nPETS
nanoParticle Emissions from the Transport Sector

Karlsruhe Institute of Technology

idaea

CSIC

Physico-chemical characterization and source apportionment of UFP at airport, harbour, subway and road: The nPETS experimental set-up in Barcelona

Sharon Ridolfo[1], X. Querol[1], A. Karanasiou[1], N. Perez[1], A. Alastuey[1], B. van Drooge[1], B. Piña[1], J. Portugal[1], U. Olofsson[2], E. Bergseth[2], E. Carbonell[3], J. Vila[4], J. Cortes[5], M. Madrid[5], I. Hernandez[6] and F. Amato[1]

[1]IDAEA (CSIC), Spain;
[2]KTH, Sweden;
[3]FGV, Spain;
[4]Port of Barcelona, Spain;
[5]AENA SME, S.A. - Josep Tarradellas Barcelona-El Prat Airport, Spain;
[6]Governement of Catalonia, Spain

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

Table of contents

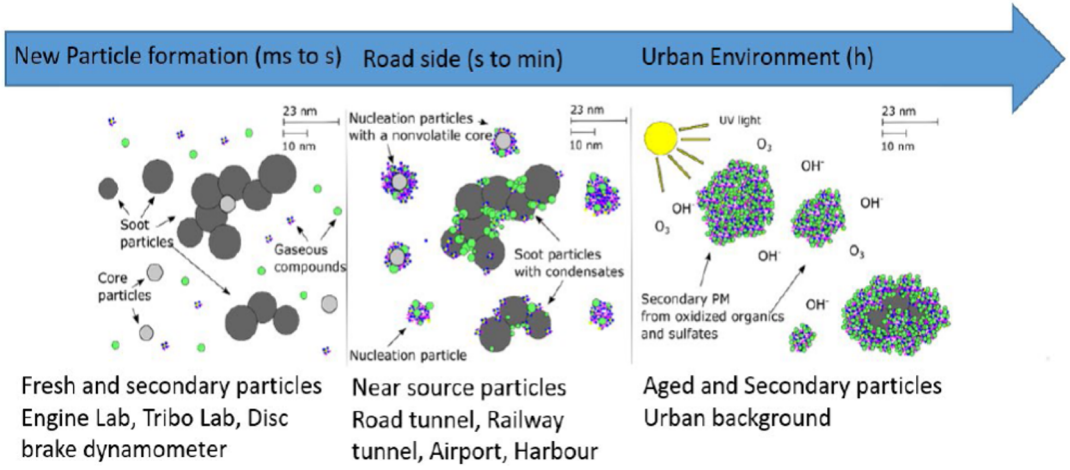
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

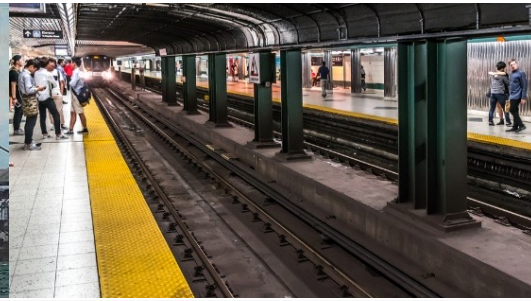
1. Introduction: The nPETS project

Nanoparticle emissions from the transport sector

- 3-years H2020 project, 4 European cities involved

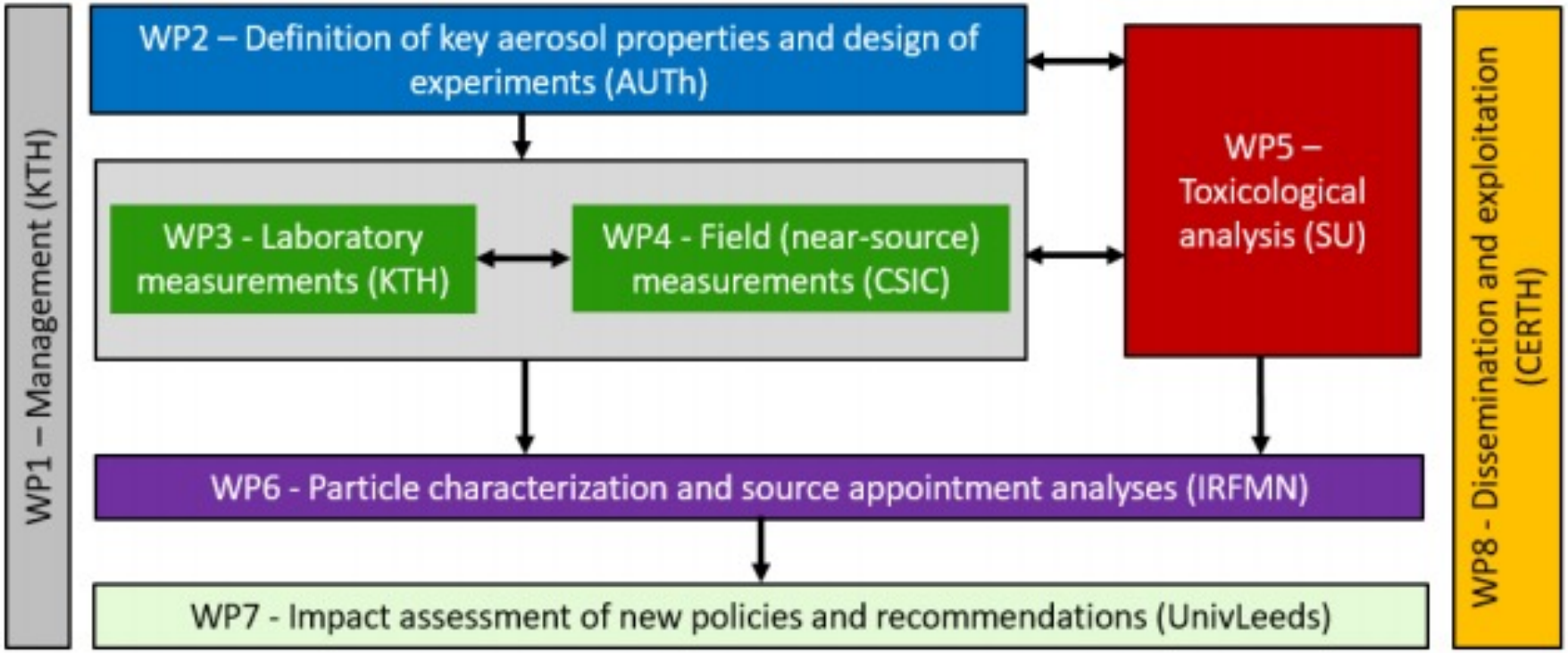
  (Milan, Thessaloniki, Stockholm, and Barcelona)





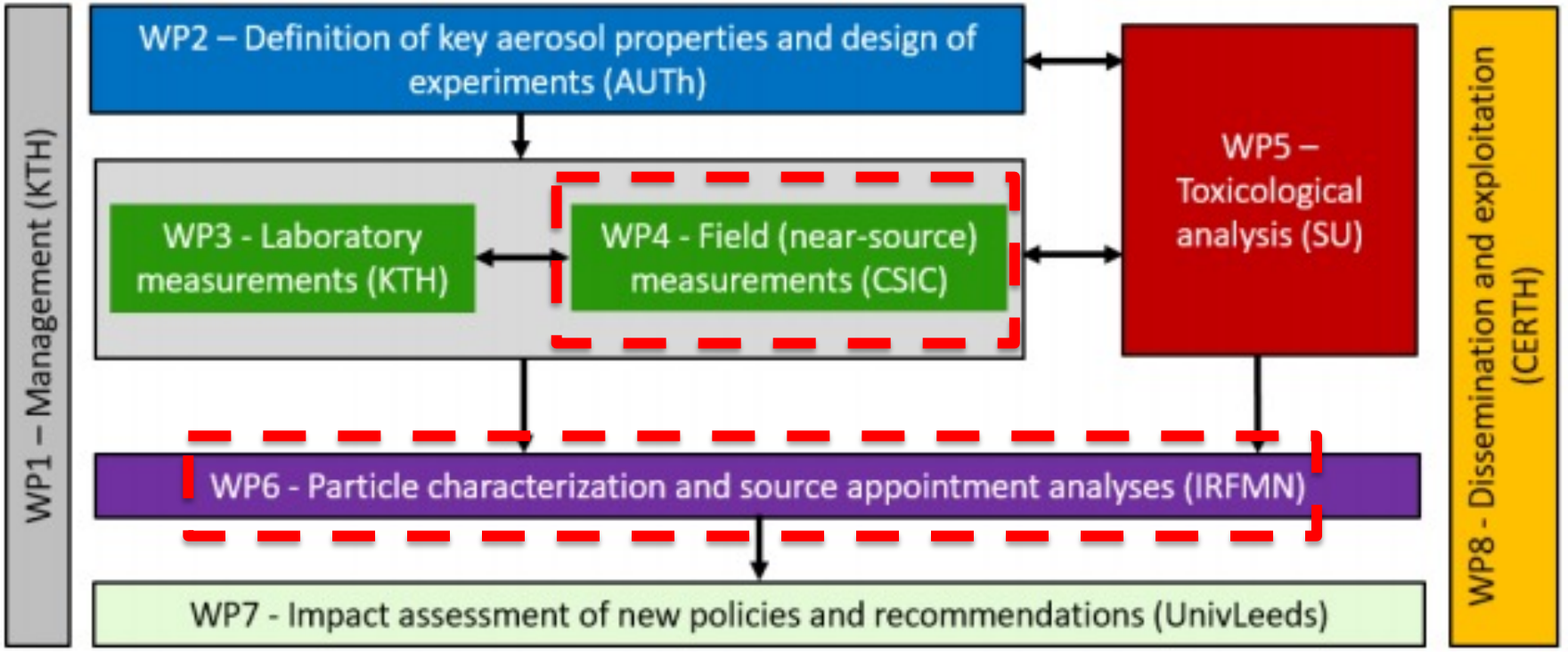
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

1. Introduction: The nPETS project



This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

1. Introduction: The nPETS project



This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

2. Objectives

- Size-segregated, **physico-chemical characterization** of UFP near different transport sources (road, harbor, airport, subway) + background;
- **Monitoring** of PNSD from 3 nm at the same environments;
- **Identifying** of typical PNSD emitted by different transport sectors;
- **Quantifying** contributions from different transport sectors to background UFP levels, by means of a **constrained source apportionment**.

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

3. Methodology: Mobile laboratory

- **Calendar:** July 2022-December 2023
- **5 sites**: Urban background, road, subway, harbor, and airport;
- **10 field campaigns** (winter/summer for each site);
- **4 weeks** of continuous sampling for each campaign;
- **7-days** resolution samplings with ELPI+ and DGIs
- **1-day** resolution of additional sampling for FESEM/TEM analyses

ELPI+ Dekati

2 DGIs Dekati

SMPS (>10nm) + CPC (>3nm), TSI

Aethalometer AE-33 (7 Wavelengths)

\+

High volume PM_1 and PM_{10} *with chemical speciation*
Grimm
Gas analyzers (NO_X, NH_3,SO_2,O_3)
Meteorological parameters

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

3. Methodology: Portable equipments

- 2 **Portable SMPS** for PNSD 9–241 nm (90s time resolution; 0.13 lpm, 4h autonomy) developed by Hanyang University (*Lee et al., 2015*), with the addition of other portable instruments.

Environmental Research 191 (2020) 109978

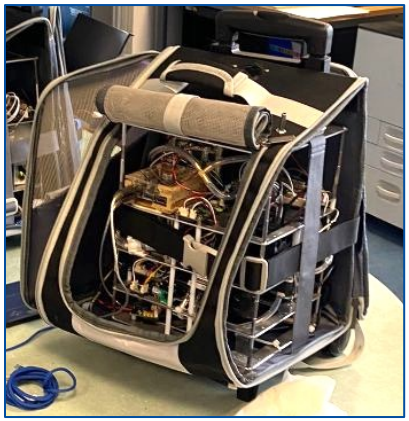
Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Using miniaturised scanning mobility particle sizers to observe size distribution patterns of quasi-ultrafine aerosols inhaled during city commuting

Teresa Moreno [a,*], Cristina Reche [a], Kang-Ho Ahn [b], Hee-Ram Eun [b], Woo Young Kim [b], Hee-Sang Kim [b], Amaia Fernández-Iriarte [a,c], Fulvio Amato [a], Xavier Querol [a]



+

MiniDISC

MicroAeth

PO_3M

ModulAIR_PM QuantAQ

- Used for route measurements to obtain UFP/O_3/BC/PM **pollution maps** at subway, harbor, airport and road environments.

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

3. Methodology: Airport Campaigns

Upwind and downwind measurements

Focus on ***idling***, ***taxing***, ***departure*** and ***landing***

Portable SMPS1 Portable SMPS2

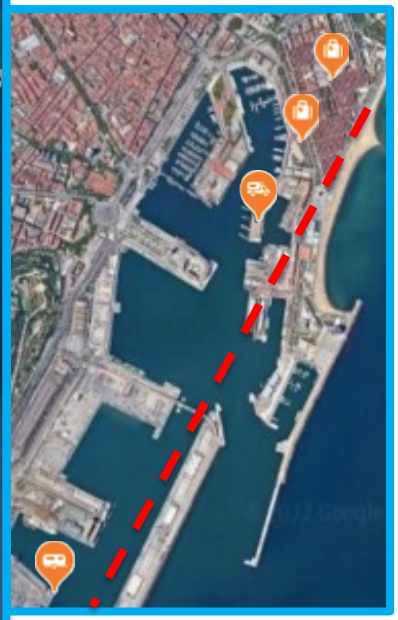
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

3. Methodology: Harbor Campaigns

Upwind and downwind measurements

Focus on ***ferries***, ***cruises*** and ***shipping emissions***

Traffic & ***background***



Portable SMPS1 Portable SMPS2

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

3. Methodology: Sampling substrates

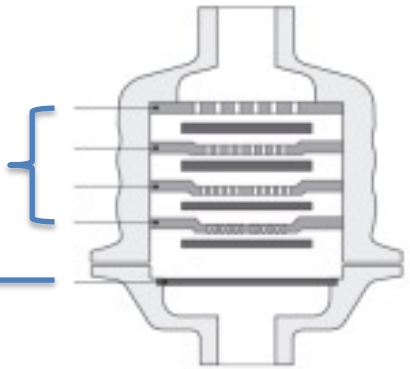
DGI

Inlet

Greased aluminium foils

0.130 - 2.5 µm

(extraction and metals analysis)



100 lpm

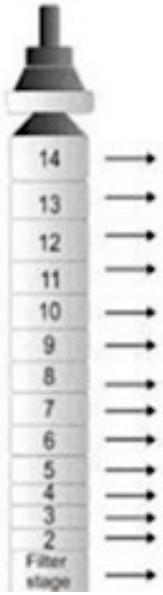
PTFE back-up filter (<130nm):

- Major and trace elements: ICP MS/AES,
- Ion-chromatography: sulphate, nitrate, chloride
- Specific electrode: ammonium
- Organic compounds: GC-MS

ELPI+

PM_{10} cut-off inlet

Drier



Greased aluminium foils

9 stages from 0.250 to 10 µm

(extraction and metals analysis)

Polycarbonate filters

5 stages from 10 to 205 nm

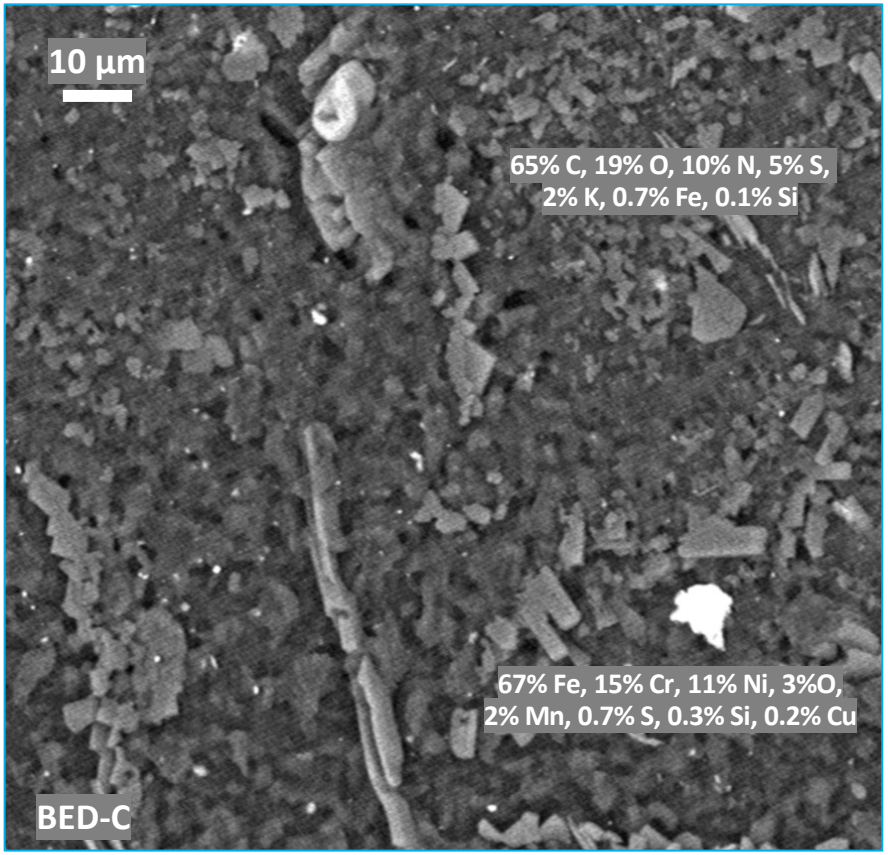
(metals analysis)

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

3. Methodology: Why our protocol?

- **No grease → Bouncing effect**: micrometric metal particles from coarser stages.

- **No drier → Water condensation** in stages with D_{50}> 165 nm due to the greater presence of sulphate (*hygroscopic*):
  - Dissolution and precipitation of sulphate and nitrate salts.
  - Formation of a homogeneous cement that captures even the finest particles in the wrong stages.
  - Change in composition and size of PM.



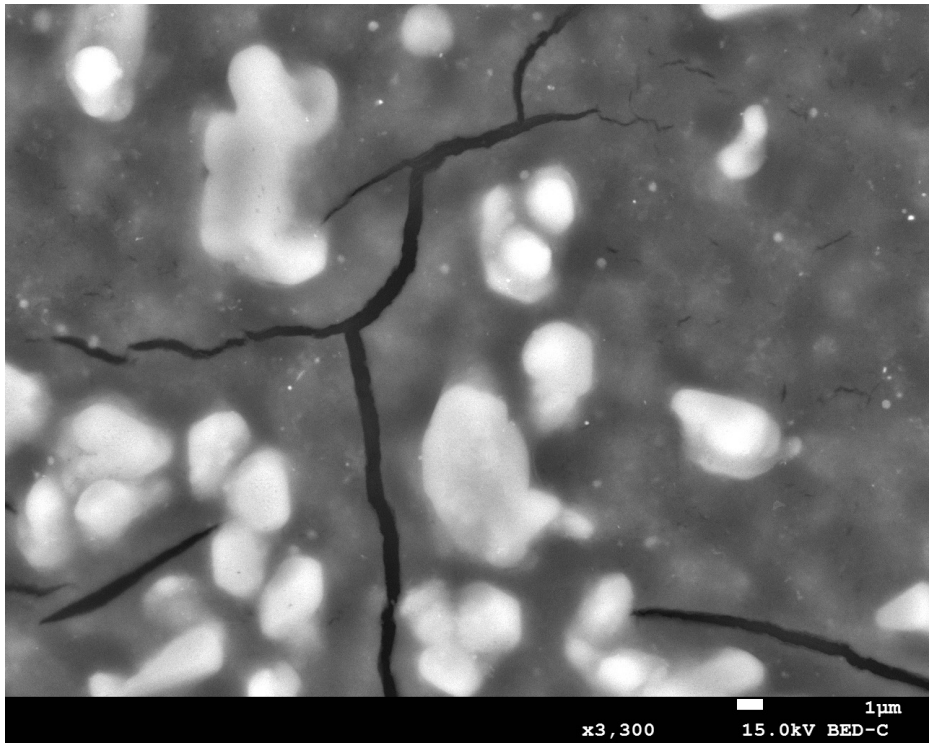
ELPI+ Stage 6 (D_{50}=165nm), polycarbonate filters

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

3. Methodology: Why our protocol?

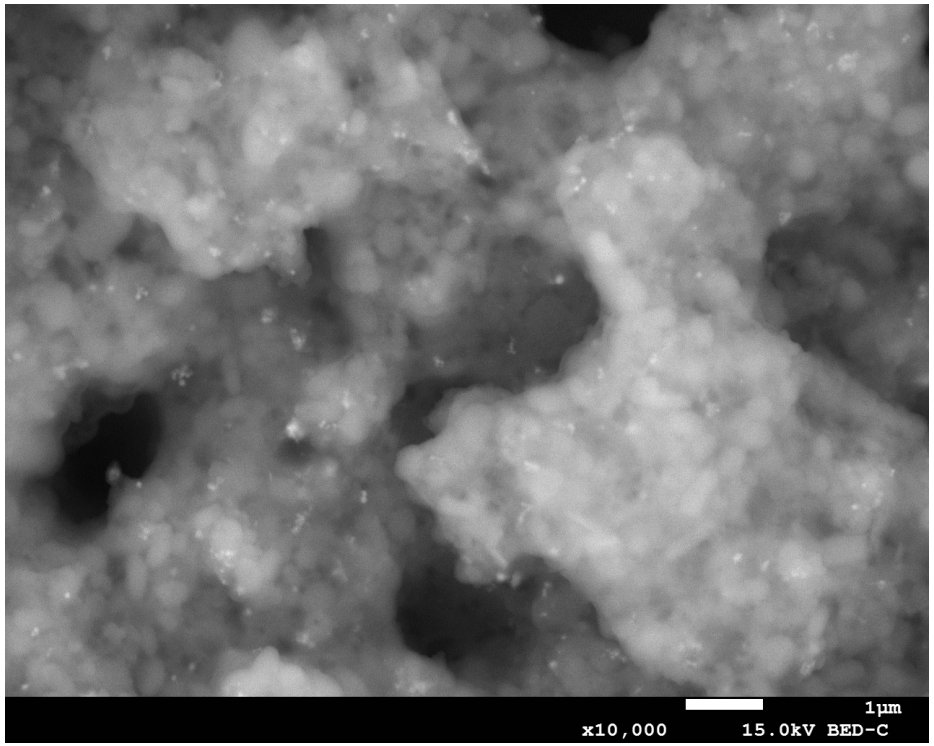
Stage 6 (D_{50}=165nm) of ELPI+

Without dryer



Stage 6 (D_{50}=165nm) of ELPI+

With dryer



This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

3. Methodology: Source apportionment

Positive Matrix Factorization (PMF) by means of the Multilinear Engine (ME-2) for:

1. **Near-source PNSD source apportionment** (>3nm) using also gaseous pollutants data (*Rivas et al., 2020*) at harbor, airport, roadways and subway in order to identify typical PNSD from each transport source.

$$x_{ij} = \sum_{k=1}^{p} g_{ik} f_{kj} + e_{ij}$$

- Uncertainties estimation method (*Rivas et al. 2020*): $\sigma_{ij} = \alpha_j \cdot (N_{ij} + \bar{N}_j)$

2. **Use typical PNSDs as a-priori information** for a «constrained PMF» at urban background using pulling equations in ME-2 (*Amato et al., 2009*)

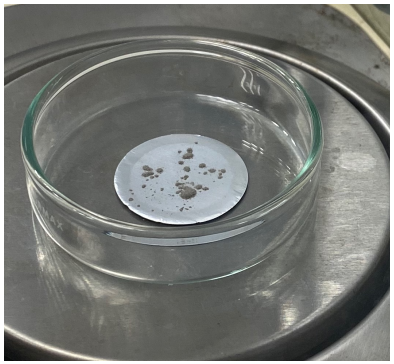
$$Q_{aux} = \frac{\left(f_{jk} - a_{jk}\right)^2}{\sigma_{jk}^{aux^2}}$$

3. **Size-segregated metals** source apportionment (*Pere-Trepat et al., 2007*)

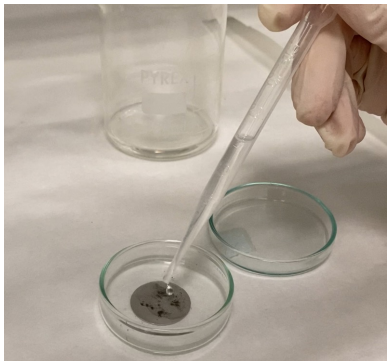
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

4. Preliminary results: PM extraction from greased aluminium foils (Apiezon-L, Dekati)

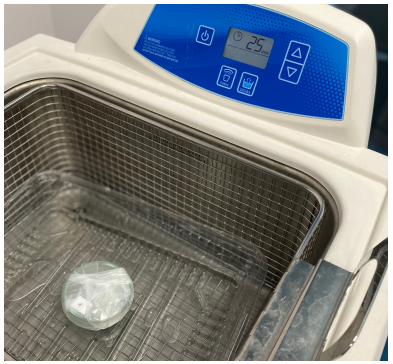
1. Deposition of standard material (4 mg – P1633b)



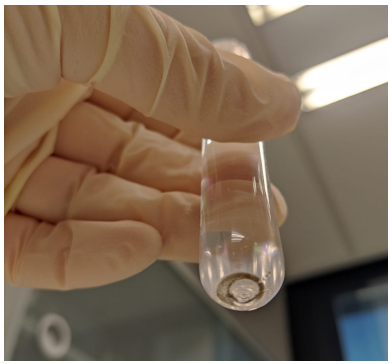
2. Leachate of the foil with the solvent



3. Ultrasonic bath (1h) & further leachate



4. Centrifugation (20 min 3000 rpm) x2 + evaporation



5. Acid digestion in Teflon vessels:

- 1,25 ml HNO_3 + 2,5 ml HF
- 4h in stove at 90°C, 24h cooling
- 1,25 ml $HClO_4$, evaporation
- 0,6 ml HNO_3, 10+2 ml miliQ water

6. Centrifugation (20 min), separation and ICP analysis of the supernatant.

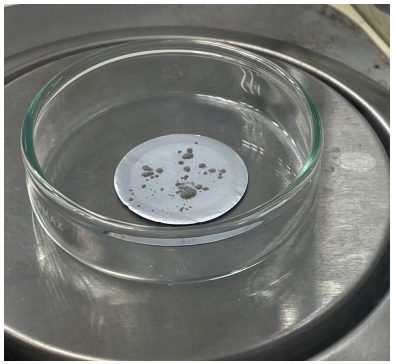
Solvent	Isopropanol	Toluene	Hexane	Acetone
ICP-MS (Trace elements) Recovery % (SD)	62.0 ± 17.5	75.5 ± 21.8	53.8 ± 21.9	72.0 ± 11.6**
ICP-AES (Mayor elements) Recovery % (SD)	70.8 ± 8.25	84.7 ± 12.3	60.6 ± 19.4	72.3 ± 11.3*

**Fe, P, S excluded; **Cd, Sn excluded*

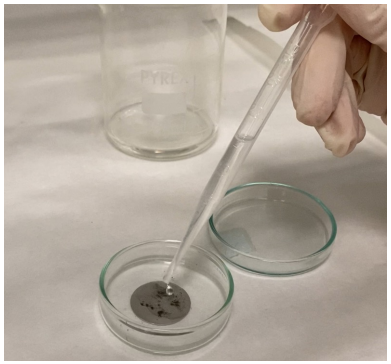
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

4. Preliminary results: PM extraction from greased aluminium foils (Apiezon-L, Dekati)

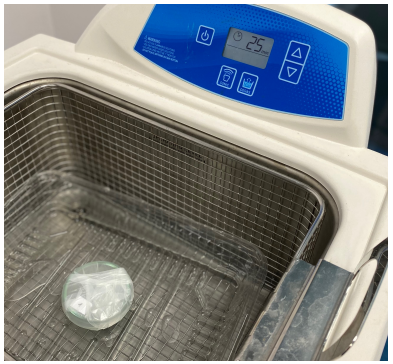
1. Deposition of standard material (4 mg – P1633b)



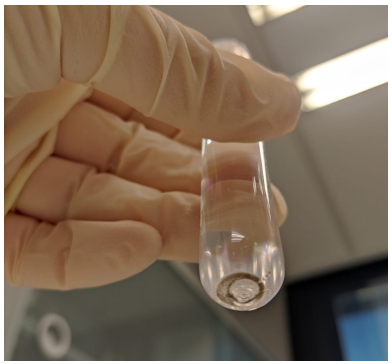
2. Leachate of the foil with the solvent



3. Ultrasonic bath (1h) & further leachate



4. Centrifugation (20 min 3000 rpm) x2 + evaporation



5. Acid digestion in Teflon vessels:

- 1,25 ml HNO_3 + 2,5 ml HF
- 4h in stove at 90°C, 24h cooling
- 1,25 ml $HClO_4$, evaporation
- 0,6 ml HNO_3, 10+2 ml miliQ water

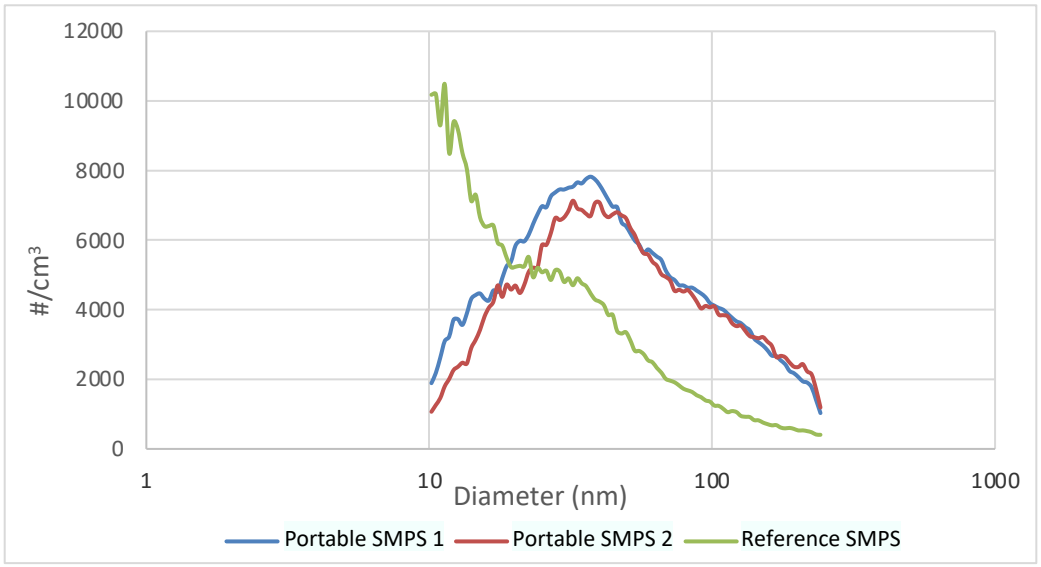
6. Centrifugation (20 min), separation and ICP analysis of the supernatant.

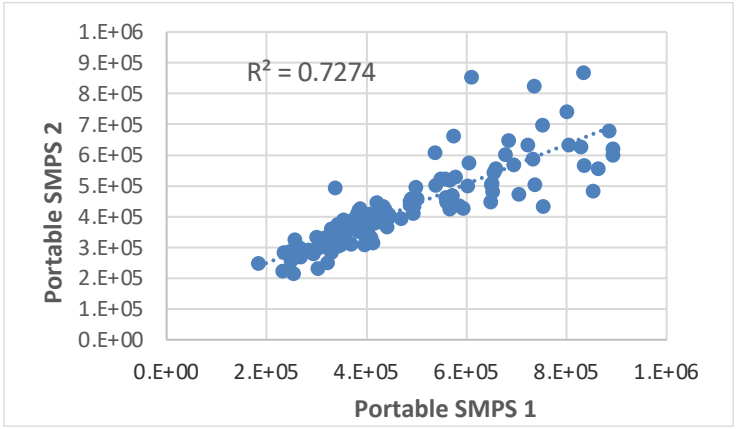
Solvent	Isopropanol	Toluene	Hexane	Acetone
ICP-MS (Trace elements) Recovery % (SD)	62.0 ± 17.5	75.5 ± 21.8	53.8 ± 21.9	72.0 ± 11.6**
ICP-AES (Mayor elements) Recovery % (SD)	70.8 ± 8.25	84.7 ± 12.3	60.6 ± 19.4	72.3 ± 11.3*

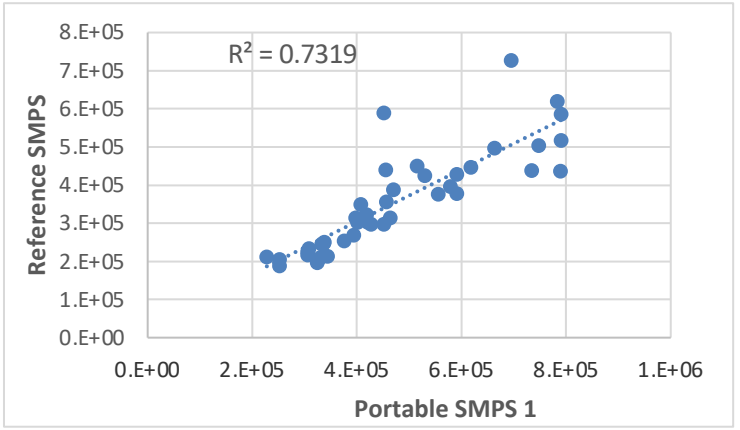
**Fe, P, S excluded; **Cd, Sn excluded*

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

4. Preliminary results: portable equipments intercomparisons for quality assurance

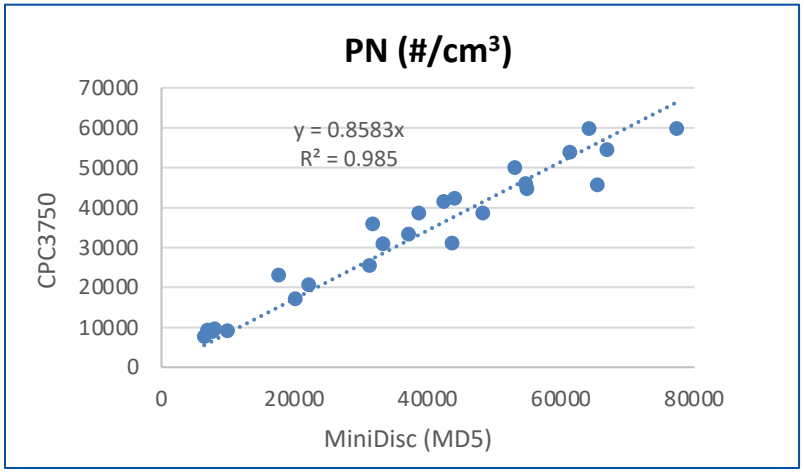


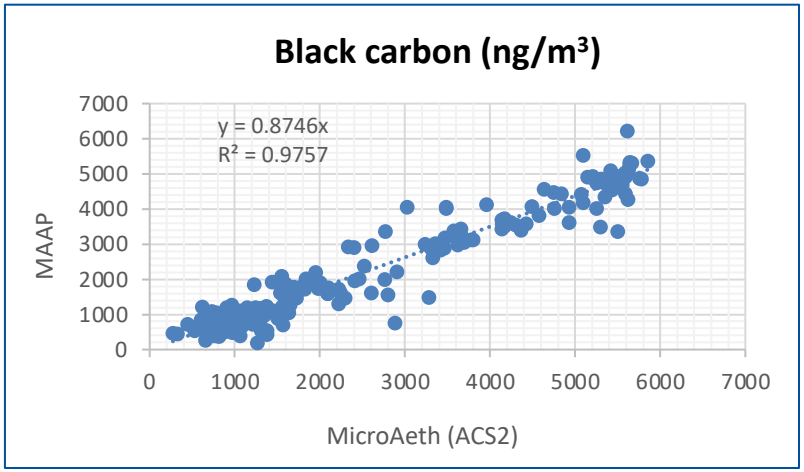


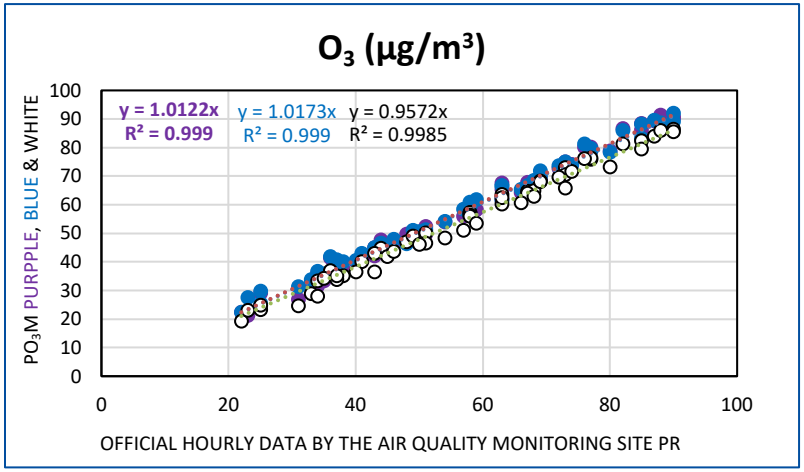


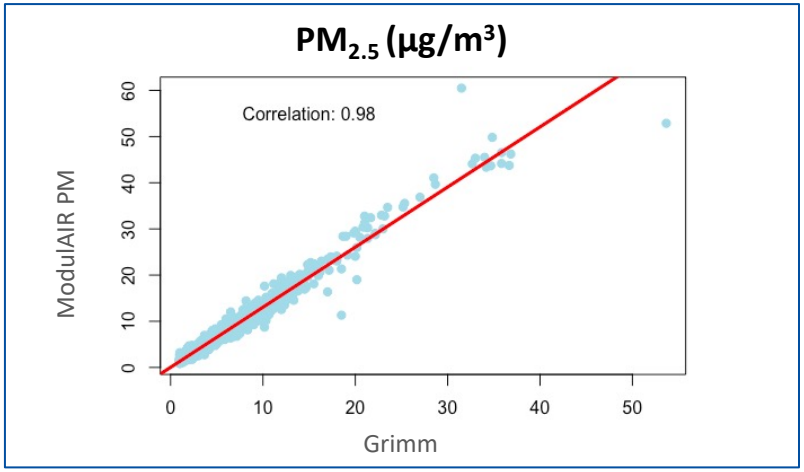
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

4. Preliminary results









This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

5. Conclusions

- **nPETS** project aims at physico-chemically characterizing and monitoring of UFP emitted from road traffic, shipping, aviation and railway emissions;
- A **sampling protocol** has been developed for DGI and ELPI+ impactors, including extraction and acid digestion of samples collected on aluminium foils:
  - Drier & grease minimize positive and negative artefacts;
  - Toluene seems to be the best dissolvent for particle extraction from Apiezon-L greased aluminium foils;
- **4 SMPSs** (2 from TSI + 2 portable SMPS) will be used simultaneously at each site to study spatial gradients;
- **Different levels of complexity of source apportionment (PMF)** will be applied in order to determine PNSD and UF metals emitted from different transport sectors and calculate their contribution to average exposure levels.

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.

Thank you
for your attention!

Sharon Ridolfo, IDAEA (CSIC)

Email: sharon.ridolfo@idaea.csic.es

nPETS

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme, under grant agreement № 954377.