

Filter media design for Dust Holding Capacity by computer simulations

Interpore 2018, New Orleans, May 14-17, 2018

Christopher Kühnle, Mehdi Azimian, Liping Cheng,
Sven Linden, Andreas Wiegmann



Product



Spun Off



Started



Location



Employees



Customers

Location and Contact

MATH
2 MARKET

Offices and visitor address

Richard-Wagner-Str. 1
67655 Kaiserslautern, Germany

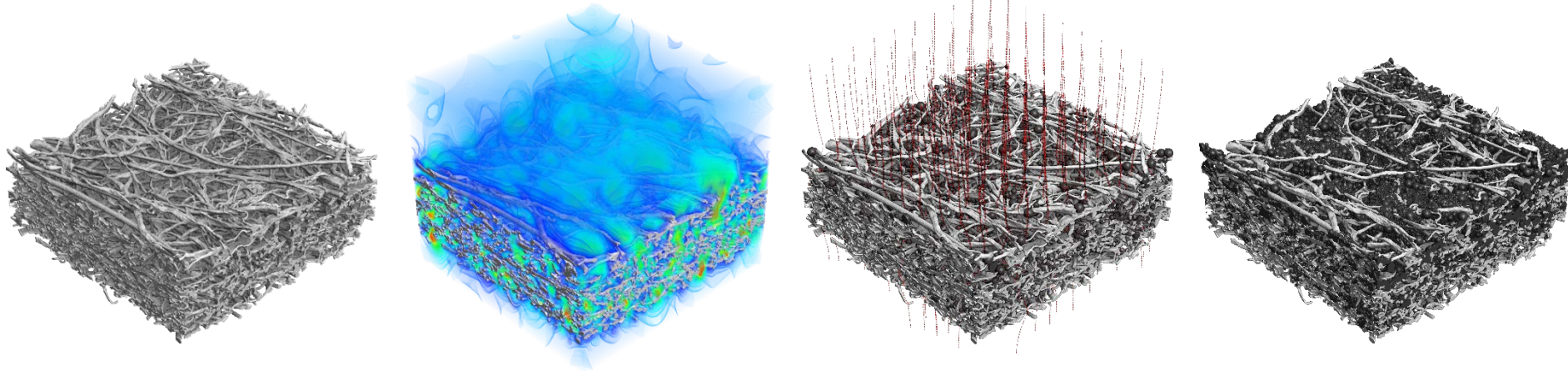
Phone + 49 631 / 205 605 0
Fax + 49 631 / 205 605 99

WWW.GEODICT.COM



GeoDict for Filtration: Liquid Filtration Portfolio

MATH
2 MARKET



Filter Media

Clean Filter Parameters

Liquid Filtration Experiments

Liquid Filtration Results

- Nonwoven fabrics
- Woven fabrics
- Foams
- Membranes
- Metal wire meshes
- Pleats & support meshes

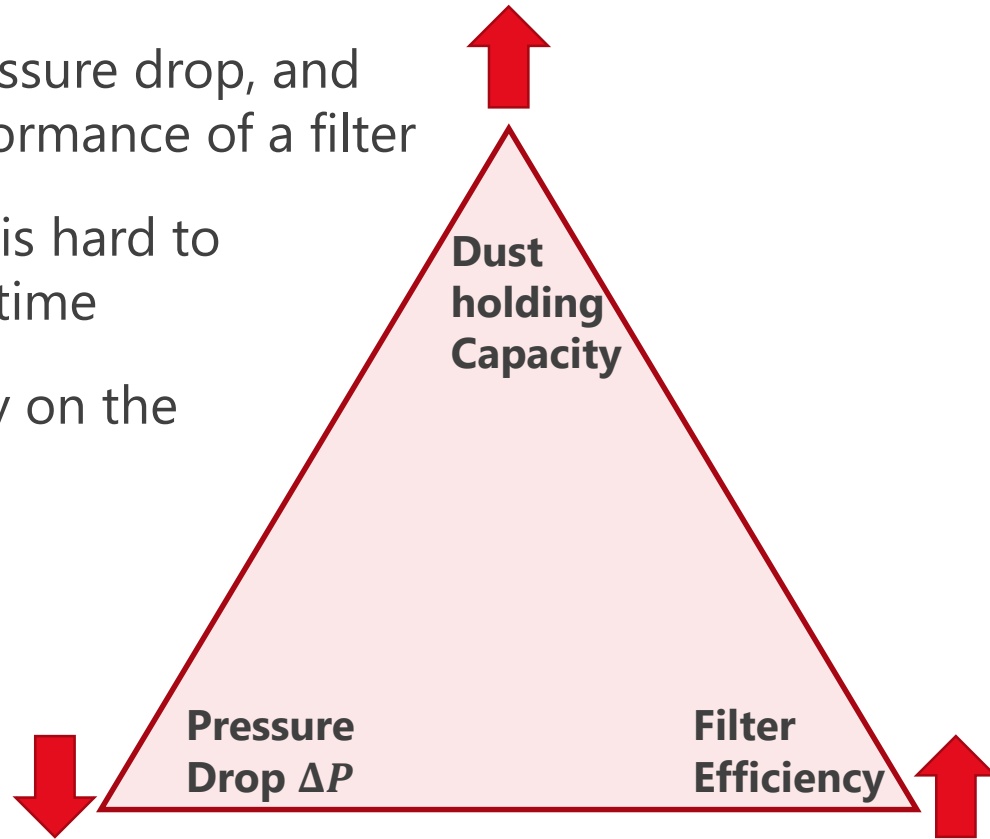
- Media thickness
- Fiber diameters
- Fiber orientation
- Grammage
- Pore size distribution
- Bubble point
- Percolation path

- Multi pass tests
- Standard test dusts

- Initial pressure drop
- Pressure drop evolution
- Initial filter efficiency
- Fractional efficiencies
- Filter capacity
- Filter class
- Filter clogging behavior

Filter Media Design

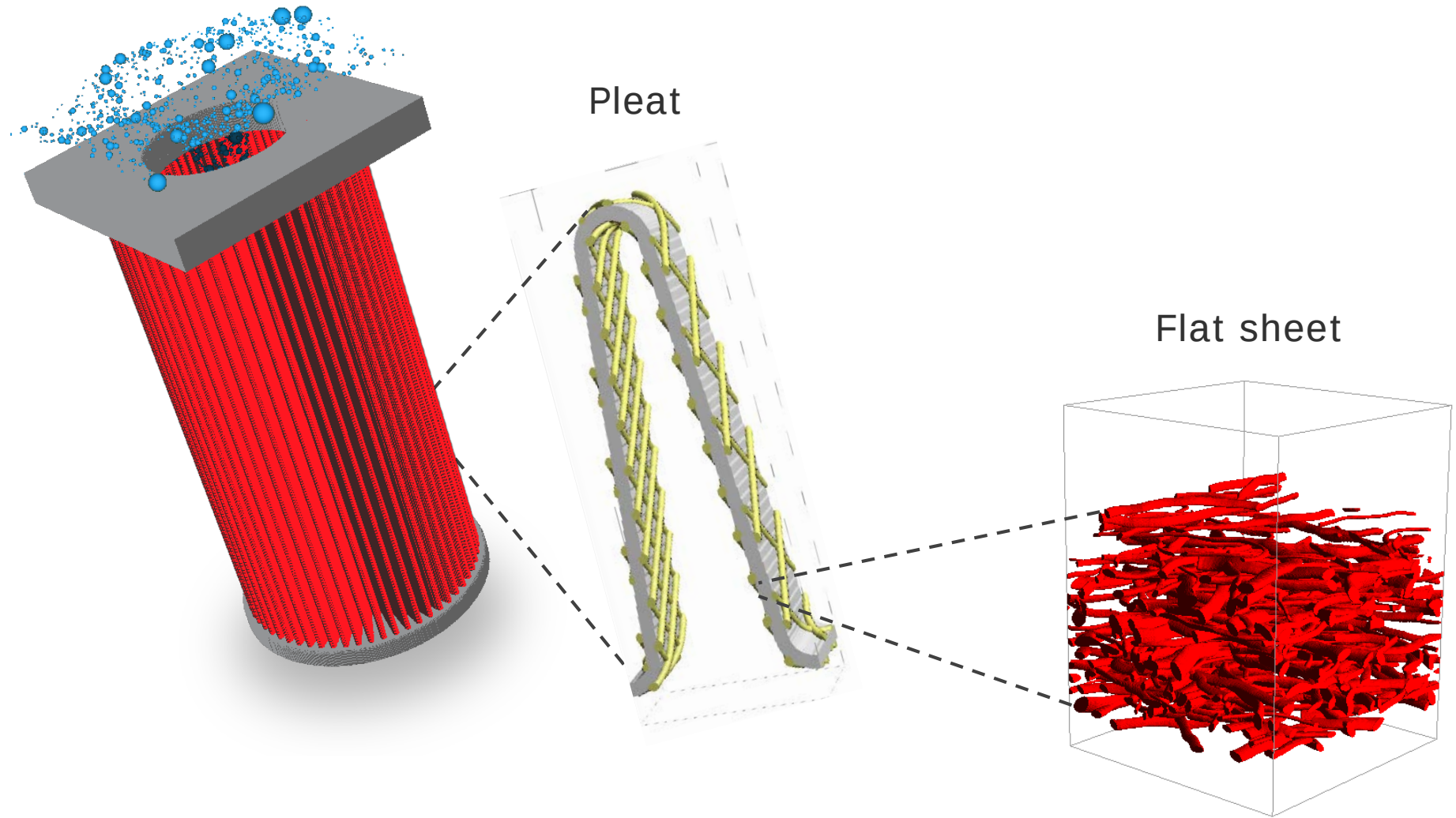
- Dust holding capacity (DHC), pressure drop, and filter efficiency describe the performance of a filter
- They influence each other and it is hard to improve all of them at the same time
- These parameters depend mainly on the porous microstructure (e.g. pore size distribution)



- In this presentation we want to optimize the DHC while keeping initial pressure drop and clean filter efficiency the same

Simulate filtration at different scales

MATH
2 MARKET

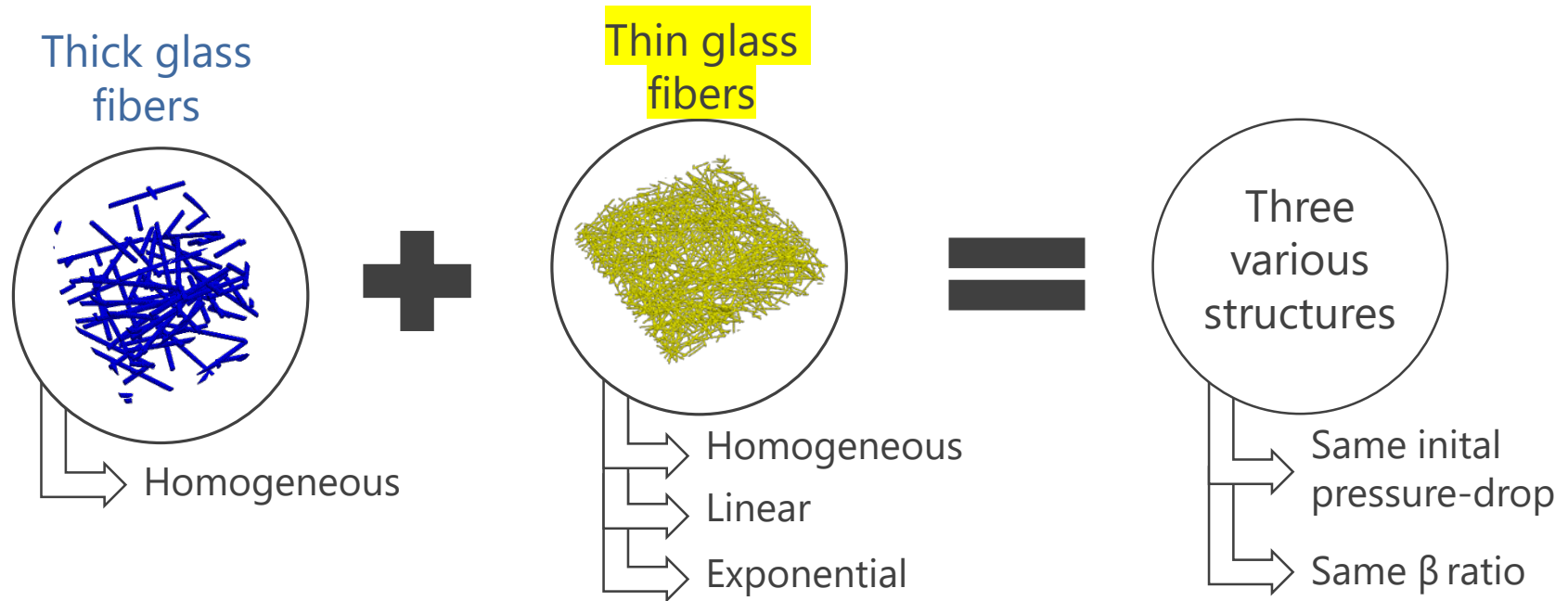


Filter life-time simulations



Modeling of coarse/fine mixed media filter

MATH
2 MARKET



Thick fibers (blue):

Diameter: 20 μm
Orientation: Anisotropic 8/1
Material: Glass
Vol. ratio: 60%

Thin fibers (Yellow):

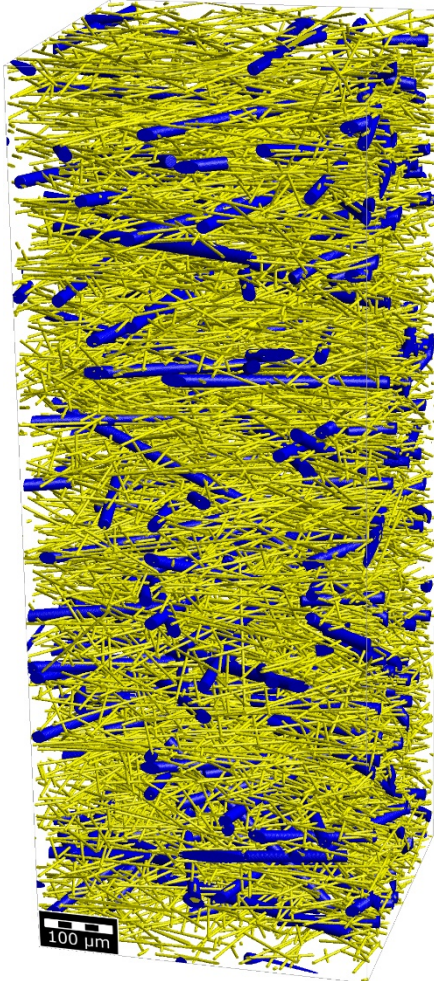
Diameter: 4 μm
Orientation: Anisotropic 8/1
Material: Glass
Vol. ratio: 40%

$$\beta_d = \frac{n_{\geq d, \text{Upstream}}}{n_{\geq d, \text{Downstream}}}$$

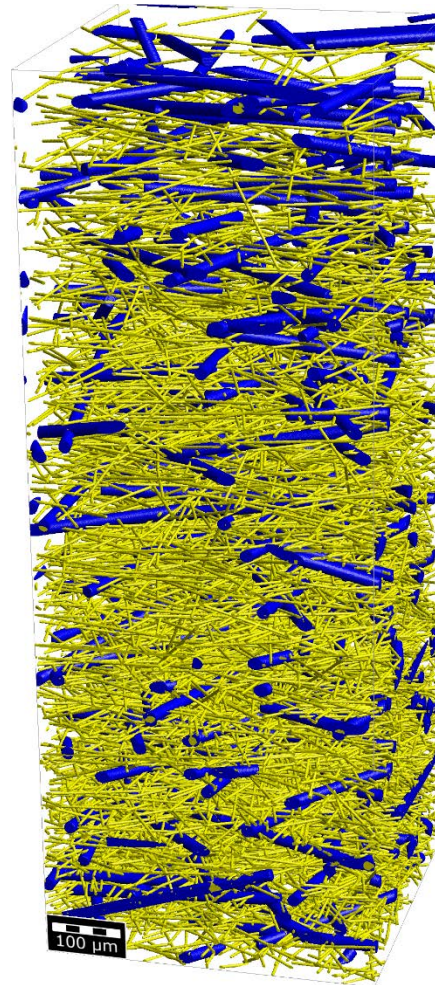
Modeling of three filter media structures

MATH
2 MARKET

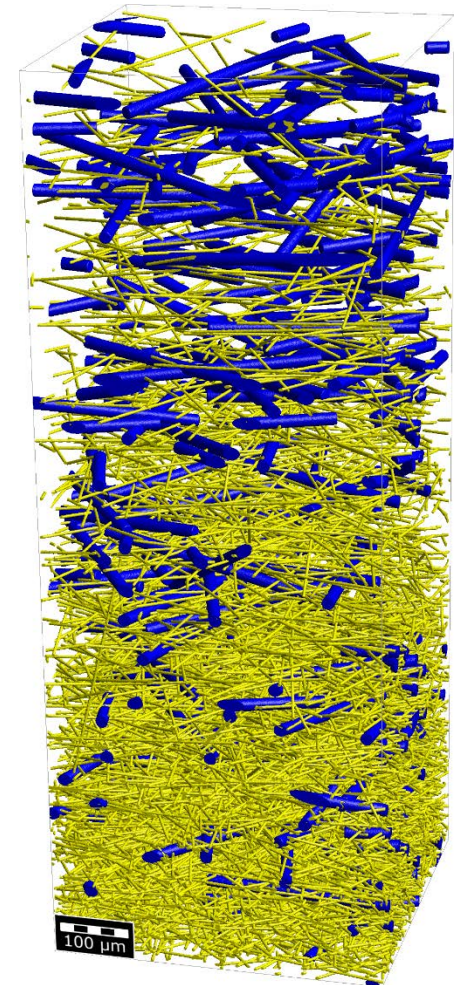
Homogeneous



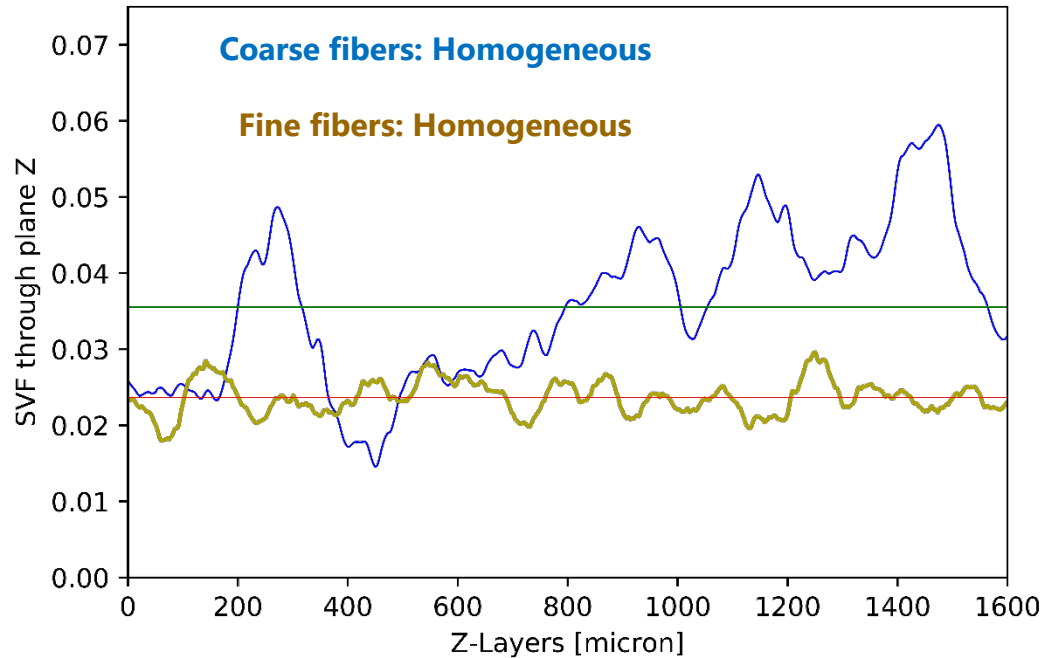
Linear



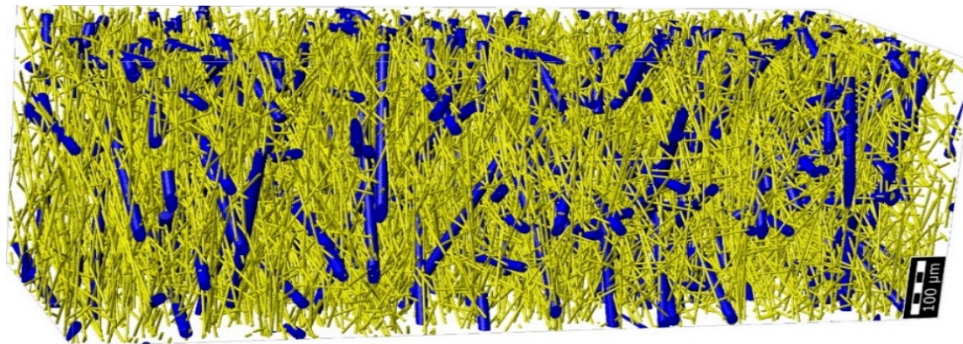
Exponential



Homogeneous medium

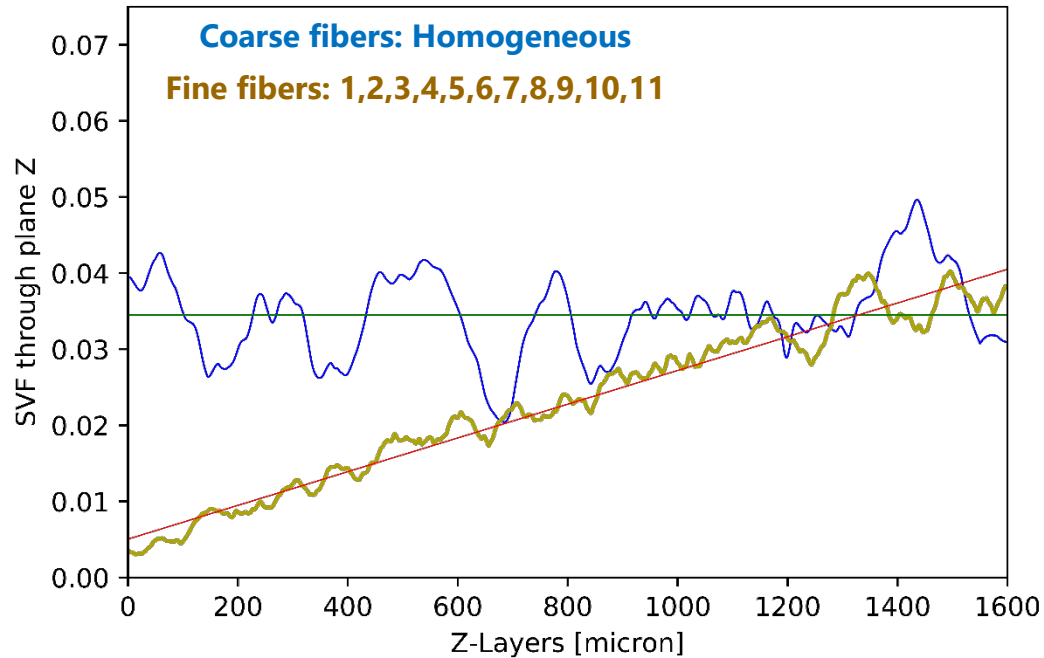


Flow direction

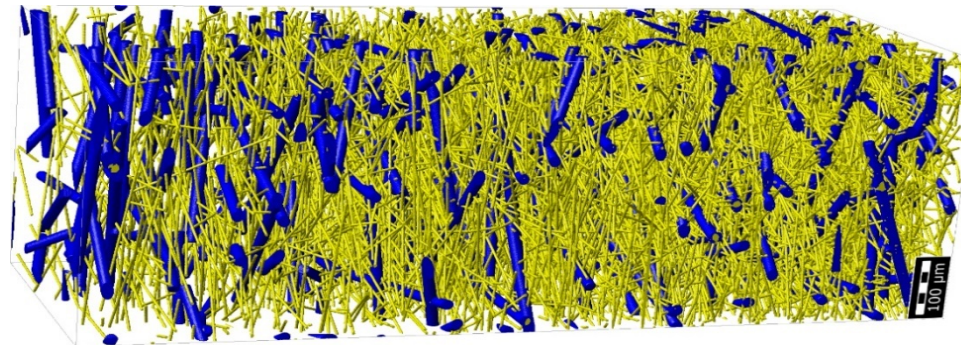


Domain
600x600x1600 μm

Linear medium

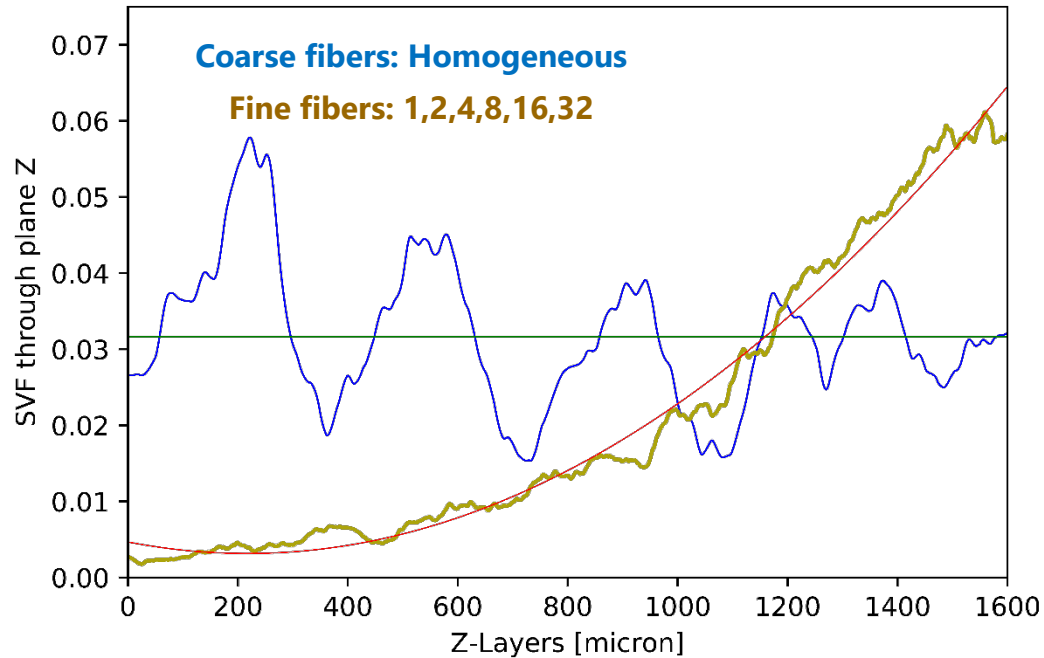


Flow direction

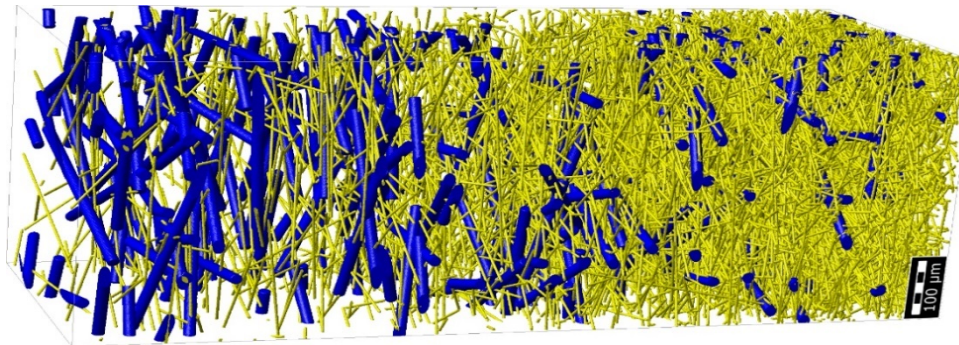


Domain
600x600x1600 μm

Exponential medium



Flow direction



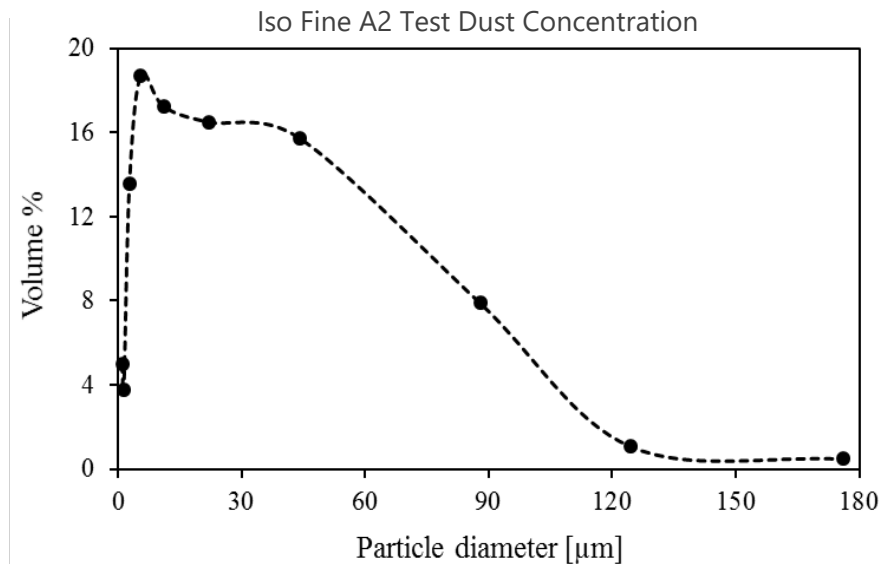
Domain
600x600x1600 μm

Structural comparison

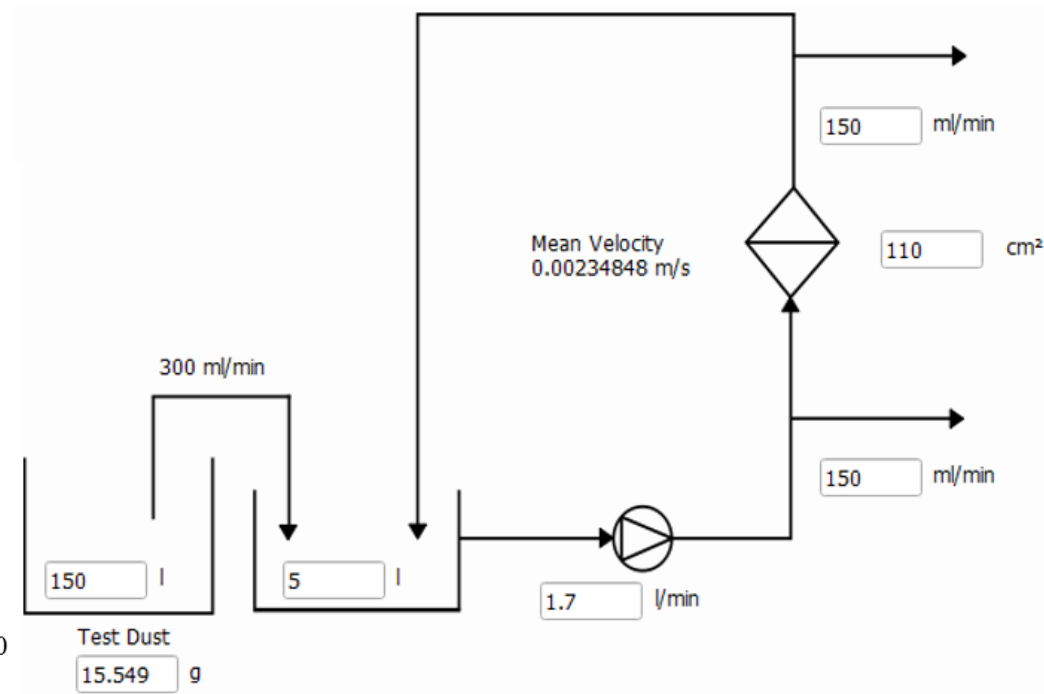
Structure	Homogeneous	Linear	Exponential
Size [μm]	600x600x1600	600x600x1600	600x600x1600
Distribution of coarse fiber / fine fiber	Uniform / Uniform	Uniform / Linear(1,2,3,4,5,6,.....)	Uniform / Exponential(1,2,4,8,16,.....)
Permeability [m^2]	5.47E-11	5.48E-11	5.53E-11
$\beta_{22\mu\text{m}}$	200	200	200
Object solid volume percentage in domain (porosity in %)	6.11 (93.89 %)	5.9 (94.1 %)	5.43 (94.57 %)
Volume coarse fiber / Volume fine fiber	60/40	60/40	60/40

Experimental setup

Used Fluid: Oil
Temperature: 20 °C
Used Particles: ISO Fine A2 test dust
Particle Density: 2560 kg/m³
Particle Collision Model: Sieving
Flow regime: Laminar

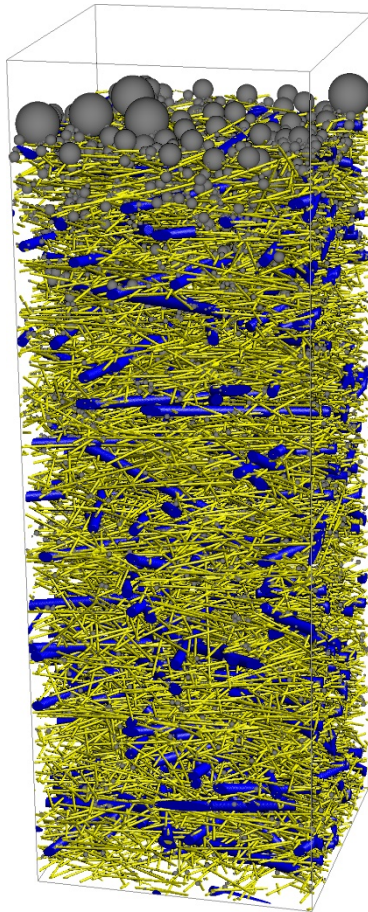


Multi-pass filter test schematic based on ISO 4548-12

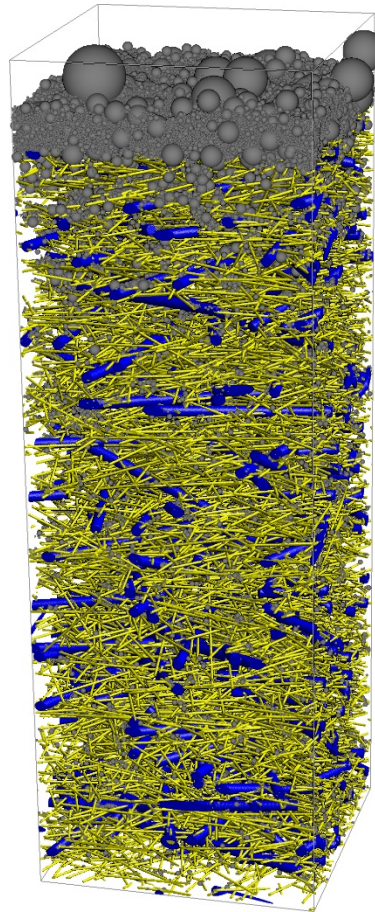
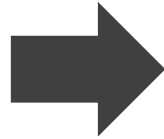


Transient filtration simulation (Homogeneous structure)

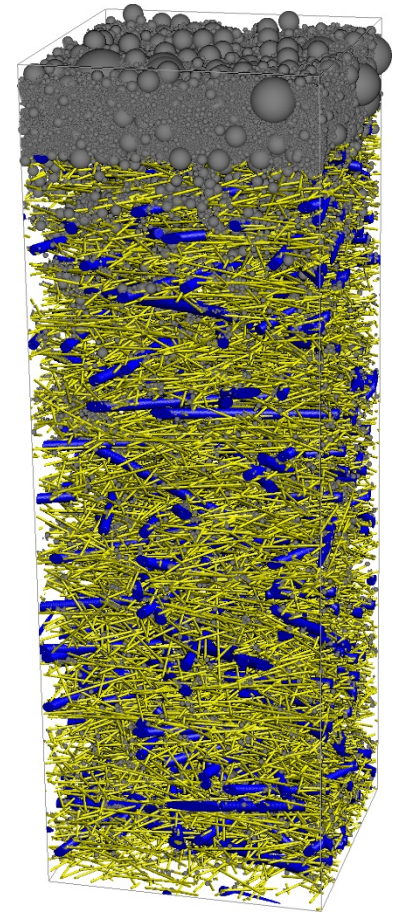
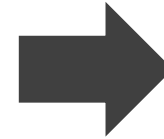
MATH
2 MARKET



45 min



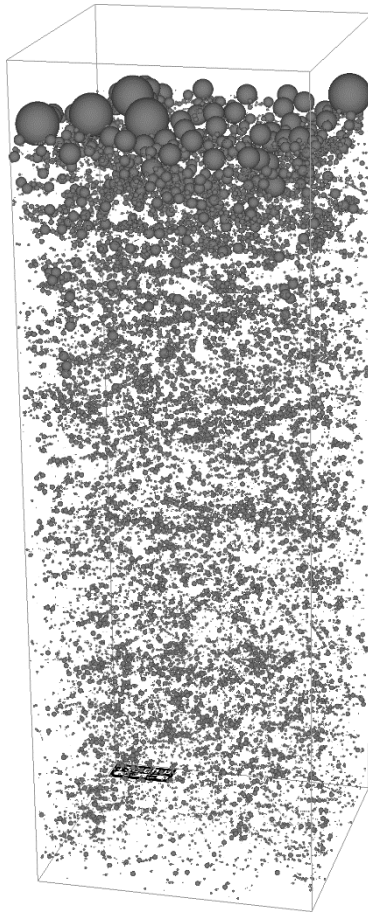
2 hr 25 min



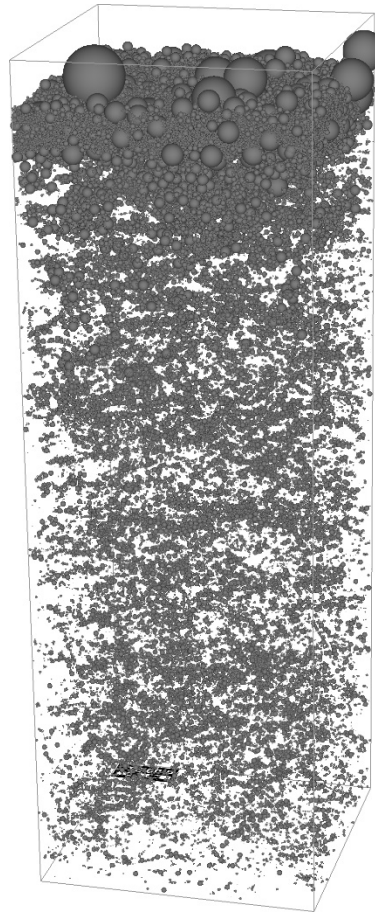
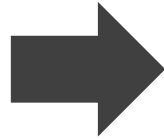
3 hr 10 min

Transient filtration simulation (Homogeneous structure)

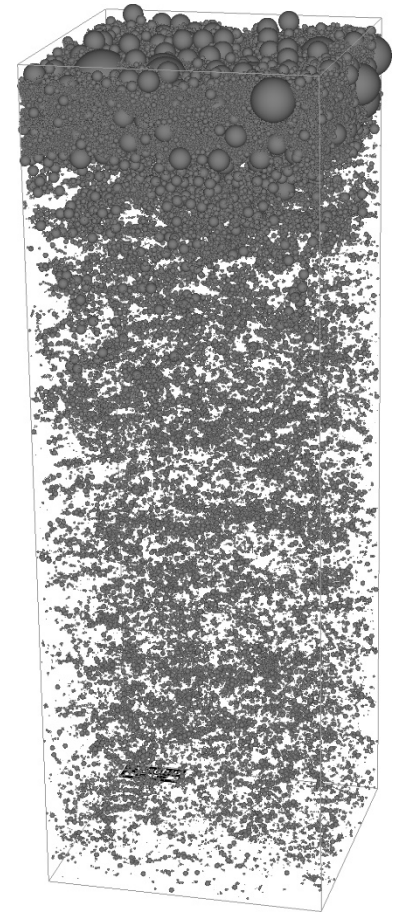
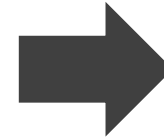
MATH
2 MARKET



45 min



2 hr 25 min



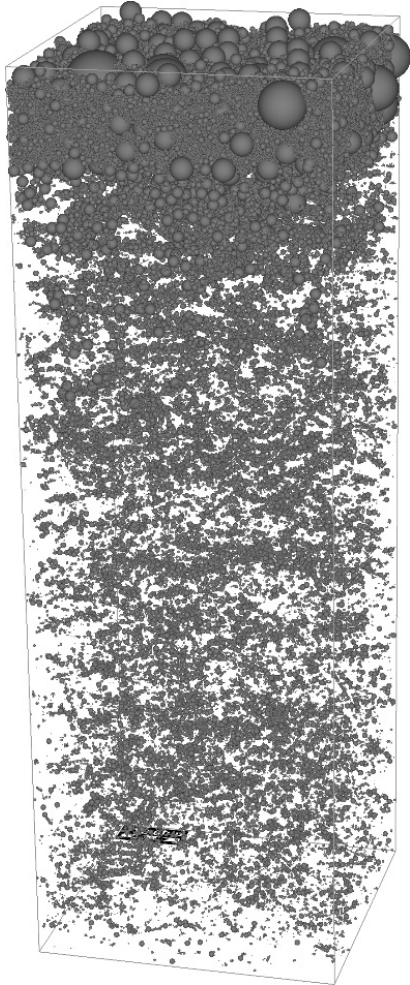
3 hr 10 min

Animation of the filtration simulation (Linear structure)

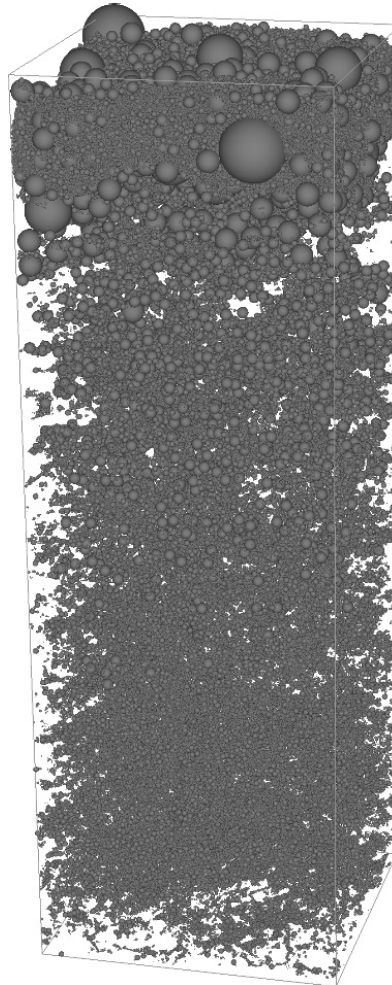


Comparison of particle depositions

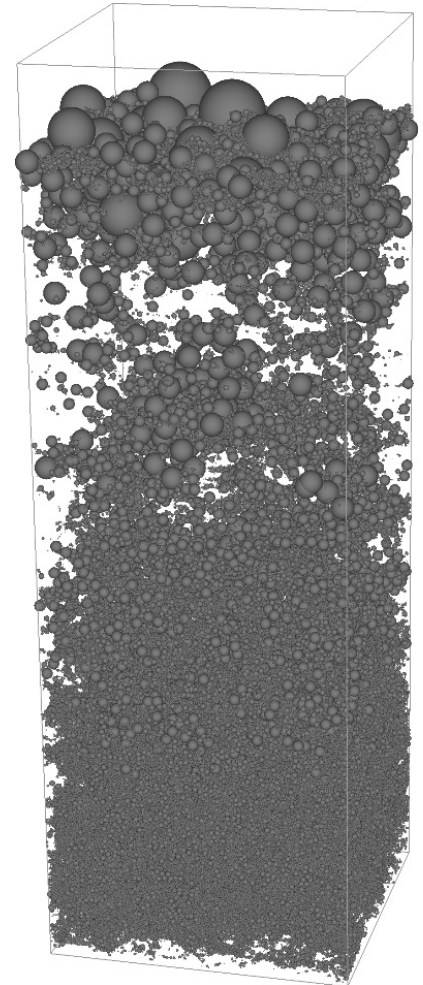
Homogeneous



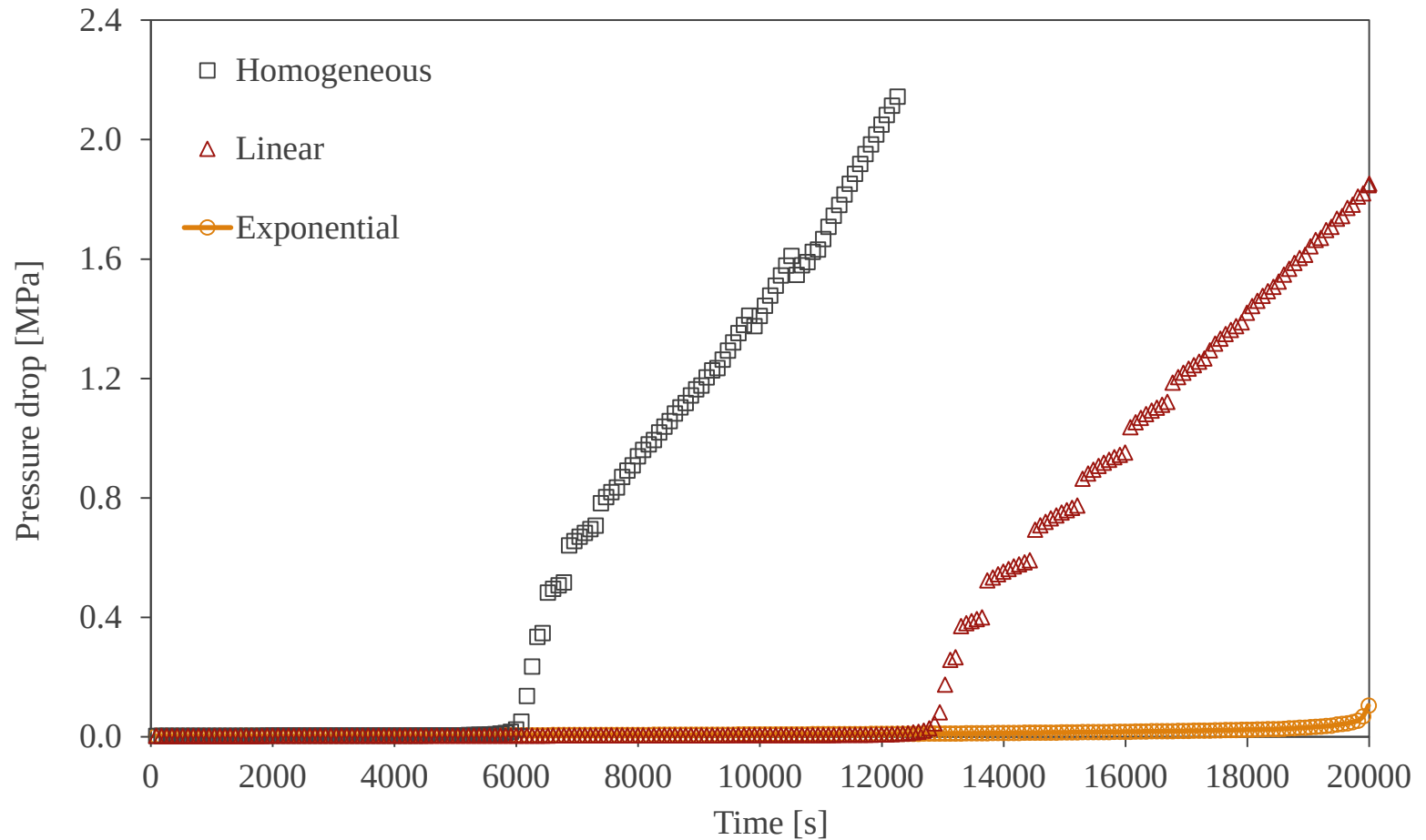
Linear



Exponential

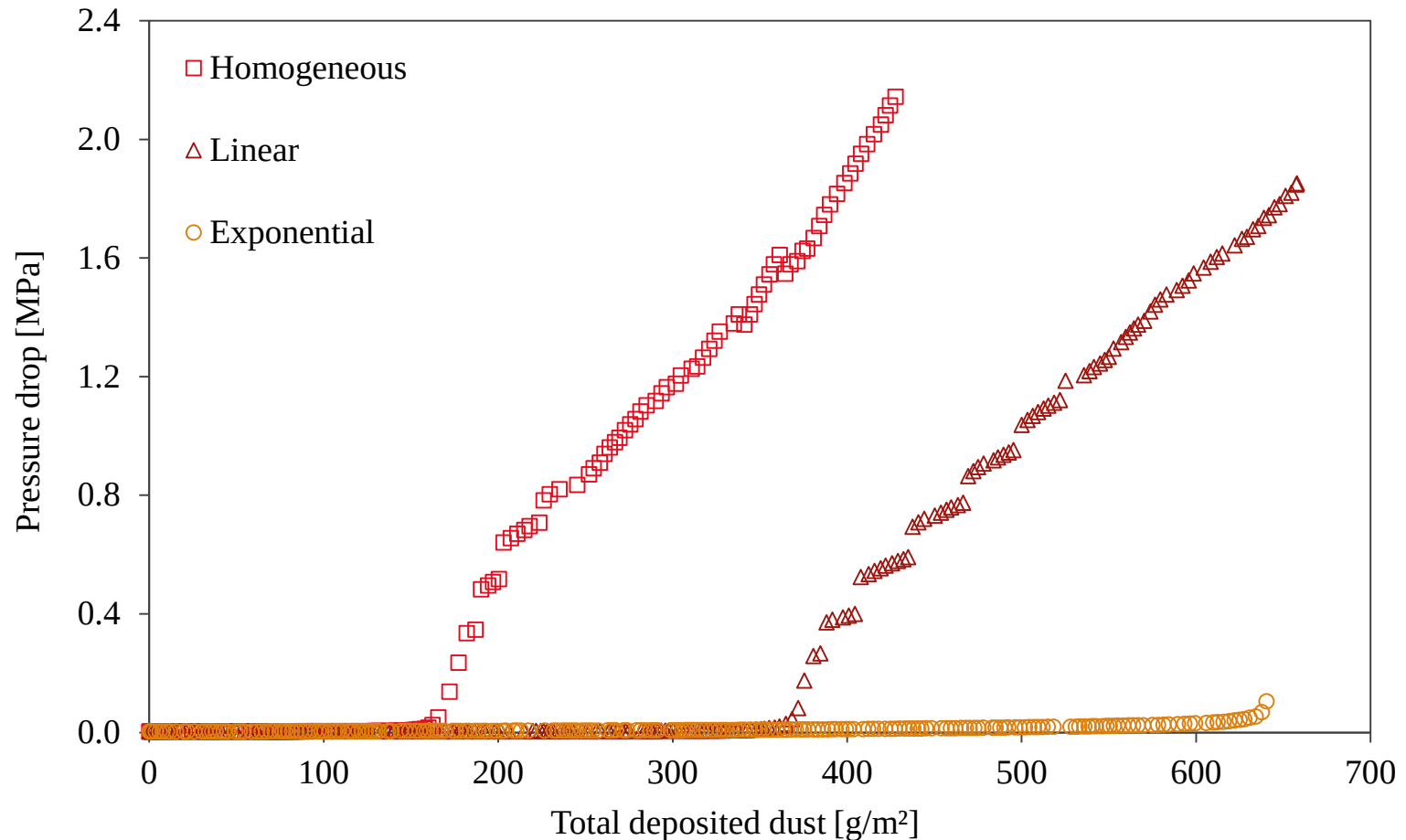


Multipass simulation results: Pressure-drop over time



➤ The exponentially increasing media shows the lowest pressure-drop increase through the life-time simulations.

Multipass simulation results: Pressure-drop over total deposited dust



- The exponentially increasing media shows the lowest pressure-drop increase & the highest DHC through the life-time simulations.

Conclusions

- ✓ The simulations of filter and filtration can be done in different scales.
- ✓ By modification of the micro-structure of filter media, the macroscopic properties can be optimized.
- ✓ The gradient distribution of fibers through the media thickness, can improve the filtration characteristics.
- ✓ The exponential media shows the lowest pressure-drop increase & the highest DHC through the life-time simulations.
- ✓ The computer simulation helps to find the best performed filter media without being physically produced.

Thank you for your attention.
Visit us at our Booth #8 in Hall I-1

MATH
2 MARKET

