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Envisaging a world with greener cities

Managing Air for Green Inner Cities - Partner Meeting

Experiments

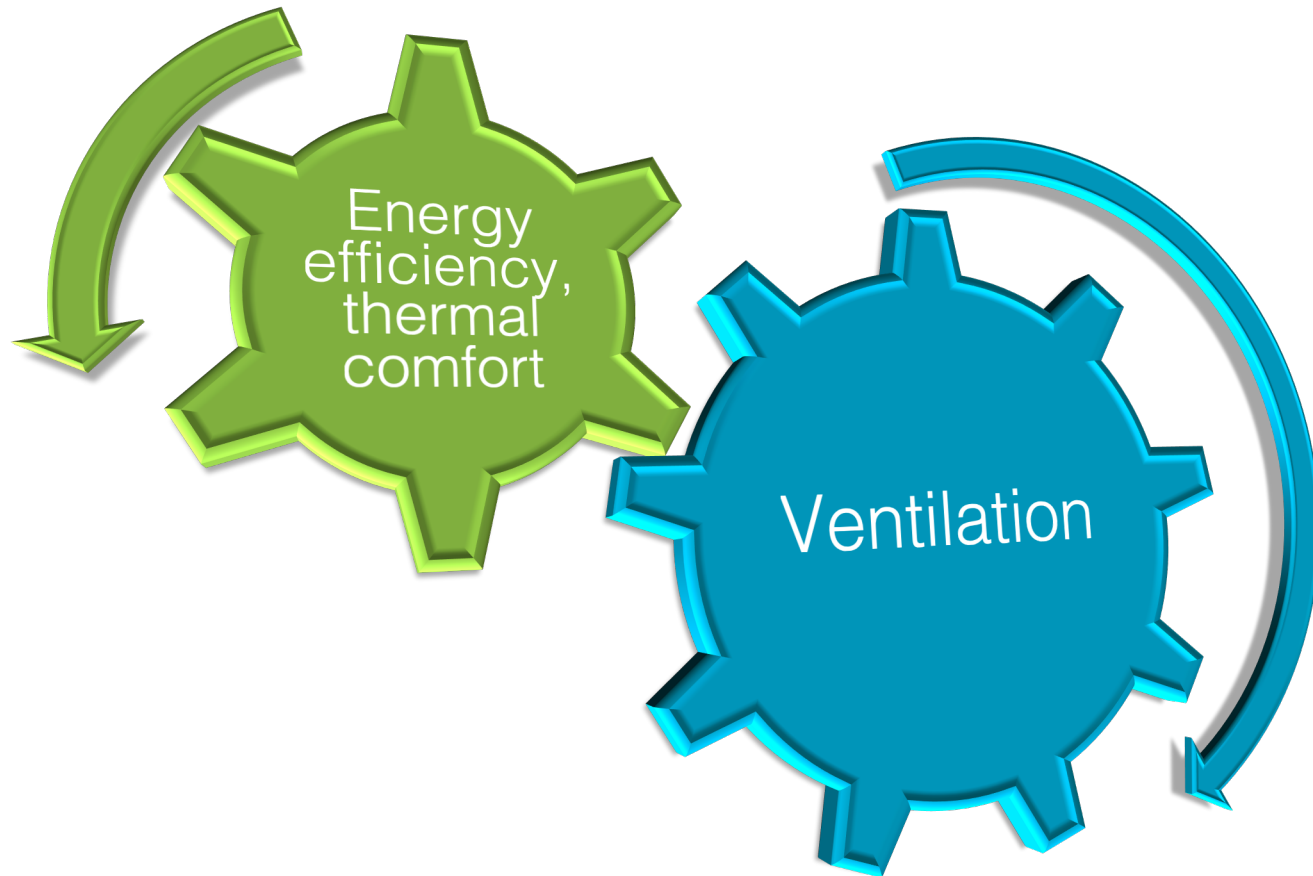
Rajesh Kumar Bhagat, Paul Linden

08 December 2020

Background

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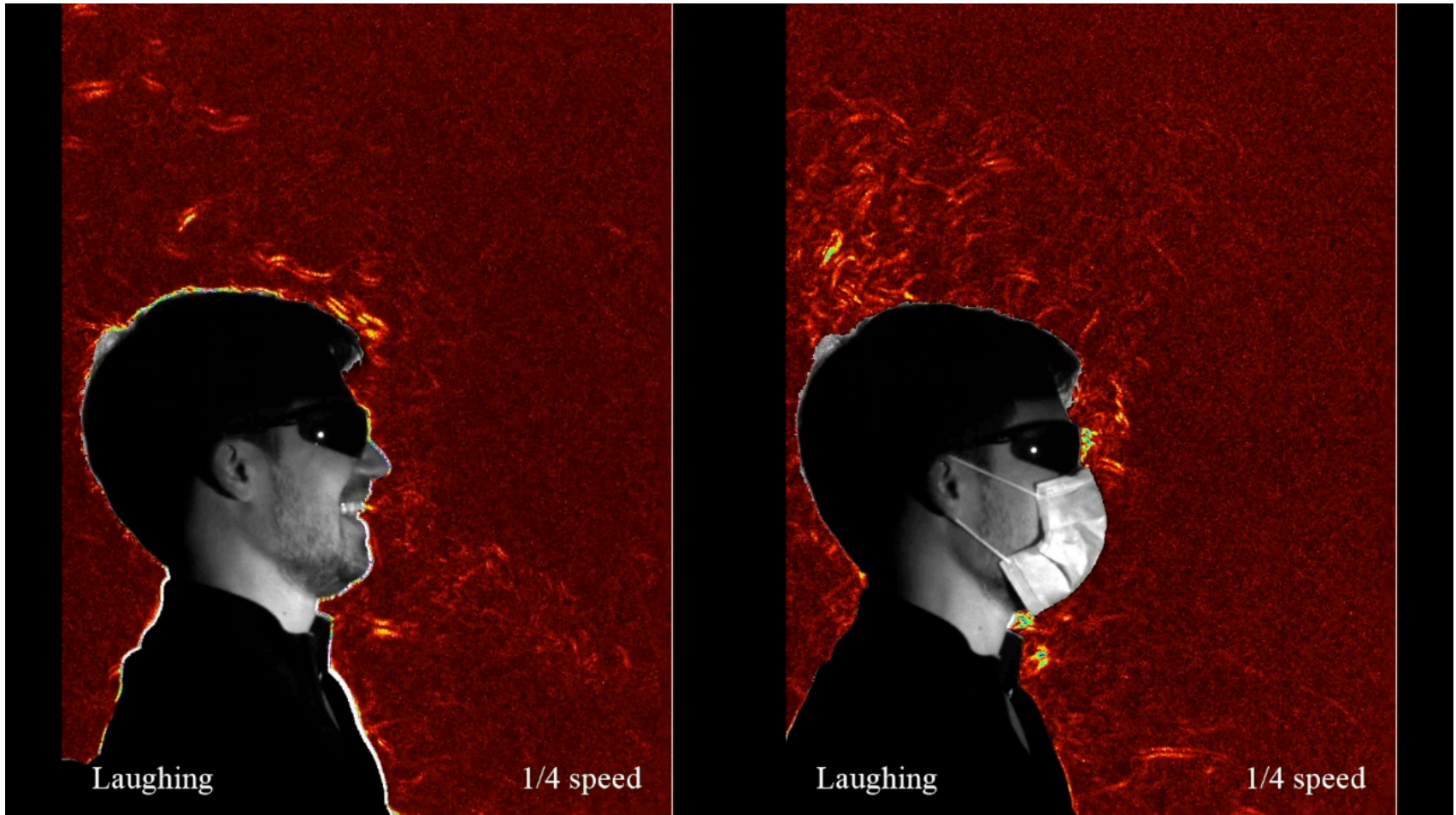
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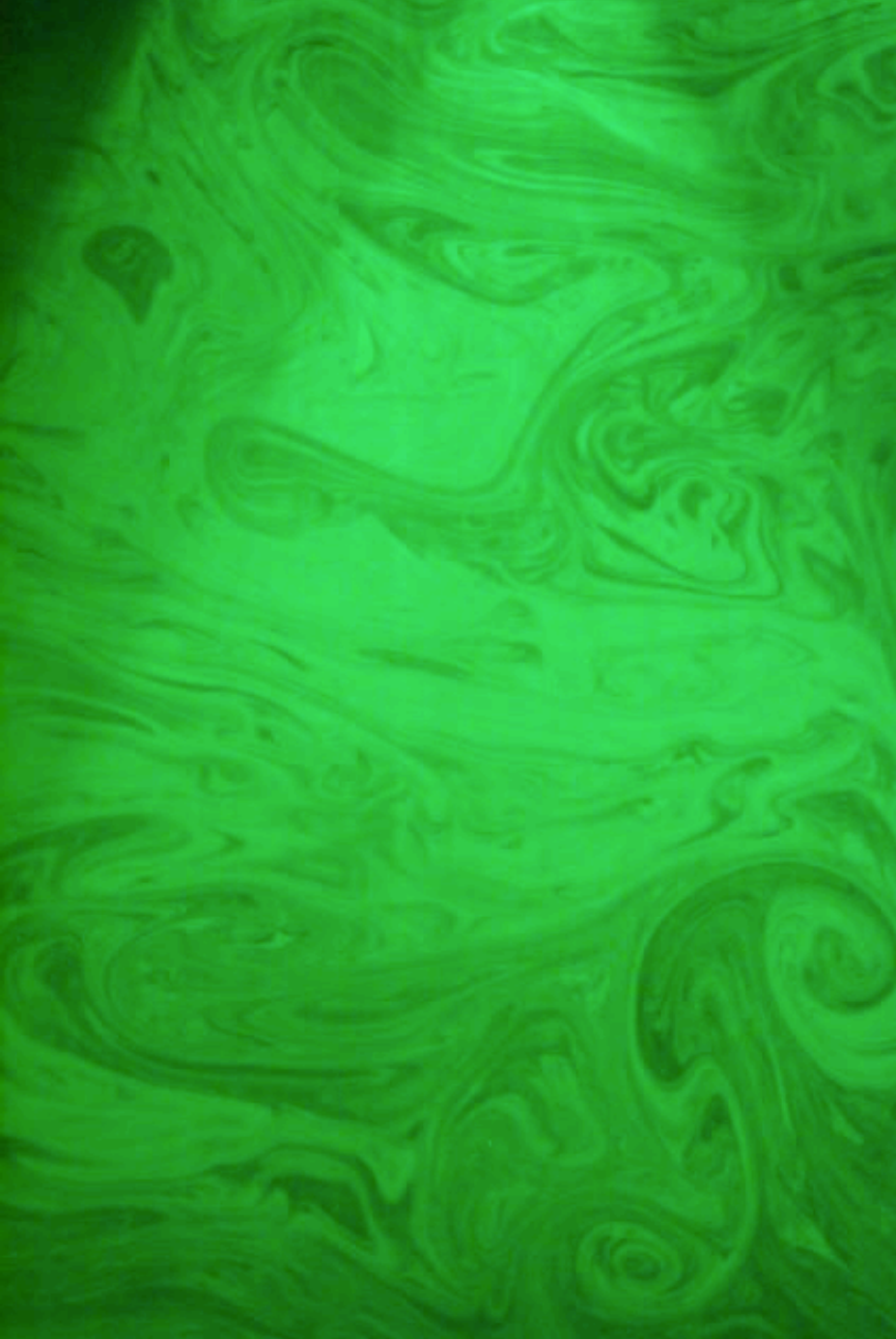


Flow visualisation

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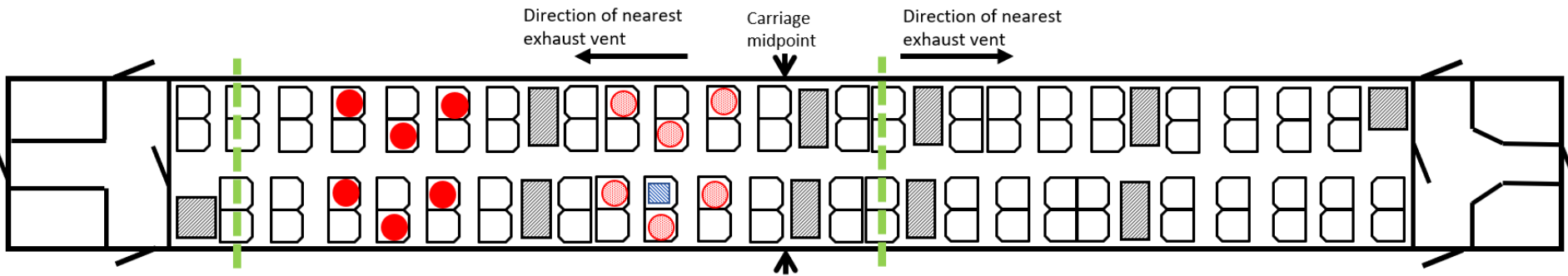
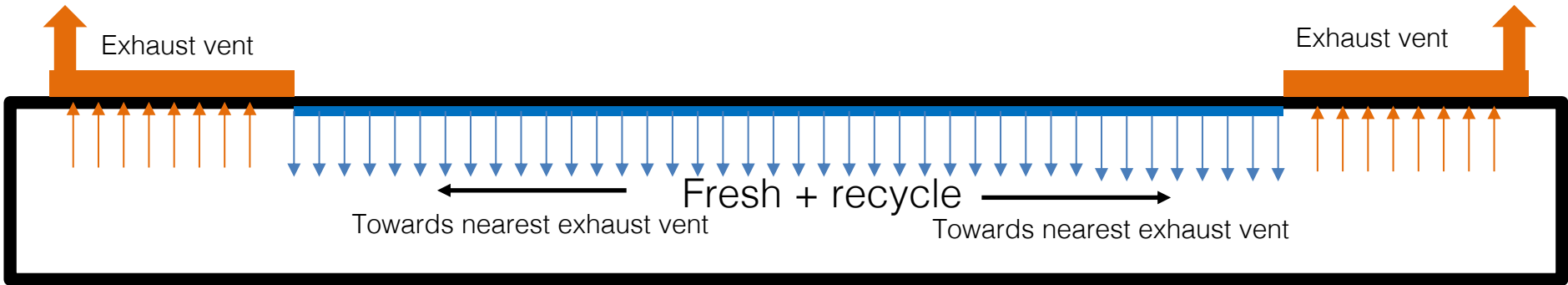
CAMBRIDGE

London



SURREY

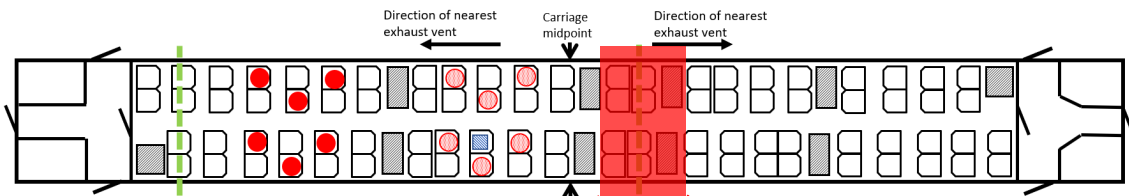
Train carriage



- CO_2 middle experiment passenger
- CO_2 end experiment passenger

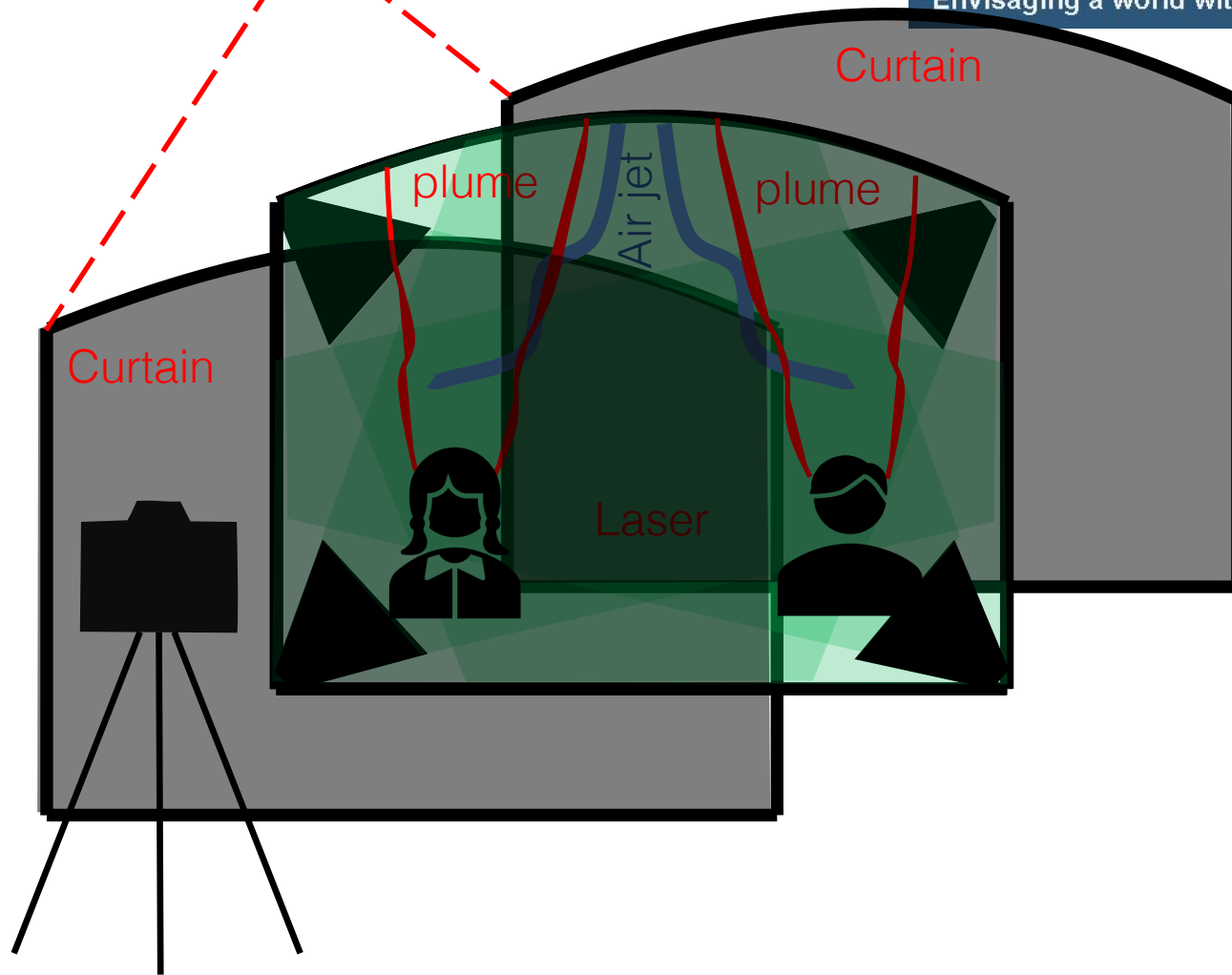
- Nebuliser for particle experiment
- Flow visualisation cross-section

- Seat
- Table or luggage rack



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Flow visualisation -1

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Flow visualisation -2

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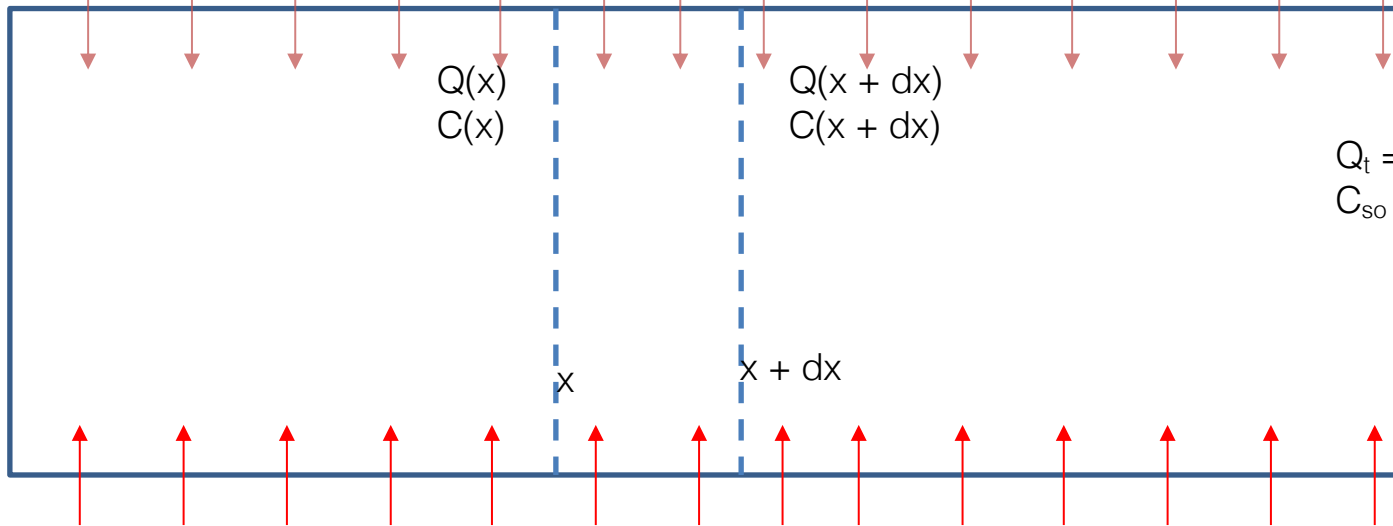
Analytical model for CO₂ concentration



$$Q(x)C(x) \Big|_x - Q(x + \Delta x)C(x + \Delta x) \Big|_{x+\Delta x} + q(x)C_s dx + B(x)C_0 dx = 0$$

Q_p = Purge flow rate
C_{s0} = Final CO₂ concentration

q(x) = dQ/dx = flow rate / length
C_s = steady state concentration



Q_t = Net flow rate
C_{s0} = Final CO₂ concentration

B(x) = breathing rate/length
C₀ = CO₂ concentration

Analytical model

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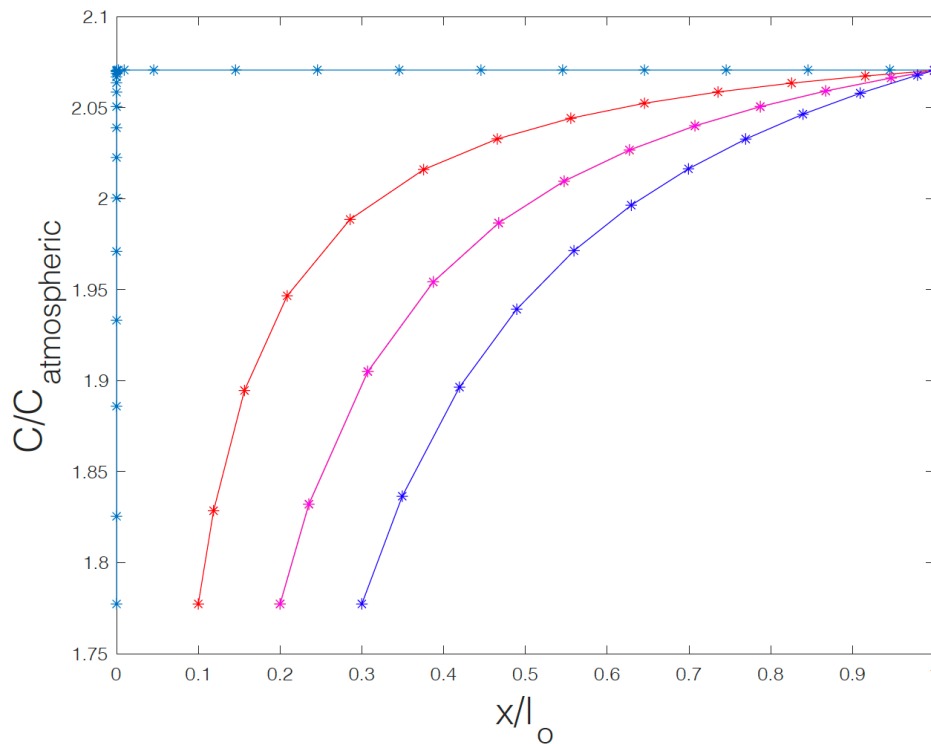
$$Q(x) \frac{dC}{dx} + C(x) \frac{dQ}{dx} = q(x)C_{s0} \left(1 - \frac{Q_p}{Q_t}\right) + B(x)C_0$$

For a uniform line jet

$$x \frac{dC}{dx} + C(x) = C_s + B(x)C_0$$

Analytical solution for an uniform line source

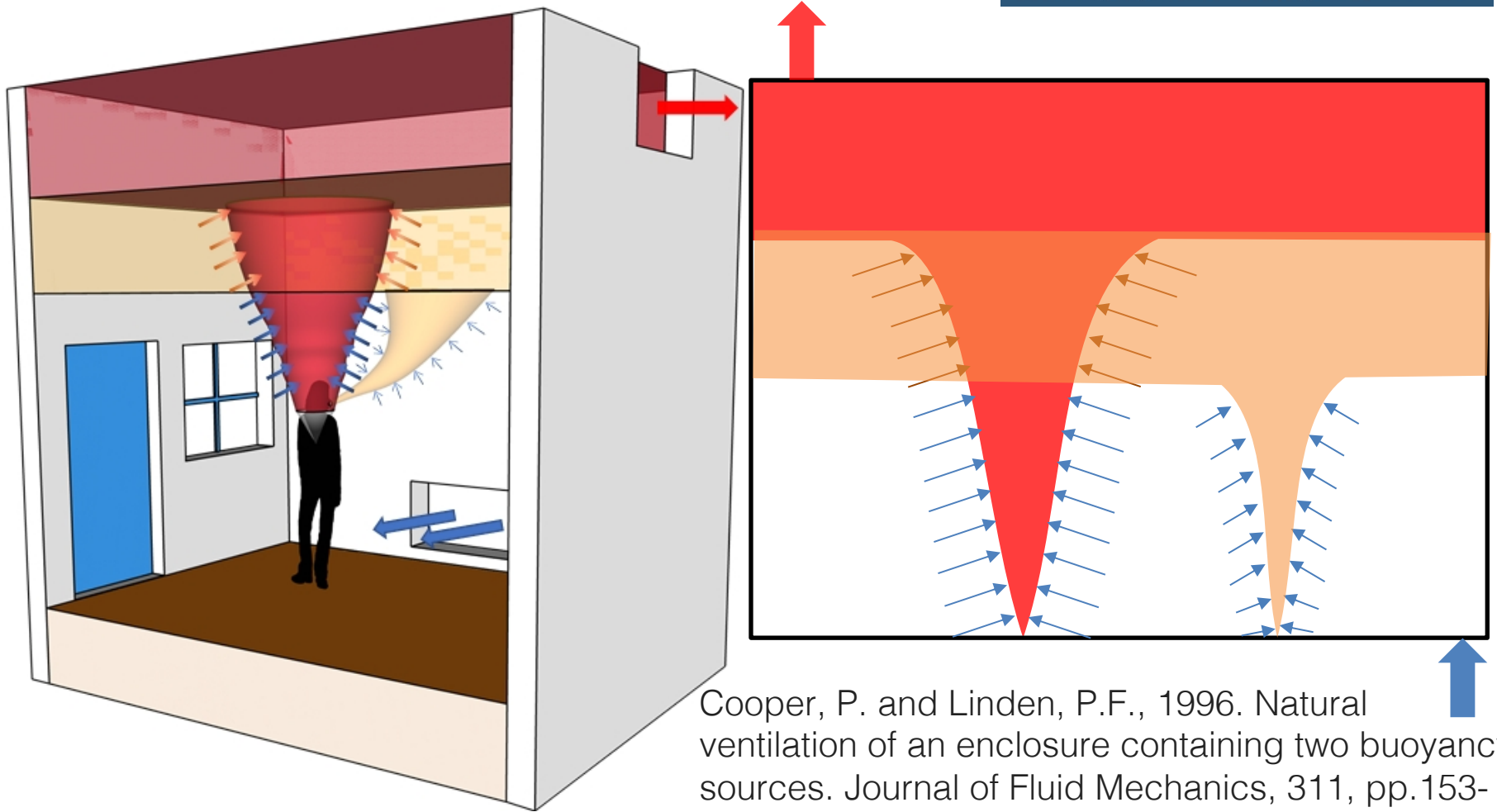
$$C(x) = C_s + BC_0 - \frac{BC_0 x_0}{x}$$



Indoor pollutant transport

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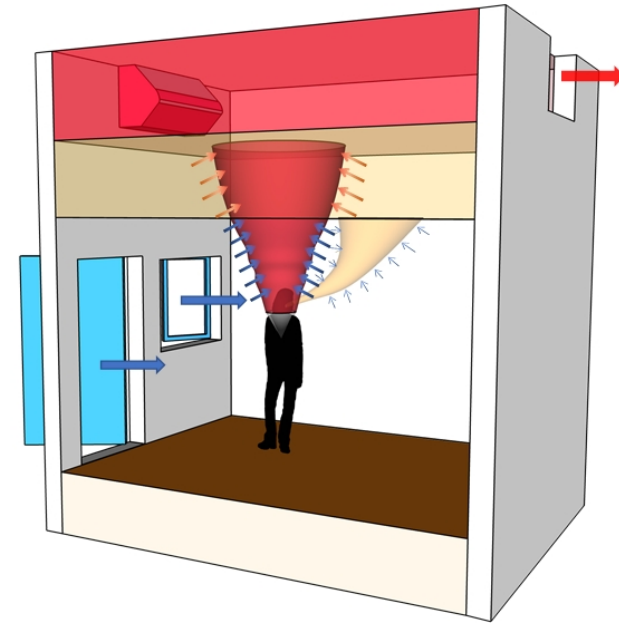
Cooper, P. and Linden, P.F., 1996. Natural ventilation of an enclosure containing two buoyancy sources. *Journal of Fluid Mechanics*, 311, pp.153-176.

Future work

- Water flume experiments on indoor transport of pollutants
- Indoor outdoor exchange - Single sided ventilation; wind direction
- Single sided ventilation; Heat vs wind
- Qualitative to quantitative measurement of full scale flow

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Agenda

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- Full scale flow visualisation
- Indoor transport of pollutants
- Ventilation in buses and trains
- Future studies