# Sensitivity Studies

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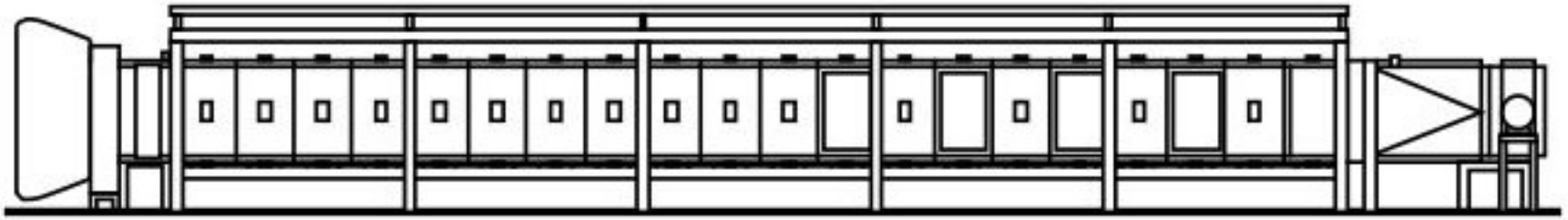
dapple

ENVIRONMENTAL FLOW RESEARCH CENTRE
NATIONAL POWER

# Wind tunnel simulations

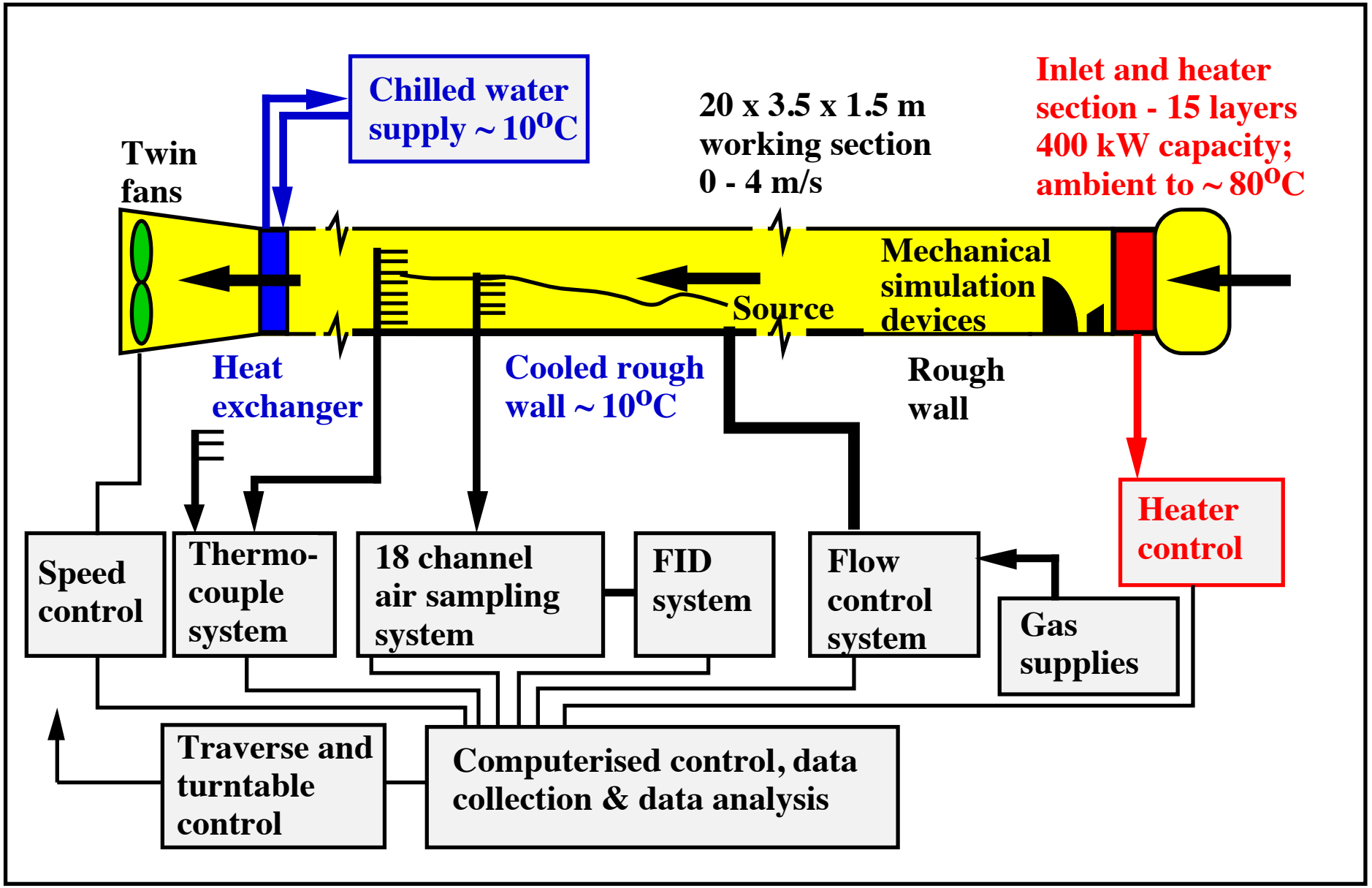


Alan Robins, Paul Hayden, Hong Cheng, Matteo Carpentieri, Sando Baldi, Paolo Giambini, Tom Lawton, James Hamilton, Alex Nicolson, Nadia Bahar, James Fabian, Khaled Bashiti, et al

Content:

- The EnFlo Wind tunnel
- Comparisons with field data
- Flow and dispersion characteristics
- Sensitivity studies
- Conclusions

# The EnFlo wind tunnel



# Wind speed ratios

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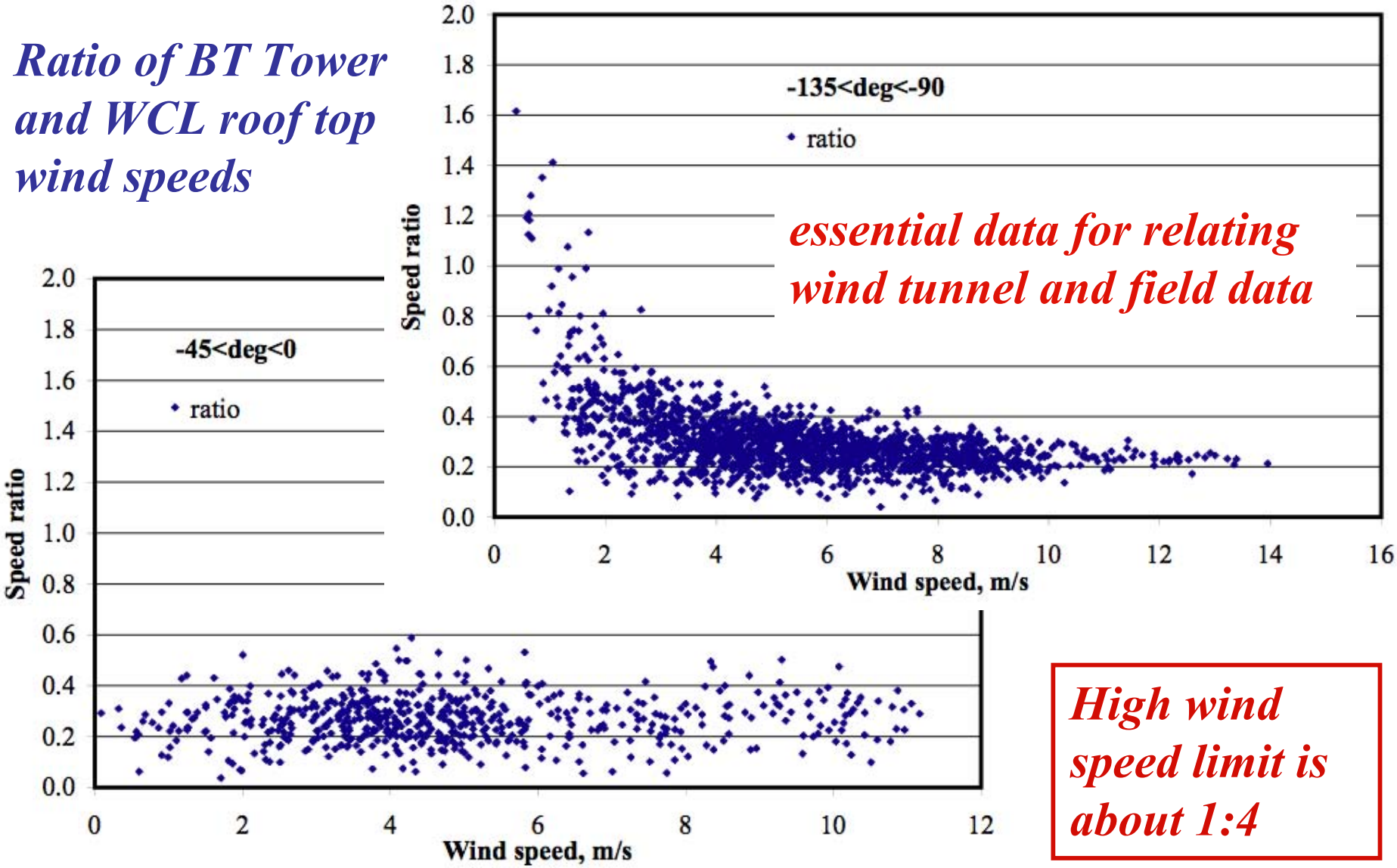
***Ratio of BT Tower and WCL roof top wind speeds***







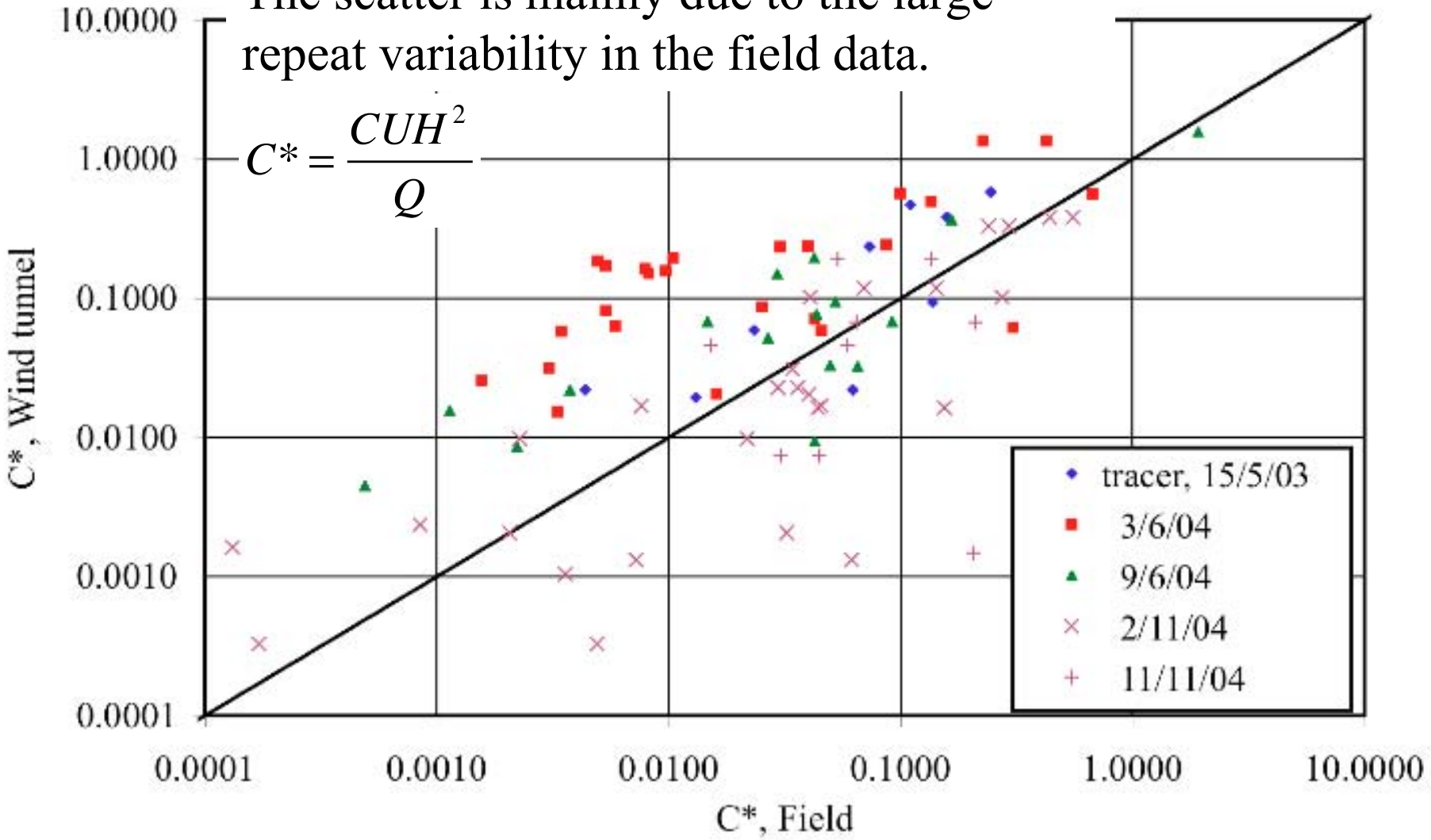
***essential data for relating wind tunnel and field data***

***High wind speed limit is about 1:4***

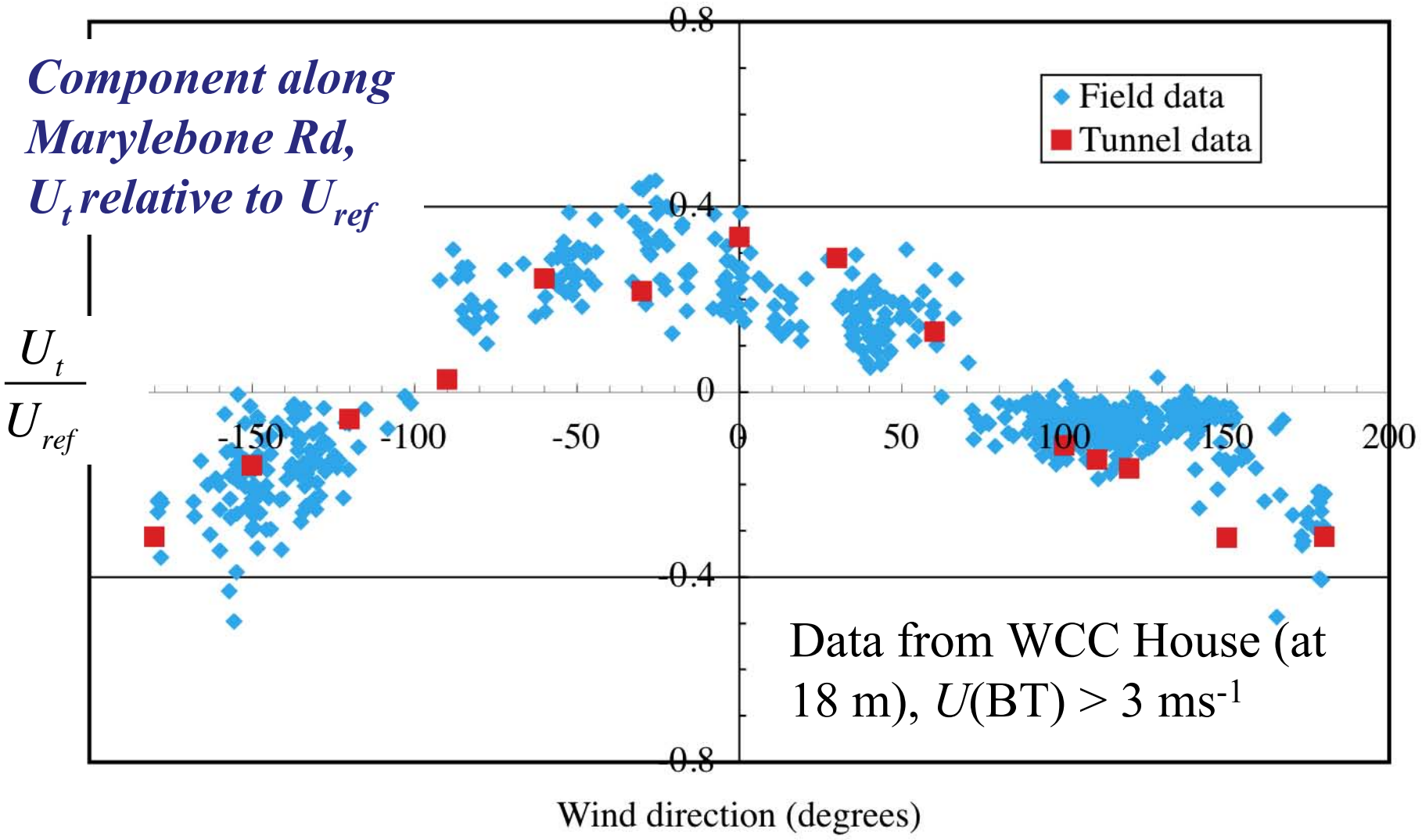
# Comparison of concentrations

The scatter is mainly due to the large repeat variability in the field data.

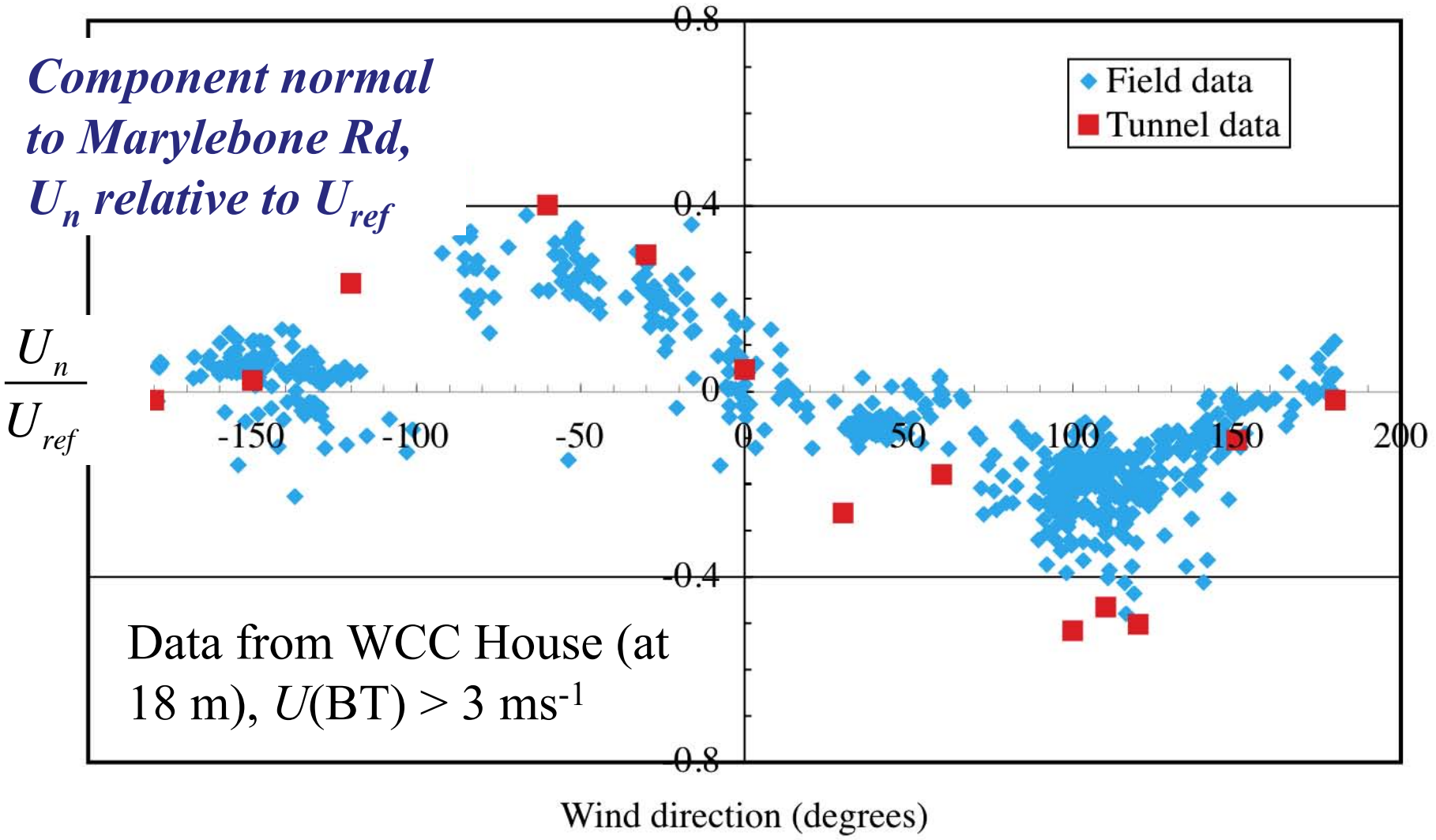
$$C^* = \frac{CUH^2}{Q}$$



# Comparison of flow fields

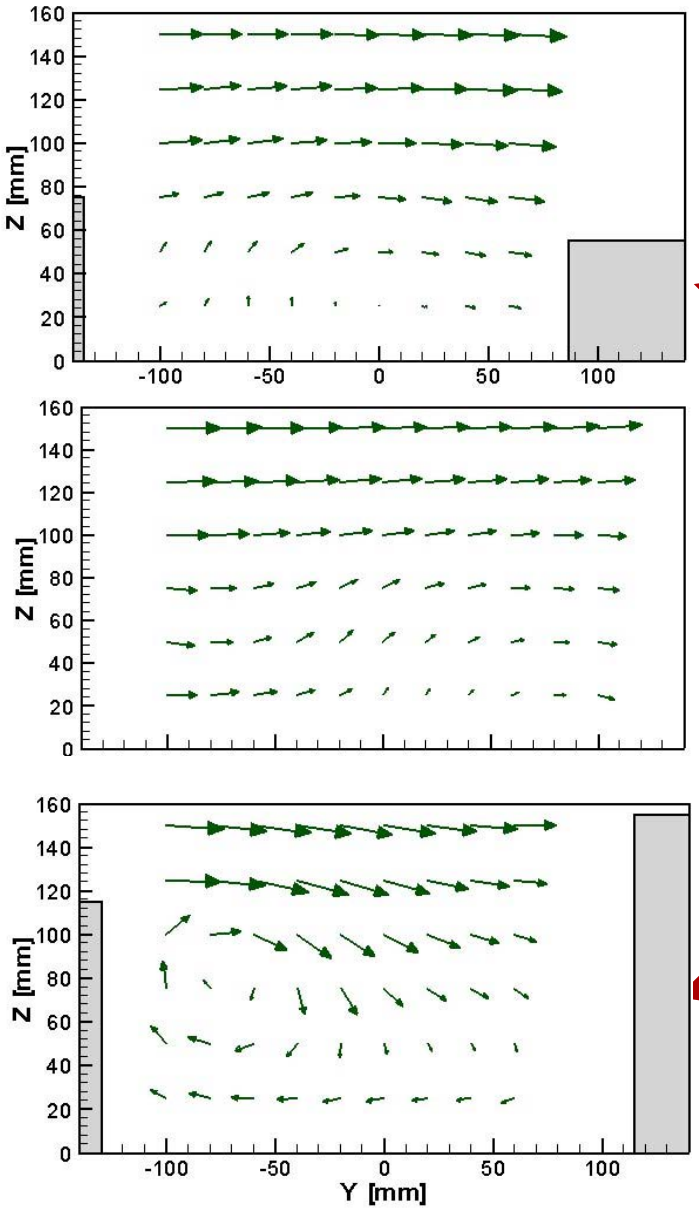


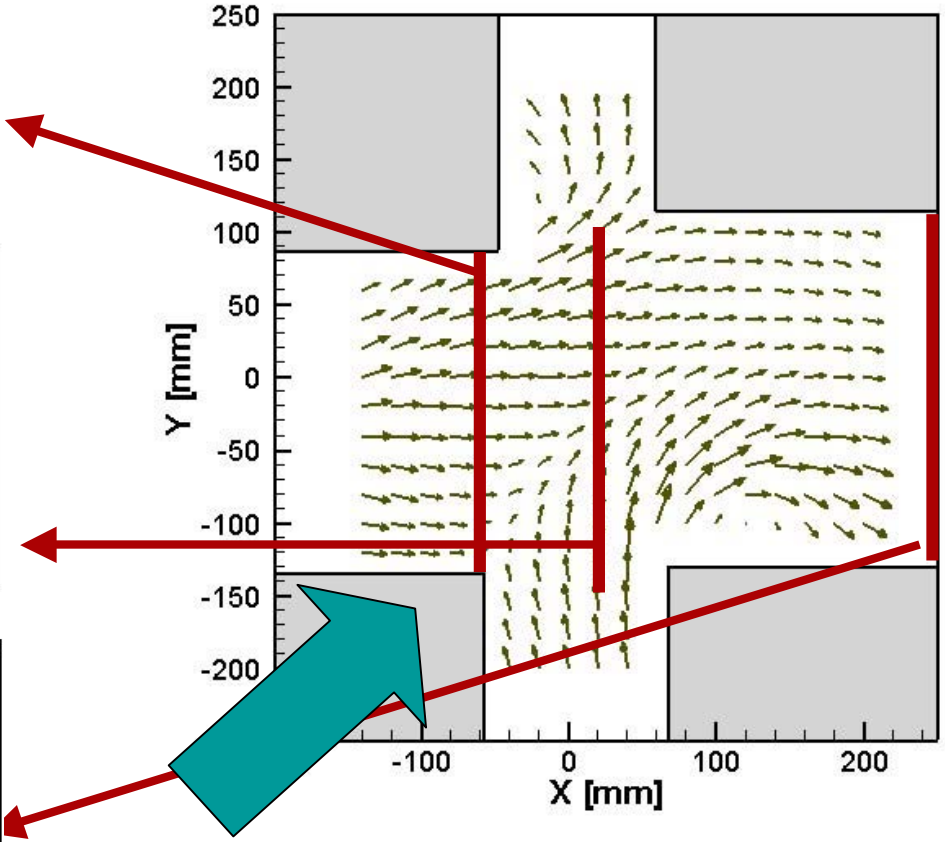
# Comparison of flow fields



# Flow structure at an intersection

Clarification of physical processes in support of field measurements



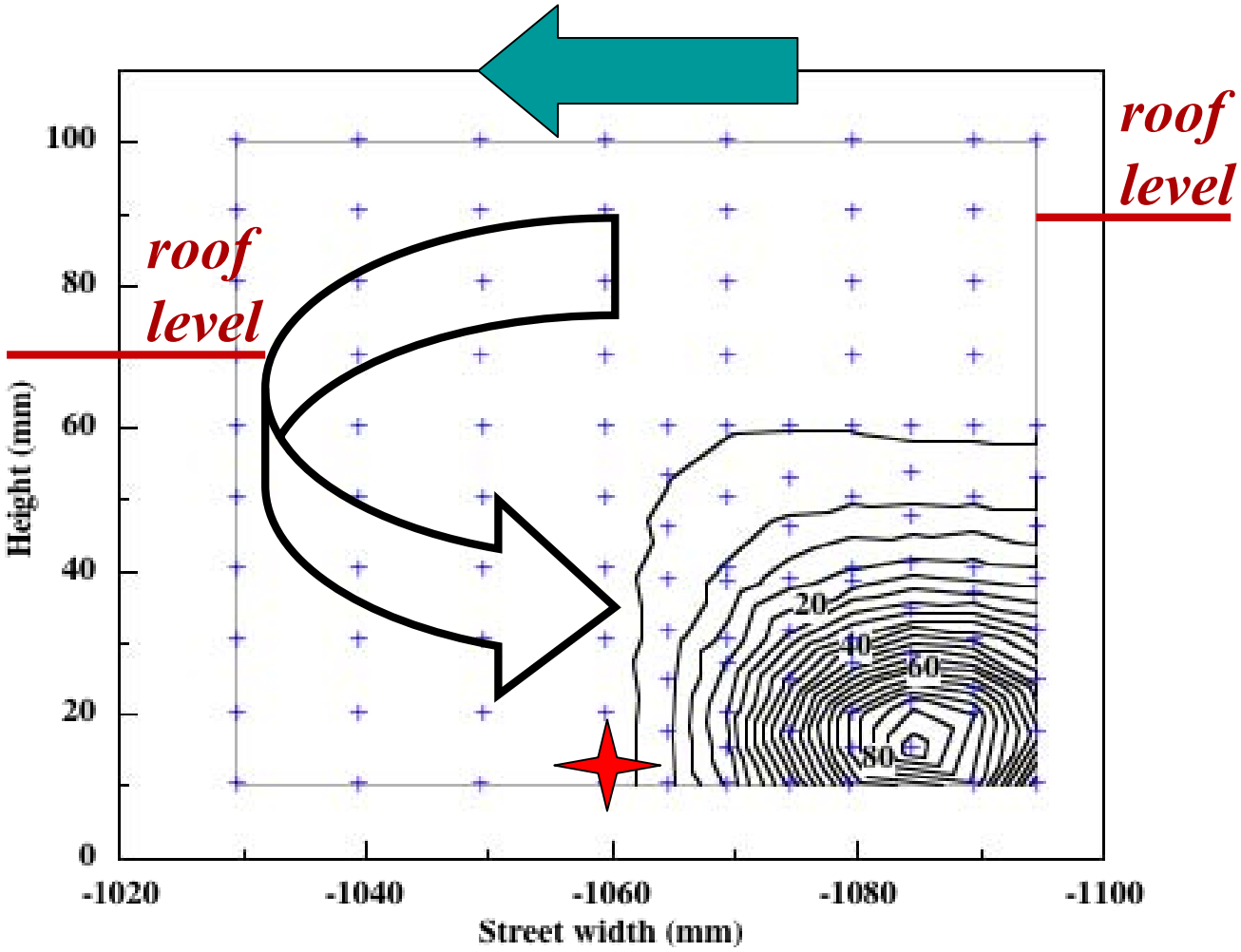

***Mean velocity vectors at height of 5 m - extract from full data set***

# Near-source concentrations in helical circulation

Wind at 45 degrees to street

$\Delta x \sim W$ at location of measurements

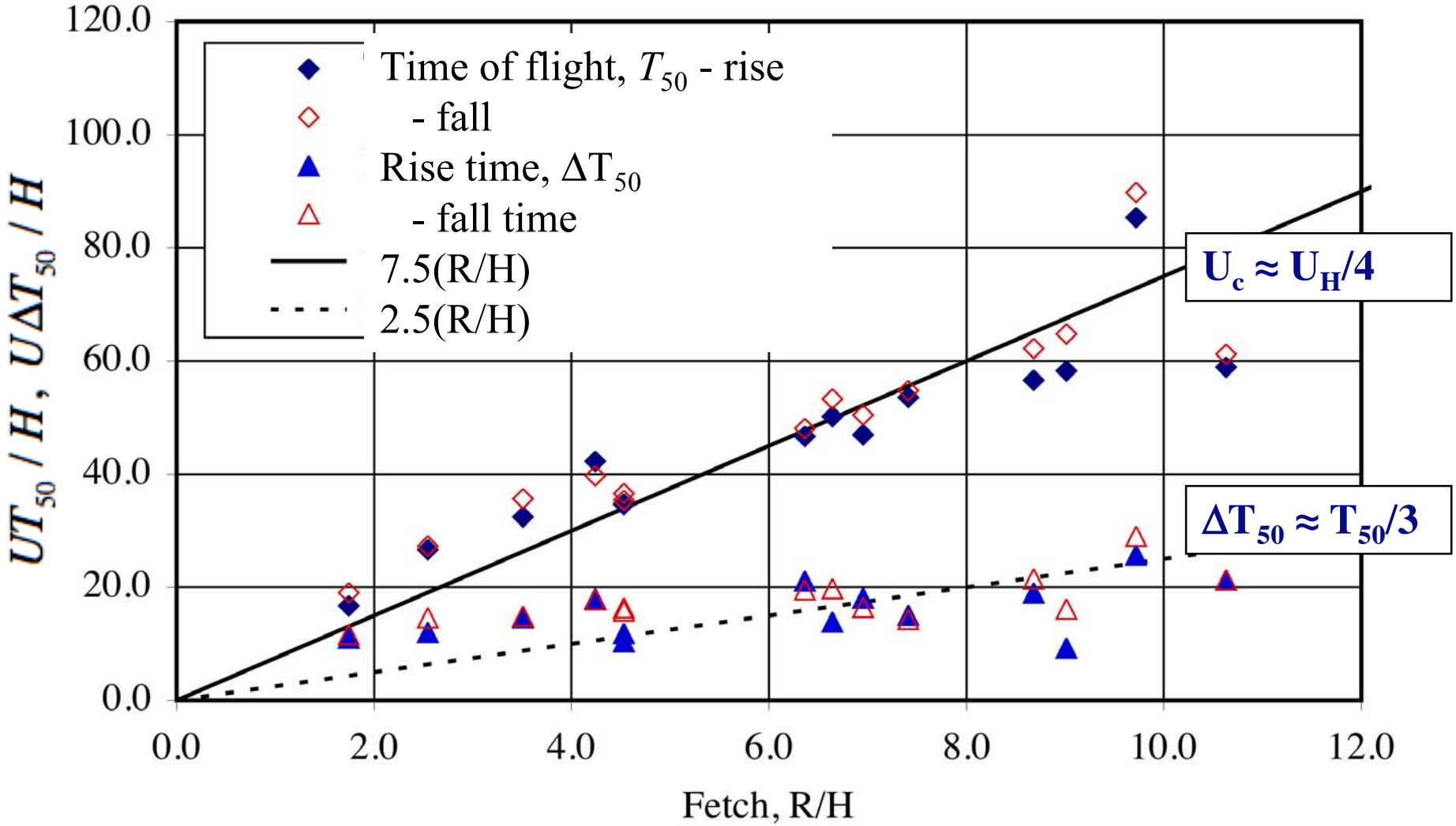
Emission released upstream at street centre - dispersion prior to uniform mixing across the street



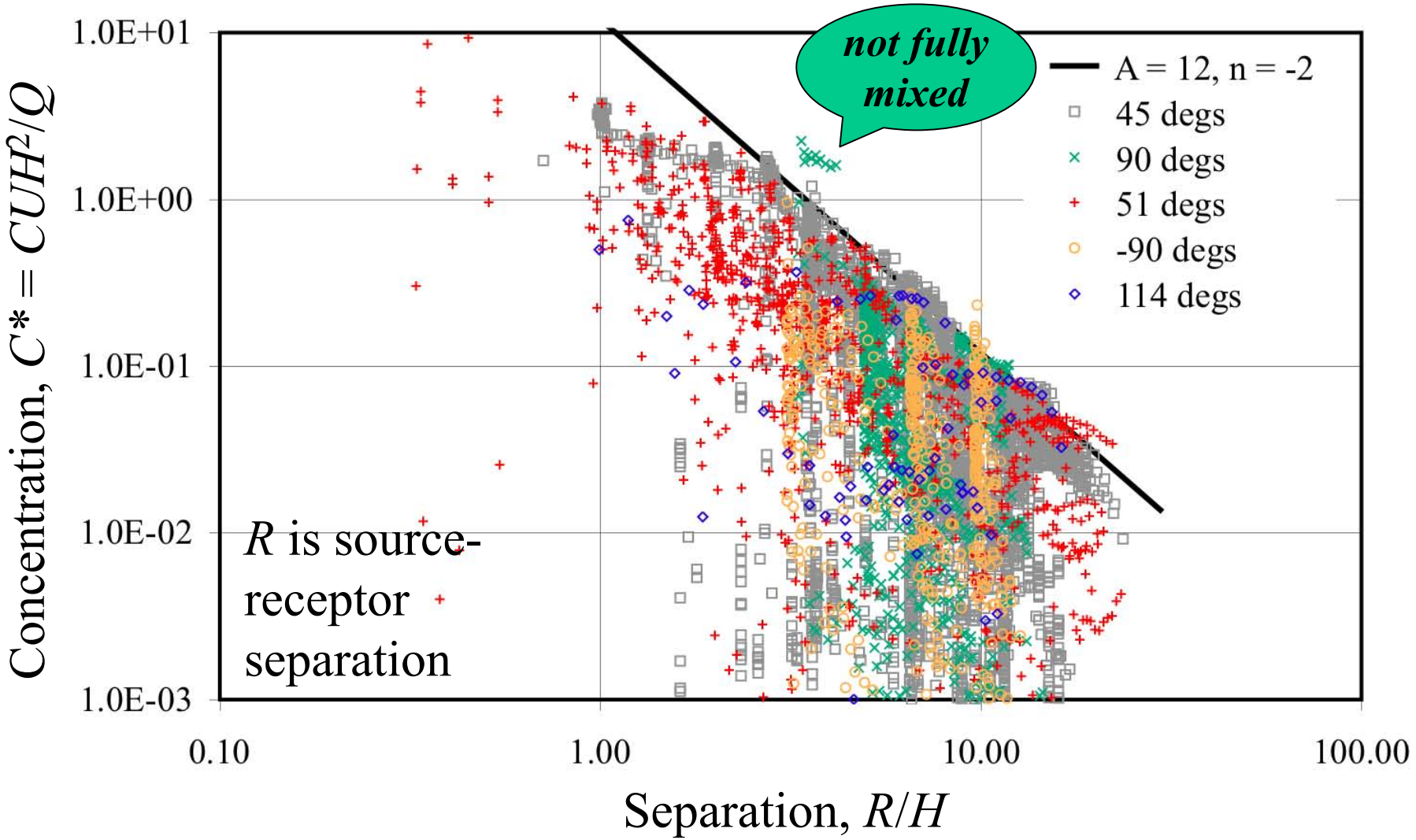

*Concentration contours in cross-section; H/W≈1.0*

# Short Duration Emissions

Characterisation of advection speed, $U_c$, and along wind mixing.

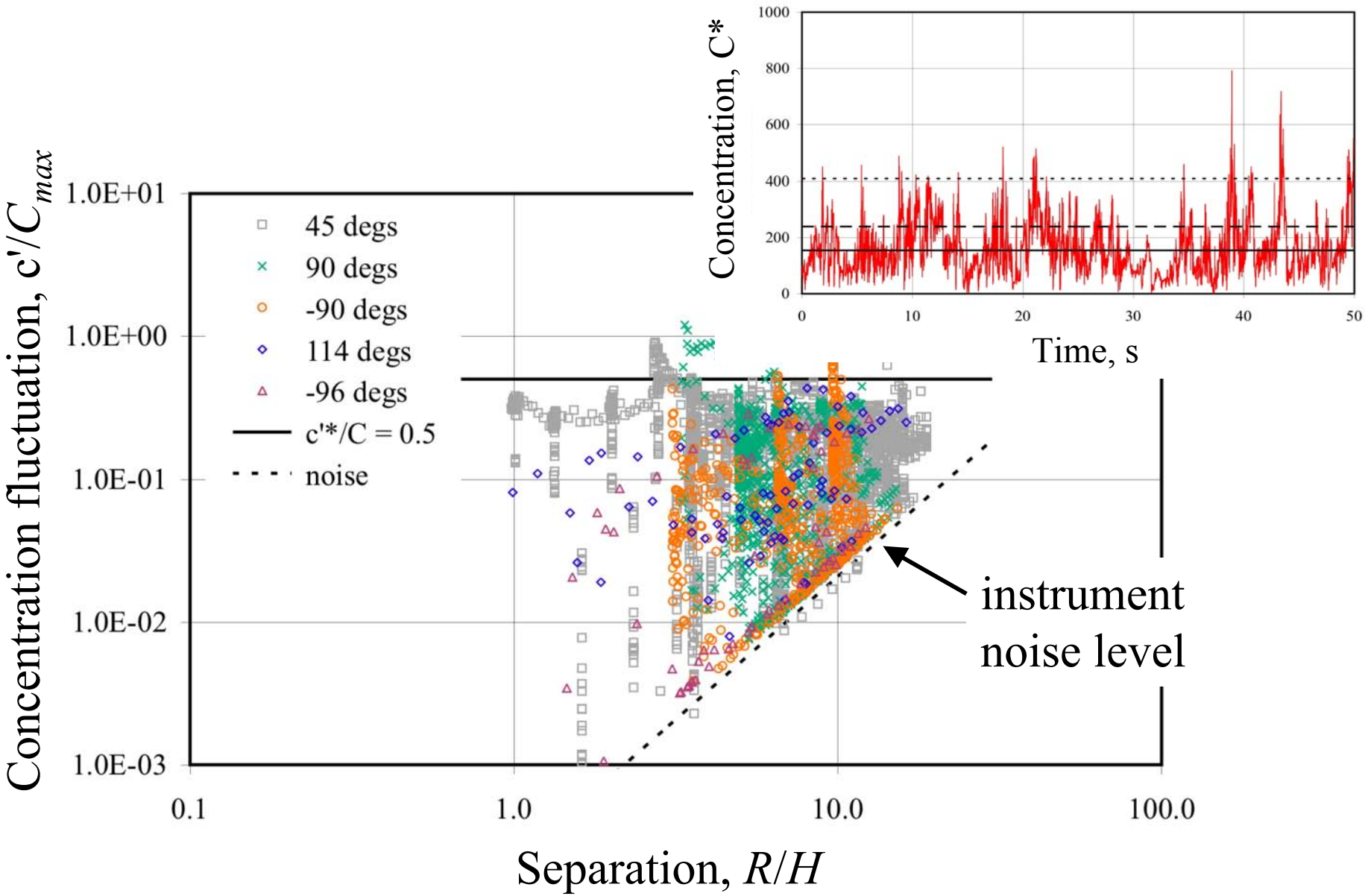


# Concentration decay

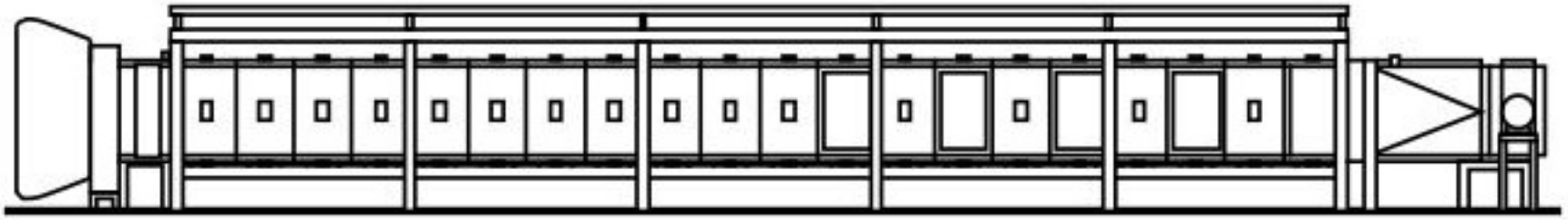



The basic mean concentration decay function, $CUH^2/Q = 12\ (R/H)^{-2}$

# Fluctuation levels



# Wind tunnel research



EnFlo 20x3.5x1.5 boundary layer wind tunnel

0 to 3.5 m/s; inlet flow heating; surface heating and cooling

***Sensitivity studies***

***examples***

# Basic sensitivity studies

***Dispersion repeat run to run variability better than ±10% - so take ± 20% as the target for singificant effects***

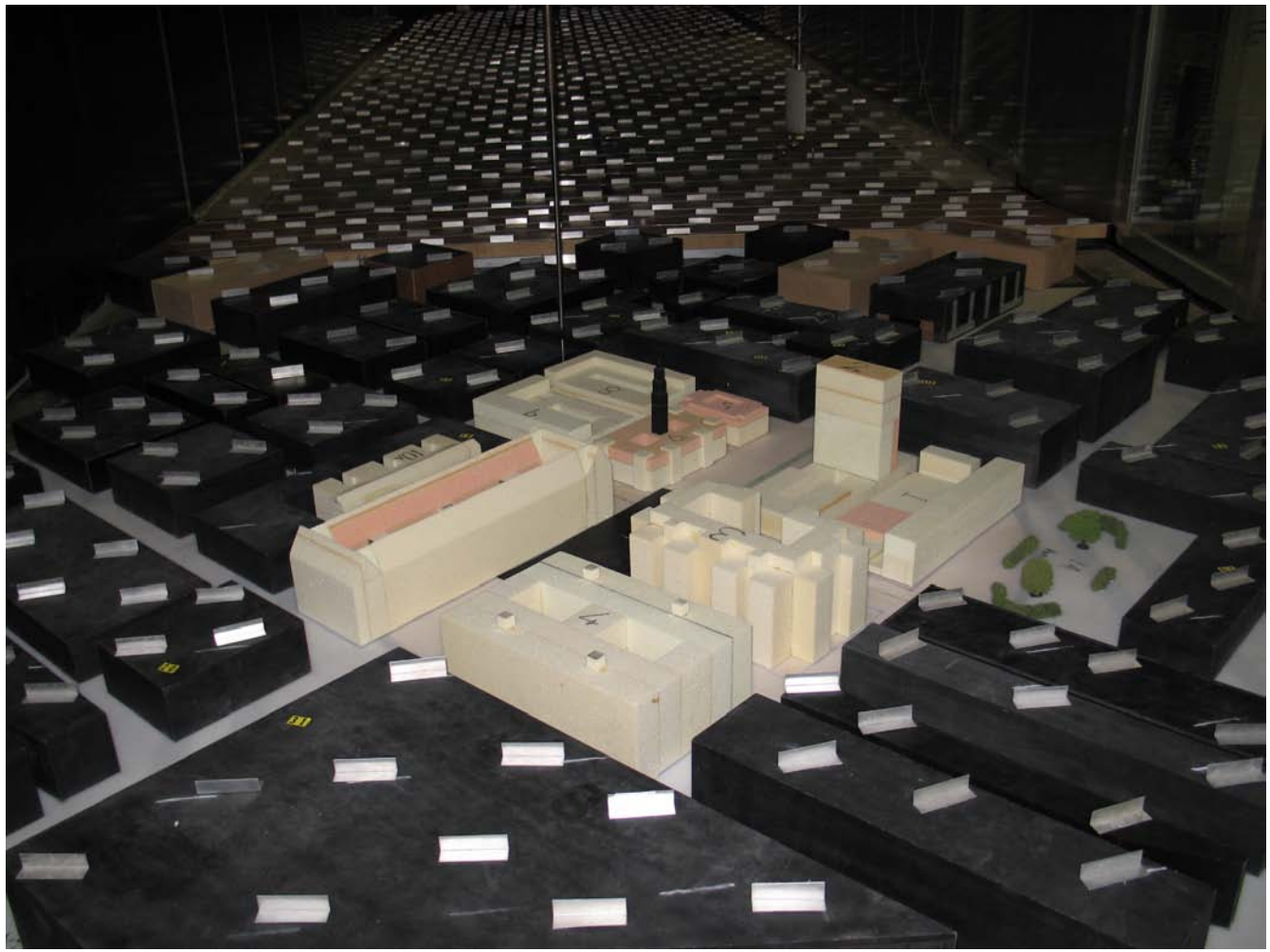
On this basis, results shown to be insensitive to:

- modest variations in upwind boundary layer conditions

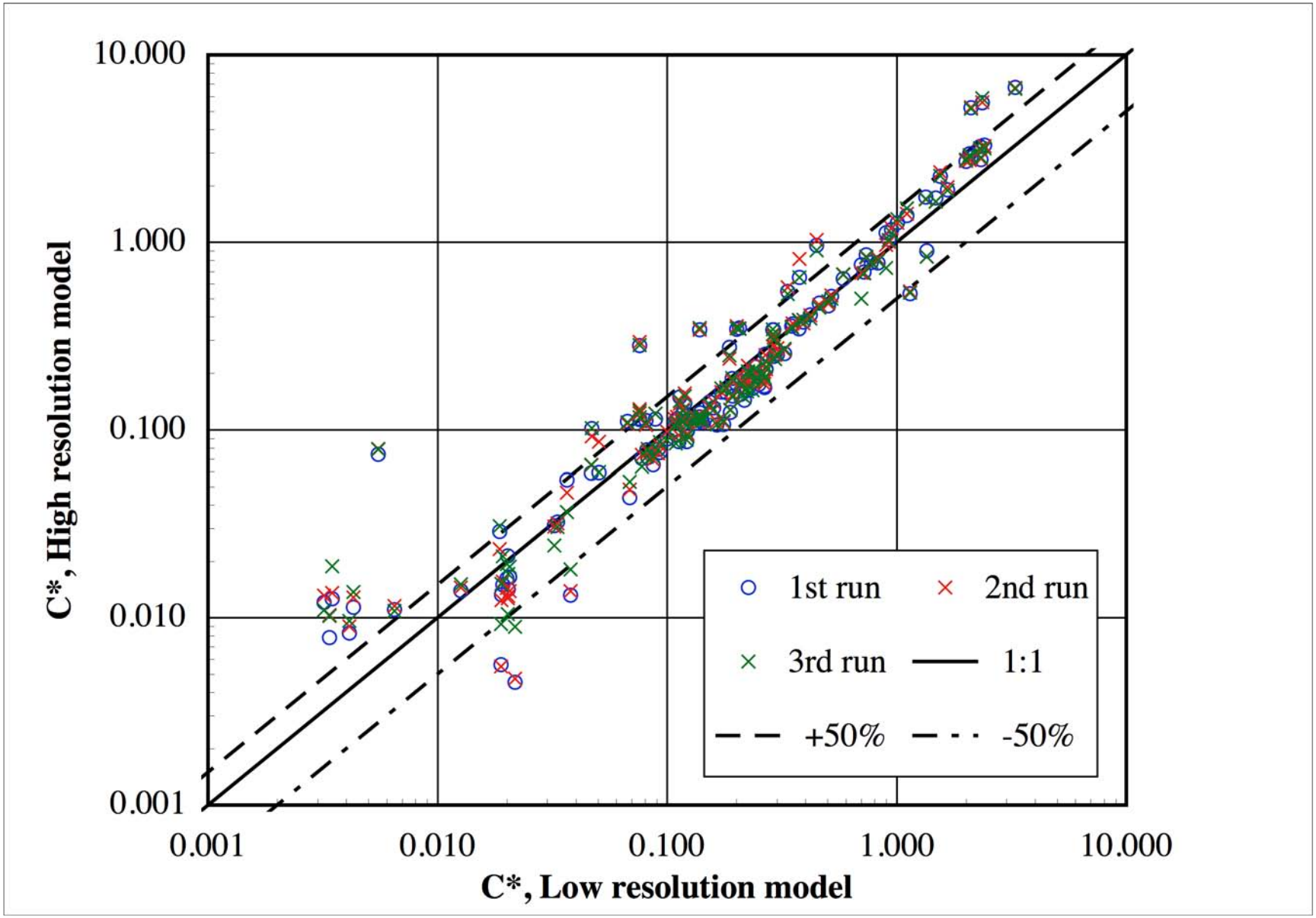
  including slightly stable approach flow ($L_{MO} \sim H_{bl} \sim$ 1 m)
- addition of roof roughness
- modification to zero-plane level at upwind edge of model
- source design and emission rate (speed ratio)
- Reynolds, $U(H)H/\nu$, number from about 2,000 to 14,000

# 1. Model detail

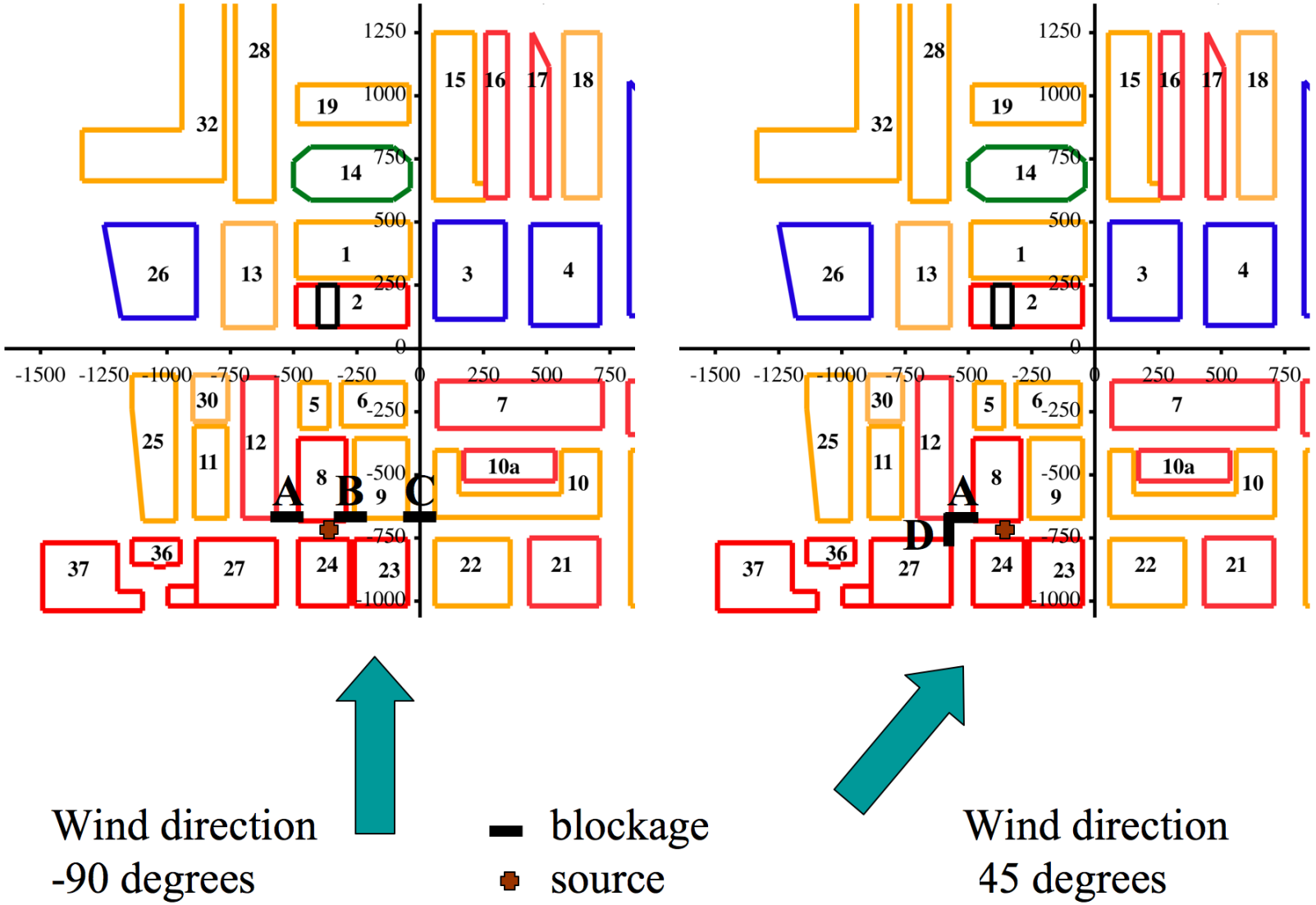
***Comparison of results from low and higher resolution models; significant differences confined to short ranges.***



# Model detail

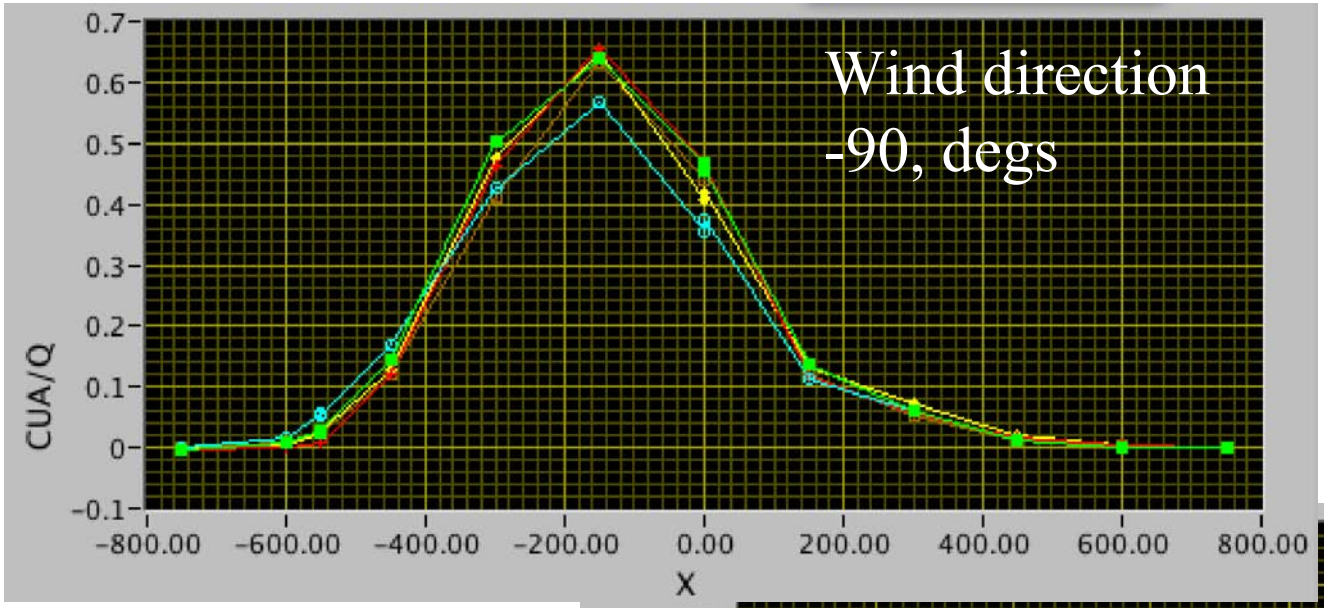


# 2. Street blockages - ineffective

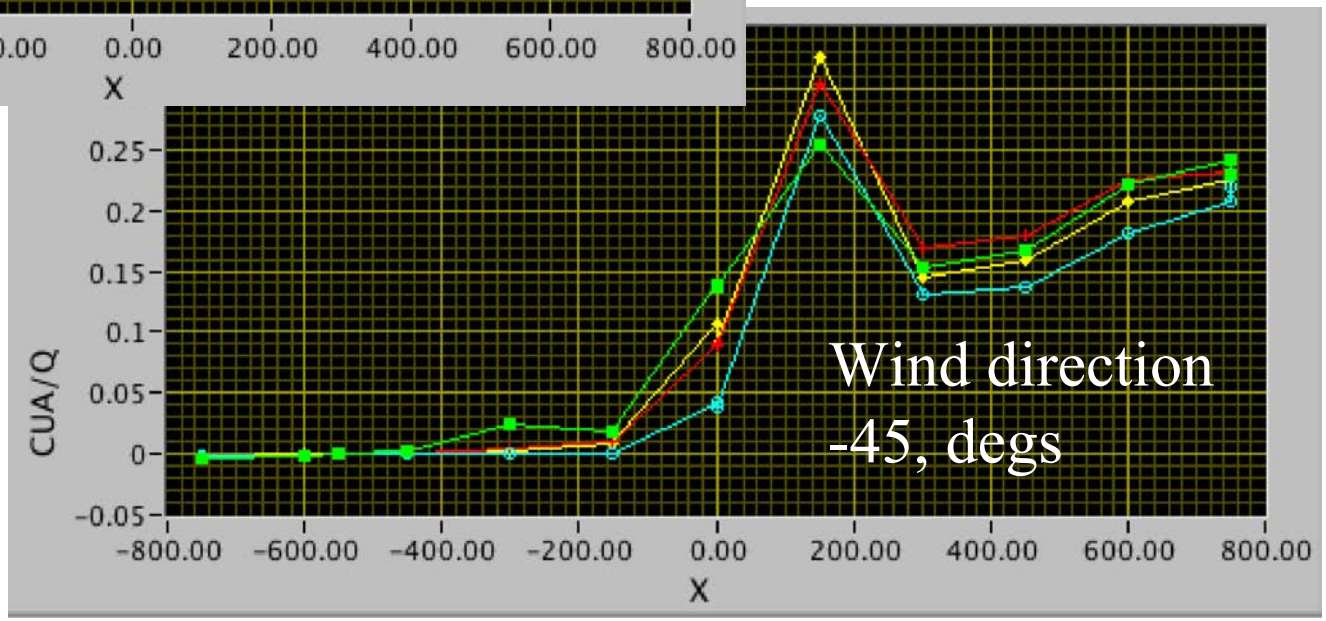


# Street blockage

Concentrations along Marylebone Road

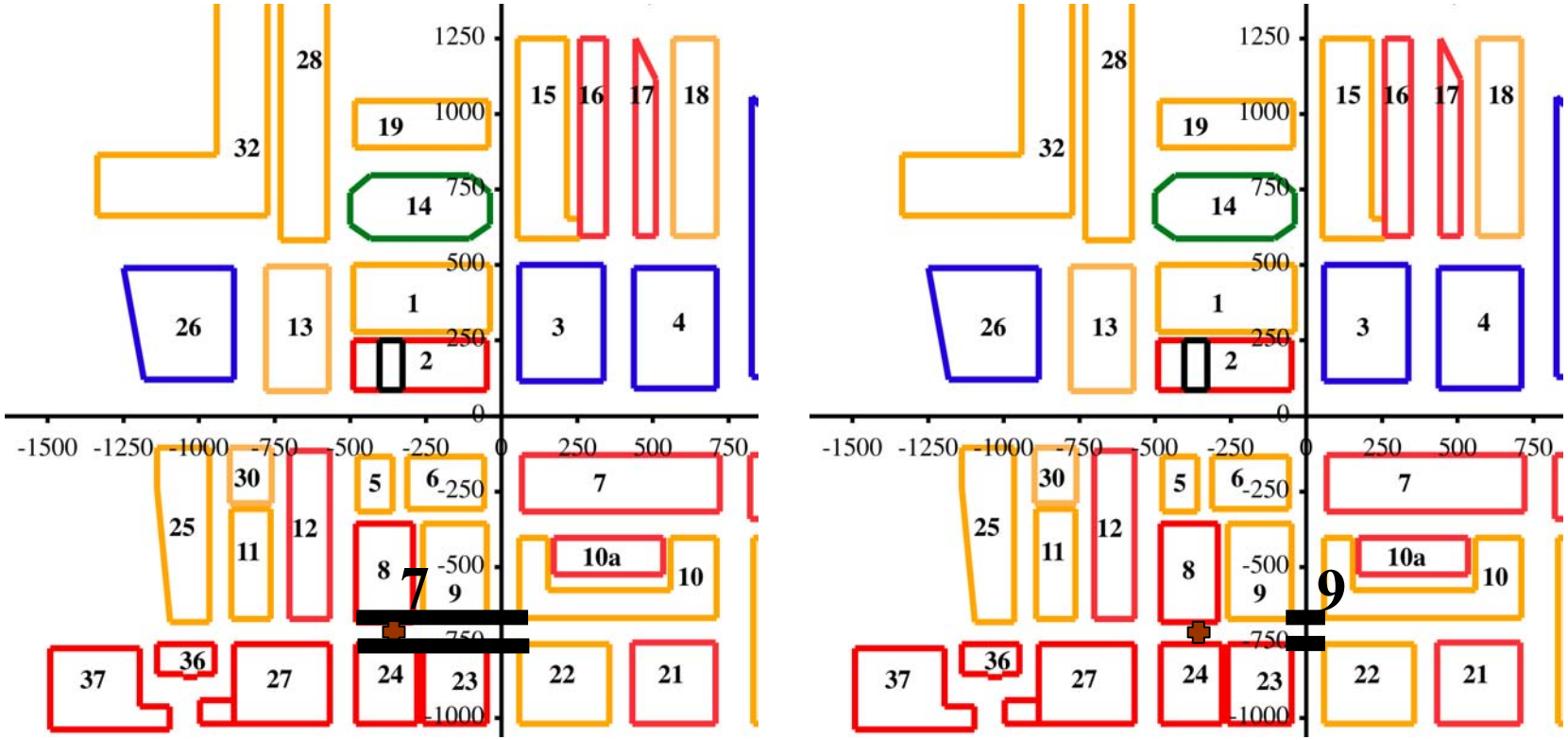



Reference; blockage at A, B or C; blockage at A, B & C.




Green, reference; blue, blockage at A; red, at D; yellow at A & D.

# 3. Street blockage - effective




blockage

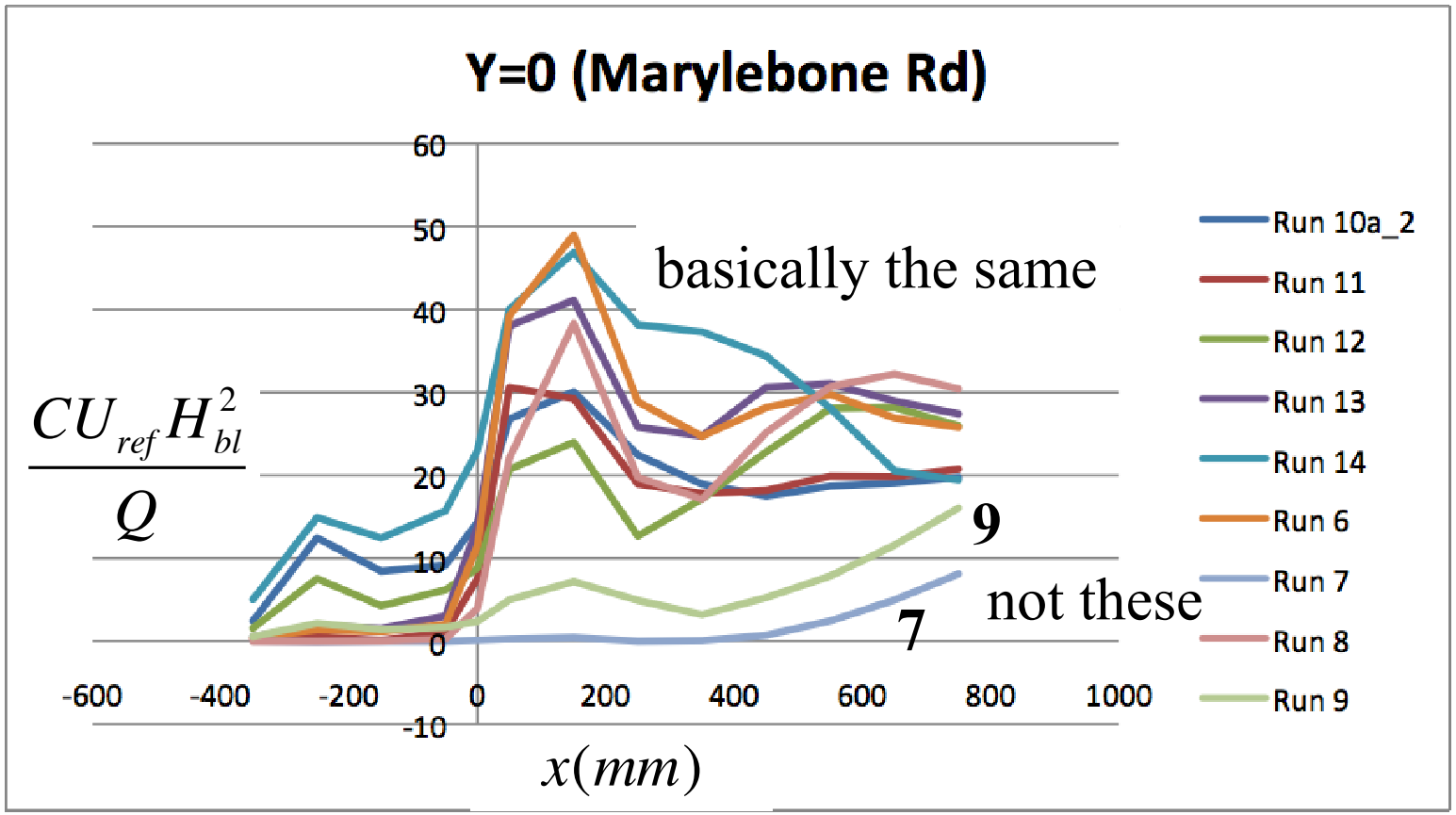
source

Wind direction
45 degrees

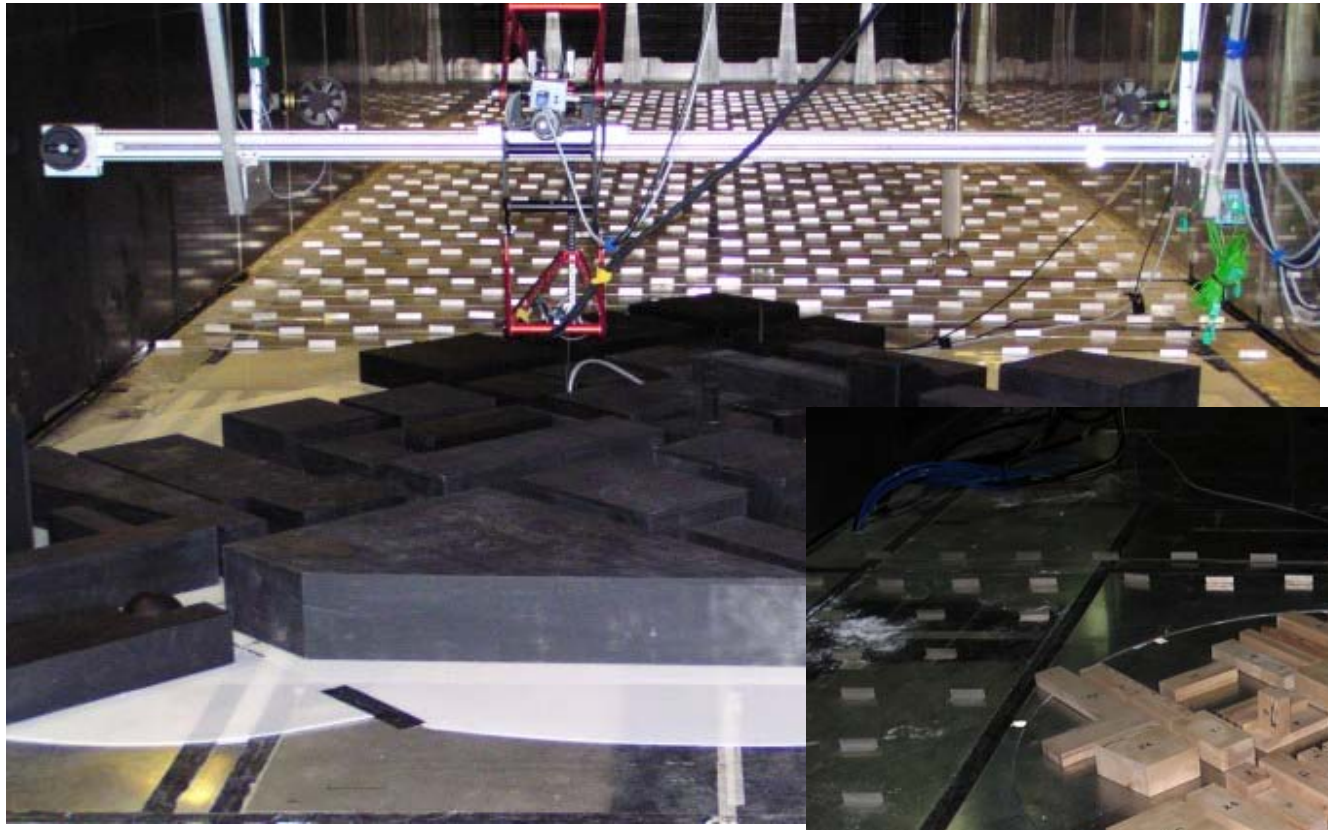
# Blockage

Run 7, York St a canyon from west of Upper Montagu Street to east of Gloucester Place

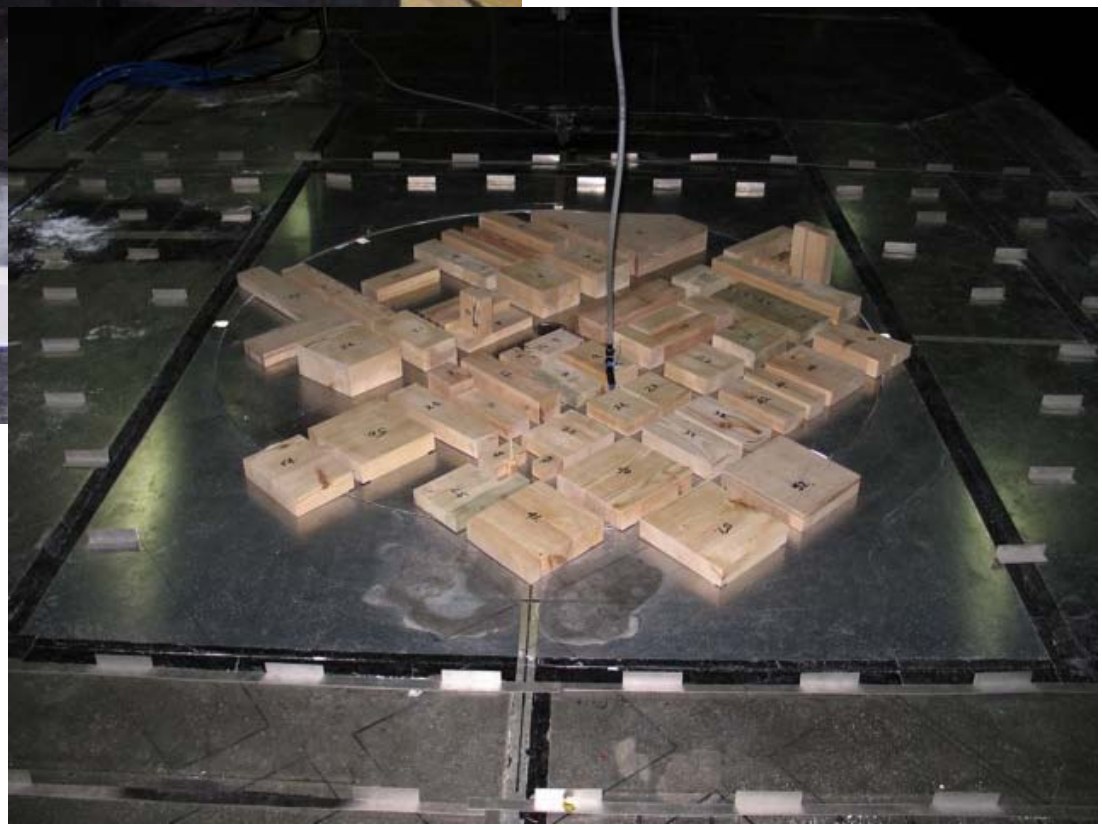
Run 9, Gloucester Place closed at York Street



# 4. Scale effects



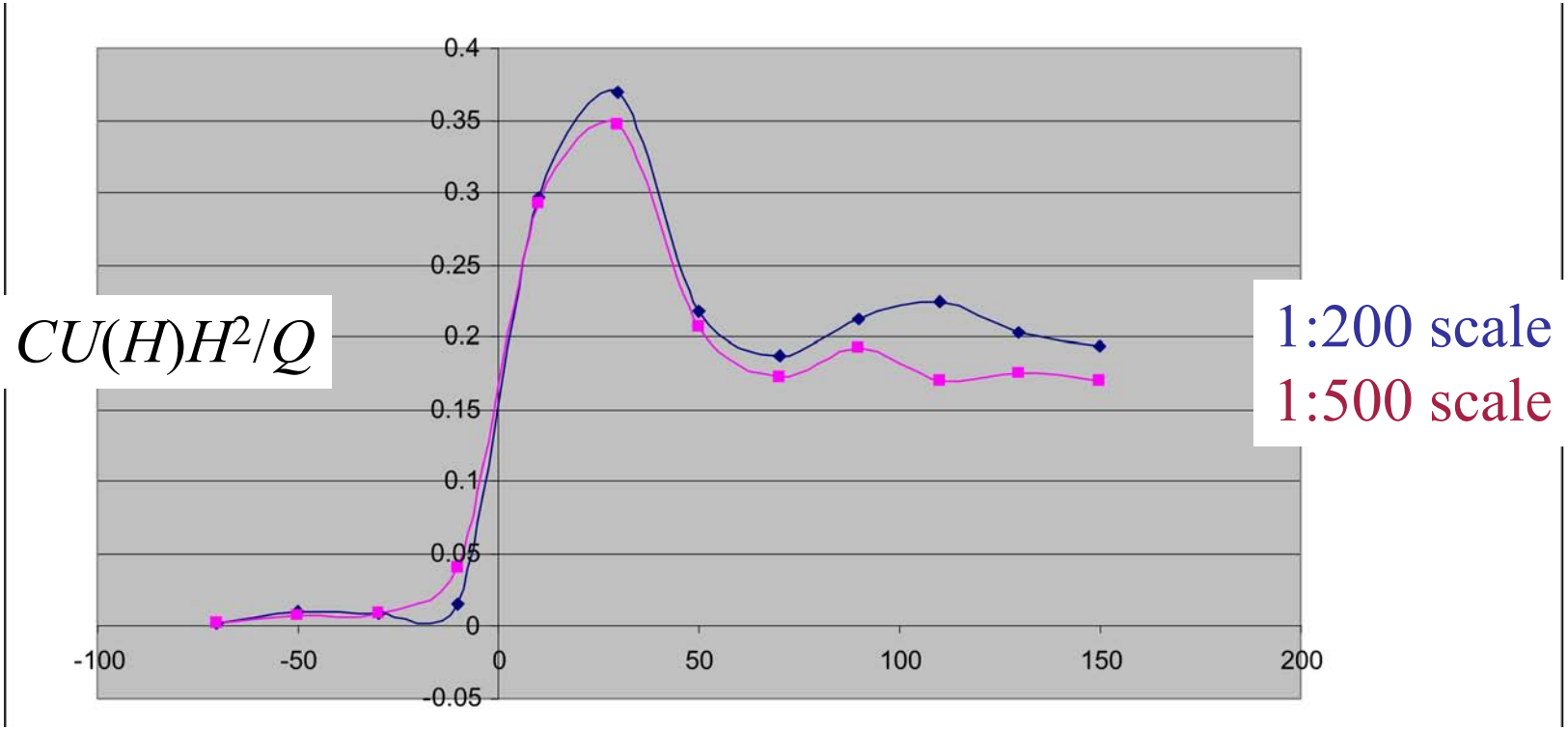
1:200 scale model



1:500 scale model

# Scale effects

$CU(H)H^2/Q$ along Marylebone Road, source York Street



# 5. Slightly unstable approach flow

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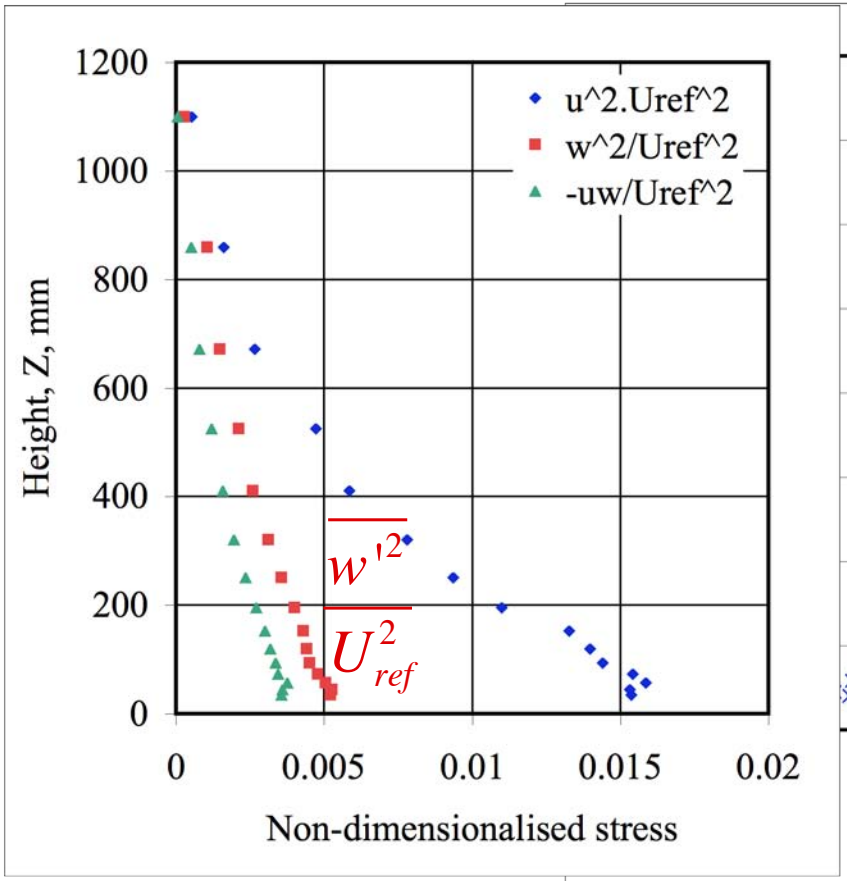
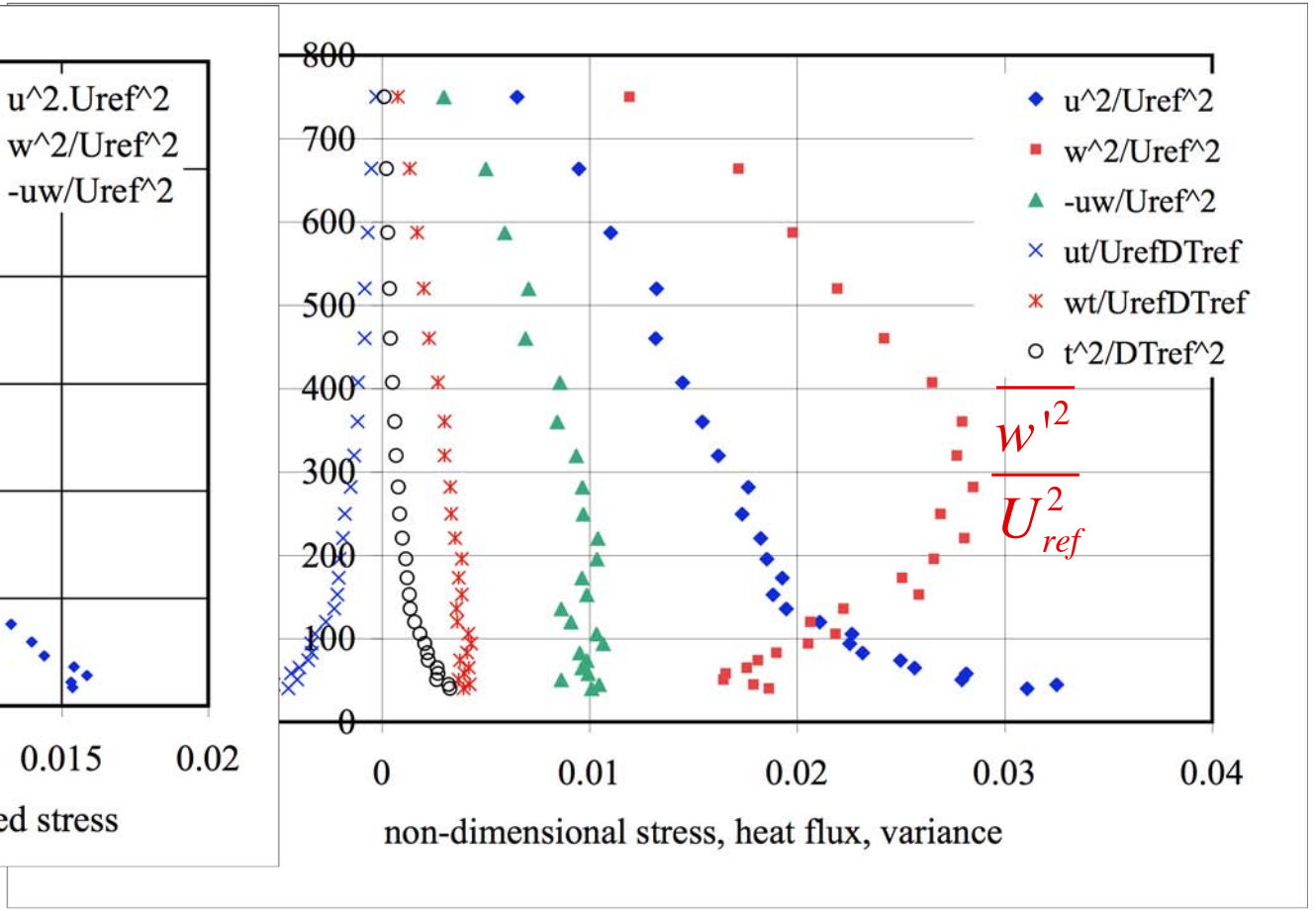
Neutral

$u^*/U_{ref} = 0.06$




Unstable

$H_{bl}/L_{MO} \sim -2.7, \quad u^*/U_{ref} = 0.10$

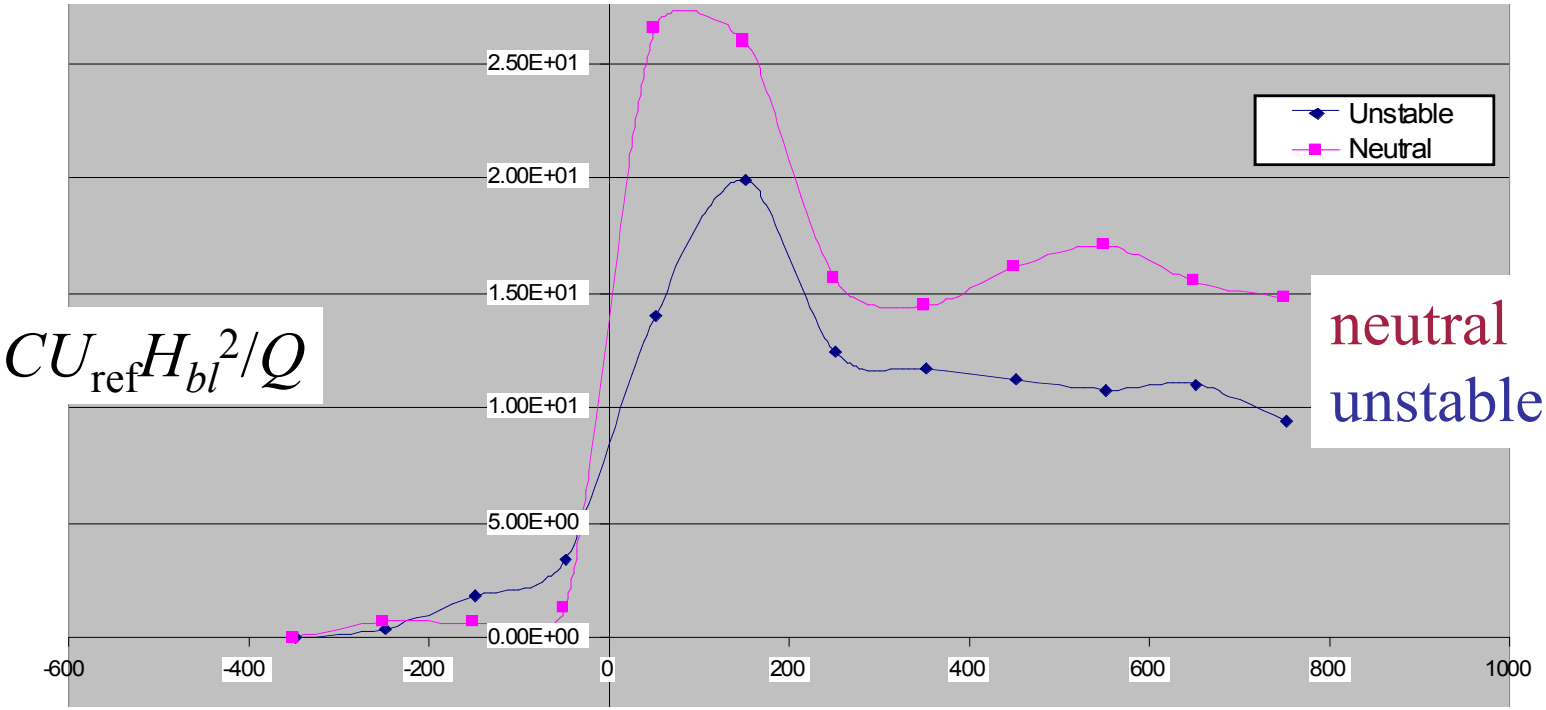


# Slightly unstable approach flow

$H_{bl}/L_{MO} = -2.7$

Marlylebone Rd

$CU_{ref}H_{bl}^2/Q$ along Marylebone Road, source York Street




Distance from intersection, mm

# Sensitivity studies

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- $C^* = CU_H H^2/Q$ independent of $Re$ ($U$) and $Q$ over range examined
- $C^*$ independent of model scale 1:200 to 1:500
- $C^*$ repeatability (multi-user) better than ±10%
- Effect of shallow boundary layer on $C^*(x,y,0) \sim$ -25% (not shown)
- Effect of model detail on $C^* \leq$ +30%
- Effect of upwind detail on $C^* <$ ±25%
- Effect of slightly unstable approach flow on $C^* \sim$ - 30%
- … but $C^* \sim 12(R/H)^{-2}$ robust