Examples of the use of AI in solving problems from engineering practice

EURO CZECHIA | NATIONAL COMPETENCE CENTRE IN HPC

ENERGY SECTOR

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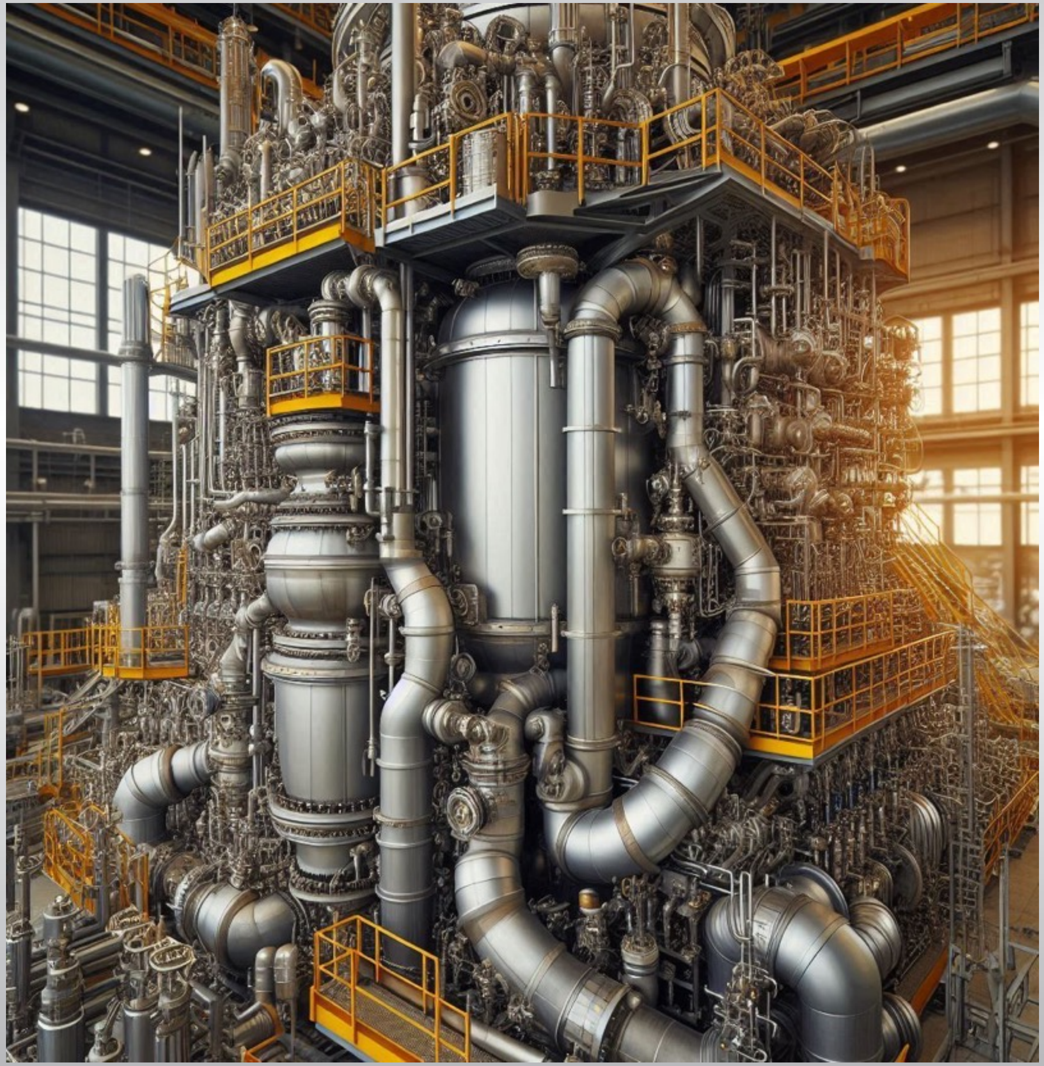

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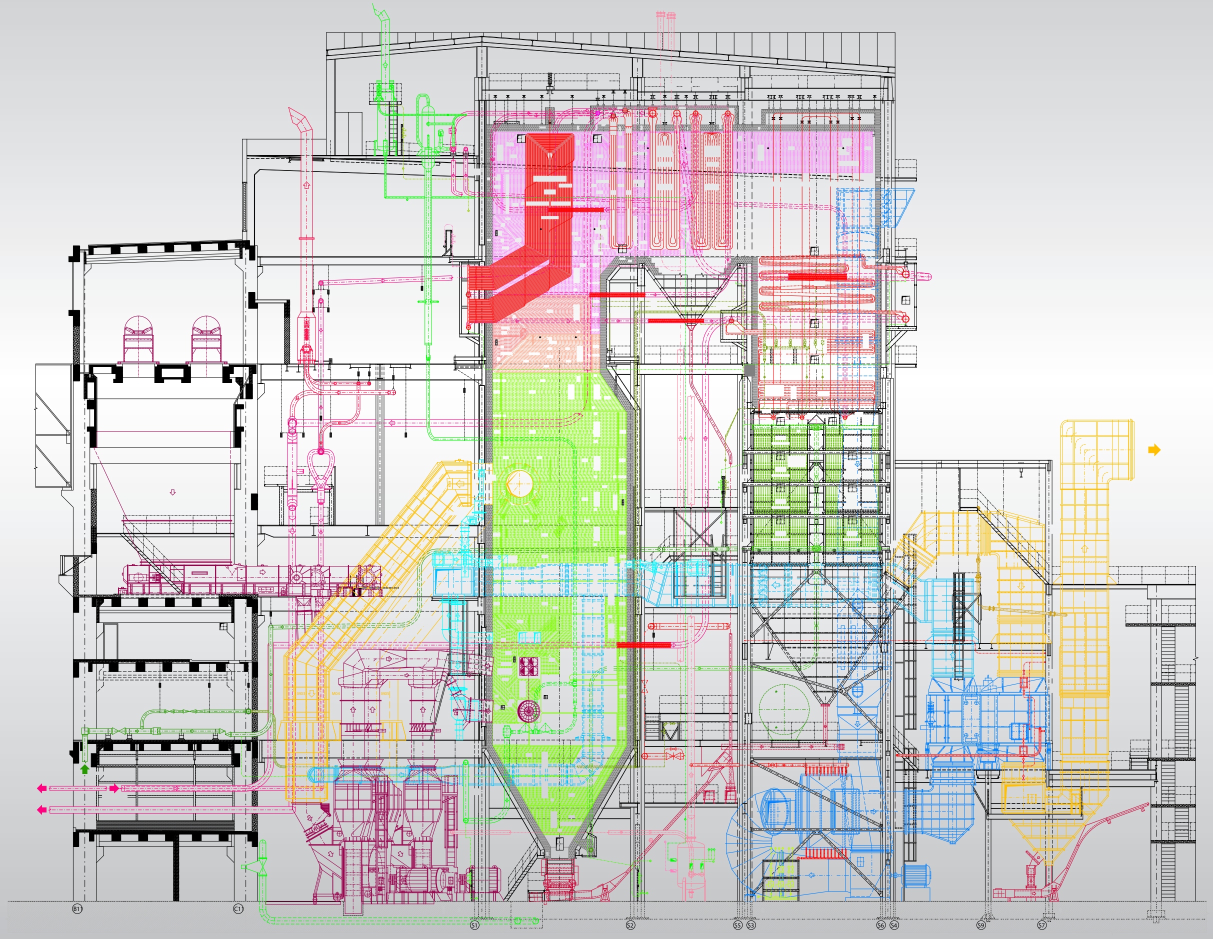

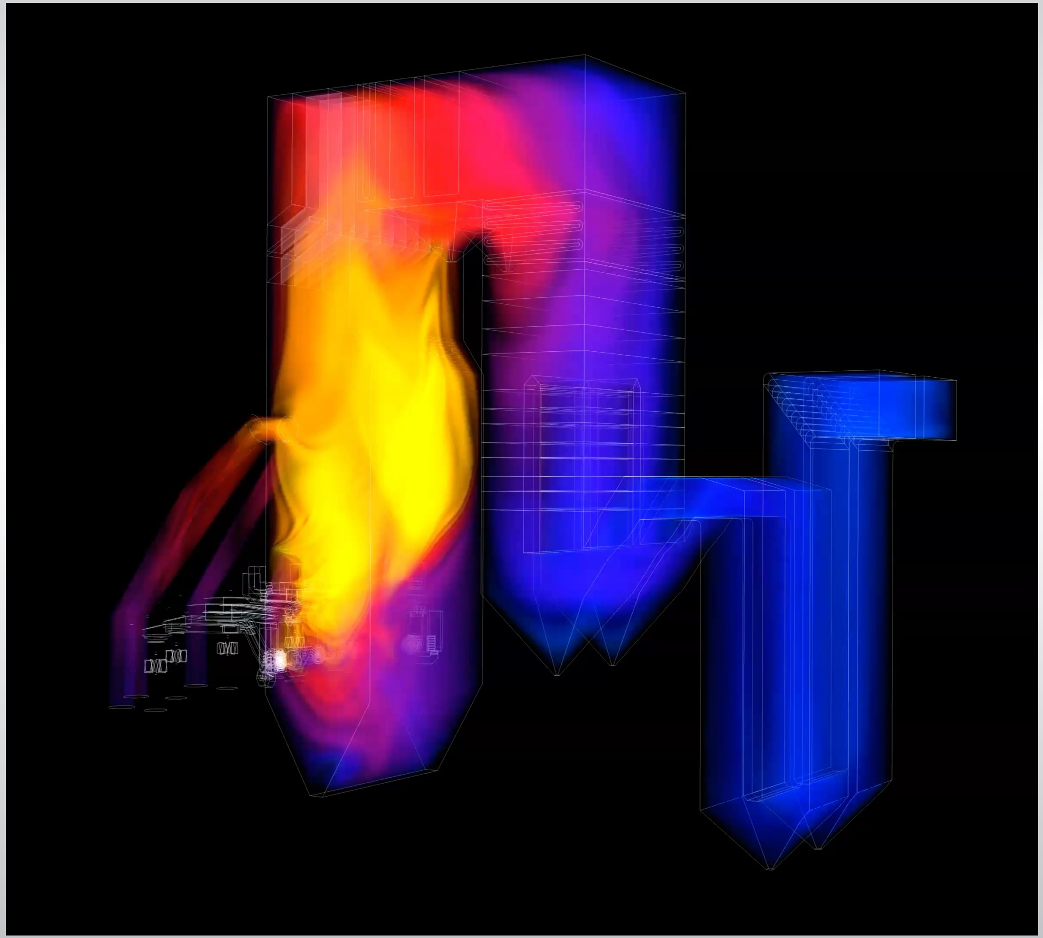

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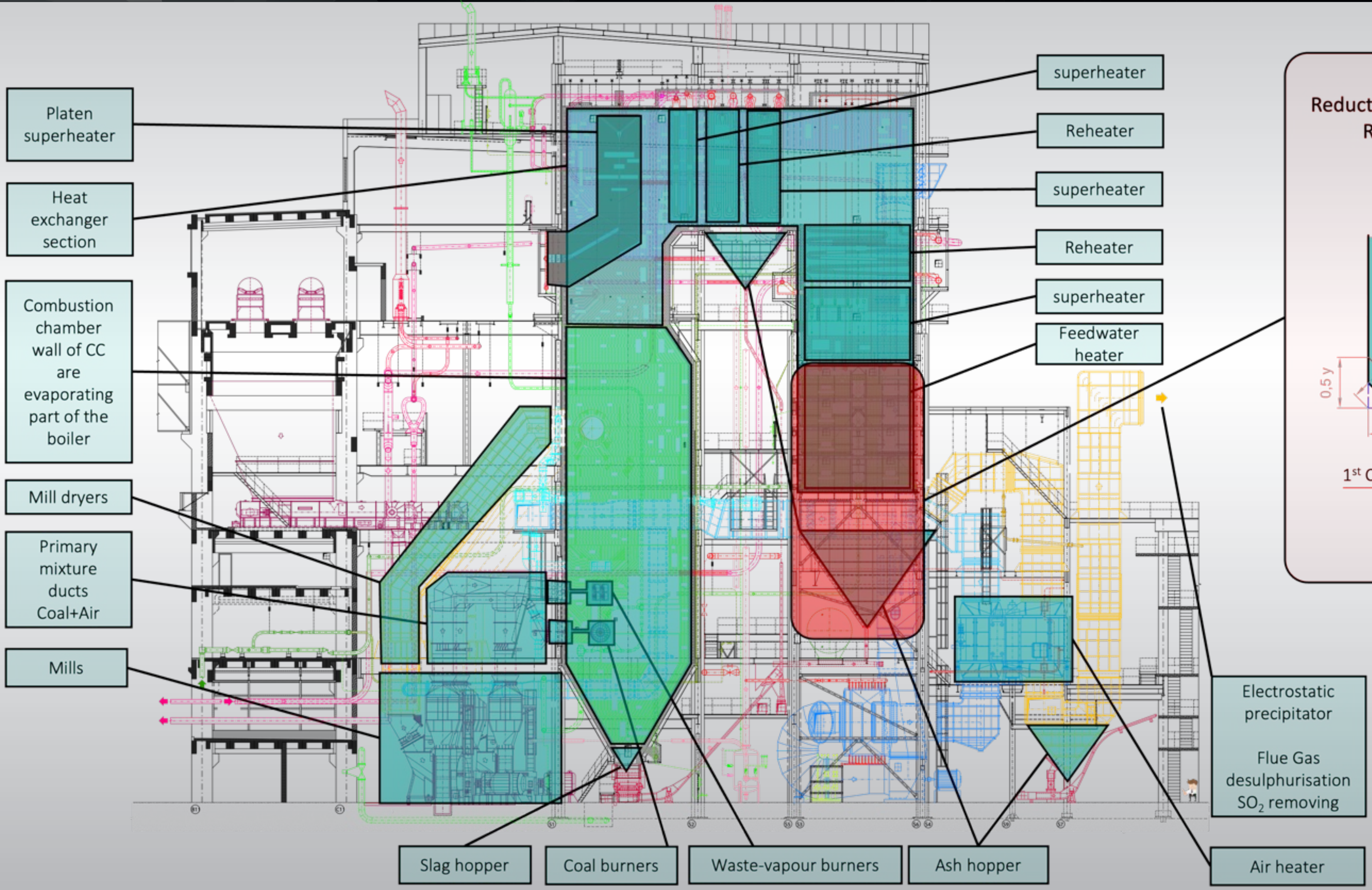

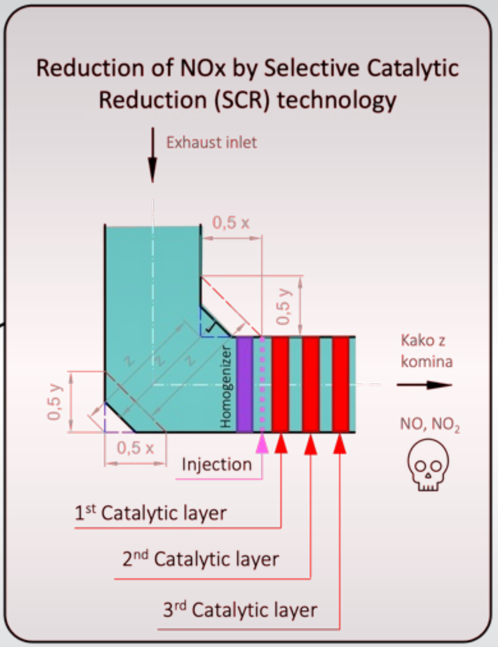

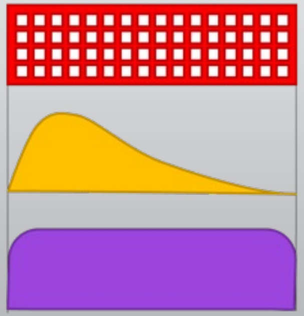

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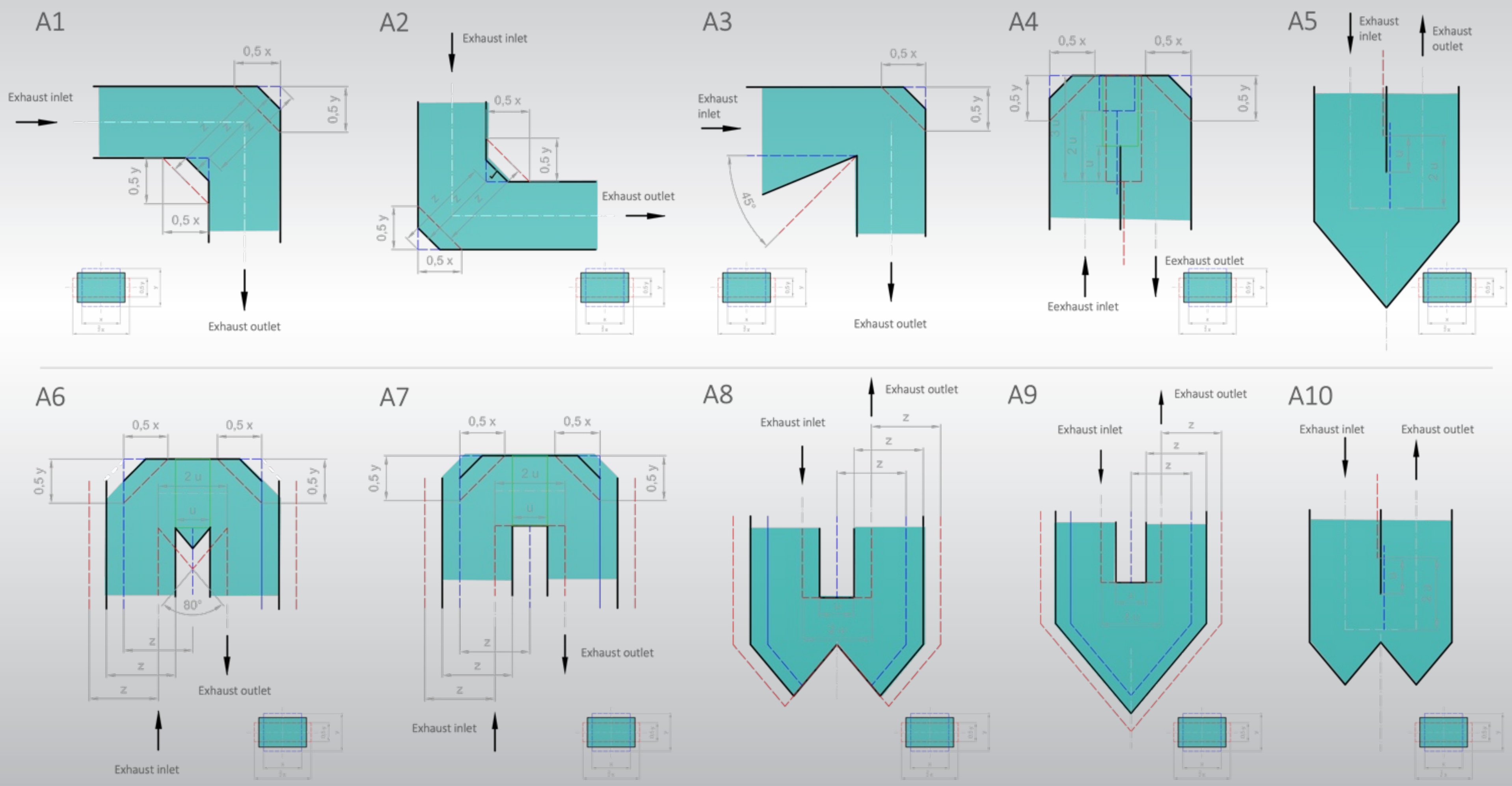
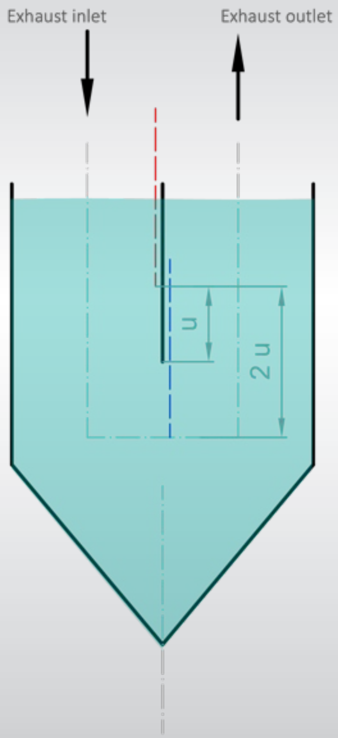


Variant A5



CFD analysis

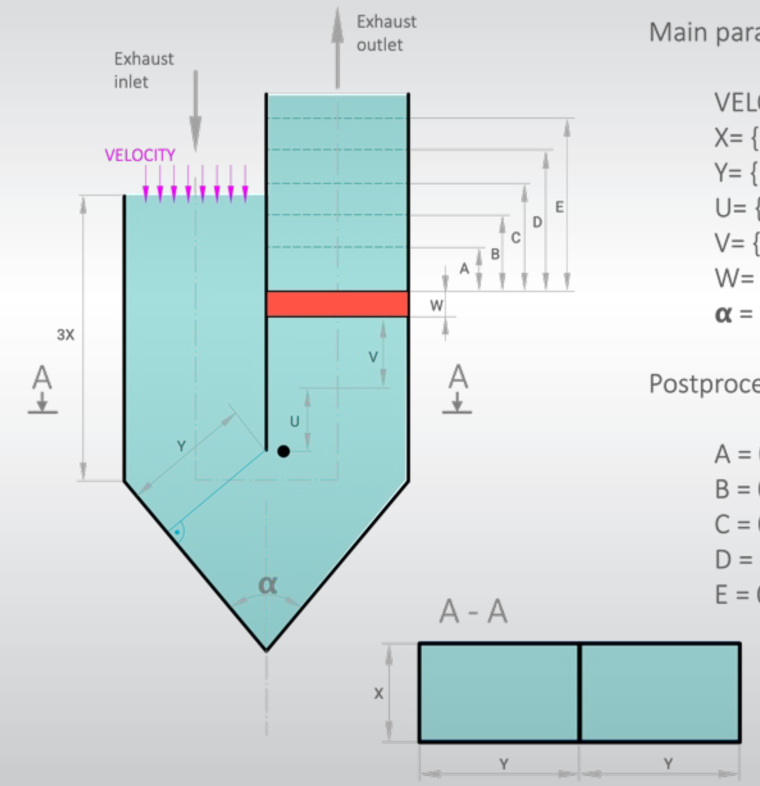
ESI OpenFOAM v2112

- Steady-state solution
- SIMPLE algorithm
- k-epsilon turbulence model
- Turbulence intensity 10%
- Velocity inlet – 2.4 m/s
- Pressure outlet – 0
- Exhaust temperature 500°C
- Exhaust density 0,52 kg/m^3
- Stopping criteria 1e-4
- Pure hexahedral mesh
- 1.275 Million Cells

Postprocessing

- Uniformity of velocity profile evaluation in defined slices

Geometry parametrization

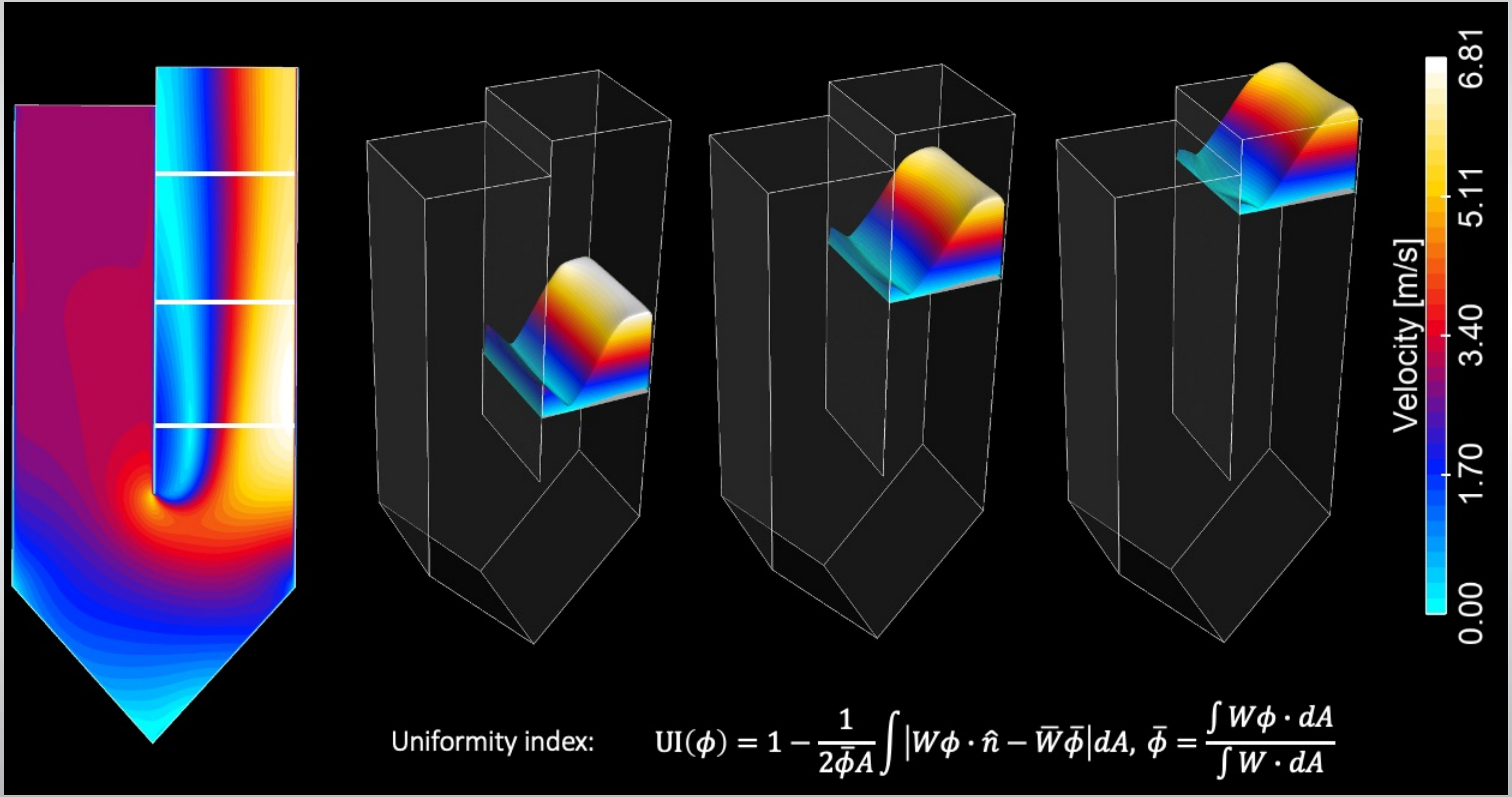


Main parameters:

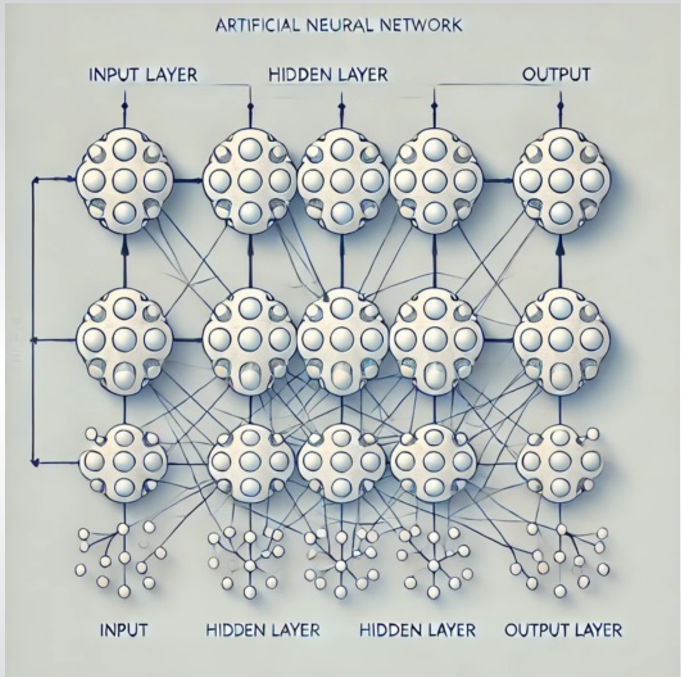
VELOCITY= { 2 ⋯ 4 } [m/s]
X= { 2 ⋯ 20 } [m]
Y= { 0.5X ⋯ X} [m]
U= { 0 ⋯ Y } [m]
V= { 0 ⋯ Y } [m]
W= { 0,1,2 } [m]
α = { 70° ⋯ 90° }

Postprocessing parameters:

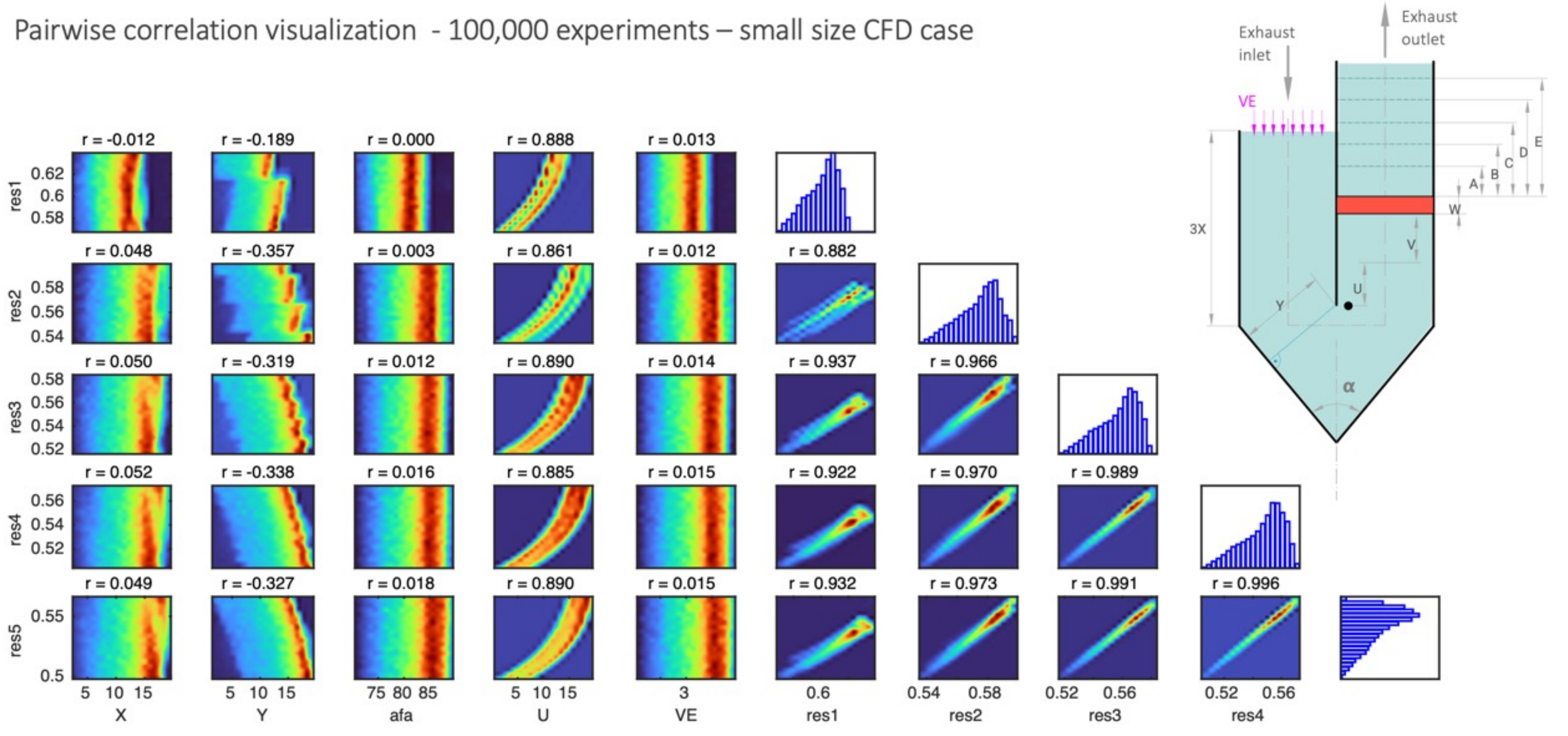
A = 0.1Y
B = 0.2Y
C = 0.3Y
D = 0.4Y
E = 0.5Y


Velocity [m/s]
6.81
5.11
3.40
1.70
0.00
Uniformity index:
$UI(\phi) = 1 - \frac{1}{2\bar{\phi}A}\int \left|W\phi \cdot \hat{n} - \bar{W}\bar{\phi}\right| dA,\ \bar{\phi} = \frac{\int W\phi \cdot dA}{\int W \cdot dA}$

ENERGY SECTOR



Pairwise correlation visualization - 100,000 experiments – small size CFD case



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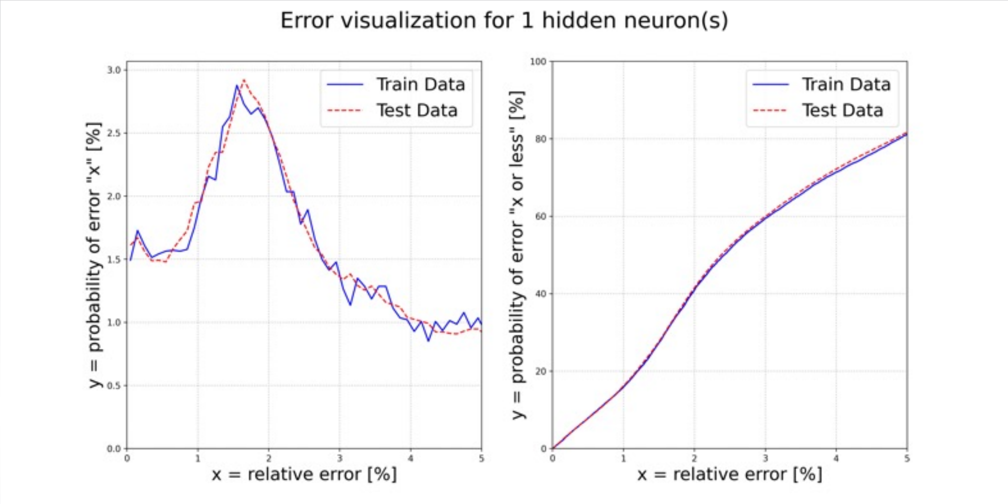

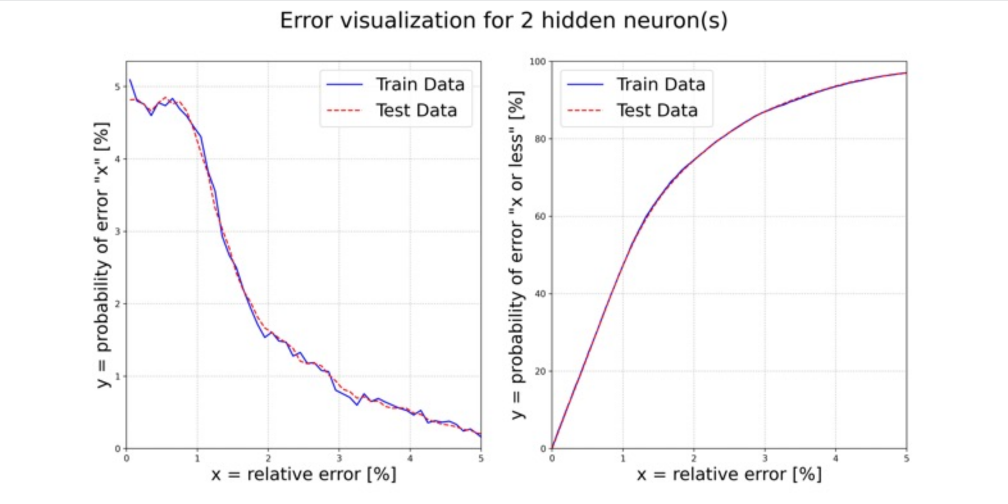

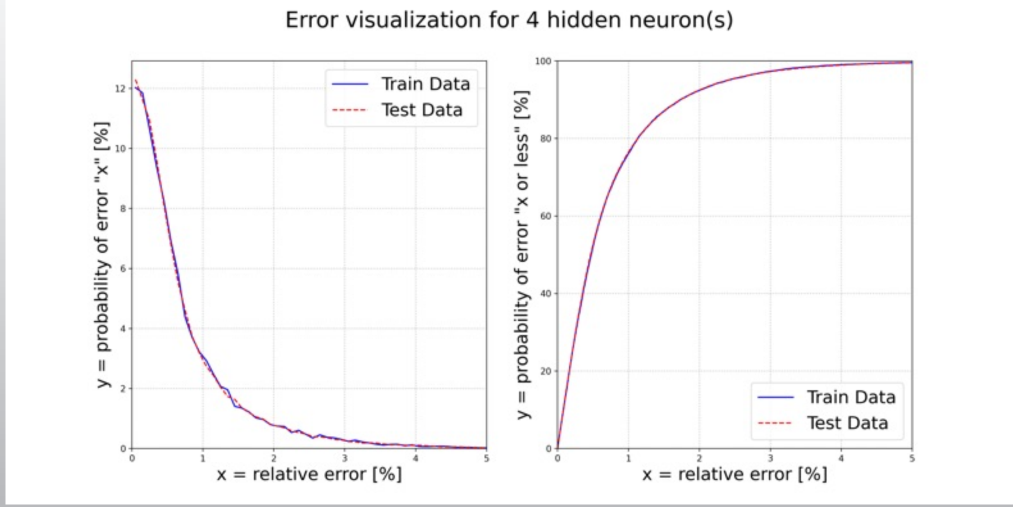

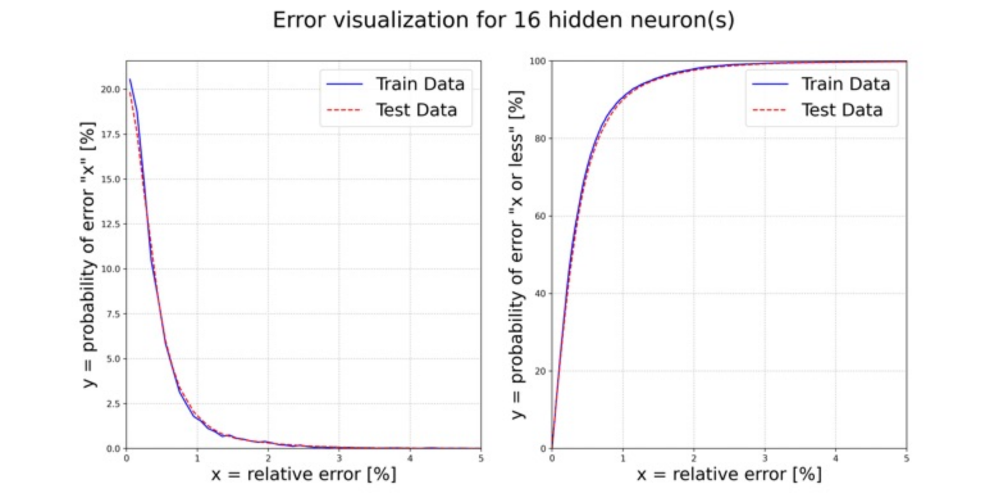

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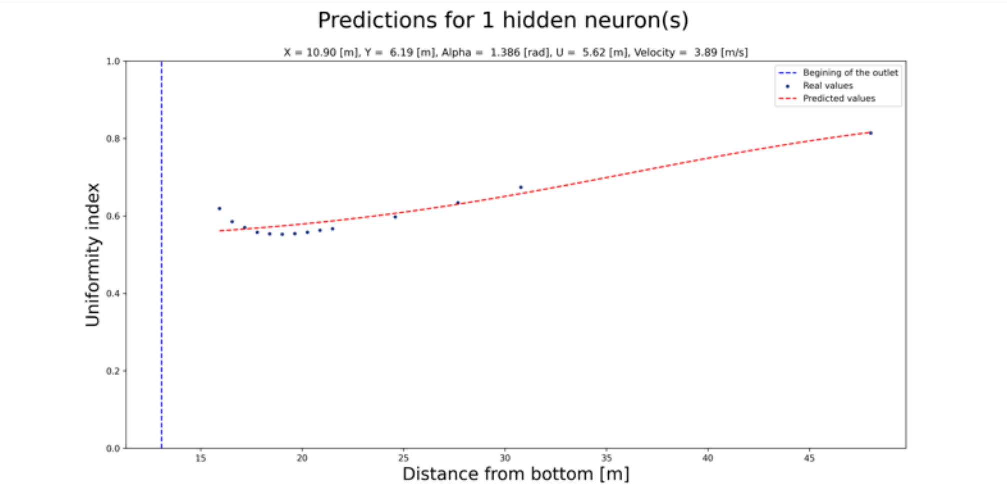
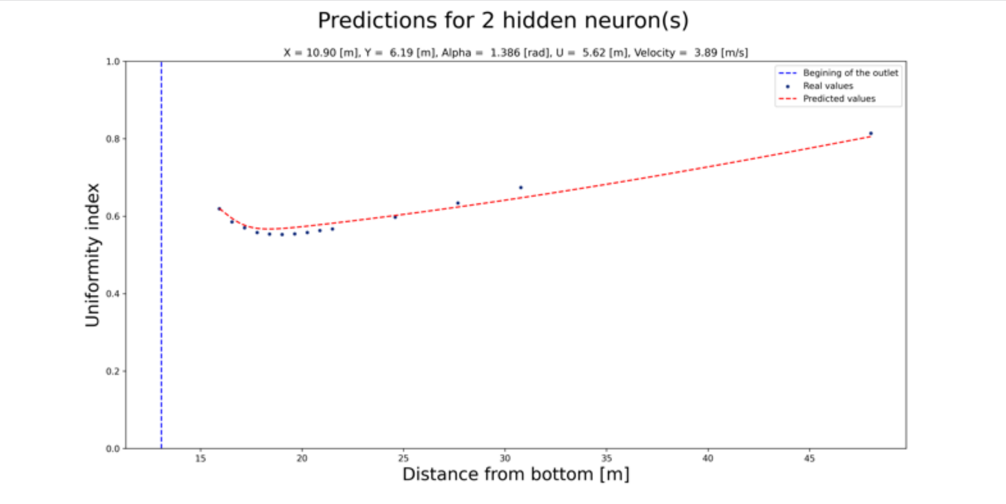
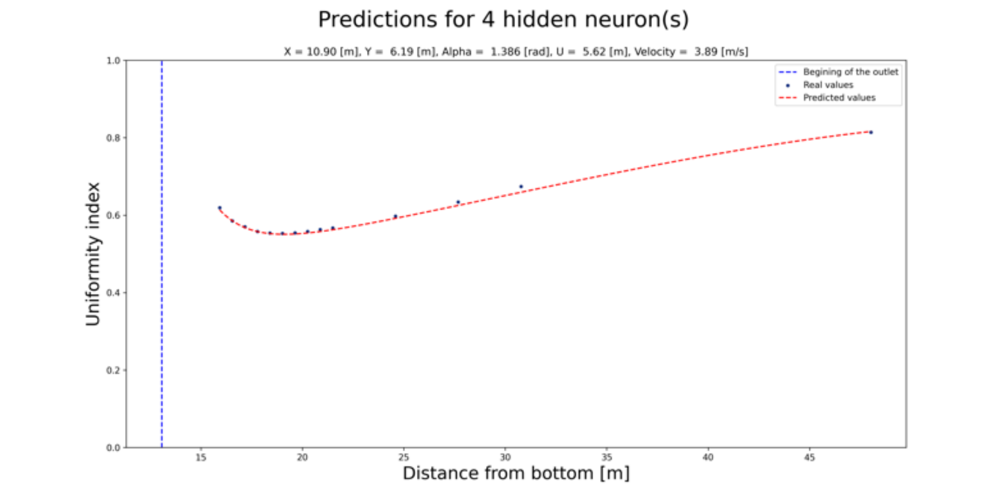
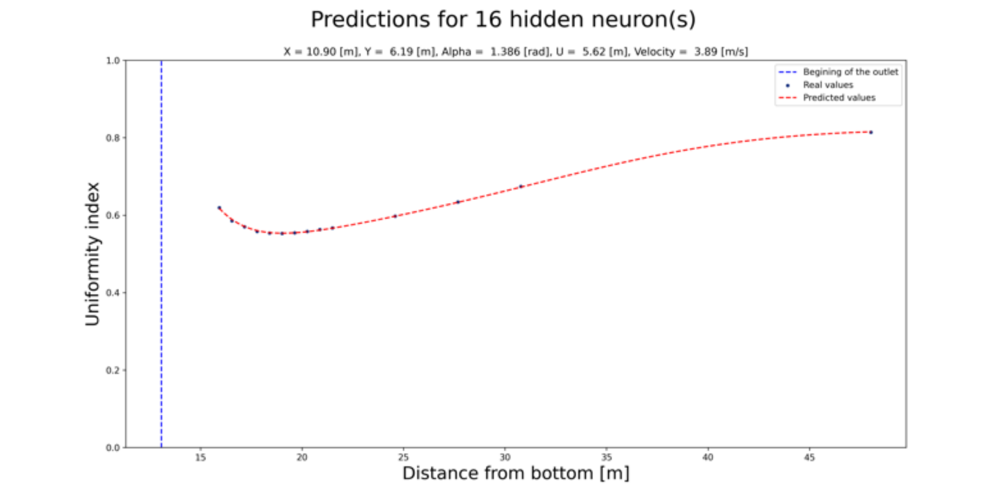


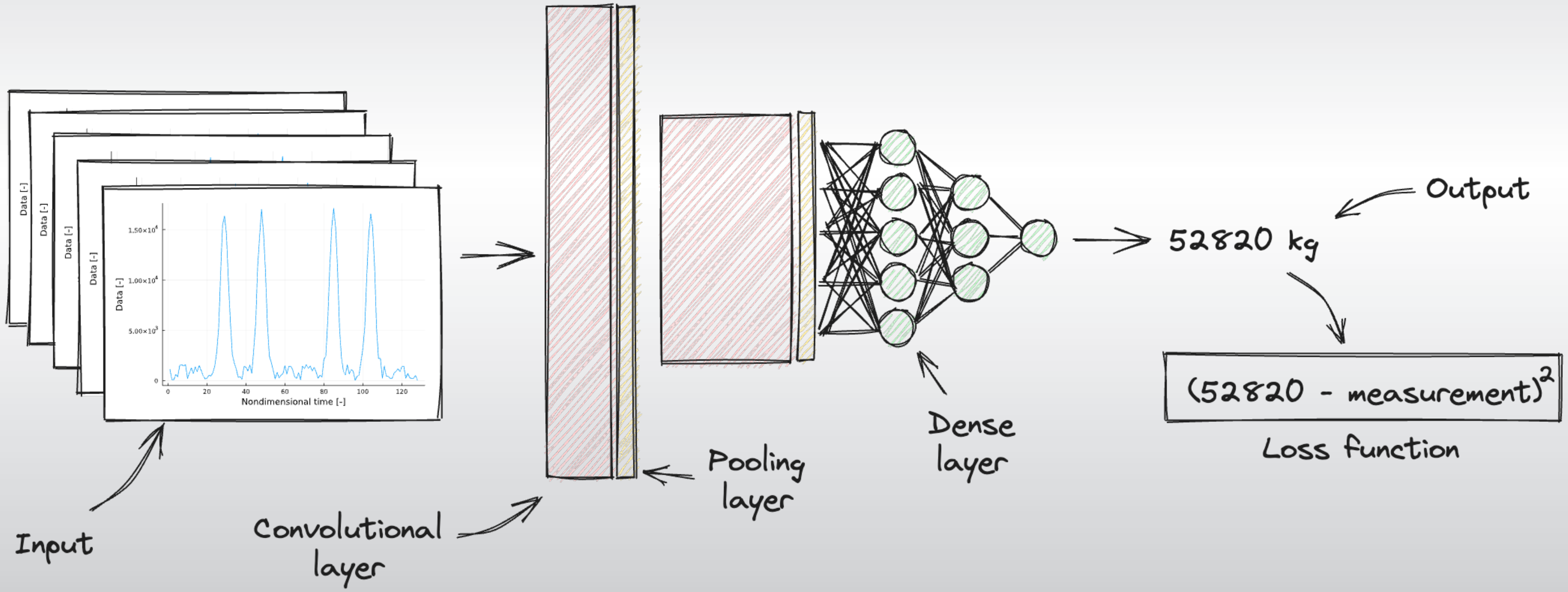






TRANSPORTATION

TRANSPORTATION



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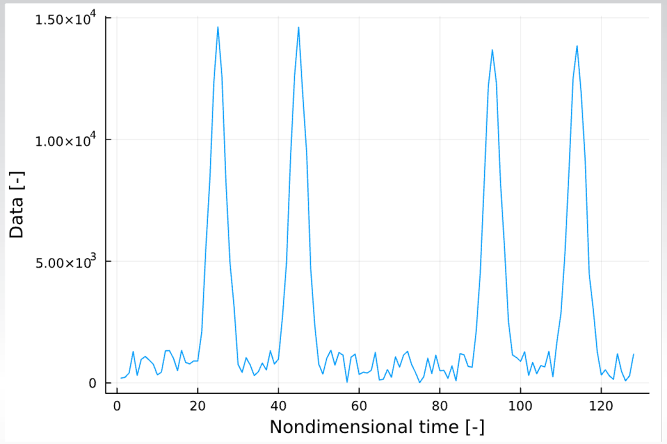

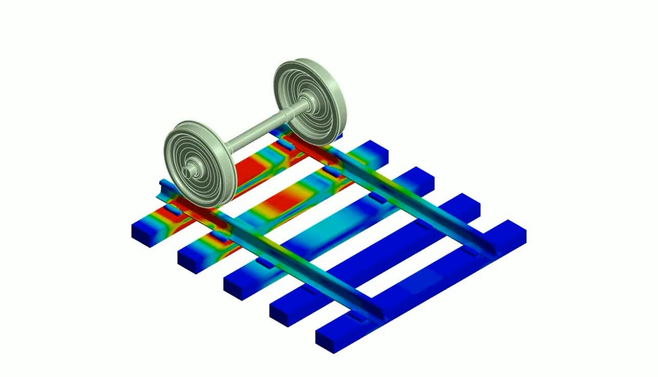

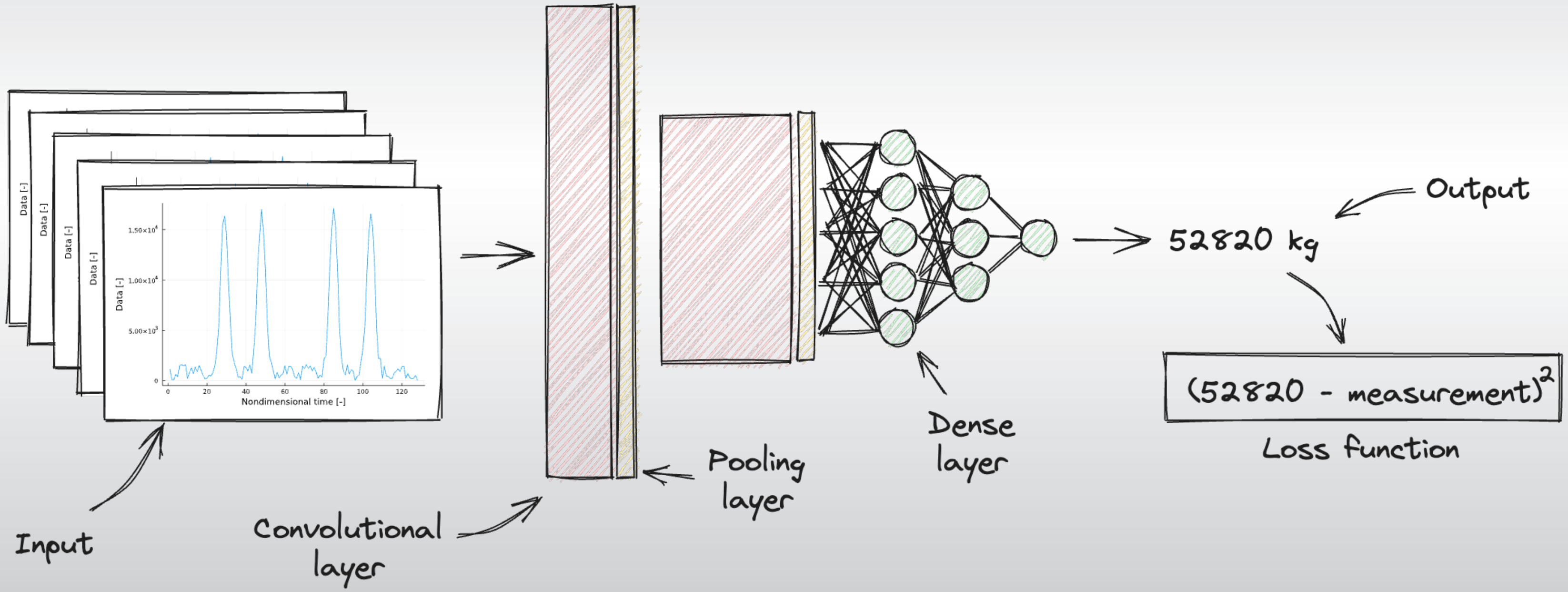

TRANSPORTATION

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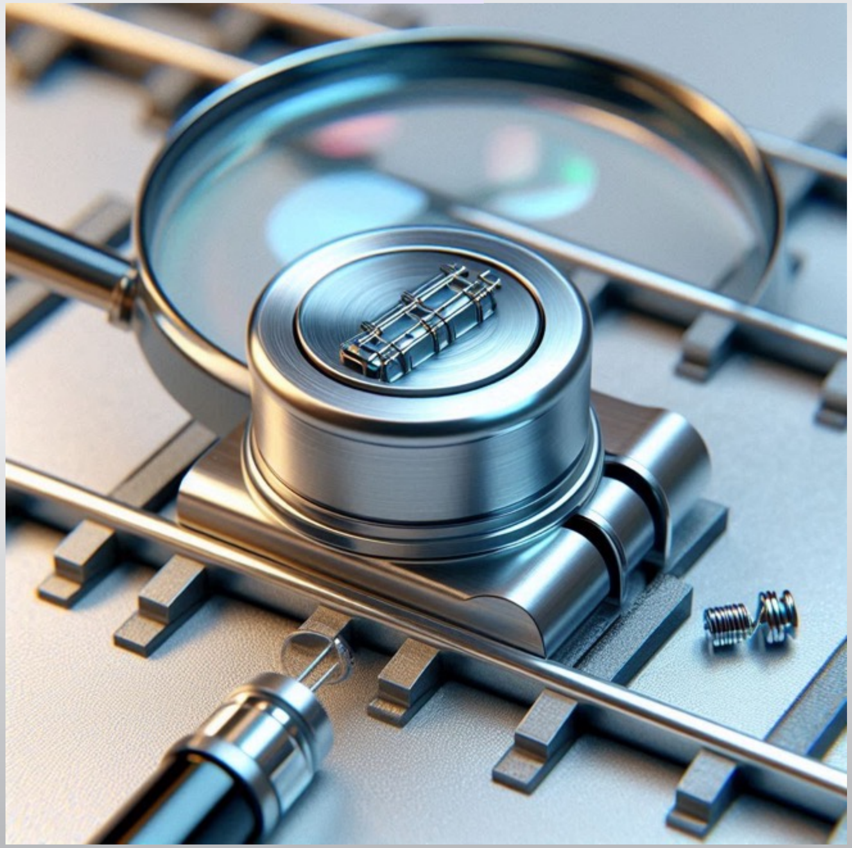
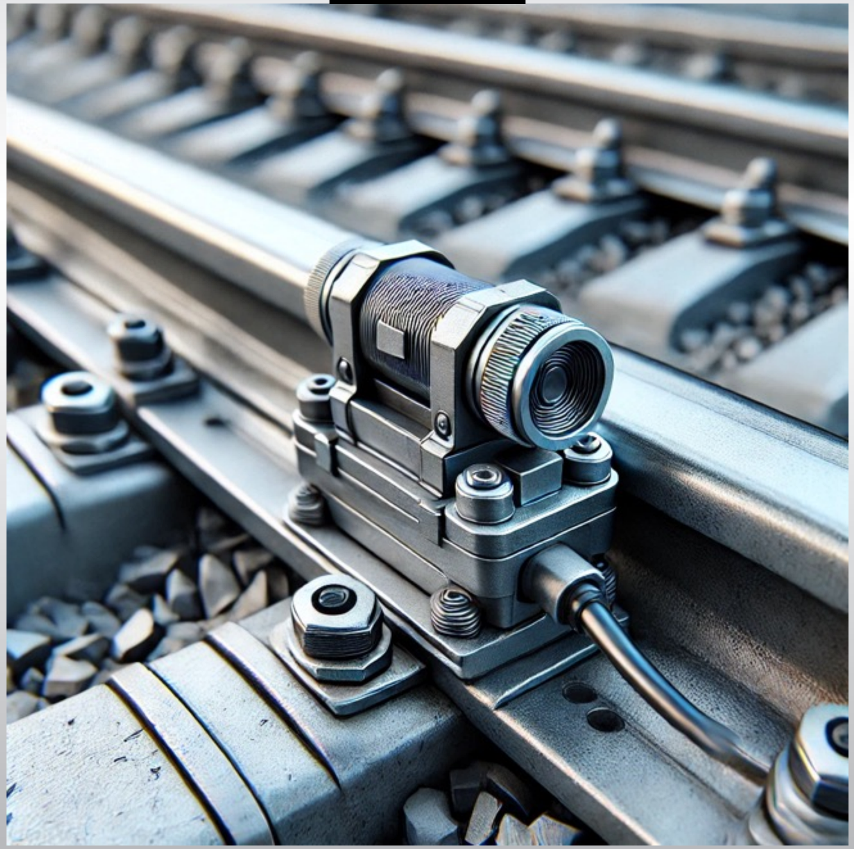
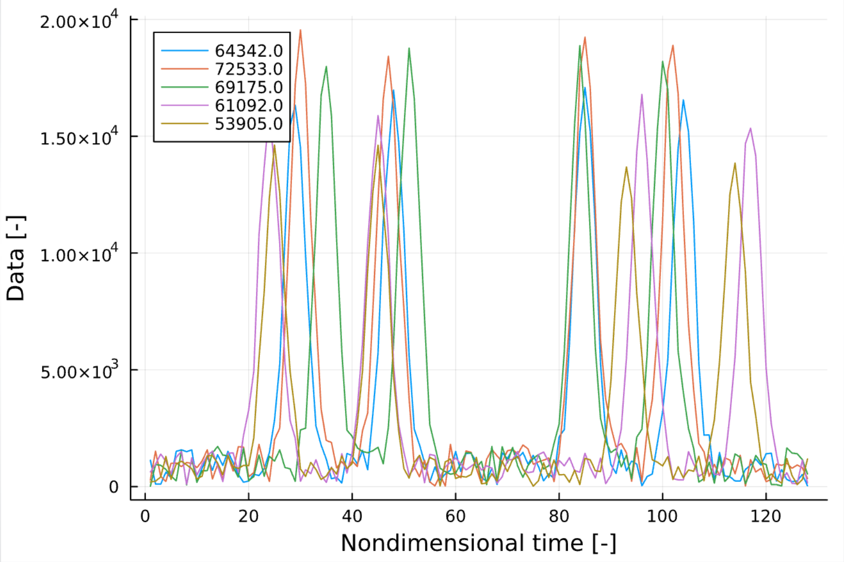
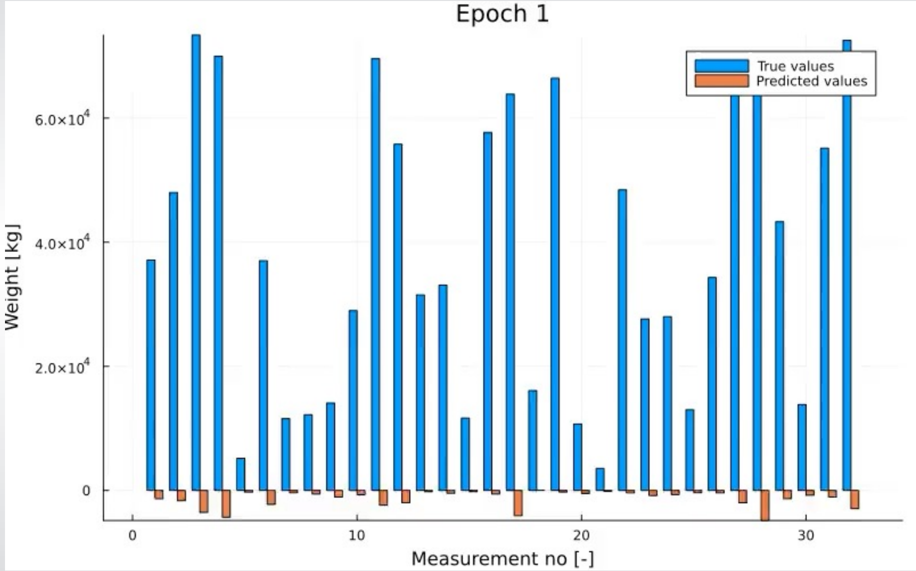
Copilot





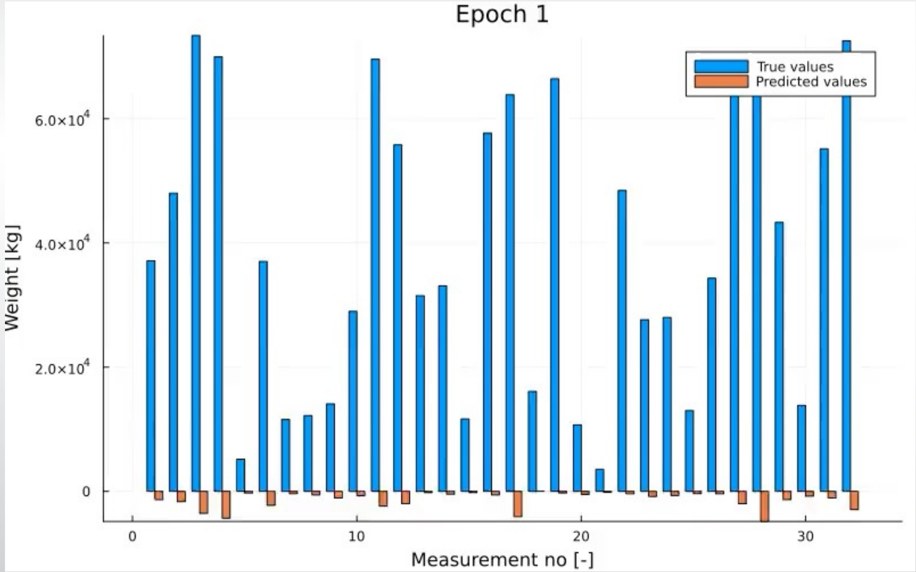
Synthetic data – training phase

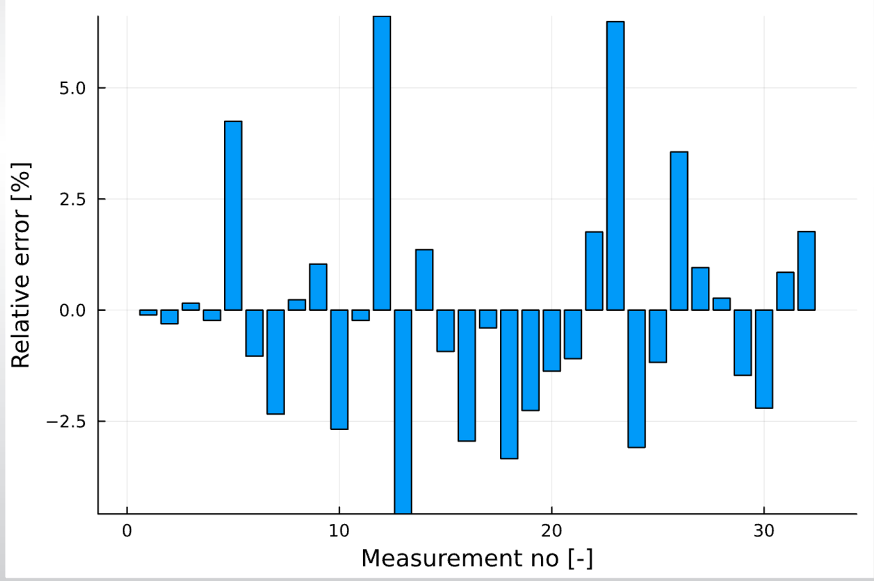




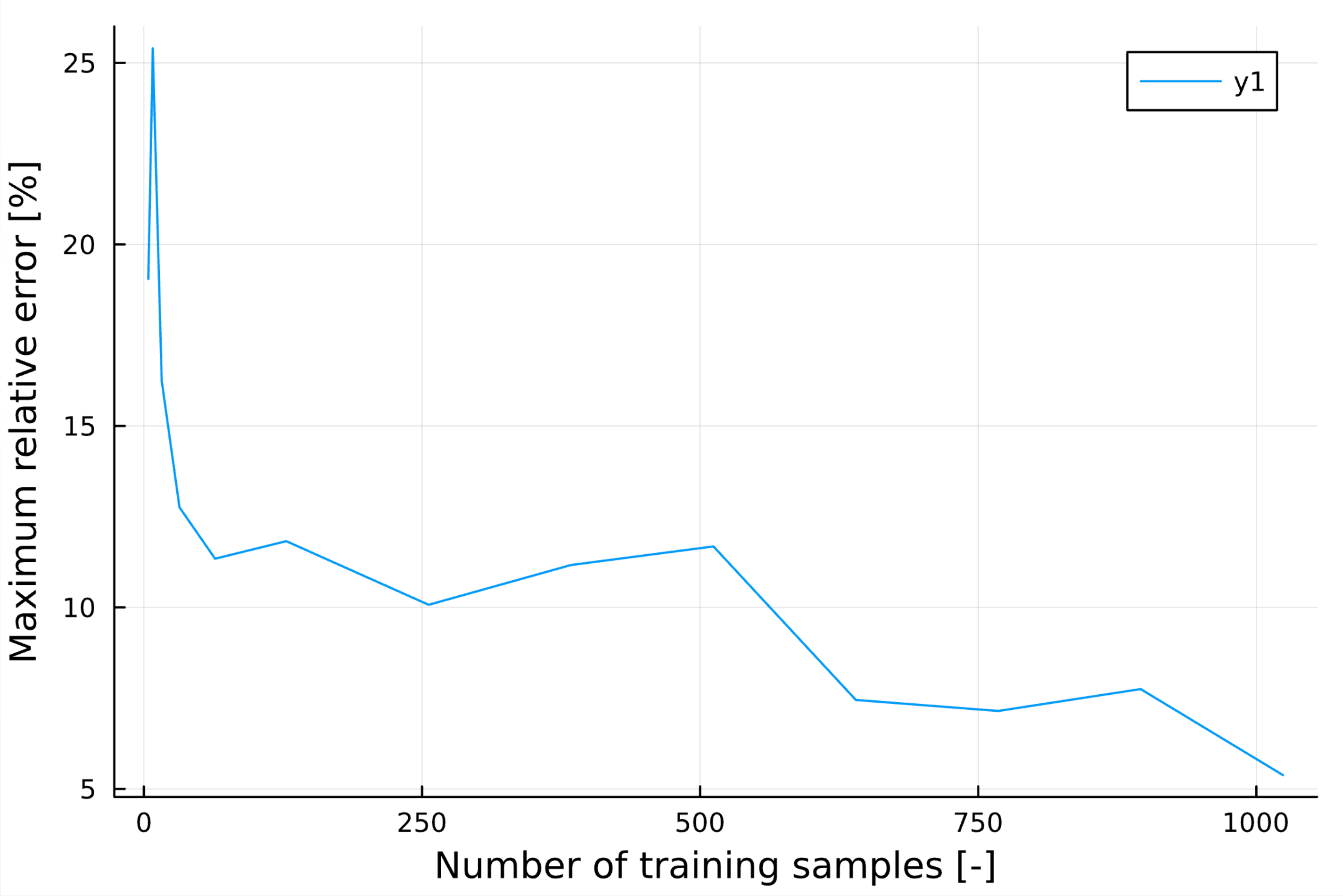
- Implemented with Flux.jl, NN with 70 000 parameters
- 512 measurements for trainig, 32 measurements for testing
- measurements contain 10 % noise

Synthetic data – validation

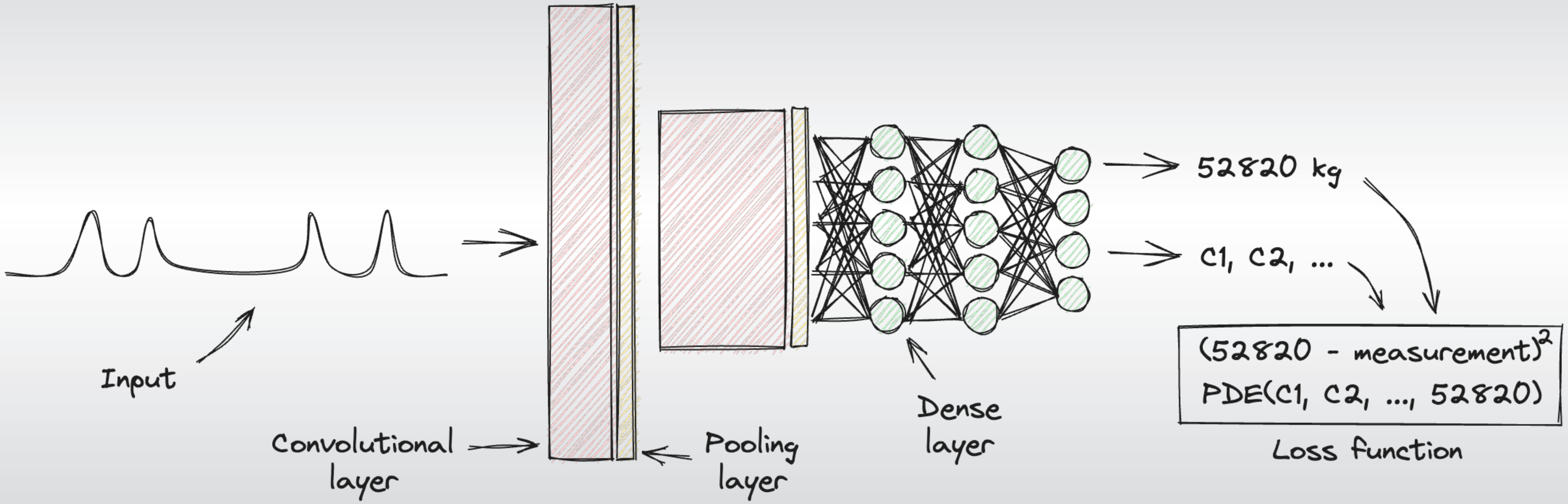




Synthetic data – dataset size



Physics-informed neural networks (PINNs) approach



- physics is included in the model by PDE, NN must satisfy PDE
- parameters C1,C2,… represent e.g. foundation stiffness, rail thermal stress, speed,…
- due to physics information, less training data is needed (less calibration passes -> cheaper)

Thanks for the support.

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