Preliminary Results for Brake Wear Particle Emission PN and PM Concentration and Size Distribution Measurements

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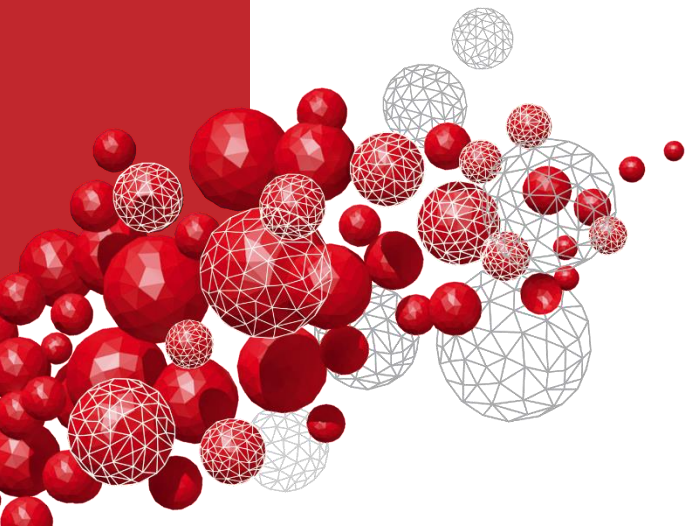
ITT, J. Vanhanen, Airmodus ltd.



50th PMP meeting 3-4 April 2019 Brussels

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DEKATI

DEKATI Ltd. –Excellence in Particle Measurement

- Sales, manufacturing and development of fine particle (aerosols) measurement solutions (automotive/power plant emissions, pharmaceutical, air quality, nanotechnology, defence, science/R&D etc.)
- Core competence: Real-time fine particle size & concentration measurement and sample conditioning technologies
- Privately owned technology spin-off company from TUT Aerosol Physics Lab (1994)
- Located in Kangasala Finland
- Exports ~ 95 % of sales, distributors in ~35 countries worldwide
- ~20 high-know-how employees

Airmodus Ltd

It’s the small things that count

Founded in 2010

Spin-off from the University of Helsinki by a group of aerosol experts specialized in nanoparticle detection

Offers particle detectors capable of detecting nanoparticles starting from 1 nm is diameter

Located in Helsinki, Finland

AIRMODUS

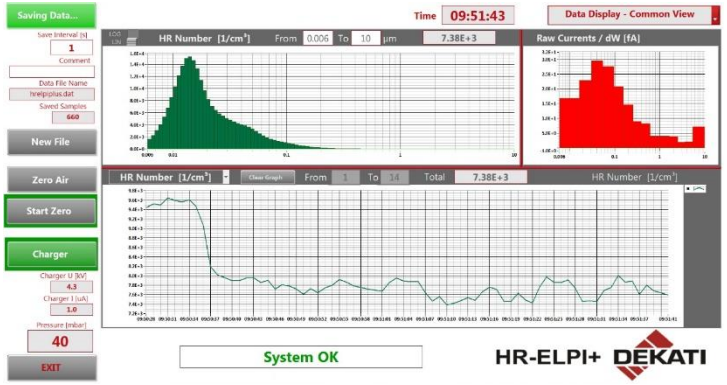
Gas Phase Nano particles Particles emitted by Traffic Pollen

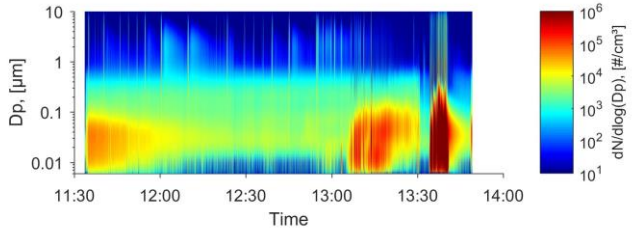
Goal of the study

- Part 1 of longer measurement campaign, part 2 not yet completed
  - Ford WLTP test cycle
- Determination of brake event repeatability
  - Size distribution, real-time behaviour
- Testing of brake dyno, WLTP cycle and temperature dynamics
- Instrument development
- Determination of system operation and instrument operation
  - ELPI+, CPC a20, eFilter (DC+mass)
  - NOT a full instrument comparison!

ELPI®+: Electrical Low Pressure Impactor

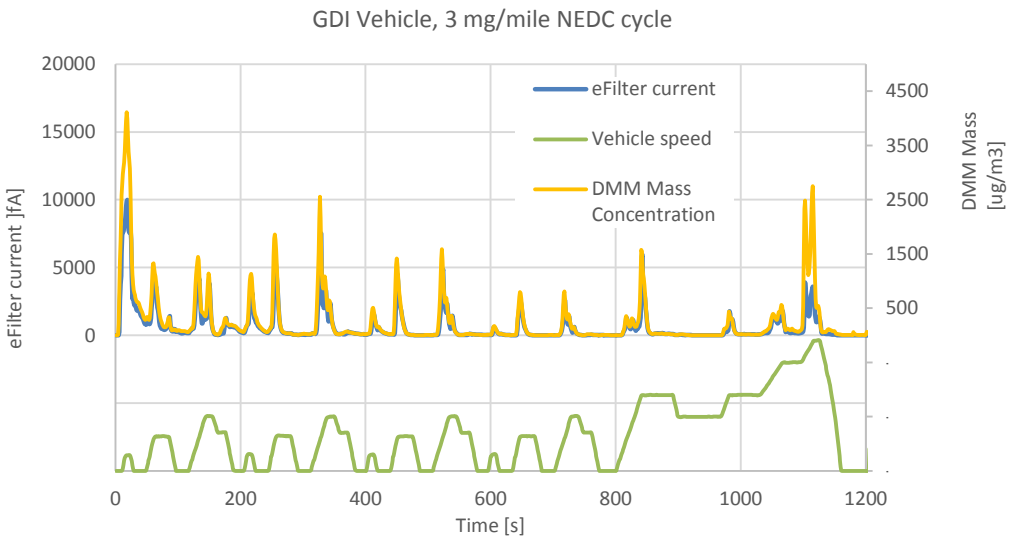
- Number size distribution and concentration
  - Real-time, 10 Hz
- 6 nm - 10 µm
  - 14 size fractions
  - 100 or 500 with High Resolution ELPI®+
- Particles are collected
  - Possibility for chemical analysis on the collected samples
- Wide dynamic range
  - From outdoor air to power plant stack concentrations
- High Temperature (HT-ELPI®+)
  - For undiluted sampling a up to 180ºC

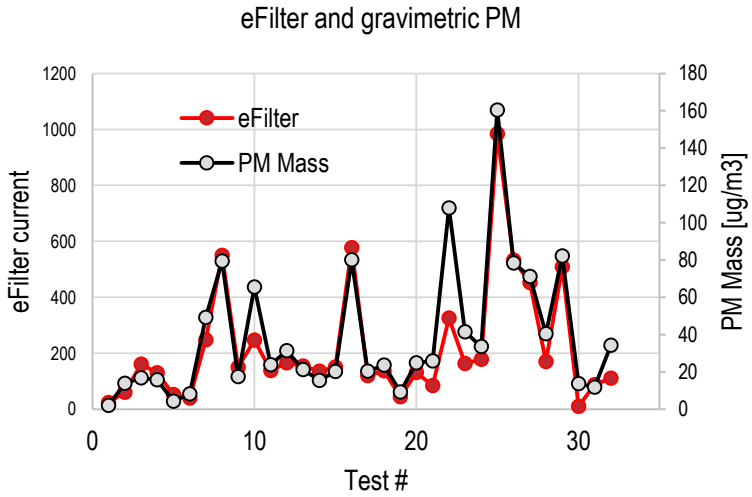




Dekati® eFilter™

- Standard gravimetric PM filter holder
- Real-time measurement of PM accumulation on the filter
- Both standard and gravimetric measurements integrated in one instrument
- Fully automated operation





Niemelä et al. 26th CRC Real World Emissions Workshop
Data courtesy by Ford Motor Company

Airmodus A20
butanol Condensation Particle Counter

Robust CPC for long term measurements

SPECS:

One flow design with 50% cut-off at **10 nm** (can be delivered with cut-off from 5-10 nm)

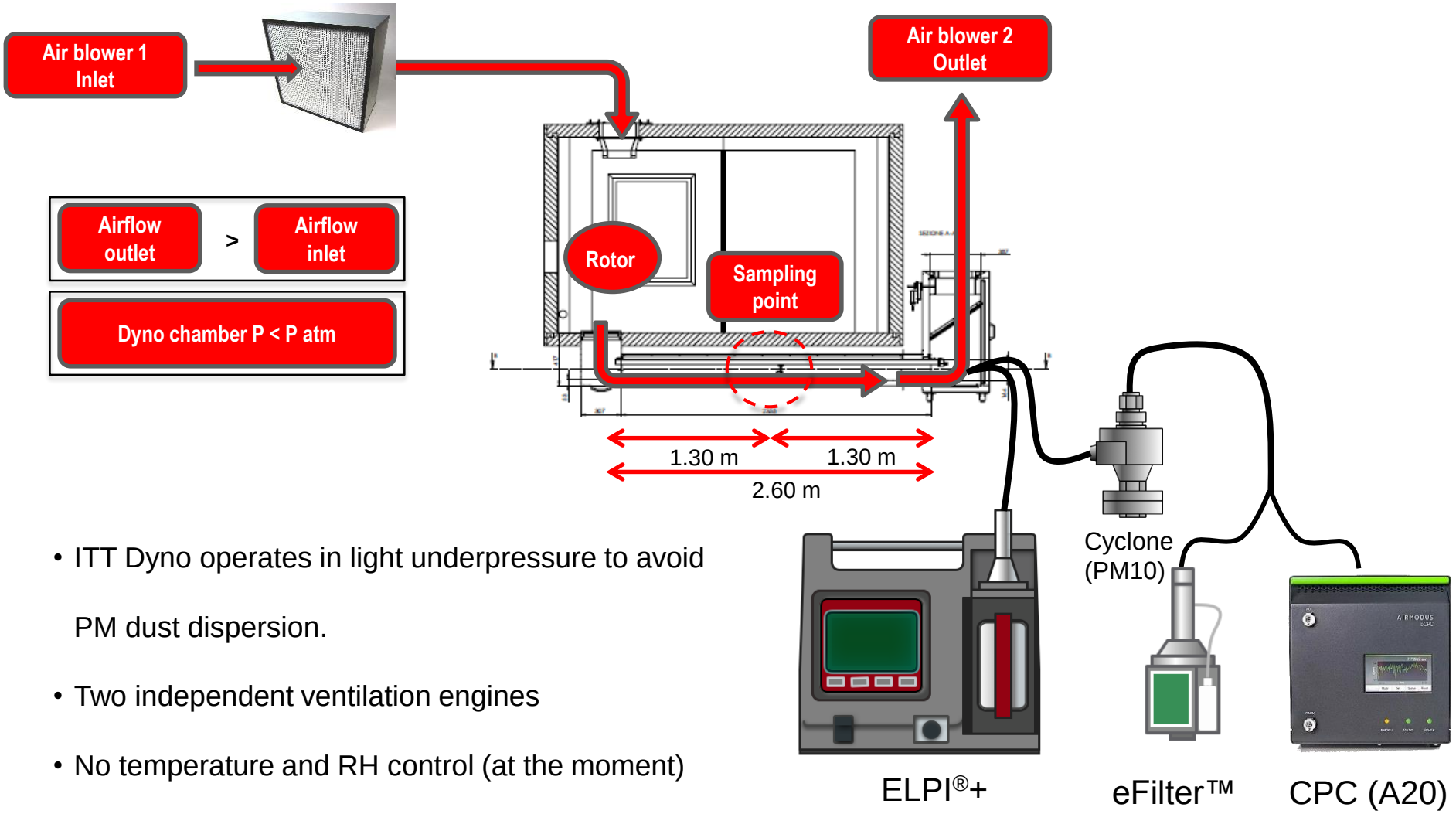
Total aerosol particle number concentration with single particle detection from **1-30 000 #/cc**

Every CPC is calibrated for size cut-off and different particle concentrations up to **100 000 #/cc**. Calibration curve fit provided with the instrument.

Designed to be used as stand-alone, with the Airmodus A10 PSM, or within an integrated measurement system such as DMPS, SMPS or PMP.

Measurement setup

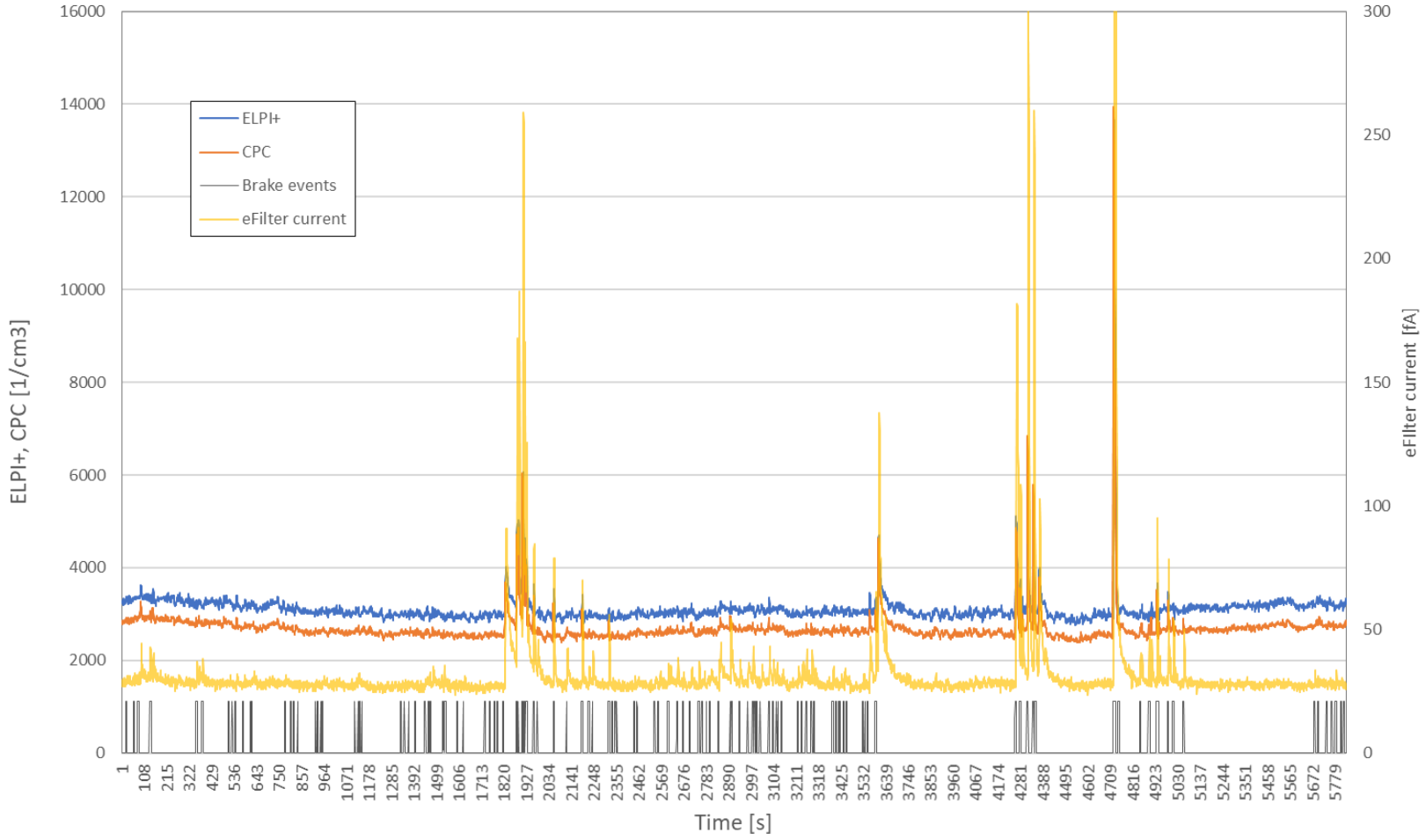
Filter system: 1° G4, 2° F9 , 3° H13



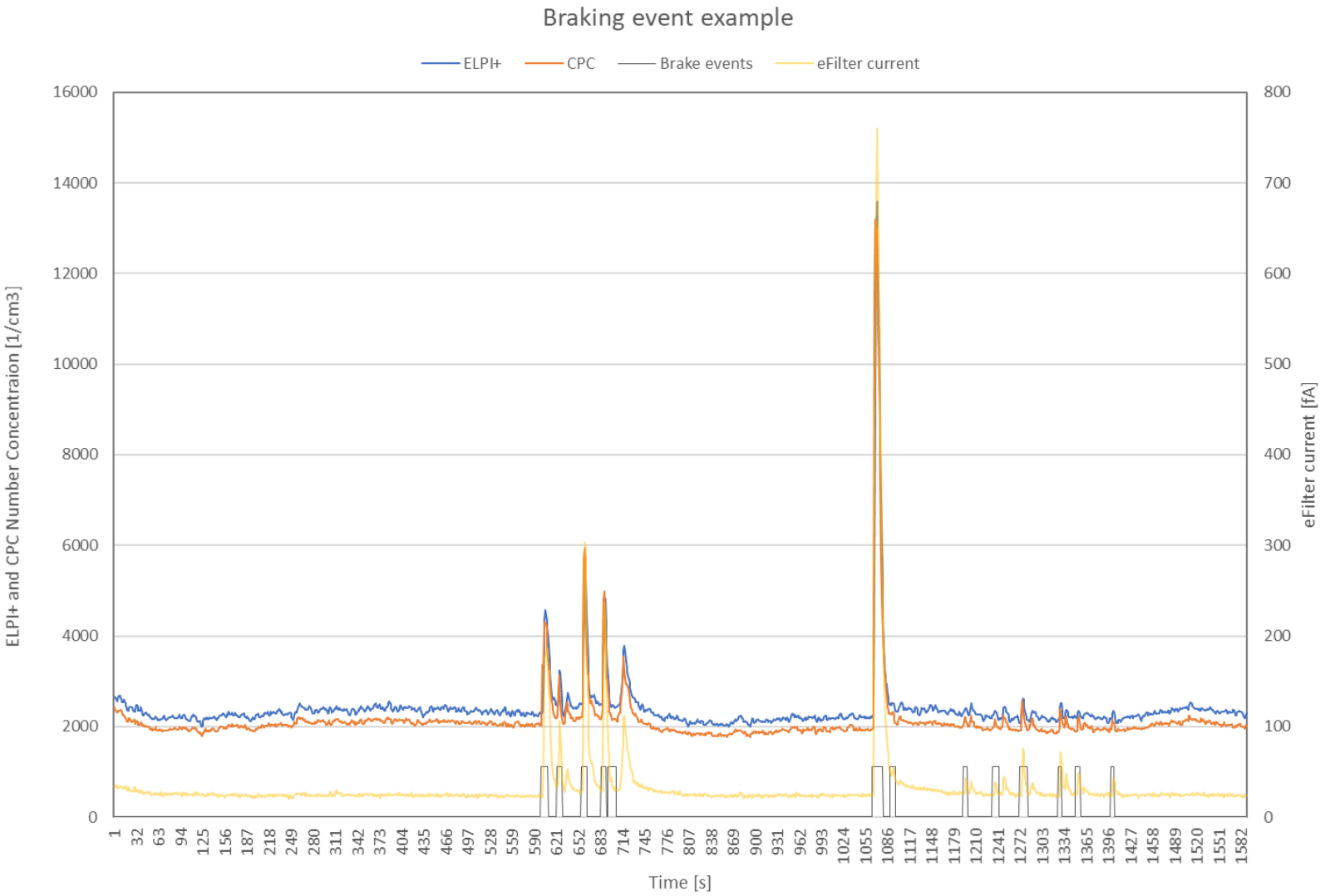
- ITT Dyno operates in light underpressure to avoid PM dust dispersion.
- Two independent ventilation engines
- No temperature and RH control (at the moment)

Measurement Setup

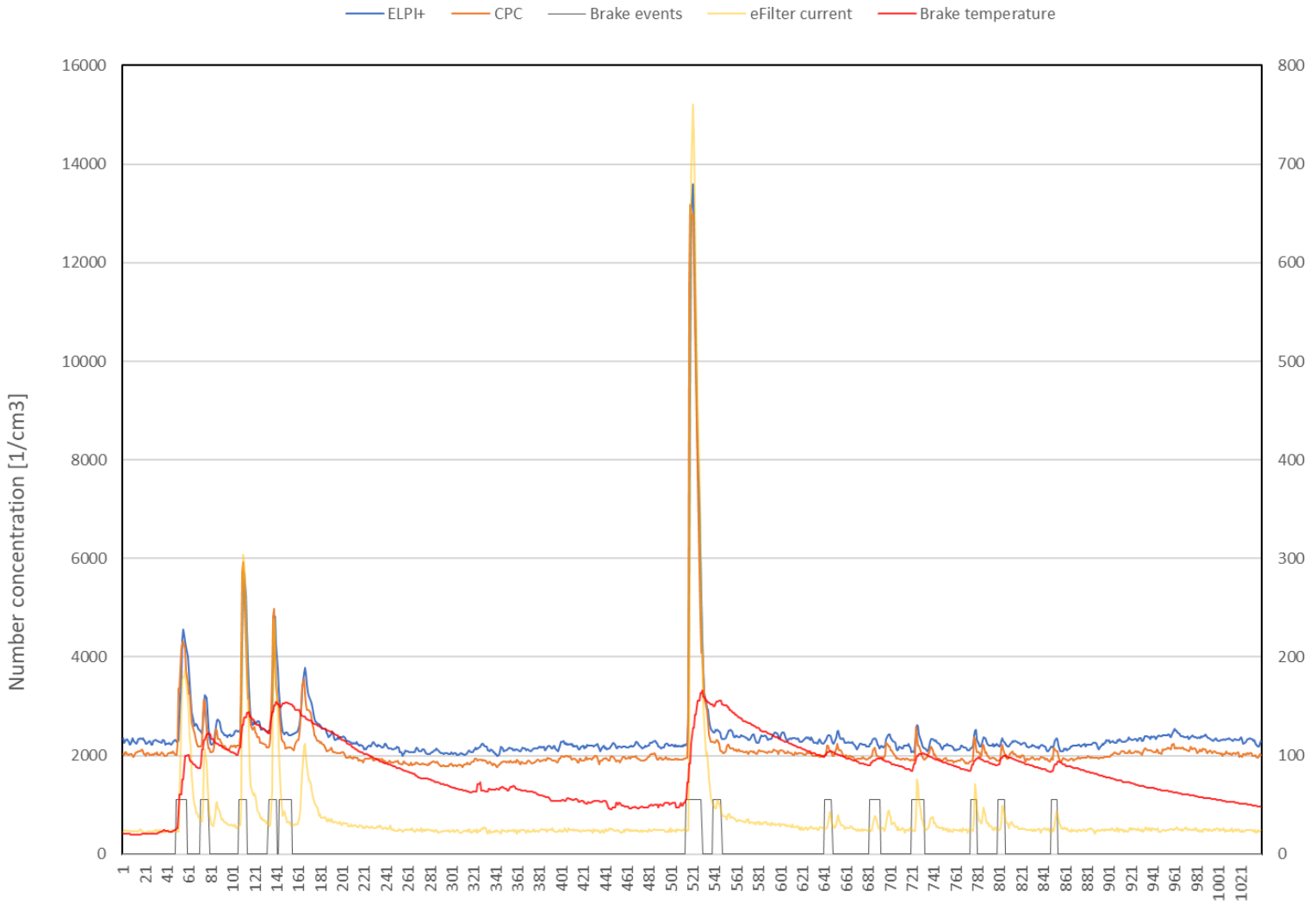
Brake event determination



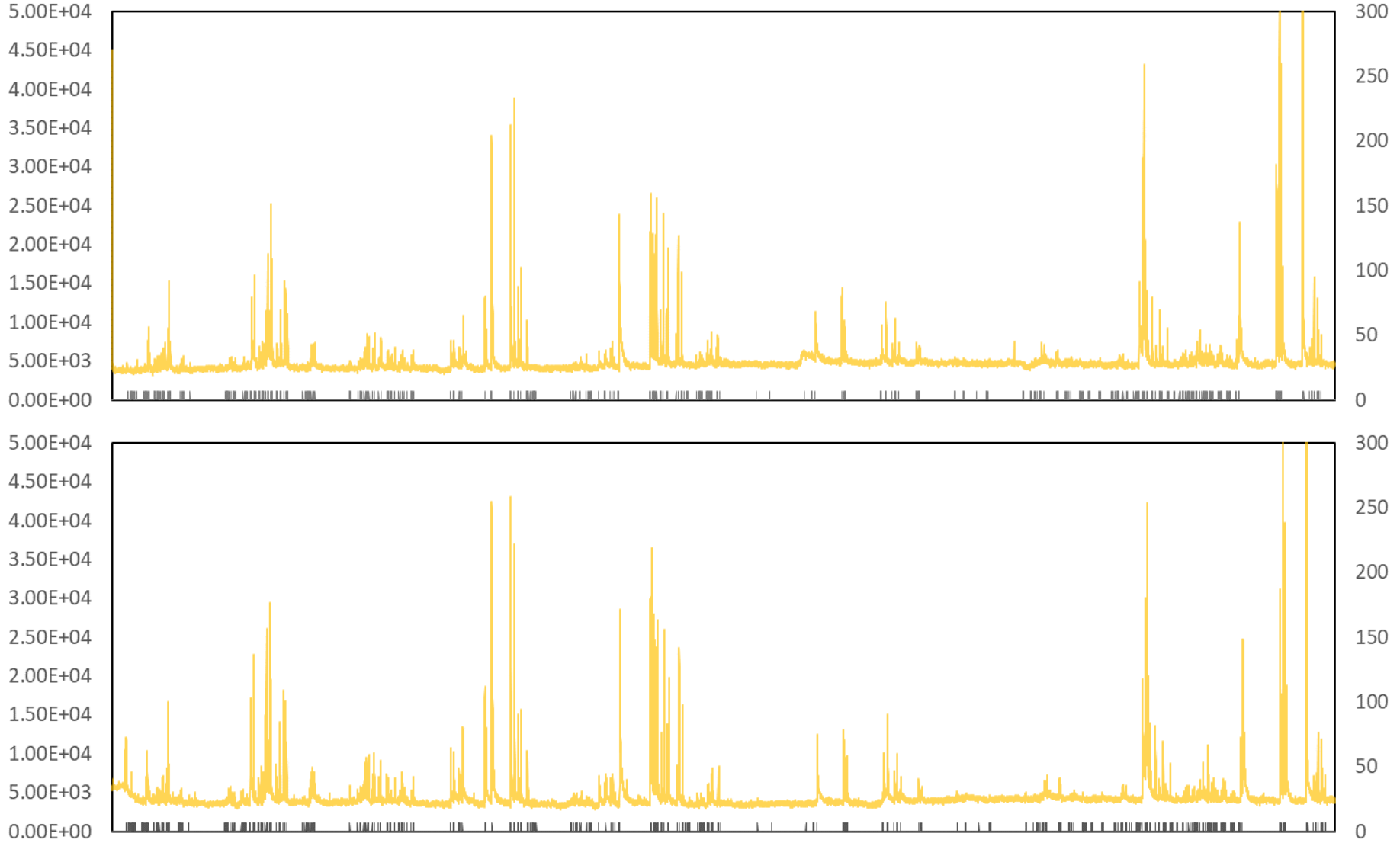
ELPI+ vs CPC concentration & brake events
Example with eFilter current



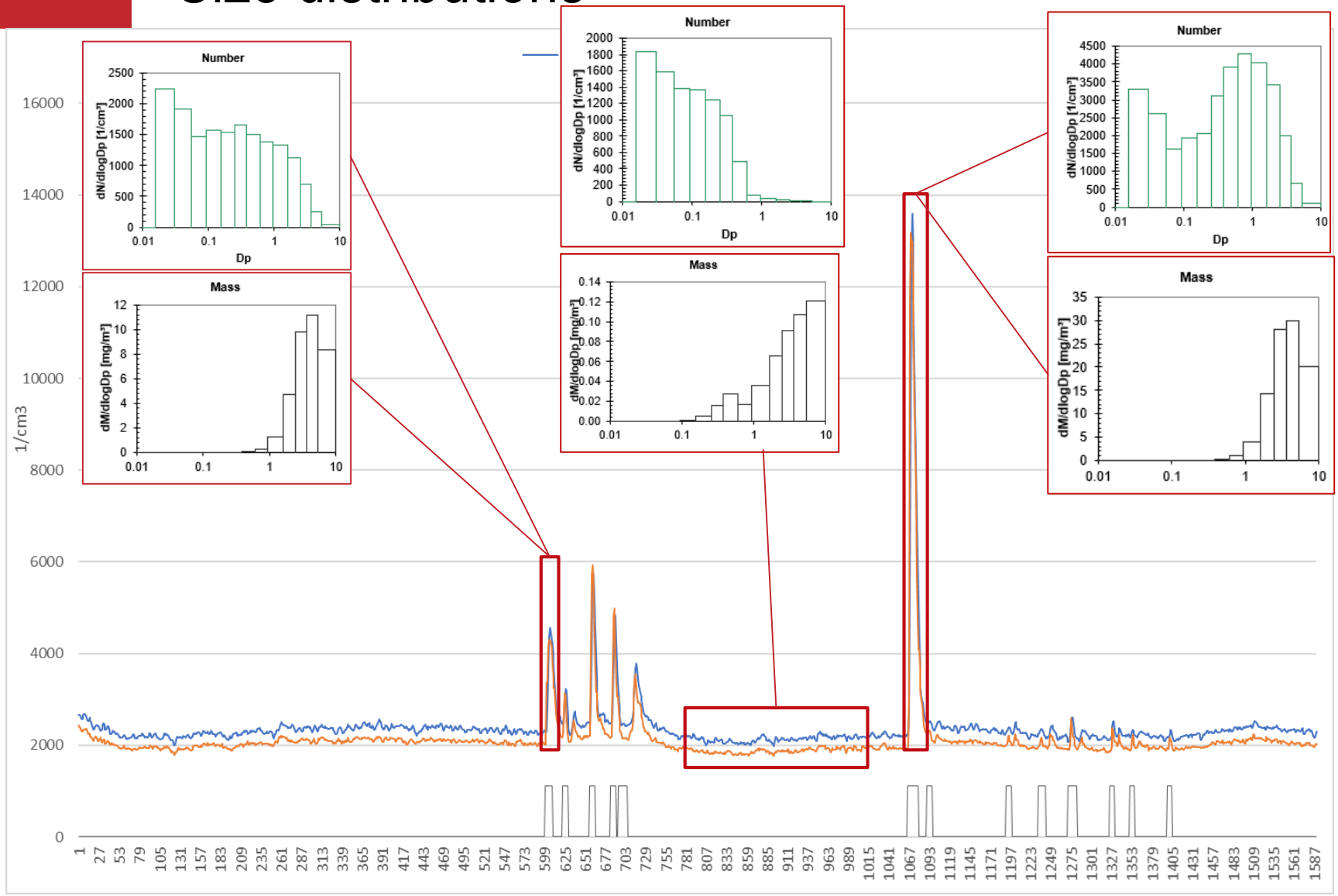
ELPI+ vs CPC concentration & brake events
Example with eFilter current and brake temperature



Repeatability (eFilter)

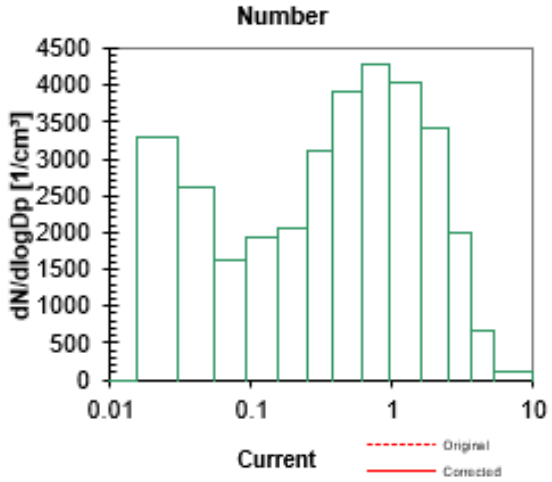


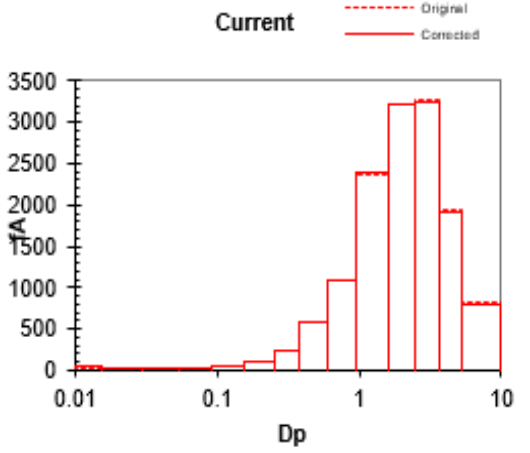
ELPI+ vs CPC concentration & brake events
Size distributions

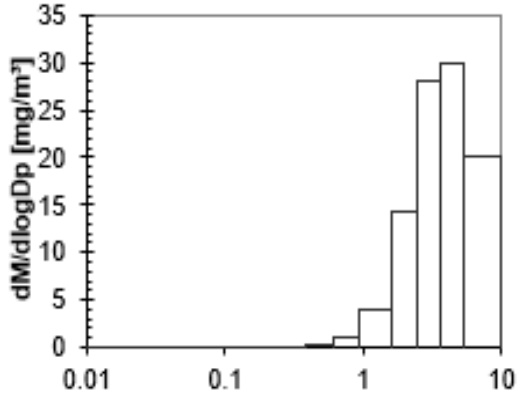


Size distributions

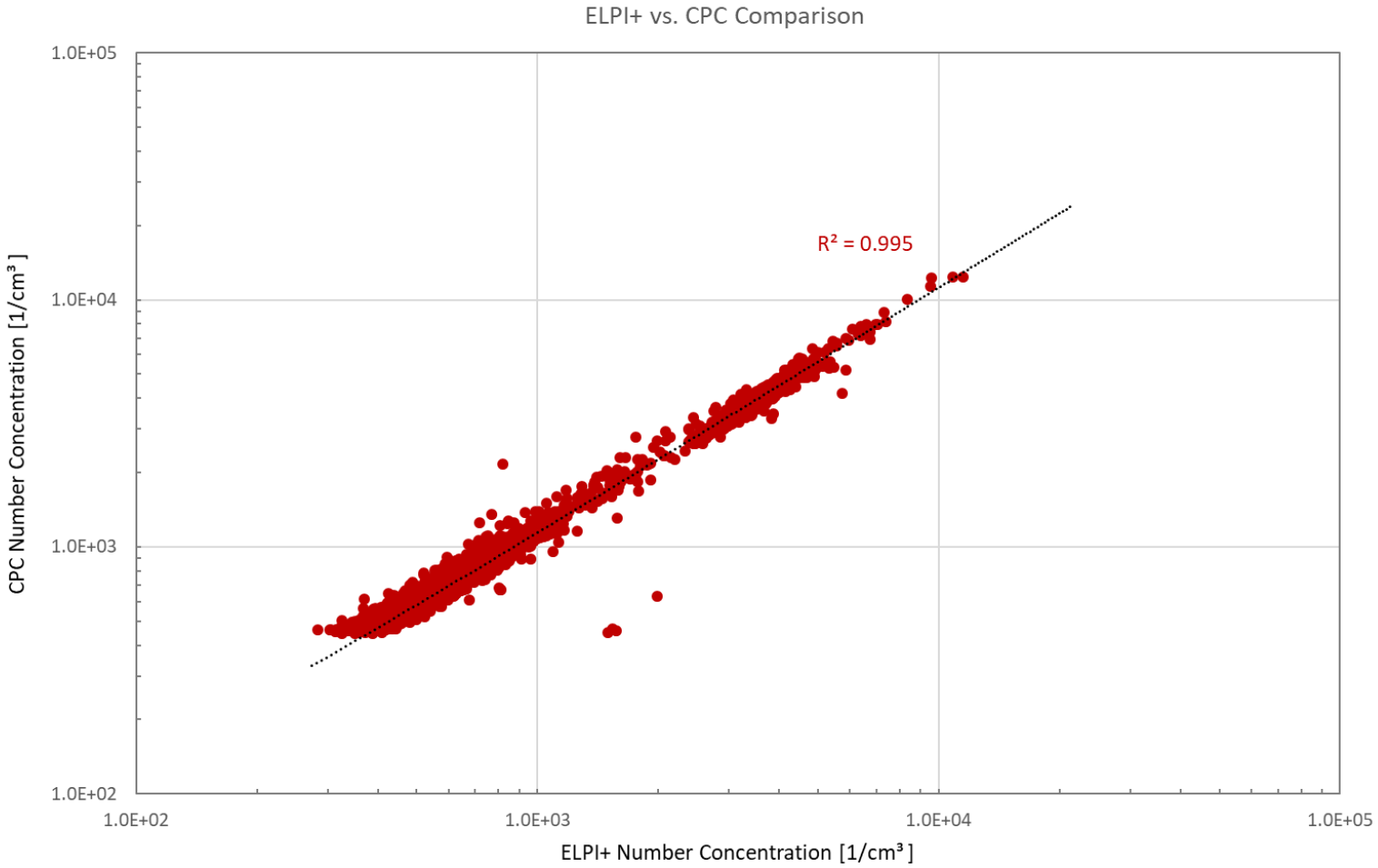
- Brake event peaks repeatable and shape rather constant
- Wide size distibution
- Nucleation, accumulation and coarse modes visible
- Mass dominted by >1 um
- Even number concentration show coarse fraction



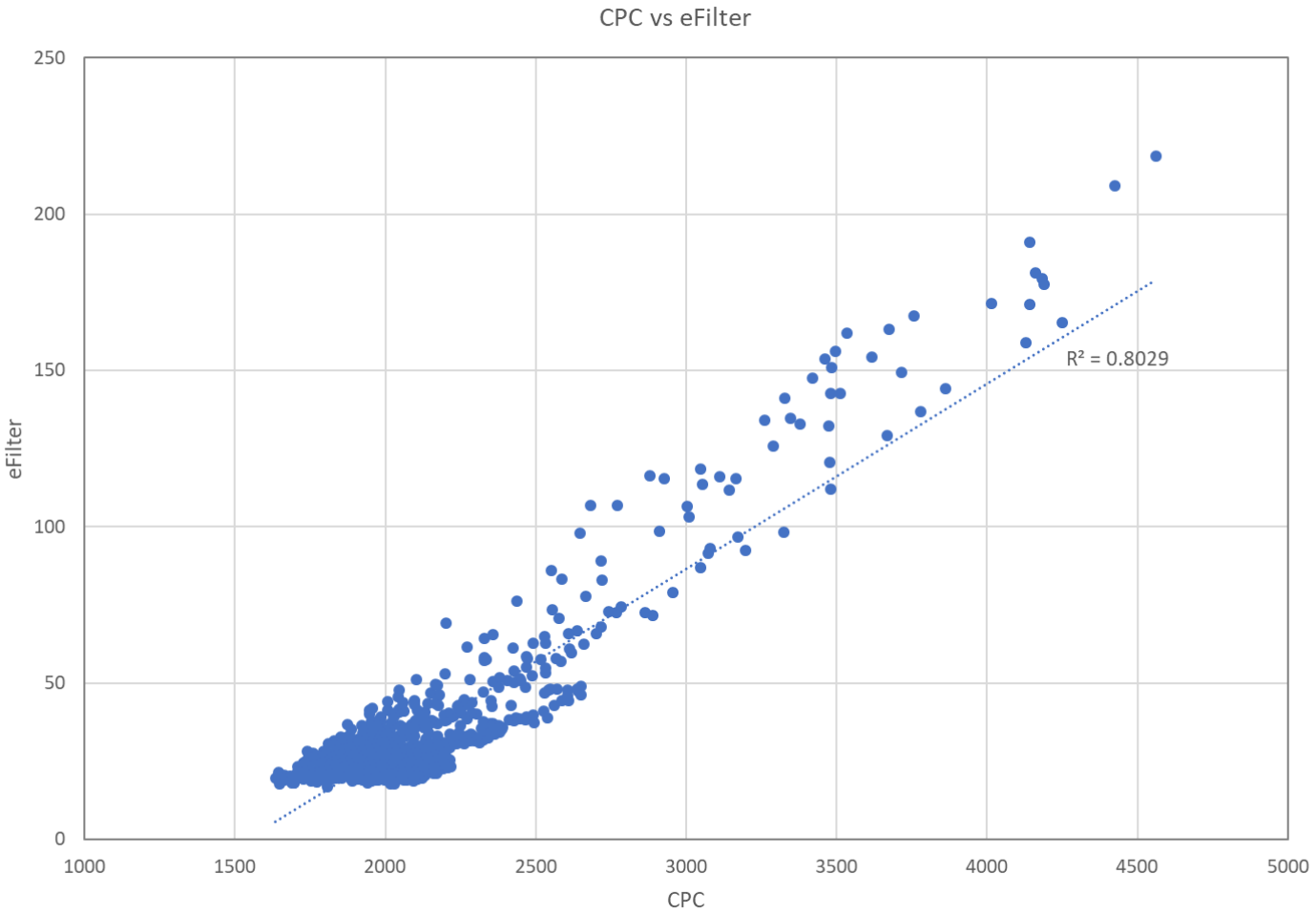




ELPI+ vs. CPC



CPC vs. eFilter



Total mass, eFilter collection vs. ELPI®+

- eFilter collected 2.2 mg over the whole measurement period (3 WLTP cycles plus some background periods)
  - Flow 10.1 lpm, sampling time ~ 28h 57min(10:18 (8/1/2019) - 15:15 (9/1/2019))
  - Average PM10 mass, by total sampling time: **0.130 mg/m^3**
  - Average PM10 mass, divided by actual cycles(~18h): **0.202mg/m^3**

- ELPI®+ average mass concentrations (mg/m3):

Cycle no.	PM10	PM2.5	PM1
1	0.230	0.054	0.012
2	0.236	0.055	0.017
3	0.278	0.055	0.015

Preliminary tests -observations

- Good dyno and temperature operation and results
- Particle instruments working well
- Concentrations in operational range (low for the PM mass)
- ELPI+ vs. CPC PN correlation very good
- ELPI+ vs. eFilter SA/LDSA (current) very good
- ELPI+ distributions very good
- eFilter braking spike resolution good

- Dyno system under modifications
- Future work
  - Loss modelling
  - PM10, PM2.5, impactor mass analysis
  - Cycle emission estimations

Thank you!

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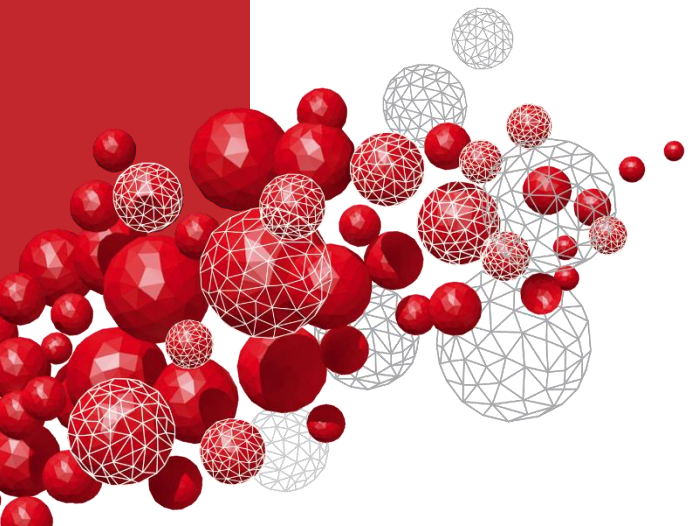

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