

Experimental assessment of process intensification by increased transverse dispersion in 3D-printed logpile structures

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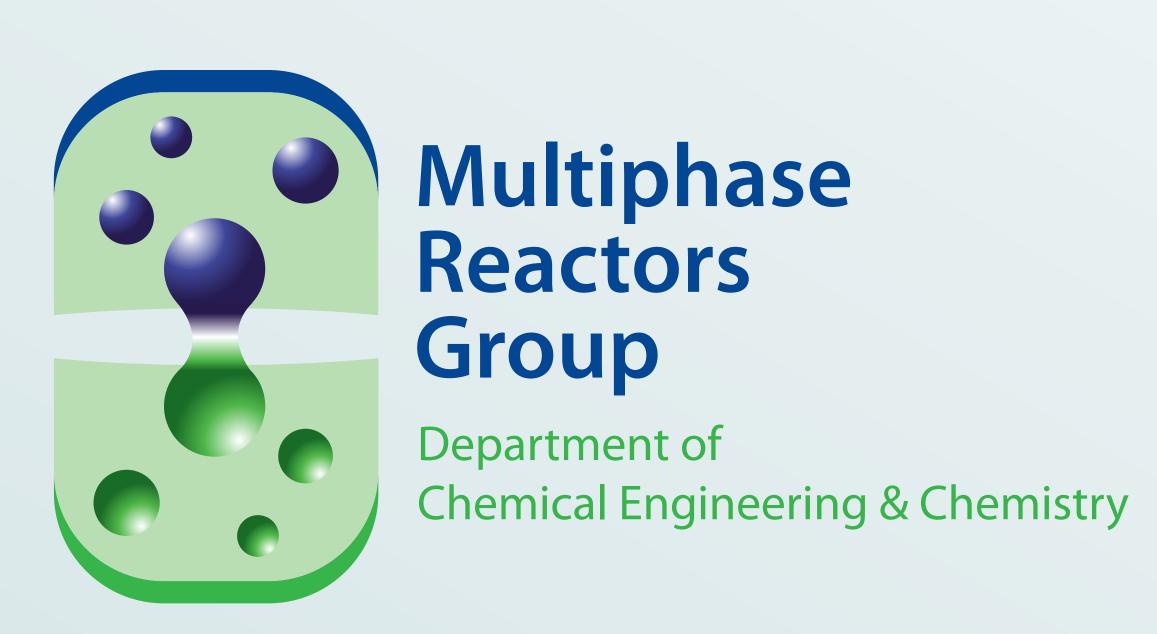
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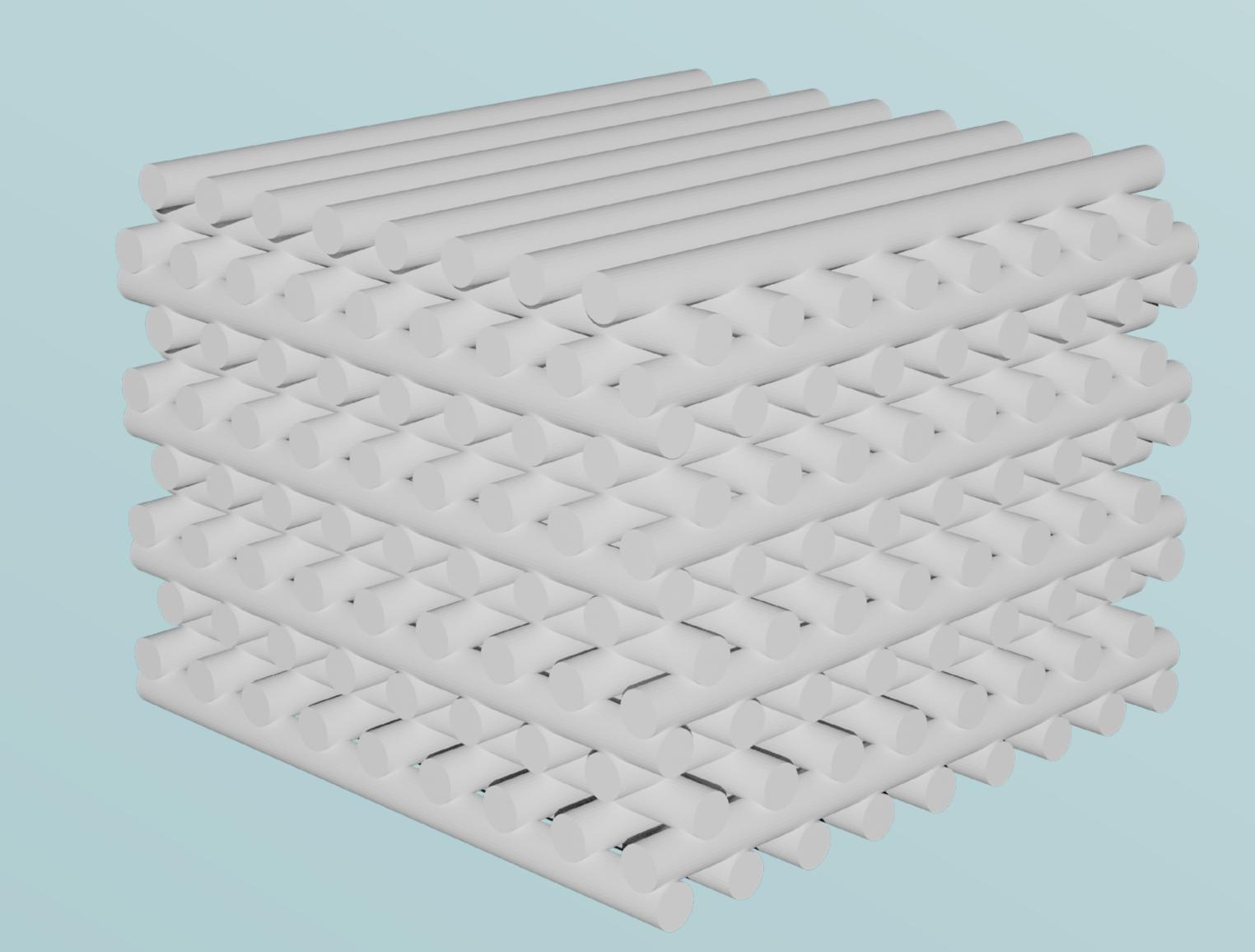
Experimental assessment of process intensification by increased transverse dispersion in 3D-printed logpile structures

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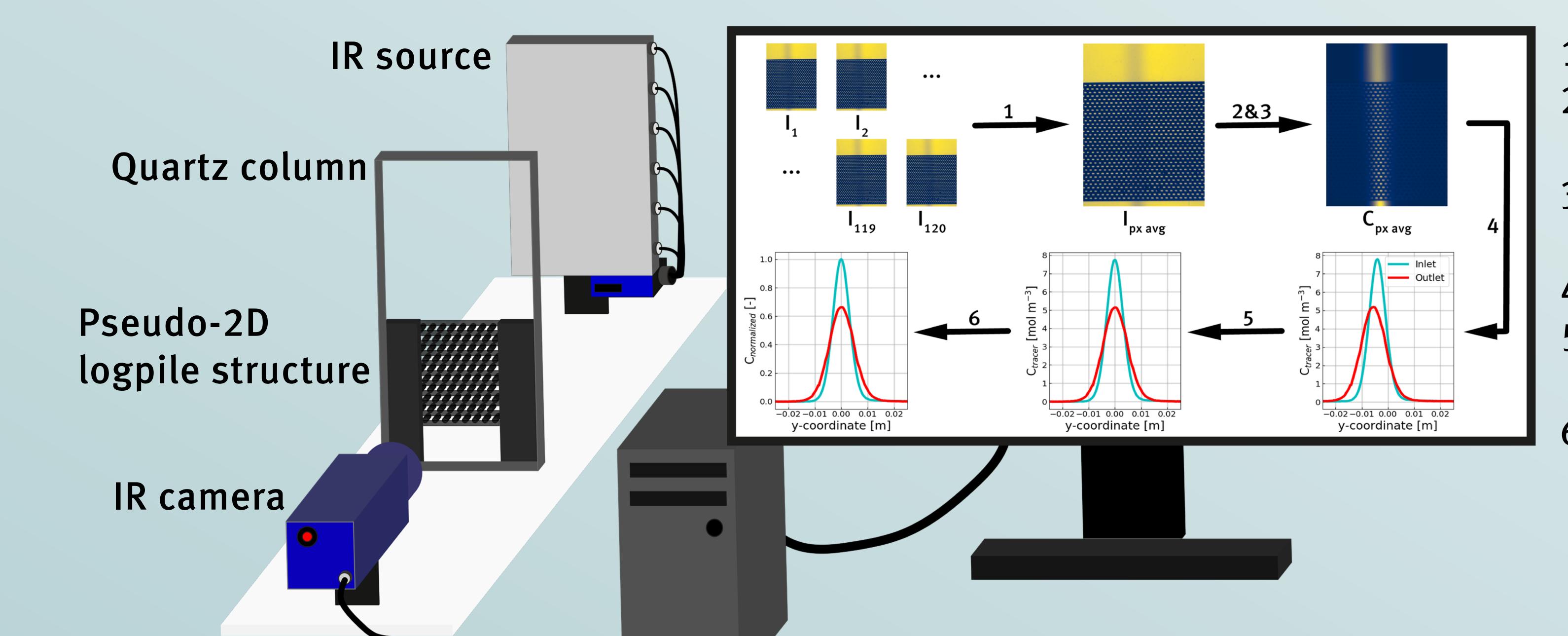
Logpile structures

- Flexible design
- High catalyst holdup
- Favorable transport properties?



Experimental quantification of transverse dispersion

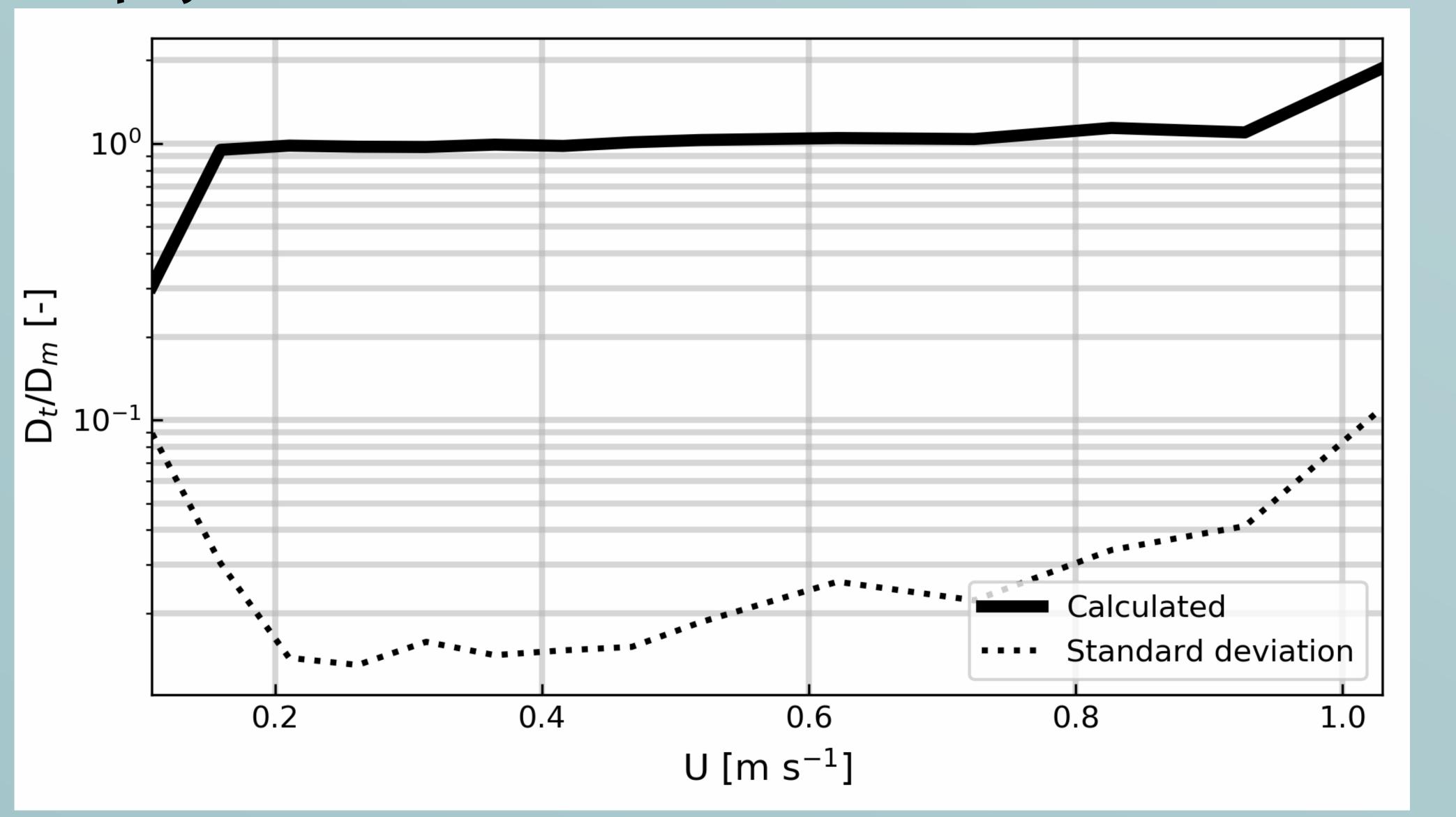
Novel non-invasive infrared transmission technique



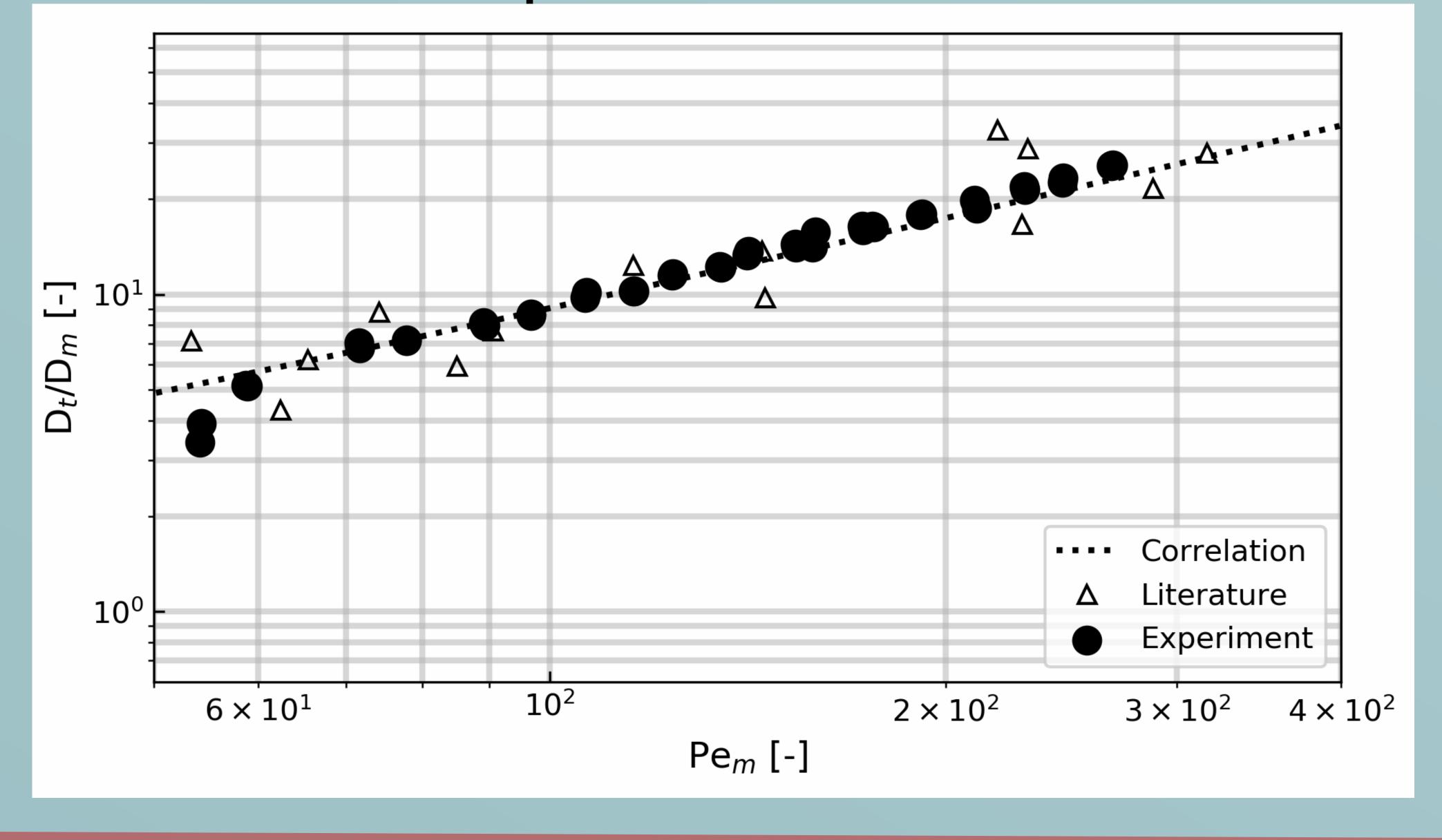
- 1. Element-wise averaging
- 2. Convert intensity to absorbance
- . Convert absorbance to concentration
- 4. Extract inlet and outlet
- 5. Peak centering and baseline correction
- 6. Peak normalization

Validation

Empty column

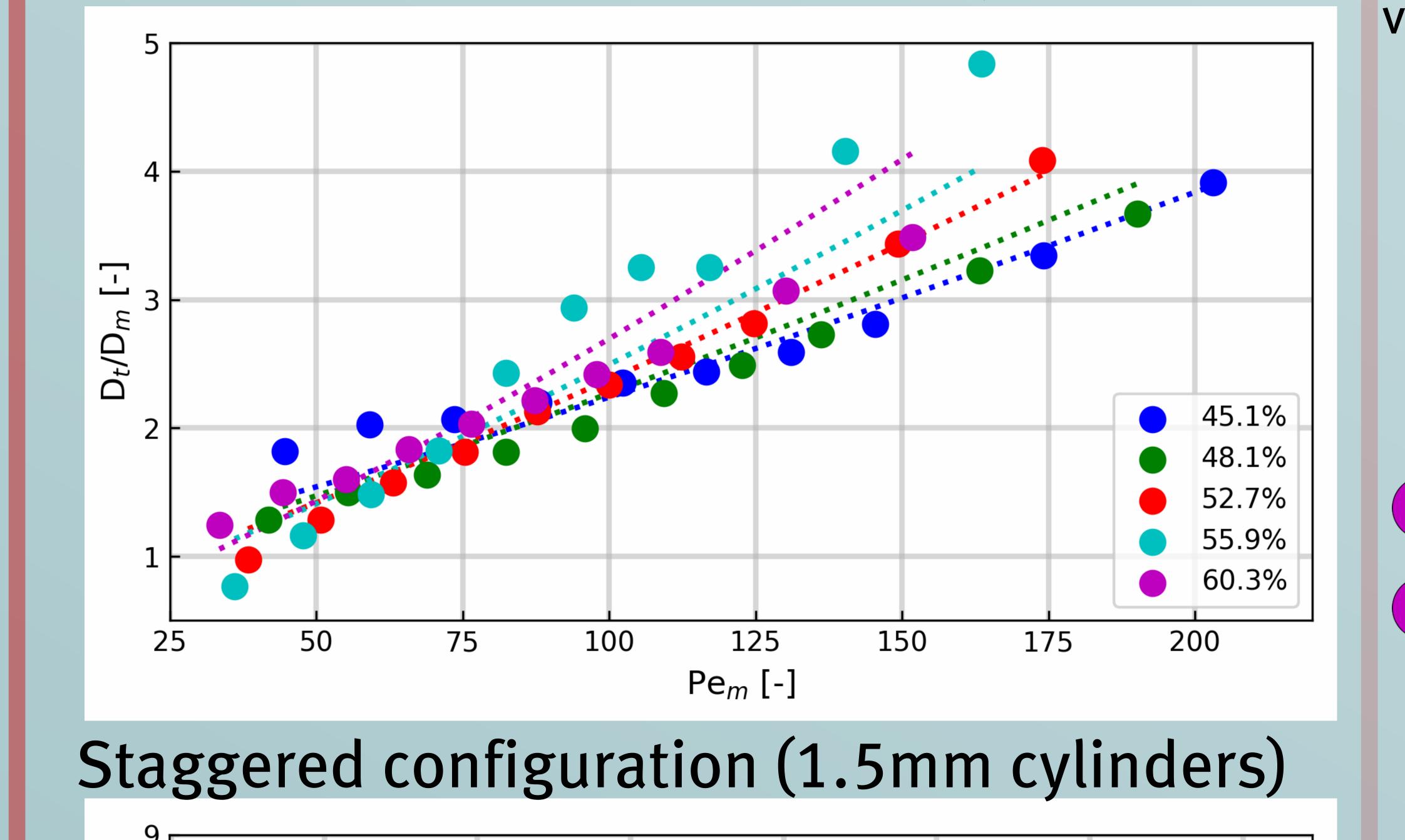


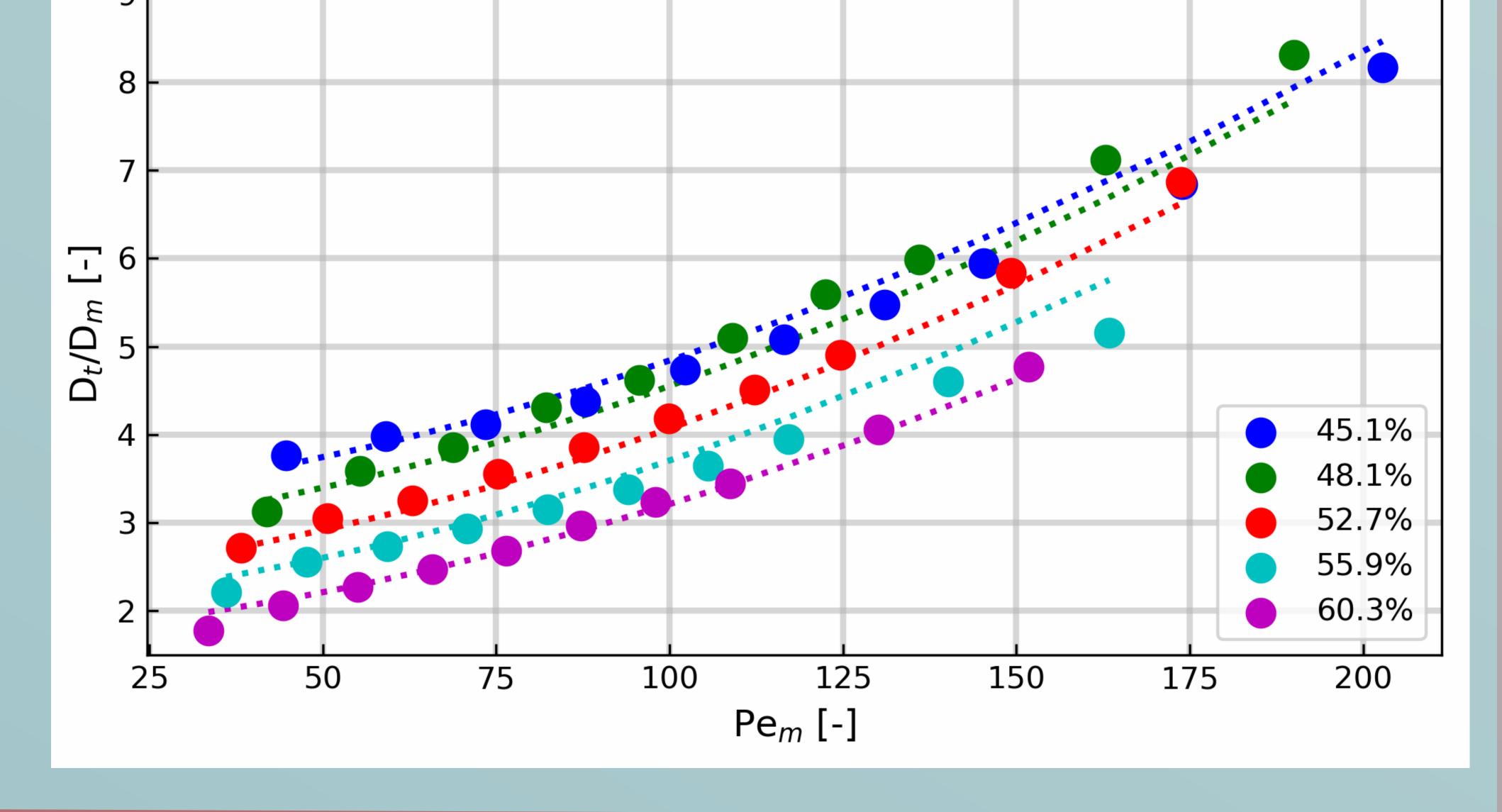
Packed bed of spheres



Key results

Straight configuration (1.5mm cylinders)





Transverse dispersion can be correlated to strucvisualisation ture's properties, for straight configuration:

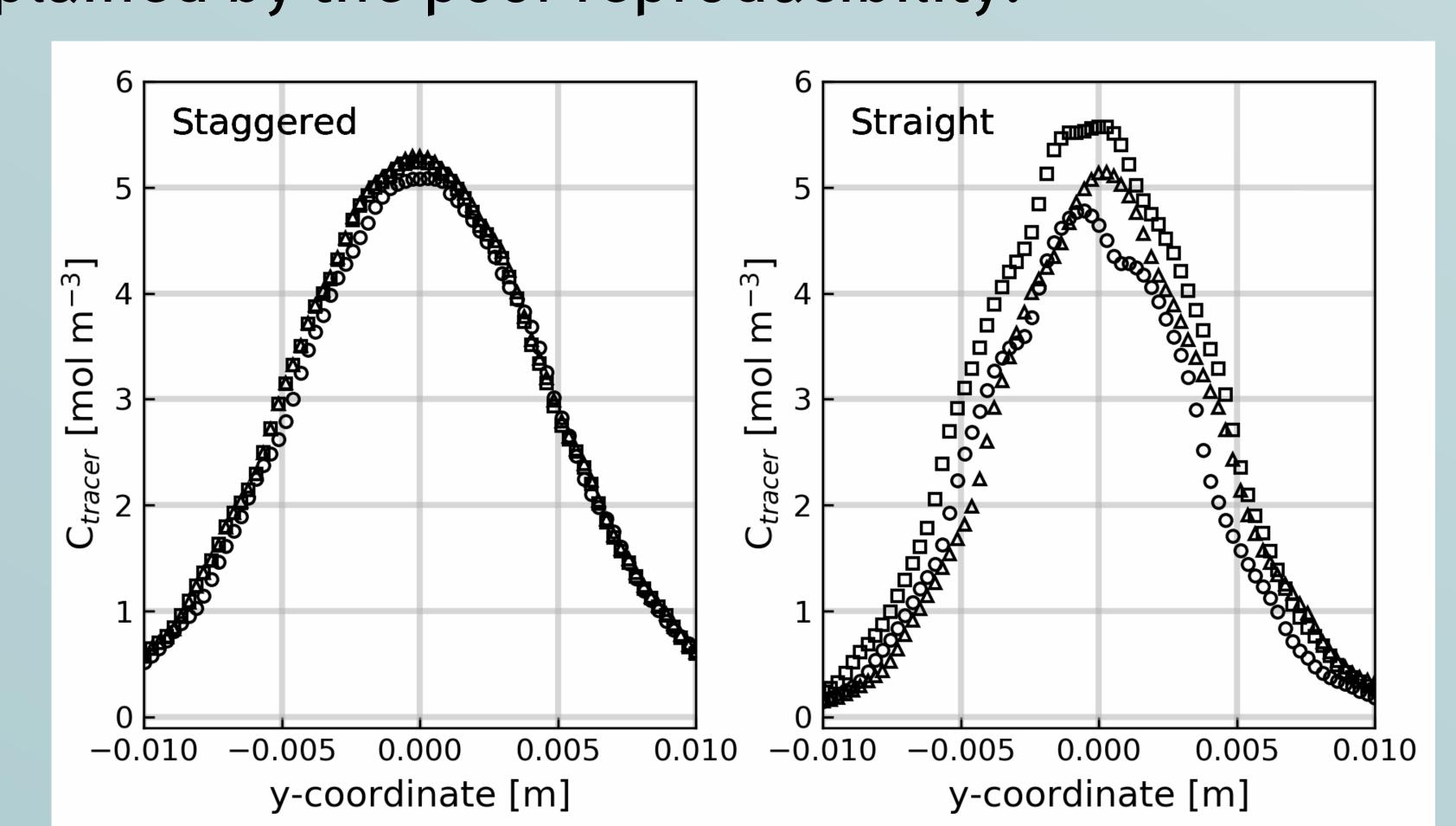
 $\frac{D_t}{D_m} = 0.769 \left(\frac{1-\epsilon}{\epsilon}\right)^{1.31} + 0.0262 \epsilon^{2.04} Pe_m^{1.19}$

and for staggered configuration:

Porosity

$$\frac{D_t}{D_m} = 2.64 \frac{1 - \epsilon}{\epsilon} + 0.00631 \left(\frac{1 - \epsilon}{\epsilon}\right)^{2.65} \left(\frac{d_h}{d} Pe_m\right)^{1.67}$$

The staggered correlation has a low MAPE of 3.74%, but the straight correlation has a fairly high MAPE of 9.26%. This can partially be explained by the poor reproducibility:



Full paper:



Conclusions

- Novel experimental method is validated for accurate determination of the transverse dispersion coefficient.
- Staggered 3D-printed logpile structures allow for tuning of transverse dispersion coefficient by changing of geometrical parameters.
- While tuning is possible, high transverse dispersion values cannot be achieved. This limits the process intensification potential of these structures.
- Correlations do not yet offer fundamental insights.

Next steps

- Modelling the flow through these structures (in OpenFOAM) to get better understanding of the operating trade-offs.
- Designing new structures with baffle-like internals which can better realize the process intensification potential.
- Experimental testing of these novel structures in reaction systems with strong heat effects.
- Conceptualizing further enabling developments for 3D-printing in process intensification: co-printing of multiple catalysts or sorbents and printing of entire reactors.

