IMPROVED CONTROL FOR MEDIA-SCALE MULTI PASS SIMULATIONS

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AFS 2011

May 11, 2011
Louisville, KY, USA

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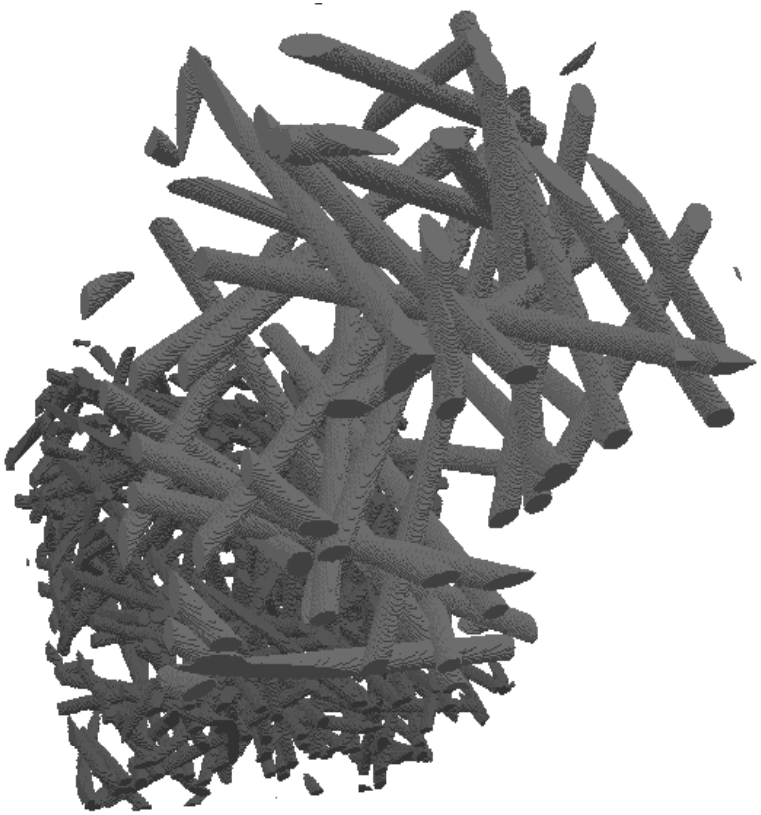
Outline

- Introduction
- Approach
- Results
- Future Work
- Conclusions

Introduction

- Goal: Optimization of Oil Filters
  - Increased Dust Holding Capacity
  - Lower Pressure Drop
  - Higher Efficiency
- Simulation of Multi Pass Test ISO 4548-12
- Media-Scale Simulation by Resolving the Medium's Microstructure
- Use CFD for Flow Field
- Use Fully Resolved Particles for Trajectory Computation



Filtration Simulation & Optimization

GEO DICT

1. Parameters for existing media

OPTIMIZATION

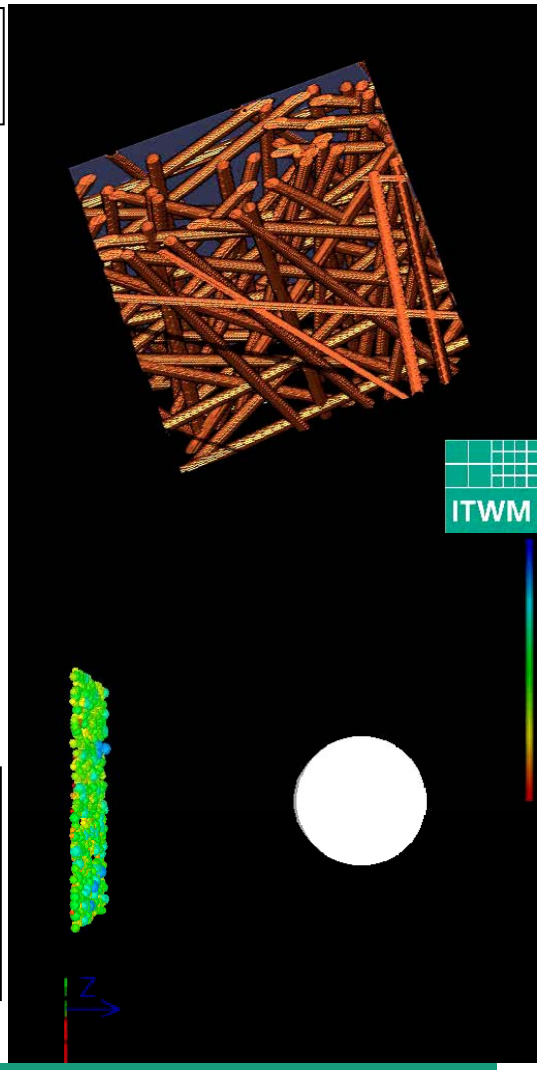
2. Generate Structure
3. Compute Fluid Flow
4. Compute Particle Transport & Deposition
5. Compute Filter Efficiency and Pressure Drop

TEST TIME

6. Choose Better Parameters

Steps 2.-5. are called a ***Batch*** of particles

Fluid Flow



Particle Deposition on a Single Fiber

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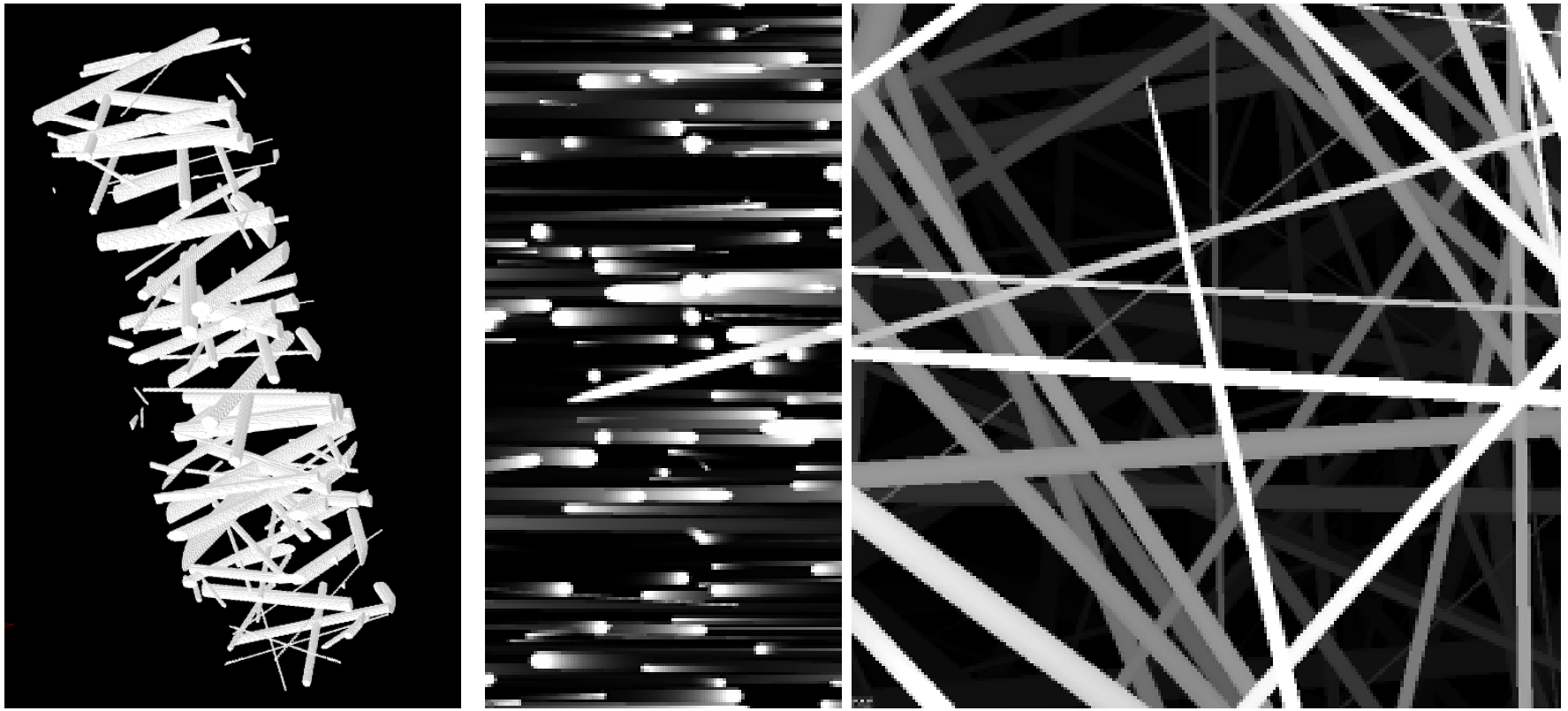
Virtual Oil Filter Media

GEO DICT



3D Fiber Structure and Cross Sections of a Virtual Medium
(from Lehmann et al, WFC 2008, Leipzig, Germany)

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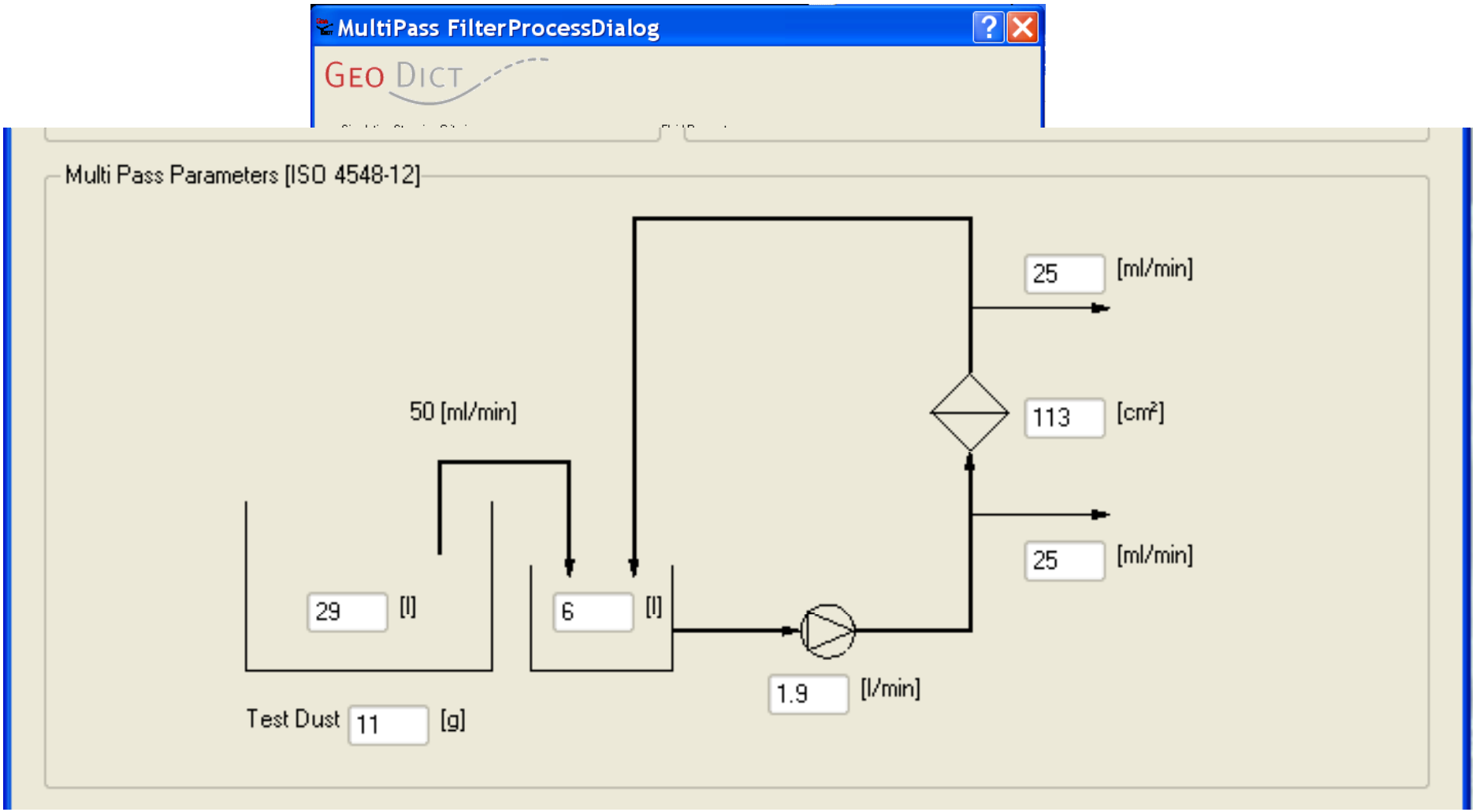
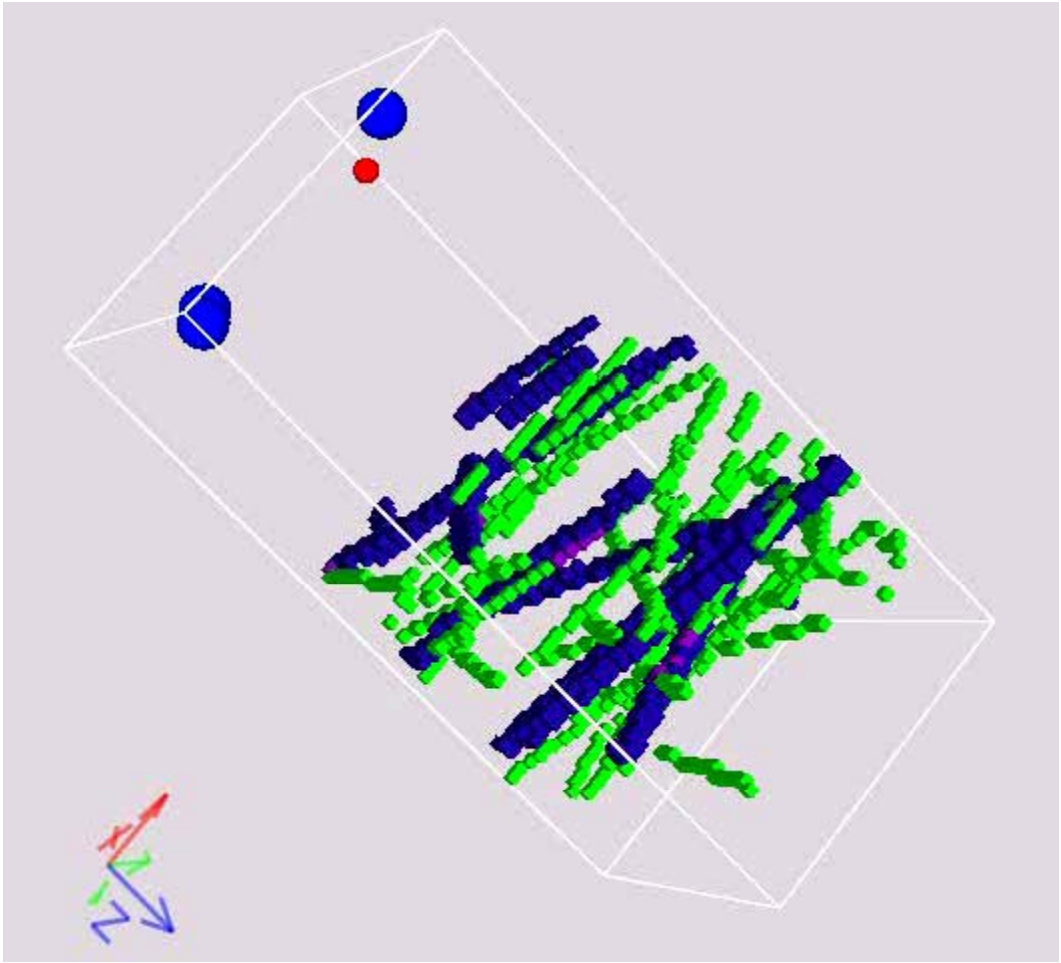
Simulation Software Interface



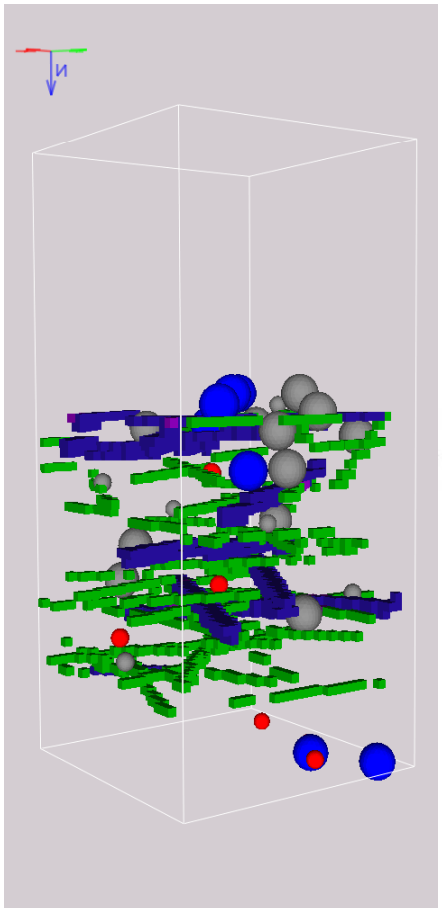
Latest Multipass Improvements

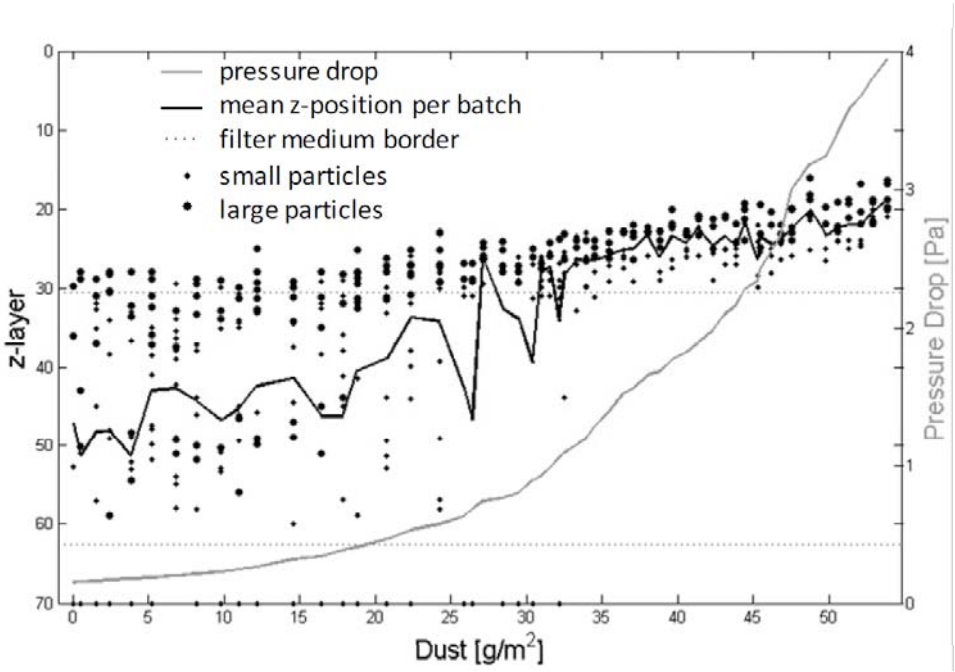
- Automatic choice of batch size (time step) based on detection of the clogging point, the transition point from depth to cake filtration
- Filling a volume vs. deposition on a surface
- Large batches (time steps) during depth filtration portion of multi pass simulation
- Small batches (time steps) during cake filtration portion of multi pass simulation

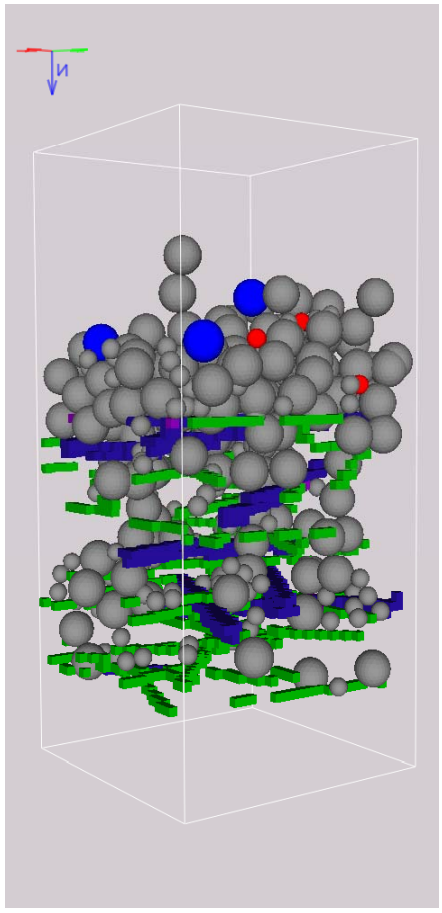
Results



Results

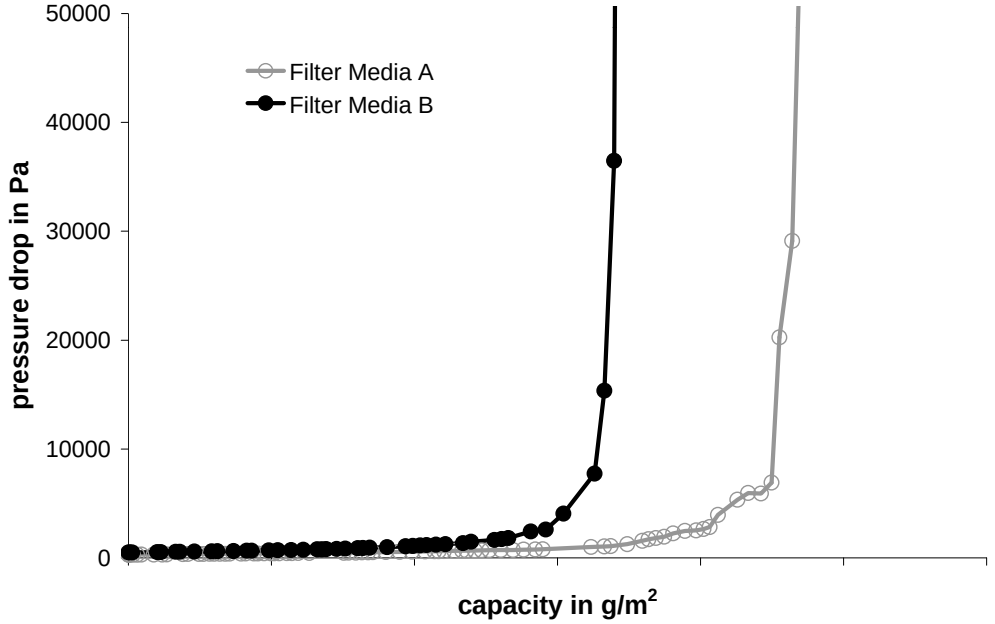



pressure drop
mean z-position per batch
filter medium border
small particles
large particles
z-layer
Pressure Drop [Pa]
Dust [g/m²]
0
10
20
30
40
50
60
70
0
5
10
15
20
25
30
35
40
45
50
4
3
2
1
0



Future Work

- Application of New Methodology to Real Media
- Validation by Experiments



Conclusions

- Successful implementation of adaptive time stepping
- Step control according to the filtration regime
- Deposition pattern and slope of pressure drop resembles test results
- Larger time steps for depth filtration, smaller time steps for cake filtration
  - Speed-up of simulation expected
  - Potentially physically better results due to reduced particle overlap
- Mean depth coordinate is good candidate for clogging point detection

Outlook for multi pass simulations:

- Switch from batch concept to time periods, re-compute flow while particles are “still in motion”
- Keep particle information between batches / time periods to prepare for re-entrainment, pulse cleaning and coalescence simulations