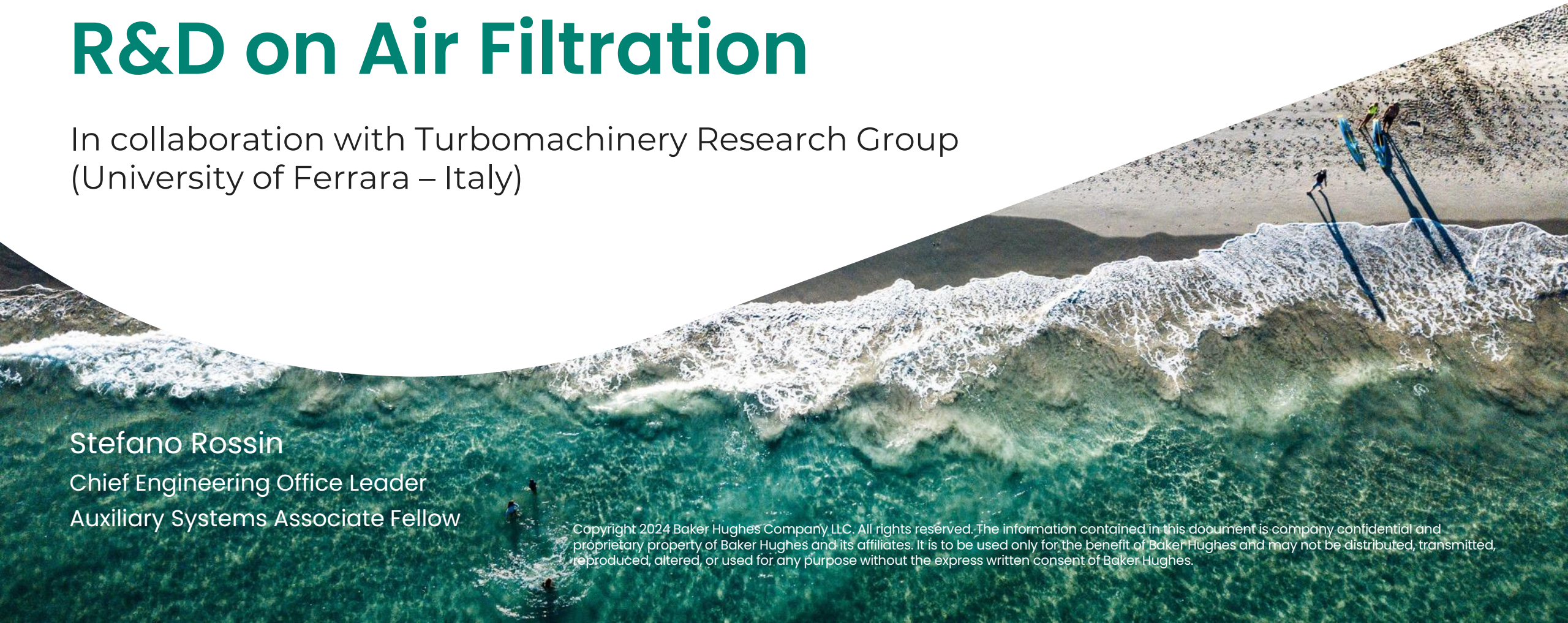
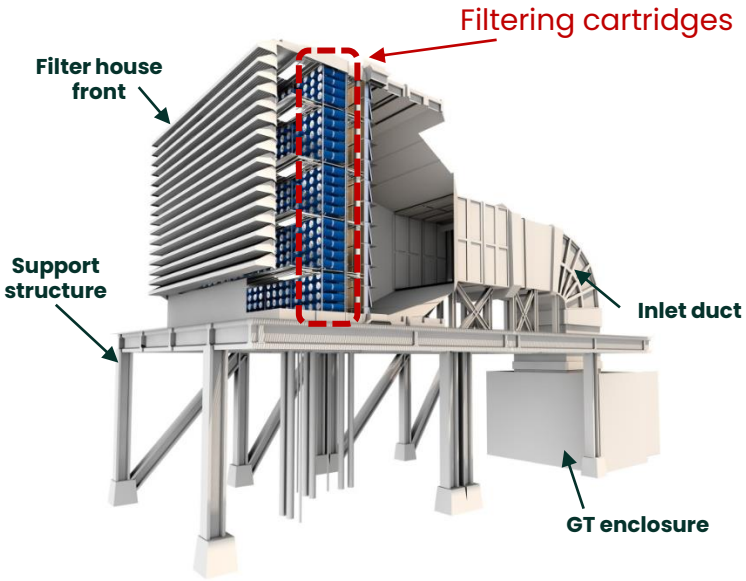
R&D on Air Filtration

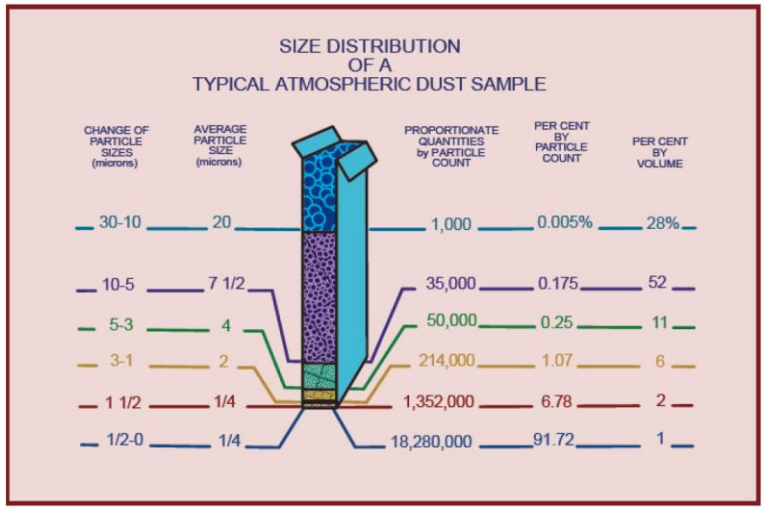
In collaboration with Turbomachinery Research Group
(University of Ferrara – Italy)



Stefano Rossin
Chief Engineering Office Leader
Auxiliary Systems Associate Fellow

GT Filtration Systems





Guideline for gas turbine inlet air filtration systems

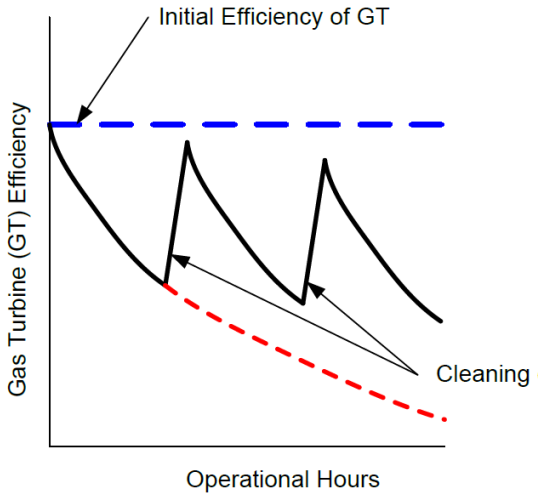
Conventional Filters

Pro

- High filtration efficiency
- Proven solution
- Suitable for different environmental conditions

Cons

- Periodic swap (Online / Offline)
- Pressure drop increase
- Filtration cartridges cost



Guideline for gas turbine inlet air filtration systems

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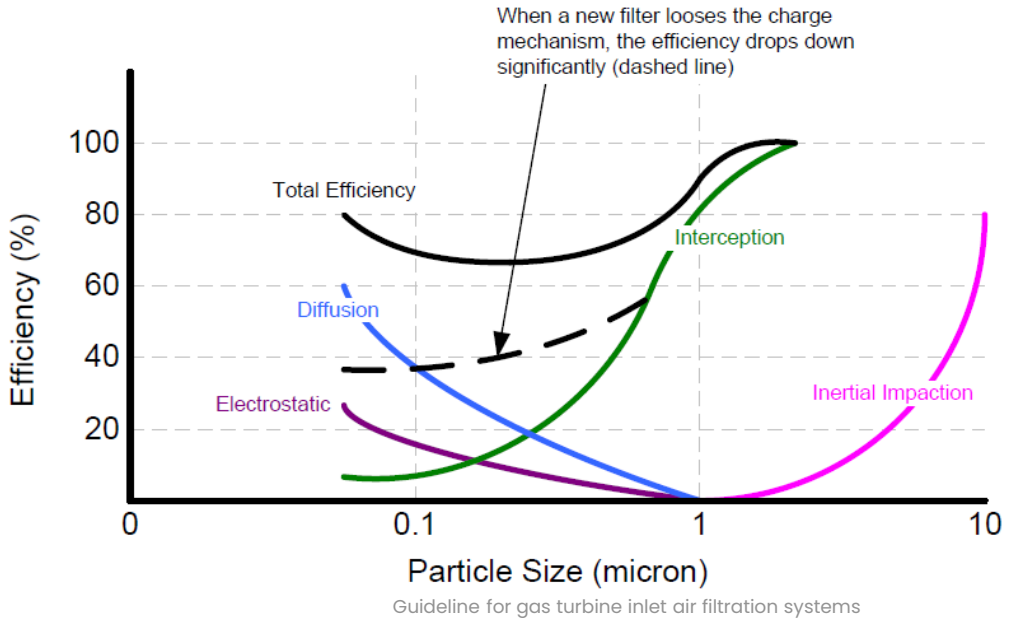
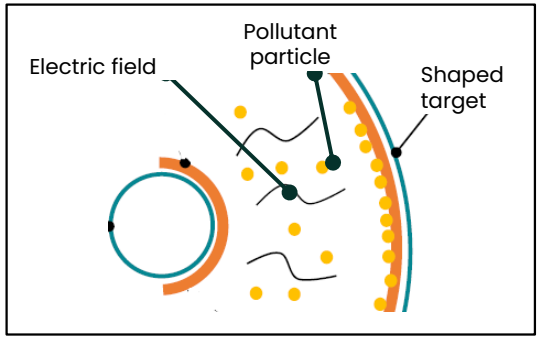
State of the Art vs. Alternative Solution

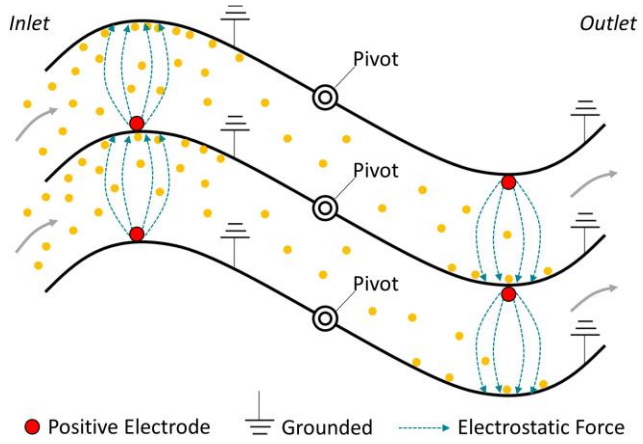


Guideline for gas turbine inlet air filtration systems

Common solutions are based on inertial, diffusive and electrostatic strategy.

Contaminants collected within the media fibers





Electrostatic / electrodynamic **agglomeration** via non-thermal plasma and/or fluid dynamic flow field

Separation via inertia effect

Non-thermal plasma (NTP) is electrically energized matter in a gaseous state, and can be generated by passing gases through electric fields

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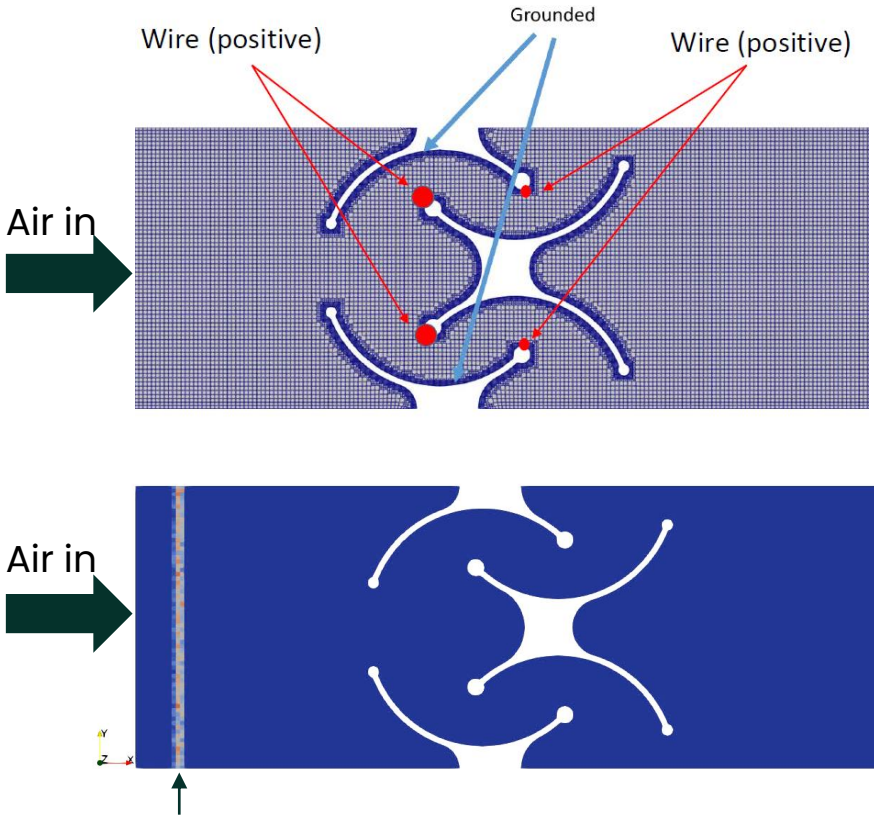
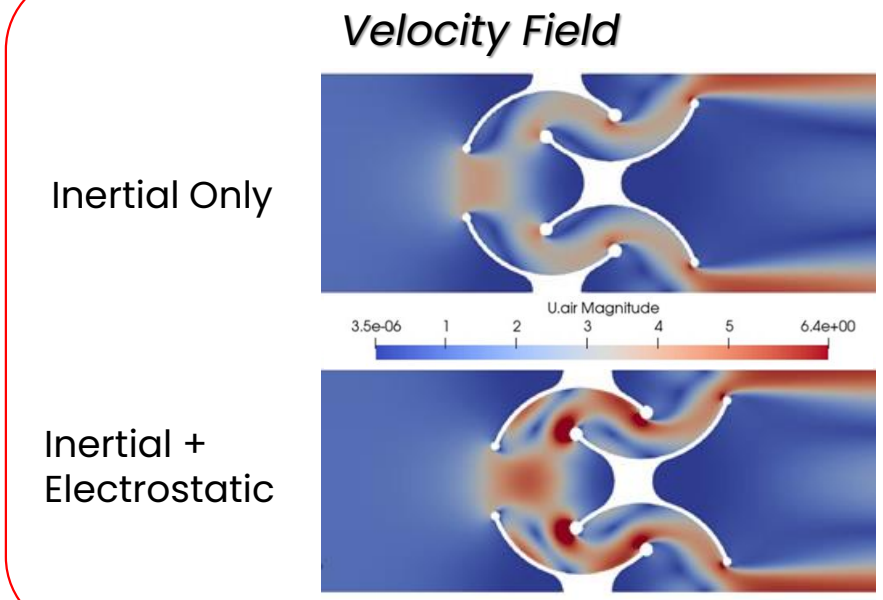
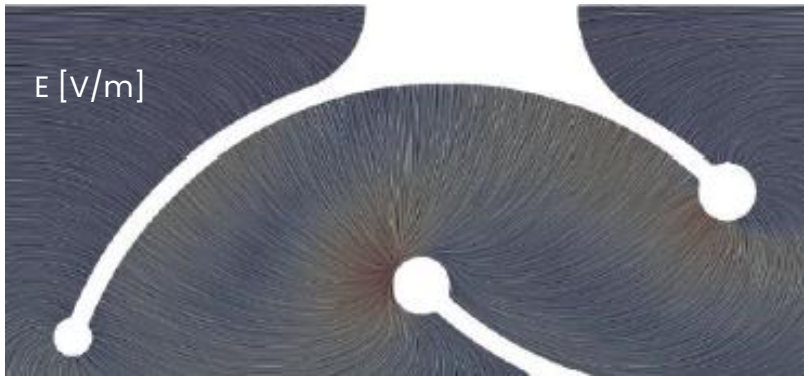
Conceptualization and Optimization

Built a reliable CFD platform in openFOAM CFD code including:

- Flow field and electrostatic field
- Lagrangian transport function
- Electrostatic / Electrodynamic force in the Lagrangian phase
- Particle Collision

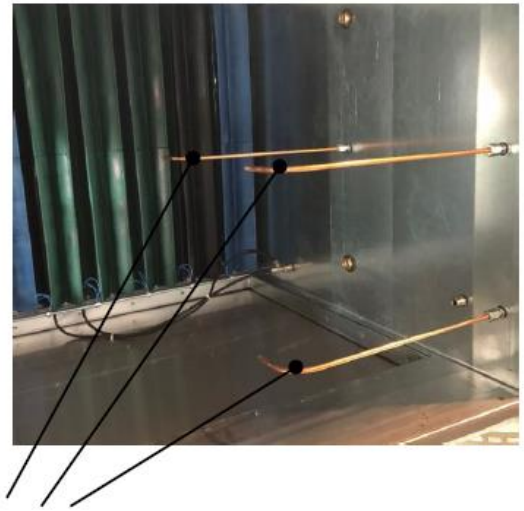




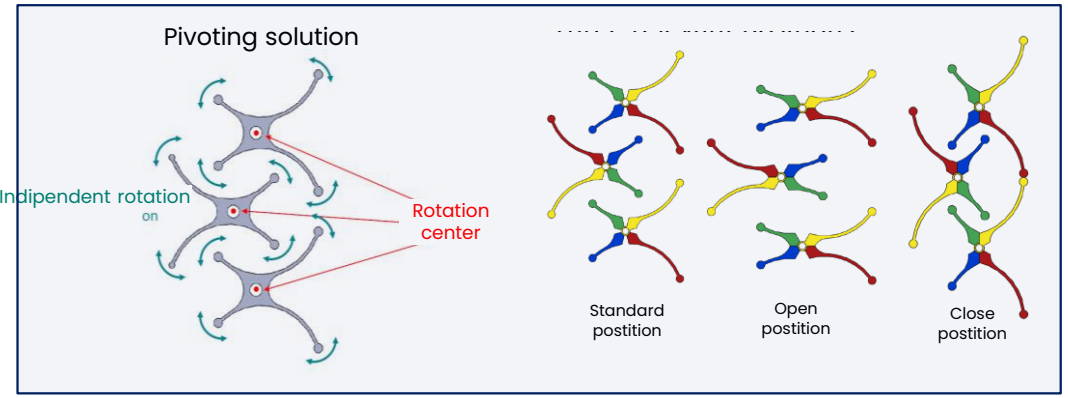


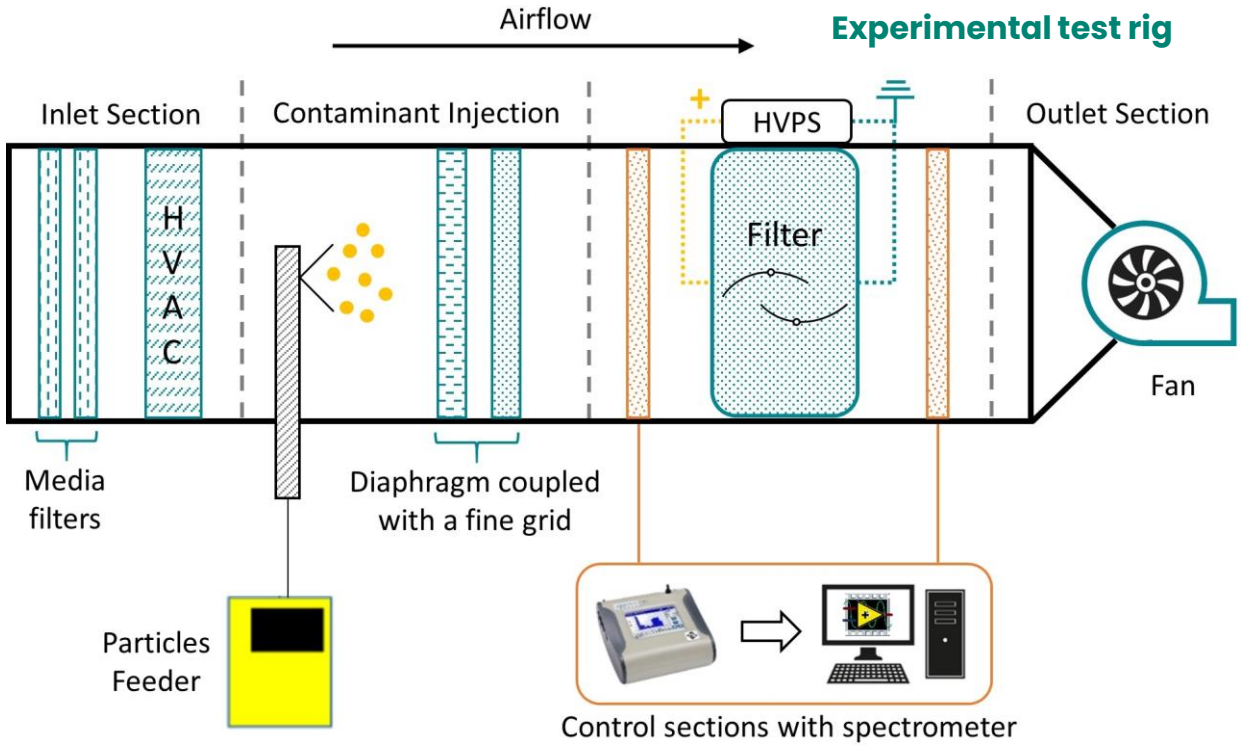
Channel Rig - Experimental Test

Fully stacked element array



Iso-kinetic probes





Experimental system consisting of:

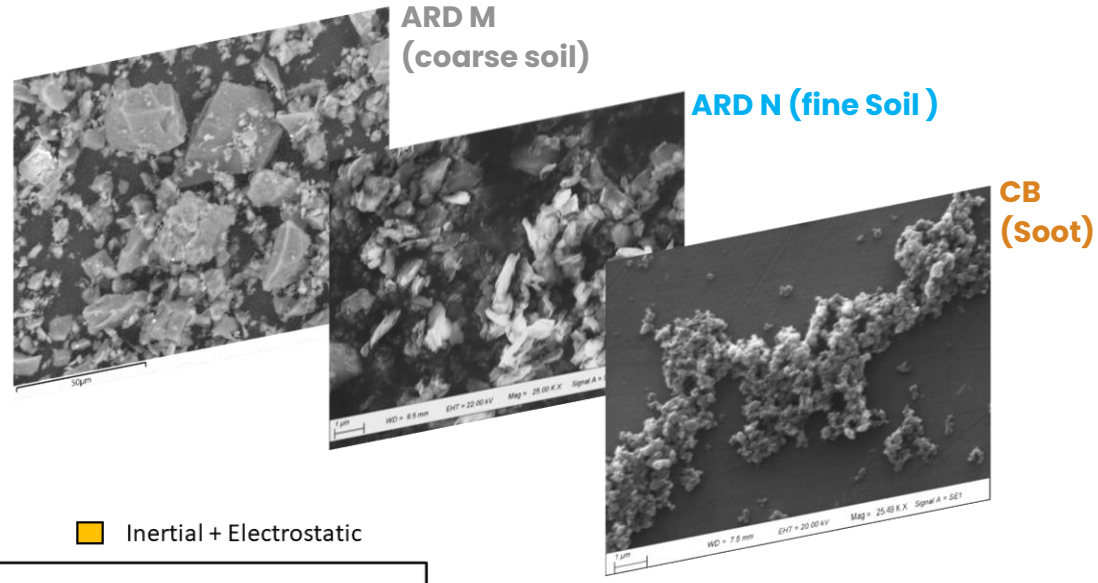
- Contaminant dosing system
- Residual contamination detection
- Adjustable position to adapt the inertial efficiency according to the contaminant characteristics

Measured pressure losses 25-50 Pa @ 1 m/s depending on open angle (Standard pre-filters range from 55 to 450 Pa)

Experimental Tests - Normal Operating Conditions

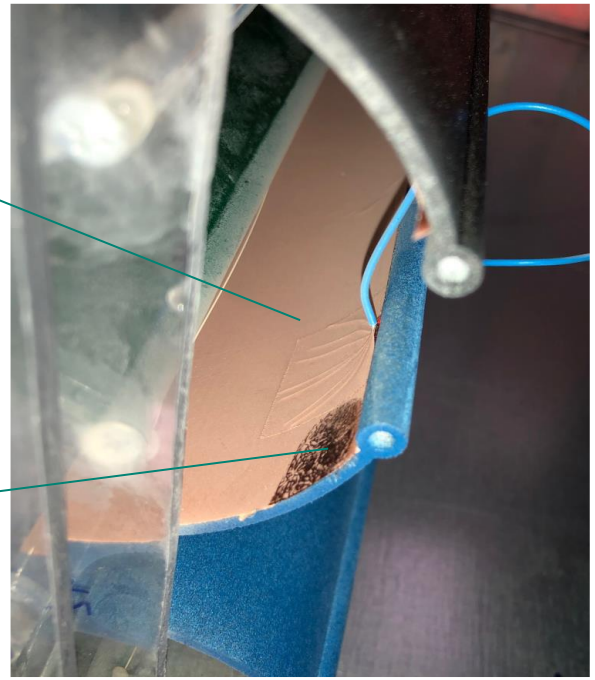
Contaminant concentration - actual installation (10 – 50 μg/m³):

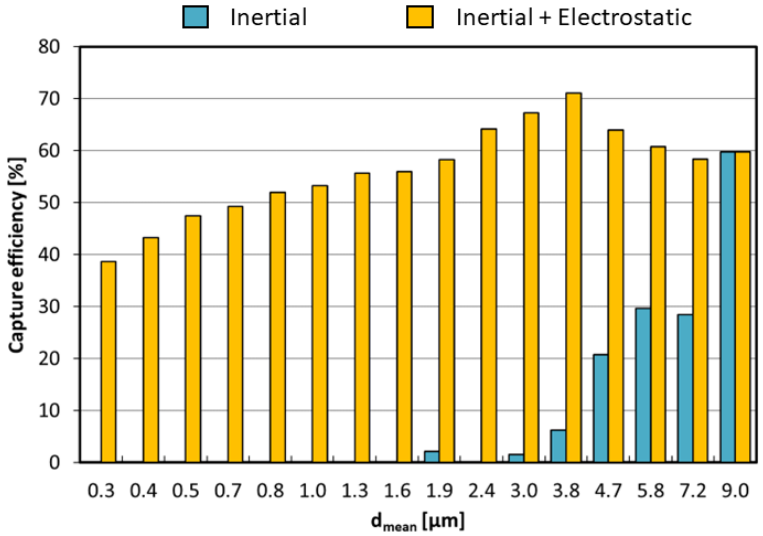
- Contaminants: soil (fine and coarse) and soot
- Dry and wet conditions by changing the %RH
- Airflow: matching different filter house design and space requirements (1-4 m/s)

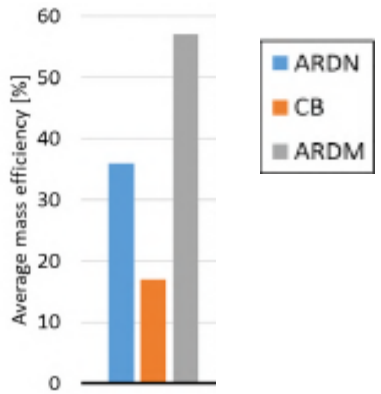


Collected contaminants
(layer on the ground)

Ground scratched
by hand
(for demonstration purpose only)







Standard pre-filter Average efficiency ~ 60%

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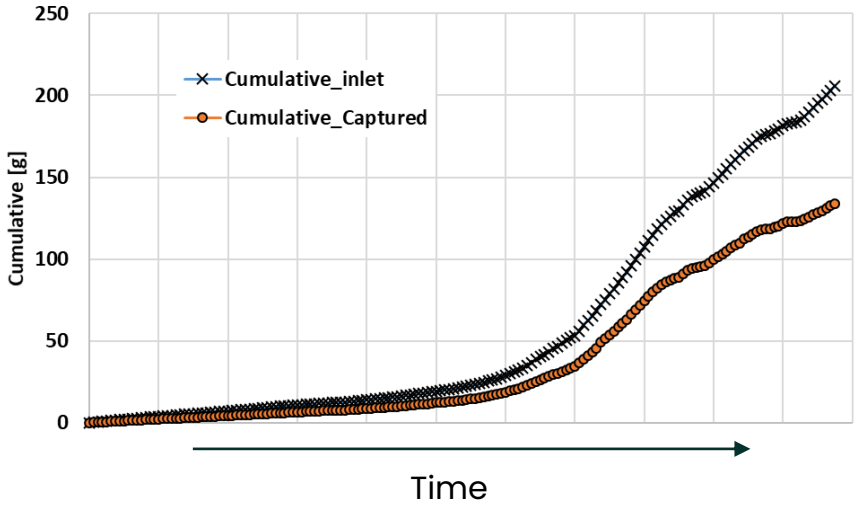
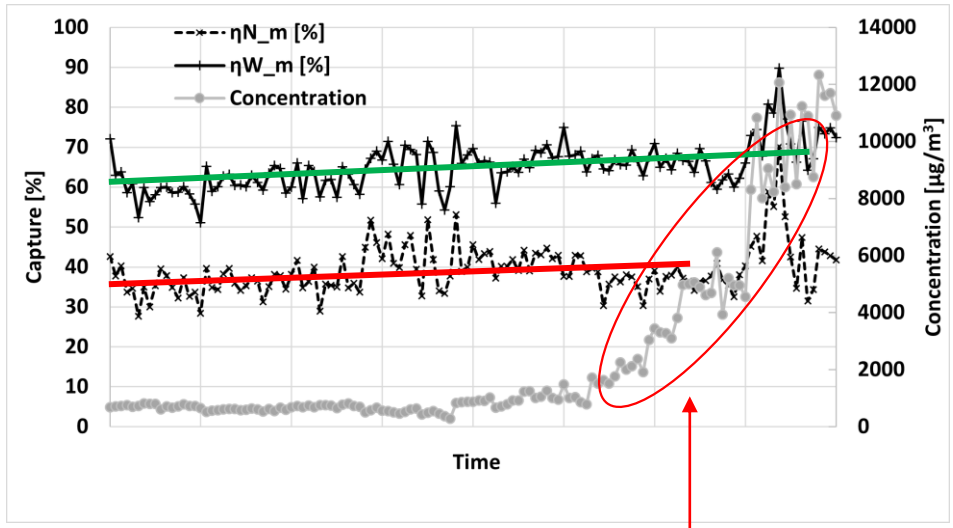
Experimental Tests: Sand Storm and Cumulative Performance

Contaminant concentration – sandstorm (1500 μg/m³)
Performance stability (capture and pressure drop) even in the presence of huge contaminant concentration at the inlet

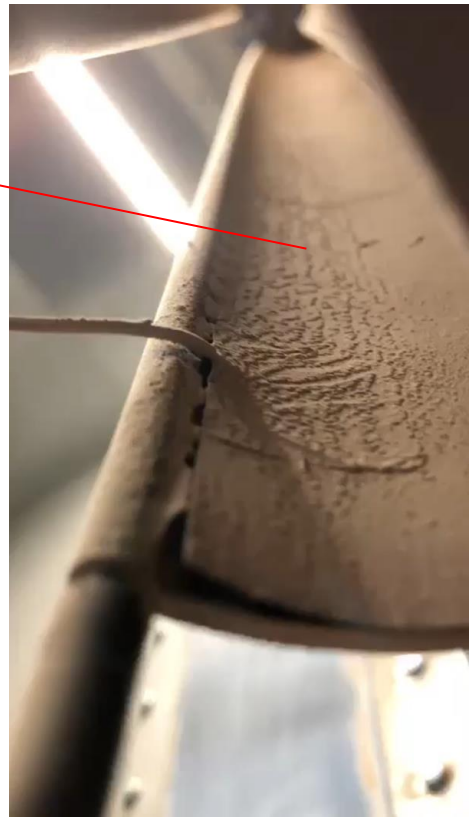


Efficiency and pressure drops stable for almost 8 months with a common contaminant concentration (< 10 μg/m³)



Sandstorm condition

loaded ground



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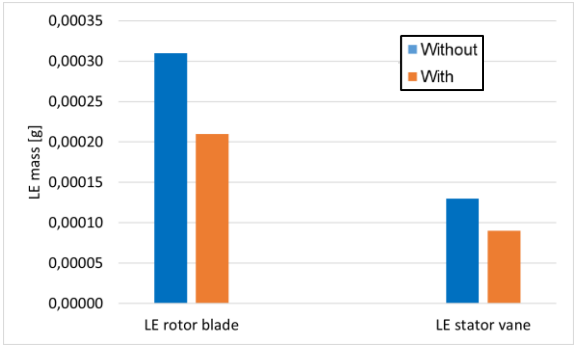
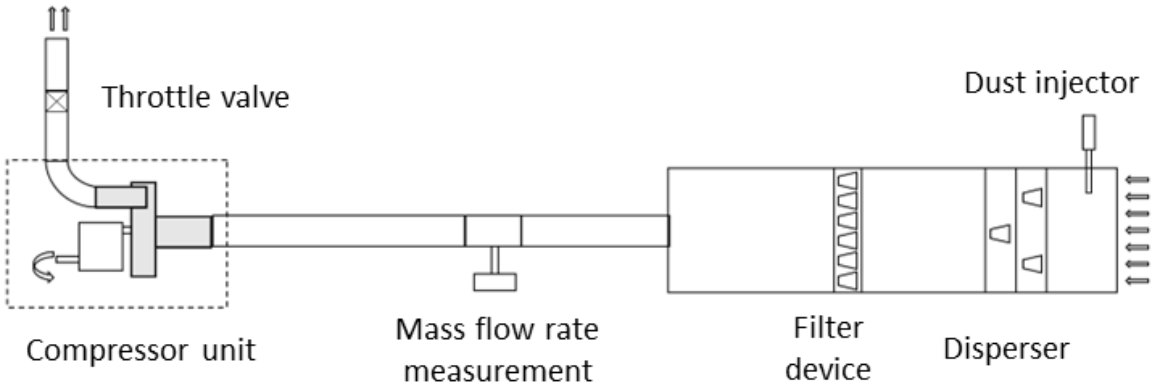
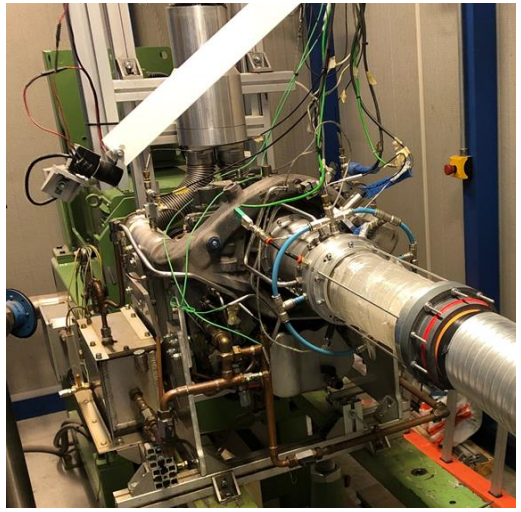
Axial Compressor Setup (Testing)

- Aero derivative compressor unit equipped with the innovative filter solution.
- Contamination rate is detected by **image analysis** and local **deposited-mass** detection

Grey (fouled) regions are reduced







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Conclusions

- Inertial barrier and high-voltage electric field combined promote **agglomeration and removal** of micro-sized particles.
- The reliability of the device is **tested in a real compressor unit** comparing the fouled surfaces with and without the filter.
- Filter performance characterized upon three standardized test powders, representative of **soil and soot** particles.
- The experimental results show the electric field playing a fundamental role in stopping the smaller particles (<10 μm) while the inertial barrier works better against bigger particles.
- The capture efficiency appears **highly dependent on the contaminant type**: soot particles (CB) are more difficult to be captured by electrostatic forces in spite of soil particles of comparable diameter (ARD N).
- **Pressure drop is independent** from the amount of collected particles (Dirty vs Clean Filters)

Future efforts to tune the inertial barrier and the magnitude of the electric field according to different contaminant scenarios and the operating conditions of the turbine, e.g. airflow velocity.