

AI/ML applications in NEAMS Fuels

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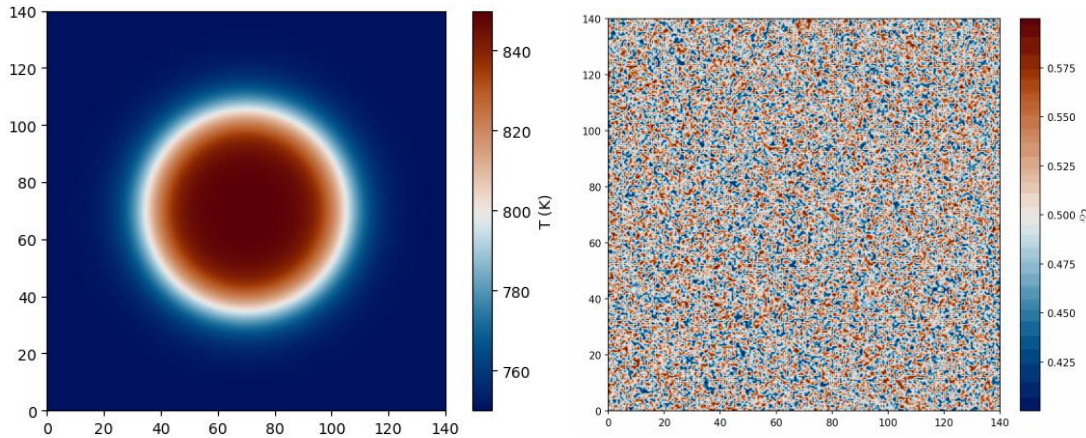
NEAMS Annual Meeting, INL



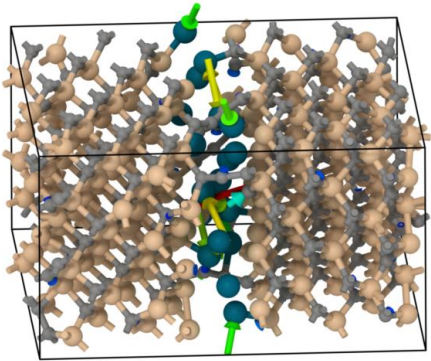
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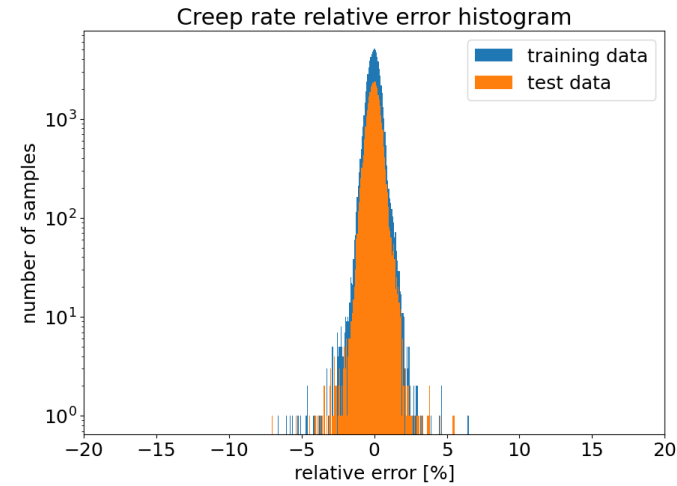
Neural network accelerated modeling across scales



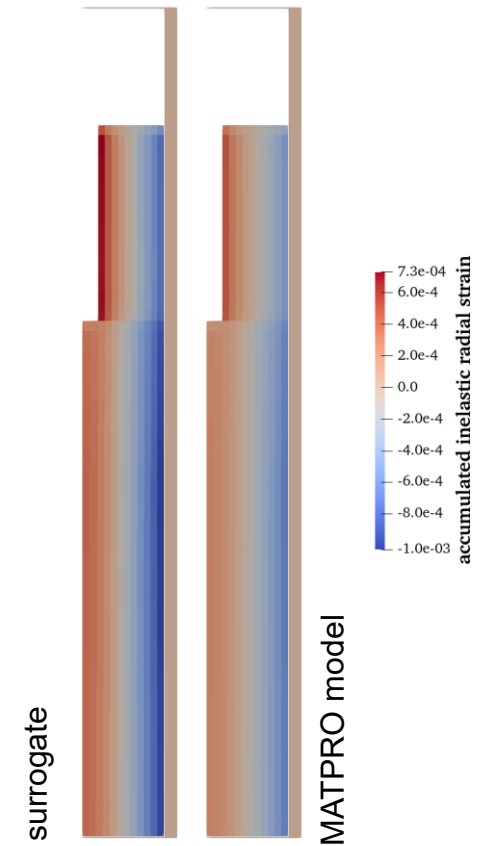
PyTorch neural networks represent the Gibbs free energy of the BCC Fe-Cr phase



Machine learning inter-atomic potentials for fuels



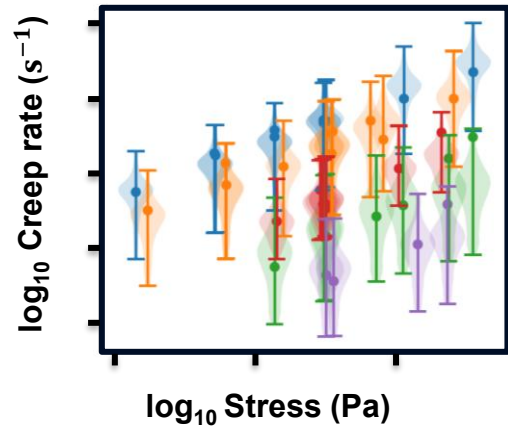
PyTorch **GPU accelerated** training and evaluation of creep models in BISON



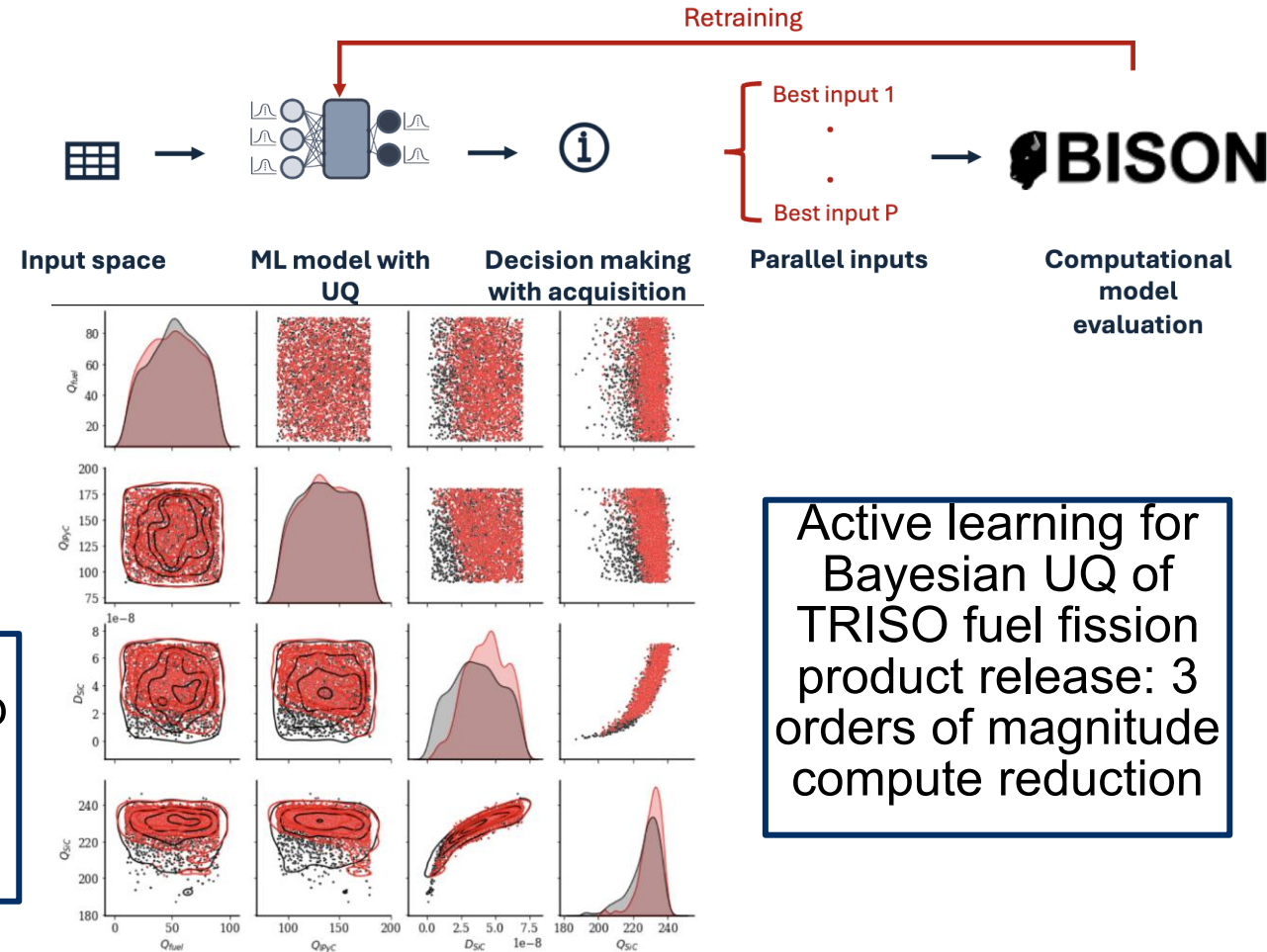
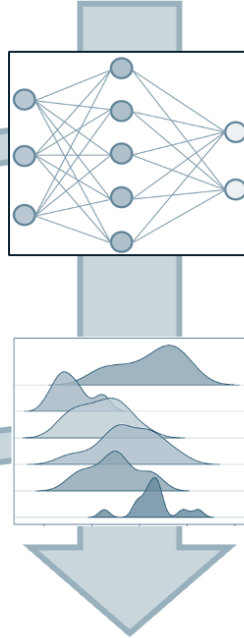
Uncertainty-informed ML-accelerated modeling across scales

Train rapid AI models to replicate physics-based mechanistic models
Allows scale bridging and many rapid evaluations of model

Use UQ techniques to infer parameters based on existing experiments
Requires $>10^7$ evaluations of many models



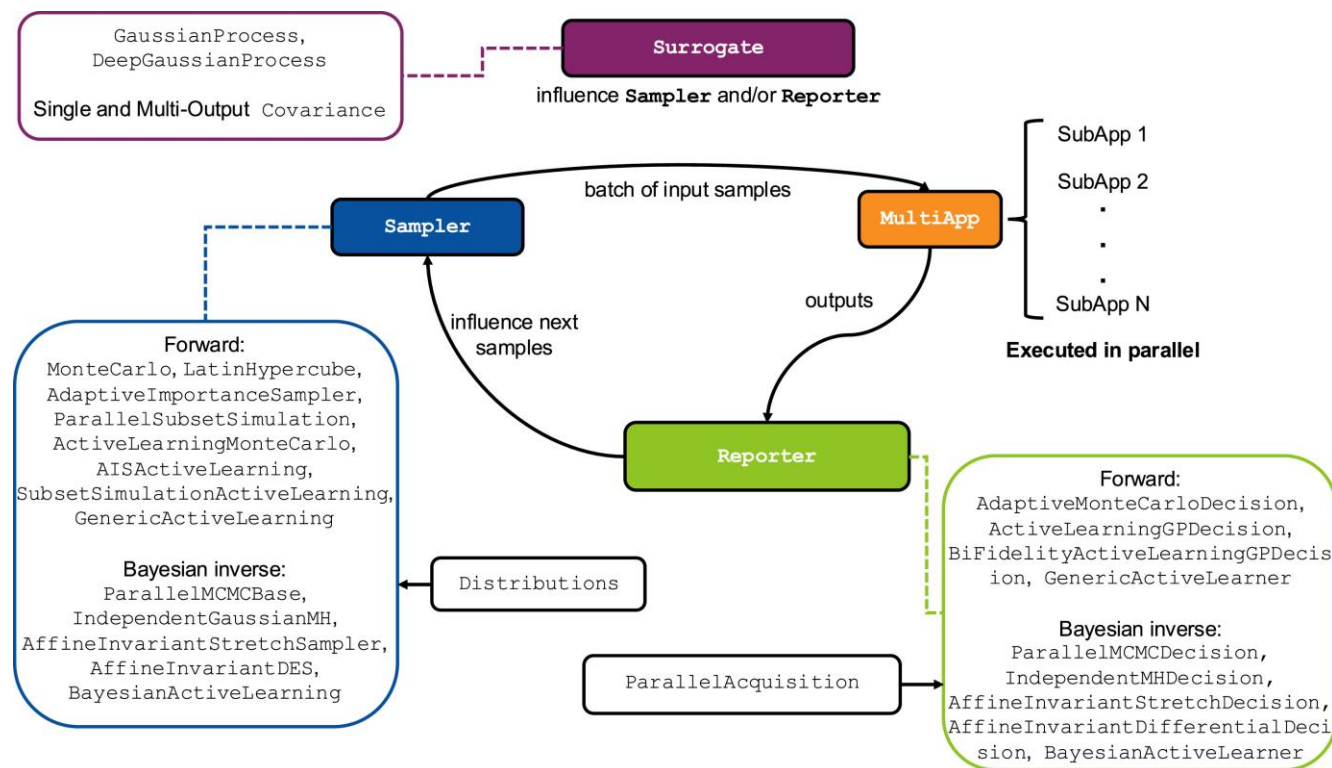
Systematic calibration of this mechanistic UO_2 creep model incorporating uncertainty and prior knowledge



Active learning for Bayesian UQ of TRISO fuel fission product release: 3 orders of magnitude compute reduction



Co-development of software and applications



MOOSE ProbML: Parallelized Probabilistic ML and UQ for Energy Applications, *Journal of Computational Science* (2026)

Application of AI/ML and UQ techniques to nuclear fuel performance modeling and simulation: A review

David Andersson^a, Julien Tranchida^b, Janne Heikinheimo^c, Johann Bouchet^b, Denise Adorno Lopes^d, Michael Cooper^a, Somayajulu L. N. Dhulipala^e, Joshua J. Gabriel^g, Conor Galvin^a, Chao Jiang^e, Luca Messina^b, Gustav Robertson^f, Peyman Saidi^g, Anton Schneider^a, Daniel Schwen^e, Stephen Novascone^e

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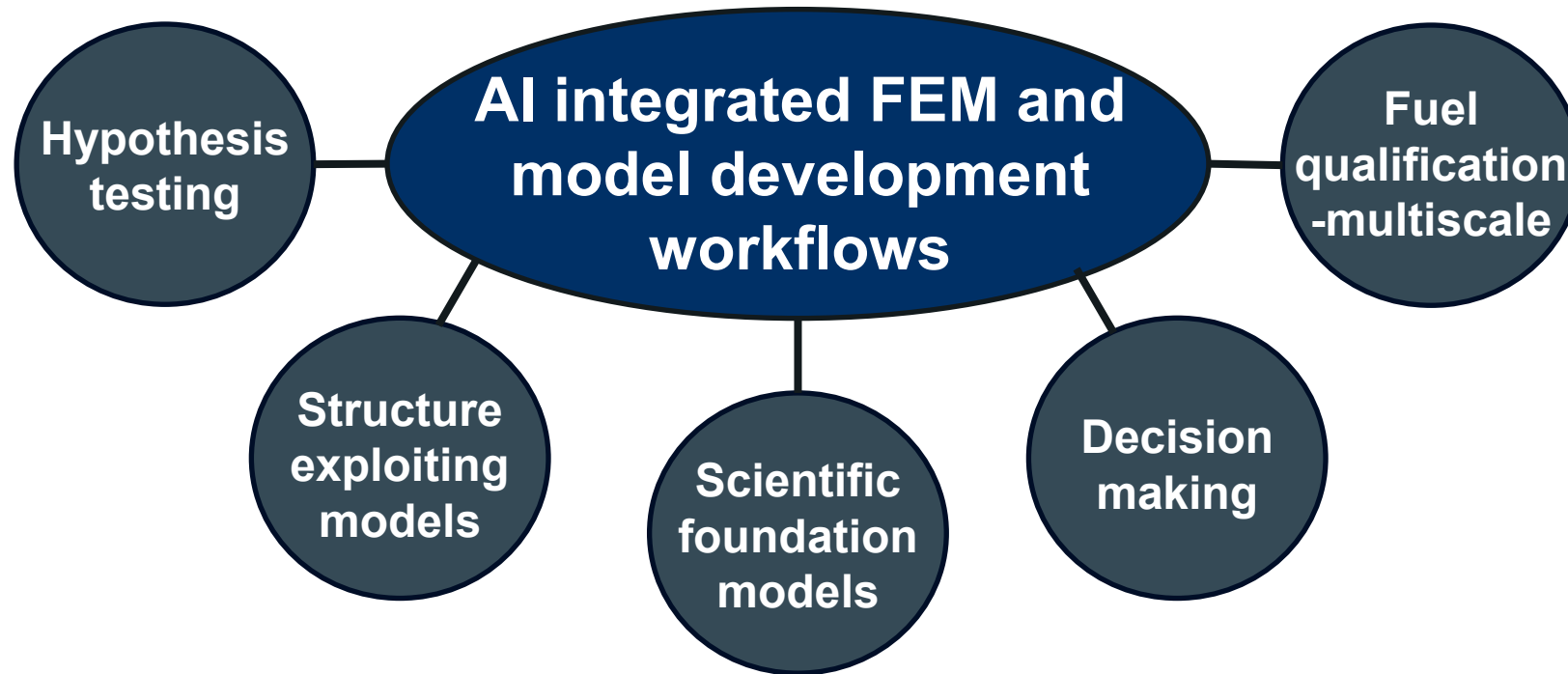
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International collaboration to advance AI/ML and UQ for fuel performance modeling (paper under review)



Incorporating the state-of-the-art in AI for fuel performance





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