Research & Development

CIGARETTE DESIGN IMPACT ON TOBACCO SMOKE PARTICLE SIZE

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British American Tobacco

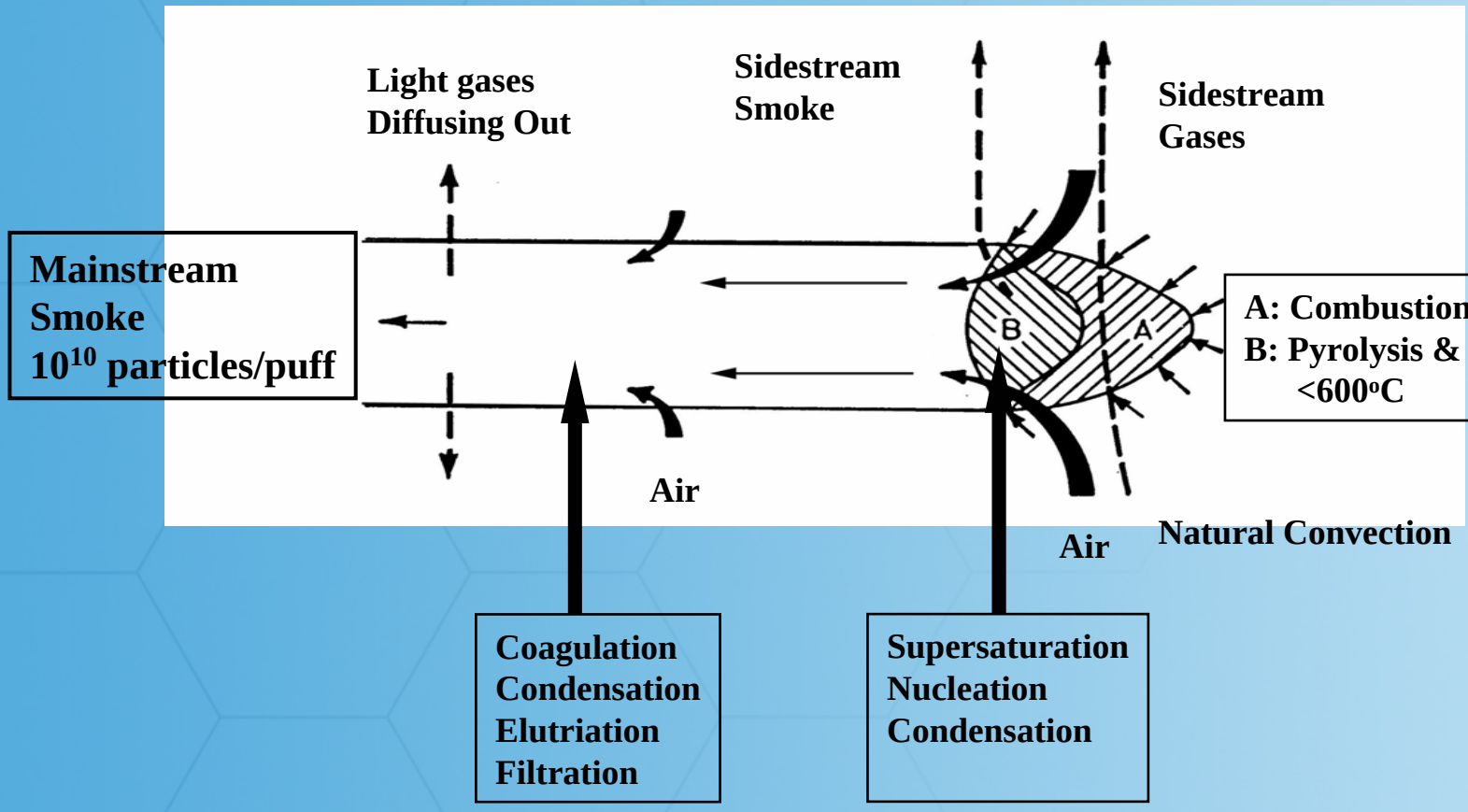
Study Objectives

- Impact of cigarette design parameters on cigarette yields e.g. tar, nicotine, CO, Hoffmann analytes
- HA : list of 44 key combustion-derived toxins including nitrosamines, PAHs
- Improved predictive capability to design progressively reduced delivery products for existing smokers
- Aerosol measurement incorporated into measurement matrix

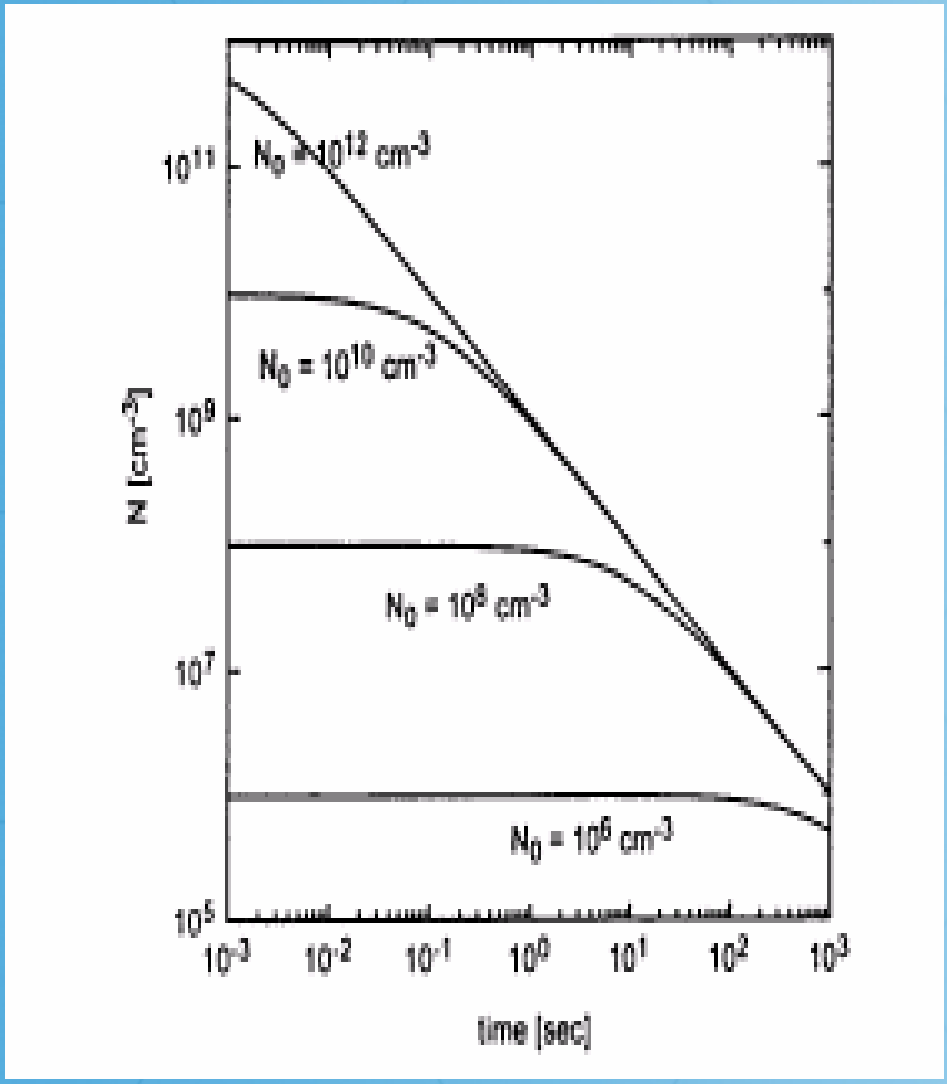
Abbreviated 'Hoffmann List' Health Canada, 2000, Mass., 2001

•'Tar', nicotine, CO	3
•NH_3, HCN, NO_x	3
•Tobacco specific nitrosamines	4
•Phenols	6
•Volatile carbonyls (e.g. HCHO, acrolein)	8
•Benzo[a]pyrene	1
•Aromatic amines (e.g. 3- and 4- aminobiphenyl)	4
•Semi volatiles (e.g. quinoline, styrene, benzene)	8
•Trace metals (Pb, Cr, Ni, Hg, As, Cd, Se)	7

Thermal and physical processes inside a burning cigarette

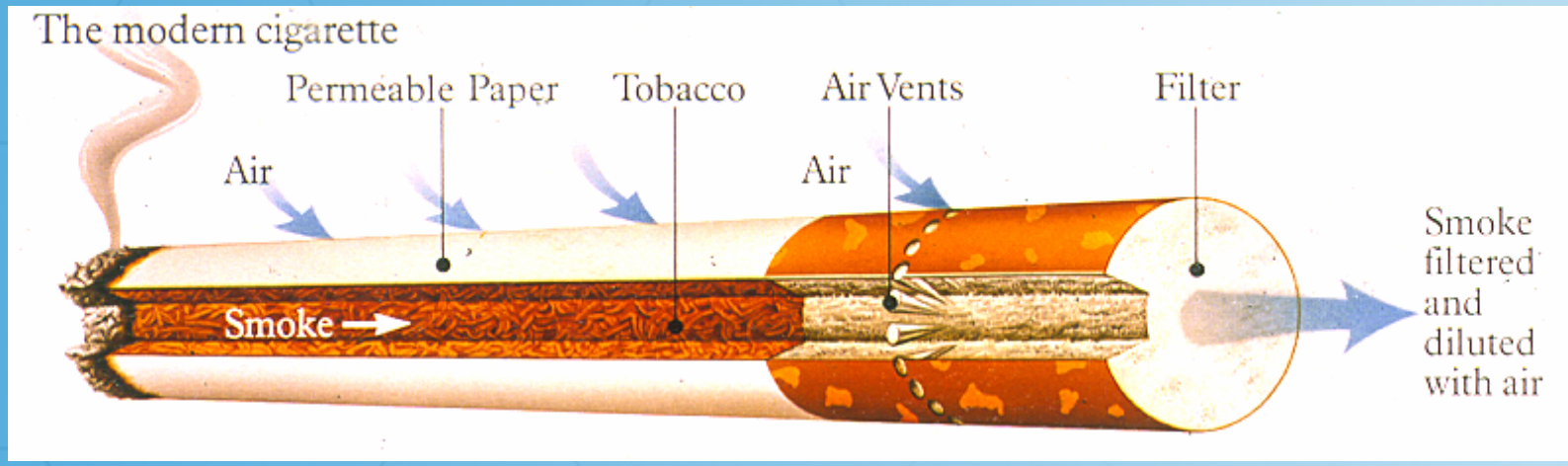


Aerosols & Combustion / Pyrolysis



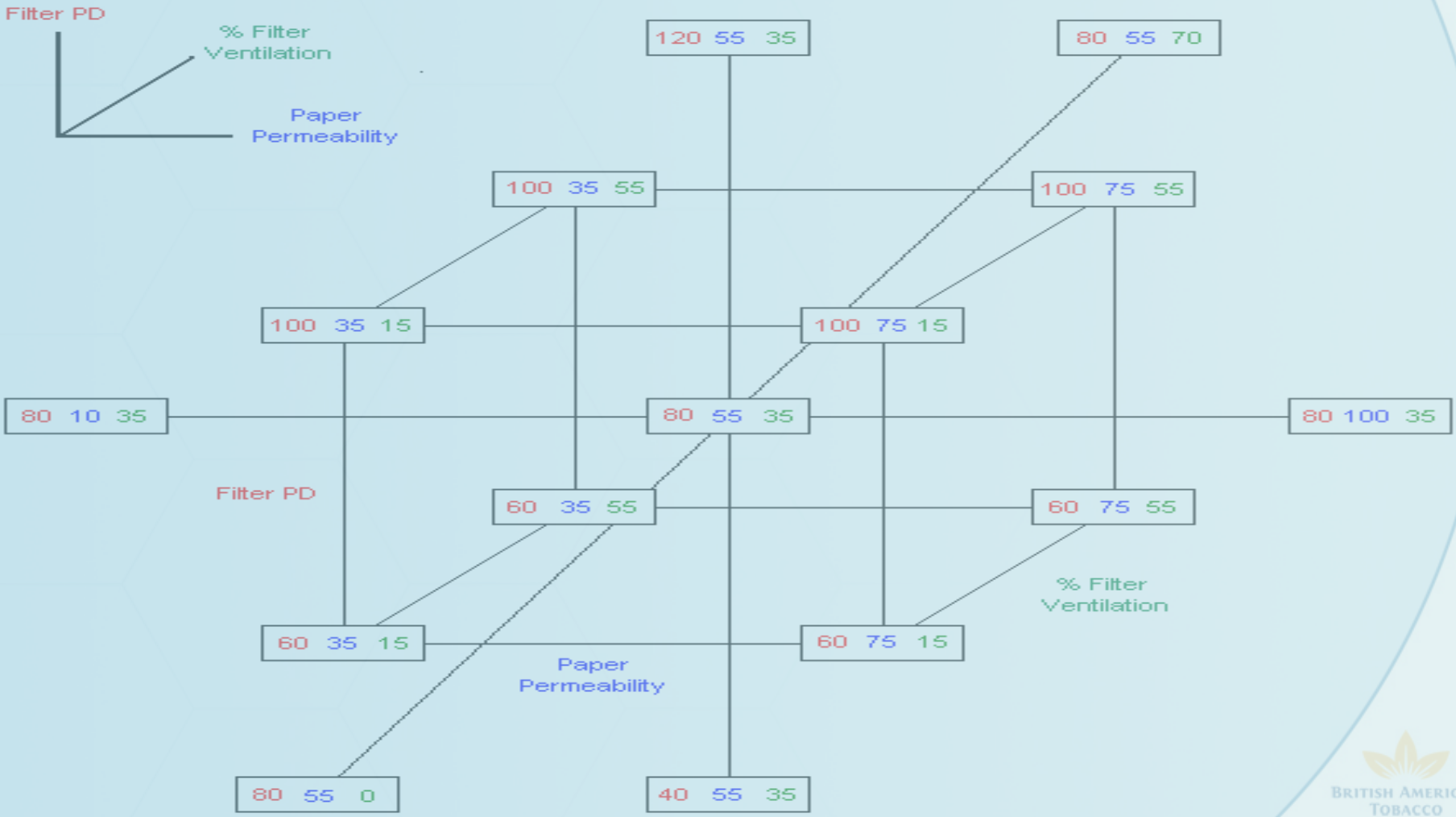
- Nucleation : molecular seeding
- Condensation : Vapour super-saturation
  - Heterogeneous
  - Homogeneous
- Coagulation : Collisions at high concentration

Cigarette Design Parameters



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

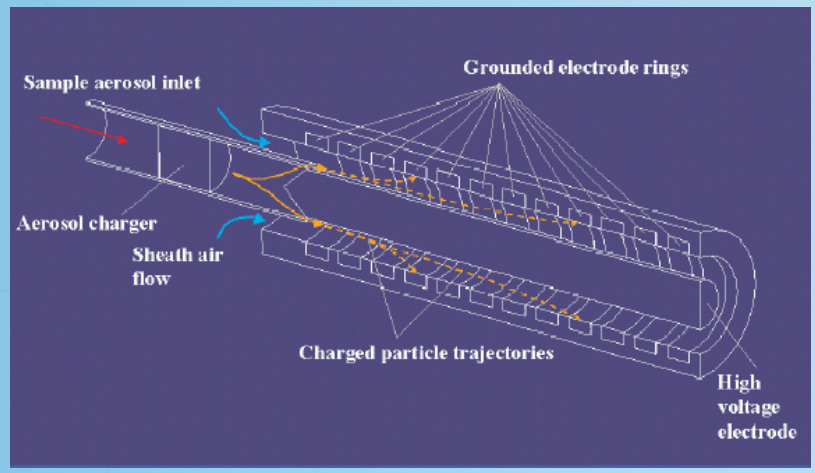
Central Composite Design

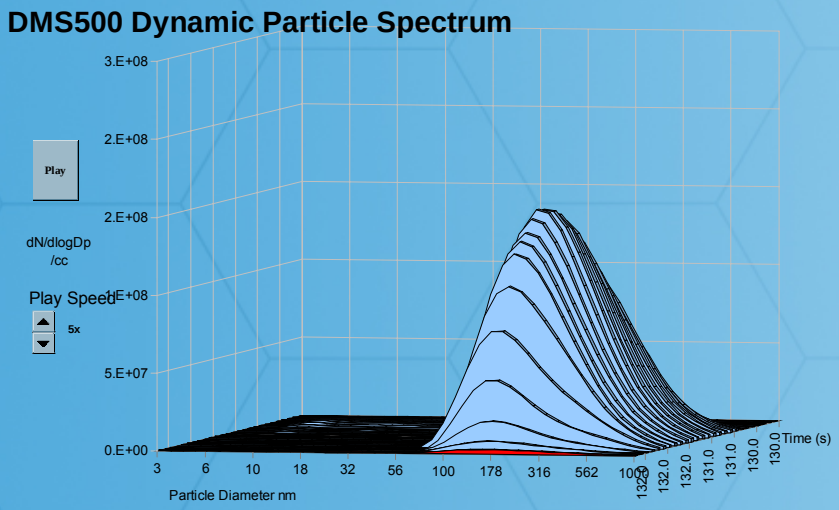


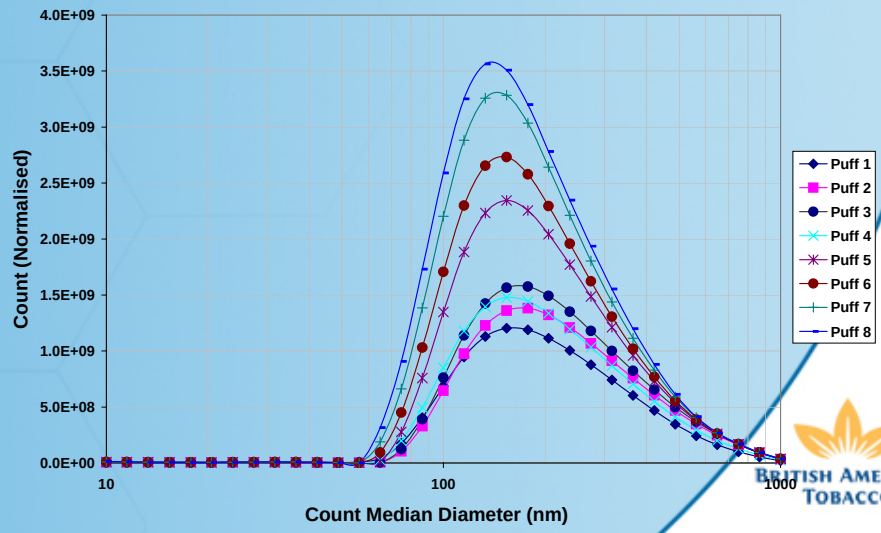
Measurement campaign

- 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
  - concentration by TSI Model 3022 CPC
  - repeat measure with TSI Model 3090
  - calibration with PSL standards

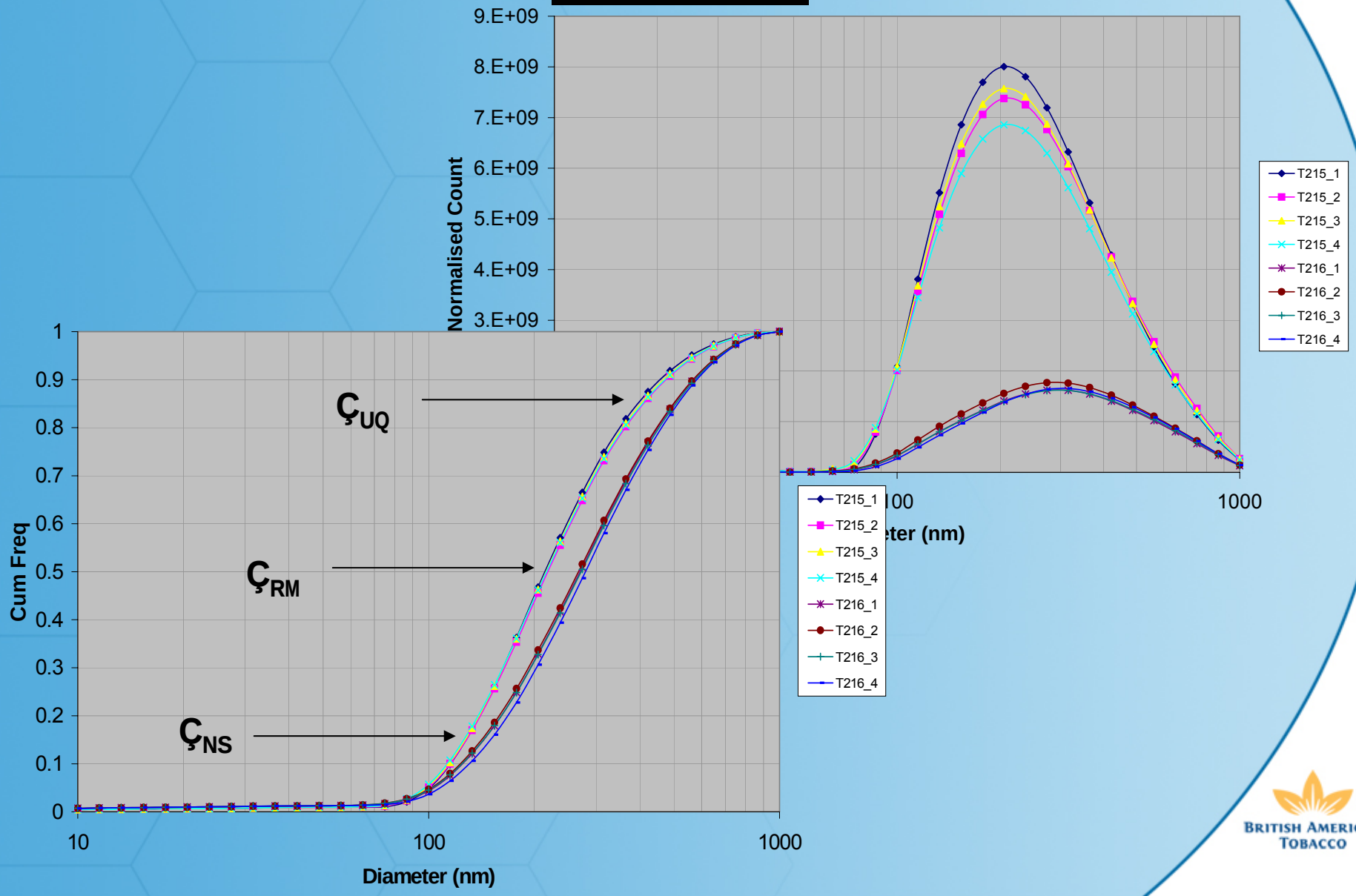
Measurement Sequence







Results


Normalised Count
9.E+09
8.E+09
7.E+09
6.E+09
5.E+09
4.E+09
3.E+09
T215_1
T215_2
T215_3
T215_4
T216_1
T216_2
T216_3
T216_4
1000
eter (nm)
Cum Freq
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
ÇUQ
ÇRM
ÇNS
10
100
1000
Diameter (nm)

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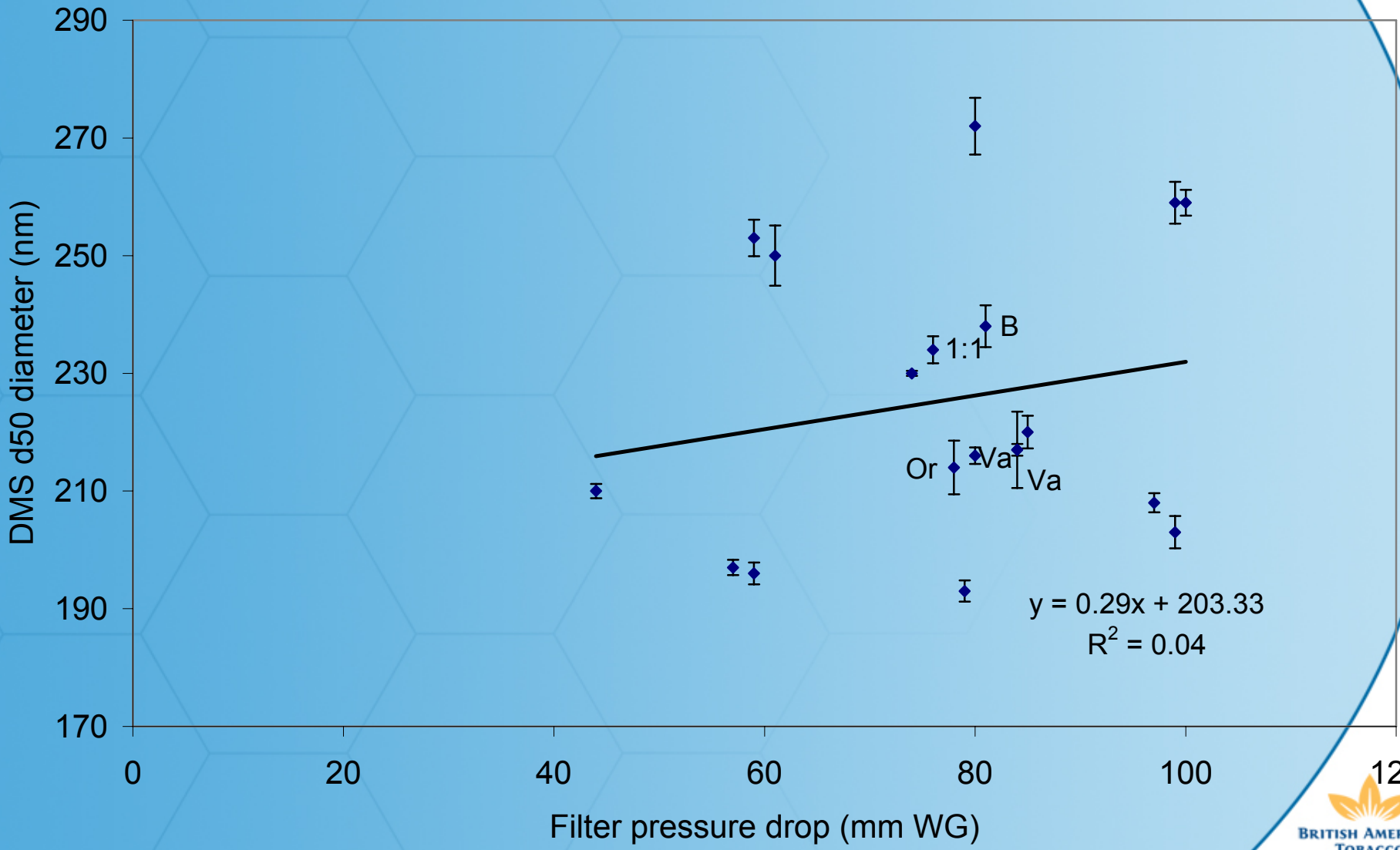
Diameter v Filter pressure drop



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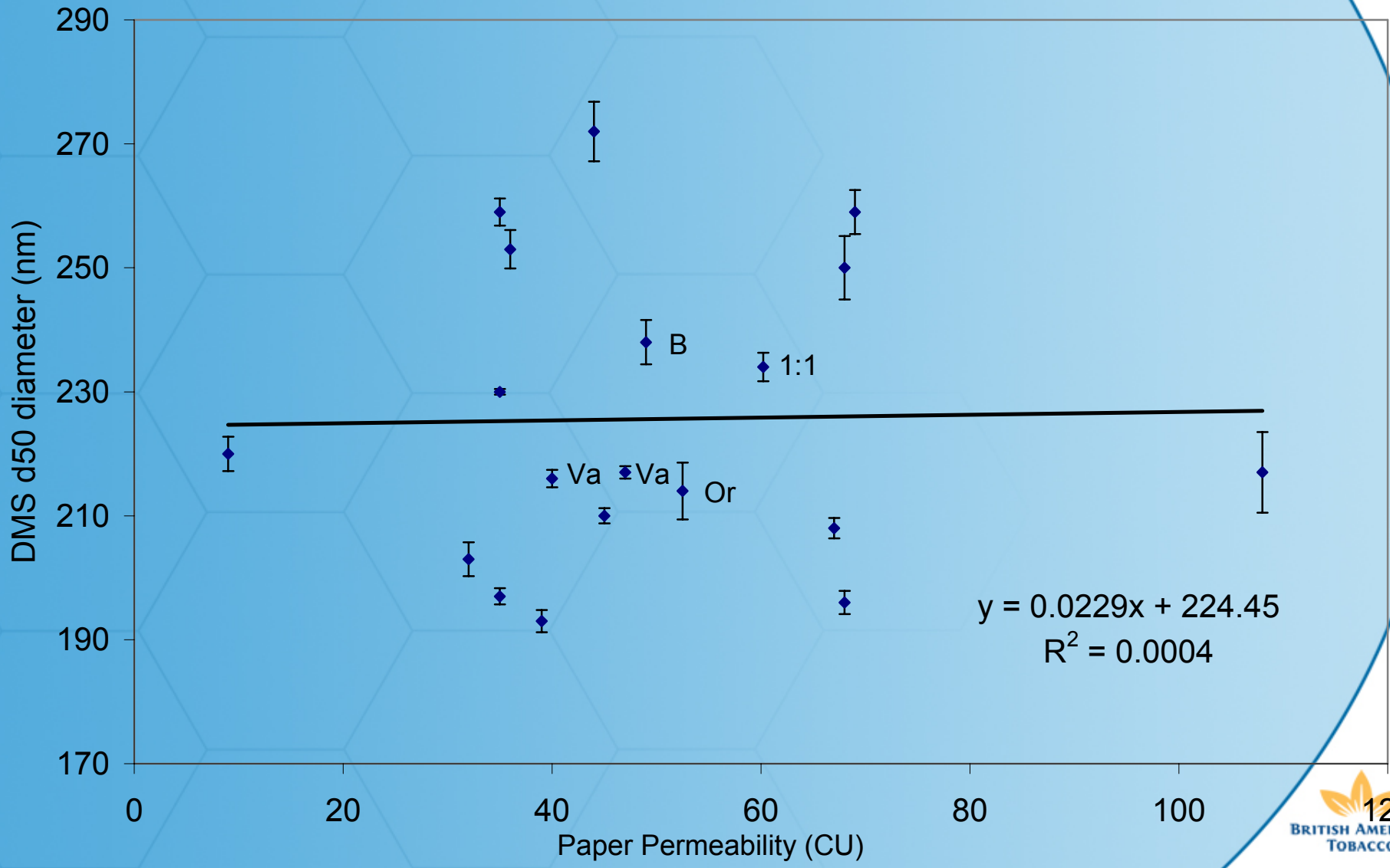
Diameter v Paper permeability



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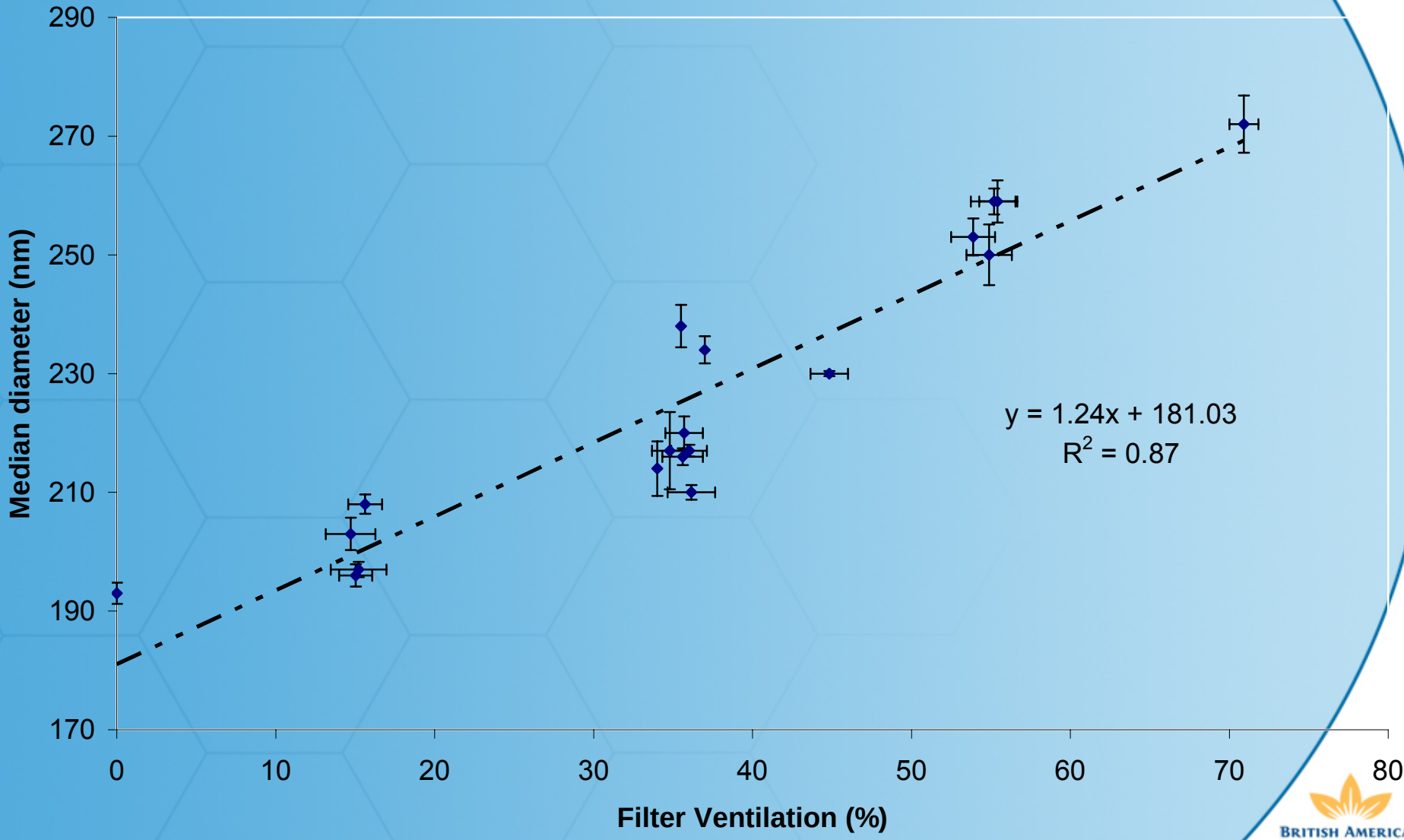
Diameter v Ventilation



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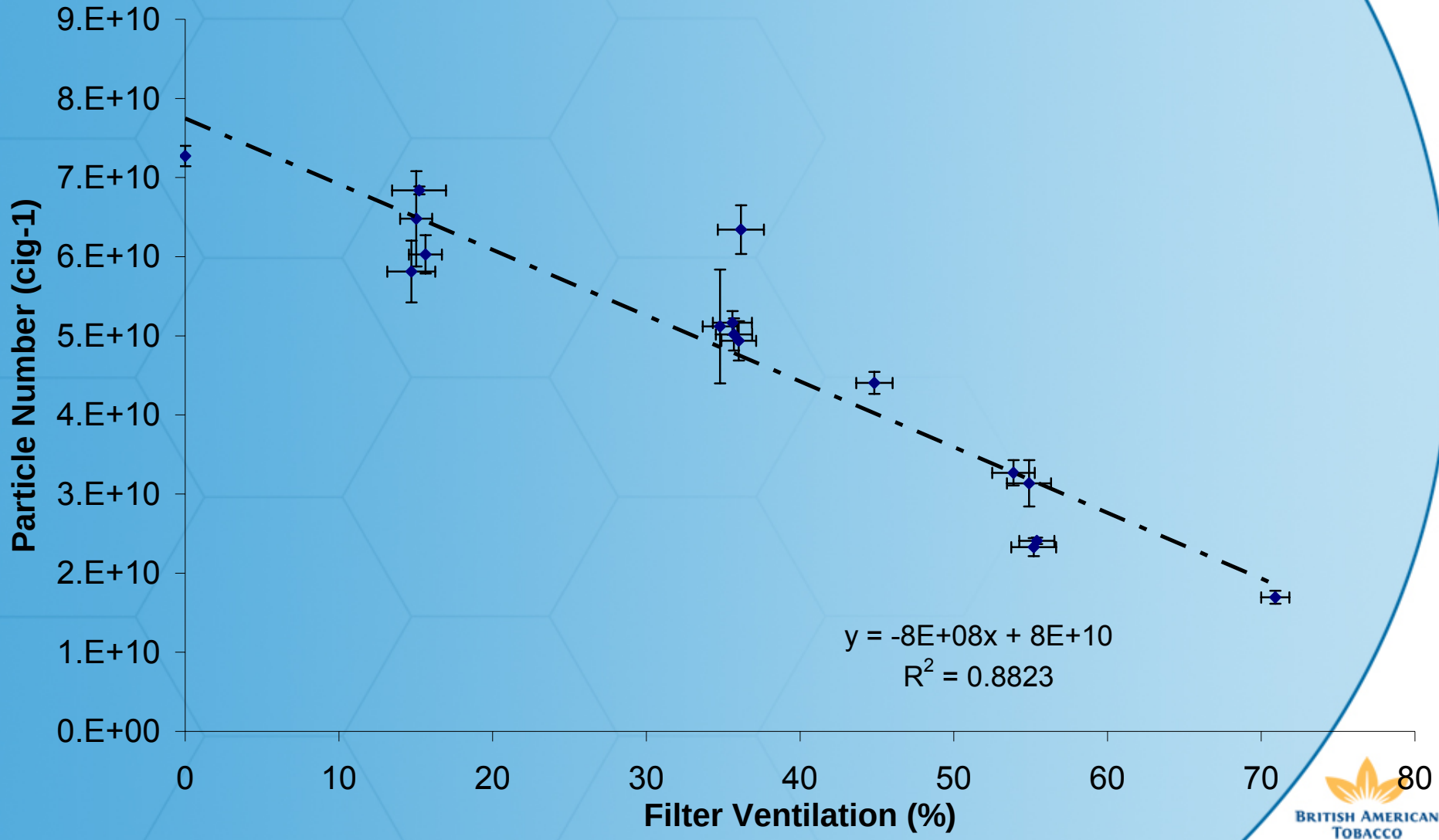
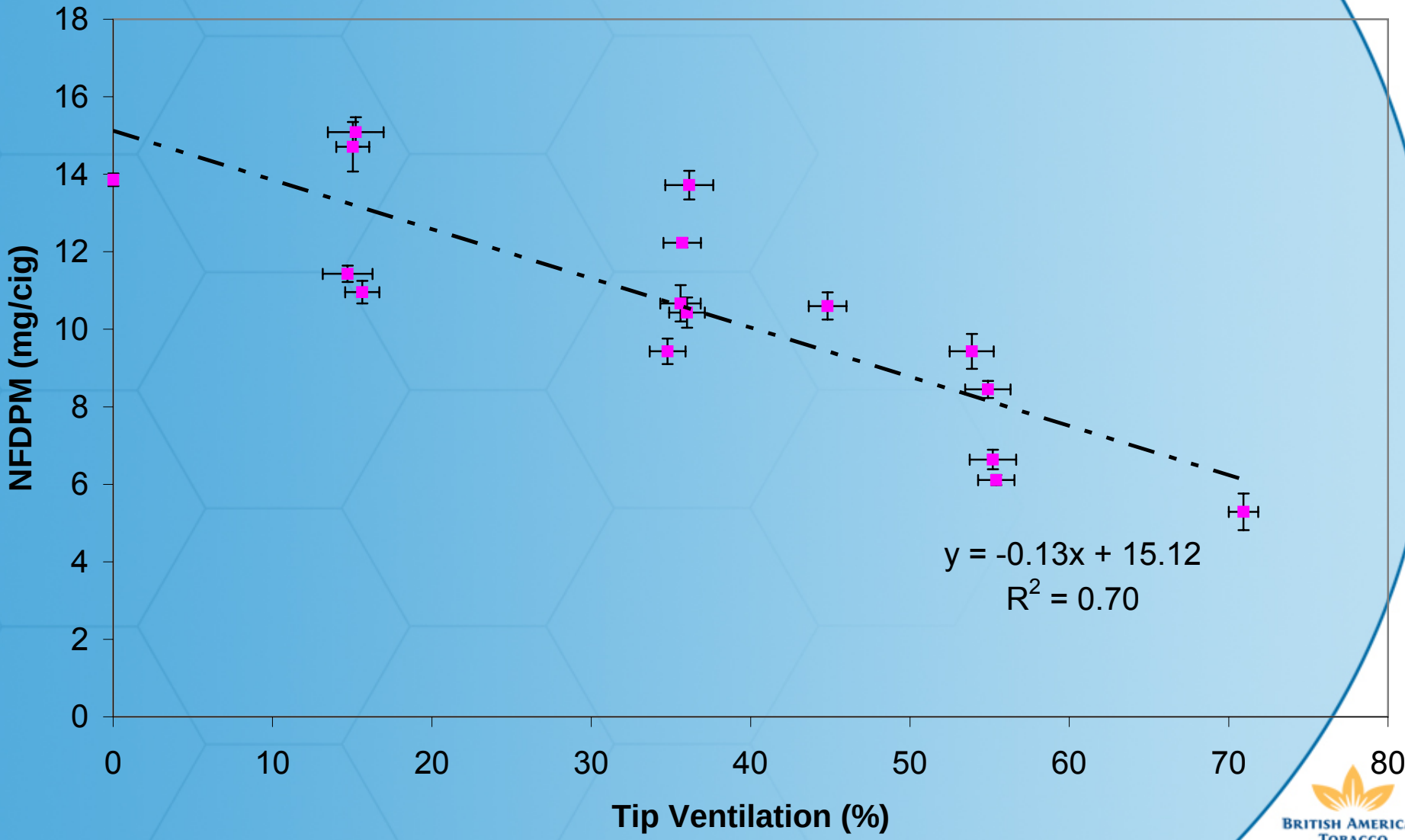
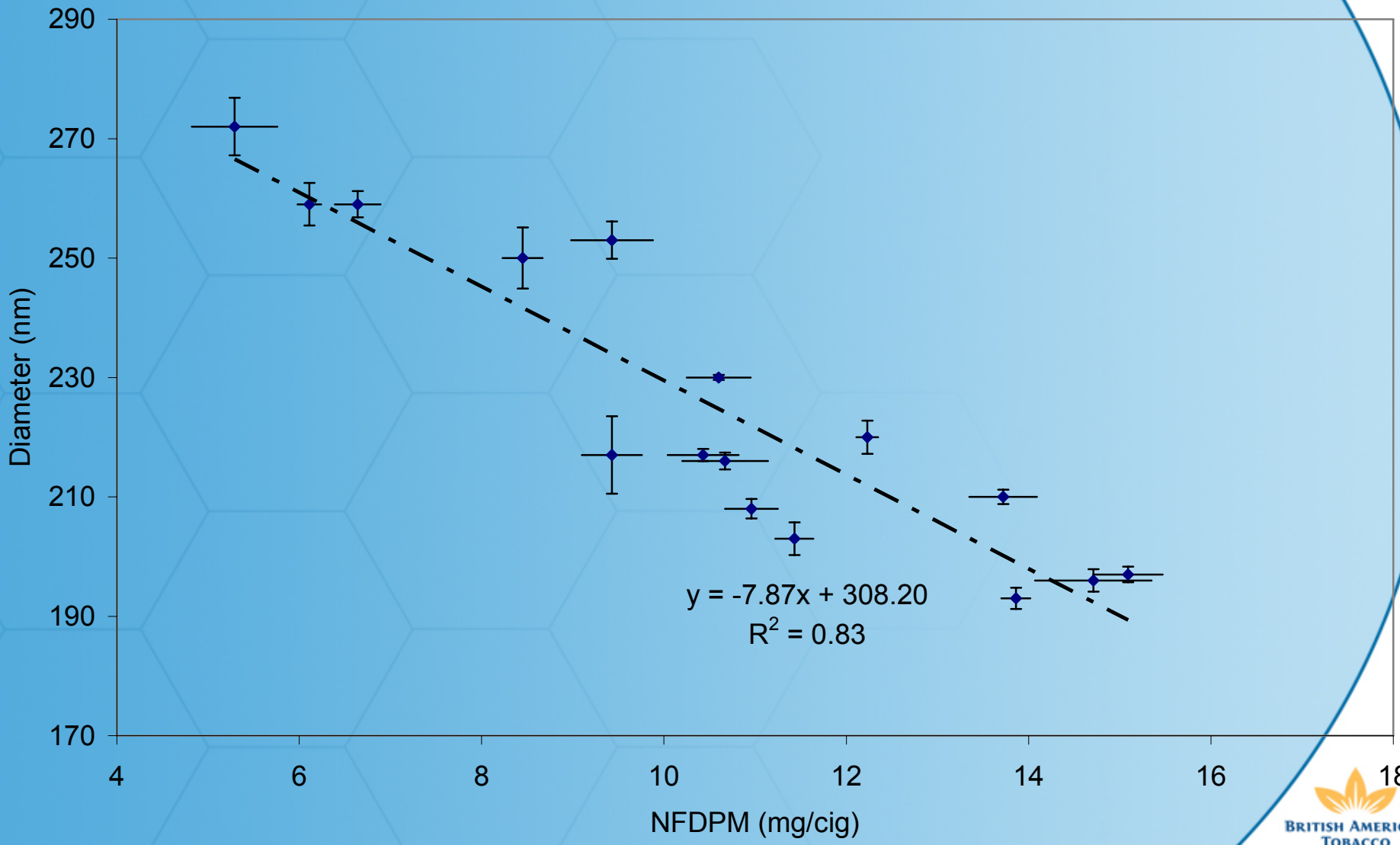
Particle number v Ventilation



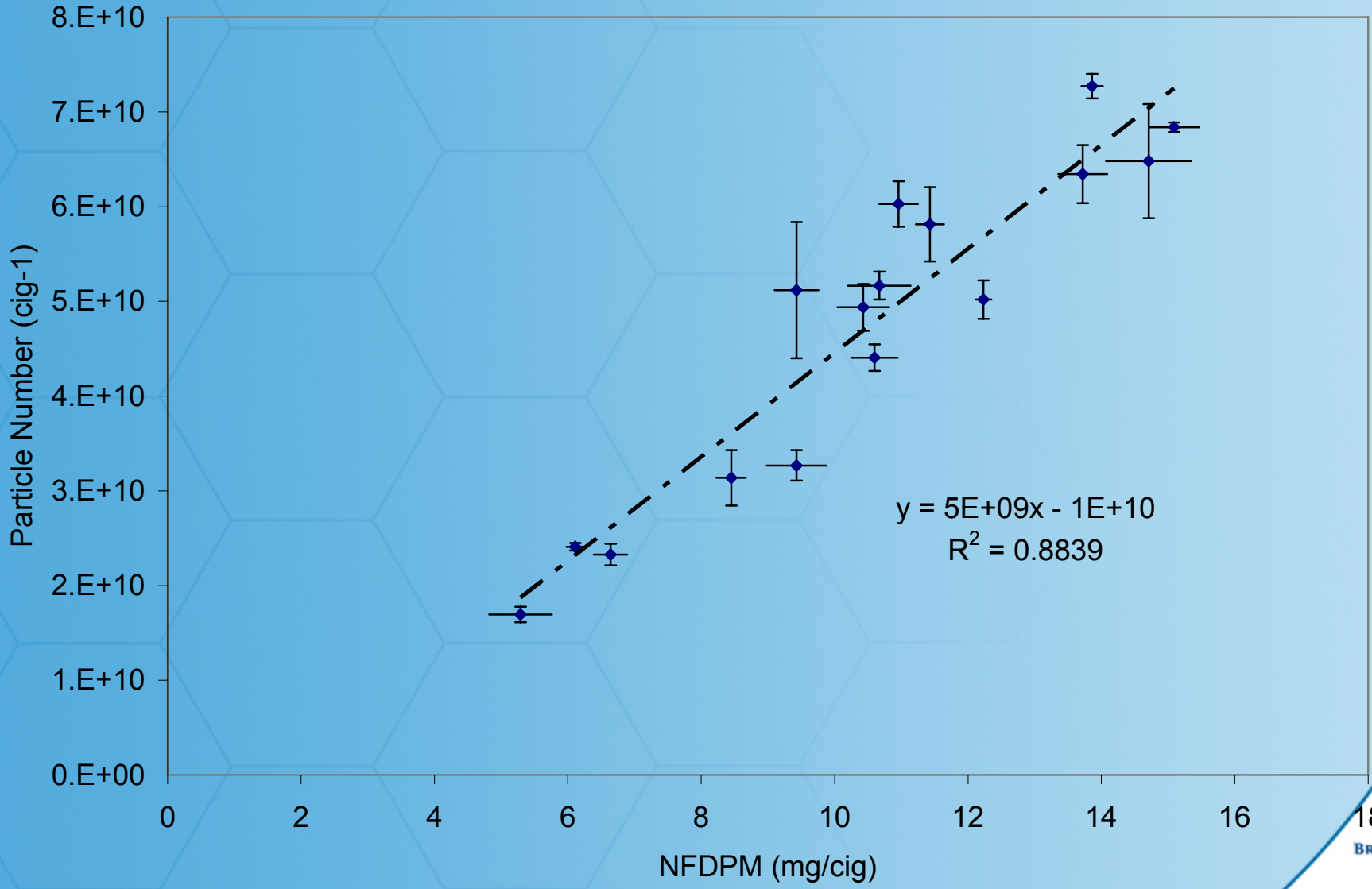
NFDPM v Ventilation



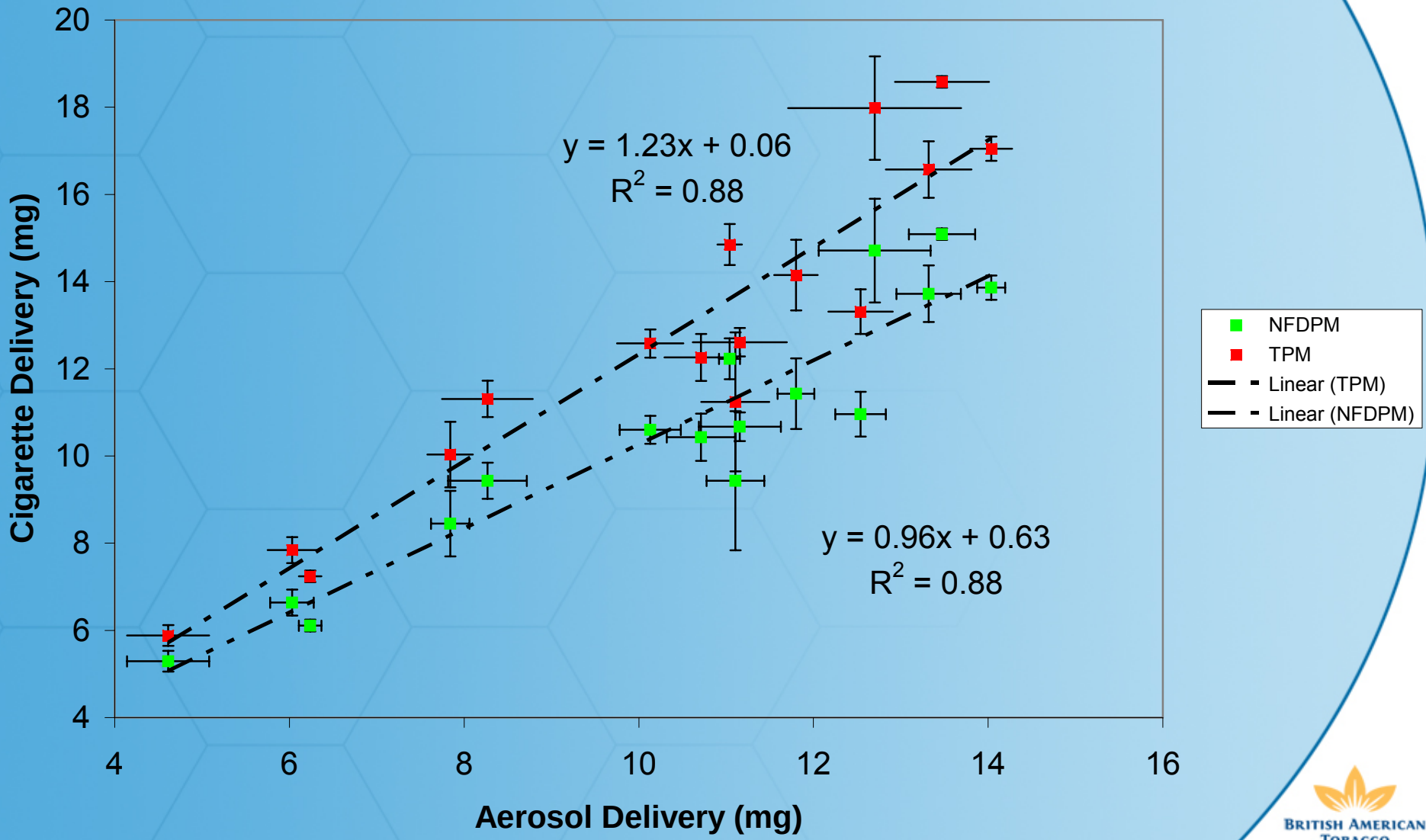
NFDPM v Diameter



NFDPM v Particle Number



Measured v Predicted Tar Mass



Summary

- Electrical mobility techniques have shown value in real-time smoke measurement wrt sensitivity, resolution
- Strong relationship observed for cigarette filter ventilation versus NFDPM, particle diameter, number concentration
- Aerosol changes consistent with residence time changes in rod & filter, that is coagulation drives particle growth and reduction in particle number
- Calculated particle mass in good agreement with ISO machine smoking; scope for improved prediction of human smoking intake

"If you ask me, the fire has the most potential, but it's the smoke that has people talking"