SAND2020-2438C

Sandia National Laboratories

Kellin Rumsey, Gabriel Huerta

Embracing Unidentifiability in Bayesian Modal Calibration with Modularization

Introduction

- Bayesian model calibration (BMC) refers to coupling of limited experimental data with an expensive computer simulator [1].

$$y(x_i) = \eta(x_i, \theta) + \delta(x_i) + \epsilon_i$$

- Computer simulator takes a high dimensional set of inputs known as calibration parameters.
- Goal: Use Bayesian inference to learn the posterior distribution of the physical parameters.

Physical parameter inference

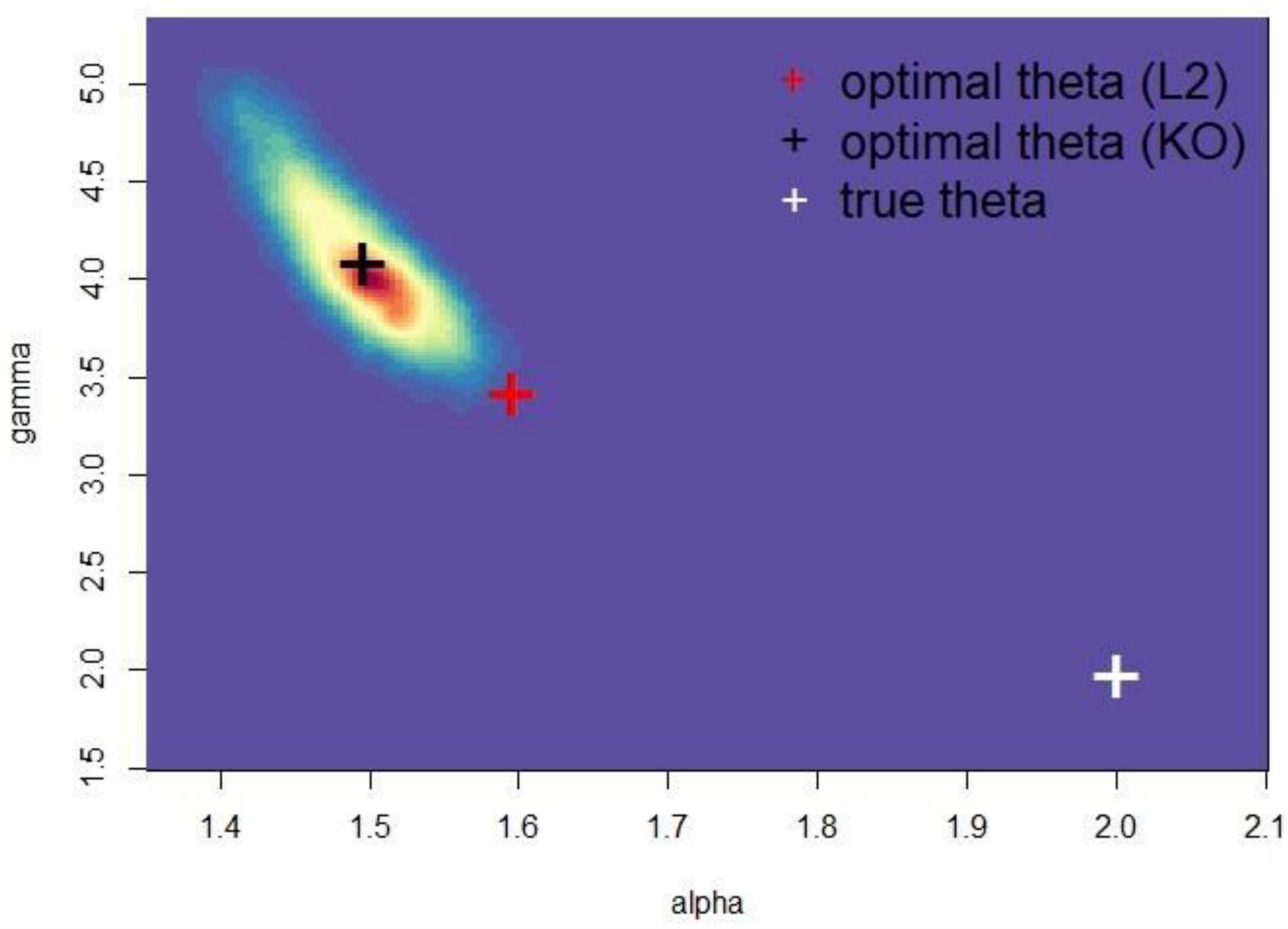
- Consider the simple machine [2].

$$\zeta(\mathrm{x}) = \frac{2\mathrm{x}}{1 + \mathrm{x}/10}$$

- The efficiency is 2 (physical parameter).
- Model discrepancy: Use a piecewise linear simulator with slope α when $x < \gamma$ and slope β when $x \geq \gamma$.
- Optimal parameter values minimize a loss function [3]

$$\mathcal{L}(\zeta(\cdot), \eta(\cdot, \theta)).$$

- Optimal parameter values are often not the same as the "true" parameter values.



Modularization

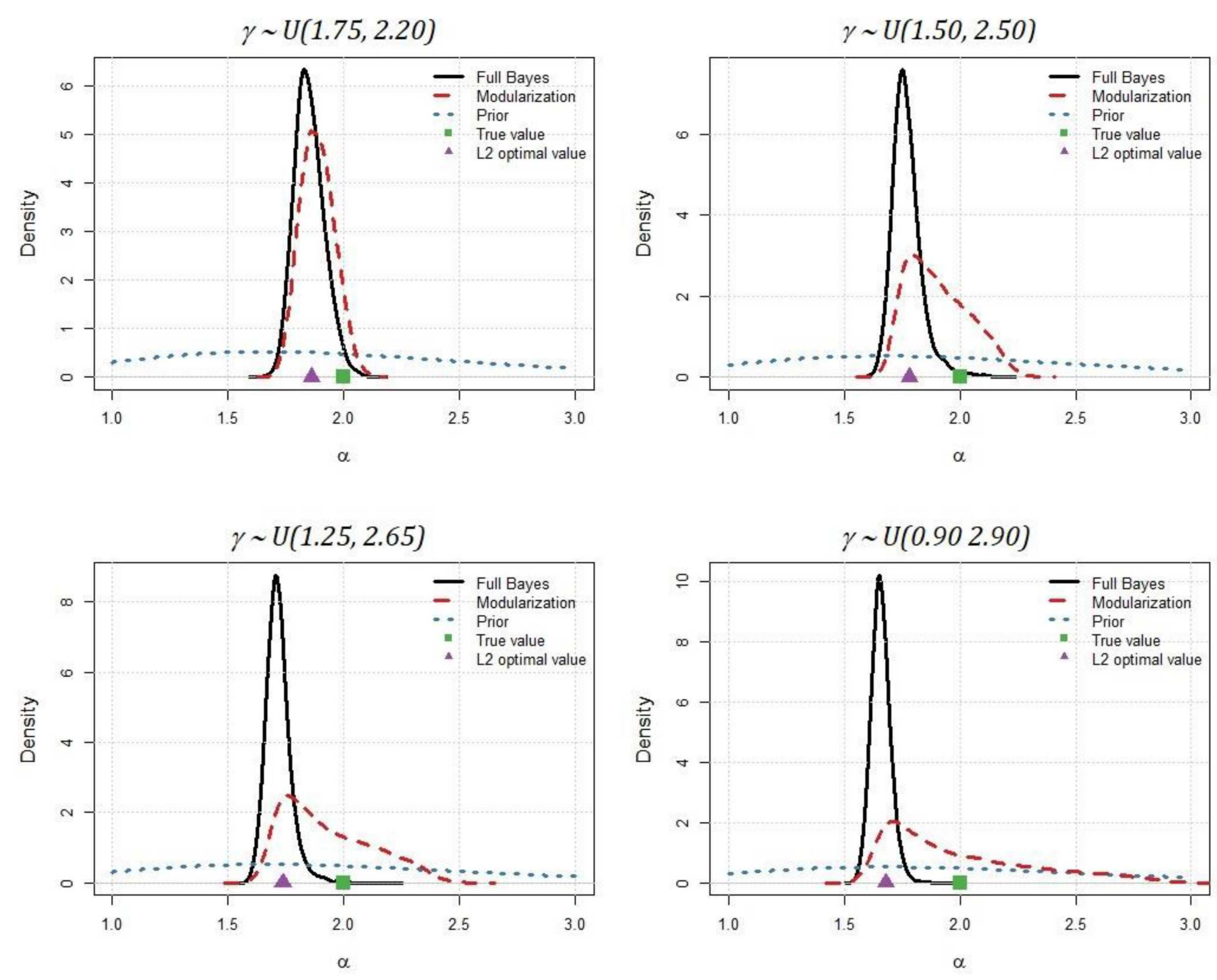
- Sometimes physical parameters α and nuisance parameters γ are inherently jointly unidentifiable.

- Modularization improves identifiability by forfeiting the ability to learn about nuisance parameters, while rigorously accounting for the associated uncertainty [4].

$$\pi_{\mathrm{M}}(\alpha|y) = \int_{\mathbb{R}^q} \pi(\alpha|\gamma, y)\pi(\gamma)d\gamma$$

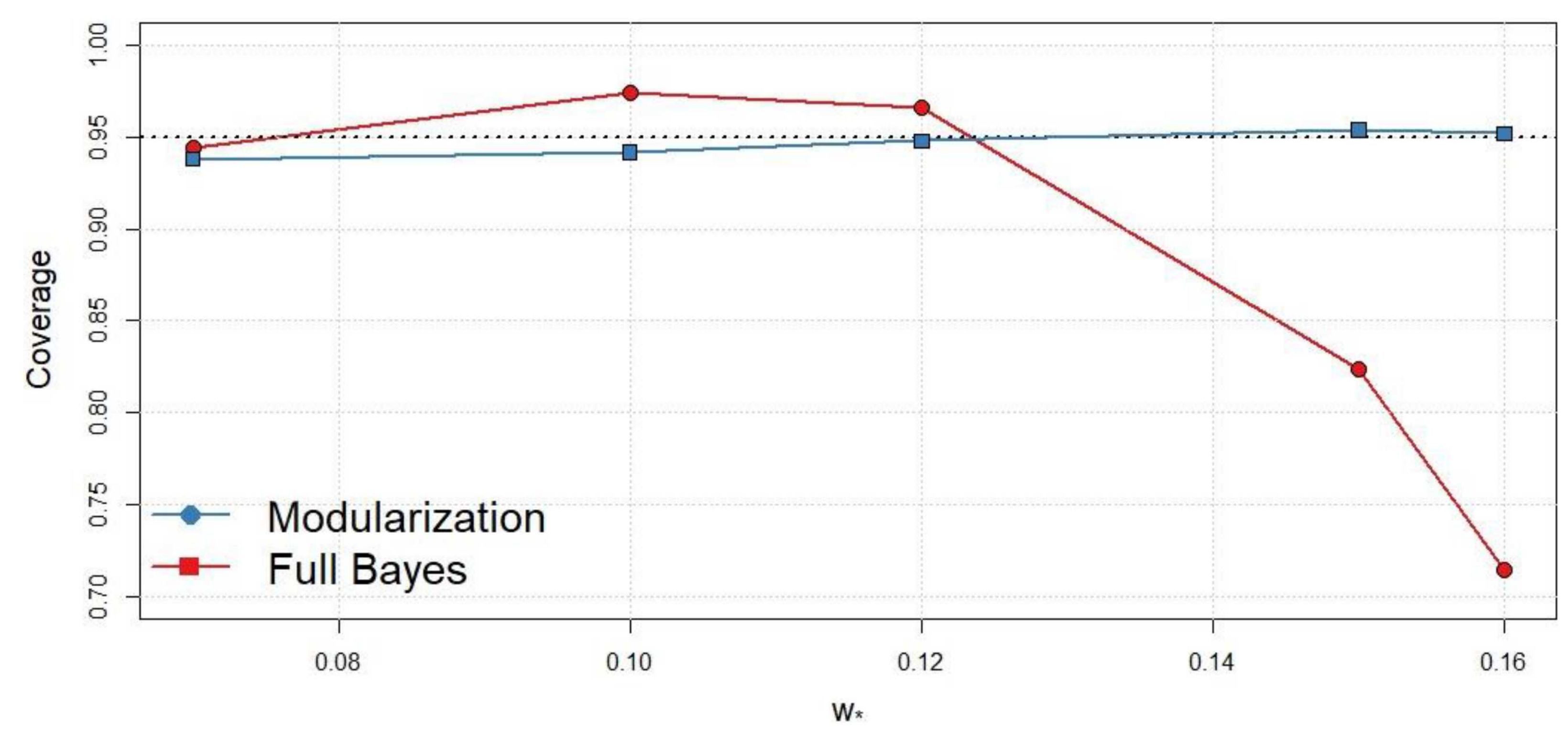
- The Modularization posterior can be efficiently approximated numerically by emulating the conditional posterior.

- Simple machine example:

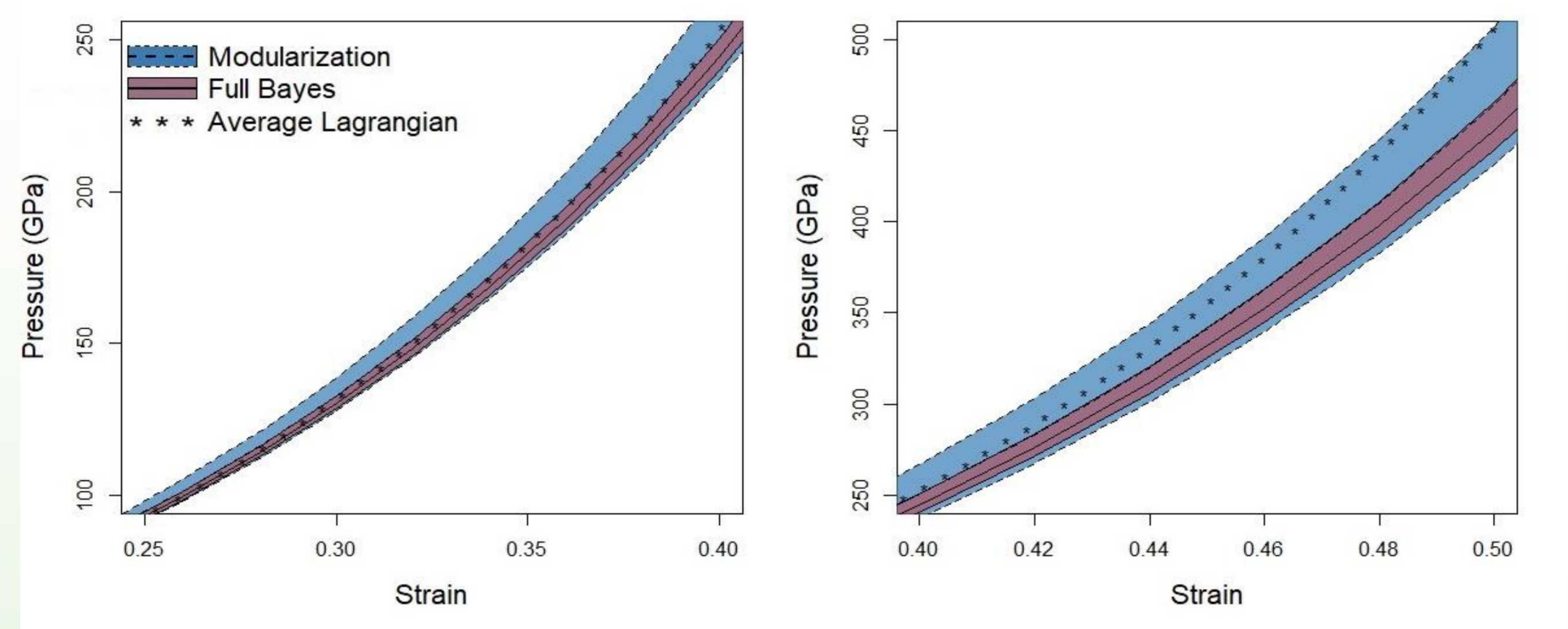


Applications

- Borehole function simulations.



- Dynamic material property calibration.



Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.
SAND No. SAND2019-13565 C

[1] Kennedy, M.C. and O'Hagan, A., 2001. Bayesian calibration of computer models. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, *63*(3), pp.425-464.

[2] Liu, Fei, M. J. Bayarri, and J. O. Berger. "Modularization in Bayesian analysis, with emphasis on analysis of computer models." *Bayesian Analysis* 4.1 (2009): 119-150.

[3] Tuo, Rui, and CF Jeff Wu. "Efficient calibration for imperfect computer models." *The Annals of Statistics* 43.6 (2015): 2331-2352.

[4] Rumsey, K., Huerta, G. and Hund, L., 2019. Embracing unidentifiability in Bayesian model calibration with modularization.

Acknowledgements: This poster has been supported by the Sandia ASC Advanced Machine Learning program. We also thank Lauren Hund for her contributions to preliminary versions of this work.

Sandia National Laboratories