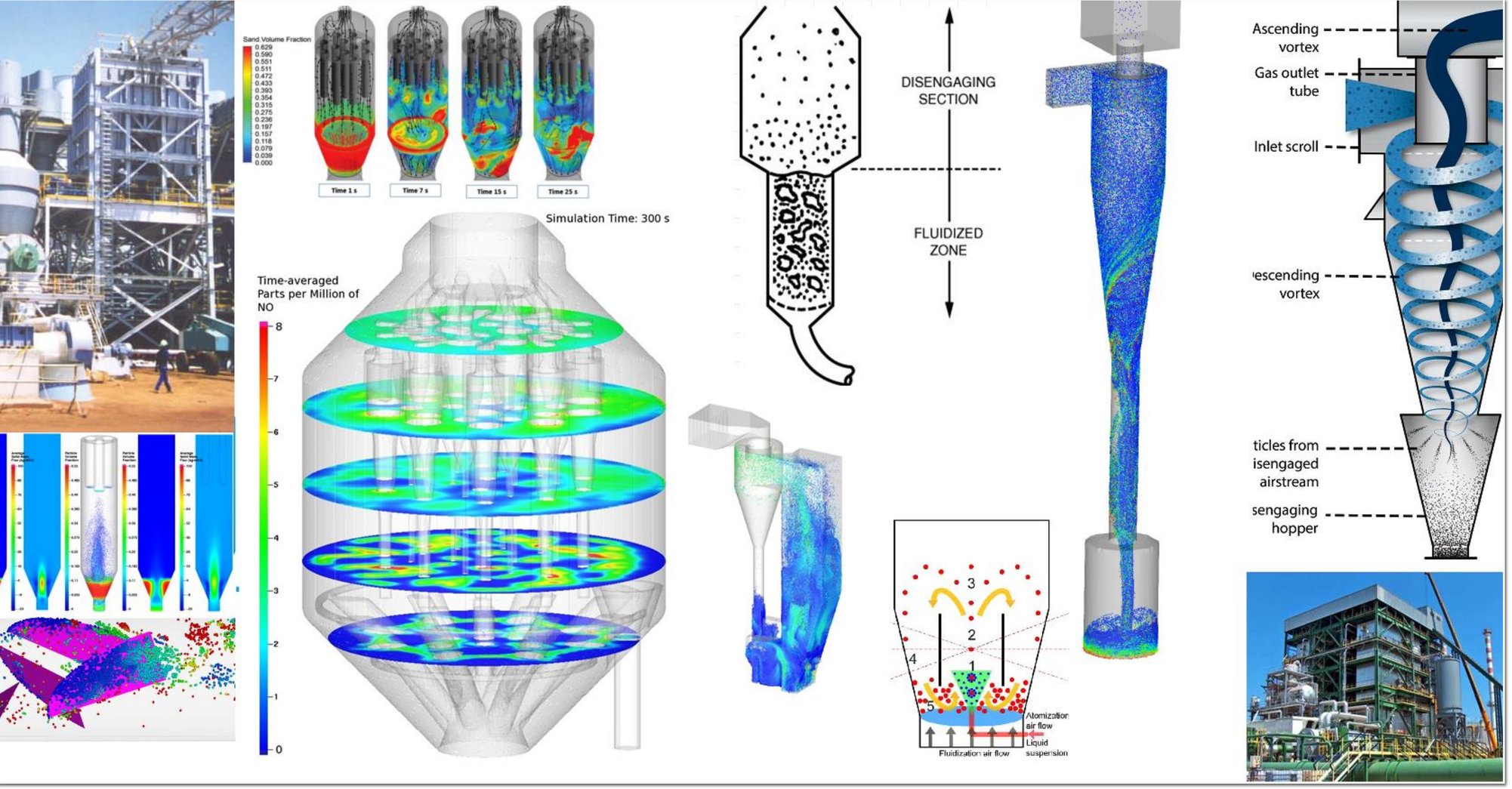

Unconventional Barracuda Applications: an Overview

Federico Monterosso - OMIQ srl

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Motivation

- To describe our experience in the past two years, promoting Barracuda VR in Italy
- Typical challenges:
  - The Benchmark: some company wants to put you to the test
  - The Support Case: some user runs into trouble
  - The University Collaboration/Partnership: where your future users are raised.
- A good dose of creativity is needed to meet these challenges and succeed.

“

Barracuda VR is well renowned as a software tool dedicated to fluidised beds problems. We found out, however, that it can be used very efficiently for other fluid dynamics applications, like filters, ovens, mixers, valves.

”

SnowFlakes for a Christmas Card

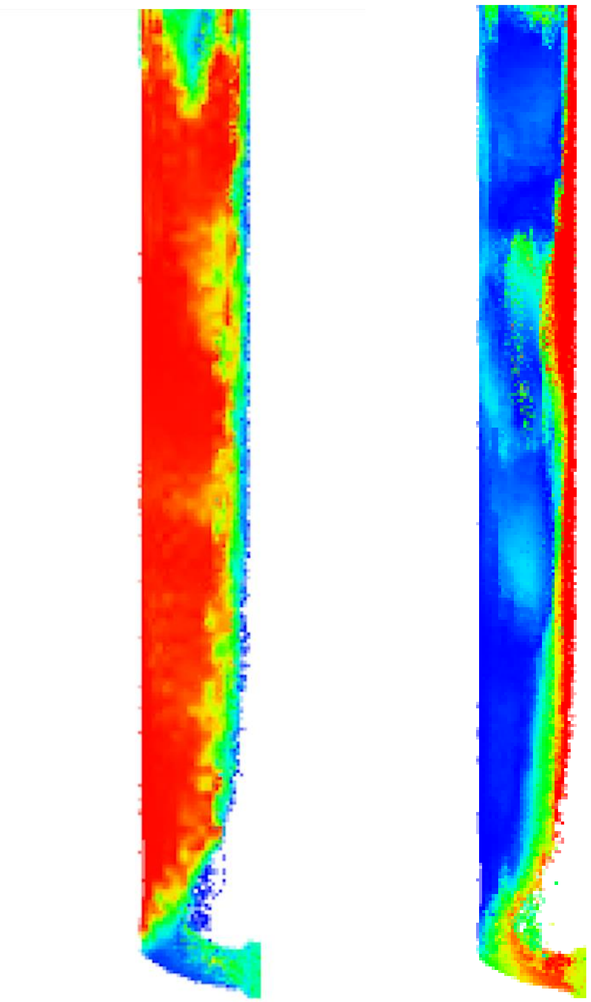
Challenges

- The Benchmark: some company wants to put you to the test
- The Support Case: some user runs into trouble
- The University Collaboration/Partnership: where your future users are raised.

The Benchmark

Basell - Fluidised Bed

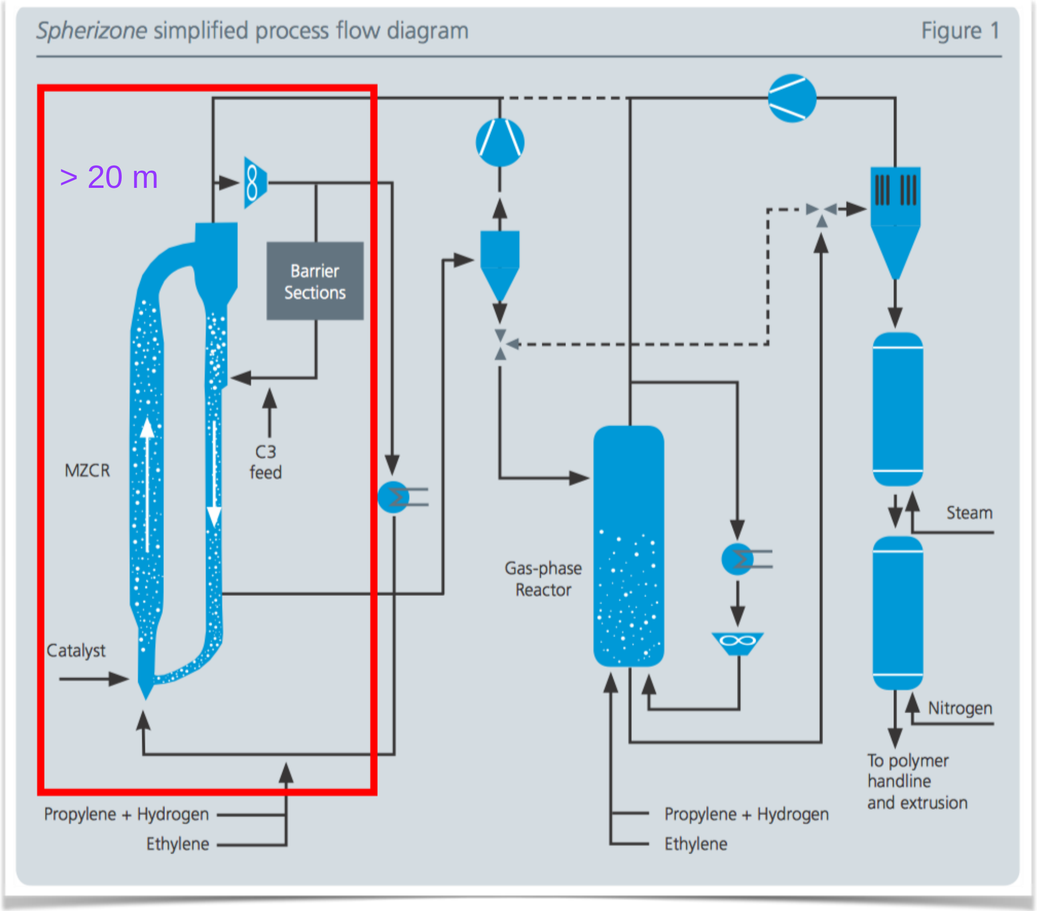
- Companies are scared by simulation
- Two main reasons:
  - The tool they use is not adequate for their problem
  - Gather reliable experimental data is not trivial
- As a result the benchmark they propose you is NOT a good benchmark, i.e. is not a case that helps you prove the quality of your tool.

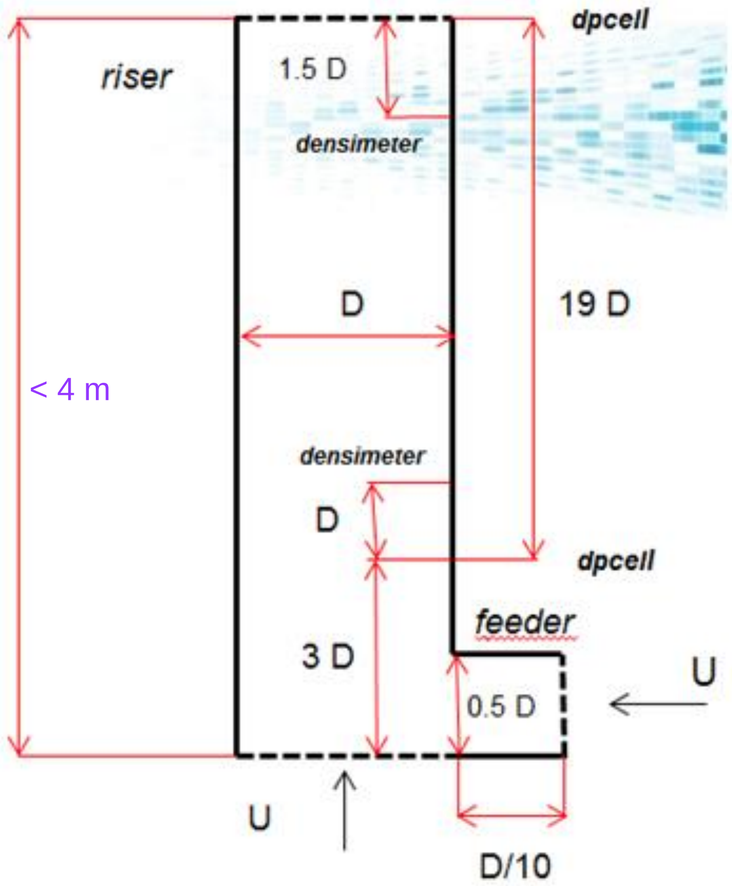


The Benchmark

Basell - Fluidised Bed

- Spherizone vs Benchmark Case



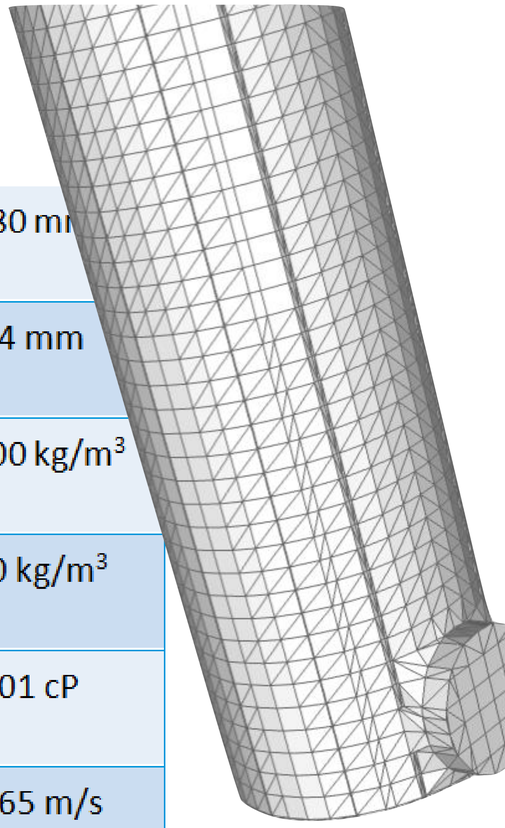


The Benchmark

Basell - Fluidised Bed

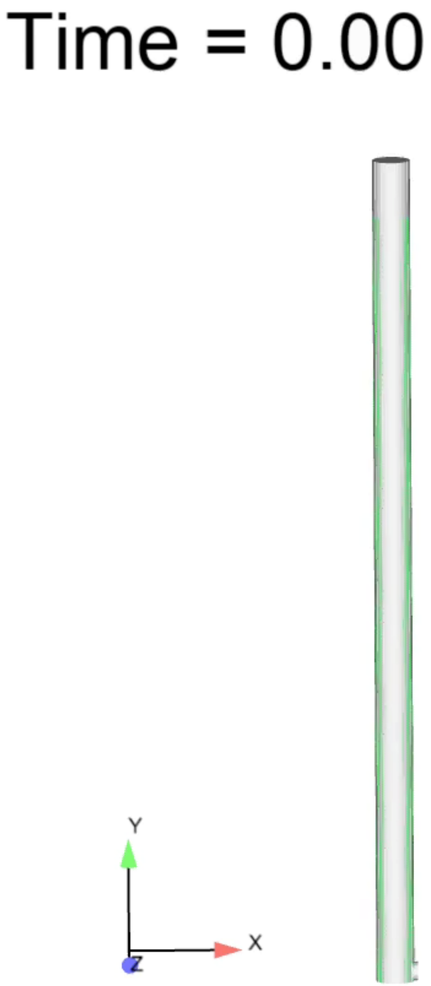
- Setup:
  - No PSD, all particles have the same diameter
  - Particles very big compared to the computational domain
    - → Typical Barracuda cell/particle volume ratio: o(1e^9)
    - → The coarsest mesh possible: 50000 cells.
- Data to compare:
  - Concentration at 4D and 20.5D
  - Pressure at 3D

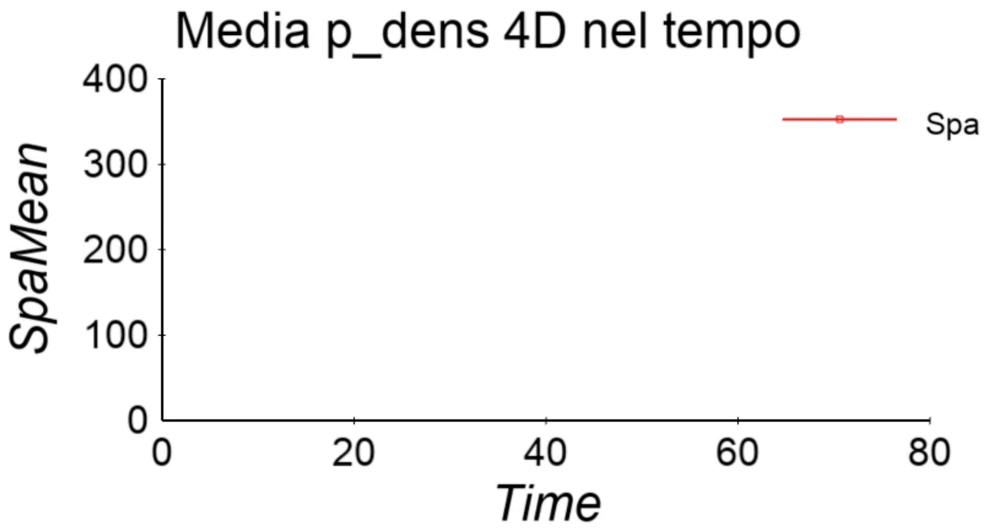
Riser diameter	180 mm
Particle diameter	2.4 mm
Particle density	800 kg/m^3
Gas density	60 kg/m^3
Gas viscosity	0.01 cP
Superficial gas velocity U	1.65 m/s

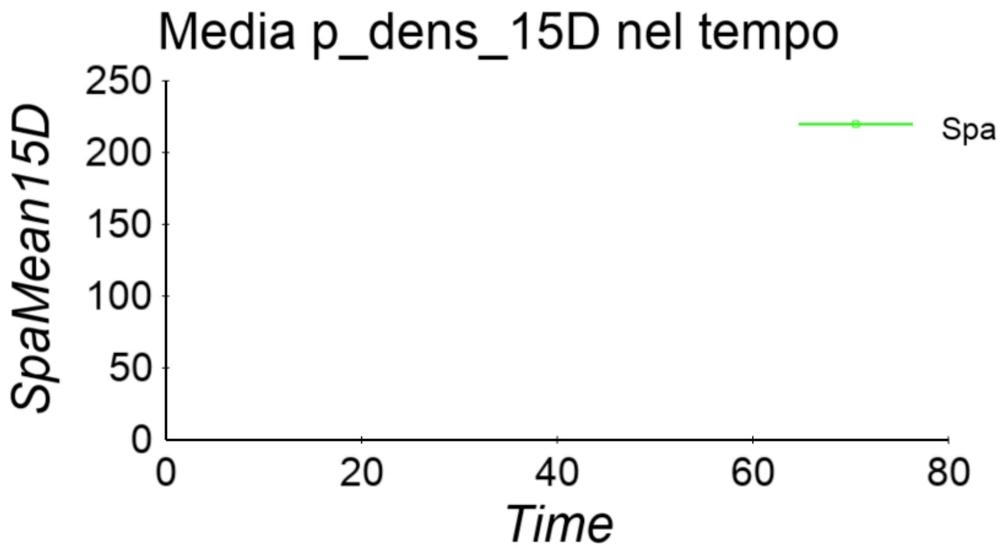


The Benchmark

Basell - Fluidised Bed







The Benchmark

Basell - Fluidised Bed

- Compared two different drag models because some area of the model showed very high particle volume fraction and we assumed that the Ergun variation could help.
- Average Pressure at 3D very close to experimental data
- Average concentration slightly under-predicted at riser top

➡ Overall, you would agree, very good results.

➡ NOTE that their actual software tool was 100 times slower to run and would not get the pressures right.

Plane/Drag	WenYu	WenYu Ergun	Experimental
3D	6440 Pa	6450 Pa	6500 Pa

Plane\Drag	WenYu	WenYu Ergun	Experimental
4D	293.9 kg/m^3	300.55 kg/m^3	280 kg/m^3
20.5D	95.46 kg/m^3	97.79 kg/m^3	120 kg/m^3

The Benchmark

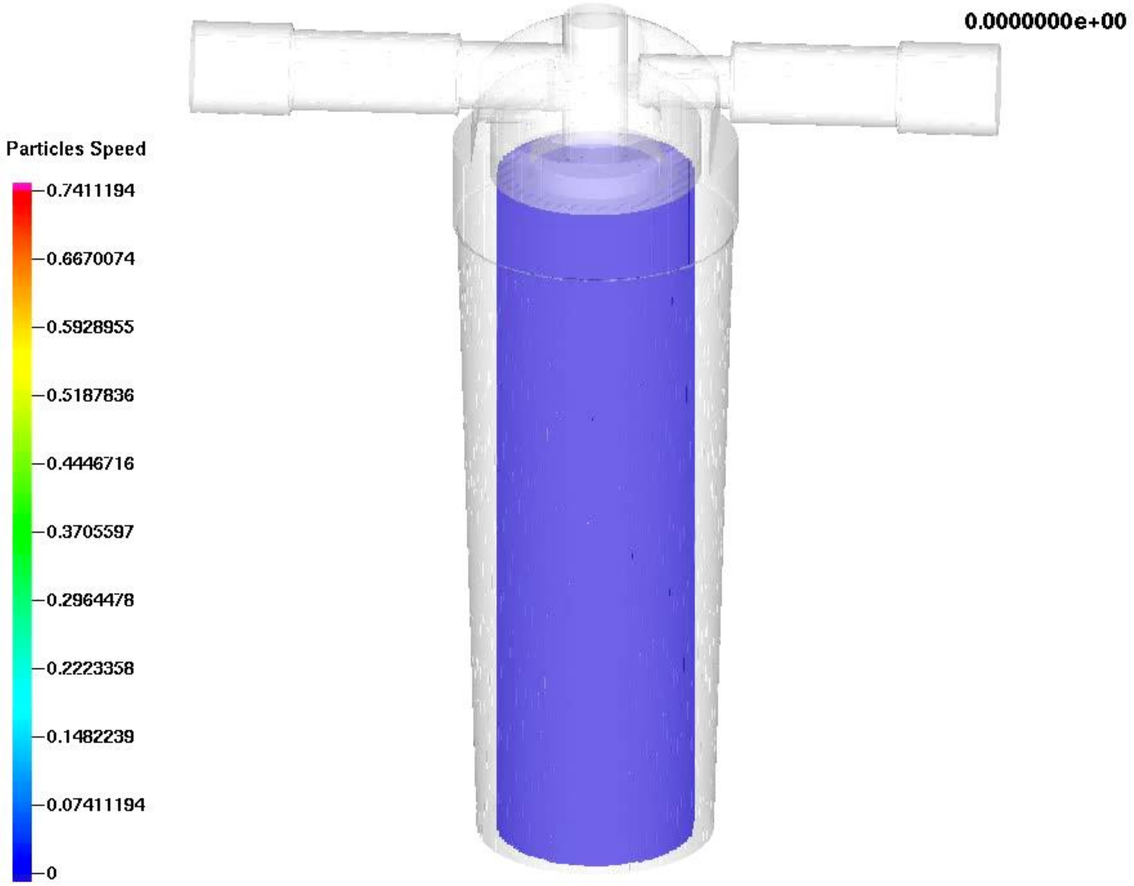
- It’s not always possible to get the “right” benchmark
- It’s very important to use the software “flexibility” to get the best possible results
- Good results are the best possible strategy to convince the discouraged engineer.

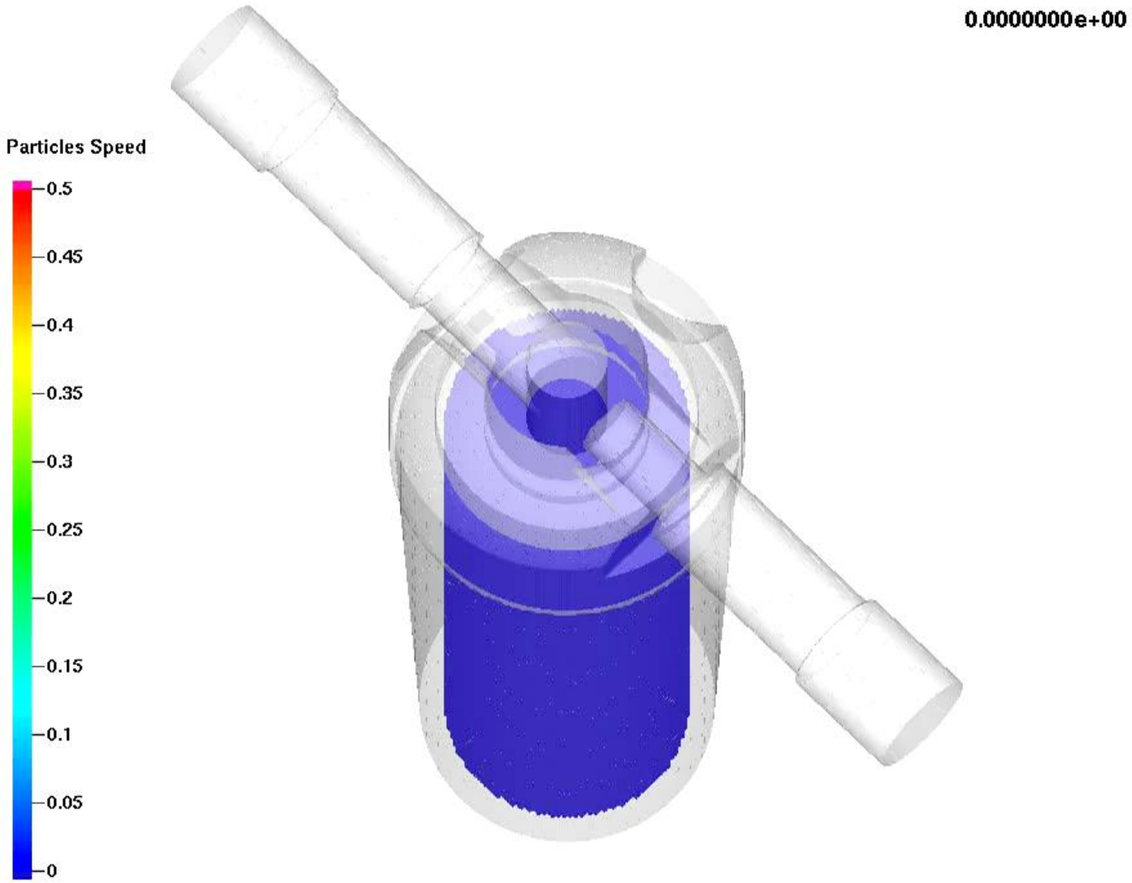
Challenges

- The Benchmark: some company wants to put you to the test
- The Support Case: some user runs into trouble
- The University Collaboration/Partnership: where your future users are raised.

The Support Case

Pollutant Filters - Sacmi

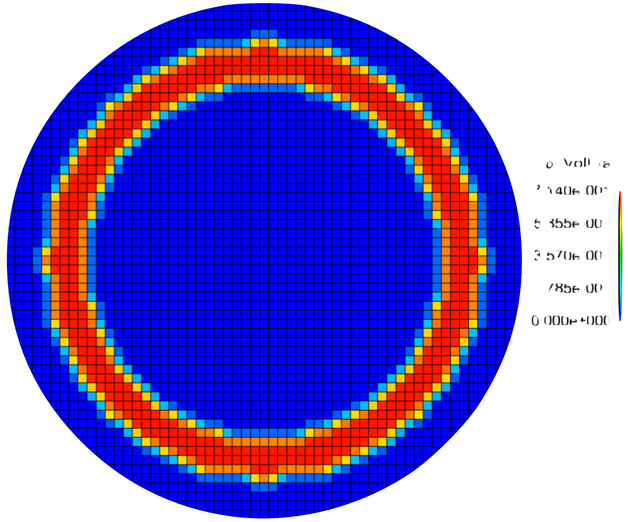




The Support Case

Porous media prediction using a particles fixed bed

- Why don’t we use a particle fixed bed to model the porous medium?
  - Assumption: the total wetted surface (available from POPUL…) matches the theoretical filter wetted surface
    - ➡ We can therefore work out the particles diameter (constant).
  - Particle species will be solid, physical proprieties not relevant
- Initialise a particles fixed bed with no momentum
  - Vol Frac = 1- filter porosity
- Some mesh sensitivity check maybe necessary (to achieve an acceptable filter thickness)
- Note that a cylindrical initialisation is not trivial in Barracuda: you need a small hack, i.e. a python script that works out automatically the Particle IC’s.



Particle IC Manager

ID	Species-ID	Vol frac	np	i1	i2	j1	j2	k1	k2	Temperature	Momentum	Comment
000	001 -	0.7	NA	54	54	132	132	1	306	300	No	
001	001 -	0.7	NA	55	55	132	132	1	306	300	No	
002	001 -	0.7	NA	56	56	132	132	1	306	300	No	
003	001 -	0.7	NA	57	57	132	132	1	306	300	No	
004	001 -	0.7	NA	58	58	132	132	1	306	300	No	
005	001 -	0.7	NA	59	59	132	132	1	306	300	No	
006	001 -	0.7	NA	60	60	132	132	1	306	300	No	
007	001 -	0.7	NA	61	61	132	132	1	306	300	No	
008	001 -	0.7	NA	62	62	132	132	1	306	300	No	
009	001 -	0.7	NA	63	63	132	132	1	306	300	No	
010	001 -	0.7	NA	64	64	132	132	1	306	300	No	
011	001 -	0.7	NA	65	65	132	132	1	306	300	No	
012	001 -	0.7	NA	66	66	132	132	1	306	300	No	
013	001 -	0.7	NA	67	67	132	132	1	306	300	No	
014	001 -	0.7	NA	68	68	132	132	1	306	300	No	
015	001 -	0.7	NA	69	69	132	132	1	306	300	No	
016	001 -	0.7	NA	50	50	133	133	1	306	300	No	
017	001 -	0.7	NA	51	51	133	133	1	306	300	No	
018	001 -	0.7	NA	52	52	133	133	1	306	300	No	
019	001 -	0.7	NA	53	53	133	133	1	306	300	No	
020	001 -	0.7	NA	54	54	133	133	1	306	300	No	
021	001 -	0.7	NA	55	55	133	133	1	306	300	No	
022	001 -	0.7	NA	56	56	133	133	1	306	300	No	
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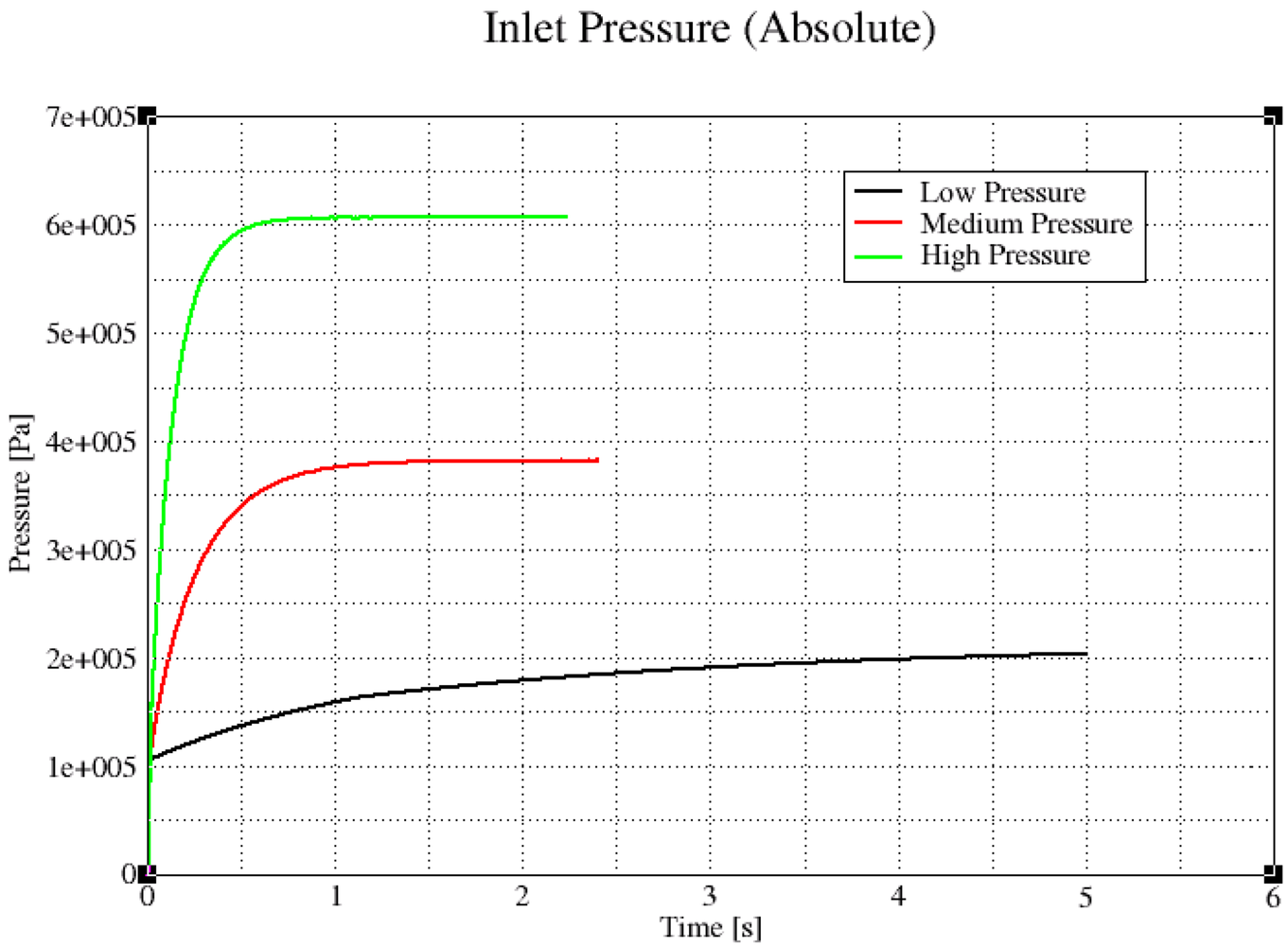
024	001 -	0.7	NA	58	58	133	133	1	306	300	No	
025	001 -	0.7	NA	59	59	133	133	1	306	300	No	
026	001 -	0.7	NA	60	60	133	133	1	306	300	No	
027	001 -	0.7	NA	61	61	133	133	1	306	300	No	

The Support Case

Porous media prediction using a particles fixed bed

- Convergence to steady state is very quick even though mesh are quite large (>4 mill actual cells)
- Convergence is also different from case to case, lower pressure takes longer.



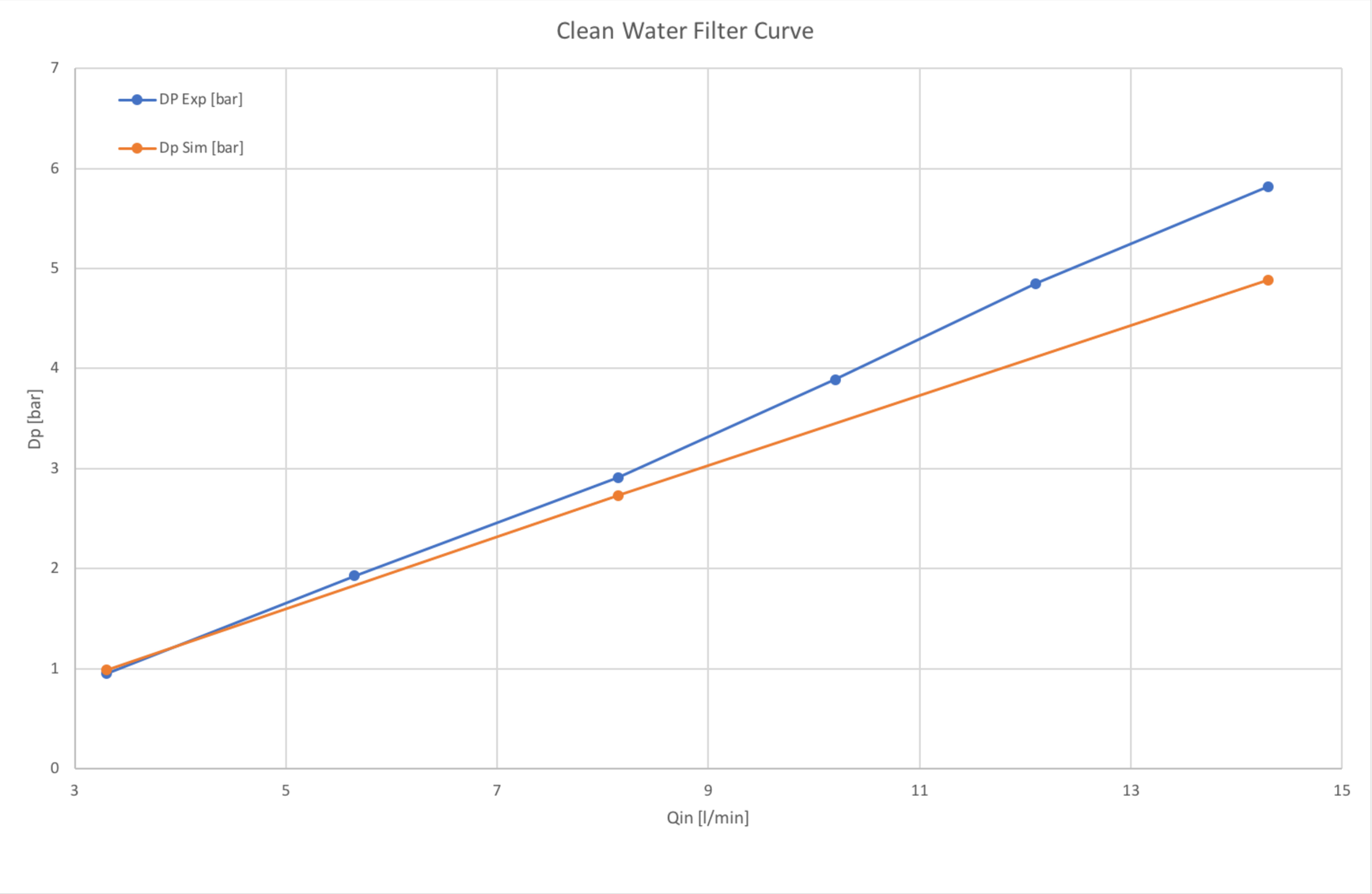
The Support Case

Porous media prediction using a particles fixed bed

Results were good (4% difference) at low pressures and reasonable (16% difference) at high pressures.

At high pressures results could probably be improved with a further mesh refinement, but we had not enough memory on our GPU.

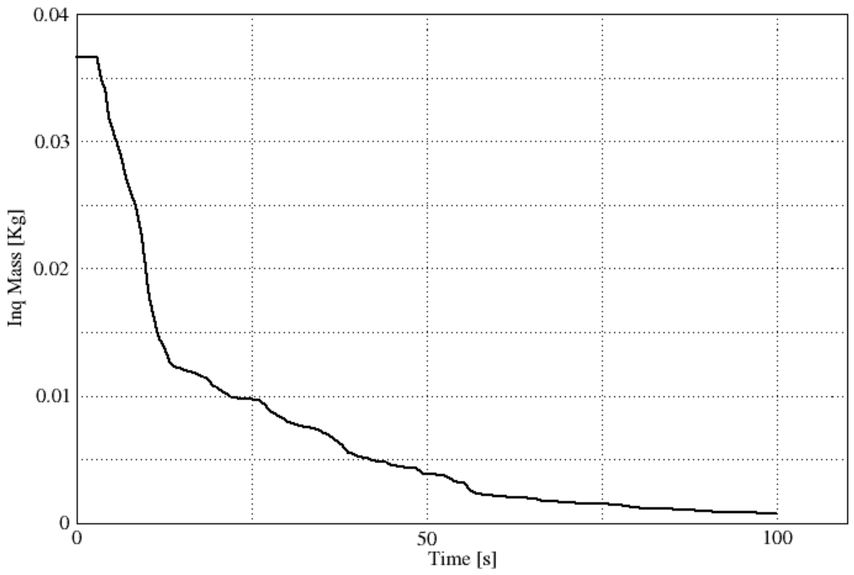
Note that being predictive on pressure drop across a porous medium is a “unique” feature.

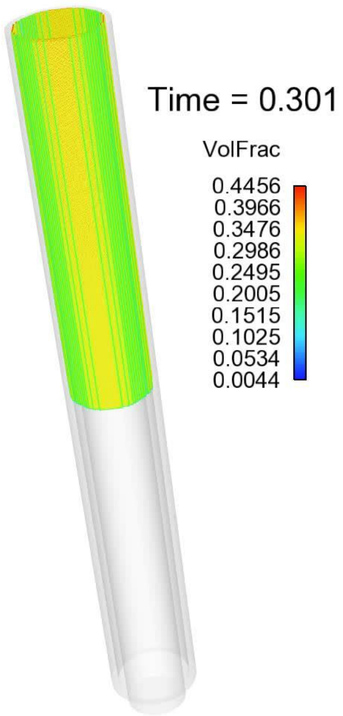


The Support Case

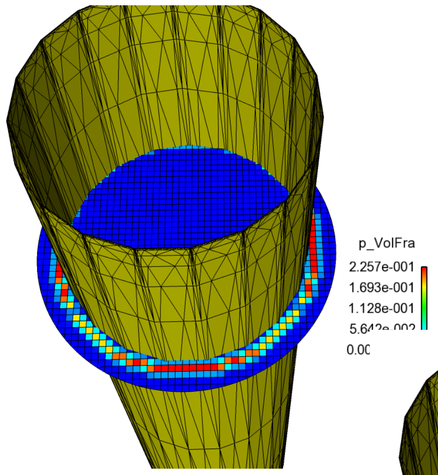
Pollutant Filter - other applications

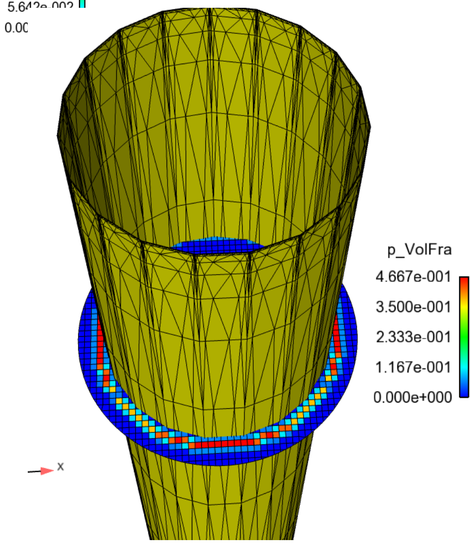
- Once the pressure drop due to the porous medium is known, Barracuda VR is used for other applications:
  - Investigate the saturation cycle and the pressure build-up due to pollutant particles deposition on the filter
  - Study the cleaning cycle (flow inversion)





Nominal concentration = 0.3



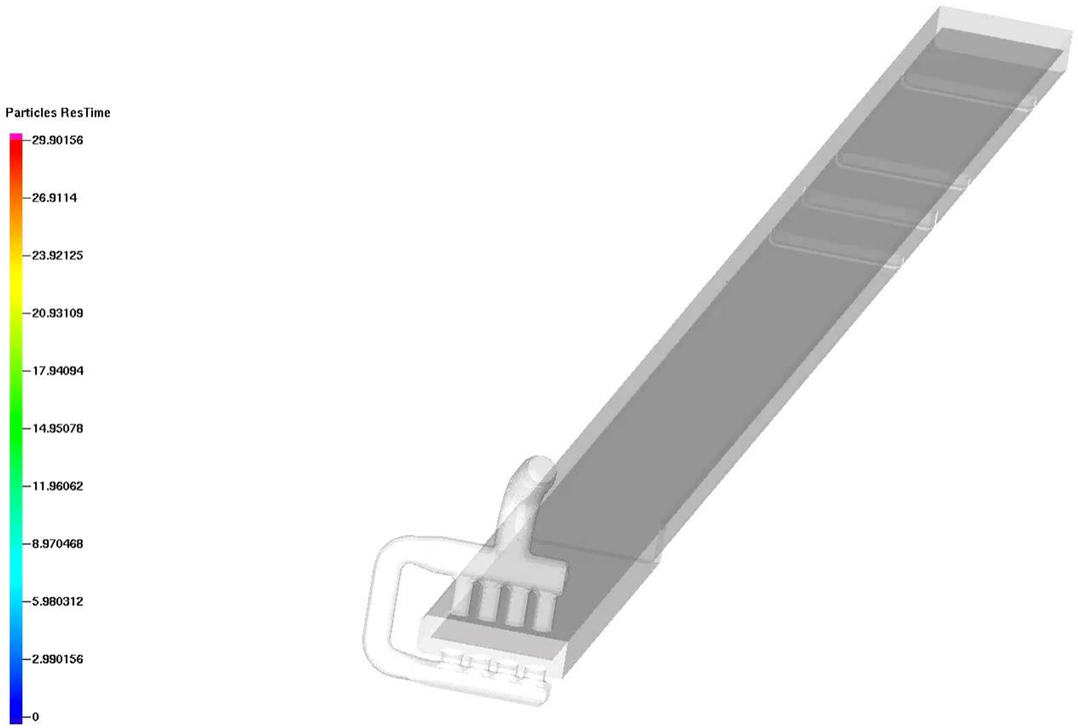


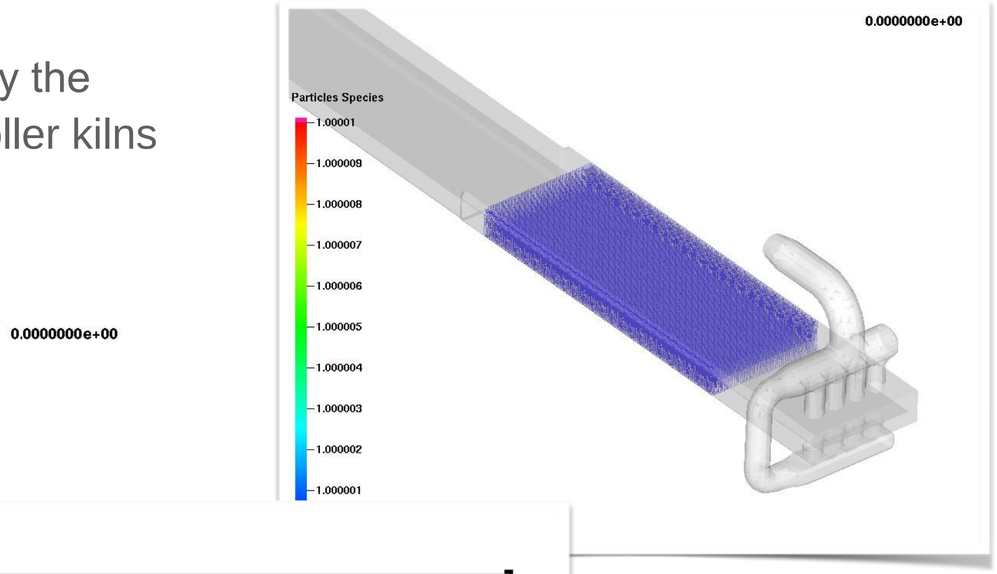
Nominal concentration = 0.6

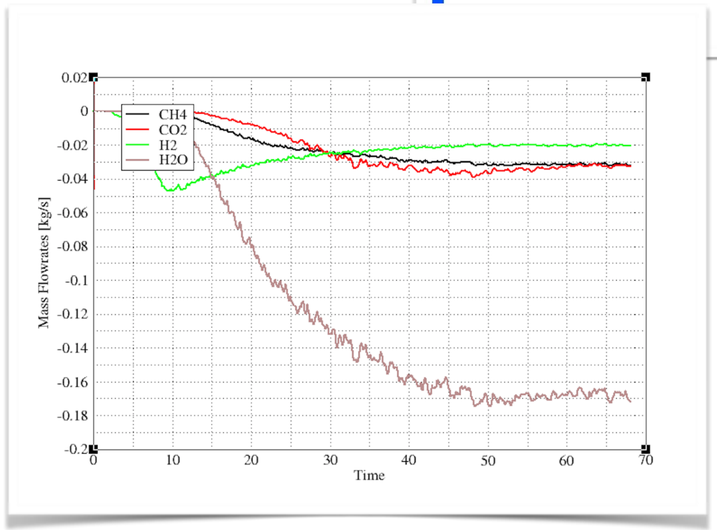
The Support Case

Further developments @Sacmi

- The “fixed bed approach” to model porous media was also applied by the customer to conceptual CO2 recovery studies (by methanation) in roller kilns (the ovens were tiles are actually “cooked”).
- Methanation normally requires a Ni-based catalyser bed.







The Support Case

- Support cases are often not only software-related questions but may extend to “how do we solve this problem” questions.
- Support cases can suggest interesting and innovative developments
- Technical Support is not a cost, it’s an opportunity.

Challenges

- The Benchmark: some company wants to put you to the test
- The Support Case: some user runs into trouble
- The University Collaboration/Partnership: where your future users are raised.

The University Collaboration/Partnership

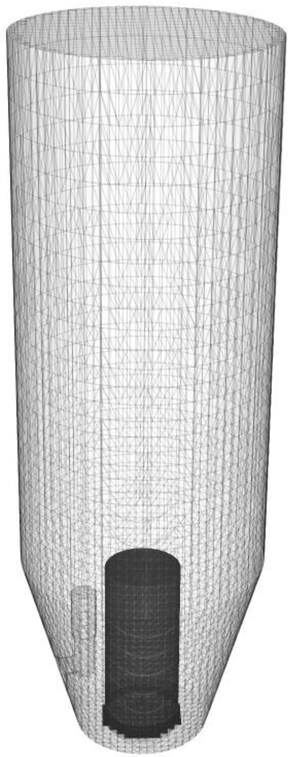
Fluid Bed Processor - University of Ferrara

- Partnerships with Universities are established for two reasons:
  - Have young engineers learn how to use Barracuda
  - Develop innovative applications and research work
- In the case of University of Ferrara, we started a collaboration based on a PHD project in conjunction with an important pharmaceutical packaging company, IMA Group.
- Multi-function processor: granulation, coating and drying based on the Wurster tube concept.
- Lots of runs over the past year and a half, first trying to validate the tool, then focusing on understanding the machine behaviour.

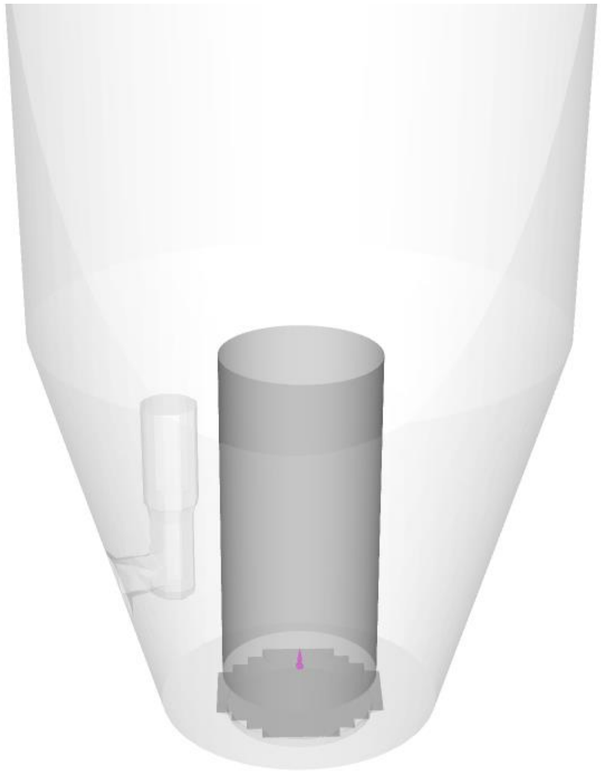
The University Collaboration/Partnership

Fluid Bed Processor - Coating process

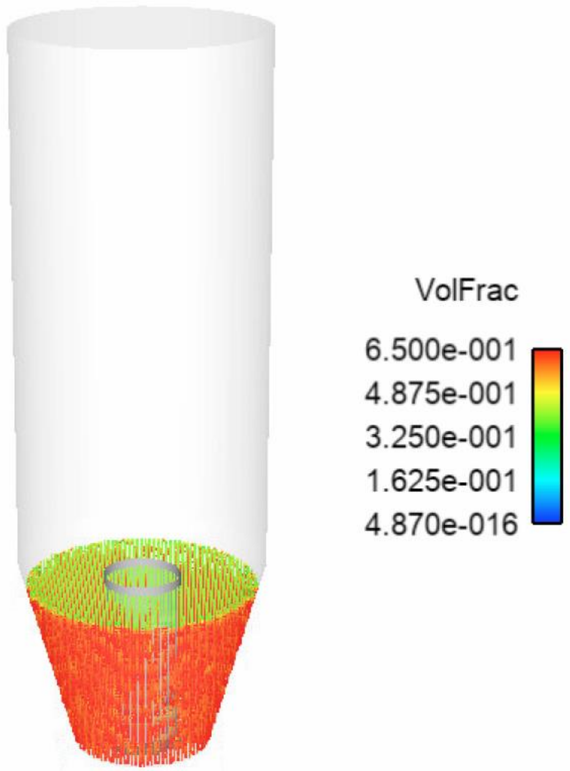
Relatively coarse mesh to be able to run for long



Water injection at the bottom of the Wurster Tube

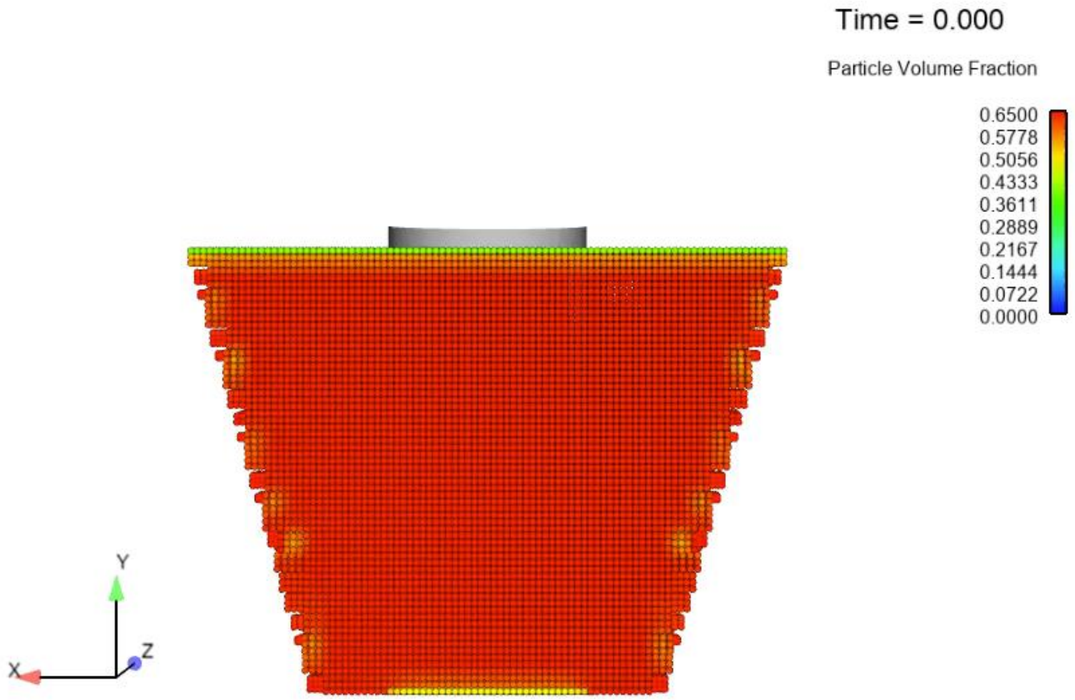


Pellets Initialisation



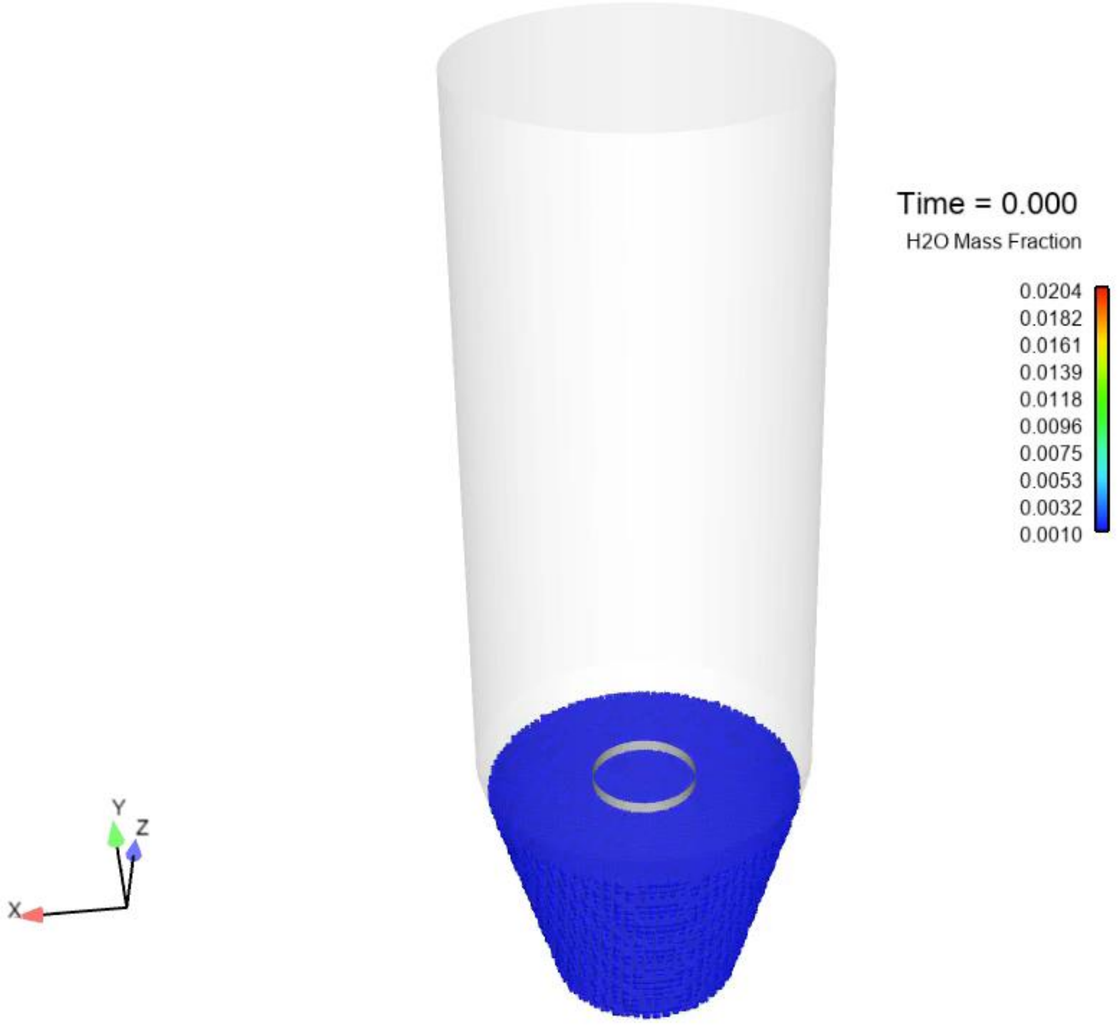
The University Collaboration/Partnership

Fluid Bed Processor - Coating process



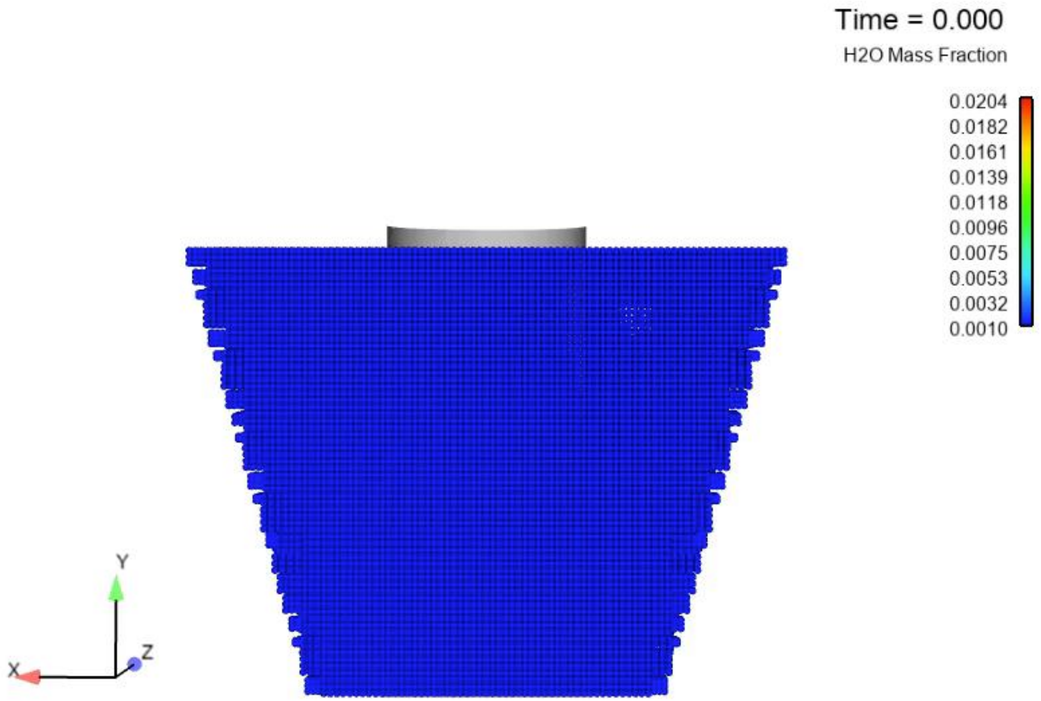
The University Collaboration/Partnership

Fluid Bed Processor - Coating process



The University Collaboration/Partnership

Fluid Bed Processor - Coating process



The University Collaboration/Partnership

Fluid Bed Processor - University of Ferrara

- Luca del Bene will present his PHD thesis next month.
- He's investigated 2 out of 3 functions of the Processor.
- He's struggled a lot with the poor experimental data provided by IMA Group.
- He's managed to suggest some improvements based on the Barracuda simulation results.
- He's already got a job as a fluidised bed specialist engineer (NOT at IMA Group)
- … and I am waiting for a call from him soon….

The University Collaboration/Partnership

University of Naples/Institute for Research on Combustion

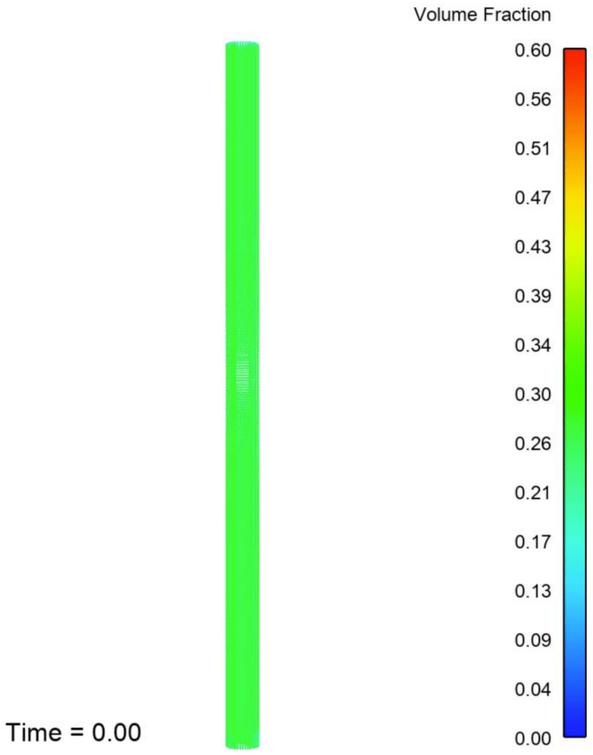
- The Faculty of Chemical Engineering at the University of Naples “Federico II” has one of the leading research groups on fluidised beds in Italy,
- Institute for Research on Combustion is also based in Naples and has strong research links with the University. It has also a well established research focus on the simulation of particle flows.
- In the (past) few months that we have actually worked together, I have already collected two or three good suggestions for new features !!!!.
- … and seen the code being put to very hard tests.
- This is also an important added value for us in this type of partnership.

The University Collaboration/Partnership

- It’s crucial to have young engineers learn about simulation in general and how to do it with Barracuda in particular.
  - It’s important for marketing and sales but also, on a more ethical tone, to help the companies where they will go to work to embrace innovation and new technologies.
- Universities are also a kind of institution where commercial tools are, by default, used to the limit. This approach can provide useful feedback to the software community and to the developers.

Conclusion

- I have tried to describe our experience with Barracuda in the past couple of years and the challenges involved.
- Creativity and flexibility are often needed to meet the challenges and also to open new opportunities.



Questions ?

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