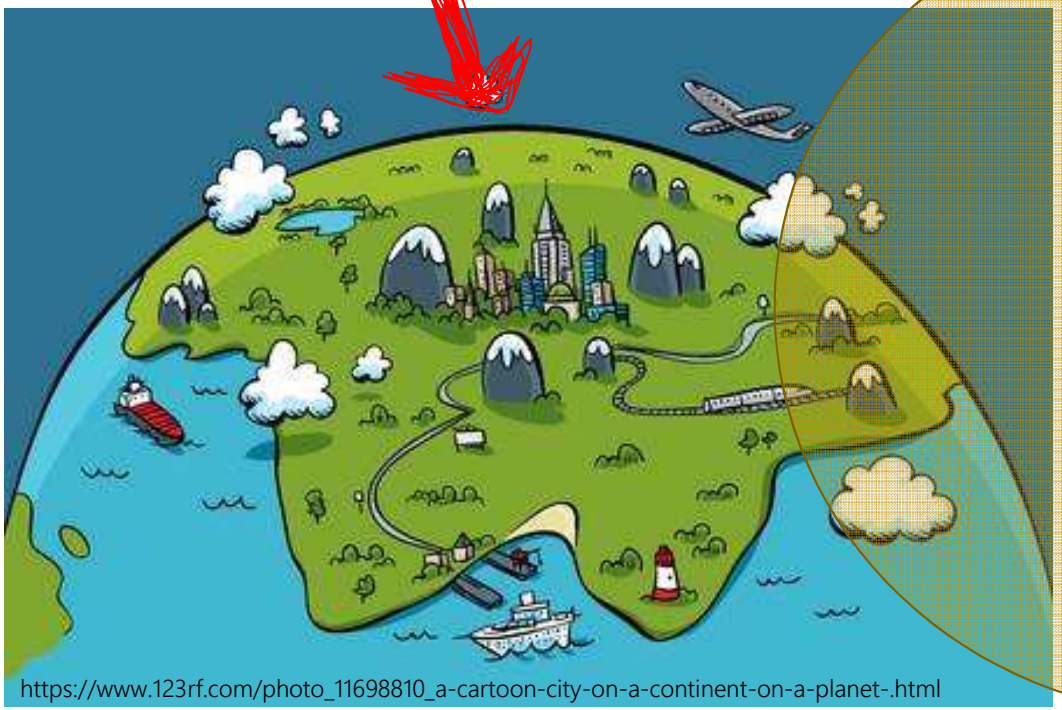
What ~~can~~ can't we measure with PM sensors?

EBEN CROSS

September 13, 2018
ASIC 2018
Oakland, CA

Air Quality Measurement Domains -



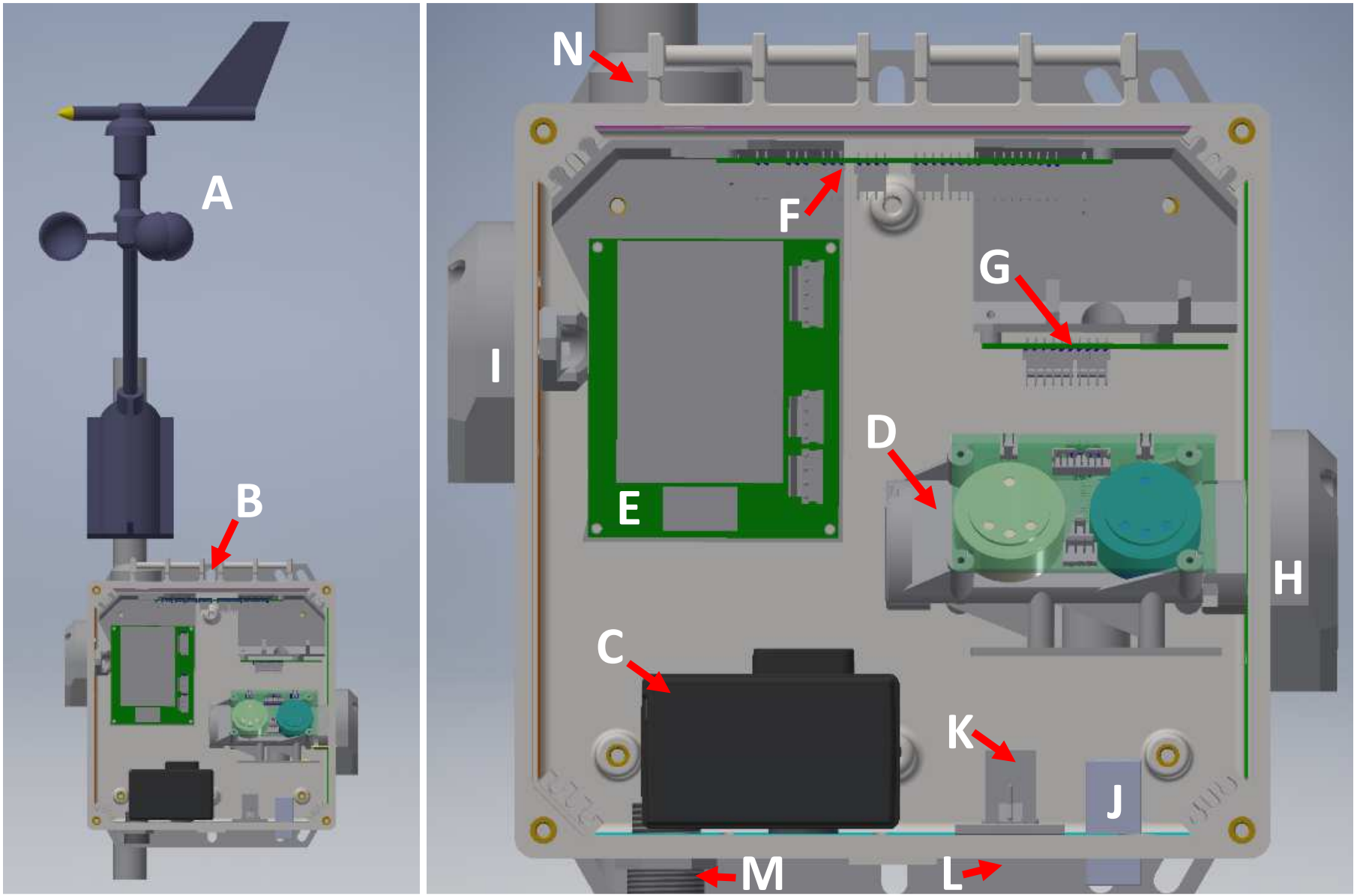
Regional

Local

Personal

EASY

HARD


A
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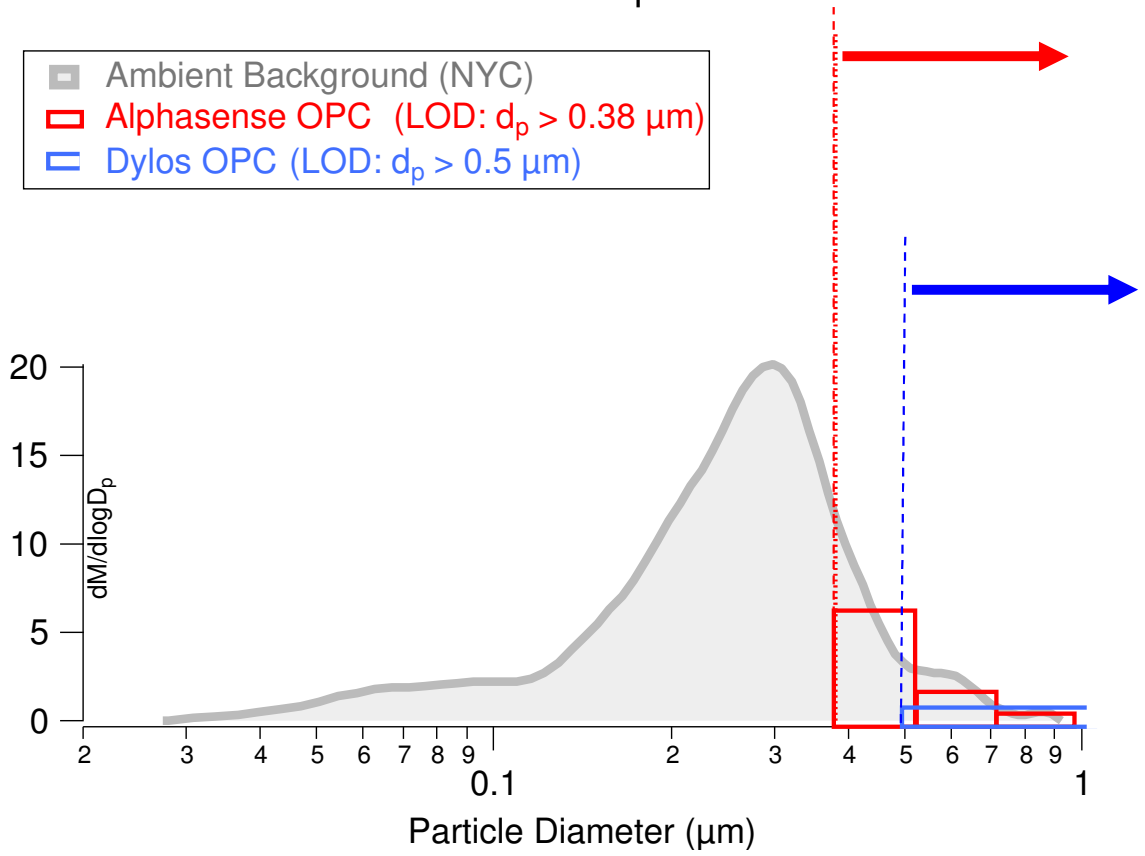
Challenge: Real-world particle size distributions –
'accumulation mode' d_p ~ 0.2 – 0.3 µm



Ambient data from Canagaratna et al., 2004

Challenge: Real-world particle size distributions –
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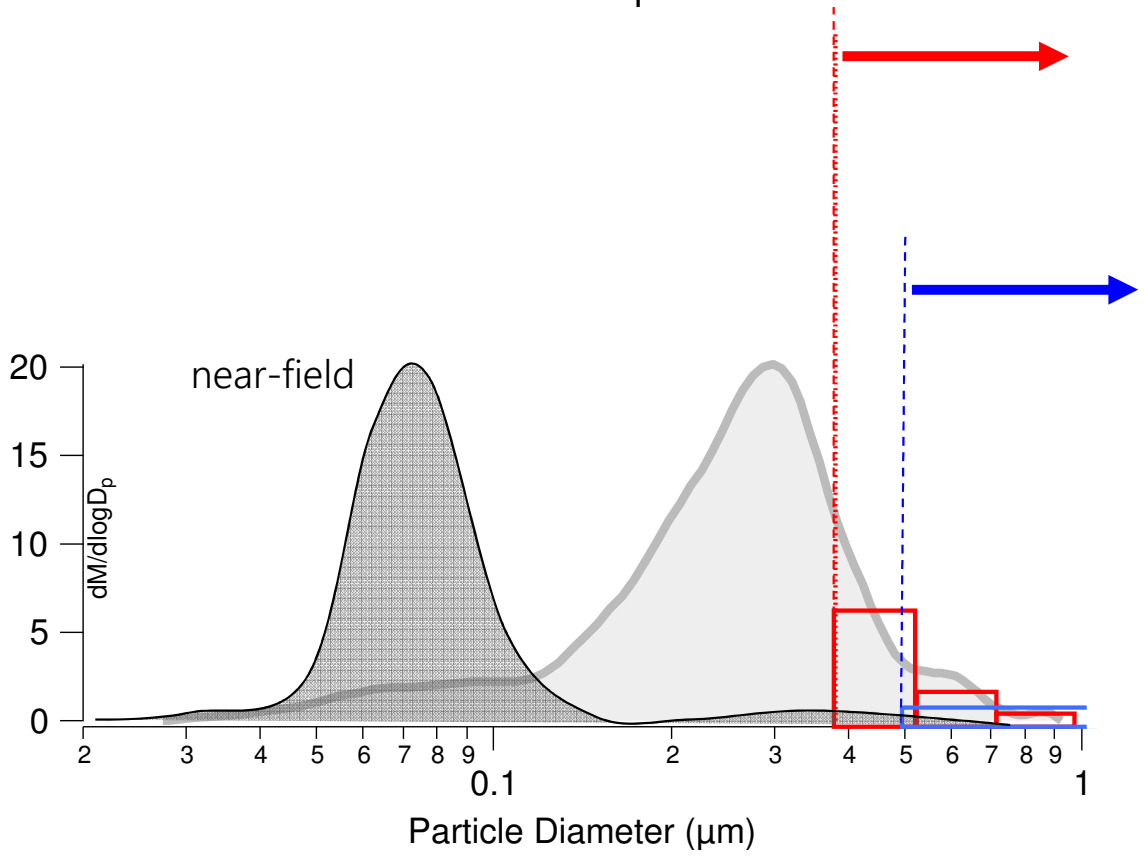

Challenge: Real-world particle size distributions –

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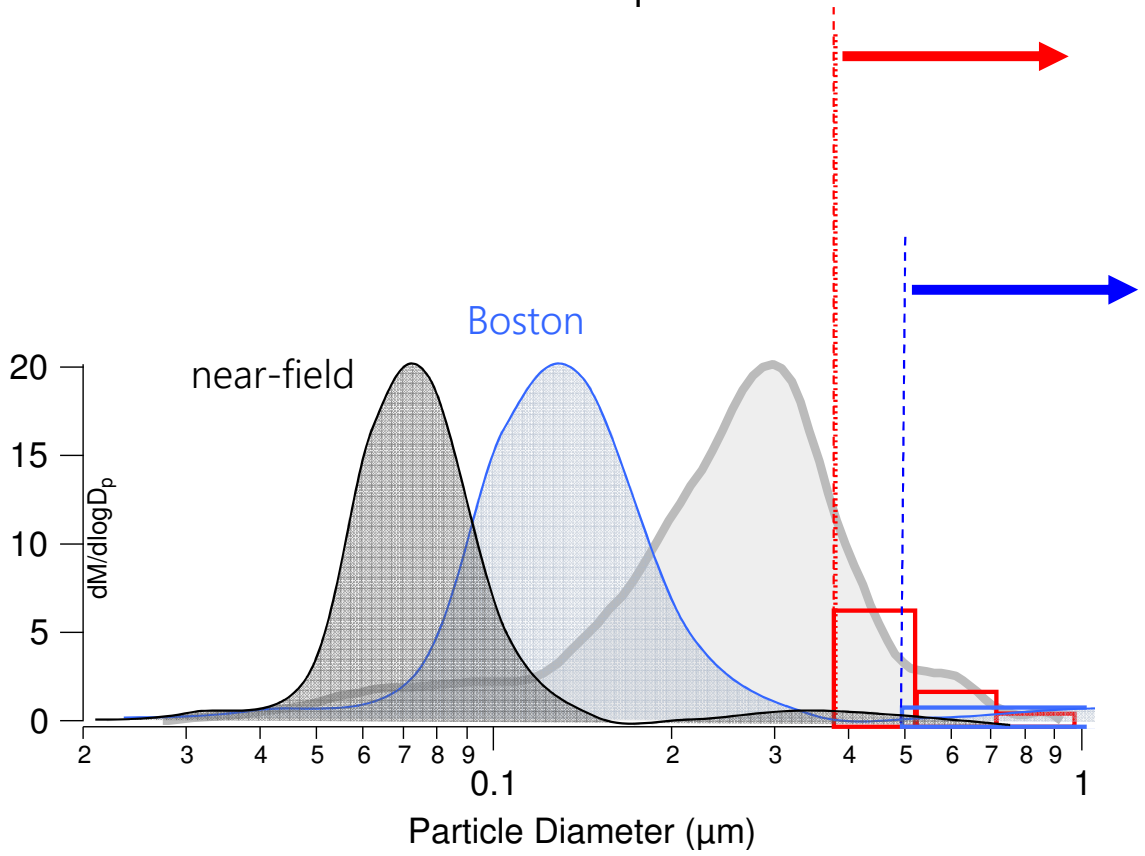
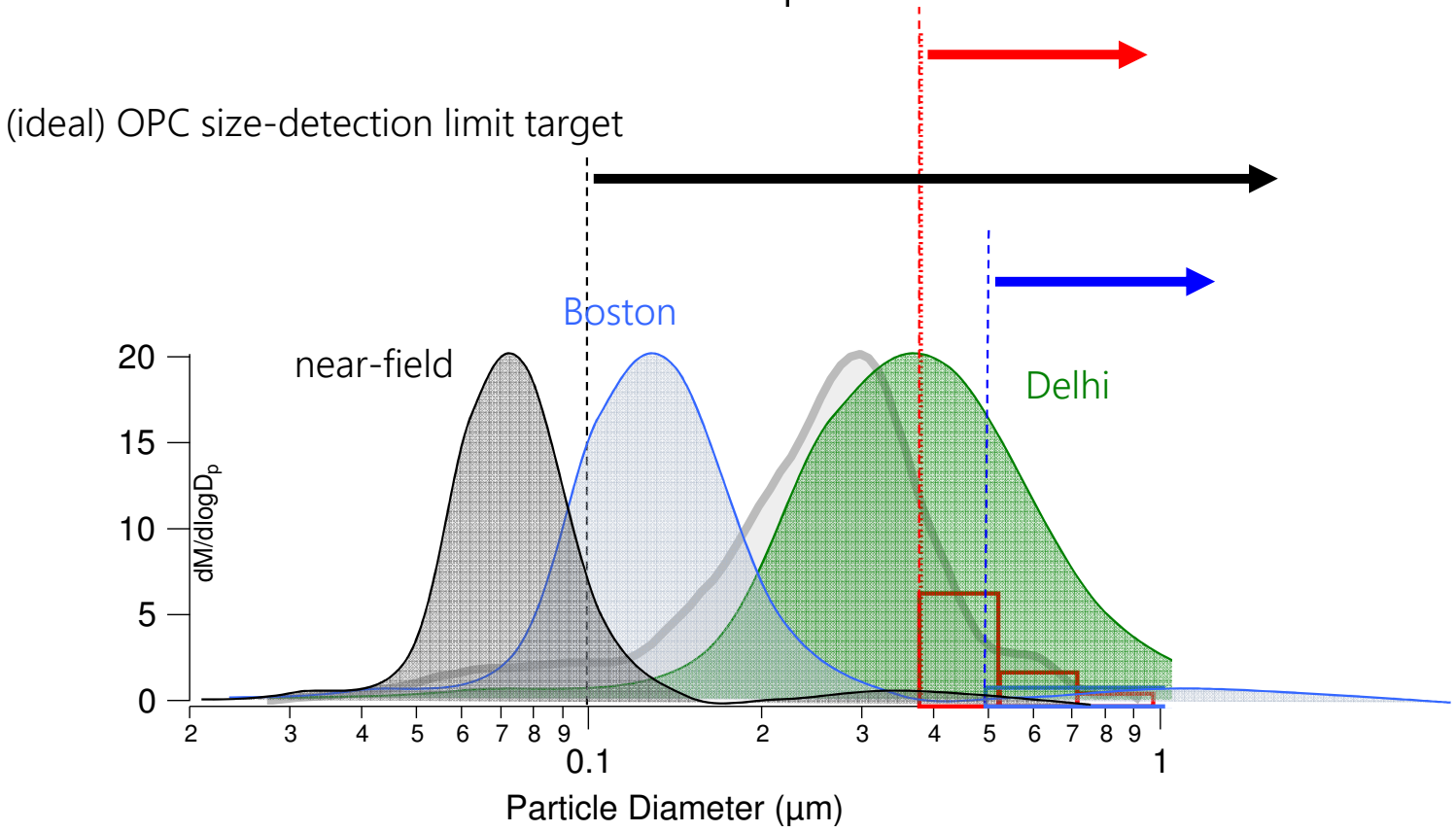
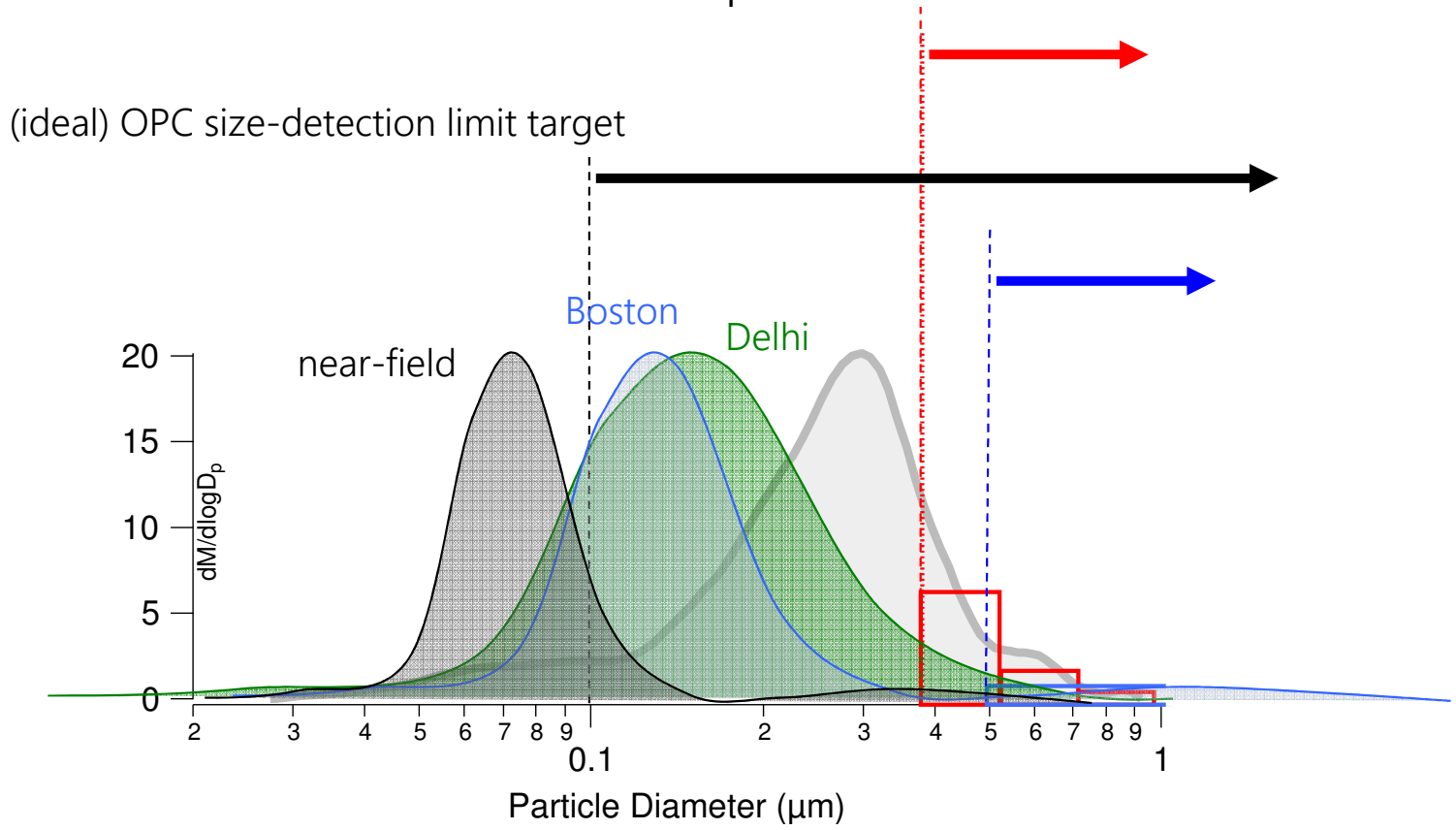


Challenge: Real-world particle size distributions –
'accumulation mode' d_p < 0.2 µm



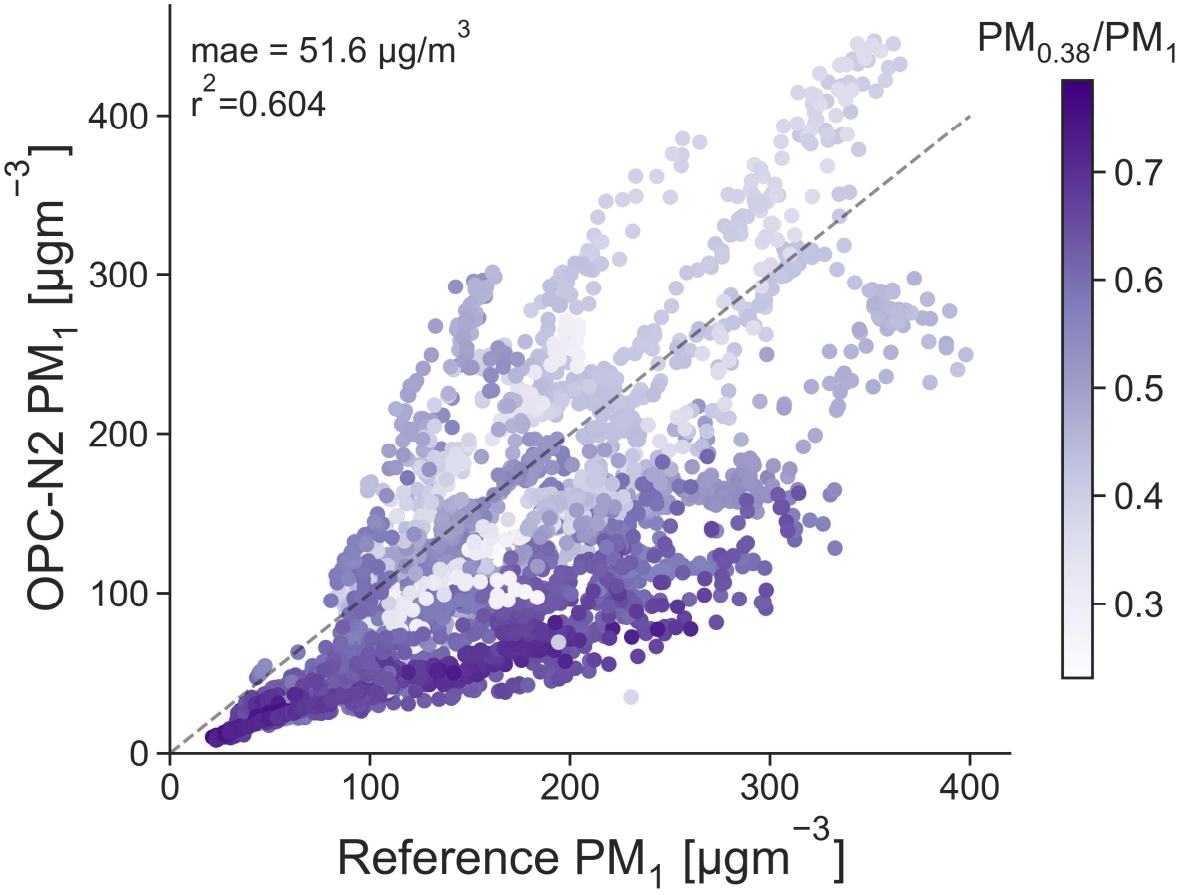
Variability in the size distribution of ambient particulate matter changes the fraction of suspended PM detected by the low-cost OPC

Challenge: Real-world particle size distributions –
'accumulation mode' d_p ~ 0.2 – 0.3 µm



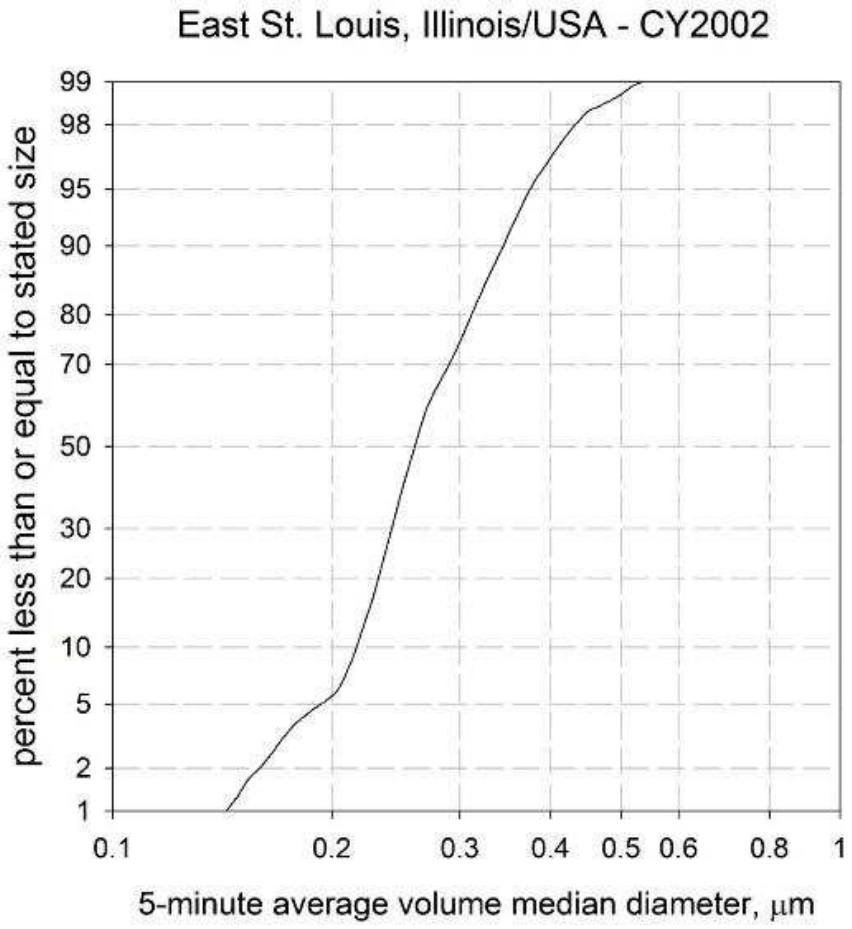
Variability in the size distribution of ambient particulate matter changes the fraction of suspended PM detected by the low-cost OPC

Real world PM size distributions change over time. This is a fact.



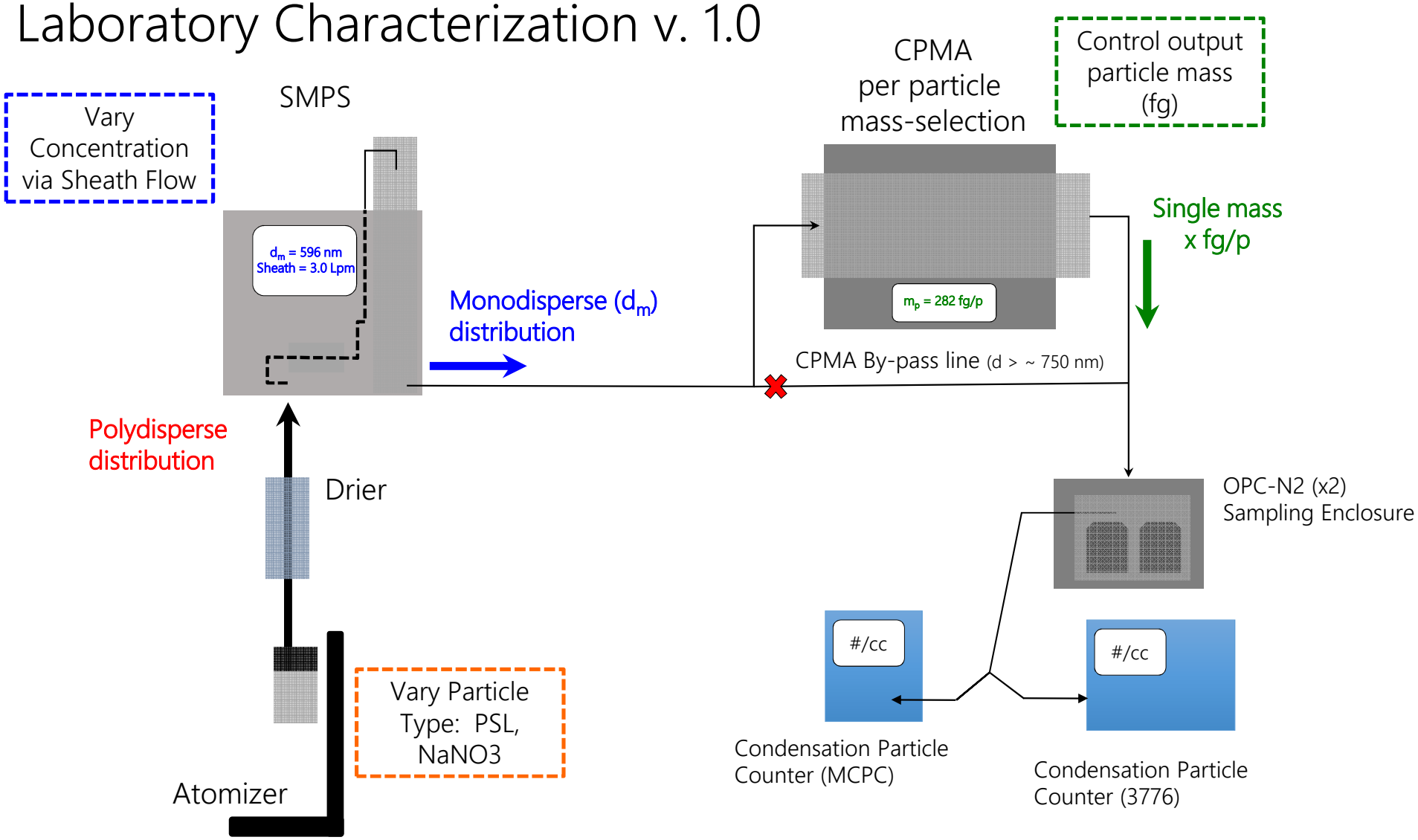
- Figure thanks to David Hagan – Check out his poster later this afternoon.

Real world PM size distributions change over time. This is a fact.

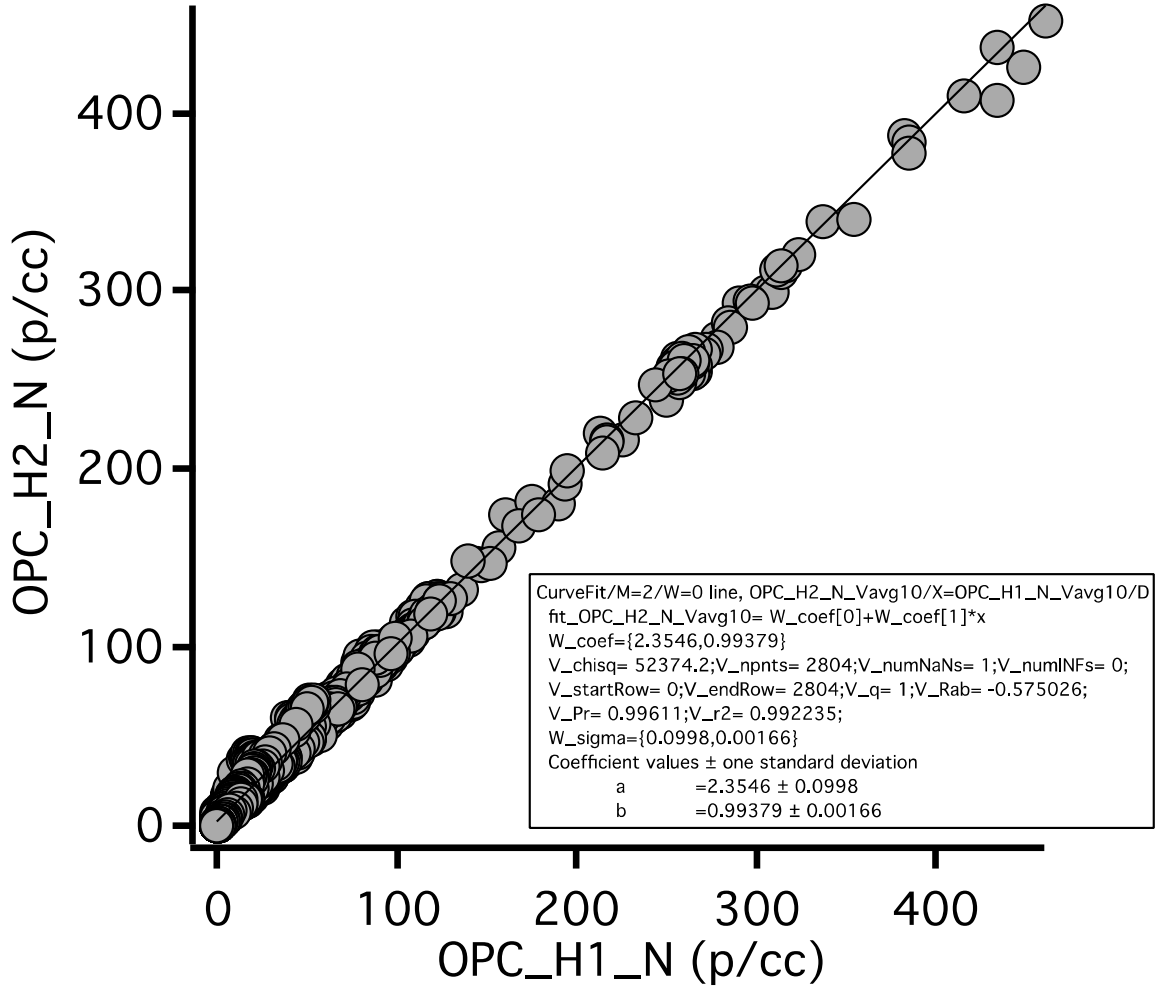


- Figure thanks to Jay Turner

PM Laboratory Characterization v. 1.0

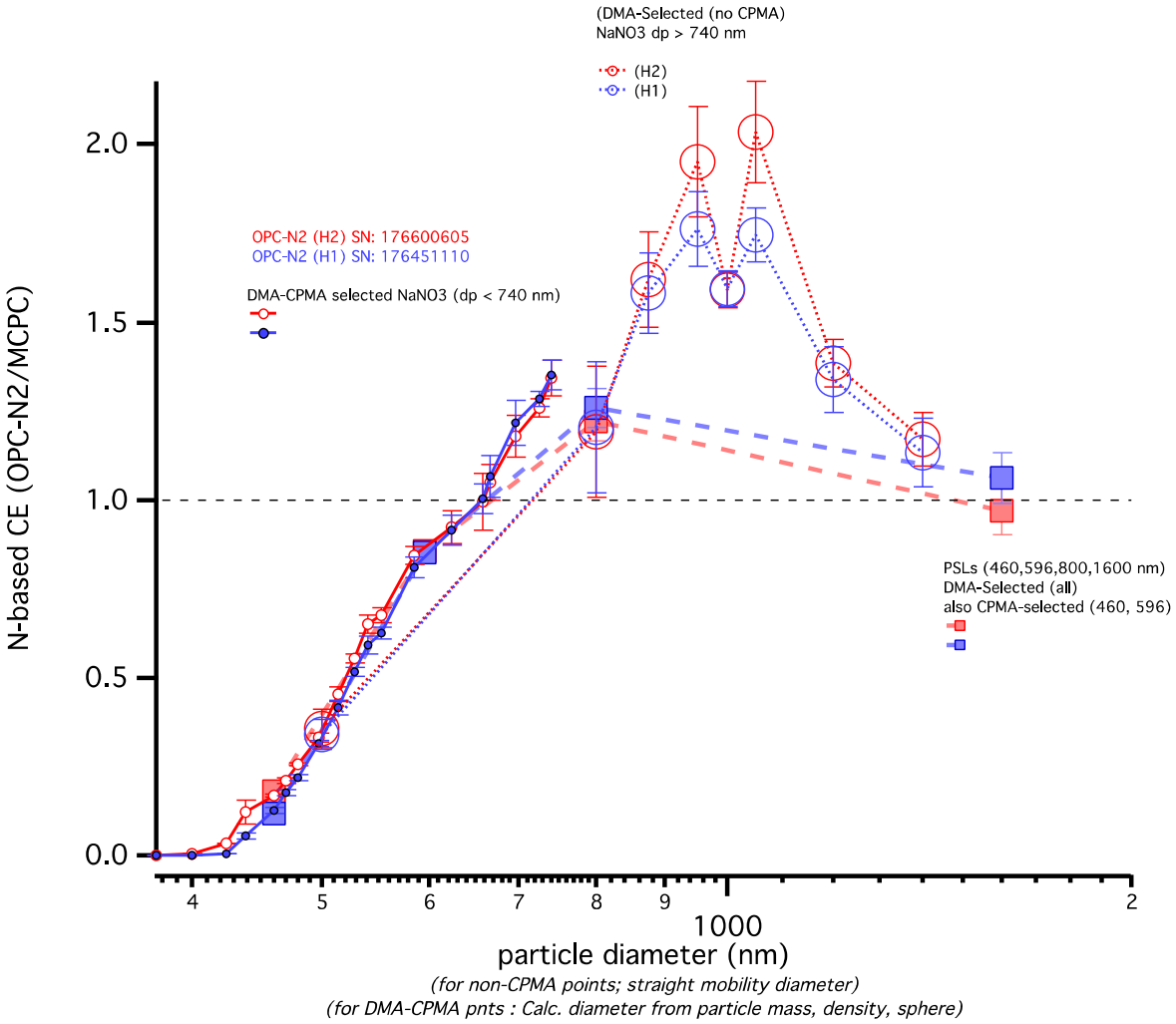


OPC-N2 unit-to-unit comparison (NUMBER CONC)



- OPC-N2 unit exhibit similar response/detection.
- Integrated N based on integration of my own dN/dLogd matrix combining raw counts and real-time flow rate metrics

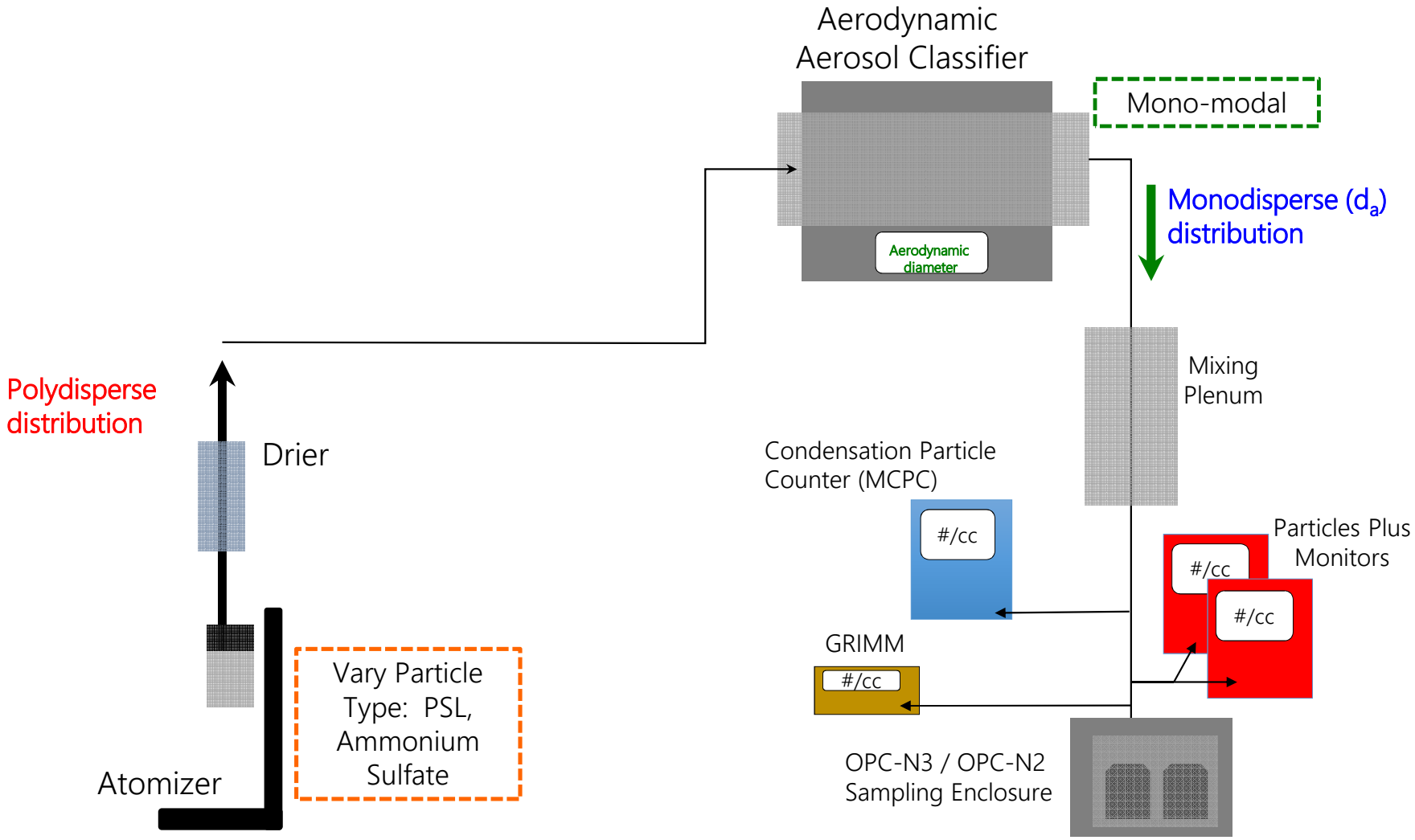
Size dependent collection efficiency (N-based) of OPC-N2



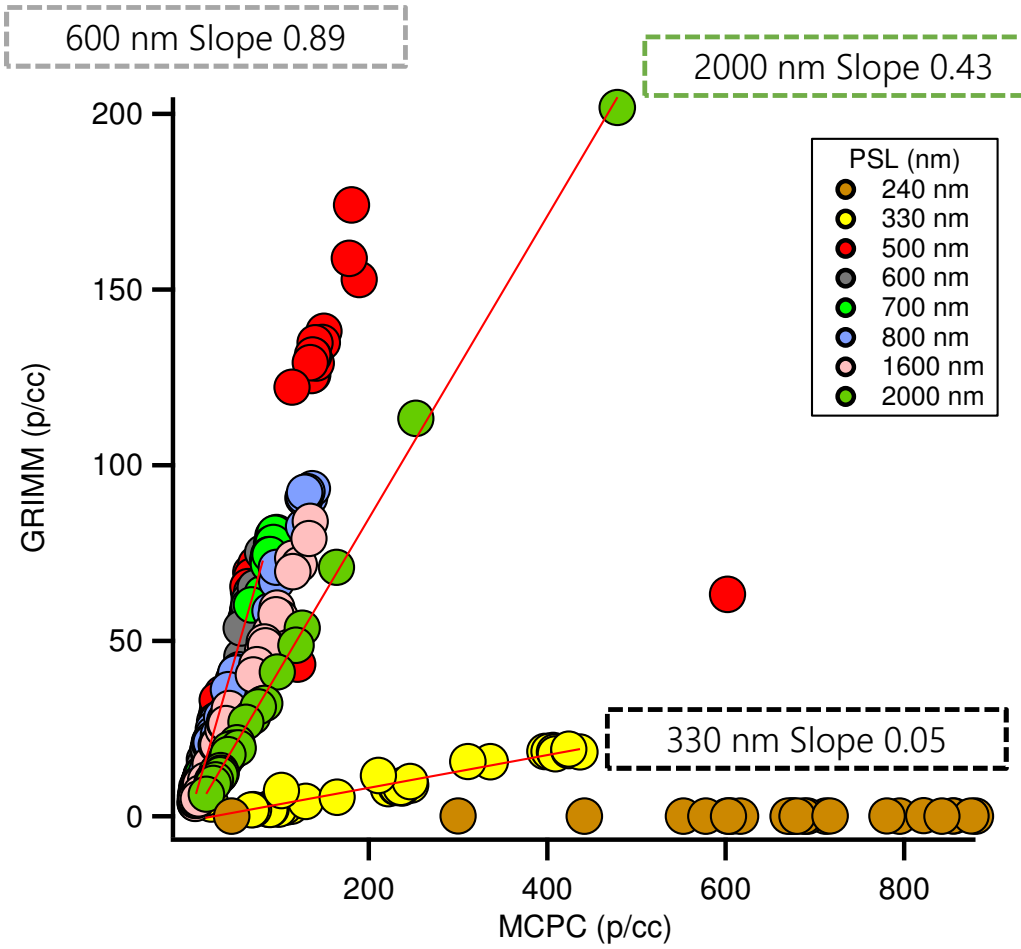
Number-based size detection efficiency of the two OPC-N2 units is LOD_{50} ~ 550 nm

- 460 nm PSL: 12%; 19% CE
- 596 nm PSL: 85% CE

PM Laboratory Characterization v. 2.0



“Truth isn’t true”

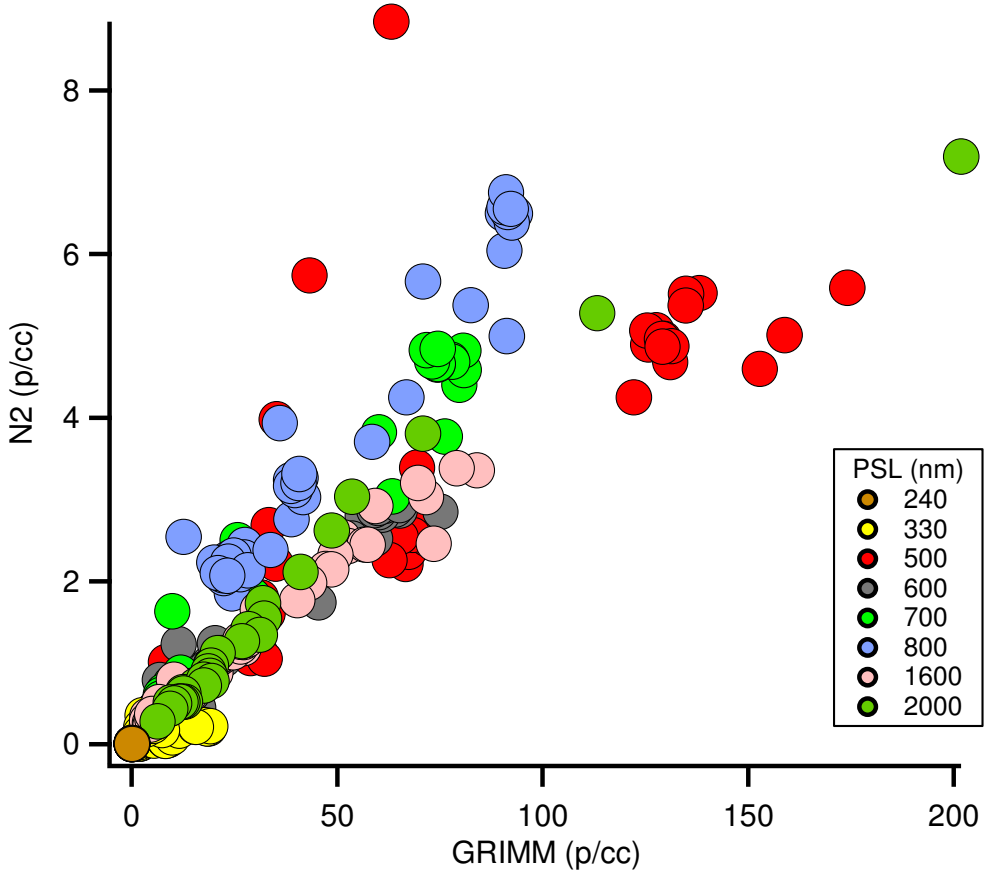


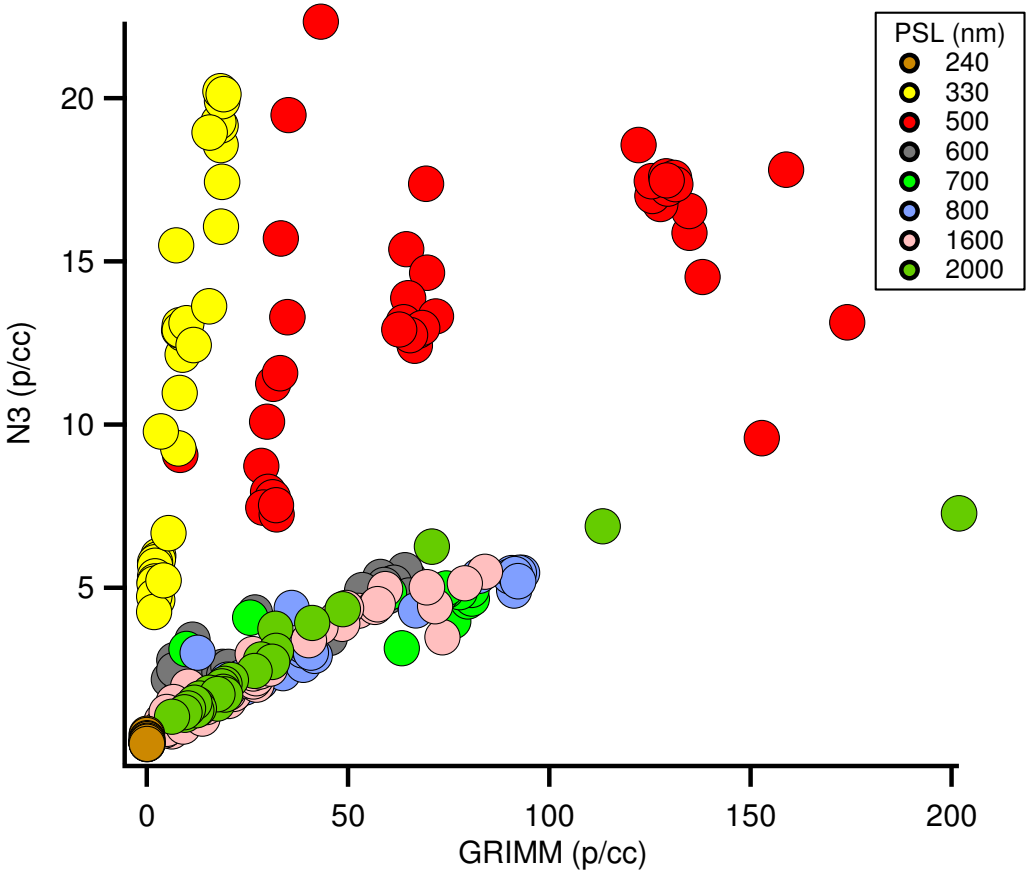
Need to understand the GRIMM-to-CPC ratio for 2 um PSLs. It is not clear why the GRIMM is apparently undercounting at this size.

Suspect that 330 nm detection issues with GRIMM are due to minimum size detection limit. If operating at SPEC, GRIMM should measure 100% of these particles.

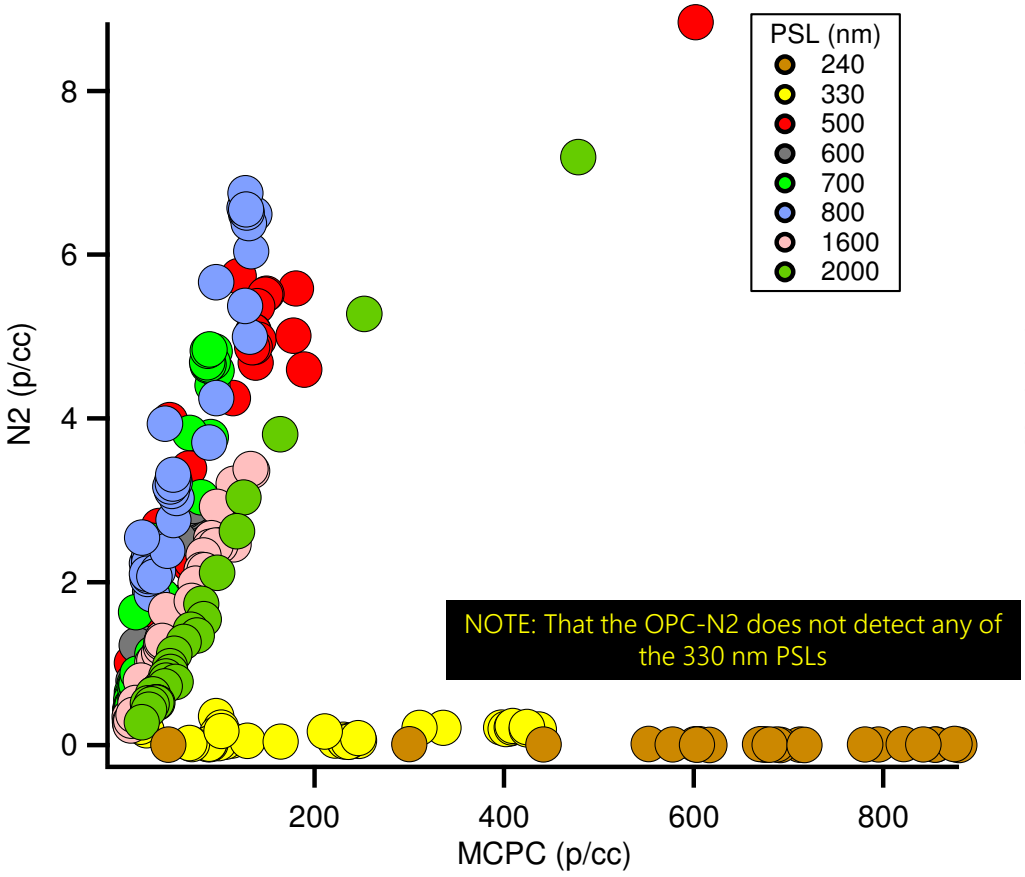
OPC-N2 / OPC-N3 vs GRIMM

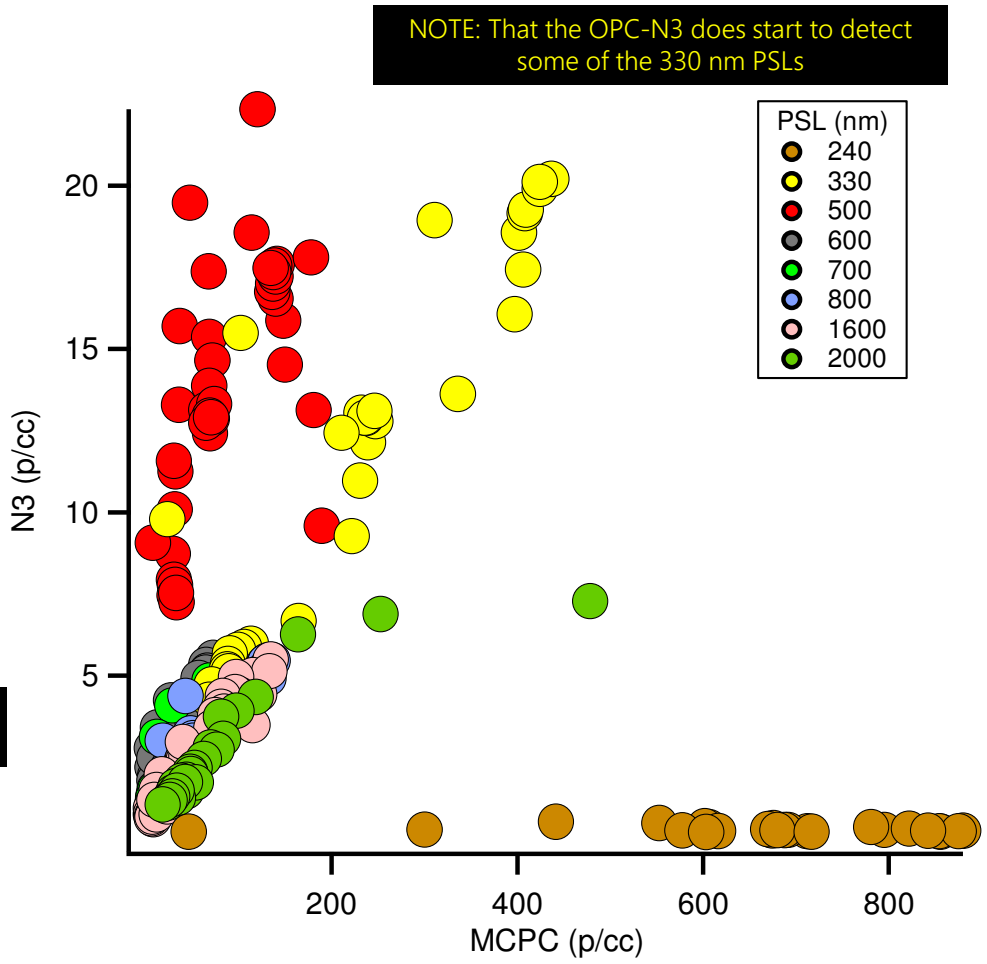
Residence time of the sample volume for the OPC-N2/N3 enclosure needs to be more closely examined..



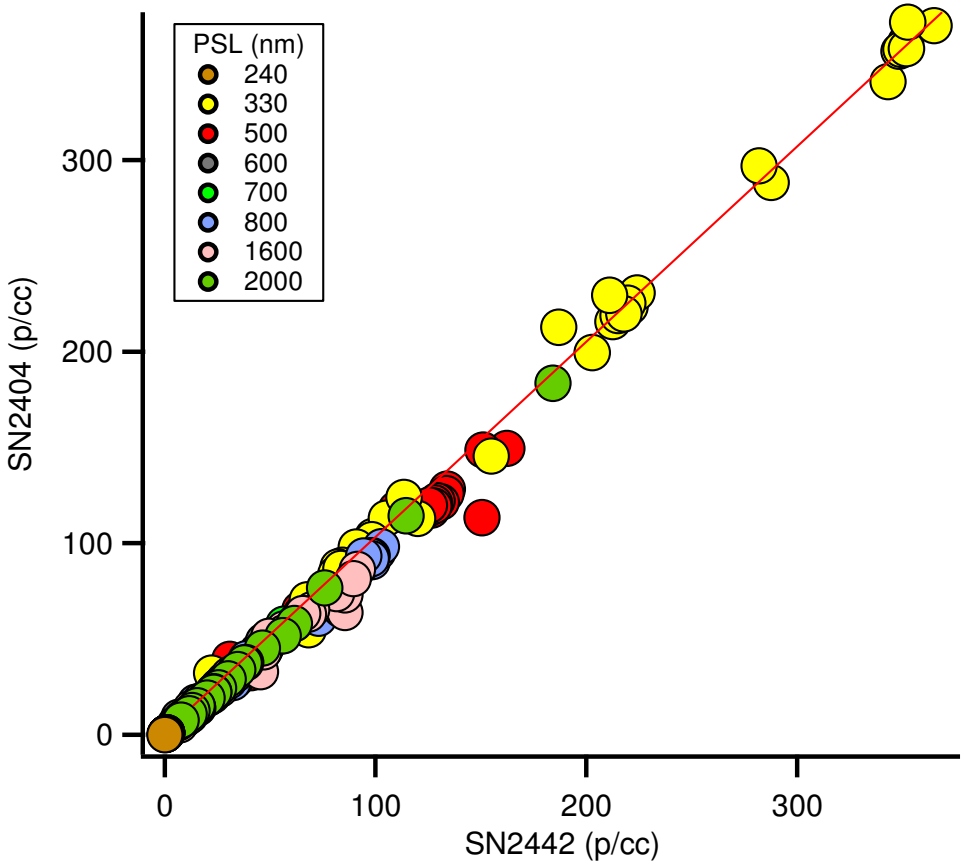


OPC-N2 / OPC-N3 vs CPC





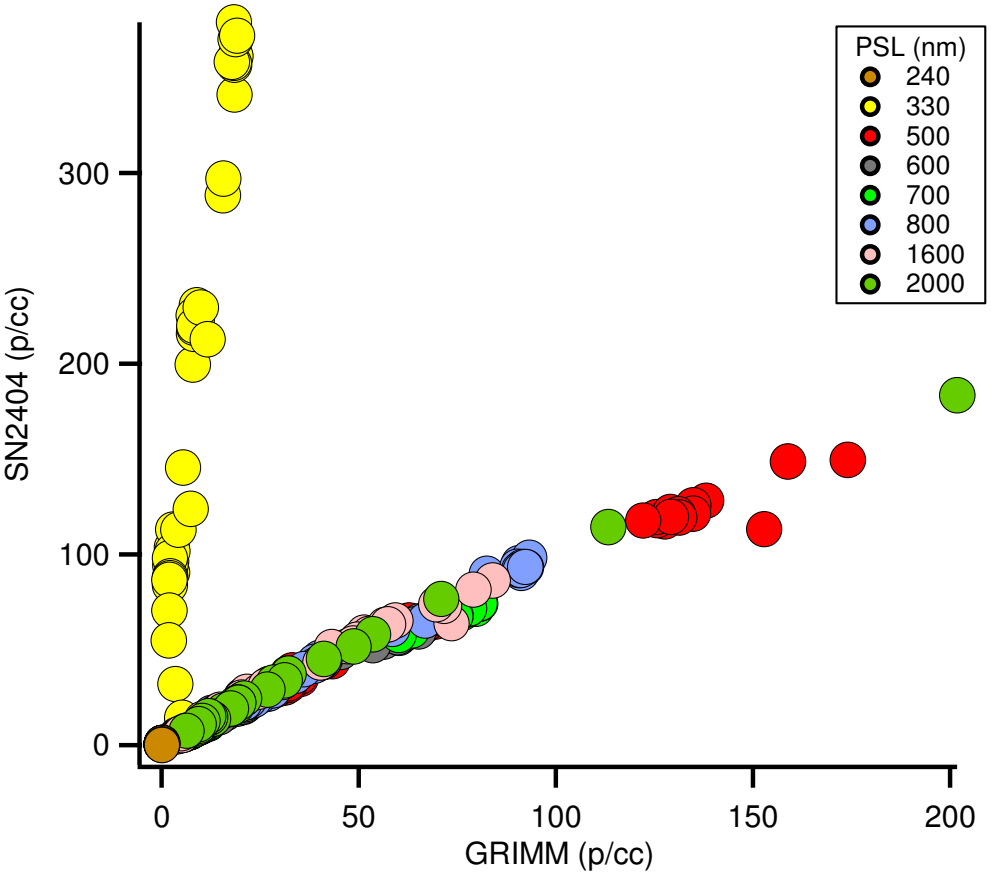
Particles Plus 2404 vs Particles Plus 2442

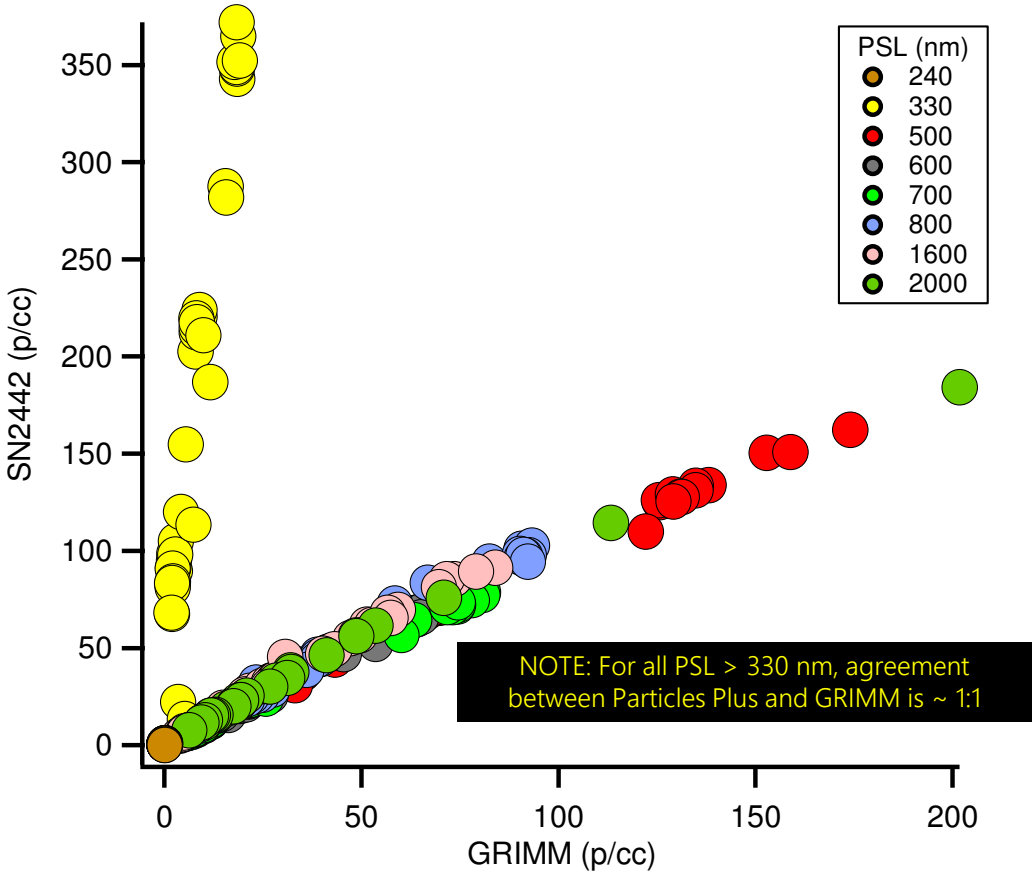


CurveFit/M=2/W=0 line,
SN2404_intN_Vavg30[17559,17595]/X=SN2442_intN_Vavg30[17559,17595]/D
Curve fit with data subrange:
SN2404_intN_Vavg30[17559,17595]
fit_SN2404_intN_Vavg30= W_coef[0]+W_coef[1]*x
W_coef={1.3403,1.0197}
V_chisq= 1795.16;V_npnts= 37;V_numNaNs= 0;V_numINFs= 0;
V_startRow= 17559;V_endRow= 17595;V_q= 1;V_Rab= -0.860209;
V_Pr= 0.99808;V_r2= 0.996164;
W_sigma={2.31,0.0107}
Coefficient values ± one standard deviation
a =1.3403 ± 2.31
b =1.0197 ± 0.0107

Particles Plus vs GRIMM

NOTE: We know that GRIMM is systematically undercounting 330 nm particles (see slide 15)

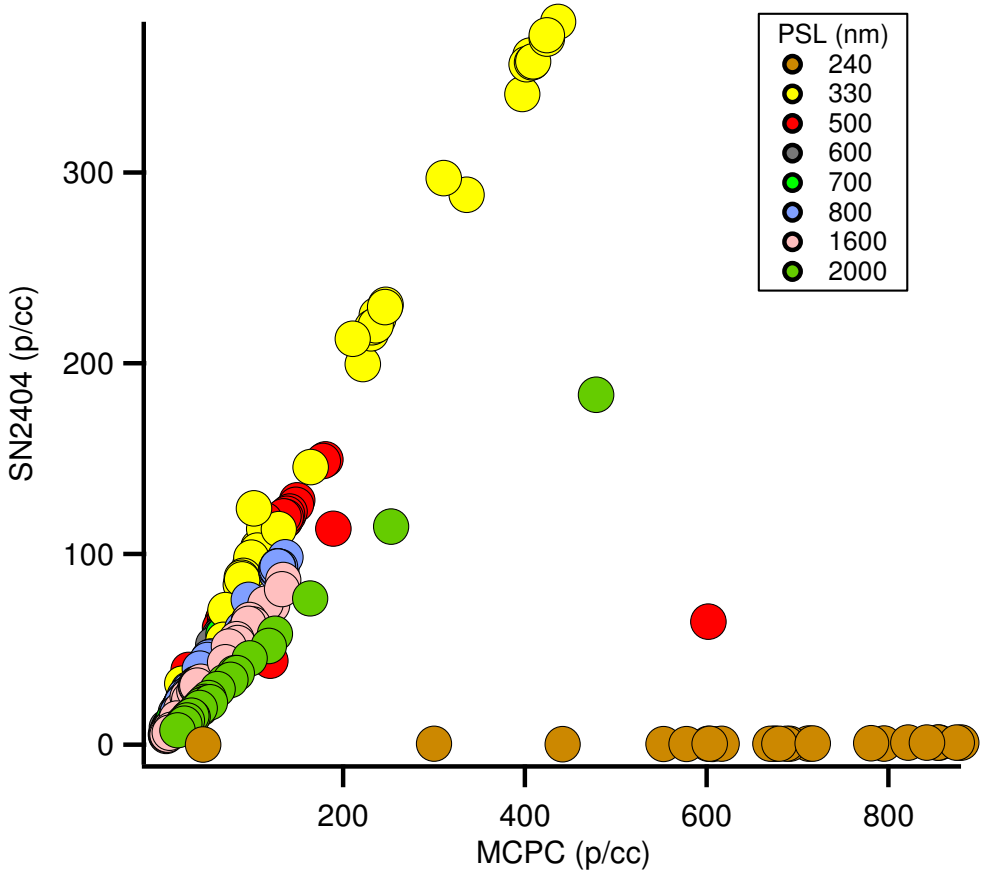


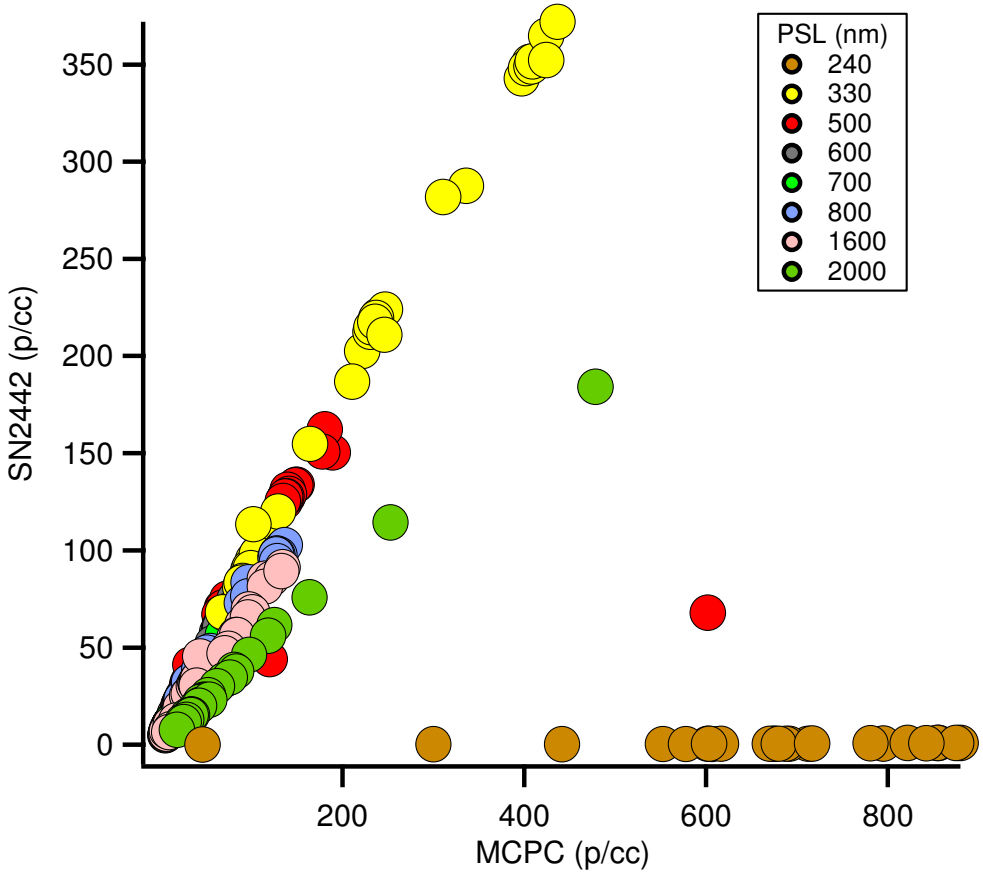


NOTE: For all PSL > 330 nm, agreement between Particles Plus and GRIMM is ~ 1:1

Particles Plus vs CPC

- Slope ~ 0.84-0.85 @ 330 nm PSL
- Slope ~0.4 @ 2000 nm PSL (relative to CPC counts); GRIMM-to-CPC also ~0.4

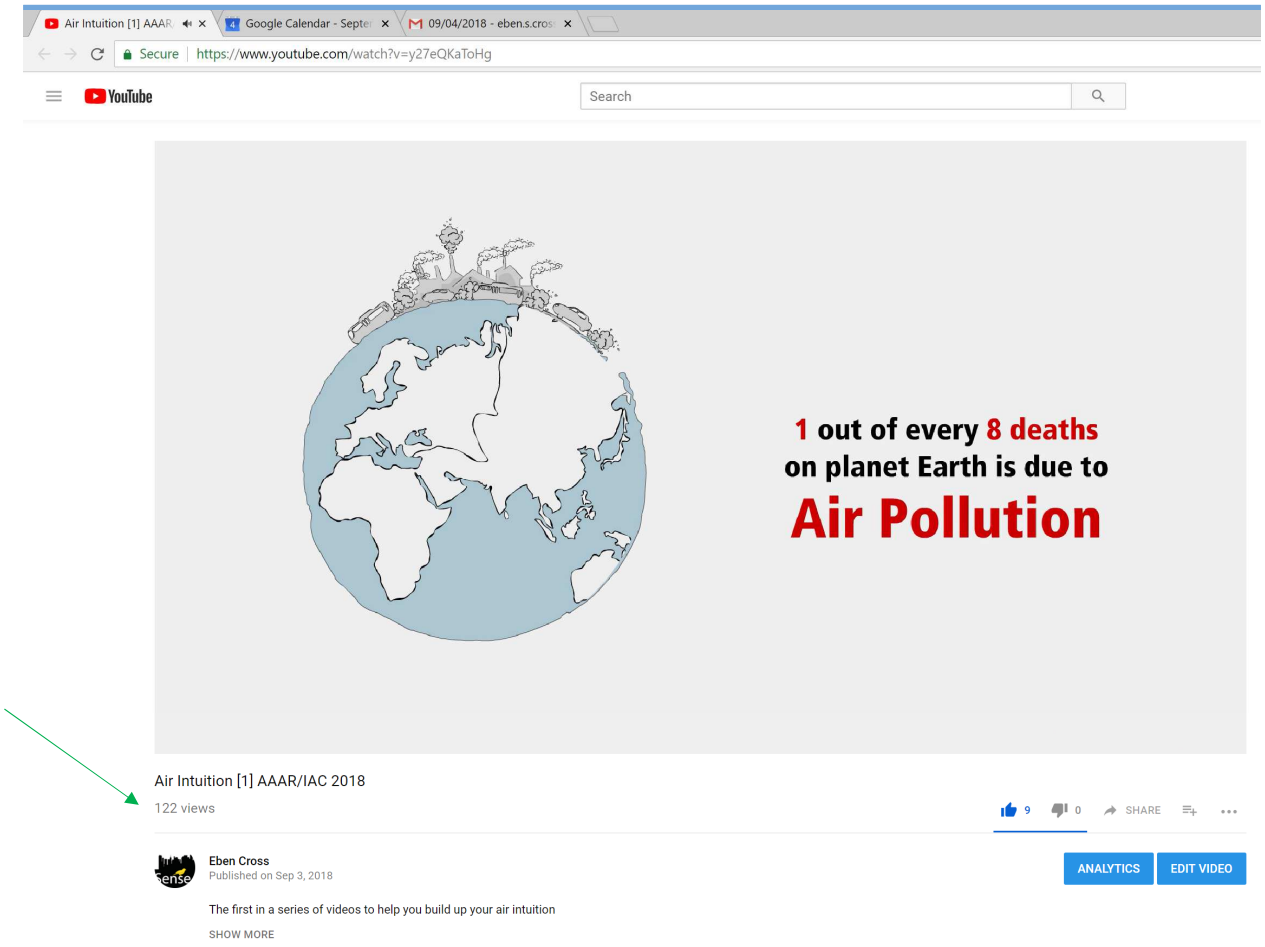




Ask yourself:

- Do I trust the stated minimum size detection limit of my low-cost OPCs?
- Does my OPC measure single particle scattering events (counting and binning them one by one) or total scattering of the all the sampled particles at once? (if the later, can I really trust the 'counting' and 'binning' data… or is all that just 'make believe')
- How does variability in RH effect my measurement? Is this effect bigger than the effect of temperature, chemistry (refractive index), morphology, or density?
- How many particles (per cm3) can my device measure before coincidence becomes an issue?
- How does the size-mode of my actual ambient PM2.5 distribution change over time and what does that mean for the fraction of PM2.5 (or PM1) that is reported by my device?
  - If/when my device encounters a wildfire plume, will that lead to over (or under) counting of the PM?
  - If I use my device near a roadway, what PM signal is the device actually seeing? Does that signal reveal pollutant variability due to combustion source emissions or am I simply measuring re-suspended road dust with my device.

Extra: Helping the general public build up their 'Air Intuition'



Sharing is caring

https://www.youtube.com/watch?v=y27eQKaToHg

Funding: AAAR Strategic Funds