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# Robust Inference for Physical Parameters with Bayesian Model Calibration

## Introduction

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

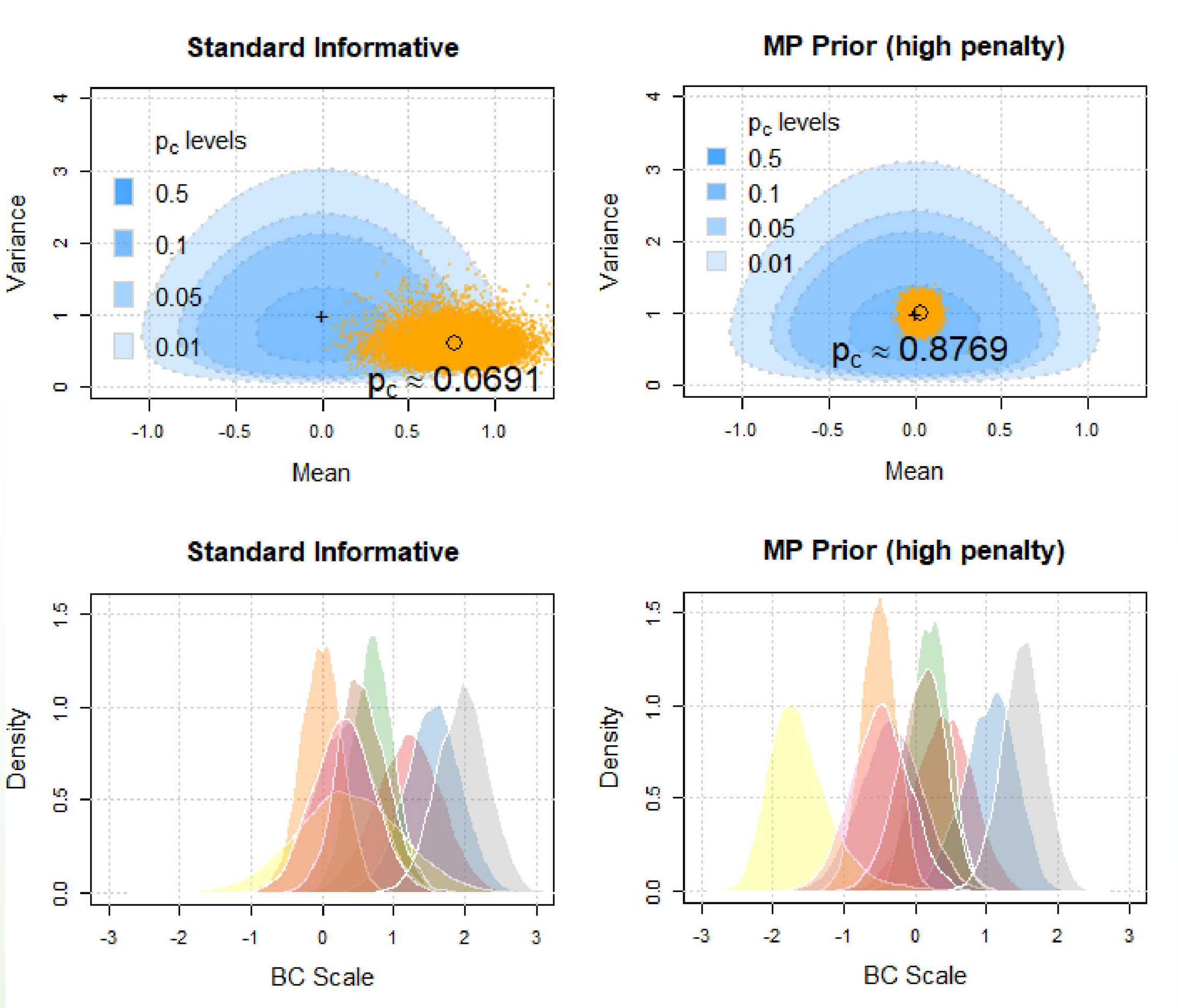
$$y(x_i) = \eta(x_i, \alpha, \gamma) + \delta(x_i) + \epsilon_i$$

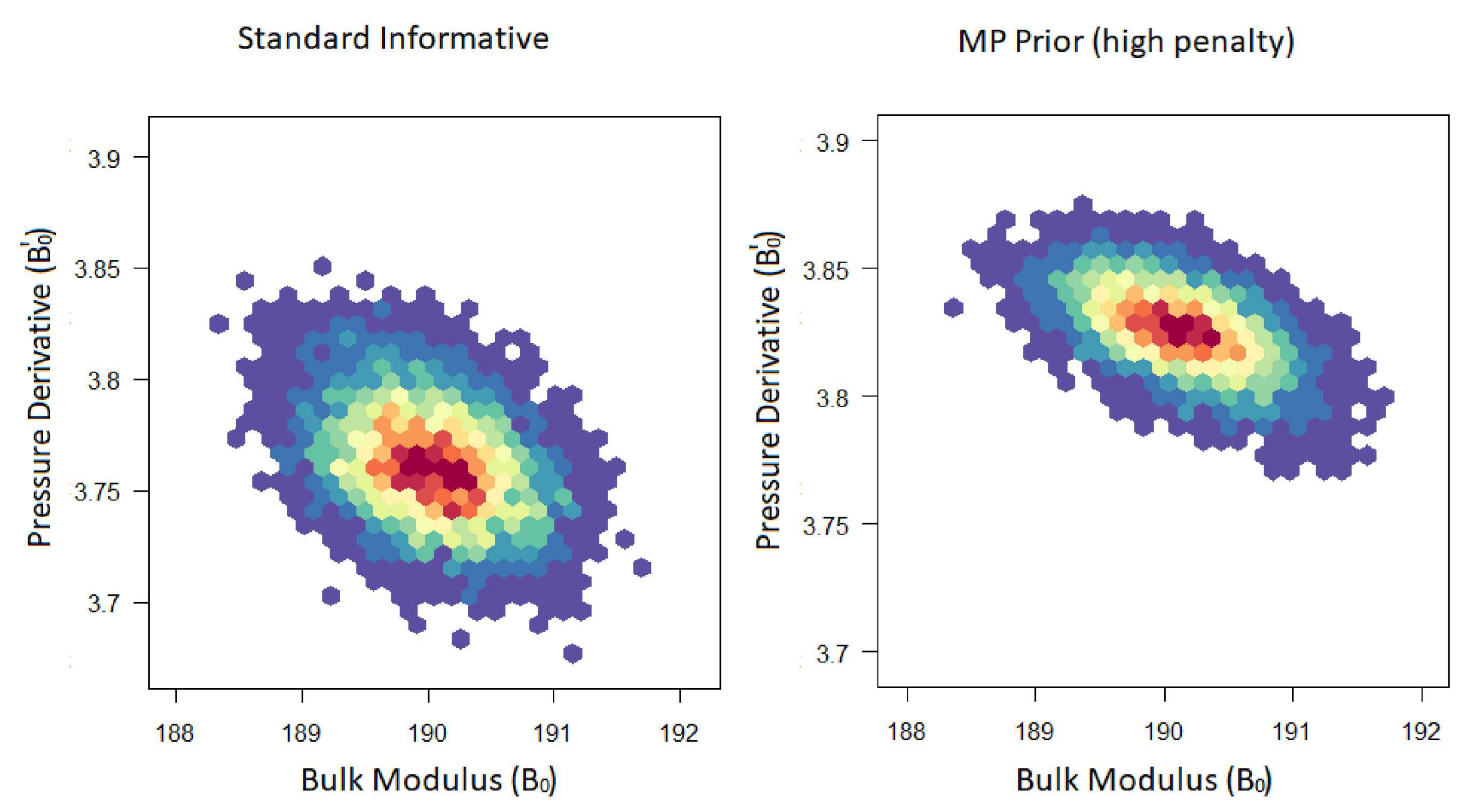
- Computer simulator takes a high dimensional set of inputs known as calibration parameters.
- Modeling the discrepancy function directly leads to overfitting and unidentifiability[2].
- Goal: Use Bayesian inference to learn the posterior distribution of the physical parameters.

## Regularization

- The addition of meaningful constraints in order to reduce overfitting.
- Example: Computer simulator takes 6 inputs, 3 of which vary across experiments.
- Some inputs represent measurement uncertainties, with known mean μ and variance ν.
- Overfitting can be identified with the probability of prior coherency and can be reduced or diagnosed via moment penalization[3].

$$\pi_{\text{MP}}(\gamma) \propto \exp\left\{-\lambda_1(M-\mu)^2 - \lambda_2(V-\nu)^2\right\}$$



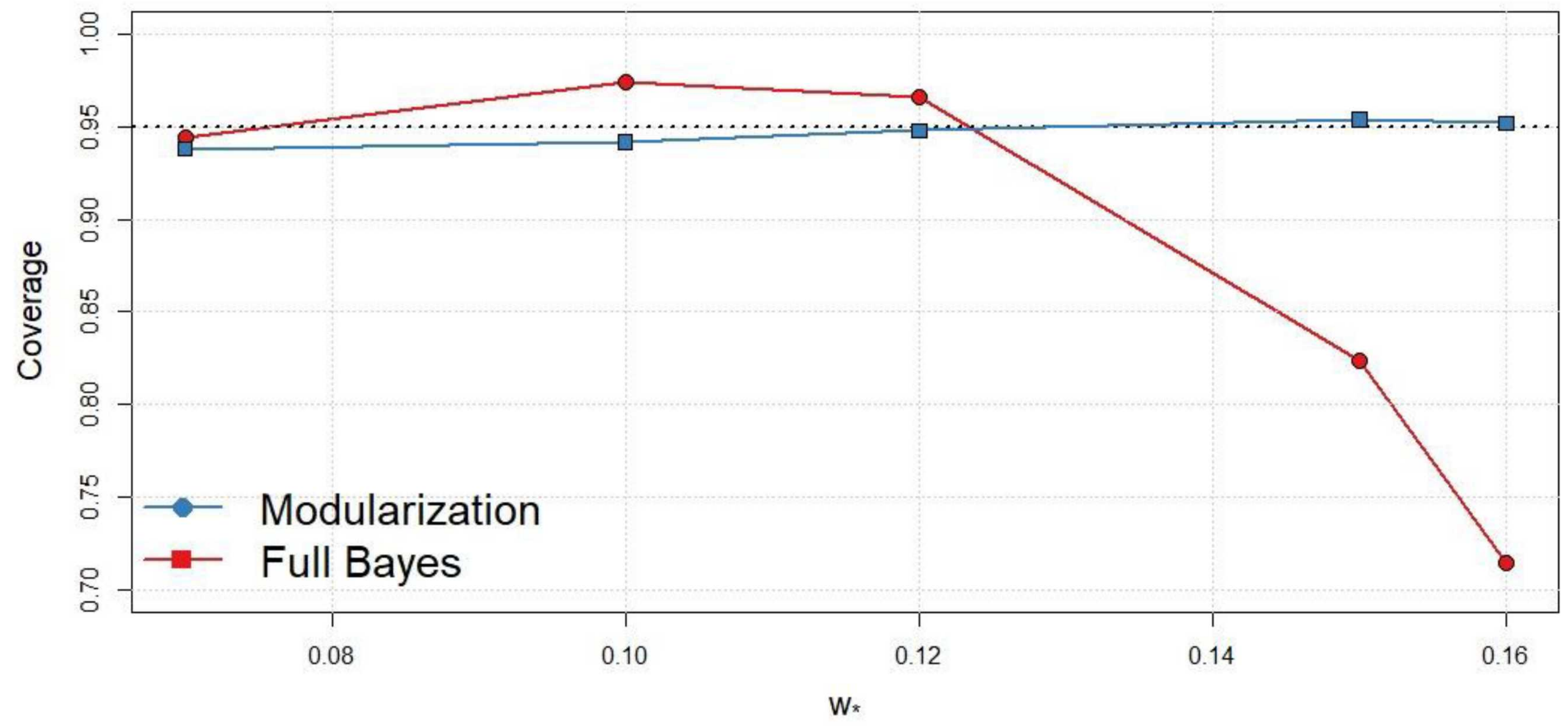

- Moment penalization leads to a shift in the posterior distribution of the physical parameters.
- More consistent with the physicists prior beliefs.

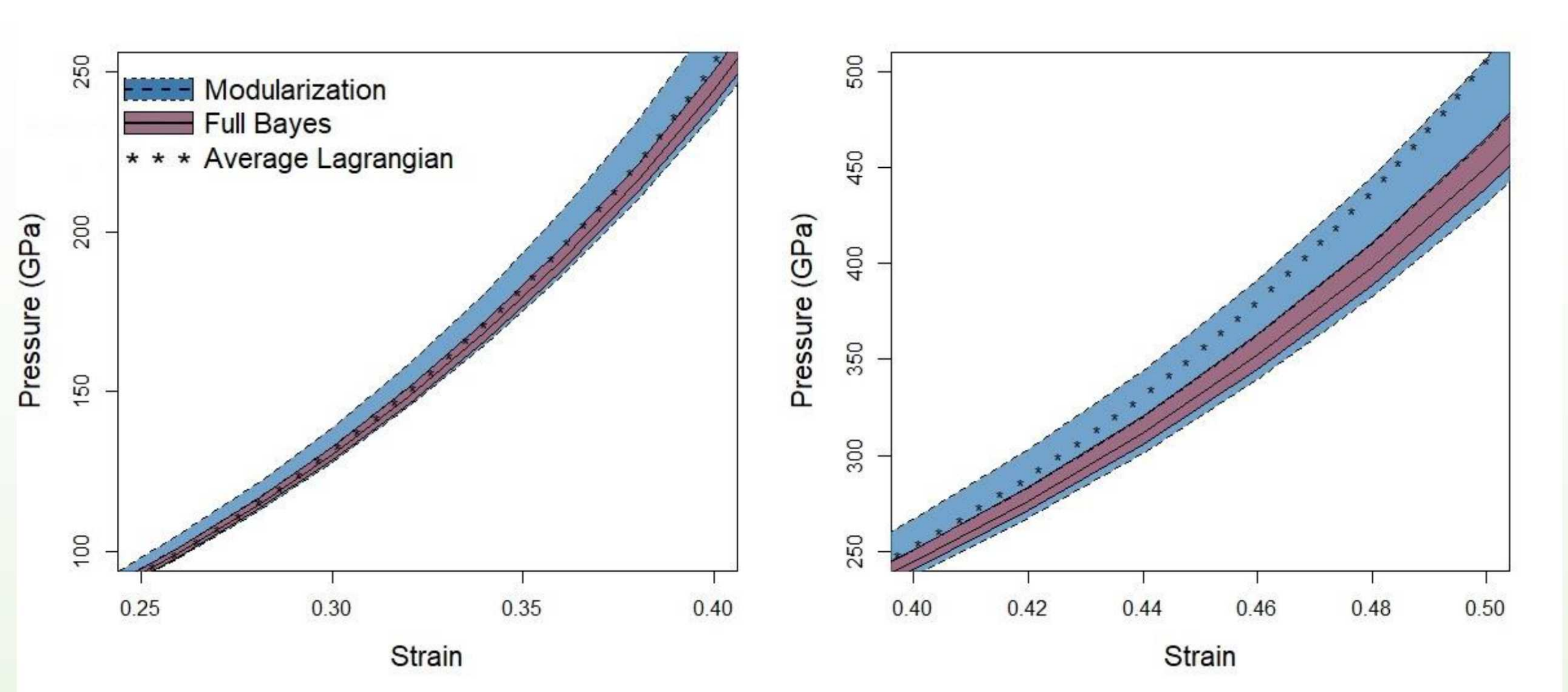
## Modularization

- 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].

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

- The Modularization posterior is efficiently approximated numerically using the Sequential Gaussian Process (SGP)

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