

Gaussian Process Bayesian Optimization for the Design of a Precision Particle Physics Experiment

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on behalf of the Muon EDM Collaboration.

Optimization parameters:

- Injection Channel Angle (Theta)
- Injection Channel Position (Injection Radius, Phi)
- Magnetic Kicker Strength (BPI)
- Magnetic Kicker Delay (ptoffset)
- Magnetic Field Strength (B)



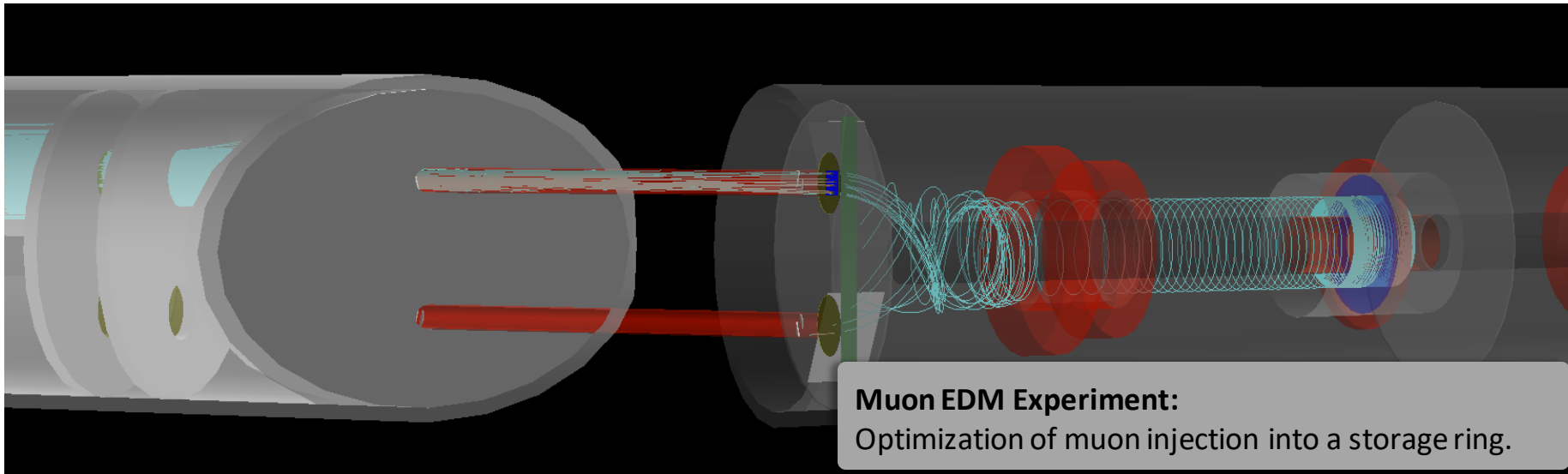
Objective:

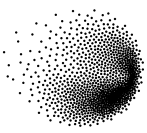
Maximize injection efficiency



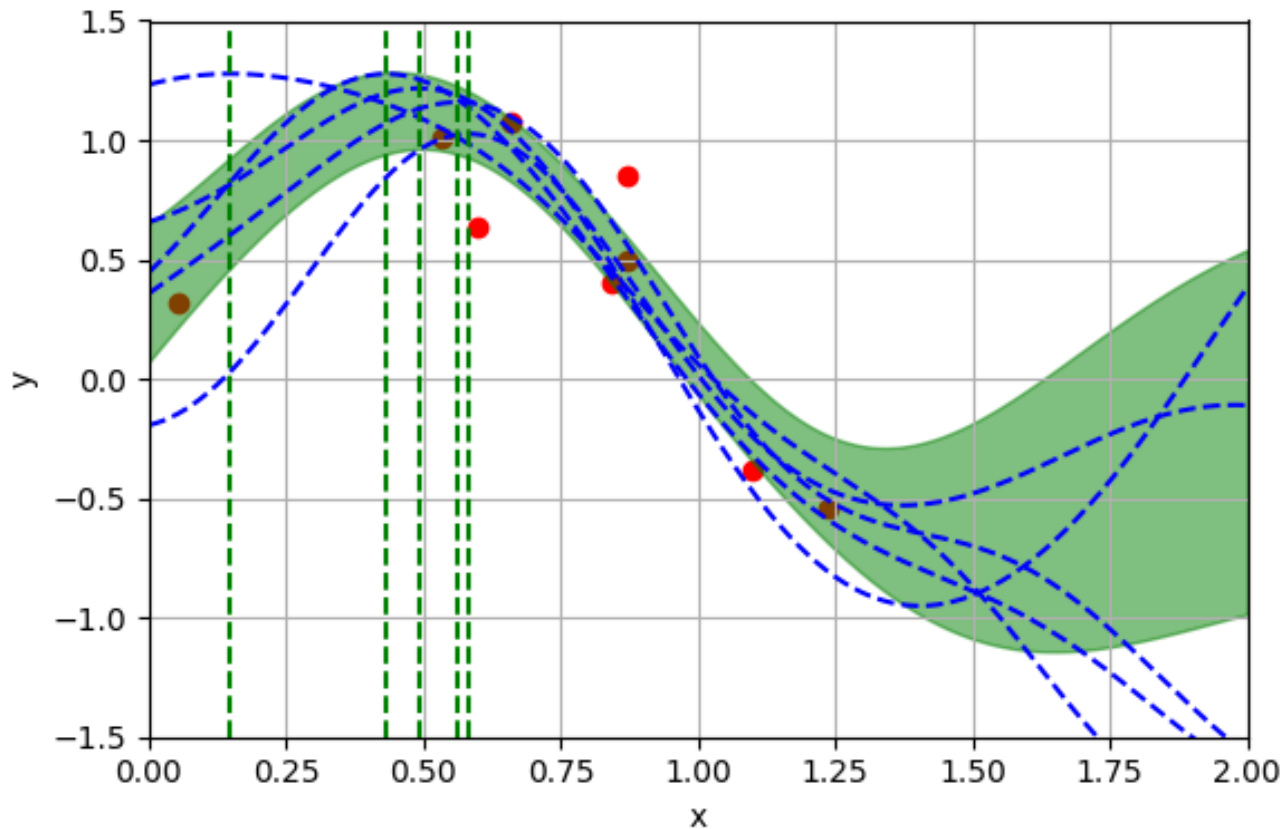
Challenge:

Expensive simulations (hours)





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Bayesian Optimization



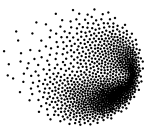
Gaussian Process
Fit to the data



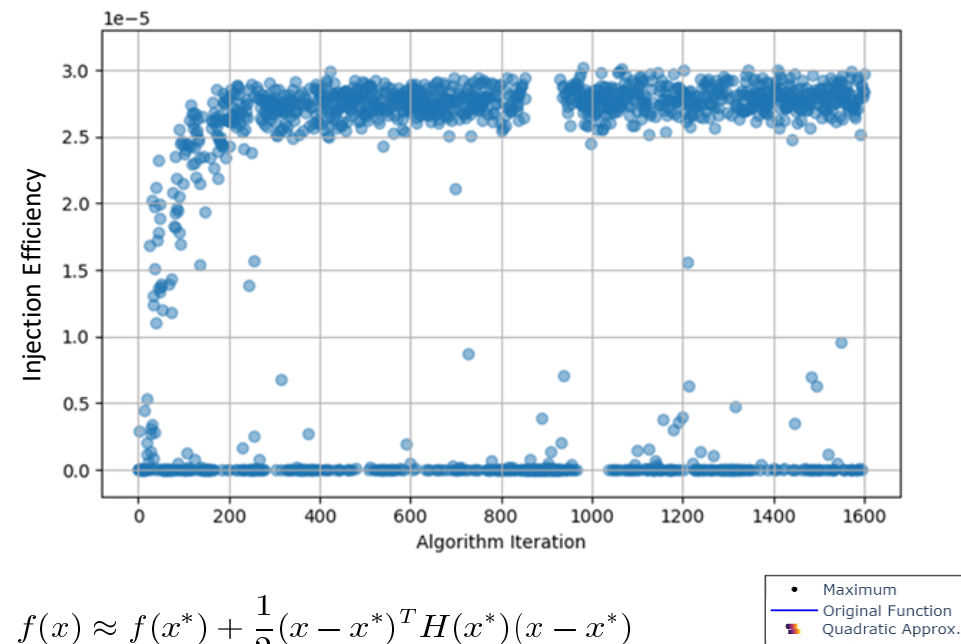
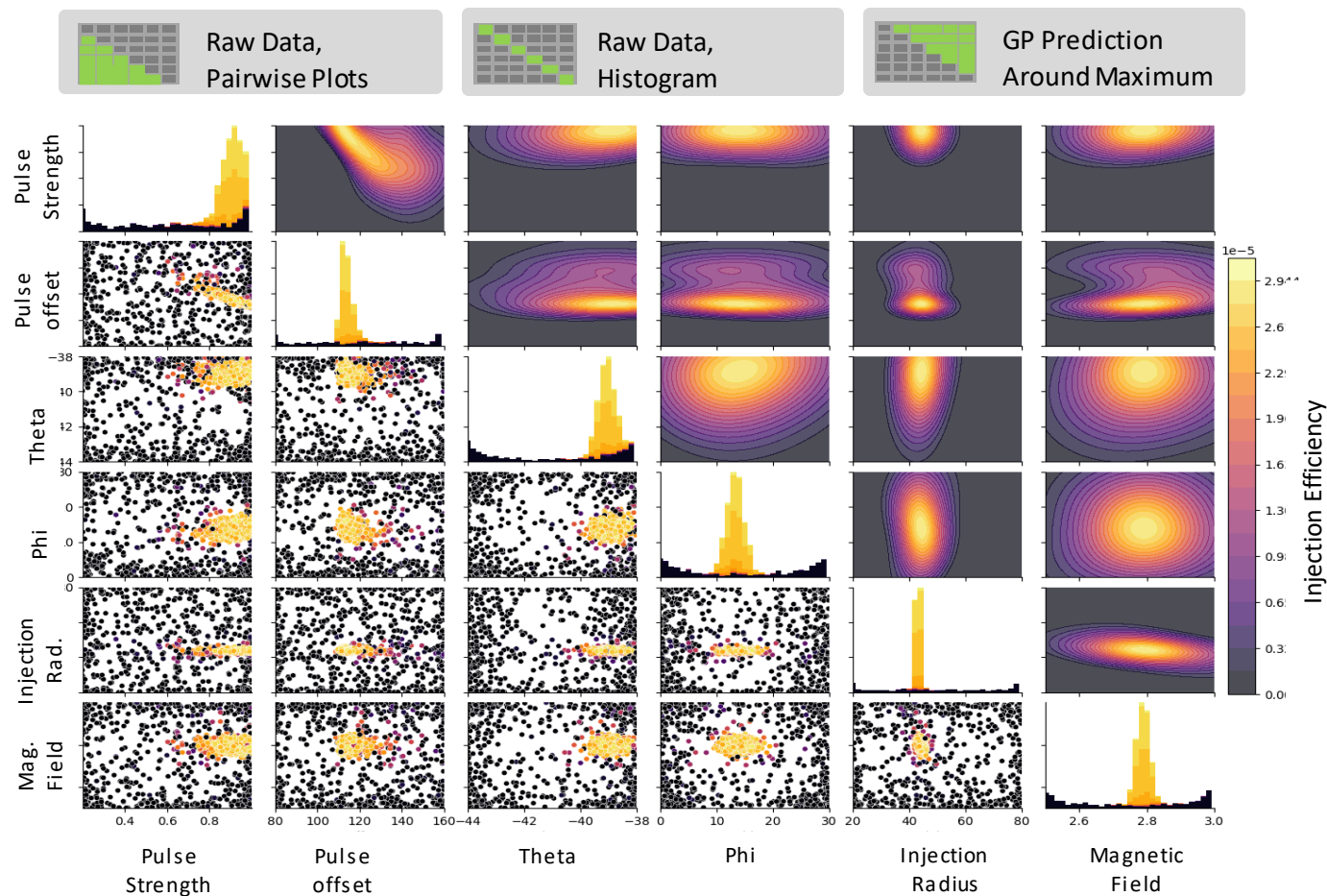
Acquisition Function:
Choose the next parameters



Simulator
G4Beamline Simulation



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$$f(x) \approx f(x^*) + \frac{1}{2}(x - x^*)^T H(x^*)(x - x^*)$$

Parameter tolerances

$$f(x^* \pm \delta x) = \alpha f(x^*) \quad 0 < \alpha < 1$$

$$\|\delta x_j\| = \sqrt{\frac{2(1 - \alpha)}{f(x^*)} (H^{-1})_{jj}}$$

