

# SMOKE AEROSOL PROPERTIES

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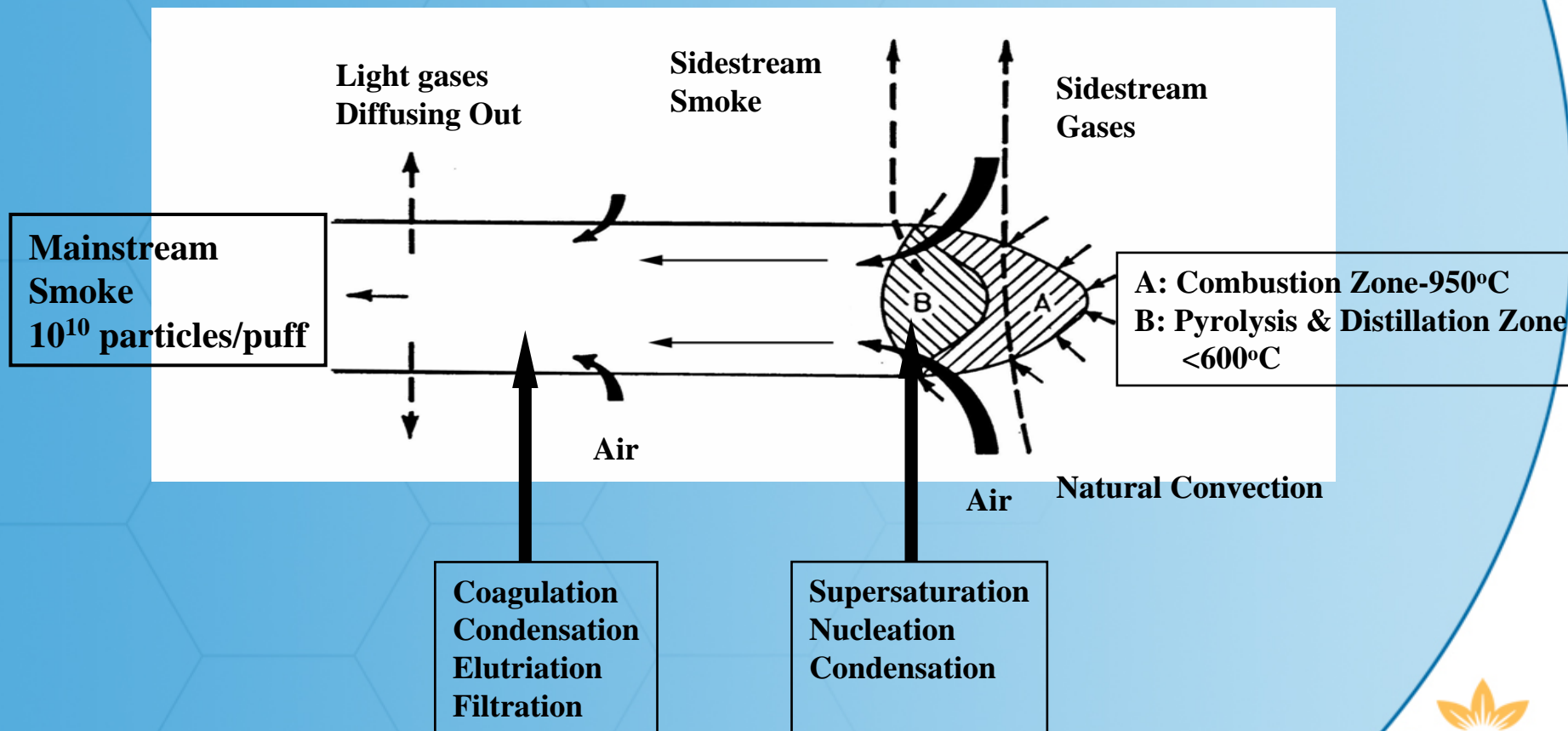
Jon Sheppard and Paul Case

British American Tobacco

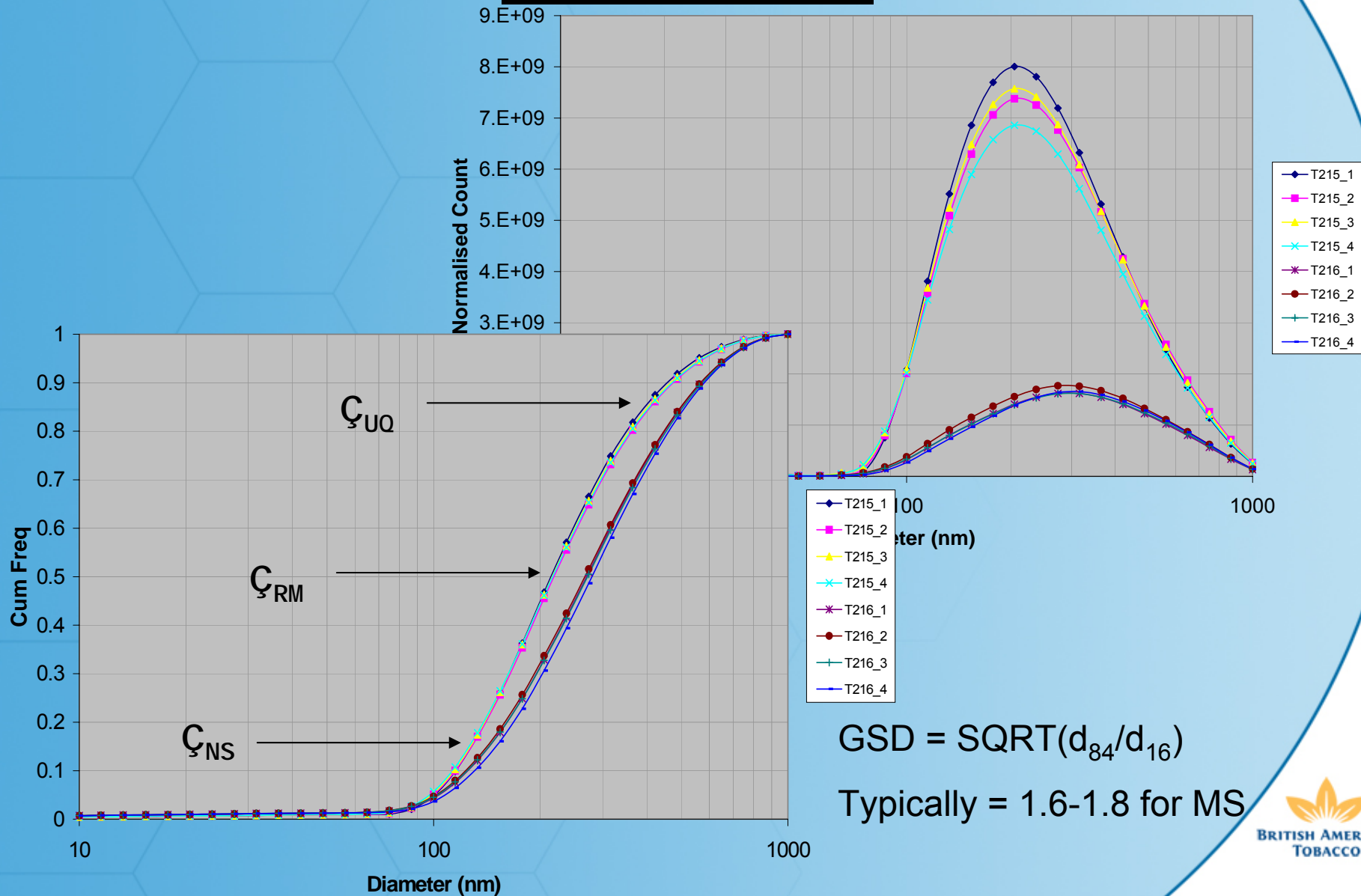
# Study Objectives

- Tobacco smoke diameters 180 – 860 nm in literature (e.g. Ingebrethsen (1986), McRae (1990), Bernstein(2005))
- Improve time-resolved measurement of mainstream tobacco smoke particles – by puff ?
- Address existing measurement issues
  - Light scattering intensity  $\propto d^{-6}$  and  $d \ll \lambda_{\text{vis}}$
  - Condensation & evaporation effects
  - Coagulation effects
- Validated by measurement of cigarette design matrix for filter ventilation, filter pressure drop and paper permeability

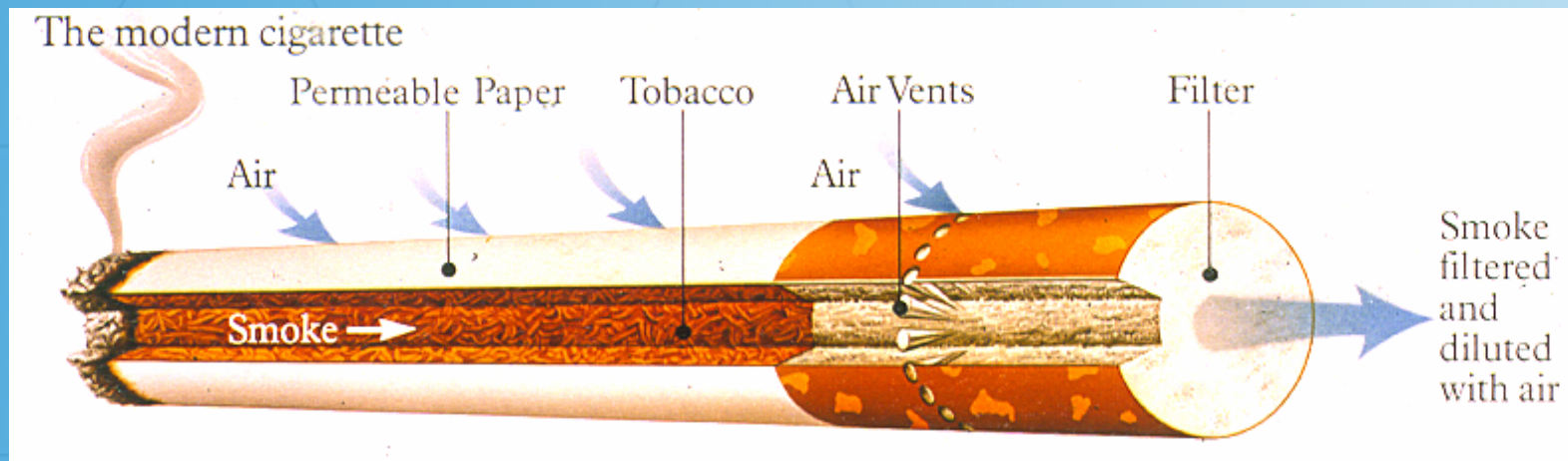
# Thermal and Physical Processes Inside a Burning Cigarette



# Definitions



# Cigarette Design Parameters



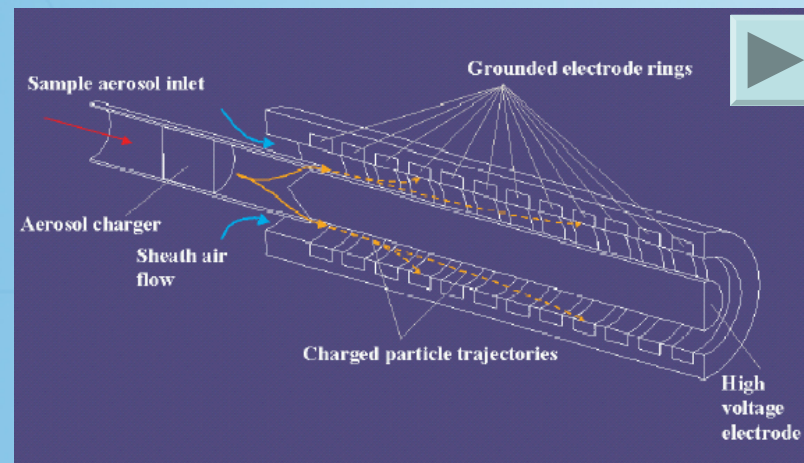
- Filter Ventilation ▲, smoke yields ▼
- Paper Permeability ▲, smoke yields ▼  
(but small magnitude effect)
- Filter Pressure Drop ▲, smoke yields ▼



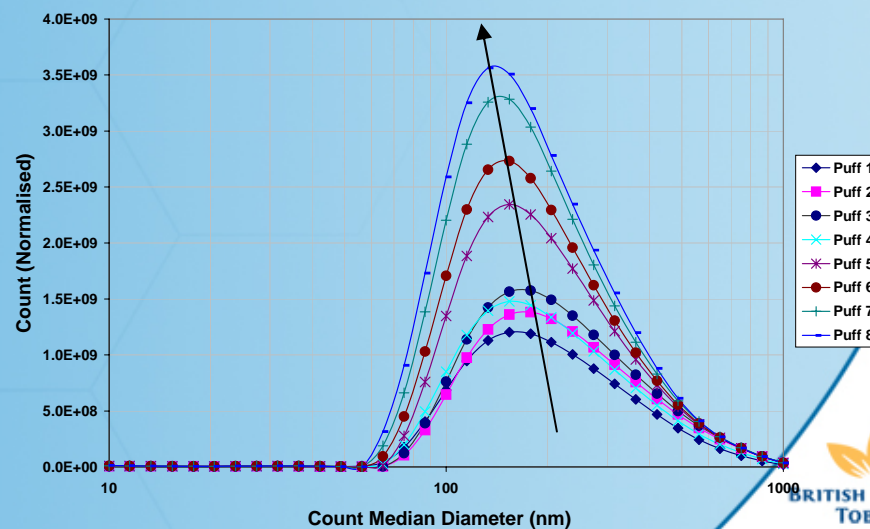
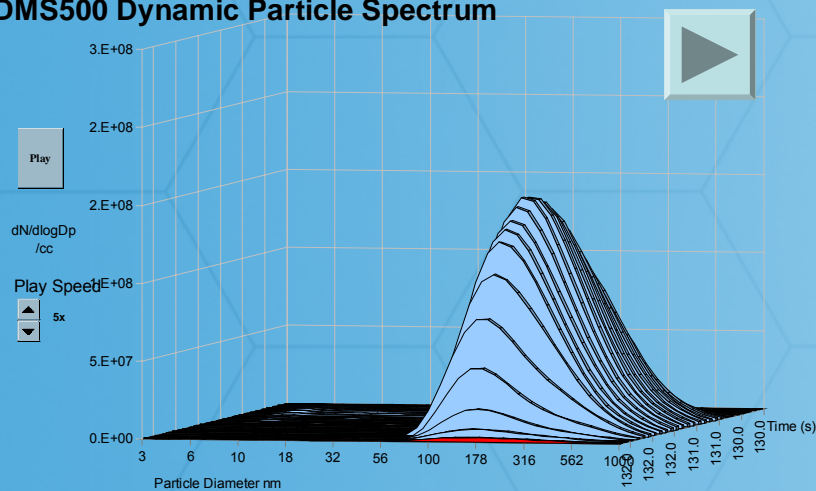
# Measurement Campaign

- Cigarette
  - 24.6 mm circumference
  - 84 mm rod
  - 27 mm filter
  - Lamina (Virginia, Burley, 1:1, Oriental)
- Smoking
  - 35 ml puff
  - 2 s duration
  - 60 s interval
  - 8 puffs
  - 4 replicates
- Dilution
  - 50:1 Dilution ratio
- Measurement
  - diameter by Cambustion DMS-500
  - number concentration by TSI Model 3022 CPC
  - calibration with PSL standards

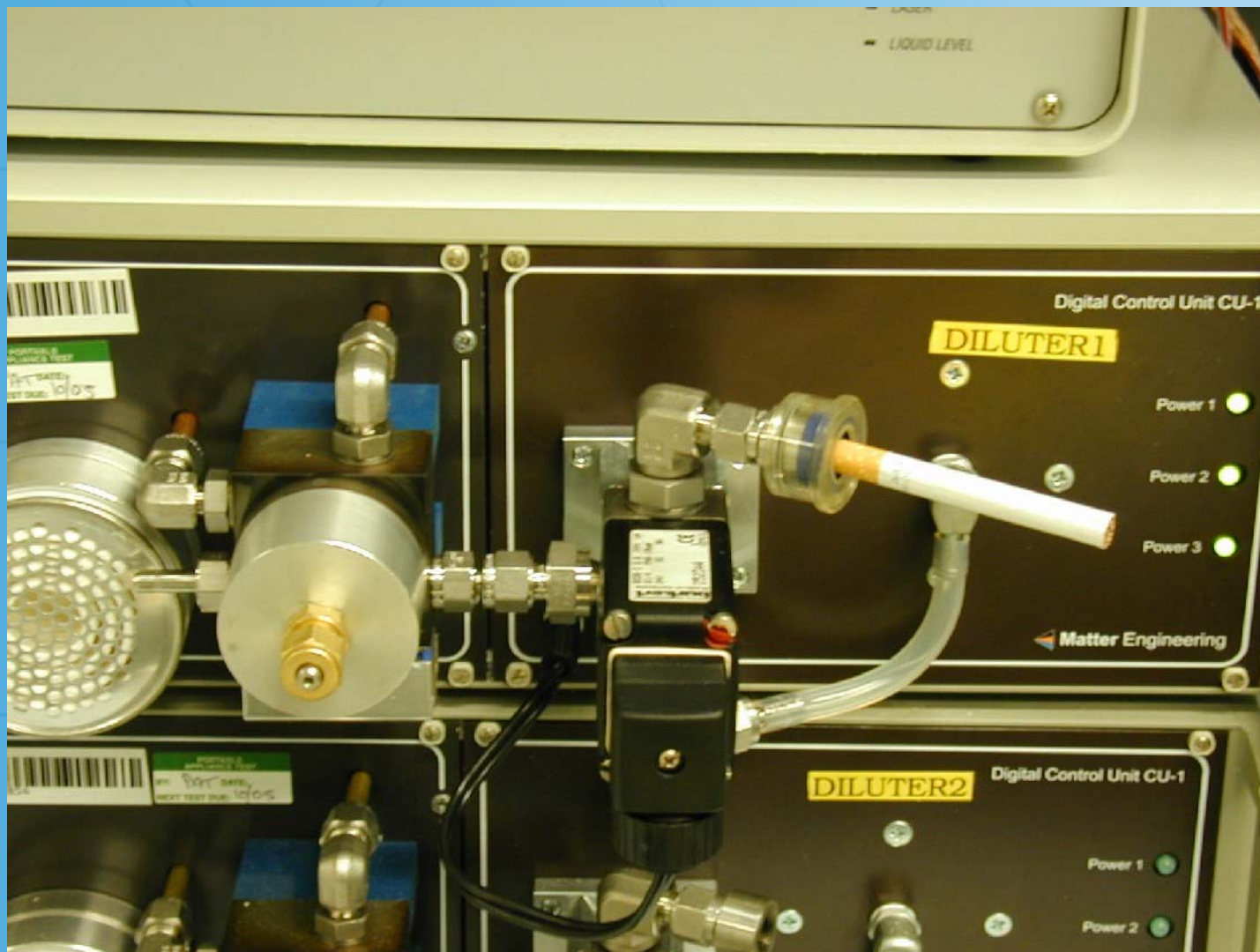
# Measurement Sequence



DMS500 Dynamic Particle Spectrum

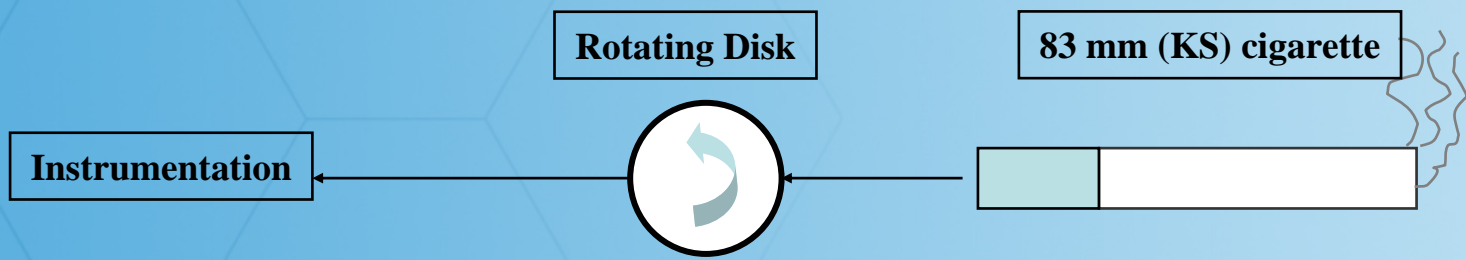


# Smoking & dilution

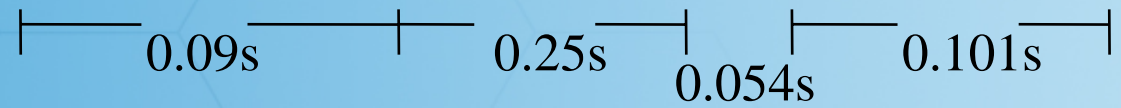




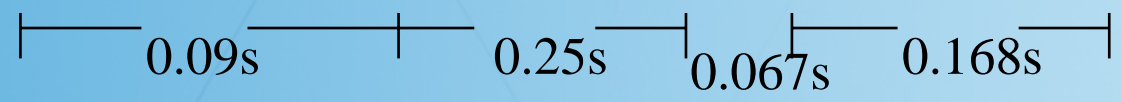
# Calculated Transport Times



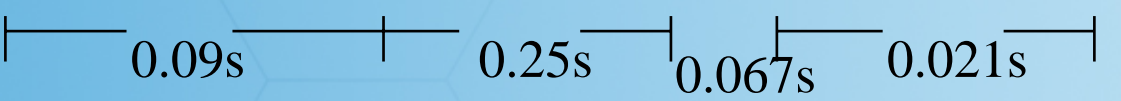
Unventilated



Ventilated – Puff 1

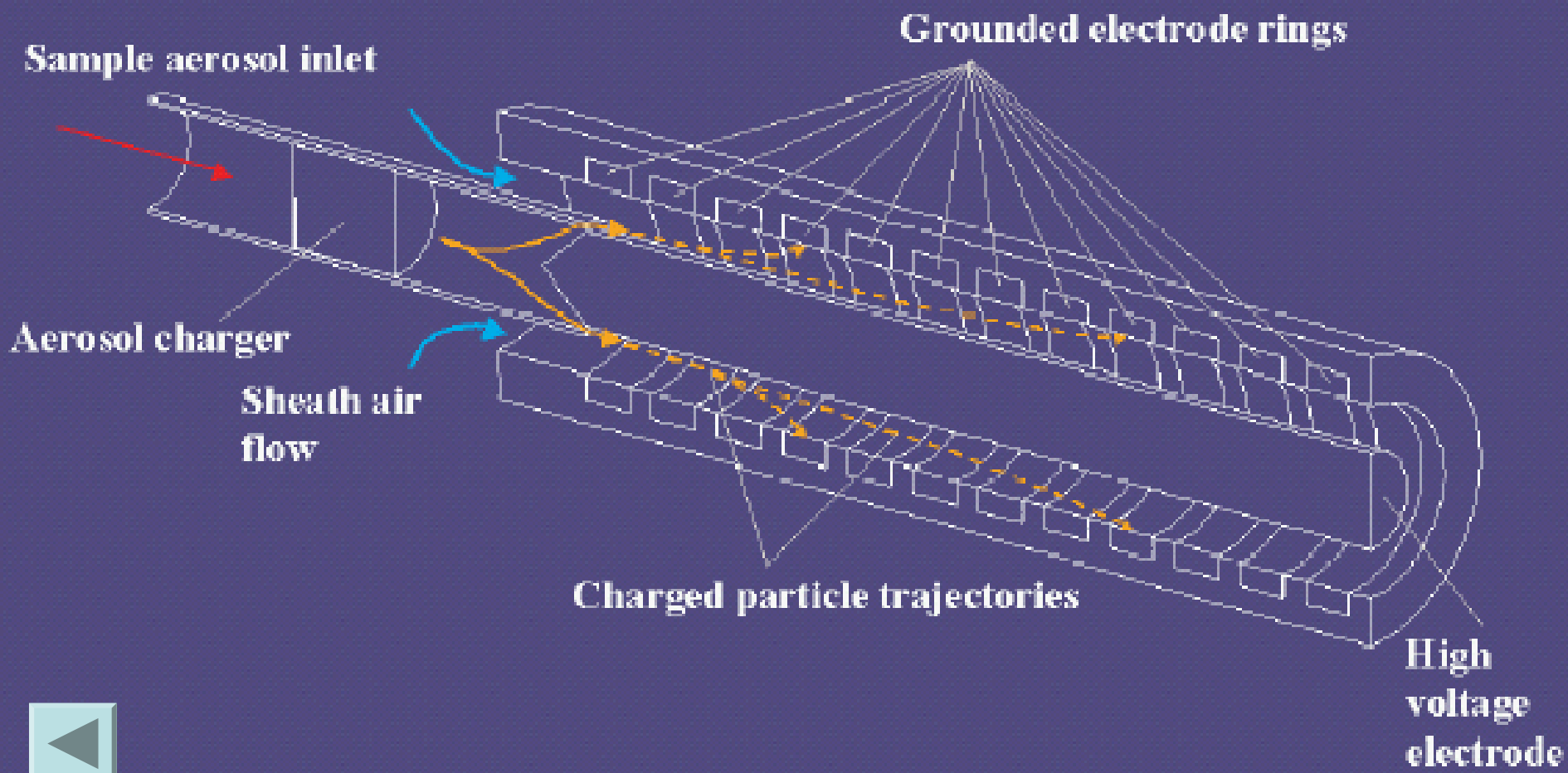


Ventilated – Puff 8



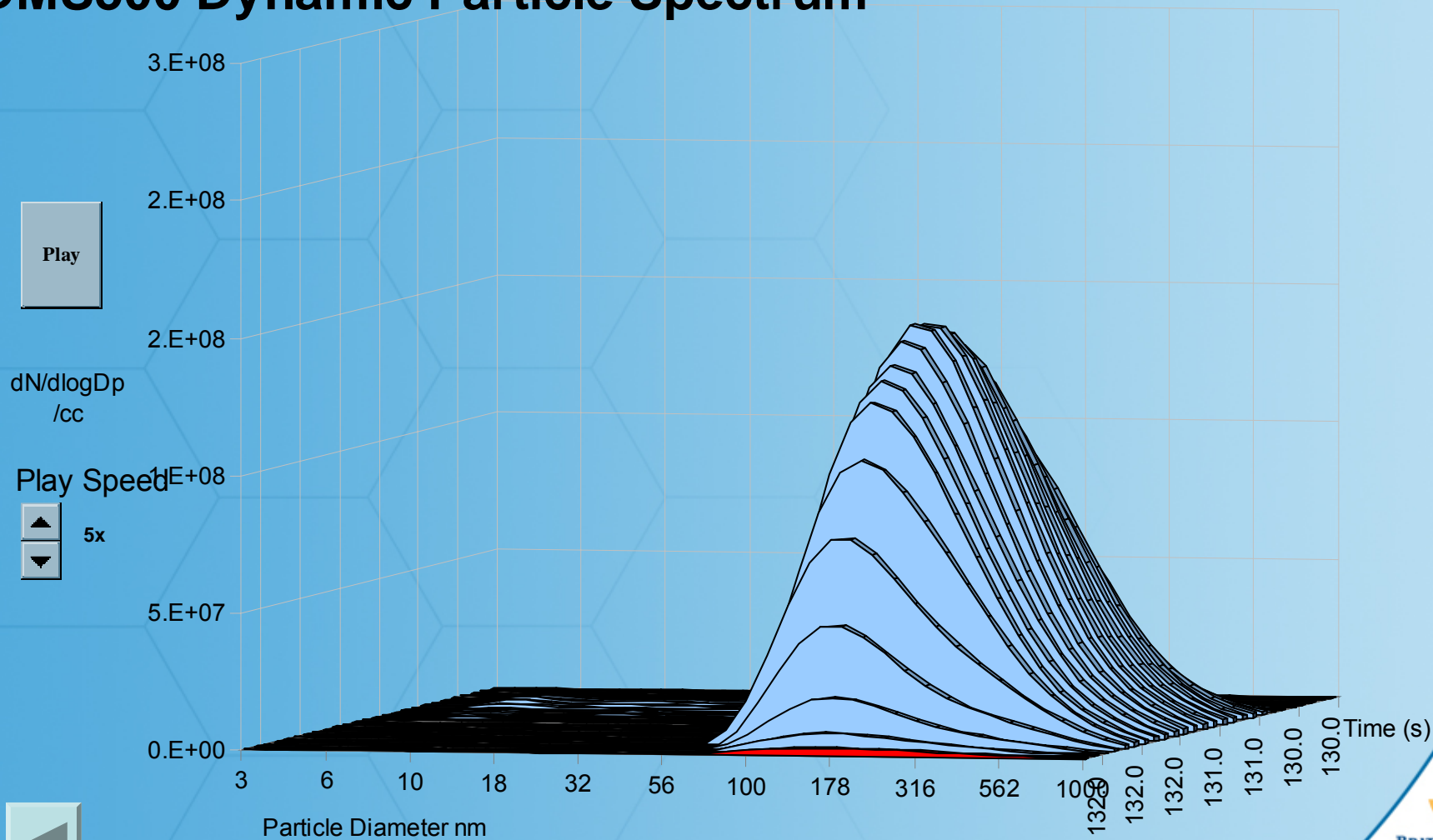
Flow = 1.05 l/min

# Electrical mobility spectrometer

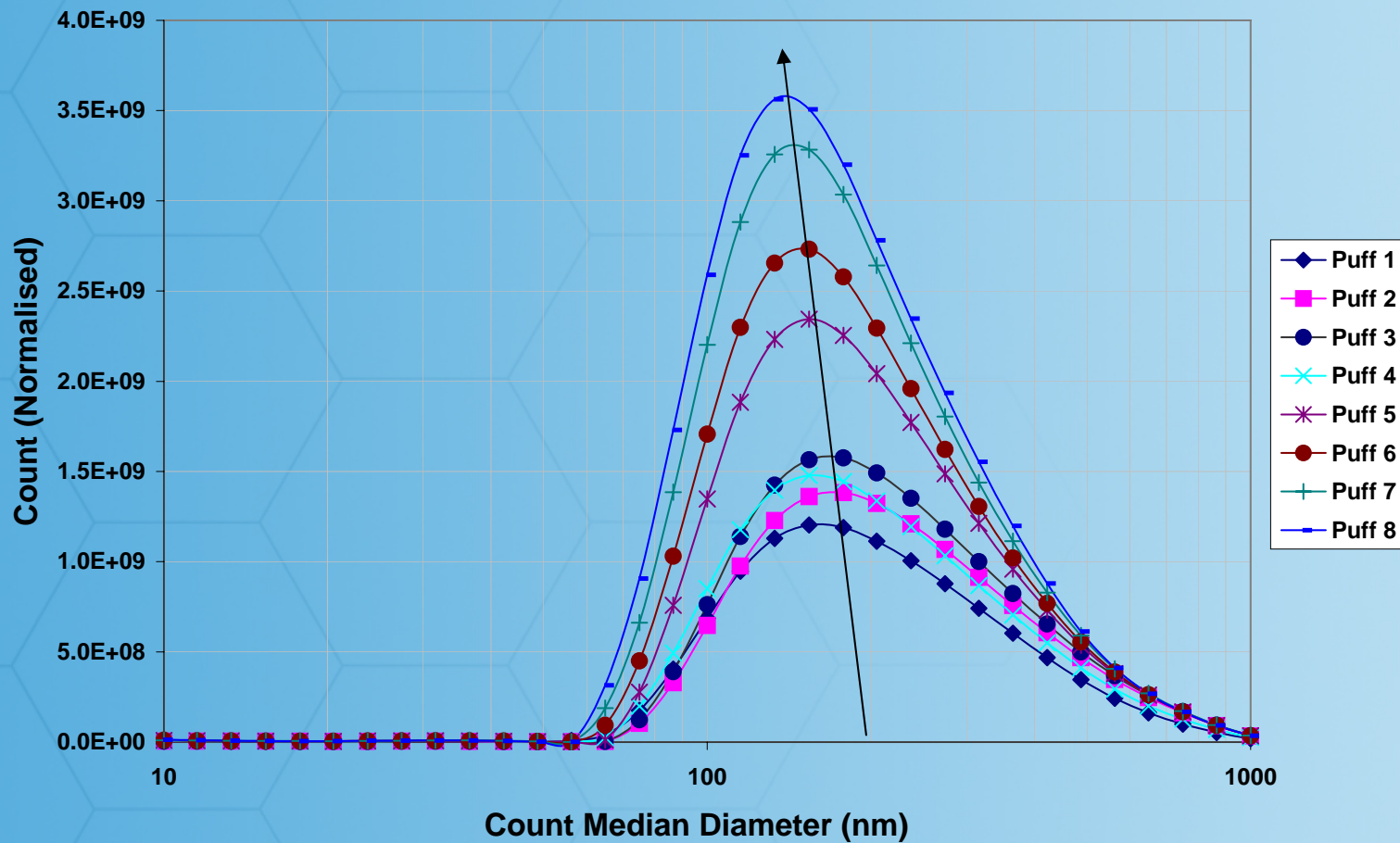


# Data output – 100 ms resolution

## DMS500 Dynamic Particle Spectrum

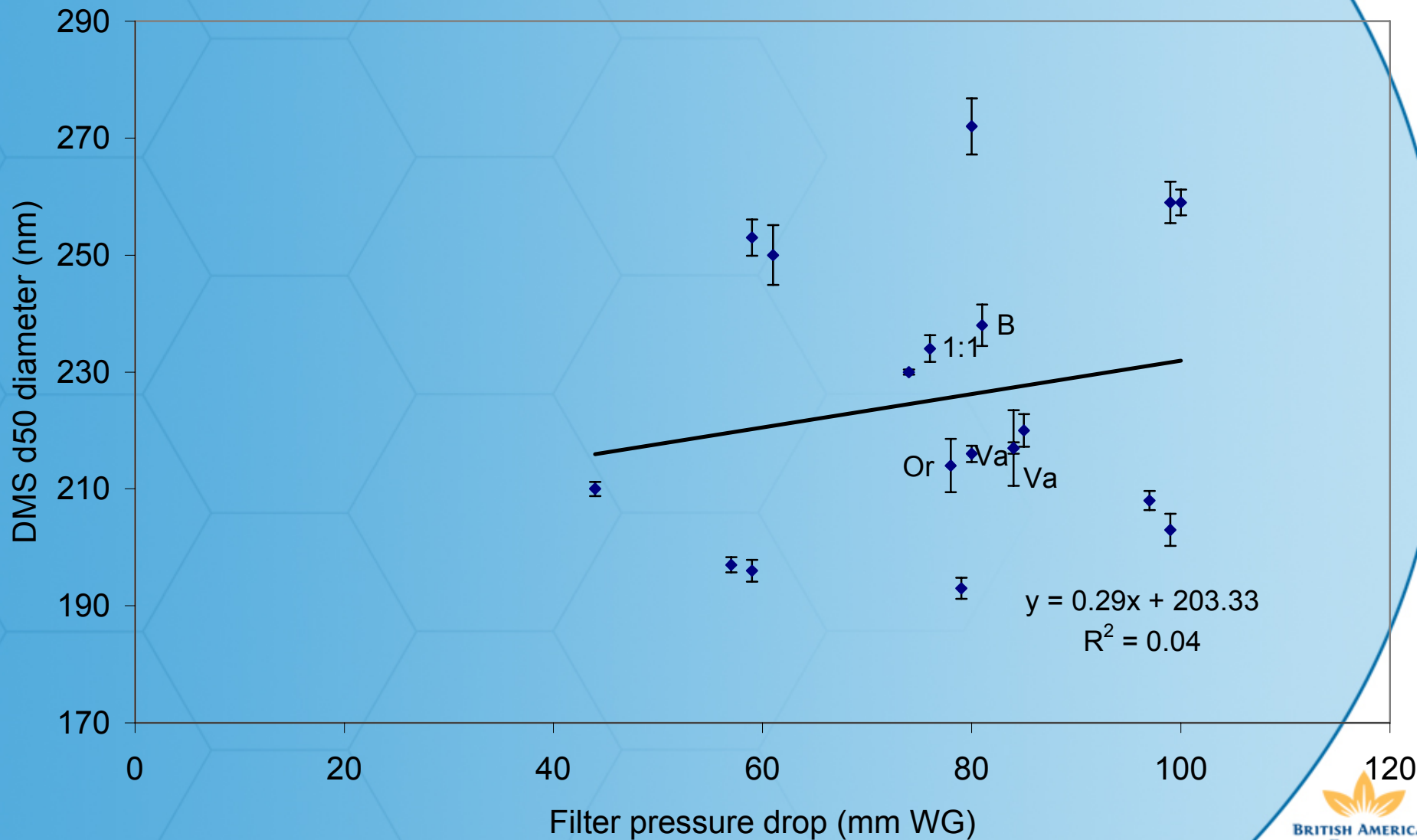


# Puff Analysis

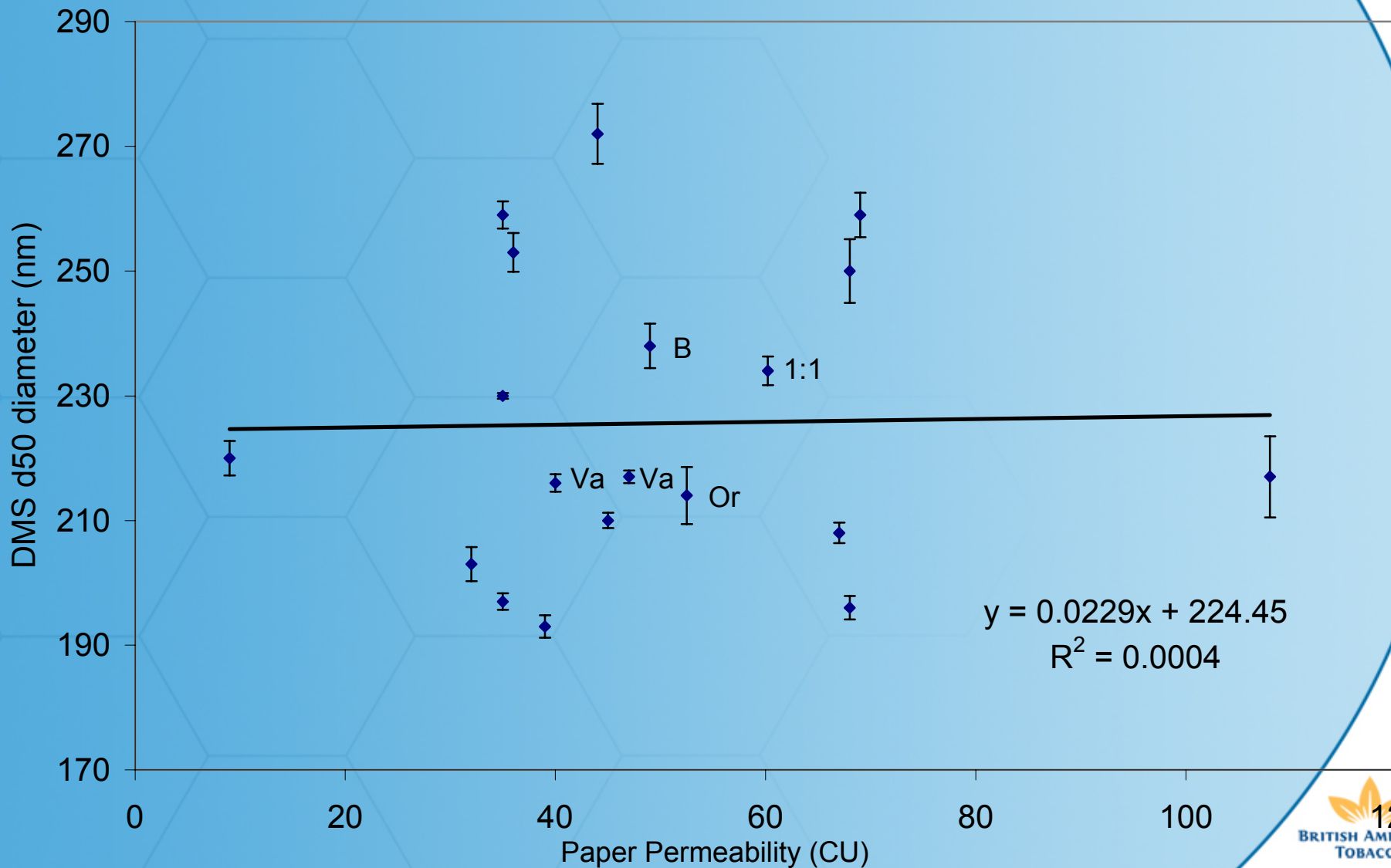




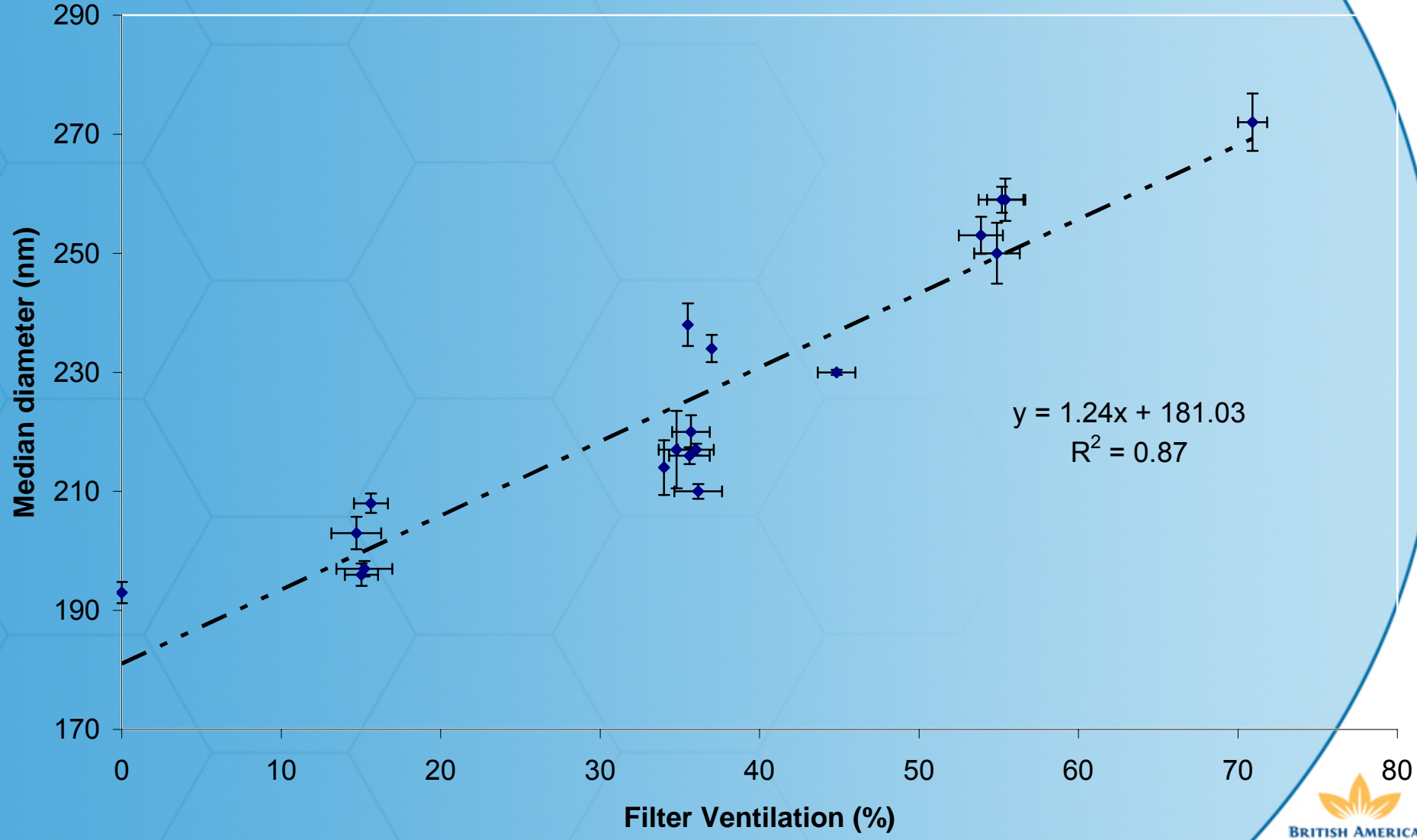
# Diameter v Filter Pressure Drop



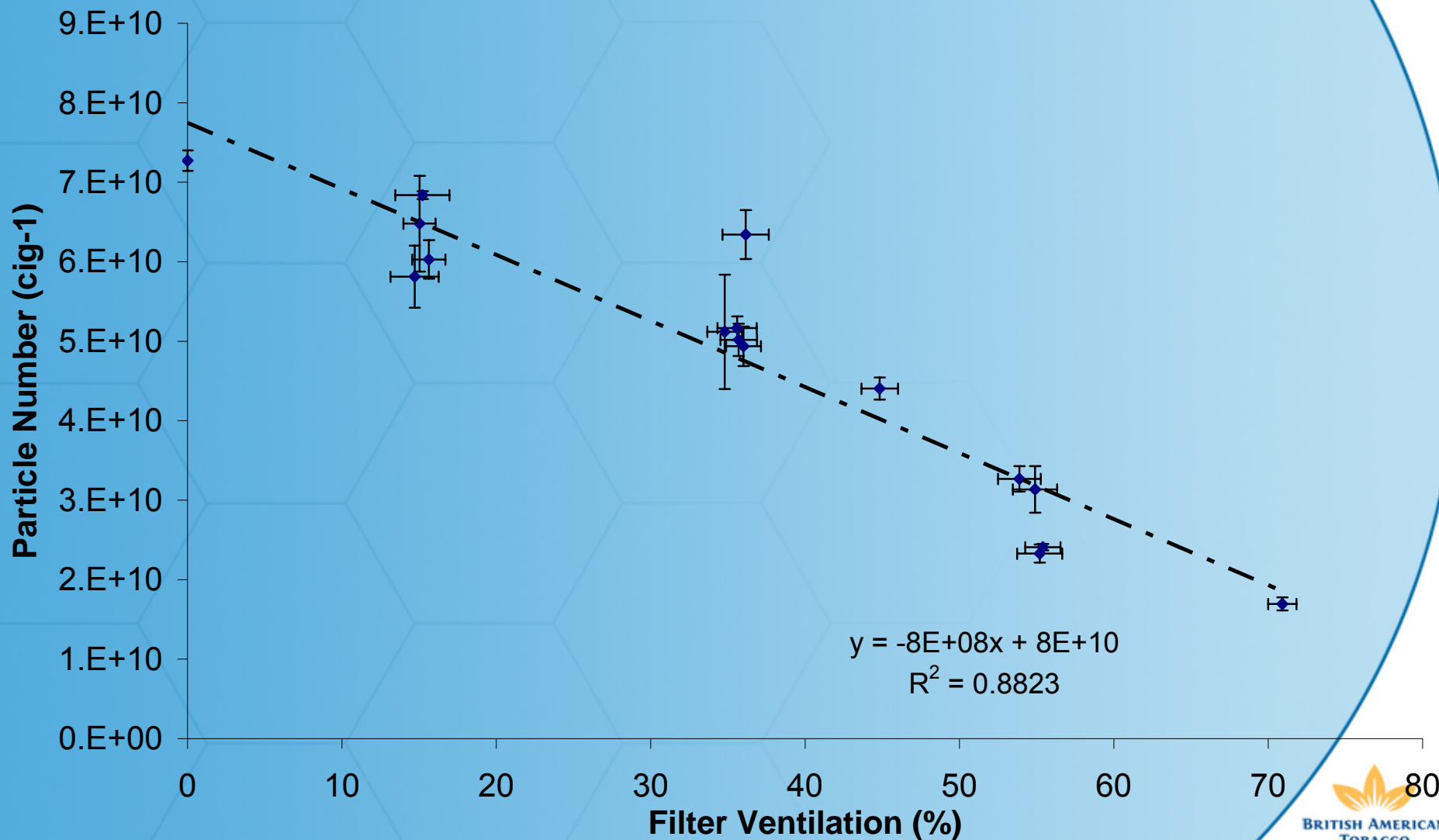
# Diameter v Paper Permeability



# Diameter v Ventilation

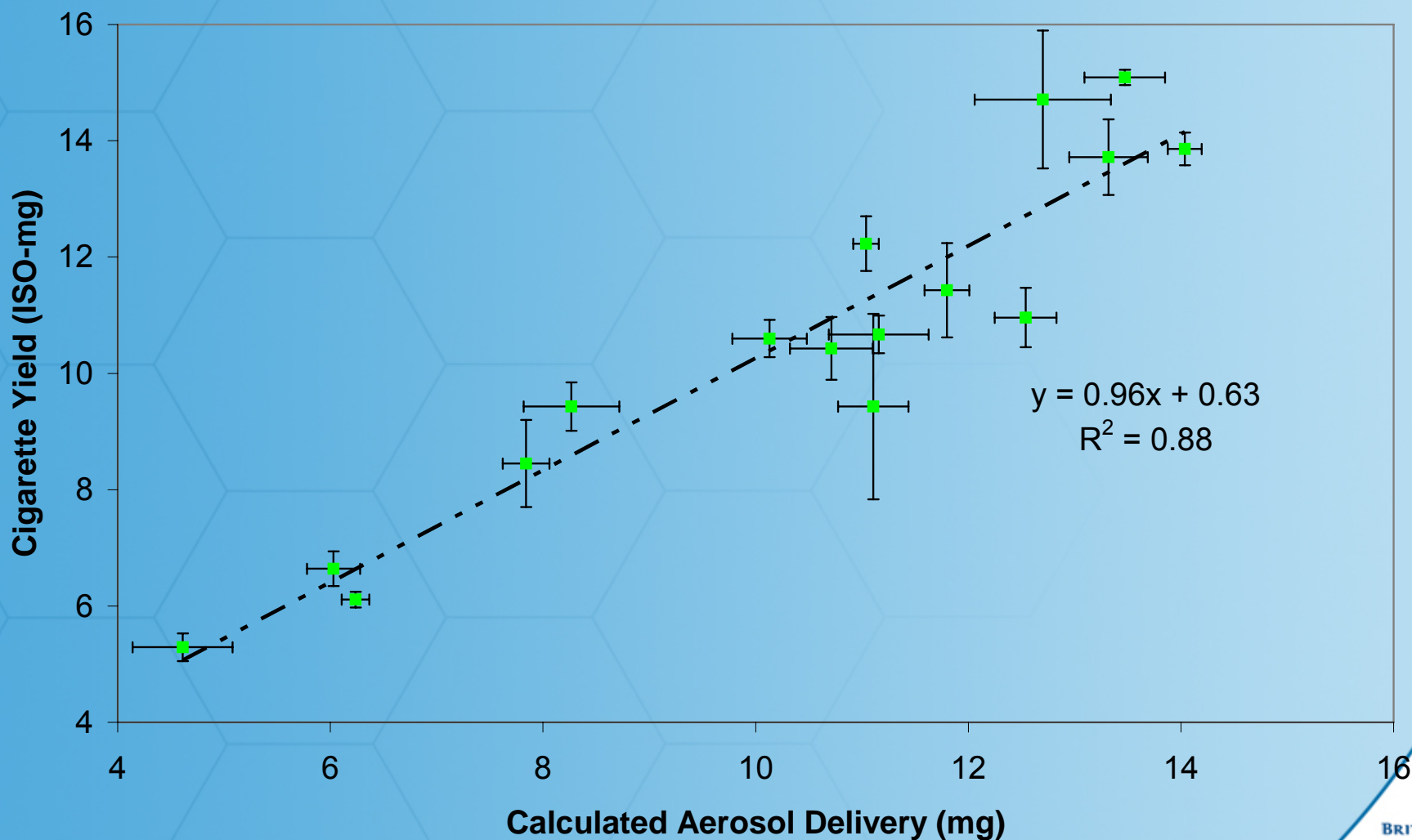


# Particle Number v Ventilation





# Measured v Predicted Tar Mass



# Summary

- Electrical mobility techniques have shown value in real-time smoke measurement with respect to sensitivity & time resolution at minimal transit time & dilution ratios
- Strong relationship observed for cigarette filter ventilation versus NFDPM and specific PM associated chemicals, particle diameter, number concentration
- Calculated particle mass in good agreement with ISO machine smoking
- Aerosol changes consistent with residence time changes in rod & filter, that is coagulation drives particle growth and reduction in particle number