ERA Chair MATTER: Süsteemide, materjalide ja protsesside modelleerimine

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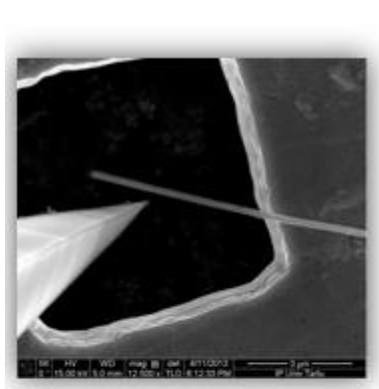
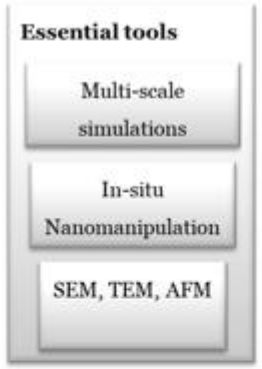
My background

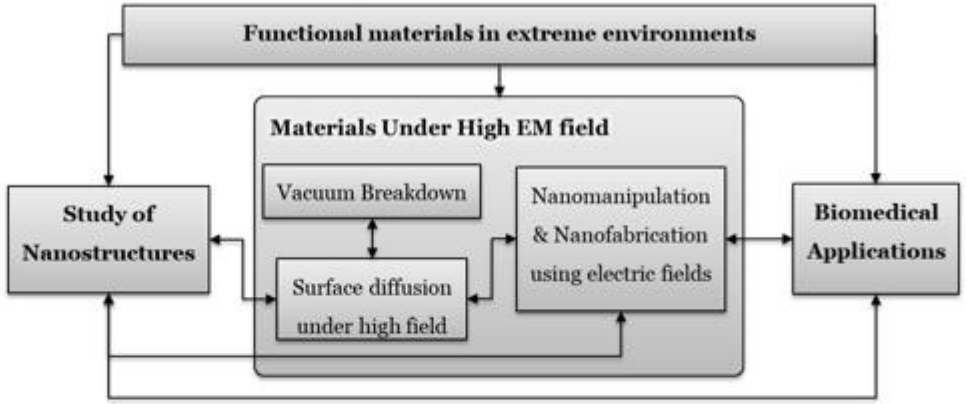
- Professor of Materials Technology in Institute Of Technology
- Lead Simulation Scientist in Milrem Robotics
- Estonian Group leader in CTF-3 experiment in CERN since 2013

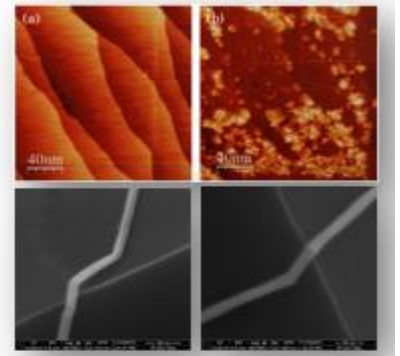
- Background
  - BSC in Physics
  - MSC in Applied Physics
  - PHD in Physical Engineering
  - Postdoc in University of Helsinki
- Chartered Mechanical Engineer, EstQF level 8

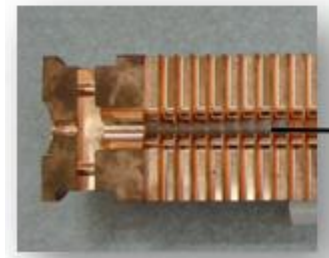
ERA Chair MATTER

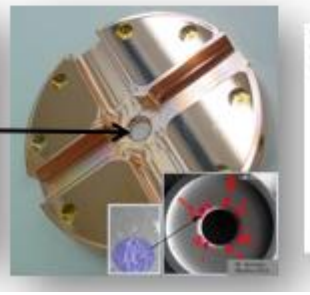


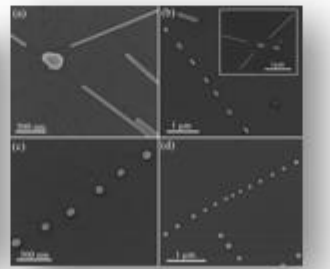


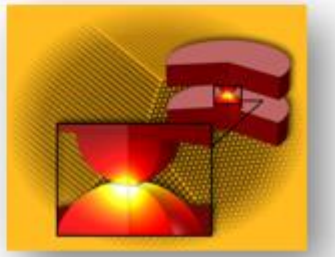


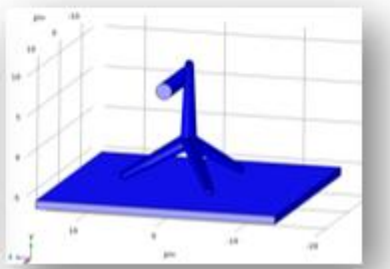




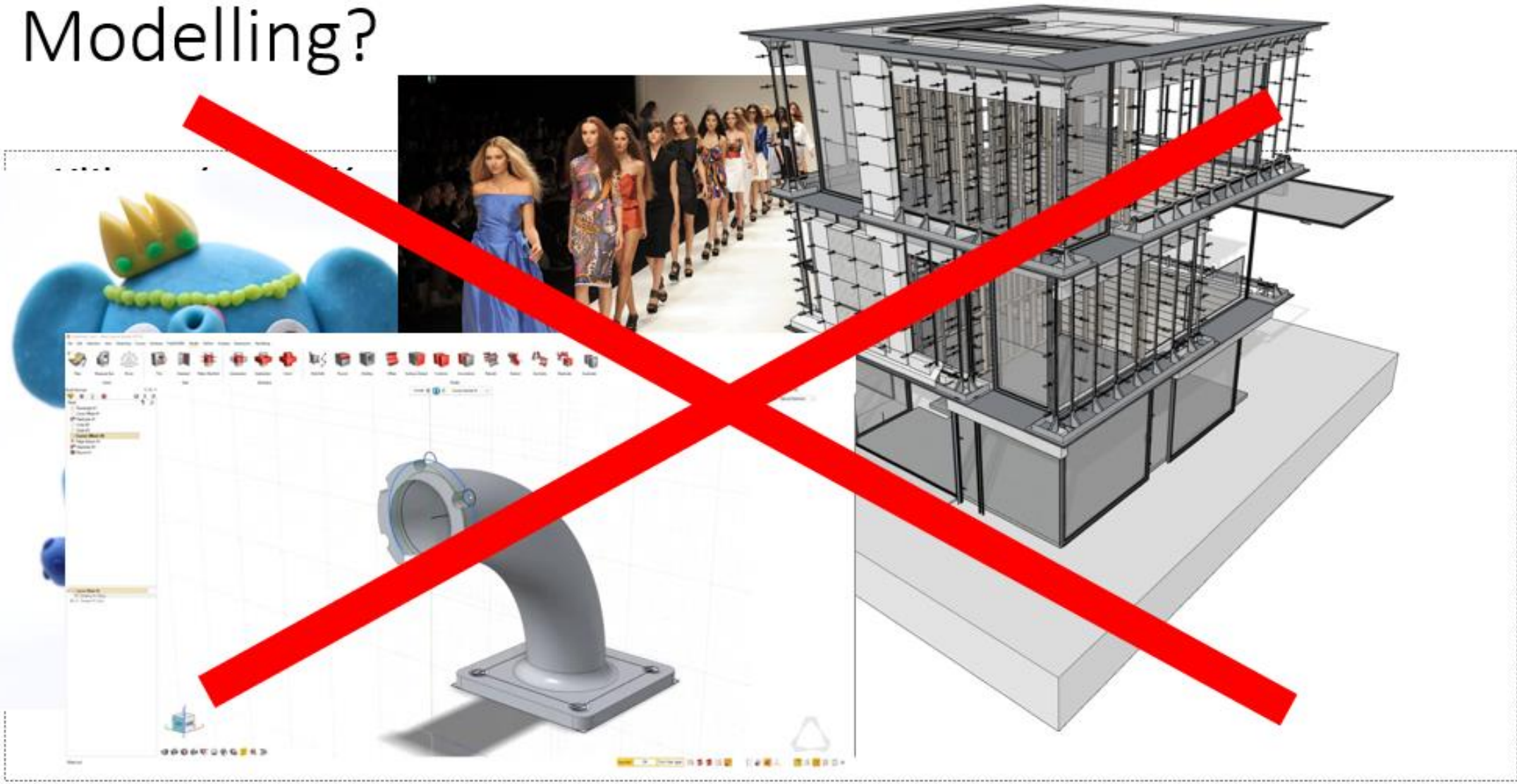






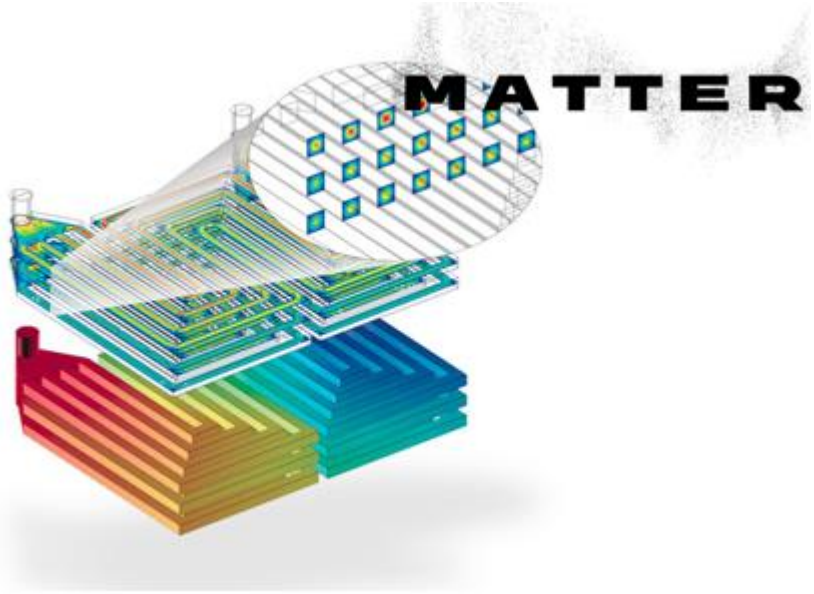


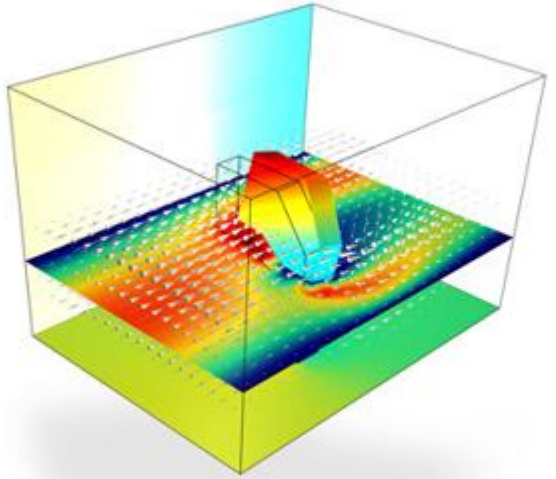
Modelling?



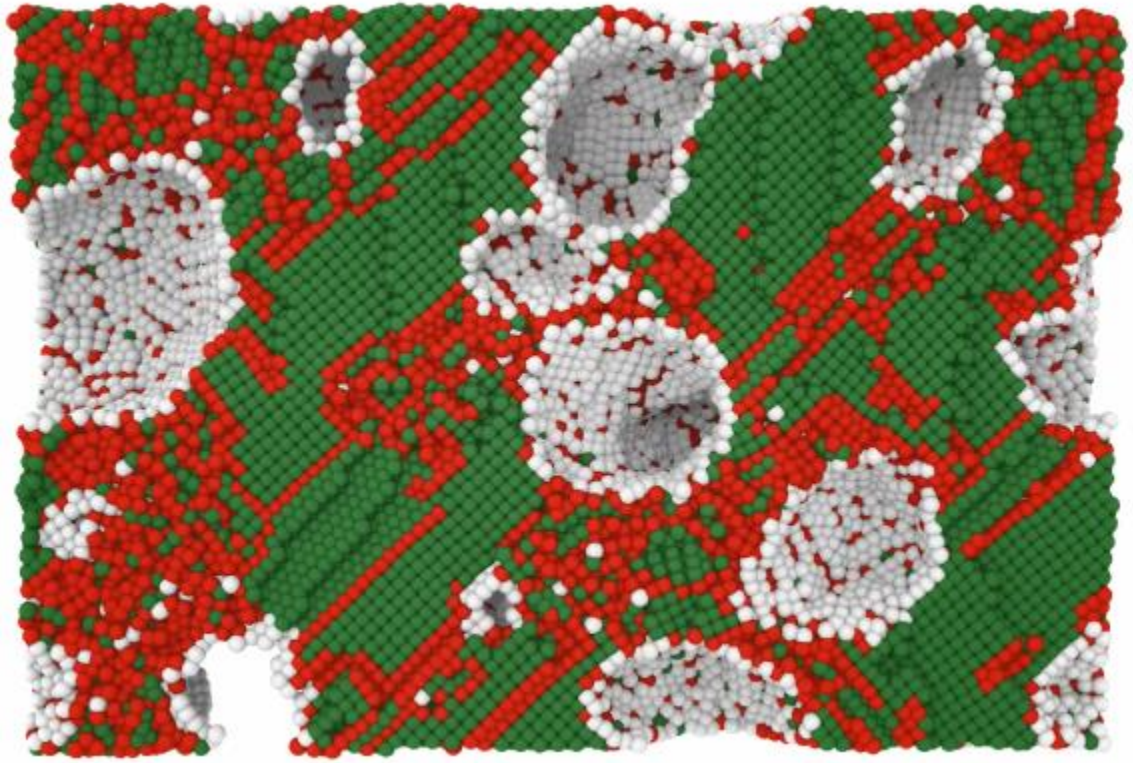
Practical simulation capacity

- **Solid Mechanics**
- Fluid dynamics
  - Turbulent flow
  - Laminar flow
  - Multiphase flow
- Heat transport(with conduction and convection)
- AC/DC
  - Electrostatics, electrodynamics
- Diffusion
  - Chemical reactions
  - electrochemistry(batteries/fuel cells)
- Acoustics
- General second order partial differential equations
- **Multiphysics!**



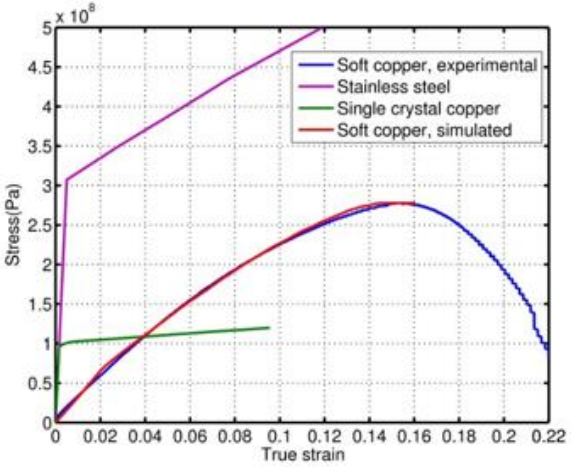


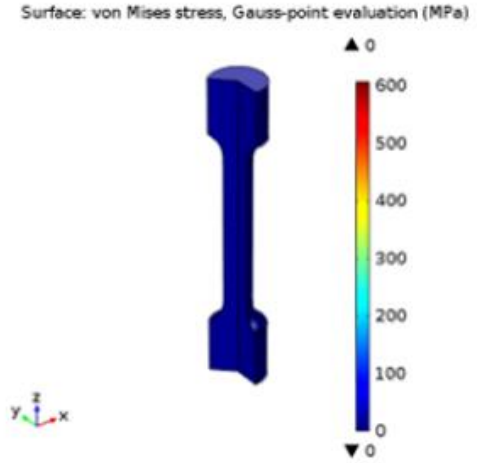
Extensive plastic deformation damage



Material damage due to the plastic deformations

- Elastoplastic deformation of material, simulation of large strains
- Very good agreement between the experimental measurements and simulation results
- Wide range of applications
  - Different materials
  - From micro to macro scale

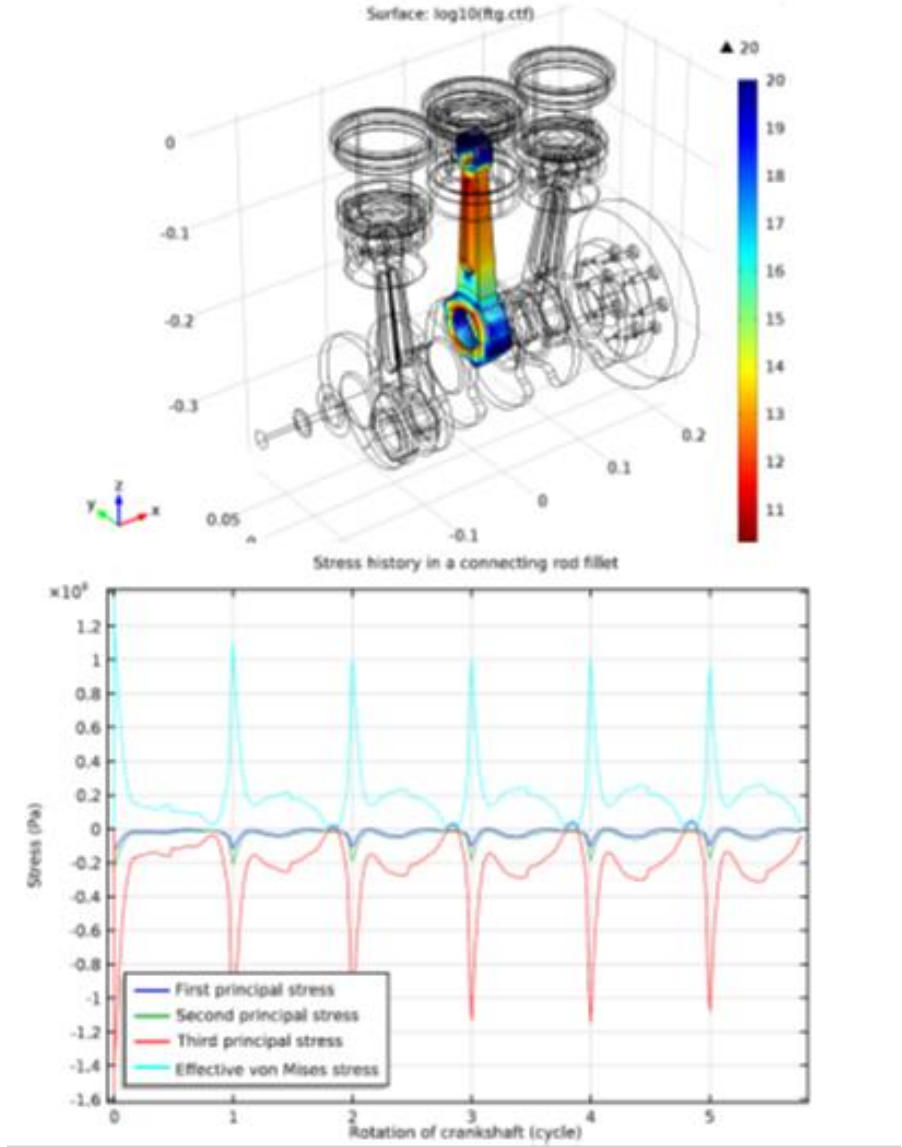




Material fatigue damage

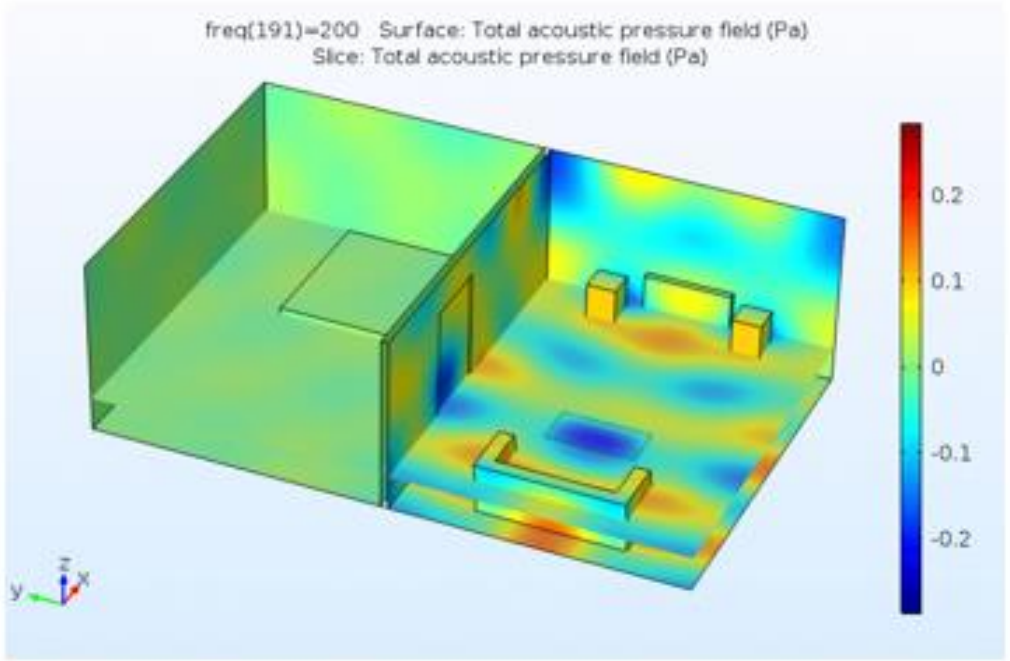
- **Fatigue** is the weakening of a material due to periodic loads.
  - progressive and localized structural damage
  - maximum stress values that cause fatigue may be much less ultimate tensile stress or the yield stress

- **Application example: High-Cycle Fatigue of a Reciprocating Piston Engine**
- The critical point is at the fillet close to the top end of the connecting rod
- Predicted fatigue life is longer than twenty-five billion cycles

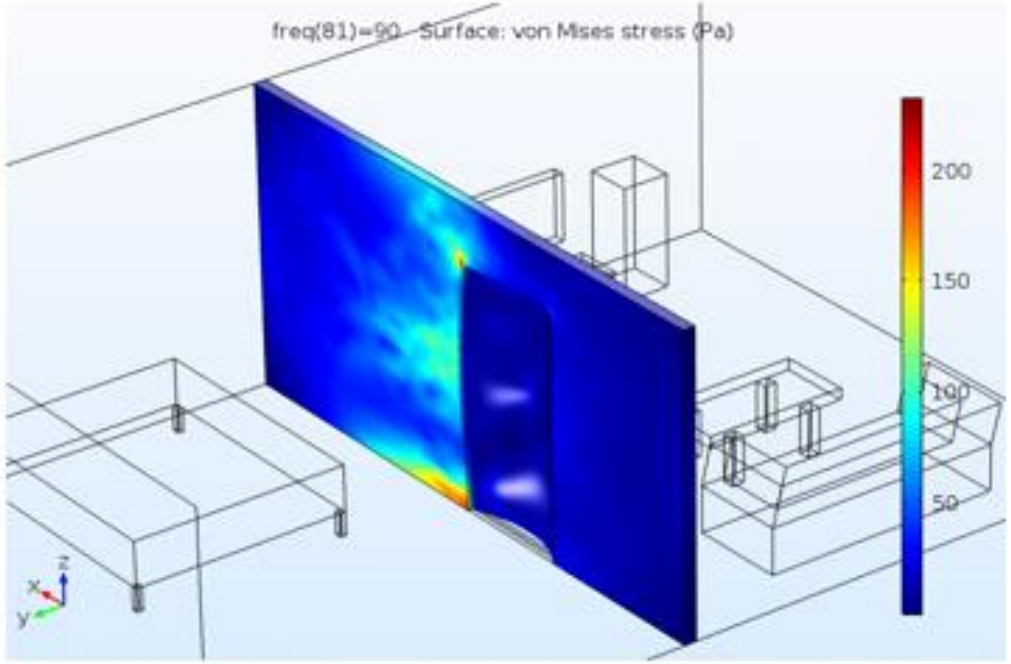


Acoustics: two room apratment

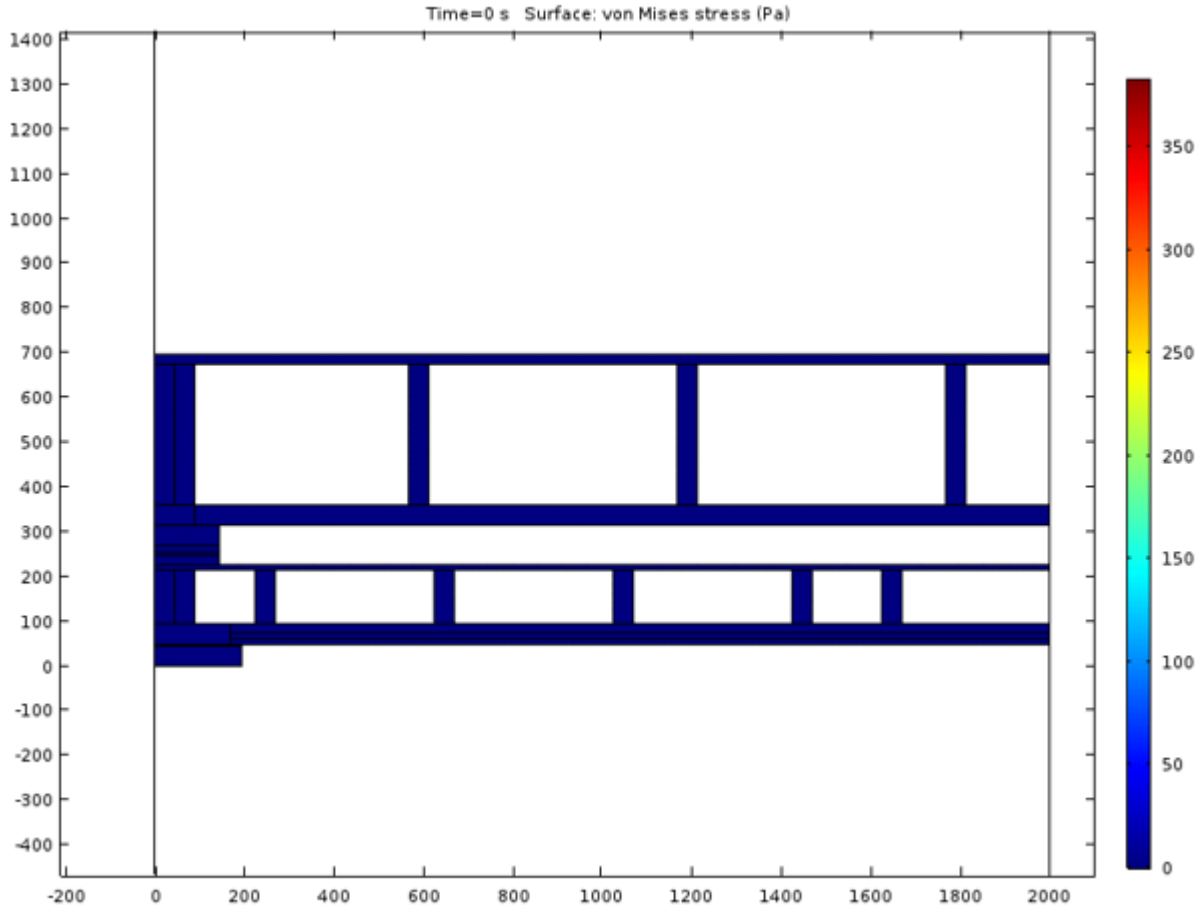
Frequency: 200 Hz



Frequency: 90 Hz

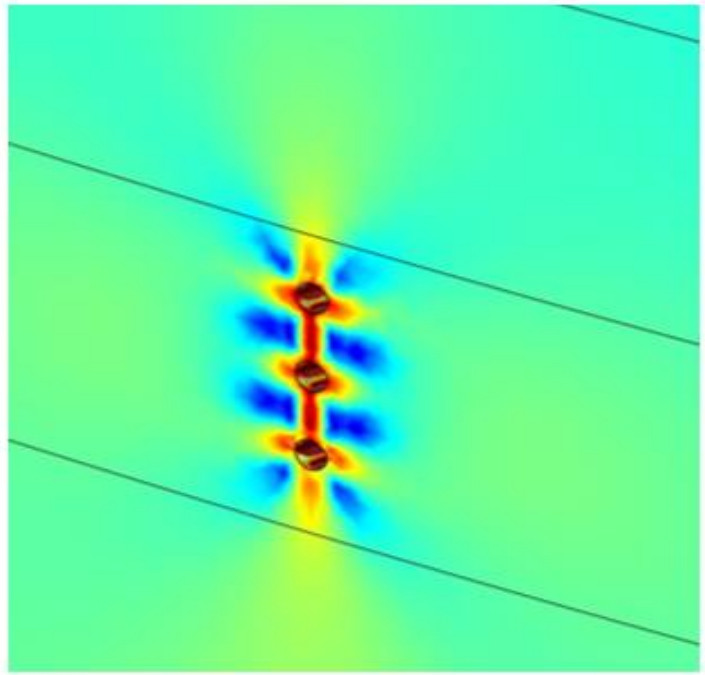


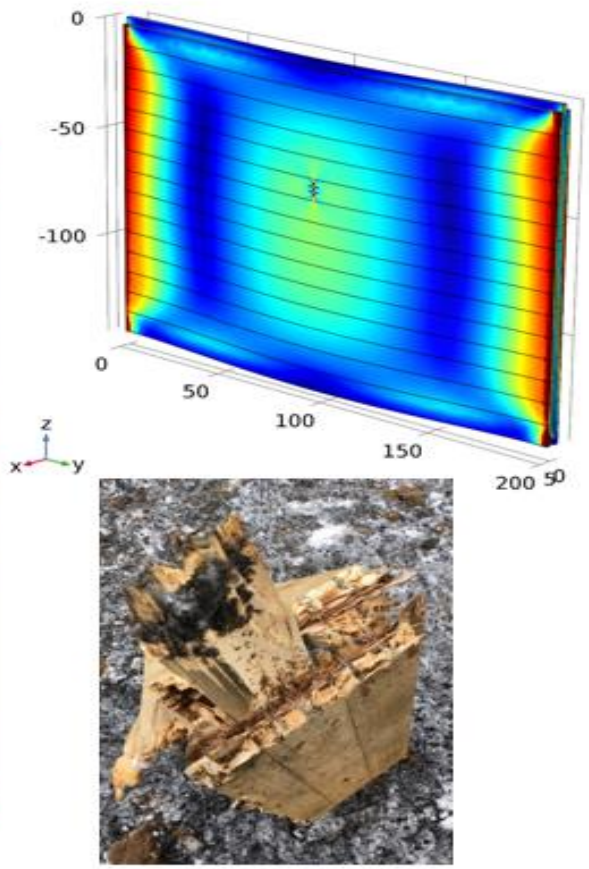
Time dependet mechanical responses

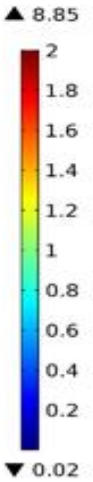


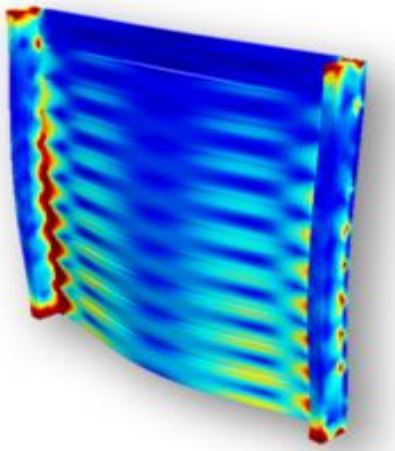
Trench design - experiment

Trench design evaluation



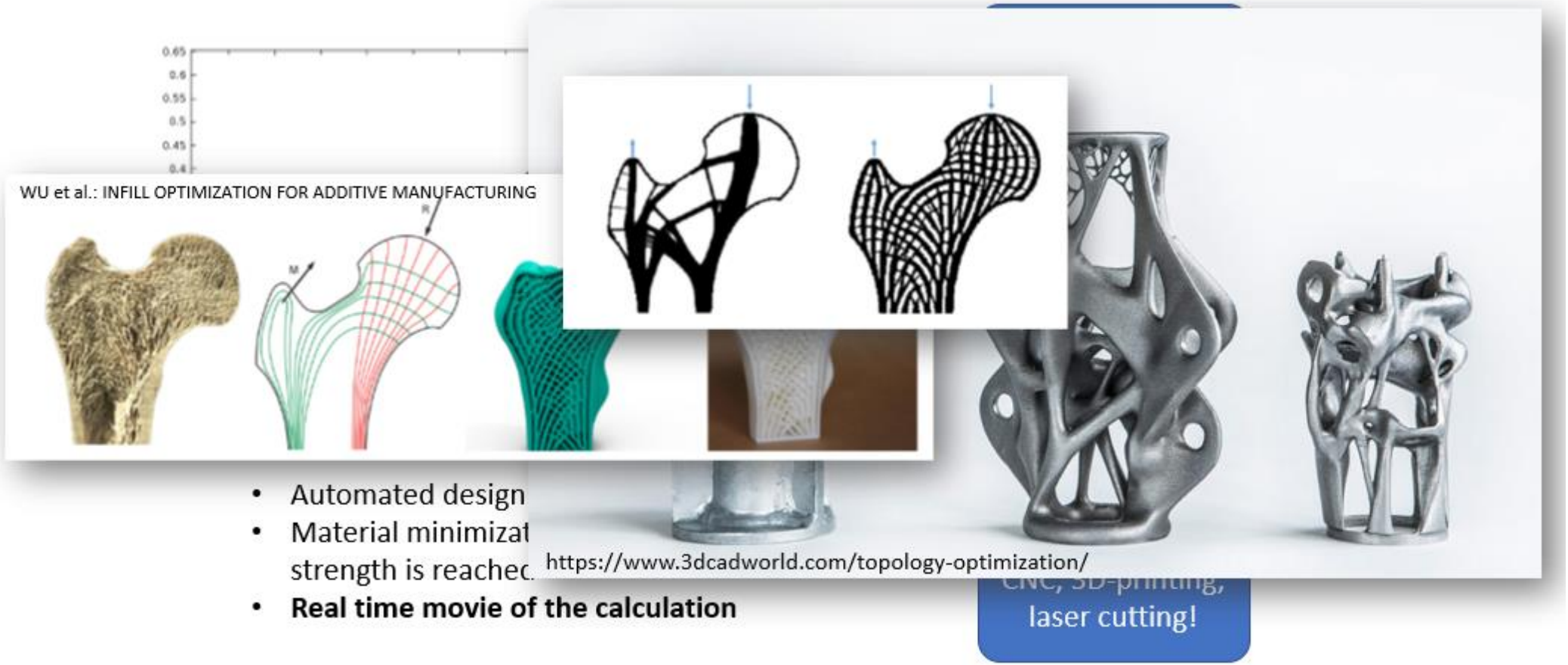






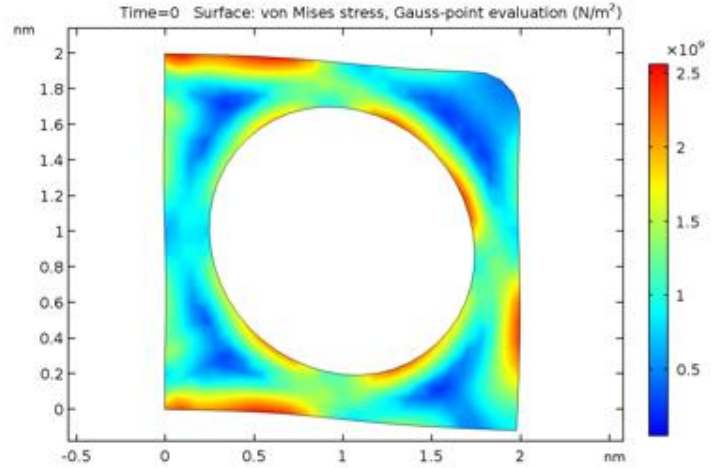
Automated design examples

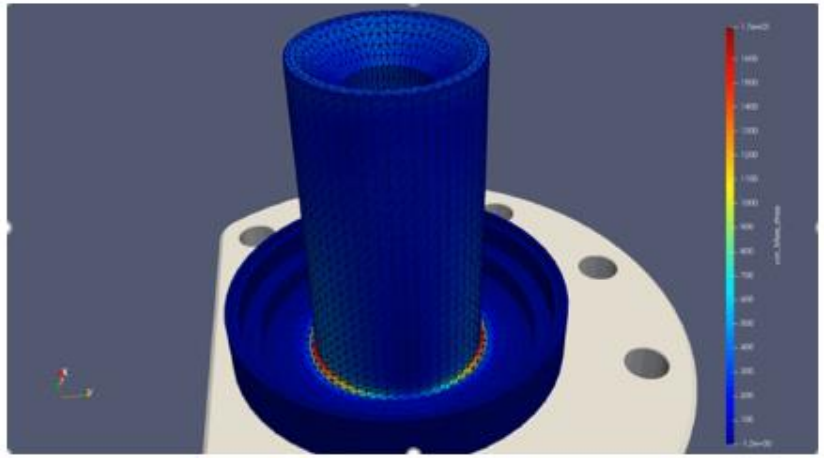
Workflow: from idea to product

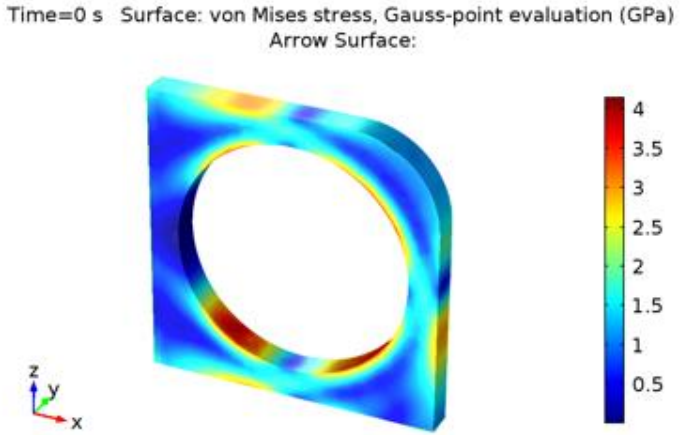


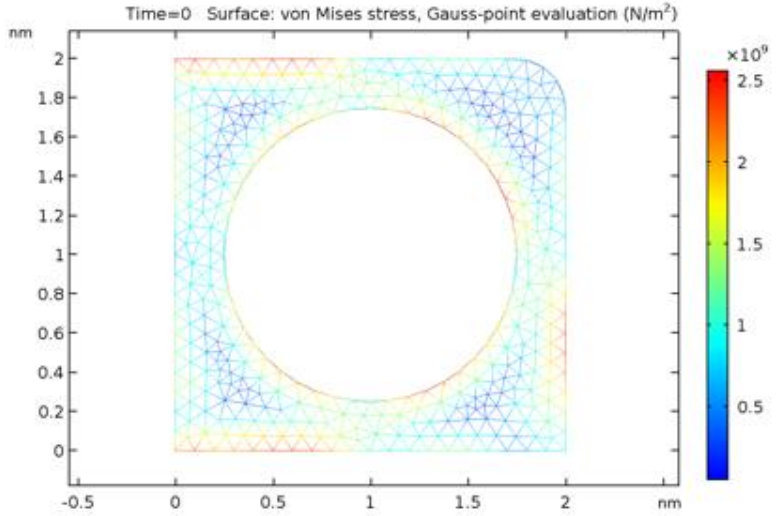
- Automated design
- Material minimizat
  strength is reachec
- **Real time movie of the calculation**

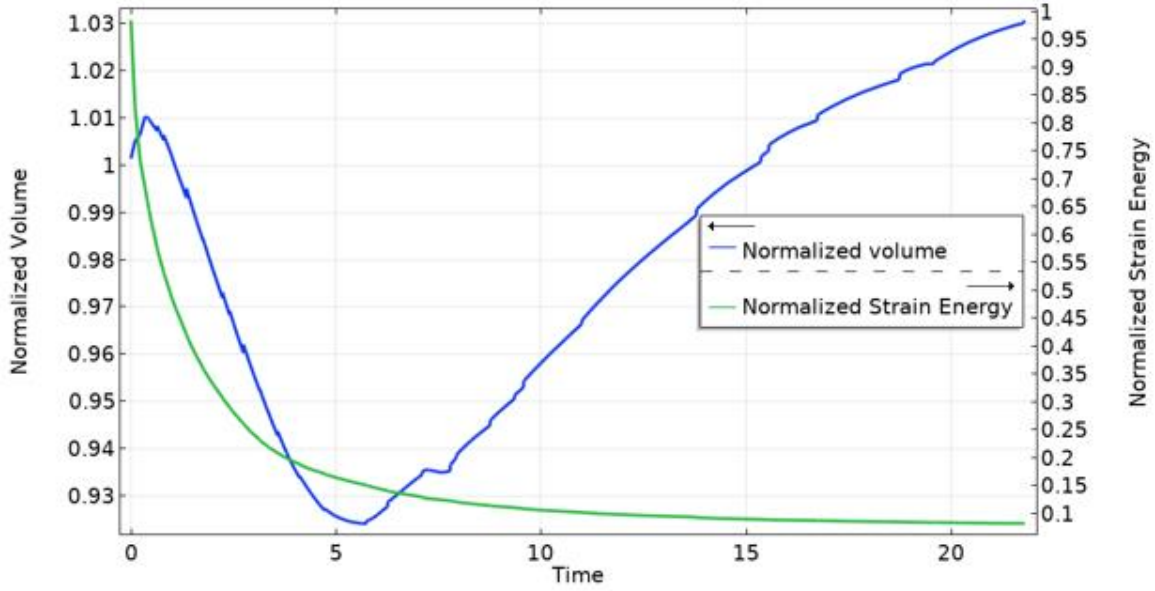
Benchmark cases



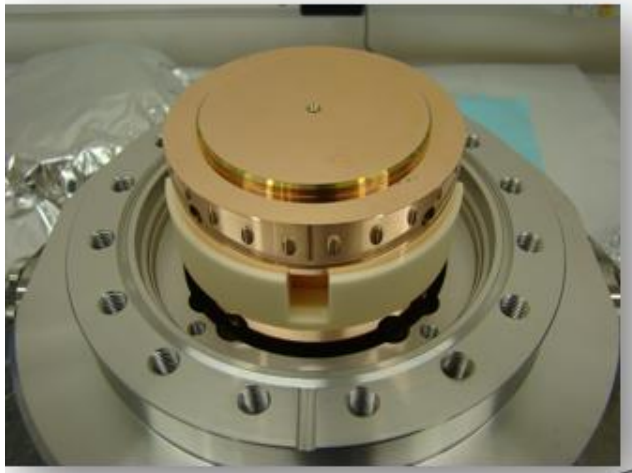








Optimization of breakdown testing bench in CERN



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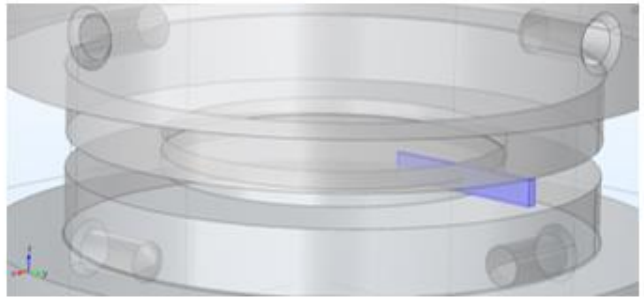

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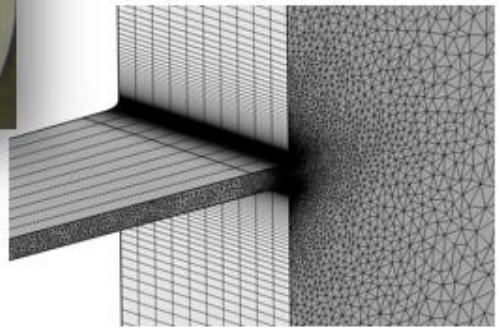

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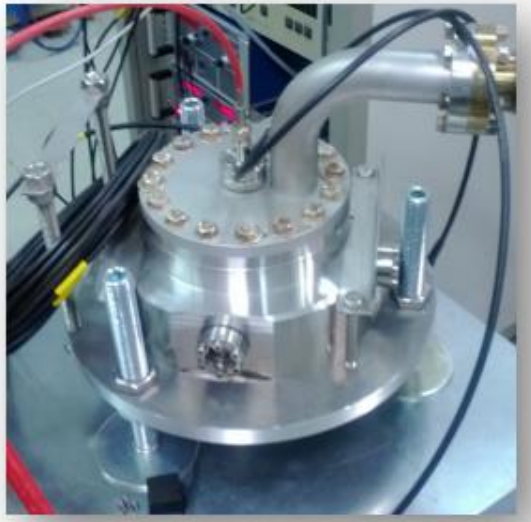
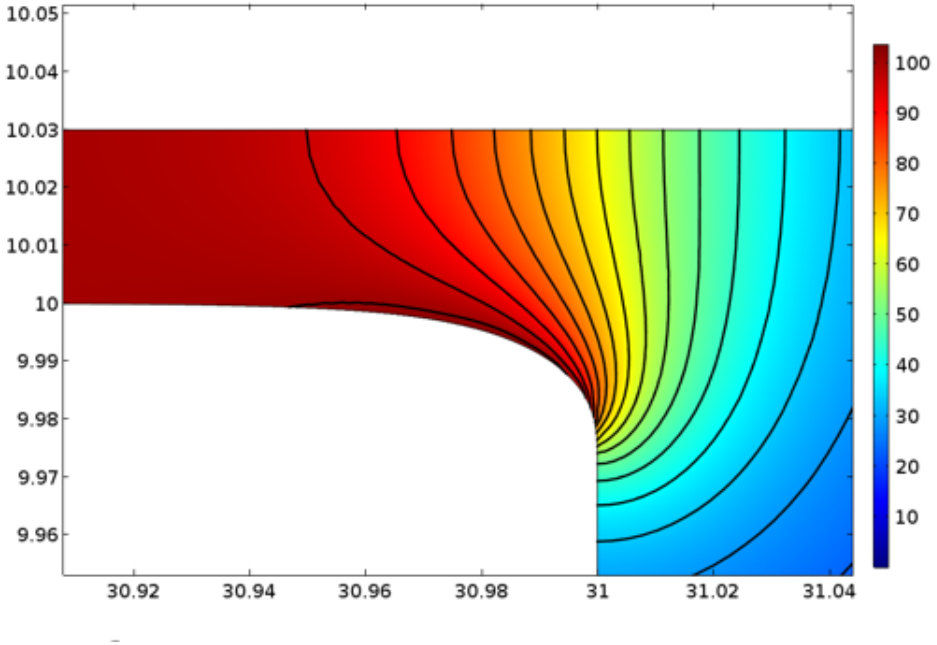
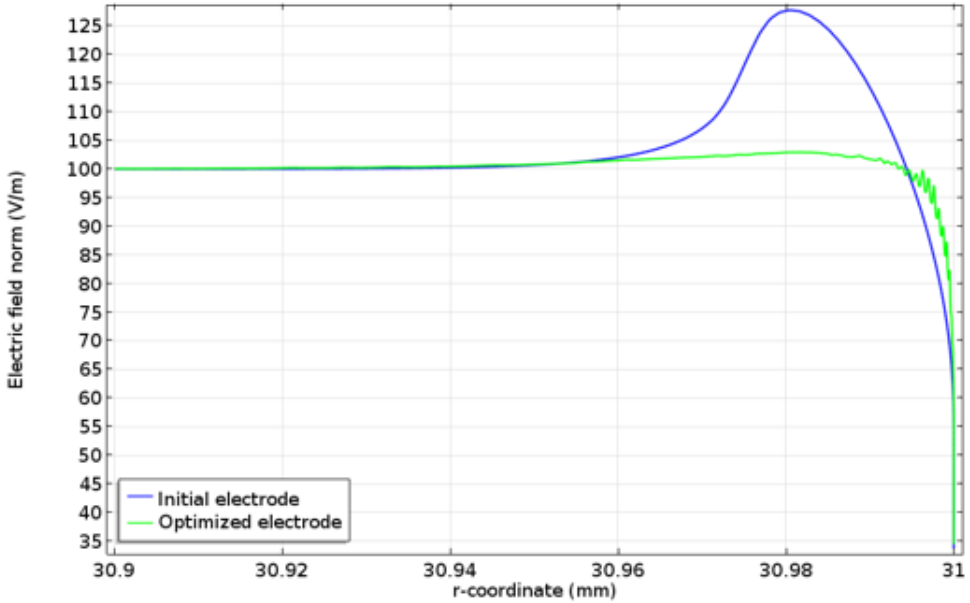


Electric field distributions

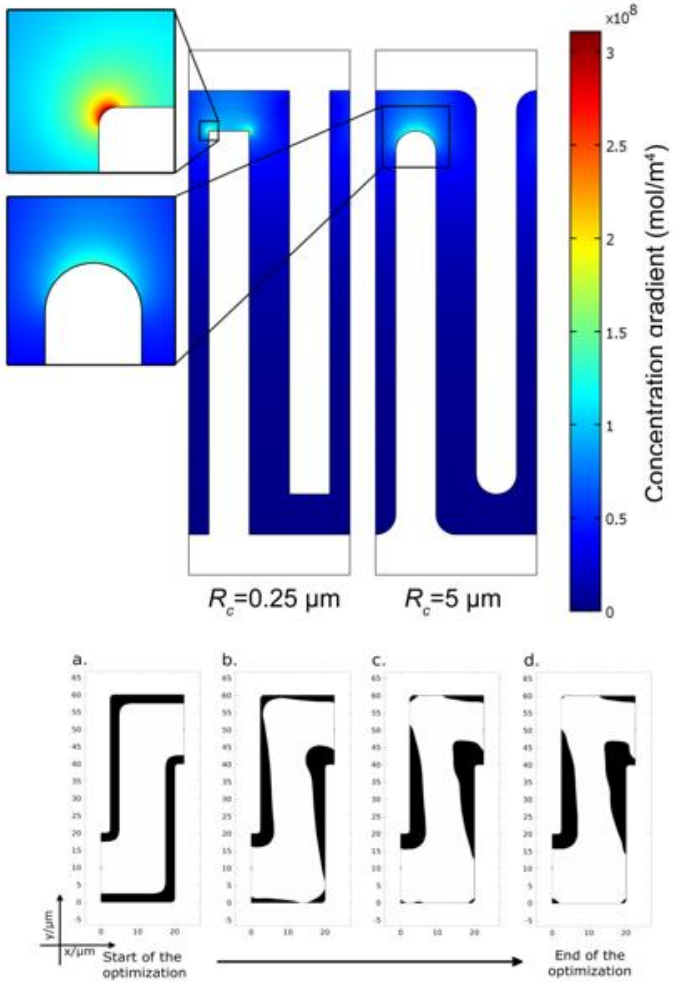
- **The problem:** Edges of electrode enhance field and attract breakdowns
- Automtic electrode shape design by applying **geometry optimization**
- **The aim:** reduce field enhancement as much as possible



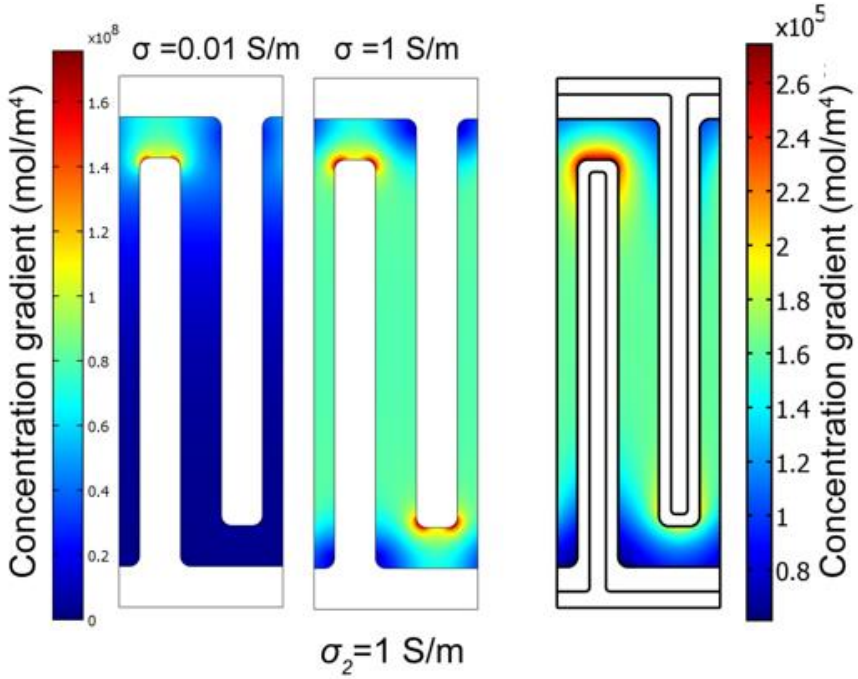


- Final Cad implementation of optimized geometry shows some oscillations of field enhancement near the edge
- **Maximum field enhancement ~1.06 in new CAD geometry, vs. ~1.03 in optimized and ~1.25 in initial one**

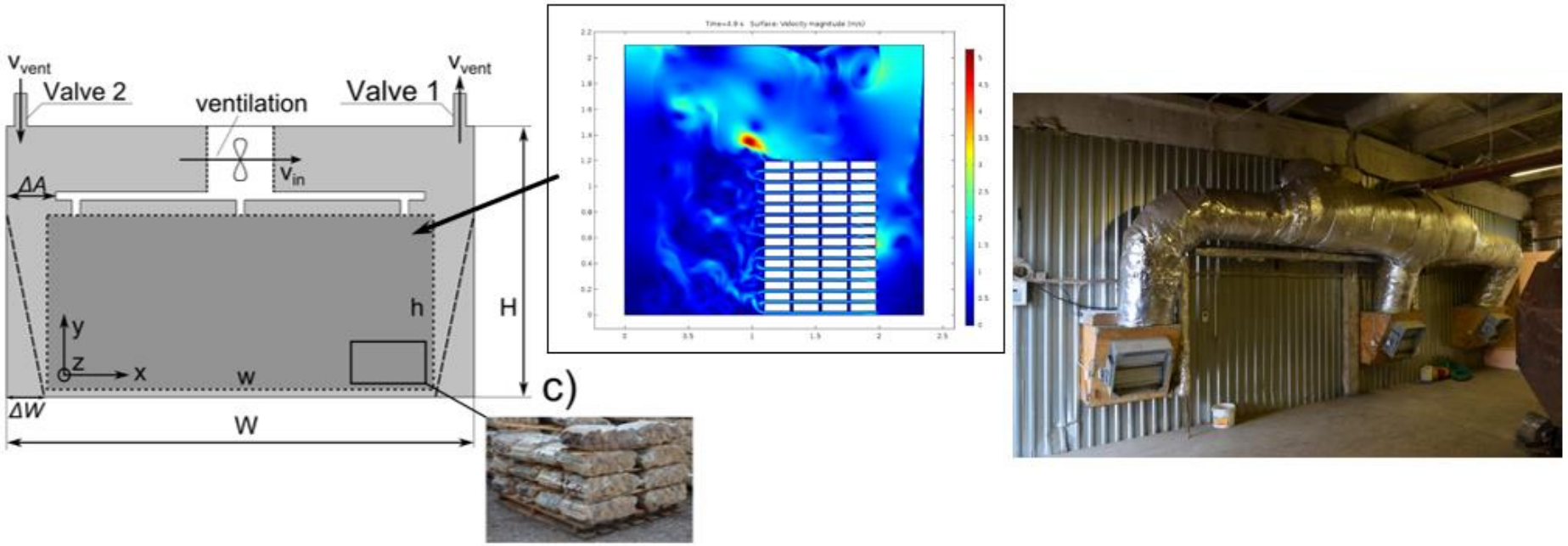
Current density in a micro battery



- High current is achieved only in case of correct electrode geometry!
- Suboptimal geometry will lead to lower performance than in case of conventional battery

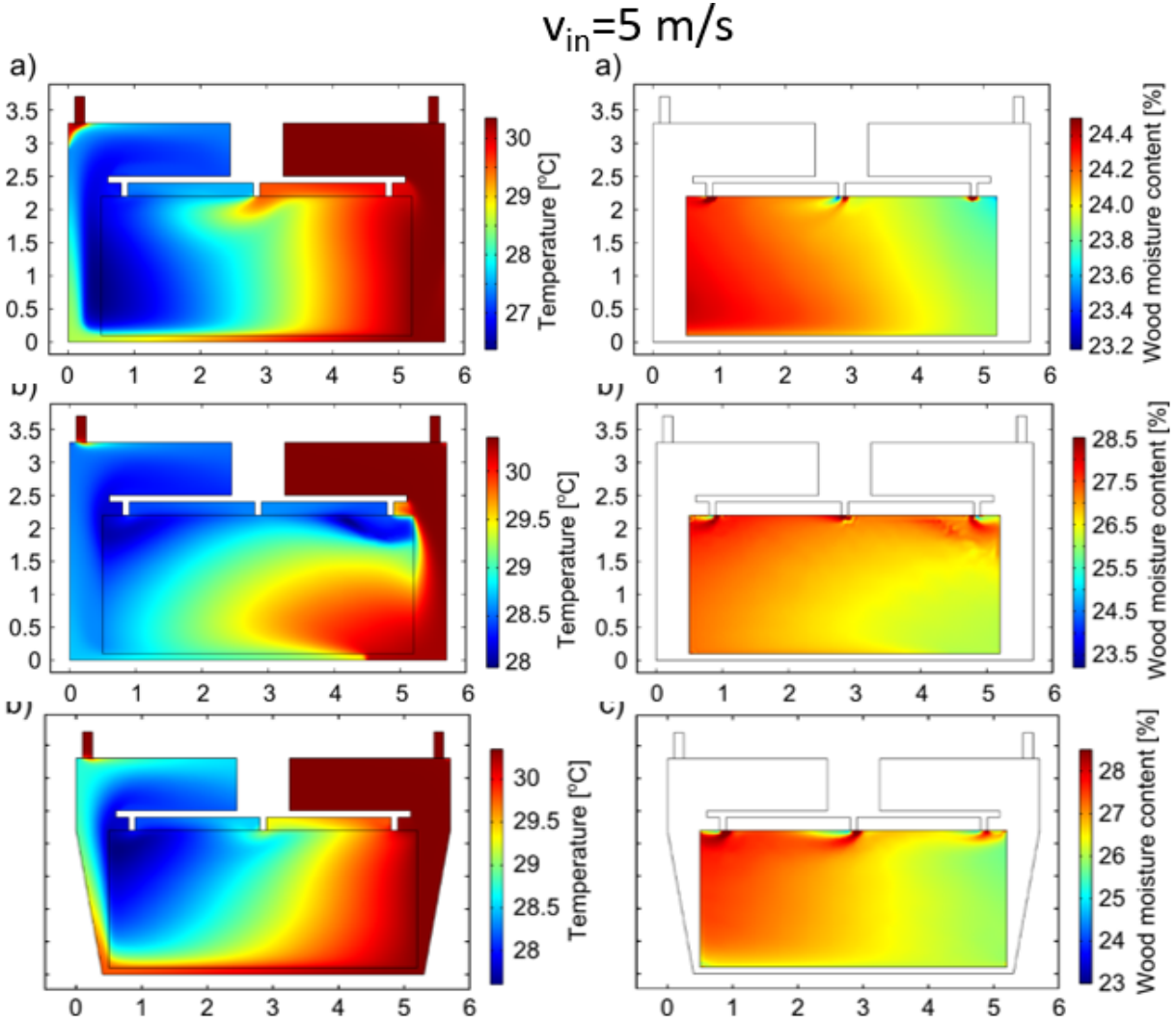


Design optimization of wood drying kilns



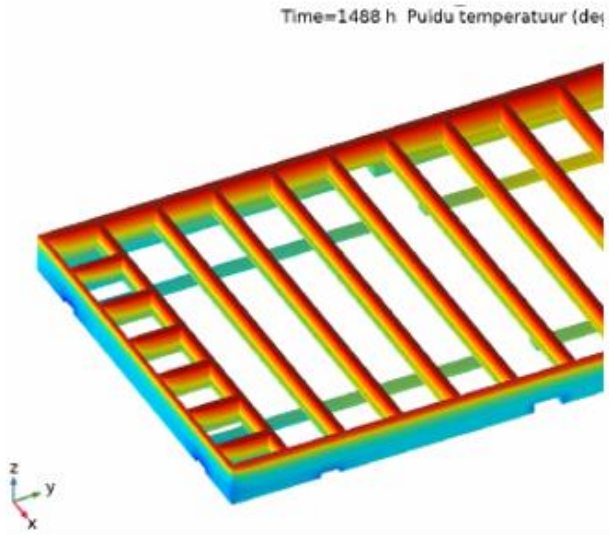
- Firewood drying – cheap, easy to build custom made equipment is needed
- All companies supported by Enterprise Estonia (EAS)

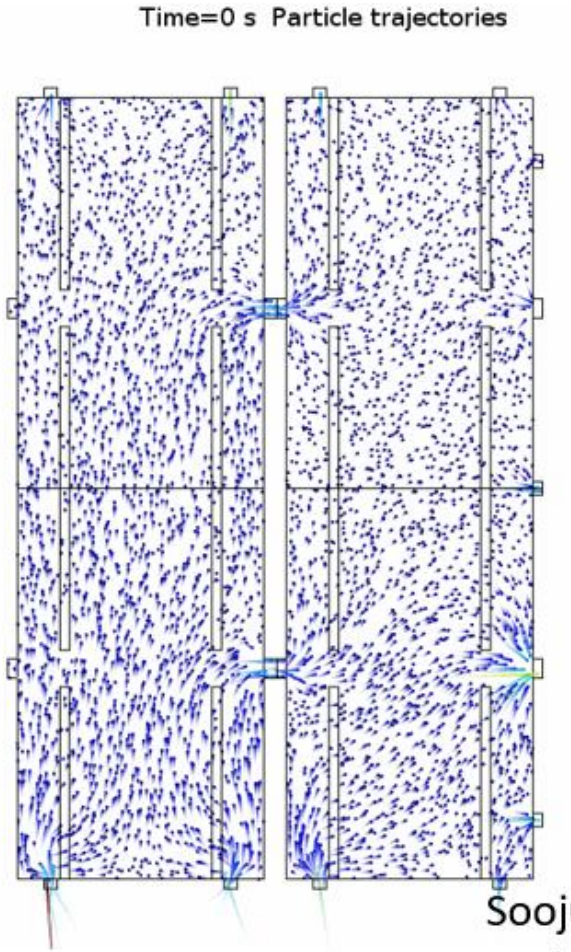
Air flow in the kiln

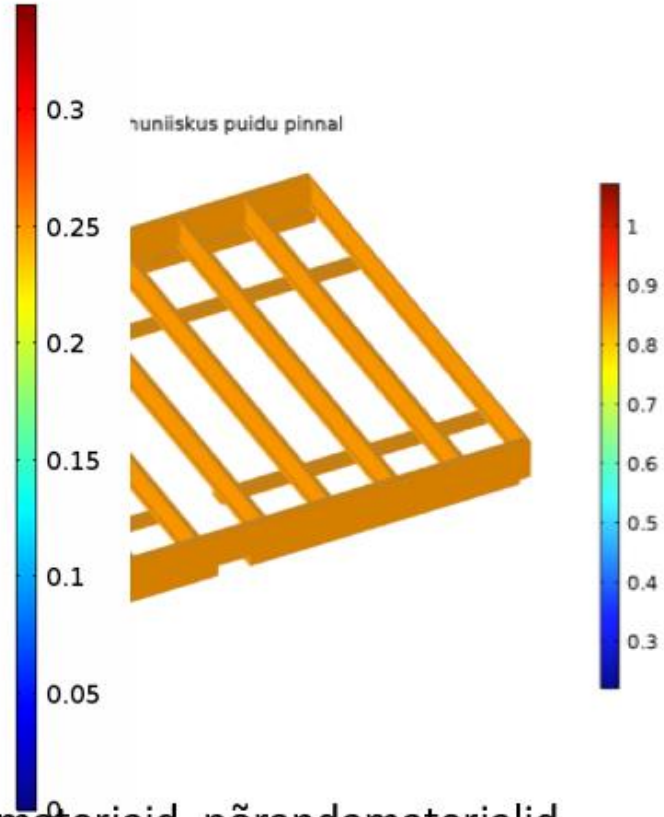


- Uniform flow field leads to uniform drying!
- Flow field is the basis for optimization
- Significant dependence from geometry and the speed of ventilators
- **Geometry optimization helps to achieve uniform flow field at high vent. speeds**

Temperatuur, niiskus, hallitus





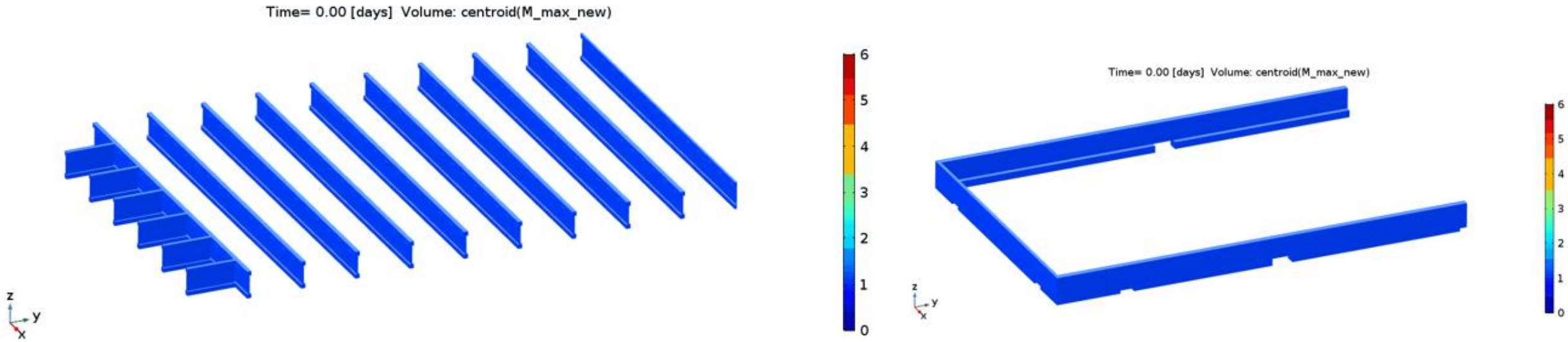


- Simu pikkus ~6 kuud ... 2 aastat
- Välistemperatuur ja õhuniiskus ilmaja
- Ajasamm 30 minutit
- Eeldatud on ajas muutumatut tuulutust (eelnevalt välja arvutatud)

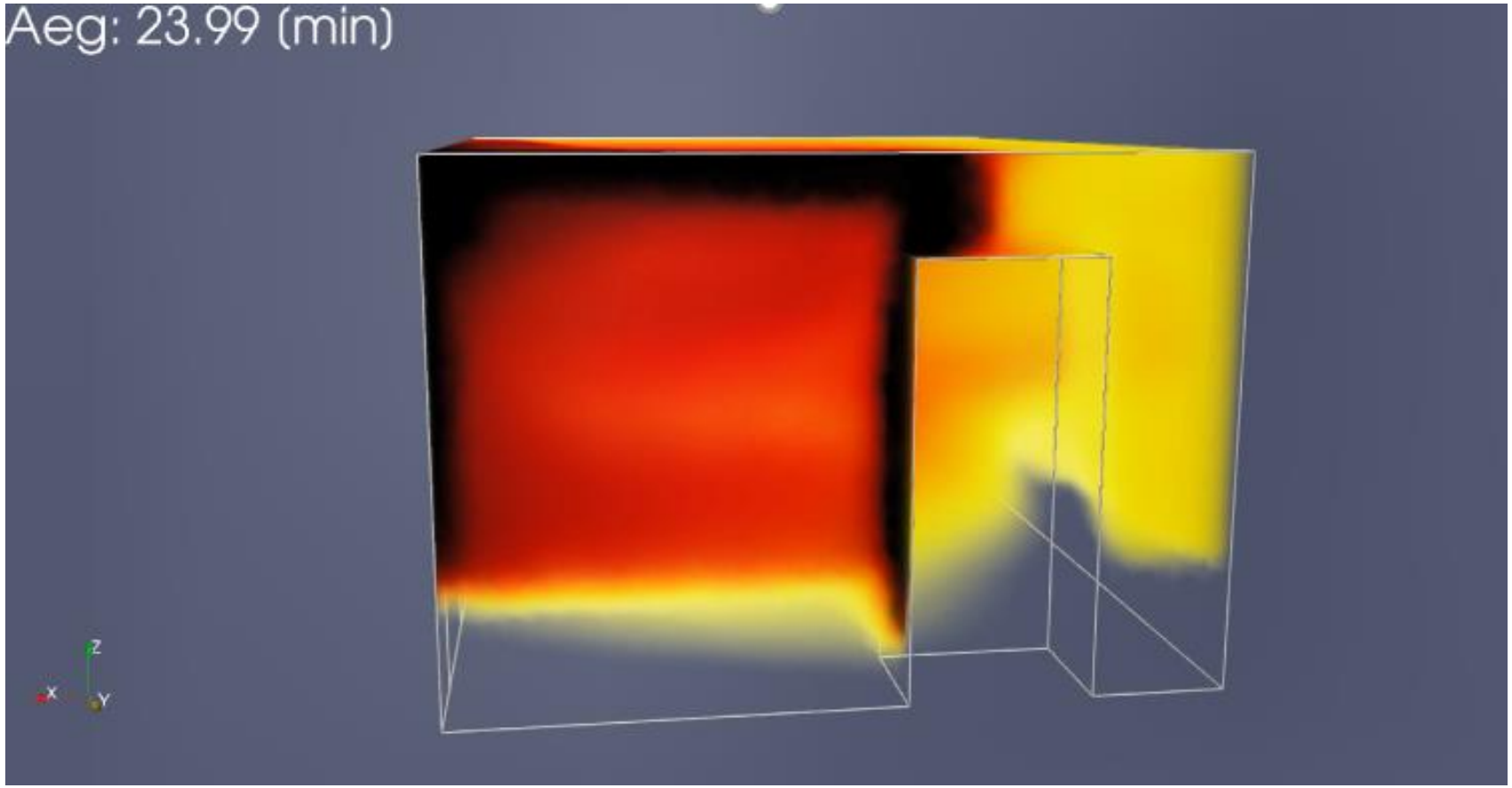
Soojustusmaterjaid, põrandamaterjalid

- Arvutusse kaasaatud
- Välja jäetud visualiseerimisest

Maximum Mould index behaviour in time



Nonisothermal air flow with mass transport



- CO concentration in a living room
- Test case for Nublu CO sensor by G4S
- Presented in ”Ringvaade”, spring 2020

Our interests

- Long term strategic partnership
  - R&D proposals and collaboration at Estonian and EU level
    - Product development with Nutikas
    - Participation in EU calls such as ERA NET etc. (industry partners needed!!!!)
  - Student exchange
    - Industry practice and internship of PhD students (couple of months)
    - Industry PhD – collaborative PhD work with industry with co-supervision for novel R&D in your company
    - Industry inspired and induced MSC theses

Thank You for Your attention!

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ABB, AS Kodumaja, Eesti Merevägi, Eesti Kaitsevägi, Saint-Gobain Glass Estonia SE
Kuma Wood OÜ, Milrem Robotics, Estelaxe, Tark Laut, Venteco Systems OÜ, Koivakonnu OÜ, Robolab OÜ, CERN, Scannersock OÜ, Ars Inc, Aqua Consult Baltic OÜ

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