

Reverse Engineering as a source of CFD uncertainty



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RESEARCH**
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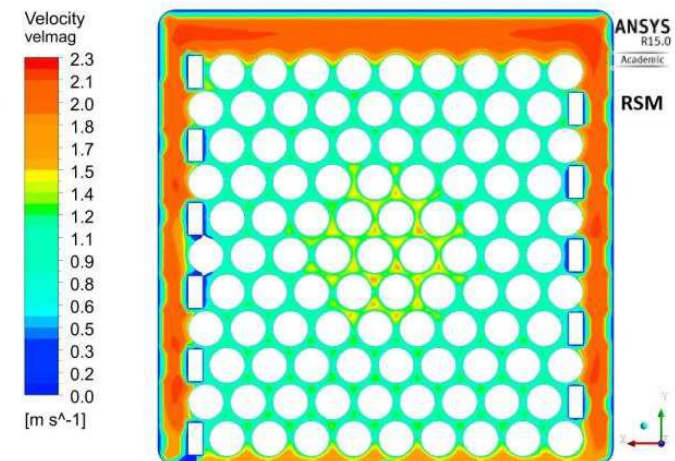
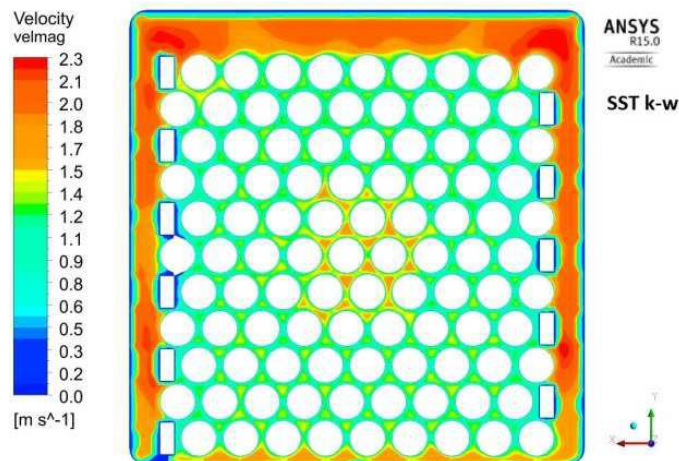
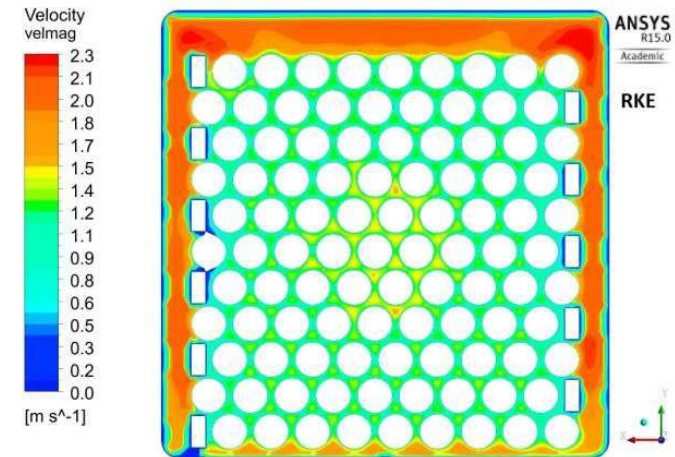
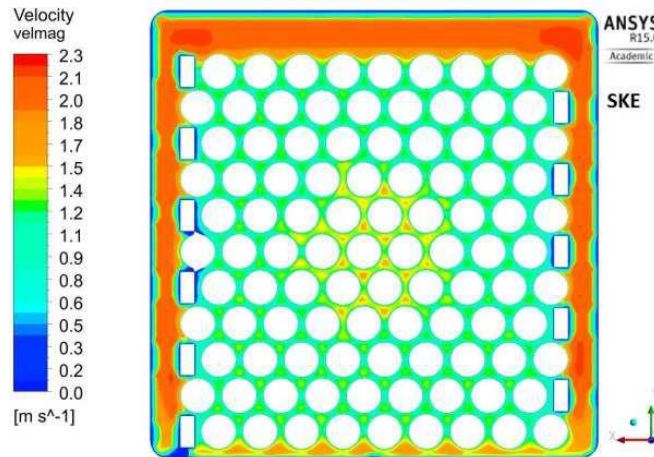
Tomasz Kwiatkowski

Piotr Prusiński

Piotr Warzybok

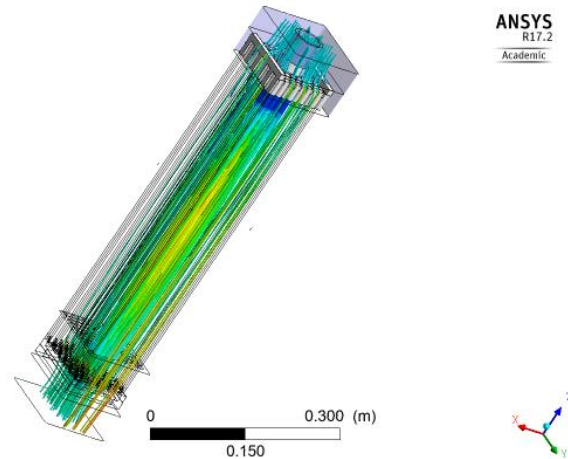
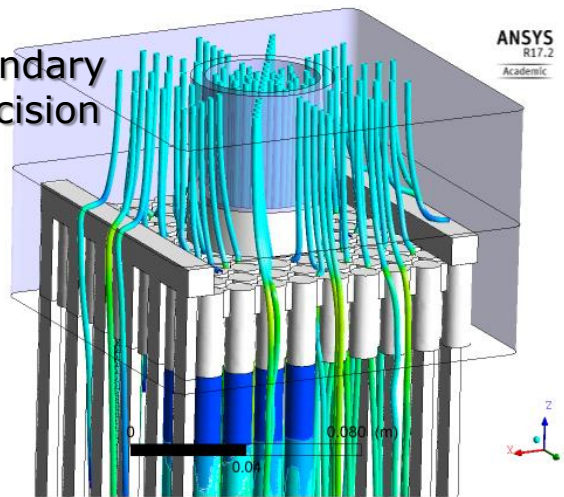
Typical CFD analysis result

Turbulence model choice

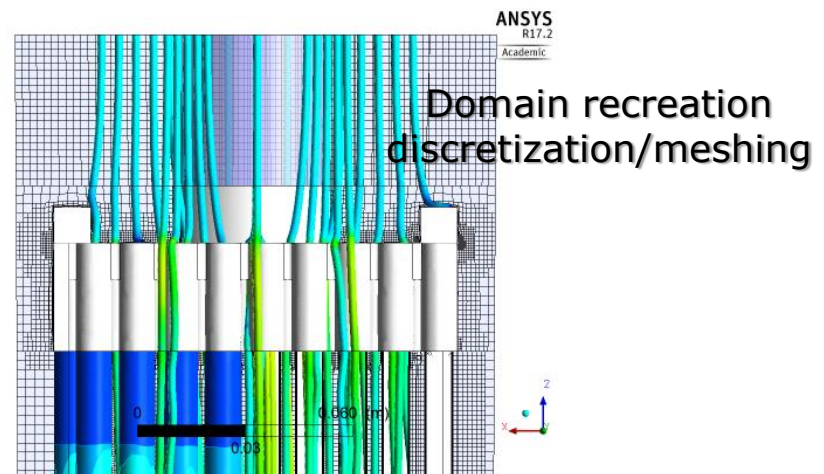
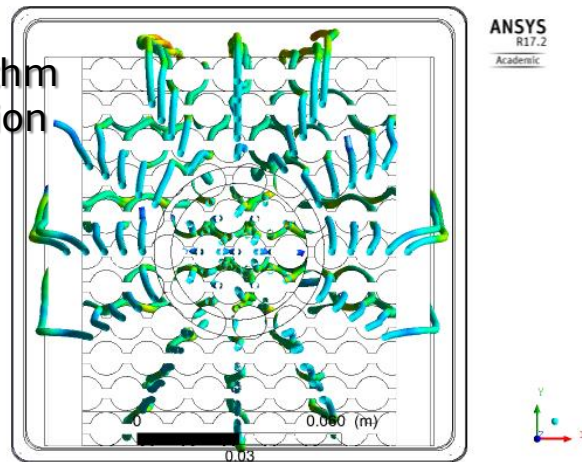


Sources of uncertainty

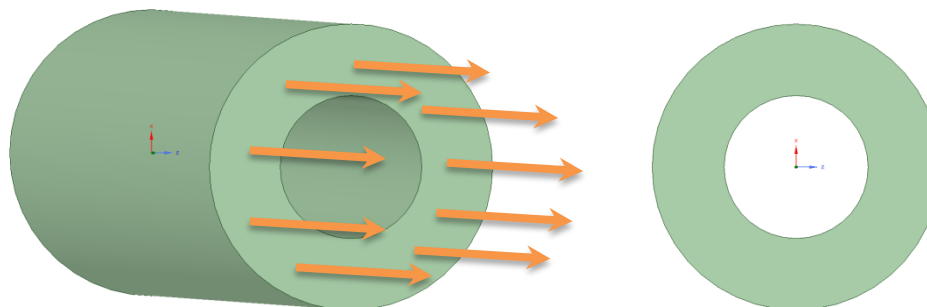
Initial and boundary conditions precision



Solver/algorithm implementation



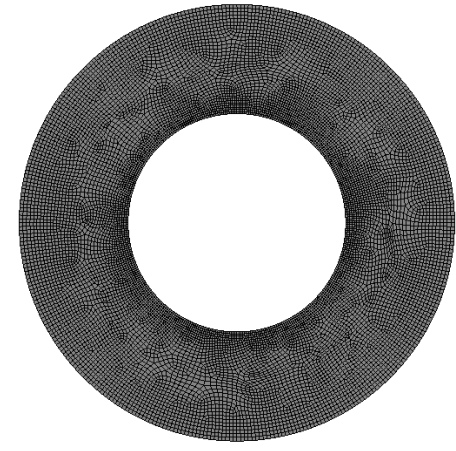
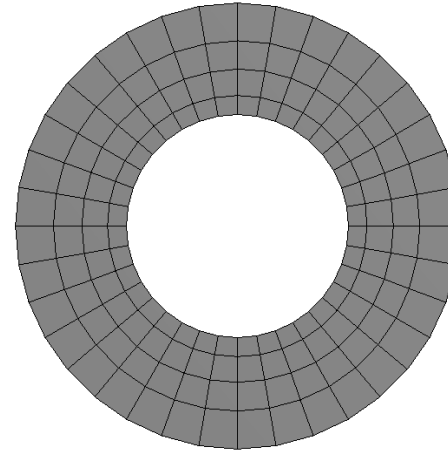
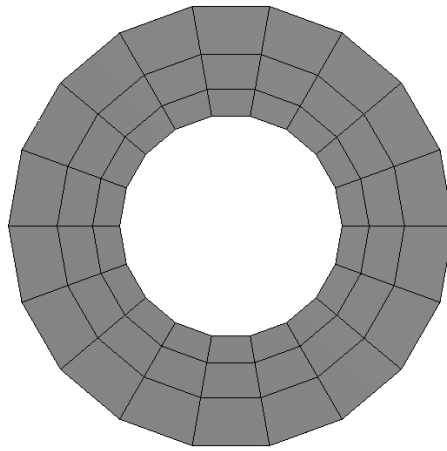
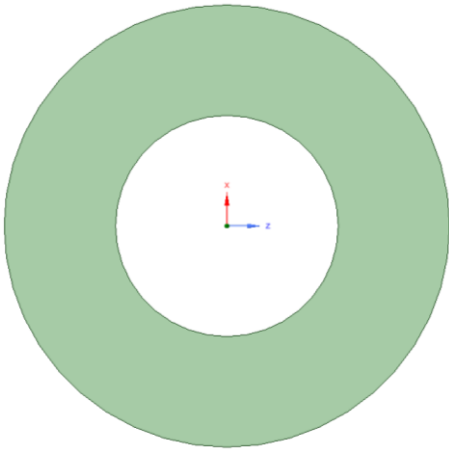
Domain reconstruction issue example



Parameter	Value
Length	0.5 m
Inner diameter	0.05 m
Outer diameter	0.1 m
Inlet area	0.00589 m ²
Inner surface area	0.0785 m ²
Outer surface area	0.157 m ²



Domain reconstruction issue example



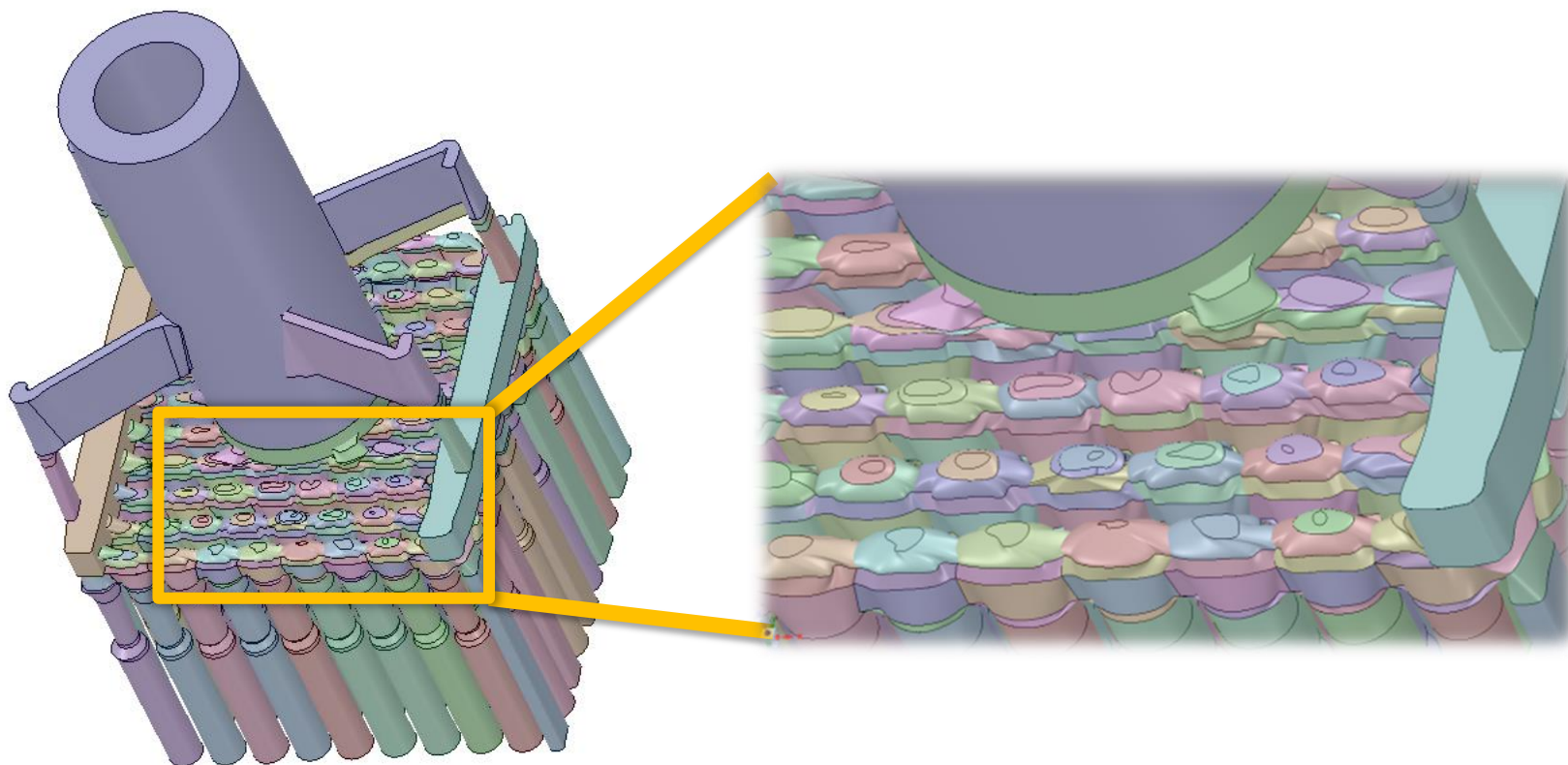
Inlet area	97.98%	99.49%	99.99%
Surface area	99.49%	99.87%	99.99%
Velocity	2% ↗	0.5% ↗	0.1% ↗
ΔT (inlet – outlet)	1.5% ↘	0.4% ↘	0.1% ↘



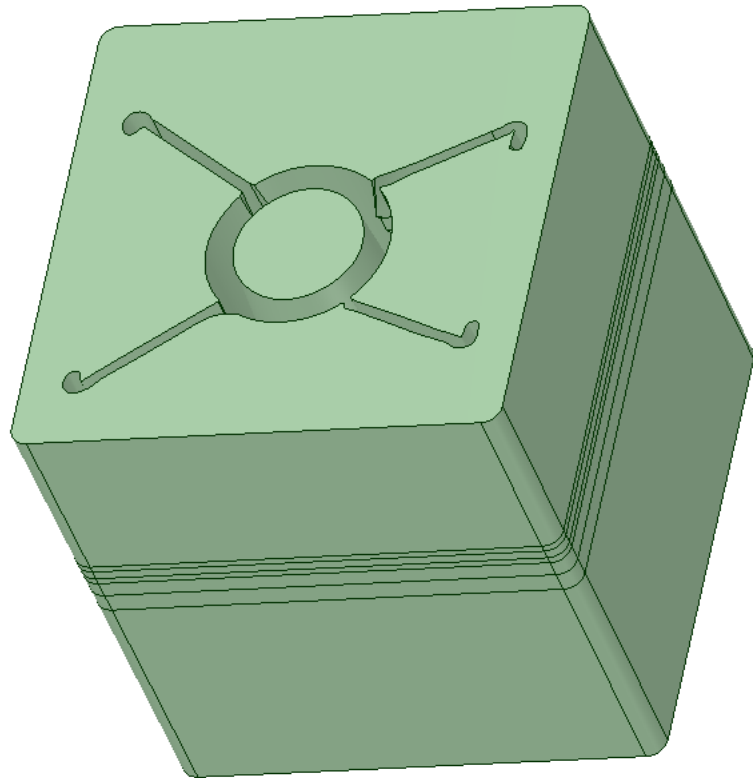
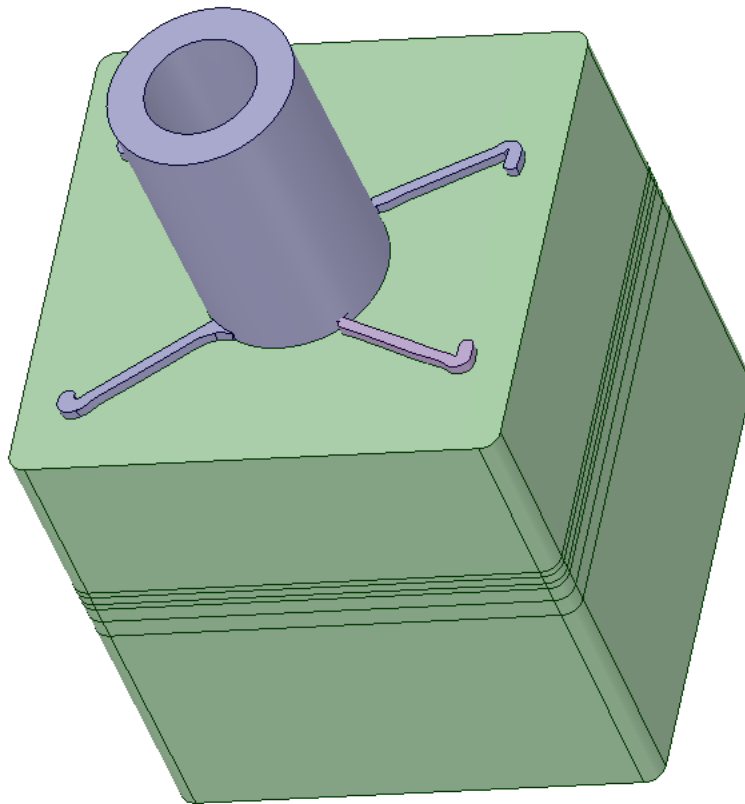
What if surface is irregular?



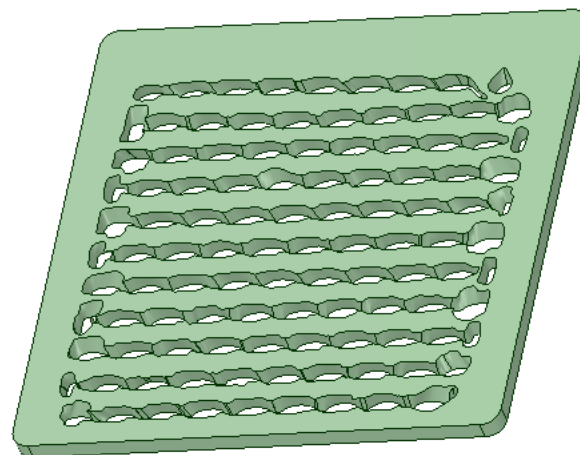
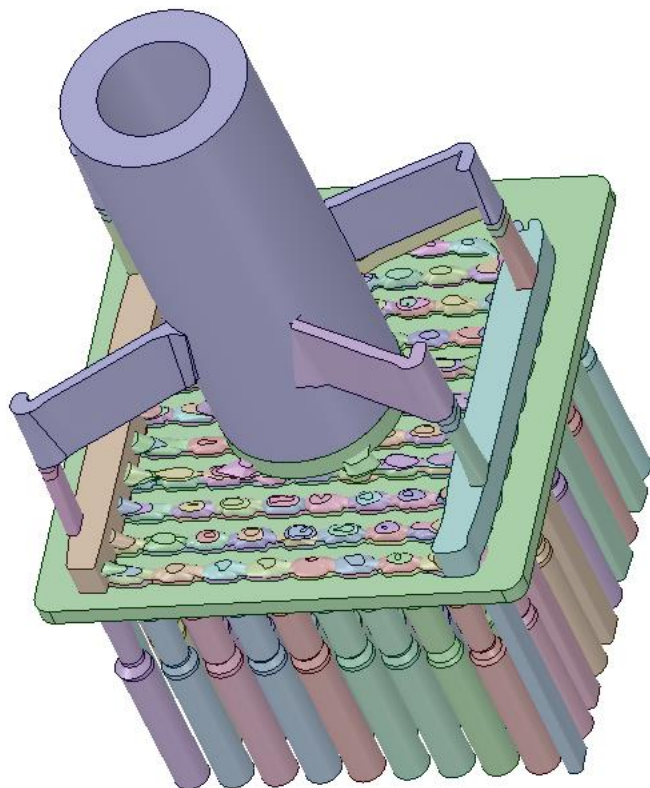
What if surface is irregular?



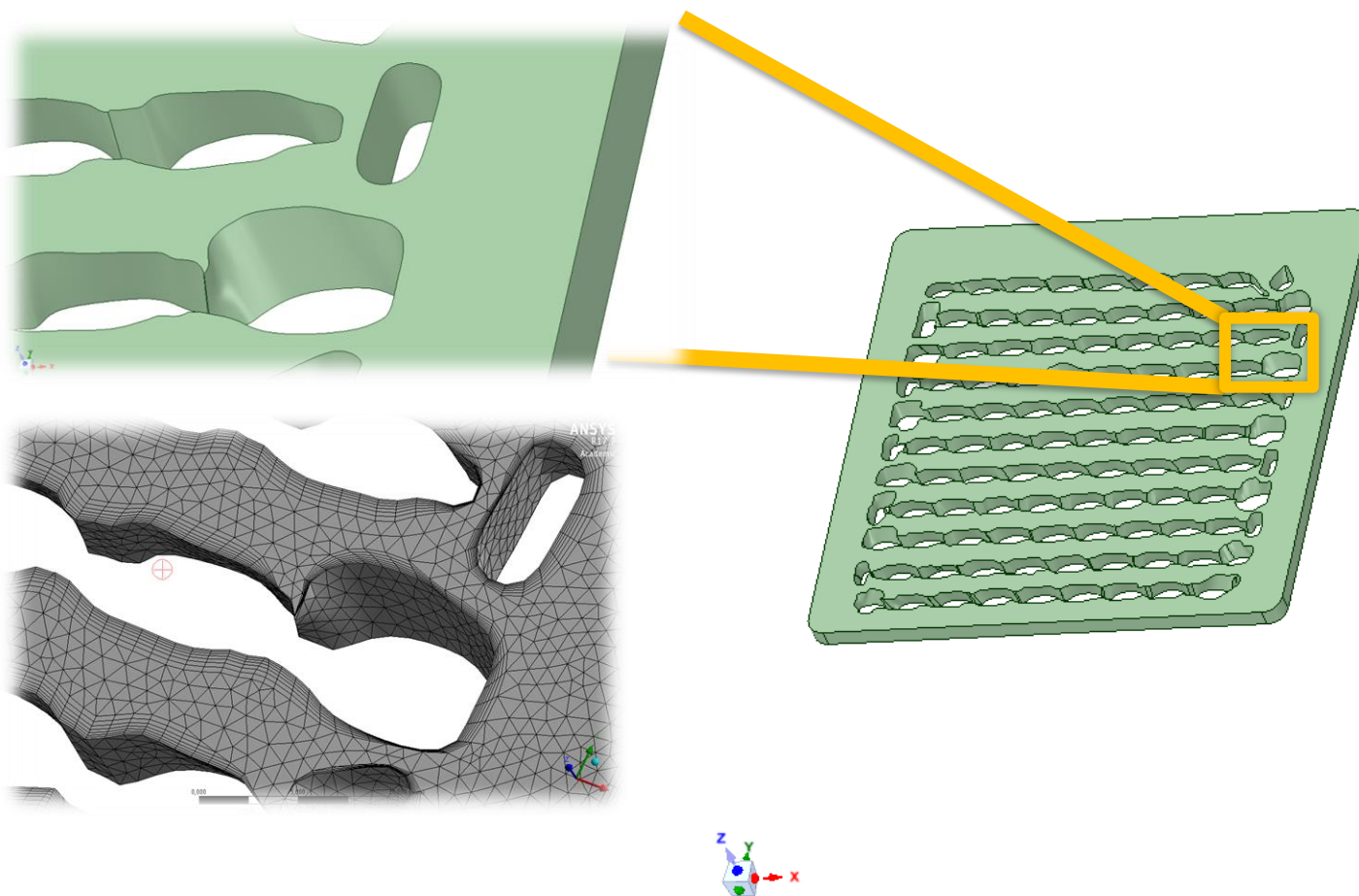
What if surface is irregular?



What if surface is irregular?



What if surface is irregular?





Importance to the industry

- Efficiency and safety:
 - Post-manufacturing differences
 - Ageing processes
- Old installation upgrades
- Understanding and lowering uncertainties leads to improvement!



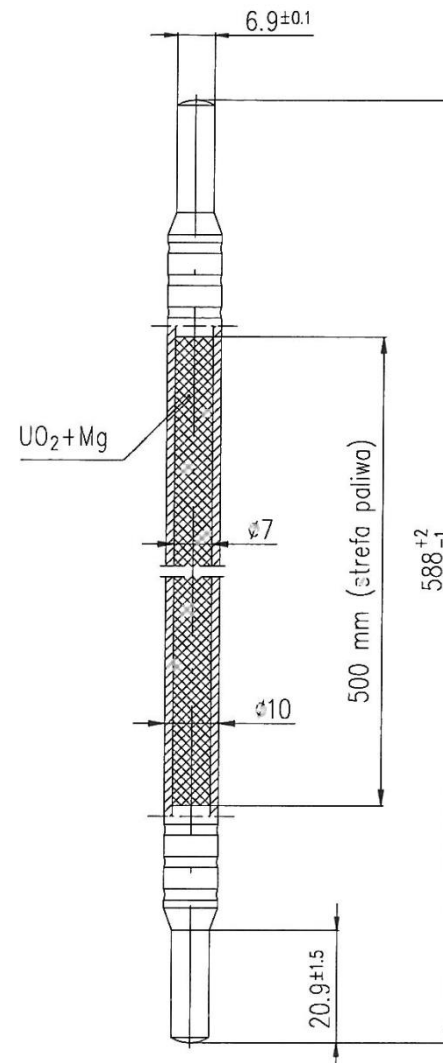
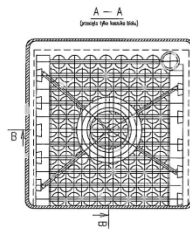
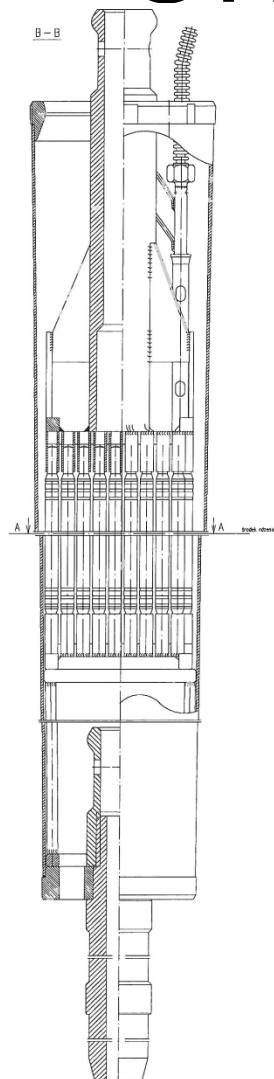
Origin of questions



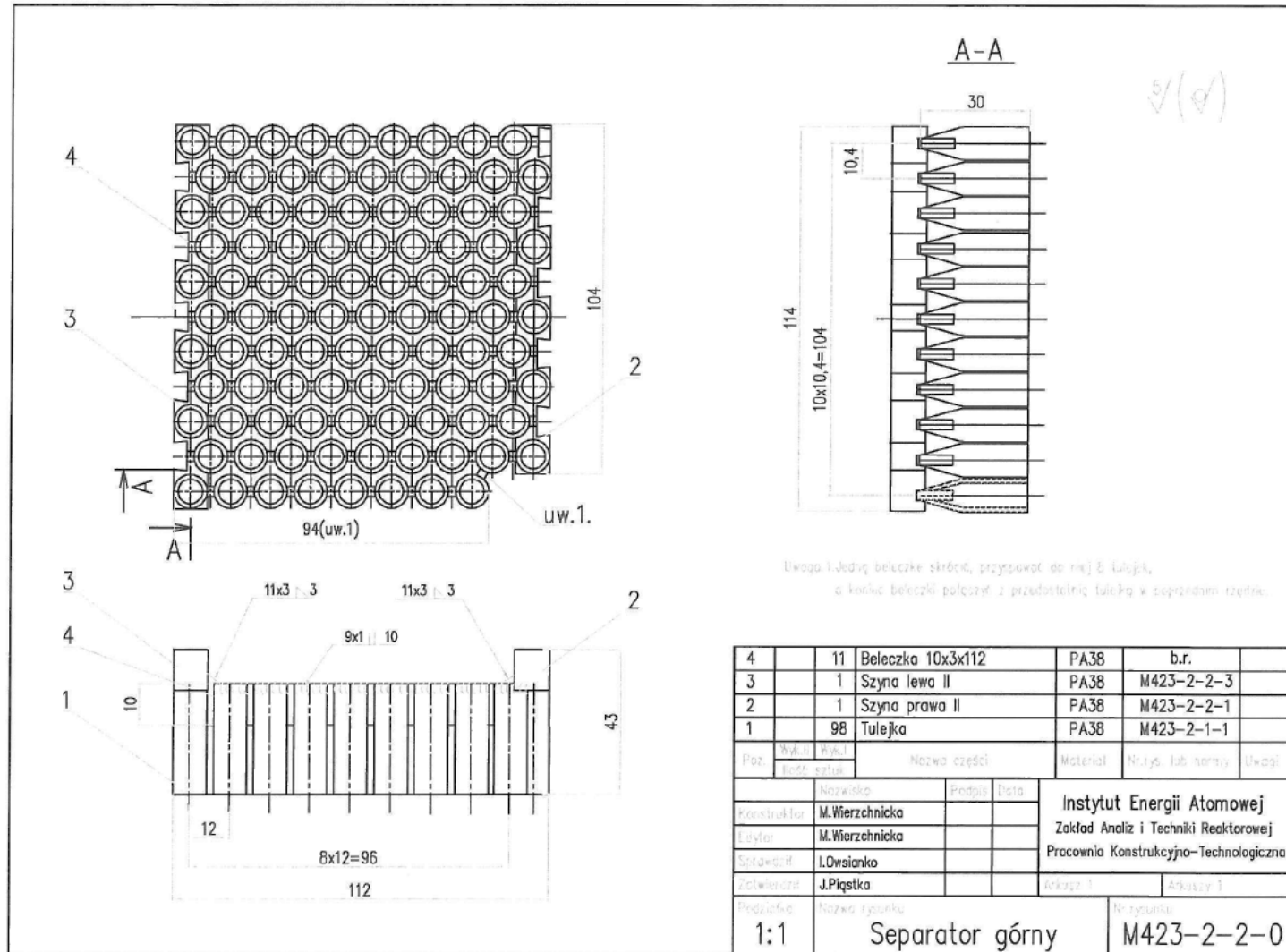
CAD
blueprints



Origin of questions



Origin of questions



Origin of questions



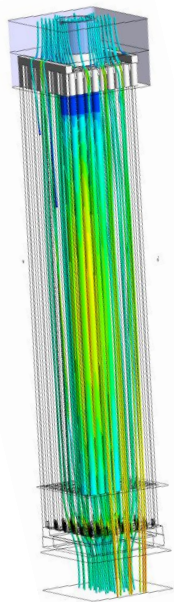
CAD
blueprints



Origin of questions



CAD
blueprints

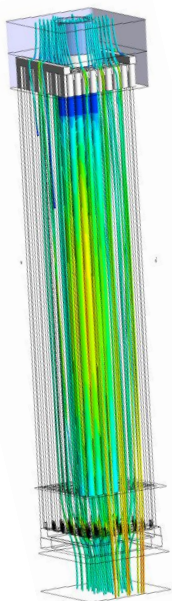


Safety
analysis
i.e. CFD

Origin of questions



CAD
blueprints



Safety
analysis
i.e. CFD

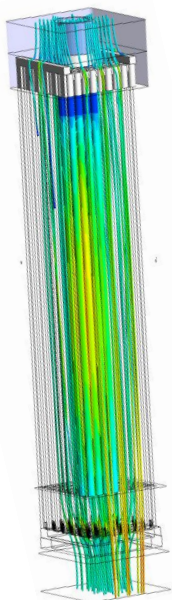


Manufactured
object

Origin of questions



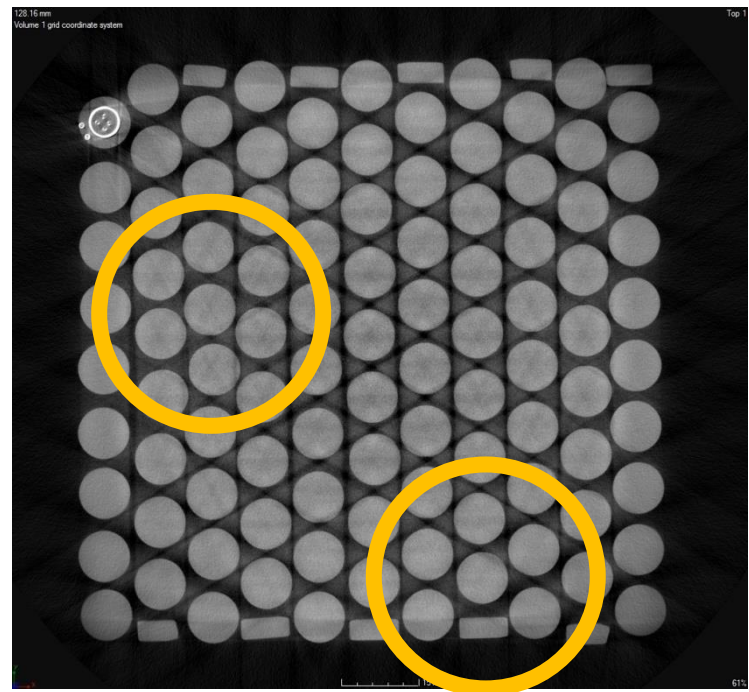
CAD
blueprints



Safety
analysis
i.e. CFD



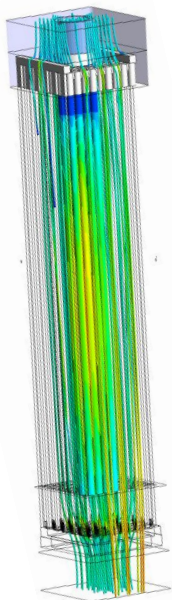
Manufactured
object



Origin of questions



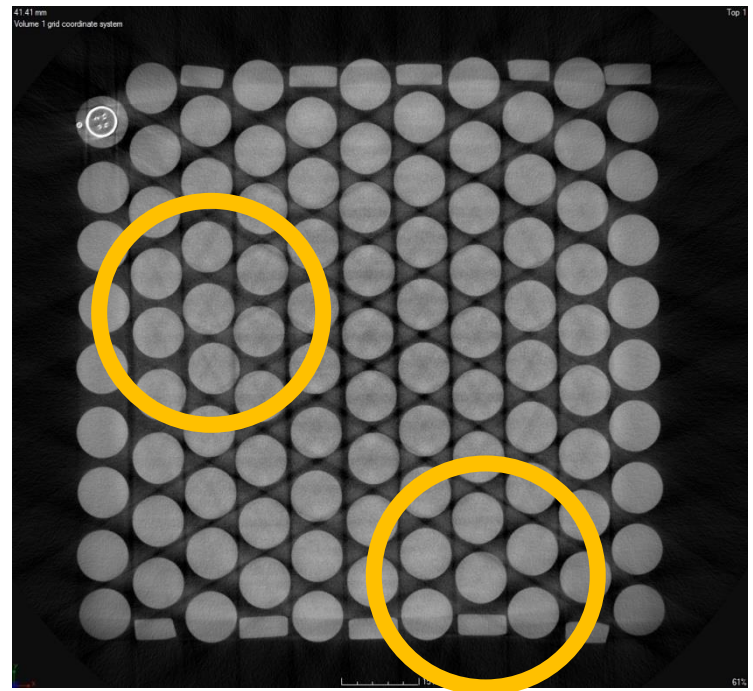
CAD
blueprints



Safety
analysis
i.e. CFD



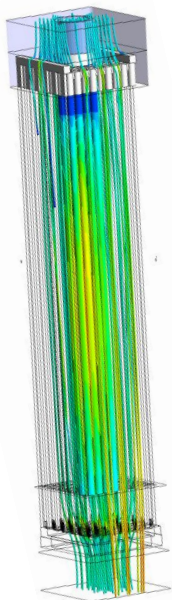
Manufactured
object



Origin of questions



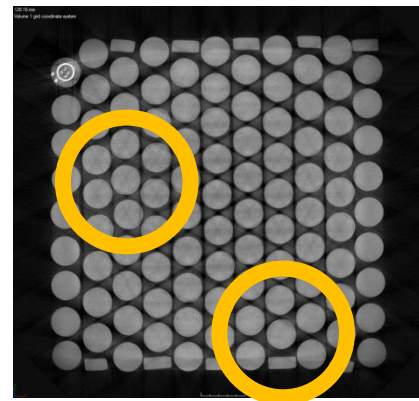
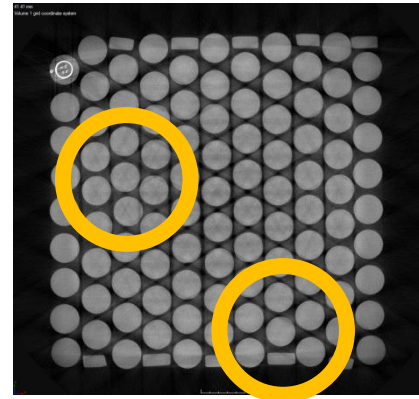
CAD
blueprints



Safety
analysis
i.e. CFD



Manufactured
object

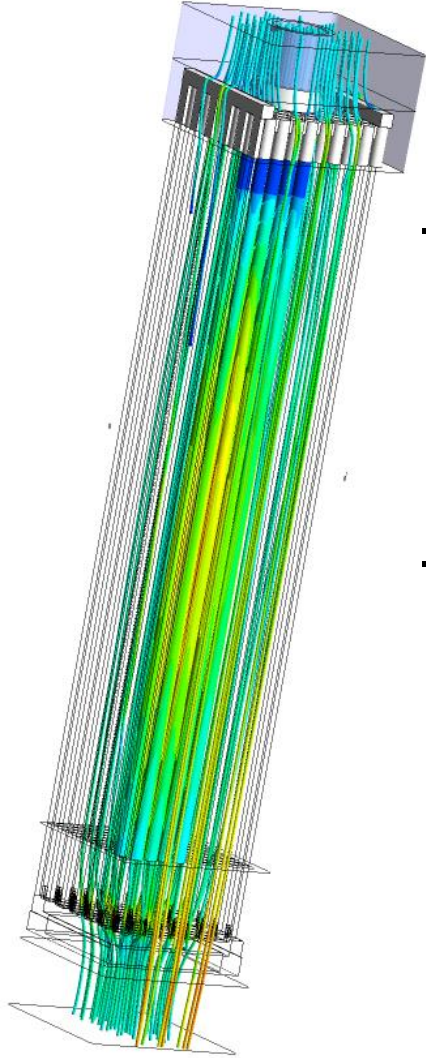


Computer
Tomography



3D scan

Fuel Bundle case



- Preliminary CFD study based on simplified CAD geometry
 - flow conditions
 - heat and flow
- CFD study of reversed engineered 3D fuel bundle:
 - flow conditions:
 - separate samples, i.e. **top** and bottom **spacer grids**, rods treated individually
 - full body
 - heat and flow for full body
- Final comparison

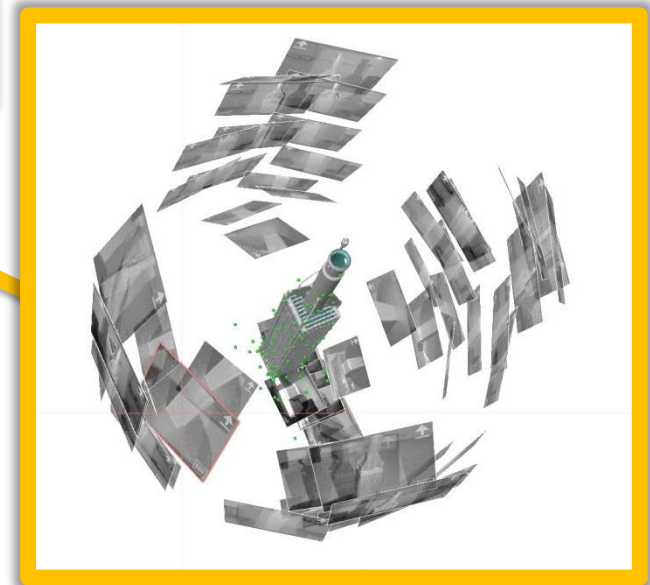
Geometrical data acquiring

- Reverse Engineering procedure
 - Scanning
 - Extracting single point clouds
 - Filtering point clouds
 - Point clouds alignment (reorientation)
 - Surface mesh creation
 - ~~new CAD documentation (CAD vs. scan comparison)~~
 - Body domain (void) construction (boolean operations)

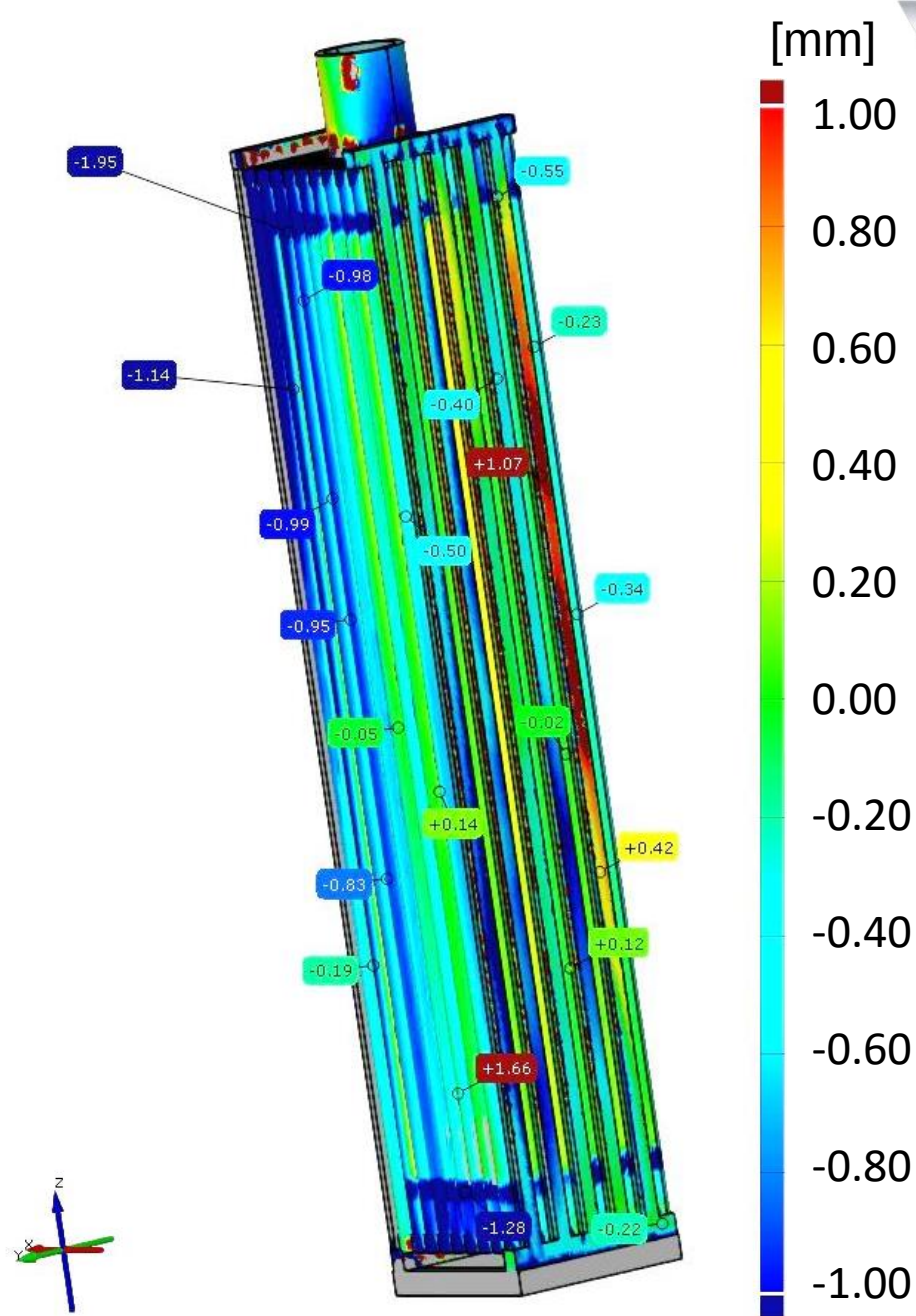


Single scan

All projections (~50 scans)



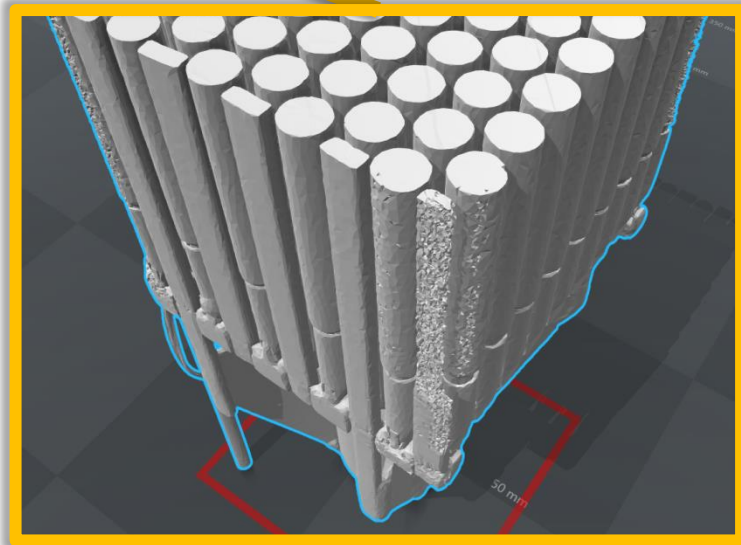
CAD vs. 3D scan comparison



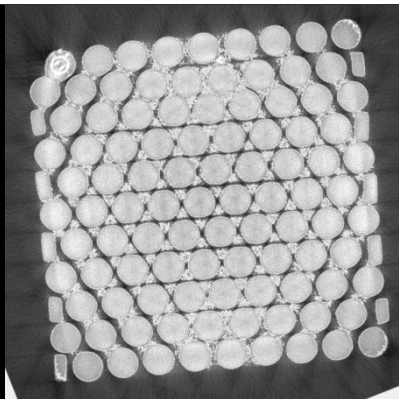
Comments on scanning

- Two techniques have been applied
 - Optical Scanning
 - Computer Tomography

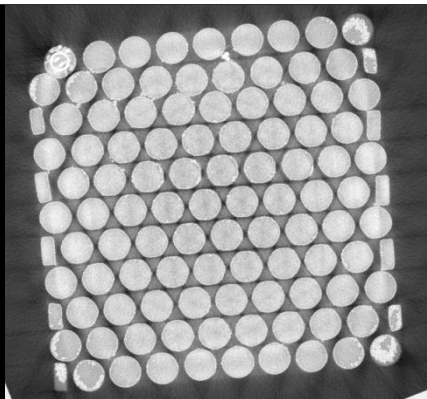
- Why?



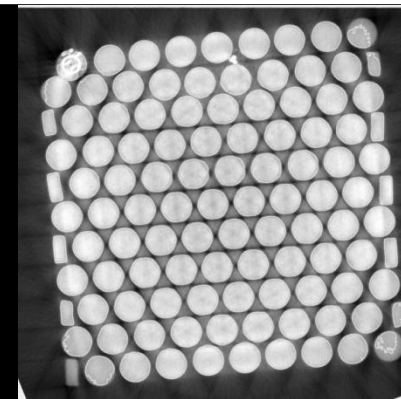
Comments on data filtering



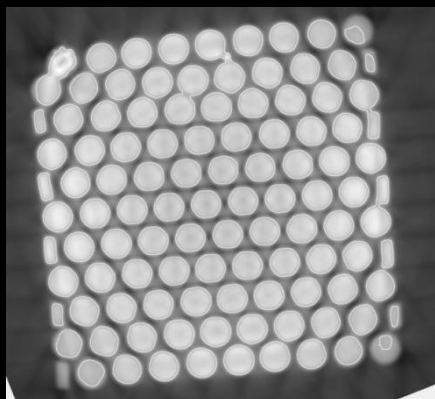
reconstruction (RAW data)



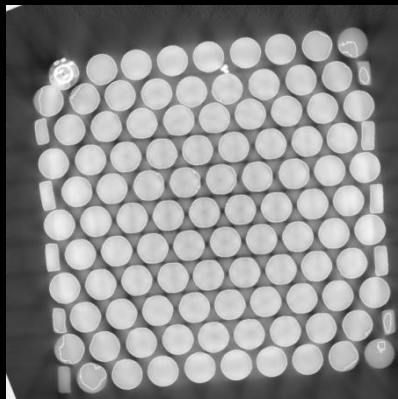
noise and void cancellation



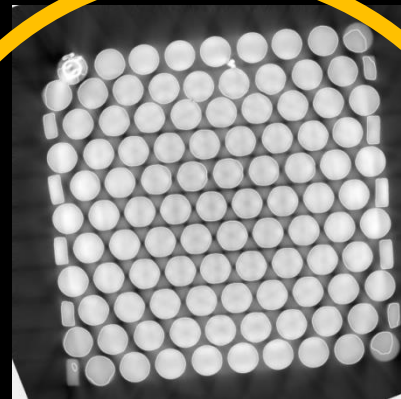
gauss filter



adaptive gauss high filtering



adaptive gauss low filtering



adaptive gauss low filtering +
gauss filter

Optical Scanner

- **GOM ATOS Triple Scan**
 - **type:**
structural light
 - **work area:**
320x320 or 560x560 mm
 - **resolution:**
up to 10^{-5} m
(teens of micrometers)



Computed Tomography Scanner

- **Nikon XT H 225 ST**

- **volume area:**

450 x 350 x 725 mm

- **Detector:**

Perkin Elmer 1620,
16-bit, 3.75 fps

- **Lamps/sources:**

- 180kV, 20W, 1 μm -10 μm ,
 - 225 kV, 225W, 3-225 μm ,
 - 225kV, 450W, with rotating target 10-160 μm



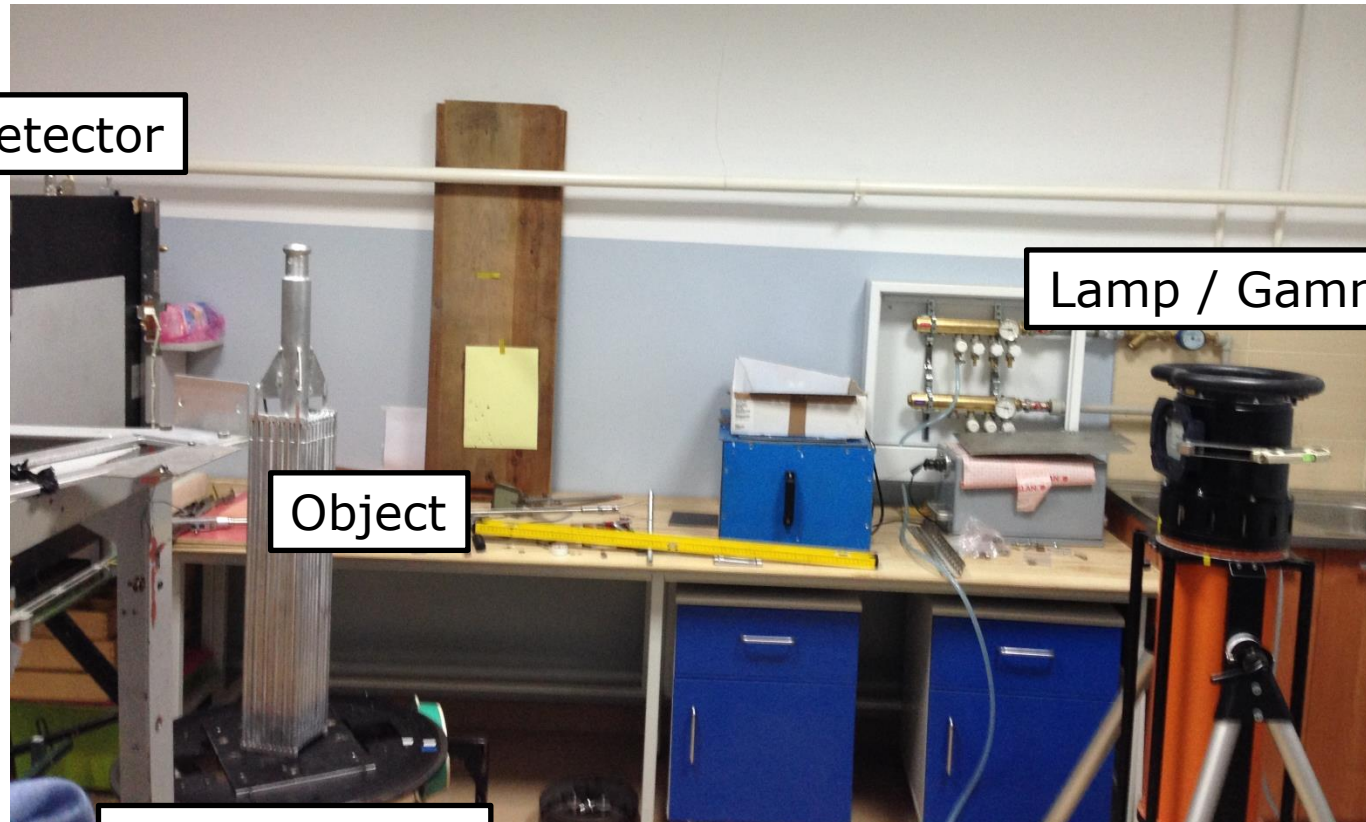
DIY hardware

Detector

Lamp / Gamma Source

Object

Rotating table



Feel free to ask questions
I'll do my best to answer them 😊



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