Informal presentation:

Kristofer Gamstedt

Division of Applied Mechanics
Uppsala University
Education, research and industry in Sweden

UPPSALA
UNIVERSITET

CICY Mérida, October 14, 2016

GENERAL INFORMATION
Geography

- Forests (mostly coniferous): 54%
- Mountains: 17%
- Cultivated land: 8%
- Lakes and rivers: 9%
- Highest mountain: Kebnekaise, 2,111 m (6,926 ft)
- Distance north–south: 1,574 km (977 miles)
- Distance east–west: 499 km (310 miles)

GENERAL INFORMATION
Geography

- Average temperature

	IN JANUARY	IN JULY
Malmö	-0.2°C (31.6°F)	+16.8°C (62.2°F)
Stockholm	-2.8°C (30.0°F)	+17.2°C (63.0°F)
Kiruna	-16.0°C (3.2°F)	+12.8°C (55.0°F)

- Daylight (approx. values)

	JANUARY 1	JULY 1
Malmö	7 hours	17 hours
Stockholm	6 hours	18 hours
Kiruna	0 hours	24 hours

Geographic presentation of my humble self

Uppsala University

Founded 1477

Nine faculties

40 000 students

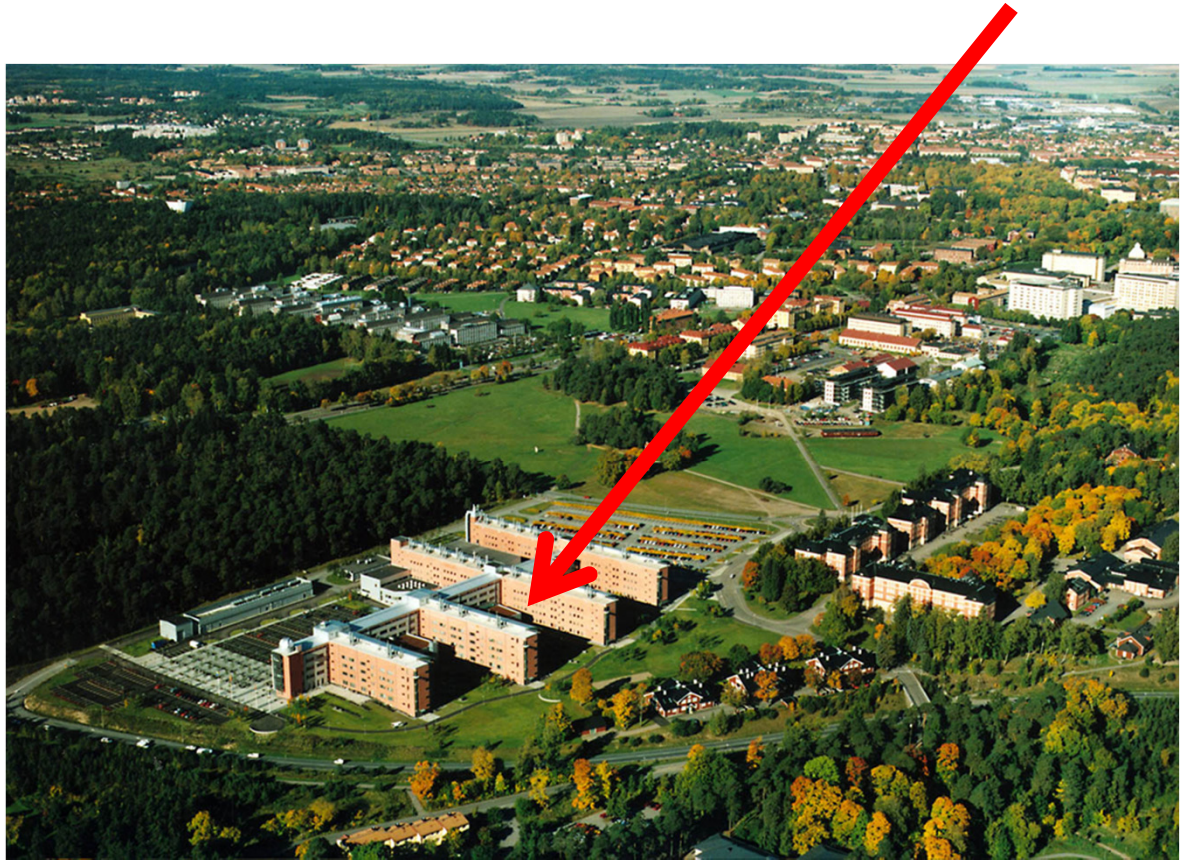
2 000 PhD students

5 600 employees

454 M€ annual revenue

Applied mechanics 5 years

Welcome to the Ångström Laboratory at Uppsala University!



Ångström Laboratory: House 4, floor 2

http://www.teknik.uu.se/applmech

Re-start of Solid Mechanics

- Now: Division of Applied Mechanics
- Applied mechanics = Solid mechanics +
  + Structural and civil eng.
  + Fluid mechanics
- Previously 2 persons: prof.em. Bengt Lundberg & associate professor Urmas Valdek

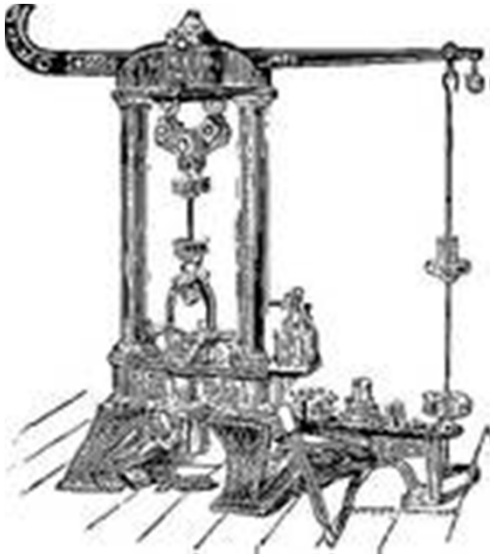
Our best asset: The human resources…

Division of Applied Mechanics, 2013

Division of Applied Mechanics, 2014

Division of Applied Mechanics, 2016

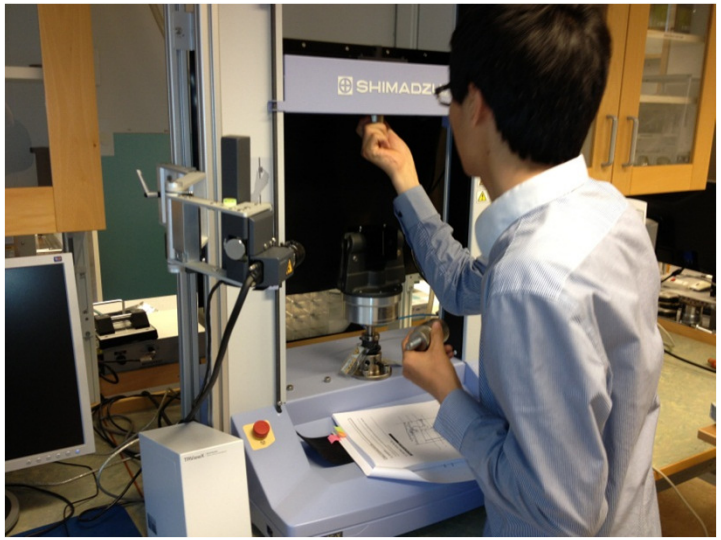
Laboratory

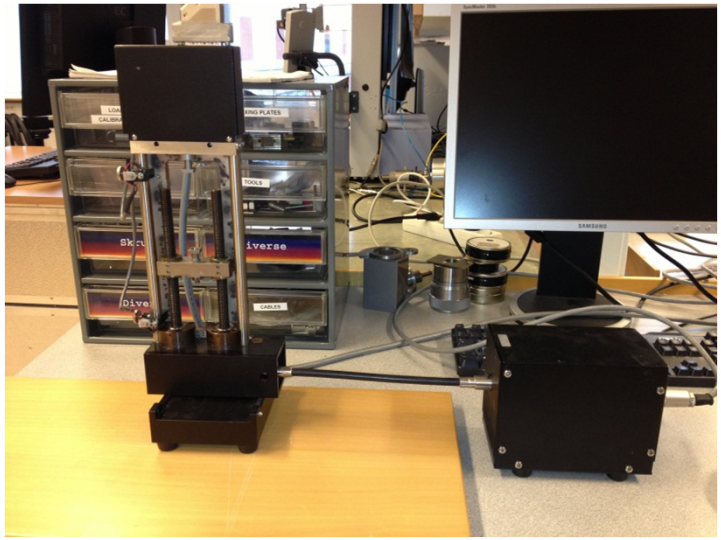


Technician
Peter Bergkvist

Mechanical testing

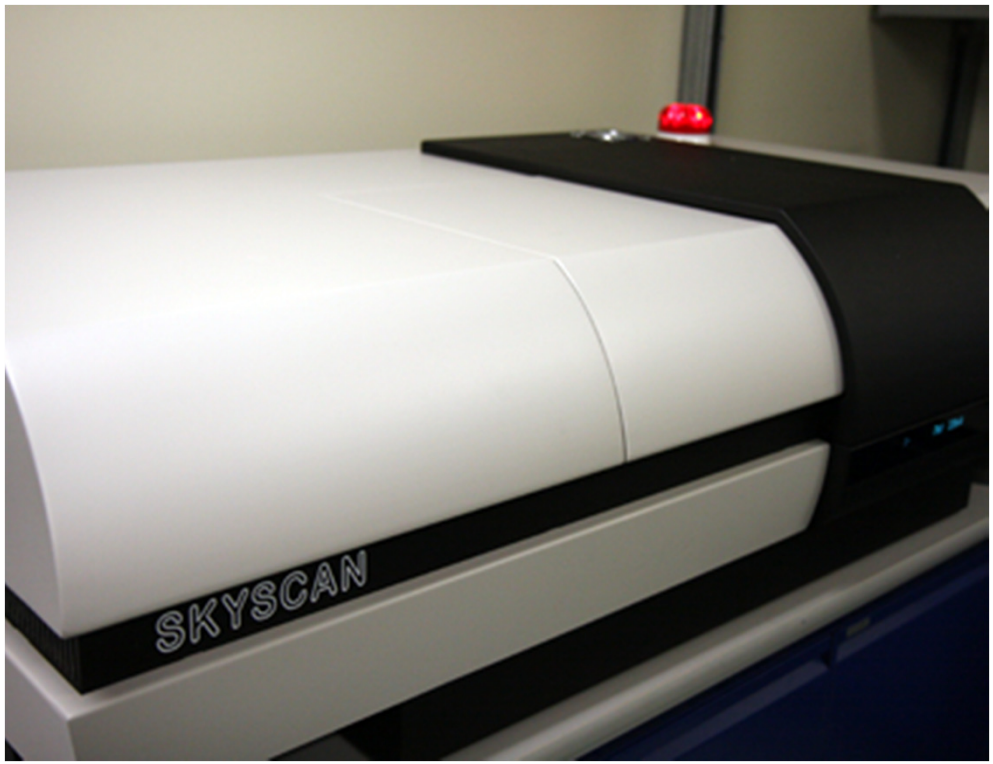
100 kN, 50 kN, 200 N, 50 N, 20 N, 1N load cells, optical extensometry
Instron (servohydraulic), Shimadzu, Scientific Rheometric



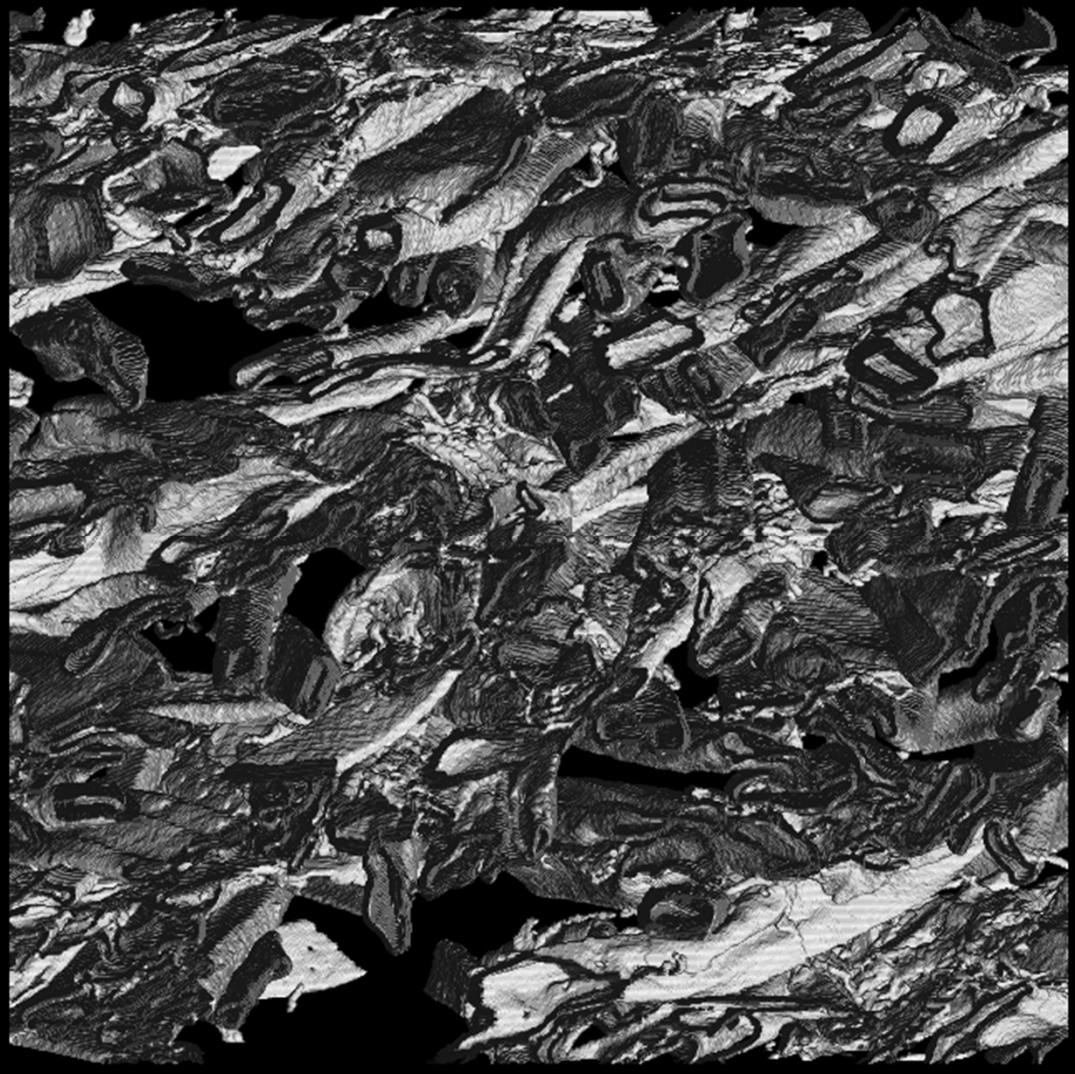


X-ray micro-computed tomography

Skyscan 1172, voxel resolution ≈ 1 μm^2

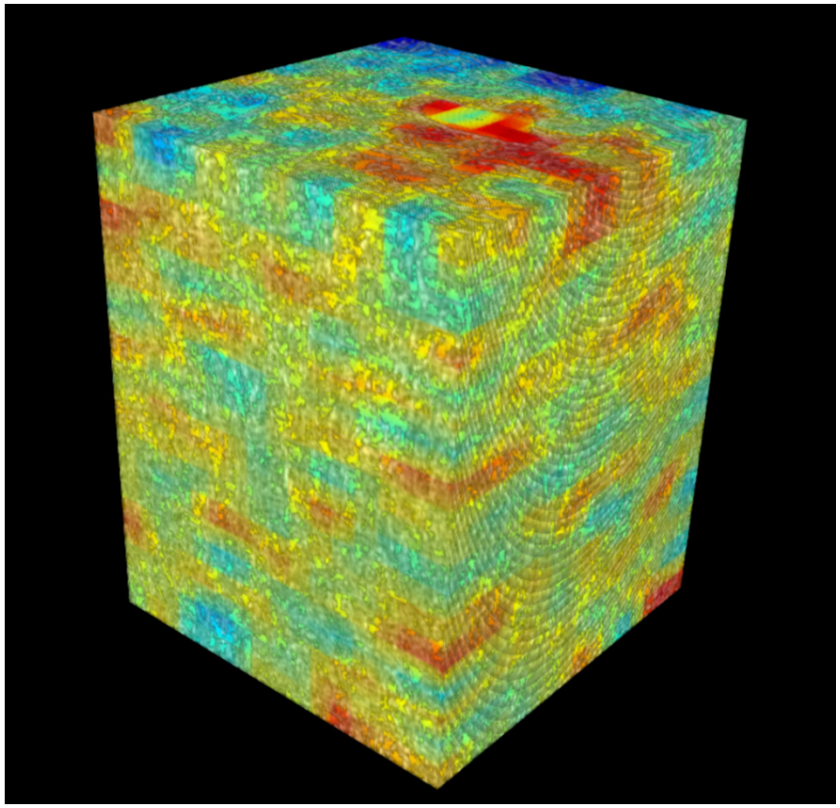


ESRF synchrotron 3D image of wood fibre composite



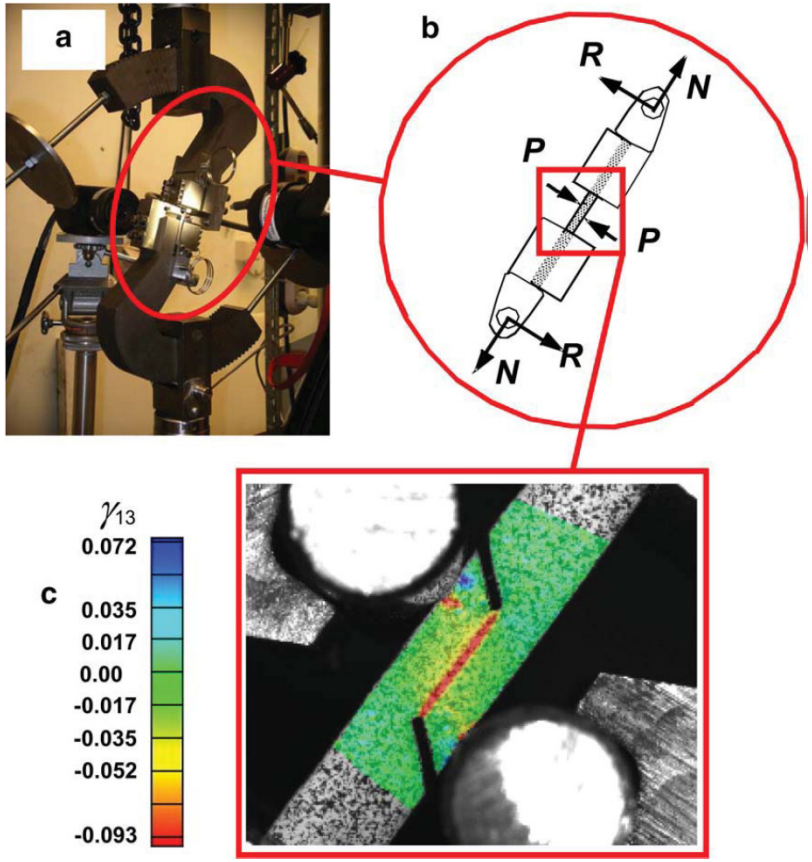
3D strain fields from digital volume correlation

Maximum principal strain in a volume of compressive loaded fibrous material
In collaboration with industry, and Luleå University of Technology



Strain fields from Digital image correlation

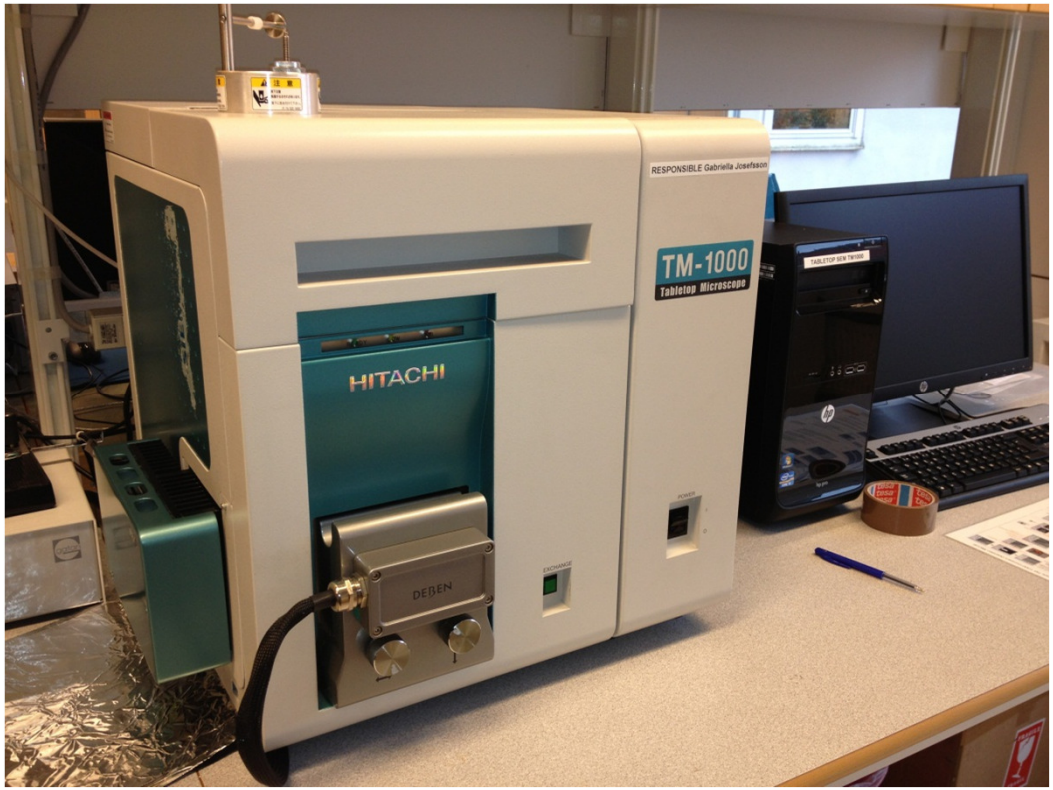
Aramis 3D from GOM



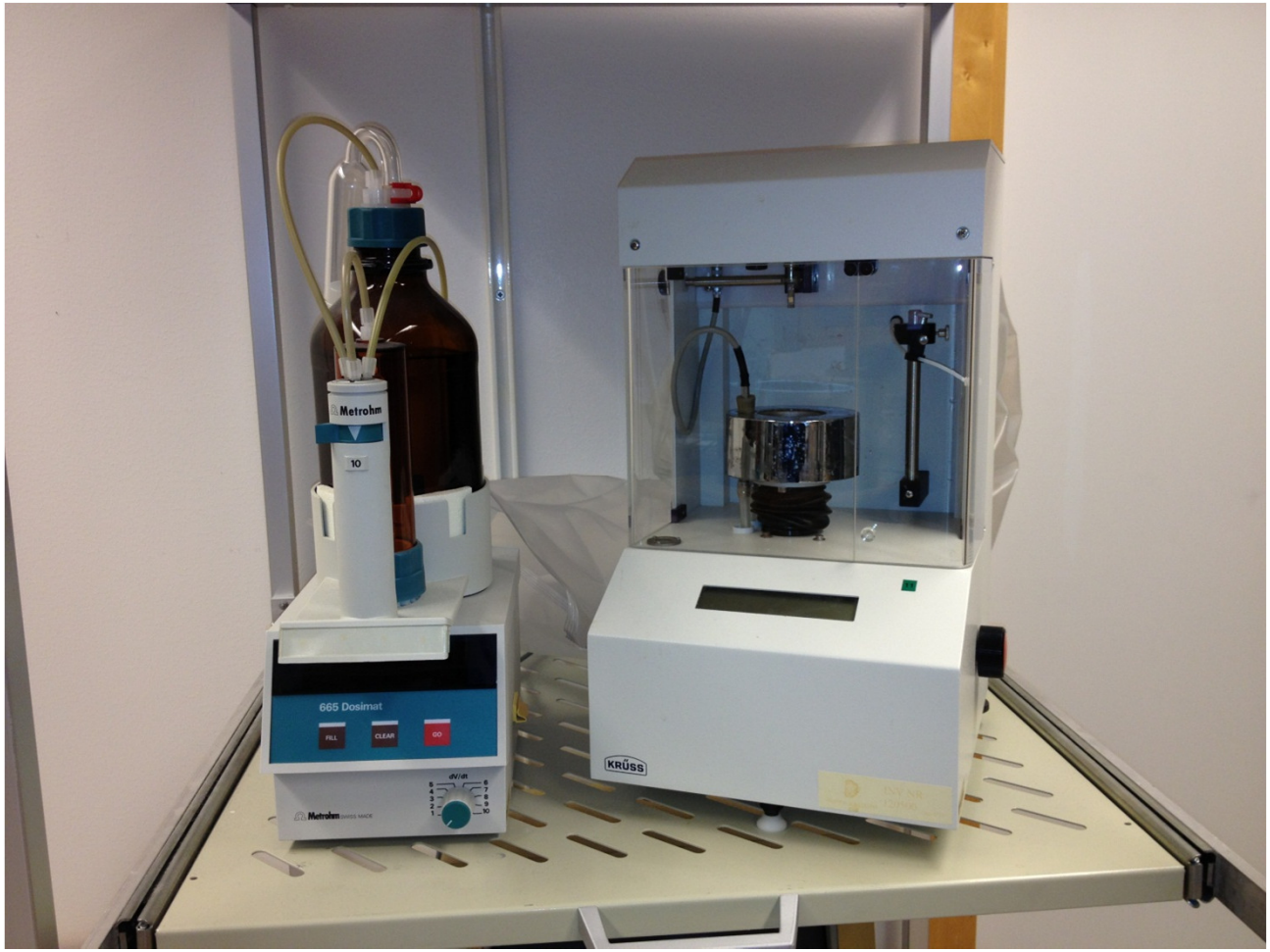
Pettersson, Neumeister, Gamstedt, Öberg
Composite Structures 2006

In-situ mechanical testing in SEM

Hitachi 1000 SEM + ESD + 300 N tensile stage



Contact angle measurements



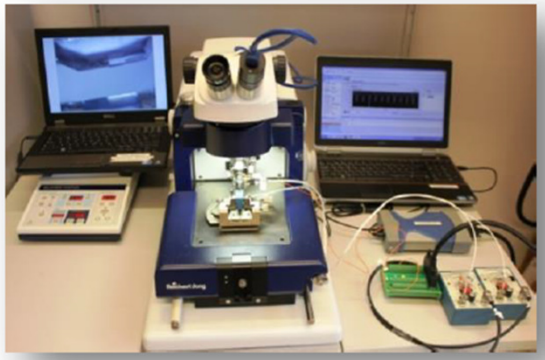
Examples of research projects

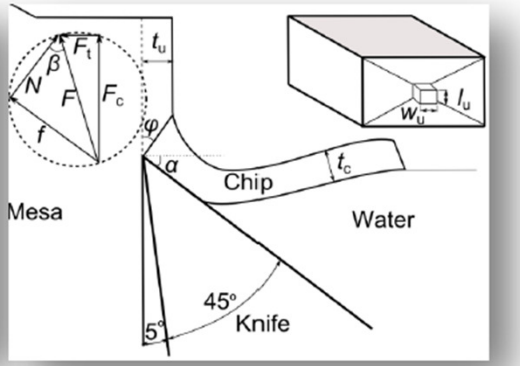
Diamond Sectioning of Polymeric Materials at Nanoscale

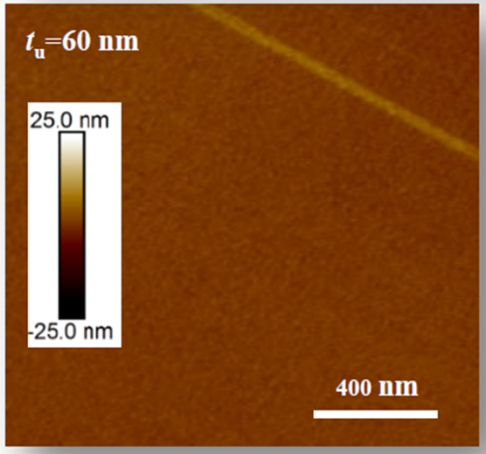
Fengzhen Sun

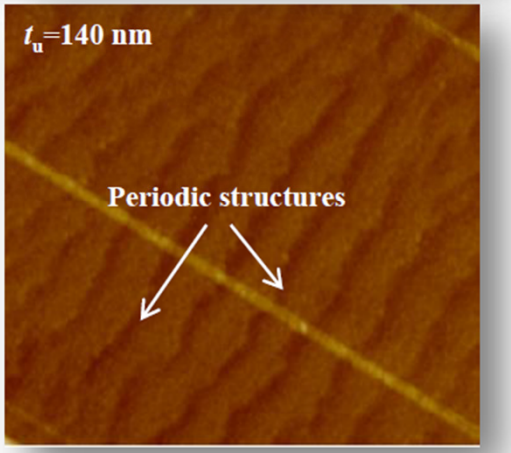
An instrumented ultramicrotome was built for the investigation of materials deformation (fracture) at nanoscale.

- **The nanoscale fracture toughness of polymers(composites) by nanosectioning.**
- **The crietical condition for the onset of periodic structures (shear bands) in sectioning PMMA: uncut chip thickness ≥ 85 nm for speed of 1 mm/s; sectioning speed ≥ 1.0 mm/s for thickness of 85 nm.**







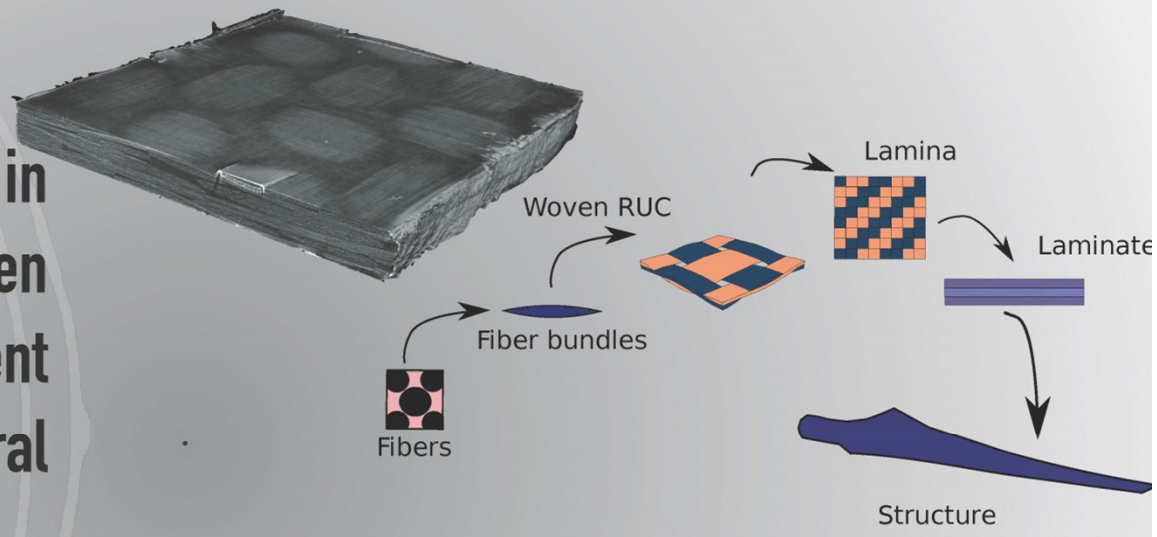


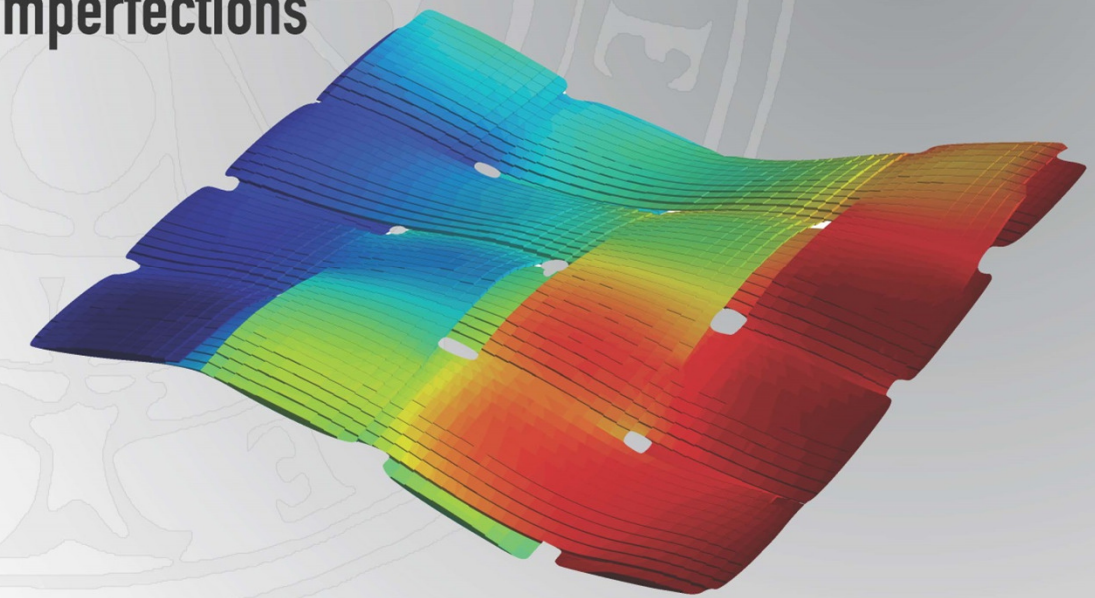
ON THE EFFECT OF MICROSTRUCTURAL IMPERFECTIONS IN WOVEN COMPOSITES

Espadas Escalante Juan José.

GENERAL OBJECTIVE

"To investigate the variation in mechanical properties of woven composites laminates at different levels due to microstructural imperfections"

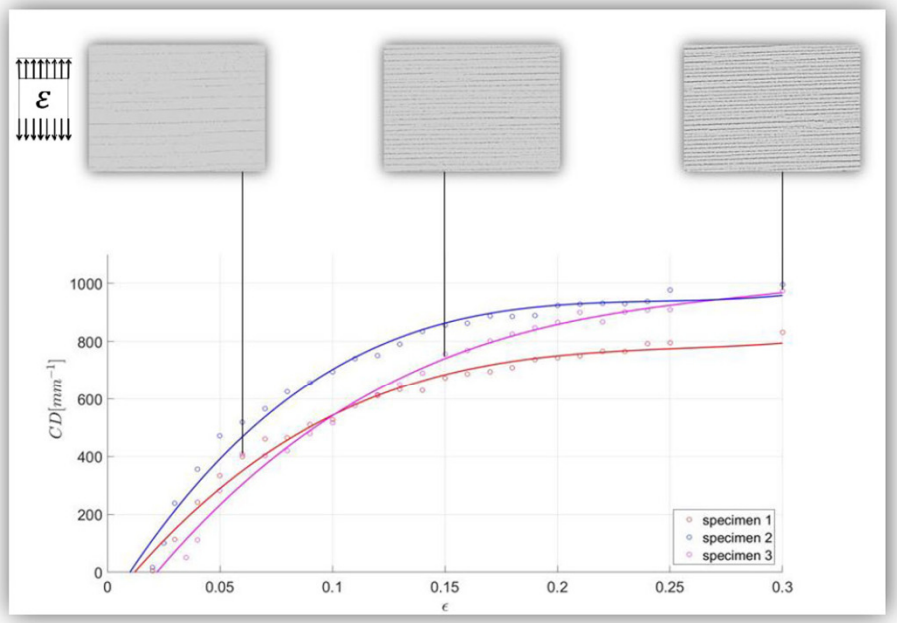




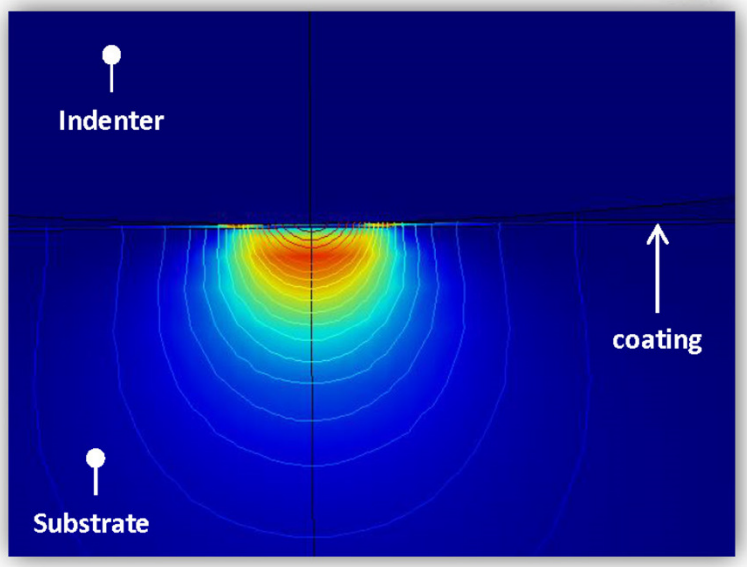
POTENTIAL APPLICATIONS

CHARACTERIZATION OF THIN METAL OXIDE COATINGS ON POLYMER FILMS

In this research we investigate the adhesive and cohesive properties of nanometer brittle thin coatings deposited on polymer film. Such coatings have excellent barrier properties as well as transparency, where the main application of the tested films for this present work is in food packaging.



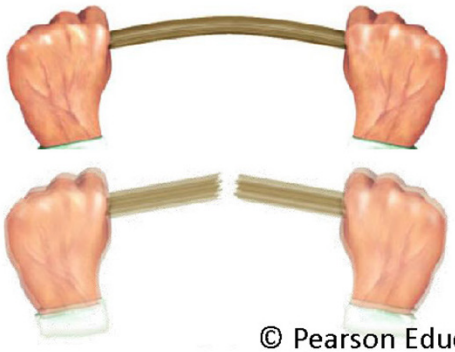
In-situ Fragmentation tests: scheme using SEM pictures to show the cracking evolution at different strains.



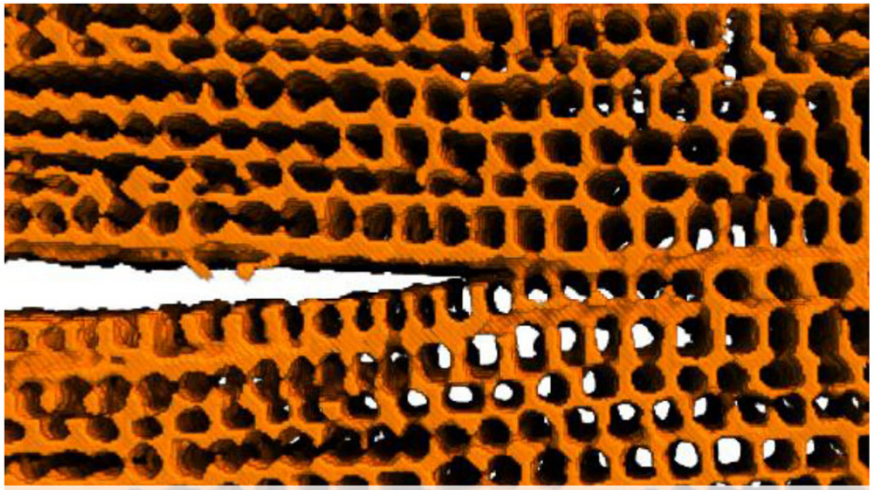
Nanoindentation FEM simulations

High resolution modelling of rapid fractures in cellular materials

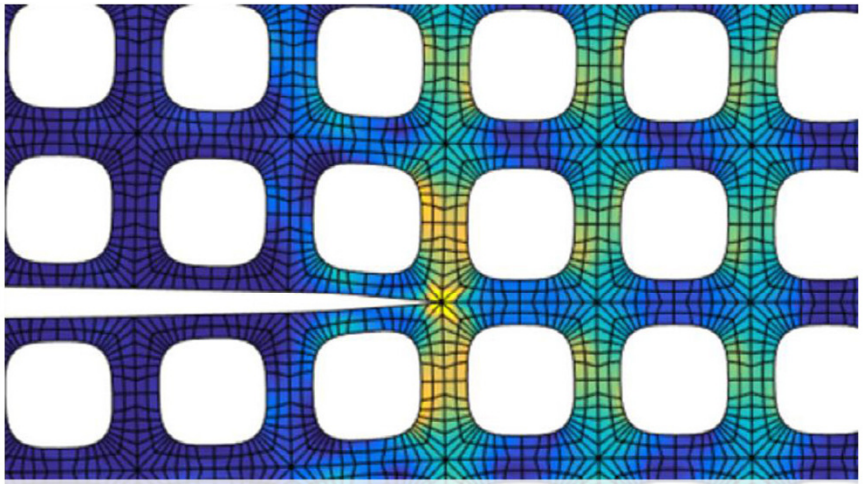
Wood is a complex material and the fracture mechanisms depend on what scale is being studied. In this project we are increasing the physical understanding of rapid fracture of wood and other cellular materials in the cell scale.



A characteristic of a rapid fracture is that stress waves are induced in the material, deforming the microstructure.



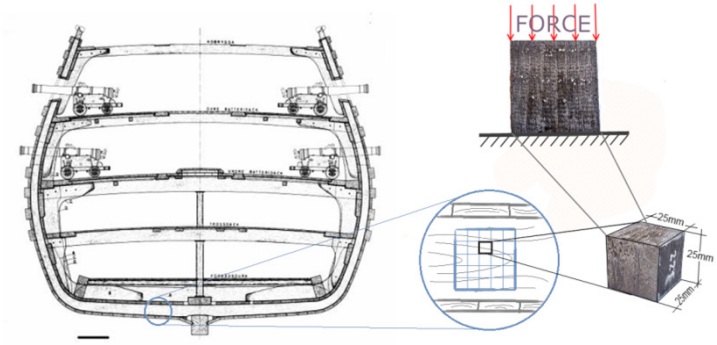
X-ray computational tomography scan of a crack propagating in wood.



High resolution finite element model of crack in a cellular material ($Stress\ S_1$).

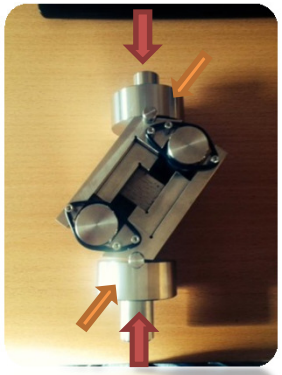
Determination and comparison of mechanical properties of Vasa oak

Vasa oak, is a complex composite. Being waterlogged for 333 years and afterwards PEG impregnated wood has changed its mechanical properties. Vasa oak is a good example to work on.



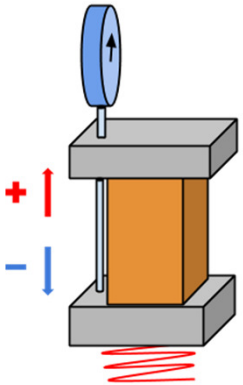
Vasa oak is taken from the hull of Vasa ship

Recent oak (left), Vasa oak (right)



Shear test device

Shear modulus (G), is another important mechanical property, which is hard to identify. Shear test device is specially designed for the cube samples



Creep test device

Creep compliance $\frac{\sigma}{\varepsilon(t)}$, will provide needed information for predicting time dependent behavior of Vasa oak. Prestressed spring is constantly applying load on the sample. Vertical displacements are logged the same time.

- Work with optical strain measurement equipment and universal testing mashine in order to perform compression and shear tests in all orthotropical directions
- Obtaining all necessary stiffness constants for orthotropic material
- Creep tests performance

Alexey Vorobyev, PhD student,
The Ångström Laboratory,
Uppsala University

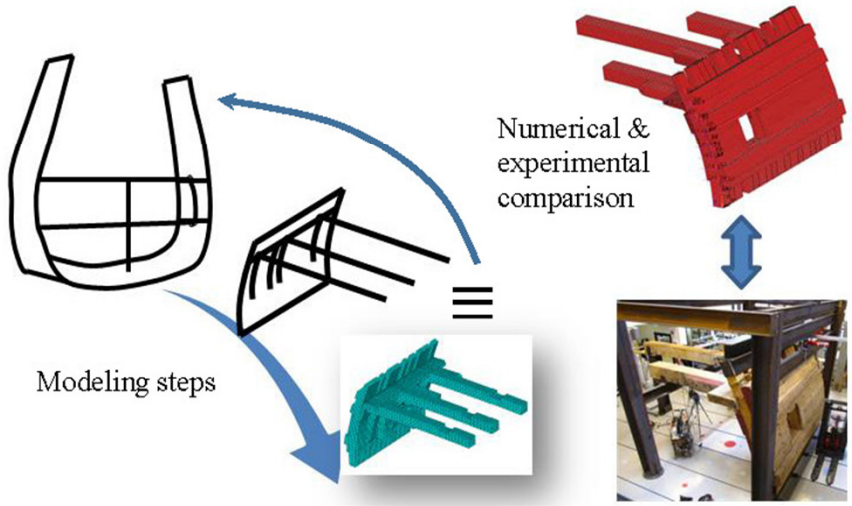
Finite element modeling of the Vasa ship to design an improved support structure

Reza Afshar, Researcher at Applied Mechanics Division

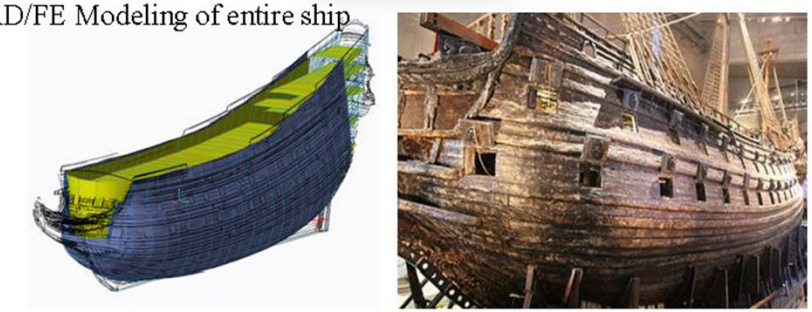
Geodetic measurement on the 17th century Vasa ship shows that it is deforming over time. Therefore, the necessity for an improved support cradle for the hull is recognized.

The main objective of this project is to use the mechanical and chemical analysis of the Vasa oak as input data to a full-scale 3D finite element model as an analytical tool to help designing an improved support structure.

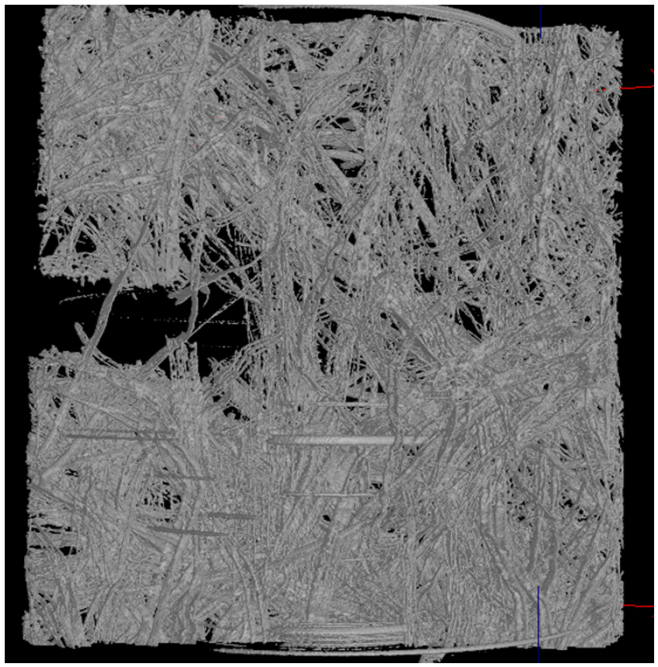
The structural analysis of the ship is based on a top-down approach. First the entire ship will be modeled using the solid shell, beam and shell elements. Then some joint stiffness parameters will be calculated by using an equivalent solid shell-beam-spring model of corresponding solid model from the section of the ship. Finally, the joint stiffness parameters will be input in the full model to perform the structural analysis.

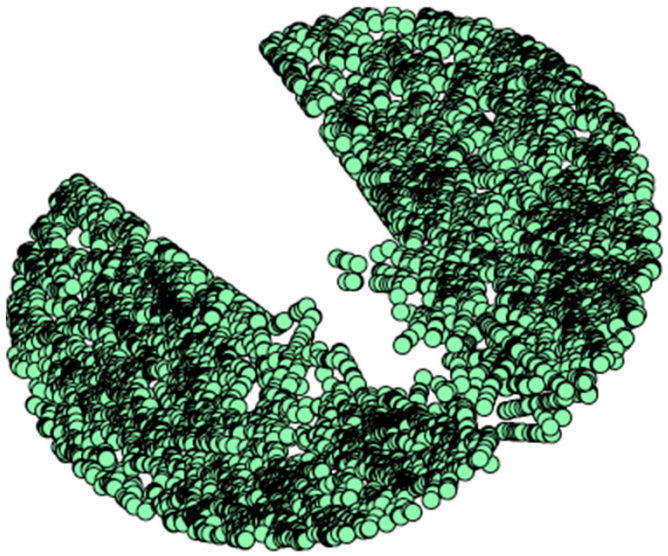


CAD/FE Modeling of entire ship



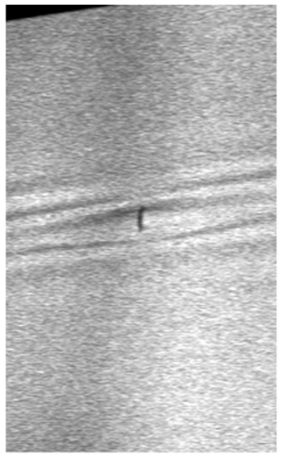
Example 1: Modelling of fracture in fibrous materials (prof Per Isaksson)

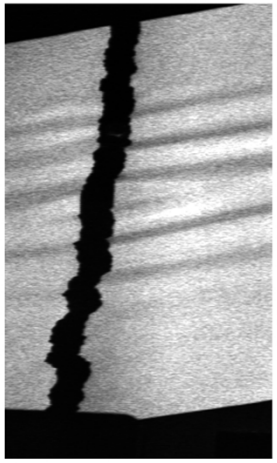


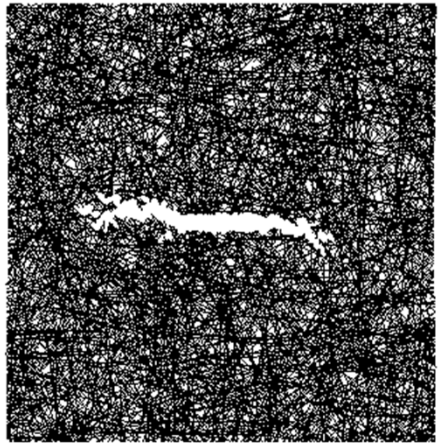


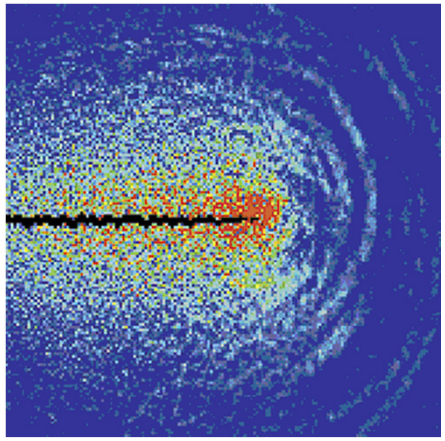
3DμCT from ESRF Grenoble. Computer modeling using novel particle methods.

Dynamic fracture mechanics in papermaking (Per Isaksson)



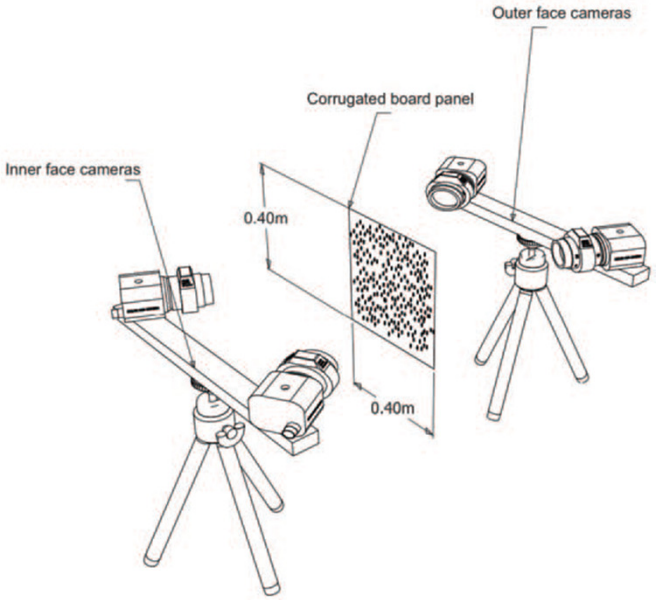


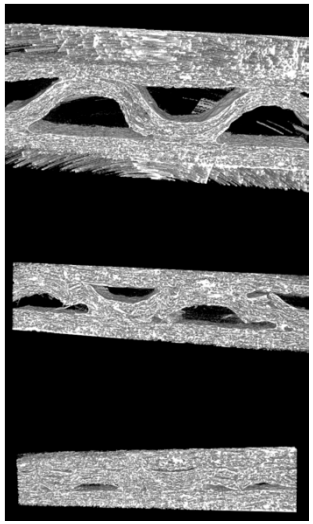




Modelling and experiments in dynamic fracture in a fibre web

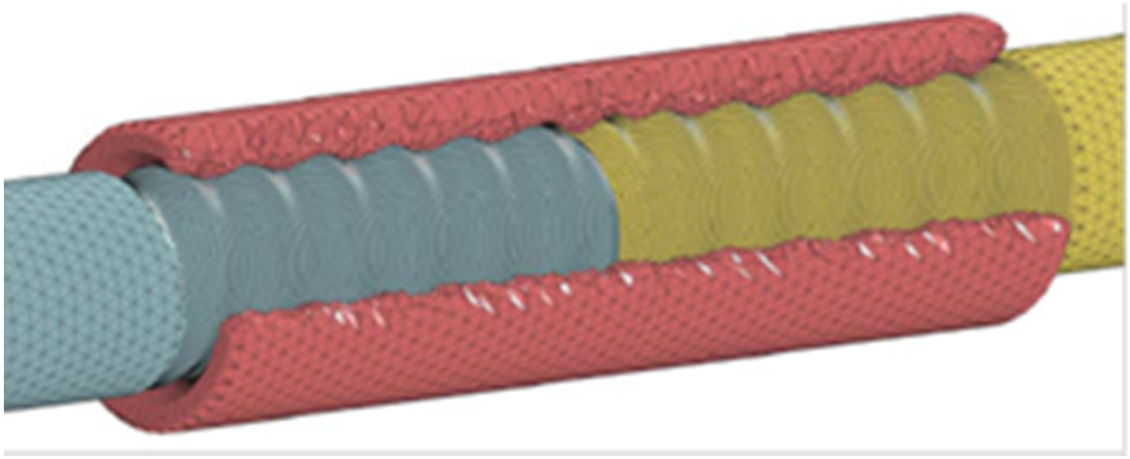
Material degradation in corrugated board (Per Isaksson)





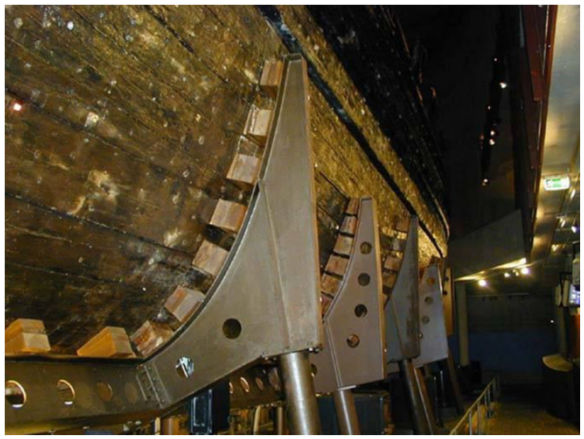
Determine failures in loaded boxes to reveal deformations and full-scale nonlinear finite element modelling

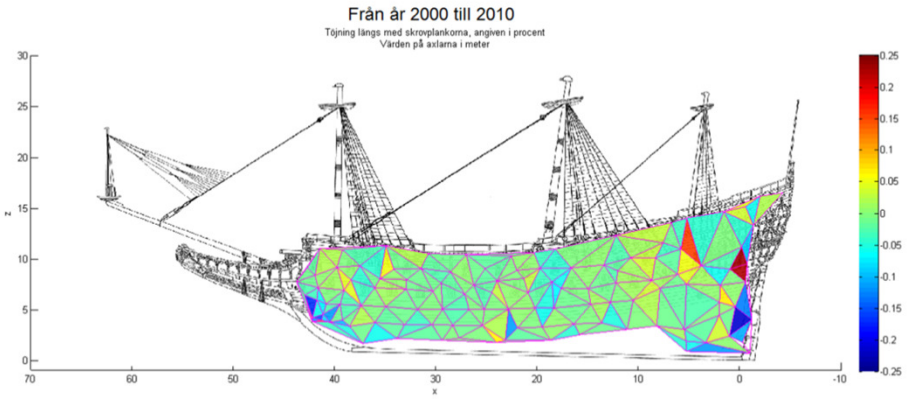
Example 2: Simulation of dissipation in percussive drill rod joints (Sandvik, Bengt Lundberg)



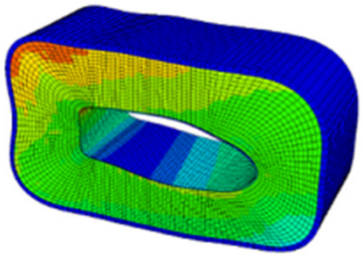
Example 3: ”Stötta Vasa” (Ingela Bjurhager + 3)

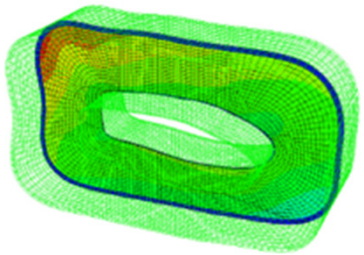
Design of a new support system for the Vasa ship:
From materials characterization, numerical modelling to structural optmization





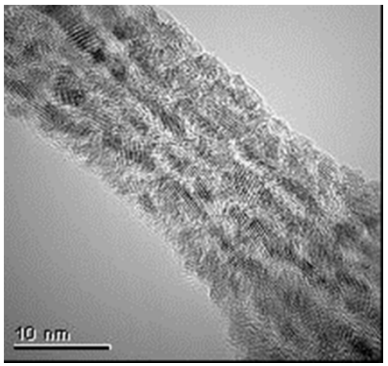
Examples of research projects (4-6)





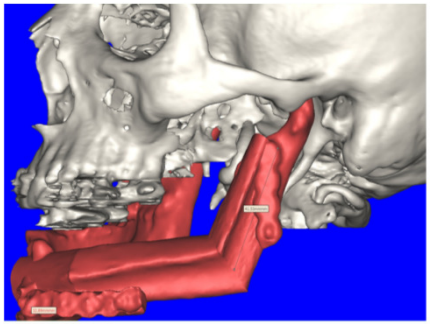
Thomas Joffre (PhD student)

Dimensional instability of
wood-fibre composite materials



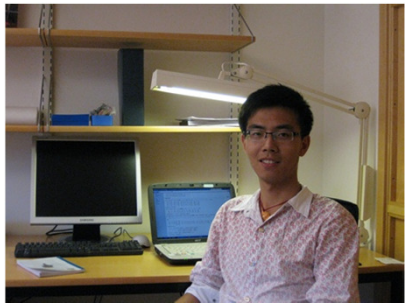
Gabriella Josefsson (PhD student)

Stiffness contribution on
nanofibrillated cellulose to
composite materials



Jinxing Huo (PhD student)

Design of maxilliofacial implants
by additive manufacturing



PhD courses

- Continuum mechanics, 18 ects
- Dimensional analysis, 3 ects
- Scientific writing, 3 ects
- Researchers and media
- Composite mechanics, 3 ects

Industrial collaboration

- SCA
- Innventia
- Sandvik
- ABB
- Tetra Pak
- …

ECONOMY & TRADE
Engineering industry

- Accounts for just over 50% of Sweden's industrial production and 10% of total GDP
- 2/3 of Swedish-produced engineering products exported
- 50% of the sector are engine and vehicle manufacturers
- Most companies small or medium-sized
- High degree of specialisation
- Focus on knowledge-intensive engineering, services and R&D

ECONOMY & TRADE
Foreign Trade

- Exports by important commodity groups (percent of total value) :
  - Forestry products 13.5%
  - Mineral products 8.5%
  - Chemical products 12.8%
  - Energy products 3.2%
  - Engineering products 50.5%
  - Other 11.4%

EDUCATION

- 9 years' compulsory education (tax financed)
- English is the compulsory first foreign languages
- Upper secondary school (high school) 3 years
- No tuition fees
- Undergraduate education:
  - Bachelor's degree (3 years)
  - Master's degree (4-5 years)
- Four years of doctoral studies and an approved dissertation are required for a doctorate

Gracias - Tack