# 3D Imaging Center at DTU: Examples of X-ray micro-CT

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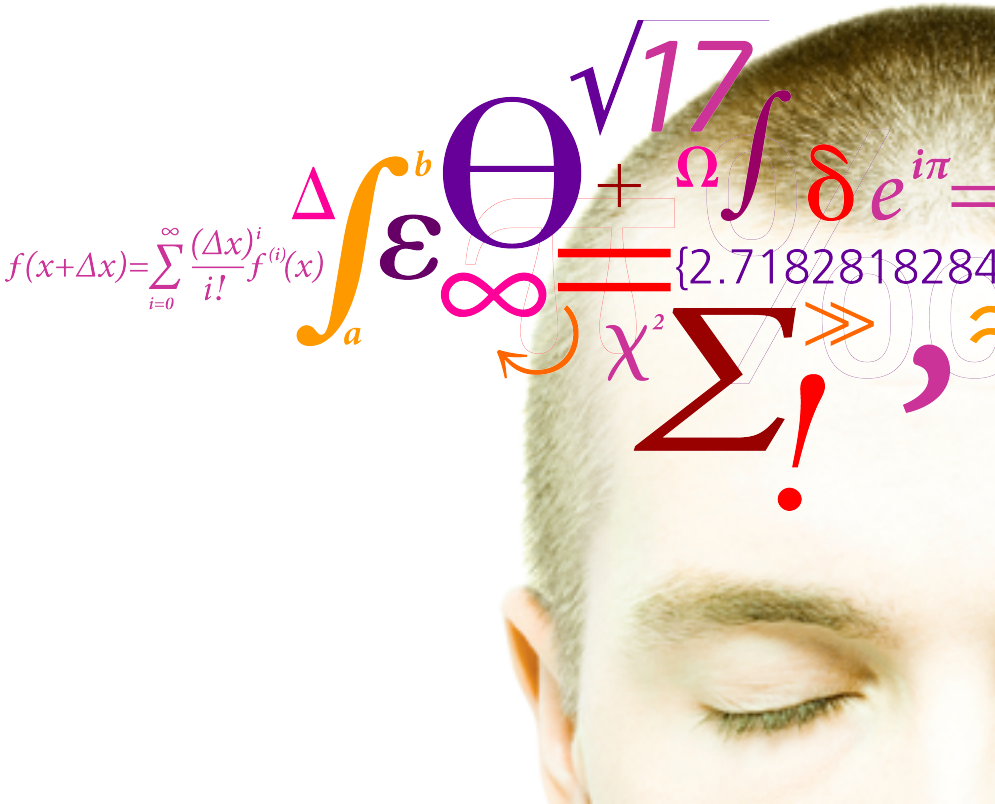
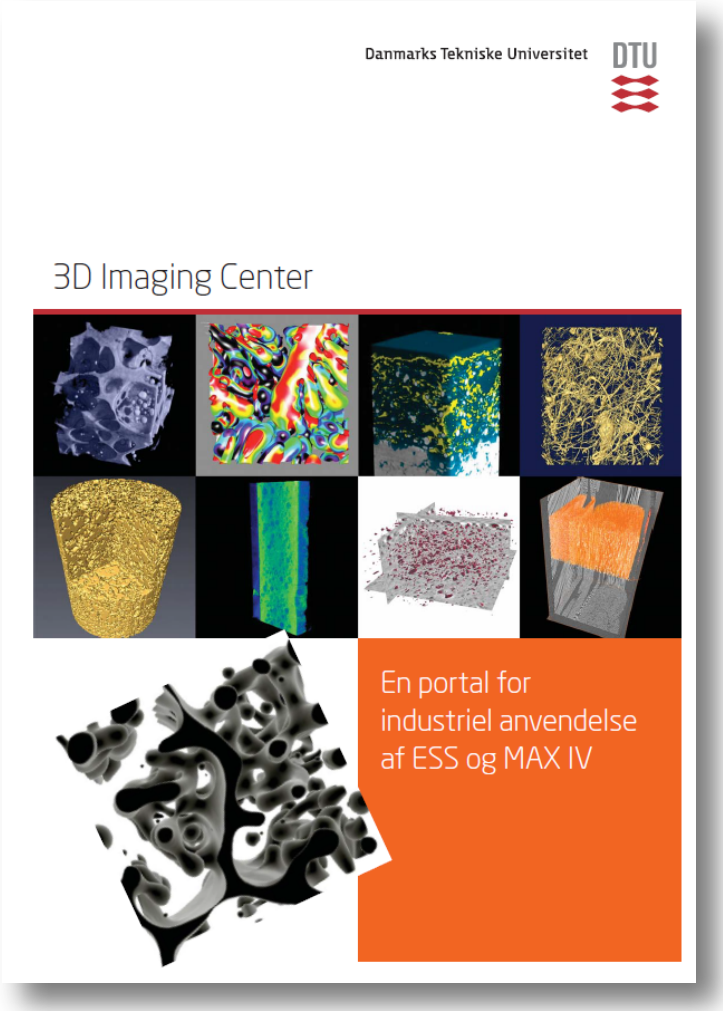


# Background for 3D imaging Center

Different research groups working within the fields of:

- Material research using tomography as one tool
  - Metals
  - Energy materials
- Method development within X-ray microscope techniques
  - 3DXRD
- Algorithm development within the fields of:
  - Image segmentation
  - Tomography reconstruction



# Nucleation

Coming world class research facilities in Lund


**Project "ESS and MAX IV as growth engines in the capital region of Denmark", 2013-2014**

**Vaekstmotor.dk**

# Development of the imaging industry portal

- Past years - **Demonstrator within the *vækstmotor* project**
  - Industry activities
  - Concept development for X-ray imaging center at DTU

- Next goal– **Part of a national industry portal**
  - Industry activities
  - Continued development for X-ray imaging center at DTU

- Long term goal – **X-ray imaging center at DTU**
  - Industry portal
  - Science hub
  - Research activities
  - Teaching

# The Imaging Industry Portal

The Imaging Industry Portal is a collaborations between different departments with different strengths.

- DTU Physics – Development within X-ray methods and focus on hard materials
- DTU COMPUTE – Development of tomography reconstructions and image segmentation
- DTU Energy – X-ray science and energy materials
- KU NBI – Development within X-ray methods and x-ray science for food products
- DTU Mechanics - Metrology

# The Imaging Industry Portal

Core group of people with experience in X-ray imaging and image analysis

Team:

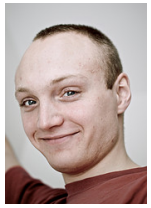
Henning Friis
DTU-Physics

Jette Oddershede,
DTU-Physics

Carsten Gundlach,
DTU-Physics

Anders L. Dahl
DTU-Compute

Søren Bredmose
DTU-Energy



Torsten Lauridsen
NBI, KU

Camilla H. Trinderup
DTU-COMPUTE

Yi Zheng,
DTU-Physics

Within the last 2 years we have worked on 30+ projects with industry

# Vision and future

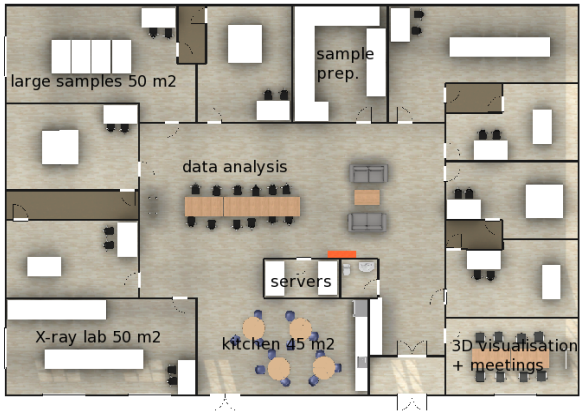
- Combined industry portal with 3 legs
  - Imaging Industry portal at DTU
  - NXUS at KU
  - Diffraction Industry Portal Aarhus University

- Imaging Center
  - Application for founding to more instruments
  - Expanded user program

- New building
  - 1000 $m^2$ dedicated laboratory space and local computer power

# Vision - Imaging facility at DTU

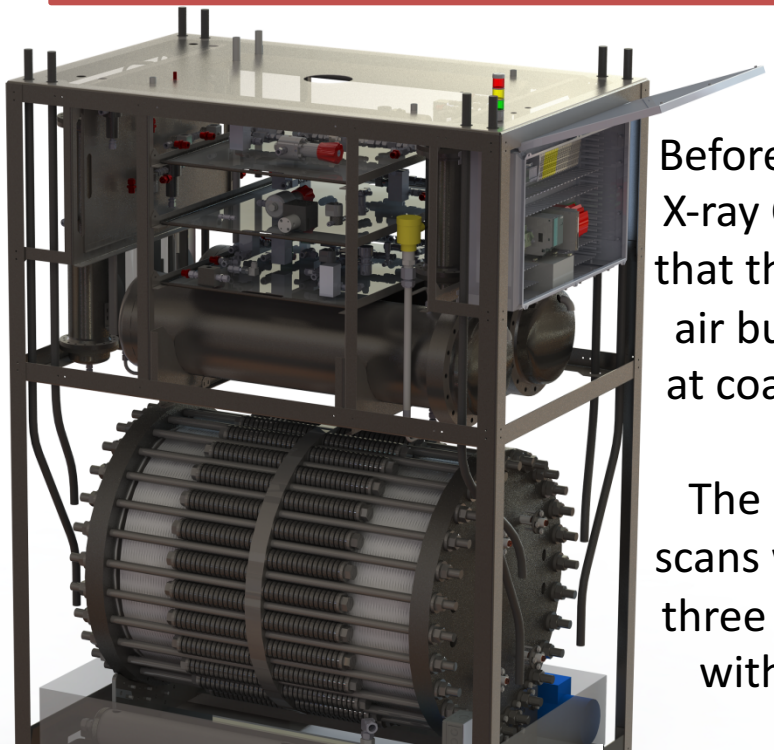
- Local equipment:
  - Nano-tomography equipment (in-operandum)
  - Micro-tomography equipment
    - General version
    - Optimized for mechanical testing
  - High-energy tomography equipment
    - Large samples and/or heavy materials
  - Helical scanning tomography equipment
    - Large samples (e.g. components for windmills)
  - Homemade equipment optimized for nano-tomography and phase contrast
  - Homemade equipment optimized for diffraction based imaging
- Local analysis tools
  - Optimized software
- Same location!
- Interaction with researchers and trained staff




Work conducted as part of the project **ESS and MAX IV as Growth Engines for the Capital Region of Denmark**

# Air bubbles in injection-molded plastic

Alkaline electrolysis module from Siemens. The large cylinder contains injection-molded plastic discs. X-ray CT was employed as a tool to locate unwanted air bubbles during optimisation of the injection-molding process.

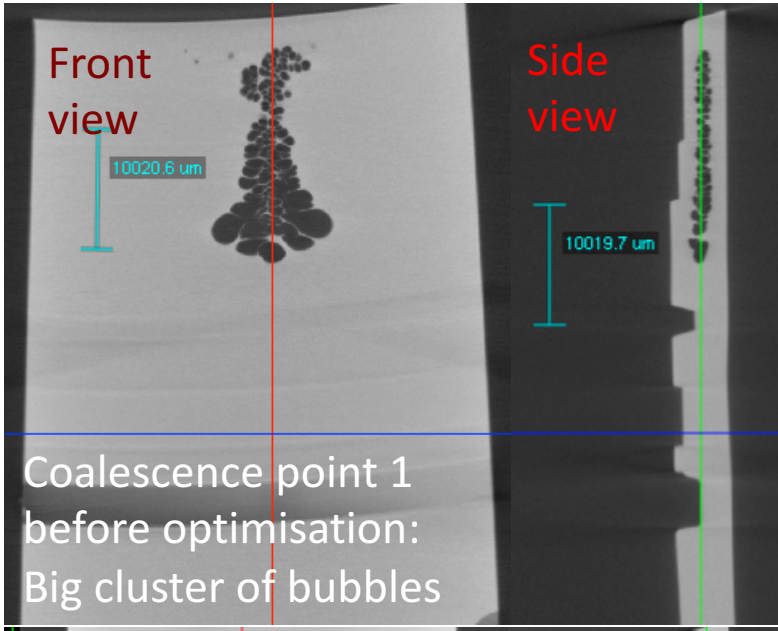


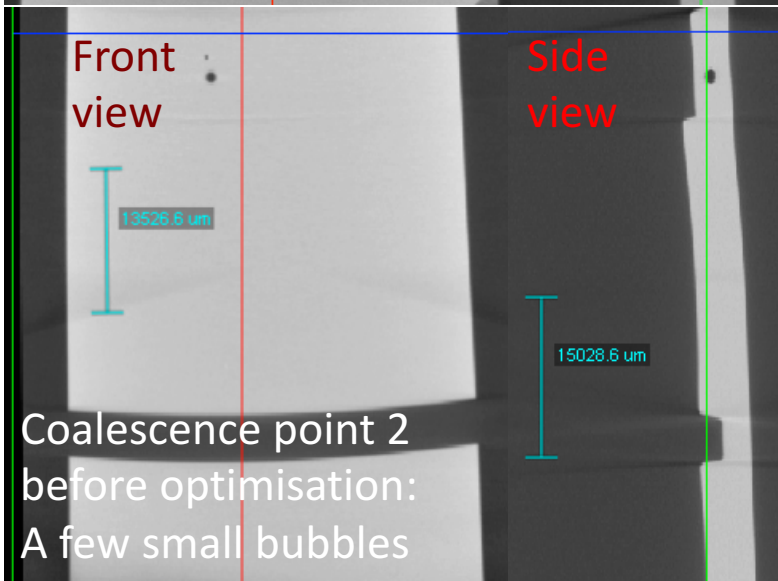
SIEMENS

Before optimisation the X-ray CT scans revealed that the parts had many air bubbles, especially at coalescence point 1.

The before and after scans were repeated for three different samples with similar results.

After optimisation no air bubbles were found.

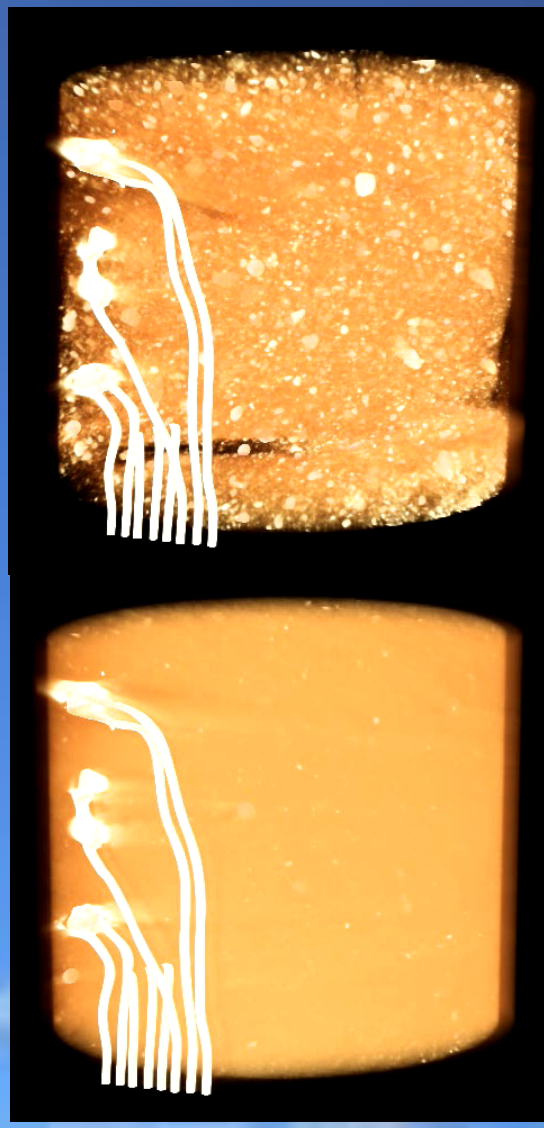


# Reducing NOx exhaust from diesel engines

NOx exhaust from diesel engines can be removed by reacting with $NH_3$. Amminex Emmisions Technology has developed a safe and Efficient material where $NH_3$ is bound in the salt AdAmmine.

The mass uptake of $NH_3$, the temperature and the 3D structure of AdAmmine were measured during saturation at the DTU Imaging Facility.



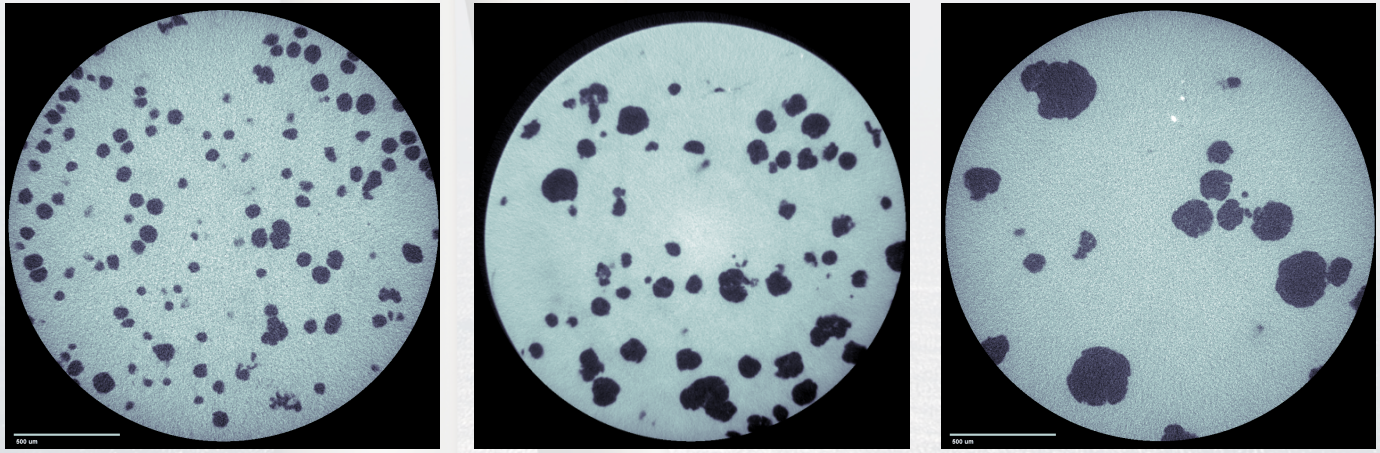
The AdAmmine structure before and after $NH_3$ saturation.

AMMINEX

# Ductile iron casting for wind turbines

- Iron properties depends on form, size and distribution of graphite (in cast iron)
- CT imaging of iron castings
- Shape, size and distribution analysis of graphite

- 4X
- 150kV
- 10 or 15sec
- HE2
- 1601 projections



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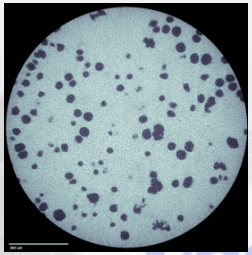
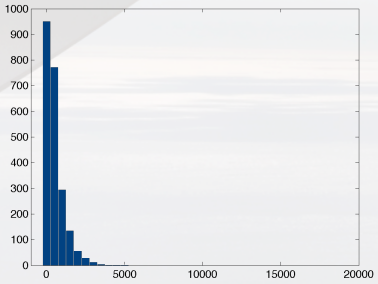
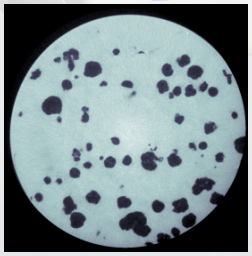
# Ductile iron casting

## Analysis results for the three samples

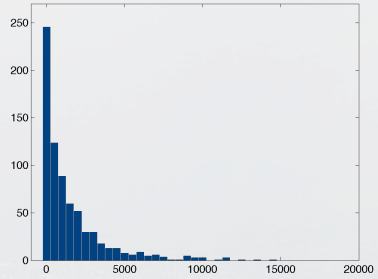


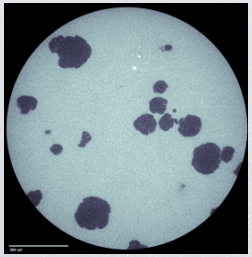
No. particles: 2,268
Avg. size: 8,650
Samp. dia.: 3 mm



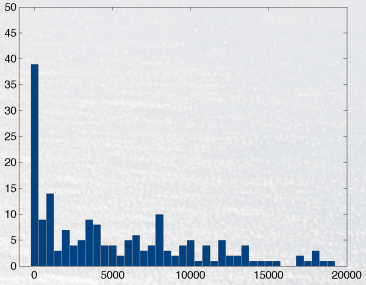



No. particles: 733
Avg. size: 24,700
Samp. dia.: 4 mm



No. particles: 181
Avg. size: 83,100
Samp. dia.: 3 mm

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# Characterization of subcutaneous insulin injections

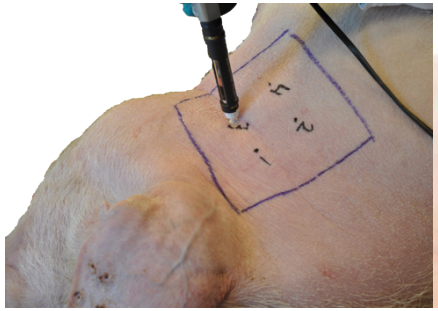
Diabetes is a metabolic disease where the patients lack the ability to control their blood sugar level

Diabetes is treated by daily injections of insulin under the skin.

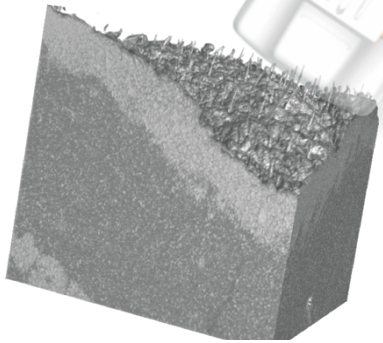
Optimization of the drugs contribute to a reduced risk of complications and an improved life quality.

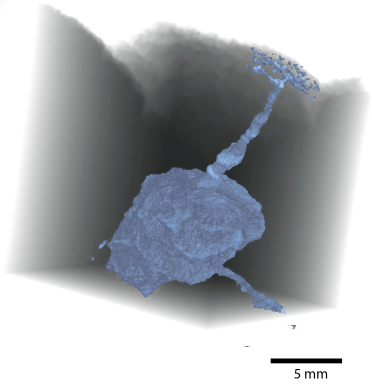
# Characterization of subcutaneous insulin injections

Pigs are commonly used as an animal model for optimization of new drug formulations.

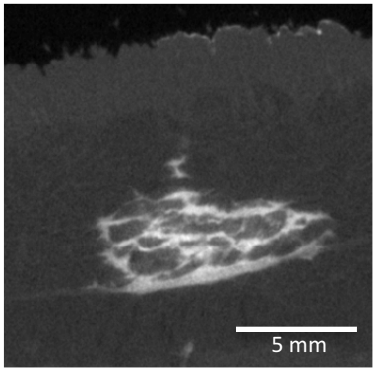


- LFOV
- 40 kV
- 5 sec
- LE2
- 401 projections

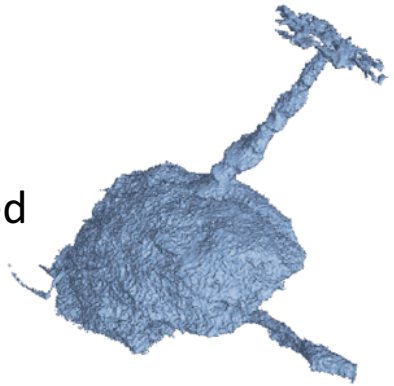





Insulin drugs mixed with an iodine based contrast agent has been injected under the skin of research pigs.




The drug distribution has been visualized with high spatial resolution using the Xradia Versa VRM-410 at DTU.

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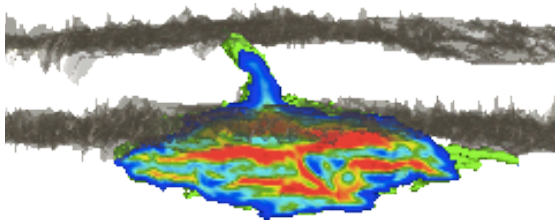
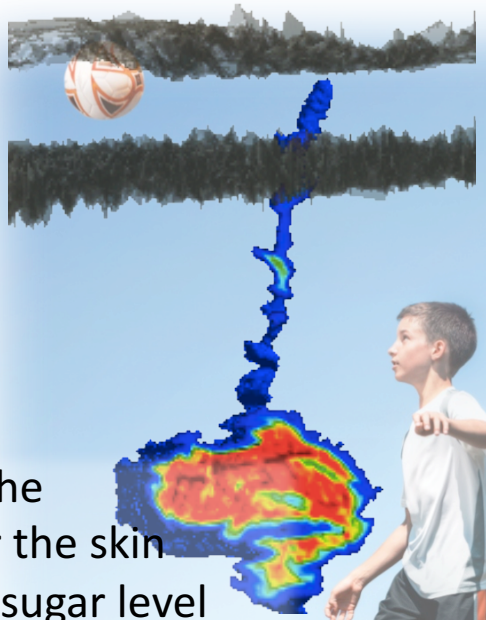
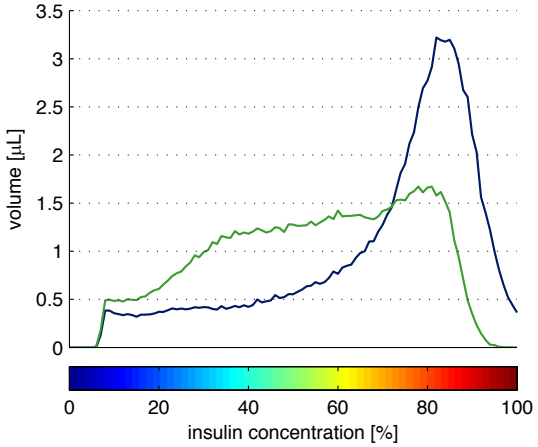
# Injection depth and drug dissolution





The different skin layers can be separated and the dissolution of insulin can be evaluated for the CT-scan.




The position of the drug and the concentration of insulin under the skin influences how fast the blood sugar level decreases after the drug has been injected.

Visualization of the injection process is an important step on the way to understanding the drug device interaction and to potentially improve both drugs and devices in the future.

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3D Imaging for industrial purposes

# Biomar: Optimizing fish feed pellets production with X-ray

## Company

**Biomar**: supplier of high performance fish feed to the aquaculture industry

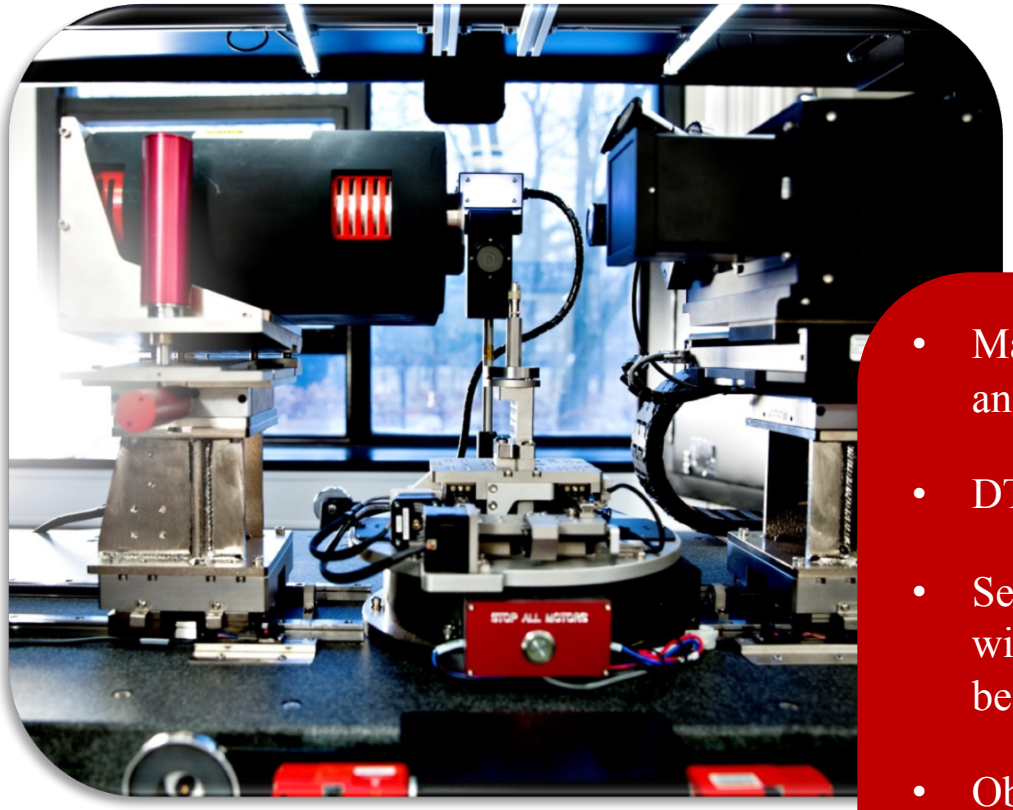
## Product

Fish food pellets containing +20% oil

## Challenge

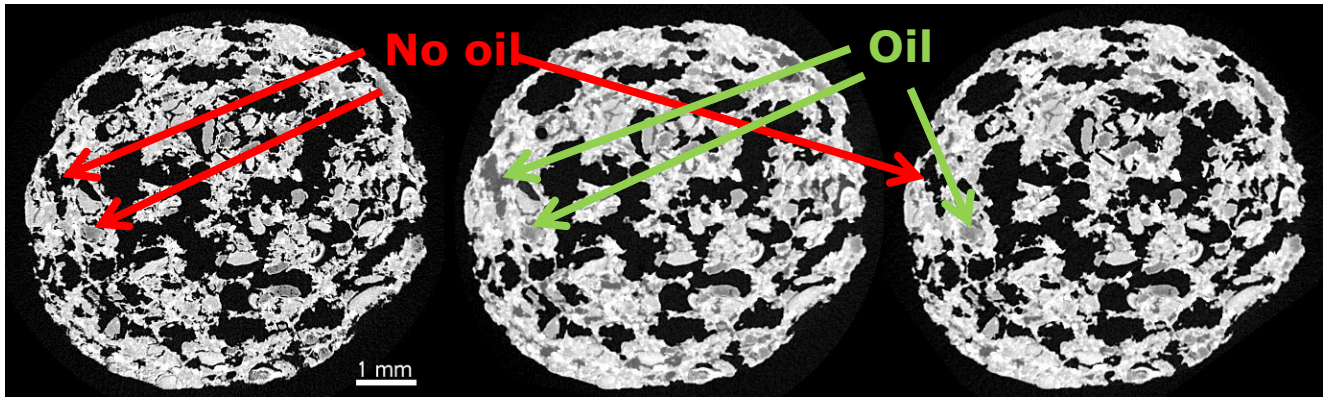
Optimize oil retention in the pellets to ensure the required oil content and diminish production costs

# Cooperation with the Imaging Industry Portal at DTU




- Master student during one year (measurements and data analysis)
- DTU Physics and DTU Compute
- Series of X-ray scans of the pellets with and without oil / before and after centrifugation / before and after coating
- Objective: identify the structures retaining oil inside the pellets

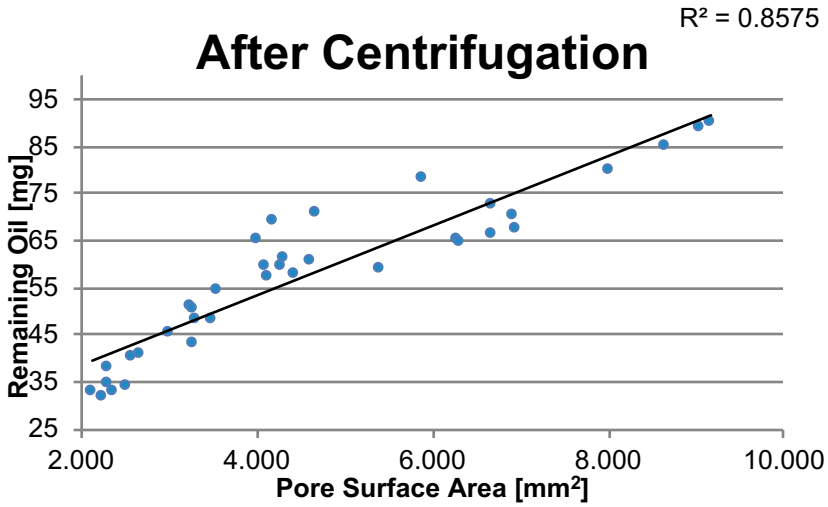
# Results



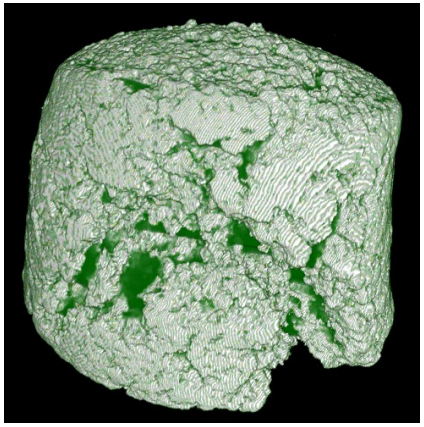

Before coating | After coating | After centrifugation

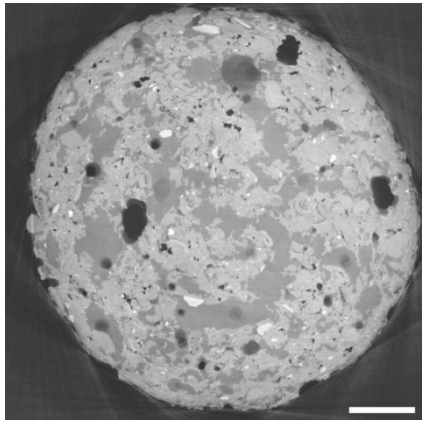
New insights into the porous structure of the pellets showing that small pores are better to keep the oil in the pellet.

Therefore, large surface areas are preferred.

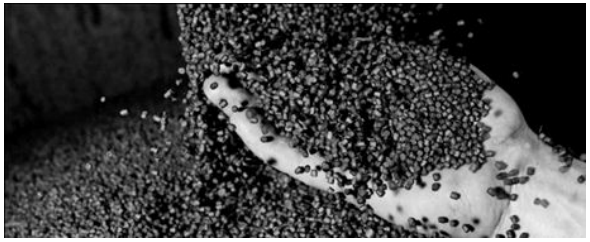


# Perspectives





Explore new ways of optimizing pellet production to ensure maximum oil retention, e.g. by testing alternative raw materials and their impact on the pellets' pore structure.



Contact

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Web page: http://www.imaging.dtu.dk/Industriportal

# Examples

- Examples can be found on this webpage http://www.imaging.dtu.dk/Industry-Portal/Cases