

# Neurotoxicity of non-volatile and semi-volatile diesel exhaust-derived ultrafine particles

**Lora-Sophie Gerber**

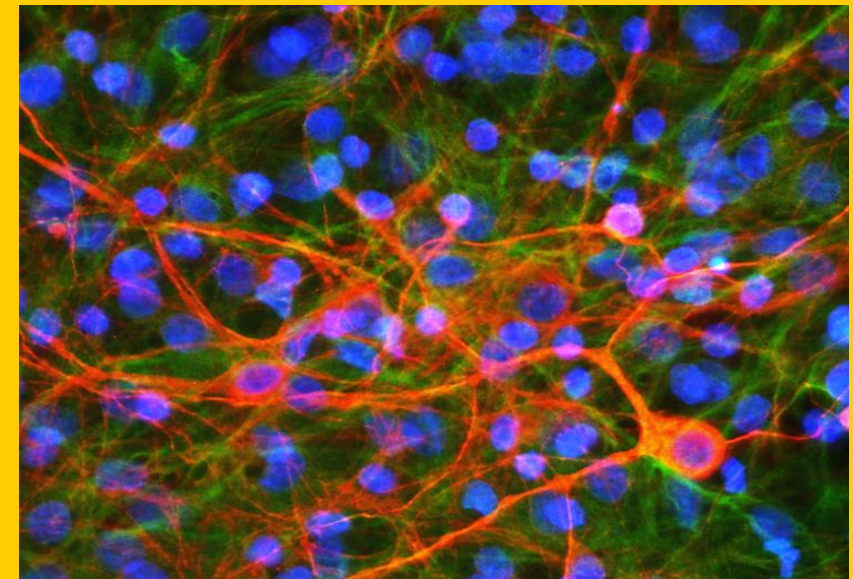
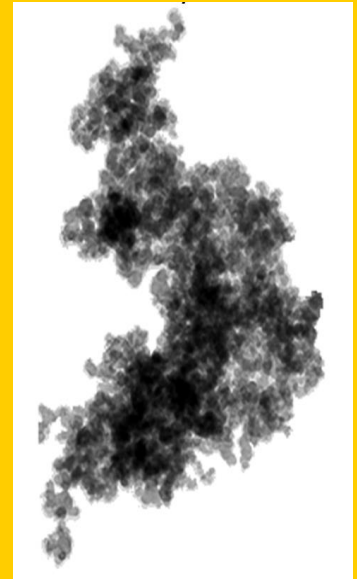
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Supervisor: Remco HS Westerink

INA-18 meeting, Durham  
May 21, 2023



Transport derived Ultrafines and  
the Brain Effects



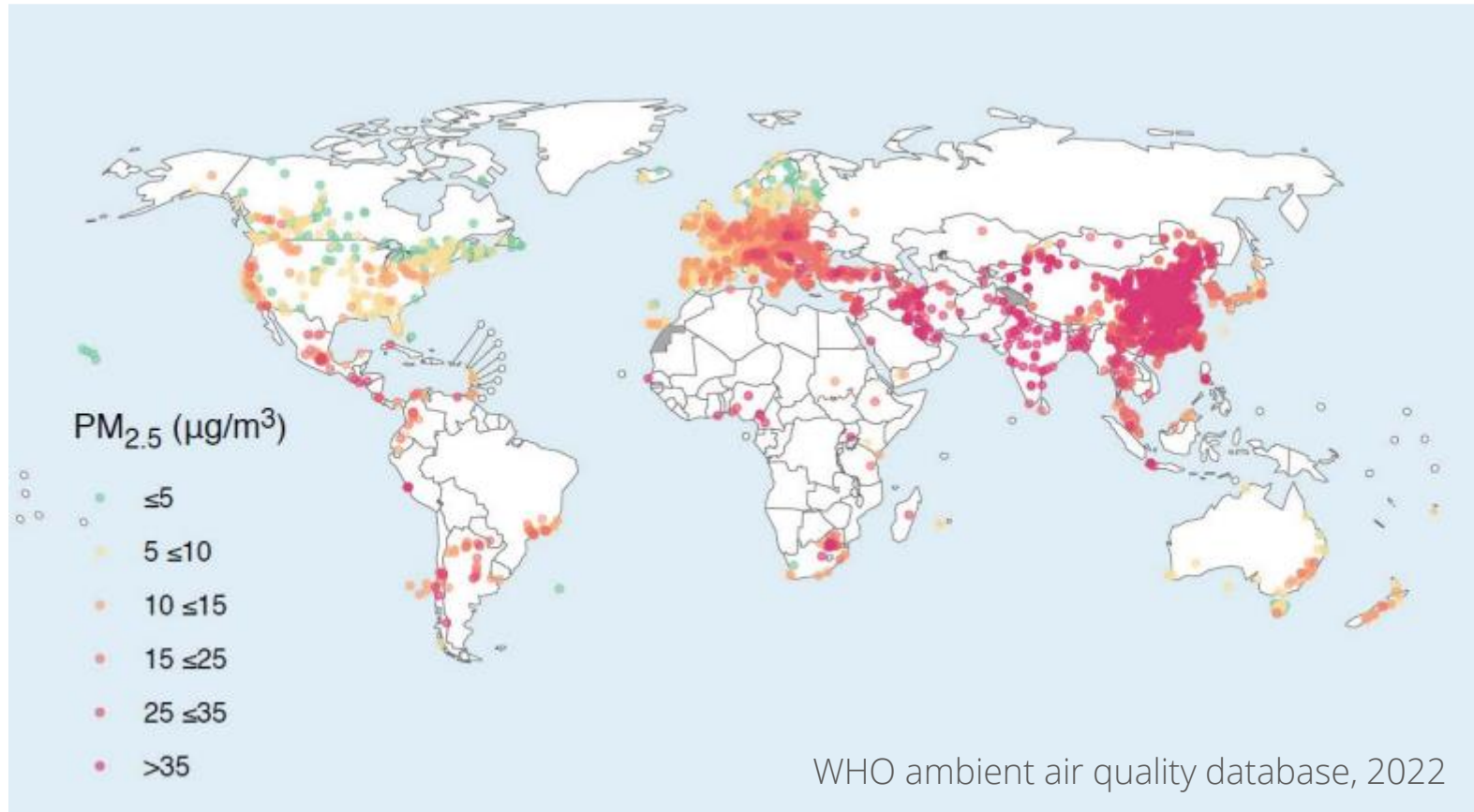
## Air pollution and particulate matter



tatze, stock.adobe.com

## Air pollution and particulate matter

PM<sub>2.5</sub> monitoring in settlements (2010-2020)



**99% of the population is exposed to concerning levels of air pollutants**

# Particulate matter

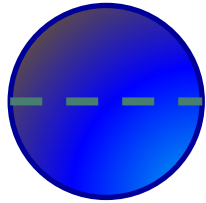
A complex and dynamic mixture

PM10 (Coarse)

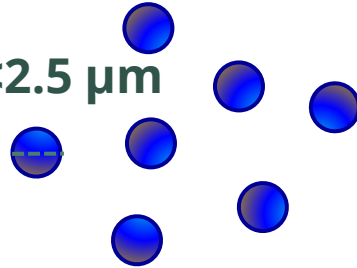
PM2.5 (Fine)

PM0.1 (Ultrafine)

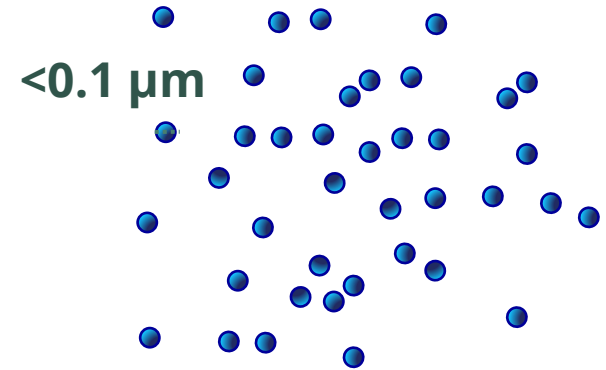
<10  $\mu\text{m}$



<2.5  $\mu\text{m}$



<0.1  $\mu\text{m}$

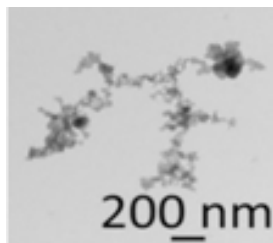


Total surface area per mass



# Air pollution, particulate matter and neurotoxicity

## Air pollution Particulate matter

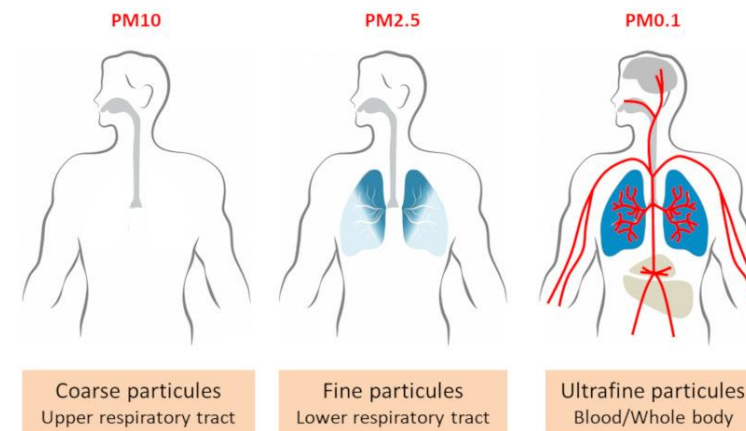


Baldelli, 2020

Translocation  
Ultrafine particle (UFP)

## Traffic

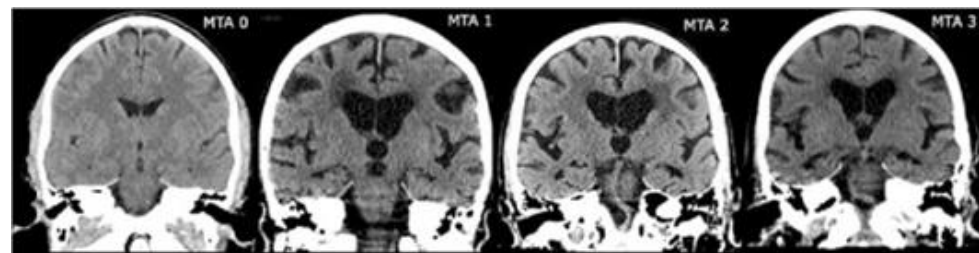
Diesel engine emission



Encyclopédie de l'environnement

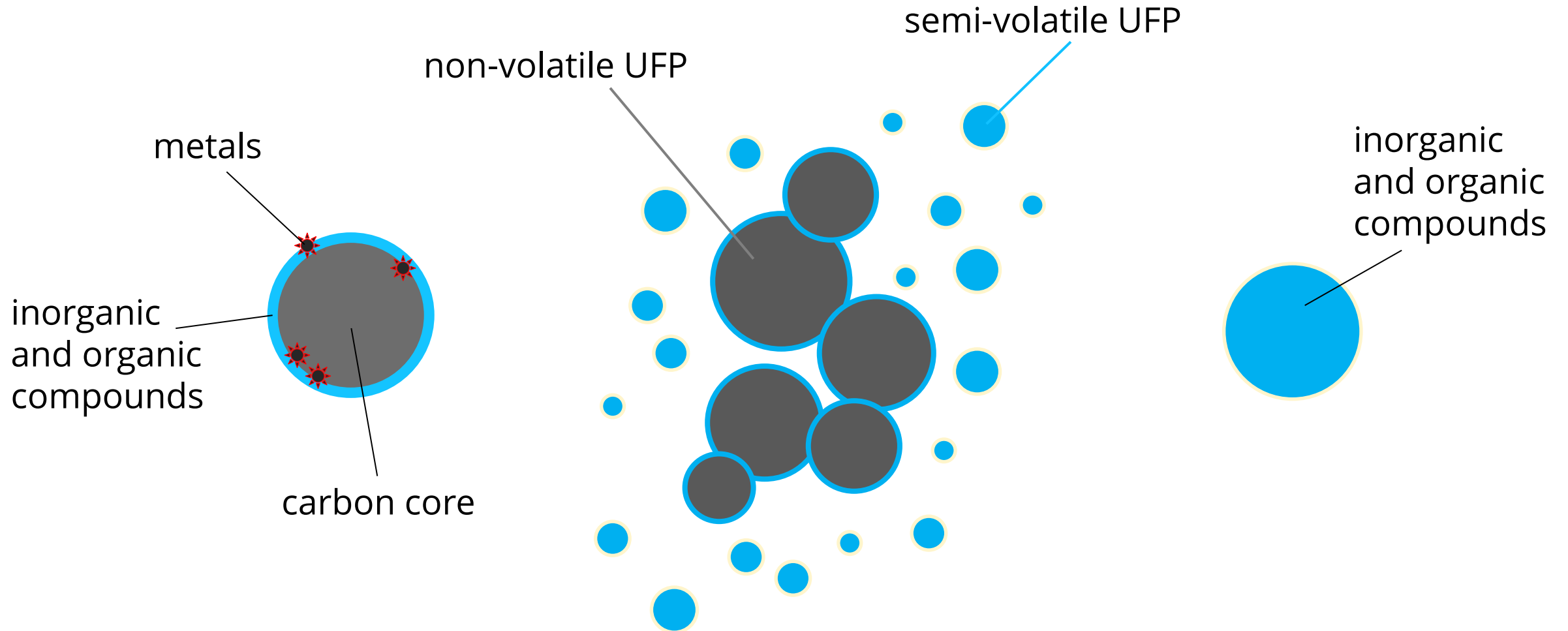
## Neurological diseases

- Neurodegeneration
- Neuroinflammation
- Neurodevelopmental disorders
- Neuropsychiatric disorders

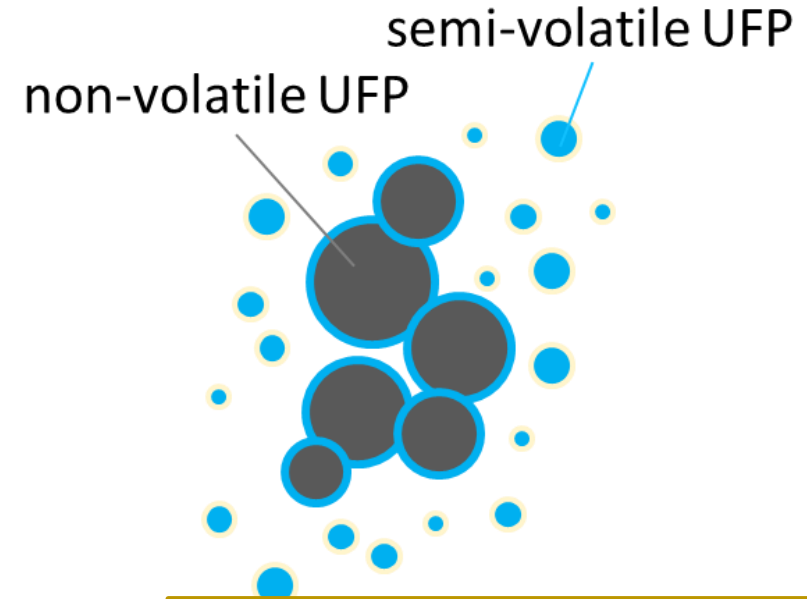


## Diesel exhaust-derived ultrafine particles (UFP)

Solid particles and liquid droplets



Little is known about the (possibly different) effects and hazards of non-volatile UFP and semi-volatile UFP for the brain.



Neuronal function *in vitro*

## Research aim

- ➔ Investigate and compare the neurotoxic effects and hazard of non-volatile and semi-volatile ultrafine particles from diesel exhaust.
- ➔ Does aromatic content in fuel affect neurotoxic potency of UFP?

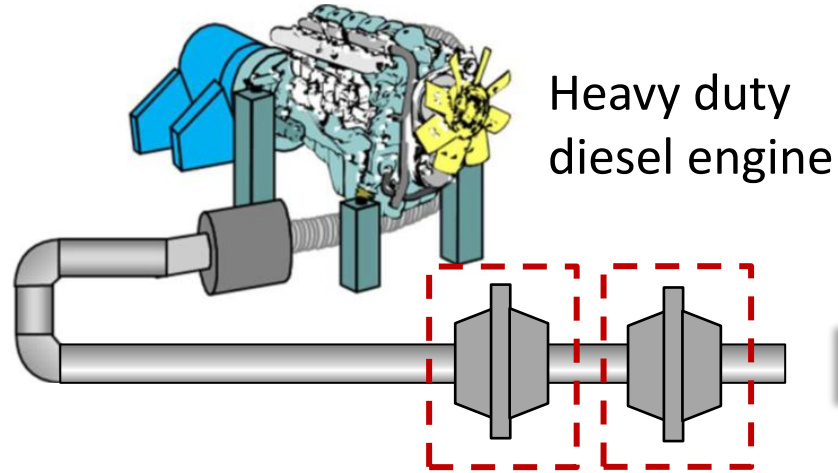
## Sample generation and collection



20%-aromatic diesel (EN590)



aromatic-free diesel  
(0.1% aromatics)

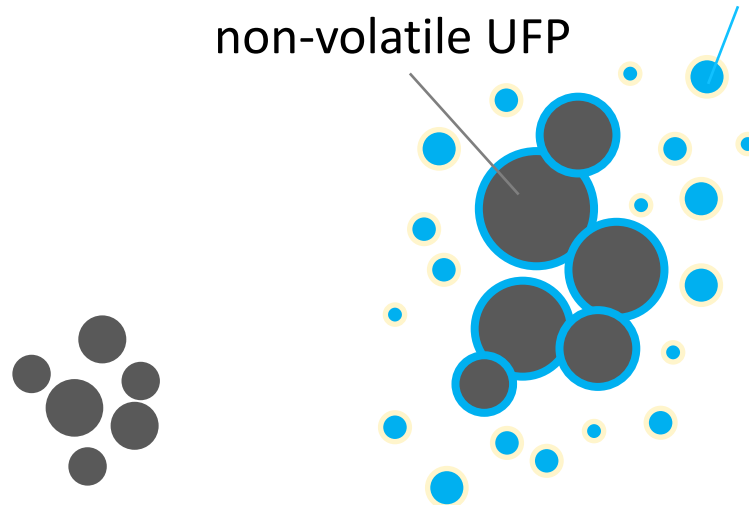


Heavy duty  
diesel engine



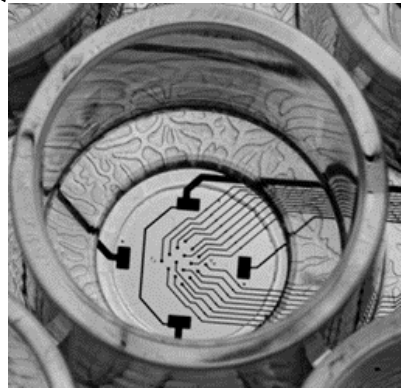
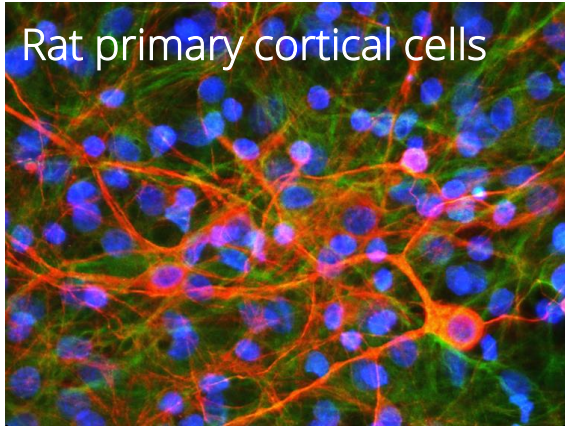
Fuel type	UFP fraction
Ar20	non-volatile UFP
	semi-volatile UFP
Ar0	non-volatile UFP
	semi-volatile UFP
Reference material	clean carbon particles (Ø 60 nm)

semi-volatile UFP  
non-volatile UFP





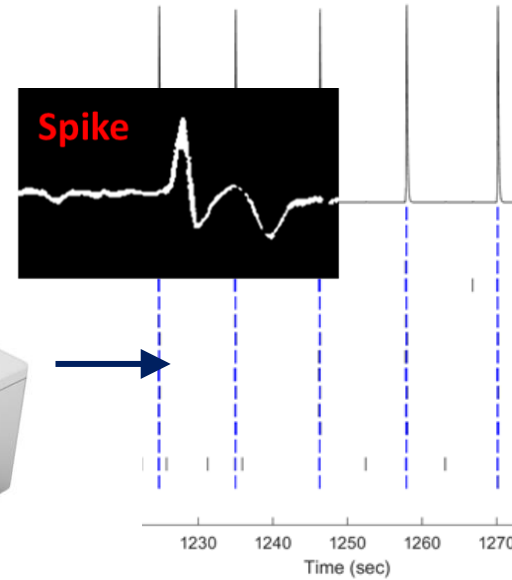
## *In vitro* neurotoxicity testing



Micro-Electrode Array (MEA)

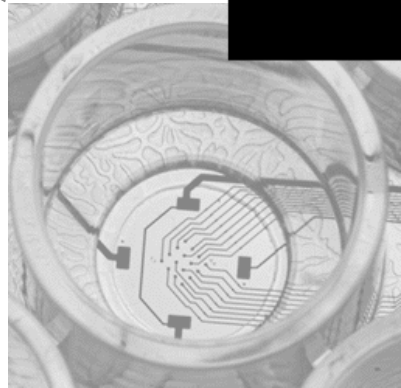
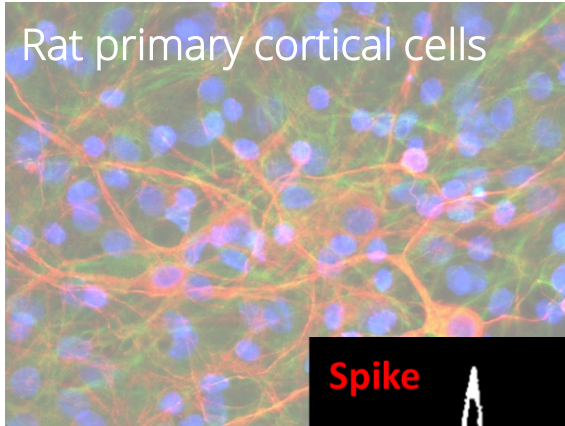


Maestro Pro MEA system  
(Axion BioSystems)

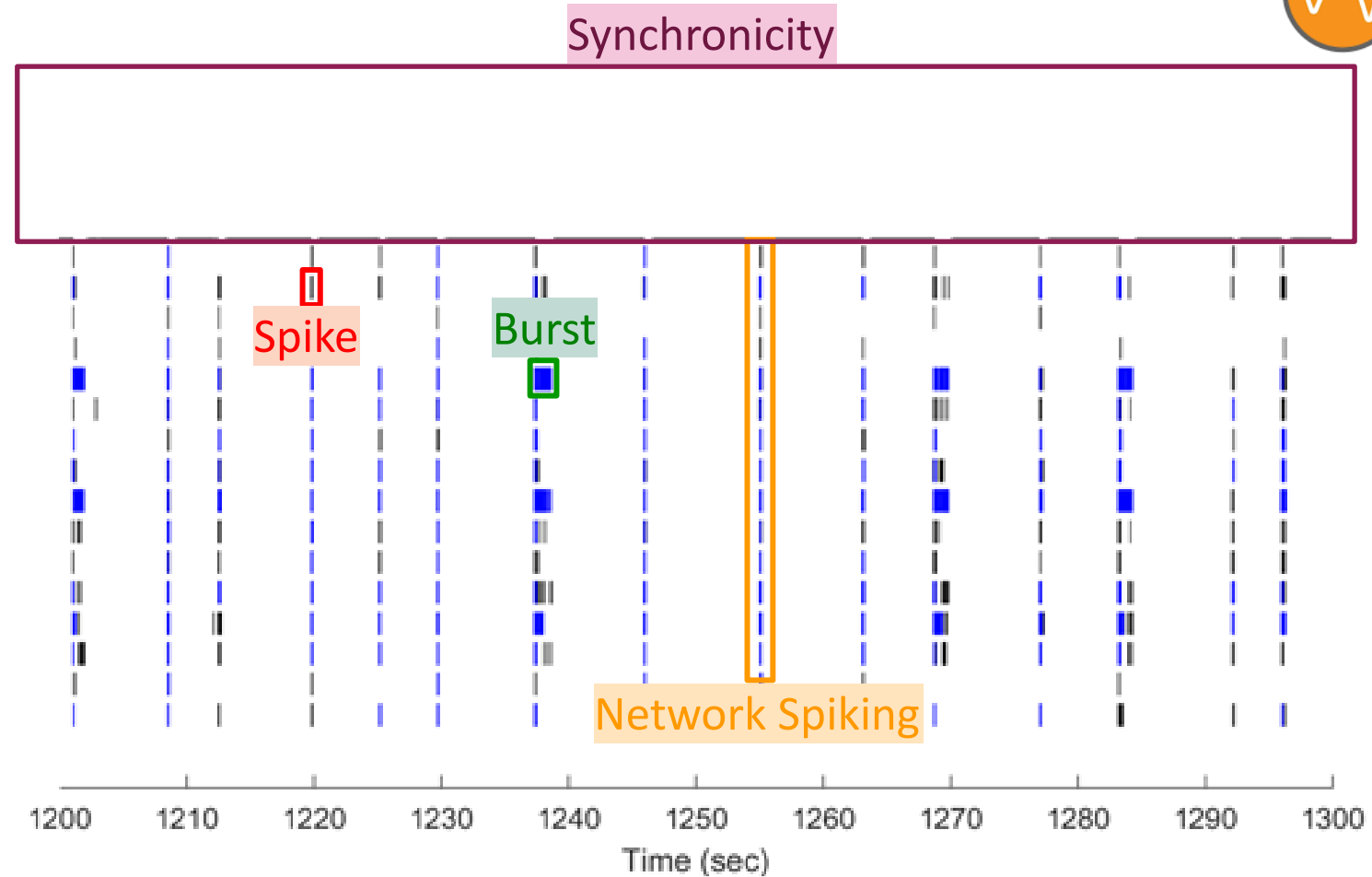


Baseline  
neuronal activity

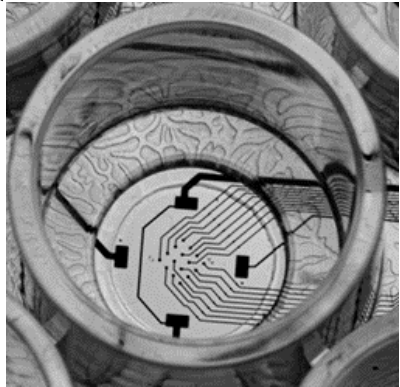
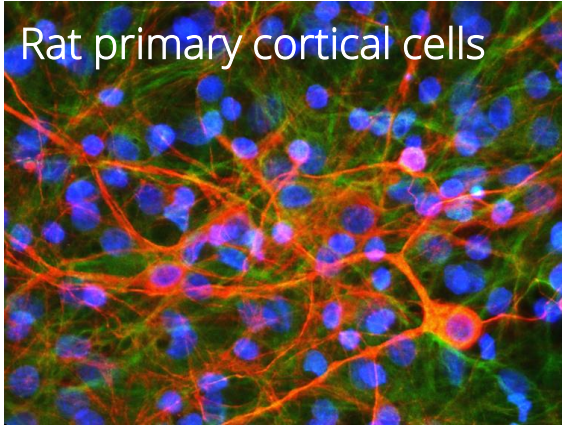
## *In vitro* neurotoxicity testing



Micro-Electrode Array (MEA)



## *In vitro* neurotoxicity testing



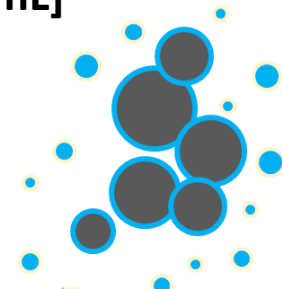
Micro-Electrode Array (MEA)



Maestro Pro MEA system  
(Axion BioSystems)

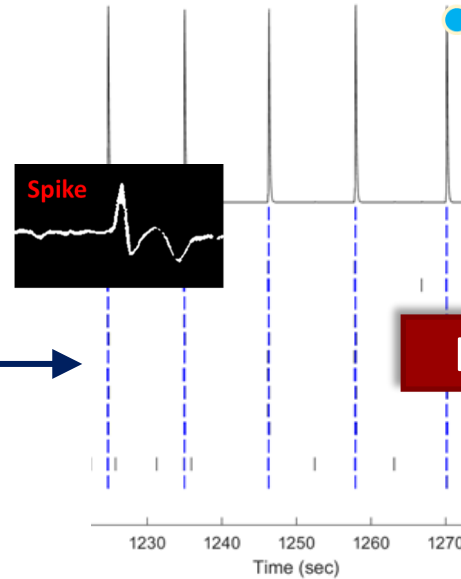
semi-volatile UFP  
[Exhaust volume (L)/mL]

non-volatile UFP  
[collected mass ( $\mu\text{g}$ )/mL]  
carbon particle

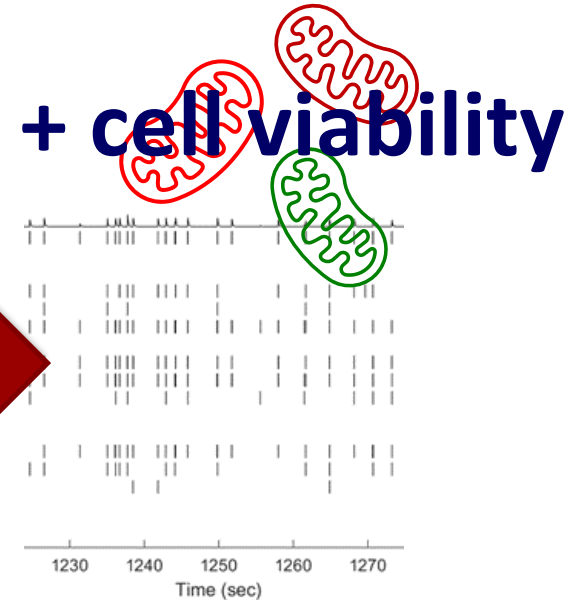


0.5 h  
24 h  
48 h  
120 h

Exposure



Baseline  
neuronal activity



Exposure-induced change in  
neuronal activity

## Non-volatile UFP

Non-volatile UFP inhibit neuronal activity equally potent, but effect is only modest

- Ar20
- Ar0

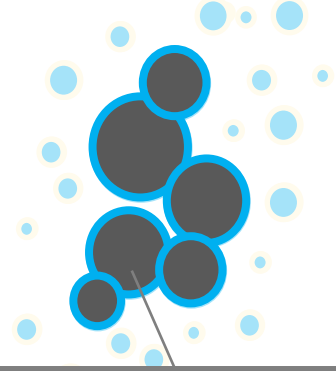
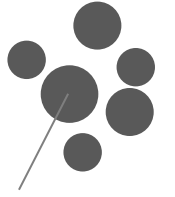


Figure redacted as this will feature in a manuscript that is in the progress of being published.

## Carbon particles

Carbon core unlikely cause inhibition of neuronal activity induced by non-volatile UFP



clean carbon particles

- carbon particle

Figure redacted as this will feature in a manuscript that is in the progress of being published.



# Results

## Semi-volatile UFP

Ar20 disrupt activity pattern whereas Ar0 reduce neuronal activity at medium dose

● Ar20

● Ar0

acute exposure

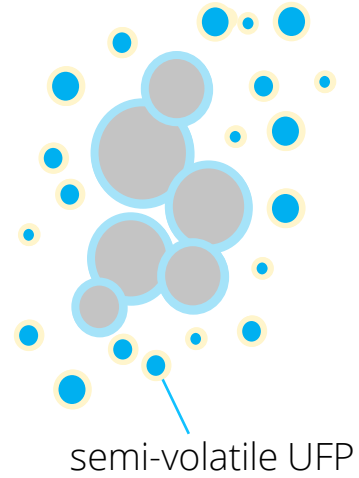
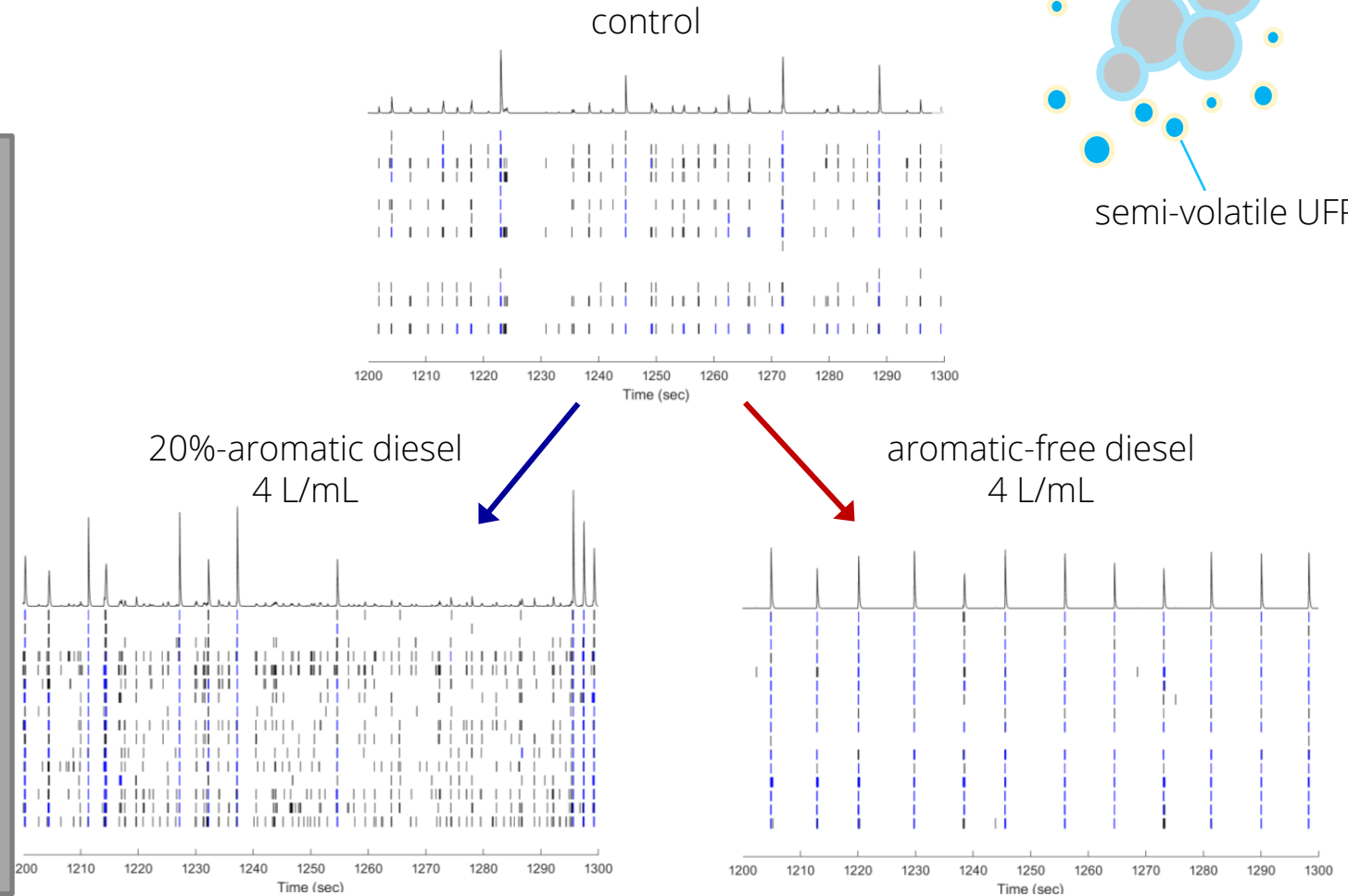


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# Results

## Semi-volatile UFP

Ar20 disrupt activity pattern whereas Ar0 reduce neuronal activity at medium dose

● Ar20

● Ar0

prolonged exposure (48h)

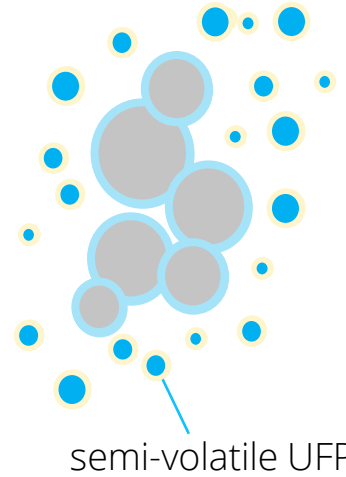
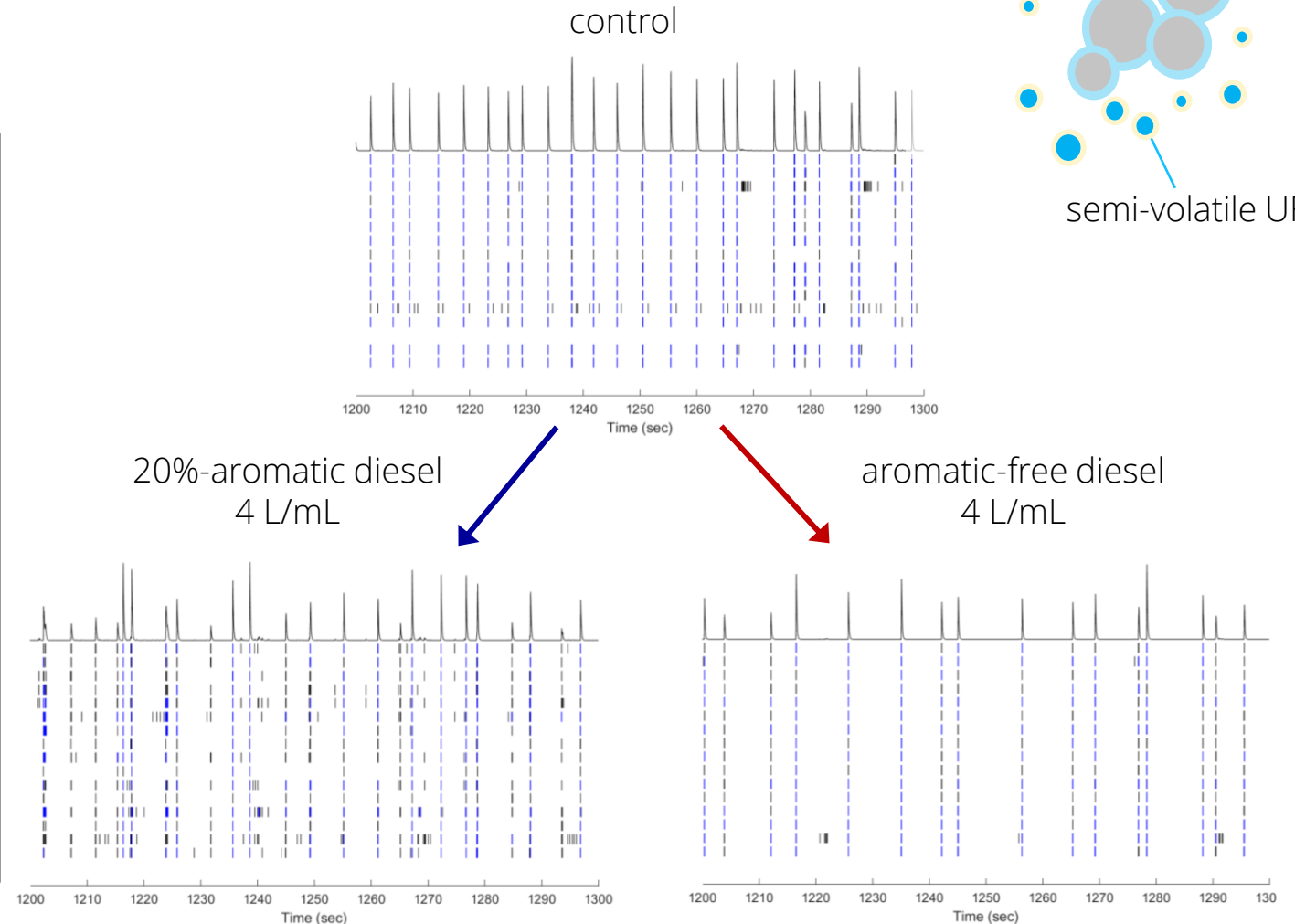


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## Semi-volatile UFP

Reduced neuronal activity at high doses is associated with cytotoxicity

- Ar20
- Ar0      prolonged exposure (48h)

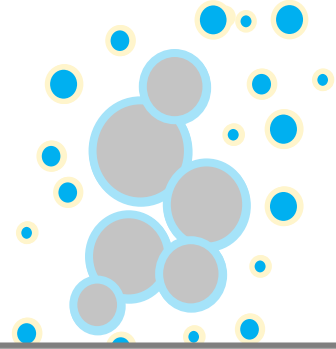


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## Summary results

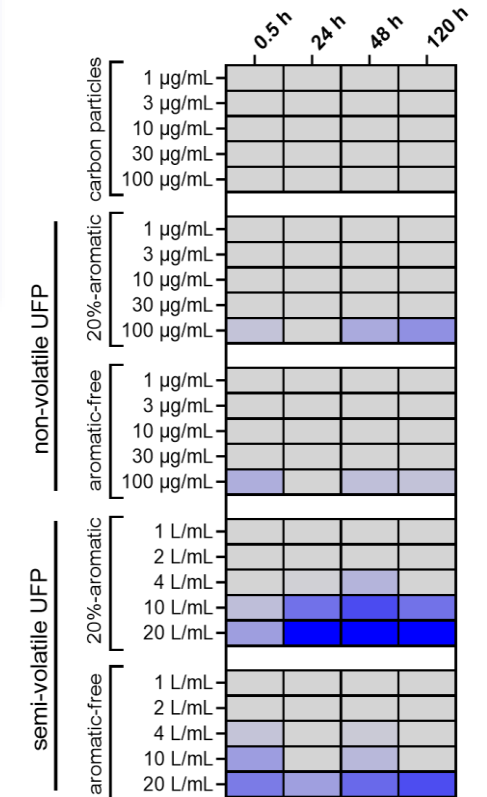
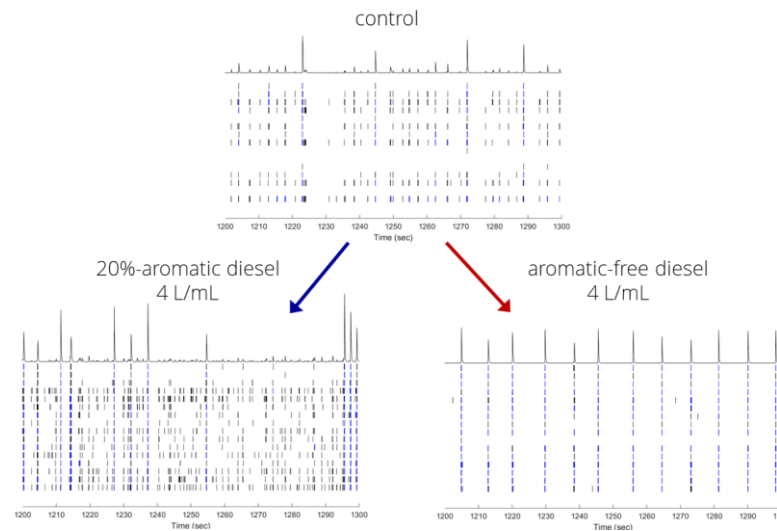
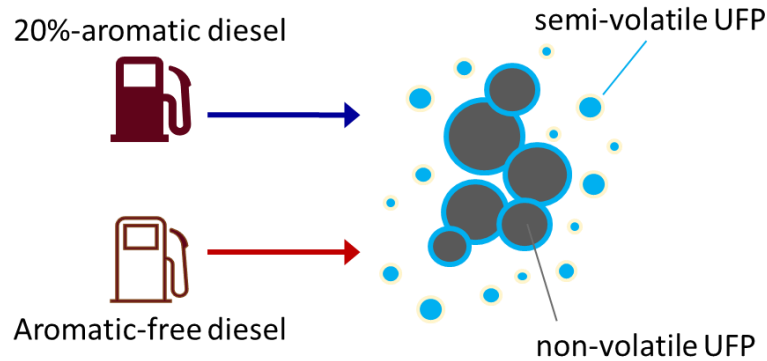
- Non-volatile UFP: only limited effects
- Carbon particles: no effect
- Semi-volatile UFP:
  - different neurotoxic effect for Ar20 and Ar0
  - cytotoxic potency higher for Ar20

Figure redacted as this will feature in a manuscript that is in the progress of being published.

# Conclusion

➔ Semi-volatile UFP exhibit higher neurotoxic potency than non-volatile UFP and should be included in air quality guidelines.

➔ Aromatic content in diesel fuel affects the neurotoxic effect and potency of semi-volatile UFP suggesting that the reduction of aromatics in the fuel results in less harmful diesel exhaust.





# Thank you

Supervisor: Remco HS Westerink

Promoter: Flemming R Cassee (RIVM, UU)

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