



Particle exposure and dosage on public transport



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**>70% of all journeys are
undertaken on public
transport**

Programa Integral de Movilidad 2013-2018, CDMX

15 million daily trips

40% Bus & microbus

30% Subway

11% Taxi

7% Bus Rapid Transit (BRT)

2% Bicycle

Diverse sources

Mexico City



Singapore

63% of all journeys in peak hours are undertaken on public transport

Land Transport Authority

7.7 million daily trips

49% Bus

38% Subway

13% Taxi

Land Transport Authority

Which is the best transport mode in terms of pollution exposure?

What do we breathe while waiting for a bus?



**PLANES, TRAINS
AND AUTOMOBILES**

**BUS, MRT, TAXI
AND WALKING**



PM₁₀, PM_{2.5}, PM₁

Particle # concentration

Active Surface Area

Particle-bound PAH (pPAH)

Black carbon

Carbon monoxide

Noise

Temp. & RH



Instruments

Carbon monoxide
T15n Langan

Temp. & RH
HOBO Pro v2

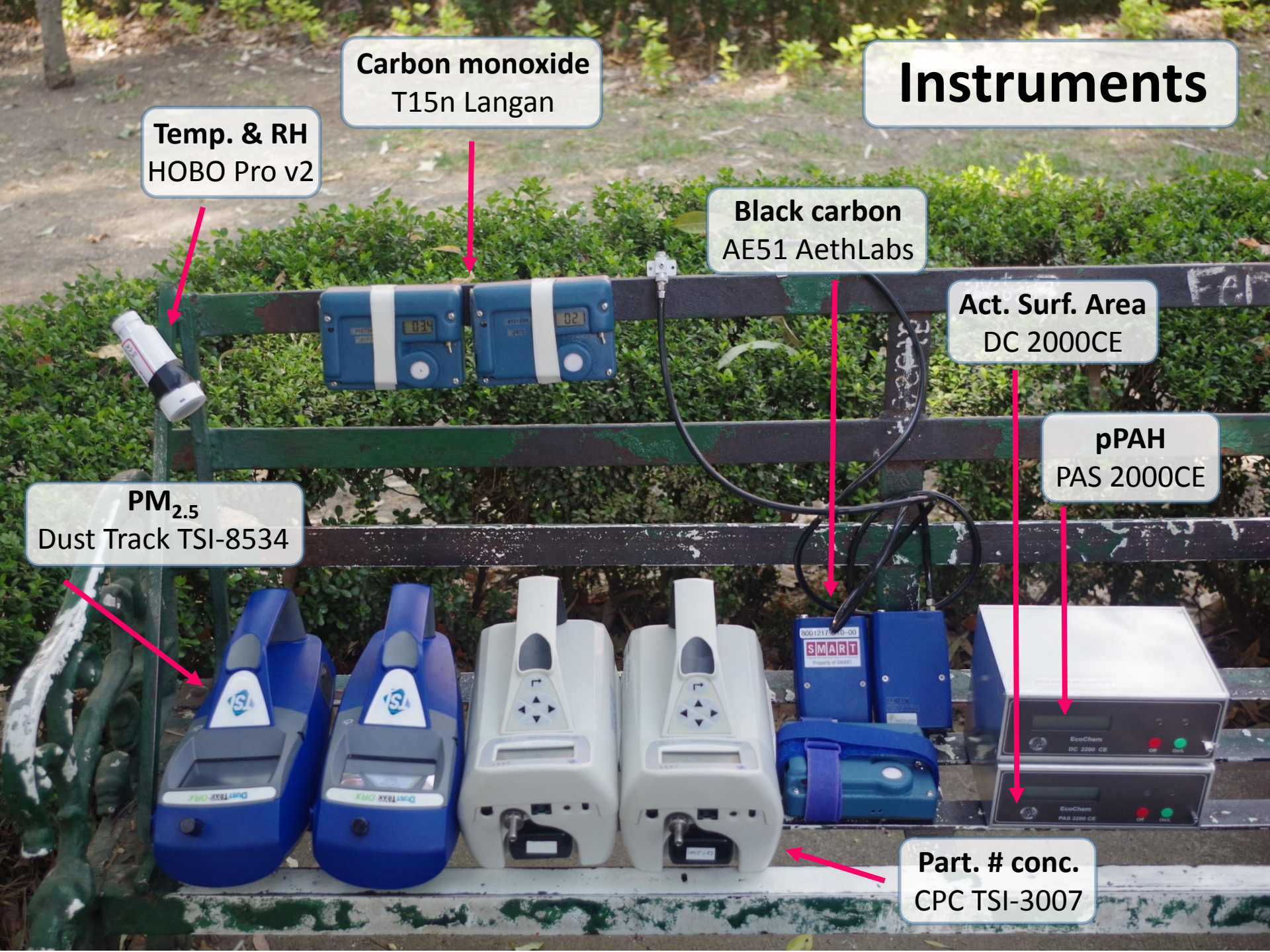
Black carbon
AE51 AethLabs

Act. Surf. Area
DC 2000CE

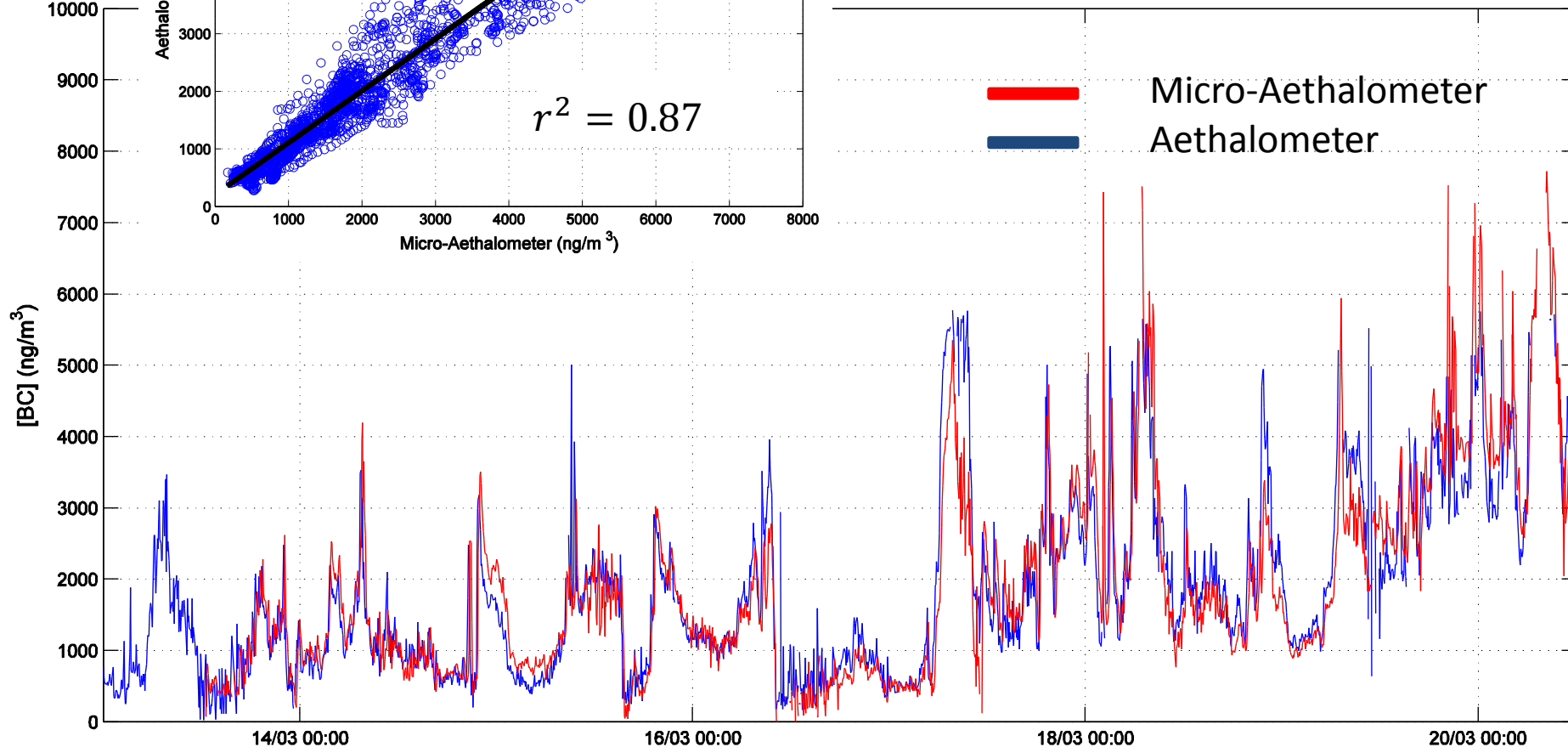
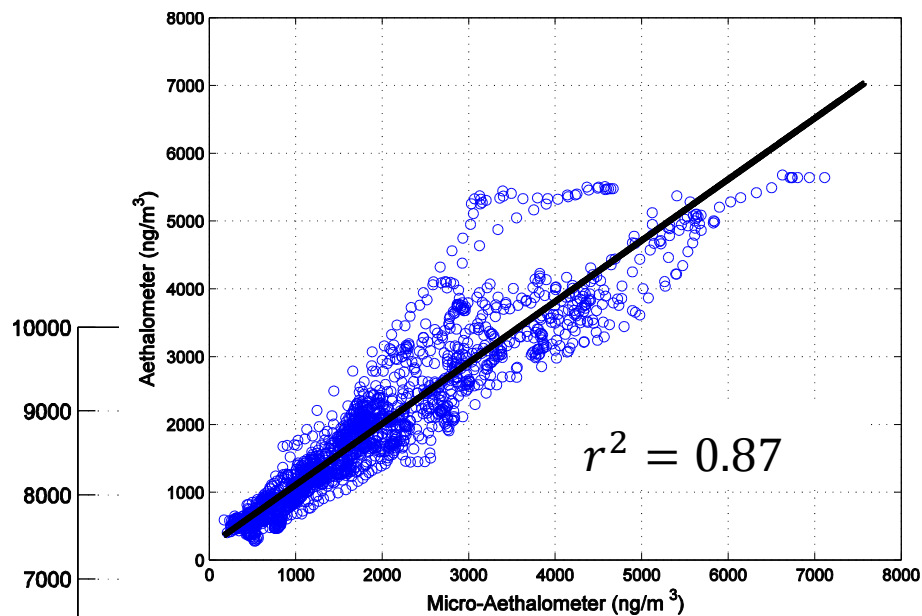
pPAH
PAS 2000CE

PM_{2.5}
Dust Track TSI-8534

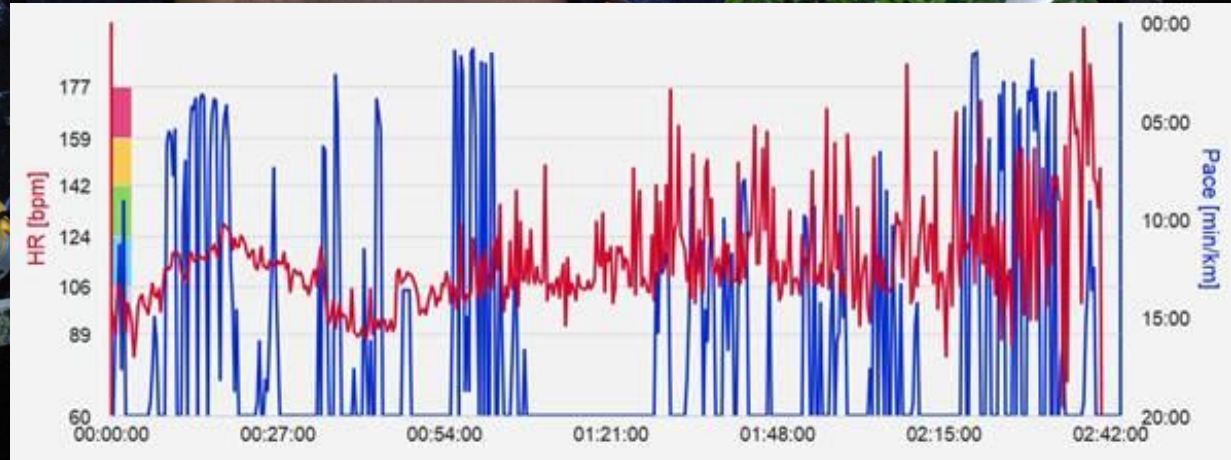
Part. # conc.
CPC TSI-3007



Instruments validation



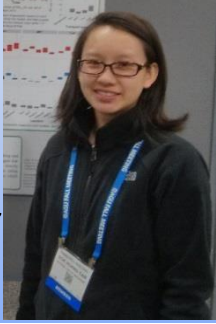
Heart rate



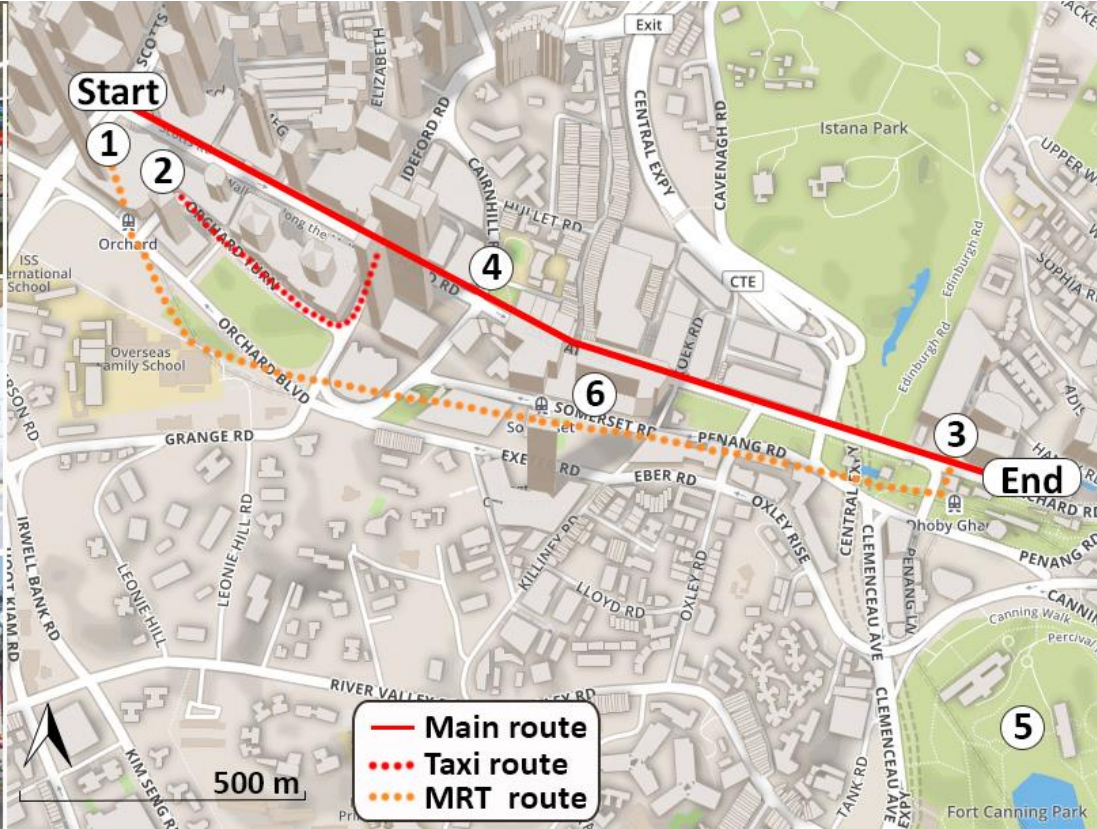
Commuter exposure to particles on public transport

Sok Huang Tan




Now at Ministry of the Environment and Water Resources



- Short duration but close proximity to emission sources
- Possible significant contribution to total exposure



The cleanest mode of transport is ...

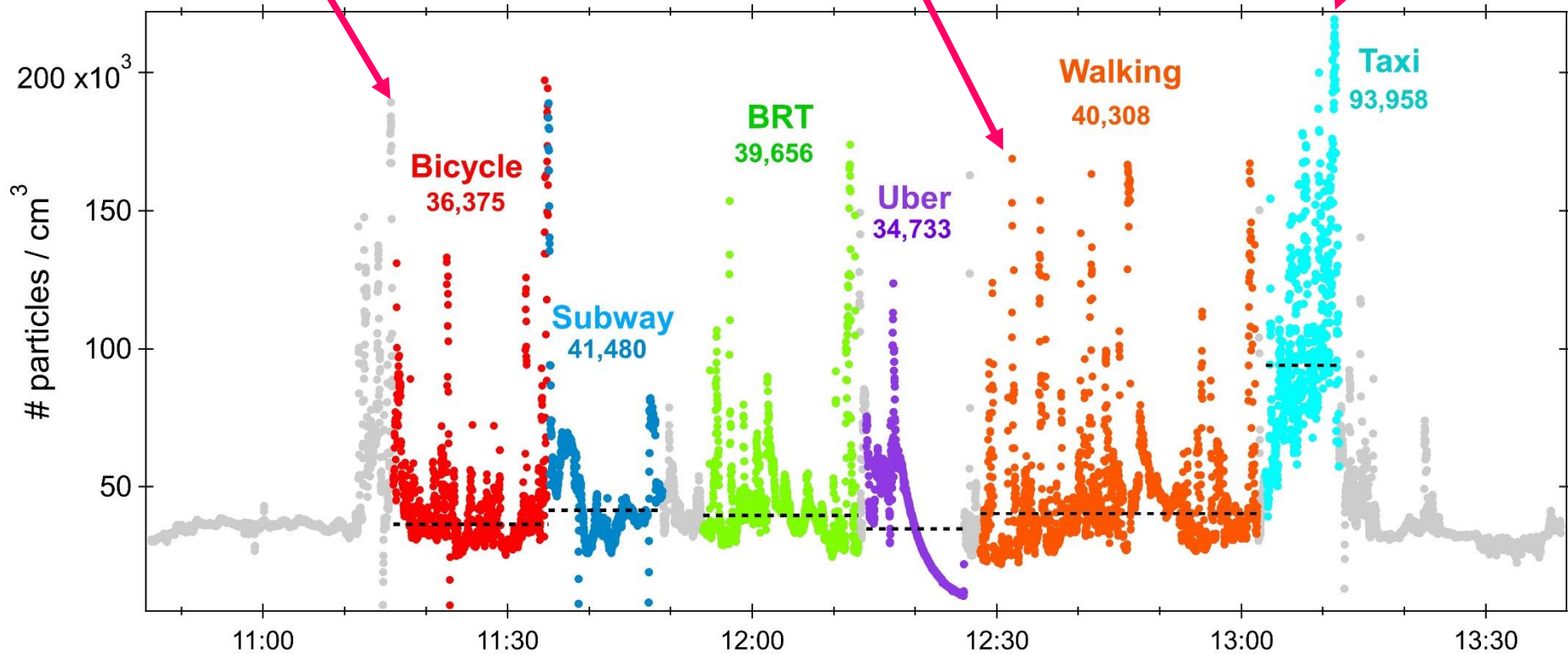
	<i>Exposure concentration</i>				<i>Inhaled dose</i>			
	PM _{2.5}	PN	BC	pPAHs	PM _{2.5}	PN	BC	pPAHs
 <p>Bus</p>	0.78	0.64	0.58	0.80	0.38	0.32	0.28	0.39
 <p>MRT</p>	0.73	0.32	0.35	0.30	0.39	0.17	0.19	0.16
 <p>Taxi</p>	0.76	0.69	0.58	0.87	0.45	0.42	0.34	0.52
 <p>Walk</p>								

Transport mode

Walk mode

Mexico City

A first glimpse to Av. Cuauhtémoc

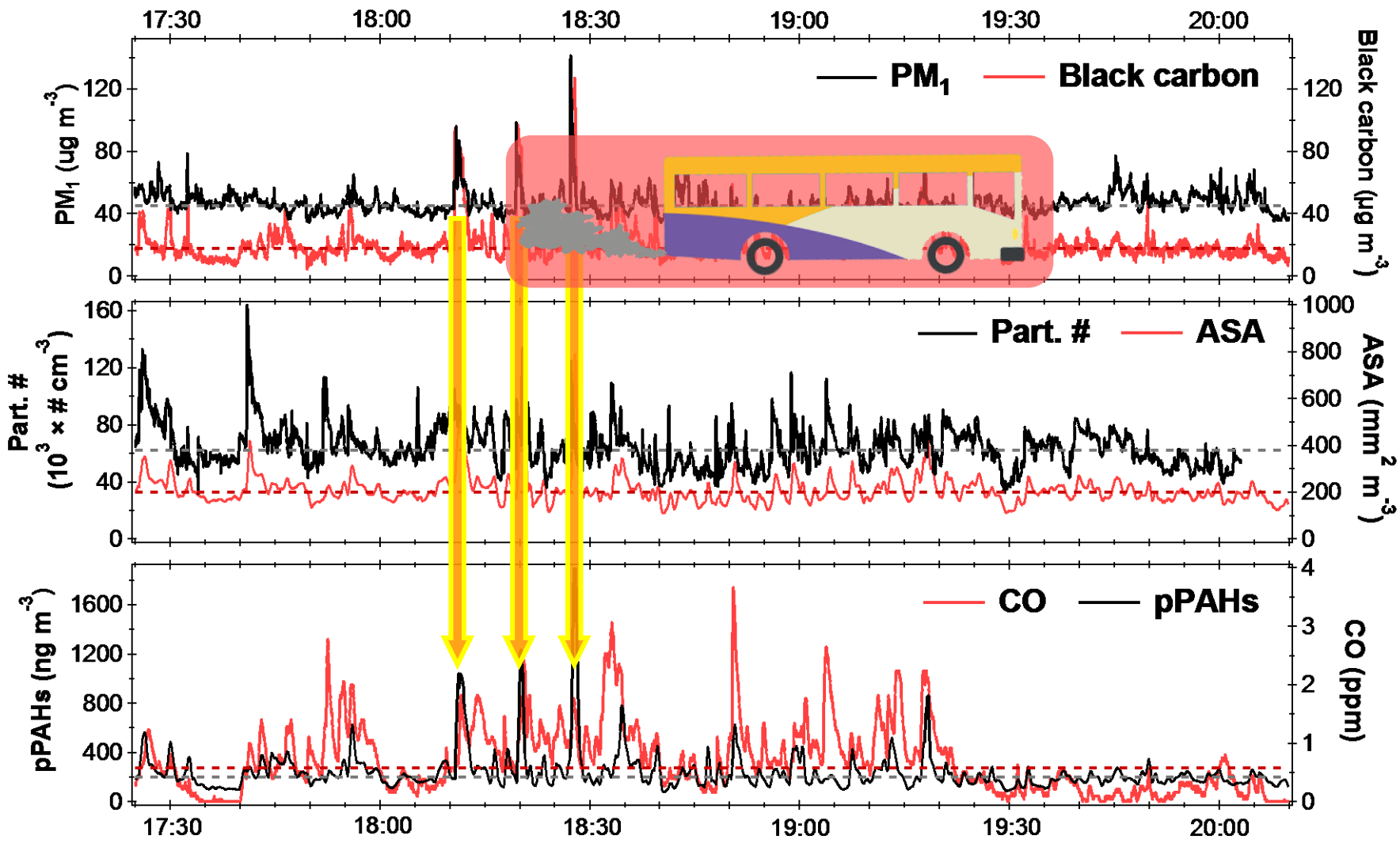




Particles exposure at bus stops

5 bus stops

Morning & evening rush-hours



Findings on bus stops

$$PM_1 = 0.97 PM_{2.5}$$

22 - 55 (34) $\mu\text{g}/\text{m}^3$

1.5 - 3 times > ambient level

spikes > 100 $\mu\text{g}/\text{m}^3$ @ 5 min

Black carbon $\approx 0.60 PM_{2.5}$

Inside a tunnel: 0.40 $PM_{2.5}$

¹Gasoline: 0.25 - 0.43 $PM_{2.5}$

¹Diesel: 0.51 - 0.71 $PM_{2.5}$

**Ultrafine particles
($\leq 100 \text{ nm}$)**

45 - 158 (78) $\times 10^3 \text{ \#}/\text{cm}^3$

ambient level: $22 \pm 5 \times 10^3 \text{ \#}/\text{cm}^3$

~3.5 higher

**Particle-bound PAH
(pPAH)**

112 - 446 ng/m^3

²L.A., US: 123 ng/m^3

³Quito, Ecuador: 340 ng/m^3

⁴Hong Kong: 405 ng/m^3

⁵Mexico City: 484 ng/m^3

¹McDonald et al., *Environ. Sci. Technol.* 2015

²Houston et al., *Atmos. Environ.* 2013

³Brachtel et al., *Environ. Pollut.* 2009

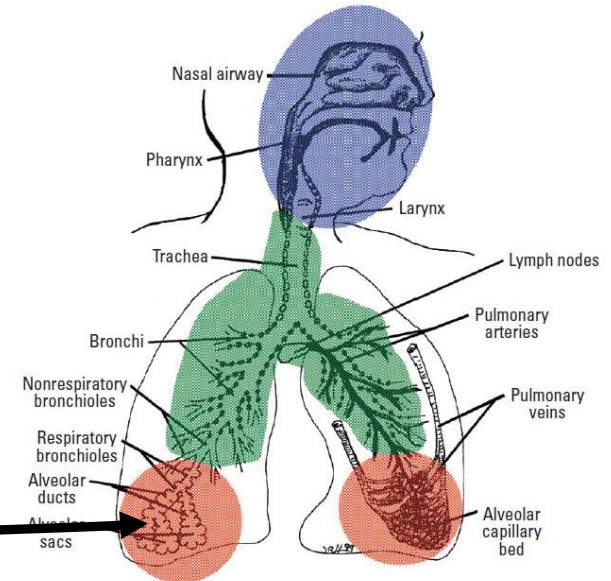
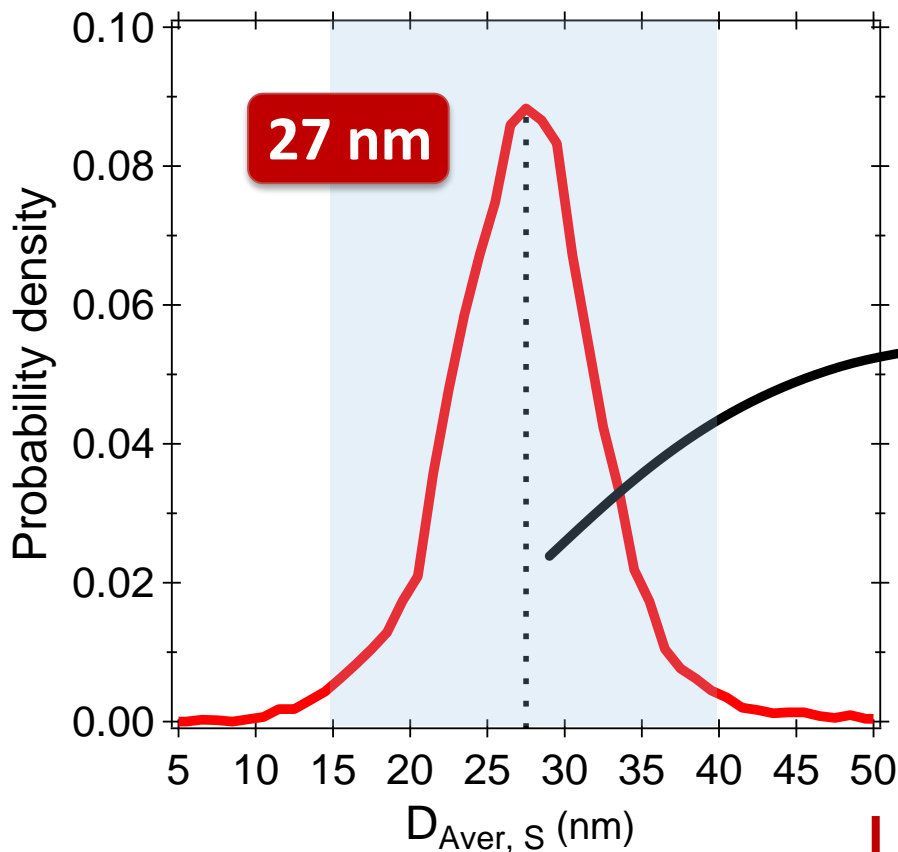
⁴Cheng et al., *Aerosol Air Qual. Res.* 2012

⁵Velasco et al., *Atmos. Environ.* 2004

Particles size distribution

$$D_{Aver,S} = f(\text{Part. \#}, \text{Act. Surf. Area})$$

Kittelson et al., SAE Tech. Paper, 2000



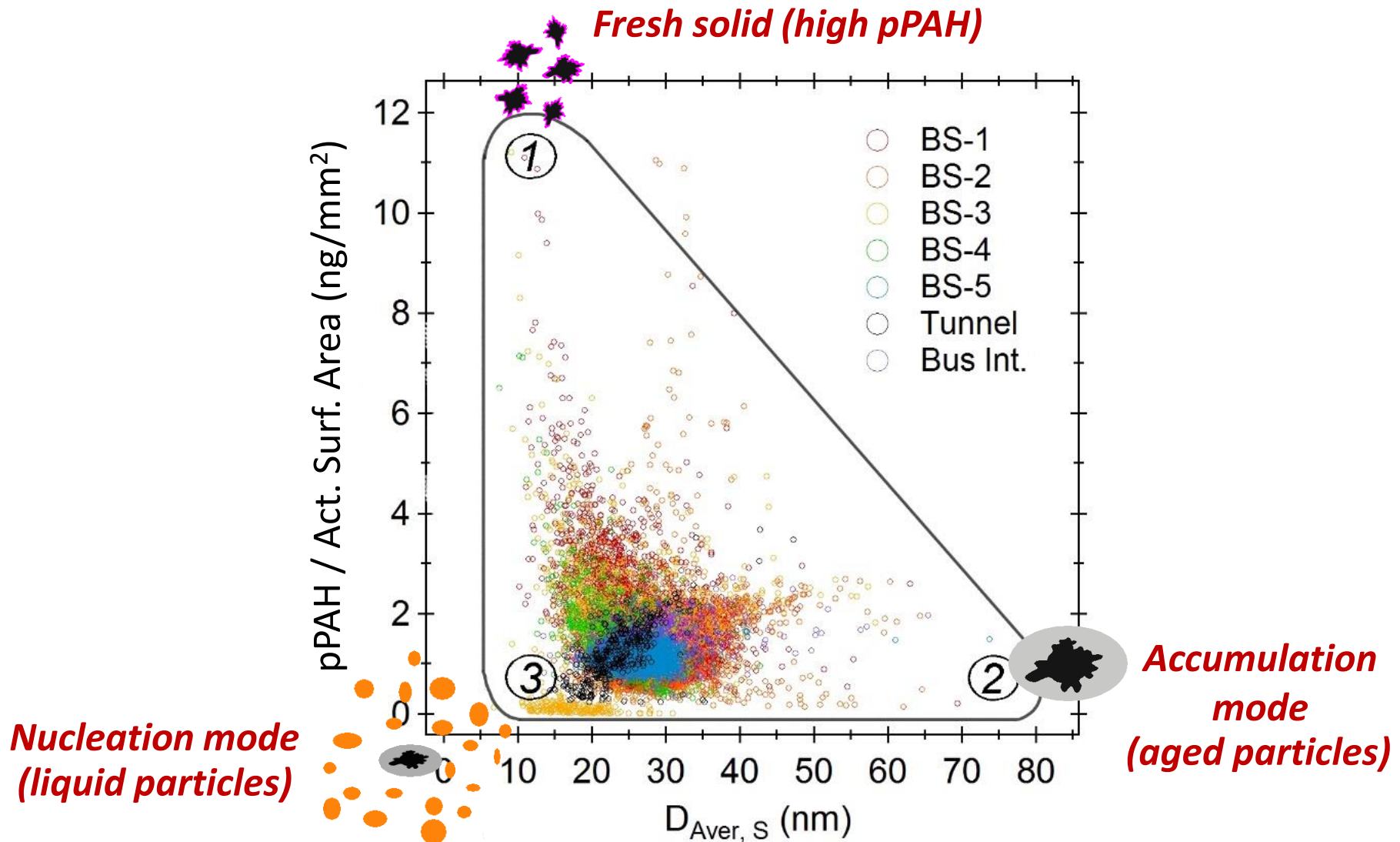
Taken from Env. Health Persp. 113, 823, 2005

15 – 40 nm

- Modern diesel engines (Euro IV or newer)
- Gasoline vehicles

Nucleation mode

Presence of nucleation and accumulation mode particles



A short exposure?

10-min wait during peak hours

Serangoon Rd

Land Transport Authority

**A commuter should ideally
linger ≤ 20 min per day**

1 week \rightarrow 100 min = 1.7 h

1 month \rightarrow 400 min = 6.7 h

1 year \rightarrow 4800 min = 3.3 days

one life \rightarrow 276 days = 9 months

(82.7 years, Statistics Singapore, 2015)

Lung Cancer

**Very short (< 1h)
exposure to traffic
particles exacerbates
existing pulmonary and
cardiovascular diseases**

- Increase in heart rate
- Myocardial ischemia
- Decline in expiratory flow
- Lung inflammatory responses

Brook et al., *Circulation* 2004
Peters et al., *N. Engl. J. Med.* 2004
Dales et al., *Int. Arch. Occup. Environ. Health* 2007
McCreanor et al., *N. Engl. J. Med.* 2007
Lanki et al., *J. Occup. Env. Med.* 2008
Sehlstedt et al., *Inhal. Toxicol.* 2010
Zuurbier et al., *Epidemiology* 2011
Shields et al., *Environ. Health* 2013
Xu et al., *Part. Fibre Toxicol.* 2013
Hemmingsen et al., *Mutat. Res. Fundam. Mol. Mech. Mutagen.* 2015
Upadhyay et al., *Eur. Med. J. – Resp.* 2015
....., etc.

Sorry, but as shocking as it might be to have lung cancer on "sale", we believe it's more shocking that many Singaporeans still aren't adequately covered to deal with financial risk.

With lung cancer, your hospital bills, post-treatment and daily expenses could be more than \$100,000. But with the help of a professional, you can pay much less and be able to focus on your health instead.

Be ready for tomorrow with a professional. Speak to your insurance adviser, call 6788 5515 or visit www.haveaplan.com.sg today.

IMPORTANT NOTES

The figures above are for illustrative purpose only.

*This figure is calculated based on an insured who is covered under both VivoCare and Enhanced IncomeShield at the same time. Visit www.haveaplan.com.sg for the detailed computations.

This advertisement is for general information only and is not a contract of insurance. You should seek advice from a qualified adviser if in doubt. If you choose not to, you will have to take sole responsibility to ensure that the product you purchase is appropriate to your financial needs and insurance objectives. Buying a life insurance policy is a long-term commitment. An early termination of the policy usually involves high costs and the surrender value payable may be less than the total premiums paid. Buying health insurance products that are not suitable for you may impact your ability to finance your future healthcare needs.

An intense daily dosage of pollutants



Are masks a solution ?

Ho Chi Minh City, Vietnam

of particles

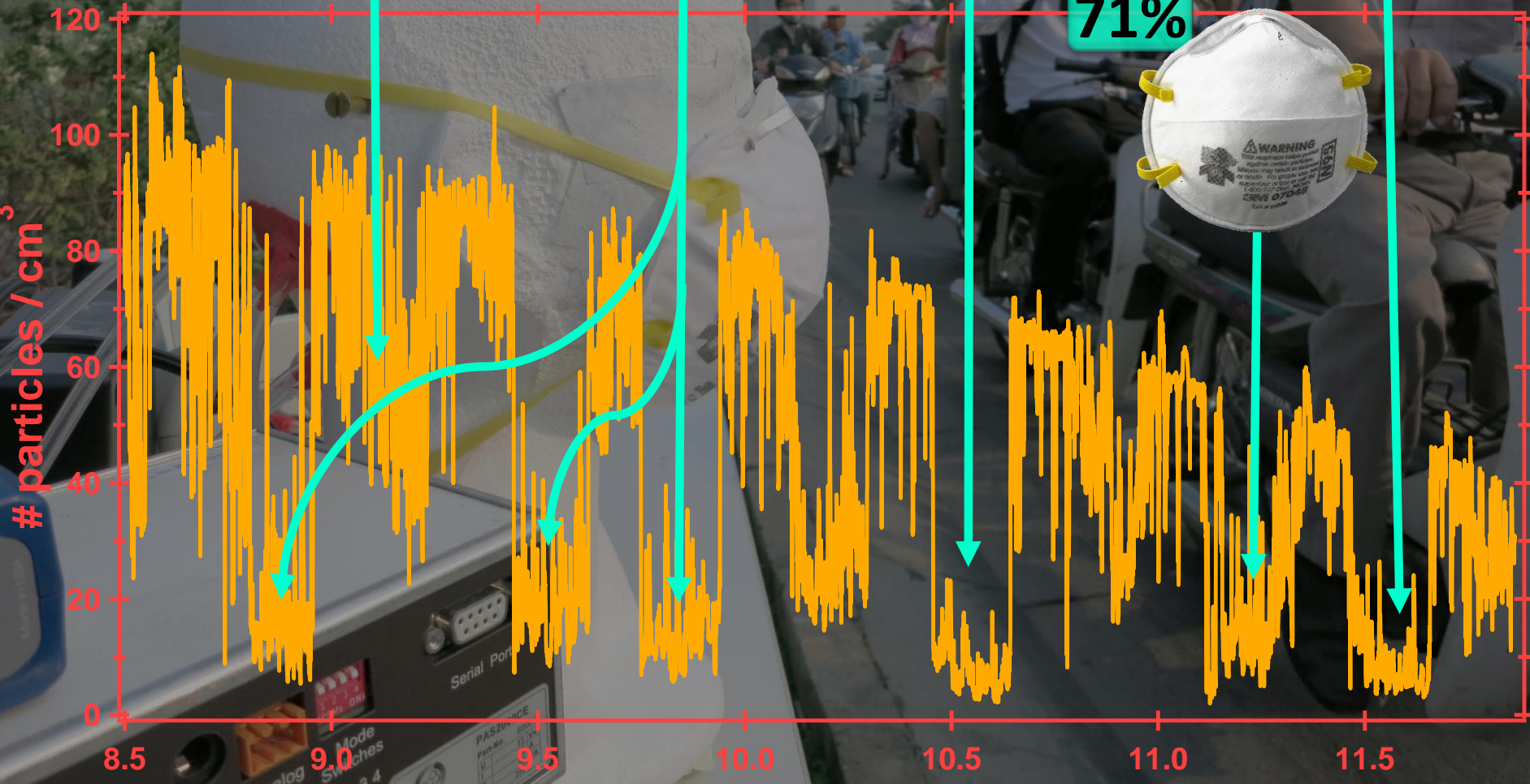
30%

77%

90%

81%

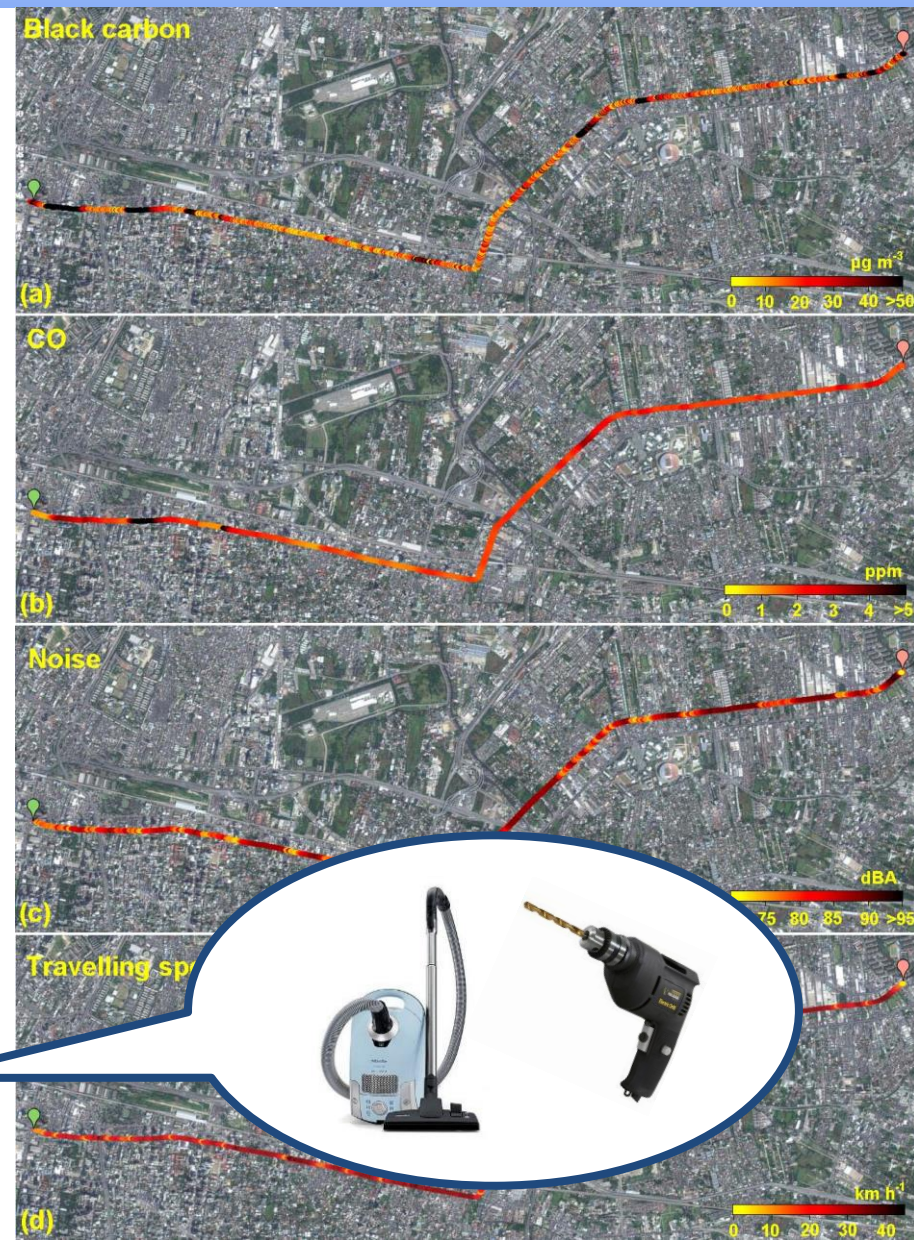
71%



Khlong boats, Bangkok, Thailand



	Pier	Inside the boat
Black carbon ($\mu\text{g m}^{-3}$)	74 – 136	15 - 411
PM _{2.5} ($\mu\text{g m}^{-3}$)	110 – 200	295 – 1,470
Equivalent sound level (dBA)	70 - 78	83 - 95



*A extremely chaotic
intersection*

Nuguyen Van Linh Av. & Nguyen Huu Tho Rd.



*Particle fingerprint of
motorbikes exhaust*



Ton Duc Thang University parking lot



**No need of finding a
needle in the haystack**

Cycling is great, but no next to emission sources



San Francisco, California

Take home message

When commuting consider not only exposure concentration, think also on travelling time and physical effort

At the end it is a problem of public health and mobility



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Elvagris Segovia
Kevin Ho
Matthias Roth
Alan Ziegler



Phạm Anh Đức
Tony Huang
Duang Nhat Tan
Tuấn Nguyễn Thanh
Do Minh Thu



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