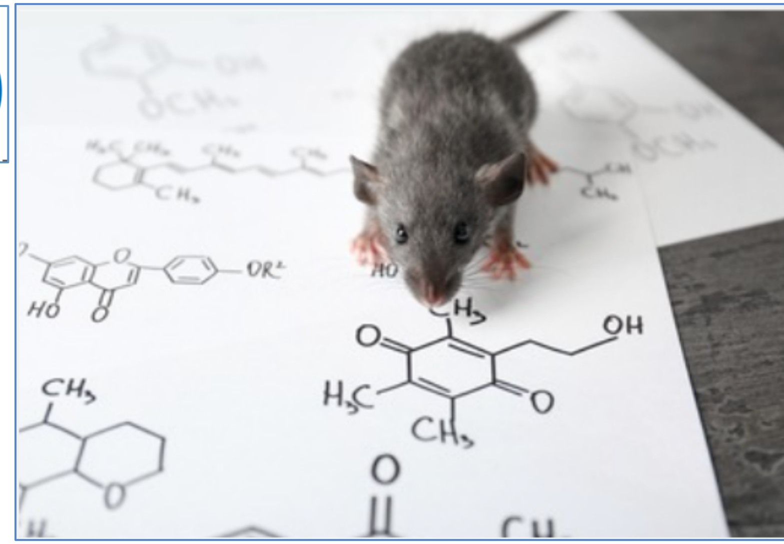


HOW ATMOSPHERIC SIMULATION CHAMBERS CAN HELP TO INVESTIGATE THE IMPACT OF AIR QUALITY ON HEALTH

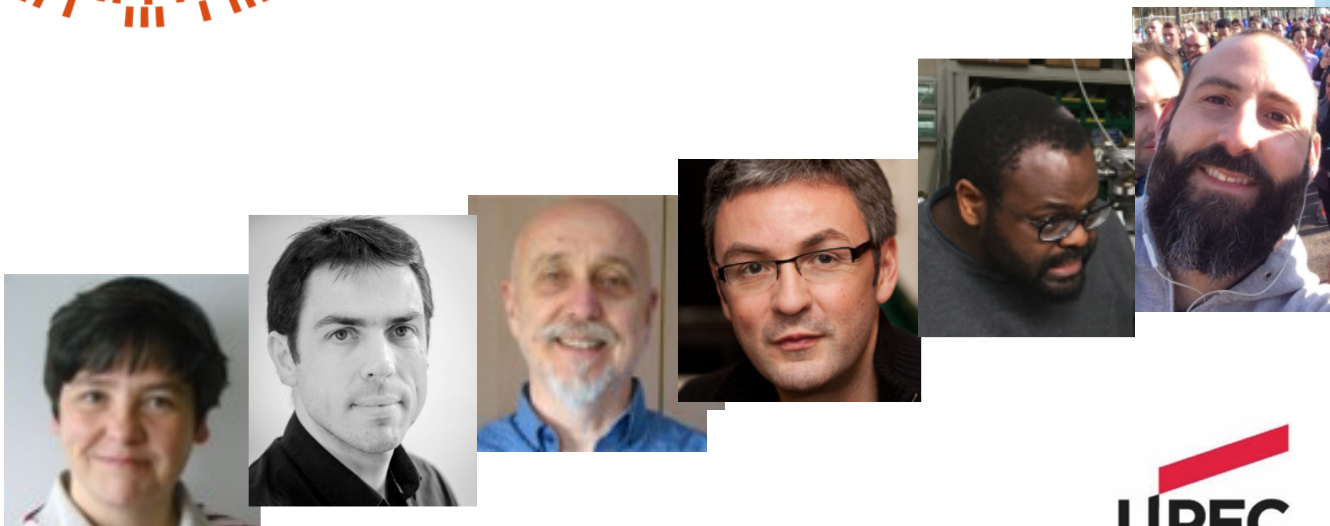
<u>Patrice Coll</u> (1), Mathieu Cazaunau (1), Jean-François Doussin (1), Edouard Pangui (1), Aline Gratien (1), Paola Formenti (1), Isabelle Coll (1), Gilles Foret (1), Cécile Gaimoz (1), Vincent Michoud (1), Claudia Di Biagio (1), Elie Al Marj (1), Marion Blayac (2), Zhuyi Lu (2), Audrey Der Vartanian (2), Stéphane Jamain (2), Geneviève Derumeaux (2), Maria Pini (2), Sophie Hüe (2), Frédéric Relaix (2), Jorge Boczkowski (2) and Sophie Lanone (2).

LISA, UMR CNRS 7583, Université de Paris, Université Paris-Est, 61 avenue du Général de Gaulle, 94010 Créteil cedex, France.

IMRB - Inserm U955, Faculté de Médecine de Créteil, 8 rue du Général Sarrail, 94010 Créteil cedex, France.

lisa | Laboratoire Inter-universitaire des Systèmes Atmosphériques

IMRB



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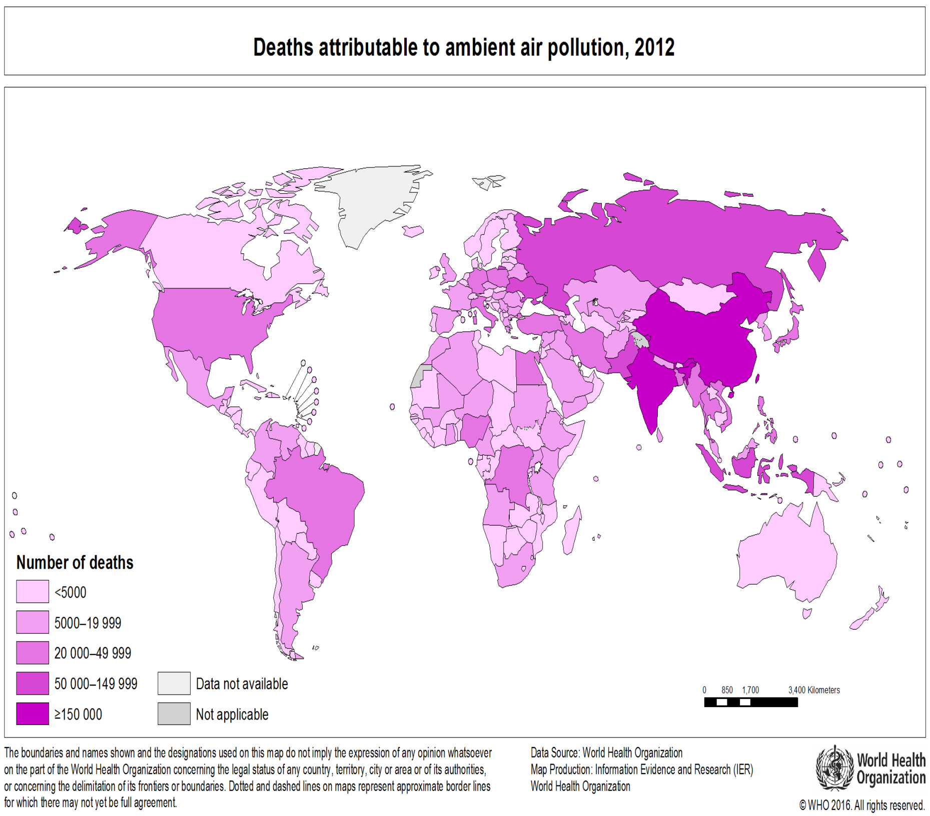
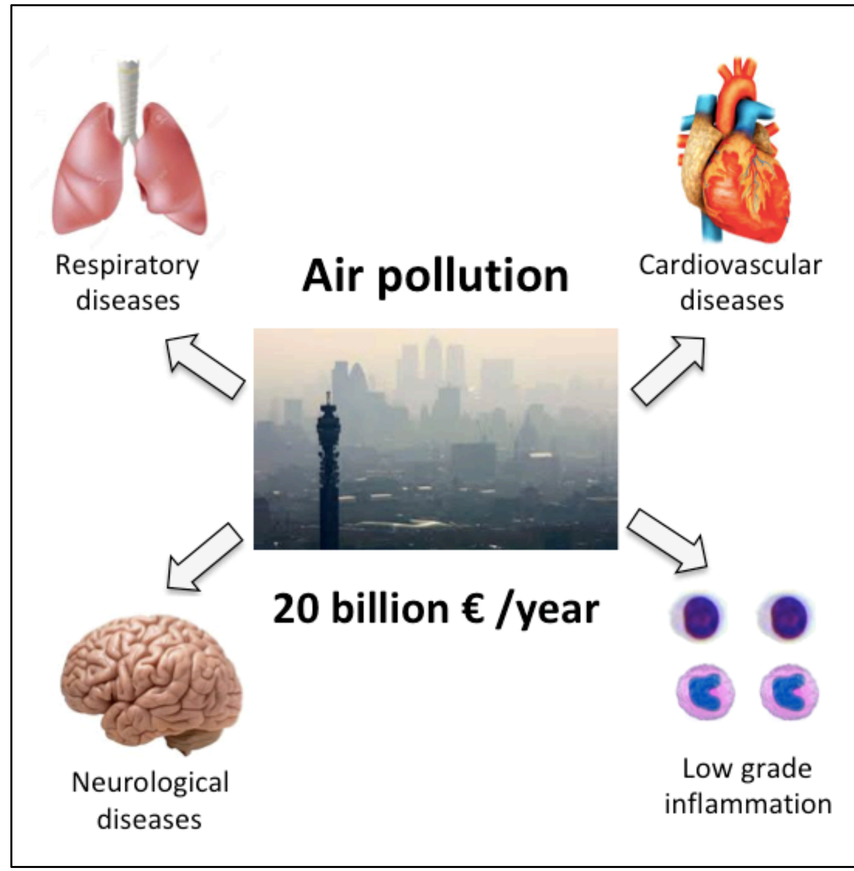
"This project/work has received funding from the European Union's Horizon 2020 research and innovation programme through the EUROCHAMP-2020 Infrastructure Activity under grant agreement No 730997".

1. **Context**
2. **The *PolluRisk* platform**
3. **The CESAM chamber**
4. **Illustration : the Beijing case**
5. **A few results**
6. **the H2020 REMEDIA project**

Very contemporary context



Map of the distribution of deaths attributable to air pollution (Source: WHO, 2012)



How to study these Health impacts ?

- **Epidemiologic studies:**

Objective: to establish an association between exposure to certain substances and the occurrence of diseases in humans

  - Exposure qualification difficult to establish
  - Difficult to link pollutants and diseases

- **Experimental studies :**

Objective: cells/organisms/animals exposure

  - Exposure(s) control
  - One study per pollutant
    - Non representative of the polluted atmosphere
    - Can not reproduce the synergy of pollutants

to simulate Atmospheric Pollution

- *"Smog chamber" : the most direct way to study the relation between emission and air quality*

Finlayson-Pitts and Pitts, 1986

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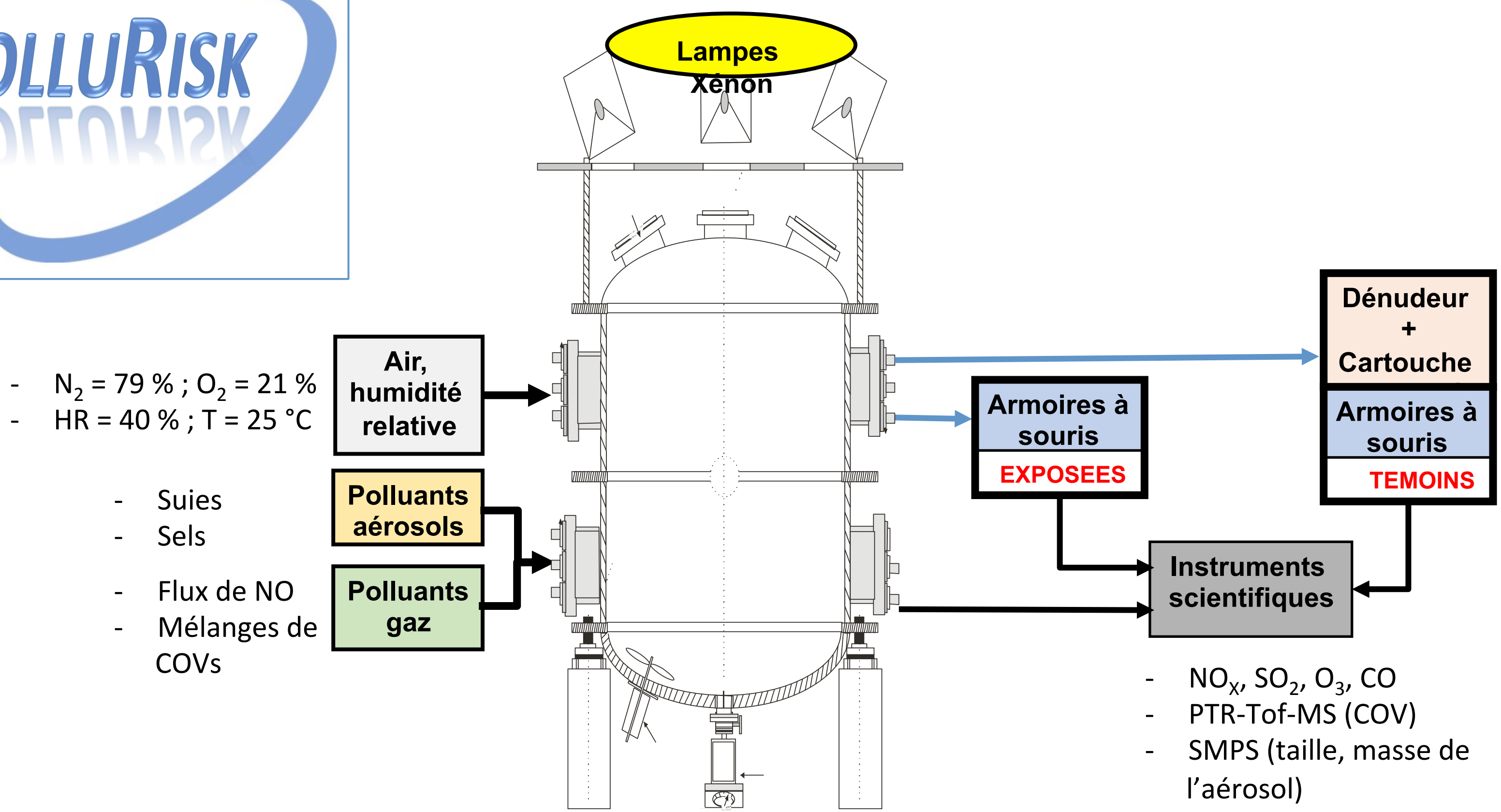
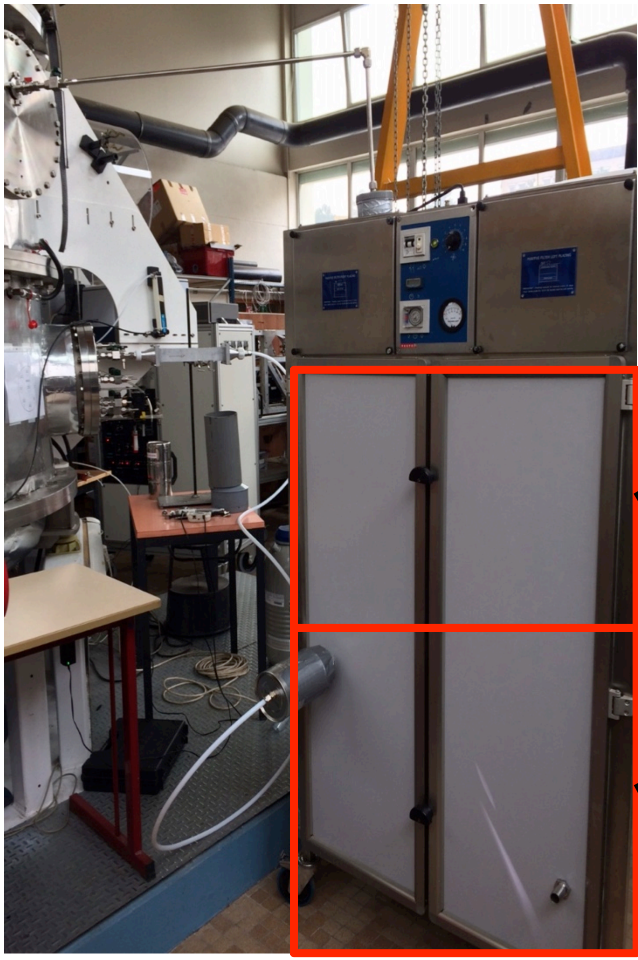
Strategy associated to PolluRisk

Objectives: ***to generate a representative model atmosphere of a large metropolis and maintain it for several days to expose mice (for several days)***

Use CESAM as a reactor to generate the model atmosphere and feed a two-stage compartmentalized mouse cabinet (exposed mice and control mice***)***

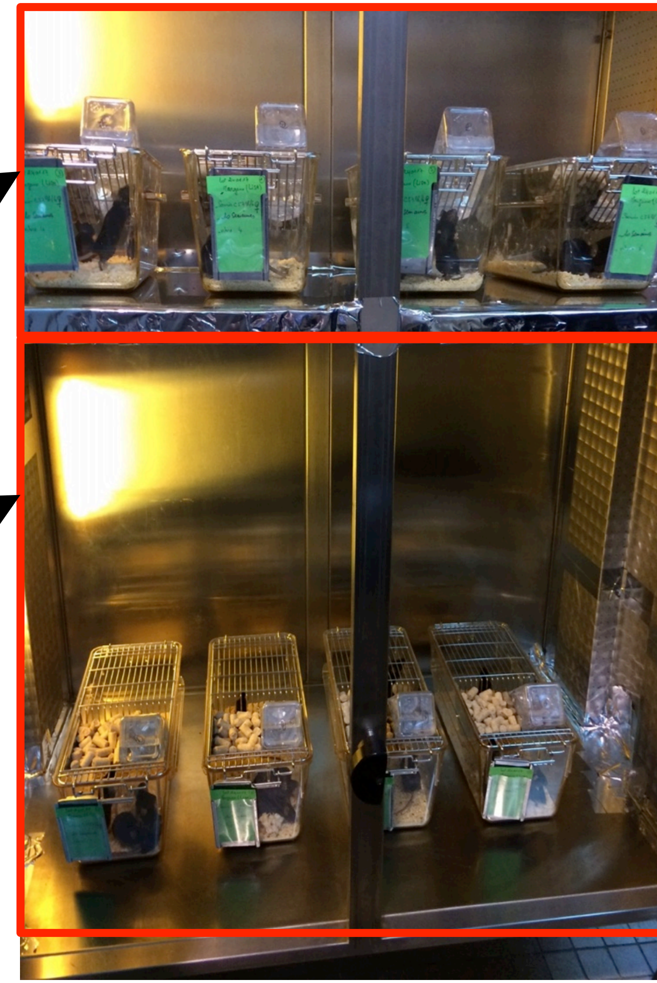


View of the platform



Mice exposed to the atmosphere of CESAM

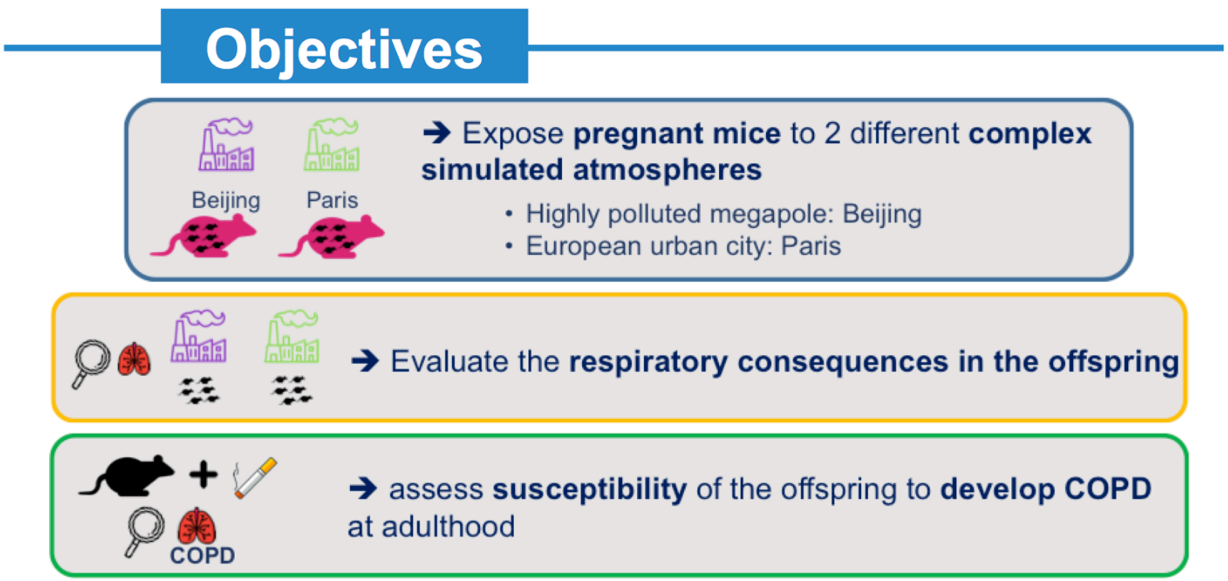
Mice exposed to the purified atmosphere (controls)



the *PolluRisk* platform

- Innovative transdisciplinary project (LISA and IMRB)
- <u>Objective:</u> to study the different impacts of AQ on living organisms

<u>Illustration with PolluRisk#1 :</u>



Vented cabinet

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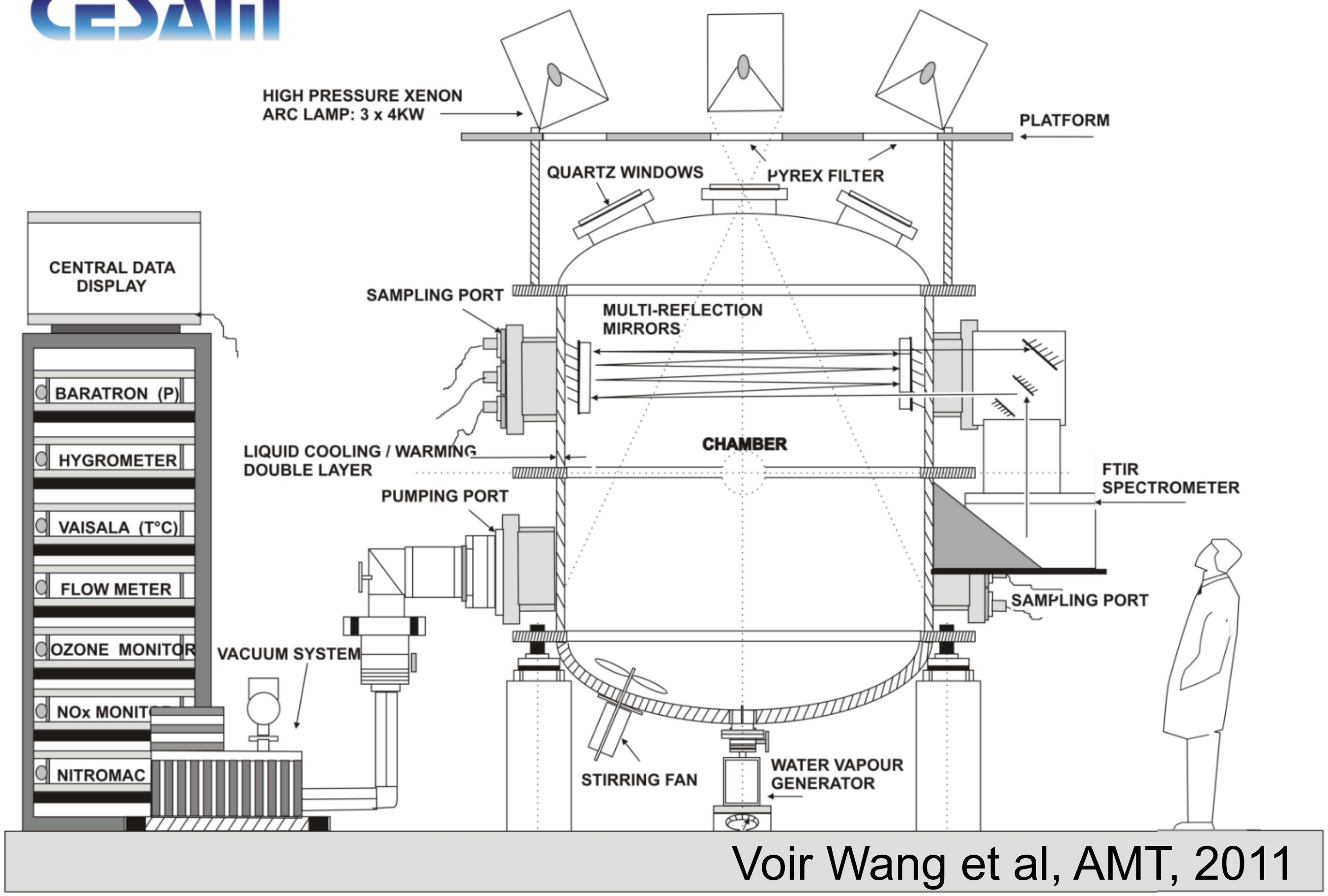
the CESAM chamber

- $V = 4.2\ m^3$
- $S/V = 4.29\ m^{-1}$
- Inox 304L
- Evacuable
- Artificial irradiation
- Controled in temperature (10°C to 60°C)

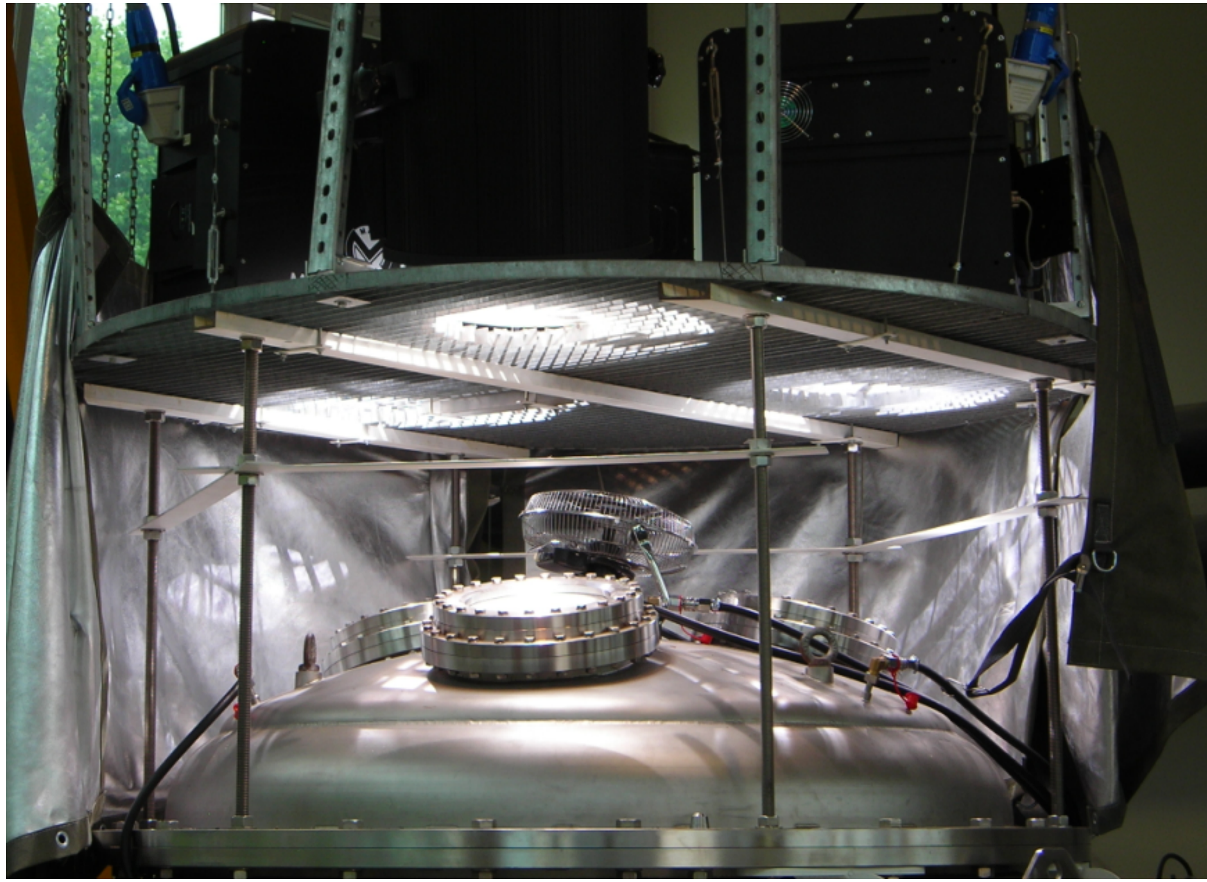


Voir Wang et al, AMT, 2011


CESAM - RACK INSTRUMENTAL
RIBER
lisa
Equipe MEREIA
ZARGES

Solar Simulator

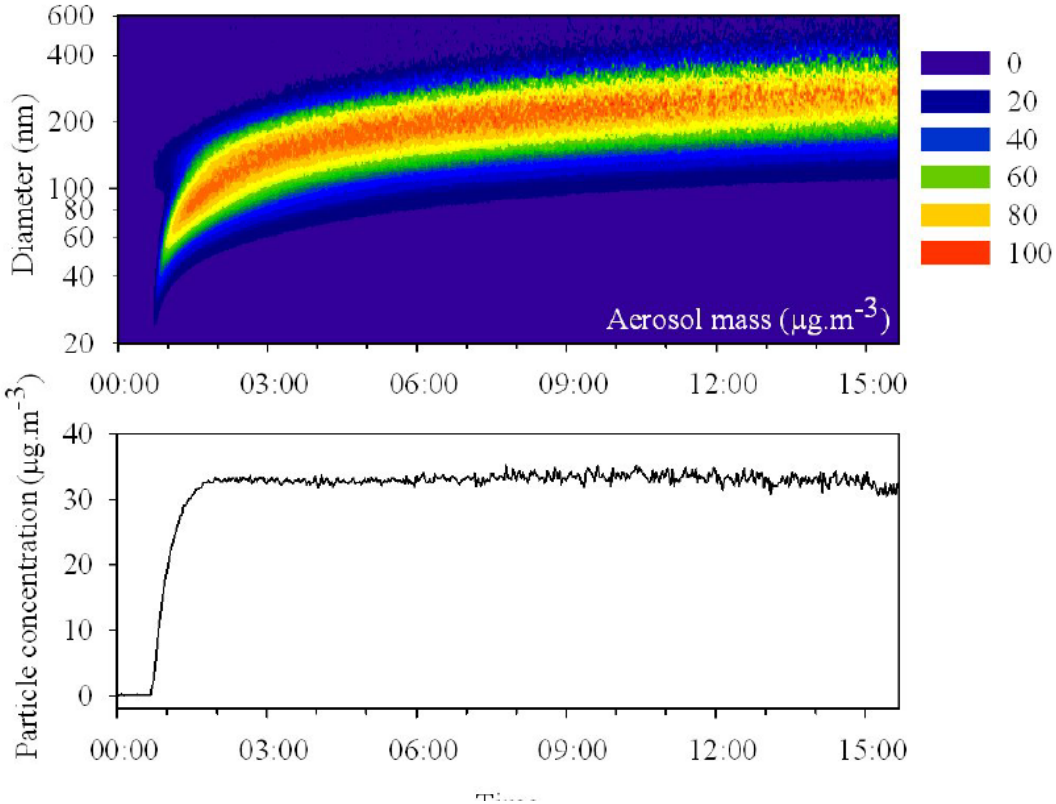
- 3 Xenon arc lamps of 4kW…
- arranged above the chamber…
- illuminate through portholes of synthetic quartz



Life time of the aerosol

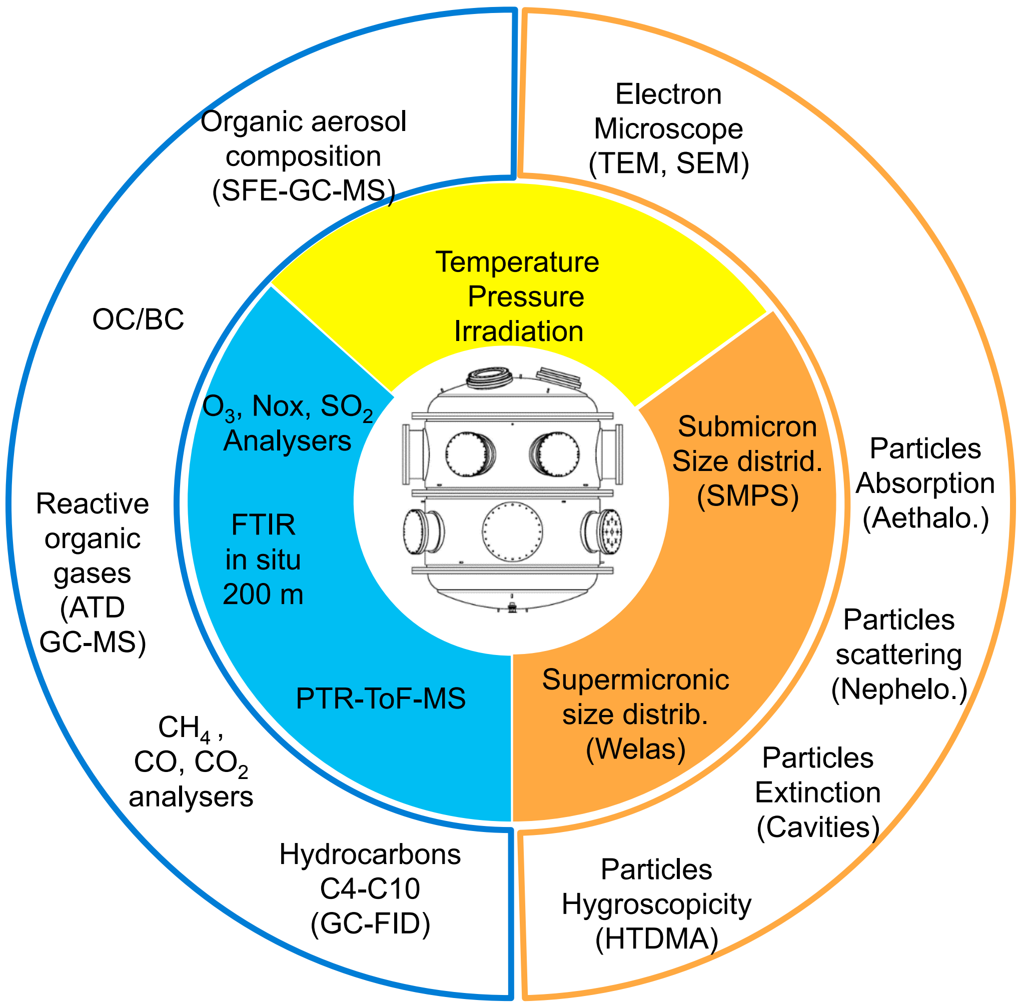
Due to the low electrostatic charges on the walls (unlike rooms made of Teflon® film), CESAM has very long aerosol lifetimes.

Up to 4 days for a 200 nm aerosol



NB : Lifetime of an atmospheric particle from 1 to 3 days according to Williams et al. (2002)

Analytical environment



A wide set of instruments to address a wide set of problematics !

The Eurochamp-2020 initiative

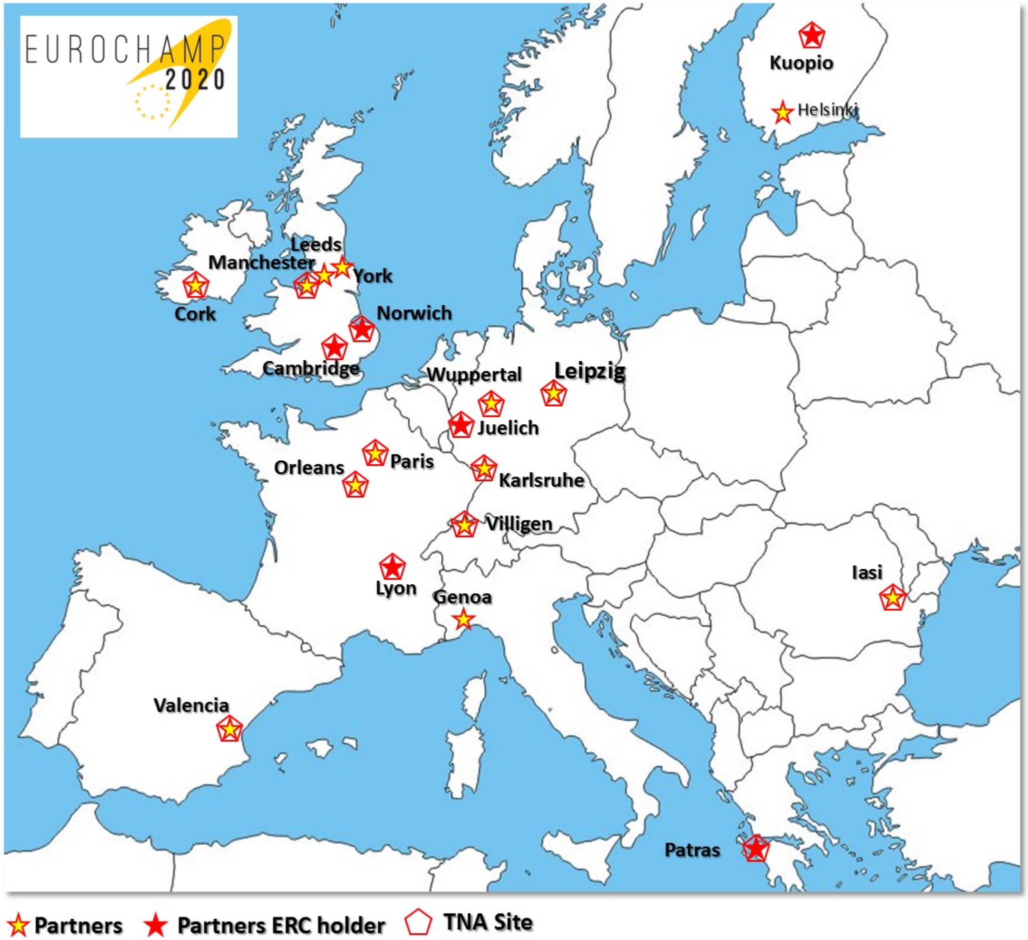
Since the 1st of december 2016 and for 4 years…

14 partners comprising 19 groups :

1A – CNRS-Paris	9 – Kuoppio
1B – CNRS-Orleans	10 – Patras
1C – CNRS-Lyon	11 – Genoa
2 – Wuppertal	12 – Iasi
3 – Karlsruhe	13A – NCAS - Leeds
4 – Julich	13B – NCAS - Manchester
5 – Villigen	13C – NCAS - Cambridge
6 – Valencia	13D – NCAS - Norwich
7 – Leipzig	14 – Uni. Helsinki
8 – Cork	

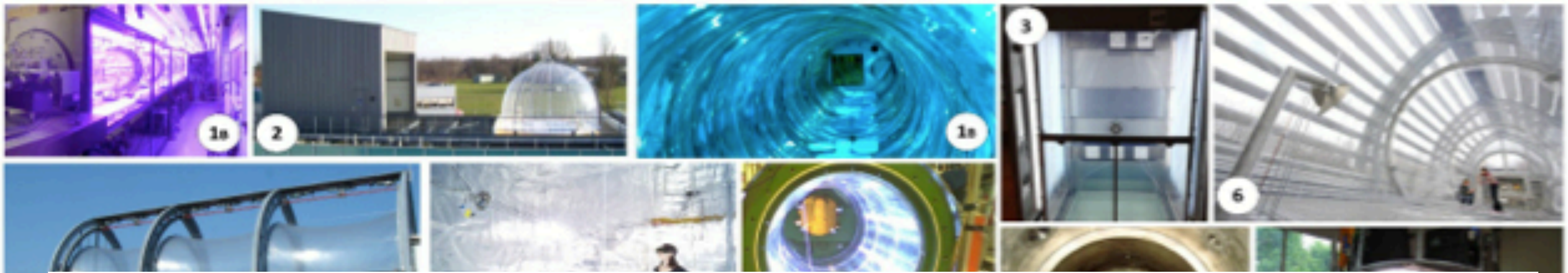
- The French under the banner of CNRS
- The British under the banner of NCAS

Open call for Associated Partnership



Airmodus Ay, Biral, PlumeLabs, Nanothinx
National Physical Laboratory, Aarhus University, Babcock Noell, Universität W. Goethe - Frankfurt am Main

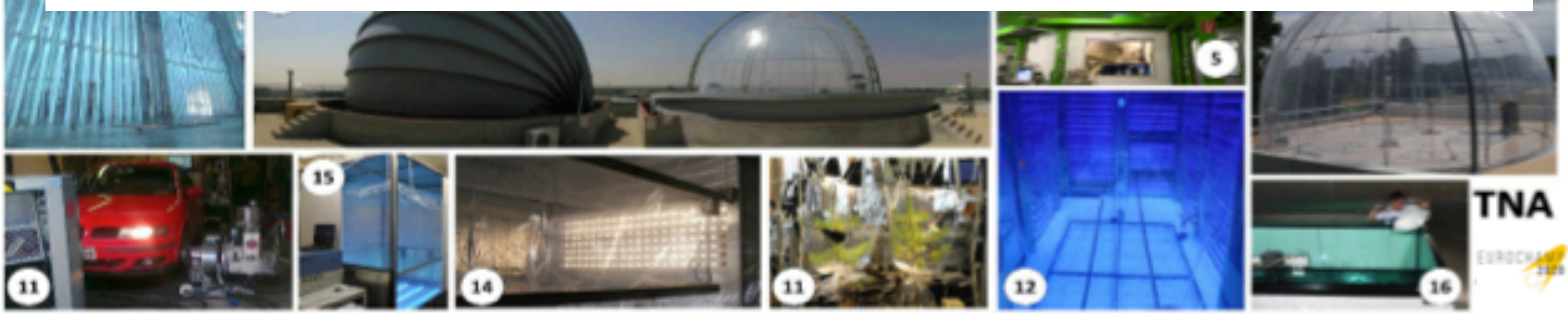
Services to the community



10.2 - air quality on health and on cultural heritage

(M. Kalberer)

- Biological effect of air pollution and bio-aero-contamination
- impact of air quality on cultural heritage,



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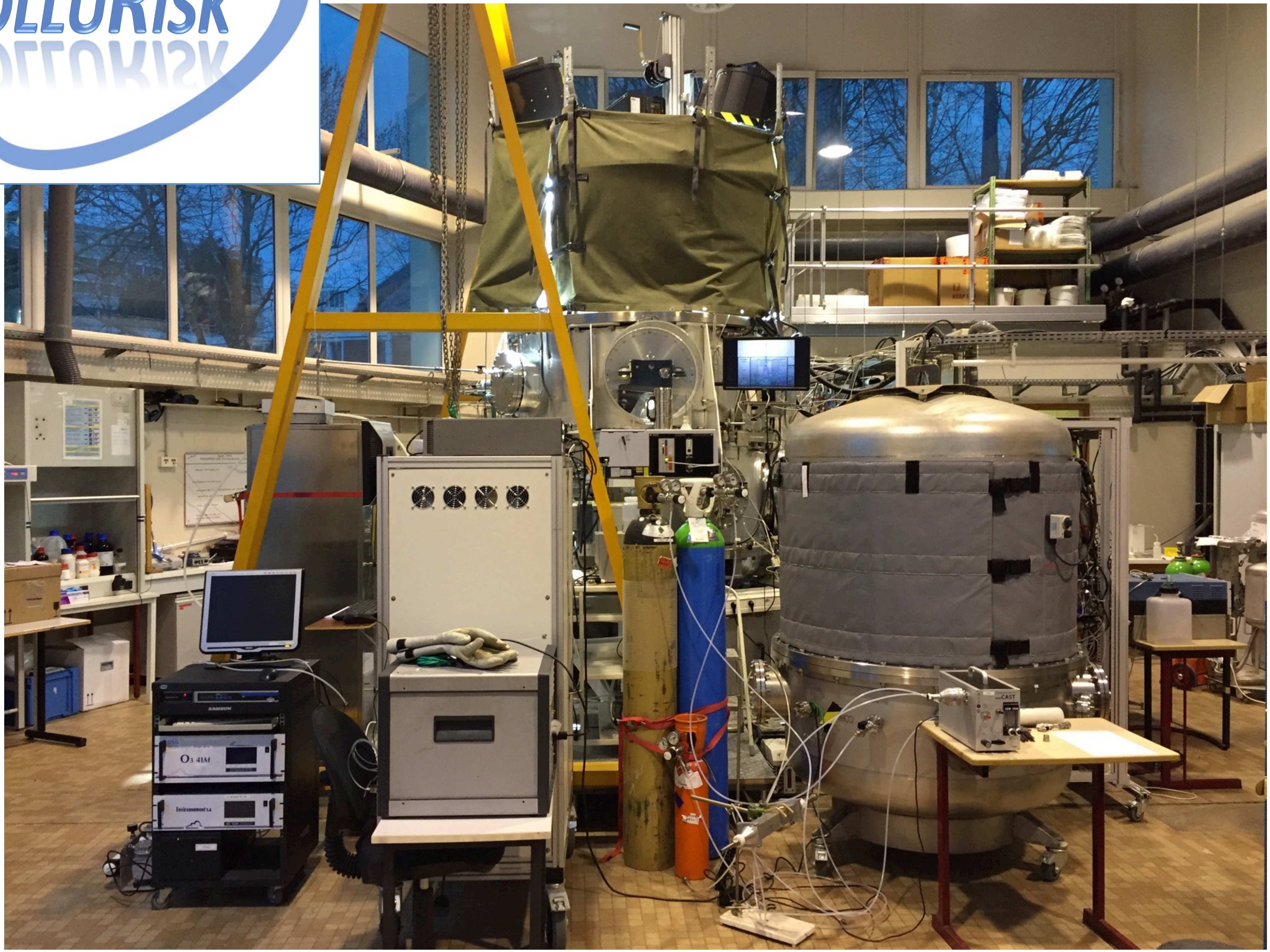
PolluRisk



Volatile organic compounds in 43 Chinese cities, Barbara Barletta (2001)

Average mixing ratio expressed in part per billion by volume (ppbv) of ethane (C2h6),ethyne, 1-3 butadiène, benzene and toluene. The one sigma standard deviation (SD) is also reported

Ville	C2H6	SD	C2H2	SD2	1,3-butadi
Benjing	16,4	3	34,7	3,6	1,4
SD3	C6H6	SD4	C7H8	SD5	
0,08	5,9	1,4	7,5	2,7	

Tropospheric volatile organic compounds in China, H.Guo (2017)

Sampling sit	Site categor	Sampling pe	Mixing ratio	Number of VOC	Articles
Beijing	Urban	March, July an	132.6 ±52.2 ug/	108	**Liu et al. (2005).**
Beijing	Urban	August 2005	43.4 ppbv	31	Song et al. (2007).
Beijing	Urban	August 2006	40.5 ppbv	57	Duan et al. (2008).
Beijing	Urban	August 2004-20	33.2 ± 23.4 ppb	20	Shao et al. (2009b).
Beijing	Urban	May 2014	29.4 ppv	56	Li et al. (2015).

Atmospheric BTEX and carbonyls during summer seasons of 2008 2010 in Beijing, Yujie Zhang (2011)

Concentrations moyennes en été en ug/m3

Colonne1	2008	2009	2010
benzene	3.3 ± 2.0	3.2 ± 3.3	2.1 ± 1.5
toluene	5.6 ± 4.0	8.6 ± 5.5	5.9 ± 3.7
ethylbenzene	2.1 ± 4.0	3.3 ± 2.1	2.3 ± 1.4
m-p xylene	3.3 ± 2.2	4.6 ± 3.4	3.4 ± 2.4
o xylene	1.7 ± 1.3	1.9 ± 1.3	1.7 ± 1.2
Total	16.0 ± 9.3	21.5 ± 13.7	15.4 ± 9.3

Levels, sources and health risks of carbonyls and BTEX in the ambient air of Beijing, Yujie Zhang (2012)

Colonne1	FADH	Acetaldehyd	Acetone	Benzene	Toluene	Ethylbenzen	m, p xylene	o xylène
Automne 2008	5,9	6,6	13,1	4,6	8,5	3,4	5,7	2,8
Hiver 2008	4,8	6	11,6	6,9	10,4	2,5	4,9	2,2
Printemps 2009	5,3	6,8	[illegible]	4,8	9,4	2,7	4,3	1,8
Eté 2009	8,8	[illegible]	[illegible]	3,2	8,6	3,3	4,6	1,9
Automne 2009	8,3	[illegible]	[illegible]	5,1	11,2	4,1	7,2	2,8
Hiver 2009	4,3	[illegible]	16	9,2	14,5	4,4	7,5	3,5
Printemps 2010	6,6	[illegible]	28,9	[illegible]	9,2	3,2	5,3	2,6
Eté 2010	3,7	[illegible]	28,7	[illegible]	5,9	2,3	3,4	1,7
Moyenne (ug/m	5,9625	[illegible],575	18,887[illegible]	4,9[illegible]	9,7125	3,2375	5,3625	2,4125

Biblio. VOCs

Thèse de Cecile GAIMOZ

Teneurs moyennes des 10 COV les + abondants pour la [illegible] Péki[illegible]

Atmospheric volatil organic compounds in a typical u[illegible] of [illegible]jing..., Hao Zhang (2017)

Mesures réalisées entre avril 2014 et Juin 2015

Hao Zhang	Annual conc	Cecile GAIM	Co[illegible]atio	Concentrations	Masse mol	Concentratic	Réactivité	DEBIT MOL (
ALCANES								
ethane	5,40	ethane	3,65	4,53	30,07	9,06E+10		3,62E+05
propane	8,42	propane	6,22	7,32	44,1	1,00E+11		4,00E+05
i-butane	3,10	i-butane	7,84	5,47	58,12	5,67E+10		2,27E+05
n-butane	4,66	n-butane	8,78	6,72	58,12	6,96E+10		2,78E+05
i-pentane	0,19	i-pentane	14,65	7,42	72,15	6,19E+10		2,48E+05
cyclopentane	2,99			2,99	72,15	2,50E+10		9,98E+04
n-hexane	1,61			1,61	86,18	1,13E+10		4,50E+04
n-pentane	1,45	n-pentane	5,43	3,44	72,15	2,87E+10		1,15E+05
n-dodecane	5,29			5,29	170,34	1,87E+10		7,48E+04
ALCENES								
ethylene	6,15			6,15				
propene	3,18			3,18	42,08	4,55E+10		1,82E+05
isoprene	2,01			2,01				
ALCINES								
acetylene	3,84	acetylène	4,32	4,08	26,04	9,44E+10		3,77E+05
HYDRACARBURES AROMATIQUES								
benzene	4,09	benzène	5,87	4,98	78,11	3,84E+10		1,54E+05
toluene	6,10	toluène	8,86	7,48	92,14	4,89E+10		1,95E+05
ethylbenzene	2,69			2,69				
m,p-xylene	5,57	m,p-xylène	4,69	5,13	106,16	2,91E+10		1,16E+05
o-xylene	1,24			1,24				

Air quality of Beijing and impacts of the new ambiant quality standard, Wei Chen (2015)

Etude réalisée de 2000 à 2013

8 stations en zone urbaine de Pékin	PM 10 (ug/m3	PM 2.5 (ug/m3)	Ozone (ug/m3	SO2 (ug/m3)	NO2 (ug/m3)	CO (mg/m3)
Whanshouxigong	135,88	91,09	55,98	27,24	56,99	1,62
Dongsi	137,83	125,7	54,24	50	74,92	2,46
Tiantan	114,17	89,78	59,76	21,78	54,54	1,51
Nongzhanguan	114,75	90,4[illegible]	[illegible]2,12	28,1	60,82	1,5
Guanyuan	116,43	89,[illegible]	[illegible]83	27,14	59,69	1,41
Wanliu	125,48	[illegible]	51,81	36,28	72,17	1,48
Gucheng	119,47	[illegible]47	62,08	21,82	61,87	1,54
Aoti	[illegible]93	[illegible]	48,84	21,15	60,61	1,16
MOYENNE	[illegible]22,[illegible]	[illegible]8875	57,0825	29,18875	62,70125	1,585

Atmospheric volatil organic compound[illegible] a ty[illegible]l u[illegible] are[illegible] Beijing..., Hao Zhang (2017)

Mesures réalisées entre avril 2014 [illegible]15

Colonne1	A[illegible]	[illegible]olec/cm3
NO	[illegible]	6,06013E+11
NO2	[illegible]	1,16788E+12
NH3	[illegible] 8.9	2,06687E+1[illegible]
SO2	23.2 ± 49.8	4,65547E[illegible]
CO	1.92 ± 1.72	385[illegible]000
O3	44.3 ± 53.2	[illegible]39[illegible]+11
PM 2.5	117 ± 108	[illegible]

Biblio. gas

Chemical characterization and source identification of PM 2.5.... Xiaojun Huang (2017)

Etude réalisée de Juin 2014 à Avril 2015

Composition chimique PM 2.5	%
OM (= 1.6*OC)	25,00%
sulfate	14%
nitrate	18,00%
ammonium	11,60%
mineral dust	16,80%
EC	6,20%
chlorure	[illegible]
métaux traces	[illegible]
non identifié	5[illegible]

Concentration moyenne PM 2.5	[illegible]g/m[illegible]
PM 2.5	[illegible].5 ±[illegible]

A systematic analysis in PM 2.5 in Beijing and its sources from 2000 to 2012, Baolei Lv (2015)

de 2000 à 2012

Composition chimique	%
OM (=1.4*OC)	35,5
sulfate	11,4
nitrate	7,9
[illegible]ium	5,2
[illegible]	5,8

Concentration PM 2.5	ug/m3
en 2002	147
en 2010	72,2

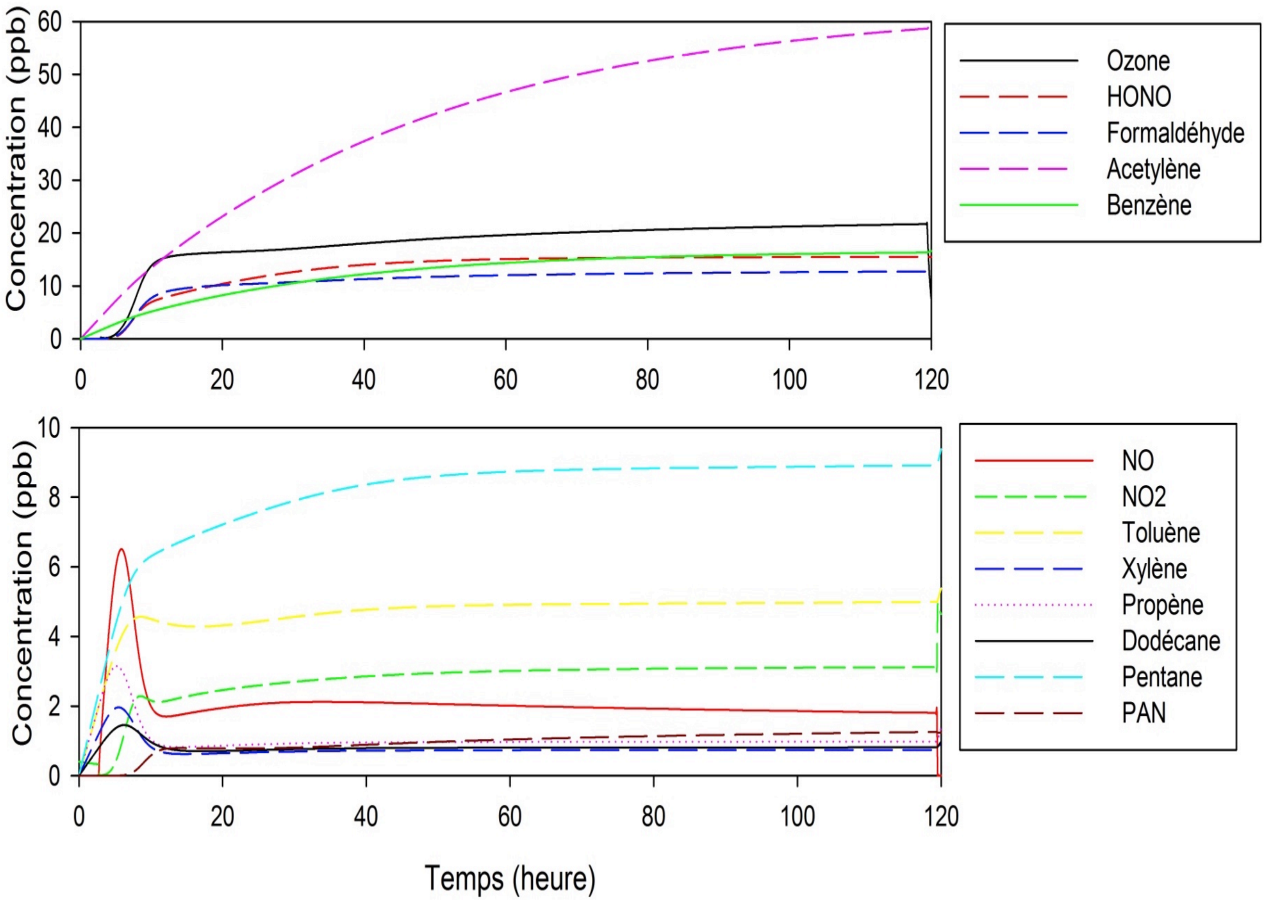
concentratio[illegible]oyenne en PM 2.5 selon les saisons

Printem[illegible]	Été	Automne	Hiver
123,3	92,1	108,9	140,1
moyenne[illegible]3)	116,1		

	Chemical characterization and source identification of PM 2.5.... Xiaojun Hua[illegible] (2017)	A systematic [illegible] in PM[illegible] in B[illegible] [illegible]s fr[illegible] [illegible] to [illegible]aol[illegible] Lv ([illegible]	[illegible] se[illegible]ry a[illegible] part[illegible] [illegible]ollu[illegible] haze events [illegible]hina, [illegible]uang (2014)
	Etude réalisée de Juin 2014 à Avril 2015	[illegible]2012	[illegible] réalisée au cours de l'année 2013
OM	25,00%	35,5	40,70%
sulfate	14%	11,4	12%
nitrate	18,00%	7,9	16,00%
ammonium	11,60%	5,2	9,80%
mineral dust	16,80%		
EC	6,20%	5,8	9,60%
chlorure	3%		4%
métaux traces	0%		5%
non identifié	5%		4%
PM 2.5 (concentration moyenne) ug/m3	99.5 ± 67.4	116,1	158.5 moyenne journalière

Biblio. PM

to simulate Beijing



Model output obtained by FACSIMILE for long-term exposure (5 days)

Prediction of concentrations in the chamber

The model takes into account:

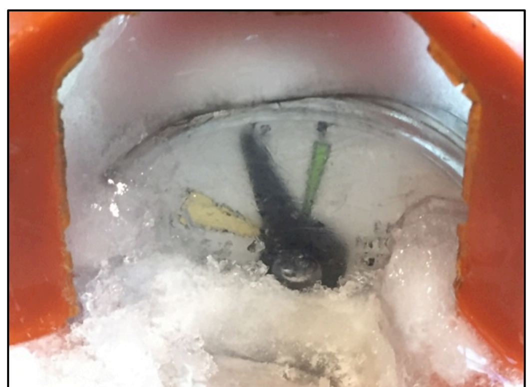
- 1500 species and 3000 reactions
- injection of 7 organic precursors
- Introduction of NO

➢ <within 20h, concentrations are stable

to simulate Beijing

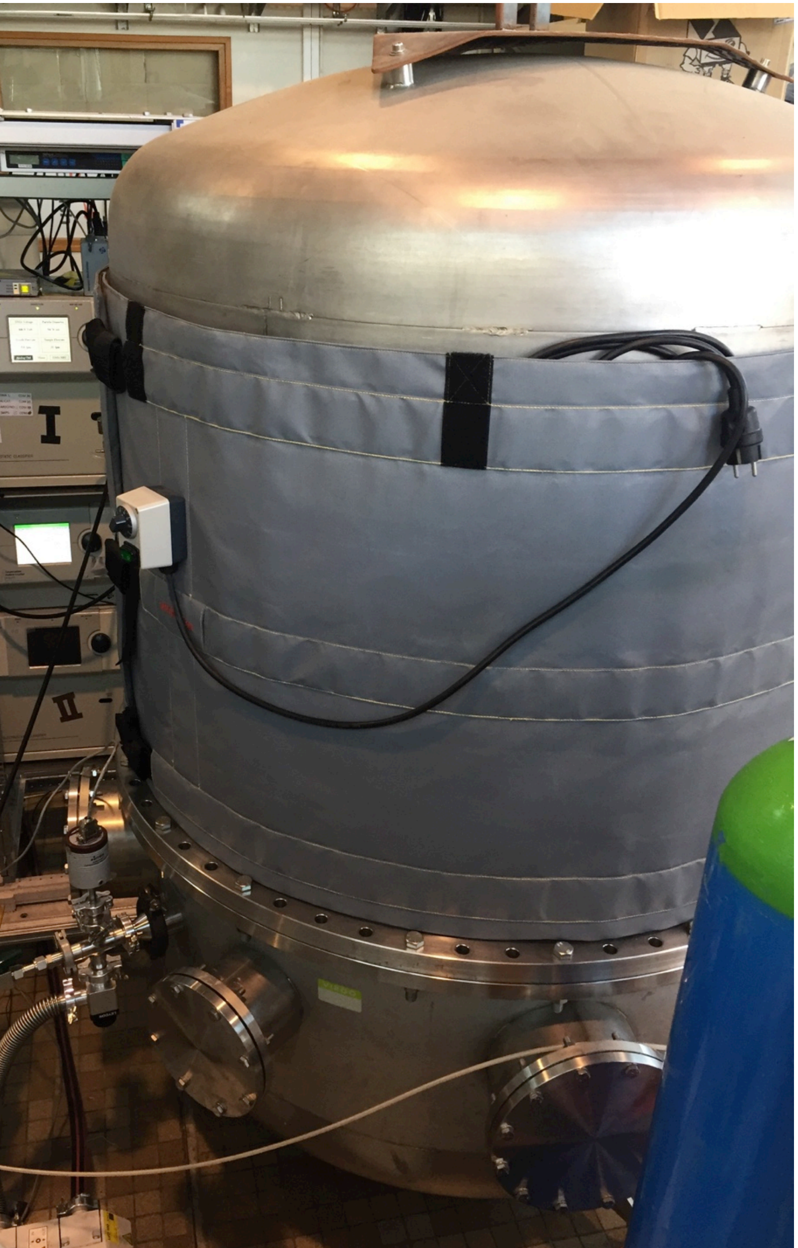
to simulate Beijing

Gaseous phase ...

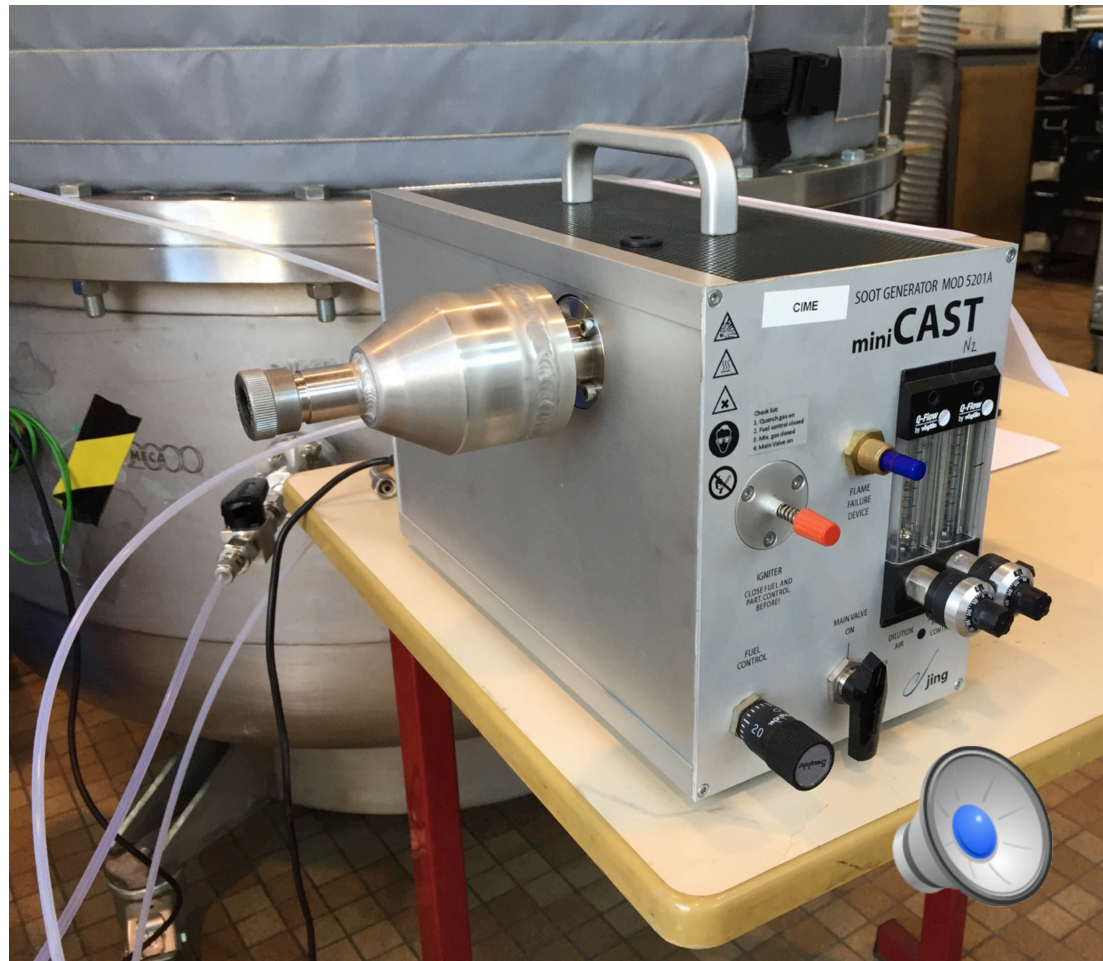


N_2 from N_2 liq sublimation

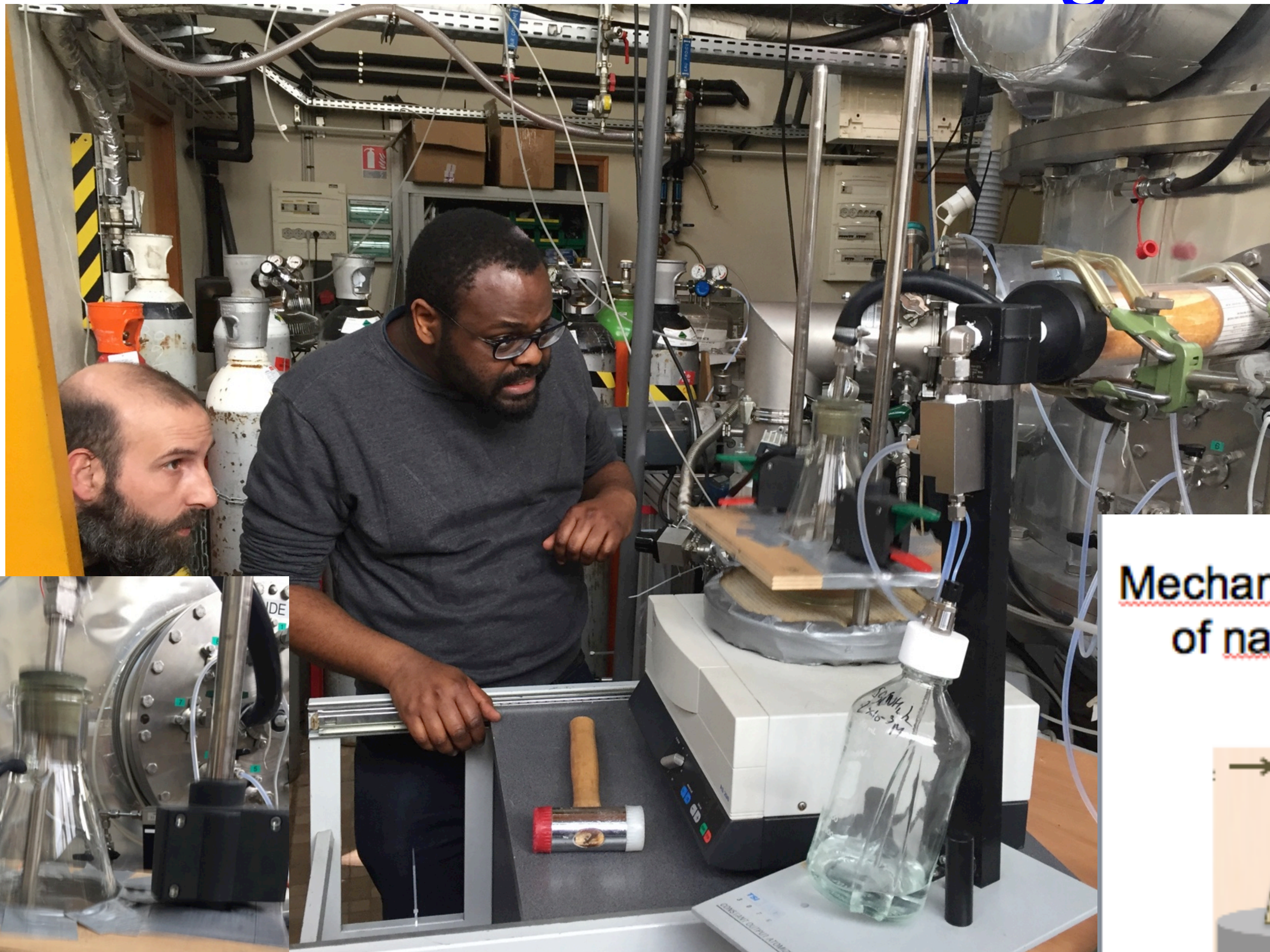
to simulate Beijing



Soot



to simulate Beijing

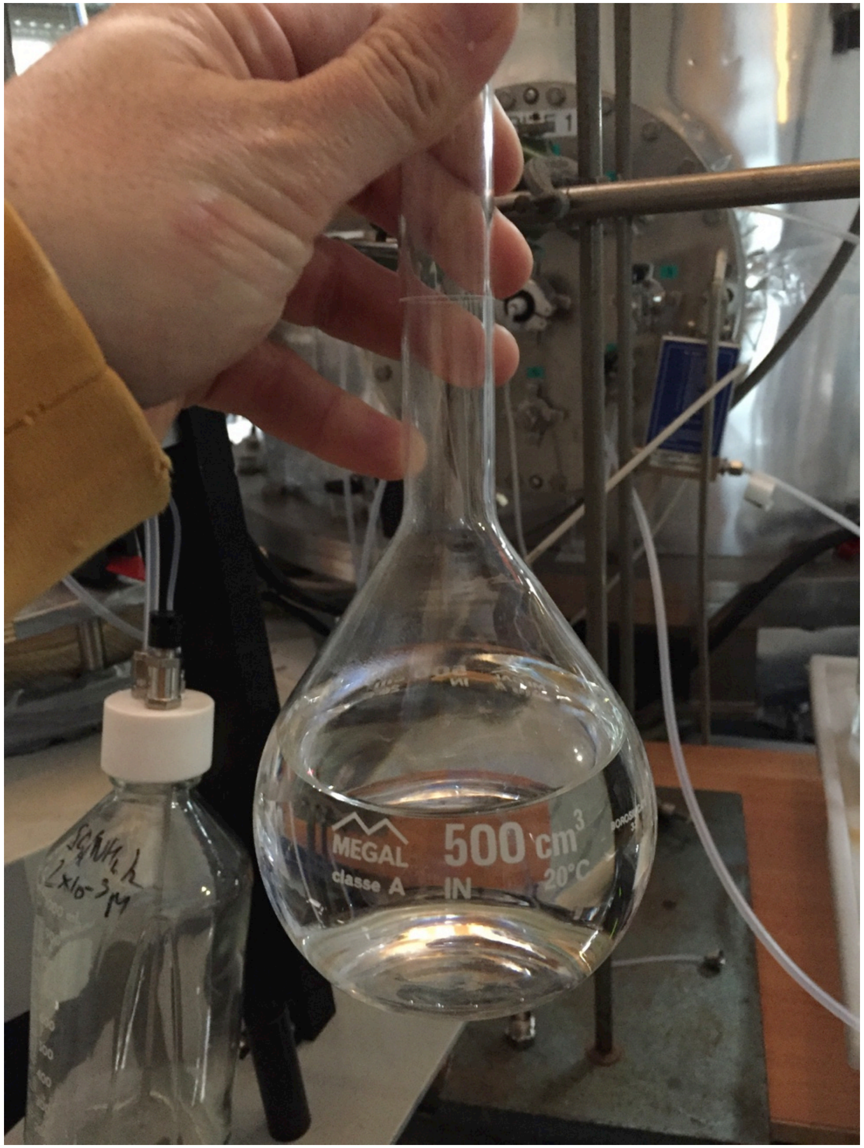


Dust particles

Mechanical shaking of natural soils

Mineral dust aerosols

to simulate Beijing

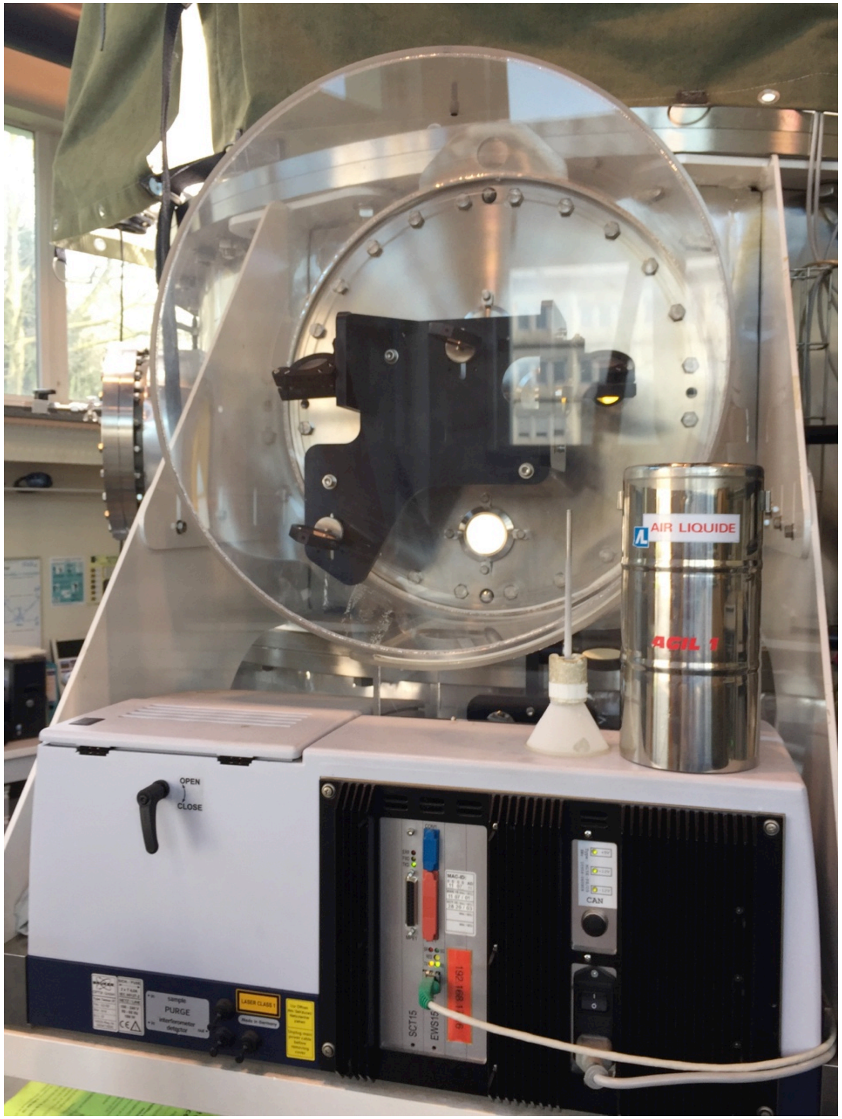


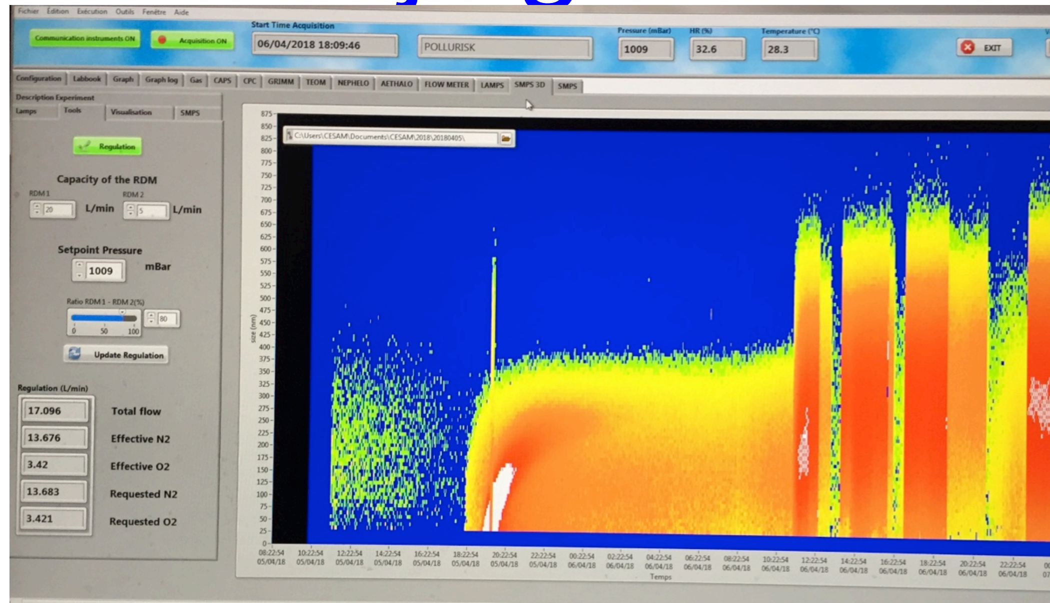
inorganic aerosols

to simulate Beijing

Metrology

to simulate Beijing



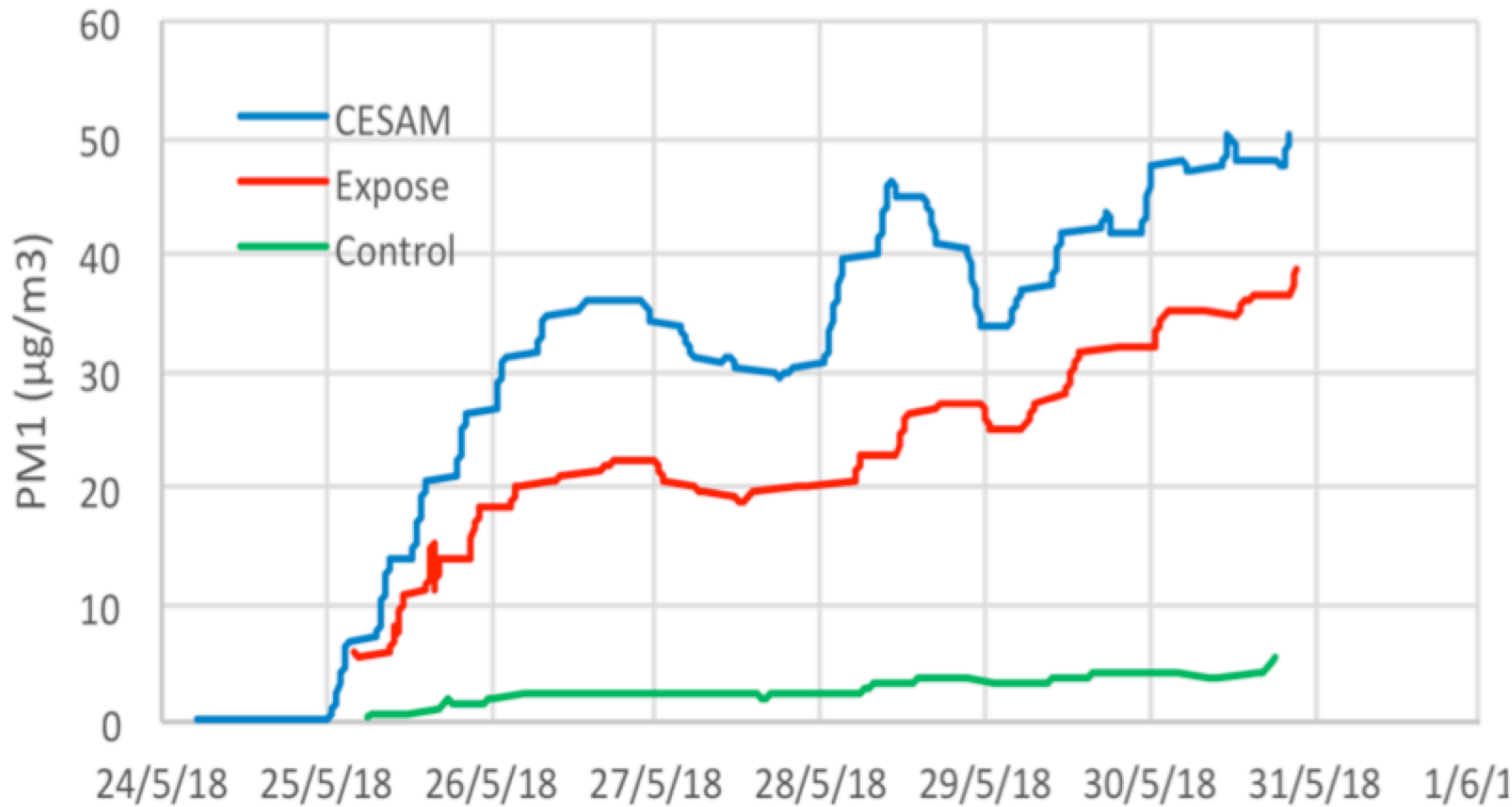


Metrology

budget(s) illustration

Typical Beijing simulated atmosphere

(particle total concentrations)



PolluRisk : task force

- 8 days of mice exposure

- Samples from:
  - lungs
  - Heart
  - Fat tissue
  - Spleen
  - Mesenteric lymph nodes
  - Muscle (anterior tibialis)

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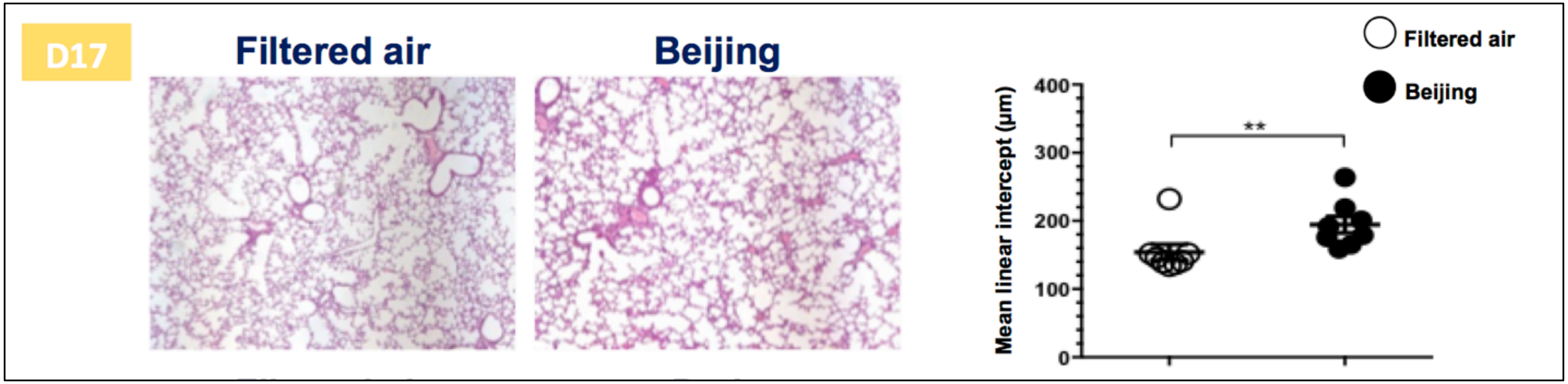
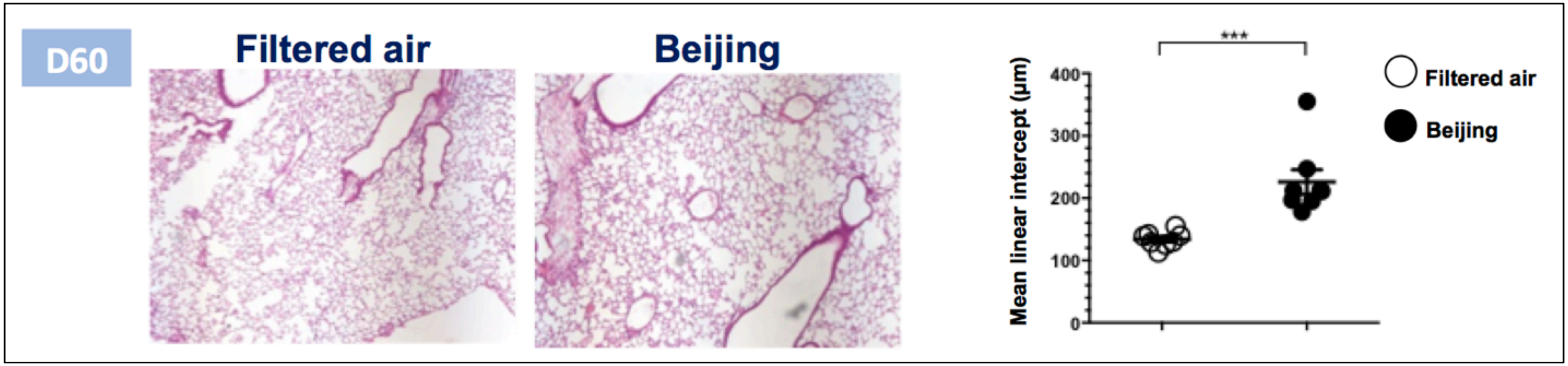
PolluRisk#1 illustrative results





Beijing : Hypoalveolarization, which remains persistant at adulthood.

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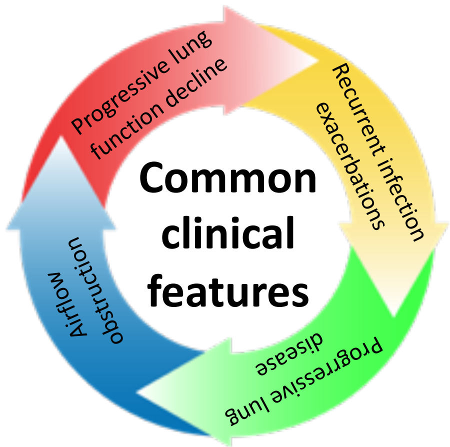
6. the H2020 REMEDIA project

Following "Genetics load the gun but environment pulls the trigger"…



COPD

Inheritance

Acquired multifactorial disorder

CFTR

Acquired CFTR dysfunction

Onset

- Diagnosis > 40 yrs;
- Increases with age

Clinical phenotype

- Bronchitis & emphysema
- Chronic infection (less common)
- Bronchiectasis (less common)

CF

Inheritance

Inherited

CFTR

Loss of function mutations in *CFTR* gene

Onset

Birth

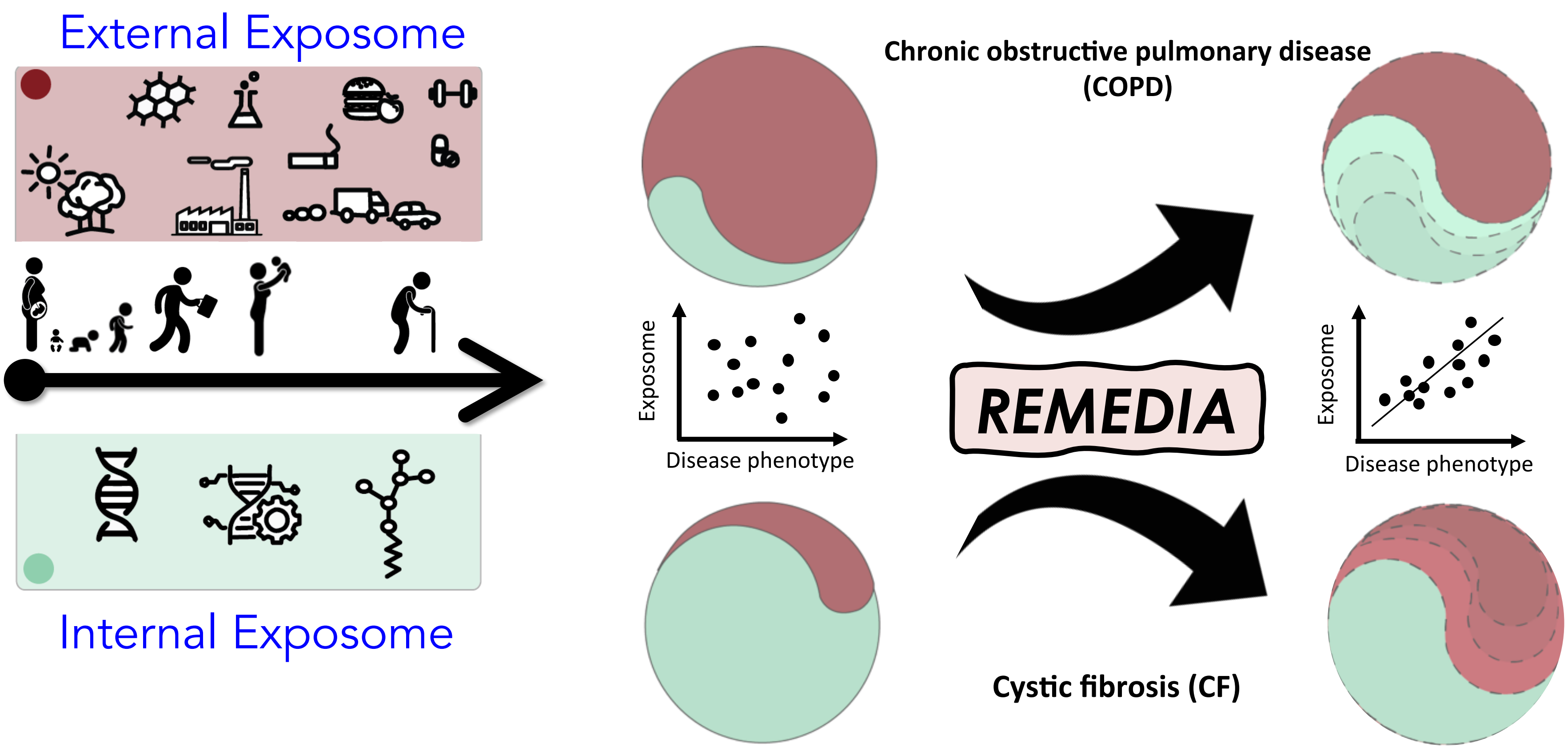
Clinical phenotype

Early chronic airway infection
Bronchiectasis

➔ Two very different diseases

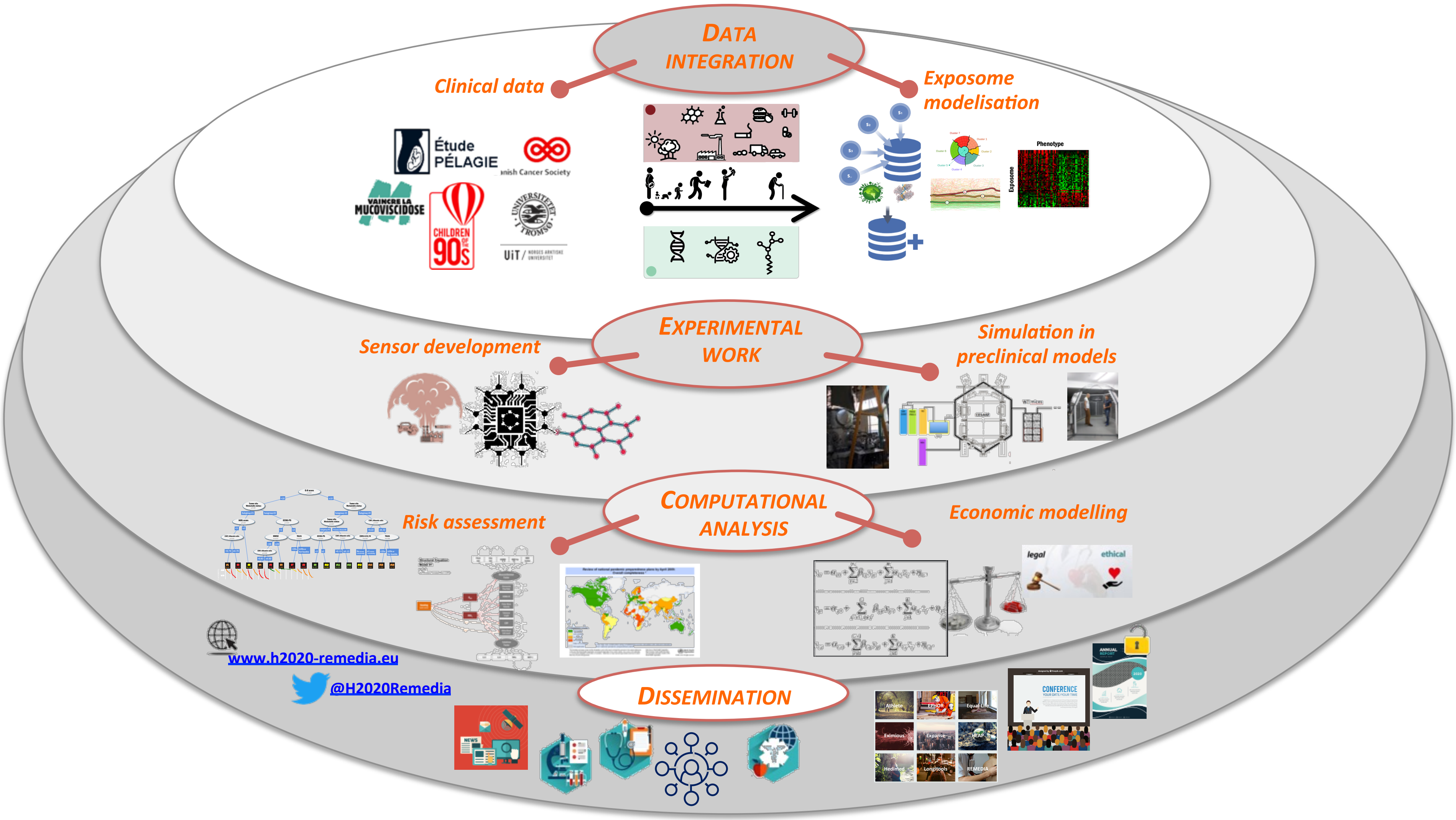
REMEDIA – the Concept (PI Dr. Sophie Lanone, INSERM)

Impact of exposome on the course of pulmonary pathologies



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 874753

Action Plan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Exposome modelisation
Étude PÉLAGIE
VAINCRE LA MUCOVISCIDOSE
CHILDREN OF THE 90s
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REMEDIA

IMPACT OF EXPOSOME
ON THE COURSE OF LUNG DISEASES

WP4 – Simulation of exposome in preclinical models

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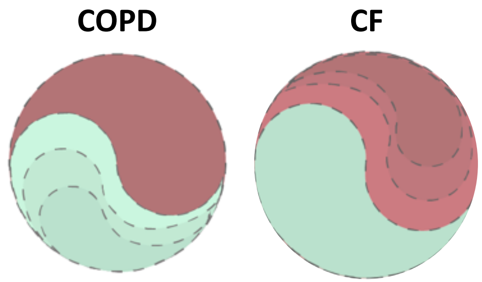
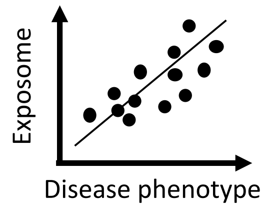
Impacts





Global unified database

Combined sensor device

Versatile atmospheric simulation chamber to target specific complex exposomes

Machine learning supervised analyses to predict health outcomes

Causal inference models to identify relevant risk factors

New guidelines and recommendations based on REMEDIA findings to better predict disease risks

Cost-effectiveness models to assess the costs, performance and cost-effectiveness of a selection of prevention strategies targeting exposome risk factors

Econometric models to test the interactions between economic, environmental and epidemiological variables

A **Pan-European multi-criteria risk assessment** tool to map the overall exposome risk-related pulmonary diseases in Europe

REMEDIA

IMPACT OF EXPOSOME
ON THE COURSE OF LUNG DISEASES

THANKS FOR YOUR ATTENTION !

POLLURISK: AN INNOVATIVE EXPERIMENTAL PLATFORM TO INVESTIGATE HEALTH IMPACTS OF AIR QUALITY

PATRICE COLL[1], MATHIEU CAZAUNAU[1], JORGE BOCZKOWSKI[2], MAËVA ZYSMAN[2], JEAN-FRANÇOIS DOUSSIN[1], ALINE GRATIEN[1], GENEVIÈVE DERUMEAUX[2], MARIA PINI[2], CLAUDIA DI BIAGIO[1], ÉDOUARD PANGUI[1], CÉCILE GAIMOZ[1], SOPHIE HÜE[2], FRÉDÉRIC RELAIX[2], AUDREY DER VATANIAN[2], ISABELLE COLL[1], VINCENT MICHOUD[1], PAOLA FORMENTI[1], GILLES FORÊT[1], LAURENCE THAVARATNASINGAM[1], ADELA AMAR[1], MICKAËL LACAVALERIE[2], MARGAUX MÄDER[1] & SOPHIE LANONE[2]
[1]LISA UMR CNRS 7583, Universities Paris Est Créteil and Paris Diderot, France
[2]IMRB – Inserm U955, Faculté de Médecine de Créteil, France

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