

# Brake emissions measurement: BREMBO Experimental set-up

16<sup>th</sup> November 2017

---

**PMP – Task Force 2**

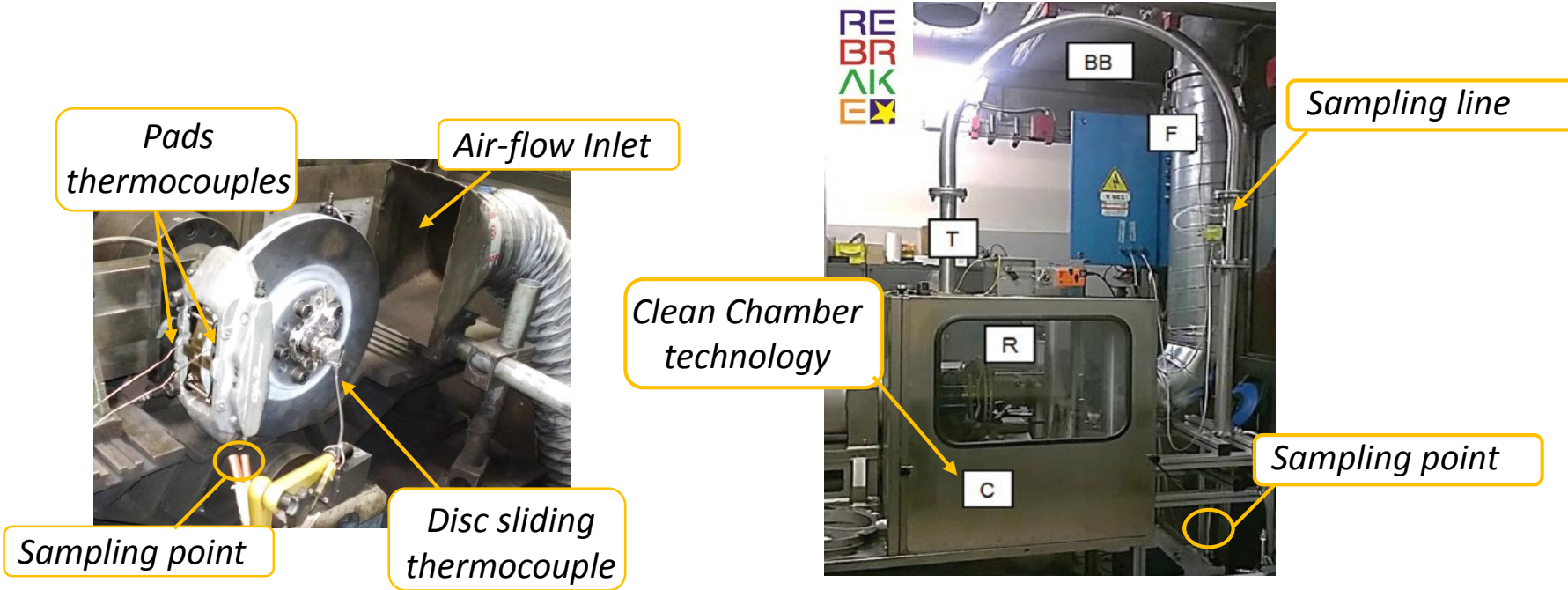
Speaker name: Mattia Alemani (Brembo)

# Agenda

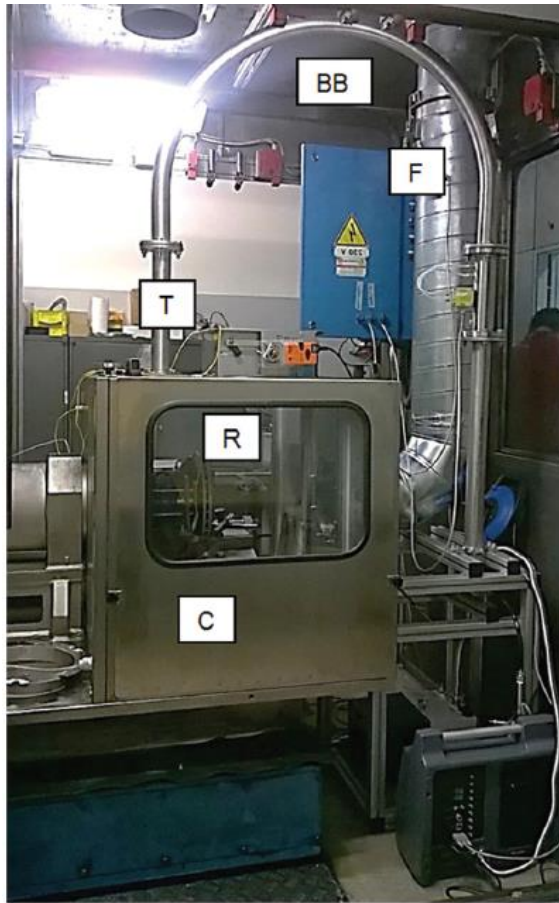


- Background
- The dyno-bench
- Testing procedure
- Outcomes

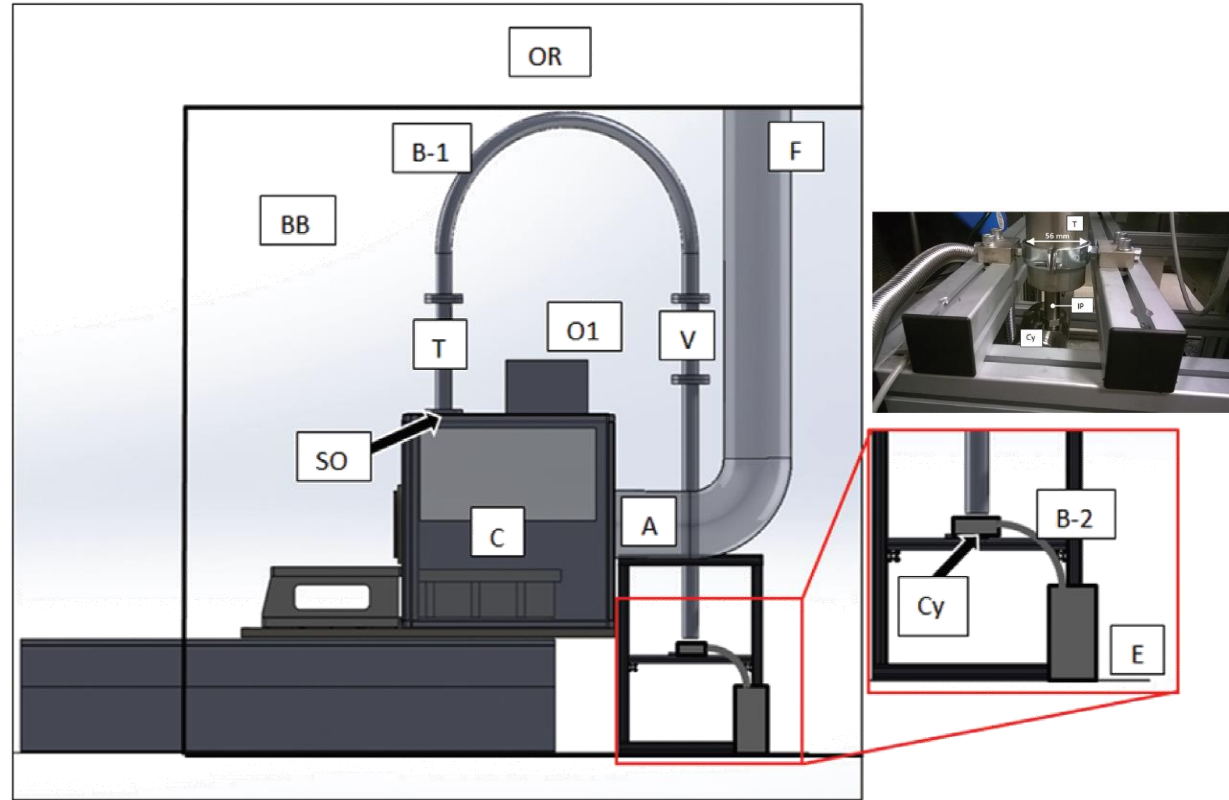
# Background - dyno evolution



# The Dyno-bench



**A photograph of the bench design.** BB: bigger box (door open); F: inlet tube from which clean air enter; T: outlet tube; R: rotor; C: dust-box chamber

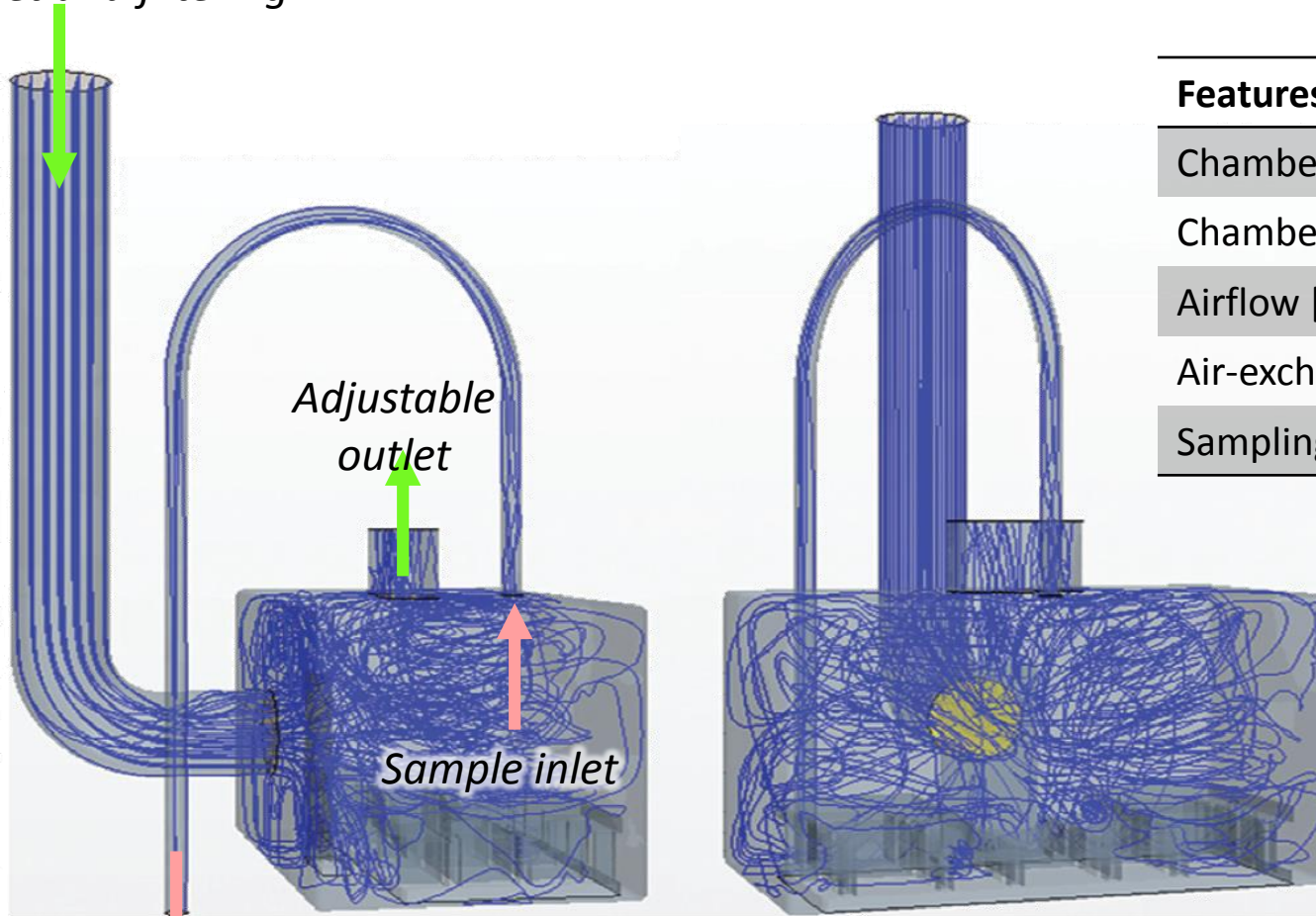


**Schematic diagram of the test stand.** OR: outdoor room; B-1: 0.4m bend tube; F: flow measurement point and filter; BB: bigger box; T: tube; O1: first outlet gap; V: Venturi flow measurement tube; SO: sampling outlet; C: dust-box chamber; A: Air inlet opening; Cy: Cyclone; B-2: 90°, 0.1m bend tube; E: ELPI+® cascade impactor

Source: 2015, Proc IMechE Part D: J Automobile Engineering, p. 1–8

# The Dyno-bench – Fluid dynamics

Air Inlet and filtering



Features	Characteristics
Chamber dimensions [mm]	1296x793x795 (WxLxH)
Chamber volume [m <sup>3</sup> ]	0.817
Airflow [m <sup>3</sup> /h]	1175 ( adj. 500-2500)
Air-exchange [# /min]	24.0
Sampling speed [m/s]	3.47

$$\eta_{\text{total}} = 90.8 - 98.6\% \quad (d_{\text{particle}} 10\mu\text{m})$$

$$\eta_{\text{total}} \approx 100\% \quad (d_{\text{particle}} 1\mu\text{m})$$

Source: 2015, Proc IMechE Part D: J Automobile Engineering, p. 1–8

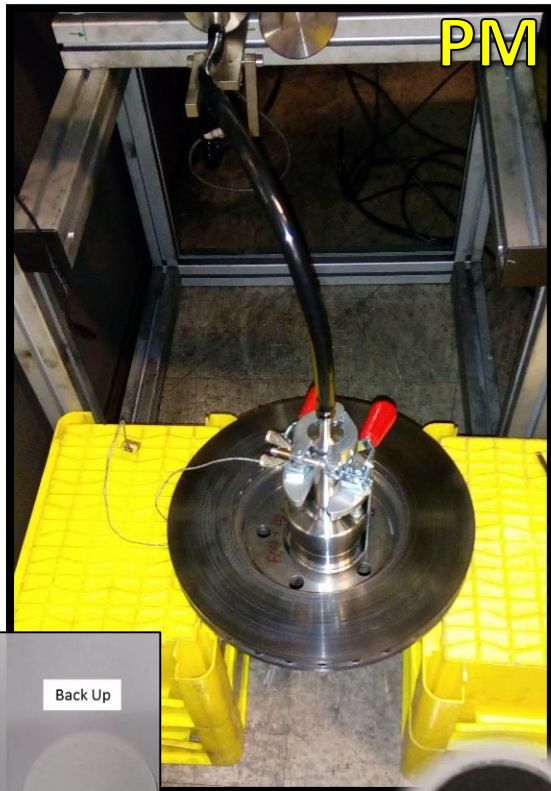
# The Dyno-bench – Parameters



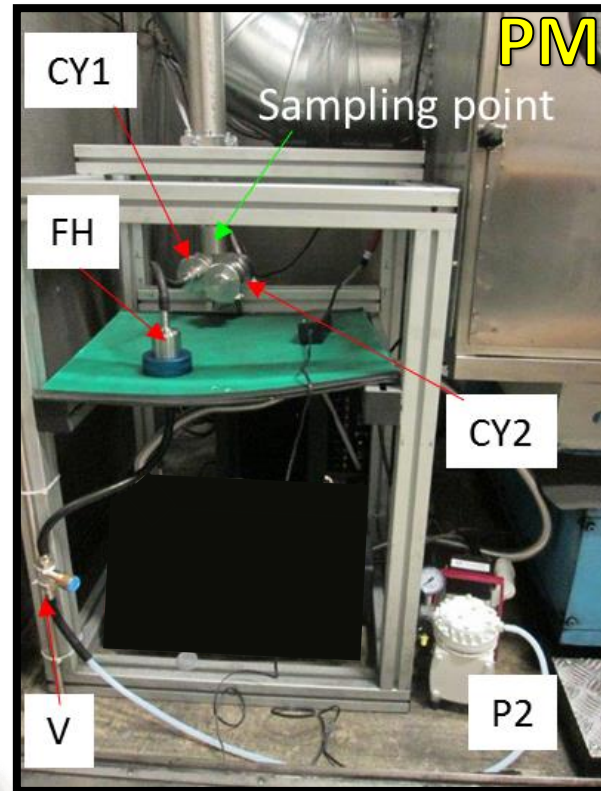
Parameter	Dyno Bench
<b>Wear</b>	Measured after test (weights/thickness)
<b>Pressure</b>	Applied
<b>Torque</b>	Torque transducer
<b>Friction</b>	Calculated
<b>Disc Temperature</b>	1 k-type thermocouple
<b>Pad Temperature</b>	2 k-type thermocouples (one for each pad)
<b>Sliding velocity</b>	Imposed/measured
<b>Flow rate</b>	Imposed (1 full exchange every 3s)
<b>PN/PM</b>	Elpi+ (with collection)/47mm filter (Quartz)/ PM10 Impactor (Al+glass fiber filters)

# The Dyno-bench – Particles sampling

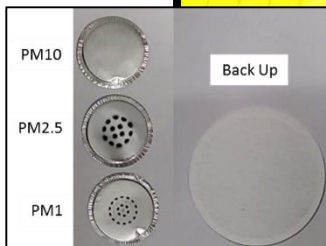
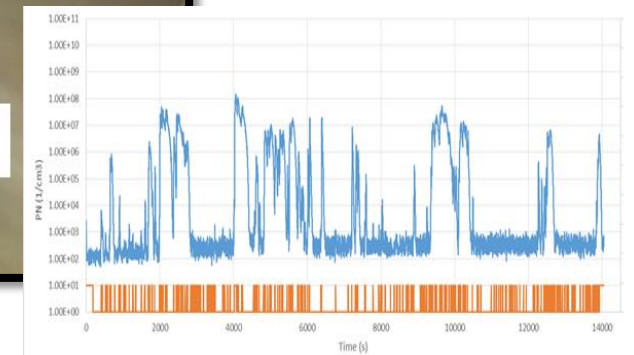
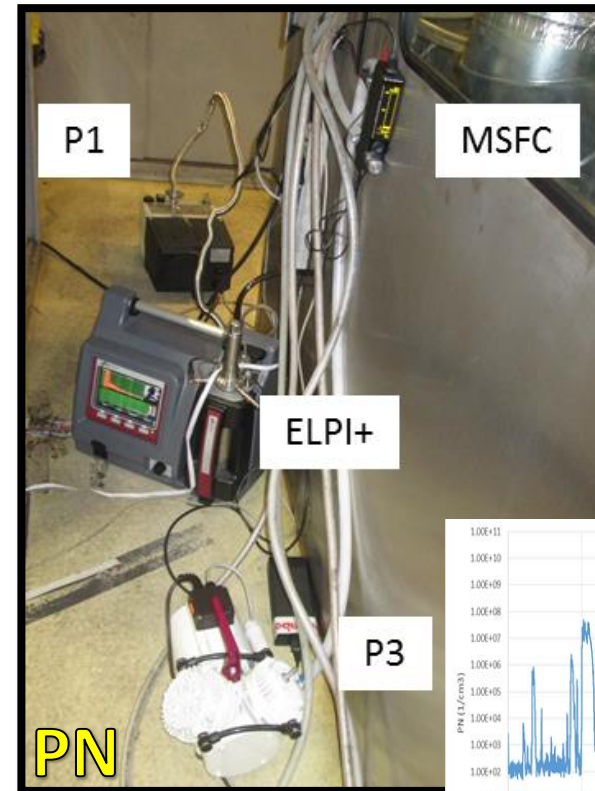
PM10 impactor



Filter Holder



ELPI+



# Testing procedure – PN measurement

Dekati® ELPI+ (*Electrical/ Impactor*)  
6 nm – 10 μm



Particles are collected on aluminum foils to allow subsequent chemical characterization

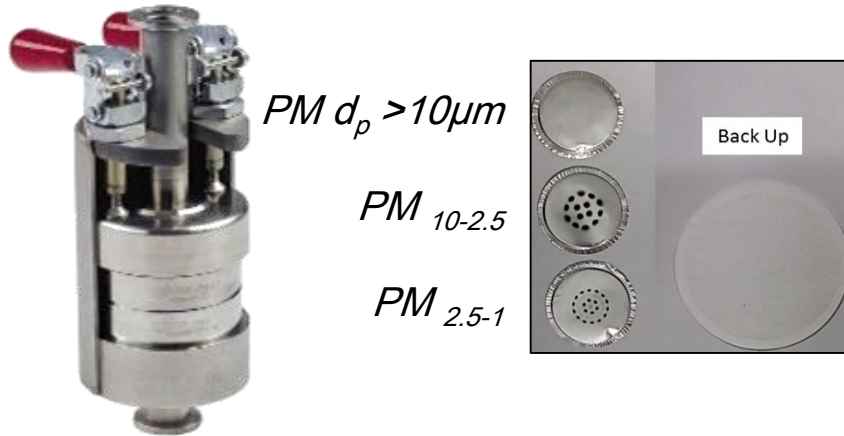




# Testing procedure - PM measurement

Dekati® PM10 impactor

$d_{particle} < 10 \mu m$



Filter Holder (47mm)

$d_{particle} < 10 \mu m$



$$PM10_{imp} = PM_{10-2.5} + PM_{2.5-1} + PM1(backup)$$



$PM10_{filter\ holder}$

Conditioning parameters:

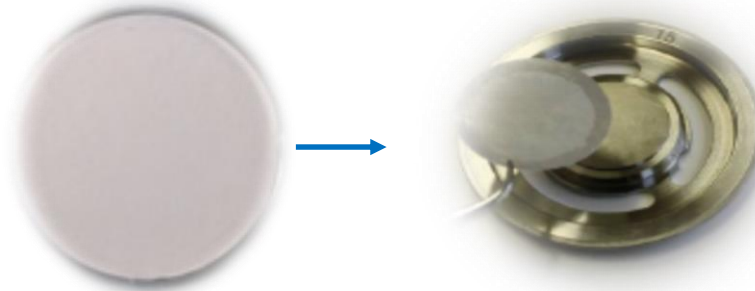
$RH=50\%$ ,  
 $T=20^\circ C$   
 $time=24h$

# Testing procedure - PM measurement

## 24h Filters Conditioning and weighting



## Assembling



$w_{filter}$

## Testing

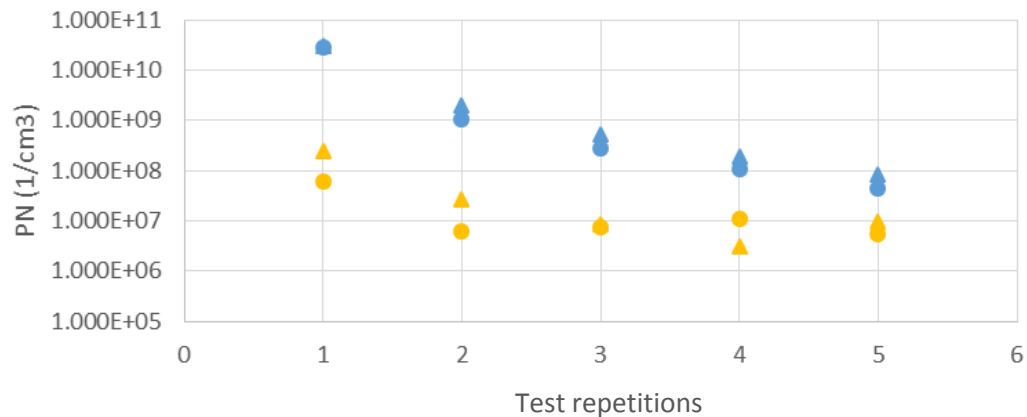
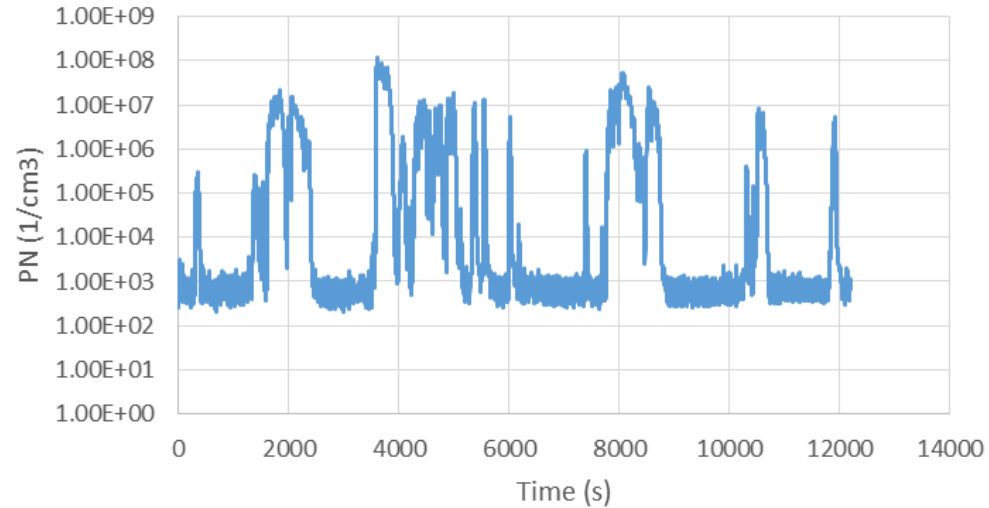


$$w_{test} = w_{filter} + w_{PM10}$$

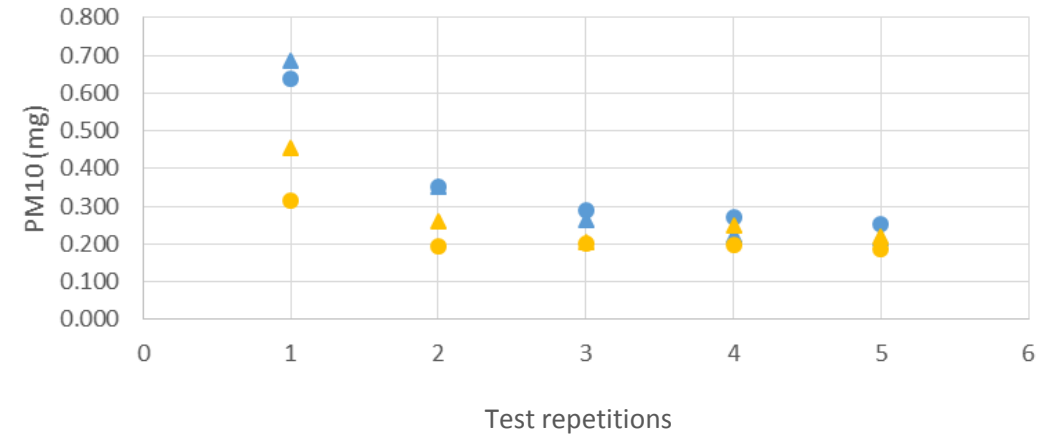
$$PM10 [g] = w_{test} - w_{filter}$$

# Outcomes

## PN - Particle number [# / cm<sup>3</sup>]



## PM - Particle mass [g]



### LEGEND

- ▲ Frictional couple 1 – rep 1
- Frictional couple 1 – rep 2
- ▲ Frictional couple 2 – rep 1
- Frictional couple 2 – rep 2

# Thank you!



[www.lowbrasys.eu](http://www.lowbrasys.eu)

Mattia\_alemani@brembo.it

ConsulenteDatab\_Riccobono@brembo.it