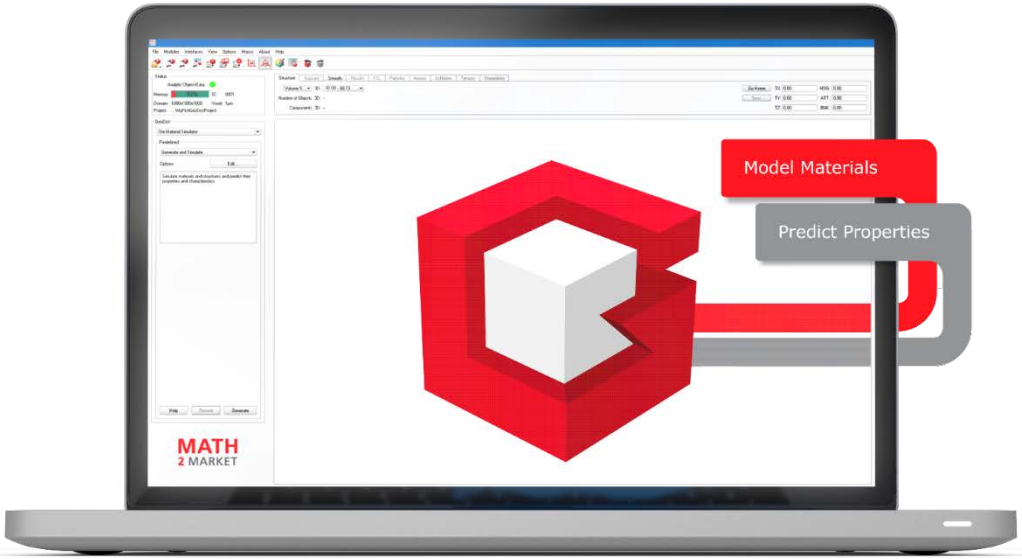
Jahrestreffen der ProcessNet-Fachgruppen Mechanische Flüssigkeitsabtrennung, Trocknungstechnik & Grenzflächenbestimmte Systeme & Prozesse, 26. - 28. Februar 2018 Radisson Blu Hotel / Ständehaus, Merseburg

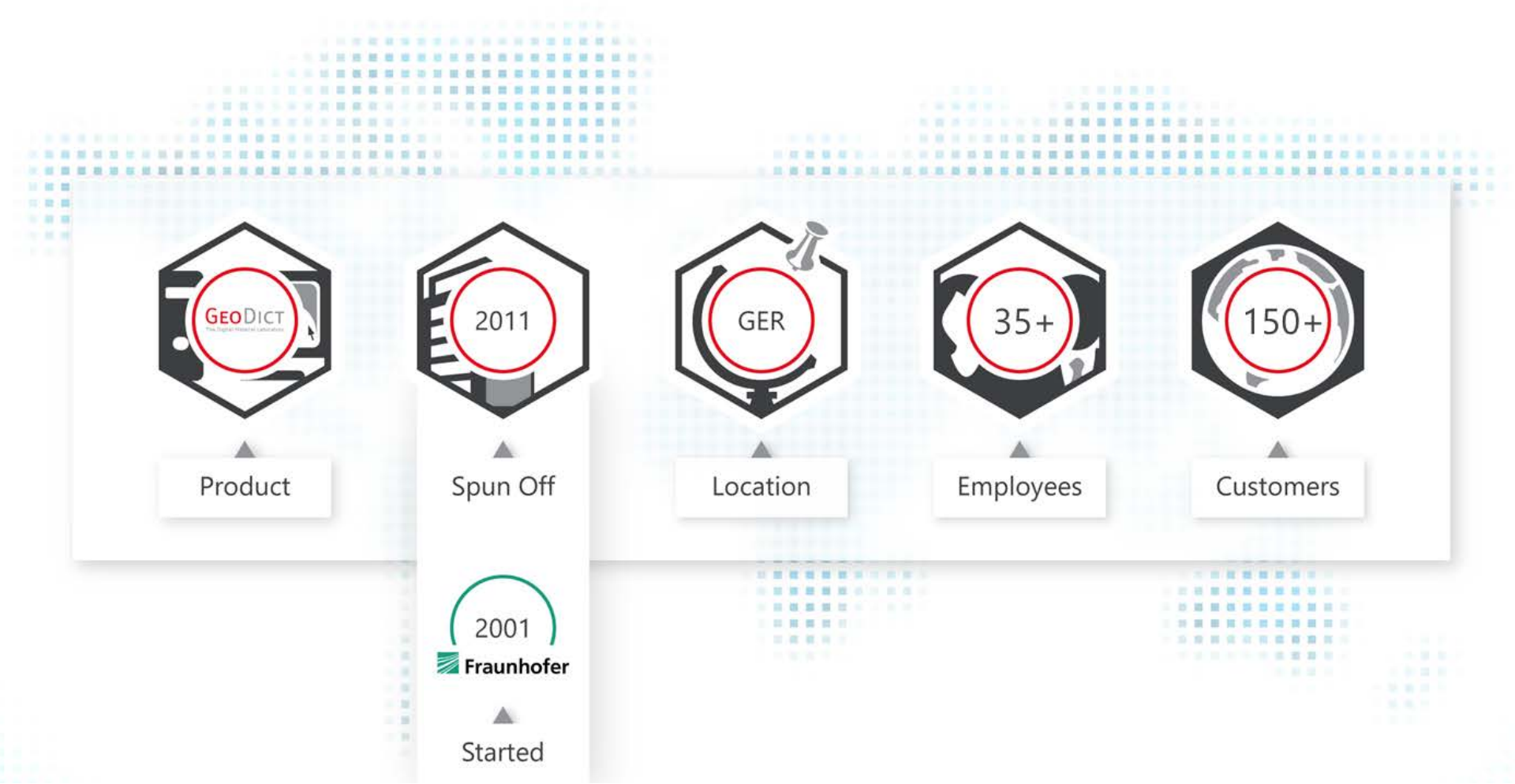
Optimization of filter media characteristics with GeoDict

Mehdi Azimian, Christopher Kühnle, Andreas Wiegmann

Math2Market GmbH,
Kaiserslautern, Germany

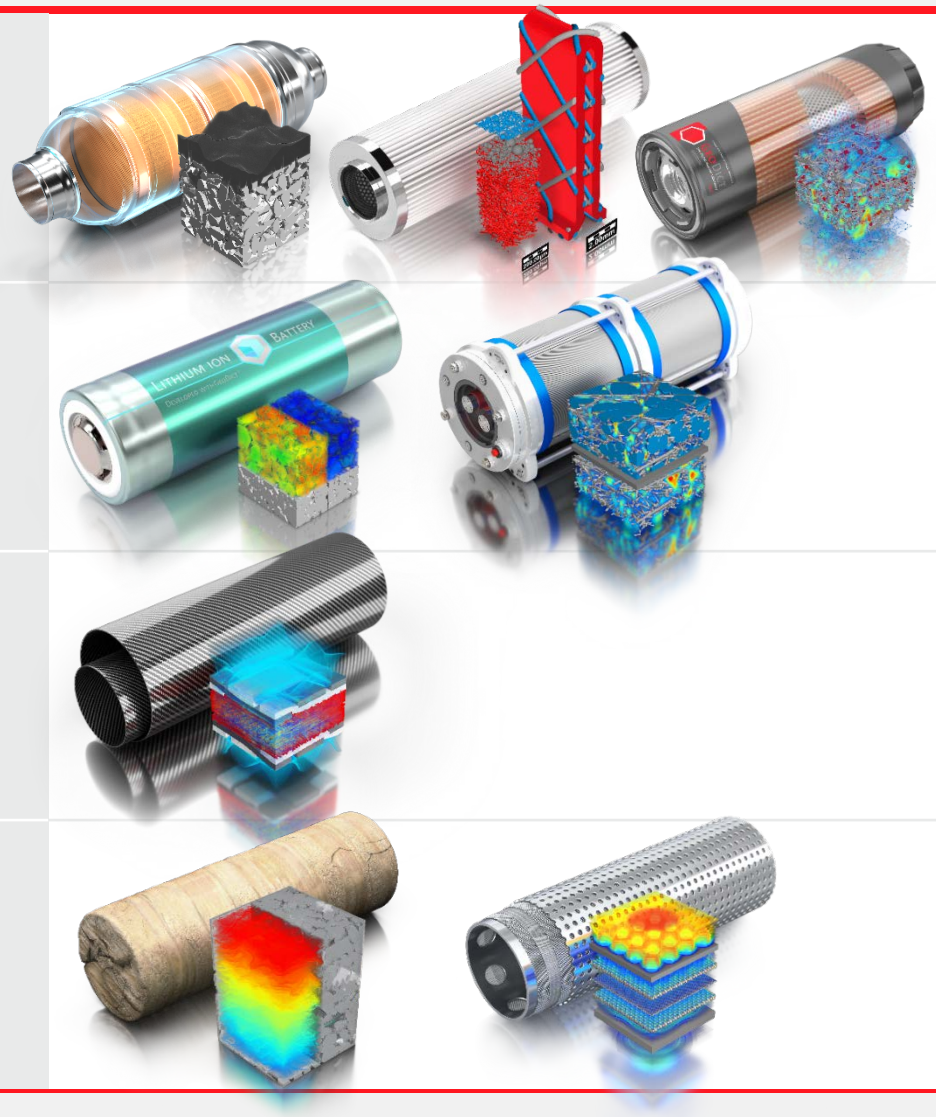


Math2Market GmbH overview



GeoDict The Digital Material Laboratory

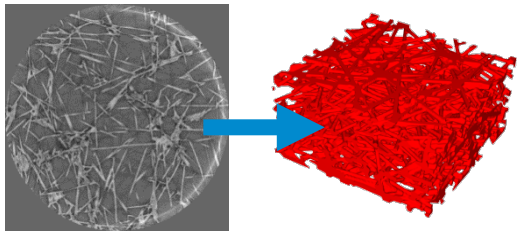
Filtration	Mostly automotive, filter media & filters for water, sludge, oil, air and fuel
Electrochemistry	Fuel cell media & battery materials, catalyst materials
Composites	CFRP, GFRP, mostly automotive, lightweight materials
Oil and Gas	Digital rock physics, digital sand control



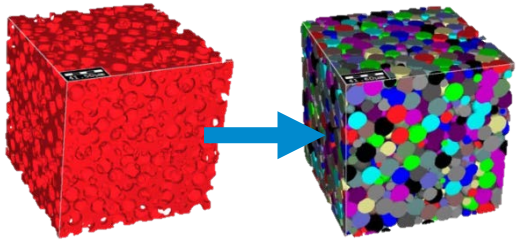
GeoDict introduction

With GeoDict you can...

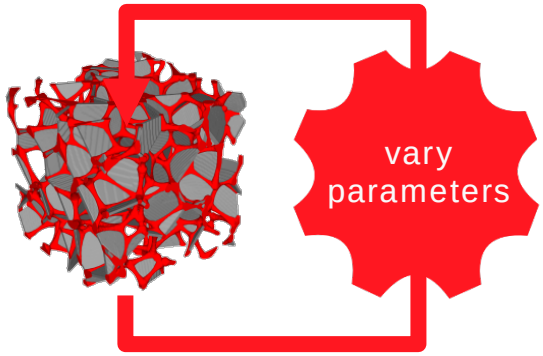
Import µCT & FIB-SEM



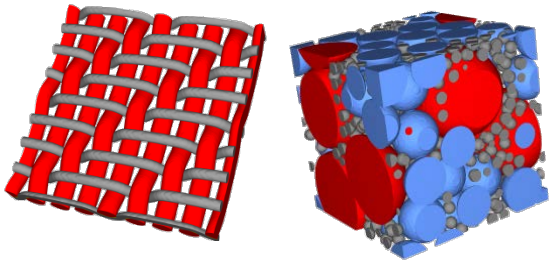
Analyse Materials



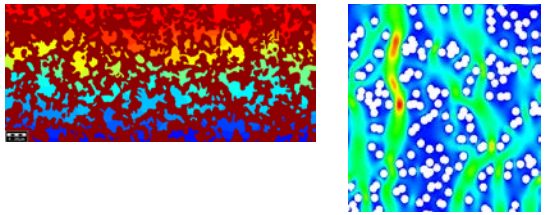
Optimize Materials



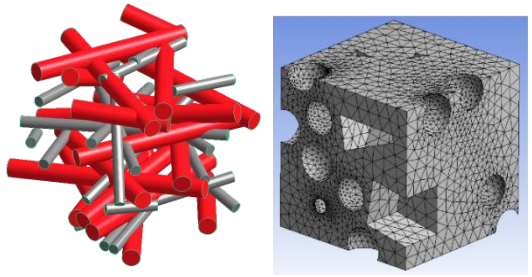
Model Materials



Analyse Properties

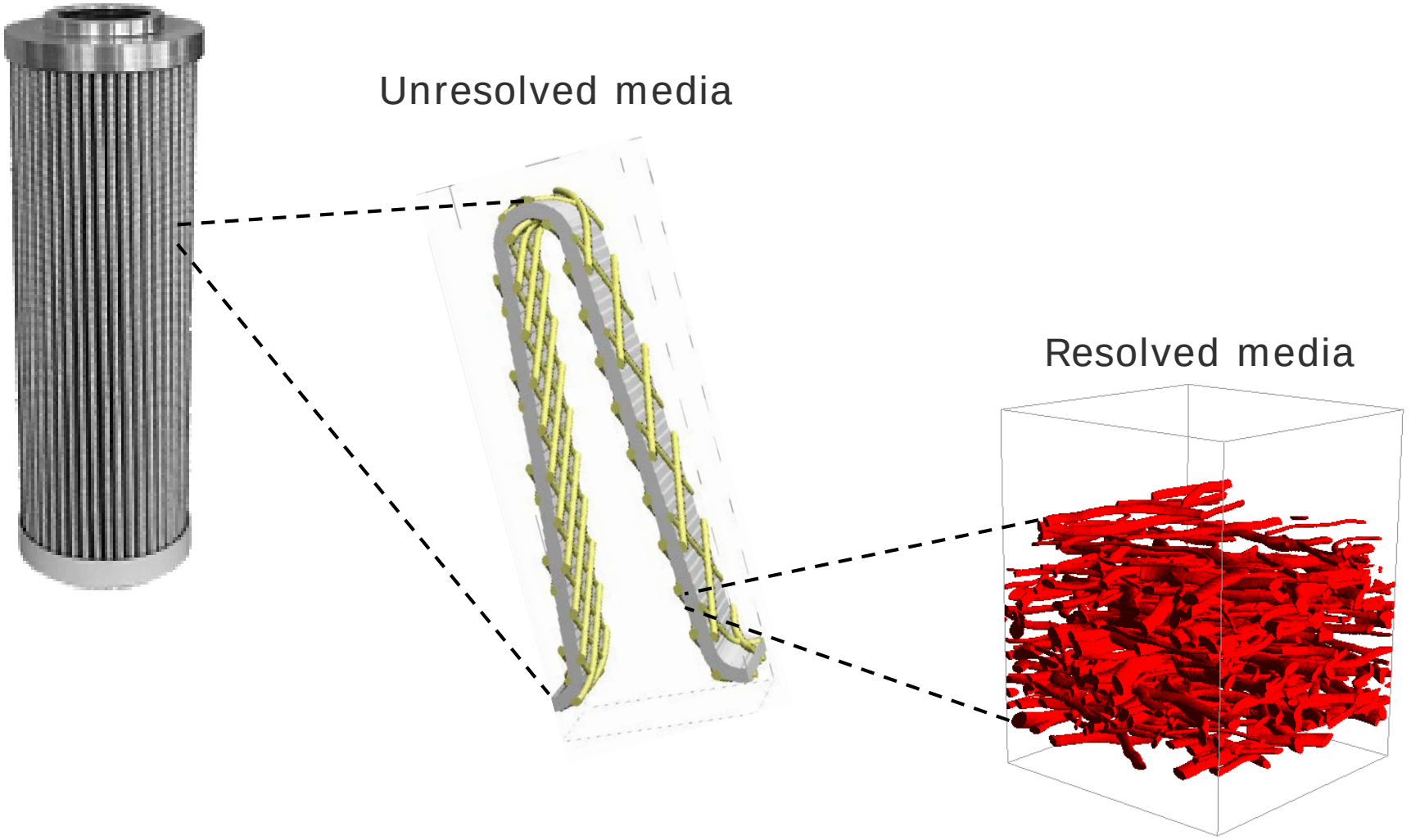


Export Materials



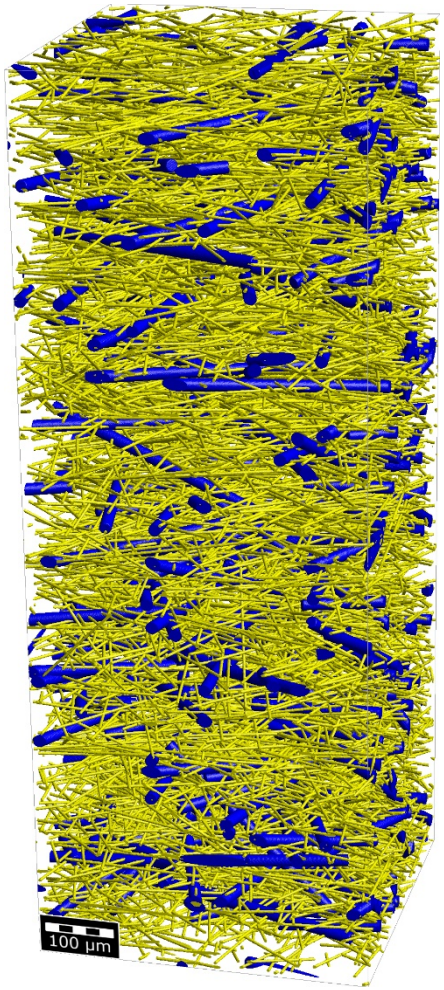
Modeling & simulation of micro-structure of filter media

Simulate filtration at different scales

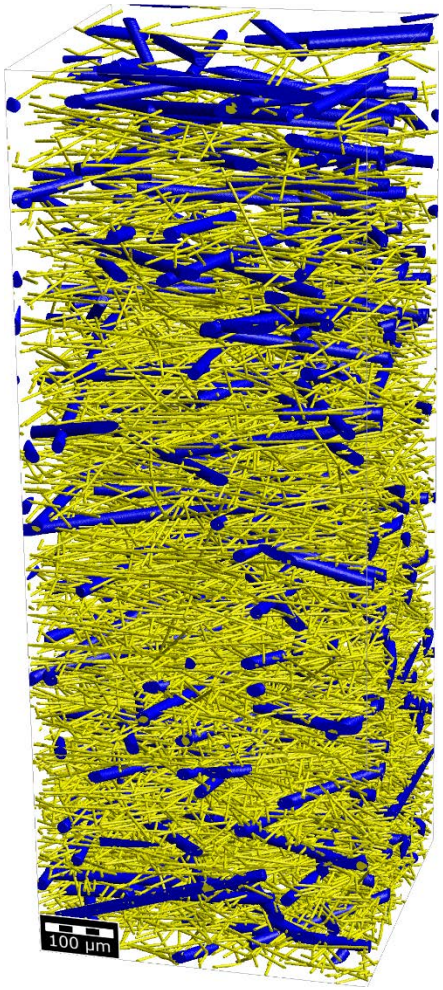


Modeling of three various filter media structures

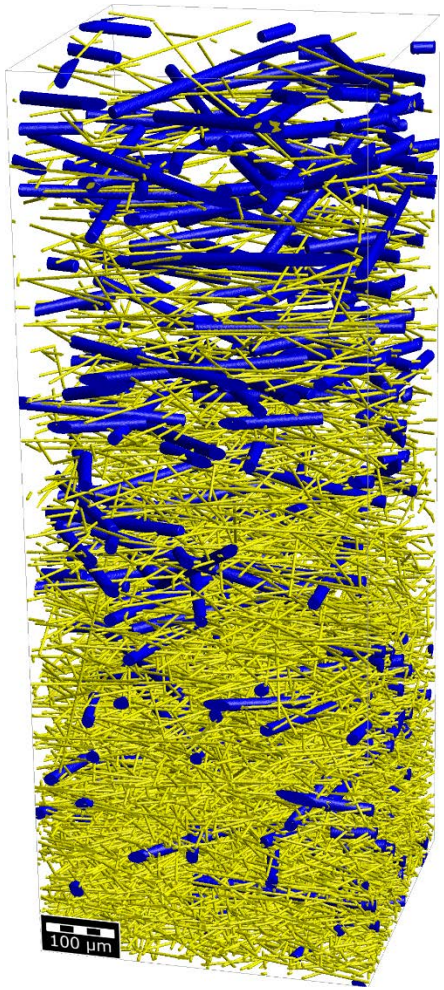
Homogeneous



Linear



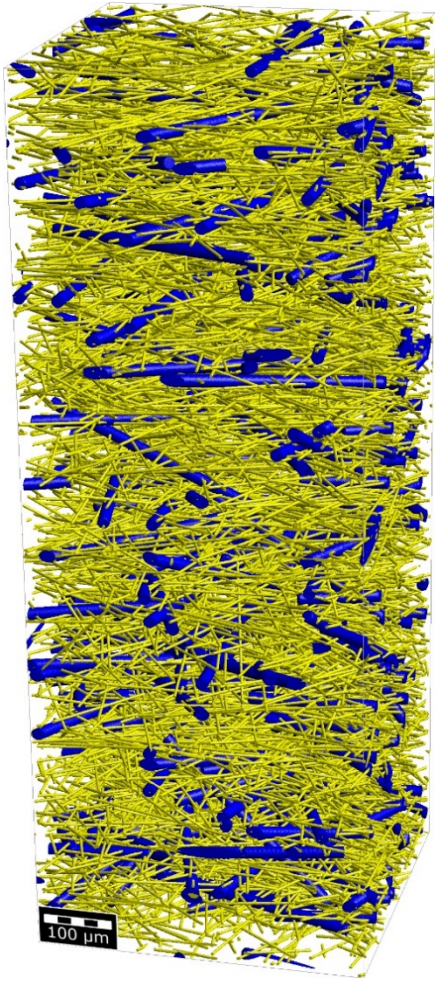
Exponential



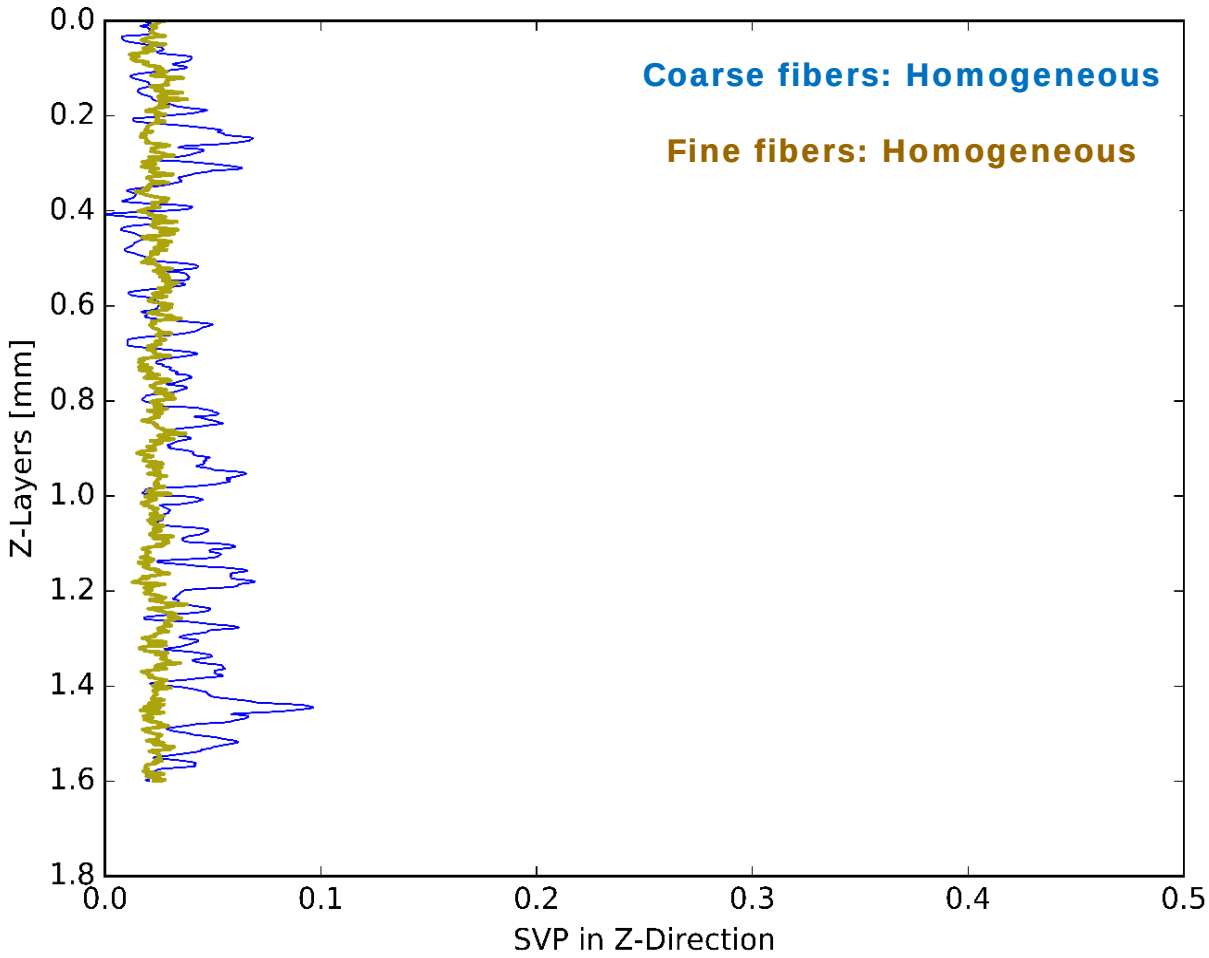
Modeling of three various filter media structures

Structure	Homogeneous	Linear	Exponential
Size [Voxels]	600x600x1600	600x600x1600	600x600x1600
Distribution of coarse fiber / fine fiber	Uniform / Uniform	Uniform / 1,2,3,4,5,6,7,8,9,10,11	Uniform / 1,2,4,8,16,32
Permeability [m^2]	5.47E-11	5.48E-11	5.53E-11
$\beta_{22\mu m}$	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

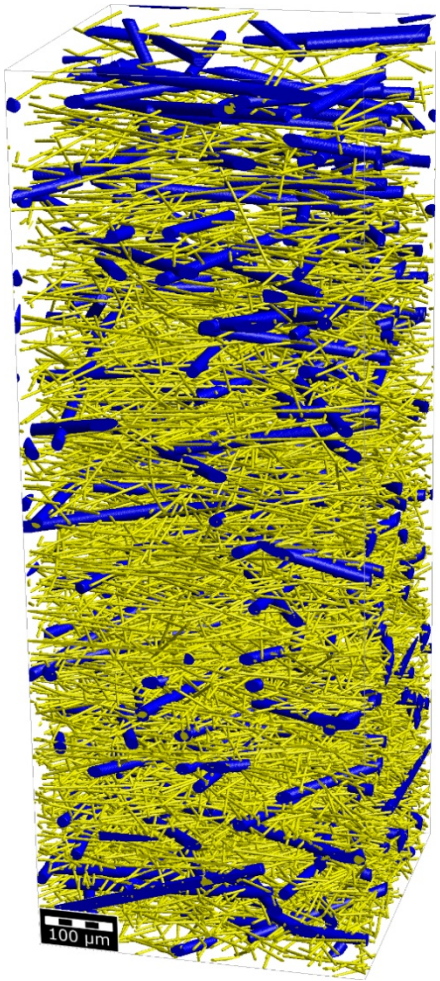
Homogeneous



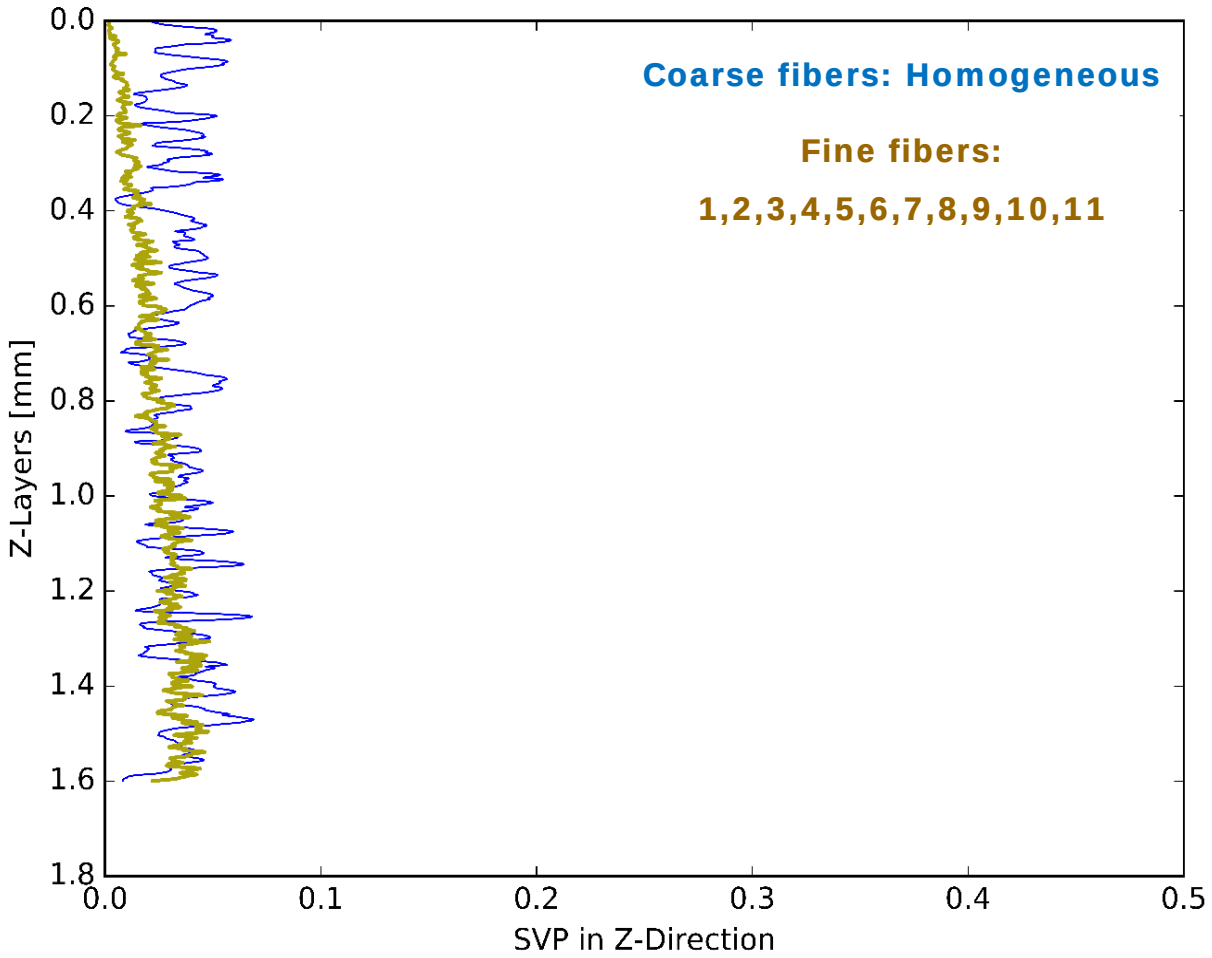
Domain 600x600x1600 voxels



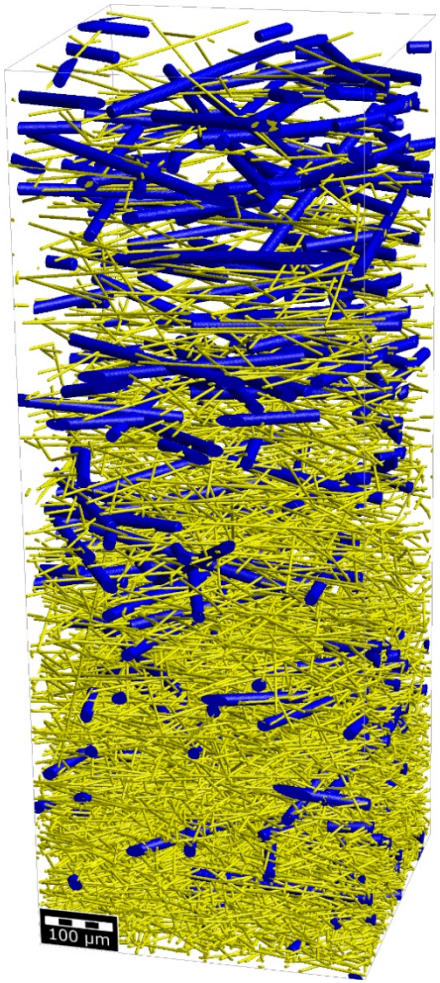
Linear



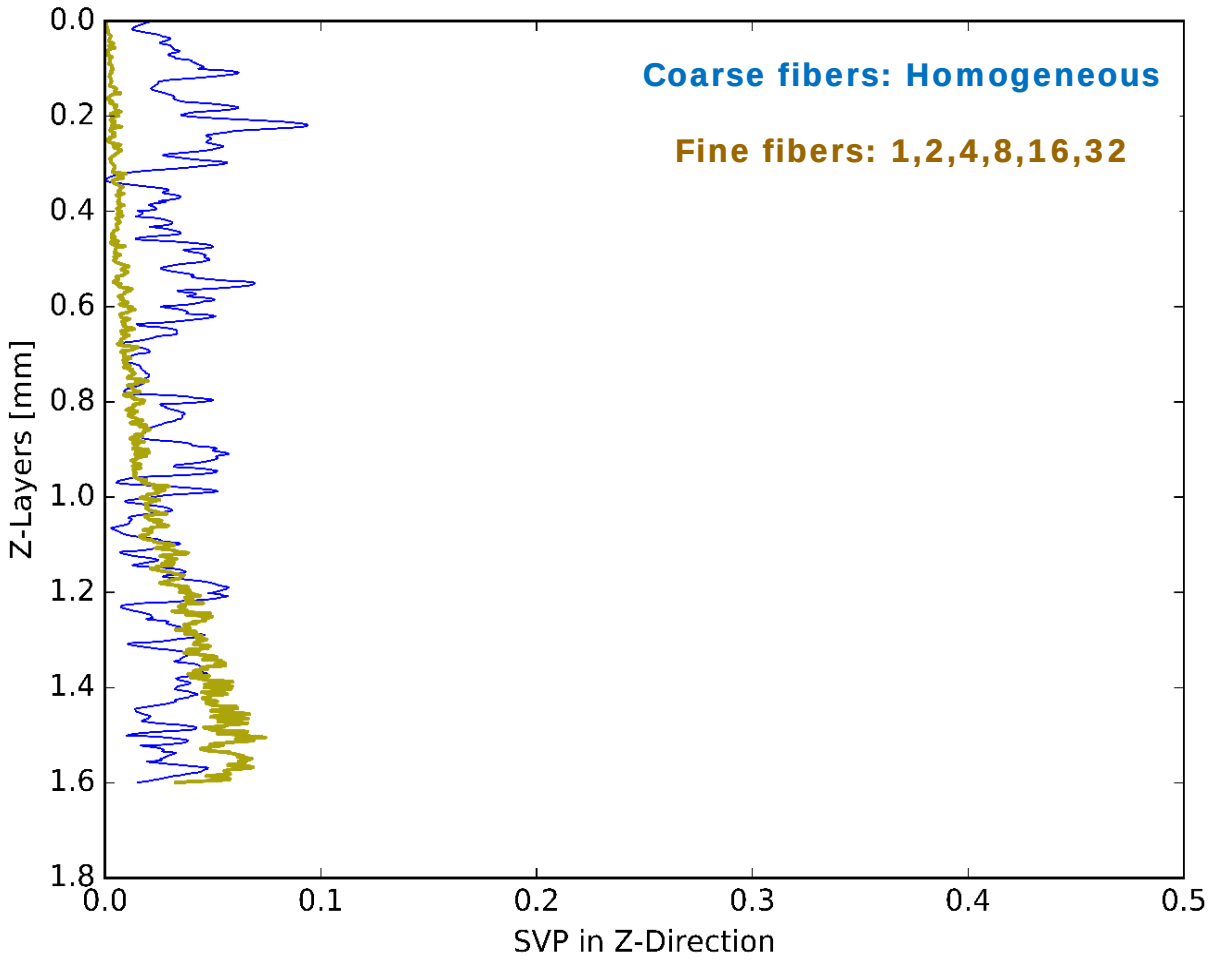
Domain 600x600x1600 voxels



Exponential

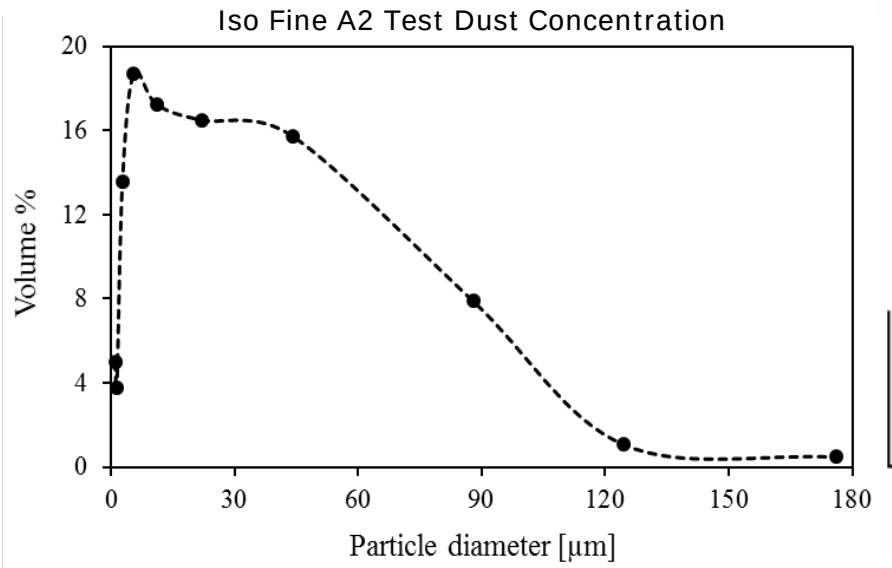


Domain 600x600x1600 voxels

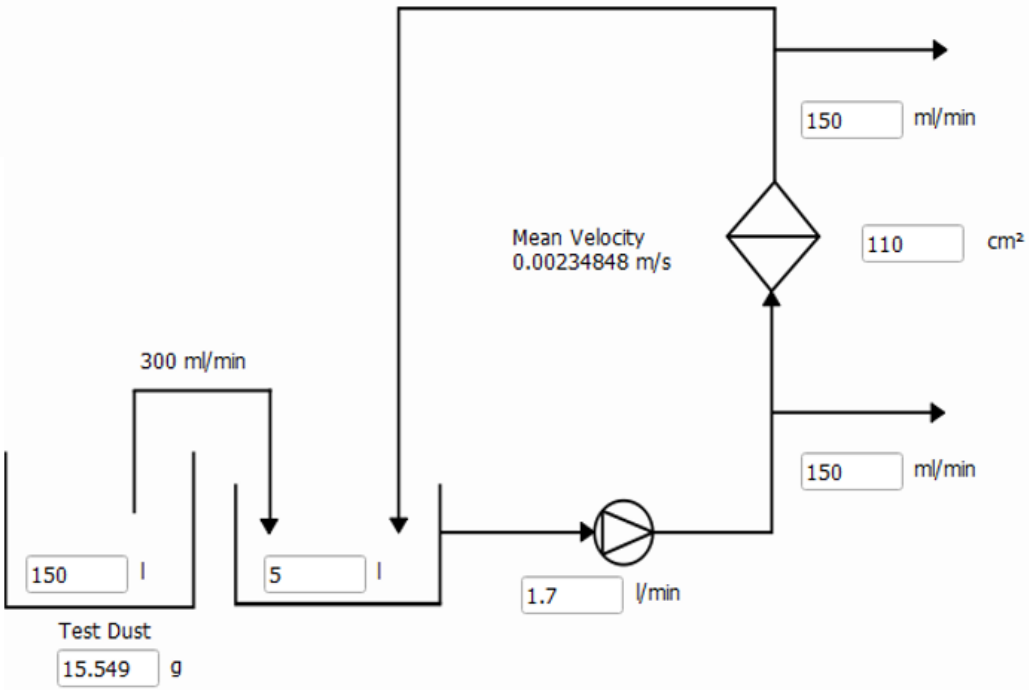


Particulate oil flow parameters

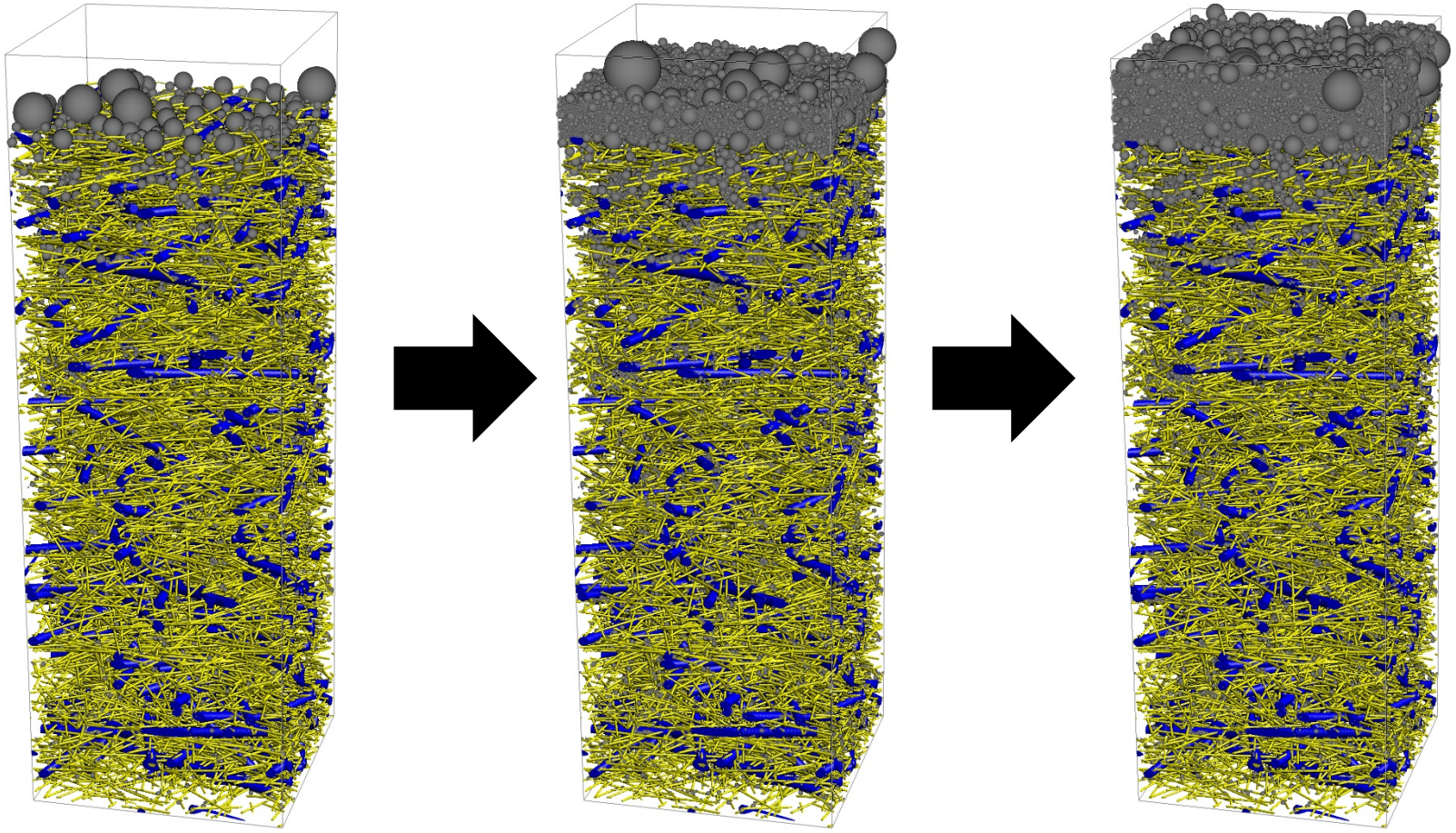
Used Fluid:	Oil
Temperature:	20 °C
Used Particles:	ISO Fine A2 test dust
Particle Density:	2560 kg/m³
Particle Collision Model:	Sieving
Solver:	LIR (Adaptive grids based)
Flow regime:	Laminar



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



Transient filtration simulation (Homogeneous structure)

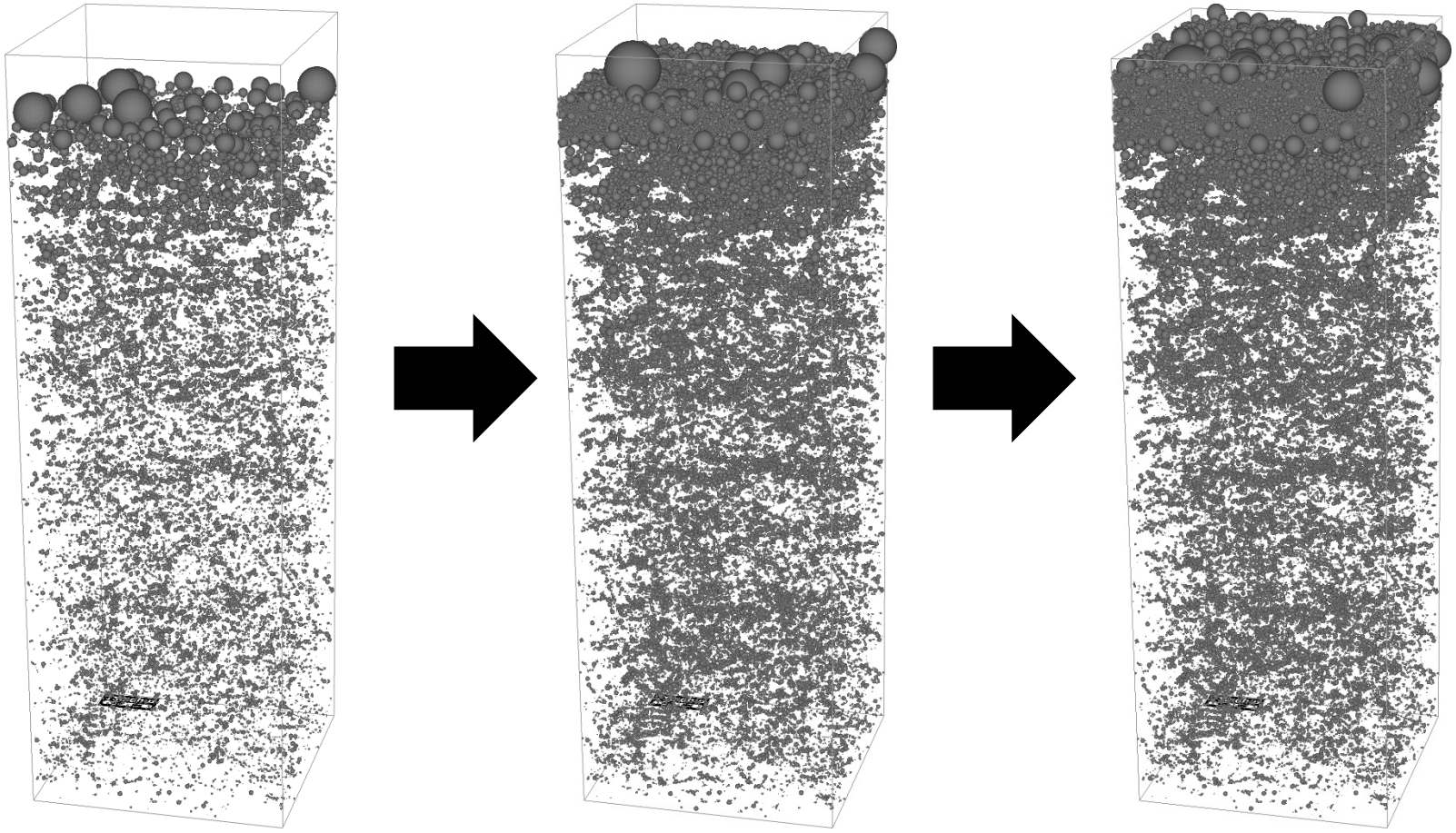


2650 s

8733 s

11340 s

Transient filtration simulation (Homogeneous structure)

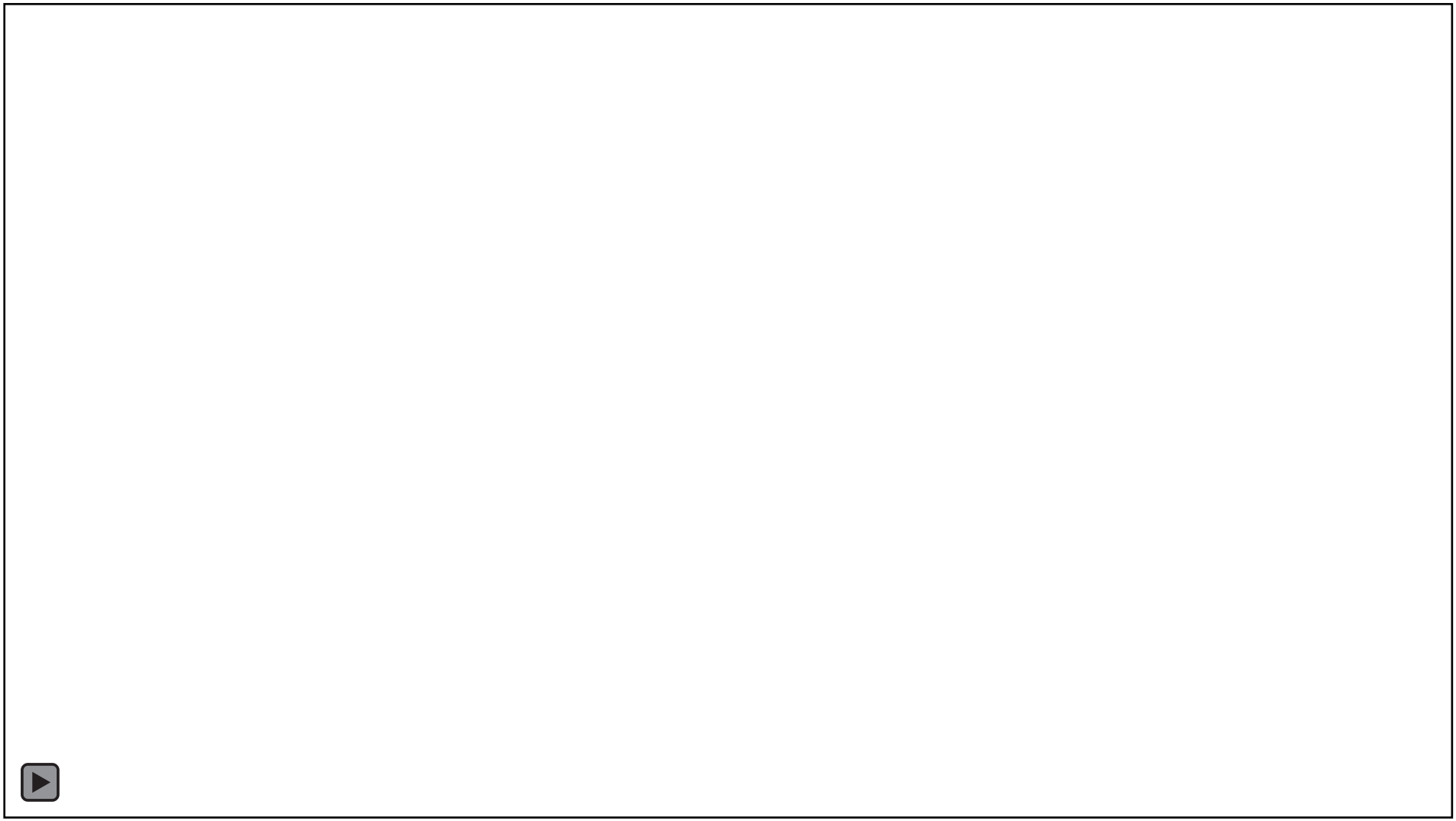


2650 s

8733 s

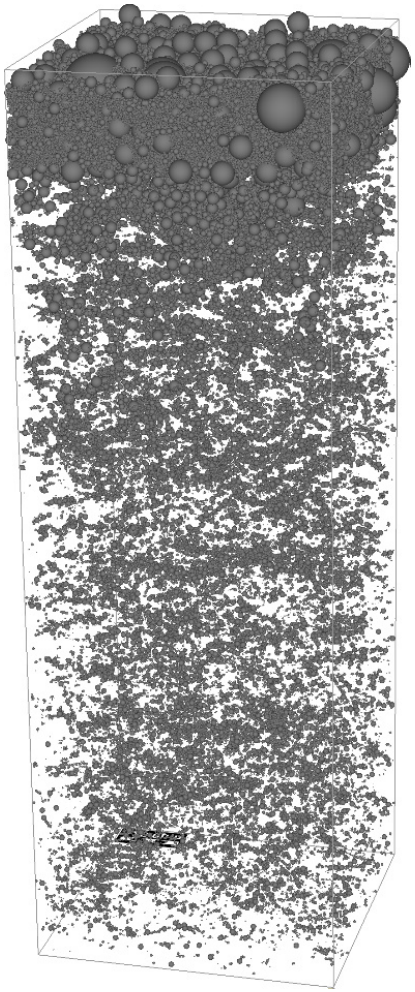
11340 s

Animation of the transient filtration simulation (Linear structure)

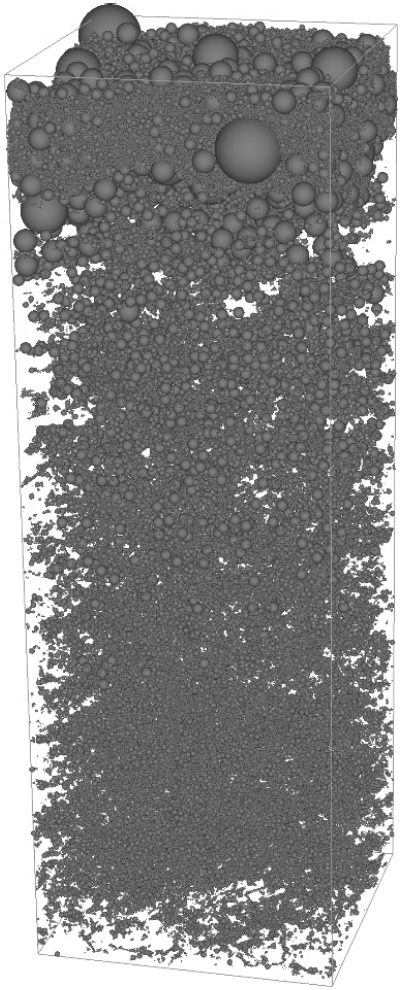


Comparison among the three structures

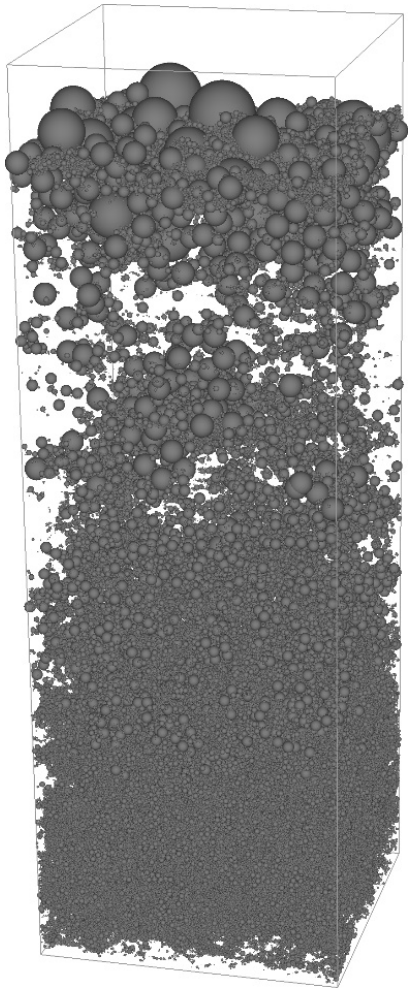
Homogeneous



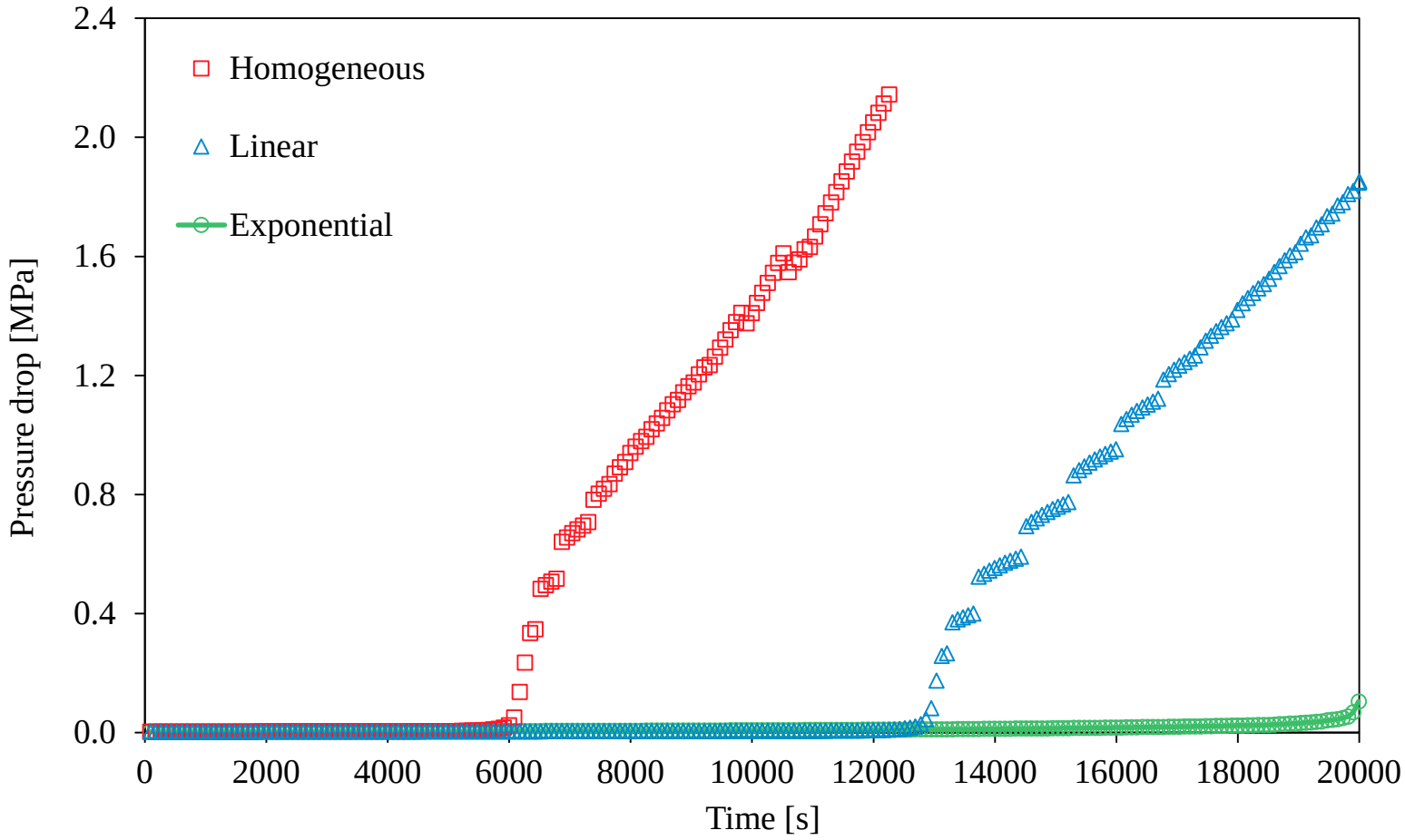
Linear



Exponential

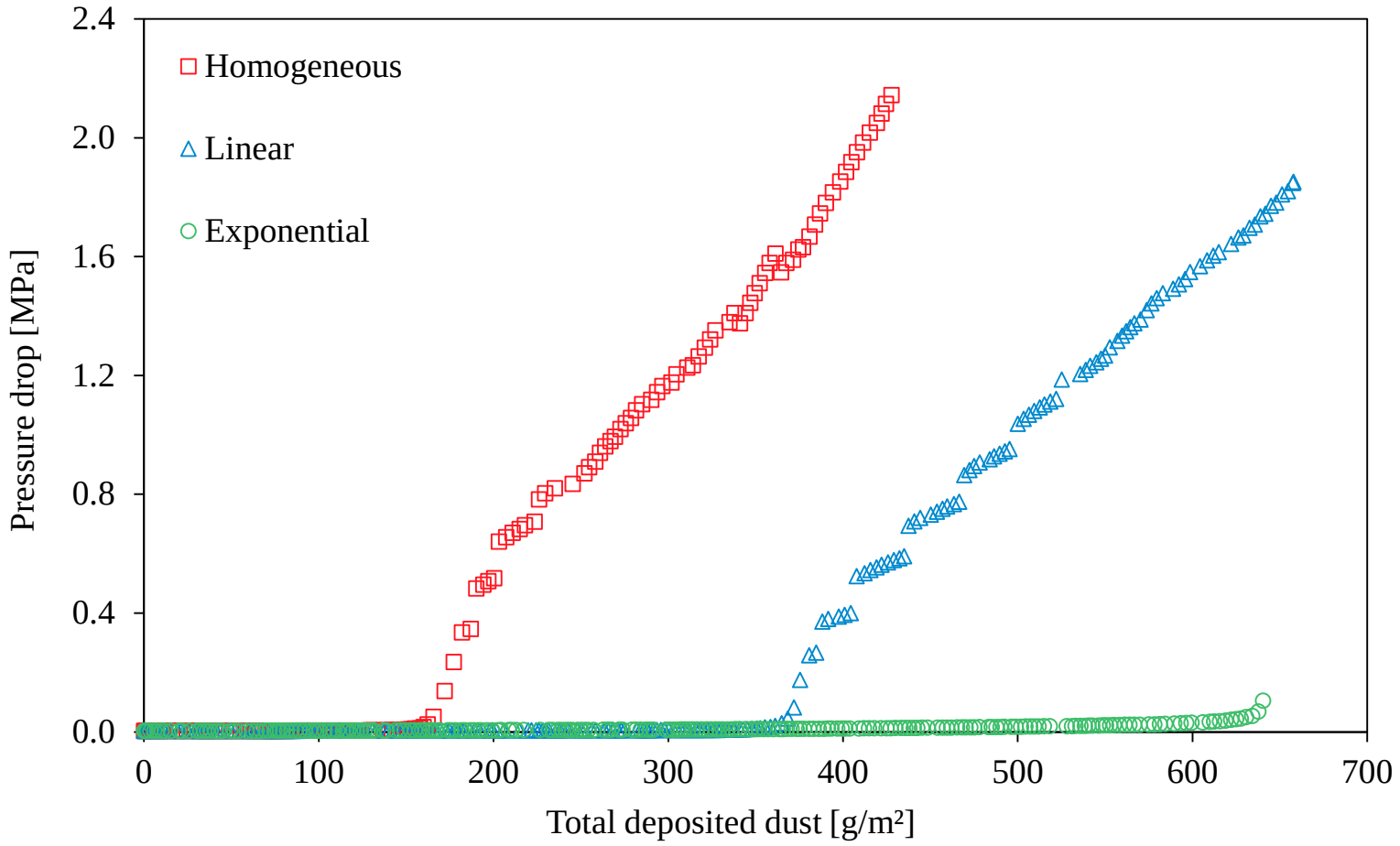


Multipass simulation results: Pressure-drop over time



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

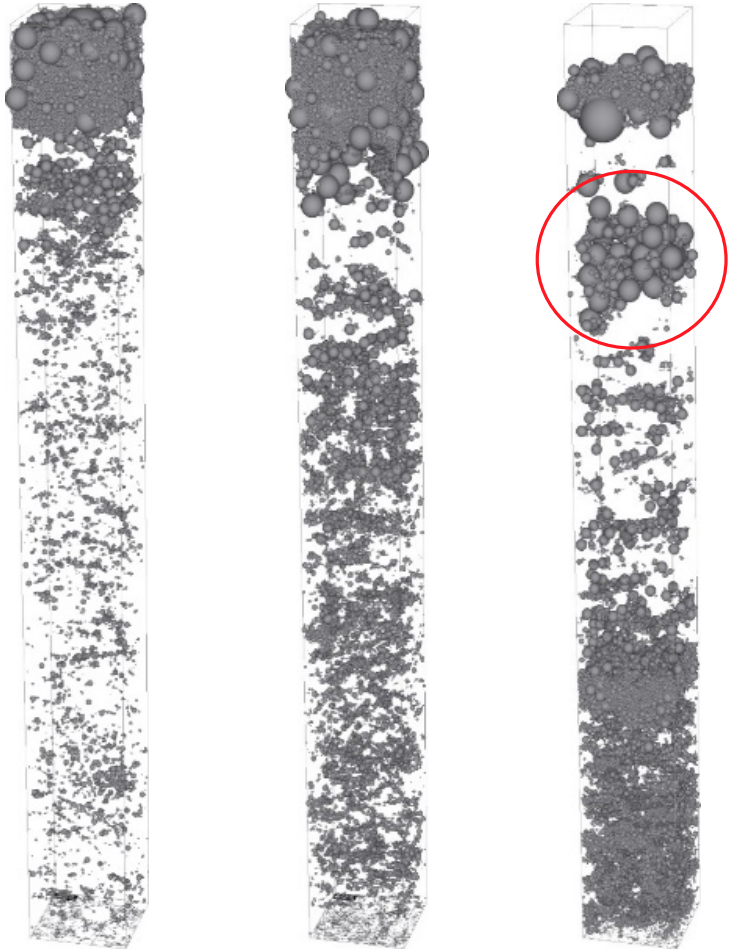
Multipass simulation results: Pressure-drop over total deposited dust



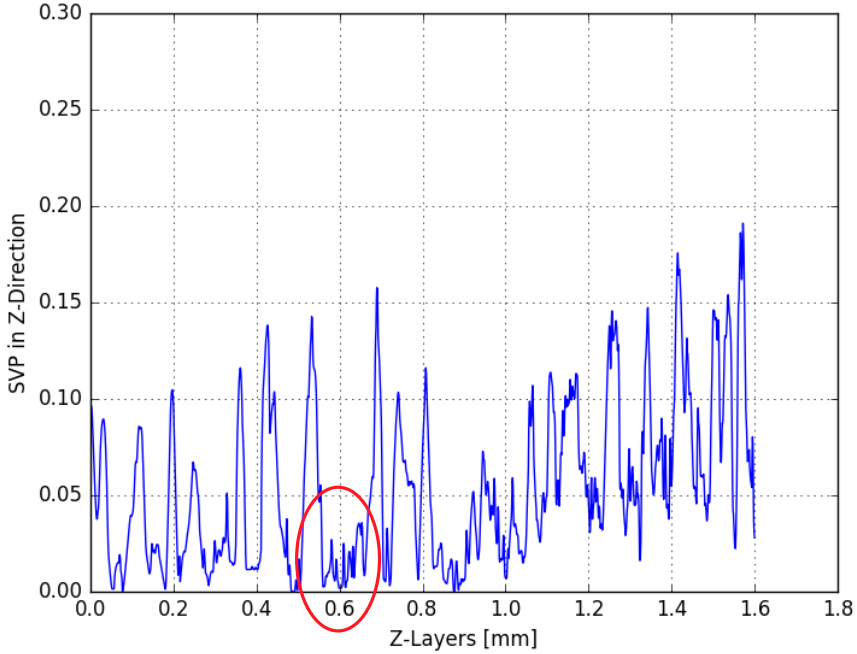
- The exponentially increasing media shows the lowest pressure-drop increase & the highest DHC through the life-time simulations.

Selection of a representative computational domain

Domain 200x200x1600 voxels



Homogeneous Linear Exponential



Subcakes will form, if there is a gap between high and low solid volume fraction.
Such subcakes will lead to a lower DHC.

Conclusions

- ✓ By modification of the micro-structure of filter media, the macroscopic properties can be optimized.
- ✓ Computational domain has to be large enough to be representative.
- ✓ 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.
- ✓ Results are published recently:

  M. Azimian, C. Kühnle, A. Wiegmann, Design and optimization of fibrous filter media using life-time multi-pass simulations, Chemical Engineering & Technology, 2018.

Thank you for your attention.