

PM_{2.5} and UFPs in Sweden and Northern China – The Influence of Filter Age and Pre-Ionization

VIAQ-22-04

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(Wei et al. 2020)

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Background

➤ Volvo Cars Industrial PhD Project:

Develop energy efficient air quality solutions for vehicle cabins



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1. Literature study



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1. Literature study



2. Baseline testing

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1. Literature study

3. Model development &
validation

2. Baseline testing

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1. Literature study

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4. AQ solution evaluation

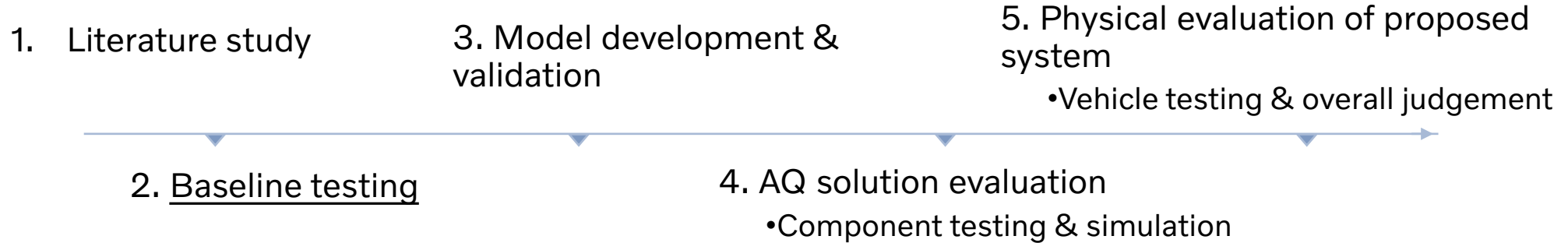
•Component testing & simulation



Background

➤ Volvo Cars Industrial PhD Project:

Develop energy efficient air quality solutions for vehicle cabins



Background

- Scope: Focus on pollutants from incoming sources:
 - Particulate matter (UFP, PM_{2.5})
 - Ozone
 - NO_x SO_x
 - CO₂

Road testing objective

Previously

Increase knowledge

Road testing objective

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- In-cabin exposure levels and outside levels

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- Influence from ventilation airflow and air recirculations (SW controlled HVAC settings)

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Increase knowledge

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- Pre-ionization

Road testing objective

Previously

- In-cabin exposure levels and outside levels
- Influence from ventilation airflow and air recirculations (SW controlled HVAC settings)

Increase knowledge

- Filter status
- Pre-ionization
- Compare different test locations

Measurement method and setup

➤ Campaign 1

- 2018 May-Aug
- Gothenburg, Sweden (Road Tunnel)
- Outside: PM_{2.5} mostly 40 – 80 $\mu\text{g}/\text{m}^3$
- XC90



Measurement method and setup

➤ Campaign 1

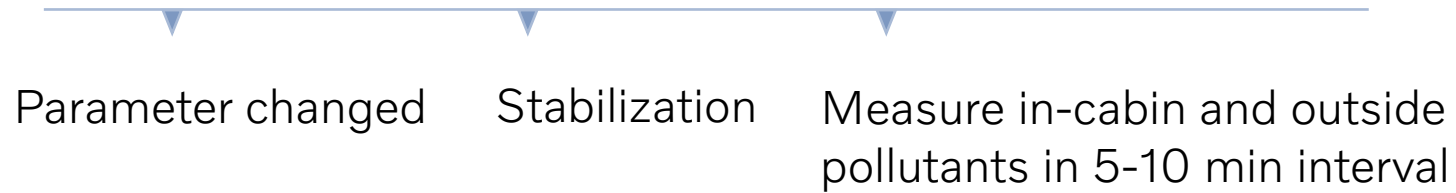
- 2018 May-Aug
- Gothenburg, Sweden (Road Tunnel)
- Outside: PM_{2.5} mostly 40 – 80 µg/m³
- XC90

➤ Campaign 2

- 2019 Jan
- Northern China (Driving on highway/city roads)
- Outside: PM_{2.5} mostly 80 – 300 µg/m³
- S90



Measurement method and setup



Measurement method and setup

Parameter changed

Stabilization

Measure in-cabin and outside
pollutants in 5-10 min interval

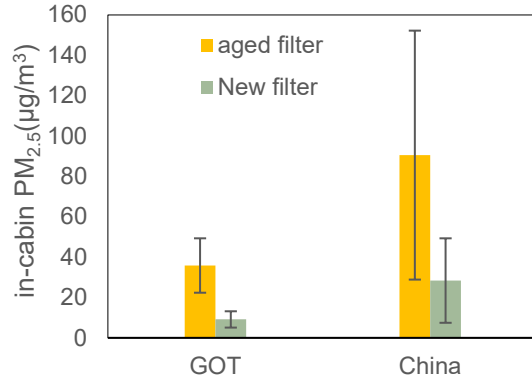
Varied parameters	
Filter status	new and end-of-service
Pre-ionization	on and off
Ventilation airflow and air recirculation	4 levels

Measurement method and setup

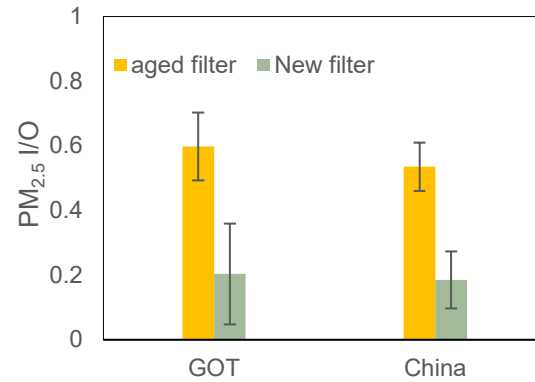
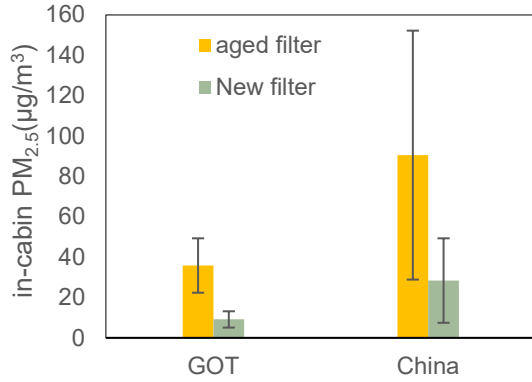


RESULTS - Particle exposure using new & aged filter

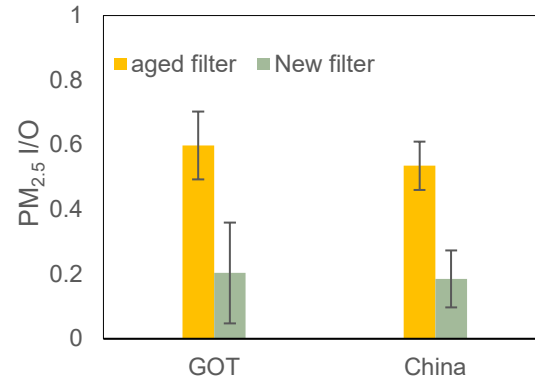
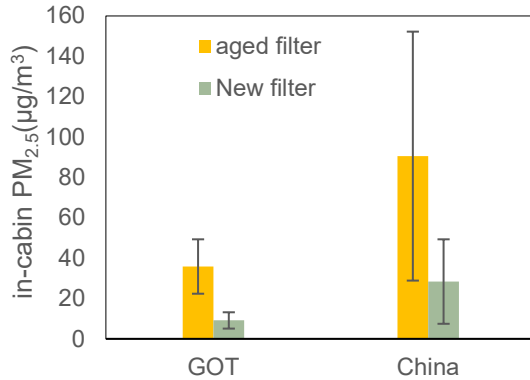
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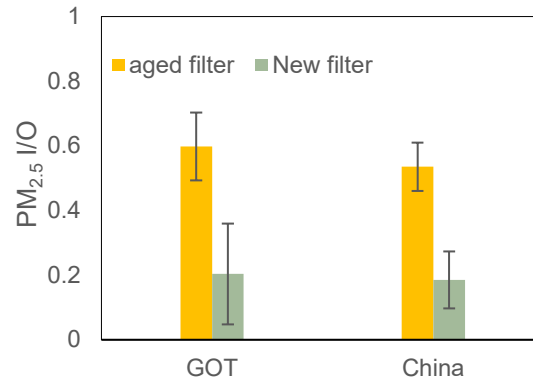
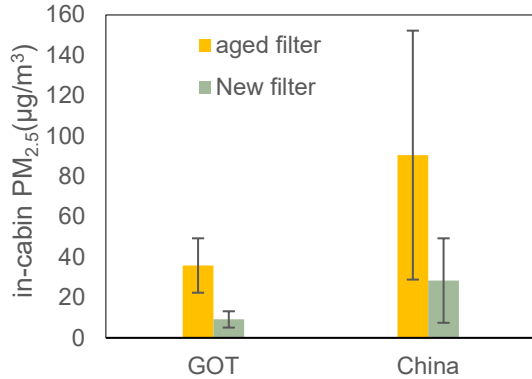


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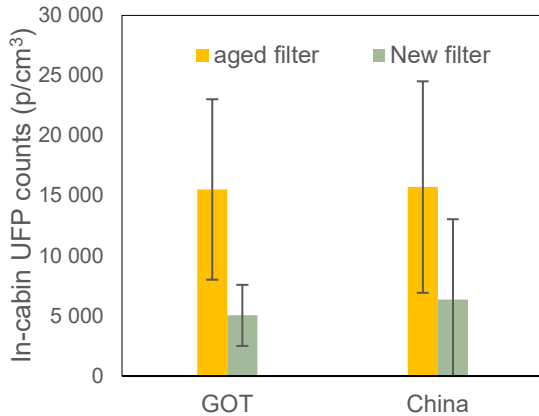


- I/O ratio: ratio of in-cabin to outside $PM_{2.5}$ concentration or UFP counts

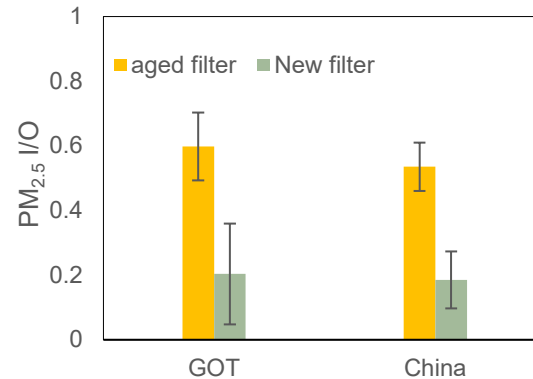
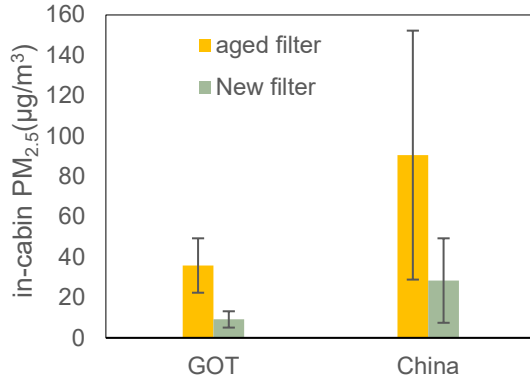
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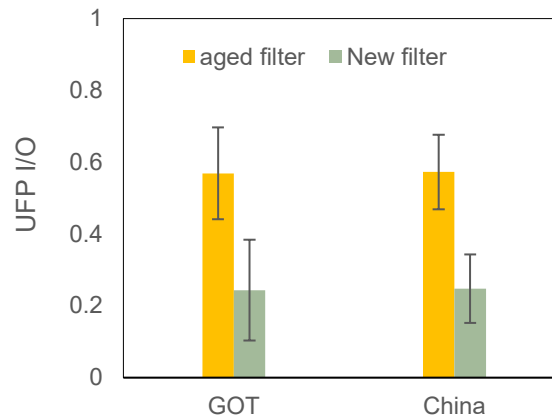
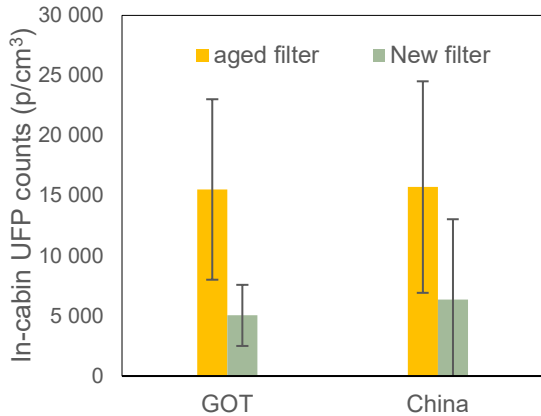
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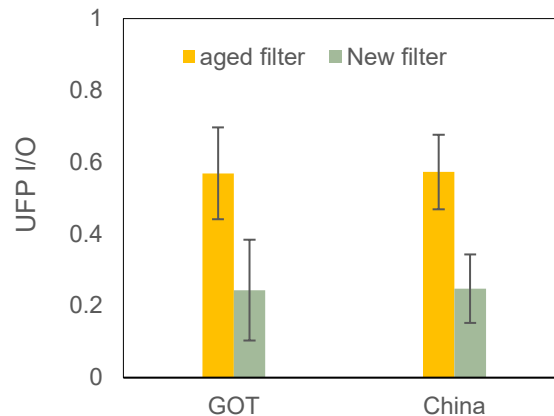
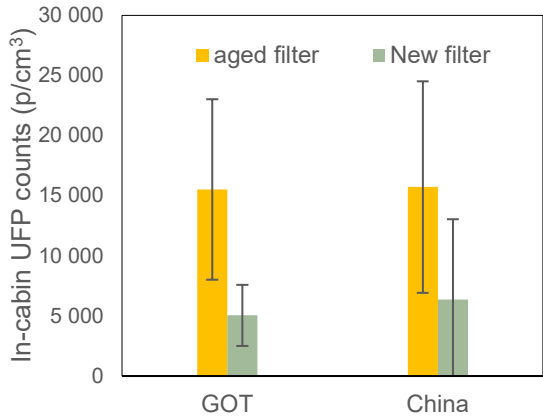
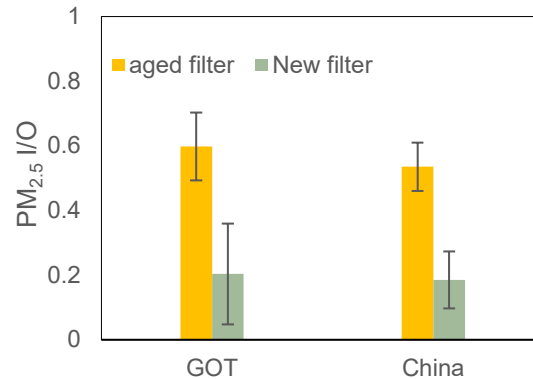
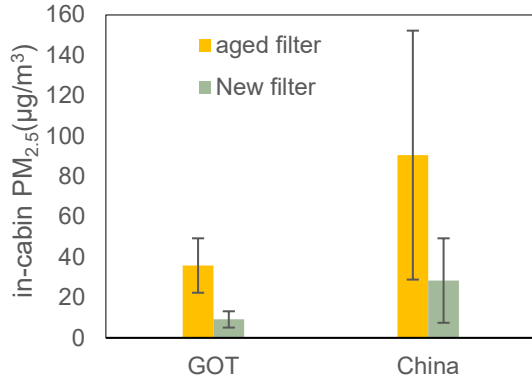
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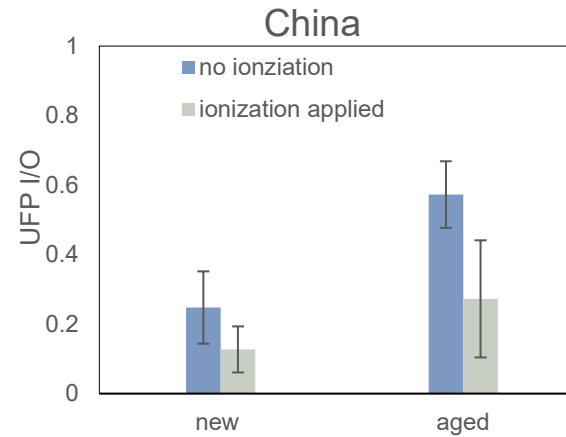
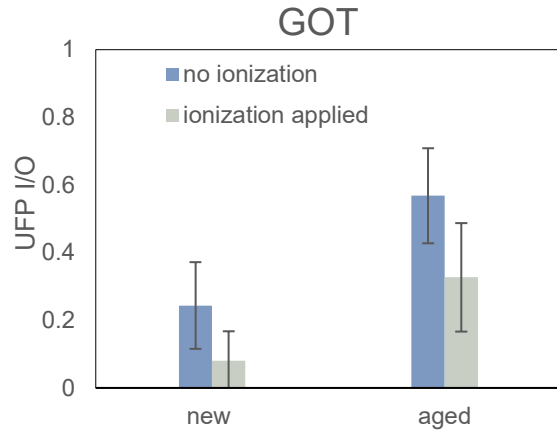
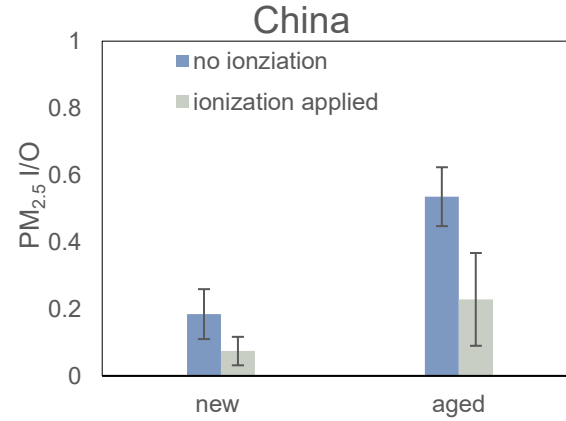
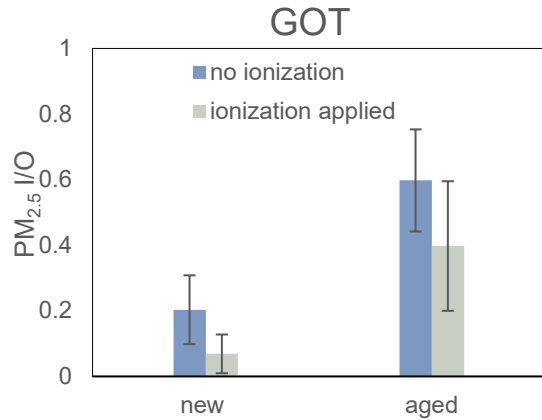


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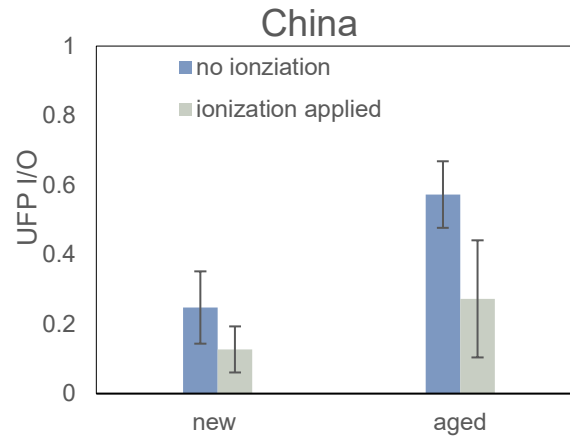
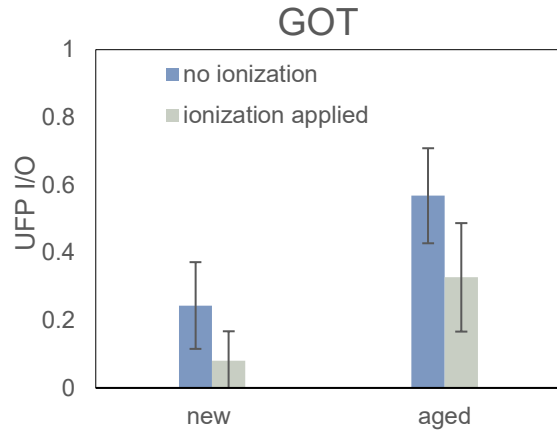
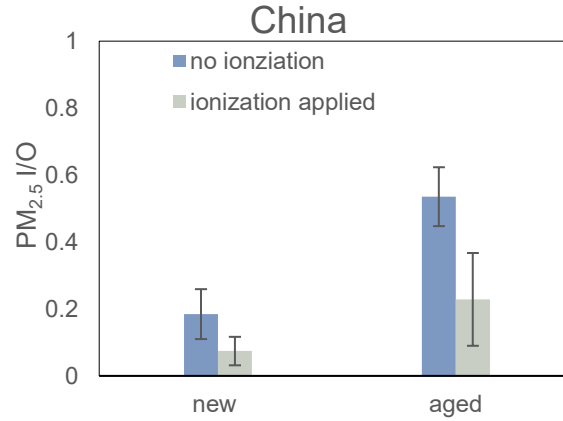
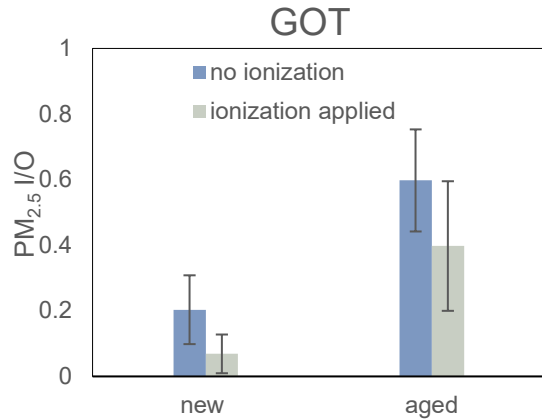


- I/O ratio: ratio of in-cabin to outside PM_{2.5} concentration or UFP counts
- Aged filter (End-of-service interval filter) largely loses effectiveness.

RESULTS – Pre-ionization

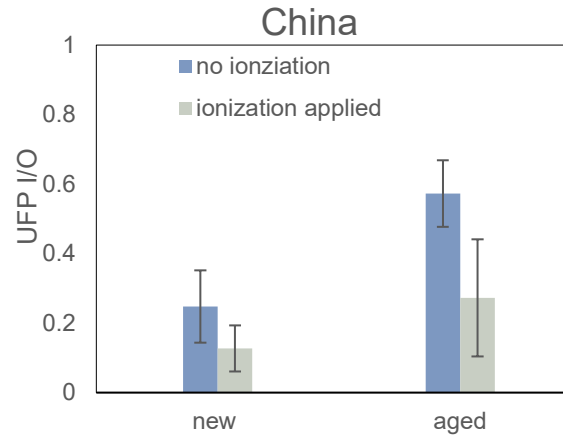
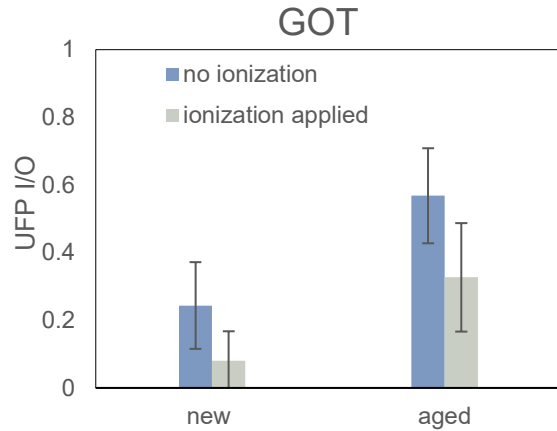
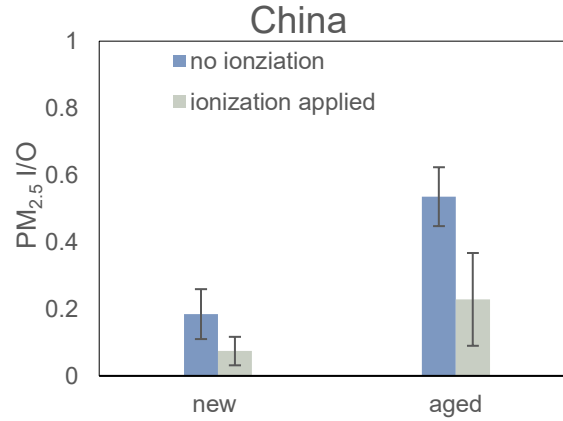
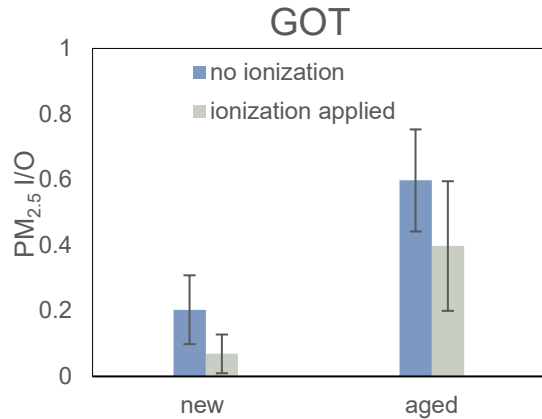


RESULTS – Pre-ionization



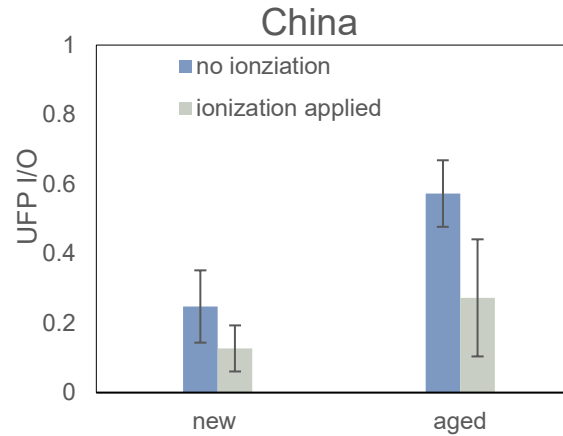
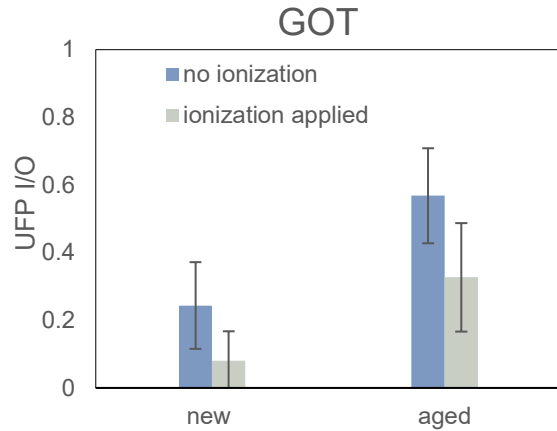
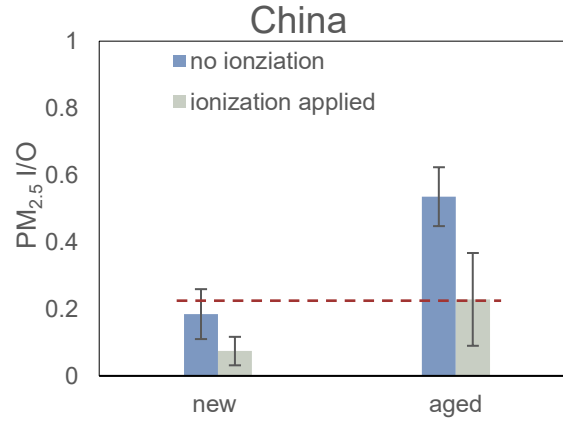
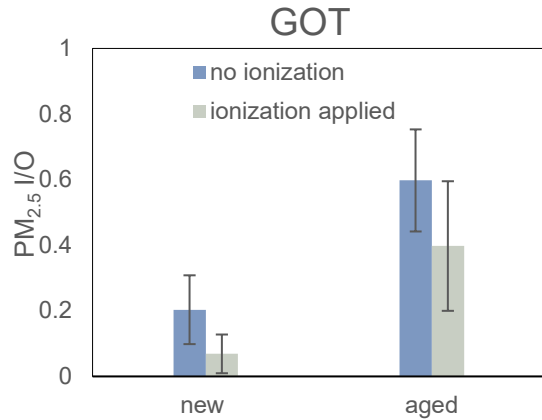
- Results conform with effectiveness of pre-ionization assisted filtration

RESULTS – Pre-ionization



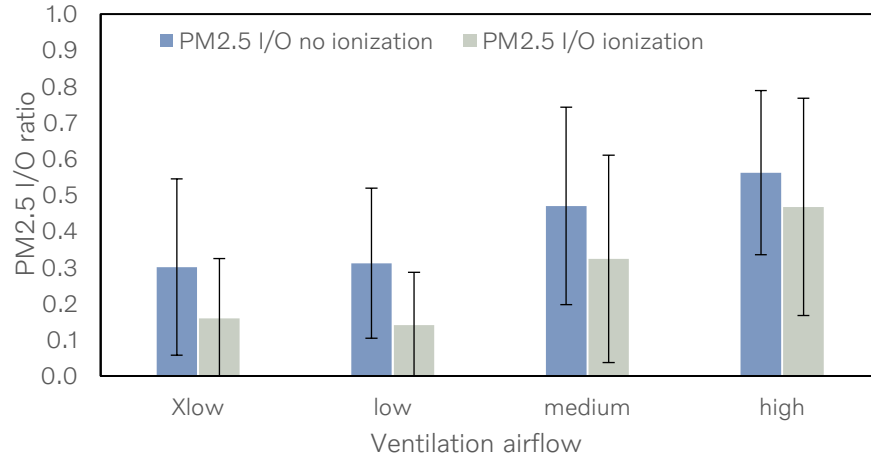
- Results conform with effectiveness of pre-ionization assisted filtration
- Aged filter with ionization reached a performance level closer to new filter without ionization

RESULTS – Pre-ionization



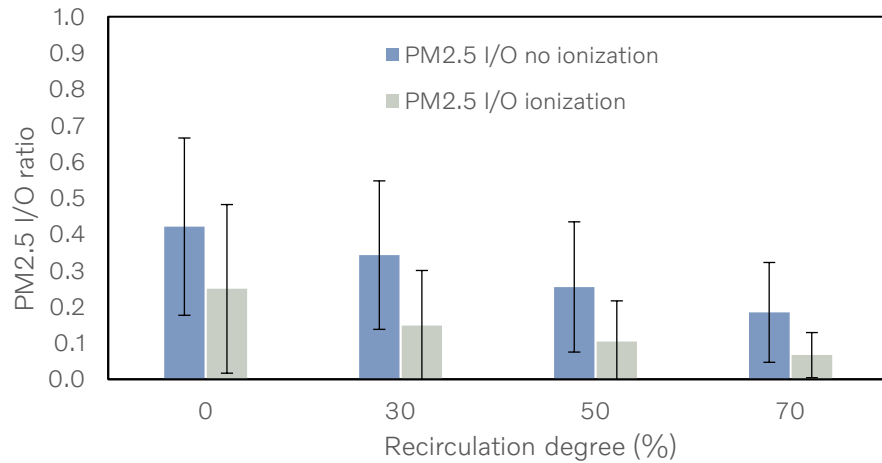
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RESULTS - Ventilation airflow rate



- Lower ventilation airflow rate increases contact time and particle removal through interception, electrostatic attraction etc.

RESULTS - Recirculation



- Recirculated air is mixed with incoming air and then filtered
- Recirculated air normally contains less particulate matter
- Another concern factor in cabin is CO₂ could accumulate within long recirculation interval

REFLECTION

1. End-of-service filter has reduced filtration ability.
2. Pre-ionization was effective, especially in Northern China using aged filter.
3. Outside air largely affect the in-cabin particle concentration, while I/O ratio are close in different locations under same setups.
4. Besides, airflow rate, RC degree could be controlled to reach better in-cabin AQ and maintain/improve energy efficiency.



Thank you.