
AVIATOR

# AVIATOR PROJECT: Aircraft engine exhaust stack PM characterisation at INTA's test facility

V. Archilla, D. Hormigo, J. Sánchez-Valdepeñas, M. Sánchez-García, P. Moreno, A. Crayford, M. Pujadas, J. Rodríguez-Maroto, I. Ibarra, E. Rojas, D. Raper & M. Johnson

Corresponding author e-mail: archillapv@inta.es

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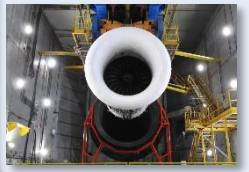
# Rationale

Standardize Measurement Systems for Aircraft Engine Emissions campaigns



**WP2**

1. Certified test cell engine exit,
2. In stack plume

**WP3**

1. On-wing engine exit
2. Downstream plume
3. APU

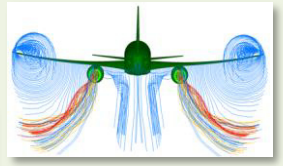
**WP4**

1. Airport Ambient measurements
2. Sensor network development

Create new knowledge on Aircraft exhaust and Airport pollutants Modelling

**WP5**

1. Physical dynamics of the exhaust plume
2. Microphysics and chemistry of pollutants



**WP6**

1. Numerical modelling and transport in and around airports
2. Prediction of airport's contribution to LAQ

Bridge the gap between Aircraft Engine Certification and Local Air Quality (LAQ) Regulations

**WP7**

Aircraft engines and LAQ regulation

**WP8**

Communication, dissemination and exploitation

European Agency for Safety and Health at Work

European Environment Agency



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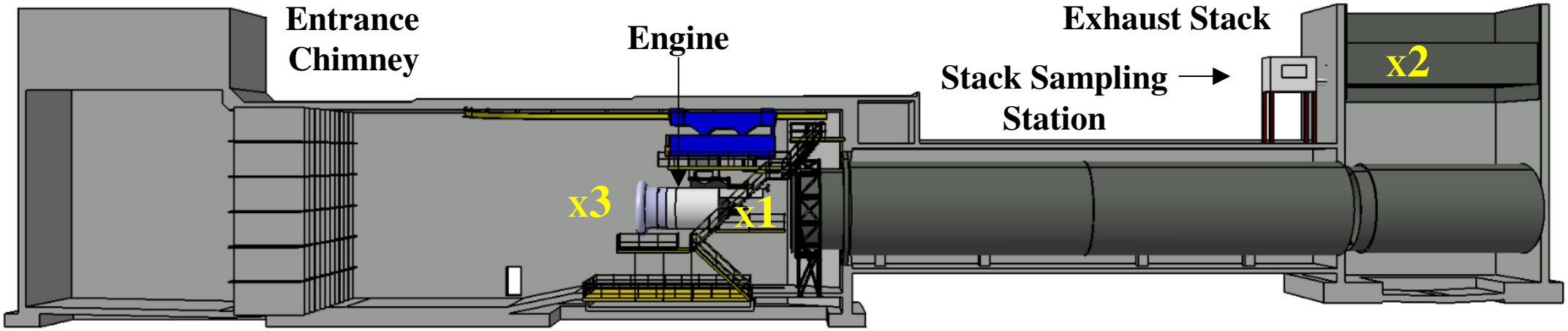
# AVIATOR: WP2




**x1 COMPREHENSIVE SYSTEM (Dedicated)**

- vPM mass and composition
- Total PM mass and VOC composition
- SOA gaseous precursors)
- VOC gas composition
- Smoke

**EASA Reference System (>10 nm)**

- nvPM number conc.
- nvPM mass conc.

**Off line analysis**

- Total PM mass conc.
- Chemical composition (morphology)

**x3 BACKGROUND**

- Total PM number & size dist.
- Gases: UHC, $CO_2$, CO, $NO_x$, $SO_2$
- T
- P
- RH

**x2 BASELINE SYSTEM (Piggyback & Dedicated)**

- Total PM number conc. (>7 nm)
- PM size dist. (>5 nm)
- nvPM number conc. (>7 nm)
- $CO/CO_2$ conc.
- nvPM mass conc.
- nvPM size dist.

**Off line analysis**

- Total PM mass conc.
- Chemical composition (morphology)

**Piggyback tests** have been carried out in parallel with the **baseline system** design and development

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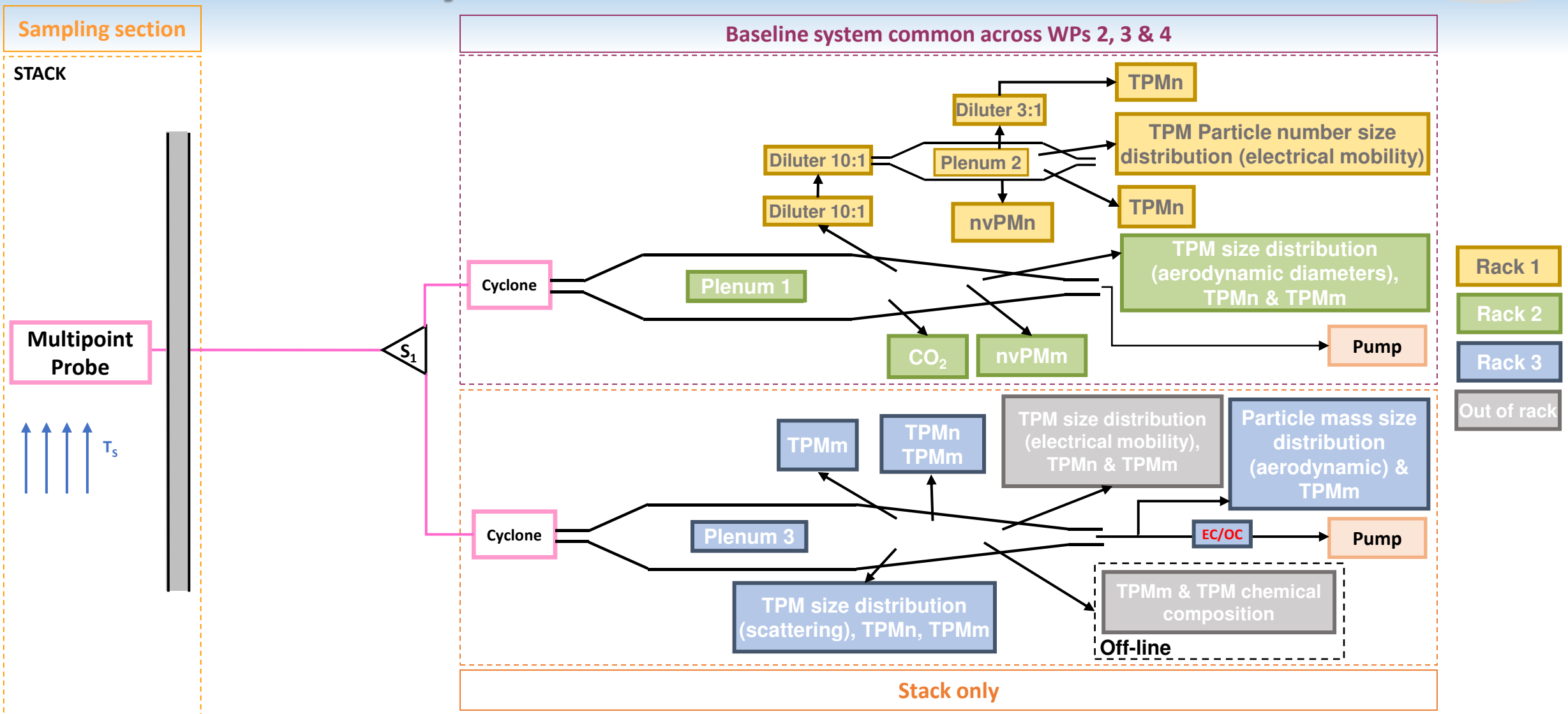
# WP2: Baseline system status







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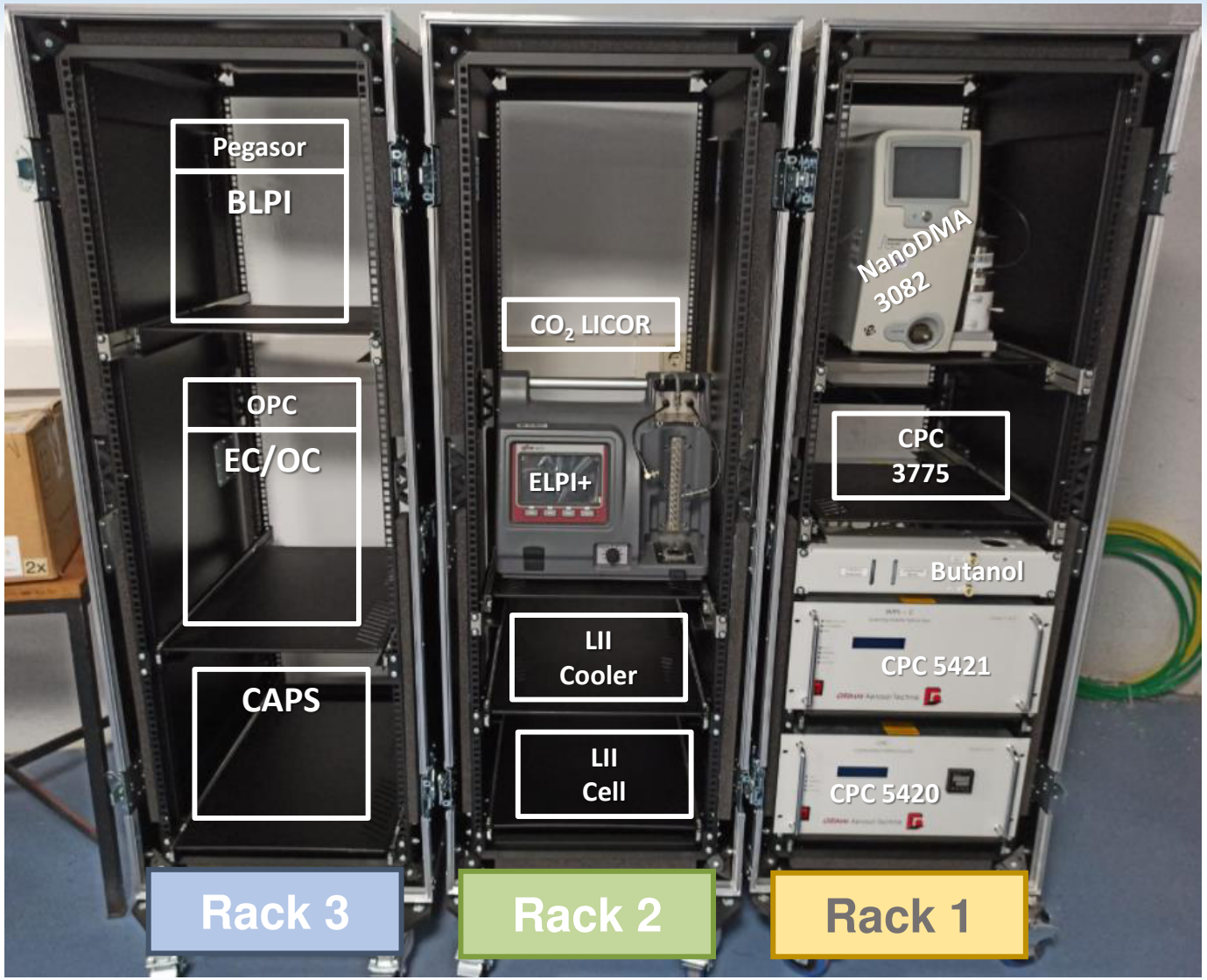
# WP2: Baseline system status







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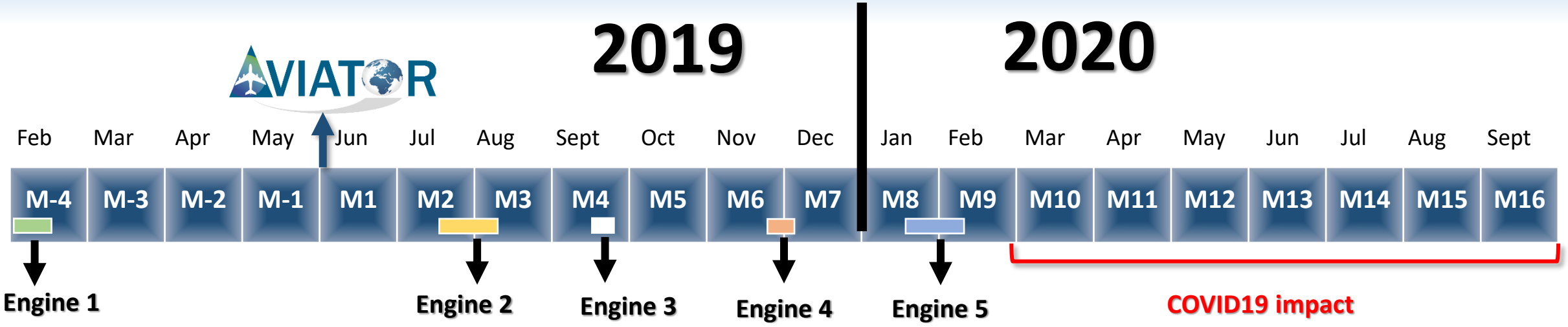
# WP2: Piggyback tests at INTA




**#1 and #5 Same engine family**

| # Engine | Sampling point | Parameters measured |
|---|---|---|
| 1 | ETP | PMn, nvPMm, size distribution and $CO_2$ |
| 2 | Stack | PMn, nvPMn, nvPMm, size distribution and $CO_2$ |
| 3 | Stack | PMn, nvPMm and $CO_2$ |
| 4 | Stack and ETP* | PMn, nvPMn, nvPMm and $CO_2$ |
| 5 | Stack | PMn, nvPMn, nvPMm, size distribution and $CO_2$ |

*Only one test was carried out measuring in ETP. In this test only was studied nvPMm and $CO_2$

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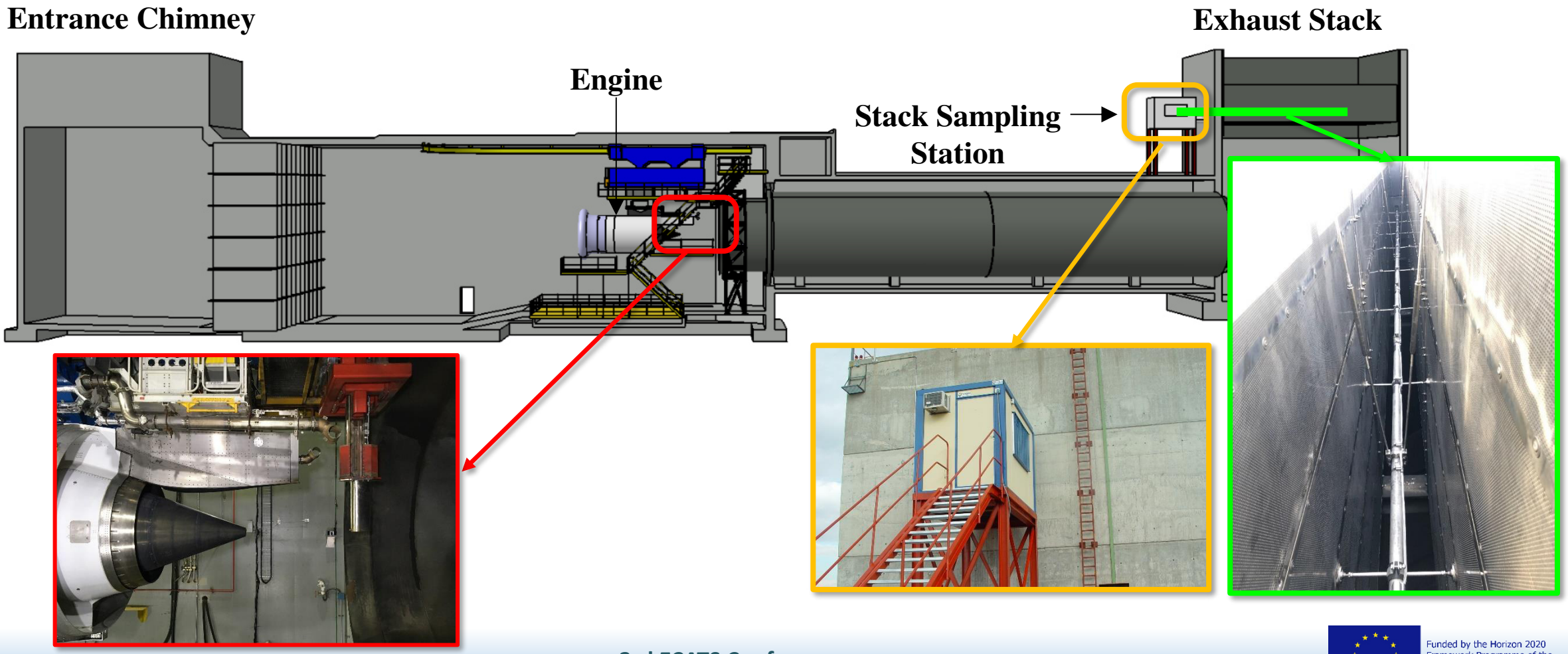
# WP2: Piggyback tests

Emissions from Rolls-Royce large engines were assessed by the Emissions Traverse Probe (ETP) installed in the **Engine Exhaust Plane** and a multi-orifice probe installed in the **Exhaust Stack.**







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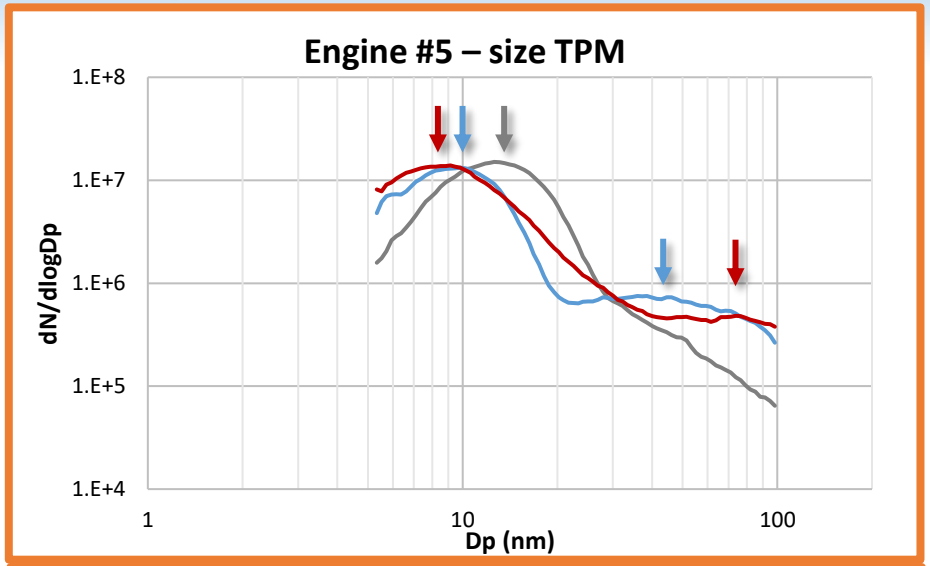
# Results: STACK particle size distribution

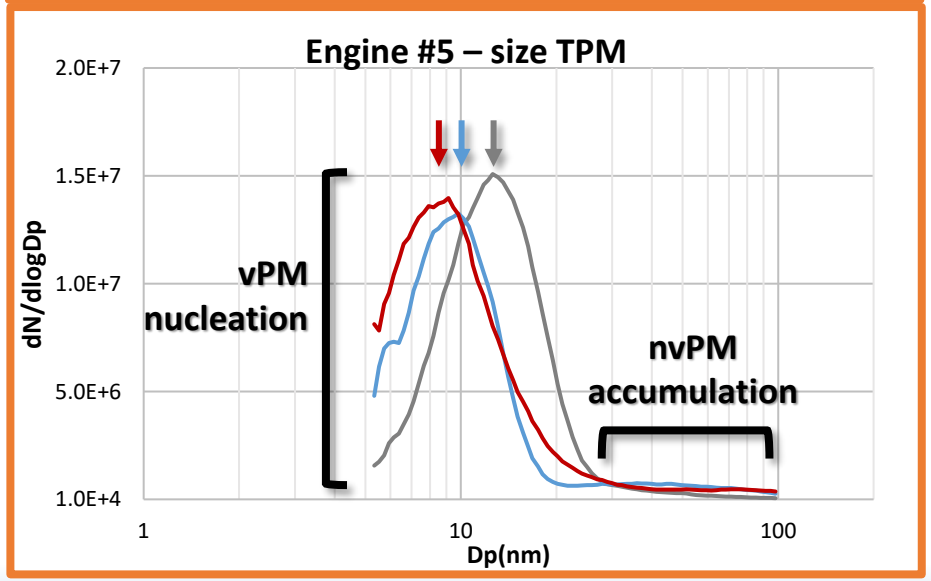
## Size TPM:

- **High power** = bimodal distribution (nuclei 8-9 nm; accumulation 50-70 nm)
- **Low power** = unimodal distribution (15 nm)

## Size nvPM:

- **High power** = unimodal distribution (50-70 nm)
- **Low power** = unimodal distribution (20-30 nm)

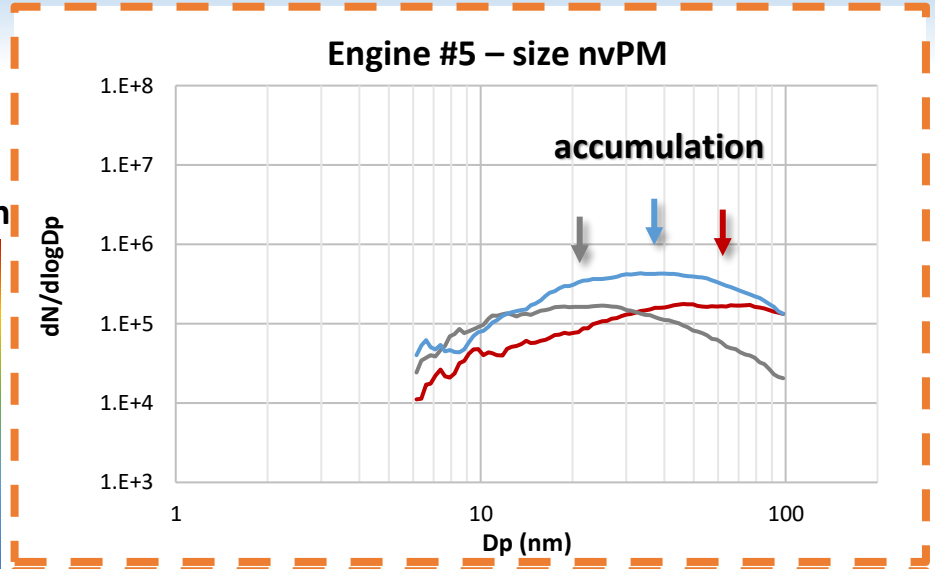


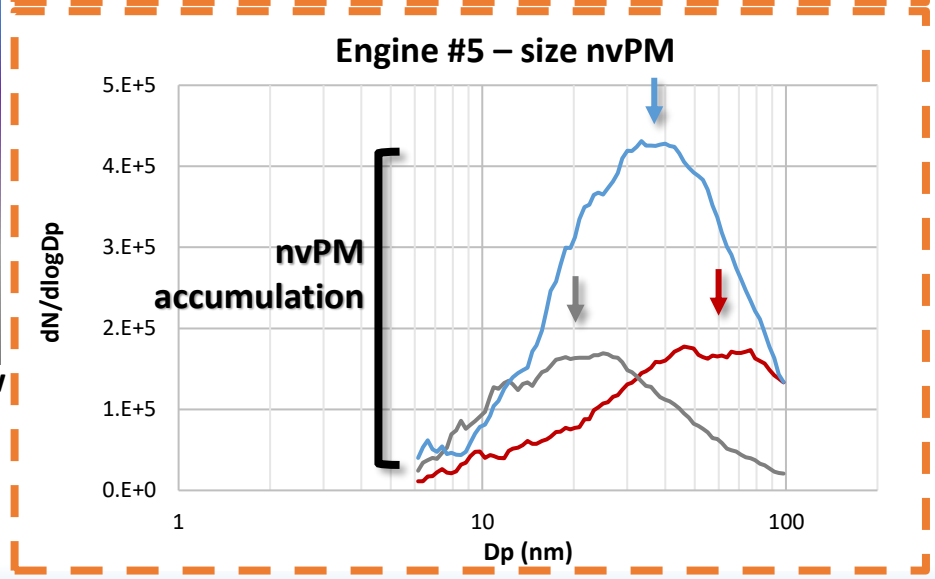




High

Engine Power Level

Low







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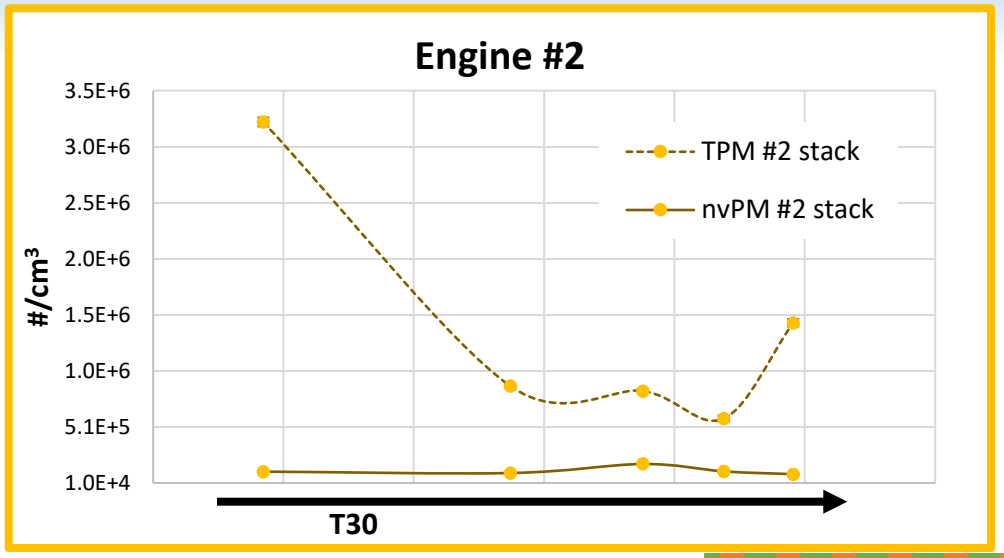
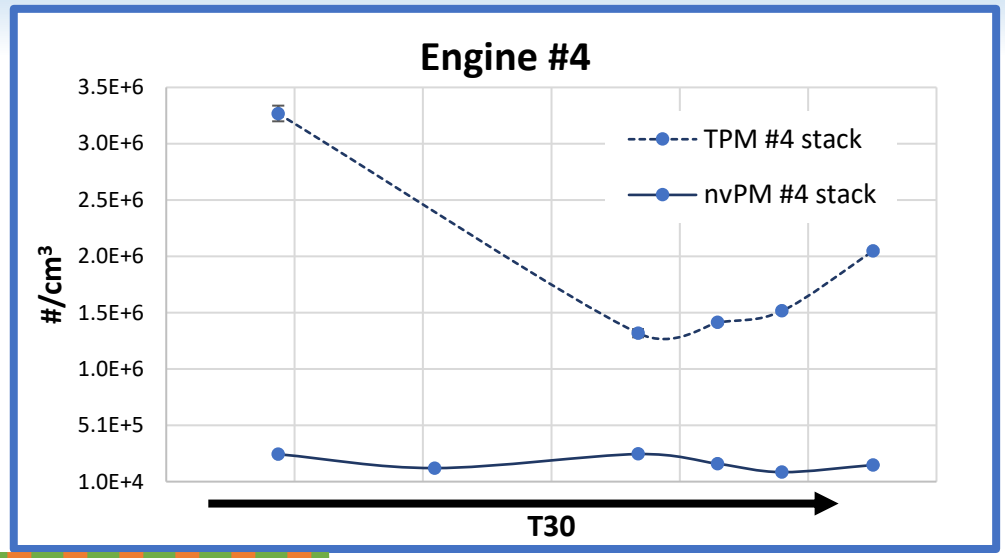
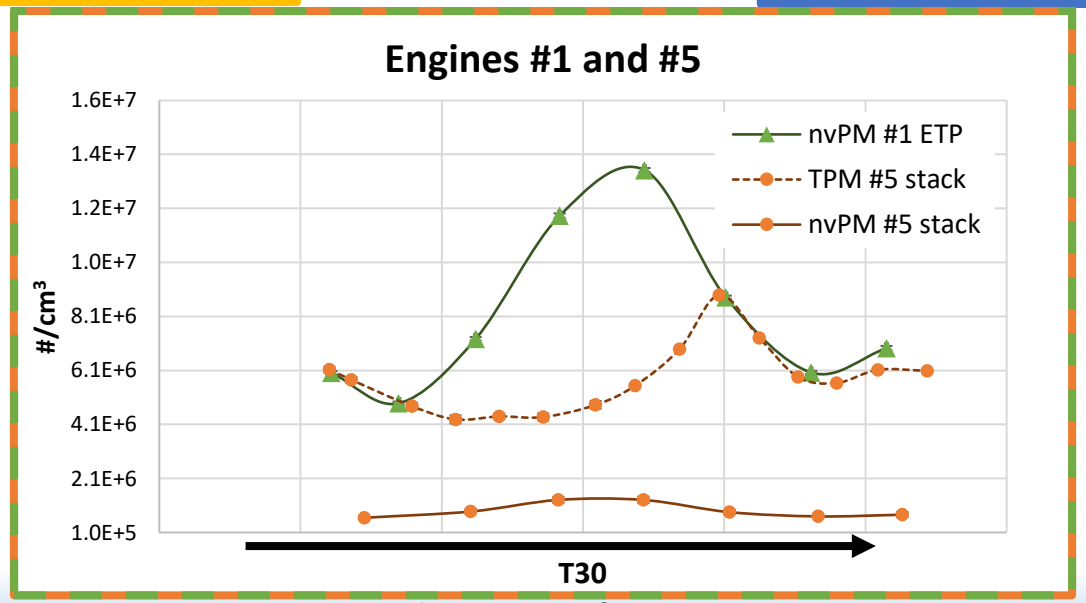
# Results: TPM and nvPM number conc.







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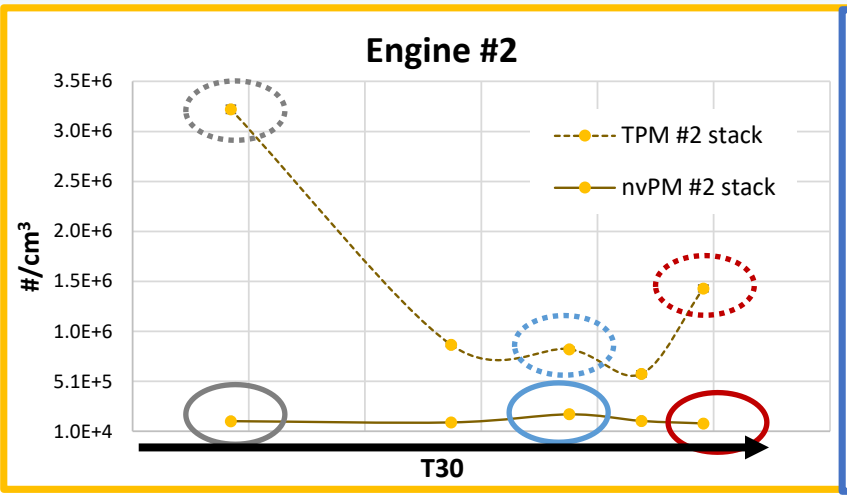
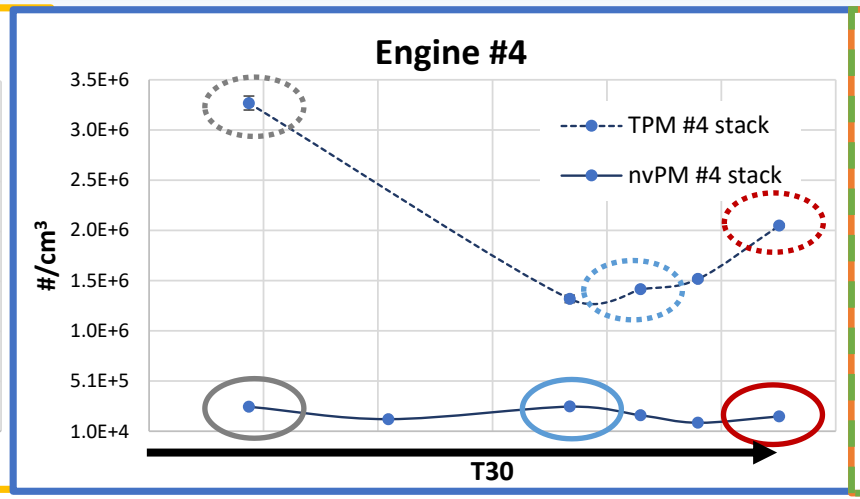
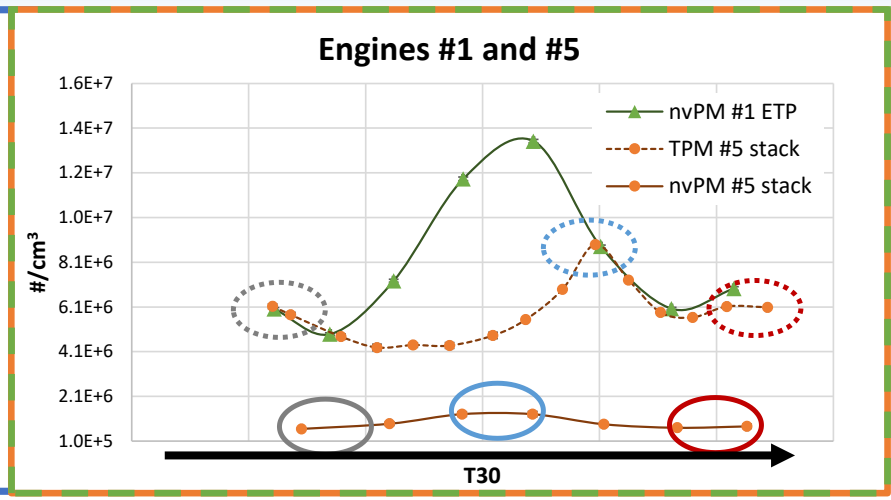
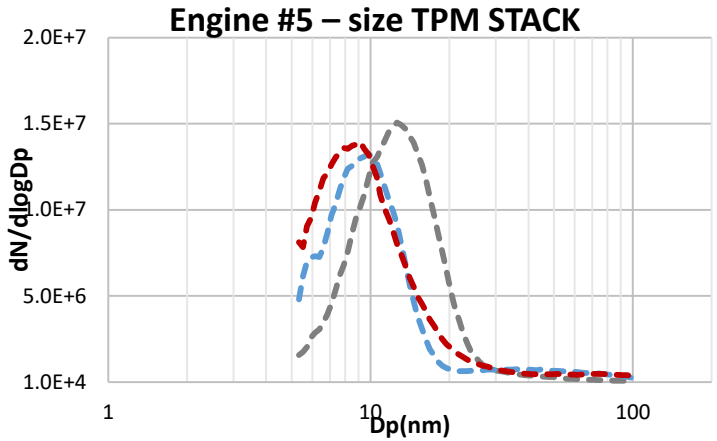
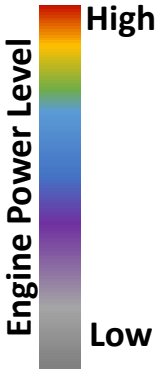
# Results: TPM and nvPM number conc. vs size

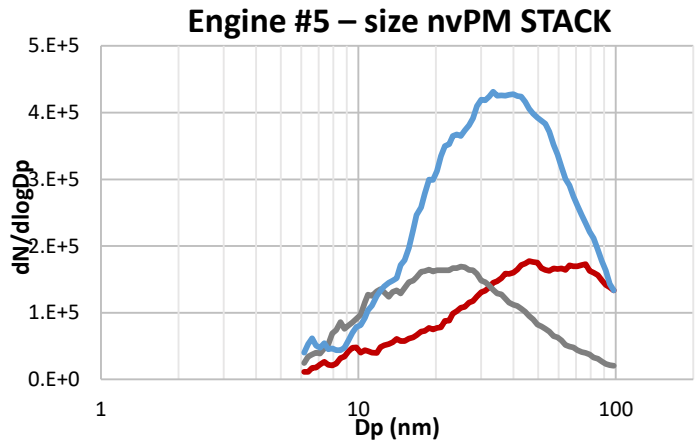



**TPM number conc.** Low power > **High power** > Medium power

**nvPM number conc.** Medium power > **High power** > Low power

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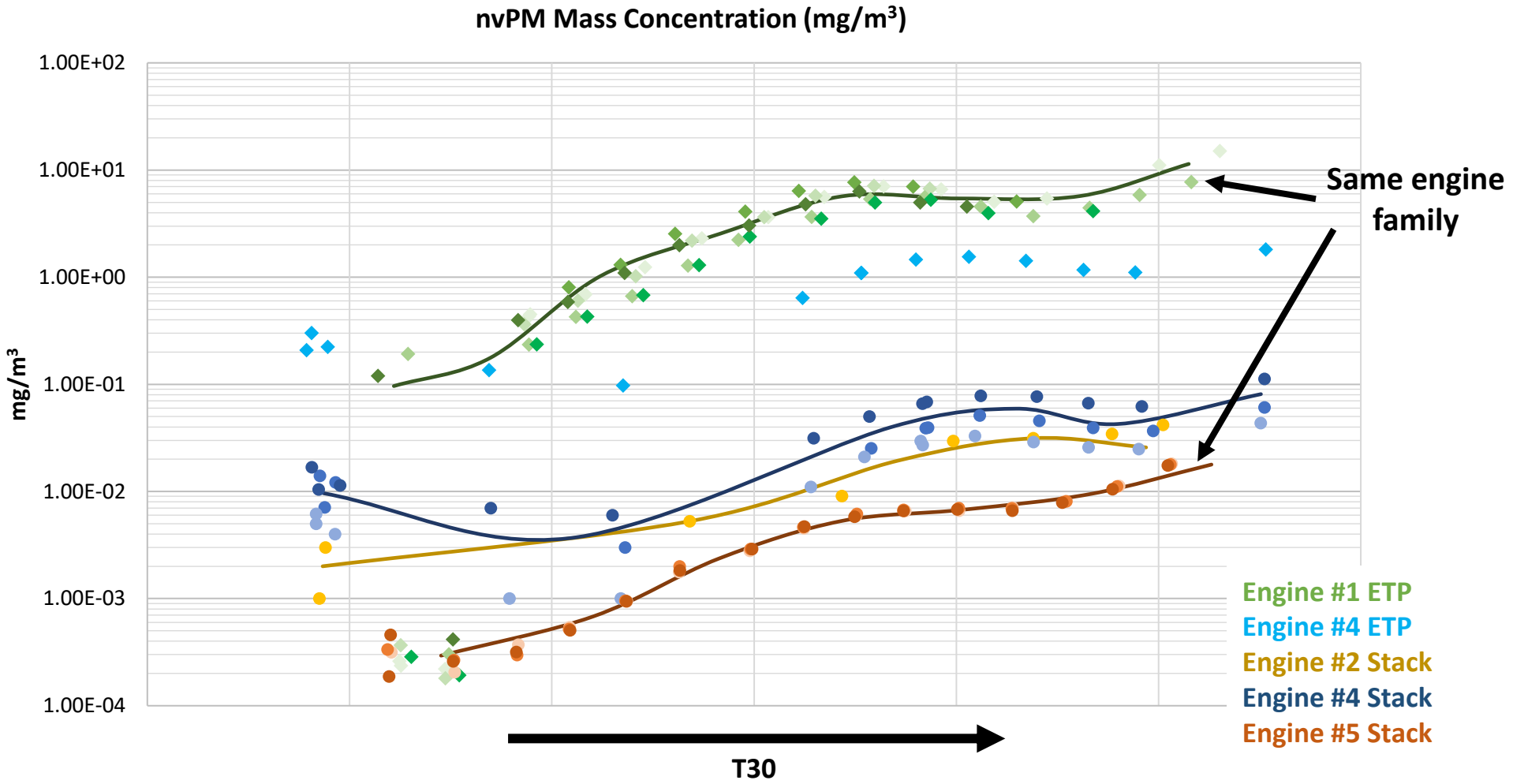
# Results: nvPM mass conc.







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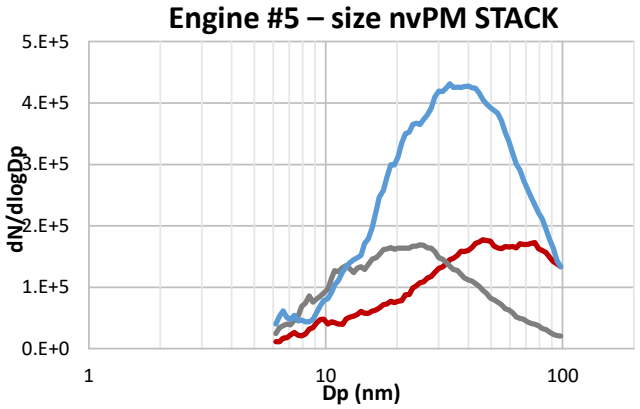
# Results: nvPM mass conc. vs size




**nvPM mass conc.**

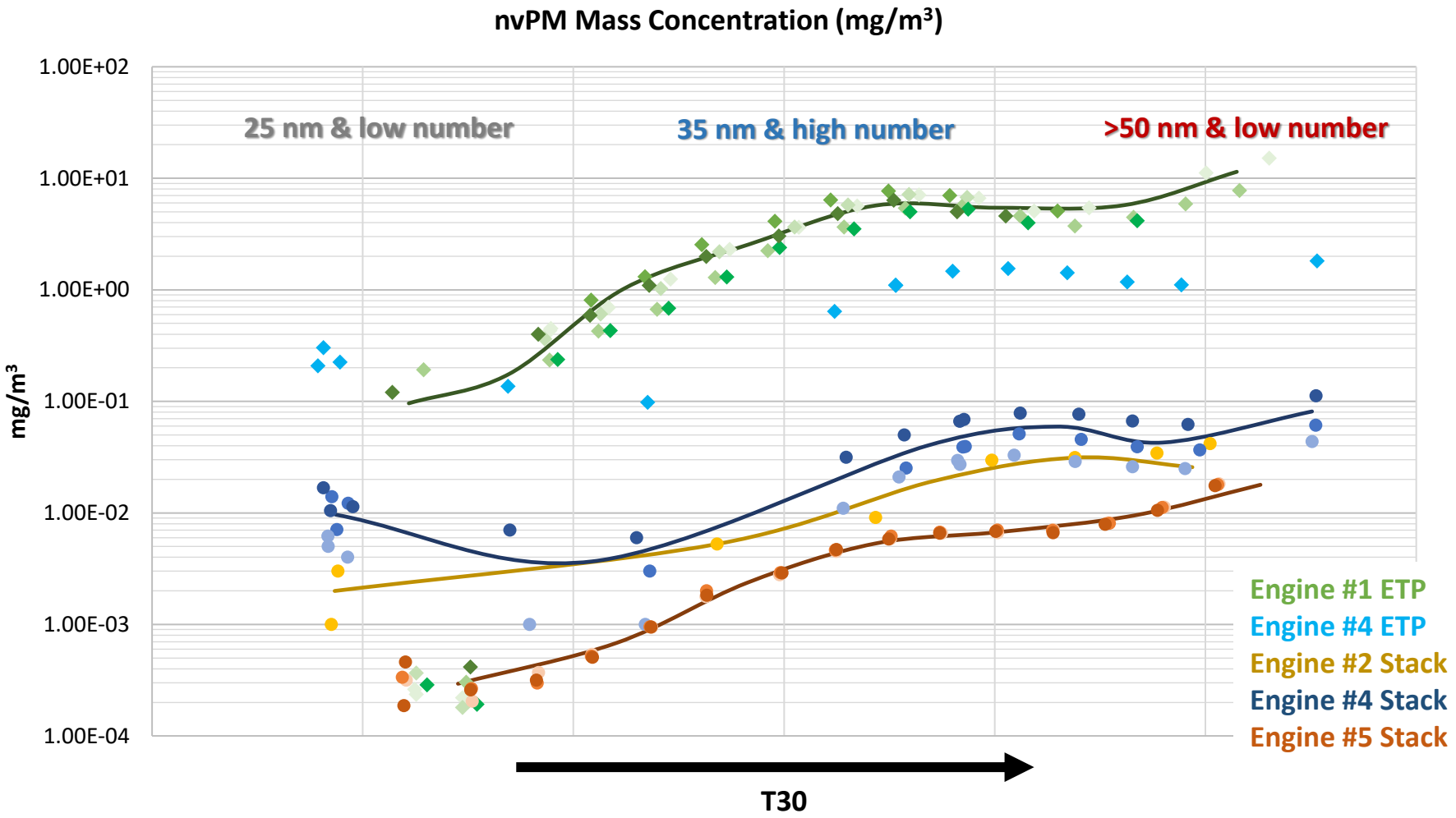
**High power** > Medium power > Low power

**nvPM size**

**High power** > Medium power > Low power

**nvPM number conc.**

Medium power > **High power** > Low power







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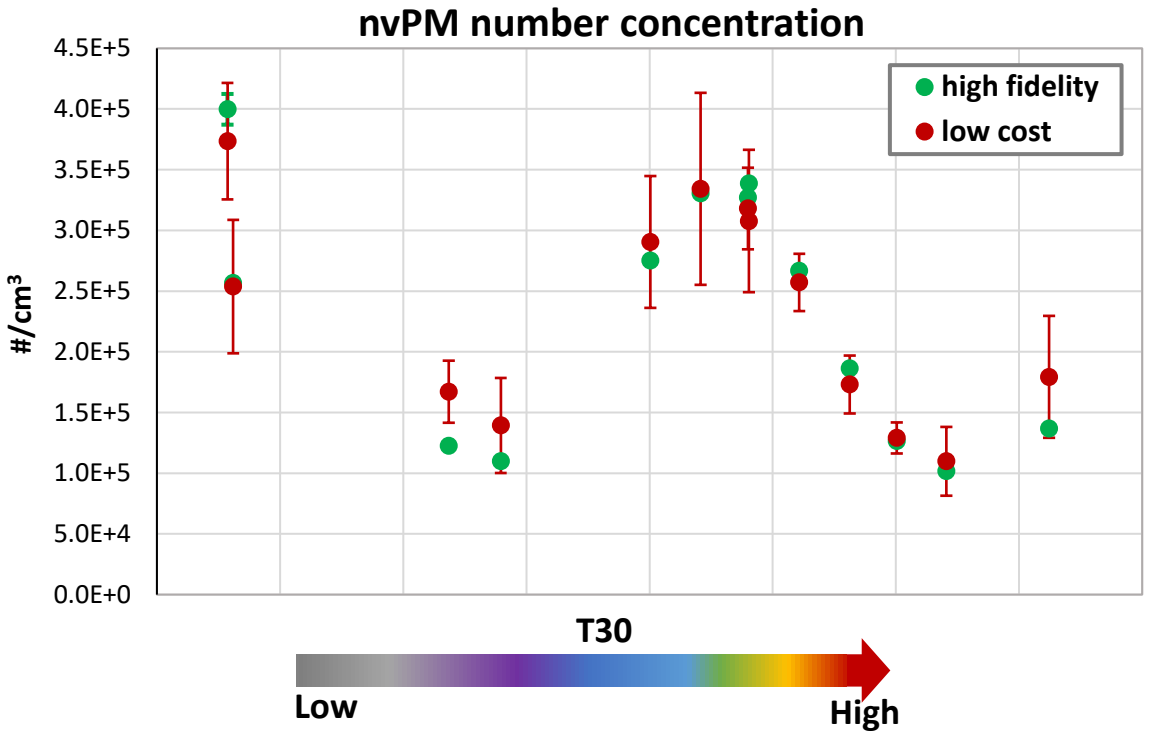
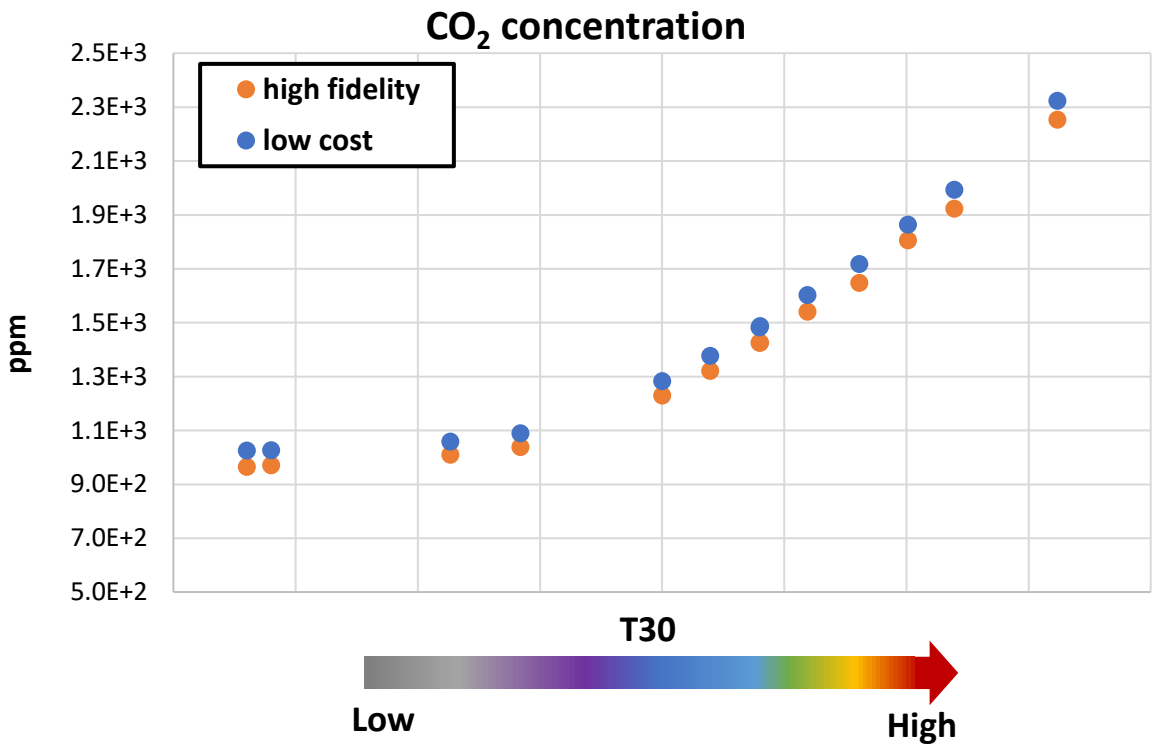
# Results: high fidelity vs low cost equipment




**High fidelity and low cost sensors show good repeatability in both cases**

Low cost sensor measures higher concentrations of number conc. and has higher deviations than high fidelity

Low cost sensor measures similar concentrations of $CO_2$ as high fidelity (4% higher with LCS) with small deviations

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# Thank you for you attention

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