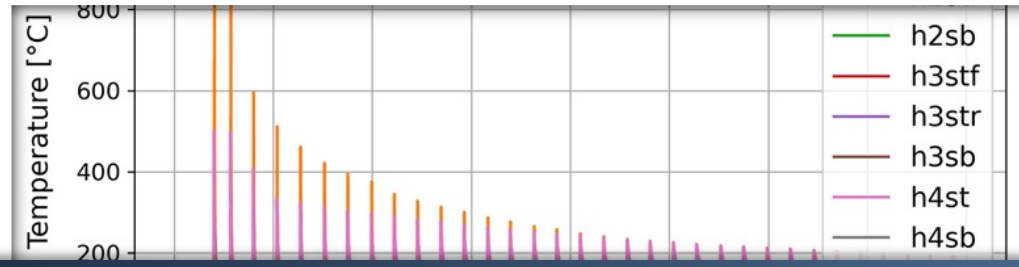
Empa ETH zürich

ECM | Experimental Continuum Mechanics
▪ High Temperature Integrity Group



Applied Machine Learning Days 2022

Physics Informed Neural Networks (PINNs) for thermal analysis of LPBF Process

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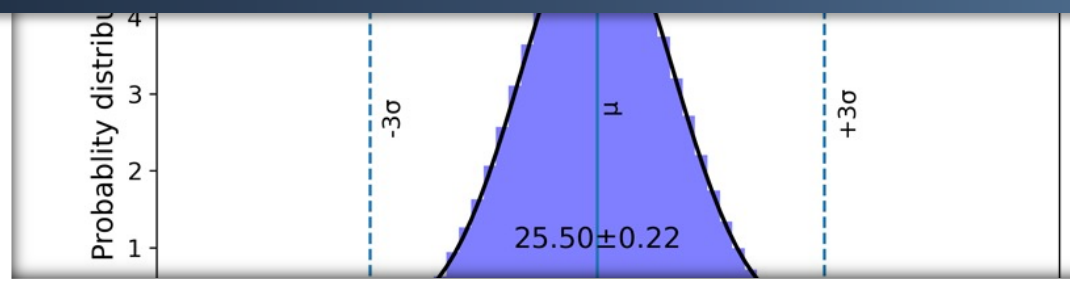
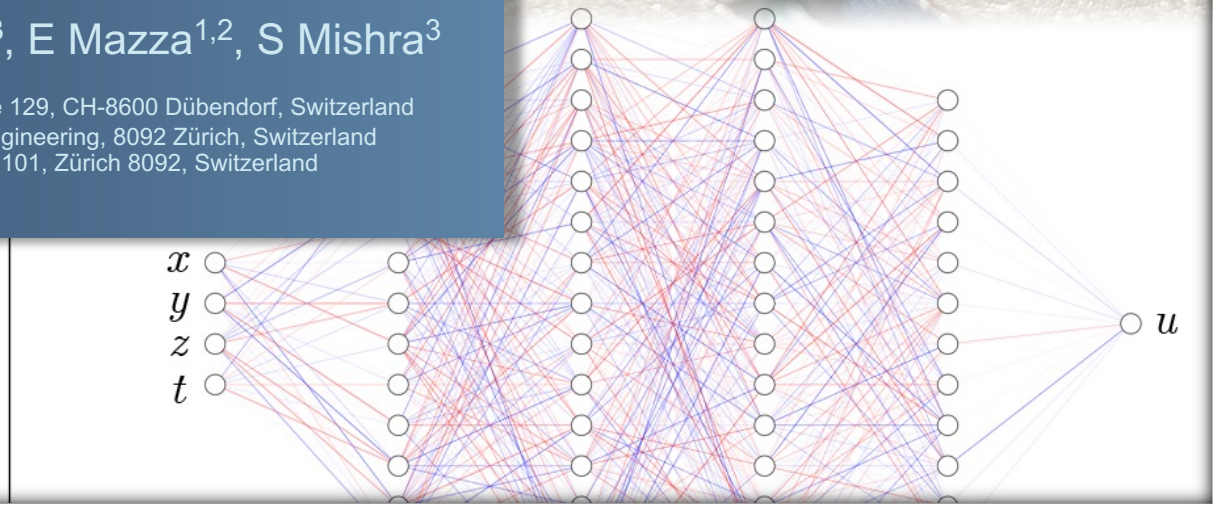
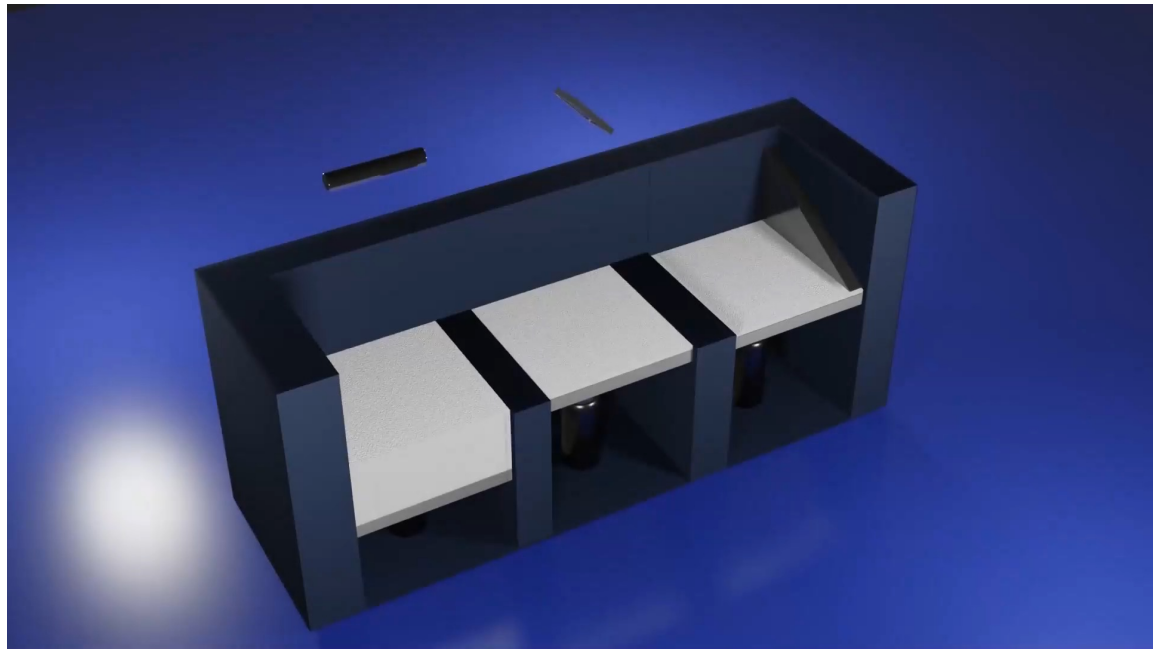




Laser Powder Bed Fusion Additive Manufacturing

- **Advantages**
  - Freedom of design
    - Complex, lightweight parts
  - Short delivery time
  - Elimination of production steps

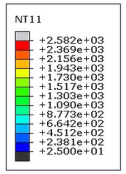


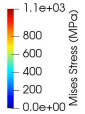
Bradley Clayburn

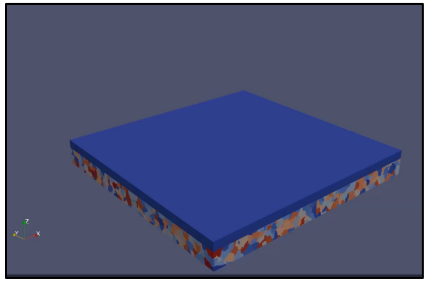
- Challenges
  - Cost
    - Slow build rates
    - Expensive feed material
  - Limited choice of materials
  - Uncertainty in quality
    - Requirement for better understanding of the ongoing phenomena during LPBF

Numerical Analysis of LPBF Process

- **A multi-physical field problem**
  - Thermal, mechanical, metallurgical, etc.







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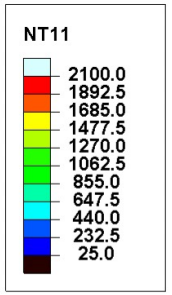
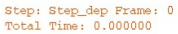
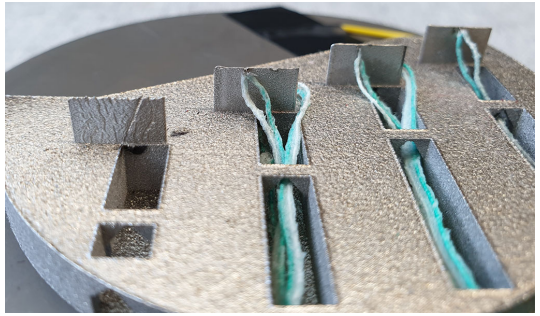
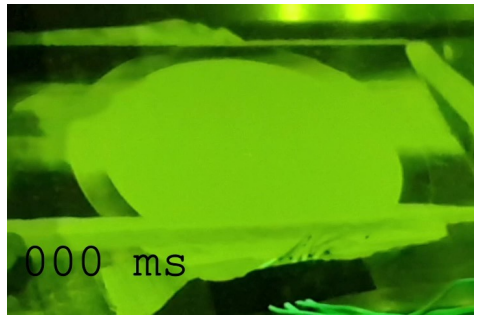
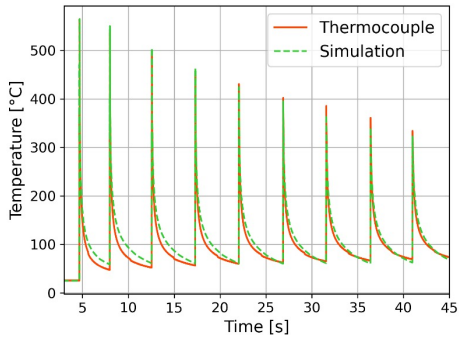


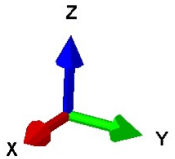


- Continuum based thermal analysis of LPBF (FEM)
  - Experimental validation







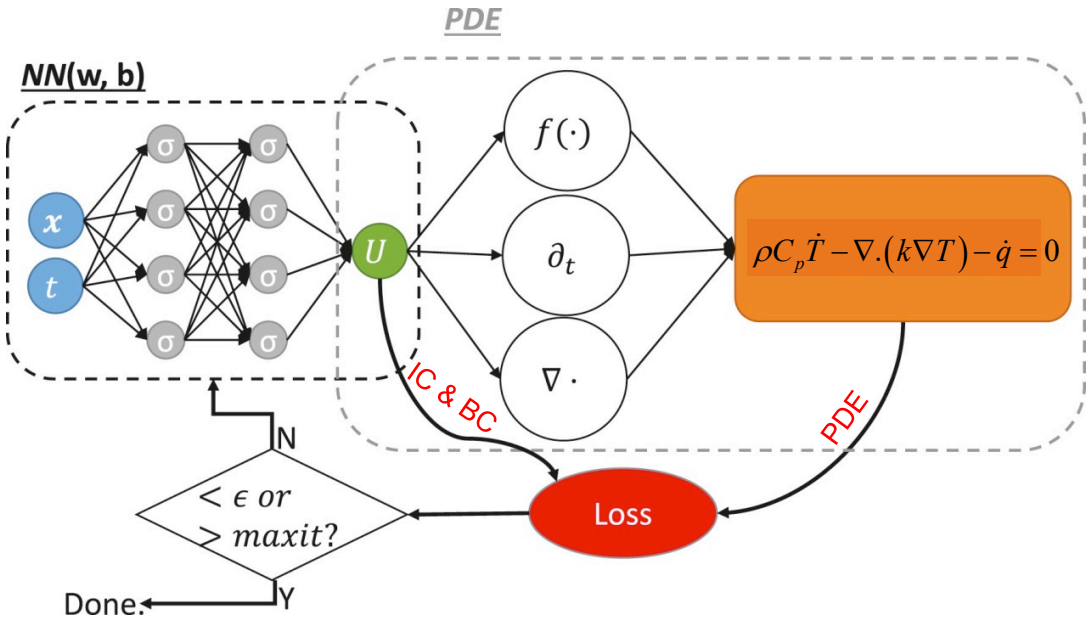


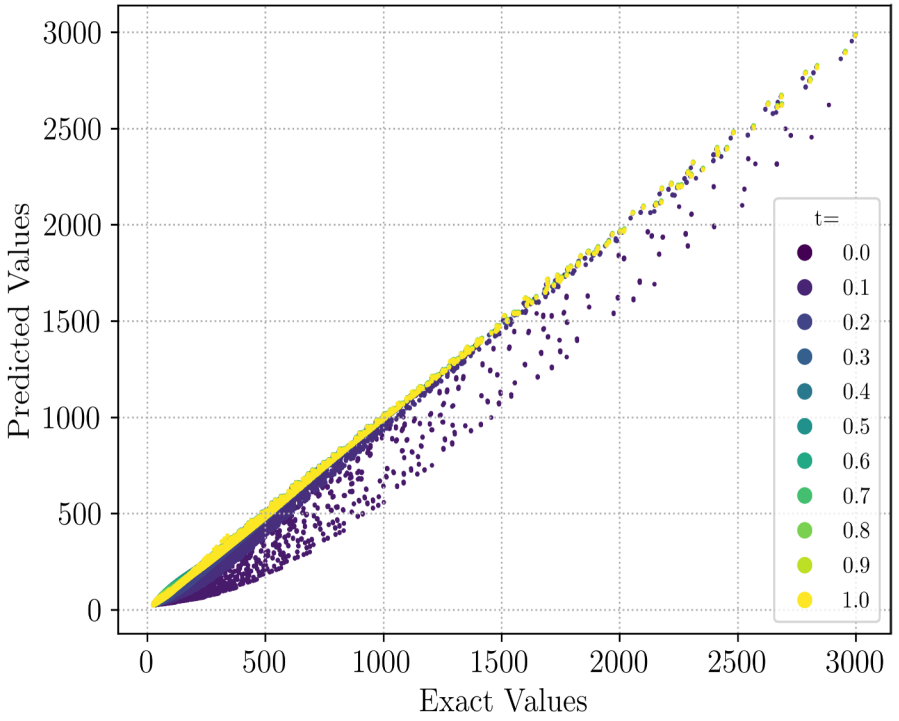
Computational cost: 12-16 hours

Deploying ML for Analysis of MAM Processes

- **Data-driven approaches**
  - Surrogate modelling (PCE), neural network (supervised training)

- **Physics Informed Neural Networks (PINNs)**
  - Numerical simulations = Solving PDEs





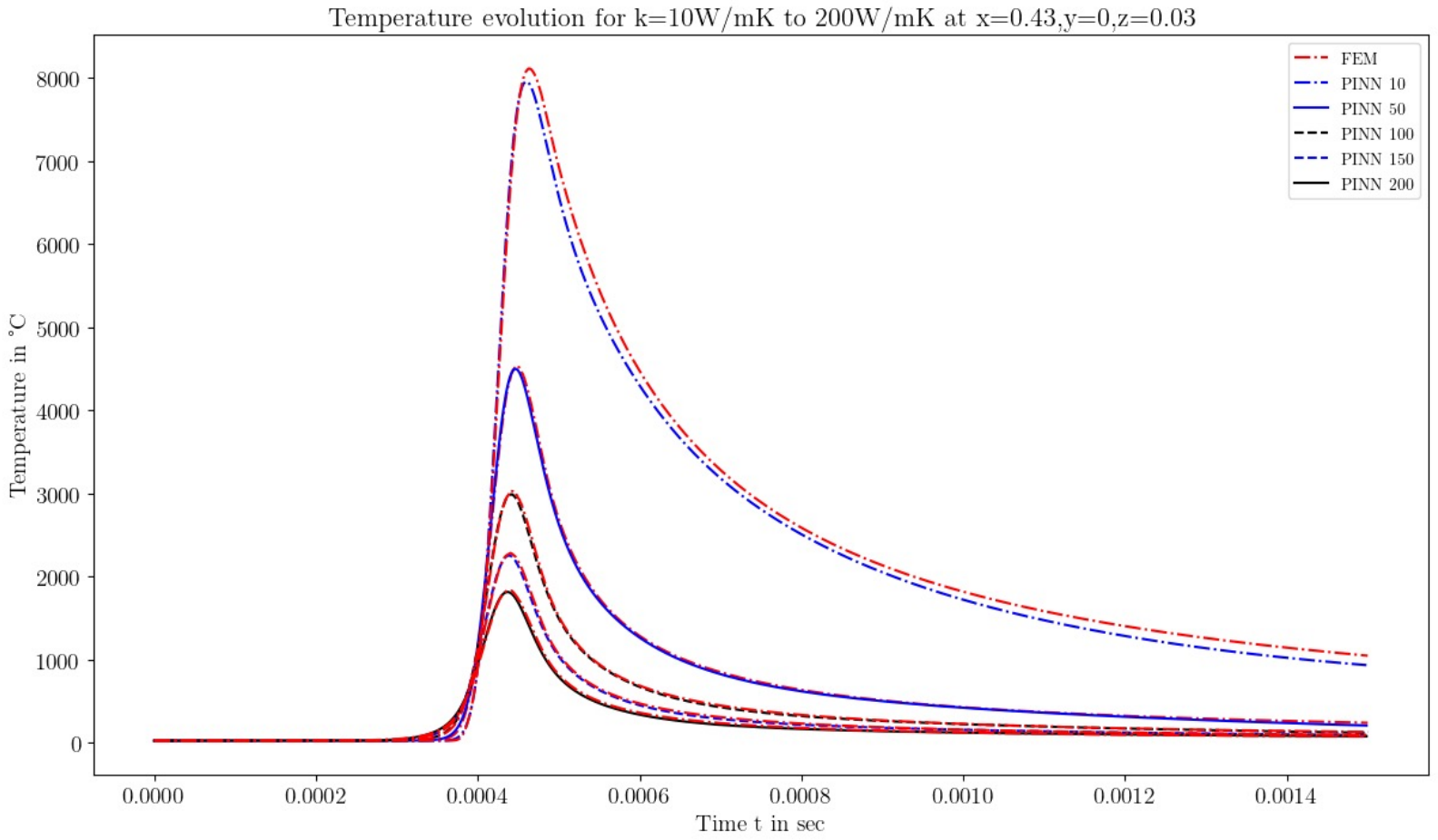
Physics Informed Neural Networks for Parametric Assessment

- **Parameters**
  - Laser power
  - Scan speed
  - Thermal conductivity
  - Heat capacity

- **PINNs training cost**
  - 0.4h (GPU)

  ≈ 9.4 h (CPU)

- **Evaluation time**
  - Real-time simulation
  - Towards Digital Twins



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