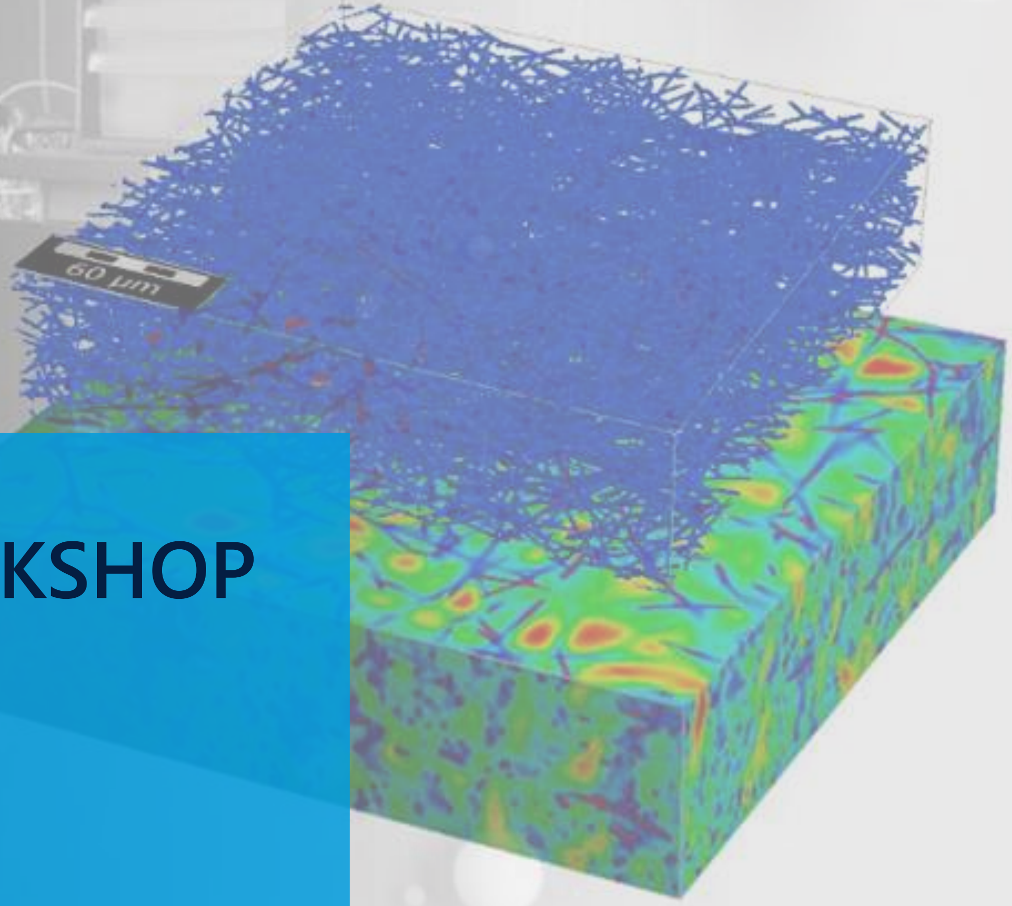
WELCOME TO RIGAKU VIRTUAL WORKSHOP

DEEP DIVE: FILTRATION ANALYSIS

3. Filtration Simulations

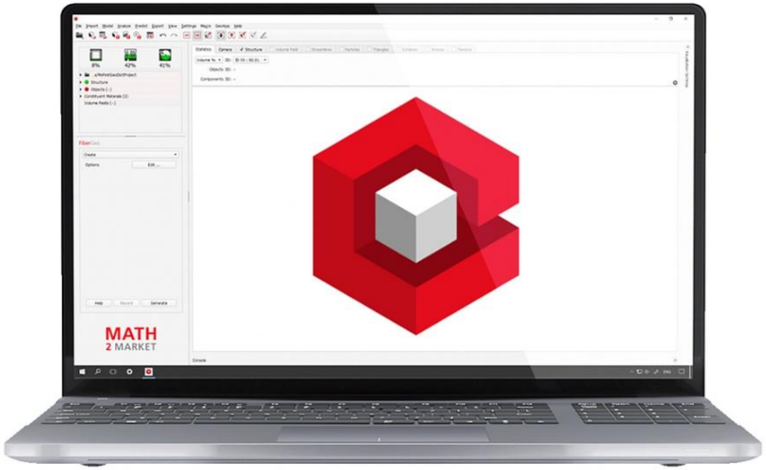
Watch the recording



Presenter: **Angela Criswell** | Senior Scientist

Co-presenter: **Aya Takase** | Director of X-ray Imaging

Host: **Tom Concolino** | Analytical X-Ray Consultant



GeoDict
The Digital Material Laboratory

Philipp Eichheimer, Ph.D. | Math2Market

Application Engineer

You can ask questions during the presentation.
We might turn on your microphone for further discussions.

Recording will be available tomorrow.

Filtration Analysis – 3. Filtration simulations

Virtual Workshop presented by Angela Criswell

FILTRATION ANALYSIS SERIES

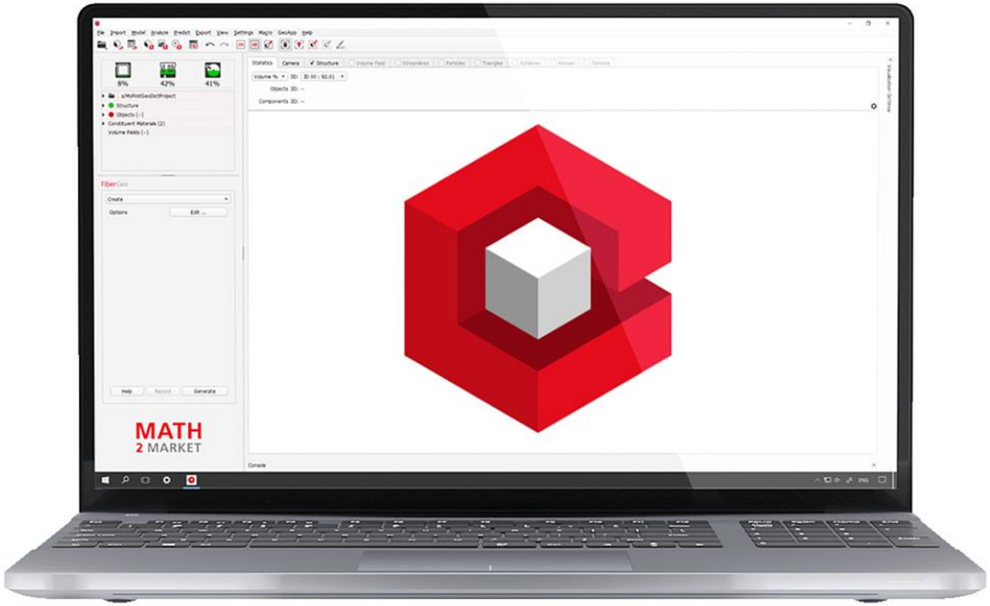
1. Data collection
2. Segmentation and property analyses
3. Filtration simulations

THINGS WE'LL COVER

- How to simulate the filtration process for filter media
- How to track particles during filtration simulations
- How to examine filter efficiency and filter life time

nano3DX by Rigaku

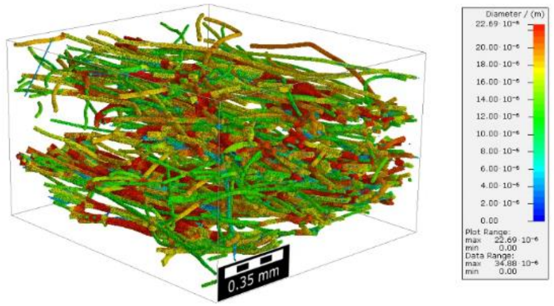
High resolution and high contrast for soft materials



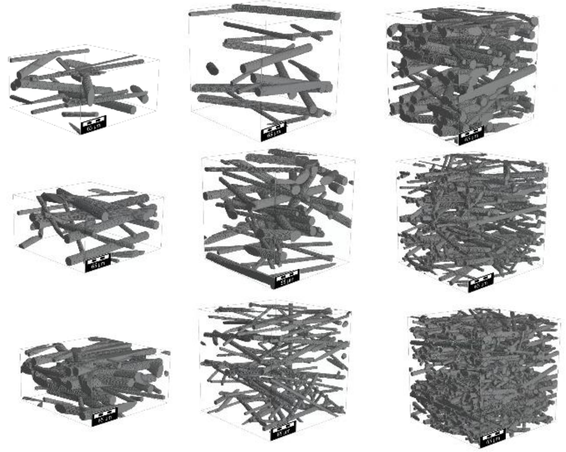
GeoDict by Math2Market

The Digital Material Laboratory

CT data



Filter media analysis



Filter media modeling

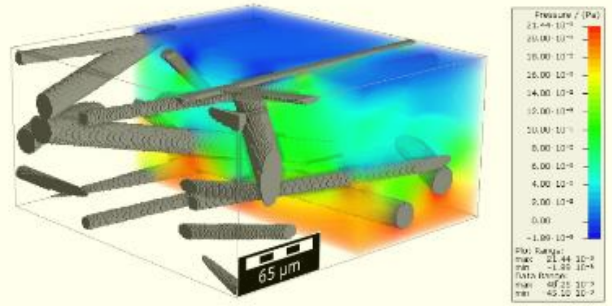
Filter optimization

http://www.tsi.com

Testing

http://www.airfilterusa.com , http://www.zoro.com

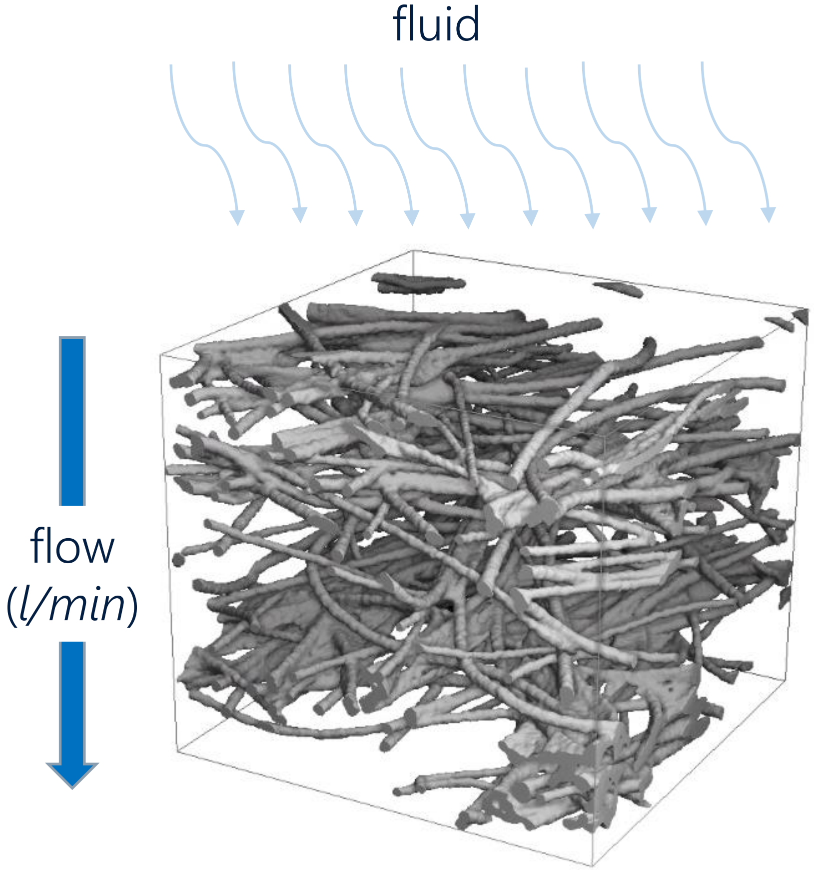
Manufacturing



Filtration simulations

HOW DO WE SIMULATE FILTRATION?

FILTRATION SIMULATION

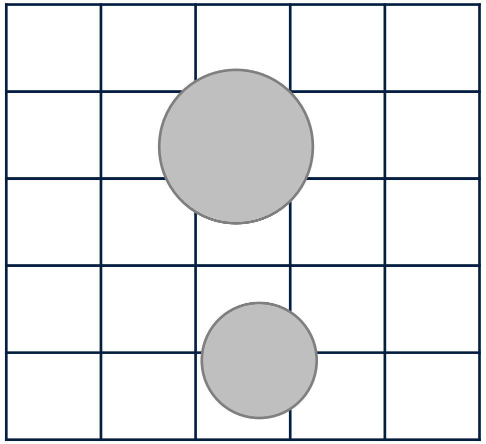


- Fluid flow
- Particle tracking
- Clogging and resistivity models

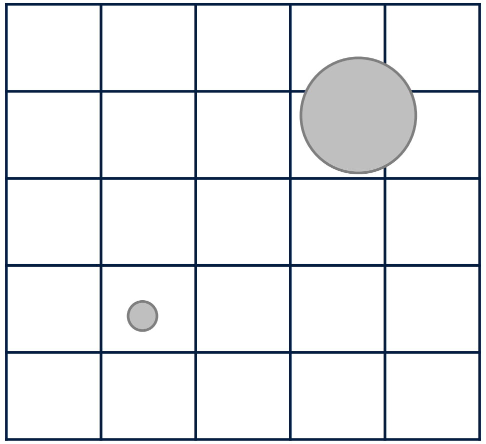
FLUID FLOW

- Navier-Stokes
  - Pores are resolved
- Navier-Stokes-Brinkman
  - Pores are not resolved

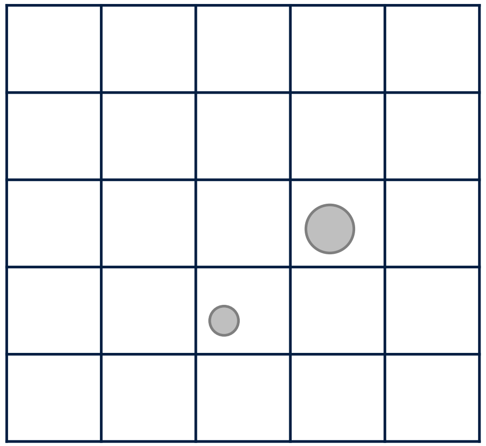
RESOLVED VERSUS UNRESOLVED



Resolved particles



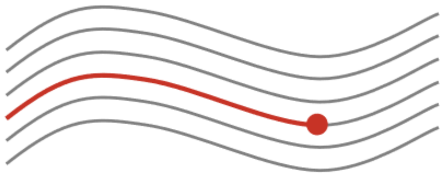
Partially resolved particles



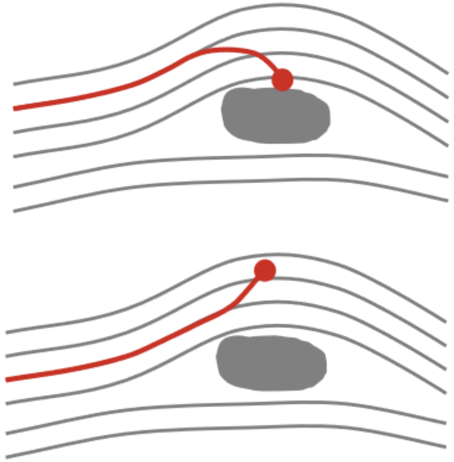
Unresolved particles

PARTICLE TRACKING

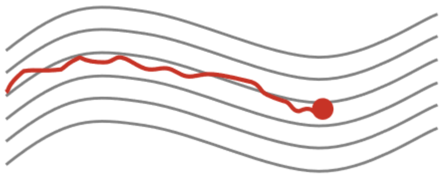
Drag flow



Electrostatic effects

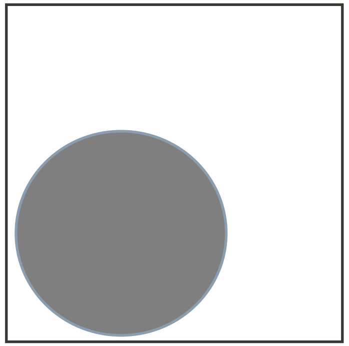


Diffusive (or Brownian) motion



CLOGGING AND RESISTIVITY MODEL

voxel



particle

$$fill = \frac{v_{particle}}{v_{voxel}}$$

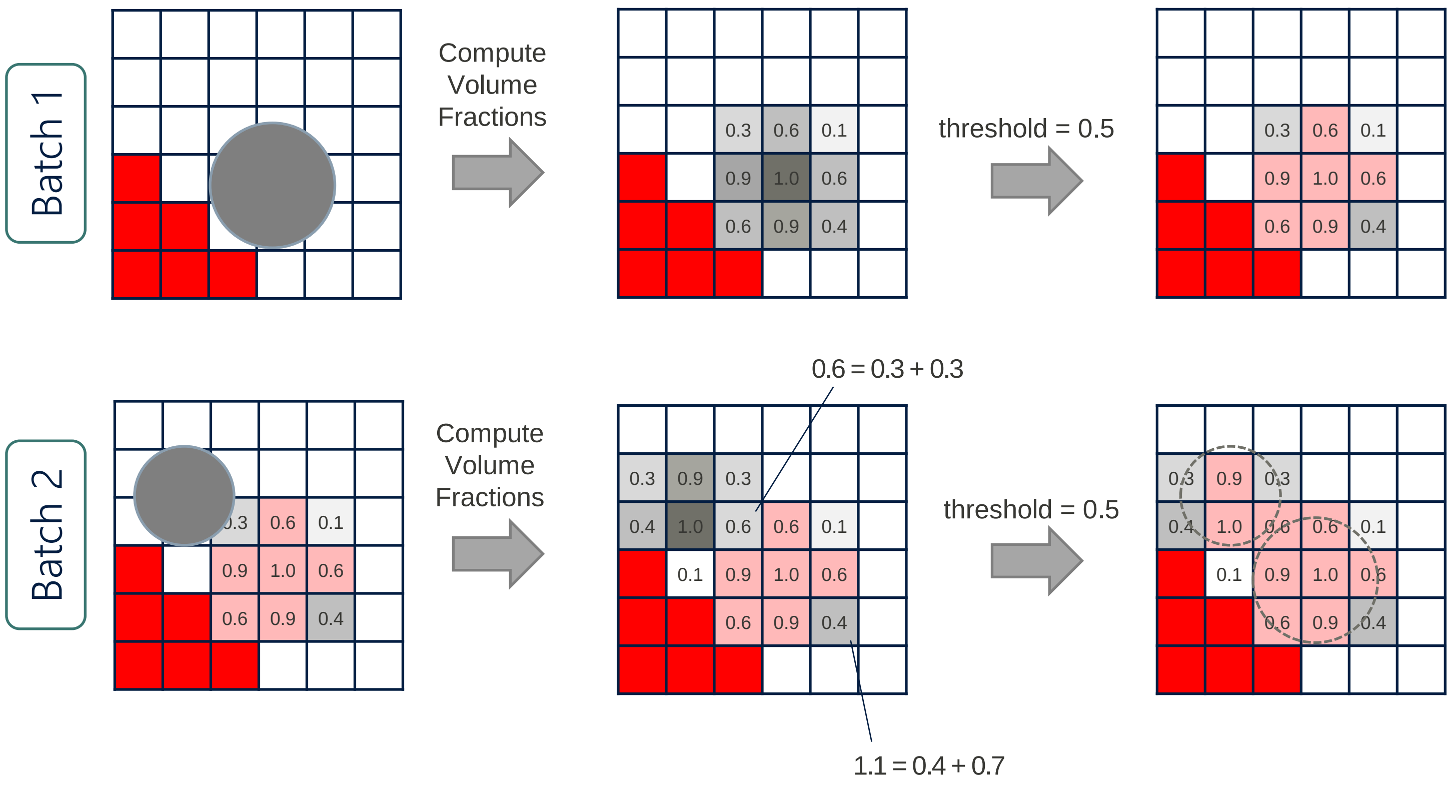
$$threshold < fill \quad < threshold$$

solid

pore

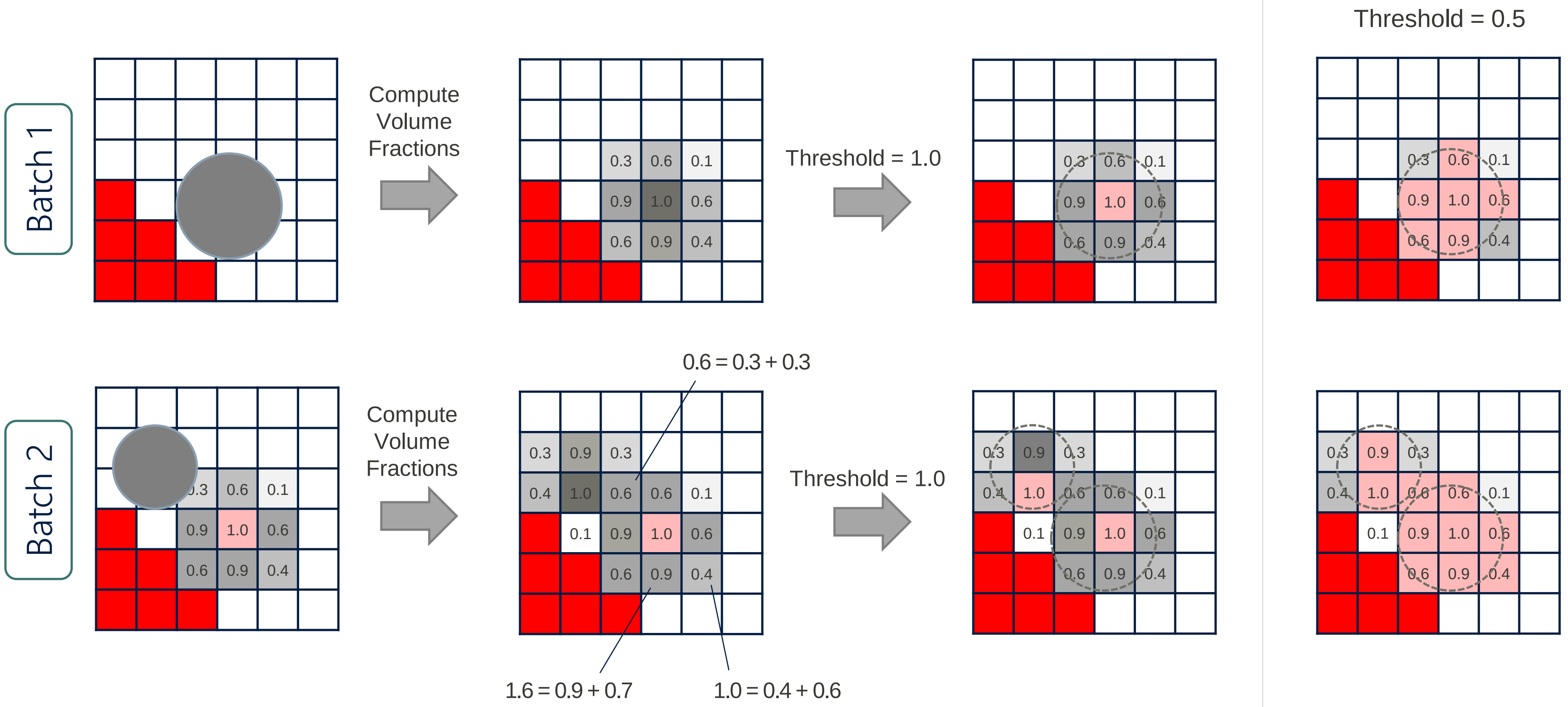
CLOGGING AND RESISTIVITY MODEL

- Resolved (threshold = 0.5)



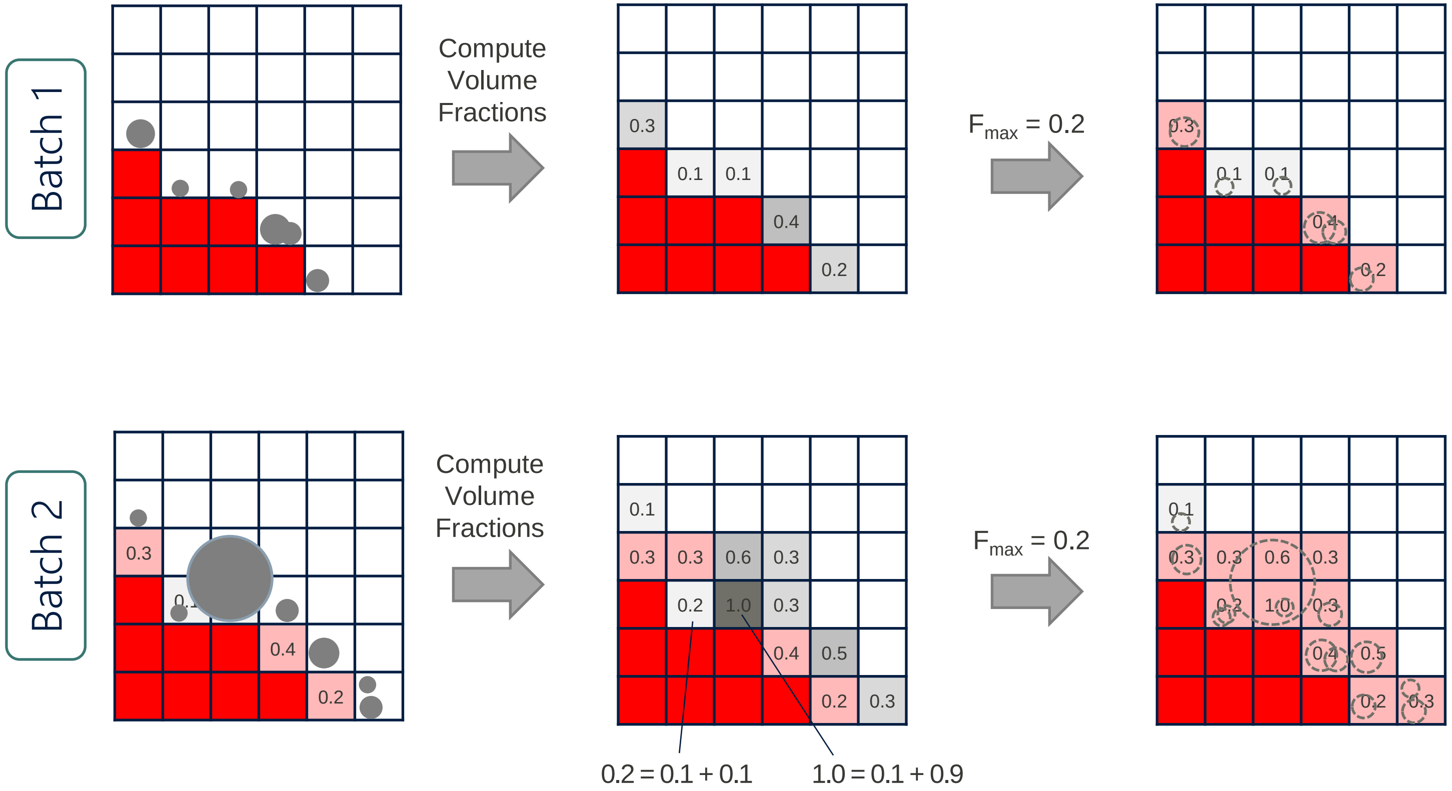
CLOGGING AND RESISTIVITY MODEL

- Resolved (threshold = 1.0)



CLOGGING AND RESISTIVITY MODEL

- Unresolved (F_{max})



COLLISION MODELS

- Caught on first touch
- Hamaker model

$$v^2 < \frac{H}{4\pi\rho a_0 R^2}$$

adhesion (Hamaker constant) — H

particle radius — R

adhesion distance (~0.4 nm) — a_0

particle density — ρ

- Sieving

$$\text{Restitution coefficient} = \frac{v_2}{v_1}$$

velocity after collision — v_2

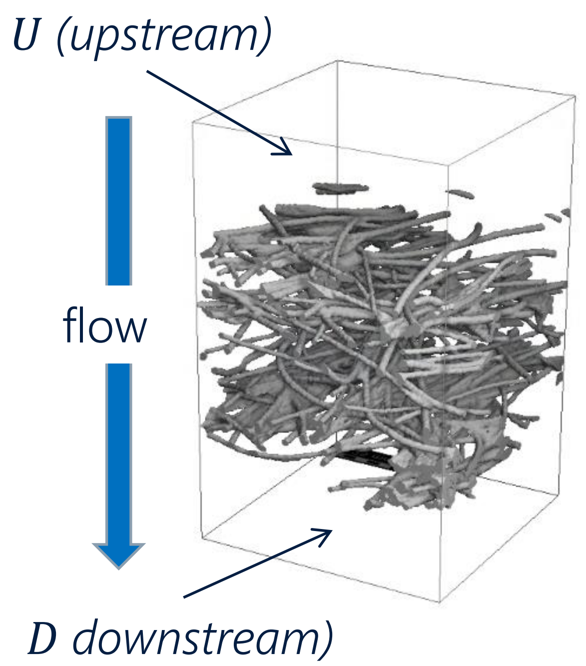
initial velocity — v_1

H. Krupp, Advances in Colloid and Interface Sci., 1967, 1 (2), 111.

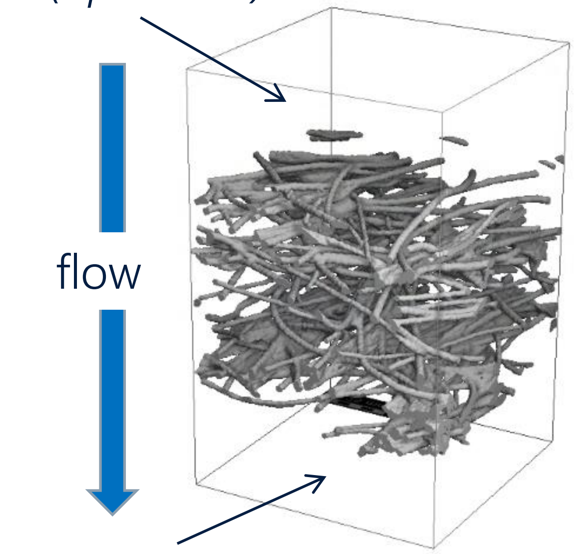
SO, HOW IS FILTER PERFORMANCE DESCRIBED?

DEFINING FILTER PERFORMANCE

- Pressure drop
- Dust holding capacity (DHC)
- Filter efficiency (*e*)
  - β ratio is efficiency for a given particle size



FILTER EFFICIENCY AND β RATIO



d = particle diameter

Efficiency: $$e_d = \frac{n_{d,filtered}}{n_{d,initial}}$$

β ratio: $$\beta_d = \frac{100}{100 - e_d}$$

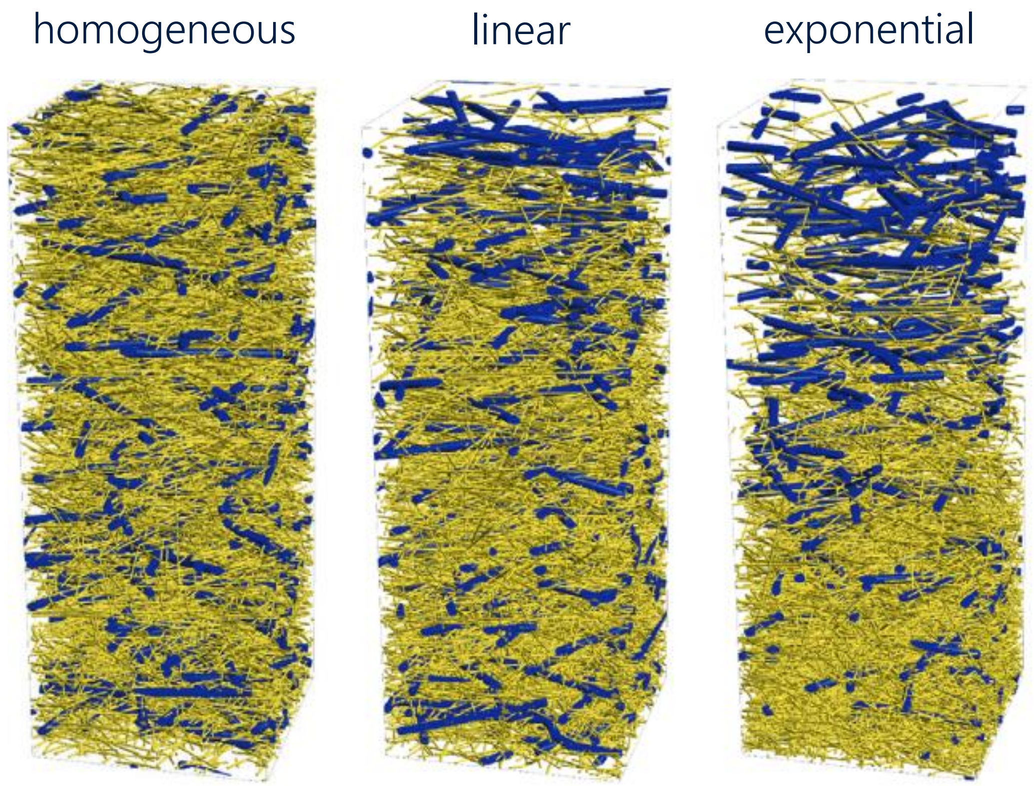
$$\beta_d = \frac{n_{d,initial}}{n_{d,D}}$$

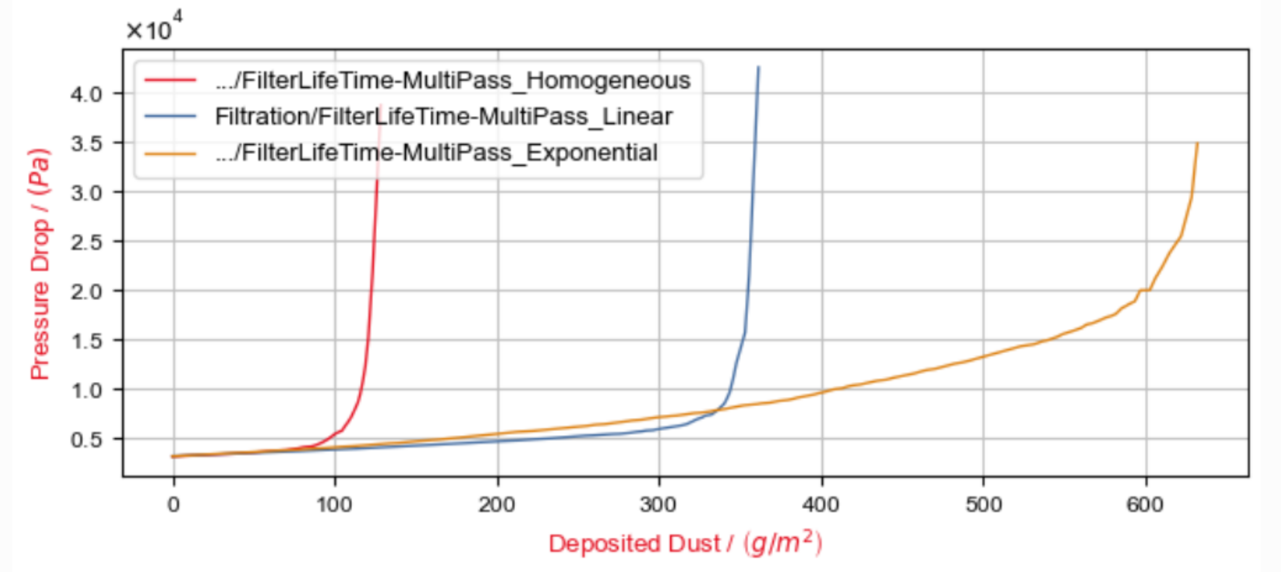
$n_{initial}$	n_D	β ratio	e
100,000	50,000	2	50.0 %
100,000	25,000	4	75.0 %
100,000	10,000	10	90.0 %
100,000	5,000	20	95.0 %
100,000	1,000	100	99.0 %
100,000	500	200	99.5 %
100,000	100	1,000	99.9 %

Hutten, I.M., **2007**. "Handbook of Nonwoven Filter Media." Elsevier.

Math2Market GmbH, Becker, J., Eichheimer, P., Planas, B., 2021. "GeoDict User Guide - FilterDict 2022." Math2Market GmbH, DE.

FILTER LIFETIME EXAMPLE





Microstructure	Pressure drop (10^4 Pa)	Dust holding (g/m^2)
Homogeneous	3.867	129
Linear	4.247	361
Exponential	3.477	632

Azimian, M., Kühnle, C., Wiegmann, A., 2018. Chemical Engineering & Technology 41, 928–935.

THINGS WE COVERED

- How to simulate the filtration process for filter media
- How to track particles during filtration simulations
- How to examine filter efficiency and filter life time

Q & A SESSION

We'll follow up with
your questions.

Recording will be
available tomorrow.

Register for
the next workshop.

GEODICT
The Digital Material Laboratory

USER MEETING & WORKSHOPS

30. Jan. – 03. Feb. 2023

Online

Broad program with presentations and workshops by GeoDict experts from Math2Market and international GeoDict users on

- Image analysis & Image processing for CT-scans, and
- Simulations in the fields of
  - Filtration,
  - Batteries and fuel cells materials,
  - Digital Materials R&D and
  - Digital Rock Physics (DRP) -Digital Core Analysis (DCA).


THANK YOU FOR JOINING US
SEE YOU NEXT TIME