

AEROSOLS

Air Quality and Health Impact of Primary Semi-volatile
and Secondary Particles and Their Abatement



PMP 55th session

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AEROSOLS Project Insights

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Primary emissions from transportation

- *Overall impact of transport emissions on air quality and health, relatively well known, as far as direct regulated pollutant emissions are concerned (i.e. particulate, NO_x, hydrocarbons, etc.)*

Atmospheric chemistry & secondary emissions

- *Some of the emissions from engines, and combustion processes in general, are also leading to further formation of health impacting compounds due to atmospheric aerosol chemistry*

Potential effects of secondary emissions

- *Specific impact of these compounds, less understood*

Particle emissions vs regulations

- *Vehicle exhaust particle emission regulations historically consider Particulate Mass (PM) + more recently Solid Particle Number (SPN) above 23 nm and going towards above 10 nm under Euro 7*
- *In the current PMP exhaust PN protocol, the target is to remove volatile and semi-volatile aerosol before measurements*
 - *Main advantage: Robustness improvement of the automotive certification protocol in view of the market sale*
 - *Among the drawbacks: Underestimation of the impact on air quality and health*



Programme “HORIZON Europe” call for tender (2021)

- *HORIZON-CL5-2022-D5-01: Clean and competitive solutions for all transport modes*
- *Topic “HORIZON-CL5-2022-D5-01-07”: Prevent smog episodes in Europe: Air quality impact of engine-emitted volatile, semi volatile and secondary particles*

Expected outcomes

- *Achieve better understanding of (semi)volatile particles and secondary aerosol formation as well as their effects on health, air quality (in particular during winter season) and climate*
- *Assess the contribution to $PM_{2.5}$ of precursors present in exhaust from transport (i.e. volatile organic compounds, NO_x, unburned hydrocarbons, nano-particles below 23nm, ammonia, etc.) through the formation of secondary aerosol (organic –SOA– and inorganic –SIA–)*
- *Find ways in which scientific evidences of the role of emissions in atmospheric processes could be an input to develop policies and mitigate SOA formation in urban areas of EU*
- *Improved quantification of transport externalities*
- *Support of future emissions legislation and of “polluter pays” legislation*



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3 projects funded



(project ID n°101096133)
[CORDIS - EU: PAREMPI](#)



(project ID n°101095457)
[CORDIS - EU: EASVLEE](#)



(project ID n°101096912)
[CORDIS - EU: AEROSOLS](#)

AEROSOLS Project's Consortium





UNIVERSITY OF BIRMINGHAM
() Project Scientific Coordinator*



UNIVERSITY OF OSLO

AIRMODUS



University of Nottingham
UK | CHINA | MALAYSIA



Umwelt Bundesamt



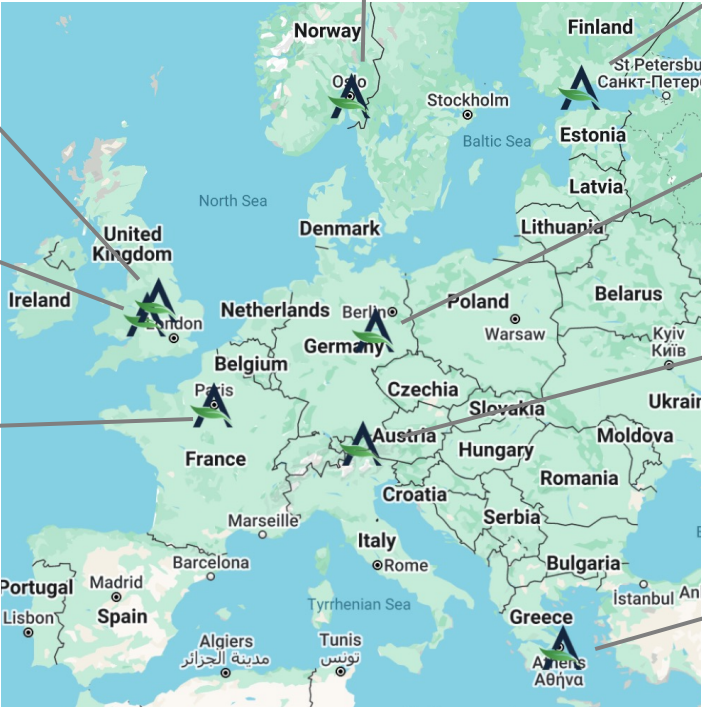
ifp Energies nouvelles



IONICON



ΑΗ ΜΟ ΚΡΙ ΤΟΣ
() Project Coordinator*





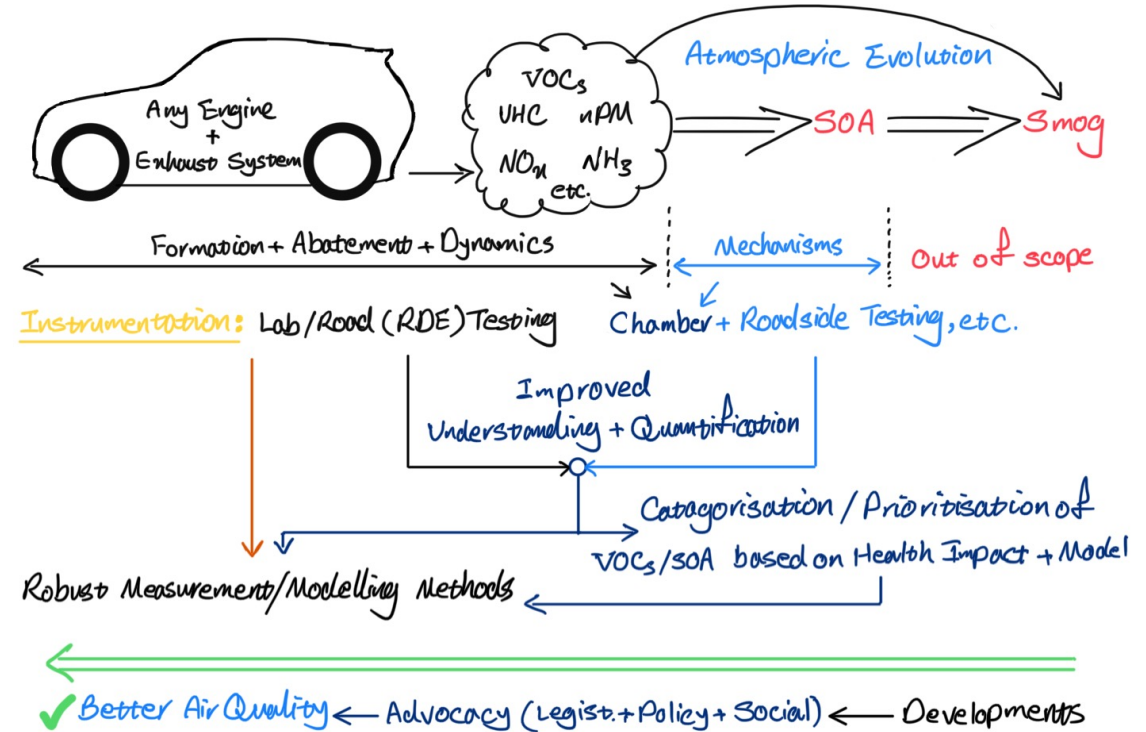
Start date: 01st January 2024



Duration: 36 months



N° of work packages: 7



Aim:

To define robust and transparent measurement and modelling methodologies to quantify the currently disregarded volatile/semi-volatile primary and secondary emissions, assess their associated risks, and propose technological and legislative monitoring/abating mechanisms to help improve air quality and public health.

Objectives:

1. Primary emissions characterisation



2. Secondary emissions characterisation



3. Impacts and taxonomisation



4. Methods for improved quantification

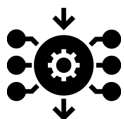


5. Advocacy and future abatement policies





WP5: Defining robust measurement, analysis & modelling methods for measurement/derivation of total emissions indices



Emissions taxonomisation assisted by AI
Unified measurement programmes
V/S-V + SA contribution to $PM_{2.5}$ & PM_{10}
Equivalent total particle emissions indices



WP4: Investigation & quantification of the health, environmental & social impacts of V/S-V & secondary compounds



Health studies
Environmental life cycle assessment
Social life cycle assessment



WP6: Dissemination of the advocacy information to the stakeholders & legislation/policy makers



WP7: Project management & coordination



WP3: Assessment of atmospheric processing of emissions



Aerosol aging
Climatic effects on secondary aerosols



WP1: Lab-based investigation & quantification of volatile/semi-volatile (V/S-V) compounds formation, abatement & dynamics within engine/exhaust systems

Compilation of relevant databases
Engine-out emissions indices at RDE-compliant conditions
Emissions abatement techniques
Artefacts within the exhaust system and dilution impact



WP2: Onboard vehicle RDE investigation and quantification of V/S-V emissions

Vehicles' setup
On-board emissions equipment
On-road and chassis-dyno RDE vehicle experiments



⇒ **From automotive "Euro" standards to secondary emissions, going through the particular role of VOCs**

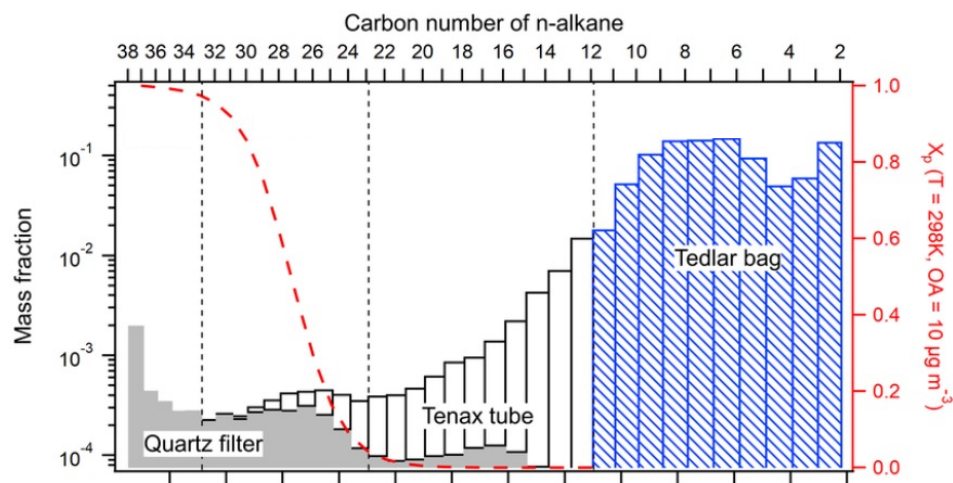
Volatile Organic Compounds (VOCs)



An extended family of chemical compounds

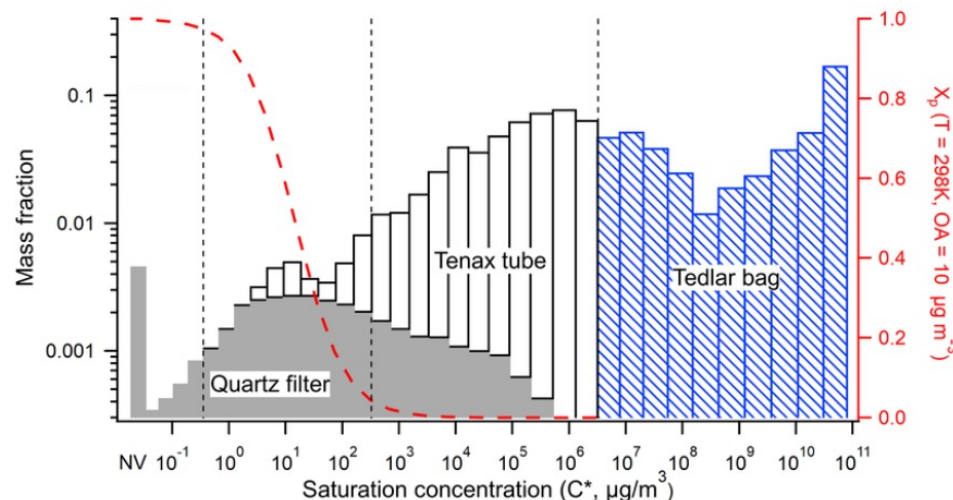
- With various definitions (based on chemical composition, boiling T° , saturation vapor concentration)
- Exhibiting a wide volatility range
- Distributed between gaseous & particulate phase emissions, depending on conditions (T° , P , RH , $[x]$)

Gasoline engine



Organic emissions volatility
Contribution to particulate phase

Diesel engine



Organic emissions volatility
Contribution to particulate phase

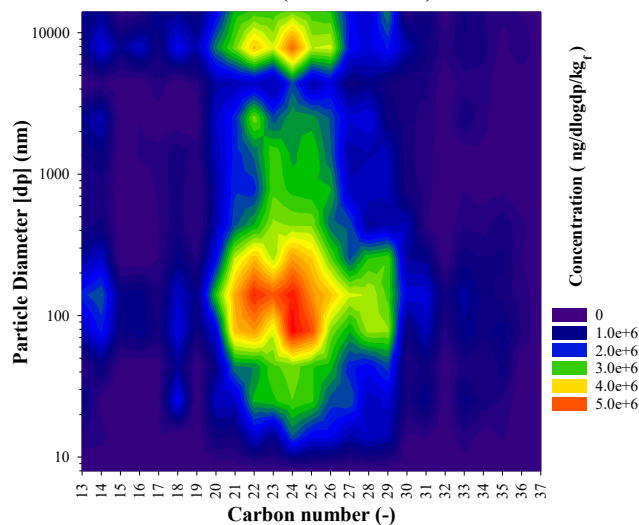
(based on: Lu, et al. (2018). Atmos. Chem. Phys., 18, 17637–17654, <https://doi.org/10.5194/acp-18-17637-2018>)

⇒ **Need for an extended sampling + analytical protocol to evaluate the whole range of compounds in both gaseous/particulate phases**

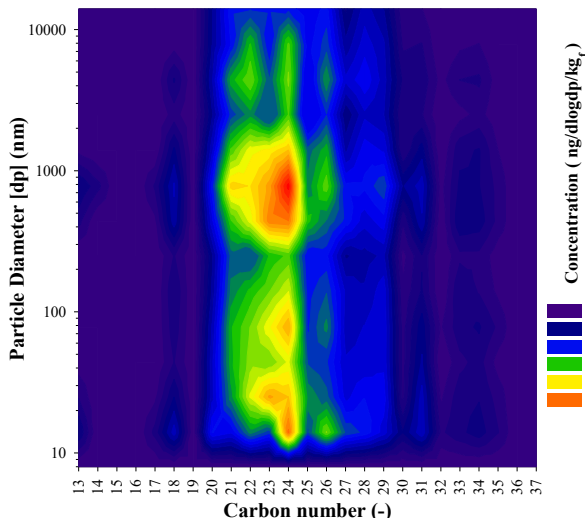
Originating from extremely complex reactions and numerous compounds

- Can derive from thousands of hydrocarbons (carbon number C1 to $\approx$ C40) in unburnt fuel & engine lubricating oil
- Contain compounds resulting from partial combustion & pyrolysis

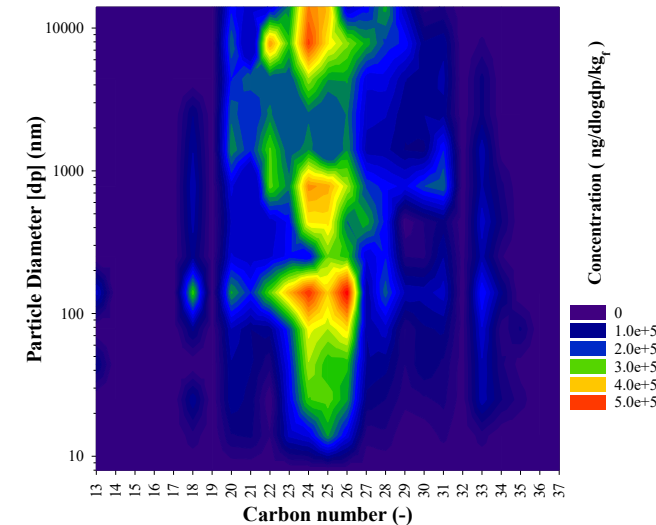
Alkanes (Before DOC)



Alkanes (After DOC)



Alkanes (After DOC+DPF)



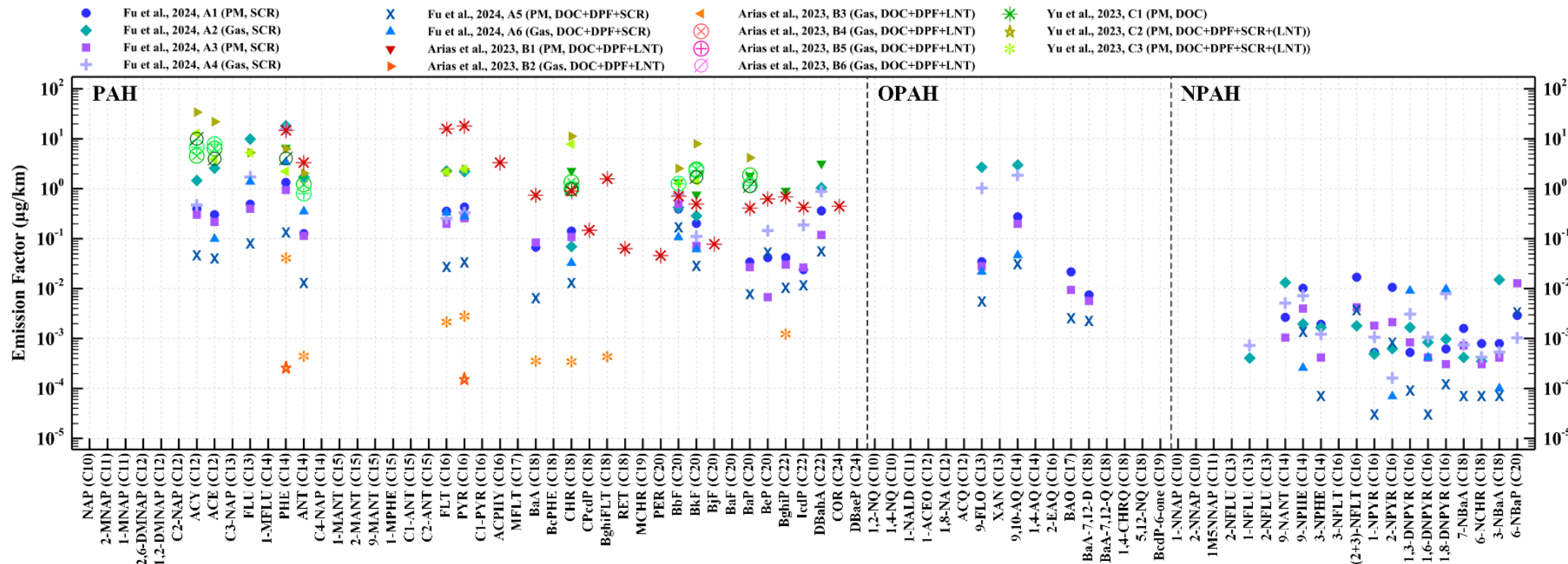
Presence of $\approx$ C>11 intermediate-/semi-volatile organic compounds (I/SVOC) can result in uncertainty in physico-chemical characterisation of particle emissions, mainly due to:

- Active gas-particle partitioning & interaction with other species under the exhaust conditions
 - Contribution to the formation of secondary aerosols
- ⇒ **An extended characterization and better knowledge of VOCs partitioning & variety of compounds, to accurately evaluate the potential contribution of these particular precursors to the formation of Secondary Organic Aerosols**

Preliminary Results from WP1's Compilation of Relevant Databases



Example: PAHs-CI-with Aftertreatment



⇒ **Continuous review of relevant literature and data bases is ongoing and subject to publication.**

Overview of the “AEROSOLS” Protocol to Evaluate, Primary/Secondary Emissions + Ageing



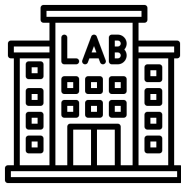
WP2

WP3

Vehicle's evaluation



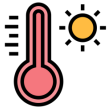
On-road



In-lab.

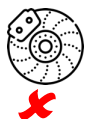
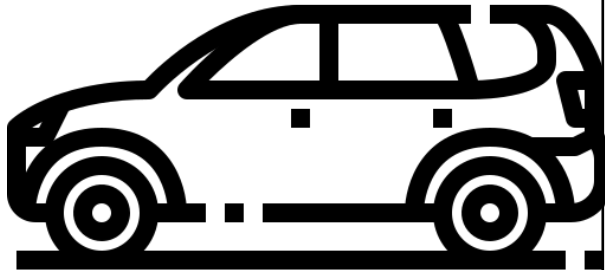


Ambient...



...hot start

*2



Vehicle's primary emissions

Euro 6

Gaseous phase ⇨

CO, CO₂, NO_x, HC_{total}, nMHC

Particulate phase ⇨

Particulate Mass (PM)

Particle Number (SPN₂₃)

Euro 7

Gaseous phase ⇨

CO, CO₂, NO_x, HC_{total}, nMHC

Particulate phase ⇨

Particulate Mass (PM)

Particle Number (SPN₁₀)

Unregulated, Aerosols & SOA precursors

Gaseous phase ⇨

N₂O, NH₃, SO₂, CH₂O, CH₄O, individual HCs, HONO, VOCs, iVOCs, sVOCs...

Particulate phase ⇨

Particulate Mass (PM₁, PM_{2.5}, PM₁₀)

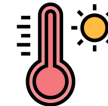
Particle Number (Solid/volatile; from PN₁)

Size distribution & composition (organic, metals,...)

Ageing



RH



RH



3 ageing devices

Secondary emissions

Euro 6

Not applicable

Euro 7

Not applicable

Unregulated & Secondary Aerosols

Gaseous phase ⇨

Potential gaseous precursors of SOA in particular (VOCs, iVOCs, sVOCs,...)

Particulate phase ⇨

Particulate Mass (PM₁, PM_{2.5}, PM₁₀)

Particle Number (Total; from PN₁)

Size distribution

Composition (BC, organic, nitrate, sulfates,...)

⇨ To WP4: Health, Environmental & Social impacts
⇨ & WP5: Robust measurement & modelling methods

Upcoming Activities Relevant for PMP



- Vehicle-level measurement campaign under summer/winter conditions on-road and lab-based using a comprehensive set of techniques to characterize primary emissions and secondary formation of particulates from diesel/gasoline exhaust.
- April 29th/30th 2025: Co-convened session (AS3.30: Transport and air pollution, from real-world emissions to their impacts) during 2025 European Geoscience Union General Assembly, Vienna, Austria.
- November 4th to 6th 2025: Transport and Pollution (TaP) conference hosted by IFPEN and AEROSOLS project workshop (tbd, possibly Nov. 7th) open to the professional public and interested stakeholders.

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