ForMAX/Treesearch

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Formax

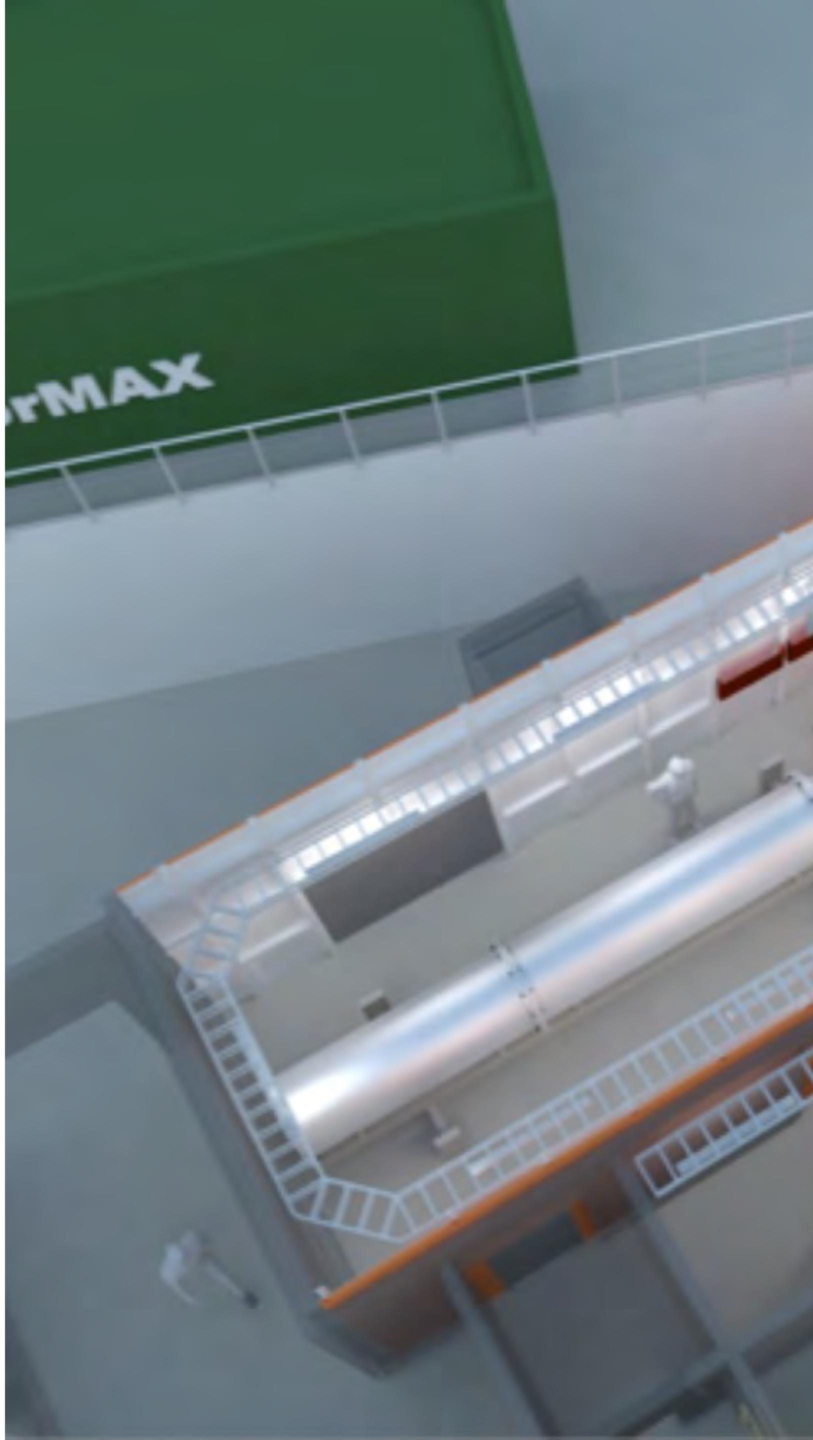
MAX IV – ForMAX

A unique tool to facilitate leading research on new materials from the forest:

- ForMAX is a beamline at MAX IV in Lund, aimed at advanced characterisation. User access starts 2022
- The ForMAX-portal gives prioritised access to Treesearch researchers, including to other beamlines at MAX IV
- Access for academia and industry to world-class research infrastructure
- ForMAX is made possible through a 100 MSEK donation by Knut och Alice Wallenbergs Stiftelse and Treesearch, where Treesearch funds operations until 2031 with in total 80 MSEK

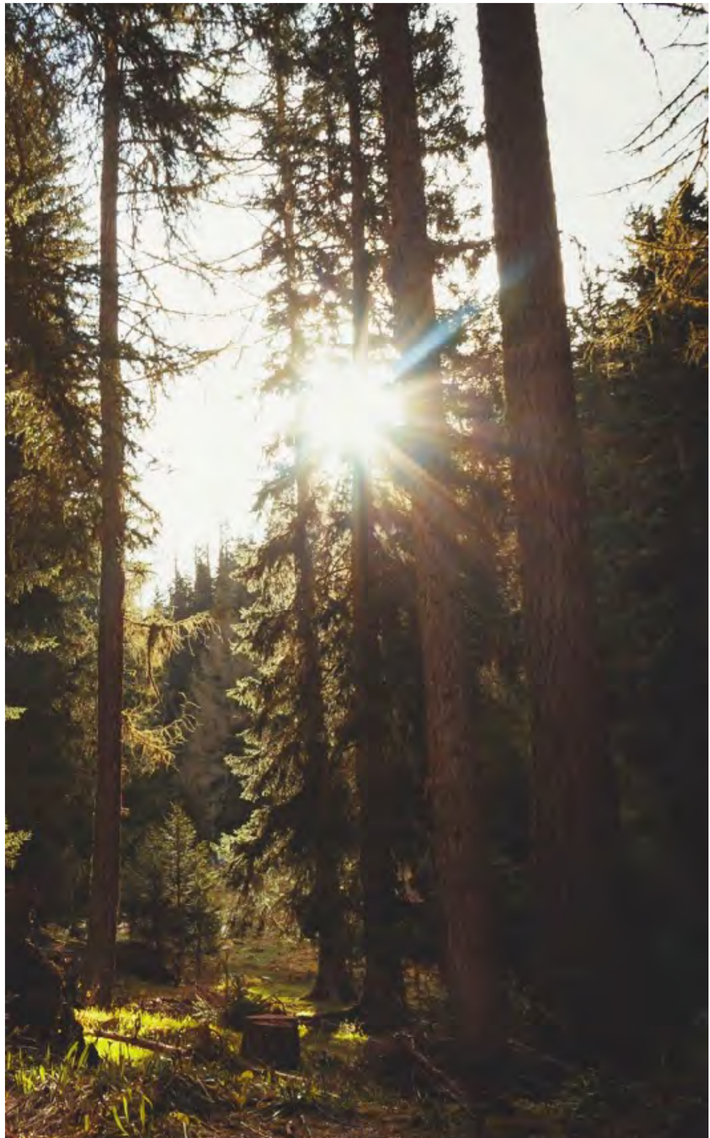
TREESEARCH

Knut och Alice Wallenbergs Stiftelse



Wallenberg Wood Science Centre – the reason

- Multidisciplinary, broad competence platform in biomass materials and processing
- Goal: Leading international position in Wood Science (and Engineering)
- Started in 2009 through an initiative from the Knut & Alice Wallenberg Foundation (KAW)
  - 450 MSEK 2009 – 2018
- Continues 2019-2028
  - 800 MSEK by KAW, industry and universities



WWSC
WALLENBERG WOOD
SCIENCE CENTER

2014.12.08

High-level seminar på KTH:

ForMAX started with an additional workshop in 2015 and ended with a decision 2018

- A Knut and Alice Wallenberg Initiative
  - including a 100 mkr funding commitment
- Charged industry to join!

TREESEARCH

Collaboration for new materials from the forest

Links to the films

- https://youtu.be/MMhmHyZ0NDg?si=GF351EWAihhyIrLI
- https://youtu.be/OyMf5ayqtbI?si=IFEuxbm-7TSDjQsw
- https://www.youtube.com/@treesearch

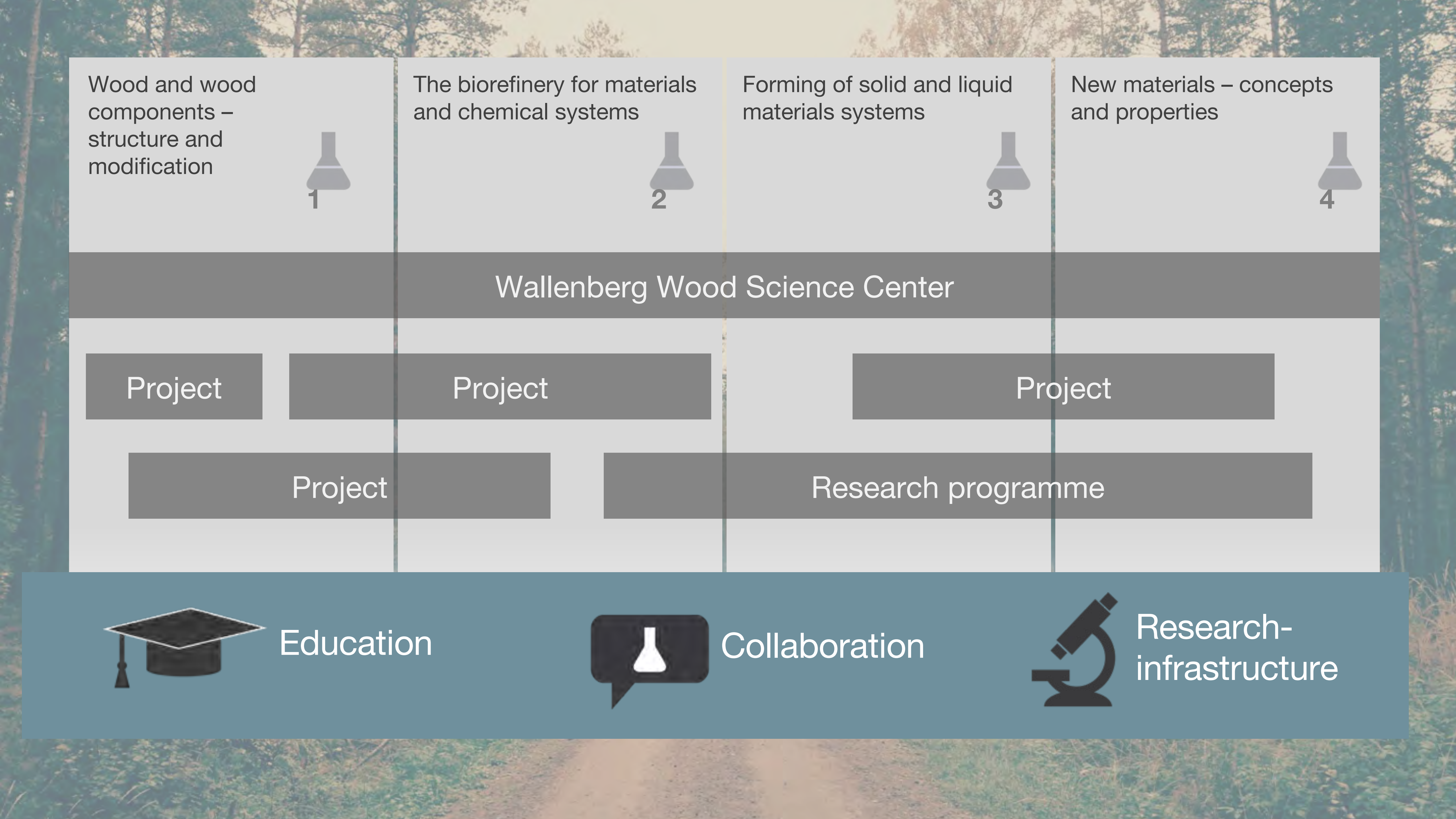
WWSC
WALLENBERG WOOD SCIENCE CENTER

Treesearch – a national effort

Today 18 organisations and >400 associated researchers

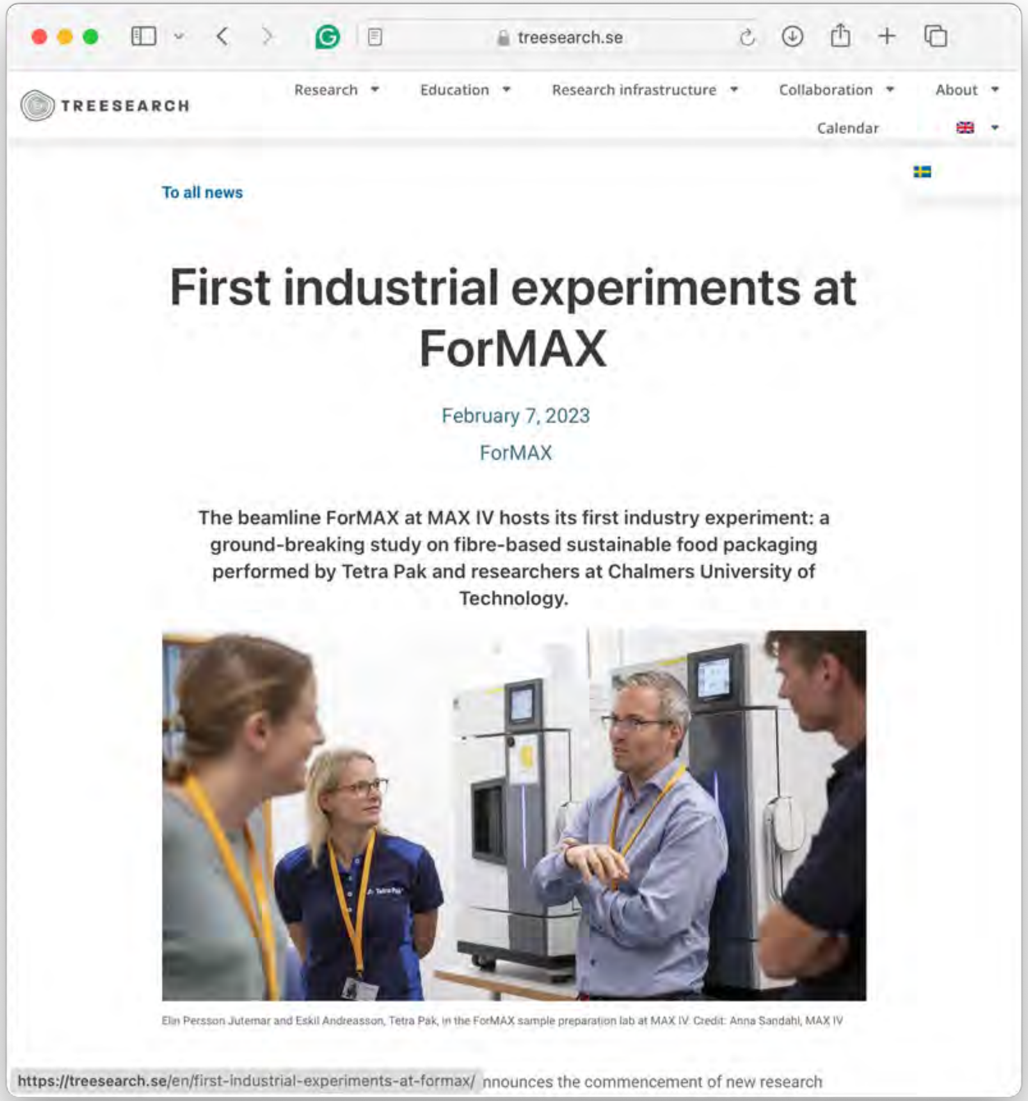
> *The number of partner organisations in Treesearch has doubled since 2017. Research and education activities from Lund in the south, to Luleå in the north can be reached within Treesearch.*

TREESEARCH


Wood and wood components – structure and modification
1
The biorefinery for materials and chemical systems
2
Forming of solid and liquid materials systems
3
New materials – concepts and properties
4
Wallenberg Wood Science Center
Project
Project
Project
Project
Research programme
Education
Collaboration
Research-infrastructure

The set-up of ForMAX

- All contracts signed: October 2018
- Commissioning: October 2021
- First friendly users: December 2021
- First normal users: March 2022
- Under budget and on time!



We made a long list of examples where ForMAX could make a difference (with the detailed arguments if challenged!)

- Wood raw material
  - Characterisation
  - Surface treatments*
  - Chemical modification

- ”New” materials and processes
  - Nano-paper
  - Nano-filaments
  - Nano-porous materials
  - Nano- and micro-foams
  - Manufacturing of nanocellulose
  - Drying processes

- Pulp manufacturing
  - Pre-treatments (for pulp and nanocellulose manufacturing) *
  - Pulping*
  - Drying*
  - Chemical modifications*

- Paper and paperboard manufacturing
  - Process development*
  - Dimensional stability*
  - Surface functionalization and treatment*

*= research where results can be directly applied in industry, e.g. development

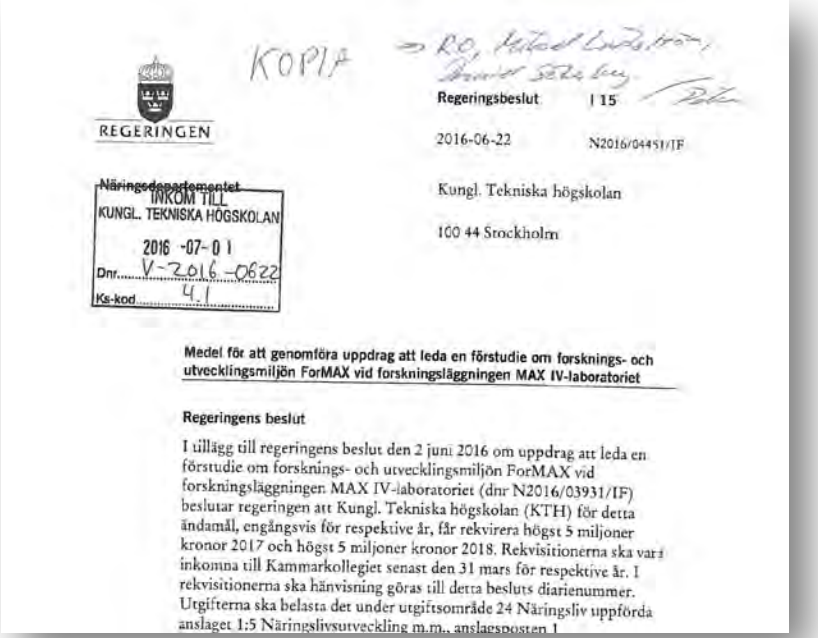
Why industrial direct involvement?

- Development of own competence and abilities
- Attractiveness for engineering students and PhD-students
- From a technical perspective:
  - Processes – time-resolved and atomic selectivity
  - Penetration depth
  - "Beam damage" – biology and soft materials
  - Engineering science (e.g. availability)

What I believe are success factors…

- Open up the bubble!
  - Involvement of researchers in the whole of Sweden
    - A focus on Lund is, unfortunately an efficient turn-off for other universities and researchers
    - A focus on the (relatively few) users today by the argument that they have publications using e.g. neutrons, does not promote wider involvement
  - More involved researchers within engineering disciplines give a stronger interface to the industry

- Someone needs to fund based on strategic considerations not open calls (peer review)
  - Instrument building, as well as research!



REGERINGEN

KOPIA

Regeringsbeslut I 15

2016-06-22 N2016/04451/IF

Näringsdepartementet

INKOM TILL KUNGL. TEKNISKA HÖGSKOLAN 2016 -07- 01 Dnr V-2016-0622 Ks-kod 4.1

Kungl. Tekniska högskolan

100 44 Stockholm

Medel för att genomföra uppdrag att leda en förstudie om forsknings- och utvecklingsmiljön ForMAX vid forskningsläggningen MAX IV-laboratoriet

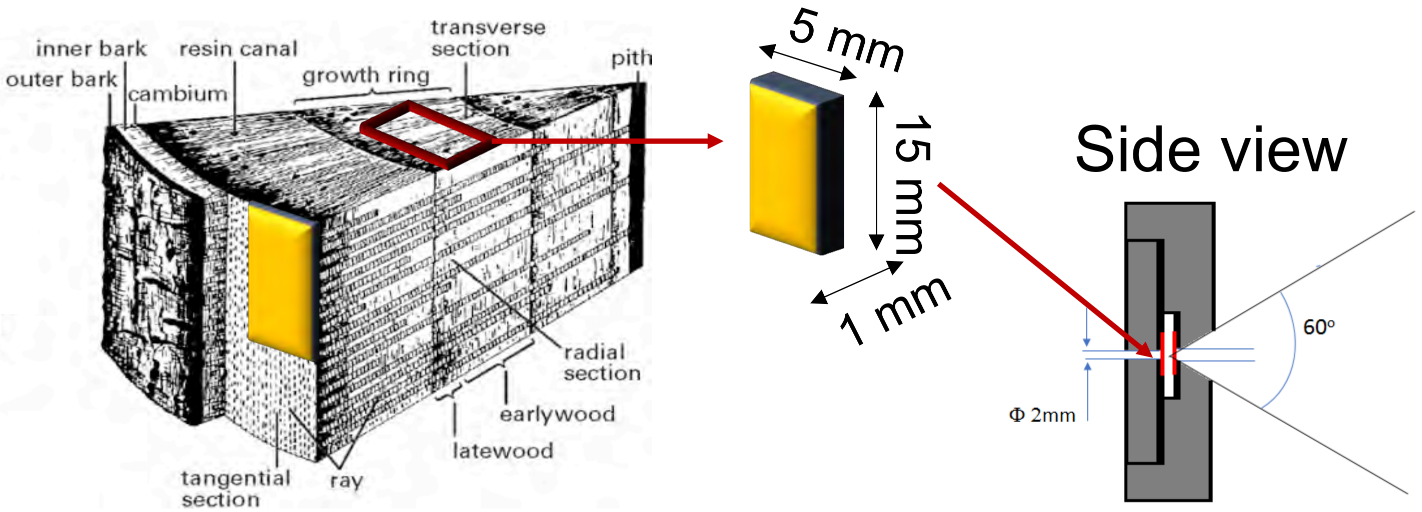
Regeringens beslut

I tillägg till regeringens beslut den 2 juni 2016 om uppdrag att leda en förstudie om forsknings- och utvecklingsmiljön ForMAX vid forskningsläggningen MAX IV-laboratoriet (dnr N2016/03931/IF) beslutar regeringen att Kungl. Tekniska högskolan (KTH) för detta ändamål, engångsvis för respektive år, får rekvirera högst 5 miljoner kronor 2017 och högst 5 miljoner kronor 2018. Rekvisitionerna ska vara inkomna till Kammarkollegiet senast den 31 mars för respektive år. I rekvisitionerna ska hänvisning göras till detta besluts diarienummer. Utgifterna ska belasta det under utgiftsområde 24 Näringsliv uppförda anslaget 1:5 Näringslivsutveckling m.m., anslagsposten 1

Direct funding (20 mSEK) for collaborative pre-study that involved industry

Structural changes during industrial pulping

DESY, P03



Reactor

Collaboration

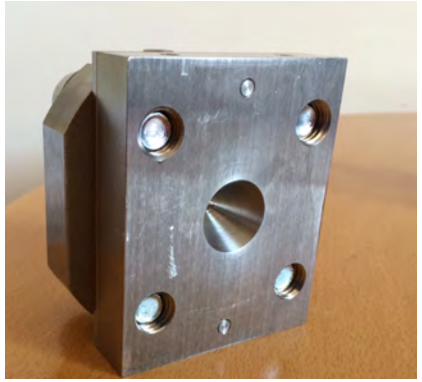
- Theliander (Chalmers)
- Salmén
- Brelid (Södra)

Temperature and pressure control

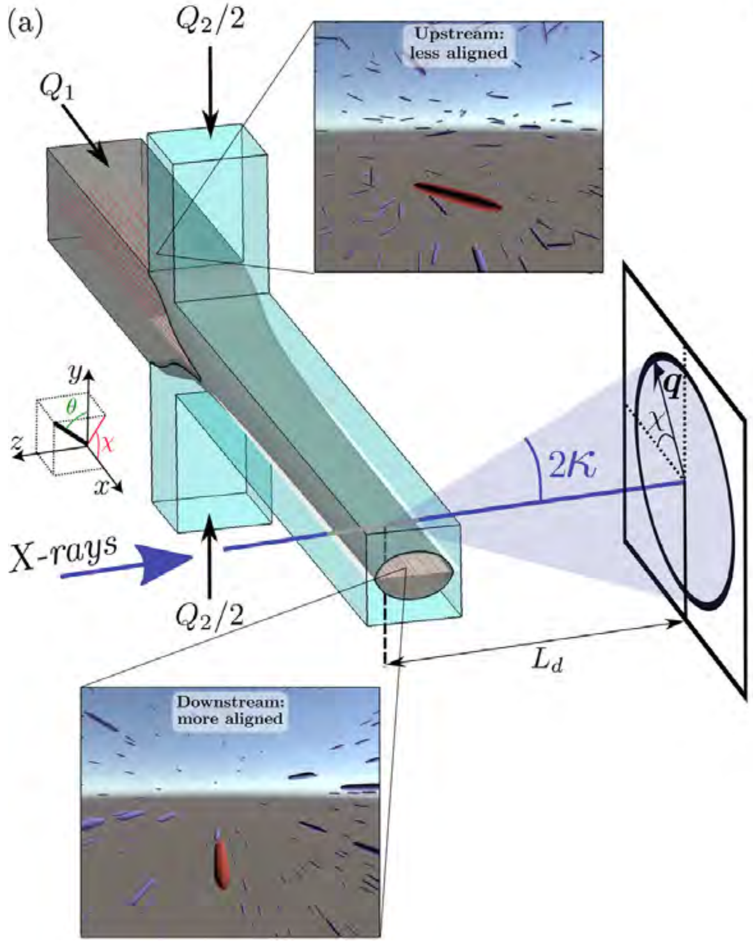
- Up to 220°C
- 15 bar
- Most liquids

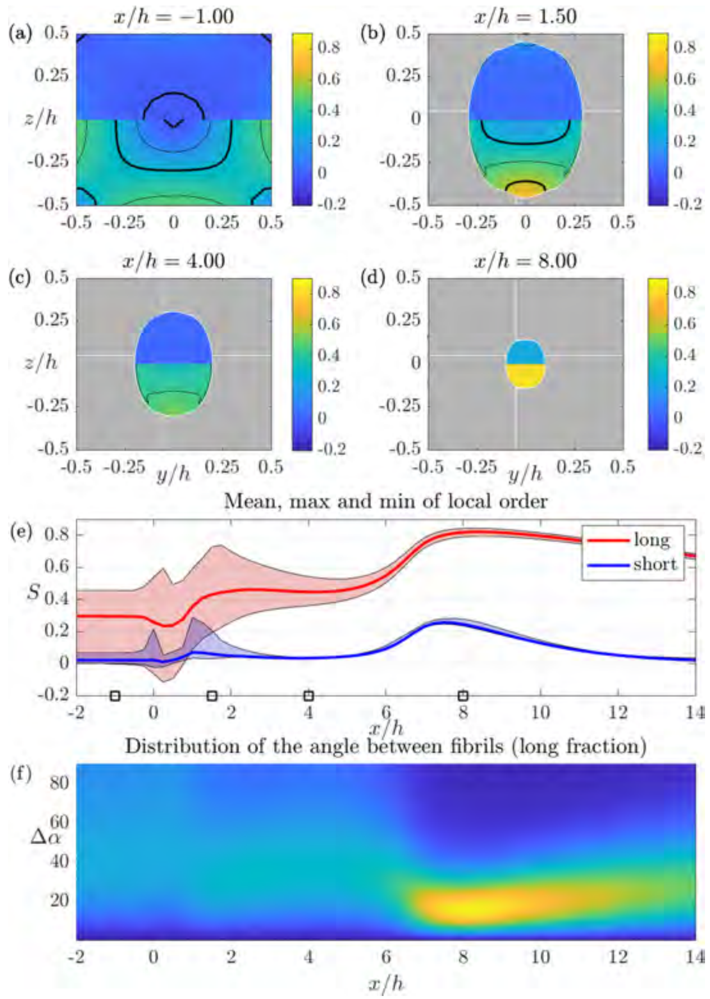
Front view

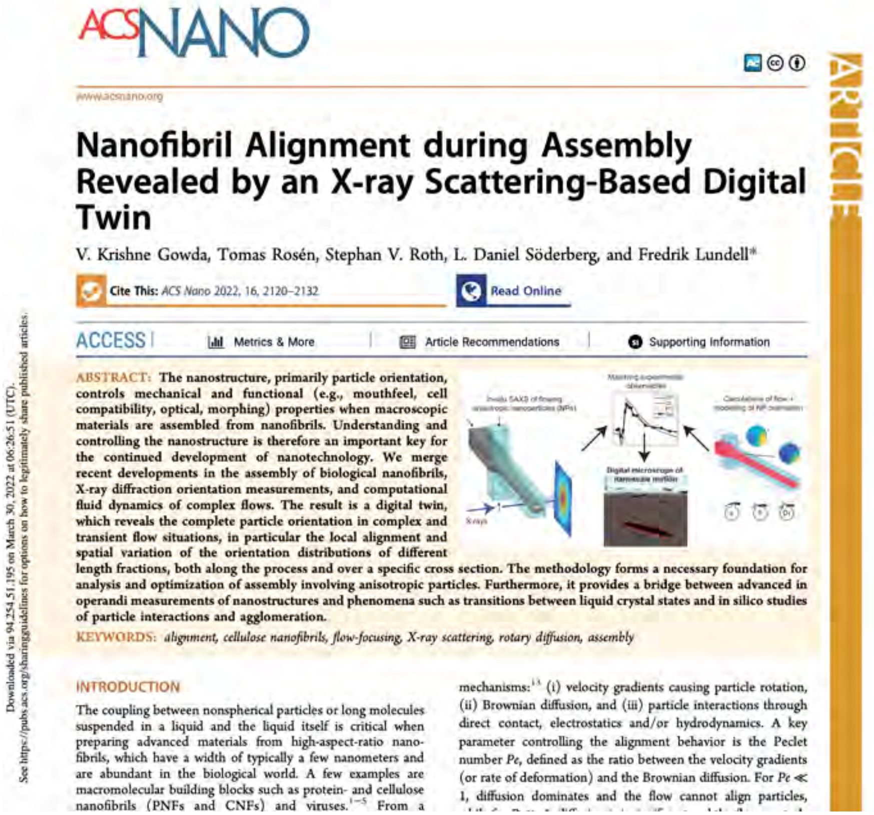
Back view



Digital Twin for (nano) process control







ACSNANO
www.acsnano.org

Nanofibril Alignment during Assembly Revealed by an X-ray Scattering-Based Digital Twin

V. Krishne Gowda, Tomas Rosén, Stephan V. Roth, L. Daniel Söderberg, and Fredrik Lundell*

Cite This: ACS Nano 2022, 16, 2120–2132
Read Online

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ABSTRACT: The nanostructure, primarily particle orientation, controls mechanical and functional (e.g., mouthfeel, cell compatibility, optical, morphing) properties when macroscopic materials are assembled from nanofibrils. Understanding and controlling the nanostructure is therefore an important key for the continued development of nanotechnology. We merge recent developments in the assembly of biological nanofibrils, X-ray diffraction orientation measurements, and computational fluid dynamics of complex flows. The result is a digital twin, which reveals the complete particle orientation in complex and transient flow situations, in particular the local alignment and spatial variation of the orientation distributions of different length fractions, both along the process and over a specific cross section. The methodology forms a necessary foundation for analysis and optimization of assembly involving anisotropic particles. Furthermore, it provides a bridge between advanced in operandi measurements of nanostructures and phenomena such as transitions between liquid crystal states and in silico studies of particle interactions and agglomeration.

KEYWORDS: alignment, cellulose nanofibrils, flow-focusing, X-ray scattering, rotary diffusion, assembly

INTRODUCTION

The coupling between nonspherical particles or long molecules suspended in a liquid and the liquid itself is critical when preparing advanced materials from high-aspect-ratio nanofibrils, which have a width of typically a few nanometers and are abundant in the biological world. A few examples are macromolecular building blocks such as protein- and cellulose nanofibrils (PNFs and CNFs) and viruses.[1−5] From a

mechanisms:[13] (i) velocity gradients causing particle rotation, (ii) Brownian diffusion, and (iii) particle interactions through direct contact, electrostatics and/or hydrodynamics. A key parameter controlling the alignment behavior is the Peclet number Pe, defined as the ratio between the velocity gradients (or rate of deformation) and the Brownian diffusion. For $Pe \ll 1$, diffusion dominates and the flow cannot align particles,

Neutrons as a tool for improving process efficiency during the production of cellulose-based materials for electricity transformers

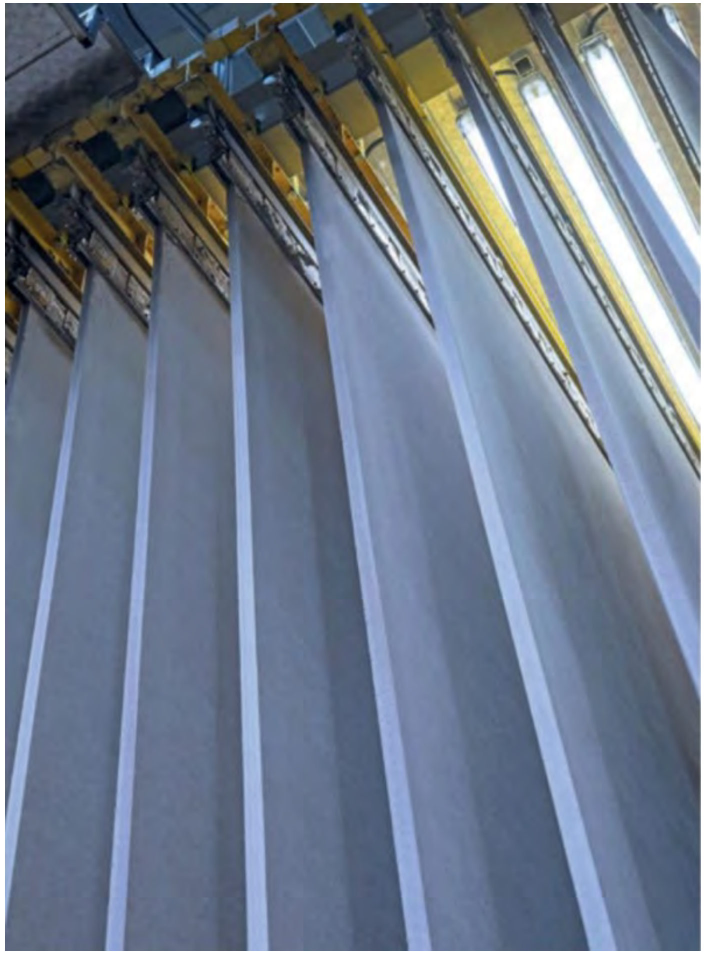
D. Söderberg[1,2], H. Holzinger[1], A. Riazanova[1,2], U. Sand[3], R. Bel Fdhila[3], L.-E. Schmidt[4]

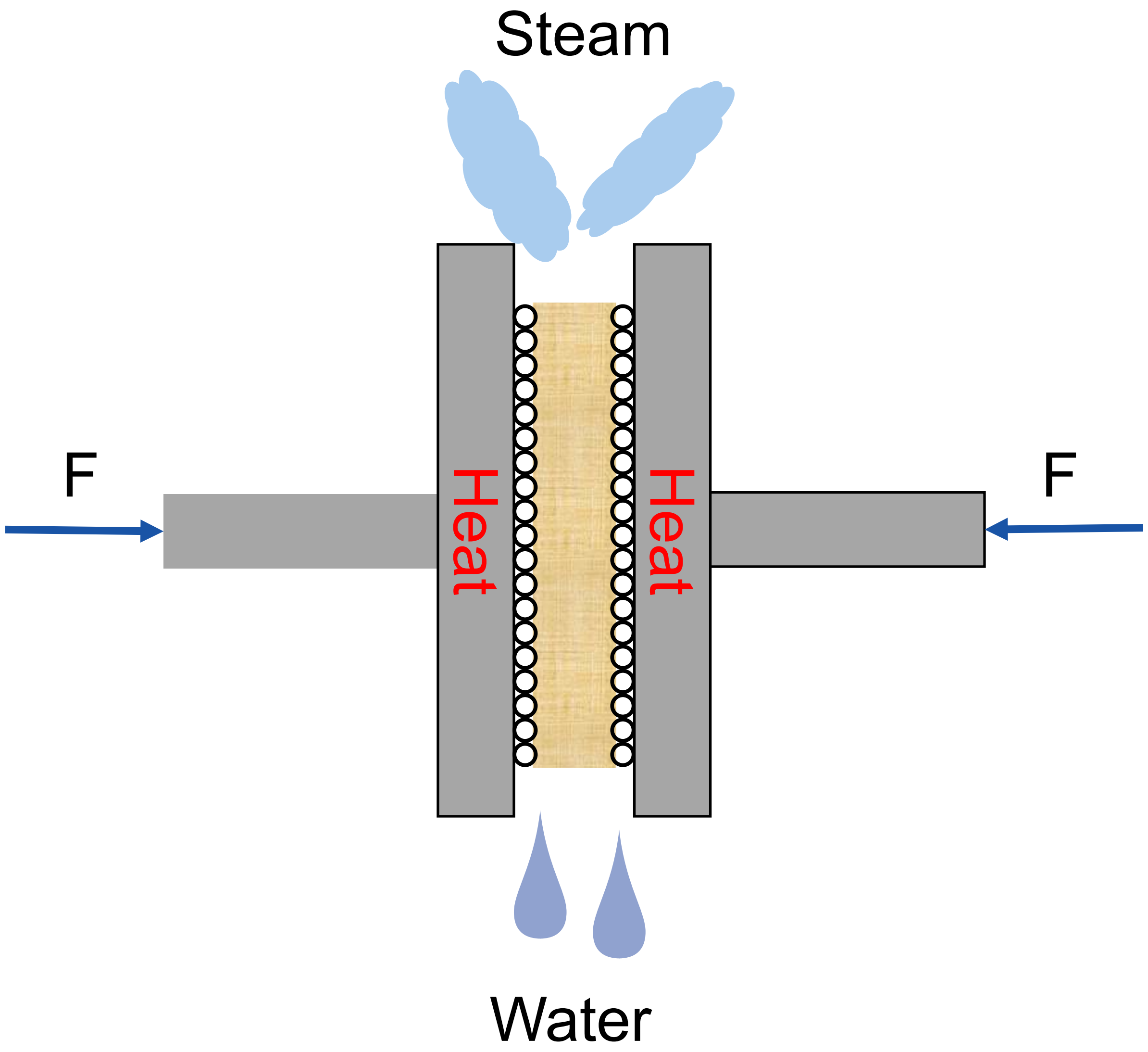
1. KTH Fibre and Polymer Technology, 2. Wallenberg Wood Science Center, 3. Hitachi Energy Research,
4. Hitachi Energy – PGTR Insulation

What does cellulose have to do with transformers?

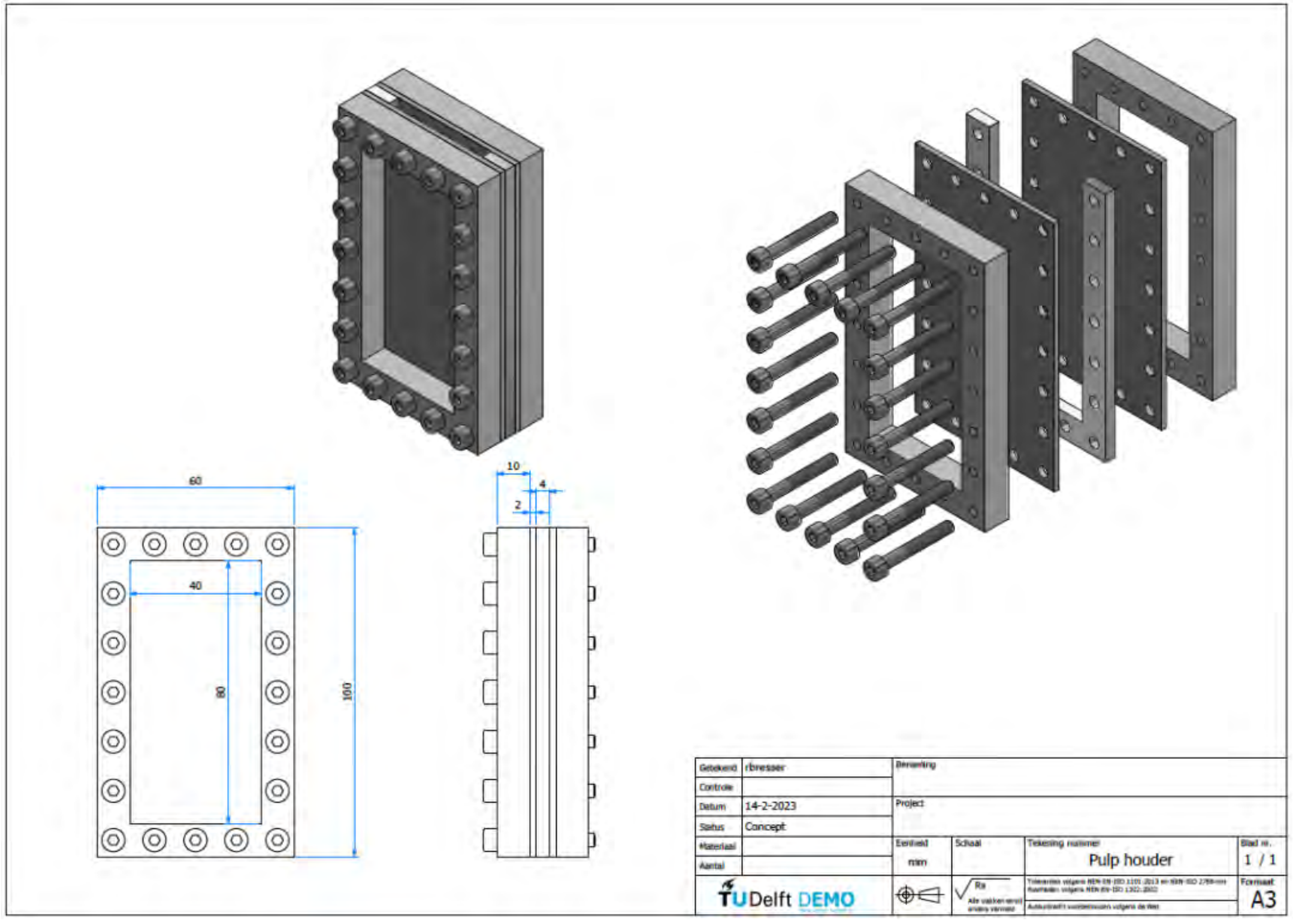
Pressboard

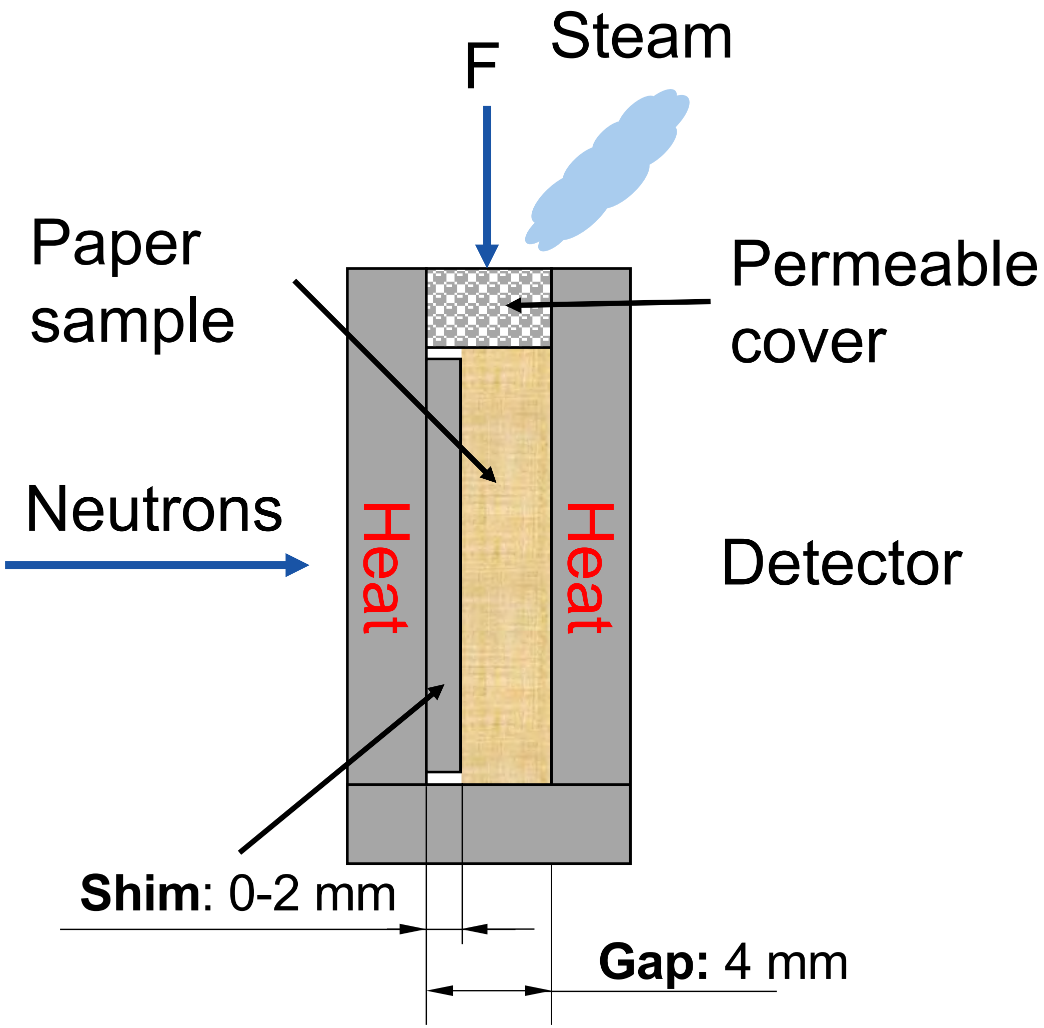
Pressboard is formed by hot pressing thick cellulose sheets (paper)

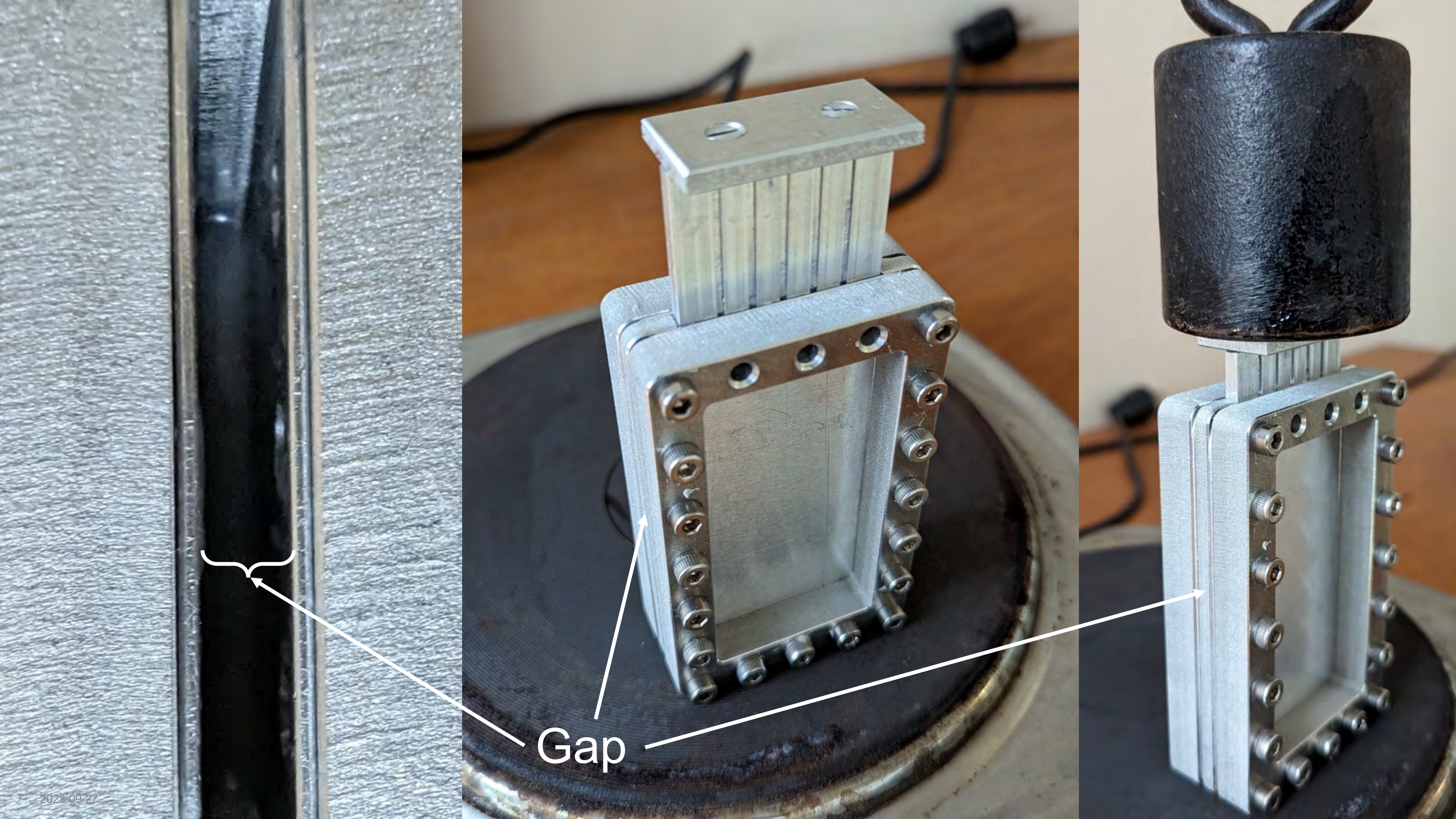


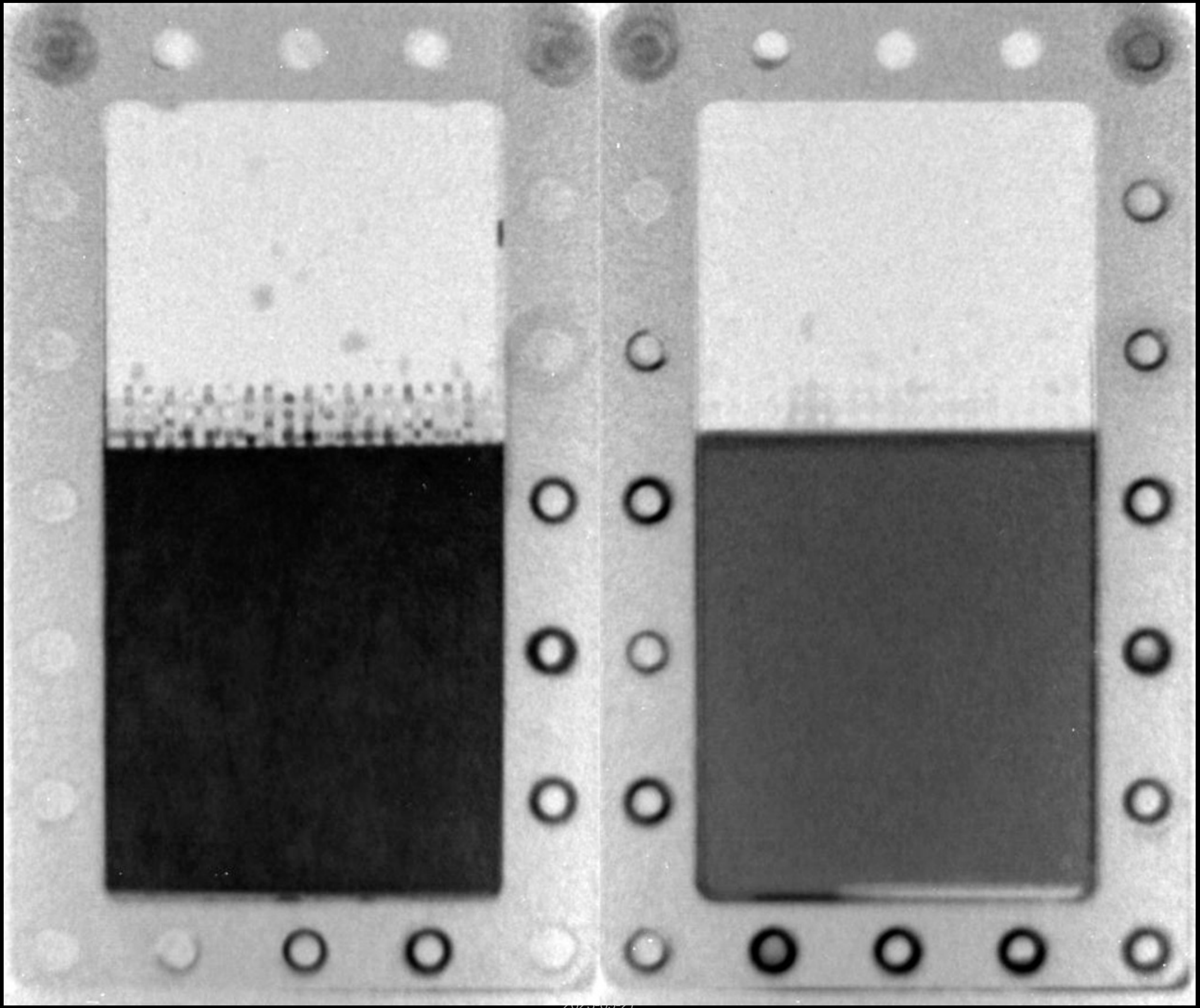


The set-up used






Gap
2023-09-27



Boiling in a static porous media (known!)

Relative permeability$_{\text{Phase}}$

Pressure$_{\text{Phase}}$

Porosity

Liquid saturation

$$\frac{\partial}{\partial t}\left(\phi\, S\, \rho_l + \phi\,(1-S)\,\rho_v\right) + \nabla\cdot\left[\begin{array}{l}\rho_l \frac{k_{rl}K}{\mu_l}\left(-\nabla P_l + \rho_l \mathbf{g}\right)\\ +\rho_v \frac{k_{rv}K}{\mu_v}\left(-\nabla P_v + \rho_v \mathbf{g}\right)\end{array}\right] = 0$$

Density$_{\text{Phase}}$

Viscosity$_{\text{Phase}}$

Entropy$_{\text{Phase}}$

Enthalpy$_{\text{Phase}}$

Absolute permeability

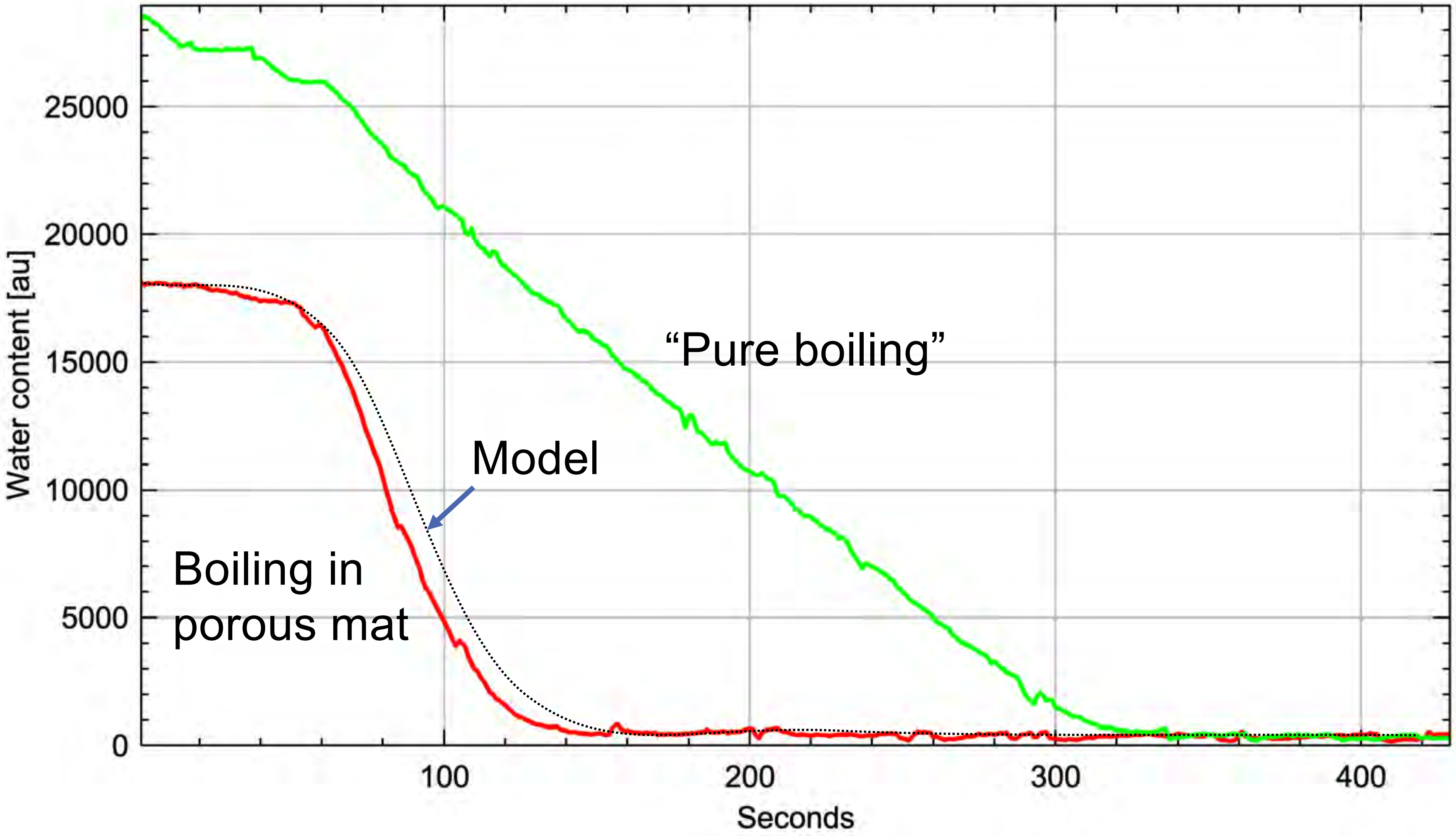
$$\left[\begin{array}{l}T\frac{\partial}{\partial t}\left(\phi\, S\, \rho_l\, \eta_l + \phi\,(1-S)\,\rho_v\, \eta_v\right)\\ +T\frac{\partial}{\partial t}\left((1-\phi)\,\rho_s\,\eta_s\right)+\\ g_l\frac{\partial}{\partial t}\left(\phi\, S\, \rho_l\right) + g_v\frac{\partial}{\partial t}\left(\phi\,(1-S)\,\rho_v\right)\end{array}\right] + \nabla\cdot\left[\begin{array}{l}h_l\rho_l \frac{k_{rl}K}{\mu_l}\left(-\nabla P_l + \rho_l \mathbf{g}\right)\\ +h_v\rho_v \frac{k_{rv}K}{\mu_v}\left(-\nabla P_v + \rho_v \mathbf{g}\right)\\ -\left(\lambda_{\text{wet}}\, S + \lambda_{\text{dry}}\,(1-S)\right)\nabla T\end{array}\right] = \bar{Q}$$

Heat source

Gibbs potential$_{\text{Phase}}$

Thermal conductivity

Extraction of data for modelling



Conclusions

- Neutron imaging provides a tool that can be used to study the process *in operando*
- Shrinkage of the paper web can be studied as a function of water content
- The structure of the final material can be characterised