

❖ Determining Probability Density Functions (PDF) by fitting the corresponding Cumulative Density Function (CDF) using an adiabatic QML ansatz.

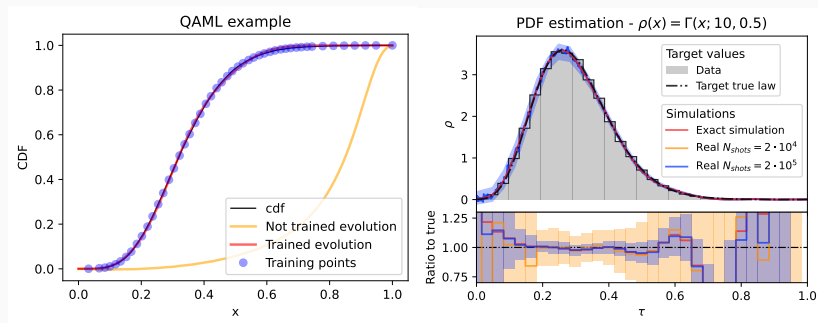
⚡ Algorithm's summary:

1. we optimize the parameters θ of the following adiabatic evolution:

$$H_{\text{ad}}(\tau; \theta) = [1 - s(\tau; \theta)]\hat{X} + s(\tau; \theta)\hat{Z} \quad (1)$$

in order to approximate some target CDF values with $\hat{F}(x_k \equiv \tau) = \langle \psi(\tau) | \hat{Z} | \psi(\tau) \rangle$;

2. we derivate from H_{ad} a circuit $\mathcal{C}(\tau; \theta)$ whose action on the GS of \hat{X} returns $|\psi(\tau)\rangle$;
3. the circuit at step 2. can be used to calculate the CDF;
4. we compute the PDF by derivating \mathcal{C} with respect to τ using the Parameter Shift Rule.

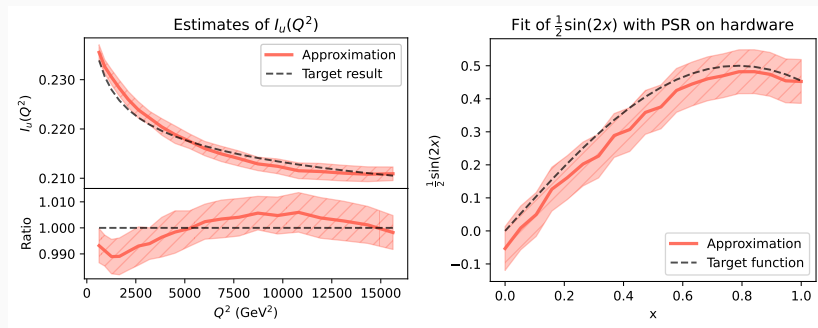


✦ Use Variational Quantum Circuits to calculate multi-dimensional integrals of the form:

$$I(\alpha) = \int_{x_a}^{x_b} g(\alpha; \mathbf{x}) d^n \mathbf{x}. \quad (2)$$

⚡ Algorithm's summary:

1. inspired by arXiv:2211.02834, we train the derivative of a VQC with respect to the integral variables \mathbf{x} to approximate the integrand $g(\mathbf{x})$;
2. the derivatives are computed using the Parameter Shift Rule and this allows the same circuit \mathcal{C} to be used for approximating any integrand marginalisation and the primitive!
3. thanks to 2., it's much more convenient to compute Eq. (2) when varying α .



❖ Cleaning up the parameters space with a real time error mitigation strategy in order to overcome Noise-Induced Barren Plateaus (NIBP) when training a QML model.

⚡ Algorithm's summary:

1. we mitigate all the expected values E through Clifford Data Regression (CDR):

$$E_{\text{mit}} = \alpha_{\text{cdr}} E_{\text{noisy}} + \beta_{\text{cdr}}; \quad (3)$$

2. reduced CDR computational cost by updating $(\alpha, \beta)_{\text{cdr}}$ periodically during the training;
3. the mitigation removes the bounds and accelerate the training process.

