STUDIES OF NANOPARTICLES IN DIESEL EXHAUST AND AMBIENT AIR

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and

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FASTER: Fundamental Studies of the Sources, Properties and Environmental Behaviour of Exhaust Nanoparticles from Road Vehicles

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SCIENCE TOPIC

ST1 Characterisation of Emissions

ST2 Laboratory Studies

ST3 Field Measurements

ST4 Street canyon and Urban modelling

INTERMEDIATE OBJECTIVE

Define the SVOC composition and size distribution

Define the physico-chemical properties of SVOC

Demonstrate real-world behaviour of SVOC

Simulate nanoparticle behaviour

FINAL OBJECTIVES

Quantify the evaporative potential of nanoparticles

Test the evaporative potential against field data

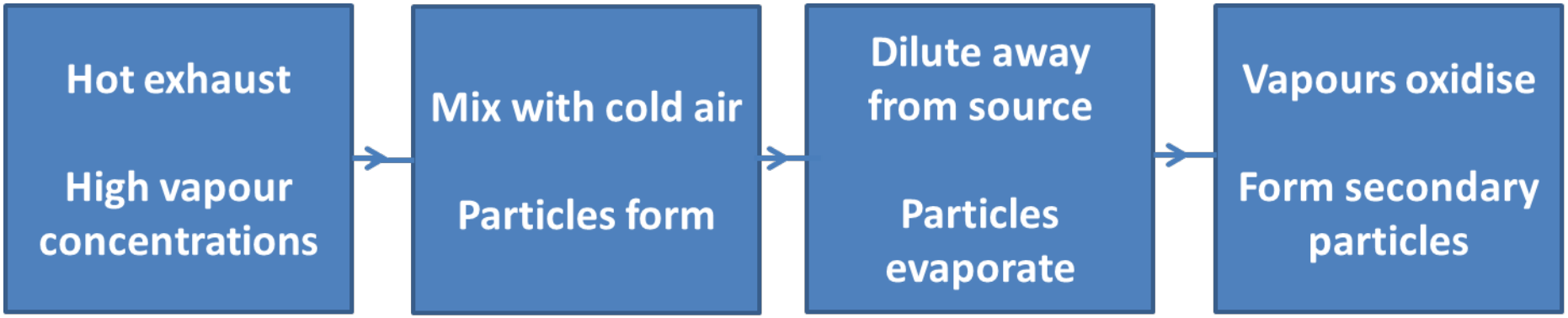
Predict behaviour on a larger scale

Estimate source potential for SVOC vapour components

Predict fate of nanoparticles in urban air

Semi Volatile Compounds

- Compounds that partition directly between the vapour and condensed phase



- Composition of primary vehicle exhaust aerosol and contribution to SOA
- Uncertainties relate to semi volatile component of particles

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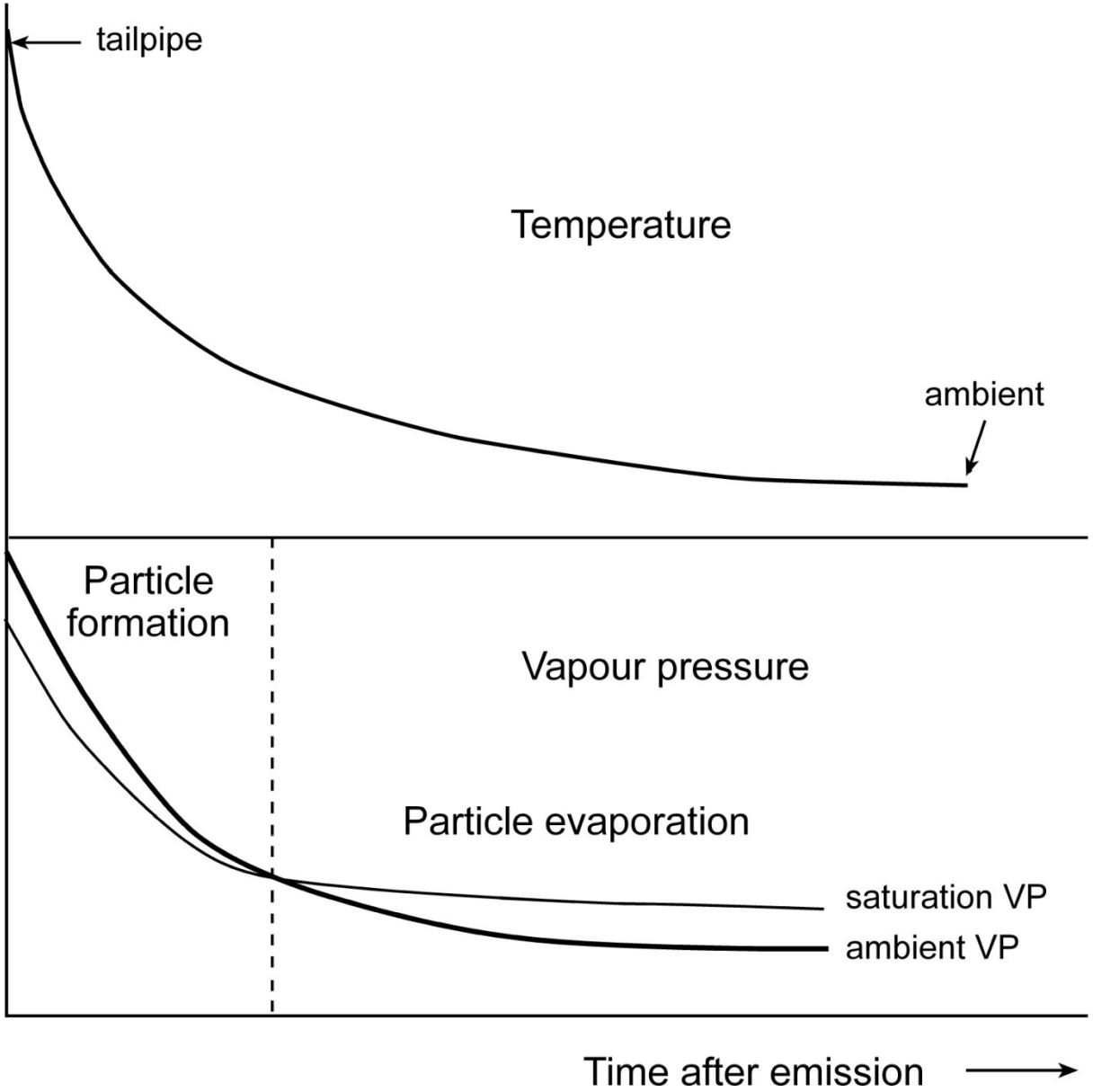
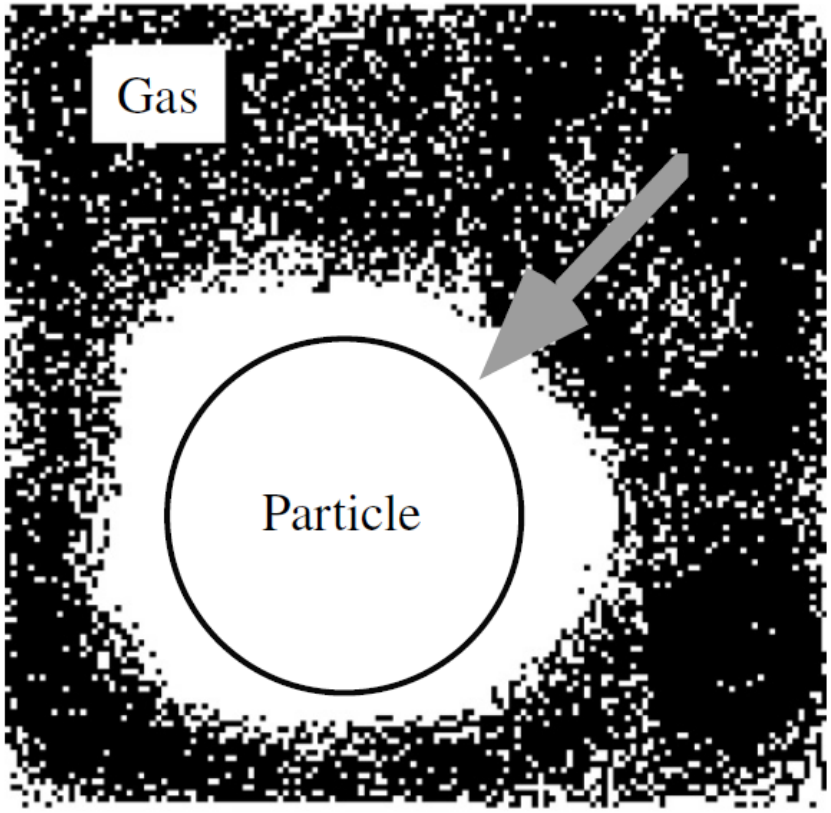
Processes influencing nanoparticle formation from semi-volatile compounds upon emission in hot gases from a vehicle tailpipe

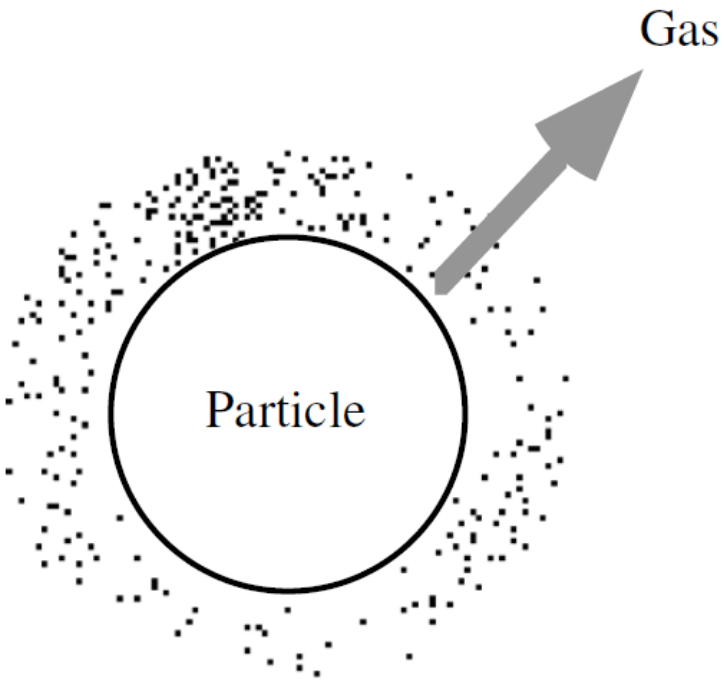


Condensation/evaporation: driven by the difference between the partial pressure of a gas and its saturation vapour pressure over a particle surface.

(a) Condensation



(b) Evaporation



Jacobson (2005)

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Characterisation of Engine Emissions

Engine Facility at the University of Birmingham

Control Room

Engine test cell

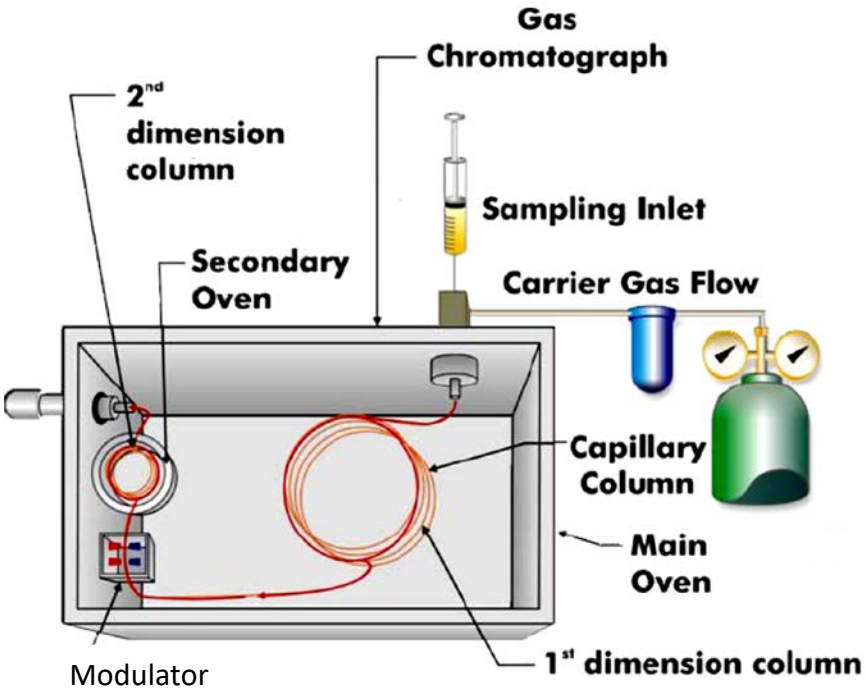
Utilities Room

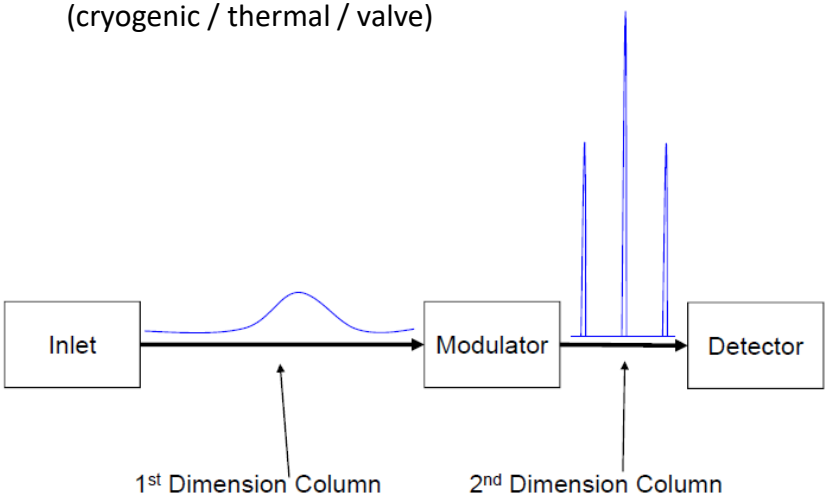
DMS 500

SPC Smart Sampler

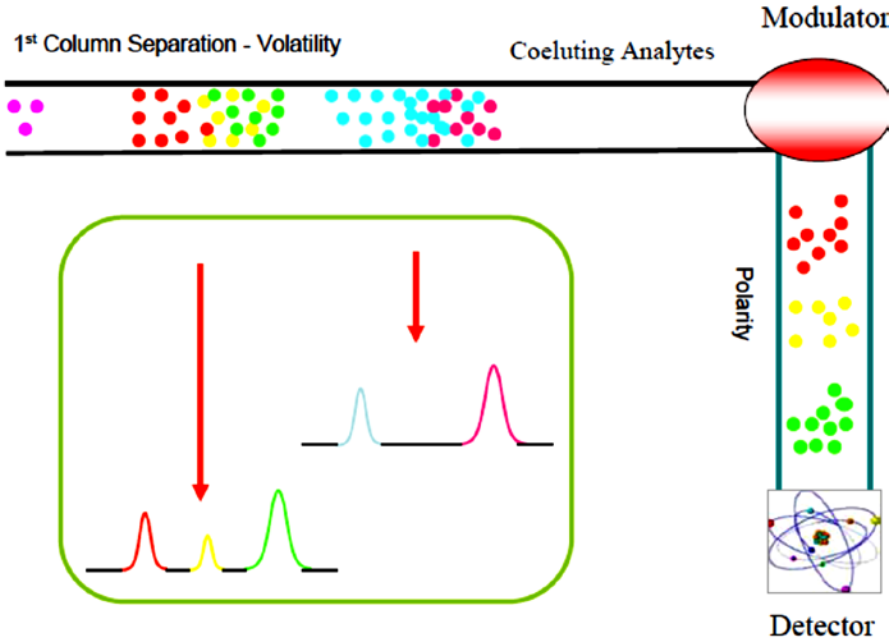
AMA i60

Gas Chromatography × Gas Chromatography (GC × GC)



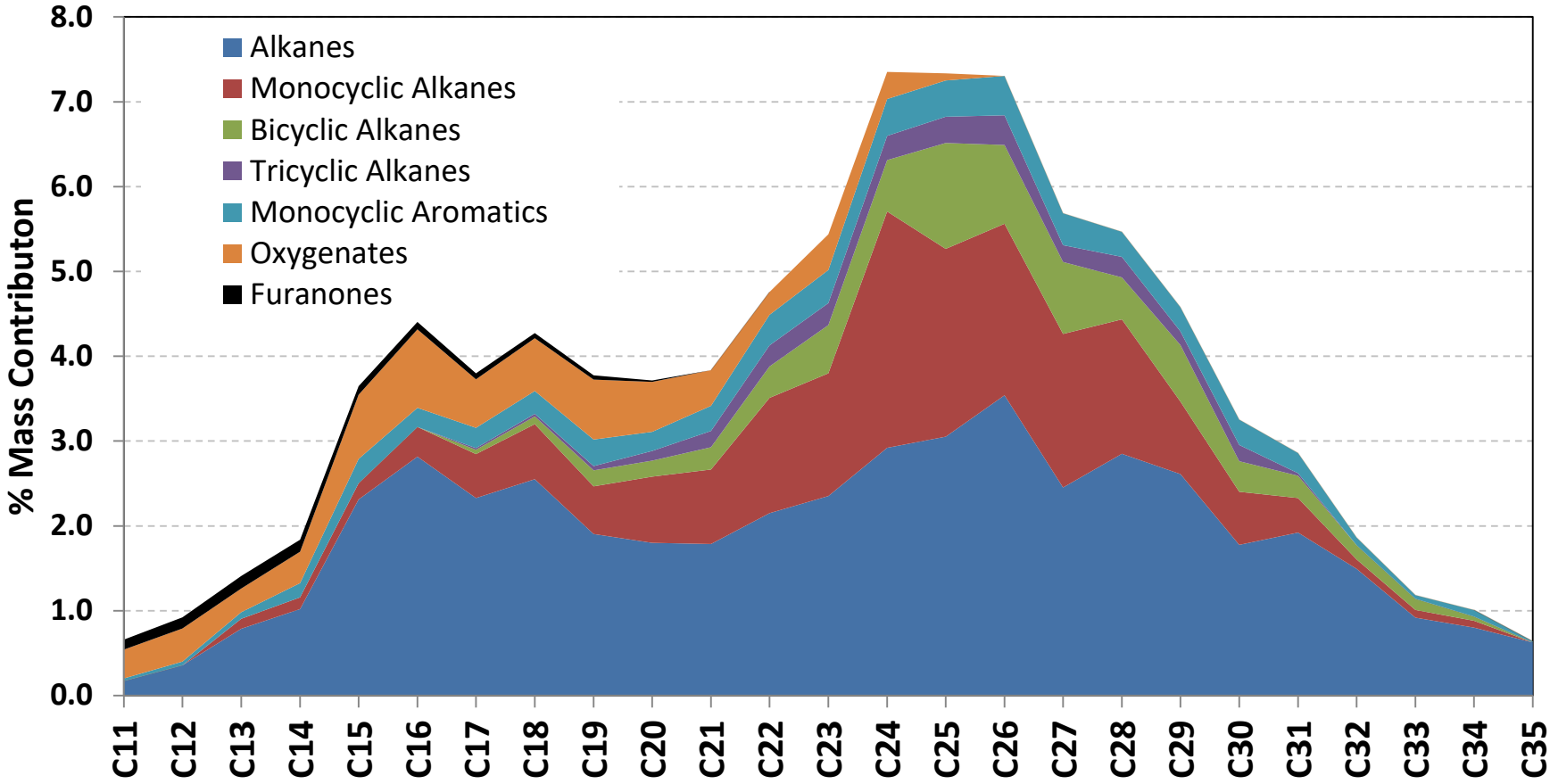


The modulator traps and releases sequential portions of the 1st column effluent and injects it into the 2nd column of different selectivity where it is separated and detected.



Alam and Harrison (2016) Chem. Sci. (7) 3968-3977

Particulate Phase Emissions Composition



Alam et al., 2018 Atmos. Meas. Tech.

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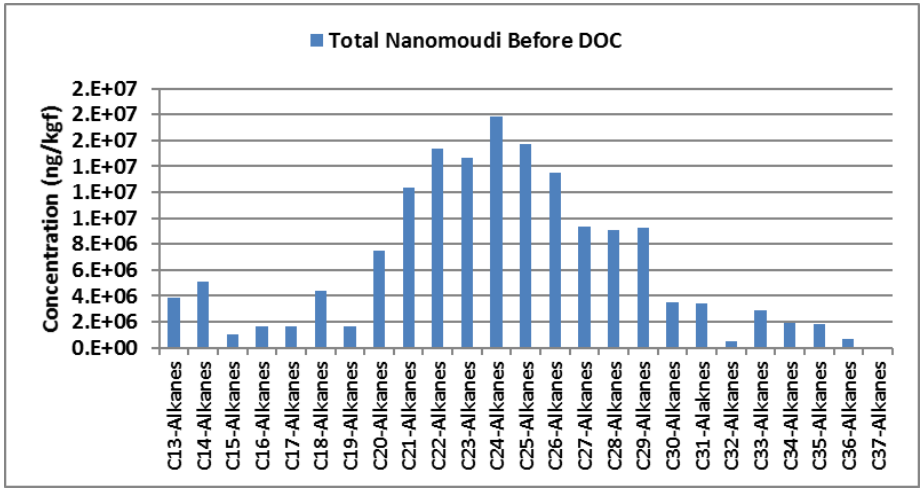
Alkanes in engine exhaust before and after control technologies

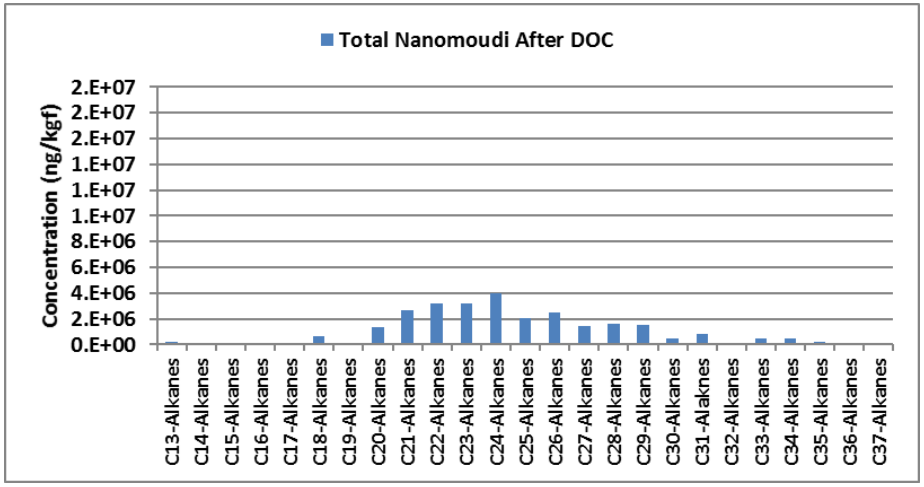
Alkanes (n + i) in exhaust

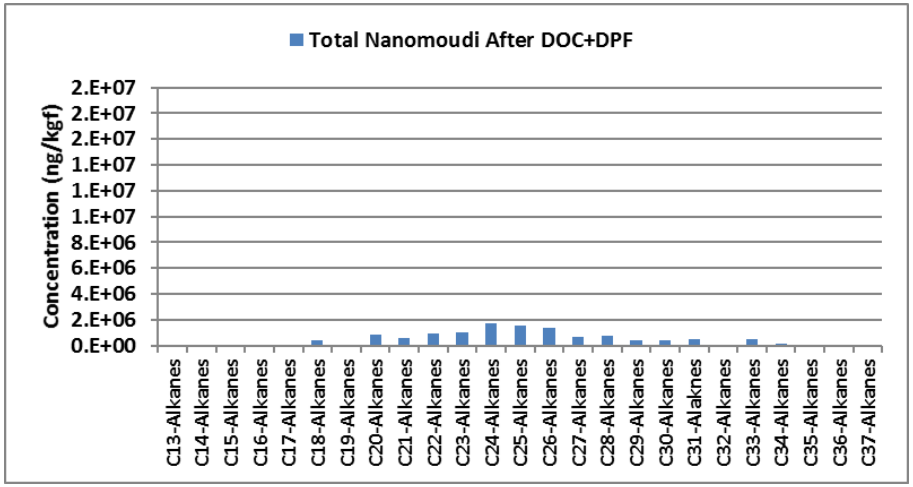


Alkanes

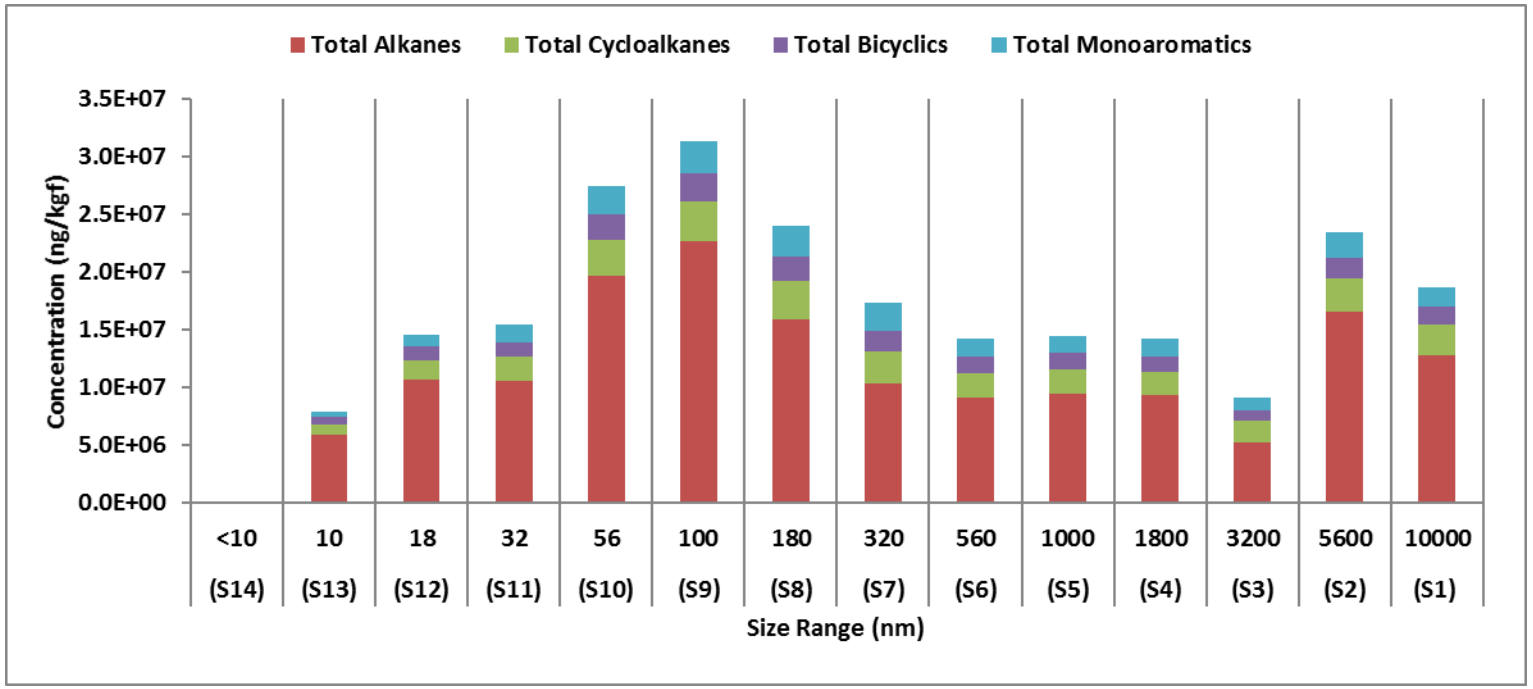
Nano-Moudi Results (Particle Phase)

1.4 bar BMEP and 1800 RPM





Size fractionated hydrocarbons in exhaust



Nano-Moudi Results (Particle Phase)
14 size fractions from <10nm to 5.6-10µm diameter
1.4 bar BMEP and 1800 RPM
Before DOC

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Ambient Air Measurements from Marylebone Road, London

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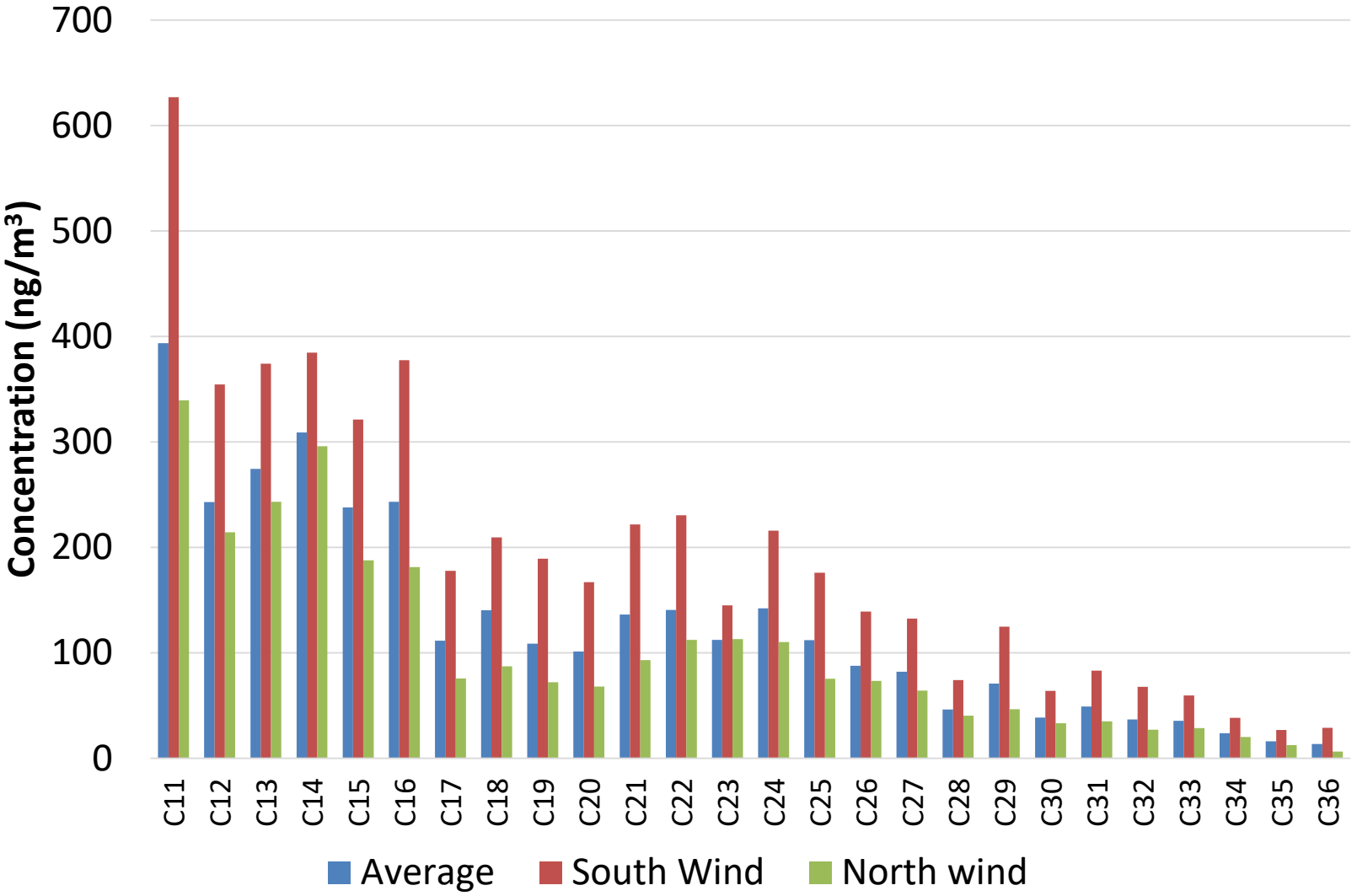
MARYLEBONE ROAD

Alkanes in Marylebone Road (Vapour + Particle)



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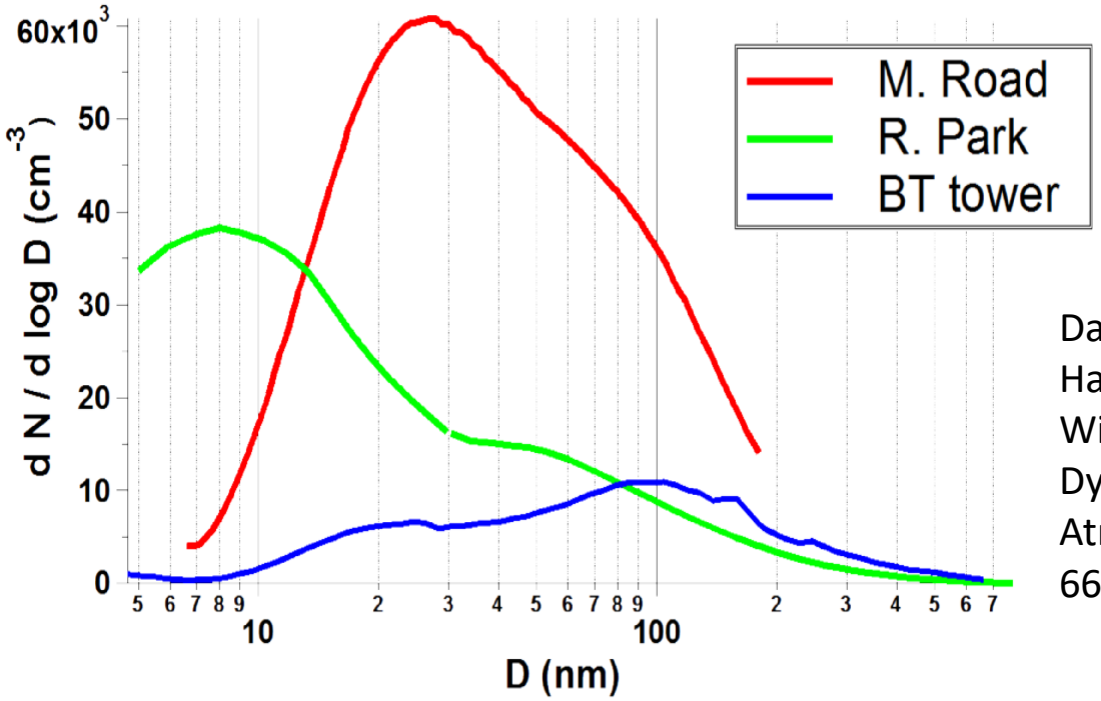
What was measured in London?



Dall'Osto, M., Thorpe, A., Beddows, D.C.S., Harrison, R.M., Barlow, J.F., Dunbar, T., Williams, P.I. Coe, H., 2011. Remarkable Dynamics of Nanoparticles in the Urban Atmosphere, *Atmos. Chem. Phys.* **11**, 6623-6637.

- **The typical size distribution measured at the Road site peaking between 20 and 30 nm diameter.**
- **In contrast, data from the Park site showed a mode which had shifted downwards to below 10 nm diameter.**
- **There is almost complete loss of the sub-30 nanometre mode at the BT Tower site.**

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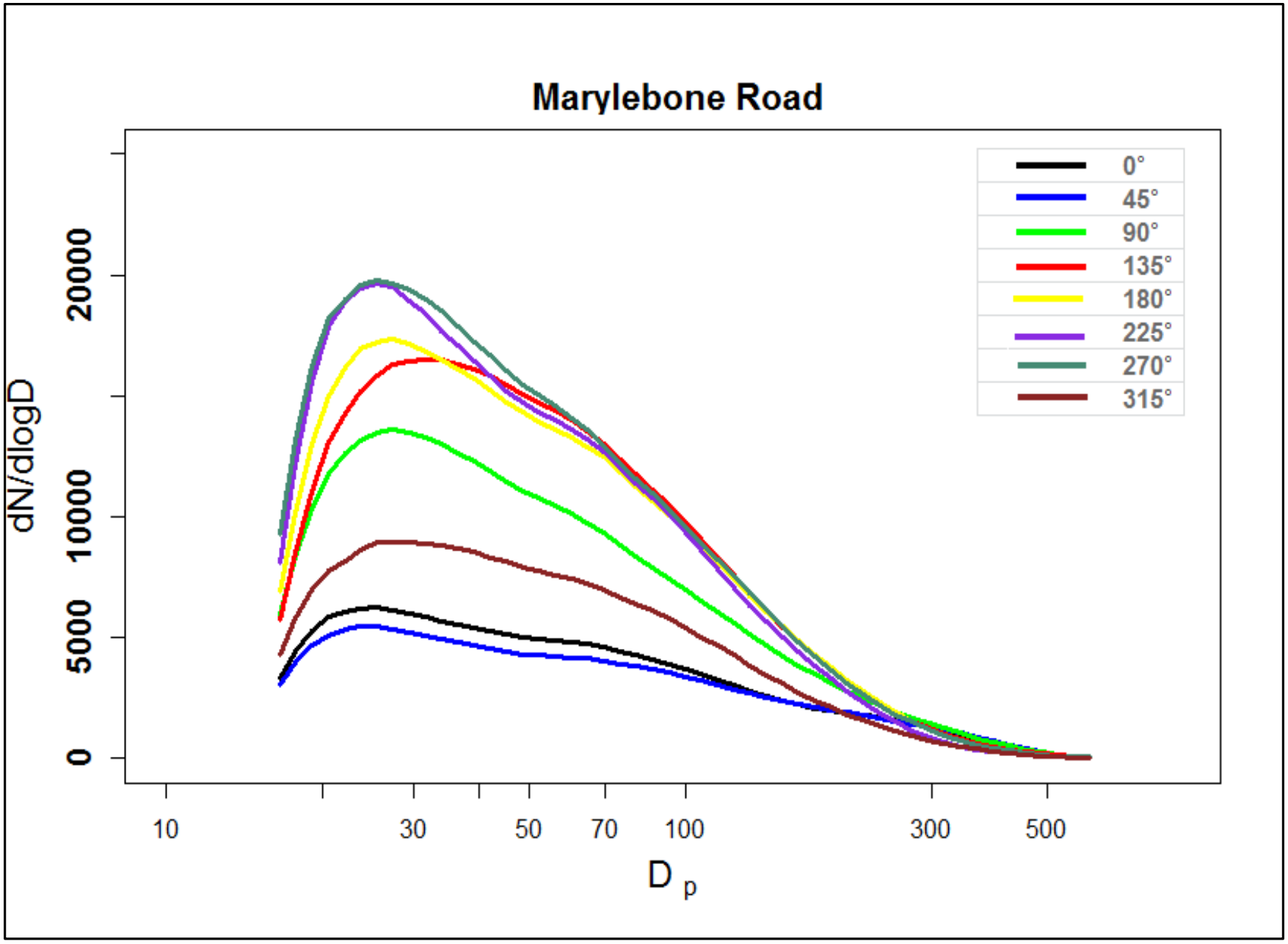
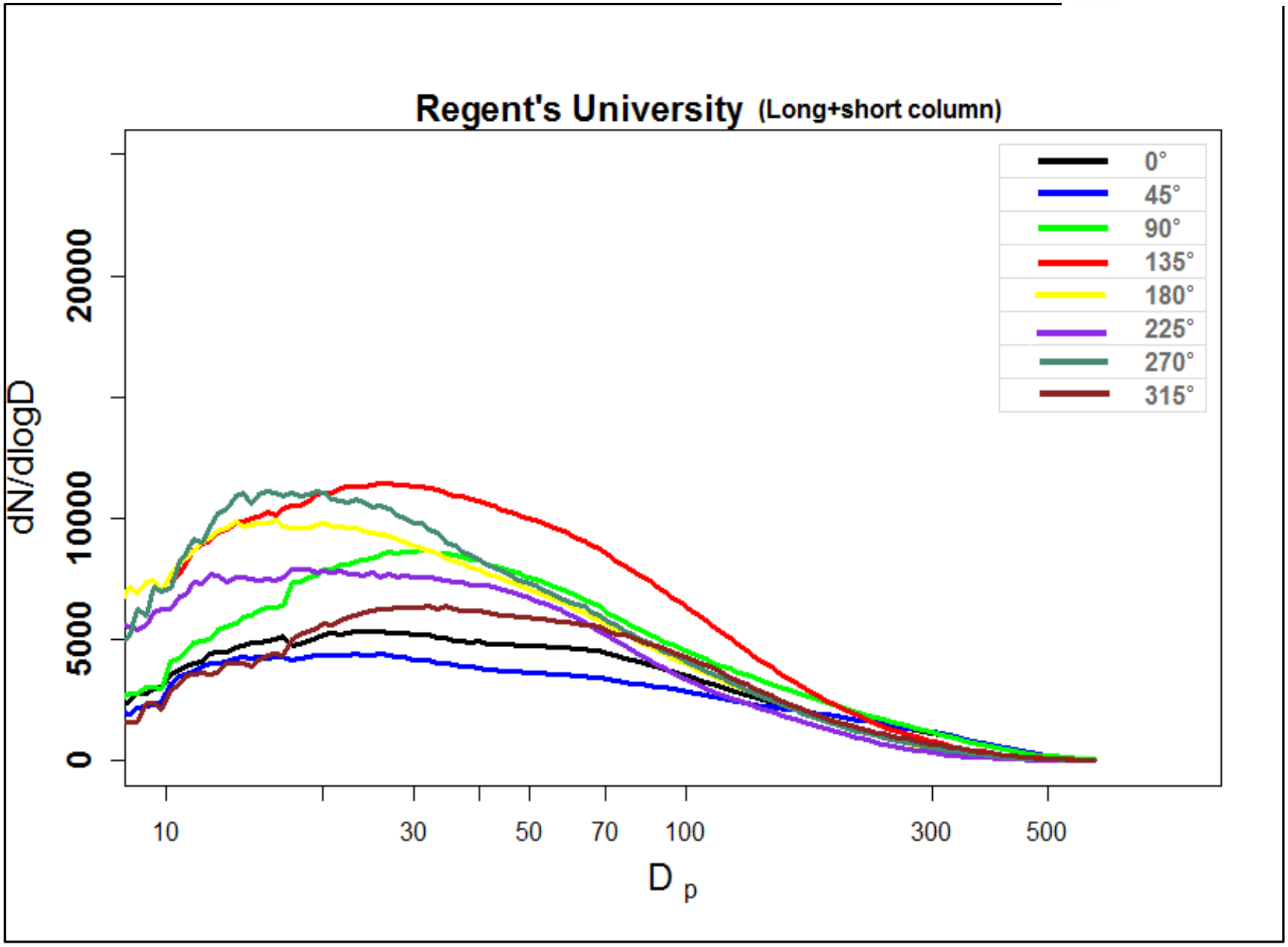
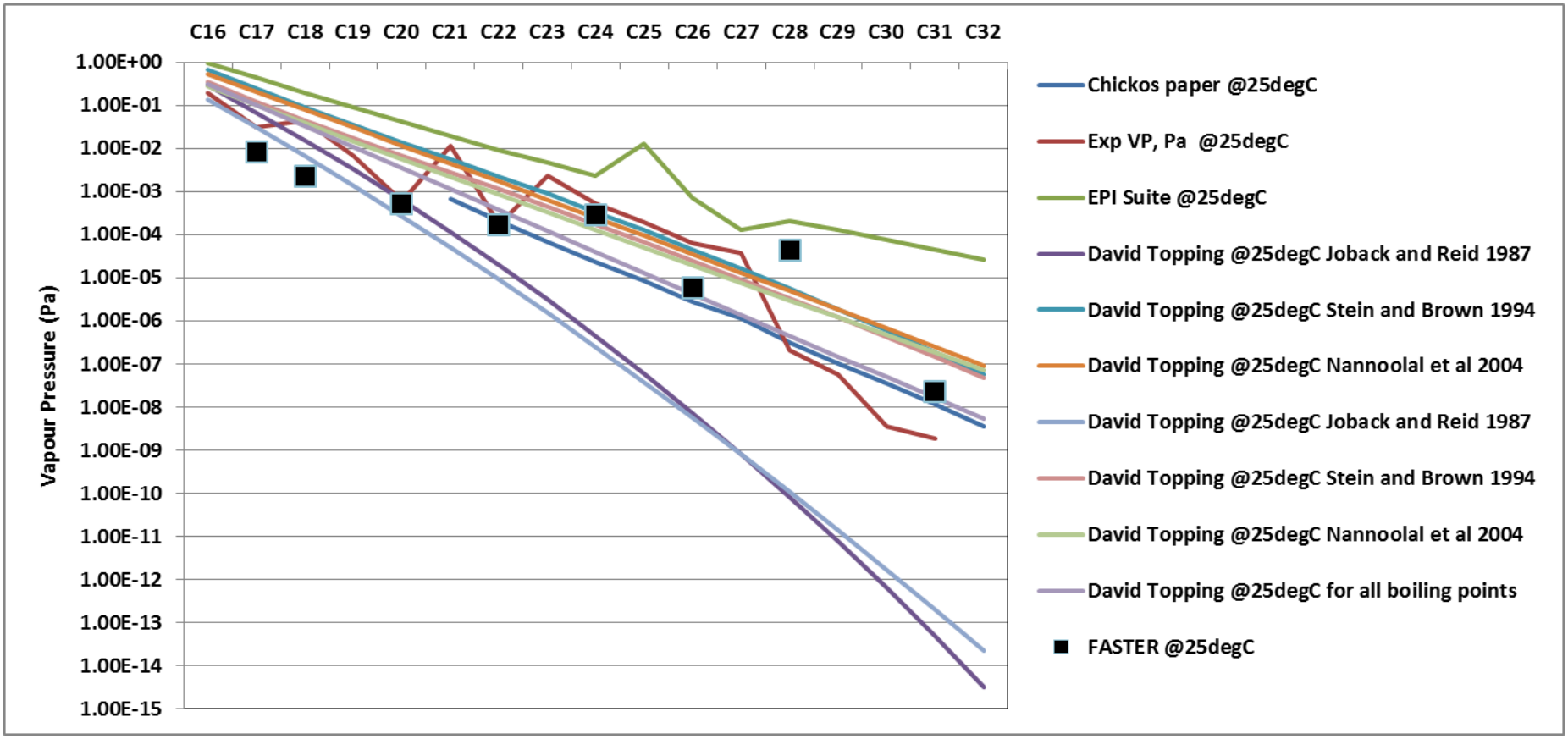
New Field Data


Marylebone Road
0°
45°
90°
135°
180°
225°
270°
315°
dN/dlogD
0
5000
10000
20000
10
30
50
70
100
300
500
D p

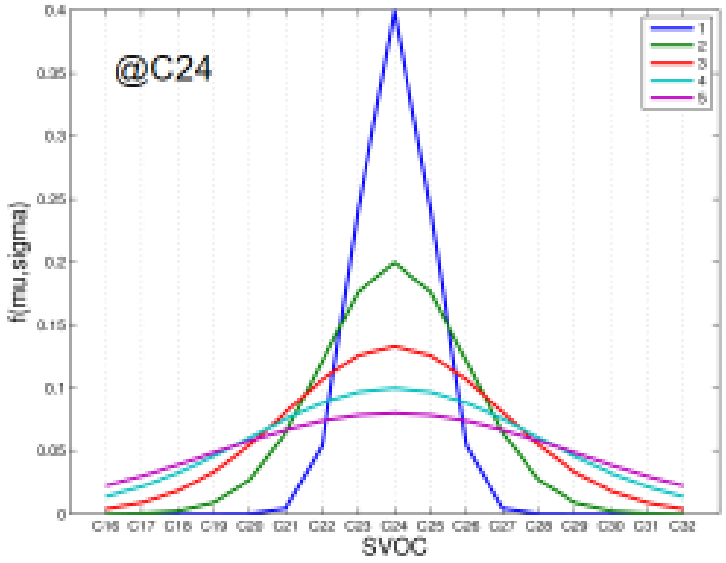

Regent's University (Long+short column)
0°
45°
90°
135°
180°
225°
270°
315°
dN/dlogD
0
5000
10000
20000
10
30
50
70
100
300
500
D p

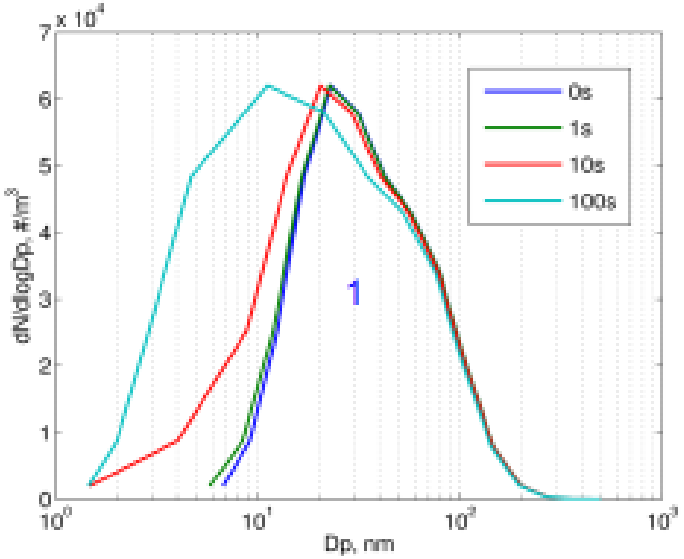
Vapour pressure measurements

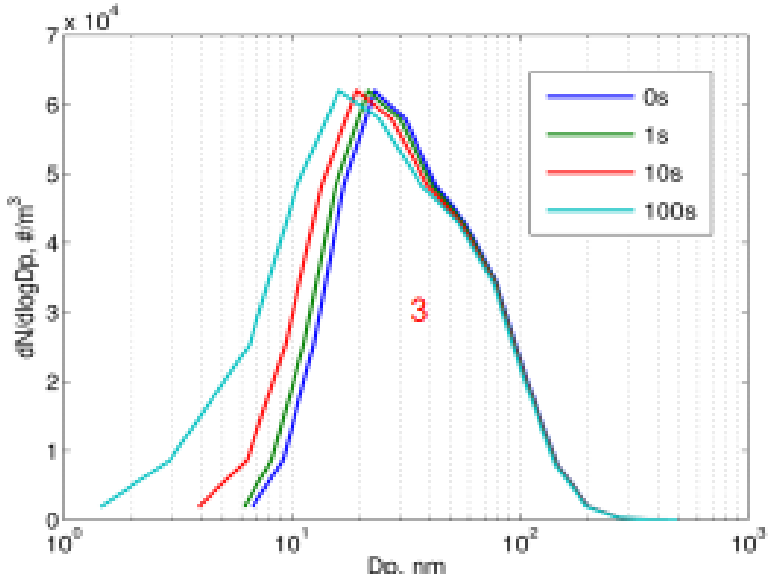


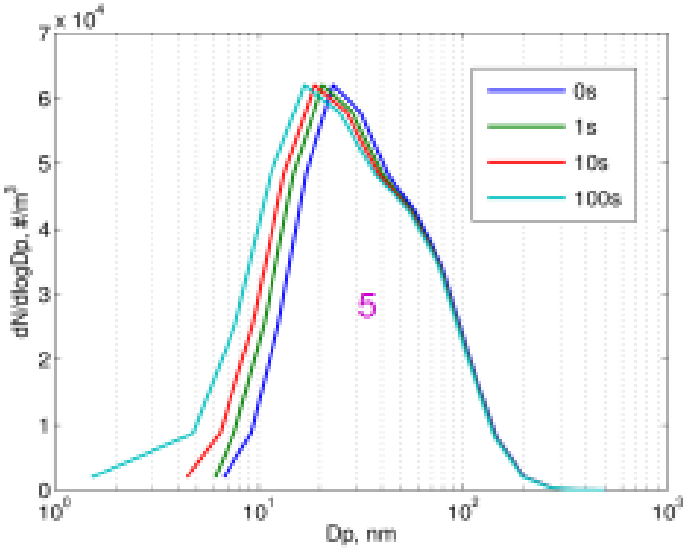
Example particle compositions, given as mass fraction for surrogate compounds C16-C32, represented by a Gaussian distribution with σ from 1 to 5

Change in size distribution according to sigma and travel time









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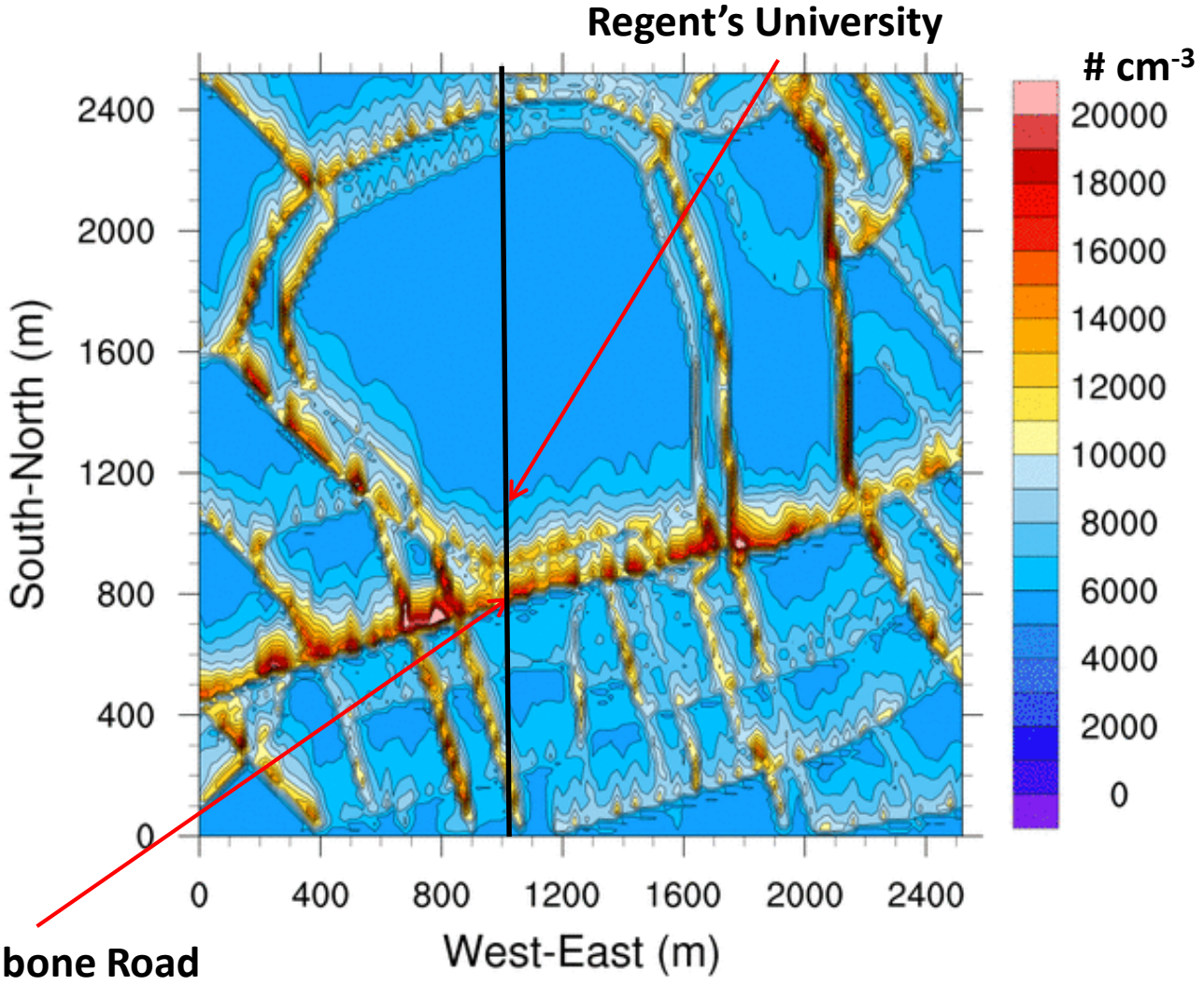
Neighbourhood-scale Model

The 3D WRF-SVOC model

Total UFP number concentration at roof-level



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The FASTER Team…

Geography, Earth & Environmental Sciences

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- Dr Jian Zhong
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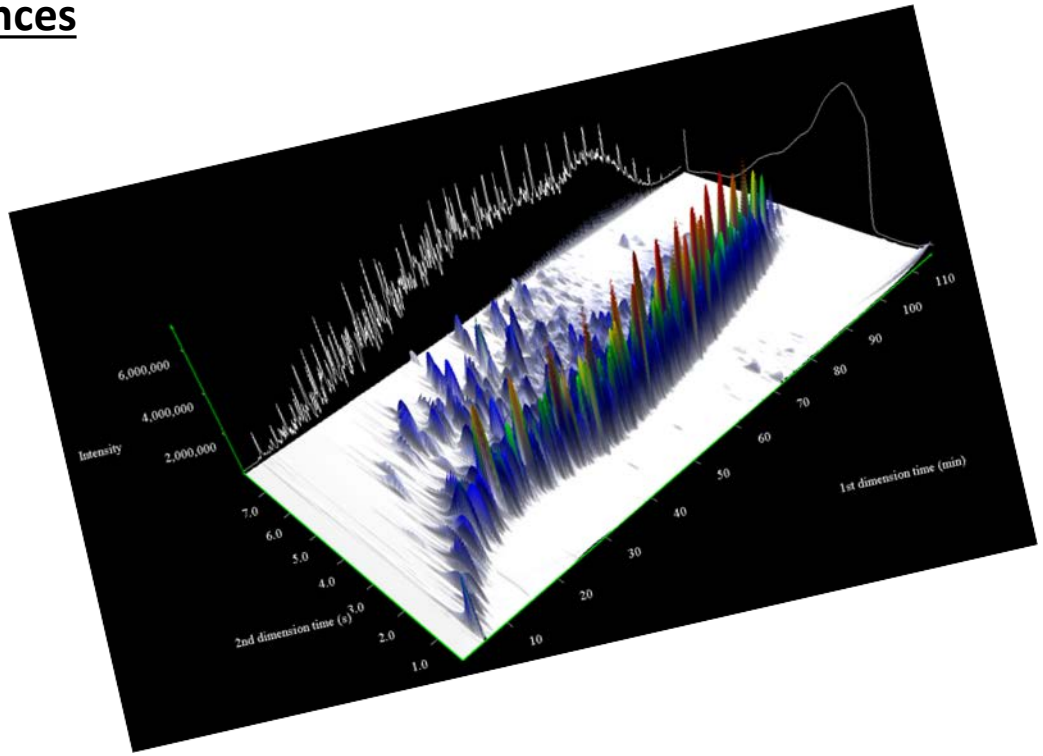
- Miss Ruixin Xu



Mechanical Engineering

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THANK YOU