LMH Laboratory for Hydraulic Machines

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Towards Multiscale Numerical Simulations of Pelton Turbine Erosion

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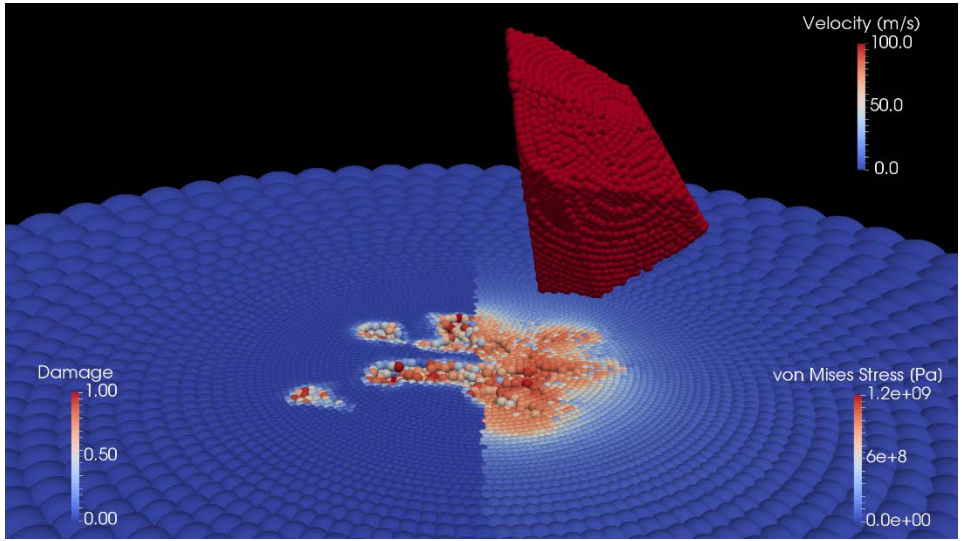
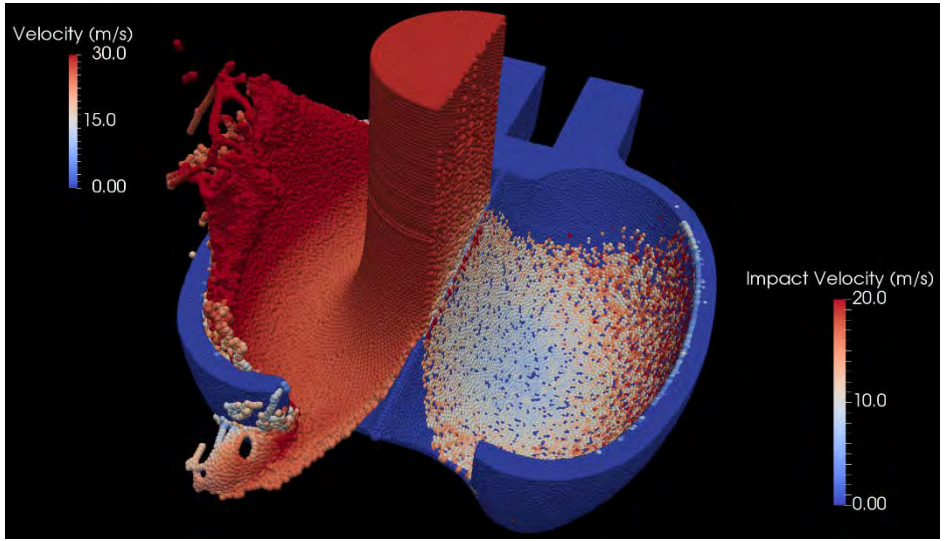
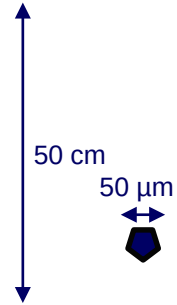




Introduction and Motivation

- Hydraulic turbomachines
- Components prone to erosion
- Quantitative prediction tool: design and operation



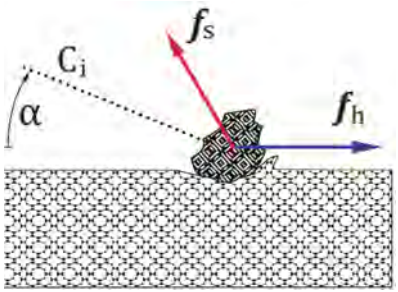
Bieudron Pelton Turbine

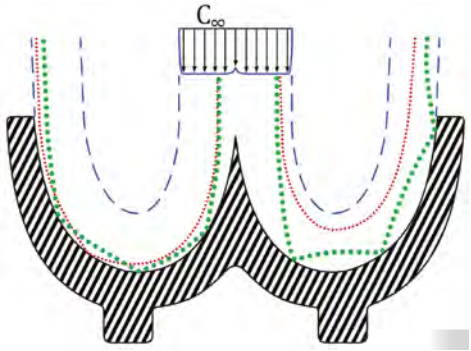
C. Vessaz, Ph. D. thesis EPFL No. 6470

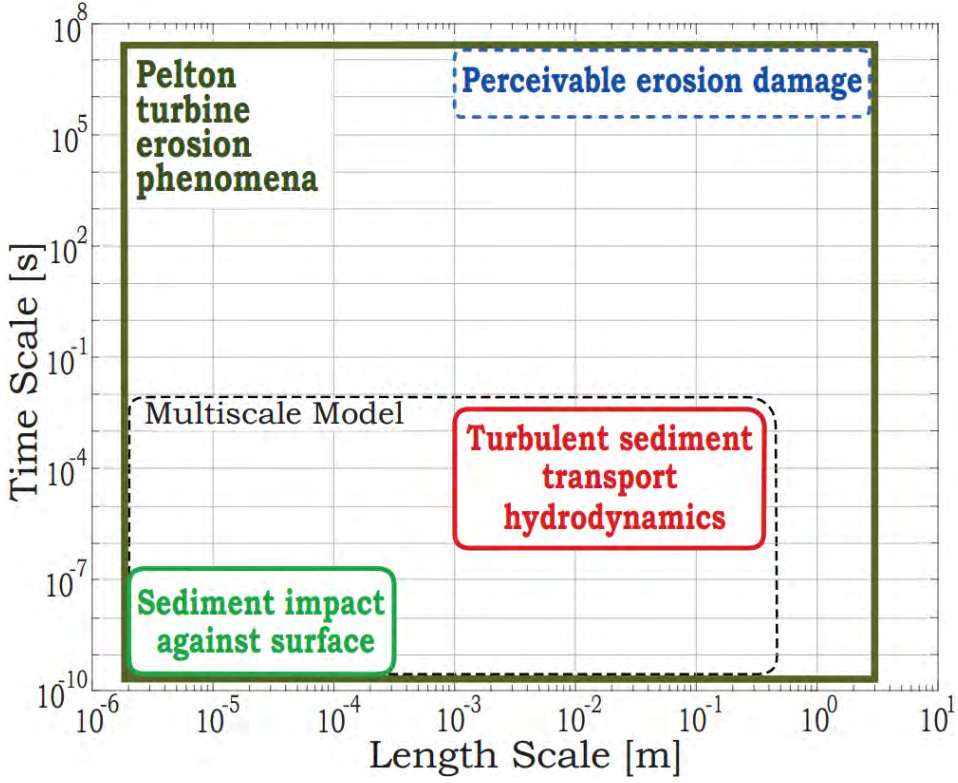
K. Winkler, *Understanding hydro-abrasive erosion for sustainable solutions*, Hydro Vision India (2011)

Multiscale Modeling of the Erosion Process

- The erosion process is multiscale
- Two existing simulation approaches
- A third approach is possible



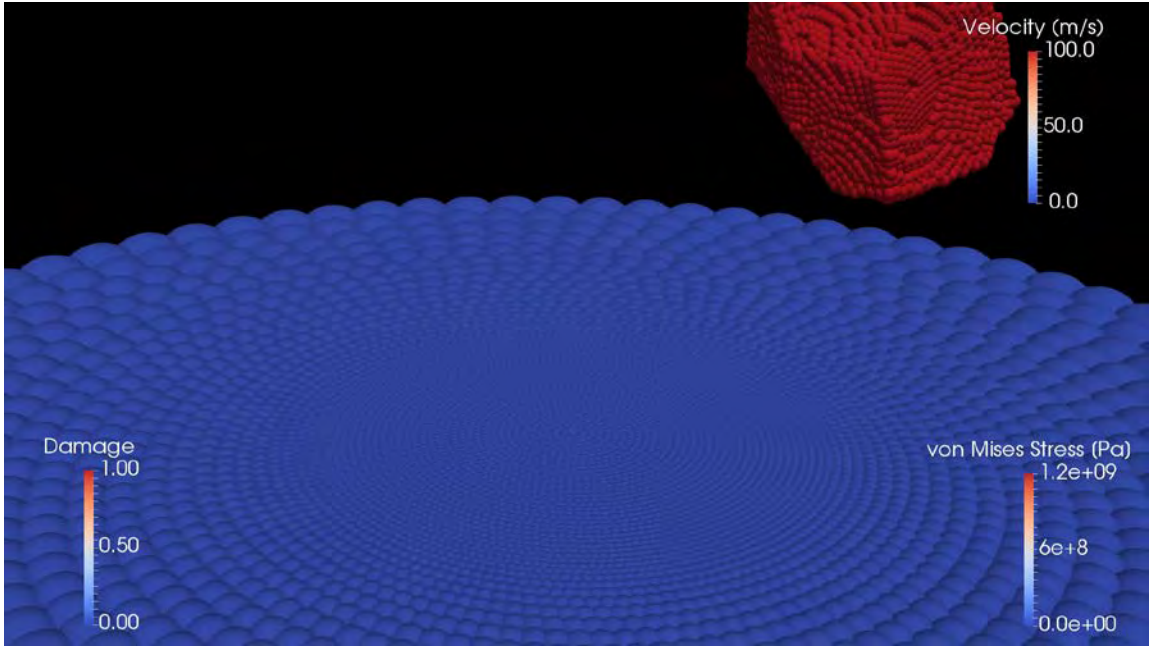




Multiscale Model of Erosion

Microscale

- Steady-state erosion ratio $f(\alpha_i, C_j)$
- Restitution coefficients $f(\alpha_i, C_j)$



Multiscale Model of Erosion

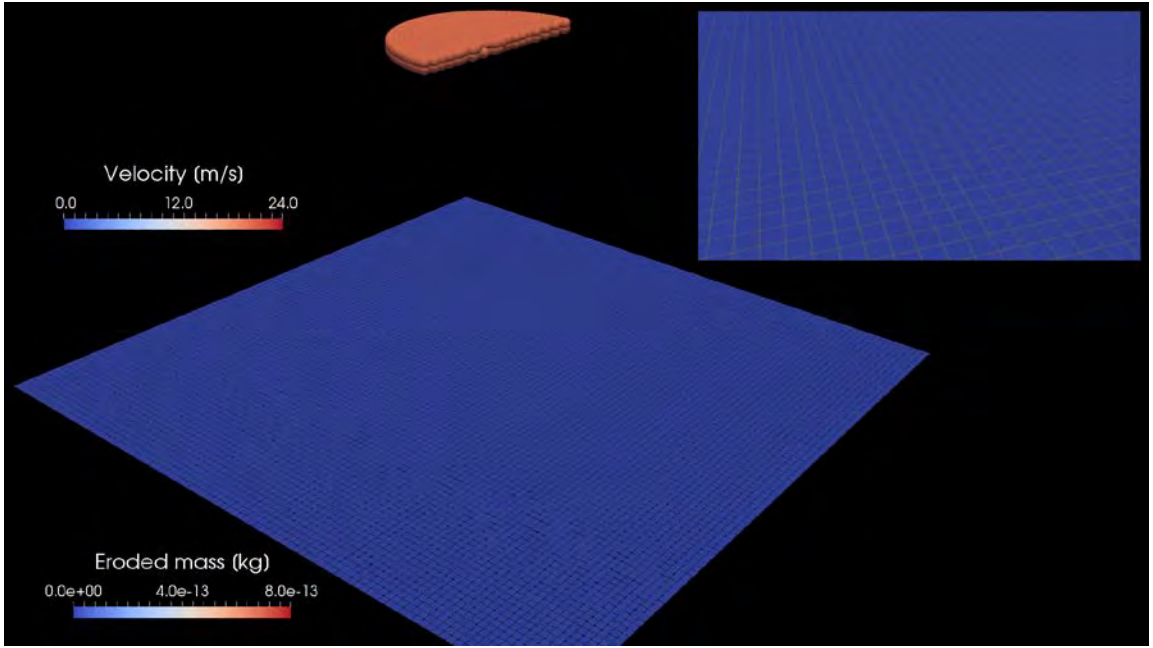
Microscale

- Steady-state erosion ratio $f(\alpha_i, C_j)$
- Restitution coefficients $f(\alpha_i, C_j)$

Sequential coupling

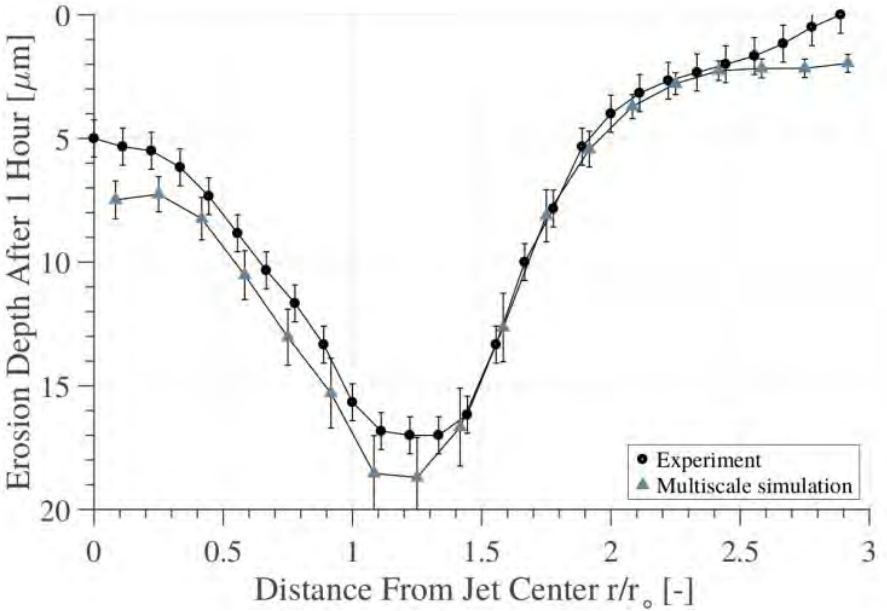
Macroscale

- Impact condition distributions
- Sediment flux against the surface
- Erosion distribution
- Global erosion rate

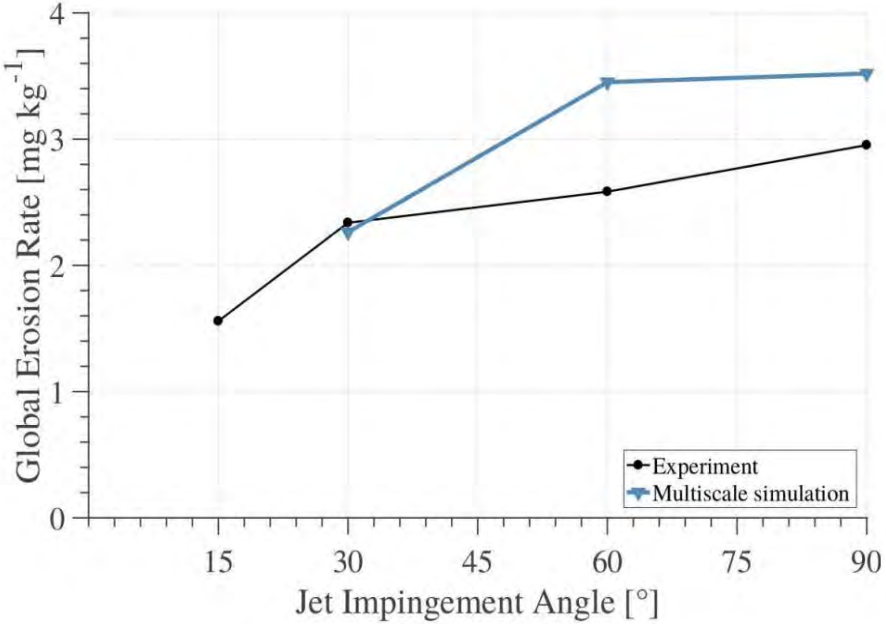


Validation Test Case: Copper Erosion

Erosion profile at 90° impingement



Erosion ratio

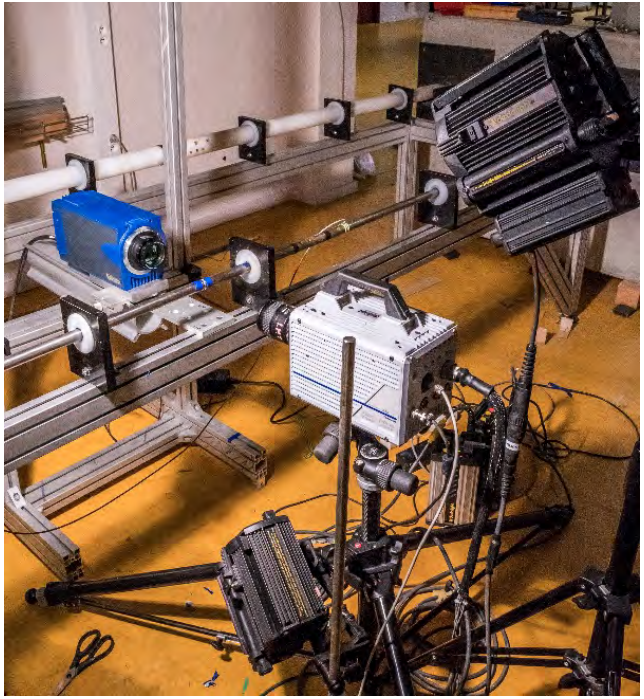


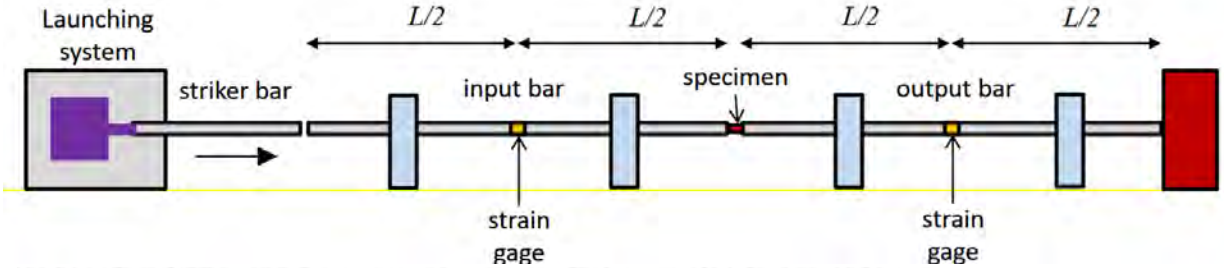
S. Leguizamón et al., *A multiscale model for impact erosion simulation using the finite volume particle method*, Wear 392-393 (2017)

Material Characterization of Stainless Steel 13Cr-4Ni

Split-Hopkinson bar tests

- Several strain rates
- Deduce true stress and strain
- Temperature measurement

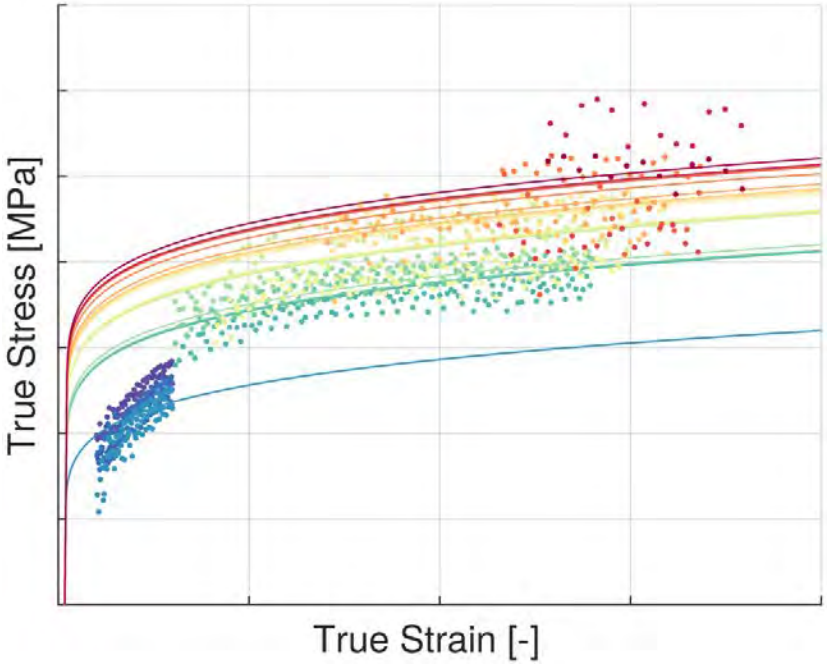


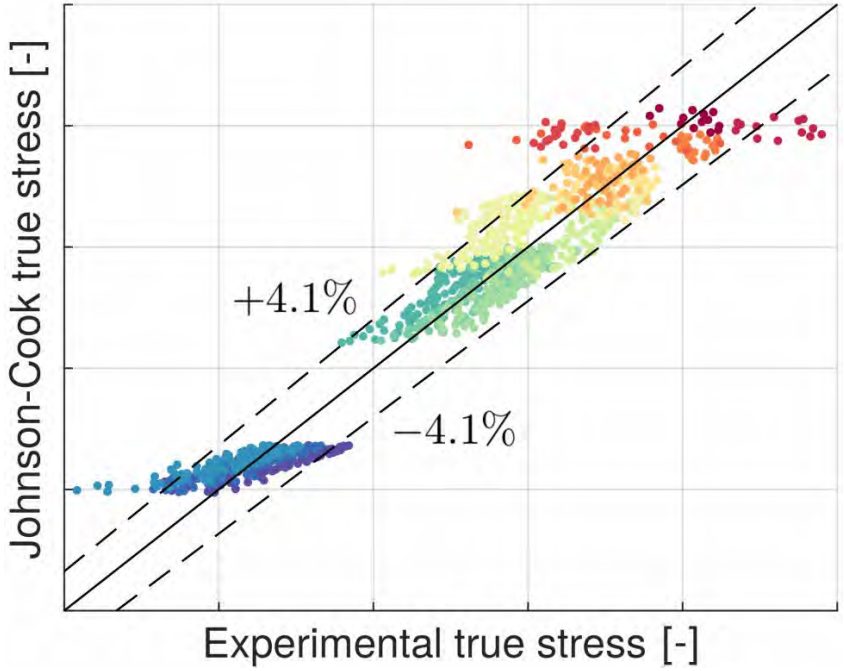


[1] Mohr D 2015 Split hopkinson bar systems lecture notes, Deptartment of Mechanical and Process Engineering, ETH Zurich

Material Characterization: Johnson-Cook Model Fitting

- Genetic algorithm to find optimum fit of model parameters
- Significant experimental spread, but good results: 4.1% standard deviation

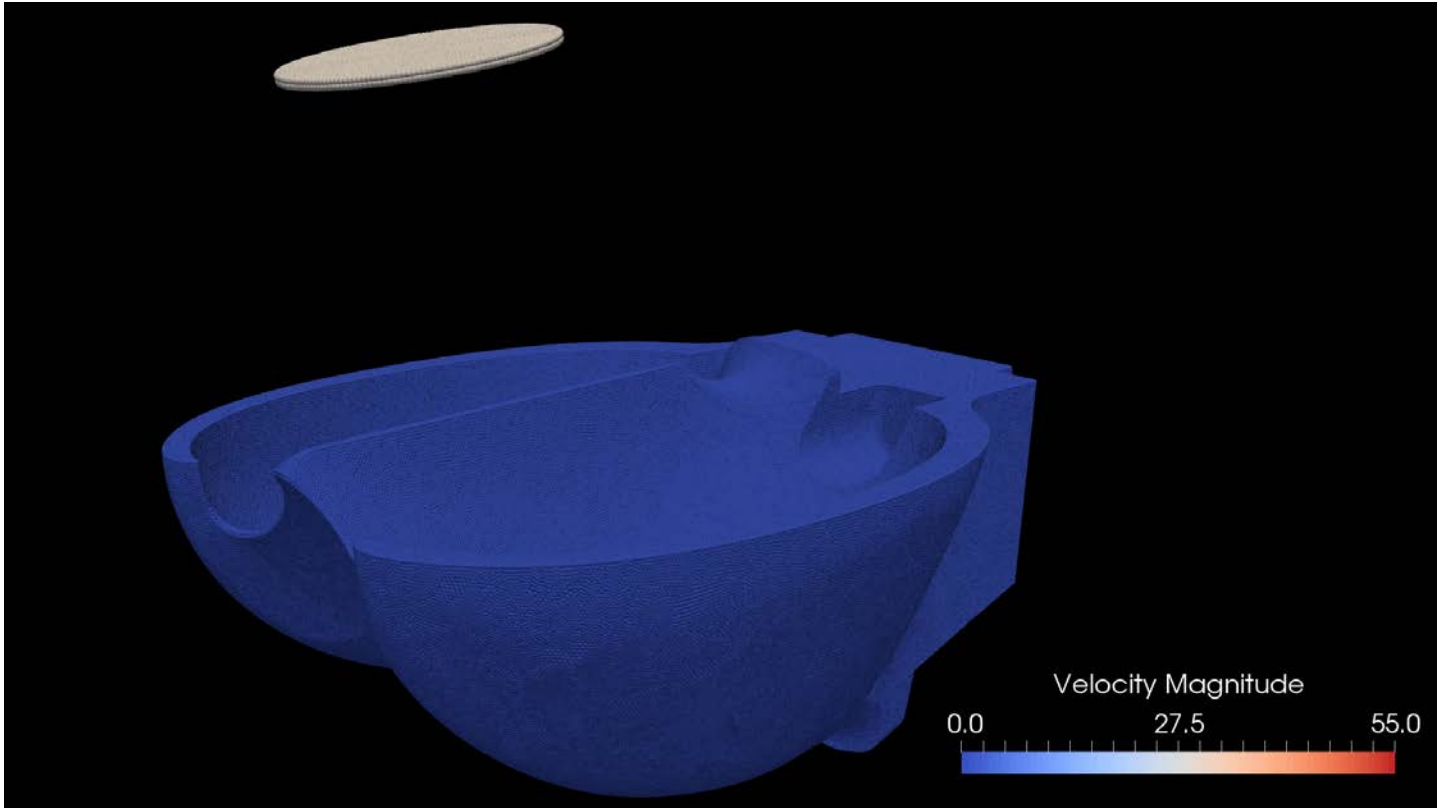




Prototype-Scale Pelton Bucket Multiscale Erosion Simulation

- B_2 = 0.38 [m]
- D_{jet} = 140 [mm]
- V_{jet} = 28.5 [m/s]
- Real sediment size distribution

- 1,000,000 sediments
- 1,460,000 particles in total
- 24 GPUs at CSCS in Lugano



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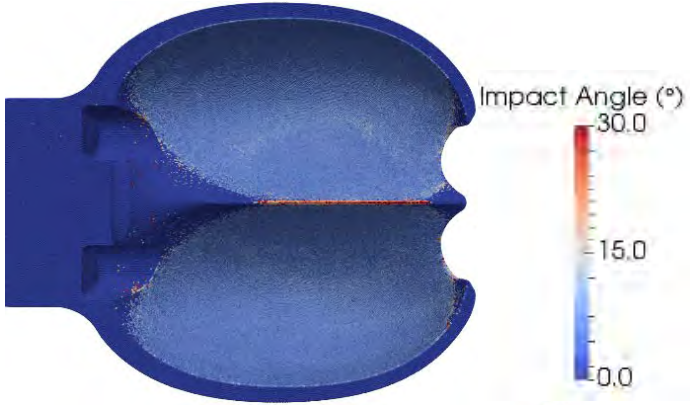

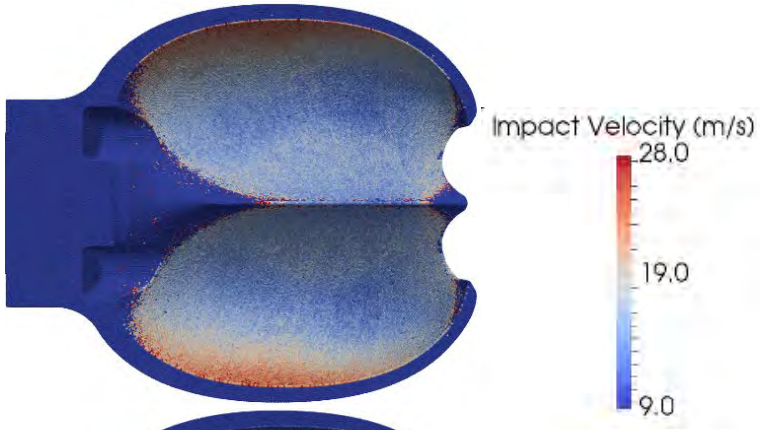

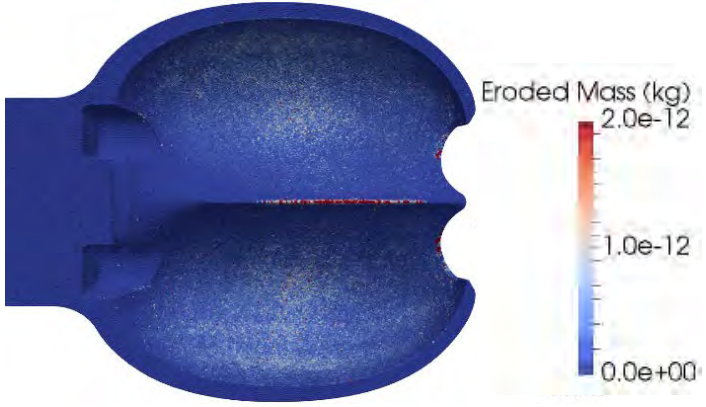

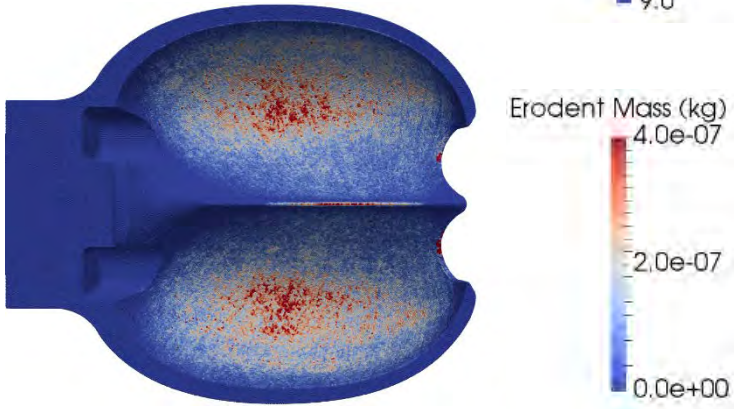

Take-Away Message

- The multiscale erosion model has been validated for the copper case (*Wear* **392**, 2017)
- A material characterization for SS 13Cr-4Ni has been performed
- The code is ready for prototype-scale Pelton erosion simulations
- Currently performing validation on experimental data provided by General Electric
  - Flat plate erosion by impinging jet
  - Industrial-scale Pelton turbine erosion

Acknowledgements

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Swiss Confederation

Commission for Technology and Innovation CTI

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CSCS
Centro Svizzero di Calcolo Scientifico
Swiss National Supercomputing Centre

SCCER SoE
SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

Thank you for your kind attention

Any questions?