

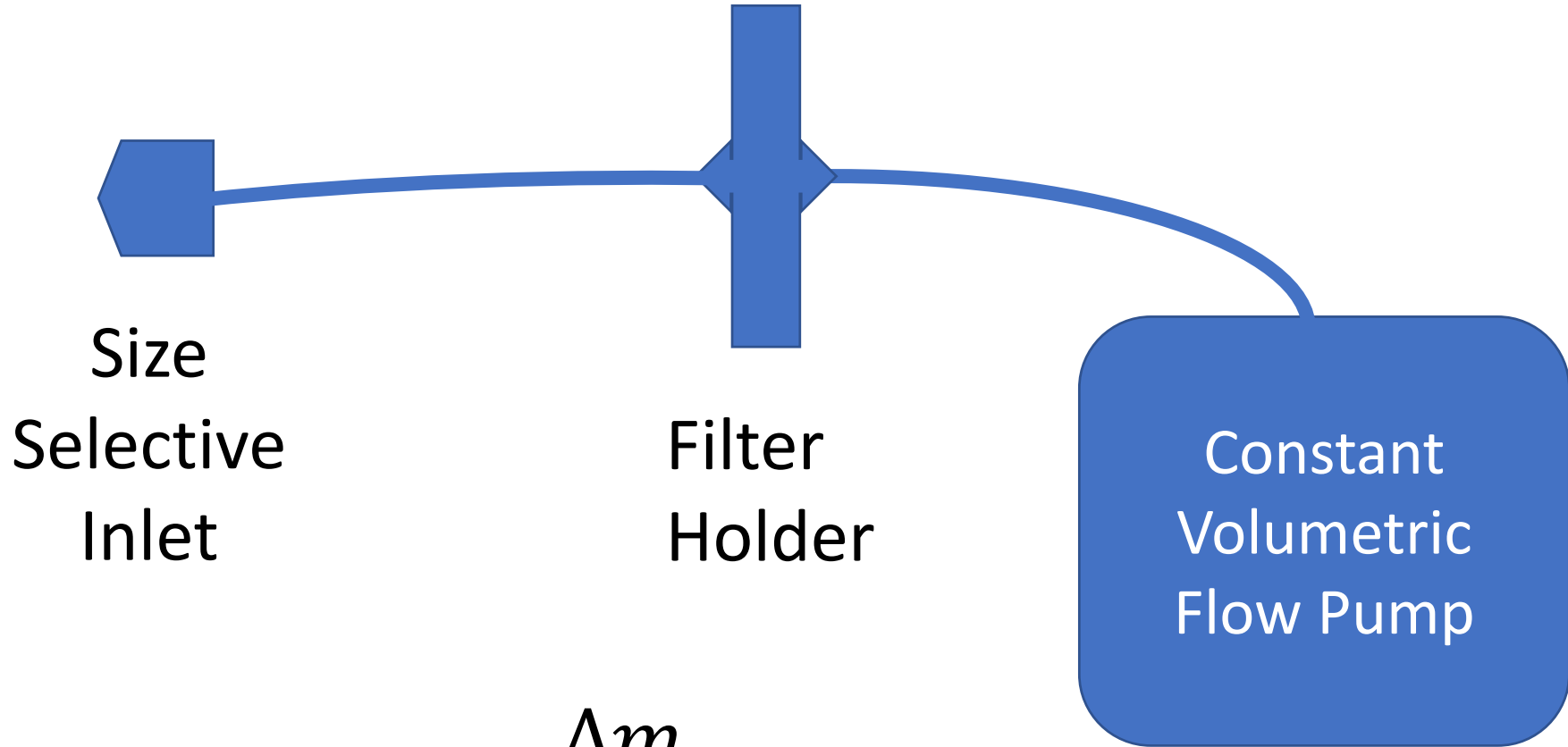


CLIMATE
SOLUTIONS
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Enabling Regional Stove Testing Centers to do Personal Exposure Measurement

Combining gravimetric measurements with real
time filter
reflectance and pressure drop measurements

Gravimetric Measurement



$$[PM2.5] = \frac{\Delta m}{Flow * \Delta t}$$

Problem: the balance available in testing centers are not precise enough.

$$\Delta m = [PM_{2.5}] * Flow * \Delta t$$

$$\Delta t = 24\text{h}$$

$$\text{Flow} = 1.5 \text{ L/min}$$

$$PM_{2.5} = 50 \text{ ug/m}^3$$

$$\Delta m = 108 \text{ ug (filter weight } \sim 100\text{mg)}$$

Micro balance repeatability error = $3\text{ug} * 2 = 6\text{ug}$ (5.5% of mass loading)

Semi Micro balance repeatability error = $30 \text{ug} * 2 = 60 \text{ug}$ (55% of mass loading)

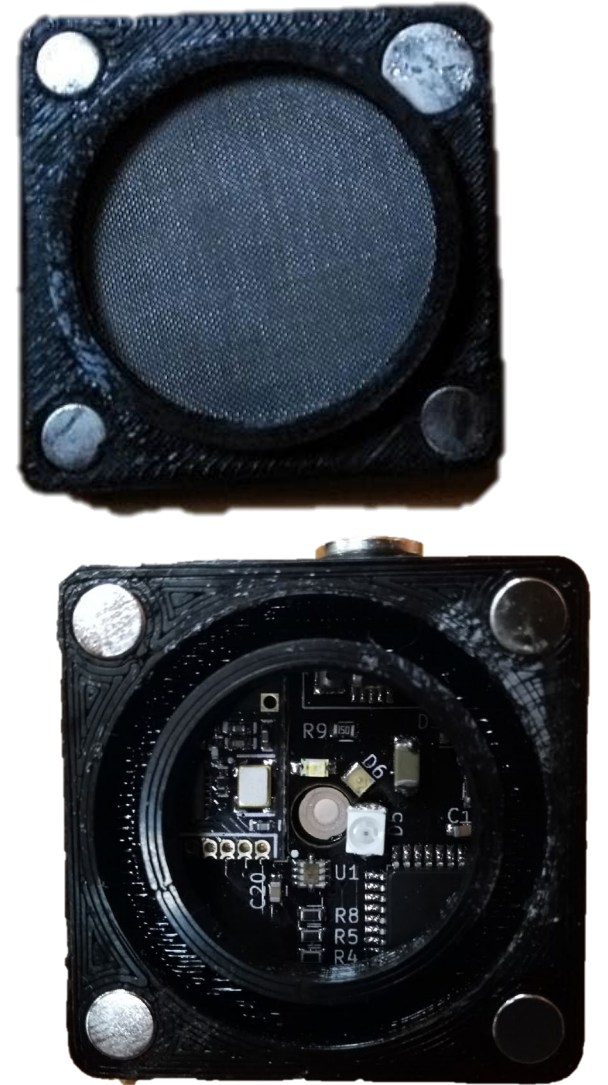
Solutions: how can we increase mass loading?

$$\Delta m = [PM_{2.5}] * Flow * \Delta t$$

- Higher flow: Flow is limited by the size of the battery
- Longer duration
 - Single household: duration is limited by willingness to cooperate and the battery
 - Multiple households, one filter = solve size and compliance issue but we lose inter-intra household variance measurement.
 - Variance is needed to do statistical inference.
 - => **How can we measure inter-household variance?**

New Tools: “Smart Filter Holder”

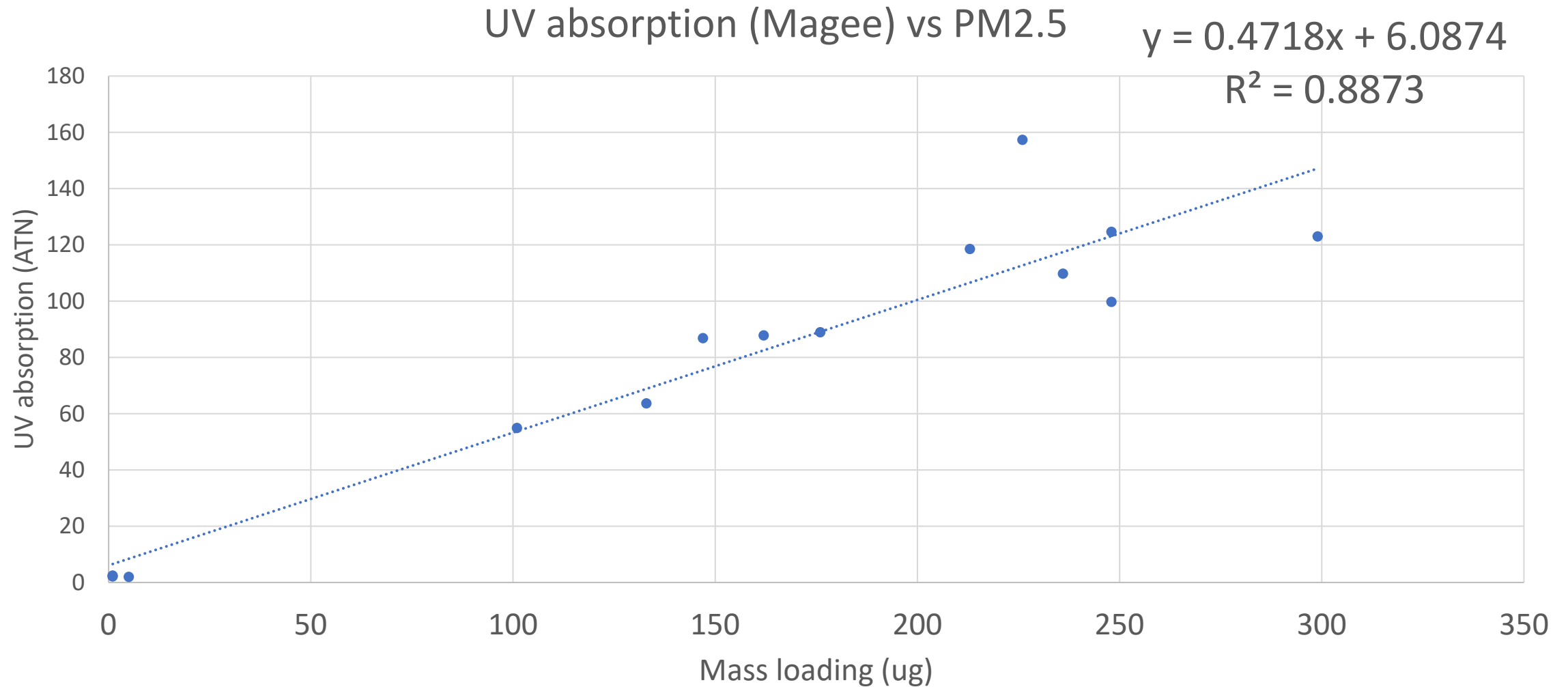
- Hold the filter
- Provide real time readings of the Infra-Red, Green and UV light reflected
- Measure temperature/humidity of air just before the filter.
- Wireless
- Integrated with HAPEX, EXACT, FUEL



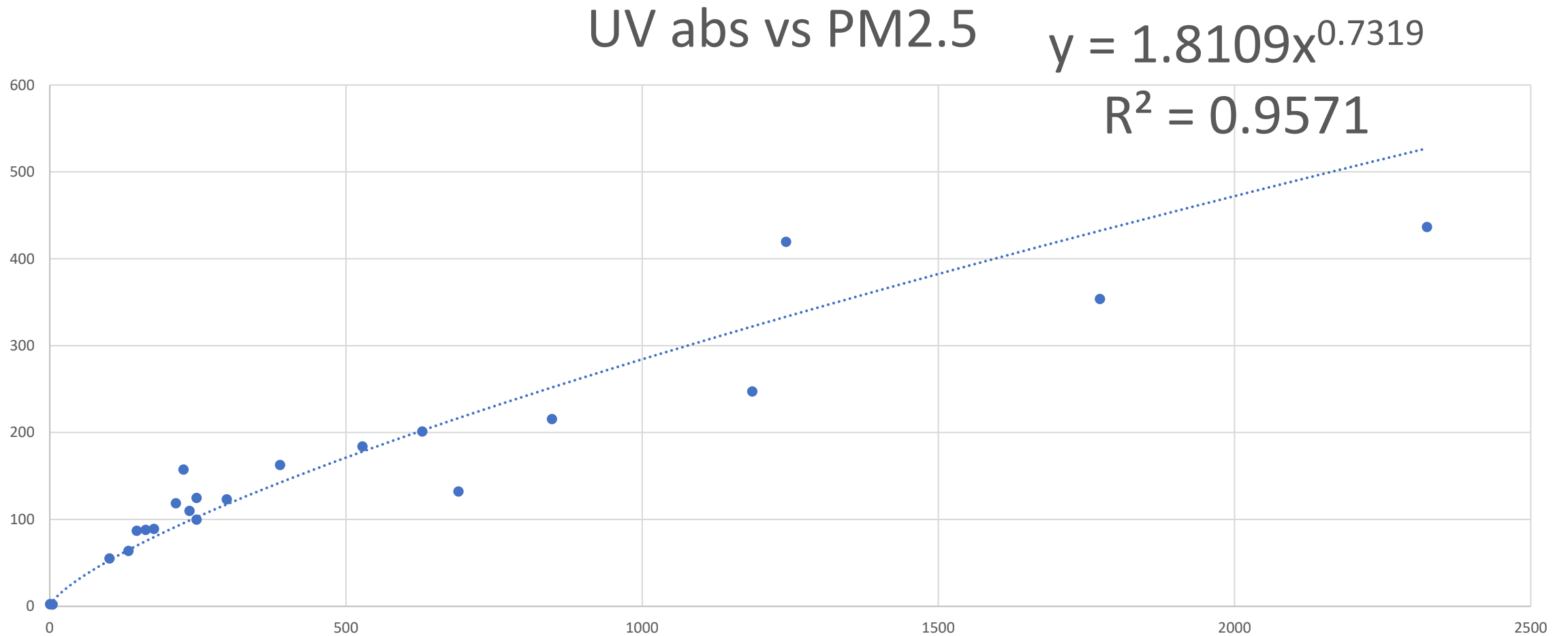
New Tool: “Micro Pump”

- 0.5 L/min for up to 24h
- Close loop flow regulation
- Compensation for change of Temperature, Pressure, Relative Humidity
- Measure pressure drop across the filter down to 0.02 Pa (1/20 inch of air) – No Pulsation
- Small
- Wireless
- Integrated with HAPEX, EXACT, FUEL

How well can change of filter absorption can reflect mass loading?

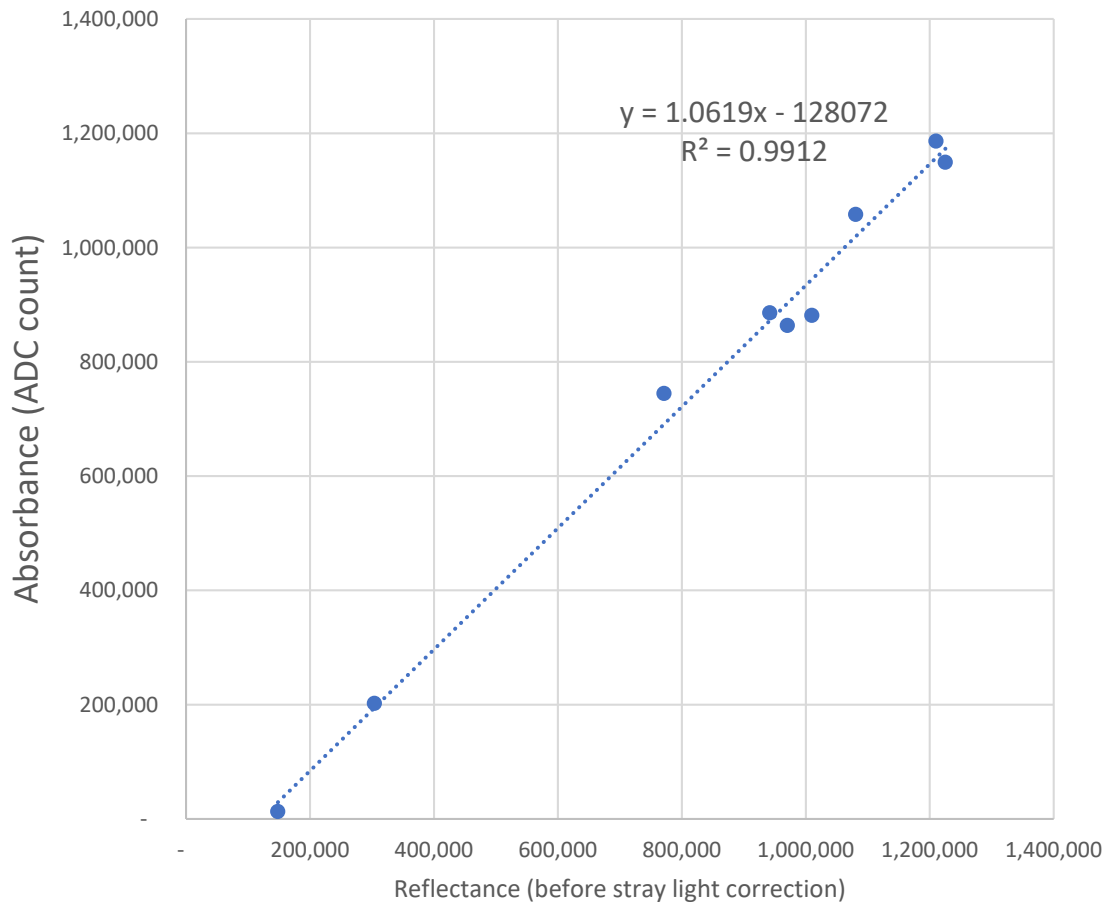


Loading artifact at higher concentration

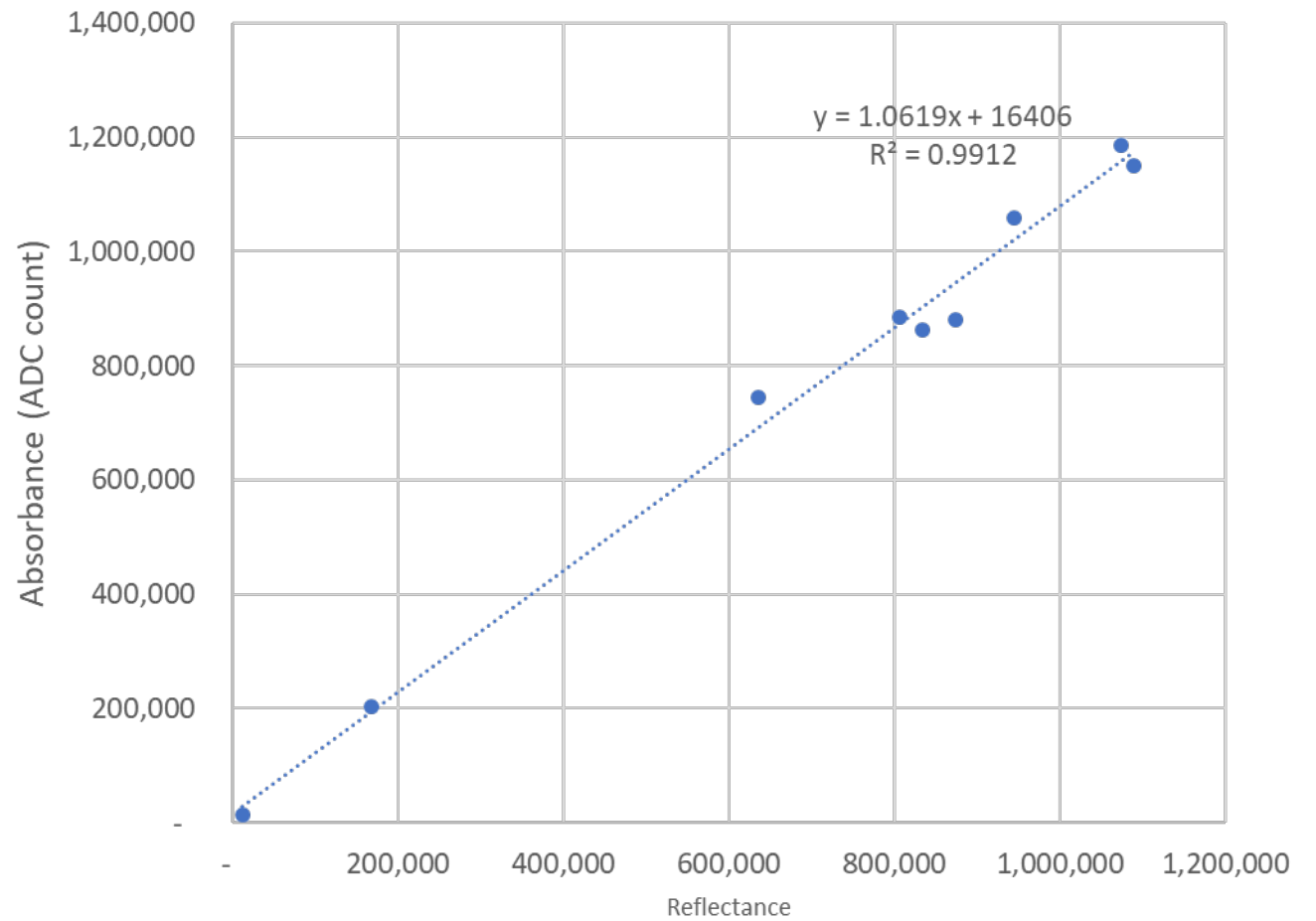


Light Absorbed vs Light Reflected

Correlation between Absorbance and Reflectance (Emfab filters)



Correlation between Absorbance and Corrected Reflectance (Emfab filters)

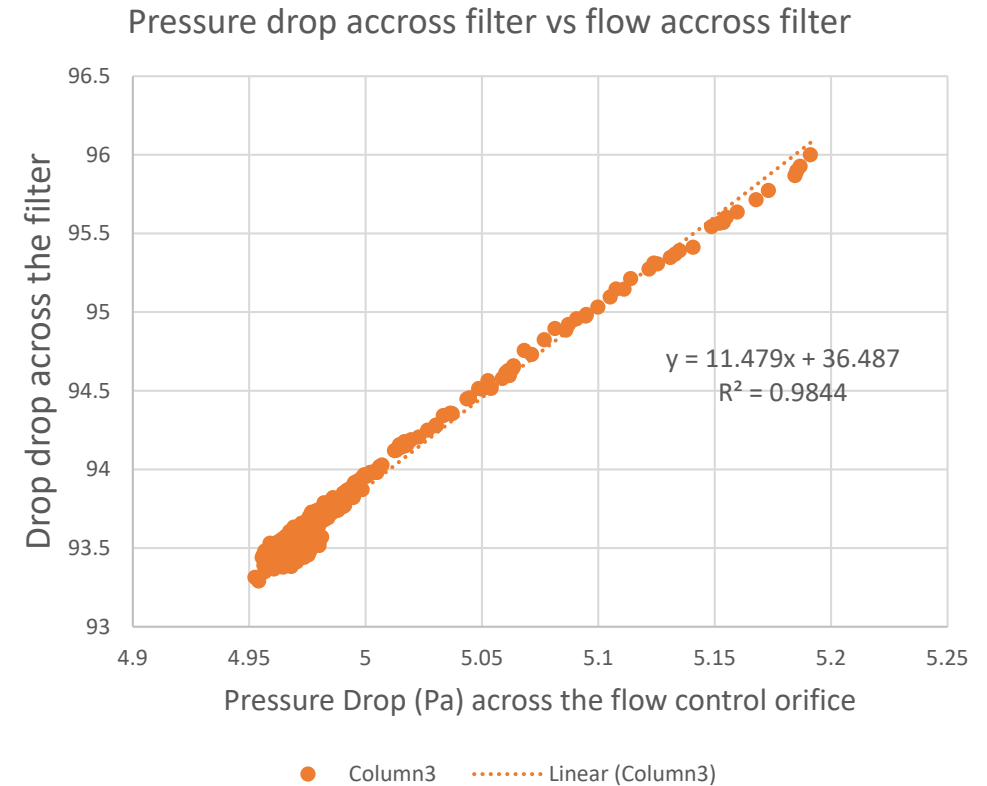


How well can change in pressure drop reflect mass loading?

- Hard Problem!

- At low flow, pressure drop change due to mass loading are small
- The flow impact the pressure drop across the filter.
- Need precise flow control and correction to isolate effect of mass loading

=>No conclusion at this time



Potential of this method

- Get mean exposure with precision similar to individual filter on a micro-balance
- Get variance close to actual variance
- Cost of filter analysis is 20 times cheaper
- Might perform better than individual filter at low mass loading.

Limit of the method

- Quite complicated.
- Potentially challenging to remain within the specified range (avoid loading artifact)
- At what time scale Intra –household variation analysis is possible?

Other potential application

- Stove field emission testing (with CO/CO₂ sensor)
- Black Carbon / Brown Carbon emission analysis
- Filter integrity: monitor temperature during&after sampling (volatilization of OC), check that the holder was not opened.

Future Work

- Compare Absorbance/Reflectance/Mass Loading on a set of 100 PTFE and 100 Emfab Filters
- Investigate further effect of mass loading on pressure drop
- Test the method on a 2 weeks lab simulation against “classic” gravimetric measurement
- Test the method in the field against “classic” gravimetric measurement
- Characterize precision achievable (intra household variation).
- Please reach out if you want to collaborate on this:

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