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# Partially Saturated Flow through Deformable Porous Media

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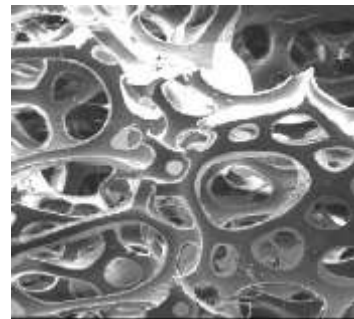
Controlled by: Sandia National Laboratories, Scott A. Roberts, sarober@sandia.gov



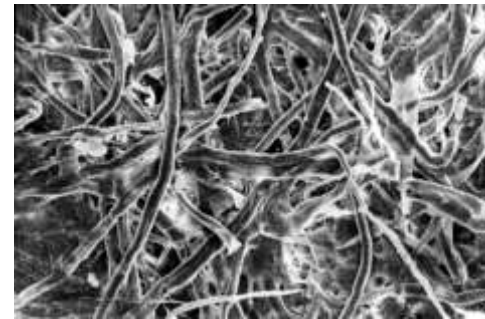


# Motivation: multi-everything problems

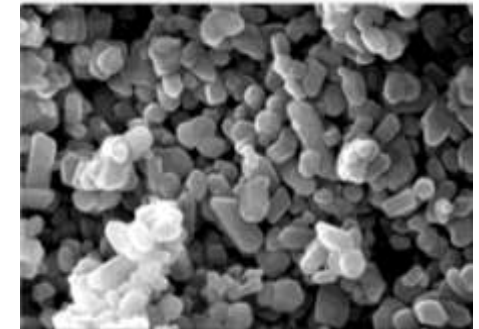
Foam

cellular  $600 \mu\text{m}$ 

Paper

fibrous  $100 \mu\text{m}$ 

Oil extraction

granular  $100 \mu\text{m}$ 

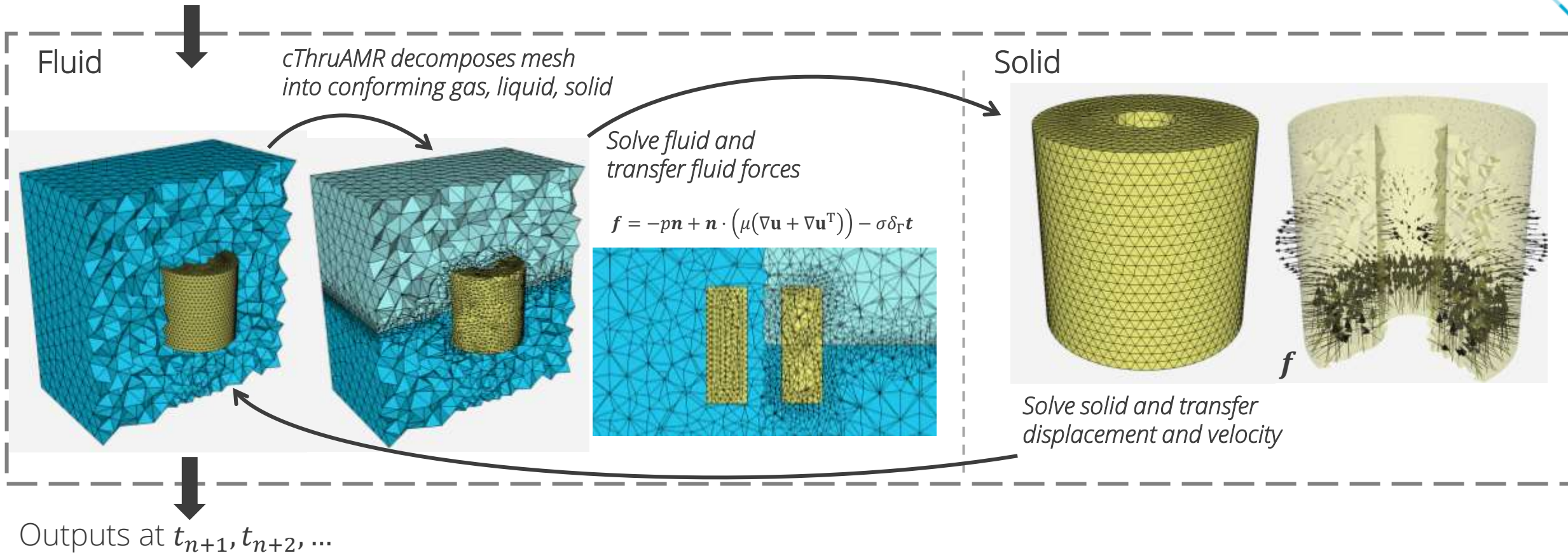
Multiphase  
Multiscale  
Multiphysics

Energy consumption is governed by the relationship between capillary pressure and saturation



# FSI overview

Inputs at  $t_n, t_{n-1}, \dots$



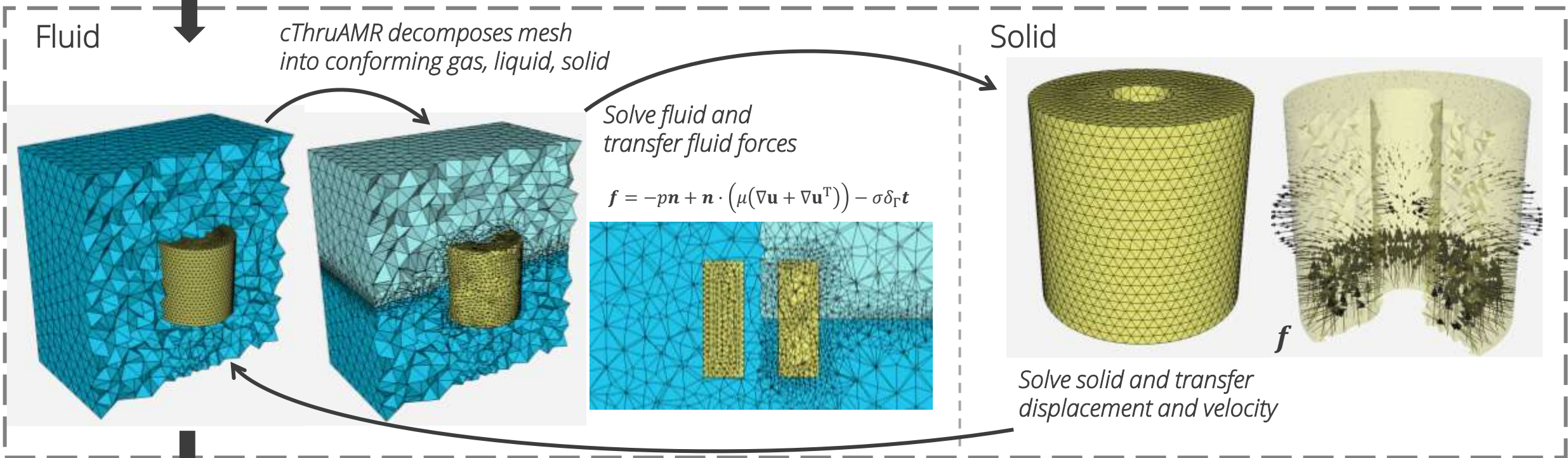
CDFEM: Noble, D.R., Newren, E.P. and Lechman, J.B. (2010), A conformal decomposition finite element method for modeling stationary fluid interface problems. *Int. J. Numer. Meth. Fluids*, 63: 725-742. <https://doi.org/10.1002/fld.2095>

cThruAMR: <https://www.osti.gov/servlets/purl/1899670>



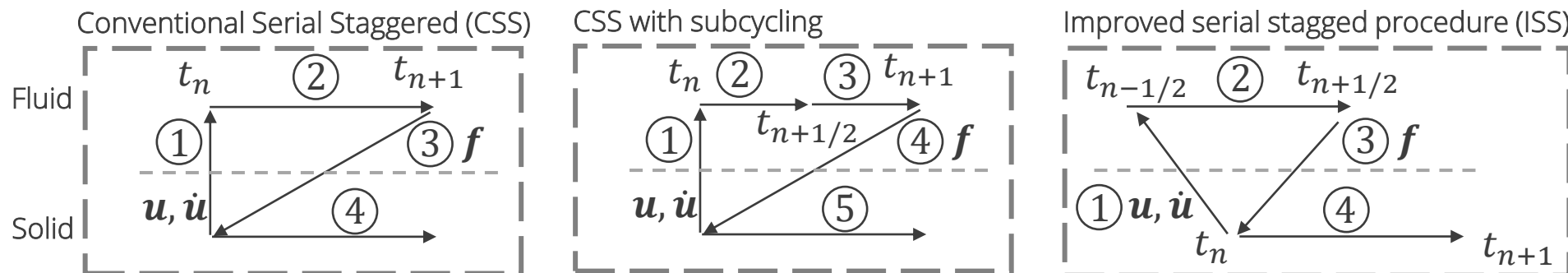
# FSI overview

Inputs at  $t_n, t_{n-1}, \dots$



Outputs at  $t_{n+1}, t_{n+2}, \dots$

Example schemes:

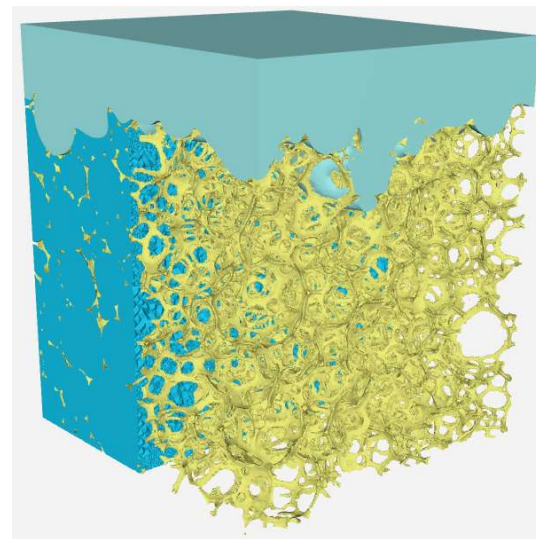
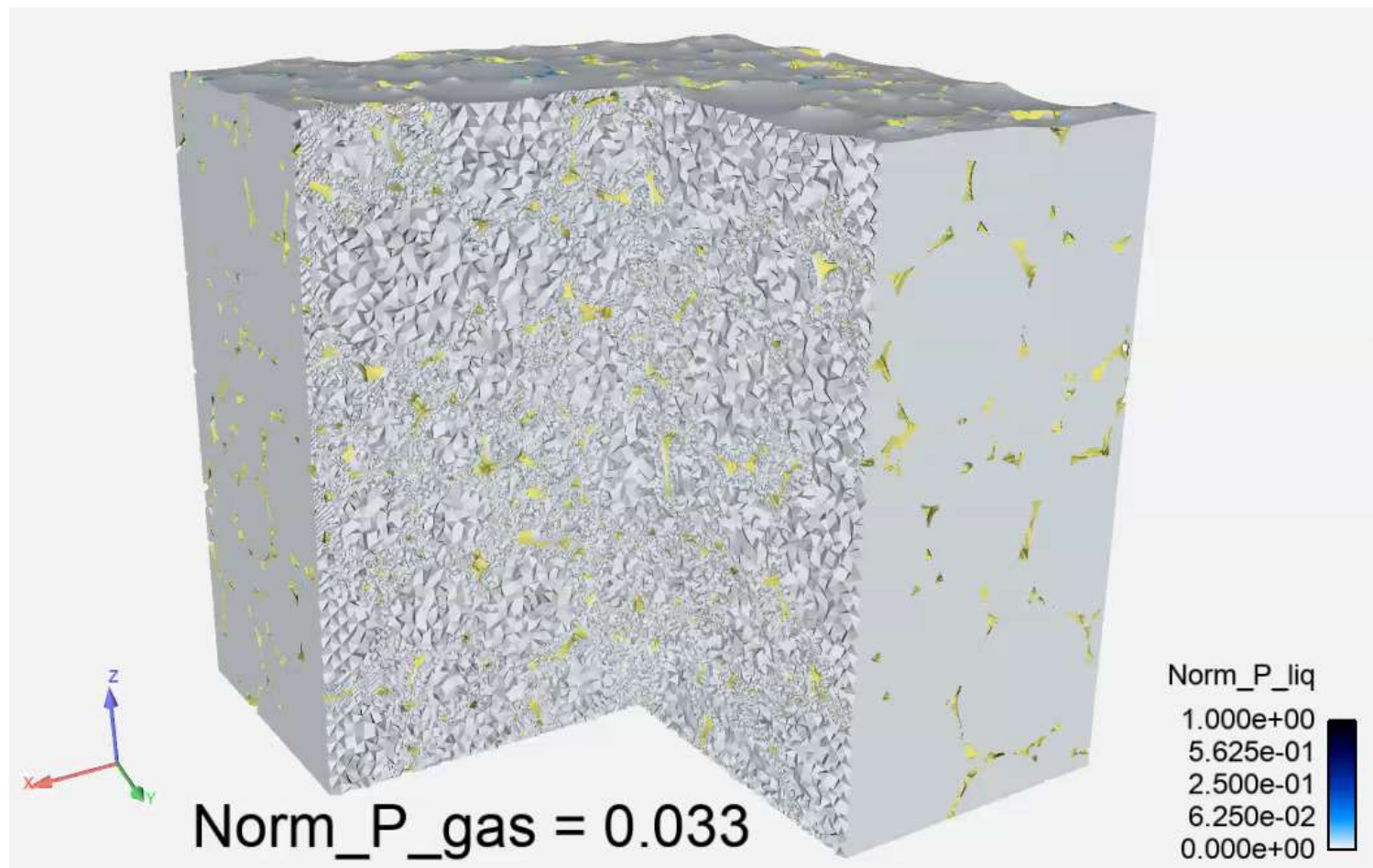




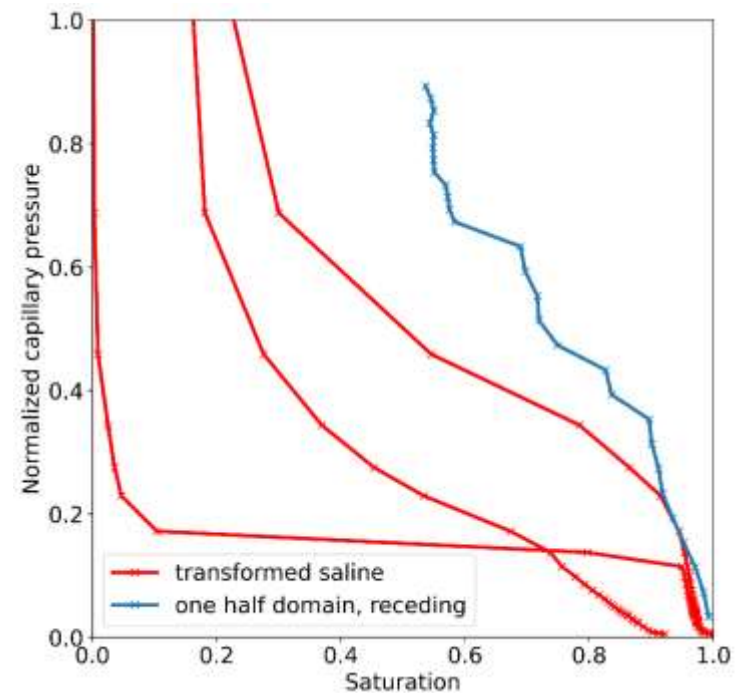
# Results: capillary flow



# Capillary flow through a rigid foam



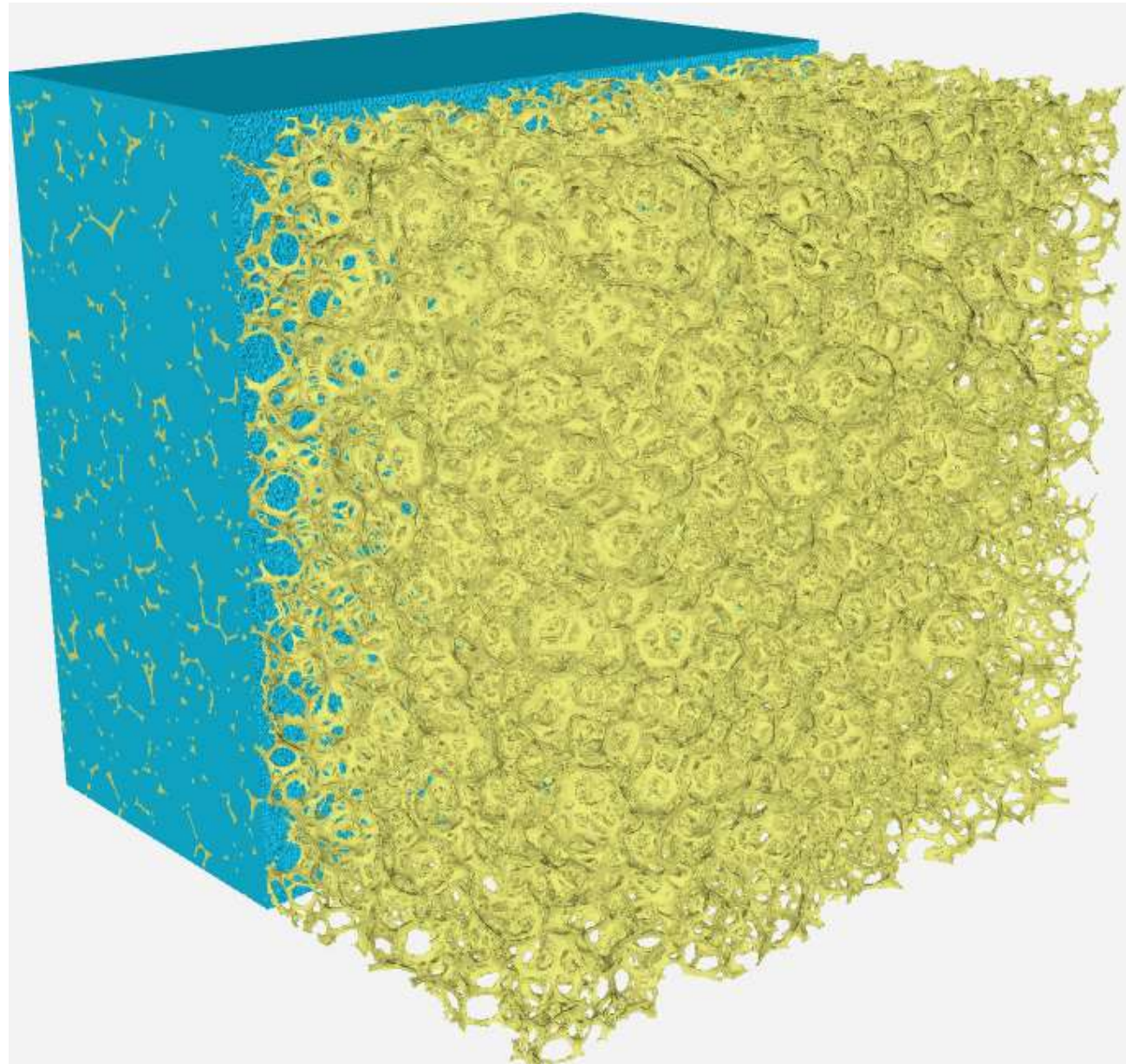
~32.8 million  
elements





# Next steps: scale up

~395 million elements





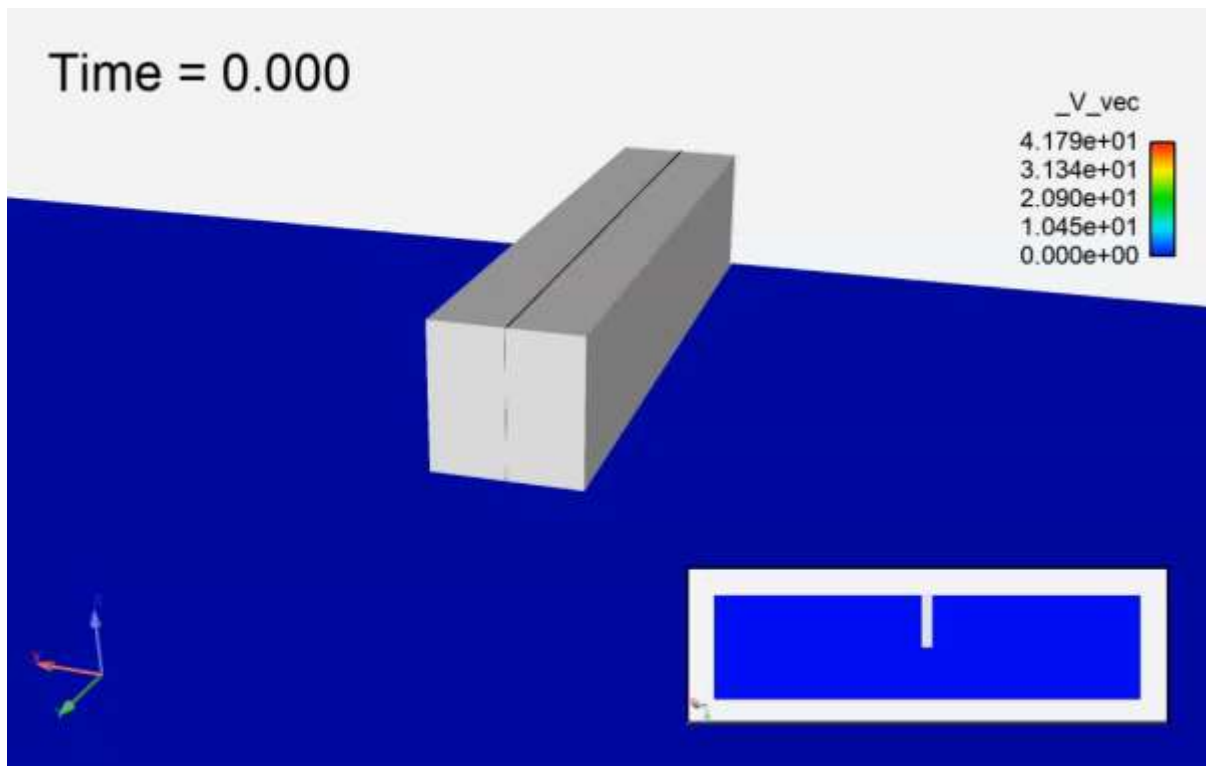
# Results: FSI



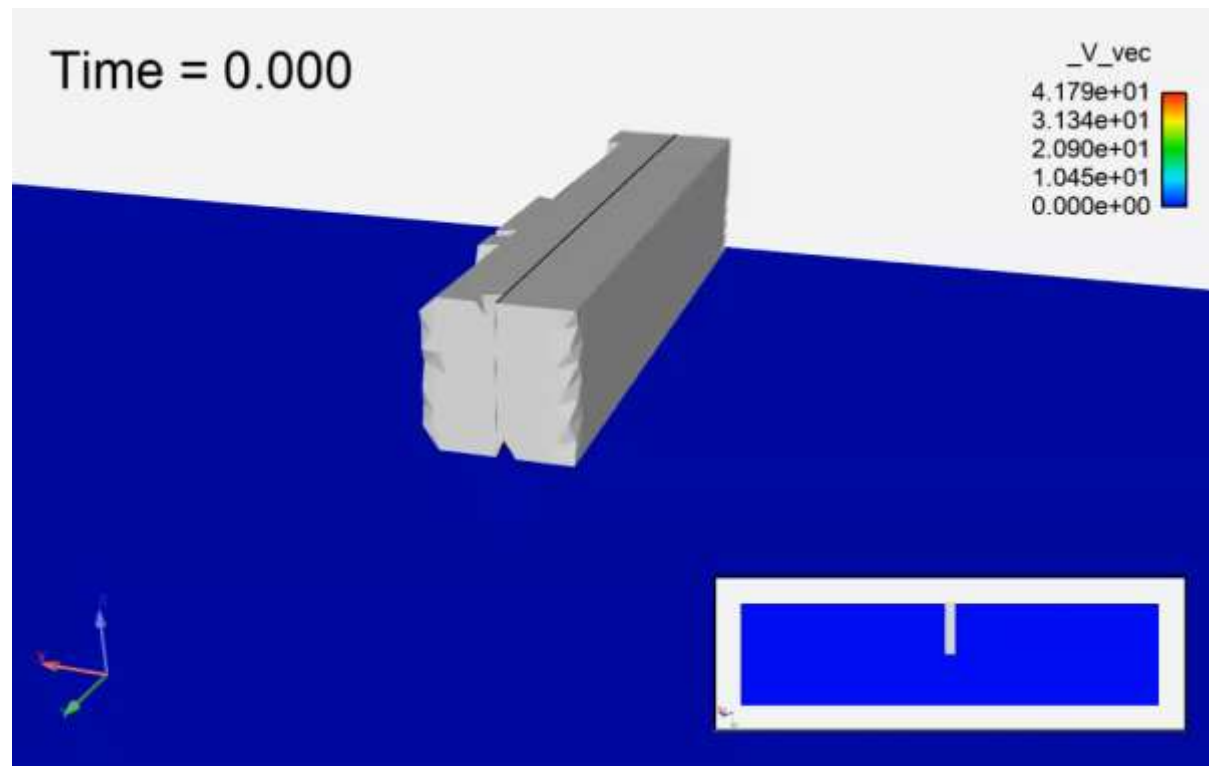


# Rigid results

ALE

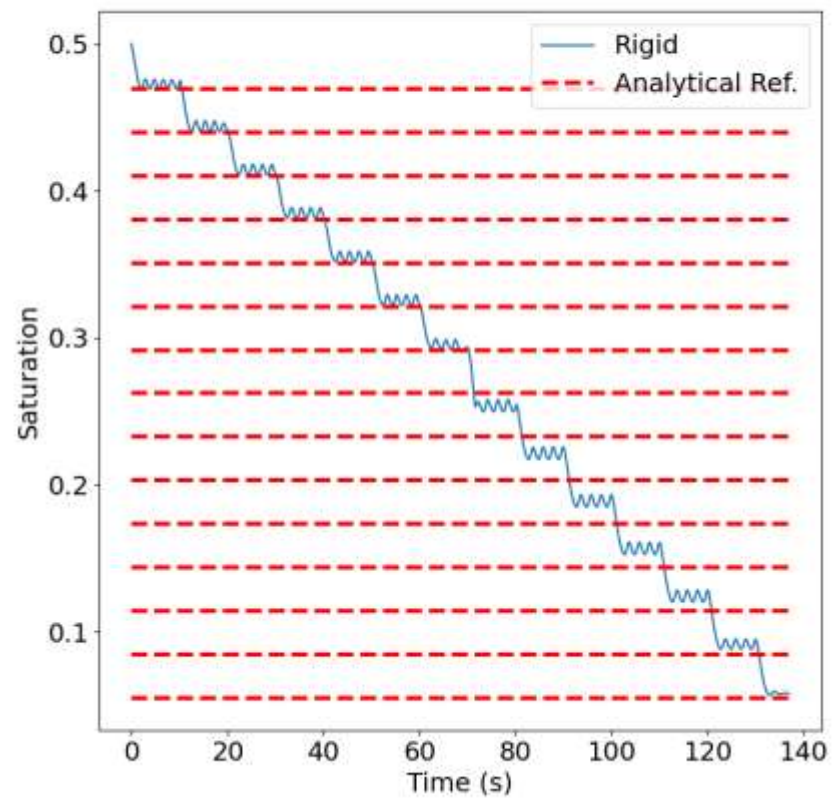
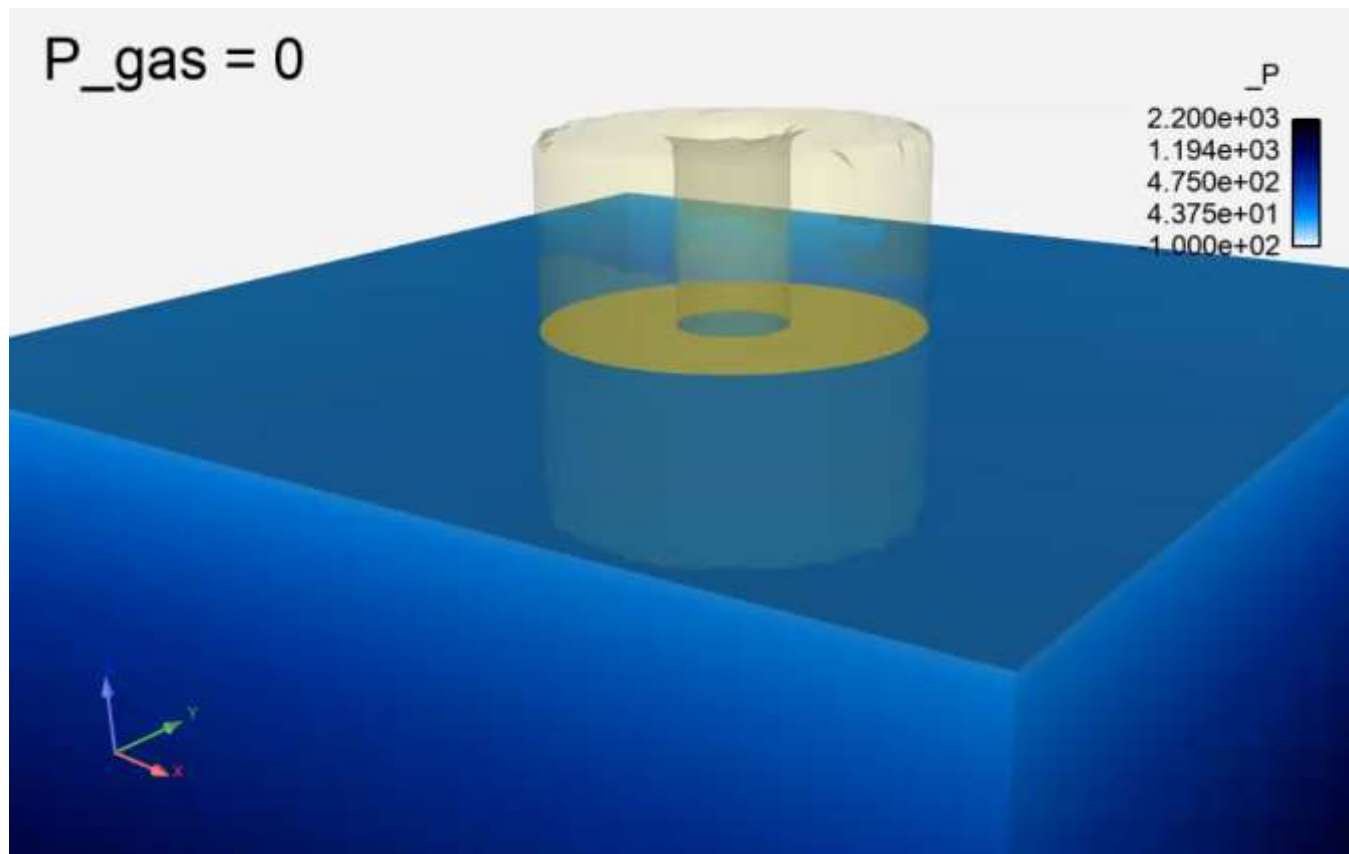


cThruAMR



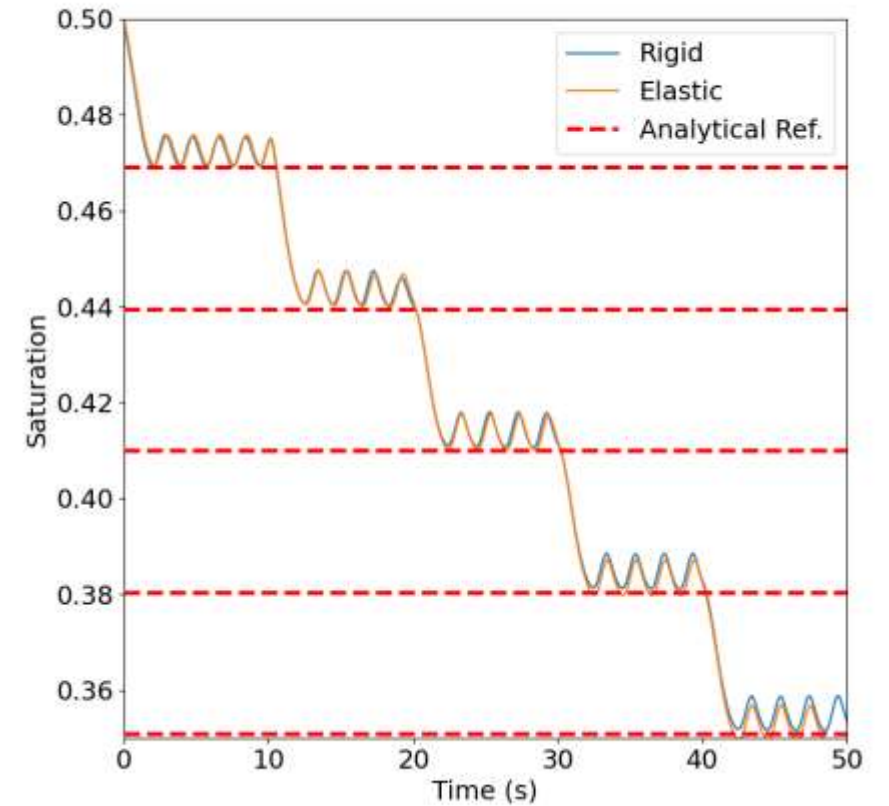
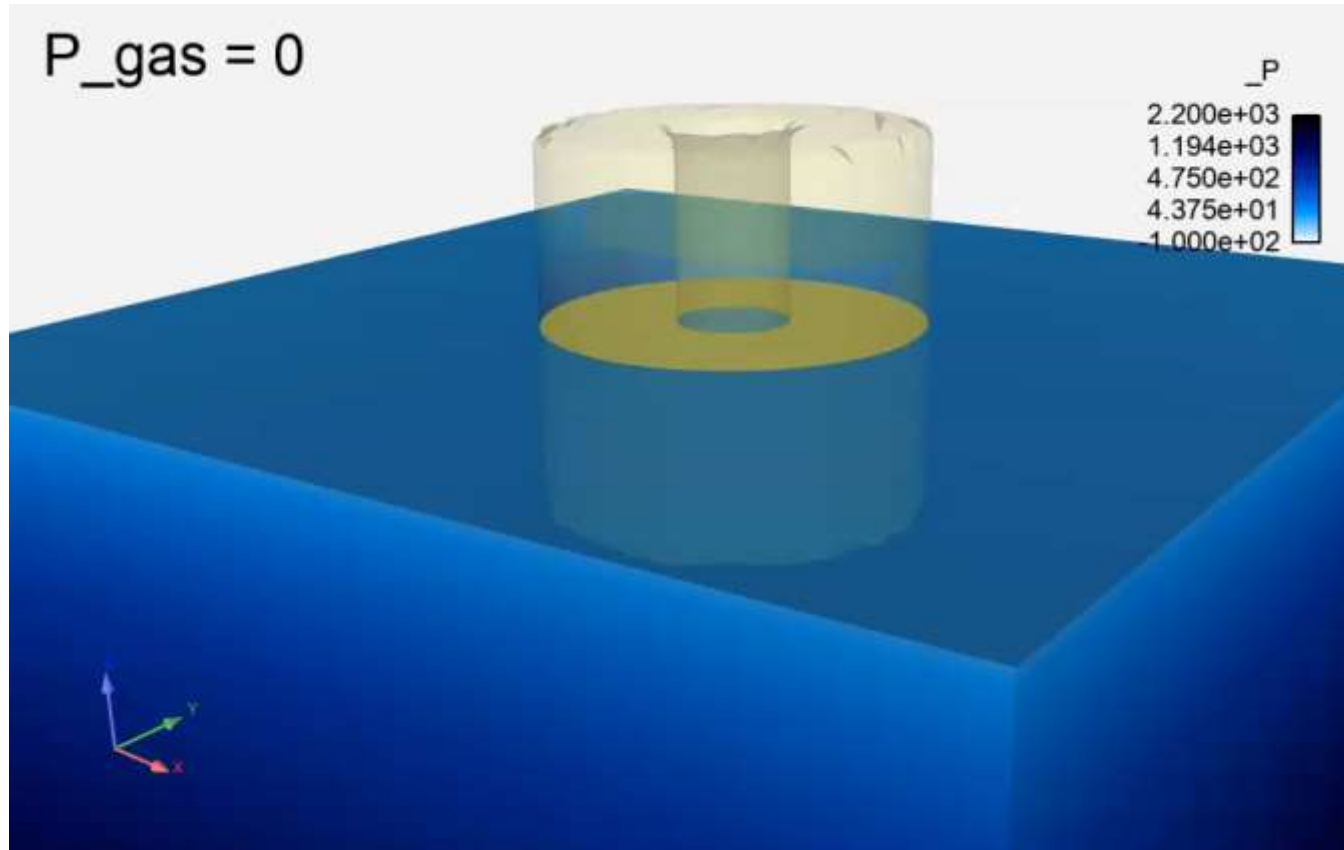


# Rigid results



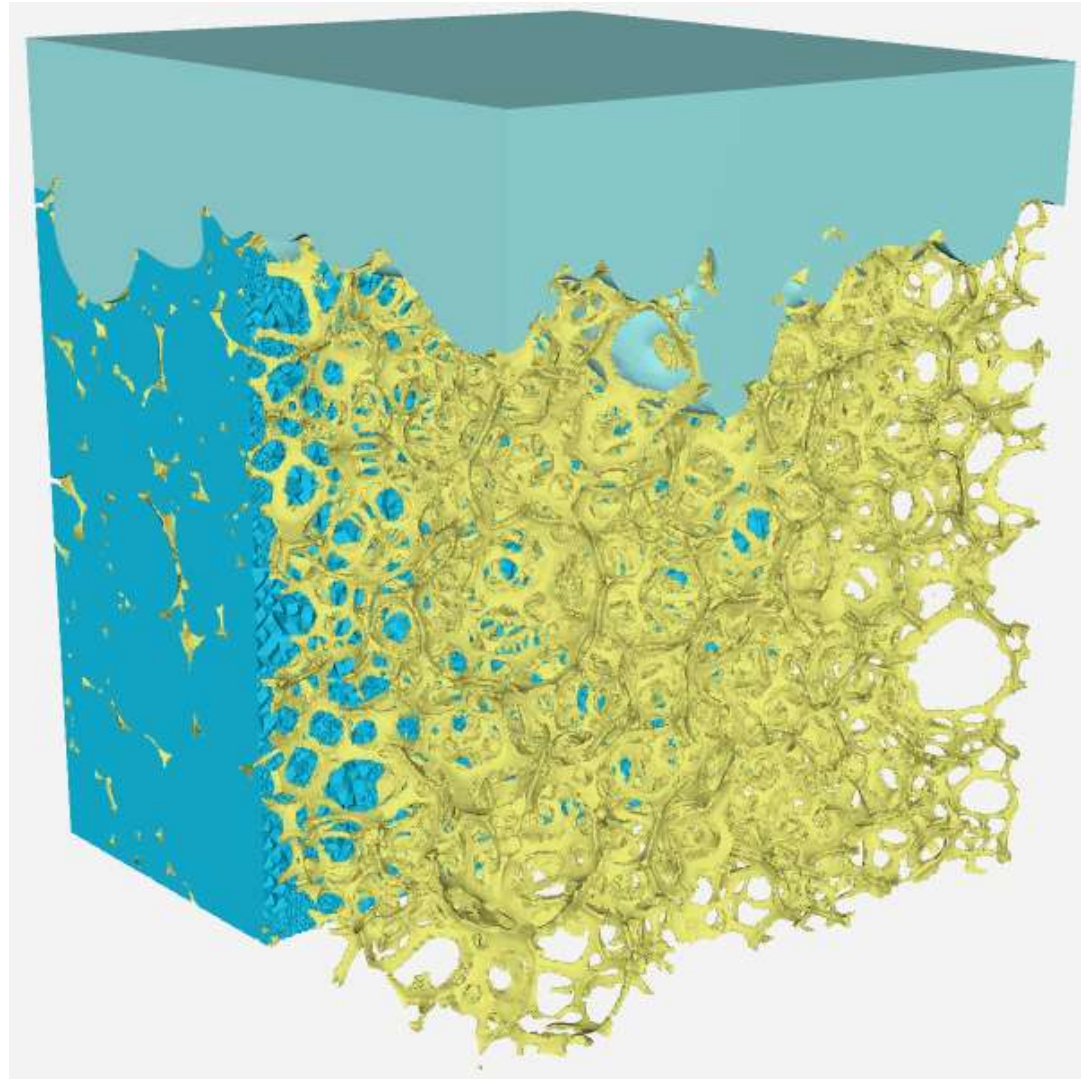


# Elastic results





## Next steps: apply to foam





# Backup