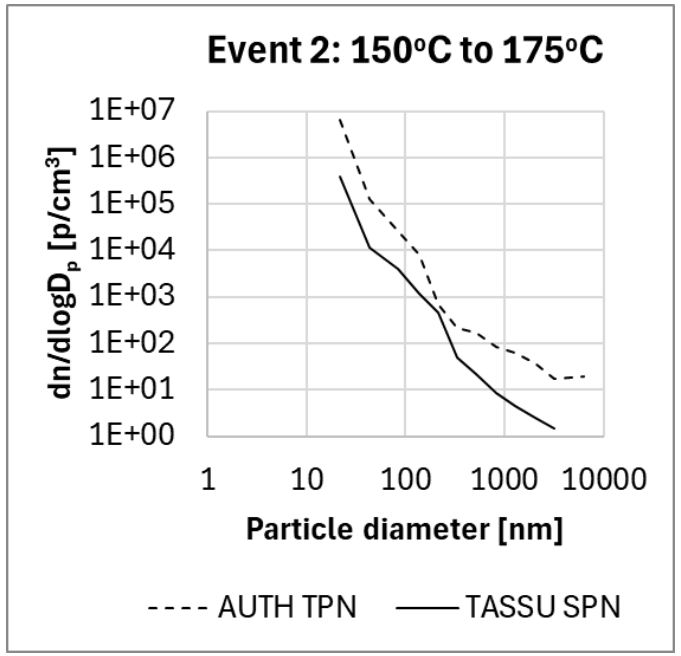
Oven results

→ A solid particle release observed between 125°C and 150°C

→ A volatile particle release observed between 150°C and 175°C

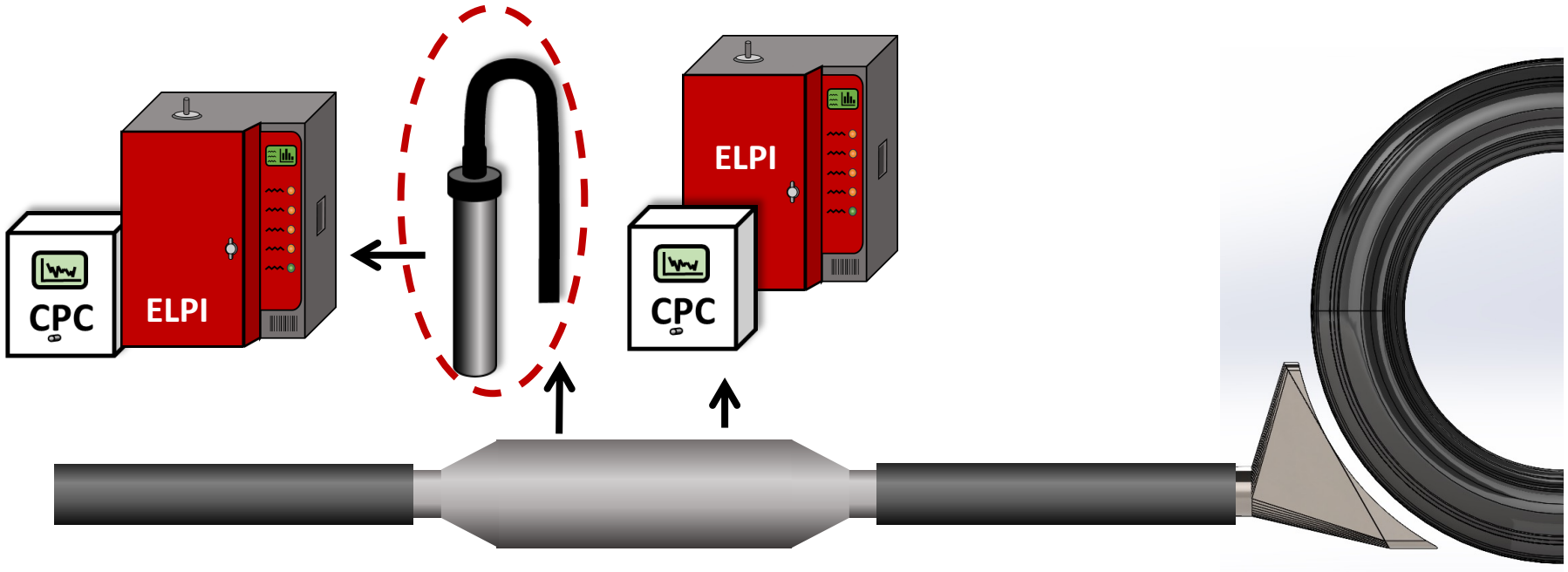




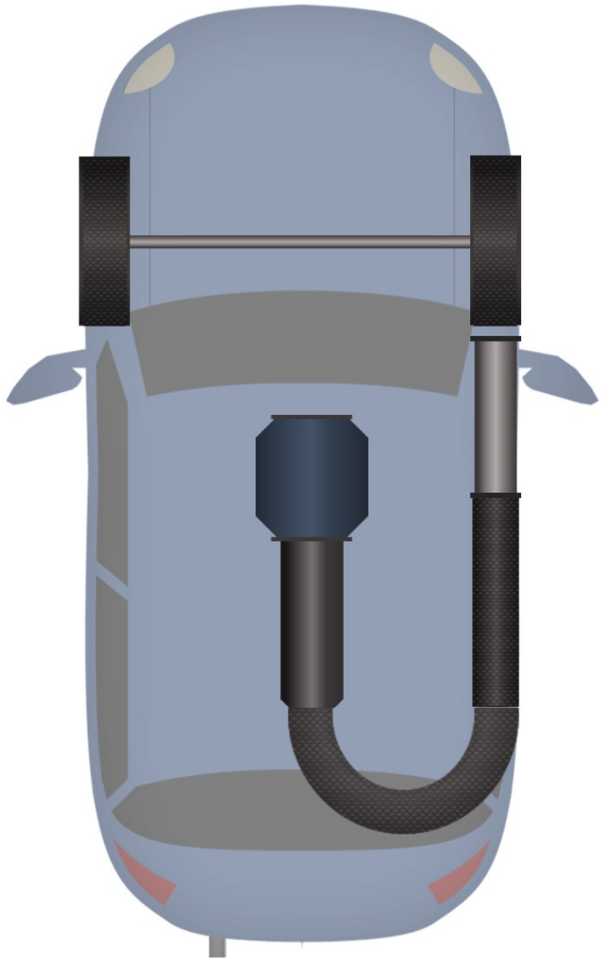


Implementation of the findings in driving conditions

- ✓ Setup for capturing tyre particles under **real driving**
- ✓ 2 driving cycles:
  - RDE
  - upHilly (1 Full and 1 half repetition)

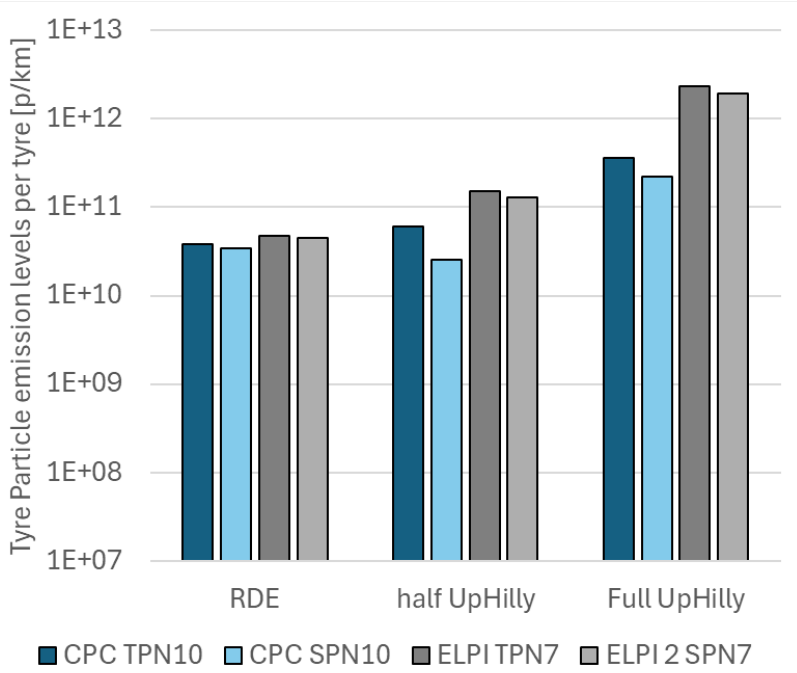


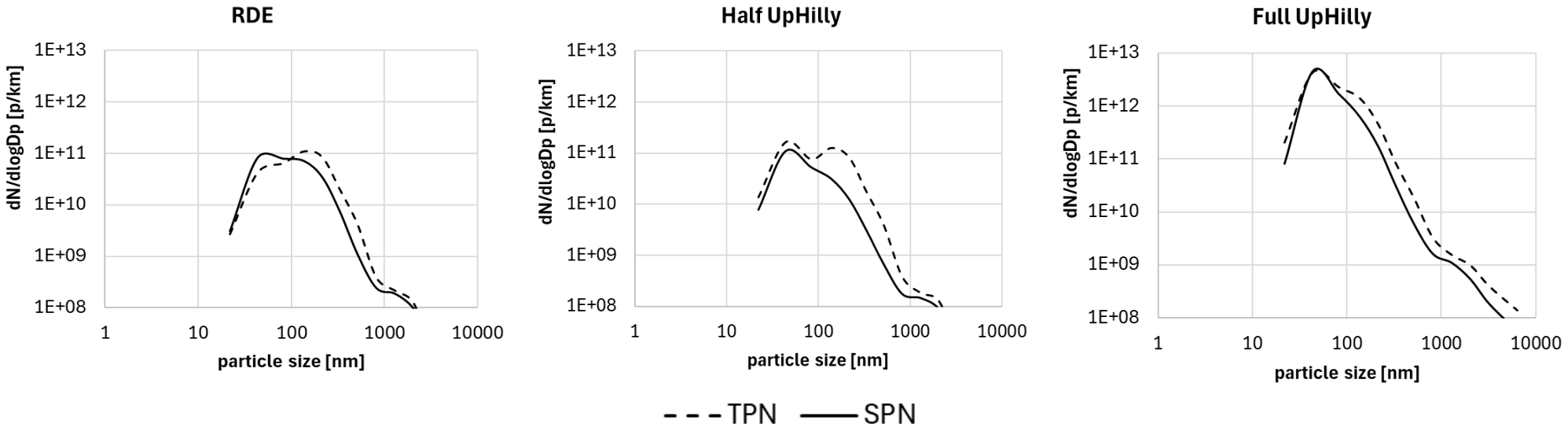
Chassis dyno experiment



Chassis dyno results 1/3

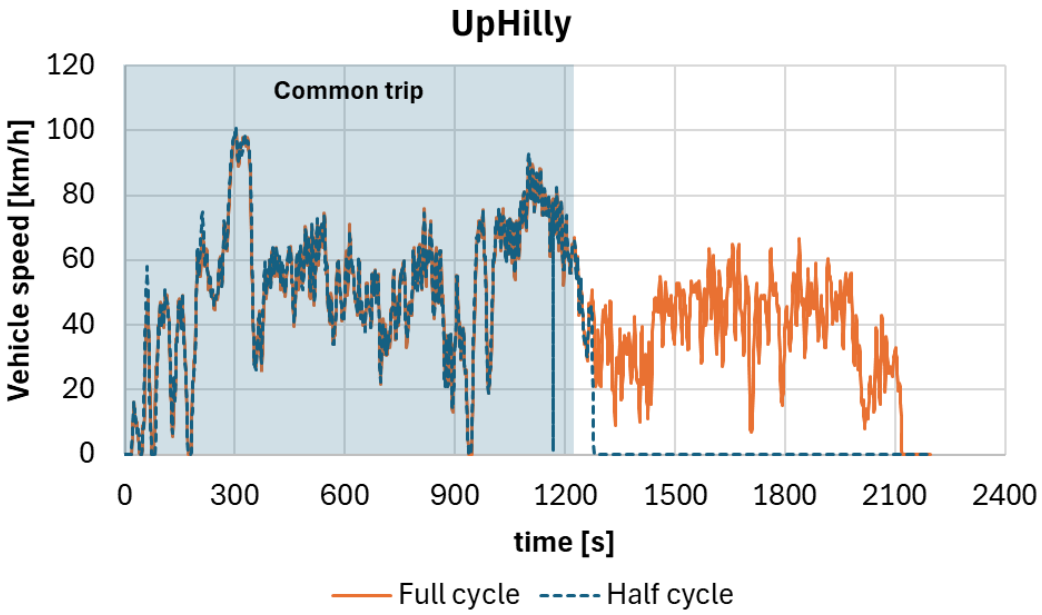
- RDE cycle emits near-zero volatile particles, likely due to lower tyre temperatures.
- UpHilly cycle shows increased volatile particle emissions, likely due to higher tyre temperatures from demanding driving.

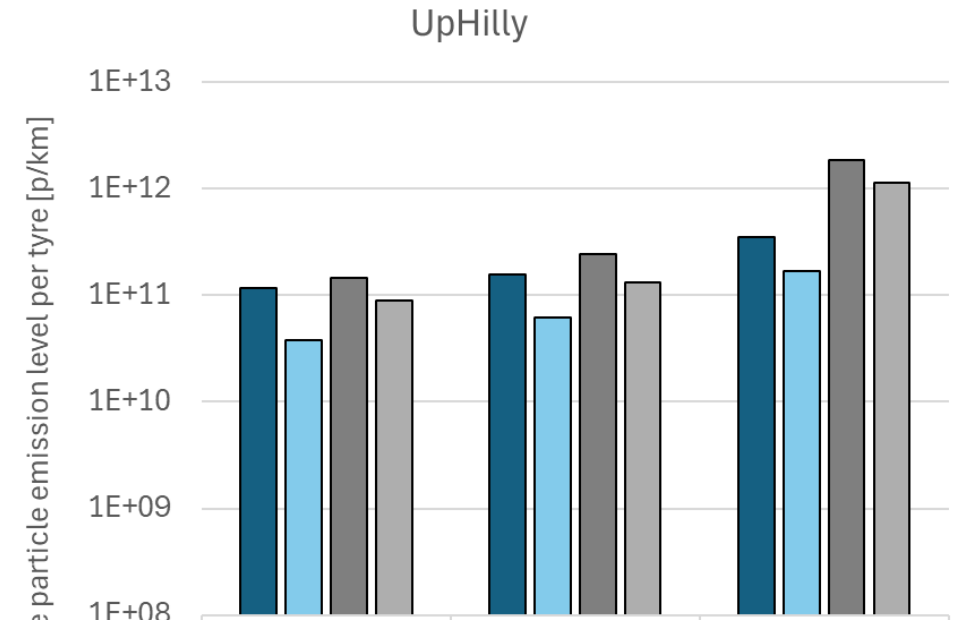




Chassis dyno results 2/3

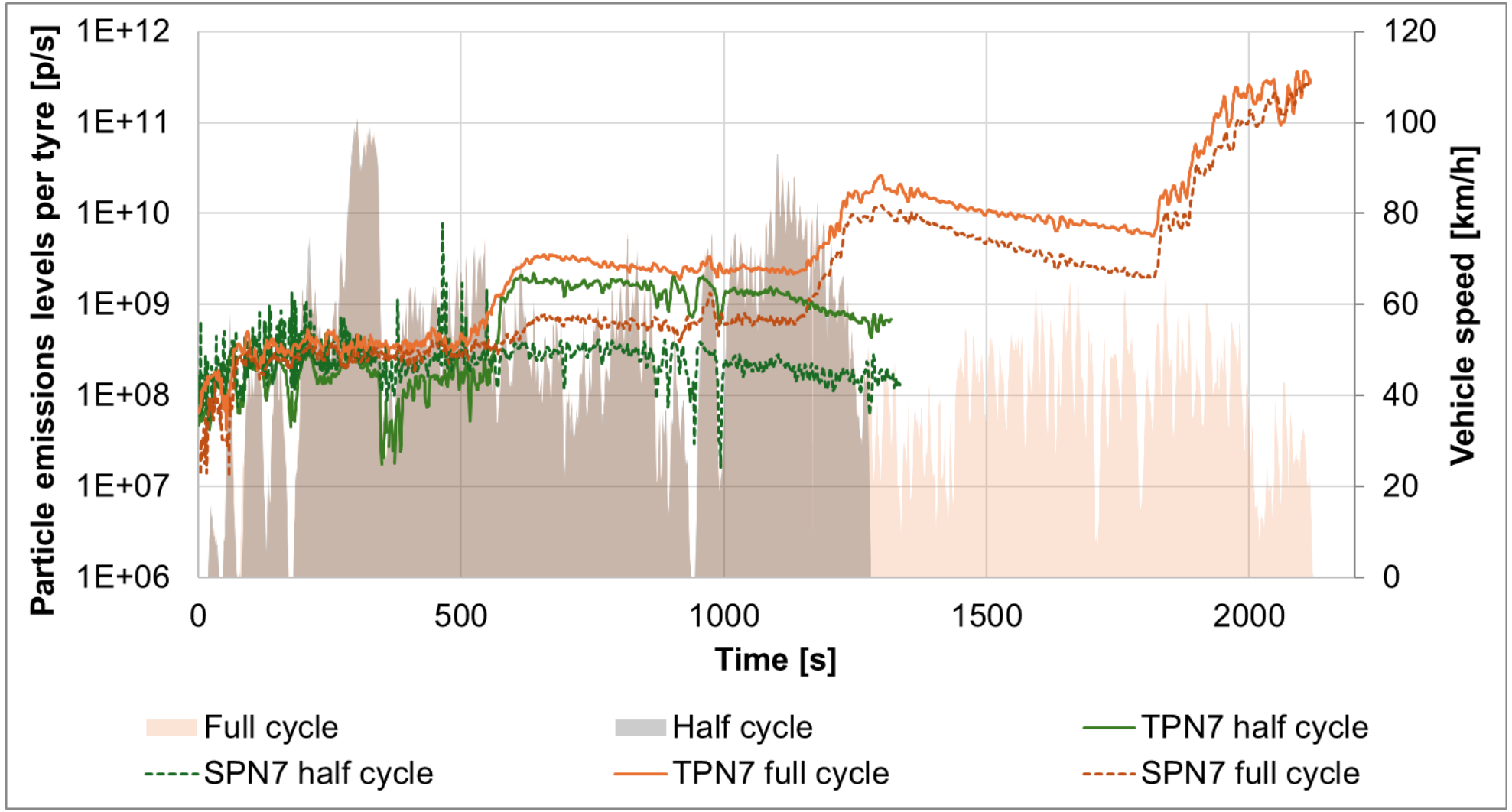
- Comparing the common section of the two UpHilly cycles shows good repeatability.
- Running the full UpHilly cycle results in much higher emission levels.





	Half Uphilly	Full Uphilly common trip	Full Uphilly all trip
CPC TPN10	1E+11	2E+11	4E+11
CPC SPN10	4E+10	6E+10	2E+11
ELPI TPN7	1E+11	2E+11	2E+12
ELPI SPN7	9E+10	1E+11	1E+12

Chassis dyno results 3/3



Conclusions

→ The thermodenuder effectively removes the volatile particle fraction and the ideal operating temperature is 180°C.

→ A volatile particle release was observed at 160°C.

→ Under the most demanding driving conditions, volatile particle release can be observed on the chassis dynamometer.

→ Hotspots for volatile particle release may occur at even higher temperatures, but such temperatures are unlikely to be reached under real driving conditions; therefore, they were excluded from further investigation.

Georgios Tsakonas
PhD Student
e: geortsak@auth.gr

THANK YOU

LABORATORY
OF APPLIED
THERMODYNAMICS
ARISTOTLE UNIVERSITY
SCHOOL OF MECHANICAL ENGINEERING