# QCBM Documentation 5

Akash Malemath, Yannick Werner, Bashar Karaja,
Maximilian Kiefer-Emmanouilidis

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## 1 Model Description

**Training Data**: RELU + Sigmoid + Elu + Tanh Distribution
**Pre-training**: Particle number distribution
**Number of qubits**: 10
**Number of Ancillas**: 2
**Loss Function**: MMD Loss
**Kernel**: Gaussian RBF kernel
**Accuracy**: KL Divergence
**Learning rate**: 0.1 - 0.01
**Optimizer**: optax.adam

## 2 Observations

### 2.1 Uniform superposition Pre - Training (No Ancillas)

| S.No | qcbm circuit | Layers | min KL Div | Model |
|---|---|---|---|---|
| 1 | RX + RZ + CNOT | 10 | 0.3633 | Converges |
| 2 | RZ + IsingXY + IsingZZ | 10 | 0.0421 | Converges |

### 2.2 Uniform superposition Pre - Training (With Ancillas)

| S.No | qcbm circuit | Layers | min KL Div | Model |
|---|---|---|---|---|
| 1 | RX + RZ + CNOT | 10 | 0.0061 | Converges |
| 2 | RZ + IsingXY + IsingZZ | 10 | 0.0069 | Converges |

# 3 Conclusion

By now we know that, pre-training the model with particle number distribution, only helps in the case of RZ + IsingXY + IsingZZ circuit and doesnt improve the performance of fully entangling circuit RX + RZ + CNOT. This has been verified again.

For the same number of layers, further observations to be noted are:

1) The presence of ancilla qubits **improves the convergence** order by $10^{-1}$ for the case of Ising entangling circuit and by the order of $10^{-2}$ for the fully entangling circuit.

2) IN THE PRESENCE OF ANCILLAS: the performance of RZ + IsingXY + IsingZZ circuit with the pre-training scheme of uniform superposition of all the possible particle number states is **equivalent** to that of the Fully entangling circuit RX + RZ + CNOT.

3) IN THE ABSENCE OF ANCILLAS: The RZ + IsingXY + IsingZZ circuit with the pretraining scheme of uniform superposition of all the possible particle number states has **better convergence** compared to the fully entangling circuit RX + RZ + CNOT, **by the order of** $10^{-1}$.